

**LA GRANGE HYDROELECTRIC PROJECT  
FERC NO. 14581**

**DRAFT LICENSE APPLICATION**

**ATTACHMENT J**

**FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT  
PROGRESS REPORT**

This Page Intentionally Left Blank

# **FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT PROGRESS REPORT**

## **LA GRANGE HYDROELECTRIC PROJECT FERC NO. 14581**



**Prepared for:**  
**Turlock Irrigation District – Turlock, California**  
**Modesto Irrigation District – Modesto, California**

**Prepared by:**  
**HDR, Inc.**

**February 2016**

This Page Intentionally Left Blank.



# Fish Passage Facilities Alternatives Assessment Progress Report

## TABLE OF CONTENTS

Section No.	Description	Page No.
<b>1.0</b>	<b>INTRODUCTION.....</b>	<b>1-1</b>
1.1	Background.....	1-1
1.2	Licensing Process.....	1-4
1.3	Study Plan .....	1-5
<b>2.0</b>	<b>STUDY GOALS AND OBJECTIVES.....</b>	<b>2-1</b>
<b>3.0</b>	<b>STUDY AREA.....</b>	<b>3-1</b>
<b>4.0</b>	<b>METHODOLOGY .....</b>	<b>4-1</b>
4.1	Phase 1 – Evaluation of General Biological and Engineering Design Parameters and Identification of Potential Fish Passage Alternatives.....	4-1
4.2	Phase 2 – Preliminary Functional Layouts and Cost Estimates.....	4-1
<b>5.0</b>	<b>RESULTS OF 2015 STUDIES AND WORKSHOPS.....</b>	<b>5-1</b>
5.1	Collaboration with Licensing Participants.....	5-1
5.1.1	Workshop No. 1 .....	5-1
5.1.2	Workshop No. 2 .....	5-2
5.1.3	Workshop No. 3 .....	5-3
5.1.4	Technical Memorandum No. 1 .....	5-4
5.2	Fish Passage Facilities Considerations .....	5-5
5.2.1	Anadromous Fisheries Resources .....	5-5
5.2.1.1	Fall-run Chinook Salmon.....	5-5
5.2.1.2	Spring-run Chinook Salmon .....	5-6
5.2.1.3	<i>Oncorhynchus mykiss</i> .....	5-6
5.2.2	Characteristics of Target Species Under Consideration for Fish Passage.....	5-6
5.2.3	Physical Characteristics of Don Pedro and La Grange Dams.....	5-8
5.2.4	Site Accessibility .....	5-9
5.2.5	Project Operations.....	5-10
5.2.5.1	La Grange Pool Operations.....	5-10
5.2.5.2	Don Pedro Reservoir Operations .....	5-10

5.2.6	Hydrologic Conditions Relevant to Fish Passage .....	5-15
5.2.6.1	Inflow to Don Pedro Reservoir .....	5-16
5.2.6.2	River Flow below LGDD.....	5-17
5.2.6.3	Minimum Releases to Support Aquatic Resources on the Tuolumne River .....	5-18
5.3	Design Criteria and Guidelines for Fish Passage Design .....	5-18
5.3.1	Reservoir Pool Fluctuation Criteria .....	5-19
5.3.2	River Flow Design Criteria.....	5-20
5.3.3	Fish Screen Criteria.....	5-21
5.3.4	Fish Bypass Criteria.....	5-22
5.3.4.1	Bypass Entrance Criteria.....	5-22
5.3.4.2	Bypass Conduit Criteria.....	5-23
5.3.4.3	Bypass Exit Criteria .....	5-23
5.3.4.4	Velocity Barrier Criteria .....	5-24
5.3.5	Fishway Criteria.....	5-24
5.3.5.1	Fishway Entrance.....	5-25
5.3.5.2	Fish Ladder Design .....	5-25
5.3.5.3	Fishway Exit .....	5-25
5.3.6	Debris Rack Criteria .....	5-26
5.3.7	Fish Trapping and Holding Criteria.....	5-26
5.4	Factors that Require Further Consideration .....	5-27
<b>6.0</b>	<b>DISCUSSION AND FINDINGS .....</b>	<b>6-1</b>
<b>7.0</b>	<b>STUDY VARIANCES AND MODIFICATIONS.....</b>	<b>7-1</b>
<b>8.0</b>	<b>REFERENCES.....</b>	<b>8-1</b>

### List of Figures

<b>Figure No.</b>	<b>Description</b>	<b>Page No.</b>
Figure 1.1-1.	La Grange Hydroelectric Project location map. ....	1-2
Figure 1.1-2.	La Grange Hydroelectric Project site plan.....	1-3
Figure 5.2-1.	Mean daily pool elevation for the Historical (top) and Base Case (bottom) Don Pedro Dam operational scenarios.....	5-12

---

**List of Tables**

<b>Table No.</b>	<b>Description</b>	<b>Page No.</b>
Table 1.2-1.	Studies approved or approved with modifications in FERC's Study Plan Determination. ....	1-5
Table 5.2-1.	General characteristics of select species (Bell 1991; TRTAC 2000). ....	5-7
Table 5.2-2.	Anticipated life history timing of potential targeted species. ....	5-8
Table 5.2-3.	Summary of general physical characteristics of Don Pedro and La Grange dams. ....	5-8
Table 5.2-4.	Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for Historical observations (Oct 1, 1974 to Apr 30, 2013). ....	5-13
Table 5.2-5.	Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for outmigrating juvenile salmonids using Historical observations (Oct 1, 1974 to Apr 30, 2013). ....	5-13
Table 5.2-6.	Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for arriving adult salmonids using Historical observations (Oct 1, 1974 to Apr 30, 2013). ....	5-14
Table 5.2-7.	Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for the Base Case operational scenario (Oct 1, 1970 to Sept 30, 2012). ....	5-14
Table 5.2-8.	Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for outmigrating juvenile salmonids using the Base Case operational scenario (Oct 1, 1970 to Sept 30, 2012). ....	5-15
Table 5.2-9.	Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for arriving adult salmonids using the Base Case operational scenario (Oct 1, 1970 to Sept 30, 2012). ....	5-15
Table 5.2-10.	Historical exceedance Tuolumne River flows into Don Pedro Reservoir for outmigrating juveniles using a period of record of Oct 1, 1970 to Sept 30, 2012. ....	5-16
Table 5.2-11.	Base Case exceedance Tuolumne River flows into Don Pedro Reservoir for outmigrating juveniles using a period of record of Oct 1, 1970 to Sept 30, 2012. ....	5-17
Table 5.2-12.	Historical exceedance Tuolumne River flows below LGDD for arriving adults using a period of record of Oct 1, 1970 to Dec 31, 2013. <sup>1</sup> ....	5-17
Table 5.2-13.	Base Case exceedance Tuolumne River flows below LGDD for arriving adults using a period of record of Oct 1, 1970 to Sept 30, 2012. ....	5-18
Table 5.3-1.	Fish passage facility flows calculated for the anticipated period of migration for target fish species. ....	5-20

---

**List of Attachments**

Attachment A	Record of Consultation for Phase 1
--------------	------------------------------------

## List of Acronyms and Abbreviations

---

ac-ft .....	acre-foot
BLM .....	Bureau of Land Management
BOR .....	Bureau of Reclamation
CCSF .....	City and County of San Francisco
CDFG .....	California Department of Fish and Game, now CDFW
CDFW .....	California Department of Fish and Wildlife
cfs .....	cubic feet per second
CG .....	Conservation Group
Districts .....	Turlock Irrigation District and Modesto Irrigation District
FERC .....	Federal Energy Regulatory Commission
FLA .....	Final License Application
FPA .....	Federal Power Act
GIS .....	geographic information system
ILP .....	Integrated Licensing Process
ISR .....	Initial Study Report
LGDD .....	La Grange Diversion Dam
LP .....	Licensing Participant
M&I .....	municipal and industrial
MID .....	Modesto Irrigation District
NMFS .....	National Marine Fisheries Service
NPS .....	National Park Service
O&M .....	operation and maintenance
PAD .....	Pre-Application Document
PSP .....	Proposed Study Plan
QA/QC .....	quality assurance/quality control
RM .....	river mile
RSP .....	Revised Study Plan
SD2 .....	Scoping Document 2
SPD .....	Study Plan Determination
TAF .....	thousand acre-feet
TID .....	Turlock Irrigation District
TM .....	technical memorandum
USFWS .....	United States Fish and Wildlife Service
USGS .....	United States Geological Survey
USR .....	Updated Study Report

## **1.0 INTRODUCTION**

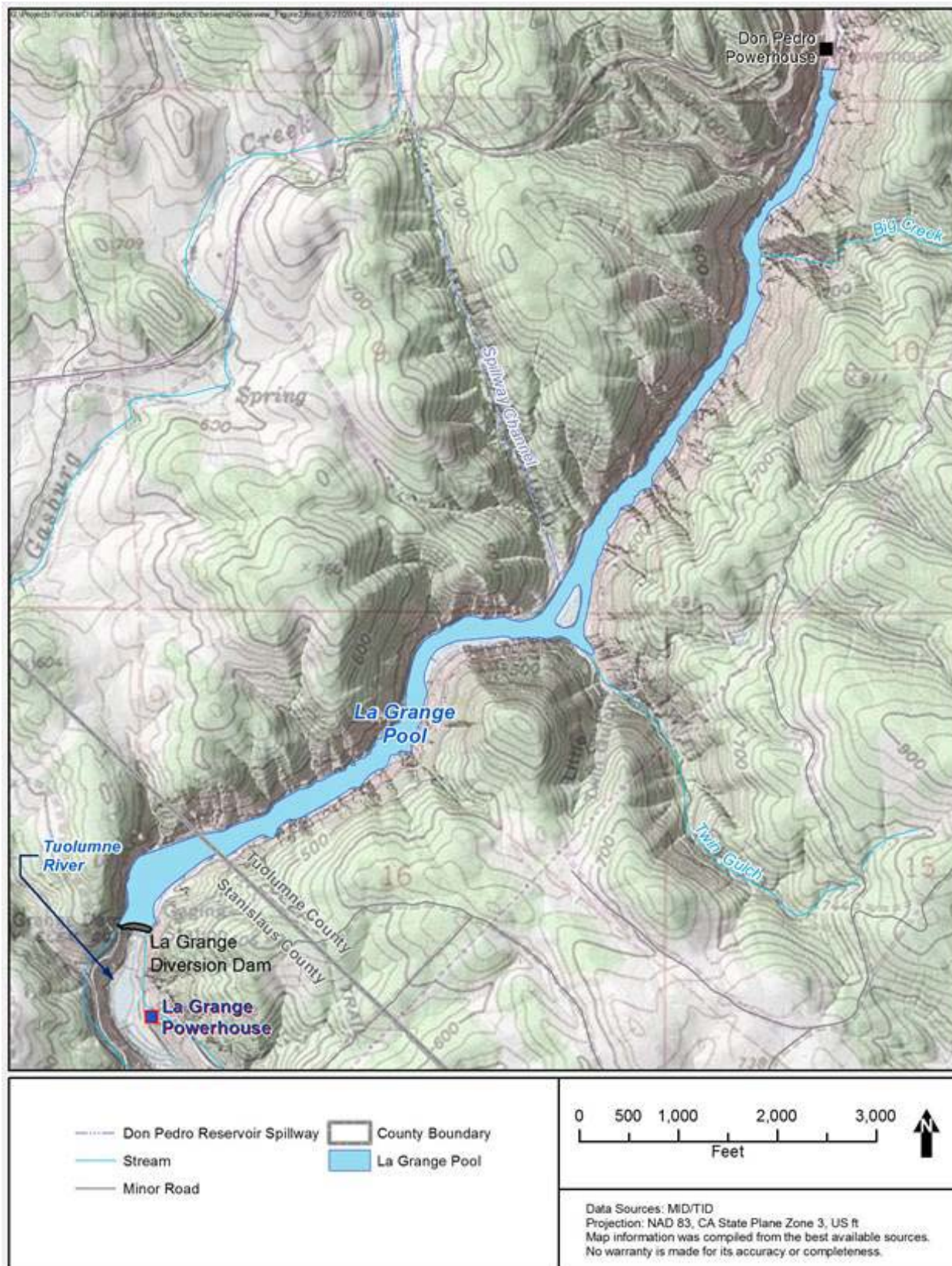
---

### **1.1 Background**

The Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) own the La Grange Diversion Dam (LGDD) located on the Tuolumne River in Stanislaus County, California (Figures 1.1-1 and 1.1-2). LGDD is 131 feet high and is located at river mile (RM) 52.2 at the exit of a narrow canyon, the walls of which contain the pool formed by the diversion dam. Under normal river flows, the pool formed by the diversion dam extends for approximately one mile upstream. When not in spill mode, the water level upstream of the diversion dam is between elevation 294 feet and 296 feet approximately 90 percent of the time. Within this 2-foot range, the pool storage is estimated to be less than 100 acre-feet of water.

The drainage area of the Tuolumne River upstream of LGDD is approximately 1,550 square miles. Tuolumne River flows upstream of LGDD are regulated by four upstream reservoirs: Hetch Hetchy, Lake Eleanor, Cherry Lake, and Don Pedro. The Don Pedro Hydroelectric Project (Federal Energy Regulatory Commission [the Commission or FERC] No. 2299) is owned jointly by the Districts, and the other three dams are owned by the City and County of San Francisco (CCSF). Inflow to the La Grange pool is the sum of releases from the Don Pedro Project, located 2.3 miles upstream, and very minor contributions from two small intermittent streams downstream of Don Pedro Dam.

LGDD was constructed from 1891 to 1893 displacing Wheaton Dam, which was built by other parties in the early 1870s. LGDD raised the level of the Tuolumne River to permit the diversion and delivery of water by gravity to irrigation systems owned by TID and MID. The Districts' irrigation systems currently provide water to over 200,000 acres of prime Central Valley farmland and drinking water to the City of Modesto. Built in 1924, the La Grange hydroelectric plant is located approximately 0.2 miles downstream of LGDD on the east (left) bank of the Tuolumne River and is owned and operated by TID. The powerhouse has a capacity of slightly less than five megawatts. The La Grange Hydroelectric Project (La Grange Project or Project; FERC No. 14581) operates in a run-of-river mode. The LGDD provides no flood control benefits, and there are no recreation facilities associated with the Project or the La Grange pool.



**Figure 1.1-1. La Grange Hydroelectric Project location map.**





**Figure 1.1-2. La Grange Hydroelectric Project site plan.**

## 1.2 Licensing Process

On January 29, 2014, the Districts commenced the pre-filing process for the licensing of the La Grange Project by filing a Pre-Application Document (PAD) with FERC<sup>1</sup>. The Districts' PAD included descriptions of the Project facilities, operations, and lands as well as a summary of existing information available on Project area resources.

On September 5, 2014, the Districts filed their Proposed Study Plan (PSP) to assess Project effects on fish and aquatic resources, recreation, and cultural resources in support of their intent to license the Project. On October 6, 2014, the Districts held a PSP meeting at MID's offices in Modesto, California. Based on discussion at the PSP meeting, the Districts prepared an Updated Study Plan document that went to licensing participants (LP) for review and comment on November 21, 2014. On December 4, 2014, the National Marine Fisheries Service (NMFS), the Conservation Groups (CG), and the California Department of Fish and Wildlife (CDFW) filed comments on the PSP and/or Updated Study Plan.

On January 5, 2015, in response to comments from LPs, the Districts filed their Revised Study Plan (RSP) containing three study plans: (1) Cultural Resources Study Plan; (2) Recreation Access and Safety Assessment Study Plan; and (3) Fish Passage Assessment Study Plan<sup>2</sup>. Comments on the RSP were received from CDFW on January 16, 2015, and from NMFS, the CGs and the City of Modesto on January 20, 2015.

On February 2, 2015, FERC issued the Study Plan Determination (SPD), approving or approving with modifications six studies (Table 1.2-1). Of those six studies, five had been proposed by the Districts in the RSP. The Districts note that although FERC's SPD identified the Fish Passage Barrier Assessment, Fish Passage Facilities Alternatives Assessment, and Fish Habitat and Stranding Assessment below La Grange Diversion Dam as three separate studies, all three assessments are elements of the larger Fish Passage Assessment as described in the RSP. The sixth study approved by FERC, Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River, was requested by NMFS in its July 22, 2014 comment letter. Of the eight studies requested by LPs, FERC approved only the NMFS study noted above.

Although FERC's SPD did not require the Districts to undertake the Upper Tuolumne River Basin Habitat Assessment studies contained in the RSP, the Districts are voluntarily conducting the Upper River Barriers Study and the Water Temperature Monitoring and Modeling Study. Regarding the third component of the Upper Tuolumne River Basin Habitat Assessment, the ongoing upstream habitat characterization work being completed by NMFS, the Districts

---

<sup>1</sup> On December 19, 2012, Commission staff issued an order finding that the La Grange Hydroelectric Project is required to be licensed under Section 23(b)(1) of the Federal Power Act. Turlock Irrigation District and Modesto Irrigation District, 141 FERC ¶ 62,211 (2012), aff'd Turlock Irrigation District and Modesto Irrigation District, 144 FERC ¶ 61,051 (2013). On May 15, 2015, the U.S. Court of Appeals for the District of Columbia Circuit denied the Districts' appeal and affirmed the Commission's finding that the La Grange Hydroelectric Project requires licensing. Turlock Irrigation District, et al., v. FERC, et al., No. 13-1250 (D.C. Cir. May 15, 2015).

<sup>2</sup> The Fish Passage Assessment Study Plan contained a number of individual, but related, study elements.



anticipate the results of this work becoming available for consideration in this licensing proceeding.

**Table 1.2-1. Studies approved or approved with modifications in FERC’s Study Plan Determination.**

No.	Study	Approved by FERC in SPD without Modifications	Approved by FERC in SPD with Modifications
1	Recreation Access and Safety Assessment		X
2	Cultural Resources Study		X
3	Fish Passage Barrier Assessment		X <sup>1</sup>
4	Fish Passage Facilities Alternatives Assessment		X
5	Fish Habitat and Stranding Assessment below La Grange Dam		X
6	Effects of the Project and Related Activities on the Losses of Marine-Derived Nutrients in the Tuolumne River	X <sup>2</sup>	

<sup>1</sup> Page A-1 of Appendix A of FERC’s SPD states that FERC approved with modifications the Fish Passage Barrier Assessment. However, the Districts found no modifications to this study plan in the SPD and page B-7 of the SPD states that “no modifications to the study plan are recommended.”

<sup>2</sup> FERC directed the Districts to conduct the study plan as proposed by NMFS.

In addition to the six studies noted in Table 1.2-1, the SPD required the Districts to develop a plan to monitor anadromous fish movement in the Project’s powerhouse draft tubes and to determine the potential for injury or mortality from contact with the turbine runners. Per the SPD, the Districts developed a study plan in consultation with NMFS and other LPs. The Districts filed the Investigation of Fish Attraction to La Grange Powerhouse Draft Tubes study plan with FERC on June 11, 2015, and on August 12, 2015, FERC approved the study plan as filed.

This progress report describes the objectives, methods, and preliminary results of the Fish Passage Facilities Alternatives Assessment (herein referred to as Fish Passage Alternatives Assessment), which is one of the two study components of the Fish Passage Facilities Assessment being implemented by the Districts in accordance with FERC’s SPD. The results of the second component, the Fish Barrier Assessment, are reported on separately (TID/MID 2016a). Documents relating to the Project licensing are publicly available on the Districts’ licensing website at [www.lagrange-licensing.com/](http://www.lagrange-licensing.com/).

### 1.3 Study Plan

FERC’s Scoping Document 2 (SD2) issued on September 5, 2014 identified the potential for Project effects on the upstream and downstream migration of anadromous fish.

FERC’s SPD approved with modifications the Districts’ proposed Fish Passage Alternatives Assessment. The SPD stated that if results from Phase 1 (conducted in 2015) indicate that the most feasible concept for fish passage at either project would involve passage through the project reservoirs, FERC recommended a second-year study to evaluate the technical and biological feasibility of the upstream movement of adults and downstream movement of juvenile anadromous salmonids through the La Grange and Don Pedro project reservoirs. In that

situation, FERC recommended that the Districts include a study plan, developed in consultation with interested LPs, in its Initial Study Report (ISR).

As discussed below, the Phase 1 activities conducted in 2015 have not indicated which of the various fish passage alternatives would be selected for concept-level engineering feasibility development. This is not unexpected as the Districts' RSP and FERC's SPD both recognize that the primary engineering feasibility work was to be undertaken in Phase 2 to occur in 2016. The Phase 1 efforts, consistent with the RSP, predominantly consisted of information gathering, development of basic design criteria through collaboration with resource agencies and interested parties, identification of information gaps, and the initial defining of potential concepts, all to occur through the conduct of a number of Workshops with LPs. Therefore, any decision about a preferred engineering concept would occur as part of the studies to be conducted throughout 2016. This Fish Passage Alternatives Assessment report summarizes the work accomplished in 2015.

## 2.0 STUDY GOALS AND OBJECTIVES

---

The goal of the Fish Passage Alternatives Assessment is to identify and develop concept-level alternatives for upstream and downstream passage of Chinook salmon and steelhead at the La Grange and Don Pedro dams. The functionality, configuration, and design of such fish passage facilities must be consistent with the resource agencies' goals and objectives established for the reintroduction<sup>3</sup> of Endangered Species Act (ESA)-listed anadromous fish to the Tuolumne River between the Don Pedro Reservoir (RM 80) and the CCSF's Early Intake (RM 105). Specific objectives of the Districts' study include:

- obtain available information to establish existing baseline conditions relevant to impoundment operations and siting passage facilities;
- obtain available hydrologic data and basic biological design criteria to identify potential types, configurations, and locations of fish passage facilities consistent with estimated run size, fish periodicity, life stage requirements, and anticipated passage efficiencies for the selected species of interest;
- formulate and develop preliminary facility sizing and functional design for select, alternative potential upstream and downstream fish passage facilities consistent with the agencies' anadromous fish reintroduction goals and objectives; and
- develop reliable opinions of probable construction cost and annual operations and maintenance costs for select fish passage concept(s).

---

<sup>3</sup> While the word "reintroduction" is used commonly herein to denote the study of establishing anadromous fish runs to the upper Tuolumne River, there is no documented, empirical evidence of either spring-run Chinook salmon or steelhead populations using this reach of the Tuolumne River.

### **3.0 STUDY AREA**

---

As established by FERC in the SPD, “the geographic scope of the Districts’ proposed fish passage study includes the Tuolumne River downstream of La Grange dam at the confluence of the main river channel and the powerhouse tailrace channel to the upper Tuolumne River at the upper most extent of Don Pedro reservoir.”

The Districts are voluntarily conducting two additional studies of the upper watershed: the Upper River Barriers Study (TID/MID 2016b) and the Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study (TID/MID 2016c). The study areas for both of these studies expand the upper Tuolumne River study area extent to include portions of the North and South forks of the Tuolumne River, Cherry Creek, Eleanor Creek, and the Clavey River. Results from both studies are intended to inform the evaluation of the potential run sizes and physical suitability of fish reintroduction areas and will be considered as part of implementing fish passage facilities alternatives.

## **4.0 METHODOLOGY**

---

In accordance with the Fish Passage Alternatives Assessment study plan, the work effort is to occur in the two phases described below.

### **4.1 Phase 1 – Evaluation of General Biological and Engineering Design Parameters and Identification of Potential Fish Passage Alternatives**

Phase 1, which began in 2015 and is continuing into 2016, consists of gathering information on facility siting, facility sizing, general biological and engineering design parameters, and operational considerations in a collaborative process with LPs. The collaborative process in 2015 called for the conduct of a number of public Workshops and production of technical memoranda (TM), the goals of which were to collaboratively identify key information needs and solicit input and feedback from LPs. Identification of data gaps and subsequently addressing these data gaps within a collaborative process is necessary to complete Phase 1 of the study, which is a prerequisite to the development of a suite of fish passage conceptual alternatives that are capable of meeting the anadromous fish reintroduction goals and objectives. Facility layout, sizing, and siting to support cost estimating would follow in Phase 2 of the assessment.

### **4.2 Phase 2 – Preliminary Functional Layouts and Cost Estimates**

In 2016, based upon input developed in conjunction with LPs regarding both biological and engineering criteria, the Districts plan to develop and confirm functional site layouts, facility sizing, general design parameters, expected fish capture and survival efficiencies, and associated reliable opinions of probable construction and operation and maintenance costs for select fish passage alternatives developed in collaboration with LPs. Considerations addressed during the development of preliminary functional layouts for upstream passage alternatives will include, but not necessarily be limited to: (1) major facility siting and sizing components; (2) water supply infrastructure; (3) fish collection, acclimation, and holding facilities; (4) fish transport infrastructure and vehicles (if needed); (5) debris management; (6) fish attraction flows; (7) instrumentation and control equipment; (8) an explanation of how the proposed design complies with NMFS and CDFW fish passage criteria; and (9) identification of any additional information needs.

Similar to upstream passage conditions, considerations addressed during the development of preliminary functional layouts for downstream passage alternatives will include, but not necessarily be limited to: (1) major siting and sizing components; (2) fish sampling, acclimation, and holding facilities; (3) fish transport infrastructure and vehicles (if needed); (4) fish capture and debris management technologies; (5) provision of fish attraction flows; (6) guidance nets/curtains; (7) anchorage and flotation provisions (if needed); (8) dewatering facilities; (9) instrumentation and control equipment; (10) an explanation of how the proposed design complies with NMFS and CDFW fish passage criteria; and (11) identification of any additional information needs.

## **5.0 RESULTS OF 2015 STUDIES AND WORKSHOPS**

---

The following section summarizes the implementation and results of the Phase 1 collaboration activities with LPs and the initial biological and physical design criteria applicable to potential fish passage facilities. This information will be useful in Phase 2 for assessing the feasibility of alternative fish passage facilities.

This section identifies remaining data gaps and information needs that must be addressed prior to proceeding with the development of reliable and realistic fish passage conceptual alternatives, which would then lead to the development of cost estimates that are consistent with the goals and objectives of anadromous fish reintroduction to the upper Tuolumne River.

### **5.1 Collaboration with Licensing Participants**

As defined in the FERC-approved RSP, Phase 1 of the Fish Passage Alternatives Assessment consists of the development of general design criteria and design considerations applicable to upstream and downstream fish passage facilities at the La Grange and Don Pedro projects. As outlined in the RSP, the Districts proposed to conduct a series of Workshops to enable a collaborative process for discussing and obtaining consensus on biological and engineering design criteria. This information includes such items as site-specific physical and operational parameters; applicable regulatory requirements; NMFS, USFWS, and CDFW biological and engineering design criteria; site-specific biological/habitat information relevant to the sizing and configuration of facilities; and any other information gaps that may affect siting, sizing, general design parameters, capital cost, and operating requirements of potential fish passage facilities. In 2015, three collaborative Workshops, described below, were held with participation from a diverse group of parties including state and federal resource management agencies, non-governmental organizations, local and state government officials, representatives from local businesses and community organizations, and the general public.

#### **5.1.1 Workshop No. 1**

Workshop No. 1 was held on May 20, 2015. At this initial Workshop, the Districts provided an overview of the types of information needed to inform the development and evaluation of fish passage alternatives. As discussed at the Workshop, some of this information is readily available and easily acquired (e.g., Project-specific physical and operational information, hydrology, and published agency fish passage design criteria) while other information such as reintroduction goals and objectives, target species and life stages, anticipated run sizes and timing, habitat suitability for the target species, and impacts to other uses and users of the river resource requires either management agency input and/or additional study. The studies being conducted by NMFS regarding *Oncorhynchus mykiss* (*O. mykiss*) genetics, habitat and carrying capacity were also briefly discussed. Presentations also covered general design criteria for anadromous fish passage facilities and examples of upstream and downstream passage facilities currently in operation at other projects. These presentations provided LPs a sense of the size, scope, and complexity of fish passage facilities currently in operation in the western United States at high head dams. NMFS presented an overview of the Federal Power Act (FPA), anadromous fish habitat

availability in California rivers the San Joaquin watershed, and the Final Central Valley Salmonid Recovery Plan.

The Districts outlined the rationale for considering the need for and purpose of providing fish passage facilities in the broader context of the feasibility of anadromous fish reintroduction to the upper Tuolumne River. Since anadromous fish are not currently present in the upper Tuolumne River, the design, construction, and operation of fish passage facilities is intrinsically linked to the needs of the fish populations under consideration for reintroduction. The related question of the feasibility of fish reintroduction encompasses consideration of such issues as genetics of introduced and resident species, colonization strategy, source population, habitat suitability, carrying capacity, recreation impacts, socioeconomic effects, and compatibility with current uses, among other variables. Consideration of all these questions suggested the need for a broader reintroduction planning framework within which to evaluate the sizing, characteristics, configuration, operations, effectiveness and cost of fish passage facilities.

Workshop No. 1 resulted in two items of consensus. First, LPs agreed that the study process would benefit by active collaboration among the parties, and second, that design, construction and operation of fish passage facilities can be complex and costly, and therefore, prudence requires a sound and reliable basis for facility cost estimation. As such, a thorough investigation of the engineering, biological, regulatory and socioeconomic issues is warranted. The absence of a thorough and rigorous approach from the outset of the study could result in a set of fish passage facilities that are based on a set of unfounded assumptions that do not reflect realistic biological and performance metrics applicable to the Tuolumne River and the Don Pedro and La Grange projects. Additional details about Workshop No. 1, including meeting notes, may be found in Attachment A.

### **5.1.2 Workshop No. 2**

Workshop No. 2 was held on September 17, 2015. In support of continuing the discussions begun in Workshop No. 1, the Districts presented a conceptual framework for considering fish passage feasibility and assessing reintroduction viability. The conceptual framework is intended to provide a comprehensive, collaborative, and transparent approach for evaluating the full range of potential issues associated with the future reintroduction of anadromous fish to the upper Tuolumne River. In addition to considering aspects of the technical feasibility of building and operating fish passage facilities, the framework considers the interrelated issues of ecological feasibility, biological constraints, economics, regulatory implications, and other considerations of reintroduction. Elements of the framework are interconnected, with fish passage construction and operational requirements needing to properly reflect biological constraints, ecological considerations and economic cost:benefit assessments. The conceptual framework also represents more fully the broader interests of the LPs. Information needs and key resource considerations were discussed in greater detail in Workshop No. 2, as was the importance of establishing early in the study process the river-specific goals of reintroduction in order to enable identification, selection, and evaluation of realistic fish passage alternatives to achieve these goals. The Districts noted that reintroduction decision-making frameworks are not a new concept and implementation would be consistent with ongoing processes in other watersheds in

California and the Pacific Northwest and with recent peer-reviewed literature on reintroduction planning authored by resource management agencies and Tribes (e.g., Anderson et al. 2014).

As part of Workshop No. 2, the Districts also summarized engineering technical memorandum (TM) No. 1, which had been provided to LPs in advance of the meeting to allow sufficient time for review and feedback. Specific details regarding the purpose and content of TM No. 1 are described starting in Section 5.1.4 below. A key topic of discussion amongst LPs was the information gaps identified in TM No. 1 which are critical to moving the Fish Passage Alternatives Assessment forward to functional design and cost estimation. Examples of necessary information include, but are not limited to, identification of target species; migration timing for various life history stages; population sizes and peak run values which, in turn, are defined by site-specific habitat suitability information and calculations of carrying capacity; colonization strategies; and potential impacts caused by current recreation activities. Some of this information may be able to be provided by current studies being implemented by NMFS with potential availability in the spring of 2016. The Districts also provided examples of how biological, ecological, and regulatory information had been used to inform the functional design of fish passage facilities at other projects.

The Districts closed the Workshop by noting the importance of the group reaching consensus on a path forward for evaluating fish passage and fish reintroduction feasibility, including consensus on the range and scope of issues to be considered and the information needed to address those issues. The Districts requested that LPs provide comments and feedback on the proposed conceptual framework process and the draft TM No. 1, which includes information needed to advance fish passage functional designs and alternatives identification, by October 23, 2015. By October 23, no comments had been received from LPs. The comment period was extended to October 30, 2015; however, no comments were received by this extended deadline. Additional details about Workshop No. 2, including meeting notes, may be found in Attachment A.

### **5.1.3 Workshop No. 3**

Workshop No. 3 was held on November 19, 2015. The relatively narrow purpose of this Workshop was to seek consensus on the usefulness of and need for a structured reintroduction decision-making framework to develop the information needed to, among other things, prepare functional designs of potential alternative fish passage facilities which would meet the goals and objectives of the resource manager's anadromous fish reintroduction program. The Districts provided a review of the Fish Passage Alternatives Assessment process to date including the original objectives of the study, the previous two Workshops, the development of a structured reintroduction assessment framework, the development of TM No. 1, and the need for currently unavailable site-specific information and biological goals to move the functional design process forward. The framework also promotes a transparent and collaborative process to evaluate whether the biological goals of the upper Tuolumne River reintroduction program could be met and at what costs and impacts to local communities and other resources.

LPs unanimously indicated their support of and interest in a reintroduction decision-making framework process. Concerns were raised about the ability of the decision-making process to produce a consensus decision on reintroduction. The Districts indicated the intent of the process



was not necessarily to yield a final, formal reintroduction decision but instead to work collaboratively through a process where all LPs have been involved in identifying issues, collecting and evaluating critical information needed to support the assessment of reintroduction and fish passage, and developing opinions as to the viability of reintroduction and fish passage based on this information. Although LPs might disagree on the final conclusion regarding reintroduction feasibility, the process and information gathered through it would have been developed collaboratively and all LPs would be working with the same information base. With consensus obtained, the group agreed to meet on January 27, 2016, to begin to implement the reintroduction decision-making framework process. At this next meeting, a draft implementation process and schedule, a summary of existing available information, and a preliminary studies list (to address information gaps) would be developed to help define 2016 activities. Additional details about Workshop No. 3, including meeting notes, may be found in Attachment A.

#### **5.1.4 Technical Memorandum No. 1**

On September 4, 2015, TM No. 1 was provided to LPs for review, input, and comment. The goal of TM No. 1 was to identify the information, analysis, and design criteria necessary to characterize site-specific, functional fish passage alternatives. The document summarized existing information relevant to site-specific design considerations that will form the basis for identifying fish passage alternatives to meet the reintroduction program's goals and objectives. More specifically, the document provided information about: (1) the physical characteristics of existing La Grange and Don Pedro project facilities; (2) project operations and potential constraints associated with those operations; (3) existing facilities and facility access; (4) the physical environment in the areas of potential fish passage facility locations; (5) Chinook and steelhead life-histories and periodicities<sup>4</sup>; (6) basin hydrology as it pertains to fish periodicities and developing passage facilities; (7) potential land ownership issues; (8) applicable NMFS and CDFW fish passage facility biological and engineering design criteria and any potential limitations resulting from adherence to those criteria; and (9) factors affecting siting, sizing, general design, and operation of fish passage facilities. The information provided in TM No. 1 is summarized below in Section 5.2.

TM No. 1 also summarized existing data gaps and information needs important for informing subsequent development of fish passage alternatives. TM No. 1 noted the many data gaps, such as target species and migration timing, that can only be addressed with feedback from LPs. These data gaps are described in Section 5.4.

TM No. 1 was provided two weeks in advance of Workshop No. 2 to allow LPs time to review the document and come to the meeting prepared to discuss its contents and provide input on information needs critical to advancing the assessment. Section 5.2 below summarizes the information provided in TM No. 1. Upon receipt of feedback from LPs, future versions of the TM will be prepared and released for review.

---

<sup>4</sup> Because there are no spring-run Chinook or steelhead populations in the Tuolumne River, periodicities were based on existing information from other nearby basins.

## 5.2 Fish Passage Facilities Considerations

This section provides existing, site-specific information about the biological and physical setting of the study area. This information was presented in TM No. 1.

### 5.2.1 Anadromous Fisheries Resources

The intent of the Fish Passage Alternatives Assessment was formulated based upon information provided by LPs in their study requests. TM No.1 requested confirmation about which salmonid species were to be considered for passage. It has been reported that historically both fall- and spring-run Chinook salmon occurred in the Tuolumne River basin. Currently, only a fall-run Chinook salmon population is present; spring-run Chinook having been extirpated from the Tuolumne and San Joaquin River watersheds for decades (Yoshiyama et al. 2001; NMFS 2014). A population of resident *O. mykiss* occurs within the Tuolumne River (Ford and Kirihaara 2010). However, other than the detection of a single anadromous individual out of 148 otolith samples analyzed by Zimmerman et al. (2009), there is no evidence that a population of anadromous steelhead currently exists within the Tuolumne River watershed. No anadromous fish species currently occur above Don Pedro Reservoir. A detailed description of each species and its occurrence in the Tuolumne River is provided below.

#### 5.2.1.1 Fall-run Chinook Salmon

The migration of adult fall-run Chinook salmon in the Tuolumne River extends upstream to the vicinity of the LGDD and generally occurs from September through December, with peak migration activity occurring in October and November (TID/MID 2013b). Spawning occurs in late October to early January, soon after fish enter the river. Spawning occurs in the gravel-bedded reach (upstream of RM 24) where suitable spawning substrates exist. Egg incubation and fry emergence occur from October through early February. Juvenile fall-run Chinook have a relatively short freshwater rearing period before smolt emigrate to the ocean during the spring months.

Since completion of Don Pedro Dam in 1971, spawner estimates have ranged from 40,300 in 1985 to 77 in 1991 (TID/MID 2010, Report 2009-2). From 1971 to 2013, the date of the peak weekly live spawner count has ranged from October 31 (1996) to November 27 (1972), with a median date of November 12 (TID/MID 2010, Report 2009-2). Since fall 2009, escapement monitoring has been conducted at a counting weir established at RM 24.5, near the downstream end of the gravel-bedded reach (TID/MID 2010, Report 2009-8). Since 1971, California Department of Fish and Wildlife (CDFW; formerly known as the California Department of Fish and Game [CDFG]) has conducted annual salmon spawning surveys. In addition to CDFW's work, the Districts have studied fall-run Chinook salmon on the lower Tuolumne River through annual seine surveys conducted since 1986, annual snorkel surveys since 1982, fish weir counts since 2009, and more recently as part of the Don Pedro Hydroelectric Project relicensing.

### 5.2.1.2 Spring-run Chinook Salmon

Currently, spring-run Chinook salmon do not occur within Tuolumne River. Central Valley spring-run Chinook salmon were listed by NMFS as threatened under the ESA on September 16, 1999 (64 FR 50394). NMFS (1999) concluded that the Central Valley spring-run Chinook salmon evolutionary significant unit (ESU) was in danger of extinction and native spring-run Chinook salmon were extirpated from the San Joaquin River Basin. NMFS has acknowledged that information is limited regarding the historical adult escapement for Chinook salmon in the Tuolumne River and a review of available literature did not reveal reliable estimates of historical escapement (NMFS 2014). Spring-run Chinook escapement estimates have been described broadly for the San Joaquin River, but tributary-specific escapement estimates are not available. Moyle (2002) suggested that spring-run Chinook salmon in the upper San Joaquin River probably exceeded 200,000 fish at times, and further stated that “*it is likely that an equal number of fish were once produced by the combined spring runs in Merced, Tuolumne, and Stanislaus Rivers. However, early historical population levels were never measured.*” A reintroduction program for an experimental population of spring-run Chinook salmon to the San Joaquin River downstream of Friant Dam is currently being implemented.

### 5.2.1.3 *Oncorhynchus mykiss*

*O. mykiss* exhibits two life history forms: a resident form commonly known as rainbow trout, and an anadromous form commonly known as steelhead. Central Valley steelhead begin to enter fresh water in August and peak spawning occurs from December through April. After spawning, adults may survive and return to the ocean. Steelhead progeny rear for one to three years in fresh water before they emigrate to the ocean where most of their growth occurs. Spawning by resident rainbow trout in the Central Valley coincides with steelhead and interbreeding is possible. Although low numbers of apparent anadromous *O. mykiss* have been documented in the Tuolumne River, there is no scientific evidence of a population of steelhead currently in the Tuolumne River. Existing fish monitoring data indicate that smaller *O. mykiss* exhibiting a resident life history are common in the Tuolumne River below LGDD.

## 5.2.2 Characteristics of Target Species under Consideration for Fish Passage

Fish passage design must consider which fish species, and which life stages of those species, will be targeted for upstream and downstream passage. The Fish Passage Alternatives Assessment currently focuses on the development of fish passage alternatives for the upstream migration of adult spring-run Chinook salmon and adult steelhead and the downstream migration of juvenile life history stages for both species. Fall-run Chinook salmon may also be considered a target species for fish passage; however, the historical distribution of fall-run Chinook is generally believed to have been confined to lower elevations (i.e., below the reach of the Tuolumne River identified for possible reintroduction) (Yoshiyama et al. 2001). Juvenile upstream passage will not be considered as part of this Fish Passage Alternatives Assessment.

General characteristics for the adult life stage of each fish species are presented in Table 5.2-1. These characteristics vary based upon population genetics, return age, and other watershed-

specific factors. Over 150 studies have been conducted on the Tuolumne River since 1992 and complete datasets will be reviewed as part of design concept development.

**Table 5.2-1. General characteristics of select species (Bell 1991; TRTAC 2000).**

Target Fish Species	General Characteristics
Chinook Salmon (fall- and spring-run)	<ul style="list-style-type: none"> <li>▪ Typical weight range 10 to 30 lbs</li> <li>▪ Spend 2 to 5 years in the ocean (most fall-run return to the Tuolumne at 3 years)</li> <li>▪ Reach maturity at 3 to 6 years</li> <li>▪ Adults exhibit burst swimming speeds of 11 to 21.5 ft/s, prolonged speeds of 4 to 11 ft/s, and sustained speeds of 0 to 4 ft/s</li> </ul>
Steelhead	<ul style="list-style-type: none"> <li>▪ Typical weight range 5 to 20 lbs</li> <li>▪ Spend 1 to 4 years in the ocean</li> <li>▪ Reach maturity at 3 to 6 years</li> <li>▪ Adults exhibit burst swimming speeds of 14.5 to 26.5 ft/s, prolonged speeds of 5 to 14.5 ft/s, and sustained speeds of 0 to 5 ft/s</li> </ul>

Data supporting the determination of age-class, size, maturation, and migration timing of spring-run Chinook and steelhead life stages occurring within the Tuolumne River watershed does not currently exist. In addition, emigrating juvenile spring-run Chinook salmon and steelhead, if introduced into the upper watershed, would be expected to vary in size and seasonal run timing from fall-run Chinook that are currently monitored downstream of LGDD. Given that data are unavailable specifically for the Tuolumne River, information from the San Joaquin and Sacramento rivers was reviewed to generate potential estimates of the life history timing of upstream and downstream migration (Table 5.2-2) (Bureau of Reclamation [BOR] et al. 2013; NMFS 2014).

Results from monitoring spring-run Chinook and steelhead in the Sacramento River tributaries, such as Mill and Butte creeks and the Feather River, indicate variation in the seasonal timing of juvenile migration among watersheds and in response to variation in environmental conditions such as spring freshets (BOR et al. 2013). Data presented in Table 5.2-2 suggest that migration of adult target species may occur from October through June with the possibility of spring-run Chinook arrival in March. Downstream migration of juveniles may occur from October through the end of June. The months of July through September are anticipated to exhibit relatively little activity with regard to adult upstream migration of targeted species, while the months of July through September are anticipated to exhibit relatively little activity with regard to juvenile downstream migration. The life history timing presented in Table 5.2-2 is a generalization of typical species tendencies with regard to upstream and downstream migration and does not contain the detail necessary for an accurate assessment of fish passage facility needs.

[illegible]

<sup>2</sup> BOR et al. 2013 and NMFS 2014.

### 5.2.3 Physical Characteristics of Don Pedro and La Grange Dams

**Table 5.2-3. Summary of general physical characteristics of Don Pedro and La Grange dams.**

<sup>1</sup> Approximated from available data sources.

#### 5.2.4 Site Accessibility

Accessibility to the LGDD and to the upper areas of Don Pedro Reservoir is an important factor in siting fish passage facilities and fish release locations. Fish passage operations may occur on a daily basis throughout the migration season. The ability to access each location, travel time between facilities, and road conditions has a direct effect on construction costs as well as on long term operation costs. Trap and haul facilities require daily transport of fish and therefore the safety of drivers, route reliability, and transport duration should also be factors in site selection. If access to optimum collection or release locations is not currently available, costs to provide adequate access would need to be developed and included in fish passage facility design concepts.

LGDD is accessible from the north via La Grange Road (J59) and from the south via Yosemite Boulevard (CA-132) and La Grange Road (J59). A privately owned 1.4 mile section of La Grange Dam Road and adjacent ancillary road leads from the intersection of Yosemite Boulevard (CA-132) to the powerhouse at LGDD and TID flow bifurcation facilities on the south bank of the river. The presence of publicly owned paved roads and the privately owned section of a TID maintained road make LGDD accessible nearly 365 days a year. Severe weather and flood events have been known to limit access for short periods of time, but such events are rare and episodic. There is currently no public access to the tailrace areas below the La Grange powerhouse or the opposite shore at that location.

The head of Don Pedro Reservoir is located near RM 80. Locations near the head of Don Pedro Reservoir can be accessed at four primary locations which may be important for fish collection or release operations: Wards Ferry Bridge, Jacksonville Road Bridge, Moccasin Point Bridge, and at the CA-120/49 Bridge. No other points of access are currently available to the head of Don Pedro Reservoir.

- Wards Ferry Bridge is located at RM 78.4 and is accessed from the east and west via Wards Ferry Road. From the west, the access route requires travel to CA 120/108, then through the City of Jamestown, then through several smaller County roads, and eventually to Wards Ferry Road. One alternative would be to travel to CA 120/108, then to CA 120/49, then to Jacksonville Road, then to Twist Road, and then to Wards Ferry Road. From the east, the access route requires travel to CA 120/49, then to the City of Big Oak Flat up New Priest Grade, and then to Wards Ferry Road. Each potential route requires travel on smaller low-volume County-maintained roads which exhibit one-lane widths and switch-backs in some locations. The eastern route through Big Oak Flat requires travel to higher elevations where snow and ice can impede travel on a seasonal basis.
- Jacksonville Road Bridge near RM 72.2 is accessed from LGDD by traveling north to CA 120/49, then east to Jacksonville Road. A narrower part of the reservoir can then be accessed by traveling further north on a gravel road named River Road. With the exception of River Road, all roads are publicly owned and well maintained for travel by larger vehicles. The short 1.3 mile portion of River Road is privately owned and maintained with gravel surfacing. Existing parcels owned by BLM in the general area are also accessed via River Road. Despite the occasional rock fall, land slide, or ice, this route is likely travelable 365 days a year.

- Moccasin Point Marina is located on an easterly branch of Don Pedro Reservoir near the point of confluence with Moccasin Creek. The main reservoir can be accessed from this location at RM 72.6. Moccasin Point Marina can be accessed from the intersection of CA 120 and Jacksonville Road. Facilities at the marina include a multi-lane boat ramp, general store, campgrounds, recreational facilities, parking, and electrical power.
- The CA-120/49 Bridge near RM 70.1 can be accessed from LGDD by traveling north to CA 120/49 and then east to the bridge. All roads are publicly owned and well maintained for travel by larger vehicles. Despite the occasional rock fall, land slide, or ice, this route is generally travelable year-round.

## 5.2.5 Project Operations

### 5.2.5.1 La Grange Pool Operations

LGDD permits the diversion and delivery of water by gravity to irrigation systems owned by TID and MID. Under normal river flows, the pool formed by LGDD extends for approximately one mile upstream. When not spilling, the water level above the diversion dam is typically between elevation 294 feet and 296 feet which occurs approximately 90 percent of the time. Within this 2-foot range, the pool storage is estimated to be less than 100 acre-feet of water. Inflow to the La Grange pool is the sum of releases from the Don Pedro Project, located 2.6 miles upstream, and very minor contributions from two small intermittent streams downstream of Don Pedro Dam. Water passing the LGDD spillway continues down the lower Tuolumne River.

### 5.2.5.2 Don Pedro Reservoir Operations

The Don Pedro Project is managed consistent with providing for reliable water supply for irrigation and municipal and industrial purposes, providing flood flow management, hydropower generation, recreation, and protection of downstream aquatic resources.

Annual operations create substantial fluctuations in the Don Pedro Reservoir pool elevations. The reservoir is generally at its greatest storage volume in June, July, and August. Each year, Don Pedro Reservoir is lowered to at least elevation 801.9 feet in October to provide required flood control benefits. During the typical course of each water year, Don Pedro Reservoir is lowered further as water releases are made to accommodate water deliveries and environmental flow objectives.

Historical and potential future pool elevations are described by two available datasets: Historical observations and “Base Case” predicted estimations. The Historical dataset includes mean daily pool elevations observed at Don Pedro Reservoir for the period of record beginning in October 1, 1974 and ending in April 30, 2013 (n=40). The Base Case dataset represents predicted values of mean daily pool elevations calculated with the Tuolumne River Daily Operations Model (TID/MID 2013a). The Base Case dataset includes mean daily pool elevations for the period of record beginning in October 1, 1970 and ending in September 30, 2012 (n=43). The Base Case results depict the anticipated operation of the Don Pedro Project in accordance with the current FERC license, U.S. Army Corps of Engineers flood management guidelines, and the TID and

MID irrigation and municipal and industrial water management practices using historic watershed inputs. Given that operational changes have been made to the Don Pedro Project over the Historical record, the Base Case scenario provides estimated values of pool elevation for current operations over a longer period of record. The Base Case data therefore take into consideration more climactic variability and provide a better estimate of future pool conditions when considering the potential for implementation of future fish passage facilities. Figure 5.2-1 illustrates pool elevation trends and variation for Historical and Base Case datasets for their respective periods of record.



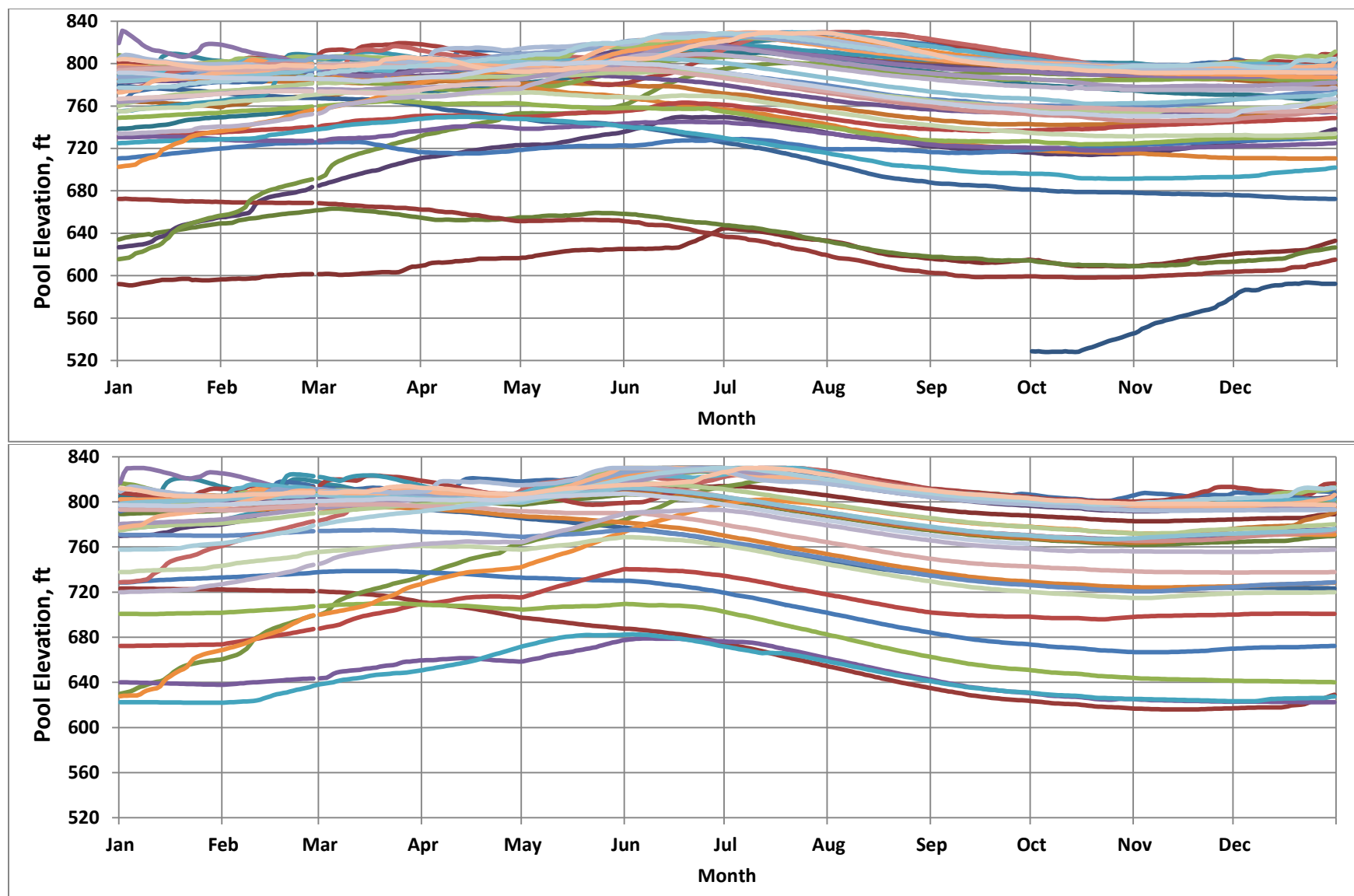


Figure 5.2-1. Mean daily pool elevation for the Historical (top) and Base Case (bottom) Don Pedro Dam operational scenarios.

Table 5.2-4 provides the percent exceedance of mean daily pool elevation over an annual basis for Historical observations. The data show that the median pool elevation on an annual basis is approximately 788.2 feet. Observed elevations, which account for 80 percent of Historical conditions from a probability of 10 to 90 percent of time exceeded, would range from 726.0 to 812.4 feet. From 5 to 95 percent exceedance, which accounts for 90 percent of Historical conditions, the range of elevations would be from 702.7 to 820.3 feet. From 1 to 99 percent, which accounts for 98 percent of Historical conditions, the range of elevations would be from 613.7 to 828.2 feet. Using these exceedance values, Historical mean daily pool fluctuations of 86.4 feet were exceeded 20 percent of the time, 117.6 feet were exceeded 10 percent of the time, and 214.5 feet were exceeded 2 percent of the time.

**Table 5.2-4. Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for Historical observations (Oct 1, 1974 to Apr 30, 2013).**

Percent of Time Exceeded	Pool Elevation (ft)
99.9%	598.5
99.0%	613.7
95.0%	702.7
90.0%	726.0
80.0%	749.7
50.0%	788.2
20.0%	802.7
10.0%	812.4
5.0%	820.3
1.0%	828.2
0.1%	829.5

Historical observation data for the anticipated migration periods of fall-run Chinook, spring-run Chinook, and steelhead were further evaluated to identify the potential fish passage facility requirements of target fish species given Historical observations. Table 5.2-5 provides the Historical percent exceedance of mean daily pool elevation for anticipated outmigration periods while Table 5.2-6 provides results of the same analysis for anticipated upstream migration periods. The annual exceedance elevation data are also provided in each table for comparative purposes.

**Table 5.2-5. Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for outmigrating juvenile salmonids using Historical observations (Oct 1, 1974 to Apr 30, 2013).**

Percent of Time Exceeded	Historical Reservoir Elevations (ft)			
	Annual	Outmigration Fall-Run Chinook 01Apr – 30Jun	Outmigration Spring-Run Chinook 01Jan – 31May	Outmigration Steelhead 01Jan – 30Jun
99.9%	598.5	639.3	620.6	621.9
99.0%	613.7	651.6	652.7	652.1
95.0%	702.7	727.3	717.6	720.3
90.0%	726.0	744.2	734.4	735.5
50.0%	788.2	794.9	788.0	790.1
10.0%	812.4	815.6	804.8	809.2
5.0%	820.3	820.5	809.1	816.1
1.0%	828.2	827.0	817.6	825.1
0.1%	829.5	828.6	821.0	828.5

**Table 5.2-6. Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for arriving adult salmonids using Historical observations (Oct 1, 1974 to Apr 30, 2013).**

Percent of Time Exceeded	Historical Reservoir Elevations (ft)			
	Annual	Arriving Adult Fall-Run Chinook 01Oct – 31Dec	Arriving Adult Spring-Run Chinook 01Mar – 30Jun	Arriving Adult Steelhead 01Oct – 31Mar
99.9%	598.5	598.3	640.0	598.3
99.0%	613.7	599.4	652.2	604.6
95.0%	702.7	680.3	725.6	691.8
90.0%	726.0	717.3	742.9	722.8
50.0%	788.2	779.4	794.0	784.5
10.0%	812.4	798.6	813.8	800.3
5.0%	820.3	800.8	818.4	803.6
1.0%	828.2	805.7	826.3	812.3
0.1%	829.5	808.9	828.5	819.4

Table 5.2-7 provides the percent exceedance of mean daily pool elevation for the Base Case operational scenario over an annual basis. The data shows that the median pool elevation on an annual basis is approximately 797.4 feet, which is 9.2 feet higher than Historical observations. Observed elevations, which account for 80 percent of Base Case conditions from a probability of 10 to 90 percent of time exceeded, would range from 698.5 to 818.5 feet. From 5 to 95 percent, which accounts for 90 percent of Base Case conditions, the range of elevations would be from 654.8 to 825.3 feet. From 1 to 99 percent, which accounts for 98 percent of Historical conditions, the range of elevations would be from 622.9 to 830.0 feet. Given these observations, Base Case annual pool fluctuations of 120 feet may be exceeded 20 percent of the time, 170 feet may be exceeded 10 percent of the time, and 207 feet were exceeded 2 percent of the time.

**Table 5.2-7. Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for the Base Case operational scenario (Oct 1, 1970 to Sept 30, 2012).**

Percent of Time Exceeded	Pool Elevation (ft)
99.9%	616.3
99.0%	622.9
95.0%	654.8
90.0%	698.5
80.0%	739.4
50.0%	797.4
20.0%	809.2
10.0%	818.5
5.0%	825.3
1.0%	830.0
0.1%	830.0

Base Case operational data for the anticipated migration periods of fall-run Chinook, spring-run Chinook, and steelhead were further evaluated. Table 5.2-8 provides the percent exceedance of pool elevation for anticipated outmigration periods while Table 5.2-9 provides results of the same analysis on anticipated upstream migration periods, both for the Base Case operational scenario.

**Table 5.2-8. Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for outmigrating juvenile salmonids using the Base Case operational scenario (Oct 1, 1970 to Sept 30, 2012).**

Percent of Time Exceeded	Base Case Reservoir Elevations (ft)			
	Annual	Outmigration Fall-Run Chinook 01Apr – 30Jun	Outmigration Spring-Run Chinook 01Jan – 31May	Outmigration Steelhead 01Jan – 30Jun
99.9%	616.3	652.3	622.0	622.0
99%	622.9	660.5	632.0	636.0
95%	654.8	682.4	667.2	673.8
90%	698.5	715.5	705.9	707.2
50%	797.4	804.4	801.0	802.1
10%	818.5	826.3	812.5	819.7
5%	825.3	829.6	818.1	826.6
1%	830.0	830.0	824.3	830.0
0.1%	830.0	830.0	830.0	830.0

**Table 5.2-9. Percent exceedance of mean daily pool elevations of Don Pedro Reservoir for arriving adult salmonids using the Base Case operational scenario (Oct 1, 1970 to Sept 30, 2012).**

Percent of Time Exceeded	Base Case Reservoir Elevations (ft)			
	Annual	Arriving Adult Fall-Run Chinook 01Oct – 31Dec	Arriving Adult Spring-Run Chinook 01Mar – 30Jun	Arriving Adult Steelhead 01Oct – 31Mar
99.9%	616.3	616.1	640.3	616.1
99%	622.9	617.5	652.6	621.5
95%	654.8	625.1	682.5	639.1
90%	698.5	667.3	710.5	678.9
50%	797.4	792.9	804.1	794.7
10%	818.5	801.4	823.3	807.1
5%	825.3	803.1	828.6	810.6
1%	830.0	810.1	830.0	821.0
0.1%	830.0	815.6	830.0	829.3

## 5.2.6 Hydrologic Conditions Relevant to Fish Passage

An objective for fish passage design is to provide suitable hydrologic conditions, over a range of stream flows, during the periods in which targeted fish species and life stages are expected to migrate, either upstream or downstream. Data on the recurrence and magnitude of stream flows are necessary for understanding the range of flows anticipated during migration, which directly influences the sizing and complexity of fish passage facilities.

Data on the hydrologic conditions in Don Pedro Reservoir and below LGDD are needed to inform upstream and downstream fish passage design. Upstream fish passage design will be influenced by the flows occurring downstream of LGDD and design for the collection of outmigrating juvenile fish for downstream passage will be influenced by a combination of seasonal flows from unregulated portions of the upper watershed and flows from the portion of the watershed regulated by the CCSF Hetch Hetchy Project. While the natural hydrograph may have the most impact during juvenile outmigration in wetter years, regulated flows may have the most impact in dry water years. During the winter, summer, and fall months, the hydrograph upstream

of the study area will be dominated by operational flows regulated by CCSF facilities. The timing, complexity, and downstream migration triggers of juvenile life stages of the target species are unknown and may vary from what is currently observed in the lower Tuolumne River below LGDD or in other Central Valley rivers where target species are present.

Flow data collected by U.S. Geological Survey gage stations upstream of Don Pedro Dam and downstream of LGDD have limited utility for characterizing the potential frequency, magnitude, and duration of flow needed for evaluating potential fish passage alternatives. Therefore, flow simulations resulting from the Tuolumne River Daily Operations Model were used to assess the potential frequency, magnitude, and duration of flow into Don Pedro Reservoir and downstream of the LGDD (TID/MID 2013a). The flow simulations provide a continuous set of mean daily values for all required locations sufficient to assess factors that may influence development of fish passage facilities concepts. The Historical dataset reflects the combination of both the regulated and unregulated portions of the upper watershed while the calculated Base Case dataset is referred to as the Base Case project operational scenario. The Base Case operational scenario depicts the operation of the Don Pedro Project in accordance with its current FERC license, U.S. Army Corps of Engineers flood management guidelines, and the Districts' irrigation and municipal and industrial water management practices. Detailed summaries of simulation development and the resulting data are presented in Exhibit B, Appendix B-2 of the Don Pedro Hydroelectric Project Final License Application (TID/MID 2014).

#### 5.2.6.1 Inflow to Don Pedro Reservoir

Inflow into Don Pedro Reservoir may be characterized using a combination of Historical observation data and Base Case operational model results. The percent exceedance of flows into Don Pedro Reservoir based upon the Historical dataset is summarized in Table 5.2-10. The calculated values show that the median inflow (50 percent exceeded) to Don Pedro is 1,240 cubic feet per second (cfs) on an annual basis and ranges from 2,319 to 3,213 cfs during the anticipated migration periods of target fish species. The percent exceedance of flows into Don Pedro Reservoir using the Base Case operational scenario is summarized in Table 5.2-11. The median inflow for this scenario to Don Pedro is anticipated to be 860 cfs on an annual basis and ranges from 2,701 to 4,024 cfs during the anticipated migration periods of target fish species.

**Table 5.2-10. Historical exceedance Tuolumne River flows into Don Pedro Reservoir for outmigrating juveniles using a period of record of Oct 1, 1970 to Sept 30, 2012.**

Percent of Time Exceeded	Historical Tuolumne River Flows into Don Pedro Reservoir (cfs)			
	Annual	Outmigration Fall-Run Chinook 01Apr – 30Jun	Outmigration Spring-Run Chinook 01Jan – 31May	Outmigration Steelhead 01Jan – 30Jun
99%	84	184	120	122
95%	194	467	372	366
90%	308	873	654	628
50%	1,240	3,213	2,319	2,415
10%	5,141	7,934	5,927	6,727
5%	7,018	10,044	7,670	8,507
1%	12,037	14,021	12,767	13,332

**Table 5.2-11. Base Case exceedance Tuolumne River flows into Don Pedro Reservoir for outmigrating juveniles using a period of record of Oct 1, 1970 to Sept 30, 2012.**

Percent of Time Exceeded	Base Case Tuolumne River Flows into Don Pedro Reservoir (cfs)			
	Annual	Outmigration Fall-Run Chinook 01Apr – 30Jun	Outmigration Spring-Run Chinook 01Jan – 31May	Outmigration Steelhead 01Jan – 30Jun
99%	101	367	154	162
95%	164	577	309	356
90%	235	859	559	555
50%	860	4,024	2,701	2,781
10%	5,828	8,208	6,854	7,337
5%	7,547	9,489	8,114	8,634
1%	11,449	14,277	11,210	13,568

### 5.2.6.2 River Flow below LGDD

River discharge immediately downstream of LGDD may be characterized using Historical observation data and Base Case operational model results. The percent exceedance of flows based upon the Historical dataset is summarized in Table 5.2-12. The calculated values show that the median discharge (50 percent exceeded) downstream of the La Grange Project is 257 cfs on an annual basis and ranges from 306 to 337 cfs during the anticipated migration periods of target fish species. The percent exceedance of flows below LGDD based upon the Base Case operational scenario is summarized in Table 5.2-13. The median inflow for this scenario is 250 cfs on an annual basis and ranges from 300 to 767 cfs during the anticipated migration periods of target fish species.

**Table 5.2-12. Historical exceedance Tuolumne River flows below LGDD for arriving adults using a period of record of Oct 1, 1970 to Dec 31, 2013.<sup>1</sup>**

Percent of Time Exceeded	Historical Tuolumne River Flows below LGDD (cfs)			
	Annual	Arriving Adult Fall-Run Chinook 01Oct – 31Dec	Arriving Adult Spring-Run Chinook 01Mar – 30Jun	Arriving Adult Steelhead 01Oct – 31Mar
99%	6	2	8	8
95%	11	61	11	92
90%	18	119	17	120
50%	257	306	321	337
10%	3,290	1,460	5,110	3,790
5%	5,000	2,750	7,130	4,930
1%	8,340	4,902	8,830	7,717

<sup>1</sup> The minimum flow release below LGDD was 3 cfs prior to the 1996 settlement agreement. After 1996, operations of the Don Pedro Project were modified to provide no less than 50 cfs even in critical years.

**Table 5.2-13. Base Case exceedance Tuolumne River flows below LGDD for arriving adults using a period of record of Oct 1, 1970 to Sept 30, 2012.**

Percent of Time Exceeded	Base Case Tuolumne River Flows below LGDD (cfs)			
	Annual	Arriving Adult Fall-Run Chinook 01Oct – 31Dec	Arriving Adult Spring-Run Chinook 01Mar – 30Jun	Arriving Adult Steelhead 01Oct – 31Mar
99%	50	126	50	126
95%	50	126	50	150
90%	50	126	75	150
50%	250	300	767	300
10%	3,884	300	5,955	3,572
5%	5,979	1,800	7,499	5,675
1%	8,747	5,310	8,845	8,784

### 5.2.6.3 Minimum Releases to Support Aquatic Resources on the Tuolumne River

In accordance with an agreement with the U.S. Department of the Interior, the San Francisco Public Utilities Commission (SFPUC) releases minimum stream flows from Hetch Hetchy Reservoir (CCSF 2008). Once made, these releases cannot be diverted below O'Shaughnessy Dam (i.e., at Early Intake); they flow down the Tuolumne River, are supplemented by flows from Cherry Creek, releases at Kirkwood and Holm Powerhouse and other tributary flows, and enter Don Pedro Reservoir. A detailed summary of minimum releases required for normal, dry, and critical years is provided in Table 5.3.1-2 of the CCSF Program Environmental Impact Report (CCSF 2008). For normal years, minimum flow releases downstream of Early Intake range from a minimum of 50 cfs in December and January to 125 cfs in June through August. For dry years, minimum flow releases are a minimum of 40 cfs in December and January to 110 cfs in June through August. For critical years, minimum flow releases are a minimum of 35 cfs in December and January to 75 cfs in June through August.

Under its FERC license, the Don Pedro Hydroelectric Project is required to provide minimum stream flows in the lower Tuolumne River. By October 1 of each year, flows are adjusted to meet minimum flow and pulse flow requirements to benefit upstream migrating adult fall-run Chinook salmon. Minimum flows are adjusted on October 16 to benefit spawning, egg incubation, emergence, fry and juvenile development, and smolt outmigration. Another adjustment is made on June 1 and continues through September 30. Minimum flow requirements ranging from "Median Dry" years to "Median Above Normal" years occur approximately 50.8 percent of the observed annual water years. Typical minimum flows during these periods range from 150 to 300 cfs from October 1 to October 16, 150 to 300 cfs from October 16 to May 31, and 75 to 250 cfs from June 1 to September 30.

## 5.3 Design Criteria and Guidelines for Fish Passage Design

NMFS and CDFW have established numerous guidelines and design criteria for fish passage design. Other literature sources are available which provide design guidance and biological criteria for the collection, handling, and transport of fish. Examples of design criteria and guidelines to be used in this assessment include:

- California Salmonid Stream Habitat Restoration Manual Part XII - Fish Passage Design and Implementation. CDFG 2009.
- Fish Screening Criteria. CDFG 2000.
- Fish Screening Criteria for Anadromous Salmonids. NMFS Southwest Region, 1997.
- Anadromous Salmonid Passage Facility Design. NMFS Northwest Region, 2011.
- Fisheries Handbook of Engineering Requirements and Biological Criteria. U.S. Army Corps of Engineers (Milo Bell), 1991.

In addition to design criteria for pool elevation and instream flow, many other design criteria and guidelines are applicable when considering upstream and downstream fish passage facility size, configuration, and complexity.

### **5.3.1 Reservoir Pool Fluctuation Criteria**

Reservoir pool fluctuation is a significant factor in determining the type, size, and complexity of upstream and downstream fish passage facilities. Upstream fish passage technologies may require safe release or exit of fish to the reservoir pool. Downstream fish passage technologies occurring in the reservoir either float or possess multiple inlets to maintain a hydraulic connection with the reservoir surface. Each type of fish technology must accommodate some form of continuous hydraulic connection throughout the anticipated range of pool elevations. As the pool fluctuations become larger, so does the facility. In many cases, certain fish passage technologies can be dismissed due to pool fluctuation alone.

The overall fish passage performance of downstream passage facilities is measured based upon reservoir passage efficiency, collection efficiency, passage efficiency to a downstream release point, and percent mortality. Typical expectations for facilities of this type often fall in the range of 85 to 95 percent overall. The overall fish passage performance expectations of upstream passage facilities are similar in nature but based upon different evaluation factors such as migration delay, collection efficiency at the facility entrance, fall back, rate at which fish are passed, and stress and mortality considerations.

Don Pedro Reservoir experiences a high level of seasonal fluctuation (see Section 5.2.5), which suggests that downstream facilities may be required to accommodate reservoir pool fluctuations on the order of 200 feet while upstream fish passage facilities may be required to accommodate reservoir pool fluctuations on the order of 230 feet.

The expectations for facility performance are unknown at this time and the above information is presented as a generalization based upon the operational requirements of other facilities. These requirements are typically set through consultation with fisheries agencies and are necessary to proceed further with the assessment of engineering and economic feasibility. Further input from LPs is required to determine performance criteria and expectations for this study. After the performance criteria and operational expectations are identified, several key factors can be selected such as the target range of reservoir elevations for accommodating upstream and downstream fish passage.



### 5.3.2 River Flow Design Criteria

Fish passage design flow criteria influences a number of factors associated with fish passage facility size and complexity. Guidelines presented by NMFS are based on exceedance calculations of daily mean flows but can be modified to suit site-specific requirements. The exceedance flows statistically represent the flow equaled or exceeded during certain percentages of the time when migrating fish may be present or collected at a facility. The established guidelines are used to set instream flow depths, flow velocities, debris and bedload conditions, fish attraction requirements, tailwater fluctuations, and numerous other factors which a facility may experience during anticipated operational periods.

NMFS (2011) states that the upper limit of operation for fish passage design shall be the mean daily streamflow that is exceeded 5 percent of the time during periods when migrating fish may be present. NMFS (2011) also states that the lower limit for operation shall equal the mean daily average streamflow that is exceeded 95 percent of the time during periods when migrating fish may be present. These criteria are generally applied to facilities which are designed to collect adult anadromous salmon and steelhead migrating upstream. Currently, there are no full-scale downstream in-river collection facilities for outmigrating juvenile fish and post-spawn adult fish. As such, there are no associated guidelines for such a facility. The anticipated operational range will largely be a function of the stipulated performance requirements if such a facility is to be permitted and constructed. Therefore, the same 5 to 95 percent guidelines are assumed for downstream collection facilities as well.

Design flow criteria for downstream in-river collection facilities would rely on records and corresponding percent exceedance values for river flows entering at the head of Don Pedro Reservoir. These values are presented in Section 5.2.6.1. Design flow criteria for upstream collection facilities would rely on the records and corresponding percent exceedance values for river flows passing downstream of LGDD. These values are presented in Section 5.2.6.2. The anticipated low (exceeded 95 percent of the time) and high (exceeded 5 percent of the time) fish passage design flows for upstream and downstream collection facilities are summarized in Table 5.3-1.

**Table 5.3-1. Fish passage facility flows calculated for the anticipated period of migration for target fish species.**

<b>Facility Type (hydrologic scenario)</b>	<b>Low Design Flow (cfs) NMFS (95% Exceedance)</b>	<b>High Design Flow (cfs) NMFS (5% Exceedance)</b>
Upstream (Historical)	11 <sup>1</sup>	7,130
Upstream (Base Case)	50	7,499
Downstream (Historical)	366	10,044
Downstream (Base Case)	309	9,489

<sup>1</sup> Although the statistical calculations identify a low design flow of 11 cfs, this low flow value will likely be regulated by the minimum flow release schedule (TID/MID 2013a). The flow release schedule suggests that minimum river flows will likely be on the order of 150 to 300 cfs for most of the primary migration period between October 1 and May 31 and may only reach a low flow of 50 cfs during the worst of drought years. Therefore, the selected range of flows to be used for concept upstream fish passage facility development is 50 to 7,499 cfs.

Concept-level designs for upstream fish passage facilities will be formulated to promote passage during the anticipated range of migration flows, which is the lowest of the low design flows through the highest of the high design flows. Based on the Historical dataset, the range of design flows is 11 cfs to 7,130 cfs. Based on the Base Case operational scenario data, the range of design flows is 50 cfs to 7,499 cfs. During flows above or below the range of design flows, compliance with fish passage criteria is not assured and is typically not expected by regulatory agencies.

Concept-level designs for downstream fish passage facilities that are to be constructed in-river will also be formulated to accommodate passage throughout a similar range of anticipated migration flows. The resulting low design flow for downstream facilities is 366 cfs and the high fish passage design flow is approximately 10,044 cfs using Historical observations. The resulting range of flows is 309 to 9,489 cfs using Base Case operational scenario data. Low flow values will be regulated by the minimum flow release schedule adhered to by CCSF. Therefore, the selected range of flows to be used for concept downstream fish passage facility development is 50 to 9,489 cfs. Since these statistics are based upon duration of time when fish are anticipated to occur, design flow criteria will require revision as fish species migration timing is finalized with input from the LPs.

### 5.3.3 Fish Screen Criteria

Any water diversions that could capture fish and introduce them into areas or flow paths that the fish cannot escape must include fish screens. The exception is both low- and high-head hydropower facilities where other means are implemented to reduce harm to outmigrating fish such as Eicher screens and/or fish-friendly turbine technologies. Specific criteria relative to adequate screen area, maintenance features, and facility hydraulics must be met to ensure compliance with regulatory requirements. Fish screens are designed using the Screening Criteria Guidelines provided by CDFG (2000) and the NMFS Northwest Region's Anadromous Salmonid Passage Facility Design (NMFS 2011). The intent of the fish screen criteria is to provide design guidelines and criteria that protect juvenile fish from entrainment or impingement and to guide juveniles to a collection and/or bypass system.

The following is a summary of fish screen criteria for the design of a screening system:

- **Structure Orientation** – In a river, the screen must be oriented parallel to river flow. Upstream and downstream transitions must minimize eddies. In a reservoir, the screening and bypass system must be designed to withdraw water from the appropriate elevation for best fish attraction and providing appropriate water temperature control downstream. The design must accommodate the entire range of forebay fluctuations (NMFS 2011).
- **Screen Size** – The minimum screen area required is determined by dividing the maximum screened flow by the allowable approach velocity (NMFS 2011).
- **Approach Velocity** – Uniform approach velocity must be provided across the face of the screen. Approach velocity for the listed target species must be less than 0.33 feet/second (ft/s) for actively cleaned systems and measures to adjust flow patterns across the face of the screen to ensure uniformity is maintained must be provided (CDFG 2000). Approach velocities of 0.4 or 0.2 ft/s are allowed for diversions less than 40 cfs (CDFG 2000). For

passively cleaned screens, approach velocity must not exceed 0.2 ft/s (CDFG 2000; NMFS 2011).

- **Sweeping Velocity** – The sweeping velocity should be greater than the approach velocity. Sweeping velocity must be maintained or gradually increase for the entire length of screen (CDFG 2000; NMFS 2011).
- **Travel Time** – Fish can only be exposed to a screen face for a maximum of 60 seconds, assuming fish are moving at a rate equal to the sweeping velocity (CDFG 2000; NMFS 2011).
- **Screen Openings** – For salmonid fry, screen opening size must not exceed 1.75 mm, with a minimum open area of 27 percent. If the screen is made from wire mesh or perforated plate, the screen opening size must not exceed 3/32 inches, with a minimum open area of 27 percent (CDFG 2000; NMFS 2011).
- **Screen Materials** – The screens must be constructed of rigid, corrosion-resistant material with no sharp edges or projections (e.g., stainless steel, plastic) (NMFS 2011).
- **Screen Cleaning** – Automatically cleaned screens are referred to as active screens. Cleaning systems should provide complete debris removal at least every 5 minutes and operated as required to prevent debris accumulation. The cleaning system should be automatically triggered if the head differential across the screen exceeds 0.1 feet or as agreed to by NMFS (NMFS 2011).
- **Redundancy** – Although not required by fisheries regulatory agencies, it is common design practice to oversize screen area for maximum diversion by a factor of 1.2 to 1.3 (BOR et al. 2006).

### 5.3.4 Fish Bypass Criteria

Bypass systems are designed to facilitate both juvenile and adult fish downstream passage back to the river system, typically around a diversion or fish screen system, in a manner that minimizes risk of injury and delay. Fish bypass systems typically contain three major components: the bypass entrance, conduit, and exit.

#### 5.3.4.1 Bypass Entrance Criteria

- **Flow Control** – Independent flow control should be provided at each bypass entrance (NMFS 2011).
- **Travel Time** – Fish are to enter a bypass within 60 seconds of exposure to any length of screen (NMFS 2011).
- **Velocity** – Bypass entrance velocity must be greater than 110 percent of the maximum screen-sweeping velocity. Velocity should not decrease between the screen terminus and bypass entrance and should accelerate gradually (NMFS 2011).
- **Acceleration** – The flow should not decelerate and should not exceed an acceleration rate of 0.2 ft/s per foot of travel (NMFS 2011).

- Lighting – Ambient lighting is required at the entrance to the bypass flow control (NMFS 2011).
- Dimensions – Bypass entrance should be a minimum of 18 inches wide, and its height must extend from floor of the screen to water surface (NMFS 2011). For weirs used in bypass systems that have diversions greater than 25 cfs, a minimum weir depth of 1 foot should be maintained throughout the smolt out-migration period (NMFS 2011).
- Juvenile Capture Velocity – A minimum velocity of 8 ft/s is a common design threshold used in situations that require the capture of juvenile salmonids. Experience with current projects will be considered if a bypass system becomes part of the facility design.

#### 5.3.4.2 Bypass Conduit Criteria

- Materials and fittings – Smooth pipes, joints, and other interior surfaces are required to minimize turbulence and the potential for fish injury. Closure valves should not be used within the bypass pipe (NMFS 2011).
- Flow Transitions – Pumping if fish are within the bypass system is not allowed. If site conditions permit, bypass flows should be open channel (NMFS 2011). Where site conditions do not permit open channel bypass flows, a bypass pipe may be used. NMFS criteria state that pressures within bypass pipes must be equal to or above atmospheric pressure. NMFS criteria also state that transitions from pressurized to non-pressurized (or vice-versa) should be avoided within the pipe. Free-fall of fish within a pipe or enclosed conduit within the bypass system is not allowed (NFMS 2011).
- Bypass Flow – Bypass flow should be approximately 5 percent of the total screened flow (NMFS 2011). Based on professional judgment, this proportion may be considered a minimum. Higher bypass flow proportions will be considered if a bypass is included in the design.
- Velocity – NMFS criteria state the bypass pipe should be designed to have velocities between 6 and 12 ft/s; however, higher velocities can be approved with special attention to pipe and joint smoothness (NMFS 2011).
- Geometry – NMFS requires the open channel or pipe diameter to be sized based on bypass flow and slope in order to meet other bypass conduit criteria.
- Bends – The ratio of bypass centerline to pipe diameter must be 5 or greater, and larger ratios may be required for super-critical velocities (NMFS 2011).
- Depth – NMFS criteria requires a minimum depth of at least 40 percent of the bypass pipe diameter, unless otherwise approved (NMFS 2011).
- Hydraulic Jump – Hydraulic jumps should not occur within the pipe (NMFS 2011).

#### 5.3.4.3 Bypass Exit Criteria

- Velocity – The outfall impact velocity, which is the velocity of the bypass flow entering the river, should not exceed 25 ft/s (NFMS 2011).

- Location – The outfall should be located in an area with strong downstream currents, at least 4 ft/s, free of eddies, reverse flow, or likely predator habitat. The outfall should also be located in an area with sufficient depth to avoid fish injuries (NMFS 2011).
- Adult Attraction – The bypass outfall must be designed to avoid the attraction of upstream migrants. Upstream migrants might leap at the outfall; therefore, provisions for minimizing risk of injury or stranding on the bank must be included in the outfall design (NMFS 2011). This criteria is only applicable where upstream and downstream passage facilities are separate.

#### 5.3.4.4 Velocity Barrier Criteria

Velocity barriers create a combination of shallow depth and high velocity conditions that restrict a fish's ability to swim and leap into oncoming flow. Barriers are commonly used to help guide upstream migrating fish to the entrance of a fish passage facility. A velocity barrier typically consists of a full-spanning concrete apron that distributes streamflow evenly across the width of the channel, and a vertical weir that is higher than the leaping ability of the target fish species. Velocity barrier design guidelines for anadromous salmonids have been developed by NMFS (NMFS 2011) and include the following:

- The minimum weir height relative to the maximum apron elevation is 3.5 feet.
- The minimum apron length (extending downstream from base of weir) is 16 feet.
- The minimum apron downstream slope is 16:1 (horizontal:vertical).
- The maximum head over the weir crest is 2 feet.
- The elevation of the downstream end of the apron shall be greater than the tailrace water surface elevation corresponding to the high design flow.
- Other combinations of weir height and weir crest head may be approved by NMFS on a site-specific basis.
- The flow over the weir must be fully and continuously vented along its entire length, to allow a fully aerated nappe to develop between the weir crest and the apron.

#### 5.3.5 Fishway Criteria

Upstream fish passage designs at dams use widely recognized fishway design guidelines and references and are traditionally designed for the adult fish life stage. There are three major components to a fishway: the fishway entrance, fish ladder, and fishway exit. The primary objective of the fishway entrance is to maximize fish attraction. A fish ladder provides hydraulic conditions that promote fish passage up and around a passage barrier. The fishway exit maintains hydraulic conditions suitable for fish passage for the range of forebay or reservoir water surface elevations. Design criteria specific to each component is presented below.

#### 5.3.5.1 Fishway Entrance

- Entrance Location – The entrance located should be based on site-specific operations and stream flow characteristics. Entrances must be placed in locations where fish can easily locate the attraction flow. Multiple entrances may be required if the site has multiple locations where fish hold (NMFS 2011).
- Entrance Geometry – The entrance should have a minimum width of 4 feet and depth of 6 feet (NMFS 2011).
- Entrance Head Differential– The head differential at the entrance should be maintained between 1.0 and 1.5 feet (NMFS 2011).
- Attraction Flow – Minimum 5 to 10 percent of high fish passage design flow (NMFS 2011). Fishway attraction flow must be adequate to compete with spillway or powerhouse flows for attraction of fish. Auxiliary water systems may be used to increase the fishway entrance attraction flow.

#### 5.3.5.2 Fish Ladder Design

- Head Differential – The hydraulic drop between each pool within the fish ladder must be a maximum of 1 foot (NMFS 2011).
- Minimum Pool Dimensions – Minimum of 8 feet long, 6 feet wide, and 5 feet deep (NMFS 2011).
- Energy Dissipation Factor (EDF) – Each pool volume should be sized to have a maximum energy dissipation factor of 4 ft-lb/sec/ft<sup>3</sup>. Only the volume of the pool having active flow and contributing to energy dissipation should be included in the energy dissipation calculation (NMFS 2011).
- Minimum Depth Over Weirs – Overflow weirs in fishways should have 1 foot of flow depth over weirs (NMFS 2011).
- Turning pools – Turning pools are required at each location where the fishway bends more than 90°. Turning pools should be at least double the length of the designed standard pool measured along the centerline (NMFS 2011).
- Orifice Dimensions – NMFS criteria state orifices should be a minimum of 15 inches high and 12 inches wide (NMFS 2011).
- Freeboard – Freeboard must be a minimum of 3 feet within the fish ladder at the high design flow (NMFS 2011).
- Lighting – The use of ambient lighting throughout the entire fishway is preferred. Abrupt lighting changes within the fishway are not allowed (NMFS 2011).

#### 5.3.5.3 Fishway Exit

- Head Differential – The fishway exit head differential should range from 0.25 to 1.0 feet (NMFS 2011). In order to accommodate forebay fluctuations this may require the use of

adjustable weirs, multiple exits at different elevations, or other engineered solutions that accommodate forebay fluctuations.

- Length – A minimum channel length of two standard ladder pools should be incorporated upstream of the exit control (NMFS 2011).
- Location – The exit should be located along the shoreline at a location with similar depths to those within the fishway and with velocities less than 4.0 ft/s. Exits should be located well upstream of spillways, sluiceways, and powerhouses to minimize the risk of being swept downstream.
- Debris Rack – Coarse trash racks should be installed at the fishway exit and must be oriented at a deflection angle greater than 45° relative to the river flow (NMFS 2011).

### **5.3.6 Debris Rack Criteria**

Debris racks are commonly used to exclude large debris from entering fish passage facilities. Debris rack openings should be a minimum of 8 inches clear, or 12 inches clear if adult Chinook are present. NMFS criteria state that approach velocity should be less than 1.5 ft/s. Debris racks should be sloped at 1:5 or flatter to assist with manual cleaning. In systems with coarse floating debris, debris booms or other provisions must be incorporated into the debris rack design (NMFS 2011).

### **5.3.7 Fish Trapping and Holding Criteria**

If the design requires trapping, holding, and handling of fish then the following criteria apply:

- Holding Pool Volume – Fish holding pools must be sized to provide a minimum volume of 0.25 cubic feet per pound of fish. For holding durations greater than 72 hours, holding pool volumes should be increased by a factor of three. The maximum daily fish return, or number of fish expected to be trapped before fish are removed, is used to determine the required trap capacity (NMFS 2011).
- Temperature – Water temperatures must be less than 50° F. If temperatures exceed this threshold, the poundage of fish held should be reduced 5 percent for each degree above 50° F (NMFS 2011). Use of these criteria must include consideration of water temperatures typically experienced by target fish species in the Tuolumne River. As an example, Mokelumne River juveniles collected for transport are held in water temperatures of approximately 70° F (21.1° C).
- Dissolved Oxygen – Must be maintained between 6 and 7 parts per million (NMFS 2011).
- Water Supply – A minimum of 0.67 gallons per minute per adult fish must be supplied to the holding pool (NMFS 2011).
- Handling – Fish must be handled with extreme care and use of nets should be minimized or eliminated. Fish should be anesthetized before being handled and should only be handled by individuals trained to safely handle fish (NMFS 2011).
- Frequency of Removal – Fish must not remain in traps for more than a day. Traps may have to be cleared more often to prevent crowding or adverse water quality (NMFS 2011).

- Adult Jumping Provisions – Fish may be injured by jumping and provisions must be included in the holding pool design to minimize adult jumping. Provisions can include: freeboard of 5 feet or more; covering of the holding pool to create a darkened environment; use of netting over the pool; or sprinklers above the holding pool (NMFS 2011).
- Segregation of fish – Specific criteria for segregating different species and life stages of fish are established on a site-specific basis. This could include picket panels, screens, and other materials to limit certain sizes of fish holding in pools.

## 5.4 Factors that Require Further Consideration

There are a number of remaining factors that require careful consideration before siting, selecting and formulating fish passage alternatives for both adult and juvenile life stages of target fish species. The following list summarizes additional considerations that should be evaluated prior to subsequent phases of alternatives development.

- Confirmation of Target Species – The target species must still be agreed upon. None of the three potential target anadromous species currently occur above Don Pedro Reservoir. The viability, funding, or planning of such reintroduction is unknown at this time and therefore the inclusion of these three target species into the Fish Passage Alternatives Assessment is speculative. Further discussion and concurrence with LPs is necessary to finalize target species.
- Migration Timing for Various Life Stages – The migration timing of target fish species has a significant influence on the applicability and selection of potentially viable fish passage facilities alternatives. Information on the seasonal timing of adult and juvenile passage would be required for all three of the potential target fish species for use in the Fish Passage Alternatives Assessment. Currently, assumptions regarding these factors are only available through other regional data sources where populations of these species currently exist. Input from LPs is required to finalize assumptions regarding these potential future populations and their various life history characteristics.
- Population Size and Peak Run Values – The number of fish to be passed has a significant impact on the size and configuration of facility components. At the time this document was prepared, there is no known or assumed population numbers or objectives set forth for the upper Tuolumne River relative to the target species assumed to be reintroduced. Information on the availability of suitable habitat and potential carrying capacity for all relevant life stages of target species (e.g., adult spawning, juvenile rearing, etc.) in the reintroduction area will be necessary to inform potential population sizes and peak run values that should inform the specific facility design characteristics.
- Performance Criteria and Expectations – Fish passage facility designs and their operation are highly influenced by performance expectations and compliance requirements scripted by fisheries resource agencies. Performance factors may include reservoir passage efficiency, collection efficiency, combined passage efficiency, and mortality. As with other factors mentioned herein, these performance criteria affect the type, size, and complexity of a facility which ultimately impacts both capital and lifecycle costs. More information is required from



LPs to confirm the performance criteria and expectations for potential fish passage facilities considered in this study.

- **Suitability of Reservoir Passage** – Reservoirs foster slow and deep hydraulic conditions which provide habitat for predators of outmigrating juvenile fish. The potential for predation on target species and its effect on escapement objectives should be evaluated prior to final determination of facility siting and technology selection. As noted above in Section 1.3, the applicability of reservoir passage will be evaluated if fish passage alternatives requiring reservoir passage are selected for further development in Phase 2.
- **Suitability of Reservoir Water Quality**– In addition to predation, reservoir water quality (temperature and dissolved oxygen levels, etc.) can have a detrimental impact on both adult and juvenile life stages. Water quality, the potential residence time for fish in the reservoir, and any potential detrimental effects of such adverse conditions will be evaluated if alternatives requiring reservoir passage are selected for further development in Phase 2.
- **Water Supply** – All upstream fish passage facilities require operational flow and fish attraction flow to successfully guide fish to a facility entrance and to support fish handling systems. The source of the supplied water will need to be of a unique temperature and water quality that attracts fish to a facility entrance and sufficiently maintains their health when in a holding facility prior to transport. The source and type of water required will be evaluated further as the alternative evaluation and design development moves forward.
- **Power Supply** – Virtually all fish passage technology options of the magnitude considered in this assessment will require some level of electrical power supply to operate measurement, automated control, monitoring, lighting, pumping, and other miscellaneous systems. The accessibility to power supply for each potential location should be evaluated prior to final determination of facility siting and technology selection.
- **Reservoir Recreation** – Don Pedro Reservoir fosters a high level of sport fishing, boat touring, and aquatic activities. When backwatered, the head of reservoir is used heavily by rafters to access the take-out point at Wards Ferry Bridge. Fish passage facilities present within the reservoir may interfere with such public activities and in some cases may become a safety hazard. Careful consideration of both safety and interference with existing recreational opportunities should be considered as the design process moves forward.

## 6.0 DISCUSSION AND FINDINGS

---

Results presented in this document provide a summary of consultation with LPs and site-specific considerations and potential design criteria that may be carried forward into Phase 2. However, given that anadromous salmonids are not currently present in the target reintroduction area, much of the biological information presented above is based upon assumptions. Therefore, this information may not be representative of current or future conditions in the Tuolumne River. In addition, there are numerous data gaps relevant to informing the biological basis of design for concept alternatives. Feedback from LPs on these factors is necessary to advance the study with confidence in the biological assumptions.

Through a series of Workshops conducted in 2015 and 2016, the Districts in collaboration with LPs plan to broaden the scope of the Fish Passage Alternatives Assessment to implement an Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework process. Elements of the framework are interconnected where fish passage engineering and design represent one of several key elements that require evaluation. Other reintroduction elements include ecological feasibility and biological constraints and economic, regulatory, and other key considerations. As discussed in Section 5.1 above, fish passage in the Tuolumne River is fundamentally a decision to pursue fish reintroduction and as such, fish passage should be evaluated in this broader context. Additionally, TM No. 1 identified data gaps and assumptions that are critical to advancing the fish passage design process and the framework would provide an opportunity for collecting this information and confirming biological assumptions. The design, construction, and operation of fish passage facilities can be extremely complex and costly. As such, a thorough investigation of the engineering, biological, regulatory, and economic issues surrounding such a proposal is necessary to ensure that reintroduction is appropriate and rigorously collected and scientifically defensible information is available to inform cost-effective and efficient fish passage facility design. LPs identified January 27, 2016 for a meeting to begin the Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework process. For this meeting, a draft process and schedule, a summary of potential information gaps, and a preliminary studies list (to address information gaps) will be developed to help define 2016 activities. At the time of report development, meeting information was not available for inclusion in this document. However, if at the January 27, 2016 meeting, consensus is achieved on framework process and schedule, information gaps, and needed 2016 studies, this information will be presented at the ISR meeting on February 25, 2016 and included in meeting notes filed with FERC.

## **7.0 STUDY VARIANCES AND MODIFICATIONS**

---

There has been one modification and no variances to the study. The FERC-approved study plan states that Phase 1 will occur in 2015 and Phase 2 will occur in 2016. As noted above, Phase 1 will continue into 2016 to allow for coordination with LPs on the Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework process.

## 8.0 REFERENCES

---

- Anderson, J. H. et al. 2014. Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery. *North American Journal of Fisheries Management*, 34:1, 72-93.
- Bell, M. 1991. *Fisheries Handbook of Engineering Requirements and Biological Criteria*. U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.
- Bureau of Reclamation (BOR) et al. 2006. *Fish Protection at Water Diversions: A Guide for Planning and Designing Fish Exclusion Facilities*. April 2006.
- \_\_\_\_\_. 2013. Public Review Draft of the Bay Delta Conservation Plan Draft Environmental Impact Report/ Environmental Impact Statement. <http://baydeltaconservationplan.com/EnvironmentalReview/EnvironmentalReview/2013-2014PublicReview/2013PublicReviewDraftEIR-EIS.aspx>. Accessed December 2015.
- California Department of Fish and Game (CDFG). 2000. *Fish Screening Criteria*.
- \_\_\_\_\_. 2009. *California Salmonid Stream Habitat Restoration Manual Part XII Fish Passage Design and Implementation*.
- City and County of San Francisco (CCSF). 2008. *Final Program Environmental Impact Report for the San Francisco Public Utilities Commission Water System Improvement Program: Volume 3 of 8*. October, 30, 2008.
- Ford, T., and S. Kiriara. 2010. *Tuolumne River *Oncorhynchus mykiss* monitoring report*. Prepared by Turlock Irrigation District/Modesto Irrigation District, California and Stillwater Sciences, Berkeley, California for Federal Energy Regulatory Commission, Washington, D.C. January.
- Moyle, P.B. 2002. *Inland fishes of California*. University of California Press, Berkeley, California. 408 pp.
- National Marine Fisheries Service (NMFS). 1997. *Fish Screening Criteria for Anadromous Salmonids*. Southwest Region.
- \_\_\_\_\_. 1999. *Endangered and Threatened Species; Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California*. Final Rule. *Federal Register* 64, No. 179 (September 16, 1999): 50394-50415.
- \_\_\_\_\_. 2011. *Anadromous Salmonid Passage Facility Design*. NMFS, Northwest Region, Portland, Oregon.
- \_\_\_\_\_. 2014. *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the*

- Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office. July 2014.
- Tuolumne River Technical Advisory Committee (TRTAC). 2000. Habitat Restoration Plan for the Lower Tuolumne River Corridor.
- Turlock Irrigation District and Modesto Irrigation District (TID/MID). 2010. FERC - 2009 Lower Tuolumne River Annual Report.
- \_\_\_\_\_. 2013a. Project Operations/Water Balance Model Study Report (W&AR-02). Prepared by Dan Steiner. December 2013.
- \_\_\_\_\_. 2013b. Salmonid Population Information Integration and Synthesis Study Report (W&AR-05). Prepared by Stillwater Sciences. January 2013.
- \_\_\_\_\_. 2014. Don Pedro Hydroelectric Project Final License Application. April 2014.
- \_\_\_\_\_. 2016a. Fish Barrier Assessment Progress Report. Prepared by FISHBIO. Attachment to La Grange Hydroelectric Project Initial Study Report. February 2016.
- \_\_\_\_\_. 2016b. Upper Tuolumne River Basin Fish Migration Barriers Study Progress Report. Prepared by HDR, Inc. Attachment to La Grange Hydroelectric Project Initial Study Report. February 2016.
- \_\_\_\_\_. 2016c. Upper Tuolumne River Basin Water Temperature Monitoring and Modeling Study Progress Report. Prepared by Watercourse Engineering, Inc. Attachment to La Grange Hydroelectric Project Initial Study Report. February 2016.
- Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. Pages 71–176 in R.L. Brown, editor. Contributions to the biology of Central Valley salmonids. California Department of Fish and Game Bulletin 179.
- Zimmerman, C. E, G. W. Edwards, and K. Perry. 2009. Maternal origin and migratory history of steelhead and rainbow trout captured in rivers of the Central Valley, California. Transactions of the American Fisheries Society 138: 280–291.

**FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT  
PROGRESS REPORT**

**ATTACHMENT A**

**RECORD OF CONSULTATION FOR PHASE 1**

This Page Intentionally Left Blank.

**Workshop No. 1**

**May 20, 2015**



**La Grange Hydroelectric Project Licensing (FERC No. 14581)**  
**Fish Passage Assessment Workshop No. 1**  
**Modesto Irrigation District**  
**1231 11<sup>th</sup> Street, Modesto, California**

**Wednesday, May 20, 2015**  
**9:00 am to 12:00 pm**

**Meeting Notes**

On May 20, 2015, Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) hosted the first of a series of Workshops for the La Grange Hydroelectric Project Fish Passage Facilities Assessment (the Study). This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting. Attachment A to this document includes the following meeting documents: agenda, sign-in sheet, presentations, and handouts.

Mr. John Devine of HDR, Inc. (HDR), consultant to the Districts, welcomed meeting attendees. Attendees went around the room and introduced themselves. Attendees on the phone introduced themselves; Mr. Tom Engstrom of Sierra Pacific and Mr. Bob Hughes of CDFW were the only two individuals participating remotely (see Attachment A: meeting sign-in sheet).

Mr. Devine provided an introduction to the Workshop. He stated that this is the first of three planned collaborative workshops on the subject of evaluating the various factors regarding the feasibility of implementing upstream and downstream anadromous fish passage at the La Grange Diversion Dam and the Don Pedro Dam. Among today's attendees, there is a wide range of expertise and knowledge related to the topic of fish passage, the issues involved in the investigation of fish passage, and the regulatory process surrounding fish passage decision-making. In light of this, Mr. Devine said this first Workshop would primarily be focused on educating participants on the potential scope and scale of fish passage facilities, what these facilities might look like, and examples of fish passage at other facilities. The National Marine Fisheries Service (NMFS) will present a description of the agency's Federal Power Act Section 18 mandatory conditioning authority which is the primary regulatory mechanism for prescribing fish passage at hydroelectric facilities as part of the Federal Energy Regulatory Commission (FERC) licensing proceedings. Mr. Devine said that the meeting would also touch on the suitability of habitat above Don Pedro Dam for anadromous fish and other information needs that may be valuable in the overall fish passage decision-making process. The Districts encourage an open and collaborative dialogue at today's meeting; anyone with thoughts or questions is encouraged to speak up.

Mr. Devine stated that the purpose of anadromous fish passage at the La Grange Diversion Dam and Don Pedro Dam is to provide anadromous fish access to river reaches upstream of Don Pedro Dam between Early Intake and Don Pedro Reservoir in order to increase populations of Central Valley spring-run Chinook salmon and steelhead. Mr. Devine noted that the Districts have questions about whether fall-run Chinook salmon are also to be considered as part of this

assessment. Mr. Devine noted that the Districts hope to get clarification on this today. Mr. Devine also noted that Mr. Jim Hastreiter, the FERC Project Manager, would not be able to participate in the Workshop due to NMFS' filing of a Request for Rehearing on one of the studies NMFS requested but FERC rejected. According to FERC, the Request for Rehearing triggers FERC's legal protocols governing *ex parte* communications and thereby prevents Mr. Hastreiter, or any other FERC staff members, from participating in this Workshop.

Mr. Devine said that the design, construction and operation of fish passage facilities at high-head dams can be very complex and costly. The Districts hope that through the series of workshops and the La Grange Fish Passage Facilities Assessment, a thorough investigation of the engineering, biological, regulatory, and economic issues surrounding fish passage will be completed. As currently proposed, the Study will be a two-year process. Through these workshops, the Districts' role is to develop an understanding of design criteria for fish passage facilities at La Grange and Don Pedro dams, evaluate what facilities would be most appropriate, and prepare detailed cost estimates. Mr. Devine reiterated that this is a two-year process and that during this first year, the goal is for all parties to come together as a group to thoroughly discuss the feasibility of providing fish passage by getting all the issues related to the reintroduction of anadromous fish to the river above Don Pedro Reservoir on the table. He noted that providing fish passage would result in anadromous fish having access to the upper Tuolumne River where they are currently not present. The use of this reach by anadromous fish will constitute another managed use of the existing resource.

Mr. Devine presented introductory slides. Mr. Devine described the La Grange Project and gave an overview of the La Grange Project Integrated Licensing Process (ILP). The Fish Passage Facilities Assessment is one component of a larger study about fish passage. Mr. Devine reviewed the objectives of the overall Fish Passage Facilities Assessment as well as the study area and schedule for reporting. Mr. Devine briefly discussed FERC's February 2, 2015, Study Plan Determination, noting that while FERC required the Districts to develop a study of alternative fish passage facilities and associated cost estimates, FERC indicated it was the responsibility of the resource agencies, and not the Districts, to evaluate the suitability of upstream habitat and preparation of a full anadromous fish life-cycle model, as requested by the agencies. Mr. Devine stated that the Districts were very willing to assist the agencies with certain tasks as they had indicated in their Revised Study Plan, even though not required to do so. He then reviewed the Workshop agenda and introduced Mr. Steve Edmondson of NMFS.

Mr. Edmondson presented slides on the history of hydropower regulation, the Federal Power Act, and details on FERC's environmental analysis and decision-making process. Mr. Edmondson explained that FERC requires studies to understand a project's impacts on developmental and non-developmental resources. He described how other federal legislation plays into the licensing process as well as general methodology for fisheries studies. He reviewed the resource issues commonly raised in FERC relicensing proceedings and the number of FERC hydro projects with fish passage. Lastly, Mr. Edmondson presented on the amount of riverine habitat estimated by NMFS in the overall Central Valley region that had been made unavailable because of dam construction.

Mr. Devine thanked Mr. Edmondson for the presentation. He noted that Mr. Edmondson reviewed the information FERC will use to conduct their environmental analysis and prepare their environmental document. However, as part of the La Grange Hydroelectric Project Licensing, NMFS had indicated a need for significant amounts of information to support fish passage decision-making as detailed in their study requests during the study planning process. Of the studies requested by NMFS, some had been approved by FERC and some had not been approved. Mr. Devine asked that Mr. Edmondson speak to NMFS' Section 18 Authority, as included in the Workshop agenda, and how the information and studies NMFS has requested will be used to decide whether or not to exercise that authority to require fish passage as part of the license proceeding.

Mr. Edmondson responded that NMFS is going to take a hard look at the information in FERC's EIS and from there NMFS would be able to identify the information gaps. NMFS does not require the information requested by studies to make fish passage recommendations. FERC determined the scope of impacts to be from the Golden Gate Bridge to the Tuolumne River headwaters; therefore, FERC will look at the developmental and non-developmental impacts in that reach. Mr. Edmondson noted that FERC included a study about fish passage in the Study Plan Determination because FERC needs basic information about fish passage to undertake its assessment. FERC may itself include fish passage in the license. Mr. Edmondson said that NMFS can recommend fish passage through various parts of the Federal Power Act, including Sections 10(a), 10(j), or 18. In addition to the Federal Power Act, there are according to NMFS other regulatory avenues for requiring fish passage. For example, fish passage may be required under California state law 5937, the Clean Water Act, or the Coastal Zone Management Act, or by federal land management agencies under Section 4(e) of the FPA. Fish passage may also be included in a settlement agreement. Mr. Edmondson stated that NMFS had never required fish passage in California under Section 18. He reiterated that at this time he could not be certain about what information NMFS would need because the information gaps were not yet known.

Mr. Devine said that many individuals attending the workshop do not understand what process NMFS follows under the FPA's Section 18 mandatory conditioning authority. He said it would be helpful for Mr. Edmondson to explain what the prescription is; that it is a mandatory authority (i.e., FERC must accept any Section 18 fishway prescriptions as part of a new license regardless of what FERC determines in its environmental analysis); what information NMFS, as the agency possessing this authority, would use to decide whether to prescribe fishways; and how the decision would be made (e.g., what is the process, how is the information used, are there criteria, is it collaborative, how does NMFS involve all interested parties; what role does economics play, etc.). Mr. Devine noted that both NMFS and the U.S. Fish and Wildlife Service (USFWS) have Federal Power Act Section 18 prescription authority.

Mr. Edmondson replied that it was relatively unusual for the prescription authority to be exercised in California. NMFS had never exercised its Section 18 mandatory conditioning authority in California and, except for the Klamath Project, the USFWS had also never exercised Section 18 authority in the state. The more usual routes for requiring fish passage at a project are by FERC or through settlement. Regarding Section 18 prescription, Mr. Edmondson said NMFS has no specific information requirements and that essentially NMFS uses the best available

information. Mr. Edmondson cited the Edwards Dam Project, in which the best available information indicated that the cost of fish passage outweighed the benefit and the decision was made by FERC to instead remove the dam. Mr. Devine clarified that the Edwards Project dam removal was based on a settlement that was driven politically and not for any inability of the project to pass target species of fish. FERC never issued an order requiring removal of the dam.

Mr. Steve Boyd (TID) thanked Mr. Edmondson for his presentation. He noted that a diverse audience was in attendance today with varying degrees of familiarity with the relicensing process and appreciated what Mr. Edmondson presented. However, Mr. Boyd said that the specific details on how Section 18 was implemented had still not been discussed as contained in the agenda and that the audience would appreciate if NMFS could give an overview of Section 18, what information is required to support the process, and how that information informs a decision to require or not require fish passage.

Mr. Edmondson replied that he thought this meeting was looking at the fish passage engineering study. He said that Section 18 is a section of the Federal Power Act that gives NMFS and USFWS mandatory conditioning authority for fish passage. Mr. Edmondson noted that the bar for prescribing fish passage is fairly low and that a project that provides a barrier to fish going to or from spawning or rearing habitat may trigger Section 18 authority. Mr. Edmondson reiterated that fish passage may also be required under Section 401 of the Clean Water Act, CDFW code, the Coastal Zone Management Act, and by FERC or through settlement. Regarding a decision to require fish passage, Mr. Edmondson said that we are all in the information gathering process and it is unknown where the process will lead.

Mr. Devine said that on the projects he had worked on in the past, including projects all across the country, resource agencies with prescription authority provided their preliminary prescriptions for fish passage during the development of FERC's NEPA document. Once FERC has enough information to start its environmental review, the agencies have 60 days to provide recommendations, including preliminary prescriptions under Section 18. In other words, the preliminary prescriptions are considered early in the process before preparation of the environmental document. At this stage of the process, there is supposed to be sufficient information available for NMFS or USFWS to make their decision, though preliminary, about whether to prescribe fish passage. Mr. Devine stated that he was not familiar with any project where the initial agency fish passage prescriptions did not occur until after FERC issued the EIS. In fact, the ILP requires the initial prescriptions be filed early in the FERC review process. Mr. Edmondson said that after FERC issues a notice of Ready for Environmental Analysis (REA), NMFS provides preliminary terms and conditions for use in the NEPA process. At this time it is unknown whether other agencies or FERC will use their authorities. It is unknown what the available information will be at the time. Those decisions are down the road; it is not even known yet whether it is possible to provide fish passage.

Mr. Edmondson said that the first cut at the information would be to determine if there is historical habitat above Don Pedro Dam. Considering the Lindley analysis (Lindley 2007), it appears that fish used to be able to reach the headwaters and now they cannot. The second cut would determine if fish passage is possible and feasible through engineering and whether fish

passage is consistent with agency management plans. Just because something can be done does not mean it should be done. The final step is FERC would weigh the developmental and non-developmental effects to determine if fish passage makes sense. This process happens in the “black box” at FERC, according to NMFS.

Mr. Devine requested that Mr. Edmondson touch on the NMFS Recovery Plan (NMFS 2014) and the relationship of the recovery plan to the species being considered for fish passage. Mr. Edmondson replied that Section 4 of the Endangered Species Act required NMFS to publish a recovery plan. A team of 20 individuals with various backgrounds (biology, business, etc.) reviewed existing information and drafted recommendations for recovery criteria. Congress directed NMFS to identify what the standards would be to delist a species. Mr. Edmondson said that the goal of all resource agencies is to delist species. In the recovery plan, the goal for the San Joaquin River is to sustain populations of Chinook salmon and steelhead below the dams and to secure access to habitat for these species above the dams.

Mr. Devine asked what fish species the Study should investigate. He noted that the NMFS recovery plan refers to spring-run Chinook salmon and steelhead. Mr. Edmondson replied that spring-run Chinook salmon and steelhead are the two listed species in the Tuolumne River but are not the only anadromous species in the river. Most fish passage facilities at other projects are for non-listed species and even non-native species. Mr. Edmondson said that there are not currently populations of either spring-run Chinook salmon or steelhead below the dam. Due to federal law resulting from the San Joaquin settlement, NMFS cannot prescribe fishways specifically for spring-run Chinook in the Tuolumne River until 2025.

Meeting took a 10-minute break. Meeting resumed.

Mr. Devine thanked Mr. Edmondson for his presentation and his description of the FERC process. He noted that it was important for participants to understand that both NMFS and USFWS can require fish passage facilities at FERC-licensed projects, whether or not FERC agrees with the need for such facilities. Mr. Devine said that in his experience, FERC had not ordered a licensee to build extensive upstream and downstream fish passage facilities unless required by an agency mandatory condition. He added that even if FERC, through its own analysis, determines that a fishway is unnecessary, the agencies may still require that a fishway be built since Section 18 prescriptions are mandatory.

Mr. Devine introduced Mr. Bao Le (HDR). Mr. Le is the project lead for the Study and has a background in fish biology.

Mr. Le said that the purpose of his presentation was to begin exploring whether consideration of fish passage at La Grange Diversion Dam and Don Pedro Dam was better addressed through a larger and more robust reintroduction evaluation framework since the focal species to be considered as part of any Tuolumne River fish passage program would be comprised of spring-run Chinook and steelhead to comply with the NMFS recovery plan, both of which are reported to have accessed the upper Tuolumne River (above Don Pedro Reservoir) historically, but are not currently present in this reach. As such, any decision by NMFS to require fish passage at La

Grange and Don Pedro would fundamentally be a decision to reintroduce these fish species back to the upper Tuolumne River. Mr. Le stated that his presentation was intended to focus on this idea of reintroduction, the types of information deemed to be critical to informing the planning and decision-making process, and whether agency guidelines existed to implement such a framework. Mr. Le said that after he concludes his presentation, Mr. Chuck Hanson (Hanson Environmental, consultant to the Districts) would present his views about specific information needs for decision-making.

Mr. Le presented slides. Mr. Le reviewed the fish passage study requests and provided an overview of the Anderson et al. paper (Anderson 2014) on planning Pacific salmon and steelhead reintroductions. Mr. Le described the information needed to inform reintroduction (and therefore, fish passage) decision-making. Mr. Hanson presented slides on the general life cycle specific information needs to consider when evaluating fish passage and reintroduction.

Regarding the term “volitional fish passage,” Mr. Peter Drekmeier (Tuolumne River Trust (TRT)) asked what the term “volitional” meant. Mr. Devine replied that volitional means that fish can move upstream and/or downstream under their own power and motivation. For example, fish must “decide”, and be sufficiently fit, to climb a fish ladder in order to migrate upstream past a barrier. In contrast, “trap and haul” fish passage requires that fish be collected, transported, and released under a schedule imposed by human intervention.

Mr. Devine said the Districts thought it would be valuable to provide examples of fish passage facilities at other high-head dam projects. He noted that to his knowledge there are no examples of fish passage facilities at high-head dams in California, but there are a few examples in the Pacific Northwest.

Mr. Michael Garello (HDR) presented slides to introduce the process of developing fish passage engineering concepts. Mr. Garello summarized general design criteria needs for fish passage facilities and provided examples of upstream and downstream fish passage facilities at other projects for anadromous fish.

Referring to slide 12, Mr. Larry Byrd (MID Board Member and area landowner) asked if the downstream fish passage facility screens could become clogged with debris in the river. Mr. Garello replied that the screens had very small openings and could become clogged with debris. He added that in general, screens are cleaned regularly by an automated system and that precautions are often taken upstream to prescreen debris, before the debris can reach the entrance to the fish passage facilities.

Mr. Byrd asked what the fish passage success rate was at the Upper Baker Project. Mr. Garello replied that at that particular project, the licensee had been experimenting with fish passage technology since the 1980s. Over time and through trial and error, the licensee had worked to improve how the fish were guided to collection facilities. To determine the fish collection success rate for downstream passage, fish are tagged and then placed in the reservoir upstream of the entrance to the fish passage facility. The number of tagged fish collected by the fish passage facility helps to determine the collection efficiency. Today, projects are often expected to

achieve fish passage efficiencies as high as 98%. When fish passage facilities are first commissioned, the efficiency is generally lower. Through trial and error and tweaks to operations, efficiencies may be improved. Mr. Devine added that fish passage facilities at high-head dams are still largely experimental and therefore it is hard to predict what the performance will be when the facilities are built. Although resource agencies may require a specific performance metric, because the facilities are experimental, it is difficult to know whether this metric can be achieved. Mr. Devine said that the purpose of Mr. Garelo's presentation was to provide a sense of the scope and scale of fish passage facilities that would likely be considered in the feasibility study to be conducted for Don Pedro and La Grange.

A meeting attendee asked what project has the most successful fish passage facilities. Mr. Garelo replied that every project is different and how success is defined varies from project to project.

Regarding the experimental nature of fish passage facilities at high-head dams, Mr. Devine said upstream passage facilities are much less experimental and there are many examples of successful upstream passage facilities. In contrast, downstream passage facilities at high-head dam projects like Don Pedro are much more difficult to engineer. For downstream passage, young fish need to be guided toward facilities, collected and then moved downstream. For projects like Don Pedro where the reservoir is large, spatially complex, and experiences very significant water level fluctuations (greater than 200 ft), it would likely be very challenging to build a facility that could collect the juvenile fish. The facilities necessary to do this work would be considered experimental, in his opinion.

Mr. Thomas Orvis (Stanislaus County Farm Bureau) added that because Don Pedro Reservoir can fluctuate well over 150 ft, reservoir fluctuation would need to be considered for upstream passage as well, such as where and how the fish would be released into the reservoir. Mr. Garelo agreed that reservoir fluctuation was one of many issues to be considered. Given the reservoir fluctuation, downstream fish passage facilities may need to be sited upstream of the reservoir. Mr. Garelo said that of the five or six fish passage facilities that exist at projects of similar size to Don Pedro Dam, all the facilities collect fish for downstream passage directly at the dam, not at the head of reservoir. Mr. Garelo said he did not know of any high-head dam projects where the downstream fish passage facility was permanent and located at the head of the reservoir. Mr. Garelo reiterated that while he knew of temporary facilities located at the head of the reservoir for data collection, he did not know of any permanent facilities.

Mr. Orvis said that the drought had resulted in changes to temperatures in the reservoir, and that reservoir water temperatures would also need to be considered in this study. Mr. Garelo agreed that water temperature would be among the issues requiring evaluation.

Referring to what Mr. Garelo said about facility performance metrics, Mr. Devine noted performance metrics are specified by the resource agencies and will likely include how many fish, of all the fish moving downstream, must be collected and safely transported downstream. To achieve a 90% collection efficiency or greater in Don Pedro Reservoir, it would likely be insufficient to collect fish using only a collection facility. Fish would need to be directed toward

the facility with guidance systems using large nets that span the entire depth and width of the reservoir at any collection location. Mr. Orvis noted that such nets would also likely have issues with debris blockage. Mr. Devine added that collecting fish upstream of the reservoir was also not without potential issues. For example, the large variability of spring runoff may be a problem at this collection location. All potential issues must be examined.

Mr. Byrd asked how it is determined when the nets will be dropped to corral the fish into the collection facilities. Mr. Garelo replied that the guide nets are left out, and as the fish assemble near the nets, the nets are drawn in, moving the fish to one central location (i.e., collection facility). Mr. Devine said that the guide nets could also have implications for recreational use of the reservoir.

Regarding where fish are released downstream, Mr. Orvis asked if fish predators eventually learn where the fish are released. Mr. Devine replied that such a problem had occurred at other projects and that predator removal was required. A predator removal program would also need to be considered here. According to a study completed for the Don Pedro relicensing (TID/MID 2013), there is a high predation rate in the river below La Grange Diversion Dam. Fish released below La Grange Diversion Dam would be at high risk of predation. These factors would need to be considered, especially in terms of performance metrics. Mr. Devine reiterated that given the high cost of fish passage facilities, it is very important to know the performance metrics at the earliest planning of design. For example, designing for a performance metric of 50% would yield a much different facility than designing for a performance metric of 90%.

Referring to the meeting attendees, Mr. Orvis noted that there were not many TID or MID ratepayers in attendance at the meeting and that it would be the ratepayers who would ultimately be paying the cost for fish passage facilities. Mr. Devine said it was important to note that there are only five or six juvenile downstream collectors currently in existence, and that each was built by an entity, like PacifiCorp or Portland General Electric, with a large number of ratepayers. The Districts collectively have far fewer ratepayers to shoulder the cost of upstream and downstream fish passage facilities. Mr. Devine noted that just the capital costs of such facilities can be in the range of \$100 million.

Mr. Garelo resumed his presentation. Mr. Garelo presented slides related to capital costs of other potentially somewhat similar installations. Slide 18 indicated that construction costs at several fish passage facilities in the Pacific Northwest ranged from \$10.4 million to \$60 million. Mr. Garelo noted that the 2015 Northwest Hydroelectric Association (NWA) annual conference had included a three-member panel discussion about fish passage. Each individual on the panel worked for a licensee with a recent large fish passage project. Regarding the cost of fish passage facilities, Mr. Garelo said that each panelist had noted that, for each of their respective projects, the fish passage facilities had cost 30 – 40% more than had been originally estimated indicating the challenges of designing and operating such facilities.

Mr. Devine said that in his experience, if fish passage facilities are not thoroughly and rigorously evaluated from the very beginning of planning, the resulting design are likely not to achieve the performance metrics required by the agencies. Therefore, it was very important to know from the



very beginning what those performance metrics would be so that the fishway could be planned accordingly. Given the high cost of the facilities, it would be unsatisfactory to build something only to determine that the facility could not achieve the performance metric.

Mr. Devine reiterated the importance of producing realistic cost estimates and the types and level of information needed to do so early in the process. Mr. Byrd asked what the schedule was for producing a cost estimate for this project. Referring to the Study schedule, Mr. Devine replied that a good cost estimate was approximately two years away. He added that to produce an accurate cost estimate, the Districts needed information from the agencies now. For example, if the Districts assume a certain performance metric in the planning, but down the road the agencies provide a different performance metric, the reliability of the cost estimate would be jeopardized.

Mr. Orvis asked what happens if the cost estimate is very high. Mr. Devine asked Mr. Edmondson if the agencies consider costs in their decision-making. Mr. Edmondson replied that FERC considers costs relative to the benefits, but did not indicate how NMFS considers cost. Mr. Devine asked how a determination is made by NMFS that a project is too costly. Mr. Edmondson replied that all the issues needed to be weighed. Mr. Devine asked if Mr. Edmondson could share examples of assessments where the agencies considered cost and the cost was deemed to be too expensive. Mr. Edmondson replied that the Edwards Dam Project is an example where the cost to change the project to meet environmental standards was more than the cost to remove the dam, so the project was removed. Mr. Devine, who was involved in that project, disagreed with Mr. Edmondson's characterization of the Edwards Dam project, stating that the decision to remove the dam was instead politically motivated, and that FERC had never ordered the dam to be removed. Mr. Devine said that the two target migratory species, American shad and alewife, could have been easily passed at the dam (Note: Edwards Dam was only 18 ft high).

Mr. John Shelton (CDFW) said it was disingenuous to say that the agencies make the decision about whether or not to build fish passage. Most of the time, the applicants help make the decision. In the settlement process, the agencies look to the applicants to weigh-in on the decision; the agencies do not come in and force a settlement. The applicants have a big part in the decision and what the feasibility of fish passage is, given the information. Mr. Shelton said that, similar to what Mr. Edmondson said happens at NMFS, at CDFW, the process of gathering the information is key. Mr. Shelton said he agreed completely that at this time the costs are unknown as well as what the efficiencies should be and what the benefits would be. These are all issues to be worked through. Mr. Shelton said that from what he had seen in California, fish passage is usually decided on among the parties during settlement. Mr. Shelton added that he could only speak to the ecology side of the process, and that any political motivations in the equation were beyond CDFW's part in the process. Mr. Edmondson agreed with Mr. Shelton that the agencies do not make a unilateral decision about fish passage. Instead, the agencies work closely with the licensee and stakeholders to work through the information and make a judgment call. Mr. Edmondson added that he was not familiar with a project where the agencies made a unilateral decision about fish passage.

Mr. Devine thanked Mr. Shelton and Mr. Edmondson for their commitments to a collaborative decision-making process that takes into account all parties' concerns. Mr. Devine added that he

hoped the resource agencies would be active participants in the study and share information early on to help support the development of reliable fish passage cost estimates.

Mr. Edmondson said that a big part of the decision process is knowing the condition of the habitat above Don Pedro Dam and the ability of that habitat to support a new fish population. Mr. Edmonson said that habitat suitability was not a small issue.

Mr. Devine said that NMFS had made several study requests related to upstream habitat suitability and production not adopted by FERC. Although the Districts had volunteered to complete some of these studies, other studies were not being completed by the Districts. Mr. Devine said that in the NMFS study request, NMFS had noted that they needed the information provided by these studies. Mr. Devine asked who would complete those studies, to get the information that NMFS needed. Mr. Edmondson clarified that NMFS had not stated they needed the information from the requested studies. Instead, the studies were recommendations to FERC about what studies should be completed. FERC would use the results of those studies to inform their decision. Regarding the studies that FERC did not require the Districts to complete, Mr. Edmondson was under the impression that NMFS was completing some of those studies. In particular, he noted that NMFS was completing an *O. mykiss* genetics study and an upper river temperature study.

Mr. Devine said that from the La Grange study dispute resolution process, the Districts understood that NMFS did not have enough funding to complete a genetics study. Mr. Devine asked if that had changed. Mr. John Wooster (NMFS) affirmed that NMFS was moving forward with a genetics study. Mr. Devine asked if there was a study plan for the genetics study that could be shared with the Districts and participants. Mr. Wooster replied that there was not a study plan similar to a study plan document drafted for a FERC licensing process. Mr. Wooster added that although there was not a written study plan, he could provide a written description of the study. Mr. Devine said that during the study dispute resolution technical conference, there was a thorough discussion about the number of samples to be collected and where those samples would have to be collected. Mr. Devine said it would be helpful to know what studies the agencies were completing and what the schedules are for completing those studies.

Regarding the genetics study, Mr. Wooster said that NMFS had actually taken some samples last week and would continue to take samples through the summer and into the fall. NMFS staff was performing most of the work and was receiving some help from NGOs. In response, Mr. Devine said that Mr. Larry Thompson (NMFS) had said at the dispute resolution technical conference that the genetics information would be used early on in the decision process to point to whether or not it would be appropriate for fish to be passed. Mr. Devine asked when the results from the genetics study, and subsequently NMFS' decision about the genetic suitability for passage of *O. mykiss* would be available. Mr. Wooster replied that the report is due from the NMFS science center in early 2017. He added that NMFS had not said they needed to have the information, only that the information was helpful to inform the decision.

Referring to slide 8 (Information Needs to support Reintroduction Planning) of Mr. Hanson's presentation, Mr. Wooster said the "substrate" habitat suitability study was a component of the

NMFS LiDAR/hyperspectral study. Regarding a study of stream flow, Mr. Wooster said he hoped that existing information and the Districts' upcoming temperature modeling work would suffice. Mr. Wooster said that at this time, NMFS did not plan to conduct a study about channel morphology, sediment budget, large woody debris or cover, and that the hope was that existing information would suffice for these items as well.

Mr. Wooster asked if the City and County of San Francisco (CCSF) had studied any of these upstream reaches. Mr. Bill Sears (CCSF) replied that CCSF had not studied these reaches. Referring to McBain and Trush (2007), Mr. Wooster asked if CCSF was implementing any of the report's recommendations for monitoring. Mr. Sears replied that CCSF had not implemented those recommendations and that at this time CCSF had no plans to implement those recommendations.

Mr. Noah Hume (Stillwater Sciences, consultant to the Districts) asked if NMFS would be completing some habitat typing as part of the LiDAR/hyperspectral study. Mr. Wooster affirmed that NMFS would be completing some habitat typing as part of the study and that the schedule for completing that study was April 2016.

Mr. Le said that in its study request, NMFS had requested that the Districts develop a life cycle model however FERC had not required the Districts to develop the model. Mr. Le asked if NMFS was planning to build a life cycle model per its own request. Mr. Wooster replied that NMFS was planning to complete work on this subject, but it would not exactly be a life cycle model. Instead, NMFS was planning to calculate the carrying capacity of the upper river using the habitat data and LiDAR/hyperspectral study results and the thermal suitability data produced by the Districts' modeling work. Mr. Le asked if the scope and methods NMFS was planning to use to calculate carrying capacity would be made available to the public for review and comment. Mr. Wooster said that making the methods available for public comment was up for discussion. Mr. Le requested that NMFS provide the methods for review and comment.

Mr. Orvis asked how a Biological Opinion would tie into the decision-making process. Mr. Wooster replied that the information generated in this process would be fed into the Biological Opinion for the project. Mr. Devine asked if the Biological Opinion could recommend to FERC that the Districts build fish passage. Mr. Wooster replied that fish passage could be recommended in the Biological Opinion as a reasonable and prudent measure (RPM). Mr. Edmondson added that fish passage could also be recommended as a measure under section 10(j) and 10(a).

Mr. Chris Shutes (California Sportfishing Protection Alliance or CSPA) asked what the schedule was for public consultation in the future. Mr. Devine reviewed the schedule for 2015. He said that the Districts needed input from the resource agencies to inform the facility design planning process. For example, the Districts needed to know what fish species would be passed, how large the fish runs would be, the timing of the runs, the performance criteria, etc. Mr. Devine said that, going forward, the hope was to be able to have comprehensive discussions of the full suite of engineering and biological criteria as appropriate to a fish reintroduction plan. The Districts would use the results from those discussions to formulate alternative design possibilities

consistent with FERC's Determination to be shared with licensing participants. At Workshop No. 2, the Districts would hope to go through the design basis/design criteria document and leave that Workshop with agreement on the fundamental design basis. To facilitate that, the Districts will issue a draft Design Basis Report prior to the Workshop. At Workshop No. 3, alternatives that meet the design basis would be put forward for consideration with the goal of narrowing the options to a single or a couple of the most appropriate options for the projects. For 2016, the Districts plan to develop detailed sizing, configurations, and preliminary engineering designs for the option(s) selected and perform detailed cost estimates. Regarding the dates for Workshops No. 2 and No. 3, Mr. Devine said that the Districts would circulate some possible dates shortly to find out what works best for everyone's schedules.

Mr. Byrd said that as a local rancher, he has been on the Tuolumne River for 35 years. There was a lot of science talk in today's Workshop. After coming to lots of these types of meetings, Mr. Byrd said he was starting to understand the scientific issues involved. He had direct experience with salmon in the Tuolumne by virtue of living along the river. Mr. Byrd said that when salmon get to the upper end of the spawning reach at Basso Bridge, the fish are nearly spent. There is no fish passage facility in the world that could make a difference to these fish. Mr. Byrd stated that the Tuolumne River system is different from the other projects covered into today's presentations. No one wants to see these greater numbers of fish more than him. Mr. Byrd suggested that someone should film what happens when the salmon lay their eggs. He has seen the suckers and pikeminnows eat the newly-laid eggs. He said that juvenile fish do not make it down the river because the eggs are being eaten before they can hatch. In Mr. Byrd's opinion, until the predator fish and suckers are dealt with, the runs will never return to their historic sizes.

Mr. Patrick Koepele (Tuolumne River Trust or TRT) asked how the public could submit comments on the Workshop and any notes that are provided. Ms. Jenna Borovansky (HDR) replied that the Districts would set something up on the La Grange Project licensing website to allow individuals to submit comments. Also, individuals are welcome to email their comments to Ms. Rose Staples (HDR) ([rose.staples@hdrinc.com](mailto:rose.staples@hdrinc.com)), and Ms. Staples would distribute the comments to the Districts and all interested parties.

Mr. Koepele asked if notes from today's meeting would be circulated for review and entered into the record. Mr. Devine replied that, unlike the Don Pedro relicensing process, the La Grange licensing process does not have a formal Consultation Workshop process required by FERC. Although the Districts were not required to provide notes from today's workshop, Mr. Devine said that the Districts would pull together notes from the meeting and post these notes on the La Grange licensing website.

Mr. Edmondson said that NMFS had contracted for a documentary about fish passage. The documentary looked specifically at projects in the Pacific Northwest and includes interviews with licensees and operators about the decision to build fish passage at their facilities. Mr. Edmondson said that NMFS would like to make that link available to folks who would like to view the documentary. Mr. Devine replied that the Districts would make that link available.

Mr. Devine thanked Mr. Edmondson for his presentation and said he was pleased to hear that NMFS is committed to a collaborative process and that the final decision on fish passage would be made collaboratively among all the interested parties.

Mr. Shutes asked what information the Districts needed to answer the questions covered in the presentations, including what species the Districts should consider for fish passage. Mr. Devine replied that the Districts would circulate a draft design criteria/design basis document prior to the next Workshop and it would contain a list of questions needing to be addressed, and that this would be discussed at the next workshop.

Meeting concluded at 12:10 pm.

## **ACTION ITEMS**

1. NMFS will provide a written description of its Tuolumne River *O. mykiss* genetics study plan and methods.
2. The Districts will circulate to licensing participants potential dates for the next two Fish Passage Assessment workshops.
3. The Districts will provide a way for licensing participants to submit comments on the La Grange Licensing Website.
4. The Districts will post notes from Workshop No.1 on the La Grange Licensing Website.
5. The Districts will make available a link to the NMFS fish passage documentary.
6. The Districts will circulate the design criteria document prior to the next Workshop.
7. NMFS will provide a copy of its presentation.

## REFERENCES

- Anderson, Joseph H., George R. Pess, Richard W. Carmichael, Michael J. Ford, Thomas D. Cooney, Casey M. Baldwin & Michelle M. McClure. 2014. Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery. *North American Journal of Fisheries Management*, 34:1, 72-93.
- Lindley, Steven T., Robert S. Schick, Ethan Mora, Peter B. Adams, James J. Anderson, Sheila Greene, Charles Hanson, Bernie P. May, Dennis McEwan, R. Bruce MacFarlane, Christina Swanson and John G. Williams. 2007. Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento–San Joaquin Basin. *San Francisco Estuary and Watershed Science*, 5(1).
- McBain and Trush, Inc., and RMC Environmental, 2007. Upper Tuolumne River: Description of River Ecosystem and Recommended Monitoring Actions Final Report. Technical Memorandum prepared for San Francisco Public Utilities Commission, San Francisco, California.
- NMFS. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter Run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. NMFS, West Coast Region, Sacramento, CA. July 2014.
- Turlock Irrigation District and Modesto Irrigation District. 2013. Predation Study Report (W&AR-07). Attachment to Don Pedro Hydroelectric Project Updated Study Report. December 2013.

# **ATTACHMENT A**



## La Grange Hydroelectric Project Fish Passage Assessment Workshop No. 1

**Wednesday, May 20, 9:00 am to 12:00 pm**

**MID Office, 1231 11<sup>th</sup> Street, Modesto, California**

**Conference Line: 1-866-994-6437, Passcode: 8140607**

**Join Lync Meeting <https://meet.hdrinc.com/jesse.deason/8DZ4NVN>**

### Meeting Objectives:

1. Introduce the fish passage-evaluation concept, process/framework, and relevant information needs.
2. Present and discuss the Tuolumne River Fish Passage Evaluation Framework.
3. Confirm schedule/tasks, subsequent workshops, and opportunities for collaboration.

TIME	TOPIC
9:00 am – 9:10 am	Introduction of Participants (All)
9:10 am – 9:30 am	Background/Overview of Tuolumne River Anadromous Fish Passage Facilities Assessment Collaborative (Districts)
9:30 am – 10:30 am	Overview of FPA, Section 18 Authority (Fish Passage Prescription), and NMFS' Section 18 Decision Process (NMFS) <ol style="list-style-type: none"> <li>a. Description of FERC study process, FPA and Section 18 Authority</li> <li>b. Section 18 Decision Framework and how/where an engineering feasibility of fish passage evaluation fits in</li> <li>c. Discussion of additional studies being undertaken (NMFS sponsored and Districts) that will support Section 18 Decision Process</li> <li>d. Discussion of NMFS' Recovery Plan and how it relates to the Tuolumne River</li> </ol>
10:30 am – 11:15 am	Overview of the Tuolumne River Fish Passage Evaluation Framework (Districts) <ol style="list-style-type: none"> <li>a. Review fish passage evaluation process</li> <li>b. Information needs and key resource considerations</li> <li>c. Available data, data gaps, and potential data sources</li> </ol>
11:15 am – 11:45 am	Overview of Examples of Anadromous Fish Passage Facilities (Districts) <ol style="list-style-type: none"> <li>a. Key fish passage considerations</li> <li>b. Upstream passage types and related facilities</li> <li>c. Downstream passage types and related facilities</li> </ol>
11:45 am – 12:00 pm	Tuolumne River Passage Assessment Schedule and Next Steps (All) <ol style="list-style-type: none"> <li>a. Schedule: Opportunities for collaboration and incorporation of feedback</li> <li>b. Workshops 2 and 3 – confirm dates and content</li> </ol>





**La Grange Fish Passage  
Workshop No. 1  
Wednesday, May 20, 2015  
9:00 a.m. – 12:00 p.m.**



**PLEASE SIGN IN**

	Name	Organization	Telephone No.	E-mail	Time In	Time Out
1.	Amanda Theis	Tullock Chamber of Commerce			8:45a	
2.	MARCO MORENO	LCR			8:45	
3.	ALISON MCNALLY	CSU Stanislaus			8:49	
4.	Ronald Yoshigama	San Francisco			8:49	
5.	Daniel Richardson	Tulare County CA			8:51	
6.	Zac Jackson	USFWS			8:53	
7.	Jake Osterman	WHD			8:57	
8.	Bob Hackawalt	TRT			8:55	
9.	Jean "					
10.	Allyson Benister	TR Conservancy			9:00	
11.	John Wooster	NMFS			9:00	
12.	Sarah HENDERSON	US Fish & Wildlife			9:00a	



**La Grange Fish Passage  
Workshop No. 1  
Wednesday, May 20, 2015  
9:00 a.m. – 12:00 p.m.**



**PLEASE SIGN IN**

	Name	Organization	Telephone No.	E-mail	Time In	Time Out
13.	Theresa Sinsiman	ALW			8:45	
14.	Alfred Souza	K.F.C.			8:45	
15.	Gretchen Murphey	COFA			8:45	
16.	William Sears	SFPUC			8:45	
17.	Brandon McMillan	TulackCityNews.com			8:50	
18.	Josh Werner	TID			8:55	
19.	Dave Baucher	Tulelake Conservancy			8:55	
20.	Tom Holley	NMFs			8:55	
21.	Calvin Cuttin	TID			8:55	
22.	Peter Barnes	SWRCB			8:55	
23.	Paul Zeek	Asm. Kristin Olsen			9:00	
24.	Peter Drehmeier	TIRT			9:00	



**La Grange Fish Passage  
Workshop No. 1  
Wednesday, May 20, 2015  
9:00 a.m. – 12:00 p.m.**



**PLEASE SIGN IN**

	Name	Organization	Telephone No.	E-mail	Time In	Time Out
25	Chris Sauter	CSFA			9:00	
26	Jim Alves	City of Modesto			9:00	
27	John W. Fisher	Self			9:00	
28	ROTHI ODEH	CSU Stanislaus			9:00	
29	John Holland	Modesto Bee			9:00	
30	Patrick Koepke	TAT				
31	Dan Freeman	CCSF			9:00	
32	Ray Campbell	Alliance			9:00	
33	Jim M. Jara	Sierra Pacific			9:00	
34	Steve Edmonds	NMFS			9:00	
35						
36						



**La Grange Fish Passage  
Workshop No. 1  
Wednesday, May 20, 2015  
9:00 a.m. – 12:00 p.m.**



**PLEASE SIGN IN**

	Name	Organization	Telephone No.	E-mail	Time In	Time Out
25.	DAVE SIGOUR	TID DPR A			9:09	
26.	John Shelton	DFW			9:14	
27.	Keb GRASSO	Yosemite NP			9:43	
28.	Dr Dow Swatman	Public			9:45	
29.	Leonard Van Eldere	Yosemite Farm Cred			10:05	
30.	Helen Condit	Senator Cannella			ca. 9:01 11:00	
31.						
32.						
33.						
34.						
35.						
36.						

37

38

39

40

41

42

43

44

45

46

47

48



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# **La Grange Hydroelectric Project FERC No. 14581**

## **Fish Passage Assessment - Concept Level Passage Alternatives Workshop #1**





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## La Grange Project History



La Grange Diversion Dam

- La Grange Diversion Dam was constructed from 1891 to 1893
- The dam is owned jointly by Turlock Irrigation District and Modesto Irrigation District
- Purpose is to divert irrigation and municipal and industrial (M&I) water
- La Grange powerhouse was constructed in 1924. The powerhouse is owned by TID



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Overview of La Grange Project ILP

ILP Milestone	Schedule
Pre-Application Document (PAD)	January 2014
Scoping and study plan development	January 2015
FERC Study Plan Determination	February 2015
NMFS Request for Rehearing	April 2015
Study plan dispute resolution	May 2015
Study plan implementation	2015/2016
Initial Study Report	February 2016
Updated Study Report	February 2017
Final license application	June 2016



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# Revised Study Plan

## Study Components

**Fish Passage Facilities  
Assessment**

**Concept-Level Fish Passage  
Alternatives**

**La Grange Project Fish  
Barrier Assessment**

**Upper Tuolumne River  
Basin Habitat  
Assessment**

**Barriers to Upstream  
Anadromous Salmonid  
Migration**

**Water Temperature  
Monitoring and Modeling**

**Upstream Habitat  
Characterization**

**Habitat Assessment and  
Fish Stranding  
Observations below  
LGDD and Powerhouse**

**Develop Hydrologic Data for  
Flow Conduits at the La  
Grange Project**

**Collect Topographic, Depth,  
and Habitat Data in the  
Vicinity of the La Grange  
Project Facilities**

**Assess Fish Presence and  
Potential for Stranding**





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Concept-Level Fish Passage Alternatives - Objectives**

- Identify and develop concept-level alternatives for upstream and downstream passage of Chinook salmon and steelhead at the La Grange and Don Pedro dams
- For select upstream and downstream alternatives:
  - Identify, formulate and develop preliminary design basis, design criteria, sizing and configuration
  - Develop capital costs and O&M costs



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Study Area

- Downstream of La Grange Diversion Dam (confluence of powerhouse tailrace channel and Tuolumne River mainstem) to the upper Tuolumne River at the upper most extent of Don Pedro Reservoir
- Study area scope defined in FERC's February 2, 2015 Study Plan Determination



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Overview of Tuolumne River Fish Passage Study Phase I (2015)**

- Three collaborative workshops to identify and discuss biological and engineering passage parameters and alternatives, including implementation sequence.
- Gather information on project facilities/operations, environment, target species, biological criteria, run timing and size, basin hydrology, agency regulations/criteria, and land ownership.
- Initial sizing, siting and layouts developed and collaboratively selected based upon criteria including accessibility, costs, impacts to other resources (e.g., recreation, boating, etc.), predation, land ownership, etc.



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Overview of Tuolumne River Fish Passage Study Phase II (2016/2017)**

- Develop site layouts, general design parameters and capital and O&M costs for select alternatives (from 2015 work) – both upstream and downstream.
- Investigate siting/sizing, water supply, collection/acclimation/holding, transport, debris management, attraction flows, instrumentation/controls, compliance with regulatory criteria, timing of implementation, etc.
- Identify additional information needs [e.g., reservoir study may be necessary if 2015 process identifies concept involving passage through the project reservoir(s)].



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Reporting

- The Initial Study Report (February 2016) will include all Phase I activities.
- The Updated Study Report (February 2017) will include:
  - A summary of biological, engineering, and cost considerations
  - Identification of fish passage alternatives
  - Functional layouts, sizing and siting information for selected alternatives
  - Capital and annual O&M cost estimates for selected alternatives



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Study Team

- Study Lead: Bao Le (HDR)
- Salmon/Steelhead Technical Advisors: Chuck Hanson (Hanson Environmental) and Paul Bratovich (HDR)
- Lead Fish Passage Engineer: Mike Garello, HDR



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Workshop #1 Agenda**

- Background/Overview of Tuolumne River Anadromous Fish Passage Facilities Assessment (Districts)
- Overview of FPA, Section 18 Authority (Fish Passage Prescription), and NMFS' Section 18 Decision Process (NMFS)
- Overview of the Tuolumne River Fish Passage Evaluation Framework (Districts)
- Examples of Anadromous Fish Passage Facilities (Districts)
- Tuolumne River Passage Assessment Schedule and Next Steps (All)



# Tuolumne Fish Passage Study Workshop





# History of Non-federal Hydropower Regulation

- Before passage of the Federal Water Power Act in 1920, developers needed a special act of Congress to build and operate a hydroelectric power plant on navigable streams, or federal lands.
- Congress had authorized construction of the first hydroelectric project in 1884.
- Demand for electric power suddenly increased during World War I.
- In 1920, Congress responded to this demand by enacting the Federal Water Power Act, which established the Federal Power Commission (FPC).
- The FPC was responsible for licensing non-federal hydroelectric power projects that affect navigable waters, occupy federal lands, use water or water power at a government dam, or affect the interests of interstate commerce.

- **1935, Congress amended the Federal Water Power Act of 1920 as Part 1 of the Federal Power Act extending the FPC's authority to regulate interstate aspects of the electric power industry.**
- **1977, Congress abolishes the FPC and creates the Federal Energy Regulatory Commission (FERC). FERC's authority includes the licensing of non-federal hydroelectric power projects.**
- **1978, Public Utilities Regulatory Policies Act (PURPA), required public utilities to purchase power produced by qualifying facilities at the utilities avoided costs.**
- **1980, Energy Resource Act and Energy Security Act, provided financial and regulatory incentives that made small hydro attractive to entrepreneur developers.**

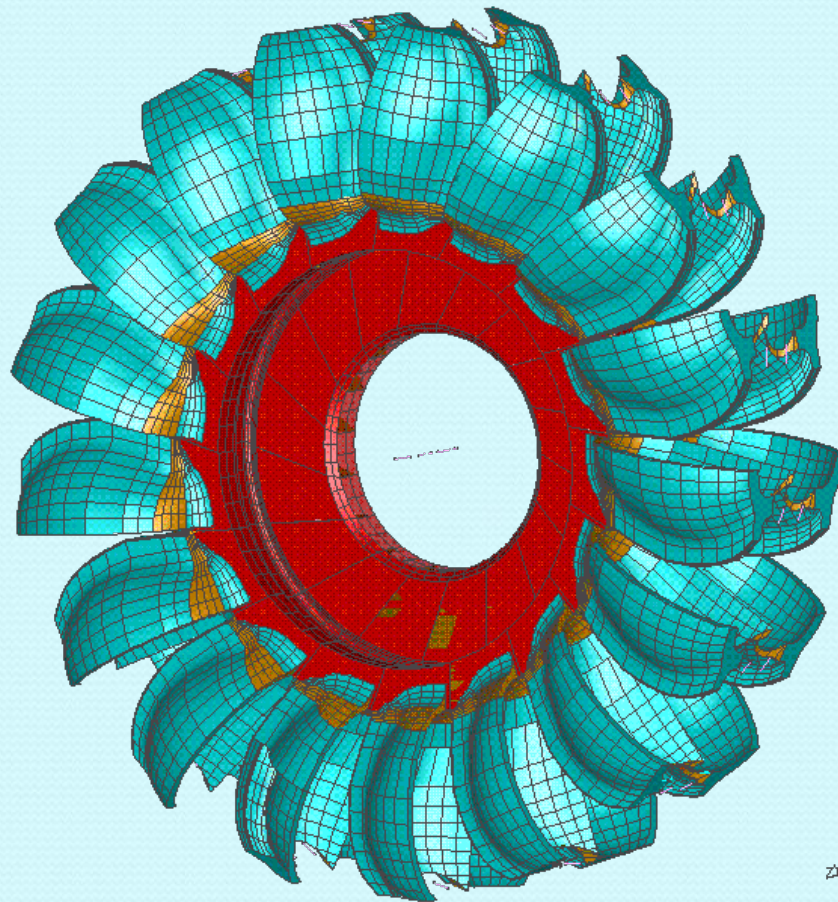


- **1986, Congress passed the Electrical Consumers Protection Act (ECPA), which amended the Federal Power Act:**
  - **required FERC to base its license conditions on the recommendations from federal and state fish & wildlife agencies, and to negotiate disagreements with agencies (10j).**
  - **requires equal consideration to environmental, recreation, fish and wildlife, and other non-power values.**
- **1992, Congress enacts the National Energy Policy Act**
  - **prohibits licensees from using eminent domain in parks, recreational areas or wildlife refuges.**
  - **provided for third party contracts for environmental documents.**
  - **recovery of agency costs incurred in licensing process.**

**Most recently, Energy Policy Act of 2005 included review of mandatory conditions and filing alternatives**



# FERC Requires Studies to understand Project impacts on Developmental and non-Developmental Resources





# Project Effects on Non-Developmental Resources

- Water Quality
  - Dissolved Oxygen
  - Temperature
- Fisheries
  - Aquatic Habitat
  - Passage
- Wildlife
  - ROW clearing
  - Transmission line and avian interactions





# Developmental Resources

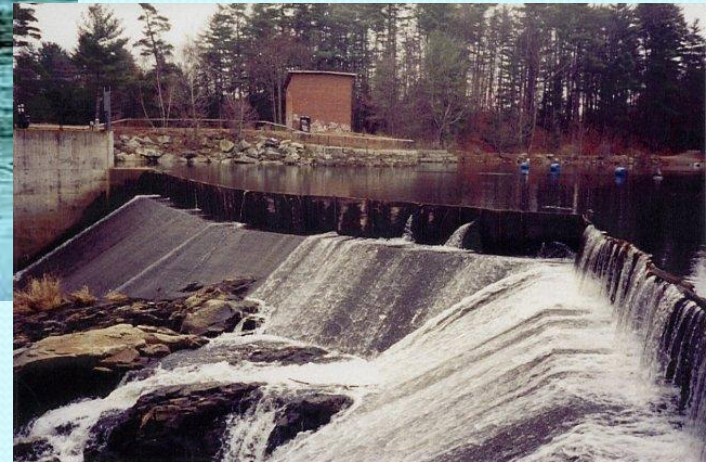
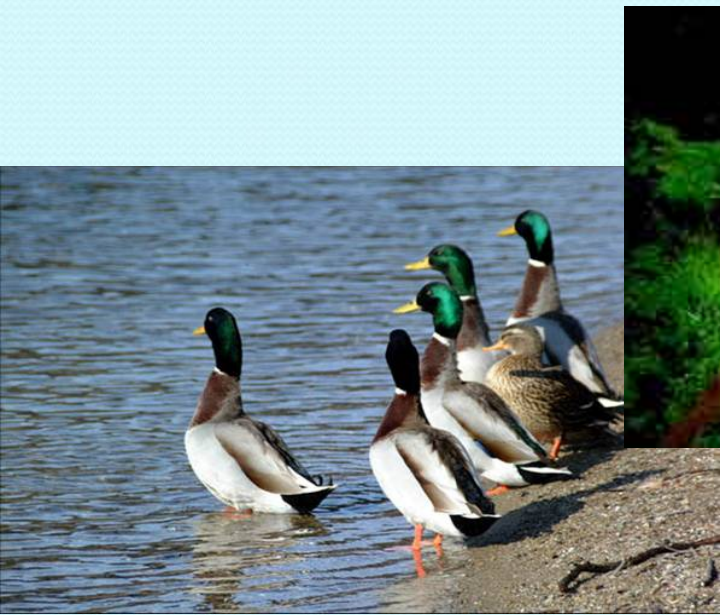


- Flood Control
- Navigation
- Water Supply
- Energy Production
- Irrigation



# FERC's Study Needs - Licensing

- Fish and Wildlife Coordination Act
- Magnuson-Stevens Fishery Conservation and Management Act
- National Historic Preservation Act





# Other Elements of Licensing

- Clean Water Act – Section 401
- Coastal Zone Management Act of 1972
- Endangered Species Act of 1973
- National Environmental Policy Act of 1972





# AGENCY COOPERATION



IN FERC  
RELICENSING



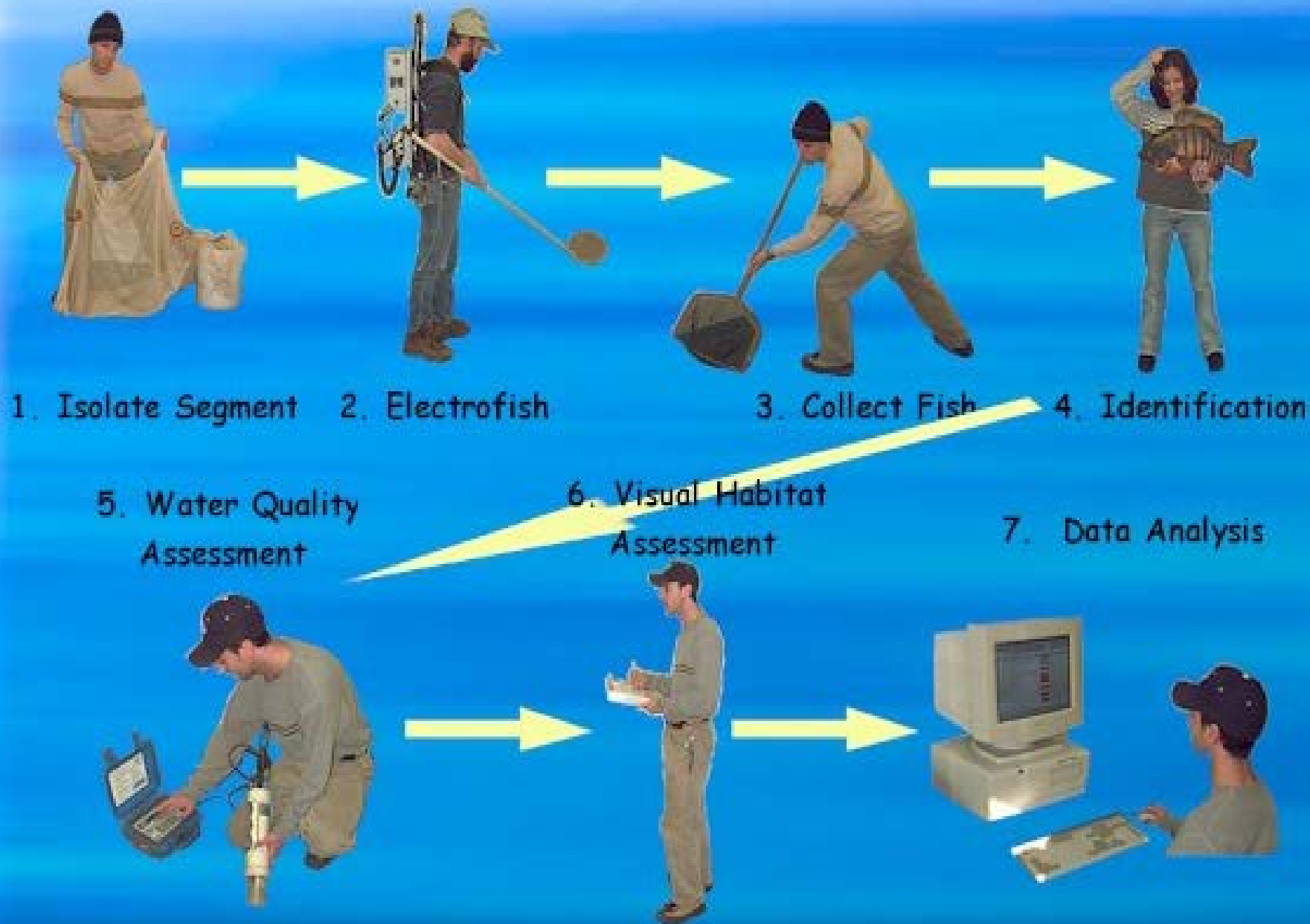
# **Recommending Studies to Support Licensing**

**Under §§ 14 and 15 of the FPA, FERC must make the same inquiries in a relicensing proceeding as in an initial licensing determination and there is no question that fishery protection is among the licensing issues that must be addressed when evaluating all beneficial water uses as required by § 10(a) of the FPA. [\[1\]](#) [\[2\]](#)**

**[\[1\]](#) Confederated Tribes and Bands of the Yakima Indian Nation et al. V. FERC, Nos. 82-7561 et al. (9th Cir. June 7, 1984.**

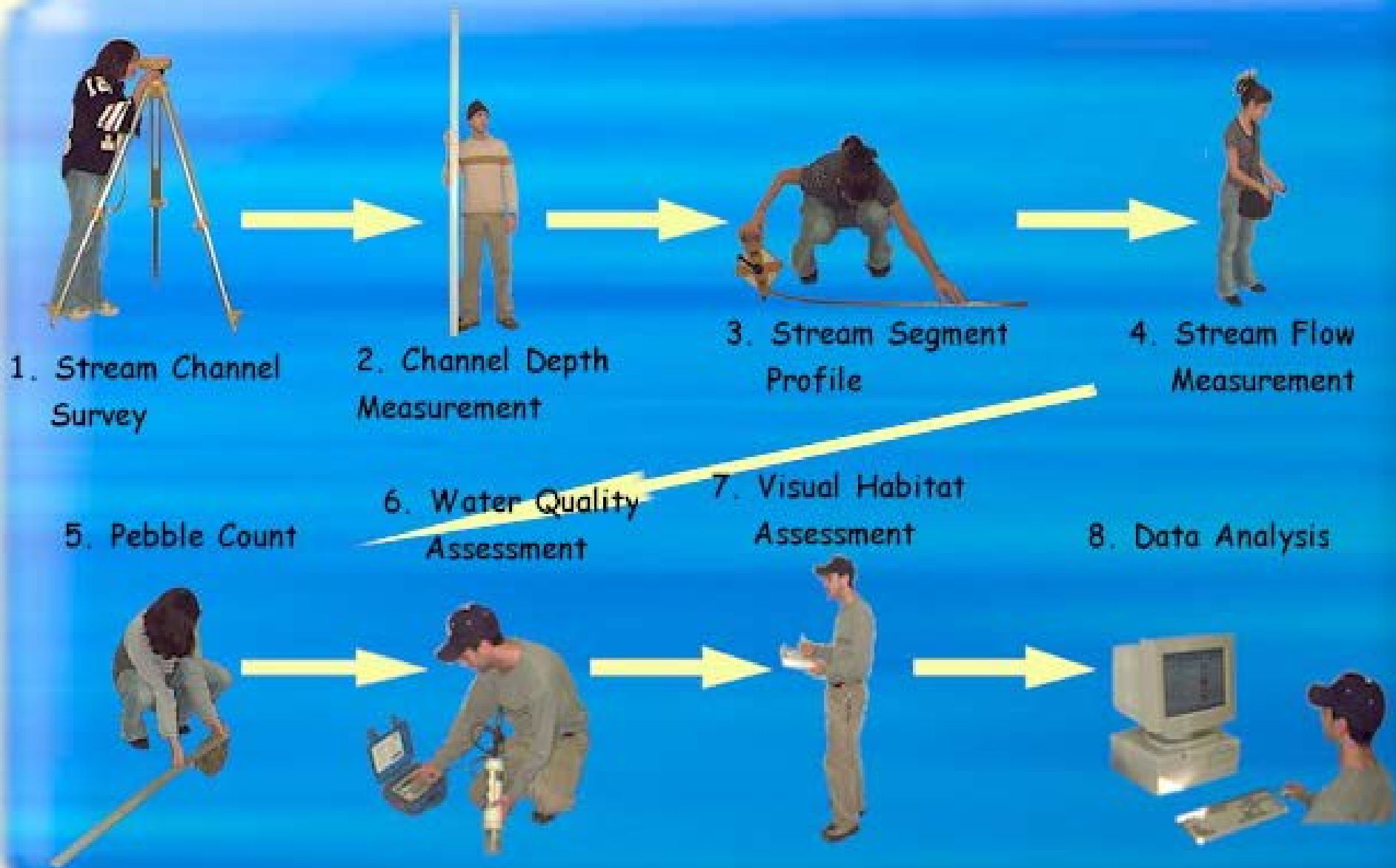
**[\[2\]](#) Id. At 11-12 (citing 16 U.S.C. § 803 (a) and Udall v. FPC, 387 U.S. 428, 440, 450 (1967)).**

# FISHERIES ASSESSMENT





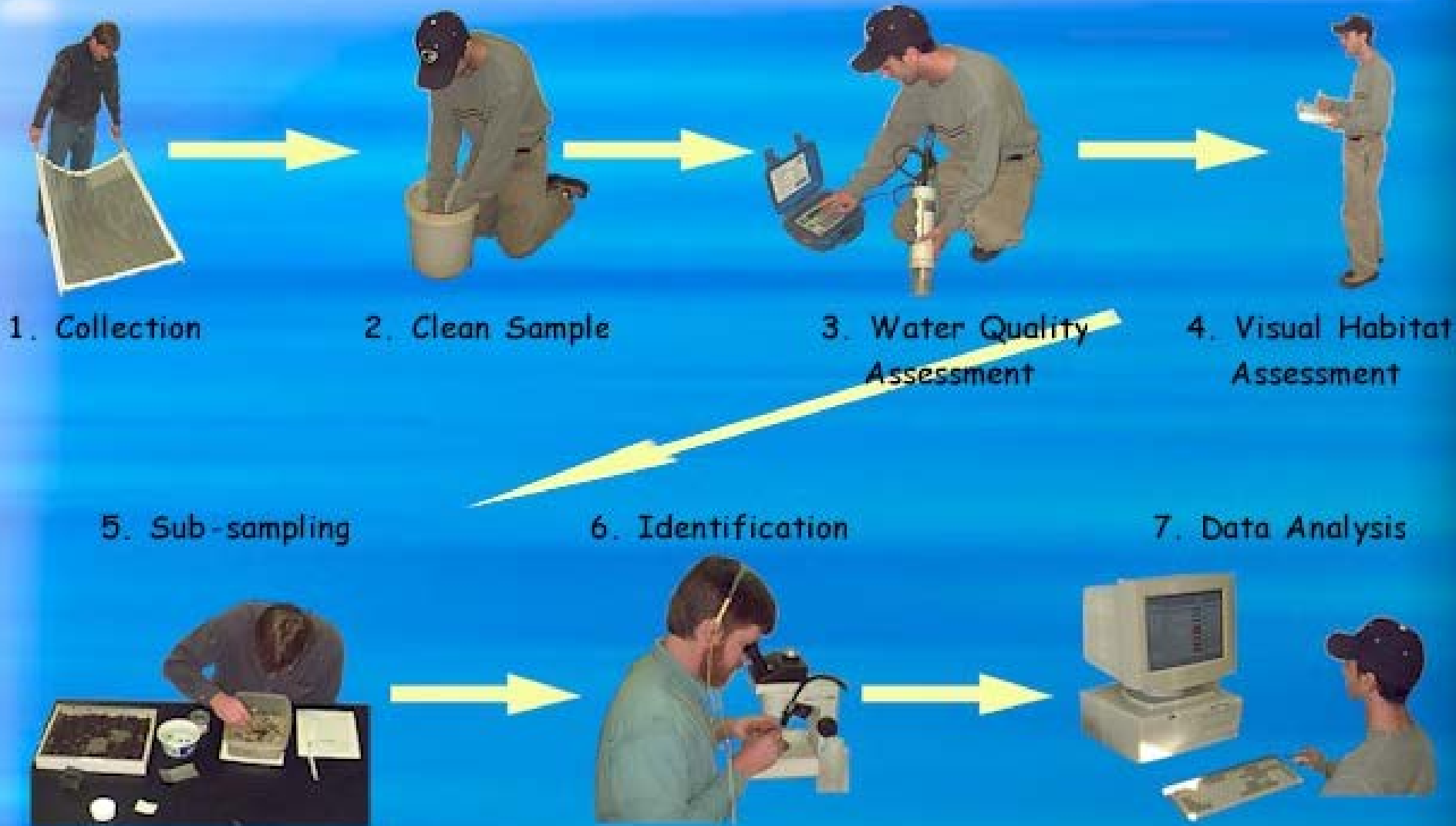
# PHYSICAL HABITAT ASSESSMENT



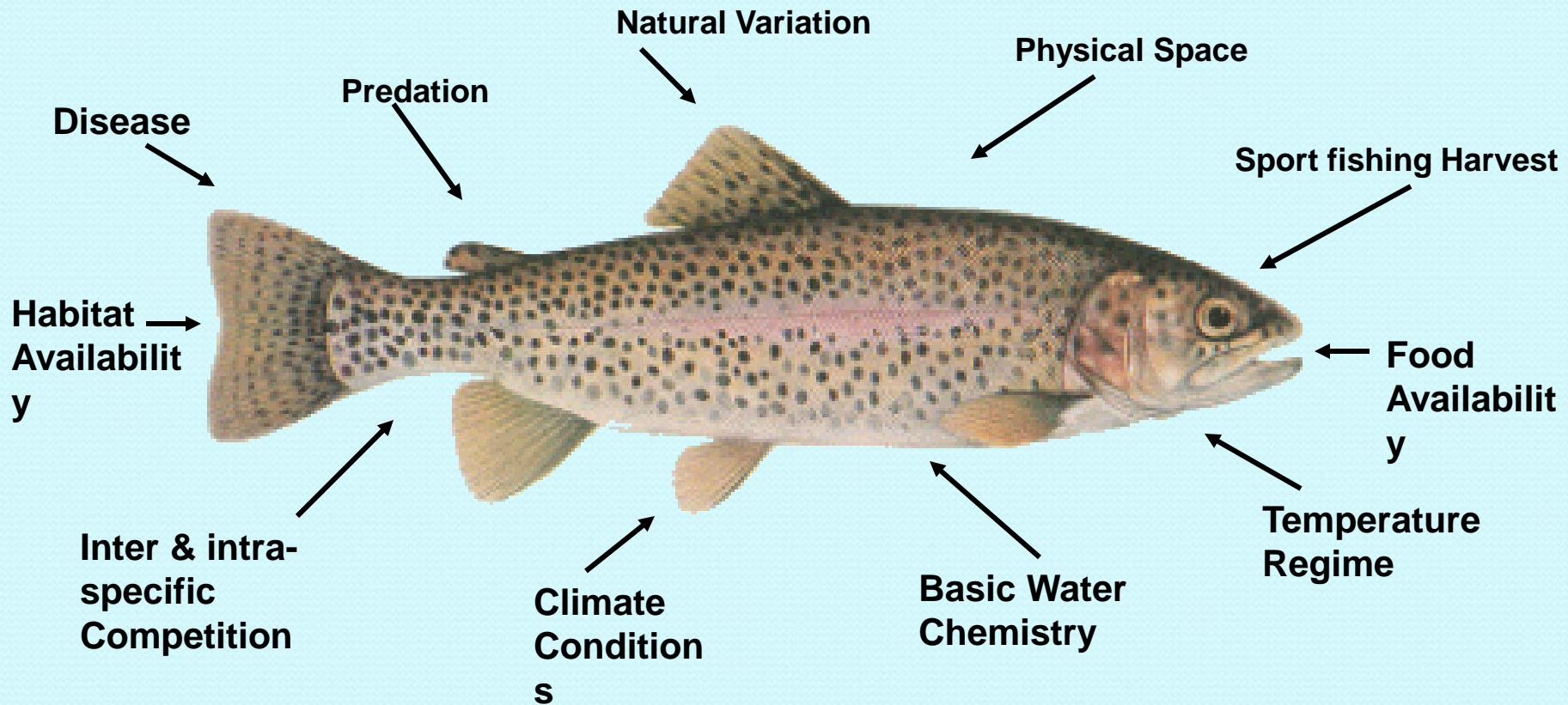


FLATHEADED MAYFLY  
(*Stenonema interpunctatum*, larva)

# STREAM MACROINVERTEBRATES AS STREAM HEALTH INDICATORS

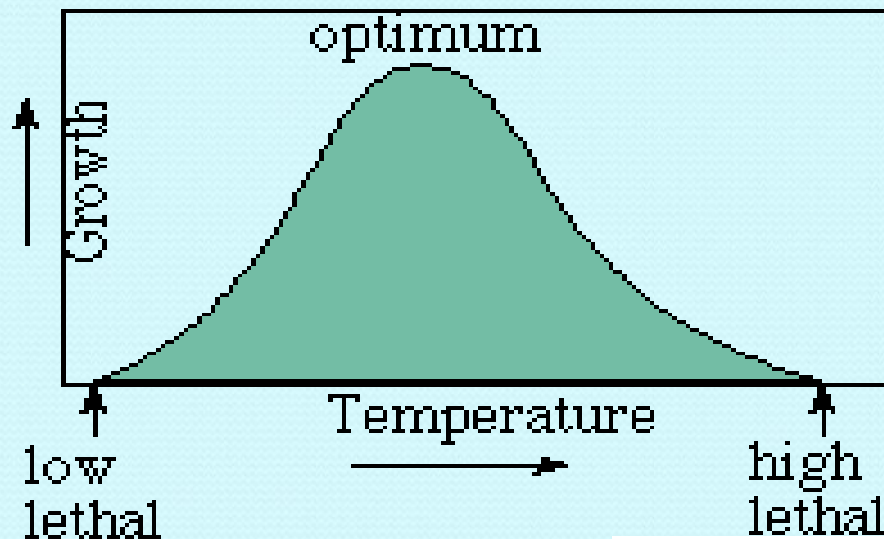


# UNDERSTANDING THE ECOLOGICAL FACTORS





# WATER TEMPERATURE MANAGEMENT AND THE HEALTH OF AQUATIC ORGANISMS



## TROUT ACTIVITY AND WATER TEMPERATURE



Preferred Range	80°	Lethal conditions for trout
	70°	Trout begin heading for tributaries and natural springs.
	65°	Feeding begins to slow.
	63°	Optimum feeding temperatures.
	62°	
	61°	
	60°	
	55°	Food chain begins to activate. Trout start looking up.
	50°	Trout are sluggish; they feed sporadically.
	45°	

# **RESOURCE ISSUES COMMONLY RAISED IN FERC RELICENSING PROCEEDINGS**

## **HYDROLOGY**

- **Historical data (unimpaired hydrology)**
- **Impaired hydrology (mean daily, monthly & average annual)**
- **Adequate gauging stations**
- **Reservoir data (minimum pool & seasonal fluctuations)**

## **OTHER FLOW RELATED ISSUES**

- **Flows to protect instream biological resources (fish/macros)**
- **Flows necessary for on-water recreation**
- **Ramping criteria**
- **Run-of-River vs Peaking Operations**



# RIVERINE PROCESSES

- **Flows necessary to maintain riverine ecosystem processes**
  - channel maintenance, gravel recruitment & sediment budgets
  - maintain riparian vegetation corridors
- **Timing of flows**
  - replicates natural hydrograph
  - ramping criteria

## WATER QUALITY

- **Basin Plan Beneficial Uses and Objectives**
- **Historical data-Background water quality**
- **Current water quality with project (project related impairment)**
- **Controllable Factors**

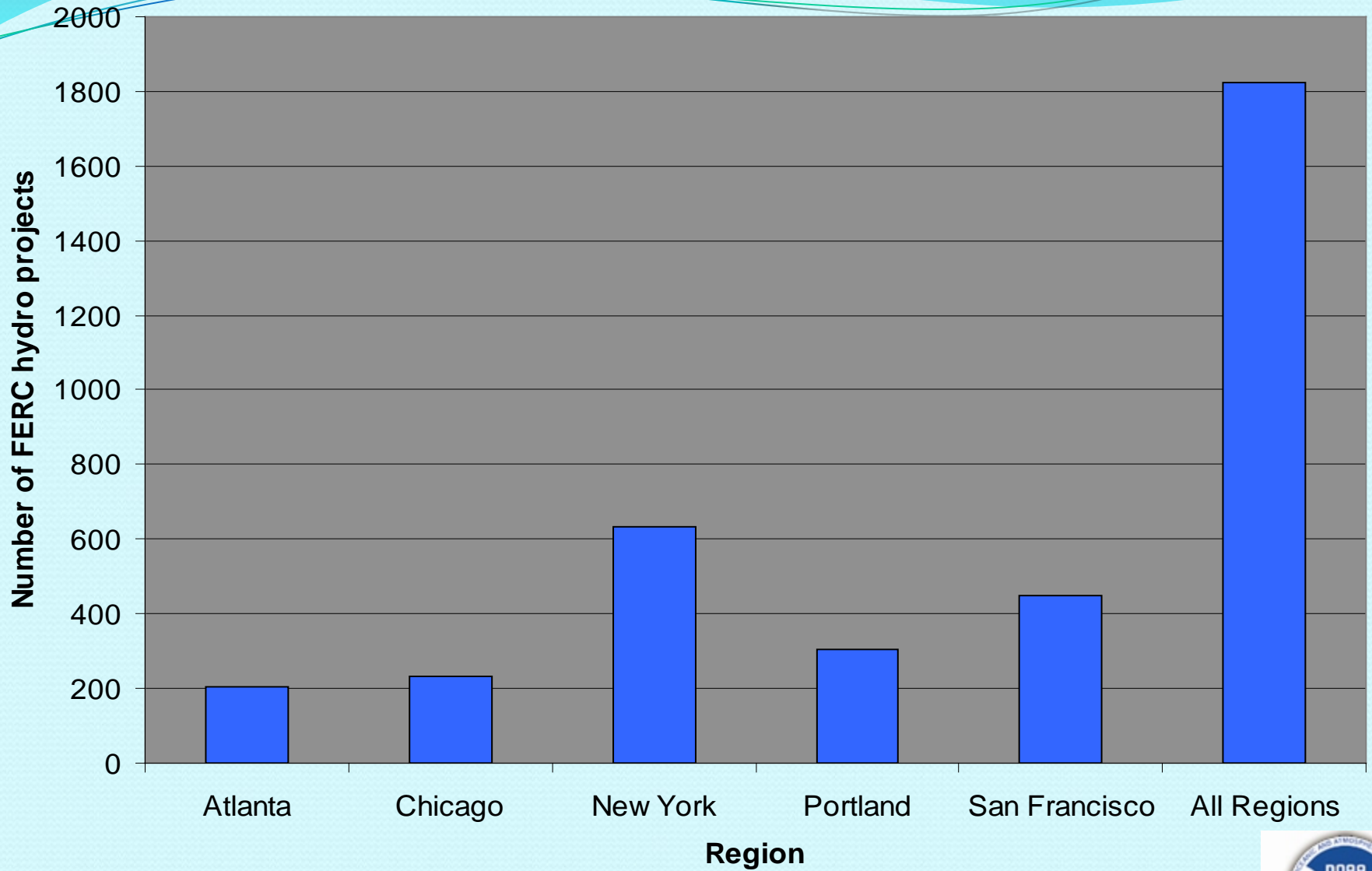
# **WATERSHED SCALE ISSUES**

- **Land Management Practices (historic and current)**
- **Multiple Licensees vs Coordinated Watershed Operations**

## **FERC PROCESS ISSUES**


- **Environmental Baseline for Relicensing**
- **Study Protocols and Timing**
- **Timing Requirement for filing the 401 Request**
- **Cumulative Impact Assessment**
- **Timing of Environmental Analysis**
- **Timing of Licensing Actions**
- **Identification and Participation of appropriate Stakeholders**
- **FERC Staff Participation**





Percent FERC hydro projects with fish passage facilities





For instance, in California's Central Valley (Sacramento and San Joaquin Watersheds) dams block as much as 95% of historic salmonid spawning habitat. As a result, anadromous salmon are extirpated from approximately 5,700 miles of their historic habitat in the Central Valley. In most cases the habitat remaining is of much lower quality than the habitat lost and is subject to further degradation by direct and indirect impacts of hydroelectric operations. According to a FERC review a total of 149 FERC licensed and exempted projects are located in the Central Valley. Although most of the 149 projects are small (114 have capacities less than 5 MW), total reservoir storage is about 40 percent of all surface water storage in the Central Valley. Most storage is located at relatively few projects. Twenty nine projects account for 95 percent of the FERC-licensed storage in the Valley.



## Tuolumne River Watershed

Linear Stream Miles  
Above La Grange Dam - 1,864  
(excluding lake/reservoir centerline)

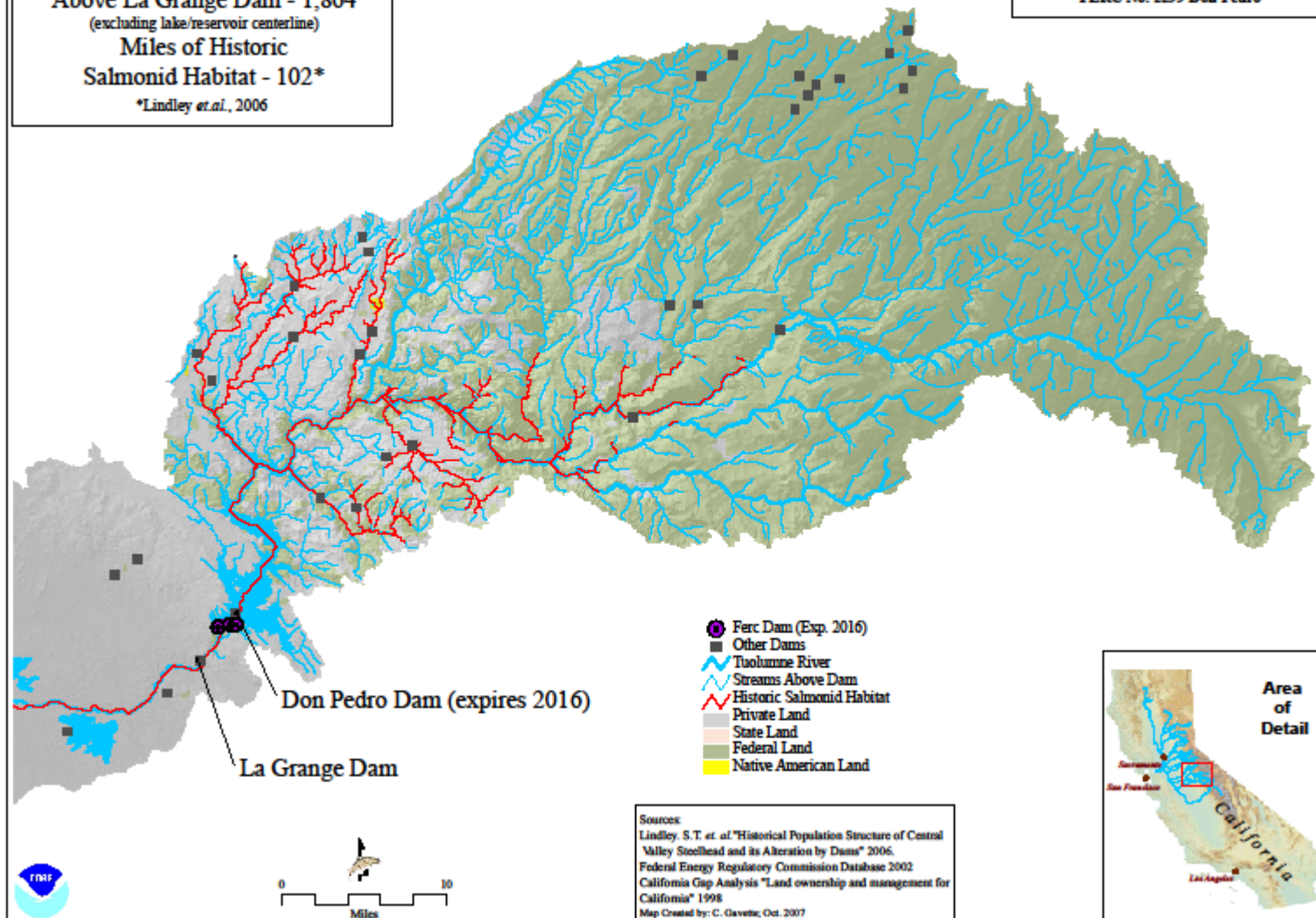
Miles of Historic  
Salmonid Habitat - 102\*

\*Lindley *et al.*, 2006

## Year of FERC License Expiration

**2016**

FERC No. 2299 Don Pedro



# **Generic List of Types of Passage Facilities Employed at FERC Hydro Projects**

## **Upstream**

### Passive

- fish ladders
- canals
- dam removal

### Directed

- fish lifts
- trap and haul

## **Downstream**

### Passive

- fish ladders
- canals
- flumes
- screens (v-screens, barrier nets, eichers, angled bar racks)
- notches
- spill
- behavioral guidance
- louvers
- dam removal

### Directed

- trap and haul
- surface collection (traps, gulpers, salvage devices)







TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# Overview of the Tuolumne River Fish Passage Evaluation Framework



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Overview of Fish Passage at Don Pedro and La Grange**

- Section 18 of Federal Power Act (FPA) gives the Dept. of Commerce (NMFS) and Dept. of Interior (USFWS) the authority to prescribe fishways
- NMFS has not made a decision on whether to exercise Section 18 authority
- In this instance, any Section 18 fishway prescription would be to support the reintroduction of extirpated species to the Upper Tuolumne River



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Fish Passage Study Requests at La Grange and Don Pedro**

“NMFS’ Recovery Plan identifies the Upper Tuolumne River above Don Pedro Reservoir as a candidate area for reintroduction of steelhead and spring-run Chinook salmon to further recovery of these species (NMFS 2014).”

- NMFS Study Request #3 (Enclosure F, page 35, July 22, 2014)

“Results from NMFS’ upper Tuolumne information request (see NMFS’ Study Request #3) shall be used to estimate carrying capacity and population sizes at various life-stages in the upper Tuolumne habitats, to inform design criteria for fish passage facilities.”

- NMFS Study Request #1 (Enclosure F, page 9, July 22, 2014)



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Overview of Tuolumne River Fish Passage

- Anderson et al., “Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery,” North American Journal of Fisheries Management, 2014.
- Peer-reviewed paper co-authored by NMFS Northwest Fisheries Science Center, state departments of fish and wildlife (Oregon and Washington) and the Colville Tribe (Washington).
- Presents a framework for planning reintroductions designed to promote recovery of salmonids listed under ESA.



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Overview of Tuolumne River Fish Passage

- “[R]eview of the salmonid reintroduction literature [...] suggests that there are large uncertainties in the success of reintroduction in establishing self-sustaining populations, particularly for programs employing active colonization strategies.” (Anderson et al., page 88)
- “Rigorous scientific evaluation is particularly important for projects at large dams or those using active colonization strategies because they face the highest constraints and greatest risks.” (Anderson et al., page 89)



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Overview of Tuolumne River Fish Passage Info Needs to Inform Section 18 Prescription**

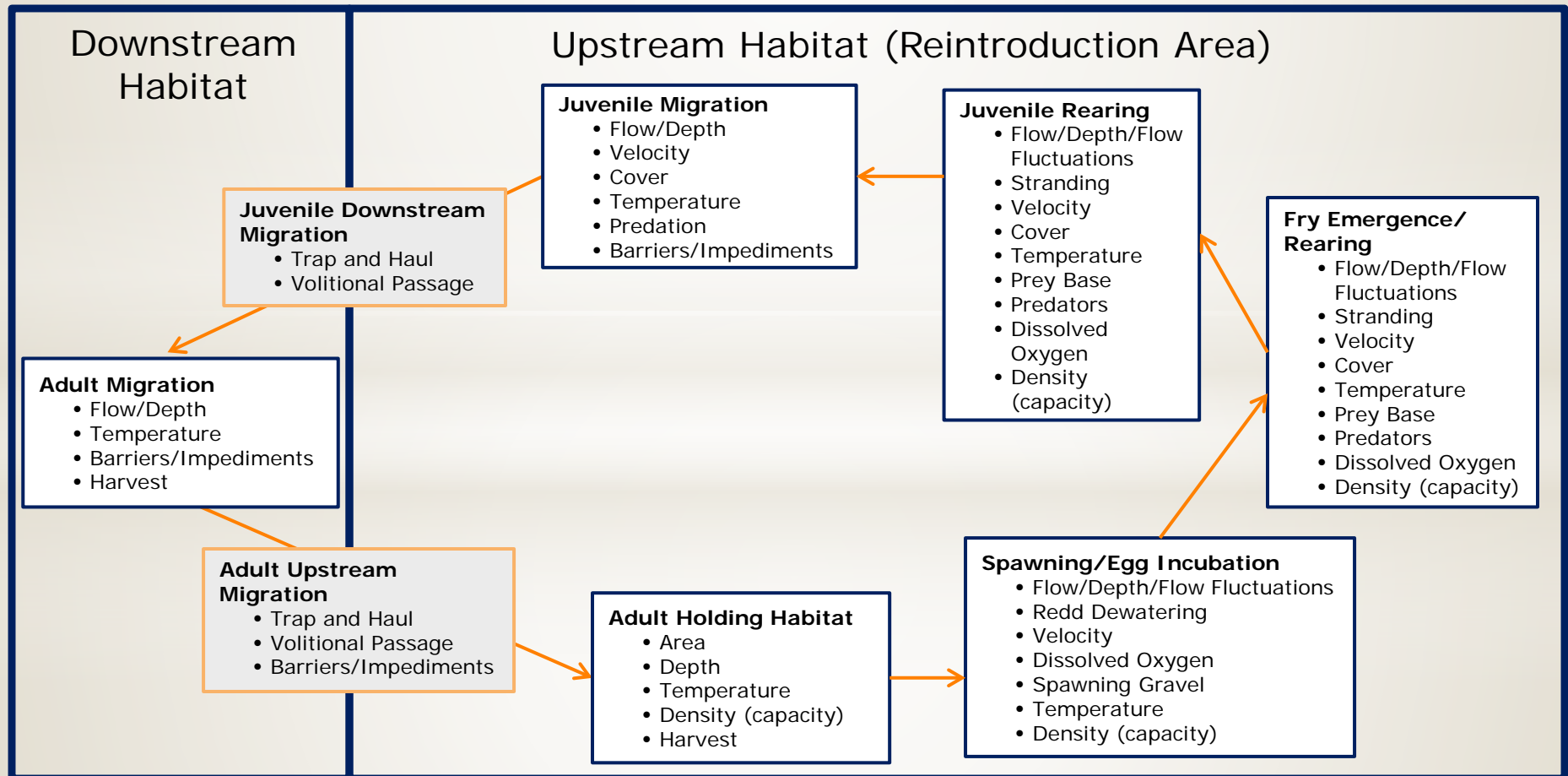
- NMFS study requests and recommendations of Anderson et al. applied to the Tuolumne River:
  - Genetics (*O. mykiss*) – NMFS Study Request #4
  - Upper Tuolumne River Studies – NMFS Study Request #3/Anderson et al.
  - Fish Passage Engineering Concept Alternatives – NMFS Study Request #1/Anderson et al.
  - Colonization Strategy (natural, transplant, or hatchery releases) – Anderson et al.
  - Source Populations – Anderson et al.
  - Socioeconomics (effects to existing uses; cost-benefit analysis) – Anderson et al.





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# General Life Cycle Considerations





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Information Needs Specific to the Tuolumne River

Information Needs	Lead Entity	Schedule
Genetics Testing ( <i>o. mykiss</i> )	NMFS	??
Identify Target Species (fall-run Chinook, spring-run Chinook, steelhead)	NMFS	June 2015
Define Upstream Reaches	FERC	Feb 2015 (Complete)
Compile Existing and Historical Habitat Information	NMFS/Districts	Feb 2016
<b><i>Habitat Suitability Studies</i></b>		
• Migration Barriers Assessment	Districts	Feb 2017
• Channel morphology/sediment budget	NMFS	??
• Substrate	NMFS	??
• Cover and LWD	NMFS	??
• Habitat features (e.g., holding pools, riffles)	NMFS	??
• Streamflow (Hetch Hetchy Operations)	NMFS	??
• Water temperature monitoring/modeling	Districts	Feb 2017
• LiDAR/Hyperspectral Study	NMFS	April 2016





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Information Needs Specific to the Tuolumne River

Information Needs		Lead Entity	Schedule
<b><i>Recolonization Strategy</i></b> <ul style="list-style-type: none"> <li>Source population (genetics/ecology)</li> <li>Passive or active reintroduction</li> </ul>	<ul style="list-style-type: none"> <li>Disease</li> <li>Climate change</li> </ul>	NMFS	??
<b><i>Fish Community</i></b> <ul style="list-style-type: none"> <li>Current assemblage and abundance</li> <li>Species interactions</li> <li>CDFW's Heritage and Wild Trout Program designation (e.g., Clavey River)</li> </ul>		??	??
<b><i>Regulatory and Recreation Issues</i></b> <ul style="list-style-type: none"> <li>CCSF peaking operations</li> <li>Whitewater boating</li> <li>ESA (NEEP designation, take requirements)</li> <li>Wild and Scenic designation</li> <li>Tribal consultation</li> <li>Forest management plan</li> </ul>	<ul style="list-style-type: none"> <li>Public land use</li> <li>Private land use</li> <li>Harvest</li> <li>Fishing regulations</li> <li>Don Pedro Reservoir fishery management</li> <li>Moccasin Hatchery</li> </ul>	??	??
Concept-level fish passage alternatives and capital and O&M cost estimates for upstream and downstream passage		Districts	Feb 2017



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# Overview and Examples of Anadromous Fish Passage Facilities



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

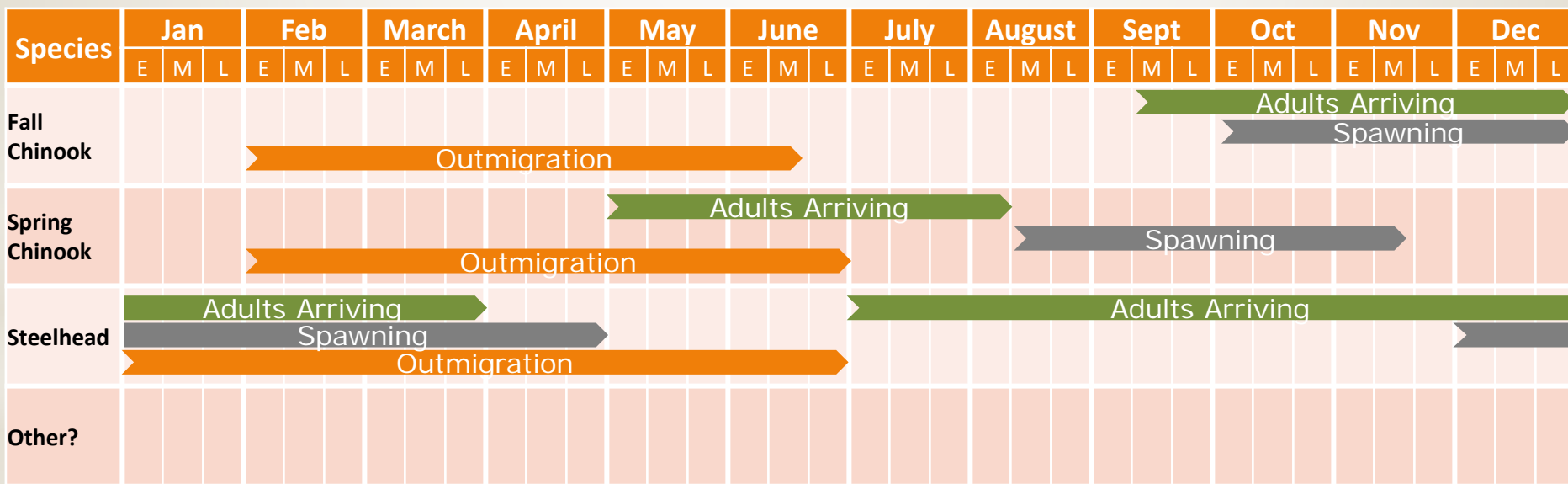
## General Design Criteria

- **Target fish species**
- **Peak run characteristics (numbers and timing)**
- **Reservoir passage considerations**
- **Performance expectations**
- Reservoir operations and hydrology
- Specific design guidance by NMFS and CDFW: barriers, fishways, bypass systems, collection, holding, etc.
- Access and transportation corridors
- Monitoring requirements



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Example Migration Timing (Periodicity)





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Examples of Upstream Fish Passage**

- Fishways
- Lifts, Locks, and Elevators
- CHTR – Collect, Handle, Transfer, Release (“Trap and Haul”)
- Bypass Facilities
- Other Technologies such as Transport Tube Systems (“Whoosh”)





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Upstream Passage - Fishways

- Nature Like Fishway  
Weber Dam, NV
- Ice Harbor Style Fishway  
Ice Harbor Dam, WA



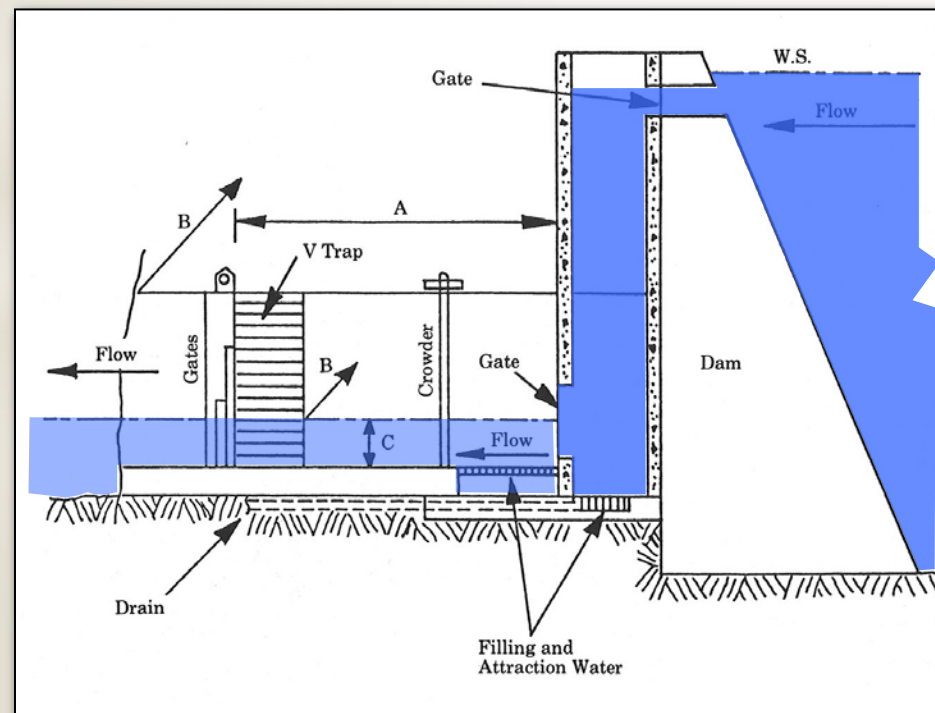




TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# Upstream Passage - Lifts, Locks, and Elevators

- Typical Fish Lock or Elevator at Dam
- Example Fish Lift Mounted on Rails  
Paradise Dam, Australia





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Upstream Passage - CHTR

- Fish Transport Truck  
Lower Granite Adult Collection  
Facility, WA
- Upstream CHTR Facility  
Cougar Dam, OR





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Downstream Fish Passage

- Forebay Collectors (fixed or floating)
- Surface Spill Facilities
- Turbine Passage
- Head of Reservoir or Tributary Collection
- Many Facilities are Combined with CHTR and/or Bypass Components





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# Downstream Passage – Forebay Collectors

- Fixed Forebay Surface Collector  
Pelton Round Butte, OR
- Floating Forebay Surface Collector  
Upper Baker Dam, WA





## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

Inlet to Baker  
Surface Collector  
being moved into  
position during  
construction  
(Puget Sound  
Energy)







## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT



Floating Collection Barge  
prior to deployment  
(PacifiCorp)







## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

Entrance to Pelton  
Round Butte Fixed  
Surface Collector  
under construction  
(PGE)





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Downstream Passage – Surface Spill

- Juvenile Surface Spill Bypass Unit  
Priest Rapids Dam, WA
- Juvenile Surface Spill Facility  
Wanapum Dam, WA







TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Downstream Passage – Bypass Facilities

- 14,000 ft Juvenile Bypass  
Clackamas River, North Fork Dam, OR
- Juvenile Bypass Conduit Outlet  
Rocky Reach, WA





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# More Downstream Passage

Rotary Screw Trap



Portable Floating Fish Collector  
Cougar Dam, OR

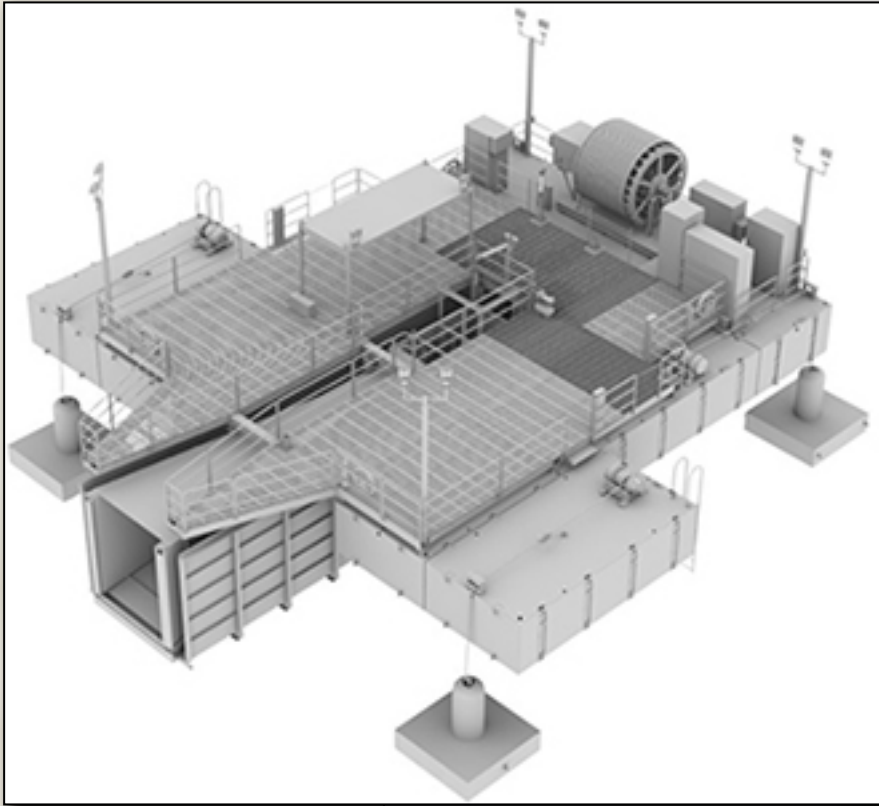


Temporary Guide Panels with Trap

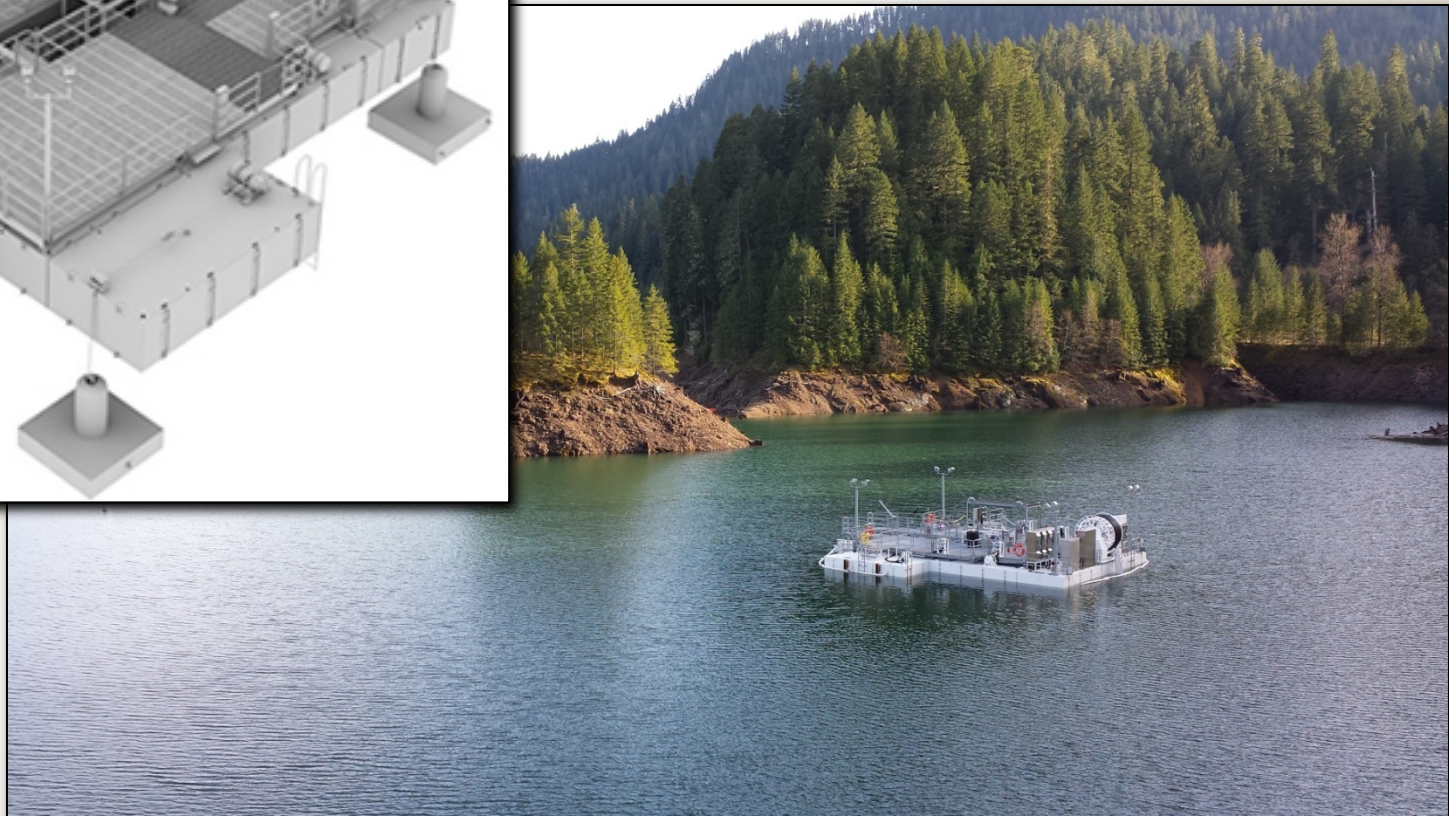




## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT



Portable Floating Fish Collector  
deployed at Cougar Dam, Oregon  
(USACE)





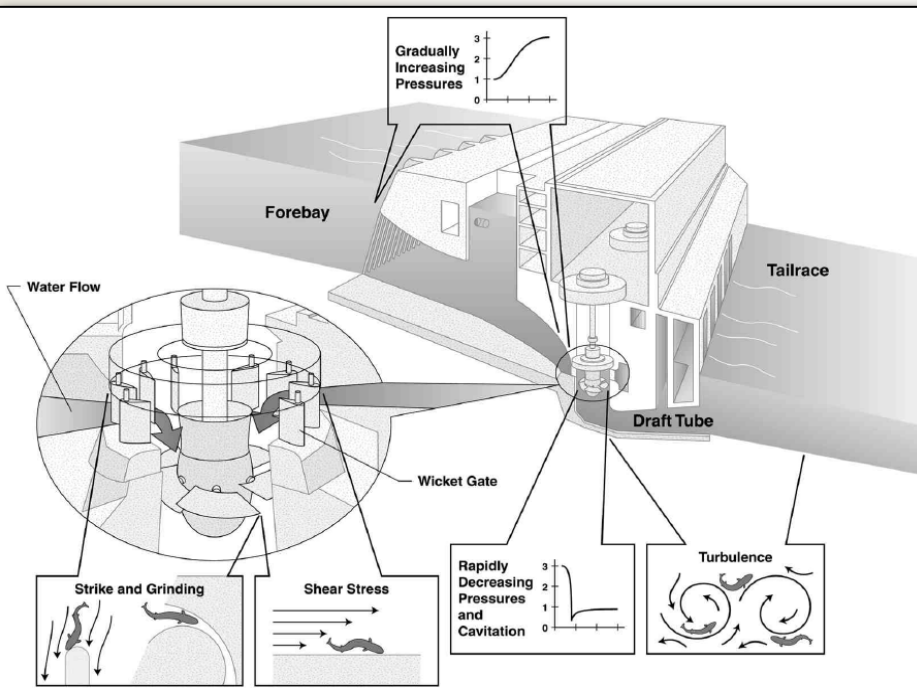


TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# Downstream Passage – Turbine Passage

- Potential Fish Injuries Through Turbines

- Voith Minimum Gap Runner (MGR) Turbine  
Wanapum Dam, WA





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Example Costs of New Fish Passage Facilities or Retrofits to Existing Facilities

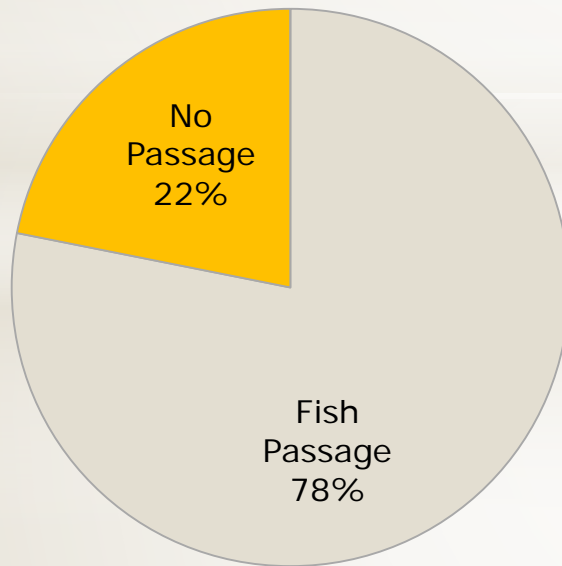
Facility	Available Construction Cost Data
Round Butte FSC	\$110M
Swift FSC	\$60M
Upper and Lower Baker	\$50M Each
Priest Rapids Retrofit	\$28M
Cougar Adult Collection	\$10.4M
Minto Adult Collection Rebuild	\$27.4M



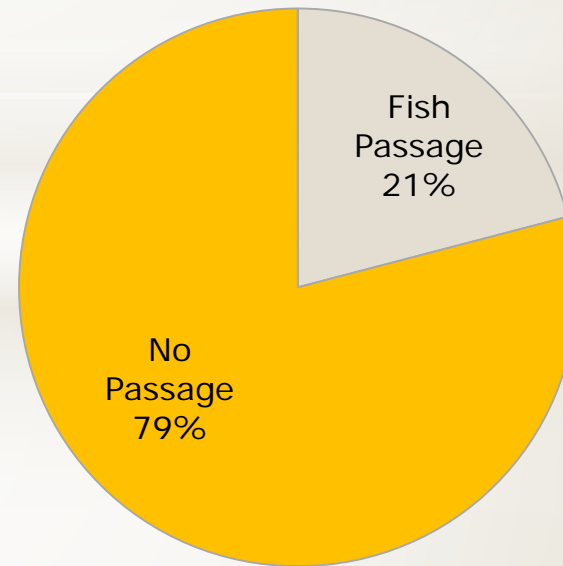
TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Background and Facility Research – Western US

- Results - case studies of 32 dams between 50 and 150 ft within WA, OR, ID, and CA



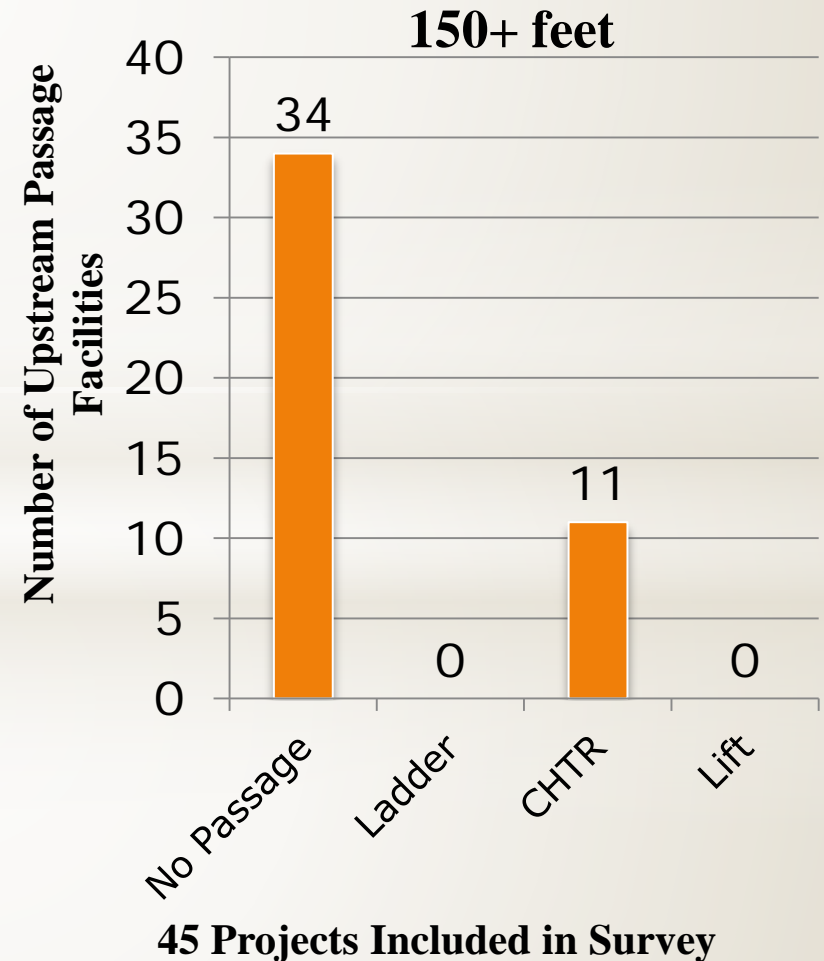
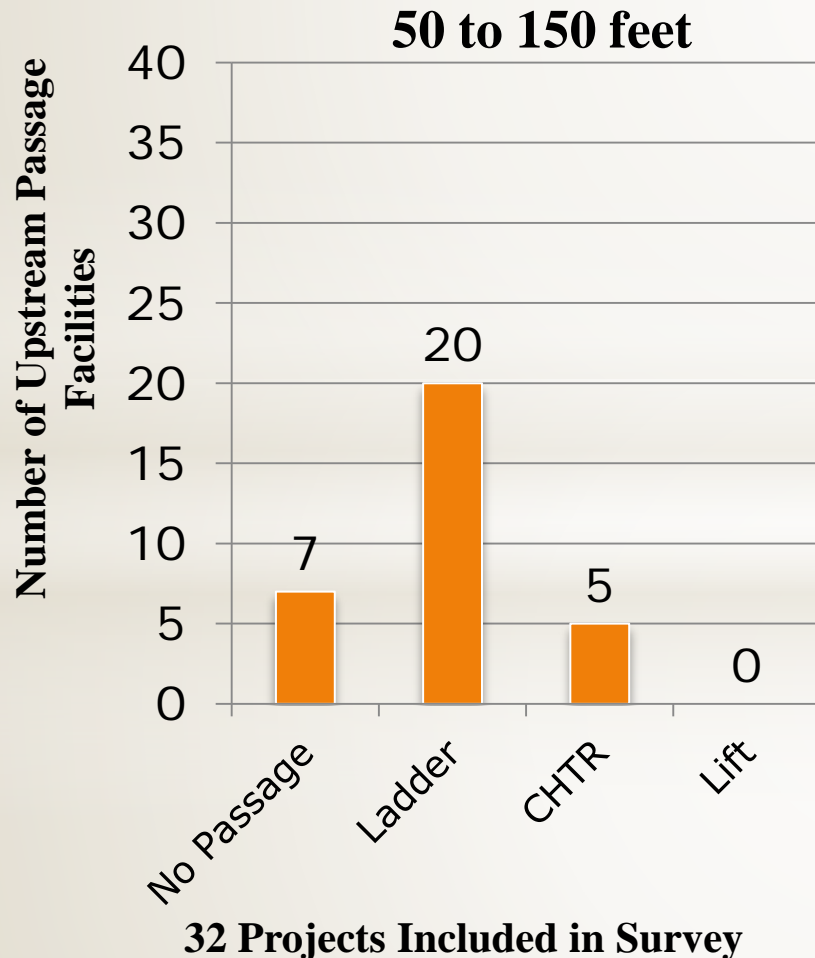
- Results - case studies of 45 dams over 150 ft within WA, OR, ID, and CA





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Background and Facility Research – Western US





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Examples of Recent Fish Passage Projects in the Pacific NW**

- Lower and Upper Baker Dams on Baker River, WA
- River Mill, Faraday, and North Fork Dams on Clackamas River, OR
- Pelton and Round Butte Dams on Deschutes River, OR
- Merwin and Swift Dams on Lewis River, WA
- Mayfield and Cowlitz Falls Dams on Cowlitz River, WA





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

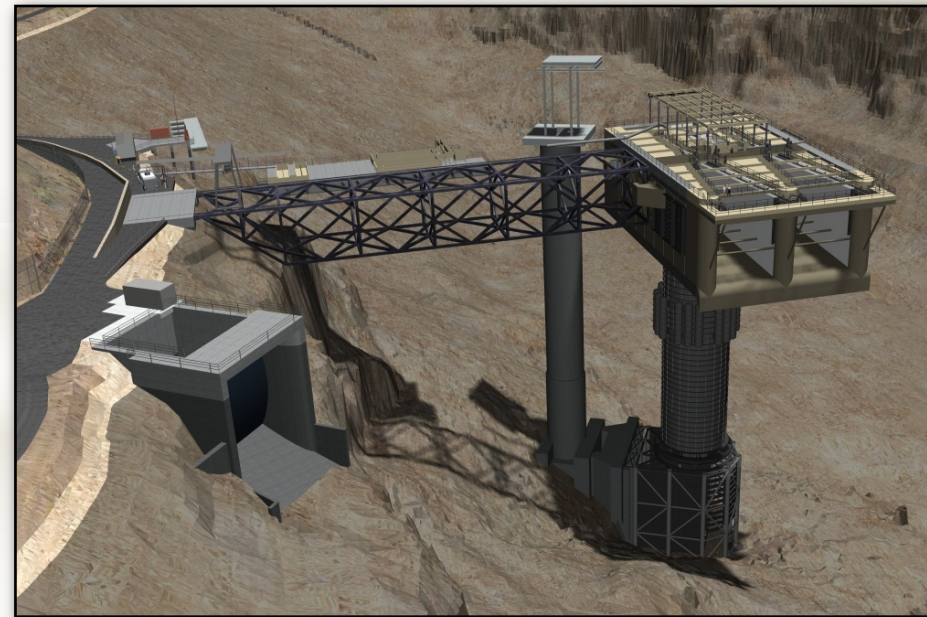
# Deschutes River, OR - Project Overview

## Dams: Downstream to Upstream

- Reregulating Dam – hydraulic height 25 ft
- Pelton Dam – hydraulic height 204 ft
- Round Butte Dam – hydraulic height 425 ft

## Current Facilities

- Upstream Passage: CHTR from below Reregulating Dam to reservoir above Round Butte Dam
- Downstream Passage: Forebay collector with CHTR to below Reregulating Dam (\$110 Million)



Tower collection facility.



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

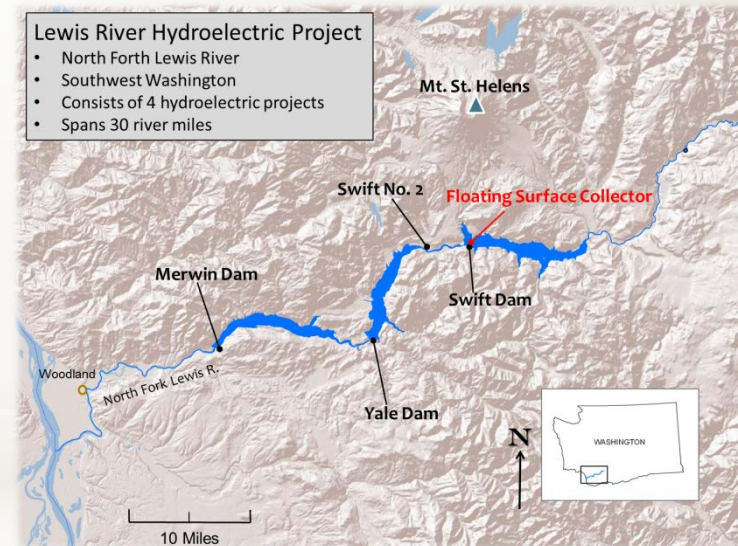
## Lewis River, WA - Project Overview

### Dams: Downstream to Upstream

- Merwin Dam – hydraulic height 230 ft
- Yale Dam – hydraulic height 309 ft
- Swift Dam – hydraulic height 400 ft

### Current Facilities

- Upstream Passage: Currently Constructing CHTR from below Merwin Dam to reservoir above Swift Dam (estimated >\$50 Million)
- Downstream Passage: Floating forebay collector with CHTR to below Merwin Dam (>\$60 Million)



Swift Floating Surface Collector. Photo and Figure from PacifiCorp





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

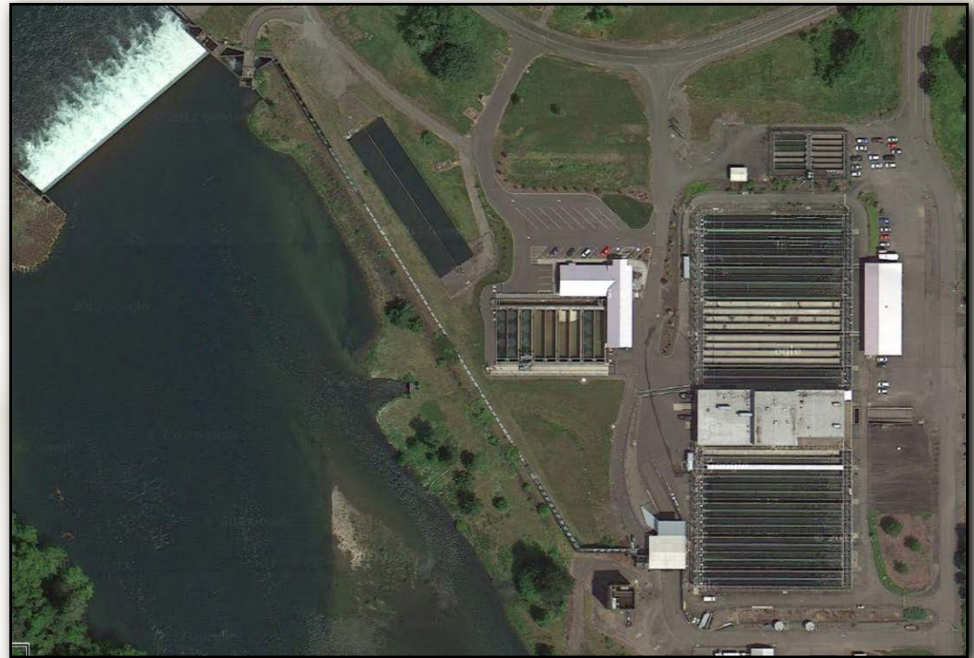
# Cowlitz River, WA - Project Overview

## Dams: Downstream to Upstream

- Mayfield Dam – hydraulic height 230 ft
- Mossyrock Dam – hydraulic height 366 ft
- Cowlitz Falls Dam – hydraulic height 120 ft

## Current Facilities

- Upstream Passage: CHTR from below Mayfield Dam to Tilton River upstream of Mayfield Dam and upstream of Cowlitz Falls Dam
- Downstream Passage: Surface collection flume at Cowlitz Dam with CHTR to downstream of Mayfield Dam. Two louvered intake facilities at Mayfield Dam with bypass pipe to river downstream



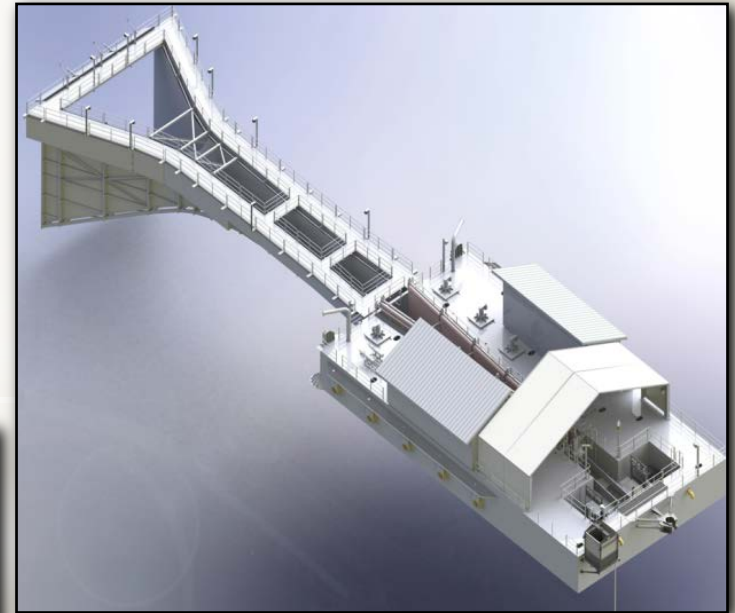
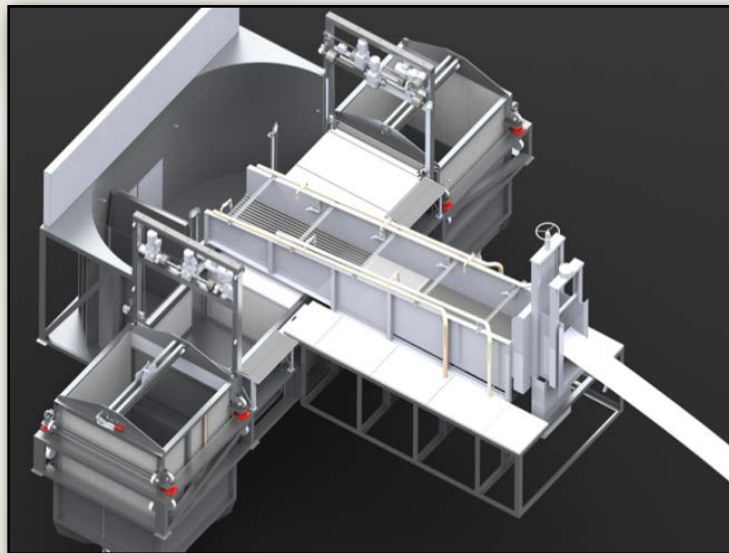
Mayfield CHTR. Photo from Google Maps



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Pacific NW Technology Assessment

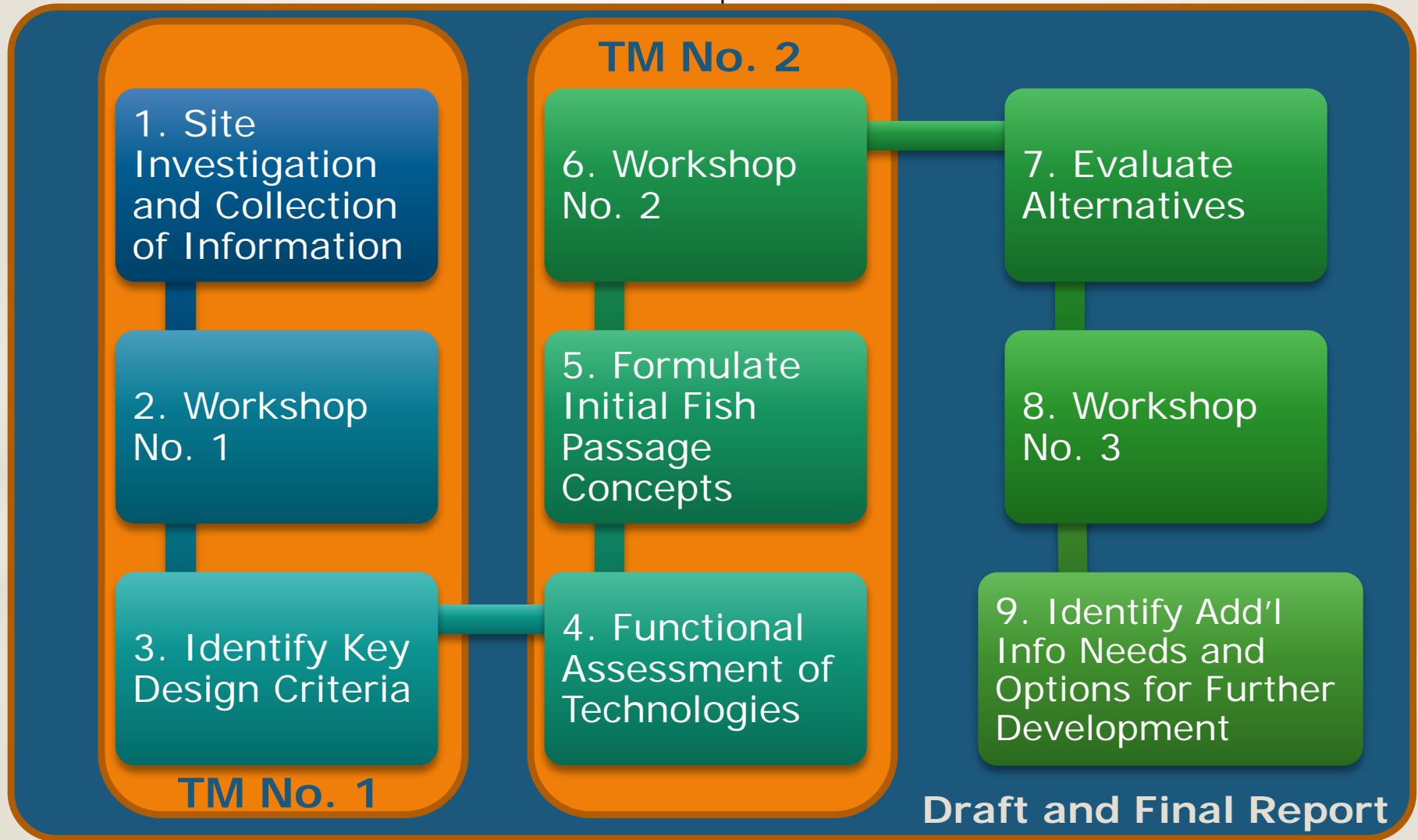
- Most projects at high head dams in Pacific Northwest use CHTR for upstream passage
- Constructed projects in California?



Cushman Surface Collector and Fish Handling Equipment.  
Figures by Tacoma Power



## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT







TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# Process Coordination and Feedback – Workshops

Meeting / Deliverable	Schedule
Consultation Workshop No. 1	May 2015
Interim Work Product – TM No. 1	July 2015
Consultation Workshop No. 2	August 2015
Interim Work Product – TM No. 2	October 2015
Draft Fish Passage Facility Report	December 2015
Consultation Workshop No. 3	January 2016
Initial Study Report document	February 2016
Final Fish Passage Facility Report	March 2016



## North American Journal of Fisheries Management

Publication details, including instructions for authors and subscription information:  
<http://www.tandfonline.com/loi/ujfm20>

### Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery

Joseph H. Anderson<sup>a e</sup>, George R. Pess<sup>a</sup>, Richard W. Carmichael<sup>b</sup>, Michael J. Ford<sup>a</sup>,  
Thomas D. Cooney<sup>c</sup>, Casey M. Baldwin<sup>d f</sup> & Michelle M. McClure<sup>a</sup>

<sup>a</sup> National Oceanic and Atmospheric Administration, National Marine Fisheries Service,  
Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington,  
98112, USA

<sup>b</sup> Oregon Department of Fish and Wildlife, Eastern Oregon University, 203 Badgley Hall, One  
University Boulevard, La Grande, Oregon, 97850, USA

<sup>c</sup> National Oceanic and Atmospheric Administration, National Marine Fisheries Service,  
Northwest Fisheries Science Center, 1201 Northeast Lloyd Boulevard, Portland, Oregon,  
97232, USA

<sup>d</sup> Washington Department of Fish and Wildlife, 3515 State Highway 97A, Wenatchee,  
Washington, 98801, USA

<sup>e</sup> Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia,  
Washington, 98501, USA

<sup>f</sup> Colville Confederated Tribes, Fish and Wildlife Department, 470 9th Street Northeast,  
Suite 4, East Wenatchee, Washington 9, 8802, USA

Published online: 30 Jan 2014.

To cite this article: Joseph H. Anderson, George R. Pess, Richard W. Carmichael, Michael J. Ford, Thomas D. Cooney, Casey M. Baldwin & Michelle M. McClure (2014) Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery, North American Journal of Fisheries Management, 34:1, 72-93

To link to this article: <http://dx.doi.org/10.1080/02755947.2013.847875>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

ARTICLE

# Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery

**Joseph H. Anderson\*<sup>1</sup> and George R. Pess**

*National Oceanic and Atmospheric Administration, National Marine Fisheries Service,  
Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112, USA*

**Richard W. Carmichael**

*Oregon Department of Fish and Wildlife, Eastern Oregon University, 203 Badgley Hall,  
One University Boulevard, La Grande, Oregon 97850, USA*

**Michael J. Ford**

*National Oceanic and Atmospheric Administration, National Marine Fisheries Service,  
Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112, USA*

**Thomas D. Cooney**

*National Oceanic and Atmospheric Administration, National Marine Fisheries Service,  
Northwest Fisheries Science Center, 1201 Northeast Lloyd Boulevard, Portland, Oregon 97232, USA*

**Casey M. Baldwin<sup>2</sup>**

*Washington Department of Fish and Wildlife, 3515 State Highway 97A, Wenatchee,  
Washington 98801, USA*

**Michelle M. McClure**

*National Oceanic and Atmospheric Administration, National Marine Fisheries Service,  
Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112, USA*

---

## Abstract

Local extirpations of Pacific salmon *Oncorhynchus* spp. and steelhead *O. mykiss*, often due to dams and other stream barriers, are common throughout the western United States. Reestablishing salmonid populations in areas they historically occupied has substantial potential to assist conservation efforts, but best practices for reintroduction are not well established. In this paper, we present a framework for planning reintroductions designed to promote the recovery of salmonids listed under the Endangered Species Act. Before implementing a plan, managers should first describe the benefits, risks, and constraints of a proposed reintroduction. We define benefits as specific biological improvements towards recovery objectives. Risks are the potential negative outcomes of reintroductions that could worsen conservation status rather than improve it. Constraints are biological factors that will determine whether the reintroduction successfully establishes a self-sustaining population. We provide guidance for selecting a recolonization strategy (natural colonization, transplanting, or hatchery releases), a source population, and a method for providing passage that will maximize the probability of conservation benefit while minimizing risks. Monitoring is necessary to determine whether the reintroduction successfully achieved the benefits and to evaluate the impacts on nontarget

---

\*Corresponding author: joseph.anderson@dfw.wa.gov

<sup>1</sup>Present address: Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, Washington 98501, USA.

<sup>2</sup>Present address: Colville Confederated Tribes, Fish and Wildlife Department, 470 9th Street Northeast, Suite 4, East Wenatchee, Washington 98802, USA.

Received September 10, 2012; accepted August 30, 2013

species or populations. Many of the benefits, especially diversity and the evolution of locally adapted population segments, are likely to accrue over decadal time scales. Thus, we view reintroduction as a long-term approach to enhancing viability. Finally, our review of published salmonid reintroduction case studies suggests that large uncertainties remain in the success of reintroduction in establishing self-sustaining populations, particularly for programs employing active methods.

Reintroducing species to areas from which they have been extirpated is a common and sometimes successful approach to conserving biodiversity. Indeed, reintroductions played a prominent role in some of the most spectacular success stories in conservation, including species that have recovered from the brink of extinction such as the Arabian oryx *Oryx leucoryx* (Spalton et al. 1999) and alpine ibex *Capra ibex ibex* (Stüwe and Nievergelt 1991). However, despite considerable cost and effort, reintroduction efforts often fail to establish self-sustaining populations (Wolf et al. 1996; Fischer and Lindenmayer 2000). A recent proliferation of reintroduction literature suggests that scientifically based management principles can improve the efficacy of these efforts (Seddon et al. 2007; Armstrong and Seddon 2008).

Conceptually, reintroductions offer an enormous potential to benefit the conservation of Pacific salmon *Oncorhynchus* spp. and steelhead *O. mykiss* (anadromous Rainbow Trout). For many anadromous salmonid populations, the primary cause of local extirpation is easily identified: obstructed access to suitable spawning and rearing habitats due to dams or other stream blockages. Large barriers are responsible for extirpation from nearly 45% of the habitat historically occupied by Pacific salmon and steelhead in the western contiguous United States (McClure et al. 2008a). Numerous smaller structures, such as irrigation diversion dams and culverts, also limit access to anadromous salmonid habitat (Gibson et al. 2005). Impassable dams are only one cause of declining salmonid populations and local extirpations (NRC 1996), but they are widespread. The removal or circumvention of dams and other barriers, therefore, provides many opportunities for the reestablishment of natural populations of Pacific salmon.

Despite the potential benefits of reintroduction, regional recovery planners must grapple with a variety of challenges in selecting and implementing such projects. Which populations should be prioritized for reintroduction? What methods should be used to reintroduce anadromous salmonids? How should managers evaluate whether efforts have been successful? Although previous authors have provided general guidelines for fish reintroductions (Williams et al. 1988; Minckley 1995; George et al. 2009; Dunham et al. 2011), the unique biology and management of Pacific salmon and steelhead merit special consideration.

In this paper, we provide recommendations for planning reintroductions of anadromous salmonids, focusing primarily on Pacific salmon and steelhead. Our guidelines are intended to help

resource managers design reintroduction programs that contribute to the recovery of Pacific salmon and steelhead listed under the U.S. Endangered Species Act (ESA) by establishing or expanding self-sustaining natural populations. Thus, we present recommendations couched in the terminology, scientific concepts, and broad conservation objectives guiding ongoing salmonid recovery efforts under the ESA (McElhany et al. 2000). The International Union for the Conservation of Nature (IUCN 1998) defined reintroduction as “an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated.” Using this broad definition, we consider a suite of management approaches to reintroduction, including passive strategies, such as barrier removal followed by natural colonization, and active strategies, such as transplanting or hatchery releases.

Reintroductions alter patterns of connectivity among populations. We therefore first develop a metapopulation framework to describe the ecological processes governing population connectivity and their evolutionary consequences. We then broadly overview a set of planning concepts (benefits, risks, and constraints) to help guide scoping efforts and determine if a proposed reintroduction has conservation merit. Next, we describe methods of executing reintroductions that increase the likelihood of achieving benefits while overcoming constraints and reducing risks, including a review of examples in which these methods have been employed. Finally, monitoring is essential to assess whether the effort was successful and, if not, how the program should be modified. Throughout, we focus on biological issues, acknowledging that a socioeconomic cost-benefit analysis will be crucial for policy decisions regarding large-scale restoration projects.

## A METAPOPULATION PERSPECTIVE

A regional, landscape perspective is important for effective salmonid recovery (ISAB 2011). We therefore present our recommendations within a metapopulation conceptual framework. A metapopulation is a collection of spatially structured populations inhabiting discrete habitat patches, with dispersal between patches providing some level of connectivity between populations (Hanski and Gilpin 1997). Reintroductions intentionally alter connectivity among populations, so it is important to consider the consequences of such actions on the demography, ecology, and evolution of the metapopulation at large.

The metapopulation concept is readily applied to anadromous salmonids (Schtickzelle and Quinn 2007) and especially the case of population colonization. Pacific salmon have a strong tendency to return to their natal stream but also “stray” and breed in nonnatal streams (Hendry et al. 2004), providing the interpopulation dispersal characteristic of metapopulations. Dispersal, combined with variation in population growth rate, can lead to source–sink dynamics whereby populations with net demographic deficits (i.e., “sinks”) are supported by immigration from populations with net demographic excesses (i.e., “sources”) (Pulliam 1988). For colonizing Pacific salmon, source population dynamics will, in large part, determine the rate of numerical and spatial expansion (Pess et al. 2012).

Salmonid metapopulations might adopt a variety of different structural configurations depending on the spatial arrangement of habitat, heterogeneity in habitat quality among patches, and connectivity between populations (Schtickzelle and Quinn 2007; Fullerton et al. 2011). Metapopulation structure is useful to conceptualize the potential outcomes of reintroductions (Figure 1). Furthermore, an assessment of metapopulation structure might inform reintroduction methods. For example, a reintroduction that expands an existing population (Figure 1A) or establishes a new well-connected population (Figure 1B) might achieve success through passive natural colonization, whereas active methods might be required for more isolated reintroduction sites (Figure 1C).

Metapopulation structure, and the degree of connectivity among populations, also affects the evolution of locally adapted traits. Spatially structured populations experiencing different selection regimes within a heterogeneous landscape will tend to evolve traits advantageous in each environment, a process that is counterbalanced by connectivity between populations, which tends to homogenize gene pools (Barton and Whitlock 1997). Local adaptation is a fundamental aspect of salmonid population structure (Taylor 1991; Fraser et al. 2011). Furthermore, life history diversity exhibited by locally adapted populations buffers salmonid species against environmental variation, increasing stability and resilience (Greene et al. 2010; Schindler et al. 2010) while reducing extinction risk (Moore et al. 2010).

Increasing population connectivity, an implicit goal of all reintroduction programs, can have both positive and negative consequences on species viability. Some level of connectivity is beneficial because it can lead to the colonization of new habitat (Pess et al. 2012), demographically rescue extant populations experiencing periods of low productivity or abundance (Pulliam 1988), and provide new genetic material essential for fitness in populations suffering from fragmentation (Tallmon et al. 2004). However, excessive connectivity can have negative consequences such as genetic homogenization (Williamson and May 2005) and demographic synchrony (Liebhold et al. 2004), both of which would tend to reduce resilience.

For administering listing and recovery of Pacific salmon under the ESA, the National Marine Fisheries Service (NMFS) uses an explicitly defined population structure. For vertebrates,

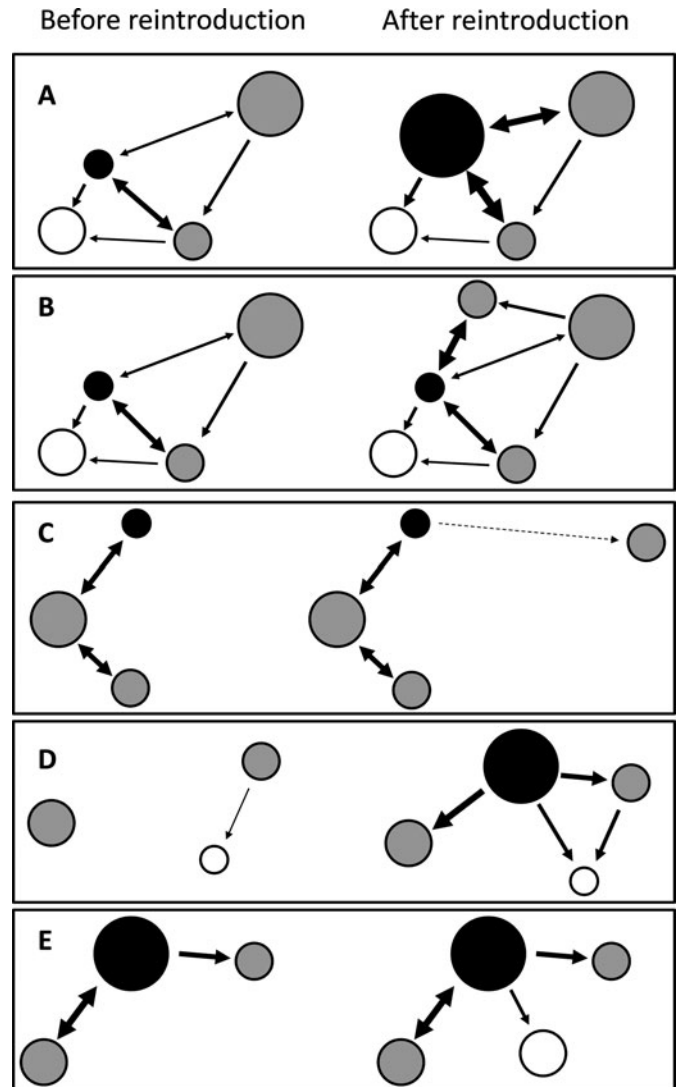


FIGURE 1. Possible effects of reintroduction on metapopulation structure are as follows: (A) increase the abundance of the existing population, (B) establish a new, independent population well connected to the metapopulation, (C) establish a new, independent population isolated from the other populations, (D) establish a new, independent mainland population in a historic mainland–island metapopulation, and (E) establish a new, independent sink population in a historic mainland–island metapopulation. In these diagrams, the size of the circle represents habitat capacity, the shade represents population density (darker shades are more dense), the thickness of the arrows represents the magnitude of connectivity, and the dashed lines indicate intermittent connectivity. These scenarios are not intended to represent all possible outcomes.

the ESA allows listing of Distinct Population Segments (DPSs), subspecies, or entire species. For Pacific salmon, the NMFS has defined a DPS to be an Evolutionary Significant Unit (ESU), which is a population or group of populations that is both substantially reproductively isolated from other populations and represents an important component of the evolutionary legacy of the species (Waples 1991). For steelhead, the NMFS uses the joint NMFS–U.S. Fish and Wildlife Service DPS definition



(NMFS 2006). We refer to both Pacific salmon ESUs and steelhead DPSs as ESUs in this paper for consistency and brevity. Similar to metapopulations, most Pacific salmon ESUs contain multiple independent populations that interact through dispersal (e.g., Myers et al. 2006; Ruckelshaus et al. 2006). Furthermore, metapopulation concepts are explicitly considered in the criteria used to evaluate the viability of Pacific salmon and steelhead ESUs and the populations within them (McElhany et al. 2000).

### PLANNING CONCEPTS: BENEFITS, RISKS, AND CONSTRAINTS

Before implementing a reintroduction, it is essential to comprehensively consider the potential outcomes. Poorly planned reintroduction efforts might waste resources that would be better invested in other conservation approaches or, worse, impair the viability of an extant population. In evaluating a potential reintroduction, there are three primary concepts to consider: the benefits if the reintroduction is successful, the risks of causing biological harm to extant populations, and the constraints that might prevent population establishment. Weighing the potential benefits against the risks and constraints will help determine whether or not to implement a proposed reintroduction (Figure 2).

#### Benefits

Due to our focus on ESA-listed salmonids, we assess benefits with the same criteria used to evaluate recovery under the ESA. The biological viability of salmonid ESUs and the populations within them is dependent upon four characteristics: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). We use these same attributes for evaluating the potential benefits of a reintroduction that successfully establishes a self-sustaining population (Table 1). Abundance, productivity, and spatial structure (i.e., connectivity) are variables in metapopulation models useful for guiding salmonid management (Cooper

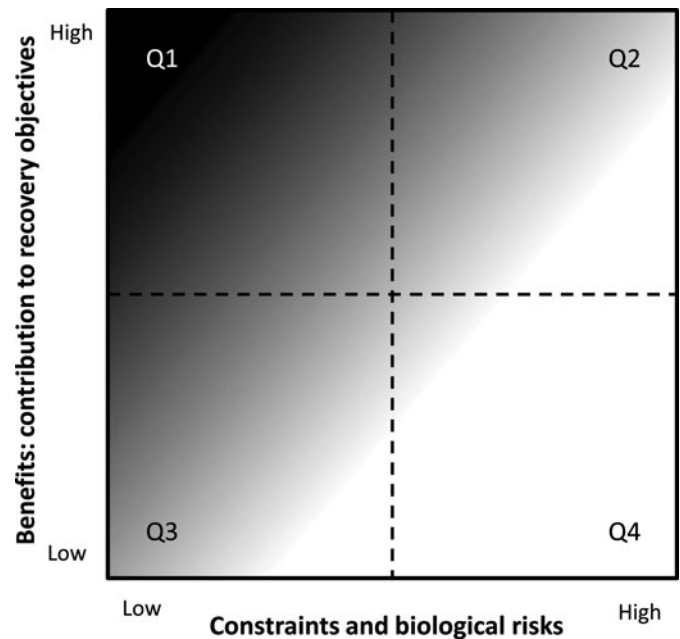


FIGURE 2. Framework for gauging the net benefit of reintroduction options, with darker colors representing a higher likelihood of contributing to conservation and recovery goals. In each case, the benefits are weighed against the constraints and risks of the project. In quadrant 1 (Q1), the benefits are high and the overall constraints and risks are low, providing the best opportunity for reintroduction to effectively contribute to the recovery objectives. Quadrant 2 (Q2) also has a high potential benefit, but either the difficulty in implementation or the risk of a negative outcome makes projects in this region less attractive. Both quadrants 3 (Q3) and 4 (Q4) have relatively low benefits; some in quadrant 3 may be selected owing to the low risk and ease of execution, whereas those in quadrant 4 will generally be avoided.

and Mangel 1999; Fullerton et al. 2011; Pess et al. 2012), and diversity promotes resilience at a broad, regional (hence metapopulation) scale (Moore et al. 2010; Schindler et al. 2010).

Numerical increases in abundance and productivity are perhaps the most obvious benefits afforded by reintroductions.

TABLE 1. Potential benefits of a successful reintroduction.

Type	Definition	Potential benefit afforded by reintroduction
Abundance	Total number of naturally spawned fish in a population or ESU	Increase the carrying capacity of an existing population or establish a new, discrete, demographically independent population
Productivity	Numerical ratio of recruits in generation $t$ to the spawners that produced them in generation $t - 1$	Increase average vital rates (e.g., reproductive success, survival) of an extant population or ESU by reestablishing occupancy of high quality habitat
Spatial structure	Geographic arrangement of fish across the landscape and connectivity of populations linked by dispersal	Reduce isolation of extant populations, thereby restoring natural patterns of dispersal and connectivity within the metapopulation
Diversity	Variation in morphological, behavioral, and genetic traits within a population or ESU	Reestablish occupancy of habitats that are rare or underrepresented within the extant distribution, thereby promoting ecological and evolutionary processes responsible for local adaptation and diverse life histories

Increased abundance has several beneficial consequences, including shielding a population from extinction due to stochastic variability (Lande 1993), minimizing genetic processes that can reduce fitness in small populations (Allendorf and Luikart 2007), exceeding thresholds for compensatory density-dependent processes (Liermann and Hilborn 2001), and providing marine-derived nutrient subsidies to aquatic and riparian ecosystems (Gende et al. 2002). Status evaluations of ESA-listed Pacific salmon and steelhead populations focus on numerical productivity (Ford 2011), or population growth rate as it is known in the ecological literature, so recruits per spawner is also an important variable to consider. Reintroductions can have either positive or negative impacts on the productivity of a given population or ESU, depending on the quality of the new habitat and survival through migration and ocean rearing. In general, a reintroduction resulting in a “sink” has far less value for long-term viability than a reintroduction yielding a self-sustaining population. Indeed, reintroduction to a sink would result in a net loss if the animals would have been more productive in their natal habitat. However, in highly connected metapopulations, sinks may increase the stability of the entire system by promoting higher abundance in source populations (Foppen et al. 2000).

Reintroductions that reduce the isolation of formerly connected extant populations will benefit spatial structure (Figure 1). In practice, this can be estimated as the extent to which a newly established population would reduce gaps between spawning areas or populations that were not historically separated. Given the spatial arrangement, models of dispersal, and estimates of habitat capacity, reintroduction could target areas that might have a significant role in metapopulation connectivity and serve as sources supporting less productive populations (Figure 1D; Fullerton et al. 2011; Pess et al. 2012). In addition, at the ESU scale, dispersion of populations across the landscape helps reduce vulnerability to catastrophic events (Good et al. 2008), so increasing spatial complexity via successful reintroduction will reduce ESU extinction risk.

Reintroductions can enhance salmonid diversity through a variety of mechanisms. Dams often selectively block access to certain habitat types, particularly snowmelt-dominated headwater streams (Beechie et al. 2006; McClure et al. 2008a). Therefore, reintroductions into habitats that are rare or underrepresented within the extant species distribution may promote unique local adaptations and life history traits. Barrier removal may provide seaward access for populations of facultatively migratory species (e.g., *O. mykiss*) that historically had anadromous components (Brenkman et al. 2008b). Reintroductions to large watersheds with multiple tributaries and subbasins also offer opportunities to enhance diversity through the evolution of population substructure and local adaptation to distinct spawning areas. In general, a reintroduction that establishes a new locally adapted population will provide a greater benefit to diversity than one that expands an existing population (Figure 1A, 1B).

Outlining the time frame required to achieve reintroduction benefits will help set expectations and establish benchmarks for monitoring. Some reintroductions may provide immediate benefits within a generation or two, but those requiring adaptation to new habitat will likely take decades. If an implemented project suffers initial setbacks and lacks a scientifically based timeline of expectations, it might be unnecessarily abandoned or altered before it has a chance to succeed. In general, reintroduction can provide benefits to viability characteristics that change on ecological time scales (abundance, productivity, and spatial structure) faster than benefits to diversity, which will accumulate over generations as a reintroduced population becomes demographically independent and evolves in response to local selective pressures. Salmonids have developed population structure within 20 years of introduction to new environments (Ayllon et al. 2006); evidence that such divergence is adaptive has been found after 50–100 years (Hendry et al. 2000; Quinn et al. 2001; Koskinen et al. 2002).

Moreover, in some cases adaptive evolution might be necessary to observe significant increases in abundance. Indeed, there is often a time lag from the initial introduction of an invading species to population growth that might be explained by evolutionary processes required to increase population fitness (Sakai et al. 2001). Dams have altered the evolution of traits such as adult spawn timing, embryonic development rate, and juvenile migration strategies (Angilletta et al. 2008; Williams et al. 2008), so some level of adaptive evolution may be necessary to overcome this “Darwinian debt” if reintroduction includes restoration of the natural flow regime (Waples et al. 2007b).

## Risks

We define risks as unintended or undesirable negative consequences for nontarget species or nontarget populations of the reintroduced species (Table 2). Minimizing those risks is important if a reintroduction is to have a positive overall conservation effect (George et al. 2009). Here we outline the concepts underlying four categories of risk: evolutionary, demographic, ecological, and disease. More details on minimizing them are provided below in the Executing a Reintroduction section.

In terms of evolutionary risks, reintroduction could result in genetic homogenization, reduced fitness, or both. Transfers of fish between basins and large-scale hatchery releases, historically common practice throughout the Pacific Northwest, have eroded population structure that is essential for the local adaptation and hence fitness of salmonid populations (Williamson and May 2005; Eldridge and Naish 2007; McClure et al. 2008b). Hatchery fish often have lower fitness than wild fish when both groups breed sympatrically (Araki et al. 2008). Thus, although hatchery releases may provide short-term demographic benefits, they may compromise fitness in the long term, thereby limiting the probability of recovery (Bowlby and Gibson 2011). In many cases, populations or spawning areas near the reintroduction site are of conservation concern. Fish

TABLE 2. Summary of the major reintroduction risks, defined as unintended or undesirable negative consequences for nontarget species, nontarget populations, spawning areas, or life history types of the reintroduced species.

Type	Description	Methods of minimizing risk
Evolutionary	Homogenized population structure and reduced fitness within reintroduction site and adjacent areas	Avoid geographically and genetically distant source populations; opt for natural colonization rather than hatchery releases or transplanting; design passage facilities to minimize straying to adjacent areas
Demographic	Depletion of source population via removal of adults or gametes for reintroduction	Ensure that source population can sustain removal for multiple successive years or opt for natural colonization rather than hatchery releases or transplanting
Ecological	Invasion by nonnative species and suppression of preexisting native species within reintroduction site	Design passage facilities with selective access; avoid hatchery releases that alter density-dependent ecological interactions
Disease	Spread of pathogens	Establish baseline disease levels prior to reintroduction; screen individuals for pathogens prior to release

released into the reintroduction site, and their offspring, may not return there as adults, so fitness reductions and the erosion of population structure of the wild populations in adjacent spawning areas are potential consequences of excessive straying.

Reintroductions also pose demographic risks because the removal of individuals from the source population may harm its viability. If reintroduced fish experience poor reproductive success, the new habitat may become a sink that depletes an extant population but fails to provide the benefit of a newly established self-sustaining population. Transplanting or collecting broodstock from wild populations will exacerbate this risk, but it applies in concept to natural colonization as well. Ensuring that the population donating colonists has a net demographic excess (i.e., it is a true “source” in metapopulation source–sink dynamics) will help reduce demographic risks.

Nonnative fishes present a serious conservation threat to salmonids in the Pacific Northwest (Sanderson et al. 2009) and may invade the reintroduction site following barrier removal (Fausch et al. 2009). Invasion might not only reduce the likelihood of reintroduction success but also threaten preexisting native species. A careful examination of the likelihood of nonnative dispersal into the new habitat entails identifying any proximate populations of nonnative fishes and evaluating habitat suitability above the barrier. It is also important to consider whether reintroduction might suppress preexisting native species (which might be threatened or endangered themselves) through competition or predation. The few empirical assessments of reintroduction impacts have found little effect on preexisting native species (Pearsons and Temple 2007; Buehrens 2011).

Finally, reintroductions have potential to spread disease (Viggers et al. 1993). Colonists may serve as vectors of disease spread within the species they are intended to benefit, thereby hindering conservation efforts (Walker et al. 2008), or transmit pathogens to other species or resident life history types cur-

rently occupying the target site. Hatchery fish in particular, due to the crowded conditions in which they are typically reared, may act as vectors of disease transfer to wild populations (reviewed in Naish et al. 2008). Reintroduced animals might also be vulnerable to endemic pathogen strains within new habitat, and this could decrease the likelihood of successful population establishment if the effect is severe. Establishing a baseline of pathogen densities within the area prior to reintroduction will permit monitoring of disease during reintroduction (Brenkman et al. 2008a), and screening captively reared or transplanted animals prior to release will minimize the risk of spreading disease. Both are important components of reintroduction.

### Constraints

We define a constraint as a factor limiting the ability of colonists to establish a self-sustaining population (Table 3). In some cases, an extirpated area may have a high potential to benefit long-term recovery, but current conditions do not support a reintroduction. Evaluating whether the original causes of the extirpation have been adequately ameliorated is an important step in determining whether a site is “reintroduction ready” (IUCN 1998). Importantly, more than one factor may have led to the original extirpation, and in many cases determining a logical sequence of restoring functioning conditions will be an important component of the reintroduction effort. Here, we describe the primary constraints affecting the ability of colonists to reach the reintroduction site, their reproductive success, and the survival of their offspring.

In many cases, migration barriers are the most obvious constraint to the reestablishment of a natural population. Evaluating the best methods for providing passage at barriers is heavily dependent on engineering and social considerations such as the geological setting, human benefits derived from the barrier, and expense. Furthermore, many river systems with reintroduction opportunities have more than one blockage to anadromous

TABLE 3. Summary of constraints to reintroductions, defined as factors that might limit the ability of colonists to establish a self-sustaining population.

Type	Description	Required action
Barriers	Engineering issues; prioritization among multiple blockages in a watershed or region	Removal or circumvention
Habitat quality	Poor habitat quality will limit reproductive success of colonists and survival of their offspring	Restoration prior to reintroduction
Migratory and ocean survival	Poor survival along migration corridor and during ocean residence	Improve survival through downstream dams; estuary restoration; wait for favorable ocean conditions or scale expectations to match poor ocean conditions
Harvest	Reduces number of potential colonists and survival of their offspring	Reduce fishing pressure on potential source population(s) during colonization
Interactions with other species and populations	Competition and predation from native and nonnative species	Suppress predator population or transport fish during migration to avoid predators
Changing conditions	Climate and land-use change will alter geographic patterns of habitat suitability	Prioritize reintroductions that enhance diversity, are likely to serve as refuges in a warming climate, or are located in river networks whose high connectivity will allow species distributions to shift in response to climate change

passage, requiring prioritization among multiple removal or circumvention options.

The quality of habitat in the reintroduction site will have a large effect on colonist productivity. In gauging habitat quality within an area targeted for reintroduction, planners should consider the requirements of all life phases. Spatially explicit models incorporating known fish–habitat relationships (e.g., Scheuerell et al. 2006; Burnett et al. 2007; Pess et al. 2008) can help identify potentially productive streams; determining the anthropogenic degradation of habitats can draw on the many efforts (largely expert opinion) to identify degraded habitat (e.g., subbasin or recovery plans). Where habitat quality is low due to anthropogenic disturbance, habitat restoration may be necessary for successful reintroduction and premature efforts to put fish into degraded habitat may simply be a waste of resources. For example, liming of rivers affected by acidification (Hesthagen and Larsen 2003) and reducing pollution (Perrier et al. 2010; Kesler et al. 2011) were necessary components of reestablishing Atlantic Salmon *Salmo salar* runs in Europe. When restoration is necessary, process-based restoration will maximize the long-term sustainability of habitat improvements (Beechie et al. 2010).

Interactions with existing species in the target area could influence the likelihood of a successful reintroduction. Dams that block salmonid habitat often create the warm, lentic reservoirs preferred by nonnative fishes (e.g., Channel Catfish *Ictalurus punctatus*, Smallmouth Bass *Micropterus dolomieu*, Yellow Perch *Perca flavescens*, and Walleye *Sander vitreus*) and “native invaders” (e.g., Northern Pike *Esox lucius*, Bullheads *Ambloplites rupestris*), species that consume a considerable quantity of salmonids (Sanderson et al. 2009; Carey et al. 2012). Competition and pre-

dation from preexisting species might not be confined to reservoirs or degraded habitats. Nonnative Brook Trout *Salvelinus fontinalis*, for example, have invaded relatively pristine, free-flowing streams throughout the Pacific Northwest (Sanderson et al. 2009) and may have suppressed populations of ESA-listed Chinook Salmon *O. tshawytscha* (Levin et al. 2002). Slimy Sculpin *Cottus cognatus*, a native generalist predator, reduced the recruitment success of reintroduced Atlantic Salmon (Ward et al. 2008).

Due to climate forcing (Mantua et al. 2010) and alterations in land use (Bilby and Mollot 2008), salmonid habitat quality is likely to change over the time required for a reintroduction to result in a self-sustaining population. Thus, the likely future condition of the reintroduction site is an important consideration in reintroduction planning efforts. Climate and land-use models can inform restoration opportunities (Battin et al. 2007; Lohse et al. 2008) but have been applied to relatively few watersheds. In the absence of large-scale predictive models, two qualitative guidelines for reintroductions warrant consideration. First, dams selectively block access to certain habitat types (Beechie et al. 2006; McClure et al. 2008b), suggesting that reintroduction to mountain headwater reaches with higher elevations and cooler temperatures may provide refuges in a warming climate. Second, maintaining a diversity of habitat types will buffer against uncertainty in the response of salmonid populations to climate change (Schindler et al. 2008), suggesting that reintroduction should target habitats that are unique, rare, or underrepresented in the current species distribution.

High mortality during migration and ocean rearing due to impaired migratory corridor, poor ocean conditions, or harvest pressure may limit reintroduction success. Passage through

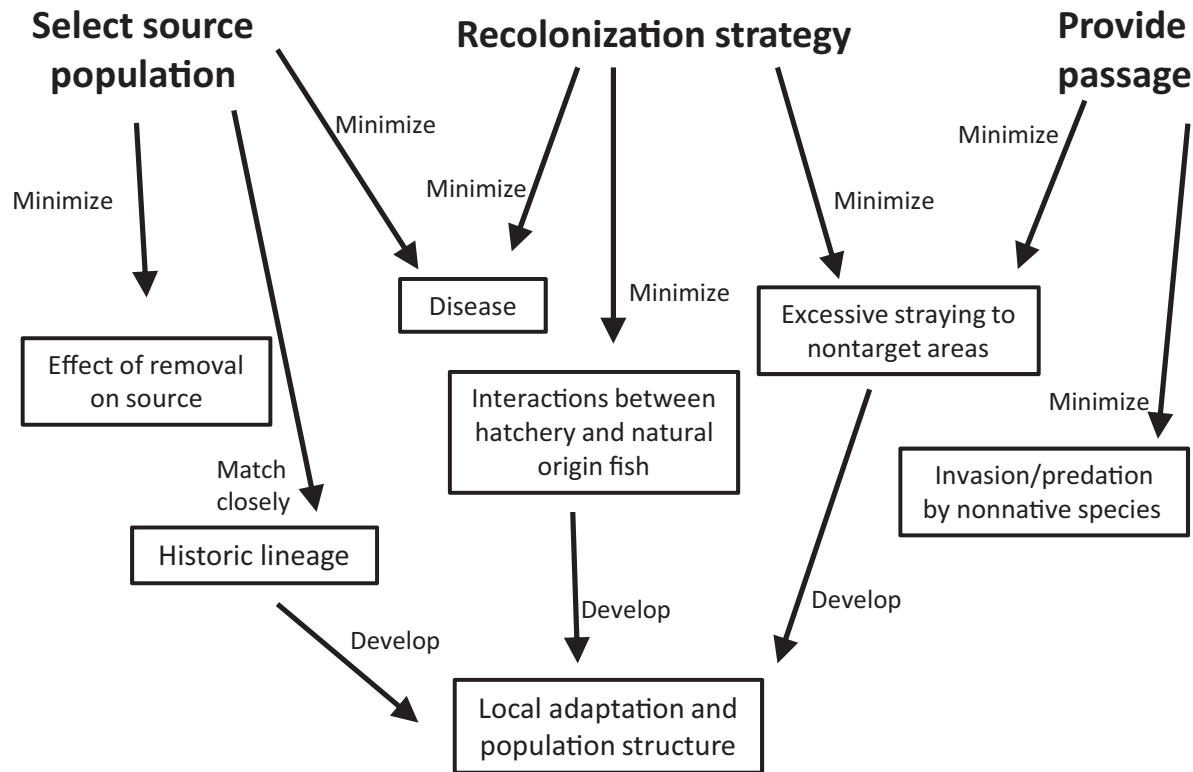


FIGURE 3. Minimizing biological risks in reintroduction planning. Biological risks are unintended negative consequences that may harm nontarget species, other populations, spawning areas, or life history types of the reintroduced species.

downstream dams, for example, may reduce the migratory survival of juveniles, either directly or through delayed effects that manifest in subsequent life stages (Budy et al. 2002; Schaller and Petrosky 2007). Dams may also cause the delay and eventual failure of upstream-migrating adults (Caudill et al. 2007). It is possible to improve survival through dams, even large ones (Ferguson et al. 2007), and this may be an essential action prior to reintroduction. Marine survival patterns are also a major determinant of salmonid population productivity. Ocean survival responds to long-term climatic processes such as the Pacific Decadal Oscillation (Mantua et al. 1997), as well as short-term processes such as interannual variation in sea surface temperature, marine upwelling, and river conditions experienced during migration (Mueter et al. 2005; Scheuerell and Williams 2005; Scheuerell et al. 2009; Petrosky and Schaller 2010). As our ability to identify favorable ocean and river conditions improves (e.g., Burke et al. 2013), there may be opportunities to time reintroduction efforts to favorable conditions. Harvest rates vary among ESUs and in some cases may limit recolonization potential. Fishing quotas set on aggregate stocks may constrain the ability to selectively reduce harvest rates on individual colonizing populations and their sources.

#### EXECUTING A REINTRODUCTION: COLONIZATION, SOURCE POPULATION, AND PASSAGE

In this section, we discuss the strategies for recolonization, the choice of a source population, and, in the case of reintroduc-

tions involving barriers, the techniques used to provide passage. Decisions related to these three execution elements will largely determine reintroduction risks (Figure 3). We define the colonization strategy as the mechanism of fish movement into the reintroduction site; it can be either passive (natural colonization) or active (transplanting or hatchery releases). We suggest that it is important to consider the colonization strategy and source population as two separate planning decisions. For example, even in cases where a hatchery stock is the source, it may be possible to reduce evolutionary risks by allowing hatchery adults to colonize naturally rather than planting hatchery-produced juveniles.

#### Colonization Strategy

The three basic types of colonization strategies are natural, transplant, and hatchery release. Importantly, these approaches differ in the effects on the viability parameters that will ultimately be used to judge the success or failure of a reintroduction. In general, natural colonization is the lowest-risk approach because it minimizes the interruption of natural biological processes. Transplanting and hatchery releases can immediately place fish in the reintroduction site, but tend to increase the risks associated with reintroduction relative to natural colonization. Fortunately, active reintroduction strategies will be most necessary for isolated reintroduction sites (e.g., Figure 1C), the very situations where evolutionary risks of straying to neighboring extant populations are the lowest. In general, a precautionary



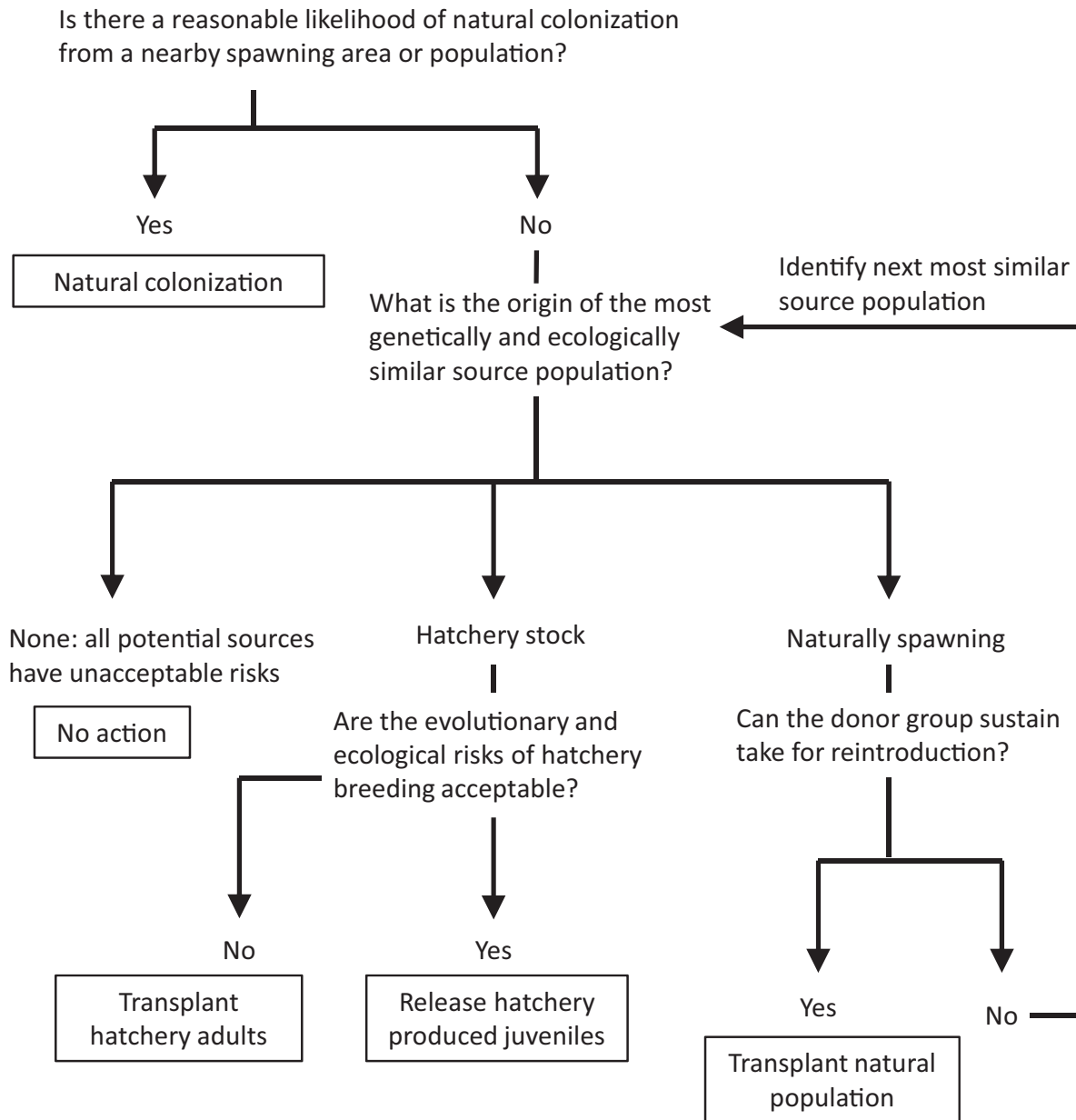


FIGURE 4. Decision framework for selecting a low-risk colonization strategy and source population. This diagram does not encompass every possibility but is intended to highlight the key decisions affecting reintroduction risks. Boxes indicate decision endpoints.

approach, outlined in Figure 4, adopts the lowest risk colonization strategy that has a reasonable chance of promoting long-term improvement in population and ESU viability.

What is the minimum number of fish necessary to establish a self-sustaining population? This is a crucial question applicable to all three colonization strategies whenever the goal is to establish a new population (e.g., Figures 1B–1E). On one hand, compensatory processes (Allee effects) may depress productivity at low densities through a variety of mechanisms (Courchamp et al. 1999; Liermann and Hilborn 2001) and, if the effect is severe, prevent population establishment

following reintroduction (Deredec and Courchamp 2007). On the other hand, reintroduced species, particularly those with an extensive stream-rearing juvenile phase, may be released from density-dependent processes during colonization and enjoy high survival due to the lack of competition (Pess et al. 2011). Although the ultimate result will depend heavily on the constraints (Table 3), the choice of colonization strategy will have a strong influence on the number of fish that reach the reintroduction site. Here, we outline the benefits and risks of each colonization strategy, providing empirical examples if they are available.

*Natural colonization.*—Pacific salmon can rapidly exploit newly accessible habitat through natural colonization, which we define as volitional dispersal into a reintroduction site without human-assisted transport. Following construction of a fishway circumventing an anthropogenic blockage, Pink Salmon *O. gorbuscha* naturally dispersed upstream and established self-sustaining populations in multiple subbasins of the Fraser River, British Columbia, within a decade (Pess et al. 2012). Chinook Salmon and Coho Salmon *O. kisutch* immediately colonized habitat made accessible by modification of a dam on the Cedar River, Washington (Kiffney et al. 2009; Burton et al. 2013), and both species produced a significant number of returning adult offspring that bypassed the dam in the next generation (Anderson et al. 2010; Anderson et al. 2013a). In this system, extensive dispersal by juvenile Coho Salmon, including immigration into a tributary where survival was relatively high, contributed to colonization success (Pess et al. 2011; Anderson et al. 2013b). Steelhead and fluvial Rainbow Trout accessed Beaver Creek, Washington, in the very first season after barrier removal (Weigel et al. 2013). Atlantic Salmon naturally colonized rivers in Estonia, Norway, England, and France following improvements in water quality (Hesthagen and Larsen 2003; Perrier et al. 2010; Griffiths et al. 2011; Kesler et al. 2011), and some of these examples resulted from long-distance dispersal. Dam removal promoted natural colonization of the Upper Salmon River, New Brunswick, by Atlantic Salmon, though this population later crashed to near zero abundance for unknown reasons (Fraser et al. 2007).

In some cases, increasing water releases from dams has promoted natural colonization. In the Bridge River, British Columbia, Coho Salmon, Chinook Salmon, and steelhead were observed immediately following restoration of flow to a 4-km reach that had been dewatered for decades (Decker et al. 2008). Experimental water releases from dams on the Alouette and Coquitlam rivers, British Columbia, led to the reappearance of Sockeye Salmon *O. nerka* after 90 years of extirpation, and genetic and otolith analysis confirmed that the anadromous adults were the offspring of resident kokanee (lacustrine Sockeye Salmon) (Godbout et al. 2011).

Natural disturbances and circumvention of natural barriers provide additional examples of natural colonization. Steelhead recolonized the Toutle River, Washington, to relatively high densities 7 years after a catastrophic destruction following the eruption of Mount Saint Helens (Bisson et al. 2005). Natural colonization tends to proceed more slowly (e.g., decades) in initially barren glacial emergent streams, as evidenced by rates of Coho Salmon and Pink Salmon colonization in Glacier Bay, Alaska (Milner and Bailey 1989; Milner et al. 2008). Several salmonid species rapidly colonized Margaret Creek, Alaska, following construction of a fish ladder at a falls, although the Coho Salmon and Sockeye Salmon populations were supplemented by hatchery releases (Bryant et al. 1999).

Establishing a self-sustaining population via natural colonization is contingent on a reasonable likelihood of natural dis-

persal into the new habitat. The probability of colonization, in turn, is determined by metapopulation attributes such as the location of the potential source population, abundance of the source population, and stray rate (i.e., connectivity) as a function of distance (Pess et al. 2012). Despite these observations, it is difficult to predict precise colonization rates following barrier removal. Most examples of natural colonization by Pacific salmon in Table 4 had nearby, relatively robust source populations, but colonization rates of isolated reintroduction sites are likely to be much lower. Furthermore, one might predict colonization rate to vary by species, but there are few multispecies comparisons to guide expectations (Table 4). In this situation, habitat preferences and life history patterns offer a means to make species-specific predictions (Pess et al. 2008).

Natural colonization minimizes anthropogenic disturbance to biological processes during population establishment and expansion. Natural colonization provides the greatest opportunity for the evolution of locally adapted traits through natural selection on individuals that disperse into the new habitat, sexual selection during reproduction of the initial colonists, and natural selection on their offspring. In many cases, evolution resulting from the novel selection pressures during colonization may increase population fitness and the likelihood of establishment (Kinnison and Hairston 2007). In the Cedar River, Washington, strong selection on the breeding date and body size of Chinook Salmon and Coho Salmon colonists emphasized the importance of natural and sexual selection in promoting local adaptation during reintroduction (Anderson et al. 2010, 2013a).

*Transplanting adults.*—In areas that are isolated or distant from extant populations, long-distance dispersal from extant populations may be unlikely. In these cases, transplanting can ensure that an adequate number of adult fish reach the reintroduction site. Under this strategy, adult fish are trapped at one location then transported to the reintroduction site, where they are released to breed naturally. Here, we describe the process and consequences of transplanting from both hatchery and wild sources.

Although stock transfers have been common for Pacific salmon, there are relatively few examples in which only adults were released (Withler 1982). In programs that combined transplanted adults with hatchery releases (e.g., Burger et al. 2000; Spies et al. 2007), it is difficult to isolate the effects of each strategy. In a reintroduction or supplementation context, transplants often involve surplus hatchery adults. For example, hatchery-origin spring Chinook Salmon were transplanted to Shitike Creek, Oregon because the habitat was considered underseeded 15 years after dam removal and produced a significant fraction of the juveniles captured the following spring (Baumsteiger et al. 2008). Atlantic Salmon that had spent their entire lives in captivity successfully spawned following release into Wilmot Creek, Ontario (Scott et al. 2005b). Transplanting adults is frequently used to circumvent large dams and reservoirs in a “trap and haul” strategy (Table 5), and we discuss this approach further in the Providing Passage section below.

TABLE 4. Examples of anadromous salmonid reintroductions from the published literature.

Location	Date initiated	Species	Colonization strategy	Passage provision	References
Fraser River, British Columbia	1947	Pink Salmon	Natural colonization	Fishway	Pess et al. 2012
Clearwater River, Idaho	1960	Chinook Salmon	Hatchery juveniles	Dam removal	Narum et al. 2007
Upper Salmon River, New Brunswick	Mid-1960s	Atlantic Salmon	Natural recolonization	Dam removal	Fraser et al. 2007
Connecticut River, Connecticut, Massachusetts, Vermont, and New Hampshire	1967	Atlantic Salmon	Hatchery juveniles	Fishways	Gephard and McMenemy 2004; Ward et al. 2008
River Thames, England	1975	Atlantic Salmon	Natural colonization and hatchery juveniles	None	Griffiths et al. 2011
Rivers Rhine, Ems, Weser, and Elbe, Germany	1978	Atlantic Salmon	Hatchery juveniles	Primarily fishways	Monnerjahn 2011; Schneider 2011
Point Wolfe River, New Brunswick	1982	Atlantic Salmon	Hatchery juveniles	Dam removal	Fraser et al. 2007
Sawtooth Valley lakes, Idaho	1993	Sockeye Salmon	Hatchery juveniles	None	Griswold et al. 2011; Kalinowski et al. 2012
Middle Fork Willamette River, Oregon	1993	Chinook Salmon	Transplanted adults	Trap and haul	Keefer et al. 2010, 2011
Various Norwegian rivers	Mid-1990s	Atlantic Salmon	Natural colonization and hatchery juveniles <sup>a</sup>	None	Hesthagen and Larsen 2003
Seine River, France	Mid-1990s	Atlantic Salmon	Natural colonization	None	Perrier et al. 2010
River Selja, Estonia	Mid-1990s	Atlantic Salmon	Natural colonization and hatchery juveniles <sup>b</sup>	None	Väsemagi et al. 2001
Bridge River, British Columbia	2000	Chinook Salmon, Coho Salmon, steelhead	Natural colonization	Increased water releases from dam	Decker et al. 2008
Wilmot Creek, Ontario	2000	Atlantic Salmon	Transplanted adults	None	Scott et al. 2005a, 2005b
Salmon River, New York	2000	Atlantic Salmon	Hatchery juveniles	None	Coghlan and Ringer 2004
Shitike Creek, Oregon	2002	Chinook Salmon	Transplanted adults	Dam removal	Baumsteiger et al. 2008
Cedar River, Washington	2003	Chinook Salmon, Coho Salmon	Natural colonization	Fishway	Kiffney et al. 2009; Anderson et al. 2010, 2013a, 2013b; Pess et al. 2011; Burton et al. 2013
Various Lake Ontario tributaries, New York	2003	Atlantic Salmon	Hatchery juveniles	None	Coghlan et al. 2007

TABLE 4. Continued.

Location	Date initiated	Species	Colonization strategy	Passage provision	References
Alouette and Coquitlam rivers, British Columbia	2005	Sockeye Salmon	Natural colonization	Increased water releases from dams	Godbout et al. 2011
River Purtse, Estonia	2005	Atlantic Salmon	Natural colonization and hatchery juveniles <sup>c</sup>	None	Kesler et al. 2011
Beaver Creek, Washington	2005	Steelhead	Natural colonization	Fishways	Weigel et al. 2013

<sup>a</sup>Colonization strategy varied by river.

<sup>b</sup>Genetic analysis indicates that natural dispersal, not hatchery releases, were primarily responsible for colonization.

<sup>c</sup>Hatchery releases commenced after natural colonization was observed.

Conceptually, transplanting allows for natural patterns of natural and sexual selection within the new habitat and thus has many of the benefits of natural colonization. The offspring of any adults that successfully spawn will spend the entire freshwater phase, from embryonic incubation to the smolt migration, within the reintroduction site. Compared with hatchery releases, this will increase their exposure to natal odors and local geomorphic, hydrologic, and biotic conditions, all of which are likely to promote local adaptation. However, transplanting introduces artificial selection of the individuals that reach the reintroduction site. In some cases, natural selection during migration could be important for the evolution of traits (i.e., body morphology or energy reserves) that are advantageous for a particular migration route (i.e., long or steep) (Quinn et al. 2001). Thus, considering the run timing, size, and other phenotypic traits of individuals selected for transplantation is an important component of minimizing the negative, unintended consequences of transplanting.

The number and frequency of transplants is an important consideration. Reintroductions with many individuals are more likely to be successful (Wolf et al. 1996; Fischer and Lindenmayer 2000), but with few salmonid examples, it is difficult to provide precise guidance on the number to transplant. Metapopulation structure might provide guidance, as reintroduction sites isolated from the regional metapopulation are unlikely to receive large numbers of natural colonists and, therefore, will require a greater number of transplanted fish than those connected to potential source populations. Williams et al. (1988) observed that 50 individuals (25 males and 25 females, annually) is the absolute minimum for establishing a hatchery population in a controlled setting, so transplanting to a dynamic river environment will certainly require a greater number of fish. Some fraction of transplanted adults may die prior to spawning (Keefer et al. 2010) or depart the release site because they fail to detect natal odors (Blair and Quinn 1991). Continuing transplants for a full generation and into a second generation provides additional reproductive potential and new genetic material that may reduce the impact of a genetic bottleneck (e.g., Hedrick

and Fredrickson 2010). In addition, selecting the highest quality habitat within the reintroduction site for the release site may increase the reproductive success of the colonists.

We suggest that reintroduction should maximize the total number of fish transplanted while minimizing the risks (Table 2), which are likely to increase as the number of fish transplanted increases. Given the same total number of transplanted fish, risks might be reduced by releasing a small number of fish each year for many years rather than many fish for a short period. The release strategy will affect density-dependent processes, which in turn will affect both the performance of the reintroduced species and the ecological risks of reintroduction. For example, it may be possible to reduce density-dependent processes by dispersing colonists among several release sites (Einum et al. 2008). With few empirical examples, the outcomes of these risks are difficult to precisely predict a priori, highlighting the importance of a well-designed monitoring program.

**Hatchery releases.**—The third colonization strategy is a hatchery reintroduction that stocks artificially propagated juvenile fish or eggs within the reintroduction site. There are a number of examples of reintroductions releasing hatchery-produced juveniles (Table 4). In the Clearwater River, Idaho, out-of-basin stocks were used to reintroduce ocean- and stream-type Chinook Salmon; these hatchery populations are now sustained by returns to the Clearwater River, and the naturally produced juveniles of the two run types are genetically distinct (Narum et al. 2007). Hatchery releases of Atlantic Salmon reintroduced to the Connecticut River (flowing through Connecticut, Massachusetts, Vermont, and New Hampshire) are also sustained by local returns (Gephard and McMenemy 2004). However, abundances in the Connecticut River and in other reintroduced New England populations have continued to decline despite heavy stocking, and there is very little natural spawning because most returning adults are bred in captivity (Wagner and Sweka 2011). A captive broodstock hatchery program has played an essential role in the persistence of Snake River Sockeye Salmon, which reached critically low abundances in the mid-1990s (Griswold

TABLE 5. Examples of proposed, ongoing, or relatively recent reintroduction programs for Pacific salmon, steelhead, and Bull Trout *Salvelinus confluentus*.

River basin	Species	Comments on execution
Elwha River, Washington	Chinook Salmon, steelhead, Coho Salmon, Pink Salmon, Chum Salmon <i>O. keta</i> , Sockeye Salmon, Bull Trout	Removal of Elwha and Glines Canyon dams; for some species, adults trapped within lower Elwha River relocated above former dam site
Umbrella Creek and Big River, Ozette Lake, Washington	Sockeye Salmon	Hatchery releases for both locations; some natural colonization of Big River prior to hatchery releases
Cowlitz River, Washington	Chinook Salmon, Coho Salmon, steelhead	Hatchery releases, trap and haul above Mayfield, Mossyrock, and Cowlitz Falls dams
Clackamas River, Oregon	Bull Trout	Transplanted juvenile and adult fish from Metolius River
North Santiam River, Oregon	Chinook Salmon, steelhead	Trap and haul adults above Big Cliff and Detroit dams
South Santiam River, Oregon	Chinook Salmon, steelhead	Trap and haul adults above Foster and Green Peter dams
Calapooia River, Oregon	Chinook Salmon, steelhead	Removal of Brownsville, Sodom, and Shearer dams
McKenzie River, Oregon	Chinook Salmon	Trap and haul adults above Cougar and Trail Bridge dams
White Salmon River, Washington	Chinook Salmon, steelhead, Coho Salmon	Removal of Condit Dam
Hood River, Oregon	Chinook Salmon	Removal of Powerdale Dam; hatchery releases derived from neighboring Deschutes River
Deschutes River, Oregon	Chinook Salmon, steelhead, Sockeye Salmon	Hatchery releases for Chinook Salmon and steelhead; passage for adults and juveniles around Reregulation, Pelton, and Round Butte dams
Umatilla River, Oregon	Chinook Salmon, Coho Salmon	Hatchery releases
Yakima River, Washington	Sockeye Salmon, Coho Salmon	Sockeye Salmon: adults captured at Priest Rapids Dam transplanted above Cle Elum Dam; Coho Salmon: hatchery releases
Wenatchee River, Washington	Coho Salmon	Hatchery releases
Methow River, Washington	Coho Salmon	Hatchery releases
Okanogan River, Washington	Chinook Salmon, Sockeye Salmon	Hatchery releases for both species; passage above McIntyre Dam for Sockeye Salmon
Walla Walla River, Washington	Chinook Salmon	Hatchery releases
Lookingglass Creek, Oregon	Chinook Salmon	Hatchery releases derived from nearby Catherine Creek
Big Sheep Creek, Oregon	Chinook Salmon	Transplant surplus hatchery adults captured in adjacent Imnaha River
Pine Creek, Oregon	Chinook Salmon, steelhead	Transplant surplus hatchery adults captured at Hells Canyon Dam
Klamath River, California and Oregon	Chinook Salmon, Coho Salmon, steelhead	Proposed removal of Iron Gate, Copco 1, Copco 2, and J.C. Boyle dams
San Joaquin River, California	Chinook Salmon	Proposed under San Joaquin River Restoration Settlement Act

et al. 2011). Although this population is demographically dependent on the hatchery, abundance has grown substantially in recent years and progress has been made towards the reestablishment of natural reproduction. The hatchery has retained approximately 95% of the genetic diversity present in the founders of the captive broodstock program (Kalinowski et al. 2012).

There are also examples of hatchery reintroductions, mainly of Atlantic Salmon, that have failed, or that have had insufficient time, to generate persistent returns of hatchery fish. Despite decades of stocking nonlocal Atlantic Salmon on the Thames

River, most adult Atlantic Salmon observed recently have dispersed naturally from nearby river systems (Griffiths et al. 2011). Although some Atlantic Salmon returned to Point Wolfe Creek, New Brunswick, following 4 years of hatchery releases, the population subsequently crashed, similar to neighboring populations in the inner Bay of Fundy (Fraser et al. 2007). Atlantic Salmon have been reintroduced to several rivers in Germany, but these populations are still demographically reliant on importing nonlocal eggs and fry despite some observations of natural spawning (Monnerjahn 2011). Finally, the initial phase of



Atlantic Salmon reintroduction to tributaries of Lake Ontario in New York State has focused on experimental testing of various release strategies and sites in an effort to maximize survival (Coghlan and Ringler 2004; Coghlan et al. 2007).

Overall, despite initial successes in establishing hatchery populations in some systems, we found no clear-cut examples in which a reintroduction employing hatchery releases yielded a self-sustaining naturalized population. Importantly, even the most successful programs to date continue to release hatchery fish, so it is largely uncertain whether any natural spawning would persist without supplementation. It is worth noting, however, that hatchery releases have been used to introduce self-sustaining salmonid populations to new locations not previously inhabited by the species in question. Out-of-basin hatchery releases established multiple self-sustaining populations of Sockeye Salmon in Lake Washington, Washington, but it is uncertain whether these areas historically supported anadromous fish (Gustafson et al. 1997; Spies et al. 2007). Other examples include Sockeye Salmon in Frazer Lake, Alaska (Burger et al. 2000), Pink Salmon in the Great Lakes (Kwain 1987), and Chinook Salmon in New Zealand (Quinn et al. 2001). Collectively, these results suggest that it is possible to establish runs of anadromous fish through hatchery releases, and perhaps failed reintroduction efforts did not adequately solve the problems that caused extirpation in the first place (i.e., constraints).

Employed in a conservation setting, hatcheries generally aim to reduce the early life mortality that occurs in the egg incubation and juvenile-rearing phase relative to that of natural spawning (Waples et al. 2007a). Thus hatchery releases have the potential to approach juvenile-rearing carrying capacities faster than the other two approaches, and this may ultimately lead to a greater number of adults returning to the reintroduction site within a generation or two of reintroduction. In addition, hatchery releases may provide opportunities to test the effectiveness of new passage facilities without risking wild fish from a low-abundance source population.

However, even if managed properly, hatchery releases pose significant evolutionary and ecological risks. Domestication selection, or adaptation to a captive-breeding environment, can reduce the fitness of animals released into the wild (Frankham 2008) as well as the fitness of the wild component of a supplemented population (Ford 2002). Indeed, hatchery fish often have lower reproductive success than naturally spawned fish when both groups breed sympatrically in the wild (Araki et al. 2008), and domestication selection, which can occur in a single generation, seems a likely mechanism (Christie et al. 2012; Ford et al. 2012). Large-scale hatchery programs tend to erode population structure more than small ones (Eldridge and Naish 2007), so the risk of genetic homogenization is likely to be proportional to the number of fish released. In terms of ecological risks, hatchery releases could induce density-dependent processes that would limit the growth, survival, and other vital rates of naturally produced fish (Buhle et al. 2009; Kostov 2009).

These risks apply not only to the incipient population within the reintroduction site but also to any nearby extant populations. Hatchery reintroduction programs should therefore aim to minimize straying to proximate extant populations. Acclimating juvenile hatchery fish in the target area prior to release may improve the precision of homing (Dittman et al. 2010). Hatchery fish released into a reintroduction site may also interact ecologically with juvenile wild fish originating from proximate spawning areas in downstream rearing habitats, potentially competing for limited resources. The specific breeding protocols and rearing practices will influence the severity of these ecological and evolutionary effects, but some level of risk is unavoidable.

An important consideration for hatchery reintroductions is the length of time over which supplementation is planned. Evolutionary and ecological risks will tend to increase with the duration and magnitude of hatchery releases. A precautionary model would aim for a brief release of one to two generations, followed by cessation for at least a similar time frame, accompanied by a monitoring program to track performance. Such a pulsed release would provide the initial demographic boost to establish a population in an area unlikely to be colonized naturally and subsequently permit natural and sexual selection to shape local adaptation and the expression of natural diversity patterns. In the event that more than a generation or two of supplementation is needed to rebuild the run, specifying a timeline for phasing out releases in a detailed plan prior to reintroduction will help prevent hatchery efforts from becoming institutionalized. Abundance targets for naturally spawned fish would indicate when the incipient population has sufficient reproductive potential without supplementation. Contingencies for short-term environmental trends would permit flexibility in the timeline should poor migratory or ocean survival delay population establishment.

### Choice of Source Population

Source populations with life history, morphological, and behavioral traits compatible with the target area will increase the probability of successful reintroduction. Anadromous salmonids are frequently adapted to local environmental conditions (Taylor 1991; Fraser et al. 2011), and so some source populations may be more successful than others during colonization. For example, following circumvention of a natural barrier, multiple populations of Sockeye Salmon were introduced to Fraser Lake, Alaska, and each preferentially colonized the habitats most similar to the source (Burger et al. 2000). Reintroductions employing transplants or hatchery releases must explicitly choose a source population; evaluating potential sources of natural colonization will help predict patterns of population expansion (Pess et al. 2008) and interpret reintroduction results (Burton et al. 2013). We suggest that reintroduction planners consider the genetic and ecological characteristics of potential source populations.

In general, selecting a source genetically similar to the historic population that inhabited the reintroduction site would

maximize the benefits and reduce the risks of a reintroduction. Matching the genetic lineage of the extirpated population or spawning area as closely as possible helps ensure that following a successful reintroduction, regional population structure would accurately represent natural patterns of evolutionary diversity and thus contribute to long-term ESU viability. The evolutionary risks of straying to adjacent populations during reintroduction will be reduced if the source is genetically similar to these populations. In practice, genetic analysis may not be possible, so one might assume an isolation-by-distance model (e.g., Matala et al. 2011) and use the distance along the river corridor between the reintroduction site and source as a coarse guide for comparing options. Regardless of the specific criteria, ESUs were designated to comprise lineages with a distinct evolutionary legacy (Waples 1991), so reintroductions using sources with out-of-ESU ancestry would rarely, if ever, be expected to provide clear conservation benefits to an ESU.

Ecological considerations should focus on the morphological and behavioral traits of the source population and whether they are well suited for the reintroduction site. One approach is to assume that similar habitats promote the evolution of similar traits and evaluate metrics such as elevation, precipitation, and hydrologic patterns or composite indices such as the U.S. Environmental Protection Agency's ecoregions. However, sometimes genetic and ecological patterns will be in conflict. Some coastal rivers, for example, contain both fall- and spring-run Chinook Salmon populations, which are more genetically similar to each other than to other populations of the same run type in different major rivers (Waples et al. 2004). In these cases, selecting a source population will involve some degree of compromise.

Potential source populations affected by hatchery production require special consideration. Three main factors will determine the ecological and genetic suitability of a hatchery stock. The first is its origin. Stocks that were founded with individuals collected near the reintroduction site, preferably within the same basin, present less evolutionary risk than more distantly related stocks. Many of the most widespread hatchery stocks are mixed-lineage, composite-origin stocks with significant contributions from several populations, sometimes from separate ESUs (Busby et al. 1996; Myers et al. 1998). Although these stocks are probably the most available, and hence logistically practicable for reintroductions, they also pose much greater evolutionary risks than locally derived stocks. A second consideration is the current breeding protocol. Programs that operate under an integrated model by consistently incorporating wild or naturally spawned broodstock (without posing demographic risks to that population) will reduce (but not eliminate) domestication selection compared with segregated programs (Möbrant et al. 2005). A final consideration is the number of generations that the stock has been artificially propagated. Domestication selection accumulates over time, making populations that have been artificially propagated for many generations less similar to their wild counterparts than stocks that have been in captivity for few generations (Araki et al. 2008; Frankham 2008). In

some cases, a hatchery stock directly derived from native fish that inhabited the reintroduction site may retain the only genetic legacy of the extirpated population and may be desirable for that reason.

What are the options if there is an unacceptable demographic risk of depleting the most attractive source population? In some cases, managers must either wait for the most appropriate stock to recover to levels that could sustain removal or select a less desirable stock that can immediately provide sufficient donors. This is a difficult trade-off, especially if recovery of depleted potential source populations is uncertain or is expected to take several generations even under optimistic scenarios. When removal does occur, monitoring should track the source population abundance during reintroduction to ensure that it remains healthy. If a single population cannot sustain removal for reintroduction, it may be possible to combine individuals from several sources. From a genetic perspective, this could have either positive or negative consequences. On one hand, mixing sources could benefit the genetic diversity of the colonist group, but on the other, it could lower fitness via outbreeding depression (Huff et al. 2010).

Finally, for facultatively migratory species, the presence of resident conspecifics may provide additional reproductive potential and serve as a source population. For example, resident Rainbow Trout frequently spawn with anadromous steelhead (McMillan et al. 2007; Pearsons et al. 2007). In fact, *O. mykiss* often exhibit partial anadromy in which a single, panmictic, interbreeding population contains both resident and migratory individuals (McPhee et al. 2007; Heath et al. 2008). Resident populations isolated by dams may retain significant anadromous ancestry and the physiological traits of smoltification (Clemento et al. 2009; Godbout et al. 2011; Holecek et al. 2012). However, if selection against anadromy has occurred in the resident population, it is also possible that secondary contact with reintroduced anadromous fish might decrease the rate of anadromy in the combined population. Life history models (Satterthwaite et al. 2009, 2010) offer one method of predicting the complicated interactions between resident fish and reintroduced anadromous populations. Regardless, we suggest that promoting the persistence and reproductive contribution of resident fish directly descended from formerly anadromous populations inhabiting the reintroduction site will ultimately contribute to local adaptation, diversity, and long-term viability.

### Providing Passage

Providing passage is relevant to all reintroductions involving barriers regardless of the colonization strategy or the choice of source population. This must include passage for adults migrating upstream to spawning grounds as well as juveniles migrating downstream towards the ocean. Plans for passage can be categorized as either volitional or active transport (i.e., trap and haul).

Under volitional passage, a barrier is modified or removed such that fish arrive at the site under their own power, swimming

through or around and eventually past the former blockage. Primary examples include culvert replacements, dam removals, engineered step-pools, fish ladders, increased releases from upstream dams, and screened bypass facilities for juveniles. Volitional fish passage facilities have advantages over more managed methods because they operate constantly, require little if any handling, are less stressful to the fish, are mechanically less likely to break, and are less costly to maintain and operate. A primary biological consideration is the degree to which passage structures reduce juvenile and adult migrant survival relative to a free-flowing river. Unnaturally high mortality imposed by passage at barriers will have to be compensated for elsewhere in the lifecycle to maintain a self-sustaining population. Furthermore, depending on the design, water velocity and gradient may restrict passage to certain species or size-classes, reducing the diversity of the incipient population. If poorly designed, passage facilities could increase the risk of straying into nontarget populations or spawning areas.

Barrier or dam removal is a special case of volitional passage that will provide substantial ecological benefits beyond salmonid recovery. Dam removal can repair riverine ecosystem processes, such as natural flow regime, sediment and wood transport, and nutrient cycling, that create and maintain habitat for many plants and animals (Poff and Hart 2002; Roni et al. 2008). The rehabilitation of these processes, especially where they have been substantially altered, will certainly provide long-term benefits for the Pacific salmon and steelhead populations targeted for reintroduction. However, in the short term, dam removal is a disturbance that may increase turbidity and deposit fine sediment downstream or mobilize toxic-laden materials (Stanley and Doyle 2003). Therefore, it is an approach most appropriate for enhancing long-term viability rather than rapid increases in abundance, and these “side effects” are important considerations for the planning process. Several recent dam removals (Table 5) provide important opportunities to study the salmonid response to dam removal.

In some cases, it may be possible to incorporate selective access into a volitional passage strategy. This would involve a weir, gate, or trap such that fish are handled prior to upstream passage. Such structures increase operation and maintenance costs and may adversely affect adults due to increased handling. However, they also allow managers to exclude fish that could undermine reintroduction objectives. For example, excluding the homogenizing influence of hatchery colonists may benefit diversity and excluding nonnative fish would reduce the ecological risks of reintroduction. Such structures would also assist research and monitoring because they would permit precise counts and measurements of fish.

Active transport, sometimes called trap and haul, is most appropriate for situations in which volitional passage is not logistically, technically, or biologically possible. Large dams, especially several occurring in sequence, are more likely to require trap and haul than small structures due to engineering and socioeconomic constraints. Particularly for juveniles, impound-

ments may present challenges that cannot be overcome with volitional passage, such as low water velocity that disrupts fish migration, predators that reduce survival below acceptable levels, or downstream passage routes that cannot be engineered to be safe and effective. Selection or exclusion of particular groups of fish will be fundamentally simple. Passage via trap and haul is similar in concept to a transplanting colonization strategy and thus has many of the same benefits, risks, and consequences.

Trap and haul, often combined with hatchery releases, is employed in several ongoing large-scale reintroduction efforts (Table 5). These examples will provide crucial case studies to evaluate the success and refine the methods of reintroducing Pacific salmon and steelhead above large, high-head dams. Research on the Middle Fork Willamette River, Oregon, has found significant prespawn mortality related to poor condition of spring Chinook Salmon adults prior to release and warm temperatures encountered in the migration corridor (Keefer et al. 2010). In addition, juvenile mortality at dams was high and deep-water passage routes severely restricted passage in the spring, when Chinook Salmon would ordinarily migrate downstream but reservoirs were filling rapidly (Keefer et al. 2011).

Despite few published examples, we suspect that at high-head dams, transporting adults upstream is much easier (and less expensive) than providing safe, efficient downstream passage for their offspring. Juvenile fish will be vulnerable to size-selective predation in reservoirs (Poe et al. 1991; Fritts and Pearsons 2006) and dam passage mortality unless they are collected and routed around these hazards. Survival rates will vary by species, life stage, and timing of migration but are likely to depend on the efficiency of juvenile collection methods and the design of engineered bypasses at dams. In some cases, successful reintroduction will require a mechanistic understanding of dam passage mortality, but this is difficult to predict generally and varies substantially by dam. For example, some studies have found greater mortality in small fish (Ferguson et al. 2007) while others found greater mortality in large fish (Keefer et al. 2011). Consequently, detailed studies of route-specific juvenile mortality rates are likely to be an essential component of reintroductions involving active transport (Keefer et al. 2011).

## Execution Overview

One thing is clear—each case will be unique, and reintroduction planners will face trade-offs between the benefits and risks in selecting a colonization strategy, choosing a source population, and providing passage. These options need not be mutually exclusive, as a carefully planned reintroduction program may decide to use multiple colonization strategies. A precautionary model would initially adopt a low-risk approach and monitor its success, thereby permitting a scientific evaluation of whether higher-risk strategies are necessary. For active reintroduction strategies, planners could view an initially small release as a pilot study to assess reintroduction benefits and risks prior to full implementation.

Our review of the salmonid reintroduction literature (e.g., Table 4) suggests that there are large uncertainties in the success of reintroduction in establishing self-sustaining populations, particularly for programs employing active colonization strategies. Despite the increased risks of methods such as transplanting adults and hatchery releases, we found no direct evidence that these approaches have established a demographically independent, self-sustaining natural population. It is possible that situations in which active methods have been employed are inherently more difficult, but a lack of rigorous scientific evaluation precludes us from describing the benefits, risks, and constraints more explicitly or quantitatively. We strongly encourage managers of reintroduction efforts to disseminate results so that we may build on lessons learned in planning future programs.

MONITORING

Monitoring is an essential component of any reintroduction program (Williams et al. 1988; IUCN 1998; George et al. 2009), permitting an assessment of whether or not the reintroduction was successful. Monitoring before, during, and after the reintroduction provides information on both the target and neighboring populations that is needed to evaluate modifications to the program execution in an adaptive management feedback loop. In addition, monitoring provides the data that is essential for the effective planning of future programs.

We suggest that the monitoring program focus on the benefits, risks, and constraints likely to have a large impact on the success of the project. First, in order to quantify the benefits and determine if the goals have been achieved, unambiguously stating project objectives at the outset will help identify specific monitoring metrics (Tear et al. 2005). Second, for reintroductions in which the initial planning efforts identified some risks (Table 2), there must be monitoring in order to determine whether the benefits outweighed the risks. Third, monitoring constraints will promote a mechanistic understanding of why a reintroduction succeeded or failed. Even where barriers block migration, other factors may have contributed to extirpation. Consequently, although some biological constraints (Table 3) may have been addressed prior to reintroduction, others may persist that will limit project success. Identifying factors that limit survival and reproductive success will provide insight towards alternative reintroduction strategies that might lessen a negative impact. The specific monitoring methods will vary depending on the benefits, risks, and constraints of the reintroduction effort; Roni (2005), Johnson et al. (2007), and Schwartz (2007) provide guidance on establishing a robust monitoring program.

It is difficult to provide general criteria on whether a reintroduction effort has succeeded or failed because every situation is likely to be different. However, writing a detailed reintroduction plan, including specific viability targets or benchmarks, is a crucial component of project implementation. This will simplify interpretation of monitoring data, clarify any need for adaptive management during the program, and prevent the institutionalization of actions (e.g., hatchery releases) that impose risk

to nontarget populations or spawning areas. In deriving targets and benchmarks, the reintroduction plan should explicitly consider patterns in annual abundance, productivity, and survival of comparable populations. We strongly urge all entities conducting or planning reintroductions to write a publicly available implementation plan that includes robust monitoring because it is essential to a scientifically rigorous reintroduction effort and will improve our ability to effectively conserve species in the future.

CONCLUSIONS

We have based our approach to planning, executing, and monitoring reintroductions upon the broad conservation goals and scientific principles guiding the recovery of ESA-listed Pacific salmon and steelhead populations. We acknowledge that there are other possible goals for reintroductions, including providing harvest opportunities, which might lead to different approaches than those described here. Although our recommendations are specifically designed for ESA recovery, more generally they are intended to promote the natural demographic, ecological, and evolutionary processes essential to the conservation benefit of all reintroductions, regardless of formal listing status. Even in cases where ESA recovery is not the primary goal, the concepts discussed here will help evaluate the overall conservation value of a reintroduction (Figure 5).

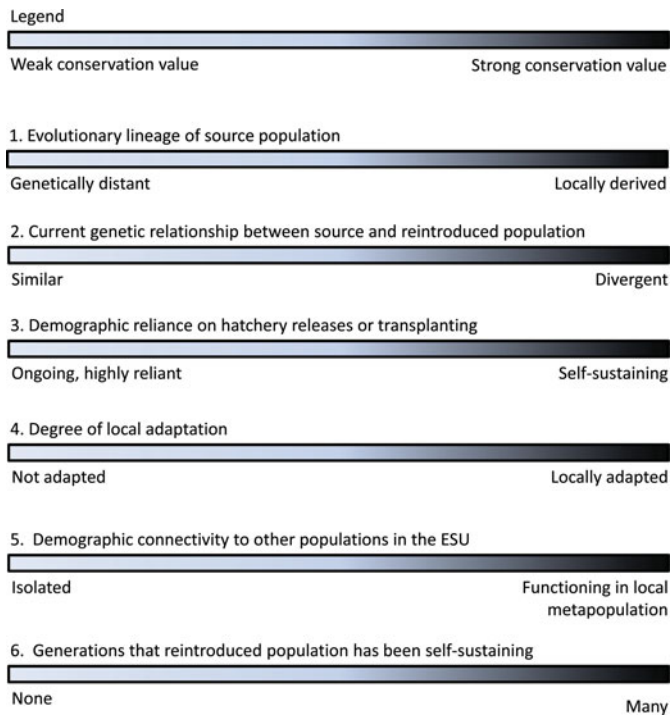


FIGURE 5. Factors to consider in evaluating the conservation value of reintroductions. Each bar is intended to represent a gradient of outcomes in between the extremes described at either end. The extent to which natural demographic, ecological, and evolutionary processes operate uninterrupted will strongly influence the overall conservation value of a reintroduction.

Despite the number of salmonid reintroductions (e.g., Tables 4 and 5), the science of reestablishing previously extirpated salmonid populations is still in its infancy. We found few direct assessments of reintroduction benefits, risks, and constraints, forcing us to provide general, qualitative rather than specific, quantitative recommendations. If reintroduction is to become a successful recovery tool, it is essential that monitoring and dissemination of results become standard practice in nearly every program. Rigorous scientific evaluation is particularly important for projects at large dams or those using active colonization strategies because they face the highest constraints and greatest risks.

The number and scale of Pacific salmon and steelhead extirpations suggest that reintroduction offers great potential to advance salmon recovery. However, complicated trade-offs, challenging obstacles, and uncertainty over the ultimate result confront reintroduction planners. Combined with the multiple generations probably required to achieve potential benefits, this suggests that reintroduction will rarely be a quick fix for improving the status of an ESU or population at immediate risk of extinction. It is also important to remember that reintroduction is only one management option. In some cases, reintroduction may be essential for the conservation of a particular life history type or evolutionary lineage. In other cases, management strategies designed to improve the reproductive success, survival, and productivity of extant populations might offer a better return on the investment dollar than reintroduction. We suggest that evaluating the potential benefits, risks, and constraints is necessary to weigh reintroduction against other management options and ensure that reintroductions contribute to long-term population and ESU viability.

## ACKNOWLEDGMENTS

Funding support for J.H.A. was provided by the U.S. National Research Council's Research Associateship Program. Discussions with the Recovery Implementation Science Team contributed to the concepts presented in this paper. We thank Lynne Krasnow, Ritchie Graves, Rick Gustafson, and four anonymous reviewers for helpful comments on earlier drafts of the manuscript.

## REFERENCES

Allendorf, F. W., and G. Luikart. 2007. Conservation and the genetics of populations. Blackwell Scientific Publications, Oxford, UK.

Anderson, J. H., P. L. Faulds, W. I. Atlas, G. R. Pess, and T. P. Quinn. 2010. Selection on breeding date and body size in colonizing Coho Salmon, *Oncorhynchus kisutch*. *Molecular Ecology* 19:2562–2573.

Anderson, J. H., P. L. Faulds, W. I. Atlas, and T. P. Quinn. 2013a. Reproductive success of captive bred and natural origin Chinook Salmon colonizing newly accessible habitat. *Evolutionary Applications* 6:165–179.

Anderson, J. H., G. R. Pess, P. M. Kiffney, T. R. Bennett, P. L. Faulds, and T. P. Quinn. 2013b. Dispersal and tributary immigration by juvenile Coho Salmon contribute to spatial expansion during colonization. *Ecology of Freshwater Fish* 22:30–42.

Angilletta, M. J., E. A. Steel, K. K. Bartz, J. G. Kingsolver, M. D. Scheuerell, B. R. Beckman, and L. G. Crozier. 2008. Big dams and salmon evolution: changes in thermal regimes and their potential evolutionary consequences. *Evolutionary Applications* 1:286–299.

Araki, H., B. A. Berejikian, M. J. Ford, and M. S. Blouin. 2008. Fitness of hatchery-reared salmonids in the wild. *Evolutionary Applications* 1:342–355.

Armstrong, D. P., and P. J. Seddon. 2008. Directions in reintroduction biology. *Trends in Ecology and Evolution* 23:20–25.

Ayllon, F., P. Davaine, E. Beall, and E. Garcia-Vazquez. 2006. Dispersal and rapid evolution in Brown Trout colonizing virgin Subantarctic ecosystems. *Journal of Evolutionary Biology* 19:1352–1358.

Barton, N. H., and M. C. Whitlock. 1997. The evolution of metapopulations. Pages 183–210 in I. A. Hanski and M. E. Gilpin, editors. *Metapopulation biology: ecology, genetics, and evolution*. Academic Press, San Diego, California.

Battin, J., M. W. Wiley, M. H. Ruckelshaus, R. N. Palmer, E. Korb, K. K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. *Proceedings of the National Academy of Sciences of the United States of America* 104:6720–6725.

Baumsteiger, J., D. M. Hand, D. E. Olson, R. Spatheolts, G. FitzGerald, and W. R. Ardren. 2008. Use of parentage analysis to determine reproductive success of hatchery-origin spring Chinook Salmon outplanted into Shitike Creek, Oregon. *North American Journal of Fisheries Management* 28:1472–1485.

Beechie, T., E. Buhle, M. Ruckelshaus, A. Fullerton, and L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. *Biological Conservation* 130:560–572.

Beechie, T. J., D. A. Sear, J. D. Olden, G. R. Pess, J. M. Buffington, H. Moir, P. Roni, and M. M. Pollock. 2010. Process-based principles for restoring river ecosystems. *BioScience* 60:209–222.

Bilby, R. E., and L. A. Mollot. 2008. Effect of changing land use patterns on the distribution of Coho Salmon (*Oncorhynchus kisutch*) in the Puget Sound region. *Canadian Journal of Fisheries and Aquatic Sciences* 65:2138–2148.

Bisson, P. A., C. M. Crisafulli, B. R. Fransen, R. E. Lucas, and C. P. Hawkins. 2005. Responses of fish to the 1980 eruption of Mount St. Helens. Pages 163–182 in V. H. Dale, F. R. Swanson, and C. M. Crisafulli, editors. *Ecological responses to the 1980 eruption of Mount St. Helens*. Springer, New York.

Blair, G. R., and T. P. Quinn. 1991. Homing and spawning site selection by Sockeye Salmon (*Oncorhynchus nerka*) in Iliamna Lake, Alaska. *Canadian Journal of Zoology* 69:176–181.

Bowlby, H. D., and A. J. F. Gibson. 2011. Reduction in fitness limits the useful duration of supplementary rearing in an endangered salmon population. *Ecological Applications* 21:3032–3048.

Brenkman, S. J., S. L. Mumford, M. House, and C. Patterson. 2008a. Establishing baseline information on the geographic distribution of fish pathogens endemic in Pacific salmonids prior to dam removal and subsequent recolonization by anadromous fish in the Elwha River, Washington. *Northwest Science* 82:142–152.

Brenkman, S. J., G. R. Pess, C. E. Torgersen, K. K. Kloehn, J. J. Duda, and S. C. Corbett. 2008b. Predicting recolonization patterns and interactions between potadromous and anadromous salmonids in response to dam removal in the Elwha River, Washington State, USA. *Northwest Science* 82:91–106.

Bryant, M. D., B. J. Frenette, and S. J. McCurdy. 1999. Colonization of a watershed by anadromous salmonids following the installation of a fish ladder in Margaret Creek, Southeast Alaska. *North American Journal of Fisheries Management* 19:1129–1136.

Budy, P., G. P. Thiede, N. Bouwes, C. E. Petrosky, and H. Schaller. 2002. Evidence linking delayed mortality of Snake River salmon to their earlier hydrosystem experience. *North American Journal of Fisheries Management* 22:35–51.

Buehrens, T. W. 2011. Growth, movement, survival and spawning habitat of coastal cutthroat trout. Master's thesis. University of Washington, Seattle.

Buhle, E. R., K. K. Holsman, M. D. Scheuerell, and A. Albaugh. 2009. Using an unplanned experiment to evaluate the effects of hatcheries and environmental



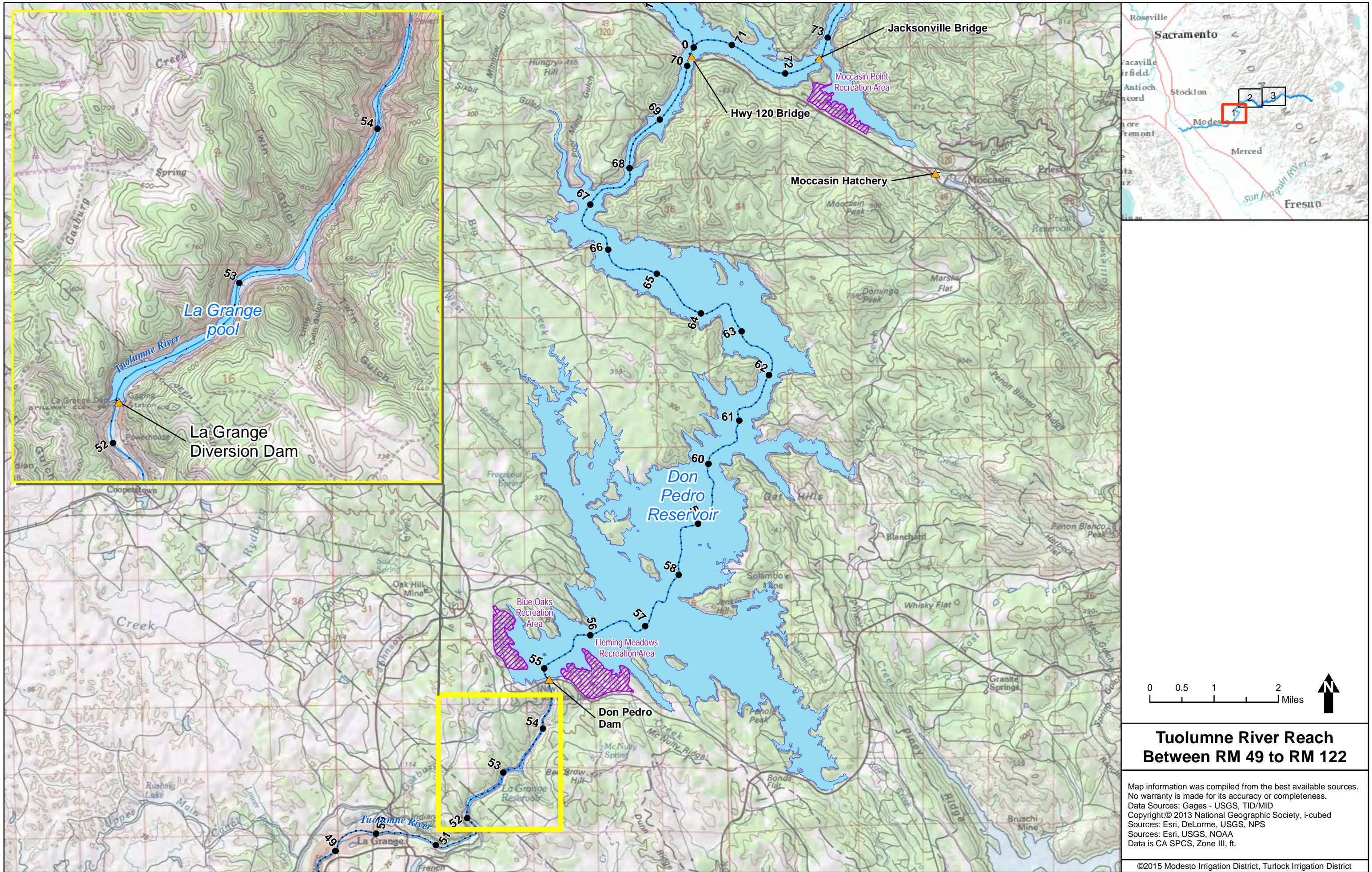
- variation on threatened populations of wild salmon. *Biological Conservation* 142:2449–2455.
- Burger, C. V., K. T. Scribner, W. J. Spearman, C. O. Swanton, and D. E. Campton. 2000. Genetic contribution of three introduced life history forms of Sockeye Salmon to colonization of Frazer Lake, Alaska. *Canadian Journal of Fisheries and Aquatic Sciences* 57:2096–2111.
- Burke, B. J., W. T. Peterson, B. R. Beckman, C. Morgan, E. A. Daly, and M. Litz. 2013. Multivariate models of adult Pacific salmon returns. *PloS One* 8:e54134.
- Burnett, K. M., G. H. Reeves, D. J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of salmon habitat potential relative to landscape characteristics and implications for conservation. *Ecological Applications* 17:66–80.
- Burton, K. D., L. G. Lowe, H. B. Berge, H. K. Barnett, and P. L. Faulds. 2013. Comparative dispersal patterns for recolonizing Cedar River Chinook Salmon above Landsburg Dam, and the source population below the dam. *Transactions of the American Fisheries Society* 142:703–716.
- Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon and California. NOAA Technical Memorandum NMFS-NWFSC-27.
- Carey, M. P., B. L. Sanderson, K. A. Barnas, and J. D. Olden. 2012. Native invaders: challenges for science, management, policy and society. *Frontiers in Ecology and the Environment* 10:373–381.
- Caudill, C. C., W. R. Daigle, M. L. Keefer, C. T. Boggs, M. A. Jepson, B. J. Burke, R. W. Zabel, T. C. Bjornn, and C. A. Peery. 2007. Slow dam passage in adult Columbia River salmonids associated with unsuccessful migration: delayed negative effects of passage obstacles or condition-dependent mortality? *Canadian Journal of Fisheries and Aquatic Sciences* 64:979–995.
- Christie, M. R., M. L. Marine, R. A. French, and M. S. Blouin. 2012. Genetic adaptation to captivity can occur in a single generation. *Proceedings of the National Academy of Sciences of the United States of America* 109:238–242.
- Clemente, A. J., E. C. Anderson, D. Boughton, D. Girman, and J. C. Garza. 2009. Population genetic structure and ancestry of *Oncorhynchus mykiss* populations above and below dams in south-central California. *Conservation Genetics* 10:1321–1336.
- Coghlan, S. M., M. J. Connerton, N. H. Ringler, D. J. Stewart, and J. V. Mead. 2007. Survival and growth responses of juvenile salmonines stocked in eastern Lake Ontario tributaries. *Transactions of the American Fisheries Society* 136:56–71.
- Coghlan, S. M., and N. H. Ringler. 2004. A comparison of Atlantic Salmon embryo and fry stocking in the Salmon River, New York. *North American Journal of Fisheries Management* 24:1385–1397.
- Cooper, A. B., and M. Mangel. 1999. The dangers of ignoring metapopulation structure for the conservation of salmonids. *Fishery Bulletin* 97:213–226.
- Courchamp, F., T. Clutton-Brock, and B. Grenfell. 1999. Inverse density dependence and the Allee effect. *Trends in Ecology and Evolution* 14:405–410.
- Decker, A. S., M. J. Bradford, and P. S. Higgins. 2008. Rate of biotic colonization following flow restoration below a diversion dam in the Bridge River, British Columbia. *River Research and Applications* 24:876–883.
- Dereced, A., and F. Courchamp. 2007. Importance of the Allee effect for reintroductions. *Ecoscience* 14:440–451.
- Dittman, A. H., D. May, D. A. Larsen, M. L. Moser, M. Johnston, and D. Fast. 2010. Homing and spawning site selection by supplemented hatchery- and natural-origin Yakima River spring Chinook Salmon. *Transactions of the American Fisheries Society* 139:1014–1028.
- Dunham, J., K. Gallo, D. Shively, C. Allen, and B. Goehring. 2011. Assessing the feasibility of native fish reintroductions: a framework applied to threatened Bull Trout. *North American Journal of Fisheries Management* 31:106–115.
- Einum, S., K. H. Nislow, S. McKelvey, and J. D. Armstrong. 2008. Nest distribution shaping within-stream variation in Atlantic Salmon juvenile abundance and competition over small spatial scales. *Journal of Animal Ecology* 77:167–172.
- Eldridge, W. H., and K. A. Naish. 2007. Long-term effects of translocation and release numbers on fine-scale population structure among Coho Salmon (*Oncorhynchus kisutch*). *Molecular Ecology* 16:2407–2421.
- Fausch, K. D., B. E. Rieman, J. B. Dunham, M. K. Young, and D. P. Peterson. 2009. Invasion versus isolation: trade-offs in managing native salmonids with barriers to upstream movement. *Conservation Biology* 25:859–870.
- Ferguson, J. W., B. P. Sandford, R. E. Reagan, L. G. Gilbreath, E. B. Meyer, R. D. Ledgerwood, and N. S. Adams. 2007. Bypass system modification at Bonneville Dam on the Columbia River improved the survival of juvenile salmon. *Transactions of the American Fisheries Society* 136:1487–1510.
- Fischer, J., and D. B. Lindenmayer. 2000. An assessment of the published results of animal relocations. *Biological Conservation* 96:1–11.
- Foppen, R. P. B., J. P. Chardon, and W. Liefveld. 2000. Understanding the role of sink patches in source-sink metapopulations: reed warbler in an agricultural landscape. *Conservation Biology* 14:1881–1892.
- Ford, M., A. Murdoch, and S. Howard. 2012. Early male maturity explains a negative correlation in reproductive success between hatchery-spawned salmon and their naturally spawned progeny. *Conservation Letters* 5:450–458.
- Ford, M. J. 2002. Selection in captivity during supportive breeding may reduce fitness in the wild. *Conservation Biology* 16:815–825.
- Ford, M. J., editor. 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. NOAA Technical Memorandum NMFS-NWFSC-113.
- Frankham, R. 2008. Genetic adaptation to captivity in species conservation programs. *Molecular Ecology* 17:325–333.
- Fraser, D. J., M. W. Jones, T. L. McParland, and J. A. Hutchings. 2007. Loss of historical immigration and the unsuccessful rehabilitation of extirpated salmon populations. *Conservation Genetics* 8:527–546.
- Fraser, D. J., L. K. Weir, L. Bernatchez, M. M. Hansen, and E. B. Taylor. 2011. Extent and scale of local adaptation in salmonid fishes: review and meta-analysis. *Heredity* 106:404–420.
- Fritts, A. L., and T. N. Pearsons. 2006. Effects of predation by nonnative Small-mouth Bass on native salmonid prey: the role of predator and prey size. *Transactions of the American Fisheries Society* 135:853–860.
- Fullerton, A. H., S. T. Lindley, G. R. Pess, B. E. Feist, E. A. Steel, and P. McElhany. 2011. Human influence on the spatial structure of threatened Pacific salmon metapopulations. *Conservation Biology* 25:932–944.
- Gende, S. M., R. T. Edwards, M. F. Willson, and M. S. Wipfli. 2002. Pacific salmon in aquatic and terrestrial ecosystems. *Bioscience* 52:917–928.
- George, A. L., B. R. Kuhajda, J. D. Williams, M. A. Cantrell, P. L. Rakes, and J. R. Shute. 2009. Guidelines for propagation and translocation for freshwater fish conservation. *Fisheries* 34:529–545.
- Gephard, S., and J. R. McMenemy. 2004. An overview of the program to restore Atlantic Salmon and other diadromous fishes to the Connecticut River with notes on the current status of these species in the river. Pages 287–317 in P. M. Jacobson, D. A. Dixon, W. C. Leggett, B. C. Marcy, Jr., R. R. Massengill, editors. *The Connecticut River Ecological Study (1965–1973) revisited: ecology of the lower Connecticut River 1973–2003*. American Fisheries Society, Monograph 9, Bethesda, Maryland.
- Gibson, R. J., R. L. Haedrich, and C. M. Wernerheim. 2005. Loss of fish habitat as a consequence of inappropriately constructed stream crossings. *Fisheries* 30:10–17.
- Godbout, L., C. C. Wood, R. E. Withler, S. Latham, R. J. Nelson, L. Wetzel, R. Barnett-Johnson, M. J. Grove, A. K. Schmitt, and K. D. McKeegan. 2011. Sockeye Salmon (*Oncorhynchus nerka*) return after an absence of nearly 90 years: a case of reversion to anadromy. *Canadian Journal of Fisheries and Aquatic Sciences* 68:1590–1602.
- Good, T. P., J. Davies, B. J. Burke, and M. H. Ruckelshaus. 2008. Incorporating catastrophic risk assessments into setting conservation goals for threatened Pacific salmon. *Ecological Applications* 18:246–257.

- Greene, C. M., J. E. Hall, K. R. Guilbault, and T. P. Quinn. 2010. Improved viability of populations with diverse life-history portfolios. *Biology Letters* 6:382–386.
- Griffiths, A. M., J. S. Ellis, D. Clifton-Dey, G. Machado-Schiaffino, D. Bright, E. Garcia-Vazquez, and J. R. Stevens. 2011. Restoration versus recolonisation: the origin of Atlantic Salmon (*Salmo salar* L.) currently in the River Thames. *Biological Conservation* 144:2733–2738.
- Griswold, R. G., A. E. Kohler, and D. Taki. 2011. Survival of endangered Snake River Sockeye Salmon smolts from three Idaho lakes: relationships with parr size at release, parr growth rate, smolt size, discharge, and travel time. *North American Journal of Fisheries Management* 31:813–825.
- Gustafson, R. G., T. C. Wainwright, G. A. Winans, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1997. Status review of Sockeye Salmon from Washington and Oregon. NOAA Technical Memorandum NMFS-NWFSC-33.
- Hanski, I. A., and M. E. Gilpin. 1997. Metapopulation biology: ecology, genetics, and evolution. Academic Press, San Diego, California.
- Heath, D. D., C. M. Bettles, S. Jamieson, I. Stasiak, and M. F. Docker. 2008. Genetic differentiation among sympatric migratory and resident life history forms of Rainbow Trout in British Columbia. *Transactions of the American Fisheries Society* 137:1268–1278.
- Hedrick, P. W., and R. Fredrickson. 2010. Genetic rescue guidelines with examples from Mexican wolves and Florida panthers. *Conservation Genetics* 11:615–626.
- Hendry, A. P., V. Castric, M. T. Kinnison, and T. P. Quinn. 2004. The evolution of philopatry and dispersal: homing versus straying in salmonids. Pages 52–91 in A. P. Hendry and S. C. Stearns, editors. *Evolution illuminated: salmon and their relatives*. Oxford University Press, Oxford, UK.
- Hendry, A. P., J. K. Wenburg, P. Bentzen, E. C. Volk, and T. P. Quinn. 2000. Rapid evolution of reproductive isolation in the wild: evidence from introduced salmon. *Science* 290:516–518.
- Hesthagen, T., and B. M. Larsen. 2003. Recovery and re-establishment of Atlantic Salmon, *Salmo salar*, in limed Norwegian rivers. *Fisheries Management and Ecology* 10:87–95.
- Holecek, D. E., D. L. Scarnecchia, and S. E. Miller. 2012. Smoltification in an impounded, adfluvial redband trout population upstream from an impassable dam: does it persist? *Transactions of the American Fisheries Society* 141:68–75.
- Huff, D. D., L. M. Miller, and B. Vondracek. 2010. Patterns of ancestry and genetic diversity in reintroduced populations of the slimy sculpin: implications for conservation. *Conservation Genetics* 11:2379–2391.
- ISAB (Independent Scientific Advisory Board). 2011. Using a comprehensive landscape approach for more effective conservation and management. ISAB 2011-4 for the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and National Marine Fisheries Service, Portland, Oregon.
- IUCN (International Union for the Conservation of Nature). 1998. IUCN guidelines for re-introductions. Information Press, Oxford, UK.
- Johnson, D. H., B. M. Shrier, J. S. O'Neal, J. A. Knutzen, X. Augerot, T. A. O'Neil, and T. N. Pearsons. 2007. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.
- Kalinowski, S. T., D. M. Van Doornik, C. C. Kozfkay, and R. S. Waples. 2012. Genetic diversity in the Snake River Sockeye Salmon captive broodstock program as estimated from broodstock records. *Conservation Genetics* 13:1183–1193.
- Keefer, M. L., G. A. Taylor, D. F. Garletts, G. A. Gauthier, T. M. Pierce, and C. C. Caudill. 2010. Prespawn mortality in adult spring Chinook Salmon outplanted above barrier dams. *Ecology of Freshwater Fish* 19:361–372.
- Keefer, M. L., G. A. Taylor, D. F. Garletts, C. K. Helms, G. A. Gauthier, T. M. Pierce, and C. C. Caudill. 2011. Reservoir entrapment and dam passage mortality of juvenile Chinook Salmon in the Middle Fork Willamette River. *Ecology of Freshwater Fish* 21:222–234.
- Kesler, M., M. Kangur, and M. Vetemaa. 2011. Natural re-establishment of Atlantic Salmon reproduction and the fish community in the previously heavily polluted River Purtse, Baltic Sea. *Ecology of Freshwater Fish* 20:472–477.
- Kiffney, P. M., G. R. Pess, J. H. Anderson, P. Faulds, K. Burton, and S. C. Riley. 2009. Changes in fish communities following recolonization of the Cedar River, WA, USA by Pacific salmon after 103 years of local extirpation. *River Research and Applications* 25:438–452.
- Kinnison, M. T., and N. G. Hairston. 2007. Eco-evolutionary conservation biology: contemporary evolution and the dynamics of persistence. *Functional Ecology* 21:444–454.
- Koskinen, M. T., T. O. Haugen, and C. R. Primmer. 2002. Contemporary fish-erian life-history evolution in small salmonid populations. *Nature* 419:826–830.
- Kostow, K. 2009. Factors that contribute to the ecological risks of salmon and steelhead hatchery programs and some mitigating strategies. *Reviews in Fish Biology and Fisheries* 19:9–31.
- Kwain, W. 1987. Biology of Pink Salmon in the North American Great Lakes. Pages 57–65 in M. J. Dadswell, R. J. Klauda, C. M. Moffitt, R. L. Saunders, R. A. Rulifson, and J. E. Cooper, editors. *Common strategies of anadromous and catadromous fishes*. American Fisheries Society, Symposium 1, Bethesda, Maryland.
- Lande, R. 1993. Risks of population extinction from demographic and environmental stochasticity and random catastrophes. *American Naturalist* 142:911–927.
- Levin, P. S., S. Achord, B. E. Feist, and R. W. Zabel. 2002. Non-indigenous Brook Trout and the demise of Pacific salmon: a forgotten threat? *Proceedings of the Royal Society B* 269:1663–1670.
- Liebholt, A., W. D. Koenig, and O. N. Bjornstad. 2004. Spatial synchrony in population dynamics. *Annual Review of Ecology Evolution and Systematics* 35:467–490.
- Liermann, M., and R. Hilborn. 2001. Depensation: evidence, models and implications. *Fish and Fisheries* 2:33–58.
- Lohse, K. A., D. A. Newburn, J. J. Opperman, and A. M. Merenlender. 2008. Forecasting relative impacts of land use on anadromous fish habitat to guide conservation planning. *Ecological Applications* 18:467–482.
- Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on stream-flow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. *Climatic Change* 102:187–223.
- Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. *Bulletin of the American Meteorological Society* 78:1069–1079.
- Matala, A. P., J. E. Hess, and S. R. Narum. 2011. Resolving adaptive and demographic divergence among Chinook Salmon populations in the Columbia River basin. *Transactions of the American Fisheries Society* 140:783–807.
- McClure, M. M., S. M. Carlson, T. J. Beechie, G. R. Pess, J. C. Jorgensen, S. M. Sogard, S. E. Sultan, D. M. Holzer, J. Travis, B. L. Sanderson, M. E. Power, and R. W. Carmichael. 2008a. Evolutionary consequences of habitat loss for Pacific anadromous salmonids. *Evolutionary Applications* 1:300–318.
- McClure, M. M., F. M. Utter, C. Baldwin, R. W. Carmichael, P. F. Hassemer, P. J. Howell, P. Spruell, T. D. Cooney, H. A. Schaller, and C. E. Petrosky. 2008b. Evolutionary effects of alternative artificial propagation programs: implications for viability of endangered anadromous salmonids. *Evolutionary Applications* 1:356–375.
- McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmon populations and the recovery of evolutionary significant units. NOAA Technical Memorandum NMFS-NWFSC-42.
- McMillan, J. R., S. L. Katz, and G. R. Pess. 2007. Observational evidence of spatial and temporal structure in a sympatric anadromous (winter steelhead) and resident Rainbow Trout mating system on the Olympic Peninsula, Washington. *Transactions of the American Fisheries Society* 136:736–748.
- McPhee, M. V., F. Utter, J. A. Stanford, K. V. Kuzishchin, K. A. Savvaitova, D. S. Pavlov, and F. W. Allendorf. 2007. Population structure and partial anadromy in *Oncorhynchus mykiss* from Kamchatka: relevance for conservation strategies around the Pacific Rim. *Ecology of Freshwater Fish* 16:539–547.

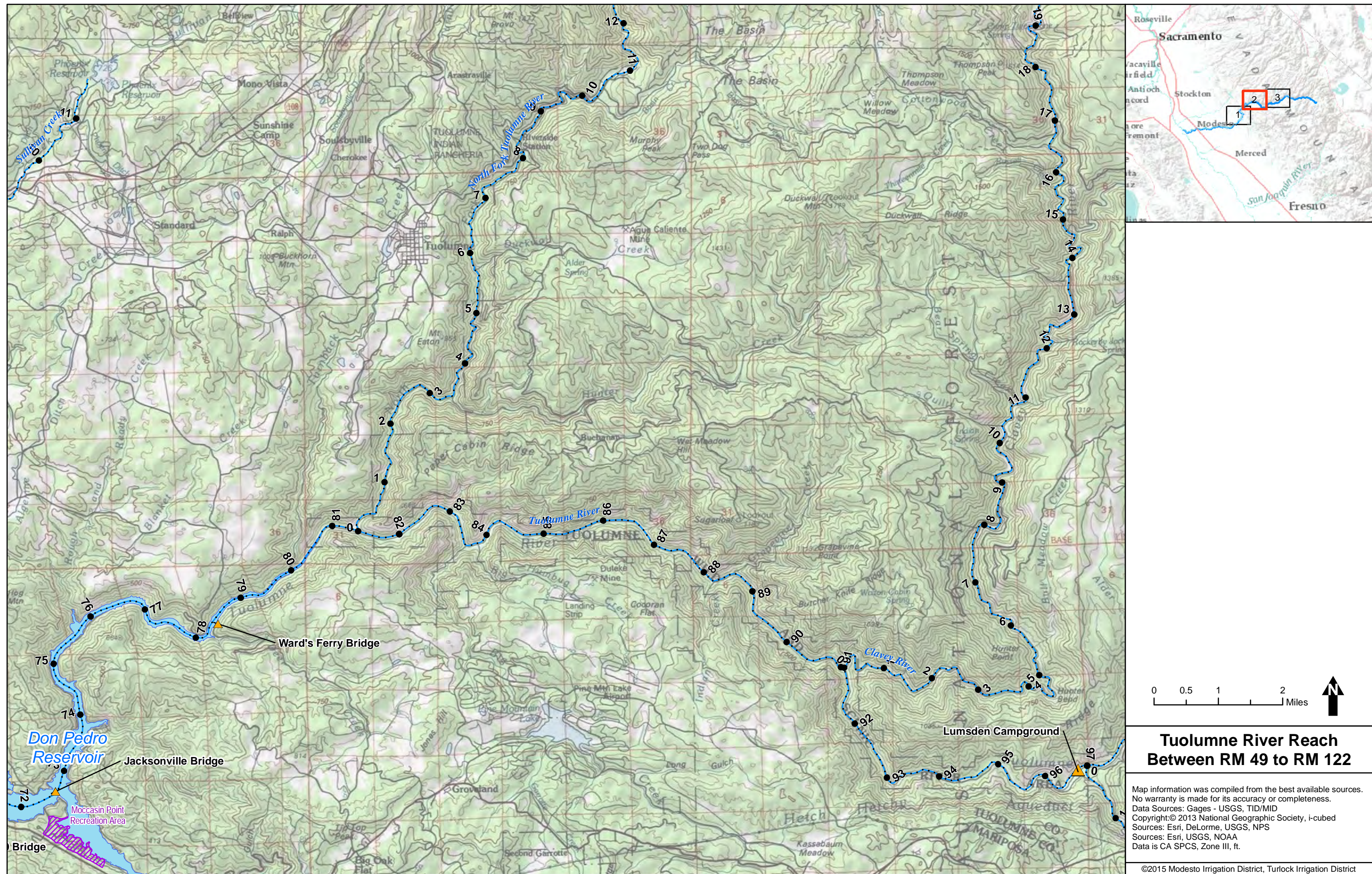
- Milner, A. M., and R. G. Bailey. 1989. Salmonid colonization of new streams in Glacier Bay National Park, Alaska. *Aquaculture and Fisheries Management* 20:179–192.
- Milner, A. M., A. L. Robertson, K. A. Monaghan, A. J. Veal, and E. A. Flory. 2008. Colonization and development of an Alaskan stream community over 28 years. *Frontiers in Ecology and the Environment* 6:413–419.
- Minckley, W. L. 1995. Translocation as a tool for conserving imperiled fishes: experiences in the western United States. *Biological Conservation* 72:297–309.
- Mobrand, L. E., J. Barr, L. Blankenship, D. E. Campton, T. T. P. Evelyn, T. A. Flagg, C. V. W. Mahnken, L. W. Seeb, P. R. Seidel, and W. W. Smoker. 2005. Hatchery reform in Washington State: principles and emerging issues. *Fisheries* 30:11–23.
- Monnerjahn, U. 2011. Atlantic Salmon (*Salmo salar* L.) re-introduction in Germany: a status report on national programmes and activities. *Journal of Applied Ichthyology* 27:33–40.
- Moore, J. W., M. McClure, L. A. Rogers, and D. E. Schindler. 2010. Synchronization and portfolio performance of threatened salmon. *Conservation Letters* 3:340–348.
- Mueter, F. J., B. J. Pyper, and R. M. Peterman. 2005. Relationships between coastal ocean conditions and survival rates of northeast Pacific salmon at multiple lags. *Transactions of the American Fisheries Society* 134:105–119.
- Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D. M. Van Doornik, and M. T. Maher. 2006. Historic population structure of Pacific salmonids in the Willamette River and lower Columbia River basins. NOAA Technical Memorandum NMFS-NWFSC-73.
- Myers, J. M., R. G. Kope, G. J. Bryant, D. J. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. Lindley, and R. S. Waples. 1998. Status review of Chinook Salmon from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-35.
- Naish, K. A., J. E. Taylor III, P. S. Levin, T. P. Quinn, J. R. Winton, D. Huppert, and R. Hilborn. 2008. An evaluation of the effects of conservation and fishery enhancement hatcheries on wild populations of salmon. *Advances in Marine Biology* 53:61–194.
- Narum, S. R., W. D. Arnsberg, A. J. Talbot, and M. S. Powell. 2007. Reproductive isolation following reintroduction of Chinook Salmon with alternative life histories. *Conservation Genetics* 8:1123–1132.
- NMFS (National Marine Fisheries Service). 2006. Endangered and threatened species: final listing determinations for 10 distinct population segments of West Coast steelhead. *Federal Register* 71:3(5 January 2006):834–862.
- NRC (National Research Council). 1996. *Upstream: salmon and society in the Pacific Northwest*. National Academy Press, Washington, D.C.
- Pearsons, T. N., S. R. Phelps, S. W. Martin, E. L. Bartrand, and G. A. McMichael. 2007. Gene flow between resident and anadromous rainbow trout in the Yakima basin: ecological and genetic evidence. Pages 56–64 in R. K. Schroeder and J. D. Hall, editors. *Redband trout: resilience and challenge in a changing landscape*. American Fisheries Society, Oregon Chapter, Corvallis.
- Pearsons, T. N., and G. M. Temple. 2007. Impacts of early stages of salmon supplementation and reintroduction programs on three trout species. *North American Journal of Fisheries Management* 27:1–20.
- Perrier, C. P., G. Evanno, J. Belliard, R. Guyomard, and J.-L. Baglinière. 2010. Natural recolonization of the Seine River by Atlantic Salmon (*Salmo salar*) of multiple origins. *Canadian Journal of Fisheries and Aquatic Sciences* 67:1–4.
- Pess, G. R., R. Hilborn, K. Kloehn, and T. P. Quinn. 2012. The influence of population dynamics and environmental conditions on Pink Salmon recolonization after barrier removal in the Fraser River, British Columbia, Canada. *Canadian Journal of Fisheries and Aquatic Sciences* 69:970–982.
- Pess, G. R., P. M. Kiffney, M. C. Liermann, T. R. Bennett, J. H. Anderson, and T. P. Quinn. 2011. The influences of body size, habitat quality, and competition on the movement and survival of juvenile Coho Salmon during the early stages of stream recolonization. *Transactions of the American Fisheries Society* 140:883–897.
- Pess, G. R., M. L. McHenry, T. J. Beechie, and J. Davies. 2008. Biological impacts of the Elwha River dams and potential salmonid responses to dam removal. *Northwest Science* 82:72–90.
- Petrosky, C. E., and H. A. Schaller. 2010. Influence of river conditions during seaward migration and ocean conditions on survival rates of Snake River Chinook Salmon and steelhead. *Ecology of Freshwater Fish* 19:520–536.
- Poe, T. P., H. C. Hansel, S. Vigg, D. E. Palmer, and L. A. Prendergast. 1991. Feeding of predaceous fishes on outmigrating juvenile salmonids in John Day Reservoir, Columbia River. *Transactions of the American Fisheries Society* 120:405–420.
- Poff, N. L., and D. D. Hart. 2002. How dams vary and why it matters for the emerging science of dam removal. *Bioscience* 52:659–668.
- Pulliam, H. R. 1988. Sources, sinks, and population regulation. *American Naturalist* 132:652–661.
- Quinn, T. P., M. T. Kinnison, and M. J. Unwin. 2001. Evolution of Chinook Salmon (*Oncorhynchus tshawytscha*) populations in New Zealand: pattern, rate, and process. *Genetica* 112–113:493–513.
- Roni, P. 2005. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, Maryland.
- Roni, P., K. Hanson, and T. Beechie. 2008. Global review of the physical and biological effectiveness of stream habitat rehabilitation techniques. *North American Journal of Fisheries Management* 28:856–890.
- Ruckelshaus, M. H., K. P. Currens, W. H. Graeber, R. R. Fuerstenberg, K. Rawson, N. J. Sands, and J. B. Scott. 2006. Independent populations of Chinook Salmon in Puget Sound. NOAA Technical Memorandum NMFS-NWFSC-78.
- Sakai, A. K., F. W. Allendorf, J. S. Holt, D. M. Lodge, J. Molofsky, K. A. With, S. Baughman, R. J. Cabin, J. E. Cohen, N. C. Ellstrand, D. E. McCauley, P. O'Neil, I. M. Parker, J. N. Thompson, and S. G. Weller. 2001. The population biology of invasive species. *Annual Review of Ecology and Systematics* 32:305–332.
- Sanderson, B. L., K. A. Barnas, and A. M. W. Rub. 2009. Nonindigenous species of the Pacific Northwest: an overlooked risk to endangered salmon? *Bioscience* 59:245–256.
- Satterthwaite, W. H., M. P. Beakes, E. M. Collins, D. R. Swank, J. E. Merz, R. G. Titus, S. M. Sogard, and M. Mangel. 2009. Steelhead life history on California's Central Coast: insights from a state-dependent model. *Transactions of the American Fisheries Society* 138:532–548.
- Satterthwaite, W. H., M. P. Beakes, E. M. Collins, D. R. Swank, J. E. Merz, R. G. Titus, S. M. Sogard, and M. Mangel. 2010. State-dependent life history models in a changing (and regulated) environment: steelhead in the California Central Valley. *Evolutionary Applications* 3:221–243.
- Schaller, H. A., and C. E. Petrosky. 2007. Assessing hydrosystem influence on delayed mortality of Snake River stream-type Chinook Salmon. *North American Journal of Fisheries Management* 27:810–824.
- Scheuerell, M. D., R. Hilborn, M. H. Ruckelshaus, K. K. Bartz, K. M. Lagueux, A. D. Haas, and K. Rawson. 2006. The Shiraz model: a tool for incorporating anthropogenic effects and fish-habitat relationships in conservation planning. *Canadian Journal of Fisheries and Aquatic Sciences* 63:1596–1607.
- Scheuerell, M. D., and J. G. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook Salmon (*Oncorhynchus tshawytscha*). *Fisheries Oceanography* 14:448–457.
- Scheuerell, M. D., R. W. Zabel, and B. P. Sandford. 2009. Relating juvenile migration timing and survival to adulthood in two species of threatened Pacific salmon (*Oncorhynchus* spp.). *Journal of Applied Ecology* 46:983–990.
- Schindler, D. E., X. Augerot, E. Fleishman, N. J. Mantua, B. Riddell, M. Ruckelshaus, J. Seeb, and M. Webster. 2008. Climate change, ecosystem impacts, and management for Pacific salmon. *Fisheries* 33:502–506.
- Schindler, D. E., R. Hilborn, B. Chasco, C. P. Boatright, T. P. Quinn, L. A. Rogers, and M. S. Webster. 2010. Population diversity and the portfolio effect in an exploited species. *Nature* 465:609–613.
- Schneider, J. 2011. Review of reintroduction of Atlantic Salmon (*Salmo salar*) in tributaries of the Rhine River in the German federal states of Rhineland-Palatinate and Hesse. *Journal of Applied Ichthyology* 27:24–32.

- Schickzelle, N., and T. P. Quinn. 2007. A metapopulation perspective for salmon and other anadromous fish. *Fish and Fisheries* 8:297–314.
- Schwartz, M. K., G. Luikart, and R. S. Waples. 2007. Genetic monitoring as a promising tool for conservation and management. *Trends in Ecology & Evolution* 22:25–33.
- Scott, R. J., K. A. Judge, K. Ramster, D. L. G. Noakes, and F. W. H. Beamish. 2005a. Interaction between naturalised exotic salmonids and reintroduced Atlantic Salmon in a Lake Ontario tributary. *Ecology of Freshwater Fish* 14:402–405.
- Scott, R. J., R. Kosick, D. L. G. Noakes, and F. W. H. Beamish. 2005b. Nest site selection and spawning by captive bred Atlantic Salmon, *Salmo salar*, in a natural stream. *Environmental Biology of Fishes* 74:309–321.
- Seddon, P. J., D. P. Armstrong, and R. F. Maloney. 2007. Developing the science of reintroduction biology. *Conservation Biology* 21:303–312.
- Spalton, J. A., M. W. Lawrence, and S. A. Brend. 1999. Arabian oryx reintroduction in Oman: successes and setbacks. *Oryx* 33:168–175.
- Spies, I. B., E. C. Anderson, K. Naish, and P. Bentzen. 2007. Evidence for the existence of a native population of Sockeye Salmon (*Oncorhynchus nerka*) and subsequent introgression with introduced populations in a Pacific Northwest watershed. *Canadian Journal of Fisheries and Aquatic Sciences* 64:1209–1221.
- Stanley, E. H., and M. W. Doyle. 2003. Trading off: the ecological effects of dam removal. *Frontiers in Ecology and the Environment* 1:15–22.
- Stüwe, M., and B. Nievergelt. 1991. Recovery of alpine ibex from near extinction: the result of effective protection, captive breeding, and reintroductions. *Applied Animal Behaviour Science* 29:379–387.
- Tallmon, D. A., G. Luikart, and R. S. Waples. 2004. The alluring simplicity and complex reality of genetic rescue. *Trends in Ecology and Evolution* 19:489–496.
- Taylor, E. B. 1991. A review of local adaptation in Salmonidae, with particular reference to Pacific and Atlantic salmon. *Aquaculture* 98:185–207.
- Tear, T. H., P. Kareiva, P. L. Angermeier, P. Comer, B. Czech, R. Kautz, L. Landon, D. Mehlman, K. Murphy, M. Ruckelshaus, J. M. Scott, and G. Wilhere. 2005. How much is enough? The recurrent problem of setting measurable objectives in conservation. *Bioscience* 55:835–849.
- Väsemagi, A., R. Gross, T. Paaver, M. Kangur, J. Nilsson, and L. O. Eriksson. 2001. Identification of the origin of Atlantic Salmon (*Salmo salar* L.) population in a recently recolonized river in the Baltic Sea. *Molecular Ecology* 10:2877–2882.
- Viggers, K. L., D. B. Lindenmayer, and D. M. Spratt. 1993. The importance of disease in reintroduction programs. *Wildlife Research* 20:687–698.
- Wagner, T., and J. A. Sweka. 2011. Evaluation of hypotheses for describing temporal trends in Atlantic Salmon parr densities in northeast U.S. rivers. *North American Journal of Fisheries Management* 31:340–351.
- Walker, S. F., J. Bosch, T. Y. James, A. P. Litvintseva, J. A. O. Valls, S. Pina, G. Garcia, G. A. Rosa, A. A. Cunningham, S. Hole, R. Griffiths, and M. C. Fisher. 2008. Invasive pathogens threaten species recovery programs. *Current Biology* 18:R853–R854.
- Waples, R. S. 1991. Pacific salmon, *Oncorhynchus* spp., and the definition of “species” under the Endangered Species Act. *Marine Fisheries Review* 53:11–22.
- Waples, R. S., M. J. Ford, and D. Schmitt. 2007a. Empirical results of salmon supplementation in the Northeast Pacific: a preliminary assessment. Pages 483–403 in T. M. Bert, editors. *Ecological and genetic implications of aquaculture activities*. Kluwer Academic Publishers, Norwell, Massachusetts.
- Waples, R. S., D. J. Teel, J. M. Myers, and A. R. Marshall. 2004. Life-history divergence in Chinook Salmon: historic contingency and parallel evolution. *Evolution* 58:386–403.
- Waples, R. S., R. W. Zabel, M. D. Scheuerell, and B. L. Sanderson. 2007b. Evolutionary responses by native species to major anthropogenic changes to their ecosystems: Pacific salmon in the Columbia River hydropower system. *Molecular Ecology* 17:84–96.
- Ward, D. M., K. H. Nislow, and C. L. Folt. 2008. Do native species limit survival of reintroduced Atlantic Salmon in historic rearing streams? *Biological Conservation* 141:146–152.
- Weigel, D. E., P. J. Connolly, K. D. Martens, and M. S. Powell. 2013. Colonization of steelhead in a natal stream after barrier removal. *Transactions of the American Fisheries Society* 142.
- Williams, J. E., D. W. Sada, and C. D. Williams. 1988. American Fisheries Society guidelines for introductions of threatened and endangered fishes. *Fisheries* 13:5–11.
- Williams, J. G., R. W. Zabel, R. S. Waples, J. A. Hutchings, and W. P. Connor. 2008. Potential for anthropogenic disturbances to influence evolutionary change in the life history of a threatened salmonid. *Evolutionary Applications* 1:271–285.
- Williamson, K. S., and B. May. 2005. Homogenization of fall-run Chinook Salmon gene pools in the Central Valley of California, USA. *North American Journal of Fisheries Management* 25:993–1009.
- Withler, F. C. 1982. Transplanting Pacific salmon. *Canadian Technical Report of Fisheries and Aquatic Sciences* 1079.
- Wolf, C. M., B. Griffith, C. Reed, and S. A. Temple. 1996. Avian and mammalian translocations: update and reanalysis of 1987 survey data. *Conservation Biology* 10:1142–1154.







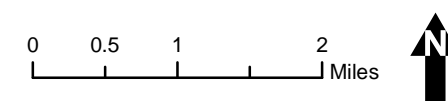
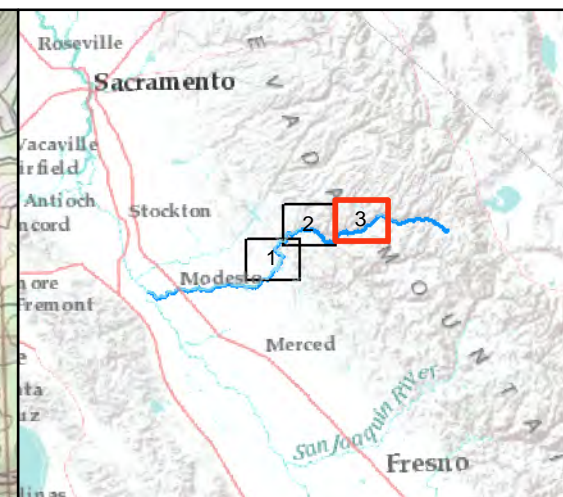
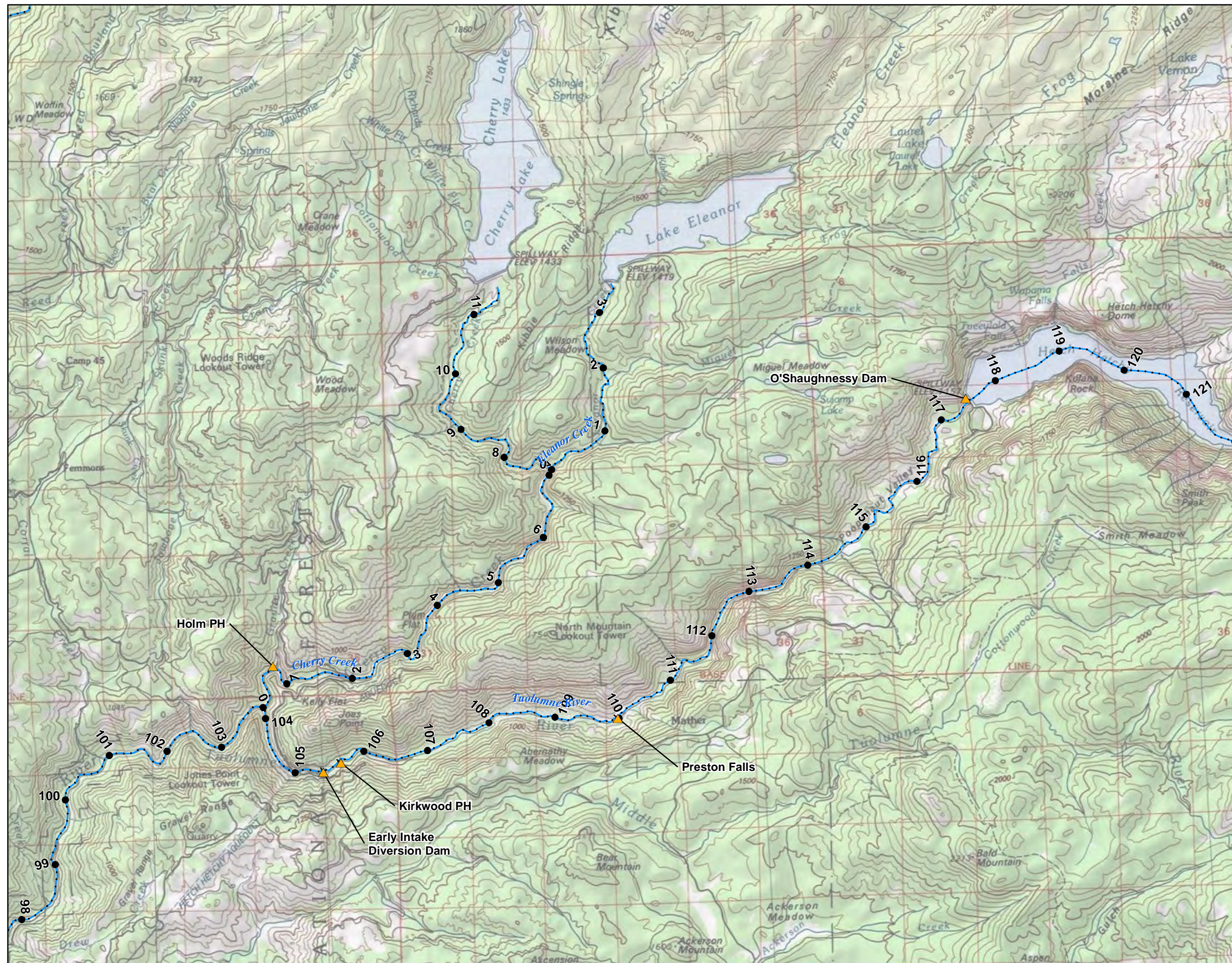


**Tuolumne River Reach  
Between RM 49 to RM 122**

Map information was compiled from the best available sources.  
No warranty is made for its accuracy or completeness.  
Data Sources: Gages - USGS, TID/MID  
Copyright:© 2013 National Geographic Society, i-cubed  
Sources: Esri, DeLorme, USGS, NPS  
Data is CA SPCS, Zone III, ft.

©2015 Modesto Irrigation District, Turlock Irrigation District





## Tuolumne River Reach Between RM 49 to RM 122

Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness.  
Data Sources: Gages - USGS, TID/MID  
Copyright: © 2013 National Geographic Society, i-cubed  
Sources: Esri, DeLorme, USGS, NPS  
Sources: Esri, USGS, NOAA  
Data is CA SPCS, Zone III, ft.



**Workshop No. 2**

**September 17, 2015**

**La Grange Hydroelectric Project Licensing (FERC No. 14581)**  
**Fish Passage Facilities Alternatives Assessment**  
**Workshop No. 2**

**Thursday, September 17, 2015**  
**9:00 am to 12:00 pm**

**Meeting Notes**

On September 17, 2015, Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) hosted the second Workshop (Workshop No. 2) for the La Grange Hydroelectric Project Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment). This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting. Attachment A to this document includes the following meeting documents: agenda, sign-in sheet, presentations, and handouts.

Mr. John Devine of HDR, Inc. (HDR), consultant to the Districts, welcomed meeting attendees. Attendees in the room and on the phone introduced themselves. Messrs. Noah Hume and Wayne Swaney of Stillwater Sciences, Mr. Matt Oh and Ms. Jenna Borovansky of HDR, and Mr. Peter Barnes of the State Water Resources Control Board participated remotely. Mr. Chris Shutes (California Sportfishing Protection Alliance) initially joined the meeting by phone and then arrived in person.

Mr. Devine summarized the meeting handouts and visuals placed around the meeting room. He reviewed the meeting agenda, which had been provided to meeting participants on September 4. Mr. Devine noted the 9:10 am and 9:30 am agenda items will be switched, but other than that the agenda remained the same. Mr. Roger VanHoy (MID) asked to be able to make some introductory remarks. Mr. Devine added he was remiss in not inviting opening remarks from anyone that would like to make them. Mr. Devine invited anyone interested to make opening remarks. There were no volunteers.

Mr. Devine presented introductory slides. He provided background on the La Grange Hydroelectric Project (La Grange Project) and summarized the licensing process to date. Mr. Devine described the Fish Passage Assessment and reviewed the status of action items from Workshop No. 1, held on May 20, 2015. He also covered the objectives of Workshop No. 2 and the schedule moving forward after Workshop No. 2.

Mr. VanHoy provided opening remarks. He said the Districts are considering the potential for fish passage at their facilities very seriously with a desire to understand the full scope of needed facilities and their cost, which is why the Districts are hosting this series of Workshops. The Districts hope to come through this process with a better understanding of the agencies' goals, what it may cost to construct and operate fish passage facilities, and the financial implications for the Districts' and their ratepayers. Mr. VanHoy noted that the Districts are putting substantial resources into this study, with the hope of facilitating engagement with the meeting attendees through the Workshops. Mr. VanHoy said that although there are many experts in attendance today, there are many non-experts too, people like himself and others from the business and legislative communities. He encouraged non-expert, community interests to become engaged as well. The Districts' goal is to understand the risks, benefits, costs, impacts and the probability of success of a fish passage/reintroduction program on the Tuolumne River. The Districts hope there is a strong interest and high level of participation in the process. Furthermore, the Districts realize and accept that there may be diverging opinions on the likelihood of success.

Mr. VanHoy said he came from a background in power and that the scale of a fish passage facility can be immense and for those unfamiliar with such facilities, it may be difficult to envision. Referring to Technical Memorandum (TM) No. 1 (available online [here](#)), Mr. VanHoy said the footprint of a floating surface collector for downstream passage could be as big as the footprint of the MID conference room. The collector would be a floating laboratory on the Don Pedro Reservoir, using nets and vacuums to guide and collect small fish. The collector would be part of a barge that would have to float up and down with reservoir fluctuations. The process of scoping and engineering a fish passage facility of this type is an intensive effort.

Mr. VanHoy reiterated the importance of coming to a common understanding about costs. He added that with some luck, meeting participants will also come to a common understanding about whether the fish passage facilities would be successful.

Mr. Devine thanked Mr. VanHoy for his remarks and asked if anyone else would like to make opening remarks. There were no volunteers.

Mr. Devine said the Districts hope to use the Workshops to move the Fish Passage Assessment through an open and collaborative process that will produce the information required to make a well-informed decision about whether fish passage facilities should be built at the La Grange Project and the Don Pedro Project to support fish reintroduction. To this end, the Districts developed a draft reintroduction decision-making framework to share with Workshop participants. The intent of the framework is to evaluate all the potential issues, not only fish passage engineering feasibility, associated with fish reintroduction into the upper Tuolumne River.

Mr. Devine said an overview of this comprehensive framework was made available to Workshop participants on September 4. Additional handouts and materials describing the decision-making framework were made available at the Workshop. It is apparent that the question of whether or not to build fish passage on the Tuolumne River is a challenging one, but the engineering of fish passage is just one element of a much broader question regarding the feasibility of fish reintroduction. However, this question has been tackled on other projects and the draft reintroduction decision-making framework presented here is not new; instead, it was adapted from processes used at other California projects to inform decision-making on reintroduction and fish passage facilities. In addition to drawing on criteria used at other projects, the decision-making framework being presented here uses concepts and approaches from peer-reviewed literature, including literature produced by the National Marine Fisheries Service (NMFS). Mr. Devine reiterated that the proposed framework draws on materials and sources that have been used at other projects.

Mr. Devine indicated the Districts recognize that this topic is complex and the goal today is not to make a decision. The goal of Workshop No. 2, as contained in the previously distributed agenda, is to discuss a potential reintroduction decision-making framework and TM No. 1 (distributed on September 4) and see if consensus on a path forward can be reached. Recognizing that very complex questions lie ahead, the Districts believe there is a need for a structured decision-making framework that is comprehensive, collaborative, and transparent, which are the goals of the draft reintroduction decision-making framework presented today.

Mr. Devine introduced Mr. Paul Bratovich (HDR) and Dr. Chuck Hanson (Hanson Environmental, Inc.) to present the conceptual reintroduction decision-making framework..

Mr. Bratovich summarized his educational and professional background. Paul Bratovich holds a Bachelor of Science degree in Fisheries from the University of Washington and a Master of Science degree in



Fisheries Resources from the University of Idaho. Mr. Bratovich reported that he was the Lead Investigator on numerous technical studies for the Oroville Project relicensing, including the development and application of a Fish Passage Assessment Model for the Feather River. He was also the lead biologist for the North Yuba Reintroduction Initiative, and Yuba County Water Agency's fisheries representative for the multi-party Yuba Salmon Forum.

Mr. Bratovich noted that the reintroduction decision-making framework is comprised of four main components: (1) Ecological Feasibility, (2) Biological Constraints, (3) Technical Fish Passage Considerations, and (4) Economic, Regulatory and Additional Key Considerations.

Mr. Devine said earlier he had failed to describe the difference between what is meant by "fish passage" and what is meant by "reintroduction". He asked Mr. Bratovich to give an overview of the difference. Mr. Bratovich replied that "reintroduction" means an overall program of introducing fish back into historical habitat, after having been extirpated from those habitats. For example, if spring-run Chinook were historically in a reach of river, and as the result of something happening, such as the construction of dam, the fish were no longer in that reach of river, bringing that same fish species back into this reach is termed "reintroduction." In contrast, "fish passage" describes the methods by which fish are moved upstream or downstream around an impediment in the river.

Mr. Bratovich summarized the elements of each of the four limbs in the reintroduction decision-making framework. At a high level, Mr. Bratovich described what types of questions should be addressed in each limb. Regarding the fourth limb, Mr. Bratovich emphasized the importance of determining what role economics would play in this process. Does economics even play a role in this process? Mr. Bratovich noted that different stakeholders may have different opinions about the role of economics in this decision process.

Dr. Hanson summarized his educational and professional background. Dr. Hanson has a Ph.D. in Ecology and Fisheries Biology from UC Davis and has over 35 years of experience working on fisheries issues in the Central Valley. Dr. Hanson participated in the NMFS Central Valley Salmonid Technical Recovery Team and the U.S. Fish and Wildlife Service Native Delta Fishes Recovery Team as well as the Bradbury Dam Technical Advisory Committee (TAC) reintroduction feasibility study on the Santa Ynez River and the San Joaquin River TAC salmon restoration/reintroduction program downstream of Friant Dam. Dr. Hanson also participated in the relicensing processes for both the Oroville and Klamath River hydroelectric projects where the feasibility of reintroducing anadromous salmon upstream of existing dams was assessed.

Dr. Hanson reported he had been tasked by the Districts with providing independent feedback on Mr. Bratovich's reintroduction decision-making framework. Dr. Hanson said that to complete this task, he had first compiled and reviewed studies that took place over the last 15 years that examined the feasibility of reintroducing salmonids in California and the Pacific Northwest. Specific projects he reviewed included projects on the Santa Clara River, Yuba River, Feather River, Santa Ynez River and Snake River and projects in the Upper Columbia River Basin. Dr. Hanson noted that as he reviewed these studies, he was struck by the commonalities between Mr. Bratovich's approach and the other processes. Commonalities included consideration of the interplay between biological, ecological, and engineering feasibility and consideration of variables such as species behavior, the quality and availability of suitable habitat for spawning and rearing, and how the quantity of habitat varies by season and water year. Dr. Hanson noted that predation was a key issue, both in terms of the upstream tributaries where juvenile rearing would occur and downstream where the juveniles would be released. The location of upstream barriers had an influence on the availability of habitat and on release locations. Limiting factor analysis and the identification of carrying capacity came up repeatedly in the studies Dr. Hanson had reviewed; these

factors formed the basis for developing estimates of juvenile productivity and subsequently, adult productivity (i.e., adult returns). Dr. Hanson noted that defined biological goals and objectives were commonplace in the studies he had reviewed. Dr. Hanson said that Mr. Bratovich's reintroduction decision-making framework was not new and had been shaped by work completed at other projects over the last 15 years, and that in his opinion Mr. Bratovich's reintroduction decision-making framework was well-founded.

Mr. Devine thanked Mr. Bratovich and Dr. Hanson for their presentations. Mr. Devine said the question for the participants is how to move forward. The reintroduction decision-making framework is a potential process for informing reintroduction, and therefore, fish passage decision-making, and is based on other recent reintroduction processes. The Districts' goal is to try to obtain consensus for a path forward and offered this draft decision-making framework, or something like it, for the overall process, because it covers the full scope of issues and concerns that need to be answered regarding reintroduction such as the costs, the risks, the constraints, the benefits, and the potential for success. As a path forward, the Districts asked licensing participants to look at this material and provide the Districts with feedback on the material presented today, so that consensus can be reached on the information that needs to be collected and the issues that need to be considered. The Districts asked that licensing participants take some time to absorb the material, perhaps over the next four or five weeks, and then provide comments.

Mr. Wooster (NMFS) said he was confused on the Districts' proposed process. The Fish Passage Assessment Study Plan corresponds with the orange boxes (technical, engineering fish passage considerations) in the decision-making framework. The orange boxes appear as only one piece of the overall decision-making framework. Do the Districts want to cover the entire decision-making framework within the context of the study identified in the study plan? Mr. Wooster noted that a series of three Workshops is planned and already this group is at Workshop No. 2. There are two years of study and the study is already halfway through the first year. Mr. Wooster indicated that it sounds like the Districts are proposing a multi-party collaborative reintroduction forum, similar to the Yuba Salmon Forum. Mr. Wooster asked if that is what the Districts are proposing. Mr. Wooster asked for clarification about the scale of what the Districts are proposing.

Mr. Devine replied that from the Districts' perspective, the answers to many of the biological and ecological questions that Mr. Bratovich and Dr. Hanson raised are critical to informing the engineering assessment and serve to demonstrate the interconnected nature displayed in the reintroduction decision-making framework. While FERC's direction was to assess fish passage, the Districts always supported the idea that many issues and data needs were raised by the question of reintroduction. The Districts' issue in the FERC study plan determination process was solely which party should be responsible for collecting the needed information. A number of important questions needed for a well-informed engineering assessment are identified in the various limbs of the decision-making framework. Consensus on this information is needed in order to move forward with the engineering study. Mr. Devine likened the engineering study to a study about constructing a building. One cannot simply say "build a building". First, factors must be known such as how many people the building needs to fit, how many offices should there be, and what the soil composition is at the site. The answers to these questions must be known in order to prepare a well-informed design and, therefore, an accurate and reliable cost estimate.

Mr. Devine noted that earlier in the meeting, Mr. VanHoy had mentioned that the Districts want to do this study right. It is important to the Districts that there is a solid foundation of information on which to build a reliable and real cost estimate. The first step is to work through this structured reintroduction decision-making framework. This is just a draft and the Districts welcome comments, feedback, and modification.

Ms. Alison Willy (U.S. Fish and Wildlife Service) asked where in the reintroduction decision-making framework is the decision point for choosing to pursue assisted passage or volitional passage. Mr. Devine described the differences between volitional and assisted passage and indicated Mr. Mike Garelo (HDR) would cover this very topic during his presentation. Mr. Devine noted that TM No. 1 is the beginning step to identifying the information needed to support the process of selecting and designing appropriate fish passage facilities. In his presentation, Mr. Garelo would be discussing TM No. 2, the goal of which is to develop potential upstream and downstream passage alternatives and then select those facility alternatives that are consistent with fish passage program goals (yet to be defined).

Ms. Willy noted that some fish passage facilities in the northwest have combinations of assisted passage and volitional passage. Some of these facilities utilize existing project structures and facilities. For example, the fish passage structure might utilize a project bypass originally built during dam construction. Ms. Willy asked if this study would consider options like that. Mr. Devine replied that the study will look at all facilities that could be useful for fish passage. He noted that as the study progresses, decisions to eliminate facilities from consideration will be made in consultation with this Workshop group. First, a draft document will be provided for review that explains the logic and reason behind any proposed decisions. The Districts' desire is to develop consensus during each step moving forward. However, to continue progressing forward, someone needs to take a first shot at the analysis – that was the purpose of TM No. 1. The Districts want to move forward on a consensus basis about what makes sense to study in detail. But as a first matter the goals and objectives of the fish passage program must be known to inform what would be appropriate to design, construct and operate.

Mr. Bao Le (HDR) noted the importance of knowing the goals and objectives and having sound information, or assumptions based on sound information, at the outset of the process. Without that information, there is a risk of moving forward with the design process and then needing to go back and re-design if new and/or more accurate information became available. This would have implications for cost and schedule.

Mr. John Shelton (California Department of Fish and Wildlife [CDFW]) noted that many ecological feasibility questions are not simple “yes” or “no” questions. Mr. Shelton agreed that questions about technical feasibility or economic feasibility may be binary; for example, technical feasibility may be a “yes” or “no” question. Mr. Shelton said that when he had participated in these types of processes in the past, the first step was to decide on goals and objectives and then to see which fish passage alternatives are feasible. Goals and objectives must be decided first, which often requires a stakeholder process. From there, alternatives are prepared. That is when Ms. Willy's question about volitional or assisted passage comes in. Mr. Shelton said he would caution against having an engineering concept already in mind and then building backwards. The concept will come out of the alternatives analysis. If there is already a concept in mind, there cannot be an objective stakeholder process.

Mr. Garelo (HDR) said the approach proposed here aligned very much with what Mr. Shelton said. He noted that the arrows in the decision-making framework point both ways, meaning that the various limbs create an integrated whole and feed into each other. Regarding determining fish passage technical feasibility and what technologies would be appropriate, the Districts have not gone down that road yet. The study is in the information gathering phase now. Mr. Garelo said the Districts need input on the biological goals and objectives of the reintroduction program to determine appropriate design criteria and constraints for fish passage alternatives.

Mr. Tom Holley (NMFS) noted the Districts are currently undertaking two studies that FERC did not order the Districts to complete. These studies focus on upstream habitat. Mr. Holley asked if the results of those studies would feed the engineering study alone or if they would inform the entire reintroduction

decision-making framework. Mr. Holley noted that studying just the upstream habitat in the Yuba Project took four years and meetings were held frequently. The process was fairly involved. Mr. Holley said it did not seem like the stakeholders would have the opportunity to have the same level of involvement in the Districts' upstream studies as they had had in the Yuba studies.

Mr. Devine responded that the results of any upstream studies would be useful for the entire decision-making framework. Mr. Devine indicated that the Districts are voluntarily performing certain studies NMFS requested but which FERC said the Districts were not required to do under the FERC study criteria. These studies are underway and the Districts will share results when they are available, which is likely at the time of the ISR. However, it does seem that an important first step is developing a reasonable process to arrive at a consensus decision on all the questions raised by reintroduction. From there you can determine what kind of information is needed, what will be involved to get the information, and what the schedule will be. The Districts fully intend to foster a collaborative process with the upstream studies as well. These studies will not be completed in a vacuum. The Districts think the results of the upstream studies will play a role in answering questions about carrying capacity and habitat availability, but many other questions remain. Some of these will be critical to informing the engineering component of the framework since all various limbs of the reintroduction decision-making framework are interconnected. The first step is achieving consensus on using this process, developing a schedule, and then trying to understand what each party can achieve and in what time frame. There is a lot of money at stake, complex decisions to be made, and potential impacts; this process needs to be done right.

Mr. Wooster said he did not think his first question was answered. What are the Districts proposing? While there is a lot of biological information needed to do the engineering study properly, there is also a lot of biological information noted in the reintroduction decision-making framework that is not needed to design the facilities. Mr. Wooster asked if the Districts are proposing to identify only the items in the framework that are needed to do the engineering study or if the Districts are proposing to look at every single item identified in the framework.

Mr. Bratovich said that from his perspective, the process should entail looking at each item in the decision-making framework. A benefit of this structured decision framework is that it provides transparency. Many of the biological issues included in the framework may not intuitively relate to engineering feasibility. However, Mr. Garelo's presentation will show how some of those items are important inputs into the engineering design. Mr. Bratovich noted that over the last several weeks, Mr. Garelo had asked Mr. Bratovich about many biological issues because those topics relate to the engineering work. Mr. Bratovich said he had not had the answers to many of those questions, several of which related to carrying capacity and productivity potential.

Mr. Wooster said that while there were clear examples of biological information that is important for Mr. Garelo to know, such as carrying capacity or the number of fish, there is other information in the reintroduction decision-making criteria that would not be important for him to know. Genetics is one example. Genetics are important but the availability of information on genetics should not delay Mr. Garelo as he develops fish passage alternatives. Mr. Wooster said he could go through the reintroduction decision-making framework and find other such examples. Mr. Wooster asked if Districts are trying to identify what is needed for the engineering feasibility study or if the proposal is to work methodically through a broader, more comprehensive reintroduction decision-making framework.

Regarding the example of genetics raised by Mr. Wooster, Mr. Devine responded that this may actually play a significant role in the type and timing of engineering facilities. If the genetic study underway by NMFS on *O. mykiss* found that passage of steelhead was not desired, as NMFS pointed out in the FERC study dispute resolution process, then the fish passage facilities design and operation would not have to



accommodate the needs and requirements of steelhead. This would likely be a much different design and operation plan for fish passage if steelhead had to be considered. The Districts are planning to work through the broader, more comprehensive assessment using a collaborative process. The framework identifies information needed to support a well-informed decision on reintroduction. One goal of this effort is to estimate the cost of the required facilities and associated operational requirements. Mr. Devine said that industry experience so far with high-dam passage is that the actual cost to build and operate these fish passage facilities has far exceeded the initial estimates. Typically, this is because the information used to generate the initial cost estimates had changed dramatically or had not been well-informed early-on. It is in all parties' interest to avoid this problem. Since the Districts and their ratepayers will be responsible for these costs, it is absolutely critical to establish a solid foundation of information to inform any cost estimates.

Mr. Wooster said he thinks that the Districts need to develop a process to work through the decision-making framework, and to not try to cram the whole framework into the engineering study. Mr. Devine replied that the engineering study is one component of the overall framework, and that various elements identified in the other three components will help define the fish passage facilities needed and when they are needed in the reintroduction program. Mr. Wooster replied that he does not know what Mr. Garelo needs for the engineering study. Mr. Devine asked Mr. Wooster to review the reintroduction decision-making framework and provide his opinion about what he thinks would be useful for the engineering study. Mr. Garelo added that his presentation later in the meeting will provide more detail on what initial information is needed specific to the fish passage engineering element.

Mr. Bratovich said that Mr. Wooster had made good points. Some of the biological constraints in the reintroduction decision-making framework do not intuitively link to the engineering, and that some elements are needed more than others. Mr. Bratovich noted that his presentation stated that the decision was not just about fish passage, but the broader concept of fish reintroduction which is applicable to the upper Tuolumne River. Broader issues and concerns have been raised about reintroduction that extend beyond just the engineering feasibility of fish passage.

Mr. Shutes said it seems as though there are some questions in particular that are crucial for informing the engineering study. Mr. Shutes said that it looks like Mr. Garelo will not be able to get answers to all the questions in the decision-making framework and still be able to abide by the study report schedule. It may be worth flagging some of the key questions and seeing if there are opportunities to make a decision on those. Some will need to be contingencies. For example, the answer to what species should be studied (steelhead and/or fall-run Chinook and/or spring-run Chinook) may need to be a contingency. Mr. Shutes said he was certainly sympathetic if folks think one of those species is not in the picture. Not answering big questions like that could potentially lead to a lot of unnecessary work for Mr. Garelo.

Mr. Shutes said that some of the issues in the decision-making framework may be design issues, such as whether the facility operates year-round or only during a specific time period. An issue like that will certainly have an effect on cost, as this group knows from dealings with Yuba and other projects. Here, that issue may have to be a contingency. Mr. Devine said that the Districts realize that some assumptions will have to be made. However, the basis for these assumptions must be sound, and be based on something other than an arbitrary choice.

Mr. Peter Drekmeier (Tuolumne River Trust) said that at the beginning of today's discussion, there was a lot of focus on a collaborative process. He appreciates this. This group works well together and they are respectful of one another. However, he is not sure this group will be able come to a consensus agreement in the end. There are some people in this room who are really rooting for a fish passage program and others that are skeptical about fish passage or opposed because of the cost. It will be a challenge. Right

now in the Bay area, the utilities, agencies and conservation groups have come together collaboratively around the importance of water conservation. Utilities participated because they wanted to make sure they have enough water. The conservation groups are hoping that some of the water saved will end up benefitting the fish. A cap was agreed to and has been successful. Mr. Drekmeier said this area of the state is in much better shape because of that collaboration. Mr. Drekmeier asked if there could be an incentive for everyone in this group to make progress on the Tuolumne, perhaps on the issue of fish passage or about something else. Depending on the goals, if there were incentives for the Districts to meet the goals, or penalties if the goals were not met, that could help the process. The cost of fish passage is very expensive, and maybe some feel it could be done in a less expensive way. The Districts have already spent millions on the relicensing of Don Pedro and it did not amount to anything positive for the river.

Mr. Devine said that in his conversations with the Districts, the decision about fish passage is of great interest and importance to many people and the only way to arrive at a common understanding of the issues is to have a collaborative process. Having a collaborative process does not mean that in the end agreement is reached, but it does mean that everyone works together and at least agrees with the information that has been collected. The Districts are committed to working in an open and direct way. However, this does not guarantee agreement about whether or not fish passage is feasible or appropriate. But working through a collaborative process is the best chance to ensure that the information that is identified, collected and evaluated for decision-making is supported by all participants. The Districts want to work with all parties with the goal that an agreed-upon data base is developed. Mr. Devine added that in the end everyone may not all agree, but hopefully at least participants will understand why those differences exist.

Mr. Drekmeier said he was wondering what could be learned from other similar projects that had been successful. He noted he was not really familiar with all the issues being discussed here, and that it might make sense upfront in the process and be cost-effective to look at how successful processes have been implemented elsewhere. Or, maybe this group could consider how the resources to be used in this effort would be better used to improve the river.

Mr. Ray Dias, a member of the public and an engineer, said he would like to second what Mr. Drekmeier said. The reintroduction decision-making framework is complex but he thought it was necessary and would work. As a member of the public, Mr. Dias said he is concerned about the economics, but as an engineer he knows best practices could be used to streamline the process. It would greatly benefit the overall process if best practices could be leveraged from other projects where this has been done successfully in the past.

Mr. Marco Moreno (Latino Community Roundtable [LCR]) said that whatever this participant group decides to do, the poor people of this area are going to pay the costs. Mr. Moreno said that LCR asks that this group make the best decision that will benefit the fish and the people. The LCR is working on a study with the University of the Pacific that is looking at how a \$50 million or \$100 million project may affect the poor in this area. There are people in this area that make \$12,000 a year, and these are the people that will have to pay for fish passage. Mr. Moreno said that the decision-makers need to be aware of this. At the last meeting, costs of \$1 million, \$2 million, and \$3 million were discussed to help the fish. Mr. Moreno said everyone can agree that something must be done for the fish but that decision-makers cannot forget that this is not Washington State, Los Angeles, or San Francisco – this is the Valley, the Appalachia of the West. There is 20% poverty in this county, with people here making as little as \$12,000 or \$15,000 or \$20,000 a year. Mr. Moreno said that decision-makers could decide to build a fish passage project but that they must remember who would be paying for it. The University of the Pacific study will show how this multimillion dollar investment will affect the poor.

Mr. Shelton said that CDFW realizes that the Latino communities are a large and important constituency. CDFW recognizes that the agency plays a very important role for this constituency and takes this very seriously. CDFW provides low-cost recreation opportunities, and the economics show that these opportunities benefit people in the Valley. Mr. Shelton said that he himself had grown up in the Valley and knew all about the communities in this region. CDFW believes that serving these populations is very important. Costs must be a component of any feasibility analysis. There has barely been any discussion about how fish passage might affect recreation such as bass fishing. If participants are really going to have a collaborative process, this group must agree on the goals and objectives and the biological issues. One cannot work through a reintroduction decision framework without first knowing the goals and objectives of the program. There is a lot of work to be done, but a lot to be gained. Without going through this framework process as a group, or something like it, Mr. Shelton said it will be very difficult to come to a common understanding or arrive at common goals and objectives.

Mr. Devine said those were excellent comments. Regarding Mr. Dias' comments, Mr. Devine said that the engineering analysis will include applying standard design criteria to the project. However, it is the Districts' thought that there is other design information needed, and a process is needed to acquire that information. A consensus is needed on starting down the path of a process.

Meeting breaks for 10 minutes. Meeting resumes at 11:15 am.

Mr. Devine reconvened the meeting. He said that just before the break, several individuals had asked questions about engineering feasibility. Those were excellent questions and segue to Mr. Garelo's presentation.

Mr. Garelo gave a summary of his professional background. Mr. Garelo has 15 years of experience working as a Senior Resource Engineer at HDR's Fisheries Design Center. Mr. Garelo has been the Engineer of Record for numerous fish passage projects in California and has worked on upstream and downstream fish passage projects across the United States and Canada.

Mr. Garelo said the study is currently in the information gathering phase and would look at physical baseline conditions, the biological design basis, and operational requirements. Mr. Garelo explained how these three information areas link to one another and then provided examples from other projects of how this type of information has important design implications.

Referring to one of Mr. Garelo's slides, Ms. Willy asked what the change in reservoir level is at that Cougar Dam facility and how fish are retrieved from the floating mobile collector. Mr. Garelo replied that the U.S. Army Corps of Engineers built the facility so that it was portable and could be moved around the reservoir. The facility can remain in one spot and accommodate 160 feet of forebay fluctuation. A really challenging issue at this project is that the reservoir can change up to 50 feet in one day. Regarding how fish are removed, this facility is a "trap and haul" facility. After the fish are collected, there is a small holding pool and hopper. The hopper raises the fish to deck level where staff can net the fish and put them in containers. The service barge brings the fish to shore where a truck picks them up and transports them downstream. The Cougar facility is a pilot project, gathering real time research level information not obtainable through desk-top study.

A meeting attendee asked about how fish would be colonized in the upper river. Mr. Bratovich replied that colonization could be achieved in a variety of ways. For example, eggs could be planted in boxes. Or, adults could be planted from a hatchery. Colonization could begin using any number of life stages or be based on other considerations such as location or time of year. Mr. Garelo that the colonization decision

could affect what passage facilities are provided at what point in the reintroduction process, which affects cost.

Ms. Dana Ferreira (Office of U.S. Congressman Jeff Denham) asked what input is needed. Mr. Garello discussed the information needed for the engineering study. Mr. Devine said he believed that the information needed will come primarily from the resource agencies, such as information included in agency recovery plans and overall management plans. However, input from the conservation groups and others will also be helpful and welcome.

Referring to the introductory slide summarizing the status of action items from Workshop No. 1, Ms. Ferreira noted that the slide mentioned that NMFS had not provided a written description of the genetics study. She asked when that description will be provided. Mr. Wooster replied that he can answer any questions about the genetics study today. Ms. Ferreira again asked when a *written* description will be provided. Mr. Wooster replied that he would draft something up about the study. Mr. Devine said that it was not necessary for Mr. Wooster to provide a written description today, but hopefully sometime soon. Mr. Devine added that genetics are important to this process. As NMFS noted during the La Grange Project Study Dispute Resolution Panel Meeting and Technical Conference, the results of the genetics work could indicate definitively if it is undesirable to move *O. mykiss* into the upper watershed. The Districts are interested to know the schedule because if the genetics work shows that introducing *O. mykiss* into the upper watershed would be inappropriate, *O. mykiss* could be excluded from further study.

Ms. Ferreira asked if Mr. Wooster could provide a schedule for providing a written description of the study. Mr. Wooster volunteered to provide details about the study now. He said that researchers started sampling in May of this summer. To date, three sampling trips have been completed. Another trip is planned for this fall. The trips have been very successful. Over 500 samples have been collected from throughout the upper watershed. NMFS is hoping to do a second year of sampling, with this sampling being informed by the results from the first year's samples. Regarding schedule, the fall trip will be in early October. The lab will process the samples over the winter. Once they are processed, the data will be run through computer algorithms. The hope is that there will be preliminary results available by mid-spring, around April, to inform the second year of sampling, so that the sampling in the second year can be more targeted. If a second year of sampling is completed, Mr. Wooster said that the schedule for processing and analyzing samples in the second year would likely mirror the schedule from the first year; therefore, results would be available around April 2017.

Mr. Devine asked when Mr. Wooster thought the genetics study would be far enough along that a go/no-go decision could be made about the reintroduction of *O. mykiss*. Mr. Wooster replied that he did not know the answer and that he would have to look to the experts at the Science Center. Mr. Wooster said that was something he could not weigh-in on and that he did not know how much the lab expected to know after the second year. Mr. Wooster said he could see the study taking the full two years.

Mr. Shelton asked if Mr. Devine had said the genetic results were *necessary* for the decision-making process. Mr. Devine replied that the results were important and could substantially affect the reliability of the cost estimate. Mr. Shelton said that the Districts had said during the study development phase of the FERC licensing that the genetics study was not necessary, and that is why the Districts are not collecting the information themselves. Mr. Devine replied that that characterization was incorrect. The Districts said they did not offer to do the study because, given the FERC study criteria and FERC regulations, the study did not meet the criteria necessary for FERC to require the Districts to perform the study. The Districts are on record saying the study is important, but that it is NMFS's responsibility to perform the study and not the Districts'. The Districts think the study is important because the data could result in a "yes" or "no" answer about the genetic suitability of *O. mykiss* for reintroduction. If the genetics study is extended



for two more years, the Districts may still need to make some assumptions about *O. mykiss* passage but it may not be informed by sound information.

Mr. Shelton asked who makes the decision about *O. mykiss*. The biological goals and objectives should be set during this stakeholder process. Regarding the species to be considered in this process, Mr. Shelton said that CDFW would not want to make a decision about that on its own, and would want input from others like NMFS, the conservation groups, and all entities and individuals with a stake in this process. Mr. Devine said the Districts agree with Mr. Shelton in that input should be considered from all stakeholders, and not only the resources agencies.

Mr. Larry Byrd (MID Director and local rancher) asked Mr. Wooster if the NMFS study had found anything indicating that steelhead are in the upper Tuolumne River. Mr. Wooster replied that the sampling had only been conducted in the upper watershed, meaning above Don Pedro Dam, and that the question about steelhead was not really part of the genetics study. The study analysis will show if the samples have markers that point to migratory behavior; however, the samples have not yet been analyzed. Mr. Wooster added that the study is not testing for anadromy versus non-anadromy. Fish would have to be killed to test for this. Because the study is only looking at fish that do not have access to the ocean, it is already known that those fish are not steelhead.

Mr. Byrd said the presentations noted the importance of not spending time studying things that did not need to be studied. Mr. Byrd said it seems like studying spring-run Chinook or steelhead would be slowing down the process, and that it would make the most sense to focus the study on fall-run Chinook.

Mr. Shelton said that the question of whether spring-run Chinook and steelhead are in the Tuolumne River *now* is much different than the question of whether those species were in the system *historically*. It is important that nothing be done to keep them out of the river. Mr. Shelton said it is known that steelhead and spring-run Chinook are in the system and that as the San Joaquin River Restoration Program moves forward, the potential for a spring-run Chinook or a steelhead run will increase. If there continues to be no screen to the river, there will always be a chance for a run. Mr. Shelton said that the Tuolumne River may not necessarily have a viable population and fishery of steelhead or spring-run Chinook or fall-run Chinook, but that is what is trying to be achieved, and that will influence what type of fish passage facilities should be built. Those are the biological goals and objectives. Mr. Shelton reiterated that CDFW's position is that if there are fish in the system, those fish should be allowed to thrive. He does not want the Tuolumne River to be a population sink, where every fish that comes into the system dies. He did not think that is what the Districts are trying to say. Mr. Shelton asked if resources should be put into the populations that are viable on their own. Or, perhaps resources should be focused on achieving a fishery that produces a lot of juveniles. Or, efforts should only be focused during the good water years, and the bad water years would be written-off and instead a conservation hatchery would be utilized. There are many decisions to be made and the decisions are very complex. Getting back to the reintroduction decision-making framework, Mr. Shelton said a lot of those issues are simply not just "yes" or "no" answers. There is a lot of nuance to them. Although fish may not be present this year, fish may be present in future years. Mr. Shelton said that he is a fisheries biologist, and as a fisheries biologist he would not want to make any decisions based on just one year of studies which occurred during a prolonged drought. That would not be a good time to make a decision.

Mr. Byrd asked if there is scientific proof that salmon existed historically in the reach above Don Pedro Dam. Mr. Drekmeier replied that yes, there is evidence that salmon existed there. Mr. Drekmeier said he will provide some articles from when Wheaton Dam was built. The articles say that when Wheaton Dam was constructed, individuals in the area were concerned that the salmon migration would be cut-off. A lawsuit was filed regarding this concern. Mr. Devine requested that Mr. Drekmeier send the articles to

him also, so that they can be sent out to the whole group. Mr. Dreke-meir said he will do that. Mr. Dreke-meir noted the presence in the Workshop of Dr. Yoshiyama of UC Davis, the recognized expert on historical fish runs and asked if there were actual scientific documentation of anadromous fish in the upper Tuolumne River. Dr. Yoshiyama indicated there was no documentation of spring-run Chinook or steelhead in the upper river.

Mr. John Buckley (Central Sierra Environmental Resource Center) said that it was apparent there are many complex questions to be answered by many people. Some of those in attendance today are more informed than others. It may make sense for those with the greatest amount of expertise to take the first shot at answering these questions raised by the decision-making framework. The resource agencies may want to develop the first draft of biological goals and objectives. What would be a realistic timeframe for the resource agencies to provide answers to some of these questions? Individuals do not necessarily need to limit answers to just one answer – instead, it may make sense to provide two or three alternative answers for the group to consider, with the understanding that different answers would result in different outcomes and costs. Without knowing the desired goals and objectives from the outset, participants will be trying to develop answers to unclear questions.

Mr. Devine said the Districts agree with that. The Districts suggest a timeline of four or possibly six weeks to submit initial comments on TM No. 1, the draft reintroduction decision-making framework, and biological goals and objectives. With respect to more Workshops, Mr. Devine said that Districts will have as many Workshops as it takes to work through these discussions.

Referring to the reintroduction decision-making framework, Mr. Shelton said that he believes many of the questions in the framework amount to judgment calls. Many do not have clear “yes” or “no” answers. It is not realistic that a “no” for some of the questions will end the process outright. Mr. Shelton said that if participants are going to have a collaborative process, it may be that there are clear “no” answers but that participants continue to move forward in the process. Mr. Shelton said he doubted that people here want to rewrite the decision framework. What is more important is how this process can move forward but not be bound to such strict consequences for “no” answers.

Mr. Byrd said he can assure the group that the Districts want to work collaboratively. The Districts would like to see a salmon run in the lower Tuolumne River. Mr. Byrd said that speaking for himself, he does not want to end up with a fish passage facility or a reintroduction that is not successful. Mr. Byrd said he thinks that a fish ladder at the La Grange Diversion Dam is probably infeasible. He noted that his property borders seven miles of the Tuolumne River and that when the fish arrive, they are in very poor condition. In Mr. Byrd’s opinion, there is no ladder in the world that will help. Mr. Byrd said that he would like to echo Mr. Moreno and note that he too is worried that those who cannot afford to pay would be the ones to shoulder the cost of fish passage. Mr. Byrd said that he would be approaching the decision of fish passage differently if it was known that fish passage would be effective on the Tuolumne River and would make a large difference in the fish populations. However, Mr. Byrd said he did not see fish passage resulting in that kind of success. Mr. Byrd added that he looked forward to receiving the information promised here today.

Mr. Dreke-meier said he appreciated the presentations made today and asked if the presentations would be made available. Mr. Devine replied that the presentations are available as of this morning on the La Grange Project Licensing Website (presentations are available online [here](#)).

Mr. Devine asked NMFS for a schedule for initial comments on the information shared today. Mr. Wooster asked whether Mr. Devine meant comments on the design criteria presented in Mr. Garelo’s presentation or on the overarching reintroduction decision-making framework. Mr. Devine replied that the

Districts would like to receive comments on the information Mr. Garelo had listed in his presentation and that getting that information could serve as a starting place. That information is a subset of the information identified in the overarching framework. However, the Districts think it is important to work through all limbs of the reintroduction decision-making framework, as they will all have an impact on the decision process.

Mr. Shutes asked when will the Districts be moving down those paths and if the process will align with the FERC timeline. Mr. Devine replied that the first question is can consensus be reached on using this process. Once participants provide comments on the process, the group can meet to discuss the information needed and the information that is already available. From there a schedule can be prepared. Mr. Devine added that he believes that FERC wants a valid and realistic assessment of fish passage and its cost, and that FERC is also looking for good and reliable cost estimates not built on arbitrary assumptions. If there is a collective sense about what this group would like to accomplish, and those ideas were then presented to FERC with the explanation that the group would like to move through a process to support a fishway decisions and develop reliable information, Mr. Devine said he thought FERC could be approached and might be amenable to extending the schedule.

Mr. Shutes asked if Mr. Devine is envisioning a series of meetings with the whole group or if the technical issues would be broken out and covered in individual meetings. Mr. Devine responded that like similar forums, sub-groups may be appropriate for this process. However, that is up for discussion. Mr. Devine said he envisions a series of information-sharing meetings, where a schedule for producing information would be developed along with a description of the parties responsible for collecting the information.

Mr. Shutes said he thinks it will be helpful if there is a process to go along with the reintroduction decision-making framework. Mr. Shutes noted that he has participated in something similar on the Yuba River. Although that process took several years, Mr. Shutes said he thinks the process for this project could probably be done in less time. If that is the model Mr. Devine is thinking of, Mr. Shutes said it will be important to first gauge the level of interest because that type of process requires a significant time commitment from the participants. The process will also likely need financial resources. Mr. Shutes noted that although the conservation groups do not have a lot of financial resources to contribute, they do have staff time.

Mr. Shutes reiterated that it will be helpful to have a process to go along with the reintroduction decision-making framework. Mr. Devine responded that the Districts or another entity can prepare a first draft of the process. Mr. Wooster said that that seems like a reasonable first step. He said the Districts seem to be the main author and that the process can be built on what happened with the Yuba Salmon Forum. Mr. Wooster added that he agrees that the reintroduction decision-making framework needs a process to go along with it and that he is supportive of what the Districts are proposing.

Regarding what species Mr. Garelo should consider in the engineering feasibility study, Mr. Shutes said he is not sure that fall-run Chinook would be an appropriate species to consider because historically, according to his understanding, that species has not been upstream. Mr. Shutes said that he does not know if that is something the agencies can go along with. Mr. Devine said that would make for a good discussion. Mr. Shutes said that the group may just have to make assumptions about species and that there may not be definitive decisions.

Mr. Devine summarized next steps. First, the Districts will put together an initial process with which to implement the reintroduction decision-making framework. He said the Districts will aim to get something out to the group two to three weeks before the next Workshop. Referring to the information gaps and

questions included in Mr. Garelo's presentation, Mr. Devine said the Districts would like to get feedback from the group on those. Mr. Devine said it would be perfectly fine if participants, upon reviewing some of those questions, decided that a decision cannot be made at this point in time. Mr. Devine asked if four weeks is enough time for individuals to provide feedback on Mr. Garelo's information gaps.

Mr. Wooster noted that Mr. Le said earlier that if the details are not determined now, problems may occur later when estimating cost. Mr. Wooster said by nature, the engineering study is intended to be at a conceptual level, and NMFS' feedback would be conceptual as well. Consider peak run values as an example. In the Northwest, projects are sized to handle 10% of the run in any given day. Mr. Wooster said that that could constitute NMFS' feedback for Mr. Garelo's study but that it would not be very precise. This group can discuss ways to estimate a potential run size, and the estimate can be bracketed, but it still may not be very precise. Mr. Wooster added that four weeks to provide feedback seems reasonable.

A meeting participant noted that the schedule in the presentation has January 16, 2016 for the next Workshop and asked if that is correct. Mr. Devine responded that the next Workshop date will hinge on when individuals can provide feedback. If feedback can be provided by October 19, it seems reasonable that the next Workshop could be held in early November. Ms. Willy asked if the Districts would accept feedback up until October 23, just in case there was a government shutdown. Mr. Devine said that comments due by October 23 would be acceptable.

Regarding the dates for the next Workshop, Mr. Devine said the workshop will likely be scheduled for early- or mid-November. He said the Districts will provide some dates following this meeting.

Mr. Devine thanked everyone for their comments and participation. He said the Districts will make available meeting notes from today.

Meeting adjourned.

## **ACTION ITEMS**

1. Mr. Wooster will provide a written description of the NMFS genetics study.
2. Mr. Drekmeier will provide articles from when Wheaton Dam was built.
3. The Districts will prepare a first cut at a process for implementing the reintroduction decision framework.
4. By Friday, October 23, licensing participants will provide comments on TM No. 1, the reintroduction decision framework, and/or the information gaps identified for fish passage engineering study. This information may be found [here](#) on the La Grange Project Licensing website.
5. The Districts will provide some dates for the next Workshop. This Workshop will likely be scheduled for early- or mid-November.
6. The Districts will provide Workshop No. 2 meeting notes.





**La Grange Hydroelectric Project**  
**Fish Passage Assessment Workshop No. 2**  
**Thursday, September 17, 9:00 am to 12:00 pm**  
**MID Office, 1231 11<sup>th</sup> Street, Modesto, California**  
**Conference Line: 1-866-583-7984, Passcode: 814-0607**  
**Join Lync Meeting <https://meet.hdrinc.com/jesse.deason/8DZ4NVN>**

**Workshop Objectives:**

1. Discuss and receive feedback on the fish passage/reintroduction decision-making framework concept.
2. Review Technical Memorandum No. 1 and address information needs.
3. Confirm schedule/tasks, subsequent workshop date, and opportunities for collaboration.

TIME	TOPIC
9:00 am – 9:10 am	Introduction of Participants (All)
9:10 am – 9:30 am	Opening Statements (Districts)  Brief review of Tuolumne River Anadromous Fish Passage Facilities Assessment Collaborative (Districts)  Review agenda, workshop objectives, and action items from previous workshop (Districts)
9:30 am – 10:30 am	Overview of Conceptual Tuolumne River Fish Passage/Reintroduction Decision-Making Framework (All) <ol style="list-style-type: none"><li>a. Review and discuss fish passage/reintroduction decision-making framework</li><li>b. Information needs, key resource considerations, linkages to design process</li><li>c. Available data, data gaps, and potential data sources related to fish passage/reintroduction decision-making</li></ol>
10:30 am – 11:30 am	Fish Passage Facility Assessment - Technical Memorandum #1 (All) <ol style="list-style-type: none"><li>a. Key physical and biological design criteria</li><li>b. Fish passage design and operations criteria</li><li>c. Links between information needs and design concept</li><li>d. Discussion of information needs and input from Licensing Participants</li></ol>
11:30 am – 12:00 pm	Tuolumne River Passage Assessment Schedule and Next Steps (All) <ol style="list-style-type: none"><li>a. Schedule: Opportunities for collaboration and incorporation of feedback</li><li>b. Workshop No. 3 – confirm date and content</li></ol>



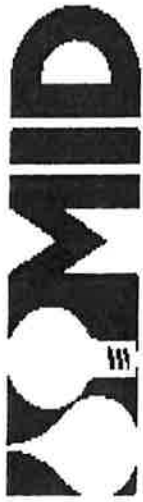
Modesto Irrigation District

**La Grange Fish Passage  
Workshop No. 2  
Thursday, September 17, 2015  
9:00 a.m. – 12:00 p.m.**



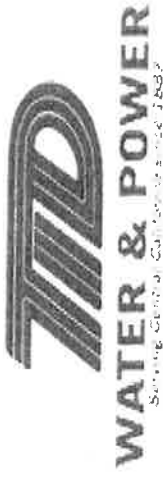
**PLEASE SIGN IN**

	Name	Organization	Telephone No.	E-mail	Time In	Time Out
1.	Paul Zeek	Asm. Krishnakumar			8:45	10:00
2.	Mike Wade	CA Farm Water Coalition			8:47	
3.	John Buckner	CSERC			8:50	
4.	Chuck Hansen	Hansen Env.			8:50	env. com
5.	Josh VERNER	TID			8:50	
6.	ALISON WILLY	USFWS			8:51	
7.	Graham Murphy	CDFW			8:55	ca.gov
8.	Tom Davis	SCFD			early	
9.	Peter Drekmeier	TRT			8:55	
10.	Ray Davis	N/A			8:58	
11.	STEVE RANK	MOS CHAMP			11:00	11:00
12.	Brendi Poter	CWA			8:58	11:00



Modesto Irrigation District

**La Grange Fish Passage  
Workshop No. 2  
Thursday, September 17, 2015  
9:00 a.m. – 12:00 p.m.**



**PLEASE SIGN IN**


	Name	Organization	Telephone No.	E-mail	Time In	Time Out
13.	John Sheehan	FARMER			8:45	12:40
14.	Alfred A. Sanchez	YFC			8:46	
15.	Marina Moreno	UCR			8:47	8:48
16.	Dana Becker	RES BENTON			8:48	
17.	Brandon McMillan	TID				
18.	Ron Yoshinaga	San Francisco			8:48	
19.	Daniel Richardson	Tudumme County			8:50	
20.	Bill Ketscher	Farmer			9:00	
21.	John Sheehan	DFW			9:00	
22.	William Sears	SFPLC			9	
23.	Leonard Van Elden	Yosemite Farm Credit				11:11
24.	Rob Grasse	Yosemite Nat'l Park				



**La Grange Fish Passage  
Workshop No. 2  
Thursday, September 17, 2015  
9:00 a.m. – 12:00 p.m.**



**PLEASE SIGN IN**

	Name	Organization	Telephone No.	E-mail	Time In	Time Out
25.	Allen Zanker	local property owner			9:00 am	2:40
26.	Ellen Levin	SF				
27.	Dann Fulman	SF				
28.	Jonathan Kravitz	SF				
29.		NMFS			9:15	1:00
30.	Tom Holley	"			9:15	1:00
31.	John Ho II and	Modesto Bel			9:30	
32.	Chris Skates	CSPA			9:40	
33.	Paula LaSalle	CWA			9:50	1:09
34.	MET GORDWIN	TID			11:15	
35.						
36.						





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# **La Grange Hydroelectric Project FERC No. 14581**

## **Fish Passage Assessment**

### **Workshop No. 2**



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## La Grange Project



La Grange Diversion Dam

- La Grange Diversion Dam was constructed from 1891 to 1893
- The dam is owned jointly by Turlock Irrigation District and Modesto Irrigation District
- Purpose is to divert irrigation and municipal and industrial (M&I) water
- La Grange powerhouse was constructed in 1924. The powerhouse is owned by TID



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Workshop No. 2 Background**

- Request for studies: July 2014
- Districts' Revised Study Plan: December 2014
- FERC Determination: February 2015; study's geographic scope
- Dispute Resolution Determination: May 1, 2015
- Workshop No. 1: May 20, 2015



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Workshop No. 1 Summary**

- Introduction to fish passage and fish passage decision making process
- Discussed scope of fish passage facilities assessment as part of anadromous fish reintroduction decision
- Parties committed to collaborative decision-making process
- Discussed other related studies underway



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Action Items from Workshop No. 1

No.	Action Item	Status
1	NMFS will provide a written description of its Tuolumne River O. mykiss genetics study plan and methods.	Incomplete
2	The Districts will circulate to licensing participants potential dates for the next two Fish Passage Assessment workshops.	Partially complete
3	The Districts will provide a way for licensing participants to submit comments on the La Grange Licensing Website.	Complete
4	The Districts will post notes from Workshop No. 1 on the La Grange Licensing Website.	Complete
5	The Districts will make available a link to the NMFS fish passage documentary.	Complete
6	The Districts will circulate the design criteria document prior to the next Workshop.	Complete
7	NMFS will provide a copy of its presentation.	Complete





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Workshop No. 2 Objectives**

- Share and discuss potential fish passage/reintroduction framework
- Share and discuss TM No. 1
- Updates on related studies
- Confirm schedules and path forward to Workshop No. 3
- Other opportunities for collaboration



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

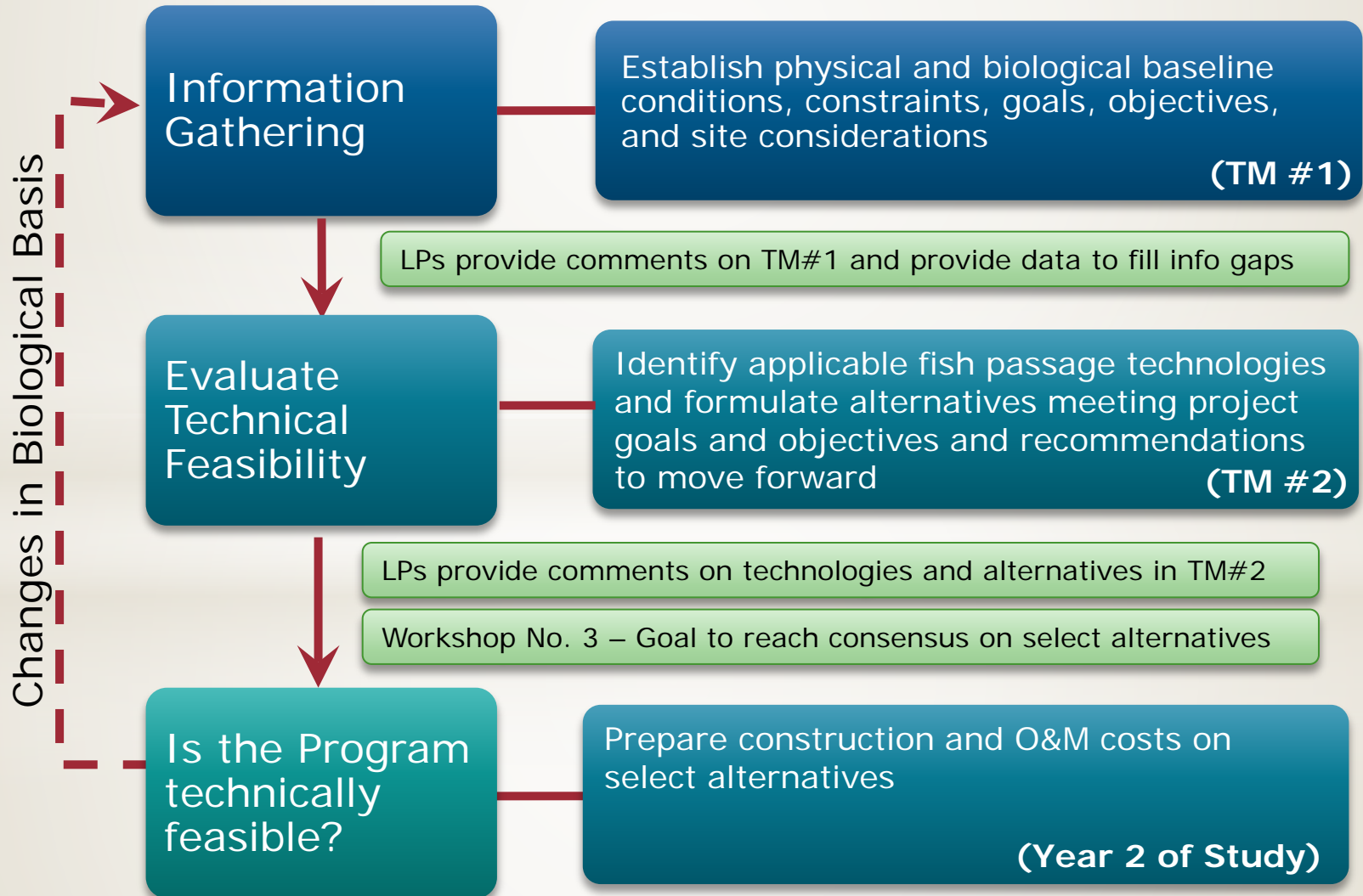
# **La Grange Hydroelectric Project FERC No. 14581**

## **Fish Passage Facilities Alternatives Assessment Workshop No. 2**

**September 17, 2015**



## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Information Gathering

### Physical Baseline Conditions

- Physical boundary of study area
- Basic physical characteristics of existing facilities
- Access to facilities and study area
- Existing facility operations
- River flow into Don Pedro Reservoir
- River flow in the Lower Tuolumne River
- Reservoir fluctuation
- Other beneficial uses (e.g., recreation)

### Biological Design Basis

- Target species and life stages requiring passage
- Migration timing
- Population abundance and peak rate of migration
- Colonization method

### Operational Requirements

- Performance expectations



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Tuolumne River Fish Passage Facility Alternatives Assessment

### Engineering and Biological Linkages

Why are biological linkages important to the engineering and economic feasibility?

**Facility type, size,  
location, configuration,  
and operational  
requirements**

#### Biological Design Considerations

- Target species and life stages requiring passage
- Migration timing
- Population abundance and peak rate of migration
- Colonization method

#### Operational Requirements

- Performance expectations





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Example: Influence Of Population Size And Peak Run On Fish Transport



Multiple species  
Multiple release locations  
Thousands of fish per day



Single species  
Single release location  
Under 100 fish per year





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Example: Influence Of Population Size And Peak Run On Fish Collection



Multiple species  
Thousands of fish per day



Single species  
Under 100 fish per year





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Example: Influence Of Population Size And Peak Run On Downstream Passage Facility Configuration



Holding capacity = 76,000 smolt  
Pumping capacity = 1,000 cfs  
Performance criteria = 75%  
\$60M – 70' x 120' barge



Holding capacity = 200 smolt  
Pumping capacity = 100 cfs  
Performance criteria = R&D  
\$10M – 40' x 60' barge



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Biological Design Considerations For The Tuolumne River**

- Target species
- Life stages requiring passage
- Migration timing
- Population abundance
- Peak rate of migration
- Colonization method
- Operational performance criteria



## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

### Target Species And Life Stages For Consideration

- Fall-run Chinook present in lower river.
- Spring-run Chinook not currently present.
- Steelhead population not currently present.

Target Fish Species	Life Stage
Fall-run Chinook Salmon	Upstream Adults Downstream Smolts and/or Fry
Spring-run Chinook Salmon	Upstream Adults Downstream Smolts and/or Fry
Steelhead	Upstream Adults Downstream Kelts, Smolts and/or Fry

- All three species require reintroduction to the Upper Tuolumne River.







TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Population Abundance And Peak Rate Of Migration In The Tuolumne River**

- Current estimates of population abundance and peak rate of migration do not exist on the Upper Tuolumne River.
- The current method of colonization is unknown.
- Operational performance criteria is unknown.
- Typically provided as a biological basis of design.
- **Input needed from licensing participants.**



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Physical Basis of Design**

- River flow into Don Pedro Reservoir
- River flow in the Lower Tuolumne River
- Reservoir fluctuation



## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

### **Example: Influence of Design Flows on Fish Passage Facility Size and Configuration**

- Guidance structures and attraction flows are necessary to facilitate movement of fish into passage facilities
- For design of ladders, NMFS guidelines suggests that attraction flow should be 10% of the total river flow
- Conceptually, flows in fish ladders could range from 5 to 50 cfs
- With streamflow of 5,000 cfs, attraction flow out of a ladder may be 500 cfs
- Auxillary water systems required to meet attraction flow requirements







TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **How are fish passage design flows established?**

- Examination of historical daily flow information
- High Design Flow = Mean daily average streamflow that is exceeded 5% of the time when target fish species is anticipated to be present
- Low Design Flow = Mean daily average streamflow that is exceeded 95% of the time when target fish species is anticipated to be present

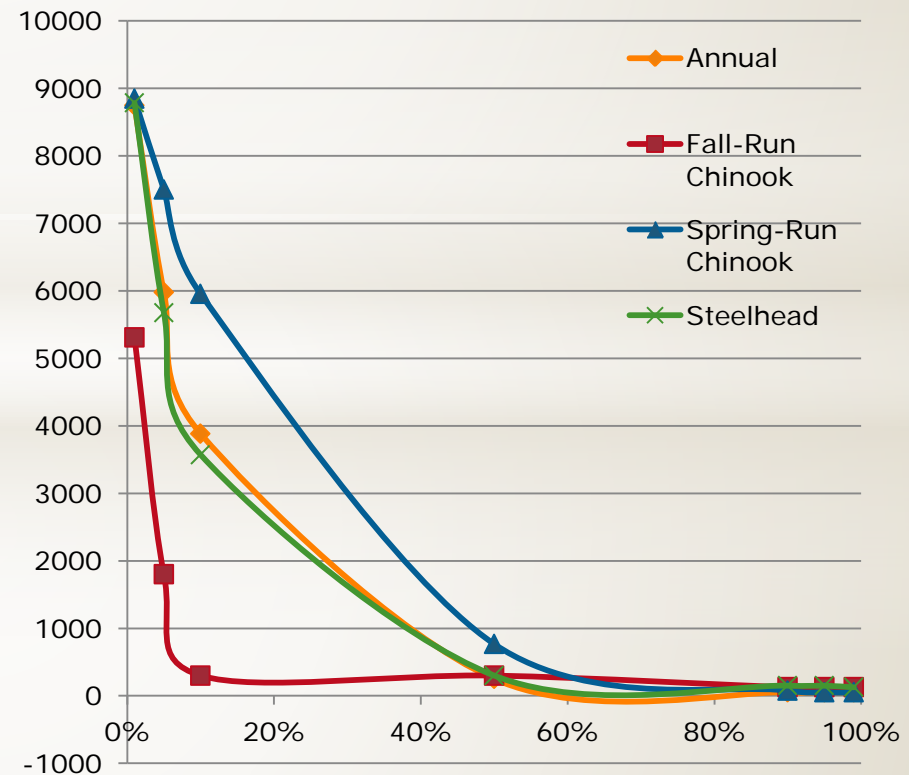


# TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Estimates Of Fish Passage Design Flows In The Lower Tuolumne River

Approximately 50 – 7,500 cfs

Percent of Time Exceeded	Base Case Tuolumne River Flows in the Lower Tuolumne River (cfs)			
	Annual	Arriving Fall-Run Chinook	Arriving Spring-Run Chinook	Arriving Steelhead
99%	50	126	50	126
95%	50	126	50	150
90%	50	126	75	150
50%	250	300	767	300
10%	3,884	300	5,955	3,572
5%	5,979	1,800	7,499	5,675
1%	8,747	5,310	8,845	8,784



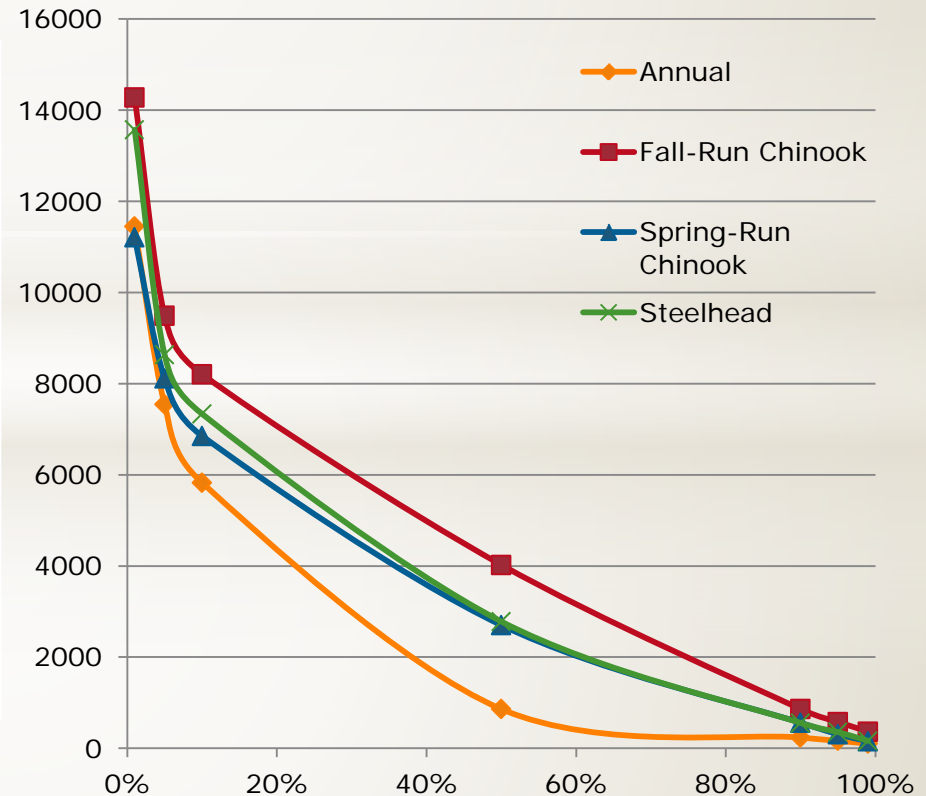


# TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Estimates of Fish Passage Design Flows into Don Pedro Reservoir

Approximately 310 – 9,500 cfs

Percent of Time Exceeded	Base Case Tuolumne River Flows into Don Pedro Reservoir (cfs)			
	Annual	Outmigration Fall-Run Chinook	Outmigration Spring-Run Chinook	Outmigration Steelhead
99%	101	367	154	162
95%	164	577	309	356
90%	235	859	559	555
50%	860	4,024	2,701	2,781
10%	5,828	8,208	6,854	7,337
5%	7,547	9,489	8,114	8,634
1%	11,449	14,277	11,210	13,568





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Example: Influence of Reservoir Fluctuation on Fish Passage Facility Size and Configuration



**Swift FSC, Lewis River, WA**  
**~ 100 ft reservoir fluctuation**  
**\$60M**



Source: PacificCorps





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Example: Influence of Reservoir Fluctuation on Fish Passage Facility Size and Configuration



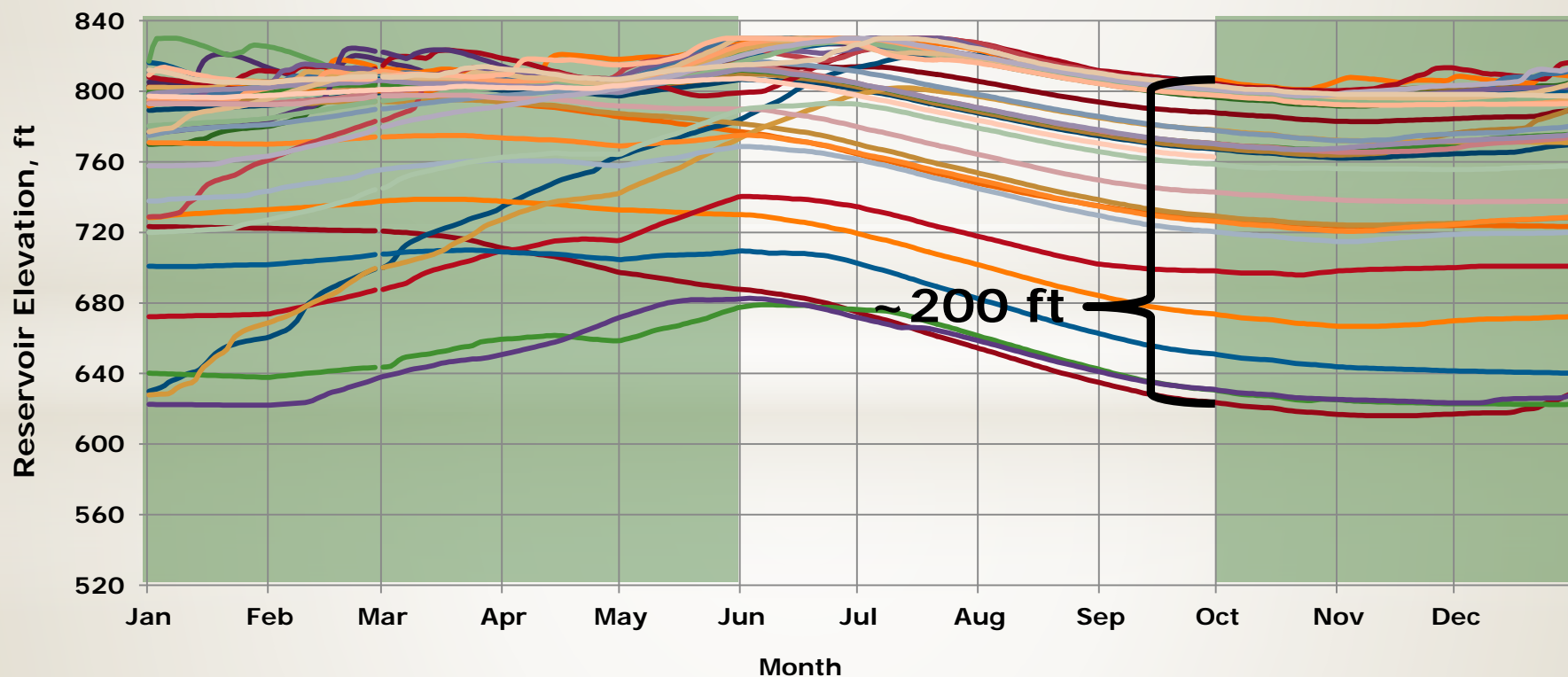
**Fixed Collector, Clackamas River, OR**  
**~ 10 ft reservoir fluctuation**  
**\$12M**





## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

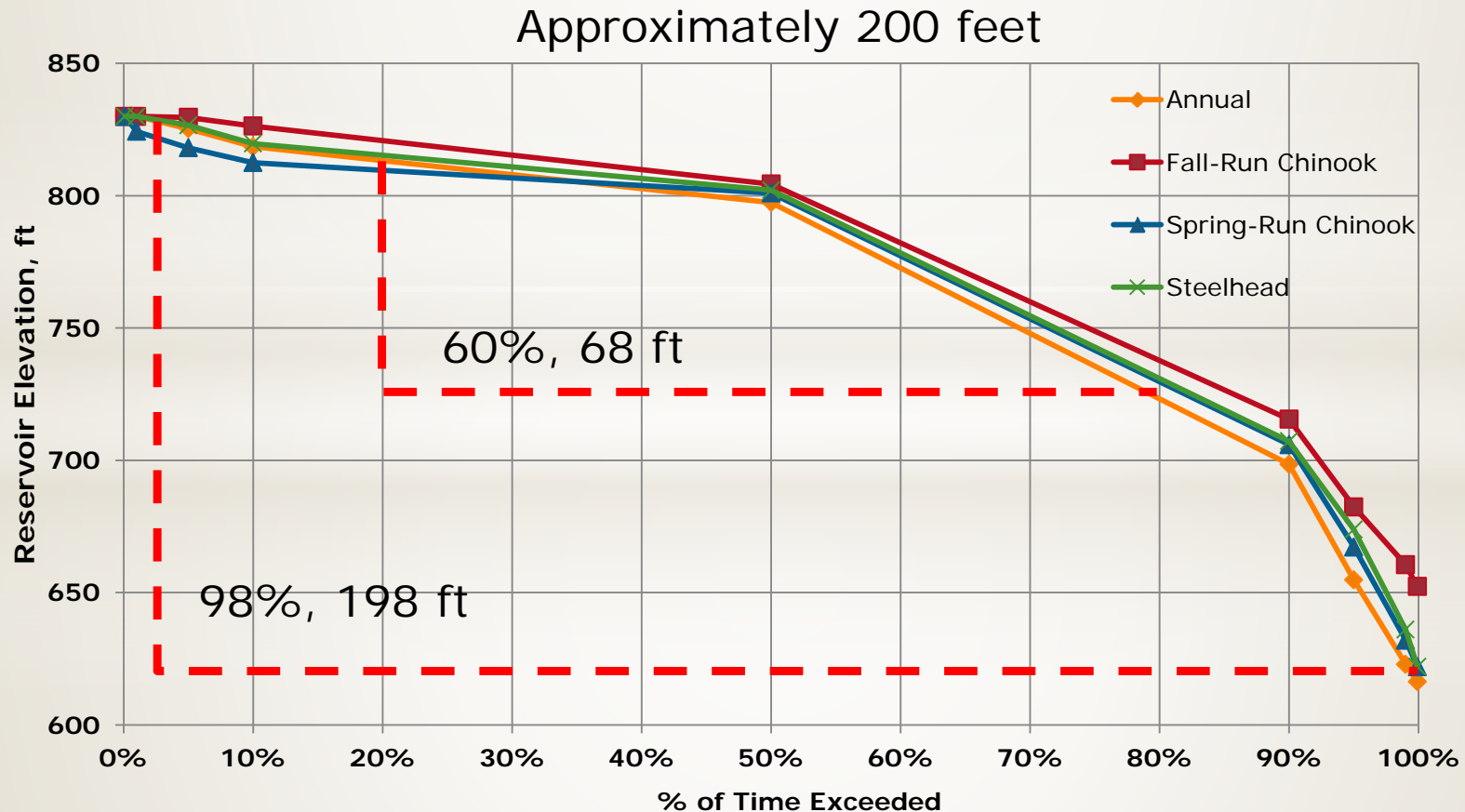
### Reservoir Fluctuation Variability (Base Case)





## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

### Estimates Of Don Pedro Reservoir Fluctuation When Fish Would Be Migrating Downstream

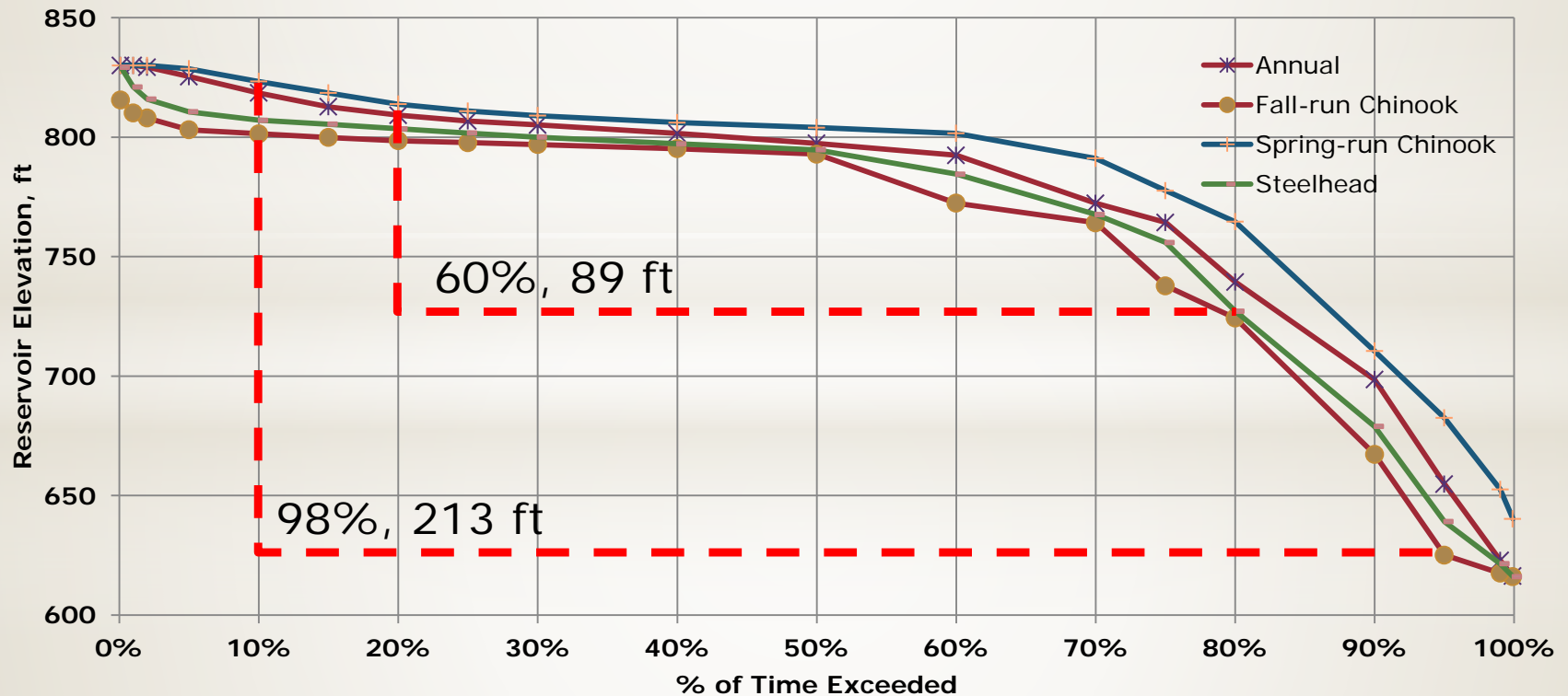




TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Estimates Of Don Pedro Reservoir Fluctuation When Fish Would Be Migrating Upstream

Approximately 230 feet







## TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

### Initial Findings

- Downstream fish passage facilities
  - Operational period October through June
  - Reservoir fluctuations of approximately 200 ft
  - River flows ranging from 310 to 9,500 cfs
- Upstream fish passage facilities
  - Operational period October through June
  - Reservoir fluctuations of approximately 230 ft (pertaining only to fish ladders)
  - River flows ranging from 50 to 7,500 cfs
- **Input needed on biological design basis to confirm initial findings.**





TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## **Data Gaps And Information Needs**

- **Input needed from licensing participants:**

- Confirmation of target species
- Life stages to be passed
- Migration timing
- Population size
- Peak run values
- Colonization method
- Operational performance criteria



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

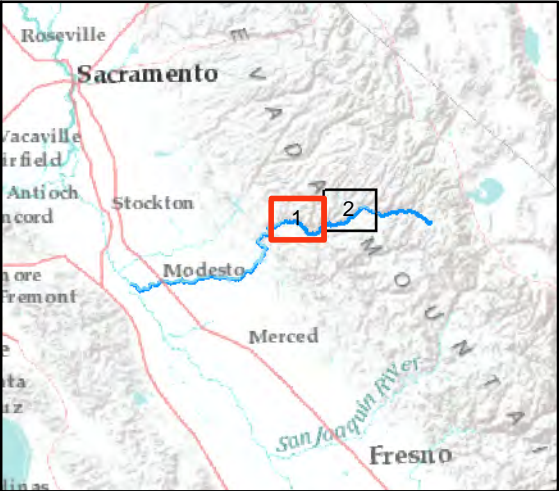
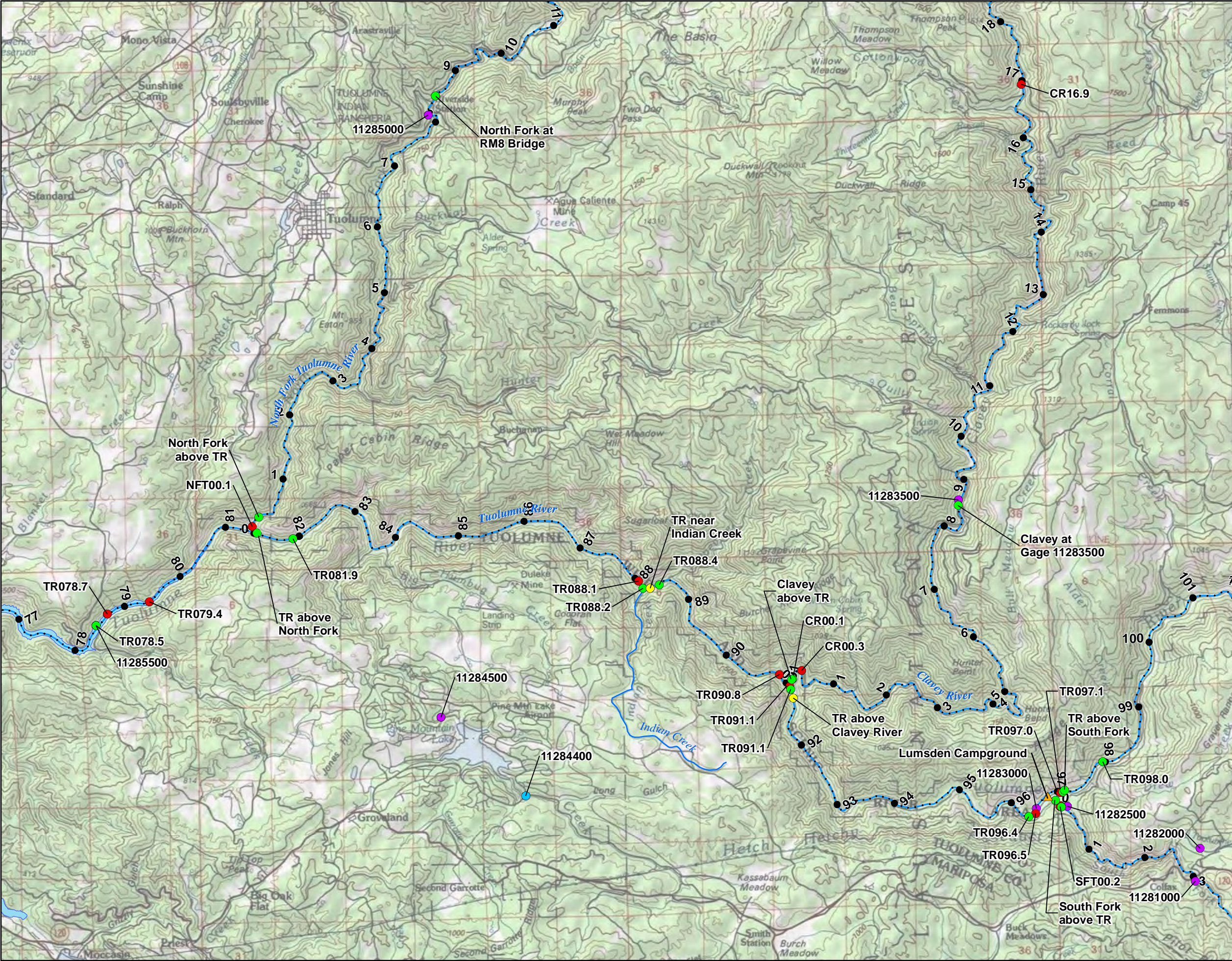
## Process Feedback

Meeting / Deliverable	Schedule
Consultation Workshop No. 1	May 20, 2015
Interim Work Product – TM No. 1	September 4, 2015
Consultation Workshop No. 2	September 17, 2015
Feedback and Comments Due on Decision Framework and TM No. 1	<i>October 19, 2015 (??)</i>
Final TM No. 1 and Decision Framework Distributed	<i>December 1, 2015 (??)</i>
Draft TM No. 2 Distributed	<i>December 16, 2015 (??)</i>
Consultation Workshop No. 3	<i>January 14, 2015 (??)</i>
Initial Study Report document	February 2, 2016









Stream / Flow Gage

● Active ● Inactive

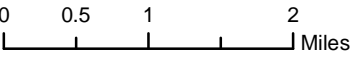
Label	Agency	Active	Site Name
11281000	USGS	Inactive	SF TUOLUMNE R NR OAKLAND RECREATION CAMP CA
11282000	USGS	Inactive	MT TUOLUMNE R A OAKLAND RECREATION CAMP CA
11282500	USGS	Inactive	SF TUOLUMNE R NR BUCK MEADOWS CA
11283000	USGS	Inactive	TUOLUMNE R NR BUCK MEADOWS CA
11283500	USGS	Inactive	CLAVEY R NR BUCK MEADOWS CA
11284000	USGS	Active	BIG C AB WHITES GULCH NR GROVELAND CA
11284500	USGS	Inactive	BIG C NR GROVELAND CA
11285000	USGS	Inactive	NF TUOLUMNE R AB DYER C NR TUOLUMNE CA
11285500	USGS	Active	TUOLUMNE R A WARDS FERRY BR NR GROVELAND CA

Water Temperature Logger

● Active ● Inactive ● Proposed\*

Label	Agency	Active	Site Locations
CR00.1	TID/MID	YES	Clavey above TR
CR00.1	NMFS	YES	Clavey R. just US of confluence
CR00.3	UC Davis	NO	Clavey River, upstream of Tuolumne River confluence
CR08.4	TID/MID	YES	Clavey River at USFS Bridge
CR16.9	CCSF	NO	Clavey River at 1N04 Bridge
NFT00.1	TID/MID	YES	North Fork above TR
NFT00.1	UC Davis	NO	North Fork Tuolumne above Tuolumne River
NFT08.0	TID/MID	YES	North Fork at RM8 Bridge
SFT00.1	TID/MID	YES	South Fork above TR
SFT00.2	CDFG	NO	South Fork of the Tuolumne River near confluence
SFT00.2	CCSF	NO	South Fork Tuolumne River near 1N10 Bridge
SFT00.2	NMFS	YES	S Fork Tuolumne R. just US of confluence
TR078.5	USGS	YES	Tuolumne River at Wards Ferry Bridge
TR078.7	CDFG	NO	Tuolumne River upstream of Wards Ferry Bridge
TR079.4	CCSF	NO	Tuolumne River, upstream of Ward's Ferry
TR081.3	TID/MID	YES	TR above North Fork
TR081.9	NMFS	YES	Tuolumne R DS of Mohecan Br.
TR088.1	UC Davis	NO	Tuolumne River, downstream of Indian Creek confluence
TR088.2	TID/MID	YES	Tuolumne River at Indian Creek Trail
TR088.4	NMFS	YES	Tuolumne R DS of Grapevine Cr.
TR090.8	UC Davis	NO	Tuolumne River, downstream of Clavey Creek confluence
TR091.1	UC Davis	NO	Tuolumne River, upstream of Clavey Creek confluence
TR091.1	NMFS	YES	Tuolumne R US of Clavey R.
TR096.4	NMFS	YES	Tuolumne R DS of Lumsden Campground
TR096.5	CDFG	NO	Tuolumne River below the South Fork
TR097.0	CDFG	NO	Tuolumne River above the South Fork
TR097.0	TID/MID	YES	TR above South Fork
TR097.1	CCSF	YES	Tuolumne River, upstream of South Fork
TR098.0	NMFS	YES	Tuolumne R DS of Lumsden Bridge

\* Proposed logger locations will be added to table when exact coordinates are known.



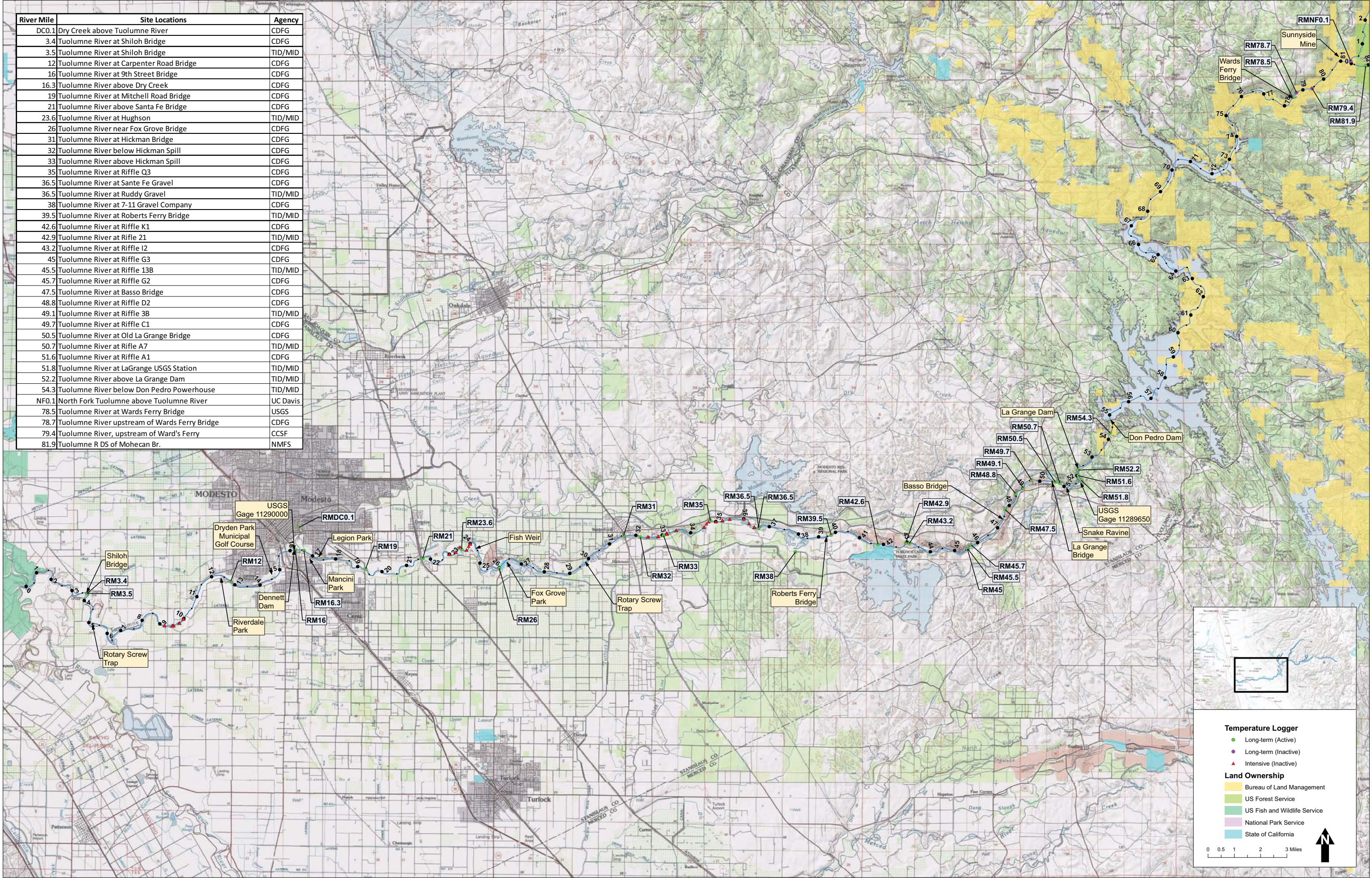
Upper Tuolumne River Gages

Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness. Data Sources: Gages - USGS, TID/MID Copyright:© 2013 National Geographic Society, i-cubed Sources: Esri, DeLorme, USGS, NPS Sources: Esri, USGS, NOAA Data is CA SPCS, Zone III, ft.





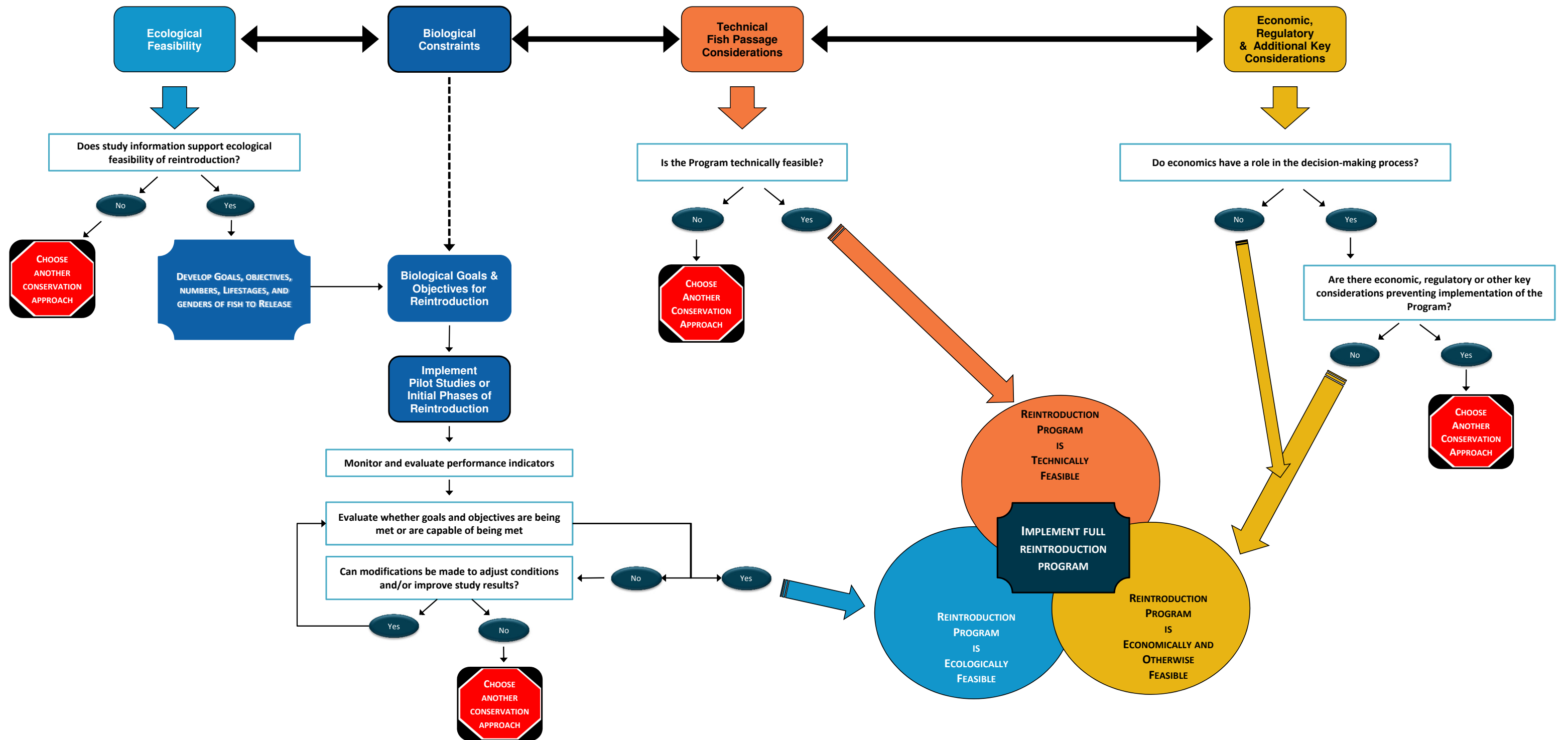






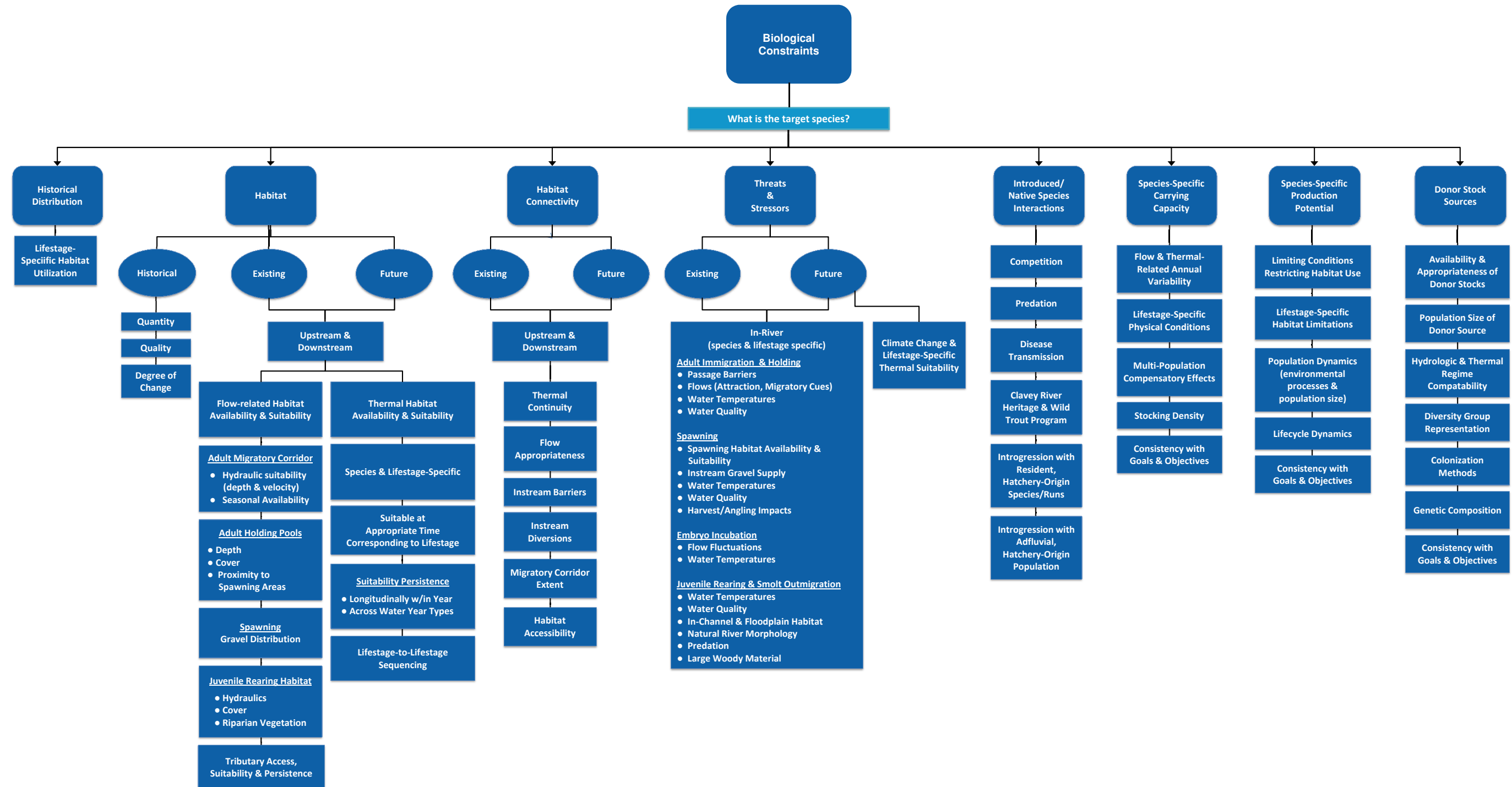
# Reintroduction Decision Criteria

## Decision Tree Overview



# Reintroduction Decision Criteria

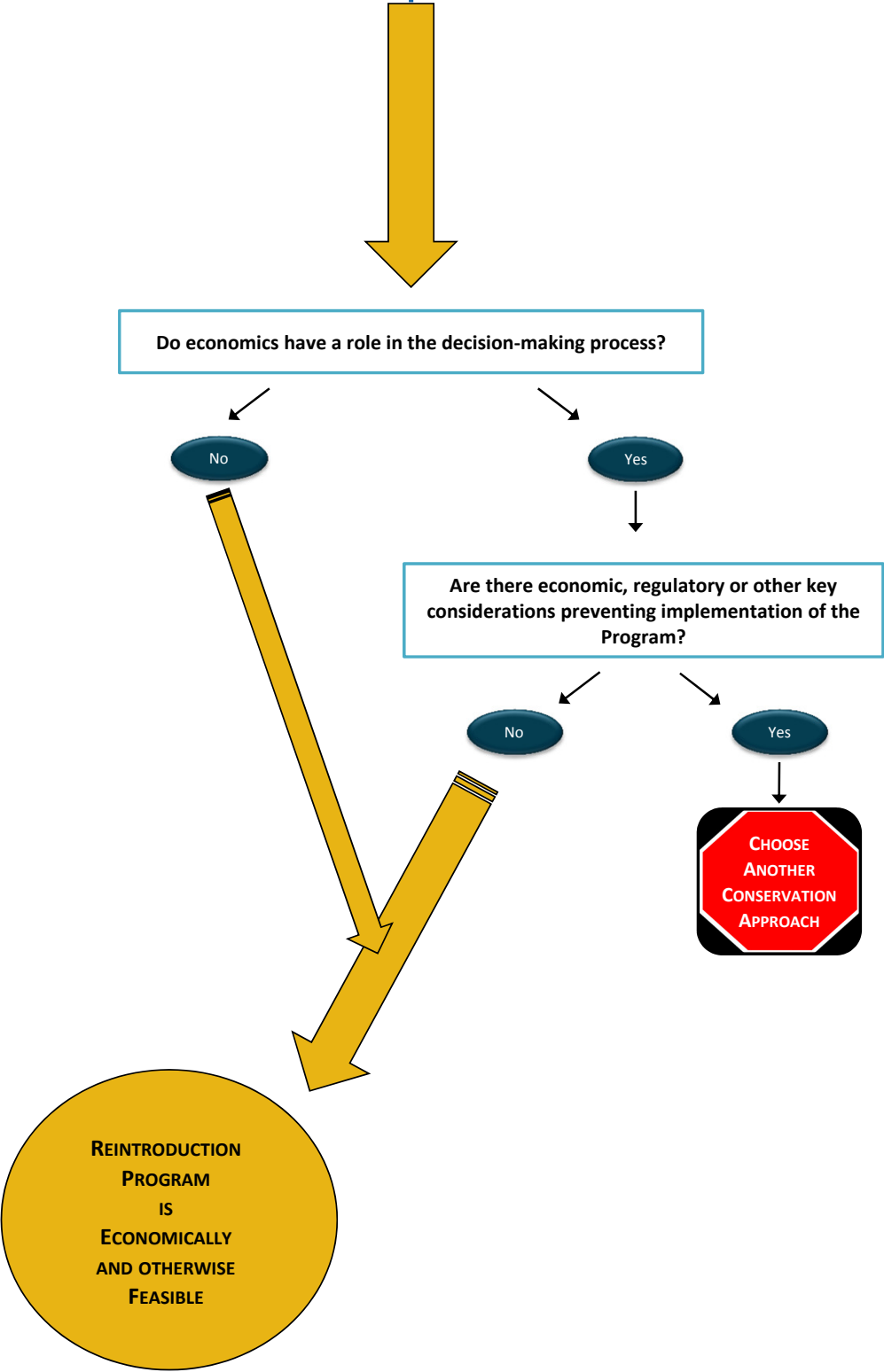
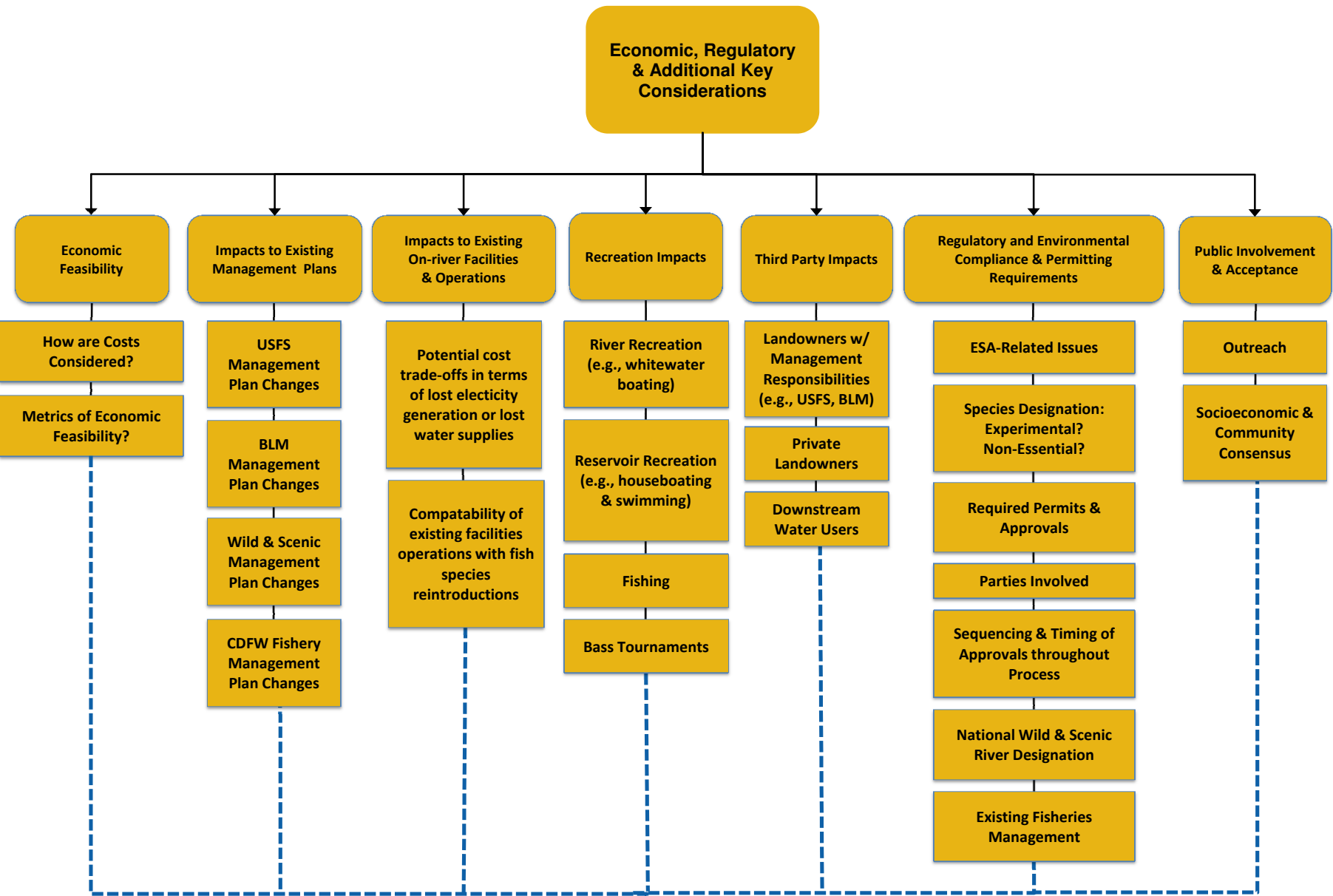
## Biological Constraints





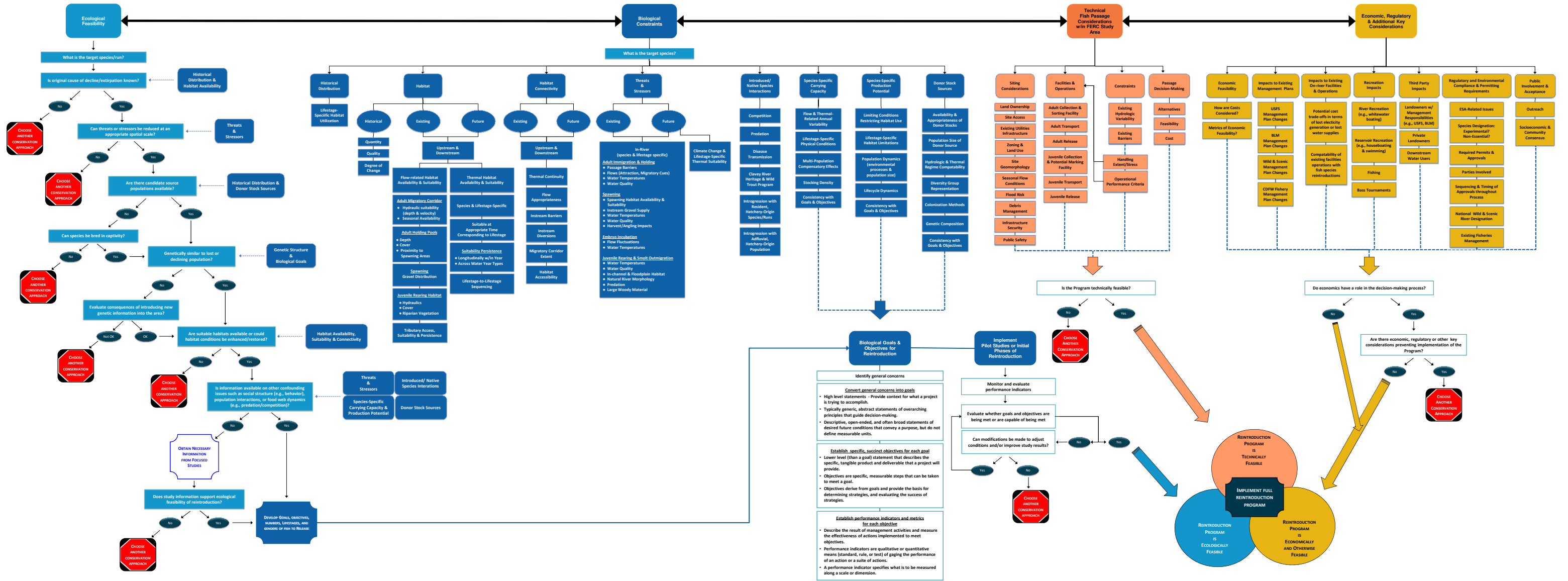
Reintroduction Decision Criteria

Economic, Regulatory & Other Considerations



Reintroduction Decision Criteria

Integrated Decision Tree



**Workshop No. 3**

**November 19, 2015**

**La Grange Hydroelectric Project Licensing (FERC No. 14581)**  
**Fish Passage Facilities Alternatives Assessment**  
**Workshop No. 3**

**Thursday, November 19, 2015**  
**10:00 am to 12:00 pm**

**Meeting Notes**

On November 19, 2015, Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) hosted the third Workshop (Workshop No. 3) for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment. This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting. Attachment A to this document includes the following meeting documents: agenda, sign-in sheets, presentation slides, and handouts.

Mr. John Devine (HDR, Inc. [HDR]), consultant to the Districts, welcomed meeting attendees. Attendees in the room and on the phone introduced themselves. The following individuals participated remotely: (1) Mr. Peter Barnes (State Water Resources Control Board [SWRCB]), (2) Ms. Leigh Bartoo (U.S. Fish and Wildlife Service [USFWS]), (3) Ms. Jenna Borovansky (HDR), (4) Ms. Jesse Deason (HDR), (5) Ms. Suzy Driver (Negotiation Guidance Associates), (6) Mr. Steve Edmondson (National Marine Fisheries Service [NMFS]), (7) Mr. Tom Holley (NMFS), (8) Mr. Chris Shutes (California Sportfishing Protection Alliance), and (9) Mr. John Wooster (NMFS).

Mr. Devine provided background information on the La Grange Project and described the upper Tuolumne River habitat-related studies the Districts are conducting voluntarily. Mr. Devine said NMFS is also doing some work related to habitat and asked that Messrs. Edmondson and Wooster provide an update later in the meeting on the progress of the study. Mr. Devine noted the La Grange Project Initial Study Report (ISR) will be filed with the Federal Energy Regulatory Commission (FERC) on February 2, 2016 and that later in the meeting he would like to discuss with the group the possibility of getting an extension of time for the ISR meeting.

Mr. Devine provided an overview of the Fish Passage Facilities Alternatives Assessment schedule into 2016. He indicated that the study plan identifies the task of reviewing existing information and assessing data gaps before moving forward with the 2016 study year. The Districts propose that this data gap assessment be conducted collaboratively as an approach to identifying studies that may be needed in 2016. Relatedly, he stated the primary purpose of Workshop No. 3 is to determine if there is consensus on whether the Districts and licensing participants (LPs) will proceed forward with pursuing a fish reintroduction decision-making framework (decision framework or framework). Mr. Devine introduced Mr. Bao Le (HDR) to provide a summary of previous workshops and how the discussions during these engagements have led up to Workshop No. 3.

Mr. Le provided a brief overview of Workshops No. 1 (held on May 20, 2015; meeting notes and materials available [here](#) on the La Grange Project Licensing Website) and No. 2 (held on September 17, 2015; meeting notes and materials available [here](#)). He stated Workshop No. 1 focused on three specific topics; (1) an overview of the Federal Power Act and Section 18 Fishway Authority as presented by NMFS, (2) an introduction to fish passage engineering and design, including an overview of information needs, general design criteria, and examples of currently operable facilities (primarily in the Pacific Northwest) to convey the potential size and scale of fish passage projects, and (3) an introduction of a



broader discussion of the issue of fish passage on the Tuolumne River and how in this case, a decision to develop fish passage is fundamentally a decision to proceed with the introduction or reintroduction of anadromous fish to the upper Tuolumne River. To this last point, Mr. Le stated that evaluating fish passage in the broader context of reintroduction was consistent with other ongoing, similar processes in CA, and current reintroduction /recovery literature. Workshop No. 1 ended with a discussion of the types of information that would be necessary to support a reintroduction assessment, including but not limited to engineering and that elements of this information would be critical in the development of reliable and defensible fish passage design concepts and associated cost estimates. He also noted that a key agreement arrived at in Workshop No. 1 was that the fish passage/reintroduction process should be a collaborative and transparent process. At Workshop No. 2, the Districts presented a conceptual process identifying the scope of a comprehensive Fish Passage Facilities Assessment process, which focused not only on engineering technical feasibility, but also the related ecological, biological, socioeconomic and regulatory aspects of reintroduction decision-making. This conceptual process was presented diagrammatically as a Fish Passage/Reintroduction Decision Making Framework (decision framework). In addition to this conceptual framework, the Districts developed and distributed Technical Memorandum No. 1 (TM 1) to LPs in advance of the Workshop. TM 1 provided information and analysis of site-specific considerations necessary to inform the facility design process. To date, Mr. Le stated that no comments or input on TM 1 had been received from LPs.

Mr. Shutes asked if target species have been established. Mr. Devine said the question of target species is still outstanding and the Districts would like to get feedback on that topic today, if possible. Mr. Devine noted that input from resource agency managers on target species was one of a number of information needs identified in TM 1.

Mr. Paul Bratovich (HDR) provided an overview of the decision framework concept presented by the Districts in Workshop No. 2. Mr. Bratovich reminded LPs that the framework is an approach to providing a clear and structured process to guide efforts moving forward. The decision framework has four interrelated components: (1) Ecological Feasibility, (2) Biological Constraints, (3) Technical Fish Passage Considerations, and (4) Economic, Regulatory and Additional Key Considerations. Mr. Bratovich noted the components are highly integrated and interrelated and each “limb” has ramifications for the others. Mr. Bratovich reviewed current data gaps such as migration timing, habitat suitability, the goals and objectives of the reintroduction program, and how success is defined. Mr. Bratovich said without this information, it is impossible to move forward with the fish passage program and assess whether it could be successful. Mr. Bratovich reiterated the decision framework is intended to be a draft concept and feedback is invited and welcome.

Mr. John Buckley (Central Sierra Environmental Resource Center) described a seven-year process he had been involved with that was collaborative and successful. He believes the process was successful because the full spectrum of diverse interests was considered in the decision-making process. Mr. Buckley suggested that the fundamental questions in this process are whether there were anadromous fish in the upper Tuolumne River before La Grange Diversion Dam was built and whether there is an opportunity to put fish back in that stretch of river. Mr. Buckley said a decision framework can be highly valuable as a guide for participants and as a tool to help inform decision-making. He said he had not yet made up his mind about the question of fish passage viability on the Tuolumne River. Mr. Buckley said he is worried the group could work through the decision framework and end up with a result with exorbitant costs. Mr. Buckley said he would not want the group to be burdened with a binding decision and said he thinks the decision framework would be more valuable if it were viewed as a guidance tool. However, he added the decision framework process identifies important questions that should be answered.

Ms. Jennifer Carlson Shipman (Manufacturer's Council of the Central Valley) said she represents many food and beverage manufacturers and processors and disagrees with Mr. Buckley's comment regarding the framework being a tool for decision-making versus guidance. She thinks collaboration and transparency are integral and the decision framework is critical and necessary. Ms. Shipman said sometimes guidelines are followed and sometimes they are ignored and this framework should require a commitment to embark upon a structured process to establish program goals and objectives, collect information to evaluate the feasibility of those objectives, and reach a decision upon pursuing or not pursuing a program.

Mr. Peter Drekmeier (Tuolumne River Trust) requested clarification on the intended role of the decision framework. Mr. Drekmeier said ultimately FERC is going to make the decision about fish passage unless this group comes to a consensus. Mr. Devine said FERC will make a judgment about fish passage facilities in the Environmental Impact Statement, but there are other entities with the independent legal authority to make decisions on fish reintroduction/fish passage, including NMFS, USFWS, and SWRCB. FERC cannot override the authority of these entities. In addition, other agencies under different statutes have authorities independent of FERC. In response to Mr. Buckley's comments, Mr. Devine said the purpose of the framework is not necessarily to arrive at a decision that everyone agrees on. The framework primarily is intended to provide a platform through which all participants may interact in a collaborative way to identify items and issues that should be addressed so that all parties are aware of the full impacts, benefits, and concerns related to reintroduction and fish passage. Mr. Devine said it is possible that entities end up interpreting information differently, which is not uncommon in licensing proceedings. However, the benefit of using the framework is that everyone is using the same information base and there is consensus on the manner of developing the information and its usefulness. Mr. Devine said the framework is a guideline that allows the group to identify, acquire, and evaluate information. Groups may interpret the information differently and a consensus is not guaranteed. Mr. Devine said committing to the framework is committing to a process to get the information in a collaborative way, but it does not guarantee anything else.

Mr. Shutes said in addition to the regulatory pathways identified by Mr. Devine, there may also be a collaborative path to implement something. Mr. Shutes noted that at a previous Workshop, Mr. Edmondson described a scenario in which a decision is reached through a settlement. Mr. Shutes said the apparent disagreement between Ms. Shipman and Mr. Buckley is not about the content of the framework but is instead about how deterministic the decision process would be. Mr. Shutes said the framework suggests a "go/no-go" approach, but the actual process may be more complex than that. For example, instead of a "go/no-go" answer, the answer might be "this could be done if" decision. Mr. Shutes said he thinks it would be helpful to identify key items in the framework and then to move forward. He added he believes most of the relevant concepts are included in the framework, but he would like a better understanding of the process for making progress.

Mr. Wooster said he agrees with Mr. Shutes' suggestion. Mr. Wooster said it is unclear what the Districts are proposing. The FERC study plan is fairly clear but this proposal is essentially a reintroduction forum. Mr. Devine said the Districts tried to explain the various connections between the biological constraints and the engineering process at Workshop No. 2. For example, understanding the colonization strategy for reintroduction would be important to know as it would have significant potential implications for siting and sizing an acclimation facility. The question of whether steelhead reintroduction would rely on using pre-spawn adults or introduction of fry to grow in the upper Tuolumne substantially affects facility design considerations. Mr. Devine gave examples of high dam fish passage projects in the Pacific Northwest where a lack of reliable information had resulted in cost estimates that greatly underestimated the actual cost to build and operate the fish passage facilities. Mr. Shutes said he agrees with what Mr. Devine is saying but it is unclear how we start to answer these questions.

Mr. Buckley said calling the framework a “decision” framework may be a misnomer. A better term may be “assessment” framework. Mr. Buckley said at this point, the group needs to move quickly to identify key questions and information needs. Mr. Buckley added he does not believe anybody is advocating for building a \$150 million project. The group needs to agree on how to get started with this process.

Mr. Paul Campbell (MID) said that as an MID Board Member, he is obligated to understand and consider the total potential costs of any facilities required by others and to be built and operated by the Districts. He would not hide the costs from the citizens he represents. Mr. Campbell said he believes a decision framework is critical for having an open and transparent process. It is apparent that the customers of MID and TID and the City and County of San Francisco will be the ones who pay these costs. Mr. Campbell said the reality of this situation is that a project of the potential magnitude being considered will be hugely expensive.

Mr. Devine said he believes a next logical step to move the process forward is to develop a draft structure and schedule which would include steps for identifying goals and objectives and the information necessary to assess the biological constraints, ecological feasibility, and potential impacts to other users of the water resource. Mr. Devine said as a starting point, the Districts are willing to provide existing information, take a first cut of potential information gaps, and identify what studies might be needed to address these gaps. If the group can provide feedback and come to an agreement on information needs, the Districts would finalize the approach and develop a draft list of additional information needs for 2016, which would be a key study year for collecting this information. Regarding the word “decision” in the title of the framework, Mr. Devine said “decision” refers to the many decisions that should be explored and addressed because they are interconnected. “Decision” is not meant to refer to just a bottom-line decision, but all the decisions along the path of the conceptual framework. Mr. Devine said the Districts would suggest having a meeting in mid-January to discuss more concrete process steps and schedule, and what studies should be conducted, in order to document with FERC the overall study schedule and course of action.

Mr. Shutes said he supports this path forward. He said all parties are aware of the potential costs and are concerned about costs. Mr. Shutes said he does not think the Districts and San Francisco would bear the entire cost of a reintroduction program. Others may be able to provide support in the form of dollars or resource personnel. Mr. Shutes added he hopes the Conservation Groups can participate and contribute in a productive way to help answer these important questions.

Mr. Wooster asked for clarification on the role of the January meeting. Mr. Devine replied the role of the meeting would be to establish an assessment framework and overall schedule, identify information needs and studies, make decisions on topics such as target species, and to come to consensus on the goals and objectives of the reintroduction program. The Districts will bring suggestions to the January meeting. Mr. Devine noted that the Districts have consistently agreed with the need for information about the upper Tuolumne River as it relates to fish passage and reintroduction, but only questioned who, under the rules of the FERC ILP, should be responsible for collecting the information. Mr. Devine added the Districts are committed to participating and potentially funding some studies.

Ms. Dana Ferreira (Office of U.S. Congressman Jeff Denham) asked if the group could make progress today, such as deciding on the target species. Mr. Devine said a decision on target species would need to come from the resource agencies. He asked if any agency personnel at the meeting would like to speak to that. Mr. Wooster said spring-run Chinook and steelhead are definitely on the list of target species. Regarding fall-run Chinook, Mr. Wooster said NMFS needs to discuss this internally and more discussion

is needed with the California Department of Fish and Wildlife (CDFW) and USFWS before NMFS can provide feedback. Mr. Wooster said those discussions could take place ahead of the January workshop.

Mr. Tom Orvis (Stanislaus County Farm Bureau) said he has spent considerable time talking with constituents. Mr. Orvis said very few fish are running in the Tuolumne River this year, while the Stanislaus River is seeing thousands. Mr. Orvis said water hyacinth may be having a negative effect on the Tuolumne River run and any fish passage program must also include more comprehensive river management. Ms. Gretchen Murphy (CDFW) confirmed water hyacinth is in both the Tuolumne River and San Joaquin River and said fish are able to swim past it. Mr. Drekmeier noted fish passage is one component of licensing but other issues can be addressed by flow or non-flow measures. He said pulse flows on the Stanislaus River have helped with the hyacinth issues there.

Mr. Larry Byrd (MID) asked for confirmation that “reintroduction” means reintroducing salmon in the upper Tuolumne River and asked what science is available that proves spring-run Chinook existed upstream of La Grange Diversion Dam before the dam was built. Mr. Drekmeier said he previously provided an article to this group from the Sonora Inquirer about this topic. Mr. Drekmeier and Mr. Byrd disagreed about whether the article confirmed the existence of spring-run Chinook in the upper Tuolumne River.

Mr. Byrd said he would like to see this process speed up and he agreed that predation and water hyacinth issues in the lower river must be addressed, and questioned the benefit of fish passage if the young fish can’t make it out of the Tuolumne, San Joaquin, Delta and Bay because of predation. Mr. Byrd said he is also concerned that building fish passage would leave a huge debt for our children and grandchildren. He added the FERC process or the SWRCB process will likely require the Districts to increase flows even though the last time flows were increased, there was not a corresponding increase in fish production. Mr. Drekmeier disagreed with this statement and said the data show a correlation between increased flows and production. Mr. Byrd said fish passage is a multi-million dollar investment and would be a waste of resources because these fish do not exist in the upper river. Mr. Drekmeier said nobody is proposing fish passage at any cost. He believes Mr. Byrd’s thoughts on individual measures have merit and spending future dollars on concrete items like river restoration may be better than continuing with more meetings and more studies. Mr. Byrd said it is frustrating how slow this process is moving. He added the low-income folks in the community would be the ones to bear the heaviest burden of paying for fish passage facilities.

Mr. Buckley said he appreciates Mr. Byrd’s thoughts and said he believes these meetings and forums do allow for progress to be made. Mr. Buckley said the participants in these meetings hear and understand there is concern about cost. Mr. Bill Paris (MID) said he disagreed with Mr. Buckley that everyone is in agreement that costs must be considered. Mr. Paris said he has not heard any of the agency personnel say they consider costs and until they do, the issue of cost is relevant. Mr. Wooster said economics is considered in Section 18 Fishway Prescriptions. Mr. Wooster said NMFS has economists on staff and often funds economic studies. Mr. Paris said saying economics is part of the process is different than explaining exactly how economics is applied in the decision process. Mr. Paris said economic considerations at NMFS appear to occur in a black box. Mr. Wooster replied that several months ago Mr. Edmondson sent a letter to Representative Kristen Olsen that described a little about how NMFS makes decisions. Mr. Wooster said there is no equation or threshold that determines whether a project is a “go” or not from an economic perspective. Mr. Wooster said NMFS keeps data on project costs and there is somewhat of a ratio between the cost of fish passage and megawatts of generation.

Ms. Shipman said there has been a lot of discussion about the unknowns and this seems like justification for implementing a framework that is open and transparent. Mr. Shutes cautioned against goals and



objectives with too many details so as not to slow down the process at the outset, but agreed that it is important to have, at the very least, general goals and objectives of the fish reintroduction up front.

Mr. Ray Dias (a member of the public and an engineer) said this process should start with defining the goals and objectives to be attained, and should not back into these down the road. Mr. Dias said he is not seeing any progress being made and it is frustrating. He said whatever the process is called, we must ensure it is open and transparent.

Mr. Devine said there appears to be agreement among the group to go forward with the framework. He asked if the individuals on the phone agree. Mr. Shutes replied he supports this process and believes a list of priority items is critical to moving forward. Mr. Shutes said this list should include what species should be reintroduced, a desktop study of the history of salmon and steelhead in the Tuolumne River, and gathering information on thermal suitability, migration barriers, spawning gravels, and flow regimes. Mr. Shutes said he is not sure the group is ready to develop goals and objectives and perhaps this could be informed by a study of habitat carrying capacity. Mr. Wooster said NMFS agrees to gather and evaluate information and is open to a reintroduction forum that evaluates this issue. However, NMFS does not agree to the framework as a decision-making process. Ms. Bartoo, Ms. Murphy, and Mr. Barnes all confirmed their respective agencies would continue to participate in the process envisioned by the conceptual framework.

Mr. Buckley said it is important to note that most agency representatives in attendance can contribute to the process with their expertise but do not have the authority to sign-off on major decisions. Mr. Buckley said it is also important to note that these processes take time and he understands that folks are frustrated at the perceived lack of progress. Mr. Buckley noted fish passage cannot be considered in a vacuum and the process will consider a range of other issues and options as well. The big picture approach requires sensitivity to a wide range of participants.

Ms. Shipman said she does not want this group to make up the process as they go along. Instead, she would like to see a very direct, thoughtful, and precise path forward. She said such a process is necessary given the important implications fish passage would have on the region.

Mr. Jim Alves (City of Modesto) said the City of Modesto concurs with using a process such as this for moving forward because it is open and transparent and provides an opportunity for everyone to participate. Mr. Alves said cost is a major concern and effects on those who will pay for these efforts must be considered.

Mr. Orvis said he agrees with Mr. Buckley that agency participants may not have decision-making authority. Mr. Orvis said that in order to ensure a productive decision framework process, agency participants must keep their agency management and decision-makers apprised of the process and be ready to provide input that is representative of their agency.

Mr. Shutes asked who will be the point person for managing this process. Mr. Devine said the Districts and HDR will take on managing the process. Mr. Devine reiterated Mr. Orvis' feedback on the importance of all participants coming to the meetings and being prepared and ready to interact and take action. Mr. Devine said there will be many decisions along the way and parties must provide feedback for progress to be made. Participants must ensure that decision points and requests for feedback are communicated to the appropriate management personnel.

Mr. Devine said it appears a consensus has been reached to move forward with this general process. No participants spoke in disagreement. Mr. Devine proposed January 27, 2016 for the date of the next Workshop. Participants agreed with this date. Mr. Devine said the Districts will send out materials ahead of the meeting.

Mr. Devine said the La Grange Project ISR is due to FERC by February 2, 2016. Per FERC's regulations, the Districts must hold the ISR meeting within 15 days of filing the ISR, which would mean holding the meeting on or before February 17. Mr. Devine said due to scheduling conflicts, the Districts would like to have the meeting instead on Thursday, February 25. Mr. Devine asked if meeting attendees are available to attend on that date. No participants objected to having the ISR meeting on February 25. Mr. Devine said the Districts will submit a letter to FERC requesting a delay in holding the ISR meeting and noting that this group did not object to having the meeting on February 25.

Meeting adjourned.

## **ACTION ITEMS**

1. The Districts will circulate materials in advance of the meeting scheduled for Wednesday, January 27, 2016.

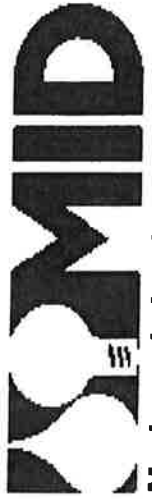
## La Grange Hydroelectric Project Fish Passage Assessment Study Workshop No. 3

**Thursday, November 19, 10:00 am to 12:00 pm**  
**MID Office, 1231 11<sup>th</sup> Street, Modesto, California**  
**Conference Line:** 1-866-583-7984, Passcode: 814-0607  
**Join Lync Meeting** <https://meet.hdrinc.com/jesse.deason/8DZ4VNVN>

### Workshop Objectives:

1. Discuss and amend the Conceptual Tuolumne River Reintroduction/Fish Passage Evaluation Framework (Reintroduction Decision Framework or Framework) including participant comments and potential implementation concepts.
2. Gain consensus on pursuit of Reintroduction Decision Framework.
3. Discuss potential Framework implementation methods, schedule and opportunities for collaboration.

TIME	TOPIC
10:00 am – 10:10 am	Introduction of Participants (All)
10:10 am – 10:30 am	Opening Statements (All)  Summary review of Tuolumne River Anadromous Fish Passage Facilities Assessment Collaborative (Districts)  Review agenda, workshop objectives, and action items from previous meeting (Districts)
10:30 am – 11:30 am	Conceptual Tuolumne River Reintroduction Decision Framework (All) <ol style="list-style-type: none"> <li>a. Summary review of the Reintroduction Decision Framework</li> <li>b. Participant comments on Framework, preferences and potential process implementation concepts</li> <li>c. Decision regarding Reintroduction Decision Framework implementation</li> </ol>
11:30 am – 12:00 pm	Next Steps (All) <ol style="list-style-type: none"> <li>a. Schedule: Further opportunities for collaboration and incorporation of feedback</li> <li>b. Action Items</li> </ol>



Modesto Irrigation District

**La Grange Fish Passage  
Workshop No. 3  
Thursday, November 19, 2015  
10:00 a.m. – 12:00 p.m.**

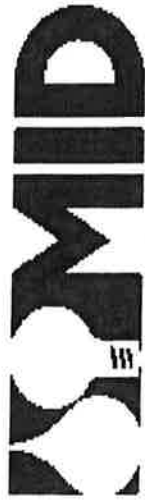


**WATER & POWER**  
Serving Central California Since 1887

**PLEASE SIGN IN**

	Name	Organization	Telephone No.	E-mail	Time
13.	Brandon Melillo	TIP			
14.	Bill Befcher	farmer			
15.	Peter Drekeimer	TRT			
16.	Gavin Bruce	Stanislaus Business Assoc			
17.	Fred Souza	YFC			
18.	Adrianne Carr	BAWSA			
19.	Tim Heyne	DFW			
20.	John Holland	Bee			
21.					
22.					
23.					
24.					





Modesto Irrigation District

**La Grange Fish Passage  
Workshop No. 3  
Thursday, November 19, 2015  
10:00 a.m. – 12:00 p.m.**



**WATER & POWER**  
Serving Central California Since 1887

**PLEASE SIGN IN**

	Name	Organization	Telephone No.	E-mail	Time In
1.	Bill Pans	MID			
2.	Jennifer Carlson	MCCV			
3.	Gretchen Murphy	CDFW			
4.	Joan Weimer	TID			
5.	Tom Leuc	sub			
6.	Calvin Curtis	TID			
7.	DANA FERREIRA	REG. DEATHAM			
8.	John Buckley	CSERC			
9.	Joe Zed	Abm Kristina Oku			
10.	Jim Alves	Craig + Mademo			
11.	KAY DIAZ	Pulse			
12.	Inna Edings	Senator Cannella			



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

# **Overview of Tuolumne River Reintroduction Structured Decision-Making Framework**



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

## Reintroduction Decision-Making

- Fish reintroduction involves numerous complex considerations
- There are extensive and complicated interactions among reintroduction considerations
- Structured decision-making requires careful analysis of complex interactions
- Identify the numerous issues to develop an agreed-upon framework for structured decision-making



TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

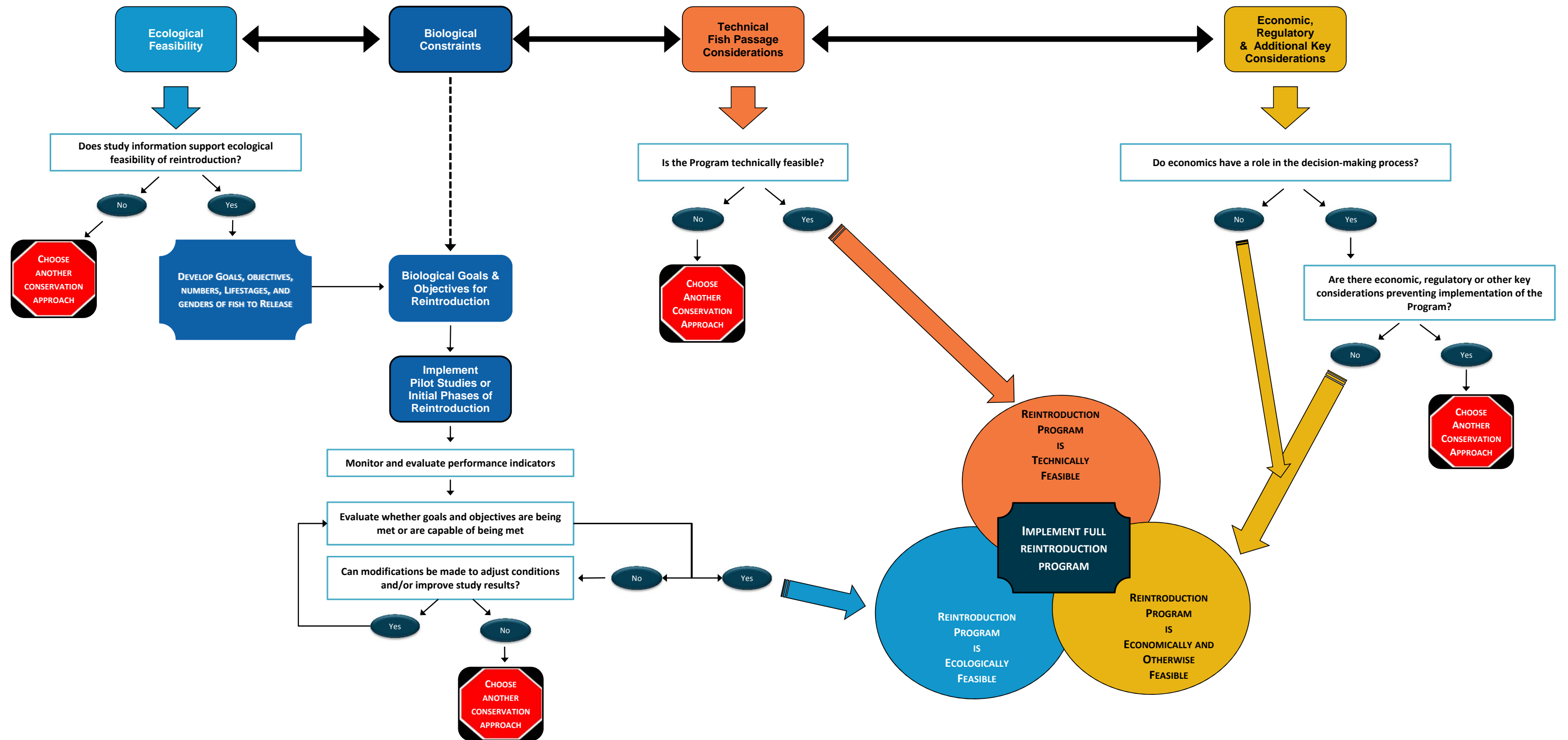
## Integrated Decision Tree

- An example of how structured decision-making can be approached regarding Tuolumne River reintroduction considerations
- Comprised of 3 distinct (but related) decision trees
  - ❖ Ecological Feasibility (with input from Biological Constraints)
  - ❖ Technical Fish Passage Feasibility
  - ❖ Economic, Regulatory & Other Key Considerations
- Informed by Biological Constraints & considerations
- A detailed work-flow would need to accompany the structured decision-making framework

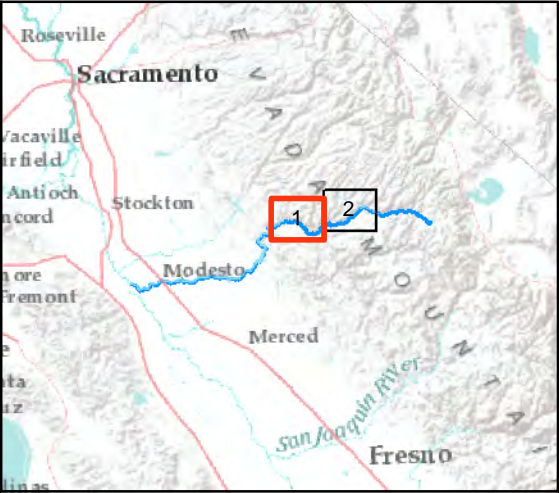
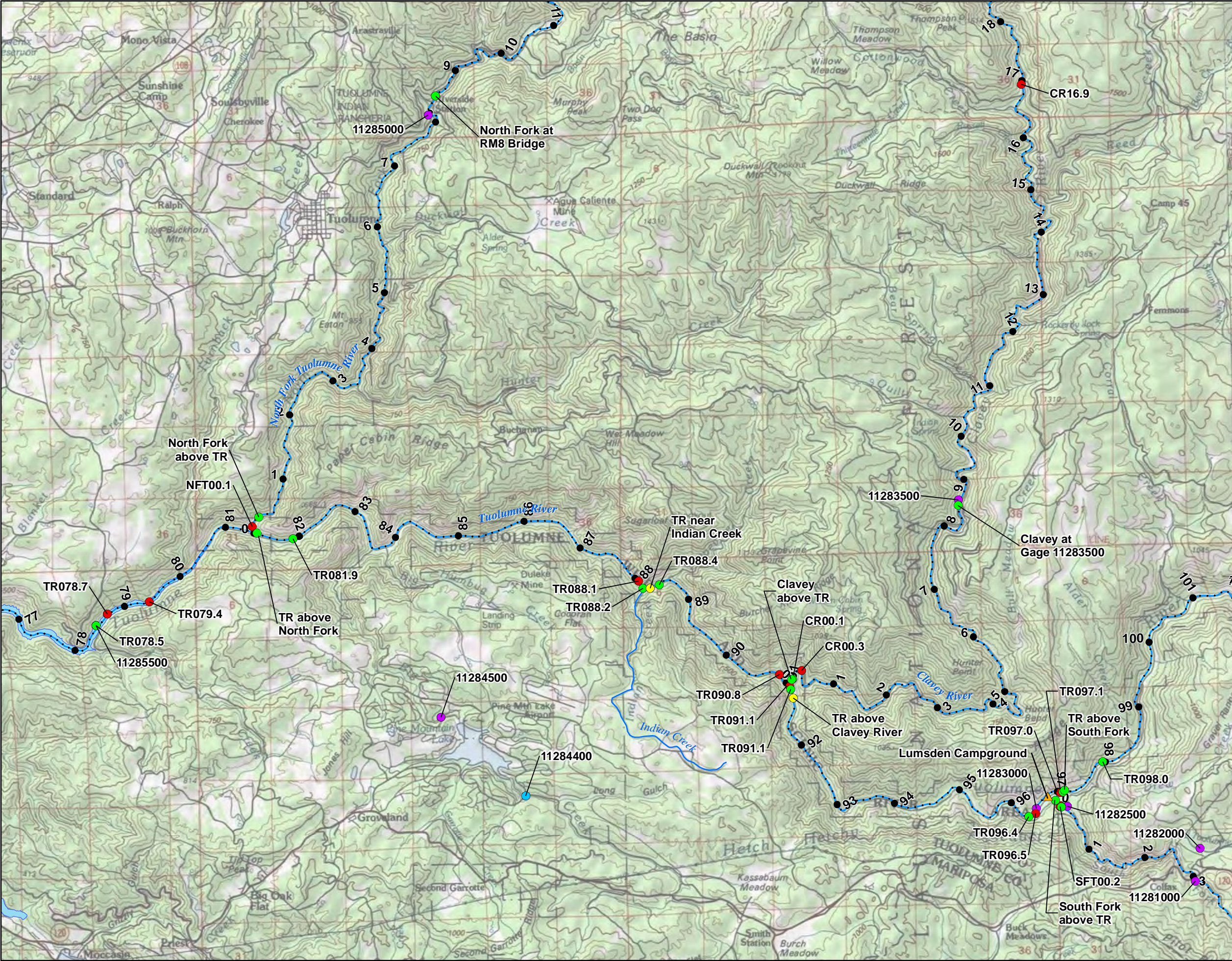


# Reintroduction Decision Criteria

## Decision Tree Overview







Stream / Flow Gage

● Active ● Inactive

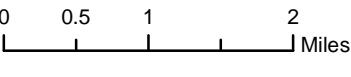
Label	Agency	Active	Site Name
11281000	USGS	Inactive	SF TUOLUMNE R NR OAKLAND RECREATION CAMP CA
11282000	USGS	Inactive	MT TUOLUMNE R A OAKLAND RECREATION CAMP CA
11282500	USGS	Inactive	SF TUOLUMNE R NR BUCK MEADOWS CA
11283000	USGS	Inactive	TUOLUMNE R NR BUCK MEADOWS CA
11283500	USGS	Inactive	CLAVEY R NR BUCK MEADOWS CA
11284000	USGS	Active	BIG C AB WHITES GULCH NR GROVELAND CA
11284500	USGS	Inactive	BIG C NR GROVELAND CA
11285000	USGS	Inactive	NF TUOLUMNE R AB DYER C NR TUOLUMNE CA
11285500	USGS	Active	TUOLUMNE R A WARDS FERRY BR NR GROVELAND CA

Water Temperature Logger

● Active ● Inactive ● Proposed\*

Label	Agency	Active	Site Locations
CR00.1	TID/MID	YES	Clavey above TR
CR00.1	NMFS	YES	Clavey R. just US of confluence
CR00.3	UC Davis	NO	Clavey River, upstream of Tuolumne River confluence
CR08.4	TID/MID	YES	Clavey River at USFS Bridge
CR16.9	CCSF	NO	Clavey River at 1N04 Bridge
NFT00.1	TID/MID	YES	North Fork above TR
NFT00.1	UC Davis	NO	North Fork Tuolumne above Tuolumne River
NFT08.0	TID/MID	YES	North Fork at RM8 Bridge
SFT00.1	TID/MID	YES	South Fork above TR
SFT00.2	CDFG	NO	South Fork of the Tuolumne River near confluence
SFT00.2	CCSF	NO	South Fork Tuolumne River near 1N10 Bridge
SFT00.2	NMFS	YES	S Fork Tuolumne R. just US of confluence
TR078.5	USGS	YES	Tuolumne River at Wards Ferry Bridge
TR078.7	CDFG	NO	Tuolumne River upstream of Wards Ferry Bridge
TR079.4	CCSF	NO	Tuolumne River, upstream of Ward's Ferry
TR081.3	TID/MID	YES	TR above North Fork
TR081.9	NMFS	YES	Tuolumne R DS of Mohecan Br.
TR088.1	UC Davis	NO	Tuolumne River, downstream of Indian Creek confluence
TR088.2	TID/MID	YES	Tuolumne River at Indian Creek Trail
TR088.4	NMFS	YES	Tuolumne R DS of Grapevine Cr.
TR090.8	UC Davis	NO	Tuolumne River, downstream of Clavey Creek confluence
TR091.1	UC Davis	NO	Tuolumne River, upstream of Clavey Creek confluence
TR091.1	NMFS	YES	Tuolumne R US of Clavey R.
TR096.4	NMFS	YES	Tuolumne R DS of Lumsden Campground
TR096.5	CDFG	NO	Tuolumne River below the South Fork
TR097.0	CDFG	NO	Tuolumne River above the South Fork
TR097.0	TID/MID	YES	TR above South Fork
TR097.1	CCSF	YES	Tuolumne River, upstream of South Fork
TR098.0	NMFS	YES	Tuolumne R DS of Lumsden Bridge

\* Proposed logger locations will be added to table when exact coordinates are known.



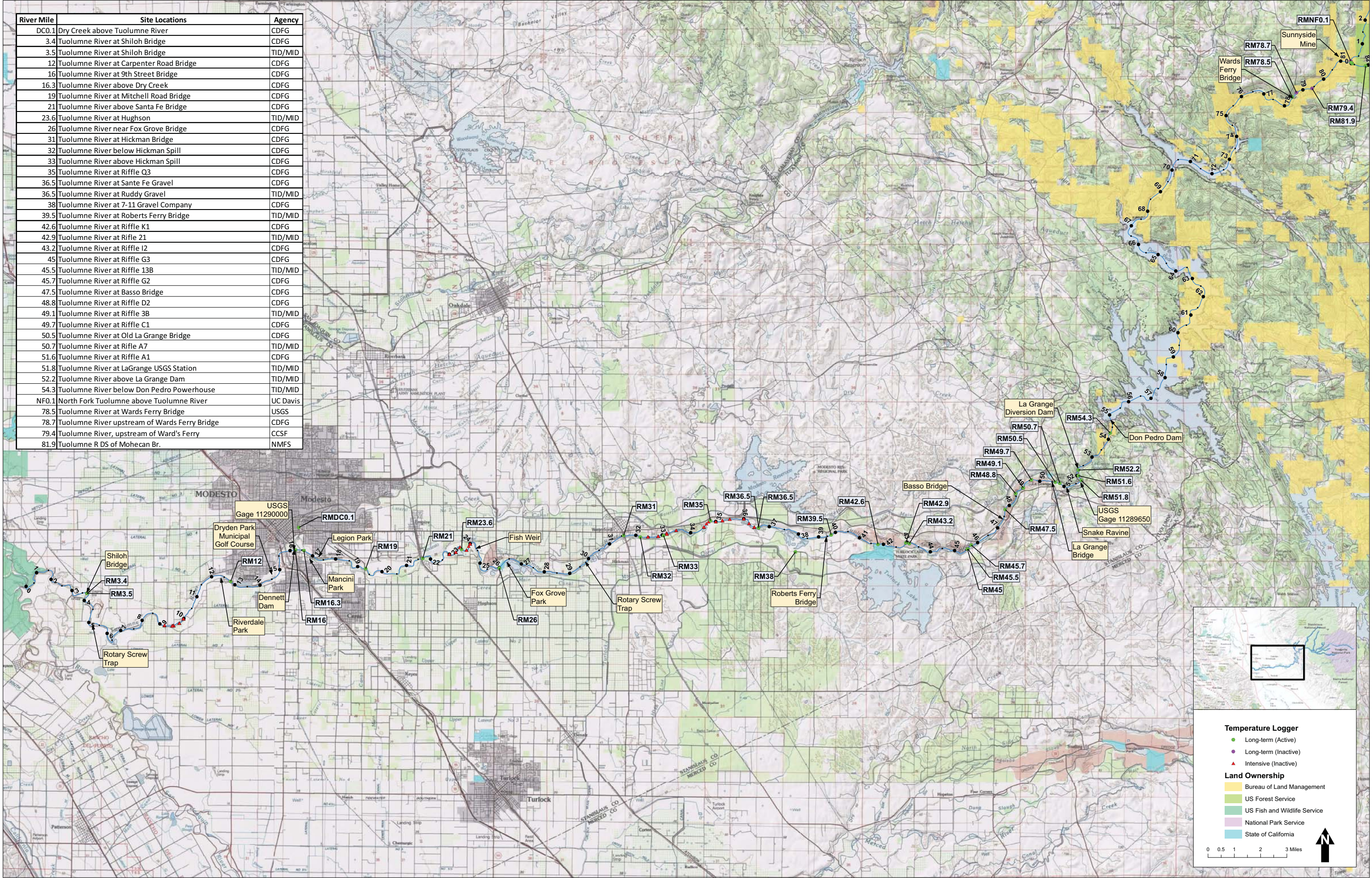
Upper Tuolumne River Gages

Map information was compiled from the best available sources. No warranty is made for its accuracy or completeness. Data Sources: Gages - USGS, TID/MID Copyright:© 2013 National Geographic Society, i-cubed Sources: Esri, DeLorme, USGS, NPS Sources: Esri, USGS, NOAA Data is CA SPCS, Zone III, ft.











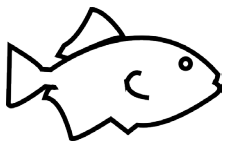


# Fish Passage on the Tuolumne River

## Overview

In the Federal Energy Regulatory Commission's (FERC) Study Plan Determination for La Grange Hydroelectric Project licensing, Modesto Irrigation District (MID) and Turlock Irrigation District (TID) were directed to undertake an assessment of fish passage facility alternatives at the La Grange Project and Don Pedro Hydroelectric Project. The cost of upstream and downstream fish passage can exceed \$100 million. Since MID and TID are public utilities, any fish passage costs will ultimately be paid by our customers.

Providing fish passage on the Tuolumne River would be a major undertaking for MID, TID and its customers, both financially and logistically. Fish passage has become one of the key issues in the La Grange licensing process.



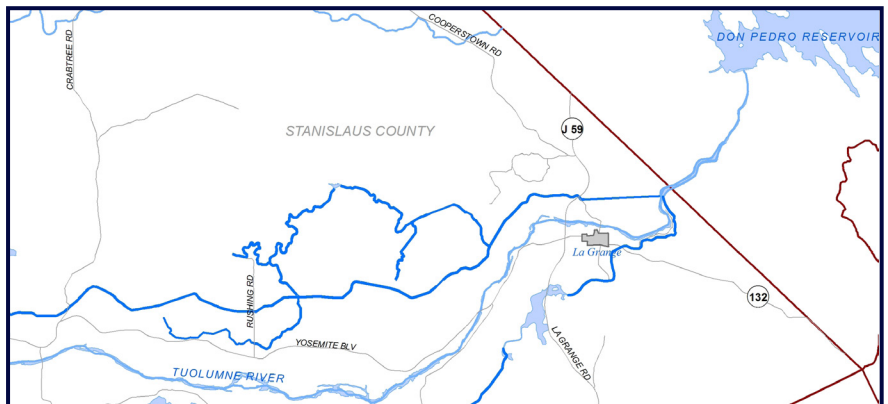
Since the target fish species for a fish passage program don't currently exist in the Upper Tuolumne River, there are many questions that need to be answered before decisions are made to reintroduce salmon or steelhead to the area above Don Pedro Dam.

## What is fish passage?

Fish passage is the movement of fish past existing barriers. Fish passage can be accomplished by constructing ladders or other structures that allow the fish to swim past the barrier or that capture the fish and transport them past the barrier.

## What would a fish passage program be used for on the Tuolumne River?

A fish passage program would move upstream migrating anadromous fish from below the La Grange Diversion Dam to above Don Pedro Dam. Upstream migrating fish return from the ocean and move through the Delta, San Joaquin River and Tuolumne River to La Grange Diversion Dam. Any fish passage program would also transport young outmigrating offspring of these returning fish downstream from above Don Pedro Dam to below La Grange Diversion Dam.



\$\$\$

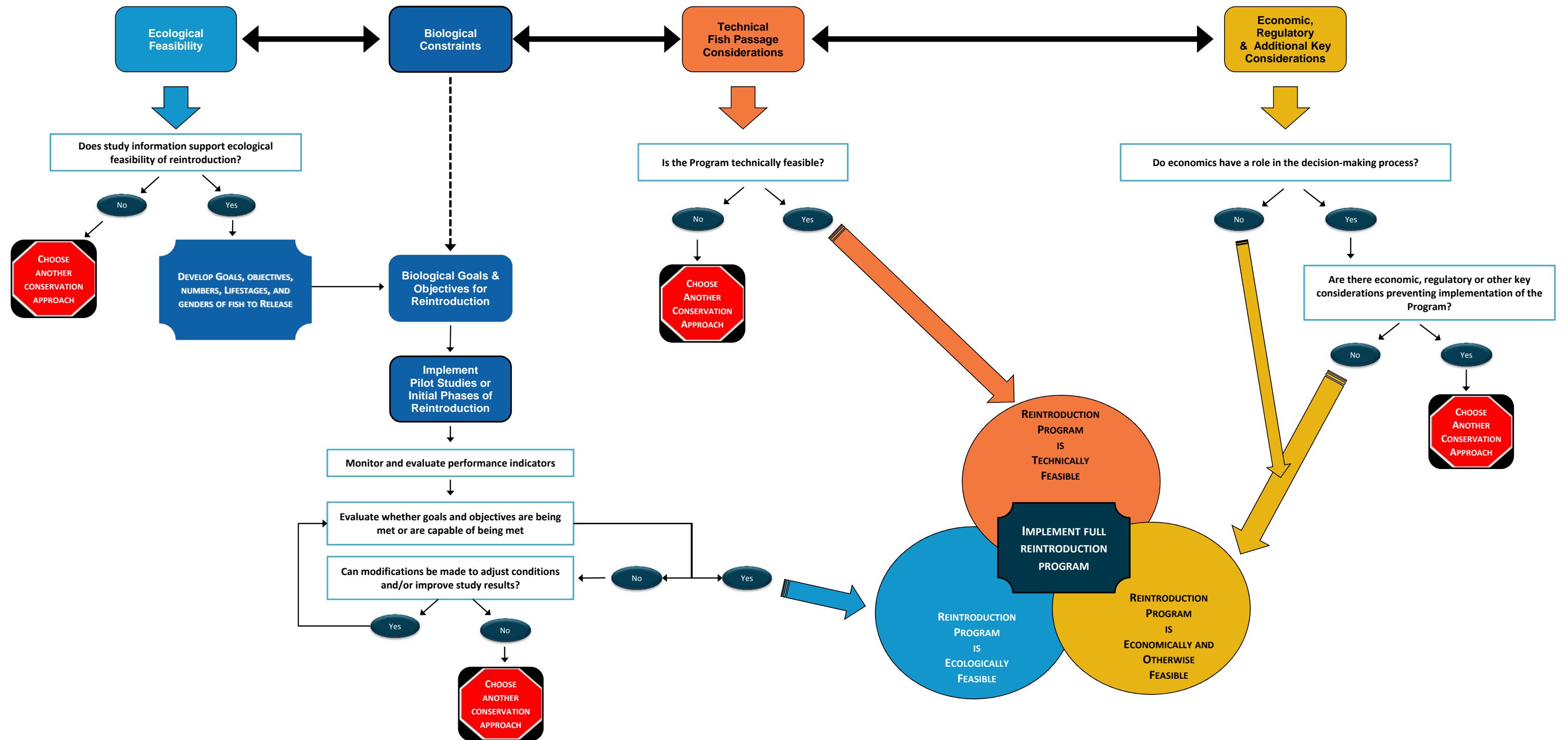
Fish passage can be an expensive endeavor. When assessing a potential fish passage program, MID and TID must take into consideration permitting, design and construction, operation and maintenance, and monitoring and evaluation costs. These costs will directly impact MID and TID customers.



Currently, little information exists to know what fish facilities might be appropriate or if the habitat above Don Pedro Dam is sufficient to support reintroduction goals. To encourage a collaborative process, a series of workshops are being held to identify, collect and share information.

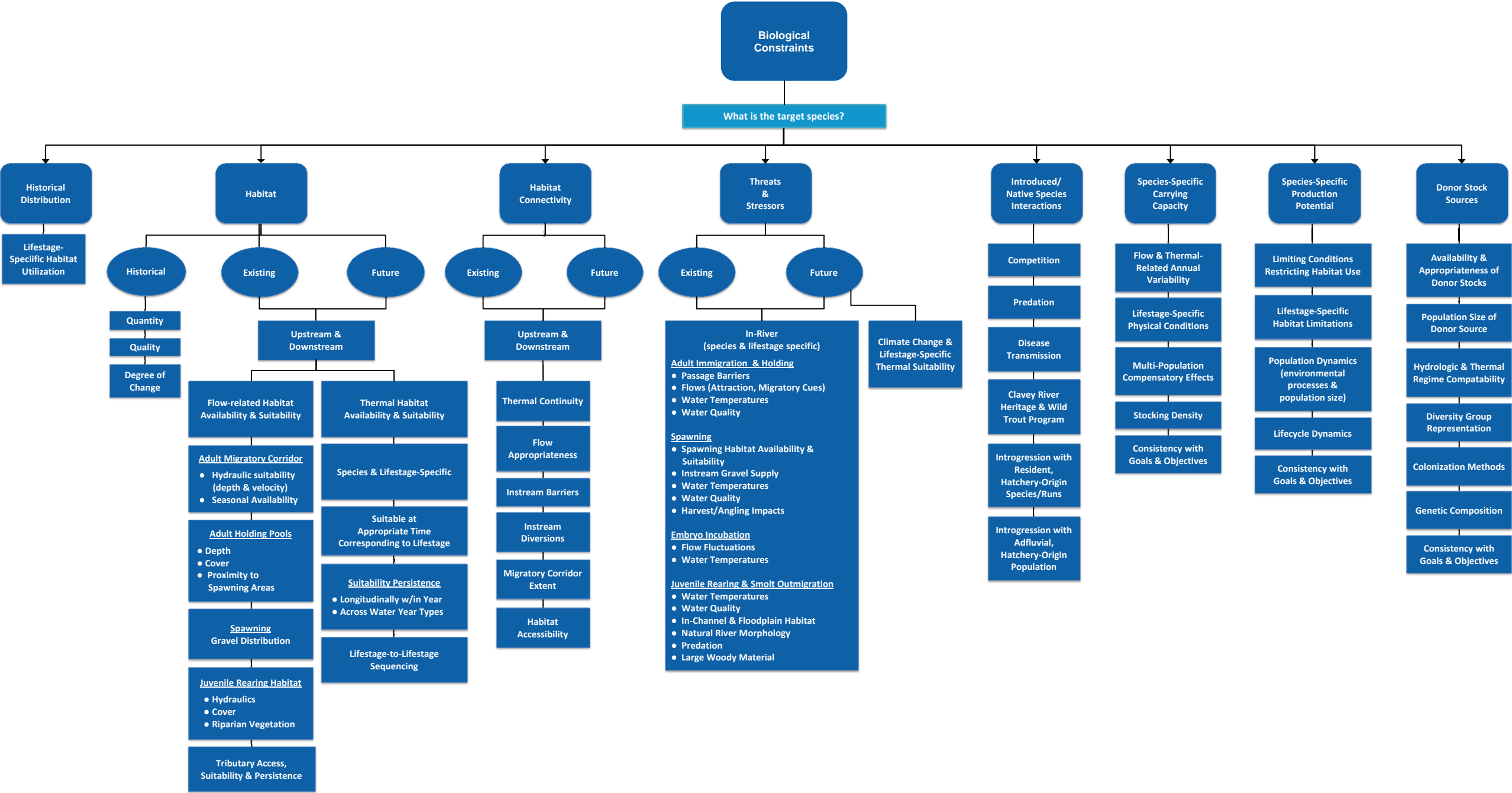
# Reintroduction Decision Criteria

## Decision Tree Overview



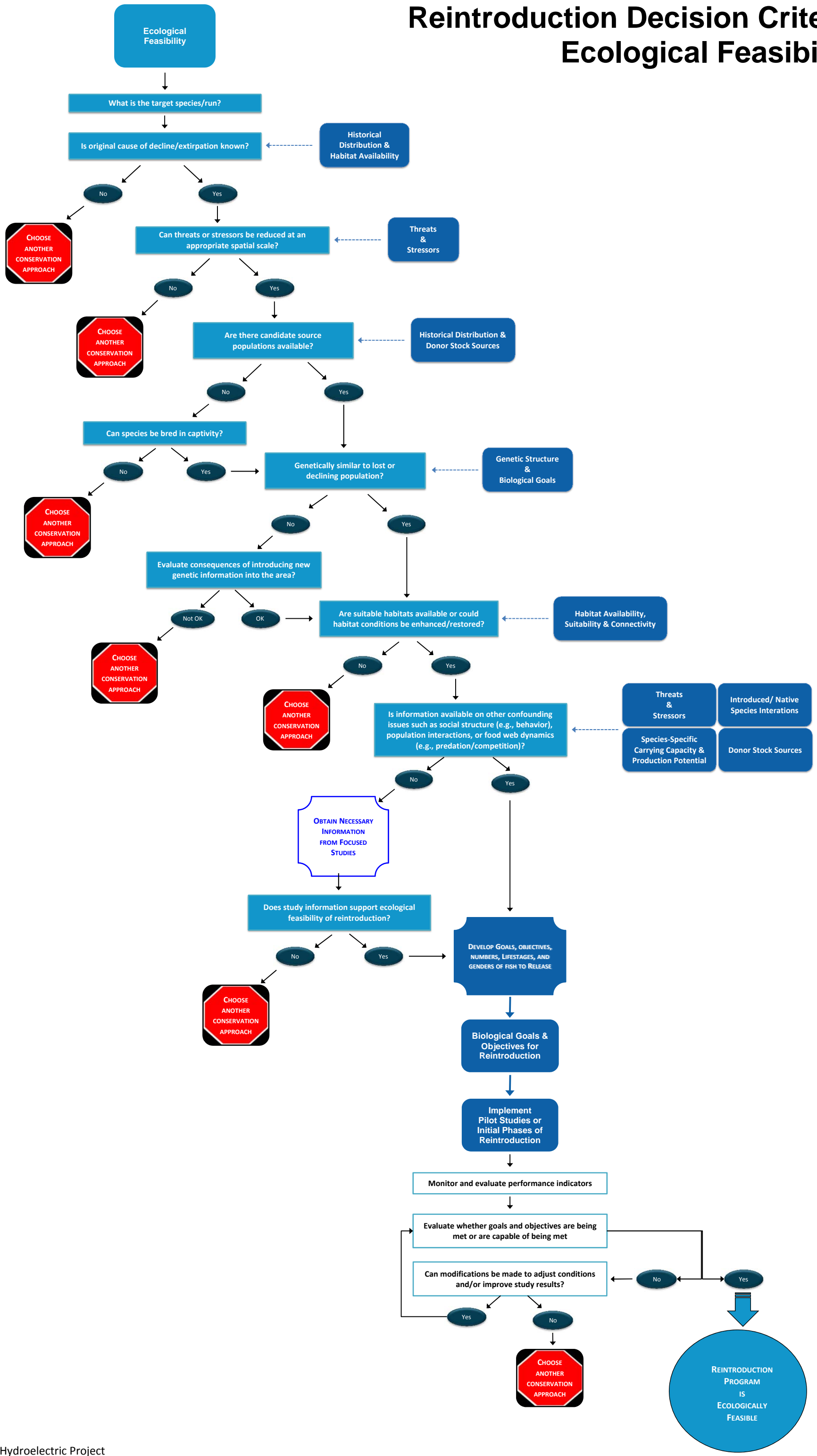
# Reintroduction Decision Criteria

## Biological Constraints



# Reintroduction Decision Criteria

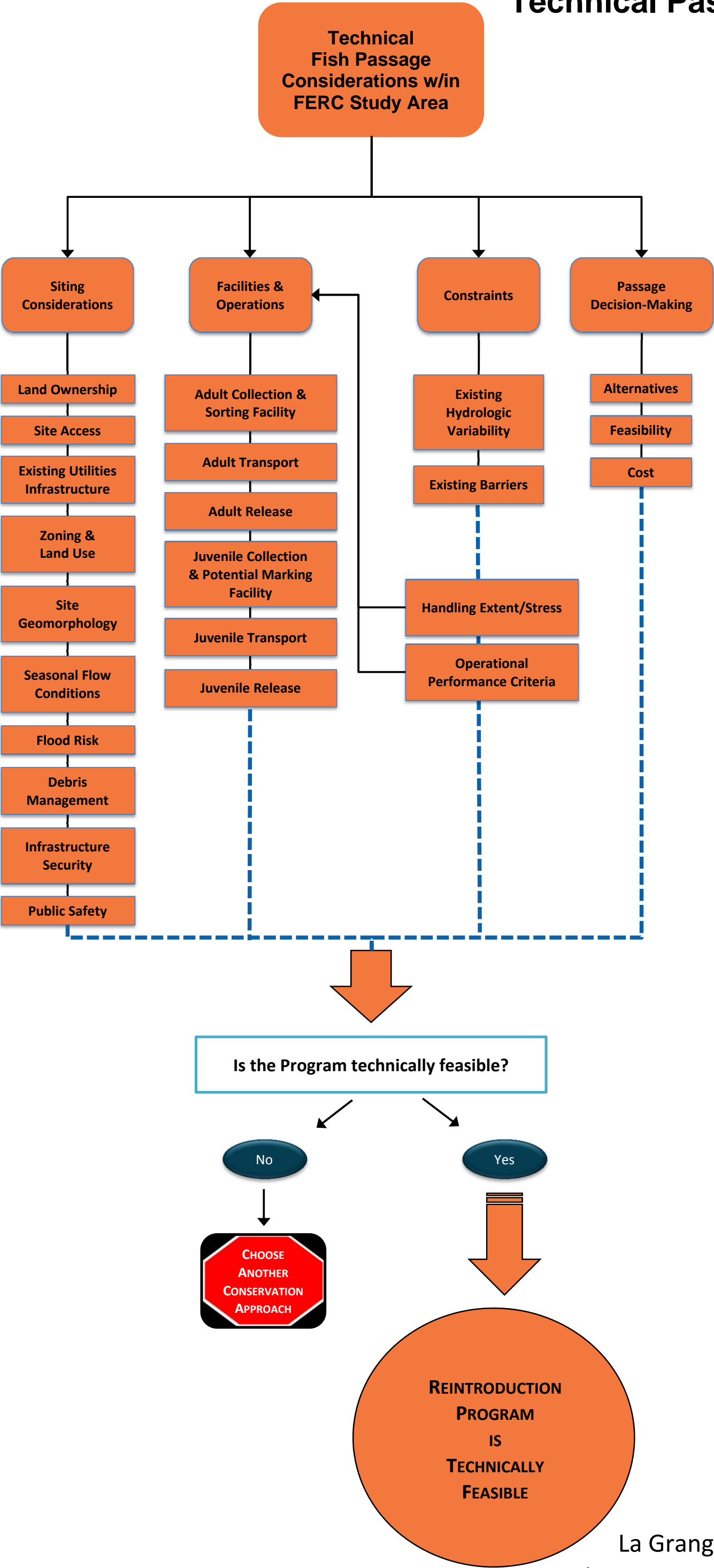
## Ecological Feasibility





# Reintroduction Decision Criteria

## Technical Passage Feasibility



# Reintroduction Decision Criteria

## Economic, Regulatory and Other Considerations

