UNITED WATER CONSERVATION DISTRICT

"Conserving Water Since 1927"

SANTA FELICIA PROJECT
FERC LICENSE NO. 2153

Fish Passage Feasibility Report

Prepared by:

United Water Conservation District

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APRIL 2017

Background

On September 12, 2008, the Federal Energy Regulatory Commission (FERC) issued a license (FERC Project P-2153) to United Water Conservation District (United) for its Santa Felicia Project on Piru Creek in the Santa Clara River watershed, Ventura County, California. On May 5, 2008, the National Marine Fisheries Service (NMFS) issued a biological opinion to FERC addressing the effects of the issuance of this license on endangered southern California steelhead (*Oncorhynchus mykiss*). Articles 401 and 402 of the license incorporate requirements contained in the biological opinion. Specifically, element 3 of the reasonable and prudent alternative (RPA 3) in the biological opinion requires that United provide passage of steelhead at or around Santa Felicia Dam (SFD) or other suitable alternatives to passage. RPA 3 consists of the following five sub-elements.

a) Preparation and implementation of a plan that will guide the conduct of the steelhead-passage feasibility assessment

b) Implementation of the assessment of steelhead-passage feasibility

c) Preparation of a steelhead-passage feasibility report

d) Development of criteria to guide implementation timing of the preferred alternative

e) Implementation of the preferred alternative

In 2013, United completed RPA 3(a), with NMFS and FERC approving its Santa Felicia Fish Passage Feasibility Assessment Study Plan (Study Plan). The Study Plan sets the framework for an independent panel of fish passage experts (Panel) to conduct a fish passage feasibility assessment for Santa Felicia Dam (tasks 1 through 7) and establishes a process for making decisions in consultation with resources agencies following receipt of the Panel's final report (identified as tasks 8 and 9 in the Study Plan). The Panel completed tasks 1 through 7 and issued its final report, *Santa Felicia Dam Fish Passage Alternatives Feasibility Report* (Panel Report), dated February 26, 2016.

United initiated task 8 of the Study Plan on February 26, 2016, by providing NMFS and California Department of Fish and Wildlife (CDFW) [collectively, United, NMFS, and CDFW comprise "the Group"] with the Panel Report. The Study Plan summarizes tasks 8 and 9 as following.

Task 8: Group[1] Fish Passage Decision

- *Task: The Group will review the Final Panel Fish Feasibility Study report, and consider its recommendations at a meeting of the Group and Panel. A possible outcome of the meeting is for the Group to agree upon the Panel's recommendation of Task 7 of a recommended fish passage alternative or further study. If there is a consensus of the Group, the Study terminates, and the implementation process can begin. If there is no consensus among the Group, the Study continues with Task 9, an examination of off-site alternatives including an economic analysis.*

[1] The Study Plan defines the "Group" as NMFS, CDFW, and United

- *Outcome: Decision to either continue with evaluation of off-site alternatives and economic analysis, or to proceed directly to implementation.*

Task 9: Biological and Economic Feasibility Analysis and Off-Site Alternatives Assessment

- *The process for Task 9 will follow a process similar to that established in the Study Plan for passage alternatives at Santa Felicia Dam.*
- *The Panel will identify and develop feasible off-site alternatives (other than fish passage at Santa Felicia Dam) that might satisfy the biological goal of the Project avoiding jeopardizing the continued existence of the Southern California steelhead DPS.*
- *Biological performance will be examined to assess contributions of these alternatives to the increased viability of the DPS and provide a means of comparison among all alternatives.*

In undertaking task 8, the Group conducted a meeting on January 25, 2017, during which the Group reached general consensus around the recommendations contained in the Panel Report with the following stipulations.

- The Panel Report allows for task 9 to carry over into the implementation phase of RPA 3. Page 7-3 of the Panel Report states, "The path from Task 8 to the fish passage implementation process would signify a Group [NMFS, CDFW, United] consensus that fish passage is the "preferred alternative to restore steelhead access to and from historical spawning and rearing habitats," and a Group consensus that the Panel's recommended alternatives would meet the overall objective of providing safe and efficient upstream and downstream passage for steelhead at SFD. However, it is still possible that during the course of the implementation process, additional technical, biological, engineering design, social, and other issues may be identified that may reduce the overall feasibility of providing fish passage at SFD (i.e., fatal flaw), thereby leading to re-consideration of non-fish passage alternatives as shown in Figure 7.1-1."
- In a December 2, 2016, letter to FERC, NMFS provided its "general agreement" with the Panel Report. However, NMFS states that the agreement is subject to the completion of additional studies or elemental processes described in the letter.
- Similarly, United's agreement on a preferred long-term solution for fish passage is contingent on resolution of certain outstanding issues, including reaching agreement on the biological criteria required in RPA 3(d).
- Prior to implementation of any of the agreed upon actions, United will need to obtain various required approvals. Examples include approval from CDFW to move steelhead in light of the quagga mussel infestation and approvals by the US Department of Agriculture Forest Service (Forest Service) to conduct studies or construct facilities on lands under its jurisdiction.

Therefore, the Study Plan (specifically tasks 8 and 9) will technically remain in the implementation stage and will not be considered complete until these stipulations are resolved to the satisfaction and agreement of the Group.

Nevertheless, United believes enough information is known and agreement has been reached within the Group to submit the feasibility report in fulfillment of RPA 3(c) and to move forward with implementing specific actions related to fish passage. Therefore, United submits this document, which includes the Panel Report, as its Fish Passage Feasibility Report (Feasibility Report).

Feasibility Report – RPA 3(c) Requirements

RPA 3(c) of the biological opinion issued by NMFS requires that United prepare and obtain NMFS's agreement on a feasibility report for steelhead passage. RPA 3(c) specifically requires that United prepare and submit a feasibility report containing the following information:

(1) Describes the findings obtained from the assessment of the steelhead-passage feasibility and all related studies (see reasonable and prudent alternative 3a and 3b).

(2) Identifies the preferred long-term solution to restore steelhead access to and from historical steelhead spawning and rearing habitats upstream of Santa Felicia Dam (if volitional steelhead passage is determined to be infeasible, then the study shall consider non-volitional steelhead passage; if non-volitional passage is determined to be infeasible, then the Licensee shall consult with NMFS to develop an alternative to steelhead passage [such as an habitat compensation plan based on measurable biological criteria to minimize the effects of the loss of habitat upstream of Santa Felicia Dam on steelhead], which will be presented in the report).

(3) Includes a plan and defines schedules for implementing and completing the executable element(s) of the feasibility report, including the preferred long-term fish-passage solution once criteria are triggered under reasonable and prudent alternative 3(d) or alternative to steelhead passage.

(4) Describes the environmental and regulatory permits and approvals that will be needed to implement the executable elements of the feasibility report.

This Feasibility Report, including the attached Panel Report, contains these elements listed under RPA 3(c).

Findings

The attached Panel Report addresses RPA 3(c) element 1. The Panel Report fully describes the studies completed by the Panel for the assessment. Through the Study Plan process, the Panel considered a suite of upstream and downstream fish passage alternatives. Generally, United agrees with the Panel's findings regarding its assessment of the feasibility of steelhead passage at Santa Felicia Dam with the understanding that tasks 8 and 9 of the Study Plan will remain in the implementation stage until the identified stipulations are resolved to the satisfaction and agreement of the Group.

RPA 3(c) element 2 requires that the feasibility report identify the "preferred long-term solution to restore steelhead access" past the Santa Felicia Dam. The Panel Report states that, "the Panel finds that volitional passage is currently an unrealistic option" (page 6-4). United supports this finding. The Panel Report identifies one recommended feasible long-term alternative each for non-volitional upstream and downstream passage based on the application of evaluation criteria and a matrix for ranking and comparing alternatives. For upstream fish passage, the Panel identified alternative U4, a collection and transport system. For downstream fish passage, the Panel identified alternative D7 (a middle Piru Creek collector with a provisional 200 cubic feet per second (cfs) design flow). Based on the Panel's study and findings, United agrees that U4 and D7 appear to be the best feasible alternatives for providing permanent long-term fish passage from an engineering and fish biology standpoint.

However, the Panel Report identifies a number of uncertainties regarding the engineering and biological feasibility of the collection and transport methods involved with U4 and D7. In its December 2, 2016, letter to FERC, NMFS agreed and stated "due to a number of uncertainties, there is a possibility during implementation of the recommended fish passage alternatives U4 and D7 that one or both of the selected alternatives may be determined to be infeasible by the Fish Passage Science and Technology Panel." Therefore, United's agreement with the Panel Report's recommendation of U4 and D7 as its preferred long-term fish passage solution is contingent upon resolving these uncertainties. United's commitment to implement U4 and D7 as the preferred long-term fish passage solution is contingent on the results of certain further studies regarding the feasibility and likely success of a fish passage program at Santa Felicia Dam. Task 8 of the Study Plan would not be considered complete until these additional studies are completed. If the results of the studies show U4 and D7 to be not feasible, the process would move into task 9 of the Study Plan.

In addition, RPA 3(d), which requires the development of "measurable biological criteria to trigger implementation of the preferred alternative," must be completed as part of the Group achieving full consensus around fish passage for Santa Felicia. The intention is that U4 and D7 would only be implemented once those triggers are met. Therefore, reaching agreement on appropriate triggers is critical for completing task 8 of the Study Plan. If consensus cannot be reached, the process would move to task 9 of the Study Plan.

The Panel Report (section 7-Recommended Implementation Process) describes a process by which the studies and development of biological criteria would be accomplished. United endorses the recommended process which includes the formation of a Fish Passage Science and Technology Panel (FPSTP) and development of an Implementation and Adaptive Management Process (IAMP). The FPSTP will consist of technical representatives from numerous agencies. The Panel Report identifies NMFS, U.S. Fish and Wildlife Service (USFW), California Department of Fish and Wildlife (CDFW), and United for the FPSTP. United will also invite representatives of the Forest Service. The FPSTP would be expected work as a cooperative group to provide expertise and guidance. Consistent with NMFS's December 2, 2016, letter to FERC, the FPSTP would not have any discretionary roles or responsibilities under the Endangered Species Act.

As described in section 7.2.2 of the Panel Report, the FPSTP will be tasked with coordinating and overseeing the following activities:

1) establishing a phased IAMP

2) developing biological criteria to trigger formal implementation of permanent fish passage facilities

3) identifying pre-implementation studies to resolve uncertainties that influence the engineering and biological feasibility of alternatives U4 and D7

4) developing and implementing a compliance monitoring program

5) developing biological performance standards and an effectiveness monitoring program

United may contract with consultants when appropriate to provide technical assistance or produce products for achieving specific tasks under the IAMP. The FPSTP and IAMP will be the means for completing tasks 8 and 9 of the Study Plan and RPA 3(d). They will also provide the framework for assessing if the biological criteria triggering implementation of U4 and D7 have been met, allowing the process to move to RPA 3(e).

As part of establishing the FPSTP and developing and implementing the IAMP, United will design and implement low technology collection facilities for 1) capturing adult migrating steelhead from below Santa Felicia Dam for transport and release above Lake Piru, and 2) capturing migrating steelhead from above Lake Piru for transport and release below the Santa Felicia Dam. United would implement these facilities to support conducting the necessary studies and for monitoring whether the biological criteria under RPA 3(d) have been met. Design of these facilities and operational strategies will be developed through the coordination and oversight of the FPSTP. By agreeing to put in place these low technology collection facilities, United is not opining on whether steelhead are present either at Santa Felicia Dam or in Middle Piru Creek at this time.

Implementation Schedule

RPA 3(c) element 3 requires that the feasibility report contain a plan and schedule for implementation of the actionable items. The following table contains this information

Action	***Days to complete***
Invite agencies to participate in FPSTP	7 days following submittal of feasibility report to FERC
Coordinate initiation meeting for FPSTP	60 days following invitation to FPSTP
FPSTP milestones 1. Establish a phased Implementation and Adaptive Management Process (IAMP) 2. Develop biological criteria to trigger formal implementation of permanent fish passage facilities 3. Identify pre-implementation studies to resolve uncertainties 4. Develop a compliance monitoring program 5. Develop biological performance standards and an effectiveness monitoring program	1 year following first meeting of FPSTP
Design low-technology collection facilities in coordination with FPSTP	1 year following first meeting of FPSTP, in conjunction with

	development and implementation of IAMP
Obtain permits to implement IAMP including the collection facilities a. USFS scientific collection b. CDFW scientific collection and 1600 c. USFW scientific collection d. CEQA/NEPA e. 401 & 404 for installation	1 year following first meeting of FPSTP, in conjunction with development and implementation of IAMP
Implement IAMP, including pre-implementation studies, as developed by the FPSTP	In accordance with the schedule in the IAMP

Santa Felicia Dam Fish Passage Alternatives Feasibility Report February 26, 2016

Prepared for: The United Water Conservation District, in association with the National Marine Fisheries Service, and the California Department of Fish and Wildlife

Prepared by: The Santa Felicia Dam Fish Passage Panel, represented by the following firms:

Santa Felicia Dam Fish Passage Alternatives Feasibility Report

February 26, 2016

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Photo Sources: Google Earth and Santa Felicia Dam Fish Passage Panel

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ACRONYMS AND ABBREVIATIONS

°C	Degrees in Celsius
AACE	American Association of Cost Engineers International
AWS	Auxiliary Water Supply
BGS	Behavioral Guidance Systems
BO	Biological Opinion
BPG	Biogeographic Population Group
BPT	Biological Performance Tool
CDFW	California Department of Fish and Wildlife
CFR	Code of Federal Regulations
cfs	Cubic feet per second (also ft^3/s)
CEII	Critical Energy Infrastructure Information, FERC Regulations
CMP	Corrugated Metal Pipe
CMWD	Casitas Municipal Water District
COE	U.S. Army Corps of Engineers
COMB	Cachuma Operation and Maintenance Board
CPUE	Catch Per Unit Effort
CTS	Collector Transition Structure
D	Downstream (as part of the Alternatives options)
DPS	Distinct Population Segment
DWR	Department of Water Resources
EL	Elevation
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FL	Fork Length
fps	Feet per second
FPSTP	Fish Passage Science and Technology Panel
FSC	Floating Surface Collector
ft	Feet
Group	Project stakeholders guiding this study, composed of United, NMFS, and CDFW,
IAMP	Implementation and Adaptive Management Plan
ITP	Incidental Take Permit
kW	Kilowatts
LMB	Largemouth Bass (*Micropterus salmoides)*

M&E	Monitoring and Evaluation
MAH BPG	Monte Arido Highlands Biogeographic Population Group
mg/l	milligram per liter
mi^2	square miles
mm	millimeters
NMFS	National Marine Fisheries Service
NTP	Notice to Proceed
O&M	Operations and Maintenance
OPCC	Opinion of Probable Construction Cost
Panel	Santa Felicia Dam Fish Passage Panel
PMF	Probable Maximum Flood
Project	Santa Felicia Project, including Santa Felicia Dam, Lake Piru, and associated facilities
Report	Santa Felicia Dam Fish Passage Alternatives Feasiblity Report
RM	River mile
RPA	Reasonable and Prudent Alternative
RSF	Redear Sunfish (*Lepomis microlophus)*
SCADA	Supervisory Control And Data Acquisition
SCS DPS	Southern California Steelhead Distinct Population Segment
SFD	Santa Felicia Dam
Study	Santa Felicia Dam Fish Passage Feasiblity Assessment Study
Study Plan	Santa Felicia Dam Fish Passage Feasiblity Assessment Study Plan
SYR	Santa Ynez River
U	Upstream (as part of the Alternatives options)
United	United Water Conservation District
USBR	United States Bureau of Reclamation
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VFD	Vern Freeman Diversion
WSEL	Water Surface Elevation
WY	Water Year

EXECUTIVE SUMMARY

In early 2011, in accordance with the FERC License requirements for the Santa Felicia Hydroelectric Project (Project) (FERC Project No. 2153-012), United Water Conservation District (United) convened a seven-person independent panel (Panel) consisting of fishery biologists, fish-passage engineers, and a resource economist to develop a Santa Felicia Dam Fish Passage Feasibility Assessment Study Plan (Study Plan).[1] The Panel prepared a draft Study Plan in June 2012 that was reviewed with members of United, the National Marine Fisheries Service (NMFS) and California Department of Fish and Wildlife (CDFW), collectively, the Group. The Study Plan was subsequently revised and was approved by FERC in February, 2013. The Study Plan guided the Panel in completing the Santa Felicia Dam Fish Passage Feasibility Assessment Study (Study). A Draft Report was prepared by the Panel and distributed to the Group for review on April 6, 2015 and comments were received from NMFS on July 6, 2015 and United on July 17, 2015. The Panel carefully reviewed and considered both sets of comments, and completed this document, Final Santa Felicia Dam Fish Passage Alternatives Feasibility Report (Report).

Throughout the Study, the Panel has functioned independently but has periodically met with the Group (Group meetings) as needed to update the Group on progress, present concepts and alternatives under consideration, address questions, obtain feedback from the Group on data or issues to be considered by the Panel, and to seek biological, engineering, and operational information of relevance to the development of certain alternatives. Four separate meetings were held among the Panel members (Panel meetings) to brainstorm and compile an initial list of concepts, review the concepts and define an initial set of alternatives, and evaluate and refine alternatives.

The Panel completed Tasks 1 through 7 described in the Study Plan that are summarized as follows. Commencing with **Task 1 – Feasibility Study Preparation,** the Panel first assembled and reviewed important background information concerning the Santa Felicia Dam (SFD) and its operations, the Piru Creek watershed, and the ecology and life history characteristics of the

[1] The Study Plan was a requirement stemming from the NMFS issuance of a final biological opinion (BO) on May 5, 2008, addressing the effects of the proposed action on the endangered Southern California Steelhead Distinct Population Segment (SCS DPS) (*Oncorhynchus mykiss)* (NMFS 2008), and specifically Reasonable and Prudent Alternative (RPA) Element 3. That element specified that United *"....provide passage of steelhead at or around Santa Felicia Dam, or other suitable alternative to passage. Prior to implementing this action, the Licensee shall implement a plan after receiving written agreement on the plan from NMFS to assess the feasibility of providing passage of adult and juvenile steelhead around or over Santa Felicia Dam".*

Southern California steelhead DPS. This defined the geographic/topographic and hydrologic setting of the project and provided information necessary for the development of the **Biological Performance Tool (BPT) - Task 2** that was later used as part of the evaluation process for comparing downstream passage alternatives. **Task 3 – Identify Fish Passage Concepts,** consisted largely of a Panel brainstorming session during which an initial list of upstream and downstream passage concepts were compiled. This list was intended to be comprehensive and was not constrained by the Project's physical or operational characteristics. The list was subsequently refined in **Task 4 – Concept Development and Alternative Definition,** based on the compatibility of the concepts with the SFD, and alternatives formally developed. These alternatives were then initially evaluated in **Task 5 – Initial Evaluation** using a matrix evaluation and scoring process that included results from the BPT. Further refinement and evaluation of the alternatives was completed in **Task 6 - Fish Passage Alternative Refinement** that included additional testing of the alternatives using the BPT and a refinement in the matrix evaluation, and an independent ranking of alternatives by each member of the Panel. The results of the evaluation culminated in the Panel's identification of a recommended set of alternatives, and this Report completes **Task 7 – Reporting and Fish Passage Recommendations.** The Study Plan will continue with **Task 8 – Group Fish Passage Decision** which involves the Group's review of the Panel's final Report and a Group decision regarding implementation of a recommended alternative. If needed, the Study Plan includes **Task 9 – Biological and Economic Feasibility Analyses and Off-Site Alternatives Assessment** to conduct a broader examination of the biological and economic feasibility of fish passage, including off-site alternatives**.**

The identification and evaluation process the Panel applied in Tasks 3 – 6 resulted in the selection of four upstream passage alternatives for further consideration and conceptual development. These are presented below in Table ES-1 along with associated Enhancements[2] and Supplementals[3]. A similar evaluation process resulted in the selection of nine downstream passage alternatives that are presented in Table ES-2 along with various Enhancements;

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[2] Enhancements - as defined by the Panel, are features that add efficiency to a primary alternative but do not perform the same overall fish passage function. For example, a guide curtain might be added to a reservoir collector to help guide fish to the collector. The guide curtain does not collect fish, but it enhances the efficiency of the collector alternative.

[3] Supplementals - the Panel uses the term Supplementals to denote those alternatives that are potentially stand-alone, but are associated with a specific primary alternative to improve performance of that alternative. For example, fish might be attracted to and trapped in the plunge pool at the downstream end of the spillway chute. A spillway pool collector may be employed to collect those fish and to reduce stranding or delay. Operation of the spillway pool collector is not directly related to upstream fish passage, but the overall success of passage might be improved with the effort.

Supplementals were not part of the downstream alternatives as some of the downstream alternatives contained components that were not stand-alone as defined for a Supplemental. A final ranking of the alternatives was completed based on the Panel's combined professional judgment, consideration of results of the matrix evaluation and the BPT scores, and consideration of least risk of failure and greatest likelihood of success in providing safe and efficient passage performance. Results of the rankings are shown in parentheses ( ) in each of the tables.

Table ES -1. Summary of the Preferred Upstream Passage Alternatives (Alt), and Enhancements and Supplementals Identified by the Santa Felicia Dam Fish Passage Panel. Panel rankings are shown in ( ); Panel's recommended alternative is shaded.

Alt # (Ranking)	Name of Alternative	Enhancements	Supplementals
U1 (4)	Pool and Weir Fishway, Tunnel and Tower; Reservoir Range El 980' to 1,056'	• Operate to minimize spill • Monitoring facility	• Spillway Pool Collector
U2 (3)	Pool and Weir Fishway to EL 1,030', East Alignment to Exit Structure; Reservoir Range EL 1,030' to 1,056'	• Operate to minimize spill • Monitoring facility • Challenge section • Release pond	• Spillway Pool Collector • Collection and transport facility
U3 (2)	Pool and Weir Fishway to EL 1,056', West Alignment with Slide Release; Reservoir Range EL 980' to 1,056'	• Operate to minimize spill • Monitoring facility • Challenge section	• Spillway Pool Collector
U4 (1)	Collection and Transport with Multiple Release Locations; Reservoir Range EL 980' to 1,056'	• Operate to minimize spill • Monitoring facility • Challenge section • Release pond	• Spillway Pool Collector

Table ES-2. Summary of Preferred Downstream Alternatives with Enhancements (no supplementals). Panel rankings are shown in ( ); Panel's recommended alternative is shaded.

Alt # (Ranking)	Name of Alternative	Enhancements
D3*(7)	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps	• Operate to minimize spill • Collector Transition Structure • Guide curtain • Cover in front of collector • Release pond • Reduced deep outlet screen
D4*(8)	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps, Volitional Bypass with U1	• Operate to minimize spill • Collector Transition Structure • Guide curtain • Cover in front of collector • Release pond • Reduced deep outlet screen
D5*(6)	Surface Collector at Intake Tower, 500 cfs Screen, Gravity with Pumps	• Operate to minimize spill • Collector Transition Structure • Guide curtain • Cover in front of collector • Release pond
D7 (1)	Piru Creek Collector, 200 cfs Screen	• Release pond • Deep outlet screen
D9*(5)	Piru Creek Collector (D7) with Spillway collector	• Operate to minimize spill • Release pond • Deep outlet screen
D10 (2)	Piru Creek Collector (D7) with 150 cfs Surface Collector D3	• Operate to minimize spill • Release pond • Deep outlet screen
D11 (3)	Piru Creek Collector (D7) with 500 cfs Surface Collector (D5)	• Operate to minimize spill • Release pond
D12 (4)	Piru Creek Collector (D7) with Movable FSC	• Operate to minimize spill • Release pond • Deep outlet screen
D14 (9)	Multi-level Crest Gate Collector with Helix Bypass	• Operate to minimize spill • Guide curtain • Cover in front of collector • Deep outlet screen

* Note – D3 through D5 and D9 are not preferred stand-alone alternatives but are listed and described because they were developed as stand-alone alternatives and were then combined with D7 as preferred alternatives.

The ranked list of alternatives framed the Panel's recommended preferred upstream and downstream fish passage alternatives, consisting of U4, a collection and transport system for upstream passage, and D7, a Piru Creek collector with provisional 200 cfs design flow, for downstream passage. The ranking substantiated the overall high level of confidence the Panel espoused to these two alternatives in that they would be effective in providing safe and efficient passage for adult and juvenile/smolt SCS DPS above and below SFD. Specific to U4, the Panel found that it provides:

- a proven concept and high relative likelihood of success of providing passage, given examples throughout the Pacific Coast region - all other upstream alternatives have components that are experimental or highly complex and would require substantial commitment of resources to address risks and uncertainties, such as the effect of the length of the fishways on performance and challenges to design and build the associated complex structures;
- a clear pathway to evaluate effectiveness - evaluation of the effectiveness of the other three upstream passage alternatives would involve substantial commitment to resolve risks without clearly benefitting the objective of providing safe and successful upstream passage;
- a good foundation for responding to results of performance including opportunities and direction for phasing;
- the basic components or building blocks that the other alternatives can employ as a first step in implementation - expansion of U4 into other alternatives can be readily made and will be based on effectiveness monitoring; and
- a relatively simple concept, design, and a record of implementation with many historical and contemporary examples, and that fits within the existing infrastructure and operational characteristics of SFD.

For D7, the Panel found that it:

- represents the logical first step for addressing downstream passage, given the uncertainties associated with the reservoir (i.e., water quality, predation potential, flow paths) and unknowns regarding how SCS DPS will respond to fish passage above SFD;
- is compatible with the existing infrastructure and operational characteristics of SFD;
- provides the greatest flexibility and opportunity to phase implementation of the alternative with minimal commitment of resources (time and cost); and
- allows the opportunity to phase in modifications to the facility and/or develop other alternatives (e.g., floating surface collector) as determined through monitoring and an adaptive management process.

The Panel also found that the actual and relative risks associated with U4 and D7 are less than the other alternatives. That is, both U4 and D7 are compatible with the existing infrastructure of SFD, inherently amenable to phasing, employ proven technologies, and are relatively inexpensive compared to other alternatives. These attributes are especially attractive when considering fish passage measures at SFD given the general lack of Piru Creek-specific information on the life history and behavior of the SCS DPS, and the uncertainties regarding the quality and quantity of habitat in Lake Piru. Given these uncertainties, the Panel considers it a far greater risk to proceed with more rigid, complex and costly measures that may not even be warranted, than to proceed with lower cost, yet proven technologies that can be readily modified as information is learned and conditions dictate

The Panel realizes that identification of recommended preferred fish passage alternatives is but a possible first step in effecting the long-term restoration of SCS DPS above SFD and that many questions and details remain regarding the if, what, where, how and when individual measures would be implemented. The overall decision on what constitutes "… the preferred long-term solution to restore steelhead access to and from historical steelhead spawning and rearing habitats upstream of Santa Felicia Dam" (NMFS 2008, page 102, RPA 3(c)) ultimately involves a Group decision (**Task 8**) on whether this can and should be achieved via installation of fish passage facilities at SFD, or via non-fish passage alternatives. If steelhead passage is determined to be technically and economically infeasible, then non-fish passage alternatives "such as a habitat-compensation plan based on measurable biological criteria to minimize the effects of the loss of habitat upstream of Santa Felicia Dam on steelhead" would be considered through the process identified in **Task 9** of the Study Plan. Figure ES-1 depicts the Group decision process and possible outcomes that may result subsequent to completion of Task 7 and preparation of this Report. The path from Task 8 to the fish passage implementation process would signify a Group consensus that fish passage is the "preferred alternative to restore steelhead access to and from historical spawning and rearing habitats," and a Group consensus that the Panel's recommended alternatives would meet the overall objective of providing safe and efficient upstream and downstream passage for steelhead at SFD.

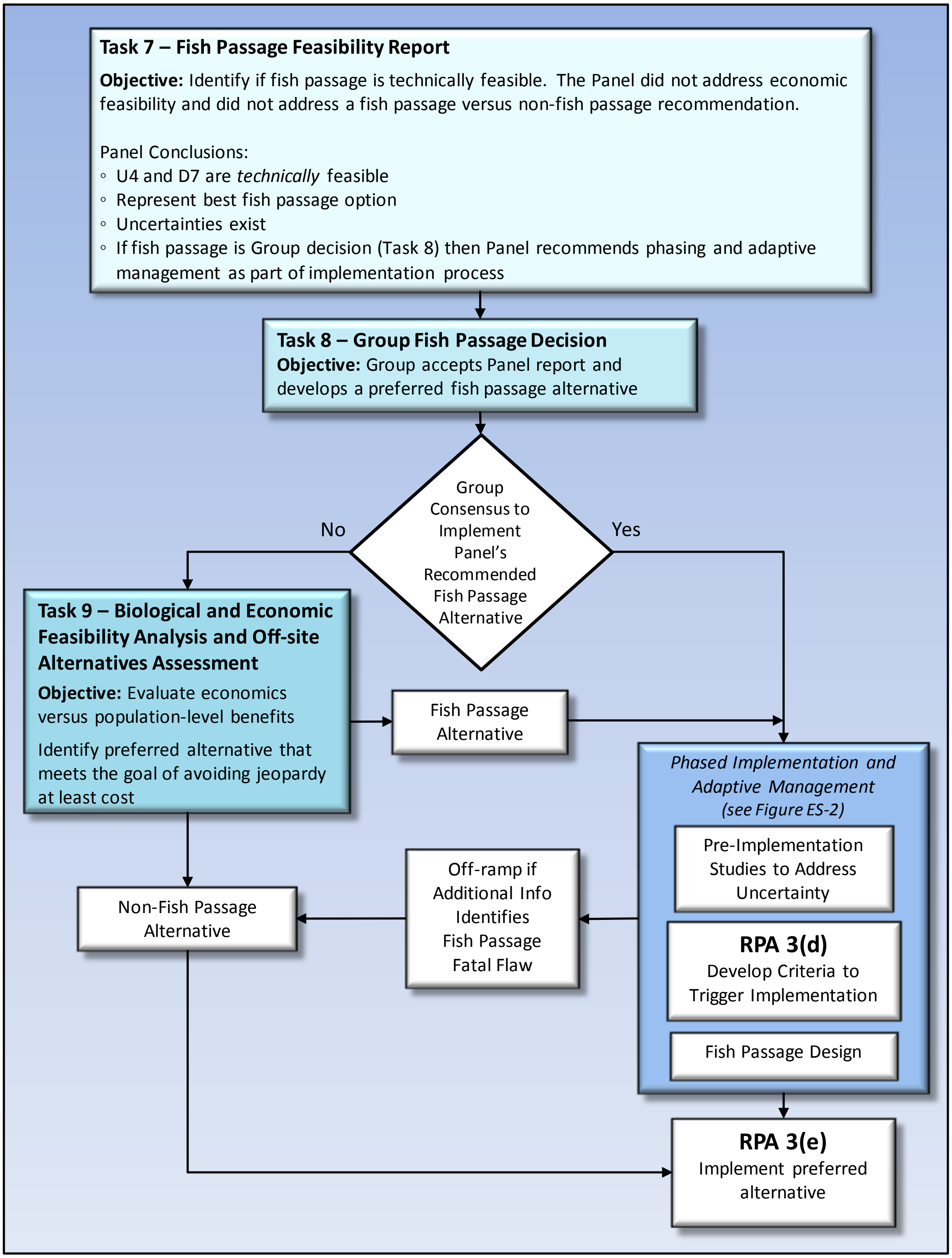


Figure ES-1. Decision process guiding selection and implementation of preferred alternative associated with Tasks 7, 8 and 9 of the Study Plan.

However, an affirmative decision by the Group in Task 8 would not directly lead to the design, construction, operation, and monitoring of U4 and D7. Rather, that decision hinges on the triggering of certain yet to be determined biological criteria developed under RPA 3(d). Even so, the Panel suggests that an affirmative decision should mark the start of a process structured to gain a better understanding of the biology and life history characteristics of the SCS DPS applicable to the Piru Creek watershed, and evaluate potential biological and ecological watershed conditions that could constrain or otherwise influence the design and success of selected fish passage alternatives. Certain engineering issues should be evaluated during the early stages of this process, such as identifying any seismically imposed constraints and conducting prototype testing of low-technology smolt and adult collection facilities.

The Panel suggests that this process is best addressed through development of a phased implementation and adaptive management process and recommended and described the framework of this process in the Report. Figure ES-2 illustrates the process and commences with the Group decision to implement fish passage via either Task 8 or Task 9 (as shown in Figure ES-1). Certain preliminary actions would occur with that decision including formation of a Fish Passage Science and Technology Panel (FPSTP) who would be responsible for development of a detailed Implementation and Adaptive Management Plan (IAMP). The IAMP would serve as the primary guide for advancing the recommended preferred upstream and downstream fish passage alternatives through preliminary testing and refinement that could ultimately lead to the design, construction and full operation of the selected alternatives. The IAMP would also guide the development and conduct of certain high priority pre-implementation studies that the Panel has identified, designed to address or reduce uncertainties that could affect the ultimate facility design and operation. Further details of the IAMP including recommendations regarding monitoring and evaluation are provided in the Report.

In summary, the Panel concludes with Task 7 of the Study and this Report that fish passage is technically feasible, and if a Group decision favors fish passage, recommends U4 and D7 as the preferred fish passage alternatives. The Panel further recommends that the development of U4 and D7 follow a phased implementation and adaptive management process.

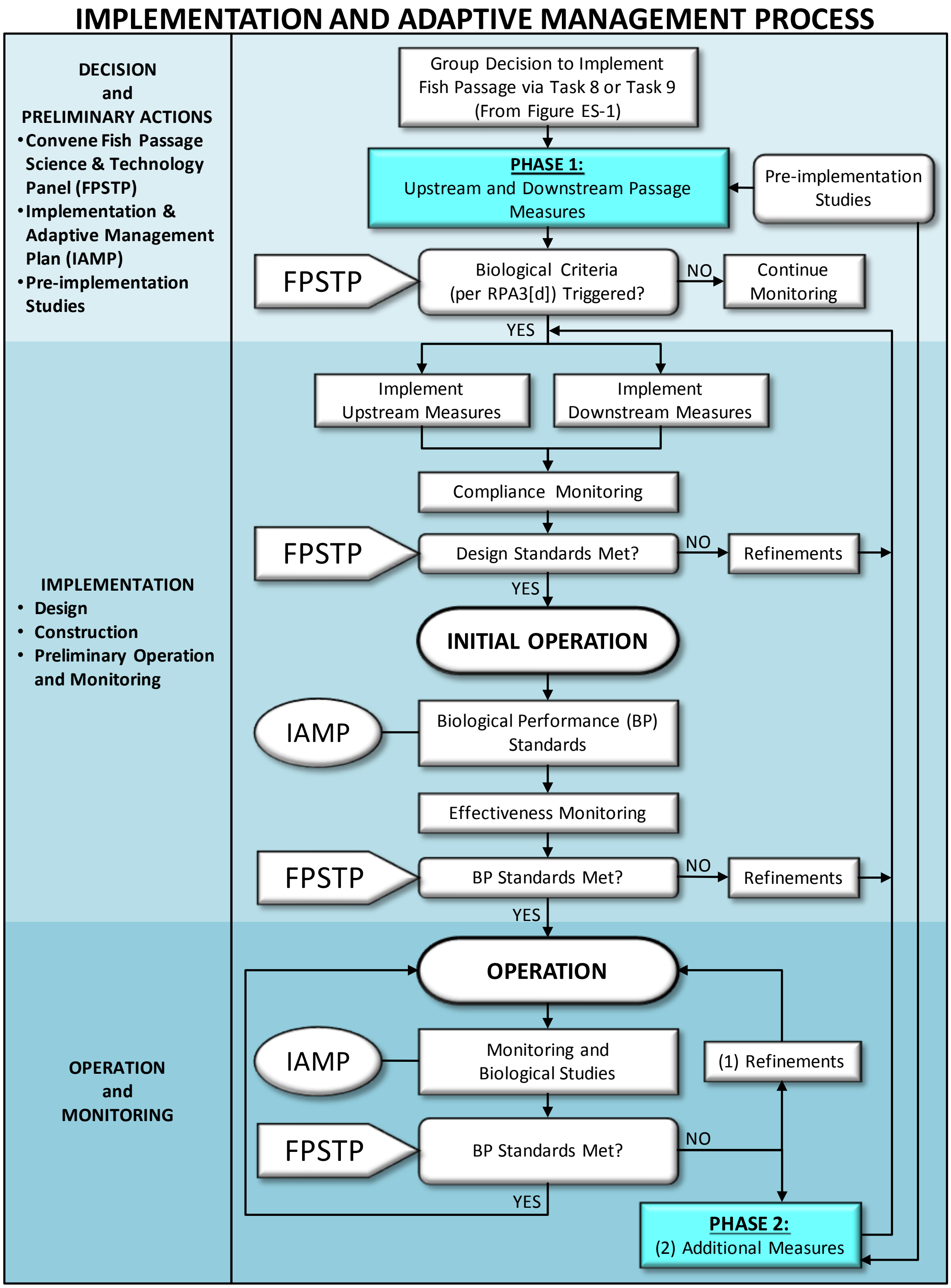


Figure ES-2. Implementation and Adaptive Management Process for the Panel's recommended preferred fish passage alternatives (U4 and D7) for Santa Felicia Dam. The process would be initiated by a Group decision to implement fish passage via Task 8 or Task 9. See text for further explanation.

1. INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

The purpose of this Santa Felicia Dam Fish Passage Alternatives Feasibility Report (Report) is to comply with Reasonable and Prudent Alternative (RPA) 3(c) of the National Marine Fisheries Service (NMFS) biological opinion (BO) (NMFS 2008) of the effects of the Santa Felicia Hydroelectric Project (Project) on the federally listed Southern California Steelhead Distinct Population Segment (SCS DPS) *(Oncorhynchus mykiss*). RPA 3(c) directed United Water Conservation District (United) to prepare a report addressing steelhead-passage feasibility to:

- *"describe the findings obtained from the assessment of the steelhead-passage feasibility and all related studies including results of reasonable and prudent alternative 3a and 3b (described below),*
- *identify the preferred long-term solution to restore steelhead access to and from historical steelhead spawning and rearing habitats upstream of Santa Felicia Dam (if volitional steelhead passage is determined to be infeasible, then the study shall consider non-volitional steelhead passage; if non volitional passage is determined to be infeasible, then Licensee (United) shall consult with NMFS to develop an alternative to steelhead passage [such as an habitat-compensation plan based on measurable biological criteria to minimize the effects of the loss of habitat upstream of Santa Felicia Dam on steelhead], which will be presented in the report),*
- *include a plan and define schedules for implementing and completing the executable element(s) of the feasibility report, including the preferred long-term fish-passage solution once criteria are triggered under reasonable and prudent alternative 3(d) or alternative to steelhead passage, and*
- *describe the environmental and regulatory permits and approvals that will be needed to implement the executable elements of the feasibility report."*

As such, the primary objectives of this Report are to present results of the Santa Felicia Dam Fish Passage Feasibility Assessment Study (Study), identify and recommend a preferred fish passage alternative based on results of the Study, recommend a process for implementing and completing the preferred alternative (if the Group is in agreement with the alternative), and describe approvals and permits that will likely be needed for implementation of the alternative.

1.1.1 Feasibility Study

The Study is to conduct an objective and thorough analysis of the full range of upstream and downstream fish passage alternatives (both volitional[4] and non-volitional) for passing steelhead above and below SFD, that are compatible with existing SFD operations and prevailing watershed characteristics. The Study also fulfills a requirement of the RPA Element 3 to conduct a steelhead-passage feasibility assessment.

The objective of the Study as defined in the Santa Felicia Dam Fish Passage Feasiblity Assessment Study Plan (Study Plan, SFDFPP 2013) was to conduct:

> *"… an impartial assessment of the biological and technical feasibility for allowing upstream and downstream steelhead passage at Santa Felicia Dam, while incorporating cost and time efficiency to the extent consistent with Reasonable and Prudent Alternative 3 of NOAA's National Marine Fisheries Service's May 5, 2008, biological opinion for the Santa Felicia Hydroelectric Project."*

The Report is the end product of Tasks 1 through 7 of the Study Plan, and culminates in this Report that contains the Panel's recommended upstream and downstream fish passage alternatives for the SFD.

In the Report, the concept of "feasibility" is defined in terms of both engineering and fish passage requirements. Engineering feasibility is governed (constrained) by the physical and operational characteristics of the dam and reservoir, the hydrologic characteristics of the watershed, and capital and operating costs. Fish passage feasibility is governed by steelhead behavioral responses to site conditions, including migration timing, and migratory pathways. In this way, the test of "feasibility" reflects an affirmative response to questions addressing four aspects of feasibility considered herein:

1. Technical feasibility; does it satisfy fish passage and water supply objectives of the project?
2. Biological feasibility; does it satisfy biological goals?
3. Engineering feasibility; can it be built and operated?
4. Economic feasibility; is it worth doing either inherently or relative to other actions?

[4] Volitional passage is the concept of giving fish the choice of moving upstream or downstream based on their own motivation.

Additional definitions of terms used throughout this Report are presented in Section 1.5.

1.2 BACKGROUND AND OVERVIEW

United was issued a new license from the Federal Energy Regulatory Commission (FERC) on September 12, 2008 to operate the Santa Felicia Hydroelectric Project (Project) (FERC Project No. 2153-012) on Piru Creek in the Santa Clara River watershed, Ventura County, California. The Project consists of Santa Felicia Dam (SFD), Lake Piru and appurtenant facilities. SFD is operated as a water resource reservoir as well as hydropower generation. The project's authorized generating capacity is 1,420 kilowatts (kW). Piru Creek is designated as critical habitat for the endangered SCS DPS. As a consequence, and in accordance with Section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq*.), the NMFS issued a final BO on May 5, 2008, addressing the effects of the proposed action on the species (NMFS 2008).

In this BO, NMFS included an RPA that required the implementation of a Santa Felicia Dam Operations Plan that (NMFS 2008, p. 96):

> *"…requires establishing and preserving essential features of critical habitat for the endangered Southern California DPS of steelhead in Piru Creek and the Santa Clara River, and restoring anadromy of steelhead to the Piru Creek drainage. This reasonable and prudent alternative has three sub-elements, and all three elements must be implemented to avoid jeopardizing the continued existence of the Federally endangered Southern California steelhead DPS, and destroying or adversely modifying critical habitat for this species."*

The first two RPA sub-elements referenced above are under development and are pending agency and FERC approvals; they include (NMFS 2008, pp. 96-101):

> ***RPA Element 1** – Prepare and implement a plan to "<u>quantify the geomorphic effects</u> (e.g., effects to channel-bed morphology, substrate characteristics and condition) <u>of Santa Felicia Dam and its operations</u> on the quality and quantity of habitat for steelhead in Piru Creek downstream of the dam," and "implement habitat-improvement measures to minimize individual geomorphic effects…"*

> ***RPA Element 2** – Prepare and implement a plan to "ensure that the magnitude, timing, frequency, duration, and rate-of-change of water released from Santa Felicia Dam into Piru Creek will provide unimpeded migration of adult and juvenile steelhead in Piru Creek downstream of Santa Felicia Dam and in the*

> *Santa Clara River from the confluence of Piru Creek downstream to the Vern Freeman Diversion Dam, formation and preservation of freshwater rearing sites for steelhead throughout Piru Creek downstream of Santa Felicia Dam, and creation and maintenance of freshwater spawning sites (including incubation and emergence life stages of steelhead) for steelhead throughout Piru Creek downstream of Santa Felicia Dam…"*

Effectiveness monitoring plans have been developed for both of these elements; Cardno-Entrix et al. 2013 for RPA Element 1, and Normandeau et al. 2013 for RPA Element 2.

The third (RPA Element 3), and the subject of this Report is to (NMFS 2008, p. 101):

> *"…provide passage of steelhead at or around Santa Felicia Dam, or other suitable alternative to passage. Prior to implementing this action, the Licensee shall implement a plan after receiving written agreement on the plan from NMFS to assess the feasibility of providing passage of adult and juvenile steelhead around or over Santa Felicia Dam. The approach to assess feasibility and implement a preferred alternative shall involve five principal steps: [1] preparation and implementation of a plan that will guide the conduct of the steelhead-passage feasibility assessment, [2] implementation of the assessment of steelhead-passage feasibility according to the plan, [3] preparation of a steelhead-passage feasibility report, [4] development of criteria to guide implementation timing of the preferred alternative, and [5] implementation of the preferred alternative."*

These five steps were further described under separate headings as RPA (a) through RPA (e).

Regulations (50 CFR §402.02) implementing Section 7 of the ESA define "reasonable and prudent alternatives" as alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technically feasible; and (4) would, NMFS believes, avoid the likelihood of jeopardizing the continued existence of a listed species or resulting in the destruction or adverse modification of critical habitat.

The BO provides specific details on the preparation and implementation of a study plan for assessing steelhead-passage feasibility. In accordance with the FERC License requirements, in early 2011 United convened an independent panel (Panel) of fishery biologists, fish-passage biologists, and fish-passage engineers to develop the required Study Plan. A resource economist was added as an advisor to the Panel in September, 2011. Beginning in May, 2011, with the initial meeting of the Panel, United, NMFS, and the California Department of Fish and Wildlife (CDFW),[5] the Panel prepared a Study Plan that was completed in June, 2012. At several stages in the development of the Study Plan, United, NMFS, and CDFW (hereafter referred to collectively as the Group) provided input and comments on the components and elements of the Study Plan. The Study Plan was submitted to FERC for their approval. Following a period of comments and revisions, the final plan, dated February, 2013, was approved. That document constitutes the Study Plan, which guided the Panel in conducting the feasibility analysis discussed in this Report.

1.2.1 Elements of the Study Plan

The requirements of the Study Plan are detailed in the BO (NMFS 2008, p. 102) as follows:

> *"this plan shall include:*
> *(a) a clear statement of objectives to guide the conduct of the assessment of the steelhead-passage feasibility,*
> *(b) a clear description of science-based investigations of steelhead behavior, ecology, and habitat requirements (to inform the assessment of steelhead-passage feasibility) as well as an analysis of the full range of physical steelhead-passage alternatives (volitional and non-volitional) and alternatives to steelhead passage, and engineering and cost analyses,*
> *(c) the requirement to convene a panel of professional technical fishery biologists, fish-passage biologists, and fish-passage engineers with expertise in the evaluation and design of fish passage at dams, who will participate in the assessment of steelhead-passage feasibility at Santa Felicia Dam,*
> *(d) a clear description of the specific methods that will be used to perform the various tasks related to the assessment of the steelhead-passage feasibility, including objective decision criteria for judging feasibility in accordance with the information obtained through reasonable and prudent alternative 3(a)(3)(B),*
> *(e) task schedules and milestones to monitor and track performance of the assessment of the steelhead passage feasibility over time, and*
> *(f) a contingency program to effectively address and resolve unforeseen circumstances in a timely manner."*

[5] The agency name of California Department of Fish and Game was changed in 2012 to California Department of Fish and Wildlife, and is referred to as CDFW in the remainder of this report.

The feasibility evaluation includes a total of nine tasks; six (Tasks 1-6) of which are related to the identification and review of fish passage concepts and the development and evaluation of specific alternatives; one (Task 7) involves the preparation of this Report which describes the Panel's evaluation process and presents a recommended alternative; one (Task 8)involves a Group decision point concerning the Panel's recommended alternatives, and one (Task 9) would involve a biological and economic evaluation of both the fish passage alternatives as well as off-site measures for avoiding jeopardizing the continued existence of the SCS DPS. This latter task would only be conducted if the Group cannot reach agreement on the specific fish passage alternatives. The tasks are summarized briefly below in Table 1.1-1.

1.3 OVERVIEW OF FISH PASSAGE PANEL PROCESS

Since its formation in 2011, the Panel has operated in accordance with the tasks and protocols specified in the FERC approved Study Plan of February 2013 (SFDFPP 2013). The Panel has functioned independently but has periodically met with the Group (Group meetings) as needed to update the Group on progress, present concepts and alternatives under consideration, address questions, obtain feedback from the Group on data or issues to be considered by the Panel, and to seek biological, engineering, and operational information of relevance to the development of certain alternatives. A Panel member was responsible for taking notes at each of the Group meetings, and the Panel-reviewed notes were distributed to the Group approximately two weeks after each meeting. Group members were provided an opportunity to submit comments, seek clarification, or ask questions of the Panel based on the meeting notes, and the Panel provided written responses to the inquiries.

Four separate meetings were also held among the Panel members (Panel meetings) to brainstorm and compile an initial list of concepts, review the concepts and define an initial set of alternatives, and evaluate and refine alternatives. In addition, the Panel participated in regular, periodic (every two to three weeks) web-based teleconferences to coordinate on study issues, provide updates on individual progress, address topics requiring Panel decisions, and prepare for Panel and Group meetings. At times, more frequent conference calls were necessary. In each case, a Panel member kept notes of the conference calls, and the notes are maintained as part of the official Panel record.

Table 1.1-1. Description of the nine tasks associated with the Study Plan. This Report presents the results of Tasks 1-7.

Task	Title	Description	Outcome
Task 1	Feasibility Study Preparation	Compiled and review background information necessary for development of fish passage concepts.	Base drawings, maps, and operational protocols necessary to conduct the study. Additional information needs were identified and communicated to the Group.
Task 2	Prepare Biological Performance Tool (BPT)	Developed a spreadsheet-based Biological Performance Tool (BPT) for use in evaluating biological performance of downstream fish passage alternatives. Results of the BPT analysis were incorporated into the overall matrix evaluation.	Development and application of a BPT for evaluating downstream alternatives. Prepared documentation of metrics and parameters used in the BPT.
Task 3	Identify Fish Passage Concepts	Developed an initial list of fish passage concepts and refined the list by eliminating those with fatal flaws.	Developed a full list of potential fish passage concepts, discussed fatal flaw analysis, documented concepts eliminated from further consideration, and selected a short list of fish passage concepts for further development.
Task 4	Concept Development and Alternative Definition	Developed the fish passage concepts identified in Task 3 into fish passage alternatives for SFD to address site-specific applicability, hydraulic functional design, construction and operating cost estimates, general layout, and identification of any uncertainties for further examination. Performance of the downstream alternatives was evaluated using the BPT (Task 2). Alternatives deemed technically infeasible were dropped from consideration with the rationale for dropping described. The alternatives and explanation of their operation and biological performance were presented to the Group at a workshop.	Descriptions and feasibility level drawings, including estimates of biological performance of the fish passage alternatives considered feasible by the Panel were developed and presented to the Group.
Task 5	Initial Evaluation	Performed and documented the evaluation of the alternatives to estimate the effectiveness of selected facilities, and to identify further improvements. Updated descriptions, drawings and the results of the initial evaluation of alternatives were presented to the Group during a workshop.	Updated descriptions, feasibility level drawings and the results of the initial evaluation process were developed.

Table 1.1-1. Description of the nine tasks associated with the Study Plan. This Report presents the results of Tasks 1-7.

Task	Title	Description	Outcome
Task 6	Fish Passage Alternative Refinement	Fish passage alternatives were further refined based on opinions of probable construction and operating costs, operational issues, consideration of Group comments, final runs of the BPT, and a final quantitative matrix evaluation of the alternatives.	A summary of changes to the alternatives and the final evaluation were developed and provided to the Group as part of the Task 7 Report.
Task 7	Reporting and Fish Passage Recommendations	This consisted of four components: • Documentation and reporting of progress and Panel decisions made during the Study to the Group during specified meetings[6] (G1 and G2). • Preparation of a Draft Santa Felicia Dam Fish Passage Project Alternatives Feasibility Report (Draft Report) that: o described the methods used and process followed by the Panel to prepare the Draft Report, o described the development of technically and biologically feasible fish passage alternatives, o summarized upstream and downstream alternatives and the pros and cons of each; include those that were eliminated from further consideration and reasons why they were eliminated, o listed the evaluation criteria and described the procedures used to compare alternatives, o presented the results of the Panel's final evaluations and the recommended alternatives for upstream and downstream fish passage at SFD, along with an implementation schedule, o described various uncertainties relevant to the	Prepared Draft Report and this Report that contains the Panel's recommended alternatives for upstream and downstream fish passage at SFD.

[6] The Panel specified a total of five Group meetings termed G1 through G5 to occur during key milestones of the study. See Table 1 of Santa Felicia Dam Fish Passage Feasibility Study Plan (2013).

Table 1.1-1. Description of the nine tasks associated with the Study Plan. This Report presents the results of Tasks 1-7.

Task	Title	Description	Outcome
		design and implementation of the alternatives and summarized technical studies designed to reduce the uncertainty, and o outlined a monitoring and adaptive management program that will be needed as part of the implementation and operation of the fish passage facilities. • Presentation of the Draft Report to the Group during a meeting (G3 meeting). • Based on comments received from the Group, preparation of a Final Santa Felicia Dam Fish Passage Alternatives Feasibility Report (Report; this document) that presented the Panel's final recommendations for a preferred fish passage alternative, and other elements as noted for the draft report.	
Task 8	Group Fish Passage Decision	The Group will review the Report, and consider its recommendations at a meeting of the Group and Panel (G4 meeting). A possible outcome of the meeting is for the Group to agree upon the Panel's recommended fish passage alternatives. If there is a consensus of the Group, the Study terminates, and the implementation process can begin. If there is no consensus among the Group, the Study continues with Task 9. Following the Group's review of the Report, the Panel will meet with the Group (G5 meeting) to discuss next steps.	Decision to either continue with evaluation of off-site alternatives and economic analysis, or to proceed directly to the process of implementation of the recommended fish passage alternative.

Table 1.1-1. Description of the nine tasks associated with the Study Plan. This Report presents the results of Tasks 1-7.

Task	Title	Description	Outcome
Task 9	Biological and Economic Feasibility Analysis and Off-Site Alternatives Assessment	If initiated, the basic steps involved in the completion of Task 9 include: • identification and development of feasible off-site alternatives (other than fish passage at SFD) that might satisfy the biological goals of the Project, • examination of the biological performance of the off-site alternatives for contributing to the increased viability of the DPS, as compared with all alternatives. • completion of an overall economic assessment that will include the off-site alternatives and the recommended fish passage alternatives from Task 7, including capital investments and recurring operating costs. A cost effectiveness analysis would be conducted and the *preferred* alternative would be the one that meets the project goal at the *least cost.*	Identification of off-site alternatives, if any, that satisfy the goal of the Project avoiding jeopardizing the continued existence of the SCS DPS and biological and economic comparisons of all alternatives to select a preferred alternative.

1.4 OVERVIEW OF FISH PASSAGE FEASIBILITY ANALYSIS PROCESS

The completion of the Study generally followed the sequence of the six tasks described in the Study Plan. Commencing with **Task 1,** the Panel first assembled and reviewed important background information concerning the SFD and its operations, the Piru Creek watershed, and the ecology and life history characteristics of the SCS DPS. This served to define the geographic/topographic setting of the Santa Felicia Project, and the hydrologic constraints that must be considered in developing passage alternatives. This also provided information necessary for the development of the Biological Performance Tool (BPT) (specified in **Task 2**) that was later used in Task 5 as part of the evaluation process for comparing downstream passage alternatives. **Task 3** consisted largely of a brainstorming session by the Panel during which an initial list of upstream and downstream passage concepts were compiled. This list was intended to be comprehensive and was purposely not constrained by physical or operational characteristics of the Santa Felicia Project. The list was subsequently refined in **Task 4** based on the compatibility of the concepts with the SFD, and alternatives formally developed. These alternatives were then initially evaluated in **Task 5** using a matrix evaluation and scoring process (see Section 5) that included results from the BPT. Further refinement and evaluation of the alternatives was completed in **Task 6** that included additional testing of the alternatives biological performance using the BPT and a refinement in the matrix evaluation, and an independent ranking of alternatives by each member of the Panel. The results of the evaluation culminated in the Panel's identification of a recommended set of alternatives that are presented herein and are part of **Task 7.** Specific details of the evaluation process are described in sections 4 and 5 of this Report.

1.5 SOME DEFINITIONS

The Panel uses a number of terms throughout the Report that are defined below.

1.5.1 Feasibility

This is a feasibility study. Feasibility is recognized in Section 7 of the ESA as part of the definition of reasonable and prudent alternatives. This is from the Study Plan:

> *Regulations (50 CFR §402.02) implementing Section 7 of the ESA define reasonable and prudent alternatives (RPAs) as alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technically feasible; and (4) would, NMFS believes, avoid the*

> *likelihood of jeopardizing the continued existence of a listed species or resulting in the destruction or adverse modification of critical habitat.*

There are four aspects of feasibility considered here:

1. Technical feasibility; does it satisfy fish passage and water supply objectives of the project?
2. Biological feasibility; does it satisfy biological goals?
3. Engineering feasibility; can it be built and operated?
4. Economic feasibility; is it worth doing either inherently or relative to other actions?

Technical feasibility is relative; project objectives are met to varying degrees by different alternatives. Technical feasibility is judged primarily using criteria that describe project objectives in the evaluation matrix, which is described in Section 5. Technical feasibility includes additional "fatal flaw" criteria such as dam safety, United's water supply objectives of SFD, and public and personnel safety. The fatal flaw criteria are not necessarily included in the matrix evaluation because they have to be satisfied by all alternatives.

Biological feasibility is a measure of meeting biological goals. Goals have been characterized in the BO as providing benefits to the SCS DPS through reducing fragmentation and increasing habitat availability to support a viable steelhead population. A biological feasibility evaluation would require acquisition and assessment of information on both Santa Clara River and Piru Creek habitats, the status of the SCS DPS population and a process to identify, develop and assess criteria that allow evaluation of the feasibility of meeting the biological goals.

Engineering feasibility refers to the practicality of construction and operation of a facility. The Panel cannot fully evaluate the engineering feasibility of all alternatives and with more analysis (e.g., seismic analysis), some alternatives, as currently envisioned, might prove to be infeasible from an engineering aspect.

Economic feasibility is included in the Study as a potential later phase of work and is not specifically addressed in this Report which describes a group of fish passage alternatives that meet the test of technical feasibility, but also vary significantly in cost. This may prompt the Group to further recommend studying "economic feasibility." As applied here, economic feasibility has two components, financial feasibility and cost effectiveness, which are further described in the Study Plan.

1.5.2 Criteria

There are three types of criteria mentioned in this Report; evaluation criteria, design criteria, and performance criteria.

Evaluation criteria are the criteria used in the evaluation matrix for comparison of the alternatives. They can be considered objectives of the design and relate to fish passage, operations and maintenance, cost, and other considerations. The evaluation criteria are defined in Appendix D.

Design criteria are standards used in final design. They are primarily quantitative measures that define acceptable values or ranges of flows, velocities, depths, and dimensions of hydraulic conditions and features. Design criteria are utilized in the feasibility design to establish overall dimensions and flow rates of facilities. Some of the criteria are based on criteria and guidelines published by NMFS (NMFS 2012) while others are based on professional judgment of the Panel. Any criterion applied in this Study that varies from what is published by NMFS is specifically identified in this Report.

Performance criteria are quantitative standards or targets that the facility is expected to achieve. The Panel believes these criteria, which are also referred to as Biological Performance Standards would be developed collaboratively among United, NMFS, and CDFW, as part of the implementation process. As such, the Panel did not apply specific performance criteria in the feasibility analysis. Instead, the Panel designed the best reasonable facilities and estimated the anticipated performance of each.

1.5.3 Enhancements

Enhancements, as defined by the Panel, are features that add efficiency to a primary alternative but do not perform the same overall fish passage function. For example, a guide curtain might be added to a reservoir collector to help guide fish to the collector. The guide curtain does not collect fish, but it enhances the efficiency of the collector alternative.

1.5.4 Supplemental

The Panel uses the term “supplemental” to denote those alternatives that are potentially stand-alone, but are associated with a specific primary alternative to improve performance of that alternative. For example, fish might be attracted to and trapped in the plunge pool at the downstream end of the spillway chute. A spillway pool collector may be employed to collect those fish and to reduce stranding or delay. Operation of the spillway pool collector is not directly related to upstream fish passage, but the overall success of passage might be improved with the effort.

1.5.5 Volitional Passage

The Study Plan prescribes that at least one alternative for upstream and downstream passage be volitional. The Study Plan stipulates that the Panel apply the following definition of volitional, which was adopted by the Group:

> *"Volitional fish passage is a means of fish passage with appropriate hydraulic conditions such that all individual migrating adult and juvenile fish of the species of interest have the opportunity to move freely and safely upstream and/or downstream past the Project according to their own motivation."*

A concrete fish ladder with an open-ended inlet and outlet is an example of a volitional facility for adult steelhead. In this case, adult fish could freely move into the lower end of the fishway and volitionally move upstream through a series of weirs until reaching the upper end of the fishway where they could move into the lake or reservoir. Where feasible, volitional fish passage facilities are preferred because there is little/no human intervention necessary to effect passage and they may be less costly to maintain. However, volitional facilities often provide little flexibility to accommodate uncertainties, or to allow necessary adjustments to accommodate changes in fish behavior, environmental or operating conditions.

A collection and transport operation is a type of non-volitional fish passage used where volitional passage is considered infeasible, or where there is a need to physically capture and handle fish. The Panel acknowledges that some alternatives may consist of a mix of volitional and non-volitional elements. Varying degrees of volitional passage are recognized in the evaluation of upstream passage alternatives. The concept of a challenge section is one example of this, which is described further in Section 4.

1.5.6 Phasing

In this Report, the Panel refers to Phasing in several ways, the first is in conjunction with alternatives that lend themselves to implementation in a "phased" or step-wise approach. That is, alternatives that may initially be temporary, mobile, and less complex than others but that can still provide fish passage above and below SFD. Over time and in response to changes in numbers of fish or other project considerations, the fish passage structure may be refined, upgraded, or made permanent, or may be enhanced or supplemented with additional features in order to improve performance. This phasing is intended to help address uncertainties, and is discussed further in Section 4 for each alternative, and described in more detail in Section 7. The

Panel also uses Phasing in regard to how a Group decision to implement fish passage might fit within a phased implementation and adaptive management process (see Section 7). In this case, Phase 1 activities would follow a Group decision to implement fish passage and refers to the step-wise implementation and monitoring of the Panel's recommended upstream and downstream fish passage alternatives. The Panel also acknowledges that uncertainties in SCS DPS population response and facility performance could, at some point in time lead to consideration of a Phase 2 implementation potentially involving other stand-alone components.

The Panel has identified the following reasons for considering and incorporating phasing into selection of a fish passage alternative:

- Uncertainties related to how and when Southern California Steelhead may utilize the fish passage facilities.
- Uncertainties regarding the suitability of Lake Piru for juvenile steelhead rearing and passage due to concerns of water quality and presence of predatory fish (see Section 3).
- Uncertainties regarding the biological performance of the initial facilities and the need to be flexible and able to adapt additional measures and new technologies to maintain or improve performance.
- Cost leveling (spreading fixed costs over time).
- Investment risk management.

For the purposes of this Report, the first three reasons are paramount in terms of the application of phasing.

1.5.7 Pros and Cons

Pros and cons are positive and negative attributes of any alternative relative to safe and timely fish passage and operations and social considerations.

1.6 OVERVIEW AND ORGANIZATION OF THE REPORT

There are eight sections in this Report, including

- Section 1 (Introduction) which provides background information concerning the Study and its objectives and purpose, provides an overview of the Panel process and the feasibility evaluation;
- Section 2 (Existing Conditions and Background Information Used) contains descriptions of the existing conditions and background information, including the hydrology of Piru

Creek, operational assumptions regarding Santa Felicia Reservoir, and the concurrent investigation of a new intake structure (GEI 2015a);

- Section 3 (Biological Information) provides important life history information concerning the SCS DPS including migration periods and life history patterns, and additional biological information obtained during the Study that factored into the evaluation process;
- Section 4 (Fish Passage Alternatives) contains details of the fish passage alternatives identified and evaluated by the Panel and includes potential phasing opportunities, a summary of pros and cons, and a review of challenges, uncertainties, and risks;
- Section 5 (Evaluation of Alternatives) presents the evaluation of the alternatives, including an overview of the evaluation process, and the application of the BPT and evaluation matrix tools.
- Section 6 (Recommendation of Preferred Fish Passage Alternatives) presents the upstream and downstream fish passage alternatives identified by the Panel including the recommended alternatives and the approach and rationale used to make the selections; and
- Section 7 (Recommended Implementation Process) presents the Panel's recommendations for implementing the preferred solution to upstream and downstream passage at SFD including recommended steps to be taken pending acceptance by the Group of the Panel's recommendation.
- Section 8 (References Cited).

The Report contains six appendices that include:

APPENDIX A: HYDROLOGY OF PIRU CREEK

APPENDIX B: FULL LIST OF FISH PASSAGE CONCEPTS AND ALTERNATIVES CONSIDERED

APPENDIX C: ANALYSIS OF SPILL REDUCTION OPPORTUNITIES

APPENDIX D: CRITERIA USED FOR EVALUATION

APPENDIX E: BIOLOGICAL PERFORMANCE TOOL: METHODOLOGY AND RESULTS

APPENDIX F: COMMENTS RECEIVED ON DRAFT REPORT AND PANEL'S RESPONSE

2. EXISTING CONDITIONS AND BACKGROUND INFORMATION USED

This section provides important background information that the Panel relied upon in completing the Study. This first includes a brief description of the project setting and the physical and operational characteristics of the Santa Felicia Project, and then a more detailed discussion of the hydrology of the Piru Creek watershed and how United currently operates the SFD both as a hydroelectric facility and for downstream water releases. Important considerations related to Pyramid Dam flow releases into middle Piru Creek[7] are also described. The section also presents biological information concerning the arroyo toad (*Anaxyrus californicus*) a species listed as threatened under the Federal ESA and that has been found within the Project area, as well as quagga mussels (*Dreissena bugensis)*, which is an introduced species that can proliferate and result in bio-fouling of flow diversion systems. The presence of arroyo toad will need to be addressed in terms of the siting and operation of specific alternatives that may negatively impact toad or its habitat. Quagga mussels are an operational concern and will need to be addressed as part of any alternative involving facilities placed in Lake Piru.

2.1 PROJECT SETTING

The FERC order issuing a new license to Project No. 2153-012, United Water Conservation District, September 12, 2008, provided a good description of the overall Santa Felicia Project and is largely reproduced below.

2.1.1 Project Area

The headwaters of Piru Creek are in Lockwood Valley, an upland basin in the southern section of the Los Padres National Forest about 5,200 ft above sea level. Piru Creek has a drainage area of 437 square miles and flows into Pyramid Lake, formed by Pyramid Dam (Pyramid Lake and Pyramid Dam are components of the California Aqueduct Project [FERC Project No. 2426], which carries water from Northern California to Southern California) approximately 15 river miles upstream of the Santa Felicia Project (see Section 2.5). Upon exiting Pyramid Lake, Piru Creek flows to Piru Lake, where it is impounded by the SFD. Lower Piru Creek, downstream of the SFD continues for another six miles to its confluence with the Santa Clara River approximately 30 river miles from the Pacific Ocean.

The project occupies 174.5 acres of land, a portion of which is within the Los Padres and Angeles National Forests. Approximately 121 acres are inundated by Lake Piru at the normal

[7] Upper Piru Creek extends from Pyramid Dam upstream to its headwaters; middle Piru Creek extends from Pyramid Dam downstream to the confluence with Lake Piru; lower Piru Creek extends from Santa Felicia Dam downstream to the confluence with Santa Clara River (Weaver and Mehalick 2008).

maximum water surface elevation. About 53.5 acres are above the normal maximum water surface elevation of 1,055 feet mean sea level (ft), but are included within the project boundary. Included in these 53.5 acres are the dam, powerhouse, and associated facilities as well as several recreational facilities.

2.1.2 Project Facilities

The existing Santa Felicia Project consists of:

1. a 214-foot-high, 1,260-foot-long earth-filled dam with a 30-foot-wide roadway across the crest at an elevation of 1,075 ft;
2. a 475-foot-long, separate, ungated spillway adjacent to and west of the dam with a crest elevation of 1,055 ft;
3. an 83,244 acre-foot reservoir, with a useable storage capacity of 65,294 acre-feet and a surface area of 1,182 acres at elevation 1,055 ft based on 2005 survey information;
4. a powerhouse located at the base of the dam and containing two generating units, with a total installed capacity of 1,420 kW;
5. a 150-foot-long generator lead to a step-up transformer; and
6. appurtenant facilities.

The project has no primary transmission line. Power that is generated at the site is conveyed by transmission lines owned and operated by the Southern California Edison Company.

2.1.3 Water Supply Operation

The Santa Felicia Project was designed and constructed by United in 1955, and hydroelectric facilities were added to the SFD in 1987. The project is an integral part of United's overall management to recharge downstream groundwater supplies from basins that have been depleted due to substantial overdraft and to combat saltwater intrusion in the groundwater aquifers near the Pacific Coast. To accomplish this, water is retained and stored within Lake Piru during the winter and spring months when downstream groundwater basins are at their fullest level. Utilizing the stored water, United makes conservation releases averaging approximately 270 cubic feet per second (cfs), from the SFD in September and October when the downstream groundwater basin levels are at their seasonal lows. The conservation releases are designed to maximize the amount of water that reaches the Freeman Diversion Dam, located downstream on the Santa Clara River at River Mile (RM) 12, where the water is used to recharge coastal groundwater basins.

2.1.4 Hydroelectric Power Operation

Typically, the project generates power when releases are made to recharge the groundwater basins, normally a period of about 50 days during September and October. The power plant has a maximum generation capacity of 1,420 kilowatts (kW) and the project power is sold to Southern California Edison Company. The turbines are sized to generate power with a maximum flow of 108 cfs. Power also is generated in anticipation of or during reservoir spill periods. The Santa Felicia powerhouse is operated manually. United proposes to continue operating the project in this manner and proposes no increased capacity or new facilities.

2.1.5 Project Boundary

The Santa Felicia Project boundary follows elevation 1,078.3 ft around the shoreline of Lake Piru and near the SFD, the project boundary expands to include the dam, powerhouse, and associated facilities. Several existing recreational facilities also are located within the project boundary, including the Lake Piru Marina Area, the Juan Fernandez Boat Launch Area, and the Reasoner Canyon Picnic Area and Overflow Area. The Lower Oaks and Oak Lane campgrounds are also enclosed within the project boundary.

While the current project boundary includes most project facilities, it does not include all of the existing recreation facilities. The Olive Grove campground currently provides opportunities to meet recreational demand; however, it is not located within the project boundary. In addition, the existing whitewater boating take-out on the upper end of Lake Piru, near the U.S. Forest Service (USFS) closure gate, provides whitewater boating access to project waters but is not currently located within the project boundary. FERC concluded in the order that these facilities are necessary for project purposes and therefore were brought within the project boundary.

2.2 PROJECT HYDROLOGY

The Panel relied upon hydrology data and information from several sources including the following that were provided by United:

- Hydrologic Information, United Water Conservation District Response to Information Request from Fish Passage Feasibility Panel, August 8, 2011 (included in full in Appendix A);
- Summary of Lake Piru Reservoir Model, June 12, 2011 and then revised September 10, 2013 (included in Appendix A);
- A spreadsheet named “Lake Piru data from model” initially submitted in 2011; and
- A spreadsheet named “Lake Piru Model exceedance plots 1-22-14” submitted in 2014.

The spreadsheet data files were subsequently updated through Panel consultations with United.

The Panel also relied upon hydrology data from the following three primary U.S. Geological Survey (USGS) gages:

- USGS #11109600 PIRU CREEK ABOVE LAKE PIRU CA located on the left bank near Blue Point, 1.3 miles downstream from Agua Blanca Creek, 4.3 miles upstream from SFD. This gage is listed as having a drainage area of 372 mi^2 and a period of record from October 1955 to the current year (active). Remarks indicate that the records are rated good, collected in connection with Federal Energy Regulatory Commission (FERC) project no. 2153, and that flow is regulated beginning December 1971 by Pyramid Lake (station 11109520) with imported water from the California Water Project stored and released at Pyramid Dam.
- USGS #11109700 LK PIRU NR PIRU CA located in the reservoir near the center of the dam. This gage station is operated and maintained in cooperation with United. It is listed as having a drainage area of 425 mi^2 and a period of record from May 1955 to the current year (prior to October 1985, month end elevation and contents only).
- USGS #11109800 PIRU CREEK BELOW SANTA FELICIA DAM CA located 750 ft downstream from the dam. This gage is listed as having a drainage area of 425 mi^2 and a period of record from October 1955 to September 1968 and October 1973 to the current year (active). The records are considered fair. The maximum discharge listed is 920 ft^3/s on September 6, 2000; however, it has been noted by United that this measurement may be erroneous due to backwater effects. According to United the maximum discharge measured at this gauging station, sourcing from the penstock, was 624 cfs on October 7, 2004.

United manages Lake Piru as a water resource reservoir; reservoir surface water elevations are a function of operations and natural inputs. Due to operational changes at the SFD, historic water releases and surface water levels are not representative of conditions that are expected to occur in the future. To provide meaningful information for the Panel's consideration, a reservoir model was used to simulate surface water elevations that could be expected under current operating conditions (related to sedimentation and available storage within the lake) and operating procedures (including habitat and migration releases established in the Santa Felicia Water Release Plan (United 2012). This model also accounts for storage, historical inflow, evaporation, and release flows, and incorporates the recent Department of Water Resources (DWR) policy at Pyramid Lake to release flows based on natural inflows to the lake (inflow =

outflow). The model was run using historic inflow data from the period between 1944 and 2010. Raw data are presented in the excel file as "Lake Piru data from model."

The mean daily reservoir inflow exceedance graph is presented in Figure 2.2-1. This figure was developed using results from the Lake Piru model and shows the percentage of time (probability) that the mean daily reservoir adjusted inflow would be equaled or exceeded during January through June for the downstream migration period. This was important for the development of the downstream passage alternatives. The maximum flow into the reservoir was recorded in 2005 and was 40,000 cfs (gauge height of 16 ft). Since 1955 flood flows have exceeded 6,000 cfs 16 times, and have exceeded 4,000 cfs 20 times.

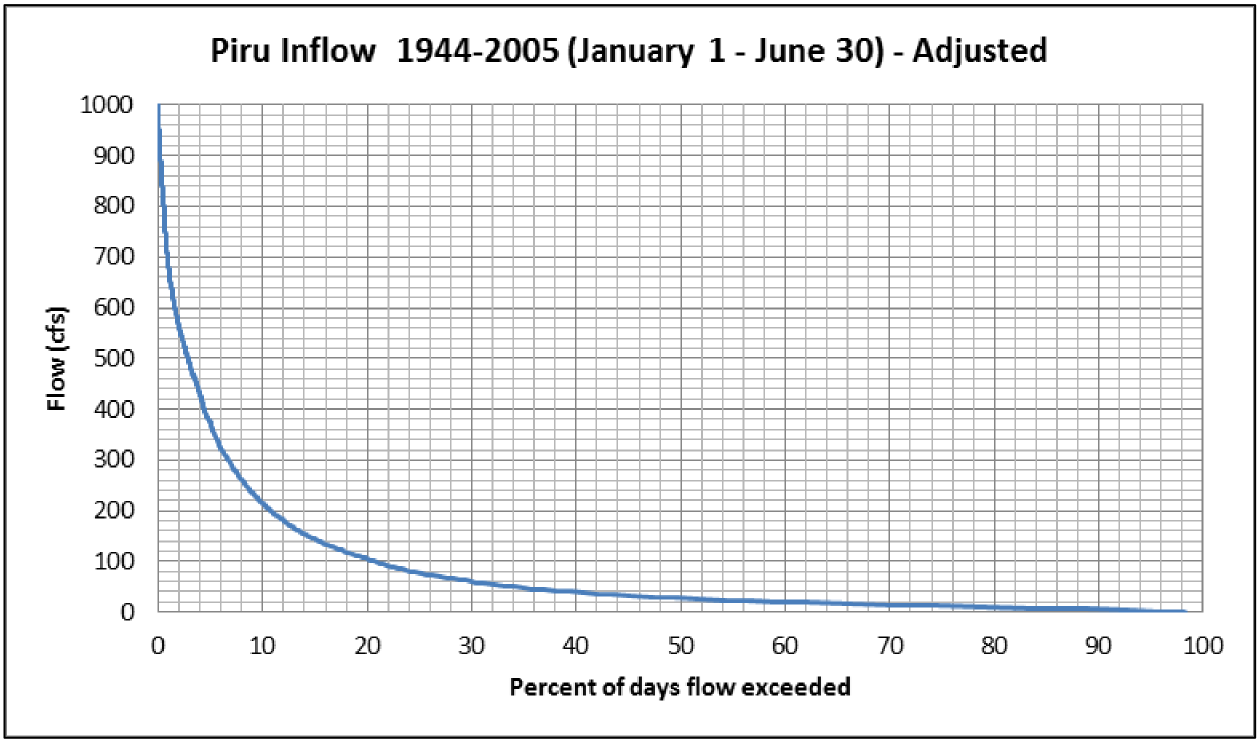


Figure 2.2-1. Lake Piru Inflow-Exceedance Plot, based on mean daily flows (source: Like Piru model, adjusted for current DWR policy for inflow=outflow).

The mean daily reservoir exceedance graph presented in Figure 2.2-2 was developed using results from the Lake Piru model and shows the percentage probability that the mean daily reservoir water surface elevation would be equaled or exceeded during January 1 through May 31 for the upstream migration period. This was important for the development of the upstream passage alternatives. The crest of the spillway is located at an elevation of 1,055 ft; therefore, any surface water elevations above 1,055 ft are indicative of spill events.

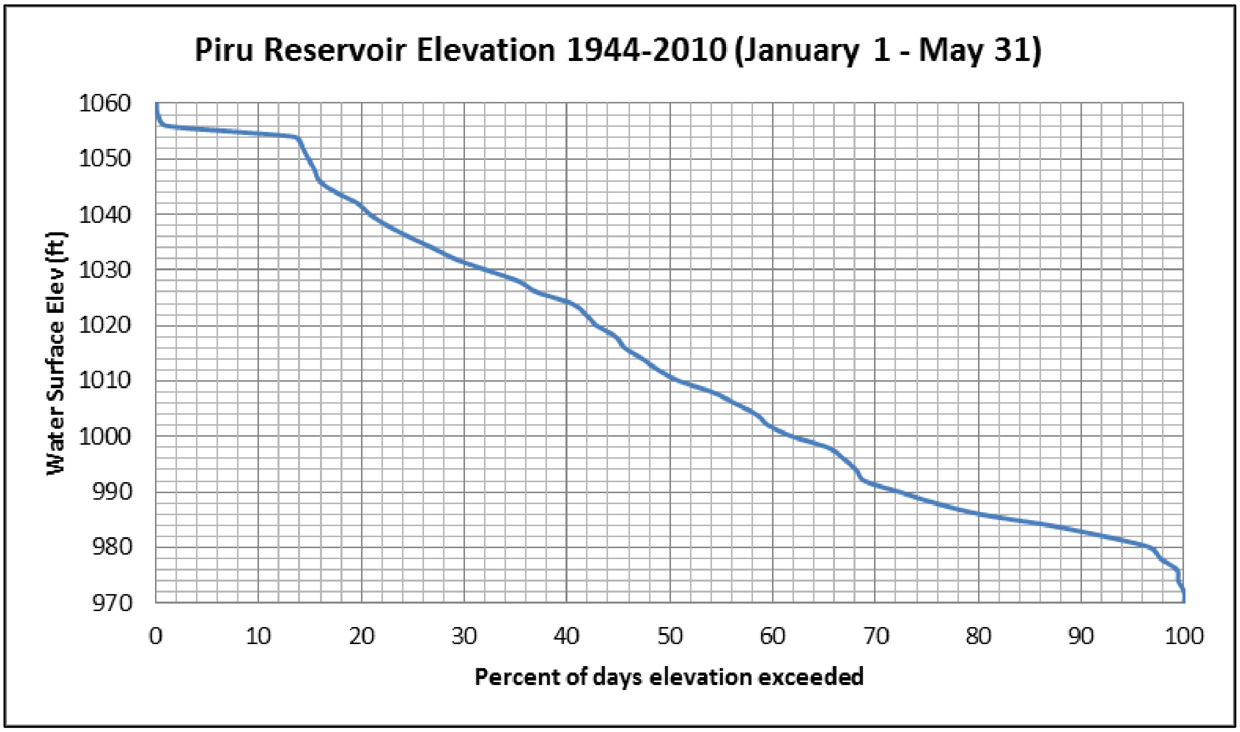


Figure 2.2-2. Lake Piru Elevation-Exceedance plot, based on mean daily flows (source: Lake Piru model, adjusted for current DWR policy for inflow=outflow).

The mean daily outflow release exceedance graph presented in Figure 2.2-3 was developed using results from the Lake Piru model and shows the percentage probability that the mean daily outflow released from the outlet works would be equaled or exceeded during January 1 through May 31 for the upstream migration period. This was likewise important for the development of the upstream passage alternatives and confirms the outflow operational regime outlined in the next section.

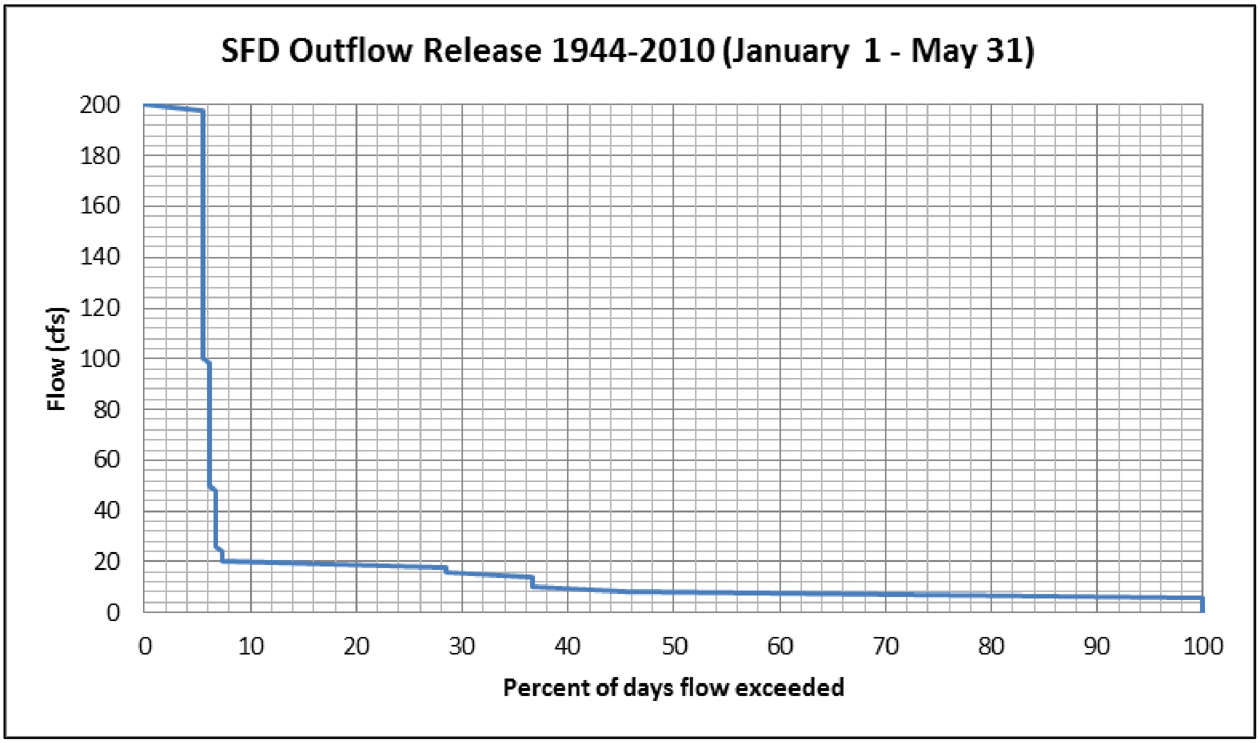


Figure 2.2-3. SFD Flow-Exceedance plot, based on mean daily flows released from the SFD outlet works (source: Lake Piru model, adjusted for current DWR policy for inflow=outflow).

In comparison, the mean daily total outflow of the combined estimated spill (based on the spillway rating curve) plus the release flow exceedance graph is presented in Figure 2.2-4 for the period of record using only the January 1 through May 31 period (upstream migration period). This shows that on a mean daily basis there is an increase in the number of days flow is exceeded for flow magnitudes above the base habitat release flow. This information was used for comparison of potential spillway flows relative to the low flow release channel. For example, when looking at the combined total outflow statistic for 100 cfs it is exceeded approximately 12% of the time on average (January through May period), compared to approximately 6% of the time on average when only considering flow released from the outlet works.

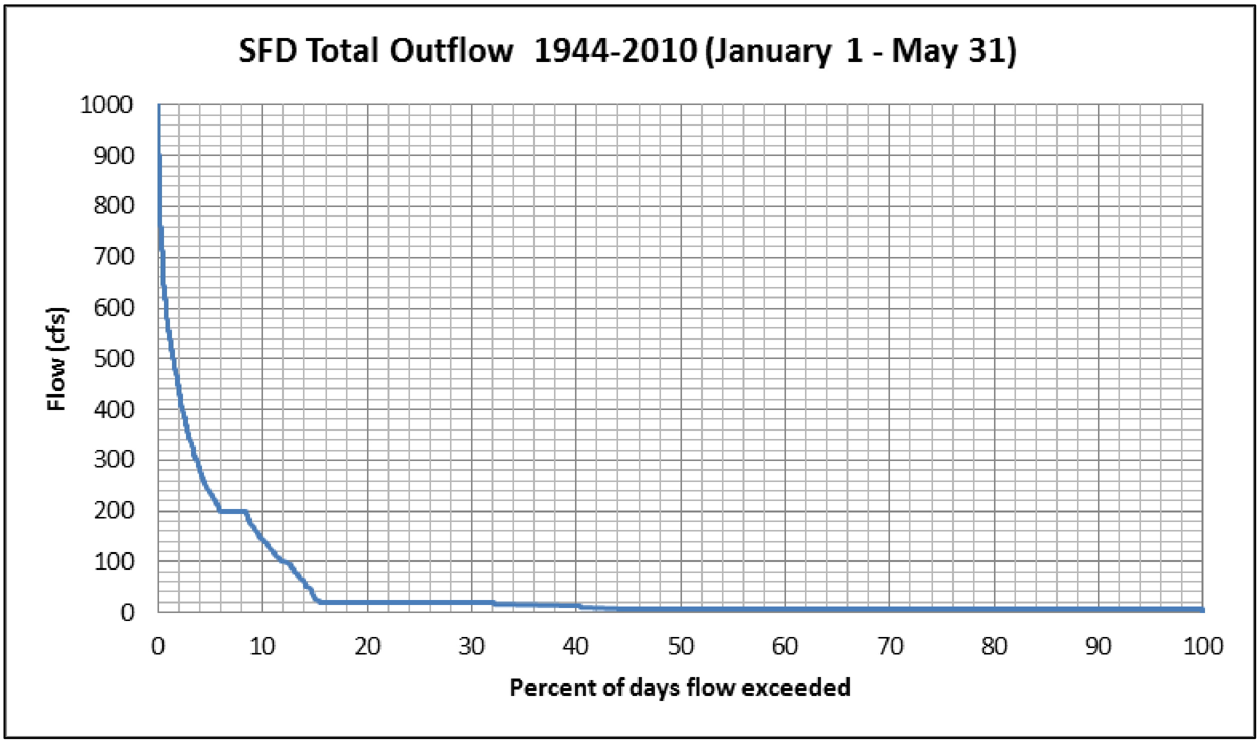


Figure 2.2-4. SFD Total Flow-Exceedance plot, based on mean daily flows released from the SFD outlet works (source: Lake Piru model, adjusted for current DWR policy for inflow=outflow).

2.3 CURRENT SANTA FELICIA DAM OPERATIONS

2.3.1 Hydraulic Features and Operational Capacities

The following descriptions of existing hydraulic features with operational capacities and limitations were taken from a United memorandum dated February 18, 2014 (see Appendix A). Note that due to timing and scope limitations of producing the Report some of this information may be outdated; however, the general information referenced is sufficient for the needs of this Study. Future work on the project should rely on obtaining the most recent available information. The 60-inch diameter penstock and intake tower are the limiting components of the outlet works. The penstock was originally designed for a normal maximum flow of 500 cfs. The absolute maximum design discharge was estimated at 880 cfs. The intake tower was extended 42 ft in 1977. The new configuration altered the hydraulic capacity of the outlet works. Based on new evaluations, the absolute maximum capacity is 771 cfs at the full reservoir elevation of 1,055 ft. The maximum discharge at elevation 980 ft (minimum pool) is 597 cfs. The discharge capacity falls to 25 cfs at elevation 933.5 ft (one foot above the intake sill).

There are two 36-inch diameter Kvaerner cone valves, each designed for an operating discharge of 500 cfs. Each valve has a maximum discharge of 682 cfs based on 200 ft of head. The maximum head of the reservoir is 190 ft. The capacity of each valve is 528 cfs at minimum pool (115 ft of head). The surplus capacity provides nearly the required flow for rapid release emergency drawdown by a single cone valve. It also provides operational flexibility so either valve can be removed from service for periodic maintenance. Experience has demonstrated that operating the valves at 5 percent open is the advisable minimum. This produces a discharge of approximately 25 cfs at elevation 980 ft (minimum pool). In order to protect existing hydraulic operating lines from possible damage during a conservation release, United typically limits the peak discharge release to between 300 to 400 cfs.

The outlet works of SFD have two low-flow discharge pipes that are used to maintain habitat flow in Piru Creek downstream of the dam. Low flows are preferentially released through the west branch low flow outlet pipe. If needed (e.g., to meet a minimum required habitat flow of 15 or 20 cfs), United can augment the flow through the east branch low-flow outlet pipe. Water releases above 20 cfs would trigger opening one or both cone valves. The east branch low- flow outlet pipe can source from either the penstock, or from an 8-inch bypass valve located in the dam's most upstream valve chamber. Under the Santa Felicia Water Release Plan (United 2012), the minimum required habitat flow ranges from 7 to 20 cfs. A second 12-inch low-flow discharge pipe (east branch) was added in 2012 to meet the new minimum habitat flow requirements. Discharges are manually controlled by 12-inch butterfly valves. The 12-inch low-flow discharge pipes can be safely operated up to 10 cfs before cavitation occurs within the piping. Although United does not advise it, the combined discharge of the two low-flow valves can operate between 20 to 25 cfs for short periods of time without opening the cone valves if needed to maintain flows, which does provide some flexibility in operations. United recently conducted a flow test of the low-flow release valves. Reservoir water surface elevation at the time of the test was 980 ft. The east valve had a maximum discharge of 17.3 cfs and the west valve a maximum discharge of 15.0 cfs.

The SFD hydro power plant was completed in 1987 and consists of two turbines. The facility has been offline since 2008 due to damaged turbines. United expects to have one or both of the damaged turbines repaired and operational in the future with the larger turbine scheduled to be operational in 2016. The larger turbine can operate for the full range between maximum reservoir capacity (elevation 1,055 ft) and minimum pool (elevation 980 ft), and has a flow range between 40 to 88 cfs. The smaller unit has design limitations and cannot operate when the reservoir has a surface elevation higher than 1,028 ft. The smaller unit operates in a flow range between 9 to 20 cfs. The power plant normally operates only during the annual conservation release or when the reservoir is spilling. The original design linked the power plant to a designated cone valve. If the power plant was taken offline, the control valves would shut off the flow to the turbines and the designated cone valve would balance the flows. The 12-inch low flow bypass valves are not automated but United is in the process of automating water releases from the Santa Felicia Dam.

United would like to preferentially release habitat flows through the smaller hydro unit, but the minimum flow and maximum head design limitations make it difficult to do so. The turbine requires mechanical upgrades in order to maintain the required habitat and migration flows in the event that the power plant is suddenly or inadvertently taken off the power grid. The proposed repair project would modify the smaller turbine to allow it to run within a wider range of head. However, the variation of the flow through the turbine is a narrow range and will be the controlling factor. The smaller hydro unit could potentially operate 24 hours a day, assuming mechanical upgrades are made.

2.3.2 Other Considerations

United bases the volume of the annual conservation release on the water resource management strategies, hydrologic conditions in the downstream basins, ramping criteria, water demands, water quality and the diversion capacity of the Vern Freeman Diversion (VFD), which currently can divert up to 375 cfs to a canal leading to irrigation and groundwater recharge basins. The conservation release was planned with a goal to deliver a specific volume of surface water to the VFD. United staff frequently monitors the release from the VFD to ensure that the surface water diverted balances with the percolation rates of the groundwater recharge basins and irrigation pipeline demands. Longer release durations make the VFD diversions more efficient and provide operational flexibility. The longer durations also allow surface water to be delivered to the irrigation pipelines over a longer period of time, which in turn reduces groundwater pumping needs.

The groundwater recharge basins at Saticoy and El Rio facilities downstream of the VFD initially have a very high rate of percolation. During wet years and large release events, the basin's earth bottoms become saturated and the groundwater beneath the basin begins to "mound." As the percolation rates slow, the release from the VFD diversion must be reduced or irrigation pipeline deliveries increased. The groundwater replenishment of the VFD forebay is enhanced when the conservation release has a constant flow over long duration.

The conservation and migration releases can cause significant scour in the channel immediately downstream of the SFD outlet works and power plant. The discharge flows can also cause significant bank erosion above and below the USGS gaging station (USGS Gage #11109800), located about 750 ft downstream of SFD. Maintenance of the channel requires the use of heavy equipment within the streambed. By limiting the releases to 300 to 400 cfs, the need to operate heavy equipment in the channel is reduced. United must also be cognizant of potential damage to downstream diversions and properties. Lower velocities reduce undesirable erosion and scour in lower Piru Creek and the Santa Clara River.

2.4 OTHER CURRENT STUDIES AT SANTA FELICIA DAM

United contracted with GEI Consultants, Inc. (GEI) to conduct two other studies at SFD related to dam safety issues. These studies were conducted in parallel with and are relevant to this Study. They were still in progress during preparation of the Draft Fish Passage Feasibility Study dated April 6, 2015, but were subsequently completed later in April 2015 as referenced below:

- Santa Felicia Dam Outlet Works Rehabilitation Project – Phase 1 (GEI 2015a).
- Santa Felicia Dam Spillway Alternative Study (GEI 2015b).

It should be noted that the Panel used the most recent information from the draft studies at the time of the Draft Report completion, and several concepts and drawings were based on this preliminary information. The Panel believes that while some details of the fish passage concepts would need to be modified, the overall recommendations or conclusions presented for this Study would not change based on the updated information in the dam safety studies. Moreover, the projects that these dam safety studies support may also change again going forward, so making further revisions to the fish passage alternatives would have minimal value at this time. Any future work on the fish passage alternatives should rely on obtaining the most recent available information from the dam safety studies and project improvements.

2.4.1 Outlet Works Rehabilitation Project Study Overview

The purpose of the Outlet Works Rehabilitation Project (also referred to as the outlet works improvements in this Report) is to study the feasibility and provide recommendations for outlet works modifications alternatives to carry forward into the next phase of conceptual design (Phase 2). The outlet works of the dam require modification to address dam safety concerns with respect to the seismic performance of the existing outlet works. The major findings of the Study include abandoning the existing intake tower and outlet works conduit and then constructing a new outlet works system.

Refer to the Santa Felicia Dam Outlet Works Rehabilitation Project – Phase 1 final report (GEI 2015a) for a summary of the facilities being currently considered for the Phase 2 evaluation. The Panel believes that the fish passage concepts presented here would generally apply should a new outlet works be located on either the right or left abutment of the dam.

The anticipated schedule for completion of Phase 1 is during the summer of 2015 and beginning Phase 2 shortly thereafter. Phase 3 (final design and permitting) would be conducted from late 2016 through 2017 with the earliest construction anticipated to start in 2018. Construction of the outlet works improvements is expected to take 2 to 3 years.

2.4.2 Spillway Alternatives Study Overview

The purpose of the Spillway Alternatives Study (also referred to as the spillway capacity improvements in this Report) is to evaluate alternatives that will address the hydrologic and hydraulic deficiencies associated with the existing dam and spillway relative to passing an updated inflow design flood. The existing spillway at SFD is not adequate to pass the inflow design flood, which for this project is the Probable Maximum Flood (PMF). In paraphrase of the draft executive summary:

> *"A range of spillway improvement alternatives to prevent overtopping of the dam and spillway chute walls were initially identified and discussed with DSOD and FERC in a May 2014 Workshop. Alternatives involving overtopping protection of the dam were dismissed from further consideration. Alternatives that were developed and further evaluated included: 1) Modify Chute and Raise Dam, 2) Replace Spillway Crest w/Labyrinth and Modify Chute, and 3) Provide an Auxiliary Spillway. Each of these had two different variations as to configuration and/or location relative the dam abutments.*
>
> *The next steps for implementation of the spillway improvements project should include performing:*
>
> - *Detailed topographic surveying and mapping in the right abutment area of the dam;*
> - *Concrete sampling and strength testing of the existing spillway structure;*
> - *Subsurface investigations and geologic studies;*
> - *Geotechnical, hydraulic and structural analyses to support further development and refinement of alternatives; and*
> - *Environmental and related studies to support federal, state and local permitting.*
>
> *Further evaluations of the spillway improvements should also include assessment of: the integration of spillway modification alternatives with the outlet works facilities and potential fish passage facilities, as appropriate; more detailed evaluations of project costs; support for environmental documentation; and coordination with FERC and DSOD."*

The next phase of studies for the spillway improvements will involve field investigations and further analyses to support preparation of conceptual designs and cost estimates for alternatives that are selected by United. The estimated schedule from the report (GEI 2015b) is included in Table 2.4-1.

Table 2.4-1. Spillway improvement study schedule (Source: GEI 2015b).

Key Activity	Target Start	Target Completion
DSOD/FERC Review of Alternatives	April 2015	June 2015
Finalize IDF for Design	July 2015	August 2015
EIR/EIS Process	April 2015	February 2017
Preliminary Field Investigations	February 2016	April 2016
Preliminary Design	May 2016	October 2016
Final Design	February 2017	December 2017
Construction	April 2018	June 2019

2.4.3 Coordination of Fish Passage and Dam Safety Studies

United has been working proactively with the Panel to facilitate coordination between the fish passage and dam safety studies. Throughout development of this Report, GEI has attended Group meetings of the Panel to coordinate on how these potential projects affect the fish passage feasibility evaluation, and to generally discuss whether any of the outlet works modification alternatives or spillway capacity improvements could be integrated with elements of the fish passage alternatives. The Panel has also attended certain meetings conducted by GEI and United for these studies to coordinate schedule and the potential for integration with potentially shared facilities and consideration of expanded facilities. This Study considers relevant GEI analyses and integrates fish passage features to the extent practical as described for applicable fish passage alternatives in Section 4. Compatibility with the potential facilities is also explained in Section 4; however, it is important to note (as explained in the introduction to Section 2.4) that the fish passage features and associated drawings and descriptions were developed based on preliminary information available at the time of the Draft Report in March 2015. Some of the alternatives and conclusions in the dam safety studies changed with the final reports published in April, 2015. However, the final fish passage feasibility report has not been updated to reflect the latest design information from the dam safety studies final reports because the Panel does not believe it will affect the overall intent in the layout or operations of the fish passage alternatives, nor the recommendations and conclusions.

Specific terminology shared between studies includes:

- The low level outlet screens for the outlet works improvements (new intake per GEI study) are referred to in this Report as the "deep outlet screen."

It is not anticipated that there will be significant changes in the outlet flow capacity due to the improvements except that for dam safety emergency releases the capacity will be increased from approximately 800 cfs to 1,060 cfs. A flow of 500 cfs will be maintained for normal operations of maximum outflow as will the 20 cfs capacity for the low flow bypass system for fish habitat releases.

2.5 ARROYO TOAD[8]

The federally listed arroyo toad is known to occupy at least the first 3.5 miles of Piru Creek upstream of Lake Piru. This reach of Piru Creek is within designated arroyo toad critical habitat, which extends from Lake Piru upstream to Fish Creek (15 miles). Any design and ultimate operation of downstream fish passage alternatives in middle Piru Creek as well as other activities supporting fish passage from Lake Piru to Piru Creek will need to consider arroyo toad life history and habitat requirements and will require consultation with the U.S. Fish and Wildlife Service (USFWS) to assure construction and operation of a Piru Creek fish passage facility does not jeopardize the arroyo toad or adversely affect its critical habitat. In general, relevant passage issues the Panel considered that might affect arroyo toad or its habitat include:

- Enhancements including buffering high flows and maintaining minimum flow (10 cfs) during steelhead migration periods;
- Maintaining passage through the Lake Piru delta during extremely low flow periods;
- Creation or enhancement of aquatic habitats potentially suitable for use by predatory species; and
- Adverse effect to breeding and rearing habitat.

2.6 QUAGGA MUSSEL – MEASURES TO CONTROL AND MANAGE BIOFOULING OF FISH PASSAGE FACILITIES

Quagga mussels were first discovered in Lake Piru in December 2013. Quagga mussels are non-native freshwater mussels native to Eurasia. They multiply quickly and can cause extensive damage to infrastructure including those associated with fish passage facilities. The mussels

[8] Status and life history information relied heavily on USFWS (2014). The arroyo toad (*Anaxyrus californicus*) species report. U.S. Fish and Wildlife Service Ventura Fish and Wildlife Office, Ventura, CA. March 24, 2014.

have the potential to disrupt water delivery and hydropower generation functions, as well as create long-term economic impacts. Mussels attach to underwater surfaces and can clog small-diameter piping (i.e., cooling water, and domestic water piping), can reduce flow in larger diameter piping, and can clog fish screens, and impact intake structures. Thus, the Panel recognizes that measures for the management of quagga mussels would need to be included in any of the fish passage alternatives located in Lake Piru. The Panel is also aware that United is already working with appropriate agencies to develop a quagga mussel management strategy for the lake which would likely be applicable to the fish passage measures.

3. BIOLOGICAL INFORMATION

This section provides pertinent biological information that factored into the Panel's identification and evaluation of various upstream and downstream passage alternatives. Foremost was the need to consider the biological requirements and life history patterns of the target species driving the Study, the SCS DPS. This included its periodicity/timing in terms of adult and smolt migrations, as well as the suitability of existing conditions in Lake Piru and in middle Piru Creek. Related to this, summary information is also presented from three studies that United initiated in response to Panel questions raised during meetings with the Group.

3.1 SOUTHERN CALIFORNIA STEELHEAD

The species targeted for fish passage around SFD is the Southern California Steelhead, referred to as SCS. Steelhead in Southern California comprise a "distinct population segment" (DPS) of the species *Oncorhynchus mykiss* that is ecologically discrete from other populations of *O. mykiss* along the West Coast of North America (NMFS 2012). Under the Federal ESA, this DPS qualifies for protection as an individual species (NMFS 2012). The SCS DPS includes all *O. mykis*s populations in the watershed from Santa Maria River (north of Point Sal) south to the Tijuana River at the U.S.-Mexico border.

For recovery planning purposes, the SCS Recovery Planning Area includes those portions of coastal watersheds that are seasonally accessible to anadromous *O. mykiss* entering from the ocean, including the upper portions of watersheds downstream of artificial or natural impassible upstream barriers. The Santa Clara River is part of the Monte Arido Highlands (MAH) Biogeographic Population Group (BPG). NMFS defined BPGs as geographic recovery planning units using similar physical geography and hydrology as surrogates for physical characteristics differentiating natural selective regimes using individual watersheds to guide recovery efforts. Per NMFS (2012), the separate watersheds comprising each BPG are generally considered as individual *O. mykiss* populations (i.e., one watershed = one population of steelhead). The MAH BPG includes 4 large watershed (Santa Maria, Santa Ynez, Santa Clara and Ventura Rivers) and 13 small watersheds.

Life history of SCS DPS is considered to be quite complex and flexible (Boughton et al. 2006, NMFS 2005) Boughton et al. (2006) provided a conceptual description of the numerous life history pathways SCS DPS could follow based primarily on concepts developed for steelhead populations well north of the SCS DPS. Little empirical data have been acquired that distinguish the life history of SCS DPS. As a result, there is uncertainty as to specific aspects of SCS DPS life history, including life histories expressed in the MAH and ultimately in the Santa Clara River watersheds. Uncertain aspects that can be critical in conceptualizing and ultimately designing fish passage around SFD include:

- Timing of adult migration.
- Triggers or cues for adult migration.
- Timing of juvenile downstream migration.
- Size composition of downstream migrants.
- Triggers or cues for downstream migration.
- Benefits or costs associated with migration through reservoirs.

Studies addressing various attributes of SCS DPS life history have been ongoing for more than a decade in several of the large watersheds in the MAH BPG, including the Santa Ynez, Ventura and Santa Clara rivers. Results of these studies that are pertinent to addressing uncertainties regarding SCS DPS life history are discussed below. The following excerpt from the SFD BO (NMFS 2005) provides a general description of Santa Clara River steelhead life history

> *"Steelhead in southern California are categorized as "winter run" because they migrate into natal streams between December and early May, arriving in reproductive condition and spawning shortly thereafter. Adults may migrate several miles, hundreds of miles in some watersheds, to reach their spawning grounds. Steelhead have evolved to migrate deep into the extreme fringes of a watershed to exploit the environmental conditions that favor production of young (e.g., Montgomery et al. 1999). Individuals spend one or two years in the ocean, though in many populations a small fraction of fish will spend a third year at sea. The most common life-history patterns of first-time spawners in coastal basins of California are 2/1 (smolt age/ocean age), 2/2 and 1/2 (Busby et al. 1996). Steelhead differ significantly from other species of Pacific salmon in that not all steelhead adults die after spawning; some individuals may return to the ocean and then spawn a second, third, or even fourth time. Roughly 10%-20% of steelhead will survive to spawn a second time, and less than 5% may spawn a third or even fourth time. Female steelhead excavate a nest in the streambed and then deposit their eggs. After fertilization by the male, the female covers the nest with a layer of gravel, and the embryos incubate within this gravel pocket. Hatching time varies from about three weeks to two months depending on water temperature. The young fish emerge from the nest two to six weeks after hatching.*

For anadromous O. mykiss, the period of freshwater residency can range from one to three years, with longer residence in northern latitudes. Steelhead migrate to sea for the first time after two or three years in fresh water (Busby et al. 1996), but in watersheds that include highly productive environments, juveniles can reach sufficient size to smolt after one year (Bond 2006). Smolting juveniles migrate downstream in spring, generally between March and June or July with peaks in April and May (Shapovalov and Taft 1954, Spina et al. 2005). The timing of emigration appears to be influenced by photoperiod, temperature, and streamflow, listed in order of potential influence. Immature steelhead may rear in a lagoon or estuary for several weeks prior to entering the ocean. Additional details about steelhead life history can be found in Shapovalov and Taft (1954), Barnhart (1986, 1991), Bjornn and Reiser (1991), Spina 2003, Spina et al. 2005, and Quinn (2005).

Habitat requirements of steelhead in streams generally depend on the life history stage (Cederholm and Martin 1983, Bjornn and Reiser 1991). Generally, discharge, water temperature, and water chemistry must be appropriate for adult and juvenile migration. Low discharge, high water temperature, physical barriers, low dissolved oxygen, and turbidity (high levels) may delay or halt upstream migration of adults and timing of spawning, and downstream migration of juveniles and subsequent entry into the estuary, lagoon, or ocean. Suitable water depth and velocity, and substrate composition are the primary requirements for spawning, but water temperature and turbidity are also important. Dissolved oxygen concentration, pH, and water temperature are factors affecting survival of incubating embryos. Fine sediment, sand and smaller particles, can fill interstitial spaces between large substrate particle types, thereby reducing waterflow through and dissolved oxygen levels within a nest. Juvenile steelhead require living space (different combinations of water depth and velocity), shelter from predators and harsh environmental conditions, food resources, and suitable water quality and quantity, for growth and survival during summer and winter. Juvenile steelhead rear in riffles, runs and pools (e.g., Roper et al. 1994, Spina et al. 2005) during much of a given year where these habitats exist, but can show specific habitat requirements as indicated by the similarity of microhabitat use despite changes in microhabitat availability in some streams (Spina 2003). Steelhead in southern California streams can be tolerant of warm water, remaining active and feeding at temperatures that are higher than the temperature preferences and heat tolerances reported for the species based on individuals from northern latitudes (Spina 2007)."

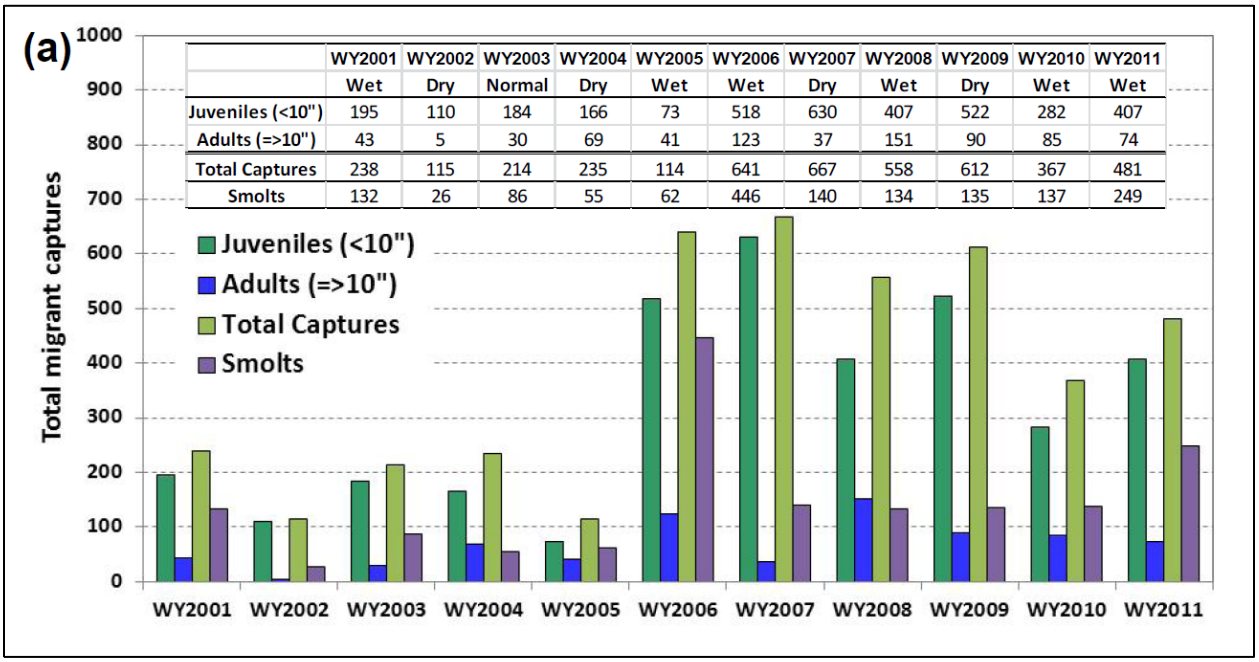
3.1.1 Steelhead Evaluations in the Monte Arido Highland Biogeographic Population Group

3.1.1.1 Santa Ynez River

The Cachuma Operation and Maintenance Board (COMB) has been monitoring SCS DPS in the Santa Ynez River (SYR) downstream of Bradbury Dam since 2001 as a condition of the Cachuma Project BO (NMFS 2000, USBR 2013, COMB 2013). Monitoring has included trapping upstream and downstream migrating fish at three sites to observe migration timing, composition, and abundance of *O. mykiss*. This monitoring program represents the most comprehensive, persistent study of SCS in the MAH BPG and in the entire DPS. As such, the study, along with results of fish passage monitoring at VFD (Entrix, Inc. 2000) provides the best available information applicable to the requirements of fish passage at SFD relative to SCS life history in the Santa Clara River watershed. The following discussion is primarily based on information reported from the 2010 and 2011 water years, which is generally consistent with information acquired since 2001.

The SYR monitoring results include information on the timing, size and development stage composition (i.e., pre-smolt, smolt), possible migration cues, and behavior of downstream migrating *O. mykiss*. The following is a brief summary of the monitoring results. A discussion of implications related to the design and evaluation of downstream fish passage facilities for SFD is provided in a subsequent section.

1. There was no apparent relationship between abundance of outmigrating *O. mykiss* and water year type. The U.S. Bureau of Reclamation (USBR) (2013) and COMB (2013) summarized the annual abundance of both upstream adult migrations and downstream juvenile/smolt migration relative to water year types and found no clear relationship (Figure 3.1-1).
2. There is no obvious relationship between timing and abundance of downstream migrating *O. mykiss* and high flow events. Although the COMB trapped downstream migrating fish during ascending and descending limbs of high flow events, monitoring could not be conducted during the highest flows. As such, the results are not conclusive especially regarding when downstream migration coincident with a high flow event occurred during the peak flow or during the descending limb of the event, which appears to be a general understanding regarding steelhead smolt emigration.
3. SCS DPS smolt emigration appears to be strongly related to time of year (mid-spring), potentially influenced by photoperiod, increasing temperatures, and/or declining flow (COMB 2013).



	WY2001	WY2002	WY2003	WY2004	WY2005	WY2006	WY2007	WY2008	WY2009	WY2010	WY2011
	Wet	Dry	Normal	Dry	Wet	Wet	Dry	Wet	Dry	Wet	Wet
Juveniles (<10")	195	110	184	166	73	518	630	407	522	282	407
Adults (=>10")	43	5	30	69	41	123	37	151	90	85	74
Total Captures	238	115	214	235	114	641	667	558	612	367	481
Smolts	132	26	86	55	62	446	140	134	135	137	249

Figure 3.1-1. Summary of migrant *O. mykiss* captures (including recaptures) at the three trapping sites within the LSYR basin from WY2001 to WY2011, from COMB 2013.

4. Most downstream migration occurred later during the season (March—May) although there were high flow events during the earlier portion of the season (January and February). Peak migration was predominantly during April (Figures 3.1-2 and 3.1-3) (COMB 2013).

5. Emigration appears to initiate early in the more distal reaches of the watershed with a relatively high proportion of pre-smolt leaving the natal reaches early. The earlier emigrating *O. mykiss* appear to spend a substantial amount of time rearing in the mainstem as evidenced by fish leaving Hilton Creek at river mile (RM 48) rearing up to 77 days before being trapped in the mainstem SYR, at RM 27. Furthermore, most *O. mykiss* leaving Salsipuedes Creek (RM 12) initiate downstream migration several weeks after Hilton Creek emigration begins. Most emigrants are smolts and are typically larger than those fish leaving Hilton Creek.

6. The size of emigrants increases with time of emigration (Figure 3.1-4). No downstream migrants captured during monitoring were smaller than fingerling (75 mm Fork Length (FL)) and most (>90 percent) of the emigrants were greater than 100 mm FL. For example, during WY 2011, mean smolt size ranged from 107 mm FL during January (Salsipuedes Creek) to over 170 mm FL for all three trapping sites during May.

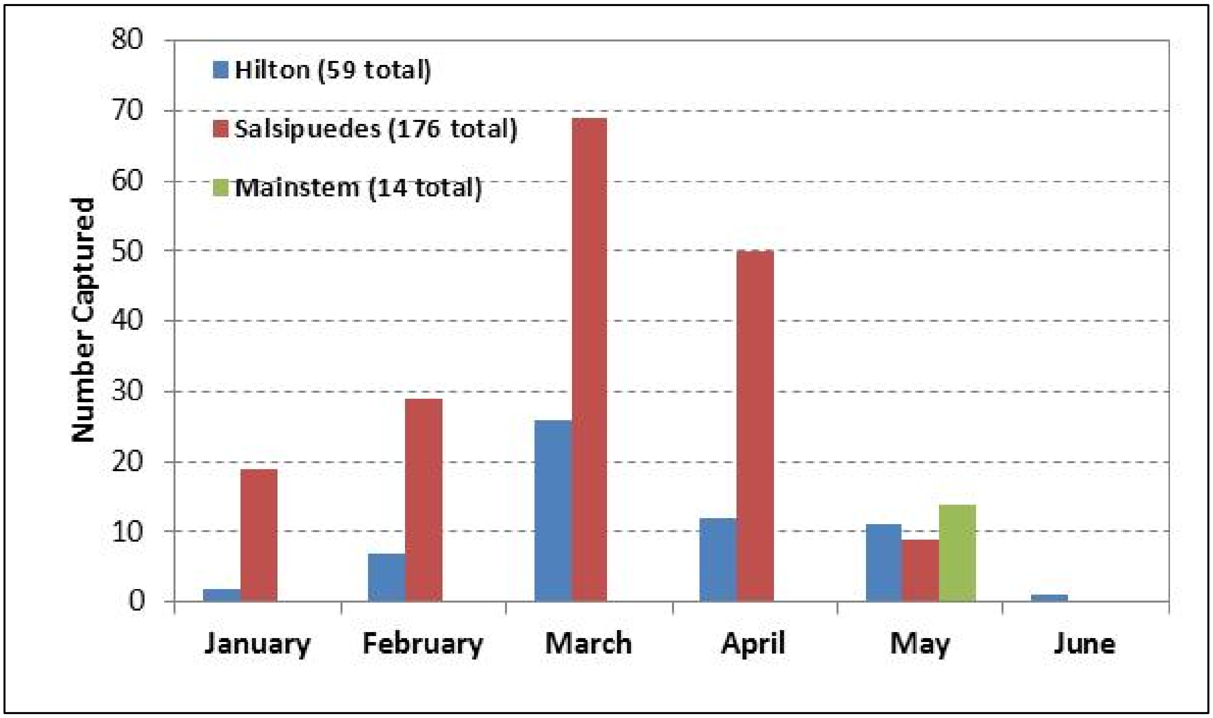


Figure 3.1-2. Temporal distribution of downstream migrating *O. mykiss* (smolt and pre-smolt) observed in the Santa Ynez River during the WY 2011 monitoring period (COMB 2013).

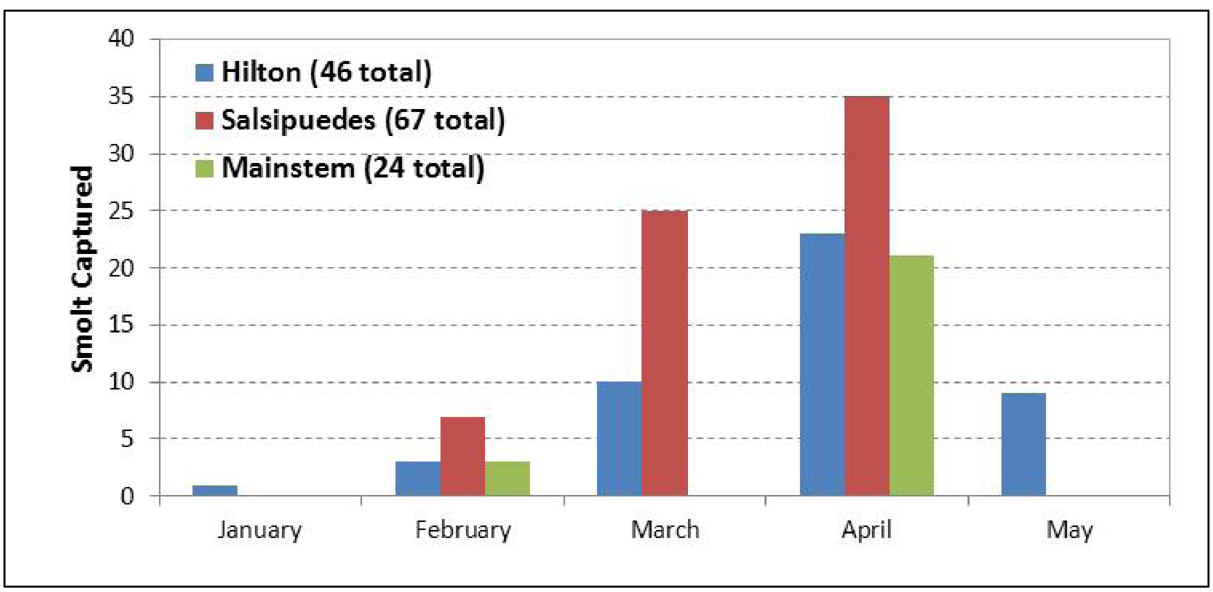


Figure 3.1-3. Temporal distribution of downstream migrating *O. mykiss* (smolt and pre-smolt) observed in the Santa Ynez River during the WY 2010 monitoring period (USBR 2013).

Upstream migration results (COMB 2013) showed that most of the known anadromous adults (includes ocean and lagoon rearing adults) captured during 2011 were captured in the lowermost reach of the watershed (i.e., Salsipuedes Creek) The one anadromous adult captured at Hilton Creek was previously captured at Salsipuedes Creek. All adult *O. mykiss* captured in the mainstem trap and all but one captured at Hilton Creek were resident adults.

The known anadromous adults were captured beginning in mid-January; most anadromous adults were captured from early March to early May. Movement of upstream migrating adults appeared to be correlated with the descending limb of storm events.

3.1.1.2 Ventura River

Similar to the monitoring program on the Santa Ynez River, steelhead studies conducted on the Ventura River at Robles Fish Passage Facility is a condition of a NMFS BO (Biological opinion for the Robles diversion fish passage facility, Ventura River, NMFS 2003). One purpose of the study was to evaluate the performance (attraction) of the facility by monitoring *O mykiss* distributions immediately upstream and downstream of the facility. Additionally, a VAKI Riverwatcher system (http://www.vaki.com/Products/RiverwatcherFishCounter/) was used to monitor adult *O. mykiss* migration through the facility. The study is being conducted by the Casitas Municipal Water District (CMWD). The following results are from monitoring that occurred from 2006 through 2013 (CMWD 2014).

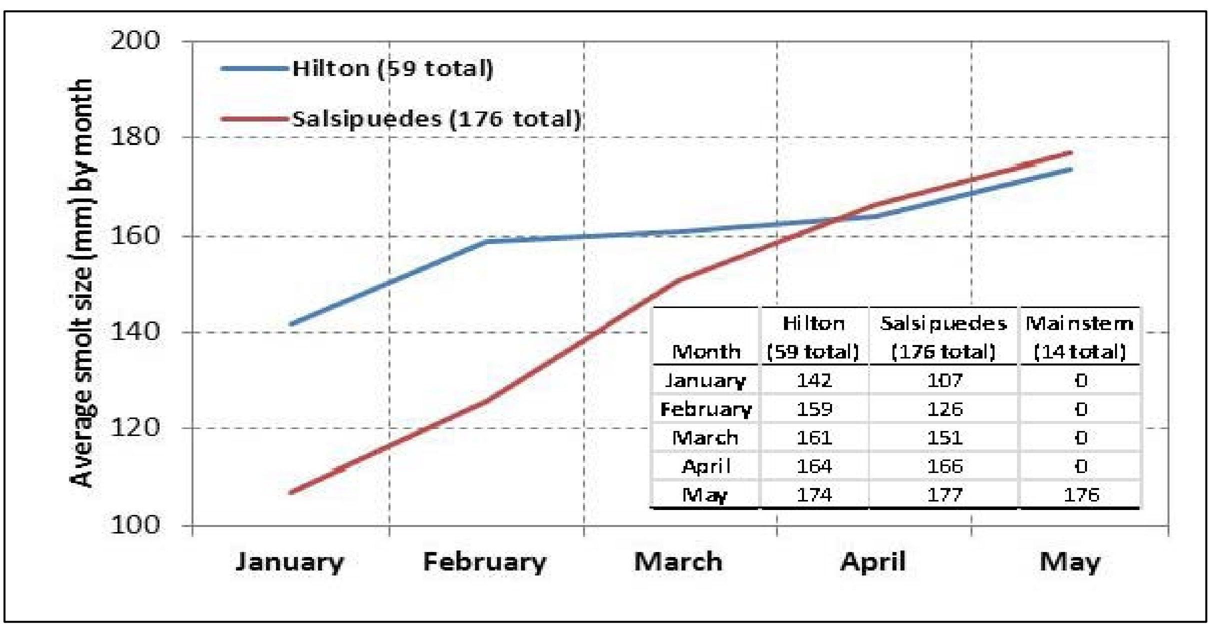


Figure 3.1-4. Mean size of smolt captured by month during the WY 2011 SYR monitoring period (COMB 2013).

Results of monitoring fish migration on the Ventura River are primarily based on counts of fish made during snorkeling and by observations from the bank. Pertinent results show that downstream migration primarily occurred late in the spring and that the migrants were predominantly smolt-sized (> 100 mm FL). Adult upstream migration appeared to be associated with the descending limb of a high flow event.

3.1.1.3 Santa Clara River

United has been monitoring fish migration at the Vern Freeman Diversion facility since 1993, although the extent of monitoring has varied over that period. The initial monitoring was conducted between 1994 and 1998[9], (Entrix, Inc. 2000) as a condition of the U.S. Army Corps of Engineers (COE) 404 Permit for Freeman Diversion Improvement Project and was intended to evaluate the recently constructed fish passage facilities associated with the project.

In 1994, 1996, and 1997 the smolt emigration began in the middle of March, with more than 50 percent of migration occurring between April 1 and April 15, and the migration was nearly complete by early May (Entrix, Inc. 2000). In 1995, smolt emigration at VFD began in late April (although three parr were captured earlier), 50 percent had been captured by about May 8, and the last smolt was captured on June 18. The emigration period lasted five weeks in 1996, eight weeks in 1994, and nine weeks in 1995 and 1997. The central 80 percent of migrants were captured over a three to six week period. The peak of emigration (largest number of smolt in a one week period) was the second week of April in 1994 and 1996, the fourth week of April in 1997, and the first week of May in 1995 (Table 3.1-1).The number of smolts captured ranged from 81 to 414. The lowest catch occurred in 1994, while 1997 had the highest. Smolt sizes ranged between 120 and 317 mm FL. Several parr, or presmolt captured in 1995 ranged from 70 to 95 mm FL. No fry-sized salmonids [< 60 mm fork length (FL)] were observed during the four-year-long study.

Few adult steelhead were observed during that monitoring period. One adult steelhead was captured in both 1994 and 1995, and two adults were collected in 1996. All four adult fish were captured during March.

Monitoring has continued at the VFD since 1998 and Booth (2015) recently summarized United's activities over the entire period (1993 through 2014) (Table 3.1-2). He noted that smolt numbers were extremely variable from year to year, ranging from 0 to 839. He attributed some of the variability to changes in stream discharge from year to year: in years where the tributaries

[9] Monitoring in 1998 was subject to obtaining a Section 10 permit from NMFS during the first year that SCS were listed. As a result, monitoring began late in April and is not representative of the migration period.

Table 3.1-1. Summary of steelhead (*O. mykiss*) downstream migrants captured in the Santa Clara River at Vern Freeman Diversion Dam, 1994—1998. (Entrix, Inc. 2000).

Month	Week Ending	1994	1995	1996	1997	1998
November	21	-	-	-		-
	28	-	-	-	0	-
December	7	-	-	-	0	-
	14	-	-	-	0	-
	21	-	-	-	0	-
	28	-	-	-	0	-
January	7	-	0	-	0	-
	14	-	0	-	0	-
	21	-	0	-	0	-
	28	-	1	-	0	-
February	4	0	1	0	0	-
	11	0	0	0	0	-
	18	0	1	0	0	-
	25	0	0	0	0	-
March	4	0	0	0	1	-
	11	0	0	0	0	-
	18	2	0	1	0	-
	25	9	2	16	11	-
April	1	16	0	14	31	-
	8	25	0	28	52	-
	15	0	0	17	46	0
	22	15	2	5	49	0
	29	9	11	1	139	1
May	6	2	27	0	36	1
	13	3	25	-	18	0
	20	0	16	-	22	0
	27	0	10	-	8	0
June	3	-	5	-	1	0
	10	-	8	-	0	0
	17	-	1	-	0	0
	24	-	0	-	0	0
July	1	-	0	-	-	0
	8	-	0	-	-	0
	15	-	0	-	-	0
	22	-	0	-	-	0
	29	-	0	-	-	0
Total		**81**	**110**	**82**	**414**	**2**

Table 3.1-2. Steelhead (*O. mykiss*) detected at United Water Conservation District's Vern Freeman Diversion Facility, 1993-2014 (Source – Booth 2015).

Year	Steelhead adult	Steelhead kelt	Steelhead smolt	Young-of-the-Year	Resident trout	Hatchery trout
1993					1	
1994	1		69		18	
1995	1		97	2	16	64
1996	1	1	83	2	11	27
1997			413	1	8	1
1998			2	3	1	
1999	1		3	2		
2000	2		839	37	14	
2001	2		123		1	
2002			3			
2003			36		5	
2004			2		1	
2005						
2006			13	4	4	
2007			12	60	2	
2008	2†		133	12	12	
2009	1	1	167		3	
2010			72	23	5	
2011			19		4	
2012	2	1	31	59	6	
2013				1		
2014			11	4	4	
Total	**11**	**3**	**2,128**	**210**	**116**	**92**

†Stray hatchery steelhead with clipped adipose fins.

had minimal connection to the mainstem of the Santa Clara River, smolt numbers were low. Booth (2015) noted that during wet years, fish can take several pathways (i.e., fish ladder, dam crest, bypass channel) that avoid detection, leading to underestimates of fish numbers. For the entire period of monitoring, smolts were typically observed in the fish trap and fish bay between early March and late May, but have been observed as late as mid-July (Figure 3.1-5)). Smolts typically ranged in size from 120-160mm, though occasionally small smolts (<100mm) have been captured (Booth 2015).

3.1.2 Fish Passage Implications

The results of the studies on the three SCS streams, in particular those on the Santa Clara River provide information regarding the timing, migration cues, and composition of *O. mykiss* migrations that may be applicable to Piru Creek.

3.1.2.1 Adult Migration

Information on adult migration obtained from the studies is sparse, as few anadromous adult *O. mykiss* were observed. Although making inferences about adult steelhead upstream migration must be done with caution, it does appear that migration is weakly tied to high flow events, primarily movement occurring on the descending limb of the event. Timing of migration spans January through May, with most (although few total) migration occurring from March through early May.

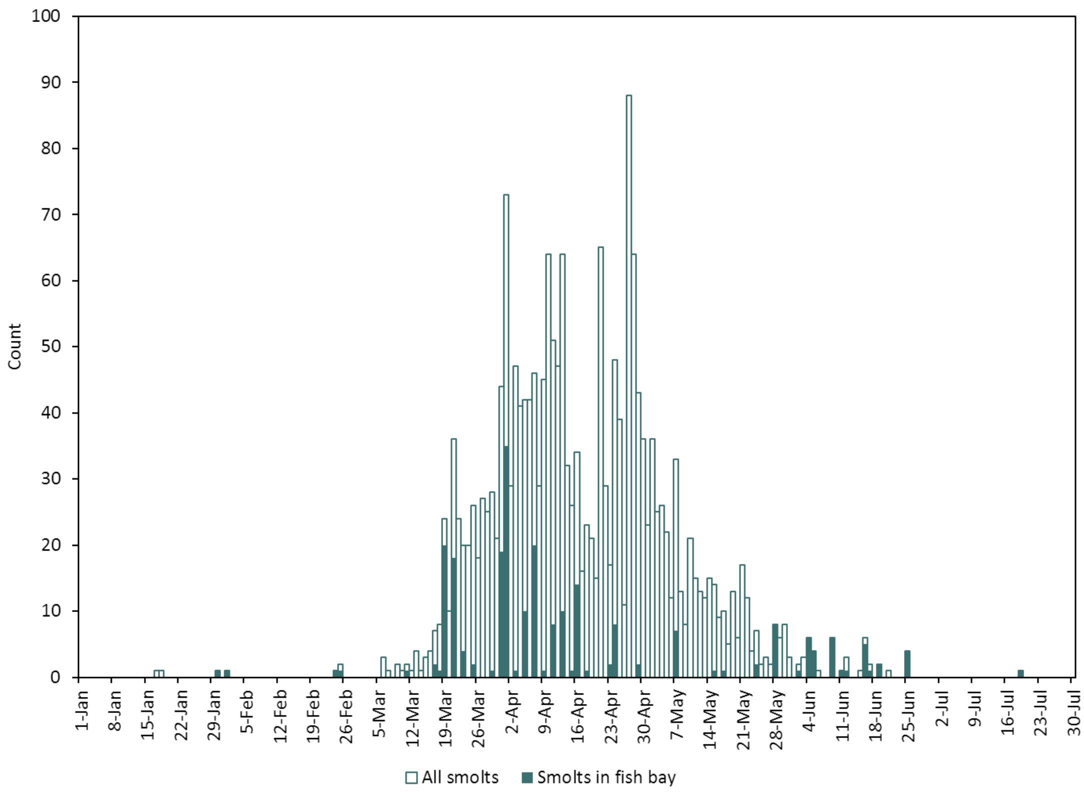


Figure 3.1-5. Temporal distribution of steelhead (*O. mykiss*) smolts captured at the Vern Freeman Diversion Facility by the United Water Conservation District based on fish captures collected from 1994 through 2014. Smolts in fish bay are those captured during a dewatering operation of the facility and are in addition to those captured in the fish trap. Source: Booth 2015

3.1.2.2 Downstream Migration

Timing of downstream migration appears to be closely associated with the time of year; most migration observed on all three streams occurred from March into May, peaking in April. Timing appears to be closely related to smolt development. Most downstream migrants were smolts. Pre smolts appeared to move from the upper watershed early, but remained in the larger portion of the stream until smolts – then migrated downstream. No fry-sized salmonids were reported to be part of the migration. This observation is consistent with studies on other streams along the central and south coast of California (Shapovalov and Taft 1954, Bond 2006)

Migration may be encouraged by high flow events, but likely only when they occur later in the season and when the fish are smolts. Downstream migration does not appear to be directly related to the water year type during migration. All three streams exhibited comparably high numbers of downstream migrants during wet, normal and dry years. Because there is uncertainty regarding the relationship between flow and smolt migration and speculation that migration is influenced by high flow events, including freshets, the Panel determined that the feasibility of downstream passage alternatives should consider wet years (see Section 5.3.2)

3.1.2.3 Lake Piru Rearing

Fish that move downstream into Lake Piru early in the migration period could benefit from increased growth. However, risks and benefits associated with moving to the reservoir are unknown. The behavior of downstream migrants, as observed in the upper watershed of the SYR suggests that lake rearing could be an advantage to early downstream migrants. Preliminary results addressing the predator population and water quality in Lake Piru (see Section 3.2.1), however, suggest that risk of predation is high and availability of suitable habitat is low, which indicates that moving to and remaining in Lake Piru for an extended period would not likely benefit steelhead migrating from Piru Creek.

3.2 ADDITIONAL INFORMATION OBTAINED DURING STUDY

3.2.1 Lake Piru Fish Populations and Habitat Conditions

As previously noted, one uncertainty that affects the success of reservoir-based downstream fish passage facilities involves the potential benefits and risks to juvenile steelhead entering Lake Piru. Specifically, is the reservoir a detriment to smolts due to predation and poor quality habitat, or is there a potential benefit of enhanced growth and survival? The risk of high reservoir mortality would favor collecting smolts in Piru Creek upstream of the reservoir; reservoir-related growth and survival would favor a reservoir-based collector to provide the opportunity for smolts to rear in the reservoir, at least early in the migration period.

3.2.1.1 Fish Populations

Previous investigations of the fish population within Lake Piru show the lake to support sustained populations of warm water fishes (Black 2014). On May 27, 2014, CDFW completed an electrofishing survey of Lake Piru. The water temperature averaged 70ºF/21.1ºC during this survey. A total of 53 fish were collected from 61.02 minutes of shock time. Species collected during this survey included largemouth bass (*Micropterus salmoides) (*LMB), redear sunfish (*Lepomis microlophus)* (RSF), bluegill (*Lepomis machrochirus)*, black crappie (*Pomoxis nigromaculatus)* and brown bullhead (*Ameiurus nebulosus)*. In addition, threadfin shad (*Dorosoma petenense*) were observed, in small numbers. The catch per unit effort (CPUE) for all species collected at Lake Piru during the spring survey was 0.87 fish/minute (Table 3.2-1). The most abundant species sampled were LMB (66%) and RSF (28%) which combined accounted for 94 percent of the total catch.

Table 3.2-1. Species composition and catch per unit effort (CPUE) collected in Lake Piru by CDFW on May 27, 2014 (Black 2014).

Species	Scientific name	Number	Percent of Total	CPUE	Length Ranges (mm)
largemouth bass	*Micropterus salmoides*	35	66	0.57	171-480
redear sunfish	*Lepomis microlophus*	15	28	0.25	288-350
bluegill	*Lepomis machrochirus*	1	2	0.02	216
black crappie	*Pomoxis nigromaculatus*	1	2	0.02	375
brown bullhead	*Ameiurus nebulosus*	1	2	0.02	279

During development of the Study Plan, the Panel requested United to collect additional information on fish species in Lake Piru. United initiated an angler survey in 2014 using voluntary questionnaires. The questions asked of the anglers included what species caught, number caught, size, effort and whether the angler was fishing for trout. The anglers were also asked to identify the location of catches by referencing subsections of the reservoir pictured on the questionnaire (Figure 3.2-1). The survey was initiated in summer (August) 2014 and is ongoing.

Results of the survey show that LMB dominated the catch (Table 3.2-2). Crappie and rainbow trout were also reported as being caught by anglers. Nine anglers indicated that they had fished for trout (Table 3.2-3).

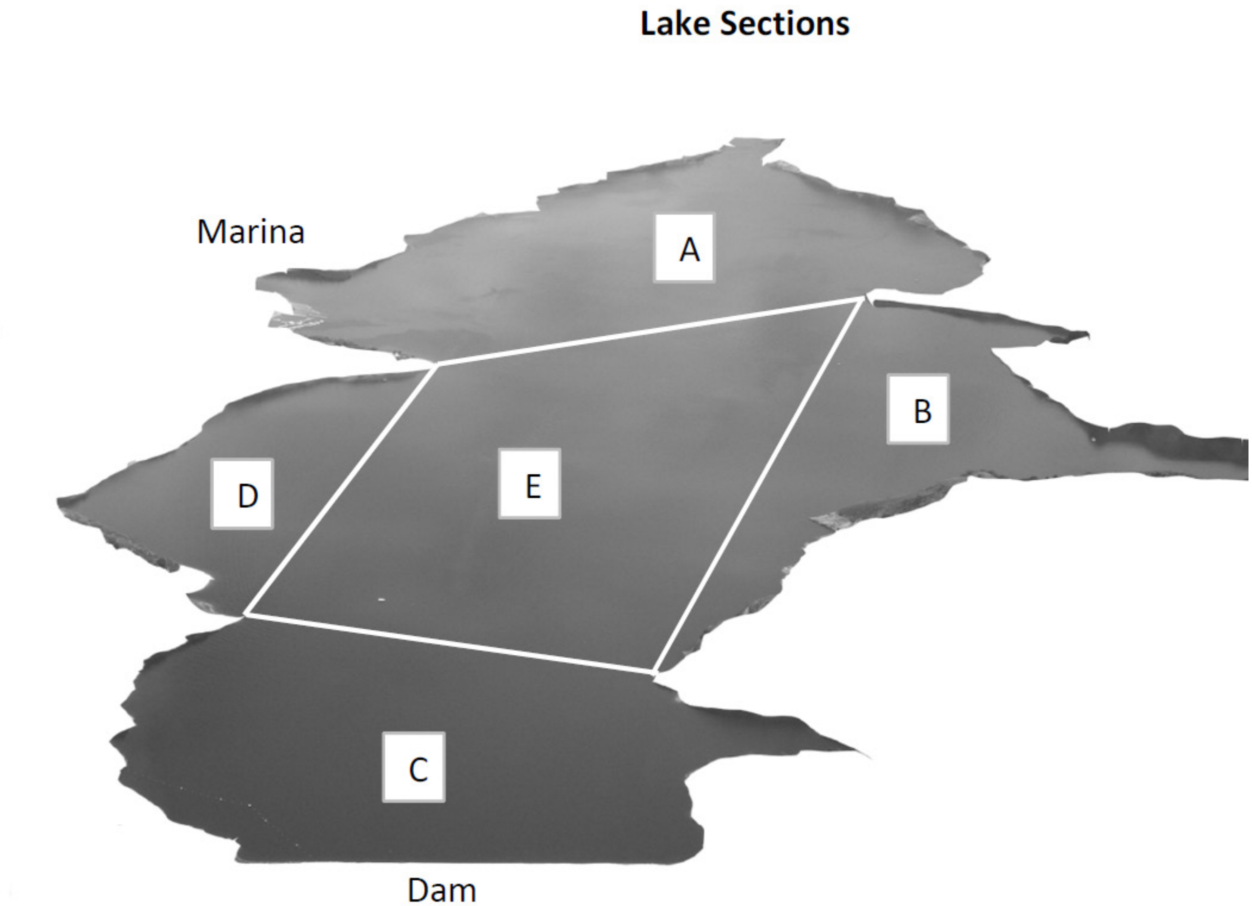


Figure 3.2-1. Location of lake sections identified in the Lake Piru creel survey questionnaire. (Source: Unpublished data from United Water Conservation District)

Table 3.2-2. Results of Lake Piru angler survey conducted between August 2014 and February 2015 (Source: Unpublished data from United Water Conservation District 2015) (see Figure 3.2-1 for locations of A, B, and C in Lake Piru).

Date	Species Caught	0-6	7-12	13-18	19-24	Depth Caught	Lake Section	Kept	Releas ed
8/17/2014	LMB			1		20	E		X
8/9/2014	LMB			1		40	B		X
8/15/2014	LMB		1			15	A		X
8/15/2014	LMB			1		21	A		X
8/31/2014	RBT	1				25	B		X
9/7/2014	LMB			1		40	E		
9/7/2014	LMB			2		10	B		
9/7/2014	LMB			2		10	A		
10/25/2014	LMB		1			10	B		X
10/25/2014	LMB	1				10	A		X
10/25/2014	LMB	1				10	D		X
10/25/2014	LMB	1				10	D		X
1/16/2015	LMB			3		10-30	A and C		X
1/18/2015	Crappie		1						
2/1/2015	LMB		1			25	B		X
2/1/2015	LMB			1		25	B		X
2/1/2015	LMB			1		40	B		X

Table 3.2-3. Results of Lake Piru trout fishing survey questions conducted between August 2014 and February 2015 (Source: Unpublished data from United Water Conservation District 2015) (see Figure 3.2-1 for locations of A, B, and C in Lake Piru).

Date	Did you fish for trout?	If you catch trout, where?	When?
8/17/2014	Yes	Blank	Blank
8/17/2014	Yes	C	Winter
8/9/2014	Yes	NA	Summer/Fall
8/16/2014	Yes	Blank	Blank
8/31/2014	Yes	B	August
9/3/2014	Yes – a few years ago	C	May-Sept
1/16/2015	Yes	A,B,C	Winter/spring
1/18/2015	Yes	C	Not for long time
2/1/2015	No	B	Dec/Jan/Feb

3.2.1.2 Habitat Conditions

Water quality parameters (temperature and dissolved oxygen) are important for determining the suitability of Lake Piru for steelhead rearing. For this discussion, the Panel is defining suitable steelhead rearing habitat as containing greater than 5 mg/l of dissolved oxygen and water temperatures less than 22° C[10]. Data on these parameters were collected by United as part of controlled seasonal flow releases from Lake Piru from September 1 to November 3, 2008 to augment surface water flow in the Santa Clara River (i.e., conservation releases) (Howard and Gray 2008). Lake Piru was stratified during thermocline measurements from August 29 to October 9, 2008. The reservoir was mixed on October 10, 2008. During the period of stratification, reservoir depths with more than 5 mg/l dissolved oxygen level also had water temperatures above 22°C.

In response to the Panel's request, in spring 2014 United began measuring dissolved oxygen levels and water temperature at reservoir depths at up to 5 sites (Figure 3.2-2). Suitable steelhead rearing habitat was available in the reservoir during the winter and early spring, but as the reservoir stratified in early summer the depths with water temperatures less than 22° C also had lower dissolved oxygen levels (Figure 3.2-3). By June 27, 2014, habitat conditions had deteriorated and by July 9 water depths with temperatures less than 22°C had less than 2 mg/l dissolved oxygen (Figure 3.2-3). The reservoir mixed in late fall and suitable conditions were available from October 2, 2014 through January 12, 2015, which is the most recent survey.

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[10] Parameters based on collective reporting by Matthews and Berg 1997, Spina 2003, Spina *et al*. 2005, Boughton *et al*. 2006, Spina 2007

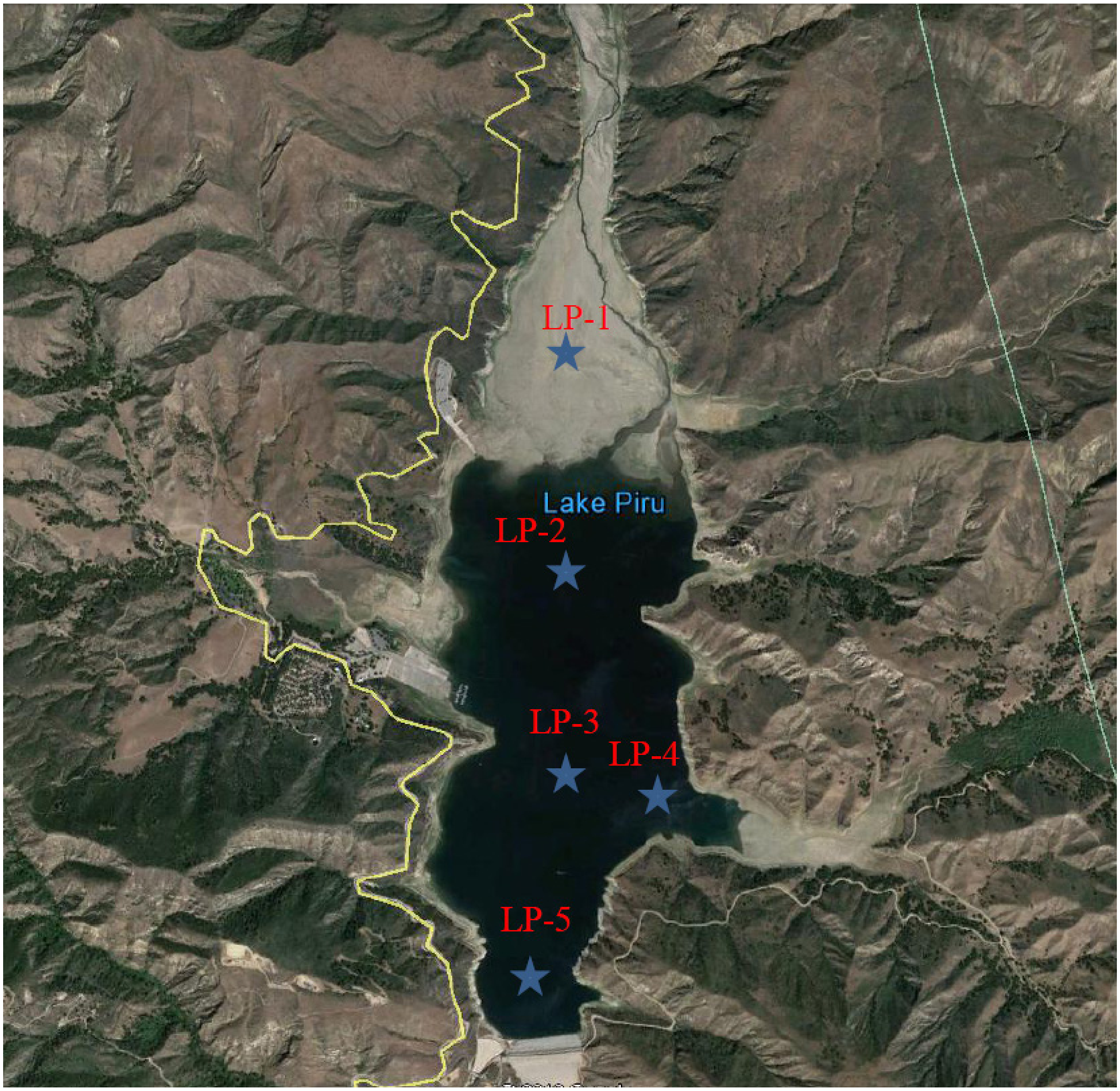


Figure 3.2-2. Location of 2014 Lake Piru water quality measurement sites. (Source: Unpublished data from United Water Conservation District)

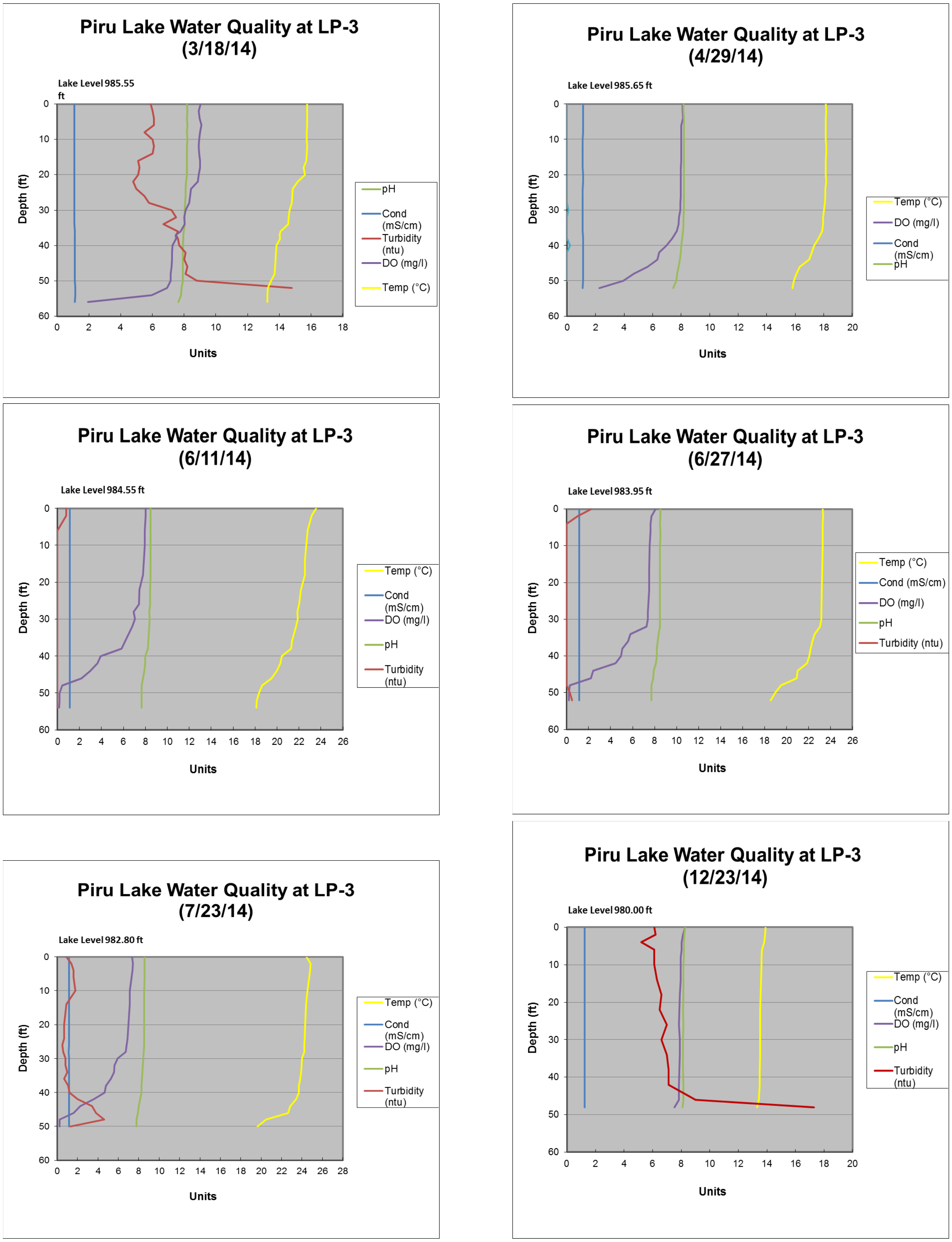


Figure 3.2-3. Representative results of dissolved oxygen and temperature distribution in Lake Piru measured from March through December 2014. (Source: Unpublished data from United Water Conservation District).

3.2.1.3 Implications

Lake Piru appears to contain a robust fish predator population with largemouth bass representing an apex predator. Largemouth bass are less active at water temperatures below 15°C; however surface water temperatures in Lake Piru during spring 2014 exceeded 15°C by March and routinely persist through September. As surface water temperatures in Lake Piru warm during the spring, bass metabolic rates increase and the risk of bass predation on steelhead juveniles increases and can occur throughout most of the smolt emigration period.

Suitable juvenile rearing habitat conditions are available in Lake Piru during the winter and early spring, but warming water temperatures and low dissolved oxygen from reservoir stratification reduces or eliminates reservoir rearing conditions during July, August, and September. Some salmonids may persist in the reservoir through the summer months at areas of groundwater inflow or other cool water refugia, but water quality conditions do not generally appear conducive to steelhead rearing.

The potential risks versus benefits associated with juvenile steelhead passage and rearing in Lake Piru are uncertain; however, the abundance of predators and poor habitat suitability during the summer months strongly suggests that Lake Piru does not benefit juvenile steelhead growth and survival. Additional information is needed regarding the overall influence of Lake Piru on the survival (mortality) of juvenile steelhead before the overall risks and benefits of reservoir-based fish passage collector alternatives can be determined.

3.2.2 Critical Riffle Study

During the field reconnaissance of the Project area in 2012, the Panel identified a delta area created where middle Piru Creek flows into Lake Piru that represents a potential barrier to fish migration at low reservoir elevations. Deltas are depositional features that form where flowing water enters a low velocity or still water environment such as where Piru Creek enters Lake Piru. Sediment carried by the stream is deposited at the lake-river interface, forming a gently sloping, delta-shaped deposit. The delta’s depositional zone varies with changes in the lake elevation. Rising water levels cause sediment carried by the stream to drop out farther upstream, filling inundated distributary channels. Falling water levels expose the delta to flowing water, which can cut through deposited sediments, moving material downstream and exposing gravel deposits across the landform. At low lake elevations, the large delta area is exposed and surface flow in Piru Creek can become disconnected from Lake Piru. During these times, both upstream and downstream fish passage would be precluded from or into Lake Piru.

United is currently evaluating the relationship between flow, reservoir elevation and fish passage through the delta area of Lake Piru using protocols prepared by CDFW for analyzing fish passage across critical riffles (Woodard 2012). Transects have been established at critical passage riffles in the lower reach of middle Piru Creek (Figure 3.2-4). Measurements were scheduled to be collected under a range of flow and Lake Piru reservoir pool levels; however, the full suite of measurements has not been completed (Steve Howard, United fisheries biologist, pers. comm. 2015) due to ongoing drought conditions.

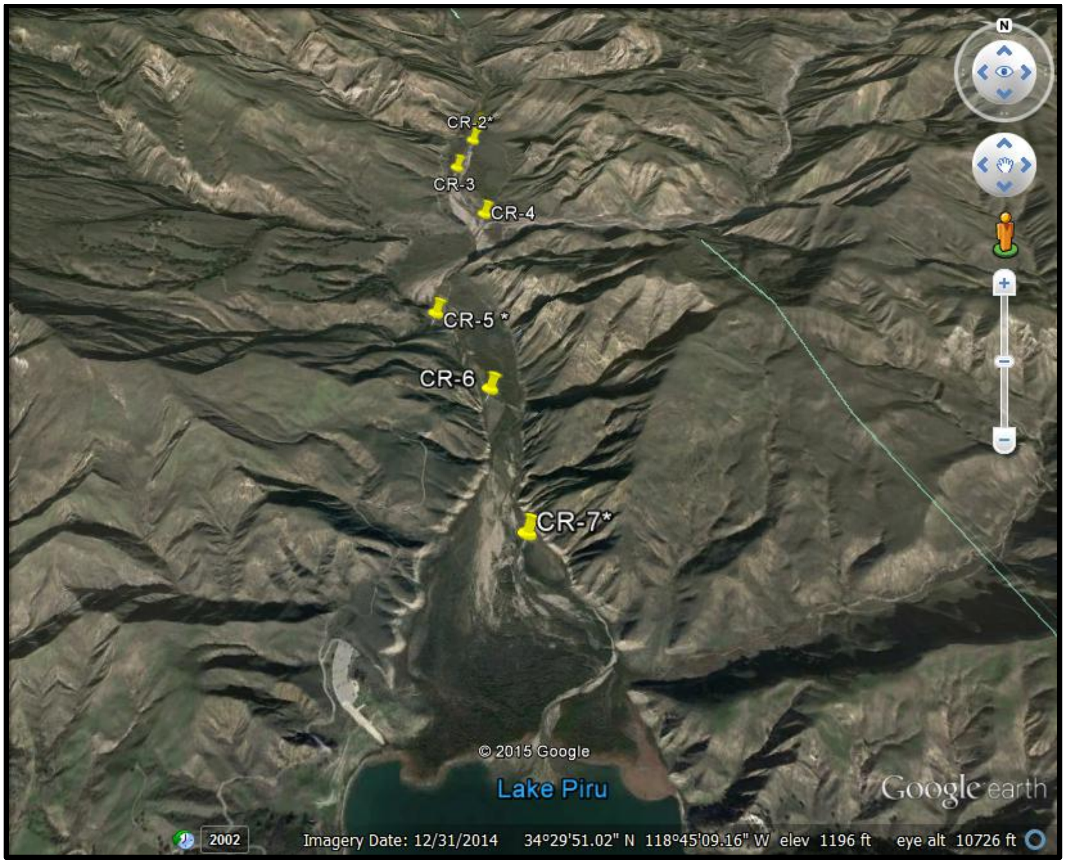


Figure 3.2-4. Image of Lake Piru and middle Piru Creek showing measurement locations for critical passage riffles. (Map Source: Google earth; Map from unpublished data from United Water Conservation District)

Results of this evaluation should help identify the range of flows that provide fish passage (both adult upstream migration and juvenile/smolt downstream migration) through this area of middle Piru Creek for a range of Lake Piru pool elevations. Flow in middle Piru Creek comes from upper Piru Creek, which is regulated by Pyramid Lake and from Aqua Blanca and Fish Creeks, two unregulated tributaries to middle Piru Creek. The Critical Riffle analysis will also help define those periods when connectivity is lost and/or suitable fish passage conditions are not provided.

4. FISH PASSAGE ALTERNATIVES

This section describes the overall process the Panel used in first identifying concepts, winnowing the concepts down to those warranting further evaluation, and then developing a set of alternatives and conceptual designs for further consideration. As noted in Section 2.4, United is conducting feasibility studies to address dam safety issues, which have identified potential revisions to the intake, intake tunnel, and spillway. All of the fish passage alternatives developed by the Panel took into account the latest information from these ongoing studies, which are being conducted in parallel with this Study. Future development of any fish passage alternative will need to incorporate the latest information from the dam safety studies.

4.1 INITIAL LIST OF FISH PASSAGE CONCEPTS

As described in Section 1.4, the Panel followed a series of steps that largely mirrored the task sequence to identify alternatives for evaluation. At an early stage of the project, the Panel conducted a brainstorming session to identify and document a "universe" of potential fish passage concepts, based on literature and the professional experience of Panel members. The Panel organized and prioritized the list, which resulted in a set of concepts to evaluate further, plus a list of options that were "deferred," along with reasons deferment. The full list, organized by upstream and downstream, is included within Appendix B of this Report.

The identified upstream concepts fell primarily into categories of capture (e.g., barrier dam, trap at powerhouse, trap at spillway pool), transfer (e.g., fish ladders of various alignments, aerial tram, collection and transport (also commonly referred to as trap and haul)), and release (e.g., release acclimation ponds, multiple release points). Downstream concepts were similarly categorized as capture (e.g., floating or movable surface collectors, multi-level fixed collector), transport (e.g., low-flow dedicated bypass from existing penstock, reservoir bypass channel), and release (e.g., volitional collector bypass to fishway).

4.1.1 Initial Concepts Deferred from Further Consideration

During the brainstorming sessions, the Panel identified a subset of concepts that were deferred from further consideration (Table 4.1-1).

4.1.2 Developing Alternatives from Initial Concepts

The Panel adjusted the initial set of remaining concepts into approaches that would be relevant to operations at SFD. Only those concepts that could be reasonably defined and were compatible with physical characteristics of the Santa Felicia site were included in an initial set of alternatives. Each alternative is described with feasibility level drawings, text descriptions, and a planning level cost estimate. The upstream alternatives included several different alignments for fish ladders which followed the terrain features of the face of the dam and surrounding area, and considered the existing roadway, penstock, tunnel, powerhouse, spillway, and other infrastructure. The downstream alternatives included several different surface collectors in the reservoir and collectors on Piru Creek, with various screen sizes and attraction pump flows as options.

Table 4.1-1. Listing of initial fish passage concepts that the Santa Felicia Dam Fish Passage Panel deferred and the rationale for deferment.

Item	**Basis for Deferment**
	Upstream
Catapult	Impractical: Height of dam
Fish pump	Unproven: Capability at high head, Hidrostal or Archimedes screw, oxygen and temperature may be limiting
Balloon fish lift	Impractical: Environmental conditions will limit practicality, safety considerations
Helicopter transport	Impractical: Human safety, high cost
Boat haul	Limited release locations due to reservoir pool level fluctuations
Convert turbine to fish pump	Unproven: Hidrostal capability at high head, oxygen and temperature may be limiting
Denil ladder	Unproven: Capability at high head, complications if connecting separate sections
Pneumatic canister	Unproven: Technology development
Fish cannon, Whoosh system	Unproven: Technology development is in experimental stage
Haul by rail	Impractical: High maintenance, reduced reliability due to slides, impractical compared to other transport
	Downstream Passage
Multi-level tower with fish-friendly outlet (turbine)	Unproven: Fish-friendly turbine technology is not developed for this high-head project
Nature-like fishway (upstream / downstream), fully volitional, bypassing dam and reservoir	Impractical: Terrain and steep slope, combined with the height of the dam, makes this option unworkable
Floating bypass channel through reservoir	Impractical: Reservoir with high elevation changes, no means for feasible outlet
Transport by rail	Other alternatives (e.g., truck transport) simpler with comparable results

4.2 UPSTREAM FISH PASSAGE

This section provides a description of the upstream alternatives that have been selected for further, detailed feasibility evaluation in this Report. Four alternatives have been carried forward, including one that is volitional. Table 4.2-1 is a summary of the preferred upstream alternatives, and identification of the Enhancements and Supplements that are combined to form them. A description of each alternative is provided in the sections following the table. Descriptions of the Enhancements are provided in Section 4.2.5, and Supplementals are described in Section 4.2.6. Cost information is provided in Section 4.4.

Table 4.2-1. Summary of the upstream passage alternatives (Alt), and enhancements and supplementals selected by the Santa Felicia Dam Fish Passage Panel for detailed feasibility evaluation.

Alternative Number	Alternative Name	Enhancements	Supplementals
U1	Pool and Weir Fishway, Tunnel and Tower; Reservoir Range EL 980 ft to 1,056 ft	• Operate to minimize spill • Monitoring facility	• Spillway pool collector
U2	Pool and Weir Fishway to EL 1,030 ft, East Alignment to Exit Structure; Reservoir Range EL 1,030 ft to 1,056 ft	• Operate to minimize spill • Monitoring facility • Challenge section • Release pond	• Spillway pool collector • Collection and transport facility
U3	Pool and Weir Fishway to EL 1,056 ft, West Alignment with Slide Release; Reservoir Range EL 980 ft to 1,056 ft	• Operate to minimize spill • Monitoring facility • Challenge section	• Spillway pool collector
U4	Collection and Transport with Multiple Release Locations; Reservoir Range EL 980 ft to 1,056 ft	• Operate to minimize spill • Monitoring facility • Challenge section • Release pond	• Spillway pool collector

4.2.1 U1 – Pool and Weir Fishway, Tunnel and Tower, Reservoir Range EL 980 ft to 1,056 ft

Operations and past reservoir level information indicate that Lake Piru elevations may vary in excess of 75 ft during the anticipated fish migration season. This large variation would mean a standard fish ladder around the dam would only be able to operate over a limited range of possible reservoir elevations and still provide the hydraulic connectivity for volitional fish passage, without a more complex system. Low and high reservoir levels during which the fish passage facilities can operate are needed to set design elevations and are based on the low frequency of occurrence. As shown in Figure 2.2-2, elevation 1,056 ft is exceeded less than 1% of the time and elevation 980 ft is exceeded about 4% of the time. Either of these elevations could be extended a few feet without significant design implications.

Alternative U1 provides volitional fish passage per the Study Plan definition. As conceptualized, adult and juvenile fish could freely move in either direction from the reservoir to the tailwater of the creek channel directly downstream of the dam outlet works. Major fish passage components would include: a channel spanning migration barrier, auxiliary water supply (AWS) system, a conventional pool and weir fishway inside a tunnel, and a fishway tower in the reservoir to accommodate approximately 76 ft of reservoir fluctuation. The reservoir tower would consist of an internal "stair-case" fish ladder configuration connected at the tower base to a horseshoe shaped vented tunnel drilled and blasted through rock to the outlet works vicinity. A fish ladder channel would be located inside the tunnel that could be shared with a new penstock and low flow release pipe. Other enhancements and supplementals that could be included with this alternative are listed in Table 4.2-1 and described below. The spillway pool collector, described in Section 4.3.5, is a supplemental collection facility included in all upstream fish passage alternatives. Alternative U1 is shown in Drawings U1.1-U1.9.

4.2.1.1 Reservoir Tower

The location of the tower is near the western reservoir bank upstream of the spillway in the same location and general configuration as the tower for alternatives D3, D4, and D5. The concrete tower would be founded entirely in rock that underlies the dam abutment and spillway. The condition and stability of the rock and seismic conditions will likely affect tower dimensions and foundation design and would need to be determined through engineering studies and detailed design. The tower is shown tied to the reservoir side with steel or concrete braces and the access bridge can serve as the top brace and anchor point. The specific location and orientation of the tower is provisional and would be refined in later stages of design to ensure it does not interfere with the spillway operation and to facilitate fish egress (upstream passage).

Tower dimensions are set by the flights, or stair-case, of the fishway channel with reasonable room for access and maintenance and considering a structural wall thickness assumed to be 2-ft thick. A stairway on the inner core of the tower (fishway tower) would follow the fish ladder flights down to the base of the tower. From the outside of the tower to inside the exit pool (exit surround) there is no head differential as the exit channels and debris rack openings for the fish exit into the reservoir are full depth. The maximum head differential on the fishway tower would be up to 190 ft representing the total head difference from a full flood pool of El. 1,070 ft to approximately El. 940 ft, representing the condition of the tower when drained with the reservoir at a high elevation. The basic outside dimensions of the tower are 90 ft long by 40 ft wide and 135 ft tall. The tower dimensions shown on the drawings are approximate and would be refined in final design, including structural wall thicknesses.

The tower would contain approximately 150 automated fishway exit gates (3 x 3-ft sluice gates) to operate the fish ladder from reservoir elevation 980 ft to 1,056 ft. Each gate would be downward opening and operated to maintain no more than 0.7 ft of drop from the exit channel into the fish ladder to provide volitional fish passage for both adult and juvenile fish. The Panel believes that fishway steps of one foot would be adequate for juvenile passage in this situation; however, this would not comply with state and federal fish passage criteria. If it is determined that only adult upstream fish passage is required or if the less severe criterion for juvenile fish is acceptable, then the number of gates can be reduced. The gates would be operated automatically based on monitoring of the reservoir level. As the reservoir level drops throughout the fish migration season the gates would sequence open with one active gate at a time. As the active gate lowers and reaches its sill for its respective pool, flow from the reservoir would switch to the next lower gate. At some point the fish ladder pool of the previously active pool disengages and fish could become trapped in the upstream non-active pool. The fishway would need to be inspected daily as the reservoir is dropping, and a small amount of pumped water supply provided to keep any trapped fish alive.

A gantry crane would be located on top of the tower for maintenance of the fishway exit gates and the debris racks. A bottom bulkhead or guard gate would separate the tower from the fishway tunnel in case of fishway exit gate failure. The bulkhead would be dropped into place using the gantry crane to close the tower during a large flood or in case of fishway exit gate failure or maintenance, in which case, the inside portion of the tower could fill up. The bulkhead would thus guard against uncontrolled releases.

The access bridge from the reservoir side would be suitable for a service truck to access the top of the tower. An electrical, instrumentation and control building would be located on an access pad cut into the reservoir side above the highest expected reservoir level (elevation 1,075 ft). Power to the tower and access area would be supplied from a local source but a backup generator or port for plugging in a temporary generator is recommended. Vehicle access to the location of the tower would be via a road cut into the hillside alongside the spillway.

4.2.1.2 Fish Ladder

Conventional fish ladders include a range of potential types of fabricated structures used to facilitate passage of fish over or around an obstacle, dam, or other migration barrier. Although there are multiple variations, the most common conventional fish ladder is the pool and weir type. One or more types of ladders can be used in combination to create a passage structure that meets site specific conditions. The overall slope of conventional fish ladders designed for adult upstream passage typically ranges from 8% up to 12% depending on the type and configuration of the ladder.

In this case a standard concrete pool and weir fish ladder is recommended. It would have a recommended maximum 10% slope with a maximum of 0.7-ft drop per pool to ensure it provides volitional fish passage for both adult and juvenile fish. The ladder would contain approximately 3 ft of minimum water depth and have inside pool dimensions of 6 ft long by 4 ft wide. The fish ladder channel height would be 6 ft for 3 ft of freeboard. The freeboard for the fish ladder inside of the tower may be less, on the order of 2 ft, for appropriate access and structural clearances. This size fish ladder can accommodate a design flow of 2 to 10 cfs with 7 cfs assumed to be a typical flow which could match the project low flow release requirement.

4.2.1.3 Fishway Tunnel

The fish ladder inside the tunnel would be the same design as described above for consistency. The fishway tunnel would be a separate tunnel and mostly follow parallel to the outlet works improvement tunnel, alignment alternative R1 (GEI 2015a), with an upstream portal at the base of the reservoir tower and a downstream portal near the outlet works. An access shaft is also shown part way down the tunnel. This would consist of an open horseshoe shaped tunnel and sized large enough for the fish ladder channel and an access walkway along the entire length. If constructed concurrently with the outlet works improvement tunnel a larger alternate tunnel configuration could have a combined use of the fish ladder channel, the penstock pipe, and the low flow release pipe with an access walkway along the entire length. It is assumed that the tunnel would be constructed using drilling and blasting techniques per the outlet works improvement study. See drawings U1.1 – U1.9 for cross-section dimensions and a potential layout. Variations of this layout for the components could be considered during conceptual design. The access walkway is important to inspect the fish ladder pools and ensure proper function.

4.2.1.4 Barrier Dam/Fish Ladder Entrance/AWS

In order to not interfere with the outlet works at the base of the dam a fish migration barrier is needed to limit upstream migration to a specified location and to guide fish to the entrance of a fish ladder. Any fish that moves past the entrance would likely move to the outlet works area where they would likely become stressed and disoriented resulting in migration delay. In order for fish to find the entrance of the fish ladder efficiently a channel spanning migration barrier is shown. Several types of migration barriers could be considered for this application. Various types of physical, hydraulic, and behavioral systems are all applicable – each one exhibiting different tradeoffs that should be considered in future iterations of design development.

A physical barrier in the form of an Obermeyer dam is shown for this alternative. For ease of access and control a barrier dam would be located approximately 150 ft downstream of the outlet works in the low flow release channel. The fish ladder would lead up the adjacent terrace from the barrier dam to the location of the downstream end of the fishway tunnel. An Obermeyer dam is essentially a bottom-hinged leaf gate raised by inflating a bladder underneath the gate structure. The dam is approximately 30 ft wide in the channel and would be at least 5 ft high. The dam would require an electrical and control building to operate the dam. An advantage of this type of barrier is that it can be easily lowered when not needed as a fish barrier and would have less impact on the outlet works or hydropower releases as compared to a fixed barrier dam (the Obermeyer dam lays nearly flat on the foundation when fully lowered). In addition, the inflation and deflation of the dam can be controlled and integrated with the outlet works controls. It also does not contain any overhead structure. This type of physical barrier dam could be substituted with another type like a picket barrier if the effect on hydropower or other operations is found to be significant. Power would be supplied from the local area, same as for the outlet works and nearby buildings.

An AWS system is typically used to supplement attraction flow at the entrance to a fishway. Fishways are typically designed to convey a specific flow or a range of flows to attract fish to the entrance. The fishway design flow is based upon several factors including: the availability of water, hydraulic variation of entrance and exit conditions, and the type of fishway that is desired. Typically, a smaller fishway that accommodates the target fish species with a lower flow is more cost effective than a fishway designed to accommodate the entire range of attraction flows. If a selected range of fishway design flows remain lower than the total attraction flow required for the project, an AWS system is included. It adds supplemental flow to or near the fishway entrance through chambers and coarse screens to dissipate the energy, distribute the flow, and optimize hydraulic conditions within and adjacent to the fishway entrance pool. Fishway entrance flow is typically up to 10% of the total stream flow per fishery agency guidelines and recommendations (NMFS 2011). For conceptual design purposes of this project the total stream flow to be considered should be the maximum capability of the outlet works for migration flow releases. While the current water release plan specifies a minimum migration flow release of

200 cfs under certain conditions, this may be subject to change. The total maximum release from the outlet works is typically 500 cfs.

The fish ladder entrance structure would be integrated with the barrier dam abutment. A special low flow entrance parallel to the primary entrance may be required for upstream passage of juvenile fish. The entrance would be a large pool sized to accommodate up to 50 cfs of AWS flow plus the maximum fish ladder flow for a combined flow of 60 cfs and be passable by adult and juvenile fish. The AWS flow would be supplied from the outlet works through an expected 18-inch diameter pipeline. The pipeline would contain a control valve for a manual setting based on prescribed flow releases to ensure there is at least 10% of the total flow emanating from the entrance pool. As noted above the AWS capacity would be refined as a design is progressed.

A Monitoring Facility is shown on the plans as an enhancement feature to count, and, if necessary, sample fish, as described in Section 4.3.5.2.

4.2.1.5 Operations

The fish passage operating season for all upstream alternatives is assumed to be from January 1 through May 31. This alternative is designed to essentially bypass the low flow release rate (normally 7 cfs but only up to 10 cfs for the fish ladder capacity) from the reservoir through the fishway tower, the tunnel and the downstream fish ladder segment to the tailwater below the barrier dam. This operation would be in lieu of providing the low flow releases through the outlet works, which would be operated for release flows greater than the fishway flow. Other than operating the fishway exit gates according to the reservoir level, the system would be a passive operation. Fish could migrate upstream and downstream of their own volition following the flow of water in the fish ladder; no fish handling would be required. It is expected that observation of the fish ladder would be needed on a daily basis to ensure proper function, checking for debris, and checking for presence or stranding of fish.

The barrier dam would be in operation as described above for the whole migration season unless otherwise indicated; e.g., during extended periods of low flow, or monitoring indicates no fish are present. The AWS would be operated anytime there is flow released from the outlet works above ten times the fishway flow to maintain at least 10% of the total flow emanating from the fish ladder entrance pool up to the normal maximum total flow release of 500 cfs.

Large debris would be managed at the debris rack on the reservoir tower. Debris could be lifted by the gantry crane with a grapple attachment into a small barge or container moored next to the tower that could later be pulled to shore where the debris would be removed. Smaller debris could be removed manually wherever it occurs. If it occurs at the fishway exit gates the gantry crane could be used for lowering a man-basket or a grapple attachment.

4.2.1.6 Phasing Opportunities

Phasing opportunities for Alternative U1 are limited. This is because it would be most feasible and efficient to construct the fishway tower and tunnel concurrently with the planned outlet works modifications to take advantage of the drained reservoir and mobilization for that work and for an enlarged tunnel section. However, the Panel assumed that construction would not be concurrent with the outlet works modifications. In this case, the base of the tower up to about elevation 990 ft could be constructed concurrently with the outlet works modifications in a partially phased approach with the possibility of adding the remaining tower later without having to dewater the reservoir again. This would consist of the lower 50 ft of the tower, more than a third of the full tower height. It could include the functional low level outlet screens and the emergency outlet structure. However, the fishway tunnel would also require these special considerations if it is not constructed with the outlet works improvements tunnel. A decision to build the outlet works tunnel larger would be needed in time to design the fishway tunnel.

Other phasing opportunities that exist with U1 include:

- Start with a collection and transport facility that includes the barrier dam and fishway entrance structure in the low flow release channel directly below the dam and outlet works. The fishway would lead to a temporary or permanent collection and transport facility similar to U4. The fishway tunnel and tower could be constructed if fish returns increase or complete volitional fish passage is required at a later time.
- Add a Piru Creek collector upstream of the reservoir (see Section 5) to collect downstream migrants and as a location to haul upstream migrants.

4.2.1.7 Compatibility with Downstream Passage Alternatives

Alternative U1 has the following possible compatibilities with the downstream passage alternatives (see Section 5):

- D4 is specifically designed to utilize the tunnel and tower for both upstream and downstream passage.
- D7 and other Piru Creek collector alternatives would add an additional location to collect downstream migrants instead of solely relying on the fishway tower and tunnel as a migration pathway.

4.2.1.8 Challenges, Uncertainties, Risks

The greatest challenge of this alternative is designing a tower of this height in a highly seismic area (peak ground acceleration = 1.13g). The Panel recognizes this challenge but does not have the expertise or scope to do a thorough seismic analysis. That analysis would be a next step in the design of this and several other alternatives.

To mitigate the challenge, the tower and tunnel are founded in bedrock and a tie-back brace supports the tower to bedrock. The dimensions of the tower could be modified to increase stability. Another challenge is the number and operation of the fishway exit gates. This alternative includes a complex system of gates and a control system that creates a risk of periods of no passage from gate failure and maintenance. A closure gate is included to isolate the tower from the tunnel in case the tower or gates are damaged.

Uncertainties of this alternative include the fish behavioral response to migrating through a long tunnel and then a stair-case tower. This alternative is unprecedented at this scale and could be considered experimental for this design. Another uncertainty is of the reservoir flow patterns and optimum location and orientation of the fish exit. Additionally, the preliminary results of the water quality monitoring being conducted by United suggests the surface water quality characteristics may not be suitable for steelhead during the majority of the year. Thus, there is uncertainty regarding the fish exit which as currently configured would always be on the surface. Measures to enhance the water quality entering the fishway tower would be considered in latter phases of design and after this uncertainty is studied.

4.2.1.9 Pros and Cons

The following lists of pros and cons summarizes points already made in the text and can also be seen in the evaluation matrix.

Pros

- Volitional (adult and juvenile fish passage) for full range of fish passage reservoir elevations.
- Accepted fish ladder technology inside "containment" structures.
- Could be combined with new outlet works improvements.
- All or a portion of low flow (habitat) release flow is fish ladder flow.

Cons

- Tunnel and tower with long fish ladder length with many steps.

- Uncertainty about fish passage behavior in tunnel and reservoir tower.
- Complicated operation for gates system in tower reduces reliability.
- Power and mechanical failures have the potential to lead to uncontrolled water releases.
- Construction requires a very low reservoir elevation.
- Structural/seismic design challenge.
- Access for construction is complex.
- Limited phasing opportunities.
- High cost; construction and operation.

4.2.1.10 Cost Considerations and Assumptions

The following considerations and assumptions were made in the cost analysis, which is summarized in Section 4.4.

- The tower and tunnel will not be constructed concurrent with modifications to the outlet works.
- Tunnel cost is calculated two ways: combined with the outlet works improvements penstock tunnel and as a separate fishway-only tunnel (see the tunnel sections in the drawings for differences). The alternate combined tunnel section includes the fish ladder, penstock and low flow release pipe with open access. The tunnel costs in the outlet works improvement study were used as a guide and scaled up for the combined fishway tunnel.

  The cost for enlarging the outlet works improvements penstock tunnel for this combined tunnel section and extending the penstock tunnel to the base of the fishway tower is provided for comparison. It is assumed that the costs of integration of the outlet works improvements intake facility with fish screens and emergency flow release inlet is minimal and not counted in the alternate combined tunnel section cost.
- Quantities of structural concrete in the fishway tower and for tunnel construction are conservative.
- Debris is managed at the reservoir tower and there is no active reservoir debris management.
- Lost revenue due to diversion of water from hydro plant to fishway entrance pool is not included.

- Capital and operating costs do not include any efficiencies from compatibilities with downstream passage alternatives.
- Daily inspections of system operations during fish migration season are required.

4.2.2 U2 – Pool and Weir Fishway to EL 1,030 ft, East Alignment to Exit Structure, Reservoir Range EL 1,030 ft to 1,056 ft

Alternative U2 is a complete alternative providing upstream passage for adult fish within a reservoir elevation range of 1,030 to 1,056 ft (a 26 ft operating range up to the high fish passage design pool elevation). As conceptualized, adult and juvenile fish could freely move in either direction from the reservoir to the tailwater of the creek channel so long as the reservoir water surface is within the range specified to provide hydraulic connectivity. Major fish passage components would include: a channel spanning migration barrier located downstream of the dam outlet works at the current gaging station weir location, an AWS system, a conventional fishway on an eastern alignment of the dam, a section of fishway tunnel through the eastern (left) abutment, and a fishway exit structure in the form of a reservoir tower to accommodate approximately 26 ft of reservoir fluctuation. The reservoir tower depicted is similar to that of Alternative U1 but is much shorter and with a higher base elevation. Enhancement and/or supplemental components that are part of this alternative are depicted in Table 4.2-1, including a collection and truck transport system that would operate when the reservoir is below 1,030. Alternative U2 is shown in Drawings U2.1-U2.4.

4.2.2.1 Fishway Exit Structure (Reservoir Tower)

The location of the fishway exit structure would be near the eastern reservoir bank upstream of the dam. The structure is shown as a concrete tower similar to that of Alternative U1 with multiple exit gates at different levels but only about 45 to 55 ft high with a base elevation at approximately 1,030 ft. This base elevation was selected primarily for constructability of the tower since it is commonly expected that the reservoir water surface will be below this elevation during a construction period for the tower and therefore may not require significant reservoir lowering or substantial cofferdam features for construction. A reservoir elevation of 1,030 ft represents a 27% level of annual exceedance meaning that 73% of the time on an average annual basis the reservoir level does not go higher than elevation 1,030 ft. For this upstream migration period (January 1 – May 31) statistic, elevation 1,030 ft has a 32% exceedance probability. The fishway exit structure could also be configured with a combination type of fish ladder (vertical slot segments) or other types of adjustable hydraulic controls (telescoping weirs). Final selection of a structure would be determined in later phases of design.

The structure would be founded in rock that underlies the dam abutment on the eastern side as determined from the outlet works improvements study (GEI 2015a). The condition and stability of the rock and seismic conditions will likely affect tower dimensions and foundation design. This would be determined through engineering studies and detailed design. The specific location and orientation of the tower is provisional and would be refined in later stages of design, similar to that of Alternative U1 (see Alternative U1 description for basic expected tower dimensions, general configuration, and components). The basic outside dimensions of the tower are 90 ft long by 40 ft wide and 45 to 55 ft tall. The tower dimensions shown on the drawings are approximate and would be refined in final design, including structural wall thicknesses.

The tower would contain approximately 50 automated fishway exit gates (3 x 3-ft sluice gates) to operate the fish ladder from reservoir elevation 1,030 to 1,056 ft. This elevation range would accommodate hydraulic connectivity to the fish ladder at least 32% of the time the reservoir level is exceeded on average during the upstream migration season. Each gate would be downward operated to maintain no more than 0.7 ft of drop from the exit channel into the fish ladder to provide volitional fish passage for both adult and juvenile fish. If it is determined that only adult upstream fish passage is required then the number gates can be reduced by changing the drop to 1.0 ft each. The gates would be automated based on monitoring of the reservoir level. As the reservoir level drops throughout the fish migration season the gates would sequence in order with one active gate at a time. As the active gate lowers and reaches a trigger elevation it would close as the next lower gate opens. At some point the fish ladder pool of the previously active pool disengages. Orifices can be provided in the weirs between pools to ensure the pools drain and fish do not become stranded as the reservoir lowers.

A gantry crane would be located on top of the tower for maintenance of the fishway exit gates and the debris racks. A bottom bulkhead or guard gate could be added to the alternative to separate the tower from the section of fishway tunnel in case of fishway exit gate failure. An access bridge or trestle from near the top of the dam on the eastern side would be used for a service truck to access the top of the tower. The bridge could be substituted with an embankment road access. This would be determined in later phases of investigation and design. An electrical, instrumentation and control building would be located on top of the tower or near the dam end of the access bridge. Power to the tower and access area would be supplied from a local source but a backup generator or port for plugging in a temporary generator is recommended. Vehicle access to the location of the tower is via the existing access road on top of the dam.

4.2.2.2 Fish Ladder and Fishway Tunnel

The fish ladder type selected for this alternative would be a standard concrete pool and weir fish ladder, same as for Alternative U1. It would have a maximum 10% slope with a maximum of 0.7-ft drop per pool to ensure it provides volitional fish passage for both adult and juvenile fish. The ladder would contain approximately 3 ft of minimum water depth and have inside pool dimensions of 6 ft long by 4 ft wide. The fish ladder channel height outside the fishway tower would be 6 ft for 3 ft of freeboard. The freeboard for the fish ladder inside of the tower may be less, on the order of 2 ft, for appropriate access and structural clearances. This size fish ladder can accommodate design flows of 2 to 10 cfs with 7 cfs being the typical fish ladder flow for the low flow release amount.

The fish ladder would start at the barrier dam and climb upward along the eastern side of the low flow release channel and the hillside forming the left dam abutment. The alignment is shown to avoid dam fill; refinement of the alignment would occur in a later phase of design. The alignment could also be located on the western side of the dam as exemplified in Alternative U3 (see Section 4.3.3). A section of the fish ladder would need to be inside a tunnel through the abutment rock to accommodate the low end of the fishway at elevation 1,030 ft. The tunnel would be an open horseshoe shaped tunnel, very similar to the alternate version shown for Alternative U1 (the alternate version without the penstock pipe). The fishway tunnel alignment could follow the outlet works improvement tunnel alignment L1 (GEI 2015a) with an upstream portal at the base of the reservoir tower and a downstream portal embedded in the hillside southeast of the dam crest. It is assumed that the tunnel would be constructed using drilling and blasting techniques per the outlet works improvement study. Variations on this layout for the components can be considered during conceptual design. The access walkway is important to inspect the fish ladder pools and ensure proper function.

4.2.2.3 Barrier Dam/Fish Ladder Entrance/AWS

For Alternative U2, a physical barrier in the form of a solid concrete dam is included that is approximately 6 ft high. The shape of this dam creates a shallow, thin spill down its face and shallow tailrace under most flow releases making a depth/velocity barrier for fish. The barrier dam is shown located at the existing gaging weir location approximately 700 ft downstream of the outlet works in the low flow release channel and would functionally replace the gaging weir. The fish ladder would lead up the adjacent terrace from the barrier dam on the eastern side of the channel. The dam is approximately 50 ft wide in the channel. An advantage of this type of barrier is that it is fixed and requires no operation. Being located this far downstream of the outlet works also has an advantage of creating less impact on the outlet works or hydropower releases. This type of physical barrier dam could be switched out to another type as described with other alternatives and determined in a later phase of design.

The fish ladder entrance structure would be integrated with the barrier dam abutment. The entrance is a large pool sized to accommodate up to 50 cfs of AWS flow plus the maximum fish ladder flow for a combined flow of 60 cfs. The AWS flow would be supplied from the outlet works through an expected 18-inch diameter pipeline. The pipeline would contain a control valve for a manual or automated setting based on prescribed flow releases to ensure there is at least 10% of the total flow emanating from the entrance pool.

A challenge section is shown on the plans as an enhancement feature (Drawing U2.3). See Section 4.3.5.3 for more information.

A monitoring facility is also shown on the plans as an enhancement feature (Drawing U2.3), and described further in Section 4.3.5.2. The monitoring facility could also be integrated with the collection and transport facility as a standalone enhancement, as a requirement for providing fish passage when the reservoir is lower than the low fish ladder design elevation of 1,030 ft, or as part of phased approach described below.

Access to the area containing the fish ladder entrance structure, the potential monitoring facility and challenge section would be provided via existing roads serving the outlet works area. Some of the roads will need improvement for regular use and a bridge over the low flow release channel could be considered for more direct access instead of going around the outlet works between it and the dam.

4.2.2.4 Operations

The fish passage operating season for all upstream alternatives is assumed to be from January 1 through May 31. During that period, the reservoir is below elevation 1,030 ft about 32% of the time (see Figure 2.2-2 for reservoir exceedance elevations occurring Jan-May), so the ladder exit structure would not be able to operate. Instead, the collection and transport facility would operate during those times. Before the fishway becomes dewatered, it would be inspected and any trapped fish would be moved to the collection facility.

Alternative U2 is designed to essentially bypass the low flow release rate (normally 7 cfs) from the reservoir through the fishway exit structure and the fish ladder to the tailwater below the barrier dam. This operation would be in lieu of providing the low flow releases through the outlet works whenever the reservoir elevation is in the design range of 1,030 to 1,056 ft. Other than operating the fishway exit gates according to the reservoir level, the system would be a passive operation. Fish could migrate upstream and downstream of their own volition following the flow of water in the fish ladder and no fish handling is required so long as the reservoir is between 1,030 and 1,056 ft. The fish ladder would be inspected on a daily basis to ensure proper function, checking for debris, and checking for presence or trapping of fish.

Large debris would be managed at the debris rack on the fishway exit structure similar to the way it is described for Alternative U1. The AWS would be operated anytime there are flow releases from the outlet works above approximately 70 cfs and would be proportioned to maintain at least 10% of the total flow emanating from the fish ladder entrance pool up to the normal maximum total flow release of 500 cfs.

4.2.2.5 Phasing Opportunities

The primary opportunity to phase Alternative U2 is by starting with a collection and transport facility including the barrier dam and fishway entrance structure in the low flow release channel. The fishway would lead to a temporary or permanent collection and transport facility similar to U4. It would be most feasible to construct the fishway exit structure and tunnel concurrently with the outlet works modifications to take advantage of the drained reservoir and mobilization for that work, but it is still possible to construct the tower at any time reservoir levels can be managed. If full construction is not concurrent with the outlet works improvements construction, the fishway exit structure and tunnel could be constructed whenever the reservoir is below elevation 1,030 ft, which is not uncommon.

Other phasing opportunities include:

- Add a Piru Creek collector upstream of the reservoir to collect downstream migrants and as a location to haul upstream migrants when trapping and hauling fish.

4.2.2.6 Compatibility with Downstream Passage Alternatives

Alternative U2 would be compatible with the following downstream passage alternatives:

- D7 and other downstream passage alternatives: add additional collection of downstream migrants instead of solely relying on the fish ladder for the migration pathway.
- D12: the fishway exit structure could be used as an anchor point for the moveable surface collector so long as it is maintained for a reservoir elevation range of 1,030 and higher.

4.2.2.7 Challenges, Uncertainties, Risks

The greatest challenge of this alternative is designing and constructing the fishway exit structure adjacent to the dam and the tunnel through the dam abutment. The Panel recognizes this challenge and acknowledges that a seismic analysis of the alternative would be necessary to help determine feasibility. The analysis so far is not showing any fatal flaws for this alternative but more investigation and details of concept design would be a next step for this and several other alternatives.

Another challenge is the number and operation of the fishway exit gates. This alternative includes a complex system of gates similar to Alternative U1 (but with much fewer gates due to the 26 ft range of operation vs. the 80 ft range for U1) that creates risk of non-passage periods from gate failure and maintenance. A closure or bulkhead gate could be included to isolate the exit structure from the fishway tunnel in case the tower or gates are damaged. In this case, the collection and transport facility would be available for transferring fish upstream. Additionally, the detailed selection of an exit structure should be determined in later phases of design and primarily based on: potential compatibility or interactions with future outlet works improvements or spillway capacity alternatives; detailed topography and investigation of the eastern abutment area; and ease of access, operation and maintenance.

Uncertainties of this alternative include the fish behavioral response to migrating through a long fish ladder, the tunnel segment and then an exit structure. There are few fish ladders of this length and height gain and with this large of a range of headwater elevations or complex system of hydraulic controls for the exit structure. For this reason it could be considered experimental. Another uncertainty pertains to the reservoir flow patterns and defining the optimum location and orientation of the fish exit to promote fish migration up the reservoir and minimize the chance for fallback. Additionally, the preliminary results of the water quality monitoring being conducted by United suggests the surface water quality characteristics may not be suitable for steelhead during the majority of the year. Thus, there is uncertainty regarding the fish exit which as currently configured would always be on the surface.

While this alternative will allow downstream migrating fish to enter and pass down the ladder when operating, there is little attraction flow to help outmigrants find the entrance, and the Panel believes this configuration would not be very effective for downstream migration. Mixing of juveniles and adults (steelhead and other species) in these small ladder pools is also a potential for predation.

4.2.2.8 Pros and Cons

The following lists of pros and cons summarizes points already made in the text and can also be seen in the evaluation matrix.

Pros

- Volitional (adult and juvenile fish upstream passage) for a 26 ft range of reservoir elevation within the designated reservoir elevations.
- Accepted fish ladder technology.
- Low flow (habitat) release is fish ladder flow up to 10 cfs.
- Simple construction of concrete channel using existing grade as much as possible.
- Could have steeper and shorter fish ladder portions if upstream passage of juvenile fish is not required.
- Easily phased starting with a collection and transport facility.
- Good access for construction and operation.

Cons

- Fish ladder operation is cut off below approximately reservoir elevation 1,030 ft.
- Long fish ladder length with many steps.
- Uncertainty about fish passage behavior in fishway tunnel and exit structure due to darkness and light transitions or other factors not determined at this time.
- Complicated operation for gates system in exit structure.
- Structural/seismic design challenge for fishway tunnel and exit structure (reservoir tower).
- Volitional only for range of reservoir indicated.
- Volitional downstream passage is minimal; there is no attraction to the fishway other than the 7 cfs fishway flow and limited range of reservoir elevations for fish ladder operation.

4.2.2.9 Cost Considerations and Assumptions

In the cost analysis, the following considerations and assumptions were made:

- The fishway exit tower will be constructed independent and subsequent to modifications to the outlet works and when the reservoir can be lowered or is normally below elevation 1,030 ft.

- Tunnel cost is calculated using the outlet works tunnel costs as a guide and scaled for the fishway tunnel size.
- Structural concrete in tower and for tunnel construction is conservative.
- Debris is managed at the reservoir tower and there is no active reservoir debris management.
- Capital and operating costs do not include any efficiencies from compatibilities with downstream passage alternatives.
- Daily inspections of system operations during fish migration season are required.
- During collection and transport operation, it is assumed that fish will be transferred once a day and on an average of once every three days during the migration season (2/3 of season for fish ladder passage with 1/3 of season for collection and transport).

4.2.3 U3 – Pool and Weir Fishway to EL 1,056 ft, West Alignment with Slide Release, Reservoir Range EL 980 ft to 1,056 ft

Alternative U3 is a pool and weir fishway that provides volitional fish passage when the reservoir elevation is within a range of 1,054 to 1,056 ft, and non-volitional passage via a slide release when the reservoir elevation is within a range of 980 to 1,054 ft. When the reservoir elevation is lower than 1,054 ft, a pump system supplies fish ladder flow, and a false weir in the upper pool will cause fish to jump over to exit the ladder and slide down a release channel to the reservoir surface. When the reservoir water surface is within the narrow 2 ft range of 1,054 to 1,056 ft, adult and juvenile fish can freely move in either direction between the reservoir and the tailwater. Major fish passage components would include: a channel spanning migration barrier located downstream of the dam outlet works at the current gaging station weir location, an AWS, a conventional fishway on a western alignment, and a fishway exit structure with 10 cfs pump station and slide release channel. Other enhancement or supplemental components are included with this alternative as described below. Alternative U3 is shown in Drawings U3.1-U3.4.

The spillway plunge pool collector, described in Section 4.3.5 is a supplemental collection facility included in all upstream fish passage alternatives.

4.2.3.1 Fishway Exit Structure

The location of the fishway exit structure is shown on the western reservoir bank upstream of the spillway. The precise location (and orientation) would be determined during a later phase of investigation and design and could be located on the eastern side of the dam. The concrete structure would be founded in bedrock or other suitable material for structural support. The fishway exit structure is configured with the fish ladder leading into it, with the uppermost portion having adjustable hydraulic controls such as telescoping weirs. This would allow for hydraulic adjustments and flow control within a reservoir water surface elevation range of 1,054 to 1,056 ft. This range could be increased but would be limited by the selection of the adjustable hydraulic controls and considerations for fish ladder channel depth and layout relative to surrounding topography and other structures. This refinement would be conducted in a later phase of design coincident with or after the studies or designs of other projects have been completed, such as for the outlet works improvements or spillway capacity improvements.

Two telescoping weirs would operate the fish ladder from reservoir elevation 1,053.5 to 1,056.0 ft to maintain no more than 0.7 ft of drop from the exit channel into the fish ladder to provide volitional fish passage for both adult and juvenile fish. The weirs would be automated based on monitoring of the reservoir level. As the reservoir level drops below elevation 1,053.5 ft the false weir would be engaged to maintain depth over the weir. As the reservoir level drops below elevation 1,053.0 ft the false weir would be designed to supply a split of water flow for the fish ladder and the slide release channel. The details of the false weir would be determined in phases of design but conceptually it would provide 7 cfs of fish ladder flow and approximately 2 to 3 cfs of flow down the slide release channel. The water supply for the false weir would be provided from a 10 cfs submersible duplex pump system with intake fish screens near the end of the slide release channel. The fish screens would be actively cleaned since they are a critical component of the system for pumped flow at reservoir elevations below 1,054 ft. The pump and screen system would be powered and controlled from the fishway exit structure building and supply water via a pipe adjacent to the slide release channel.

The slide release channel would be a relatively steep (2 horizontal to 1 vertical) structure extending down along the reservoir side on or near existing grade from the false weir elevation to a lowest elevation of 980 ft, or as determined to be the minimum necessary to provide a safe fish exit into the reservoir during the anticipated upstream fish migration season. The structure could consist of a smooth fiberglass slide or other smoothed surface channel supported by piles or other foundations. Typical dimensions of the channel expected are 3 ft deep by 3 ft wide in a U or V shape to concentrate the channel flow of 1 to 3 cfs. Because it is expected that the channel would be at a slope of 2:1 the flow would be supercritical and the exact amount would be determined to ensure a cushion of water for the fish as it descends the channel. A shallower sloped channel could be used to provide more depth of flow considering the tradeoff of increased transit time and other tradeoffs of adaptation to local topography. A helix-shaped configuration could also be considered for minimizing the footprint of the structure. This would be determined in a later phase of design.

The slide release channel could be covered to minimize potential reservoir debris getting into the channel and injuring fish. However, this covering would require fish to swim down the submerged portion to the end of the release channel after it "lands" in the reservoir (at the surface). Another approach would be to provide an exit pen contained by floating trash booms, with a hinged flip-lip exit. In either case, access to the channel would be required to ensure the channel is clear of debris or other obstructions. As currently shown, grated stairs would descend on top of the channel to allow for such inspection and access. Optionally, the stairs could be placed directly to the side of the channel and use a removable grating over the channel for ease of maintenance. Sections of the grating can be added or removed as the reservoir elevation fluctuates to minimize the submerged length that fish would need to negotiate.

A small jib crane could be located on top of the fishway exit structure building for general maintenance of the fishway exit, debris removal or management, and potential operation of a guard gate. The guard gate would be used to isolate the fish ladder exit from the reservoir during periods of non-operation of the fish ladder and for higher reservoir levels that may occur during a flood. Access to the fishway exit structure building would be from the walkway grating on top of the fish ladder channel. For vehicular access, either a special road could be constructed adjacent to the fish ladder channel similar to that for Alternative U1, or an additional supporting structure could be added adjacent to the fish ladder channel and the channel covered to essentially drive on top of the channel. Power to the fishway exit structure would be supplied from a local source.

4.2.3.2 Fish Ladder

The fish ladder type selected for this alternative would be a standard concrete pool and weir fish ladder as described for alternatives U1 and U2. It would have a maximum 10 percent slope with a maximum of 0.7 ft drop per pool to ensure it provides volitional fish passage for both adult and juvenile fish. The ladder would contain approximately 3 ft of minimum water depth and have inside pool dimensions of 6 ft long by 4 ft wide. The fish ladder channel height would be 6 ft for 3 ft of freeboard. This size fish ladder can accommodate a design flow of 2 to 10 cfs with 7 cfs being the typical fish ladder flow for the low flow release amount.

The fish ladder would start at the barrier dam and climb upward along the western terrace of the low flow release channel and then the hillside southerly of the right dam abutment following natural grades as much as possible. The fish ladder alignment could also be considered for the eastern side of the dam similar to Alternative U2 if a fish ladder alternative is selected, but this would require a detailed topographic survey and site investigation. As currently shown with the west alignment, once the fish ladder climbs along the hillside it would encounter the lower end of the spillway channel where it would need to be bridged over the spillway. This portion could be co-located with the existing access bridge or as part of an improved access bridge. From this location the fish ladder is shown aligned adjacent to the western spillway wall. This alignment would avoid the existing dam fill and other structural issues that may be present between the spillway channel wall and dam fill.

Like Alternative U2, refinement of the alignment would occur in a later phase of design and after a detailed study of topography and investigation of surface and subsurface conditions. Portions of the fish ladder may need to be inside a tunnel and supported by hillside excavations or other special stabilizing construction techniques. The controlling factor for the fish ladder alignment is to maintain the design slope with considerations for maximum "runs" for the ladder legs before needing resting or turning pools. If it is determined that upstream passage is only needed for adult fish, there could be steeper and shorter fish ladder portions. An access walkway on top of the fish ladder channel or a walkway along its side would be provided to allow inspection of pools and ensuring proper function.

4.2.3.3 Barrier Dam/Fish Ladder Entrance/AWS

For this alternative the same physical barrier as described for U2 would be used consisting of a solid concrete dam. It would be constructed at the existing gaging weir location in the low flow release channel and would functionally replace the gaging weir. The fish ladder would lead up the adjacent terrace from the barrier dam on the western side. This type of physical barrier dam could be switched out to another type such as the one described for Alternative U1 as determined in a later phase of design. In this particular case selection of the type of barrier dam would need to consider its compatibility with the function as a gaging station.

The fish ladder entrance structure would be integrated with the barrier dam abutment, similar to Alternative U2. The entrance would be sized to accommodate up to 50 cfs of AWS flow plus the maximum fish ladder flow for a combined flow of 60 cfs. The AWS flow would be supplied from the outlet works through an expected 18-inch diameter pipeline. The pipeline would contain a control valve for a manual setting based on prescribed flow releases to ensure there is at least 10% of the total flow emanating from the entrance pool.

A challenge section is shown on the plans as an enhancement feature. This is a bypass channel adjacent to the fish ladder with entrance and exit openings at fish ladder pools to provide enough head difference to drive the hydraulic design of the challenge section. These pools would have slide gates in the side of fish ladder and adjustable weirs (downstream of challenge section exit and upstream of challenge section entrance) for interrupting ladder flow in that portion and diverting flow to the Challenge Section. The challenge section channel would include provisions for customization to allow removable weirs or boards to adjust hydraulic conditions desirable to challenge fish.

A monitoring facility is shown on the plans as an enhancement feature and is described further in Section 4.3.5.2. The monitoring facility could also be substituted or integrated with a collection and transport facility as a standalone enhancement or to be used for any times that the fish ladder and slide release are not functioning correctly such as for pumped fish ladder flow interruptions, if it becomes a requirement to collect and transport for other reasons such as poor reservoir water quality and other fish migration impacts associated with fish transiting the reservoir, or as part of a phased approach described below. Essentially, collection and transport would be a primary backup for this alternative. Power for the facility would be supplied from the local area, same as for the outlet works and nearby buildings.

Access to the area containing the fish ladder entrance structure, the potential monitoring facility and challenge section would be provided via existing roads serving the outlet works area. Some of the roads would likely need improvement for regular use.

4.2.3.4 Operations

The fish passage operating season for all upstream alternatives is assumed to be from January through May and would mainly be in response to flow releases and downstream migration conditions. The alternative is designed to essentially bypass the low flow release rate (normally 7 cfs but only up to 10 cfs for the fish ladder capacity) from the reservoir through the fishway exit structure and the fish ladder to the tailwater below the barrier dam. This operation would be in lieu of providing the low flow releases through the outlet works whenever the reservoir elevation is in the design range of 980 to 1,056 ft (supplemented with pumped flow for reservoir elevations below 1,053.5 ft). This alternative requires operating the fishway exit telescoping weir(s) and the pumped flow false weir according to the reservoir level. Additionally, the bulkhead gate would need to be operated at reservoir elevations above 1,056 ft to close off the ladder. In this way the system would be more of an actively managed operation but could be automated as indexed to the reservoir elevation. Even if it is automated, it would be important to monitor and maintain the system on a daily basis during operation.

In this alternative, fish could volitionally migrate upstream and downstream within the narrow reservoir elevation range of 1,054 to 1,056 ft following the flow of water in the fish ladder. It would not be volitional once the reservoir elevation drops below 1,054 ft since there would be no opportunity for downstream migration from the reservoir. However, it is not expected that there would be any fish handling required for upstream migrants. If the ladder is closed off for reservoir elevations above 1,056 ft, it would be necessary to check the ladder for fish. Some flow down the ladder can be maintained via the pump system even if it is closed off. It is expected that observation of the fish ladder would be needed on a daily basis to ensure proper function, checking for debris, and checking for the presence of fish, and on a more frequent basis during critical operations such as when the ladder is closed to the reservoir.

Large debris would be manually managed at the fishway exit structure and provisions for debris racks and booms determined in a later phase of design. A critical area to monitor for debris loading is the fish release channel slide. The channel would be covered, however even small debris that could make its way into the channel could injure fish as they slide down from the higher elevation of the exit structure and impact the water surface. Access stairs alongside the release channel and hinged grating covers would allow for monitoring and keeping the release channel clear.

The AWS for the fish ladder entrance pool would be operated anytime there is excess flow releases from the outlet works above approximately 70 cfs and would be proportioned to maintain at least 10% of the total flow emanating from the fish ladder entrance pool up to the normal maximum total flow release of 500 cfs.

4.2.3.5 Phasing Opportunities

As for U1 and U2, the primary opportunity to phase Alternative U3 would be by starting with a collection and transport facility to include the barrier dam and fishway entrance structure in the low flow release channel. The fishway could lead to a temporary or permanent collection and transport facility similar to Alternative U4. It would be most feasible to construct the fishway exit structure and slide release channel concurrently with a drained or lowered reservoir, potentially with the mobilization and work for the new intake associated with the outlet works improvements. If full construction is not concurrent with either of those conditions, the slide release channel could be constructed in phases whenever the reservoir surface is below certain elevation intervals or below approximately elevation 970 ft for the currently planned end elevation of 980 ft for the channel.

Other phasing opportunities include:

- After using the collection and transport facility and determining the need for volitional fish passage to the normal reservoir full pool, construct the fish ladder and exit structure.
- Add a Piru Creek collector upstream of the reservoir to collect downstream migrants and as a location to haul upstream migrants to, when trapping and hauling fish.

4.2.3.6 Compatibility with Downstream Passage Alternatives

Alternative U3 has the following compatibilities with the downstream passage alternatives:

- D7 and other Piru Creek collector alternatives; adds additional collection of downstream migrants instead of solely relying on the fish ladder for the migration pathway (only operable when the reservoir is at or near full pool, EL 1,054 – 1,056 ft).
- D12; the fishway exit structure could be configured to be used as an anchor point for the moveable surface collector so long as the anchor point is designed for a specified reservoir elevation range.

4.2.3.7 Challenges, Uncertainties, Risks

One challenge of this alternative is designing and constructing the fish ladder on existing grade, while balancing the need for tunneling or other special construction techniques and those associated costs. Another challenge is the unique fishway exit structure and slide release channel. The operation of the exit structure could create a risk of non-passage periods from gate failure and maintenance requirements, or from pumped flow interruptions (power/mechanical failure). Additionally, this configuration and operation of a slide release channel on a permanent basis is unprecedented. While it can be designed for certain hydraulic criteria that would be established there would still be some uncertainty about the fish behavior and use at the false weir and for the slide release channel. A movable release section with a debris barrier pen and possibly a hinged flip-lip type exit structure could be explored to address the final release and debris issue.

The configuration of the fish ladder, exit structure, and release channel should be determined in later phases of design and primarily based on: potential compatibility or interactions with future outlet works improvements or spillway capacity alternatives; detailed topography and investigation of the western spillway inlet area; fish passage requirements; and ease of access, operation and maintenance.

Other uncertainties of this alternative include the fish behavioral response to migrating through a long fish ladder. There are few fish ladders of this length and height gain. For this reason and the type of fishway exit structure with a slide release channel it could be considered experimental. Another uncertainty is the reservoir flow patterns and optimum location and orientation of the fish exit and slide release channel. Additionally, the preliminary results of the water quality monitoring being conducted by United suggests the surface water quality characteristics may not be suitable for steelhead during the majority of the year. Thus, there is uncertainty regarding the fish exit which as currently configured would always be on the surface, while the water supply for the ladder would come from the deeper portion of the lake.

4.2.3.8 Pros and Cons

The following lists of pros and cons summarizes points already made in the text and can also be seen in the evaluation matrix.

Pros

- Does not require trapping and handling of fish for upstream fish passage at all reservoir water surface elevations above 980 ft.
- Volitional (adult and juvenile fish upstream passage) when the reservoir elevation is plus or minus one foot of the normal full pool elevation of 1,055 ft.
- Accepted fish ladder technology for the majority of the fishway.
- Low flow (habitat) release flow is fish ladder flow up to 10 cfs.
- Simple construction of concrete channel using existing grade as much as possible (could have steeper and shorter fish ladder portions if adult upstream fish passage only is specified).
- More easily phased to start with a collection and transport facility.
- Good access for construction and operation of lower fishway portion.

Cons

- Long fish ladder length with many steps, risk of reliable passage with long and high ladder.
- Some complicated rock excavations/anchoring and/or tunneling.
- Uncertainty about fish passage behavior in fishway and exit structure/release channel.
- Pumped fish ladder flow for reservoir elevations below 1,054 ft.
- Volitional only up to fishway exit structure and then for a very narrow range of reservoir elevations.
- Requires more diligent monitoring and maintenance, especially for the fishway exit structure and slide release channel.
- Fish release component is experimental technology.
- Challenges with managing debris at the reservoir surface for lower water surfaces relative to the fish release slide.

- Poorer access for construction and operation of upper fish ladder portion and the fishway exit structure.

4.2.3.9 Cost Considerations and Assumptions

In the cost analysis, the following considerations and assumptions were made:

- The exit structure and release channel would be constructed concurrent with modifications to the outlet works to take advantage of the drained reservoir and mobilization for that work or when the reservoir can be lowered or is normally below elevation 980 ft.
- Capital and operating costs do not include any efficiencies from compatibilities with downstream passage alternatives.
- Pumped fish ladder flow costs are assumed for a continuous use during the entire migration season as a maximum-case cost.
- Daily inspection of system operations during fish migration season is required.
- There is no active reservoir debris management.

4.2.4 U4 – Collection and Transport with Multiple Release Locations, Reservoir Range EL 980 ft to 1,056 ft

Alternative U4 is a complete alternative providing non-volitional fish passage as a collection and transport method regardless of reservoir elevation; see Drawings U4.1-U4.5. Facilities of this nature are typically utilized for higher head dams (>100 ft), and if implementation of a conventional fishway is identified as an impractical or non-viable project option. This alternative includes the necessary system components for the safe and effective collection, handling, transfer, and release of fish to a suitable location into or upstream of the reservoir. As conceptualized, adult and juvenile fish can move upstream from the tailwater of the creek channel via a short length of fish ladder to a fish collection facility with holding pools. From the collection facility, fish can be either selectively transferred to a truck or collectively transferred via a water-to-water hopper mechanism to a truck for transport upstream to the release location. Fish would typically be released upstream of the reservoir but could be released at other optional facility locations depending on reservoir conditions and management decisions including: at the top of dam on east side; at the southerly boat ramp (main ramp); at the northerly boat ramp, near the road crossing downstream of the inactive Blue Point campground; or at a Piru Creek collector (see Alternative D7 – Section 4.3.4).

Major fish passage components would include: a channel spanning migration barrier located downstream of the dam outlet works at the current gaging station weir location, an AWS system, a conventional fishway on the western side of the low flow release channel, a collection and transfer facility, truck transport, and holding and release facilities. Other enhancement or supplemental components are listed in Table 4.2-1 and described below. The spillway plunge pool collector, described in Section 4.3.5 is a supplemental collection facility included in all upstream fish passage alternatives.

4.2.4.1 Fish Release Structure

The potential locations of a fish release structure are shown in Drawing U4.5. The precise location (and orientation) of release structures would be determined during a later phase of investigation and design but the primary release location is expected to be upstream of the reservoir near the road crossing, downstream of the inactive Blue Point campground. The transport route to this location is approximately 9 miles. The release facilities would include a vehicle access pad, overhead roof structure, fish transfer equipment, a holding tank and supporting equipment (circulation pump, segregation panels, controls), and a release pipe or channel, if needed. The facility would be located high enough above high flow levels to enable operation during those periods. Security fencing and alarm provisions are also recommended as these sites are likely prone to vandalism.

A holding tank would be used to ensure fish acclimate to the water of the release area and to observe fish condition before final release. The details of the release facility would be determined as part of future design activities, but conceptually it would include a pump of approximately 2 to 3 cfs flow capacity for circulating the water from the ultimate release location (e.g., the creek upstream of the reservoir) into the holding tank, and then down the release pipe or channel. The water supply would be provided from a submersible pump with an intake fish screen in the nearby receiving water. The pump and other equipment would be powered and controlled at the main part of the release facility. Power supply would be provided from the local area or via a portable generator.

The holding tank would have slide gates and perforated panels for controlling flow and segregating fish into one of two pools with possible separation into even smaller portions of the holding tank. A gate or panel would be opened to the release pipe or channel when conditions are determined appropriate to allow fish to volitionally move out of the holding tank. The release pipe or channel would be sited to provide a safe fish exit into the receiving waters during the anticipated upstream fish migration season. The pipe or channel would be relatively steep (5 to 10%) extending down existing grade along the side of the creek channel or reservoir and supported by piers or other foundations. The pipe or channel would consist of a smoothed surface material.

4.2.4.2 Fish Transport

Fish that are collected will require transfer to the desired release location. Fish could be moved from the holding area to a specially equipped vehicle by net (hand), or via water-to-water transfer mechanisms. Water-to-water transfer is state of the art; it gently moves fish, includes no manual handling, and keeps them in the water at all times. For the purposes of this alternative it is assumed that fish will be transferred via a water-to-water transfer hopper mechanism (a self-contained transfer tank). Vehicles and tanks used for this purpose are sized for the number and size of fish that are anticipated to be collected on a daily basis in addition to the water that is required to safely accommodate them. The vehicle would be a standard flatbed utility truck with generator power for the transfer tank. Using a standard flatbed utility truck allows for obtaining spare trucks (can be rented) for potential breakdowns or backup during higher transport frequencies.

Spare transfer tanks would be maintained for backup, for multiple fish transfers within a short period of time, or for fish size class segregation. Each transfer tank would be equipped with life sustaining and water conditioning equipment to maintain adequate temperature, dissolved oxygen, and carbon dioxide levels during transfer. At a minimum, fish are typically transferred upstream once every 24-hour period. During periods of peak migration, more trips to the desired release site or additional transport vehicles may be necessary. The transport route to the Blue Point location is approximately 9 miles. Approximately 4 miles of the existing paved road is in poor condition and will need improvements to ensure safe fish transport and operation of the truck.

4.2.4.3 Fish Collection Facility

After fish enter the fishway entrance and ascend to the top of the fish ladder, they would enter the collection and holding facility. Facilities of this nature are composed of a wide range of structural, civil, hydraulic, aquaculture, and mechanical design systems. It is expected that the facility would be an on-grade covered utility type building located on the adjacent terrace downstream of the outlet works. It would likely have partial walls with perimeter security fencing. In the facility there are typically one or more holding pools that are separated by fykes, picket panels, and segregation screens. Fish move into the first collection pool and move past a fyke, vee-trap or false weir which prevents adult fish from swimming back down into the previous section of the fishway or collection pool. An automatic fish sensor or video would be used to inform operators that fish are present so they can respond and transfer the fish. After they enter the initial collection pool, fish would be allowed to continue upstream into the next holding area, physically crowded to separate holding areas, and/or separated into species or size classes. Here, fish would be collected and handled for additional monitoring purposes or coerced directly into a hopper style transfer tank for water-to-water transfer (fish stay in water continuously – no handling unless for direct measurement or sampling). The transfer tank is then loaded onto a transport vehicle (truck). The transfer tank is self-contained for maintaining water quality. The truck loading area includes an overhead crane for lifting the transfer tank.

Power for the collection facility would be supplied from the local area, same as for the outlet works and nearby buildings. Flow for the collection facility and fish ladder would be supplied from the outlet works through an expected 18-inch or larger diameter pipeline. The facility would be outfitted with water quality and level sensors and alarms with remote display and tie in to existing SCADA systems to ensure fish safety at all times.

The fishway entrance, entrance pool, and short fishway to the holding pool would be similar to those described in U1, U2, and U3. The fish ladder would start at the picket barrier and climb upward along the western terrace of the low flow release channel and then to the collection facility. The length of the fish ladder would be enough to go from the entrance at approximately elevation 865 ft to the adjacent terrace elevation of approximately 880 ft. The fish ladder type selected for this alternative is the same as for alternatives U1, U2, and U3, a standard concrete pool and weir fish ladder. It would have a recommended maximum 10% slope with a maximum of 0.7 ft drop per pool to ensure it provides volitional fish passage for both adult and juvenile fish to enter the collection facility. The ladder would contain approximately 3 ft of minimum water depth and have inside pool dimensions of 6 ft long by 4 ft wide. The fish ladder channel height would be 6 ft for 3 ft of freeboard. This size fish ladder can accommodate a design flow of 2 to 10 cfs with 7 cfs assumed to be a typical flow which would match the project low flow release requirement.

4.2.4.4 Picket Barrier/Fish Ladder Entrance/AWS

For this alternative a physical barrier in the form of a picket weir is included. It would be located approximately 150 ft downstream of the outlet works in the low flow release channel. The fish ladder entrance would be directly adjacent to the picket barrier on the western side of the low flow release channel. This type of physical barrier could be substituted with another type such as the one described for Alternative U1 as determined in a later phase of design. The picket weir would be about 150 ft long to achieve an average velocity of less than 1 fps at higher release flows (500 cfs) to avoid fish jumping. It would also be angled to help guide fish to the fishway entrance. An advantage of a picket barrier is that it would not have a backwatering impact on the outlet works and hydropower releases and it would be subjected to minimal debris load from the outlet works.

The fish ladder entrance structure would be integrated with the picket barrier abutment, similar to Alternative U1. A special low flow entrance parallel to the primary entrance may be required for upstream passage of juvenile fish. The entrance would be sized to accommodate up to 50 cfs of AWS flow plus the maximum fish ladder flow for a combined flow of 60 cfs. The AWS flow would be supplied from the outlet works penstock upstream of the hydro plant through an expected 18-inch diameter pipeline. The pipeline would contain a control valve for a manual setting based on prescribed flow releases to ensure there is at least 10% of the total flow emanating from the entrance pool.

A challenge section is included as an enhancement in the alternative as described in Section 4.2.5.1. This consists of a bypass channel adjacent to the fish ladder with entrance and exit openings at fish ladder pools to provide enough head difference to drive the hydraulic design of the challenge section. The pools would have slide gates in the side of fish ladder and adjustable weirs (downstream of the challenge section exit) for interrupting ladder flow in that portion and diverting flow to the challenge section. The challenge section channel would include provisions for customization with removable weirs or boards to provide hydraulic conditions desirable to challenge fish.

A monitoring facility is also included as an enhancement feature. It would be built into the collection facility and function similarly to that described for the Alternatives U1, U2 and U3.

Access to the collection facility, the picket barrier, the fish ladder entrance structure, and the fish ladder would be provided via existing roads serving the outlet works area.

4.2.4.5 Operations

The fish passage operating season for all upstream alternatives is assumed to be from January 1 through May 31. Continuous flow through the collection facility, fish ladder, and AWS (depending on flow releases) would occur during the migration season. This alternative, like the other upstream alternatives, can be used to bypass the low flow release rate (normally 7 cfs but only up to 10 cfs for the fish ladder capacity) from the outlet works through the collection facility, down the fish ladder to the tailwater below the picket barrier. The outlet works would continue to be operated for release flows greater than the fish ladder flow and in combination with the AWS flow when needed. The AWS for the fish ladder entrance pool would be operated anytime there is flow released from the outlet works above ten times the fishway flow to maintain at least 10% of the total flow emanating from the fish ladder entrance pool up to the normal maximum total flow release of 500 cfs.

It is expected that monitoring of the collection facility and fish ladder would be needed on a daily basis to ensure proper function, checking for debris, and checking for presence of fish. Frequency of operations may vary depending on the presence and migration tendencies of the target fish species. Fish detection could be automated or triggered based on monitoring devices but ultimately direct observation would be expected to determine if fish are to be transferred. Once fish are detected and collected in the collection facility they would be transferred within 24 hours. Fish passage delay is expected to be minimal or non-existent relative to alternatives in which fish must climb a high fishway, travel through the lake, and pass the lake delta.

The fish transfer would be via water-to-water to a truck as described above. Once fish are loaded onto the truck they would be transported to a suitable release location based on lake conditions and management decisions. The transport route to the Blue Point location is approximately 9 miles from the collection facility. It is assumed that it would take approximately 30 minutes of truck travel time. Protocols would need to be developed for frequency of operation, handling procedures, and the handling and destination of non-target species.

Once a fish transfer is initiated, advance watering up of the holding tank at the designated release location by at least one-half hour is recommended. Once the truck arrives at the designated release location, fish would be transferred to the holding tank for acclimation and observed for at least one-half hour prior to allowing passage through a release pipe or channel. Transfer tanks can have a side release gate and pipe for releasing fish into the holding tank or directly into the stream or lake at release sites, if deemed acceptable.

4.2.4.6 Phasing Opportunities

Since Alternative U4 is a collection and transport facility, it is inherently a possible first phase of other upstream passage alternatives, as described for U1, U2 and U3.

With relatively easy vehicle access to the low flow channel a more rudimentary temporary picket weir with a box trap could be placed in the low flow release channel for seasonal trapping of adult steelhead over an interim period. This would be very similar to the kind of trap that is used for instream monitoring, trapping and segregation of different species and runs of salmonids. A slightly more robust collection and transport facility adjacent to the existing gaging weir or a modified gaging weir could also precede permanent facilities as a phased approach. A temporary and removable section of fish ladder could lead up from the tailwater of the gaging weir to a collection pool (trap) on the bank of the low flow release channel. The trap could be configured to accept a transport tank for water-to-water transfer or fish can be netted in the holding pool for hand transfer to the transport tank. The transport tank would be fitted to a flatbed truck for transport of any fish to a planned location upstream of the reservoir. Release of fish would be either by hand or by a large diameter hose from the transport tank to a suitable location in the stream. The trap and fish ladder could either be supplied flow via a pump in the low flow release channel or through temporary piping from the outlet works. Supplemental flow to the sides of the fish ladder entrance could provide additional attraction to the fish ladder if needed. The trap and holding pool size could start small and be incrementally increased with additional holding pools and other features for extra capacity if fish numbers increase or in response to higher flow-through requirements.

Another phasing opportunity or combination alternative is to complement Alternative U4 with the Piru Creek collector upstream of the lake (Alternative D7). The transport and fish release components of Alternative U4 could be used to hold and acclimate fish collected at the Piru Creek collector and vice-versa; additionally, the Piru Creek collector could be used as a location to haul upstream migrants to for release.

4.2.4.7 Compatibility with Downstream Passage Alternatives

As mentioned above, Alternative U4 has compatibility with the downstream passage alternative D7 as a main release location for upstream migrants. Additionally, Alternatives D3 or D5 could be used as release locations into the lake as a substitute for other lake release sites, and likewise, the collection facility or fish ladder entrance could be used as release locations for downstream migrating fish that are transferred from trapping with Alternatives D3 or D5.

4.2.4.8 Challenges, Uncertainties, Risks

The greatest challenge of this alternative is inherent in the collection and transport operation. While contemporary facilities will be designed and used, there is always some risk with the transfers and transportation of fish compared to "passive" types of fish passage. Life support and temperature controls during transport would be with mechanical systems that can fail, but this risk could be mitigated with redundancy of key components. There are some uncertainties regarding how fish will behave during the collection and transport process, and subsequently post-release. It is possible fish may be released to locations they may reject or that have predatory animals. Testing of the fish handling and transport operations should be conducted with surrogate fish to detect any potential harm or stress, and to make any necessary modifications or adjustments in design. Additional studies may be needed to advance design efforts for the outlet works/tailwater hydraulics related to siting the fish barrier.

4.2.4.9 Pros and Cons

The following lists of pros and cons summarizes points already made in the text and can also be seen in the evaluation matrix.

Pros

- Configurable barrier dam and trap optimized to location and attraction.
- Flexible release location depending on lake and creek conditions.
- Proven with salmon/steelhead species.
- Collection facility size and transport capabilities are easily scaled up for large numbers of fish.
- Common technology and operation, especially for higher head dams.
- Habitat release flows can be the collection facility and fish ladder design flow.
- Good access for construction and operation with constructed features.
- Releases at above lake sites may increase survival rates of fish.
- Simple construction of facilities with no work in the lake or on the dam.
- Can be easily phased.
- Capital costs are much less than other alternatives.

Cons

- Risks associated with holding/handling/transporting fish (potential delay or injury).
- Equipment breakdowns/operator error.
- Operationally intensive during fish migration season; relatively high operating costs.
- Facility water supply may be difficult to integrate with hydropower plant.
- Security of fish being held.
- Uncertainty about fish passage behavior in holding pools, transfer tanks and release locations.
- Requires diligent monitoring and maintenance.

4.2.4.10 Cost Considerations and Assumptions

In the cost analysis, the following considerations and assumptions were made:

- Features for monitoring, security and alarms were included.

- Redundancies of critical components were included.
- Assumes inspections of system operations and daily fish transfers during the fish migration season (January 1 through May 31) so that fish are not held for more than 24 hours.
- Assumes 1 general support staff and 2 fisheries technicians for fish transfers.
- Assumes fish transfers take one-half day.
- Assumes 18 miles round trip for hauling to furthest release location.
- Mitigation requirements of arroyo toad habitat for the Blue Point release site are not clear and are not included in the cost estimate.
- Capital and operating costs do not include any efficiencies from compatibilities with downstream passage alternatives. For example, road maintenance, hauling truck, and hauling trips are included in both D7 and U4. If these two alternatives are implemented, at least some of those costs could be consolidated.
- Lost revenue due to diversion of water from hydro plant to collection facility is not included.

4.2.5 Enhancements

Enhancements were generally defined in Section 1.5.3. This section describes specific enhancements the Panel identified and recommends for some of the upstream passage alternatives.

4.2.5.1 Upstream Fish Passage Challenge Section

Adult anadromous fish returning to freshwater systems move upstream in an attempt to return to their natal area. The objective of upstream fish passage facilities is to allow those fish to continue their upstream migration without being blocked or hindered by dams or other barriers. However, returning adult fish may also exhibit upstream and downstream movements independent of spawning migrations and may temporarily inhabit tributaries or reaches other than their natal areas. Fish entering upstream fish passage collection facilities may not be associated with upstream spawning habitat and can be inadvertently relocated upstream of barriers and have difficulty returning downstream to natal areas. Some anadromous fish prevented from returning to natal areas may spawn in non-natal streams or areas, but others will not spawn and their productivity may be lost.

The potential mixing of stocks from upstream and downstream areas can be complicated by the presence of spawning habitats in the proximity of upstream collection facilities. One of the habitat improvement measures of the Piru Creek Habitat Improvement Plan is the addition of gravels to improve steelhead spawning habitat below SFD. These spawning areas may contribute to improved steelhead production in Piru Creek, but could also increase the risk of steelhead straying from these spawning areas, entering an upstream fish passage collection facility, being relocated above SFD, and separated from downstream natal areas.

Providing volitional upstream passage facilities, where fish can freely move upstream and downstream, minimizes the risk of relocating adult fish to non-natal areas. However, volitional upstream passage facilities may be difficult to achieve given site conditions at SFD. If volitional upstream fish passage cannot be achieved, options to minimize the inadvertent relocation of upstream migrants from their natal areas may include the use of a challenge feature in the design of the upstream fish passage facility.

The objective of a challenge feature is to require upstream migrants to exhibit directed behavior indicative of upstream migration instead of random or non-directed movements. The concept is to implement a series of steps, weirs, or a velocity chute to “challenge” the fish after entering the facility and separate fish attempting to migrate upstream from those that may enter the collection chamber for other reasons. A challenge feature should not prevent upstream migration but should require adult fish to exhibit directed behavior to pass the feature.

A challenge section is shown on the plans as an enhancement feature for applicable upstream fish passage alternatives (Alternatives U2, U3 and U4). As specifically conceptualized for the alternatives it is a bypass channel adjacent to the fish ladder with entrance and exit openings at fish ladder pools to provide enough head difference to drive the hydraulic design of the challenge section, and divert flow to the challenge section from that portion of the ladder. The challenge section channel would include provisions to customize it with removable weirs or boards for the hydraulic conditions desirable to challenge fish. The hydraulic design of the challenge section would be based on the target fish size using selected swimming capability thresholds and would be done later when detailed design begins for an alternative. Specific details of this item would require further clarification of specific goals and design development during final design.

In addition to, or instead of, a specific challenge feature, handling protocols can also be implemented to reduce the inadvertent relocation of fish to non-natal areas. For example, handling protocols for adult Chinook salmon (*O. tshawytscha*) and bull trout (*Salvelinus confluentus*) at the Baker River upstream fish collection facility, Washington have included tagging some species that enter the collection chamber and releasing them into the Skagit River several miles downstream of the Baker River upstream collection facility. The upstream fish trap is located on the Baker River 0.6 miles upstream of the confluence of the Baker River and the much larger Skagit River. If the tagged fish enter the Baker River upstream collection facility a second time, they are relocated above the Baker Project dams. Genetic testing of tagged bull trout has shown that requiring a second entry significantly reduced the number of non-Baker River bull trout entering the upstream fish trap (Small et al. 2011).

4.2.5.2 Operate to Minimize Spill

According to the lake hydrology model described in Section 2.2, the current operation of SFD does not attempt to minimize spill. Minimizing spill would have a benefit for both upstream and downstream fish passage with most alternatives. It would benefit upstream passage by minimizing the frequency of fish being attracted into the spillway channel. It would benefit downstream passage with the lake collectors located near the dam by reducing the frequency that fish might pass through the spillway. Operating to minimize spill is included as an enhancement for all upstream and downstream passage alternatives except for D7 and D12, which are not affected by the spill.

There are two ways spill could be minimized relative to the current operations: 1) if whatever flow being released from SFD, up to the safe capacity of the outlet works, is directed first through the outlet works, whether through the deep outlet screen (bypass or turbine flows) or a fish collector, less flow would be spilled; and 2) the lake could be operated slightly lower than the spillway crest to provide some flood storage before spill occurs. These two ways could also be combined.

This section describes a sensitivity analysis the Panel performed to help quantify potential benefits of a reduced spill operation, which is described further in Appendix C. Because this enhancement measure is recommended for both the upstream and downstream passage needs, the longer migration period for downstream passage from January 1 through July 15 was used for the analysis to maximize the benefits of reduced spill.

The Panel recommends maximizing the outlet flow from the deep outlets or the fish collectors in all four of the upstream passage alternatives as shown in Table 4.2-1 and for all of the downstream passage alternatives located in Lake Piru, as described in Section 4.3. Flow in Piru Creek below the confluence of the spill channel and the outlet channel would not change, just the distribution of flow in those two channels. The more flow that could be routed through the outlet, the less frequent the spill. In the feasibility analysis, the Panel assumed a maximum safe outlet flow of 500 cfs, as described in Section 2.4.3.

Operating at a lower lake operation, on the other hand, would affect storage available and would slightly affect the peak flows downstream. This operation could also be used for a portion of the season most prone to high flows in an effort to minimize the effect on storage.

Table 4.2-2 shows the effect of each of three scenarios of operational changes on the total days of spill, frequency of spill events (defined as each time the project spills, regardless of the duration of the event), and other parameters as noted over the 67 years of the period of hydrology. The results in the table for operating at a lower lake include maximizing the outlet flow up to 500 cfs as well. Interestingly, when maximizing outlet flow up to 500 cfs, the number of spill events would increase from 16 to 21. This is because the duration of the spills shortens significantly, and several of the longer duration events get split into multiple, smaller events. Operationally, two small spill events in close succession would be no different than a single event. Additional plots and information describing this sensitivity analysis are provided in Appendix C.

Table 4.2-2. Characteristics of spill frequency at SFD for the period of record when spill was minimized for three spill reduction scenarios compared to current operations.

	Current Operation	**Scenario 1 Maximize Outlet Flow Up to 500 cfs**	**Scenario 2 Maximize Outlet Flow Up to 1,000 cfs**	**Scenario 3 Operate Lake at Elevation 1,053 ft**
Total days of spill	1,857	228	82	182
Average days of spill per event	116	11	7	13
Number of spill events	16	21	11	14
Average number of years between spill events	4.2	3.2	6.1	4.8
Average number of years between years with spill events (accounts for multiple spill events in a single year)	4.5	6.1	8.4	>5*

* The model did not calculate this number precisely, so this is a rough estimate.

The Panel has defined this enhancement concept as Scenario 1 – utilizing the first 500 cfs of spill through a fish passage system or screened deep intake as a minimum practice, as it could be achieved within the constraints of the existing and planned intake works and has no effect on storage. Because the 1,000 cfs and reduced pool level operating scenarios would both have additional benefits, the Panel recommends they be further considered. Additional analysis could refine the estimates of spill reduction and engineering feasibility and cost of increasing the outlet works flow capacity. The increased flow capacity should be considered in conjunction with the modifications of the outlet works.

4.2.5.3 Monitoring Facility

A Monitoring Facility is an enhancement feature that would count and, if necessary, allow sampling of fish. One location for this facility is illustrated on Drawing U1.2 for Alternative U1, where it would be adjacent to the fish ladder below the downstream tunnel portal and upstream of the fish ladder entrance on the terrace for ease of access. It could consist of two holding pools, one with a crowder or guide panels to facilitate either handling of fish or coercing fish through or over a monitoring device, or it could consist of completely passive monitoring devices. The monitoring function could also be automated. To be volitional, the monitoring station could consist of just a video camera station to view fish as they swim by a constriction. Power for the facility would be supplied from the local area, same as for the outlet works and nearby buildings.

4.2.5.4 Release Facility

Fish that are transported upstream using the collection and transport facility described in Alternative U4 or a supplemental feature need a release facility to transfer fish into before being released in the natural channel. This facility will allow for monitoring of the fish to ensure good health before final release and for acclimation to potentially different water quality. This facility would be the same as that described for Alternative U4 fish release structures in Section 4.2.4.

4.2.6 Supplementals

Supplementals were generally defined in Section 1.5. This section describes specific supplementals that the Panel has recommended for some of the upstream passage alternatives (see Table 4.2-1).

4.2.6.1 Spillway Pool Collector

For times when longer duration spills from the reservoir may occur there is a chance that upstream migrating fish may be attracted to the spillway channel flow and move upstream into the plunge pool at the downstream end of the spillway chute, rather than stay within the main creek channel leading to the powerhouse at the base of SFD. The spillway channel is separate from the low flow release channel with the confluence of the two channels being approximately 3,000 ft downstream of the dam. If fish are attracted to the spillway channel they may become stranded in the plunge pool or be delayed from collection at the base of the dam with the primary upstream fish passage alternatives. To minimize the chance of fish being stranded in the plunge pool and to minimize delay a spillway pool collector is proposed as a supplemental to the upstream fish passage alternatives. Since the frequency of spills is small in comparison to regular release flows from the outlet works it is anticipated that the collector is a temporary measure to be used during spills (if safe) and after spills for a period of time. The length of operation would likely be determined when actually in operation and based on whether fish are being collected. An operational protocol could be established based on the time it takes to collect fish from the pool after the spill.

As conceptualized the spillway collector is a portable facility consisting of a short section of fishway and supporting framework, a headtank and trap, a pumping system, and the use of a generator to power the pumping system and lights for night operation. These components would be located in the large plunge pool near the end of an existing access road (see Figure 4.2-1). A permanent concrete ramp, similar to a boat ramp, for the equipment would be required for ease of set up and for adjustability to varying spillway plunge pool water levels. The existing road would need to be improved (approximately 650 ft) for all-weather access to the boat ramp. The pumping system would be designed to draw water from the spillway plunge pool for flow to the headtank, trap and fishway. It would likely consist of a large submersible pump and fish screen of 2 to 5 cfs capacity. The generator could be rented but may be needed on a short notice. All of the equipment would be staged on trailers at the nearby dam facilities.

4.2.6.2 Collection and Transport Facility

A collection and transport facility similar to that described for U4 could also serve as a supplemental to Alternative U2 when the pool level is below elevation 1,030 ft and the fish ladder no longer has flow. The supplemental would likely be at a smaller scale than U4, with one or more holding pools that are separated by fykes, picket panels, and segregation screens. The facility would be integrated with the fish ladder near the downstream end.

Once fish move up a short section of fish ladder they would enter the first collection pool and move past a fyke, vee-trap or false weir which prevents adult fish from swimming back down into the previous section of the fishway or collection pool. An automatic fish sensor or video would inform operators that fish are present so they can respond and transfer the fish. After they enter the initial collection pool, fish can be allowed to continue upstream into the next holding area, physically crowded to separate holding areas, and/or separated into species or size classes. Here, fish are collected and handled for additional monitoring purposes or they are guided directly into a hopper style transfer tank for water-to-water transfer. The transfer tank is then loaded onto a transport vehicle (truck). A truck loading area would include an overhead crane for lifting the transfer tank.

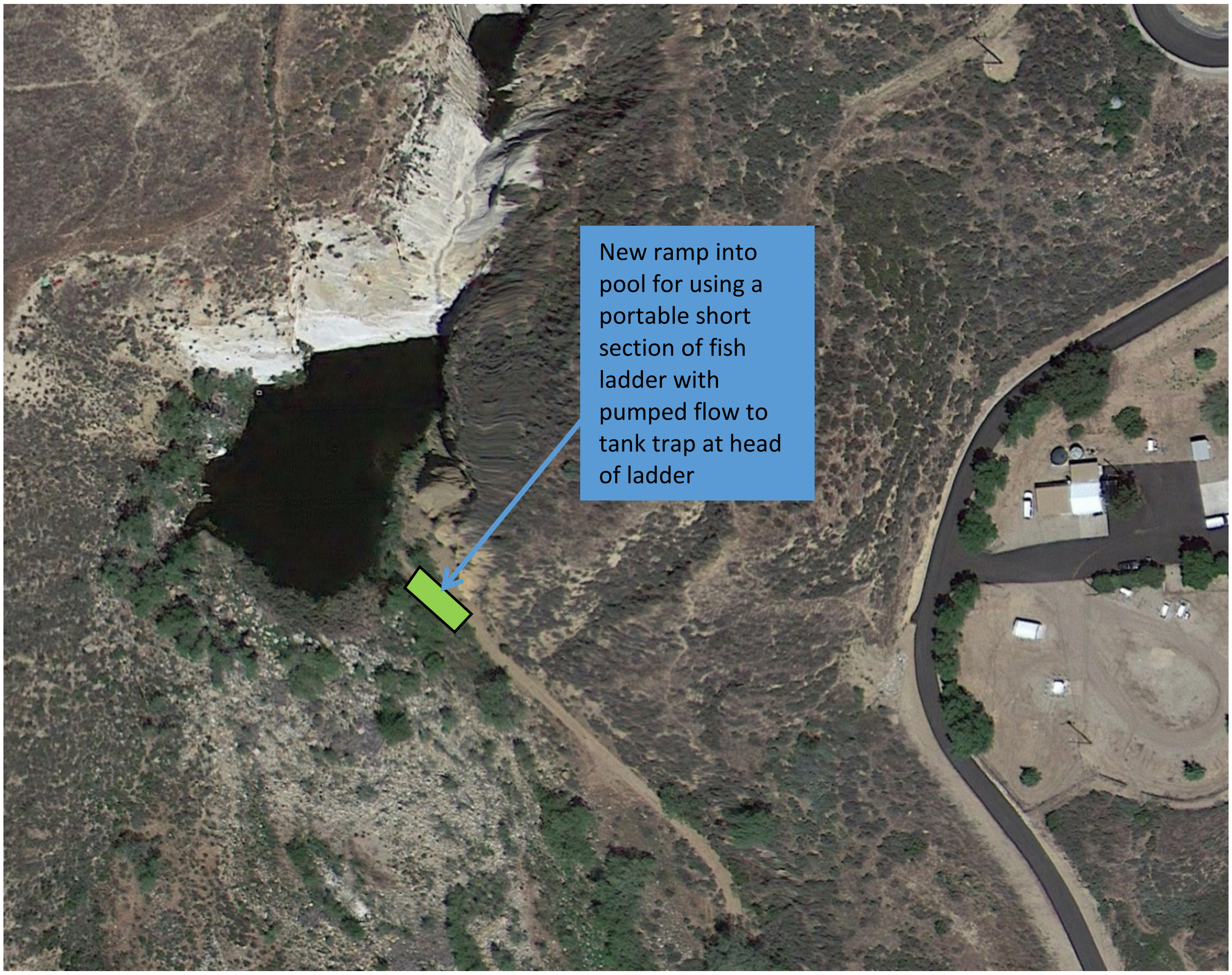


Figure 4.2-1. Spillway pool collector location.

Power for the facility would be supplied from the local area, same as for the outlet works and nearby buildings. Flow for the facility and fish ladder would be supplied from the outlet works through a pipeline. The facility would be outfitted with many sensors and alarms with remote display to ensure fish safety at all times.

4.2.7 Documentation of Upstream Concepts Deferred

Table 4.2-3 contains the list of twelve concepts, including supplements and enhancements, for upstream fish passage that the Panel considered, but ultimately deferred from further evaluation or concept development. Five of the twelve concepts were determined to be fatally flawed due to issues related to dam safety, complexity and unreliability, and their incompatibility with lake operations.

Table 4.2-3. Upstream fish passage concepts the Santa Felicia Dam Fish Passage Panel deferred from consideration, including those considered fatally flawed.

Concept	Basis for Deferral
Pierce the dam with mid-level lock	Concerns about dam safety
Trap at lower Piru Creek	Floodplain location would inundate structure, risk of capturing non-Piru Cr migrants unless farther upstream from confluence
Transport from Freeman Dam	Does not meet criteria for upstream passage feasibility; could be considered in Task 9
Channel bypassing the lake	Steepness and ruggedness of terrain
Trap and transport (via fish lift with overhead tram)	Structure on top of dam may affect dam safety; other alternatives are better
Fish lock	Height of dam; other alternatives are better
Long-ladder flume (1-2 percent slope)	Length of flume required may not work with topography, very long fish transit time; other alternatives are better
Nature-like fishway	Fatal flaw: Height of dam and required shallow slope would require an extremely long fishway that may not work with topography, very long fish transit time; other alternatives are better
Fish lift over dam via rail	Fatal flaw: Complexity of system; dam safety concerns; other alternatives are better
Permanent spillway pool collector (trap) or channel to outlet works	Fatal flaw: At risk from high spill events, location would inundate structure, frequency of need for fish collection is very small
Fish ladder on the dam	Fatal flaw: Dam safety
Rail transport around the lake	Fatal flaw: Complexity; terrain

4.3 DOWNSTREAM FISH PASSAGE

This section provides a description of the Panel's selected downstream alternatives that have been developed for this Report. Ten alternatives have been carried forward, including four that are components of other alternatives listed. Table 4.3-1 is a summary of the selected downstream alternatives, and the enhancements included to form them. A description of each alternative is provided in the sections following the table. There are no supplementals associated with the downstream alternatives. Cost information is provided in Section 4.4, and a summary of the cost estimates is provided in Section 4.4.3.

Table 4.3-1. Summary of the downstream passage alternatives (Alt) and enhancements selected by the Santa Felicia Dam Fish Passage Panel for detailed feasibility evaluation.

Label	Name of Alternative	Enhancements
D3*	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps	• Operate to minimize spill • Collector Transition Structure • Guide curtain • Cover in front of collector • Release pond • Reduced deep outlet screen
D4*	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps, Volitional Bypass with U1	• Operate to minimize spill • Collector Transition Structure • Guide curtain • Cover in front of collector • Release pond • Reduced deep outlet screen
D5*	Surface Collector at Intake Tower, 500 cfs Screen, Gravity with Pumps	• Operate to minimize spill • Collector Transition Structure • Guide curtain • Cover in front of collector • Release pond
D7	Piru Creek Collector, 200 cfs Screen	• Release pond • Deep outlet screen
D9*	Piru Creek Collector (D7) with Spillway collector	• Operate to minimize spill • Release pond • Deep outlet screen
D10	Piru Creek Collector (D7) with 150 cfs Surface Collector D3	• Operate to minimize spill • Release pond • Deep outlet screen
D11	Piru Creek Collector (D7) with 500 cfs Surface Collector (D5)	• Operate to minimize spill • Release pond
D12	Piru Creek Collector (D7) with Movable FSC	• Operate to minimize spill • Release pond • Deep outlet screen
D14	Multi-level Crest Gate Collector with Helix Bypass	• Operate to minimize spill • Guide curtain • Cover in front of collector • Deep outlet screen

* Note – D3 through D5 and D9 are not selected stand-alone alternatives but are described because they were developed as stand-alone alternatives and then combined with D7 as selected alternatives.

4.3.1 D3 – Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps

This alternative is a floating surface fish collector near the west end of the SFD spillway that operates with a relatively high (150 cfs) fish attraction and collection flow regardless of the SFD outflow. The function of the alternative is to collect downstream migrants from near the spillway at all fish passage design elevations (elevation 980 to 1,056 ft) and haul them by truck to a release point in Piru Creek below the dam.

Alternative D3 is shown in Drawings D3.1-D3.6. The specific location and orientation of the collector is provisional and would be refined in later stages of design to be sure it does not interfere with the spillway operation and that it would be oriented to maximize fish collection. An understanding of flow patterns created by the collector, outlet screens, spillway, and wind might affect the specific orientation and location. Hydraulic modeling may be useful to support that future design effort.

4.3.1.1 Collector and Screens

The collector consists of an intake sized to optimize fish attraction, screens to separate fish from the bulk of the water for ease of handling, a hopper and loading/hauling system to move the fish downstream. Pumps are located in the base of the tower to return most of the flow used for fish attraction to the lake. The screens and hopper system are contained within a steel box that floats and is nested in a concrete tower.

The overall size of the collector was determined by the attraction flow that would be drawn into the system, the velocity distribution through it, and the screen approach velocity. The design flow of the collector and screens for this alternative is 150 cfs. The flow of 150 cfs is intended as a provisional flow rate for several of the lake collectors. The flow was chosen by optimizing the flow versus performance, which showed little marginal gain in performance with increasing collector capacity. The optimization is described as part of the results of the BPT described in Section 5.1.3 and Appendix E. The optimization analysis and the other sizing issues were based on current information and should be refined and a final design flow selected in the final design.

The collector flow of 150 cfs could be exceeded at any time with high release flows or by combining release flow with pumpback flow. This would increase the screen approach velocity. The collector and screen could also be designed with the capability of being expanded in the future to increase the collector flow capacity.

The screens are configured in a vee shape and are sized for an approach velocity of 0.8 fps for protection of yearling fish. The velocity distribution creates a gradually accelerating flow through the collector up to a velocity from which the target fish cannot escape. This is called the "capture point." The purpose of the capture point is to ensure fish capture so they do not reject conditions downstream and swim back to the lake. The configuration shown on Drawing D3.3 starts with an attraction velocity at the screen entrance of 2 ft per second (fps) and accelerates up to 8 fps, which has been used successfully at the Baker and Swift FSCs. To be conservative, the design was developed with a capture zone once the sweeping velocity reaches 8 fps, and holds that velocity for a length of 20 ft. The capture velocity and zone length should be revisited and refined during final design, and a less conservative approach might shorten the overall structure. An enhancement feature called the Collector Transition Structure (CTS) is provided upstream of the screens to gradually increase the entrance velocity as described in Section 4.3.10.

The screens proposed for this collector, and the screens in all collector alternatives, are vertical travelling screens. The front face of the screen rises and lifts most impinged debris, most of which would be carried over the top of the screen and down the back where it would be washed off by the flow moving through the screens. Debris that is not carried over the screens would end up in the fish collection area, where it would be handled and disposed of manually. Brush and/or spray cleaners can be added to the screen if necessary, which are common with the newer facilities. A photo of typical traveling screens is included on Drawing D3.5. The screen material would consist of engineered polymer mesh panels assembled in an interlocked belt similar to what is manufactured by Hydrolox[11]. The traveling screens would operate automatically either based on a timer or the headloss measured across the screens.

Water that passes the screens and the capture zone would carry fish into a fish hopper, which would be lifted by a gantry crane to load the fish into a tank on a hauling truck. Two hoppers would be provided so one would always be in operation. An automated flip gate would switch the operation between hoppers. The hoppers would include smaller hoppers within them with passive grader bars to separate adult fish from small fish so steelhead smolts would be separated from predators and kelts in the hopper. Those fish would be hauled separately from the juveniles. Protocol should be developed to stipulate where and how specific species are handled and released.

Fish would be hauled and released downstream of SFD. Though specific release sites have not been developed in detail, it is assumed fish would be released into a section of the fishway entrance pool appropriately designed for holding fish.

[11] Hydrolox brand screens are mentioned several places in this report as an example and are not necessarily endorsed by the Panel.

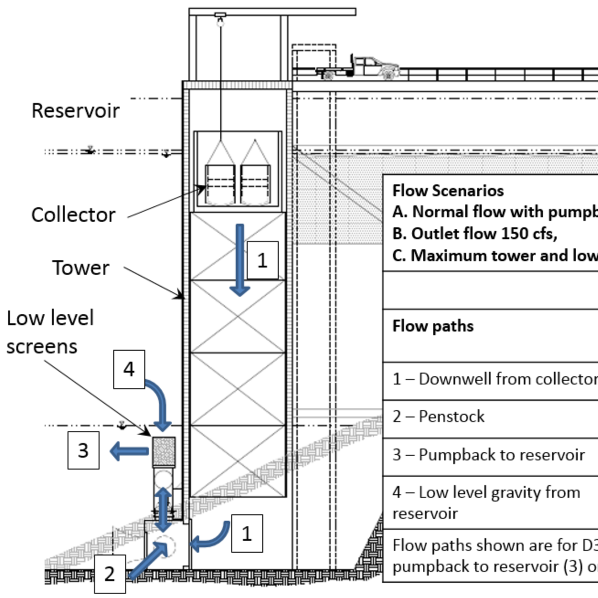
4.3.1.2 Outlet Screens and Pump-back

The typical highest controlled outflow of the SFD outlet works is 500 cfs and the maximum is 800 cfs for emergency situations. Higher flows are either stored, or spilled if Lake Piru is at the spillway crest level (EL 1,055 ft). The collector screens for this alternative would have a capacity of 150 cfs at the collector entrance. Stationary cylindrical outlet screens with an additional capacity of 350 cfs would be mounted on the tower near its base to make a total screen capacity of 500 cfs. These outlet screens are in lieu of the outlet screens described by GEI (2015a), as this presents an opportunity to consolidate the low level screens into the tower. These 350 cfs screens are also identified as Enhancement measures, described in Section 4.3.10. Distribution of flow through the collector and outlet screens would be controlled by a set of automated roller gates, as shown on Drawings D3.4 and D3.6.

The collector design flow of 150 cfs is intended to be provided whenever the fish collector is in operation. When the SFD outlet flow is 150 cfs or more, 150 cfs is passed through the collector by gravity and additional flow is passed through the outlet screens. When the SFD outlet flow is less than 150 cfs, all of the flow would be passed through the collector and the difference between 150 cfs and the outlet flow pumped back through the outlet screens. The reverse flow through the outlet screens would clean those screens. Figure 4.3-1 is taken from Drawing 3.4 to show several operating scenario examples based on the collector design flow and outlet flow. The following flow scenario examples are shown in the figure:

A. Normal flow with pumpback (range 0 to 150 cfs); outlet flow 100 cfs (range 7-150 cfs),
B. Outlet flow 150 cfs (range 7-150 cfs),
C. Maximum screen and low level gravity flow; outlet flow 500 cfs (see Section 4.3.3 for description of Alt-D5).

Two 75 cfs pumps are shown to illustrate this concept; specific pump types and sizes would be selected during final design. These could be low head pumps such as the low head high flow pumps manufactured by Flygt. These pumps have been used recently on floating surface collectors in the Northwest. The screens, pumps, and control gates would be combined into a single structure which would be mounted on rails so it could be lifted to the surface for maintenance. To consolidate gates, the tower includes an emergency outlet gate, which has been described by GEI (2015a), which could be built if the fish passage alternative is built concurrently with the outlet works. That gate is not included in the fish passage cost estimates.



Flow Scenarios
A. Normal flow with pumpback; outlet flow 100 cfs,
B. Outlet flow 150 cfs,
C. Maximum tower and low level gravity flows; outlet flow 500 cfs.

	Flow Scenarios / Flows in cfs			
Flow paths	A	B	C	C - for Alt D5
1 – Downwell from collector	150	150	150	500
2 – Penstock	100	150	500	500
3 – Pumpback to reservoir	50	0	0	na
4 – Low level gravity from reservoir	0	0	350	na

Flow paths shown are for D3 and D4. For Alt D5, there is no pumpback to reservoir (3) or low level gravity (4)

Figure 4.3-1. Flow paths for example D3 (Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps) operating scenarios.

4.3.1.3 Tower

A concrete tower would hold the collector and fish transport facilities and would move water from the collector to the penstock or recirculate it back to the lake. One end of the tower would be open and the collector component would nest inside the tower with the entrance to the collector protruding into the lake (see Drawings D3.3 and D3.5). The collector would be held longitudinally and laterally by guides at openings in the tower and rollers or guides near the rear of the collector.

The tower dimensions shown on the drawings are approximate and would be refined in final design. The dimensions of the tower were set by the collector nested into it and the weight distribution of the collector, since it would be supported by cables and winches.

The Panel recognizes the area has a significant seismic risk, and that the structural and seismic design of the tall and slim tower structure would be a challenge. The tower and associated pipelines would be founded on bedrock. A steel tieback frame would connect it to the adjacent rock cliff. The maximum head differential on the tower would be about five feet. A higher differential might be needed in the lower part of the tower so maintenance could be performed on gates at the base of the tower when the lake is low.

4.3.1.4 Elevation Control

The collector would normally operate at lake elevations from elevation 980 to 1,056 ft and it can be operated from about 976 to about 1,060 ft, which corresponds to about 18,500 cfs of spill. The collector would move with the lake water surface as it rises or lowers. If the lake drops to elevation 976 ft, the collector would rest on supports within the tower and would not operate. When the lake rises above 1,060 ft, tower bulkheads below the collector would open and unscreened flow would be released through the tower.

The collector component would float with a slight negative buoyancy. Cables attached to winches on the tower deck support the collector and would control its elevation precisely. Any change in lake elevation would cause the winches to operate via level sensors and automated controls. When the collector is in a high position, a series of four telescoping bulkheads would seal the front of the tower below the collector. When the collector is in its lowest position, the bulkheads would be overlapped and stored at the base of the tower. The top bulkhead is attached to the collector. The bulkheads would fall by their weight and be lifted by the collector flotation, the control winches, and attachment to each other. These bulkheads will need to be designed to be "fish tight," but would not have to be 100% water tight, as this is all a low-pressure system (the pressure differential between the water surface in the tower and the pool level will be less than 5 ft as noted above).

The specific geometry of the flotation has not been designed and might be optimized by placing flotation tanks beneath the screen box, thus reducing the necessary width of the screen structure and the tower.

The lowest bulkhead could be designed to be released and swing inward when the head differential on the tower is greater than the design target, which is expected to be about 5 ft. To remove the bulkheads for maintenance, the collector would have to be removed from the tower.

4.3.1.5 Optional Design Elements

In the process of developing the design, the following optional design elements were considered but were not included in the current design or cost estimates:

- Instead of a concrete tower, a steel frame with telescoping tower segments could be used to mitigate the seismic design challenge. This change would present challenges of supporting the segments and sealing them against each other.

- The entire collector and screen structure could be contained in a larger tower. Support of the collector from the tower would be easier. Debris management would be easier. However, the tower would be more costly.
- The tower could be smaller and the entrance of the collector could be supported on a pair of steel towers independent of the tower. This would greatly reduce the length of the concrete tower. Only about 20 ft of length of the tower is required for the hopper system and downwell, which could potentially eliminate 30 ft of tower length. Until seismic analysis is completed, it is not clear which design is better for seismic conditions and which is less costly. For the purpose of a consistent design among the alternatives, the full length concrete towers were retained in the design of D3. As will be seen in later sections, this also applies to D4, and D5. Figure 4.3-2 shows a comparison of the two tower options.

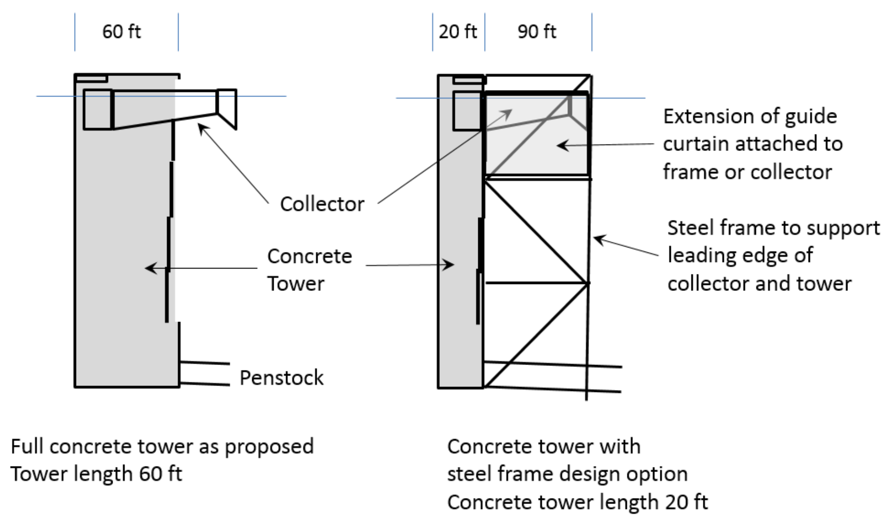


Figure 4.3-2. Schematic comparison of concrete tower and tower with steel frame support as could be applied for downstream Alternatives D3, D4 and D5.

4.3.1.6 Operations

The fish passage operating season for all downstream lake collectors is assumed to be from January through mid-July. If D3 were a stand-alone alternative, the pumpback system could operate any time the outlet flow is less than 150 cfs to create a constant attraction flow of 150 cfs. Any flow greater than the project flow release and up to 150 cfs would be pumped back to the reservoir. Over time, a relationship could be developed between Piru Creek flows (freshets and/or extended periods of low flow) and fish presence that could lessen pumping requirements some of the time. D3 and D5 however are presented in this Report as a supplement to D7 to make up D10 and D11. See the descriptions of D10 (Section 4.3.6) and D11 (Section 4.3.7) for timing of pumping.

When the collector is not in operation, the D3 alternative would have an outlet capacity of only 350 cfs. If additional flow is to be released through the outlet structure, the collector would have to be operated or additional outlet screens could be provided.

Normal fish hauling would include at least one daily inspection of the hoppers in the collector and hauling those fish to a release point downstream. The following sequence describes how the collection and hauling of fish would occur:

- Fish enter the collector and pass through the capture zone of the collector.
- Flip gate distributes fish to one of two hoppers.
- An insert within the hopper (passive grader bar rack) allows smolts to separate from adults and predators.
- When a load is ready to haul, the flip gate moves to other hopper.
- Gantry crane lifts hopper over truck and fish are transferred to hauling tank by water-to-water transfer.
- Large fish such as kelts, bass can be transferred into separate hauling tanks or returned to the lake. It will be necessary to develop a protocol for handling non-native species for any alternative.
- Truck hauls downstream migrants to the tailrace area where they are transferred to Piru Creek or an acclimation pond.
- Final release could be delayed to follow a period of acclimation and stress relief or as fish are motivated to move.

Debris could be managed at several levels. All lake collectors would include a trash boom for large debris. The D3 alternative includes a trashrack and powered trash rake on the face of the collector. Trash could be lifted into a small pen area moored next to the collector that could later be pulled to shore where the debris would be removed. An alternative would be to actively manage the lake for debris. In that case debris would be removed from anywhere in the lake where it accumulates.

4.3.1.7 Phasing Opportunities

Given the overall scale and complexity of Alternative D3, there are only a few opportunities for phasing. It would be most feasible to construct the tower concurrently with the planned outlet works modifications to take advantage of the drained lake and mobilization for that work. If full construction is not concurrent with that project, the base of the tower up to about elevation 990 ft could be done with the possibility of adding the remaining tower later without having to dewater the lake again. This would be the lower 50 ft of the tower, more than a third of the full tower height. It could include functional low level outlet screens and the emergency outlet structure. Alternately, the lake could be drained, and the entire project constructed in the future.

Some of the phasing opportunities that could be considered with this alternative include:

- Add a collector in Piru Creek (D7), either before or after D3. This would essentially comprise Alternative D10 (see Section 4.3.6).
- Start with a lower pumping capacity and move to a higher capacity later. The collector could be designed with any capacity and could be designed to add capacity later.
- Start with floating surface collector (described as a component of D12; see Section 4.3.8) to evaluate the flow and location needed to optimize collection.
- Start without outlet screens and conduct entrainment study.

4.3.1.8 Compatibility with Upstream Passage Alternatives

Alternative D3 has the following possible compatibilities with upstream passage alternatives:

- U1; utilize tunnel and tower similar to D4.
- U2; utilize tower depending on its location.
- U2 and U4; utilize hauling trucks.

However, the cost estimate of D3 as well as other alternatives, does not consider any of these compatibilities.

4.3.1.9 Challenges, Uncertainties, Risks

The greatest challenge of this alternative is designing a tower of this height in a highly seismic area (peak ground acceleration = 1.13g). The Panel recognizes this challenge but does not have the expertise or scope to do a thorough seismic analysis. That analysis would be a next step in the design of this and several other alternatives.

To mitigate the challenge, the tower and penstock are founded in bedrock and a tie-back brace supports the tower to bedrock. The dimensions of the tower could be modified to increase stability. A closure gate is included to isolate the tower from the penstock in case it is damaged. A telescoping tower as described in Section 4.3.1.5 (Optional Design Elements) could be considered.

Uncertainties of this alternative include its exact location, entrance orientation, and the collector flow requirement. The location of the tower shown was intended to be good for collection of fish that approach the dam, and it is far enough upstream from the spillway so it would not affect the spillway capacity or present an operational safety hazard. Studies of lake flow patterns and fish presence/behavior relative to outlet flow would be useful and help guide a final location and orientation. These types of hydraulic modeling or measurement studies and fish tracking studies are typically performed prior to final design efforts with this scale of project. The collector flow rate of 150 cfs was assumed to be adequate for attraction of fish and to enhance flow patterns for attraction.

4.3.1.10 Pros and Cons

The following lists of pros and cons summarizes points already made in the text and can also be seen in the evaluation matrix.

Pros

- Exclusionary surface screen.
- Proven outlet concept for attracting fish.
- Release flow is collector flow.
- No net loss of water.
- Good access for operation and maintenance.
- Can complement revisions to outlet works.

Cons

- Construction requires drained lake.
- Seismic design challenge.
- Not practical to phase.
- High cost; construction and operation.
- Challenges associated with debris handling during operation.

4.3.1.11 Cost Considerations and Assumptions

The following considerations and assumptions were made in the cost analysis, which is summarized in Section 4.4.

- The collector would be constructed independent and subsequent to modifications to the outlet works. There would be savings if they were done concurrently.
- The penstock tunnel would be in place as part of the outlet works revision. The cost for D3 includes the cost of extending the penstock 100 ft to the collector tower.
- Alternative D3 could reduce the size of the low level outlet screens under study for the outlet improvements from 500 to 350 cfs. Credit was given to the alternative for the cost of 150 cfs outlet screen assuming 25% of the cost of screens included in the outlet works revision design.
- D3 would be built as a component with D7 to create D10. In that case, D3 would operate only after high Piru Creek flows and the operation of D7 is temporarily interrupted. The trap would be operated until no more fish are collected. It was assumed D3 would operate 50% of the time.
- The trap would be inspected for the presence of fish and any fish would be hauled once per day. For costing, it was assumed there would be fish present once every three days.
- Debris is managed at the collector and there is no active lake debris management.
- Capital and operating costs do not include any efficiencies from compatibilities with upstream passage alternatives.

If not built concurrently with the outlet works revisions, there would be future additional costs of again draining the lake, including any power revenue losses.

4.3.2 D4 – Volitional Surface Collector in Intake Tower

This alternative is a floating surface fish collector near the west end of the SFD spillway that operates with a relatively high flow regardless of the SFD outflow. The function of the alternative would be to collect downstream migrants from near the spillway and let them move volitionally to below the dam. The configuration and features of D4 are similar to Alternative D3 with the primary difference being that D4 was designed to provide volitional passage, D3 was not. Alternative D3 is described above in detail; only the aspects of D4 that are different from D3 are described here.

The location of D4 would be the same as D3 and U1. Alternative D4 could stand alone but it is included in this Report as attached to upstream passage Alternative U1, which is the volitional upstream passage alternative.

4.3.2.1 Collector and Screens

The differences between D4 and D3 are due to the volitional passage design of D4. To be volitional for downstream passage, a collector, screen, and bypass must have hydraulic characteristics that allow a fish to pass downstream, or to turn around and move back upstream at any point in the system. D4 therefore has no capture zone in the collector. The velocities throughout the collector and bypass would be low enough for juvenile fish to move upstream. Instead of a capture zone, as in D3, the dimensions of the D4 bypass entrance flume would allow a maximum velocity of 2.0 fps. It includes the flexibility to insert a false floor to raise that maximum velocity to 4.0 fps to reduce the uncertainty of fish behavior when they are passing through a low velocity area with confined dimensions. The elimination of the capture zone reduces the overall length of the collector from about 105 ft to about 44 ft and affects the dimensions of the collector entrance opening.

Fish that move past the screens and through the bypass entrance flume would pass directly into the exit pool of the U1 fishway, through an open exit gate of U1, and down the fishway. The flow out of the collector and into the U1 could range from 7 cfs, which is within the design flow range of the fishway and the minimum required release flow from SFD to 10 cfs, the maximum fishway flow. The fishway steps would be designed to allow upstream passage of juveniles. Since passage is volitional, there are no flip gates, hoppers, or fish hauling facilities. All other aspects of the collector operation are the same as for Alternative D3.

4.3.2.2 Tower

Since the collector is smaller than for D3, the tower would also be slightly smaller. Its length could be reduced from about 60 ft for D3 to about 23 ft for D4. The differences are shown on Drawings D4.4 and D3.3. It would be a common tower and share one wall with U1. It would increase the length of the U1 tower by about 40 ft.

4.3.2.3 Optional Design Elements

Fish that leave the collector would enter the exit pool of the U1 fishway. That pool surrounds the U1 fishway and could be as deep as 75 ft. The depth and unorganized flow patterns in the exit pool may make it difficult for fish to find the fishway exit gate currently in operation. A floating floor within the exit pool was considered but was not included because of the difficulty of including seals to prevent fish from moving below it.

A design option of using a pair of steel towers at the front of the collector to support the collector instead of the tower was described for D3. If that option were applied to D4, it would essentially eliminate the need to extend the U1 tower at all.

4.3.2.4 Operations

The operating season and operation of the screens would be the same as for D3. There would not be any operations for the bypass beyond what is required for U1; operational aspects of D4 downstream of the bypass entrance flume are described for Alternative U1 (see Section 4.2.1). Based on biological information presented in Section 3, the Panel assumed upstream passage of adult steelhead would occur during March through June and downstream passage of smolts for the lake collectors would occur from January through mid-July. Thus, six additional weeks of operation of U1 would be required for D4 operation each year. Kelts would move downstream through the fishway just as the smolts. If they are observed in the fishway, they could be removed and hauled downstream.

4.3.2.5 Phasing Opportunities

Phasing opportunities are similar to D3 (see Section 4.3.1).

4.3.2.6 Compatibility with Upstream Passage Alternatives

Alternative D4 depends on the presence and operation of upstream Alternative U1. U1, however, does not depend on D4.

4.3.2.7 Challenges, Uncertainties, Risks

In addition to the challenges, uncertainties, and risks described for D3, D4 has additional fish passage risks and uncertainties. The low velocity bypass would allow volitional passage. It would also allow fish to wander in and out of the collector or bypass fishway and may cause delay and more exposure to risks in the lake.

In addition, fish might reject entering the low velocity bypass entrance flume. Two common reasons fish reject entering a bypass are confined dimensions and decreasing velocity. Both of these could occur in this case. Some flexibility in the dimensions of the bypass flume would help mitigate this risk.

Downstream fish passage through adult fishways is generally discouraged due to risks and uncertainties of juvenile fish stress or predation by being mixed with larger fish. Predators would be able to enter the collector and bypass (U1 ladder) and prey on juvenile fish moving through it. In addition to the risk of predation, passage through the fishway might delay the outmigration of fish.

4.3.2.8 Pros and Cons

The following lists of pros and cons summarizes points already made in the text and can also be seen in the evaluation matrix.

Pros

- Exclusionary surface screen.
- Release flow is collector flow.
- Good access.
- Can complement revisions to outlet works.
- Low construction and operating cost. This assumes the construction and operating costs of U1 fishway are attributed to U1 rather than D4.

Cons

- High mechanical failure risk of complex design.
- Risk of predation and delay in the collector and bypass fishway.
- Risk of fish avoiding or delaying entering the bypass.
- Construction requires drained lake.
- Seismic design challenge.
- Not practical to phase.
- Challenges associated with debris handling during operation.

4.3.2.9 Cost Considerations and Assumptions

The following considerations and assumptions were made in the cost analysis, which is summarized in Section 4.4. These are all major cost considerations, not just those that are different from D3.

- The collector would be constructed independent and subsequent to modifications to the outlet works. There would be savings if they were done concurrently.
- It is assumed U1 fishway would be constructed at the same time. D4 would not be built without U1 (because of this, capital cost appears low).

- U1 fishway would operate from January through June. D4 would operate continuously from January through mid-July, which is six weeks longer than U1 would operate just for upstream passage. The cost of operating the fishway for six weeks is included in the operating cost of D4.
- Alternative D4 reduces the size of the low level outlet screens from 500 to 350 cfs. Credit is given to the alternative for the cost of 150 cfs outlet screen assuming 25% of the cost of screens included in the outlet works revision design.
- Debris would be managed at the collector and there would be no active lake debris management.

4.3.3 D5 – Surface Collector in Intake Tower 500 cfs

This alternative is a floating surface fish collector near the west end of the SFD spillway that would operate with a relatively high flow regardless of the SFD outflow. The function of the alternative is to collect downstream migrants from near the spillway and haul them by truck to below the dam. The configuration and features of D5 are similar to Alternative D3, with the primary difference being that D5 is designed with a capacity of 500 cfs, rather than 150 cfs as in D3. The collector would typically operate with a flow of 150 cfs during the passage season and up to 500 cfs when more than 150 cfs is being discharged. Figure 4.3-1 shows the flow paths through D5 compared to D3. Only aspects of D5 that differ from D3 are described in this section.

The location of D5 would be the same as D3. Alternative D5 could serve as a standalone alternative as a downstream passage facility, or it could be combined with U1 similar to D4.

4.3.3.1 Collector and Screens

As noted above, the primary difference between D5 and D3 is the increased flow capacity of 500 cfs in D5. The increased capacity results in a proportional increase in screen area and a slight increase in collector and tower dimensions. The collector length would be increased from about 105 ft, including the CTS, to 114 ft.

The collector design flow would normally be 150 cfs pumped back to the lake as described in D3 or up to 500 cfs when the outlet flow exceeds 150 cfs. There would be no need for the deep outlet screen that was proposed in the design of the outlet works upgrades because the surface screen would have the same capacity and would be used in lieu of the deep screen.

4.3.3.2 Screen Design

The screen design for D5 would be conceptually the same as D3 but with a design flow of 500 cfs. Alternative D5 eliminates the need for the low level outlet screens.

4.3.3.3 Tower

Since the collector is larger than for D3, the tower in D5 would be slightly longer; about 67 ft compared to 60 ft for D3. The tower dimensions shown on Drawings D5.3 and D5.4 are approximate and would be refined in final design.

4.3.3.4 Optional Design Elements

The pumpback pumps were sized with a capacity of 150 cfs. That flow could be increased with additional pumping capacity to achieve a higher attraction and collection flow.

4.3.3.5 Phasing Opportunities

Phasing opportunities are similar to those for D3 (see Section 4.3.1). Alternative D3 could be a phase that would possibly lead to D5. The tower and collector dimensions could be designed as part of D3 to accommodate the D5 screens.

4.3.3.6 Compatibility with Upstream Passage Alternatives

Potential compatibility with upstream passage alternatives is similar to those for D3 (see Section 4.3.1).

4.3.3.7 Challenges, Uncertainties, Risks

Challenges, uncertainties, and risks are similar to those for D3 (see Section 4.3.1). The uncertainty of fish attraction to the collector is greatly reduced by the increased flow and is the primary reason this alternative was developed.

4.3.3.8 Pros and Cons

The following lists of pros and cons summarizes points already made in the text and can also be seen in the evaluation matrix. These are all significant pros and cons; not just those that are different from D3.

<u>Pros</u>

- Exclusionary surface screen.
- Release flow is collector flow for all outlet works flows.
- Good access.

- Can complement revisions to outlet works.
- Better attraction of fish than other lake collectors.

Cons

- Construction requires drained lake.
- Seismic design challenge.
- Not practical to phase.
- High cost; construction and operation.
- Challenges associated with debris handling during operation, proportionally more difficult than D3 and D4, due to higher flows.

4.3.3.9 Cost Considerations and Assumptions

The following considerations and assumptions were made in the cost analysis, which is summarized in Section 4.4. These are all major cost considerations, not just those that are different from D3.

- The penstock would be in place as part of the outlet works revision. The cost for D5 included the cost of extending the penstock 100 ft to the collector tower.
- D5 would be built as a component with D7 to create D11. In that case, D5 would operate only after high Piru Creek flows and the operation of D7 was temporarily interrupted. The trap would be operated until no more fish were collected. The costs assume that D5 would operate 50% of the time.
- The trap would be inspected for the presence of fish and any fish hauled once per day. For costing, it was assumed there would be fish present once every three days.
- Alternative D5 would eliminate the need for the low level outlet screens. Credit is given to the alternative for the cost of the outlet screen that would be included in the design of the outlet works revisions.
- Debris would be managed at the collector and there is no active lake debris management.
- Operating costs do not include any efficiencies due to compatibilities with upstream passage alternatives.

If not built concurrently with the outlet works revisions, there will be future additional cost of again draining the lake, including any power revenue losses.

4.3.4 D7 – Piru Creek Collector

The Piru Creek Collector is a downstream fish trap located in middle Piru Creek upstream of the lake. The function of the collector is to collect fish upstream of the lake and haul them downstream of Santa Felicia dam. A low rubber dam would divert Piru Creek flow into an off-channel dewatering screen. The screened water would return to Piru Creek and the lake. Fish would be bypassed and collected in a tank, loaded on a truck and hauled to a location downstream of SFD. A fishway would be provided for upstream passage of adult and juvenile steelhead and resident fish.

This alternative was sized to function to collect fish effectively up to 400 cfs, but would continue to collect fish (less effectively) at higher flows up a point when the trap would be overwhelmed, perhaps about 1,000 cfs. At that point, the dam would be lowered. Fish collection would cease when the dam is lowered and any fish migrating at that time could move downstream into Lake Piru. Alternative D7 is presented as a stand-alone alternative, but is combined with several alternatives involving surface and spillway collectors (D9 through D12) to examine the value of collecting fish in the lake that may make it past the Piru collector during higher flows.

4.3.4.1 Location

The collector would be located upstream of the normal lake backwater. Several candidate sites have been identified; the preferred site is shown on Drawing D7.2. This location was selected with the intent to locate the collector immediately upstream of the backwater when SFD just starts to spill at elevation 1,055 ft (full pool for Lake Piru).

While this site is desirable to maximize the fish collection capacity immediately upstream of full pool, it has some uncertainties that affect its efficacy. These include:

1. Operation of the D7 dam might affect the USGS gauge located upstream. If this site was used, the gauge might have to be relocated.
2. As described in Section 2.5, there is critical habitat for arroyo toad in the vicinity of the collector location. The diversion dam would create a temporary pool during the downstream fish passage season. It is not clear if the impacts on arroyo toad habitat of construction and operation of the collector could be mitigated.
3. The dam might also backwater into USFS property and affect a private stream crossing ford. Easements, operating agreements, and/or road relocation would presumably be needed to address this issue. The Panel understands that decommissioning of this crossing is currently being studied.

All of these issues would require further study.

Though a specific location is shown on the drawings, it is a provisional selection. The Panel has not visited the specified site, but has visited the area just upstream in order to establish an understanding of general channel conditions and practicality of the site. The location was selected based on aerial photos that show the extent of the lake. Extent of the D7 dam backwater was calculated with channel slopes from preliminary survey information.

A second general potential location was identified upstream of the USGS gauge at the inactive Blue Point Campground, which is the upper extent of an improved access road (see Drawing D7.1). This location would not affect the USGS gauge, is entirely within USFS property, but is outside of the FERC project (No. 2153) boundary. All design descriptions and drawings were based on the assumption that the lower site will be used.

Access to the lower site would include 3.6 miles of existing paved road that is in poor condition and needs to be repaved. The USFS is responsible for maintenance of the road as per an agreement with United. That agreement would have to be revisited during the pre-design of this alternative. An additional half mile of new access road would be required to the collector site. All but several hundred feet of the access road would be on United property. About 2.75 miles of new single phase power would have to be extended from the north boat launch to the site.

4.3.4.2 Dam

An Obermeyer dam, which is a pneumatically actuated flat plate dam (see Drawing 7.4) would be raised for operation and lowered during high flows. Primary benefits of this style of dam are that the upstream water level can be precisely controlled regardless of the flow and the dam can be entirely deflated to pass flood flows, debris, and sediment unhindered.

Though the site has not been surveyed, the Panel assumed a dam with a length of 30 ft and an inflated height of 5 ft would be appropriate. The height of the dam directly affects both the extent of the backwater created and the size and number of screen panels. For example, if the dam is a foot lower, the backwater will be reduced from about 1,700 ft (estimate range 860 to 1,667 ft) to 1,300 ft (estimated range 690 to 1,333 ft) and the number of 8-ft wide screens panels would be increased from 13 to 16.

The precise dimensions of the channel are not known. Based on the published USGS rating curve, the bank heights of the channel near the USGS gauge are about 3 ft high. To be sure there is adequate bank height to contain the backwater of the dam; low levees were included on each bank.

A pool and weir fishway would be provided at the end of the dam for upstream migrants, although its general location is provisional. It is shown on the right bank so it would be easily accessible for maintenance. The fishway could be designed to meet adult and juvenile passage criteria. The fishway exit would be located downstream of a headwall so juvenile fish and debris moving downstream would more likely enter the screen bay instead. The fishway is expected to have a low flow; perhaps from 1 to 6 cfs. The flow will depend on whether adult steelhead are released into Lake Piru and have to pass the Piru collector, or whether they would be released above the collector. The operation might also vary depending on whether a recent flow has overtopped the dam, creating the possibility of fish moving downstream over it. The design flow is a trade-off between high flows for attraction of adult fish and low flow to minimize passage of juvenile fish to Lake Piru. That flow could be varied for different streamflows by precisely controlling the dam backwater elevation.

4.3.4.3 Screen

The screens proposed for this collector, and the screens in all collector alternatives, are vertical travelling screens. The front face of the screen rises and lifts any impinged debris, which is carried over the top of the screen and down the back where it is washed off by the flow moving through the screens. Brush and spray cleaners can be added to the screen if necessary to enhance the cleaning. A photo of typical traveling screens is included on Drawing D7.3. The screen material would consist of engineered polymer mesh panels assembled in an interlocked belt similar to what is manufactured by Hydrolox. The screens would operate automatically either based on a timer or the headloss across the screens.

The screen area was sized to screen 200 cfs with a fry approach velocity of criteria of 0.4 fps. The design flow of 200 cfs is a provisional flow developed for the feasibility analysis. It is optimized based on preliminary sensitivity analysis of the BPT, which showed little marginal gain in performance with increasing collector capacity. The analysis is described in Appendix E. The sizing was also based on what the Panel believes is reasonable to operate in Piru Creek considering sediment and debris issues. The optimization analysis and the other sizing issues were based on current information and should be refined and a final design flow selected in the final design if this alternative is further developed.

The BPT analysis indicates there may be a benefit to continue operating the screen to some degree up to 1,000 cfs. The NMFS fry approach criterion was complied with at all flows up to

200 cfs. At flows from 200 to 400 cfs, all of the flow is screened; the fry approach velocity criterion would be exceeded, but the screen continues to comply with the NMFS fingerling criteria. These flows are selected because of the added complexity of operating a larger screen (e.g., sized for fry to 400 cfs), but marginal value indicated by the BPT results as described in Appendix E, E.4.2. At flows from 400 cfs to 1,000 cfs, 400 cfs is screened and the remaining flow passed over the dam, resulting in fish being passed to the lake. It is assumed that at 1,000 cfs the dam would be lowered to pass the flow and debris and sediment. These BPT assumptions should be tested in operational studies.

The hydrology of Piru Creek is described in Section 2.2. From that information, Table 4.3-2 shows the frequency that these specific flows are exceeded. Since proportionately more fish might move at higher flows than low flows, the flow frequencies, in themselves, do not accurately reflect proportions of fish moving.

Table 4.3-2. Flow exceedence frequencies for Piru Creek. Percentages (%) represent the percentage of time that a particular flow is equaled or exceeded in a given month, based on USGS records (USGS Gage #11109600).

Flow (cfs)	Jan	Feb	Mar	April	May	June	Jan-June
200	5%	18%	14%	12%	3%	0	9%
400	3%	7%	10%	4%	0	0	4%
1,000	1%	3%	1%	< 1%	0	0	1%
4,000	< 1%	< 1%	< 1%	< 1%	0	0	< 1%

Continued operation of the trap at flows greater than the design flow would depend entirely on its overall value for fish passage. There is likely value in operating up to some higher approach velocity to collect fish that would otherwise pass over the dam and be required to migrate through the lake. All of these flows are provisional and should be refined during final design and/or operational studies.

Table 4.3-3 shows an example of the flows and approach and sweeping velocities at the 200 cfs designed screen at the operational flows described above. Screen dimensions and geometry can be varied in final design to optimize the hydraulic conditions. The approach velocity (App Vel) is the velocity approaching the screen at its face. The sweeping velocity is the velocity at the upstream end of the screens assuming uniform flow in the cross section. With the velocities shown in Table 4.3-3, the screen would operate within NMFS and CDFW screening criteria for fry at flows up to 200 cfs and for smolts up to 400 cfs.

Table 4.3-3. Estimated hydraulic conditions of a 200 cfs screen design, under different flows.

Flow (cfs)	Screen Flow (cfs)	Fishway Flow (cfs)	App Vel (fps)	Sweep Vel (fps)
10	8	2	0.02	0.07
100	95	5	0.19	0.70
200	190	10	0.38	1.4
400	200 – 390	10	0.40 – 0.77	1.5 – 2.9
1,000	200 – 390	10	0.40 – 0.77	1.5 – 2.9

The dam crest could be controlled to hold the upstream water level constant up to a flow of about 1,000 cfs, which is further described below. The rating curve at the USGS gauge shows a water depth of about 3.5 ft. Low levees were included on each bank to contain the backed up flow from the Obermeyer Dam, to an elevation about 3 ft above the dam crest.

Electric power is required for operation of the screens and other features. Power can be extended from the northerly boat launch, a distance of about 2.75 miles. In case of power failure, a portable generator would be brought to the site.

4.3.4.4 Operation

D7 would operate throughout the downstream fish passage season (January through July 15 for Piru Creek collectors), except during very high flows. Operation would include an average of at least one inspection of the trap per day and fish would be hauled any time they are present. With experience and studies, a relationship of fish movement to hydrologic and weather influences might develop that could be used to refine trap operations. All fish would be transported within 24 hours of capture, which would likely be a shorter period of time than if fish have to traverse and be captured in the lake. The following sequence describes how the collection and hauling of fish would occur at the collector:

- Fish are diverted from Piru Creek into the collector and pass through the screen bypass.
- Flip gate distributes fish to one of two hoppers.
- A passive separator rack within the hopper would allow smolts to separate from held adults and predators.
- When a load is ready to haul, the flip gate moves to the other hopper to allow full-time collection of fish when the system is operating.

- A Gantry lifts the hopper over the truck and fish are transferred to hauling tank by water-to-water transfer.
- Large fish (such as kelts, bass, etc.) can be transferred manually into separate hauling tanks. It will be necessary to develop a protocol for handling non-native species for any alternative.
- Truck transports downstream migrants to the tailrace area where they are transferred to an acclimation pond, a transport distance of about 7 miles. Final release could be delayed to follow a period of acclimation and stress relief or as fish are motivated to move. Section 4.3.10 describes a Release Pond enhancement measure for release details. No specific release site or improvements have been considered.

Much of the normal operation of the screens and collector would be automated. Precise elevation of the dam and deflation during high flows would be controlled pneumatically with a compressor and actuated by water level and dam position sensors.

At very high flows, the dam would be entirely deflated and bulkheads dropped in front of the trashrack to protect the screen facility from sediment and debris. This closure is estimated to occur at a flow of 1,000 cfs, which is the flow at which the operating water level of the screens would be exceeded. After such a closure, the intake would be re-activated manually.

At about 4,000 cfs, based on the USGS gauge rating curve, the screen structure would be overtopped. Sediment and debris would likely have to be removed from the structure in order to put it back into operation. The frequency of flows exceeding 4,000 cfs has occurred an average of once every six years. The maximum flow into the reservoir was recorded in 2005, a flow of 40,000 cfs with a gauge height of 16 ft. These conditions will submerge the facility and will require repair and cleaning operations to put it back into service. The access road might also be damaged during extreme flows.

Screen cleaning operation would be automated and would be triggered by either a time period or headloss across the screens. Water level sensors would be installed to report headloss across the trashrack and screens and water level above the dam. Other sensors and automatic features would include screen operation and water level (flow) in the holding tank and status and security alarms. All sensors would report locally and remotely.

4.3.4.5 Optional Design Elements

In the process of developing the design, the Panel considered the following optional design elements, but these were not included in the current design or cost estimates:

- An alternative location at Blue Point was considered and might be necessary depending on the impacts and mitigation of the alternative on arroyo toad.
- Other screen capacities were considered. The selected design flow optimized the alternative and should be reviewed in final design.
- Lower and higher dams were considered.
- An angled orientation of the dam was considered to help guide fish to the screen bay. It was rejected because of operational difficulties caused by the angle of the inflation bladder relative to the streamflow and abutments.
- A fish ladder on the right bank was considered in conjunction with the angled dam. Without adding a bridge, there would be no access to the fishway during high flows.
- Access ramp for cleaning equipment to the screen forebay was considered.
- Several in-stream overflow screen structures were considered and dropped due to high and difficult maintenance requirements.
- A Farmer's Irrigation District style passive screen was considered. This is a screen that requires less head and therefore a lower dam, but as a trade-off needs significantly more length for the channel diversion. While this technology has recently been approved by NMFS and is no longer experimental technology, it is not clear how well it would operate in this situation. The Farmer's screen should be considered if this option is carried forward, but would not change the expected performance alternative.

4.3.4.6 Phasing Opportunities

D7 has several opportunities for phasing. D7 is a stand-alone alternative but can also be combined with other alternatives to form D9 (Section 4.3.5), D10 (Section 4.3.6), D11 (Section 4.3.7), or D12 (Section 4.3.8). It could be built as a first phase leading to any of the other alternatives.

D7 could be built with any design flow with the expectation that the structure might be expanded in the future to increase the design flow. The ultimate maximum operating flow would depend on how fish movement relates to flow and physical requirements to accommodate high flows (e.g., footprint and available, permissible sites; debris; sediment maintenance; etc.).

As with all downstream passage alternatives, the first phase would include design and implementation of studies to address basic uncertainties and potentially test potential sites. The implementation of D7 would likely begin with a simple fyke net collection facility in Piru Creek as part of the first phase to evaluate attributes of downstream fish movements relative to design.

4.3.4.7 Compatibility with Upstream Passage Alternatives

Alternative D7 has the following possible compatibilities with the upstream passage alternatives:

- A fish hauling truck could be shared with U4. The cost estimate assumed that D7 and U4 are separate operations, but they could be combined to reduce operating costs.
- D7 could provide a good release site for U4.

4.3.4.8 Challenges, Uncertainties, Risks

- The specific location of the D7 proposal is provisional. Siting was based on preliminary survey information and has not been investigated on site.
- Piru Creek is a flashy stream, which creates some risk related to operational timing. Most normal trap operations would be automated to mitigate the risk.
- The effects of sediment and debris are not thoroughly analyzed. The specific flow at which the screen must cease operation will not be understood until the facility is built and/or studies of sediment and debris transport are completed.
- The site is remote. Security is a risk. Fish will be held for some time before transport, which is a risk at a remote site.
- The USGS gauge, a private road crossing ford, and some USFS property might be backwatered. These are uncertainties and mitigation is not included in the design or cost estimate.
- The location might be moved to any specific location to minimize arroyo toad impacts though some impact might be unavoidable.
- The backwater effects on arroyo toad habitat are not clear and were not included in the design or cost estimate.

4.3.4.9 Pros and Cons

Pros

- Bypasses lake.
- Minimizes delay of outmigration.
- Could be phased with temporary trap.
- Phased step leading to further phases of D10-D12.
- Lowest capital cost and average annual cost.

Cons

- Sediment, bedload and debris might limit high flow operation.
- Screen criteria possibly exceeded (9% of season).
- Operation reduced during high flows (4% of migration season) and fish are passed to the lake.
- Backwater effects; including likely impacts to Arroyo toad habitat.
- Might require backwater onto USFS property and beyond the FERC project boundary.
- High operating cost.
- Remote site creates access, power, and security issues.
- Challenges associated with debris handling during operation, likely more difficult than D3 and D4, due to location upstream of reservoir.

4.3.4.10 Cost Considerations and Assumptions

The following considerations and assumptions were made in the cost analysis, which is summarized in Section 4.4.

- We assume that the trap will be inspected and fish hauled at least initially once a day. Based on operation experience, a relationship between flows (flows, flow changes, seasonality) and fish movement will be developed. The cost estimate assumes that over the long term, the trap will be inspected and fish hauled once every three days based on that relationship.
- The trap will be inspected for the presence of fish and any fish will be hauled once per day.
- Mitigation for backwater to the USGS gauge, a private road crossing, and USFS property are not included in the cost estimate.
- Mitigation of impacts to the arroyo toad is not clear and is not included in cost.
- Construction mobilization is higher for D7 because of its remote location, limited access road, and no power at the site.
- Operating costs do not include compatibilities with upstream passage alternatives. For example, road maintenance, hauling truck, and hauling trips are included in both D7 and U4. If these two alternatives are implemented, at least some of those costs could be consolidated.

4.3.5 D9 – Piru Creek Collector (D7) with Spillway Collector

Alternative D9 is a combination of D7 (the Piru Creek Collector), with the addition of a dedicated Spillway Collector located at the dam as shown on Drawing D9.1. The intent of this alternative is to supplement D7. As described in Section 4.3.4, the Piru Creek Collector would operate to efficiently collect fish to the 200 to 400 cfs design flows, but the collection efficiency would decrease at inflows greater than 400 cfs. This would be especially true when the rubber dam integral to Alternative D7 is dropped so fish could easily bypass the collection facility. During these periods, fish not collected at the Piru Creek collector would move downstream into Lake Piru, and would not likely find their way back upstream and into the collector. The Panel assumed that any fish passing the Piru Creek collector would not be collected again at that facility. As a result, several alternatives to supplement Alternative D7 were developed to collect fish downstream of Piru Creek.

The Spillway Collector is shown in Drawings D9.1 – D9.6, and could operate to attract and collect fish when Lake Piru is at or above its full pool elevation of 1,055.0 ft. The collector would utilize the first 500 cfs of flow that would normally be spilled, when inflows exceed the normal flow releases through the hydroplant and/or the low flow release valves. This alternative includes the Operate to Minimize Spill Enhancement (see Section 4.3.10), so the deep intake would take the second 500 cfs of flow, meaning no spill would occur until total outflows exceed 1,000 cfs. The facility would continue to operate and collect fish as the lake level rises above the spillway crest, up to elevation 1,058 ft, and then it would be turned off to protect the facility. Fish collected into the system would be screened from the collector's 500 cfs attraction flow and bypassed via a gravity flow open channel pipeline to a release site downstream of the dam (see Drawing D9.2). This alternative includes the Release Pond Enhancement, which is not yet developed or shown on the drawings, but is described in Section 4.3.10. The screened attraction flow would be routed back into the spillway downstream of the screens via a conveyance channel structure that would penetrate the spillway wall far enough downstream so it does not affect the spillway capacity. The spillway collector was sized at 500 cfs to provide a fair comparison between the high flow Alternatives D5 and D11, which also utilize 500 cfs collectors near SFD.

4.3.5.1 Location

The spillway collector is located at the dam, between the existing spillway and the earth fill dam section as shown on Drawings D9.2 and D9.3. This location takes advantage of the bedrock adjacent to the earth fill dam that the spillway is founded on, so the Panel assumed the collector entrance and structure can be safely constructed as a penetration through the existing spillway abutment and training wall by avoiding the earth fill section. The collector structure and screen would be parallel to and utilize the existing spillway wall, as shown on Drawing D9.3. This location would also accommodate the planned spillway improvements under consideration by United, and any consideration of this alternative would benefit from coordinated planning (see GEI 2015b).

Attraction flows of up to 500 cfs would be routed through the collector entrance. At flows up to 500 cfs there would be no other competing attraction flows near the collector entrance, and the location and entrance conditions should provide good fish attraction with a surface flow outlet. Subsequently, there would be less of a need for any hydraulic modeling to confirm the resulting flow patterns would be reasonable for fish attraction as described for the collectors located upstream of the dam (D3, D4, D5), other than to perhaps help design the entrance channel rock excavation leading to the collector opening.

4.3.5.2 Collector and Screens

The entrance at the Spillway Collector is configured to be similar to the 500 cfs condition described for D5, with a 2 fps velocity that results in a similar 16 ft wide by 16 ft high entrance as shown on Drawing D9.4. Like the other alternatives, the 500 cfs is considered provisional, and could be optimized based on further study if this alternative is carried forward. The bedrock located upstream of the collector would be excavated to slope up to the invert at an approximate 5% slope, so the attraction flow patterns would be amenable for fish attraction to the collector at the full pool elevation.

A trash rack and mechanical cleaner would be located at the entrance to prevent large debris from entering the collector. Given the debris loading seen at SFD, the Panel assumed an Atlas Polar type trash rake would be necessary to manage and dispose of debris collecting at the trash rack. An inlet gate would be provided behind the trash rack to fully isolate the collector entrance during times when it is not operating and to protect the facility during extreme high spill events.

There will be marginal fish attraction effectiveness after the pool reaches elevation 1,058 ft based on the ratio of spillway collector flow to flow passing down the spillway (see Section 4.3.5), so the Panel recommends that the collector be fully closed above that pool elevation. An inlet gate would be provided that can operate under flowing conditions to close the entrance to this collector. The gate would open from the bottom up, from invert elevation 1,039 ft until the bottom of the gate is fully out of the water at elevation 1,060 ft at the high design pool elevation for operation at elevation 1,058 ft. In its down position, the top of the gate would seal against a head wall across the top of the entrance that would protect the inlet to elevation 1,078 ft. The inlet gate would need to be functional under flowing conditions, so would likely be a roller gate rather than a simple bulkhead. If the gate was not closed at high flows, the trash rack and screen bay would be submerged and possibly buried in sediment. During extreme high flows (PMF), the entire structure will be backwatered by the high reservoir and significant effort will be required to put back into service.

The screens to separate the attraction flow from the fish bypass flow would be similar to the 500 cfs vertical traveling vee screens shown in D5; however, the “capture zone” was eliminated to facilitate discussion of this feature. The capture zone was included on the Swift and Baker FSCs; however, there are other similar FSCs coming on-line and some do not have this feature. The capture zone is a detail the Panel recommends requires further study. There is adequate length along the spillway wall, so addition of this feature would be feasible if studies show it is beneficial.

The downstream ends of the screens would converge to a 2.5 ft wide rectangular channel with an upward opening ramp gate configured with a 3 ft operating range to control the flow level in the fish bypass channel and flow into the bypass pipe (see Drawings D9.4 and D9.5). The floor of the screened section would be fixed for this alternative (Drawing D9.5), but unlike the floating collectors that move to track the variable pool level which also provides a constant area and resulting velocity through the collector, the fixed floor would result in lower entrance and conveyance velocities in the screen section at pool levels greater than 1,055.0 ft. The design of vee screens with a varying inlet condition to provide slightly increasing velocities towards the bypass is a technical challenge so this configuration will not result in ideal attraction and conveyance flow conditions towards the ramp gate. An adjustable floor through the screen could address this issue, which is noted as an optional item, and this detail can be studied further if this concept is advanced.

4.3.5.3 Spill Bypass and Spillway Survival Opinion

In developing this alternative the Panel considered bypassing the 500 cfs flow through its own “fish friendly” bypass channel created in the existing or updated spillway, but abandoned this concept as the screen and bypass pipe concept will be more feasible and have significantly higher fish survival given configuration of the spillway. The spillway starts out as a relatively wide, concrete lined channel that converges from about 500 ft wide to 110 ft wide along its 500 foot length of concrete lined channel. The spillway would then proceed down a 500 ft long unlined and rocky channel with a steep cascade/drop into a shallow spillway pool (see Drawings D9.2, and D9.6).

Studies of these types of spillways have shown that shear and strike associated with fish passage through spillways can result in significant injury and mortality to fry and smolt size fish (R2 Resource Consultants, Inc. (R2) 2006; Neitzel et al. 2000; R2 1998). Issues associated with this observation are the size and shape of the spill jets that enter plunge pools, the spread of flow across the spillway section, and whether or not the spillway is concrete lined and smooth, or rough rock. If the flow is confined and deeper, a smaller percentage of the fish are likely to be exposed to the periphery of the spill flow jet. Fish entrained in the middle of the flow will not experience extreme shear forces; rather they will gradually decelerate with the bulk of the flow as it enters the tailrace. On the other hand, with shallow wide sheeting type flow a greater percentage of fish would likely be exposed to extreme shear along the periphery of the jet both as it enters the tailrace and as it passes along the rock section of the spillway channel. This explains the typical field results showing greater mortality for small magnitude spills and reduced mortality with larger spill flows.

Dissipation of a spillway jet as it passes through the air in its trajectory to the plunge pool can also lead to injury and mortality. The more the flow breaks up and becomes aerated mist and less of a coherent jet, the greater the percentage of the fish that will leave the jet and freefall into the tailrace. Smaller fish are relatively resistant to the effects of a freefall into water, and were commonly stocked in alpine lakes by being dropped from planes or helicopters. However, larger fish (above 300 mm) experience higher rates of mortality when freefalling from the high spillway discharges. Therefore, larger fish are likely to fair better if they stay in the jet, whereas smaller fish would fare better if they fully leave the jet and freefall into the tailrace (R2 2006).

Based on the review of previous studies at other projects and laboratory studies concerning the effects of shear forces on fish, the following assumptions were made concerning the impact on fish of passing through the SFD spillway (note that additional refinement of the assumptions below was provided with the BPT analysis, but this discussion captures the overview for consideration of the fish bypass system for D9).

1. *Low to medium spill flow rates; the flow passes down along the wide and shallow spillway, and cascades down the rocky channel.* Assumed from 1,000 to 3,000 cfs. Assumed 70 to 95% mortality for fish of all sizes. Note per the spill analysis shown in Appendix C, this will be the case during a large majority of the flows. In fact, over the 67 year period of record, only two or three spill events exceeded this condition of the total 11 spill events modeled.
2. *Spill > 3,000 cfs; some of the flow remains in a coherent plume to the tailrace:* Assuming the fish do not strike the rocky channel or impact the bottom of the spillway pool the major source of mortality would be due to the shear effects on fish near the

periphery of the jet. The greater the magnitude of the spill the more likely the fish will be in the body of the flow and not exposed to the peripheral shear effects so there is a range of mortality probability, with decreasing estimated mortality associated with increasing spill flow rates. Assumed 60 to 90% mortality.

Note that these are just estimates based on field studies at other sites, laboratory tests of the effect of shear, looking at the spillway with no spill flow during a site visit, drawings of the spillway shape, and videos and photographs of spill at SFD. No actual field studies estimating mortality have been performed at this project. Results of spillway mortality field studies have varied and do not always fit in to what one might expect to find. There tend to be individual features of the spillways, stilling basins, and plunge pools at each project that do not fit neatly into a predictive model. Therefore, actual mortality rates for fish passing through the spillway cannot be known without actually performing field tests at the spillway. Even if the spillway was extended over the rock section and cantilevered over an excavated plunge pool, the expected survival would be substantially less than the survival expected with this alternative.

4.3.5.4 Fish Bypass Pipe

Fish exiting the ramp gate would pass through a rectangular to circular transition, and enter an enclosed 30-inch diameter (2.5 ft diameter) bypass pipe. Several options were examined for this pipeline, with the intent to meet NMFS fish bypass criteria hydraulic parameters (NMFS 2011).

The invert of the bypass pipe at the spillway collector is about 1,053.0 ft (Drawings D9.5 and D9.6), and the creek elevation downstream of the powerhouse is at about 863.0 based on limited topographic surveys and Google Earth elevations. An open air discharge at 865.0 ft would result in a total head of 197 ft to dissipate via the pipeline.

A smooth pipe alternative sized for 7 cfs bypass flow resulted in an 18-inch diameter pipe, with a slope of 0.003 feet/foot. This approach would require a 12 mile long pipeline, which is impractical at this site and would not be desirable from a fish passage perspective due to the long transport time. Therefore, the Panel proposed a 30-inch diameter corrugated metal pipe (CMP) bypass, with the following hydraulic parameters calculated using Manning's Equation for open channel flow:

Bypass Pipe Hydraulic Design Input Parameters

- Diameter: 30-inches (2.5 ft).
- Depth of flow, set at 0.4 x Diameter = 1.0 ft.
- Manning's n: set at 0.024 for CMP.

- Velocity: set at maximum 12 fps per NMFS criteria.

Bypass Pipe Hydraulic Design Resulting Parameters using Manning's Equation

- Slope: 0.086 foot/foot.
- Flow: 22.0 cfs.
- Froude Number: 2.44 (supercritical flow).
- Critical Depth: 1.59 ft.
- Critical Slope: 0.0181 foot/foot.

The resulting slope of 0.086 foot/foot would require a bypass length of at least 2,300 ft, or about a half-mile to descend the 197 ft. This approach for a bypass would fit well with the site, and could be routed along the spillway to pass below the existing access bridge, then follow the slopes along the hillside to the south of the dam and back towards the desired outfall location below the powerhouse as shown on Drawing D9.2. Some extra pipe length would be required to accommodate the actual topography and existing infrastructure, including some existing buildings, parking areas, access roads, etc. The pipe would likely need to bridge some areas, and be buried under the access road leading to the powerhouse.

This bypass would operate in supercritical flow, and this type of design with CMP material has been successfully utilized on several Columbia River fish bypass system bypass pipes. Alternate bypass configurations could be explored if this alternative is carried forward, but this is a reasonable starting point for discussion and the initial evaluation. Final design issues would include recommendations for as wide of a bend radius as possible, but likely no less than an R/D (Pipe Bend Radius / Pipe Diameter) of 5:1. Given the supercritical flow, as large of radius as possible is desired to maintain suitable flow conditions. Additionally, pipeline access ports near bends, and possibly spaced at an interval of approximately 250 ft should be considered to allow access throughout the pipe to assure it remains clear of debris. Other facilities have provided enough access to assure bends and joints are constructed correctly with no sharp edges or protrusions, and for inspection via remote camera.

The outfall of the pipe would be a free discharge into a release pond located downstream of the powerhouse (see Section 4.3.10). The 22 cfs flow is not seen as detrimental to upstream passage conditions in addition to the powerhouse flow and minimum flow release of 7 cfs, as this alternative would only operate during times when there would otherwise be spill; therefore no pump-back facility would be required to capture bypass flow in excess of 7 cfs (as compared to D14).

4.3.5.5 Screen and Conveyance Channel

Based on the 22 cfs bypass pipe design flow, 478 cfs would be screened and returned to the spillway given the 500 cfs spillway collector design flow. Drawings D9.3 – D9.5 illustrate the overall layout of the screen and conveyance channel. A set of guides would be provided between the trashrack and the inlet gate to allow closure with a maintenance bulkhead for entrance gate servicing. A transition section shown as 40 ft long downstream of the entrance gate would provide a section for flow straightening to provide good entrance and boundary conditions to obtain uniform flow through the vee screens.

Following the screened section, the conveyance channel would parallel the spillway wall, and terminate with an angled wall to direct flow back to the spillway channel through a penetration in the spillway wall. A sluice gate would be provided at the spillway wall to control the attraction flow rate and depth in the conveyance channel. This sluice gate would also close to isolate the spillway collector channel from backwater in the spillway channel during high spill flows. The invert of the spillway collector is set at an elevation high enough above the spillway floor so it would not to affect the spillway capacity during low to medium spills. Additional study would be required to finalize the design of this concept, and coordination with United's planned spillway improvements would also be necessary.

4.3.5.6 Operation

This section summarizes how the spillway collector operates, followed by a discussion of when it would typically operate to supplement D7, the Piru Creek Collector.

Spillway Collector Operation

The Spillway Collector would only operate between pool levels 1,055 to 1,058 ft, as described above. The inlet gate would typically be closed, until conditions allowed operation as described in the next section. The following steps provide an overview of the system operation.

- As operation of the system is anticipated (based on pool levels and flow predictions), operators would inspect the intake area and confirm the trashrack is clean prior to opening the intake gate. The Panel envisions a modified Atlas-Polar type hydraulic trash rack rake system, with a changeable head on an articulated arm that could grab and pick up debris such as logs in addition, to the normal rash rack cleaning head normally provided with these rakes. As a normal operating protocol, the trashrack should be cleaned after each operation of the spillway collector, so it is ready for the next spill as operations staff will likely be coordinating several items when spill is anticipated.

- When the pool is at or near 1,055 ft, the inlet gate would be fully opened. Once the gate is opened, automated controls would regulate the ramp gate and the conveyance channel sluice gate to control total flow and water levels. For this alternative we assume the system would operate with a full flow of 500 cfs, which would be maintained from pool elevation 1,055 to 1,058 ft. Note that the ratio of flow through the spillway collector relative to total flow over the spillway and spillway collector decreases (see Table 4.3-4).

Table 4.3-4. Summary of spillway collector operation, flows relative to spillway and total spill based on pool elevation (from hydrology records, modeled taking first 1,000 cfs).

Pool WSEL (ft)	Spillway Collector Flow (cfs)	Flow over Spillway (cfs)	Total Flow (Collector + Spillway) (cfs)	Percent of Spillway Collector Flow over Total Flow	Total Number of Days with Spill	% of 82 days with spill when modeled spill flow exceeds when taking first 1,000 cfs*
1,055.0	500	0	500	100%	82	100.0%
1,055.5	500	707	1,207	41%	37	45.1%
1,056.0	500	2,000	2,500	20%	18	22.0%
1,056.5	500	3,525	4,025	12%	9	11.0%
1,057.0	500	5,200	5,700	9%	5	6.1%
1,057.5	500	7,013	7,513	7%	1	1.2%
1,058.0	500	8,885	9,385	5%	0	0.0%
> 1,058.0	0	> 8,885	> 8,885	0%	0	0.0%

* calculated by taking the number of days of spill for each row, divided by the base of 82 days

- Flow and fish entering the system would move downstream through the collector and bypass system, over the ramp gate and down the CMP bypass pipe, where they would travel about 0.5 miles and spill into a receiving pool downstream of the powerhouse.
- The screened attraction flow and spill would pass down the conveyance channel under automated regulation by the sluice gate, and would pass into the spillway downstream of the spillway crest. This flow would proceed down the spillway as it does now.
- The operation described above would be held constant by automated controls up to elevation 1,058 ft on a rising limb of a flood or spill hydrograph, and then would be stopped by closing the inlet gate and then the conveyance channel sluice gate to protect the facility during extreme floods. This is an infrequent event, and is described further in

Appendix C for the "maximize to take up to 1,000 cfs prior to spill" scenario (Scenario 3).

- The above process could be reversed on the falling limb of a hydrograph, as the pool dropped in elevation back through the elevation 1,058 to 1,055 ft ranges, if debris accumulated at the dam is not too severe.

Debris for the Spillway Collector would need to be managed at several levels similar to the reservoir collector alternatives D3, D4, and D5.

- A floating trash boom for large debris could be provided similar to the floating boom for D3 and D5, and a potential trash boom alignment is shown on Drawing D9.1. The boom could extend upstream along the east shore of Lake Piru, and be angled across the dam face towards the spillway to help route floating debris over the spillway during high flows. Given the large fluctuation of the lake levels, this debris boom will require special design and potentially could be removed or partially released during lower lake levels.
- As noted for D3 and D5, actively managing the reservoir for debris when flows allow could also help mitigate debris at the dam; however, with the spillway collector alternative this may still not be feasible during extreme floods that cause heavy inflows of debris into the lake.
- A trashrack and mechanical trash rake would be included at the upstream end of the collector as shown on Drawing D9.2 – D9.4. Given the proximity to the top of the dam, trash could be lifted to the deck level and disposed of, or lifted and placed onto the downstream side of the spillway. The floating debris pen described for D3 and D5 is not seen as a desirable solution for this alternative, as it could be difficult to maintain during a rising limb when spill is occurring.
- The vee screens would be fabricated with vertical traveling screens that would help to mitigate debris collecting or clogging the screens or getting stuck in the transition from the ramp gate into the bypass. Debris that passes the screens and ramp gate would proceed down the fish bypass pipe. A video camera monitoring system could help operators monitor this location and send staff to assist with debris removal when needed.
- Access ports within the bypass pipe would be desirable at some interval in case debris gets clogged in the closed pipe system (see Section 4.3.5).

<u>Operational Periods</u>

The 500 cfs collection flow was selected to provide a fair comparison between D5 and D11, which also utilize 500 cfs collectors near the dam that can operate at any pool elevation. As noted earlier, the fish passage operating season for all downstream collectors is assumed to be from January through July 15. Because the spillway collector feature of D9 is presented in addition to the Piru Creek Collector, D7, it would typically only need to operate when high flow conditions allow fish to pass D7. As configured for this analysis, the spillway collector feature can only operate at or above the full pool elevation of 1,055 ft, when the project would normally be spilling.

This alternative includes the "operate to minimize spill" enhancement described in Section 4.2.5, with the spillway collector taking the first 500 cfs, then the deep intake taking the second 500 cfs. This operation would result in the spillway collector operating every 8.4 years on average, with an operational frequency based on the number of spill events every 6.1 years on average (see Table 4.2-2). The total number of operational days expected over the 67 years of record is 82 days, or 11 spill events. The percent time of the spill days at various pool levels is reported in Table 4.3-4. This table also illustrates how infrequently this system would operate when spilling. Given this low frequency, the high design pool elevation could be refined to a lower level if this option is carried forward to a lower elevation.

In addition to the infrequent operation, the spillway collector's effectiveness is optimal only when there is little or no spill. As shown in Table 4.3-4, the collection efficiency of the collector would decrease as the ratio of flow through that collector is reduced relative to the total flow through the collector and over the spillway. For example, at Pool WSEL 1,056 ft, the 500 cfs through the Spillway Collector is only 20% of the total flow being spilled (500 cfs collector plus 2,000 cfs of spill). If it is assumed that fish follow the mass flow then 80% of the outmigrating fish may pass over the spillway.

4.3.5.7 Optional Design Elements

The following optional design elements were considered by the Panel but are not included in the current design or cost estimates:

- Deepen the invert at the spillway collector entrance to allow operation at reservoir elevations lower than 1,055 ft. This approach would require bypassing flow that currently is stored. This approach would also need a 15 cfs pump-back facility to return all but the 7 cfs minimum flow release from the 22 cfs fish bypass pipe.
- Movable floor in vee screen. As noted above, a fixed floor was assumed for the fish bypass towards the ramp gate in the vee screen configuration. The disadvantage of this approach is a decreased velocity into the collector at pool elevations greater than elevation 1,055 ft, for which the fixed floor was optimized. A movable floor and variable geometry could be developed to better control velocity and attraction through the bypass.

- In addition to the 500 cfs collector, the Panel considered other spillway improvements to increase fish passage survival for fish that would pass over the spillway. Due to the infrequent spills that would benefit from these concepts (see Section 4.3.5), these alternatives were not developed further or evaluated. The following elements could enhance spillway survival through the existing system:
    - Smooth existing spillway channel to reduce potential for fish injury in the spill channel;
    - Notch the spillway and add an additional gate, potentially with a guide wall or curb to contain spill flow dedicated to fish passage;
    - Lengthen the concrete lined section, and cantilever the downstream end over a plunge pool, and excavate a deeper plunge pool (energy dissipation at the almost 200 ft of head will still be an issue).
- Eliminate the fish screens and bypass pipe, and use the full 500 cfs for a passive, dedicated fish bypass. This is similar to the second bullet in the item above, and was not carried forward due to the challenge of fish survival given the energy dissipation necessary for such a large plunge.

4.3.5.8 Phasing Opportunities

Alternative D9 is defined as a combination alternative that would be phased to follow D7. It could also be constructed without draining the lake.

Given the space available near the spillway, the size of the spillway collector could also be developed in phases. For example, space could be created in the collector box for larger screens, but would initially start at a lower flow such as 150 cfs vs. the 500 cfs assumed for this analysis. There is also adequate space for larger screens, such as 1,000 cfs.

4.3.5.9 Compatibility with Upstream Passage Alternatives

Alternative D9 is completely independent of and fully compatible with all of the upstream passage alternatives. It would require coordination of placement of the fish bypass pipe discharge point, to be downstream of any upstream fish collection weir, and to avoid confusing flow patterns from the 22 cfs fish release flow.

4.3.5.10 Challenges, Uncertainties, Risks

One area of concern with the spillway collector is its location in the existing spillway abutment, its compatibility with the earth fill dam and future spillway improvements, and general dam safety concerns. The interface and stability of the spillway wall would need further analysis to better define the exact location and costs. For the purposes of evaluation, the Panel has assumed there are no fatal flaws associated with dam safety issues for this alternative.

The ability to reliably shut off the entrance gate will be somewhat dependent on debris control. The open distance between the trashrack bars will need further study, but typical openings for fish collector trashracks are on the order of 4 to 6 inch to accommodate downstream passage, which is larger than typical hydro intake bar spacing. It is possible that small logs and other debris could pass through the rack and prevent the gate from closing fully. This in itself would not be a dam safety issue, and the flow could be controlled by the downstream sluice gate and ramp gate, allowing maintenance under the entrance gate.

The attraction velocity into the system with a fixed screen bypass floor would decrease as the lake level rises during a rising hydrograph. This situation, in addition to the decreased ratio of spillway collector flow versus the increasing spill down the spillway would both render the spillway collector less efficient as the lake level rises. Provisions could be considered to help maintain the 2 fps entrance flow at all lake levels with a movable screen floor.

The need for the approximate 20 ft long capture zone would require further study and monitoring of existing surface collector systems, and new similar systems planned for the Pacific Northwest region that collect steelhead.

4.3.5.11 Pros and Cons

Pros and cons listed below are in addition to those noted for D7.

<u>Pros</u>

- The Spillway Collector provides a means to collect fish that bypass the Piru Creek collector.
- Does not require any additional water, operates on flow that would be otherwise be spilled.
- The Spillway Collector is independent of all other options, and could be phased at any time.
- Ability to phase screen size.
- Screening technology and fish bypass system is proven effective at existing facilities.
- Introduces bypassed fish to Piru Creek in a controlled flow section not affected by flood flows.

- No predation concerns.
- Good access for construction and maintenance. Would not require draining of the reservoir, only lowering the lake below the collector invert elevation which is a common and predictable condition.

<u>Cons</u>

- Use of the Spillway Collector would be very infrequent, creating a marginal benefit to fish passage.
- Lack of use for long periods could result in non-operational parts or systems if proper maintenance and exercising was not performed.
- Typical debris, cleaning, and maintenance issues associated with traveling screens and moving gates.
- Challenges associated with debris handling during operation, as noted with Alternative D3.
- Automation would need to be able to act fast to take advantage of spill when it exists. Manual observation and removal of debris prior to the fish bypass pipe entrance would be desirable during high debris load periods.

4.3.5.12 Cost Considerations and Assumptions

The following considerations and assumptions were made in the cost analysis, which is summarized in Section 4.4.

- Capital and operating costs are the sums of the costs for D7 plus the Spillway Collector cost for D9.
- The spillway collector associated with D9 would operate only after high Piru Creek flows and the operation of D7 is temporarily interrupted. The trap would be operated only at full pool or above. To help estimate labor associated with debris management at the trashrack and upstream of the fish bypass pipe, the Panel assumed that the spillway collector would only operate when pool level and flow conditions allow (estimated as every 8.4 years on average).
- There would be no lost storage or hydro operation.
- Operation and maintenance costs were assumed based on limited operation, and routine maintenance and inspection associated with all systems and moving parts.

4.3.6 D10 – Piru Creek Collector (D7) with 150 cfs Surface Collector

Alternative D10 is a combination of the Piru Creek collector (D7) and the 150 cfs surface collector (D3) as shown on Drawing D10.1. These alternatives were assumed to be implemented in a phased manor. This section describes only the aspects of combining D3 and D7; specific details of D3 and D7 are described in Section 4.3.1 and Section 4.3.4 respectively.

When D3 is operated in conjunction with D7, D3 would only need to operate when the dam in Piru Creek integral to D7 is partially lowered and fish have potentially passed into the lake. It was assumed that D3 would then operate for a specific period of time, perhaps two weeks, or until there are no more fish trapped. In some years, no fish will bypass the D7 collector, in which case D3 may not need to operate that season. For the operating cost analysis, it is assumed that D3 would operate a third of the time overall.

4.3.6.1 Cost Considerations and Assumptions

- Capital and operating costs are the sums of the costs for D3 and D7.

4.3.7 D11 – Piru Creek Collector (D7) with 500 cfs Surface Collector

Alternative D11 is a combination of the Piru Creek collector, D7 and a tower collector in Lake Piru with the 500 cfs surface collector, D5. A schematic drawing for this alternative as component locations is shown in D11.1. The same assumptions and cost considerations apply to D11 as D10 (see Section 4.3.6 for the combination description and Section 4.3.3 for D5).

4.3.8 D12 – Piru Creek Collector (D7) with Movable FSC

Alternative D12 is a combination of D7 with the addition of a movable Floating Surface Collector (FSC). The intent of this alternative is similar to D9, but D7 would be supplemented with a movable FSC rather than the spillway collector to help collect fish that bypass the Piru Creek Collector at high flows.

Drawings for the movable FSC are shown in D12.1-D12.3. The movable FSC is similar to the floating collector shown in D3, with the 150 cfs attraction flow capacity and similar screening and fish collection and transport system, except this collector would be a self-contained barge that could be positioned essentially anywhere in the reservoir. Fish transport would be via barge to shore, where they would be moved onto trucks for transport downstream of SFD.

A movable FSC alternative was initially considered as a stand-alone alternative (originally designated as Alternative D2); however, it was not ranked high by the Panel so was dropped. It had the lowest score in the initial evaluation matrix including the lowest BPT score, primarily related to challenges with collection and transport due to seasonal repositioning, and a lower safety score due to access.

Three enhancement features were included with the design of D12 as shown in Table 4.3-1 including Operate to Minimize Spill, Release Pond, and the Deep Outlet Screen.

4.3.8.1 Location

The primary advantage of the movable FSC is the ability to locate the collector anywhere in the reservoir. The initial benefit of this feature is the ability to keep the FSC near the upstream end of the lake at all pool elevations to allow the collection of fish as soon as they enter the lake before they disperse. The only limit of how close the FSC could be to the mouth of the creek is the depth necessary to operate and moor the barge. A location close to the creek/lake confluence was assumed to perform better for fish collection, with less risk of exposure to predation, potentially poor water quality, and a larger area by definition for fish to find collectors located downstream of this location. This alternative would benefit from results of studies on fish movement, predation risk, and water quality which would enable it to be located where it would have the best opportunity for fish collection.

Drawing D12.1 shows three potential locations of the movable FSC at various pool elevations. As noted above, the location possibilities are only limited by depth and anchorage needs. These locations include:

- Full Pool (High Fish Passage Pool elevation 1,056 ft): located at the far north end of Lake Piru at the creek confluence.
- Mid Pool: located at or in the delta, where the creek has created a flowing channel, and there is adequate depth for the FSC.
- Low Pool (Low Fish Passage Pool elevation 980 ft): located in the deep water near the north end of lake.

4.3.8.2 Collector and Screens

The fish collection feature of the movable FSC would be similar to that described for D3 with an intake sized to optimize fish attraction, screens to separate fish from the bulk of the pumped attraction flow water for ease of handling, and short term holding pools with a hopper and loading/hauling system to move the fish downstream. A plan view of the movable FSC is shown on Drawing D12.2, and a section view through the center of the FSC is illustrated on Drawing D12.3. The entire FSC is a self-contained floating barge, which allows a constant operating condition to attract fish at any pool elevation. Attraction flow is created by low-head pumps that are located towards the upstream end of the floating barge, near the screen inlet for fish. The screens and hopper system are contained within the barge.

The size of the FSC is determined by the attraction flow and resulting screen configuration and size, as described for D3. For this alternative the exact same screen box sized for 150 cfs, with a vee configuration, capture zone, and approach velocity of 0.8 fps to protect yearling fish was developed to allow comparison with D3. Note that this design flow is provisional (see Section 4.3.1 for a full description of the screen configuration and features).

Water that passes the screens and the capture zone would carry fish through a flow control gate that maintains a constant flow into the bypass independent of the tilt (fore and aft) and the list (side to side) of the floating barge. As this would be a dynamic, floating facility, an automated flow monitoring and control system would be required to maintain a constant flow into the bypass. After the flow control gate, the bypass flow and fish would pass a flume switch gate, which would direct fish into one of two short term holding tanks. Small, floating debris would also be conveyed through the bypass and into the holding tanks. At other facilities (for example the Swift FSC on Lewis River in Washington) this can be a labor intensive exercise during times of high debris loads. However, it is beneficial to remove debris prior to entering the holding tanks and to keep the bypass channel clear to help minimize potential for fish injury.

A trash rack would be located at the entrance to prevent large debris from entering the collector. Floating debris has been a high-maintenance issue at other FSCs, so a mechanical cleaner is recommended to help handle large debris, and minimize debris that enters the screening system. Disposal of debris would be an issue to work out depending on where the FSC was positioned. Either passing the debris downstream or lifting and storing debris on a barge may be necessary. In either case, the debris management is a key issue to address.

4.3.8.3 Fish Holding and Transport

The fish holding system envisioned for the movable FSC is relatively simple, with holding tanks sized as 8 ft square by 8 ft deep for illustration. The tanks would be fitted with fish hoppers and passive gradation racks to help provide refuge for juvenile fish away from adults or other large fish that may be predators. Fish would be held with circulating water in these tanks until transfer. Two tanks are provided so the collector can always be operating with one tank while the other is being transferred. A redundant, duplex pump water circulation system is recommended to assure proper water quality if a pump should fail.

The FSC would have a gantry crane to lift the hoppers and transfer the tanks to the side of the barge, where it would transfer the load onto a work boat. The FSC would have a secure moorage for the work boat to allow a rigid connection (like a hydraulic boat lift) for stable and safe transfer of fish and personnel access, even during rough water. The hopper would then transfer its load via water-to-water transfer to fish tanks on the work boat. These portable tanks would be used for the duration of the downstream transport.

The transport tanks would be driven to shore, to designated loading stations. Drawing D12.1 shows several options for truck loading depending on the lake level and FSC location. These locations include:

- Off-loading location at existing southerly boat ramp and marina for use at low-pool.
- Off-loading location at existing northerly boat ramp for use at mid-pool.
- Off-loading location at a new truck loading ramp and access road provided near the north end of the lake for use at full-pool.
- Once at shore, the tanks would be lifted from the work boat and set on a fish truck. There are several ways to achieve this lift, given the variable pool elevation: A portable crane could be brought in and kept at the site for the fish migration season. This is assumed for costing of this alternative. The crane would then lift the tanks from the work boat, and set them on a flatbed truck.
- The fish trucks could be fitted with a portable crane arm sized with adequate capacity and reach to transport the tanks onto a flatbed truck.
- A permanent crane system could be built on a rail along a boat launch ramp that could track the varying pool levels.

In any of the above scenarios, some improvements would be necessary for the existing boat ramps. A decision could be made later on how many access points are needed based on a more detailed study of these alternatives, and transport by boat vs. truck time and risk.

The transport tanks would all be fitted with life support systems to provide circulating water while on the work boat, and oxygen while on the fish trucks. Temperature control may also be necessary, which is achieved at other similar collection and transport systems with addition of ice blocks or mechanical chillers on the fish trucks.

Fish would be hauled and released downstream of SFD. Though no specific release site have been developed in detail, it was assumed fish will be released into a section of the fishway entrance pool appropriately designed for holding fish, or a separate release facility.

The tank dimensions, configuration, and transport system would all need to be revisited and refined if this concept is carried forward.

4.3.8.4 Barge and Anchorage Features

The FSC barge shown is sized to incorporate some of the features of the Swift FSC which is on the Swift Reservoir in Washington, and the Cougar FSC on Cougar Reservoir in Oregon. Given the screen box shown, this facility would be about 100 ft long by 50 ft wide. The Panel assumed this would be a dedicated FSC destined to remain in Lake Piru, so modular construction for transport would not be necessary, and the FSC could be fabricated on site.

Given the goal of multiple locations within the lake, the barge would need to be self-contained with a fuel source, on-board generator system to run the attraction flow pumps, controls, and lighting, and likely a back-up generator. The barge would need suitable provisions for staff to operate, inspect, and transfer fish from the facility on a daily basis. There would be room for portable toilet facilities on deck, and water storage for potable water. Considerations for personnel covers and any office space were deferred for this analysis.

A self-contained anchorage system with at least four anchors and automated winches is shown (D12.1), which is similar to the Cougar FSC. The anchors would be designed to be deployed at all lake depths expected for its location and pool levels, and would need to maintain the barge within a target watch circle for all wave and wind conditions.

Some FSCs have adjustable ballast tanks, and are configured such that they can be raised to allow above-water access to the screen systems for maintenance. Those issues can be addressed during any final design effort if this alternative is carried forward.

4.3.8.5 Operation

It was assumed that the FSC would be operated only when the D7 dam has overtopped and fish have potentially passed into the reservoir. It would then operate for a specific period of time, perhaps two weeks, or until there are no more fish being trapped. In some years, no fish will bypass the D7 trap. For the operating cost analysis, it was assumed that D12 would operate a third of the time overall.

4.3.8.6 Optional Design Elements

The following optional design elements were considered by the Panel but are not included in the current design or cost estimates:

- A Collector Transition Structure (CTS) was identified as an optional design element, and is described further in Section 4.3.10 as a downstream enhancement item. Additional study is recommended on the biological attraction performance and collection efficiencies of the existing FSCs in service prior to making a decision on whether a CTS would be beneficial for SFD.
- More advance fish holding, life support, and sampling facilities could be considered, to reduce handling on fish and return any residents or species not destined for transport on the barge. For this alternative no sorting was assumed and that anything collected would be transported downstream.
- An adjustable ballast and belly tank system could be provided to float the FSC up into a maintenance level when it is not in use. This has the benefit of full screen access for maintenance, and to reduce the time operating parts are submerged; however, this is a complex system that requires more capital and operating cost, and special training and certifications to operate to assure stability and personnel safety.
- Barrier or guide nets could be used to provide a more positive guidance of fish into the FSC. However, given the highly fluctuating lake levels and movable concept, nets would be difficult to deploy and maintain.
- More automation, operator provisions, and control features could be provided over time as operational experience is gained.

4.3.8.7 Phasing Opportunities

Alternative D12 is defined as a combination alternative with the Piru Creek Collector, D7. By definition, this concept would have the same phasing opportunities as D7, and the spillway collector could likewise be added as a potential final phase to D7. Additional improvement and phasing opportunities include:

- More permanent anchorages could be provided.
- Loading improvements.
- The flow capacity of the FSC could be sequentially expanded (for example, design and construct as modular to allow possible expansion from 150 cfs to 500 cfs if fish do not find the entrance and data shows higher flows could be beneficial).
- Permanent mooring with shore access could be provided.

4.3.8.8 Compatibility with Upstream Passage Alternatives

Alternative D12 is completely independent, and is fully compatible with all of the upstream passage alternatives.

4.3.8.9 Challenges, Uncertainties, Risks

Effective and efficient fish collection is the largest risk of the FSC option, D12. It is a partial collector by definition, so it relies largely on the ability to attract fish from the lake. The 150 cfs flow capacity is provisional as described for Alternative D3.

From an operational perspective, safety risks for personnel working over and on the water are higher than shore-based facilities. This is especially true for operation in high wind and wave conditions.

Debris handling, and especially means for debris removal during periods of high debris loading, would be a challenge.

The movable FSC will need to be repositioned and that would make it difficult to structurally support a CTS (see Section 4.3.10). The Panel has assumed a CTS will not be included with the movable FSC; however, the need for a CTS on this facility will require further study and monitoring of existing surface collector systems, and new similar systems planned for the Pacific Northwest region that collect steelhead.

4.3.8.10 Pros and Cons

Pros and cons listed below are in addition to those noted for Alternative D7.

<u>Pros</u>

- FSC technology is starting to be considered a proven design with salmon/steelhead (surface oriented species with a drive to outmigrate).
- More flexible location, could locate anywhere in reservoir.
- Can position for more favorable lake location than fixed collectors, and can adjust the location as more fish location data is available.
- Movable FSC component is completely independent of other alternatives, could be phased at any time.
- Pump driven system does not require any water reduction from existing operations.
- Screening technology and fish bypass system is proven effective at existing facilities.

- Would not require full draining of the lake to construct.

Cons

- Partial collection device, may miss some fish.
- Complications of anchorage with variable water level and movable location.
- Operation of a vessel/barge and work on/over water for personnel safety.
- Existing FSCs utilize barrier nets to enhance performance; nets would be difficult for these design conditions.
- Generators need fuel, create noise.
- Fish transfer more difficult with boats or floating pods.
- Interference with recreational use of Lake Piru.
- Challenges associated with debris handling during operation, as noted with Alternative D7.
- Typical debris, cleaning, and maintenance issues associated with traveling screens and moving gates, plus more limited options for removing debris from the FSC and inlet area.

4.3.8.11 Cost Considerations and Assumptions

The following considerations and assumptions were made in the cost analysis, which is summarized in Section 4.4.

- Capital and operating costs are the sums of the costs for D7 plus the movable FSC cost for Alt D12.
- The Movable FSC component of D12 will operate only after high Piru Creek flows and the operation of D7 is temporarily interrupted. To help estimate labor associated with debris management at the trashrack and on the collector, it was assumed that D12 will operate a third of the time overall (see Section 4.3.8).
- Operation and maintenance costs are assumed based on limited operation, and routine maintenance and inspection associated with all systems and moving parts.

4.3.9 D14 – Multi-Level Crest Gate Collector with Helix Bypass

Alternative D14 is a stand-alone downstream passage alternative that provides 150 cfs attraction flow via multi-level intakes that track the pool level through the full fish passage range. This alternative uses the full attraction flow as the bypass through the dam, and has a dewatering screen and pumpback facility below the dam. A total of 7 cfs bypass flow with fish is routed back to the creek, and 143 cfs is pumped back to the lake. This concept is a more passive means to collect and bypass fish than by screening at the inlet end, and was examined based on input received from NMFS in November 2014. It was intended to capture the concept under development by the USBR for the Cle Elum Dam Helix bypass system in Washington State. The final design for that project is scheduled to be completed by the end of June, 2015, with construction to follow possibly later in the year.

The Cle Elum project is a USBR water storage project on the Cle Elum River in the Yakima River basin, and the reservoir has a similar high water level fluctuation to Santa Felicia but more regularly on an annual basis. The biggest difference between these two projects is the flow release regime: where Santa Felicia has a relative low typical bypass flow (7 cfs), the Cle Elum project is being designed to release about 300 to 400 cfs over a 60 foot pool elevation when the fish bypass system is running. This is a significant difference, as the USBR is relying on that full amount for their fish attraction flow that will all be bypassed down their helix energy dissipation system directly to the river (USBR 2014). The helix design provides a relatively high slope, small diameter open channel flume oriented in a vertical helix with velocities ranging from 35 to 40 ft per second at 400 cfs. This is a new technology and the USBR has performed extensive physical hydraulic modeling to develop and hydraulically validate the concept for safe fish bypass.

In developing D14, the Panel considered several options for using this “multi-level intake gate with helix bypass” technology. As a starting point the same 150 cfs attraction flow as the previous alternatives (D3, D4, and D10) was selected to allow a consistent comparison of alternatives. Given the normal 7 cfs bypass flow at SFD, the options then considered to define this alternative included:

- Use a similar screening system to D3 to screen the attraction flow prior to bypass, and provide the helix as a passive bypass system for the resulting 7 cfs bypass flow. This approach would require a movable screen system to track the lake levels, or multiple screens. The only difference then between D3 and this concept is the bypass system, which would be more complex than the truck concept, so the Panel did not develop this concept.
- Use an Eicher style inclined screen within a closed conduit to dewater from 150 cfs to 7 cfs, pass the 7 cfs through a tunnel in the dam, and use the Helix on the downstream side of the dam to return the bypass flow. This screen could be provided upstream of the dam which would locate the pumpback facility closer to the return flow and decrease the return flow pipe length; however, the screen would need to be at a low elevation so would need to be in an underwater vault to allow maintenance. An alternate approach

would be to provide multiple screens at different intake levels, or a moving screen structure. The Panel considered both of these concepts too complex due to confined space concerns and the difficulty of handling debris.

- Provide multi-level passive intakes sized for 150 cfs attraction flow, and bypass the full amount to a location downstream of the dam. This approach would be totally passive, and unless it was only operated during normal times of spill would result in a significant yield loss to United, and so it does not meet the design goals.
- Provide the same multi-level 150 cfs passive intake gates as the above bullet, and pass the full 150 cfs in a tunnel through the dam with a pump back facility to return 143 of the 150 cfs attraction flow.

The last concept noted above was unique to the other downstream alternatives, and represented the best use of the helix technology for SFD. That concept was therefore applied in the development of D14 as shown on Drawings D14.1-D14.8. This facility would have the same operational range as D3 and D5, from the low fish passage design pool elevation 980 ft to the high pool design elevation 1,056.0 ft.

This alternative could also be explored at the higher 500 cfs attraction flow, but given the complexity of the pump-back and screening system, the 150 cfs was utilized as a starting point for the analysis and to see how it compares with other alternatives.

4.3.9.1 Location and Access

The intake facility for D14 would be located similarly to the towers for D3, D4, and D5, upstream of the planned low level intake as shown on Drawing D14.1. This location is intended to be far enough upstream to avoid interference with spillway flows, but near enough to the deep intake location to take advantage of flow fields from that intake to help attract fish to the area. This alternative is shown as completely separate from the new intake, with a separate bypass tunnel, and would be compatible with the planned intake and spillway dam safety modifications. Attraction flows of 150 cfs would be passed over intake gates that track the pool level, and bypassed into a closed conduit helix rectangular open channel flume constructed in a tunnel through the dam.

The exact location and orientation of the collector is provisional like D3, and would be refined in later stages of design to be sure it does not interfere with the spillway operation and to be oriented to maximize fish collection. An understanding of flow patterns created by the collector, outlet screens, spillway, and wind might affect the specific orientation and location, and hydraulic modeling would support that design effort.

The intakes, gates, and trashracks would need to be accessible on a regular basis for inspection and maintenance. Access to the facility was assumed to be via boat, as it would allow direct access to the operating level. This may be easier than a large stairway that would often be submerged; however, an access stair is shown for discussion. An alternate access via a foot or maintenance vehicle bridge could be provided similar to D3, D4, and D5; however, this was not included in the cost estimates.

Alternative D14 could be developed as a standalone measures or combined with the Piru Creek collector (D7) or other facilities. It was considered as a stand-alone alternative for evaluation purposes.

4.3.9.2 Collector Inlet Gates

The multi-level intakes are illustrated on Drawings D14.2-D14.4. Each intake has two gates with automated operators: an upward opening flow control ramp gate, and a downward closing isolation gate to fully close the intake when it is submerged. Each ramp control gate is set within a 5 ft wide rectangular channel, and would have a depth of about 4.5 ft over the crest to convey the 150 cfs design flow. Each upward opening ramp gate could accommodate a pool elevation range of 8.5 ft, so this concept would require 10 gates to cover the 76 ft operation range (low fish passage design pool elevation 980 ft to high fish passage design pool elevation 1,056 ft). At full pool, the lower gates would all be closed with positive closure gates, and the upper gate would track the pool elevation until it overlapped with the next lower gate.

Drawing D14.3 provides a view looking downstream at the intake entrance, and illustrates the elevation range for each gate structure. Because this range overlaps, the intake was configured in a staggered manner to provide room for the intake gates, and ramp control gate structure. Drawing D14.4 provides a sectional view looking across the gates, showing how each gate would control flows, and how the bypass channel would connect into the helix bypass. Note that the intakes must also be staggered upstream, to allow room for the closure gate operators, trash racks, and trash rack cleaning system.

The gate width and depth was selected to help minimize the necessary transition length into the 3 ft wide helix flume described in the next section. Entrance velocities would be controlled by critical depth over the ramp gate, at about 6.7 fps. An inlet transition upstream of the gates is shown schematically on Drawing D14.2, with a transition length, a closure gate, and a trashrack. The 6 ft transition length shown would likely need to be longer, and possibly flare into a wider entrance to provide velocities at the trashrack closer to 2 fps.

Trash racks with some type of mechanical cleaner would be located at each inlet to prevent large debris from entering the collector. This will be a design challenge, given that the intakes will often be submerged, so a movable rake is envisioned that could be set manually or on a rail system for each bank of intakes to track the pool level.

4.3.9.3 Helix Bypass and Tunnel

Fish exiting the ramp gate would pass through transition into a smaller rectangular channel, and then enter the helix to drop elevation towards a tunnel entrance. The goal of the USBR helix design was to provide a non-turbulent flow that does not roll over as it follows the relatively tight radius and steep slope, which caused turbulence and potential for fish injury in their modeling. This is a departure from normal NMFS criteria, which could also be used to convey flow in a bypass pipe or channel at a flatter slope, which would require a much larger helix diameter.

In order to scale the USBR 400 cfs helix to the 150 cfs flow for D14, the Panel used the basic hydraulic parameters from the USBR model data and estimated flow characteristics using open channel flow calculations as an estimate. This was sufficient for an initial evaluation but hydraulic modeling would be required to perform this scaling properly. Table 4.3-5 summarizes the results of that analysis. The first column shows the hydraulic design parameters, the second column is a summary of hydraulic design parameters provided in the USBR presentation for their model results, with the calculated Froude Number in the last row for the USBR Helix, and the third column shows similar calculated values for a 150 cfs flow for Alternative D14's helix.

The layout shown would utilize the 30 ft diameter helix, with a minimum depth of 1.5 ft. Just for comparison, the Panel examined an alternate helix layout to meet NMFS criteria setting the maximum velocity of 12 fps. That layout would require a 7 ft diameter corrugated pipe, with a slope of 2.5% and resulted in a 100-foot diameter helix.

Because much of the helix is underwater, the channel would be a closed conduit in order to cover the full pool range. Access ports would be provided at regular intervals, to allow access to the conduit for inspection and maintenance, which would only be accessible when each loop is above the pool level. The helix is shown with walls that extend above the high pool level to protect the structure; this approach will require further study. For example, the entire helix could be constructed in a cylindrical tower design that is hollow to allow an access stair. This approach would require significant structure strength given the total design head at depth.

Table 4.3-5. Summary of USBR helix concept and Alternative D14 helix hydraulic design parameters.

Parameter	USBR Helix	Alternative D14 Helix
Flow	400 cfs	150 cfs
Rectangular channel width	4 ft	3 ft
Helix diameter	52 ft	30 ft
Centerline slope of channel	7.8 %	8.1 %
Drop per loop of helix	12.7 ft	7.63 ft
Manning’s n	.010	.010
Depth of flow	2.3 ft	1.5 ft
Velocity	43 fps	35 fps
Froude Number	5.04	5.00

The 3 ft wide channel would continue from the base of the helix tower and transition into a 5 ft (60 inch) diameter pipe that would flow as an open channel, and pass through a tunnel leading to a portal downstream of the dam. The tunnel alignment shown on Drawing D14.1 assumes this facility would be constructed independently of the GEI intake improvements. The bypass tunnel could be parallel to the GEI tunnel, and the Panel has assumed a 30 ft edge-to-edge distance of the two tunnels would be adequate. This assumption is beyond the Panel’s expertise, and should be verified if this alternative is carried forward. The tunnel slope shown on Drawing D14.5 was approximate but considered reasonable to illustrate the alternative, and was based on following the GEI tunnel concept illustrated for the intake improvements. The bypass channel slope would range from 2.2% to 6.0%, and would daylight at a tunnel portal near the creek, leading into a dewatering and pumpback facility. The depth in the bypass pipe would range from 1.6 to about 2.0 ft deep, and would flow at 20 to 32 fps in the configuration shown.

Drawing D14.6 provides a conceptual cross section of the tunnel envisioned for the bypass pipe and pump back pipe, with a similar shape and vertical alignment to the new intake tunnel. An alternate arrangement is shown at the bottom of the page, which would assume a combination tunnel with the intake improvements, and fish ladder shown in U1.

4.3.9.4 Dewatering and Pump Back Facility

Drawings D14.7 and D14.8 illustrate the location and conceptual layout for a dewatering screen and pump back facility designed to screen 143 cfs from the 150 cfs total flow, and pass fish with 7 cfs transport flow to Piru Creek downstream of the powerhouse. Flow from the 5 ft diameter bypass pipe would enter a transition section, and then flow through a vee screen facility similar to Alternative D3. The transition section will need to be carefully designed to transition the relatively high velocity (about 21 fps) and shallow depth (2 ft) supercritical flow to a slower and deeper velocity with a uniform and stable approach flow, including a hydraulic jump and suitable length for the flow to stabilize. The screens shown could be traveling belt screens and would be designed for a 0.8 fps approach velocity like D3. As a safety measure, the vee screens should be designed with pressure relief panels that would open should debris on the screens cause a high differential load across the screen panels. An upward opening ramp gate would be provided at the downstream end of the vee screens to help fine tune and adjust depth on the screens and control the bypass flow. Flow would then enter a transition into an 18 inch diameter release pipe, which would discharge fish and the 7 cfs transport flow to a release location downstream of the powerhouse.

Screened flow would be conveyed to a pump chamber, where it would be pumped and returned to the lake via a 4 ft diameter pipeline. The pumps would need to be designed to pump against a variable head depending on the lake elevation, up to the static lift of 191 ft plus pipeline head losses. The dewatering facility would also be provided with overflow provisions and an overflow weir, release gate, and channel or conveyance feature to allow operation without pumping back (for example this would be an option during times of spill) and to convey the full 150 cfs should a pressure relief panel open resulting in unscreened flow containing fish and debris.

The structure and pipeline dimensions shown are approximate for illustration of the concept and definition of various components. Additional study would be required to finalize the design of this concept, and coordination with United's other planned improvements is recommended.

4.3.9.5 Operation

Alternative D14 would operate between pool levels 980 to 1,056 ft as described above, during the downstream fish passage migration season of January 1 through July 15. The system would operate with the full 150 cfs design flow. The pumpback facility could be operated at all times the facility is running; however, it could be turned off during spill events. The appropriate intake would be operated to track the pool levels, and would transition to the next intake when operational ranges between the intake gates overlapped.

Debris for D14 would need to be managed similar to the other reservoir collector alternatives.

- A floating trash boom for large debris could be provided similar to the floating boom for D3 and D5 (not shown).

- As noted for the other alternatives, actively managing the reservoir for debris when flows allow could be helpful.
- A trashrack and mechanical trash rake would be included for each intake. Access to these cleaners will be difficult, and is assumed by boat. A floating work platform would also be provided to allow maintenance staff accessibility to the mechanical components, and a place to deposit debris.
- The vee screens in the dewatering facility would be fabricated with vertical traveling screens that would help to mitigate debris collecting or clogging the screens or getting stuck in the converging screen area upstream of the ramp gate. Personnel access would also be provided at this location to inspect and remove debris by hand.
- Access ports within the helix would be needed at some interval in case debris gets clogged in the closed pipe system.

4.3.9.6 Optional Design Elements

The following optional design elements were considered by the Panel but are not included in the current design or cost estimates:

- Parking area with access road, and access bridge similar to D3 (see Drawing D14.1). Access to the multi-level gates and helix bypass is assumed to be via boat from an existing marina or boat access location.
- A movable floor upstream of the ramp gates in the multi-level intake could be provided to provide a more uniform attraction velocity.

4.3.9.7 Phasing Opportunities

Phasing opportunities would be similar to D3. One difference to note with D14 is that it basically would need to be constructed in the final format shown to operate; the only phasing alternative could be to construct limited intake levels to connect to the helix, and monitor performance prior to adding other intake levels. The D3 phasing opportunities are repeated below with D14 substituted for D3 text:

- Add a collector in Piru Creek (D7), either before or after D14. These would result in a new alternative similar to D10 (which utilizes D3 in combination with D7).
- Start with floating surface collector (described as a component of D12) to evaluate the flow and location needed to optimize collection.

4.3.9.8 Compatibility with Upstream Passage Alternatives

Alternative D14 is completely independent of and is fully compatible with all of the upstream passage alternatives. It would require coordination of placement of the fish bypass pipe discharge point, to be downstream of any upstream fish collection weir, and to avoid confusing flow patterns from the 7 cfs fish release flow. It could also utilize the tunnel similar to D4.

4.3.9.9 Challenges, Uncertainties, Risks

Challenges for this alternative are listed by system.

Multi-level Intake

- The operation and maintenance of multiple, submerged intakes leading to closed conduits with limited access would be a key challenge with this alternative. The resulting risk is how reliable this alternative would be relative to the others, and if something did go wrong, how long would the facility be down during maintenance.
- Debris removal with 10 separate trash racks at varying levels with limited access would also be a challenge associated with the intake facility.
- Fish attraction and entrance into a weir system can be effective, but is very site specific. Given the complexity of the intake, the ability to expand or change the intake configuration and velocity to track the flow would be relatively limited, and it would not be feasible to expand the 150 cfs attraction flow given the constraints of this overall system.
- Access by boat, and the limited access for each level, would be difficult to address. Even with the addition of a stairway and access bridge, personnel and equipment access for this alternative would be relatively difficult.
- This intake facility would be a relatively tall and narrow structure, with similar seismic design concerns as Alternative D3.

Helix Bypass

- The hydraulics in the steep and relatively narrow helix concept would need to be verified in a model, to assure that the 400 cfs concept developed by the USBR would scale to the 150 cfs flow. The resulting 3 ft wide by 1.5 ft deep with 35 fps velocities would definitely be considered experimental by NMFS, and would require further development and validation for fish injury. To address this concern, an alternate configuration was examined with corrugated metal pipe and a maximum flow velocity of 12 fps, resulting in a 100 ft diameter helix layout.

- The relatively narrow and shallow channel would also be susceptible to debris, and access to inspect the flume would be challenging.
- The transitions into and out of the channel described above would require further analysis, and likely longer transitions than shown on these conceptual layouts.
- Access to the helix tower would be limited. The facility could be constructed as a hollow tower with access stairs on the inside and access ports, but the hydrostatic head would require thick walls for high loads at depth.
- The helix tower would also be relatively tall and narrow, so the seismic design concerns would also apply to this feature.

Tunnel

- The pipe into the tunnel would need to have isolation gates for tunnel safety.
- Coordination of a new tunnel with the planned tunnel for the intake improvements would need further study.
- Once filled with cellular concrete, access for any changes would be eliminated.

Dewatering and Pumpback Facility

- Proper design of the transition of fast, shallow flow into the screen chamber would need further study to design a minimal impact of the hydraulic jump. This would require a balance of a hydraulic jump and higher bypass velocities to reduce the chance of holding upstream of the screens with a uniform and stable screen flow requirement.
- Overflow provisions would need to have appropriate fail-safe features to assure proper dewatering and operation if the pumps fail or a screen pressure relief panel opens.

4.3.9.10 Pros and Cons

Pros and cons listed below are in addition to those noted for D7.

Pros

- No predation concerns; once in the system fish would pass quickly to the bypass with no human handling.
- Passive intake system would use all attraction flow for bypass. Less opportunity for fish to reject the entrance to the facility.
- Completely independent alternative and could be phased at any time.

- Believed to be compatible with the planned spillway modifications and dam safety measures.
- Introduces bypassed fish to Piru Creek in a controlled flow section not affected by flood flows.

Cons

- Complex intake facility, with numerous operating gates. Automation would need careful consideration, with provisions for manual backup.
- Difficult access for maintenance and inspection, with many submerged gates and operators. Lack of use for long periods could result in non-operational parts or systems if proper maintenance and exercising was not performed.
- Limited access to bypass channel for debris inspection and maintenance.
- Typical debris, cleaning, and maintenance issues associated with trash racks, traveling screens and moving gates.
- Challenges associated with debris handling during operation, as noted with other alternatives.
- Pumpback of 143 cfs would require maintenance, and long pipeline.
- Seismic design challenge.
- Experimental technology, no proof of concept for 150 cfs flow with steep helix bypass.
- High cost; construction and operation.

4.3.9.11 Cost Considerations and Assumptions

The following considerations and assumptions were made in the cost analysis, which is summarized in Section 4.4.

- The collector and tunnel would be constructed independent and subsequent to modifications to the outlet works. There would be savings if they were done concurrently.
- Debris would be managed at the collector, but due to complexity associated with debris management at the intake, it was assumed there would be active reservoir debris management.
- Capital and operating costs do not include any efficiencies from compatibilities with upstream passage alternatives.
- Cost of pumpback of the 143 cfs was included in the Operations costs.

- Operation and maintenance costs assumed limited operation, and routine maintenance and inspection associated with all systems and moving parts.

4.3.10 Enhancements

Enhancements, as defined by the Panel (see Section 1.5), are features that add efficiency to a primary alternative but do not perform the same overall fish passage function. This section provides descriptions of the Enhancements that were defined for each alternative in Table 4.3-1.

4.3.10.1 Operate to Minimize Spill

The enhancement Operate to Minimize Spill is the same operational measure described for upstream passage in Section 4.3.5. It is also an enhancement for downstream passage because it would reduce the frequency, duration and flow amounts of spill events and therefore the number of downstream migrants using the spillway. This Enhancement was included for all downstream passage alternatives except for D7, which is located upstream of Lake Piru.

4.3.10.2 Collector Transition Structure (CTS)

The attraction flow field and velocity distribution into surface oriented fish attraction and collection systems has been shown to be critical to their success. By definition, these systems are partial collection devices, because fish have a choice to either enter the collectors or to avoid them by going around or under the collection entrances. Additionally, they can partially enter the device, but can turn around and swim back out of the collectors until the capture velocity has been reached (see Section 4.3.1 for more information about capture velocity and capture zones).

The research and development efforts for existing surface collectors is ongoing, with no 100% clear definition on the best combination of several variables, including: attraction flow amount, depth, width, and velocity at the entrance and exit of collector screens; as well as the velocity gradient entering the screens, rate of convergence of the screens, and ultimate minimum width and depth at the downstream terminus of surface collector screening systems. Multiple studies are underway on these systems in the Pacific Northwest, with variable success on different configurations and for different species (including steelhead), and variable results each year of study on the same systems. One conclusion is certain; each of these devices must operate for site specific conditions to attract animals whose behavior cannot be fully predicted.

The use of a CTS feature has been implemented on several FSCs in existence to help transition flow into the screening system. The original idea behind this structure for the Baker FSC was to help simulate a natural lake outlet to a river or creek, where the lake typically transitions to a shallower and narrower channel operating in open channel flow that accelerates as it transitions from a deep lake to a relatively shallow and narrow river or stream. The feature allows a slow and gradually increasing velocity gradient into the screen system, which both aligns flow into the screens for better control and provides a guiding surface that fish seem to like to follow.

For this Report, the Panel identified a CTS as a downstream enhancement measure for the three tower based surface oriented collectors on Lake Piru, as shown in Table 4.3-1 (D3, D4 and D5). The CTS for D3, is shown in detail on Drawing D3.3 and would be constructed out of a lighter weight metal frame system with fabric or metal panels. The structure would transition the flow velocity from 0.5 fps at the CTS entrance to 2.0 fps at the FSC screen entrance. The corresponding dimensions at the upstream end of the CTS are 15 ft deep and 18 ft wide, leading to the 8 ft wide by 10 ft deep screens. This CTS concept is currently in use at the two Baker FSCs, the Swift FSC, and the River Mill (on Clackamas River, Oregon) surface collector. The Panel recommends additional study of the biological attraction performance and collection efficiencies of the existing FSCs in service prior to making a decision on whether a CTS would be beneficial for the SFD. Similar dimensions are shown for the surface collectors with D4 and D5.

CTS's are not identified as initial Enhancements for the other downstream collectors for the following reasons:

- D7 – not a lake based collector, so the CTS would have no benefit in the small creek location.
- D9 – the spillway collector component of this alternative is defined with an approach channel that effectively achieves what a CTS is intended to provide, with a narrowing transition into the collector. Therefore, a CTS would not provide any additional benefit, plus it would be difficult to maintain during spill conditions.
- D12 – a CTS was not identified as an initial component of the movable FSC component of this alternative as it would be more complex to move and anchor with the FSC barge, and because it would be deeper than the FSC intake and would limit how close the FSC could be anchored to the Piru Creek flowing channel in the lake. A CTS is shown on Drawings D12.2 and D12.3 that could be added later if study results indicate it could be beneficial.
- D14 – the Panel originally planned on adding a CTS to this alternative, but given the complexity and dimensions of the intake structure shown for the multi-level intake, decided it would be too complex to operate and maintain. This could be studied further if D14 is carried forward.

4.3.10.3 Guide curtain

Guide Curtains, also called Behavioral Guidance Systems (BGS) have been implemented and studied at several surface oriented fish collection systems with varying success depending on species and very site specific conditions. The concept provides a fabric or metal "curtain" that typically hangs from a floating boom structure to a depth of 10 to 30 ft that fish can behaviorally guide along and follow as they are led towards the surface collector entrance. These curtains can lead from shore to the edge of the collector, can extend upstream from the center of a collector, and can be used in any combination of the above depending on flow patterns, velocities, and the issue they are trying to address with their implementation.

Guide Curtains are included as an enhancement measure for downstream alternatives D3, D4, D5, and D14 as shown in Table 4.3-1. The goal of the guide curtain is to provide a guiding surface from the shoreline towards the collector entrance as shown on Drawings D3.2 and D3.4, by suspending the curtain from the access bridge. Fish following the shore from either the downstream or upstream side of the collector would encounter the curtain, and likely follow it towards the collector entrance. Their alternative behavior would be to turn around, or swim deeper to go below the curtain.

Given the variable lake elevation, the guide curtain would ideally be suspended from a floating structure that would follow the collector entrance as it moves up and down in relation to the fixed shoreline. The challenge with this concept is the slope of the shoreline, which would cause the curtain to hit the shore and fold over as the lake lowers, or create a gap depending on the curtain dimension as the lake level rises. Alternative D3 shows a fixed curtain suspended from the access bridge structure to a depth of 25 ft below the full pool elevation. In this configuration, the curtain would lose effectiveness as the lake level lowered, and would be hanging at pool levels below elevation 1,030 ft. While not shown on the drawings, the goal of the curtain would be to end it at the collector entrance for D3. The challenge with this configuration is the collector entrance is far away from the access bridge to accommodate the fish loading into trucks, so a separate fixed or floating guide curtain support boom may be required from shore to the collector entrance to truly maximize this concept for that alternative.

Additional study on the specific goals and configuration for each alternative would be required for the concepts that are carried forward. These studies should address: anticipated flow patterns specific to each collector entrance; changes in the flow patterns at different lake elevations; the desired curtain alignment and geometry for each configuration; means to support and protect the curtain for varying depths, and to provide the desired direction in to the collector; wind and wave loading for design; effects on recreational use; and results of ongoing fish studies and observed behavior for any guide curtain configuration.

4.3.10.4 Cover in Front of Collector

The enhancement feature defined as Cover in Front of Collector is based on an experimental floating surface collector installed at the Cowlitz Falls Project in Washington State, where fish were observed to hold beneath a surface mat of debris immediately upstream of the collector. The hypothesis that providing a cover upstream of the collector was tested in a second year of study by suspending a larger, opaque tarp on the surface immediately upstream of the collector entrance. Radio tracking studies showed that fish were attracted to this area, which provided a shade and refuge area upstream of the collector, which helped to congregate them in the proper area to find the collector entrance.

Similar to the Guide Curtain, this behavioral enhancement measure was included for downstream alternatives D3, D4, D5, and D14 as shown in Table 4.3-1. Each of these collectors has a fixed location entrance, which in addition to the CTS would be feasible to provide a cover feature.

Similar to the CTS, further study should be performed on the other alternatives that may benefit from a cover feature, but that would be more difficult to operate and maintain given their other characteristics.

4.3.10.5 Release Pond

Fish that are transported might benefit from a release pond where they could acclimate to the temperature of their receiving water and to safely hold until any hauling and handling stress is relieved and they are motivated to continue their migration. A release pond typically includes a fish unloading facility, water supply, holding pond, protection from predators, and final release structure or gate. Specific release sites and designs have not been identified or conceptually designed for this project. One option would also be to release fish into a section of the fishway entrance pool for upstream passage options that is appropriately designed for holding fish. This enhancement measure is included for all downstream collectors with transport.

4.3.10.6 Deep Outlet Screen / Reduced Deep Outlet Screen

The Deep Outlet Screen is the new screened intake described in Section 2.4.3, that is currently under study by United through GEI Consultants. This enhancement measure would be beneficial to all of the downstream alternatives, as it prevents the possibility of fish exiting the lake through the turbine or bypass valves, which would result in high or complete mortality.

The Reduced Deep Outlet Screen is only associated with alternatives D3 and D4, which have the 150 cfs fish screen intake. These two alternatives include a 150 cfs surface oriented fish screen that would take the first 150 cfs of flow under normal (non-emergency) conditions. Therefore the deep intake planned for 500 cfs could be reduced by the 150 cfs, and could be designed for 350 cfs.

Alternative D5 and the combination D11 would not require the Deep Outlet Screen, as the surface fish screen associated with those alternatives would be used in lieu of the deep intake screen under normal operating conditions.

4.3.11 Documentation of Downstream Concepts Deferred

Table 4.3-6 contains the list of concepts, including supplements and enhancements, for downstream fish passage that the Panel considered in the early phases of the concept development but ultimately deferred from further evaluation or concept development. Some of these concepts were initially described in Table 4.1-1. Among the seventeen concepts deferred, four were determined to be fatally flawed, in the sense that physical site limits are prohibitive, technology is not proven or is excessively complex and could not be guaranteed to work, or the concept would substantially alter the purpose and operation of the reservoir.

Table 4.3-6. Downstream fish passage concepts the Santa Felicia Dam Fish Passage Panel deferred from consideration and the rationale for deferral, including those that are fatally flawed.

Concept	Basis for Deferral
Dewater and transport	Not compatible with purpose and operation of the reservoir; safety of fish; other alternatives are selected
Reservoir bypass channel	Steepness and ruggedness of terrain
Dual fish locks	Impractical: Height of dam; other alternatives are better
Piru Creek in-channel collector	Off-channel collectors work better with more control over hydraulics for fish safety; risk of in-channel collector failing due to high flows
Temporary trap in Piru Creek	Other technologies (e.g., fyke nets) work better for enhancements or initial facilities. Temporary trap not reliable for long-term facilities
Multi-level intake on new intake tower to 800 cfs, Eicher Screen	Perceived hydro limitations and increased size of conduit necessary for Eicher (or bifurcation), Eicher is experimental technology, difficulty with bypass system, addressed by D14 helix bypass concept.
FSC near dam, 150 cfs Screen (*was D1*)	No longer a stand-alone alternative; D3 is preferable

Table 4.3-6. Downstream fish passage concepts the Santa Felicia Dam Fish Passage Panel deferred from consideration and the rationale for deferral, including those that are fatally flawed.

Concept	Basis for Deferral
FSC, Movable, 150 cfs Screen (*was D2*)	Now combined with Piru Creek collector (D7) to form D12
Multi-level Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps (*was D6*)	Impractical: Complexity with large tower and telescoping bulkheads, screen collector inside tower, and no comparable prototype
Piru Creek Collector, 100 cfs Screen (*was D8*)	Ranked low among Piru Creek alternatives; screen flow optimized for 300 cfs collector (D7)
150 cfs Screen similar to D4 with Helix bypass (USBR Cle Elum style) (*was D13*)	Relatively low score for performance, and higher cost (including BPT analysis). Requires significant pump back of low to reservoir. Not a unique solution, D14 helix bypass concept with multi-level intake carried forward in place of this alternative.
Bypass conduits	Fatal flaw: Terrain creates considerable challenges, and the conduits may not work due to head differential, bypass needs, and high/variable head.
Pump fish to a reservoir bypass flume	Fatal flaw: Ruggedness of terrain/interfaces with dam; fish pump is risky transfer mechanism for endangered fish, better alternatives are available
Fish-friendly turbines	Fatal flaw: Technology is not proven in practice for high head projects (greater than about 90 ft, Santa Felicia is 190 ft)
Nature-like fishway	Fatal flaw: Height of dam and required shallow slope would require an extremely long fishway that may not work with topography, very long fish transit time; other alternatives are better
Floating bypass channel through reservoir	Fatal flaw: Elevation change in reservoir makes the bypass channel unworkable
Rail transport around the reservoir	Fatal flaw: Complexity; terrain

4.4 OPINION OF PROBABLE COSTS

4.4.1 Purpose

This section provides information on the estimated costs associated with implementing the alternatives, and serves a number of purposes. First, by considering the general construction materials and components, it clarified and brought focus on the assumptions used in developing the alternatives. Second, the development of cost estimates helped the Panel integrate phased construction and adaptive management considerations, and provides for uniform relative comparisons among alternatives. Third, although cost did not factor into the Panel's feasibility analysis, cost detail does provide the Group with useful information about the alternatives.

The goal of this section is to present a summary of costs as ranges of values in order to provide relative comparisons among alternatives. This is accomplished by first defining the following cost categories:

- Capital Costs – Includes construction of fish passage facilities. This is otherwise known as the Opinion of Probable Construction Cost (OPCC).
- Annual Operations and Maintenance Costs (O&M Costs).
- Power Costs – This is a subset of the annual O&M Costs, and includes the cost of power to run the electrical powered components of a passage system on an annual basis.

Section 4.4 provides basic assumptions for estimating all costs associated with the implementation of an alternative based on the above categories. Upon implementation, additional costs may be incurred, such as compliance and permitting, technical studies, and Monitoring and Evaluation (M&E); estimates for these costs are not included in this Report. A comparison summary across all upstream and downstream alternatives is provided in Section 4.4.

4.4.1.1 Implications of Integration with Outlet Works Improvements

The Panel is aware of concurrent feasibility studies that are underway addressing dam safety improvements associated with spill capacity improvements and outlet works replacement as discussed in Section 2.4, and has worked with United throughout this Study to stay informed on their latest study results and ideas. Some of these dam safety improvement alternatives being considered could affect the design of several upstream fish passage alternatives, or could offer total project savings if developed concurrently. In addition, the alternatives being considered for the spill capacity improvements and outlet works replacement have the potential to be integrated with several of the downstream fish passage alternatives. In some cases (i.e., surface collectors D3, D4, and D5) at the intake tower, and the floating surface collector (part of D12), the design of the intake tower could be affected by or integrated with the outlet works. If the outlet works design remains independent of the fish passage facility, some coordination on construction could yield some project efficiencies and potential overall cost savings.

In finalizing the Report, the Panel believes that the schedule for the dam safety studies and planned implementation of the outlet works and spill capacity improvements may precede the ultimate selection, design, and construction of any upstream and downstream fish passage facilities. As a consequence, the Panel made the assumption for the development of cost estimates that any fish passage facilities would be implemented completely independent of, and likely *following,* any dam safety improvements. This has the following implications:

- Cost estimates for U1, D3, D4, D5, and D12 are conservative, assuming totally independent intakes/tunnels and independent construction of tower improvements;
- There would likely be some cost savings if the dam safety and outlet works projects were combined with fish passage projects;
- This approach is transparent and generally conservative; and
- Additional cost estimating efforts could be performed to explore potential cost savings of concurrent project construction, and the evaluation of this issue is outside of the Panel's responsibility.

4.4.2 Alternative Cost Components

The following sections define the various cost components that are summarized for the alternatives in Section 4.4. Costs associated with getting to a decision point on whether to implement an alternative and the initial technical studies are not estimated for this Report.

4.4.2.1 Capital Costs

A conceptual level OPCC was made for each alternative based on the descriptions for each alternative contained within Section 4, and their reference concept drawings. These cost estimates should be considered Class 5, as designated by the Association of American Cost Engineers (AACE), for which engineering is typically 0% to 10% complete. They are typically used for any number of business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, or long-range capital planning. Virtually all Class 5 estimates use stochastic estimating methods such as cost curves, capacity factors, and other parametric and modeling techniques. Expected accuracy ranges are from -20% to -50% on the low side and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. As little as 1 hour or less to perhaps more than 200 hours may have been spent preparing the estimate depending on the project and estimating methodology (AACE International Recommended Practices and Standards).

The Panel has no control over costs of labor, materials, competitive bidding environments and procedures, unknown field conditions, financial and/or market conditions or other factors affecting the cost of the construction and the operation of the facilities, all of which are unavoidably in a state of change. The Panel cannot and does not make any warranty, promise, or representation either expressed or implied, that proposals, bids, or cost of operation or maintenance associated with these alternatives will not vary substantially from their estimates.

As noted in the introduction to this subsection, the cost opinions developed for SFD are intended primarily for comparative purposes between alternatives, and are not intended to be used for economic analyses and financial planning. No more than about 20 hours were utilized to develop the OPCC for each alternative, and many of the OPCCs were developed with little more than two hours each as several of the alternatives were similar so components were scaled between the alternatives.

Unit prices for the major items such as concrete, excavation, and backfill were assigned based on recent bidding experience in the region of SFD. Lump sum prices for items such as dewatering and electrical and controls were estimated parametrically from similar projects. Costs for some items, such as crest gates, were estimated by obtaining budget quotes from manufacturers and by applying a doubling factor to account for shipping, installation, startup, and contractor markups.

A contingency of 25% was added to account for possible changes in bidding climate, material prices, and the general economy. This is a reasonable amount based on the level of design, and is intended to also account for unforeseen items.

The costs of design, permitting, procurement of a general contractor, contract administration and professional services during construction, and owners' program expenses are not included in these OPCCs. Cumulatively, these costs can add from 30% to over 50% to the OPCC estimates, depending on the ultimate project complexity and how the project is executed. These costs also do not account for costs of funding these relatively large capital projects.

These estimate ranges should be considered preliminary for this Report; however, the Panel believes they are adequate and reasonable for initial comparison of alternatives and definition of key passage system components.

4.4.2.2 Annual Operations and Maintenance (O&M) and Power Costs

Similar to the capital cost estimates, annual O&M and power (energy) cost estimates were developed in a uniform manner and combined for each alternative to help quantify total annual O&M costs associated with the ongoing operation of each alternative. Power costs include the electrical costs associated with daily or other frequency of operation for any powered mechanical equipment (such as traveling screen motors, winches, gates, pumps, site lighting, etc.). A uniform cost of $0.10/kWh was utilized for these estimates.

The Panel's collective experience with this effort indicates that development of more accurate O&M cost estimates should be pursued as any alternative is carried forward, and as the owner can better define site specific needs and how various budgets are applied and accounted for with these large capital projects. For example, some owners lump many of the O&M costs into a defined capital maintenance program budget, while others employ temporary or agency personnel to administer the facilities operations and track these costs separately.

While the absolute value for each alternative may not be accurate enough for budgeting, these estimates were developed in a uniform manner that will provide a good comparison between alternatives.

4.4.3 Costs of Implementing Alternatives

In general, the cost of implementing alternatives includes more than construction and operation of facilities. In its process of evaluation, the Panel considered the influence of an adaptive management process, including the possibility of phasing components and making adjustments, on the cost of full implementation. There are also important costs that should be included during implementation; they include costs associated with permitting, initial compliance, ongoing monitoring and evaluation (M&E), and other required or recommended technical studies. Cost estimates are based on current industry costs, as described above, in 2015 US Dollars. Phasing, or staged implementation of alternatives or projects, can also influence the effective cost and financing options. For Alternatives D9 through D12, the cost of construction includes that of D7 as a first phase and the other major component as a second phase. For these alternatives, the Panel assumed the second phase would occur ten years after the initial phase and the construction cost would increase by an annual inflation rate of 3%.

Table 4.4-1 displays a summary of the capital cost range and total annual O&M cost range (includes power costs as described above) required by each of the alternatives. Note that the Panel developed detailed cost estimates for each alternative as a basis for this table. However, those costs are not included in the Report as the Panel believes summary of cost ranges is more appropriate for this level of analysis.

Table 4.4-1. Alternative costs summary (2015 U.S. Dollars, AACE Class 5 Estimates).

Alternatives	Capital Cost Range	Total Annual O&M Cost Range
U1	$30,000,000 – $40,000,000	$100,000 – $200,000
U2	$13,000,000 – $18,000,000	$100,000 – $200,000
U3	$7,000,000 – $12,000,000	$80,000 – $150,000
U4	$6,000,000 – $9,000,000	$100,000 – $200,000
D3	$12,000,000 – $17,000,000	$55,000 – $70,000
D4	$5,000,000 – $8,000,000	$70,000 – $100,000
D5	$13,000,000 – $17,000,000	$70,000 – $100,000
D7	$3,000,000 – $5,000,000	$30,000 – $50,000
D9 (D7+spillway)	$8,000,000 – $12,000,000	$50,000 – $80,000
D10 (D7+D3)	$15,0000,000 – $22,000,000	$80,000 – $125,000
D11 (D7+D5)	$16,000,000 – $23,000,000	$100,000 – $150,000
D12 (D7+D2)	$11,000,000 – $17,000,000	$150,000 – $200,000
D14	$29,000,000 – $34,000,000	$130,000 – $160,000

5. EVALUATION OF ALTERNATIVES

5.1 OVERVIEW AND DESCRIPTION OF EVALUATION PROCESS

The Study Plan guided the Panel in the identification, selection and evaluation of fish passage alternatives. The evaluation process and results augmented the professional judgment of the Panel members and ultimately provided direct and indirect input to the Panel's recommended fish passage alternatives. The Panel evaluated the feasibility of the 13 alternatives (4 upstream and 9 downstream passage alternatives) identified in Section 4, following the approach described in the Study Plan (Tasks 5 and 6). Evaluation was guided by a grid matrix technique (evaluation matrix), also known as a Pugh matrix or criteria-based matrix. Engineers routinely use this technique to develop and compare alternatives in context of criteria that best define the more important attributes of the targeted outcome. For the SFD fish passage evaluation, criteria were identified during preparation of the Study Plan (see Appendix D)[12] and were based on conditions of feasibility as defined in Section 1.5 above. Many of the criteria addressed conditions commonly associated with measures of fish passage performance (NMFS 2008) that were made specific to SFD.

A condition labeled "unaltered" was included in the evaluation. It is not intended to be an alternative, but is representative of the condition as if there were no dam and is included as a benchmark to show how close any alternative comes to that condition.

Upstream and downstream passage alternatives were evaluated using different sets of criteria. A primary difference was the inclusion of a specific biological performance criterion for downstream passage. The BPT was developed and used to integrate a collection of conditions considered to affect performance of downstream migration facilities and produce a performance criterion to compare among the various alternatives. A description of the BPT is provided in Section 5.1.3.

5.1.1 Development of Evaluation Criteria and Evaluation Matrix

This grid analysis was essential in guiding the development of design solutions and establishing consensus on what fish passage alternatives should be pursued. Using the grid analysis technique allowed development of a mutual understanding of each alternative, understanding each Panel member's values and points of view, and optimizing alternatives. It also provided

[12] The background and process used to define the criteria and the definitions of the criteria are described in detail in Appendix D.

opportunity for structured consideration of input from Group members as the process evolved. The evaluation matrix is not just about selecting the highest score as the winner.

Some benefits of using this method are:

- Quantitative technique to rank multi-dimensional options.
- Helps remove personal judgments from decisions.
- Develops a clear common understanding of options being considered.
- Helps diverse stakeholders understand each other's values and issues.
- Can test sensitivity of objectives and project features.
- Rational and consistent. Engineers and managers have high regard for numbers and rational decisions.
- Most importantly, a framework for discussion, understanding, consensus-building.

The general process of the analysis was as follows, with each of the steps including a discussion of how the matrices were developed explained further below:

- Define evaluation criteria.
- Weight criteria.
- Develop and describe alternatives.
- Evaluate relative performance using a Biological Performance Tool (BPT) for each downstream passage alternative.
- Score alternatives for each criterion.
- Multiply each score by the criteria weight.
- Sum the score-weight products for each alternative.

5.1.1.1 Define Evaluation Criteria

The initial criteria were selected during the development of the Study Plan. Some criteria refinement occurred during the Study resulting from discussions during Panel workshops and input solicited from the Group on the criteria and weights.

Each criterion can be considered a component of fish passage feasibility by which the feasibility of the alternatives will be evaluated. Each criterion is positive; that is to say that higher compliance is reflected by a higher score. Few, if any, hard data were available to use in the weighting and scoring of criteria. As such, weights and scores were generally based on professional opinion, experience with similar facilities or other similar species. The criteria are not all thresholds that must be entirely satisfied. Most criteria were satisfied to different degrees by various alternatives.

5.1.1.2 Weight Criteria

The criteria have different levels of importance and were weighted accordingly. The weighting used a scale of zero to ten. One criterion was weighted as “zero” (fish access out of fishway to Piru Creek) and has no influence on the design but it was left on the list because it might be an important consideration to other parties. To challenge the Panel to differentiate among the criteria by not allowing all criteria to be weighted “ten,” the Panel stipulated that the mean weight needed to be near five. So, for example, if there are 20 criteria, the sum of the weights had to be 100.

The criteria were grouped into four categories; Fish Passage, Operations and Maintenance, Social, and Cost. Cost was not scored during the evaluation but remained in the matrix for potential use during considerations subsequent to the Panel’s final recommendations. The number of criteria within each category varied. For example upstream passage has 13 criteria for the fish passage category, downstream passage has 9 criteria for the fish passage category. The matrix was designed so each category could be weighted separately, that is, total scores solely for fish passage issues or solely for operations and maintenance issues could be calculated. All of the categories were weighted equally in all scores presented in this Report.

The initial weighting of criteria was done during preparation of the Study Plan and was revised slightly during the Study. The weighting was done before the alternatives were developed so they would be reflected in the alternatives as they were selected and developed.

In addition to the weights, specific criteria considered essential could be highlighted with a fatal flaw threshold. If the score of any alternative does not exceed the threshold, the alternative would be considered fatally flawed. However, no criteria were specifically identified as having a fatal flaw threshold.

5.1.1.3 Score Alternatives

Evaluation scorings in the matrix reflected the opinions of the fish passage Panel members based on consideration of site specific information, panel member experience, the standard of practice for fish passage projects, and conceptual-level calculations incorporating facility size, capacity and design. The Panel considered evaluating alternatives relative to specific (quantitative) performance criteria (objectives) associated with establishing steelhead passage to and from historic spawning and rearing habitats upstream of SFD. Quantitative performance objectives could be structured as a percentage of all migrating steelhead that safely pass the project within a specified period. However, the Panel determined that application of results from other passage facilities currently operating along the Pacific Coast to project performance or related criteria for evaluation of SFD fish passage would be entirely subjective due to a substantial number of differences between the SFD passage conditions and extant passage facilities. Differences include targeted species, hydrology, reservoir and riverine morphology and project operations. In short, until site specific evaluations are conducted to reduce biological and technical uncertainties, developing quantitative criteria to assess passage performance is meaningless. In the BO, NMFS recognizes that quantitative (measureable) criteria would likely be developed following conduct of this evaluation in order to guide implementation of the evaluation results per RPA Subsection 3, Part d:

> *"**(d) Development of criteria to guide implementation timing of the preferred alternative.** If steelhead passage is identified as the preferred alternative in the final steelhead-passage feasibility report agreed upon by NMFS, the Licensee shall develop in coordination with NMFS and the California Department of Fish and Game measurable biological criteria to trigger implementation of the preferred alternative…."*

Absence of quantitative evaluation criteria was a primary reason for using the comparative, matrix evaluation technique.

Each criterion was scored as to how well it was satisfied by each alternative. The Panel used a ten-point (zero to ten) scoring system. The Panel did the initial scoring and refined it several times during the Study as alternatives were developed and better understood. Each Panel member scored alternatives independently and the scores were compared. Large differences among the products of individual scores and weights highlighted differences among the team that most affected the final results and that therefore merited discussion. Large differences might be due to different information available or the experience of individual team members or differences in understanding of the alternative. Regardless, those differences were addressed. Some descriptions of alternative were modified as necessary until there was a common understanding of it. The point was to achieve a common understanding of each score, not just to agree on a number.

5.1.1.4 Compute Weighted Scores

Each final score was multiplied by the weight for that criterion to get the weighted score. Then the weighted scores were totaled for each alternative and compared. They were totaled by calculating the average weighted score for each category, multiplying that average by the weight for that category, and summing those products.

5.1.2 Application of Evaluation Criteria and Evaluation Matrices

The criteria matrices were divided into two components; upstream passage and downstream passage. For the most part, these components can each be designed individually and then combined into a complete facility. The Panel used a spreadsheet to implement the matrix; an example of a scored matrix is provided in Figure 5.1-1 (values in the example are meaningless other than for demonstration). The left column of the matrix shows the criteria used in the evaluation, grouped in categories of fish passage, operation and maintenance, “social,” and cost. A general discussion of each criterion is provided in Appendix D. The alternatives are listed in a row across the top of the spreadsheet.

	Criteria / Category Weight	Alternative 1		Alternative 2		Alternative 3		St Dev of Alt Prods		Unaltered	
		Score 0-10	Weighted Score	Score 0-10	Weighted Score	Score 0-10	Weighted Score			Score 0-10	Weighted Score
Upstream fish passage category	10										
Criterion #1	10	10.0	100	10.0	100	10.0	100	0.0		10.0	100
Criterion #2	7	7.1	50	6.7	47	6.7	47	1.5		10.0	70
Criterion #3	2	5.0	10	5.0	10	4.9	10	0.1		10.0	20
Operation and maintenance category	10										
Criterion #1	8	5.0	40	3.9	31	6.4	51	8.4		10.0	80
Criterion #2	8	5.3	42	4.3	34	9.6	77	18.3		10.0	80
Social category	10										
Criterion #1	10	7.7	77	6.9	69	7.1	71	4.0			
Criterion #2	2	6.6	13	5.3	11	7.3	15	1.8		10.0	20
Cost category - Not part of Panel evaluation											
Criterion #1											
Criterion #2											
Total Category Weighted - Normalized			85		76		97				100
Total - fish pasage only - totaled, not averaged			160		157		157				190
Total Fish Passage Only - Normalized			84		83		82				100

Figure 5.1-1. Example of evaluation matrix (**example only; values are meaningless other than for demonstration**) the Santa Felicia Dam Fish Passage Panel applied to the Study.

The Panel weighted each criterion to establish relative levels of importance as part of the grid analysis. The second column of the matrices lists the weights given to each of the criterion and for each category group of criteria. The weighting uses a scale of zero to ten. If a criterion scores “zero” it has no influence on the evaluation but it was left on the list because it might be important to other parties.

Each criterion was scored as to how well it was satisfied by each alternative using a ten-point (zero to ten) scoring range. Each final score was multiplied by the weight for that criterion to yield the weighted score.

The column to the far right of the matrix is the standard deviations of the weighted scores for that row. It is an indicator of criteria for which there are significant differences among the alternatives; the criteria with the higher numbers in this column are those that most affect any differences in the comparison of alternatives. The column for a criterion with a high standard deviation is shaded dark green.

The green highlighted weighted scores, especially for criteria where the standard deviation is also highlighted, are indicators of aspects of an alternative that are strongly favorable (pros) and the cells that are red highlighted are indicators of negative attributes (cons) of that alternative. These are reflected in the attributes of alternatives listed in the descriptions of each alternative in Sections 4.2 and 4.3.

The totals of the weighted score for each alternative are the relative ability of that alternative to achieve all of the criteria as they are weighted by importance. Since this is a relative comparison, the total scores were normalized so the scales are the same for all charts and so one alternative will always score an arbitrary value of 100.

Cost was included as a set of criteria in the matrix but was not evaluated by the Panel because the Panel did not evaluate the relative importance of cost relative to fish passage performance.

The entire process provided the Panel a means for communication of different perspectives of each of the alternatives, reaching a mutual understanding regarding each alternative, and optimization of the alternatives. To optimize alternatives, the lower-ranking alternatives were "challenged" by addressing the specific criteria that caused them to score low. This focused on the criteria for which the weighted scores differed the most. This used the highest scoring alternatives to optimize the low-scoring ones and was an important part of this process.

As noted above, the matrices used to evaluate each set of alternatives included three general categories: fish passage performance, passage facility operation and maintenance, and social. Each category for each set of passage alternatives (i.e., upstream or downstream) was assessed individually as well as collectively to identify if and how the scoring of the three categories influenced the overall feasibility (score)

As discussed in Section 5, each Panel member independently scored each alternative during each evaluation episode. Each episode included a review of the initial scoring, a discussion of each criteria for each alternative with a focus on those criteria and alternatives that had a wide spread or substantial variation among the scores. The discussions allowed the Panel to first clarify the criteria and its application to the alternative, clearly state/describe the alternative and typically reach relative consensus (reduce variability or range of scoring). The result of the discussion included redefining alternatives, characterization of uncertainty, and an overall understanding of how and to what degree alternatives performed relative to each other and to the criterion. Each episode also included a reality check – did the scoring make sense based on individual and a collective understanding (which represented experience and knowledge of panel members). When scores appeared to misrepresent the perceived understanding of relative performance, where ranking was out of expected order, or the score spread among alternatives appeared unrepresentative, the Panel revisited the alternative scoring. Following often lengthy and detailed discussions of the issues, the Panel would rescore the alternatives as a group in an attempt to agree on the ultimate scoring. This process led to a variety of results that included redefining alternatives, identifying and recognizing relative uncertainties in the scoring, combining alternatives, and clarifying pros and cons.

5.1.3 Biological Performance Tool (BPT)

The Panel developed the Santa Felicia Dam Fish Passage-(BPT to support evaluation of a multitude of conditions that collectively can influence the number of steelhead smolts that are captured and moved downstream of SFD. The Panel used results from the BPT in the evaluation matrix to compare the effectiveness of downstream passage alternatives. The BPT score for each alternative was used as the weighted score in the downstream evaluation matrix. The BPT scores were normalized to 100 to be comparable to the other weighted scores in the matrix.

5.1.3.1 Description and Use of the Biological Performance Tool

Successfully attracting, capturing, and transporting juvenile steelhead outmigrating through Piru Lake and around SFD will involve the integration of structural, operational, environmental, and biological factors. Downstream passage facilities could be sited in Piru Creek or at multiple possible reservoir locations. Passage facilities must accommodate seasonal fish movements, behavioral response of fish to flow and flow changes, reservoir pool level fluctuations, fish response to stream and reservoir thermographs, migration pathways, interactions with other fish species, localized flow patterns near facility entrances, and the influence of channel and reservoir morphology.

To facilitate integration and analysis of these factors, the BPT was developed to provide a structured process to calculate downstream fish passage effectiveness as the proportion of smolt outmigrants that successfully pass from Piru Creek to downstream of SFD. Downstream fish passage, especially through reservoirs and past substantial dams, is substantially more complex, and thus less certain than upstream passage. Downstream passage in the industry has shown to be widely variable, and can depend on the target species and site specific and facility conditions. Within the evaluation matrix, the results of the BPT were used to score downstream fish passage alternatives on the relative effectiveness for passing outmigrating steelhead. The BPT is a tool used by the panel to provide input to the evaluation matrix on passage performance. The results of the BPT represent an important criterion, but are not the only measure of feasibility.

Upstream fish passage facilities on the other hand will have a limited range of entrance, transport, and release options; and factors affecting their siting and sizing of these facilities for anadromous salmonids are relatively well understood in the industry. The potential performance of upstream fish passage alternatives was evaluated without the use of a biological performance tool.

In addition to providing quantitative scoring of evaluation criteria in the evaluation matrix, the BPT was also used to provide information on facility sizing, siting, range of operations, and effectiveness of individual components. For instance, the BPT was used to evaluate a range of Piru Creek design flows to tentatively identify an optimum size of a Piru Creek collector. The BPT was also used to evaluate the relative sensitivity of biological assumptions and identify associated research needs. The BPT results are considered one of a suite of factors affecting the feasibility of fish passage alternatives; they do not independently forecast preferred passage alternatives.

The BPT is a simulation model that routes flows and outmigrating smolts through Piru Creek, into and through the reservoir, into fish collector facilities, and downstream of SFD. The model incorporates user-specified smolt migration periodicity to account for the seasonal distribution of fish migrating down Piru Creek. The model also provides an algorithm to adjust the percentage of smolts moving into the reservoir on a daily basis as a function of river flow and/or freshets (i.e., high flow pulses) to accommodate the assumption smolt migration is directly influenced by flows. The model starts each year with an assumed 10,000 smolts entering the system from Piru Creek. The selection of 10,000 smolts was an arbitrary annual starting condition and served as a normalizing factor to provide comparative evaluations between downstream passage alternatives. The model output, in terms of the number of smolts outmigrating downstream of SFD, does not reflect actual smolt production, but rather a proportion of the initial 10,000 smolts assumed to be migrating down Piru Creek. The BPT will not estimate the number of smolts outmigrating from the Piru Creek watershed, or the number of adults returning to Piru Creek. Rather, the BPT provides a relative comparison of facility performance and should not be considered an indication of the future passage rate of a constructed facility.

Downstream fish passage alternatives can consist of one or more downstream fish passage facilities, with each facility providing collection and transportation of outmigrating smolts. At each potential collector, the model utilized user specified facility-specific response functions (e.g., capture rate and mortality rate for each collector) to account for the smolt passage conditions under the selected hydrograph. For example, intake tower collector capture rates are modeled as a function of flow entering the collector. Different flow volumes entering the collector are associated with different capture rates, which in turn result in different numbers of smolts captured on a particular day. Smolts that are not captured in a collector as they enter the system remain in the reservoir and are available to be captured on successive days through mid-July. A user-specified reservoir mortality rate exposes smolts in the reservoir to predation and other risk factors.

Model outputs include the number of smolts passed immediately downstream of SFD (i.e., system outmigrants), the number of smolts remaining in the reservoir at the end of each year (i.e., potential carryover), and total annual smolt mortalities. Smolts remaining in the reservoir at the end of each year could overwinter and outmigrate the following year; however, each model year begins with the uniform assumption of 10,000 smolts. For purposes of the evaluation matrix, the performance of downstream fish passage alternatives was based on the percent of the assumed annual 10,000 system smolts that were passed downstream of SFD.

Users can review summary information for the entire period of available flows from 1944 to 2004 or for an individual calendar year. Information can be displayed in both tabular and graphical formats. The output can also be printed, saved to a file, or copied to a computer memory clipboard and pasted to spreadsheets or word processing applications. For documentation, the user can print input data that are used for the model run as well as detailed simulation results. A summary of BPT results is presented in Section 5.3.2; modeling assumptions, additional modeling details, and full results for selected alternatives are provided in Appendix E.

5.2 UPSTREAM PASSAGE EVALUATION RESULTS

The four upstream passage alternatives are summarized in Table 5.2-1 to provide a brief description and reference for the labels used to identify the alternatives in the following sections.

Table 5.2-1 is identical to Table 4.2-1 and is repeated here to help the reader review the evaluation results.

Table 5.2-1 Summary of upstream fish passage alternatives included in the feasibility evaluation.

Alt #	Alt Name	Enhancements	Supplementals
U1	Pool and Weir Fishway, Tunnel and Tower; Reservoir Range EL 980 ft to 1,056 ft	• Operate to minimize spill • Monitoring facility	• Spillway Pool Collector
U2	Pool and Weir Fishway to EL 1,030 ft, East Alignment to Exit Structure; Reservoir Range EL 1,030 ft to 1,056 ft	• Operate to minimize spill • Monitoring facility • Challenge section • Release pond	• Spillway Pool Collector • Collection and transport facility
U3	Pool and Weir Fishway to EL 1,056 ft, West Alignment with Slide Release; Reservoir Range EL 980 ft to 1,056 ft	• Operate to minimize spill • Monitoring facility • Challenge section	• Spillway Pool Collector
U4	Collection and Transport with Multiple Release Locations; Reservoir Range EL 980 ft to 1,056 ft	• Operate to minimize spill • Monitoring facility • Challenge section • Release pond	• Spillway Pool Collector

5.2.1 Criteria for Upstream Fish Passage Facilities

The Panel identified the following 10 criteria for evaluation of upstream fish passage alternatives:

- Attraction of Adult Fish to Fish passage facility – Normal, Mid-high, and High Flows.
- Passage Effectiveness through Upstream Fish Passage Facility.
- Volitional Upstream Fish Passage.
- Fish Access Out of Fish Passage Facility to Piru Creek.
- Attraction and Passage of Non-target Species.
- Potential for Fish Passage Evaluation or Biological Monitoring.
- Safety of Juvenile Fish.
- Certainty of Collection and Passage.

- Adaptability of Collection and Passage.
- Relationship to Dam Operations and Downstream Passage Facilities.

The Panel weighted each criterion based on the collective consideration of its importance in ultimately determining feasibility. Criteria for all categories (e.g., fish passage) were weighted as a group to achieve a mean weight of 5 (out of 10). The highest weighted criteria for upstream passage included attraction, effectiveness, and certainty of performance. Other high rated criteria included safety and meeting Project objectives.

5.2.2 Upstream Passage – Evaluation Matrix

The results of the evaluation matrix analysis for upstream passage are presented in this section as:

- Overall Evaluation Results, which includes combined scores for all categories; fish passage, operations and social.
- Fish Passage Evaluation Results which only includes scores for the fish passage category.
- Operations and Social Evaluation Results which only includes scores for the operations and social category (i.e., all but the fish passage criteria).

5.2.3 Upstream Passage Evaluation Results for All Categories

Figures 5.2-1 and 5.2-2 show the results of the upstream passage evaluation with all categories weighted equally so fish passage, operations, and social each have the same importance.

Based on the results of the combined scoring for all upstream passage categories:

- U4 had the highest score which was significantly higher than U1 and U2.
- U4 rated highest in 13 of the 23 criteria evaluated and tied for highest in 5 more criteria.
- U3 had the second highest scoring, which was slightly higher than U1.
- The Unaltered condition scores were low because operation of SFD would not exist in this case so the water supply objectives of the project could not be met.

	Criteria / Category Weight	U1 P&W fishway tunnel and tower 980-1056		U2 P&W fishway East alignment 1030-1056		U3 P&W fishway West alignment, slide release 980-1056		U4 Trap and transport		St Dev of Alt Prods	Unaltered	
		Score 0-10	Weighted Score	Score 0-10	Weighted Score	Score 0-10	Weighted Score	Score 0-10	Weighted Score		Score 0-10	Weighted Score
Upstream fish passage	10											
Collection up to normal flow (200 cfs)	10	10.0	100	10.0	100	10.0	100	10.0	100	0.0	10.0	100
Collection at mid flow (500 cfs)	7	7.1	50	6.7	47	6.7	47	6.7	47	1.5	10.0	70
Collection at high flow (1000 cfs incl 500 cfs spill)	2	5.0	10	5.0	10	5.0	10	4.9	10	0.1	10.0	20
Passage effectiveness through upstream passage facility	10	7.3	73	7.1	71	7.1	71	8.9	89	8.4	9.4	94
Volitional upstream passage	4	9.1	37	4.0	16	6.7	27	1.6	6	13.1	10.0	40
Fish access out of fishway to above Lake Piru	0	4.6	0	5.9	0	4.4	0	9.7	0	0.0	10.0	0
Certainty of collection and passage performance	7	6.3	44	6.6	46	6.9	48	9.3	65	9.6	9.4	66
Attraction and Passage of Non-Target Native Species	3	6.7	20	6.3	19	6.0	18	9.0	27	4.1	10.0	30
Opportunity to monitor fish passage	3	8.0	24	8.1	24	8.3	25	9.9	30	2.6	2.0	6
Opportunity to block non-natives	2	5.6	11	5.6	11	5.6	11	9.3	19	3.7	0.8	2
Safety of juvenile fish in upstream passage facility	2	7.0	14	5.3	11	6.7	13	7.9	16	2.1	9.0	18
Complementary to downstream passage facility	3	7.0	21	4.3	13	3.7	11	2.0	6	6.2		
Adaptability of collection and passage	5	4.4	22	4.7	24	4.9	24	8.0	40	8.4		
Operation and maintenance	10											
Simplicity of fish passage facility and operations	8	5.0	40	3.9	31	5.0	40	6.4	51	8.4	10.0	80
Debris management	8	5.3	42	4.3	34	6.3	50	9.6	77	18.3	10.0	80
Durability of Structure	6	5.7	34	4.6	27	5.9	35	6.3	38	4.4		
Operations safety	10	5.2	52	6.2	62	8.3	83	4.8	48	15.8		
Certainty of meeting SFD Project objectives	10	10.0	100	10.0	100	10.0	100	10.0	100	0.0	0.0	0
Effect on normal operation of water supply and generation	4	8.7	35	9.0	36	9.0	36	9.8	39	1.9	0.0	0
Social	10											
Public safety	10	7.7	77	6.9	69	6.9	69	7.1	71	4.0		
Aesthetics	2	6.6	13	5.3	11	5.6	11	7.3	15	1.8	10.0	20
Education	2	6.1	12	5.7	11	6.4	13	7.3	15	1.3		
Permitting and environmental impact	2	7.7	15	6.6	13	6.9	14	7.6	15	1.1		
Cost - Not part of Panel evaluation												
Construction												
Operation and maintenance												
Certainty of cost												
Total Category Weighted - Normalized			92		85		94		100			82

Figure 5.2-1. Results of the evaluation matrix for the four upstream passage alternatives for all categories combined. See Section 5.1.2 for explanation of table and colors.

5.2.4 Upstream Fish Passage Evaluation Results for Fish Passage Category

Results of the evaluation matrix for just the fish passage category are presented in this section. Figure 5.2-3 graphically shows the results of the upstream passage evaluation considering only fish passage. i.e., all but the fish passage category are weighted as zero and are ignored.

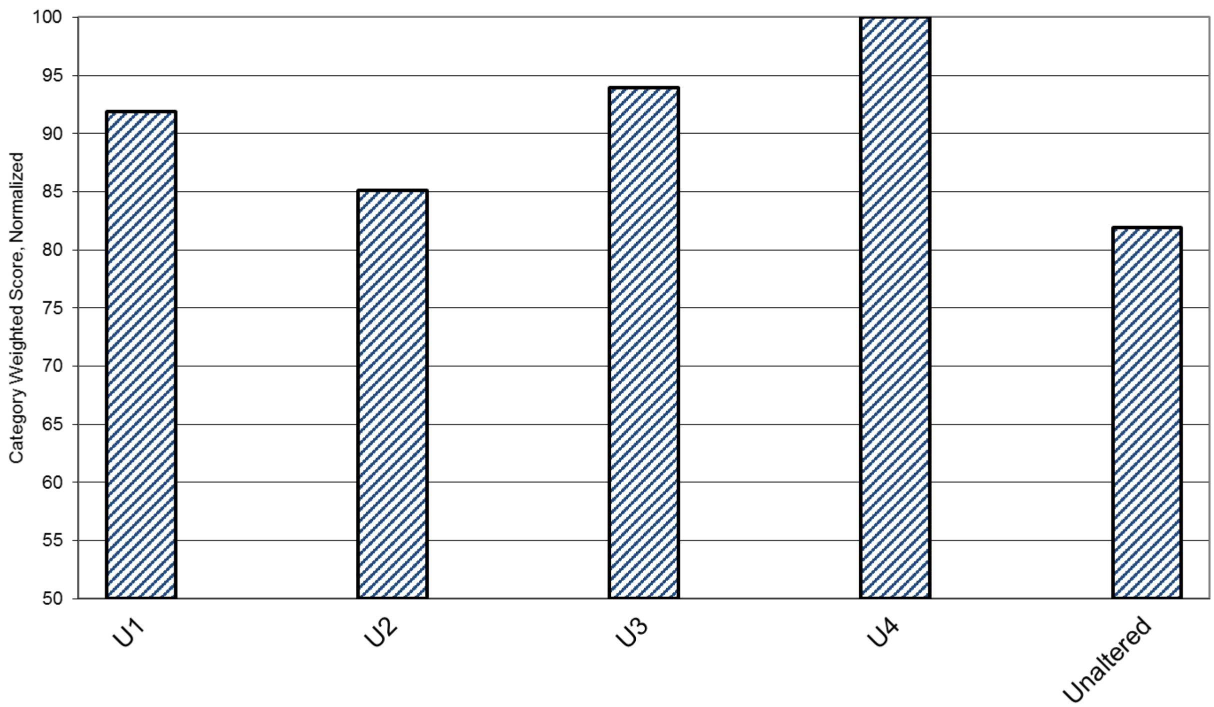


Figure 5.2-2. Comparison of the total evaluation matrix scores for the four upstream passage alternatives and the unaltered condition based on results for all three evaluation categories.

Based on the results of the scoring of all four upstream alternatives and the unaltered condition for just the fish passage criteria:

- Unaltered condition[13] scored highest when only considering fish passage criteria because it considered fish passage without SFD.
- U4 scored highest among alternatives evaluated, scoring 85% of the unaltered condition.
- U4 scored highest in 6 of the 13 criteria and ties for highest in 4 more criteria.
- U4 scored low in three categories- volitional upstream passage, attraction at mid flow and complimentary to downstream passage facility.
- U1 scored second highest among the four alternatives.

[13] Unaltered condition was included in the evaluation for comparison purposes only. It was not considered as an alternative, as discussed in Section 4.

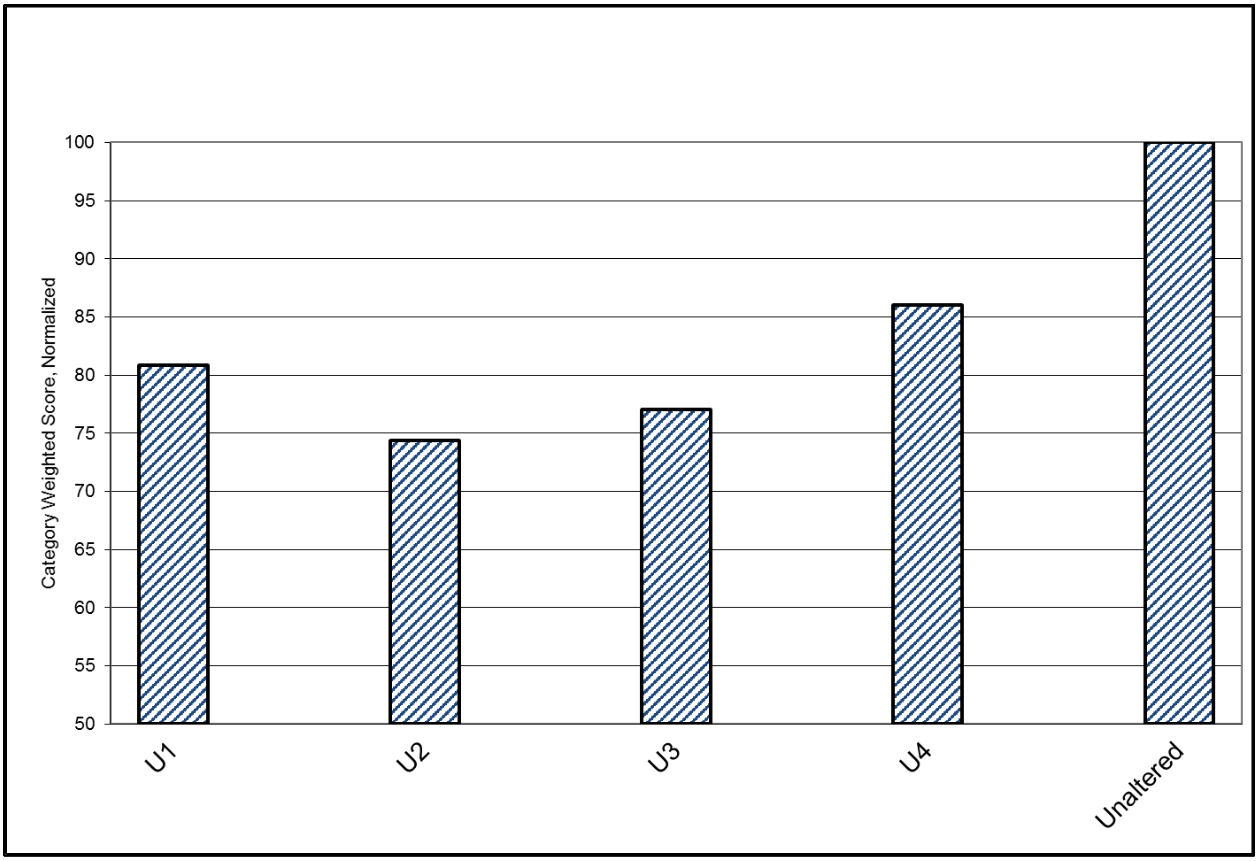


Figure 5.2-3. Comparison of the total evaluation matrix scores for the four upstream passage alternatives based only on results for fish passage evaluation category.

5.2.5 Upstream Passage Evaluation Results for Operations and Social Categories

Results of the evaluation matrix analysis for all but the fish passage criteria (i.e., operations and social categories) are presented in this section. Figure 5.2-4 shows the results of the upstream passage evaluation considering only the operations and social categories. The fish passage category was weighted zero so is ignored.

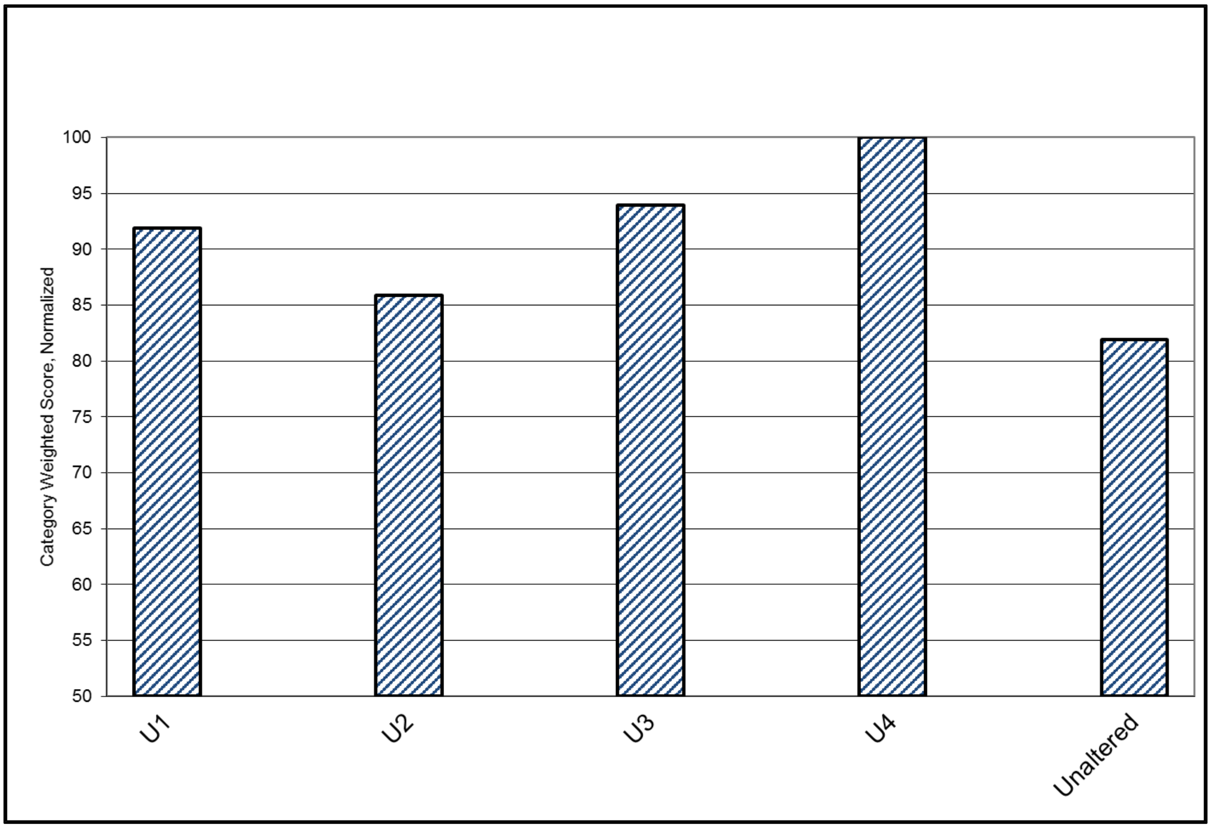


Figure 5.2-4. Comparison of the total evaluation matrix scores for the four upstream passage alternatives based only on results for the operations and the social evaluation categories.

5.2.6 Upstream Passage Evaluation Summary

Based on the results of the combined scoring of all upstream passage alternatives and the unaltered condition for the operations and social evaluation criteria:

- U4 had the highest score when evaluated overall as well as when evaluated just for fish passage or just for operation and maintenance.
- U4 rated highest in 7 of the 13 fish passage category criteria evaluated and tied for highest in 3 additional criterion.
- U3 scored second highest overall.
- U2 scored lowest overall or when scored solely for either fish passage or operations and maintenance.

U4 scored highest regardless of the weighting of categories, whether considering only fish passage, only operations, or equally considering all criteria. U4 scored highest for all the high weighted criteria, including attraction (tied with all alternatives), effectiveness and certainty of performance.

5.3 DOWNSTREAM PASSAGE EVALUATION RESULTS

The nine downstream passage alternatives are briefly described in Table 5.3-1 to provide a reference for the abbreviated naming used to identify the alternatives evaluated in the following sections. This table is identical to Table 4.3-1 and is repeated here to help the reader review the evaluation results.

Table 5.3-1. Summary of selected downstream alternatives, with enhancements.

Label	Name of Alternative	Enhancements
D3*	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps	• Operate to minimize spill • Collector Transition Structure • Guide curtain • Cover in front of collector • Release pond • Reduced deep outlet screen
D4*	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps, Volitional Bypass with U1	• Operate to minimize spill • Collector Transition Structure • Guide curtain • Cover in front of collector • Release pond • Reduced deep outlet screen
D5*	Surface Collector at Intake Tower, 500 cfs Screen, Gravity with Pumps	• Operate to minimize spill • Collector Transition Structure • Guide curtain • Cover in front of collector • Release pond
D7	Piru Creek Collector, 200 cfs Screen	• Release pond • Deep outlet screen
D9*	Piru Creek Collector (D7) with Spillway collector	• Operate to minimize spill • Release pond • Deep outlet screen
D10	Piru Creek Collector (D7) with 150 cfs Surface Collector D3	• Operate to minimize spill • Release pond • Deep outlet screen
D11	Piru Creek Collector (D7) with 500 cfs Surface Collector (D5)	• Operate to minimize spill • Release pond

Table 5.3-1. Summary of selected downstream alternatives, with enhancements. (continued)

Label	Name of Alternative	Enhancements
D12	Piru Creek Collector (D7) with Movable FSC	• Operate to minimize spill • Release pond • Deep outlet screen
D14	Multi-level Crest Gate Collector with Helix Bypass	• Operate to minimize spill • Guide curtain • Cover in front of collector • Deep outlet screen

* Note – D3 through D5 and D9 are not stand-alone alternatives but are listed and described because they were initially developed as stand-alone alternatives but were combined with D7 as selected alternatives.

5.3.1 Downstream Passage – Evaluation Matrix

The evaluation matrix analysis, summary charts and significant observation of the results for downstream alternatives are described in this section. The downstream evaluation matrix is similar to the upstream evaluation matrix described above, but it also includes BPT as one criterion, which summarizes into a single criterion the attributes of what it takes for a fish to successfully pass downstream.

Alternatives D3 and D5 are included here; they are not proposed stand-alone alternatives but are included to show their relative performance as components in other alternatives.

5.3.2 Biological Performance Tool Results

The BPT was used to estimate the performance of downstream fish passage facilities by calculating the number of steelhead smolts passed downstream of SFD assuming 10,000 smolts enter the system each year. For each downstream fish passage alternative, smolts were assumed to enter the system in Piru Creek immediately above Lake Piru. The timing and distribution of outmigrants were based on an algorithm integrating a response to freshets and periodicity based on the timing of steelhead outmigration in nearby basins (see Section 3).

When encountering downstream fish passage facilities, smolts are captured based on a response function dictating the rate of smolt capture in relation to flow. In view of the uncertainty associated with predicting the likelihood of smolts encountering and entering a capture facility, the Panel identified a low and high estimate of potential fish capture for each facility. For each facility, the Panel also identified a low and high estimate of mortality associated with capture, transport, and release of smolts immediately below SFD, and a low and high estimate of daily outmigrant mortality while smolts are in the reservoir. The BPT was originally configured to calculate smolt passage rates and mortality through the turbines, cone valves, and butterfly valve. The small size of the devices and high head associated with flow releases through the turbines, butterfly valves, and cone valve were expected to cause high or complete mortality to outmigrating smolts. During redesign of the intake tower, United opted to include screens that would block off potential fish passage through those devices. The spillway is also being evaluated as part of United's consideration of project changes, and potential use of the spillway as a potential migration route was retained in the BPT. A full description of the BPT and the response functions is presented in Appendix E: Biological Performance Tool Methodology and Results.

The timing and rate of steelhead smolt outmigration is affected by environmental factors including water temperature and flow. Steelhead smolt migration may vary from year to year and smolts may not outmigrate during Dry Years when middle Piru Creek immediately above Lake Piru is dewatered for extended periods. During Dry Years smolts may continue rearing in upstream reaches that remain wetted and outmigrate the following year, may residualize, or may suffer increased mortality in the stream environment. Wet Years may play an important role in smolt production and outmigration but the influence is not well understood. A high volume spring runoff could lead to improved rearing conditions. Steelhead smolts outmigrate at Age 1 and 2 and the number of outmigrants may increase following a Wet Year. Wet Years provide increased magnitude and frequency of freshets which may contribute to increased smolt outmigration. Site specific information on timing and rate of steelhead smolt outmigration is unavailable for Piru Creek. Screw traps and other sampling techniques used to monitor outmigration in nearby systems may be ineffective during high flow events; however, it appears that increased numbers of smolts outmigrate in association with freshets.

The BPT requires daily values for reservoir inflow, reservoir releases, spill, and associated daily reservoir water surface elevations for any year of interest. Daily hydrology for years 1944-2004 was developed by United modeling existing operations. Daily values for example Wet, Average, and Dry Years were used to examine BPT modeling output and assess the influence of various response factors. After the model was tested and response functions were developed, downstream passage alternatives were evaluated using all years in the 1944-2004 period of record. This provided an assessment of alternatives over the entire range of flow conditions (Figure 5.3-1).

Under All Years, collection in the downstream alternative D7- Piru Creek Collector ranged from 82 percent to 94 percent of the assumed annual 10,000 smolts (Figure 5.3-1). Of the alternatives selected for the evaluation matrix, D4 had the lowest performance. Due to the uncertainties associated with smolts passing through the reservoir and finding and entering the surface collector, D4 performance ranged from 25 percent to 81 percent of the assumed annual 10,000 smolts. The BPT results using All Years are presented for discussion purposes, but were not used in the evaluation of downstream passage alternatives.

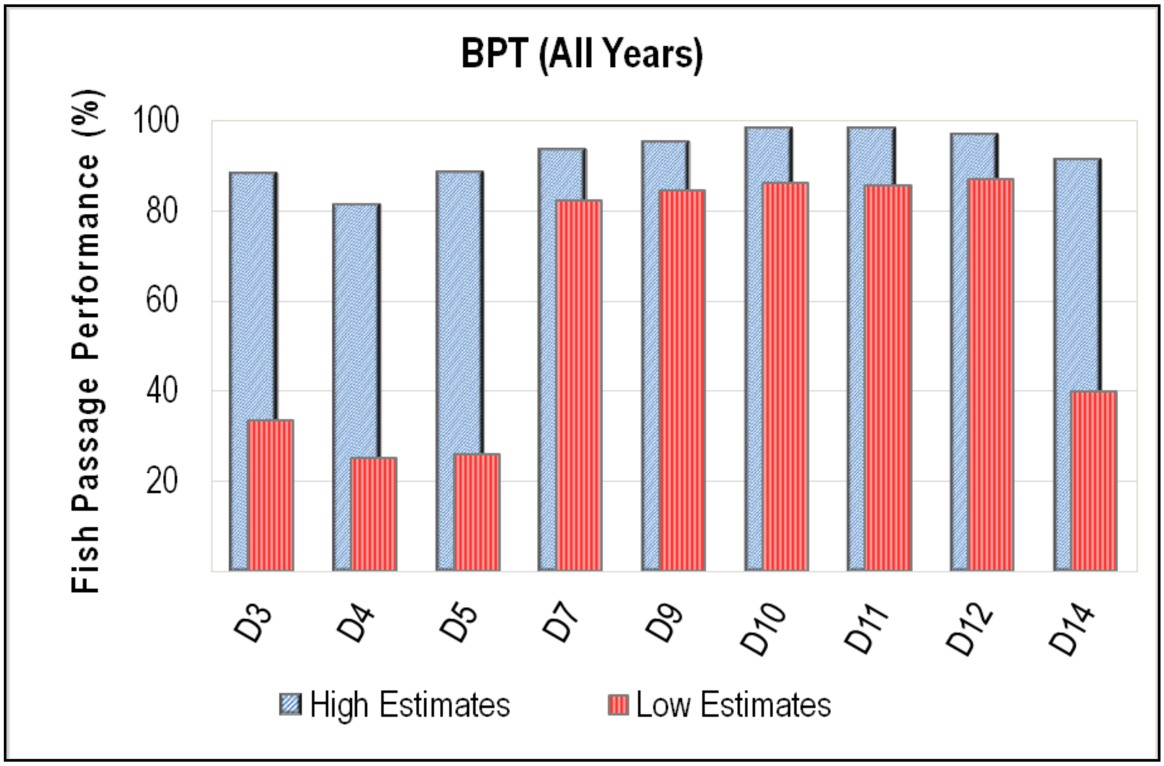


Figure 5.3-1. Performance of downstream fish passage alternatives D3, D4, D5, D7, D9, D10, D11, D12, and D14 for the period 1944-2004. In order to provide equal comparison of alternatives, the evaluation assumes that 10,000 smolts enter the system each year. High estimates based on best-case assumptions for Biological Performance Tool response functions and low estimates based on assumed worst-case response functions.

Because Wet Years may have increased numbers of smolts and increased outmigration and also represent the most challenging conditions for downstream collection, downstream passage alternatives were also evaluated using a period of three consecutive Wet Years to encompass both Wet Years and years following a Wet Year. Potential Wet Years were identified by totaling the volume of Piru Creek reservoir inflow during January through June for the period of record and ranking them from the highest to lowest volume (Figure 5.3-2). Out of 61 years, 1978 ranked 57, 1979 ranked 48, and 1980 ranked 53 and were selected to provide an analysis of downstream passage alternatives under Wet Year conditions.

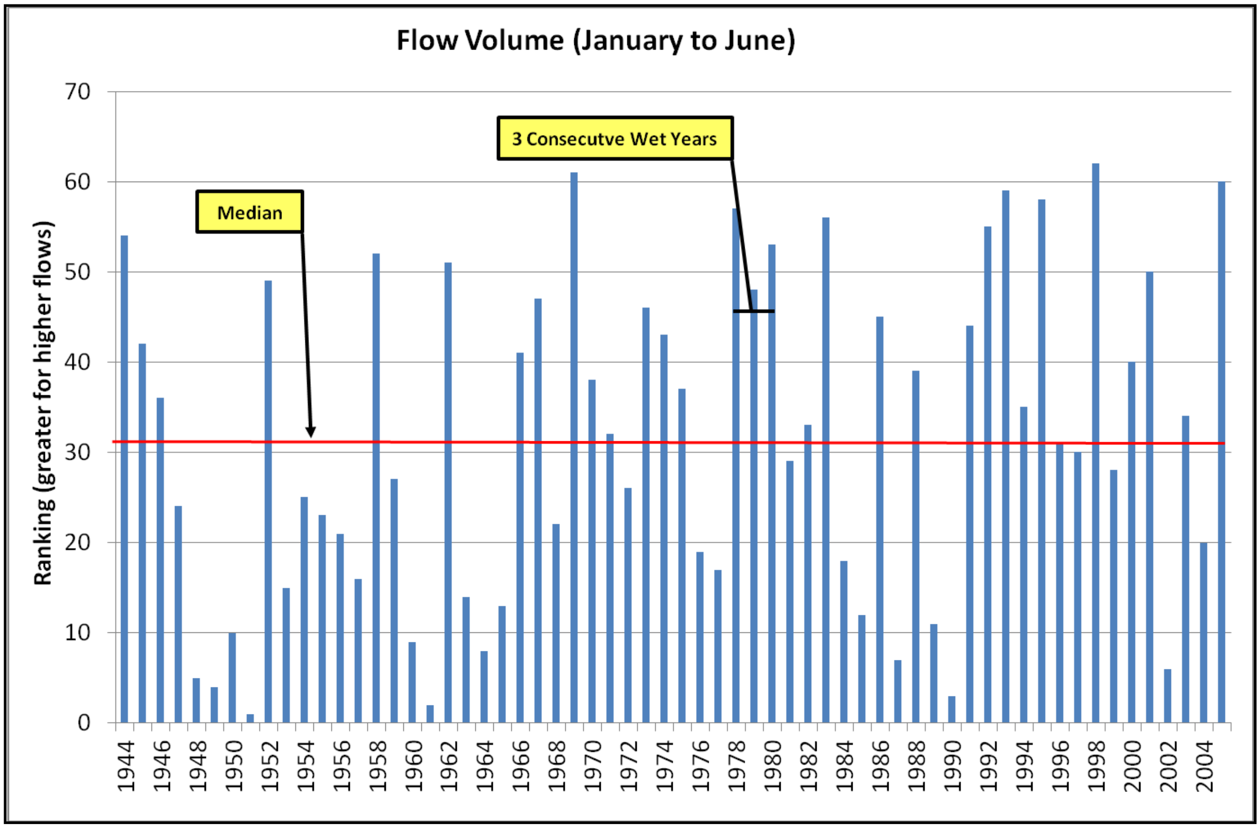


Figure 5.3-2. Volume of Piru Creek inflow to Lake Piru during January through June for the period 1944 to 2004 ranked from highest volume to lowest volume. Three consecutive Wet Years (1978, 1979, and 1980) were selected to evaluate downstream passage alternatives.

The results of the BPT using the three consecutive Wet Years showed similarities and differences compared to results using All Years. Under Wet Years, D7 – Piru Creek Collector had a lower performance compared to All Years, but even during Wet Years performance ranged from 73 to 88 percent of the assumed annual 10,000 smolts. As described in Section 4.3.4: D7 – Piru Creek Collector, it was assumed that the fry criterion was met at all flows up to 200 cfs. At flows from 200 to 400 cfs, all flow is screened, but the approach velocity criterion is exceeded. At flows from 400 cfs to 1,000 cfs, 400 cfs is screened and the remaining flow and associated smolts are passed over the dam into the reservoir. When flows in Piru Creek exceed 1,000 cfs, the dam is lowered and no smolts are captured in the Piru Creek Collector. During January through June 1978, 1979, and 1980, Piru Creek inflow exceeded 1,000 cfs a total of 25 days out of 543 and all days of flow exceeding 1,000 cfs occurred on or prior to April 1. During the assumed peak outmigration month of April, Piru Creek inflow only exceeded 400 cfs on 3 days over the 3-year period. The design flow of 200 cfs was selected, in part, based on a BPT sensitivity analysis of a Piru Creek Collector over a range of design flows (Figure 5.3-3).

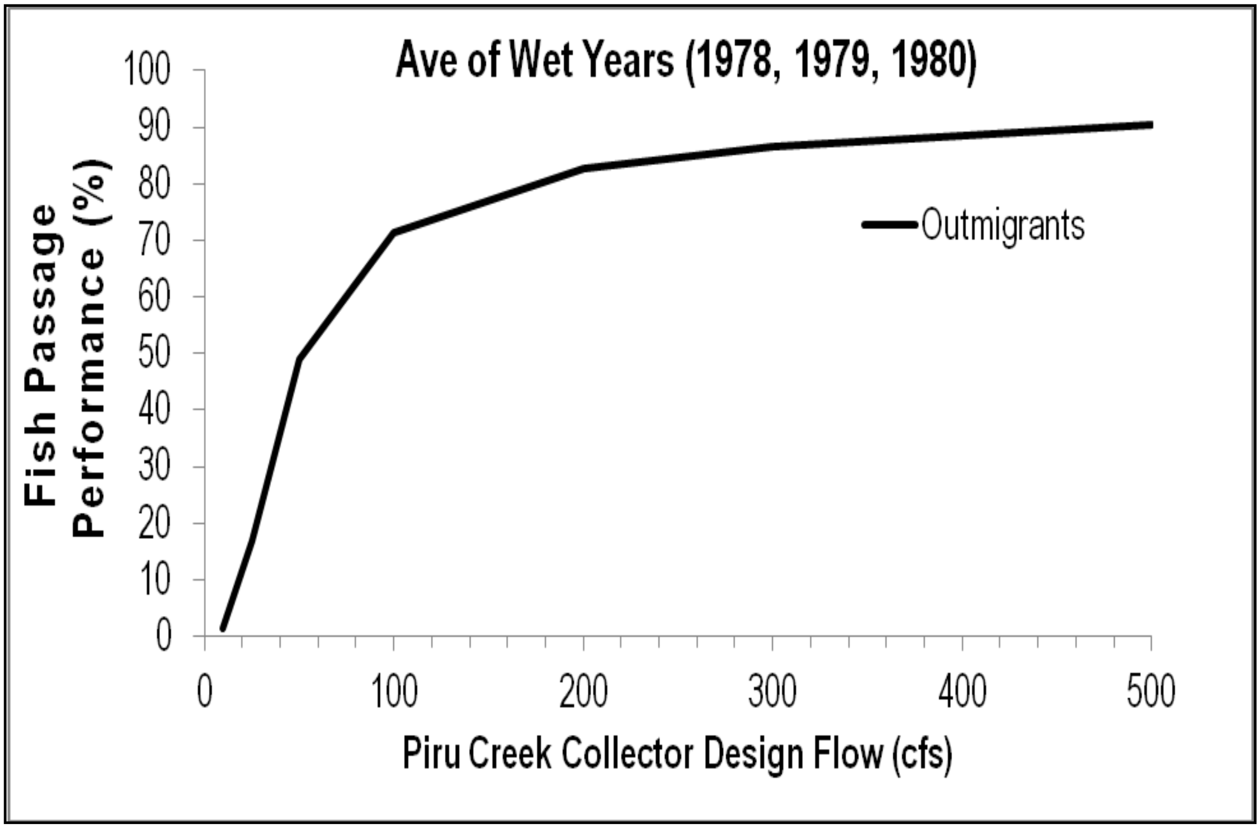


Figure 5.3-3. Performance of Piru Creek collector under a range of design flows. A design flow of 200 cfs was selected for the initial evaluation of a Piru Creek Collector as part of downstream fish passage alternative D7.

The results of the BPT using the average of Wet Years 1978, 1979, and 1980 were input to the evaluation matrix and used to assess fish passage feasibility under the selected downstream passage alternatives. Under the three Wet Years, the performance of D7 ranged from 73 percent to 88 percent of the assumed annual 10,000 smolts passed downstream of SFD, compared to 82 – 94 percent under All Years. Under both All Years and Wet Years, D7 had the highest performance of any of the single-facility alternatives. The difference between All Years and Wet Years was less pronounced for reservoir-based fish passage facilities since the reservoir tends to mute the effects of the flashy tributary hydrology. Since smolt outmigration may be higher during or after years with high runoff volume, the results of the BPT using the average of three consecutive Wet Years (Figure 5.3-4) were used as input to evaluation matrix.

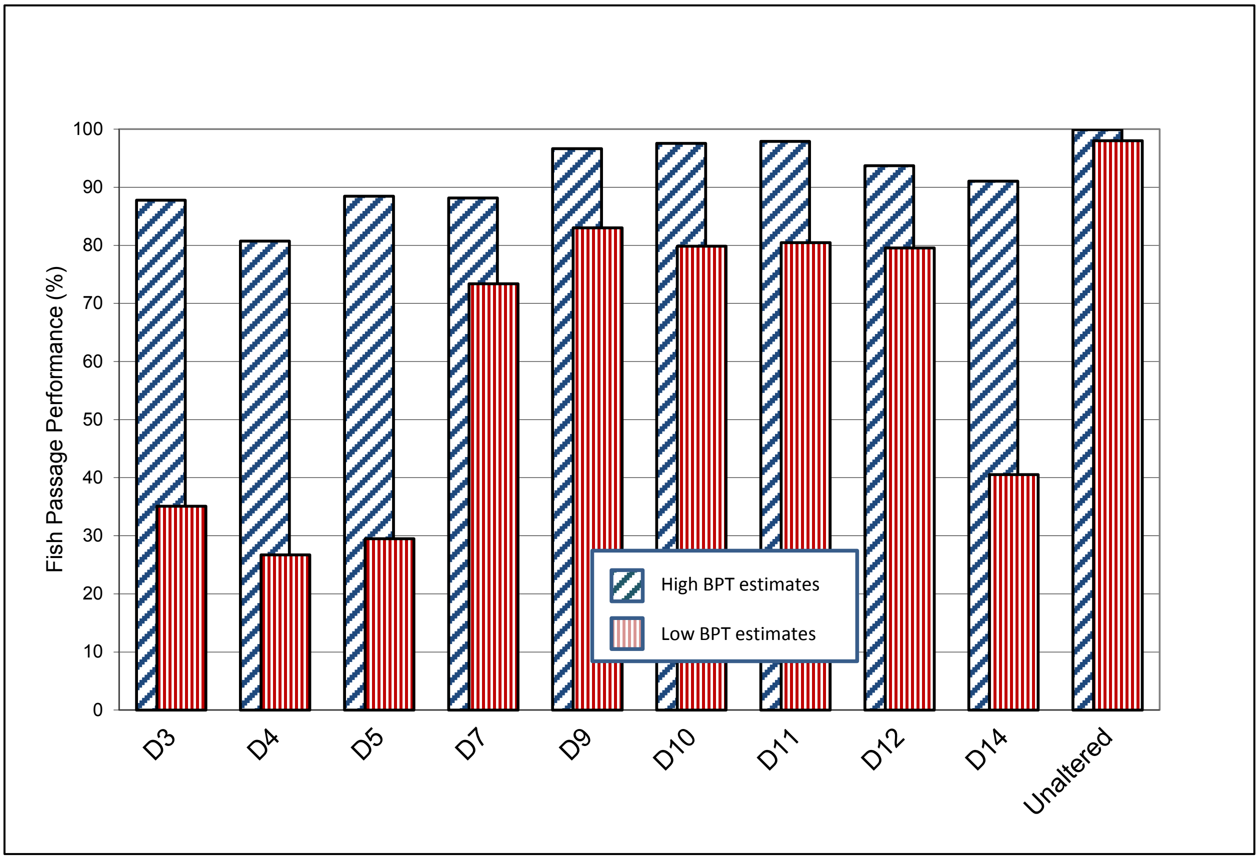


Figure 5.3-4. Performance of downstream fish passage alternatives D3, D4, D5, D7, D9, D10, D11, D12, and D14 calculated as the average for Wet Years 1978, 1979, and 1980. Evaluation assumes that 10,000 smolts enter the system each year. High estimates based on best-case assumptions for Biological Performance Tool response functions and low estimates based on assumed worst-case response functions.

For comparison purposes, the evaluation matrix included BPT estimates for a hypothetical condition without the project or “unaltered” condition. The BPT estimates for the “unaltered” conditions were assumed to be 98% for a low estimate and 99.9% for a high estimate and are included in Figure 5.3-4.

5.3.3 Downstream Passage Evaluation Results for All Categories

Figure 5.3-5 shows the results of the downstream passage evaluation with all categories weighted equally so fish passage, operations, and social categories each have the same importance. The BPT scores for the alternatives were used as the weighted scores and were normalized to a range up to 100 to be comparable to the other weighted scores in the matrix. Two scores are shown for each alternative representing both the high and low values of the BPT and reflecting the range of uncertainty in each BPT result. The BPT values for the wet years were used, as described in Section 5.1.3) throughout the matrix evaluation process.

	Criteria / Category weight	D3 Surface Col 150 cfs screen		D4 Surface Col 150 cfs screen Volitional		D5 Surface Col 500 cfs screen		D7 Piru Col. 200 cfs		D9 Piru Col w/ 500 cfs spillway collector		D10 Piru Col 200 cfs w/ 150 cfs collector		D11 Piru Col 200 cfs w/ 500 cfs collector		D12 Piru Col 200 cfs w/ movable FSC		D14 Multi-level outlet, 150 cfs, flume bypass, no screen		Std Dev of Products	Unaltered	
		Score 0-10	Weighted Score	Score 0-10	Weighted Score	Score 0-10	Weighted Score	Score 0-10	Weighted Score	Score 0-10	Weighted Score	Score 0-10	Weighted Score	Score 0-10	Weighted Score	Score 0-10	Weighted Score	Score 0-10	Weighted Score		Score 0-10	Weighted Score
Downstream fish passage	10																					
Biological Performance Tool - High estimate	10	8775	87.8	8071	80.7	8844	88.4	8815	88.2	9663	96.6	9754	97.5	9789	97.9	9369	93.7	9103	91.0	7.9	9990	99.9
Biological Performance Tool - Low estimate	10	3509	35.1	2670	26.7	2951	29.5	7336	73.4	8302	83.0	7986	79.9	8046	80.5	7953	79.5	4052	40.5	21.4	9500	98.0
Timeliness of passage	9	3.0	27	3.0	27	5.0	45	7.0	63	8.0	72	8.5	77	10.0	90	8.0	72	3.0	27	24.3	9.0	81
Kelt collection, safety, and passage	7	5.1	36	5.0	35	5.9	41	5.7	40	5.9	41	7.4	52	8.0	56	7.1	50	5.6	39	8.3	10.0	70
Potential for Biological Monitoring	2	6.6	13	6.0	12	6.7	13	6.1	12	5.9	12	7.3	15	7.3	15	7.1	14	3.3	7	1.1	2.7	5
Safety of upstream migrants	2	8.1	16	9.1	18	8.0	16	8.3	17	7.6	15	7.7	15	8.0	16	7.3	15	4.4	9	1.0	9.3	19
Complimentary to upstream facilities	2	5.9	12	10.0	20	6.0	12	4.9	10	5.1	10	5.7	11	5.6	11	5.0	10	3.0	6	3.1		
Opportunity to block non-natives	2	4.1	8	4.1	8	4.9	10	3.6	7	3.6	7	5.7	11	5.1	10	5.6	11	2.0	4	1.5	0.0	0
Adaptability of collection and passage	8	5.3	42	4.3	34	5.7	46	6.4	51	5.6	45	7.0	56	6.6	53	8.0	64	1.4	11	10.6		
Operation and maintenance	10																					
Simplicity of fish passage operations	8	5.9	47	2.9	23	5.3	42	5.9	47	4.9	39	4.3	34	4.0	32	2.4	19	5.6	45	9.0	10.0	80
Debris management	8	5.3	42	3.4	27	4.6	37	6.6	53	4.7	38	5.7	46	4.7	38	5.7	46	5.3	42	6.4	10.0	80
Durability of Structure	6	6.3	38	4.6	27	6.3	38	4.3	26	4.1	25	3.9	23	3.7	22	3.1	19	6.0	36	7.1	10.0	60
Operations safety	10	5.0	50	5.9	59	5.0	50	6.3	63	4.2	42	5.3	53	5.0	50	4.0	40	7.3	73	8.9		
Certainty of meeting SFD Project objectives	10	10.0	100	10.0	100	10.0	100	10.0	100	10.0	100	10.0	100	10.0	100	10.0	100	5.7	57	0.0	0.0	0
Effect on normal operation of water supply and generation	4	10.0	40	10.0	40	10.0	40	10.0	40	10.0	40	10.0	40	10.0	40	10.0	40	10.0	40	0.0	0.0	0
Social	10																					
Public safety	10	7.9	79	7.9	79	7.9	79	5.9	59	5.3	53	5.3	53	4.9	49	3.6	36	7.9	79	16.8		
Aesthetics	2	6.4	13	6.4	13	6.3	13	6.0	12	5.4	11	5.3	11	4.9	10	3.4	7	6.4	13	2.0	10.0	20
Education	2	5.2	10	5.3	11	5.2	10	5.6	11	5.9	12	6.3	13	6.0	12	6.1	12	4.5	9	0.9		
Permitting	2	6.7	13	6.6	13	6.7	13	4.0	8	3.2	6	3.3	7	3.2	6	2.6	5	6.4	13	3.4		
Cost - Not part of Panel evaluation	0																					
Construction																						
Operation and maintenance																						
Certainty of cost																						
Category Weighted, High BPT - Normalized			98		92		100		99		92		98		96		88		89			97
Category Weighted, Low BPT - Normalized			93		86		94		98		91		96		95		87		84			96

Figure 5.3-5. Results of the evaluation matrix for the nine downstream passage alternatives for all categories combined. See Section 5.1.2 for explanation of table and colors.

Figure 5.3-6 shows the following results of the downstream passage evaluation with all categories weighted equally so fish passage, operations, and social categories each have the same importance:

- Based on BPT high estimate score,
  - D5 scored highest.
  - D7 scored second highest.
  - D12 scored lowest.
- Based on BPT low estimate score,
  - D7 scored highest.
  - D10 scored second highest.

- D14 scored lowest.
- Overall,
    - D7 scored highest and with the least uncertainty reflected by the range of the BPT scores.
    - D10 and D5 scored second highest.
    - D4, D9, D12, and D14 scored significantly lower than other alternatives.

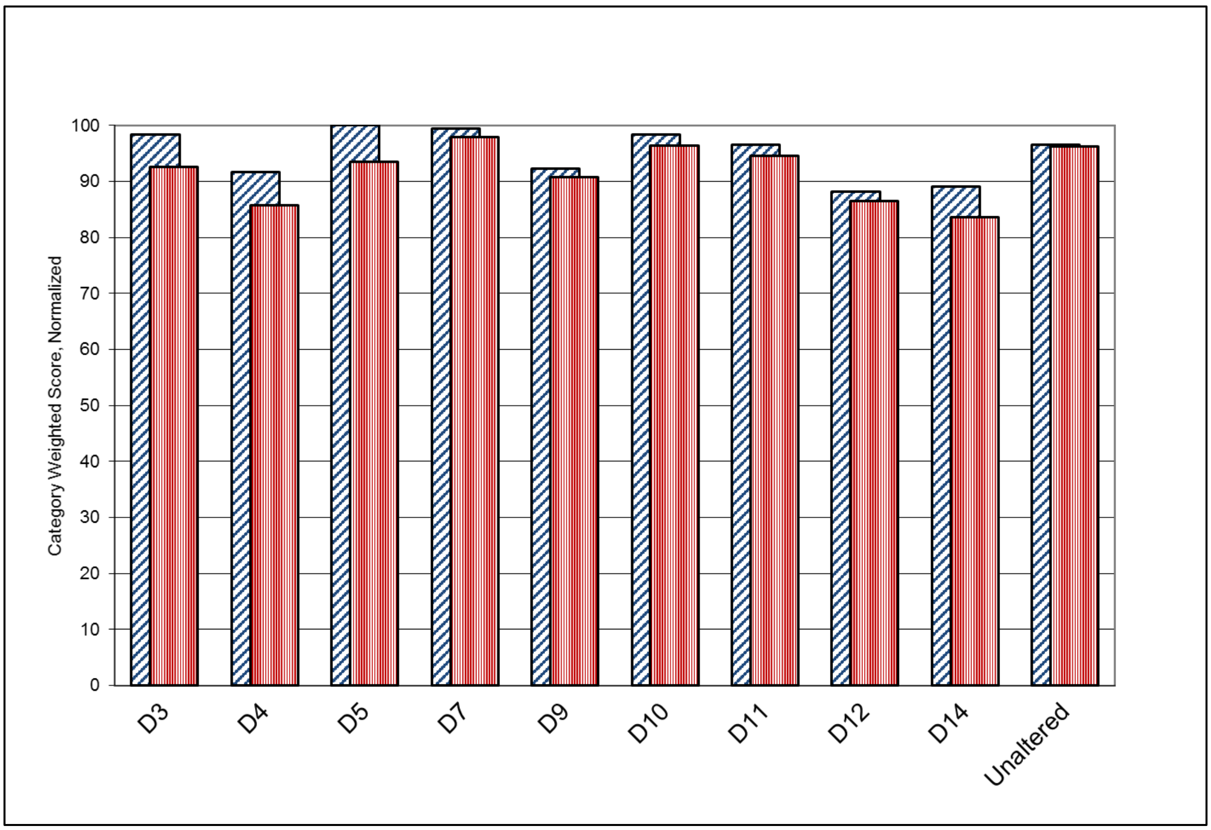


Figure 5.3-6. Comparison of the total evaluation matrix scores for the downstream passage alternatives and the unaltered condition based on results for all three evaluation categories. Pairs of data bars are for high and low BPT scores for each alternative.

5.3.4 Downstream Passage Evaluation Results for Fish Passage Category

Figure 5.3-7 graphically shows the results of the downstream passage evaluation considering only fish passage.

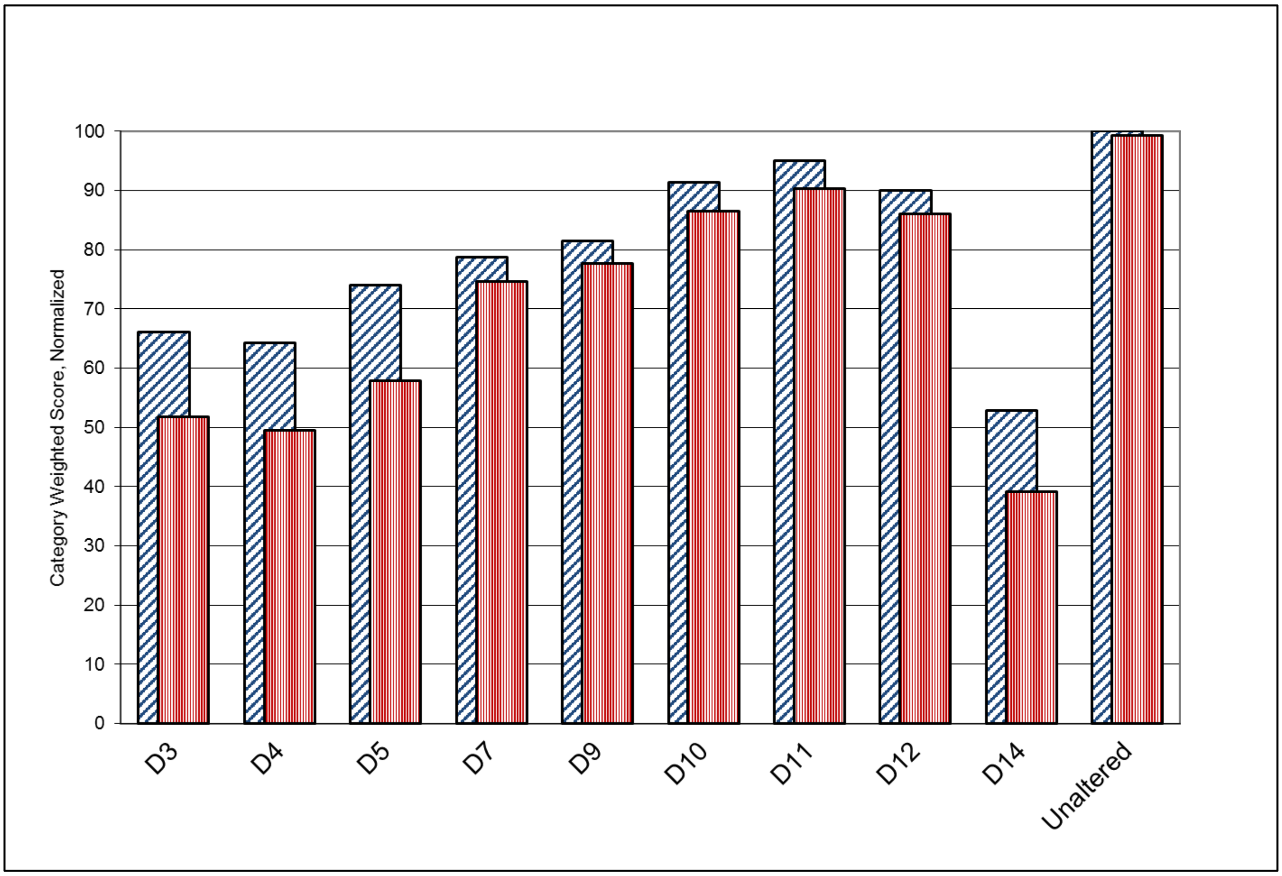


Figure 5.3-7 Comparison of the total evaluation matrix scores for the nine downstream passage alternatives and the unaltered condition based on results for the fish passage evaluation category. Pairs of data bars are for high and low BPT scores for each alternative.

The range in scores in this case is much broader than that for the overall (all categories) evaluation:

- D11 scored highest; it and D10 and D12 are nearly equal. These three alternatives are significantly higher than other alternatives because they combine the aspects of D7 – Piru Creek fish passage collector (highest rated stand-alone alternative) with the three reservoir collector alternatives. These alternatives score from 87% to 95% of the unaltered condition.
- D3, D4, D5, and D7 scored significantly lower.
- D14 scored very low. It scored lowest of the alternatives for all but a few of the fish passage criteria.

5.3.5 Downstream Passage Evaluation Results for Operations and Social Categories

Figure 5.3-8 graphically shows the results of the downstream passage evaluation considering only operations and social categories. Since there is no BPT included, there is no range of scores in this comparison.

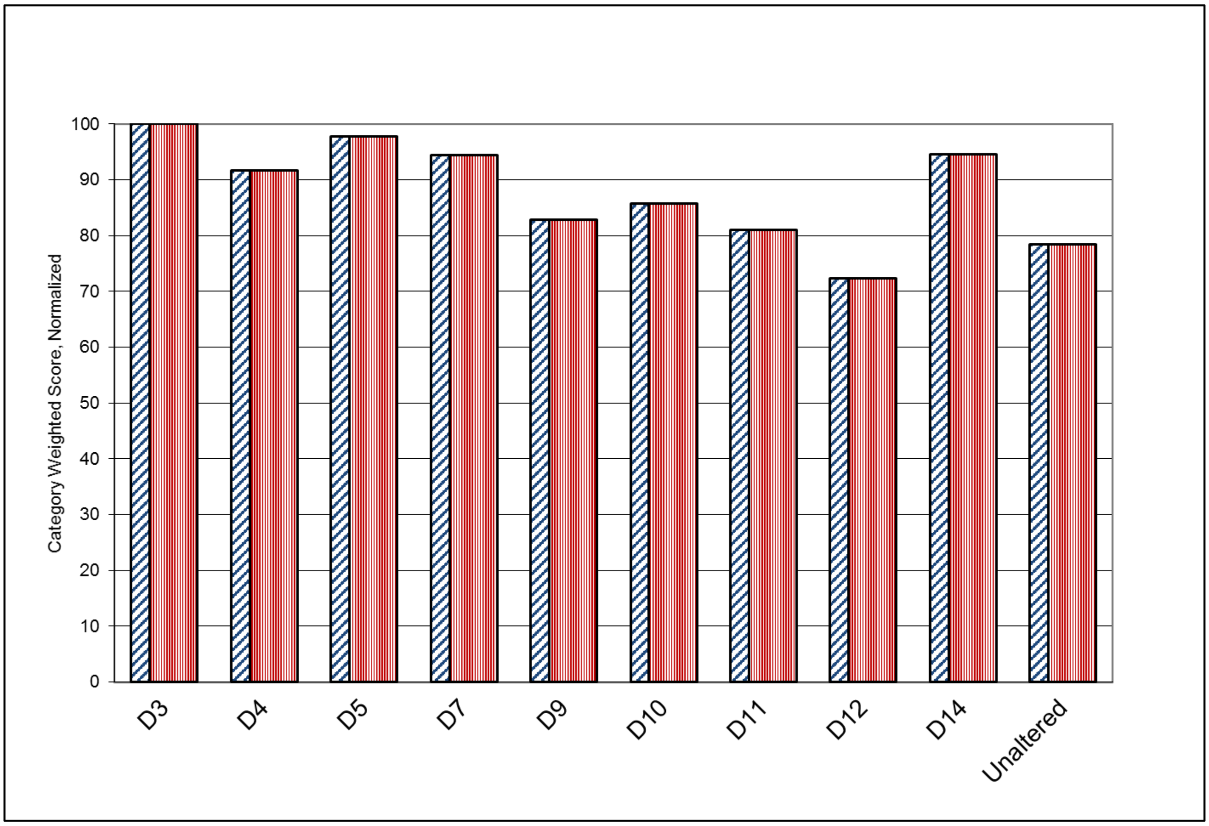


Figure 5.3-8. Comparison of the total evaluation matrix scores for the nine downstream passage alternatives and the unaltered condition based on results for the operation and social evaluation categories.

Results of the operation and social categories evaluation are essentially the opposite of the results of the fish passage category evaluation. Higher fish passage scores are gained at the expense of greater and more complex operational efforts:

- D3 and D5 score significantly higher than the combinations that include D7.
- D7 scores slightly lower than D3 and D5 and the highest of the stand-alone alternatives.
- D14 scores high due to its simplicity of operation and its high relative safety score. It would score highest except it includes a flow pumpback from the tailrace that affects normal operation of SFD. The pumpback operation is also costly, which is reflected in operating costs.

- D4 also scores relatively high. It is operated passively so normal operations are simple and scores high but high operation score is offset by mechanical complexity, debris management, and durability – all scoring substantially lower than D3 or D5.
- D12 scores very low due high effort and safety issues with mobile operations in the reservoir and low durability.

5.3.6 Downstream Passage Evaluation Summary

Based on the results of the combined scoring of all downstream passage alternatives and the unaltered condition:

- D5 and D7 scored highest overall, followed closely by D3 and D10, including scores with high and low BPT estimates. Of these, D7 has significantly less uncertainty, as seen by the separation between low and high estimates.
- Alternatives combining the Piru Creek collector (D7) with reservoir collectors yield the highest scores for fish passage (i.e., D11, D10 and D12).
- Alternatives combining D7 with reservoir collectors yield the least uncertainty (separation between low and high estimates).
- D11 scores highest for the fish passage category, followed closely by D10 and D12.
- D7 score the highest of the stand-alone alternatives for operations and maintenance, followed closely by D3.

6. RECOMMENDATION OF PREFERRED FISH PASSAGE ALTERNATIVES

The final recommendation of the Panel includes a preferred fish passage alternative and a phased implementation and adaptive management process (described in Section 7) for implementing the recommendation. The recommendation was based on the information regarding the description of the selected alternatives in Section 4 and the results of the feasibility evaluations provided in Section 5. The following summarizes the process the Panel used for developing the above information and ultimately identifying the preferred alternative. First, and specifically related to the BO, per RPA 3c

> *"The steelhead passage feasibility report shall… (2) identify <u>the preferred long-term solution</u> to restore steelhead access to and from historical steelhead spawning and rearing habitats upstream of Santa Felicia Dam (if volitional steelhead passage is determined to be infeasible, then the study shall consider non-volitional steelhead passage; if non volitional passage is determined to be infeasible, then the Licensee shall consult with NMFS to develop an alternative to steelhead passage [such as an habitat-compensation plan based on measurable biological criteria to minimize the effects of the loss of habitat upstream of Santa Felicia Dam on steelhead], which will be presented in the report)…"*

Task 7 of the Study Plan states that the Report should be structured to organize and report on the full development of the final fish passage alternatives. The overall content of the Report was described in Section 4.7 of the Study Plan (pages 42-43 of SFDFPP 2013) as summarized below:

> *"The final feasibility report is to document the process followed, in the development of potentially feasible fish passage alternatives and the formulation of evaluation criteria, provide a summary of alternatives deferred and a final feasibility evaluation, and identify the final recommended alternatives. Each alternative is to be described with text and conceptual level design drawings, an OPCC, an estimate of operating costs, an implementation schedule and description of construction issues, a listing of pros and cons, and a summary and details of the final evaluation. Potential indirect costs, such as lost power opportunities or impacts to aquifer recharge, are to be identified but not included in the cost estimate. At least one volitional alternative for upstream and downstream passage is to be included, regardless of its feasibility.*
>
> *The final feasibility report will include the Panel's recommendation regarding the technical and biological feasibility of providing volitional steelhead passage at*

> *SF Dam. If the Panel cannot recommend a volitional passage facility due to site constraints, uncertainties, or other factors, the Panel will recommend a non-volitional passage facility if deemed feasible. If the Panel cannot identify a feasible fish passage alternative, the Panel will document its rationale and describe potential next steps to respond to RPA Element 3. Recommendations for next steps will be developed, which might include: fish passage alternatives to be pursued; further studies, if needed to address uncertainties or risk; or economic assessments and recommendations to explore non-passage alternatives."*

The Panel used RPA 3(a-e) as a guide when completing the Study but deferred to the final FERC approved Study Plan for determining the scope and final content of this Report. The Panel notes for example that RPA 3(c) infers that the report should identify the preferred long-term solution to restore steelhead access "…upstream of Santa Felicia Dam…" However, the FERC approved Study Plan contains no such requirement, but rather as noted above, that the Report document the process the Panel followed for evaluating the technical and biological feasibility of different fish passage alternatives, and then recommend a preferred alternative. The actual identification of the long-term solution to restore access of SCS DPS above SFD will occur as a Group decision as described in Task 8 of the Study Plan, which occurs following the final publication of this Report. This process is more fully described in Section 7.1.

To accommodate the intent of both the BO (RPA 3c) and the Study Plan in evaluating and identifying a preferred alternative, the Panel considered and addressed the following elements:

- Feasibility of Alternatives.
- Opportunity for Volitional Fish Passage.
- Feasibility Evaluation Results (i.e., relative feasibility).
- Permitting Requirements.

6.1 FEASIBILITY OF ALTERNATIVES

Section 4 provided details of each of the upstream and downstream fish passage alternatives selected for detailed evaluation, including details of features after full build-out. Sections 5.1 through 5.3 addressed the alternative feasibility analyses and the evaluation results as a comparison among alternatives. The results of the evaluation found that all four upstream passage alternatives and all nine downstream passage alternatives have some uncertainties and risks, but the Panel believes they are feasible.

The tests of alternatives meeting complete "feasibility" would reflect an affirmative response to the following questions (see Section 1.5.1):

1. Technical feasibility; does it satisfy fish passage and water supply objectives of the project?
2. Biological feasibility; does it satisfy biological goals?
3. Engineering feasibility; can it be built and operated?
4. Economic feasibility; is it worth doing either inherently or relative to other actions?

Economic feasibility is only included in the Study Plan as a potential later phase of work, based on a Group Decision that will occur in Task 8 as noted above and described further in Section 7. This Report provides a set of fish passage alternatives that meet the tests of technical, biological, and engineering feasibility per the first three metrics noted above, but that also vary significantly in cost. This Report provides information to the Group for further consideration in Task 8, which can result in a decision to either move forward with a selected fish passage implementation project (which may consider the cost estimates provided in Section 4.4), or can result in a Group decision to initiate Task 9 which includes an analysis of "economic feasibility."

6.2 OPPORTUNITY FOR VOLITIONAL PASSAGE

The concept of volitional passage was addressed on numerous occasions both within the Panel and among the Group, primarily to confirm that the concept was being correctly interpreted by the Panel and that volitional passage was a persistent consideration in developing and evaluating passage alternatives, as prescribed in RPA 3(c).

As discussed in Section 1.5.5, the Study Plan stipulated that the Panel apply the following definition of volitional passage, which was adopted by the Group:

> *"Volitional fish passage is a means of fish passage with appropriate hydraulic conditions such that all individual migrating adult and juvenile fish of the species of interest have the opportunity to move freely and safely upstream and/or downstream past the Project according to their own motivation."*

The only upstream passage alternative that meets the above definition for the anticipated full range of reservoir elevations during the adult migration period from the tailwater to the reservoir is Alternative U1 (Pool and Weir Fishway, Tunnel and Tower). Alternatives U2 and U3 provide volitional passage within a certain range of reservoir elevations as follows:

- Alternative U2 provides volitional passage between reservoir elevations 1,030 ft and 1,056 ft, which occurs about 32 percent of the time on average for the reservoir period of record during the adult migration period. It requires trap and transport passage when the reservoir elevation is below 1,030 ft.
- Alternative U3 provides volitional passage only when the reservoir elevation is between 1,054 and 1,056 ft. When the reservoir is below elevation 1,054 ft passage is limited to only the upstream direction as fish leap over a false weir and slide into the reservoir (i.e., once fish ascend the ladder and enter the reservoir they cannot move freely back downstream via the U3 ladder). Collection and transport passage is not required for upstream passage when the reservoir is above the lowest expected reservoir operating elevation of 980, since the fish ladder release slide extends to that elevation.

The only downstream volitional passage alternative evaluated in this Report is Alternative D4. This alternative could stand alone, but it is included in this Report as attached to upstream passage Alternative U1, which is the volitional upstream passage alternative.

Providing volitional passage around SFD is highly challenging with significant, known obstacles (i.e., not just uncertainties). The complexity and risk to passage performance and dedication of resources are high compared to other alternatives, and the advantage to SCS DPS is questionable relative to the goal of establishing secure, safe, and effective fish passage around SFD, even within the constraints of proven concepts and technology associated with the non-volitional alternatives evaluated in this Report. As such, the Panel finds that volitional passage is currently an unrealistic option. If the Group disagrees with this assessment, the Panel recommends volitional passage alternatives only be considered as appropriate if and when the risks and uncertainties are addressed and its performance can be shown to be substantially superior to the recommended preferred alternative described below.

6.3 FEASIBILITY EVALUATION RESULTS

As described in Section 5, the use of a matrix-based evaluation of the alternatives provided the opportunity for Panel members to focus on attributes of the various alternatives in an iterative, progressively informative manner that captured individual and collective Panel experience and expertise (including knowledge of fish passage performance data at comparable facilities). As deliberation of the alternatives progressed, and questions were asked and uncertainties refined, a basis for recommending a preferred solution to fish passage at SFD evolved and the more pertinent attributes underlying the recommendation were identified. Although the process generated a relative ranking or scoring of the alternatives, the most informative result of the process was the determination of how best to use the evaluation in the selection of a preferred solution.

The primary consideration underlying identification of a preferred solution to long term fish passage was risk. The Panel assessed risk by contemplating the following:

- The likelihood of an alternative performing as expressed in the matrix evaluation results;
- How resolving the identified uncertainties could potentially affect selection of a preferred alternative, or could dramatically change the assumptions applied in the evaluation matrix;
- The flexibility of an alternative to be configured (phased) to meet the BO objective;
- The challenges, risks and uncertainties as described for each alternative in Section 4; and
- The consistency or reasonableness of the scoring results in the evaluation matrix based on professional experience and expertise of the Panel members.

In the end, the Panel used a combination of the matrix evaluation and the risk assessment noted above, along with personal experience and professional judgment to determine which alternative(s) had the greatest likelihood of success.

6.3.1 Recommended Upstream Fish Passage Alternative

The Panel identified U4 (collection and transport) as the upstream fish passage component of the preferred alternative. An overall summary of the key elements that the Panel considered in this selection are presented in Table 6.3-1.

Results of the matrix-based evaluation showed that U4 had the highest scoring for stand-alone alternatives, was a principal component of all alternatives, and had the least uncertainty in potential performance. As presented in Section 5, based on the results of the combined scoring of all upstream passage alternatives:

- U4 had the highest score when evaluated overall as well as when evaluated just for fish passage or just for operation and maintenance;
- U4 rated highest in 7 of the 13 fish passage category criteria evaluated and tied for highest in 3 additional criterion;
- U4 scored highest for all the high weighted criteria, including attraction (tied with all alternatives), effectiveness and certainty of performance;
- U3 scored second highest overall; and
- U2 scored lowest overall or when scored solely for either fish passage or operations and maintenance;

Additionally, based on the evaluation of risk (Table 6.3-1), the actual and relative risks associated with U4 are low. Overall, U4 provides:

- a proven concept and high relative likelihood of success of providing passage, given examples throughout the Pacific Coast region - all other upstream alternatives have components that are experimental or highly complex and would require substantial commitment of resources to address risks and uncertainties, such as the effect of the length of the fishways on performance and challenges to design and build the associated complex structures;
- a clear pathway to evaluate effectiveness - evaluation of the effectiveness of the other three upstream passage alternatives would involve substantial commitment to resolve risks without clearly benefitting the objective of providing safe and successful upstream passage;
- a good foundation for responding to results of performance including opportunities and direction for phasing;
- the basic components or building blocks that the other alternatives can employ as a first step in implementation - expansion of U4 into other alternatives can be readily made and will be based on effectiveness monitoring (see Section 7); and
- a relatively simple concept, design, and a record of implementation with many historical and contemporary examples.

Table 6.3-1. Summary of key elements that were considered in the Panel's selection of U4 (collection and transport) as the recommended upstream fish passage alternative for the Santa Felicia Dam.

Alternative	Description	Phasing Opportunities	Challenges and Uncertainties	Volitional	Risk
U1	Pool and Weir Fishway, Tunnel and Tower; Reservoir Range EL 980 ft to 1,056 ft	• Start with a collection and transport facility that includes the barrier dam and fishway entrance structure in the low flow release channel directly below the dam and outlet works. • The fishway would lead to a temporary or permanent collection and transport facility similar to U4. If performance criteria are met, then expand the alternative into full build-out or develop the next partial phase. • The fishway tunnel and tower could be constructed if fish returns increase or complete volitional fish passage is required at a later time.	• Seismic design challenge • Complex system of gates and control system • Fish behavioral response to migrating through a long tunnel and a stair-case tower • Reservoir flow patterns and water quality issues for location and orientation of the fish exit • Fish behavioral response to migrating through the reservoir • May not be very effective for downstream migration	Yes	High • Unproven (experimental). • Complex. • Dependent on seismic retrofit. • Fish passage behavioral response to migrating through the reservoir.
U2	Pool and Weir Fishway to EL 1,030 ft, East Alignment to Exit Structure; Reservoir Range EL 1,030 ft to 1,056 ft	• Start with a collection and transport facility that includes the barrier dam and fishway entrance structure in the low flow release channel directly below the dam and outlet works. • The fishway would lead to a temporary or permanent collection and transport facility similar to U4. If performance criteria are met then expand the alternative into full build-out or develop the next partial phase.	• Seismic design challenge (but less than U1) • Complex system of gates and control system (but much less than U1) • Fish behavioral response to migrating through a long fish ladder, partial tunnel and the exit structure • Reservoir flow patterns and water quality issues for location and orientation of the fish exit • Fish behavioral response to migrating through the reservoir • May not be very effective for downstream migration and no access for downstream migration below minimum reservoir operating elevation	Partial – limited to a 26 ft range of the upper reservoir elevations, depends on collection and transport below this elevation range	Moderately High • Unproven component of exit structure (experimental like U1). • Complex. • Fish passage behavioral response to migrating through the reservoir.
U3	Pool and Weir Fishway to EL 1,056 ft, West Alignment with Slide Release; Reservoir Range EL 980 ft to 1,056 ft	• Start with a collection and transport facility that includes the barrier dam and fishway entrance structure in the low flow release channel directly below the dam and outlet works. • The fishway would lead to a temporary or permanent collection and transport facility similar to U4. If performance criteria are met then expand the alternative into full build-out or develop the next partial phase.	• Constructing a long fish ladder on existing grade with potential for some tunneling and other special construction techniques. • Unique fishway exit structure and slide release channel relying on pumped flow and an unprecedented slide release channel. • Fish behavioral response at the false weir and for the slide release channel. • Fish behavioral response to migrating through a long fish ladder. • Reservoir flow patterns and water quality issues for location and orientation of the fish exit. • Fish behavioral response to migrating through the reservoir.	Partial – limited to very narrow reservoir elevation range (2 ft);the rest of the time with pumped fish ladder flow, volitional fish passage is only upstream (cannot return from the reservoir)	Moderately High • Unproven component of exit structure and slide release (experimental). • Complex ladder exit. • Fish passage behavioral response to migrating through a long fish ladder and the reservoir.
U4	Collection and Transport with Multiple Release Locations; Reservoir Range EL 980 ft to 1,056 ft	• Can phase into all other upstream alternatives (since Alternative U4 is a collection and transport facility it is inherently a possible first phase of other upstream passage alternatives, as described for U1, U2 and U3). • An interim or temporary trap in the low flow release channel could precede permanent facilities as a phased approach and facility sizes could start small and be added to in response to increased performance requirements. • Another phasing opportunity or combination alternative is to complement Alternative U4 with the Piru Creek collector upstream of the lake (Alternative D7). The transport and fish release components of Alternative U4 could be used to hold and acclimate fish collected at the Piru Creek collector and vice-versa; additionally, the Piru Creek collector could be used as a location to haul upstream migrants to for release.	• Fish behavioral response to trapping and trucking/post-release. • Few challenges, none of significance that cannot be handled with some study and good design.	No	Low

6.3.2 Recommended Downstream Fish Passage Alternative

The Panel identified Alternative D7, a Piru Creek collector with provisional 200 cfs design flow, as the downstream fish passage component of the preferred alternative based on the discussions in Sections 4 and 5 and the evaluation of risk associated with the alternatives. An overall summary of key elements that the Panel considered in this selection is provided in Table 6.3-2.

As noted in the matrix-based evaluation of downstream alternatives presented in Section 5:

- D7 had the highest scoring for stand-alone alternatives, was a principal component of all high scoring alternatives, and had the least uncertainty in potential performance;
- D5 and D7 scored highest overall, followed closely by D3 and D10, including scores with high and low BPT estimates. Of these, D7 had significantly less uncertainty, as indicated by the small separation between low and high estimates;
- Alternatives combining the Piru Creek collector (D7) with reservoir collectors (i.e., D11, D10 and D12) yielded the highest scores for fish passage;
- Alternatives combining D7 with reservoir collectors yielded the least uncertainty (separation between low and high estimates);
- D11 scores highest for the fish passage category, followed closely by D10 and D12; and
- D7 scored the highest of the stand-alone alternatives for operations and maintenance, followed closely by D3.

The Panel also found that the actual and relative risks associated with D7 are low, and that although it would be subject to permitting conditions associated with the arroyo toad which may dictate its precise location, D7:

- represents the logical first step for addressing downstream passage, given the uncertainties associated with the reservoir (i.e., water quality, predation potential, flow paths) and unknowns regarding how SCS DPS will respond to fish passage above SFD;
- is compatible with the existing infrastructure and operational characteristics of SFD;
- provides the greatest flexibility and opportunity to phase implementation of the alternative with minimal commitment of resources (time and cost); and allows the opportunity to phase in modifications to the facility and/or develop other alternatives (e.g., FSC) as determined through monitoring and an adaptive management process (see Section 7).

Table 6.3-2. Summary of key elements that were considered in the Panel's selection of D7 (Piru Creek collector with provisional 200 cfs design flow) as the recommended downstream fish passage alternative for the Santa Felicia Dam.

Alternative	Description	Phasing Opportunities	Challenges and Uncertainties	Volitional	Risk
D3	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps	• Most feasible to construct the tower concurrently with the planned outlet works modifications. • Add collector in Piru Creek (D7), either before or after D3 (becomes Alternative D10). • Start with a lower pumping capacity and expand later. • Start with floating surface collector (becomes Alternative D12). • Start without outlet screens and conduct entrainment study.	• Suitability of Lake Piru as rearing habitat is unknown. • Seismic design challenge. • Uncertainty of overall efficiency of fish collection. • Uncertainty of exact location, entrance orientation, and the collector flow requirement for most efficient fish collection. • Specific location of the tower to not affect spillway capacity or present an operational safety hazard.	No	High • Potential effect of reservoir on juvenile passage and survival. • Potential inadequate attraction and collection of fish. • Large investment and commitment to test and refine concept.
D4	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps, Volitional Bypass with U1	• Same as D3 • Must be completed concurrently with U1.	• Same as D3, plus: • Uncertainty of value of volitional passage to satisfying project objectives.	Yes	High • Same as D3, plus: • Combined with U1, which has high risk of mechanical complexity. • Low velocity bypass may cause delay or rejection and more exposure to risks in the lake. • Stress or predation of juvenile fish mixed with larger fish in fishway.
D5	Surface Collector at Intake Tower, 500 cfs Screen, Gravity with Pumps	• Same as D3	• Same as D3 but reduced uncertainty due to higher flow capacity. • Fish behavioral response to low velocity when operating at less than 500 cfs.	No	High • Same as D3.
D7	Piru Creek Collector, 200 cfs Screen	• Start with reduced scale and increased later for higher flow capacity and high design flow.	• Specific location is provisional and has not been confirmed on site. • Frequency and effect of high flows on operations; sediment, debris, fish bypass to reservoir. • Number and consequence of fish bypassed to reservoir. • Migration timing of juveniles relative to Piru Creek flow and freshets. • Specific flow at which the screen must cease operation not accurately known until the facility is built and tested. • Other properties might be backwatered. • Impact on arroyo toad might be unavoidable. Permitting uncertainty.	No	Low • Low relative initial investment. • Some fish will bypass to reservoir. • Security and fish holding risks at remote site. • Damage and maintenance requirements due to high flow events.

Table 6.3-2. Summary of key elements that were considered in the Panel's selection of D7 (Piru Creek collector with provisional 200 cfs design flow) as the recommended downstream fish passage alternative for the Santa Felicia Dam.

Alternative	Description	Phasing Opportunities	Challenges and Uncertainties	Volitional	Risk
D9	Piru Creek Collector (D7) with Spillway collector	• Start with D7; add spillway collector as additional phase. • Start with reduced capacity spillway collector and add capacity later.	• Similar to D7 though reduced uncertainty because some fish bypassed at D7 are collected from reservoir. • Number and consequence of fish in reservoir when reservoir is below minimum operating level 1055. • Collector flow requirement for most efficient fish collection. • Compatibility with the earth fill dam and future spillway improvements, general dam safety concerns. • Operational reliability of entrance gate due to debris. • Attraction of fish as the lake level rises and entrance velocity is reduced.	No	Low • Similar to D7. Initial risk is low assuming first phase is D7.
D10	Piru Creek Collector (D7) with 150 cfs Surface Collector (D3)	• Same as combination of D7 and D3. • Start with D7 as first phase.	• Same as combination of D7 and D3 though less uncertainty than either because of dual collection opportunity.	No	Low • Similar to D7; initial risk is low assuming first phase is D7. • Large investment and commitment to test and refine concept.
D11	Piru Creek Collector (D7) with 500 cfs Surface Collector (D5)	• Same as combination of D7 and D5. • Start with D7 as first phase.	• Same as combination of D7 and D5 though less uncertainty than either because of dual collection opportunity.	No	Low • Similar to D7; initial risk is low assuming first phase is D7. • Large investment and commitment to test and refine concept.
D12	Piru Creek Collector (D7) with Movable FSC	• Start with D7; add surface collector as additional phase. • Modify flow capacity of collector. • Add additional surface collector. • Improvements in mooring or collector might be set at fixed location if a single preferred location is identified.	• Overall efficiency of fish collection. • Exact location and entrance orientation. • Collector flow requirement for most efficient fish collection. • Frequency of movement of collector in reservoir. • Debris handling, and especially means for debris removal during periods of high debris loading.	No	Moderate • Similar to D7; initial risk is low assuming first phase is D7. • Operational safety risks for personnel working over and on the water.
D14	Multi-level Crest Gate Collector with Helix Bypass	• Most feasible to construct the tower concurrently with the planned outlet works modifications. • Start with floating surface collector (Alternative D12. • Start without outlet screens and conduct entrainment studies. • Scale of collector is not alterable in future phase (risk).	• Same as D3, plus: • Challenge of operating and maintaining complex submerged gates. • Debris removal from 10 trash racks at varying levels. • Maintenance access by boat. • Hydraulic conditions in helix bypass. Model verification needed. • Fish safety through helix. Study needed. • High hydrostatic head on tower.	No	High • The operation and maintenance of multiple, complex, submerged intakes and gates. • Debris in transition to bypass. • Inaccessible closed conduit tunnel. • Some maintenance access only by boat. • Design flow is unalterable, either by operation or future phasing.

6.4 PERMITTING REQUIREMENTS

Another consideration that is relevant to the selection of the preferred alternatives pertains to permitting requirements. While all of the alternatives would be subject to and require permits if implemented, those that are more complex and require modifications to the existing infrastructure of the dam (i.e., U1, U2, U3, D3, D4, D5, D9) would likely involve a more detailed permitting process. The primary features associated with the two recommended alternatives, U4 and D7 are distinct and separate from the dam infrastructure and therefore the permitting process should be comparatively easier – especially in consideration of dam safety issues. Nevertheless, environmental and regulatory permits will be required and a detailed permitting process and schedule will need to be developed if fish passage is selected. This process would serve to identify all necessary local, state and federal permits needed for the construction and operation of the alternatives, and identify a critical path for their acquisition. The development of a detailed permitting schedule is outside of the Panel's scope of work defined in the Study Plan and moreover should occur in tandem with the detailed design process as part of implementation.

However, the Panel envisions the need for acquisition of several environmental and regulatory permits related to certain Pre-implementation studies and to allow construction and initial testing of low-technology/prototype facilities. The Pre-implementation studies could involve the collection and handling of different fish species found in Lake Piru and middle Piru Creek, as well as working within areas adjoining Piru Creek potentially inhabited by the ESA federally listed endangered arroyo toad. The arroyo toad is known to occupy at least the first 3.5 miles of middle Piru Creek upstream of Lake Piru while designated arroyo toad critical habitat extends 15 miles upstream from the lake. Also, any studies or activities that would infringe on USFS lands (Los Padres National Forest) would likely require special use permits.

A brief listing of the initial permits likely needed to support pre-implementation activities includes:

- USFS Special Use Permit as defined under 36 Code of Federal Regulations 251; this permit would be needed to provide for access (access easements), allow fish sampling to occur, and allow for the installation, operation, maintenance and monitoring of temporary fish trapping facilities (e.g., fyke nets, prototype collection traps);
- California Department of Fish and Wildlife Scientific Collection Permits (Section 1002 of California Fish and Game Code, and Section 650 (Scientific Collection Permit) and possibly Section 670.7 (Permits to take fully protected species for scientific purposes) of

Title 14 California Code of Regulations (CCR); these permits would be needed to allow the collection and handling of fish species in Lake Piru and middle Piru Creek;

- U.S. Fish and Wildlife Service Section 10 Incidental Take Permit (ITP) (for scientific research purposes); this permit would be needed since fish collection activities in middle Piru Creek may result in the incidental capture (take) of arroyo toad and may also adversely affect its critical habitat; acquisition of this permit would require joint consultation with the USFWS and NMFS;
- National Marine Fisheries Service Section 10 permits:
    a. *O. mykiss* populations above SFD are not listed under the ESA and therefore a Section 10 ITP should not be required to conduct fish sampling in Lake Piru or middle Piru Creek.
    b. Pre-implementation activities could potentially include the use of steelhead (adults and juveniles) to be located above SFD to provide information on fish behavior and habitat use and testing of prototype systems. Use of surrogate steelhead would be subject to NMFS approval of an acceptable source of fish as well as a determination of the status of the introduced fish relative to an experimental population as required under ESA Section 10(a)(1)(A).
    c. *O. mykiss* populations below SFD are considered SCS DPS and are listed under the ESA and therefore a Section 10 ITP would be required to conduct fish sampling or prototype testing of fish collection devices below the dam or in lower Piru Creek. This may also include activities related to the collection of *O. mykiss* captured above SFD and transported and released below SFD.

Ultimately, all permanent facilities associated with U4 and D7 would require a variety of local, state and federal permits to allow their construction and operation.

7. RECOMMENDED IMPLEMENTATION PROCESS

The Panel completed the Study based on the best available information. As part of this, the Panel developed a suite of fish passage alternatives for consideration, performed a rigorous evaluation process comparing the alternatives described in Section 5, and identified recommended preferred upstream and downstream fish passage alternatives in Section 6 that are considered technically feasible. The review consisted of an independent evaluation of different engineering designs and concepts as to their technical feasibility and expected biological performance. Costs were identified; however, the Panel did not evaluate the importance of cost relative to fish passage performance.

The Panel's recommendations are Alternative U4 for upstream passage with collection and transport facilities, and Alternative D7 for downstream passage consisting of a Piru Creek collector provisionally sized for 200 cfs. The Panel is confident that these recommended alternatives will provide safe and efficient passage for adult and juvenile/smolt SCS DPS above and below SFD. By definition of the Study Plan, the Panel realizes that this recommendation is but a possible first step in effecting the long-term restoration of SCS DPS above SFD and that many questions and details remain regarding the if, what, where, how and when individual measures would be implemented. Specific questions to be addressed by the Group following completion of Task 7 (this completed Santa Felicia Dam Fish Passage Alternatives Feasibility Report) include:

1. What is the Group decision regarding the Panel's recommendations for upstream and downstream passage measures; i.e., Group Consensus or No Group Consensus to implement the recommended fish passage alternatives?
2. If No Group Consensus, document the reasons why, then determine how and when Task 9 would be completed to address the Group concerns (i.e., economic feasibility, consideration of other non-fish passage mitigation measures, etc.).
3. If the Group reaches consensus to implement fish passage measures, what are the biological criteria that will trigger Implementation (RPA 3(d))?
4. Are pre-implementation studies warranted, and if so, how and when will they be conducted?
5. Should pre-implementation, preliminary measures be constructed and monitored, and if so, what, where and when?
6. Once biological criteria are triggered, how will the measures be implemented? The following details will need to be addressed by the Group:

   a. Design and Permitting Sequence/Schedule.
   b. Construction Sequence/Schedule.
   c. Start-up and Compliance monitoring.
   d. Selection of Biological Performance (BP) Standards.
   e. Effectiveness monitoring.
7. How will the measures be operated (timing, duration) and monitored, and what biological studies will be completed during operations?
8. How will decisions be made concerning the need for refinements to the existing facilities and/or the need for phasing-in of additional measures or alternatives?

The sheer number of questions and issues that need to be addressed, along with the noted uncertainties in the Panel's recommendations regarding specific details of the fish passage alternatives, strongly supports application of a flexible implementation process grounded within an adaptive management framework. This section first briefly discusses potential outcomes of the Panel's Recommendation relative to the Group Fish Passage Decision to be addressed in Task 8 of the Study Plan, and then describes the framework of a phased-implementation and adaptive management process that the Panel recommends be followed if the recommended fish passage alternative is selected by the Group. Nested within this latter discussion are the Panel's recommendations regarding monitoring types and how monitoring fits within the Implementation and Adaptive Management process.

7.1 THE PANEL'S RECOMMENDATION AND THE GROUP DECISION PROCESS

The decision on what constitutes "… the preferred long-term solution to restore steelhead access to and from historical steelhead spawning and rearing habitats upstream of Santa Felicia Dam" (NMFS 2008, page 102, RPA 3(c)) ultimately involves a Group decision on whether this can and should be achieved via installation of fish passage facilities at SFD, or via non-fish passage alternatives. If steelhead passage is determined to be technically and economically infeasible, then non-fish passage alternatives "such as a habitat-compensation plan based on measurable biological criteria to minimize the effects of the loss of habitat upstream of Santa Felicia Dam on steelhead" will be considered through the process identified in Task 9 of the Study Plan. The Panel's work to date has focused entirely on evaluating the technical feasibility of providing fish passage at SFD: as defined in the Study Plan, no consideration was given to economic feasibility of the recommended alternatives, or to non-passage alternatives.

In this Report, as specified in **Task 7** of the Study Plan, the Panel completed an evaluation of the technical feasibility of providing fish passage for SCS DPS and identified and considered four upstream and nine downstream passage alternatives. Although varying in the degree and number of risks and uncertainties, all of the alternatives were considered technically feasible. Based on the evaluation criteria and selection process described in Section 5 and Section 6 respectively, the Panel recommends Alternatives U4 and D7 as the preferred fish passage alternatives for SFD. Neither of these alternatives provides a volitional solution, but as noted in Section 6 both have the least risk and provide the best chance of fish passage success. The Panel's recommendations are the culmination of Task 7 of the Study Plan, as illustrated in the top box of Figure 7.1-1. The remainder of this section describes the Panel's recommended next steps to aid in the Group Fish Passage Decision process which will occur in Task 8.

There are at least two outcomes that may result from the Task 8 Group Fish Passage Decision: one would lead directly to a recommended Phased Implementation and Adaptive Management Process targeting the recommended upstream and downstream fish passage alternatives; the other would lead to **Task 9** that, as described in the Study Plan (see Section 4.9, pages 45-49), would involve a Biological and Economic Feasibility Analysis and Off-site Alternatives Assessment. Task 9 would occur if there is no consensus on fish passage from the Group (at the completion of Task 8), and would involve an economic evaluation of the costs of implementing fish passage versus the biological/population level benefits to the SCS DPS, and potentially other non-passage alternatives identified by the Group. Outcomes from Task 9 could lead back to implementation of fish passage as the "preferred long-term solution," or identification of non-fish passage as the "preferred long-term solution" and lead to immediate implementation under RPA 3(e). The decision to come back to implementation of fish passage facilities as the preferred Task 9 solution may require that certain modifications be made to the Panel's recommendation, or that additional alternatives be considered pending results and recommendations of Task 9.

The path from Task 8 to the fish passage implementation process would signify a Group consensus that fish passage is the "preferred alternative to restore steelhead access to and from historical spawning and rearing habitats," and a Group consensus that the Panel's recommended alternatives would meet the overall objective of providing safe and efficient upstream and downstream passage for steelhead at SFD. However, it is still possible that during the course of the implementation process, additional technical, biological, engineering design, social, and other issues may be identified that may reduce the overall feasibility of providing fish passage at SFD (i.e., fatal flaw), thereby leading to re-consideration of non-fish passage alternatives as shown in Figure 7.1-1. The decision process leading to that determination is outside of the Panel's scope through Task 7, and would need to be defined in the Implementation and Adaptive Management Plan (IAMP) to be developed and agreed to by the Group (see Section 7.2.1).

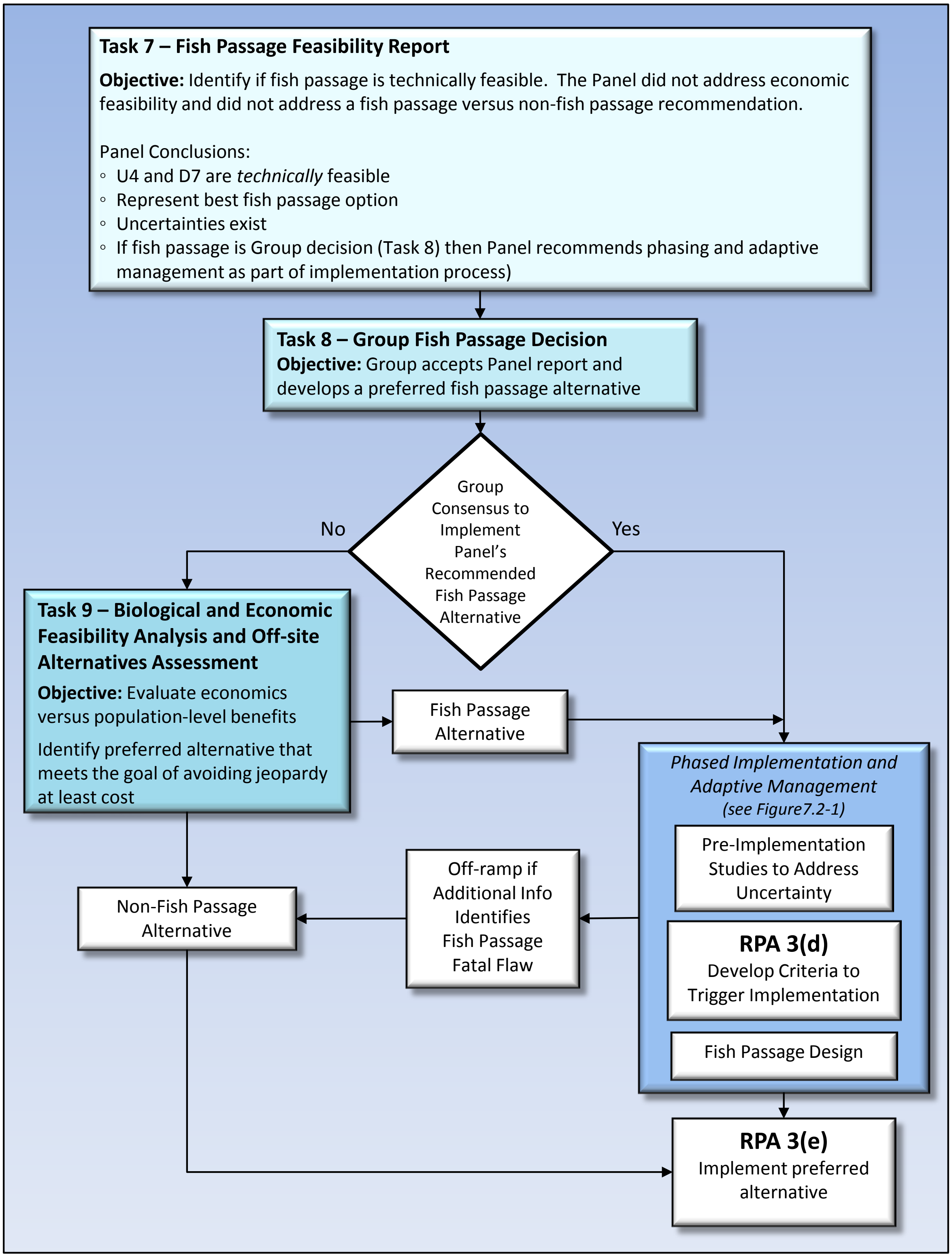


Figure 7.1-1. Decision process guiding selection and implementation of preferred alternative associated with Tasks 7, 8 and 9 of the Study Plan.

7.2 PHASED IMPLEMENTATION AND ADAPTIVE MANAGEMENT PROCESS

An affirmative decision by the Group in Task 8 to pursue implementation of the Panel's recommended fish passage alternatives does not directly lead to the design, construction, operation, and monitoring of U4 and D7. Rather, that decision hinges on the triggering of certain yet to be determined biological criteria developed under RPA 3(d). Even so, the Panel suggests that an affirmative decision should mark the start of a process structured to gain a better understanding of the biology and life history characteristics of the SCS DPS applicable to the Piru Creek watershed, and evaluate potential biological and ecological watershed conditions that could constrain or otherwise influence the design and success of selected fish passage alternatives. Certain engineering issues should be evaluated during the early stages of this process, such as identifying any seismically imposed constraints. This process will need to be patterned so it is logical (makes sense), informative (provides information needed to address risk and uncertainty), progressive (findings serve to advance the knowledge base including engineering design considerations), and adaptive (affords a feedback mechanism for retroactive adjustments based on new information). The following discussion represents the Panel's recommendations regarding phasing, and the major steps, components and activities associated with an Implementation and Adaptive Management process. The recommendations represent the framework of this process, as its full development is beyond the Panel's scope of work.

7.2.1 SFD Fish Passage Implementation and Adaptive Management Plan

If fish passage is the Group consensus as the preferred long-term solution to restore SCS DPS access above SFD in Task 8, the Panel recommends that the Group consider the process outlined below and then proceed with formal development of a SFD Fish Passage IAMP. This will also ensure that the plan is correctly aligned with specified objectives and passage components. The IAMP would contain the dependencies and resulting decisions emanating from the process described below. The IAMP would serve as the primary guide for advancing the recommended preferred upstream and downstream fish passage alternatives through preliminary testing and refinement that could ultimately lead to the design, construction and full operation of the selected alternatives. The Panel recommends the plan also contain a formal implementation schedule (that includes a design and construction sequence) and a monitoring plan that specifies monitoring requirements and defines BP Standards. Further, the fully developed IAMP would provide details regarding phasing opportunities and their triggers, and describe how results would be used in an adaptive management context that activates refinements/modifications in facility design or operation.

7.2.2 Fish Passage Science and Technology Panel (FPSTP)

Central to the successful development and implementation of the IAMP is the Panel's recommendation that the Group consider formation of a Fish Passage Science and Technology Panel (FPSTP). The FPSTP envisioned by the Panel would consist of technical representatives from NMFS, USFWS, CDFW and United who would serve to coordinate and oversee all activities related to the development and operation of the selected fish passage alternatives. These activities would include but not be limited to:

- preparation of the IAMP as described above;
- development of **biological criteria** to trigger formal implementation of the fish passage alternative (RPA 3(d));
- identification of **pre-implementation studies** and development of associated study plans to resolve uncertainties that influence the engineering and biological feasibility of certain alternatives;
- development and implementation of a **compliance monitoring program** to ensure design standards are met (if facilities constructed);
- development of **BP Standards** and an associated **effectiveness monitoring program**; and others to be determined.

The Panel recommends that the FPSTP be formed immediately following an affirmative Task 8 decision to pursue the Panel's recommended fish passage alternatives.

7.2.3 Uncertainty and the Role of Phasing and Pre-implementation Studies

The Panel recognizes that there is uncertainty (see Section 1.5.6) affiliated with a number of biological and technical issues pertinent to the eventual selection, design and performance of the fish passage alternatives. Identifying and addressing uncertainty and risk has been a common discussion point within the Panel and as well during discussions with the Group. Specific uncertainties and information needs that have been identified include:

1. understanding the timing and behavioral patterns of SCS DPS that may occur in the Santa Clara River and Piru Creek basin including within Lake Piru (Biological uncertainty);
2. determining the spatial and temporal suitability of steelhead rearing habitats within Piru Lake that considers both water quality and predation risk (Biological uncertainty);
3. understanding potential steelhead population responses (numbers and time frame) resulting from implementation of fish passage alternatives (Biological);

4. understanding the hydrodynamics of Lake Piru as they pertain to the timing of smolt outmigrations (Design and Operation);
5. determining the timing and duration of flow conditions in Middle Piru Creek that afford connectivity with Lake Piru (Design and Operation);
6. determining the timing and duration of flow conditions in Lower Piru Creek that provide connectivity to the Santa Clara River (relates to RPA 2) (Design and Operation);
7. understanding seismic constraints and related dam safety projects for design of fish passage facilities (Design and Operation, Dam Safety);
8. estimating the performance of the selected fish passage alternatives; i.e., how well the alternatives will function and the anticipated biological response (Design and Operation).

The biological uncertainties are due to both a general lack of in-depth understanding of steelhead in its southern range and a paucity of empirical data on the SCS DPS in the Santa Clara River and Piru Creek watersheds. As a result, it is difficult to confidently predict how the species will respond once fish passage measures have been constructed and implemented, and connectivity has been restored above SFD. There are also uncertainties associated with how certain fish passage components will function both in terms of specified design (i.e., location and hydraulic performance), and operation (i.e., effectiveness in passing fish and biological performance).

The above uncertainties factored directly into the Panel's evaluation process resulting in the conclusion and Panel's recommendation that the implementation process should be phased (Section 1.5.6). Indeed, among the feasible alternatives, the relative opportunity to construct and implement the facilities in stages (phases) strongly influenced the Panel's ultimate selection of its recommendation; in particular, the compatibility of the alternative to mesh with existing Piru Creek watershed characteristics and potentially new SFD infrastructure, and its flexibility to advance and adjust designs in stages. Phasing has advantages biologically but also financially for United and all project stakeholders. Risk of committing to a less than well-suited or poorly functioning alternative is reduced, and the commitment to a larger, potentially unnecessary alternative is avoided; or can be incrementally phased-in from an initially lower cost alternative based on results of biological monitoring. Phasing also may allow for optimization of facilities and making the best capital investments. The fish passage concepts developed with this Study were for determining feasibility and making a recommendation; they represent a starting point in a design development process. As with any major project, these concepts will require additional design prior to construction.

The decision or "trigger" to proceed from an initial phase to another would be largely biologically based and governed by how well the facility performs in efficiently and safely passing steelhead upstream and downstream of SFD. These "biological triggers" would be used to identify, for example, modifications that must be made to existing facilities to increase capacity or efficiency; or construction of additional facilities (e.g., a full fish ladder, or an FSC at the dam). Defining specific "biological triggers" is outside of the Panel's scope and would be the responsibility of the Group, via the FPSTP and as described in the IAMP.

As noted, phasing decisions will ultimately be determined based on new information that is evinced from either compliance and effectiveness monitoring studies that would guide the design, construction, operation and monitoring of initial fish passage alternatives (including prototype and low-tech facilities), or from formalized effectiveness monitoring studies associated with a more complete alternative that tracks its biological performance against defined performance standards. This latter aspect of effectiveness monitoring is discussed in Section 7.2.4.

The Panel has identified and recommends that an IAMP consider several high-priority Pre-Implementation Studies that should be designed and initiated shortly after an affirmative Group Task 8 fish passage decision. These studies would be more fully described within the IAMP followed by development of detailed study plans and schedules, and study implementation. One additional study the Panel considers high priority has been initiated by United and the Panel recommends its completion (Critical Riffle Study, see below). All of the studies are focused on reducing some of the uncertainties noted above. The recommended studies include:

- <u>Seasonal Trapping and Tagging of Juvenile Rainbow/Steelhead Trout to Assess Migratory/Movement Patterns in the Lower Portion of Middle Piru Creek and into Lake Piru</u> – This study would serve to collect baseline information on the timing of steelhead migrations and associated hydrologic conditions, as well as information on numbers, size (length, weight, condition) and age and growth rates of fish (via scale analysis) moving downstream from middle Piru Creek into Lake Piru. Captured and tagged fish could be released within Lake Piru to track reservoir movement patterns, or transported and released below SFD as a means to jump-start the population rebuilding process.
- <u>Lake Piru Investigations</u> – The Panel believes that the majority of uncertainty related to performance of the reservoir-based fish passage alternatives (e.g., U1, U2, U3, D3, D4, D5, D9, D10, D11, D12, D14) pertains to Lake Piru. The uncertainty can be organized into three categories - fisheries, water quality, and hydraulics/hydrodynamics. The Panel believes that Pre-implementation Studies of Lake Piru should commence in conjunction with the trapping and tagging studies noted above. The Lake Piru studies should focus

first on understanding the spatial and temporal water quality conditions and the movement and behavioral patterns of rainbow/steelhead trout in the lake and identifying potential limiting factors that may affect steelhead smolt and adult survival such as poor water quality conditions, predation (juvenile and smolts), and poaching/incidental catch (adult and smolts). Contingent on the results of those studies, an additional study of the hydrodynamics of the reservoir would be useful for understanding potential migration pathways (as defined by hydraulic cues, e.g., velocity) available under different lake level and inflow conditions. The information obtained from the Lake Piru studies will be important for determining the overall viability/feasibility of reservoir linked alternatives as future phasing options.

- Prototype Testing of Low-Technology Smolt and Adult Collection Facilities – Consistent with phasing, the Panel recommends the design, construction and monitoring of low-tech and relatively low cost downstream (within middle Piru Creek) and upstream (within lower Piru Creek below SFD) collection traps. This will provide information on the timing of both juvenile and adult movements within the Piru Creek watershed and the collection efficiencies of different types of traps in response to site conditions. The testing of downstream traps should be integrated within the juvenile trapping and tagging study noted above. Testing of adult traps should be coordinated with activities related to RPA 2 and implementation of its effectiveness monitoring plan. One element of that plan is to evaluate if and how many steelhead migrate to lower Piru Creek. The Panel considers the design, construction and testing of prototype/low-tech collection facilities to be critical components of the implementation and adaptive management process. Results from these tests will be used to guide refinements in the location, design and operation of the facilities that are precursors to more permanent facilities.
- Flow Conditions in Middle Piru Creek –The Panel also recommends that United complete the "Critical riffle" analysis that was initiated in 2015 in the lower segment of Middle Piru Creek. At lower lake elevations, a large delta area forms at the mouth of middle Piru Creek and becomes disconnected from Lake Piru. During these times, fish passage would be precluded from Lake Piru to middle Piru Creek. Results of this study should help to identify the range of flows and their timing over which fish passage (both adult upstream migration, and juvenile/smolt downstream migration) is provided through this area for a range of lake elevations.
- Biological Performance Modeling **-** The BPT was developed and used by the Panel for making biologically based comparisons based on predicted effectiveness between different downstream passage alternatives as indexed by estimates of smolt survival (see Section 5.1.3, Appendix E). The BPT was based on the best available information at the time of the analysis and was founded on a number of assumptions including but not

limited to the timing of fish movements, age of smoltification, fish mortality rates in the reservoir, and collection efficiencies under different flow conditions. The Panel suggests that a simple modeling tool, like the BPT, be considered as a means to integrate and evaluate new information as part of the IAMP. The BPT provides a structured process to calculate downstream fish passage effectiveness as the proportion of smolt outmigrants successfully passed downstream of the SFD. The BPT, or a similar modeling tool, can be used to evaluate new information on facility sizing, siting, range of operations, and effectiveness of individual facility components, and to test and refine assumptions. In addition, BPT results can be used to evaluate data sensitivities, identify data gaps, and help develop research needs.

7.2.4 Implementation Monitoring and Evaluation

The Panel considers the above Pre-Implementation Studies as high priority since they address uncertainties and issues that are associated with the feasibility of alternatives, design considerations and passage performance, and phasing opportunities. The Panel assumes that the Pre-Implementation Studies would occur over several years during which the biological criteria to trigger implementation (RPA 3(d)) of the preferred fish passage alternative would have been developed by the FPSTP. Those criteria would govern when the actual implementation of the preferred alternative would occur in accordance with an agreed-to implementation schedule as defined in the IAMP.

Assuming that the biological trigger has occurred and implementation is proceeding, one of the important components that the Panel Recommends is the development and application of a monitoring plan to evaluate the passage performance measures once facilities are constructed and operational, and to help determine if modifications or additional facilities will need to be phased into the recommended alternative to meet passage performance objectives. Although details of the monitoring plan would be provided in the IAMP, the Panel has identified three types of monitoring that are relevant to implementation and recommends they be considered for inclusion in the plan: 1) compliance/implementation monitoring; (2) effectiveness monitoring; and (3) validation monitoring.

Compliance monitoring is the simplest of the three, and is used to determine if a specific condition was achieved, such as meeting fish screening and hydraulic passage criteria (e.g., approach velocity, pool depth, and other design criteria) per NMFS and CDFW guidelines and other design and site-specific criteria. This can be accomplished via post-construction hydraulic evaluations of various passage components – e.g., fish ladder, adult trapping facility, collection and transport operations, downstream collector operations, etc.

Effectiveness monitoring is commonly conducted to determine if implemented management actions actually achieve their goals and objectives. Examples of effectiveness monitoring programs related to the relicensing of the SFD include those for monitoring United's Water Release and Ramping Rate plan (Normandeau et al. 2013) and Habitat Improvement plan for lower Piru Creek (Cardno-Entrix et al. 2013). Both of these plans have well defined objectives, and methods identified for evaluating those objectives. The Panel believes effectiveness monitoring of Santa Felicia fish passage facilities would be helpful to evaluate how well the upstream and downstream fish passage facilities perform (i.e., pass fish - based on BP Standards). Passage performance would be tested once the target species/life stage is present or using surrogate fish that accurately reflect the behavior and related factors of the targeted species/life stage.

Validation monitoring is used to test various hypotheses and conceptual models that have been used to predict relationships between/among variables. Elements of validation monitoring can be integrated into the effectiveness monitoring plans identified above by incorporating specific hypotheses to be tested that involve monitoring of fish response. Validation monitoring is often used to evaluate assumptions used in choosing an action to implement. For example, validation monitoring would be appropriate for testing the hypothesis that smolts entering Lake Piru have a low probability of survival due to predation and generally unsuitable habitat conditions, or more broadly, that restoring connectivity in Piru Creek via fish passage measures will result in an increase in Piru Creek steelhead abundance.

7.2.5 Adaptive Management Process for the Santa Felicia Dam Fish Passage Project

As noted above, the Panel recommends that an Adaptive Management process of decision-making be developed by the Group and occur throughout the entire implementation sequence. This process would be used to make refinements in the selected measures needed to bring them up to specified design and BP Standards, as well as to gauge the relative performance of a selected alternative that could lead to continued operation of the passage facility alternatives as built, phased modifications of the alternative, or phased implementation of additional alternatives. Fundamentally, the process builds on new information and uses that information as a means to adapt the operations of the facilities to ensure they meet stated objectives of providing upstream and downstream passage opportunities of steelhead at SFD sufficient to avoid jeopardizing the continued existence of the SCS DPS.

This process is illustrated in Figure 7-2.1 and centers on the following components:

- group decision to implement the Panel's recommended fish passage alternatives in Task 8;

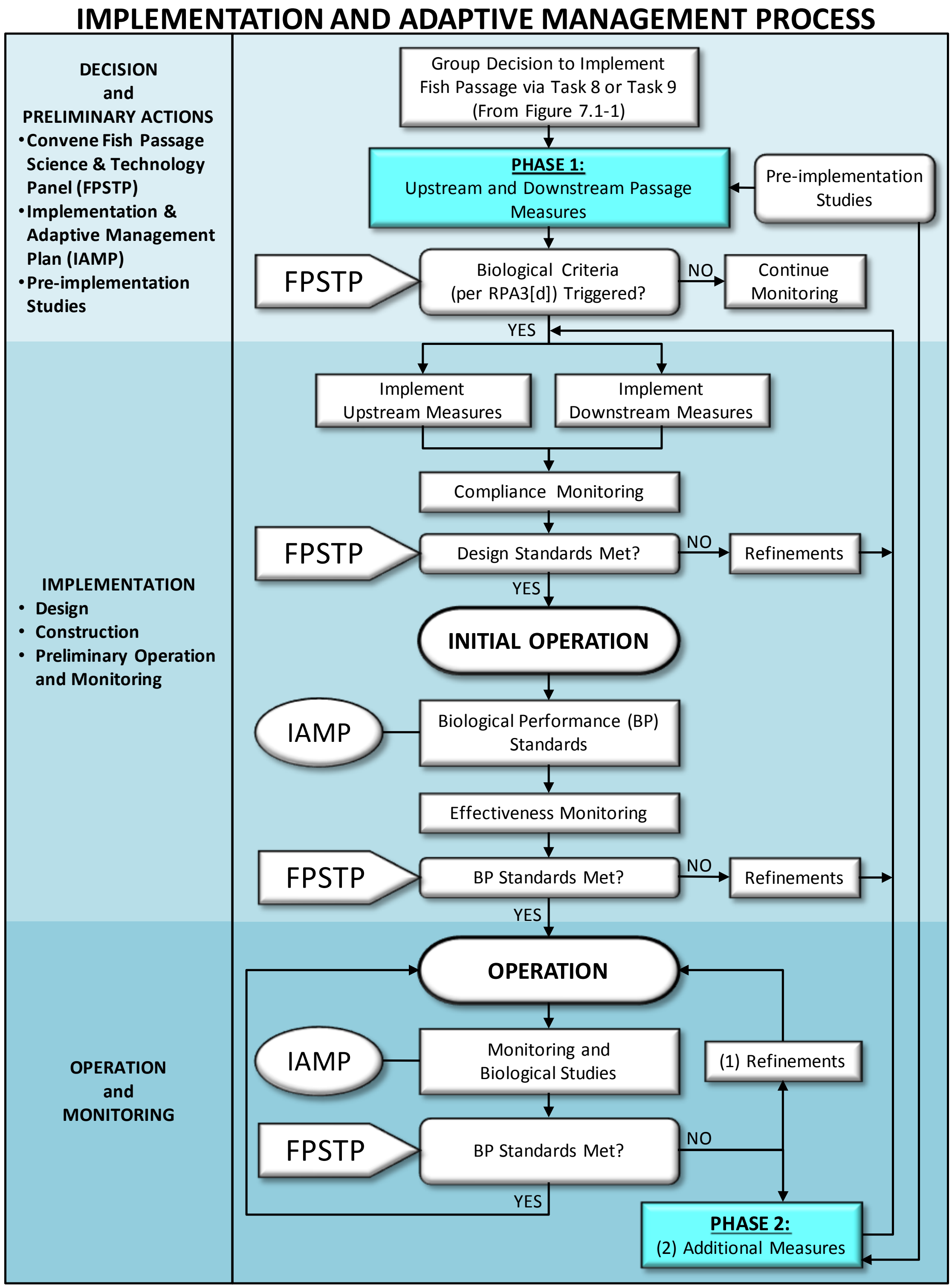


Figure 7.2-1. Implementation and Adaptive Management Process for the Panel's recommended preferred fish passage alternatives (U4 and D7) for Santa Felicia Dam. The process would be initiated by a Group decision to implement fish passage via Task 8 or Task 9. See text for further explanation.

- defining biological criteria that will be used to trigger implementation (RPA 3(d));
- conducting Pre-implementation Studies;
- implementing the recommended alternatives once biological criteria are triggered;
- testing and monitoring (compliance and effectiveness) the alternative to ensure proper operations and performance;
- determining how decisions will be made concerning the need for refinements to the existing facilities and/or the need for phasing-in of additional measures.

Assuming a Group decision to implement fish passage at SFD, the process would include the development of a set of biological criteria that would serve to trigger the implementation of the alternative (BO RPA 3d), and the development and completion of the Pre-Implementation Studies defined in Section 7.2.3. The biological criteria would be developed by the Fish Passage Science and Technology Panel (see Section 7.2.2), and should be linked to results of downstream studies and monitoring associated with the implementation of RPA 1 and 2, and the monitoring activities at Vern Freeman Diversion Dam. After the biological criteria are triggered, implementation of the preferred fish passage alternative would occur consisting of its design, construction and preliminary operation.

Once designed and constructed, the upstream and downstream measures would be initially subjected to compliance monitoring (as specified in the IAMP) during which hydraulic performance tests would be completed to ensure that each element of the upstream and downstream measures meets design criteria. An adaptive management feedback loop exists at this juncture to allow adjustments to any of the measures not meeting the design criteria.

Once the facilities are constructed and confirmed to be operating correctly, they are then subject to effectiveness monitoring and the specified BP Standards as defined by the FPSTP in the IAMP. The BP Standards would include numerical targets for upstream and downstream passage efficiencies (%) at each facility, as well as overall fish condition and survival standards as gauged from initial capture to downstream or upstream release points.

The Panel recommends testing of the BP Standards be completed via effectiveness monitoring as described above, that could require a series of studies (such as test fish releases and perhaps the use of biotelemetry or mark-recapture techniques). Details of those studies will need to be worked out with the FPSTP especially as they pertain to the identification of sources of test fish. Elements of the effectiveness monitoring program could include:

- Defining a set of clearly articulated hypotheses that capture the major questions to be addressed via tests.
- Developing appropriate, statistically derived sampling designs to be used in the tests.
- Selecting and monitoring appropriate indicators and metrics that will serve to gauge upstream and downstream fish passage performance.
- Standardizing sampling protocols to allow comparisons among facilities and at different sampling times.
- Establishing appropriate Quality Assurance and Quality Control measures for data validation.
- Developing and implementing a Decision Analysis (feedback) process that can be used for evaluating monitoring results (and results from other studies) and determining 1) whether and what additional measures are needed to meet the BP Standards; or 2) if existing conditions preclude attainment of the standards due to non-facility related causes (e.g., predation, water quality), what actions are needed to eliminate such conditions.

Once standards are met for both upstream and downstream facilities or it is agreed-to by the FPSTP as determined by the Decision Analysis that the facilities do not warrant further modification, then the facilities would become fully operational.

Once operational, the ongoing monitoring (as specified in the IAMP) would be used to determine facility maintenance needs, and evaluate operating characteristics and biological performance (how many fish are being passed). Monitoring results would be used by the FPSTP to determine whether BP Standards are being met. If they are being met, then operations would continue using the existing facilities as illustrated in Figure 7.2-1. If the BP Standards are not met, then necessary refinements would be made to the existing facilities (e.g., increase screen capacity of Piru Creek collector, flow adjustments in the fishway or attraction system, etc.) until BP Standards are met. If BP Standards are still not met even after refinements are made to existing facilities, additional measures may need to be phased-in (i.e., Phase 2 as depicted in Figure 7.2-1). For example, if monitoring reveals that the Piru Creek collector alone misses too many fish (e.g., due to large numbers of smolts during high flow event), then additional measures such as surface collectors (D10 and D11) or a moveable surface collector (D12) may be needed. These measures would be subject to the compliance and effectiveness monitoring steps to ensure hydraulic and BP Standards are met prior to becoming fully operational. However, implementation of the measures would also be contingent on the results of the Pre-Implementation studies on Lake Piru. The Panel assumes that it would be a decade or more after the initial operation of the selected facilities, before decisions regarding wholesale additions of alternatives may need to be considered. As a result, additional engineering investigations/surveys may be warranted to ensure compatibility with the dam infrastructure and prevailing conditions at that time.

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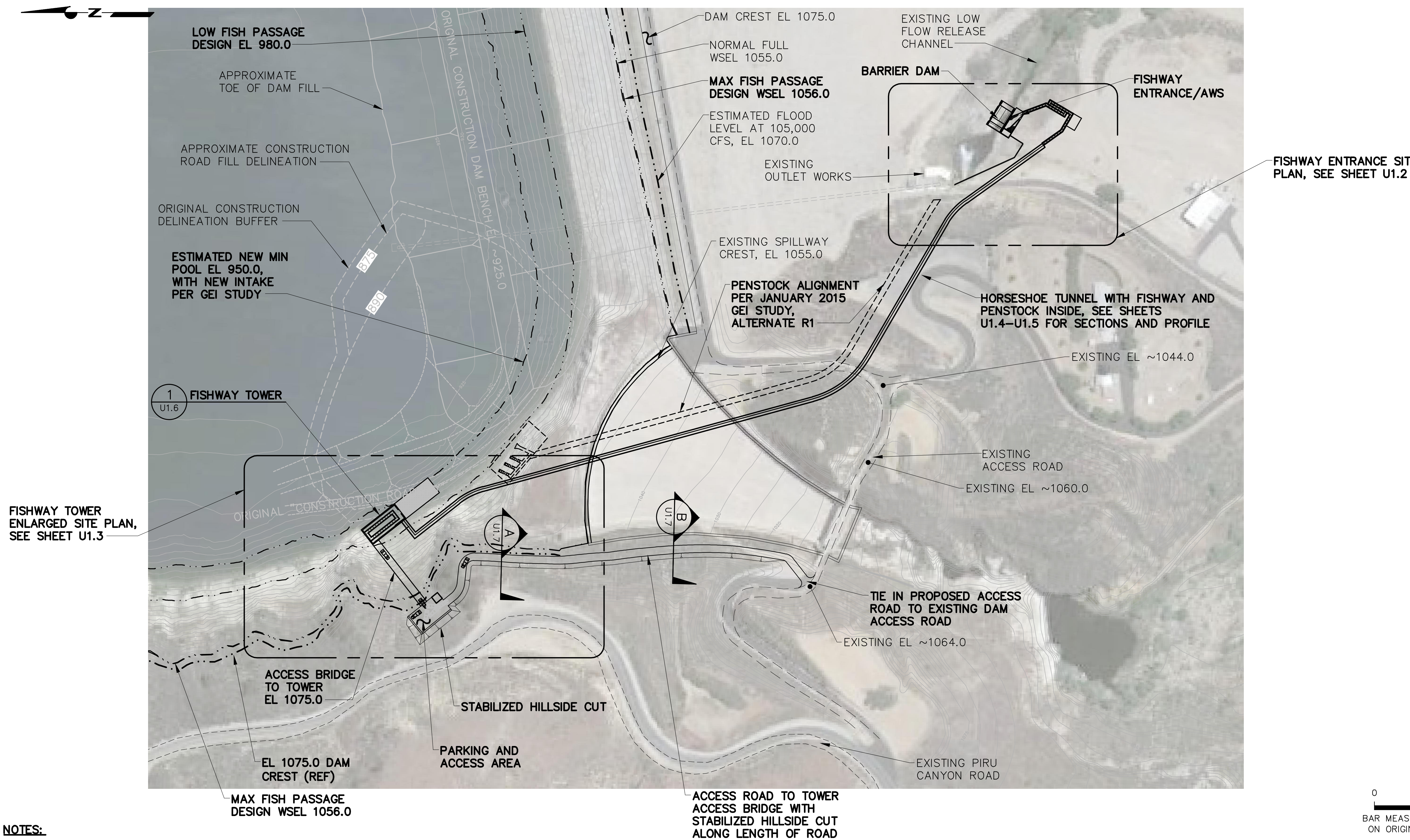
DRAWINGS
Fish Passage Alternatives



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BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

NOTES:

1. BATHYMETRY AND TOPOGRAPHIC DATA SHOWN FROM: LAKE PIRU CONTOURS DEC 2005 – FISH PASSAGE STUDY.DWG
2. AERIAL IMAGE FROM GOOGLE EARTH. IMAGE LOCATED APPROXIMATELY, THUS THE BACKGROUND IMAGE AND LINEWORK DON'T LINE UP EXACTLY DUE TO THE IMAGE NOT BEING GEOREFERENCED OR ORTHORECTIFIED.

LOCATION PLAN

200 0 100 200
SCALE: 1"=200'

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U1. POOL AND WEIR FISHWAY, TUNNEL AND TOWER, RESERVOIR RANGE EL 980' TO 1056'
LOCATION PLAN

DATE: MAR 6, 2015
DRAWING: U1.1
REV: 0

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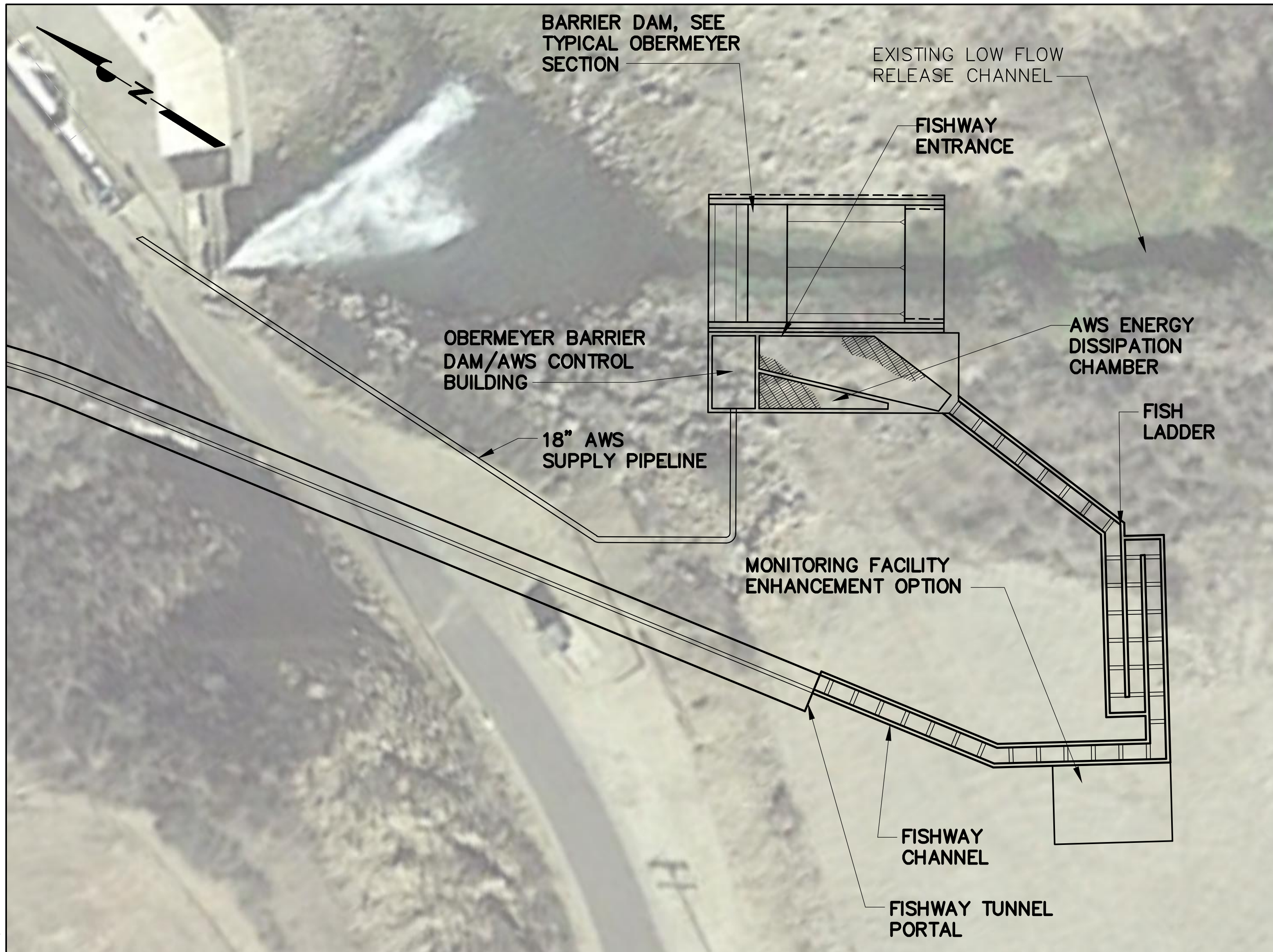

FISHWAY ENTRANCE SITE PLAN

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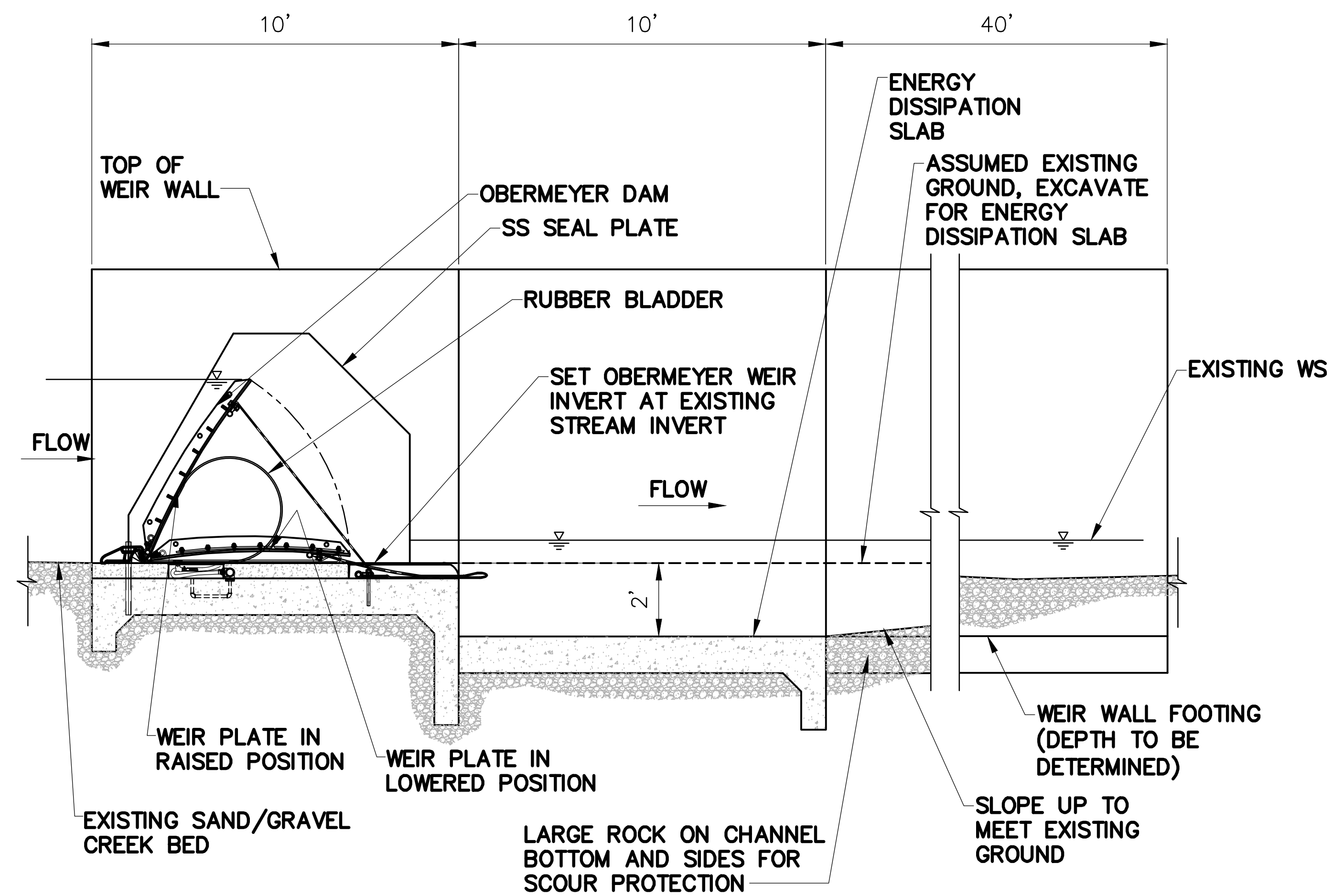
SCALE: 1"=40'



TYPICAL OBERMEYER SECTION
(BARRIER DAM OPTION)

5 0 5
SCALE: 1"=5'

EXAMPLE OF OBERMEYER DAM

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

NOTES:

1. AERIAL IMAGE FROM GOOGLE EARTH. IMAGE LOCATED APPROXIMATELY, THUS THE BACKGROUND IMAGE AND LINEWORK DON'T LINE UP EXACTLY DUE TO THE IMAGE NOT BEING GEOREFERENCED OR ORTHORECTIFIED.

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
U1. POOL AND WEIR FISHWAY, TUNNEL AND TOWER, RESERVOIR RANGE EL 980' TO 1056' FISHWAY ENTRANCE SITE PLAN	DATE: MAR 6, 2015	
	DRAWING: U1.2	REV: 0

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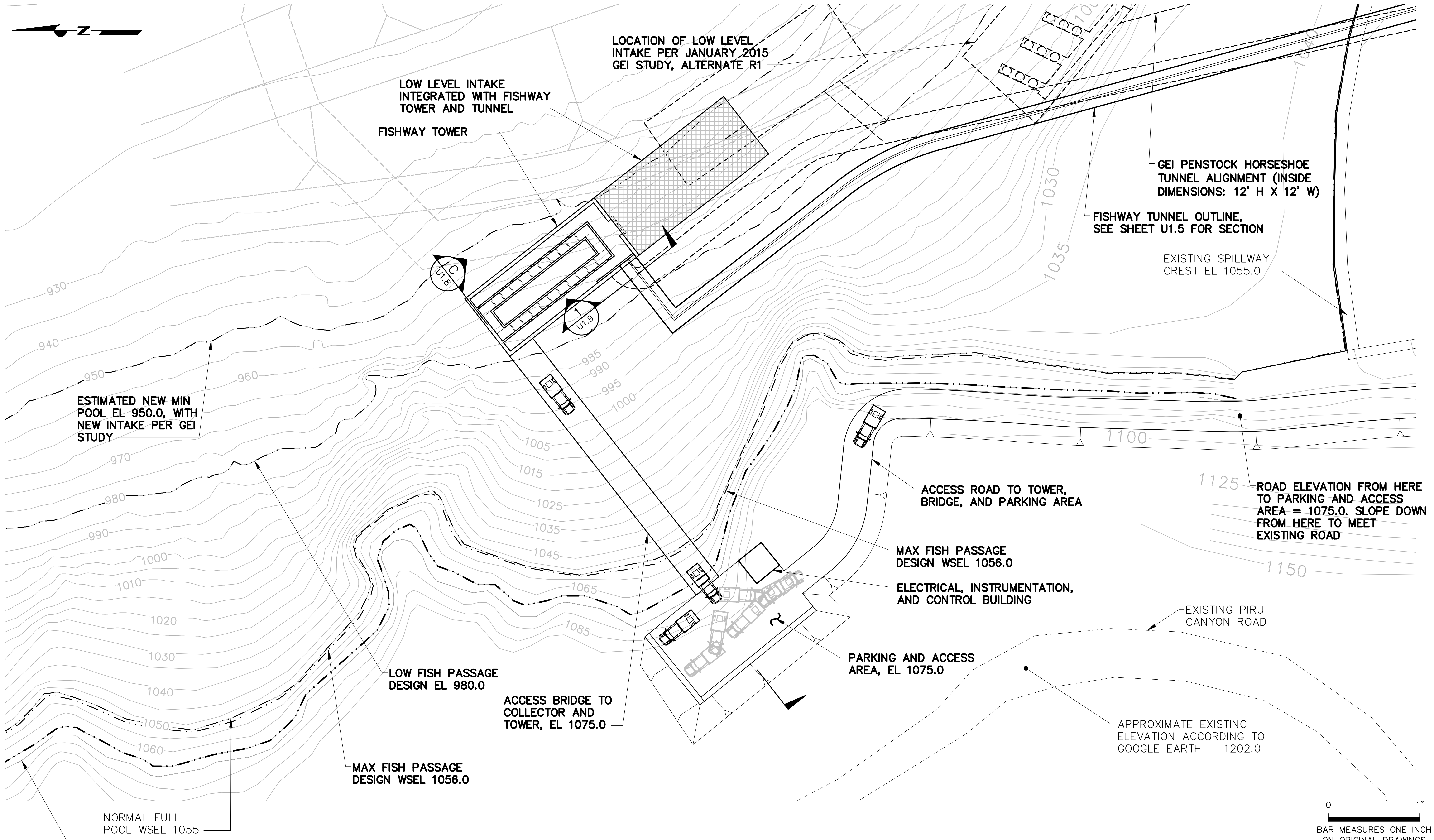
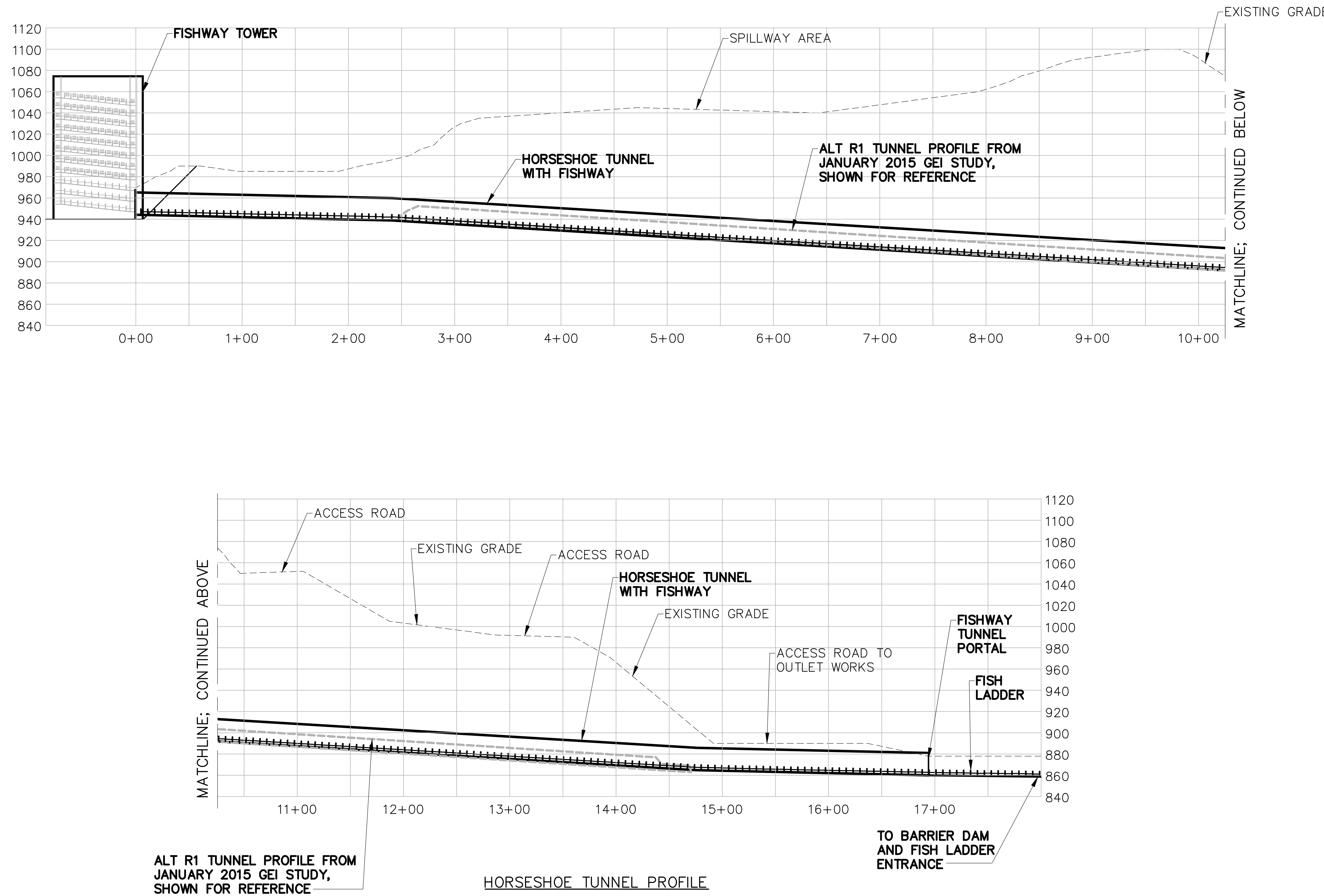


PLAN VIEW

SCALE: 1"=50'

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U1. POOL AND WEIR FISHWAY, TUNNEL AND TOWER, RESERVOIR RANGE EL 980' TO 1056' FISHWAY TOWER ENLARGED SITE PLAN	DATE: MAR 6, 2015
	DRAWING: U1.3 REV: 0



HORSESHOE TUNNEL PROFILE

100 0 50 100

SCALE: 1"=100'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

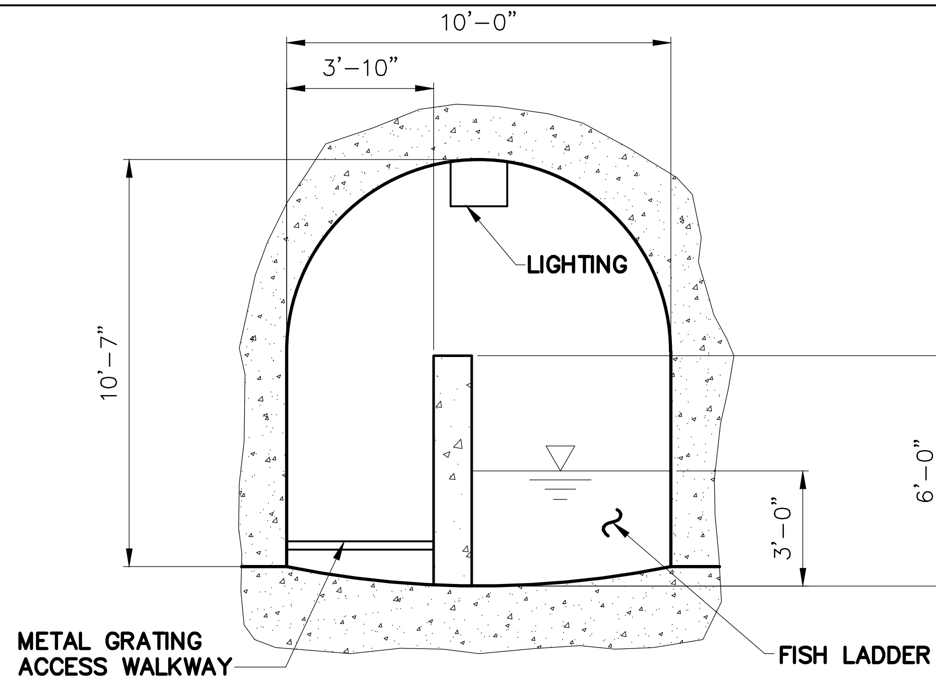
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U1. POOL AND WEIR FISHWAY, TUNNEL AND TOWER, RESERVOIR RANGE EL 980' TO 1056'
HORSESHOE TUNNEL PROFILE

DATE: MAR 6, 2015

DRAWING: U1.4

REV: 0



FISHWAY TUNNEL
TYPICAL SECTION

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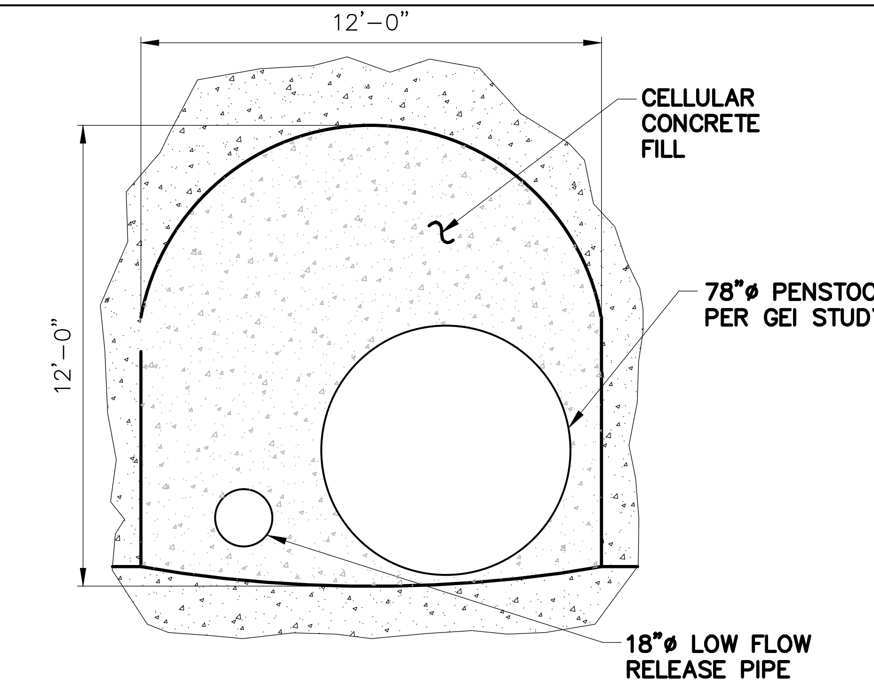
SCALE: 1"=5'



PROPOSED GEI TUNNEL SECTION

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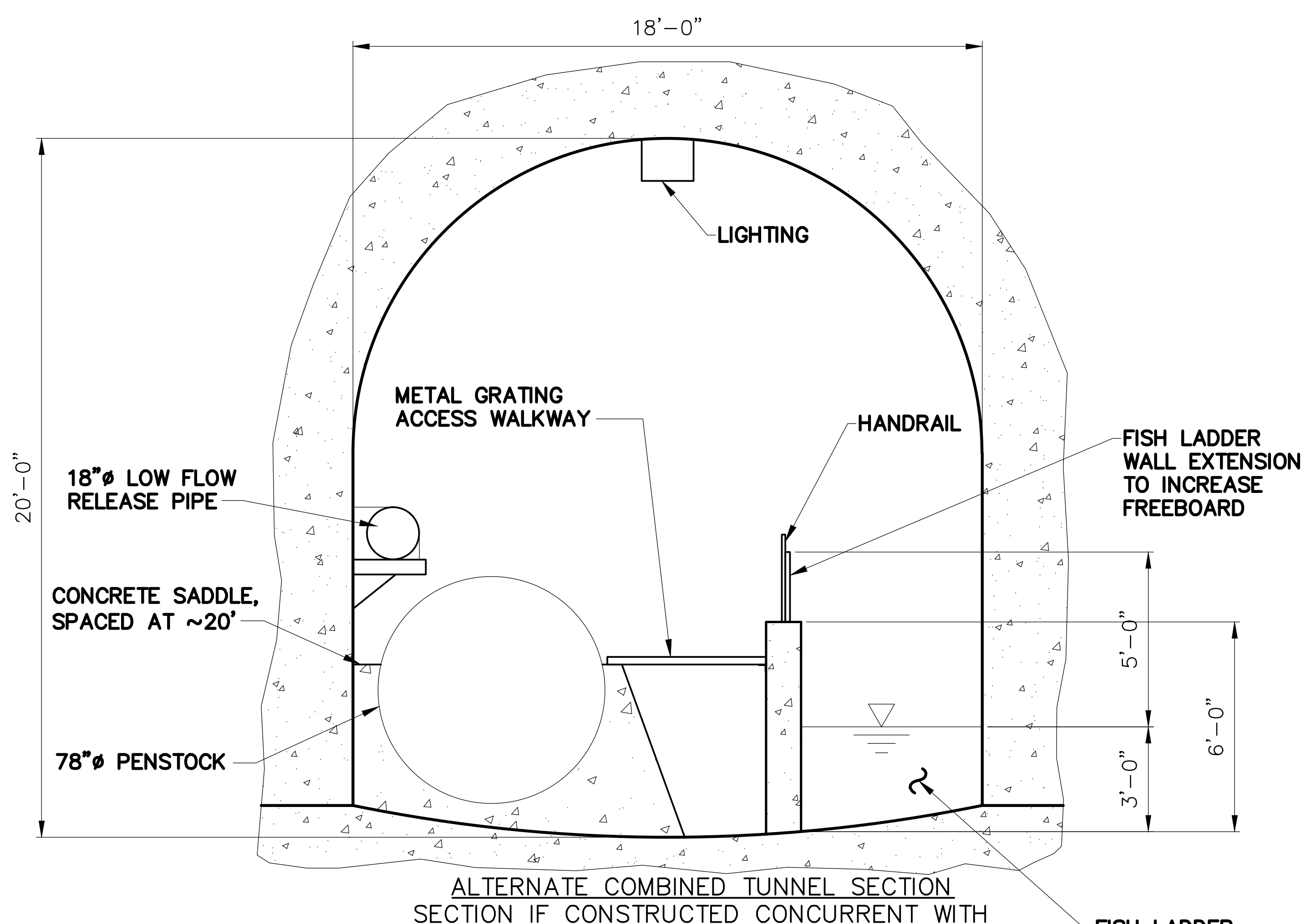
SCALE: 1"=5'



ALTERNATE COMBINED TUNNEL SECTION
SECTION IF CONSTRUCTED CONCURRENT WITH
OUTLET WORKS IMPROVEMENTS

5 0 5

SCALE: 1"=5'

0 1"

BAR MEASURES ONE INCH
ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

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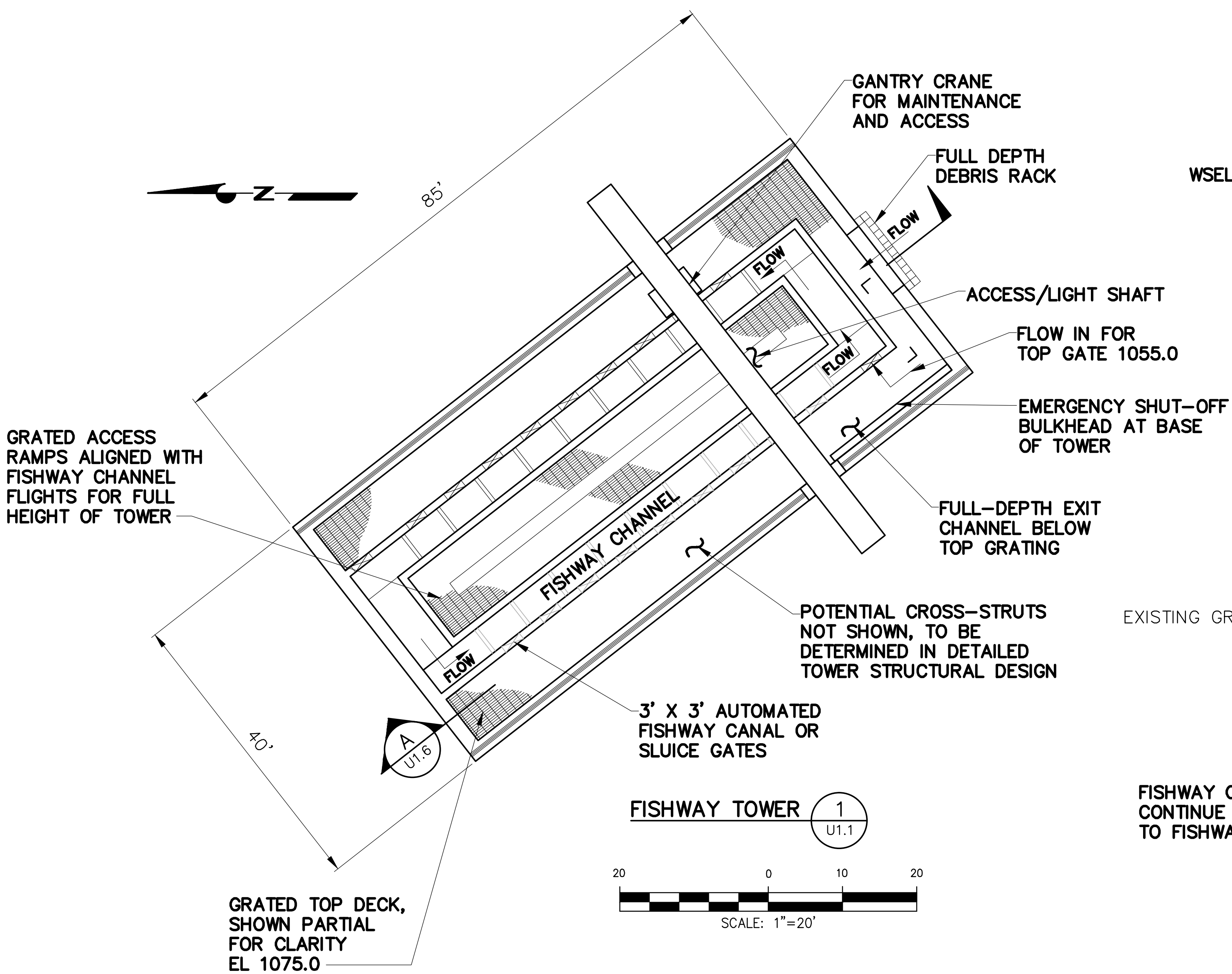
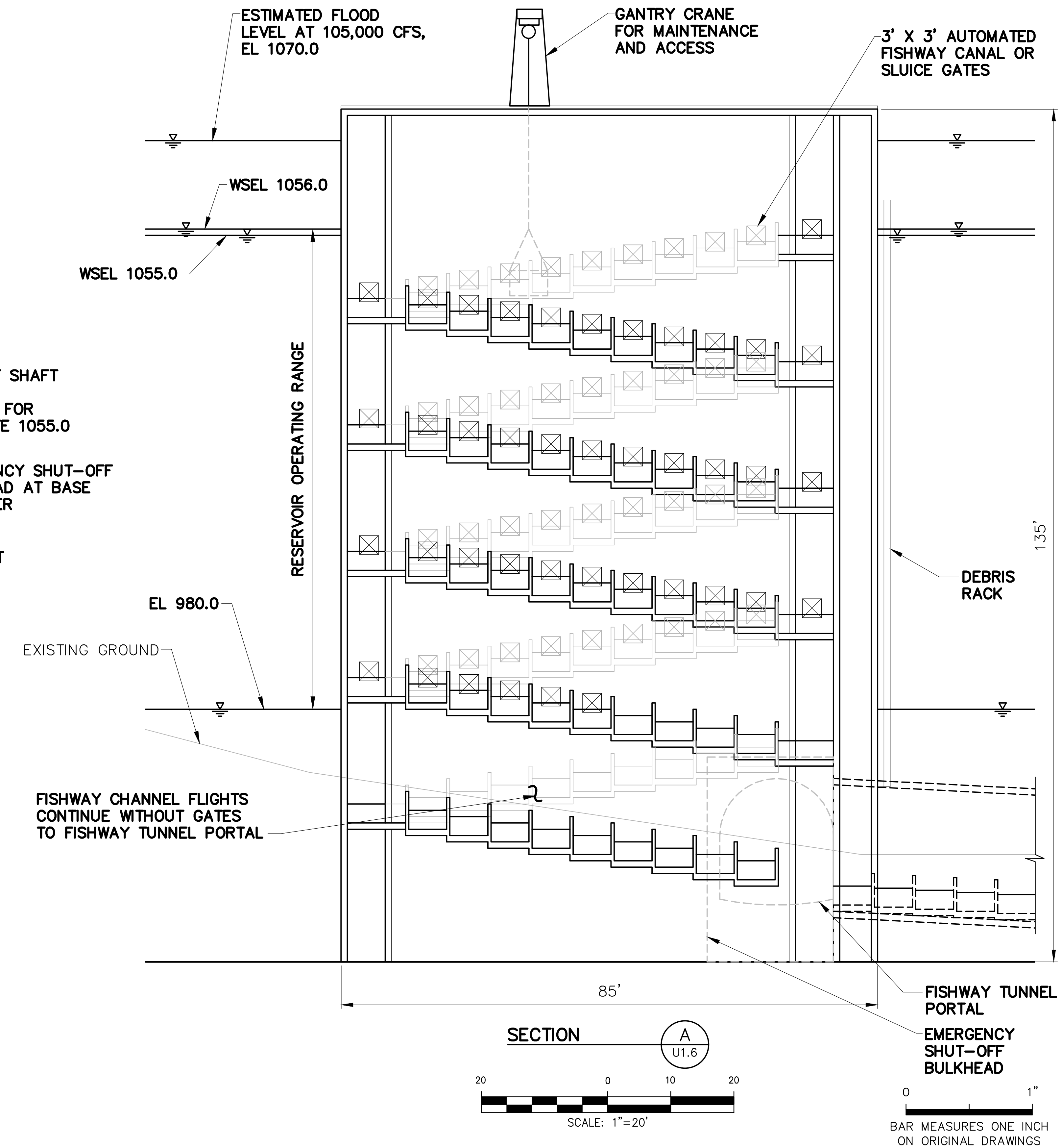
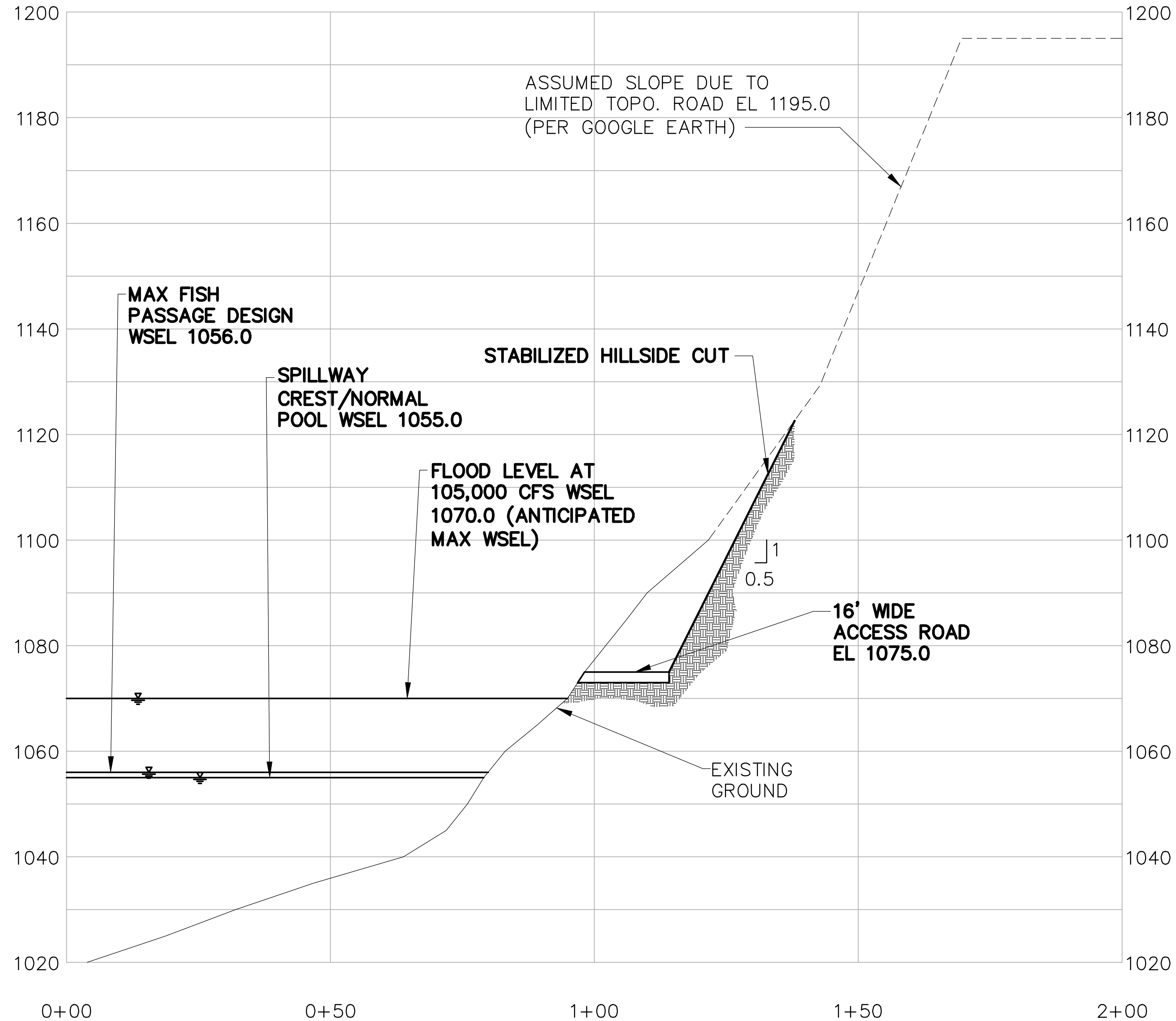




SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

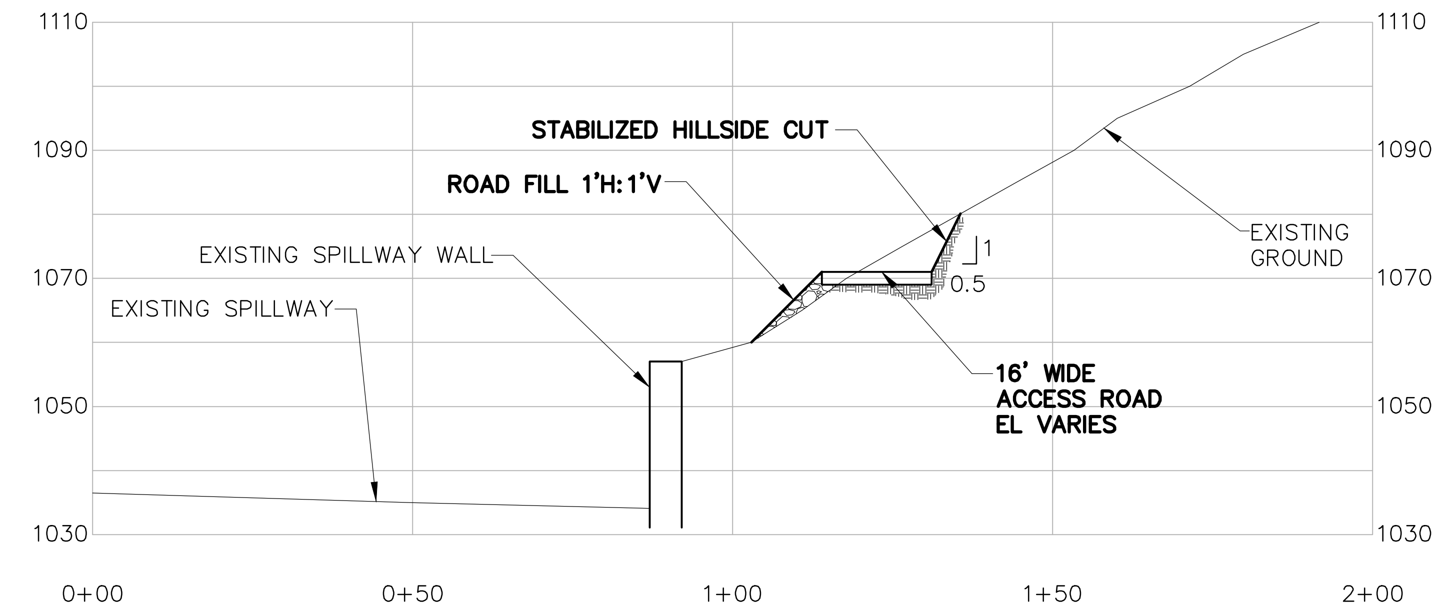
U1. POOL AND WEIR FISHWAY, TUNNEL AND TOWER, RESERVOIR RANGE EL 980' TO 1056' FISHWAY TOWER PLAN AND SECTION	DATE: MAR 6, 2015	
	DRAWING: U1.6	REV: 0



SECTION A U1.1

30 0 15 30

SCALE: 1"=30'



SECTION B U1.1

30 0 15 30

SCALE: 1"=30'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

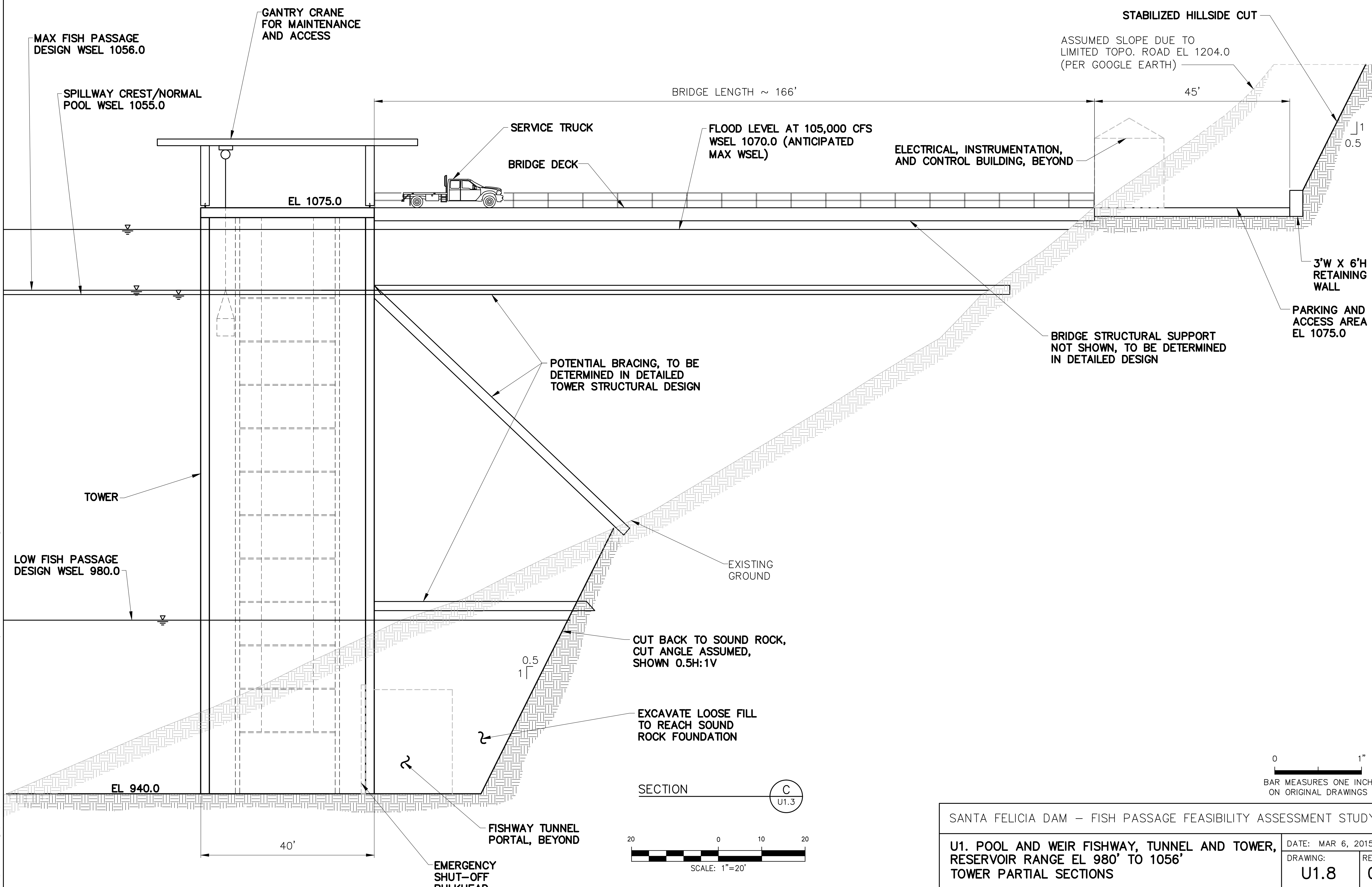
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U1. POOL AND WEIR FISHWAY, TUNNEL AND TOWER, RESERVOIR RANGE EL 980' TO 1056' ROAD SECTIONS

DATE: MAR 6, 2015

DRAWING: U1.7

REV: 0



C:\pwworking\sac\d0606810\2015-03-03 U1 Fishway Tunnel and Tower.dwg, 3/6/2015 1:14:31 PM

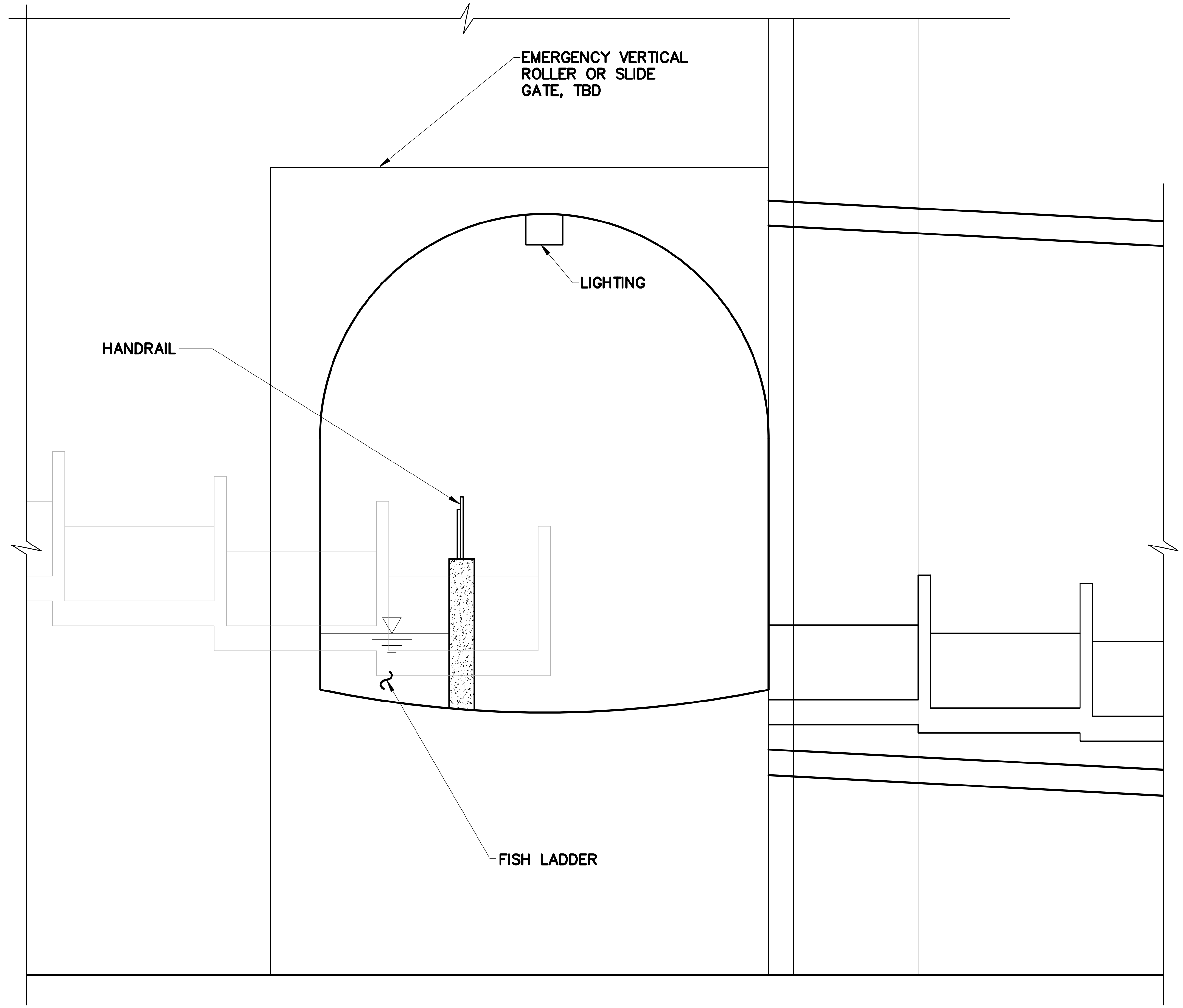
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U1. POOL AND WEIR FISHWAY, TUNNEL AND TOWER, RESERVOIR RANGE EL 980' TO 1056'
TOWER PARTIAL SECTIONS

DATE: MAR 6, 2015

DRAWING: U1.8

REV: 0



ELEVATION 1 / U1.3

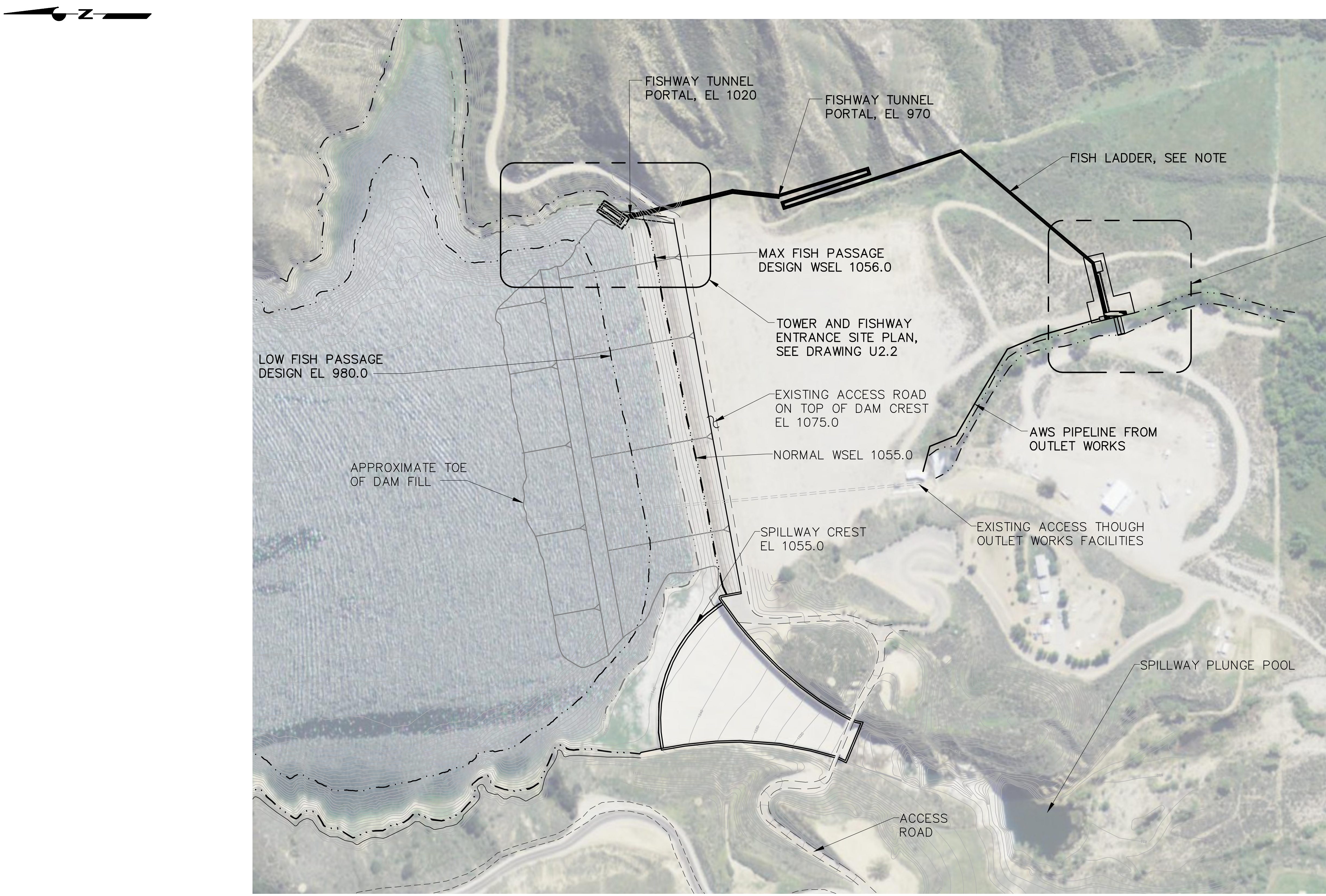
5 0 5
SCALE: 1"=5'

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U1. POOL AND WEIR FISHWAY, TUNNEL AND TOWER, RESERVOIR RANGE EL 980' TO 1056'
TUNNEL AND TOWER CONNECTION ELEVATION

DATE: MAR 6, 2015
DRAWING: U1.9
REV: 0



0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

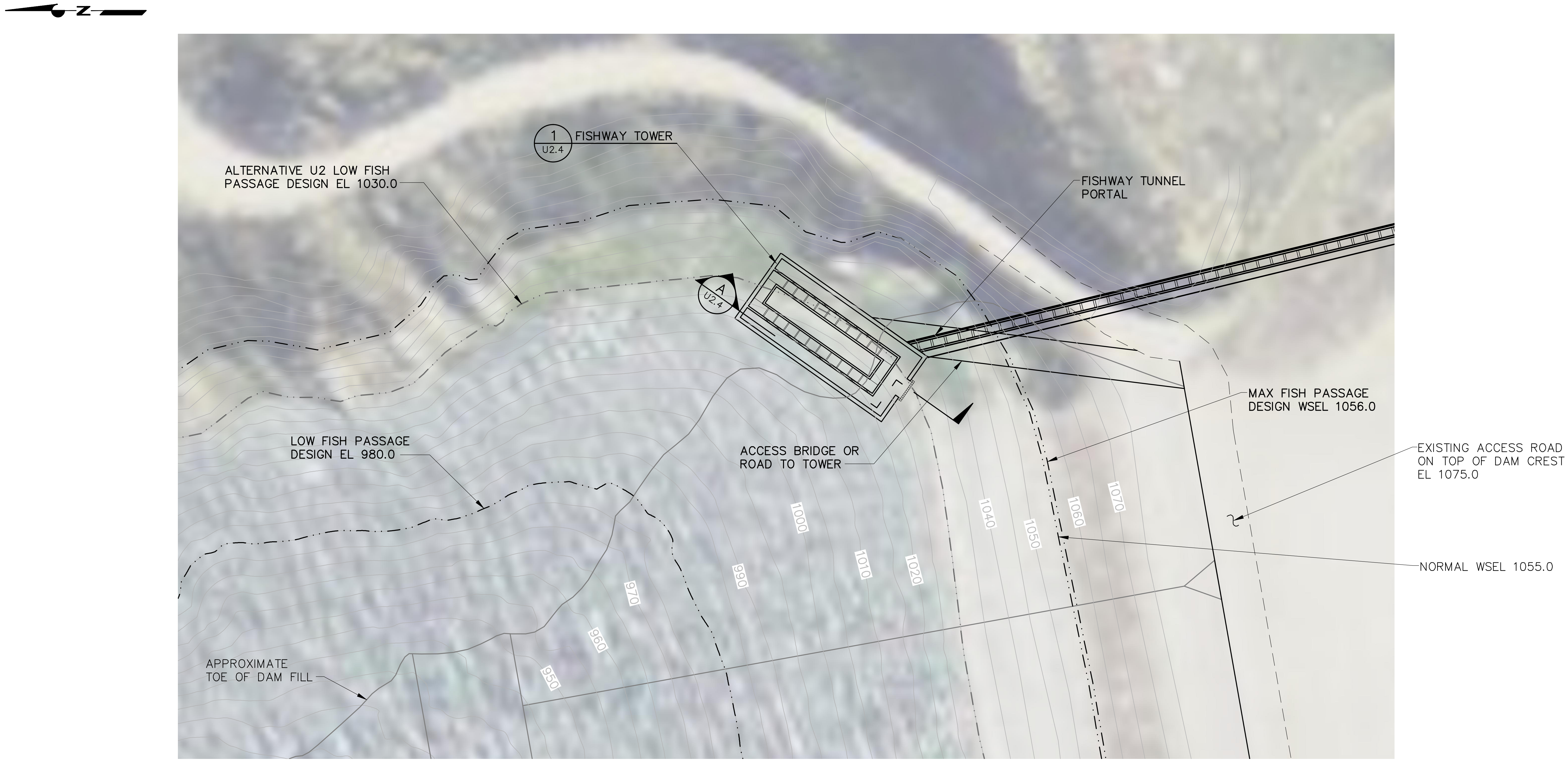
NOTE:

FISH LADDER ALIGNMENT SHOWN IS APPROXIMATE AND FOR EXAMPLE ONLY. ALIGNMENT TO BE DETERMINED DURING DETAILED DESIGN BASED ON TOPOGRAPHIC AND OTHER STUDIES.

LOCATION PLAN

300 0 150 300
SCALE: 1"=300'

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
U2. POOL AND WEIR FISHWAY TO EL 1030', EAST ALIGNMENT TO EXIT STRUCTURE, RESERVOIR RANGE EL 1030' TO 1056' LOCATION PLAN	DATE: APR 2, 2015	
	DRAWING: U2.1	REV: 0



OVERALL PLAN

100 0 50 100

SCALE: 1"=100'

NOTE:

IMAGE LOCATED APPROXIMATELY, THUS THE BACKGROUND IMAGE AND LINEWORK DON'T LINE UP EXACTLY DUE TO THE IMAGE NOT BEING GEOREFERENCED OR ORTHORECTIFIED

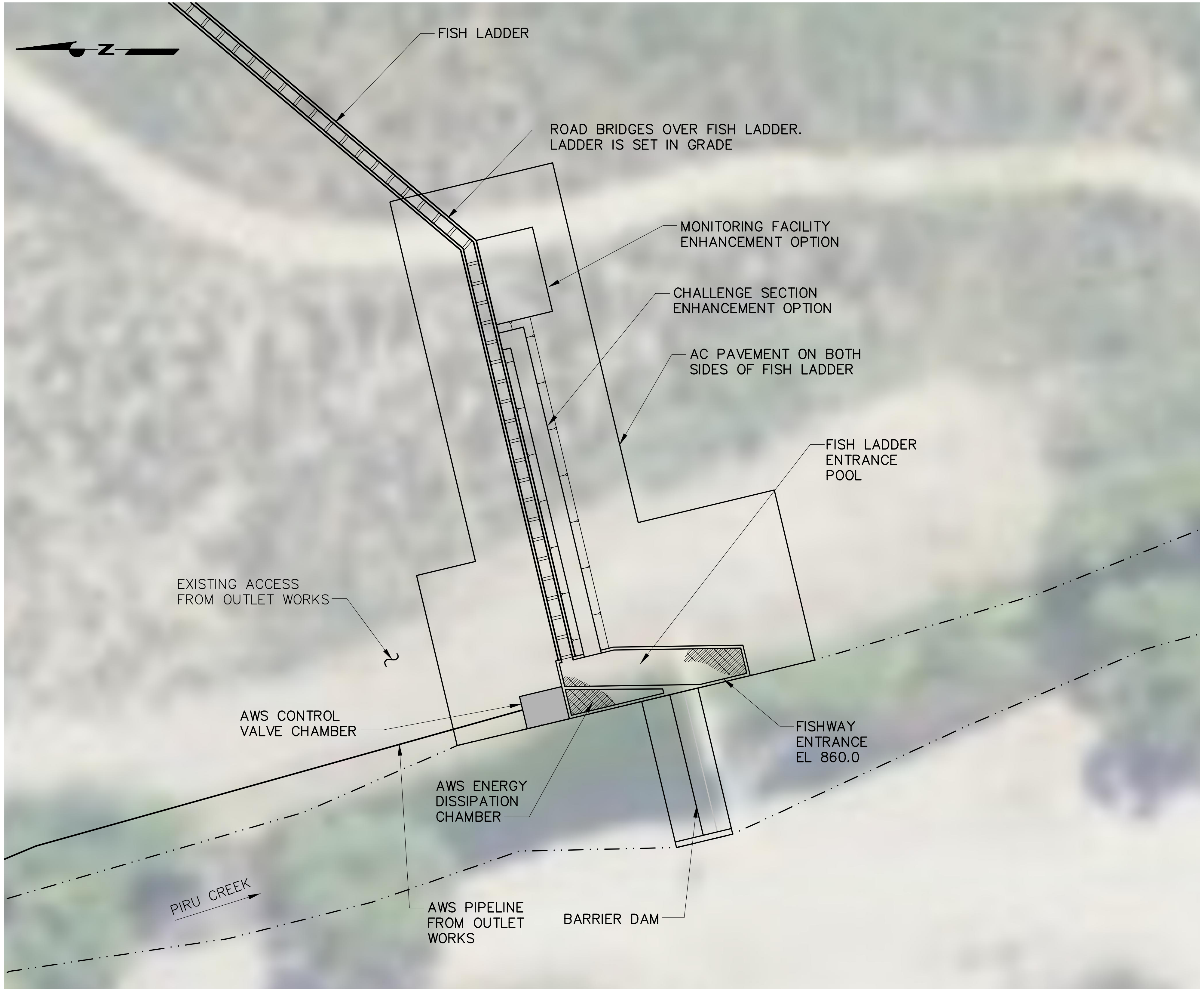
0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U2. POOL AND WEIR FISHWAY TO EL 1030', EAST ALIGNMENT TO EXIT STRUCTURE, RESERVOIR RANGE EL 1030' TO 1056' FISHWAY ENTRANCE SITE PLAN

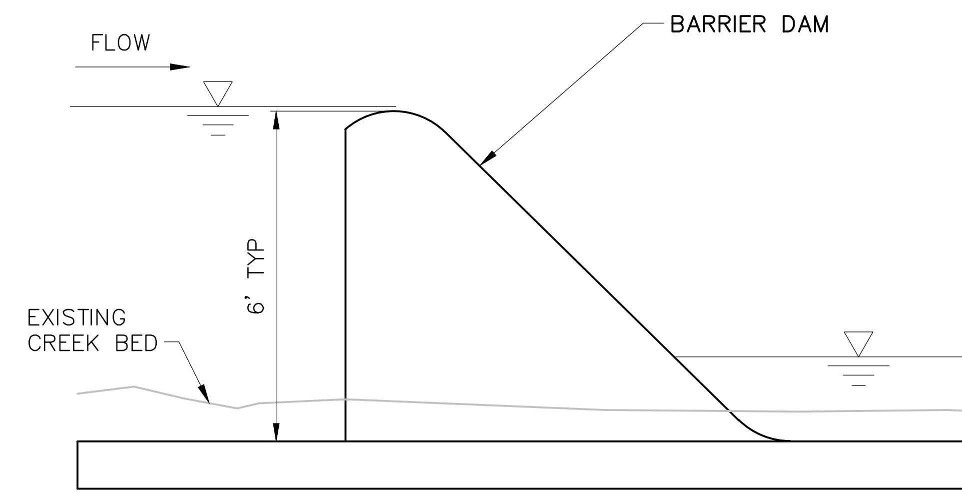
DATE: APR 2, 2015		
DRAWING: U2.2	REV: 0	



PLAN VIEW

40 0 20 40

SCALE: 1"=40'



BARRIER DAM TYPICAL SECTION

NOT TO SCALE

0 1"

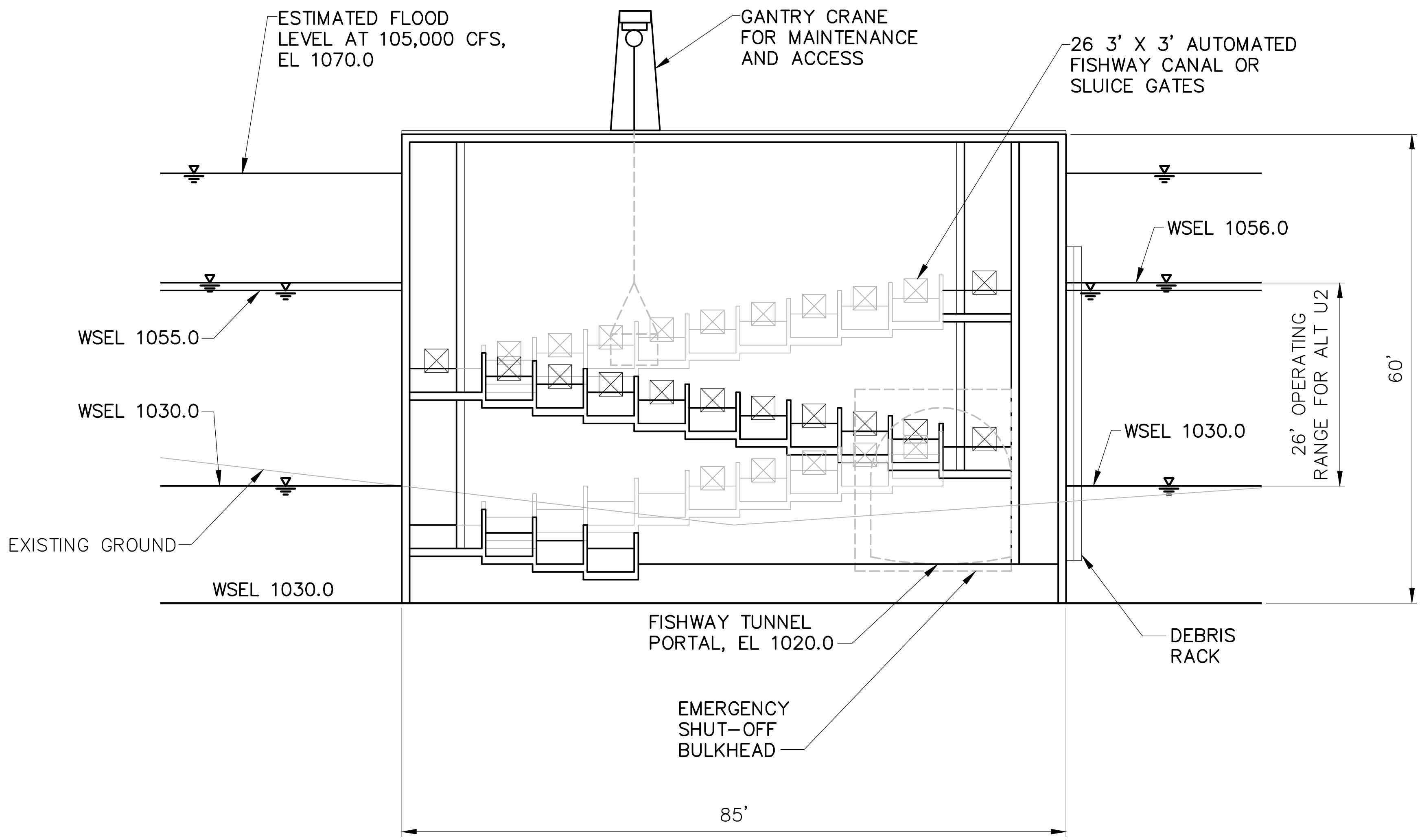
BAR MEASURES ONE INCH
ON ORIGINAL DRAWINGS

NOTE:

MONITORING FACILITY MAY BE SUBSTITUTED WITH LARGER TRAP AND HAUL FACILITY.

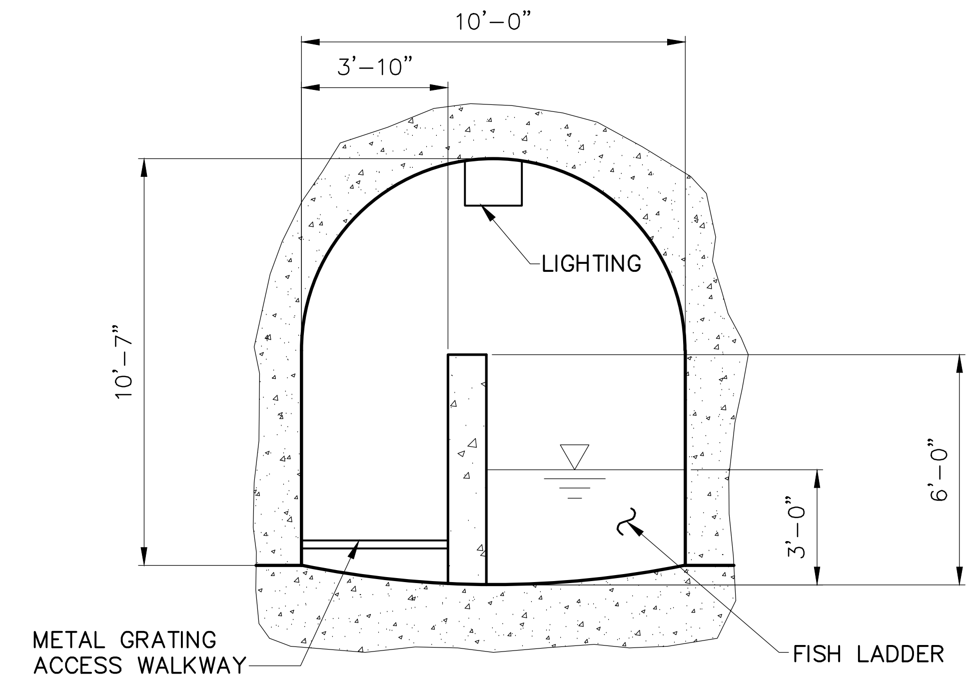
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
U2. POOL AND WEIR FISHWAY TO EL 1030', EAST ALIGNMENT TO EXIT STRUCTURE, RESERVOIR RANGE EL 1030' TO 1056' FISHWAY EXIT SITE PLAN	DATE: APR 2, 2015	
	DRAWING: U2.3	REV: 0

C:\pwworking\sac\d0606811\2014-12-05 U2.dwg, 4/2/2015 9:06:31 AM



SECTION A U2.2

SCALE: 1"=10'



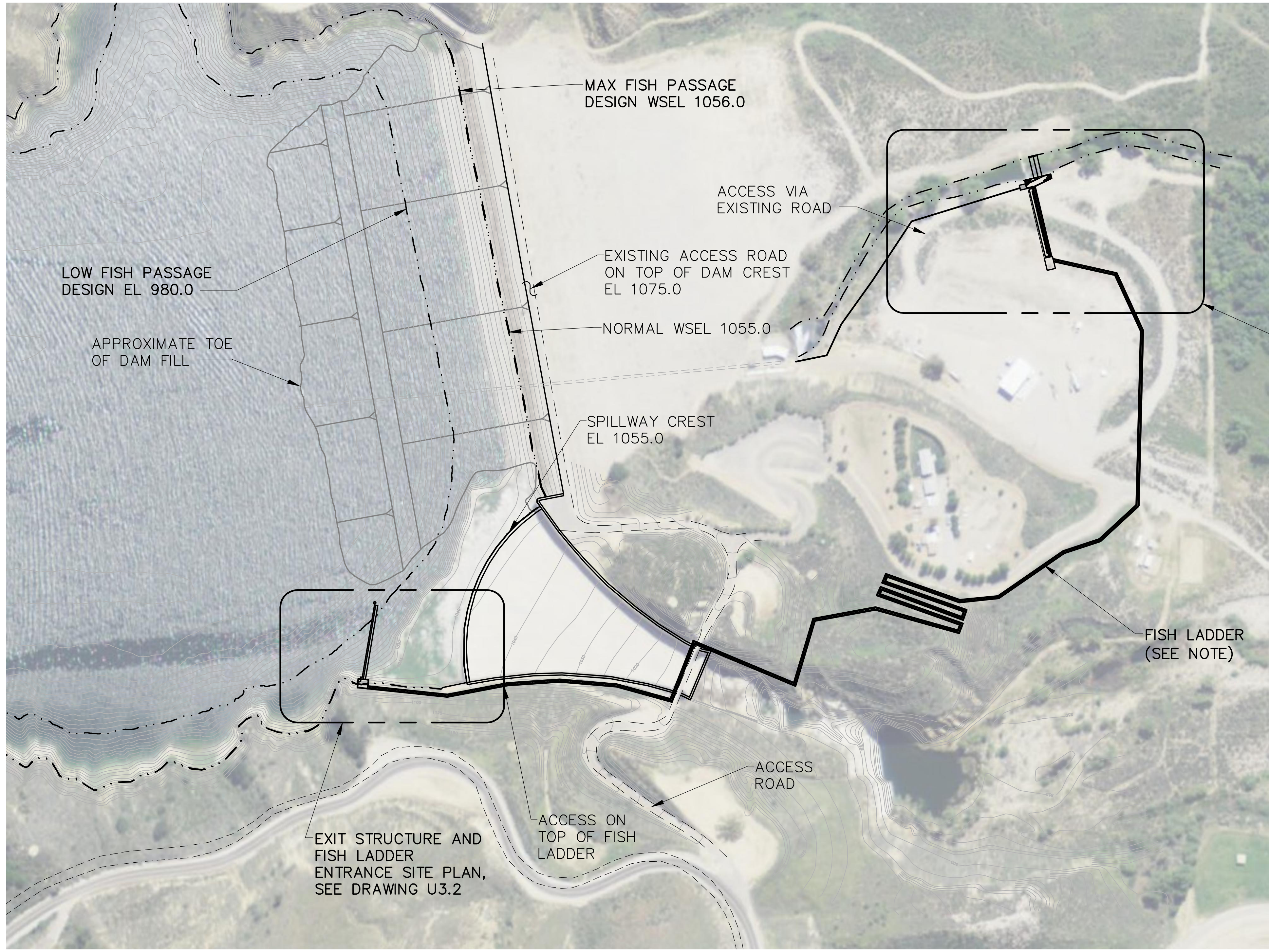
HORSESHOE TUNNEL TYPICAL SECTION

SCALE: 1"=5'

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U2. POOL AND WEIR FISHWAY TO EL 1030', EAST ALIGNMENT TO EXIT STRUCTURE, RESERVOIR RANGE EL 1030' TO 1056' FISHWAY TOWER SECTION	DATE: APR 2, 2015 DRAWING: U2.4 REV: 0



LOCATION PLAN

300 0 150 300

SCALE: 1"=300'

NOTES:

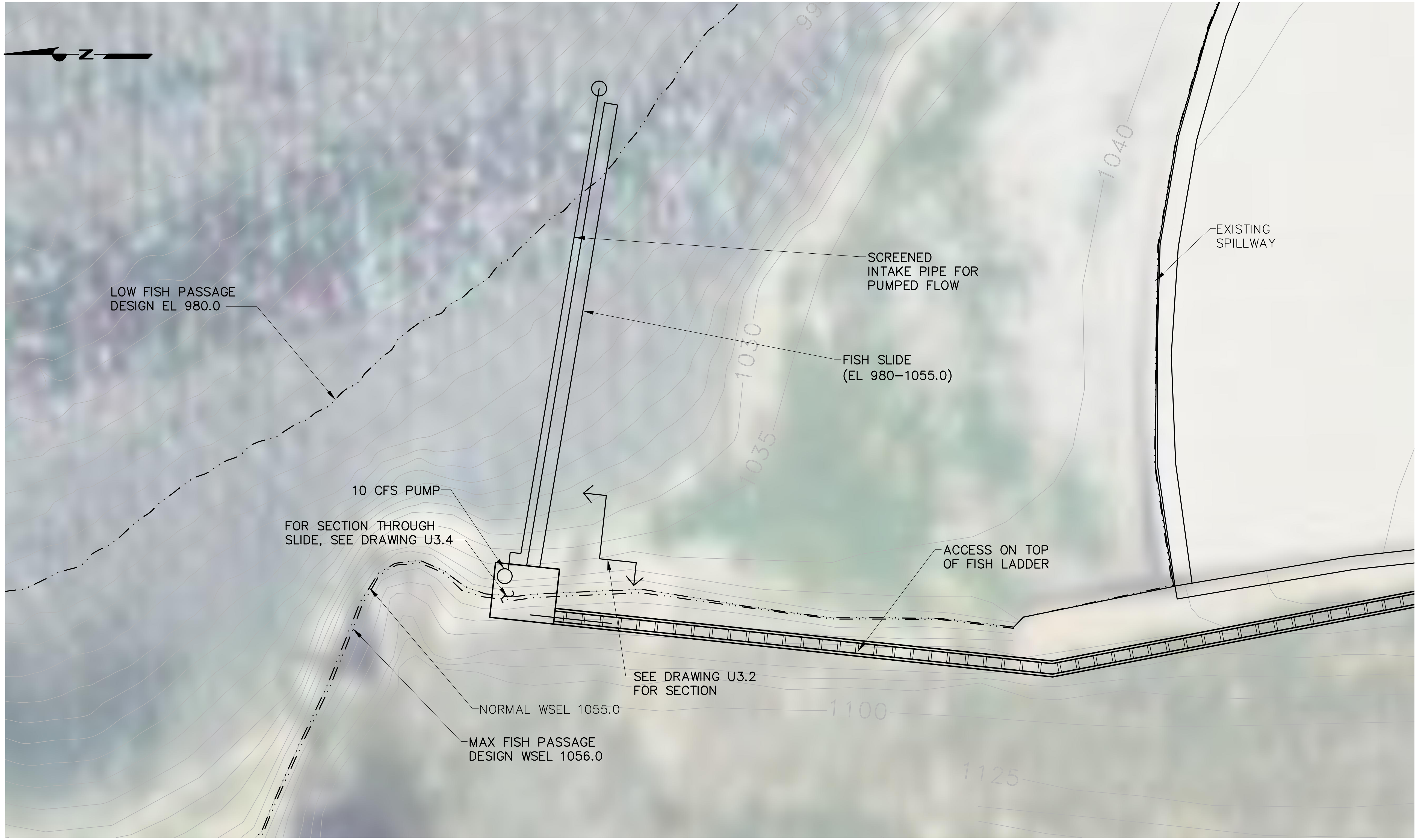
FISH LADDER ALIGNMENT SHOWN IS APPROXIMATE AND FOR EXAMPLE ONLY. ALIGNMENT TO BE DETERMINED DURING DETAILED DESIGN BASED ON TOPOGRAPHIC AND OTHER STUDIES.

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
U3. POOL AND WEIR FISHWAY TO EL 1056', WEST ALIGNMENT WITH SIDE RELEASE, RESERVOIR RANGE EL 980' TO 1056' LOCATION PLAN	DATE: FEB 13, 2015 DRAWING: U3.1	REV: 0

C:\pwworking\sac\d0606812\2014-12-09 U3.dwg, 4/2/2015 10:02:08 AM



OVERALL PLAN

40 0 20 40

SCALE: 1"=40'

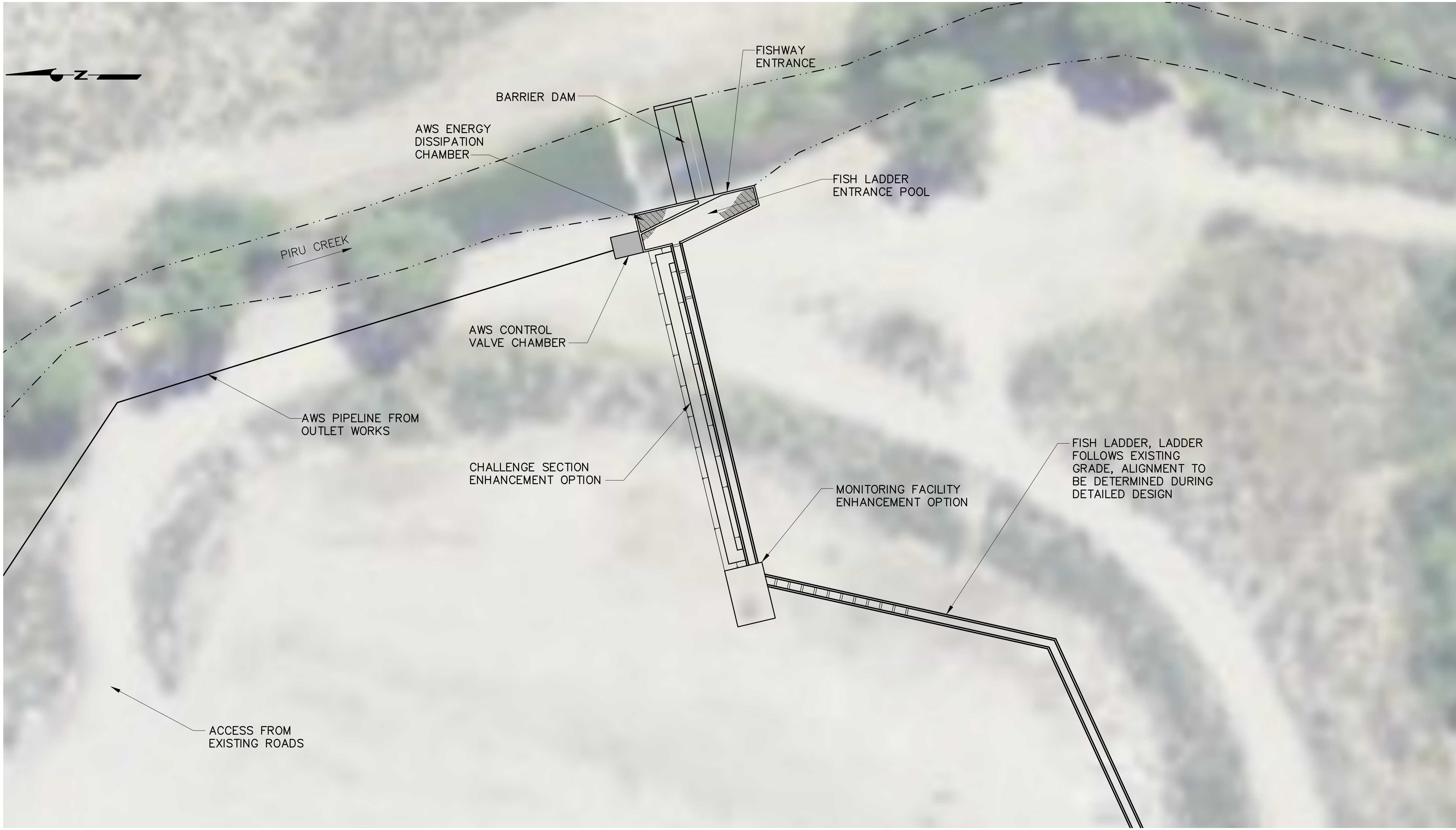
0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U3. POOL AND WEIR FISHWAY TO EL 1056', WEST ALIGNMENT WITH SIDE RELEASE, RESERVOIR RANGE EL 980' TO 1056' FISHWAY EXIT SITE PLAN	DATE: FEB 13, 2015 DRAWING: U3.2	REV: 0

C:\pwworking\sac\d0606812\2014-12-09 U3.dwg, 2/13/2015 1:56:10 PM



0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

NOTES:

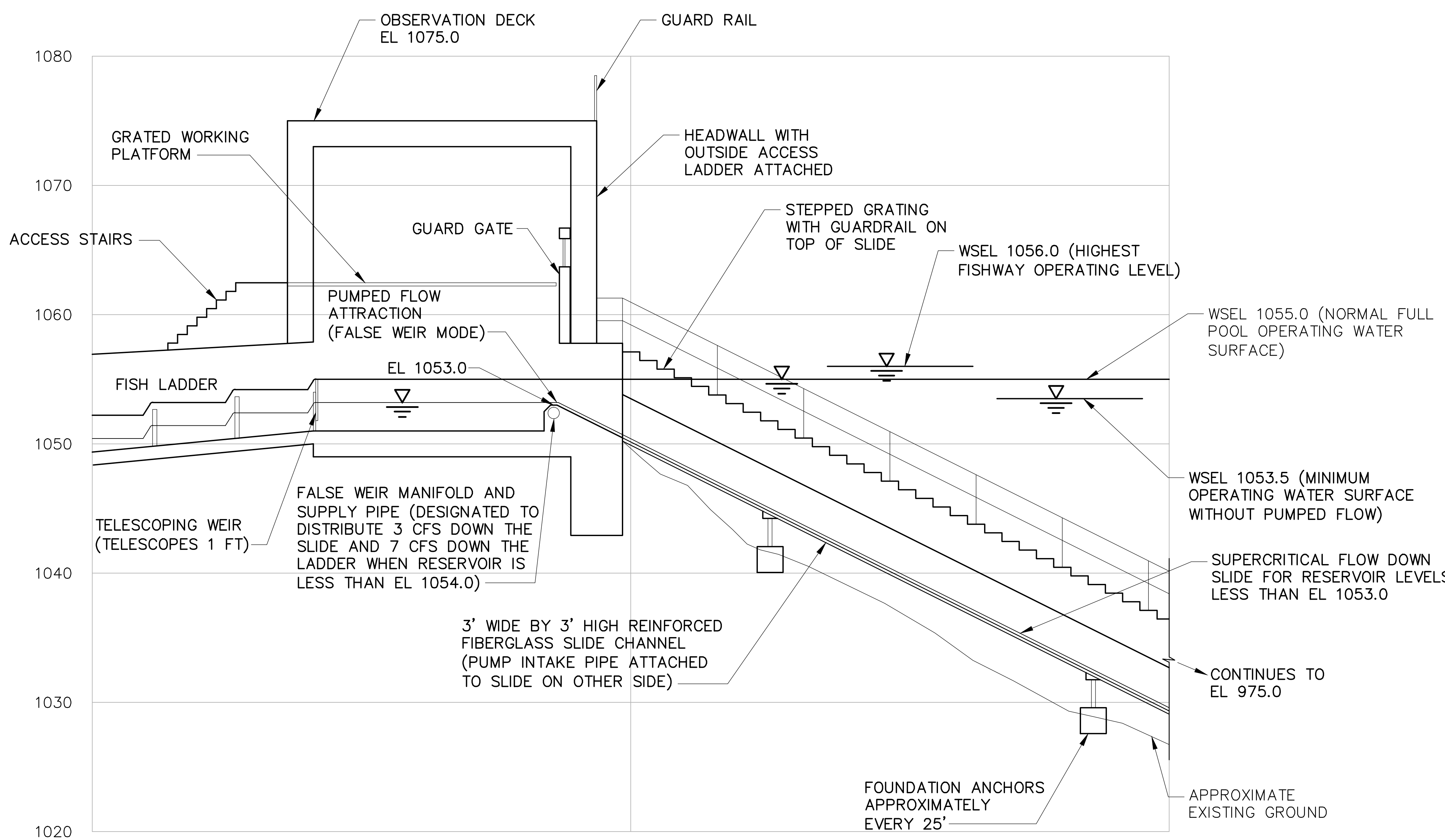
MONITORING FACILITY MAY BE SUBSTITUTED WITH LARGER TRAP AND HAUL FACILITY.

PLAN VIEW

50 0 25 50

SCALE: 1"=50'

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
U3. POOL AND WEIR FISHWAY TO EL 1056', WEST ALIGNMENT WITH SIDE RELEASE, RESERVOIR RANGE EL 980' TO 1056' FISHWAY ENTRANCE SITE PLAN	DATE: FEB 13, 2015 DRAWING: U3.3	REV: 0



FISH SLIDE SECTION

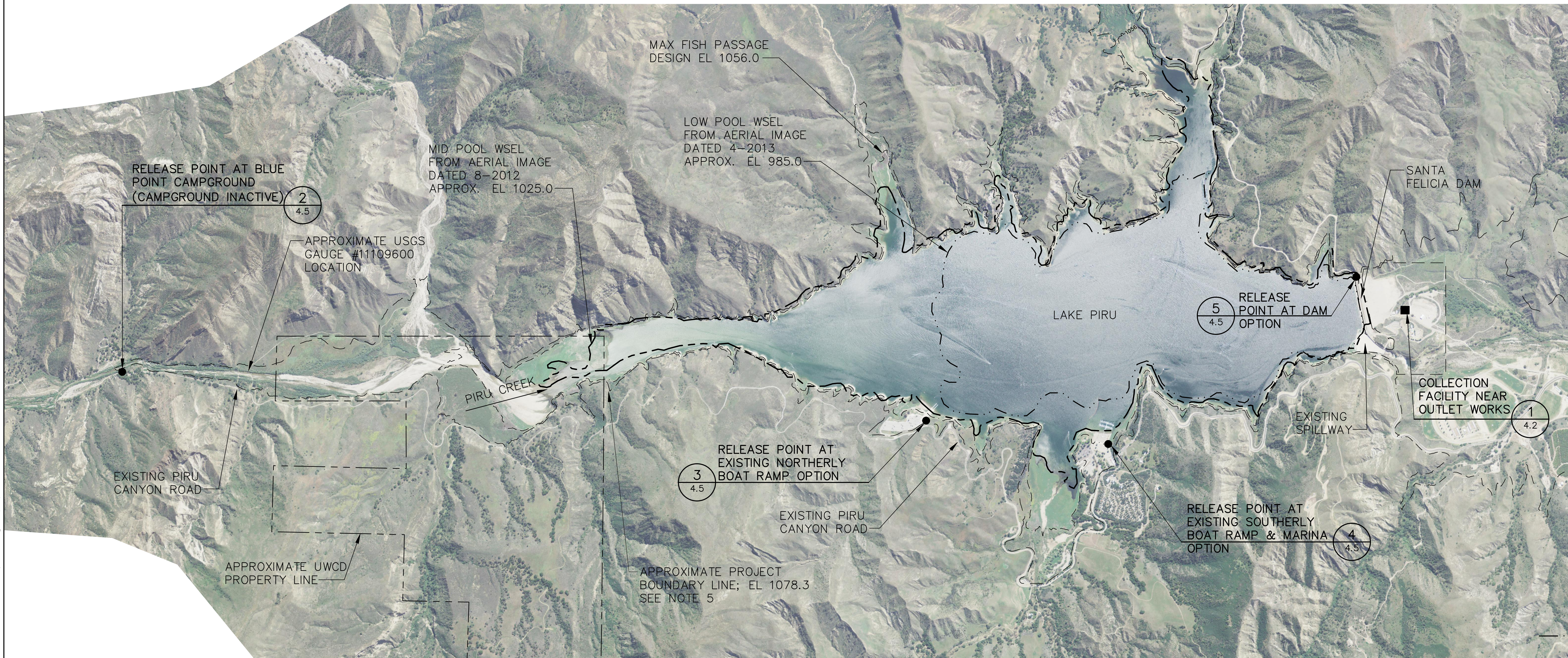
10 0 5 10

SCALE: 1"=10'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
U3. POOL AND WEIR FISHWAY TO EL 1056', WEST ALIGNMENT WITH SIDE RELEASE, RESERVOIR RANGE EL 980' TO 1056' FISH SLIDE SECTION	DATE: FEB 13, 2015 DRAWING: U3.4	REV: 0



NOTES:

1. IMAGE, VENTURA COUNTY NAIP, 2012.
2. PROPERTY LINE TAKEN FROM 14289 MAPPING.DWG IN EXHIBIT G, DATED 4-27-09.
3. NORMAL FULL POOL WSEL 1055.0.
4. DAM CREST ELEVATION 1075.0.
5. PROJECT BOUNDARY LINE TAKEN FROM "EXHIBIT G"
6. APPROXIMATELY 4 MILES OF EXISTING PAVED ROAD IS IN POOR CONDITION AND NEEDS IMPROVEMENTS TO RELEASE LOCATION AT BLUE POINT.

LOCATION PLAN

2000 0 1000 2000

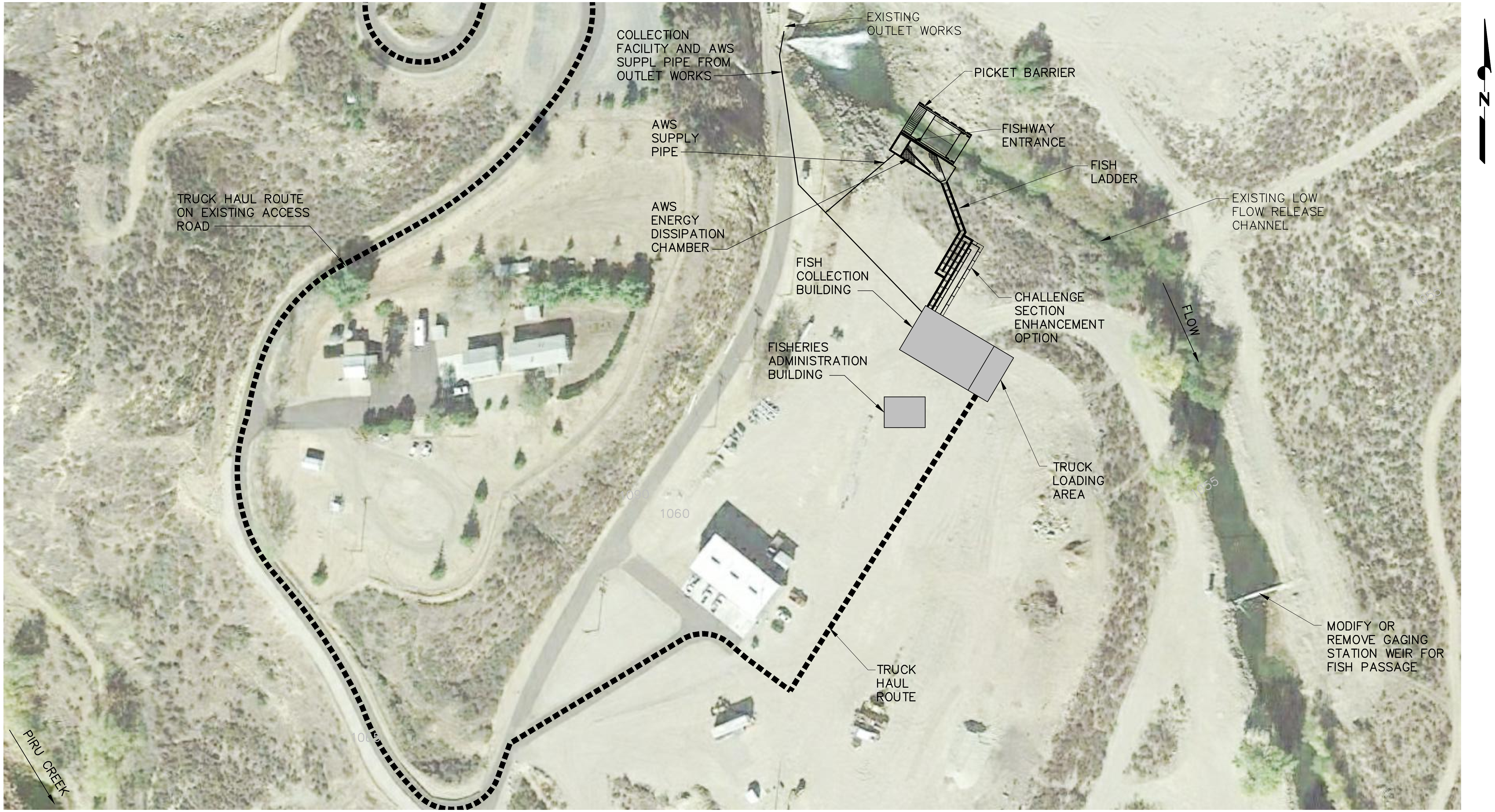
SCALE: 1"=2000'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U–4. TRAP AND TRUCK TRANSPORT WITH MULTIPLE RELEASE LOCATION OPTIONS LOCATION PLAN	DATE: JAN 9, 2015	
	DRAWING: U4.1	REV: 0



COLLECTION FACILITY SITE PLAN 1 / 4.1

100 0 50 100
SCALE: 1"=100'

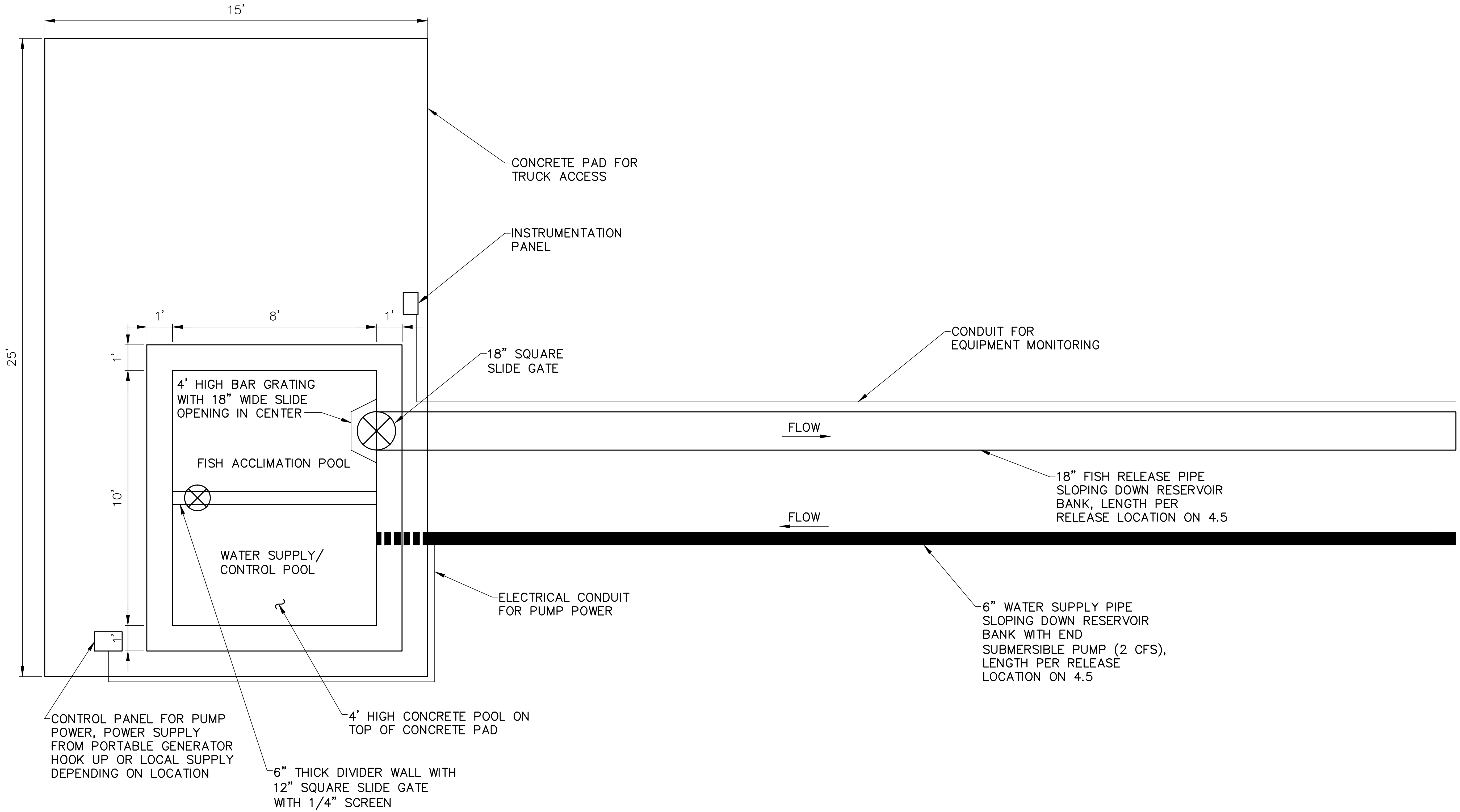
0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

NOTES:

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U-4. TRAP AND TRUCK TRANSPORT COLLECTION FACILITY PLAN

DATE: JAN 9, 2015
DRAWING: U4.2
REV: 0



0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

RELEASE FACILITY TYPICAL PLAN 2/7.5 3/7.5 4/7.5 5/7.5

4 0 2 4
SCALE: 1"=4'

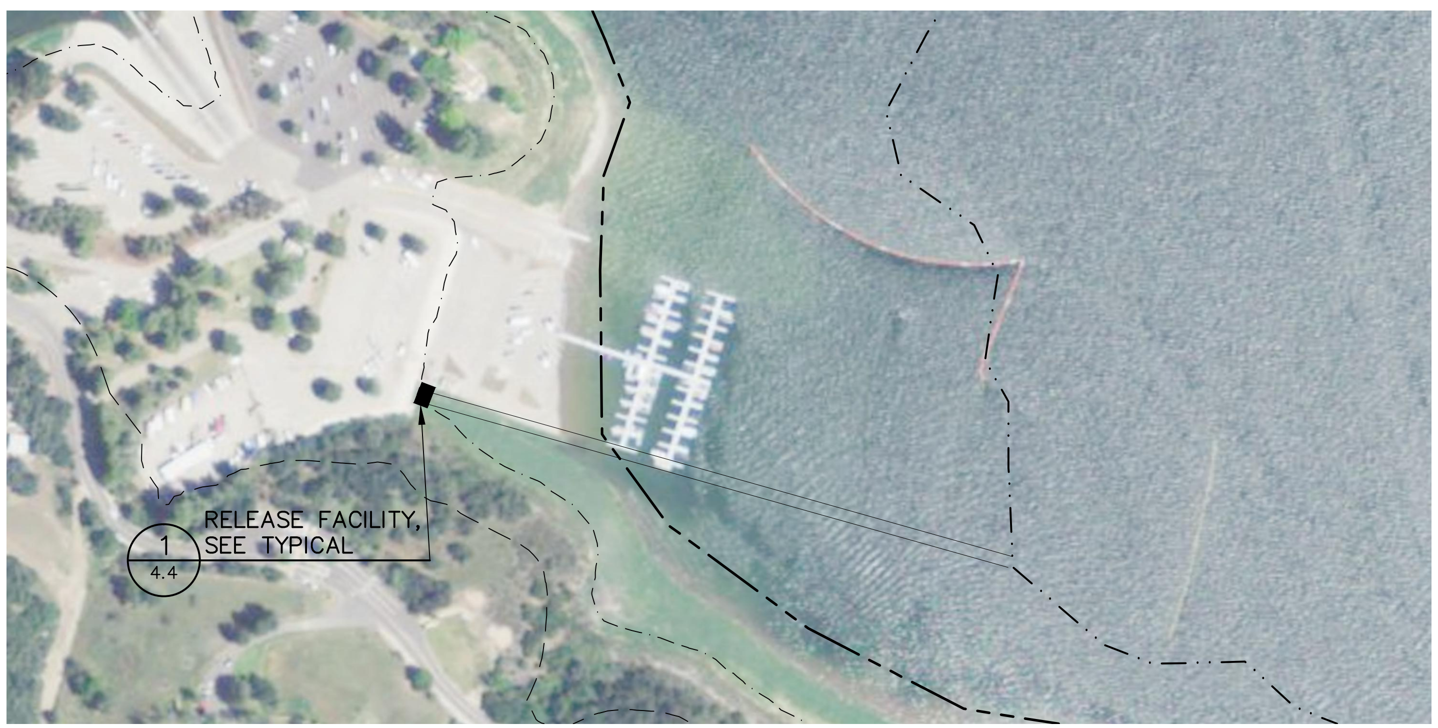
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U4. TRAP AND TRUCK TRANSPORT
RELEASE FACILITY TYPICAL PLAN

DATE: JAN 9, 2015
DRAWING: U4.4
REV: 0

BLUE POINT (2 / 4.1)
SITE PLAN

NORTHERLY BOAT RAMP (3 / 4.1)
SITE PLAN (OPTIONAL)



SOUTHERLY BOAT RAMP (4 / 4.1)
SITE PLAN (OPTIONAL)

DAM RELEASE POINT (5 / 4.1)
SITE PLAN (OPTIONAL)

LEGEND

- LOW POOL WSEL APPROX. EL 985.0
- HIGH POOL WSEL APPROX. EL 1025.0
- MAX FISH PASSAGE DESIGN EL 1056.0
- APPROXIMATE PROJECT BOUNDARY LINE; EL 1078.3

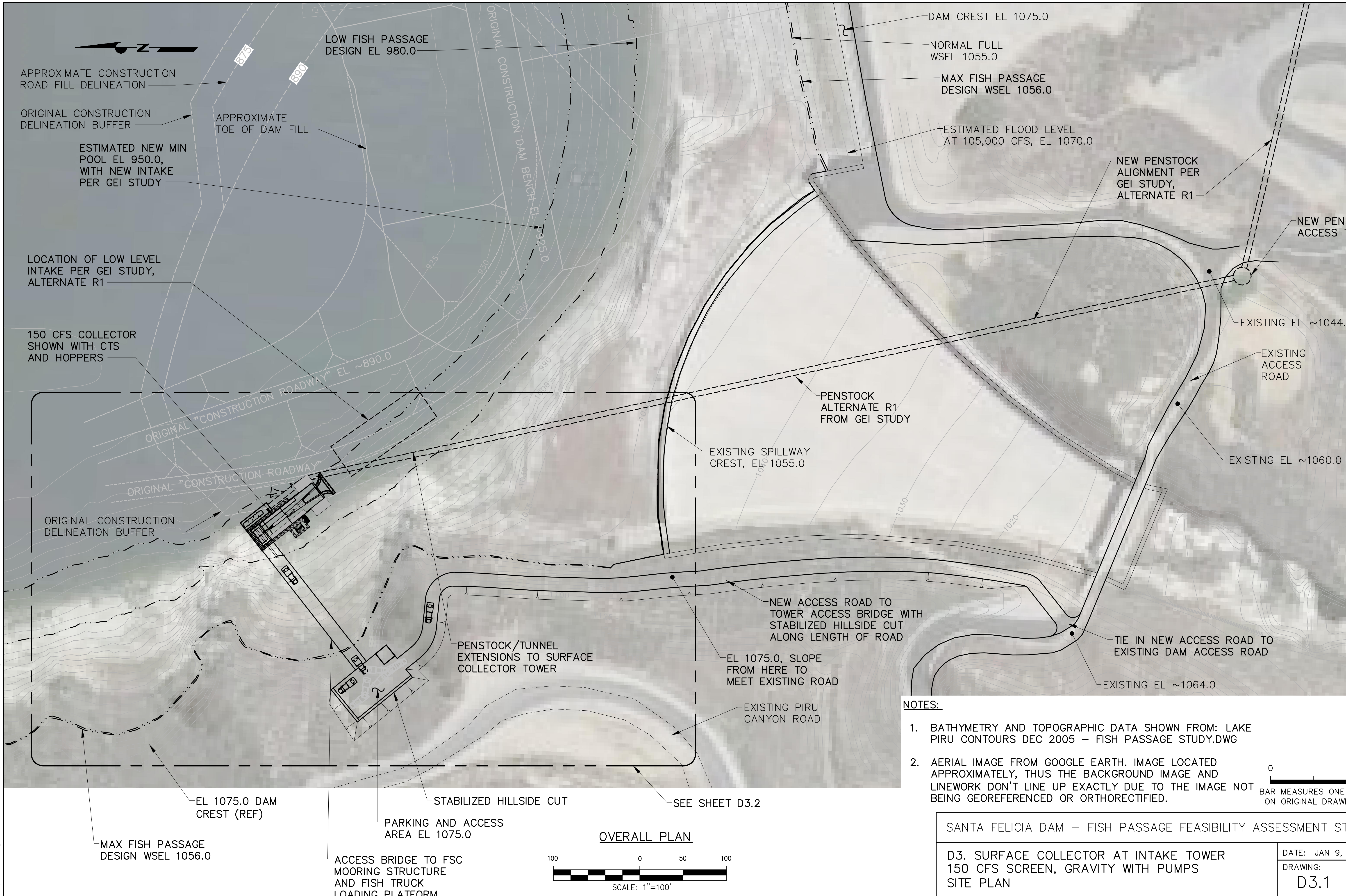
300 0 150 300
SCALE: 1"=300'

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

U4. TRAP AND TRUCK TRANSPORT
RELEASE SITE PLANS

DATE: JAN 9, 2015
DRAWING: U4.5
REV: 0

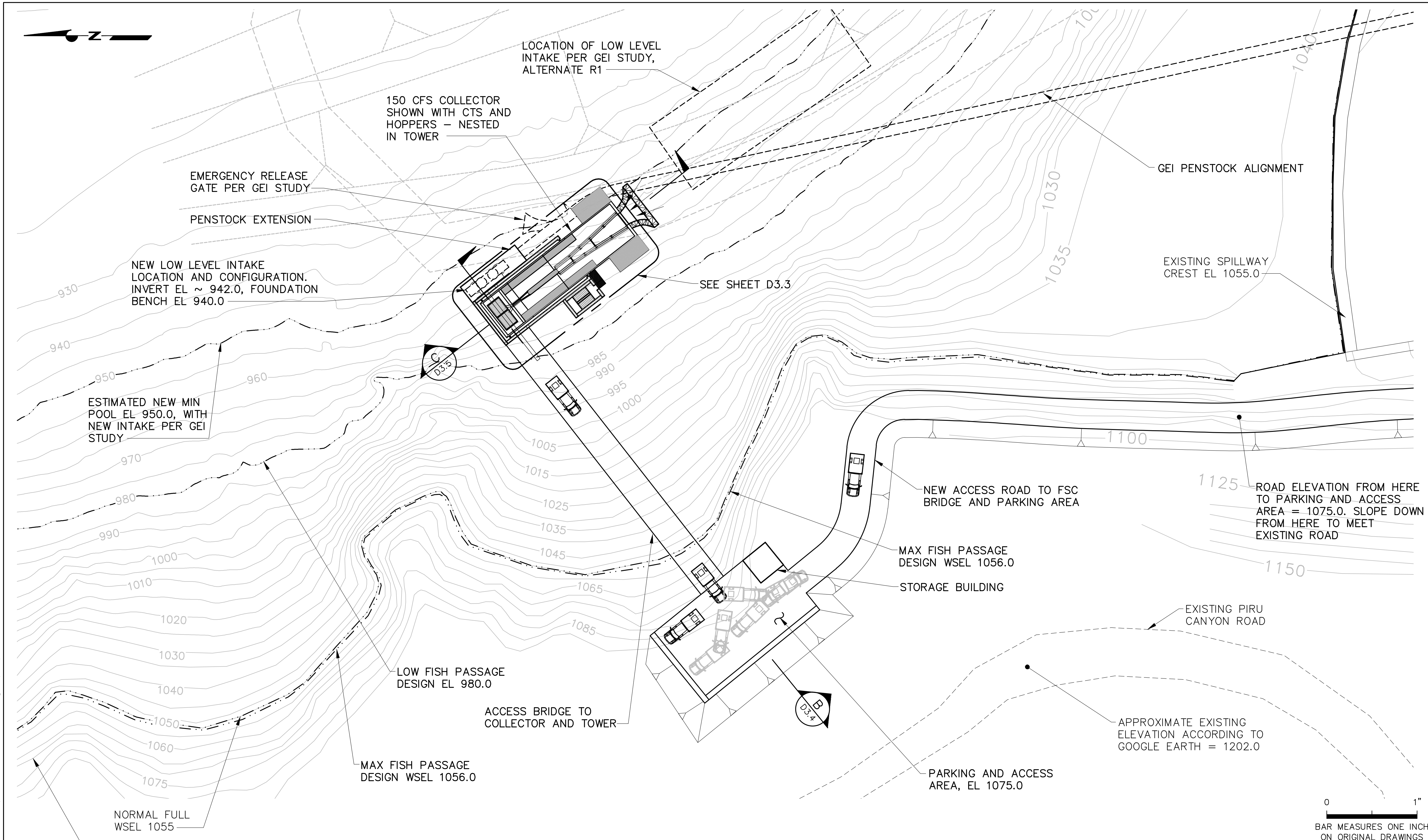


NOTES:

1. BATHYMETRY AND TOPOGRAPHIC DATA SHOWN FROM: LAKE PIRU CONTOURS DEC 2005 – FISH PASSAGE STUDY.DWG
2. AERIAL IMAGE FROM GOOGLE EARTH. IMAGE LOCATED APPROXIMATELY, THUS THE BACKGROUND IMAGE AND LINEWORK DON'T LINE UP EXACTLY DUE TO THE IMAGE NOT BEING GEOREFERENCED OR ORTHORECTIFIED.

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D3. SURFACE COLLECTOR AT INTAKE TOWER 150 CFS SCREEN, GRAVITY WITH PUMPS SITE PLAN	DATE: JAN 9, 2015	
	DRAWING: D3.1	REV: 0



PLAN VIEW

50 0 25 50
SCALE: 1"=50'

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D3. SURFACE COLLECTOR AT INTAKE TOWER 150 CFS SCREEN, GRAVITY WITH PUMPS ENLARGED SITE PLAN	DATE: JAN 9, 2015 DRAWING: D3.2 REV: 0

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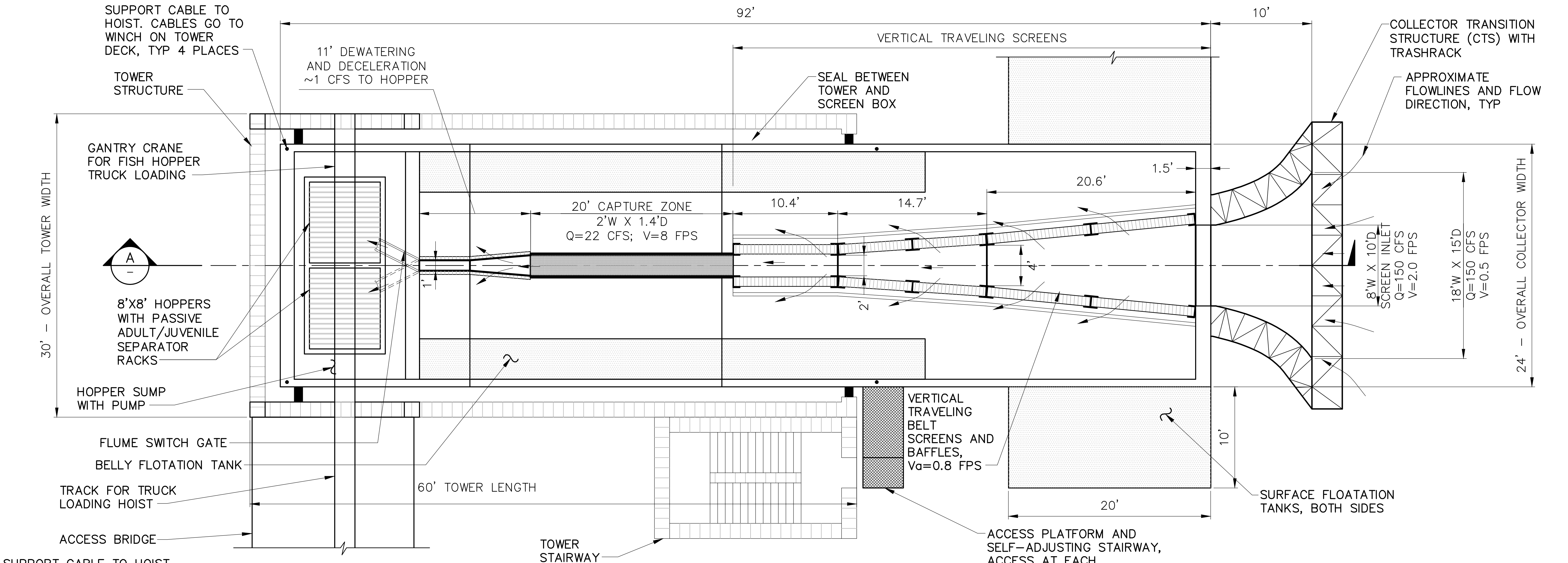
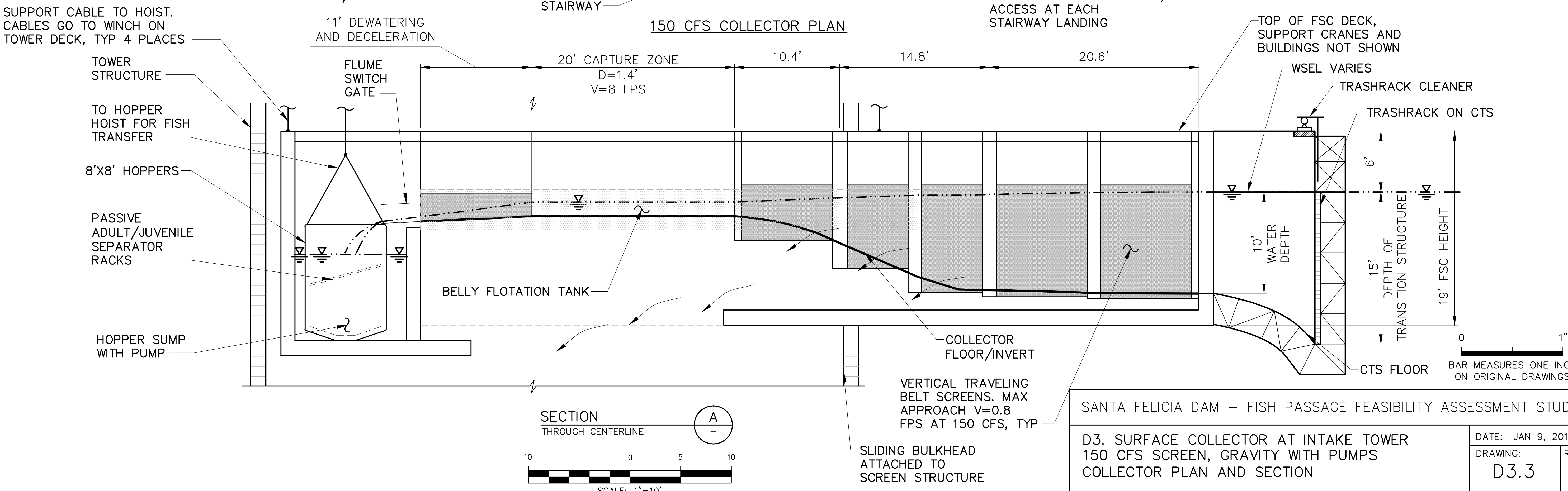


150 CFS COLLECTOR PLAN



SECTION A
THROUGH CENTERLINE

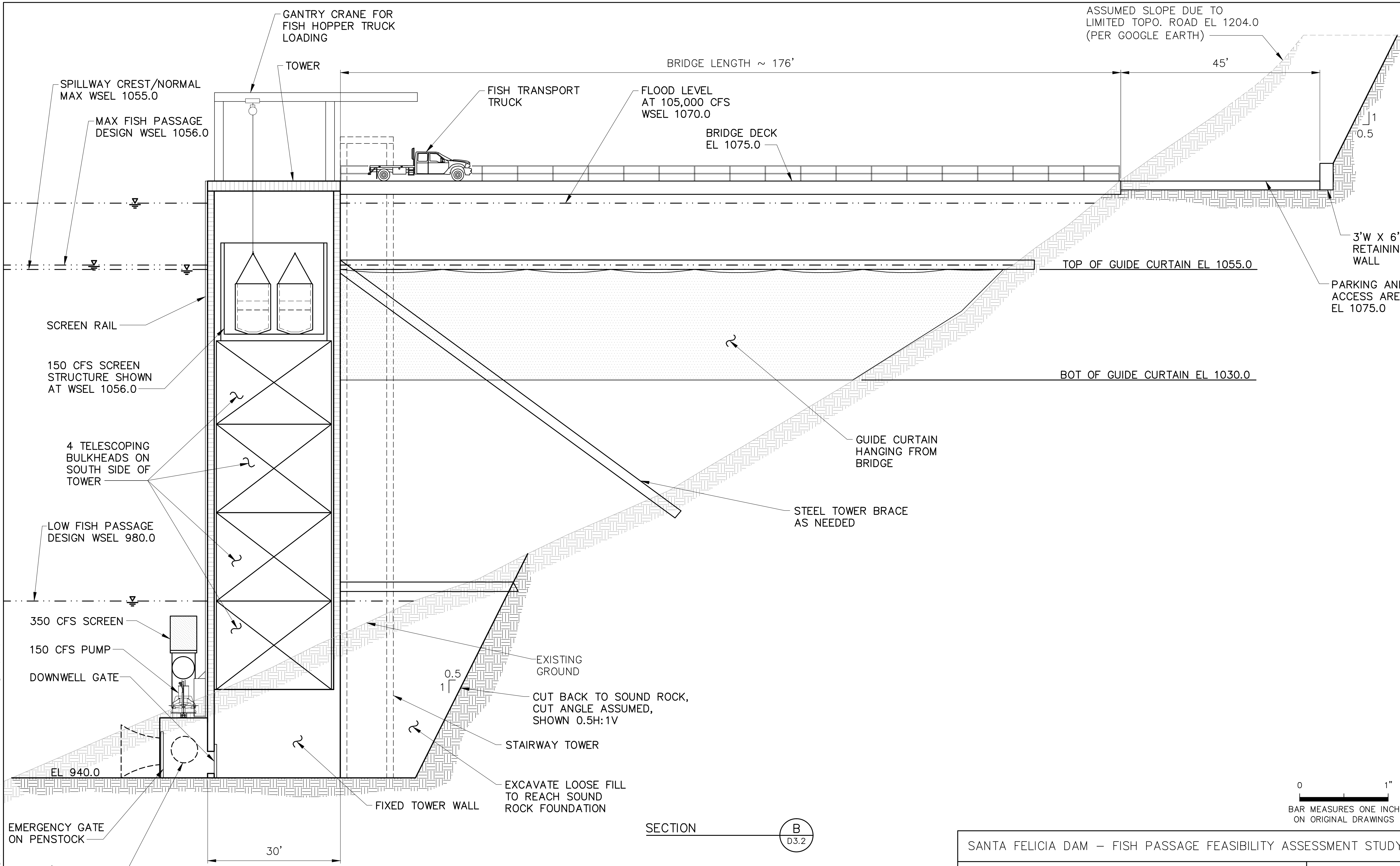
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D3. SURFACE COLLECTOR AT INTAKE TOWER
150 CFS SCREEN, GRAVITY WITH PUMPS
COLLECTOR PLAN AND SECTION

DATE: JAN 9, 2015

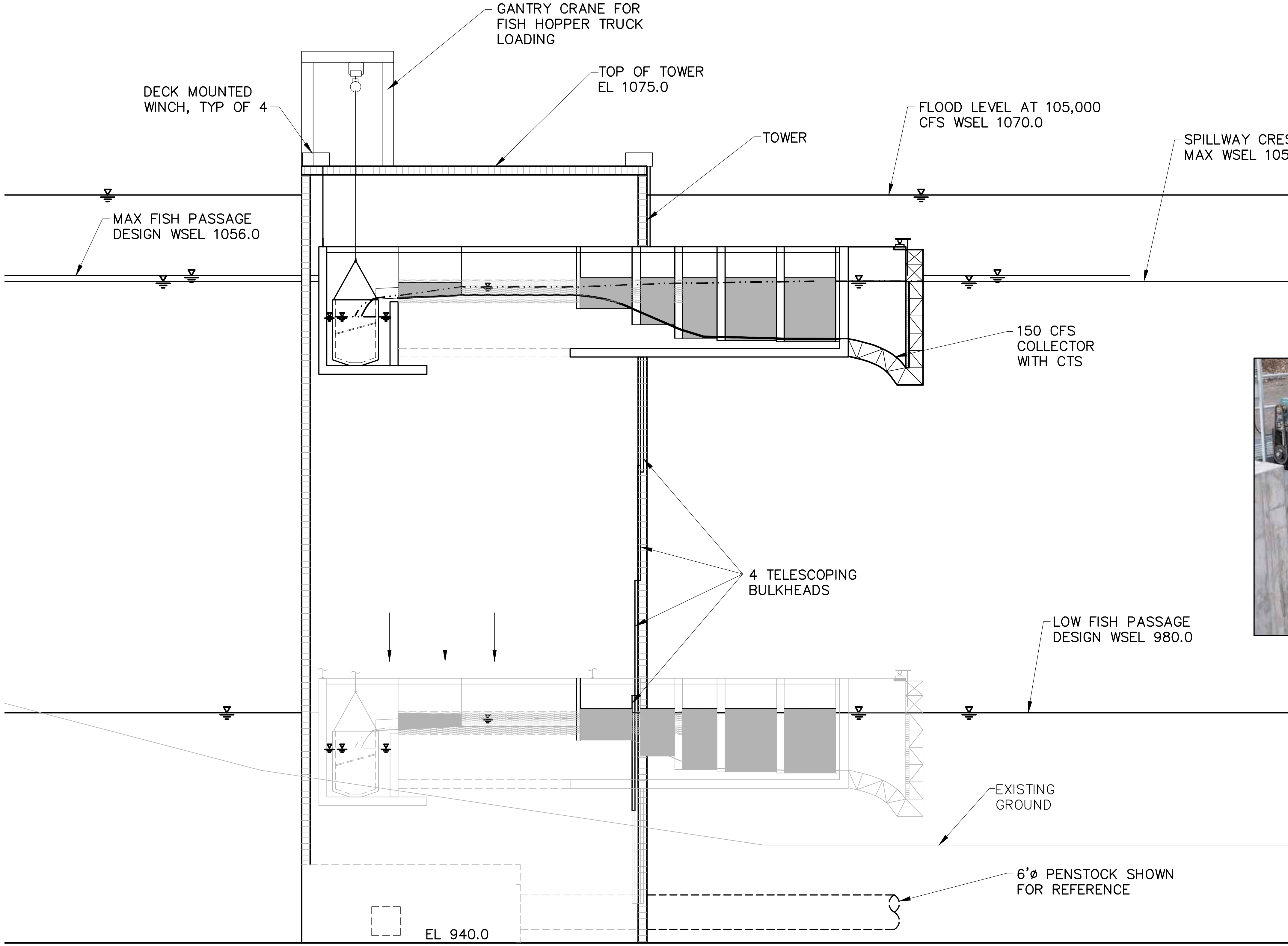
DRAWING: D3.3

REV: 0



SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D3. SURFACE COLLECTOR AT INTAKE TOWER 150 CFS SCREEN, GRAVITY WITH PUMPS SECTION THROUGH COLLECTOR TO SHORE	DATE: JAN 9, 2015	
	DRAWING: D3.4	REV: 0



EXAMPLE OF HYDROLOX VERTICAL TRAVELING BELT SCREENS

SECTION C D3.2

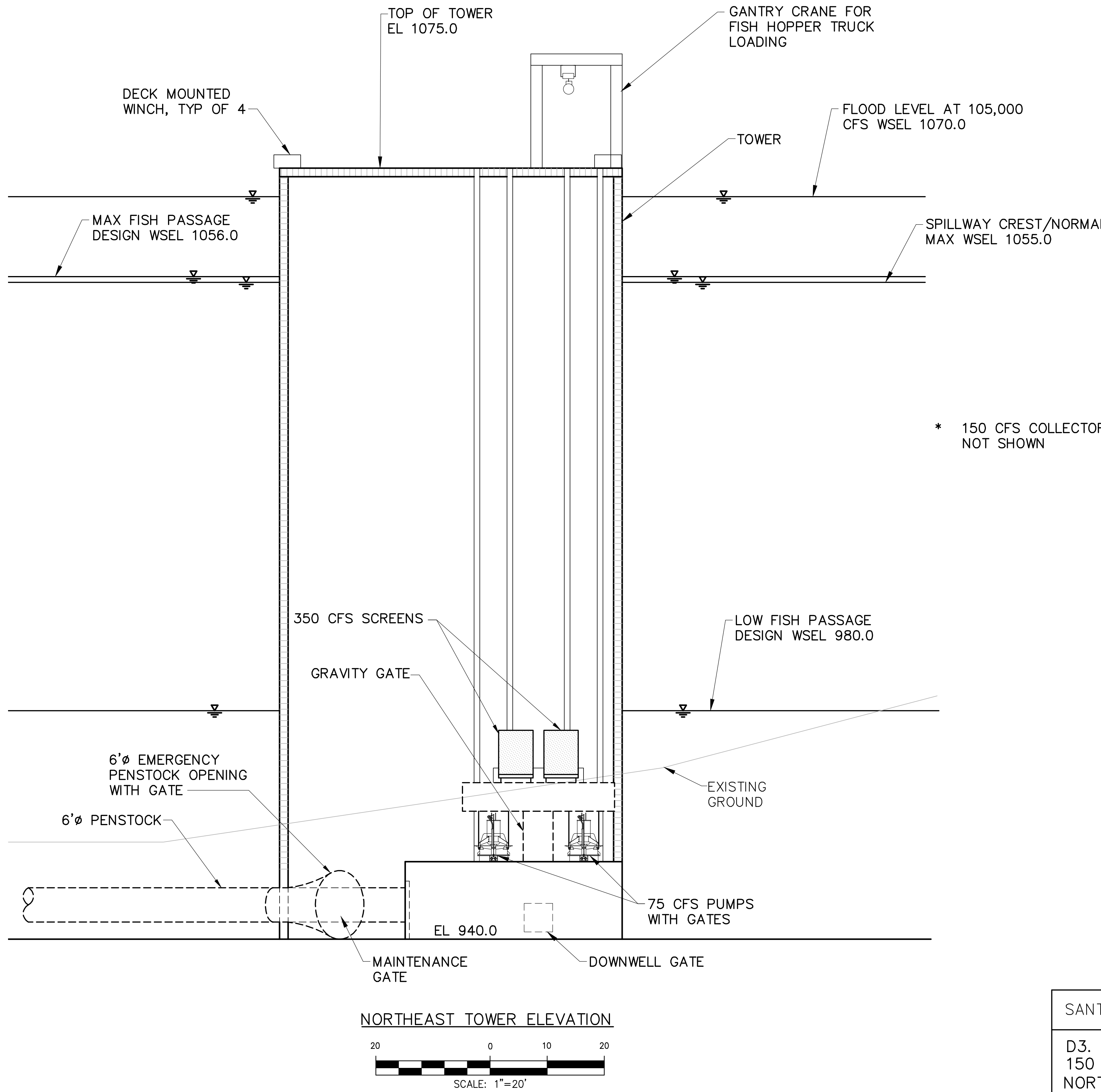
20 0 10 20
SCALE: 1"=20'

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D3. SURFACE COLLECTOR AT INTAKE TOWER
150 CFS SCREEN, GRAVITY WITH PUMPS
SECTION THROUGH TOWER AND SCREEN

DATE: JAN 9, 2015	
DRAWING: D3.5	REV: 0



NORTHEAST TOWER ELEVATION

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D3. SURFACE COLLECTOR AT INTAKE TOWER
150 CFS SCREEN, GRAVITY WITH PUMPS
NORTHEAST TOWER ELEVATION

DATE: JAN 9, 2015
DRAWING: D3.6
REV: 0

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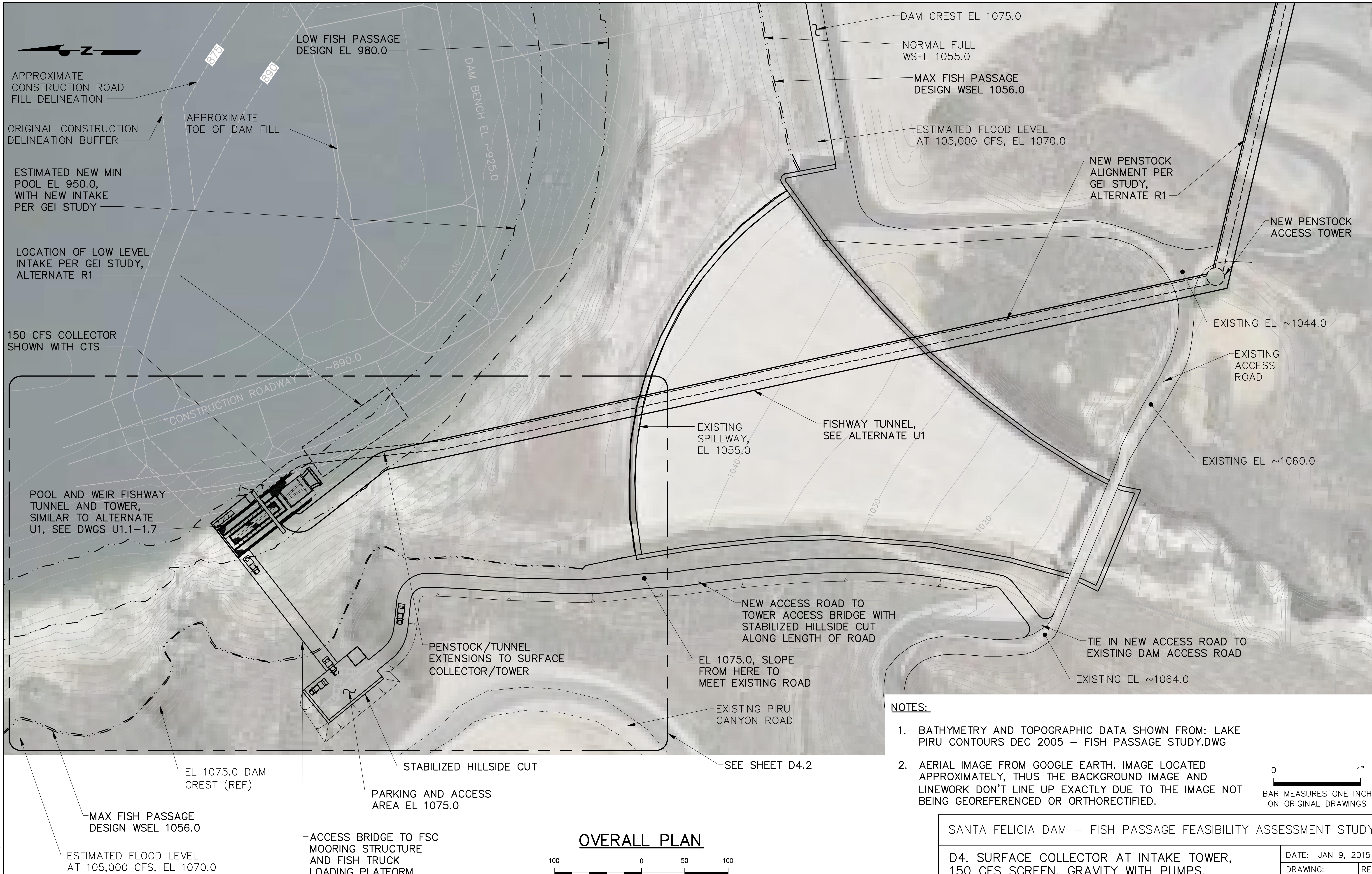


OVERALL PLAN

100 0 50 100

SCALE: 1"=100'

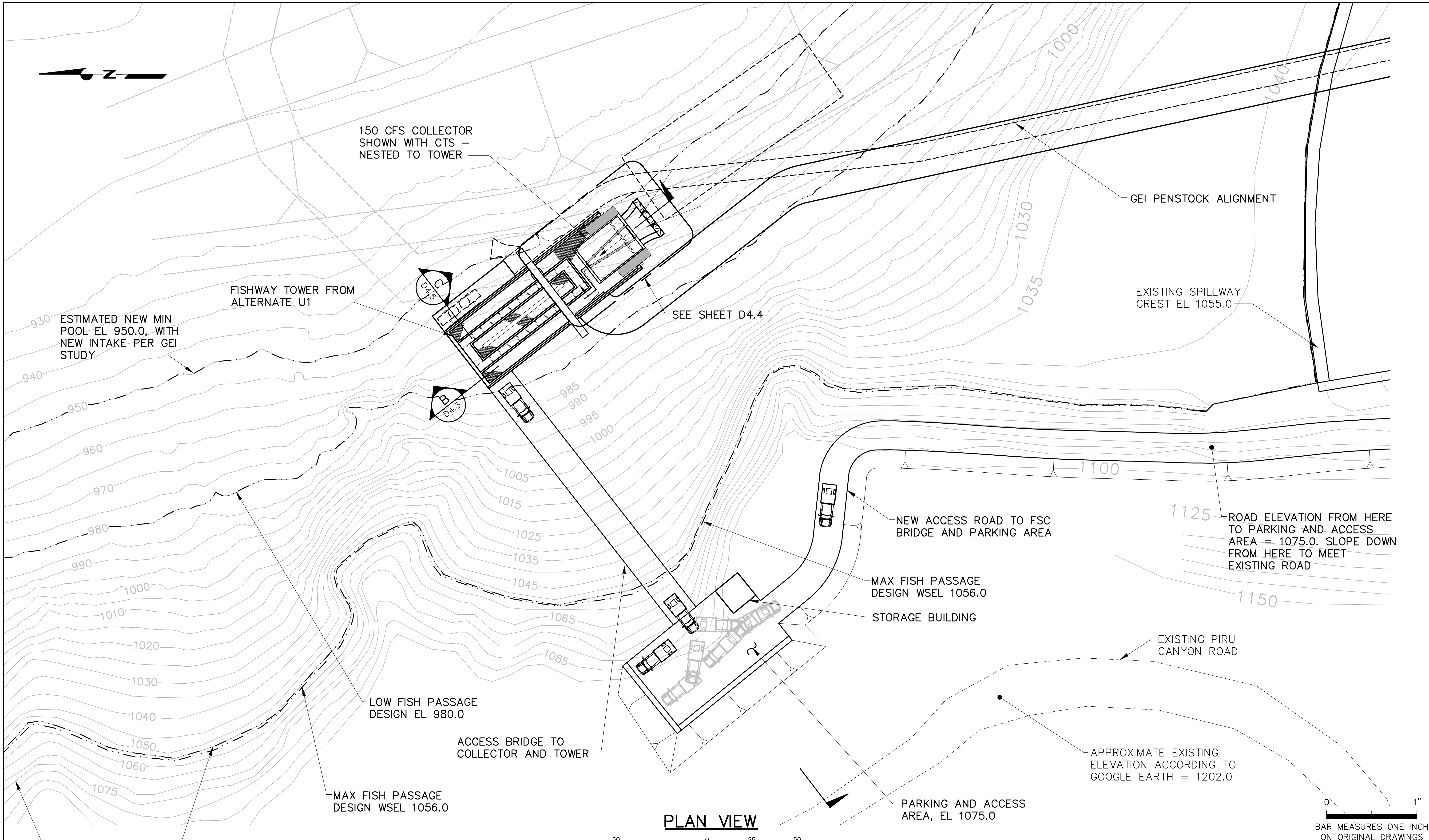
NOTES:

1. BATHYMETRY AND TOPOGRAPHIC DATA SHOWN FROM: LAKE PIRU CONTOURS DEC 2005 – FISH PASSAGE STUDY.DWG
2. AERIAL IMAGE FROM GOOGLE EARTH. IMAGE LOCATED APPROXIMATELY, THUS THE BACKGROUND IMAGE AND LINEWORK DON'T LINE UP EXACTLY DUE TO THE IMAGE NOT BEING GEOREFERENCED OR ORTHORECTIFIED.

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D4. SURFACE COLLECTOR AT INTAKE TOWER, 150 CFS SCREEN, GRAVITY WITH PUMPS, VOLITIONAL BYPASS WITH U1 TOWER SITE PLAN	DATE: JAN 9, 2015 DRAWING: D4.1	REV: 0



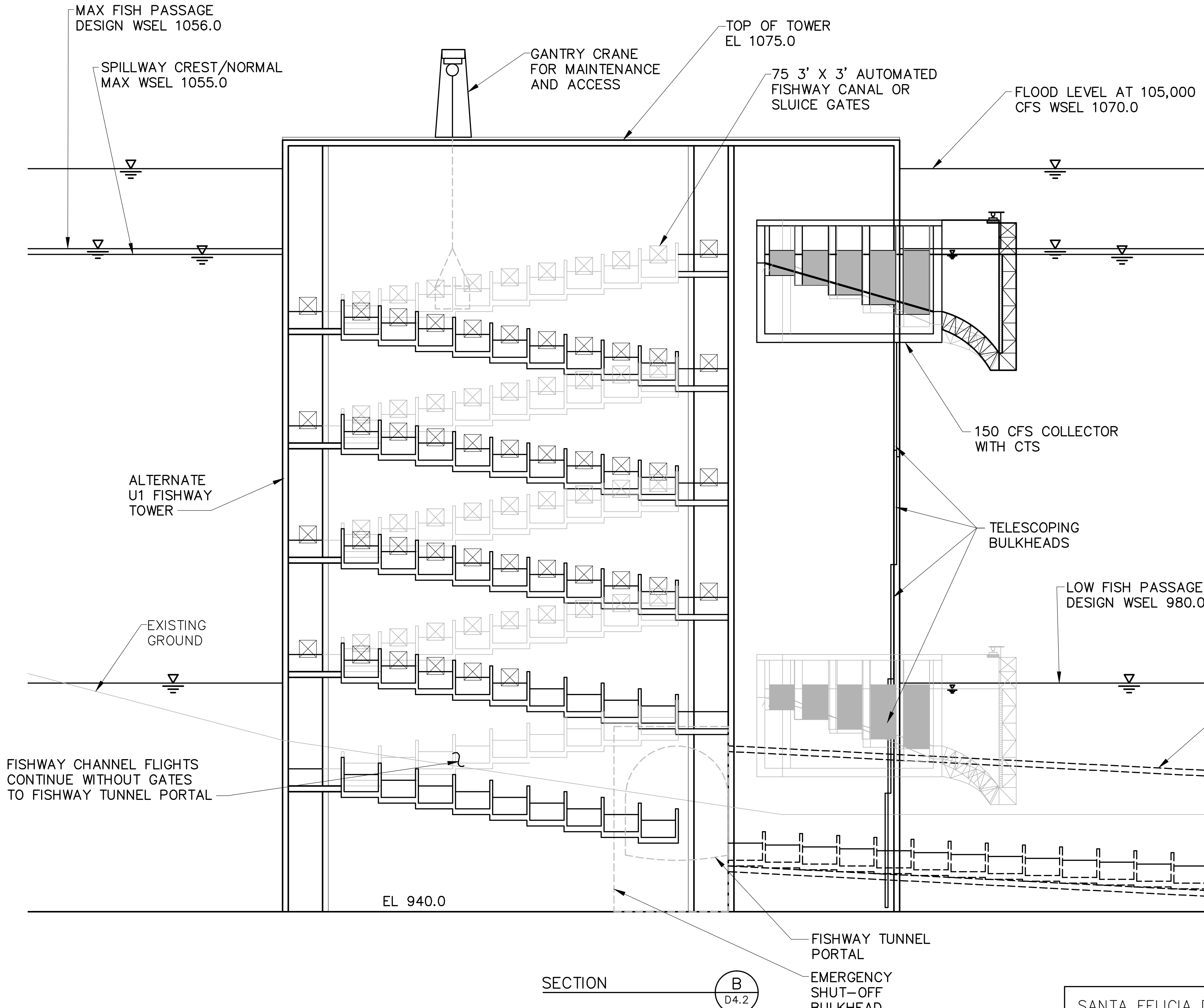
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D4. SURFACE COLLECTOR AT INTAKE TOWER,
150 CFS SCREEN, GRAVITY WITH PUMPS,
VOLITIONAL BYPASS WITH U1 TOWER
ENLARGED SITE PLAN

DATE: JAN 9, 2015

DRAWING: D4.2

REV: 0



SECTION B D4.2

20 0 10 20

SCALE: 1"=20'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

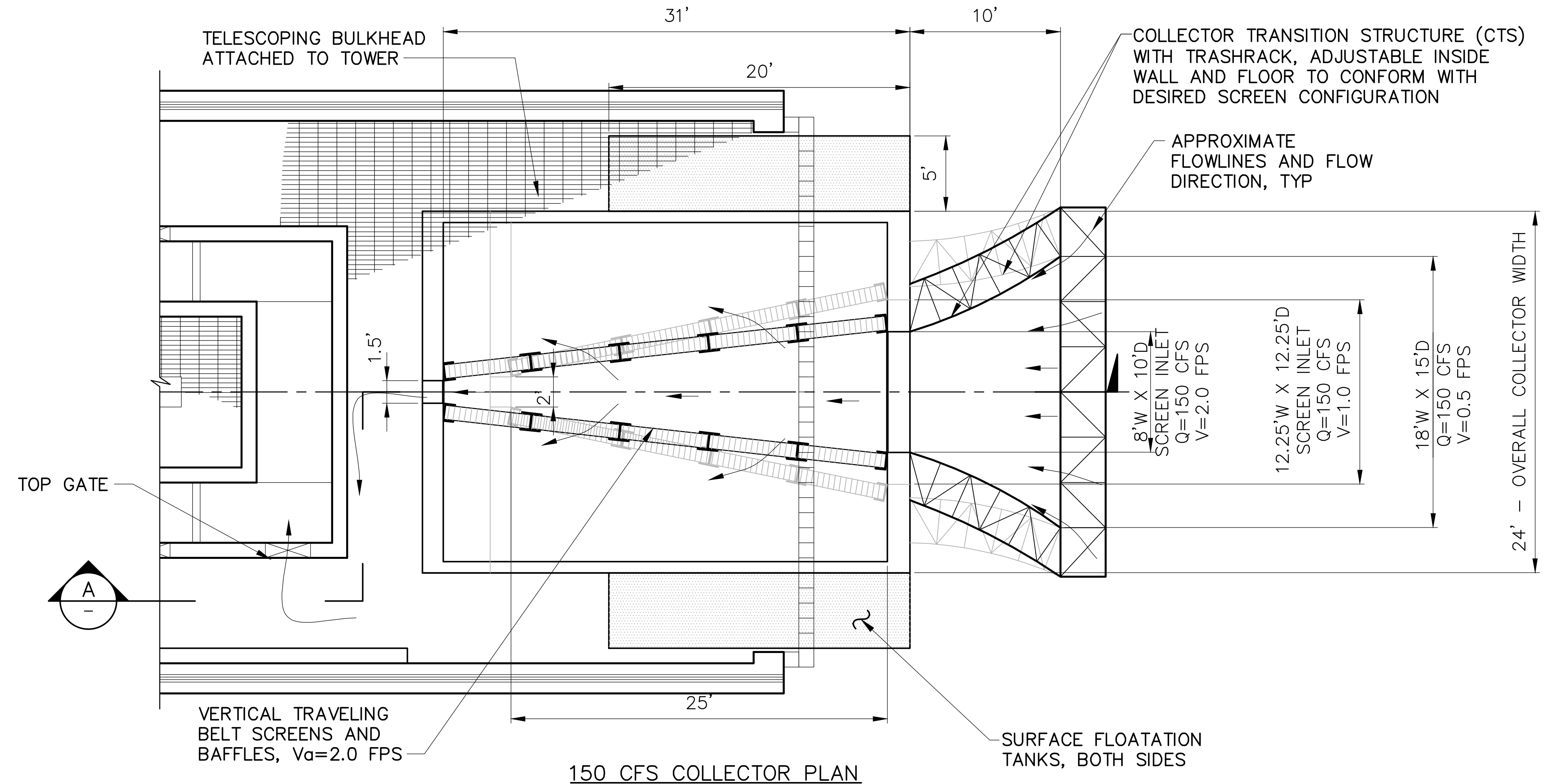
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D4. SURFACE COLLECTOR AT INTAKE TOWER, 150 CFS SCREEN, GRAVITY WITH PUMPS, VOLITIONAL BYPASS WITH U1 TOWER SECTION THROUGH COLLECTOR AND TOWER

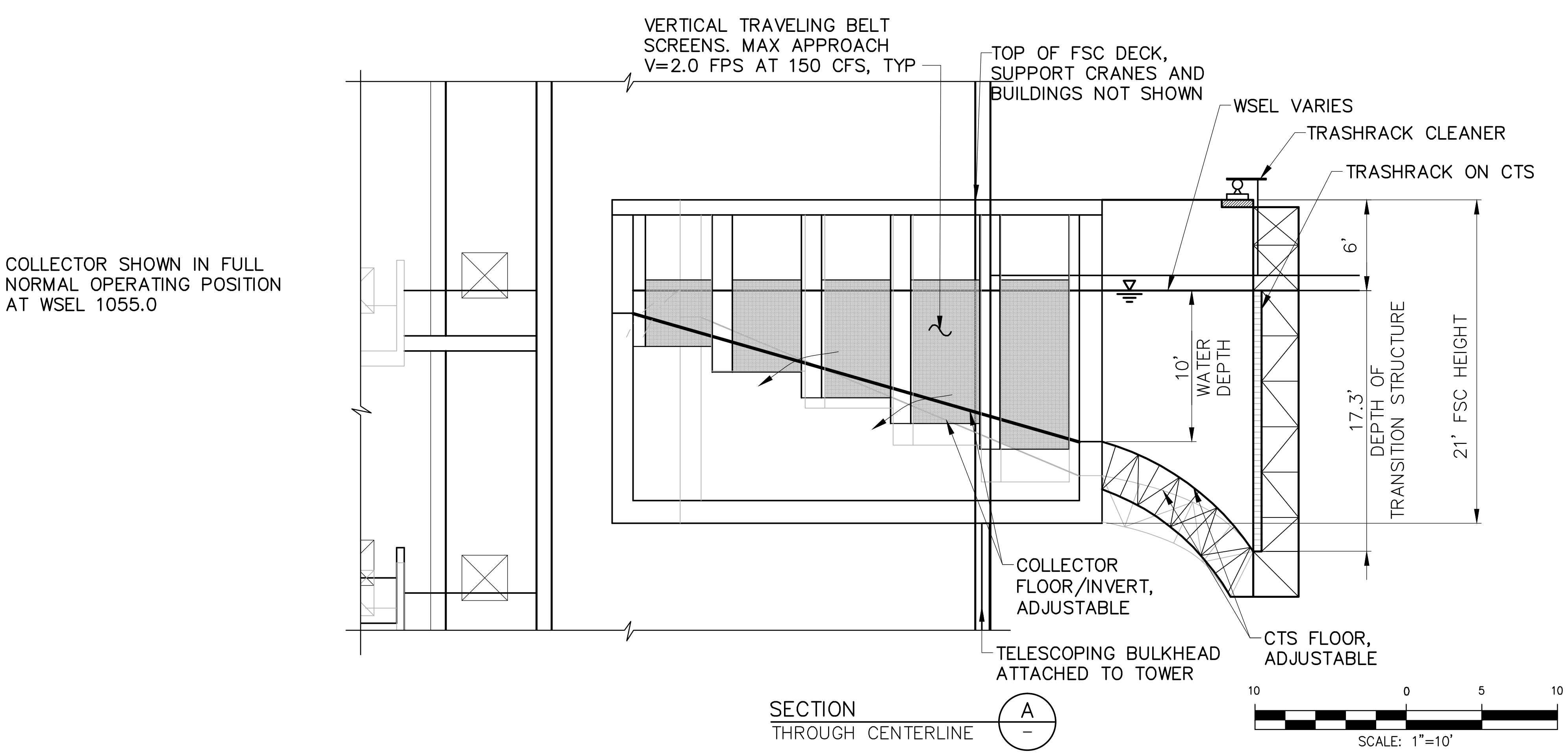
DATE: JAN 9, 2015

DRAWING: D4.3

REV: 0



150 CFS COLLECTOR PLAN



SECTION A
THROUGH CENTERLINE

NOTES:

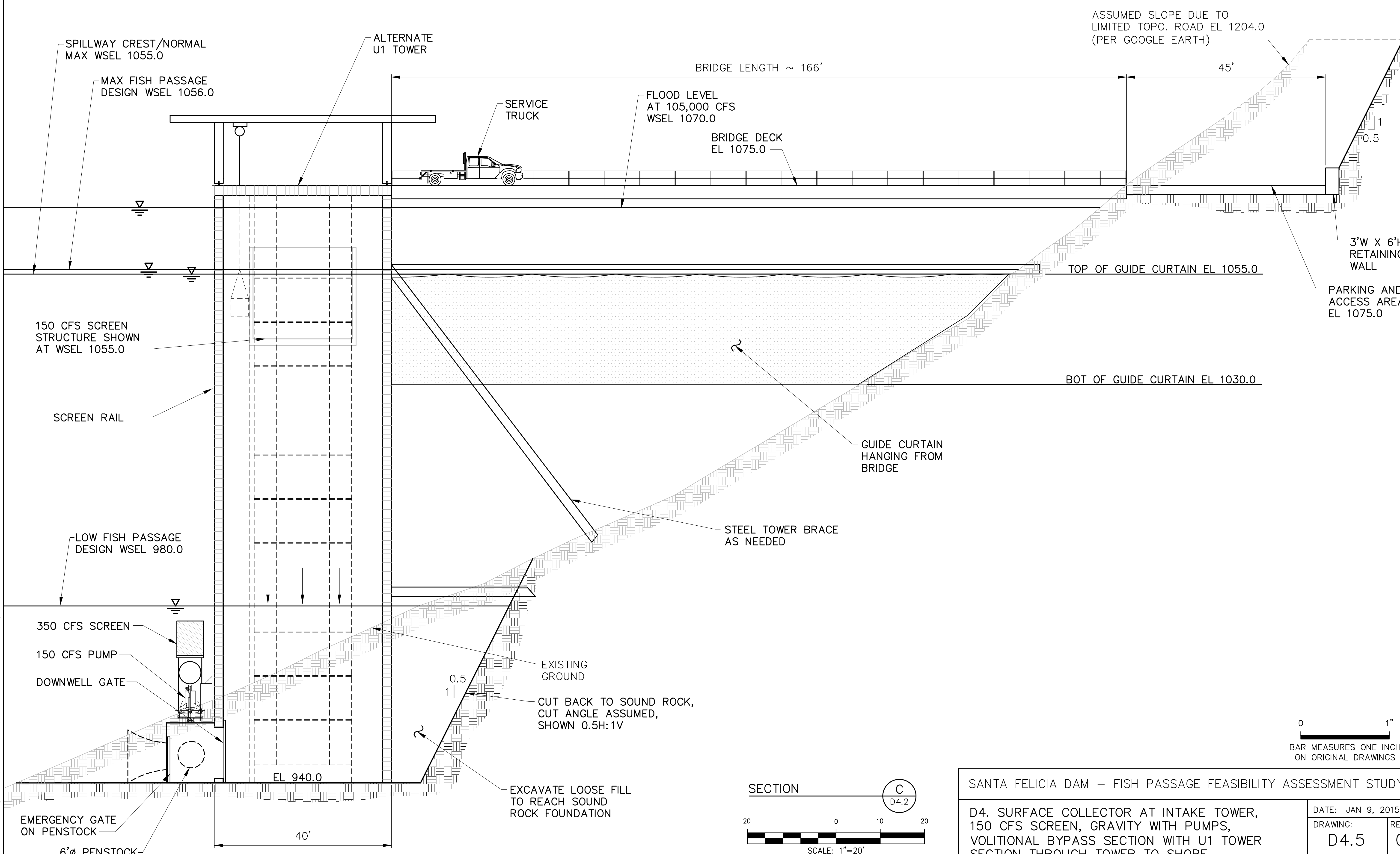
1. CTS AND FLOATING COLLECTOR BOX GEOMETRY CAN BE MODIFIED TO ACCOMMODATE ENTRANCE VELOCITIES FROM 1.0 TO 2.0 FPS.

2. GEOMETRY SHOWN AT SCREEN STRUCTURE ENTRANCE VELOCITY 2.0 FPS FOR COMPARISON WITH ALT. D3.

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D4. SURFACE COLLECTOR AT INTAKE TOWER, 150 CFS SCREEN, GRAVITY WITH PUMPS, VOLITIONAL BYPASS WITH U1 TOWER COLLECTOR PLAN AND SECTION	DATE: JAN 9, 2015	
	DRAWING: D4.4	REV: 0



SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D4. SURFACE COLLECTOR AT INTAKE TOWER, 150 CFS SCREEN, GRAVITY WITH PUMPS, VOLITIONAL BYPASS SECTION WITH U1 TOWER SECTION THROUGH TOWER TO SHORE

DATE: JAN 9, 2015	
DRAWING: D4.5	REV: 0

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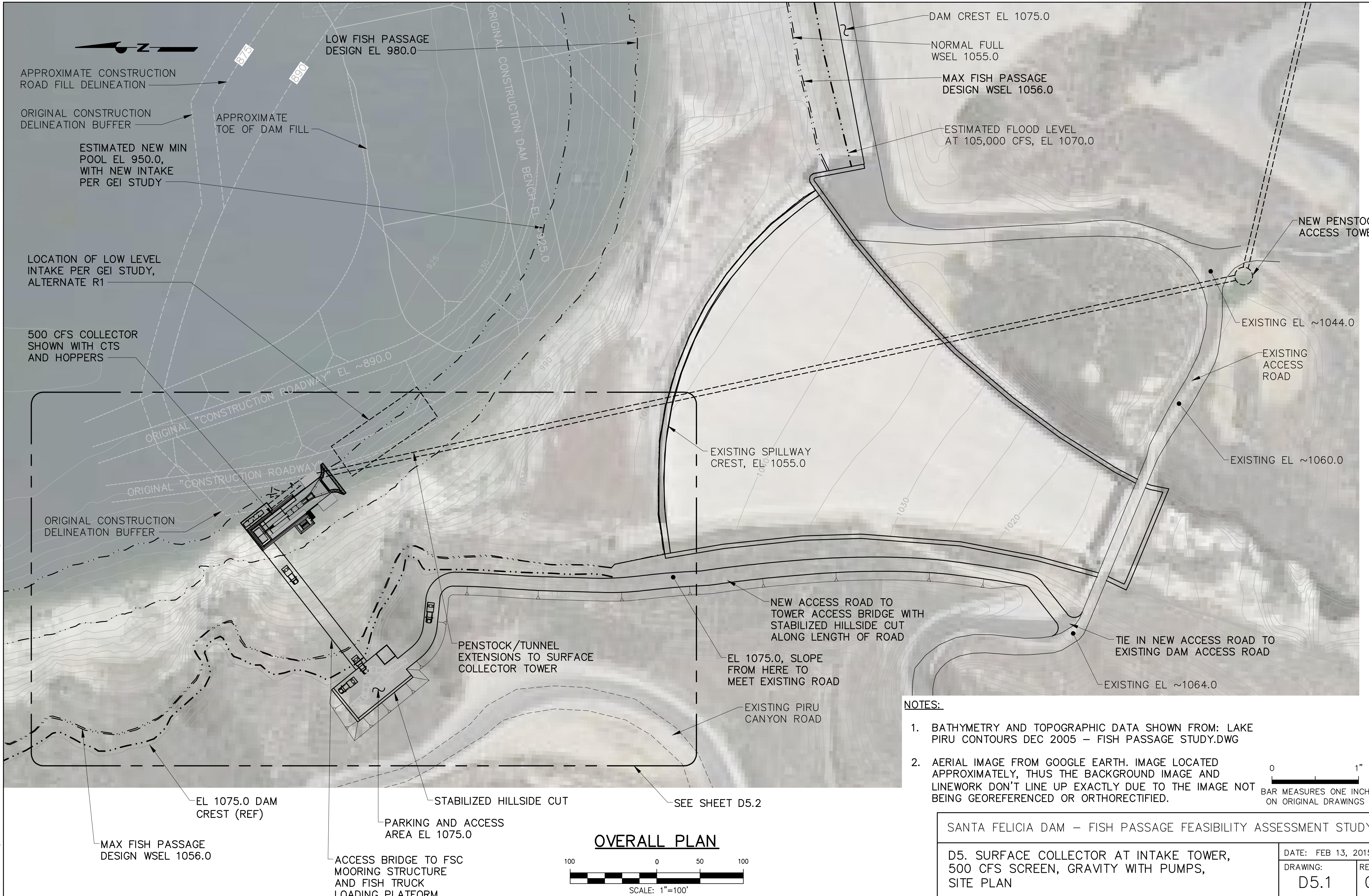


OVERALL PLAN

100 0 50 100

SCALE: 1"=100'

NOTES:

1. BATHYMETRY AND TOPOGRAPHIC DATA SHOWN FROM: LAKE PIRU CONTOURS DEC 2005 – FISH PASSAGE STUDY.DWG
2. AERIAL IMAGE FROM GOOGLE EARTH. IMAGE LOCATED APPROXIMATELY, THUS THE BACKGROUND IMAGE AND LINEWORK DON'T LINE UP EXACTLY DUE TO THE IMAGE NOT BEING GEOREFERENCED OR ORTHORECTIFIED.

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

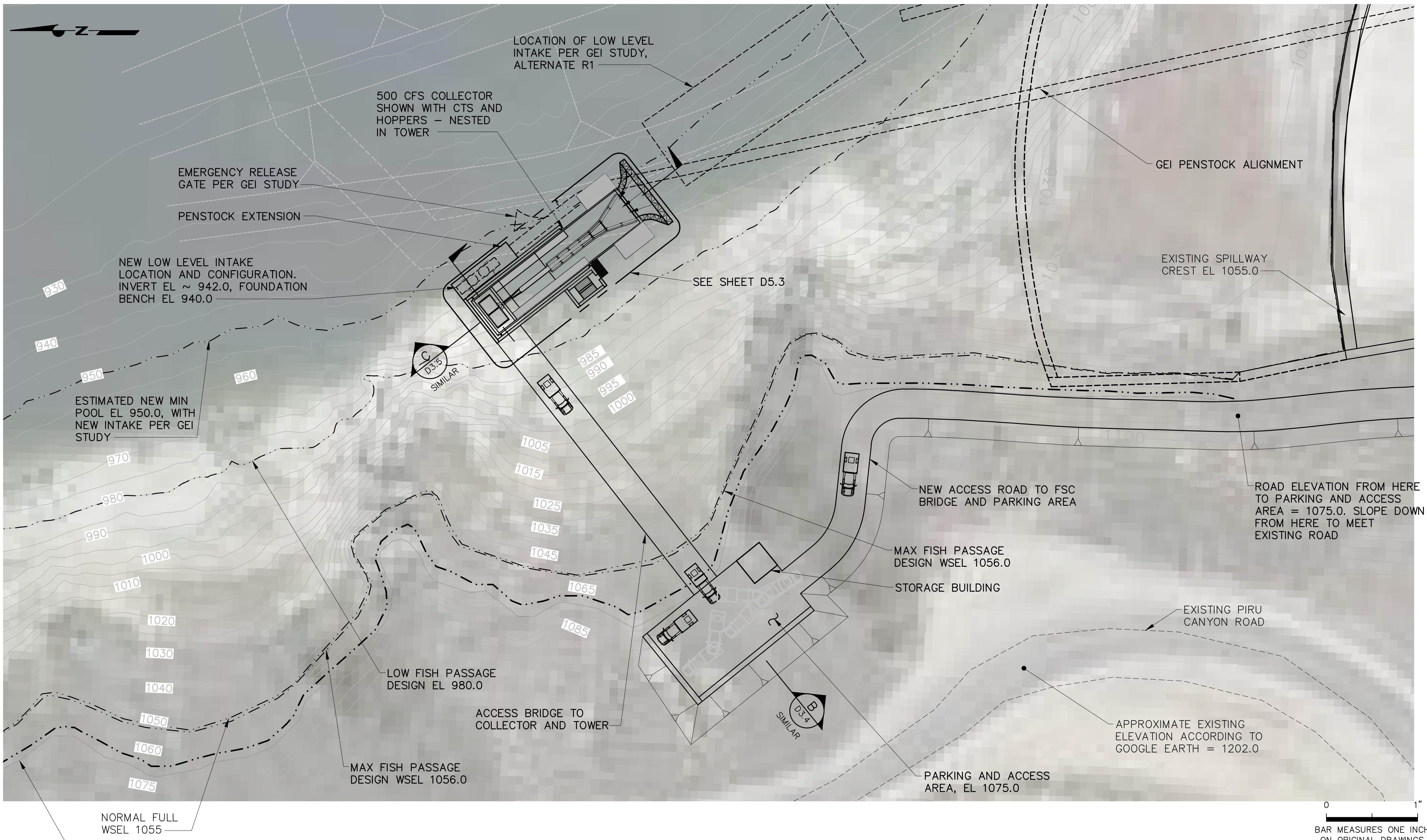
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D5. SURFACE COLLECTOR AT INTAKE TOWER, 500 CFS SCREEN, GRAVITY WITH PUMPS, SITE PLAN

DATE: FEB 13, 2015

DRAWING: D5.1

REV: 0



PLAN VIEW

50 0 25 50

SCALE: 1"=50'

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

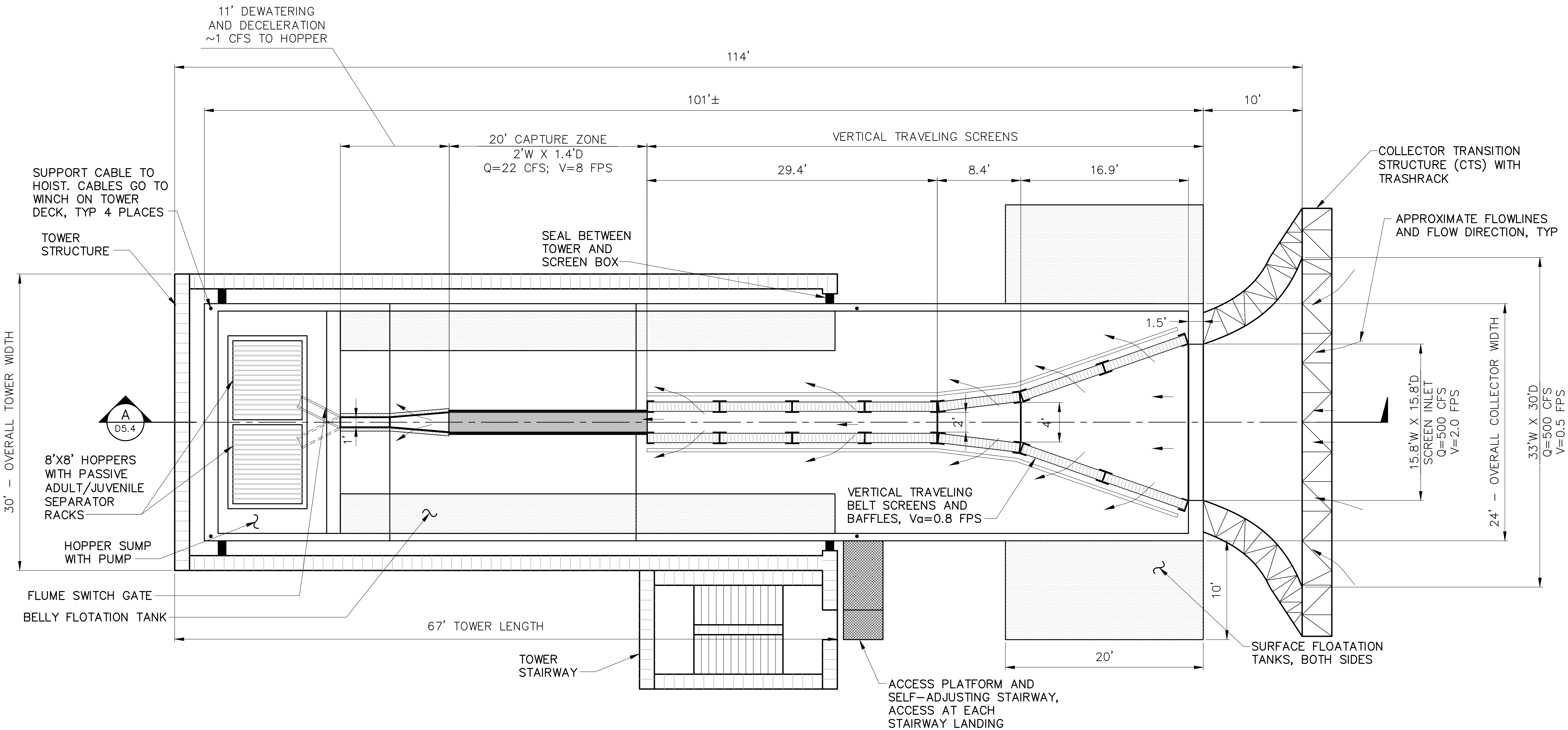
D5. SURFACE COLLECTOR AT INTAKE TOWER, 500 CFS SCREEN, GRAVITY WITH PUMPS, ENLARGED SITE PLAN

DATE: FEB 13, 2015

DRAWING: D5.2

REV: 0

C:\pwworking\sac\d0606819\2015-02-11 D5 500 CFS FSC with Tower.dwg, 2/13/2015 3:28:55 PM



D5 – 500 CFS COLLECTOR PLAN

10 0 5 10

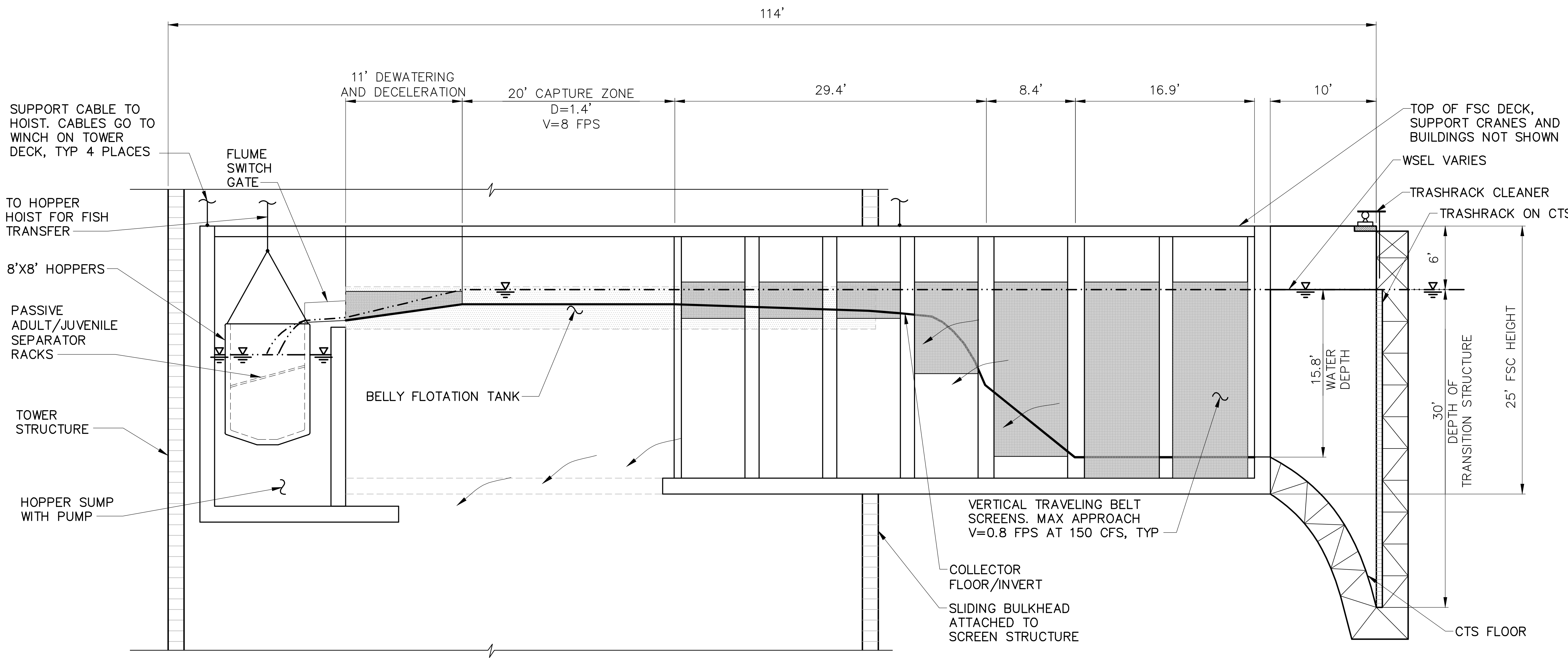
SCALE: 1"=10'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D5. SURFACE COLLECTOR AT INTAKE TOWER, 500 CFS SCREEN, GRAVITY WITH PUMPS, 500 CFS COLLECTOR PLAN	DATE: FEB 13, 2015	
	DRAWING: D5.3	REV: 0



SECTION A
THROUGH D5 CENTERLINE D5.3

10 0 5 10

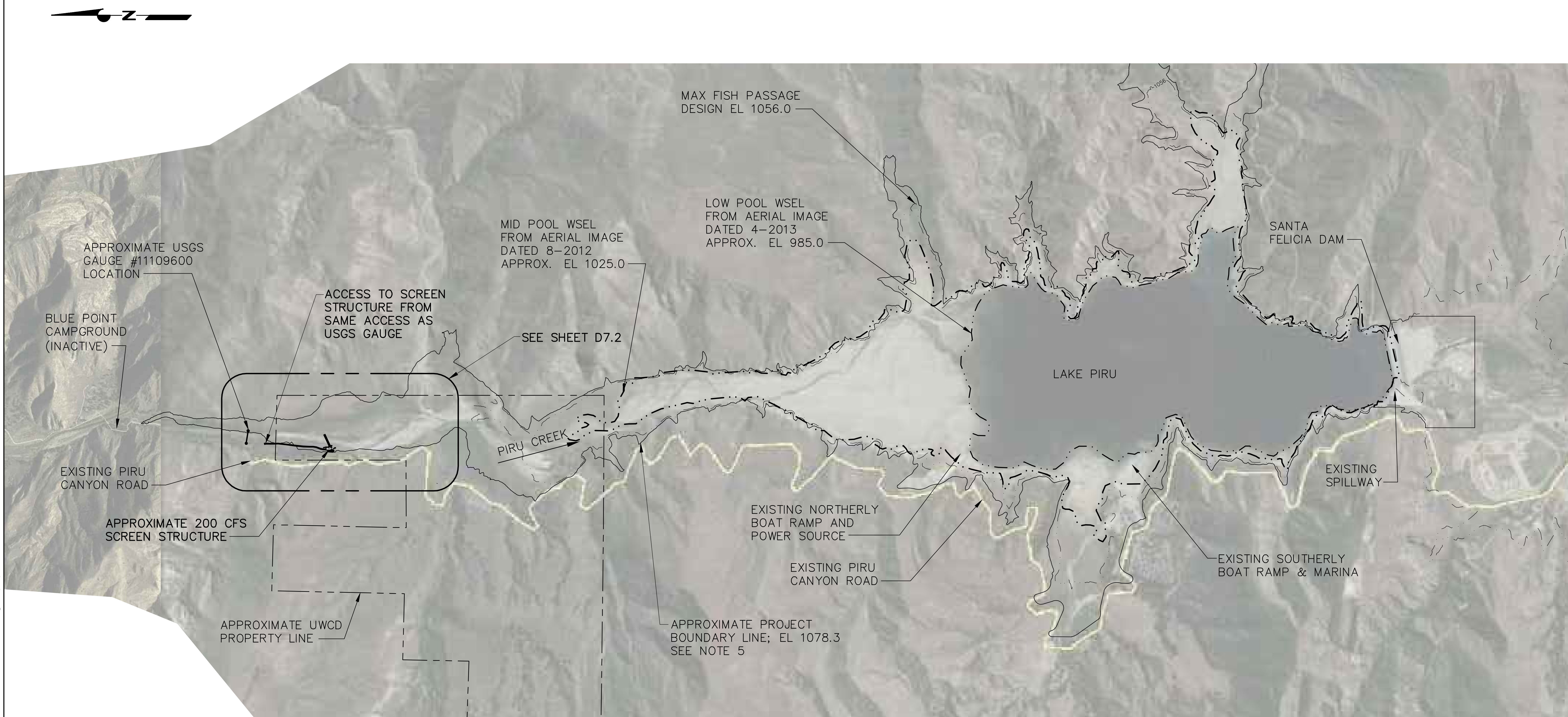
SCALE: 1"=10'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D5. SURFACE COLLECTOR AT INTAKE TOWER, 500 CFS SCREEN, GRAVITY WITH PUMPS, 500 CFS COLLECTOR SECTION	DATE: FEB 13, 2015
DRAWING: D5.4	REV: 0



LOCATION PLAN

2000 0 1000 2000

SCALE: 1"=2000'

NOTES:

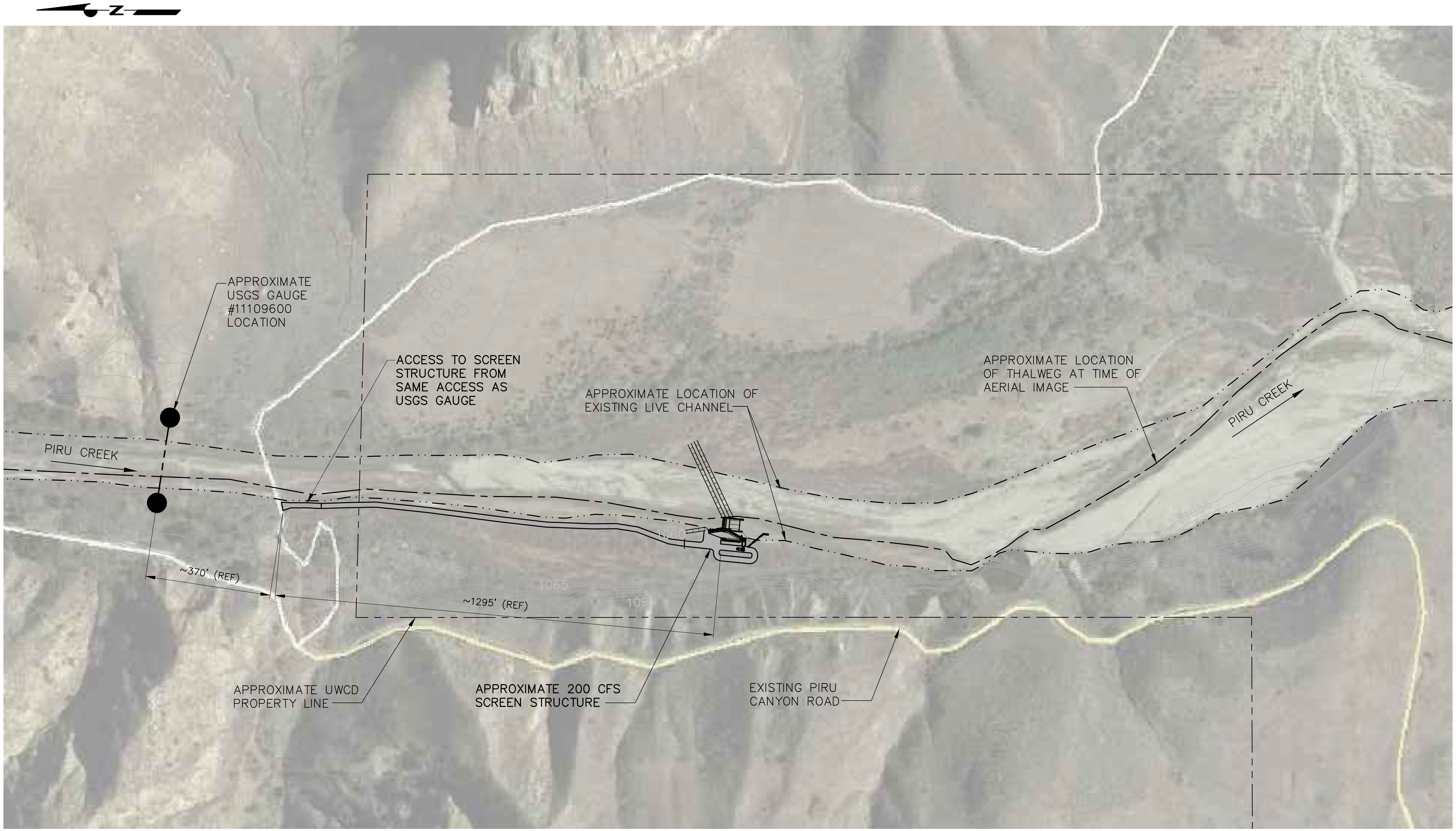
1. IMAGE TAKEN FROM GOOGLE EARTH, DATED 4-17-2013.
2. PROPERTY LINE TAKEN FROM 14289 MAPPING.DWG IN EXHIBIT G, DATED 4-27-09.
3. NORMAL FULL POOL WSEL 1055.0.
4. DAM CREST ELEVATION 1075.0.
5. PROJECT BOUNDARY LINE TAKEN FROM "EXHIBIT G" AND ADJUSTED, AS BEST AS POSSIBLE, TO FIT THE AERIAL IMAGE IN THIS DRAWING.

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D-7. PIRU CREEK COLLECTOR APPROXIMATE 200 CFS SCREEN LOCATION PLAN	DATE: NOV 14, 2014	
	DRAWING: D7.1	REV: 0

C:\pwworking\sac\d0606821\2014-10-08 D7 Piru Creek Collector.dwg, 4/2/2015 9:21:39 AM



PLAN VIEW

300 0 150 300

SCALE: 1"=300'

0 1"

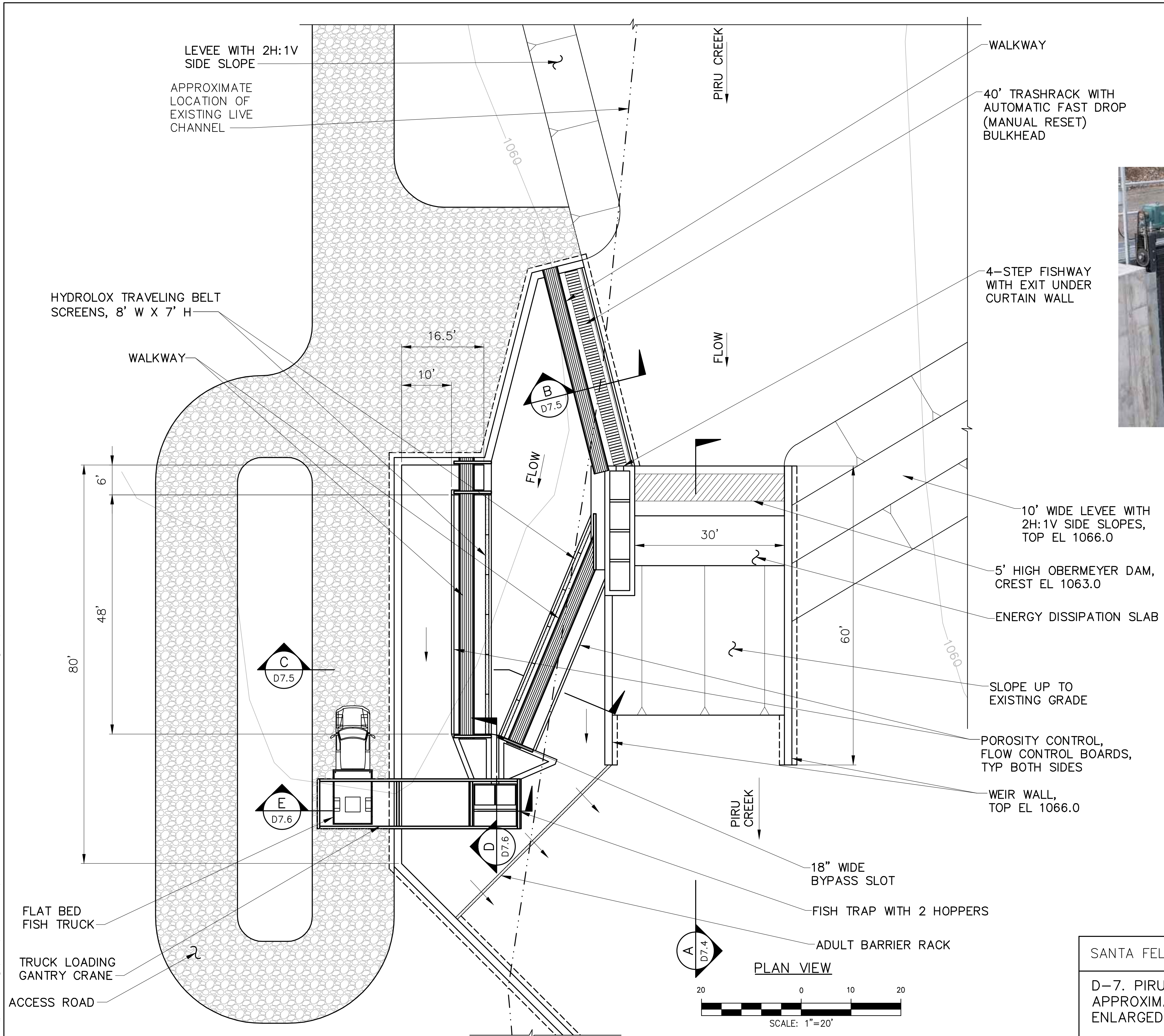
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

NOTES:

1. IMAGE TAKEN FROM GOOGLE EARTH, DATED 12-10-2013.
2. PROPERTY LINE TAKEN FROM 14289 MAPPING.DWG IN EXHIBIT G, DATED 4-27-09.

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D-7. PIRU CREEK COLLECTOR APPROXIMATE 200 CFS SCREEN SITE PLAN	DATE: NOV 14, 2014 DRAWING: D7.2	REV: 0

C:\pwworking\sac\d0606821\2014-10-08 D7 Piru Creek Collector.dwg, 2/12/2015 9:48:25 AM



PLAN VIEW

20 0 10 20

SCALE: 1"=20'

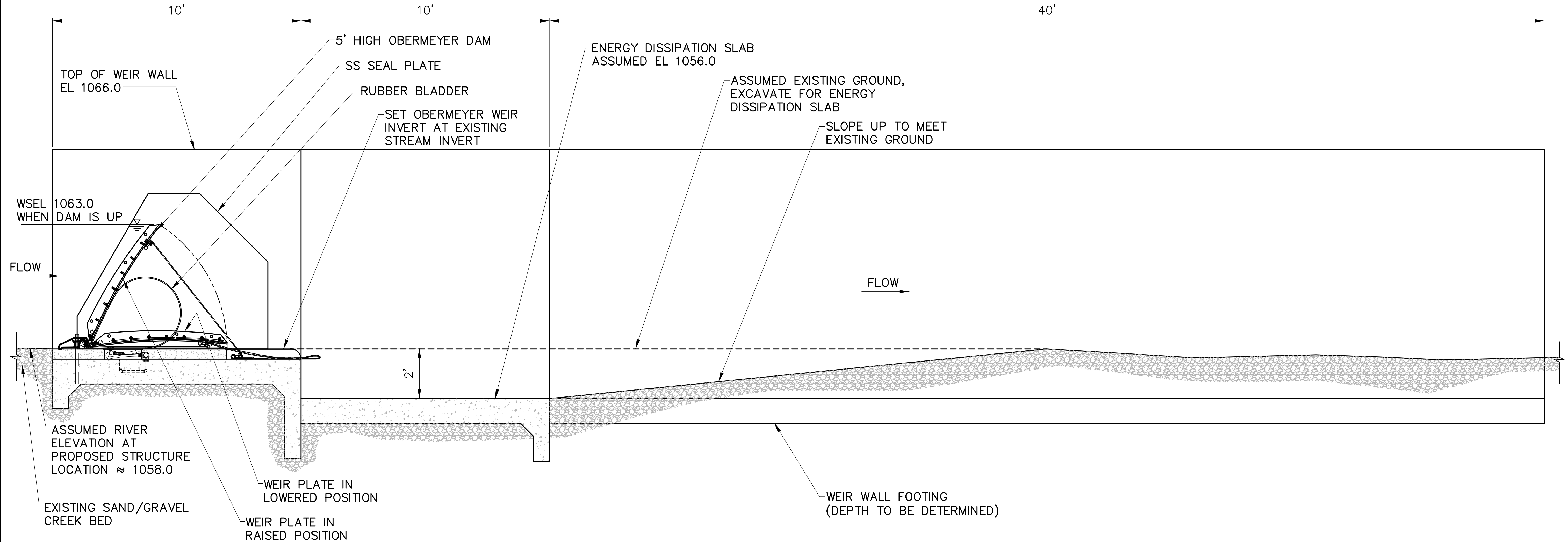
EXAMPLE OF HYDROLOX SCREENS

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D-7. PIRU CREEK COLLECTOR APPROXIMATE 200 CFS SCREEN ENLARGED SITE PLAN	DATE: NOV 14, 2014 DRAWING: D7.3	REV: 0

C:\pwworking\sac\d0606821\2014-10-08 D7 Piru Creek Collector.dwg, 2/12/2015 9:48:30 AM



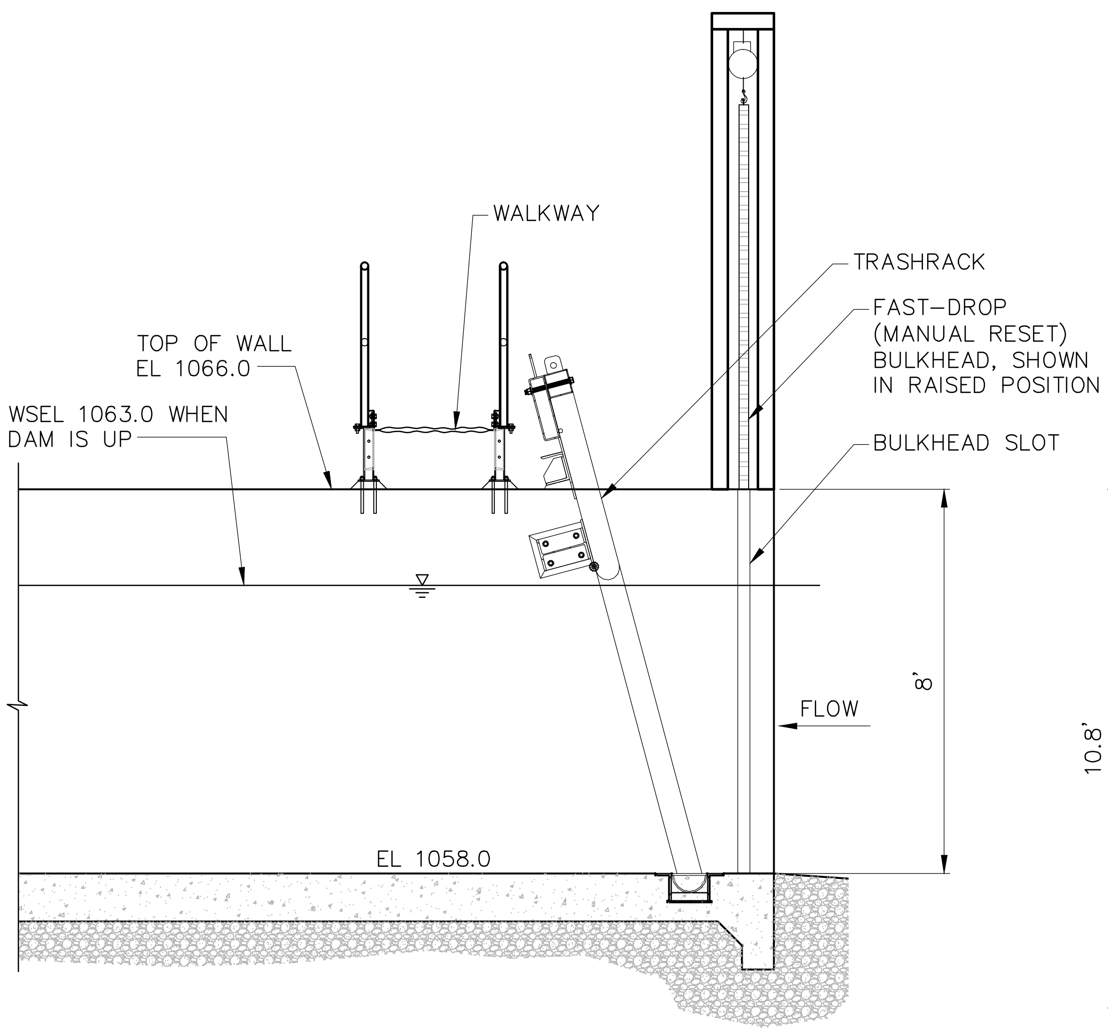
SECTION A / D7.3
SCALE: 1" = 4'-0"

EXAMPLE OF OBERMEYER DAM

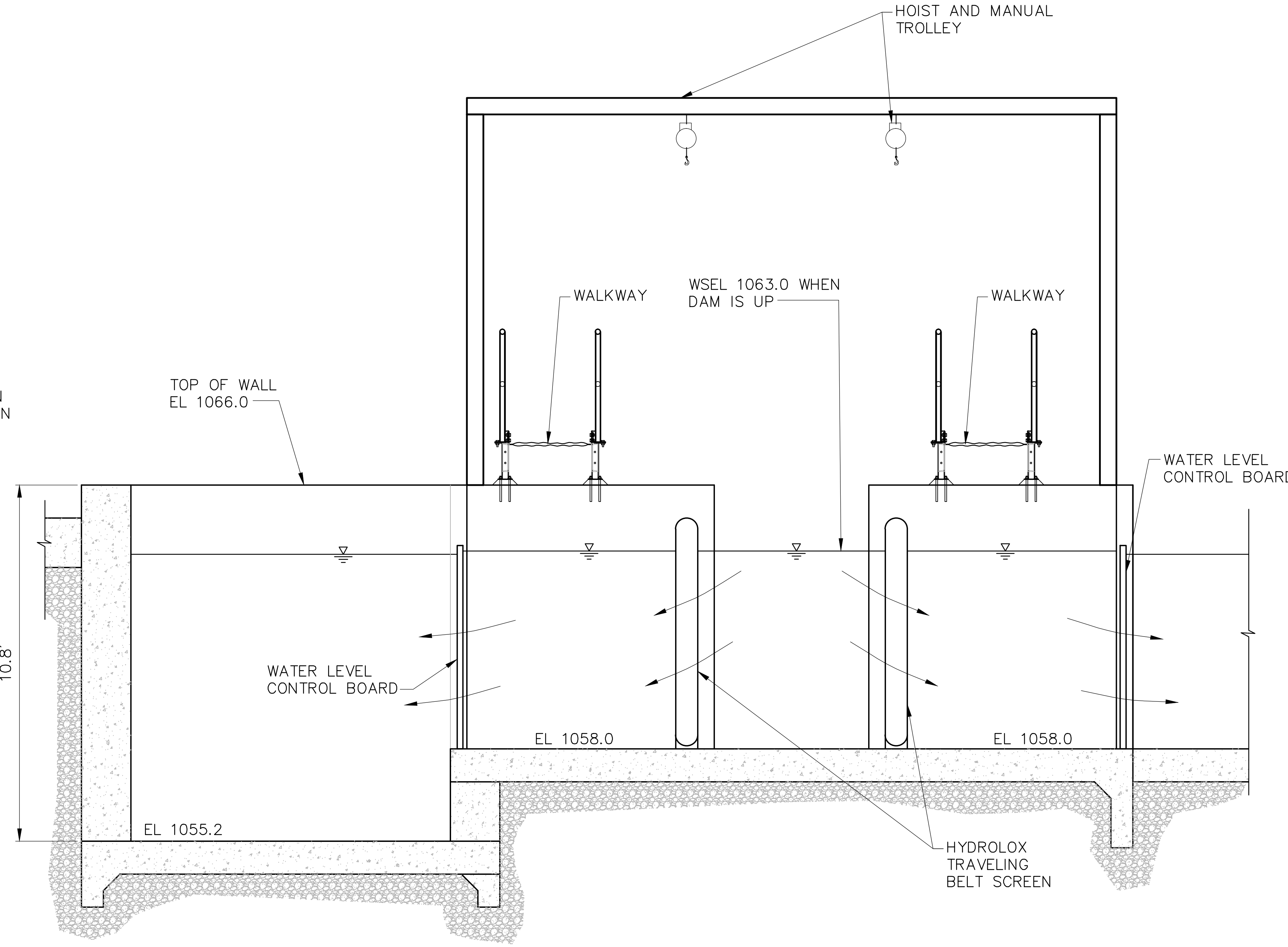
4 0 2 4
SCALE: 1"=4'

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D-7. PIRU CREEK COLLECTOR APPROXIMATE 200 CFS SCREEN DAM SECTION	DATE: NOV 14, 2014 DRAWING: D7.4	REV: 0



SECTION B
SCALE: 1" = 4'-0" D7.3



SECTION C
SCALE: 1" = 4'-0" D7.3

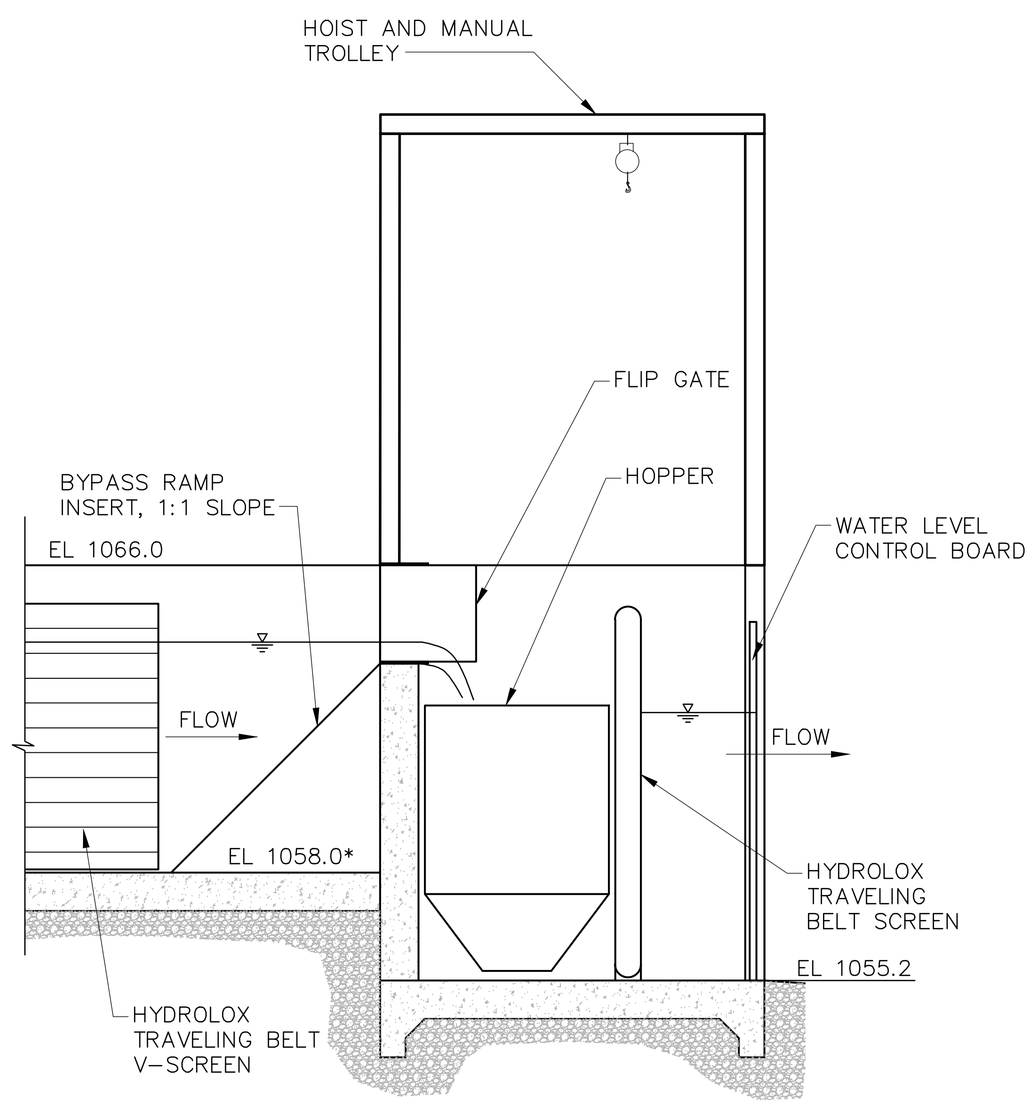
4 0 2 4
SCALE: 1"=4'

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

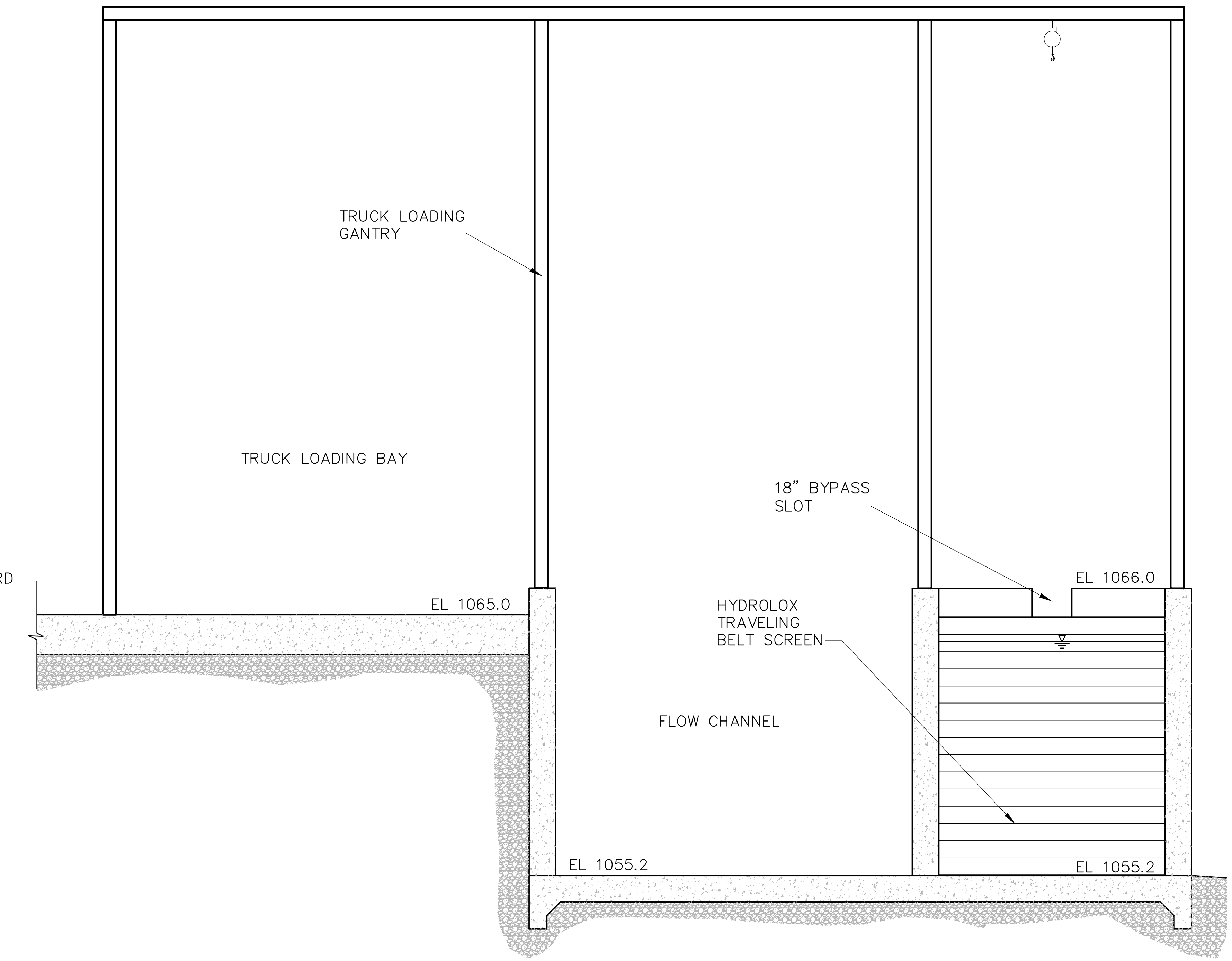
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D-7. PIRU CREEK COLLECTOR
APPROXIMATE 200 CFS SCREEN
TRASHRACK AND V-SCREEN SECTIONS

DATE: NOV 14, 2014
DRAWING: D7.5
REV: 0



SECTION D (D7.3)
SCALE: 1" = 5'-0"



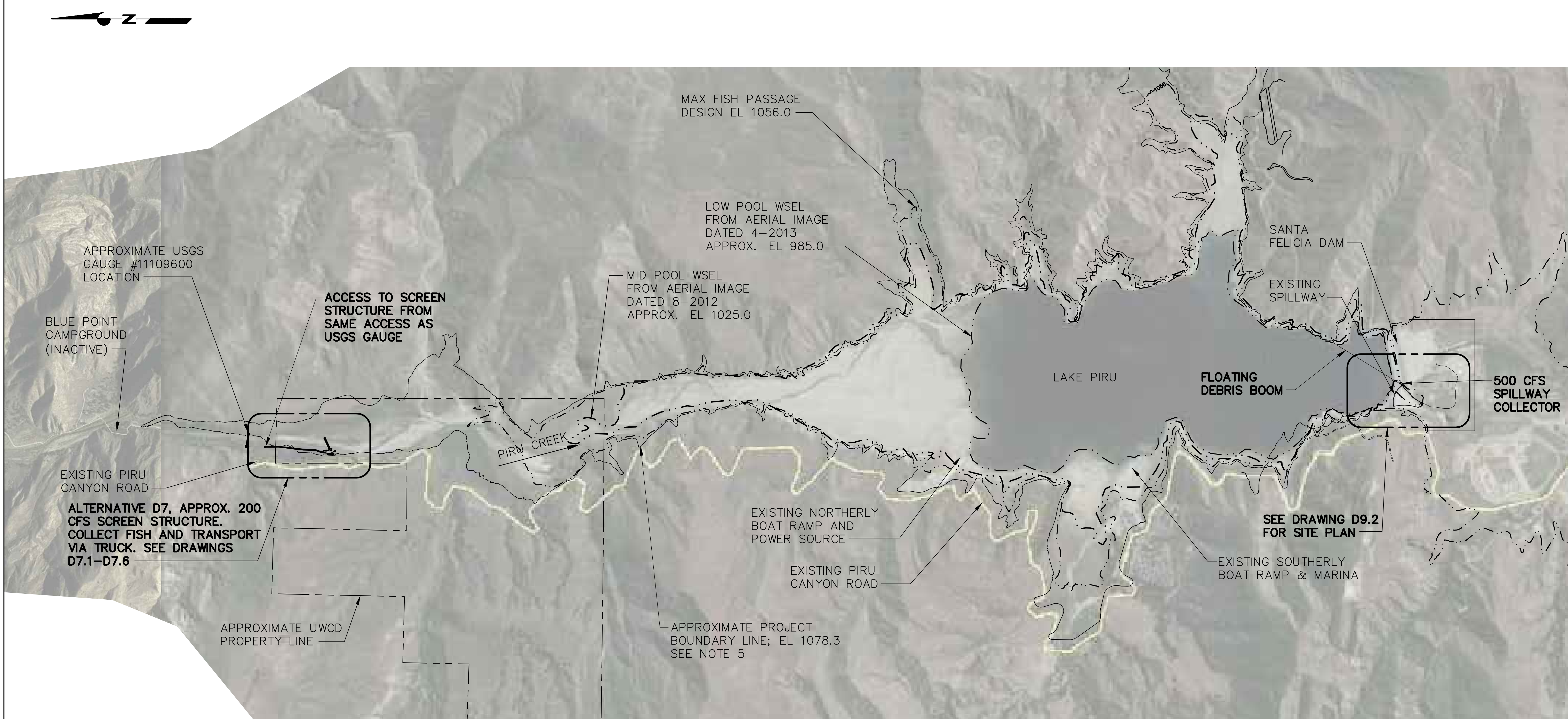
SECTION E (D7.3)
SCALE: 1" = 5'-0"

5 0 5
SCALE: 1"=5'

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

* ASSUMED RIVER ELEVATION AT PROPOSED STRUCTURE LOCATION = 1058.0

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D-7. PIRU CREEK COLLECTOR APPROXIMATE 200 CFS SCREEN BYPASS SECTIONS	DATE: NOV 14, 2014 DRAWING: D7.6	REV: 0



NOTES:

1. ALTERNATIVE D9 IS DEFINED AS A COMBINATION OF ALT D7 (PIRU CREEK COLLECTOR) WITH A 500 CFS SPILLWAY COLLECTOR.
2. THE SPILLWAY COLLECTOR IS CONFIGURED TO TAKE THE FIRST 500 CFS OF SPILL AND WILL ROUTE COLLECTED FISH TO THE CREEK DOWNSTREAM OF THE DAM AND POWERHOUSE.
3. IMAGE TAKEN FROM GOOGLE EARTH, DATED 4–17–2013.
4. PROPERTY LINE TAKEN FROM 14289 MAPPING.DWG IN EXHIBIT G, DATED 4–27–09.
5. NORMAL FULL POOL WSEL 1055.0, MAX FISH PASSAGE DESIGN WSEL 1056.0.
6. DAM CREST ELEVATION 1075.0.
7. PROJECT BOUNDARY LINE TAKEN FROM "EXHIBIT G" AND ADJUSTED, AS BEST AS POSSIBLE, TO FIT THE AERIAL IMAGE IN THIS DRAWING.

LOCATION PLAN

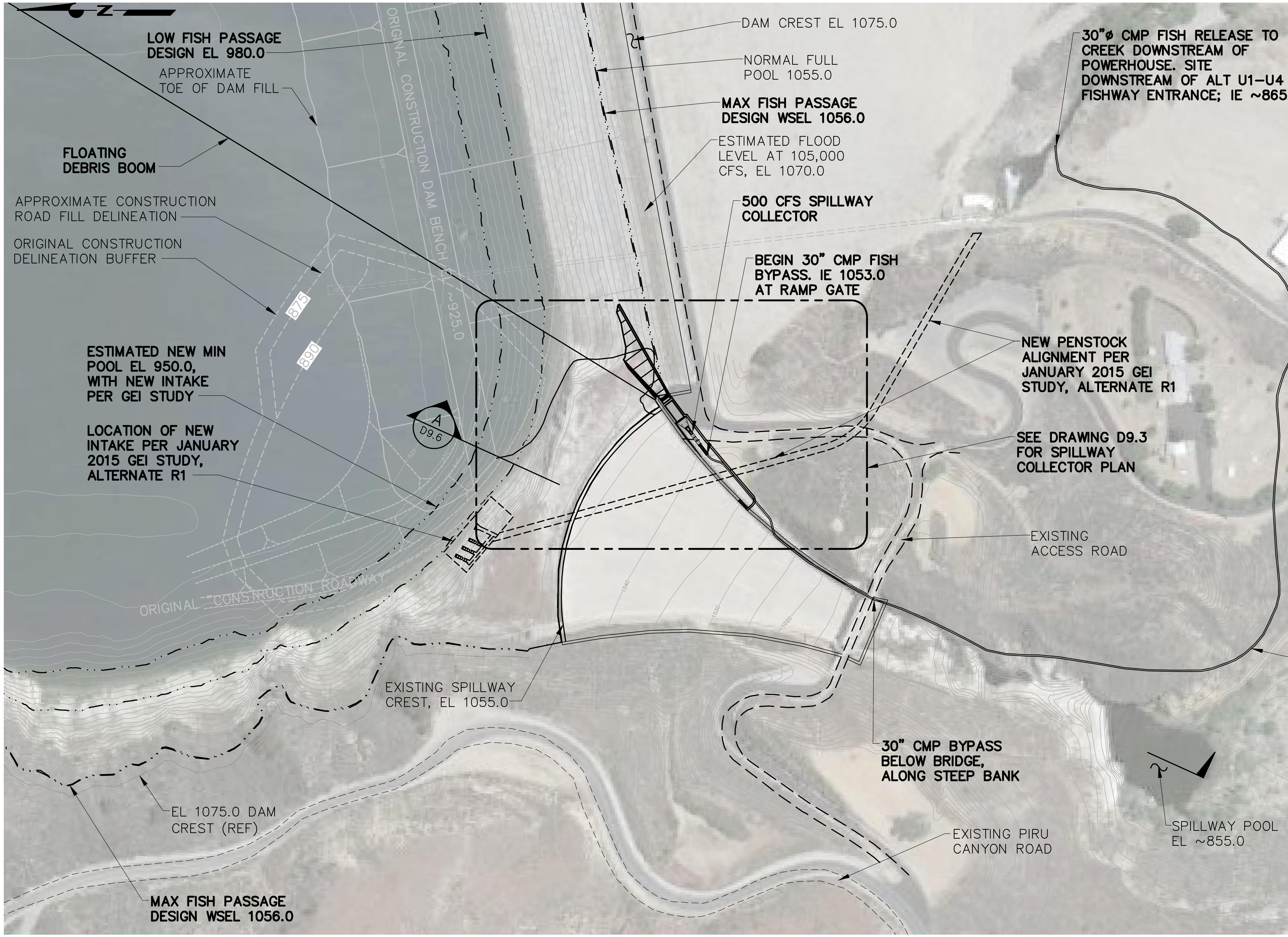
2000 0 1000 2000

SCALE: 1"=2000'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D9. ALT D7 PIRU CREEK COLLECTOR WITH 500 CFS SPILLWAY COLLECTOR LOCATION PLAN	DATE: MAR 6, 2015	
	DRAWING: D9.1	REV: 0



30"ø CORRUGATED FISH BYPASS PIPE, ~2,300 FEET LONG.
ROUTE SHOWN APPROXIMATE
Q= 22 CFS
S= 0.086 FT/FT
D= 1.0 FT
V= 12.0 FPS
F= 2.44

ALT D9 SPILLWAY COLLECTOR OPERATION NOTES:

–WSEL < 1055.0

- SPILLWAY COLLECTOR REMAINS OFF WITH INLET ROLLER GATE CLOSED UNTIL POOL ELEVATION REACHES SPILLWAY CREST ELEVATION OF 1055.0

–WSEL = 1055.0

- SPILLWAY COLLECTOR BEGINS OPERATING. INLET GATE OPENS FULLY, SPILLWAY COLLECTOR INFLOW CAN VARY FROM 100 CFS TO 500 CFS. DISCHARGE WILL HELP TO HOLD POOL LEVEL AT 1055.0 AS LAKE FLOW INCREASES.
- SPILLWAY COLLECTOR TAKES FIRST 500 CFS OF SPILL PRIOR TO ANY FLOW GOING OVER CREST. FLOW IS REGULATED BY SLUICE GATE AT DOWNSTREAM END OF COLLECTOR.
  - –22 CFS GOES TO FISH BYPASS
  - –80 TO 478 CFS SCREENED FLOW RETURNS TO SPILLWAY CHANNEL DOWNSTREAM OF CREST

–WSEL 1055.0 TO 1058.0

- AS POOL RISES, SPILLWAY COLLECTOR HOLDS FLOW AT 500 CFS. BYPASS RAMP GATE AND COLLECTOR SLUICE GATE CONTROL FLOWS
- 500 CFS CAPACITY DEFINED BY V–SCREEN SIZE
- RATIO OF FLOW THROUGH SPILLWAY COLLECTOR AND OVER SPILLWAY CREST DIMINISHES AS POOL RISES PER TABLE 1, DRAWING 9.3.

–WSEL > 1058.0

- INLET GATE CLOSES, SPILLWAY COLLECTOR TURNED OFF AS FLOW RATIO AND SPILLWAY COLLECTOR ATTRACTION FLOW FIELD WILL BE INEFFECTIVE IN ATTRACTING FISH FROM SPILLWAY AND TO PROTECT SCREENS FROM POTENTIAL HIGH DEBRIS LOADS.

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

NOTES:

1. BATHYMETRY AND TOPOGRAPHIC DATA SHOWN FROM: LAKE PIRU CONTOURS DEC 2005 – FISH PASSAGE STUDY.DWG
2. AERIAL IMAGE FROM GOOGLE EARTH. IMAGE LOCATED APPROXIMATELY, THUS THE BACKGROUND IMAGE AND LINEWORK DON'T LINE UP EXACTLY DUE TO THE IMAGE NOT BEING GEOREFERENCED OR ORTHORECTIFIED.

SITE PLAN

200 0 100 200
SCALE: 1"=200'

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D9. ALT D7 PIRU CREEK COLLECTOR WITH 500 CFS SPILLWAY COLLECTOR SITE PLAN	DATE: MAR 6, 2015	
	DRAWING: D9.2	REV: 0

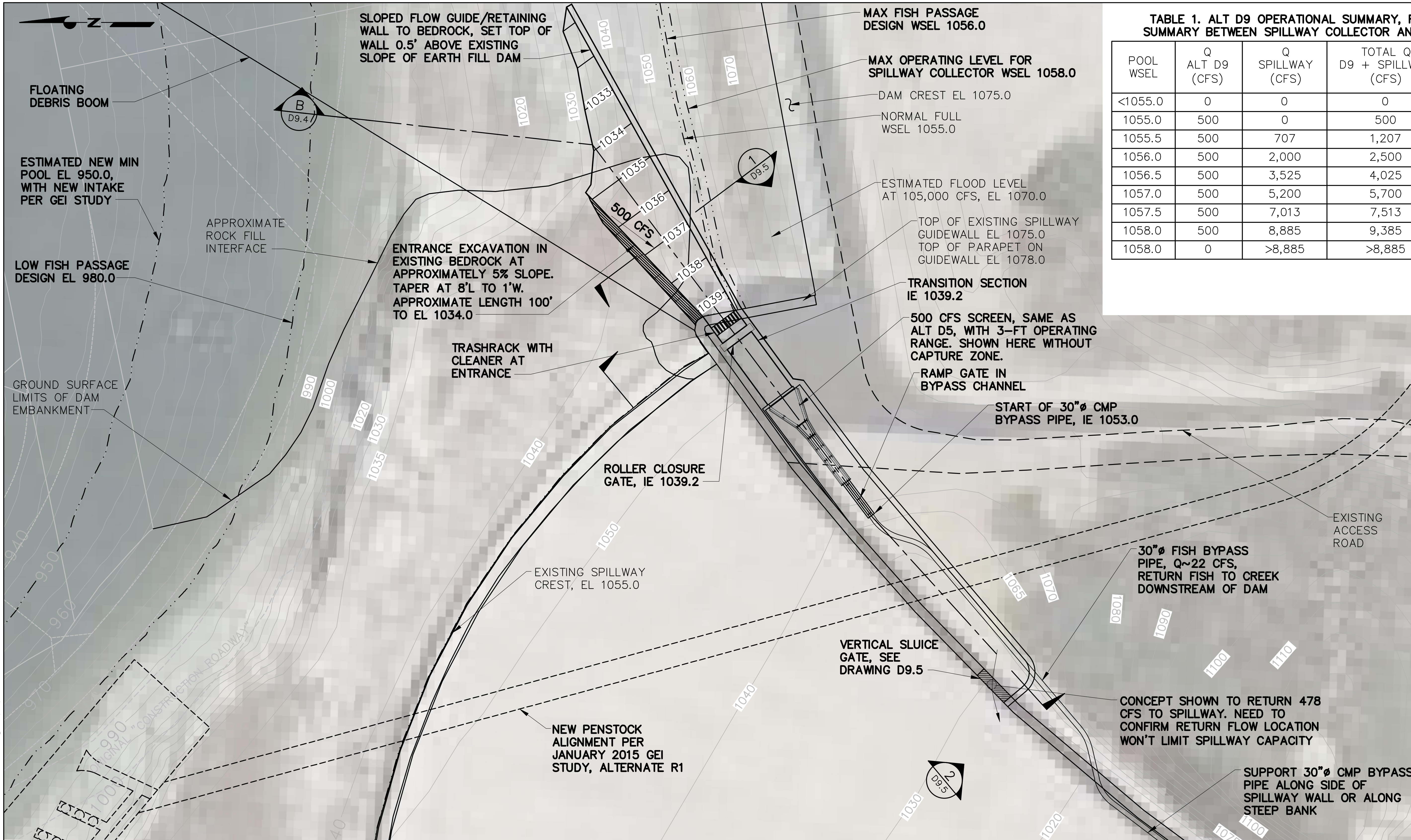


TABLE 1. ALT D9 OPERATIONAL SUMMARY, FLOW SPLIT SUMMARY BETWEEN SPILLWAY COLLECTOR AND SPILLWAY

POOL WSEL	Q ALT D9 (CFS)	Q SPILLWAY (CFS)	TOTAL Q D9 + SPILLWAY (CFS)	D9 Q / TOTAL Q
<1055.0	0	0	0	N/A
1055.0	500	0	500	100%
1055.5	500	707	1,207	41%
1056.0	500	2,000	2,500	25%
1056.5	500	3,525	4,025	12%
1057.0	500	5,200	5,700	9%
1057.5	500	7,013	7,513	7%
1058.0	500	8,885	9,385	5%
1058.0	0	>8,885	>8,885	0%

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SPILLWAY COLLECTOR PLAN

50 0 25 50
SCALE: 1"=50'

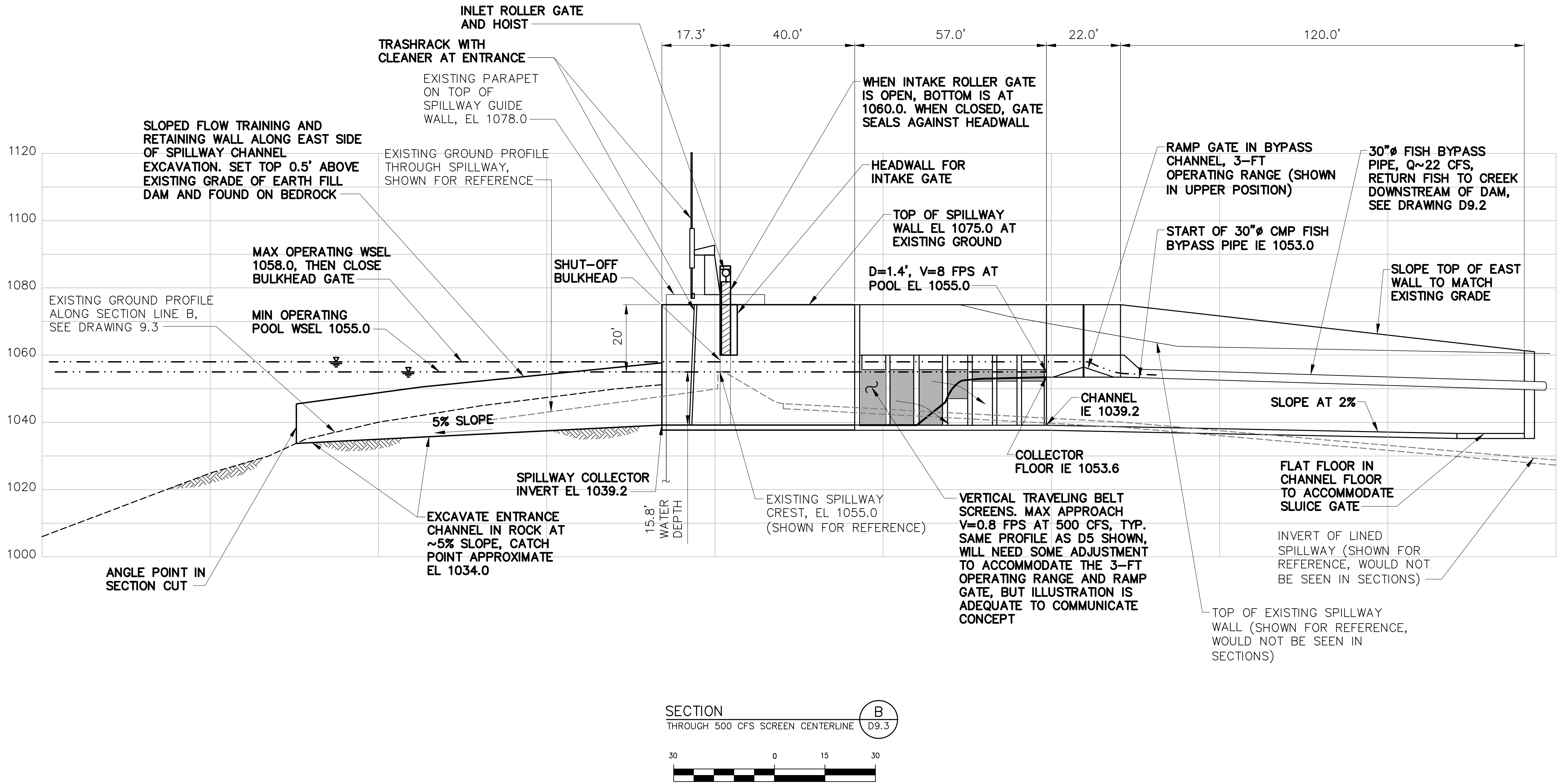
NOTES:

1. BATHYMETRY AND TOPOGRAPHIC DATA SHOWN FROM: LAKE PIRU CONTOURS DEC 2005 – FISH PASSAGE STUDY.DWG
2. AERIAL IMAGE FROM GOOGLE EARTH. IMAGE LOCATED APPROXIMATELY, THUS THE BACKGROUND IMAGE AND LINEWORK DON'T LINE UP EXACTLY DUE TO THE IMAGE NOT BEING GEOREFERENCED OR ORTHORECTIFIED.

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D9. ALT D7 PIRU CREEK COLLECTOR WITH 500 CFS SPILLWAY COLLECTOR
SPILLWAY COLLECTOR PLAN

DATE: MAR 6, 2015
DRAWING: D9.3
REV: 0

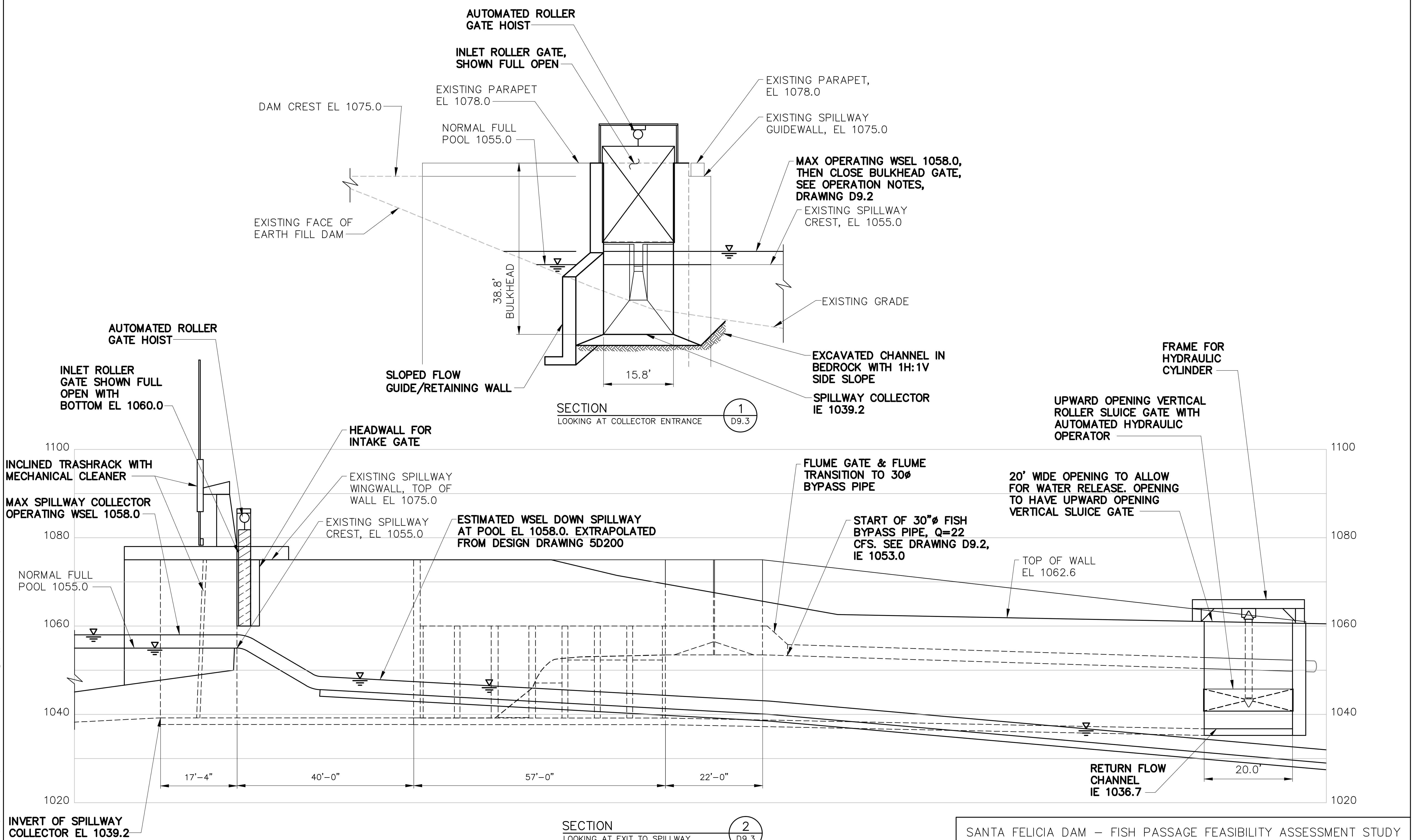


0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D9. ALT D7 PIRU CREEK COLLECTOR WITH 500 CFS SPILLWAY COLLECTOR SPILLWAY COLLECTOR SECTION

DATE: MAR 6, 2015
DRAWING: D9.4
REV: 0



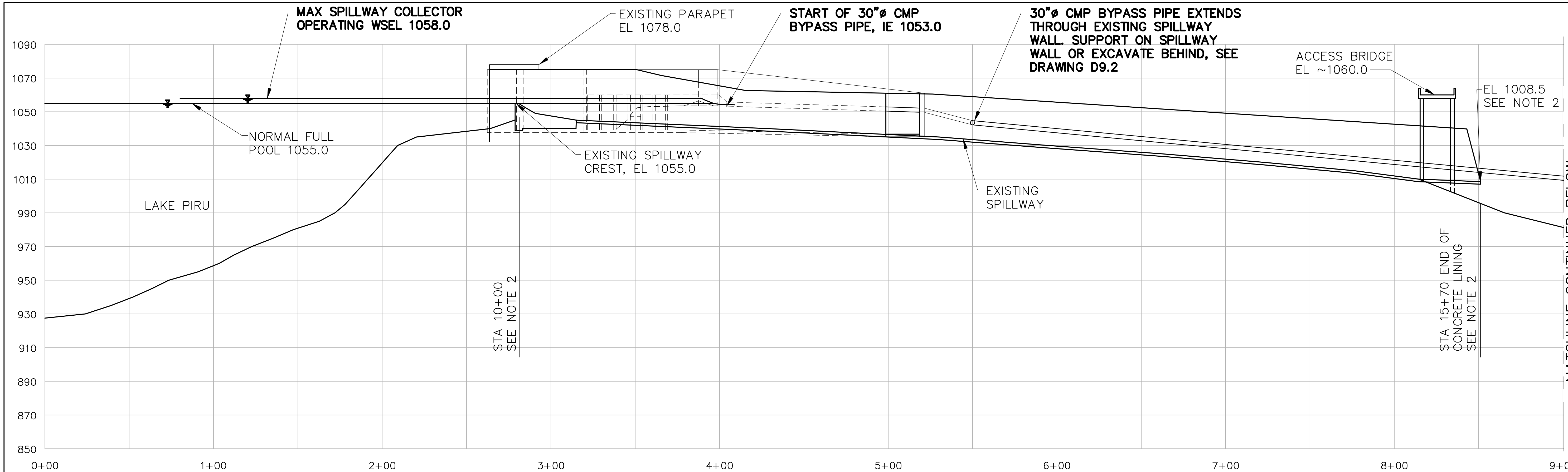
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

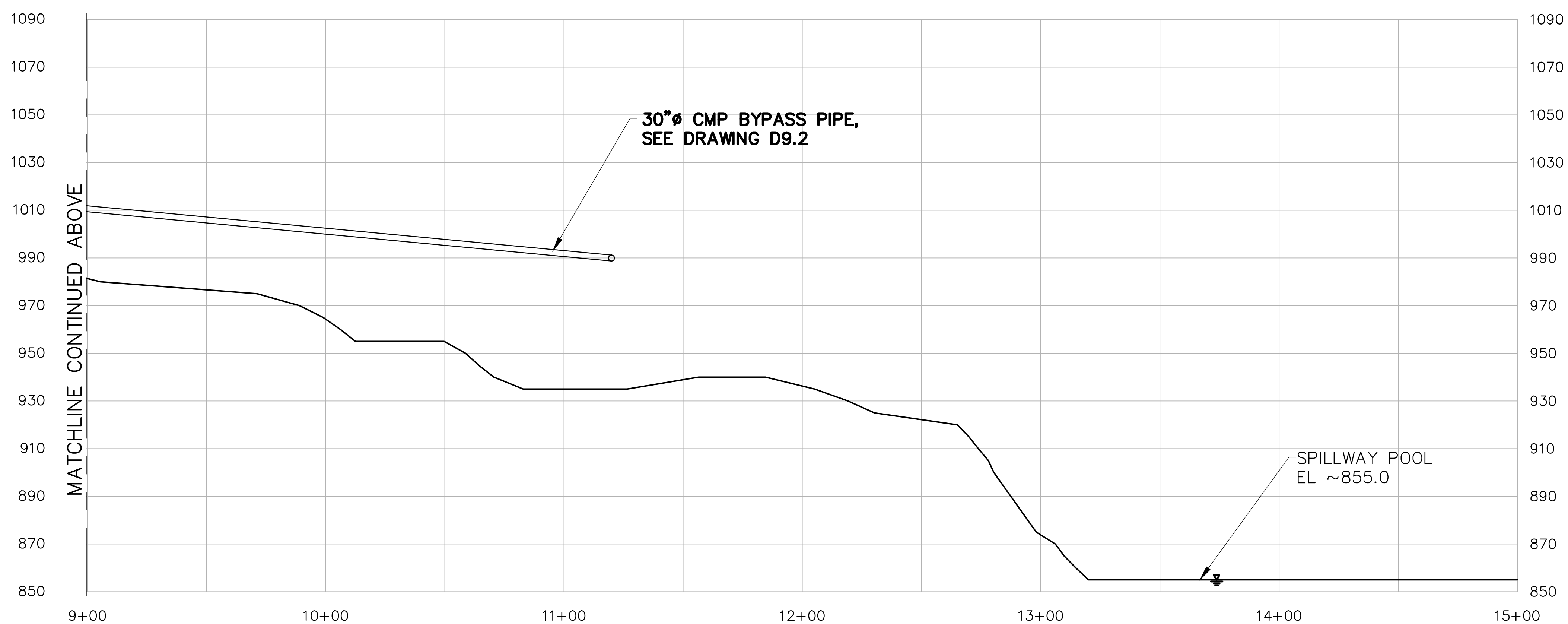
D9. ALT D7 PIRU CREEK COLLECTOR WITH 500 CFS SPILLWAY COLLECTOR ELEVATIONS

DATE: MAR 6, 2015

DRAWING: D9.5

REV: 0





NOTES:

1. THIS SHEET PROVIDED AS A REFERENCE ONLY. NO SPILLWAY IMPROVEMENTS ARE PROPOSED FOR ALT D9. BASED ON SANTA FELICIA DAM, SPILLWAY PLANS, PROFILE, AND SECTIONS DRAWING DATED OCT 1956.

2. STATIONS AND ELEVATIONS PER OCT 1956 ORIGINAL SPILLWAY DRAWING, USED FOR REFERENCE.

SECTION A / D9.2
THROUGH SPILLWAY

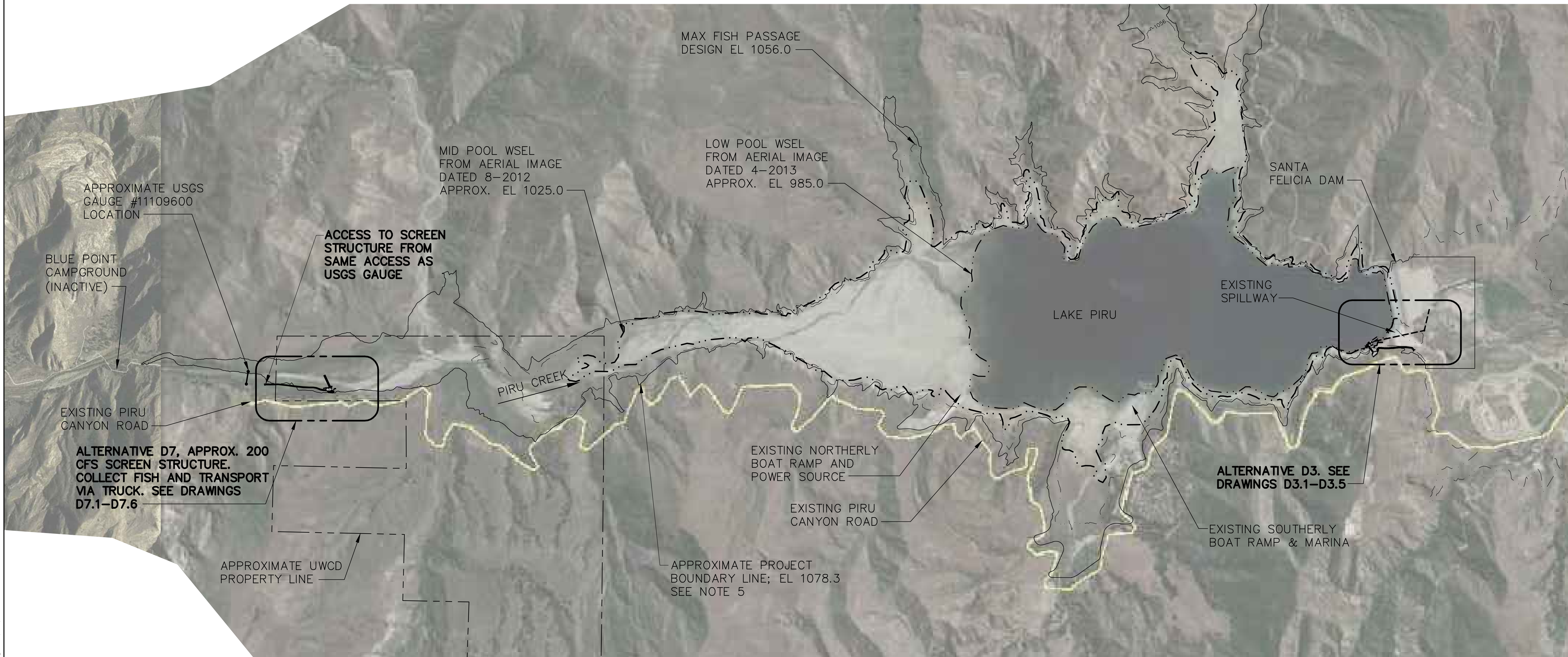
60 0 30 60
SCALE: 1"=60'

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D9. ALT D7 PIRU CREEK COLLECTOR WITH 500 CFS SPILLWAY COLLECTOR SPILLWAY SECTION

DATE: MAR 6, 2015	
DRAWING: D9.6	REV: 0



NOTES:

1. ALTERNATIVE D10 IS DEFINED AS A COMBINATION OF ALT D7 (PIRU CREEK COLLECTOR) AND ALT D3 (150 CFS SURFACE COLLECTOR AT A NEW INTAKE TOWER).
2. IMAGE TAKEN FROM GOOGLE EARTH, DATED 4–17–2013.
3. PROPERTY LINE TAKEN FROM 14289 MAPPING.DWG IN EXHIBIT G, DATED 4–27–09.
4. NORMAL FULL POOL WSEL 1055.0.
5. DAM CREST ELEVATION 1075.0.
6. PROJECT BOUNDARY LINE TAKEN FROM "EXHIBIT G" AND ADJUSTED, AS BEST AS POSSIBLE, TO FIT THE AERIAL IMAGE IN THIS DRAWING.

LOCATION PLAN

2000 0 1000 2000

SCALE: 1"=2000'

0 1"

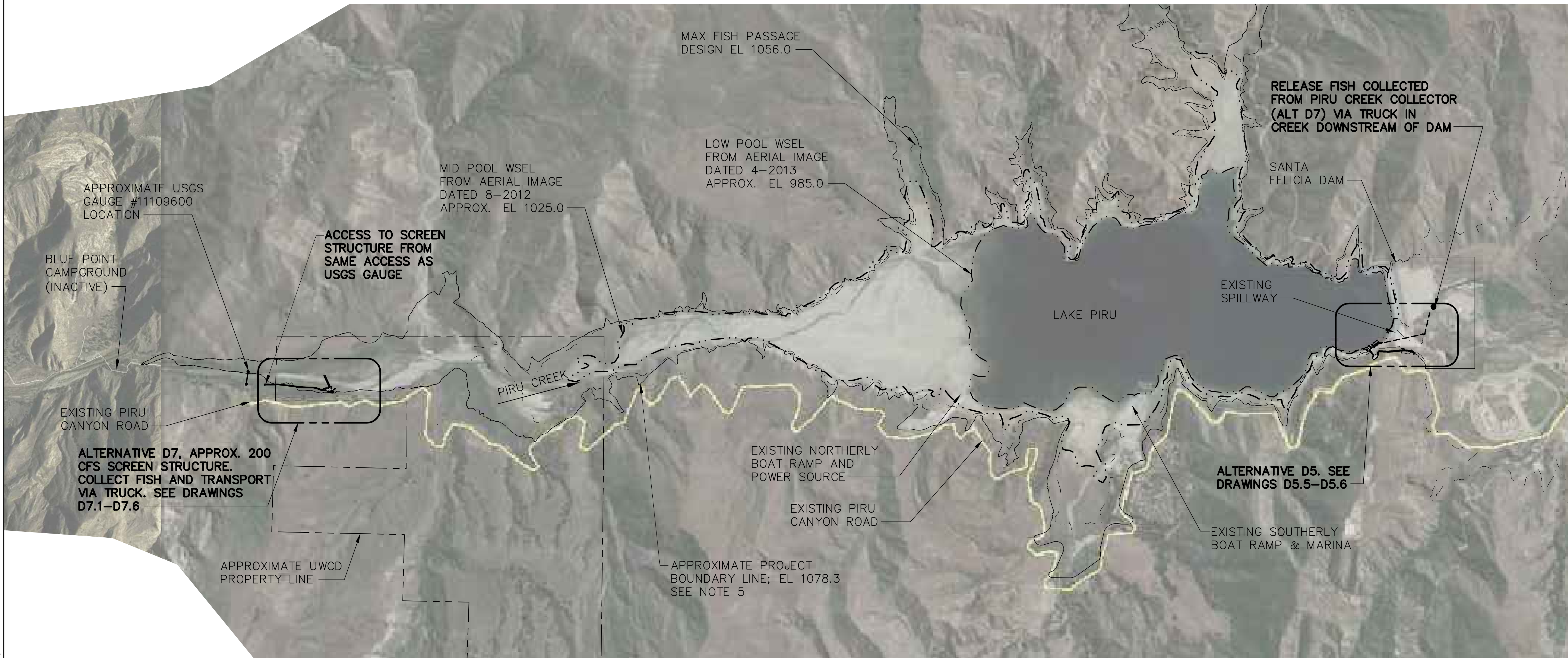
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D–10. ALT. D7 PIRU CREEK COLLECTOR AND ALT. D3 150 CFS SURFACE COLLECTOR LOCATION PLAN

DATE: NOV 20, 2014	
DRAWING: D10.1	REV: 0

C:\pwworking\sac\d0606824\2014-11-11 D10.dwg, 4/2/2015 9:25:20 AM



LOCATION PLAN

2000 0 1000 2000

SCALE: 1"=2000'

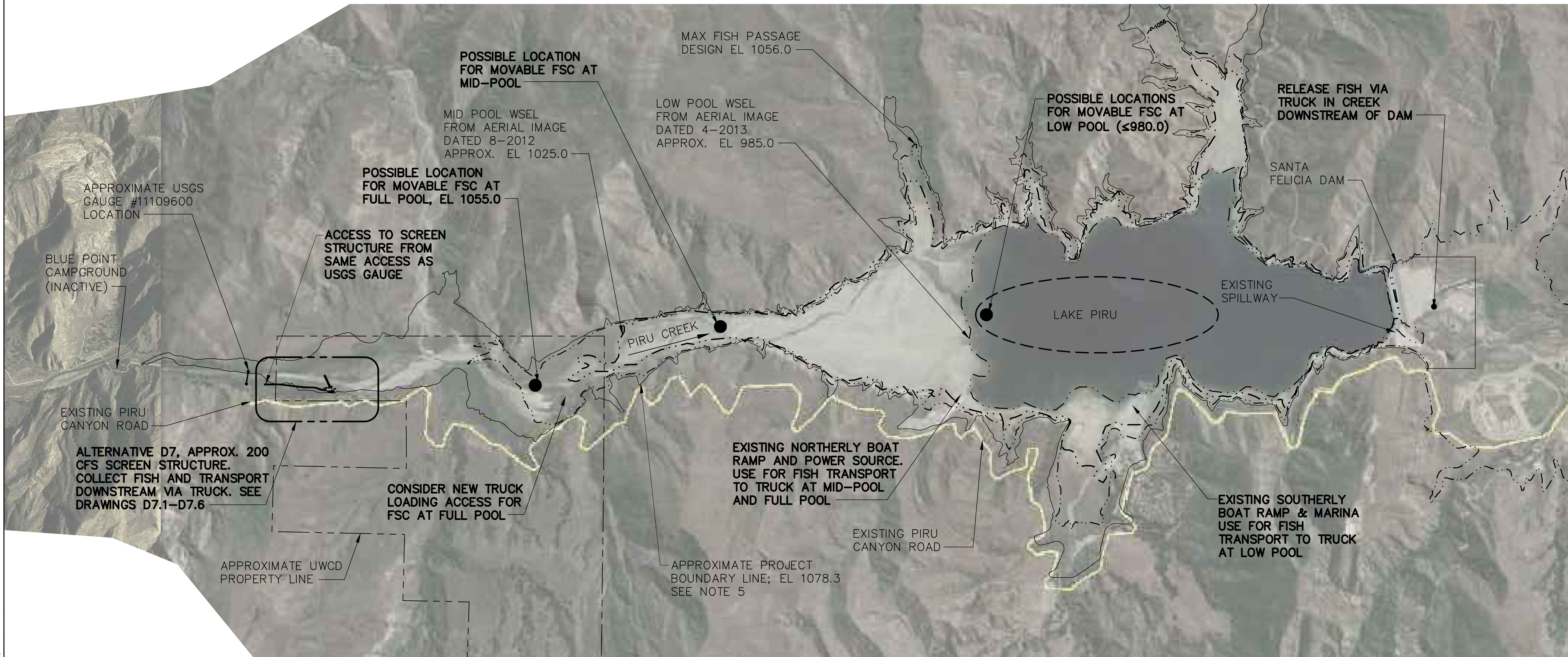
NOTES:

1. ALTERNATIVE D11 IS DEFINED AS A COMBINATION OF ALT D7 (PIRU CREEK COLLECTOR) AND ALT D5 (500 CFS SURFACE COLLECTOR AT NEW INTAKE TOWER).
2. IMAGE TAKEN FROM GOOGLE EARTH, DATED 4-17-2013.
3. PROPERTY LINE TAKEN FROM 14289 MAPPING.DWG IN EXHIBIT G, DATED 4-27-09.
4. NORMAL FULL POOL WSEL 1055.0.
5. DAM CREST ELEVATION 1075.0.
6. PROJECT BOUNDARY LINE TAKEN FROM "EXHIBIT G" AND ADJUSTED, AS BEST AS POSSIBLE, TO FIT THE AERIAL IMAGE IN THIS DRAWING.

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D-11. ALT. D7 PIRU CREEK COLLECTOR AND ALT. D5 500 CFS SURFACE COLLECTOR LOCATION PLAN	DATE: NOV 20, 2014	
	DRAWING: D11.1	REV: 0



NOTES:

1. ALTERNATIVE D12 IS DEFINED AS A COMBINATION OF ALT D7 (PIRU CREEK COLLECTOR) WITH A MOVABLE 150 CFS FLOATING SURFACE COLLECTOR.
2. IMAGE TAKEN FROM GOOGLE EARTH, DATED 4-17-2013.
3. PROPERTY LINE TAKEN FROM 14289 MAPPING.DWG IN EXHIBIT G, DATED 4-27-09.
4. NORMAL FULL POOL WSEL 1055.0, MAX FISH PASSAGE DESIGN WSEL 1056.0.
5. DAM CREST ELEVATION 1075.0.
6. PROJECT BOUNDARY LINE TAKEN FROM "EXHIBIT G" AND ADJUSTED, AS BEST AS POSSIBLE, TO FIT THE AERIAL IMAGE IN THIS DRAWING.

LOCATION PLAN

2000 0 1000 2000

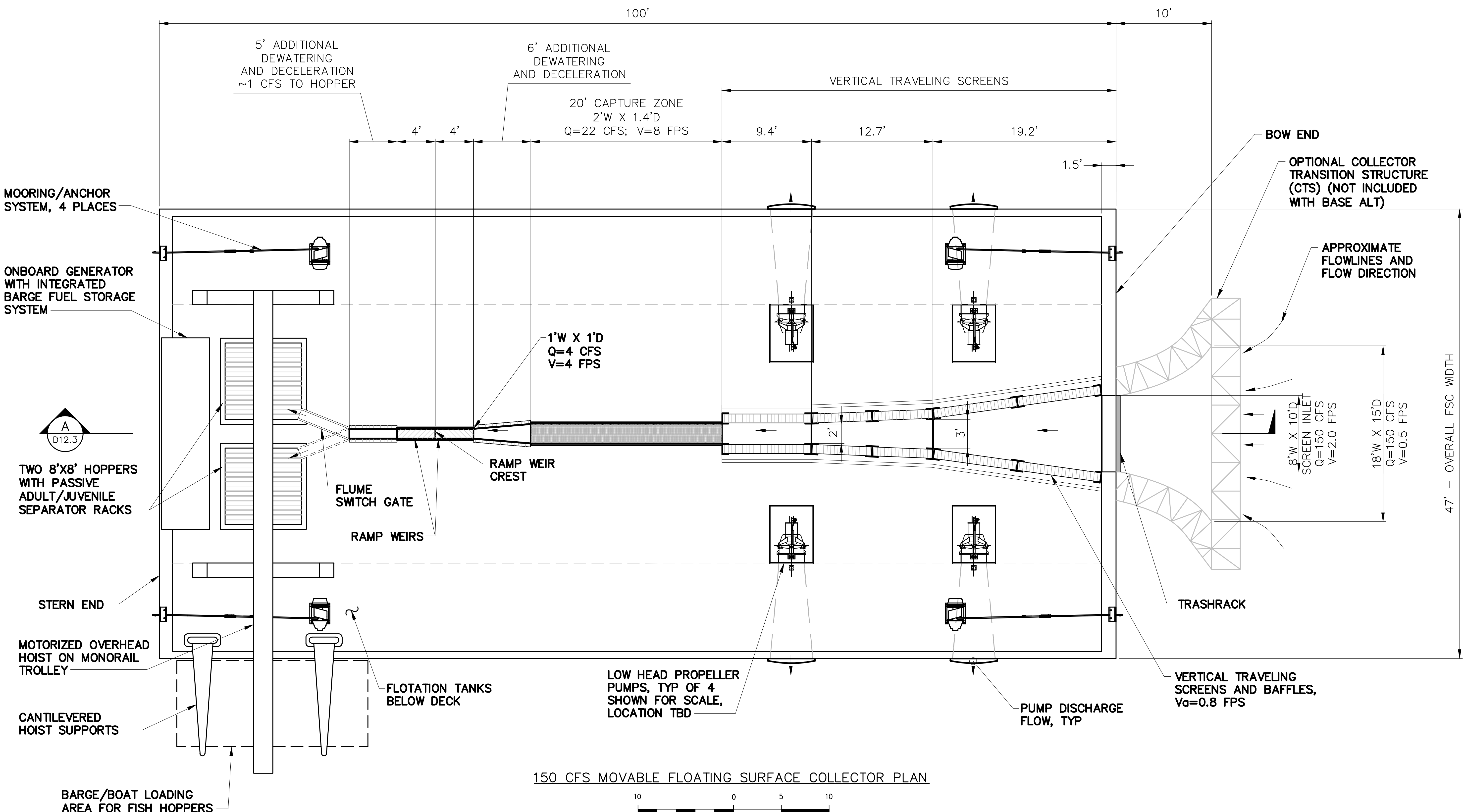
SCALE: 1"=2000'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D12. ALT. D7 PIRU CREEK COLLECTOR AND A MOVABLE 150 CFS FSC (ALT D2) LOCATION PLAN	DATE: FEB 13, 2015	
	DRAWING: D12.1	REV: 0



150 CFS MOVABLE FLOATING SURFACE COLLECTOR PLAN

10 0 5 10

SCALE: 1"=10'

0 1"

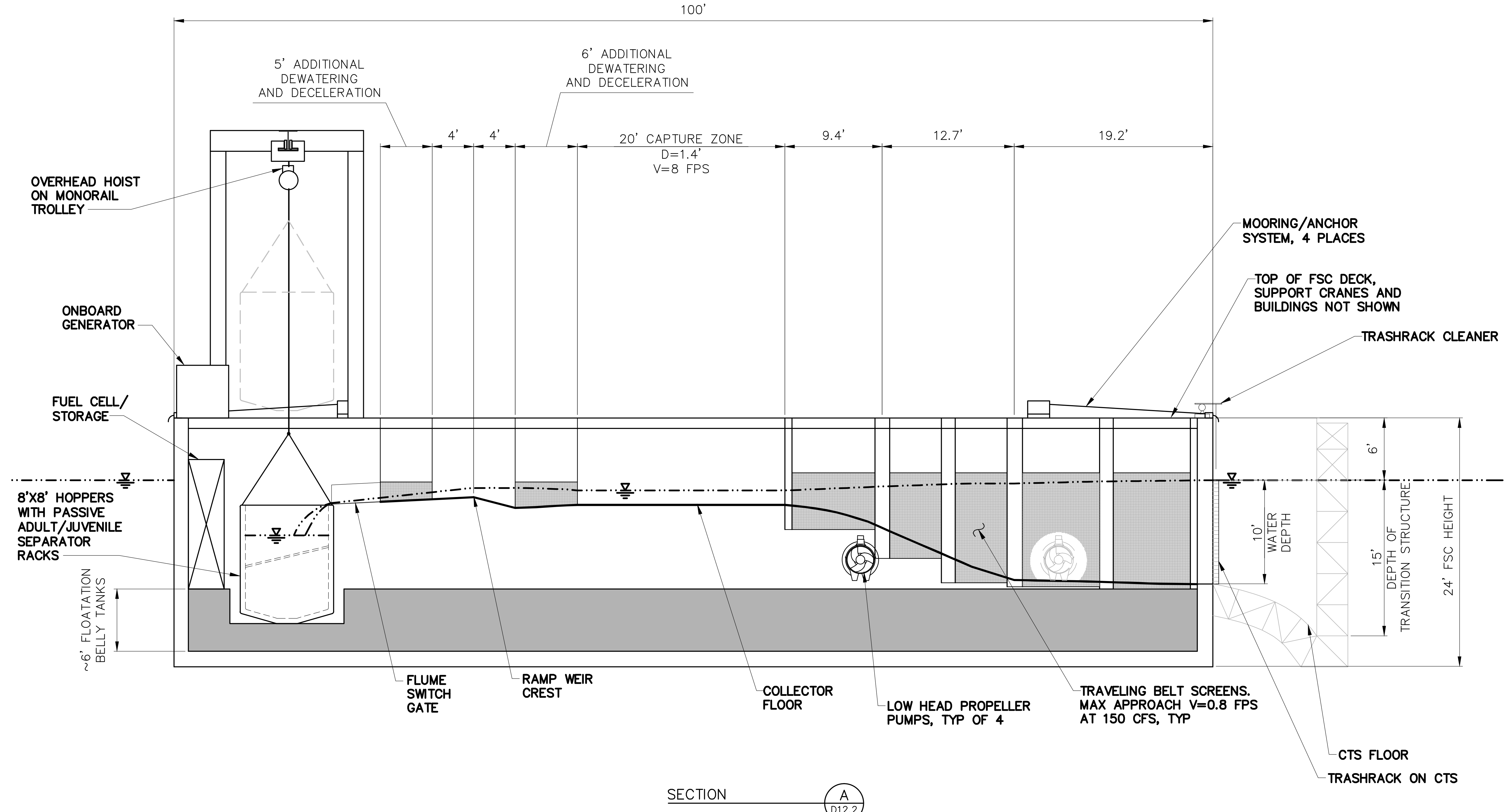
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

NOTES:

1. PLAN AND SECTION SHOWN FOR MOVABLE FSC HAVE 150 CFS SCREEN, SAME SIZE AND VELOCITY PROFILE AS ALT D3. SIZE AND OTHER FEATURES ARE BASED ON SWIFT FSC, AND SIMILAR TO COUGAR FSC.

2. MOVABLE FSC IS SELF-CONTAINED WITH PORTABLE MOORAGE SYSTEM, ONBOARD GENERATOR, AND FUEL STORAGE SYSTEM. FSC WOULD BE MOVED WITH A WORK TUG.

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D12. 150 CFS MOVABLE FSC PLAN	DATE: FEB 13, 2015	
	DRAWING: D12.2	REV: 0



0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

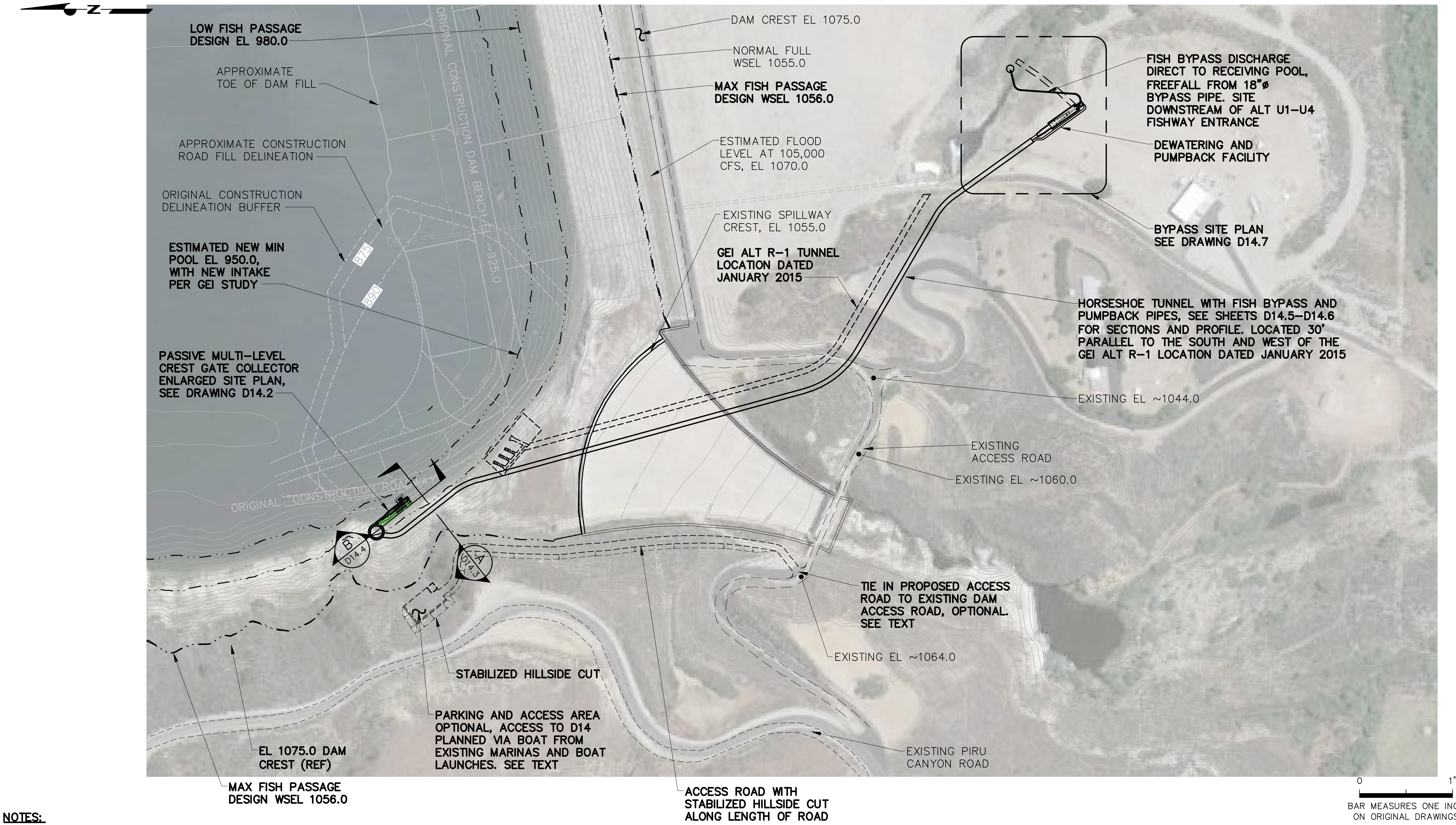
NOTES:

1. PLAN AND SECTION SHOWN FOR MEETING P4 HAVE 150 CFS SCREEN. SAME SIZE AND VELOCITY PROFILE AS ALT D3. SIZE AND OTHER FEATURES ARE BASED ON SWIFT FSC.

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D12. 150 CFS MOVABLE FSC
COLLECTOR SECTION A
(LONGITUDINAL THROUGH CENTERLINE)

DATE: FEB 13, 2015
DRAWING: D12.3
REV: 0



NOTES:

1. BATHYMETRY AND TOPOGRAPHIC DATA SHOWN FROM: LAKE PIRU CONTOURS DEC 2005 – FISH PASSAGE STUDY.DWG
2. AERIAL IMAGE FROM GOOGLE EARTH. IMAGE LOCATED APPROXIMATELY, THUS THE BACKGROUND IMAGE AND LINEWORK DON'T LINE UP EXACTLY DUE TO THE IMAGE NOT BEING GEOREFERENCED OR ORTHORECTIFIED.

LOCATION PLAN

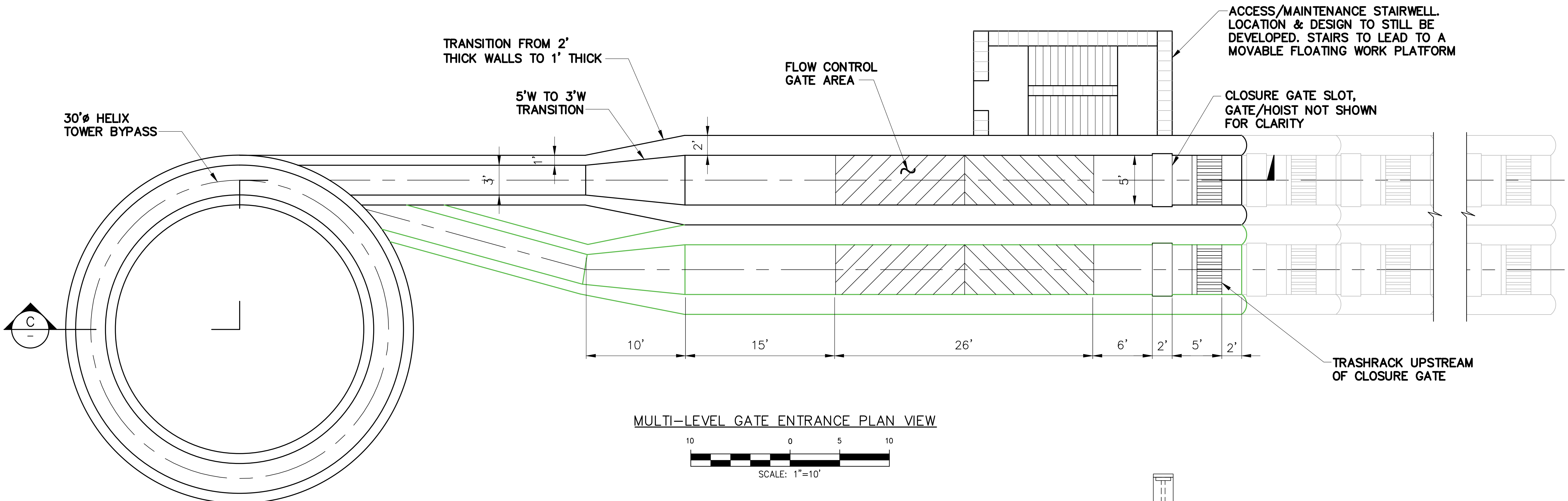
200 0 100 200
SCALE: 1"=200'

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D14. PASSIVE MULTI-LEVEL CREST GATE COLLECTOR WITH HELIX BYPASS RESERVOIR RANGE EL 980' TO 1056' LOCATION PLAN

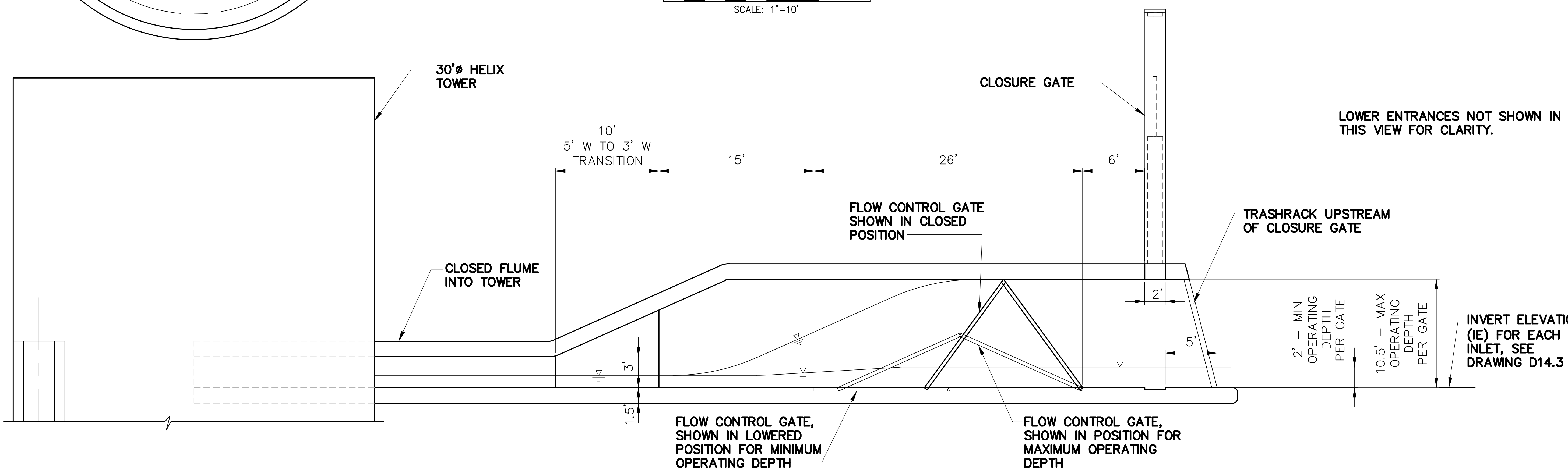
DATE: MAR 11, 2015
DRAWING: D14.1
REV: 0

C:\pwworking\sac\d0640291\2015-02-26 D14.dwg, 3/19/2015 11:08:54 AM



MULTI-LEVEL GATE ENTRANCE PLAN VIEW

10 0 5 10
SCALE: 1"=10'



SECTION C

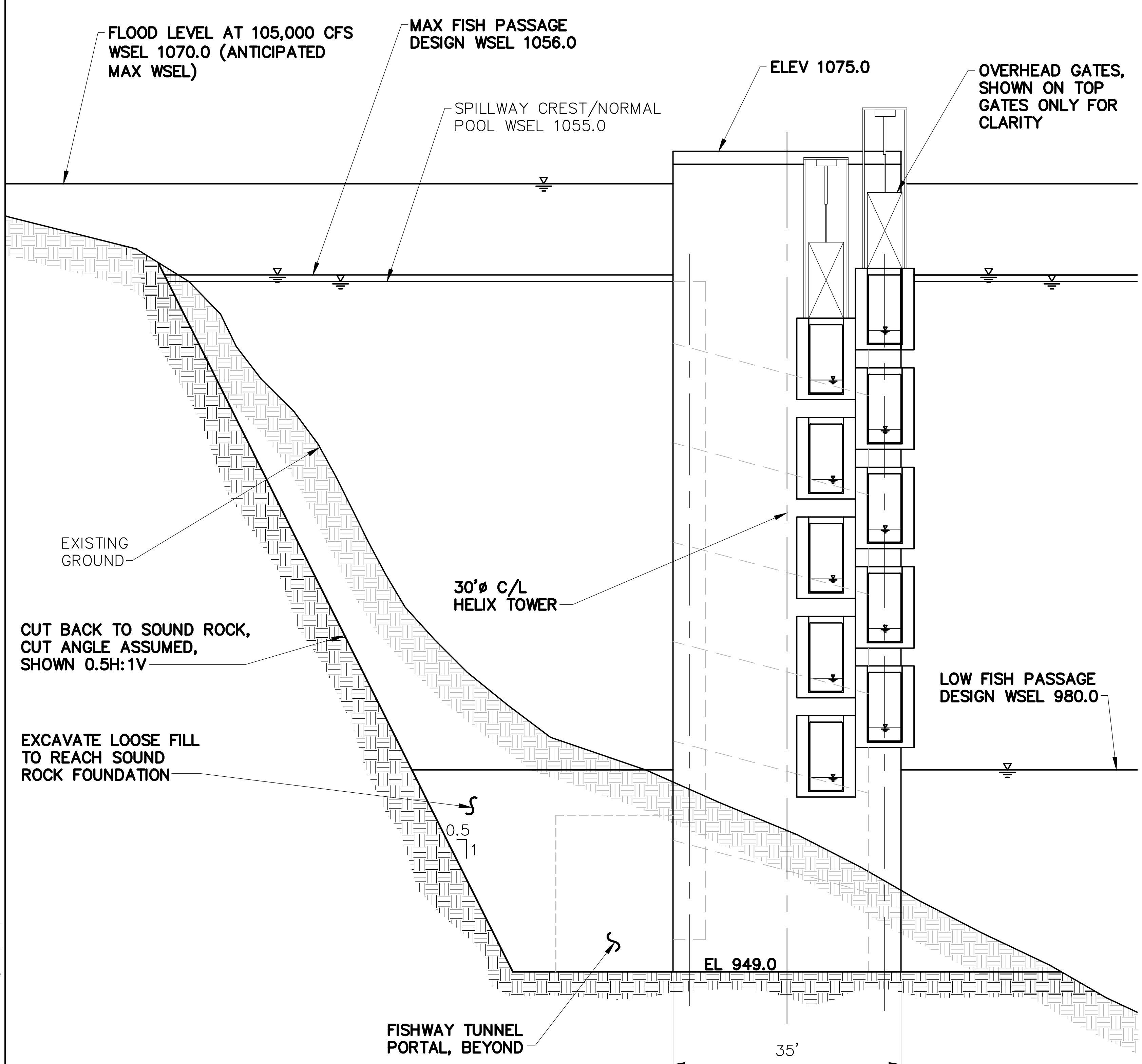
10 0 5 10
SCALE: 1"=10'

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D14. PASSIVE MULTI–LEVEL CREST GATE COLLECTOR WITH HELIX BYPASS RESERVOIR RANGE EL 980' TO 1056' FISHWAY TOWER ENLARGED PLAN

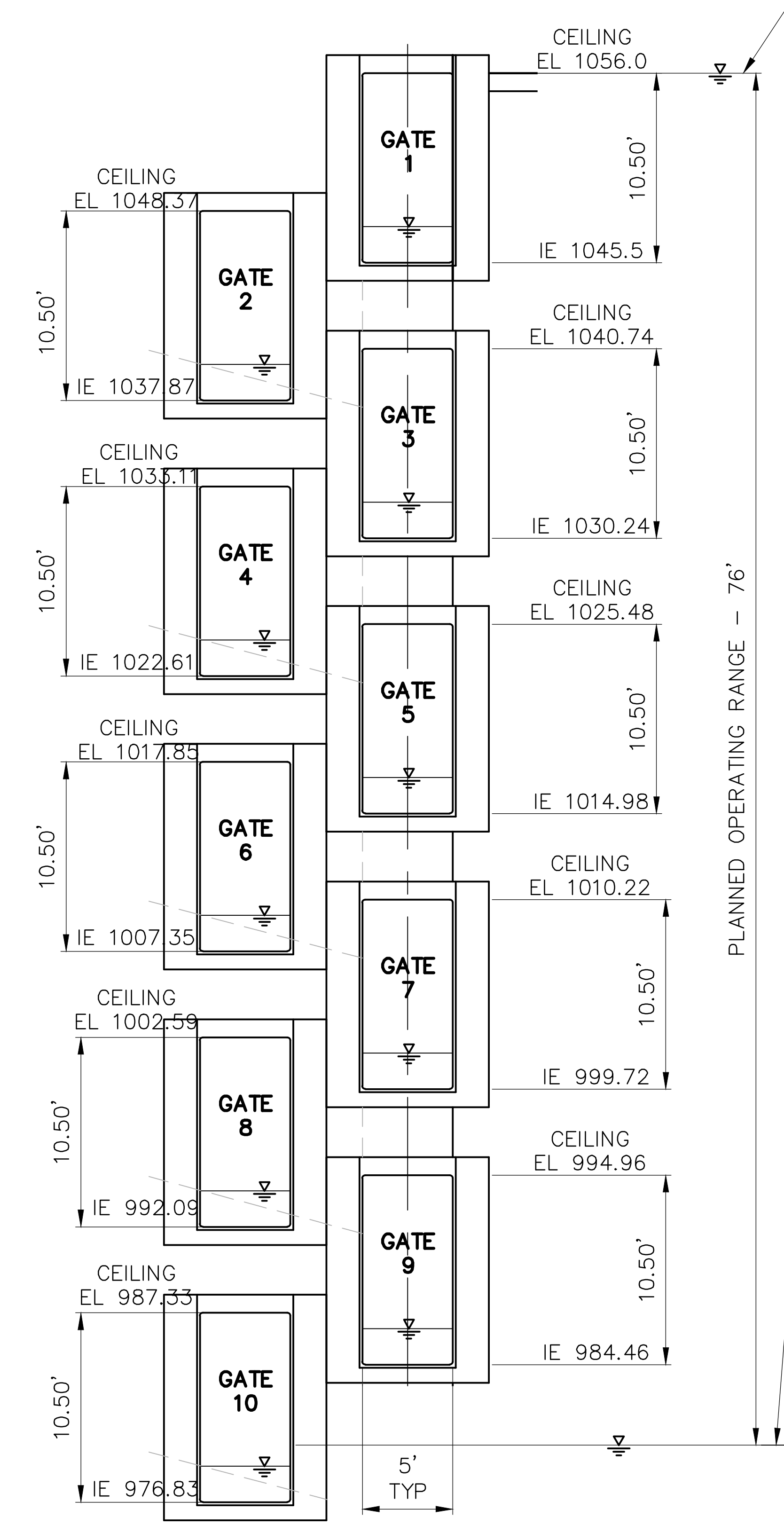
DATE: MAR 11, 2015		
DRAWING: D14.2	REV: 0	



SECTION A D14.1

20 0 10 20

SCALE: 1"=20'



ENTRANCE DETAIL

10 0 5 10

SCALE: 1"=10'

WATER SURFACE OPERATING RANGE		
	LOW WSEL	HIGH WSEL
GATE 1	1047.50	1056.0
GATE 2	1039.87	1046.37
GATE 3	1032.24	1040.74
GATE 4	1024.61	1033.11
GATE 5	1016.98	1025.48
GATE 6	1009.35	1017.85
GATE 7	1001.72	1010.22
GATE 8	994.09	1002.59
GATE 9	986.46	994.96
GATE 10	978.83	987.33

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

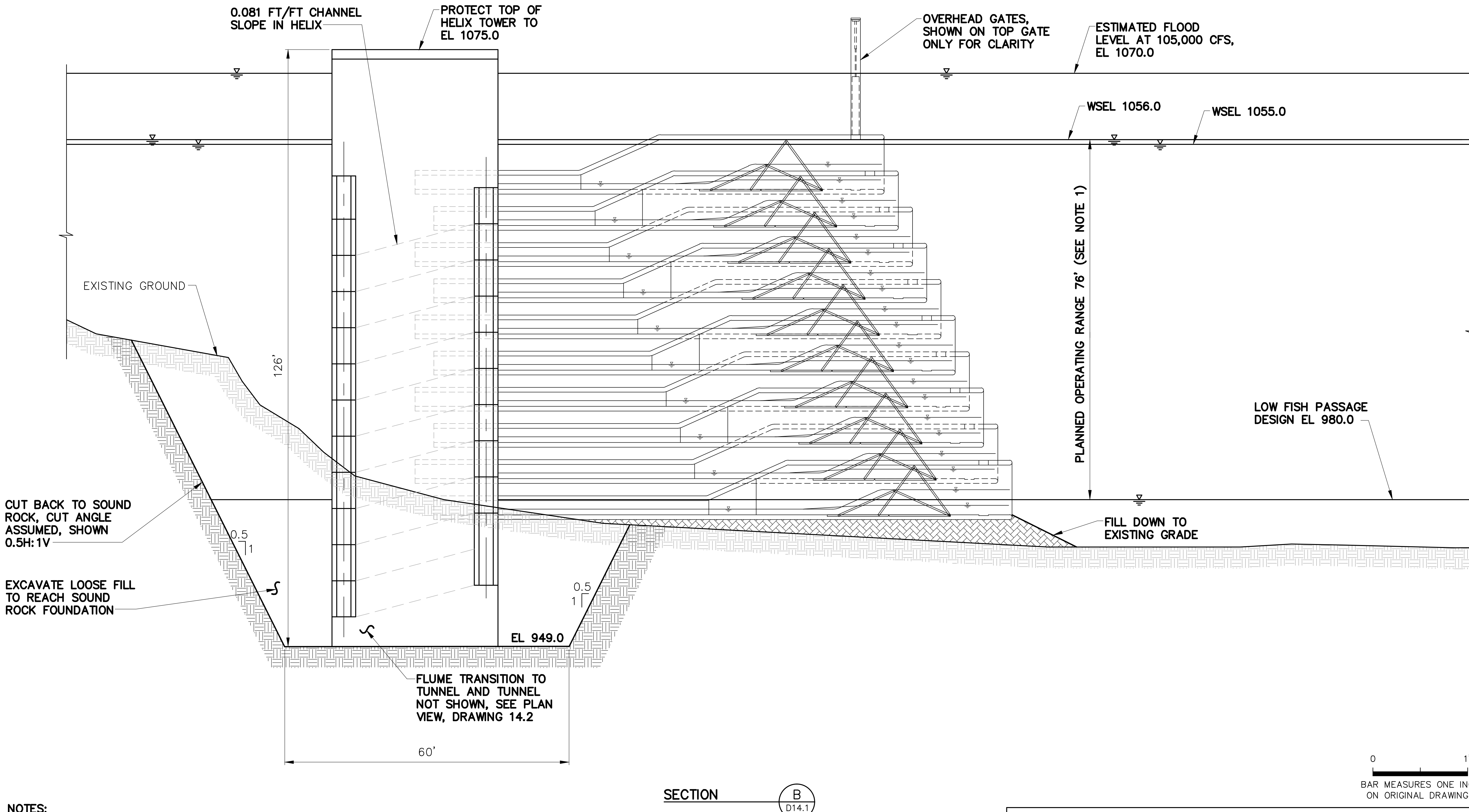
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D14. PASSIVE MULTI-LEVEL CREST GATE COLLECTOR WITH HELIX BYPASS RESERVOIR RANGE EL 980' TO 1056' TOWER SECTION AND ENTRANCE DETAIL

DATE: MAR 11, 2015

DRAWING: D14.3

REV: 0



NOTES:

1. SEE DRAWING D14.3 FOR DETAIL ON OPERATING ELEVATIONS.
2. CHANNEL IN HELIX IS 3' WIDE AND OPERATES AT 150 CFS WITH A 1.5' DEPTH AND 35 FPS VELOCITY.

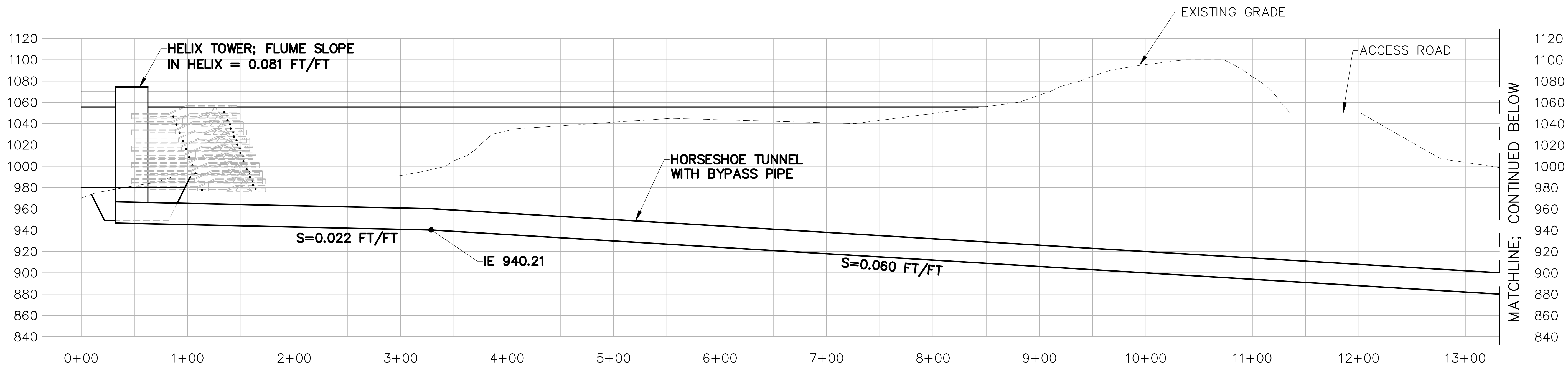
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

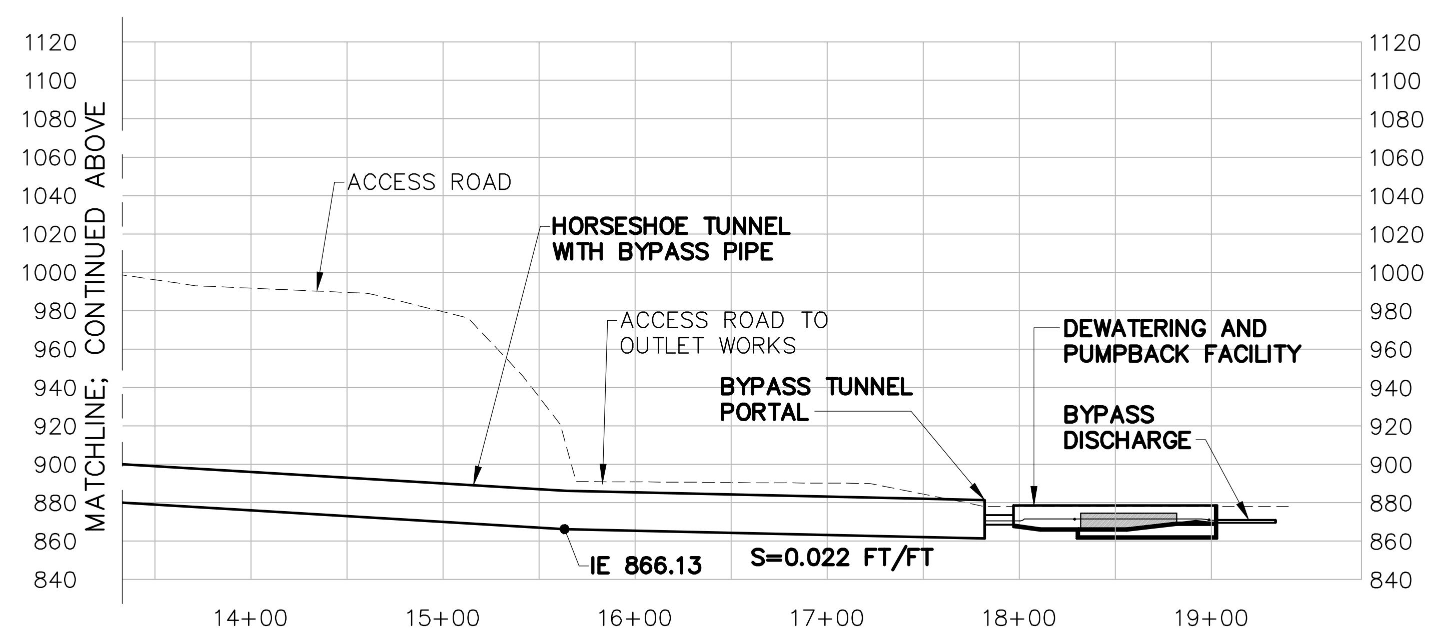
D14. PASSIVE MULTI-LEVEL CREST GATE COLLECTOR WITH HELIX BYPASS RESERVOIR RANGE EL 980' TO 1056' HELICAL TOWER SECTION

DATE: MAR 11, 2015

DRAWING: D14.4

REV: 0





HORSESHOE TUNNEL PROFILE

100 0 50 100

SCALE: 1"=100'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

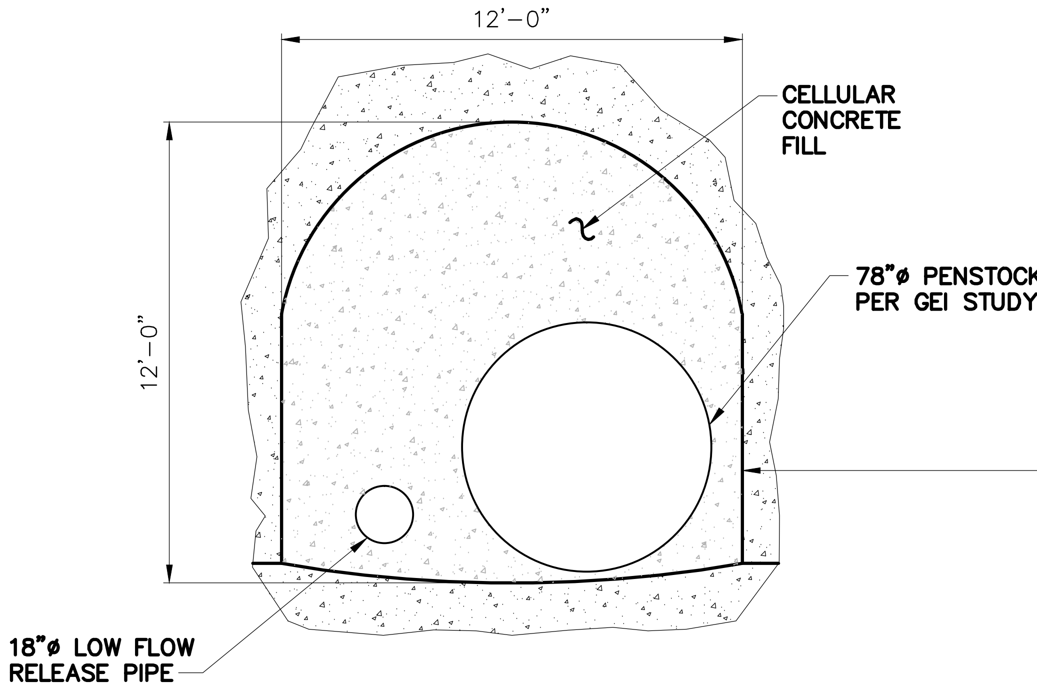
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D14. PASSIVE MULTI-LEVEL CREST GATE COLLECTOR WITH HELIX BYPASS RESERVOIR RANGE EL 980' TO 1056' HORSESHOE TUNNEL PROFILE

DATE: MAR 11, 2015

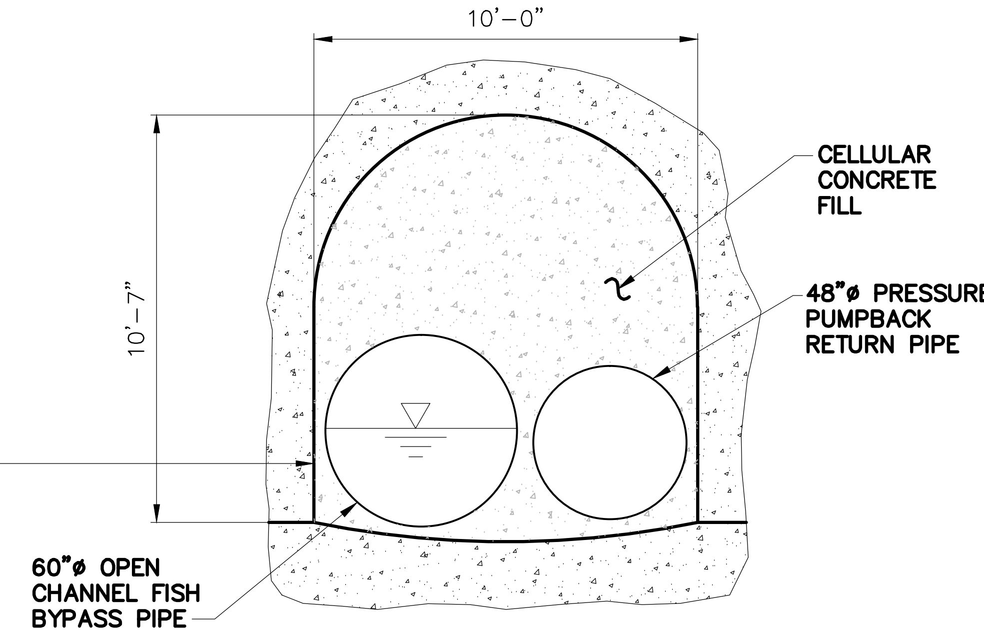
DRAWING: D14.5

REV: 0

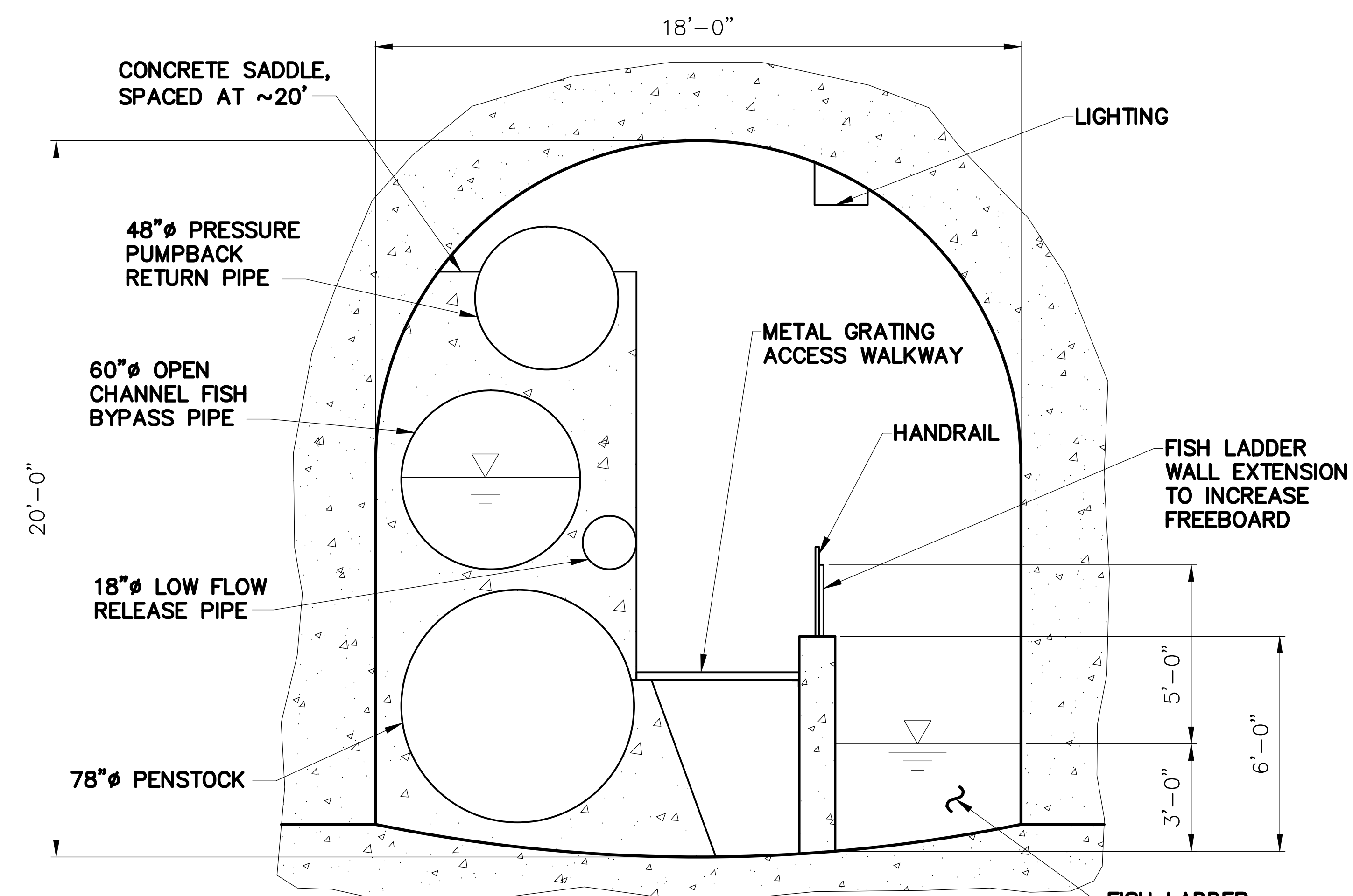


GEI HORSESHOE TUNNEL SECTION
(SHOWN FOR REFERENCE ONLY)

30' EDGE TO EDGE BETWEEN TUNNELS



D14 HORSESHOE TUNNEL TYPICAL SECTION
(SEE NOTE 1)



HORSESHOE TUNNEL SHOWN FOR ALT U1 TYPICAL SECTION – IF DIAMETER COMBINED WITH GEI INTAKE TUNNEL
(SEE DRAWING U1.5 AND NOTE 2)

NOTES:

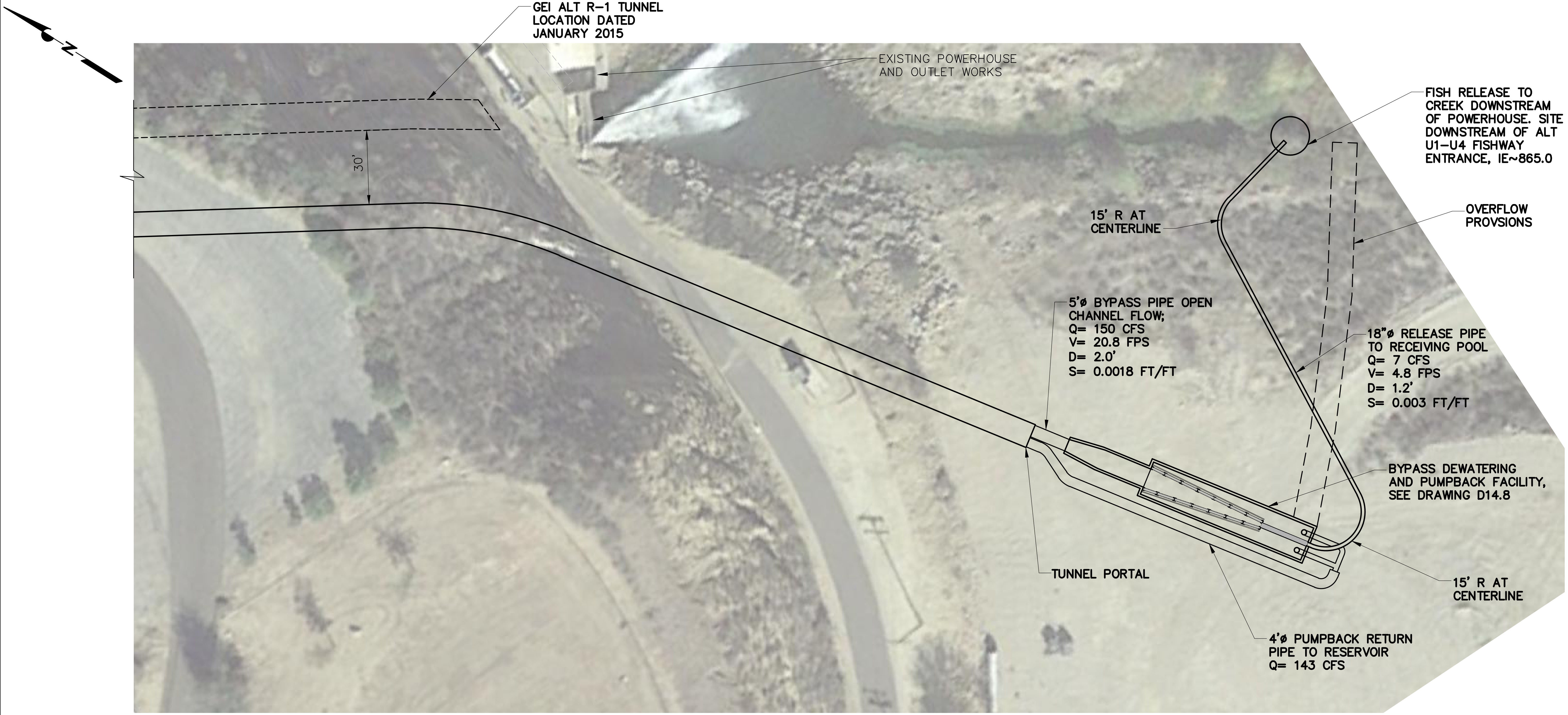
1. ASSUME CONSTRUCTION OF A D14 TUNNEL INDEPENDENT OF GEI TUNNEL, AND/OR INDEPENDENT OF ALTERNATE U1.
2. ALTERNATE D14 60"ø OPEN CHANNEL FISH BYPASS PIPE, AND 48"ø PRESSURE PUMPBACK RETURN PIPE SHOWN WITH ALTERNATE U1 HORSESHOE TUNNEL SECTION, PROVIDES FOR COST SAVING OPPORTUNITY IF TUNNELS ARE COMBINED.

5 0 5
SCALE: 1"=5'

0 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D14. PASSIVE MULTI-LEVEL CREST GATE COLLECTOR WITH HELIX BYPASS RESERVOIR RANGE EL 980' TO 1056' HORSESHOE TUNNEL SECTIONS	DATE: MAR 11, 2015	
	DRAWING: D14.6	REV: 0



BYPASS DISCHARGE SITE PLAN

40 0 20 40

SCALE: 1"=40'

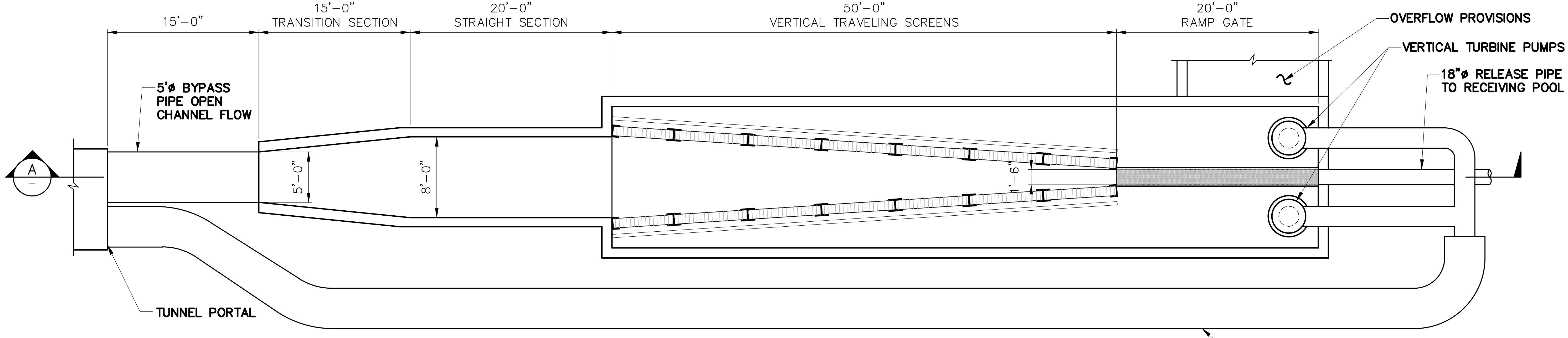
0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

NOTES:

1. AERIAL IMAGE FROM GOOGLE EARTH. IMAGE LOCATED APPROXIMATELY, THUS THE BACKGROUND IMAGE AND LINEWORK DON'T LINE UP EXACTLY DUE TO THE IMAGE NOT BEING GEOREFERENCED OR ORTHORECTIFIED.

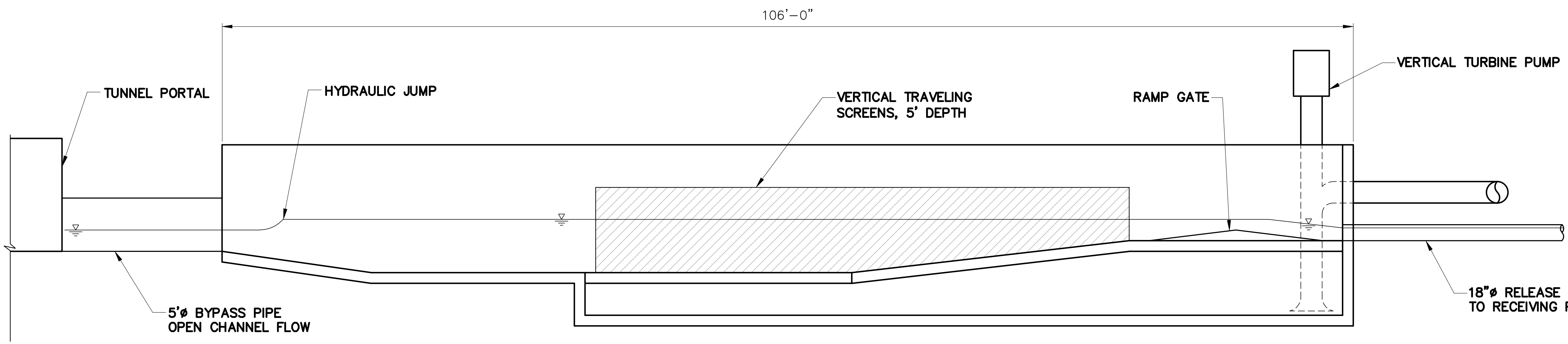
SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY		
D14. PASSIVE MULTI-LEVEL CREST GATE COLLECTOR WITH HELIX BYPASS RESERVOIR RANGE EL 980' TO 1056' BYPASS DISCHARGE SITE PLAN	DATE: MAR 11, 2015 DRAWING: D14.7	REV: 0



PLAN

10 0 5 10

SCALE: 1"=10'



SECTION A

10 0 5 10

SCALE: 1"=10'

0 1"

BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

SANTA FELICIA DAM – FISH PASSAGE FEASIBILITY ASSESSMENT STUDY

D14. PASSIVE MULTI-LEVEL CREST GATE COLLECTOR WITH HELIX BYPASS
RESERVOIR RANGE EL 980' TO 1056'
BYPASS DEWATERING/PUMPBACK PLAN & SECTION

DATE: MAR 11, 2015

DRAWING: D14.8

REV: 0

APPENDIX A:
Hydrology of Piru Creek

From: Murray McEachron

Date: 6/12/2011 (revised 9/10/2013)

Model used to simulate hydrologic conditions in Lake Piru

Due to operational changes at the Santa Felicia Dam, historic water releases and surface water levels are not representative of conditions that are expected to occur in the future. During the FERC process, a reservoir model was created by United and then refined in collaboration with the California Department of Fish and Game, and the Los Angeles Regional Water Quality Control Board. The objective of the model is to simulate hydrologic conditions that are likely to occur under the current operations using historical natural flows into the lake. In order to supply requested information to the Fish Passage Feasibility Panel, the model was used to simulate hydrologic conditions using a period of record of natural flows between 1943 and 2010.

Background

Lake Piru was built in 1955 as a water resource reservoir. Since its construction, operations at the Santa Felicia Dam have evolved to meet water resource management goals. Santa Felicia's location was chosen above the town of Piru because the upper groundwater basins (Piru, Fillmore and Santa Paula) were experiencing very low groundwater levels. Historically, conservation releases were designed to provide for a portion of the water released from the Santa Felicia Dam to be diverted for recharge into the Piru Basin. Since the 1970s, this groundwater basin has recovered. Currently, conservation releases are designed to maximize beneficial use on the Oxnard Plain. Approximately half of the water released during conservation releases percolates into the upper basins as it is transported downstream, the remainder is diverted at United's Freeman Diversion Facility. Water received at the Freeman Diversion is either delivered directly to agriculture in order to reduce pumping on the Oxnard Plain or is routed into strategically located infiltration ponds for groundwater recharge. Lake Piru was originally built with a capacity of 102,000 acre feet. Due to sedimentation throughout the years, the current capacity is 83,200 acre feet. In the past, conservation releases resulted in a reduction of water in Lake Piru to as little as several thousand acre feet. Over the years, a delta formed at the northern end of the lake. In order to prevent sediment from the delta from being drawn down toward the intake tower, the current strategy is to maintain a minimum pool of 20,000 acre feet in the lake.

Model Assumptions

Current Operations at the Santa Felicia Dam: United's current operations at the Santa Felicia Dam include water releases as prescribed in the "Santa Felicia Water Release Plan" (Release Plan), and fall conservation releases. In general, the Release Plan includes minimum migration releases of 200 cfs when flows in the Santa Clara River are elevated due to rainfall events and meet specific trigger criteria, and habitat releases between 7 and 20 cfs dependant on cumulative annual rainfall.

Simulation of conservation releases is based on the current water resource management goals of the District. On years defined as “dry” and “normal” the conservation release is modeled to begin on September 1, and terminate when the volume of water in the lake is depleted to the minimum pool of 20,000 acre feet. Conservation releases during dry and normal years are assumed to be at a rate of 400 cfs. During wet years there is a higher efficiency for released water to be transported downstream to the Freeman Diversion and a lack of available storage upon arrival. Therefore, during wet years, conservation releases are modeled to begin on August 1 and terminate when the volume of water in the lake recedes to 40,000 acre feet. Conservation releases during wet years are assumed to be at a rate of 300 cfs.

Natural Inflows to Lake Piru: Prior to 1974, the USGS gage above Lake Piru reflected the natural inflow into the lake. The flows were altered in 1974 when Pyramid Lake (DWR Project) was constructed. Since 2005, Pyramid Lake has been operated on an inflow/outflow basis. The model recalculates the flows from 1974 to 2005 in order to estimate the natural inflows. This was done by a simple addition of the gages above Pyramid Lake and subtraction of unnatural flows (imported State water) released from the Pyramid outfall. The calculated inflows to Lake Piru were then averaged over a 3 day period. The inflows are primarily used to predict storage in the lake, so averaging does not significantly change the final output. The averaging results in smoothing the hydrograph, and consequently, the model results do not represent peak storm flows.

Submittal of Hydrologic Information

1.0 Introduction

The Santa Felicia Fish Passage Feasibility Panel (Panel) requested various information related to operations at the Santa Felicia dam and hydrologic conditions in Lake Piru and Piru Creek. The following information was compiled in response to that request. The following supplemental information is included in the internet based "Box" share site folder located at http://www.box.net/files#/files/0/f/90511478/Hydrology: Lake Piru data from model; Summary of model used to simulate hydrologic conditions in Lake Piru; and, Water Release Plan.

2.0 Lake Piru Water Surface Elevation

Historical water surface elevation data is available, however, it is not informative for assessing current and future conditions. United Water Conservation District (United) manages Lake Piru as a water resource reservoir. Surface water elevations are a function of operations and natural inputs, and operations at the Santa Felicia Dam and the upstream Pyramid Dam have changed significantly over the years. In order to provide meaningful information for the panel's consideration, a reservoir model was used to simulate surface water elevations that could be expected under current conditions (related to sedimentation and available storage within the lake) and operating procedures (including habitat and migration releases established in the Santa Felicia Water Release Plan). The model also incorporates the recent Department of Water Resources (DWR) policy at Pyramid Lake to release flows based on natural inflows to the lake (inflow = outflow). The model was run using historic inflow data from the period between 1944 and 2010. Raw data is presented in the excel file "Lake Piru data from model" located on the Box share site referenced in Section 1.0 (Introduction).

The exceedance graphs presented in Figures 1 through 12 were developed using results from the reservoir model and show the percentage probability that water surface elevation would be equaled or exceeded during each month of the year under current operations given the fifty-plus year period of record of historical flows into Lake Piru. The top of the spillway channel is located at an elevation of 1,055 feet, therefore any surface water elevations above 1055 feet are indicative of spill events. The graphs also include information related to simulated water surface elevations during conditions that would require United to release migration flows from the Santa Felicia Dam.

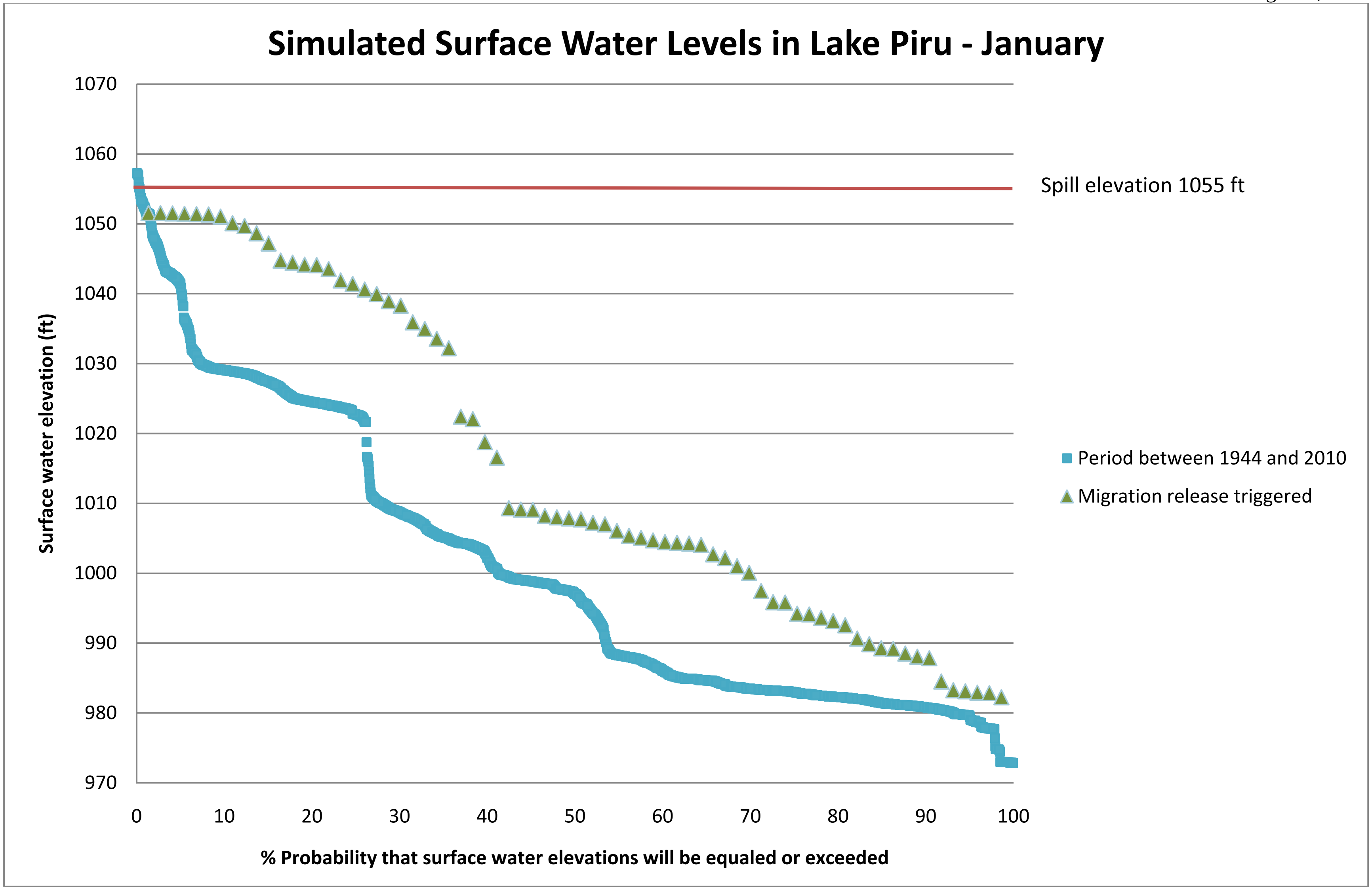


Figure 1 Exceedance graph of simulated water surface elevation for the month of January; based on recorded conditions between 1944 and 2010.

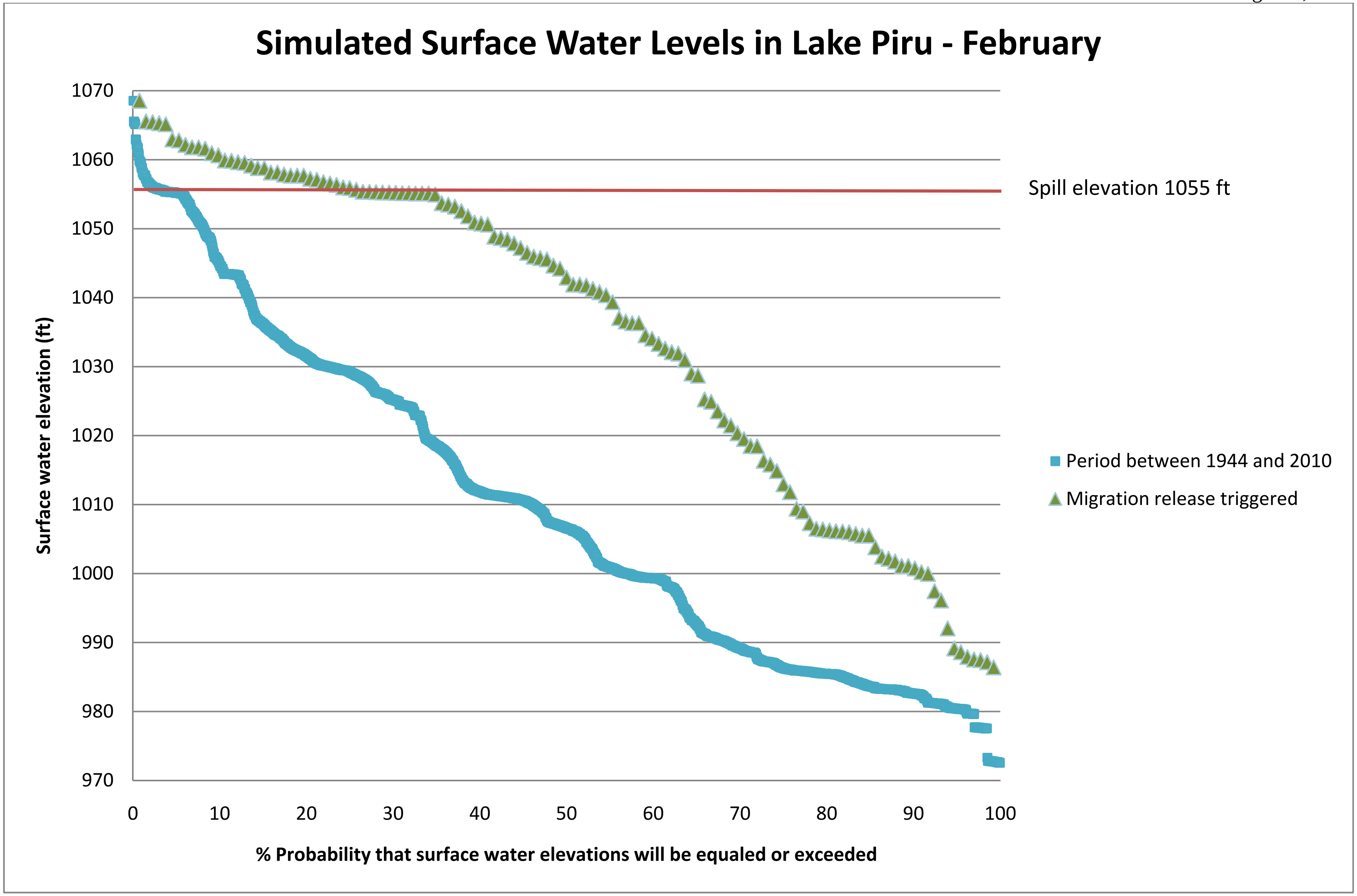


Figure 2 Exceedance graph of simulated water surface elevation for the month of February; based on recorded conditions between 1944 and 2010.

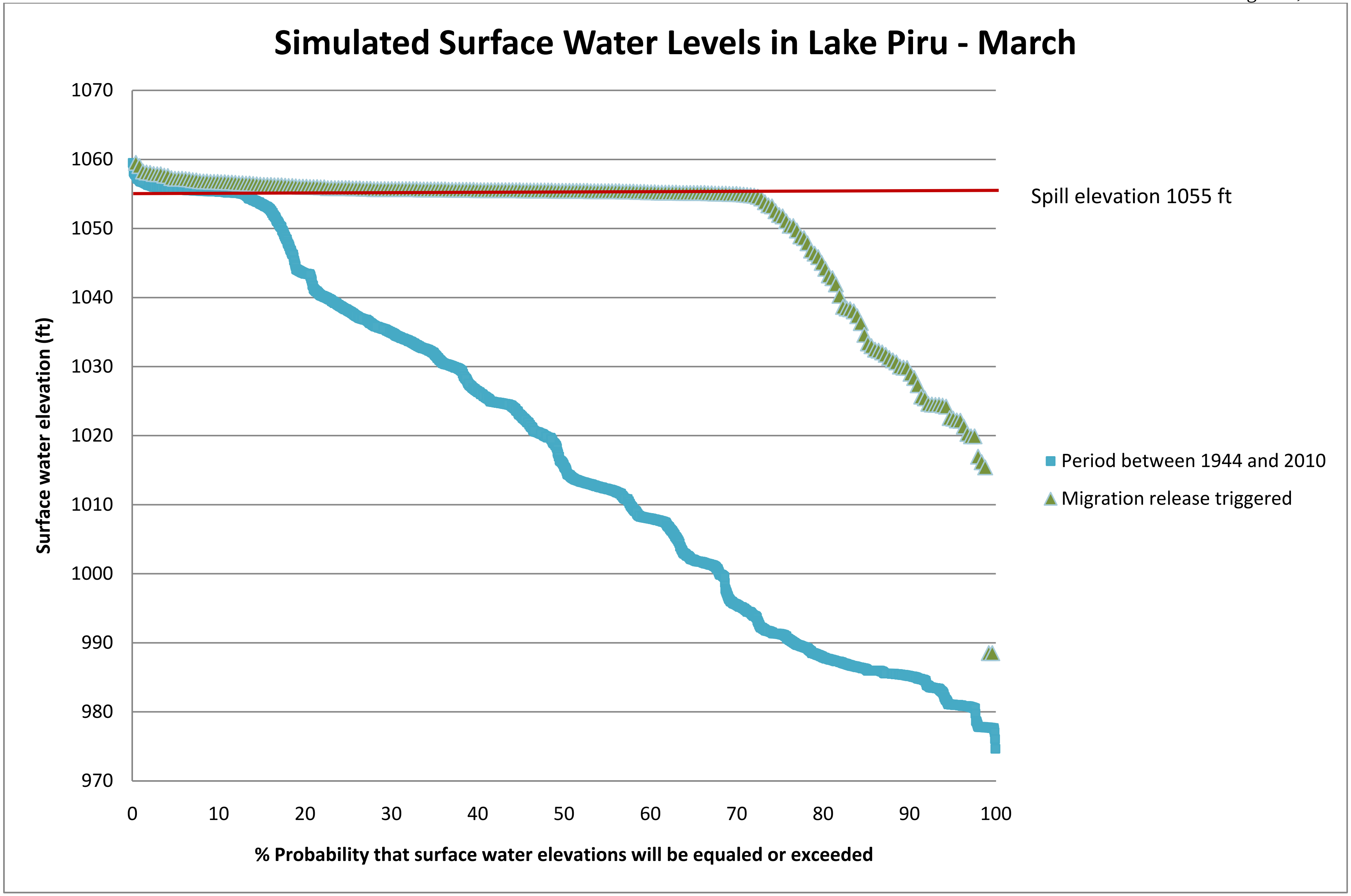


Figure 3 Exceedance graph of simulated water surface elevation for the month of March; based on recorded conditions between 1944 and 2010.

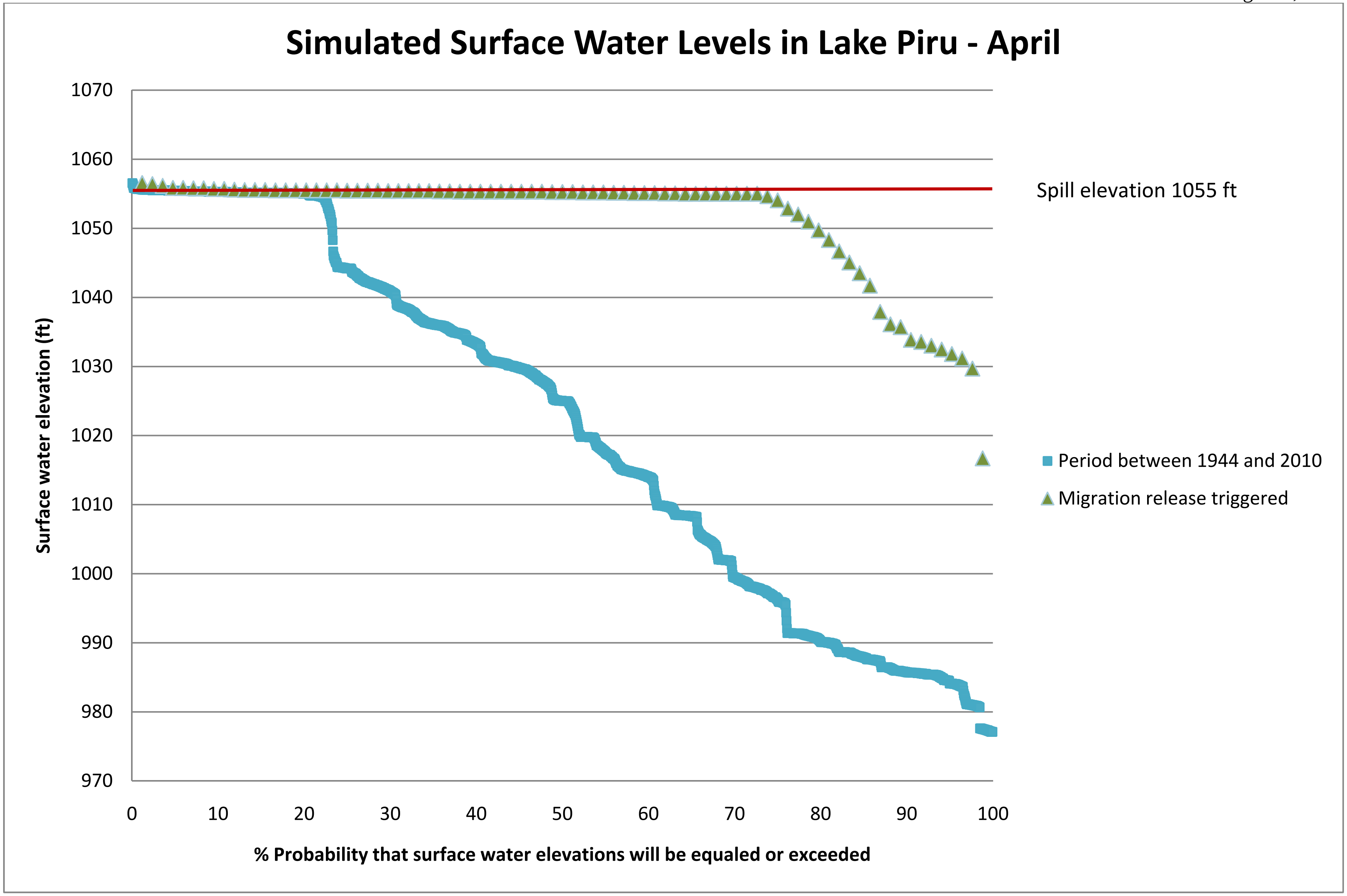


Figure 4 Exceedance graph of simulated water surface elevation for the month of April; based on recorded conditions between 1944 and 2010.

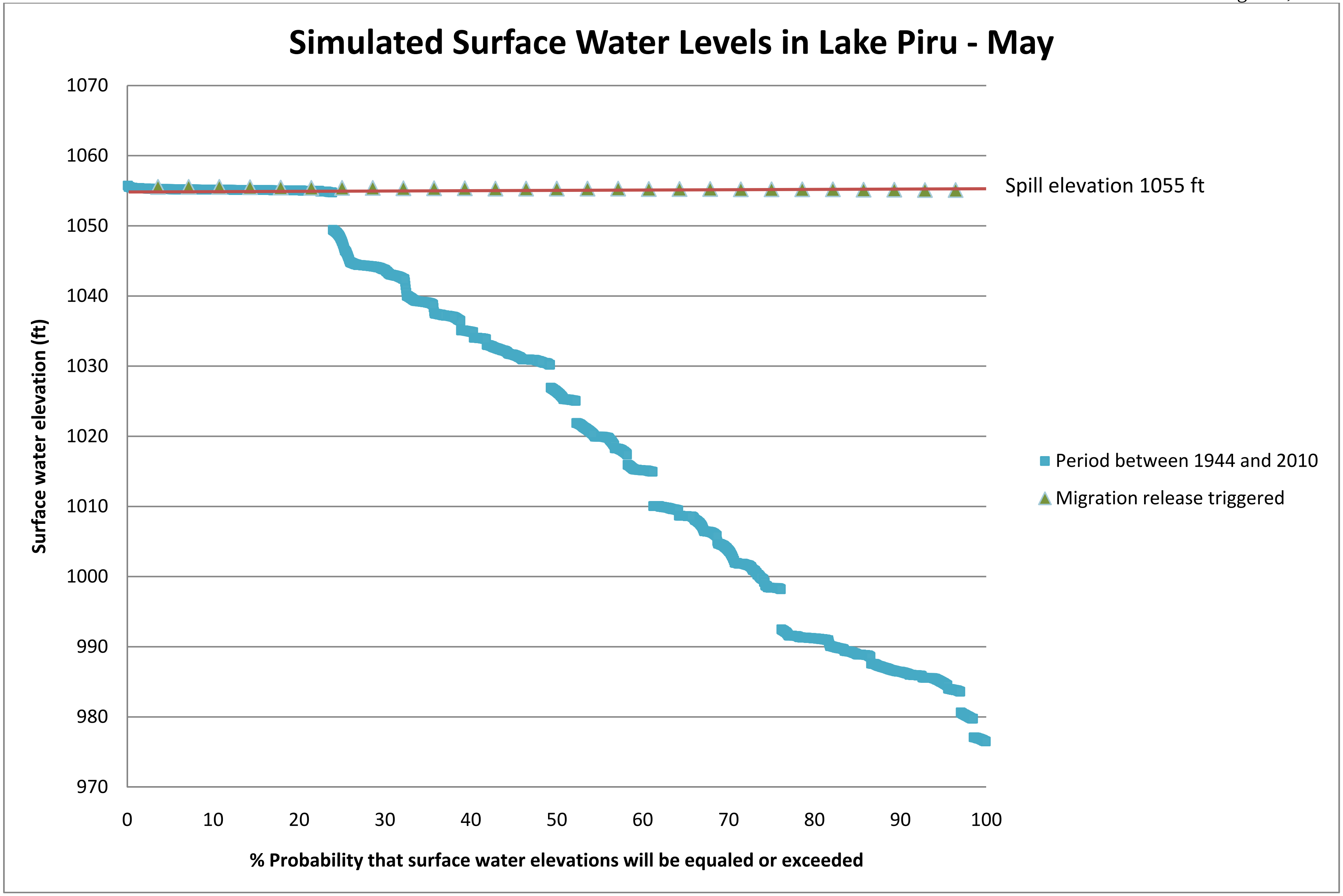


Figure 5 Exceedance graph of simulated water surface elevation for the month of May; based on recorded conditions between 1944 and 2010.

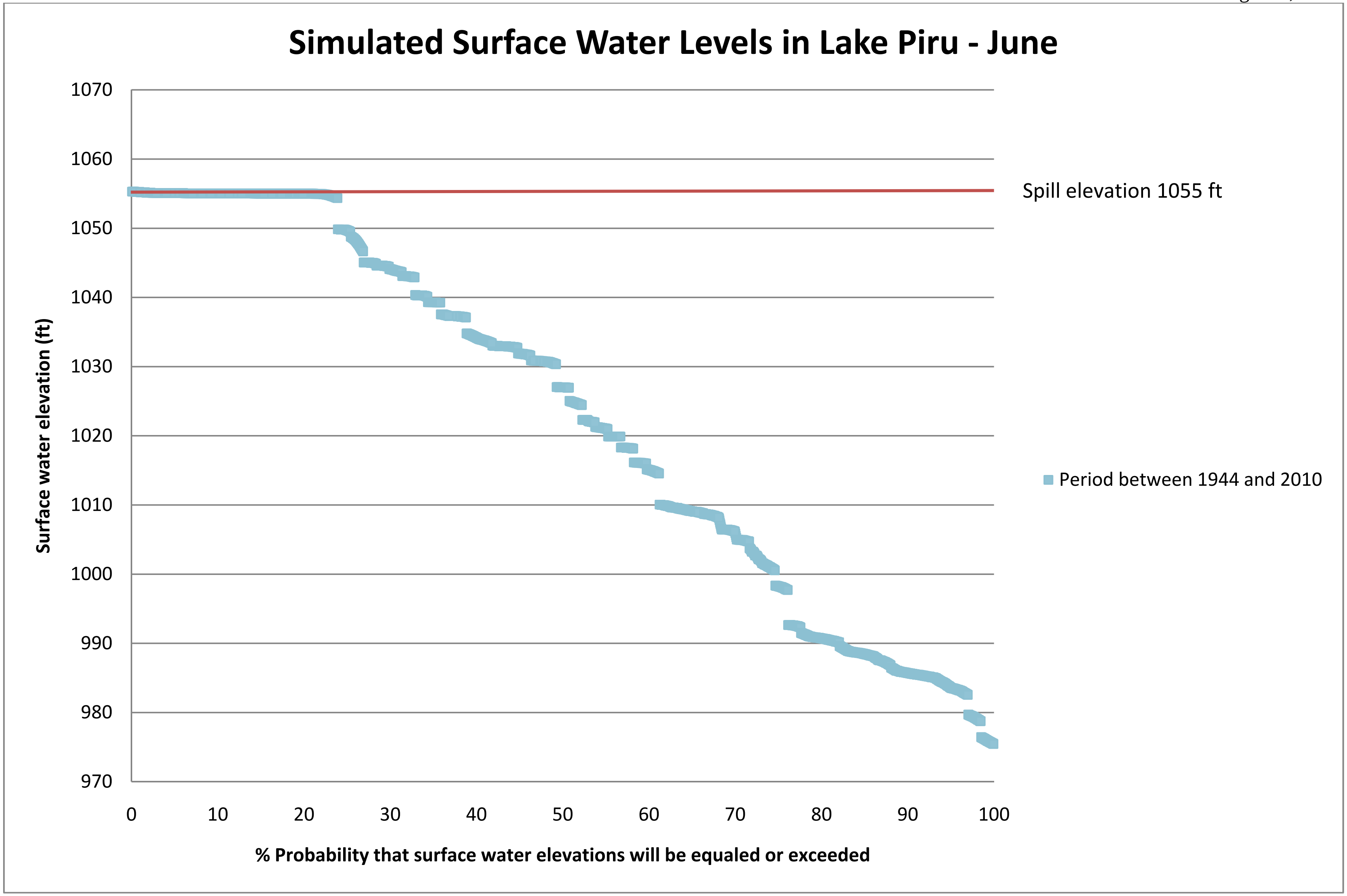


Figure 6 Exceedance graph of simulated water surface elevation for the month of June; based on recorded conditions between 1944 and 2010.

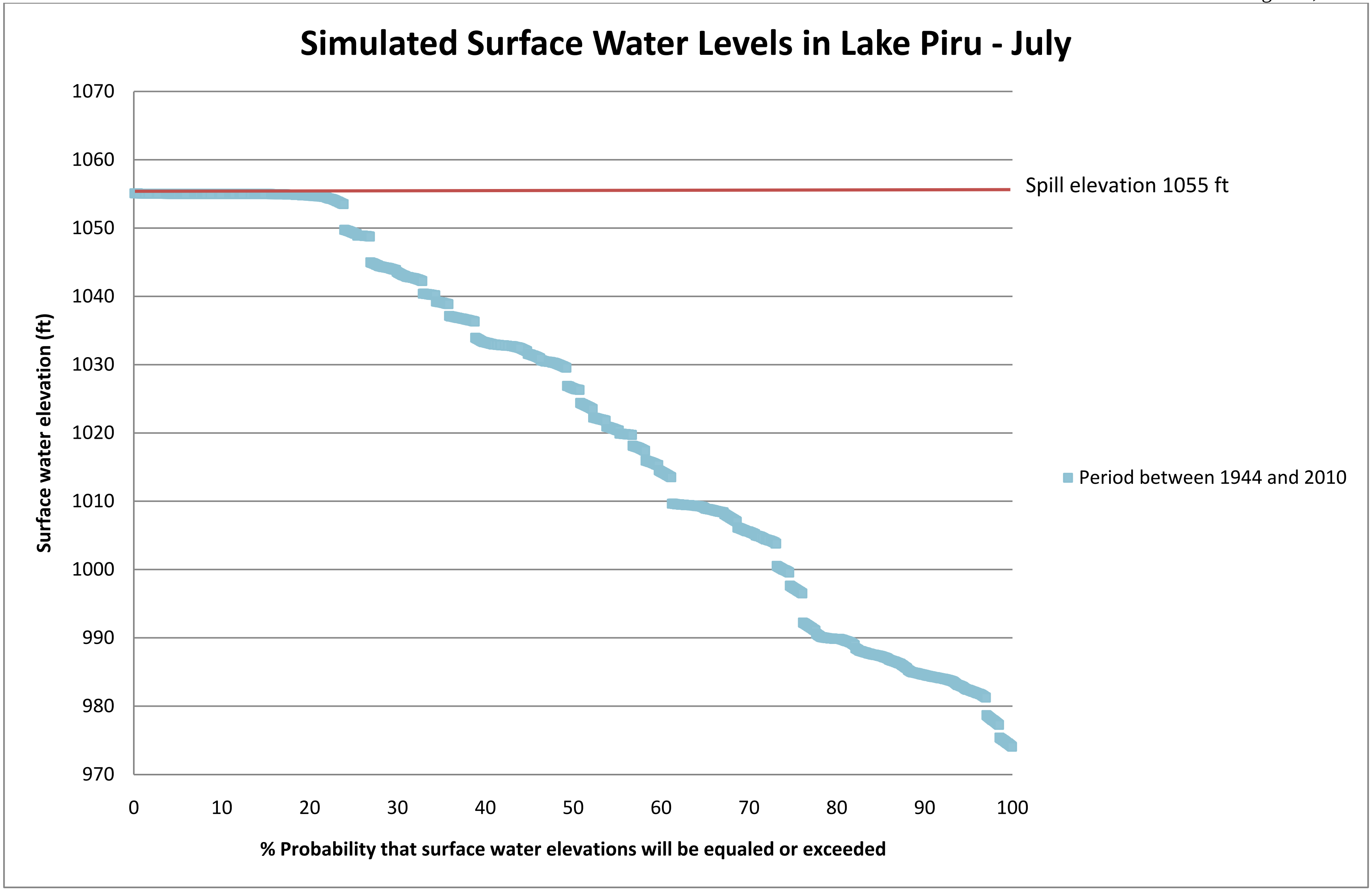


Figure 7 Exceedance graph of simulated water surface elevation for the month of July; based on recorded conditions between 1944 and 2010.

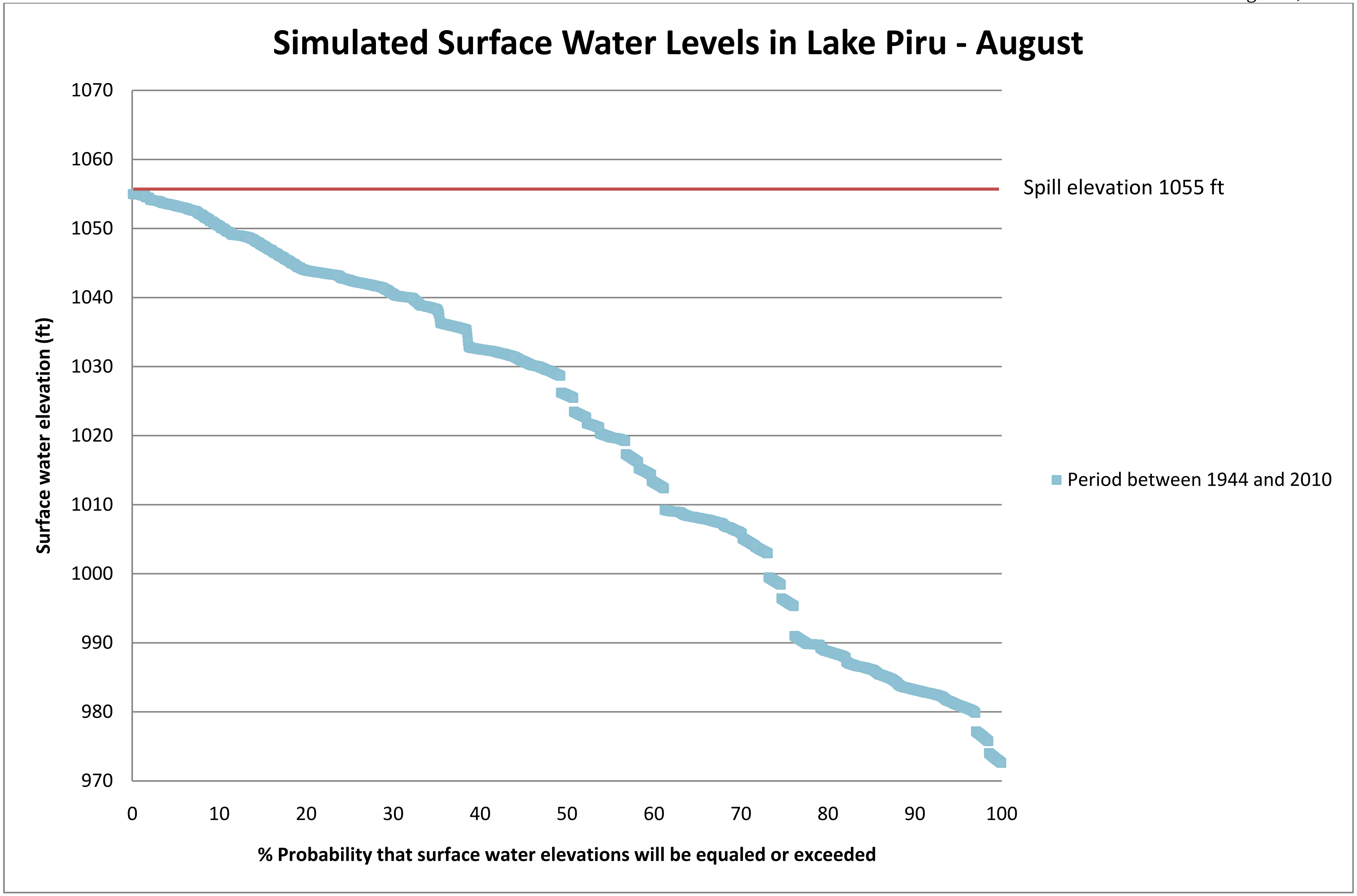


Figure 8 Exceedance graph of simulated water surface elevation for the month of August; based on recorded conditions between 1944 and 2010.

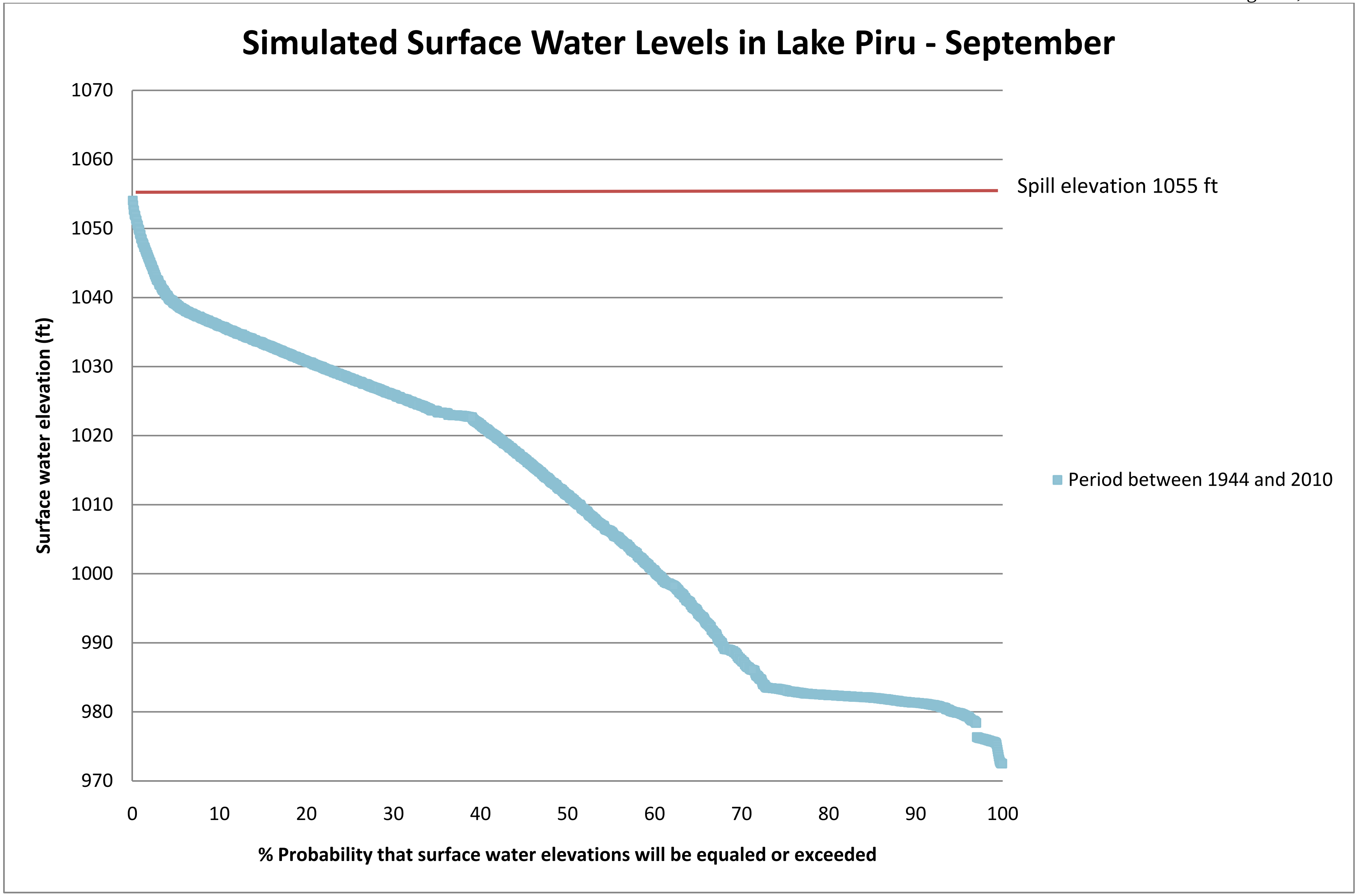


Figure 9 Exceedance graph of simulated water surface elevation for the month of September; based on recorded conditions between 1944 and 2010.

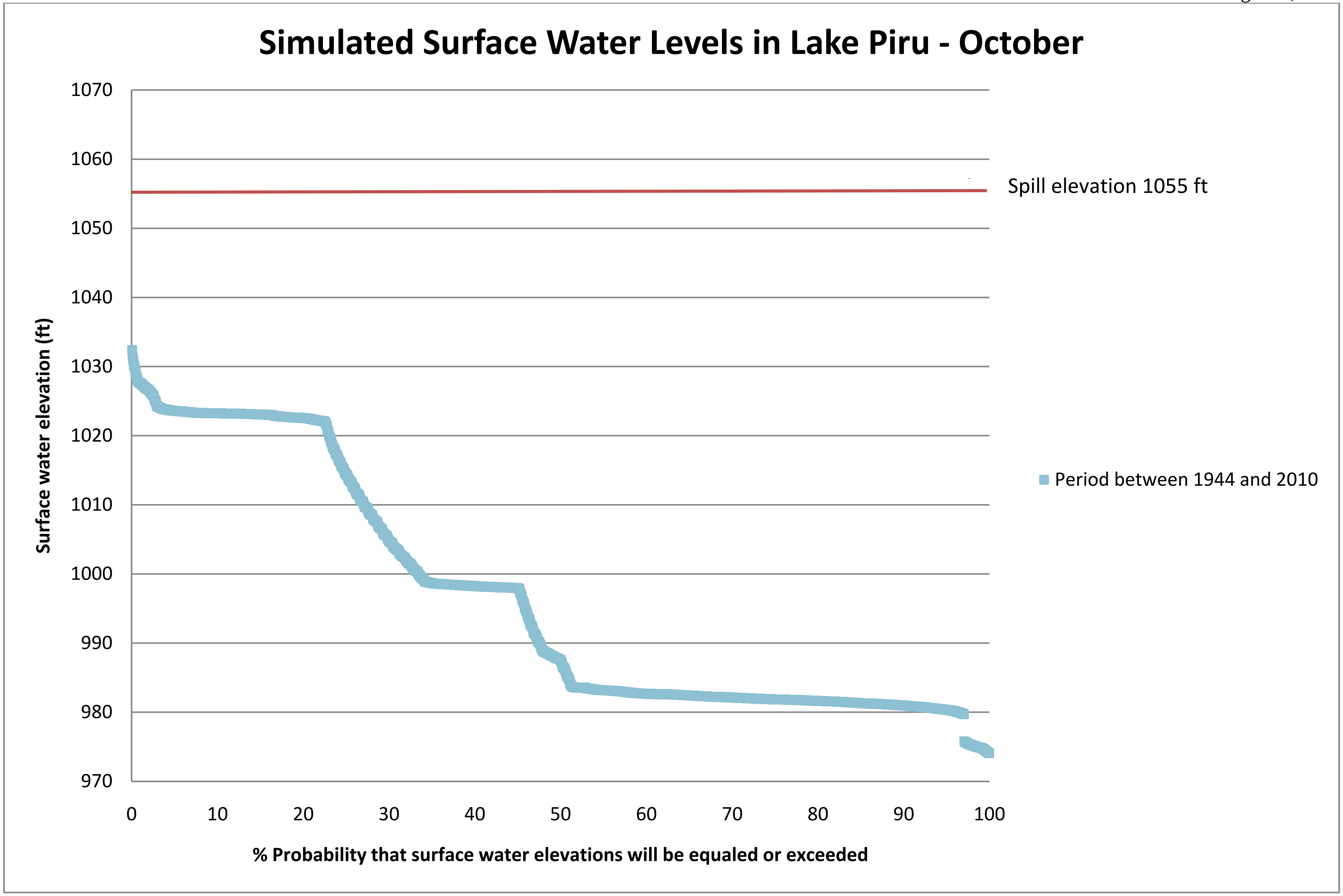


Figure 10 Exceedance graph of simulated water surface elevation for the month of October; based on recorded conditions between 1944 and 2010.

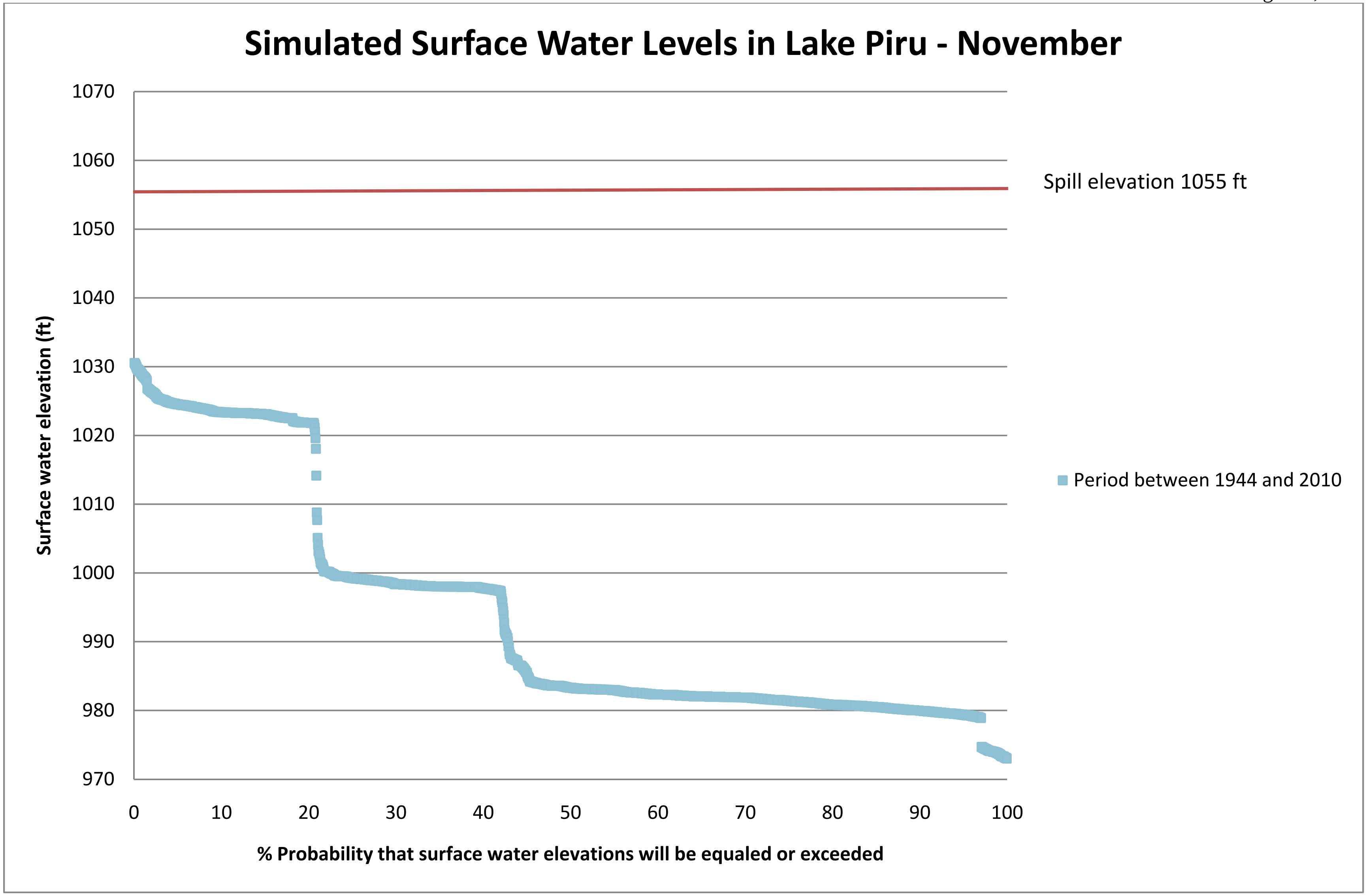


Figure 11 Exceedance graph of simulated water surface elevation for the month of November; based on recorded conditions between 1944 and 2010.

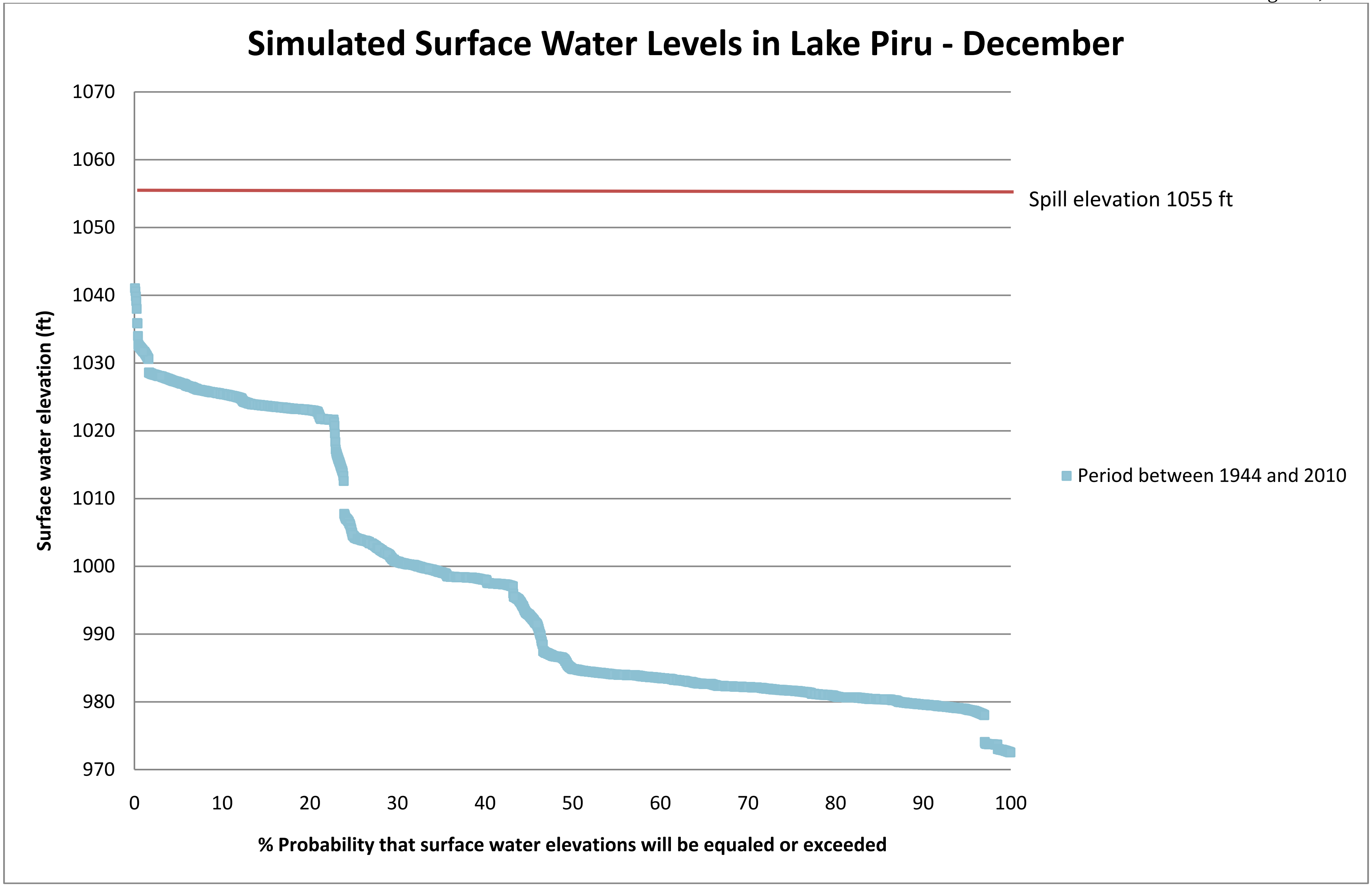


Figure 12 Exceedance graph of simulated water surface elevation for the month of December; based on recorded conditions between 1944 and 2010.

3.0 Operations

3.1 Pyramid Operations (Flows in Middle Piru Creek)

In April of 2005, operating criteria for releases out of Pyramid Dam were amended to support the life cycle requirements of the federally endangered arroyo toad. Current releases from Pyramid Lake to middle Piru Creek are designed to simulate the natural hydrology of middle Piru Creek to the extent operationally feasible and consistent with safety considerations. Throughout the year releases from Pyramid Dam into middle Piru Creek are similar to the natural inflows of water into Pyramid Lake.

Implementation of the above operational guidelines results in a flashier flow regime, with substantial volumes of water passing through middle Piru Creek following storm events. During late summer and fall, the volume and rate of flows into middle Piru Creek diminishes incrementally in response to smaller volumes of natural surface water flows entering Pyramid Lake. It is common for releases from Pyramid Dam to be terminated during these periods.

Exceedance graphs presented in Figures 13 through 24 were developed using recorded flow data from the period between 1944 and 1973, the latter being the year that Pyramid Lake was constructed. Recorded flow rates for the period between 1944 and 1955, the year Lake Piru was constructed, were obtained from USGS gaging station # 1111000 (located below Lake Piru). Flow rates for the period between 1955 and 1973 were obtained from USGS gaging station #11109600 (located near Blue Point between Pyramid Lake and Lake Piru). The graphs show the percentage probability that flows in middle Piru Creek would be equaled or exceeded during each month of the year under current release procedures at Pyramid Dam. The exceedance graphs are presented in logarithmic scale, and therefore do not show data points for zero flow.

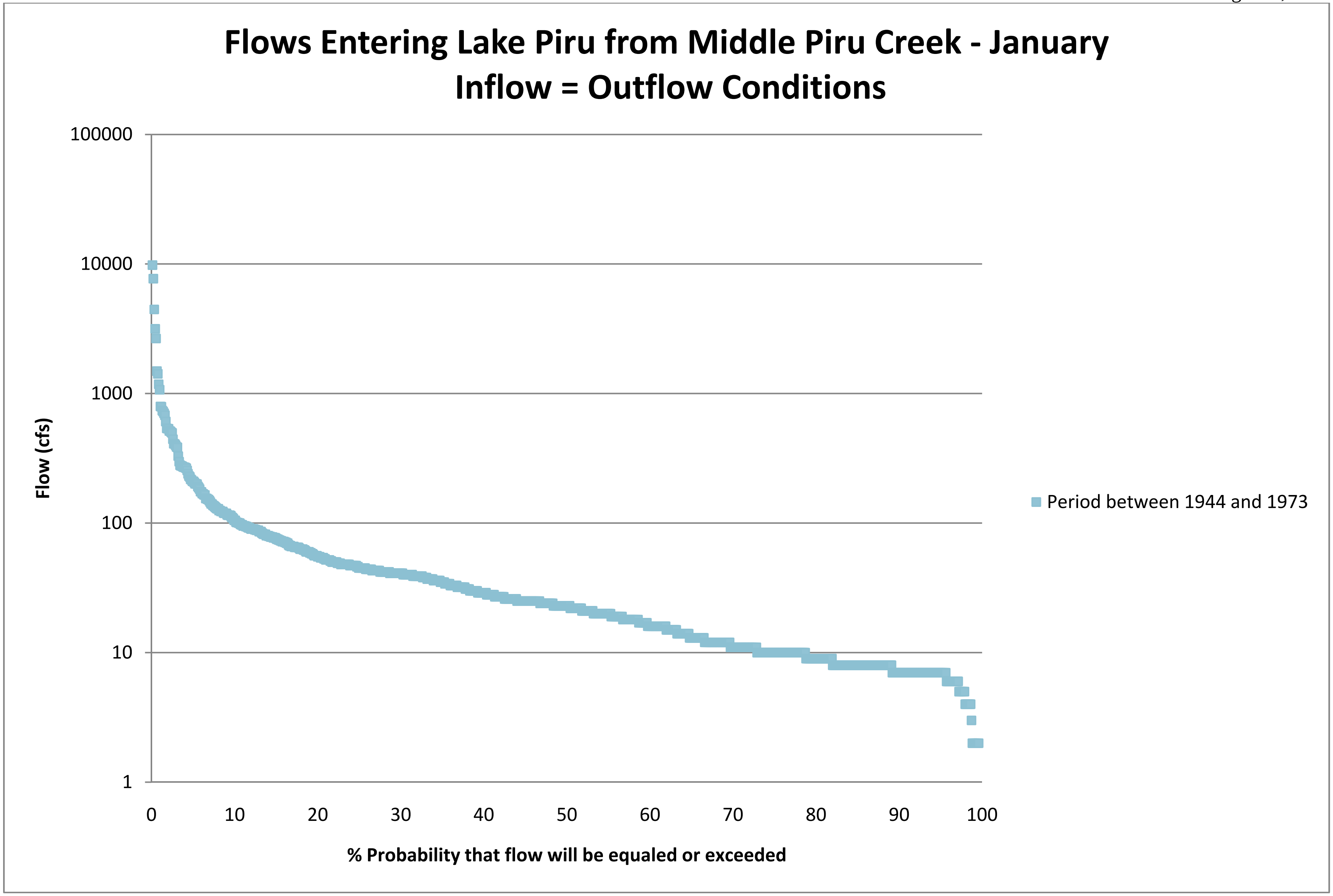


Figure 13 Exceedance graph of flow rates in middle Piru Creek during the month of January; based on recorded conditions between 1944 and 1973.

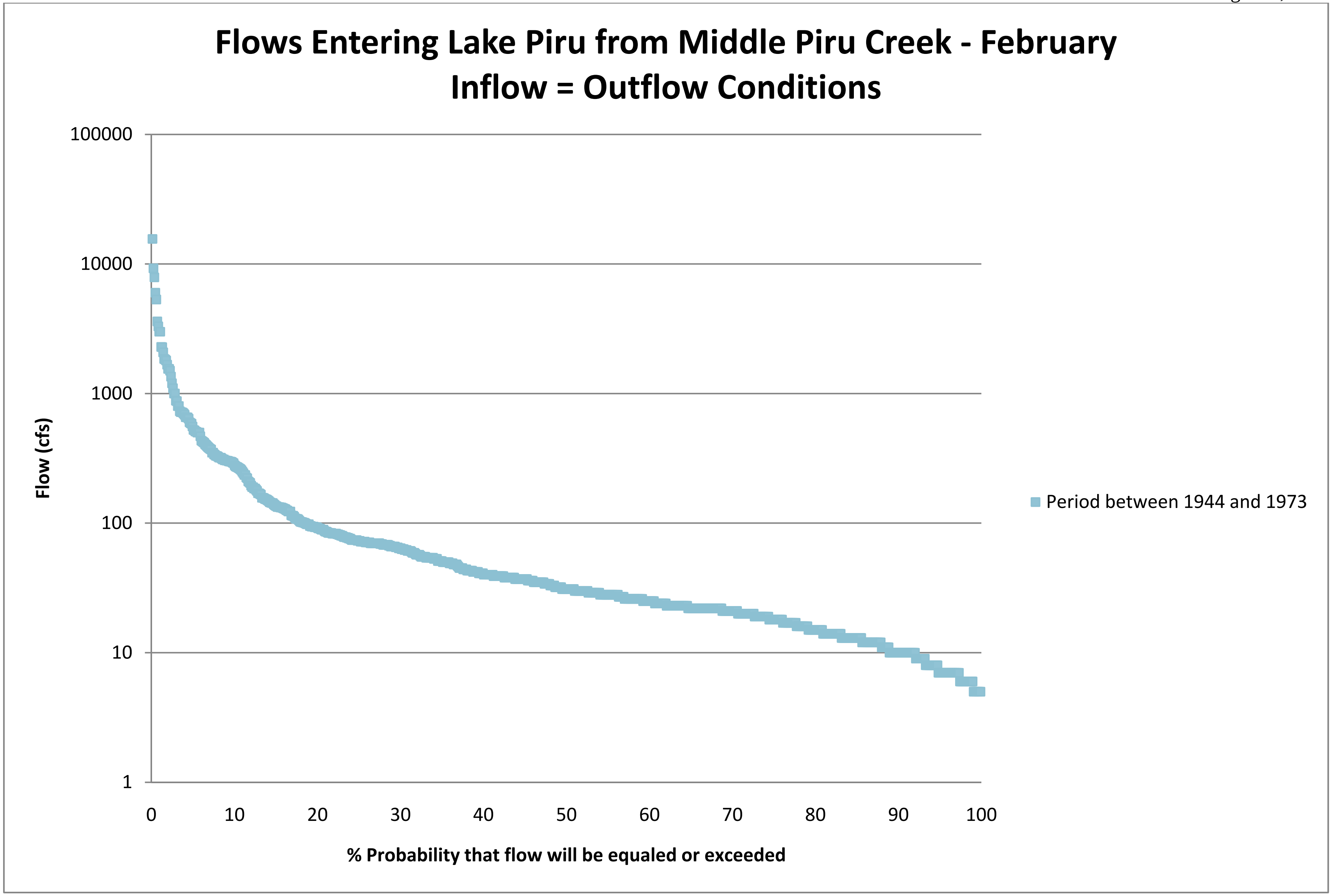


Figure 14 Exceedance graph of flow rates in middle Piru Creek during the month of February; based on recorded conditions between 1944 and 1973.

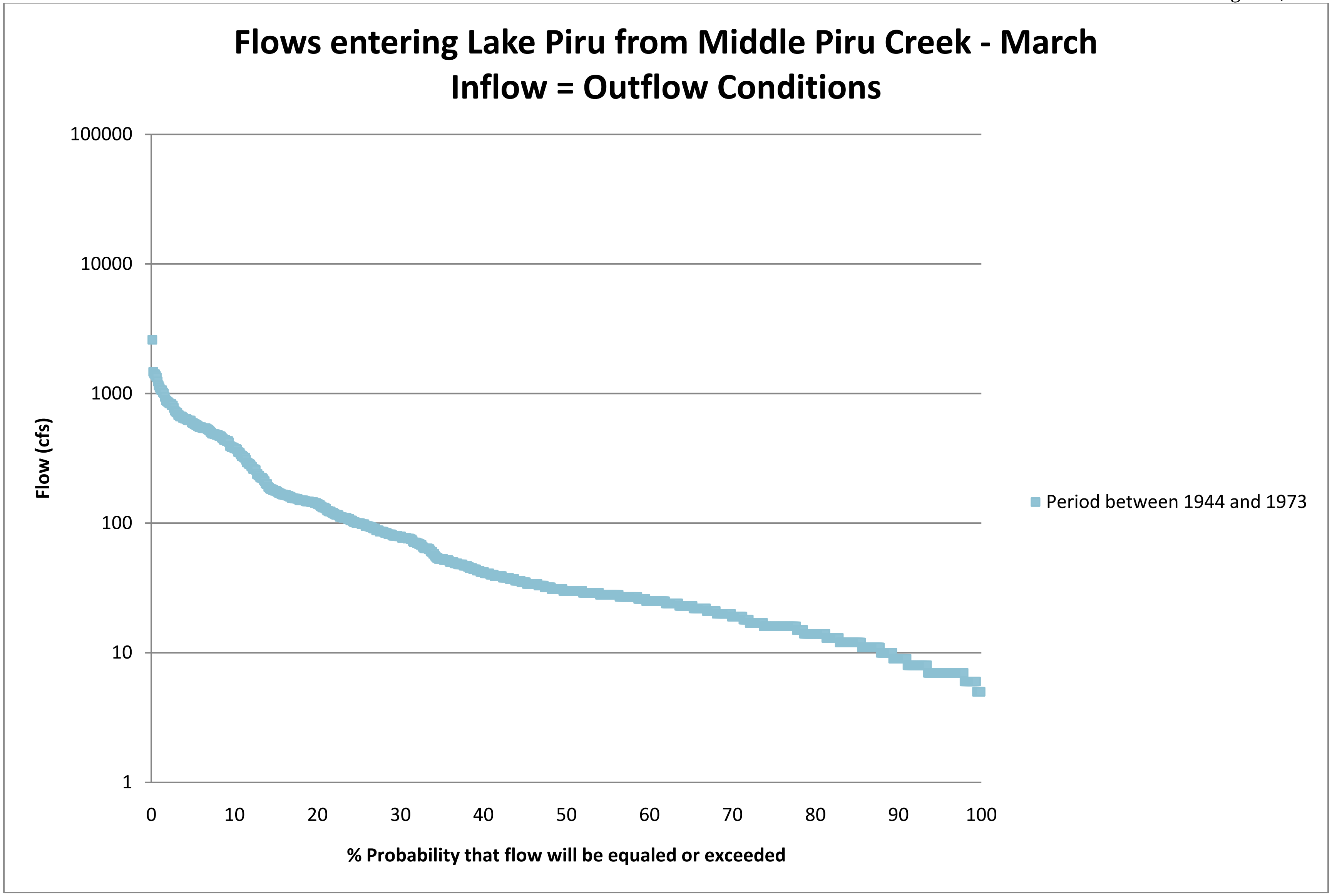


Figure 15 Exceedance graph of flow rates in middle Piru Creek during the month of March; based on recorded conditions between 1944 and 1973.

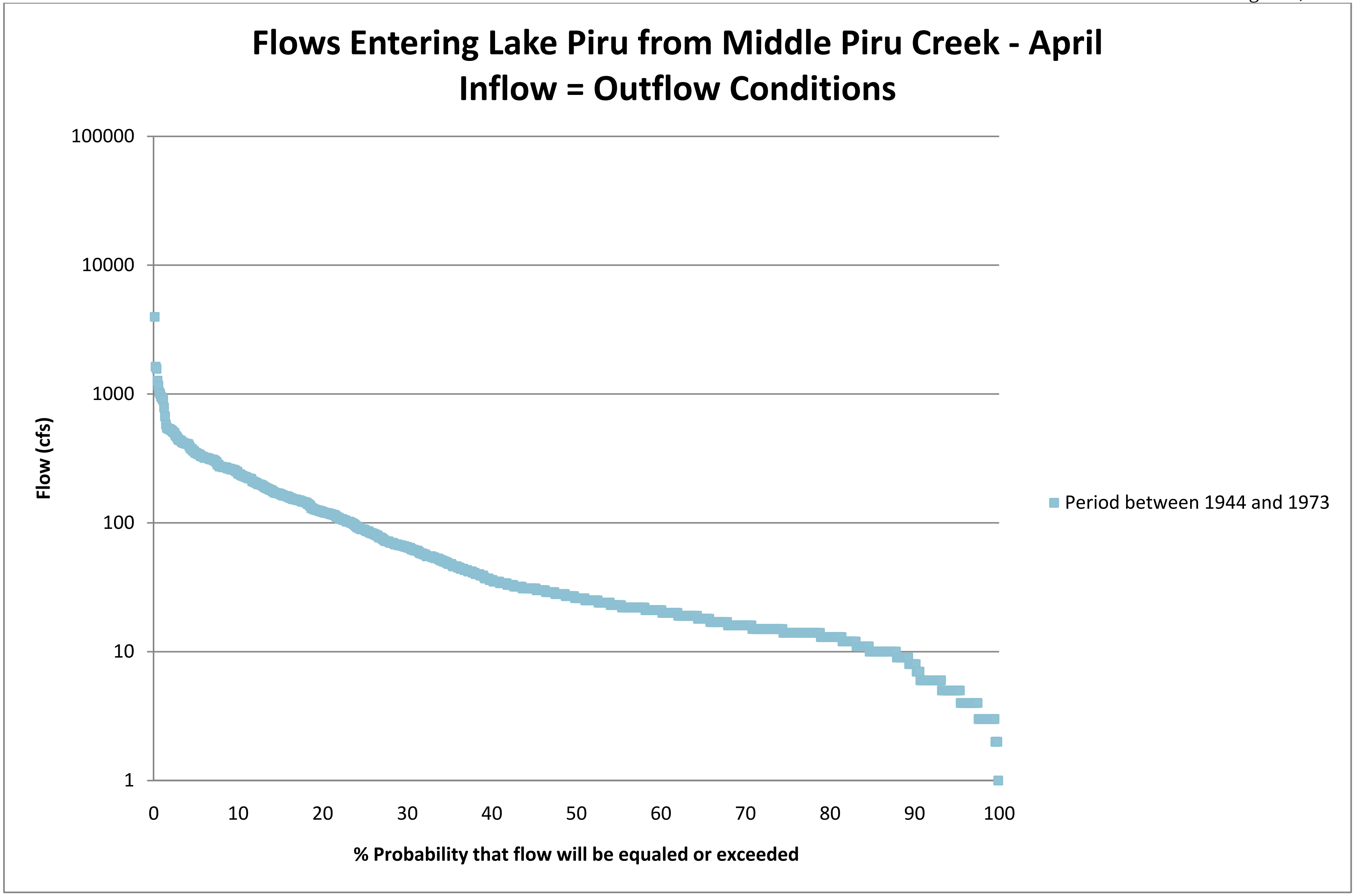


Figure 16 Exceedance graph of flow rates in middle Piru Creek during the month of April; based on recorded conditions between 1944 and 1973.

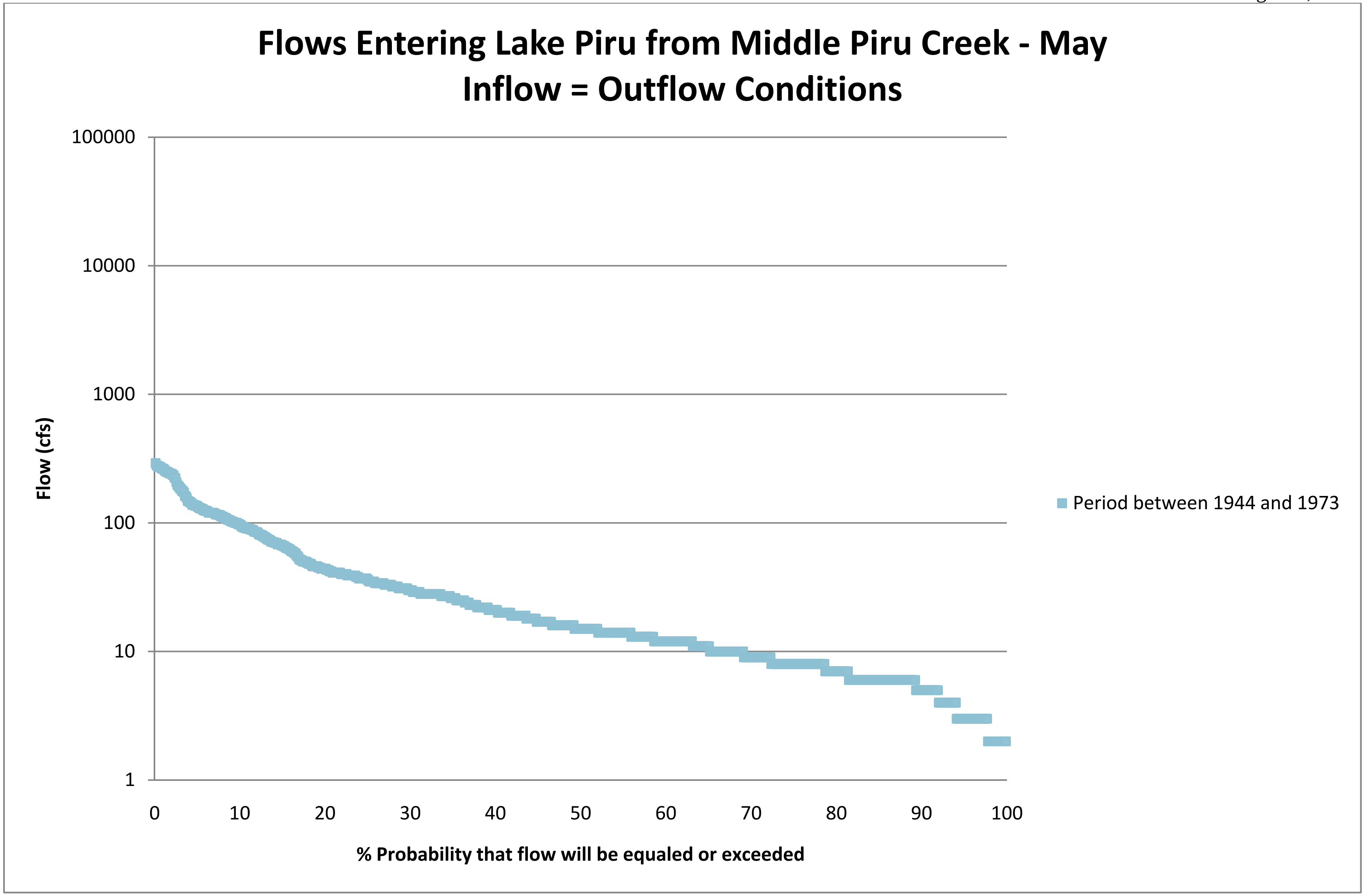


Figure 17 Exceedance graph of flow rates in middle Piru Creek during the month of May; based on recorded conditions between 1944 and 1973.

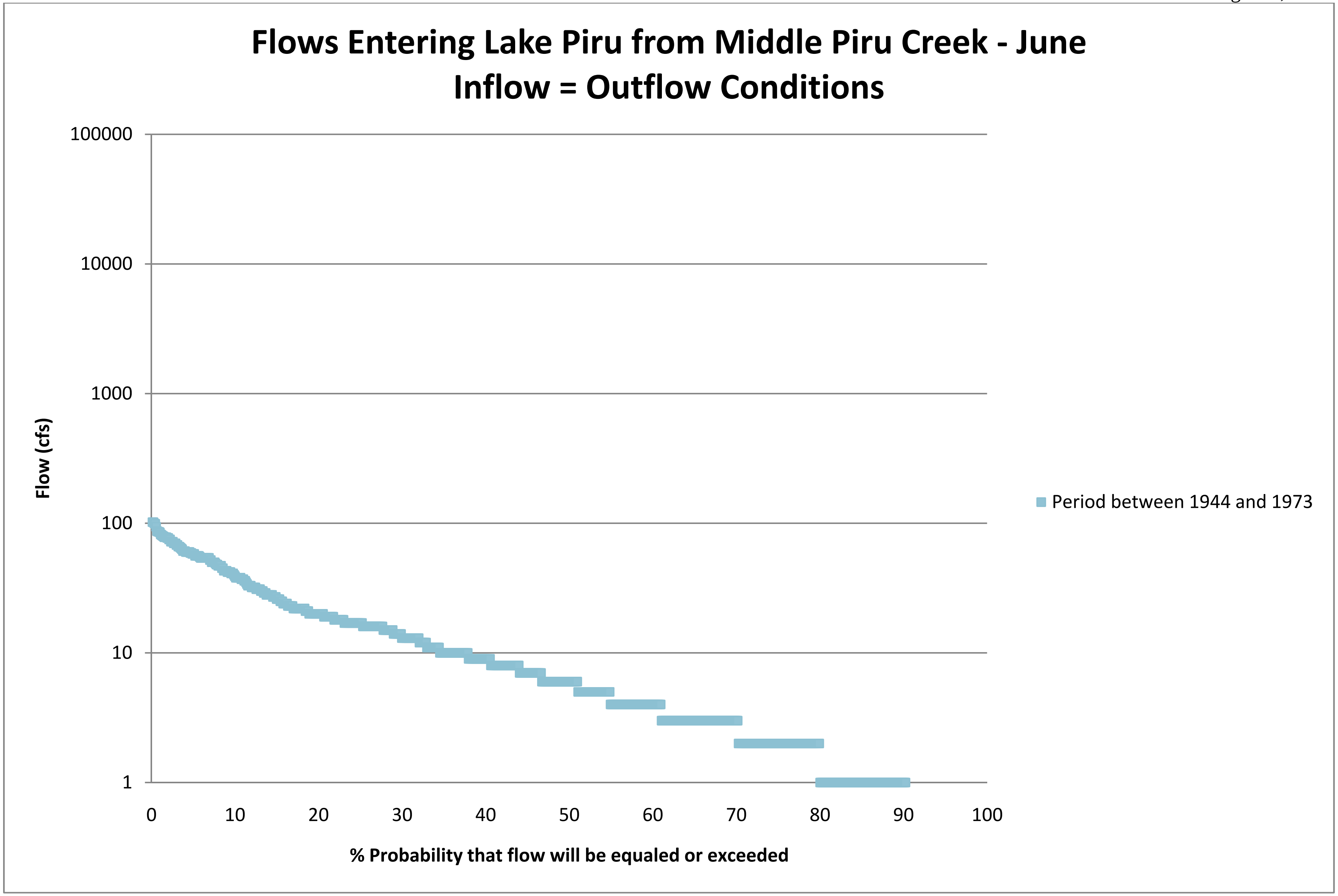


Figure 18 Exceedance graph of flow rates in middle Piru Creek during the month of June; based on recorded conditions between 1944 and 1973.

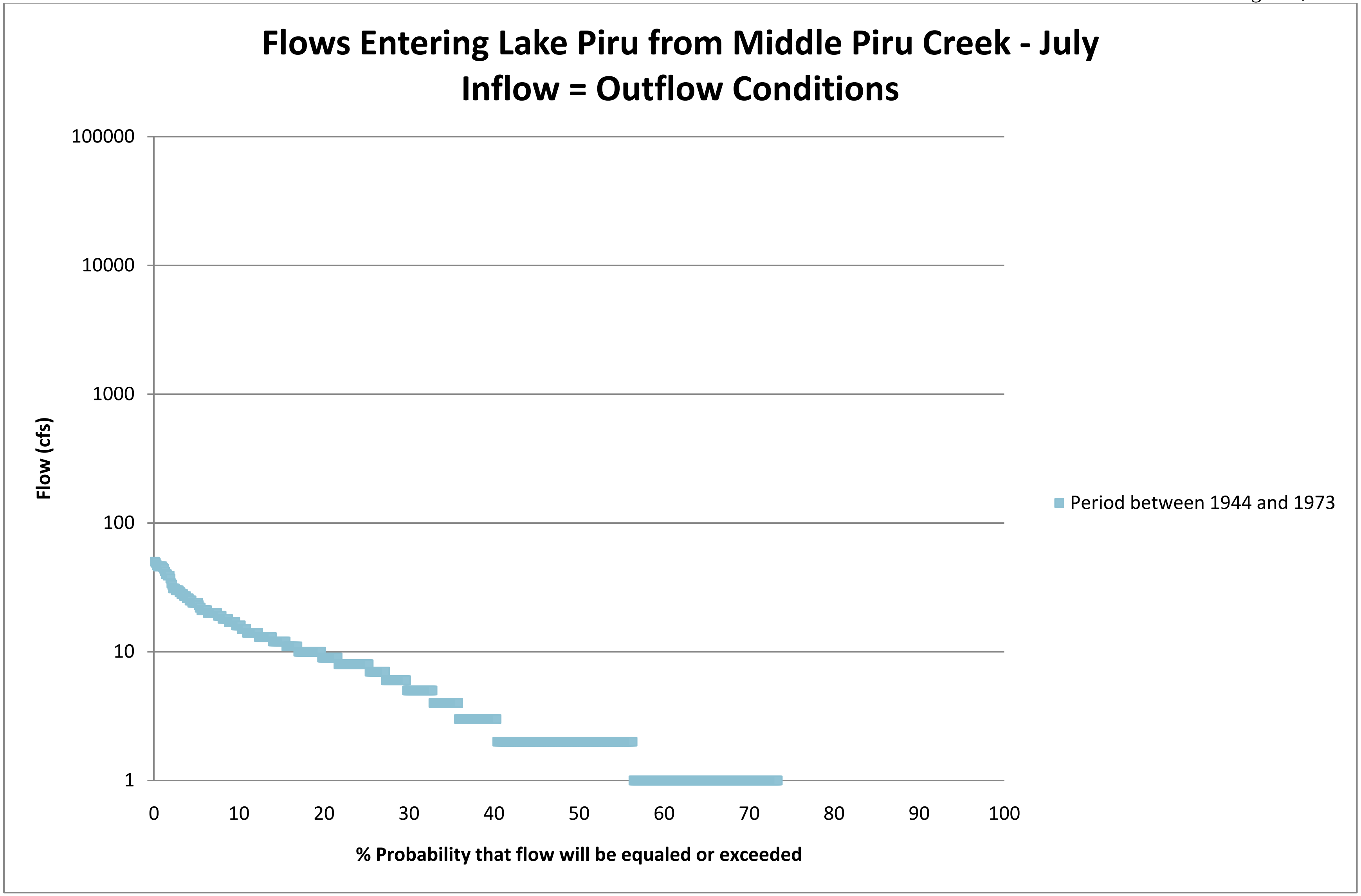


Figure 19 Exceedance graph of flow rates in middle Piru Creek during the month of July; based on recorded conditions between 1944 and 1973.

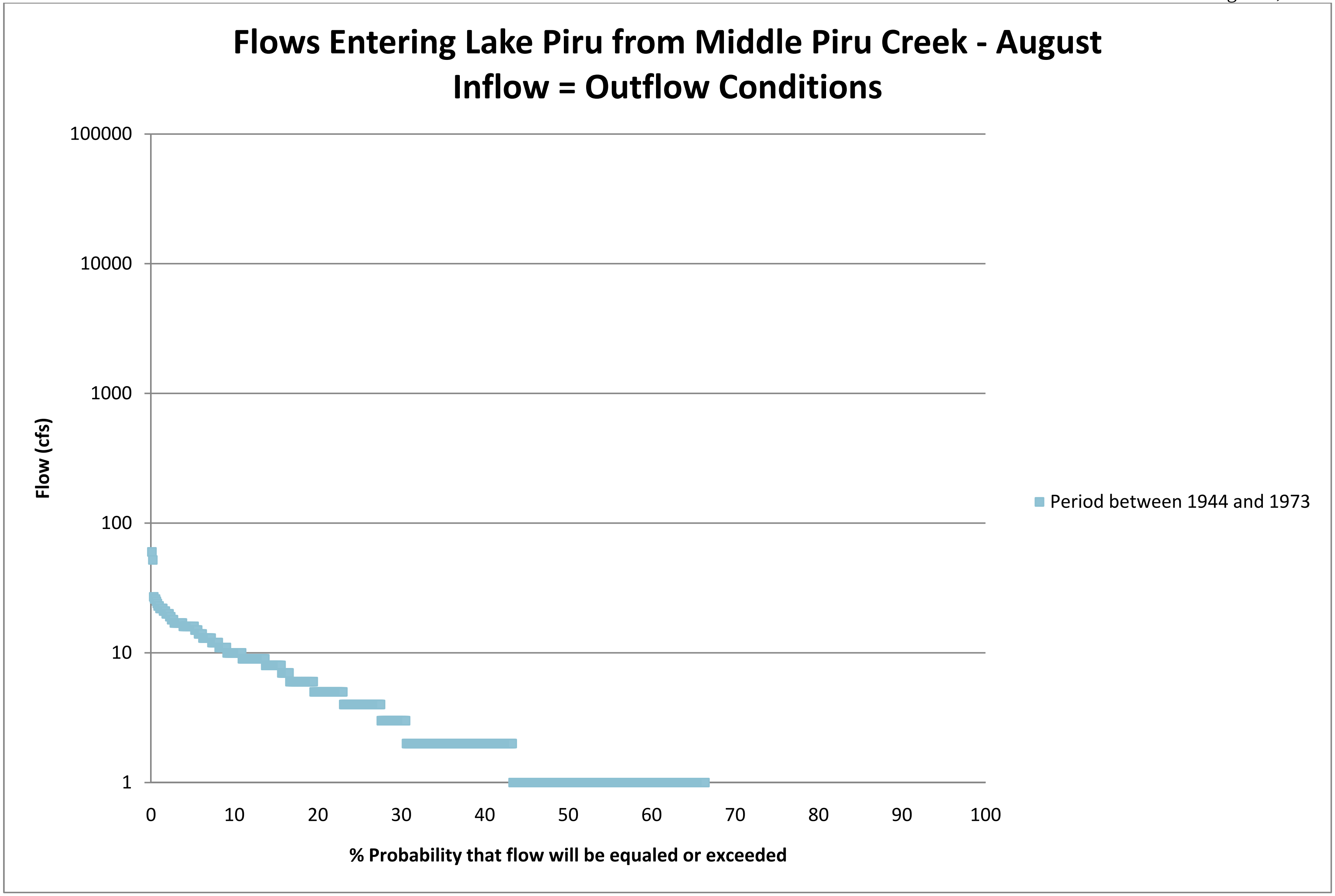


Figure 20 Exceedance graph of flow rates in middle Piru Creek during the month of August; based on recorded conditions between 1944 and 1973.

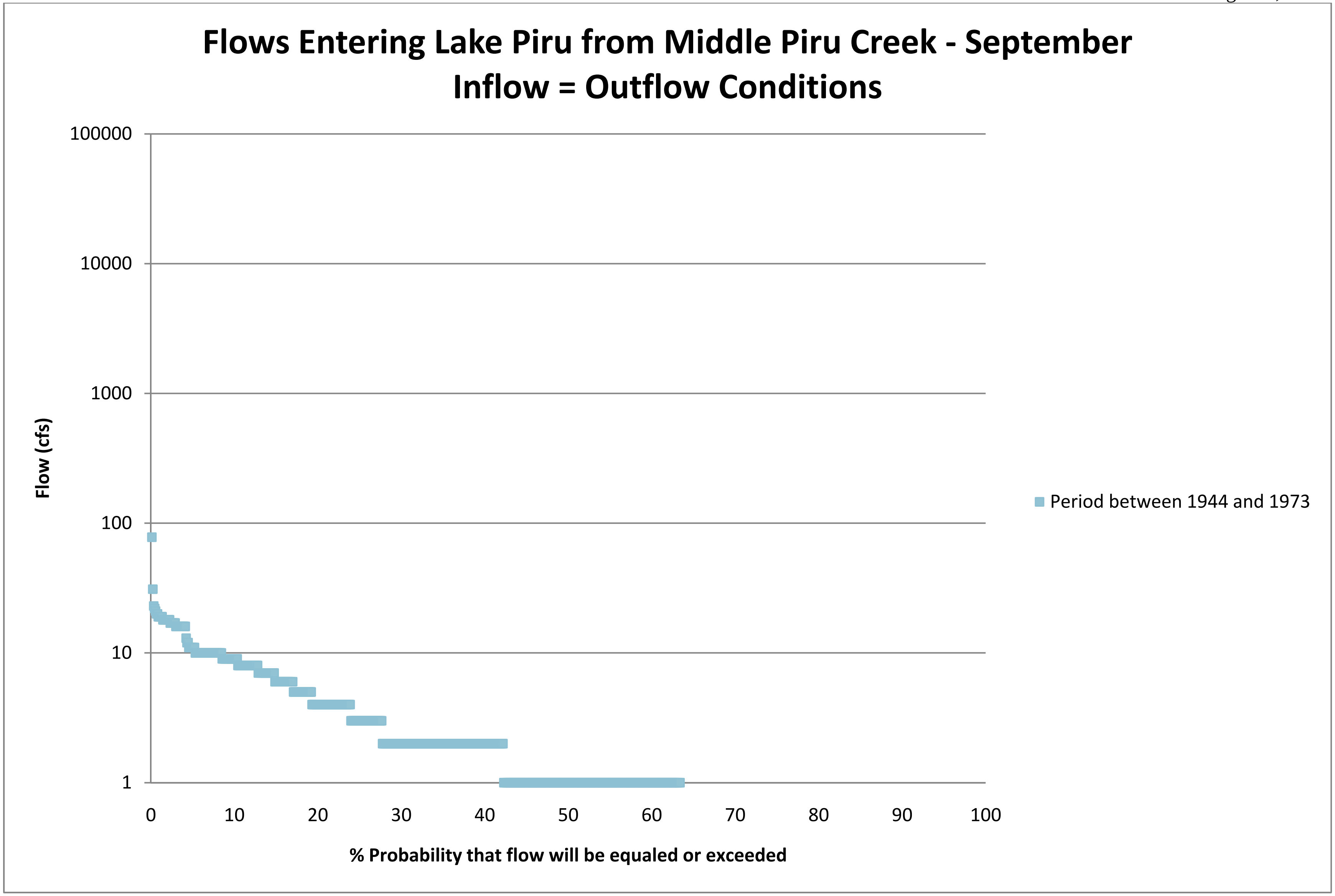


Figure 21 Exceedance graph of flow rates in middle Piru Creek during the month of September; based on recorded conditions between 1944 and 1973.

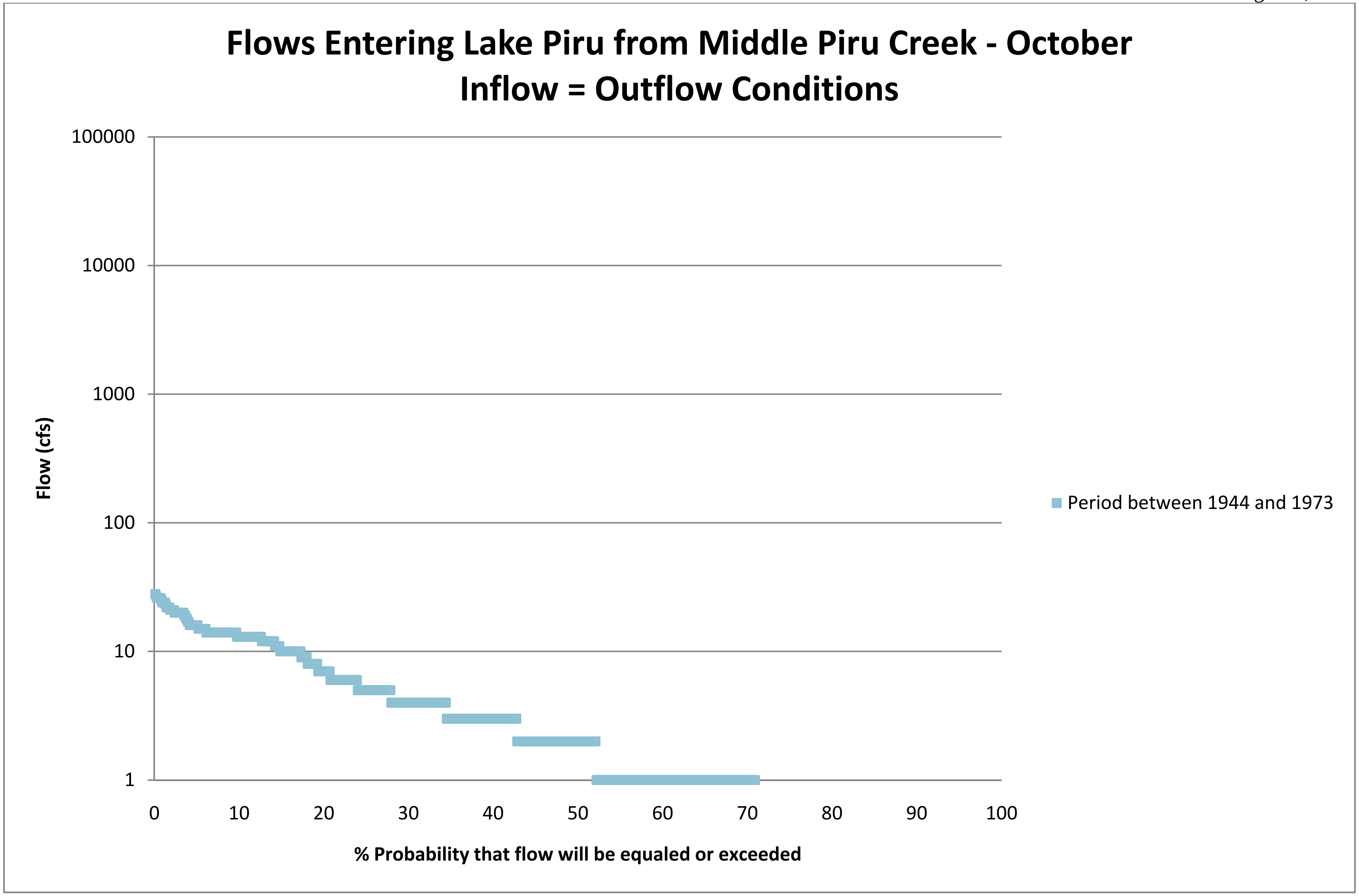


Figure 22 Exceedance graph of flow rates in middle Piru Creek during the month of October; based on recorded conditions between 1944 and 1973.

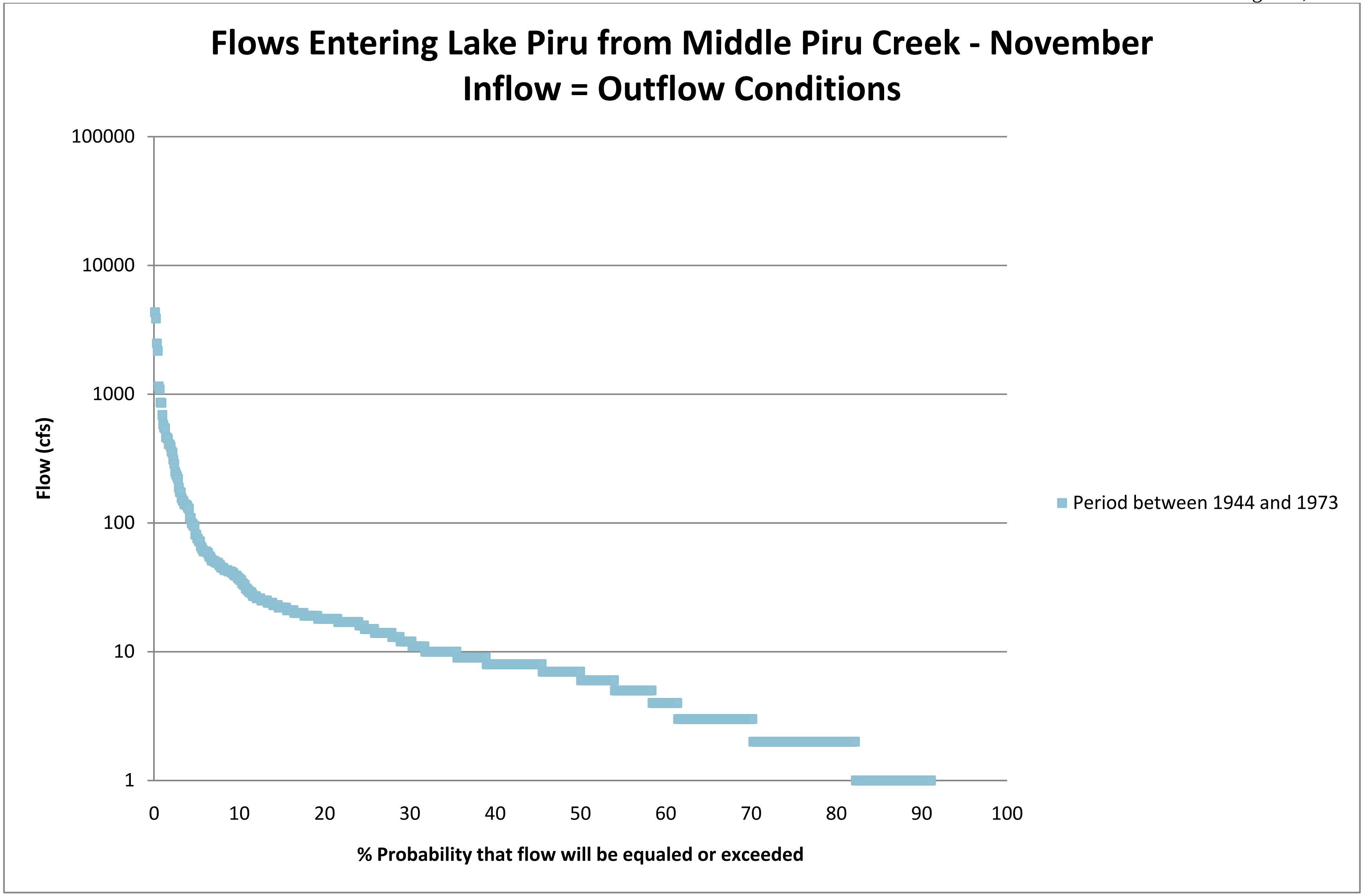


Figure 23 Exceedance graph of flow rates in middle Piru Creek during the month of November; based on recorded conditions between 1944 and 1973.

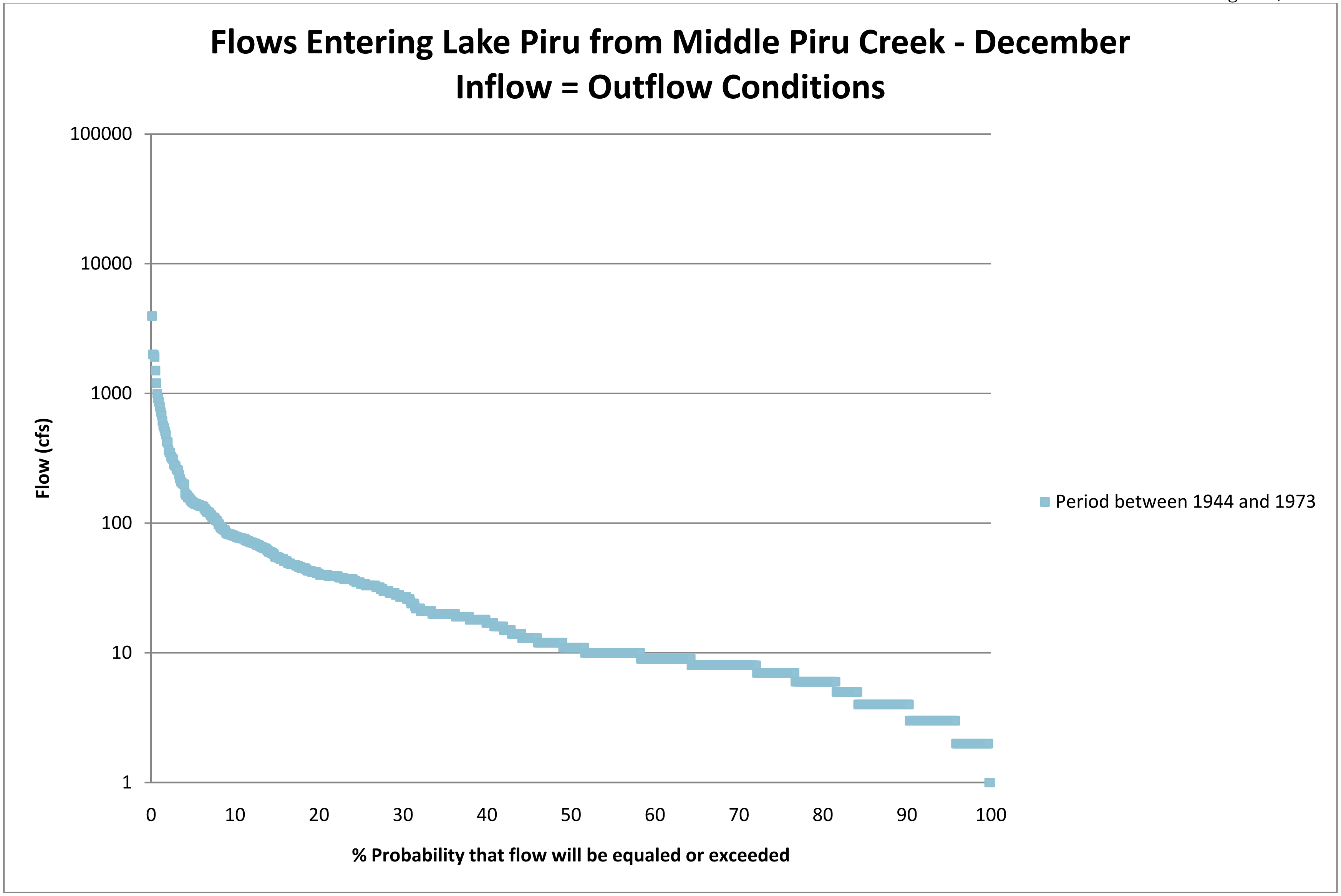


Figure 24 Exceedance graph of flow rates in middle Piru Creek during the month of December; based on recorded conditions between 1944 and 1973.

3.2 Santa Felicia Operations (Flows in Lower Piru Creek)

In June of 2011, United began implementing the Water Release Plan that was developed in compliance with United's license from the Federal Energy Regulatory Commission (FERC) to operate the Santa Felicia Project. The Water Release Plan includes criteria for both habitat and migration flow releases and is presented in the Box share site referenced in Section 1.0 (Introduction) with this document for the Panel's review. United is currently developing a Water Release Effectiveness Monitoring Plan, and a Ramping Rate and Adaptive Management Plan, and these studies may eventually result in some modifications to the water release schedule.

In order to meet water management goals, United generally conducts a conservation release during the fall of each year. Because the purpose of conservation releases is to meet water management objectives, release strategies may change depending on conditions and future needs. In general, conservation releases begin in September and end by late October or mid November. Releases follow ramping criteria specified in the Water Release Plan, and target maximum flows are in the range of 350 to 400 cfs. During dry and normal years, the release generally continues until lake retention reaches minimum pool of 20,000 acre feet. During wet years, when available storage in the Oxnard forebay is limited, the conservation release may be terminated when lake retention reaches 40,000 acre feet.

The exceedance graphs presented in Figures 25 through 36 were developed using results from the reservoir model discussed in Section 2 (Lake Piru Water Surface Elevation) and show the percentage probability that flow rates in lower Piru Creek (based on releases from the Santa Felicia dam and spills from Lake Piru) would be equaled or exceeded during each month of the year under current operations given the fifty-plus year period of record of historical flows into Lake Piru.

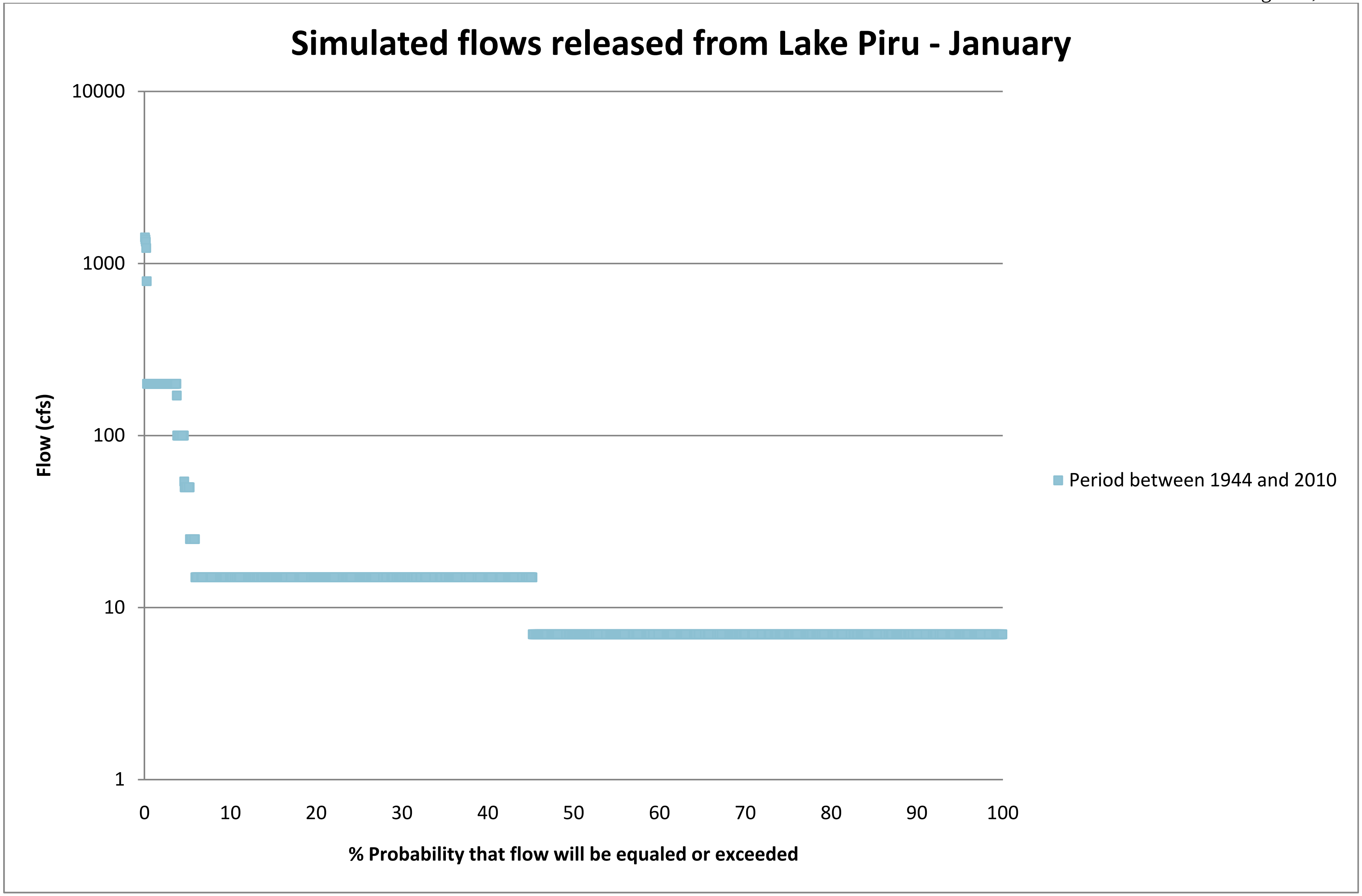


Figure 25 Exceedance graph of simulated flow rates in lower Piru Creek during the month of January; based on recorded conditions between 1944 and 2010.

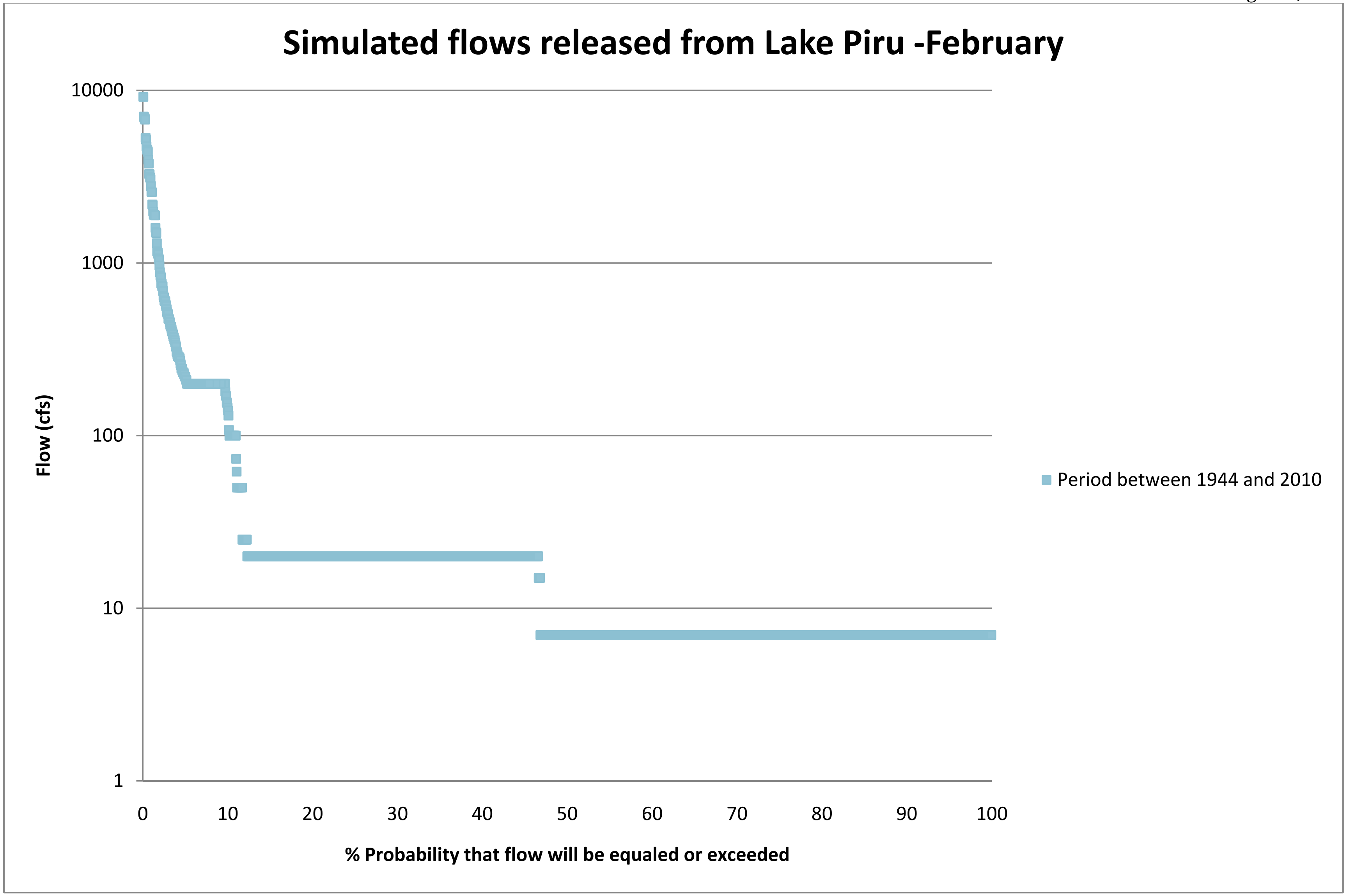


Figure 26 Exceedance graph of simulated flow rates in lower Piru Creek during the month of February; based on recorded conditions between 1944 and 2010.

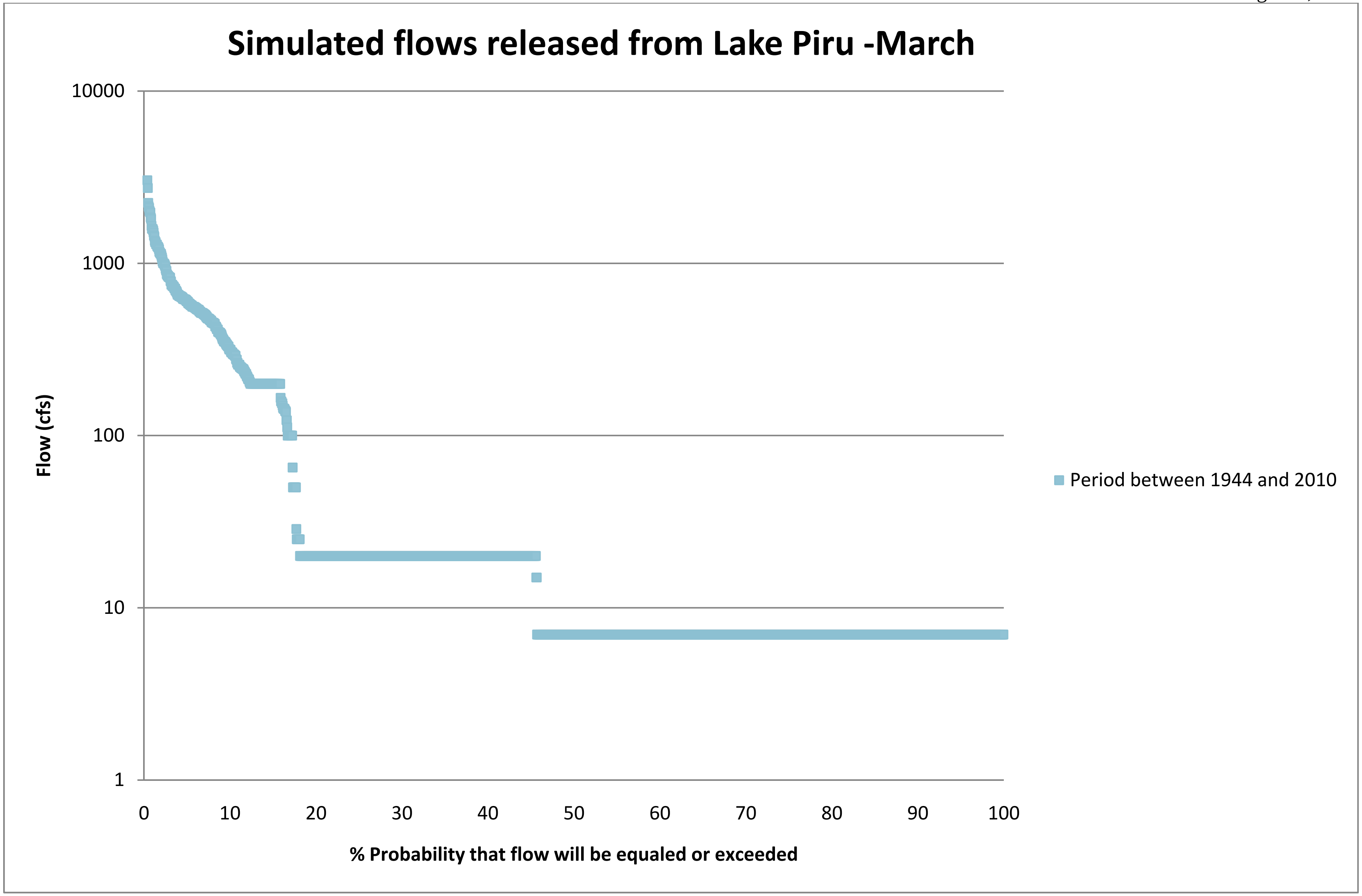


Figure 27 Exceedance graph of simulated flow rates in lower Piru Creek during the month of March; based on recorded conditions between 1944 and 2010.

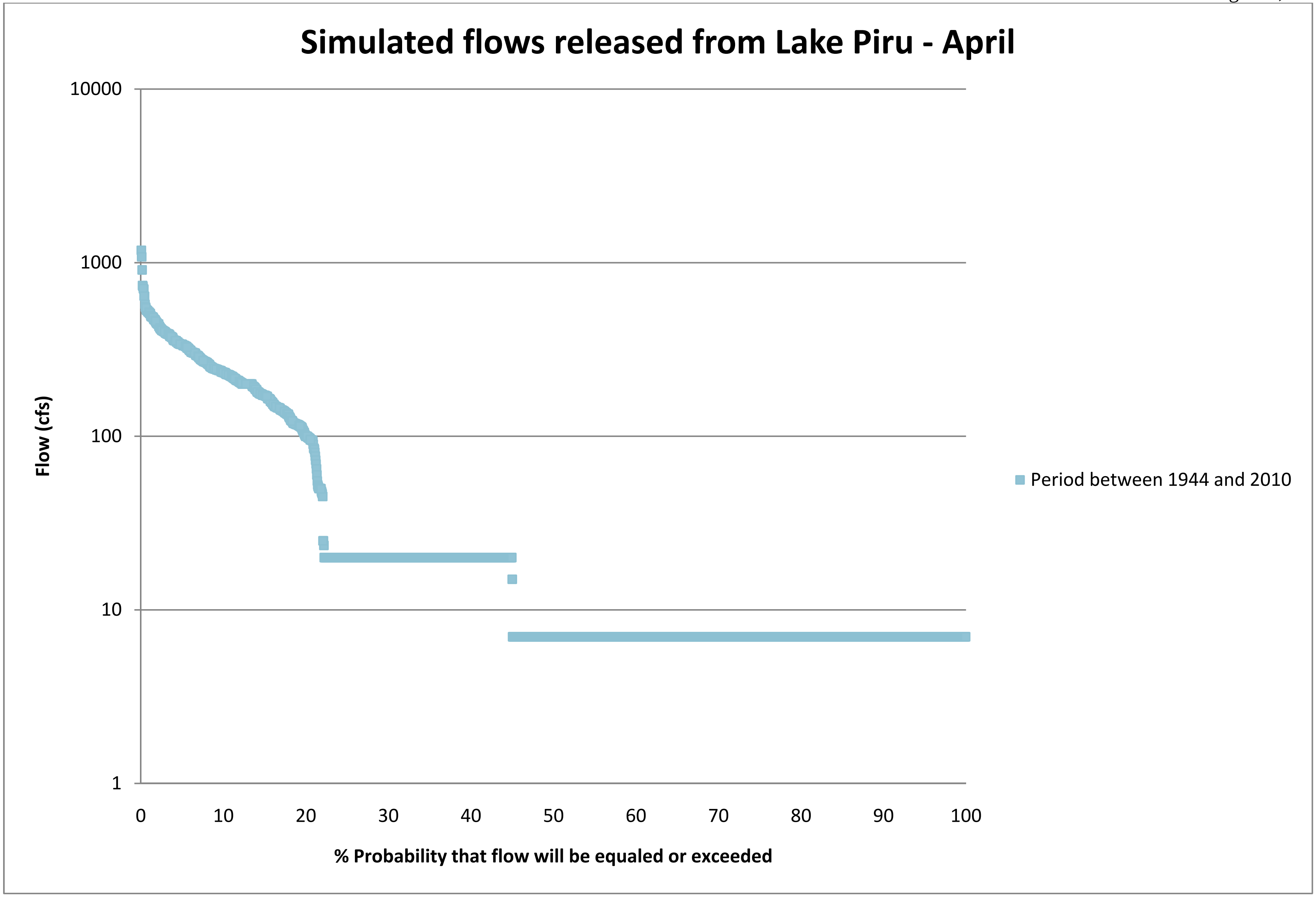


Figure 28 Exceedance graph of simulated flow rates in lower Piru Creek during the month of April; based on recorded conditions between 1944 and 2010.

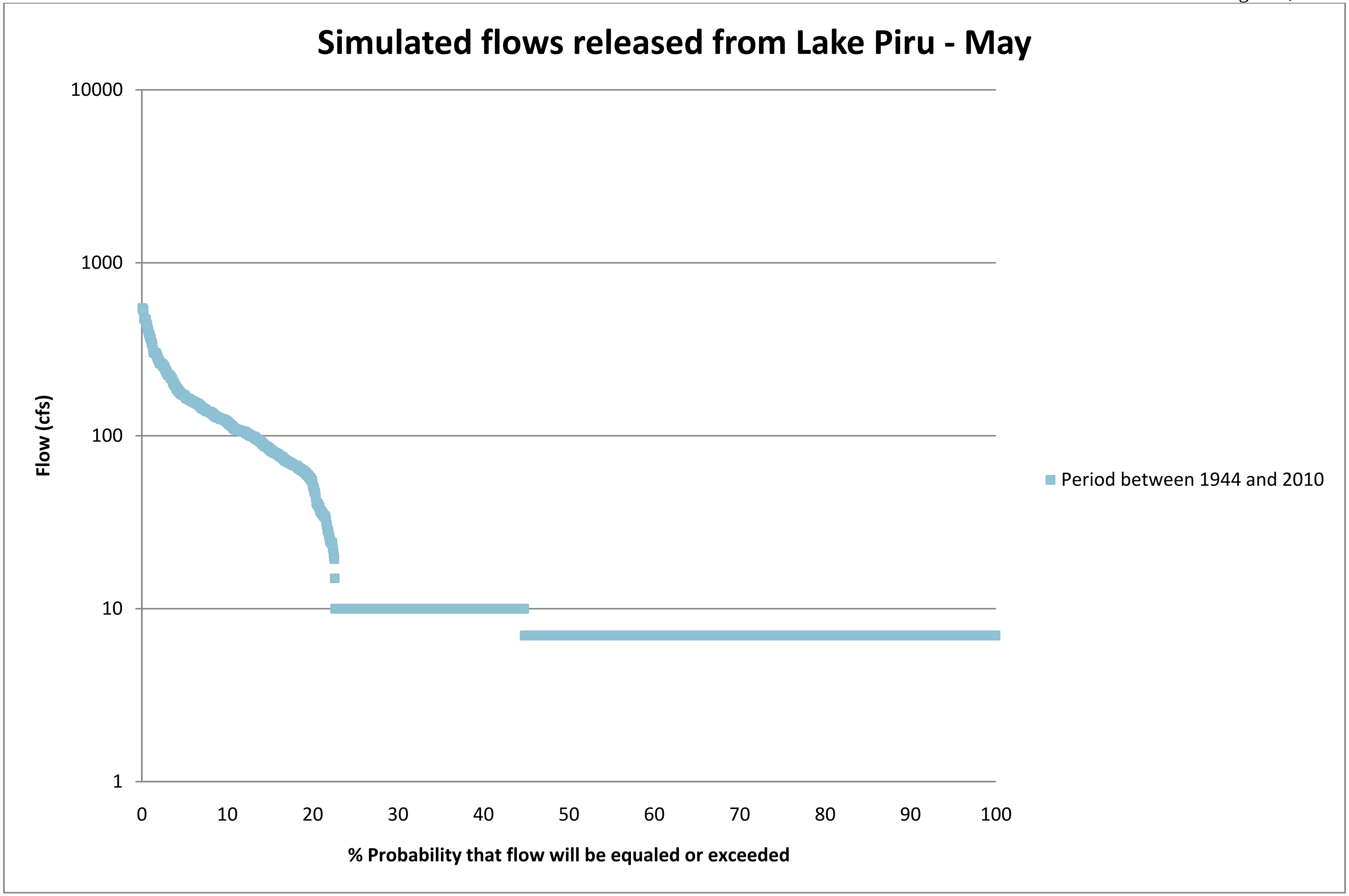


Figure 29 Exceedance graph of simulated flow rates in lower Piru Creek during the month of May; based on recorded conditions between 1944 and 2010.

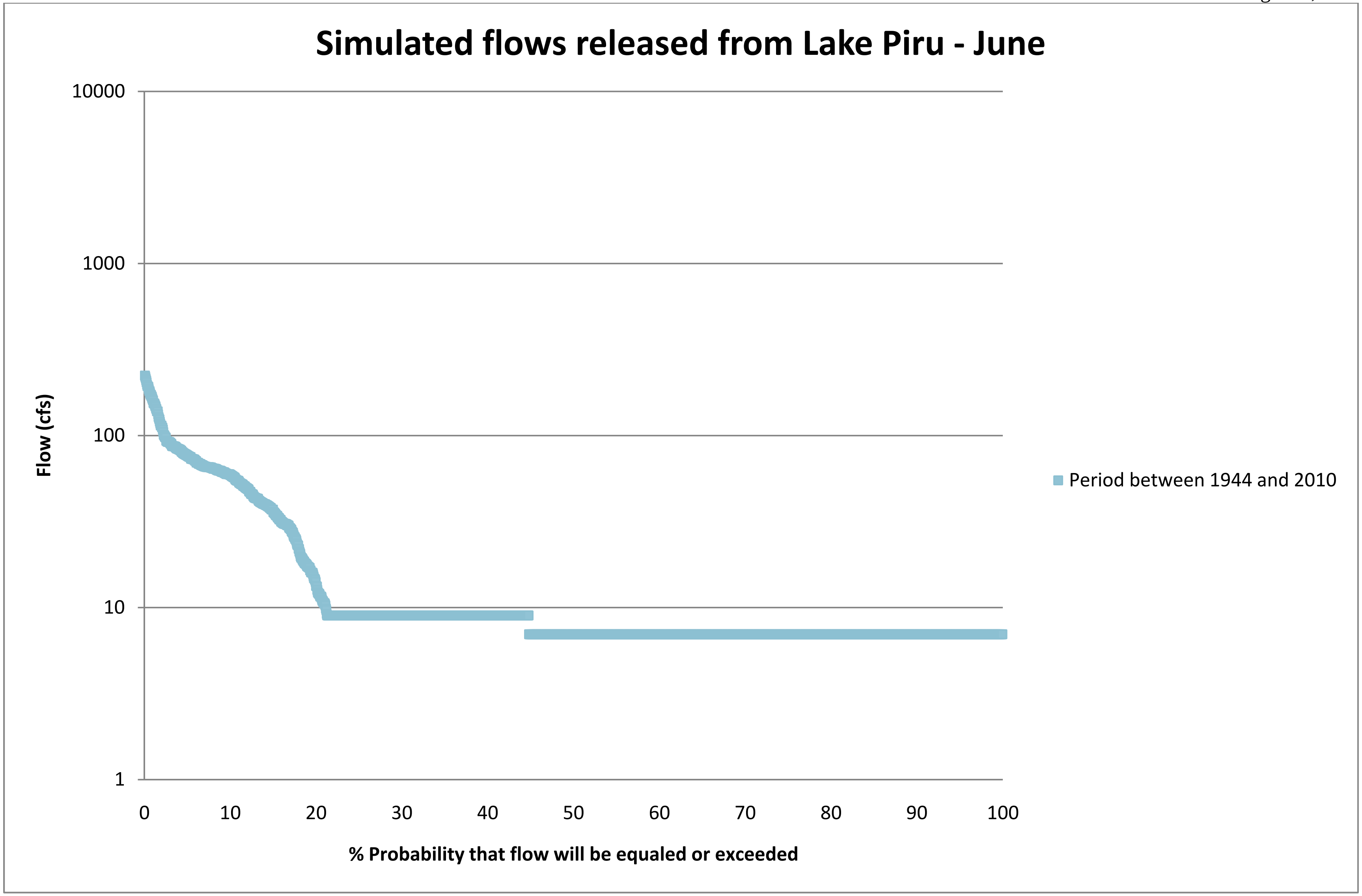


Figure 30 Exceedance graph of simulated flow rates in lower Piru Creek during the month of June; based on recorded conditions between 1944 and 2010.

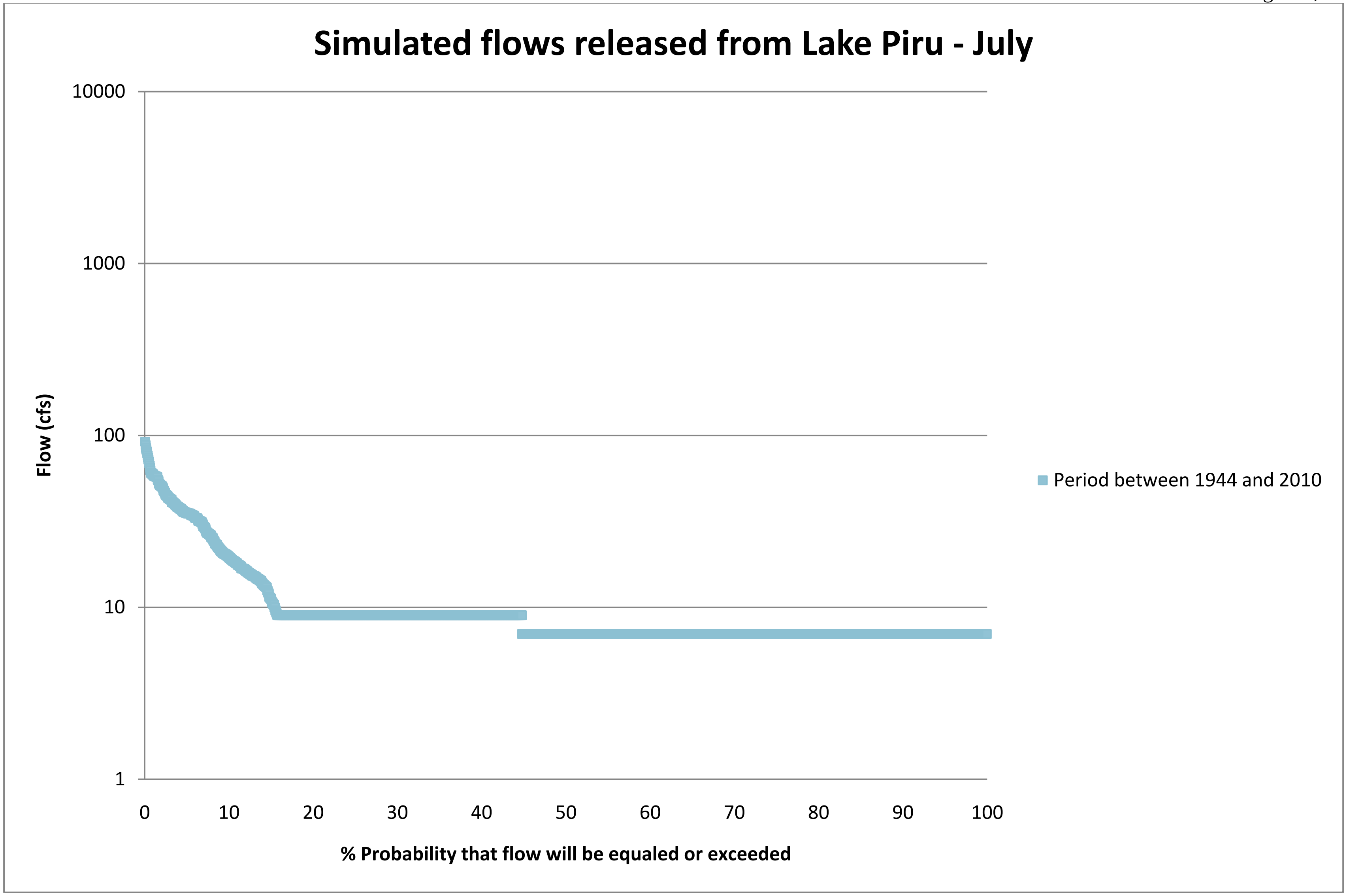


Figure 31 Exceedance graph of simulated flow rates in lower Piru Creek during the month of July; based on recorded conditions between 1944 and 2010.

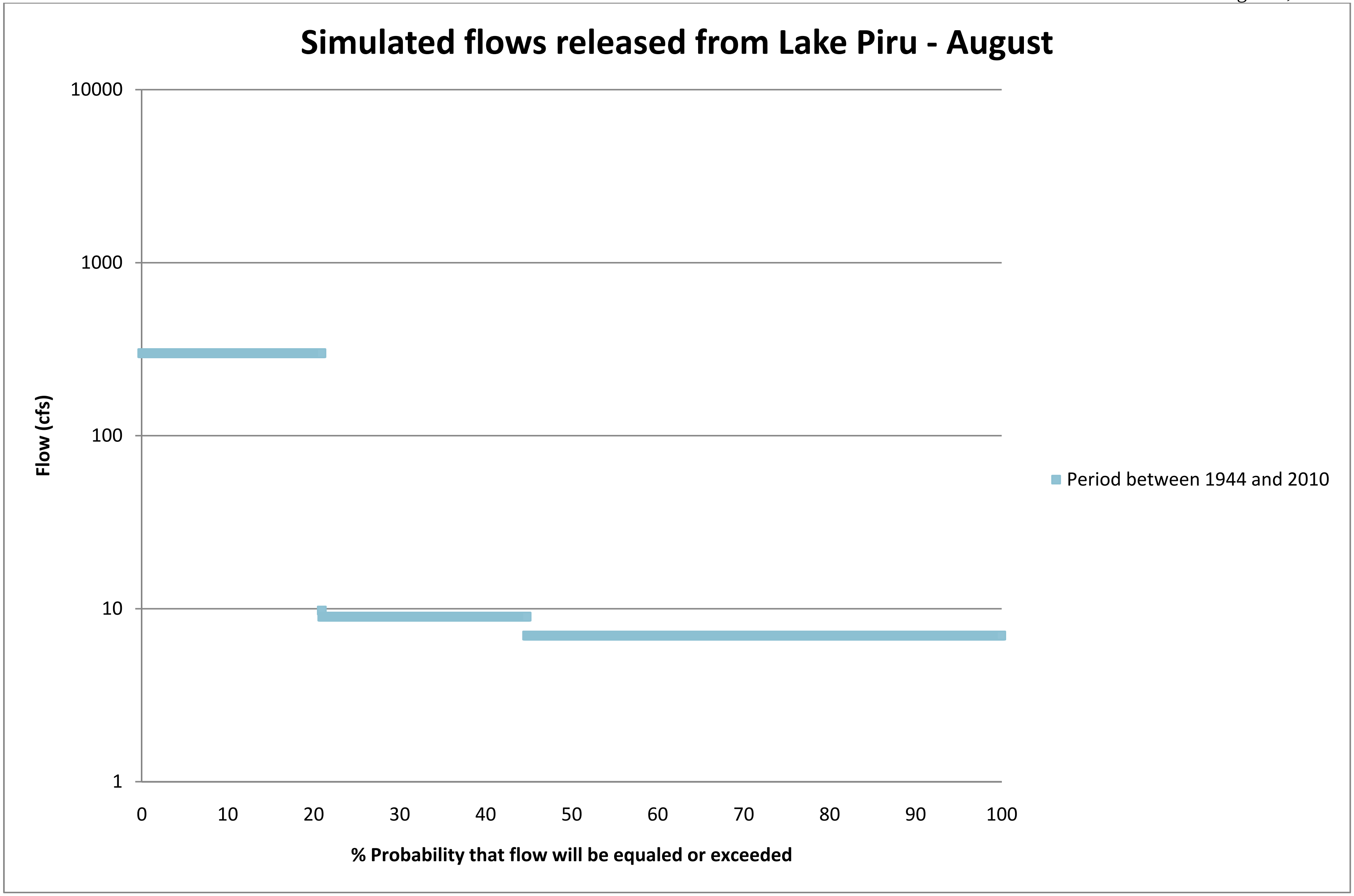


Figure 32 Exceedance graph of simulated flow rates in lower Piru Creek during the month of August; based on recorded conditions between 1944 and 2010.

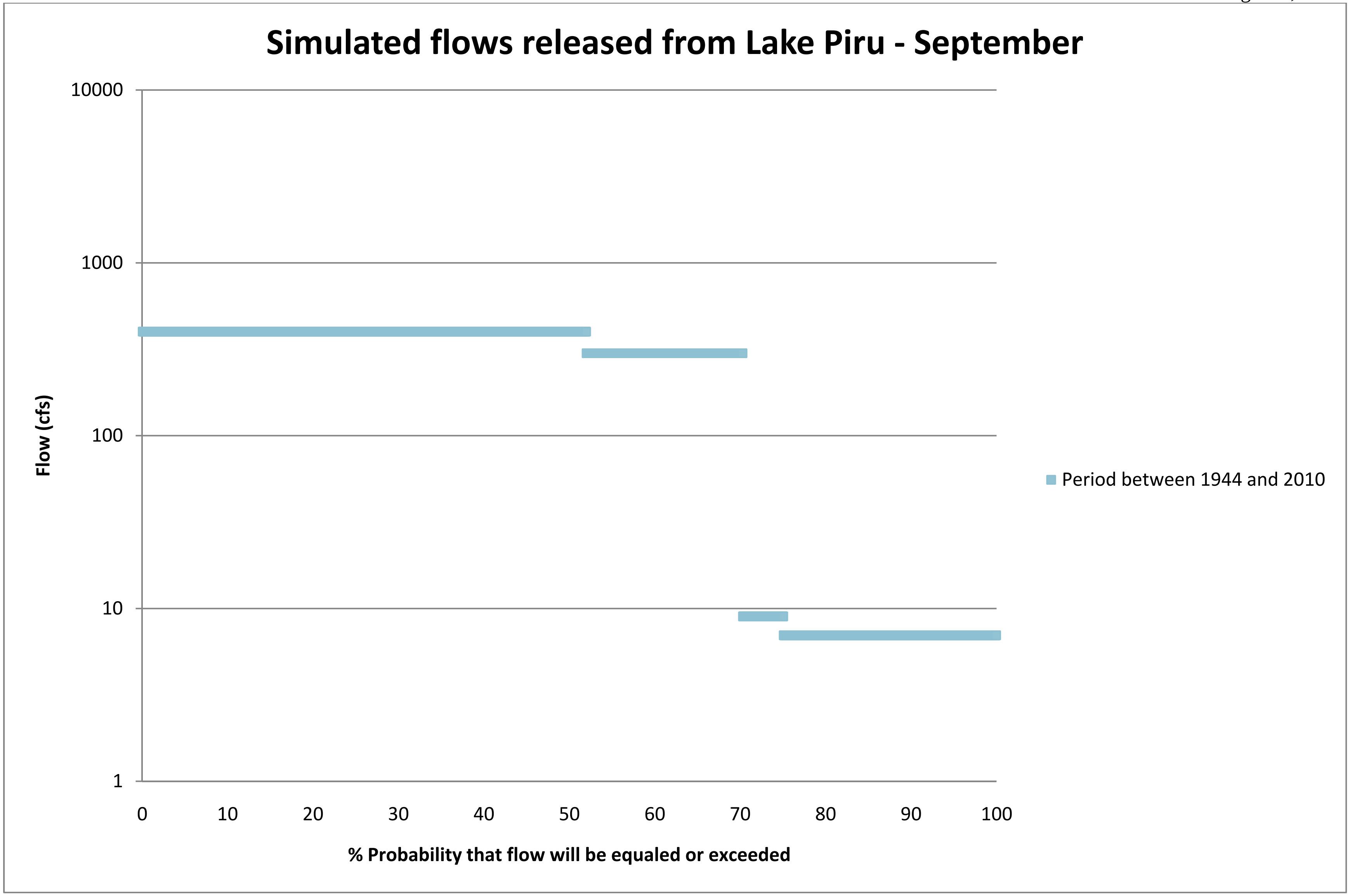


Figure 33 Exceedance graph of simulated flow rates in lower Piru Creek during the month of September; based on recorded conditions between 1944 and 2010.

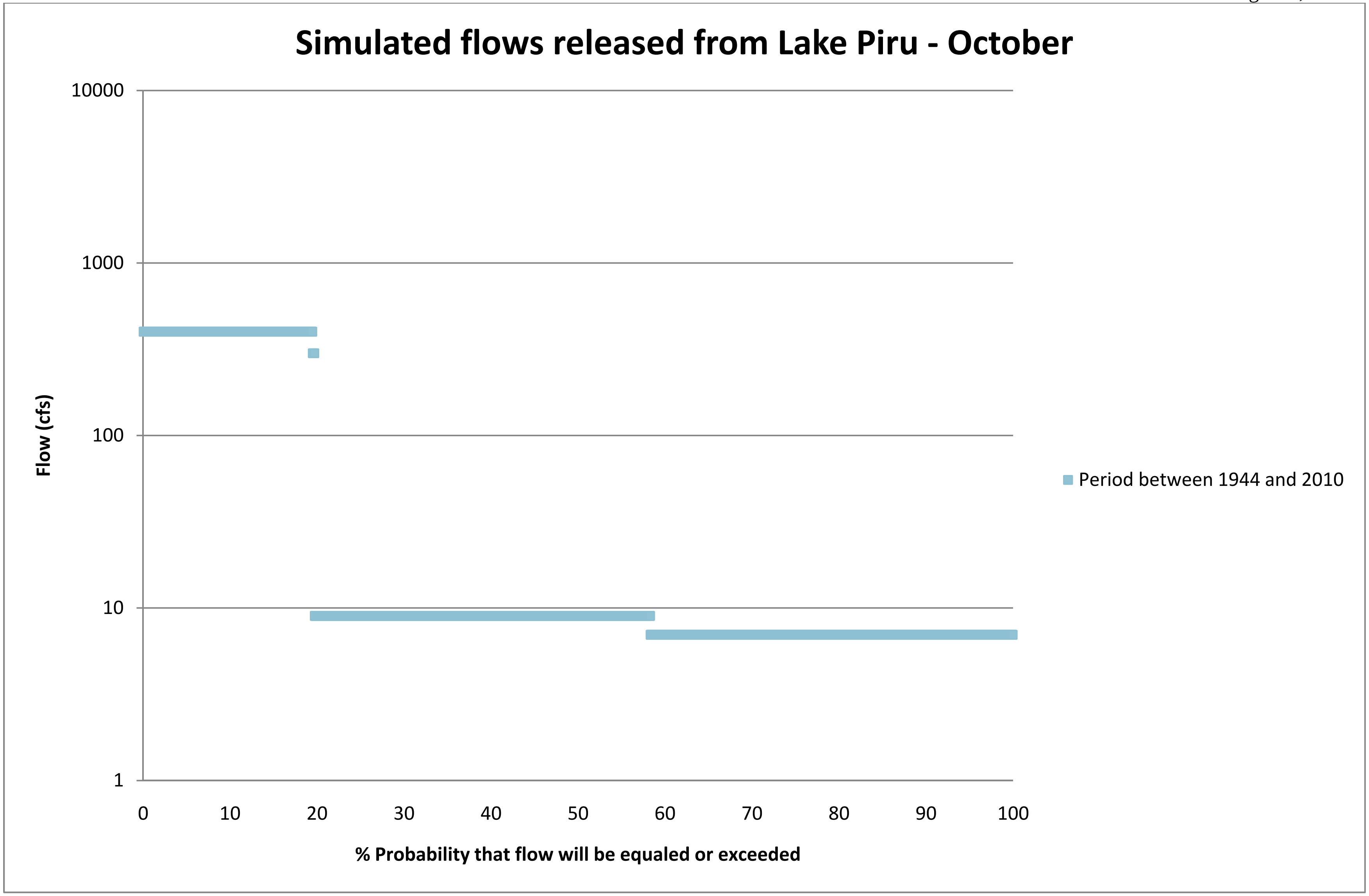


Figure 34 Exceedance graph of simulated flow rates in lower Piru Creek during the month of October; based on recorded conditions between 1944 and 2010.

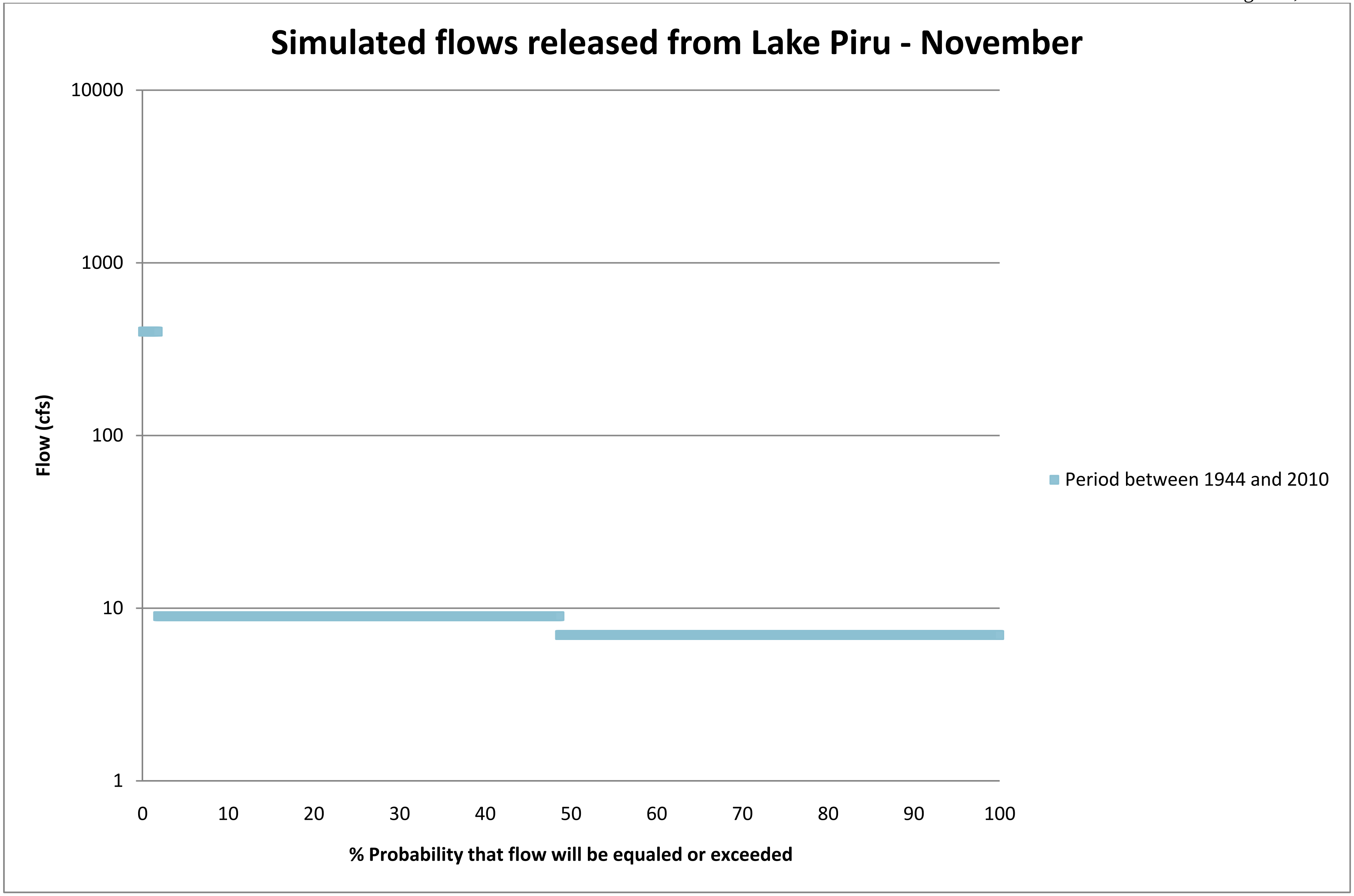


Figure 35 Exceedance graph of simulated flow rates in lower Piru Creek during the month of November; based on recorded conditions between 1944 and 2010.

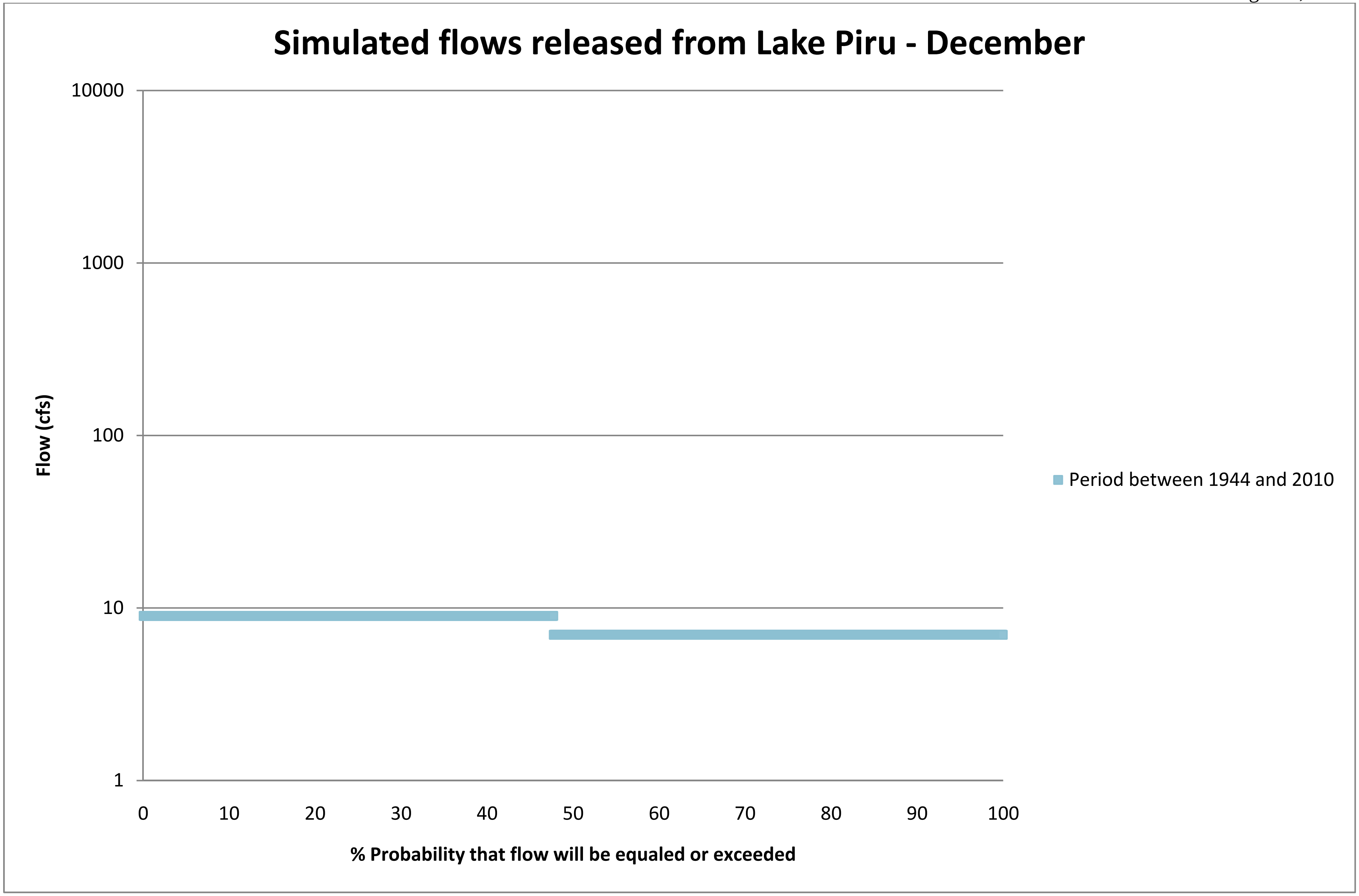
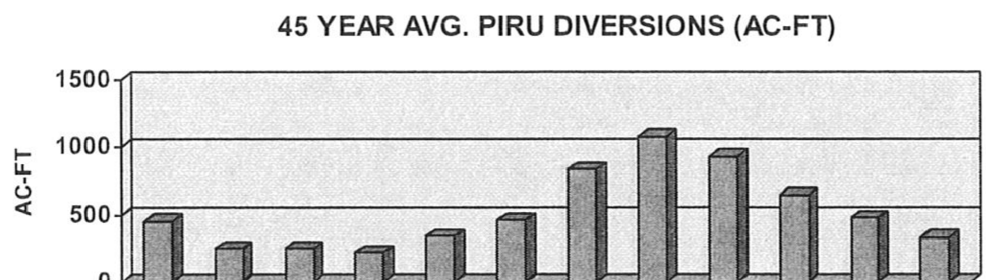


Figure 36 Exceedance graph of simulated flow rates in lower Piru Creek during the month of December; based on recorded conditions between 1944 and 2010.

Diversions

There are several diversions located between the Santa Felicia Dam and the confluence of Piru Creek and the Santa Clara River. Rancho Temescal operates two diversions, the uppermost at river mile 5.35 (from the confluence of Piru Creek and the Santa Clara River), and the other at river mile 2.0. Piru Mutual also has a diversion at river mile 2.0. United Water Conservation District operates the Piru Diversion located at river mile 1.3. There are no records quantifying the diversions by Rancho Temescal or Piru Mutual. We (United) estimate that Rancho Temescal diverts approximately 1 cfs and Piru Mutual diverts 3 to 4 cfs with seasonal variations dependant on irrigation demands. The Piru Diversion is currently not being used. United's water right allows diversion of 80 cfs, however current physical constraints limit the actual maximum diversion to 50 cfs. The graph below shows the historical average monthly diversions at United's Piru Diversion.



	OCT.	NOV.	DEC.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT
PIRU DIVERSIONS	447	247	249	219	342	456	831	1083	932	646	475	331

Average Monthly Diversions at Piru

Memorandum

To: Linda Purpus
CC: Catherine McCalvin, Mike Ellis, Craig Morgan, Kaili Taniguchi, Rick Bennie, Steve Howard

From: Jim Grisham

Date: February 18, 2014

Re: Santa Felicia Dam Hydraulic Capacity and Limitations

Hydraulic Capacity and Limitations

This memorandum is written to reconcile information distributed to various parties concerning the current hydraulic capacities and limitations of the Santa Felicia Dam outlet works. The results are summarized in the attached Table No. 1 and include the maximum and minimum discharge values for each of the outlet works components. The values are based upon the following sources:

1. "Technical Record of Design and Construction, Santa Felicia Dam, Constructed 1954-1955", Prepared by William P. Price, General Manager and Chief Engineer, United Water Conservation District (pages I-13 and I-14), November 1956. (UWCD 1956)
2. "Operations and Maintenance Manual for 36" Cone Valves, Santa Felicia Dam Outlet Work, Specification 95-05", Kvaerner Hydro Power, Inc. November 19, 1996 (Sections 2 Valve Design and Performance Data and Section 5 Operation). (Kvaerner 1996)
3. "Santa Felicia Dam Outlet Works Discharge Capacity", Technical Memorandum, prepared by Richard Westmore, GEI Consultants, Inc., October 21, 2011. (GEI 2011)

Penstock

The 60-inch diameter penstock and intake tower are the limiting components of the outlet works. The penstock was originally designed for a normal maximum flow of 500 cubic feet per second (cfs) and a pipe velocity of 25.4 feet per second (fps) at a reservoir surface elevation of 938 feet (above mean sea level-MSL). The absolute maximum design discharge was 880 cfs with a velocity of 44.8 fps when reservoir surface elevation is 1055 feet MSL (page I-14, UWCD 1956).

The intake tower was extended 42 feet in 1977. The new configuration altered the hydraulic capacity of the outlet works. In 2011 GEI Consultants was contracted to evaluate the capacity of the outlet works. Based on the GEI computer model the absolute maximum capacity is 771 cfs with a velocity of 32.4 fps at a reservoir surface elevation of 1055 feet MSL. The maximum discharge at elevation 980 feet MSL (minimum pool) is 597 cfs. The discharge capacity falls to 25 cfs at elevation 933.5 (one foot above the intake sill).

The 42-foot high tower extension with its smaller intake opening and ribbed wall construction attribute to the reduced capacity. United Water Conservation District (UWCD) has not had the opportunity to verify the computer model due to low reservoir levels.

In addition to the physical limitations, Absolute Maximum Discharge rates are subject to a factor of safety (FOS) criterion established for rapid release emergency drawdown. According to the California Division of Safety of Dams, a reservoir which impounds over 5,000 acre-feet of water must be capable of lowering the maximum storage depth by 10 percent within 10 days. For Santa Felicia Dam the maximum usable storage depth is from elevation 1055 to 932.6 feet (intake tower sill elevation) for a total maximum storage depth of 122.4 feet. Therefore the Santa Felicia Dam outlet works must be capable of lowering the reservoir 12.24 feet within 10 days. The estimated time to lower the reservoir 12.24 feet is 9.25 days. These analyses typically assume drawdown at 1 ft/day in the stability analysis to determine the FOS. The original design report (UWCD 1956) shows a FOS of 1.67 for rapid drawdown from reservoir elevation 1055 feet with a required FOS of 1.25. Therefore, a drawdown faster than 1 ft/day could be tolerated for a short period of time, but the maximum rate has not been determined. However, it should be noted that design parameters, including the FOS and slope stability, for any future modifications to the outlet structure will be considerably more conservative.

Cone Valves

The original Howell-Bunger hollow cone valves were replaced in 1996 with valves manufactured by Kvaerner Hydro Power. The original valves discharged in high arching sprays (rooster tails) to dissipate the energy of the release. The discharges of the new cone valves do not clear the valve chamber. UWCD modified the discharge chamber by installing stainless steel plates and applying epoxy coatings to protect the concrete structure from the erosive action of the annual conservation and migration releases. Reducing the maximum allowable discharge extends the service life of the concrete valve chamber.

Each 36-inch diameter Kvaerner cone valve was designed for an operating discharge of 500 cfs (Section 2, Kvaerner 1996). Each valve has a maximum discharge of 682 cfs based on 200 feet of head. The maximum head of the reservoir is 190 feet. The capacity of each valve is 528 cfs at minimum pool (115 feet of head). The surplus capacity provides nearly the required flow for rapid release emergency drawdown by a single cone valve. It also provides operational flexibility so either valve can be removed from service for periodic maintenance.

The valve manufacturer does not recommend that the cone valves be operated at less than 1 percent open (Section 5, Kvaerner 1996). Valve operation is controlled by a hydraulic ram with a stroke of 16.75 inches. The opening at 1 percent is approximately 3/16 of an inch. The operators cannot realistically operate the cone valve to that level of precision. Experience has demonstrated that operating the valves at the minimum opening accelerates the damage (particularly to the o-rings) caused by excessive velocities. The operators have been advised not to operate the valves at less than 5 percent open. This will produce a discharge of approximately 25 cfs at elevation 980 feet (minimum pool).

Peak discharges during the annual conservation release creates a violent turbulence and back pressure in the valve chamber. The hydraulic lines that operate the cone valves are exposed inside the valve chamber. If the hydraulic lines in the chamber are damaged, the operator would not be able to close or open the cone valves. The operator would be forced to close the 72-inch diameter penstock isolation valve until emergency work to repair the hydraulic line is complete. In order to protect the hydraulic lines from possible damage during a conservation release, the peak discharge release typically limited between 300 to 400 cfs.

Low-Flow Outlet Pipes

Santa Felicia Dam outlet works has two low-flow discharge pipes that are used to maintain habitat flow in Piru Creek downstream of the dam. Low flows are preferentially released through the west branch low flow outlet pipe. If needed (e.g., to meet a minimum required habitat flow of 15 or 20 cfs), flow is augmented through the east branch low-flow outlet pipe. Water releases above 20 cfs would trigger opening one or both cone valves. The east branch low-flow outlet pipe can source from either the penstock, or from an 8-inch bypass valve located in the dam's most upstream valve chamber.

The original west branch12-inch low-flow discharge pipe was designed and constructed in 2005 when minimum required release was either 5 cfs, or equal to natural flow plus 1 cfs, within a range of 1.4 to 5 cfs. Under the 2012 Santa Felicia Water Release Plan, minimum required habitat flows range from 7 to 20 cfs. A second 12-inch low-flow discharge pipe (east branch) was added to meet the new minimum habitat flow requirements in 2012. Discharges are manually controlled by 12-inch butterfly valves. The butterfly valves are considered sacrificial and are replaced as required. The 12-inch low-flow discharge pipes can be safely operated up to 10 cfs before cavitation occurs within the piping. Although it not advised, the combined discharge of the two low-flow valves can operate between 20 to 25 cfs for short periods of time without opening the cone valves.

Concurrently with the installation of the east branch 12-inch low-flow discharge pipe, a tunnel bypass pipe was installed within the penstock tunnel. The tunnel bypass pipe allows UWCD to maintain water releases to lower Piru Creek during periods when the penstock must be closed (emptied) to conduct dam safety activities such as inspections, maintenance or repairs. The 12-inch tunnel bypass pipe is approximately 800 feet long and connects to an 8-inch diameter bypass valve at the upstream end of the outlet works tunnel. At the end of the tunnel is a valve chamber that houses the 72-inch diameter penstock butterfly isolation valve. The 72-inch isolation valve includes an 8-inch diameter bypass pipe with three isolation valves.

The upstream 8-inch isolation valve is a self lubricating plug valve. The plug valve is normally closed. The 8-inch pipe then bifurcates, with one branch feeding the penstock and the second branch serving the 12-inch diameter tunnel bypass pipe. The penstock branch has an 8-inch butterfly isolation valve that is used to pressurize the penstock after inspections, maintenance or repairs have been completed. The tunnel bypass branch isolation valve is a gate valve and is open when the penstock has been closed (emptied). The 8-inch pipe and valves are a constriction that limits the bypass flows to no more than 5 cfs during penstock closure. Even at this low magnitude flow, extreme cavitation occurs within the bypass pipe and it is neither prudent nor safe to operate the bypass for extended periods of time. The 8-inch bypass valves are not sacrificial and replacement of the isolation valves is not feasible.

Hydro Power Plant

The Santa Felicia Dam hydro power plant was completed in 1987. The facility has been offline since 2008. UWCD expects to have one or both of the damaged turbines repaired and online within the next 12 months. The power plant consists of two turbines. The larger turbine can operate the full range between maximum reservoir capacity (elevation 1055 feet) and minimum pool (elevation 980 feet). The larger turbine has a flow range between 40 to 88 cfs. The smaller unit has design limitations and cannot operate when the reservoir has a surface elevation higher than 1028 feet. The smaller unit operates in a flow range between 9 to 20 cfs. The power plant normally operates only during the annual conservation release or when the reservoir is spilling. The original design linked the power plant to a designated cone valve. If the power plant was taken offline, the control valves would shut off the flow to the turbines and the designated cone valve would balance the flows. The 12-inch low flow bypass valves are not automated.

Habitat flow releases would preferentially be discharged through the smaller hydro unit. However the minimum flow and maximum head design limitations make it difficult to do so. In addition, the existing controls require upgrades in order to maintain the required habitat and migration flows in the event that the power plant is suddenly or inadvertently taken off the power grid. The proposed repair project will modify the smaller turbine to allow it to run within a wider range of head. However the variation of the flow through the turbine is a narrow range and will be the controlling factor. The smaller hydro unit could potentially operate 24 hours a day, assuming corresponding controls are installed.

Other Considerations

The volume of the annual conservation release is based on the water resource management strategies, hydrologic conditions in the downstream basins, ramping criteria, water demands, water quality and the diversion capacity of the Vern Freeman Diversion (VFD). The VFD has an instantaneous capacity of 375 cfs. The conservation release is planned with a goal to deliver a specific volume of surface water to the VFD. UWCD staff constantly monitors the release to ensure that the surface water diverted balances with the percolation rates of the groundwater recharge basins and irrigation pipeline demands. Longer release durations make the VFD diversions more efficient and provide operational flexibility. The longer durations also allow surface water to be delivered to the irrigation pipelines over a longer period of time, which in turn reduces groundwater pumping.

The recharge basins at Saticoy and El Rio facilities initially have a very high rate of percolation. Eventually, the basin’s earth bottoms become saturated and the groundwater beneath the basins begin to “mound”. As the percolation rates slow, the release must be reduced or pipeline deliveries increased. The groundwater replenishment of the forebay is enhanced when the conservation release has a constant flow over long duration.

Lower Piru Creek below the outlet works is considered critical habitat by the resource agencies. The conservation and migration releases can cause significant scour in the channel immediately downstream of the outlet works and power plant. The discharge flows can also cause significant bank erosion above and below the USGS gauging station. Maintenance of the channel requires the use of heavy equipment within the streambed. By limiting the releases to 300 to 400 cfs, the need to operate heavy equipment in the channel is reduced and less frequent.

UWCD must also be cognizant of potential damage to downstream diversions and properties. Lower velocities reduce undesirable erosion and scour in lower Piru Creek and the Santa Clara River.

TABLE No. 1
SANTA FELICIA DAM HYDRAULIC CAPACITIES

	Feature	Min. Q (cfs)	Max. Q (cfs)	Min. H (MSL)	Max. H (MSL)
1	60-inch Penstock Normal Maximum Discharge	25	597	933.5	980
2	60-inch Penstock Absolute Maximum Discharge	597	771	980	1055
3	36-Inch Cone Valve (each of 2 valves)	25	673	980	1055
4	Cone Valve (total)	50	771	980	1055
5	Hydro Unit #1 (nominal 164 kW)	9	20	980	1,028
6	Hydro Unit #2 (nominal 806 kW)	40	88	980	1,055
7	West Branch 12-Inch Low-Flow	0	10.0	N/A	N/A
8	East Branch 12-Inch Low-Flow	0	10.0	N/A	N/A

Notes:

1. Spillway elevation is 1,055 feet MSL.
2. Fixed intake tower elevation is 932.6 feet MSL.
3. Minimum pool elevation is presently 980 feet MSL.
4. Approximate elevation of the turbines and cone valves is 865 feet MSL.
5. The Normal Maximum Discharge and Absolute Maximum Discharge are the design parameters for penstock and original Howell-Bunger hollow cone valves. These values have been modified in accordance with GEI Consultants TM dated October 21, 2011.
6. The cone valves shall not be operated less 5 percent open to prevent damage to the o-rings and coating.
7. The low-flow discharge pipes can operate above 10 cfs for short periods of time when sourced through the penstock. Cavitation begins when flows exceed 10 cfs.
8. The capacities shown are for independent operation. All devices share a common 60-inch penstock and intake tower. Hence, head losses from combined operations can serve to reduce maximum discharges and/or reduce maximum head limitations.

APPENDIX B:
Full List of Fish Passage Concepts and Alternatives Considered

APPENDIX B – FULL LIST OF FISH PASSAGE CONCEPTS AND ALTERNATIVES CONSIDERED

This appendix contains a comprehensive list of the fish passage concepts considered by the Panel when conducting the Santa Felicia Dam Fish Passage Feasibility Assessment Study (Study). It also includes the full list of alternatives that were formulated, developed, and considered by the Panel.

B.1 FISH PASSAGE CONCEPTS

The set of fish passage considered by the panel is contained in Table B.1-1 (upstream) and Table B.1-2 (downstream). Each concept ("item") has one or more functions associated with it, corresponding to:

- C – collection
- T – transport
- R – release

The Panel also assigned near the beginning of the Study a preliminary ranking of priority for further investigation. The rankings include:

1. Primary (P) – high priority concepts, preferred because more reliable, more proven, less risky, and in consideration of ESA
    a. P1 – Highest among primary concepts, to be developed further
2. Secondary (S) – technically feasible, but other options are preferred
3. Enhancements (E) – additional feature intended to increase the efficiency or effectiveness of a primary concept
4. Defer (D) – removed from further consideration due to risk of fish injury, high personal safety danger, not practical, clearly better options, or does not meet passage objective

Table B.1-1. Upstream passage concepts considered by the Panel during the Santa Felicia Dam Fish Passage Feasibility Assessment Study.

Priority	Item	Function
P1	Collection and fish lift-hopper	C/T
P1	Pool and weir fish ladder	T
P1	Trap and truck transport	T
P1	Barrier	C
P1	Capture fish from spillway pool	C

Table B.1-1. Upstream passage concepts considered by the Panel during the Santa Felicia Dam Fish Passage Feasibility Assessment Study.

Priority	Item	Function
P	Barrier dam below tailrace	C
P	Picket weir	C
P	Temporary trap downstream of dam	C
P	Trap at powerhouse	C
P	Velocity barrier	C
P	Dam removal	C/T/R
P	Pierce the dam with lock at mid-level	T
S	Angling / seine, “active capture”	C
S	Channel from powerhouse to spillway to connect for collection at PH	C
S	Electrical barrier	C
S	Engineered in-channel trapping pool	C
S	Trap at lower Piru Creek	C
S	Trap at spillway pool	C
S	Transport from Freeman	C/T
S	Channel bypassing the reservoir	R
S	Release acclimation pond	R
S	Convert outlet works to lock	T
S	Fish aerial tram	T
S	Fish ladder at the Access Road	T
S	Fish ladder on dam	T
S	Fish ladder on left bank	T
S	Fish ladder on right bank	T
S	Fish lock	T
S	Fishway through new tunnel in left bank	T
S	Drop with fishway and channel in delta	T
S	Long ladder flume (1-2 percent slope)	T
S	Nature-like fishway	T
S	Spiral ladder	T
E	Low flow channel in spill channel	C
E	Multiple collection points	C
E	Trap at confluence of spillway and outlet channels	C
E	Controlled releases from Pyramid Lake	R

Table B.1-1. Upstream passage concepts considered by the Panel during the Santa Felicia Dam Fish Passage Feasibility Assessment Study.

Priority	Item	Function
E	Ephemeral channel through delta at head of reservoir	R
E	Multiple release sites	R
E	Pulse releases from Pyramid Lake	R
D	Catapult	T
D	Fish pump	T
D	Balloon fish lift	T
D	Helicopter transport	T
D	Boat haul	T
D	Convert turbine to fish pump	T
D	Denil ladder	T
D	Pneumatic canister	T
D	Fish cannon	T
D	Haul by rail	T

Table B.1-2. Downstream passage concepts considered by the Panel during the Santa Felicia Dam Fish Passage Feasibility Assessment Study.

P/S/E	ITEM	C/T/R
P1	Floating pumped collector, fixed location, at surface or at depth	C
P1	Floating surface collector attached to intake tower – collection flow	C
P1	Movable pumped surface collector	C
P1	Adjustable-level inclined screen inside of new intake tower	C
P1	Integrate multi-level fixed collector with new tower design	C
P1	Multi-level fixed collector, with spillway, existing penstock, or new bypass or truck	C
P1	New multi-level tower, existing conduit, various bypass options	C/T
P1	Multi-level low velocity volitional collector bypass to fishway	C/T/R
P1	Low flow (7-80 cfs) dedicated bypass from existing penstock	T
P1	Piru Creek collector dam with off-channel trap near upstream end of reservoir	C
P	Eicher screen in tower with multiple levels	C
P	Dam removal	C/T/R
P	Dewater and transport	T

Table B.1-2. Downstream passage concepts considered by the Panel during the Santa Felicia Dam Fish Passage Feasibility Assessment Study.

P/S/E	ITEM	C/T/R
S	Piru Creek collector at drop structure	C
S	Temporary downstream trap on Piru Creek	C
S	Spillway notch and channel in concrete section	C/T
S	Bypass conduits	T
S	Dual locks	T
S	Fish-friendly turbine(s)	T
S	Pump fish to reservoir bypass flume	T
S	Reservoir bypass channel	T
E	Active smolt capture	C
E	Behavioral guidance device	C
E	Controlled releases from Pyramid Lake	C
E	Guide/exclusionary nets	C
E	Movable low-flow Piru Creek collectors	C
E	Piru Creek fixed tributary collectors (Agua Blanca and/or Fish Creek)	C
E	Predator removal – angling, trap and remove	C
E	Pulse releases from Pyramid Lake	C
E	Rescue incidental steelhead bycatch	C
E	Low flow channel in spillway outlet channel	T
E	Screening on low flow turbine / outlet	T
E	Spillway channel modifications in rock section	T
D	Multi-level tower with fish-friendly outlet (turbine)	C
D	Nature-like fishway (upstream / downstream), fully volitional, bypassing dam and reservoir	C/T/R
D	Floating bypass channel through reservoir	T
D	Transport by rail	T

B.2 FISH PASSAGE ALTERNATIVES

Table B.2-1 displays the full set of upstream alternatives developed and considered by the Panel. Table B.2-2 contains the set of downstream alternatives.

Table B.2-1. Upstream fish passage alternatives developed and considered by the Panel during the Santa Felicia Dam Fish Passage Feasibility Assessment Study.

Alt #	Alt Name
U1	Pool and Weir Fishway, Tunnel and Tower; Reservoir Range El 980' to 1,056'
U2	Pool and Weir Fishway to EL 1,030', East Alignment to Exit Structure; Reservoir Range EL 1,030' to 1,056'
U3	Pool and Weir Fishway to EL 1,056', West Alignment with Slide Release; Reservoir Range EL 980' to 1,056'
U4	Trap and Truck Transport with Multiple Release Locations; Reservoir Range EL 980' to 1,056'
	Pierce the dam with mid-level lock
	Trap at lower Piru Creek
	Transport from Freeman Reservoir
	Channel bypassing the reservoir
	Trap and transport (via fish lift with overhead tram)
	Fish lock
	Long-ladder flume (1-2 percent slope)
	Nature-like fishway
	Fish lift over dam via rail
	Permanent spillway pool collector (trap) or channel to outlet works
	Fish ladder on the dam
	Rail transport around the reservoir

Table B.2-2. Downstream fish passage alternatives developed and considered by the Panel during the Santa Felicia Dam Fish Passage Feasibility Assessment Study.

Label	Name of Alternative
D3	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps
D4	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps, Volitional Bypass with U1
D5	Surface Collector at Intake Tower, 500 cfs Screen, Gravity with Pumps
D7	Piru Creek Collector, 200 cfs Screen
D9	Piru Creek Collector (D7) with Spillway collector
D10	Piru Creek Collector (D7) with 150 cfs Surface Collector D3
D11	Piru Creek Collector (D7) with 500 cfs Surface Collector (D5)
D12	Piru Creek Collector (D7) with Movable FSC
D14	Multi-level Crest Gate Collector with Helix Bypass
	Dewater and transport
	Reservoir bypass channel
	Dual fish locks
	Piru Creek in-channel collector
	Temporary trap in Piru Creek
	Multi-level intake on new intake tower to 800 cfs, Eicher Screen
	FSC near dam, 150 cfs Screen (*was D1*)
	FSC, Movable, 150 cfs Screen (*was D2*)
	Multi-level Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps (*was D6*)
	Piru Creek Collector, 100 cfs Screen (*was D8*)
	150 cfs Screen similar to D4 with Helix bypass (USBR Cle Elum style) (*was D13*)
	Bypass conduits
	Pump fish to a reservoir bypass flume
	Fish-friendly turbines
	Nature-like fishway
	Floating bypass channel through reservoir
	Rail transport around the reservoir

APPENDIX C:
Analysis of Spill Reduction Opportunities

APPENDIX C – ANALYSIS OF SPILL REDUCTION OPPORTUNITIES

C.1 INTRODUCTION

This appendix describes the analysis of opportunities to reduce spill at SFD and the potential benefits of the reductions. Spill reduction enhances most alternatives for upstream and downstream fish passage. The enhancement is described in Section 4.3.5.2.

There are two ways spill could be minimized relative to the current operations: 1) if the flow through the outlet works is always maximized, whether through the deep outlet screen (bypass or turbine flows) or a fish collector, less flow would be spilled; 2) the reservoir could be operated slightly lower than the spillway crest to provide some flood storage before spill occurs. These two ways could also be combined.

Three scenarios were analyzed to investigate their potential benefit to the performance of fish passage alternatives. A reservoir operating model developed and provided by United as described in Section 2.2.1 (Hydrology) was used for the analysis, based on 71 years of hydrology (1944 – 2010). Spill events were identified as times when the reservoir was higher than the spillway, resulting in spill over the fixed spillway crest. Additionally, a "spill event" for this analysis is defined as each time spill starts until it stops, and is reported in "spill days." It is recognized that minor spill events when the flow over the spillway is just a few tenths of a foot do not likely cause passage. The BPT assumes no fish will pass over the spillway until the depth reaches 0.3 feet (ft) over the crest (see Appendix E). The model was then modified to reflect the spill days reduction scenarios and the resulting spill events were identified. The analysis consisted of comparisons of the current conditions with three spill reduction scenarios.

The results of the model are shown in Table C-1 and then described below. This table is identical to Table 4.2-2 in the document.

Table C-1. Characteristics of spill frequency for the period of record when spill is minimized (Table 4.2-2 in Report) for three spill reduction scenarios compared to current operations.

	Current Operation	Scenario 1 Maximize Outlet Flow Up to 500 cfs	Scenario 2 Maximize Outlet Flow Up to 1,000 cfs	Scenario 3 Operate Reservoir at EL 1,053.0 ft
Total days of spill	1,857	228	82	182
Average days of spill per spill event	116	11	7	13
Number of spill events	16	21	11	14
Average number of years between spill events	4.2	3.2	6.1	4.8
Average number of years between years with spill events (accounts for multiple spill events in a single year)	4.5	6.1	8.4	>5*

* The model did not calculate this number precisely, so this is a rough estimate.

C.2 SCENARIO 1: OPERATE TO TAKE FIRST 500 CFS THROUGH INTAKE PRIOR TO SPILL

This scenario reduces spill by operating SFD to direct the first 500 cfs release through fish collector outlet screens and/or through the screened outlet works. That is flow that would otherwise be spilled when the reservoir is full. The 500 cfs is also the current safe operational capacity of the penstock.

Maximizing the use of the screened outlet flow up to 500 cfs would significantly decrease the total days of spill from 1,857 to 228. Additionally, the average number of days of spill per spill event is reduced from 116 to just 11. Figure C-1 shows each spill event over the modeled period under current operations and with Scenario 1. This plot illustrates the benefit of operating to minimize spill by plotting the modeled effects of: each spill event; the duration of spill per event once it begins; and the average and peak flows per spill event. Note how the number of spill events increases, but the duration (cumulative days of spill) significantly decreases.

One interesting effect of this scenario is that some of the longer duration spills are split into multiple smaller spill events so the number of spill events increases from 16 to 21. Operationally, two small spill events in close succession would be no different than a single event.

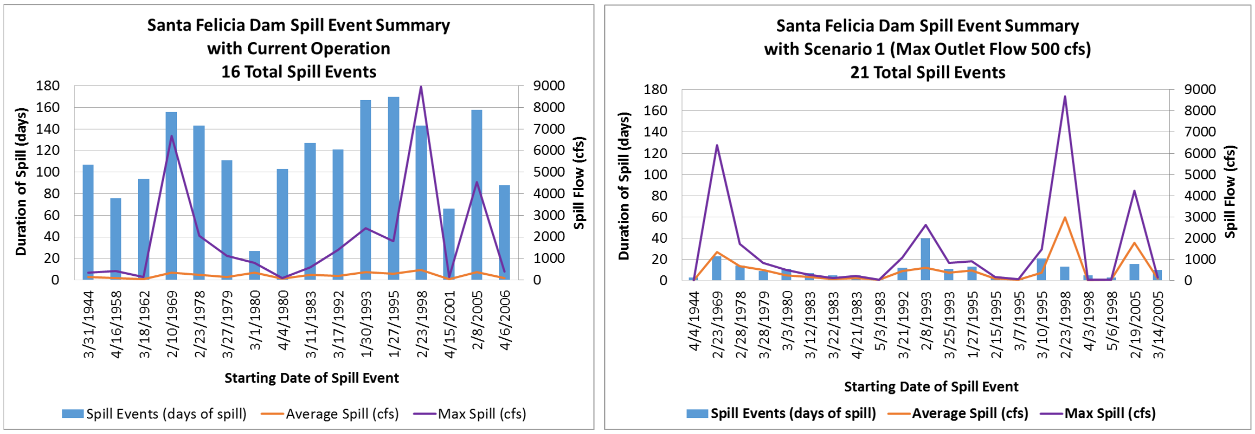


Figure C-1. Modeled Effects of Scenario 1 – Operation to Minimize Spill by taking the first 500 cfs of flow through the deep intakes or through a fish collector operating between January 1 through July 15 (based on 1944 – 2010 hydrology).

Figure C-2 shows the reduction in number of spill events (top plots) and minimum spill durations per spill event (bottom plots) to help illustrate the effects of these operational changes.

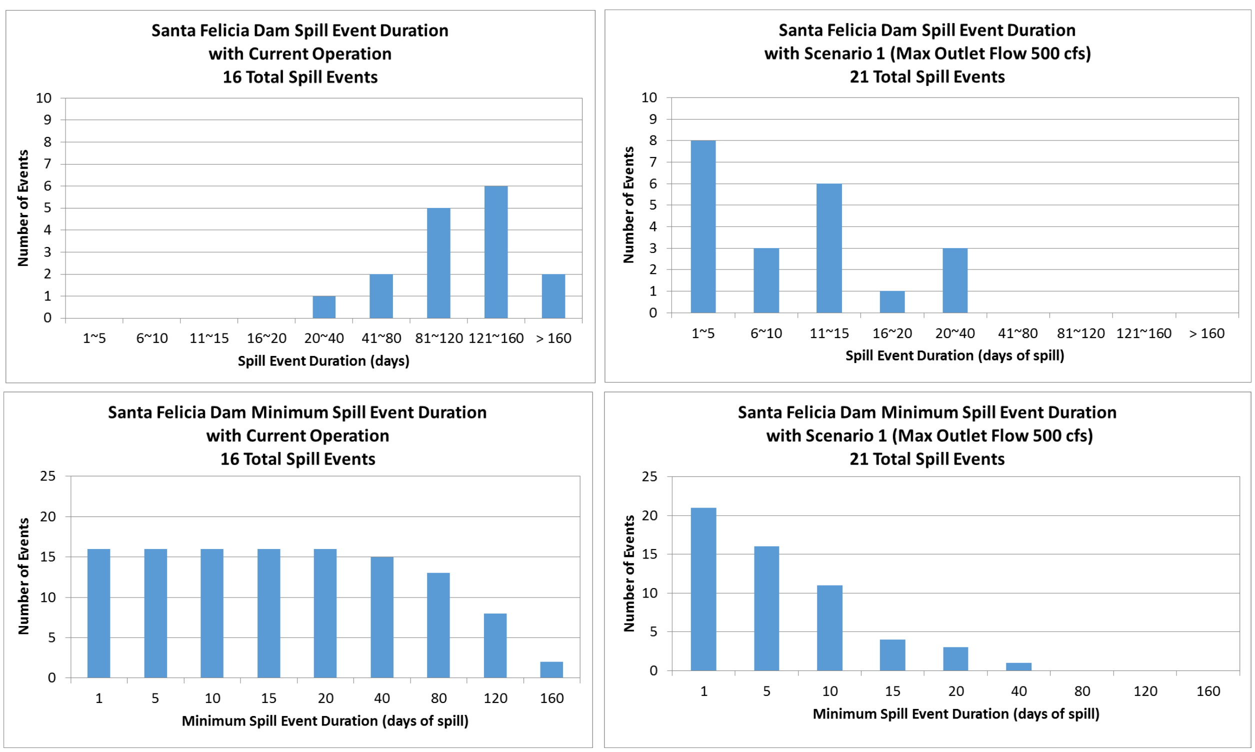


Figure C-2. Modeled Effects on spill events and duration of Scenario 1 – Operation to Minimize Spill by by taking the first 500 cfs of flow through the deep intakes or through a fish collector operating between January 1 through July 15 (based on 1944 – 2010 hydrology).

The data for this analysis was based on the mean daily flows provided by USGS gages upstream and downstream of SFD and the reservoir water level model. In order to better balance the flows and reservoir level data, United used a 3-day rolling average adjustment on the mean daily flows. Given the flashy hydrology of this watershed (influenced on an hourly basis), the effects of this 3-day averaging are to dampen the peak flows noted for a single day. This is on top of the damping of peak hourly flows, which would typically be higher than the mean daily flows. The Panel believes this initial analysis is sufficient to communicate the general idea of revised operations to minimize spill to benefit fish passage. The numerical benefits reported in this section are somewhat conservative based on the analysis methods.

C.3 SCENARIO 2: OPERATE TO TAKE FIRST 1,000 CFS THROUGH INTAKE PRIOR TO SPILL

This scenario is the same as the first but assumes the first 1,000 cfs is passed through the outlet structure instead of the 500 cfs described for Scenario 1. The 1,000 cfs flow is arbitrary and used as a sensitivity analysis. This scenario would have an even greater effect on reducing the number of spill events from 21 to 11 as shown in Table C-1. Figure C-3 provides the data for Table C-1 plotted to compare the incremental benefit from 500 to 1,000 cfs, and Figure C-4 provides the effect by spill event.

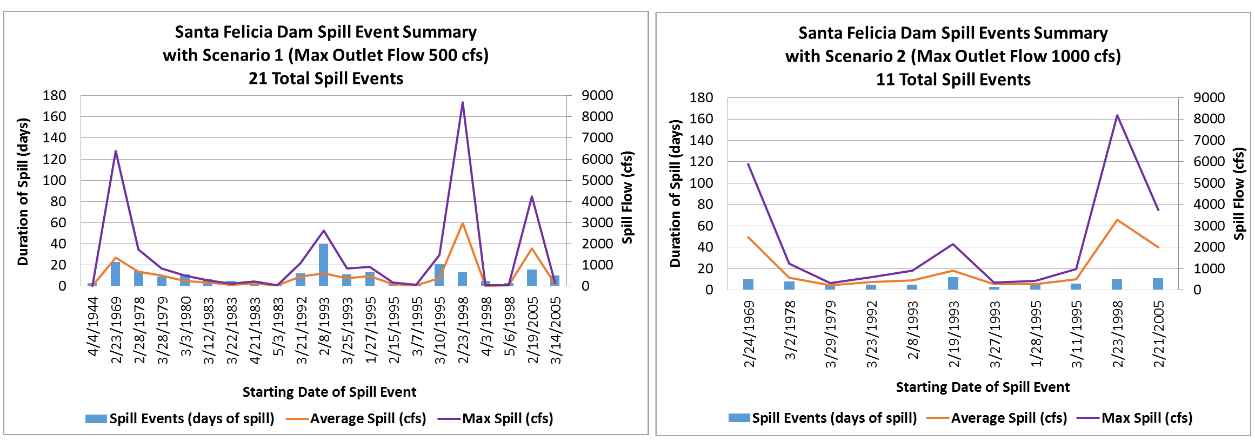


Figure C-3. Modeled Effects of Scenario 1 Operation vs. Scenario 2 – Operation to Minimize Spill by taking the first 1,000 cfs of flow through a fish collector operating between January 1 through July 15 (based on 1944 – 2010 hydrology).

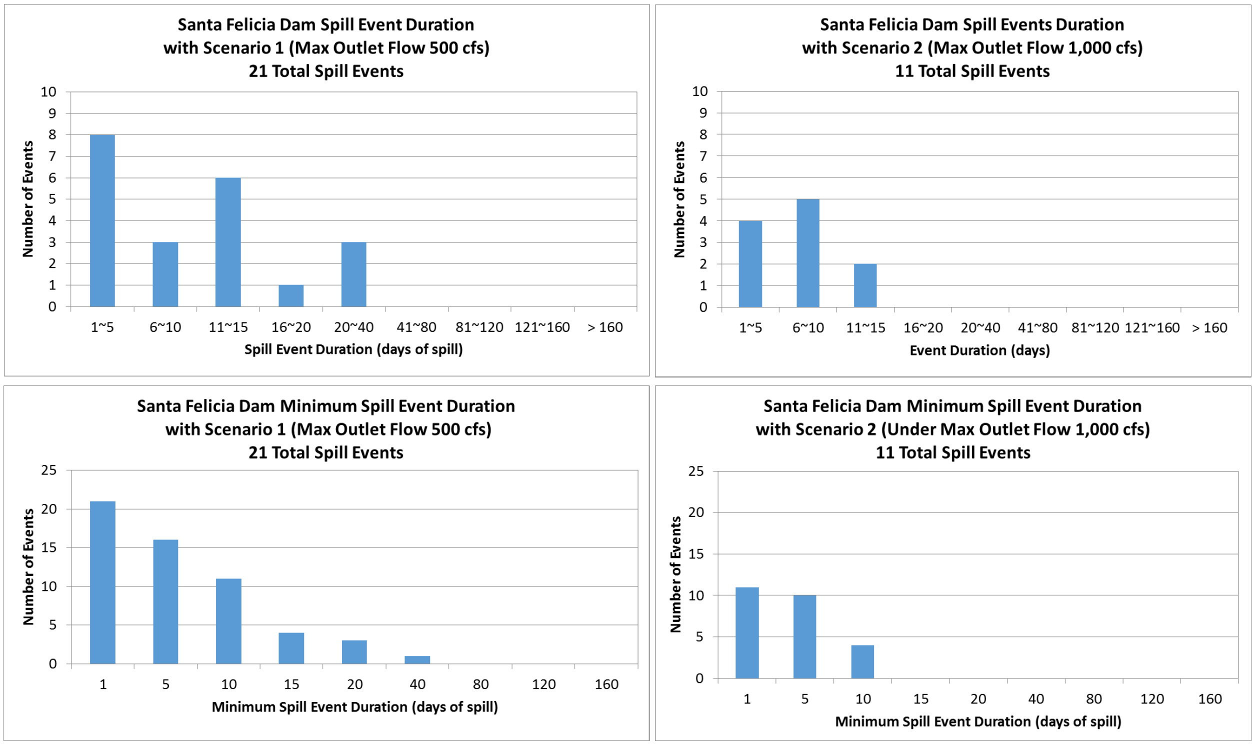


Figure C-4. Modeled Effects on spill events and duration of Scenario 1 vs. Scenario 2 – Operation to Minimize Spill by taking the first 1,000 cfs of flow through the deep intakes or through a fish collector (January 1 – July 15).

The incremental benefit of the extra 500 cfs is not as dramatic with Scenario 2 as in Scenario 1, but there is additional benefit to this scenario. The current outlet works do not have the capacity to convey 1,000 cfs, so this scenario would require capital improvements to implement.

C.4 SCENARIO 3: FIRST 500 CFS THROUGH THE INTAKE PLUS OPERATE RESERVOIR TWO FEET BELOW SPILLWAY CREST

This scenario combines Scenario 1 with the addition of operating the reservoir at a target elevation of 1,053.0 ft during the fish passage season. The elevation target is arbitrary and was used to test the efficacy and sensitivity of the operation, but elevation of 1,053.0 ft would only slightly affect peak flows downstream and any channel forming processes associated with the those flows. To show the scale, the two feet of reservoir storage (1,053.0 to 1,055.0 ft) is about 2,344 acre-feet, which is equivalent to 300 cfs for four days.

This target would result in a small change in downstream flows as large events would be slightly buffered by the storage available above 1,053.0 ft. The results are shown in Table C-1. The lower pool operation would decrease the spill days from Scenario 1 from 228 to 182, a reduction of 46 spill days.

The results for operating at 1,053.0 ft are provisional; further analysis with a reservoir storage model is needed to give an accurate estimate of the value of this enhancement. Additional sensitivity analyses could be performed to vary the operating level and the outlet flow.

APPENDIX D:
Criteria Used for Evaluation

APPENDIX D –CRITERIA USED FOR EVALUATION

D.1 INTRODUCTION

This appendix describes the criteria used to compare and evaluate the alternatives that the Panel determined were technically feasible during the initial tasks of the Santa Felicia Dam Fish Passage Feasibility Assessment Study Plan (Study Plan). Both upstream and downstream passage criteria were drafted early in the Santa Felicia Dam Fish Passage Feasibility Assessment Study (Study) to aid in evaluating concepts that eventually yielded the final group of alternatives. Most of these criteria supported discussions during the initial brainstorm, and were updated during subsequent Panel workshops and from Group comments.

Evaluation criteria are separate from, and in addition to, specific design criteria. Quantitative threshold design criteria (e.g.; maximum velocity, minimum water depth) will likely be applied in the final detailed design of any selected alternative. Quantitative design criteria are generally considered during further levels of design but conceptual alternatives are developed in consideration of satisfying design criteria.

D.2 CRITERIA USED TO EVALUATE UPSTREAM FISH PASSAGE FACILITIES

D.2.1 PASSAGE CRITERIA

D.2.1.1 Collection of Adult Fish – Normal, Mid, and High Flows

This is the guidance of fish to find and enter the fish passage facility and includes attraction to the vicinity of and passage into the passage facility entrance. Attraction is the key component to minimizing migration delay. Attraction depends on the facility entrance flow, entrance location, and shape of the entrance flow jet. Characteristics of the tailwater that affect attraction are bathymetry, velocity patterns, and competing flows that can aid or distract from the facility entrance. The facility entrance flow is crucial, especially in relation to other discharges. It is made up of the flow in the facility plus any additional auxiliary flow that is added for attraction. When a facility entrance has greater flow, it is generally more attractive. Exceptions to this are when the extra flow creates excess drops and/or excessive velocity. In those cases, fish might be attracted to the facility but may not be able to enter it.

The evaluation of attraction of upstream migrants at Santa Felicia Dam (SFD) is based on the professional judgment of the Panel and the characteristics described above. Attraction into the facility is evaluated with respect to ranges of flows applied to each alternative. Table D-1 shows the range of flows that were used to define criterion for fish passage at SFD.

Table D-1. Flow ranges considered by the Panel for defining fish passage criteria at Santa Felicia Dam.

Flow Range Descriptions	Flows
Normal flow	Up to 200 cfs from hydro or energy dissipater
Mid-high flow range	500 cfs from hydro and energy dissipater
High flow range	1,000 cfs including 500 cfs spill

Fish attraction at low flows (e.g., less than 50 cfs) is important, but was not specifically evaluated because at flows up to about 50 cfs, all of the flow will be released from the fishway entrance so it is assumed that fish under these low flow conditions will be attracted to the fishway and there is no difference among the alternatives. This is true for all of the alternatives being considered.

D.2.1.2 Passage Effectiveness through Upstream Fish Passage Facility

Passage effectiveness of target species, adult steelhead, through the passage facility pertains to the expected success and efficiency (energy, stress, and time expended to pass) of fish passage from when fish are collected to just before they are released upstream.

Timeliness (inverse of delay) is included in this criterion. A fish that is not delayed has a better chance of reaching its spawning ground and of spawning.

The physical safety of adult fish passing through the facility is included in this criterion. Safety is possibly diminished when fish are expected to leap over weirs or are unintentionally induced to leap at other locations. Safety is diminished if fish might become stranded in the facility if it is dewatered or flow in the facility is interrupted.

D.2.1.3 Volitional Upstream Fish Passage

Volitional passage is the concept of giving fish the choice of moving upstream or downstream (i.e., entrance, movement through the facility, and release or exit) based on their own motivation. The Panel will use the following definition of volitional passage, which was developed by the Group during development of the Study Plan:

> *"Volitional fish passage is a means of fish passage with appropriate hydraulic conditions such that all individual migrating adult and juvenile fish of the species of interest have the opportunity to move freely and safely upstream and/or downstream past the Project according to their own motivation."*

Volitional passage would not include any facilities that trap or haul fish. There may also be alternatives that have volitional passage characteristics though are not entirely volitional.

Scoring for volitional passage will reflect the degree to which they are volitional; entirely volitional alternatives will be scored the highest possible score.

D.2.1.4 Fish Access Out of Fish Passage Facility to Piru Creek above Lake Piru

This criterion describes physical access for fish from the facility through any flow control section, any device for accommodating the range of reservoir elevations, and past the reservoir and any effect of the reservoir. Head differential, depth of flow at the exit, certainty of adequate flow passing into the facility, and safety of exit conditions (such as discharge to a low reservoir level and potential fallback) are the primary considerations.

Fish access also includes passage through the reservoir and the delta area of the reservoir upstream to beyond the effects of SFD.

D.2.1.5 Certainty of Collection and Passage Performance

This criterion describes the confidence of the Panel regarding success of fish collection and passage. It is based on our combined knowledge of characteristics of the site, hydrology, this steelhead population, and precedents of other similar projects.

The aspect of certainty would normally be a heavily weighted criterion but, since the Panel has the opportunity in this case to make a final recommendation that includes additional studies to reduce uncertainty, low certainty should not diminish the evaluation score of any alternative unless it is believed that the uncertainty cannot be mitigated through studies.

D.2.1.6 Attraction and Passage of Non-target Native Species

The target species for upstream fish passage is adult steelhead. There might be added ecological value or risk in providing for or blocking passage of other species and life stages. The only other native anadromous species the Panel considered in this Study is Pacific Lamprey (*Entosphenus tridentatus)*. Facilities were not specifically designed for lamprey passage.

D.2.1.7 Opportunity to Monitor Fish Passage

This criterion addresses the opportunity (capability to integrate fish counting and tagging to assess performance of the facility or to monitor populations. The primary objective of the Panel's feasibility assessment is to provide fish passage alternatives; there is no stated requirement to incorporate population monitoring. Various technologies (cameras, radio tracking) are available for facility evaluation. If continuous monitoring of fish passing through the facility is considered a priority, the best means of achieving that goal can be determined in the design process.

Fish monitoring is considered an enhancement of alternatives and is included in the development and evaluation of all of the initial alternatives being considered at SFD.

D.2.1.8 Opportunity to Block Non-Native Species

This criterion addresses opportunity (capability) to add facilities for sorting and managing non-native fish instead of allowing them to move upstream. This action might involve a trap, visual sorting of fish, and netting or brailing non-natives into a hopper for transport or disposal. The trapping and sorting action would make any alternative non-volitional.

D.2.1.9 Safety of Juvenile Fish in Upstream Fish Passage Facilities

Most upstream passage facilities are not anticipated to be a preferred passage route for downstream migrants. Regardless, some alternatives may provide passage for small fish at lower risk than other alternatives. Risks to juvenile fish in an upstream passage facility could include predation, turbulence, small openings in water supply systems (entrainment), delay, and stranding.

D.2.1.10 Complementary to Downstream Passage Facility

There might be opportunities to optimize the design of upstream facilities by combining certain aspects of them with downstream passage facilities to manage costs, operations, and/or conserve water. This criterion addresses the opportunity to complement any of the downstream alternatives currently being considered. Alternatives that preclude downstream passage through the upstream facility would score low for this criterion.

D.2.1.11 Adaptability of Collection and Passage

Certainty of effective fish passage is increased with adaptability in design and/or operation. For example, an upstream passage alternative might score higher if the attraction flow can be modified in the future or if fish can be released at various locations. Adaptability includes the capability to phase or modify a project based on early fish passage results.

D.2.2 OPERATION AND MAINTENANCE CRITERIA

Operation and maintenance criteria are identical for both upstream and downstream passage. They are described here and also apply to the downstream evaluation matrix.

D.2.2.1 Simplicity of Fish Passage Facility and Operations

More complex and frequent operational demands and complexity of equipment result in greater uncertainty and risk due to the potential for improper operations or possible failure of equipment. Additional entrance gates, auxiliary water systems, mechanical flow control weirs, complex maintenance requirements, and the requirement of specialty skills add to complexity though operations might still be simple when these are automated. Complexity is also increased by remoteness of sites and hauling fish. Personnel required to operate facilities is not part of simplicity; it is included in operating cost.

D.2.2.2 Debris Management

Fish ladders and fish protection screens are vulnerable to debris. Debris can impair operations and performance if allowed to accumulate, thus compromising its passage effectiveness. Facility or auxiliary water that is pumped must be screened to exclude debris. This criterion describes the likelihood and the consequence of debris accumulation at the exit of or within the facility and at screened intakes and the ease of dealing with it.

D.2.2.3 Durability of Structure

This criterion describes the risk of damage or breakdown of fish passage facilities due to high flows, debris and sediment, changes in the channel, or normal wear and tear over time. The more durable facilities score higher.

D.2.2.4 Operations Safety

This criterion addresses inherent human safety risks in any alternative. There are no significant safety risks with any of the alternatives that cannot be mitigated; however, some alternatives have minor inherent risks. For example, there are greater safety risks with an alternative that requires frequent boat operations. Driving a truck and operating an overhead gantry to haul fish have greater risk than a passive fish bypass that requires no regular crew operations. Alternatives with less risk score higher.

D.2.2.5 Certainty of Meeting SFD Project Objectives

This criterion addresses the certainty that the SFD Project can continue to be operated to meet Project objectives including intended flow releases, reservoir storage, and integration with other UW facilities. Greater certainty scores higher.

D.2.2.6 Effect on Normal Operation of Project Water Supply and Generation

This criterion addresses the effect on normal operating procedures of SFD. Various alternatives may have differing effects on the operation of the Project to meet its normal functions. Operational effects might be added operational complexity or effort. Facilities that have no impacts to the current operations score highest in this category.

D.2.3 SOCIAL CRITERIA

These criteria are identical for upstream and downstream passage and are included in both evaluations.

D.2.3.1 Public Safety

This criterion addresses the degree that the public is safe in association with the presence and operation of fish passage facilities. There have been no significant safety risks in any of the alternatives that cannot be mitigated; however, all have some minor inherent risks. For example there are risks with any floating structure in the reservoir near recreational boat traffic. Alternatives with less risk score higher.

D.2.3.2 Aesthetics

This criterion reflects the aesthetic experience of the public visiting the area. Higher scores reflect better aesthetics.

D.2.3.3 Education

This criterion reflects the opportunities for public education. Higher scores reflect greater education opportunities.

D.2.3.4 Permitting and Environmental Impact

This criterion includes the effort and likelihood of permitting the construction and operation of fish passage facilities and environmental impacts other than fish passage specifically. Permits might include environmental agency approvals, dam safety, construction permits, critical ESA Section 7 consultation for affected species, and access to land owned by others. Higher scores indicate estimated ease or certainty of obtaining permits; lower scores would indicate higher risk, complexity, or uncertainty of obtaining permits.

D.2.4 COST CRITERIA

Costs are estimated for each alternative. Cost criteria are listed in the matrix but are weighted as zero by the Panel for no effect in the overall evaluation. Stakeholders have the option of scoring and weighting cost criteria, and all other criteria, for their unique purposes. To view the estimated costs and understand the methods of costing, see Section 4.4. Cost criteria are the same for downstream passage and are also considered there.

D.2.4.1 Construction Cost

Construction cost estimates and methods are described in Section 4.4.

D.2.4.2 Operation and Maintenance Costs

Operation and Maintenance (O&M) cost estimates and methods are described in Section 4.4.

D.2.4.3 Certainty of Cost

Part of the reason to evaluate certainty is to highlight any high uncertainties and data needs that might be resolved with additional design or more information. Higher scores will indicate a higher relative certainty of the shown value.

D.3 CRITERIA USED TO EVALUATE DOWNSTREAM FISH PASSAGE FACILITIES

D.3.1 PASSAGE CRITERIA

The following criteria are included in the evaluation of downstream alternatives.

D.3.1.1 Biological Performance High Estimate and Low Estimate

The Biological Performance Tool (BPT) is used to calculate the relative number of outmigrants passed downstream through each alternative; the results are provided in Section 5.3.2 and a description of the BPT is provided in Appendix E. In the evaluation, biological performance is represented by the high and the low BPT model estimates. The high and low BPT estimates are used directly though divided by 1,000 to normalize their scores to a base of zero to ten to be comparable with the other criteria. The following six criteria were described in the Study Plan and are consolidated into the BPT.

- Safety and Viability of Steelhead Juveniles/Smolts from Piru Creek above Lake Piru to a Collector
- Steelhead Juvenile/Smolt Collection at Low, Medium, and High Flow Ranges
- Steelhead Juvenile/Smolt Collection at Low, Medium, Full, and High Reservoir Water Surface Elevations
- Safety of Steelhead Juveniles/Smolts through Facility
- Safety of Steelhead Juvenile/Smolts through Spillway
- Certainty of Collection

The following criteria remain from the Study Plan or have been added, as noted.

D.3.1.2 Timeliness of Passage

For fish that successfully pass downstream, there is an advantage to doing it without delay. Fish tend to move during freshets, which can be brief. A fish that moves with less delay has a better chance of continuing movement downstream.

A fish that must move through the reservoir can be delayed more than a fish that is collected and hauled around the reservoir. A more efficient collector results in less delay. A passive passage system (no trapping or hauling) will likely result in less delay.

D.3.1.3 Kelt Collection, Safety, and Passage

This criterion addresses the success of collection and safety of kelts passing downstream through the SFD facility to where they are released downstream. It includes attraction to the collector and safety of passage (i.e., through the reservoir, spillway, or any other route they may move).

D.3.1.4 Potential for Biological Monitoring

This criterion addresses the potential of the alternative to support biological monitoring. The primary objective of the feasibility assessment is to identify fish passage alternatives; population monitoring is not a stated objective. However, the capability to include biological monitoring enhances the value of the alternative by providing feedback on the timing, abundance, and composition of outmigrating steelhead enabling the assessment of facility performance and population condition. Opportunity to effectively monitor steelhead in the southern extent of its range is extremely limited and the addition of monitoring capability is considered a beneficial attribute. If biological monitoring of downstream fish passage is determined to be a requirement, the best means of achieving that requirement can be considered in the design process.

D.3.1.5 Safety of Upstream Migrants

Some downstream passage facilities could affect adult fish migrating upstream. Effects could include impeded upstream passage and fallback through the facility.

D.3.1.6 Complementary to Upstream Facilities

There might be opportunities to optimize the design of downstream facilities by combining certain aspects of them with upstream passage facilities to manage costs, operations, and/or conserve water. This criterion addresses the opportunity to complement any of the upstream alternatives currently being considered.

D.3.1.7 Opportunity to Block Non-natives

This criterion addresses the opportunity (capability) to add facilities for sorting and managing specific species from being passed downstream. This action would likely involve a trap, visual sorting of fish, and netting or brailing non-natives into a hopper for transport or disposal.

D.3.1.8 Adaptability of Collection and Passage

Certainty of effective fish passage is increased with adaptability in design and/or operation. For example, a downstream passage alternative might score higher if the operational flow can be modified in the future or if fish can be released at various locations. Adaptability includes the capability to phase or modify a project based on early performance.

D.3.2 OPERATION AND MAINTENANCE CRITERIA

The downstream passage operation and maintenance criteria are identical to those described above for upstream fish passage.

D.3.3 OTHER CRITERIA

Other criteria are identical to those described above for the upstream fish passage criteria.

D.3.4 COST CRITERIA

Cost criteria are identical to those described above for the upstream fish passage criteria.

APPENDIX E:
Biological Performance Tool: Methodology and Results

APPENDIX E –BIOLOGICAL PERFORMANCE TOOL: METHODOLOGY AND RESULTS

E.1 INTRODUCTION

Successfully restoring steelhead (*Oncorhynchus mykiss*) access to and from spawning and rearing habitats upstream of Santa Felicia Dam (SFD) must consider a range of interactions including structural, operational, environmental, and biological conditions. Upstream fish passage facilities at SFD will have a limited range of entrance, transport and release options; and the design and operation of upstream passage facilities for steelhead has been generally successful. However, the science of downstream fish passage is less developed than upstream fish passage, and results in the industry can vary widely depending on site specific conditions. Additionally, downstream passage involves the integration of fish movements, periodicity, channel and flow conditions, dam and reservoir features, facility sizing and siting, and project operations; "why downstream passage structures may work well at one dam but not at another is poorly understood." (Goodwin et al. 2014).

When evaluating downstream fish passage alternatives, a standard approach is to convene a technical advisory committee of fish passage experts who apply their collective experience to identify promising alternatives. This approach depends on the experience and professional opinion of the committee members and is efficient and effective, but there has been a desire for increased transparency in the decision process. To support the evaluation of downstream fish passage alternatives at SFD, the panel used a biological performance tool (BPT) to aid in evaluating the effectiveness of downstream passage alternatives. Rather than relying on panel members to mentally integrate daily hydrology, daily reservoir pool level fluctuations, facility design features, and steelhead smolt periodicity and behavior, the BPT provides a structured process to calculate downstream fish passage effectiveness as the proportion of smolt outmigrants successfully passed downstream of the SFD. The BPT can be used to provide information on facility sizing, siting, range of operations, and effectiveness of individual facility components. In addition, BPT results can be used to evaluate data sensitivities, identify data gaps, and help develop research needs.

The BPT is a simulation model that routes flows and outmigrating smolts through Piru Creek and into Lake Piru. Smolts can be collected in Piru Creek, within the reservoir, or in the forebay of SFD. The BPT incorporates user-specified periodicity to account for the seasonal distribution of smolts migrating down Piru Creek. The model also provides an algorithm to adjust the percentage of smolts moving into the reservoir on a daily basis as a function of river flow and/or freshets (i.e., high flow pulses). The model starts each year with an assumed number of outmigrants entering the system from Piru Creek. The number of outmigrants is an arbitrary annual starting condition and serves as a normalizing factor to provide comparative evaluations between downstream passage alternatives. The model output, in terms of the number of system outmigrants, does not reflect actual smolts production, but rather a proportion of the initial number of smolts assumed to be migrating down Piru Creek. The BPT will not estimate the number of smolts outmigrating from the Piru Creek watershed, or the number of adults returning to Piru Creek. Rather, the BPT provides a relative comparison of facility performance and should not be considered an indication of the future passage rate of a constructed facility.

The BPT is a rather simplistic analysis of daily hydrology, smolt movements, and response of outmigrating smolts to hydraulic and design features associated with downstream fish passage facilities. The BPT calculates the number of outmigrants passed downstream of SFD but does not track the fate of those smolts passed downstream of the dam. Life cycle modeling, including estimates of steelhead production potential upstream of SFD, instream and estuary survival, and number of returning adults was deemed beyond the scope of the panel and the Group limited the Panel's analysis to passage of smolts through SFD and reservoir.

Fish passage models other than the BPT are available to aid in the evaluation downstream fish passage facilities, but were not deemed appropriate to SFD. For example, an Eulerian-Lagrangian-agent method (ELAM) has been used in the Columbia/Snake River system to evaluate fish passage movements through hydropower dam environments (Goodwin et al. 2014). Combining a computational fluid dynamics model of the flow field at a dam and a behavioral model that simulates fish response to water acceleration and depth, the model reproduced fish movements and passage patterns. Hydraulics are described as acceleration/deceleration fields and the ELAM model assumes that hydraulics are the only factors affecting smolt movement. Application of the ELAM at SFD would require computational fluid dynamic modeling of the near-field environments at each of the alternate fish passage facility locations and information on site-specific fish behavior. Computational fluid dynamic modeling of the dam, reservoir, and Piru Creek is beyond the scope of the Panel's evaluation and steelhead outmigrants are not currently available to record their response to local hydraulics. In addition, while flow fields may be the primary factor affecting fish movements at Columbia/Snake river dams, other factors such as water quality, feeding, day length, and predation may affect movement of smolts through the reservoir and SFD.

E.2 MODEL CONSTRUCT

E.2.1 BASIC STRUCTURE

The BPT simulation model is an executable program developed using Microsoft Visual Basic 2010 to quantify the expected response of outmigrants to conditions encountered along migratory pathways through the reservoir and SFD. The BPT is based on the evaluation of daily inflow, outflow, and reservoir water surface elevation at SFD over the period 1944 to 2004. Capture facilities can be located in Piru Creek immediately upstream of Lake Piru, Head of Reservoir, Intake Tower, or at the Dam (Figure E-1). The proportion of an assumed 10,000 steelhead outmigrants that successfully pass downstream of SFD is determined by capture and mortality rates (i.e., response functions) assigned to available migratory pathways or associated with reservoir rearing. If smolts remain in the reservoir, they may rear and subsequently pass downstream, or be exposed to mortality associated with predation, water quality, recreational fishing and other factors.

The BPT can be run on personal computers with Windows XP, Windows 7, or Windows 8/8.1 operating systems. The computer must have Microsoft Excel loaded to read the hydrology file "Lake Piru data from model-NewSpillQ.xls". Versions of Excel from 2003 forward should work. The main screen is composed of four major sections, as shown in Figure E-1: (1) a schematic map at the left of the screen showing all facilities; (2) input data section at the upper right of the window; (3) a summary table for simulation results of mortality rates and numbers of smolts at the lower right of the window; (4) Title Bar and Selection Menu at the top. Processing time for simulation runs using the 1944-2004 period of record and three individual years is typically less than five seconds. The BPT program developed by the panel for the SFD evaluation is available from United along with a user manual.

The map in Figure E-1 shows all four potential smolts collector facility locations: Piru Creek, Head of Reservoir, Intake Tower, and Dam. Each facility is represented by a circle in beige color. The light blue line at the bottom of the map is the Santa Clara River. The user can select one or multiple collectors for the simulation. Each potential collector is characterized by two facility-specific parameters: capture rate and mortality rate. The range of user specified capture rates for a given collector (see Section 3.5) is displayed in the rectangular box immediately adjacent to the beige circle. A rectangular box next to "Reservoir" displays the range of daily mortality rates in the reservoir.

In general, water exits the reservoir via the spillway or through the conduit connected to the intake tower. Once the water enters the intake tower, it may take one or all three routes including the Butterfly Valve (BFV), Cone Valve (CV), or Turbine, to exit the dam. However, since passage through these routes was expected to result in high mortality, United opted to block smolt passage through the intake and these passage routes were not used in evaluating downstream fish passage alternatives (see Section 3.6). Smolts may exit the reservoir by the spillway during spill events with spill events provided as defined inputs associated with daily hydrology.

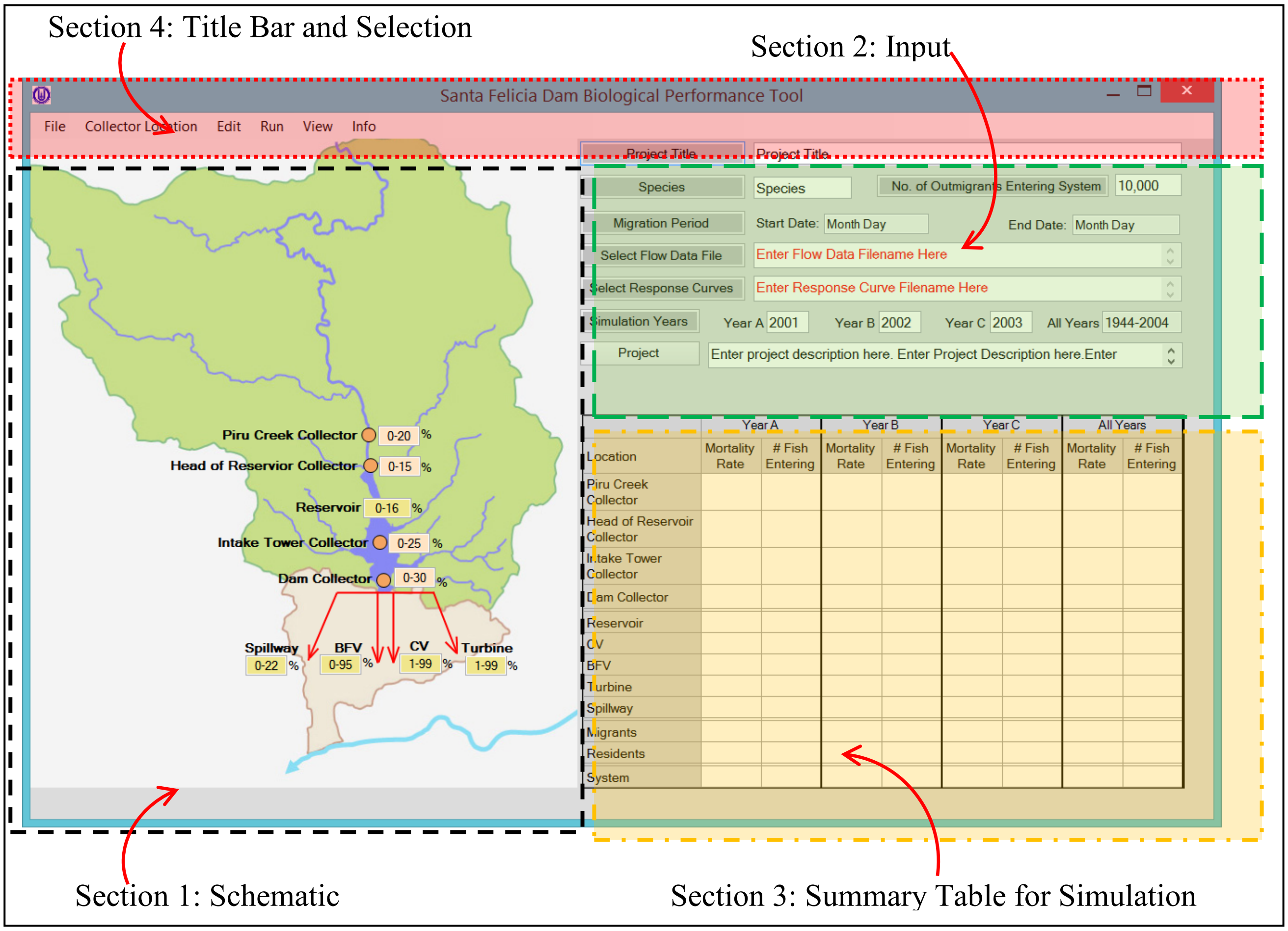


Figure E-1. Main user interface when the program starts for the first time. The input data fields are filled with informative text and the summary table is empty. The main user interface is divided into 4 sections; Section 1 is the schematic map. Section 2 is the input data. Section 3 is the summary data. Section 4 is the selection menu.

E.2.2 INPUTS

When encountering downstream fish passage facilities, smolts are assumed to be captured based on a user-specified response function dictating the rate of smolt capture in relation to flow. The panel identified a high and low estimate of potential smolt capture efficiency for each facility. High estimates were assumed to represent best-case conditions. Low estimates reflect the level of uncertainty associated with capture efficiency based on the Panel's judgement of the type, location, and design capacity of the collector. For each facility, the panel also identified a high and low estimate of mortality associated with capture, transport, and release of smolts immediately below SFD. High and low estimates were developed for daily smolt mortality while the smolts are in the reservoir. A large difference between high and low BPT results reflects a high level of uncertainty associated with that facility.

Inputs required for BPT calculations include:

- Hydrology
  - Daily Piru Creek flow
  - Daily reservoir water surface elevation

    - Daily spill volume
- Steelhead smolt periodicity
- Flow-Freshet response
- Collector capture efficiency rate
    - Piru Creek*
    - Head of Reservoir*
    - Intake*
    - Dam*
    - Spillway*
- Collector passage mortality rate
    - Piru Creek*
    - Head of Reservoir*
    - Intake*
    - Dam*
    - Spillway*
- Reservoir survival*
- Spillway passage rate*
- Passage mortality rate
    - Spillway*
    - Hydropower turbine
    - Cone valve
    - Butterfly valve

** BPT response functions include high and low estimates*

Daily Piru Creek inflow, steelhead smolt periodicity, daily reservoir pool levels, and spill are directly input to the model and are not characterized as high and low estimates. The BPT was originally configured to calculate smolt passage rates and mortality through the turbines, cone valves, and butterfly valve. The small size of the devices and high head associated with flow releases through the turbines, butterfly valves, and cone valve were expected to cause high or complete mortality to outmigrating smolts. During redesign of the intake tower, United opted to include screens that would block off potential smolt passage through those devices. The spillway was evaluated as part of United's consideration of project changes; potential use of the spillway as a potential migration route was retained in the BPT and high and low estimates of spillway passage and survival were developed based on the Panel's experience and opinion. Additional information on specific response functions used in the BPT is provided in Section 3.

E.2.3 OUTPUTS

BPT outputs include the number of system outmigrants, and the number of smolts remaining in the reservoir at the end of the year. Smolts surviving at the end of each year could be considered as reservoir carryover; however, each model year begins with the uniform assumption of 10,000 outmigrants. Users can review summary information for the entire period of available flows from 1944 to 2004 or for an individual calendar year. Information can be displayed in both tabular and graphical formats. The output can also be printed, saved to a file, or copied to a computer memory clipboard and pasted to spreadsheets or word processing applications. For documentation, the user can print input data that are used for the model run as well as detailed simulation results.

After a BPT simulation run has been successfully performed, model outputs can be viewed in table format, in graphic format, or in both formats. The three primary outputs are Daily Fish and Flows, Simulation Results Summary, and Input Data Summary.

E.2.3.1 Daily Fish and Flows

Daily Fish and Flows provides a pull-down menu to display details on 12 modeling results.

E.2.3.1.1 *Daily Flows* allows the user to view flows at different facility locations, including the selected smolt collector(s), reservoir, spillway, intake tower, butterfly valves, cone valves, turbines, and the whole system. When a location is selected (e.g., intake tower), daily flows are listed for each individual year. For *All Years*, the values represent average daily flows over the period between 1944 and 2004. The user can click *Graph* on the menu strip at the top of the window form to show the daily flow time series in graph format. The user can perform *Print*, *Copy Table to Clipboard*, *Copy Graph to Clipboard* functions by selecting from the menu strip at the top of the window form.

E.2.3.1.2 *Daily Fish Entering* allows the user to view the number of smolts entering different facilities, including the selected fish collector(s), reservoir, spillway, intake tower, butterfly valves, cone valves, turbines, and the whole system. This selection item performs similar functions depicted in (2.3.1.1) except the variable being reviewed is the daily number of smolts. It should be noted that the daily numbers have been rounded to whole numbers, and thus the sum may not exactly equal to the total number of outmigrants (i.e., 10,000) specified in the main user interface.

E.2.3.1.3 *Daily Fish Mortality* allows the user to view the number of smolt mortality at different locations, including the selected fish collector(s), reservoir, spillway, intake tower, butterfly valves, cone valves, turbines, and the whole system. This selection item performs similar functions depicted in (2.3.1.1) except the variable being reviewed is the number of smolt mortalities. It should be noted that the daily number of smolt mortalities have been rounded to whole numbers.

E.2.3.1.4 *Daily Fish Passage* allows the user to view the number of surviving smolts at different locations, including the selected fish collector(s), reservoir, spillway, intake tower, butterfly valves, cone valves, turbines, and the whole system. This selection item performs similar functions depicted in (2.3.1.1) except the variable being reviewed is the number of fish passage (i.e., surviving smolts). It should be noted that the daily numbers of fish passage have been rounded to whole numbers. The number of fish passage here is equal to the number of fish entering minus the number of fish that die in the facility.

E.2.3.1.5 *Daily Capture Rate At Collectors* allows the user to view the daily capture rates of the selected collector(s). Only the collector(s) being selected from the *Collector Location* in the main user interface will appear in the pull-down menu. This selection item performs similar functions depicted in (2.3.1.1) except the variable being reviewed is daily smolt capture rate of the collector.

E.2.3.1.6 *Daily Mortality Rate At Collectors* allows the user to view the mortality rate of the selected collector(s). Only the collector(s) being selected from the *Collector Location* in the main user interface will appear in this pull-down menu. This selection item performs similar functions depicted in (2.3.1.1) except the variable being reviewed is daily smolt mortality rate of the collector.

E.2.3.1.7 *Daily Passage Rate Through Intake Tower* allows the user to view the passage rate at the intake tower. This selection item performs similar functions depicted in (2.3.1.1) except the variable being reviewed is smolt passage rate through the intake tower. The smolt passage rate is equal to the number of smolts entering the intake tower divided by the total number of smolts in the reservoir. If the intake tower is equipped with a fish screen, the daily passage rates in this option should be all 0s.

E.2.3.1.8 *Daily Mortality Rate Through Spillway* allows the user to view the smolt mortality rate at the spillway. This selection item performs similar functions depicted in (2.3.1.1) except the variable being reviewed is the smolt mortality rate at the spillway.

E.2.3.1.9 *Cumulative Fish Entering* allows the user to view the cumulative number of smolts, from the beginning of each calendar year, entering the facilities at the selected fish collector(s), reservoir, spillway, intake tower, butterfly valves, cone valves, turbines, and the whole system. This selection item performs similar functions depicted in (2.3.1.1) except the variable being reviewed is the cumulative number of smolts (rounded to whole numbers) entering the facility.

E.2.3.1.10 *Cumulative Fish Mortality* allows the user to view the cumulative smolt mortality, from the beginning of each calendar year, at the selected fish collector(s), reservoir, spillway, intake tower, butterfly valves, cone valves, turbines, and the whole system. This selection item performs similar functions depicted in (2.3.1.1) except the variable being reviewed is the cumulative number of smolt mortalities (rounded to whole numbers) at the facility.

E.2.3.1.11 *Daily Total Fish in Reservoir* allows the user to view the daily number of smolts in the reservoir. This selection item performs similar functions depicted in (2.3.1.1) except the variable being reviewed is the daily number of smolts (rounded to whole numbers) in the reservoir.

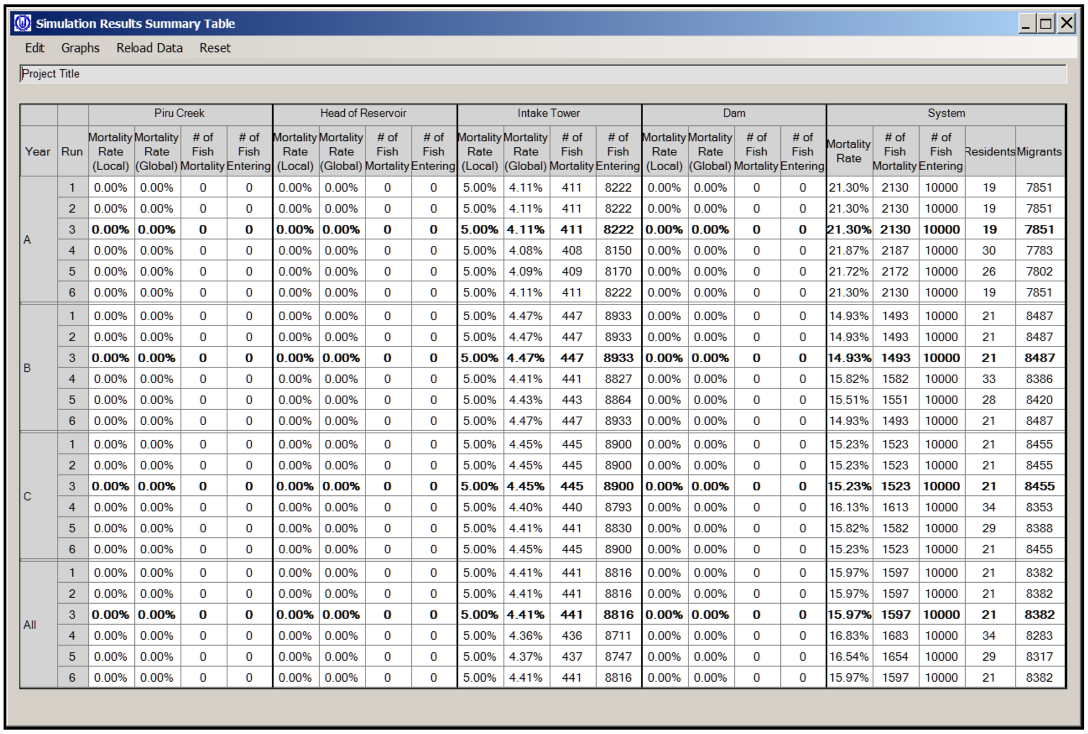
E.2.3.1.12 *Freshets*: There are three options under this menu item: *3-Day Moving-Average Flow*, *Flow Ratio*, and *Freshets*. The first selection item is self explanatory. The second one (Flow Ratio) is the ratio of the current day flow to the average flow of the previous 3 days. The third one (Freshets) shows the daily values of the freshet response. Usually there are only two values: a high value and a low value. A high value indicates the flow of the current day is a freshet. Each of the three options performs similar functions as depicted in (2.3.1.1)

E.2.3.2 Simulation Results Summary

A summary of the results for the six most recent simulation runs is displayed in tabular format (Figure E-2). The table content in the window form is similar to that of the summary table in the main user interface. The mortality rates in the main user interface represent local rates, which is the number of smolt mortalities at the facility divided by the number of smolts entering. Also included in the *Simulation Results Summary* table is the global mortality rate, which is the number of smolt mortalities at the facility divided by the total number of smolts entering the system (i.e., 10,000 each year).

There are four options on the menu strip of this window form: *Edit*, *Graphs*, *Reload*, and *Reset*.

1. *Edit* lets the user select *Copy Entire Table to Clipboard* or *Print This Screen*.
2. *Graphs* lets the user view/compare the results in graph format. The user can choose to view smolt mortalities or number of smolts for each year type (*Year A*, *Year B*, *Year C*, or *All Years*) by selecting from the pull-down menu in the window.
3. *Reload* lets the user update the simulation results in the table. After a simulation is finished and the user has clicked this option, a row of numbers turns bold to indicate the (bold) data are the results from the most recent run. There are a total of six rows for each simulation year type (i.e., *Year A*, *Year B*, *Year C* and *All Years*). When a new simulation is performed, the results will be updated at the next row with numbers turning bold. If all six rows have been used, and a 7th simulation is completed, the numbers in the first row will be replaced with the newest simulation results.
4. *Reset* lets the user clear all fields in the table.



Simulation Results Summary Table

Edit Graphs Reload Data Reset

Project Title

Year	Run	Piru Creek				Head of Reservoir				Intake Tower				Dam				System				
		Mortality Rate (Local)	Mortality Rate (Global)	# of Fish Mortality	# of Fish Entering	Mortality Rate (Local)	Mortality Rate (Global)	# of Fish Mortality	# of Fish Entering	Mortality Rate (Local)	Mortality Rate (Global)	# of Fish Mortality	# of Fish Entering	Mortality Rate (Local)	Mortality Rate (Global)	# of Fish Mortality	# of Fish Entering	Mortality Rate	# of Fish Mortality	# of Fish Entering	Residents	Migrants
A	1	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.11%	411	8222	0.00%	0.00%	0	0	21.30%	2130	10000	19	7851
	2	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.11%	411	8222	0.00%	0.00%	0	0	21.30%	2130	10000	19	7851
	3	**0.00%**	**0.00%**	**0**	**0**	**0.00%**	**0.00%**	**0**	**0**	**5.00%**	**4.11%**	**411**	**8222**	**0.00%**	**0.00%**	**0**	**0**	**21.30%**	**2130**	**10000**	**19**	**7851**
	4	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.08%	408	8150	0.00%	0.00%	0	0	21.87%	2187	10000	30	7783
	5	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.09%	409	8170	0.00%	0.00%	0	0	21.72%	2172	10000	26	7802
	6	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.11%	411	8222	0.00%	0.00%	0	0	21.30%	2130	10000	19	7851
B	1	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.47%	447	8933	0.00%	0.00%	0	0	14.93%	1493	10000	21	8487
	2	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.47%	447	8933	0.00%	0.00%	0	0	14.93%	1493	10000	21	8487
	3	**0.00%**	**0.00%**	**0**	**0**	**0.00%**	**0.00%**	**0**	**0**	**5.00%**	**4.47%**	**447**	**8933**	**0.00%**	**0.00%**	**0**	**0**	**14.93%**	**1493**	**10000**	**21**	**8487**
	4	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.41%	441	8827	0.00%	0.00%	0	0	15.82%	1582	10000	33	8386
	5	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.43%	443	8864	0.00%	0.00%	0	0	15.51%	1551	10000	28	8420
	6	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.47%	447	8933	0.00%	0.00%	0	0	14.93%	1493	10000	21	8487
C	1	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.45%	445	8900	0.00%	0.00%	0	0	15.23%	1523	10000	21	8455
	2	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.45%	445	8900	0.00%	0.00%	0	0	15.23%	1523	10000	21	8455
	3	**0.00%**	**0.00%**	**0**	**0**	**0.00%**	**0.00%**	**0**	**0**	**5.00%**	**4.45%**	**445**	**8900**	**0.00%**	**0.00%**	**0**	**0**	**15.23%**	**1523**	**10000**	**21**	**8455**
	4	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.40%	440	8793	0.00%	0.00%	0	0	16.13%	1613	10000	34	8353
	5	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.41%	441	8830	0.00%	0.00%	0	0	15.82%	1582	10000	29	8388
	6	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.45%	445	8900	0.00%	0.00%	0	0	15.23%	1523	10000	21	8455
All	1	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.41%	441	8816	0.00%	0.00%	0	0	15.97%	1597	10000	21	8382
	2	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.41%	441	8816	0.00%	0.00%	0	0	15.97%	1597	10000	21	8382
	3	**0.00%**	**0.00%**	**0**	**0**	**0.00%**	**0.00%**	**0**	**0**	**5.00%**	**4.41%**	**441**	**8816**	**0.00%**	**0.00%**	**0**	**0**	**15.97%**	**1597**	**10000**	**21**	**8382**
	4	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.36%	436	8711	0.00%	0.00%	0	0	16.83%	1683	10000	34	8283
	5	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.37%	437	8747	0.00%	0.00%	0	0	16.54%	1654	10000	29	8317
	6	0.00%	0.00%	0	0	0.00%	0.00%	0	0	5.00%	4.41%	441	8816	0.00%	0.00%	0	0	15.97%	1597	10000	21	8382

Figure E-2. Illustration of simulation summary of the most recent six runs. The table contains all four year types (*Year A*, *Year B*, *Year C* and *All Years*) and there are six rows for each year type, with each row representing a simulation run's results. The results of the most recent run are shown in bold numbers.

E.2.3.3 Input Data Summary

Input Data Summary displays the input data information used in the most recent run, as illustrated in Figure E-3. This option is activated only after a simulation run is successfully completed. The information is updated for each simulation to allow the user to associate and track simulation run inputs and outputs.

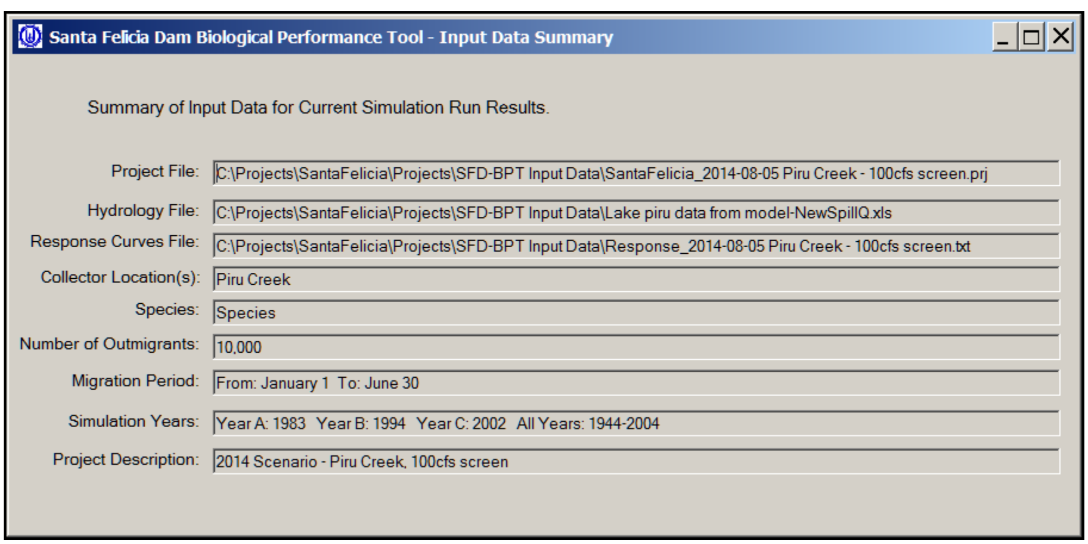


Figure E-3. Summary of input data for a BPT simulation run.

E.3 ASSUMPTIONS

Downstream fish passage alternatives can consist of one or more downstream fish passage facilities, with each facility providing for collection and transport of outmigrants. At each potential collector, the BPT incorporates user-specified, facility-specific response functions (e.g., capture efficiency and passage mortality rate) to calculate smolt passage under daily operations. For instance, the Piru Creek collector capture rate is modeled as a function of flow entering the collector. If Piru Creek flows are less than the design capacity of the collector, all smolts migrating downstream on that day are assumed to be captured. If a Piru Creek daily flow exceeds the design capacity of the collector, the capture rates will reflect a ratio of the flow passing into the collector versus passing downstream into Lake Piru. Additional discussion of BPT assumptions is provided in the following sections.

E.3.1 HYDROLOGY

The BPT requires daily values for reservoir inflow (i.e., Piru Creek flow), daily reservoir water surface elevations, reservoir flow releases, and spill for the period of interest. Daily hydrology values for years 1944-2004 were developed by United for use by the panel. Daily values for representative Wet, Average, and Dry Years were used to examine BPT modeling outputs and assess the influence of various response factors. Potential Wet, Average, and Dry years were identified by totaling the volume of Piru Creek reservoir inflow during January through June for the period of record and ranking the flow volumes from highest to lowest (Figure E-4). For illustration purposes, 2002 could be considered a Dry Year, 1994 could be considered an Average Year, and 1983 could be considered a Wet Year. After the BPT model was tested and response functions were developed, downstream passage alternatives were evaluated using all years in the 1944-2004 period of record as one indication of passage performance.

The timing and rate of steelhead smolt outmigration is affected by environmental factors including water temperature and flow. Wet Years may play an important role in smolt production and outmigration but the influence is not well understood. A high volume spring runoff could lead to improved rearing conditions. Smolts that rear for more than one year (Smith 1991; NMFS 2013) may outmigrate in greater numbers following a Wet Year, and Wet Years may provide an increased magnitude and frequency of freshets which may contribute to increased smolt outmigration. Fewer smolts may successfully pass downstream in Dry Years when surface flows in Piru Creek can become intermittent; however, smolts may continue rearing in reaches that remain wetted during Dry Years and outmigrate the following year.

Downstream passage facilities were evaluated using all years in the 1944-2004 period of record. However, because Wet Years may contribute to increased numbers of smolts and increased outmigration, downstream passage alternatives were also evaluated using a period of three consecutive Wet Years to encompass both Wet Years and years following a Wet Year.

Considering the volume of Piru Creek reservoir inflow during January through June for the period of record 1944-2004 and ranking the flow volumes from highest to lowest, out of 61 years, 1978 ranked 57, 1979 ranked 48, and 1980 ranked 53. The 3-year period encompassing the 1978, 1979 and 1980 was selected to provide an analysis of downstream passage alternatives and input to the evaluation matrix.

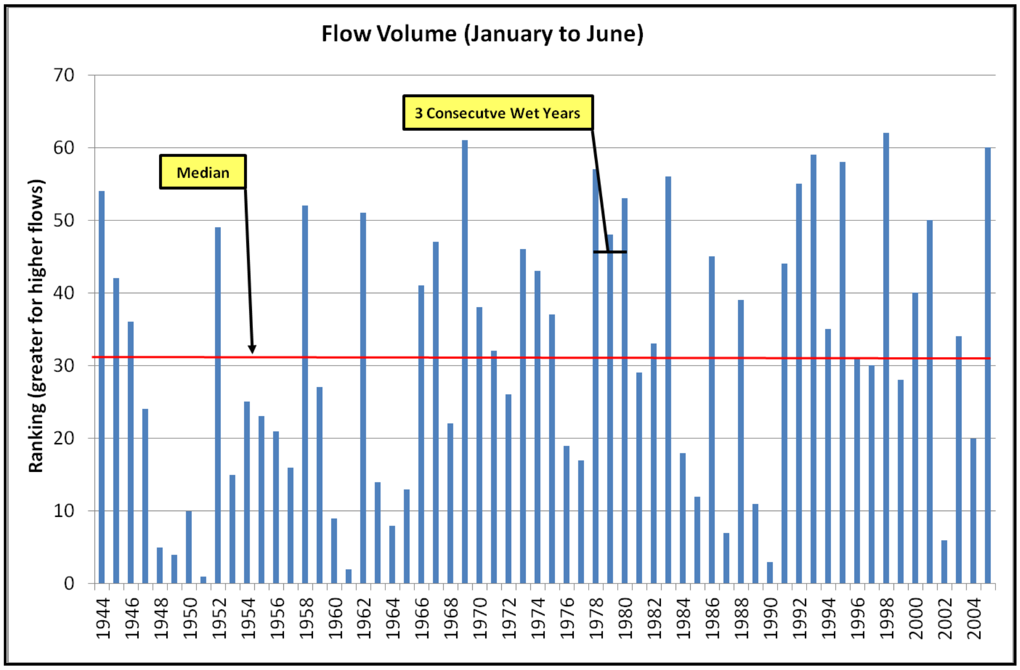


Figure E-4. Volume of Piru Creek inflow to Lake Piru during January through June for the period 1944 to 2004 ranked from highest volume to lowest volume. 1983 could be considered a Wet Year, 1994 could be considered an Average Year, and 2002 could be considered a Dry Year. Three consecutive Wet Years (1978, 1979, and 1980) were selected to evaluate downstream passage alternatives in the evaluation matrix.

E.3.2 FISH SPECIES AND PERIODICITY

The species targeted for fish passage around SFD is the Southern California Steelhead (*O. mykiss)*. Southern California Steelhead (SCS) comprise a "Distinct Population Segment" (DPS) of the species that is ecologically discrete from other populations of *O. mykiss* along the West Coast of North America. Under the U.S. Endangered Species Act of 1973, this distinct population segment qualifies for protection as an individual species. The SCS DPS includes all *O. mykis*s populations in the watershed from Santa Maria River (north of Point Sal) south to the Tijuana River at the U.S.-Mexico border. See Section 3.1 of the main report for a more detailed description of biological information pertaining to SCS DPS.

Life history of SCS DPS is considered to be quite complex and flexible. As a result, there is a great deal of uncertainty as to specific aspects of their life history as expressed in the Santa Clara

River watersheds. Life history aspects that can be critical in conceptualizing and ultimately designing downstream smolt passage around SFD include:

- Timing of juvenile downstream migration;
- Size composition of downstream migrants;
- Triggers or cues for downstream migration; and
- Benefits or costs associated with migration through reservoirs

Site specific information on timing and rate of steelhead smolt outmigration is unavailable for Lake Piru and the Piru Creek subbasin upstream to Pyramid Lake. During smoltification, the spots and parr marks characteristic of juvenile coloration are replaced by a silver and blue-green iridescent body color (Barnhart 1991) and physiological transformations occur that allow them to survive in salt water. Evidence suggests that photoperiod is the most important environmental variable stimulating the physiological transformation from parr to smolt (Wagner 1974). However, water temperature and flow-related migration cues also affect the timing and rate of outmigration. Water temperatures less than 13°C are reportedly suitable for emigrating juvenile steelhead (Zaugg and Wagner 1973), and water temperatures greater than 15°C result in decreased smolting tendencies for steelhead smolts (Zedonis and Newcomb 1997). For the BPT analysis, steelhead smolts were assumed to outmigrate January through June with peak outmigration occurring mid-March through mid-May (Figure E-5). Smolts that enter the reservoir are available for collection and transport in reservoir-based facilities through July 15. Exposure of outmigrants to 13°C water temperature for 20 days resulted in serious impairment of continued migratory behavior (Zaugg 1981).

Steelhead Smolt Periodicity	
Jan 1-15	.01
Jan 16-31	.02
Feb 1-14	.03
Feb 15-28	.04
Mar 1-15	.09
Mar 16-31	.15
Apr 1-15	.19
Apr 16-30	.19
May 1-15	.15
May 16-31	.06
Jun 1-15	.04
Jun 16-30	.02
Jul 1-15	.00
Jul 16-31	.00
Aug-Dec	.00

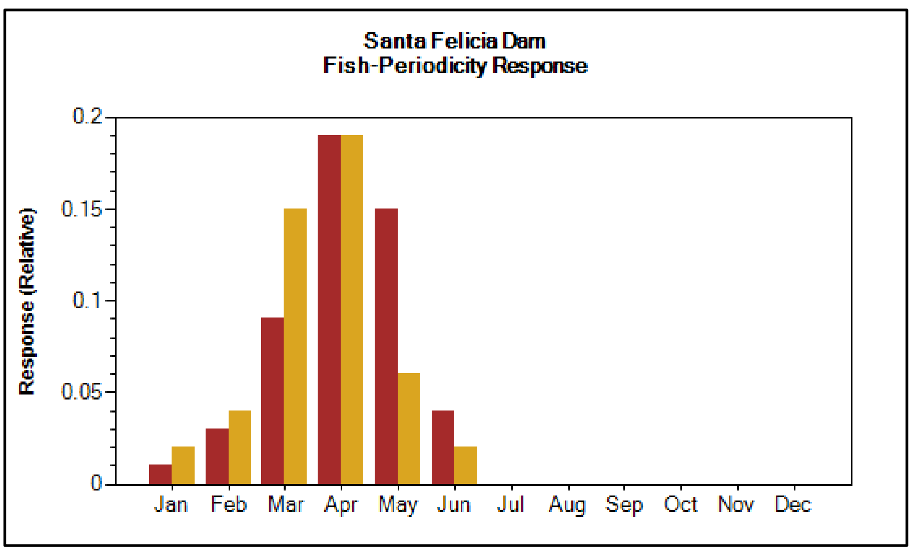


Figure E-5. Steelhead smolt periodicity response function developed for the evaluation of downstream fish passage alternatives.

E.3.3 FLOW-FRESHET RESPONSE CURVE

In addition to photoperiod and water temperature, smolt outmigration may be triggered by flow-related migration cues, particularly flows associated with freshet events. It appears that increased numbers of smolts outmigrate in association with freshets; however, screw traps and other sampling techniques used to monitor smolt outmigration may be ineffective during high flow events (Figure E-6). The influence of freshets is also a function of the proportion of the juvenile smolt population that is physiologically ready to migrate. A Piru Creek freshet occurring in early January will have less influence on smolt migration than a freshet occurring in April near the peak of the outmigration period.

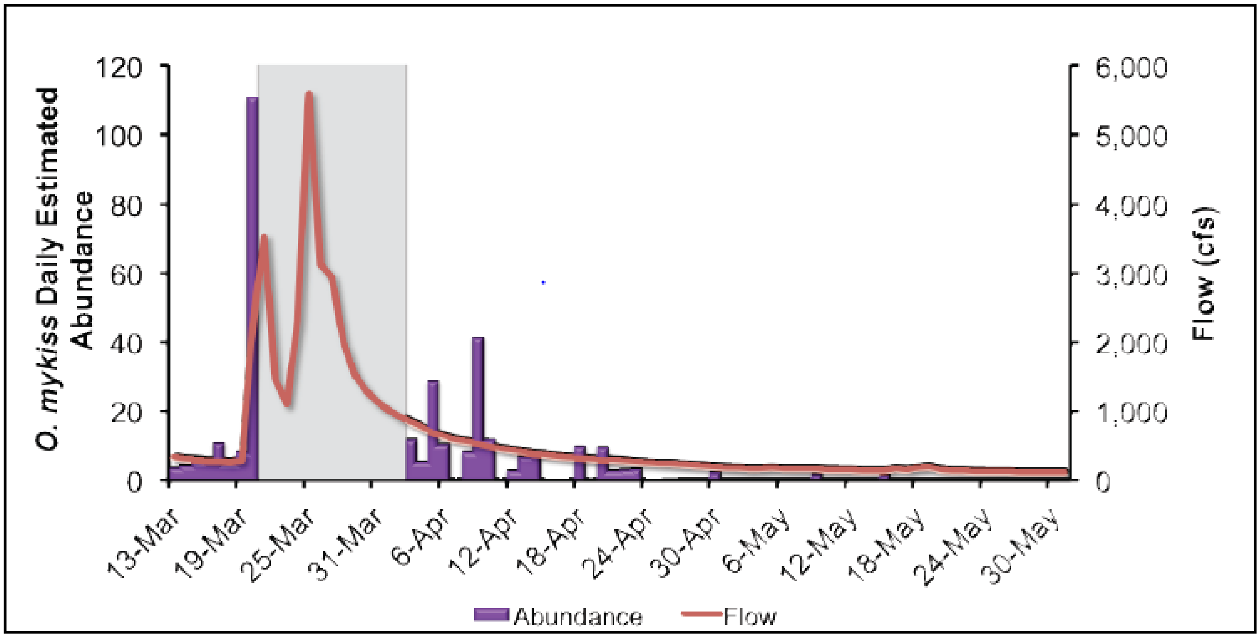
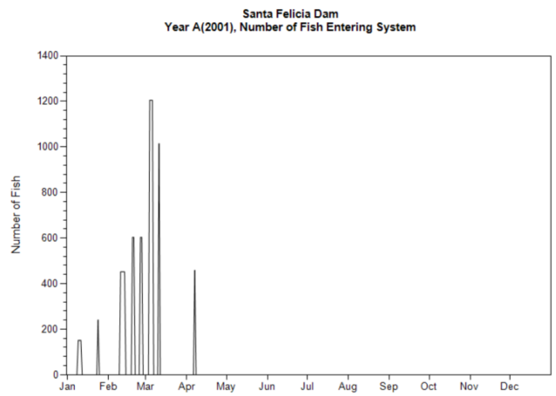
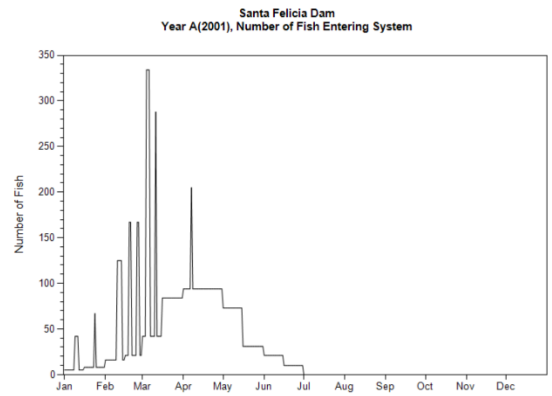


Figure E-6. Daily estimated *O. mykiss* abundance at the Arroyo Seco rotary screw trap (RM 14) and Arroyo Seco River flow near Soledad (RM 12; USGS 11152000), March 13–May 31, 2011. Gray shading indicates a no sampling period due to high flows that exceeded the operational range of the trap (adapted from Cuthbert et al. 2011).

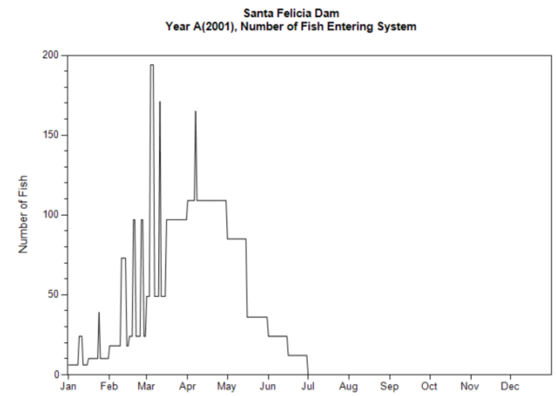
A Flow-Freshet Response Factor was developed to allow the user to define the response of steelhead smolts outmigration in response to flow-related migration cues, such as freshets. A freshet, or high flow pulse, is defined using the ratio of the average flow for the day to the average flow of the previous 3 days. A ratio greater than a threshold value indicates a freshet that is assumed to be associated with increased numbers of outmigrants entering the system (Figure E-7). Note that the freshet values in the ordinate are all relative with a higher value having more outmigrants moving down Piru Creek. For example, a value of 0.8 would likely have four times the smolts moving into the system than a value of 0.2 provided all other conditions are identical.



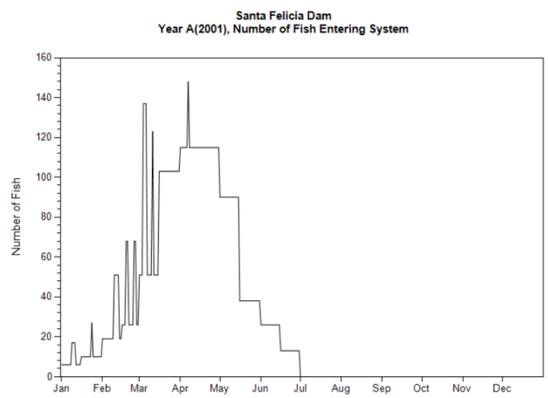
Scenario A. Smolts are only outmigrating during freshets.



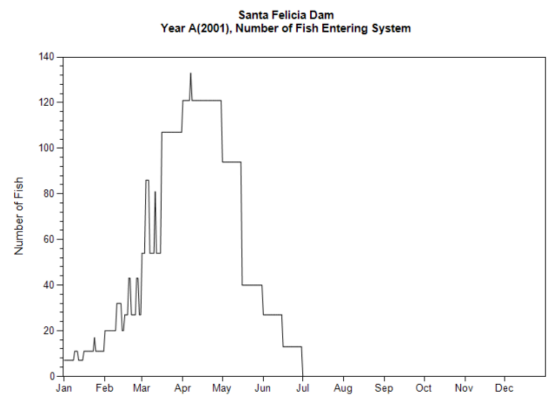
Scenario B. Smolts are eight times (8/1) more likely to outmigrate during a freshet day than periodicity alone.



Scenario C. Smolts are four times (8/2) more likely to outmigrate during a freshet day than periodicity alone.



Scenario D. Smolts are 2.7 times (8/3) more likely to outmigrate during a freshet day than based on periodicity.



Scenario E. Smolts are 1.6 times (8/5) more likely to outmigrate during a freshet day than based on periodicity.

Figure E-7. Distribution of an assumed 10,000 steelhead smolts in Piru Creek above Lake Piru under a range of freshet response values. Under Scenario A, smolts only out migrate during freshet days; as the influence of freshets declines the distribution of outmigrants is increasingly influenced by periodicity (Scenario E). For the SFD evaluation, Scenario C was selected to influence outmigrant distribution.

The Flow-Freshet Response Curve is user-specified and can range from assuming that smolts only outmigrate during freshets (see Figure E-7, Scenario A) to assuming that smolt migration is not affected by flow-related cues and is only related to periodicity. For the BPT analysis, it was assumed that steelhead smolts are four times more likely to outmigrate during a freshet day than based only on periodicity (Figure E-7, Scenario C). If more steelhead smolts outmigrate in Piru Creek during Wet Years than in Dry Years, assuming that freshets have an influence on smolt outmigration ensures that a Piru Creek collector does not overestimate smolt collection efficiency.

E.3.4 NUMBER OF OUTMIGRANTS

The number of steelhead smolts annually entering the Piru Creek/Lake Piru system is a user-specified value in the BPT. A value of 10,000 steelhead smolts has been used as an arbitrary annual starting condition for BPT runs and serves as a normalizing factor to provide comparative evaluations between downstream passage alternatives. The model output, in terms of the number of system outmigrants, does not reflect actual smolt production, but rather a proportion of the 10,000 smolts assumed to be migrating down Piru Creek each year. The BPT will not estimate the number of smolts outmigrating from the Piru Creek watershed, or the number of adults returning to Piru Creek. Rather, the BPT provides a relative comparison of facility performance and should not be considered an indication of the future passage rate of a constructed facility.

The BPT model runs integrate smolt periodicity and the Flow-Freshet Response Factor to distribute the assumed 10,000 outmigrants over the outmigration period. The BPT assumes that the same number of steelhead smolts outmigrate each year independent of water year. It is possible that more steelhead smolts outmigrate during Wet Years or following Wet Years, but rather than trying to adjust the number of smolts entering the system, the BPT results for Wet Years could be given higher priority. The BPT output includes both the number of steelhead smolts successfully passed downstream of SFD and the number of steelhead smolts that survive until the end of each calendar year (i.e., residents). The BPT does not carry surviving smolts from one year to the next; smolts surviving at the end of each calendar year are numerically removed from the model and not included in the calculation for the next year. Smolts surviving at the end of each year could outmigrate the following year, could residualize, or could suffer overwintering mortality. Assuming no carryover is a simplifying assumption since the BPT was not intended to support life-cycle modeling.

E.3.5 CAPTURE AND MORTALITY RATE AT COLLECTOR LOCATIONS

The BPT provides a drop-down menu that offers four potential collector locations: Piru Creek, Head of Reservoir, Intake Tower, and Dam/Spillway. The program allows the user to select one or more of the four potential collector locations. The program provides for serial routing of smolts through each of the collectors selected. For instance, if an alternative includes both a Piru Creek and reservoir-based collector, all 10,000 smolts are available to the Piru Creek collector while only the portion of the smolt population not collected in Piru Creek would be available to the reservoir-based collector. If only one collector is specified then all 10,000 smolts are available to the collector. The capture efficiency and facility survival must be specified by the user for each potential migratory route. The capture efficiency can vary by collector and by flow. Capture efficiency for Piru Creek and Head of Reservoir collectors is associated with daily Piru Creek flow. Capture efficiency for Intake Tower and Dam/Spillway collectors are associated with flow through the collectors. Depending on the design of the facility, flow through the Intake and Dam collector can be provided as gravity-fed dam releases or can be augmented by pumps.

Facility mortality is user-specified and reflects the mortality of smolts during capture, transport, and release. The mortality rate reflects assumed influences of screen impingement, potential predation during transport, and mechanical injury. The daily smolt mortality at a collector is equal to the number of smolts captured by the collector times the mortality (in fractions) of that day.

Assumptions for capture efficiency and facility mortality were developed by the panel through discussion, professional judgement, and experience. High values represented best case expectations and low estimates reflected the level of uncertainty associated with that design. High capture efficiency was typically associated with higher flow through the collector. However, the volume of flow must also match the screen capacity of the collector. For instance, 150 cfs passing through a 500 cfs capacity screen (i.e., D5) was assumed to result in slightly less capture efficiency than 150 cfs passing through a 150 cfs capacity screen (i.e., D3). The larger screen would take a longer distance to achieve capture velocity and the lower velocity associated with the larger screen would allow increased holding and feeding by predatory fish. A summary of percent capture efficiency and percent facility mortality is provided for each of the collectors in Table E-1.

Table E-1. Biological Performance Tool percent capture efficiency and percent facility mortality assumptions associated with downstream fish passage alternatives. Low estimates indicated by yellow shading.

ASSUMPTIONS: Daily inflow, reservoir pool level, spill, and release flow provided by United (01/22/14) but adjusted to reflect reductions in spill. Intake release: minimum 7 cfs Jan-Sep, 9 cfs Oct-Dec, max=500 cfs, Max Piru Cr inflow<30,000 cfs, Max dam release (intake and spillway) <10,000 cfs.

Low Estimates of Efficiency and Survival					High Estimates of Efficiency and Survival (Best Case)				
Downstream Alternative Description	**Flow correlation**	**Flow range (cfs) Low**	**Flow range (cfs) High**	**Collector Flow (cfs)**	**Capture Efficiency (%)**		**Facility Mortality (%)**		**Notes**
[D2] FSC, Movable, 150 cfs screen *[Head of Reservoir]*	Piru Cr	0	1	150	55	55	5	5	Assume FSC is located off of Piru Creek delta and moved as reservoir pool level changes to maintain proximity of collector to reservoir inflow. Increased efficiency compared to [D1] since closer to source of outmigrants but offset by increased susceptibility to debris and increased mortality. Less capture efficiency than Piru Creek Collector.
					90	90	1	1	
	Piru Cr	2	150	150	55	55	5	10	
					90	90	1	1	
	Piru Cr	151	500	150	55	55	10	15	
					90	90	1	5	
	Piru Cr	501	1,500	150	55	20	15	20	
					90	40	5	8	
	Piru Cr	1,501	8,977	150	20	0	20	30	
					40	0	8	15	
[D3] Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps [**No** temp fyke net in Piru Cr]	Penstock	7	150	150	40	40	5	5	No competing flow relates to better capture efficiency, opportunity to better utilize pump flow to guide < 150 cfs take all of flow, some separation between collector and intake when flows 151-500 cfs If intake is <150, pump to make 150 cfs, High survival assumes few debris impingement
					80	80	1	1	
	Penstock	151	500	150	40	45	5	5	
					80	85	1	1	
	Penstock + Spillway	501	830	150	45	50	5	5	
					85	90	1	1	
	Penstock + Spillway	831	1,500	150	50	20	5	5	
					90	40	1	1	
	Penstock + Spillway	1,501	8,977	150	20	5	5	10	
					40	5	1	5	
[D4] Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps, Volitional Bypass with U1 [**No** temp fyke net in Piru Cr]	Penstock	7	150	150	35	35	10	10	No competing flow relates to better capture efficiency, opportunity to better utilize pump flow to guide < 150 cfs take all of flow, some separation between collector and intake when flows 151-500 cfs If intake is <150, pump to make 150 cfs, Lower survival than [D3] due to higher risk of predation in bypass
					75	75	5	5	
	Penstock	151	500	150	35	45	10	10	
					75	80	5	5	
	Penstock + Spillway	501	830	150	45	50	10	10	
					80	90	5	5	
	Penstock + Spillway	831	1,500	150	50	20	10	10	
					90	40	5	5	
	Penstock + Spillway	1,501	8,977	150	20	5	10	15	
					40	5	5	10	
[D5] Surface Collector at Intake Tower, 500 cfs Screen, Gravity with Pumps [**No** temp fyke net in Piru Cr]	Penstock	7	150	150	35	35	10	10	If intake is <150, pump to make 150 cfs, 500 cfs screen will cause lower Vo so less capture efficiency and increased potential for predation Pump 150 cfs up to 350 cfs intake flow, then throttle pumps back to 0 cfs until reach 500 cfs total intake flow
					80	80	1	1	
	Penstock	151	500	151-500	35	55	10	5	
					80	90	1	1	
	Penstock + Spillway	501	830	500	55	60	5	5	
					90	91	1	1	
	Penstock + Spillway	831	1,500	500	60	45	5	5	
					91	75	1	1	
	Penstock + Spillway	1,501	8,977	500	45	10	5	10	
					75	20	1	5	

Table E-1. Biological Performance Tool percent capture efficiency and percent facility mortality assumptions associated with downstream fish passage alternatives. Low estimates indicated by yellow shading.

ASSUMPTIONS: Daily inflow, reservoir pool level, spill, and release flow provided by United (01/22/14) but adjusted to reflect reductions in spill. Intake release: minimum 7 cfs Jan-Sep, 9 cfs Oct-Dec, max=500 cfs, Max Piru Cr inflow<30,000 cfs, Max dam release (intake and spillway) <10,000 cfs.

Low Estimates of Efficiency and Survival						High Estimates of Efficiency and Survival (Best Case)				
Downstream Alternative Description	**Flow correlation**	**Flow range (cfs) Low**	**Flow range (cfs) High**	**Collector Flow (cfs)**		**Capture Efficiency (%)**		**Facility Mortality (%)**		**Notes**
[D7] Piru Creek Collector, 200 cfs fish screen	Piru Cr	0	1	0	1	0	80	5	5	Mortality function includes debris/impingement
						0	80	1	1	
		2	200	2	200	95	95	5	10	
						99	99	1	1	
		201	400	200	400	95	75	10	15	Continue diversion when in-channel flow increases from 1x fry design capacity to 2x fry design, increased Vo means increased mortality but still able to capture fish, flow >2x design goes over weir
						99	99	1	1	
		401	1,000	400	600	75	15	15	30	
						99	25	1	5	
		1,001	30,000	0	0	0	0	---	---	Diversion shuts down at 5x design capacity
						0	0	---	---	
[Base Condition] Existing spillway	Reservoir WSE > 1,055'	0	330			0	0	---	---	
		1,055.0	1,055.30			0	0	---	---	No fish passage <330 cfs (0.3 ft over lip corresponding to CA Critical Riffle Analysis(2013)
			1,000			0	2	95	95	
		331	1,055.63			0	4	75	75	
			2,000			2	4	95	90	Collection efficiency increases as flows increase, but survival decreases as turbulence and Vo goes up until 1,000 cfs - then survival stays the same – more cushion as plunge pool fills but more spray offsets
		1,001	1,056.00			4	8	75	70	
			3,000			4	6	**90**	90	
		2,001	1,056.33			8	10	**70**	70	
			8,977			6	10	90	90	
		3,001	1,058.02			10	15	70	60	
Piru Creek Collector – D7 with spillway collector D7 (200 cfs Piru Cr collector) plus 500 cfs spillway collector **[D9]**	Reservoir WSE>1,055'	0	150	500 cfs		0	16.5	5	5	
			1,055.18			0	27	5	5	
		151	300			16.5	33	5	5	
			1,055.28			27	54	5	5	Assume that all fish go into collector up to collector capacity plus 330 cfs. Collector capture efficiency improves at 500 cfs design flow is equal to D5 (500 cfs collector). No fish enter spillway until >330 cfs (0.3 ft over lip corresponding to CA Critical Riffle Analysis (2013). Collector bypass mortality is assumed to be 5% (high survival). Percent capture and % survival adjusted by ratio of collector versus spillway flow. Spillway mortality and capture efficiency at higher flows assumed from Base Condition.
		301	500			33	55	5	5	
			1,055.40			54	90	5	5	
		501	830			55	55	5	5	
			1,055.56			90	90	5	5	
		831	1,000			55	29	5	50	
			1,055.77			90	47	5	40	
		1,001	2,000			29	17	50	69	
			1,055.99			47	29	40	54	
		2,001	3,000			17	14	69	76	
			1,056.33			29	23	54	59	
		3,001	8,977			14	13	76	85	
			1,058.02			23	19	59	57	
[D14] Multi-level Crest Gate Collector with Helix Bypass [**No** temp fyke net in Piru Cr]	Penstock	7	150	150 cfs		45	45	3	3	No screens so assume collection is a little better than D3. Assume no predation so transport survival is a little better than D3
						85	85	1	1	
	Penstock	151	500			45	50	3	3	
						85	90	1	1	
	Penstock + Spillway	501	830			50	55	3	3	
						90	95	1	1	
	Penstock + Spillway	831	1,500			55	25	3	3	
						95	45	1	1	
	Penstock + Spillway	1,501	8,977			25	10	3	5	
						45	10	1	3	

E.3.6 CAPTURE AND MORTALITY THROUGH RELEASE STRUCTURES

The daily mortality associated with release structures is the total number of smolts that die in the facility divided by the total number of smolts entering the facility. The BPT was originally configured to calculate smolt passage rates and mortality through the turbines, cone valves, and butterfly valve (Table E-2). The small size of the devices and high head associated with flow releases through the turbines, butterfly valves, and cone valve were expected to cause high or complete mortality to outmigrating smolts. During redesign of the intake tower, United opted to include screens that would block off potential smolt passage through those devices. Because the intake tower is proposed to be screened and no smolts would be able to enter the intake, the BPT model runs assumed no smolt entry and the mortality rate for the turbines, butterfly valves, and cone valve were all set to "0".

The spillway is also being evaluated as part of United's consideration of project changes, and potential use of the spillway as a potential migration route was retained in the BPT. High and low estimates of smolt passage and survival were developed for the spillway based on the Panel's experience and opinion. Smolts only enter the spillway when there is a spill event. Spill events occur during the smolt outmigration period of January through June and primarily in Wet Years.

E.3.7 RESERVOIR MORTALITY

Reservoir-based downstream fish passage facilities expose outmigrating steelhead smolts to potential benefits associated with potential rearing opportunities, but also the risk of increased mortality due to predation and marginal water quality conditions during the summer months. The risk of high reservoir mortality would favor collecting smolts in Piru Creek upstream of the reservoir; reservoir-related growth and survival would favor a reservoir-based collector to provide the opportunity for reservoir rearing, at least early in the migration period. The Reservoir Mortality Rate, as illustrated in Figure E-8, allows the user to enter daily reservoir mortality rates by half month period. The mortality rates reflect factors such as predation, thermocline water quality, and natural mortality. The mortality rate values (in fractions) are constant within each half-month period. For example, a value of 0.004 represents 0.4% of the total number of smolts available in the reservoir that would die on a day, and the same fraction of 0.004 is applied to every day within the half-month period.

Table E-2. Hydraulic capacities and limitations associated with existing release structures at Santa Felicia Dam (United 2014).

Feature	Min. Q (cfs)	Max. Q (cfs)	Min. H (MSL)	Max. H (MSL)
60-inch Penstock Normal Maximum Q	25	597	933.5	1,055
60-inch Penstock Normal Maximum Q	597	771	980	1,055
36-Inch Cone Valve (each of 2 valves)	25	673	980	1,055
Cone Valve (total)	50	771	980	1,055
Hydro Unit #1 (nominal 164 kW)	9	20	980	1,028
Hydro Unit #2 (nominal 806 kW)	40	88	980	1,055
West Branch 12-Inch Low-Flow	0	10.0	N/A	N/A
East Branch 12-Inch Low-Flow	0	10.0	N/A	N/A

Notes:

1. Spillway elevation is 1,055 feet MSL.
2. Fixed intake tower elevation is 932.6 feet MSL.
3. Minimum pool elevation is presently 980 feet MSL.
4. Approximate elevation of the turbines and cone valves is 865 feet MSL.
5. The Normal Maximum Discharge and Absolute Maximum Discharge are the design parameters for penstock and original Howell-Bunger hollow cone valves. These values have been modified in accordance with GEI Consultants TM dated October 21, 2011.
6. The cone valves shall not be operated less 5 percent open to prevent damage to the o-rings and coating.
7. The low-flow discharge pipes can operate above 10 cfs for short periods of time when sourced through the penstock. Cavitation begins when flows exceed 10 cfs.
8. The capacities shown are for independent operation. All devices share a common 60-inch penstock and intake tower. Hence, head losses from combined operations can serve to reduce maximum discharges and/ or reduce maximum head limitations.

There is significant uncertainty regarding smolt survival in Lake Piru. Lake Piru contains a warm-water fishery with potential predation on juvenile steelhead. The reservoir thermally stratifies during summer months (see Section 3.2.1) and may allow separation between juvenile salmonids and warmwater predators; however, water quality during the summer months is not conducive to salmonid rearing. For the BPT evaluations, the panel assumed a low and high range of daily reservoir mortality (Figure E-8) with high mortality during the spring when the concentration of steelhead smolts may attract predators, reduced mortality during the summer, and lower mortality during the fall. Reservoir mortality represents an important uncertainty affecting potential benefits of reservoir-based collectors.

Month	Higher Mortality/ Lower Survival		Lower Mortality/ Higher Survival	
	1st half	2nd half	1st half	2nd half
Jan	.2	.2	.1	.1
Feb	.3	.4	.1	.1
Mar	.8	1.6	.2	.4
Apr	2.4	2.4	.6	.6
May	2.4	2.0	.6	.5
Jun	1.6	.5	.4	.2
Jul	.5	.5	.2	.2
Aug	.5	.5	.2	.2
Sep	.4	.4	.2	.2
Oct	.2	.2	.1	.1
Nov	.2	.2	.1	.1
Dec	.2	.2	.1	.1

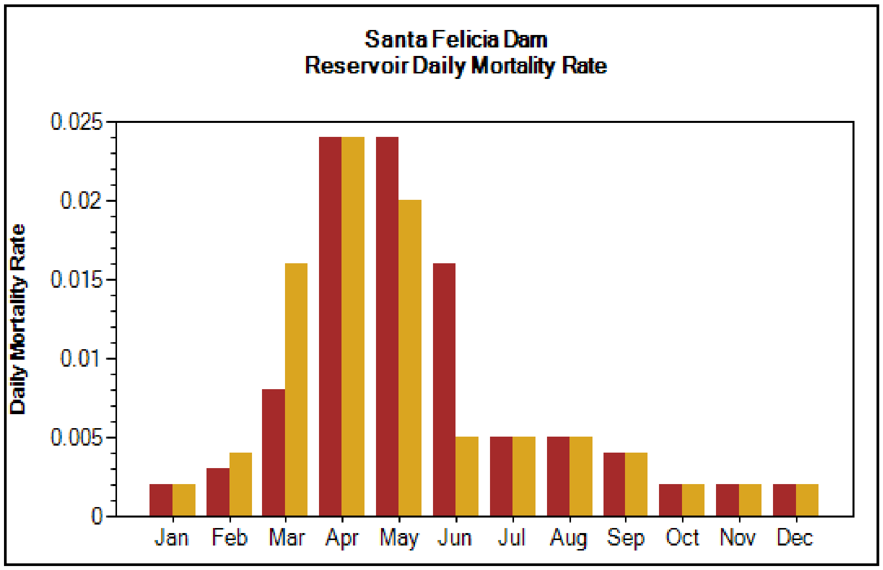


Figure E-8. Daily steelhead smolt reservoir mortality assumptions developed for the BPT evaluation of downstream fish passage alternatives. Figure illustrates estimates of daily reservoir mortality assuming lower survival/higher mortality.

E.4 RESULTS

E.4.1 DOWNSTREAM FISH PASSAGE ALTERNATIVES

Nine alternatives were developed for evaluation of downstream fish passage feasibility at SFD. A description of each alternative is provided in Section 4.4 of the main report and listed in Table E-3 below. Facility configurations D3, D4, D5, and D9 are not preferred stand-alone alternatives but were evaluated using the BPT both as stand-alone alternatives and then combined with D7 as preferred alternatives.

Performance of each alternative was evaluated using the BPT for the 60-year period of daily flows 1944-2004 and the calculated average for three consecutive wet years 1978, 1979, and 1980. Each evaluation assumed that 10,000 smolts enter the system each year. Evaluations were conducted assuming high estimates for the collector capture efficiency and survival and low estimates based on increased uncertainty regarding response functions. Numerical BPT results for the nine alternatives are presented in Table E-4, and graphs of the BPT results are presented for the period 1944-2004 (Figure E-9), and the average of three consecutive wet years (Figure E-10).

Table E-3. List of downstream fish passage alternatives considered by the Santa Felicia Dam Fish Passage Panel.

Alternative	Description
D3	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps
D4	Surface Collector at Intake Tower, 150 cfs Screen, Gravity with Pumps, Volitional Bypass with U1
D5	Surface Collector at Intake Tower, 500 cfs Screen, Gravity with Pumps
D7	Piru Creek Collector, 200 cfs fish screen
D9	Piru Creek Collector – D7 with spillway collector
D10	Piru Creek Collector – D7 with D3 (150 cfs surface collector)
D11	Piru Creek Collector – D7 with D5 (500 cfs surface collector)
D12	Piru Creek Collector – D7 with Movable floating surface collector
D14	Multi-level Crest Gate Collector with Helix Bypass

The results of the BPT analysis indicated that as a stand-alone alternative, D7 represented the highest scoring alternative when considering both high and low estimates. Several of the reservoir-based alternatives have higher scores when considering the high estimates, but the uncertainty associated with reservoir-based collectors is evident in the wide range between high and low estimates. The BPT can be used to calculate both the number of smolts passing downstream of SFD and the number of potential carryover smolts. Potential carryover smolts are those that are not passed downstream of SFD and do not die over the summer. Those smolts could potentially pass downstream the following year, residualize, or suffer overwinter mortality. Due to uncertainty of the fate of those potential carryover smolts, only the smolts that were modeled as passing downstream of SFD were used in the evaluation matrix. In response to concerns regarding the influence of wet years on juvenile steelhead production and migration, the BPT values calculated as the average of the three consecutive wet years: 1978, 1979, and 1980 were used as indicators of biological performance in the evaluation matrix.

Table E-4. Performance of downstream fish passage alternatives D3, D4, D5, D7, D9, D10, D11, D12, and D14 calculated for the period 1944-2004, and as the average for Wet Years 1978, 1979, and 1980. Evaluation assumes that 10,000 smolts enter the system each year. High estimates based on best-case assumptions for Biological Performance Tool response functions and low estimates based on increased uncertainty regarding response functions.

		Number of Potential Carryover Smolts				**Number of Smolts Passed Downstream (Outmigrants)**				
		1978	**1979**	**1980**	**All Years**	**1978**	**1979**	**1980**	**All Years**	**Ave of 3 Wet Years**
Alts	**Range**	**(Wet)**	**(Wet)**	**(Wet)**		**(Wet)**	**(Wet)**	**(Wet)**		
D3	Low	902	843	878	926	3,465	3,474	3,589	**3,367**	**3,509**
	High	390	358	387	414	8,791	8,729	8,804	**8,836**	**8,775**
D4	Low	1,005	944	987	1,044	2,723	2,635	2,651	**2,530**	**2,670**
	High	531	485	524	562	8,087	8,021	8,106	**8,146**	**8,071**
D5	Low	978	928	977	1,038	3,075	2,889	2,889	**2,613**	**2,951**
	High	374	348	380	410	8,876	8,795	8,860	**8,857**	**8,844**
D7	Low	180	159	145	155	7,118	7,433	7,456	**8,242**	**7,336**
	High	250	349	336	233	8,893	8,766	8,786	**9,361**	**8,815**
D9	Low	152	86	82	137	7,825	8,469	8,612	**8,474**	**8,302**
	High	128	41	44	179	9,485	9,752	9,752	**9,537**	**9,663**
D10	Low	94	82	72	87	7,813	8,045	8,104	**8,622**	**7,987**
	High	11	16	12	18	9,749	9,752	9,760	**9,832**	**9,754**
D11	Low	96	81	76	95	7,860	8,133	8,146	**8,583**	**8,046**
	High	9	11	9	17	9,781	9,797	9,789	**9,839**	**9,789**
D12	Low	91	94	79	75	7,816	7,967	8,076	**8,709**	**7,953**
	High	86	158	129	62	9,400	9,308	9,400	**9,707**	**9,369**
D14	Low	801	749	780	823	4,069	4,029	4,057	**4,006**	**4,052**
	High	271	250	270	289	9,120	9,067	9,123	**9,141**	**9,103**

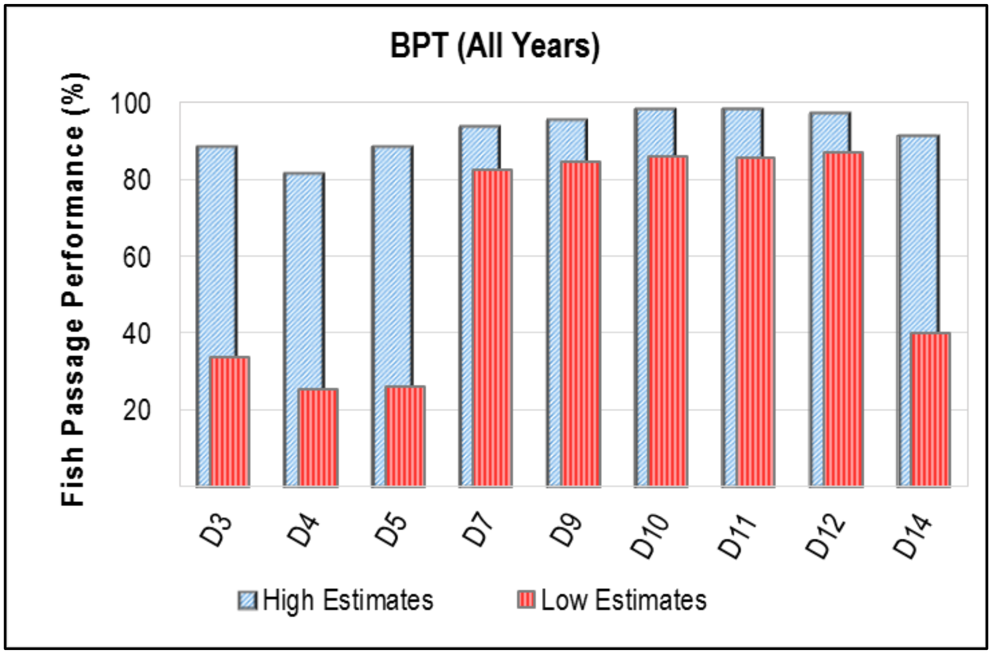


Figure E-9. Performance of downstream fish passage alternatives D3, D4, D5, D7, D9, D10, D11, D12, and D14 for the period 1944-2004. In order to provide equal comparison of alternatives, the evaluation assumes that 10,000 smolts enter the system each year. High estimates based on best-case assumptions for Biological Performance Tool response functions and low estimates based on increased uncertainty regarding response functions.

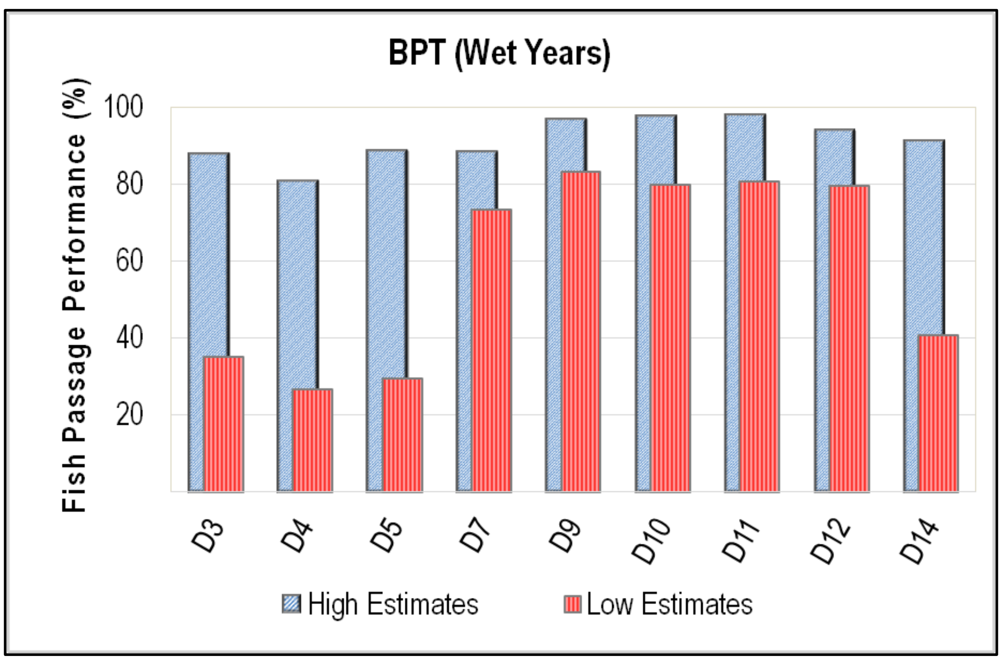


Figure E-10. Performance of downstream fish passage alternatives D3, D4, D5, D7, D9, D10, D11, D12, and D14 calculated as the average for Wet Years 1978, 1979, and 1980. Evaluation assumes that 10,000 smolts enter the system each year. High estimates based on best-case assumptions for Biological Performance Tool response functions and low estimates based on increased uncertainty regarding response functions.

The results of the BPT will be used to score the relative performance of downstream fish passage alternatives in collecting and passing outmigrating smolts past SFD, but will not be the only criterion. In addition to evaluating alternatives based on the successful collection and transport of outmigrating steelhead smolts, fish passage alternatives will include scoring based other criteria such as:

- Certainty of collection;
- Kelt collection, safety, and passage;
- Potential for biological monitoring;
- Relationship to dam operations and upstream passage facilities;
- Adaptability of collection and passage;
- Operation and maintenance;
- Public safety;
- Aesthetics; and
- Permitting.

E.4.2 PIRU CREEK COLLECTOR DESIGN FLOW

In support of the evaluation of downstream fish passage alternatives, the BPT was used to assess performance of a Piru Creek Collector (D7) under a range of potential design flows. All response functions, except for collector hydraulic capacity and collector capture efficiency and mortality, were held constant and successive runs were made assuming design flows of 10, 25, 50, 100, 200, 300, and 500 cfs. It was assumed that the fry criterion was met at all flows up to the design flow 'X'. At Piru Creek flows up to the design flow of X, capture efficiency was assumed to be 95 percent with 99 percent facility survival. At flows from the design flow up to two times the design flow (i.e., Piru Creek inflows of X to 2X cfs), all flow is screened, but the approach velocity criterion is exceeded. Capture efficiency was assumed to be 95 percent, but facility survival dropped from 99 percent at the design flow to 90 percent at 2 times the design flow. At flows from 2 times the design flow to 5 times the design flows (i.e., Piru Creek inflows of 2X to 5X cfs), 2X of the design flow is screened and the remaining flow and associated smolts are passed over the dam into the reservoir. Facility survival was assumed to drop to 85 percent at 5X of the design flow assuming increased debris and potential injury and mortality at higher flow conditions. When flows in Piru Creek exceed 5X of the design flows, the dam is lowered and no smolts are captured in the Piru Creek Collector. Smolts that are not captured in the Piru Creek Collector are assumed to pass downstream and enter the reservoir. Smolts entering the reservoir are exposed to reservoir-related growth and mortality (see E3.7), may pass downstream through spill, or pass downstream through a reservoir-based collector depending on the fish passage alternative.

The range of Piru Creek design flows were evaluated using All Years (i.e., 1944 to 2004) (Figure E-11). If the number of smolts entering the system from Piru Creek is assumed to be independent of water year, Piru Creek collector design flows of 10 to 25 cfs were calculated to capture and pass 40 to 50 percent of the smolts. During dry years, even a relatively small capacity Piru Creek Collector will screen much of the Piru Creek inflow during the January through June smolt outmigration period. Under All Years, the proportion of smolts captured increases as the design flow increases, but the incremental increase drops off at design flows above about 200 cfs.

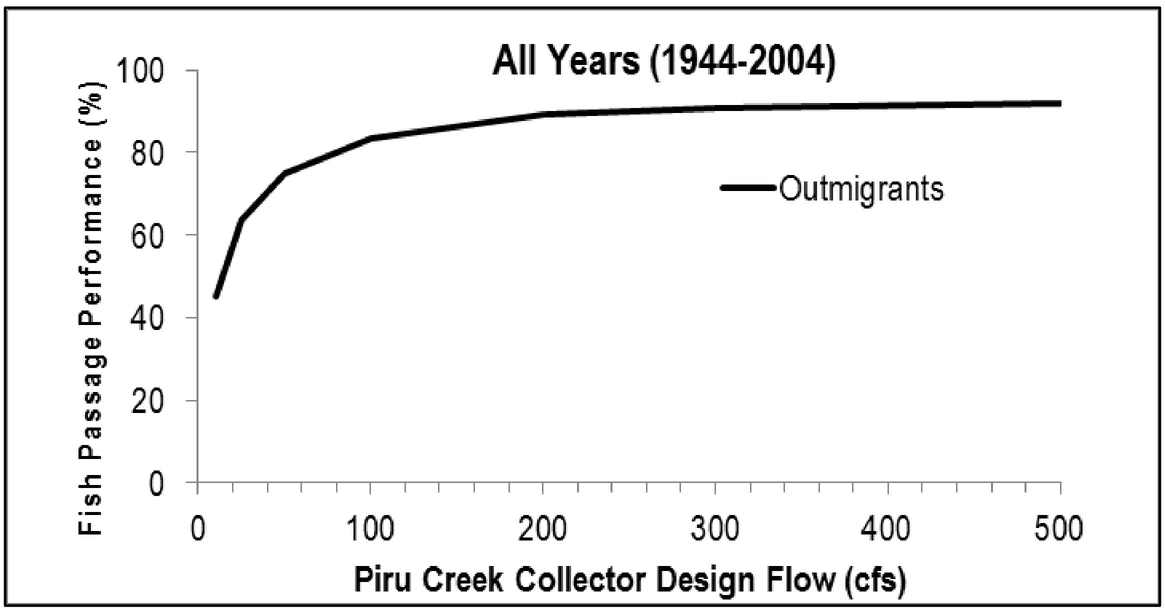


Figure E-11. Performance of Piru Creek Collector under a range of design flows for the period 1944-2004. The evaluation assumes that 10,000 smolts enter the system each year and performance is based on the number of smolts passed downstream of SFD (Outmigrants). A design flow of 200 cfs was selected for the initial evaluation of a Piru Creek Collector as part of downstream fish passage alternative D7.

In order to assess the influence of wet years, a similar range of Piru Creek design flows of 10, 25, 50, 100, 200, 300, and 500 cfs were also evaluated for three consecutive Wet Years: 1978, 1979, and 1980 (Figure E-12). Using the average results for the three consecutive wet years, Piru Creek collector design flows of 10 to 25 cfs were calculated to capture and pass less than 13 percent of the assumed annual 10,000 smolts. Under the three consecutive wet years, the proportion of smolts captured increased as the design flow increased, but the rate of increase is reduced at higher design flows. For purposes of the feasibility analysis, the design flow for the Piru Creek Collector (Alternative D7) was assumed to be 200 cfs. Although the percentage of smolts captured and passed downstream of SFD is calculated to increase as the design flow increases, the incremental increase drops off at about 200 cfs.

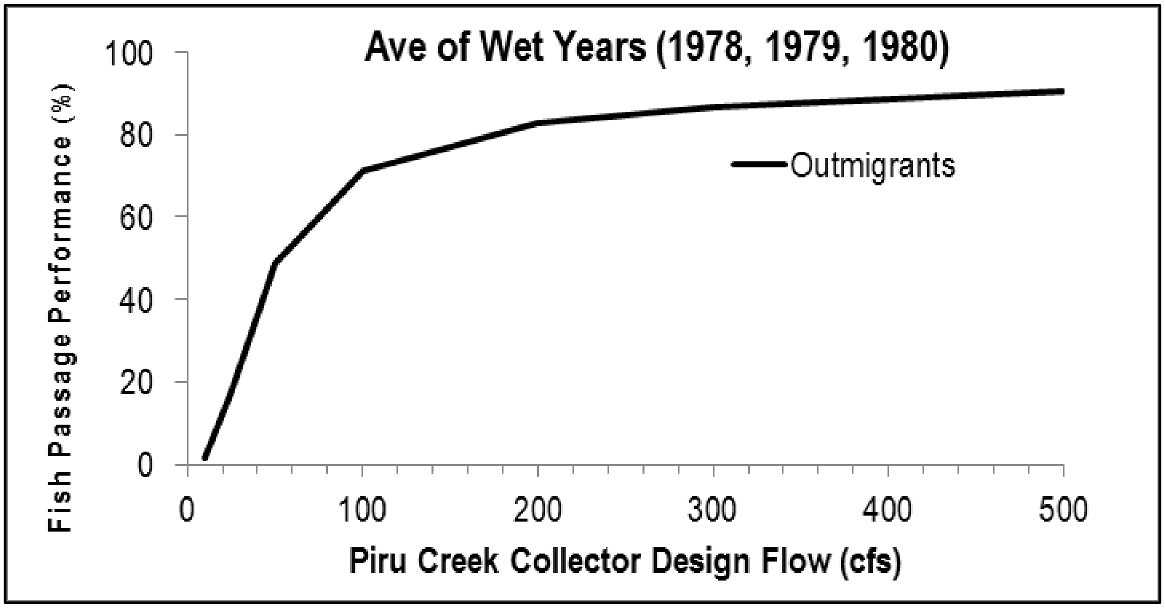


Figure E-12. Performance of Piru Creek Collector under a range of design flows calculated as the average for Wet Years 1978, 1979, and 1980. The evaluation assumes that 10,000 smolts enter the system each year and performance is based on the number of smolts passed downstream of SFD (Outmigrants). A design flow of 200 cfs was selected for the initial evaluation of a Piru Creek Collector as part of downstream fish passage alternative D7.

E.4.3 RESERVOIR COLLECTOR DESIGN FLOW

In addition to using the BPT to evaluate the design flow of a Piru Creek Collector (D7), the BPT was used to assess performance of a reservoir-based collector (D3) under a range of potential design flows. All response functions, except for collector hydraulic capacity and capture efficiency, were held constant and successive runs were made assuming design flows of 10, 25, 50, 100, 200, and 300 cfs. If dam releases through the intake were less than the target fish passage design flow, flow through the collector would be augmented by pumping up to the design flow. Collection efficiency at a design flow of 150 cfs was developed based on the collective experience and opinion of the panel. Collection efficiencies at lower design flows were then calculated as a ratio of the 150 cfs design flow. Collection efficiencies at higher design flows were calculated as the ratio between collection efficiency of D3 at 150 cfs and D5 at collection efficiency at a 500 cfs design flow. Passage survival through the collector was assumed to 95 percent for the full range of design flows.

The range of reservoir collector design flows were evaluated using All Years (i.e., 1944 to 2004) (Figure E-13). If the number of smolts entering the system from Piru Creek is assumed to be independent of water year, the reservoir-based collector D3 would capture increasing numbers of smolts as design flows increased, but the incremental increase in collection drops off at design flows above about 200 cfs. The same pattern of collection efficiency is evident when evaluating three consecutive Wet Years: 1978, 1979, and 1980 (Figure E-14) ; however, the BPT may not fully address the challenges of adjusting to rapidly increasing pool levels in response to spring high flow events.

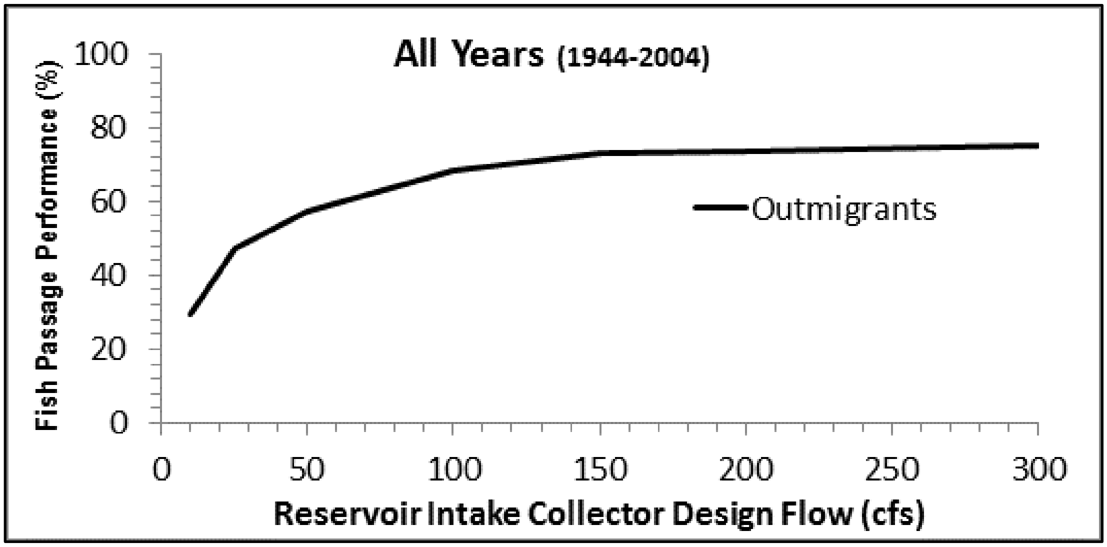


Figure E-13. Performance of Reservoir-based Intake Collector under a range of design flows for the period 1944-2004. The evaluation assumes that 10,000 smolts enter the system each year and performance is based on the number of smolts passed downstream of SFD (Outmigrants). A design flow of 200 cfs was selected for the initial evaluation of a reservoir collector as part of downstream fish passage alternative D3.

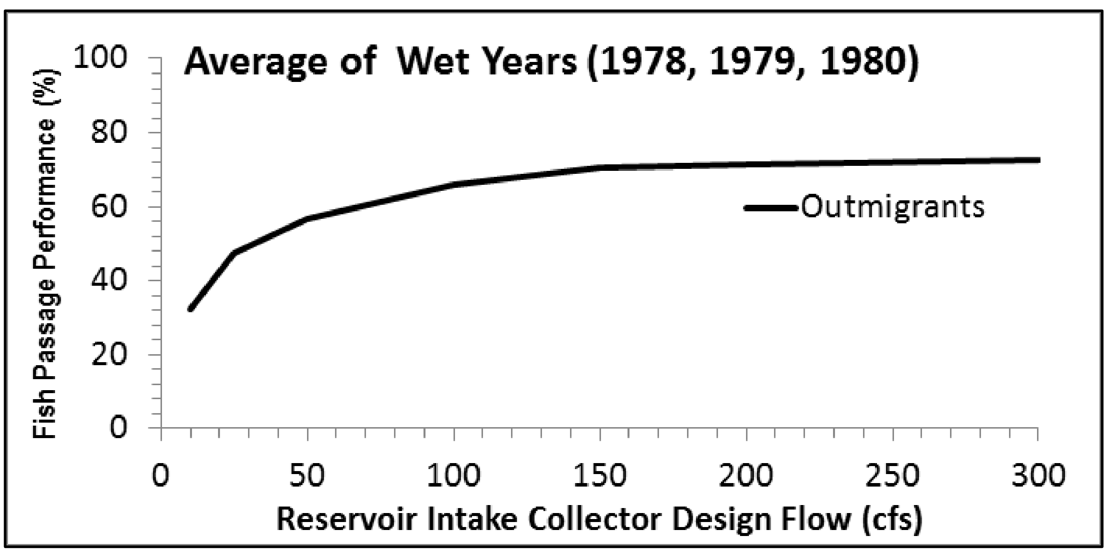


Figure E-14. Performance of Reservoir-based Intake Collector under a range of design flows calculated as the average for Wet Years 1978, 1979, and 1980. The evaluation assumes that 10,000 smolts enter the system each year and performance is based on the number of smolts passed downstream of SFD (Outmigrants). A design flow of 200 cfs was selected for the initial evaluation of a reservoir collector as part of downstream fish passage alternative D3.

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APPENDIX F:
Comments Received on Draft Report and Panel's Response

APPENDIX F – COMMENTS RECEIVED ON DRAFT REPORT, AND PANEL'S RESPONSE

This appendix documents comments received on the Santa Felicia Dam Fish Passage Alternatives Feasibility Draft Report, dated April 6, 2015, and the Panel's responses to the comments. Two formal comment letters were received as follows:

- Van Atta, Alecia. Acting Assistant Regional Administrator, National Marine Fisheries Service California Coastal Area Office, Long Beach, CA. July 6, 2015. Letter to William Snider (Panel Facilitator, HDR Engineering).
- McCalvin, Catherine. Environmental Planning and Conservation Manager, United Water Conservation District, Santa Paula, CA. July 17, 2015. Letter to William Snider (Panel Facilitator, HDR Engineering).

United Water also provided a matrix of typographical errors to be corrected, and provided comments in a matrix format per the Panel's request in their response letter.

The Panel compiled these letters into one comment documentation and response matrix, and prepared responses to each item. This matrix is provided herin following the two letters.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

July 6, 2015

William Snider
HDR Engineering, Inc.
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833

Dear Mr. Snider:

The enclosure to this letter provides NOAA's National Marine Fisheries Service's (NMFS) comments on the draft Santa Felicia Dam Fish Passage Project Alternatives Feasibility Report dated April 6, 2015. The Santa Felicia Dam Fish Passage Panel prepared this draft report to assess the feasibility of steelhead (*Oncorhynchus mykiss*) passage at Santa Felicia Hydroelectric Project (Project; P-2153). The draft report is a requirement of reasonable and prudent alternative (RPA) sub-element 3(c) of NMFS' May 5, 2008, biological opinion on the effects of the Project on endangered steelhead and designated critical habitat for this species.

The Panel has identified a number of alternatives, within certain constraints, for getting endangered steelhead around or past the dam. Although the extensiveness of the draft report and time constraints limit NMFS ability to relay comprehensive comments, consistent with its roles and responsibilities under Section 7(a)(2) of the U. S. Endangered Species Act (ESA), the enclosure attempts to capture the recommended refinements to the draft report that would (1) ensure the Federal Energy Regulatory Commission's (Commission) action avoids jeopardizing the continued existence of endangered steelhead, and (2) position the final report to receive agreement from NMFS, in accordance with requirements of RPA 3(c).

Among other substantive recommendations, the enclosure endorses refining the phasing aspect of the recommended alternative for passage of endangered steelhead, including reconfiguring the manner of phasing in a timely way. In addition, every effort must be made to facilitate downstream movement of juvenile *O. mykiss* migrants past the dam in the immediate future. Achieving downstream passage is a necessary step in making progress towards compliance with RPA 3.

With regard to the proposed fish passage committee or panel, the draft report should acknowledge NMFS cannot and will not use the committee or panel to provide it consensus recommendations or advice, and NMFS cannot delegate its roles and responsibilities under the ESA to assist and advise the Commission and licensee on compliance with the ESA. As such, while a committee may potentially help inform certain activities related to passage of endangered steelhead, the purpose of any such committee should be confined to providing scientific information to inform the adaptive management process and validate that the passage facilities are meeting biological goals and standards. NMFS must reserve its role in reviewing whether implementation of the report is consistent with the RPA and in assisting and advising the Commission and licensee in complying with the ESA.

Thank you for the opportunity to review and comment upon the draft report. Please contact Rick Bush at (562) 980-3562 or via email at Rick.Bush@noaa.gov if you have a question concerning this letter or if you would like additional information.

Sincerely,

for Alecia Van Atta
Acting Assistant Regional Administrator
California Coastal Area Office

Enclosure

cc: Robert Finucane, Federal Energy Regulatory Commission
Mary Larson, California Department of Fish and Wildlife
Catherine McCalvin, United Water Conservation District
Roger Root, U. S. Fish and Wildlife Service
Kevin Cooper, United States Forest Service, Los Padres Ranger District
Administrative File: 151422SWR2002P

ENCLOSURE

NATIONAL MARINE FISHERIES SERVICE'S COMMENTS ON THE DRAFT SANTA FELICIA DAM FISH PASSAGE PROJECT ALTERNATIVES FEASIBILITY REPORT DATED APRIL 6, 2015

July 6, 2015

INTRODUCTION

NOAA's National Marine Fisheries Service (NMFS) appreciates this opportunity to extend comments on the draft Santa Felicia Dam Fish Passage Project Alternatives Feasibility Report (and appendices) (hereafter "draft report") dated April 6, 2015. The Santa Felicia Dam Fish Passage Panel (Panel) prepared this draft report to assess the feasibility of steelhead (*Oncorhynchus mykiss*) passage at the Santa Felicia Hydroelectric Project (Project).

Before presenting specific comments on the draft report, the authority and context for these comments are described.

AUTHORITY AND CONTEXT FOR THESE COMMENTS

These comments are consistent with NMFS' roles and responsibilities under the U.S. Endangered Species Act (ESA) to advise the Federal Energy Regulatory Commission (Commission) in ensuring its action avoids jeopardizing the continued existence of endangered steelhead and avoids destroying or adversely modifying designated critical habitat for this species, consistent with the requirements of Section 7(a)(2) of the ESA. Having a direct relationship to the Commission's obligations under the ESA, the draft report is a requirement of reasonable and prudent alternative (RPA) sub-element 3(c) of NMFS' May 5, 2008, biological opinion on the effects of the Project on endangered steelhead and designated critical habitat for this species, and NMFS must review the draft report to determine whether it is consistent with RPA sub-element 3(c).

As additional context, the jeopardy analysis in NMFS' biological opinion relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR §402.02). Therefore, RPA sub-element 3(c) is a step in ensuring that the Commission's action will not jeopardize the continued existence of endangered steelhead, or is not reasonably expected to reduce appreciably the likelihood of both the survival and recovery of endangered steelhead in the wild. Yet the draft report, once finalized, is not an end in of itself for achieving compliance with the ESA.

In this context, our review of the draft report, especially the recommended alternative and related manner of 'phasing' for getting steelhead past the dam, generate a number of comments, as described in greater detail in the following pages, to refine the draft recommended alternative, including the 'phasing' aspect, into a final preferred alternative that would (1) ensure the Commission's action avoids jeopardizing the continued existence of endangered steelhead, and (2) position the final report to receive agreement from NMFS, in accordance with requirements of RPA 3(c). Overall, reconfiguring the manner of phasing in a timely way is essential for advancing an overall passage solution consistent with Section 7(a)(2) of the ESA and NMFS' May 5, 2008, biological opinion.

RECOMMENDATIONS FOR REVISING THE DRAFT REPORT TO ENSURE LONG-TERM SURVIVAL AND RECOVERY OF ENDANGERED STEELHEAD

1. ***Retain the ability to phase the project beyond the scope of the recommended alternative.—*** The Panel's current recommended alternatives for upstream (U4) and downstream (D7) passage both incorporate traditional trap and transport technology. In light of the ongoing group meeting discussions this was expected; however, NMFS anticipated the Panel would incorporate some of NMFS' recommendations into the draft report on considering the feasibility of an alternative that may be phased into a more natural (i.e., partially or fully volitional) fish passage facility over time as described in our previous comment letters (May 22, 2014, September 18, 2014, and December 10, 2014). Specifically, our May 22, 2014, letter described a phased approach in which:

   "the Panel should consider incorporating a phased design and construction approach as the fish passage concepts under consideration are further developed into fish passage alternatives applicable at Santa Felicia Dam. This approach can be used to provide proof of concept that extension of a volitional fishway over the dam will indeed result in volitional passage, and in the interim provide a partial volitional fishway ending at a collection facility that would allow for trap and haul passage and additional time for studies to occur."

   Also in the May 22, 2014, letter, NMFS provided clear guidance that the ultimate goal of a phased approach should be to achieve fish passage without handling fish:

   "NMFS is not prepared to rule out or express a preference for any of the potential fish passage provisions described by the Panel, but would like the Panel to consider how the various alternatives could be best adopted and/or combined in a phased design approach with fully volitional passage being the ultimate goal."

   And more recently in the December 10, 2014, letter NMFS recommended the Panel:

   "develop at least one alternative that has upstream passage facilities that can be deliberately phased (e.g., as run sizes increase and the ability to attract fish to an upstream fishway is proven) in a manner that will ultimately yield passage conditions equal to or nearly equal to that of complete volitional passage for upstream migrating adult steelhead."

   Based on NMFS' review, it is not apparent that the Panel fully incorporated these recommendations into the draft Report, or whether the Panel made a determination that a phased approach resulting in a volitional or partially volitional fish passage alternative was feasible. For example, Section 5.4 of the draft report discusses transition from feasible alternatives to a recommendation and states that *"'biological triggers' would be used to identify modifications that must be made to existing facilities to increase capacity or efficiency; or construction of additional facilities (e.g., a full fish ladder, or an FSC at the dam).*" Later in Section 5.5 the Panel describes their approach to carry out their recommendation, including "*evaluate and consider the potential utility and need for modification to U4 and D7, or the construction of an additional facility in the reservoir."*

Both these statements lead NMFS to believe that the Panel shares NMFS' belief that the goal of the project should be to retain the ability to phase the project beyond the scope of the current recommended alternative. However, at the conclusion of Section 5 the Panel only recommends including studies evaluating the performance of alternative D7 for the purpose of determining if/when reservoir collectors will need to be phased into the D7 alternative to effectively and safely provide downstream fish passage. Hence, NMFS reiterates the recommendation for the Panel to evaluate if a phased approach resulting in adult steelhead volitional/partially volitional passage of Santa Felicia Dam is feasible, and further develop the Panel's recommended phased-build out of alternative U4 that would have the highest likelihood of promoting feasible volitional, or partially volitional adult migration characteristics.

2. ***Facilitate downstream movement of juvenile O. mykiss migrants immediately***.— Achieving downstream passage of *O. mykiss* is the first necessary step in making progress towards compliance with RPA 3, and will also provide important *O. mykiss* behavioral data that will guide implementation of the downstream passage facility. For these reasons, this monitoring and fish tagging activity should not be categorized as a "potential study" in the draft report, but rather a required technical study that should develop information on pre-project fish movement, and continued monitoring during all phases of project implementation. NMFS reiterates guidance provided to the Panel in NMFS' May 22, 2014, letter that recommended:

   "Design and construct initial facilities that would provide immediate downstream passage, and also provide the information and flexibility for smolt collection facilities to be optimized, expanded and/or relocated over time based upon information gained on how to best collect smolts."

   Section 6.3 of the draft report describes the implementation schedules and phasing implications on when passage of steelhead at or around Santa Felicia Dam is expected to occur. The phasing for implementation is drawn out for an extended period. A timeframe of 7.5 years from the time the Group agrees on implementation has been specified. This time is in addition to the time that has elapsed since the issuance of the biological opinion for the Santa Felicia Project in 2008. NMFS believes it is prudent (and practical) for a number of reasons to initiate some aspect of the fish passage program sooner than the Implementation Schedule (Table 6.3-1) indicates. Specifically, NMFS recommends beginning with addressing the downstream (out-migration) element of the passage program first, at least on an interim basis. This could involve the use of seasonal traps upstream of Santa Felecia Dam either at the upstream entrance to the lake, somewhere in the main stem of Piru Creek below Aqua Blanca Creek, or at one or more of the mouths of the major middle Piru Creek tributaries upstream of Santa Felicia Dam (or some combination of sites).

   This approach is consistent with the identified alternatives, but differs primarily in the timing of implementation, and the utilization of temporary facilities, rather than permanent facilities, at least on an interim basis. There are a number of advantages to this approach. They include: 1) addressing the immediate need to facilitate the emigration of fish that are now attempting to emigrate to the ocean but are prevented or impeded by Santa Felicia Dam (and related facilities) and its operation; 2) providing information on the migration patterns (timing, rate, relative number of fish from individual tributaries, or mainstem, so forth) and relation of flow rates in the tributaries and main stem of Piru Creek to fish movement; 3) assisting in the design and initial operation of permanent facilities aimed at providing downstream fish passage opportunities; 4) increasing the potential number of adult steelhead returning to the Santa Clara River system, including Piru Creek, (by increasing the total number of smolts emigrating to the ocean); and, 5) potentially assisting in the design, operation, and assessment of the upstream fish passage components of the fish passage program (e.g., testing the efficacy of any upstream volitional or trapping/transporting program). Additionally, it should be emphasized that there is potential significant biological value to accelerating the restoration of downstream fish passage of smolts from the middle Piru Creek watershed, even though implementation of upstream fish passage may occur substantially later. This is because these emigrating fish returning as adults will have an opportunity, and may in fact choose, to spawn in tributaries other than Piru Creek (e.g., Santa Paula Creek, Sespe Creek, Hopper Creek) where volitional fish passage is currently possible (though constrained by the Vern Freeman Diversion facility).

NMFS recommends that the draft report should specify that juvenile *O. mykiss* tagging and monitoring should begin within 18-months after the report is finalized. Within three years of completion of the report, the intial monitoring data should be evaluated and an interim trap and transport of *O. mykiss* exhibiting an anadromous life history type should be transported downstream of Santa Felicia Dam to inform implementation of alternative D7.

3. ***Further develop adaptive management plan and list of technical studies (Appendix F***).— Although the draft report provides a good framework for addressing project uncertainties, NMFS believes additional work will be required to develop a final adaptive management plan for upstream and downstream fish passage at Santa Felicia Dam. In particular, NMFS recommends that the details of exactly how the adaptive management program will function should largely be determined in future discussions (perhaps during and/or after a preferred alternative is being agreed upon). As described in Table F-1, the draft Adaptive Management and Effectiveness Monitoring Plan (AMEMP) designed for the United's Flow Release Plan and Habitat Improvement Plan (i.e., RPA 2) is still under review by FERC and pending final approval by NMFS. Since the Adaptive Management Plan for the Santa Felicia Fish Passage Project will directly rely on results from the RPA 2 effectiveness monitoring (e.g., smolt trapping at confluence of Piru Creek and Santa Clara River), a clear feedback loop will need to be established between the two plans to inform the effectiveness of, and triggers for phasing of the Santa Felicia Fish passage facilities. Additionally, the process outlined in Appendix F lacks any meaningful adult monitoring or technical studies to evaluate the delay of adults as they encounter Santa Felicia Dam during their upstream migration. As a result, NMFS recommends United and NMFS further develop the Adaptive Management Process that is enclosed in Appendix F to address both upstream and downstream fish passage project uncertainties upon completion of the AMEMP.

4. ***Relationship of the recommended alternative to biological goals and passage standards***.— A primary concern with the Panel's recommended alternative is whether or not it can actually meet the biological goals and standards for downstream passage, particularly during wet years where Figure 5.3-4 shows an anticipated collection efficiency for D7 of between about 73% and 88%. Moreover, if a downstream biological goal/standard of approximately 93% (or greater) successful collection was adopted, then Figures 5.3-1 and 5.3-4 demonstrate that

implementing alternatives D10, D11, or D12 will likely be necessary to meet this standard. Without a reservoir collector to supplement D7, the average of the high and low BPT scores for D7 by itself (for all water years) is 88%, with a best case scenario of 93%. In contrast, Alternatives D10, D11, and D12 have average collection estimates of 92%, with best case scenario estimates of up to 98% (see Table E-4). Consequently, in order for the Panel's recommended alternative to be viable, the adaptive management program must allow the project to expand into D10, D11, or D12, or other alternative, if and when needed to meet biological goals and standards.

In addition, many of the assumptions that the Panel made regarding facility operations should be viewed as placeholders. Specifically, many operational procedures will need to be decided based upon the biological goals/standards and objectives, as well as whether the operational procedures meet NMFS and CDFW guidelines. Consequently, further discussion on many of these operational details is needed before any proposed alternative can be determined as acceptable or not.

Given the endangered status of steelhead, it is crucial that fish passage uncertainties be resolved and biological performance standards be met at any constructed facilities as soon as possible. NMFS requests that the Panel consider and outline (via modifications to Figure 5.5-1 and Table 6.3-1, and/or other means) what options are available for parallel tracking the facility design, implementation, and studies needed to determine and advance the project into Phase II construction (if needed under the Panel's proposed adaptive management plan).

5. ***Role of committee or panel.***—While NMFS recognizes the potential need for some type of committee/panel to help facilitate certain activities related to passage of steelhead, NMFS believes that the purpose of any such committee should be to provide the science needed to advise the adaptive management process and to validate that the fish passage facilities are meeting biological goals and standards. Moreover, the draft report should acknowledge NMFS cannot and will not use the committee or panel to provide it consensus recommendations or advice, and NMFS cannot delegate its roles and responsibilities under the ESA to assist and advise the Commission and licensee on compliance with the ESA. NMFS further recommends that the title of any such committee should better reflect its role as scientific advisors, e.g., Fish Passage Science and Technology Panel.

6. ***Resolving Infeasibility Concerns and Questions.***—The primary task of the Panel was to assess the feasibility of various fish passage alternatives. NMFS requests that the Panel clarify whether or not it can realistically finalize the feasibility report at this time given the unknowns the Panel states exist for several alternatives. These unknowns regard the seismic analysis of several alternatives and whether Piru Collectors are feasible based upon issues related to critical habitat for the Arroyo Toad and not having visited the secondary/backup Piru Collector site.

   If the panel recommends a preferred alternative, which the panel also believes has the potential to have a fatal flaw (i.e., infeasibility due to seismic or Arroyo Toad concerns), then NMFS requests that the panel provide a separate ranking for all of the alternatives that the panel is certain are feasible (e.g., U4, U3, D1 (which it deferred), D2 (incorporated into D12)).

Given the endangered status of the steelhead, NMFS does not believe it is prudent to pursue a preferred, but potentially infeasible solution (such as D7 with it Arroyo Toad concerns) for several years in the design and permitting phase without at the same time pursuing the design of an alternative such as D1 (floating surface collector near the dam) or D2 (moveable floating surface collector), which can be put in place as soon as possible should the preferred alternative turn out to not be feasible. Consequently, NMFS recommends that the panel either take the steps necessary to determine feasibility upfront and/or adopt and recommend a parallel track design process that assures that a feasible fish passage alternative is implemented in a reasonable time frame.

It appears to be contradictory to state that the panel evaluated only alternatives that did not have fatal flaws, but then list speculative seismic concerns as a ‘con’ for several of the alternatives that were developed. Seismic analysis was outside the scope of work defined for the Panel; therefore, NMFS believes the Panel should not speculate on which alternatives, as currently envisioned, might prove to be challenging owing to seismic limitations. NMFS recommends seismic concerns not be listed as a ‘con’ of an alternative, as presumably, if the structure were built, it would be feasible, meet seismic code, and presumably not impact the operations or passage characteristics of the facility.

NMFS recommends that if the Panel feels that an alternative could have a fatal flaw (seismically or otherwise), then the panel should recommend a course of studies or actions to address these concerns. Such studies and actions may include: contacting structural engineers to evaluate the seismic feasibility of the various alternatives; beginning informal consultation with USFS, USFWS, CDFW, FERC, DSOD as appropriate to address structural feasibility and/or the likelihood that the construction of the Piru Collector could adversely affect the Arroyo Toad or its critical habitat; and conducting a site visit to the secondary Piru Collector location to determine whether it would be in Arroyo Toad critical habitat and what, if any constraints exist regarding maximum screening capacity.

7. ***Conditional Support to Further Investigate the Feasibility of the Panel’s Proposed Project Implementation Framework*—**The height of Santa Felicia Dam, the climate of Southern California (which is very different from Northern California and the Pacific Northwest where most steelhead and salmon passage projects have been implemented) and the low population numbers of the Southern California steelhead complicate fish passage at the Project. NMFS conditionally supports further investigating the feasibility of the Panel’s recommended passage alternatives U4 and D7. Specifically, NMFS believes that the Panel’s recommended alternatives could potentially lead to suitable fish passage, provided that the alternatives adopt appropriate biological performance goals/criteria; are actually feasible (see previous comments on infeasibility concerns); are implemented/operated correctly; are constructed in a timely manner; address fish passage uncertainties; and implement appropriate modifications, as needed, to adapt to the knowledge gained by further studies and as uncertainties are addressed. However, NMFS does not yet have enough information to determine whether this will be the case and needs substantially more information/clarification from United and the Panel to clarify exactly what is included within these alternatives, the timing of the various alternative components (main facilities, supplements and enhancements) and clarifications on exactly how the adaptive management process would be implemented.

A major strength of the Panel's recommended approach is the ability to adapt, modify, and add fish passage facilities, if and when needed, based upon various fish passage studies and monitoring activities that are needed to address uncertainties. However, two major assumptions made implicitly by the Panel in their recommended approach include: a) that a reservoir collector will probably not be needed to achieve biological goals for smolt emigration; and b) that non-volitional (collection and transport) passage options will have no fatal biological flaws in terms of preventing significant numbers of steelhead from completing important life-cycle activities (e.g., preventing smolts from imprinting, preventing smolts from reaching the ocean, preventing adult steelhead from successfully spawning due to fish passage delay). These assumptions cannot be conclusively confirmed or denied at this time. Consequently, in order for NMFS to consider the U4 and D7 alternatives as potentially acceptable alternatives, the alternatives must, as recommended by the panel, be implemented with biological performance objectives/goals/standards, appropriate studies, monitoring, and an effective adaptive management protocol that would automatically require a second phase (Phase II) of facilities to be built if: a) the Phase I (U4 and D7) components do not meet biological performance standards and cannot be easily or reliably modified in a timely manner to meet biological performance standards; b) steelhead can, do, or could utilize the reservoir in significant numbers; and/or c) it is shown that volitional passage or passage without collection (as in the case of alternatives U1, U3, D4 and D14) is needed in order for steelhead to successfully complete their various lifestage activities.

NMFS cannot agree with the approach (U4 and D7 with appropriate studies, monitoring, biological performance standards and adaptive management protocol) if, at any point in the process, the approach precludes any additional monitoring, maintenance, studies, modifications, and/or building of additional fish passage facilities that are needed to meet or demonstrate that biological performance standards (which would need to be agreed upon at some point in the future) have been met. NMFS requests clarification from the panel on whether or not the proposed adaptive management framework described in the draft feasibility report precludes the possibility of requiring additional facilities (e.g., a reservoir collector or an upstream volitional ladder with slide release) beyond the full build out of U4 and D7 (Phase I), if biological performance standards are not met after full build out.

Based upon the group's discussion during the June, 8, 2015, teleconference, it appeared that United and NMFS may have different interpretations regarding how U4 and U7 would be implemented in conjunction with the Panel's proposed adaptive management framework. At this time, NMFS' expectations for this approach include, at minimum, the following key elements:

a. The setting of biological performance standards and goals that assure:

   i. That fish are effectively attracted to the entrance of the upstream fishway entrance;

   ii. A means of monitoring and verifying that fish are successfully being attracted and entering the facility must be in place; and,

iii. The establishment of a minimum attraction goal (perhaps measured as a percentile of fish successfully finding and entering the upstream passage facility).

b. The total number and/or percentage of fish collected during high flows in the Piru Collector, versus the total number/percentage of fish that are not collected and migrate downstream into the reservoir at high flows, is sufficient to meet biological goals.

c. If a significant number of resident steelhead are utilizing the reservoir, then phasing must occur so that any smolts within the reservoir can successfully emigrate.

d. The total number of smolts entering the reservoir via the Piru Collector fishway at low and medium discharges is not excessive according to biological performance standards/goals.

e. If no scientifically defensible means of establishing what proportion of smolts are missed at the Piru collector exist, then phasing must automatically occur in order to collect any smolts in the reservoir.

f. All facilities safely pass fish and have criteria for maximum allowable injury, maximum allowable mortality, and minimum total percentage of fish that successfully enter and pass through the facility unharmed and without excessive delay.

g. All facilities must have a maximum allowable passage delay time.

h. Fish are being collected over all of the discharges and time frames during which fish are present (or could be present) and migrating.

i. A means of scientifically monitoring when and at what discharges fish are migrating must be developed and implemented. The monitoring plan must, at minimum, periodically test whether fish are migrating outside initially assumed migration discharges and/or time frames. The monitoring plan must also account for the fact that low fish population numbers is not an indication that, if more fish were present, they would not be found migrating at a wider range of flows or over a wider timeframe than initially assumed.

j. All facilities will be built to meet the most current NMFS and CDFW fish passage guidelines in effect at the time the facilities are being designed and constructed.

k. All facilities including the supplements and enhancements described in U4 and D7 will be built.

l. If U4 and D7 are not capable of meeting agreed upon biological performance standards, then additional modifications, supplements, and/or enhancements that will lead to meeting the biological performance standards will be implemented. Some, but not all, potential scenarios follow:

i. If the Piru Creek collector misses (does not collect) too many smolts, then a reservoir collector or other means of attaining smolt collection goals/standards must be implemented.

ii. If the initially installed upstream passage collection facilities cannot transport the number of fish without excessive delay times, the facilities will need to be upgraded by increasing the number of transport trucks, increasing the frequency of transport, or implementing volitional passage, among other measures.

iii. If it is shown that collection and transport is causing excessive disease, stress/injury/mortality, preventing fish from imprinting or substantially impacting the steelhead population in any unforeseen manner that is due to the collection and transport process, then measures including the possibility of having to implement U3, U4, D14 or other alternative developed by the panel will be pursued.

m. Because the alternatives and design plans described and provided in the feasibility report are at the conceptual level, facility dimensions, operational procedures, etc., are not fixed and may change as the design process advances further.

n. Upstream facilities must be capable of passing adult steelhead, and all downstream facilities must be capable of passing both adult and juvenile steelhead (both resident and anadromous forms).

o. The adaptive management plan should adopt parallel tracking when conducting studies and developing plans in order to minimize the time that steelhead experience inadequate and/or no passage at SFD.

p. NMFS will have representatives on the Fish Passage Science and Technology Panel (FPSTP). Representatives may be from any of NMFS' branches and/or from NMFS' science centers.

q. A decision for requiring a Phase II build out may come sooner or later than after operating the Phase I facility for 10 years (as described in Table 6.3). NMFS suggests that a decision for needing a Phase II build out, or other modifications, should be dependent upon, if and when, it becomes evident that fish passage goals are not being met and changes are needed. Unexpected events could occur that clearly demonstrate that initial facilities are not operating as expected early in the process or it may take more than 10 years to get the data needed to make an informed decision on whether fish passage modifications are needed to meet fish passage goals/standards.

Throughout the report the Panel describes various alternatives as having different options and placeholders. In other locations (e.g., page 4-36) phrases with the word "could" are used (e.g., “It could consist of two holding pools…”). NMFS recognizes the importance of describing options, highlighting placeholders, and describing what could be done in a draft feasibility report. However, NMFS cannot completely evaluate the overall effects that alternatives with “coulds”, “options” or “placeholders” will have on steelhead passage. Consequently, NMFS would like to highlight that some, but not all, of the very important placeholders, options, etc., that will need to be discussed and resolved before being finalized for any alternative(s) that are to pursued include:

a. screen and/or pump size on the various proposed smolt collectors;

b. maximum jump height;

c. pool dimensions that meet EDF and all other NMFS and CDFW fish passage criteria;

d. high and low fish passage design discharges;

e. barrier type for the upstream passage alternatives;

f. operational periods over which fish would be collected,

g. frequency at which traps would be checked and fish transported;

h. the need for a challenge section;

i. the amount of flow that will be used to minimize spill (500 cfs, 1000 cfs, or other discharge amount);

j. fish passage operational season;

k. dimensions and features of any experimental designs such as the U3 release slide

l. ladder details such as pool and weir vs. pool and weir with orifices (U1 and U2 describe different types);

m. height and layout of barrier dam needed to be a complete barrier;

n. exact site location/orientation of various features of the alternatives

8. ***Clarifications of the Panel’s Recommended Alternative Approach***.— Consistent with RPA sub-element 3(d), United is required to develop in coordination with NMFS and CDFW measurable biological criteria to trigger implementation of the preferred alternative and submit draft criteria to NMFS no later than 6 months of the date on which the Licensee receives written final NMFS agreement on the steelhead passage feasibility report.

With regard to defining an implementation schedule, the panel needs to more precisely state what components (main fish passage facility, supplements, and enhancements, etc.) would be implemented and when. It is not clear whether the initial facilities (main passage facility, supplements and enhancements identified for U4 and D7) would be phased or all be constructed at the same time. NMFS has previously commented upon its concerns about using the terms "supplemental" and "enhancement" because, in part, whatever facilities are implemented must achieve the biological goals and standards, which have a direct relationship to the long-term survival and recovery of endangered steelhead. Consequently, NMFS does not consider any project component that is necessary to achieve the biological performance standards to be a supplement or enhancement. Instead, it is a necessary part of the overall fish passage project. It is NMFS' understanding that the Panel believes that all of the enhancements and supplements listed in the U4 and D7 alternatives are necessary in order to meet biological performance standards (qualitatively described in previous discussion as a relative high standard of fish passage). NMFS further assumes that the Panel believes that if the biological criteria used to determine whether fish passage will be implemented at SFD are triggered, then all of the supplements, enhancement and main passage facilities should be designed and constructed without any phasing. NMFS requests that the Panel either verify that this is the case or state exactly what will be built and when under alternatives U4 and D7.

By recommending D7 over options such as D10, D11, and D12, the Panel is implicitly assuming that the Piru collector will not miss (fail to collect) a substantial number of smolts and that resident steelhead are not, and will not, be present in significant numbers within the reservoir. These assumptions have not been supported. Studies and substantial monitoring will be necessary to validate whether or not the proposed Piru Creek collector screen size is sufficient to collect the numbers/percentage of smolts needed to meet biological performance criteria. NMFS believes that if the initially sized screens for the D7 alternative fail to provide adequate collection, there must be a means for addressing this problem by increasing the screening capacity of the Piru collector, constructing a reservoir collector, and/or other measures (e.g., building the equivalent of D10, D11, D12, or D14) to achieve biological performance standards. NMFS requests the Panel to clarify whether such provisions are included in the recommended alternatives and proposed adaptive management framework.

On page 4-32, the Panel states that, under U4 phasing options, a more rudimentary temporary trap could precede permanent facilities. NMFS requests that the Panel state what it is proposing with respect to how and when such phasing decisions would be made.

9. ***Panel Assumptions on Facility Operations.***—The frequency at which steelhead are monitored and transported at any upstream and downstream collection facilities should be determined after conducting a more thorough investigation into determining the effects that passage delay of up to a day could have on steelhead. NMFS requests that the Panel either demonstrate that passage delay of up to a day will not interfere with a steelhead's life cycle or state how the frequency at which steelhead are monitored and transported at any collection facilities will be determined in the future.

On page (4-8), the Panel stated that "the barrier dam would be in operation as described above for the whole migration season unless otherwise indicated; e.g. during extended periods of low flow, or monitoring indicates no fish are present." NMFS requests that the panel note that the absence of fish in a stream having low numbers of fish is not necessarily an indication that fish are not migrating at this time. Instead, it may be that there are simply no fish present to migrate at that time. Arbitrarily stopping fish passage operations because one does not see fish at a particular time may significantly truncate the time that fish actually have and would normally be migrating. Consequently, operational timing issues should be linked with biological goals and objectives.

NMFS can envision scenarios in alternatives where a reservoir collector may need to be operated for significant periods of time, possibly the entire smolt and/or adult/kelt migration season. Such scenarios include: the reservoir has or develops significant number of resident steelhead that are traveling from the reservoir to the tributary streams above the reservoir; significant numbers of pre-smolts are missed by the Piru collector and washed into the reservoir; it takes substantial time for smolts to find a collector; kelts are present and out-migrating, etc. Consequently, NMFS requests the panel, at minimum, highlight that there may be situations where any of the reservoir collectors alternatives may need to be operated throughout the entire smolt migration season and possibly throughout the entire adult migration season to accommodate kelts. NMFS also requests that the panel state that the exact circumstances and times which any reservoir collector should be operated need to be determined in the future and how that should be determined.

NMFS supports the Panel's recommendation that the possibility of designing and allowing the intake works to take the first 1,000 cfs of spill should receive further consideration. Additionally, NMFS requests that the Panel consider the merits of designing any fish ladder built as part of the upstream passage facilities to have attractions flows and have an AWS that constitutes at least 5-10% of the total flow being released through the intake works. This includes the flows that will be used to minimize spill. Such a design would likely improve upstream collection and transport efficiencies at all discharges occurring prior to spill. Moreover, this may be more consistent with providing fish passage at discharges up to 50% of the 2-year event, which is typically higher than the 1% annual exceedance in Southern California and is approximately the high fish passage design discharge (46% of the 2-yr discharge) that the Vern Freeman Dam fish passage selected and is being utilized in the Vern Freeman Diversion Fish passage project.

On page 4-38, the panel states that the Pyramid Lake minimum low flow would apply to any alternative in which fish are released into the lake. Given the uncertainty of whether a Piru Collector can prevent all steelhead from entering the reservoir, and the uncertainty as to whether or not resident steelhead can and/or do utilize the reservoir, NMFS recommends that the Pyramid Lake minimum low flow option needs to be considered for all fish passage alternatives.

On page 4-39, The Panel states that a spillway collector would operate based on whether fish are being collected. Such a protocol seems problematic when trying to protect an endangered species. With few fish in the system, ceasing to operate the facility simply because fish are not visually accounted for at all times, runs the risk of allowing fish that are not easily observed to experience significant passage delay or worse.

The Panel proposed a spillway pool collector. The spillway pool collector described on page 4-39 relies upon a 2-5 cfs capacity pump to supply water to the fishway and trap. Without an auxiliary water supply, such a system would only provide a minimum of 5% attraction flow up to discharges between 40 and 100 cfs. Thus, such a collector would have limited utility for spills greater than about 40 to 100 cfs. A better attraction flow of 10% would only be met for spills less than 20 to 50 cfs. The inability of the spillway pool collector to effectively attract fish at flows above 50 to 100 cfs, supports the importance of minimizing spill events via the intake works (an enhancement proposed by the Panel), as the spillway pool collector may not attract fish very well when significant flow is spilling.

On page 4-37, the panel proposes that “the hydraulic design of the challenge section would be based on the target fish size using selected swimming capability thresholds and would be done later when detailed design begins for an alternative.” At a minimum, it appears that a detailed review of all available information on size at maturity for Southern California *O. mykiss* is warranted to determine a target fish size for the proposed challenge section. Because resident and anadromous *O. mykiss* can produce anadromous offspring, the review should not be limited to individuals based on presumed life-history type. The need for a challenge section needs to be further discussed and developed.

10. ***Fish Passage Uncertainties.***—NMFS understands that developing full study plans is beyond the Panel’s current scope of work. However, NMFS believes that for any alternative to be viable, the means must exist to scientifically validate an alternative’s proper functioning and collect the data needed to make effective adaptive management decisions. Consequently, NMFS requests that the Panel consider either adding and/or expanding upon a section within the report to emphasize the key assumptions and uncertainties in this project. Specifically, NMFS recommends that this section focuses on the challenges and the general technologies available and/or needed for validating these assumptions and managing key uncertainties, particularly with respect to how these assumptions and uncertainties will be either addressed in the predesign studies, Phase I buildout and operations stage, Phase II design, and/or Phase II construction and operations according to the Panel’s recommended alternatives.

    NMFS believes that some of the most important uncertainties that will need to be specifically resolved throughout the design, implementation, and adaptive management framework that the Panel is recommending include: a) a definitive answer on which alternatives are seismically feasible; b) the role of the reservoir in predation rates; c) the role of the reservoir in potentially providing rearing habitat for resident steelhead; d) over what discharges and time frames (dates) that adult, juvenile, and smolts are migrating within the Santa Clara Watershed and Piru Creek basin; e) difficulties associated with monitoring and sampling low numbers of fish; and f) the extent and time frame that fish can/will respond to the implementation of fish passage facilities at SFD. NMFS requests that the panel discuss how these uncertainties could affect timing, facility buildout, and operational aspects of the various alternatives methods along with identifying means of quickly adapting fish passage facilities and operations to information acquired on these topics.

    After the Group Meeting #2, the Panel preliminarily ranked D11 as the recommended downstream passage alternative. NMFS requests that the panel explain why D7 subsequently became the Panel’s recommended downstream alternative, particularly when D11 addressed the uncertainty regarding to what extent steelhead were utilizing the reservoir by allowing smolts to be collected within the reservoir and above the reservoir. Moreover, alternative D11 also helped addressed concerns about D7 missing smolts at high flows.

Given steelhead may have low population numbers for some time, NMFS requests that the panel identify how the total number and/or percentage of smolts being collected and missed could be monitored in a fashion that could be used as a scientific basis for determining whether D7 is meeting biological performance standards. Specifically, NMFS requests that the Panel identify a scientifically defensible means of establishing how many smolts are being collected and how many are entering the reservoir. If there is no solution to address this question, then the recommended alternative needs to be reevaluated as there is no means of testing and/or validating whether D7 is meeting the biological goals/standards.

NMFS requests that the Panel briefly expand upon potential methods for determining whether and how resident steelhead may be utilizing the reservoir and migrating to the tributaries to spawn. Would such methods be capable of being performed with or without tagging hatchery supplemented fish?

The Panel highlights that several of the alternatives (i.e., U1, U2, D3, D4, D5, D10, D11, D12, and D14) may not be feasible due to not being able to build them to meet seismic codes. Yet, the Panel consistently ranked floating surface collectors lower than several options that the panel explicitly states may have a fatal flaw (seismically unsound). NMFS requests that the Panel comment upon how the alternative rankings would change if the various alternatives were conclusively demonstrated to be seismically infeasible. Specifically, would floating surface collectors (moveable or fixed location) be a recommended viable downstream passage option should a reservoir collector be determined necessary to meet biological performance standards and the various tower structures are determined to be seismically infeasible? It is not clear to NMFS why if there is seismic uncertainty regarding surface collectors and their support towers that they ranked better than floating surface collectors, particularly based upon preliminary reports upon how well floating surface collectors such as the one found at Baker Lake, WA are working. NMFS recommends that the Panel should highlight that, if various alternatives are found to be infeasible due to seismic or Arroyo Toad concerns, that the Panel has identified viable alternatives that have neither of these concerns that could be implemented.

The Panel (page 3-4) appears to conclude that there is no apparent relationship between abundance of outmigrating *O.mykiss* and water year type. Such a conclusion seems problematic in light of our own anecdotal observations specific to southern California, the published literature, and the fact that out of 11 years of data there was: one normal year; 6 wet years; and 5 dry years. NMFS requests the panel state whether this conclusion was based upon statistically significant tests and exactly how a wet, normal and dry year were quantified.

The Panel (page 3-4) appears to conclude that there is no obvious basis between timing and abundance of downstream migrating *O.mykiss* and high flow events. Such a statement seems problematic, for reasons cited above, and when it is also stated that such results were collected on the rising and falling limbs of storm hydrographs and sampling. The question becomes what constitutes a high flow event? The implied assumption in the sampling, as described in the draft report, is that fish are migrating during storm events, which may be considered relatively high flow events compared to the base flows found in southern California (which apparently were not even considered for smolt sampling). NMFS suggests that the Panel should better emphasize and/or summarize the assumptions and limitations of the migration timing results and clearly state which of the panel assumptions are based upon professional judgment and which (if any) are statistically significant. The panel should also highlight any conflicting results (if any) between the various migration studies.

If the above conclusions come directly from the authors of the study and not the Panel, then the Panel should make it clear that these were the author's conclusions and not the Panel's conclusions. The panel should also state whether these conclusions were based upon visual analysis of the data, statistical testing, or other means.

On page 4-33, the Panel assumes systems will be operated once a day from January 1 through May 31 for upstream migrating steelhead. NMFS requests the panel state whether this assumption was made solely for cost estimating purposes or whether it has sufficient evidence to conclude that fish passage delays of up to 24 hours would not interfere with a steelhead's ability to complete its various lifecycle functions. If the panel believes that it has such information, NMFS requests that the Panel provide the information that led them to conclude that such a delay is acceptable. If there is not sufficient data to conclude this, then the Panel should clearly state that such operational procedures will need to be determined in the future. This comment also applies to all of the other alternatives where the Panel assumes certain operational parameters related to the frequency and timing of collecting and transporting steelhead.

NMFS requests that the Panel briefly consider and comment on what options might be available for improving the dissolved oxygen (DO) levels (via aeration) in the reservoir owing to the concern that reservoir water quality may not be suitable for out-migrating smolts that bypass the Piru Creek collector. Conceptually, would aerating the water also cause the water column to mix and increase the total volume of water with suitable DO levels and temperature (accomplished by mixing the higher and lower temperatures found in the upper and lower portions of the water column)? One could envision aeration being conducted: throughout the reservoir; at a specific location (e.g., in the upstream portion where a portable collector is located); or along a line leading to a collector near the dam. NMFS requests that the Panel consider whether such a measure would be an appropriate enhancement option for the reservoir based collector options (all but D7). NMFS also requests the Panel consider whether the potential benefits of aeration should be recommended as a potential future study.

NMFS requests that the Panel highlight that all but one of the 'cons' regarding the floating surface collector could essentially be summarized as a single con – 'difficult to operate'. At the same time, it should be pointed out that the any lower BPT associated with the floating surface collector as compared to the other reservoir collectors appears to largely be a result of the Panel's decision to strip the collector down (e.g., not provide a curtain, not provide a CTS, etc.). However, on page 4-85 and 4-86 the Panel states that all of these things could be utilized with a floating surface collector to increase the BPT. This is important as the floating surface collector is currently the only reservoir collector (except the spillway collector – which only operates during spills and requires fish to travel the entire length of the reservoir) that has no seismic concerns and could be located at the entrance to the reservoir to collect smolts missed by D7. Moreover, if, as the Panel has initially concluded, DO and predation prevent steelhead from successfully utilizing/traversing the reservoir, the entrance to the reservoir could be locally aerated so that steelhead have the time and opportunity to find the collector, particularly with the use of guide nets, which could also potentially function to keep predators out of the area as well. Conversely, if the reservoir can be routinely utilized by steelhead, then reservoir collectors near the dam would potentially be more beneficial (based upon the Panel's BPT scores and rankings). However, if based upon the Panel's current assumptions, the reservoir creates high mortality for steelhead, then a floating surface collector, despite its difficulty to operate, may become a far more preferable choice. NMFS, therefore, requests the Panel to consider if and how studies conducted during Phase I of the Panel's recommended alternative could change what reservoir collector (if needed) would be prioritized for Phase II construction.

NMFS requests the Panel to consider how Figure 5.5-1 could be redrawn to incorporate parallel tracking in order to lead to a project that meets fish passage goals as quickly as possible. One potential option is to have Phase I design, the formation of a FS&ET and Initial Monitoring and Studies begin immediately after an alternative is agreed upon.

NMFS requests the Panel specifically comment upon how downstream passage for kelts would be achieved and managed for the various alternatives.

11**.** ***Clarifications Needed on Technical Aspects of the Report***.—It is not clear from the draft report whether the primary or secondary site for the Piru Collector are suitable for building a collector with the needed screening capacity.. Additionally, NMFS requests that the Panel state what their recommended downstream fish passage alternative becomes if the Piru Collector is not feasible owing to consultation with USFWS regarding Arroyo Toad.

NMFS requests that the Panel provide an explanation for why D7 was not designed to operate within NMFS criteria between 200 and 400 cfs. It is expected that all preferred alternatives will meet NMFS and CDFW fish passage guidelines. Similarly, many of the upstream fish ladders in the various alternatives propose 0.7' jump heights. NMFS criteria for juvenile jump heights is currently 0.5'. Why was a jump height of 0.7' used?

On page E-26, the Panel assumed that operating the screens outside of NMFS criteria would result in increasing steelhead mortality rates from 1% at the design discharge (200 cfs) to 10% mortality at 400 cfs and to 15% mortality at 1000 cfs. It should also be noted that at discharges up to 400 cfs all smolts would be screened and a 95% capture efficiency was assumed. What does the Panel assume happens to the 5% that are not captured?

NMFS requests that the Panel itemize some of the more important negative effects associated with collection and transport (versus volitional passage) in the "pro" and "con" lists for alternatives like U4 and D7. These include disease, smolts' inability to imprint, etc. (see list provided in NMFS' previous comments).

NMFS requests clarification on why collection and transport operations would have to cease when pool levels are below 980’ and above 1056’, as indicated on Table 4.2-1.

On page 4-22, it is unclear why one would want to use collection and transport via the monitoring station for all reservoir elevations below 1,053.5. This would defeat the purpose of providing nearly volitional passage (e.g., no trapping of the fish) in alternative U3. The utility of any collection and transport would be for any unforeseen times that the ladder and release was not functioning correctly. NMFS requests the Panel clarify why it is proposing to use collection and transport for water surface elevations below 1,053.5 in this alternative.

NMFS believes that the most positive feature of the U3 alternative is that it would eliminate the need for trapping and handling the fish at all of the water surface elevations above 980’. NMFS requests that the Panel list (on page 4-25) that as a “Pro” for this alternative. Similarly, NMFS requests that on page 4-26 “Volitional only up to fishway exit structure and then for a very narrow range of reservoir elevations” not be listed as “Con” as this alternative provides more volitional passage than almost all of the other alternatives provide. Essentially the “Con” (which would be shared with other completely non-volitional alternatives) would be that adult upstream migrating steelhead could not return down the fish ladder after jumping over the false weir. However, to be fair this same “Con” should be listed with every other collection and transport alternative, if it is to be listed here. Specifically, the fish cannot of their own volition move back downstream or upstream (depending on which collection facility they enter) once they enter a trap.

On page 4-40, NMFS requests the Panel to explain why collection and transport facilities used as a supplement to U2 would likely be smaller in scale than in U4. Wouldn’t the U2 collection and transport facility have to operate exactly like the U4 facility at pool elevations below 1,030’?

On page 4-5 section 4.3.2.4, the Panel assumes that adult upstream migration of steelhead occurs from March through June. NMFS’ regional survey data indicate that adult steelhead migrate upstream earlier in the season than March (as early as December if early storm events occur) based on adult redd surveys and carcass recoveries in the Ventura River and Malibu Creek.

The D7 fishway needs to be built to accommodate bidirectional movement of both juvenile and adult steelhead, pass fish up to the high fish passage design discharge flow (which the panel did not state), have an appropriate attraction flow at the high fish passage design discharge to prevent the delay or obstruction of migrating fish. Additionally, the D7 fishway design must meet all NMFS and CDFW fish passage guidelines. The conceptual drawings suggest that juvenile passage is not currently being provided in the ladder.

Two of the major ‘cons’ of D7 are not listed in the ‘pro’ and ‘cons’ list for this option. Specifically, those cons are: 1) smolts that are missed enter the reservoir and have no means of emigrating from the reservoir; and 2) it is subject to missing significant numbers of smolts at higher flows (between 12% and 18% of the time for the months of Feb, Mar, and April, according to table 4.3-2). As mentioned by NMFS in previous correspondence, these percentages could also be significantly higher during wet years as exceedance values represent a long-term percentage of time that 200 cfs would be exceeded.

The 4 to 6 inch trash rack spacing mentioned in section 4.3.5.10 does not meet NMFS' minimum passage width for trash racks.

On Page 5-2 of the draft report, the Panel highlights the benefits of the evaluation matrix, but does not describe any of its limitations/weaknesses. NMFS recommends that the Panel highlight and list some of these weaknesses which include: 1) that the selection of criteria and the weighting of criteria are subjective; and 2) that the tool is primarily used for sensitivity analysis and cannot provide a conclusive answer on exactly how well a given alternative will perform.

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Panel, 2014b. G2_Meeting Presentation-final 2014-08-12.pdf. Santa Felicia Fish Passage Panel, information presented during Group Meeting #2.

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UNITED WATER CONSERVATION DISTRICT
"Conserving Water Since 1927"

July 17, 2015

William Snyder
HDR Engineering, Inc.
2379 Gateway Oaks Drive, Suite 200
Sacramento, CA 95833

Regarding: Draft Santa Felicia Dam Fish Passage Project Alternatives Feasibility Report

Dear Mr. Snyder;

This correspondence transmits United Water Conservation District's (United) comments on the draft Santa Felicia Dam Fish Passage Project Alternatives Feasibility Report (draft Findings Report) dated April 6, 2015. The draft Findings Report presents the results of an assessment performed by an independent panel of fish passage experts (Panel) in accordance with the "Santa Felicia Fish Passage Feasibility Study Plan" (Study Plan) for the purpose of assessing the feasibility of providing passage for southern California steelhead (*Oncorhynchus mykiss*) at the Santa Felicia Dam (SFD). Development and implementation of the Study Plan is a requirement of article 401(a) of the license issued to United by the Federal Energy Regulatory Commission (FERC) for the Santa Felicia Project (FERC Project No. 2153) and reasonable and prudent alternative (RPA) element 3 of the biological opinion issued by the National Marine Fisheries Service (NMFS) for effects of the project on endangered steelhead and its designated critical habitat.

United provides the following comments for consideration by the Panel in finalizing the draft Findings Report. These comments are primarily composed of 1) requests for clarification on specific issues, 2) submittal of information associated with United's infrastructure and environmental conditions in the vicinity of the project, 3) recommendations associated with limiting content presented in the draft Findings Report to the scope of the Study Plan, and 4) recommendations associated with limiting consideration of alternatives (as well as enhancements, or supplements to alternatives) to activities that are within United's discretion. General comments are presented below and specific comments (with references to the section and/or page number of statements in the draft Findings Report) are included in a spreadsheet at the end of this submittal.

General Comments

1) <u>Consistent integration of concepts throughout the report</u>

The draft Findings Report represents a compilation of multiple concepts that have been developed by four consulting firms and seven members of the Panel. In its draft form, the report contains many elements that have not been thoroughly integrated throughout the report, resulting in inconsistencies regarding implementation steps for studies, construction and phasing of recommended alternatives, monitoring and adaptive management actions (primarily contained in sections 5, 6, and Appendix F). Several of these inconsistencies are identified with other individual comments in the attached spreadsheet.

2) Executive Summary

United understands that the Panel intends to include an executive summary in the final report. United recommends inclusion of the following elements in the executive summary.

- Presentation of specific RPA requirements for development and implementation of the Study Plan.
- A clear statement outlining the Panel's recommendations.
    - Fish passage alternatives (U4, D7) and associated phases (enhancements or supplements).
    - Definition of implementation steps with relation to pre-construction studies, trigger points for phased construction, monitoring, and adaptive management.
- Outline of the next steps of RPA requirements.

3) Panel's position regarding the feasibility of volitional alternatives

The Study Plan requires that volitional alternatives be considered concurrent with others and at least one upstream and downstream volitional passage alternative be carried throughout the study. The final findings report is to include the Panel's recommendation regarding the technical and biological feasibility of providing volitional steelhead passage at SFD. The Study Plan states that if the Panel cannot recommend a volitional passage facility due to site constraints, uncertainties, or other factors, the Panel recommend a non-volitional passage facility if deemed feasible. In the draft Findings Report, the Panel identifies multiple uncertainties associated with the volitional alternatives and recommends non-volitional alternatives U4 and D7 as having the "greatest likelihood of providing the safest and most efficient passage performance, based on the Panel's combined professional judgment, consideration of results of the evaluation, and the [Biological Performance Tool] BPT scores, and consideration of least risk of failure."

The Study Plan requires "[a]t least one volitional alternative for upstream and downstream passage […] be described, regardless of its feasibility." United seeks clarity on the Panel's position related to the technical and biological feasibility of the volitional alternatives included in the assessment and requests that the Panel clarify their position regarding "site constraints, uncertainties, or other factors" related to the volitional passage alternatives considered.

4) Modification of water releases from Pyramid Lake

United has no control or discretion over water releases from Pyramid Lake. Therefore, discussions related to modification of flows from Pyramid Lake are not appropriate for consideration in this feasibility assessment. United requests that all references to modification of water releases (enhancement or attenuation) be deleted from the draft Findings Report. For this overarching reason, no further comments are provided associated with discussions in the draft Findings Report related to this issue.

5) Implication of uncertainties identified throughout the draft Findings Report and the role of studies and phasing

Section 5.4 and Appendix F include discussions of uncertainties related to performance of the recommended alternatives (U4 and D7) and recommendations of phasing and adaptive management to address these uncertainties. For example, section 5.4 includes the following statement: “Biological uncertainties are due to both a general lack of in-depth understanding of steelhead in its southern range and a paucity of empirical data on the SCS DPS. Due to these uncertainties it is difficult to confidently predict how the species will respond once fish passage measures have been constructed and implemented, and connectivity has been restored above SFD. There is also uncertainty associated with how certain fish passage components will function both in terms of specified design (i.e., hydraulic performance), and effectiveness in passing fish (i.e., biological performance).” These statements, and others included throughout the report, clearly indicate that substantial uncertainties exist regarding these alternatives. An additional example in Appendix F is the statement that “during the study, the Panel and Group identified a number of technical issues, questions and uncertainties that either have or potentially could factor into the implementation timing and performance of these alternatives, and as well might factor into phasing decisions regarding other alternative designs.” The appendix also makes several references to task 9 from the Study Plan, but the panel makes no recommendations regarding moving to task 9. The Study Plan allows for the panel to recommend moving to task 9 if substantial uncertainties exist. Given that D7 and U4 are costly undertakings, United requests that the panel evaluate whether task 9 should be pursued prior to implementing either of these alternatives, and, that the panel revise section 5.4 and Appendix F to incorporate the role of task 9 in addressing uncertainties, if deemed appropriate. In addition, we request that the panel consider the option of a less costly, simpler version of trapping and trucking as the first phase of fish passage. This is an appropriate approach given the costs and uncertainties associated with U4 and D7. Please see comment 82 in the attached spreadsheet for more on this issue.

6) Appendix F

United requests that Appendix F be deleted from the draft Findings Report. While the content of this appendix is relevant to the process beyond task 7 (finalization of this Findings Report), much of the information in the appendix is outside the scope of the Study Plan. If the panel determines that the uncertainties discussed throughout the draft Findings Report warrant a recommendation to move into task 9, then the content of this appendix should be transferred into the body of the report and included as a recommendation. Otherwise, this appendix should be deleted from the report and held for future consideration during discussions in task 8, and in the event that task 9 is implemented in the future.

7) Appendices I and J

United recognizes the challenges of providing fish passage within arroyo toad critical habitat, and in an environment contaminated with invasive quagga mussels. Many of our past comments have been associated with these issues and they remain a serious concern. However, inclusion of the information presented in these appendices is outside of the scope of the Study Plan and redundant, or may be contradictory with other materials and projects United has produced, or is working on producing. United requests that these appendices be deleted from the draft Findings Report.

Status of Project, Contracting, and Next Steps

The Study Plan sets the framework for the Panel to “function independently (i.e., not be controlled by others in matters of opinion, conduct, so forth) and maintain the responsibility to objectively conduct the feasibility evaluation and prepare the feasibility report based on the Panel’s professional and technical expertise and experience, supported by the best available information.” The Study Plan provides for the Panel to seek and receive information from NMFS, California Department of Fish and Wildlife (CDFW), and United, (collectively, the “Group”) and includes guidelines for how and when Group participation is appropriate. The Study Plan does not require that the final Findings Report receive approval or agreement from all or any of the Group members. United is responsible for working with NMFS, CDFW, and FERC to obtain agreement on what actions United will implement to address passage. This coincides with task 8 in the Study Plan.

United believes this is an important consideration as the Panel moves forward with completing the final Findings Report. United and NMFS are providing the Panel with lengthy comments on the draft Findings Report, and the Panel has the responsibility to consider these comments in making their final recommendations. However, the Panel’s contracts with United do not authorize efforts outside the scope of the Study Plan and the Panel should not feel compelled to modify the draft Findings Report for the purpose of obtaining approval or agreement on the Findings Report from FERC, United, NMFS, or CDFW. The Panel must adhere to the Study Plan and its charge of being an independent body.

Implementation of the Study Plan to date, and development of the draft Findings Report required greater effort and funding than originally estimated. To avoid additional exceedances of contractual budgetary limitations, United issued a stop work order to the Panel on May 4, 2015, and has authorized limited efforts since that time. The Panel’s original proposal to complete implementation of the Study Plan through task 8 was $1,021,000. The contracted amount ($1,021,000) was exceeded in May 2015 by $80,000. In January, 2015, the Panel requested to modify the schedule for preparation of the draft Findings Report by one month to allow additional time to address comments provided by the Group during an earlier commentary period. United is concerned that much of the additional effort expended by the Panel to address comments exceeded the scope of the Study Plan. We believe this contributed greatly to the budgetary overrun. Our goal is to avoid this situation from occurring again as the Panel moves forward with finalizing the Findings Report.

United is in the process of authorizing the Panel members to re-start work on the project to complete the following five tasks.

UNITED WATER CONSERVATION DISTRICT

1. Review comment letters on the draft Findings Report.
2. Conduct conference call to discuss comments (Panel members only).
3. Participate in a conference call with United to review status of budget.
4. Participate in August Group conference call.
5. Develop scope of work and budget for completing final Findings Report based on the outcome of the August Group conference call.

A conference call is scheduled on August 4, 2015, for the Group and Panel to discuss the draft Findings Report and associated comments (with this submittal, the Panel has received comments from both NMFS and United). United is optimistic that discussions during this conference call will result in the Group providing the Panel with clear direction regarding the level of effort and scope of work necessary for finalizing the Findings Report. Given that the project has already exceeded the original budget, United expects that the Panel will require additional funding and contract amendments to address comments received from NMFS and United.

United appreciates the efforts and expertise of the Panel in conducting the assessment, and recognizes the challenges associated with maintaining the independent constraint of the project. We appreciate the opportunity to submit these comments for the Panel's consideration. Please contact me or my staff with any questions or concerns.

Sincerely,

Catherine McCalvin

Catherine McCalvin
Environmental Planning and Conservation Manager

Item	Reviewing Entity	Section; Page	Subject	Comment
1	UWCD	1.1; P1-1 opening sentence	Status of license	United is not seeking a new license, but was issued a new license from FERC on September 12, 2008.
2	UWCD	1.1; P1-1	Introduction	Regarding "SFD is operated to yield water for aquifer recharge as well as hydropower generation." Comment - SFD is not exclusively operated to yield water for aquifer recharge - more precisely... SFD is operated as a water resource reservoir as well as hydropower generation.
3	UWCD	1.5.1; P1-12	Biological feasibility	Regarding "A biological feasibility evaluation would require acquisition and assessment of information on Santa Clara River habitat, the status of the Southern California Steelhead DPS population and a process to identify, develop and assess criteria that allow evaluation of the feasibility of meeting the biological goals." Comment - Biological feasibility evaluation should also include Piru Creek habitat.
4	UWCD	2.1.1; P2-2 1st ¶	Facilities in Forest Service boundaries	"Included in these 53.5 acres are the dam, powerhouse, and associated facilities as well as several recreational facilities." Comment - None of these facilities are within the Forest Service property boundary
5	UWCD	2.1.2; P2-2	Project Facilities	Section has out of date information. The dam is greater than 214 feet; spillway is 475 feet long; Item 3 - Out of date information based on 1995 sediment survey of the reservoir. Based on the 2005 survey the capacity is 83,244 ac-ft and the surface area is only 1182 acres. The usable storage is only 65,294 ac-ft. United surveyed the reservoir in 2015 but the data will not be available for several weeks.
6	UWCD	2.1.3; P2-2	SFD construction completion date	1987 is the year the power plant was completed. The date is not used consistently throughout report.
7	UWCD	2.1.4; P2-3	Capacity of power plant	Regarding "The average annual generation is 1,300 megawatt…" Comment - Suggest replacing this statement with "The power plant has a maximum capacity of 1420 kilowatts (kW) and the project power is sold to Southern California Edison Company."
8	UWCD	2.1.5; P2-3 both 1st and 2nd ¶s	Project boundary	Lower Oaks and Oak Lane campgrounds are entirely within the project boundary. Olive Grove is not within the boundary.
9	UWCD	2.1.5; P2-3 2nd ¶	USFS closure gate	The gate near the Juan Fernandez Launch Ramp is within the project boundary.
10	UWCD	2.2; P2-4	Max discharge 920cfs 9/6/2000	The maximum discharge of 920 cfs is incorrect. The existing facility does not have the capacity to discharge a flow of that magnitude. The September 6, 2000, measurement is erroneous. According to Murray McEachron wildfires and landslides downstream of Santa Felicia Dam caused backwater to occur in the vicinity of the weir and altered the stream gauge rating.

Item	Reviewing Entity	Section; Page	Subject	Comment
				According to McEachron, the maximum discharge measured at that gauging station, sourcing from the penstock, was 624 cfs on October 7, 2004.
11	UWCD	2.3.1; P2-8 1st ¶	Hydraulic features and operational capacities	The information (in Appendix A) is out of date and should be based on GEI's technical memorandum on the hydraulic capacity of the penstock.
12	UWCD	2.3.1; P2-9 2nd and 3rd ¶s	Hydraulic features and operational capacities	United is in the process of automating water releases from the Santa Felicia Dam.
13	UWCD	2.3.1; P2-9	Hydraulic features and operational capacities	United recently conducted a flow test of the low-flow release valves. Reservoir water surface elevation at the time of the test was 980 feet. The east valve had a max discharge of 17.3 cfs and the west valve a max discharge of 15.0 cfs.
14	UWCD	2.3.1; P2-9	Hydraulic features and operational capacities	The larger turbine (unit #2) is scheduled to be operational by fall of 2015.
15	UWCD	2.3.1; P2-10	Hydraulic features and operational capacities	With respect to the smaller hydro turbine (unit #1) - It is not a problem with the controls or programming. The turbine has to be mechanically modified to operate outside its current parameters. Due to the cost and the long term recovery for the estimated expenditure United does not plan to rehab the smaller unit at this time.
16	UWCD	2.3.2; P2-10 2nd ¶	Terminology	Instead of "Eventually, the basin's earth bottoms…" we suggest "During wet years and large release events, the basin's earth bottoms…"
17	UWCD	2.4; P2-11	2 GEI reports	Both reports are now in final form and were submitted to Jon Mann.
18	UWCD-GEI	2.4.1; P2-11 and P2-12	GEI Report	GEI's draft *Outlet Works Rehabilitation – Phase 1* report has been finalized. The report was modified to include the possibility of placing the new outlet works on the left abutment of the dam. In the Findings Report, the paraphrasing on page 2-11 and Table 2.4-1 on page 2-12 should be modified accordingly. The Findings Report and depiction of alternatives are based on the assumption that the new outlet works system would be located on the right abutment. We suggest adding a general statement that the Fish Passage concepts presented would generally apply should a new outlet works be located on the left abutment.
19	UWCD	2.4.1; P2-11	Outlet works rehabilitation study exec summary	"The conclusion was to keep the new outlet works system on the right side of the dam." Comment - This is a premature conclusion since neither DSOD nor FERC have reviewed the reports. In addition, there are advantages to having the outlet works on the left (east) abutment that were not presented in the draft reports.
20	UWCD-GEI	Table 2.4-2	Review/schedule	Add "Review" after "DSOD/FERC" in the first row. Modify the dates in the table based on page 6-3 in GEI's final *Spillway Alternatives Study* report.

Item	Reviewing Entity	Section; Page	Subject	Comment
21	UWCD	2.6; P2-16 3rd sentence	Arroyo toad critical habitat	Should state middle Piru Creek, not lower Piru Creek
22	UWCD	P3-1 2nd ¶	Clarification	Regarding "The Southern California Steelhead DPS includes all *O. mykiss* populations in the watershed from Santa Maria River (north of Point Sal) south to the Tijuana River at the U.S.-Mexico border." Comment - Insert "below artificial or natural impassible upstream barriers" after watershed.
23	UWCD	3.1.2.2; P3-12 1st ¶	Fry migration	Regarding "No fry were reported to be part of the migration." Comment - Table 2 in Booth 2015 shows the trapping of YOY (fry) steelhead during quite a few years.
24	UWCD	3.1.2.2; 1st ¶ on P3-13	Smolt migration	Regarding "All three streams exhibited comparably high numbers of downstream migrants during wet, normal and dry years." Comment - Significantly fewer smolts migrate during dry years, especially consecutive dry years on the Santa Clara River.
25	UWCD	3.2.2; P3-21 1st ¶	Correction	Regarding "and an initial set of measurements were taken." Comment - An initial set of measurements were not taken. Only site selection occurred for the critical riffle surveys.
26	UWCD	4.2; P4-2	Upstream Fish Passage	Please note that GEI has completed both feasibility reports and the reports have been submitted to DSOD and FERC. The preferred spillway project includes widening the spillway chute and raising the crest 5 feet to pass the PMF. The location of the new outlet works has not been determined. The left abutment (east) is a viable location. This would lead to the relocation of the power plant to the left abutment. In either case the existing penstock and tunnel would be abandoned and demolished (backfilled with concrete). The reservoir range for the collectors will have to be raised above elevation 1080 feet to comply with the PMF criteria. The collectors cannot interfere with the approach to the spillway weir.
27	UWCD-GEI	4.2.1.1; P4-4	Steel tieback frame	We understand that the use of rigid struts to brace the tower against the slope to resist seismic loading is only a potential consideration at this feasibility level of evaluation. However, it is likely that use of this type of bracing would be problematic due the "out-of-phase" ground motions at the tower base and brace anchor points. Consequently, the tower itself would need to be quite robust to resist earthquake loading.
28	UWCD-GEI	4.2.1.1; P4-4	Max pool level elevation	A full pool level at elevation 1070 is assumed for determining the maximum head differential on the tower. Following proposed spillway modifications, the highest pool level will be elevation 1073.5. However, it could be elevation 1078.5 if Spillway Alternatives 1A or 1B are selected.
29	UWCD-GEI	4.2.1.1; P4-4	Elevation of crest of dam and deck of tower	The deck of the tower is at elevation 1075, the same elevation as the crest of the existing dam. If Spillway Alternatives 1A or 1B are ultimately selected, the crest of the dam would be raised to elevation 1080 and the deck of the tower would need to be raised as well.

Item	Reviewing Entity	Section; Page	Subject	Comment
30	UWCD	4.2.1.4; P4-6 2nd ¶, last sentence 3rd ¶, 4th ¶	Obermeyer dam, AWS system	The Obermayer gate as depicted would create a backwater into the power plant tailrace and the cone valve chambers. Page 4-7, second and third paragraphs, incorrectly state that the maximum water releases from the outlet works are 500 cfs. Typically (not "normal") flows are substantially lower. Maximum flows in the range of 500 cfs only occur for a short period during initial stages of the annual conservation release which is outside the migration period and therefore does not apply to this operation scenario. During the conservation releases the Obermayer gate will be fully open. When migration water releases are triggered between Jan 1 and May 31, United is required to release a minimum of 200 cfs. The AWS for the attraction flow and ladder will only be 30 cfs (or 27cfs?). The total discharge will not be capable of meeting the minimum required 200 cfs. As the migration flow ramps down, so will the attraction flow (matching the 10 percent flow requirement).
31	UWCD	4.2.1.6 1st ¶	Draining the reservoir	Replacement of the outlet works does not require that the reservoir be completely drained. Water surface elevation could be lowered to 932 feet (elevation of intake structure). Water surface elevations below 932 would preclude normal water releases to lower Piru Creek through the intake structure.
32	UWCD	4.2.1.9; P4-10 Cons	U1 Cons	Consider adding the following to the list of Cons - Power and mechanical failures have the potential to lead to uncontrolled water releases.
33	UWCD	4.2.1.10 P4-11 2nd bullet	Tunnel costs	"Scaling up" costs is not appropriate. It is not a linear scaling factor. The costs increase exponentially with increases to the tunnel diameter particularly associated with providing access for O&M personnel. Structurally and mechanically it's a more elaborate design, with ventilation, lighting, walkways, and communication systems, all in a moist corrosive environment.
34	UWCD-GEI	4.2.3.2	Location of fish ladder	The location of the fish ladder on the east side of the dam would need to be modified if Spillway Alternative 3B were selected.
35	UWCD-GEI	4.2.3.2	Maximum slope	The maximum slope of the fish ladder for U3 is stated as 7%, whereas the fish ladder slope for U1 and U2 is stated as 10%. Please explain the reason for the difference.
36	UWCD-GEI	4.2.3.2	Location of fish ladder	The location of the fish ladder on the west side of the spillway would need to be modified if Spillway Alternatives 1A, 2A, or 3A were selected.
37	UWCD-GEI	4.2.3.4	Bulkhead gate malfunction	What are the implications if the bulkhead gate cannot be closed (due to malfunction) when the reservoir rises above elevation 1056?
38	UWCD	4.2.3.8 Cons	Debris	Section 4.2.4.2 includes discussion of the need to manage debris. Recommend adding challenges associated with debris to the "cons" section in 4.2.3.8 for this alternative.
39	UWCD	4.2.4.3; P4-29	Sensors and alarms	Suggest modifying to say "The facility would be outfitted with water quality and level sensors and alarms"

Item	Reviewing Entity	Section; Page	Subject	Comment
40	UWCD	4.2.5.1 1st sentence	Operations to minimize spill events	United attempts to minimize spill events. It is the intent of the operations and maintenance staff to reduce volume of water lost during spill events. Uncontrolled flood waters discharging over the spillway crest have the potential to wash out the lower road access and cause damage to facilities and property downstream of the dam. Operations staff generally attempt to reduce spills by maintaining the surface elevation of the reservoir one to two feet below the crest of the spillway. Santa Felicia Dam and the Lake Piru Reservoir were constructed primarily as a water storage facility not as a flood control facility. Operations can attenuate storm flows and reduce the downstream peak discharge to a degree, however, during major flood events the reservoir is essentially a pass through facility.
41	UWCD	4.2.5.1	Operate to minimize spill	Minimizing duration and magnitude of spills will increase the number of smaller spills, increasing both mortality when fish go over the dam and stranding when the spillway channel is dewatered. Therefore, downstream mortality of smolts should be considered against adults following the spillway instead of the release channel. Perhaps providing justification for an improvement that would prevent fish from entering the spillway channel (coming upstream).
42	UWCD	4.2.6.1	Spillway collector	It may be more efficient to keep fish out than to try to trap them up there (both for stranding and trapping efficiency), i.e., a fish barrier downstream?
43	UWCD-GEI	4.3; P4-42	Correction	Change “upstream” to “downstream” in the third sentence (page 4-42).
44	UWCD	4.3.1.2 1st sentence	High controlled outflow of SFD	Note - Flows in the range of 500 cfs are not "normal" and only occur for a short period during initial stages of the annual fall conservation release. The maximum capacity for water releases is dependent on water surface elevations (included in Appendix A). Water releases in the range of the maximum capacity would only be conducted during emergency situations. It is inappropriate to refer to a maximum controlled outflow of 800 cfs in this context. Water releases of this magnitude are not achievable under all conditions and could compromise infrastructure at the facility.
45	UWCD-GEI	4.3.1.2 2nd ¶	Reverse flow to clean screens	In second paragraph, regarding “The reverse flow through the outlet screens would clean those screens.” It is likely that the reverse flow velocity would not dislodge quagga mussels should they be attached to the screen.
46	UWCD-GEI	Figure 4.3-1; P4-47	Additional information	Suggest adding another column for the case of: Downwell from Collector = 150 cfs, Penstock = 0 cfs, Pumpback to Reservoir = 150 cfs, and Low Level Gravity from Reservoir = 0 cfs.
47	UWCD-GEI	4.3.1.3 3rd ¶	Steel tieback frame	We understand that the use of rigid struts to brace the tower against the slope to resist seismic loading is only a potential consideration at this feasibility level of evaluation. However, it is likely that use of this type of bracing would be problematic due the “out-of-phase” ground motions at the tower base and brace anchor points. Consequently, the tower itself would need to be quite robust to resist earthquake loading.

Item	Reviewing Entity	Section; Page	Subject	Comment
48	UWCD	4.3.1.4 1st ¶	Elevation control	Elevation 1060 corresponds to a spill of 18,500 cfs (see comment below associated with section 4.3.1.6; 2nd ¶)
49	UWCD	4.3.1.6 1st ¶	Operating season	Periodicity should be consistent with the migration water release schedule in the Santa Felicia Water Release Plan.
50	UWCD	4.3.1.6 2nd ¶	Non-operation outlet capacity	Some components of this section do not make sense. The draft states that the fish passage operating season is January to Mid-July. This is not consistent with the migration water release schedule in the Santa Felicia Water Release Plan (Jan 1 through May 31). The operating range identified (P4-48) is up to water surface elevation of 1060 feet, which equates to a spillway discharge of 18,000 cfs. The correct elevation is 1056 feet with 3,000 cfs discharging over the spillway crest. The operation scenario listed in the first paragraph of P4-50 states that the pump back system could operate whenever the outlet flow is less than 150 cfs. Is this water circulated in the reservoir or being discharged below the dam? Once again, the minimum required migration water releases are 200 cfs. Flows in excess of migration water releases are only released during the fall conservation release, or under spill conditions. Flow over the spillway channel is uncontrolled.
51	UWCD	4.3.1.7 1st bullet	Fyke net - phasing	This indicates that fyke net collection is a phasing opportunity, but this has been presented as an activity associated with pre-design studies. Please define if this is considered for phasing or exclusively for pre-design studies or whether this is an initial phase of trapping and trucking. Note - also see 4.3.4.6; P4-66.
52	UWCD	4.3.1.10 Cons	Complexity and associated risks	The complexity of this alternative (specifically 150 gates) has inherent risks associated with mechanical failure and opportunities for uncontrolled releases. These implications should be considered as a "con" in section 4.3.1.10 for this alternative.
53	UWCD	4.3.1.10 Cons	Fish attraction and collection flow magnitude	Section 4.3.1 (1st sentence); and 4.3.1.2 (3rd ¶) includes a 150 cfs attraction flow (3 times greater than our El Rio facility Booster Pumping Plant). The excessive energy demand and carbon footprint should be considered as a "con" in section 4.3.1.10 for this alternative.
54	UWCD	4.3.1.10 Cons	Collector and screens	Section 4.3.1.1 includes "The velocity distribution creates a gradually accelerating flow through the collector up to a velocity from which the target fish cannot escape." Comment - The collector will also capture non-target fish, which will result in relocation of non-native fishes to lower Piru Creek. Recommend adding this to the "cons" section in 4.3.1.10 for this alternative.
55	UWCD	4.3.1.10 Cons	Debris	Section 4.3.1.1; P4-45 2nd ¶ includes discussion of debris management. Recommend adding challenges associated with debris to the "cons" section in 4.3.1.10 for this alternative.
56	UWCD-GEI	4.3.1.11; bullet 3	Updated information	The cost of the fish screen system for the outlet works improvements study was revised in GEI's final report.

Item	Reviewing Entity	Section; Page	Subject	Comment
57	UWCD-GEI	4.3.3.1; last paragraph	Pumpback system	A pumpback system capable of 150 cfs flow back to reservoir is stated. However, the pumpback system would need to be capable of 500 cfs if this alternative is to be able to operate at 500 cfs “regardless of the SFD outflow” as stated in section 4.3.3.
58	UWCD-GEI	4.3.3.1	Missing drawing	Drawing D5.5 is referenced, but there is no Drawing D5.5.
59	UWCD-GEI	4.3.3.3	Missing drawings	Drawings D5.5 and D5.6 are referenced, but there are no Drawings D5.5 and D5.6.
60	UWCD	4.3.3.9 1st bullet	Cost to extend penstock 100 feet	That is assuming that the new outlet works is constructed on the right (west) abutment. There are good reasons to locate the outlet works on the left (east abutment).
61	UWCD	4.3.4; P4-59	D-7 general comment	D7 would potentially block upstream access to spawning sites for adfluvial *O. mykiss*. Passage should be included over the D-7 gates or an upstream migrant trap should be included.
62	UWCD	4.3.4; P4-60 1st sentence	D-7 general comment	The condition of the road for accessing the collector, and potential for damage to the in-creek training berm, collector, and road during high flow events may pose challenges. Studies are essential prior to design to identify an appropriate location and determine the structural criteria necessary for operational viability (of the road and passage alternative) during and following storm events.
63	UWCD	4.3.4.1; P4-60 item 3	Blue Point wet crossing	This crossing is in the planning stages for decommissioning.
64	UWCD	P4-60 last paragraph	Arroyo toad habitat	Regarding "a second general location was identified upstream of the USGS gauge and presumably upstream of the arroyo toad habitat." Comment - Arroyo toad habitat exists from Pyramid to Lake Piru with the best breeding habitat occurring in the four miles above Lake Piru.
65	UWCD	4.3.4.2 1st sentence and 4.3.4.5 7th bullet	Electricity	There is no power near the site. The existing power poles terminate at the Juan Fernandez boat ramp. Solar is not a practical option due site requirements and hillside light blockage.
66	UWCD	4.3.4.2 2nd ¶ and Table 4.3-2 and 4.3.4.4 P 4-65 1st ¶	Estimated size requirements and exceedance frequencies	The maximum flow into the reservoir was recorded in 2005, a flow of 40,000 cfs with a gauge height of 16 feet. Since 1955 flood flows have exceeded 6000 cfs 16 times, exceeded 4000 cfs 20 times. Survivability of the structure may be a significant challenge.
67	UWCD	4.3.4.3 3rd ¶ (P4-62) and	Inconsistency	Regarding "It is assumed that at 1,000 cfs the dam would be lowered to pass the flow and debris and sediment. (4-62), This closure is estimated to occur at a flow of 4,000 cfs, which is the flow at which the operating water level of the screens would be exceeded.(4-65)" Comment - This is

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		1st ¶ on P4-65		confusing. Page 4-62 states that the dam would be lowered at 1,000 cfs and on page 4-65 it says 4,000 cfs.
68	UWCD	4.3.4.4 1st ¶	Operation	Accessibility may be an issue (road wash outs and Lisk Ranch Creek crossing).
69	UWCD	4.3.4.4 7th bullet	Transport distance	Six miles not sixteen.
70	UWCD	4.3.4.4 P 4-65 1st ¶	Exceedance of capacity (4000 cfs)	Not just flow, but gauge height.
71	UWCD	4.3.4.8	Avoid impacts to Arroyo toad by moving the collector to USFS property	The entirety of middle Piru Creek and Agua Blanca is listed as critical habitat, so no slight adjustment of location will completely avoid impacts. Recent surveys show toads distributed all the way down into the delta.
72	UWCD	4.3.4.9 Cons 3rd bullet	Operations reduced during 4% of migration season	That could be a lot more than 4 percent of possible fish migrating.
73	UWCD-GEI	4.3.5	malfunction of inlet gate	An inlet gate would be closed to protect the facility for reservoir levels above elevation 1058. What are the ramifications if the inlet gate were to be open (inoperable) for reservoir levels up to the PMF?
74	UWCD	4.3.5	General D-9 and all surface collector alts	Even though non-native fish species do enter lower Piru Creek during spill events, a Lake Piru collector could provide a safer, more continual passage downstream. The collector could also become an attractor for all fishes (fish congregate at structures) resulting in the movement of non-native fishes downstream (info could be researched from other facilities). If this alternative were implemented, a trap or holding facility could be placed at the end of the open channel pipeline to segregate non-native fishes from *O. mykiss*. Section D.2.1.8 on page D-4 in Appendix D does refer to blocking and trapping fish as an alternative as well as D.3.1.7 on page D-9.
75	UWCD	4.3.5.3	Mortality/survivorship associated with spillway	Regarding "Mortality is higher with lower magnitude spills, so it seems like it would be better to have high magnitude to ensure survivorship" Comment - Based on this discussion, it may not matter because flows rarely exceed the level necessary to increase survivorship?
76	UWCD	4.3.5.3; P4-72	Mortality/survivorship associated with spillway	Regarding "Note that these are just estimates based on field studies at other sites, laboratory tests of the effect of shear, looking at the spillway with no spill flow during a site visit, drawings of the spillway shape, and videos and photographs of spill at SFD. No actual field studies estimating mortality have been performed at this project." Comment - United realizes that these estimates were taken from other projects and lab tests and this was the best available information at the time. However, even though fish traveling over the spillway during large spill events experience high turbulence and a large plunge, observations of *O.mykiss* in lower Piru

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				Creek following the spill event in 2005 indicate that many survived and were in good condition (United biologists personal observations and reports from other biologists). No *O.mykiss* were observed in lower Piru Creek before the spill event and many were observed after, indicating they entered the creek during the spill event. United staff witnessed *O. mykiss* traveling over the spillway in 2005. A suggested study could be to tag fish in middle Piru Creek and recapture them below Santa Felicia Dam.
77	UWCD-GEI	4.3.6	Additional drawing	Suggest adding a Drawing D10.1 for completeness.
78	UWCD-GEI	4.3.7	Reference	Reference Drawing D11.1 in this section.
79	UWCD	5.2; 1st sentence	Correction	Change "downstream" to "upstream".
80	UWCD	5.3.2; P5-18 2nd ¶	Correction	Regarding "The majority of steelhead smolts outmigrate at Age 2 and the number of outmigrants may increase following a Wet Year." Comment - Based on scale and length frequency analysis conducted by ENTRIX Inc. from 1994-1998 at the Freeman Diversion, outmigrating smolts in the Santa Clara River are comprised mostly of age 1 and 2 fish.
81	UWCD	5.4; P5-27	Passage objectives	The first paragraph of this section refers to passage objectives - the panel should clarify if these objectives have been established or are these the same as the performance criteria referenced later in this paragraph.
82	UWCD	5.4; P5-28 4th ¶	Uncertainties/costs	Given the substantial uncertainties identified by the panel, United recommends that the panel develop less costly passage alternatives (e.g., simplified trapping and trucking not involving permanent or elaborate structures and specialized vehicles) for the initial phase. The first phases for up and down stream passage identified in the report (U4 and D7) are significantly costly undertakings with numerous uncertainties. This paragraph states, “Phasing has advantages biologically but also financially for United. Risk of committing to a poorly functioning alternative is reduced, and the commitment to an expansive, potentially unnecessary alternative is avoided; or can be incrementally phased-in from an initially lower cost alternative based on results of biological monitoring.” We believe that there are lower cost alternatives to U4 and D7, both multi-million dollar undertakings, that could effectively be implemented as an initial phase and that would be consistent with the above statement made by the panel. Given the substantial uncertainties, a lower-cost phased option could be implemented in conjunction with studies to determine if U4 and D7 are worth the investment.
83	UWCD	5.4; P5-27 and P5-28	Discussion of phasing broken into technical and biological	Regarding "Phasing has advantages biologically but also financially for United. Risk of committing to a poorly functioning alternative is reduced, and the commitment to an expensive, potentially unnecessary alternative is avoided; or can be incrementally phased-in from an initially lower cost alternative based on results of biological monitoring." Comment - This section discusses technical and biological uncertainty (effectiveness) with the recommended feasible alternatives

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				and adaptive management. The technical and biological uncertainties are related to the performance of a recommended alternative after it is constructed and operated. The panel presents but does not, at least in this section, further describe phasing as it relates to "the commitment to an expensive, potentially unnecessary alternative is avoided; or can be incrementally phased-in from an initially lower cost alternative based on results of biological monitoring." This relates to biological uncertainty before a recommended alternative is constructed by conducting biological monitoring. We recommend that the panel clearly distinguish technical phasing and biological phasing based on passage performance and biological phasing based on initial biological monitoring. These are not clearly distinguished throughout the document.
84	UWCD	P5-29; item #1	Inconsistency	This does not appear to follow figure 5.4-1. We realize that figure 5.4-1 is a "simple schematic of adaptive management" but it appears to show that monitoring would first be conducted before the alternative is implemented but item #1 on P5-29 states that the alternative would be implemented first before studies and monitoring would occur. This is another example of before and after construction uncertainty and related studies and monitoring. They should be clearly differentiated.
85	UWCD	P5-29; item #2 and 5.5; P5-33 2nd bullet	Criteria for defining passage performance	Criteria should be defined in advance, and then refined through study, it would be challenging to assess performance without any starting guidelines.
86	UWCD	Figure 5.4-1; P5-30	Refinement to figure	The figure should be modified to include the biological trigger that initiates implementation of phase 1, should clarify what the purpose of the first box is (Biological information), explain the role of the fyke net listed in the 5th box in the flow diagram, and include some sort of feedback between the monitoring and construction of phase 1 (assumedly the additional data might change the design?)
87	UWCD	5.5; P5-30 thru 5-32	Biological performance standards	In discussing the biological performance standards, the panel should address how the fact that many factors influence whether steelhead will ever be in a position to take advantage of any sort of up or down stream passage opportunities provided – that it may not be as easy as figure 5.5-1 depicts to evaluate success.
88	UWCD	Figure 5.5-1	Inconsistency	This figure is inconsistent with activities described in Appendix F and does not include studies and monitoring before implementation.
89	UWCD	Figure 5.5-1	Terminology	"Compliance monitoring" might be better described as "effectiveness monitoring", and "Refinements" should be linked back to "effectiveness monitoring."

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90	UWCD	5.5; P5-33 4th and 5th bullets	Sequential order	Perhaps change the order of 4th and 5th bullets.
91	UWCD	5.5; P5-33 6th bullet	Clarification	The trigger for construction of an additional facility would be established during original consultation on triggers for phasing.
92	UWCD	P5-33 (last ¶)	Phasing process	Regarding "In the meantime, studies could be initiated to address uncertainties that might inform the final alternative designs or monitoring and study planning." Comment - This implies initial studies before implementation. This should be clearly part of the phasing process as described in this section.
93	UWCD	P5-33 (last ¶)	Establishment of operation and effectiveness monitoring	Regarding "Long term operation and effectiveness monitoring will begin once the design criteria are met." Comment - Suggest deleting "long term." The Fish Passage Monitoring Oversight Committee will determine the required time frame of any monitoring.
94	UWCD	6.3	License amendment	The schedule and decision making process in phasing of fish passage needs to account for the fact that any passage action will require that United amend its FERC license. This will involve a process that includes an opportunity for the public and agencies to weigh in and also requires 401 certification.
95	UWCD	Table 6.3-1; Figure 6.3-1	Schedule	Table 6.3-1 and figure 6.3-1 – should reflect that year 0 starts when implementation trigger is met. For initial technical studies the table and figure should identify that 3 years is a minimum and these studies could require more time than this to complete. The time frame for the monitoring studies may be problematic given hydrologic cycles in southern California. Under drought conditions, many studies could not be implemented appropriately or result in representative information.
96	UWCD	Table 6.3-1	Inconsistency	Does not follow phasing steps summarized in section 5 (P5-32). Section 5 does not appear to follow Appendix F.
97	UWCD	6.3.2.4; P6-12	Inconsistency	This describes initial studies that are included in Appendix F but not in section 5 (P5-29).
98	UWCD	6.3.2.5	Procure Designer	Geotechnical investigations are missing. This is part of the project critical path.
99	UWCD	Section 7		This chapter seems unnecessary at the end of such a long document. We suggest deleting it and allowing the executive summary to serve the same purpose.
100	UWCD-GEI	P8-1	Reference correction	Change "GEI Consulting Engineers and Scientists" to "GEI Consultants, Inc."
101	UWCD	Drawing U1.1	Infrastructure	1) In order to comply with PMF criteria the top of the structures must be higher than 1080 feet. 2) Final report submitted to FERC in April 2015. New outlet works on the left (east) abutment is

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				still a viable alternative. 3) The preferred spillway project alternatives involve widening the spillway chute. See final report submitted to FERC and DSOD in April 2015.
102	UWCD	Drawing U1.2	Infrastructure	If the outlet works is relocated to the left abutment the existing penstock and powerhouse will be abandoned and demolished.
103	UWCD-GEI	Drawing U1.4	Infrastructure	The downstream 200 feet of the fish ladder would likely not be in a tunnel due to the small amount of soil cover.
104	UWCD	Drawing U1.5	Infrastructure	1) Not a good design location for the 18-inch bypass. 2) Add ventilation and communication conduits. 3) Larger tunnel will require significantly more structural reinforcements than the proposed GEI Tunnel Section above. See previous comments provided in section 4.
105	UWCD	Drawing U1.6	Infrastructure	1) In order to comply with PMF criteria the top will have to be higher than 1080. 2) See previous comments in section 4.
106	UWCD	Drawing U4.4	Infrastructure	The water supply line needs to be 8-inches or larger. Velocity would be too high with a 6-inch supply line.
107	UWCD-GEI	Drawing D3.1	Infrastructure	The tunnel alignment shown by the callout “Penstock Alternative R1 from GEI Study” does not coincide with the alignment of Alternative R1 in GEI’s report.
108	UWCD-GEI	Drawing D4.3	Infrastructure	This drawing is missing.
109	UWCD-GEI	Drawing D4.5	Infrastructure	The reservoir level lines are incorrectly plotted on Detail 5.
110	UWCD-GEI	Drawing D5.4	Infrastructure	Should the 150 cfs shown for the travelling belt screens be 500 cfs?
111	UWCD-GEI	Drawing D14.3 and D14.4	Infrastructure	Consider founding the structure at about elevation 970 instead of elevation 949. There does not appear to be a need for such a deep excavation.
112	UWCD-GEI	Drawing D14.7	Infrastructure	A shutoff valve would likely be required at the downstream end of the 60-inch diameter bypass pipe.
113	UWCD	Appendix F	Delete from findings report	Delete this appendix as part of this report. Much of the content of this appendix is relevant to the process beyond task 7 (finalization of this findings report), but outside the scope of the study plan. If the panel determines that the uncertainties discussed throughout the findings report warrant a recommendation to move into task 9 (which is within their discretion to do), then the content of this appendix should be transferred into the body of the report and included as a recommendation. Otherwise, this appendix should be deleted from the report and held for future consideration during discussions in task 8, and in the event that task 9 is implemented.
114	UWCD	Appendix H; H.2	Modification of flow from Pyramid	United has no control or discretion over water releases from Pyramid Lake. Therefore, discussions related to modification of flows from Pyramid Lake are not appropriate for

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				consideration in this feasibility assessment, and all references to modification of water releases (enhancement or attenuation) should be deleted from the findings report.
115	UWCD	Appendix I	Delete from findings report	Delete this appendix as part of this report. This goes outside the scope of the study plan.
116	UWCD	Appendix J	Delete from findings report	Delete this appendix as part of this report. This goes outside the scope of the study plan.

Comments submitted by NMFS		
NMFS Comment Number	**Comment**	**Panel Response**
1	***Retain the ability to phase the project beyond the scope of the recommended alternative.—*** The Panel's current recommended alternatives for upstream (U4) and downstream (D7) passage both incorporate traditional trap and transport technology. In light of the ongoing group meeting discussions this was expected; however, NMFS anticipated the Panel would incorporate some of NMFS' recommendations into the draft report on considering the feasibility of an alternative that may be phased into a more natural (i.e., partially or fully volitional) fish passage facility over time as described in our previous comment letters (May 22, 2014, September 18, 2014, and December 10, 2014). Specifically, our May 22, 2014, letter described a phased approach in which: the ultimate goal of a phased approach should be to achieve fish passage without handling fish: Panel evaluate if a phased approach resulting in adult steelhead volitional/partially volitional passage of Santa Felicia Dam is feasible, and further develop the Panel's recommended phased-build out of alternative U4 that would have the highest likelihood of promoting feasible volitional, or partially volitional adult migration characteristics	The Panel has revised and clarified its recommendation, including phasing and the process that is used to both implement U4 and D7, as well as establish criteria to trigger new or additional facilities. The Panel believes that adaptive management is critical to this process, and that it creates opportunities for a joint committee of resource agencies and the owner to identify passage options beyond the initial facilities. This may or may not include volitional or partially volitional passage.
2	***Facilitate downstream movement of juvenile O. mykiss migrants immediately***	This has been incorporated into a revised section on recommendations.
3	***Further develop adaptive management plan and list of technical studies (Appendix F***).—	Discussion of adaptive management has been incorporated into a revised section on recommendations, but is otherwise out of scope for this study.
4	Relationship of the recommended alternative to biological goals and passage standards.—	
4	NMFS requests that the Panel consider and outline (via modifications to Figure 5.5-1 and Table 6.3-1, and/or other means) what options are available for parallel tracking the facility design, implementation, and studies needed to determine and advance the project into Phase II construction (if needed under the Panel's proposed adaptive management plan).	See response to 3 above.
5	Role of committee or panel.—	
5	NMFS cannot delegate its roles and responsibilities under the ESA to assist and advise the Commission and licensee on compliance with the ESA. NMFS further recommends that the title of any such committee should better reflect its role as scientific advisors, e.g., Fish Passage Science and Technology Panel	Comment noted.
6	Resolving Infeasibility Concerns and Questions.	
6a	NMFS requests that the Panel clarify whether or not it can realistically finalize the feasibility report at this time given the unknowns the Panel states exist for several alternatives.	The Panel has revised the recommendations section, including noting that uncertainties exist and can and should be resolved. At the same time, the Panel has identified alternatives that have the best likelihood of success in light of the uncertainties.
6b	NMFS recommends that the panel either take the steps necessary to determine feasibility upfront and/or adopt and recommend a parallel track design process that assures that a feasible fish passage alternative is implemented in a reasonable time frame.	The Panel has identified alternatives it believes provide the greatest opportunities for success. The timeline aspect of the process has been removed from the Final Report, due in part to the fact that the regulatory process is such that a time frame can not be reasonably predicted or controlled by the owner.
6c	NMFS recommends that if the Panel feels that an alternative could have a fatal flaw (seismically or otherwise), then the panel should recommend a course of studies or actions to address these concerns.	The recommended alternatives U4 and D7 do not have seismic "feasibility" concerns. Each will have seismic design requirements but that kind of study would be conducted as part of preliminary design, typical of any facility design.
7	Conditional Support to Further Investigate the Feasibility of the Panel's Proposed Project Implementation Framework	
7a	NMFS requests clarification from the panel on whether or not the proposed adaptive management framework described in the draft feasibility report precludes the possibility of requiring additional facilities (e.g., a reservoir collector or an upstream volitional ladder with slide release) beyond the full build out of U4 and D7 (Phase I), if biological performance standards are not met after full build out.	The adaptive management framework implementation is beyond the scope of this project, but as outlined does not preclude the option to change beyond full buildout of U4 and D7.
7b	At this time, NMFS' expectations for this approach include, at minimum, the following key elements: (NMFS Line 29 lists 22 conditions primarily related to performance and adaptive management)	The Panel appreciates the clear articulation of the conditions. The Panel believes that these are important issues that are better addressed among the parties of the Group, and are beyond the scope of this Feasibility Report.
7c	Consequently, NMFS would like to highlight that some, but not all, of the very important placeholders, options, etc., that will need to be discussed and resolved before being finalized for any alternative(s) that are to pursued include: (NMFS Line 31 lists 14 design and operational criteria)	Comment is noted. The Panel believes that these are issues that are better addressed among the parties of the Group during facility design and are beyond the scope of this Feasibility Report.
8	Clarifications of the Panel's Recommended Alternative Approach	
8a	With regard to defining an implementation schedule, the panel needs to more precisely state what components (main fish passage facility, supplements, and enhancements, etc.) would be implemented and when.	The Panel has significantly revised its recommendations section, including a more incremental approach to implementation of U4 and D7 to including initial measures and monitoring studies to reduce uncertainties. This will aid in defining the precise schedule of the full implementation schedule.

Comments submitted by NMFS		
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8b	NMFS further assumes that the Panel believes that if the biological criteria used to determine whether fish passage will be implemented at SFD are triggered, then all of the supplements, enhancement and main passage facilities should be designed and constructed without any phasing. NMFS requests that the Panel either verify that this is the case or state exactly what will be built and when under alternatives U4 and D7.	See response to 8 above. The Panel also believes that supplements and enhancements are included to provide the best potential alternative, if they are consistent with the biological criteria that are established.
8c	On page 4-32, the Panel states that, under U4 phasing options, a more rudimentary temporary trap could precede permanent facilities. NMFS requests that the Panel state what it is proposing with respect to how and when such phasing decisions would be made	The recommendations section has been revised significantly, and includes discussion of the temporary measures.
9	Panel Assumptions on Facility Operations	
9a	NMFS requests that the Panel either demonstrate that passage delay of up to a day will not interfere with a steelhead's life cycle or state how the frequency at which steelhead are monitored and transported at any collection facilities will be determined in the future.	The Panel does not suggest a delay of a day is appropriate. The one-day delay and operational timing are used as basis for rough sizing of facilities and for comparative operational cost estimates. Acceptable delay is an uncertainty that should be addressed in a subsequent process, through studies and monitoring, with findings incorporated as adjustments to facilities or their operation through adaptive management.
9b	NMFS requests that the panel note that the absence of fish in a stream having low numbers of fish is not necessarily an indication that fish are not migrating at this time. Instead, it may be that there are simply no fish present to migrate at that time. Operational timing issues should be linked with biological goals and objectives.	Comment noted; see also response to 9 above.
9c	NMFS requests the panel, at minimum, highlight that there may be situations where any of the reservoir collectors alternatives may need to be operated throughout the entire smolt migration season and possibly throughout the entire adult migration season to accommodate kelts.	Comment noted; see also response to 9 above.
9d	NMFS also requests that the panel state that the exact circumstances and times which any reservoir collector should be operated need to be determined in the future and how that should be determined.	Comment is noted. The recommendations section notes that uncertainties exist, and the Panel has identified a process for resolving some of the uncertainties, including some the comment identifies.
9e	NMFS requests that the Panel consider the merits of designing any fish ladder built as part of the upstream passage facilities to have attractions flows and have an AWS that constitutes at least 5-10% of the total flow being released through the intake works. This includes the flows that will be used to minimize spill.	Auxiliary Water Supply systems for attraction flow purposes associated with upstream passage alternatives are included. The details for an AWS would be determined during a design phase for a selected upstream fish passage alternative.
9f	NMFS recommends that the Pyramid Lake minimum low flow option needs to be considered for all fish passage alternatives	The Panel acknowledges that Pyramid Lake flows are given and not subject to change within this process.
9g	On page 4-39, The Panel states that a spillway collector would operate based on whether fish are being collected. Such a protocol seems problematic when trying to protect an endangered species. With few fish in the system, ceasing to operate the facility simply because fish are not visually accounted for at all times, runs the risk of allowing fish that are not easily observed to experience significant passage delay or worse.	Comment noted. The full report text of this section reads: "Since the frequency of spills is small in comparison to regular release flows from the outlet works it is anticipated that the collector is a temporary measure to be used during spills (if safe) and after spills for a period of time. The length of operation would likely be determined when actually in operation and based on whether fish are being collected. An operational protocol could be established based on the time it takes to collect fish from the pool after the spill." The Panel feels that the operational protocol suggested, that would be developed outside of this feasibility study, could address this comment, so no changes to text were made.
9h	The spillway pool collector described on page 4-39 relies upon a 2-5 cfs capacity pump to supply water to the fishway and trap. Without an auxiliary water supply, such a system would only provide a minimum of 5% attraction flow up to discharges between 40 and 100 cfs. Thus, such a collector would have limited utility for spills greater than about 40 to 100 cfs. A better attraction flow of 10% would only be met for spills less than 20 to 50 cfs. The inability of the spillway pool collector to effectively attract fish at flows above 50 to 100 cfs, supports the importance of minimizing spill events via the intake works (an enhancement proposed by the Panel), as the spillway pool collector may not attract fish very well when significant flow is spilling.	The spillway pool collector is intended as a supplemental item, not as a stand-alone, primary facility. Operating this collector during times of higher spill would not be safe, so the intent is to collect fish after spill is done, or nearly done. No changes made to report.
9i	The need for a challenge section needs to be further discussed and developed	Agreed. This is an enhancement that should only be included if it is appropriate for the design and performance standards adapted for the project. As described in Section 4.2.5.3, "Specific details of this item would require further clarification of specific goals and design development during final design."
10	***Fish Passage Uncertainties.—***	

Comments submitted by NMFS		
NMFS Comment Number	**Comment**	**Panel Response**
10a	Consequently, NMFS requests that the Panel consider either adding and/or expanding upon a section within the report to emphasize the key assumptions and uncertainties in this project. Specifically, NMFS recommends that this section focuses on the challenges and the general technologies available and/or needed for validating these assumptions and managing key uncertainties, particularly with respect to how these assumptions and uncertainties will be either addressed in the predesign studies, Phase I buildout and operations stage, Phase II design, and/or Phase II construction and operations according to the Panel's recommended alternatives	The commenters have identified some of the key uncertainties that are also of concern to the Panel. Despite these uncertainties, the Panel has identified U4 and D7 as alternatives that have the highest probabilities of success. Furthermore, the Panel recommends that measures be taken to address some of the uncertainties before full implementation, so that designs can incorporate any new information. The recommendation also includes adaptive management, so as to allow future refinements that could affect whether or how additional facilities are implemented.
10b	NMFS requests that the panel discuss how the following uncertainties could affect timing, facility buildout, and operational aspects of the various alternatives methods along with identifying means of quickly adapting fish passage facilities and operations to information acquired on these topics. a)a definitive answer on which alternatives are seismically feasible; b) the role of the reservoir in predation rates; c) the role of the reservoir in potentially providing rearing habitat for resident steelhead; d) over what discharges and time frames (dates) that adult, juvenile, and smolts are migrating within the Santa Clara Watershed and Piru Creek basin; e) difficulties associated with monitoring and sampling low numbers of fish; and f) the extent and time frame that fish can/will respond to the implementation of fish passage facilities at SFD.	See response to previous comment.
10c	NMFS requests that the panel explain why D7 subsequently became the Panel's recommended downstream alternative, particularly when D11 addressed the uncertainty regarding to what extent steelhead were utilizing the reservoir by allowing smolts to be collected within the reservoir and above the reservoir. Moreover, alternative D11 also helped addressed concerns about D7 missing smolts at high flows.	D7 has less risk and greater flexibility than if it were initially combined with any of the reservoir collectors as summarized in Section 6.3.2. That consideration is emphasized in the final document. Additionally, the recommended plan described in Section 7 could lead to implementation of D11 depending on the performance of D7.
10d	NMFS requests that the Panel identify a scientifically defensible means of establishing how many smolts are being collected and how many are entering the reservoir. If there is no solution to address this question, then the recommended alternative needs to be reevaluated as there is no means of testing and/or validating whether D7 is meeting the biological goals/standards.	The Panel has recommended a process for resolving uncertainties, including the one identified by the commenter. However, it is beyond the scope of this feasibility report to proceed as the commenter suggested.
10e	NMFS requests that the Panel briefly expand upon potential methods for determining whether and how resident steelhead may be utilizing the reservoir and migrating to the tributaries to spawn. Would such methods be capable of being performed with or without tagging hatchery supplemented fish?	See response to previous comment.
10f	NMFS requests that the Panel comment upon how the alternative rankings would change if the various alternatives were conclusively demonstrated to be seismically infeasible. Specifically, would floating surface collectors (moveable or fixed location) be a recommended viable downstream passage option should a reservoir collector be determined necessary to meet biological performance standards and the various tower structures are determined to be seismically infeasible? It is not clear to NMFS why if there is seismic uncertainty regarding surface collectors and their support towers that they ranked better than floating surface collectors, particularly based upon preliminary reports upon how well floating surface collectors such as the one found at Baker Lake, WA are working. NMFS recommends that the Panel should highlight that, if various alternatives are found to be infeasible due to seismic or Arroyo Toad concerns, that the Panel has identified viable alternatives that have neither of these concerns that could be implemented.	The recommended alternatives U4 and D7 do not have seismic "feasibility" concerns so seismic concerns are not expected to affect the Panel's recommendation. If subsequent phases include options that do have seismic issues, technical studies should be undertaken to understand the effect of seismic conditions and appropriate modifications to feasibility and costs should be made.

Comments submitted by NMFS

NMFS Comment Number	Comment	Panel Response
10g	The Panel (page 3-4) appears to conclude that there is no apparent relationship between abundance of outmigrating O.mykiss and water year type. Such a conclusion seems problematic in light of our own anecdotal observations specific to southern California, the published literature, and the fact that out of 11 years of data there was: one normal year; 6 wet years; and 5 dry years. NMFS requests the panel state whether this conclusion was based upon statistically significant tests and exactly how a wet, normal and dry year were quantified	The life history of Southern California Steelhead is considered to be quite complex and flexible. As a result, there is a great deal of uncertainty as to specific aspects of their life history as expressed in the Santa Clara River watersheds. The Biological Performance Tool was developed to allow the user to specify the life history assumptions used to evaluate fish passage alternatives. For instance, smolt outmigration may be triggered by flow-related migration cues, particularly high flow events, or freshets. However, quantifying the relationship between smolt migration and freshets is challenging since screw traps and other sampling techniques used to monitor smolt outmigration may be ineffective during high flow events. The influence of freshets is also a function of the proportion of the juvenile smolt population that is physiologically ready to migrate. A freshet occurring in early January will have less influence on smolt migration than a freshet occurring in April. A Flow-Freshet Response Factor was developed in the Biological Performance Tool to allow the user to define the response of steelhead smolts outmigration in response to freshets. The Flow-Freshet Response Curve can range from assuming that smolts only outmigrate during freshets, to assuming that smolt migration is not affected by flow-related cues and is only related to periodicity. For the BPT analysis, it was assumed that steelhead smolts are four times more likely to outmigrate during a freshet day than based only on periodicity (see Appendix E). In Piru Creek, steelhead smolt migration may vary from year to year. Wet Years may play an important role in smolt production and outmigration but the influence is not well understood. A high volume spring runoff could lead to improved rearing conditions. Smolts that rear for more than one year may outmigrate in greater numbers following a Wet Year, and Wet Years may provide an increased magnitude and frequency of freshets which may contribute to increased smolt outmigration. Fewer smolts may successfully pass downstream in Dry Years when surface flows in Piru Creek can become intermittent, and smolts may continue rearing in upstream reaches that remain wetted during Dry Years and outmigrate the following year. Downstream passage facilities were evaluated using all years in the 1944-2004 period of record. However, because Wet Years may contribute to increased numbers of smolts and increased outmigration, downstream passage alternatives were also evaluated using a period of three consecutive Wet Years to encompass both
10h	NMFS suggests that the Panel should better emphasize and/or summarize the assumptions and limitations of the migration timing results and clearly state which of the panel assumptions are based upon professional judgment and which (if any) are statistically significant. The panel should also highlight any conflicting results (if any) between the various migration studies.	See response to previous comment.
10i	If the above conclusions come directly from the authors of the study and not the Panel, then the Panel should make it clear that these were the author's conclusions and not the Panel's conclusions. The panel should also state whether these conclusions were based upon visual analysis of the data, statistical testing, or other means.	See response to previous comment.
10j	On page 4-33, the Panel assumes systems will be operated once a day from January 1 through May 31 for upstream migrating steelhead. NMFS requests the panel state whether this assumption was made solely for cost estimating purposes or whether it has sufficient evidence to conclude that fish passage delays of up to 24 hours would not interfere with a steelhead's ability to complete its various lifecycle functions. If the panel believes that it has such information, NMFS requests that the Panel provide the information that led them to conclude that such a delay is acceptable. If there is not sufficient data to conclude this, then the Panel should clearly state that such operational procedures will need to be determined in the future. This comment also applies to all of the other alternatives where the Panel assumes certain operational parameters related to the frequency and timing of collecting and transporting steelhead.	The Panel made a number of operational assumptions, including the one suggested by the commenter, in order to obtain estimates of rough facility sizing and for operating costs. The Panel has identified the need, in several places in the report, for additional monitoring information to assist in actual operations, and when designing for full implementation.
10k	NMFS requests that the Panel briefly consider and comment on what options might be available for improving the dissolved oxygen (DO) levels (via aeration) in the reservoir owing to the concern that reservoir water quality may not be suitable for out-migrating smolts that bypass the Piru Creek collector. Conceptually, would aerating the water also cause the water column to mix and increase the total volume of water with suitable DO levels and temperature (accomplished by mixing the higher and lower temperatures found in the upper and lower portions of the water column)? One could envision aeration being conducted: throughout the reservoir; at a specific location (e.g., in the upstream portion where a portable collector is located); or along a line leading to a collector near the dam. NMFS requests that the Panel consider whether such a measure would be an appropriate enhancement option for the reservoir based collector options (all but D7). NMFS also requests the Panel consider whether the potential benefits of aeration should be recommended as a potential future study.	The Panel has recommended a process for resolving uncertainties, including the one identified by the commenter. However, it is beyond the scope of the feasibility report to proceed as the commenter suggested.

Comments submitted by NMFS		
NMFS Comment Number	**Comment**	**Panel Response**
10l	NMFS requests that the Panel highlight that all but one of the 'cons' regarding the floating surface collector could essentially be summarized as a single con – 'difficult to operate'	This comment is not clear; the Panel assumes this relates to D12. In that case, the Panel agrees with the observation, but believes the bullets under the cons provide additional detail that would be lost by lumping these into one such statement. No edits made.
10m	At the same time, it should be pointed out that the any lower BPT associated with the floating surface collector as compared to the other reservoir collectors appears to largely be a result of the Panel's decision to strip the collector down (e.g., not provide a curtain, not provide a CTS, etc.).	The Panel disagrees; a CTS was included for the three tower-based floating surface collectors (D3, D4 and D5) (See Section 4.3.10.2). Guide curtains were also assumed for downstream alternatives D3, D4, D5, and D14 (see Table 4.3-1).
10n	NMFS, therefore, requests the Panel to consider if and how studies conducted during Phase I of the Panel's recommended alternative could change what reservoir collector (if needed) would be prioritized for Phase II construction.	The Panel has recommended a process for resolving uncertainties. It is recognized that in that process, prioritization of various options for following phases could be affected.
10o	NMFS requests the Panel to consider how Figure 5.5-1 (Figure 5.5-1. Schematic presentation of the Panel's recommendation) could be redrawn to incorporate parallel tracking in order to lead to a project that meets fish passage goals as quickly as possible. One potential option is to have Phase I design, the formation of a FS&ET and Initial Monitoring and Studies begin immediately after an alternative is agreed upon.	The Panel has revised the diagram to incorporate studies that address uncertainties through adaptive management. However, it is beyond the scope of the feasibility report to proceed as the commenter suggests.
11a	NMFS requests the Panel specifically comment upon how downstream passage for kelts would be achieved and managed for the various alternatives.	Report states that passive grader bars will be provided to separate small and large fish. Clarified that kelts will be hauled separately from small fish. Also see response to UW submitted comment #74.
11b	It is not clear from the draft report whether the primary or secondary site for the Piru Collector are suitable for building a collector with the needed screening capacity. Additionally, NMFS requests that the Panel state what their recommended downstream fish passage alternative becomes if the Piru Collector is not feasible owing to consultation with USFWS regarding Arroyo Toad.	The Panel has not attempted to define possible consequences of uncertainties and their resolutions. Possible consequences regarding the siting of D7 might include capacity of the screen, style of the screen, specific location, operating conditions, and other mitigating measures, as well as reverting to other alternatives.
11c	NMFS requests that the Panel provide an explanation for why D7 was not designed to operate within NMFS criteria between 200 and 400 cfs. It is expected that all preferred alternatives will meet NMFS and CDFW fish passage guidelines.	Clarified in 4.3.3 that the BPT indicates that there is little marginal value in designing "fry" screens to flows above about 200 cfs. This analysis could be confirmed with pre-design or operations studies
11d	many of the upstream fish ladders in the various alternatives propose 0.7' jump heights. NMFS criteria for juvenile jump heights is currently 0.5'. Why was a jump height of 0.7' used?	At the time the alternatives were developed the only known criteria for upstream juvenile fish passage was listed in the NMFS publication ANADROMOUS SALMONID PASSAGE FACILITY DESIGN, 2011. In that publication the maximum hydraulic drop over fishway weirs for 45 to 65 mm sized fish is listed as 0.7 ft. This is considered a conservative number for consistent use in conceptual design of different alternatives in this phase of the project. The Panel believes that under controlled situations (geometry and flow), juvenile fish can jump drops of at least a foot. Regardless, the change in drop doesn't change the feasibility design. the fishway pool volumes are based on EDF. If the drop is lowered, the pool length is proportionately reduced and the slope and footprint of the fishway is unchanged.
11e	On page E-26, the Panel assumed that operating the screens outside of NMFS criteria would result in increasing steelhead mortality rates from 1% at the design discharge (200 cfs) to 10% mortality at 400 cfs and to 15% mortality at 1000 cfs. It should also be noted that at discharges up to 400 cfs all smolts would be screened and a 95% capture efficiency was assumed. What does the Panel assume happens to the 5% that are not captured?	Fish that are not captured are assumed to pass downstream into the reservoir. Even facilities designed to screen the entire flow may not exhibit 100% capture efficiency.
11f	NMFS requests that the Panel itemize some of the more important negative effects associated with collection and transport (versus volitional passage) in the "pro" and "con" lists for alternatives like U4 and D7. These include disease, smolts' inability to imprint, etc. (see list provided in NMFS' previous comments).	Comment noted. Cons of non-volitional passage are adequately itemized for the non-volitional alternatives for this level of feasibility analysis.
11g	NMFS requests clarification on why collection and transport operations would have to cease when pool levels are below 980' and above 1056', as indicated on Table 4.2-1	Added clarification in Section 4.2.1: Low and high reservoir levels during which the fish passage facilities can operate are needed to set design elevations and are based on the low frequency of occurrence. As shown in Figure 2.2-2, elevation 1056 is exceeded less than 1% of the time and elevation 980 is exceeded about 4% of the time. Either of these elevations could be extended a few feet without significant design implications.

Comments submitted by NMFS		
NMFS Comment Number	**Comment**	**Panel Response**
11h	On page 4-22, it is unclear why one would want to use collection and transport via the monitoring station for all reservoir elevations below 1,053.5. This would defeat the purpose of providing nearly volitional passage (e.g., no trapping of the fish) in alternative U3. The utility of any collection and transport would be for any unforeseen times that the ladder and release was not functioning correctly. NMFS requests the Panel clarify why it is proposing to use collection and transport for water surface elevations below 1,053.5 in this alternative.	Note the U3 does not fully meet the established definition of volitional passage because of the use of the slide release when the reservoir would be below elevation 1054'. The intent of this statement was that collection and transport could be used for any times that the ladder and release are not functioning correctly or for pumped flow interruptions, or if it becomes a requirement to trap and haul for other reasons such as poor reservoir water quality and other fish migration impacts associated with transiting the reservoir. Essentially, collection and transport would be a primary backup for this alternative. This has been clarified in the report.
11i	NMFS believes that the most positive feature of the U3 alternative is that it would eliminate the need for trapping and handling the fish at all of the water surface elevations above 980'. NMFS requests that the Panel list (on page 4-25) that as a "Pro" for this alternative	Added to Final Report in Section 4.2.3.8.
11j	NMFS requests that on page 4-26 "Volitional only up to fishway exit structure and then for a very narrow range of reservoir elevations" not be listed as "Con" as this alternative provides more volitional passage than almost all of the other alternatives provide.	Do not agree. As described for U3 volitional passage only occurs when the reservoir water surface is between El. 1054' and 1056'. The amount of time during the migration season that the reservoir water surface is within this range of volitional passage for U3 is much less than that for U1 or U2 and is therefore considered a "con" relative to those options. U3 volitional passage conditions occurs only 12% of the time, on average, of the migration season compared to 33% for U2 and over 95% of the time for U1. Refer to Figure 2.2-2 and the concept descriptions for the alternatives.
11k	On page 4-40, NMFS requests the Panel to explain why collection and transport facilities used as a supplement to U2 would likely be smaller in scale than in U4. Wouldn't the U2 collection and transport facility have to operate exactly like the U4 facility at pool elevations below 1,030'?	Scaling of the trap and haul portion of the alternative could be based on that expected portion of time and occurrence for its operations along with the expected size of the fish run during that occurrence. It is assumed that this mode of operation would be expected later in the migration season given the general reservoir operations and after higher flows have filled the reservoir offering queues and opportunities for upstream migration of a fish run. In other words, the trap and haul portion of this alternative would be expected to handle a smaller and later portion of the fish run. Since information for anticipated run size, duration and timing relative to flows and other stream characteristics was not available or predictable for the study, the alternatives' conceptual designs were developed at broad levels mainly for comparison purposes, as appropriate for this level of project planning and development. More appropriate sizing of facilities should be accomplished when an alternative is selected and preliminary designs are underway, and based on a reasonable estimate for fish run size, duration and timing.
11m	On page 4-5 section 4.3.2.4, the Panel assumes that adult upstream migration of steelhead occurs from March through June. NMFS' regional survey data indicate that adult steelhead migrate upstream earlier in the season than March (as early as December if early storm events occur) based on adult redd surveys and carcass recoveries in the Ventura River and Malibu Creek.	Text (2b) revised in report. The range of upstream migration will be revised to include "all potential" months with discussion of relative abundance (i.e., peak periods to rare occurrence)
11n	The D7 fishway needs to be built to accommodate bidirectional movement of both juvenile and adult steelhead, pass fish up to the high fish passage design discharge flow (which the panel did not state), have an appropriate attraction flow at the high fish passage design discharge to prevent the delay or obstruction of migrating fish. Additionally, the D7 fishway design must meet all NMFS and CDFW fish passage guidelines. The conceptual drawings suggest that juvenile passage is not currently being provided in the ladder.	Clarified in 4.3.4.2 that the fishway could be designed to comply with adult and juv passage criteria.
11o	Two of the major 'cons' of D7 are not listed in the 'pro' and 'cons' list for this option. Specifically, those cons are: 1) smolts that are missed enter the reservoir and have no means of emigrating from the reservoir; and 2) it is subject to missing significant numbers of smolts at higher flows (between 12% and 18% of the time for the months of Feb, Mar, and April, according to table 4.3-2). As mentioned by NMFS in previous correspondence, these percentages could also be significantly higher during wet years as exceedance values represent a long-term percentage of time that 200 cfs would be exceeded.	This is already included in 4.3.4.9 as a "con" for D7. Added note in 4.3.4.3 that flow frequencies don't accurately reflect fish frequencies.

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11p	The 4 to 6 inch trash rack spacing mentioned in section 4.3.5.10 does not meet NMFS' minimum passage width for trash racks. On Page 5-2 of the draft report, the Panel highlights the benefits of the evaluation matrix, but does not describe any of its limitations/weaknesses. NMFS recommends that the Panel highlight and list some of these weaknesses which include: 1) that the selection of criteria and the weighting of criteria are subjective; and 2) that the tool is primarily used for sensitivity analysis and cannot provide a conclusive answer on exactly how well a given alternative will perform	The evaluation matrix was used as one component of a multi-faceted approach to evaluating feasibility. As was described in Section 5.1.2, the evaluation matrix provided the Panel with information on relative strengths and weaknesses of alternatives, but did not provide conclusive results regarding the feasibility of any one alternative. The concerns listed in the comment are addressed in the report.

United Comment Number	Comment source	Section; Page	Subject	Comment	Panel Response
1	UWCD	1.1; P1-1 opening sentence	Status of license	United is not seeking a new license, but was issued a new license from FERC on September 12, 2008.	Corrected in final report
2	UWCD	1.1; P1-1	Introduction	Regarding "SFD is operated to yield water for aquifer recharge as well as hydropower generation." Comment - SFD is not exclusively operated to yield water for aquifer recharge - more precisely... SFD is operated as a water resource reservoir as well as hydropower generation.	Corrected in final report
3	UWCD	1.5.1; P1-12	Biological feasibility	Regarding "A biological feasibility evaluation would require acquisition and assessment of information on Santa Clara River habitat, the status of the Southern California Steelhead DPS population and a process to identify, develop and assess criteria that allow evaluation of the feasibility of meeting the biological goals." Comment -Biological feasibility evaluation should also include Piru Creek habitat.	The Panel agrees, and new text has been added it to the report.
4	UWCD	2.1.1; P2-2 1st ¶	Facilities in Forest Service boundaries	"Included in these 53.5 acres are the dam, powerhouse, and associated facilities as well as several recreational facilities." Comment - None of these facilities are within the Forest Service property boundary	Corrected in final report
5	UWCD	2.1.2; P2-2	Project Facilities	Section has out of date information. The dam is greater than 214 feet; spillway is 475 feet long; Item 3 – Out of date information based on 1995 sediment survey of the reservoir. Based on the 2005 survey the capacity is 83,244 ac-ft and the surface area is only 1182 acres. The usable storage is only 65,294 ac-ft. United surveyed the reservoir in 2015 but the data will not be available for several weeks.	Corrected in final report to note information is based on 2005 data available at time of report.
6	UWCD	2.1.3; P2-2	SFD construction completion date	1987 is the year the power plant was completed. The date is not used consistently throughout report.	Corrected in final report
7	UWCD	2.1.4; P2-3	Capacity of power plant	Regarding "The average annual generation is 1,300 megawatt..." Comment - Suggest replacing this statement with "The power plant has a maximum capacity of 1420 kilowatts (kW) and the project power is sold to Southern California Edison Company	Corrected in final report
8	UWCD	2.1.5; P2-3 both 1st and 2nd ¶s	Project boundary	Lower Oaks and Oak Lane campgrounds are entirely within the project boundary. Olive Grove is not within the boundary.	Corrected in final report
9	UWCD	2.1.5; P2-3 2nd ¶	USFS closure gate	The gate near the Juan Fernandez Launch Ramp is within the project boundary.	Corrected in final report
10	UWCD	2.2; P2-4	Max discharge 920cfs 9/6/2000	The maximum discharge of 920 cfs is incorrect. The existing facility does not have the capacity to discharge a flow of that magnitude. The September 6, 2000, measurement is erroneous. According to Murray McEachron wildfires and landslides downstream of Santa Felicia Dam caused backwater to occur in the vicinity of the weir and altered the stream gauge rating. According to McEachron, the maximum discharge measured at that gauging station, sourcing from the penstock, was 624 cfs on October 7, 2004.	Explained in revised text
11	UWCD	2.3.1; P2-8 1st ¶	Hydraulic features and operational capacities	The information (in Appendix A) is out of date and should be based on GEI's technical memorandum on the hydraulic capacity of the penstock.	It is not within the budget for the final report to update Appendix A, but the text in the report has been revised to indicate that the information may be out-dated and future work should rely on obtaining the most recent available information however, the general information referenced is sufficient for the needs of this study.
12	UWCD	2.3.1; P2-9 2nd and 3rd ¶s	Hydraulic features and operational capacities	United is in the process of automating water releases from the Santa Felicia Dam.	Added to final report
13	UWCD	2.3.1; P2-9	Hydraulic features and operational capacities	United recently conducted a flow test of the low-flow release valves. Reservoir water surface elevation at the time of the test was 980 feet. The east valve had a max discharge of 17.3 cfs and the west valve a max discharge of 15.0 cfs.	Added to final report
14	UWCD	2.3.1; P2-9	Hydraulic features and operational capacities	The larger turbine (unit #2) is scheduled to be operational by fall of 2015.	Added to final report
15	UWCD	2.3.1; P2-10	Hydraulic features and operational capacities	With respect to the smaller hydro turbine (unit #1) –It is not a problem with the controls or programming. The turbine has to be mechanically modified to operate outside its current parameters. Due to the cost and the long term recovery for the estimated expenditure United does not plan to rehab the smaller unit at this time.	Text revised in report

United Comment Number	Comment source	Section; Page	Subject	Comment	Panel Response
16	UWCD	2.3.2; P2‐10 2nd ¶	Terminology	Instead of "Eventually, the basin's earth bottoms..." we suggest "During wet years and large release events, the basin's earth bottoms..."	Text revised in report
17	UWCD	2.4; P2‐11	2 GEI reports	Both reports are now in final form and were submitted to Jon Mann.	The report citations have been revised to indicate final for these studies. Due to timing and scope limitations of producing the draft and final report it is recognized that some of this information may be out-dated. The report text was edited in Section 2.4, and Section 2.4.3 to explain that future work on the project should rely on obtaining the most recent available information for these studies, and to note that overall recommendations and conclusions reached for the fish passage feasibility study would not be affected by the updated dam safety study information.
18	UWCD‐GEI	2.4.1; P2‐11 and P2‐12	GEI Report	GEI's draft Outlet Works Rehabilitation Phase 1 report has been finalized. The report was modified to include the possibility of placing the new outlet works on the left abutment of the dam. In the Findings Report, the paraphrasing on page 2‐11 and Table 2.4‐1 on page 2‐12 should be modified accordingly. The Findings Report and depiction of alternatives are based on the assumption that the new outlet works system would be located on the right abutment. We suggest adding a general statement that the Fish Passage concepts presented would generally apply should a new outlet works be located on the left abutment.	See response to comment 17. Specific information as to outlet works rehabilitation has been deleted from the report, and a reference to the final rehab report was added in Section 2.4.1. Additionally, a statement added as the applicability of fish passage concepts for either left of right abutment locations in 2.4.1.
19	UWCD	2.4.1; P2‐11	Outlet works rehabilitation study exec summary	The conclusion was to keep the new outlet works system on the right side of the dam." Comment - This is a premature conclusion since neither DSOD nor FERC have reviewed the reports. In addition, there are advantages to having the outlet works on the left (east) abutment that were not presented in the draft reports.	See responses to comments 17 and 18. Specific information as to outlet works rehabilitation has been deleted from the report and a statement added as the applicability of fish passage concepts for either left of right abutment locations.
20	UWCD‐GEI	Table 2.4‐2	Review/schedule	Add "Review" after "DSOD/FERC" in the first row. Modify the dates in the table based on page 6-3 in GEI's final Spillway Alternatives Study report.	Text revised in report
21	UWCD	2.6; P2‐16 3rd sentence	Arroyo toad critical habitat	Should state middle Piru Creek, not lower Piru Creek	Text revised in report
22	UWCD	P3‐1 2nd ¶	Clarification	Regarding The Southern California Steelhead DPS includes all O. mykiss populations in the watershed from Santa Maria River (north of Point Sal) south to the Tijuana River at the U.S.‐Mexico border." Comment ‐Insert "below artificial or natural impassible upstream barriers" after watershed. "	Text revised in report
23	UWCD	3.1.2.2; P3‐12 1st ¶	Fry migration	Regarding No fry were reported to be part of the migration." Comment ‐Table 2 in Booth 2015 shows the trapping of YOY (fry) steelhead during quite a few years. "	Emigration survey results (Entrix 2000) show that all migrating SH were larger than fry (FL $\leq$ 50 mm. YOY does not equate to fry. VFDD annual reports do not include size (only age, i.e., YOY)
24	UWCD	3.1.2.2; 1st ¶ on P3‐13	Smolt migration	Regarding All three streams exhibited comparably high numbers of downstream migrants during wet normal and dry years." Comment ‐Significantly fewer smolts migrate during dry years, especially consecutive dry years on the Santa Clara River. "	Results of emigration survey (Entrix 2000) do not show any relationship among water year type and abundance. Additional references would be needed to support UWCD conclusion.
25	UWCD	3.2.2; P3‐21 1st ¶	Correction	Regarding and an initial set of measurements were taken." Comment ‐An initial set of measurements were not taken. Only site selection occurred for the critical riffle surveys. "	The Panel considers site selection as the beginning of the study. It included site recon and a profile survey. Text revised.

United Comment Number	Comment source	Section; Page	Subject	Comment	Panel Response
26	UWCD	4.2; P4-2	Upstream Fish Passage	Please note that GEI has completed both feasibility reports and the reports have been submitted to DSOD and FERC. The preferred spillway project includes widening the spillway chute and raising the crest 5 feet to pass the PMF. The location of the new outlet works has not been determined. The left abutment (east) is a viable location. This would lead to the relocation of the power plant to the left abutment. In either case the existing penstock and tunnel would be abandoned and demolished (backfilled with concrete). The reservoir range for the collectors will have to be raised above elevation 1080 feet to comply with the PMF criteria. The collectors cannot interfere with the approach to the spillway weir.	Comment noted. See responses to Items 17, 18, 19 for report text revisions. No other edits made to report specific to this comment.
27	UWCD-GEI	4.2.1.1; P4-4	Steel tieback frame	We understand that the use of rigid struts to brace the tower against the slope to resist seismic loading is only a potential consideration at this feasibility level of evaluation. However, it is likely that use of this type of bracing would be problematic due the "out-of-phase ground motions at the tower base and brace anchor points. Consequently, the tower itself would need to be quite robust to resist earthquake loading.	The Panel agrees with this comment; however, does not see any fatal flaws with the general concepts as currently described. No revisions were made to text to specifically address this comment.
28	UWCD-GEI	4.2.1.1; P4-4	Max pool level elevation	A full pool level at elevation 1,070 is assumed for determining the maximum head differential on the tower. Following proposed spillway modifications, the highest pool level will be elevation 1073.5. However, it could be elevation 1,078.5 if Spillway Alternatives 1A or 1B are selected.	The Panel agrees with this comment; however, does not see any fatal flaws with the general concepts as currently described. See responses to comments 17, 18, 19, and 26 above. No revisions to text specifically from this comment were made.
29	UWCD-GEI	4.2.1.1; P4-4	Elevation of crest of dam and deck of tower	The deck of the tower is at elevation 1,075, the same elevation as the crest of the existing dam. If Spillway Alternatives 1A or 1B are ultimately selected, the crest of the dam would be raised to elevation 1,080 and the deck of the tower would need to be raised as well.	See responses to comments 17-19, 26, and 28. No revisions to text specifically from this comment were made.
30	UWCD	4.2.1.4; P4-6 2nd ¶, last sentence 3rd ¶, 4th ¶	Obermeyer dam, AWS system	The Obermeyer gate as depicted would create a backwater into the power plant tailrace and the cone valve chambers. Page 4-7, second and third paragraphs, incorrectly state that the maximum water releases from the outlet works are 500 cfs. Typically (not "normal") flows are substantially lower. Maximum flows in the range of 500 cfs only occur for a short period during initial stages of the annual conservation release which is outside the migration period and therefore does not apply to this operation scenario. During the conservation releases the Obermeyer gate will be fully open. When migration water releases are triggered between Jan 1 and May 31 United is required to release a minimum of 200 cfs. The AWS for the attraction flow and ladder will only be 30 cfs (or 27 cfs?). The total discharge will not be capable of meeting the minimum required 200 cfs. As the migration flow ramps down so will the attraction flow (matching the 10 percent flow requirement). "	The issue with any barrier dam located downstream of the outlet works having potential backwater effects is already noted in the text. Relative to the typical maximum release from the outlet for the design of any AWS feature the text in the final report has been revised to be more general at this conceptual level of feasibility analysis but keeps the current conceptual design capacity of 50 cfs.
31	UWCD	4.2.1.6 1st ¶	Draining the reservoir	Replacement of the outlet works does not require that the reservoir be completely drained. Water surface elevation could be lowered to 932 feet (elevation of intake structure). Water surface elevations below 932 would preclude normal water releases to lower Piru Creek through the intake structure.	Noted. Constraints of construction would be certainly considered in a future phase of design. No revisions to text specifically from this comment were made.
32	UWCD	4.2.1.9; P4-10 Cons	U1 Cons	Consider adding the following to the list of Cons –Power and mechanical failures have the potential to lead to uncontrolled water releases.	Agreed. Text revised in Final Report. It should be noted that safeguards for control of continual uncontrolled water releases can be implemented.
33	UWCD	4.2.1.10 P4-11 2nd bullet	Tunnel costs	Scaling up" costs is not appropriate. It is not a linear scaling factor. The costs increase exponentially with increases to the tunnel diameter particularly associated with providing access for O&M personnel. Structurally and mechanically it's a more elaborate design with ventilation, lighting, walkways, and communication systems all in a moist corrosive environment. "	Noted. Due to scope and budget limitations for the final report this approach for conceptual cost estimating purposes will be retained. No revisions to text specifically from this comment were made. Also see response to Comments 17-19.
34	UWCD-GEI	4.2.3.2	Location of fish ladder	The location of the fish ladder on the east side of the dam would need to be modified if Spillway Alternative 3B were selected.	See response to comments 17-19. As explained in other responses all of the fish passage alternatives were developed with the understanding that spillway and intake alternatives were also under development in parallel with the fish passage study, and all of these projects would require ongoing coordination. No revisions to text specifically from this comment were made.

United Comment Number	Comment source	Section; Page	Subject	Comment	Panel Response
35	UWCD￾GEI	4.2.3.2	Maximum slope	The maximum slope of the fish ladder for U3 is stated as 7%, whereas the fish ladder slope for U1 and U2 is stated as 10%. Please explain the reason for the difference.	7% slope was used initially as a more conservative way to lay out the conceptual design for the fish ladders. This was updated to a maximum slope of 10% for a more general rule of thumb and the Final Report has been revised for this number in the text for U3. It should be noted that the final design slope of a fish ladder component of an alternative will depend on the precise ladder configuration, detailed hydraulic design and site constraints.
36	UWCD￾GEI	4.2.3.2	Location of fish ladder	The location of the fish ladder on the west side of the spillway would need to be modified if Spillway Alternatives 1A, 2A, or 3A were selected.	The Panel agrees with this comment; however, does not see any fatal flaws with the concepts as currently described. All of the fish passage alternatives were developed with the understanding that spillway and intake alternatives were also under development in parallel with the fish passage study, and all of these projects would require ongoing coordination. This is noted in Section 2.4. The introductory paragraph to Section 4 was edited to again note that future development of any fish passage alternative will need to incorporate the latest information from the dam safety studies.
37	UWCD￾GEI	4.2.3.4	Bulkhead gate malfunction	What are the implications if the bulkhead gate cannot be closed (due to malfunction) when the reservoir rises above elevation 1056?	If the guard gate malfunctioned flow would be released down the fish ladder channel subject to the hydraulic controlling features at the fish exit structure. As conceptually designed this would be an orifice condition restricting the flow release. In detailed design provisions for back ups to this condition could be included, including an overflow connection to the spillway.
38	UWCD	4.2.3.8 Cons	Debris	Section 4.2.4.2 includes discussion of the need to manage debris. Recommend adding challenges associated with debris to the cons" section in 4.2.3.8 for this alternative. "	Agreed. Text revised in Final Report.
39	UWCD	4.2.4.3; P4￾29	Sensors and alarms	Suggest modifying to say The facility would be outfitted with water quality and level sensors and alarms" "	Text revised in report
40	UWCD	4.2.5.1 1st sentence	Operations to minimize spill events	United attempts to minimize spill events. It is the intent of the operations and maintenance staff to reduce volume of water lost during spill events. Uncontrolled flood waters discharging over the spillway crest have the potential to wash out the lower road access and cause damage to facilities and property downstream of the dam. Operations staff generally attempt to reduce spills by maintaining the surface elevation of the reservoir one to two feet below the crest of the spillway. Santa Felicia Dam and the Lake Piru Reservoir were constructed primarily as a water storage facility not as a flood control facility. Operations can attenuate storm flows and reduce the downstream peak discharge to a degree, however, during major flood events the reservoir is essentially a pass through facility.	The Panel based our analysis on the modeled hydrologic record provided by United. We recognize that the hydrologic model may not exactly represent day to day operations, but the analysis is still relevant as described. No edits made to report.
41	UWCD	4.2.5.1	Operate to minimize spill	Minimizing duration and magnitude of spills will increase the number of smaller spills, increasing both mortality when fish go over the dam and stranding when the spillway channel is dewatered. Therefore, downstream mortality of smolts should be considered against adults following the spillway instead of the release channel. Perhaps providing justification for an improvement that would prevent fish from entering the spillway channel (coming upstream).	As indicated in Table 4.2.2, maximizing outlet flows up to 500 cfs would reduce the number of days with spill from 1,857 to 228 compared to Current Operations, and would reduce the number of years with spill events. In those years with spill events, it would break some of the large, long duration spill events into multiple, smaller spill events and potentially affect fish stranding and trapping, but the overall effect should reduce spill-related injuries.

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42	UWCD	4.2.6.1	Spillway collector	It may be more efficient to keep fish out than to try to trap them up there (both for stranding and trapping efficiency), i.e., a fish barrier downstream?	A fish barrier with high spillway flows could be explored in the future after further study. Given the wide, braided channel downstream of the spillway and high flows, with spills up to 9,000 cfs, provisions for a fish barrier would likely require some channelization, and construction of a barrier. A bar rack type barrier would be prone to clogging during higher spills, so a physical barrier or velocity barrier would be the most promising approach. Such a structure would be best located outside of United's property boundary (the confluence of the spillway channel and low flow channel are over 1500 feet downstream from UWCD's property line), to keep the fish in the main creek channel. The Panel considered this approach early in the brainstorm phase and deferred it due to property concerns and the need to channelize the spill channel. The Panel believes that given the infrequent spills, it would be more efficient to utilize a temporary collector until it is determined something else or more is needed. No change made to report.
43	UWCD-GEI	4.3; P4-42	Correction	Change "upstream" to "downstream" in the third sentence (page 4-42).	Text revised in report
44	UWCD	4.3.1.2 1st sentence	High controlled outflow of SFD	Note "Flows in the range of 500 cfs are not "normal" and only occur for a short period during initial stages of the annual fall conservation release. The maximum capacity for water releases is dependent on water surface elevations (included in Appendix A). Water releases in the range of the maximum capacity would only be conducted during emergency situations. It is inappropriate to refer to a maximum controlled outflow of 800 cfs in this context. Water releases of this magnitude are not achievable under all conditions and could compromise infrastructure at the facility. "	Clarified with revised text in the report.
45	UWCD-GEI	4.3.1.2 2nd ¶	Reverse flow to clean screens	In second paragraph, regarding "The reverse flow through the outlet screens would clean those screens." It is likely that the reverse flow velocity would not dislodge quagga mussels should they be attached to the screen.	Panel agrees. If quagga mussels were to be established in the watershed, this screen design would likely need to be cleaned on some frequency with manual brushing, or be retrofit with a brush type screen cleaner. Text revised in Section 4.3.1.2 to note this issue, and this comment should be revisited if design of this or other backwash screen designs are pursued by United following this report.
46	UWCD-GEI	Figure 4.3-1; P4-47	Additional information	Suggest adding another column for the case of: Downwell from Collector = 150 cfs, Penstock = 0 cfs, Pumpback to Reservoir = 150 cfs, and Low Level Gravity from Reservoir = 0 cfs.	The suggested scenario is another version of scenario A. A range of flow from 0 to 150 has been noted in the report in section 4.3.1.2.
47	UWCD-GEI	4.3.1.3 3rd ¶	Steel tieback frame	We understand that the use of rigid struts to brace the tower against the slope to resist seismic loading is only a potential consideration at this feasibility level of evaluation. However, it is likely that use of this type of bracing would be problematic due the "out-of-phase ground motions at the tower base and brace anchor points. Consequently, the tower itself would need to be quite robust to resist earthquake loading.	The Panel agrees with this comment; however, does not see any fatal flaws with the general concepts as currently described. No revisions to text specifically from this comment were made.
48	UWCD	4.3.1.4 1st ¶	Elevation control	Elevation 1,060 corresponds to a spill of 18,500 cfs (see comment below associated with section 4.3.1.6; 2nd ¶)	Text revised in report
49	UWCD	4.3.1.6 1st ¶	Operating season	Periodicity should be consistent with the migration water release schedule in the Santa Felicia Water Release Plan.	Downstream passage facility operations should coincide with the timing of smolt outmigration. Smolts that are unable to find or unwilling to use downstream fish passage facilities may revert to non-migratory parr. If surface flow in downstream stream channels becomes intermittent during periods of smolt outmigration, alternate downstream release locations may be appropriate.

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50	UWCD	4.3.1.6 2nd ¶	Non-operation outlet capacity	Some components of this section do not make sense. The draft states that the fish passage operating season is January to Mid-July. This is not consistent with the migration water release schedule in the Santa Felicia Water Release Plan (Jan 1 through May 31).	For planning purposes, the operating period was assumed to extend through mid-July to potentially capture late-migrating smolts. If operations demonstrate that smolt outmigration is over by May 31, the operating period could be curtailed.
50a		4.3.1.6 (should be 4.3.1.3)		The operating range identified (P4-48) is up to water surface elevation of 1060 feet, which equates to a spillway discharge of 18,000 cfs. The correct elevation is 1056 feet with 3,000 cfs discharging over the spillway crest.	Text revised to reflect 18,000 cfs spill at elevation 1060
50a		4.3.1.6		The operation scenario listed in the first paragraph of P4-50 states that the pump back system could operate whenever the outlet flow is less than 150 cfs. Is this water circulated in the reservoir or being discharged below the dam? Once again, the minimum required migration water releases are 200 cfs. Flows in excess of migration water releases are only released during the fall conservation release, or under spill conditions. Flow over the spillway channel is uncontrolled.	Text is modified to clarify that water is pumped to reservoir
51	UWCD	4.3.1.7 1st bullet	Fyke net -phasing	This indicates that fyke net collection is a phasing opportunity, but this has been presented as an activity associated with pre-design studies. Please define if this is considered for phasing or exclusively for pre-design studies or whether this is an initial phase of trapping and trucking. Note -also see 4.3.4.6; P4-66.	Text was clarified to state that fyke net initial studies are intended as a component of pre-design studies only. It has been removed from the phasing opportunities in all text.
52	UWCD	4.3.1.10 Cons	Complexity and associated risks	The complexity of this alternative (specifically 150 gates) has inherent risks associated with mechanical failure and opportunities for uncontrolled releases. These implications should be considered as a con" in section 4.3.1.10 for this alternative. "	D4 is the alternative with multiple gates. Complexity is added there (4.3.2.8) as a Con.
53	UWCD	4.3.1.10 Cons	Fish attraction and collection flow magnitude	Section 4.3.1 (1st sentence); and 4.3.1.2 (3rd ¶) includes a 150 cfs attraction flow (3 times greater than our El Rio facility Booster Pumping Plant). The excessive energy demand and carbon footprint should be considered as a con" in section 4.3.1.10 for this alternative. "	Power costs are included in each operations cost estimate so not included in pros and cons. All alternatives have various carbon footprints; no comparisons have been made. No edit made.
54	UWCD	4.3.1.10 Cons	Collector and screens	Section 4.3.1.1 includes The velocity distribution creates a gradually accelerating flow through the collector up to a velocity from which the target fish cannot escape." Comment -The collector will also capture non-target fish "which will result in relocation of non-native fishes to lower Piru Creek. Recommend adding this to the "cons" section in 4.3.1.10 for this alternative.	There is no evidence that any downstream passage facilities would alter passive movement of non-native fish. Addition of segregation facility could provide opportunity to affect non-native fish movement, uncertain if any facility would substantially affect non-native fish distribution.
55	UWCD	4.3.1.10 Cons	Debris	Section 4.3.1.1; P4-45 2nd ¶ includes discussion of debris management. Recommend adding challenges associated with debris to the cons" section in 4.3.1.10 for this alternative. "	Agree. Added notes to identify challenges associated with debris handling to all downstream alternatives con sections.
56	UWCD-GEI	4.3.1.11; bullet 3	Updated information	The cost of the fish screen system for the outlet works improvements study was revised in GEI's final report.	The Panel acknowledges that the fish screen cost estimate was revised from $1.7 m to $1.5 m in GEI's final report. The cost estimate ranges provided in the final fish passage feasibility report considered this revision.
57	UWCD-GEI	4.3.3.1; last paragraph	Pumpback system	A pumpback system capable of 150 cfs flow back to reservoir is stated. However, the pumpback system would need to be capable of 500 cfs if this alternative is to be able to operate at 500 cfs -regardless of the SFD outflow-as stated in section 4.3.3.	Clarified in text that D5 would normally operate with 150 cfs or up to 500 cfs when more than 150 cfs is discharged.
58	UWCD-GEI	4.3.3.1	Missing drawing	Drawing D5.5 is referenced, but there is no Drawing D5.5.	Text edited to delete reference to Drawing D5.5. There is no D5.5 intended.
59	UWCD-GEI	4.3.3.3	Missing drawings	Drawings D5.5 and D5.6 are referenced, but there are no Drawings D5.5 and D5.6.	Text edited to refer to intended drawings D5.3 and D5.4.
60	UWCD	4.3.3.9 1st bullet	Cost to extend penstock 100 feet	That is assuming that the new outlet works is constructed on the right (west) abutment. There are good reasons to locate the outlet works on the left (east abutment).	Clarified in 2.4. No other change made here.
61	UWCD	4.3.4; P4-59	D-7 general comment	D7 would potentially block upstream access to spawning sites for adfluvial O. mykiss. Passage should be included over the D-7 gates or an upstream migrant trap should be included.	Clarified in intro that fishway included

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62	UWCD	4.3.4; P4-60 1st sentence	D-7 general comment	The condition of the road for accessing the collector, and potential for damage to the in-creek training berm, collector, and road during high flow events may pose challenges. Studies are essential prior to design to identify an appropriate location and determine the structural criteria necessary for operational viability (of the road and passage alternative) during and following storm events.	These issues are described in the text. No changes made.
63	UWCD	4.3.4.1; P4-60 item 3	Blue Point wet crossing	This crossing is in the planning stages for decommissioning.	Text modified to reflect comment
64	UWCD	P4-60 last paragraph	Arroyo toad habitat	Regarding a second general location was identified upstream of the USGS gauge and presumably upstream of the arroyo toad habitat." Comment -Arroyo toad habitat exists from Pyramid to Lake Piru with the best breeding habitat occurring in the four miles above Lake Piru. "	Text modified in 4.3.4.1 to reflect comment
65	UWCD	4.3.4.2 1st sentence and 4.3.4.5 7th bullet	Electricity	There is no power near the site. The existing power poles terminate at the Juan Fernandez boat ramp. Solar is not a practical option due site requirements and hillside light blockage.	Panel agrees regarding solar power. Text is modified. Power at boat launch is already described; no change.
66	UWCD	4.3.4.2 2nd ¶ and Table 4.3-2 and 4.3.4.4 P 4-65 1st ¶	Estimated size requirements and exceedance frequencies	The maximum flow into the reservoir was recorded in 2005, a flow of 40,000 cfs with a gauge height of 16 feet. Since 1955 flood flows have exceeded 6000 cfs 16 times, exceeded 4000 cfs 20 times. Survivability of the structure may be a significant challenge.	Report edited to include this information on highest flow in 4.3.4.4.
67	UWCD	4.3.4.3 3rd ¶ (P4-62) and 1st ¶ on P4-65	Inconsistency	Regarding It is assumed that at 1,000 cfs the dam would be lowered to pass the flow and debris and sediment. (4-62) This closure is estimated to occur at a flow of 4,000 cfs, which is the flow at which the operating water level of the screens would be exceeded.(4-65)" Comment -This is "confusing. Page 4-62 states that the dam would be lowered at 1,000 cfs and on page 4-65 it says 4,000 cfs.	Text is corrected to say the dam is lowered at 1,000 cfs
68	UWCD	4.3.4.4 1st ¶	Operation	Accessibility may be an issue (road wash outs and Lisk Ranch Creek crossing).	Text modified with comment
69	UWCD	4.3.4.4 7th bullet	Transport distance	Six miles not sixteen.	Distance was scaled on Google maps to be about 7 miles. Text was corrected to say "about 7 miles."
70	UWCD	4.3.4.4 P 4-65 1st ¶	Exceedance of capacity (4000 cfs)	Not just flow, but gauge height.	Comment is not clear. Modified 4.3.4.4 to say that structure would be overtopped at some flow around 4,000 cfs.
71	UWCD	4.3.4.8	Avoid impacts to Arroyo toad by moving the collector to USFS property	The entirety of middle Piru Creek and Agua Blanca is listed as critical habitat, so no slight adjustment of location will completely avoid impacts. Recent surveys show toads distributed all the way down into the delta.	Modified text to say location could be moved to minimize impacts to arroyo toads
72	UWCD	4.3.4.9 Cons 3rd bullet	Operations reduced during 4% of migration season	That could be a lot more than 4 percent of possible fish migrating.	Agreed. As noted in Appendix S, Section E.3.3, it was assumed that steelhead smolts are four times more likely to outmigrate during a freshet day than based only on periodicity.
73	UWCD-GEI	4.3.5	malfunction of inlet gate	An inlet gate would be closed to protect the facility for reservoir levels above elevation 1058. What are the ramifications if the inlet gate were to be open (inoperable) for reservoir levels up to the PMF?	Added text that if the gate does not close during high flows, sediment and debris will partially bury the trash rack and screen bay. During extreme events (PMF) the entire structure will be backwatered by the reservoir and substantial effort will be required to put it back into service.

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74	UWCD	4.3.5	General D9 and all surface collector alts	Even though nonnative fish species do enter lower Piru Creek during spill events, a Lake Piru collector could provide a safer, more continual passage downstream. The collector could also become an attractor for all fishes (fish congregate at structures) resulting in the movement of nonnative fishes downstream (info could be researched from other facilities). If this alternative were implemented, a trap or holding facility could be placed at the end of the open channel pipeline to segregate nonnative fishes from O. mykiss. Section D.2.1.8 on page D4 in Appendix D does refer to blocking and trapping fish as an alternative as well as D.3.1.7 on page D9.	Any of the downstream collectors will provide a safer and more continual passage downstream than the current spill events. Regarding the ability to sort non-natives, the report states that passive grader bars will be provided to separate small and large fish. As noted under the response to NMFS comment 11, the Panel clarified that kelts will be hauled separately from small fish for those alternatives. The operational scenario the Panel has assumed for all downstream collectors is to pass any fish that enter the downstream passage system. The addition of a sorting facility could be provided for any downstream alternative, but was not considered as a need for this study. This approach could be re-visited if United desires with development of any alternative, and would add complexity to the initial facility needs and operations. No further edits made to report to address this comment.
75	UWCD	4.3.5.3	Mortality/survivorship associated with spillway	Regarding Mortality is higher with lower magnitude spills so it seems like it would be better to have high magnitude to ensure survivorship" Comment Based on this discussion it may not matter because flows rarely exceed the level necessary to increase survivorship? "	The Panel acknowledges the veracity of this comment; the text statement referred to general study findings. No change to text.
76	UWCD	4.3.5.3; P472	Mortality/survivorship associated with spillway	Regarding "Note that these are just estimates based on field studies at other sites ,laboratory tests of the effect of shear looking at the spillway with no spill flow during a site visit drawings of the spillway shape and videos and photographs of spill at SFD. No actual field studies estimating mortality have been performed at this project." Comment United realizes that these estimates were taken from other projects and lab tests and this was the best available information at the time. However, even though fish traveling over the spillway during large spill events experience high turbulence and a large plunge, observations of O.mykiss in lower Piru " Creek following the spill event in 2005 indicate that many survived and were in good condition (United biologists personal observations and reports from other biologists). No O.mykiss were observed in lower Piru Creek before the spill event and many were observed after, indicating they entered the creek during the spill event. United staff witnessed O. mykiss traveling over the spillway in 2005. A suggested study could be to tag fish in middle Piru Creek and recapture them below Santa Felicia Dam.	The Panel agrees with this comment. We understand that suggested studies will be developed outside of the feasibility study. No edits made to report.
77	UWCDGEI	4.3.6	Additional drawing	Suggest adding a Drawing D10.1 for completeness.	We agree, and inadvertently left this drawing out of the draft report. Drawing 10.1 is included in the final report
78	UWCDGEI	4.3.7	Reference	Reference Drawing D11.1 in this section.	Text revised in report
79	UWCD	5.2; 1st sentence	Correction	Change "downstream" to "upstream".	Text revised in report
80	UWCD	5.3.2; P518 2nd	Correction	Regarding The majority of steelhead smolts outmigrate at Age 2 and the number of outmigrants may increase following a Wet Year." Comment Based on scale and length frequency analysis conducted by ENTRIX Inc. from 19941998 at the Freeman Diversion outmigrating smolts in the Santa Clara River are comprised mostly of age 1 and 2 fish. "	Text (2b) revised in report
81	UWCD	5.4; P527	Passage objectives	The first paragraph of this section refers to passage objectives the panel should clarify if these objectives have been established or are these the same as the performance criteria referenced later in this paragraph.	The Panel has rewritten this section, including clarifying passage objectives.

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82	UWCD	5.4; P5-28 4th ¶	Uncertainties/costs	Given the substantial uncertainties identified by the panel, United recommends that the panel develop less costly passage alternatives (e.g., simplified trapping and trucking not involving permanent or elaborate structures and specialized vehicles) for the initial phase. The first phases for up and down stream passage identified in the report (U4 and D7) are significantly costly undertakings with numerous uncertainties. This paragraph states, "phasing has advantages biologically but also financially for United. Risk of committing to a poorly functioning alternative is reduced, and the commitment to an expansive, potentially unnecessary alternative is avoided; or can be incrementally phased-in from an initially lower cost alternative based on results of biological monitoring." We believe that there are lower cost alternatives to U4 and D7, both multi-million dollar undertakings, that could effectively be implemented as an initial phase and that would be consistent with the above statement made by the panel. Given the substantial uncertainties, a lower-cost phased option could be implemented in conjunction with studies to determine if U4 and D7 are worth the investment.	The Panel has rewritten this section, and while it has not developed additional alternatives, it has clarified the phasing process. This includes establishing low-cost initial measures and conducting monitoring and other studies to reduce uncertainty and ensure that proceeding with U4 and D7 to full implementation is effective.
83	UWCD	5.4; P5-27 and P5-28	Discussion of phasing broken into technical and biological	Regarding "Phasing has advantages biologically but also financially for United. Risk of committing to a poorly functioning alternative is reduced, and the commitment to an expensive, potentially unnecessary alternative is avoided; or can be incrementally phased-in from an initially lower cost alternative based on results of biological monitoring." Comment - This section discusses technical and biological uncertainty (effectiveness) with the recommended feasible alternatives and adaptive management. The technical and biological uncertainties are related to the performance of a recommended alternative after it is constructed and operated. The panel presents but does not, at least in this section, further describe phasing as it relates to "the commitment to an expensive, potentially unnecessary alternative is avoided; or can be incrementally phased-in from an initially lower cost alternative based on results of biological monitoring." This relates to biological uncertainty before a recommended alternative is constructed by conducting biological monitoring. We recommend that the panel clearly distinguish technical phasing and biological phasing based on passage performance and biological phasing based on initial biological monitoring. These are not clearly distinguished throughout the document.	The Panel has rewritten this section and the recommendation, and it has clarified the phasing process. This includes establishing low-cost initial measures and conducting monitoring and other studies to reduce biological uncertainties and to ensure that proceeding with U4 and D7 to full implementation is effective.
84	UWCD	P5-29; item #1	Inconsistency	This does not appear to follow figure 5.4-1. We realize that figure 5.4-1 is a simple schematic of adaptive management" but it appears to show that monitoring would first be conducted before the alternative is implemented but item #1 on P5-29 states that the alternative would be implemented first before studies and monitoring would occur. This is another example of before and after construction uncertainty and related studies and monitoring. They should be clearly differentiated. "	The Panel has revised the schematics to demonstrate more clearly the phasing process, including that initial measures would precede full implementation. Those initial measures would be accompanied by monitoring studies to reduce biological uncertainties.
85	UWCD	P5-29; item #2 and 5.5; P5-33 2nd bullet	Criteria for defining passage performance	Criteria should be defined in advance, and then refined through study, it would be challenging to assess performance without any starting guidelines.	Biological performance criteria would need to be developed by a formed Fish Passage Monitoring Oversight Committee, which is outside of the scope of the Panel.
86	UWCD	Figure 5.4-1; P5-30	Refinement to figure	The figure should be modified to include the biological trigger that initiates implementation of phase 1, should clarify what the purpose of the first box is (Biological information), explain the role of the fyke net listed in the 5th box in the flow diagram, and include some sort of feedback between the monitoring and construction of phase 1 (assumedly the additional data might change the design?)	Figure has been updated.
87	UWCD	5.5; P5-30 thru 5-32	Biological performance standards	In discussing the biological performance standards, the panel should address how the fact that many factors influence whether steelhead will ever be in a position to take advantage of any sort of up or down stream passage opportunities provided . that it may not be as easy as figure 5.5-1 depicts to evaluate success.	The Panel has revised this section and clarified factors that define triggers and success.
88	UWCD	Figure 5.5-1	Inconsistency	This figure is inconsistent with activities described in Appendix F and does not include studies and monitoring before implementation.	Figure has been revised considerably, and Appendix F removed.
89	UWCD	Figure 5.5-1	Terminology	Compliance monitoring" might be better described as "effectiveness monitoring" and "Refinements" should be linked back to "effectiveness monitoring." "	Figure has been revised.

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90	UWCD	5.5; P5-33 4th and 5th bullets	Sequential order	Perhaps change the order of 4th and 5th bullets.	Section has been revised, so the comment has been incorporated into the new presentation.
91	UWCD	5.5; P5-33 6th bullet	Clarification	The trigger for construction of an additional facility would be established during original consultation on triggers for phasing.	The section has been revised to clarify what would be necessary to trigger additional facilities, with an emphasis on adaptive management that should aid in identifying when triggers occur.
92	UWCD	P5-33 (last ¶)	Phasing process	Regarding "In the meantime, studies could be initiated to address uncertainties that might inform the final alternative designs or monitoring and study planning." Comment: This implies initial studies before implementation. This should be clearly part of the phasing process as described in this section. "	Comment noted and the suggestion incorporated.
93	UWCD	P5-33 (last ¶)	Establishment of operation and effectiveness monitoring	Regarding Long term operation and effectiveness monitoring will begin once the design criteria are met." Comment: Suggest deleting "long term." The Fish Passage Monitoring Oversight Committee will determine the required time frame of any monitoring. "	Comment noted and the suggestion incorporated.
94	UWCD	6.3	License amendment	The schedule and decision making process in phasing of fish passage needs to account for the fact that any passage action will require that United amend its FERC license. This will involve a process that includes an opportunity for the public and agencies to weigh in and also requires 401 certification.	The discussion on process for implementation was made more general for the Final Report, in response to other comments, and a new section on permitting includes indications that the process is not necessarily predictable in requirements or timing.
95	UWCD	Table 6.3-1; Figure 6.3-1	Schedule	Table 6.3-1 and figure 6.3-1 . should reflect that year 0 starts when implementation trigger is met. For initial technical studies the table and figure should identify that 3 years is a minimum and these studies could require more time than this to complete. The time frame for the monitoring studies may be problematic given hydrologic cycles in southern California. Under drought conditions, many studies could not be implemented appropriately or result in representative information.	Timeline has been removed for the Final Report, and the discussion of implementation schedule made more general in nature.
96	UWCD	Table 6.3-1	Inconsistency	Does not follow phasing steps summarized in section 5 (P5-32). Section 5 does not appear to follow Appendix F.	Implementation schedule has been removed for the Final Report.
97	UWCD	6.3.2.4; P6-12	Inconsistency	This describes initial studies that are included in Appendix F but not in section 5 (P5-29).	Section has been revised, and the comment has been noted.
98	UWCD	6.3.2.5	Procure Designer	Geotechnical investigations are missing. This is part of the project critical path.	This section is intended as an example with approximate timelines, and will need to be developed further depending on which alternatives are selected. Geotechnical investigations can be part of the "design team". Panel has revised text under 6.3.2.5, and added a one-year allowance to illustrate the need for geotechnical investigation, to be conducted in parallel with the 30% design, so the design team can help to coordinate the exact geotechnical investigation needs. Note this extended the in-service date by one year.
99	UWCD	Section 7		This chapter seems unnecessary at the end of such a long document. We suggest deleting it and allowing the executive summary to serve the same purpose.	The Panel has accepted this comment, and revised the last several sections in a major way.
100	UWCD-GEI	P8-1	Reference correction	Change GEI Consulting Engineers and Scientists" to "GEI Consultants, Inc." "	Comment noted and incorporated.
101	UWCD	Drawing U1.1	Infrastructure	1) In order to comply with PMF criteria the top of the structures must be higher than 1,080 feet. 2) Final report submitted to FERC in April 2015. New outlet works on the left (east) abutment is still a viable alternative. 3) The preferred spillway project alternatives involve widening the spillway chute. See final report submitted to FERC and DSOD in April 2015.	See responses to comments 17-19, 16, and 28. No revisions to text specifically from this comment were made.
102	UWCD	Drawing U1.2	Infrastructure	If the outlet works is relocated to the left abutment the existing penstock and powerhouse will be abandoned and demolished.	See responses to comments 17-19, 16, and 28. No revisions to text specifically from this comment were made.
103	UWCD-GEI	Drawing U1.4	Infrastructure	The downstream 200 feet of the fish ladder would likely not be in a tunnel due to the small amount of soil cover.	Comment noted. No changes made to drawings, but this comment should be retained for future consideration.
104	UWCD	Drawing U1.5	Infrastructure	1) Not a good design location for the 18-inch bypass. 2) Add ventilation and communication conduits. 3) Larger tunnel will require significantly more structural reinforcements than the proposed GEI Tunnel Section above. See previous comments provided in section 4.	Comment noted. No changes made to drawings, but this comment should be retained for future consideration.
105	UWCD	Drawing U1.6	Infrastructure	1) In order to comply with PMF criteria the top will have to be higher than 1,080. 2) See previous comments in section 4.	Comment noted. No changes made to drawings, but this comment should be retained for future consideration.

United Comment Number	Comment source	Section; Page	Subject	Comment	Panel Response
106	UWCD	Drawing U4.4	Infrastructure	The water supply line needs to be 8-inches or larger. Velocity would be too high with a 6-inch supply line.	We acknowledge that the piping may need to be larger. This is a matter of detailed design to be determined in the next phase for any selected alternative. No changes made to drawings or cost estimate, but this comment should be retained for future consideration.
107	UWCD-GEI	Drawing D3.1	Infrastructure	The tunnel alignment shown by the callout "Penstock Alternative R1 from GEI Study" does not coincide with the alignment of Alternative R1 in GEI's report.	Comment noted. The GEI study was modified prior to production of the draft drawings. Drawing D3.1 shows the general concept still reasonably accurate, so no revisions were made to the final drawings. This issue should be revisited if this alternative is carried forward. Also see responses to comments 17-19, 26, and 28.
108	UWCD-GEI	Drawing D4.3	Infrastructure	This drawing is missing.	Drawing D4.3 was not missing in our copy of the transmitted report PDF file.
109	UWCD-GEI	Drawing D4.5	Infrastructure	The reservoir level lines are incorrectly plotted on Detail 5.	There is no Detail 5 on Drawing D4.5. Is comment in error, or was there another sheet intended to be referenced?
110	UWCD-GEI	Drawing D5.4	Infrastructure	Should the 150 cfs shown for the travelling belt screens be 500 cfs?	Yes, thank you. Drawing is revised.
111	UWCD-GEI	Drawing D14.3 and D14.4	Infrastructure	Consider founding the structure at about elevation 970 instead of elevation 949. There does not appear to be a need for such a deep excavation.	Comment noted. Specific foundation details and other features of this conceptual alternative will need further development in the design phase if this alternative is carried forward. No changes made in text or drawings.
112	UWCD-GEI	Drawing D14.7	Infrastructure	A shutoff valve would likely be required at the downstream end of the 60-inch diameter bypass pipe.	Comment noted. Specific design details for this conceptual alternative will need further development in the design phase if this alternative is carried forward. No changes made in text or drawings.
113	UWCD	Appendix F	Delete from findings report	Delete this appendix as part of this report. Much of the content of this appendix is relevant to the process beyond task 7 (finalization of this findings report), but outside the scope of the study plan. If the panel determines that the uncertainties discussed throughout the findings report warrant a recommendation to move into task 9 (which is within their discretion to do), then the content of this appendix should be transferred into the body of the report and included as a recommendation. Otherwise, this appendix should be deleted from the report and held for future consideration during discussions in task 8, and in the event that task 9 is implemented.	Appendix F has been removed. Some of the material has been incorporated into a newly rewritten section on recommendations, including suggestions on what might occur following Task 8.
114	UWCD	Appendix H; H.2	Modification of flow from Pyramid	United has no control or discretion over water releases from Pyramid Lake. Therefore, discussions related to modification of flows from Pyramid Lake are not appropriate for	Discussion of revised releases from Pyramid Lake have been removed.

Comment	Panel Response
The draft Findings Report represents a compilation of multiple concepts that have been developed by four consulting firms and seven members of the Panel. In its draft form, the report contains many elements that have not been thoroughly integrated throughout the report, resulting in inconsistencies regarding implementation steps for studies,	The Panel has conducted a thorough review of comments and has conducted a complete rewrite of the final three sections of the report, all of which were intended to fully integrate the concepts and elements of the study, including a clear delineation and presentation of the Panel's recommendation.
The Study Plan requires "[a]t least one volitional alternative for upstream and downstream passage […] be described, regardless of its feasibility." United seeks clarity on the Panel's position related to the technical and biological feasibility of the volitional alternatives included in the assessment and requests that the Panel clarify their position regarding "site constraints, uncertainties, or other factors" related to the volitional passage alternatives considered.	A section has been added to the report to specifically discuss the feasibility of volitional passage. The technical feasibility with regard to volitional passage of the selected alternatives is described for each of the selected alternatives. Note that the Panel believes feasibility of volitional passage is not often a "yes" or "no" finding but more of a determination based on the established definition of volitional passage with respect to the site conditions and range of realistic constraints. In this case the reservoir level range of operations during migration periods greatly influences the "feasibility" of volitional passage. There are also uncertainties, primarily associated with the reservoir, that will influence the "feasibility" of volitional passage.
...discussions related to modification of flows from Pyramid Lake are not appropriate for consideration in this feasibility assessment. United requests that all references to modification of water releases (enhancement or attenuation) be deleted from the draft Findings Report. For this overarching reason, no further comments are provided associated with discussions in the draft Findings Report related to this issue	The Panel has removed from the Final Report discussions related to modification of flows from Pyramid Lake.
The appendix also makes several references to task 9 from the Study Plan, but the panel makes no recommendations regarding moving to task 9. The Study Plan allows for the panel to recommend moving to task 9 if substantial uncertainties exist. Given that D7 and U4 are costly undertakings, **United requests that the panel evaluate whether task 9 should be pursued prior to implementing either of these alternatives, and, that the panel revise section 5.4 and Appendix F to incorporate the role of task 9 in addressing uncertainties, if deemed appropriate.** In addition, we request that the panel consider the option of a less costly, simpler version of trapping and trucking as the first phase of fish passage. This is an appropriate approach given the costs and uncertainties associated with U4 and D7. Please see comment 82 in the attached spreadsheet for more on this issue.	The Panel has revised the presentation of its recommendations, including the role of Task 9 and resolving uncertainties. In short, the Panel has met its responsibility of identifying alternatives that are most likely to be successful given the uncertainties that exist. The Panel has not made a recommendation on whether Task 9 should be pursued.

Comment	Panel Response
United requests that Appendix F be deleted from the draft Findings Report. While the content of this appendix is relevant to the process beyond task 7 (finalization of this Findings Report), much of the information in the appendix is outside the scope of the Study Plan. If the panel determines that the uncertainties discussed throughout the draft Findings Report warrant a recommendation to move into task 9, then the content of this appendix should be transferred into the body of the report and included as a recommendation. Otherwise, this appendix should be deleted from the report and held for future consideration during discussions in task 8, and in the event that task 9 is implemented in the future.	Appendix F has been removed from the Final Report. Some elements of the former appendix have been integrated into the recommendation as a potential future path for implementation of the recommended alternatives.
United recognizes the challenges of providing fish passage within arroyo toad critical habitat, and in an environment contaminated with invasive quagga mussels. Many of our past comments have Appendices I and J been associated with these issues and they remain a serious concern. However, inclusion of the information presented in these appendices is outside of the scope of the Study Plan and redundant, or may be contradictory with other materials and projects United has produced, or is working on producing. United requests that these appendices be deleted from the draft Findings Report.	Appendix I and J have been removed from the Final Report.