LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

FINAL LICENSE APPLICATION

ATTACHMENT D
CONSULTATION RECORD

APPENDIX C
WORKSHOP AND TECHNICAL COMMITTEE MEETING NOTES

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LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

FLOW AND TEMPERATURE MONITORING/MODELING WORKSHOP

MAY 19, 2015

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project Licensing (FERC No. 14581)
Flow and Temperature Monitoring/Modeling Workshop
HDR Office
2379 Gateway Oaks Drive, Suite 200, Sacramento, CA

Tuesday, May 19, 2015
1:30 pm to 4:30 pm

Meeting Notes

On May 19, 2015, Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) hosted a workshop about the flow and temperature monitoring and modeling component of the La Grange Hydroelectric Project Fish Passage Assessment. This document summarizes discussion 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 participants to the meeting. Attendees went around the room and introduced themselves. Attendees on the phone introduced themselves: Mr. John Shelton and Ms. Gretchen Murphy of the California Department of Fish and Wildlife (CDFW) and Messrs. Tom Holly and John Wooster of the National Marine Fisheries Service (NMFS) participated in the meeting remotely.

Mr. Devine reviewed the meeting agenda and presented introductory slides. Mr. Devine described the La Grange Project and gave an overview of the La Grange Project Integrated Licensing Process (ILP). The flow and temperature monitoring and modeling is one part of a larger study of fish passage and reintroducing fish to the Upper Tuolumne River above Don Pedro Reservoir. Mr. Devine reviewed the objectives of the flow and temperature monitoring and modeling as well as the study area and schedule for reporting.

Mr. Chris Shutes (California Sportfishing Protecting Alliance) asked if there would be consultation for other components of the study request, in addition to the workshops for the flow and temperature modeling component and the fish passage feasibility component. Mr. Devine replied that for the upstream barrier study component, the Districts would be developing a criteria document, and would send the document out to licensing participants for review. The Districts will keep licensing participants apprised of the schedule and licensing participants are welcome to attend the fieldwork. Mr. Devine noted that this is a two-year study, and fieldwork will be completed this August and next spring/summer. The schedule for fieldwork in 2016 will be dependent on runoff; however, fieldwork will likely be scheduled to begin during high flows in May/June.

Mr. Shutes asked about the upper habitat characterization component of the study. Mr. Devine noted that similar to the temperature monitoring and modeling, the Districts would be voluntarily conducting a barriers assessment and summarized the study component. Mr. Devine also stated that NMFS was conducting LIDAR/hyperspectral remote sensing work to support additional upper habitat characterization objectives. Mr. Devine asked that NMFS provide the time frame for completion of this work and its availability to interested parties as the Districts would like to wait and see what the results of that work are and then come together as a group with licensing participants to discuss the data gaps. Mr. Devine noted that it would be helpful if NMFS could provide an updated schedule for completing the LIDAR/hyperspectral work and when it would be available.

Mr. Devine finished his slide presentation and noted that the meeting handouts would be made available on the La Grange Hydroelectric Project licensing website after the meeting. He then introduced Mr. Mike Deas (Watercourse Engineering) as the modeling and monitoring lead for this effort. Mr. Deas began his presentation. Mr. Deas provided additional details about the objectives of the modeling and monitoring, scope of the work, and the study area. Referring to the map of the study area, Mr. Shutes asked if RM 81 was the extent of Don Pedro Reservoir at full pool. Mr. Devine replied that RM 81 is roughly the Don Pedro Project Boundary at elevation 845 ft.

Mr. Deas resumed his presentation. Mr. Deas provided details about the availability and sources of existing flow and temperature data. He described the rationale for choosing the locations and periods to be monitored for flow and temperature and the equipment that would be used for the study. Mr. Peter Drekmeier (Tuolumne River Trust) asked if a temperature gage was installed on the North Fork Tuolumne River, as he had seen similar equipment on a recent float trip. Mr. Devine replied that it may have been a gage as both the Districts and NMFS have monitoring equipment deployed in that area.

Mr. Deas resumed his presentation. Referring to the slide summarizing the locations of currently installed loggers, Mr. Bao Le (HDR) noted that stage loggers collect both stage data and temperature data.

Mr. Drekmeier asked why data was being collected at Cherry and Eleanor, upstream of Holm Powerhouse, as Mr. Drekmeier believed Holm to be a barrier to fish passage. Mr. Deas replied that there may be suitable habitat upstream of Holm. Mr. Devine added that because the Districts had not yet completed the barrier work, Holm was not yet confirmed to be a barrier to fish passage.

Referring to the table summarizing the available water temperature data, Mr. Bill Sears (City and County of San Francisco) noted that U.S. Geological Survey (USGS) temperature gage data was not included in the table. Mr. Sears asked if the Districts were only using data that came from standardized equipment, and were thus excluding the USGS data. Mr. Deas replied that the Districts would be using USGS temp gage data, but because the team had not yet processed the USGS temp data, it had not been included in the table.

Mr. Mark Gard (U.S. Fish and Wildlife Service) asked if the Districts would be collecting seasonal flow data in the South Fork Tuolumne River, or alternatively use mass balance to calculate the flow. Mr. Deas replied that the Districts would be collecting stage data on the South Fork.

Mike Deas resumed the presentation. Mr. Deas noted that the Districts would like access to the NMFS LIDAR data as soon as possible and asked what the schedule was for data availability. Mr. John Wooster (NMFS) replied that he had not been in touch recently with the research team completing the work, but he would look into it.

Mike Deas concluded the slide presentation. Mr. Deas said anyone wanting more information about the study was welcome to contact the Districts or HDR.

Mr. Devine asked Mr. Wooster to give an update on the status of the NMFS logger deployments. Mr. Wooster replied that during the prior week, NMFS had installed a logger on the Clavey around RM 16. Referring to the three downstream Tuolumne River locations where the Districts had installed loggers, Mr. Wooster noted that last July NMFS had deployed loggers in nearly identical locations, except that the NMFS logger above the North Fork is a bit further upstream than the Districts' logger. Mr. Wooster said that the NMFS logger near the South Fork is downstream of the confluence and close to Merals Pool. Given that loggers are installed both upstream and downstream of the South Fork, there may be an opportunity to evaluate mixing in the area. Mr. Wooster said NMFS had South Fork and Clavey loggers at almost identical river miles to the locations of the Districts' loggers. Mr. Wooster noted that data from the NMFS loggers may be helpful for extending the Districts' data set.

Mr. Devine asked if there was any data available from the loggers that NMFS had installed in July. Mr. Wooster replied that so far there had been only one data download, and that download was from the loggers on the Tuolumne River below South Fork. He said NMFS would be back in the field the first week of June to revisit some of the other loggers. Mr. Devine asked if NMFS has another download visit scheduled for later in the summer. Mr. Wooster replied that NMFS has summer fieldwork scheduled throughout the watershed for the genetics sampling, and will be downloading data opportunistically as NMFS staff are in the vicinity for other fieldwork. After the summer fieldwork is complete, NMFS will try to revisit all the loggers in the fall to complete another download.

Mr. Deas asked if NMFS planned to leave the loggers deployed over the winter. Mr. Wooster said yes, the loggers would be left out over the winter.

Mr. Bob Hughes (CDFW) asked if the Districts had a written study plan. Mr. Devine replied that the study plan is available in the La Grange Revised Study Plan document filed with licensing participants and FERC. Mr. Hughes asked if the study plan includes collaboration with interested parties, such as collaboration during model development and to review the data once it is available. Mr. Devine replied that the study plan does include future collaboration. Although there are no other workshops planned at this date, the Districts would certainly consider hosting an additional meeting(s) if licensing participants were interested. Mr. Hughes said that as long as everyone is kept up to speed on the progress, a formal workshop would not necessarily be needed. Mr. Shutes added that the Don Pedro Project hydrology workshop had been helpful. He noted that prior to the workshop, there had been considerable concern about the model. However, after the workshop, people had been satisfied that the study was in good shape.

Mr. Devine said that the availability of the Districts' logger data would depend on when the data could be downloaded and the schedule for QA/QC. Preliminary results are expected this fall.

Mr. Hughes said he thought the presentation was very thorough and that all the bases had been covered.

Mr. Wooster noted that the Districts planned to model the months June through October, but thought he heard the potential to model all months. Mr. Wooster asked how and when a decision would be made about the months to be modeled. Mr. Deas replied that the Districts had identified June through October as the critical period, and as the study proceeds and identifies additional information, the time period may be adjusted. Mr. Deas clarified that the reference to modeling all months was simply to illustrate that data would be collected year-round and thus all months could be modeled. Mr. Devine added that the months included in the model would be driven by life history of the species of interest (the timing of spawning, egg incubation, fry rearing, etc.). The end of the critical period is October because that is when temperatures start to get cold. However, the time period used in the model is up for discussion.

Mr. Wooster replied that to cover steelhead migration, NMFS would be interested in including some of the spring months prior to June. Mr. Wooster asked for clarification on the significance of the June to October period for the model. Would the model be built to cover all 12 months, but only be calibrated using the months of June through October? Mr. Deas replied that the months covered in the model will be dependent on the availability of data. The Districts will have year-round data for much of the system. However, the Districts anticipate that loggers will not be able to be maintained in some places over the winter, so there will be data gaps for some places. Mr. Deas said it was important to have confidence in the period of focus. Mr. Devine added that life history of target species would inform the modeling time period, and that discussions on that topic would start the next day (May 20) at the first La Grange Fish Passage Facilities Assessment Workshop.

Mr. Hughes requested that materials for the May 20 Fish Passage Facilities Assessment Workshop be posted online prior to the start of the workshop. Mr. Devine said that the Districts would do that. Mr. Wooster requested that a set of handouts from today's workshop be brought to the May 20 workshop for NMFS, as no NMFS representatives were able to attend today's meeting in-person. Mr. Devine said that a set of handouts would be brought for NMFS.

The meeting adjourned at 3:00 pm.

ACTION ITEMS

1. The Districts will post the meeting handouts to the La Grange Hydroelectric Project Licensing Website.

2. NMFS will provide a schedule for the LIDAR/hyperspectral study report and availability of the data.

3. Regarding meeting materials for the May 20 La Grange Fish Passage Facilities Assessment Workshop, the Districts will post the meeting materials to the licensing website prior to the start of the workshop.

4. The Districts will bring a set of handouts from this meeting to the May 20 Workshop and give the handouts to NMFS.

ATTACHMENT A

La Grange Hydroelectric Project
Flow and Temperature Monitoring/Modeling Workshop
Tuesday, May 19, 1:30 pm – 4:30 pm
HDR Office, 2379 Gateway Oaks Drive, Suite 200, Sacramento, CA
Conference Line: 1-866-994-6437, Passcode: 8140607
Join Lync Meeting https://meet.hdrinc.com/jesse.deason/8DZ4VNVN

Meeting Objectives:
1. Present an overview of the La Grange Hydroelectric Project Temperature Study.
2. Review and confirm proposed temperature and flow monitoring locations.
3. Review and confirm modeling approach.
4. Confirm schedule/tasks and opportunities for collaboration.

TIME	TOPIC
1:30 pm – 1:40 pm	Introduction of Participants (All)
1:40 pm – 2:00 pm	Background/Overview of the La Grange Project Temperature Study (Districts)
2:00 pm – 4:00 pm	Temperature Study Introduction (Districts) a. Study goal and objectives, scope, and study area Review and Discussion of Existing Information a. Parameters and sources b. Review process summary c. Results, findings and recommendations Proposed Monitoring Program – Presentation and Discussion a. Rationale i. Space (locations) ii. Time (periods of interest) iii. Equipment Temperature Modeling – Presentation and Discussion a. Approach (including spatial and temporal resolution) b. Data needs c. Model information/output Schedule and Reporting
4:00 pm – 4:30 pm	Meeting Wrap-up (All) a. Confirm study approach and methods b. Agreements, action items and next steps

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MID Modesto Irrigation District
The Power to Grow

La Grange Hydroelectric Project
Flow and Temperature Monitoring/Modeling Workshop
Tuesday, May 19, 1:30 pm to 4:30 pm

Sign-In Sheet

No.	Name	Entity	Email Address
1	Bao Le	HDR	
2	Jesse Deason	HDR	
3	Bill Paris	MID	
4	Art Godwin	TID	
5	Mike Deas	Watercourse Engineering	
6	John Devine	HDR	
7	Steve Boyd	TID	
8	Ron Yoshiyama	San Francisco	
9	Peter Barnes	SWRCB	
10	Chris Shutes	CSPA	
11	Mark Gard	USFWS	
12	Bob Hughes	CDFW	
13	Bill Sears	SFPUC	
14	Peter Drekmeier	TRT	

By Phone: John Shelton (CDFW)
Gretchen Murphy (CDFW)
John Wooster (NMFS)
Tom Holley (NMFS)

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La Grange Hydroelectric Project
FERC No. 14581

Fish Passage Assessment -
Temperature Monitoring / Modeling Scope

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

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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

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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

Water Temperature Monitoring and Modeling

1. Originally a study request from NMFS. FERC determines Districts are not required to do the study. Study being conducted voluntarily by the Districts.

2. Study tasks include evaluating existing information, collecting additional information and developing a temperature model to simulate existing thermal conditions in the Upper Tuolumne River between Early Intake and Don Pedro Reservoir.

3. Primary objective is identifying where temperatures appear to be suitable for the various life stages of salmonids.

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Today's Temperature Workshop

1. Districts' proposed a collaborative Workshop with LPs.

2. Core Study Team:
   a) HDR – select and acquire monitoring equipment, deployment, maintenance, and download.
   b) Watercourse Engineering, Inc. – water temperature modeling Lead Engineer.

3. Objectives include:
   a) Review existing information and discuss additional information needs for temperature and river stage monitoring to support modeling.
   b) Discuss and confirm modeling approach.
   c) Discuss and confirm schedule/tasks and future collaboration.

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La Grange Hydroelectric Project FERC No. 14581

Upper Tuolumne River Flow and Water Temperature Assessment

May 19, 2015

Topics

- Temperature Study Overview:
  - Study Goal/Objectives, scope, and study area
- Review and Discussion of Existing Information
- Monitoring Program – Presentation and Discussion
- Temperature Modeling
- Meeting Wrap-up

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Study Objectives

- Complete a water temperature investigation to characterize thermal conditions in Upper Tuolumne River basin below Early Intake.
- Monitoring Data
  - Existing Data
  - Additional Monitoring
- Develop a flow and temperature model
  - Mainstem Tuolumne River from Early Intake to Don Pedro Reservoir and major tributaries

Monitoring Objectives

- Identify existing data and monitoring locations
- Share current and proposed District monitoring sites
- Ensure locations, methods, need for additional monitoring are consistent/acceptable among parties
- Identify operations or conditions that may be anomalous during the proposed monitoring season (e.g., extreme drought, operational changes, etc.)

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Temperature Modeling Objectives

- Develop a tool to assist in assessing a range of
  - Hydrology
  - Temperature
  - Meteorology
  - Thermal regimes and suitability for salmonid life stages on a reach scale basis.

- Model will produce data for suitability criteria at sub-daily time steps, allowing the development of a range of metrics (e.g., daily mean or maximum, 7-day average of the mean or maximum, etc.)

Study Scope

- Task 1: Identify, Synthesize, and Interpret Existing Water Temperature and Flow Data
- Task 2: Additional Monitoring -- Data Logger Deployment
- Task 3: Water Temperature Modeling and Reporting

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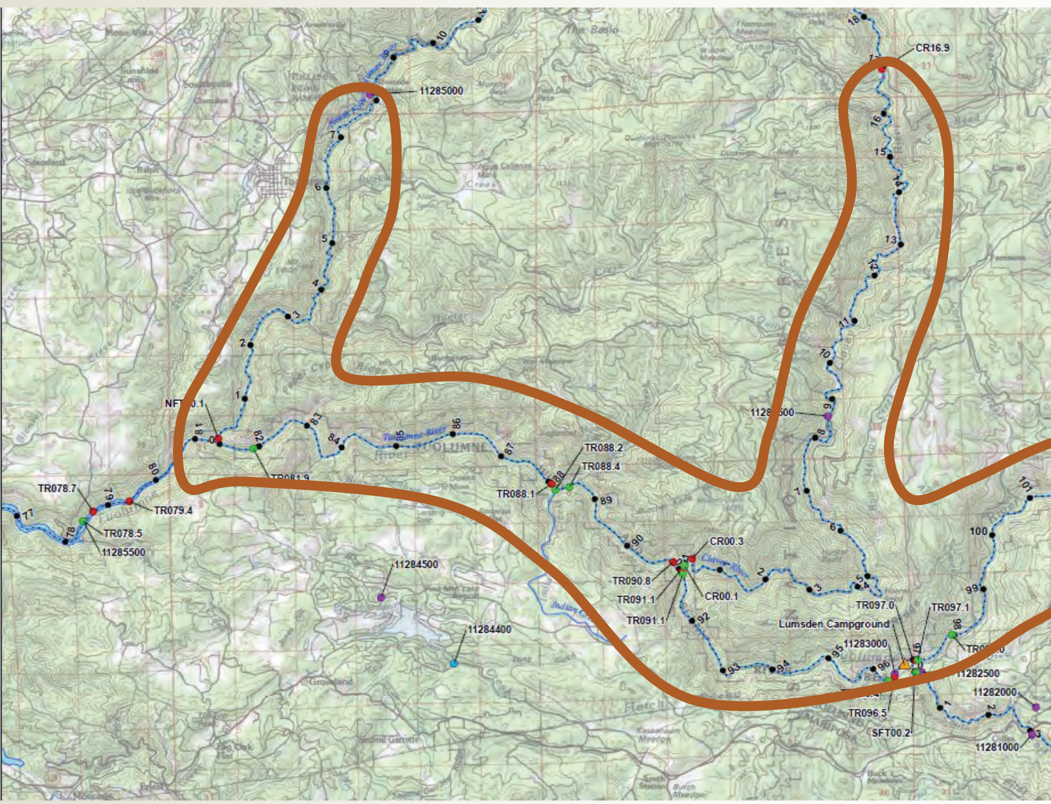
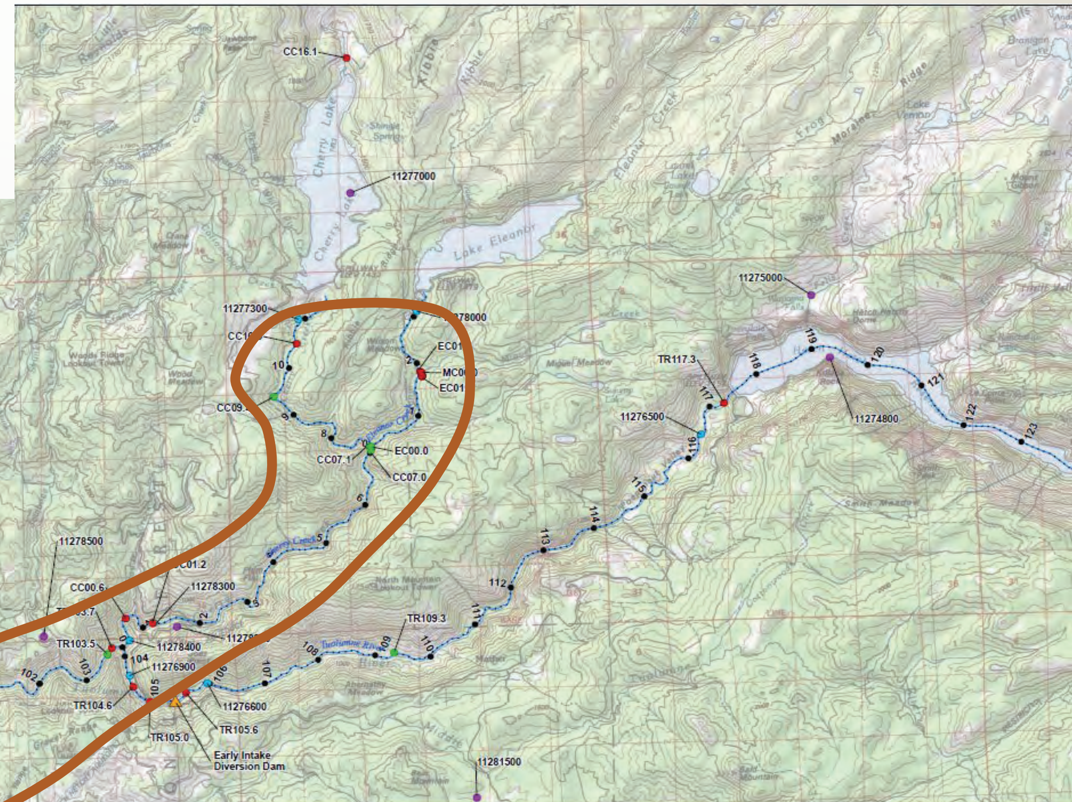
Study Area





Modeling Analysis

Tuolumne River: Early Intake (RM 105) to Don Pedro Reservoir (RM 81)

Cherry/Eleanor Creeks: Confluence to first barrier*

SF Tuolumne River: Barrier near confluence (no model)

Clavey River: Confluence to first barrier*

NF Tuolumne River: Confluence to first barrier*

* TBD

Task 1: Existing Data Analysis

- Data sources
  - Flow
  - Water temperature
  - Meteorology
- Review
  - Location, frequency, period assessment
- Findings
  - Identify data gaps
  - Characterize hydrology and thermal conditions
  - Define potential modeling periods
  - Recommendations for additional monitoring

Flow – Data Sources

- USGS
  - 11276600 TUOLUMNE R AB EARLY INTAKE NR MATHER CA
  - 11276900 TUOLUMNE R BL EARLY INTAKE NR MATHER CA
  - 11285500 TUOLUMNE R A WARDS FERRY BR NR GROVELAND CA
  - 11277300 CHERRY C BL VALLEY DAM NR HETCH HETCHY CA
  - 11278300 CHERRY C NR EARLY INTAKE CA
  - 11278400 CHERRY C BL DION R HOLM PH, NR MATHER CA
  - 11278000 ELEANOR C NR HETCH HETCHY CA
- CCSF
  - Clavey River (historic data - CDEC)
  - Minimum flow schedule
    - Cherry Creek
    - Eleanor Creek
    - Tuolumne River at Early Intake
- HDR proration methodology (ungaged tributaries)

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Flow - Summary

- Mainstem Tuolumne River
  - Early Intake – managed operation (and spill)
  - Cherry Creek to Don Pedro Reservoir – hydropower peaking with seasonal tributary contributions (e.g., spring snowmelt)
- Cherry/Eleanor Creeks
  - Above Dion R Holm PH – managed operation (and spill)
  - Below Dion R Holm PH – hydropower peaking
- SF Tuolumne, Clavey, and NF Tuolumne Rivers
  - Unregulated hydrograph
- Monitoring Recommendations
  - Additional seasonal flow data on Clavey and NF Tuolumne R.
  - Stage data on mainstem (travel time)

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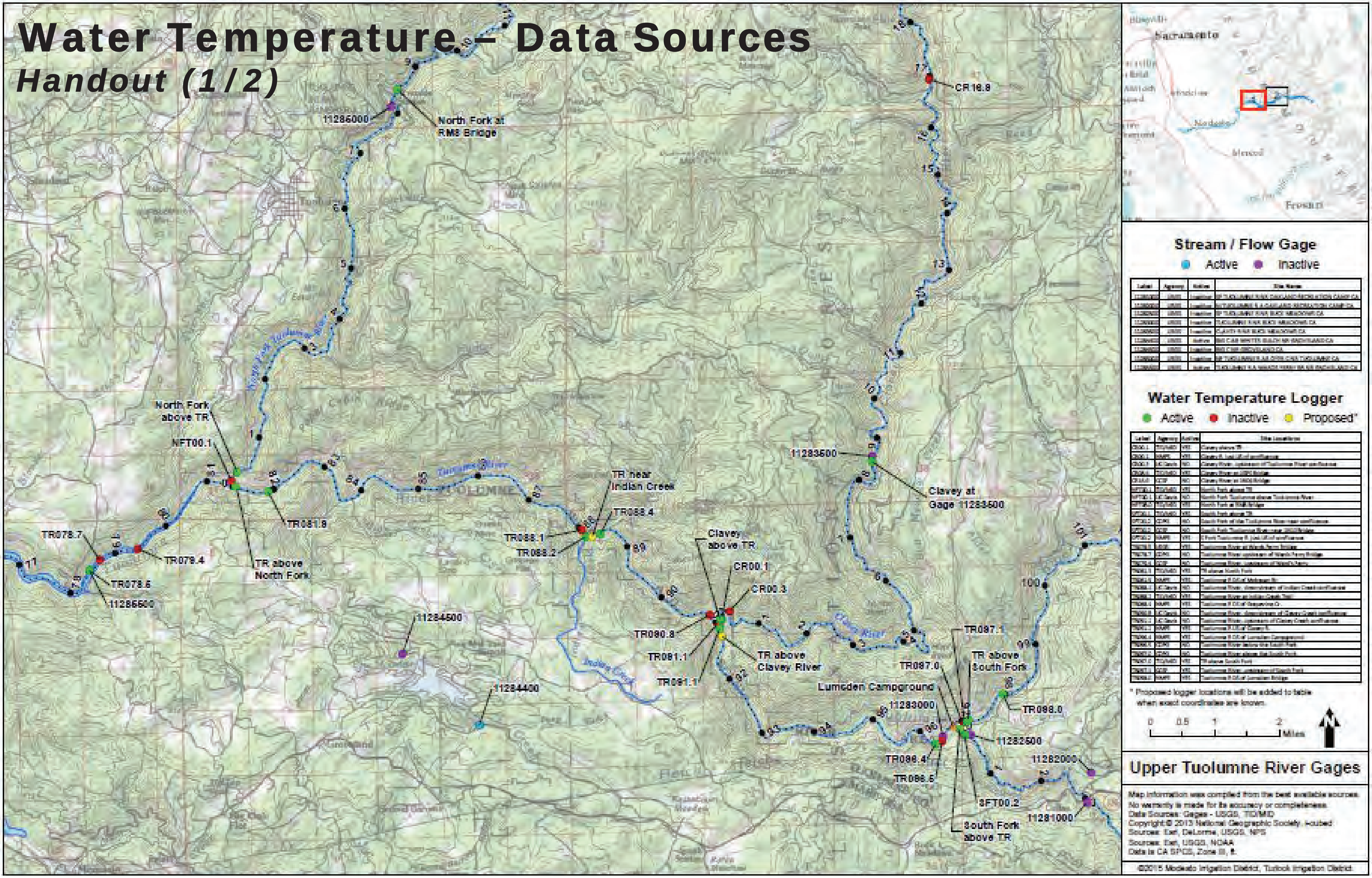
Water Temperature – Data Sources

Handout (1/2)



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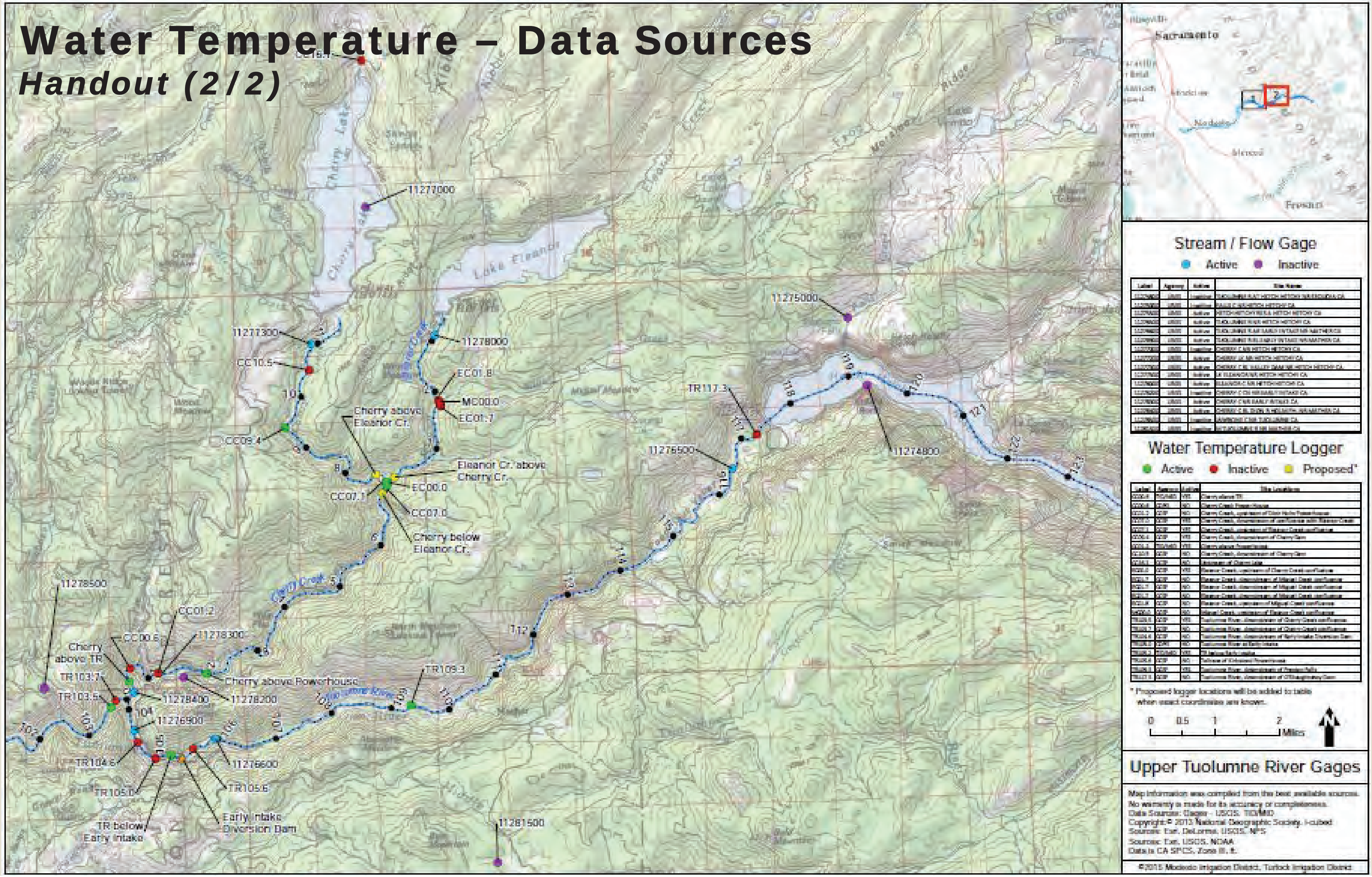
Water Temperature – Data Sources

Handout (2/2)



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Water Temperature Data - Availability

Handout

Map Label	Agency	Active	Site_Locations	2007	2008	2009	2010	2011	2012	2013	2014
Tuolumne River - Mainstem											
TR078.5	USGS	YES	Tuolumne River at Wards Ferry Bridge	*							
TR078.7	CDFG	NO	Tuolumne River upstream of Wards Ferry Bridge	5		20 22	18 7	24			
TR079.4	CCSF	NO	Tuolumne River, upstream of Ward's Ferry	6 1	25		15	24	16 15 11 10 14	16 2	
TR081.9	NMFS	YES	Tuolumne R DS of Mohecan Br.	*							
TR083.0	TID/MID	YES	Tuolumne River at Indian Creek Trail							26	
TR088.1	UC Davis	NO	Tuolumne River, downstream of Indian Creek confluence	*							
TR088.4	NMFS	YES	Tuolumne R DS of Grapevine Cr.	*							
TR090.8	UC Davis	NO	Tuolumne River, downstream of Clavey Creek confluence	*							
TR091.1	NMFS	YES	Tuolumne R US of Clavey R.	*							
TR091.1	UC Davis	NO	Tuolumne River, upstream of Clavey Creek confluence			6 28	7				
TR096.4	NMFS	YES	Tuolumne R DS of Lumsden Campgorund								
TR096.5	CDFG	NO	Tuolmune River below the South Fork	21 22 21	29					12	
TR097.0	CDFG	NO	Tuolumne River above the South Fork	30 22		22			6 6	12	
TR097.1	CCSF	NO	Tuolumne River, upstream of South Fork	6						5	
TR098.0	NMFS	YES	Tuolumne R DS of Lumsden Bridge	*							
TR103.5	CCSF	NO	Tuolumne River, ds of Cherry Ck confluence (TR4)	8			14 21	4	5	20	
TR103.7	CCSF	NO	Tuolumne River, ds of Cherry Ck confluence (TR3)	8			13				
TR104.6	CCSF	NO	Tuolumne River, ds of Early Intake Diversion Dam	8			13				
TR105.0	CDFG	NO	Tuolumne River at Early Intake		29 23					23	
TR105.6	CCSF	NO	Tailrace of Kirkwood Powerhouse	*							
TR109.3	CCSF	NO	Tuolumne River, downstream of Preston Falls	5							14
TR117.3	CCSF	NO	Tuolumne River, downstream of O'Shaughnessy								
NF Tuolumne River											
NFT00.1	UC Davis	NO	North Fork Tuolumne above Tuolumne River	*							
Clavey River											
CR00.1	NMFS	YES	Clavey R. just US of confluence	*							
CR00.3	UC Davis	NO	Clavey River, upstream of Tuolumne River confluence			6 28					
CR16.9	CCSF	NO	Clavey River at 1N04 Bridge	8			20				
SF Tuolumne River											
SFT00.2	CDFG	NO	South Fork of the Tuolumne River near confluence	7 18 16	27	19	27	22 25 14	17 29 26 1		12
SFT00.2	CCSF	NO	South Fork Tuolumne River near 1N10 Bridge	6		4					
SFT00.2	NMFS	YES	S Fork Tuolumne R. just US of confluence	*							
Cherry Creek											
CC00.6	CDFG	NO	Cherry Creek Power House	16	29 22 3 18	23 7 9		27 15	25 19 26	23	
CC01.2	CCSF	NO	Cherry Creek, upstream of Dion Holm Powerhouse	8 30 30	29	27	29	30	12		
CC07.0	CCSF	NO	Cherry Creek, ds of confluence with Eleanor Creek	7		2 29			14		
CC07.1	CCSF	NO	Cherry Creek, upstream of Eleanor Creek confluence	7		2 29			14		
CC09.4	CCSF	NO	Cherry Creek, downstream of Cherry Dam	8		4		5		5	
CC10.5	CCSF	NO	Cherry Creek, downstream of Cherry Dam	7						29	
CC16.1	CCSF	NO	Upstream of Cherry Lake	7 25 30	4						
Eleanor Creek											
EC00.0	CCSF	NO	Eleanor Creek, upstream of Cherry Creek confluence	7		3 30	21	1	25		
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence	7		27			5		
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence	7			18	29	5		
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence	7		27			5		
EC01.8	CCSF	NO	Eleanor Creek, upstream of Miguel Creek confluence	7		27			5		
MC00.0	CCSF	NO	Miguel Creek, upstream of Eleanor Creek confluence	7 5	2	26			5		

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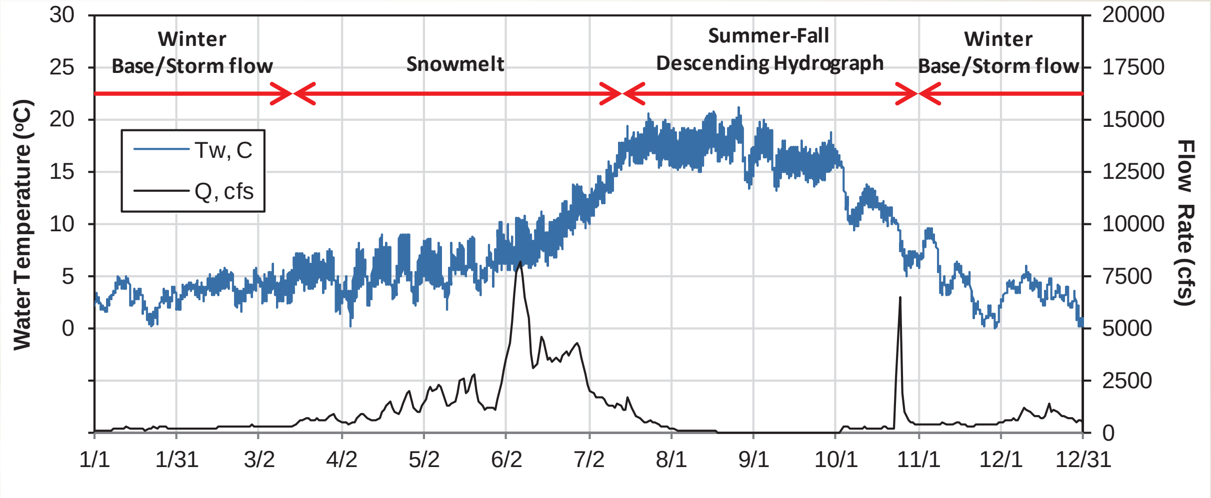
Water Temperature - Summary

- Potential modeling periods
  - June – October (critical)
  - Year-round potential
- Analysis – in progress
  - Key seasonal elements
  - Flow-temperature nexus
  - Critical periods



- Monitoring Recommendations
  - Comprehensive data set at basin scale (including tributaries)
  - Tributaries: two or three locations (initially two)
  - Flow *and* temperature at key tributary locations

Meteorology

- Several stations available in project area (CDEC):
  - CVM: CHERRY VALLEY MET STATION
  - SEW: SMITH PEAK RAWS
  - DDL: DUDLEYS (MCDIARMID FIRE STATION)
  - GIN: GIN FLAT
  - BKM: BUCK MEADOWS
  - JFR: JAWBONE LAVA FLAT RAWS
- Rim Fire destroyed long-term Buck Meadows site
- Stations of various duration, for various periods, and measured parameters
- Adopting HDR method consistent with long term data set completed under previous modeling work

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Meteorology

- HDR long-term data set determination (Don Pedro Reservoir)
- Adjusted vapor pressure terms a function of elevation and assumed lapse rate (6°C per 3,128 ft of elevation change)

Parameter	Unit	Source
Cloud Cover[1]	n/a	Calculated
Air Temperature[2]	deg C	Adjusted Stockton
Wet-Bulb Temperature[3]	deg C	Calculated
Barometric Pressure	mmHg	Adjusted Stockton
Wind Speed	m/s	Adjusted Stockton
Solar Radiation	w/m^2	Sacramento 1973-1990 and Modesto City AP 1991-2010 (both NREL Solar radiation data), 2010 to present – Oakdale CIMIS

[1] Cloud cover was estimated based on solar radiation.
[2] Air temperature was only available from the Stockton meteorological station. Air temperature to be adjusted to representative elevation using a lapse rate.
[3] Wet-bulb temperatures are calculated based on adjusted air temperature and relative humidity from Stockton.

Task 2: Monitoring

- Rationale
  - Space (locations)
  - Time (periods of interest)
- Summary of deployment
  - USFS special use permit
  - Access – whitewater boating and helicopter
  - Installation schedule

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Rationale

- System characterization – General
  - Thermal regime, flow conditions
  - Support modeling
- System characterization – Spatial/temporal
  - Spatial
    - Mainstem
    - Tributary
  - Temporal
    - Period of interest: late winter – late fall
    - Frequency: sub-daily (e.g., hourly)

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Proposed Monitoring Locations

	Logger Location	River Mile
Mainstem	TR above North Fork	TR 81.3
	TR near Indian Creek	TR 88.2
	TR above Clavey River	TR 91.1
	TR above South Fork	TR 97.0
	TR below Early Intake	TR 105.2
Tributaries	North Fork TR above TR	NF 0.1
	North Fork TR at RM8 Bridge	NF 8.0
	Clavey R. above TR	CR 0.1
	Clavey R. at Gage 11283500	CR 8.4
	South Fork TR above TR	SF 0.1
	Cherry Ck. above TR	CC 0.6
	Cherry Ck. above Powerhouse	CC 1.2
	Cherry Ck. below Eleanor Ck.	CC 7.1
	Cherry Ck. above Eleanor Ck.	CC 7.2
	Eleanor Ck. Above Cherry Ck.	EC 0.1

- 15 proposed locations
- Mainstem locations to record water temperature at 30-minute intervals
- Tributary locations to record water temperature and stage at 30-minute intervals

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Monitoring Equipment

- Hobo Pro V2 or TidBit loggers (+/- 0.2 °C) deployed at identified locations in a protective housing.
- Recorders are placed in the active channel and secured by a removable steel cable or chain tethered to a stable root mass, boulder, or man-made structure.

- Onset U20 level loggers installed to measure stage and temperature.
- Semi-permanent housings affixed to large boulders or bedrock to ensure the level logger does not move.
- A flow measurement will also be collected any location a stage recorder is installed or downloaded to develop a stage-discharge curve and continuous record.

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Site Access and Monitoring

Month	Vehicle / Hike Access	Helicopter / Boat Access
2015		
April / May (Installation)	X	X
June	X	--
July	--	--
August	X	X
September	--	--
October / November (removal or winter prep)	X	X
2016		
March / April (re-installation or first visit – flow dependent)	X	X
May	--	--
June	X	--
July	--	--
August	X	--
September	--	--
October / November (removal)	X	X

X = visit, -- = no visit

- 4 monitoring locations accessed by boat or helicopter
- 3 monitoring locations accessed by foot or helicopter (check Rim Fire conditions)
- 8 monitoring locations accessed by foot

*USFS SF-299 permit was approved on 4/22/15 for installations on Stanislaus Forest lands.

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Current Site Installations (as of 5/4/15)

Location	River Mile	Equipment	Coordinates	Notes
TR above North Fork	TR 81.3	1 water temp, 1 stage	37.896630 -120.252864	
TR above South Fork	TR 97.0	1 water temp, 1 stage, 2 barometric	37.84076 -120.04611	
TR below Early Intake	TR 105.2	2 water temp	37.87582 -119.9597	Flow from USGS
North Fork above TR	NF 0.1	2 stage	37.897235 -120.253729	
North Fork at RM8 Bridge	NF 8.0	2 stage	37.985196 -120.204608	
South Fork above TR	SF 0.1	2 stage	37.83870 -120.04852	
Cherry Creek above TR	CC 0.6	2 water temp	37.89253 -119.97121	Flow from USGS
Cherry Creek above HPH	CC 1.2	2 water temp	37.89395 -119.94917	Flow from USGS
Clavey River above TR	CR 0.1	1 stage	37.864518 -120.115802	Runoff too high to complete full install
Clavey River at USFS Bridge	CR 8.4	1 water temp	37.899398 -120.071984	Runoff too high to complete full install

Additional Work to be Completed

- Revisit Tuolumne River near Indian Creek (via Indian Creek trail) to redeploy water temperature loggers.
- Revisit two Clavey River locations to complete stage recorder installations and measure flow. Install stage recorder in Tuolumne River upstream of Clavey.
- Install stage recorder equipment at either the Cherry and Eleanor creeks confluence or at location of identified fish passage barrier.

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Additional Work to be Completed

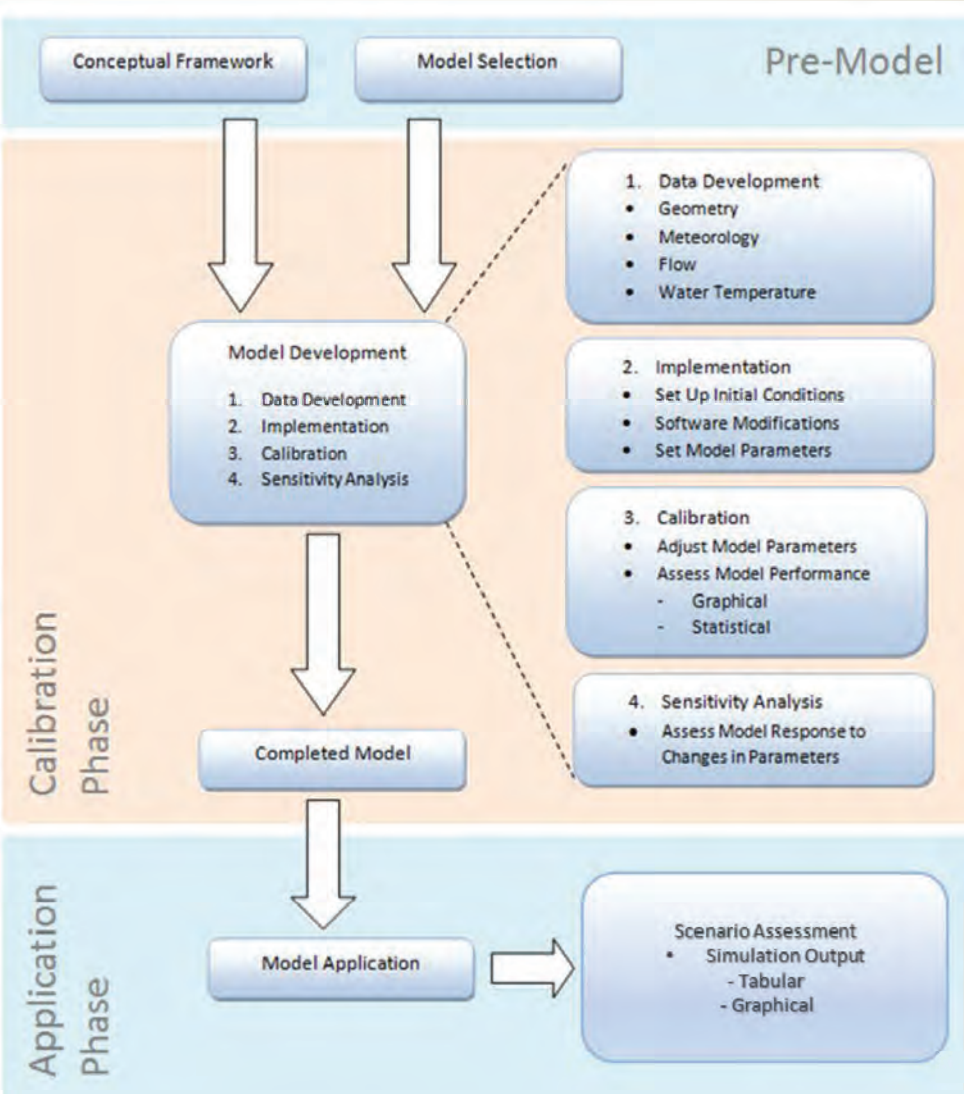
Potential Pool Stratification

- Assess potential pool stratification via temperature monitoring
- Identify one large pool in each tributary and 2-3 pools in mainstem
- Assess with handheld temperature device (e.g., profile)
- Deploy loggers near bottom and surface to identify cold water presence and persistence through time

TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

Water Temperature Modeling

- Model selection
- Data development
- Model calibration
- Model application



Model Selection Considerations

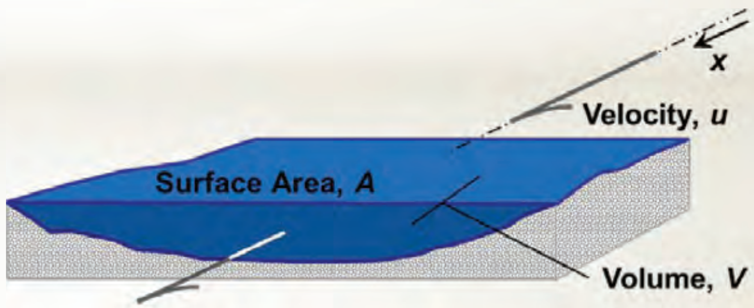
- System Characteristics
  - Steep channel gradient
  - Variable flow regime
  - Snowmelt hydrograph and thermal response
  - Low summer flows
  - Variable meteorology (spatial/temporal)
  - Topographic, riparian shade
- Previous model applications:
  - Upper Tuolumne River: Hetch Hetchy to Early Intake
  - Upper Tuolumne River: Without Dams Analysis – Tuolumne River above Hetch Hetchy to the San Joaquin River confluence
- RMA-2/RMA-11

RMA Models

- A suite of modeling software, RMA-2 (v8) for hydrodynamics and RMA-11 (v8) for water temperature, is proposed to represent the Upper Tuolumne River as a one-dimensional (laterally and depth averaged) finite element model
- RMAGEN (v74): geometry file software (to build river grid)
- RMA-2 (v8): hydrodynamic model that calculates velocity, water surface elevation, and depth at defined nodes of each grid element
- RMA-11 (v8): water quality model that uses the depth and velocity results from RMA-2 to solve advection diffusion constituent transport equations for temperature.

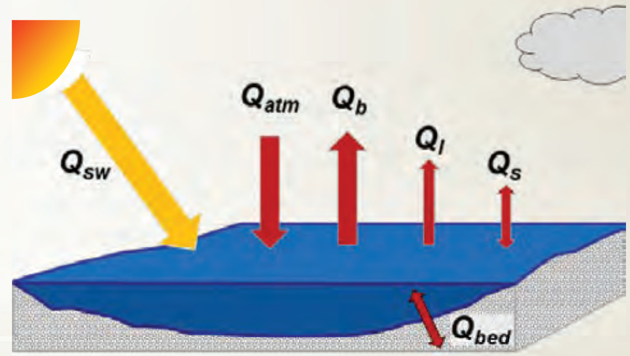
RMA-2: Hydrodynamics

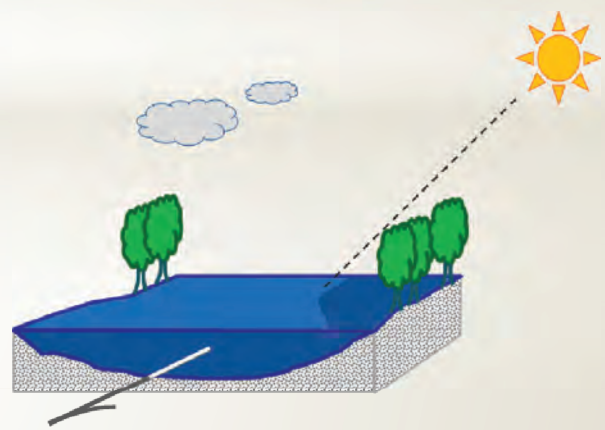
- Steady and unsteady (dynamic) flows can be analyzed (e.g., hydropower peaking) – solution of St Venant Equations
- Steep river reach capability
- Branching networks
- Low flow modeling ability
- Δt = 1 hr (maximum)
- Δx = 25-50 m (approximately)
- Open source code



RMA-11: Water Temperature

- Solves advection-dispersion equation
- Comprehensive heat budget
  - $Q_n = (Q_{sw} + Q_{atm} – Q_b – Q_l + Q_s) + Q_b$
- Bed Conduction
- Topographic shade
- Riparian Shade (tributaries)
- Capable of variable meteorology zones
- Δt = 1 hr (maximum)
- Δx = 25-50 m (approximately)
- Open source code





Stream Modeling

- Data needs
  - Geometry
  - Hydrology (time series)
  - Water temperature (time series)
  - Meteorological data (time series)

- Stream reaches
  - Tuolumne River mainstem: Early Intake to Don Pedro Reservoir
  - Cherry Creek: [TBD]
  - Clavey River: [TBD]
  - North Fork Tuolumne River: [TBD]

Stream Geometry

- Information needs:
  - Planform description of river (x-y information)
  - Longitudinal profile/bed slope
  - Channel cross sections
  - Riparian and topographic shade assumptions
- Data sources
  - LiDAR
  - DEMs
  - Previous studies (modeling, fisheries)
  - Other available information

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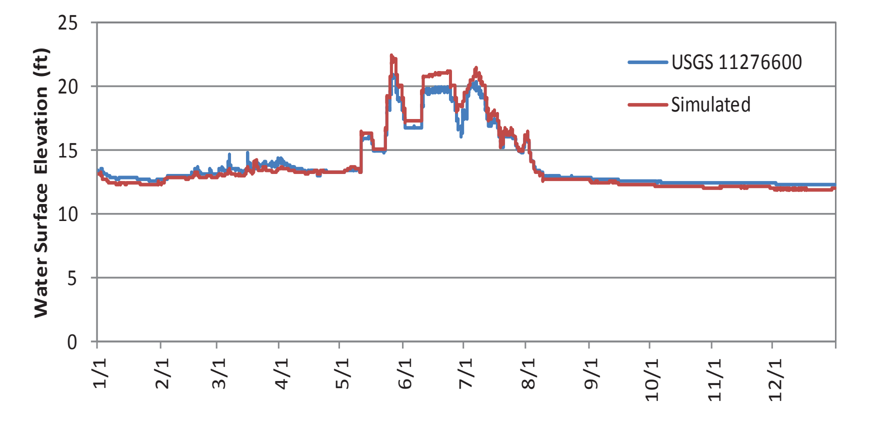
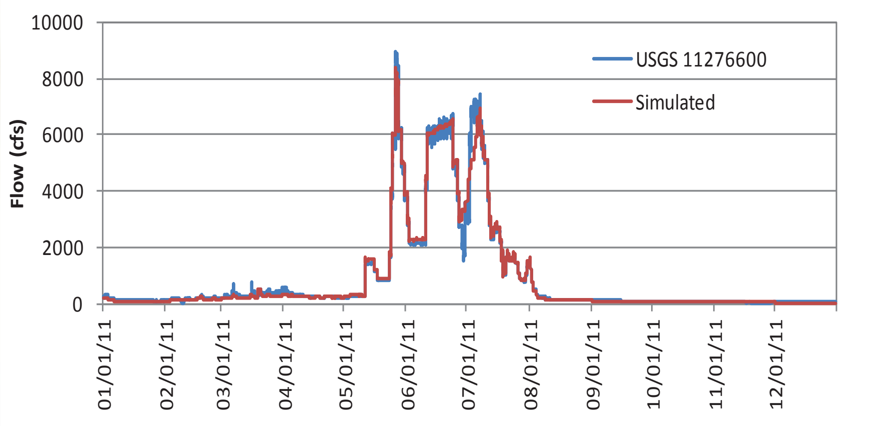
Hydrology

- Mainstem and tributary flows
  - Natural flow regimes (daily)
  - Hydropower peaking conditions (hourly)
- Accretions/depletions (calculated based on mass balance)
- Calibration data (within domain to test model)
  - Flow
  - Stage data (assess travel time (if multiple gages available))





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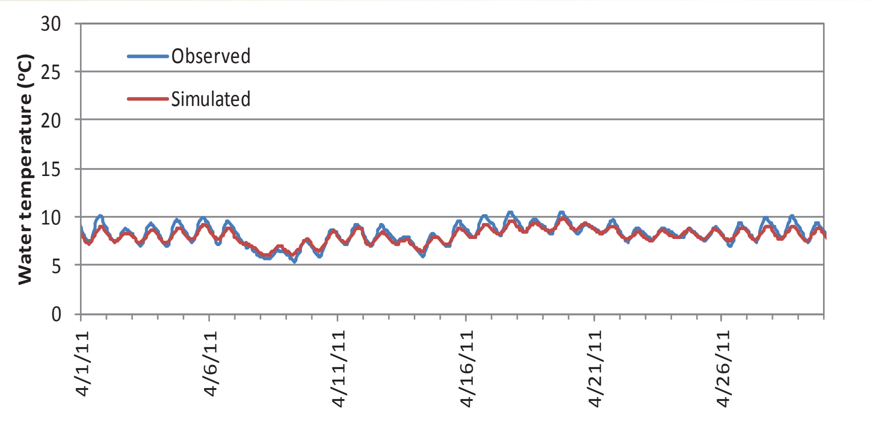
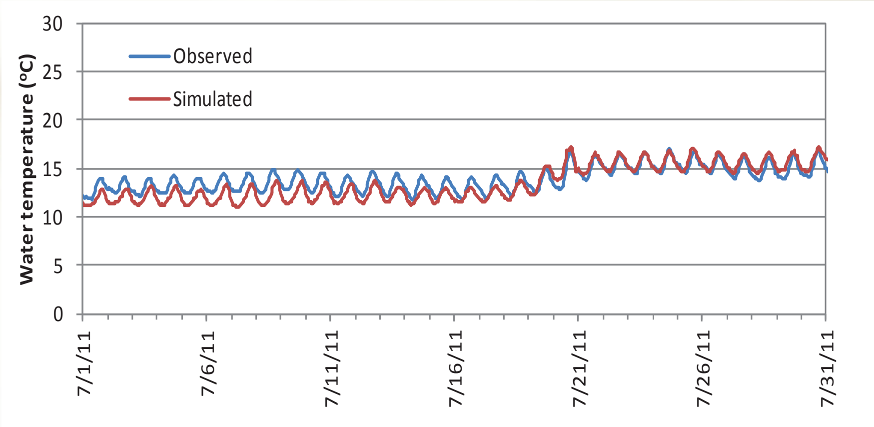
Water Temperature

- Mainstem and tributary inflow temperatures
  - Natural flow regimes (daily or hourly)
  - Hydropower peaking conditions (hourly)
- Accretions/depletions (daily, weekly, or at river temperature)
- Calibration data (within domain to test model)





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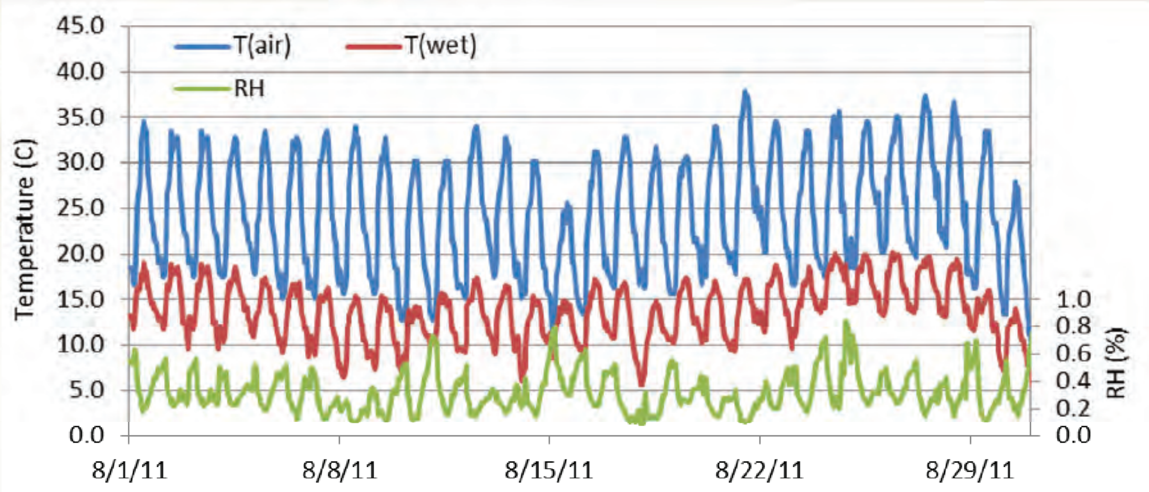
Meteorology

- Air temperature, Tair
- Relative Humidity, RH
- Dew point (calculate using Tair and RH) or wet bulb temperature
- Cloud cover (estimate or calculate)
- Atmospheric pressure (calculate)
- Wind speed
- Solar radiation



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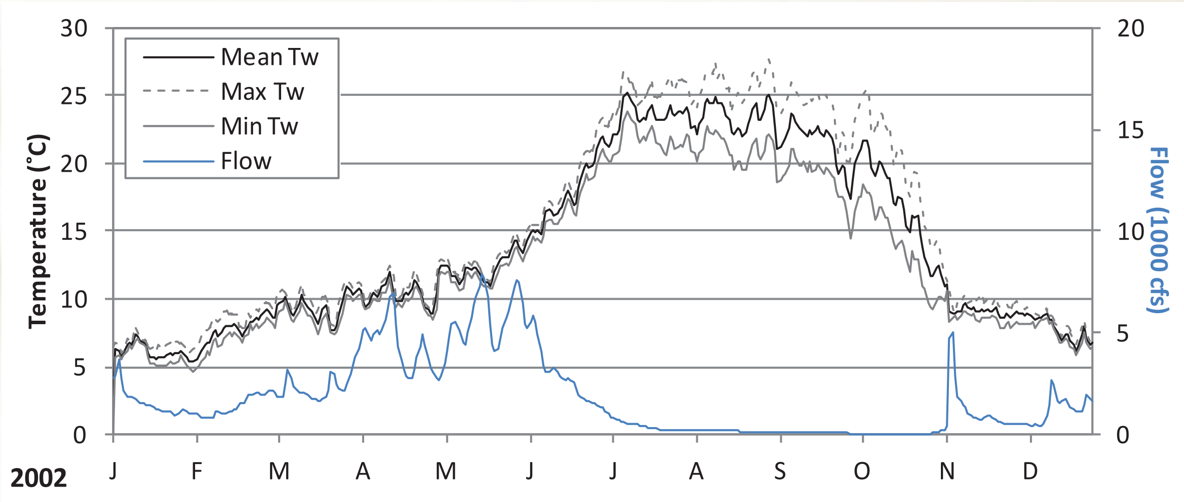
Model Implementation, Calibration, Application

- Implementation
- Calibration
    - Statistical performance
    - Graphical performance
  - Hydrology
    - Flow
    - Travel time
  - Water temperature
    - Temperature
- Application
  - Comparative analysis
  - Potential years are 2007 to present



Next Steps

- 2015
  - Data synthesis and assessment (May)
  - Continue with field monitoring (through October 2016)
  - Ongoing coordination with project team on temperature assessment questions as they relate to barrier assessment
- 2016
  - Initial Study Report (February)
  - Develop temperature model based on 2015-16 information (March – November)
- 2017
  - Updated Study Report (February)

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Questions or Comments?

Map Label	Agency	Active	Site_Locations
Tuolumne River - Mainstem			
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
TR081.9	NMFS	YES	Tuolumne R DS of Mohecan Br.
TR083.0	TID/MID	YES	Tuolumne River at Indian Creek Trail
TR088.1	UC Davis	NO	Tuolumne River, downstream of Indian Creek confluence
TR088.4	NMFS	YES	Tuolumne R DS of Grapevine Cr.
TR090.8	UC Davis	NO	Tuolumne River, downstream of Clavey Creek confluence
TR091.1	NMFS	YES	Tuolumne R US of Clavey R.
TR091.1	UC Davis	NO	Tuolumne River, upstream of Clavey Creek confluence
TR096.4	NMFS	YES	Tuolumne R DS of Lumsden Campgorund
TR096.5	CDFG	NO	Tuolumne River below the South Fork
TR097.0	CDFG	NO	Tuolumne River above the South Fork
TR097.1	CCSF	NO	Tuolumne River, upstream of South Fork
TR098.0	NMFS	YES	Tuolumne R DS of Lumsden Bridge
TR103.5	CCSF	NO	Tuolumne River, ds of Cherry Ck confluence (TR4)
TR103.7	CCSF	NO	Tuolumne River, ds of Cherry Ck confluence (TR3)
TR104.6	CCSF	NO	Tuolumne River, ds of Early Intake Diversion Dam
TR105.0	CDFG	NO	Tuolumne River at Early Intake
TR105.6	CCSF	NO	Tailrace of Kirkwood Powerhouse
TR109.3	CCSF	NO	Tuolumne River, downstream of Preston Falls
TR117.3	CCSF	NO	Tuolumne River, downstream of O'Shaughnessy
NF Tuolumne River			
NFT00.1	UC Davis	NO	North Fork Tuolumne above Tuolumne River
Clavey River			
CR00.1	NMFS	YES	Clavey R. just US of confluence
CR00.3	UC Davis	NO	Clavey River, upstream of Tuolumne River confluence
CR16.9	CCSF	NO	Clavey River at 1N04 Bridge
SF Tuolumne River			
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
Cherry Creek			
CC00.6	CDFG	NO	Cherry Creek Power House
CC01.2	CCSF	NO	Cherry Creek, upstream of Dion Holm Powerhouse
CC07.0	CCSF	NO	Cherry Creek, ds of confluence with Eleanor Creek
CC07.1	CCSF	NO	Cherry Creek, upstream of Eleanor Creek confluence
CC09.4	CCSF	NO	Cherry Creek, downstream of Cherry Dam
CC10.5	CCSF	NO	Cherry Creek, downstream of Cherry Dam
CC16.1	CCSF	NO	Upstream of Cherry Lake
Eleanor Creek			
EC00.0	CCSF	NO	Eleanor Creek, upstream of Cherry Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.8	CCSF	NO	Eleanor Creek, upstream of Miguel Creek confluence
MC00.0	CCSF	NO	Miguel Creek, upstream of Eleanor Creek confluence

2007

Map Label	Agency	J	F	M	A	M	J	J	A	S	O	N	D
TR078.5	USGS	*											
TR078.7	CDFG						5						
TR079.4	CCSF				6						1		
TR081.9	NMFS	*											
TR083.0	TID/MID												
TR088.1	UC Davis	*											
TR088.4	NMFS	*											
TR090.8	UC Davis	*											
TR091.1	NMFS	*											
TR091.1	UC Davis												
TR096.4	NMFS												
TR096.5	CDFG						21	22		21			
TR097.0	CDFG			30				22					
TR097.1	CCSF				6								
TR098.0	NMFS	*											
TR103.5	CCSF				8								
TR103.7	CCSF				8								
TR104.6	CCSF				8								
TR105.0	CDFG												
TR105.6	CCSF	*											
TR109.3	CCSF				5								
TR117.3	CCSF	*											
NFT00.1	UC Davis	*											
CR00.1	NMFS	*											
CR00.3	UC Davis												
CR16.9	CCSF				8								
SFT00.2	CDFG				7	18		16					
SFT00.2	CCSF				6								
SFT00.2	NMFS	*											
CC00.6	CDFG										16		
CC01.2	CCSF				8			30			30		
CC07.0	CCSF				7								
CC07.1	CCSF				7								
CC09.4	CCSF				8								
CC10.5	CCSF				7								
CC16.1	CCSF				7		25				30		
EC00.0	CCSF				7								
EC01.7	CCSF				7								
EC01.7	CCSF				7								
EC01.7	CCSF				7								
EC01.8	CCSF				7								
MC00.0	CCSF				7		5						

2008

Map Label	Agency	J	F	M	A	M	J	J	A	S	O	N	D
TR078.5	USGS												
TR078.7	CDFG												
TR079.4	CCSF							25					
TR081.9	NMFS												
TR083.0	TID/MID												
TR088.1	UC Davis												
TR088.4	NMFS												
TR090.8	UC Davis												
TR091.1	NMFS												
TR091.1	UC Davis												
TR096.4	NMFS												
TR096.5	CDFG	29											
TR097.0	CDFG												
TR097.1	CCSF												
TR098.0	NMFS												
TR103.5	CCSF												
TR103.7	CCSF												
TR104.6	CCSF												
TR105.0	CDFG					29	23						
TR105.6	CCSF												
TR109.3	CCSF												
TR117.3	CCSF												
NFT00.1	UC Davis												
CR00.1	NMFS												
CR00.3	UC Davis												
CR16.9	CCSF												
SFT00.2	CDFG							27					
SFT00.2	CCSF												
SFT00.2	NMFS												
CC00.6	CDFG	29					22	3			18		
CC01.2	CCSF				29								
CC07.0	CCSF												
CC07.1	CCSF												
CC09.4	CCSF												
CC10.5	CCSF												
CC16.1	CCSF									4			
EC00.0	CCSF												
EC01.7	CCSF												
EC01.7	CCSF												
EC01.7	CCSF												
EC01.8	CCSF												
MC00.0	CCSF									2			

2009

Map Label	Agency	J	F	M	A	M	J	J	A	S	O	N	D
TR078.5	USGS												
TR078.7	CDFG						20			22			
TR079.4	CCSF												
TR081.9	NMFS												
TR083.0	TID/MID												
TR088.1	UC Davis												
TR088.4	NMFS												
TR090.8	UC Davis												
TR091.1	NMFS												
TR091.1	UC Davis				6				28				
TR096.4	NMFS												
TR096.5	CDFG												
TR097.0	CDFG									22			
TR097.1	CCSF												
TR098.0	NMFS												
TR103.5	CCSF												
TR103.7	CCSF												
TR104.6	CCSF												
TR105.0	CDFG												
TR105.6	CCSF												
TR109.3	CCSF												
TR117.3	CCSF												
NFT00.1	UC Davis												
CR00.1	NMFS												
CR00.3	UC Davis				6				28				
CR16.9	CCSF												
SFT00.2	CDFG						19						
SFT00.2	CCSF											4	
SFT00.2	NMFS												
CC00.6	CDFG		23	7						9			
CC01.2	CCSF		27										
CC07.0	CCSF											2	29
CC07.1	CCSF											2	29
CC09.4	CCSF											4	
CC10.5	CCSF												
CC16.1	CCSF												
EC00.0	CCSF		3										30
EC01.7	CCSF											27	
EC01.7	CCSF												
EC01.7	CCSF											27	
EC01.8	CCSF											27	
MC00.0	CCSF											26	

2010

Map Label	Agency	J	F	M	A	M	J	J	A	S	O	N	D
TR078.5	USGS												
TR078.7	CDFG	18								7			
TR079.4	CCSF											15	
TR081.9	NMFS												
TR083.0	TID/MID												
TR088.1	UC Davis												
TR088.4	NMFS												
TR090.8	UC Davis												
TR091.1	NMFS												
TR091.1	UC Davis					7							
TR096.4	NMFS												
TR096.5	CDFG												
TR097.0	CDFG												
TR097.1	CCSF												
TR098.0	NMFS												
TR103.5	CCSF									14		21	
TR103.7	CCSF									13			
TR104.6	CCSF									13			
TR105.0	CDFG												
TR105.6	CCSF												
TR109.3	CCSF												
TR117.3	CCSF												
NFT00.1	UC Davis												
CR00.1	NMFS												
CR00.3	UC Davis												
CR16.9	CCSF										20		
SFT00.2	CDFG							27					
SFT00.2	CCSF												
SFT00.2	NMFS												
CC00.6	CDFG												
CC01.2	CCSF				29								
CC07.0	CCSF												
CC07.1	CCSF												
CC09.4	CCSF												
CC10.5	CCSF												
CC16.1	CCSF												
EC00.0	CCSF										21		
EC01.7	CCSF												
EC01.7	CCSF											18	
EC01.7	CCSF												
EC01.8	CCSF												
MC00.0	CCSF												

2011

Map Label	Agency	J	F	M	A	M	J	J	A	S	O	N	D
TR078.5	USGS												
TR078.7	CDFG								24				
TR079.4	CCSF										24		
TR081.9	NMFS												
TR083.0	TID/MID												
TR088.1	UC Davis												
TR088.4	NMFS												
TR090.8	UC Davis												
TR091.1	NMFS												
TR091.1	UC Davis												
TR096.4	NMFS												
TR096.5	CDFG												
TR097.0	CDFG												
TR097.1	CCSF												
TR098.0	NMFS												
TR103.5	CCSF										4		
TR103.7	CCSF												
TR104.6	CCSF												
TR105.0	CDFG												
TR105.6	CCSF												
TR109.3	CCSF												
TR117.3	CCSF												
NFT00.1	UC Davis												
CR00.1	NMFS												
CR00.3	UC Davis												
CR16.9	CCSF												
SFT00.2	CDFG							22		25	14		
SFT00.2	CCSF												
SFT00.2	NMFS												
CC00.6	CDFG		27									15	
CC01.2	CCSF										30		
CC07.0	CCSF												
CC07.1	CCSF												
CC09.4	CCSF										5		
CC10.5	CCSF												
CC16.1	CCSF												
EC00.0	CCSF											1	
EC01.7	CCSF												
EC01.7	CCSF										29		
EC01.7	CCSF												
EC01.8	CCSF												
MC00.0	CCSF												

2012

Map Label	Agency	J	F	M	A	M	J	J	A	S	O	N	D
TR078.5	USGS												
TR078.7	CDFG												
TR079.4	CCSF	16	15			11	10	14					
TR081.9	NMFS												
TR083.0	TID/MID												
TR088.1	UC Davis												
TR088.4	NMFS												
TR090.8	UC Davis												
TR091.1	NMFS												
TR091.1	UC Davis												
TR096.4	NMFS												
TR096.5	CDFG												
TR097.0	CDFG								6		6		
TR097.1	CCSF												
TR098.0	NMFS												
TR103.5	CCSF						5						
TR103.7	CCSF												
TR104.6	CCSF												
TR105.0	CDFG												
TR105.6	CCSF												
TR109.3	CCSF												
TR117.3	CCSF												
NFT00.1	UC Davis												
CR00.1	NMFS												
CR00.3	UC Davis												
CR16.9	CCSF												
SFT00.2	CDFG	17						29			26	1	
SFT00.2	CCSF												
SFT00.2	NMFS												
CC00.6	CDFG			25		19			26				
CC01.2	CCSF						12						
CC07.0	CCSF								14				
CC07.1	CCSF								14				
CC09.4	CCSF												
CC10.5	CCSF												
CC16.1	CCSF												
EC00.0	CCSF				25								
EC01.7	CCSF						5						
EC01.7	CCSF						5						
EC01.7	CCSF						5						
EC01.8	CCSF						5						
MC00.0	CCSF						5						

2013

Map Label	Agency	J	F	M	A	M	J	J	A	S	O	N	D
TR078.5	USGS												
TR078.7	CDFG												
TR079.4	CCSF	16					2						
TR081.9	NMFS												
TR083.0	TID/MID											26	
TR088.1	UC Davis												
TR088.4	NMFS												
TR090.8	UC Davis												
TR091.1	NMFS												
TR091.1	UC Davis												
TR096.4	NMFS												
TR096.5	CDFG								12				
TR097.0	CDFG								12				
TR097.1	CCSF				5								
TR098.0	NMFS												
TR103.5	CCSF												20
TR103.7	CCSF												
TR104.6	CCSF												
TR105.0	CDFG								23				
TR105.6	CCSF												
TR109.3	CCSF												
TR117.3	CCSF												
NFT00.1	UC Davis												
CR00.1	NMFS												
CR00.3	UC Davis												
CR16.9	CCSF												
SFT00.2	CDFG												
SFT00.2	CCSF												
SFT00.2	NMFS												
CC00.6	CDFG									23			
CC01.2	CCSF												
CC07.0	CCSF												
CC07.1	CCSF												
CC09.4	CCSF				5								
CC10.5	CCSF			29									
CC16.1	CCSF												
EC00.0	CCSF												
EC01.7	CCSF												
EC01.7	CCSF												
EC01.7	CCSF												
EC01.8	CCSF												
MC00.0	CCSF												

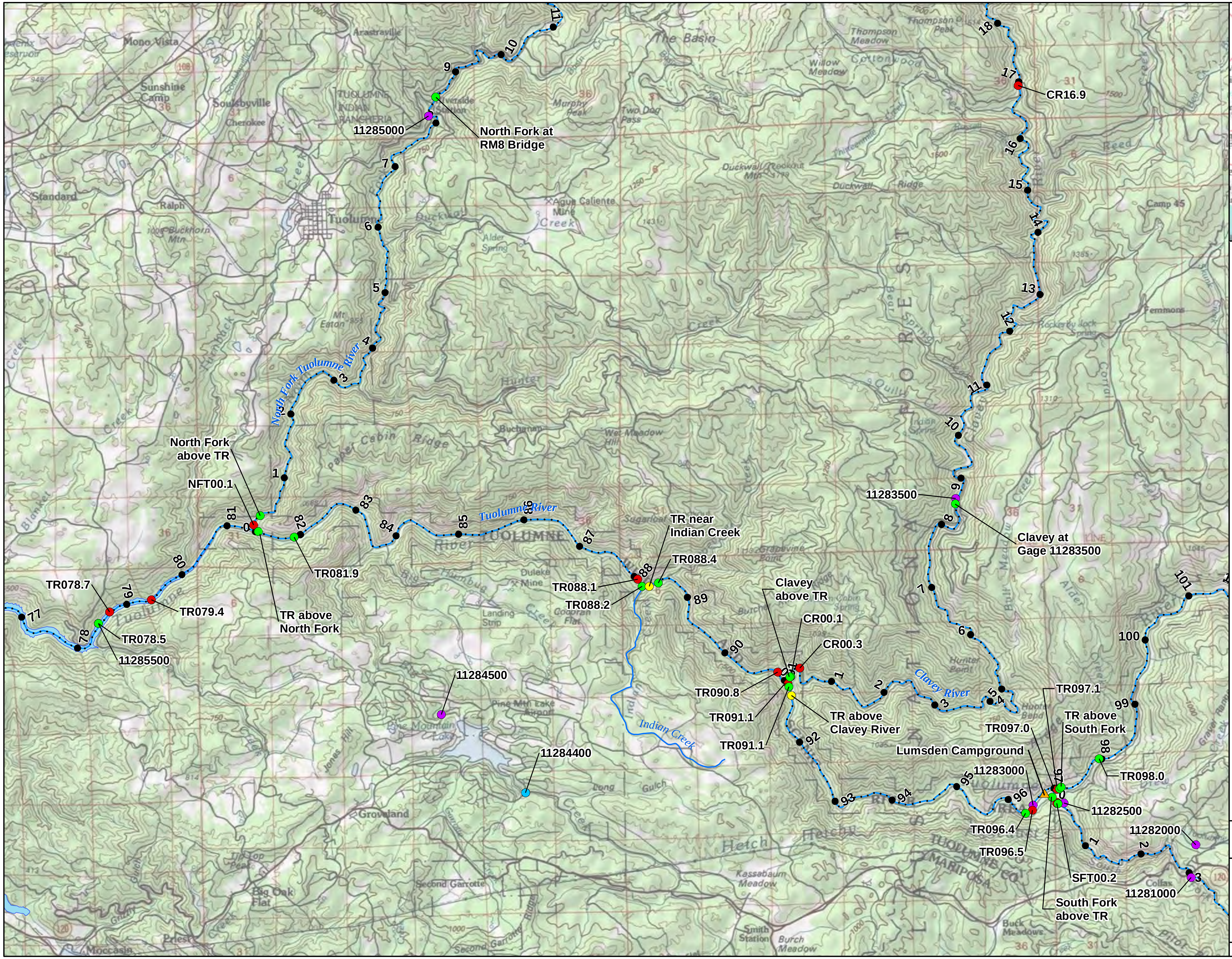
2014

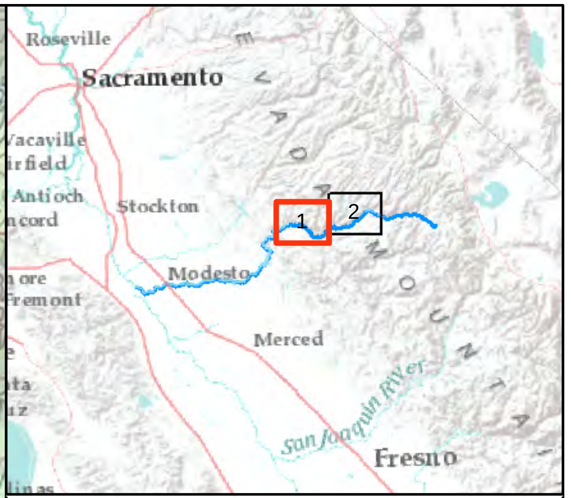
Map Label	Agency	J	F	M	A	M	J	J	A	S	O	N	D
TR078.5	USGS												
TR078.7	CDFG												
TR079.4	CCSF												
TR081.9	NMFS												
TR083.0	TID/MID												
TR088.1	UC Davis												
TR088.4	NMFS												
TR090.8	UC Davis												
TR091.1	NMFS												
TR091.1	UC Davis												
TR096.4	NMFS												
TR096.5	CDFG												
TR097.0	CDFG												
TR097.1	CCSF												
TR098.0	NMFS												
TR103.5	CCSF												
TR103.7	CCSF												
TR104.6	CCSF												
TR105.0	CDFG												
TR105.6	CCSF												
TR109.3	CCSF	14											
TR117.3	CCSF												
NFT00.1	UC Davis												
CR00.1	NMFS												
CR00.3	UC Davis												
CR16.9	CCSF												
SFT00.2	CDFG						12						
SFT00.2	CCSF												
SFT00.2	NMFS												
CC00.6	CDFG												
CC01.2	CCSF												
CC07.0	CCSF												
CC07.1	CCSF												
CC09.4	CCSF												
CC10.5	CCSF												
CC16.1	CCSF												
EC00.0	CCSF												
EC01.7	CCSF												
EC01.7	CCSF												
EC01.7	CCSF												
EC01.8	CCSF												
MC00.0	CCSF												

2015: no entries in any row for J, F, M, A.

* These data sets have been identified, but data have not been obtained and placed in data base at this time

Less than





Stream / Flow Gage

Active | Inactive

Label	Agency	Active	Site Name
11281000	USGS	Inactive	SF TUOLUMNE R NR OAKLAND RECREATION CAMP CA
11282000	USGS	Inactive	M 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
11284400	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 Campgorund
TR096.5	CDFG	NO	Tuolmune 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.

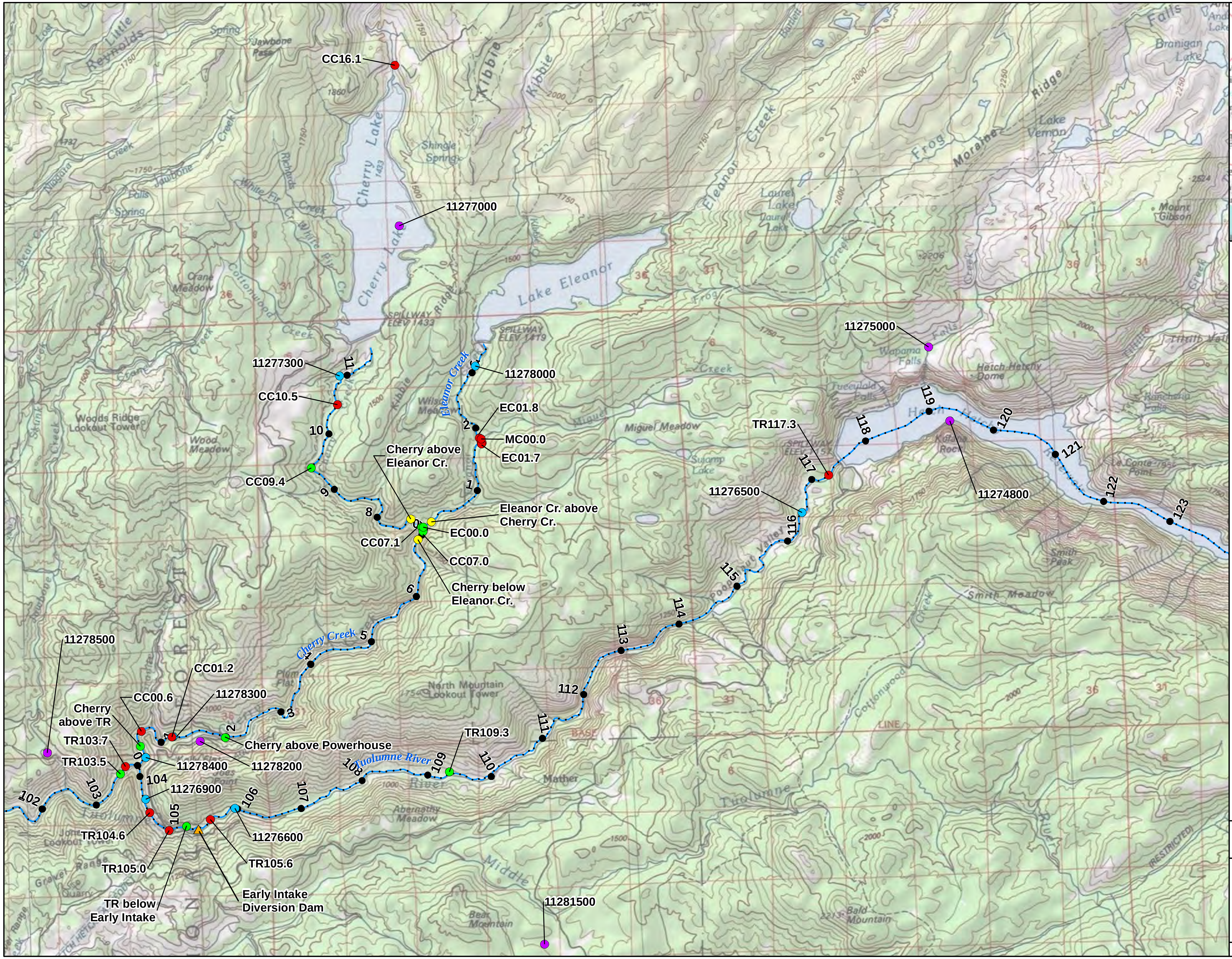
0 0.5 1 2 Miles

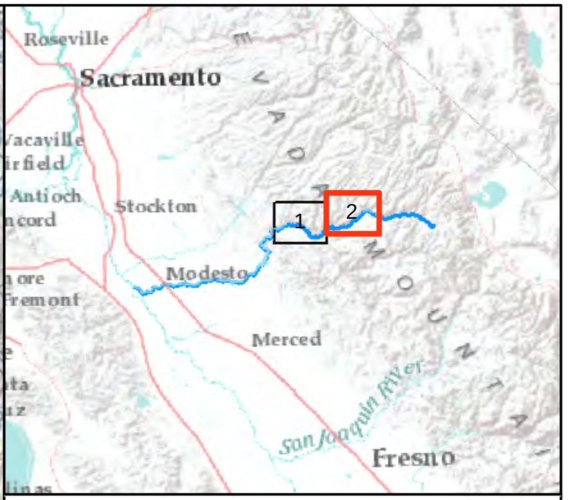
N

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

Sources: Esri, DeLorme, USGS, NPS
Sources: Esri, USGS, NOAA
Data is CA SPCS, Zone III, ft.





Stream / Flow Gage

● Active ● Inactive

Label	Agency	Active	Site Name
11274800	USGS	Inactive	TUOLUMNE R AT HETCH HETCHY NR SEQUOIA CA
11275000	USGS	Inactive	FALLS C NR HETCH HETCHY CA
11275500	USGS	Active	HETCH HETCHY RES A HETCH HETCHY CA
11276500	USGS	Active	TUOLUMNE R NR HETCH HETCHY CA
11276600	USGS	Active	TUOLUMNE R AB EARLY INTAKE NR MATHER CA
11276900	USGS	Active	TUOLUMNE R BL EARLY INTAKE NR MATHER CA
11277000	USGS	Inactive	CHERRY C NR HETCH HETCHY CA
11277200	USGS	Active	CHERRY LK NR HETCH HETCHY CA
11277300	USGS	Active	CHERRY C BL VALLEY DAM NR HETCH HETCHY CA
11277500	USGS	Active	LK ELEANOR NR HETCH HETCHY CA
11278000	USGS	Active	ELEANOR C NR HETCH HETCHY CA
11278200	USGS	Inactive	CHERRY C CN NR EARLY INTAKE CA
11278300	USGS	Active	CHERRY C NR EARLY INTAKE CA
11278400	USGS	Active	CHERRY C BL DION R HOLM PH, NR MATHER CA
11278500	USGS	Inactive	JAWBONE C NR TUOLUMNE CA
11281500	USGS	Inactive	M TUOLUMNE R NR MATHER CA

Water Temperature Logger

● Active ● Inactive ● Proposed*

Label	Agency	Active	Site Locations
CC00.6	TID/MID	YES	Cherry above TR
CC00.6	CDFG	NO	Cherry Creek Power House
CC01.2	CCSF	NO	Cherry Creek, upstream of Dion Holm Powerhouse
CC07.0	CCSF	YES	Cherry Creek, downstream of confluence with Eleanor Creek
CC07.1	CCSF	YES	Cherry Creek, upstream of Eleanor Creek confluence
CC09.4	CCSF	YES	Cherry Creek, downstream of Cherry Dam
CC01.2	TID/MID	YES	Cherry above Powerhouse
CC10.5	CCSF	NO	Cherry Creek, downstream of Cherry Dam
CC16.1	CCSF	NO	Upstream of Cherry Lake
EC00.0	CCSF	YES	Eleanor Creek, upstream of Cherry Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.8	CCSF	NO	Eleanor Creek, upstream of Miguel Creek confluence
MC00.0	CCSF	NO	Miguel Creek, upstream of Eleanor Creek confluence
TR103.5	CCSF	YES	Tuolumne River, downstream of Cherry Creek confluence
TR103.7	CCSF	NO	Tuolumne River, downstream of Cherry Creek confluence
TR104.6	CCSF	NO	Tuolumne River, downstream of Early Intake Diversion Dam
TR105.0	CDFG	NO	Tuolumne River at Early Intake
TR105.2	TID/MID	YES	TR below Early Intake
TR105.6	CCSF	NO	Tailrace of Kirkwood Powerhouse
TR109.3	CCSF	YES	Tuolumne River, downstream of Preston Falls
TR117.3	CCSF	NO	Tuolumne River, downstream of O'Shaughnessy Dam

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

0 0.5 1 2 Miles

N

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

Sources: Esri, DeLorme, USGS, NPS
Sources: Esri, USGS, NOAA
Data is CA SPCS, Zone III, ft.

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT
WORKSHOP NO. 1

MAY 20, 2015

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project Licensing (FERC No. 14581)
Fish Passage Assessment Workshop No. 1
Modesto Irrigation District
1231 11th 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. Edmonson 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. Edmonson 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. Garello'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. Garello 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. Garello 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. Garello 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. Garello 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. Garello 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. Garello agreed that water temperature would be among the issues requiring evaluation.

Referring to what Mr. Garello 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. Garello 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. Garello resumed his presentation. Mr. Garello 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. Garello noted that the 2015 Northwest Hydroelectric Association (NWHA) 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. Garello 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), 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 11th Street, Modesto, California
Conference Line: 1-866-994-6437, Passcode: 8140607
Join Lync Meeting https://meet.hdrinc.com/jesse.deason/8DZ4VNVN

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) a. Description of FERC study process, FPA and Section 18 Authority b. Section 18 Decision Framework and how/where an engineering feasibility of fish passage evaluation fits in c. Discussion of additional studies being undertaken (NMFS sponsored and Districts) that will support Section 18 Decision Process d. Discussion of NMFS' Recovery Plan and how it relates to the Tuolumne River
10:30 am – 11:15 am	Overview of the Tuolumne River Fish Passage Evaluation Framework (Districts) a. Review fish passage evaluation process b. Information needs and key resource considerations c. Available data, data gaps, and potential data sources
11:15 am – 11:45 am	Overview of Examples of Anadromous Fish Passage Facilities (Districts) a. Key fish passage considerations b. Upstream passage types and related facilities c. Downstream passage types and related facilities
11:45 am – 12:00 pm	Tuolumne River Passage Assessment Schedule and Next Steps (All) a. Schedule: Opportunities for collaboration and incorporation of feedback b. Workshops 2 and 3 – confirm dates and content

Modesto Irrigation District

La Grange Fish Passage Workshop No. 1

Wednesday, May 20, 2015

9:00 a.m. – 12:00 p.m.

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PLEASE SIGN IN

	Name	Organization	Telephone No.	E-mail	Time In	Time Out
1.	Amanda Theis	Turlock Chamber of Commerce			8:45a	
2.	Mario Moreno	LCR			8:45	
3.	Alison McNally	CSU Stanislaus			8:49	
4.	Ronald Yoshiyama	San Francisco			8:49	
5.	Daniel Richardson	Tuolumne County CAO			8:51	
6.	Zac Jackson	USFWS			8:53	
7.	Jake Oosterman	WUD			8:57	
8.	Bob Hackamack	TRT			855	
9.	Jean					
10.	Allison Boucher	TR Conservancy		rland.com	9:00	
11.	John Wooster	NMFS			9:00	
12.	John Henderson	U.S. Fish & Wildlife Svc			9:00a	

MID
Modesto Irrigation District

La Grange Fish Passage
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Wednesday, May 20, 2015
9:00 a.m. – 12:00 p.m.

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	Name	Organization	Telephone No.	E-mail	Time In	Time Out
13.	Theresa Simsiman	AW			8:45	
14.	Alfred Souza	Y.F.C.			8:46	
15.	Gretchen Murphey	CDFW			0845 ca.gov	
16.	William Sears	SFPUC			8:45	
17.	Brandon McMillan	TurlockCityNews.com			8:50	
18.	Josh Weimer	TID			8:55	
19.	Dave Boucher	Tuolumne Conservancy			855	
20.	Tom Holley	NMFS			855	
21.	Calvin Curtin	TID			8:55	
22.	Peter Barnes	SWRCB			8:55	
23.	Paul Zeek	Asm. Kristin Olsen			9:00	
24.	Peter Drekmeier	TRT			9:00	

Modesto Irrigation District

La Grange Fish Passage
Workshop No. 1
Wednesday, May 20, 2015
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	Name	Organization	Telephone No.	E-mail	Time In	Time Out
25 ~~37.~~	Chris Shutes	CSPA	(		9	
26 ~~38.~~	Jim Alves	City of Modesto			9	
27 ~~39.~~	[illegible signature]	Self			9	
28 ~~40.~~	Rotimi Odeh	CSU Stanislaus			9:00	
29 ~~41.~~	John Holland	Modesto Bee			9	
30 ~~42.~~	Patrick Koepele	TRT				
31 ~~43.~~	Dan Freeman	CCSF		org		
32 ~~44.~~	Rey Campurner	Alliance	(	ance.com		
33 ~~45.~~	Jim McJeth	Sierra Pacific	(		9:10	
34 ~~46.~~	Steve Edmonds	NMFS			9:10	
35 ~~47.~~						
36 ~~48.~~						

Modesto Irrigation District

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

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PLEASE SIGN IN

		Name	Organization	Telephone No.	E-mail	Time In	Time Out
37	~~25.~~	DAVE SIGOUR	TID DPRA			9:09	
38	~~26.~~	John Shelton	DFW			[illegible]	
39	~~27.~~	Kob GRASSO	Yosemite NP			9:43	
40	~~28.~~	Dr Dow Swatman	Public			9-45	
41	~~29.~~	Leonard Van Elderen	Yosemite Farm Cred			10:0	
42	~~30.~~	Helen Condit	Senator Cannella		.ca.gov	1pm	
43	~~31.~~						
44	~~32.~~						
45	~~33.~~						
46	~~34.~~						
47	~~35.~~						
48	~~36.~~						

Turlock Irrigation District | Modesto Irrigation District

La Grange Hydroelectric Project FERC No. 14581

Fish Passage Assessment - Concept Level Passage Alternatives Workshop #1

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

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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

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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

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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

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

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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.

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)].

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

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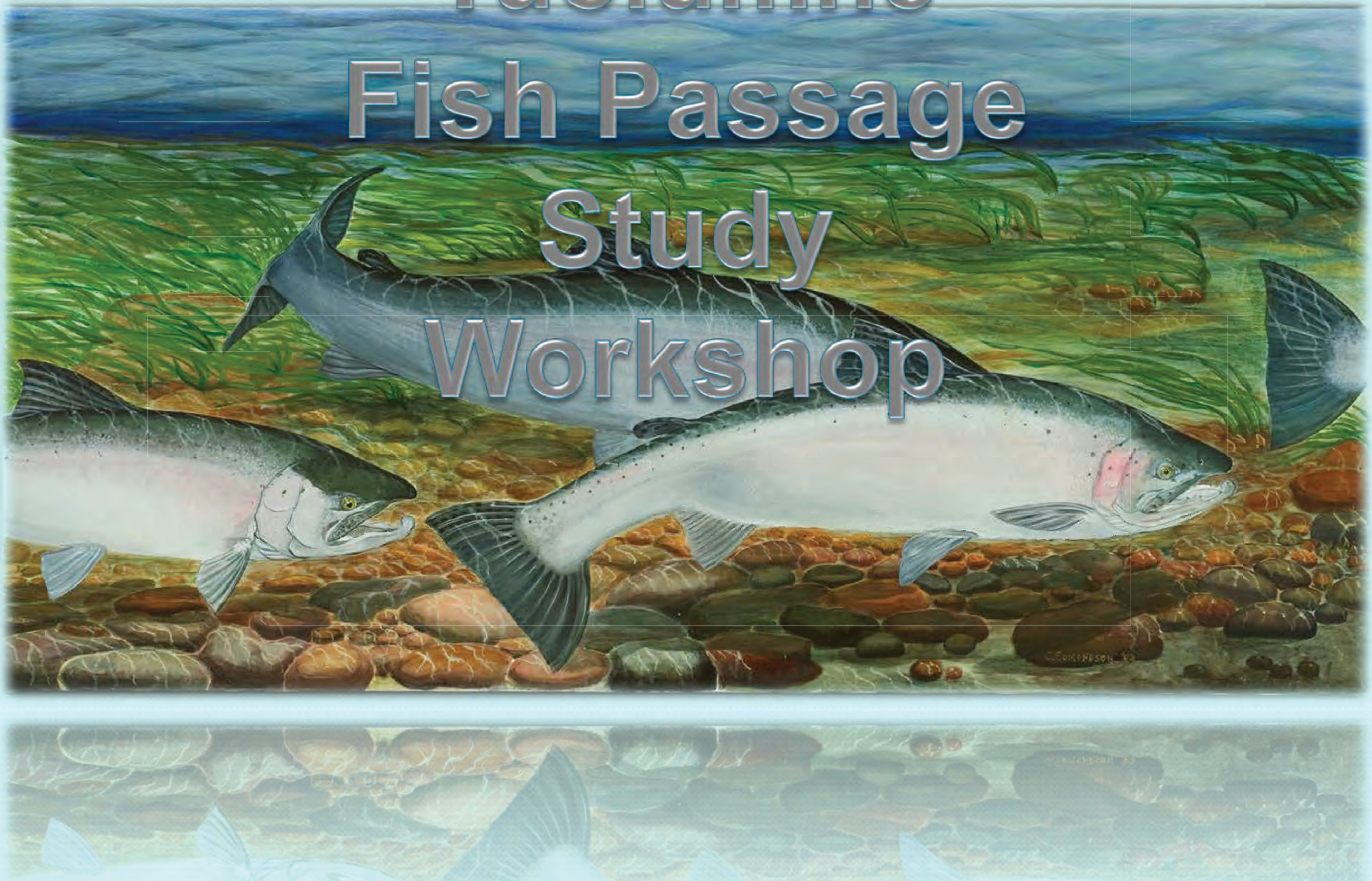
Workshop #1 Agenda

- 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

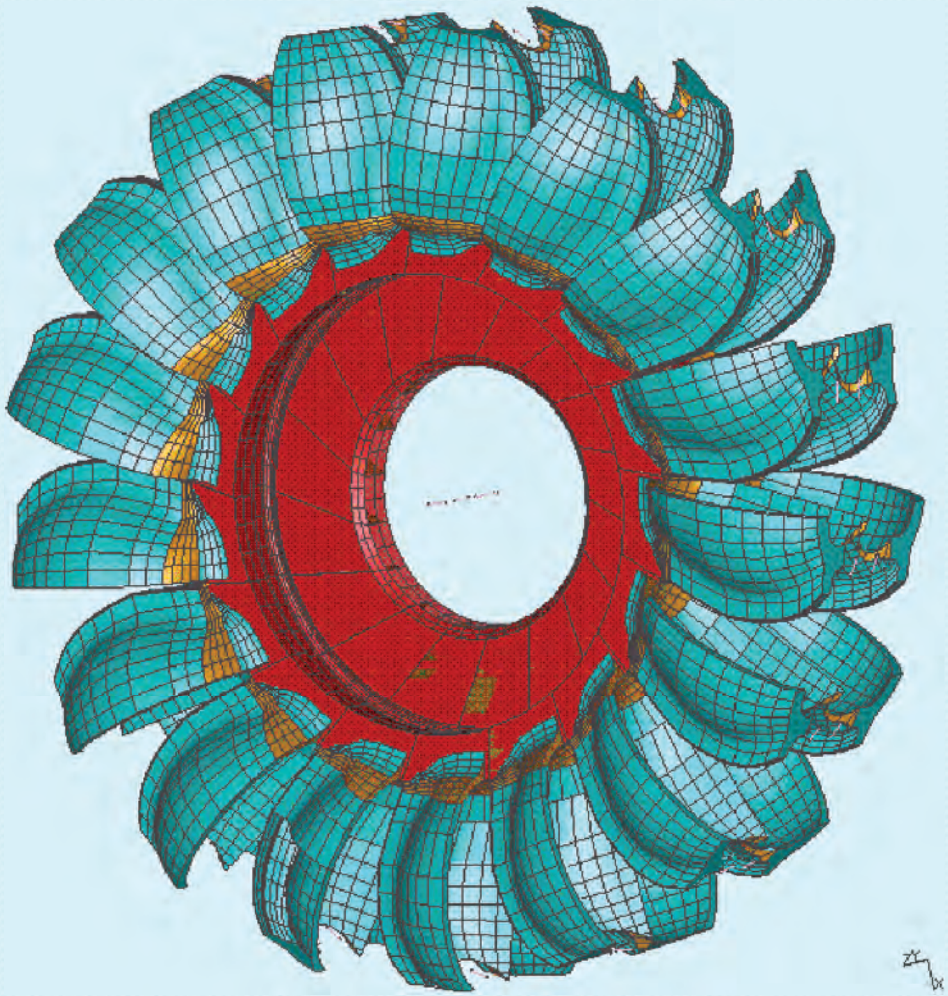
- <u>**Before passage of the Federal Water Power Act in 1920, developers needed a special act of Congress to build and operate a hydroelectric power plant on navigable streams, or federal lands.**</u>
- **Congress had authorized construction of the first hydroelectric project in 1884.**
- **Demand for 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

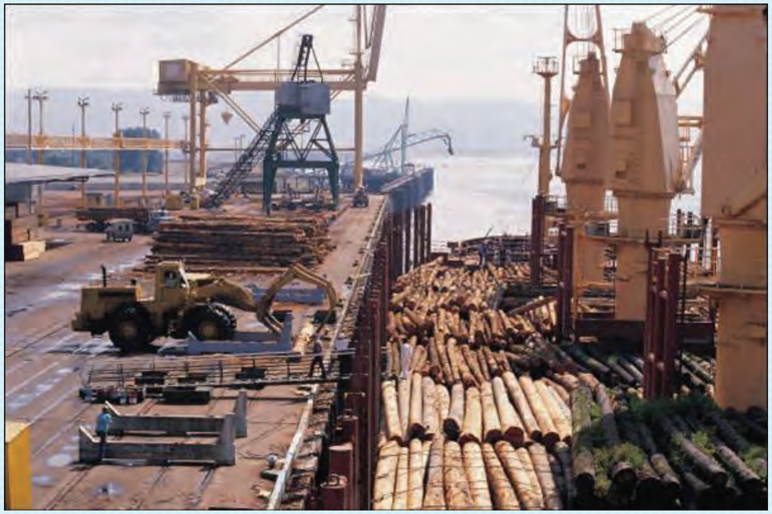
FERC Requires Studies to understand Project impacts on Developmental and non-Developmental Resources



Project Effects on Non-Developmental Resources

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

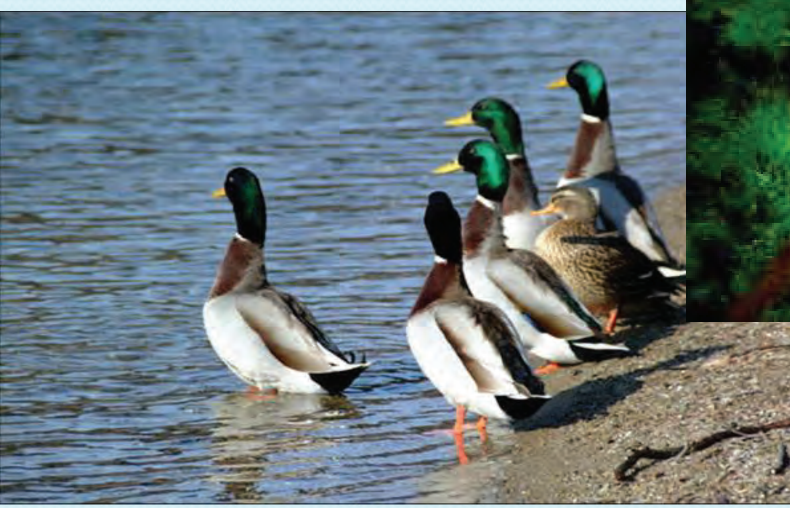
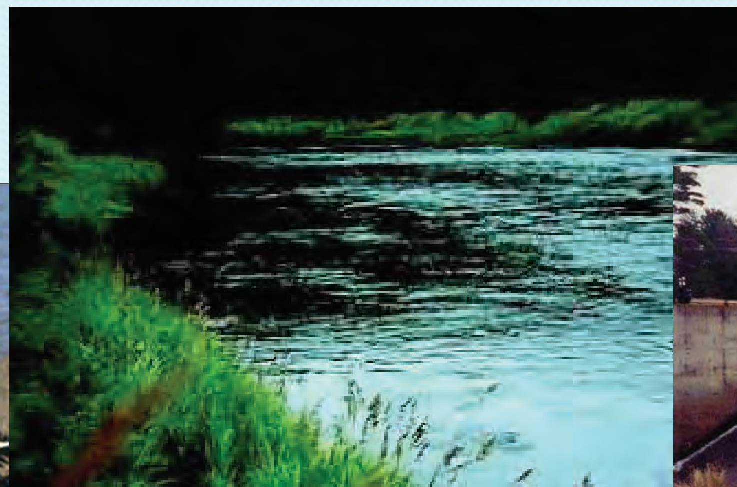
Developmental Resources



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

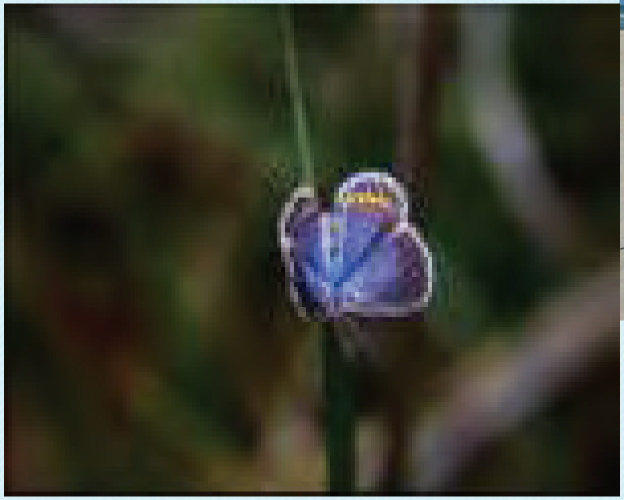
FERC's Study Needs - Licensing

- 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

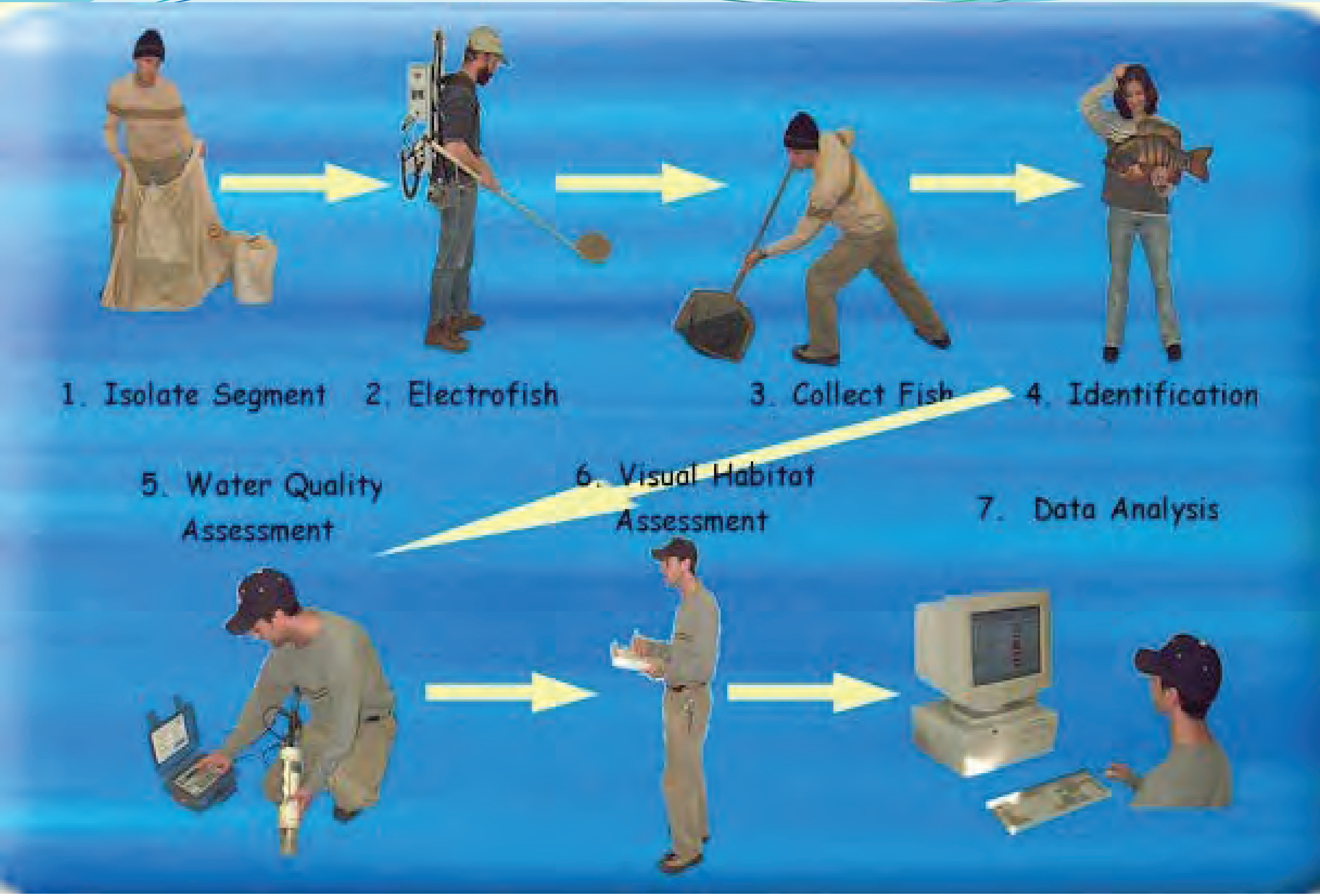
IN FERC RELICENSING

Recommending Studies to Support Licensing

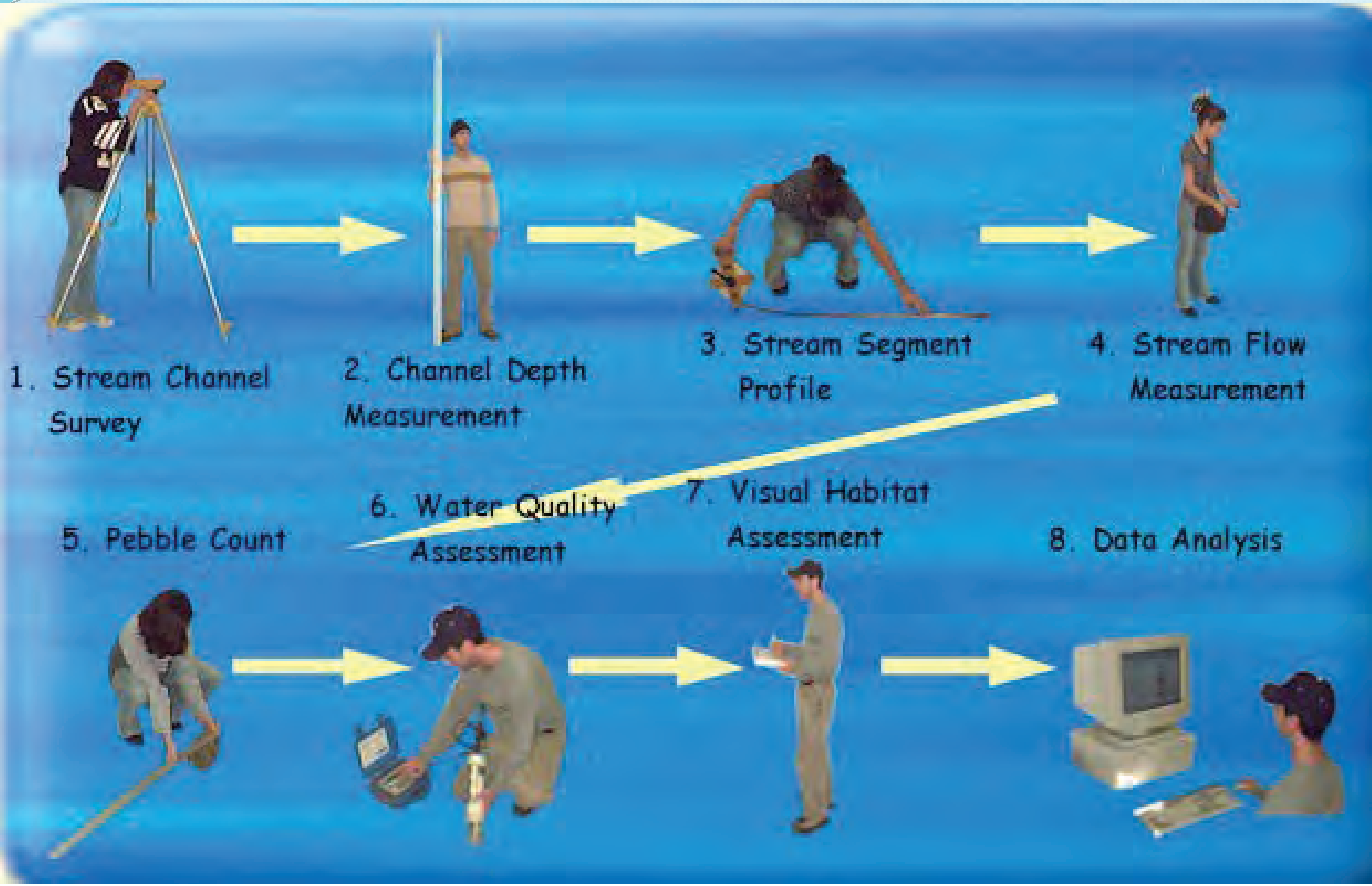
Under §§ 14 and 15 of the FPA, FERC must make the same inquiries in a relicensing proceeding as in an initial licensing determination and there is no question that fishery protection is among the licensing issues that must be addressed when evaluating all beneficial water uses as required by § 10(a) 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 (citing16 U.S.C. § 803 (a) and Udall v. FPC, 387 U.S. 428, 440, 450 (1967)).

FISHERIES ASSESSMENT

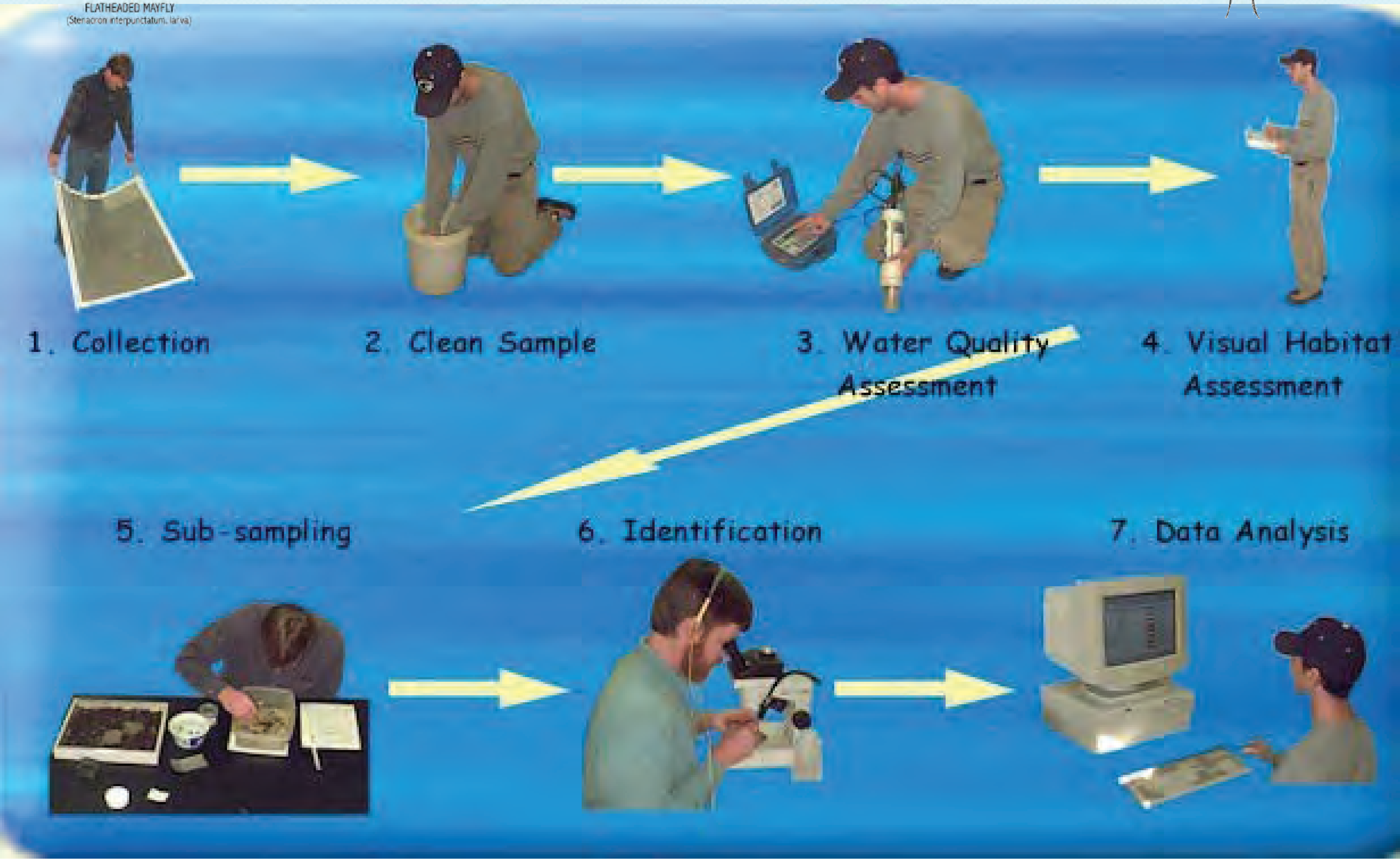


PHYSICAL HABITAT ASSESSMENT

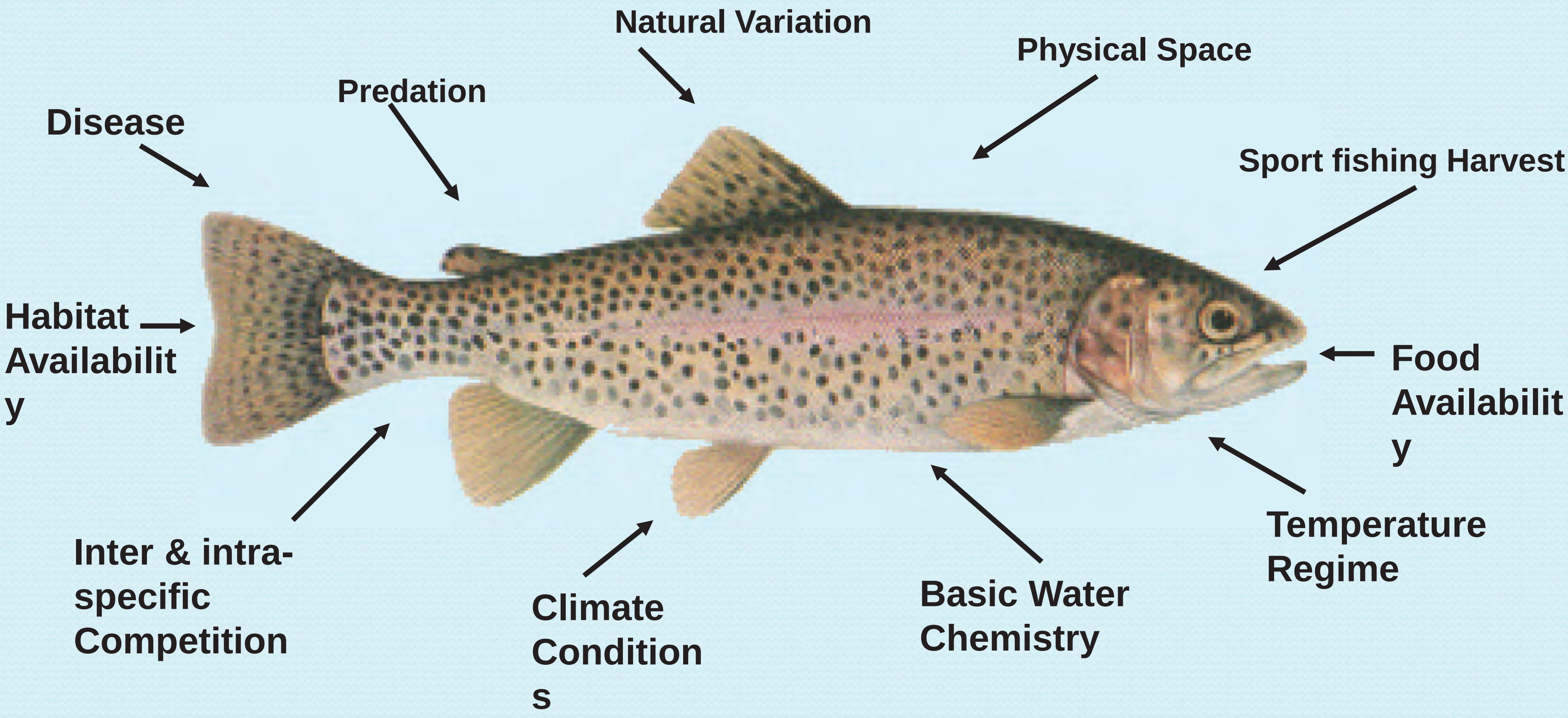


STREAM MACROINVERTEBRATES AS STREAM HEALTH INDICATORS

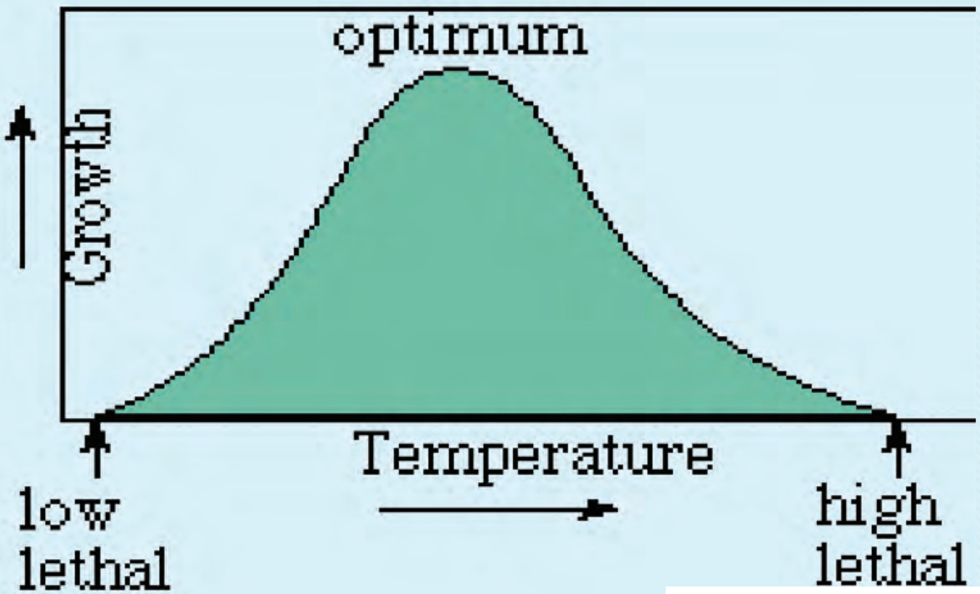
FLATHEADED MAYFLY
(Stenacron interpunctatum, larva)



UNDERSTANDING THE ECOLOGICAL FACTORS



WATER TEMPERATURE MANAGEMENT AND THE HEALTH OF AQUATIC ORGANISMS



WATER TEMPERATURE DATA LOGGER

TROUT ACTIVITY AND WATER TEMPERATURE

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

Preferred Range (65°–50°)

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

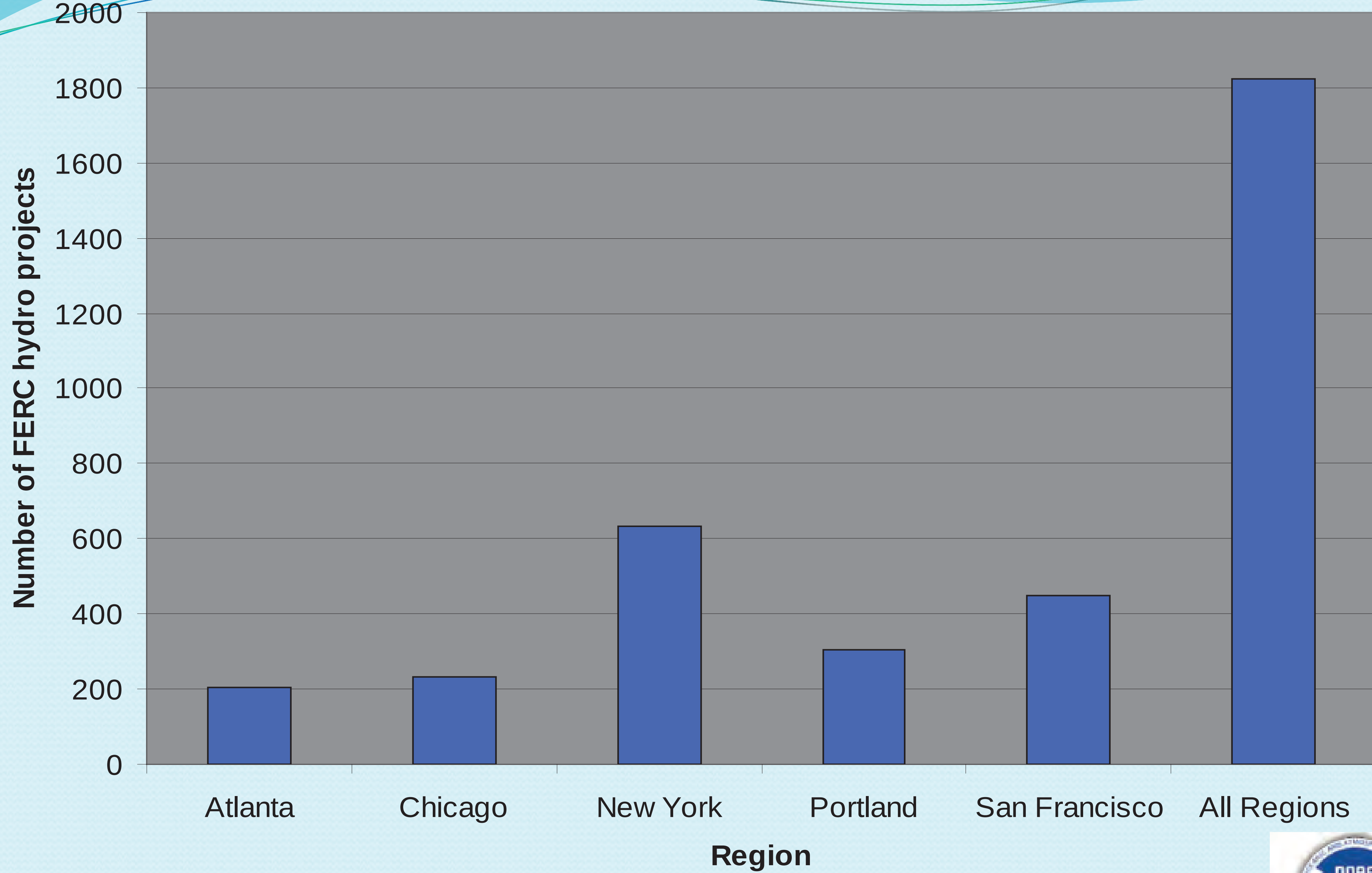
- Basin Plan Beneficial Uses and Objectives
- Historical data-Background water quality
- Current water quality with project (project related impairment)
- Controllable Factors

WATERSHED SCALE ISSUES

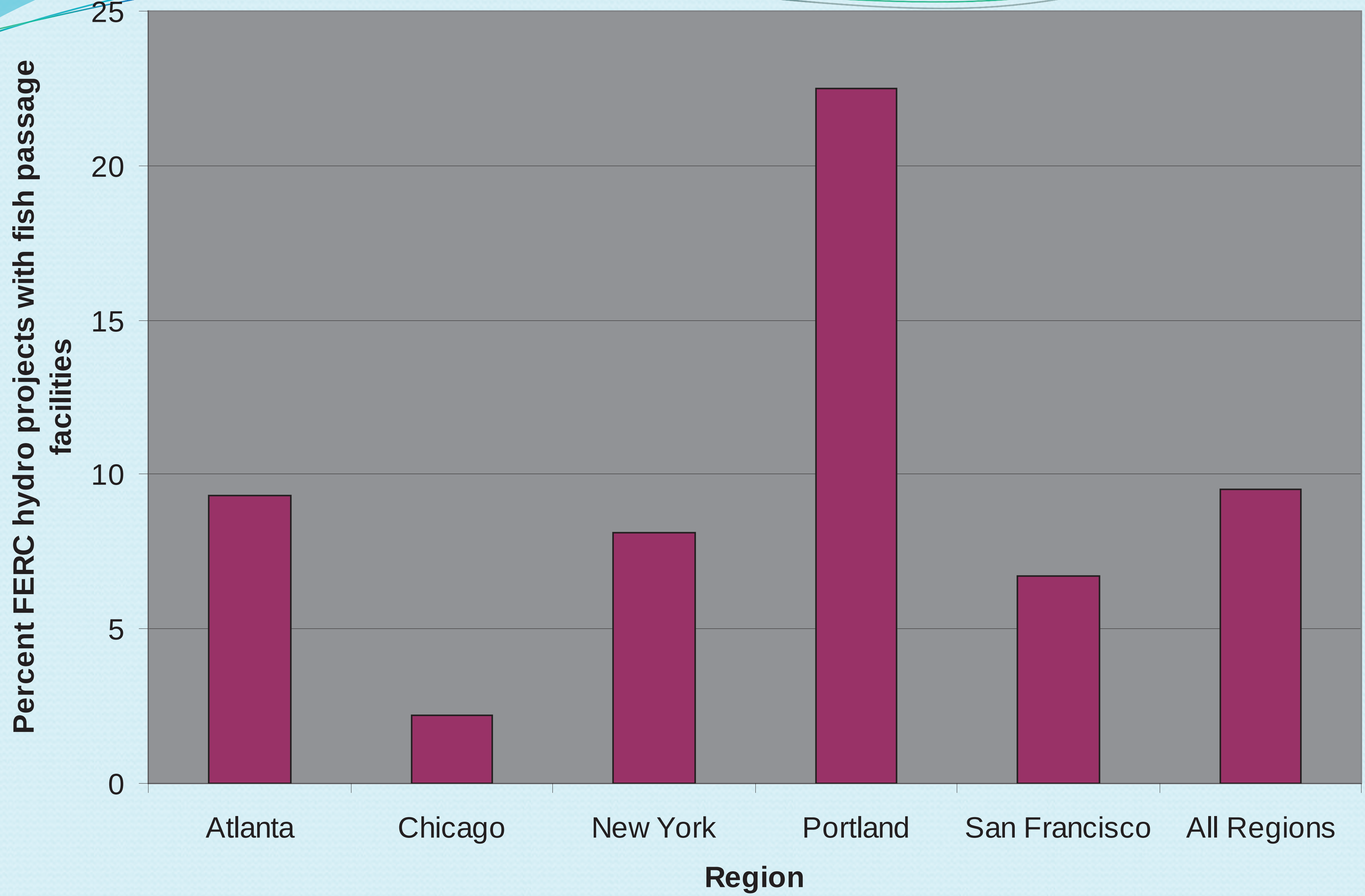
- Land Management Practices (historic and current)
- Multiple Licensees vs Coordinated Watershed Operations

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

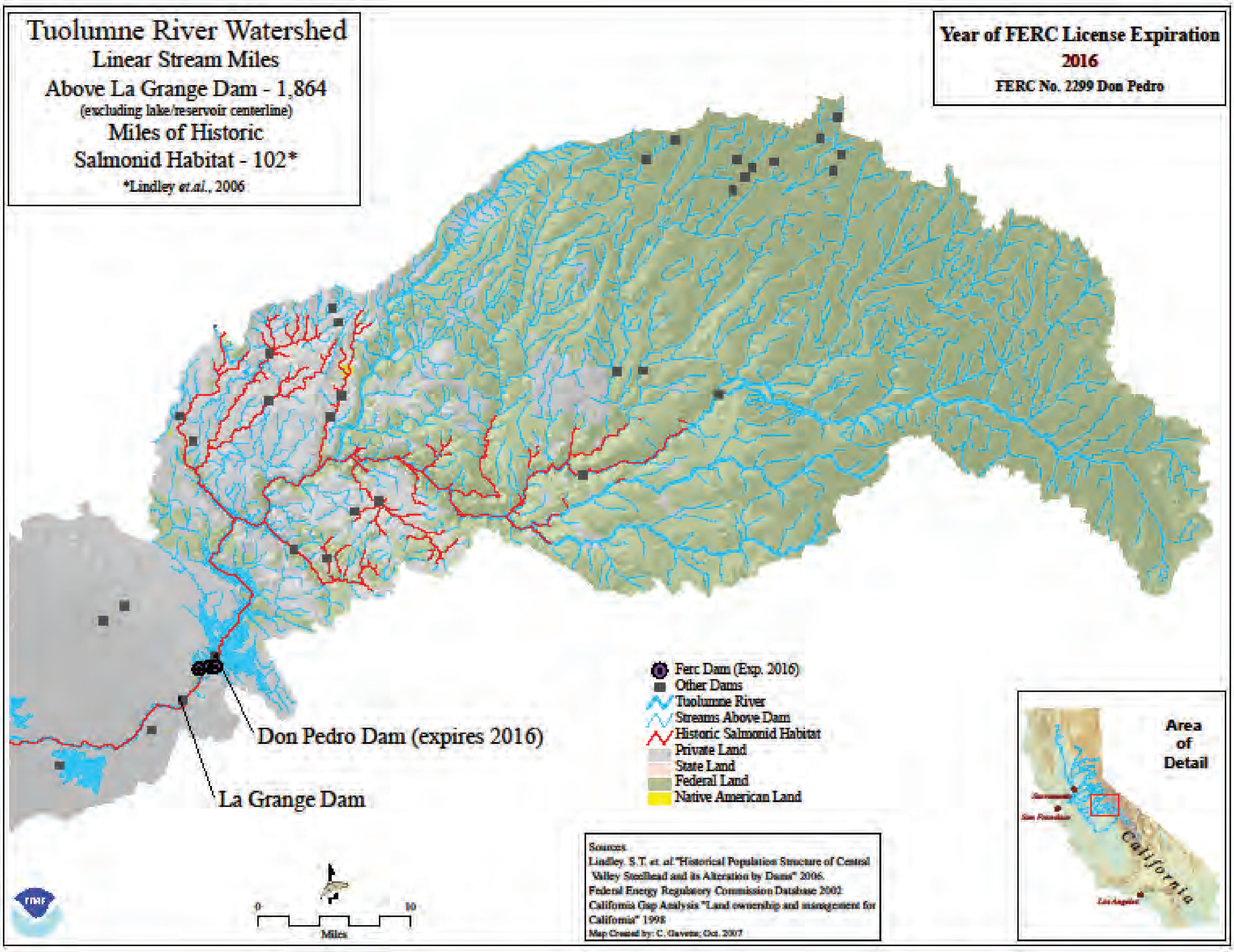


NMFS-SWR
Habitat Conservation Division



Percent FERC hydro projects with fish passage facilities
25
20
15
10
5
0
Atlanta
Chicago
New York
Portland
San Francisco
All Regions
Region

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
Don Pedro Dam (expires 2016)
La Grange Dam
Ferc Dam (Exp. 2016)
Other Dams
Tuolumne River
Streams Above Dam
Historic Salmonid Habitat
Private Land
State Land
Federal Land
Native American Land
Area of Detail
California
Sources
Lindley, S.T. et. al."Historical Population Structure of Central Valley Steelhead and its Alteration by Dams" 2006.
Federal Energy Regulatory Commission Database 2002
California Gap Analysis "Land ownership and management for California" 1998
Map Created by: C. Gavette; Oct. 2007
0
10
Miles

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

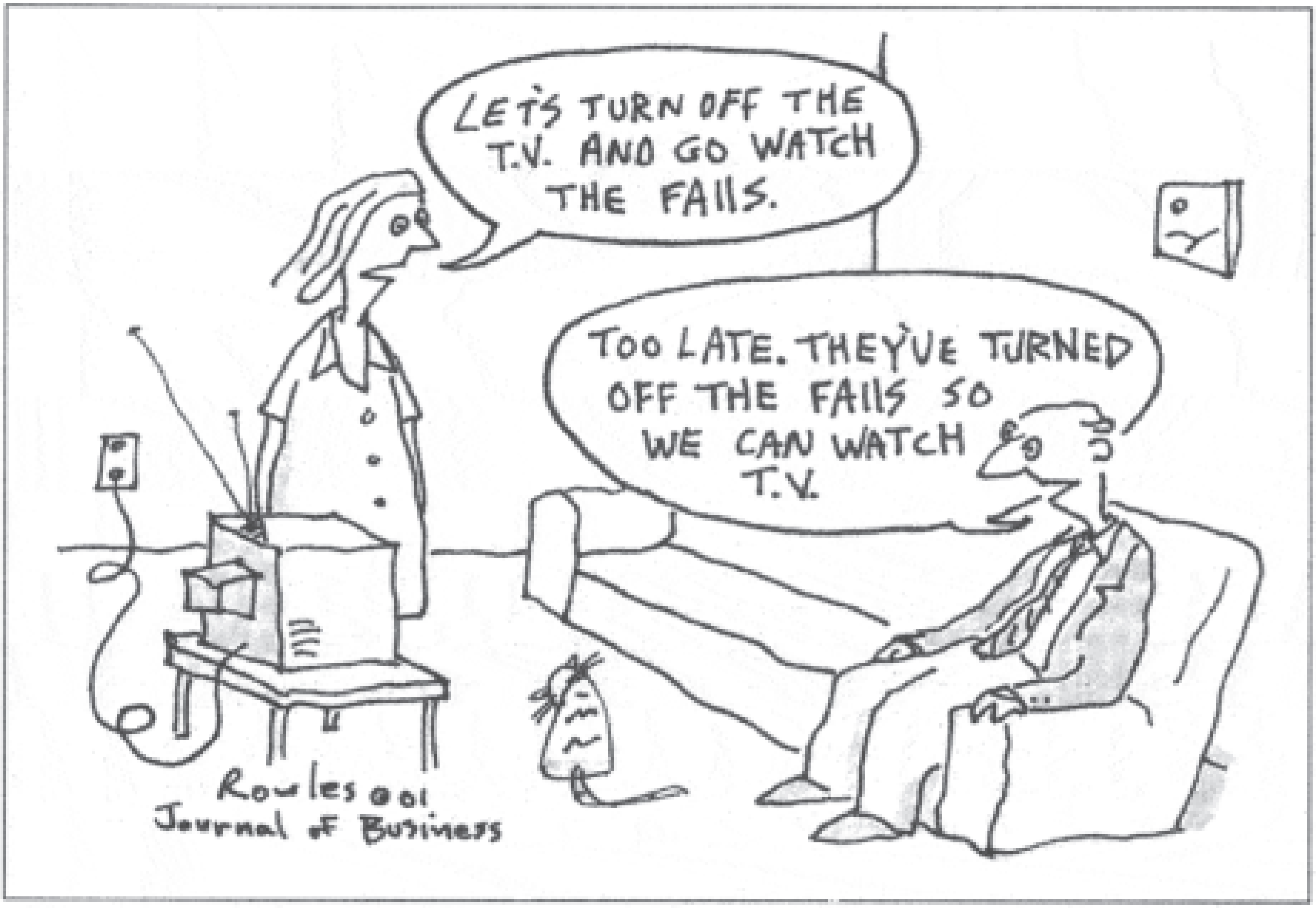
Downstream

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)


LET'S TURN OFF THE T.V. AND GO WATCH THE FALLS.
TOO LATE. THEY'VE TURNED OFF THE FALLS SO WE CAN WATCH T.V.
Rowles ©01 Journal of Business

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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

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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)

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.

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)

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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.

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General Life Cycle Considerations

Downstream Habitat

Juvenile Downstream Migration
- Trap and Haul
- Volitional Passage

Adult Migration
- Flow/Depth
- Temperature
- Barriers/Impediments
- Harvest

Adult Upstream Migration
- Trap and Haul
- Volitional Passage
- Barriers/Impediments

Upstream Habitat (Reintroduction Area)

Adult Holding Habitat
- Area
- Depth
- Temperature
- Density (capacity)
- Harvest

Spawning/Egg Incubation
- Flow/Depth/Flow Fluctuations
- Redd Dewatering
- Velocity
- Dissolved Oxygen
- Spawning Gravel
- Temperature
- Density (capacity)

Fry Emergence/ Rearing
- Flow/Depth/Flow Fluctuations
- Stranding
- Velocity
- Cover
- Temperature
- Prey Base
- Predators
- Dissolved Oxygen
- Density (capacity)

Juvenile Rearing
- Flow/Depth/Flow Fluctuations
- Stranding
- Velocity
- Cover
- Temperature
- Prey Base
- Predators
- Dissolved Oxygen
- Density (capacity)

Juvenile Migration
- Flow/Depth
- Velocity
- Cover
- Temperature
- Predation
- Barriers/Impediments

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Information Needs Specific to the Tuolumne River

Information Needs	Lead Entity	Schedule
Genetics Testing (*o. mykiss*)	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
Habitat Suitability Studies		
• 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

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Information Needs Specific to the Tuolumne River

Information Needs		Lead Entity	Schedule
Recolonization Strategy • Source population (genetics/ecology) • Passive or active reintroduction	• Disease • Climate change	NMFS	??
Fish Community • Current assemblage and abundance • Species interactions • CDFW's Heritage and Wild Trout Program designation (e.g., Clavey River)		??	??
Regulatory and Recreation Issues • CCSF peaking operations • Whitewater boating • ESA (NEEP designation, take requirements) • Wild and Scenic designation • Tribal consultation • Forest management plan	• Public land use • Private land use • Harvest • Fishing regulations • Don Pedro Reservoir fishery management • Moccasin Hatchery	??	??
Concept-level fish passage alternatives and capital and O&M cost estimates for upstream and downstream passage		Districts	Feb 2017

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Overview and Examples of Anadromous Fish Passage Facilities

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

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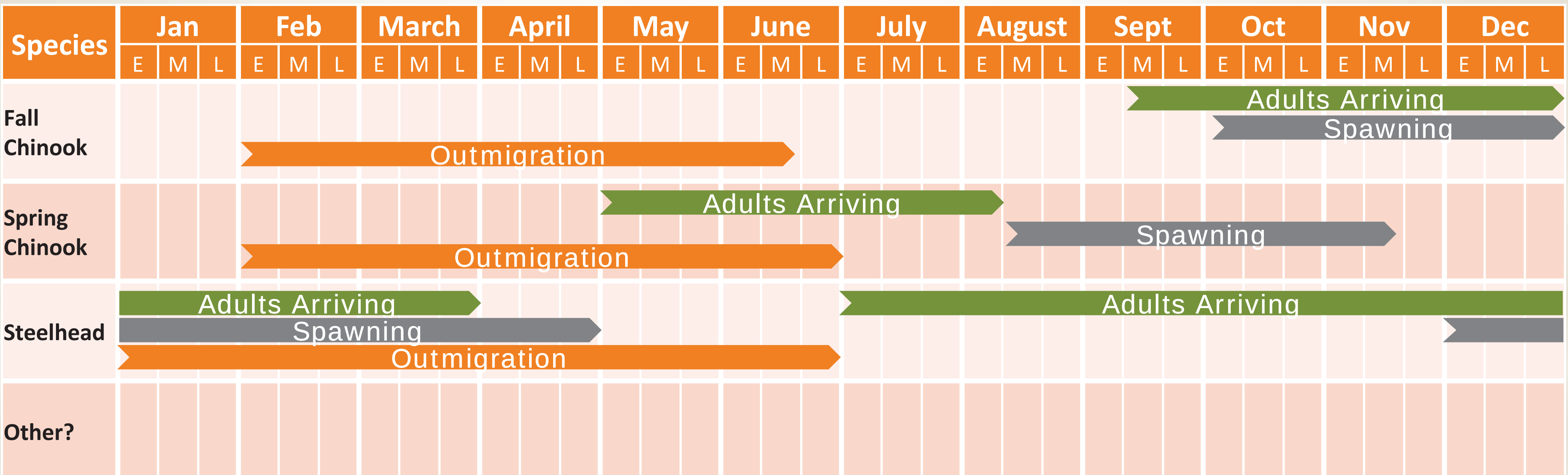
Example Migration Timing (Periodicity)



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”)

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Upstream Passage - Fishways

- Nature Like Fishway
  Weber Dam, NV

- Ice Harbor Style Fishway
  Ice Harbor Dam, WA

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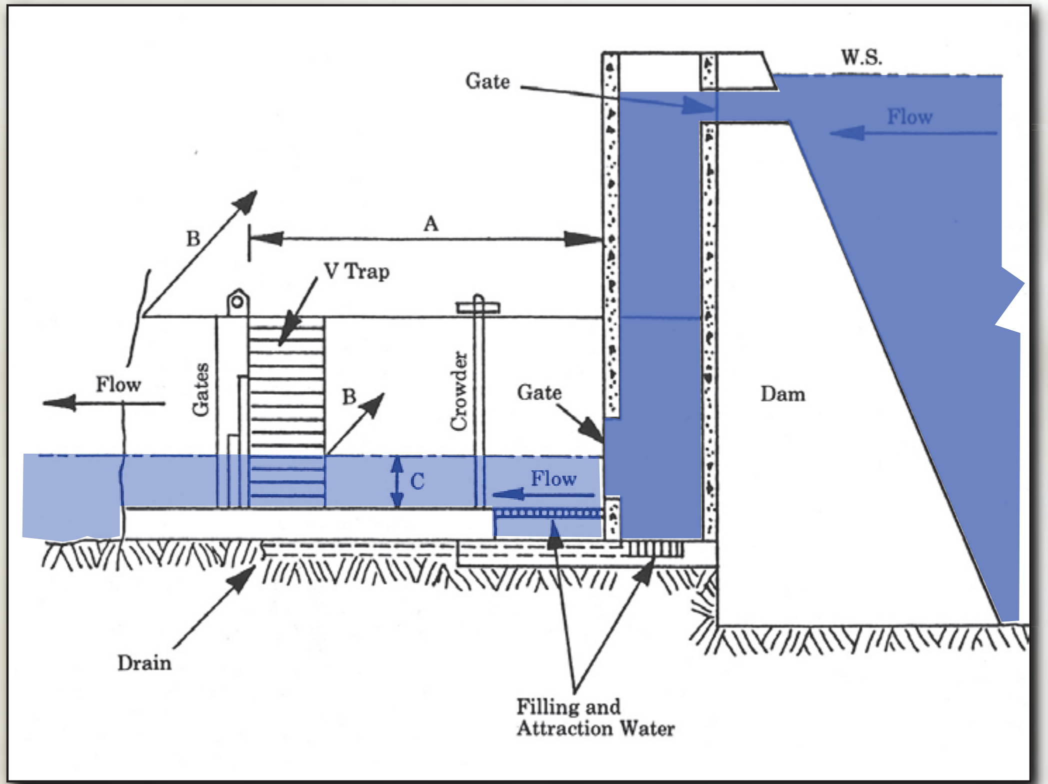
Upstream Passage - Lifts, Locks, and Elevators

- Typical Fish Lock or Elevator at Dam



- Example Fish Lift Mounted on Rails Paradise Dam, Australia

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Upstream Passage - CHTR

- Fish Transport Truck
  Lower Granite Adult Collection
  Facility, WA

- Upstream CHTR Facility
  Cougar Dam, OR

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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

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Downstream Passage – Forebay Collectors

- Fixed Forebay Surface Collector
  Pelton Round Butte, OR

- Floating Forebay Surface Collector
  Upper Baker Dam, WA

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

Floating Collection Barge prior to deployment (PacifiCorp)

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

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Downstream Passage – Surface Spill

- Juvenile Surface Spill Bypass Unit
  Priest Rapids Dam, WA

- Juvenile Surface Spill Facility
  Wanapum Dam, WA

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Downstream Passage – Bypass Facilities

- 14,000 ft Juvenile Bypass
  Clackamas River, North Fork Dam, OR

- Juvenile Bypass Conduit Outlet
  Rocky Reach, WA

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More Downstream Passage

Rotary Screw Trap

Portable Floating Fish Collector
Cougar Dam, OR

Temporary Guide Panels with Trap

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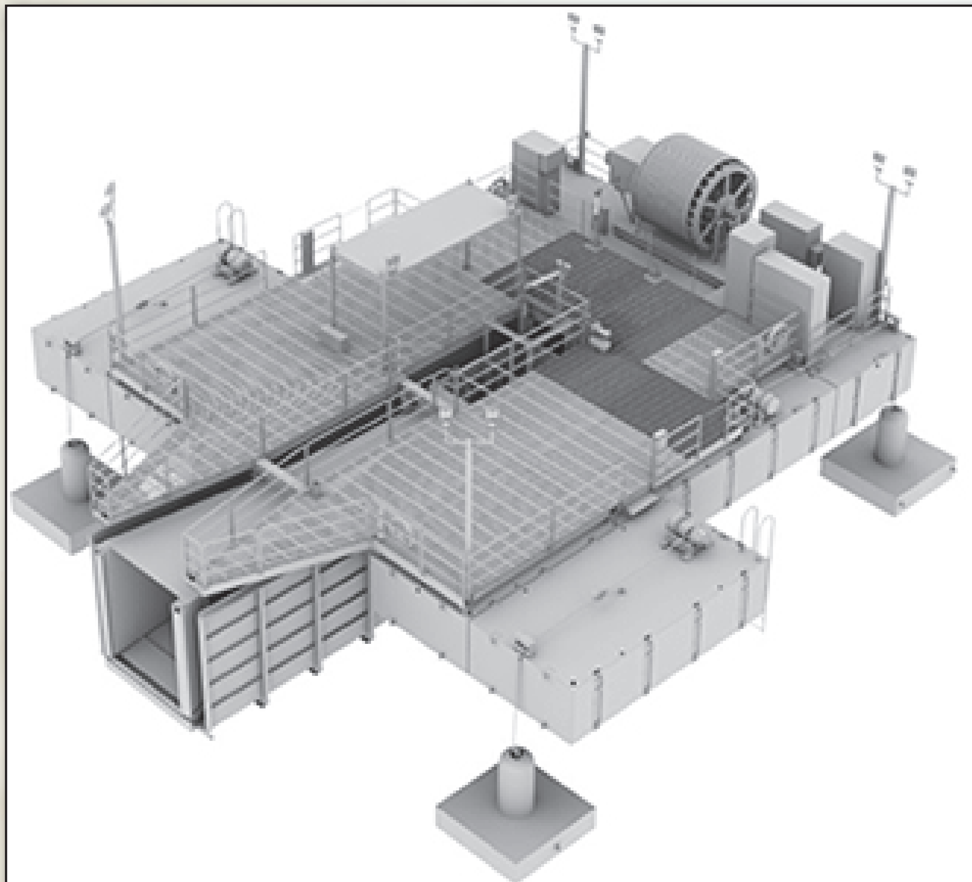
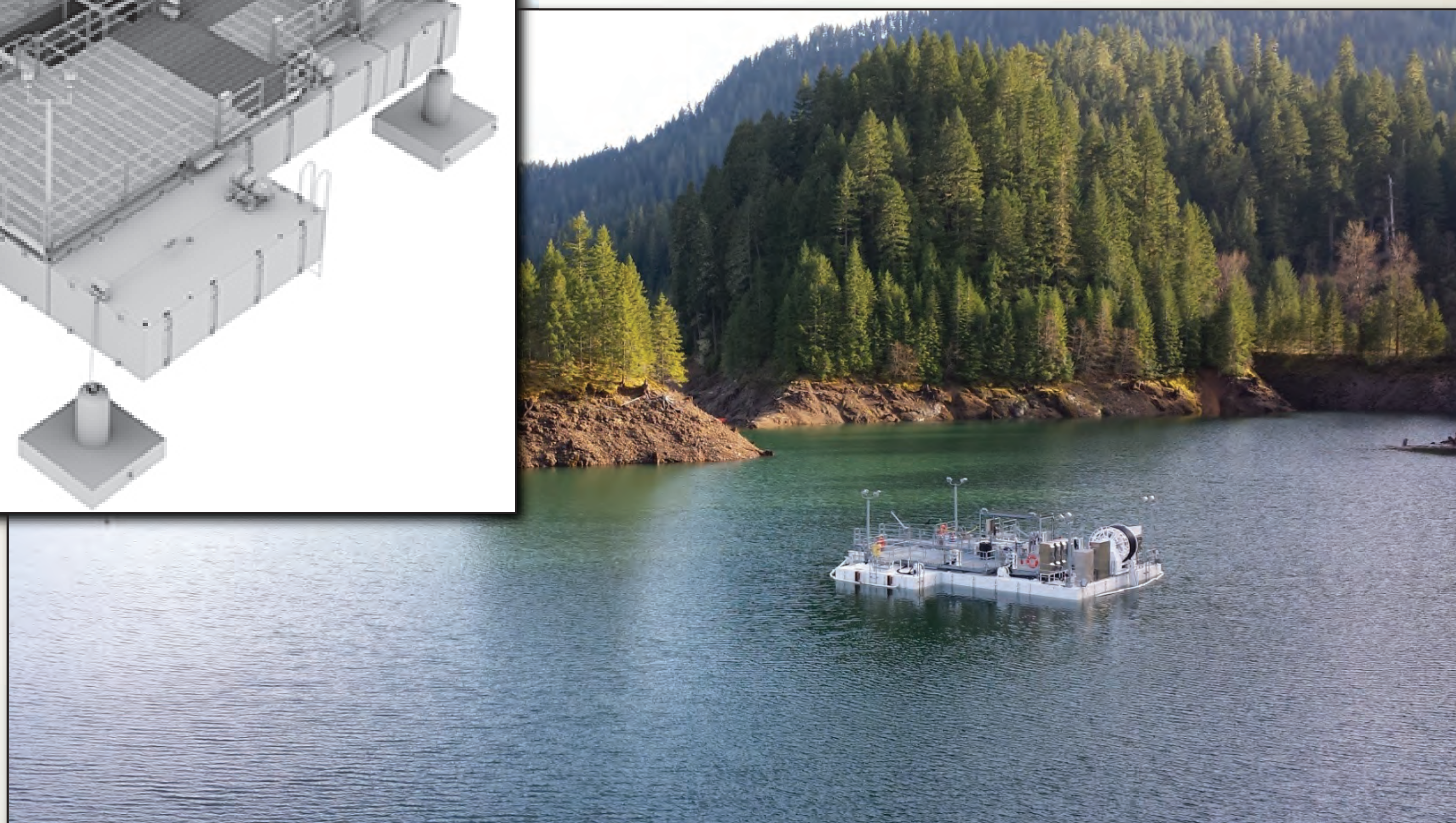


Portable Floating Fish Collector deployed at Cougar Dam, Oregon (USACE)



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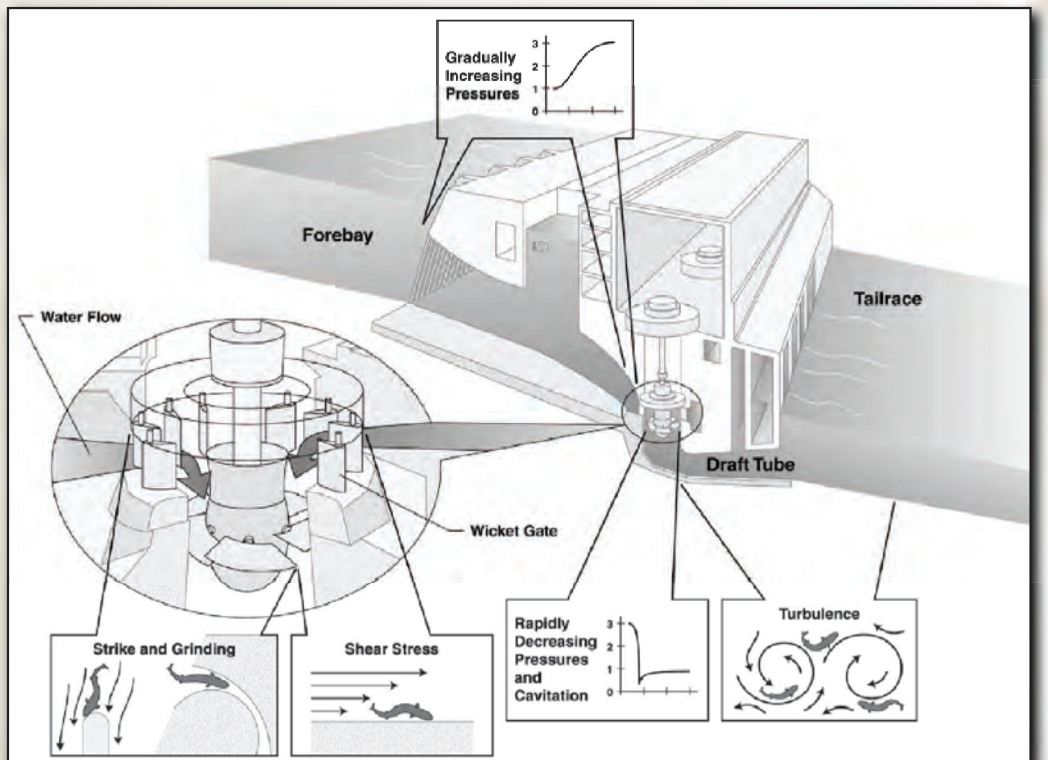
Downstream Passage – Turbine Passage

- Potential Fish Injuries Through Turbines

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



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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

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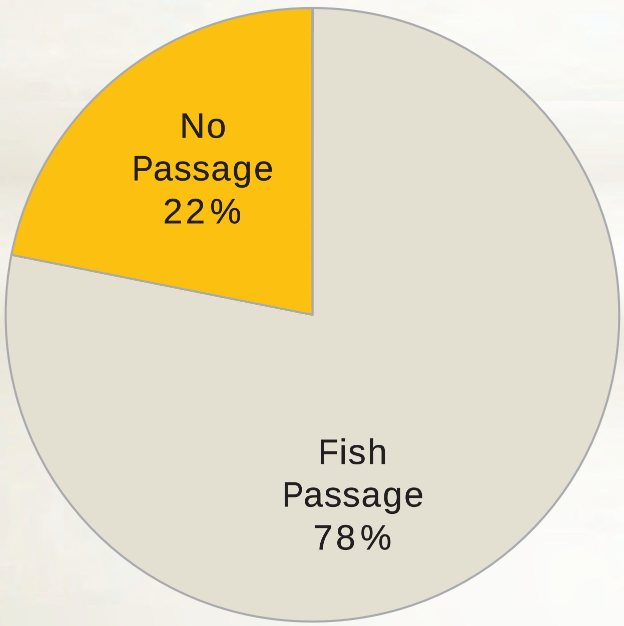
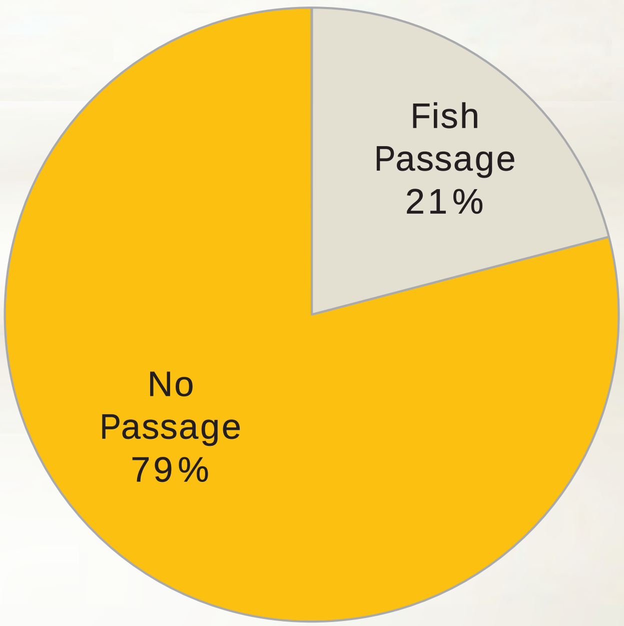
Background and Facility Research – Western US

- 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



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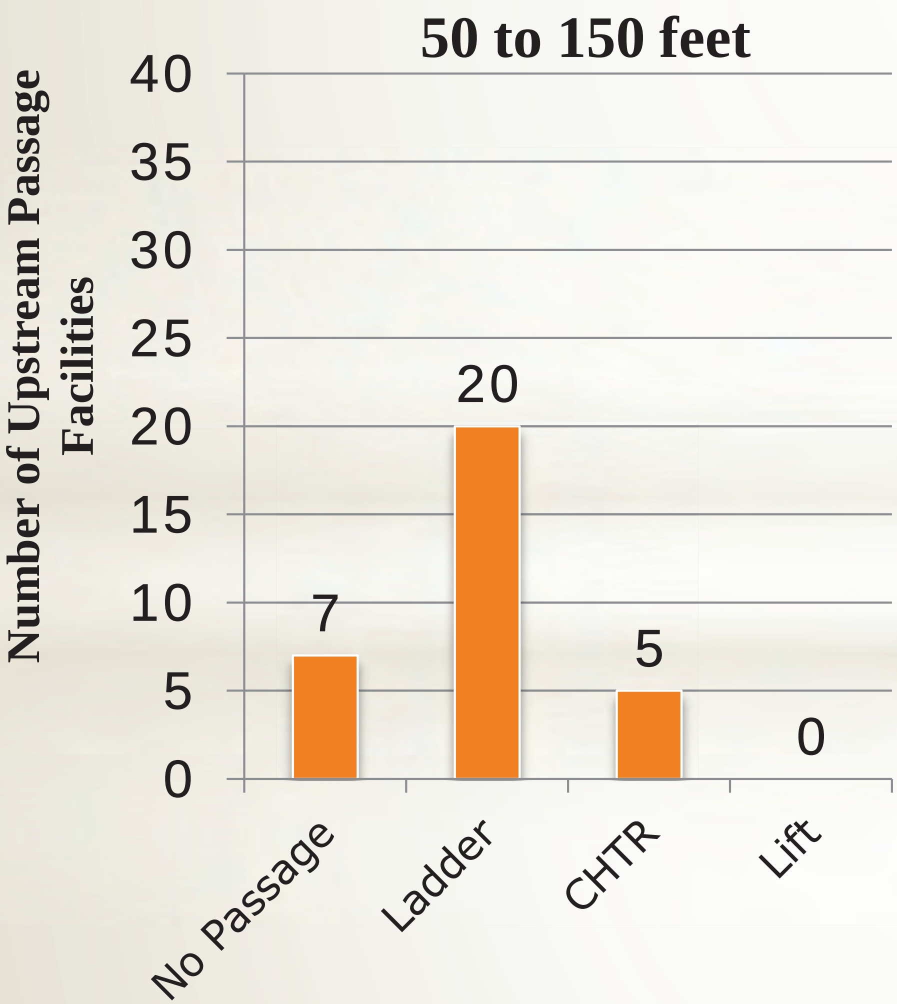
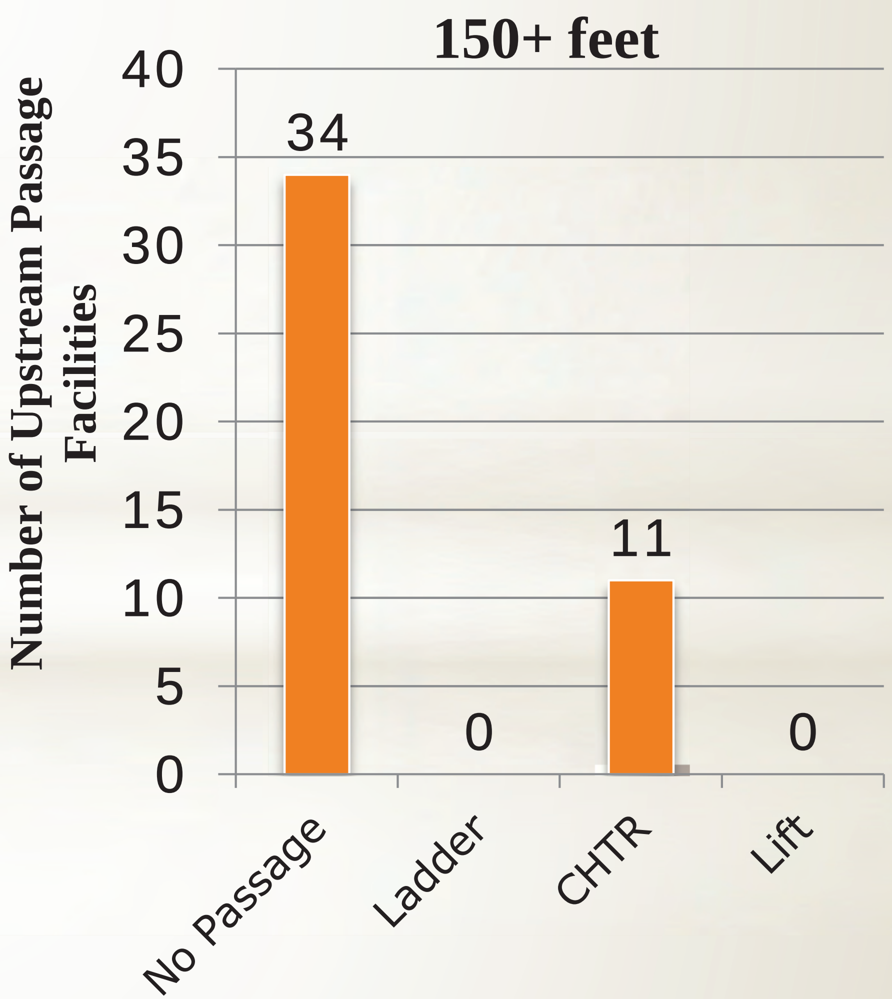
Background and Facility Research – Western US



32 Projects Included in Survey



45 Projects Included in Survey

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

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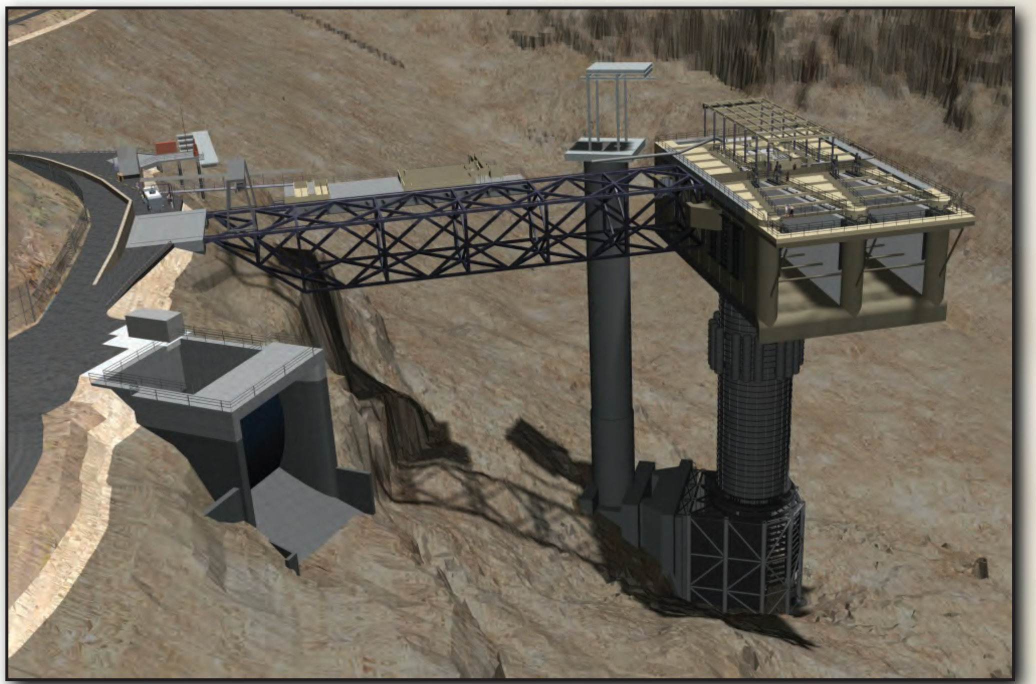
Deschutes River, OR - Project Overview

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.

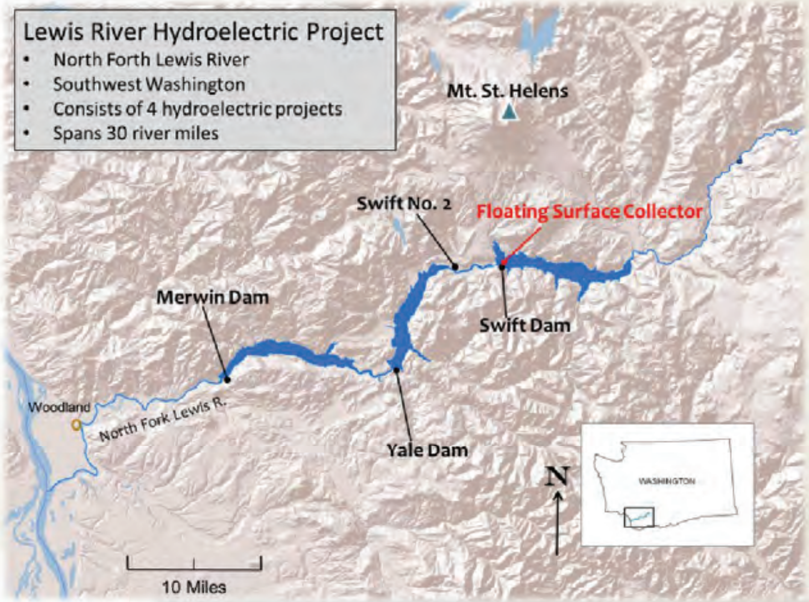
Lewis River, WA - Project Overview

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

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

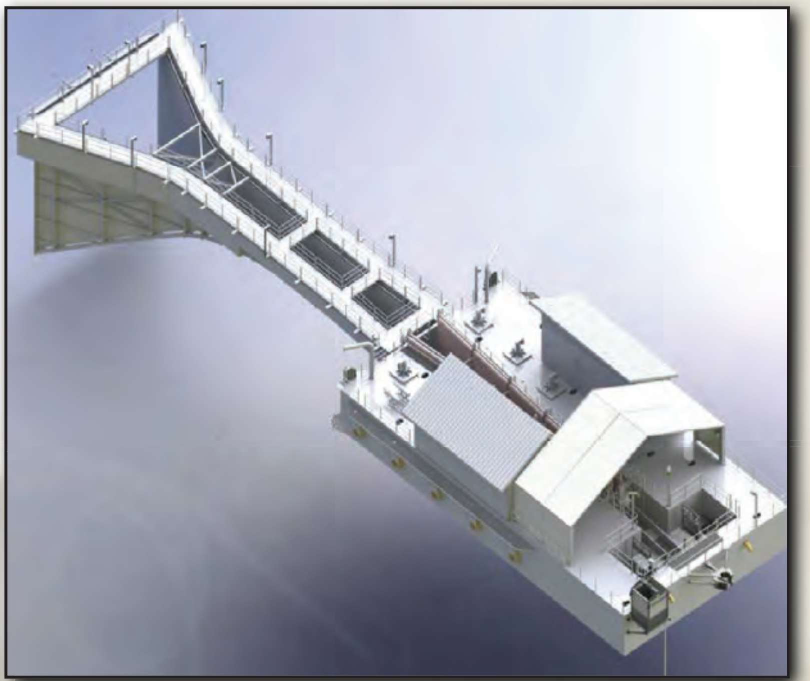
Current Facilities

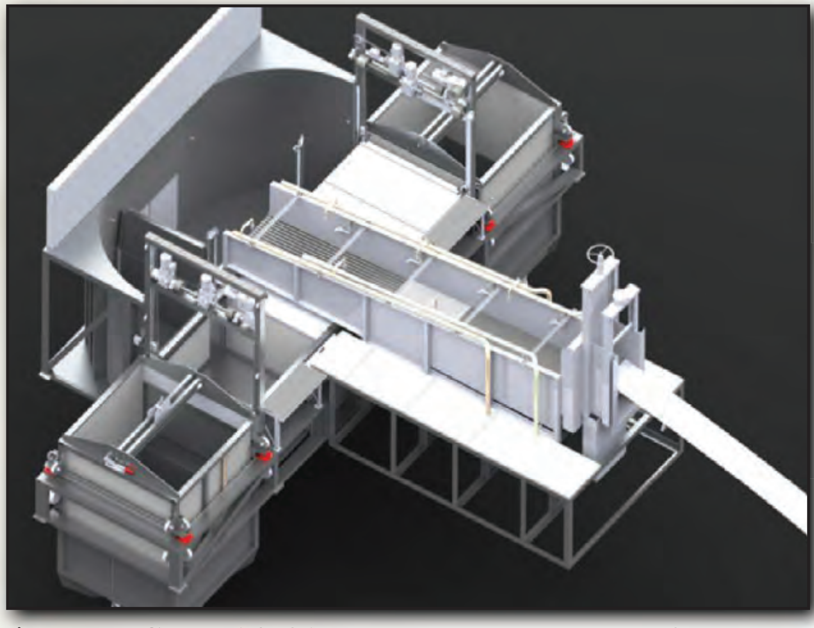
- Upstream Passage: CHTR from below Mayfield Dam to Tilton River upstream of Mayfield Dam and upstream of Cowlitz Falls Dam
- Downstream Passage: Surface collection flume at Cowlitz Dam with CHTR to downstream of Mayfield Dam. Two louvered intake facilities at Mayfield Dam with bypass pipe to river downstream

Mayfield CHTR. Photo from Google Maps

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.
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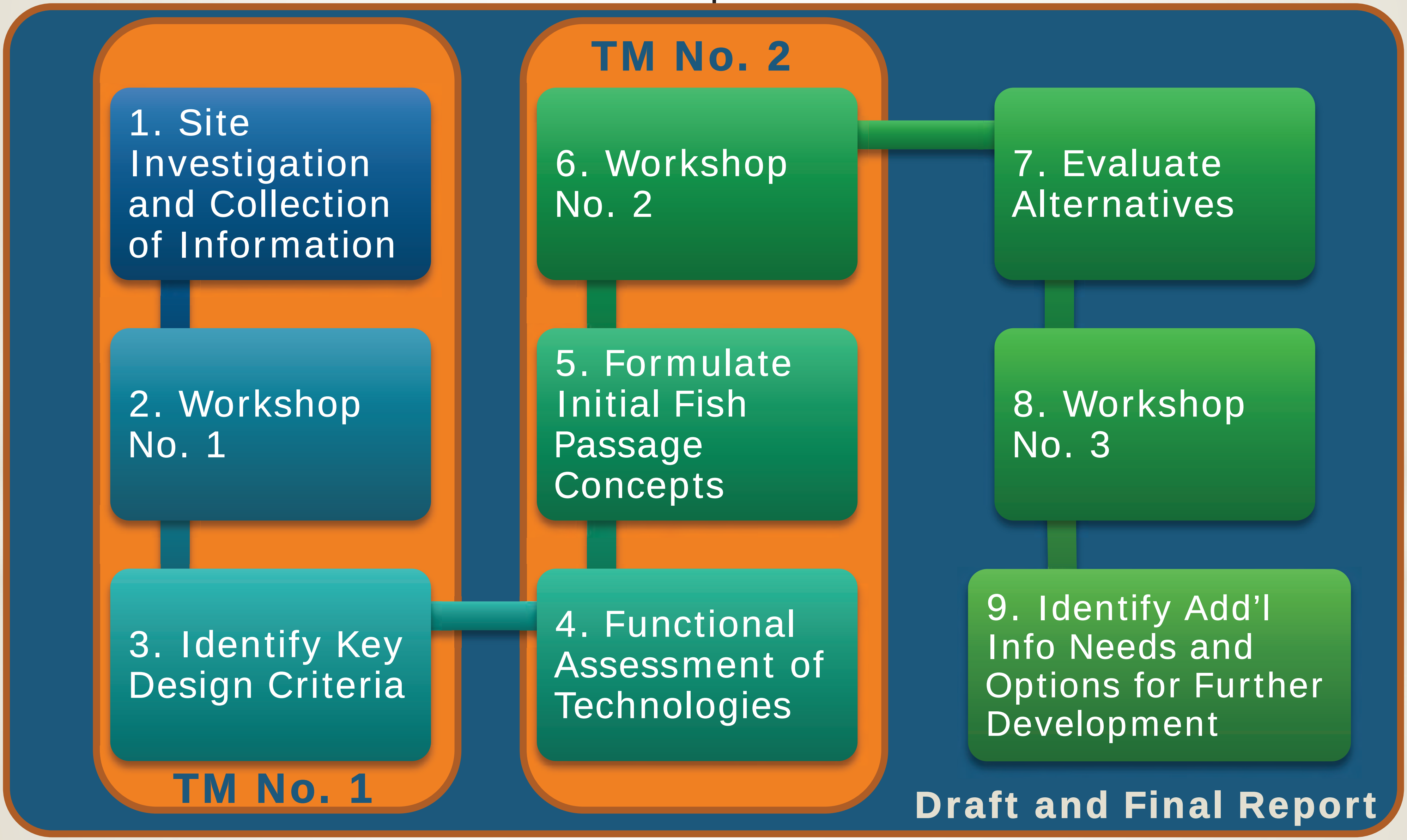

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Process Coordination and Feedback – Workshops

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

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

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ARTICLE

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

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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

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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,

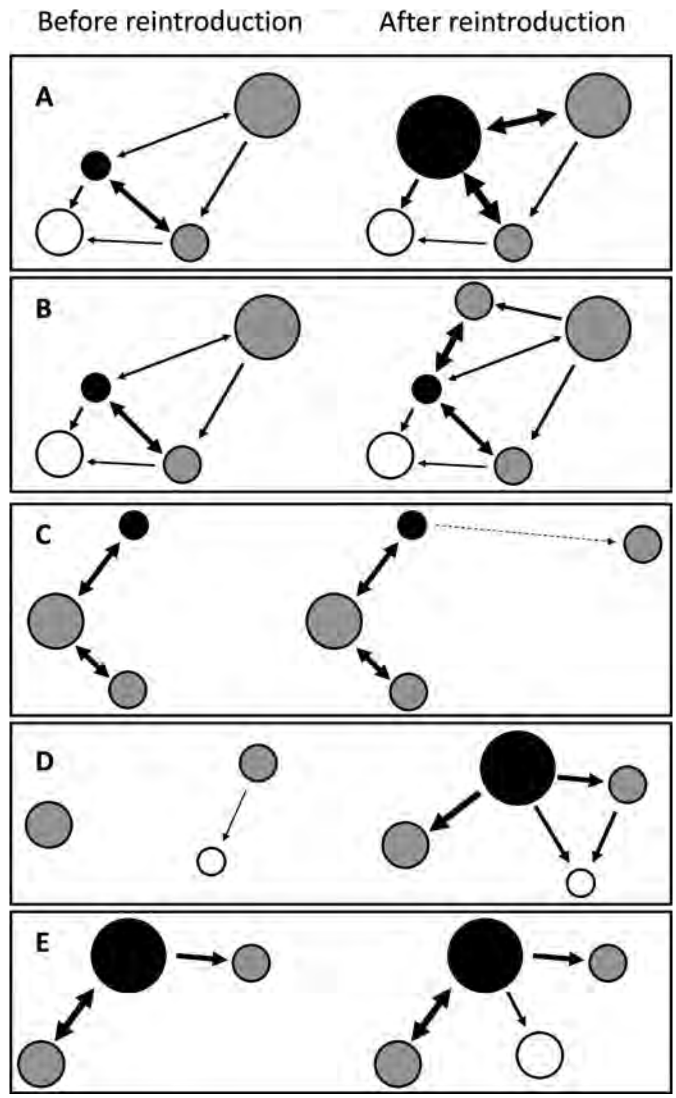

FIGURE 1. Possible effects of reintroduction on metapopulation structure are as follows: **(A)** increase the abundance of the existing population, **(B)** establish a new, independent population well connected to the metapopulation, **(C)** establish a new, independent population isolated from the other 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 metapoulation models useful for guiding salmonid management (Cooper 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).

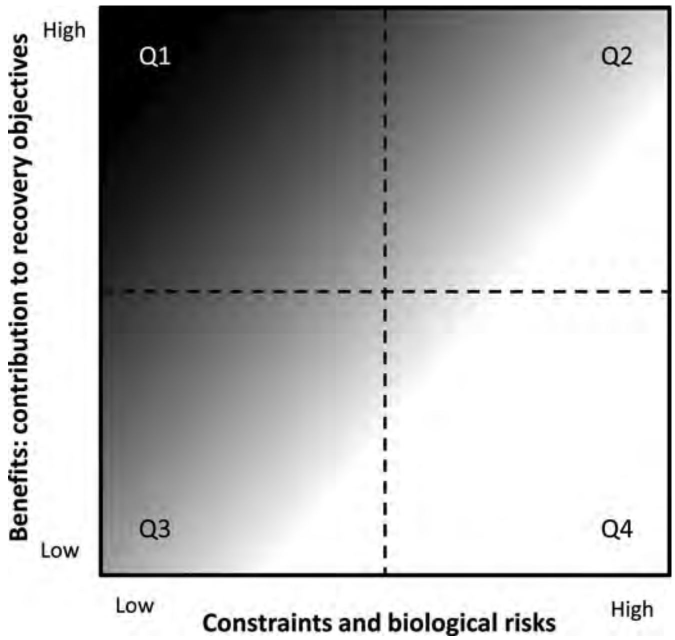

FIGURE 2. Framework for gauging the net benefit of reintroduction options, with darker colors representing a higher likelihood of contributing to conservation and recovery goals. In each case, the benefits are weighed against the constraints and risks of the project. In quadrant 1 (Q1), the benefits 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.

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 depensatory 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 currently 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 Pikeminnow *Ptychocheilus oregonensis*), species that consume a considerable quantity of salmonids (Sanderson et al. 2009; Carey et al. 2012). Competition and predation 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

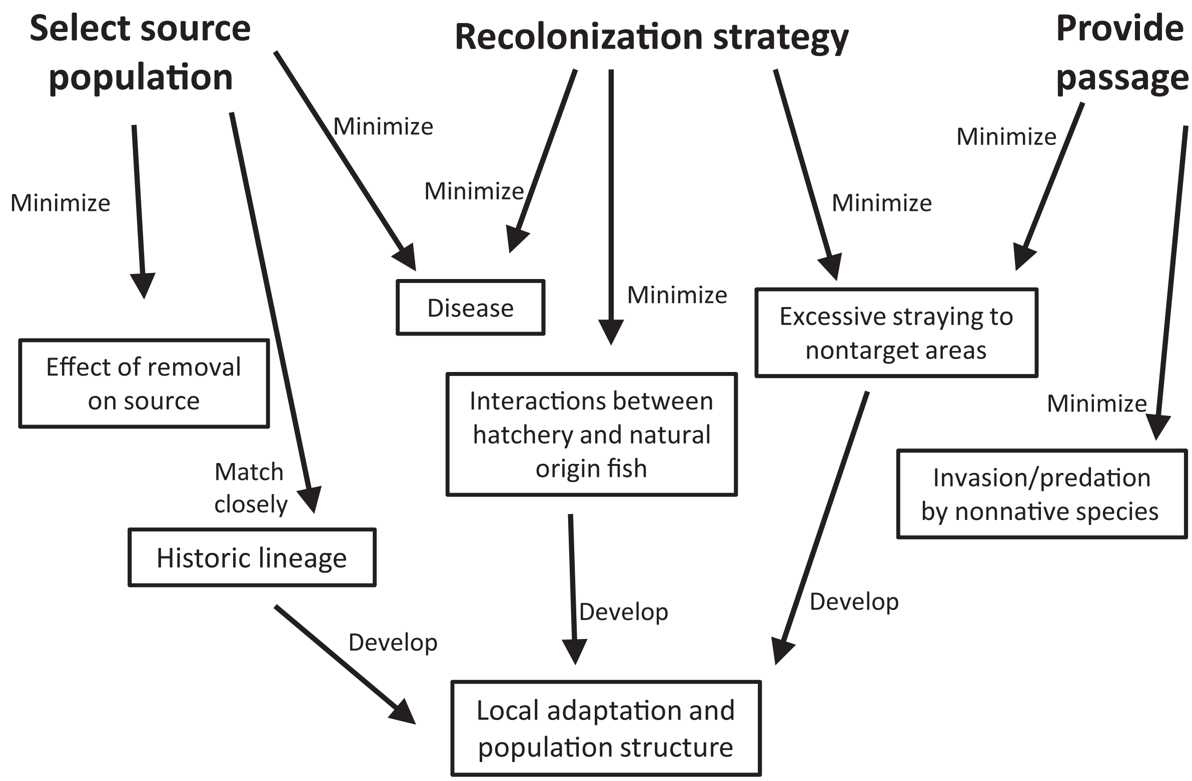

FIGURE 3. Minimizing biological risks in reintroduction planning. Biological risks are unintended negative consequences that may harm nontarget species, other populations, spawning areas, or life history types of the reintroduced species.

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 reintroductions 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

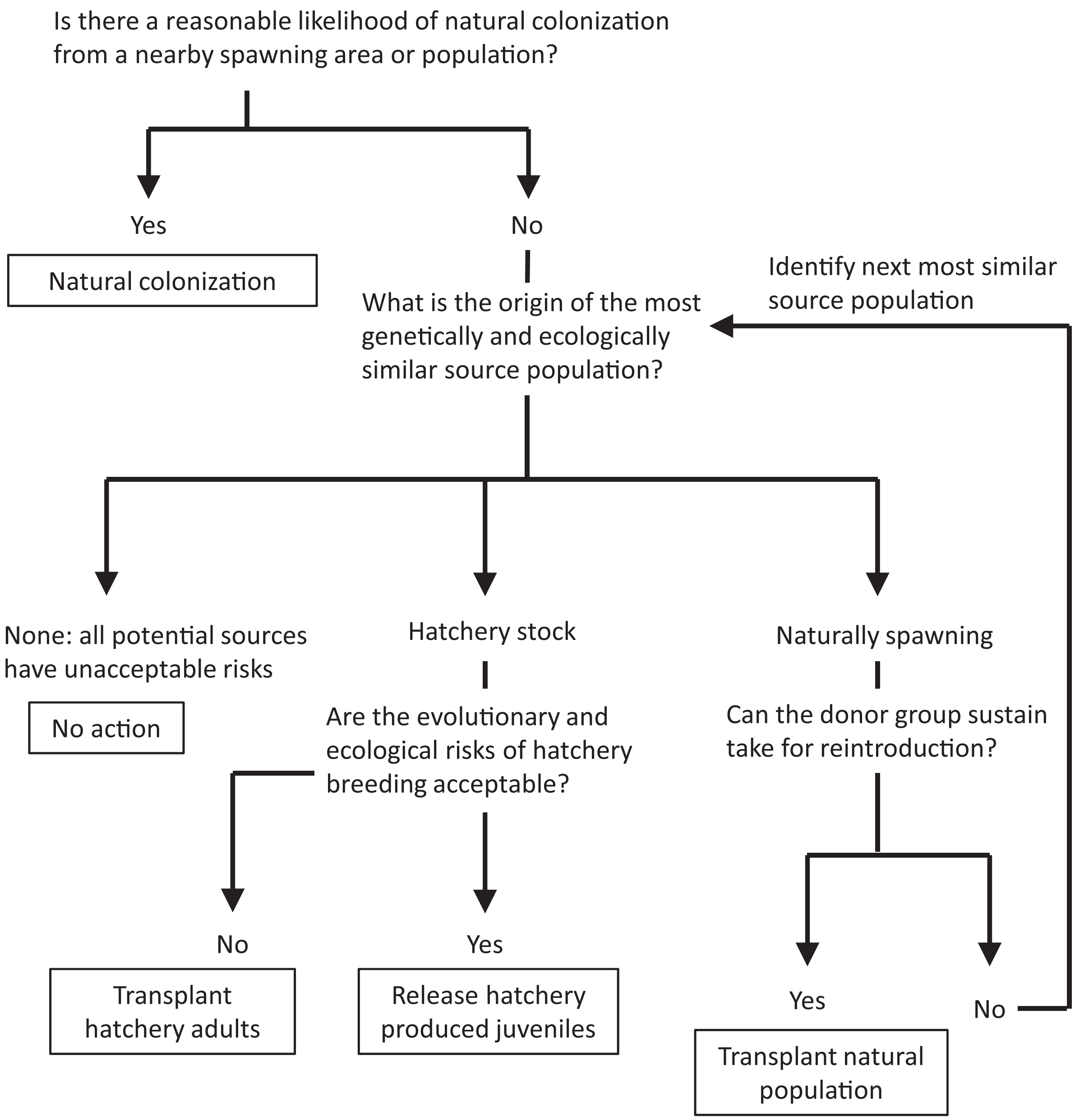

FIGURE 4. Decision framework for selecting a low-risk colonization strategy and source population. This diagram does not encompass every possibility but is intended to highlight the key decisions affecting reintroduction risks. Boxes indicate decision endpoints.

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, depensatory 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 dispersal 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[a]	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[b]	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[c]	None	Kesler et al. 2011
Beaver Creek, Washington	2005	Steelhead	Natural colonization	Fishways	Weigel et al. 2013

[a]Colonization strategy varied by river.
[b]Genetic analysis indicates that natural dispersal, not hatchery releases, were primarily responsible for colonization.
[c]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 *O. keta*, 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; Kostow 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 (Mobrand 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, impoundments 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).

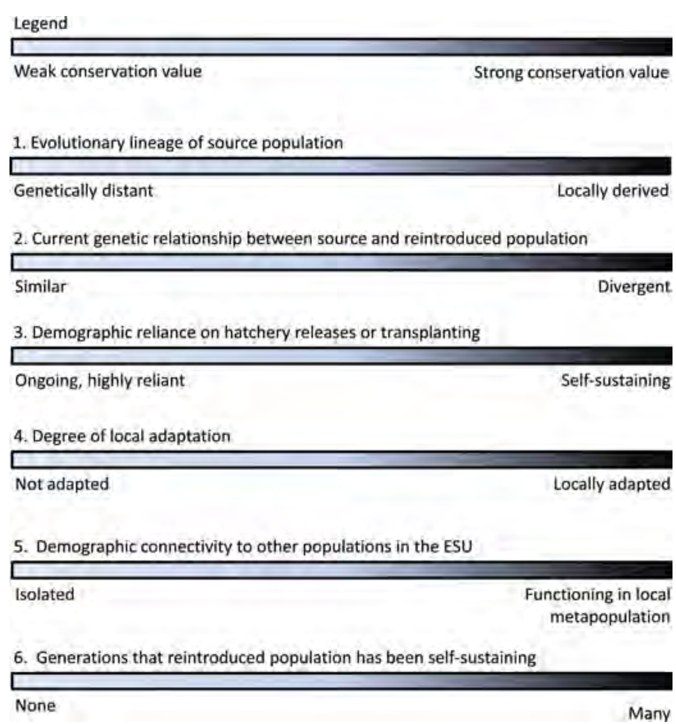

FIGURE 5. Factors to consider in evaluating the conservation value of reintroductions. Each bar is intended to represent a gradient of outcomes in between the extremes described at either end. The extent to which natural demographic, ecological, and evolutionary processes operate uninterrupted will strongly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

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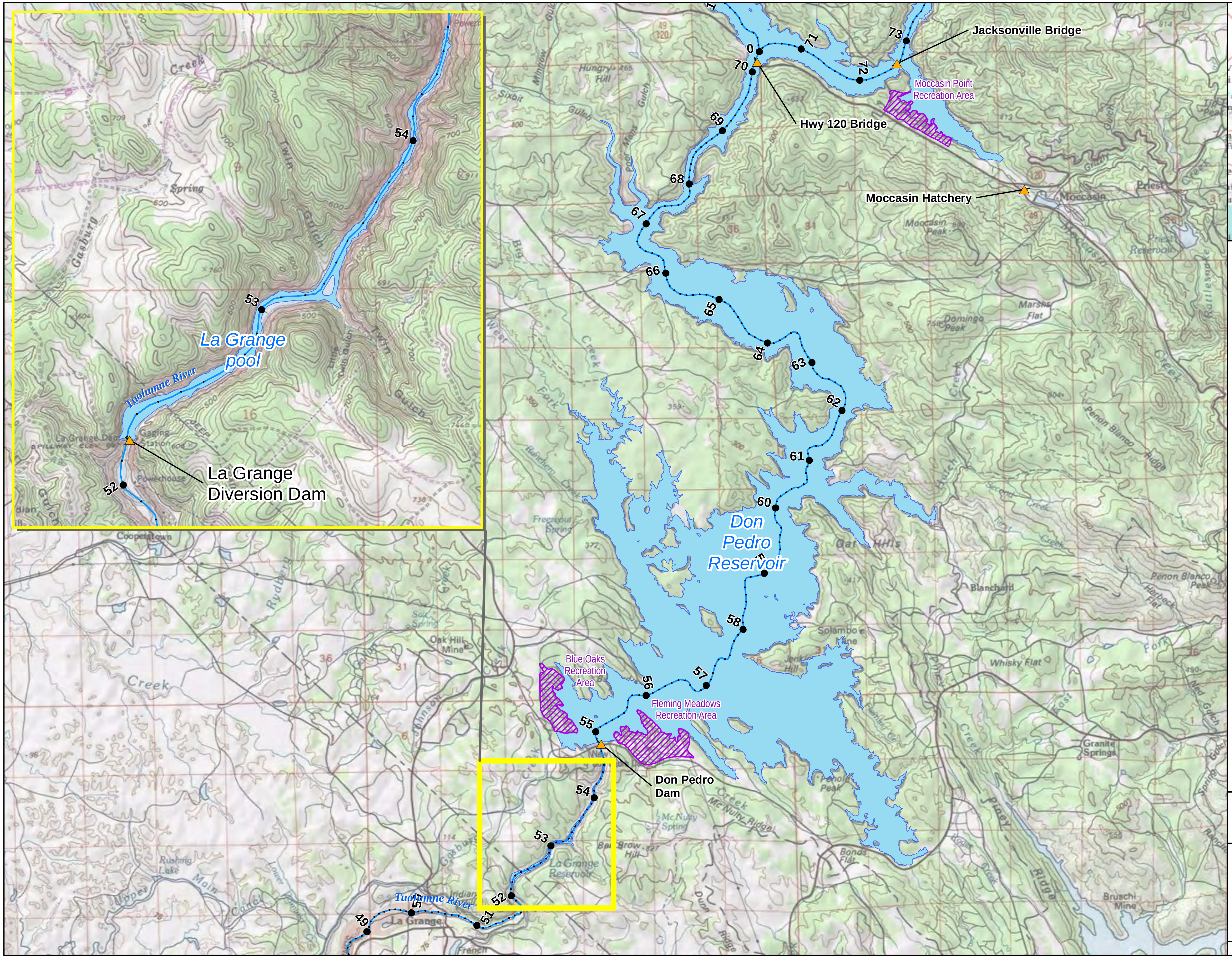

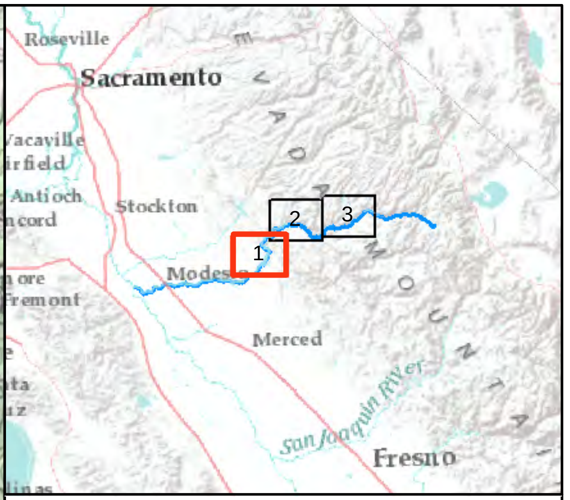

Tuolumne River Reach Between RM 49 to RM 122

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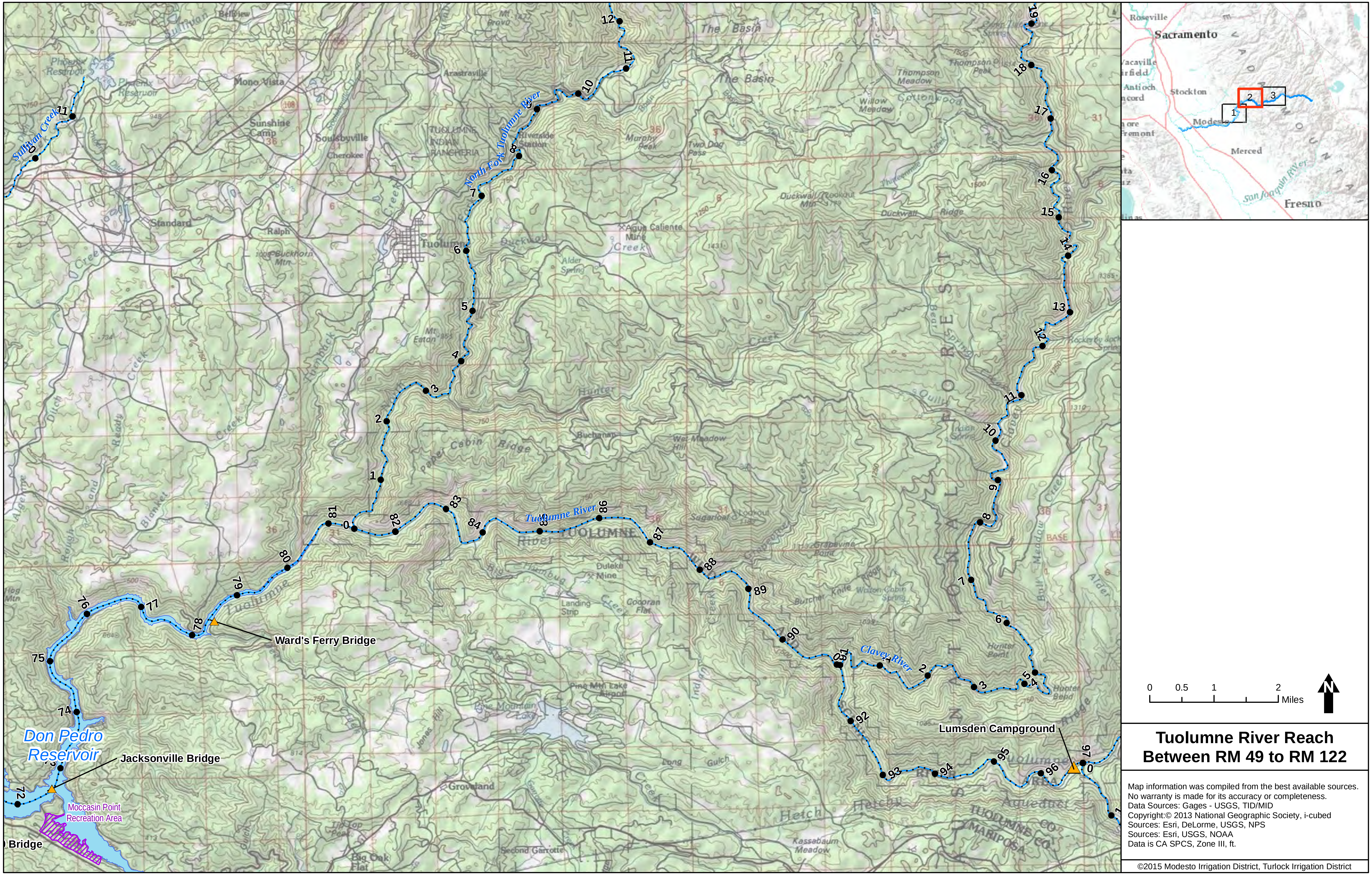

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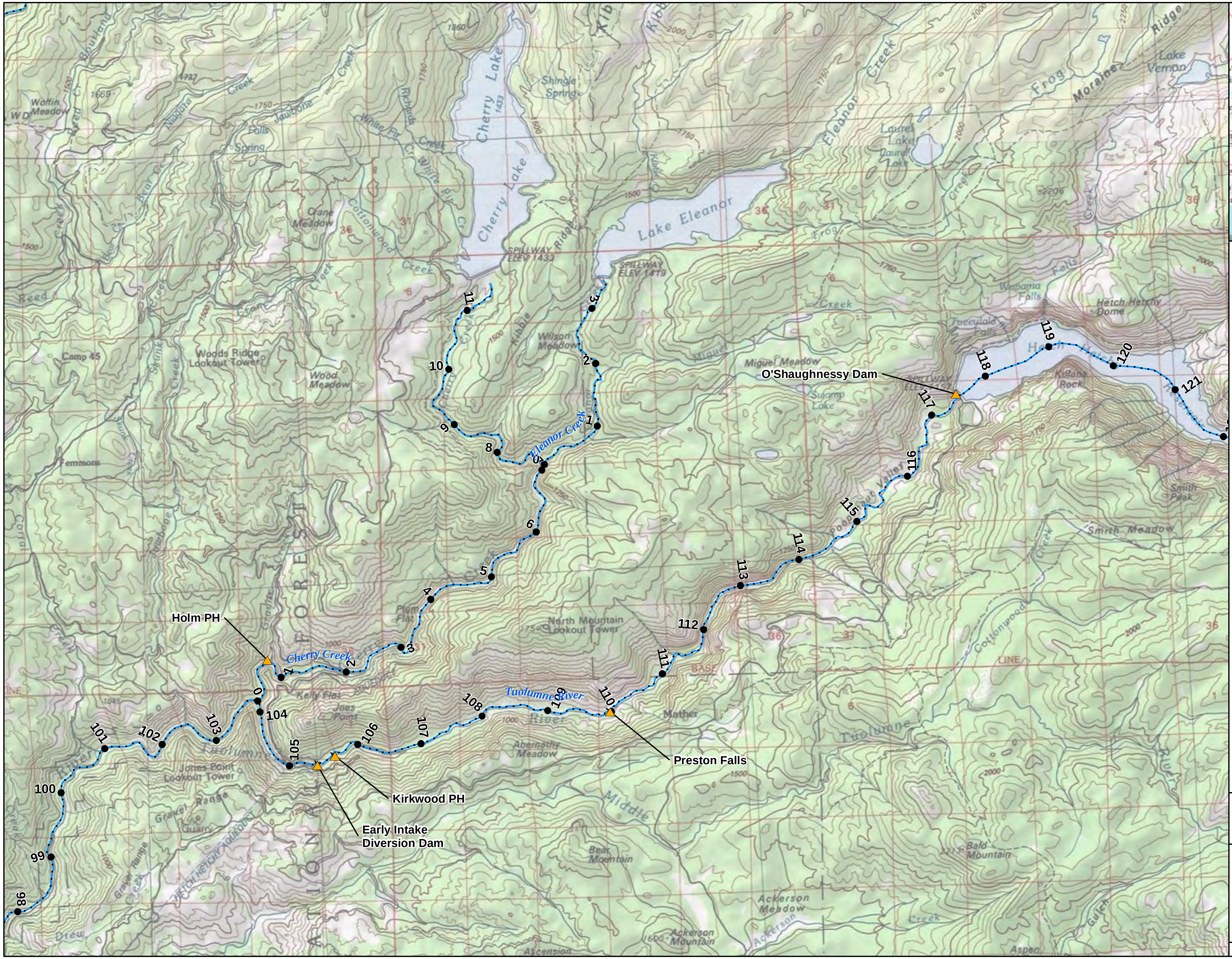

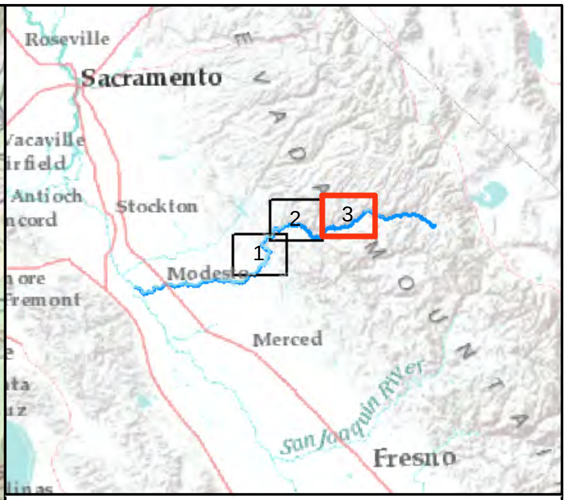

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LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT
WORKSHOP NO. 2

SEPTEMBER 17, 2015

FINAL MEETING NOTES AND MATERIALS

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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 Garello (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. Garello 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. Garello (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. Garello 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. Garello'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. Garello 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. Garello 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. Garello 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. Garello 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. Garello 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. Garello 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. Garello.

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. Garello's presentation.

Mr. Garello gave a summary of his professional background. Mr. Garello has 15 years of experience working as a Senior Resource Engineer at HDR's Fisheries Design Center. Mr. Garello 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. Garello 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. Garello 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. Garello'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. Garello 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. Garello 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. Drekemeir said he will do that. Mr. Drekmeier 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. Bryd 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. Bryd 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. Drekemeier 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. Garello'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. Garello 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. Garello 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. Garello'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. Garello'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. Garello'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 Workshop No. 2

Meeting Notes

Attachment A

La Grange Hydroelectric Project
Fish Passage Assessment Workshop No. 2

Thursday, September 17, 9:00 am to 12:00 pm
MID Office, 1231 11th 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 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) a. Review and discuss fish passage/reintroduction decision-making framework b. Information needs, key resource considerations, linkages to design process c. Available data, data gaps, and potential data sources related to fish passage/reintroduction decision-making
10:30 am – 11:30 am	Fish Passage Facility Assessment - Technical Memorandum #1 (All) a. Key physical and biological design criteria b. Fish passage design and operations criteria c. Links between information needs and design concept d. Discussion of information needs and input from Licensing Participants
11:30 am – 12:00 pm	Tuolumne River Passage Assessment Schedule and Next Steps (All) a. Schedule: Opportunities for collaboration and incorporation of feedback b. Workshop No. 3 – confirm date and content

Modesto Irrigation District

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

WATER & POWER

PLEASE SIGN IN

	Name	Organization	Telephone No.	E-mail	Time In	Time Out
1.	Paul Zeek	Asm. Kristin Olsen			8:45	10:00
2.	Mike Wade	CA Farm Water Coalition			8:47	
3.	John Buckley	CSERC			8:50	
4.	Chuck Hanson	Hanson Env.			8:50	
5.	Josh Weimer	TID			8:50	
6.	Alison Willy	USFWS			8:51	
7.	Gretchen Murphey	CDFW			08:55	
8.	Tom Orvis	SCFB				
9.	Peter Drekmeier	TRT			8:55	
10.	Ray Dias	N/A			8:58	
11.	Steve Rank	MOD CHAMB				1100
12.	Brenda LaPorte	CWIA			8:58a	1100

Modesto Irrigation District

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

TID WATER & POWER

PLEASE SIGN IN

	Name	Organization	Telephone No.	E-mail	Time In	Time Out
13.	[illegible]	FARMER			8:45	12:40
14.	Alfred A. Souza	YFC			8:46	
15.	Mario Moreno	LCR				8.48 / 11:16
16.	DANA FERREIRA	REP DENHAM			8:45	
17.	Brandon McMillan	TID				
18.	Ron Yoshiyama	San Francisco			8:48	
19.	Daniel Richardson	Tuolumne County			8:50	
20.	Bill Ketscher	Farmer			9:00	
21.	John Shelton	DFW			9:00	
22.	William Sears	SFPUC			9	[illegible]
23.	Leonard Van Elden	Yosemite Farm Credit				11:15
24.	Rob GRASSO	Yosemite Nat'l Park				

Modesto Irrigation District

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

WATER & POWER

PLEASE SIGN IN

	Name	Organization	Telephone No.	E-mail	Time In	Time Out
25.	Allen Zanker	local property owner	2		9am	12:40
26.	Ellen Levin	SF				
27.	Donn Furman	SF				
28.	Jonathan Kranz	SF				
29.	[signature]	NMFS			9:15	1:00
30.	Tom Holley	"			9:15	1:00
31.	John Holland	Modesto Bee			9:30	
32.	Chris Shutes	CSPA			9:40	
33.	Pamela Sieker	CWA			952	109
34.	ART GODWIN	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

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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

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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

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

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La Grange Hydroelectric Project
FERC No. 14581

Fish Passage Facilities Alternatives Assessment
Workshop No. 2

September 17, 2015

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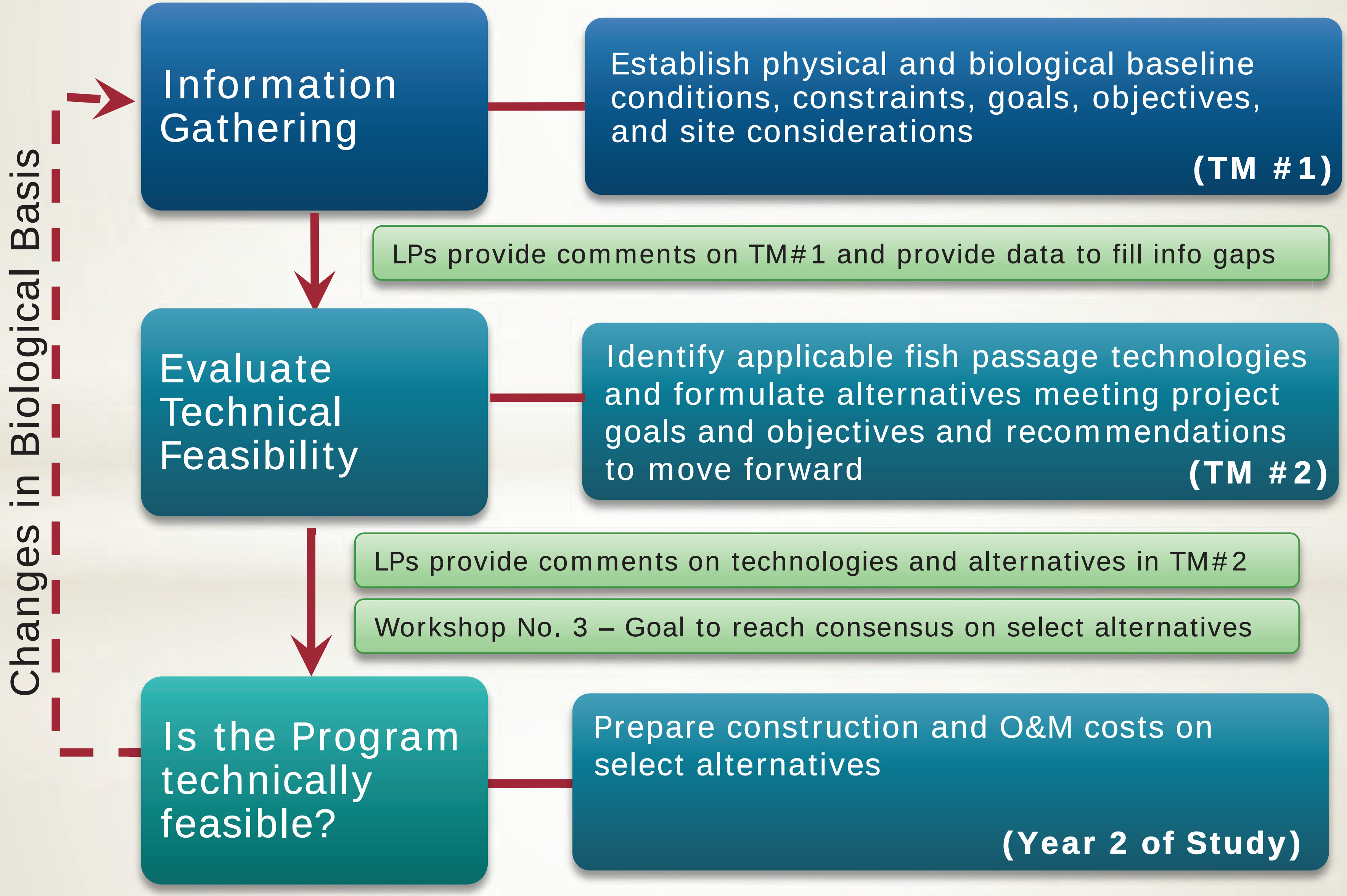

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Information Gathering

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

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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

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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

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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

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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

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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

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.

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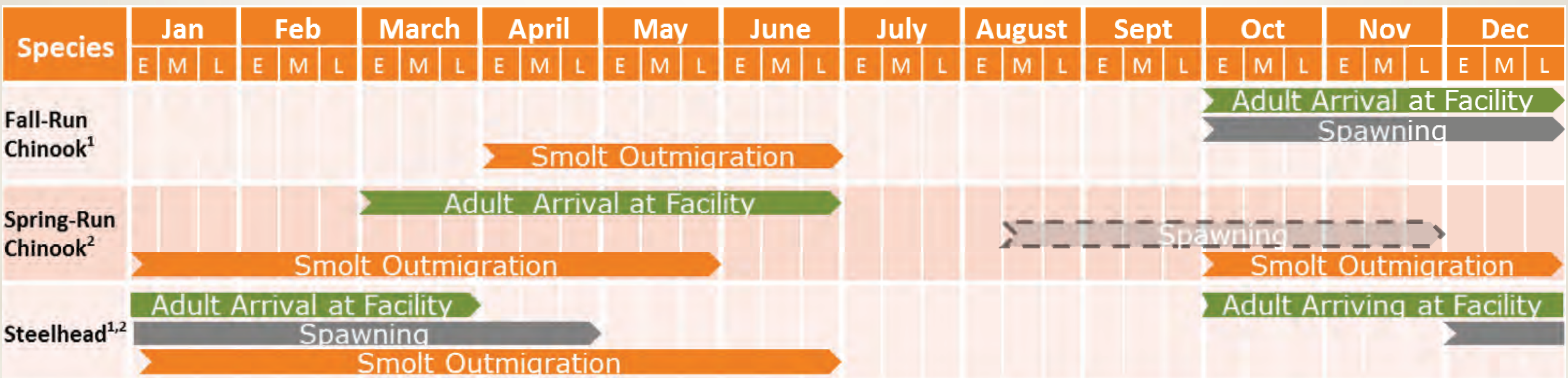
Initial Estimate Of Migration Timing For The Tuolumne River



[1](TID/MID, 2013)
[2](NMFS, 2014 Central Valley salmonid recovery plan)

Requires confirmation from licensing participants.

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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.**

Physical Basis of Design

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

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

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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

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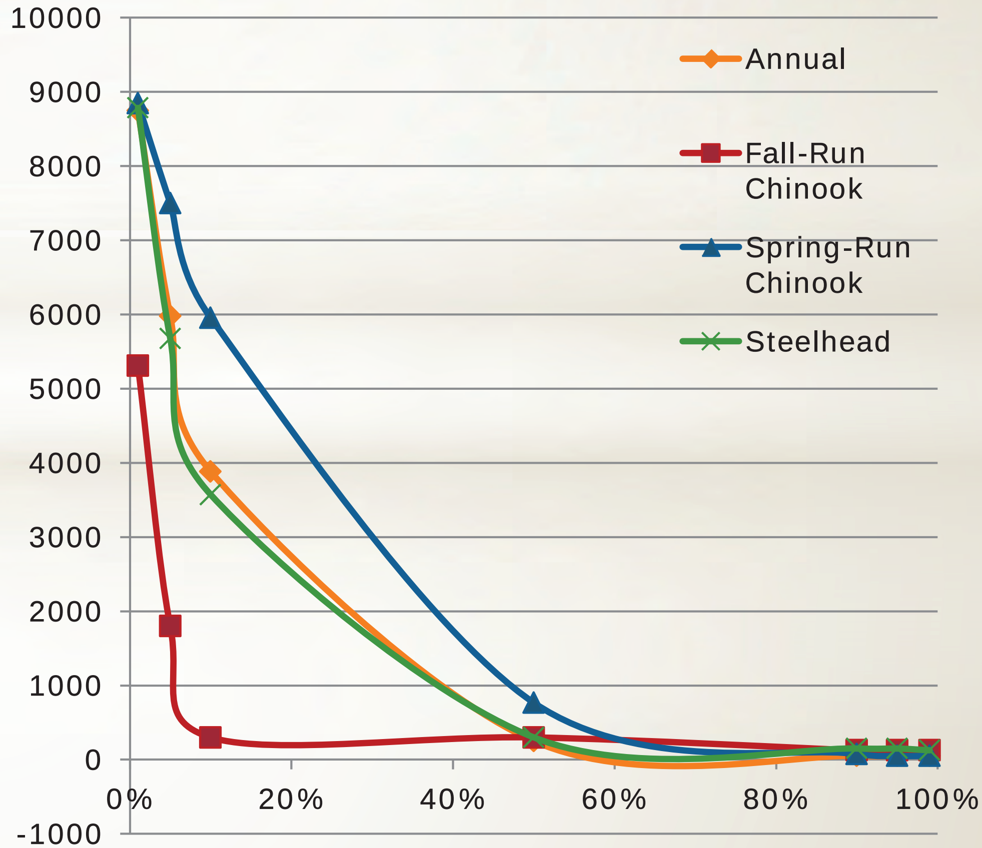
Estimates Of Fish Passage Design Flows In The Lower Tuolumne River

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



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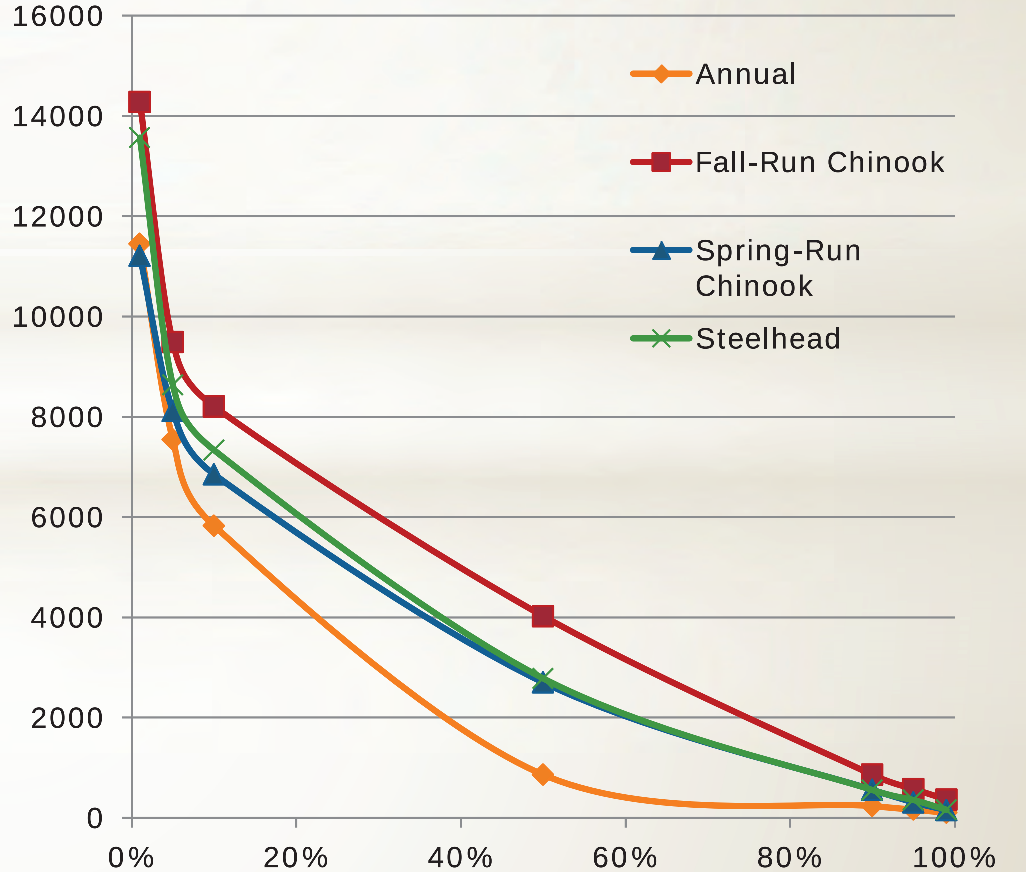
Estimates of Fish Passage Design Flows into Don Pedro Reservoir

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



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

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

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

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

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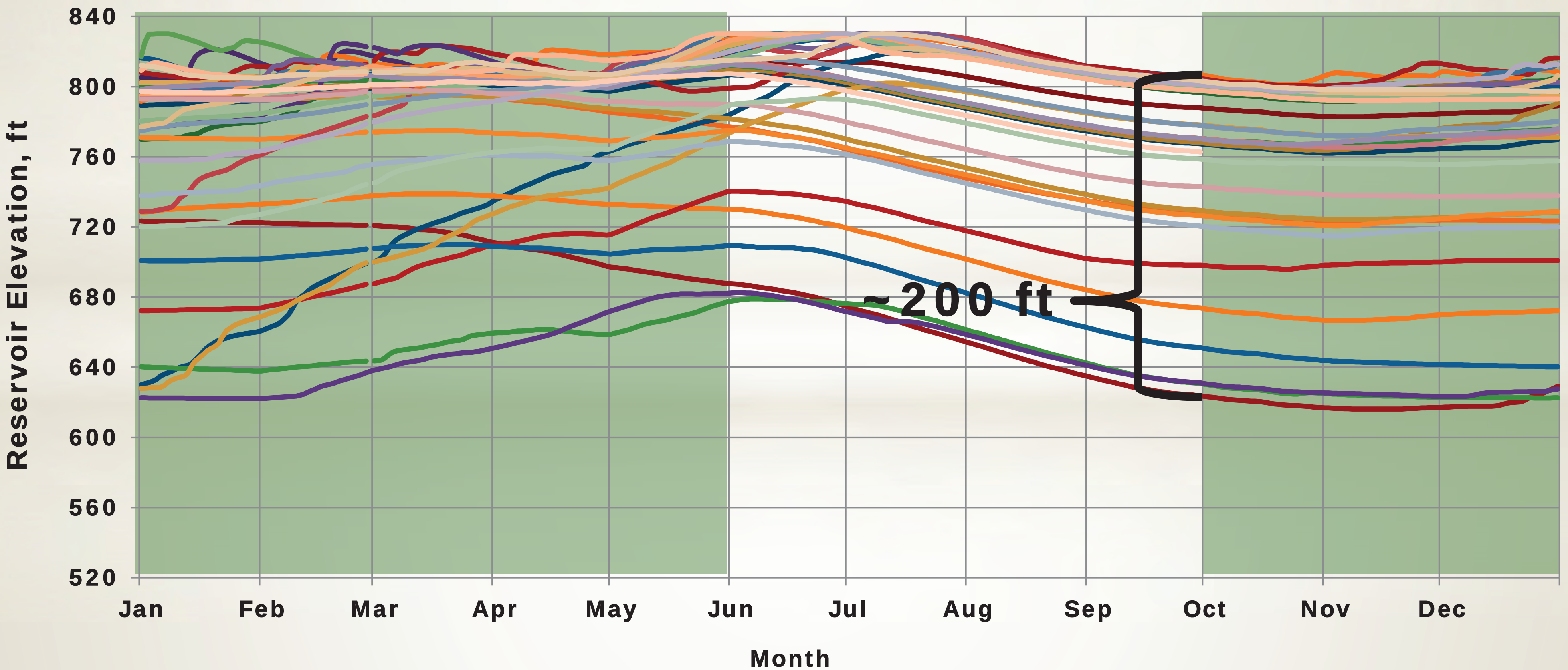
Reservoir Fluctuation Variability (Base Case)



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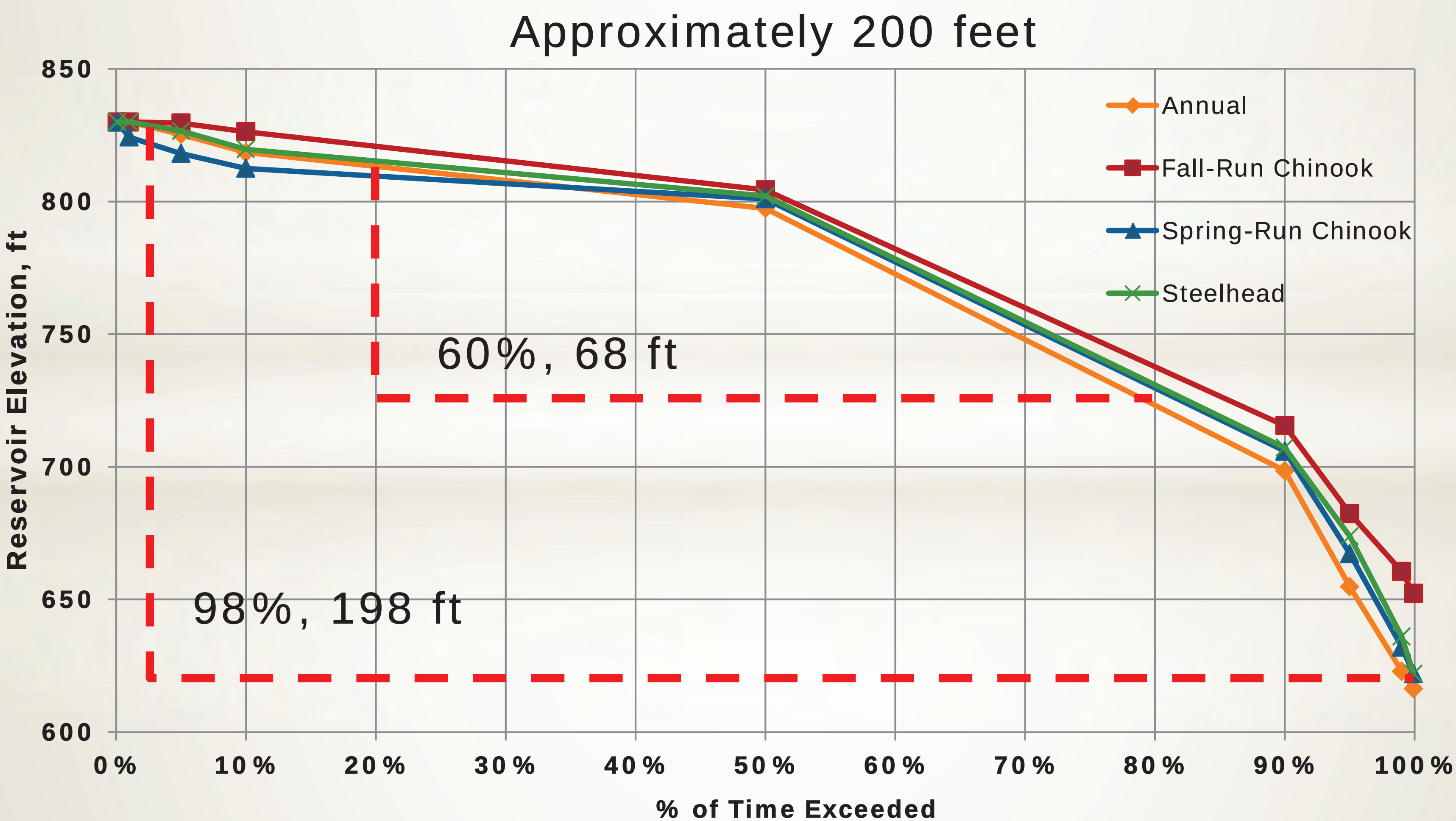
Estimates Of Don Pedro Reservoir Fluctuation When Fish Would Be Migrating Downstream



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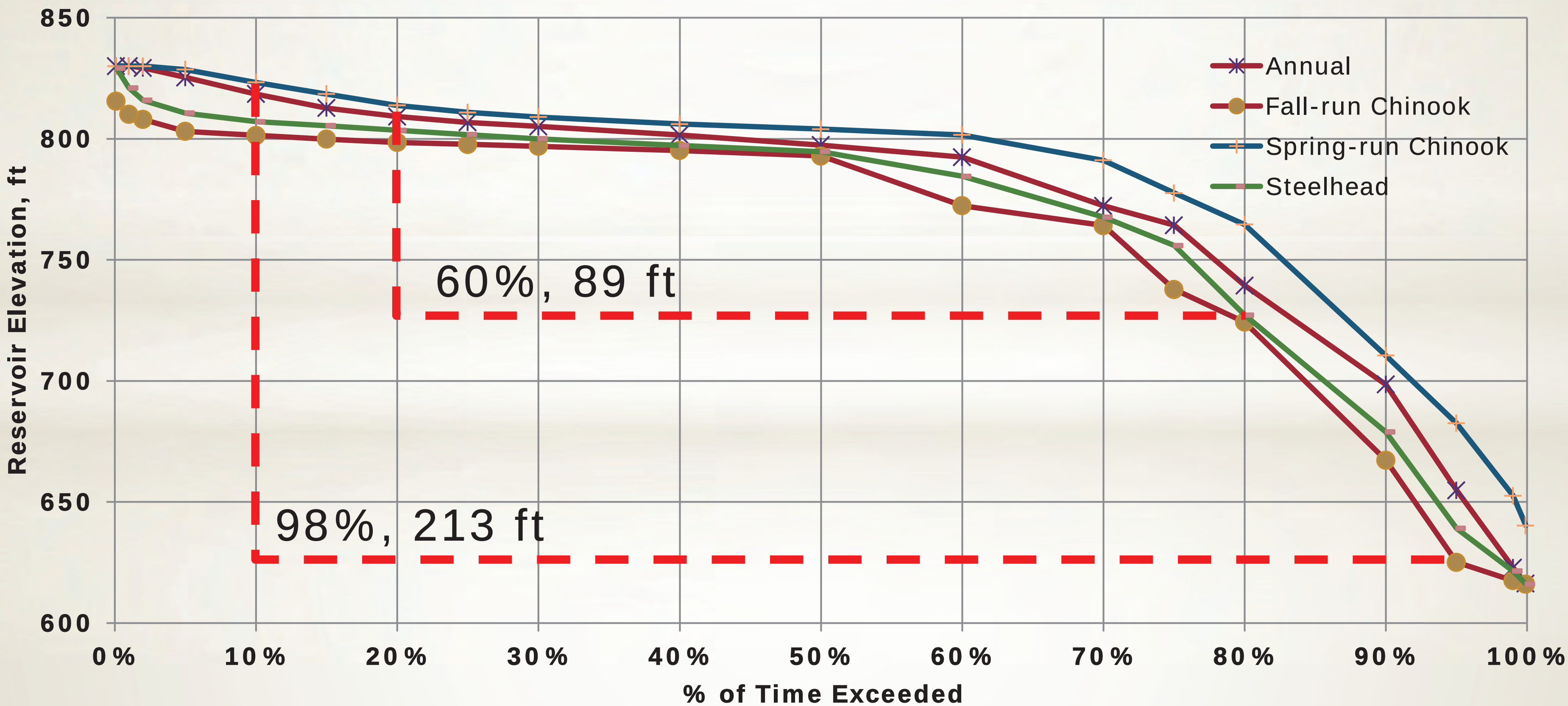
Estimates Of Don Pedro Reservoir Fluctuation When Fish Would Be Migrating Upstream

Approximately 230 feet



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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.**

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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

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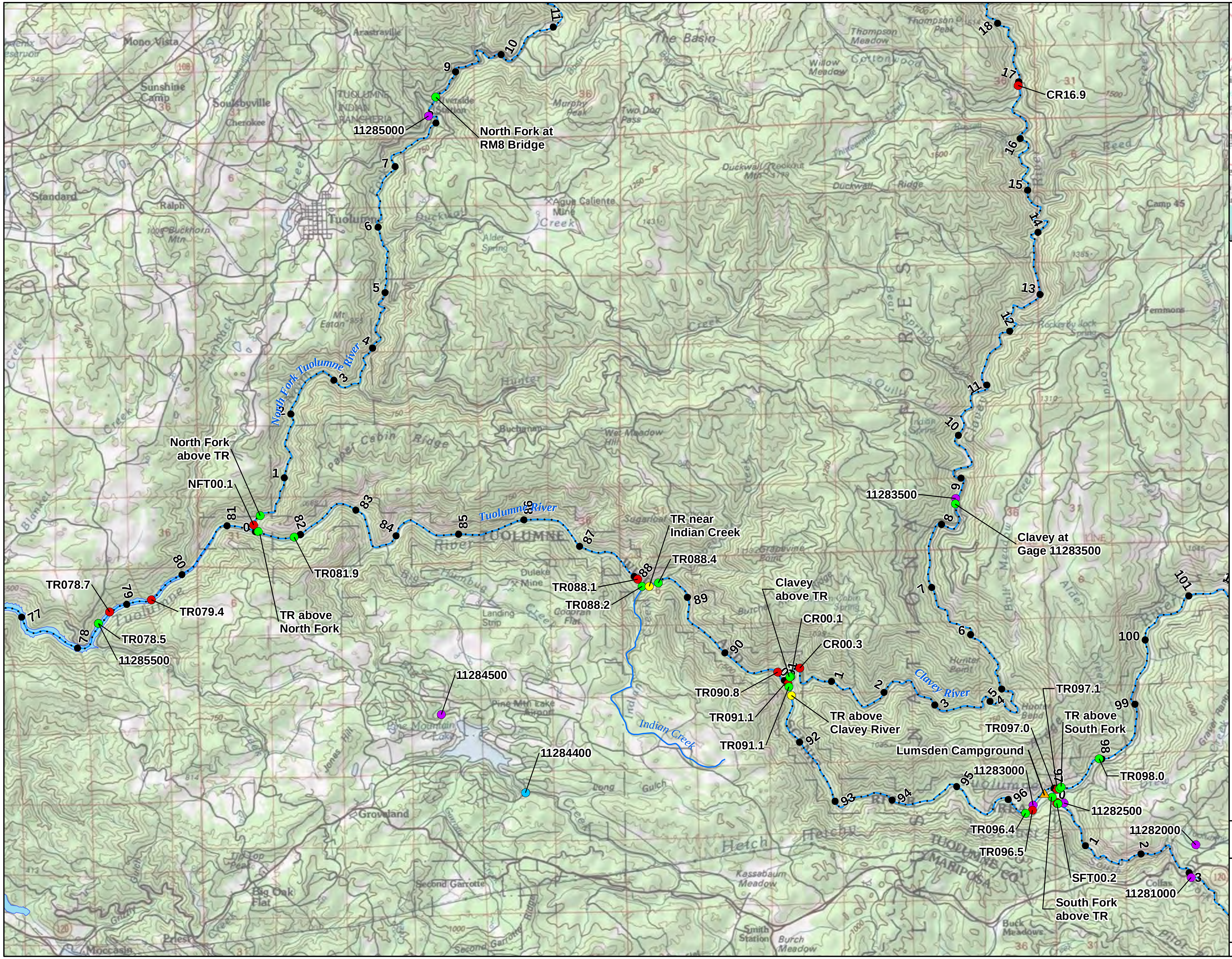
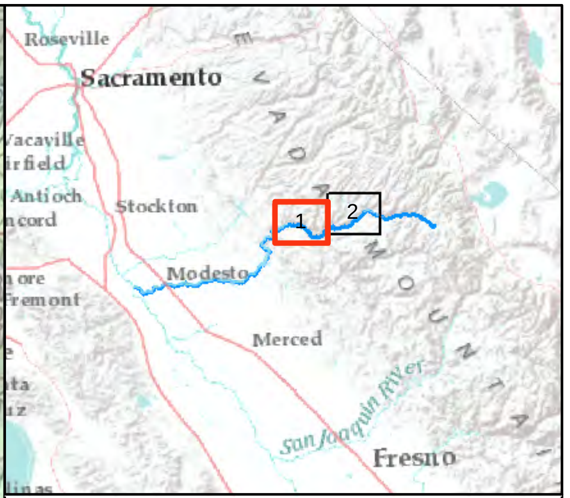
Process Feedback

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	*October 19, 2015 (??)*
Final TM No. 1 and Decision Framework Distributed	*December 1, 2015 (??)*
Draft TM No. 2 Distributed	*December 16, 2015 (??)*
Consultation Workshop No. 3	*January 14, 2015 (??)*
Initial Study Report document	February 2, 2016


Google earth





Stream / Flow Gage

Active | Inactive

Label	Agency	Active	Site Name
11281000	USGS	Inactive	SF TUOLUMNE R NR OAKLAND RECREATION CAMP CA
11282000	USGS	Inactive	M 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
11284400	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 Campgorund
TR096.5	CDFG	NO	Tuolmune 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.

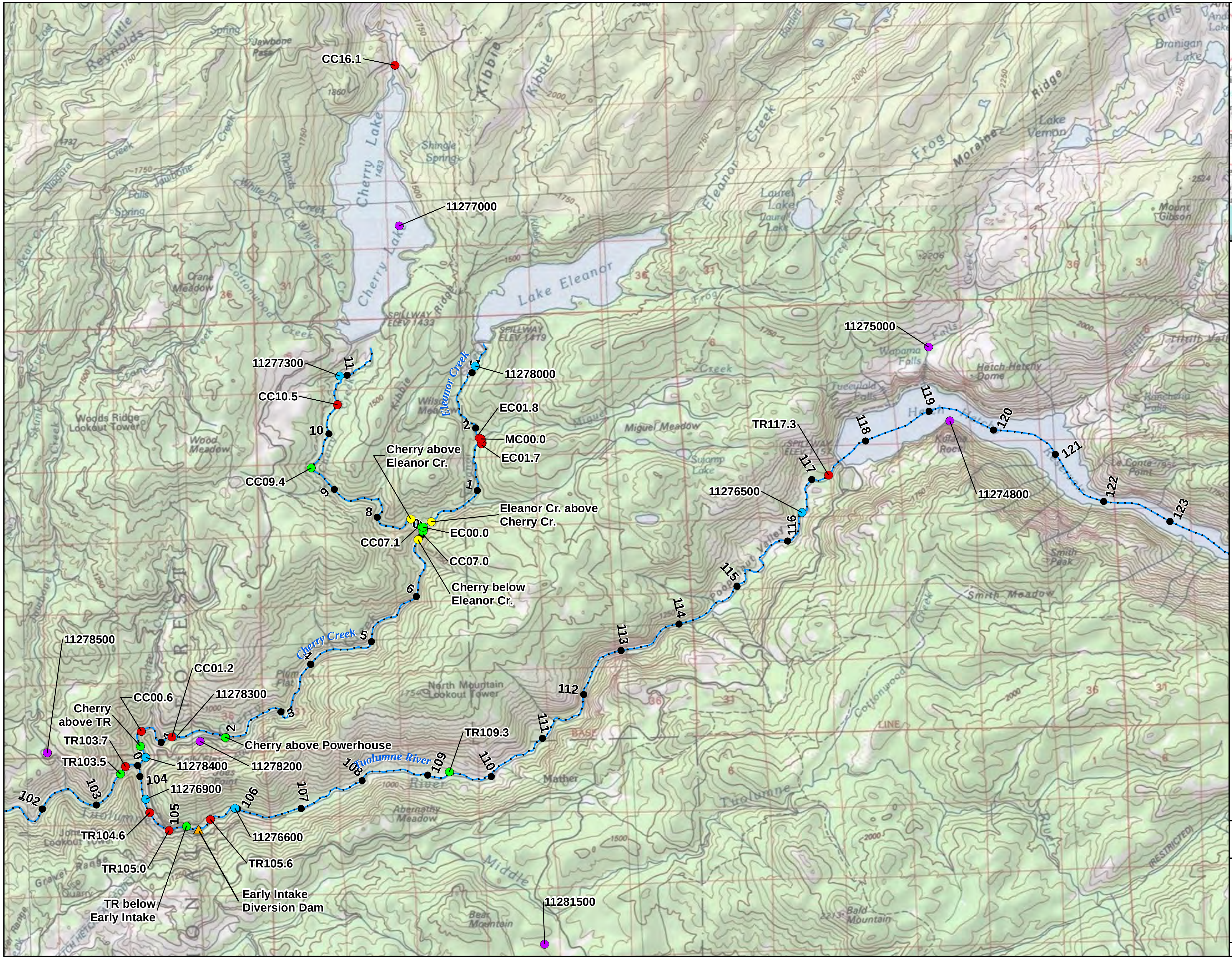
0 0.5 1 2 Miles

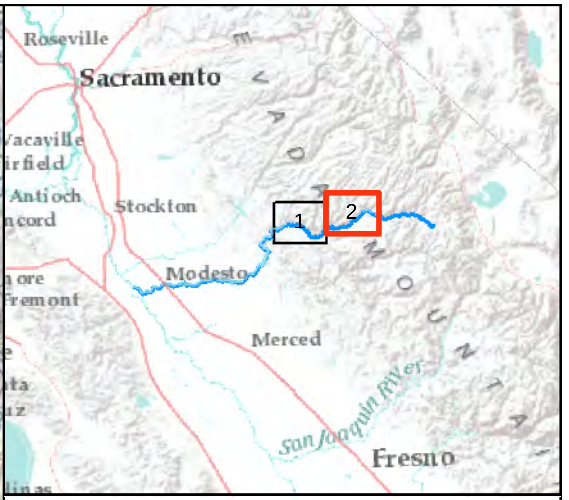
N

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

Sources: Esri, DeLorme, USGS, NPS
Sources: Esri, USGS, NOAA
Data is CA SPCS, Zone III, ft.





Stream / Flow Gage

Active · Inactive

Label	Agency	Active	Site Name
11274800	USGS	Inactive	TUOLUMNE R AT HETCH HETCHY NR SEQUOIA CA
11275000	USGS	Inactive	FALLS C NR HETCH HETCHY CA
11275500	USGS	Active	HETCH HETCHY RES A HETCH HETCHY CA
11276500	USGS	Active	TUOLUMNE R NR HETCH HETCHY CA
11276600	USGS	Active	TUOLUMNE R AB EARLY INTAKE NR MATHER CA
11276900	USGS	Active	TUOLUMNE R BL EARLY INTAKE NR MATHER CA
11277000	USGS	Inactive	CHERRY C NR HETCH HETCHY CA
11277200	USGS	Active	CHERRY LK NR HETCH HETCHY CA
11277300	USGS	Active	CHERRY C BL VALLEY DAM NR HETCH HETCHY CA
11277500	USGS	Active	LK ELEANOR NR HETCH HETCHY CA
11278000	USGS	Active	ELEANOR C NR HETCH HETCHY CA
11278200	USGS	Inactive	CHERRY C CN NR EARLY INTAKE CA
11278300	USGS	Active	CHERRY C NR EARLY INTAKE CA
11278400	USGS	Active	CHERRY C BL DION R HOLM PH, NR MATHER CA
11278500	USGS	Inactive	JAWBONE C NR TUOLUMNE CA
11281500	USGS	Inactive	M TUOLUMNE R NR MATHER CA

Water Temperature Logger

Active · Inactive · Proposed*

Label	Agency	Active	Site Locations
CC00.6	TID/MID	YES	Cherry above TR
CC00.6	CDFG	NO	Cherry Creek Power House
CC01.2	CCSF	NO	Cherry Creek, upstream of Dion Holm Powerhouse
CC07.0	CCSF	YES	Cherry Creek, downstream of confluence with Eleanor Creek
CC07.1	CCSF	YES	Cherry Creek, upstream of Eleanor Creek confluence
CC09.4	CCSF	YES	Cherry Creek, downstream of Cherry Dam
CC01.2	TID/MID	YES	Cherry above Powerhouse
CC10.5	CCSF	NO	Cherry Creek, downstream of Cherry Dam
CC16.1	CCSF	NO	Upstream of Cherry Lake
EC00.0	CCSF	YES	Eleanor Creek, upstream of Cherry Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.8	CCSF	NO	Eleanor Creek, upstream of Miguel Creek confluence
MC00.0	CCSF	NO	Miguel Creek, upstream of Eleanor Creek confluence
TR103.5	CCSF	YES	Tuolumne River, downstream of Cherry Creek confluence
TR103.7	CCSF	NO	Tuolumne River, downstream of Cherry Creek confluence
TR104.6	CCSF	NO	Tuolumne River, downstream of Early Intake Diversion Dam
TR105.0	CDFG	NO	Tuolumne River at Early Intake
TR105.2	TID/MID	YES	TR below Early Intake
TR105.6	CCSF	NO	Tailrace of Kirkwood Powerhouse
TR109.3	CCSF	YES	Tuolumne River, downstream of Preston Falls
TR117.3	CCSF	NO	Tuolumne River, downstream of O'Shaughnessy Dam

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

0 0.5 1 2 Miles

N

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
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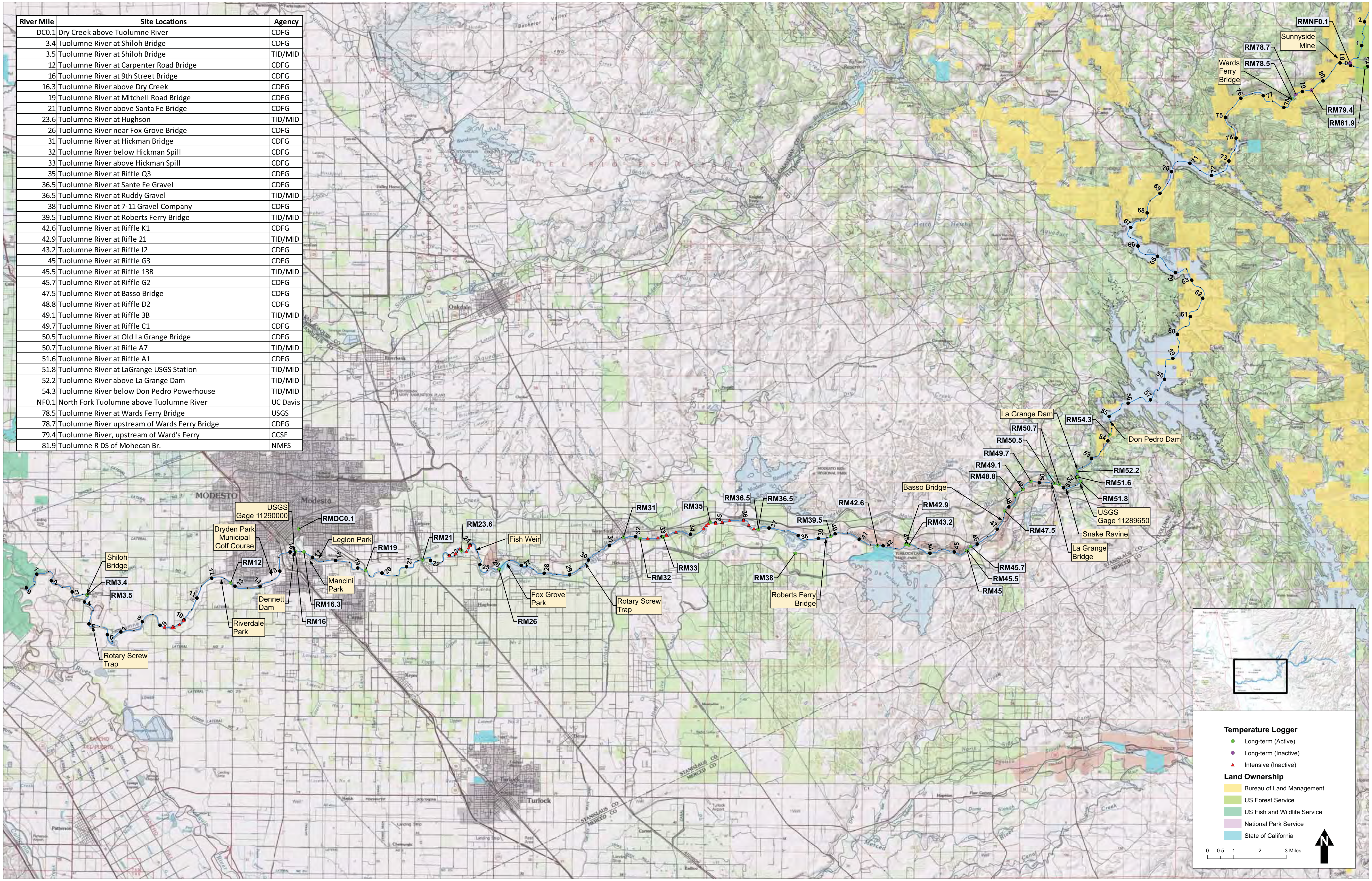
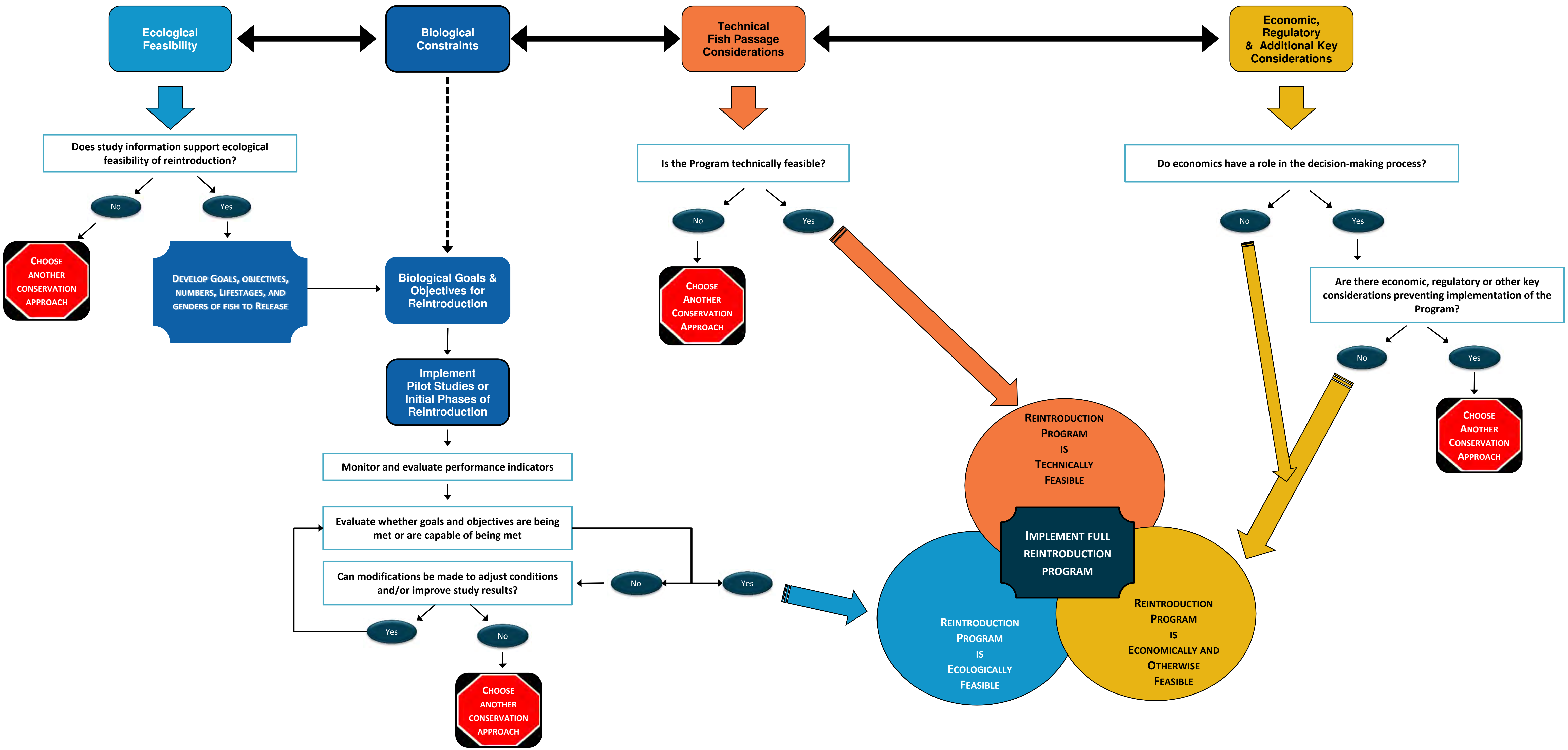
Sources: Esri, DeLorme, USGS, NPS
Sources: Esri, USGS, NOAA
Data is CA SPCS, Zone III, ft.

River Mile	Site Locations	Agency
DC0.1	Dry Creek above Tuolumne River	CDFG
3.4	Tuolumne River at Shiloh Bridge	CDFG
3.5	Tuolumne River at Shiloh Bridge	TID/MID
12	Tuolumne River at Carpenter Road Bridge	CDFG
16	Tuolumne River at 9th Street Bridge	CDFG
16.3	Tuolumne River above Dry Creek	CDFG
19	Tuolumne River at Mitchell Road Bridge	CDFG
21	Tuolumne River above Santa Fe Bridge	CDFG
23.6	Tuolumne River at Hughson	TID/MID
26	Tuolumne River near Fox Grove Bridge	CDFG
31	Tuolumne River at Hickman Bridge	CDFG
32	Tuolumne River below Hickman Spill	CDFG
33	Tuolumne River above Hickman Spill	CDFG
35	Tuolumne River at Riffle Q3	CDFG
36.5	Tuolumne River at Sante Fe Gravel	CDFG
36.5	Tuolumne River at Ruddy Gravel	TID/MID
38	Tuolumne River at 7-11 Gravel Company	CDFG
39.5	Tuolumne River at Roberts Ferry Bridge	TID/MID
42.6	Tuolumne River at Riffle K1	CDFG
42.9	Tuolumne River at Rifle 21	TID/MID
43.2	Tuolumne River at Riffle I2	CDFG
45	Tuolumne River at Riffle G3	CDFG
45.5	Tuolumne River at Riffle 13B	TID/MID
45.7	Tuolumne River at Riffle G2	CDFG
47.5	Tuolumne River at Basso Bridge	CDFG
48.8	Tuolumne River at Riffle D2	CDFG
49.1	Tuolumne River at Riffle 3B	TID/MID
49.7	Tuolumne River at Riffle C1	CDFG
50.5	Tuolumne River at Old La Grange Bridge	CDFG
50.7	Tuolumne River at Rifle A7	TID/MID
51.6	Tuolumne River at Riffle A1	CDFG
51.8	Tuolumne River at LaGrange USGS Station	TID/MID
52.2	Tuolumne River above La Grange Dam	TID/MID
54.3	Tuolumne River below Don Pedro Powerhouse	TID/MID
NF0.1	North Fork Tuolumne above Tuolumne River	UC Davis
78.5	Tuolumne River at Wards Ferry Bridge	USGS
78.7	Tuolumne River upstream of Wards Ferry Bridge	CDFG
79.4	Tuolumne River, upstream of Ward's Ferry	CCSF
81.9	Tuolumne R DS of Mohecan Br.	NMFS



Reintroduction Decision Criteria

Decision Tree Overview



La Grange Hydroelectric Project
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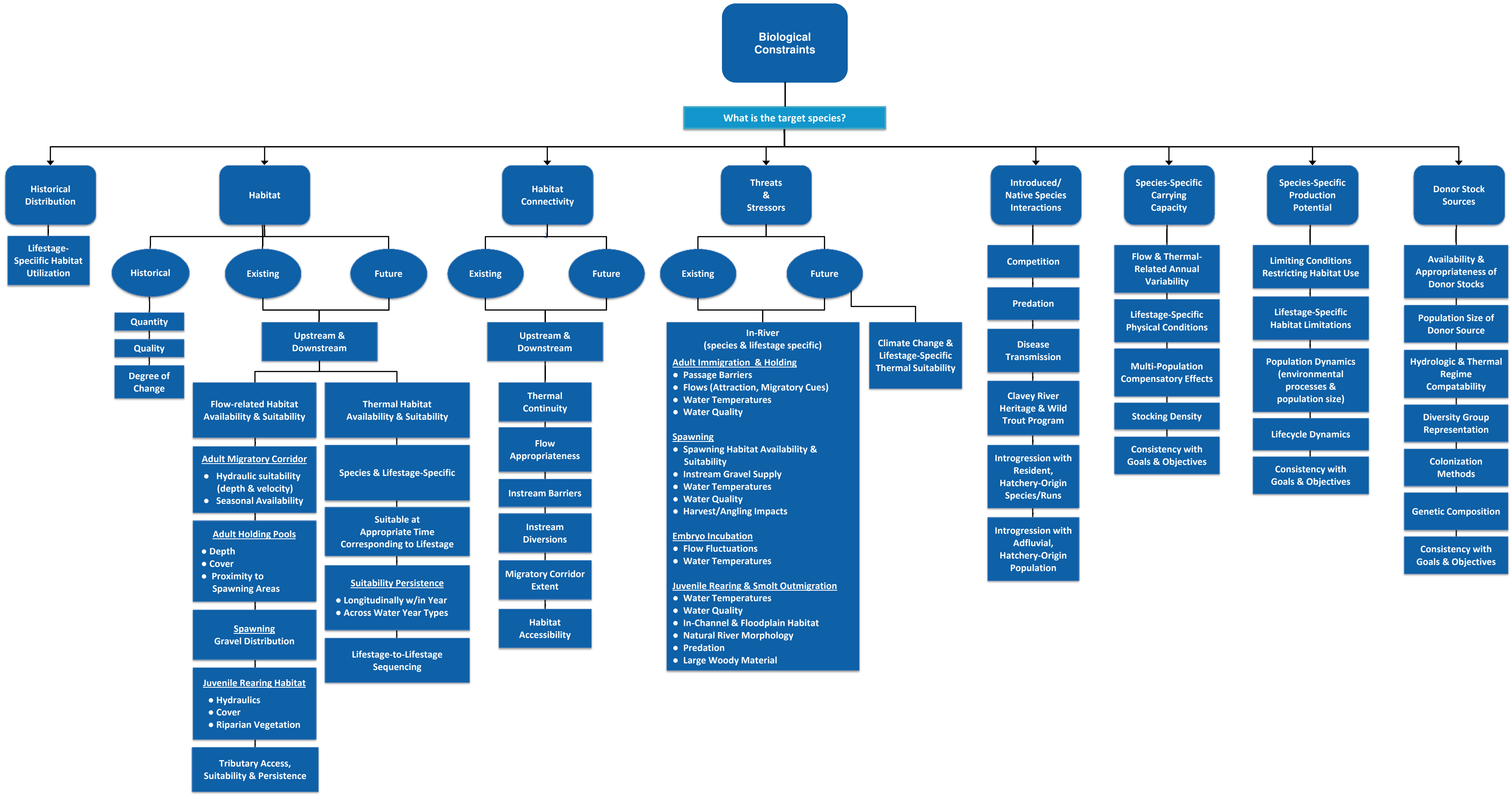
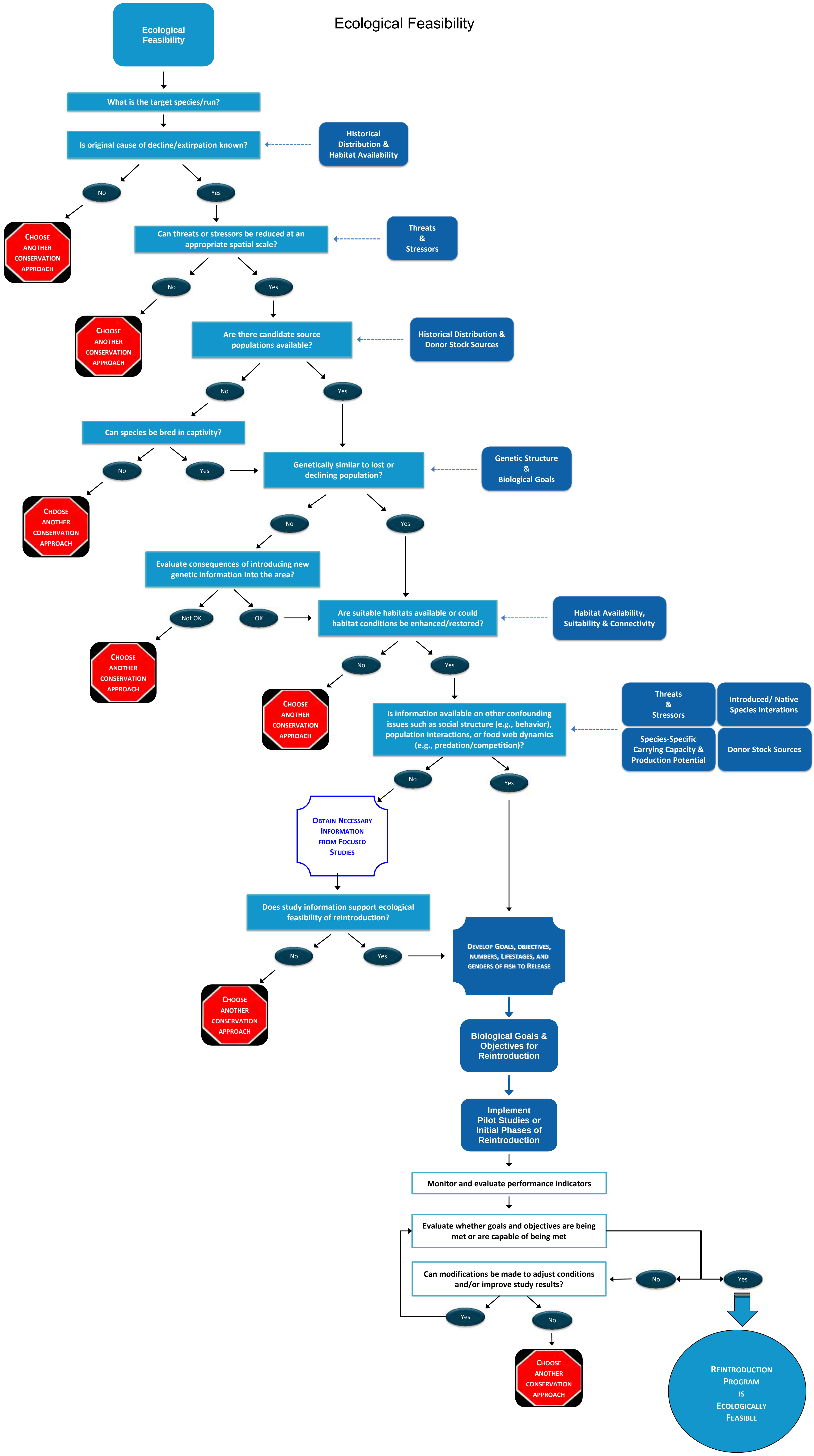
Reintroduction Decision Criteria

Biological Constraints



Reintroduction Decision Criteria

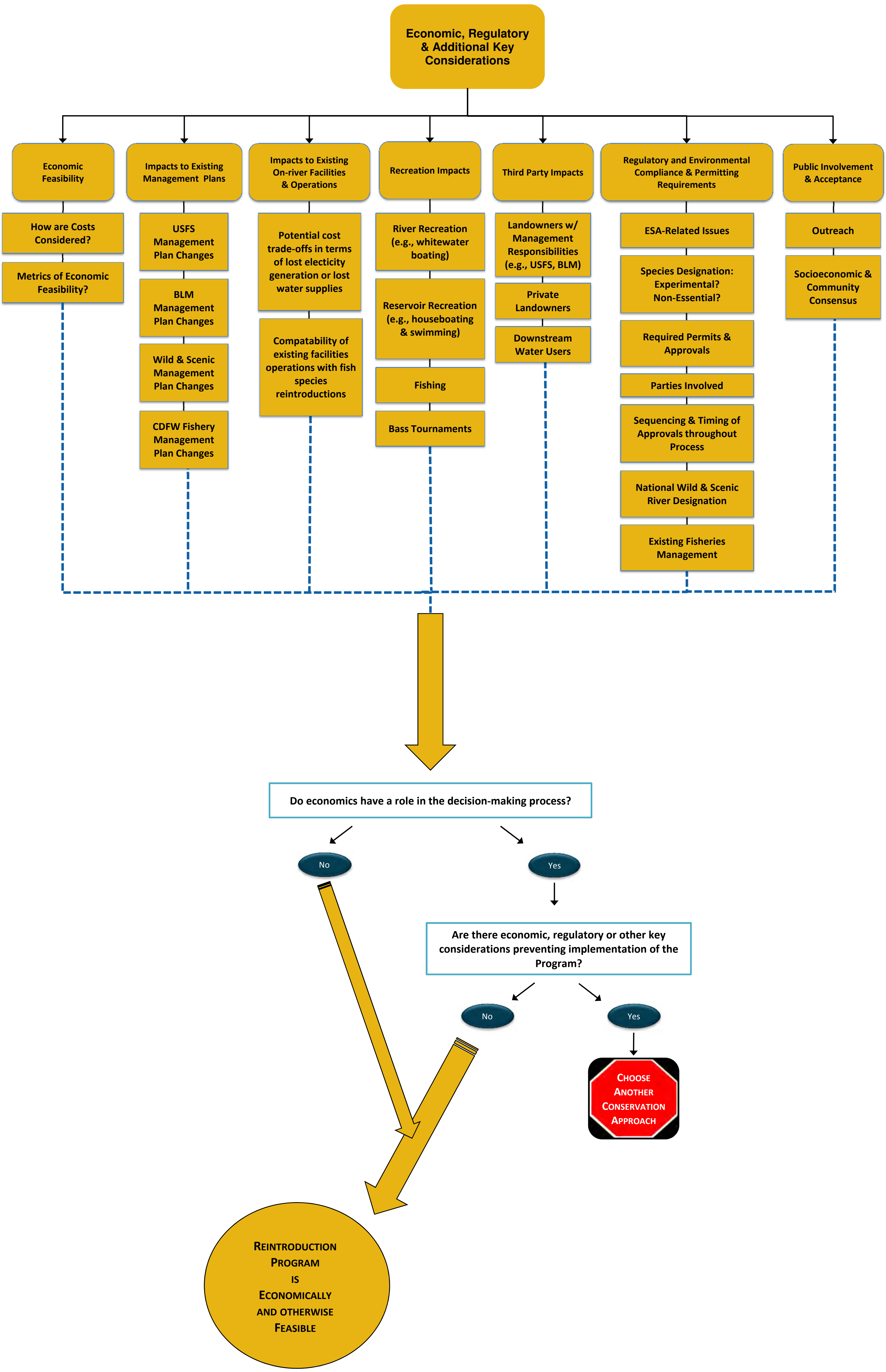
Ecological Feasibility



La Grange Hydroelectric Project
Fish Passage Alternatives Assessment
Workshop No. 2 – September 17, 2015

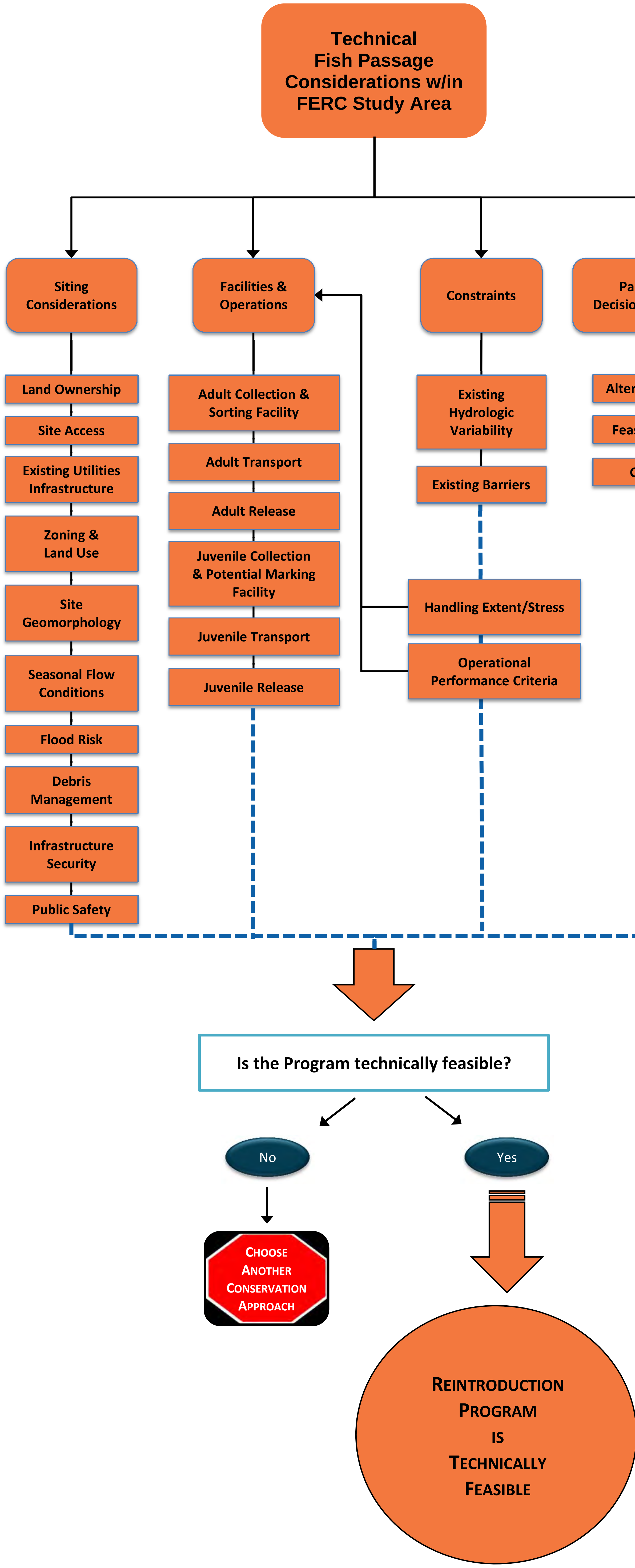
Reintroduction Decision Criteria

Economic, Regulatory & Other Considerations



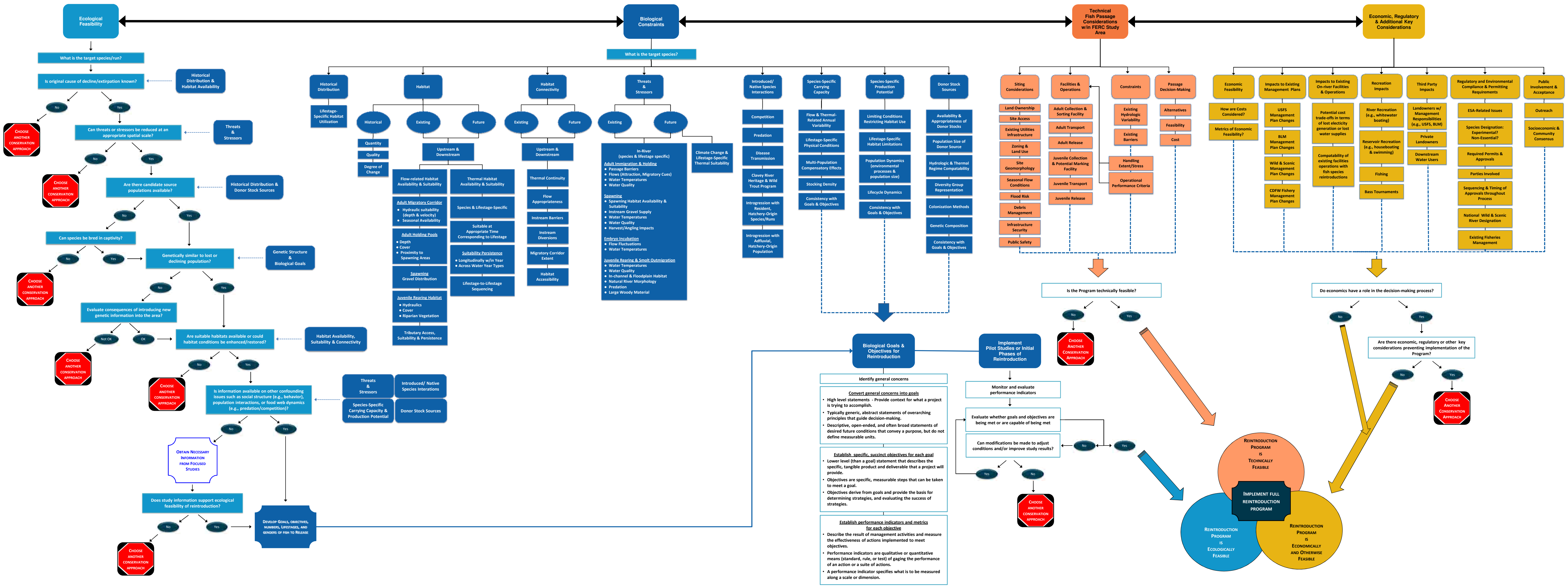
Reintroduction Decision Criteria

Technical Passage Feasibility



Reintroduction Decision Criteria

Integrated Decision Tree



La Grange Hydroelectric Project
Fish Passage Alternatives Assessment
Workshop No. 2 – September 17, 2015

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT
TECHNICAL MEMORANDUM NO. 1
EXISTING SITE CONSIDERATIONS AND DESIGN CRITERIA

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

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

Prepared by:
HDR, Inc.

September 2015

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List of Acronyms and Abbreviations

ACOE.........................U.S. Army Corps of Engineers
CCSF..........................City and County of San Francisco
CDFG.........................California Department of Fish and Game
CDFW........................California Department of Fish and Wildlife
cfs..............................cubic feet per second
Districts......................Modesto Irrigation District and Turlock Irrigation District
EDF............................energy dissipation factor
ESA............................Endangered Species Act
ESU............................evolutionary significant unit
FERC..........................Federal Energy Regulatory Commission
ft................................feet
ft/s ....feet/second
ILP.............................Integrated Licensing Process
LGDD ....La Grange Diversion Dam
LP..............................licensing participant
M&I...........................municipal and industrial
MID...........................Modesto Irrigation District
mm ....millimeters
MW ....megawatt
NGVD 29...................1929 National Geodetic Vertical Datum
NMFS.........................National Marine Fisheries Service
O&M..........................operations and maintenance
RM ....river mile
SFPUC ....San Francisco Public Utilities Commission
TID............................Turlock Irrigation District
TM.............................Technical Memorandum
TRTAC ....Tuolumne River Technical Advisory Committee
USGS ....Unite State Geological Survey

1.0 INTRODUCTION

This Technical Memorandum (TM) No. 1 is the first of three interim work products developed for the Fish Passage Alternatives Facilities Assessment for the La Grange Hydroelectric Project (La Grange Project or Project; Federal Energy Regulatory Commission [FERC] No. 14581). This TM No. 1 provides information and analysis necessary to characterize site-specific considerations and anticipated fish passage criteria which may influence the formulation, evaluation, and conceptual design of fish passage facilities alternatives which may be determined viable for the Project. Upon receipt of feedback from licensing participants (LP), future versions of the TM will be prepared and released for review. The release of multiple interim work products is intended to facilitate a collaborative process where feedback and consensus can be obtained prior to initiating next steps in the study.

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 (Figure 1.1-1). LGDD was constructed from 1891 to 1893 to replace Wheaton Dam, which was built by other parties in the early 1870s. The 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 (MW). The La Grange Project operates in a run-of-river mode. The LGDD provides no flood control benefits, and there are no recreation facilities associated with the La Grange Project or the La Grange pool.

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 above the diversion dam is between elevation[1] 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 (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 2.6 miles upstream, and very minor contributions from two small intermittent streams downstream of Don Pedro Dam.

[1] All elevations in this document are referenced to 1929 National Geodetic Vertical Datum (NGVD 29).

Figure 1.1-1. Site and vicinity of La Grange Diversion Dam.

1.2 Fish Passage Facilities Alternatives Assessment

As part of the Integrated Licensing Process (ILP) for the La Grange Project, the Districts are completing a phased, two-year Fish Passage Facilities Alternatives Assessment to identify and develop potentially viable, concept-level alternatives for upstream and downstream passage of Chinook salmon and steelhead at the La Grange and Don Pedro dams. The study area for the Fish Passage Facilities Alternatives Assessment is the Tuolumne River immediately downstream of the LGDD (at the confluence of the main river channel and the powerhouse tailrace channel) upstream to the upper Tuolumne River at the upper most extent of the Don Pedro Reservoir. For the purposes of the Fish Passage Facilities Alternatives Assessment, all facilities are assumed to occur within the designated study area in control of the Project owners TID and MID. The overall study area for the assessment is presented in Figure 1.2-1.

Specific objectives of the Fish Passage Facilities Alternatives Assessment are to:

- Obtain available information to establish existing baseline conditions relevant to impoundment operations and siting passage facilities,
- Obtain and evaluate available hydrologic data and biological information for the Tuolumne River to identify potential types and locations of facilities, run size, fish periodicity, and the anticipated range of flows that correspond to fish migration,
- Formulate and develop preliminary sizing and functional design for select, alternative potential upstream and downstream fish passage facilities, and
- Develop Class-V opinions of probable construction cost and annual operations and maintenance (O&M) costs for select fish passage concept(s).

The Fish Passage Facilities Alternatives Assessment will occur in two phases. Phase 1 (conducted in 2015) will involve collaborative information gathering and evaluation of facility siting, sizing, general biological and engineering design parameters, and operational considerations. Phase 2 (conducted in 2016) will involve the development of preliminary functional layouts and site plans, estimation of preliminary capital and O&M costs, and identification of any additional significant information needs for select passage alternatives.

To facilitate a collaborative process, the Districts will produce two TMs during Phase 1, each summarizing key results to date. Both TMs will be provided to LPs for review and comment, with the goal of soliciting feedback on the overall approach and findings and reaching a consensus prior to initiating next steps in the study.

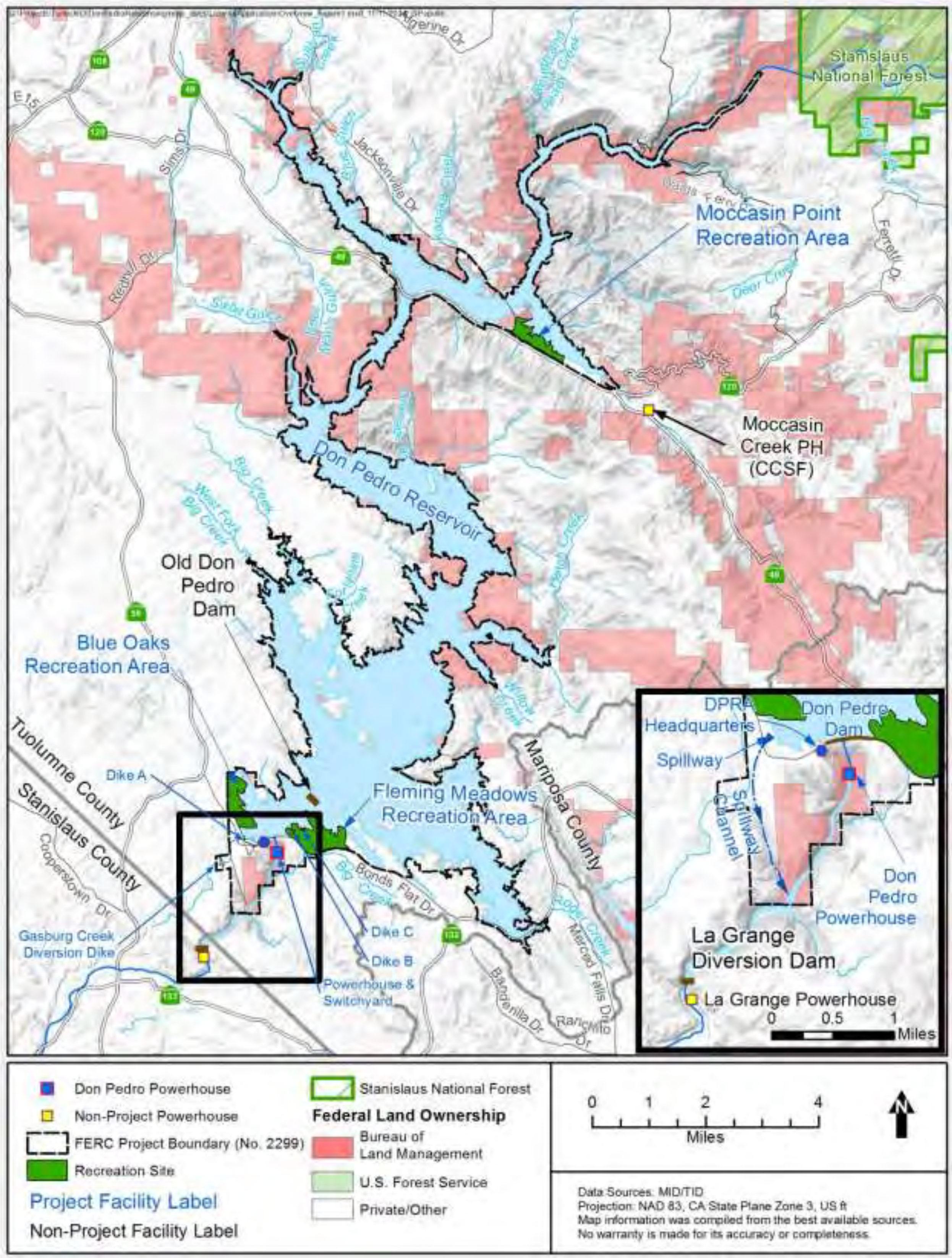

Figure 1.2-1 Overall study area for the Fish Passage Facilities Alternatives Assessment.

1.3 Goal of Technical Memorandum No. 1

The goal of this TM No. 1 is to provide the information, analysis, and design criteria necessary to characterize site-specific fish passage considerations and objectives. Where needed information is not available, data gaps have been identified. It is the Districts' hope that LPs review this document and come to the La Grange Fish Passage Facilities Alternatives Assessment Workshop No. 2 (scheduled for Thursday, September 17) prepared to discuss its contents. Information relative to future expected fish species occurrence, population sizes, run timing, and facility performance will require input from others. Input received from LPs during review and discussion of the TM No. 1 contents will be incorporated into future work being performed to complete this assessment.

2.0 FISH PASSAGE FACILITIES CONSIDERATIONS

The following sections include existing, site-specific information that characterizes the biological and physical setting of the proposed study area which influences the applicability and selection of fish passage facilities alternatives.

2.1 Anadromous Fisheries Resources

The intent of the Fish Passage Facilities Alternatives Assessment was formulated based upon information provided by LPs in their study requests and considers passage of three anadromous fish species: fall-run Chinook, spring-run Chinook, and steelhead. Historically, both fall- and spring-run Chinook salmon occurred in the Tuolumne River basin. Currently, only a fall-run Chinook salmon population is present, while spring-run have been extirpated from the Tuolumne and San Joaquin River watershed for decades. A population of *O. mykiss* occur within the Tuolumne River but there is no evidence that a self-sustaining population of anadromous steelhead currently exists within the Tuolumne River watershed. The habitat suitability and future occurrence and numbers of these species is therefore unknown as all three candidate species would require reintroduction into the Tuolumne River above Don Pedro Reservoir. The viability of reintroduction is unknown at this time and therefore the inclusion of these three target species into the Fish Passage Facilities Alternatives Assessment process may be revised as input from LPs is obtained. A more detailed description of each species and their occurrence in the Tuolumne River is provided in the following sections.

2.1.1 Fall-run Chinook

Adult fall-run Chinook salmon migration in the Tuolumne River extends upstream to the vicinity of the LGDD and occurs from September through December, with peak migration activity occurring in October and November (TID/MID 2013c). 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 Project relicensing process.

2.1.2 Spring-Run Chinook

Currently, spring-run Chinook salmon do not occur within Tuolumne River. Central Valley spring-run Chinook salmon, were listed by the National Marine Fisheries Service (NMFS) as threatened under the Endangered Species Act (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 review of available literature did not reveal readily available estimates of historical escapement estimates (NMFS 2014). Spring-run Chinook escapement estimates have been described more broadly to 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*." Reintroduction of an experimental population of spring-run Chinook salmon to the San Joaquin River downstream of Friant Dam is currently being developed.

2.1.3 Oncorhynchus mykiss

Oncorhynchus 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 anadromous *O. mykiss* have been documented in the Tuolumne River, there is no empirical scientific evidence of a self-sustaining "run" or 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.

2.2 Potential Targeted Species and Life Stages for Fish Passage Under Consideration

Selection of targeted fish species and life stages for fish passage design drives the overall selection of potential fish passage alternatives. This TM No. 1 focuses on the development of fish passage alternatives which facilitates the upstream migration of adult spring-run Chinook salmon and adult steelhead as well as the downstream migration of juvenile life history stages for these species. At this time, fall-run Chinook salmon are considered a target species for fish passage however historical distribution of fall-Chinook was generally believed to be confined to lower elevations (i.e., below the reach of the Tuolumne River identified for possible reintroduction). As such, agreement among LPs regarding assumed target species and exclusion of fall-run Chinook will be required. Recognized, general characteristics for the adult life stage of each fish species are presented in Table 2.2-1. These characteristics vary based upon population genetics, return age, and other watershed specific factors not discussed here.

Table 2.2-1. General characteristics of select species (Bell 1991; TRTAC 2000).

Target Fish Species	General Characteristics
Chinook Salmon (fall and spring run)	• Typical weight range 10 to 30 lbs • Spend 2 to 5 years in the ocean (most fall-run return to the Tuolumne at 3 years) • Reach maturity at 3 to 6 years • 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
Steelhead (winter run)	• Typical weight range 5 to 20 lbs • Spend 1 to 4 years in the ocean • Reach maturity at 3 to 6 years • 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

Monitoring of juvenile fall-run Chinook currently occurs within the lower Tuolumne River at the Waterford (RM 30) and Grayson (RM 5) rotary screw trap locations. Much of the data collected relative to numbers, fork lengths, and weights are published in FISHBIO's monthly San Joaquin Basin Update. Published data suggests that the juvenile Chinook fork lengths range from 34 to 120 millimeters (mm) with the majority of fish falling into sub-smolt categories (68 mm or less) (FISHBIO 2008 through 2010) during the outmigration period (i.e., January through June). This range of values may provide some insight on required capture velocities and need for pumped fish collection systems and the lifestage/size that may be considered feasible for collection and/or passage; but it is recognized that over 150 studies have been conducted on the Tuolumne River since 1992 and ultimately complete data sets should be reviewed as part of further design concept development.

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. For the purposes of this TM No. 1, several regional sources of information originating from the San Joaquin and Sacramento rivers were reviewed to generate potential estimates of migration timing. Potential migration timing for target species under consideration in the Tuolumne River is presented in Table 2.2-2. Results of fish monitoring in the Sacramento River tributaries, such as Mill and Butte creeks and the Feather River, show variation in the seasonal timing of juvenile migration among watersheds and in response to variation in environmental conditions such as spring freshets. Information on seasonal run timing presented in this TM No. 1 has been generalized to classify typical species tendencies with regard to upstream and downstream migration but does not reflect the detailed estimates of fish periodicity that are required to move forward with an accurate assessment of fish passage facilities needs. Future phases of the Fish Passage Facilities Alternatives Assessment will require input from the LPs and agreement on the period of migration for both adult and juvenile fish life stages. Data presented in Table 2.2-2 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 December are anticipated to exhibit relatively little activity with regard to juvenile downstream migration.

Table 2.2-2. Anticipated life history timing of potential targeted species.

[1] TID/MID 2013c
[2] NMFS 2014 Central Valley salmonid recovery plan

In addition to migration timing, the relative ages-class, fish size, population abundance, and migration timing of target fish species has a significant influence on the applicability and selection of potentially viable fish passage facilities alternatives. Currently, information regarding these factors are only available through other regional data sources where populations of these species currently exist. Input from the LPs is required to finalize the design basis regarding these potential future populations and their various characteristics for use in the future phases of the Fish Passage Facilities Alternatives Assessment.

2.3 Physical Characteristics of Don Pedro and La Grange Dams

Don Pedro Dam stands at a total height of approximately 580 feet tall with a normal maximum pool elevation of 830 feet. LGDD, located 2.6 miles downstream of Don Pedro Dam, is 131 feet tall with an approximate minimum tailwater elevation of 175 feet at the TID powerhouse. The total vertical differential between the tailwater at LGDD and the full pool elevation of Don Pedro Reservoir is therefore about 650 feet. Additional characteristics for each structure are provided in Table 2.3-1.

Table 2.3-1. Summary of general physical characteristics of Don Pedro and La Grange dams.

Item	Don Pedro Dam	La Grange Diversion Dam
Date Completed	1971	1893, Modified in 1923 and 1930
River Mile	54.8 mi	52.2 mi
Gross Storage	2,030,000 acre-feet	200 acre-feet
Drainage Area	1,533 mi^2	1,548 mi^2
Dam Height	580 ft	131 ft
Top of Dam Elevation	855 ft	N/A
Maximum/Full Pool Elevation	830 ft	N/A
Gated Spillway Crest Elevation	800 ft	N/A
Ungated Spillway Crest Elevation	830 ft	296.5 ft
Minimum Power Pool Elevation	600 ft	-
Minimum Tailwater Elevation	300 ft[1]	175 ft

[1] Approximated from available data sources

2.4 Site Accessibility

Accessibility to the LGDD and to the head 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 each migration season. The ability to access each location, travel time between facilities, and road conditions has a direct effect on construction cost 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.

2.4.1 Access to La Grange Diversion Dam

LGDD is accessible from the north via La Grange Road (J-59) and from the south via Yosemite Boulevard (CA-132) and La Grange Road (J-59). A short 1.4 mile section of La Grange Dam Road leads from the intersection of Yosemite Boulevard (CA-132) to the LGDD outlet and diversion facilities. The presence of publicly owned paved roads and only a short section of a TID/MID 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 those events are rare and episodic.

2.4.2 Access to Don Pedro Dam

Don Pedro Dam is accessible from the east and west via Bonds Flat Road. Bonds Flat Road intersects J-59 approximately 5 miles and CA-132 approximately 12 miles north of La Grange. All roads are publicly owned and well maintained for travel by larger vehicles.

2.4.3 Access to Upper Extent of Don Pedro Reservoir

The head (i.e., upstream end) of Don Pedro Reservoir can be accessed at three primary locations: Wards Ferry Bridge, Jacksonville Road Bridge, and at the CA-120/49 Bridge.

- Wards Ferry Bridge 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 is accessed directly 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.
- The CA-120/49 Bridge 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 likely travelable 365 days a year.

2.5 Project Operations

The following sections provide information on related to pertinent operational considerations of the Don Pedro and La Grange project facilities.

2.5.1 La Grange Pool Operations

LGDD is a 131-foot tall run-of-river structure that is used to split flows between irrigation, municipal, and environmental water uses managed by TID, MID, and others. 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 spilling over the LGDD structure continues down the lower Tuolumne River.

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 (M&I) 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. Then 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 with two available data sets: 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 data set 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 (ACOE) flood management guidelines, and the TID and MID irrigation and M&I 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 takes into consideration more climactic variability and provides a better estimate of future pool conditions when considering the potential for implementation of future fish passage facilities. Figure 2.5-1 illustrates pool elevation trends and variation for Historical and Base Case data sets for their respective periods of record.

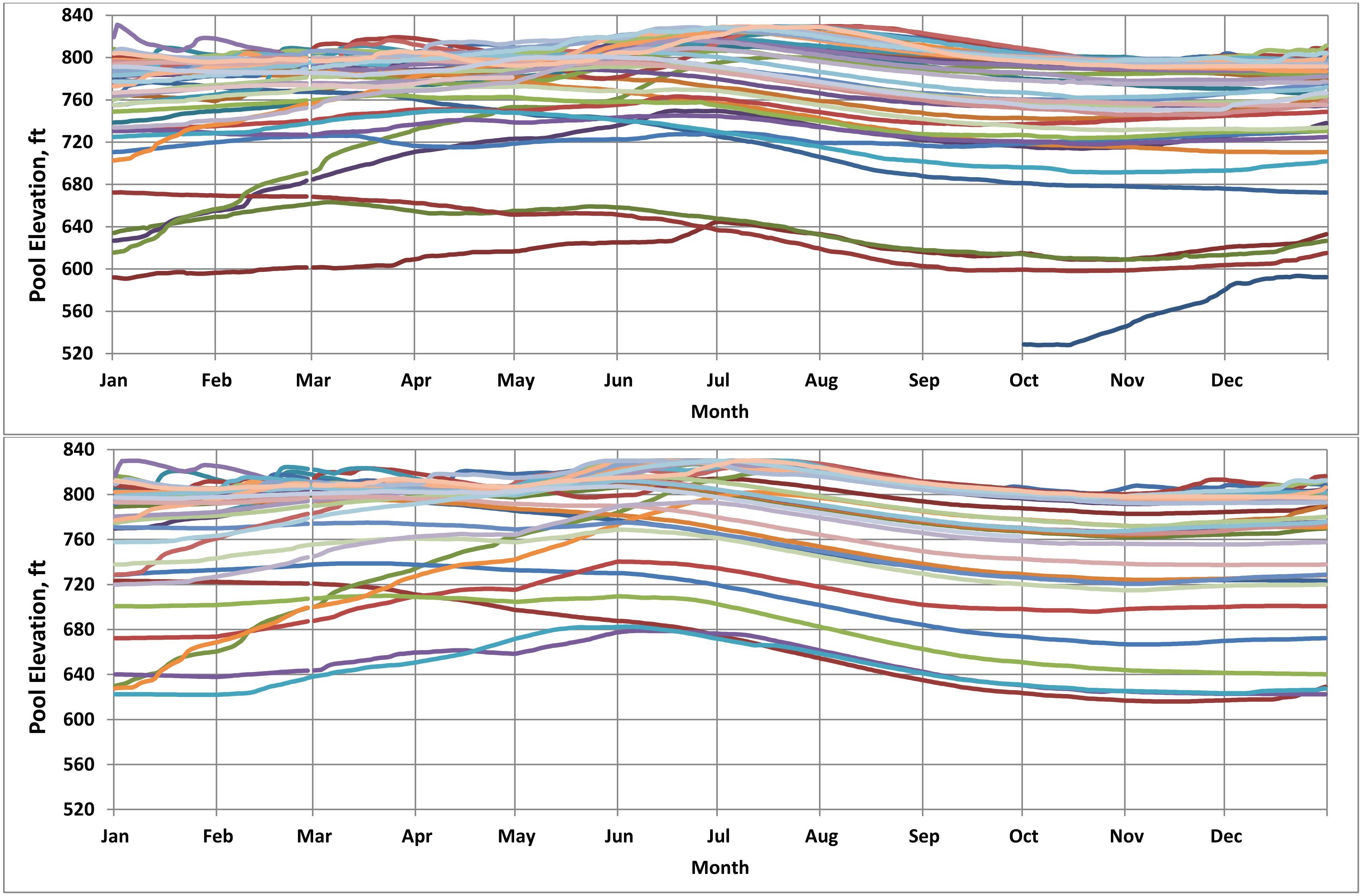

Figure 2.5-1 Mean daily pool elevation for the Historical (top) and Base Case (bottom) Don Pedro Dam operational scenarios.

Table 2.5-1 provides the percent exceedance of mean daily pool elevation over an annual basis for Historical observations. The data shows that the median pool elevation on an annual basis is approximately 788.2 feet. Observed elevations which accounts 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 2.5-1. 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

Data for the anticipated migration periods of fall-run Chinook, spring-run Chinook, and steelhead were further evaluated to identify the potential requirements of target fish species given Historical observations. Table 2.5-2 provides the Historical percent exceedance of mean daily pool elevation for anticipated outmigration periods while Table 2.5-3 provides results of the same analysis on anticipated upstream migration periods. The annual exceedance elevation data is also provided in each table for comparative purposes.

Table 2.5-2. 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 2.5-3. 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 2.5-4 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 accounts for 80 percent of Historical 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 historical 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 mean daily pool fluctuations of 120.0 feet may be exceeded 20 percent of the time, 170.5 feet may be exceeded 10 percent of the time, and 207.1 feet were exceeded 2 percent of the time.

Table 2.5-4. 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

Data occurring within the anticipated migration periods of fall-run Chinook, spring-run Chinook, and steelhead were further evaluated to identify the potential requirements of target fish species for the Base Case operational scenario. Table 2.5-5 provides the percent exceedance of mean daily pool elevation for anticipated outmigration periods while Table 2.5-6 provides results of the same analysis on anticipated upstream migration periods, each for the Base Case operational scenario.

Table 2.5-5. 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 2.5-6. 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

2.6 Hydrologic Conditions Relative to Fish Passage

The objective for fish passage design is to provide suitable hydraulic conditions over a range of reasonable streamflows under which the targeted fish species and life stages are expected to migrate, either upstream or downstream. Understanding the recurrence and magnitude of such stream flows is an important component in establishing the anticipated range of flows which directly influences the sizing and complexity of fish passage facilities. Available hydrologic data were obtained and preliminary analyses were performed in order to define the anticipated range of flows that coincide with fish migration for each target species. A summary of the available data and results of the analysis are provided in the following paragraphs.

Two different hydrologic conditions need to be addressed to accommodate upstream and downstream fish passage goals. Adult upstream fish passage design will be influenced by the flows occurring downstream of the La Grange Project. These flows are regulated by Don Pedro Reservoir operations. Downstream collection of out-migrating juvenile fish that originate above

Don Pedro Reservoir will be influenced by the 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. Depending on the water year type, the natural hydrograph may dominate during juvenile outmigration in wetter years; however, regulated flows may dominate in dry water years. In 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.

2.6.1 River Flow Data

Flow data collected by the United States Geological Survey (USGS) is available on the Tuolumne River approximately 0.5 miles downstream of the LGDD (USGS Gage 11289650). At LGDD, diversions are also made into the adjacent Modesto and Turlock main canals. USGS Gage 11289650 is active and has current data available, while USGS Gage 11289651 has daily flow data available through September 30, 2012.

Flows upstream of the Don Pedro Reservoir at Wards Ferry Bridge are collected by USGS Gage 11285500 which began collecting mean daily flow data on December 5, 2013 and is currently active. In combination, the available flow data obtained from gaging stations does not adequately characterize the potential frequency, magnitude, and duration of flow needed to evaluate potential fish passage alternatives.

For the purposes of this assessment the 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, reservoir stage, and flow measured at La Grange Bridge downstream of the LGDD. The resulting simulated data provides 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 data set reflects the combination of both the regulated and unregulated portions of the upper watershed while the calculated Base Case data set 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, ACOE flood management guidelines, and the Districts' irrigation and M&I water management practices. Detailed summaries of simulation development and the resulting data are presented in Appendix B-2 of the Don Pedro Hydroelectric Project Final License Application (TID/MID 2013b).

2.6.2 Inflow to Don Pedro Reservoir

Inflow into Don Pedro Reservoir is characterized in the following section using a combination of historical data sources and the future casted predictions from the Base Case operational model results. The percent exceedance of flows into Don Pedro Reservoir based upon the Historical data set is summarized in Table 2.6-1. 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 2.6-2. 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 2.6-1. 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 2.6-2. 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

2.6.3 River Flow below LGDD

River discharge immediately downstream of the La Grange Project is characterized in the following section using a combination of historical data sources and the future casted predicted predictions from the Base Case operational model results. The percent exceedance of flows based upon Historical data set is summarized in Table 2.6-3. 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 the La Grange Project based upon the Base Case operational scenario is summarized in Table 2.6-4. 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 2.6-3. Historical exceedance Tuolumne River flows below LGDD for arriving adults using a period of record of Oct 1, 1970 – Dec 31, 2013.

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

[1] 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 as shown in Table 2.7-4.

Table 2.6-4. 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

2.6.4 Minimum Releases to Support Existing Fisheries 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 a minimum stream flow from Hetch Hetchy Reservoir. Once made, releases cannot be diverted below O'Shaughnessy Dam (i.e., at Early Intake); they flow down the Tuolumne River, are supplemented by releases at Kirkwood and Homm powerhouse and 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 Project is required to provide minimum stream flows in the lower Tuolumne River. As of October 1 of each year, flows are adjusted to meet minimum flow and pulse flow requirements to benefit upstream migrating adult 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. The schedule of flow releases to the lower Tuolumne River by water year type are contained in FERC's 1996 order (TID/MID 2013b). 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. In critical years, instream flow requirements are as low as 50 cfs.

3.0 DESIGN CRITERIA AND GUIDELINES FOR FISH PASSAGE DESIGN

There are numerous guidelines and design criteria established by the CDFW and NMFS which provide a framework for fish passage design. Other literature sources are available which provide design guidance and biological criteria for the collection, handling, and transport of fish. Although not explicitly referenced, applicable criteria are used in this TM No. 1 throughout the passage alternatives formulation process. Some are specifically outlined in the alterative descriptions. Such reference documentation includes the following:

- 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.

3.1 Selection of Range of Reservoir Pool Elevations Coincident with Target Fish Species Migration

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 and regulated based upon reservoir passage efficiency, collection efficiency, passage efficiency to a downstream release point, and percent mortality. Typical expectations for facilities of this type are in the range of 85 to 95 percent overall with a minimum compliance of 75 percent. 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.

As introduced in the data presented Section 2.5 of this document Don Pedro Reservoir experiences a high level of seasonal fluctuation. In reference to the Historical data set, results indicate that 98 percent of potential reservoir conditions may be accommodated with a downstream passage facility designed for an overall range of reservoir pool elevations from 651.6 feet to 827.0 feet which is a total of 175.4 feet. Ninety-eight percent of potential conditions may be accommodated with an upstream fish passage facility designed for an overall range of reservoir pool elevations from 599.4 feet to 826.3 feet which is a total of 226.9 feet. Predicted Base Case conditions indicate that 98 percent of anticipated reservoir conditions would be accommodated with a downstream fish passage facility designed for an overall range of reservoir pool elevations from 632.0 feet to 830.0 feet which is a total of 198.0 feet. Ninety-eight percent of potential conditions may be accommodated with an upstream fish passage facility designed for an overall range of reservoir elevations from 617.5 feet to 830.0 feet which is a total of 212.5 feet. This information 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 on the order of 230 feet.

The expectations for facility performance are currently unknown at this point in the process and the above information is presented as a generalization based upon the operational requirements of other known facilities. These requirements are typically set through consultation with fisheries agencies and are necessary to proceed further into the related assessment of engineering and economic feasibility. Further input from the LPs is required to determine performance criteria and expectations for this study. After the performance criteria and operation expectations are identified, several key factors can be selected by the assessment team such as the target range of reservoir elevations that would require accommodation of downstream fish passage.

3.2 Selection of River Flow Design Guidelines Coincident with Target Fish Species Migration

Fish passage design flow criteria also influences a number of factors associated with fish passage facilities 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 high fish passage design flow shall be the mean daily average streamflow that is exceeded 5 percent of the time during periods when migrating fish may be present. NMFS (2011) also states that low fish passage design flow 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 with 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, for the purposes of this TM No. 1 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 2.6.2. Design flow criteria for upstream collection facilities would rely on the records and corresponding percent exceedance values for river flows passing downstream of the La Grange Project. These values are presented previously in Section 2.6.3. 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 3.2-1.

Table 3.2-1. Fish passage facility flows calculated for the anticipated period of migration for target fish species.

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

Concept level designs for upstream fish passage facilities will be formulated to facilitate conditions which promote passage throughout the range of anticipated migration flows: the lowest of the low fish passage design flows through the highest of the high fish passage design flows which represents the range of targeted fish species and life stages. The resulting low fish passage design flow is 11 cfs and the high fish passage design flow is approximately 7,130 cfs using Historical observations. The resulting range of flows is 50 to 7,499 cfs using Base Case operational scenario data. In summary, any proposed upstream passage facility will need to meet fish passage design criteria throughout this range of flows. Once flows exceed the high fish passage design flow or are below the low fish passage design flow, compliance with fish passage criteria is not assured and is typically not expected by regulatory agencies.

It should be noted that although the statistical calculations identify a low fish passage design flow of 11 cfs, this low flow value will likely be regulated by the minimum flow release schedule (refer to Table 2.5-2 in 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 downstream fish passage facilities that are to be constructed in-river will also be formulated to facilitate conditions which promote passage throughout a similar range of anticipated migration flows. The resulting low fish passage 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.

Contrary to the upstream fish passage facilities which correspond with flows occurring downstream of the La Grange Project, the downstream fish passage facility will rely on flows being conveyed into Don Pedro Reservoir. Low flow values will similarly 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.

3.3 Other Criteria and Guidelines Influencing Potential Fish Passage Facilities Configuration and Size

Many other design criteria and guidelines are applicable to upstream and downstream fish passage facilities beyond the pool elevation and instream design flows. For brevity, applicable criteria which have significant influence on fish passage facilities size, configuration, and complexity are summarized by category in the following sections.

3.3.1 Fish Screen Criteria

Any water diversions that could capture fish and introduce them into areas or flow paths that they 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 assure compliance with regulatory requirements. Fish screens are designed using the Screening Criteria Guidelines provided by CDFW (2000) and the NMFS Northwest Region's Anadromous Salmonid Passage Facility Design (NMFS 2011). The intent of the fish screening 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 the 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 assure uniformity is maintained must be provided (CDFW 2000). Approach velocities of 0.4 or 0.2 ft/s are allowed for diversions less than 40 cfs (CDFW 2000). For passively cleaned screens, approach velocity must not exceed 0.2 ft/s (NMFS 2011 and CDFW 2000).
- 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 (NMFS 2011; CDFW 2000).
- Travel Time – Fish can only be exposed to a screen face for a maximum of 60 seconds, assuming fish are moving at rate equal to the sweeping velocity (NMFS 2011; CDFW 2000).
- 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 (NMFS 2011; CDFW 2000).

- 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.

3.3.2 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.

3.3.2.1 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.

3.3.2.2 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 don't 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).

3.3.2.3 Bypass Exit Criteria

- Velocity – The outfall impact velocity, 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 to injury or stranding on the bank must be included in the outfall design (NMFS 2011). It should be noted that this criteria is only applicable where upstream and downstream passage facilities are separate.

3.3.2.4 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 two 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 Hydro Program staff 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.

3.3.3 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 fishway entrance's primary objective is to maximize fish attraction. The fish ladder's primary objective is to provide hydraulic conditions that promote fish passage up and around a passage barrier. The fishway exit's primary function is to maintain hydraulic conditions suitable for fish passage for the range of forebay or reservoir water surface elevations. The design criteria specific to each component is presented below.

3.3.3.1 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.

3.3.3.2 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/ft3. 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).

3.3.3.3 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).

3.3.4 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 assists with manual cleaning. In systems with coarse floating debris, debris booms or other provisions must be incorporated into the debris rack design (NMFS 2011).

3.3.5 Fish Trapping and Holding Criteria

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

- 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). It should be noted however that this criteria would require a variance to sufficiently accommodate water temperatures typically experienced by such fish species in the Tuolumne River. As an example, Mokelumne River juveniles collected for transport are held in water temperatures of approximately 70° F (18 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, use of nets should be minimized or eliminated. Fish should be anesthetized before being handled and 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.

3.3.6 Juvenile Salmonid Upstream Passage Criteria

Juvenile upstream passage will not be considered as part of this Fish Passage Facilities Alternatives Assessment.

3.4 Other Factors That Require Further Consideration

There are a number of remaining factors that require careful consideration when 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 alternative development.

- <u>Confirmation of Target Species</u> – 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 Facilities Alternatives Assessment is speculative. Further discussion and concurrence with the LPs is necessary to finalize target species.
- <u>Migration Timing for Various Life Stages</u> – 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 engineering feasibility study. Currently, assumptions regarding these factors are only available through other regional data sources where populations of these species currently exist. Input from the LPs is required to finalize assumptions regarding these potential future populations and their various characteristics.
- <u>Population Size and Peak Run Values</u> – The number of fish to be passed has a significant impact on the size and configuration of facility components. At the time this TM No. 1 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 reach will be necessary to inform potential population goals and specific facility design characteristics.
- <u>Suitability of Reservoir Passage</u> – 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. The applicability of reservoir passage will be evaluated if fish passage alternatives requiring reservoir passage are selected for further development.
- <u>Suitability of Reservoir Water Quality</u>– 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.

- 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 required for this project 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. 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 if the design process moves forward.

4.0 NEXT STEPS IN THE DEVELOPMENT OF THE FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT

This is the first of two TMs being prepared as part of the Fish Passage Facilities Alternatives Assessment. The purpose of the interim TMs being developed is to move forward with LP participation, identify information needs, establish the linkage of certain biological and ecological criteria to the engineering design process, obtain input and feedback in a collaborative process, and to establish when information will be available to support the feasibility assessment of alternative fish passage facilities.

Providing fish passage facilities for the reintroduction of anadromous salmonids to the upper Tuolumne River watershed would be a significant and costly undertaking. The feasibility study of fish passage facilities is one component of the investigation of the potential reintroduction of anadromous species, an investigation which must consider a host of issues ranging from engineering and regulatory guidance (e.g., ESA considerations, experimental designation, etc.) to biological objectives and ecological feasibility (e.g., upstream habitat suitability, estimated carrying capacity and adult and juvenile abundance estimates, seasonal and interannual environmental conditions, etc.). Economic feasibility and potential impacts to other resources (e.g., recreation, existing fisheries, etc.) must also be determined. As such, implementing a collaborative process to collect needed information at the appropriate level of detail is critical to supporting the study process and ensuring the information produced is accurate and can be used to inform future decision making.

The assessment of potential fish passage and reintroduction to the upper watershed requires information on a number of factors that currently have high uncertainty and require agreements among the LPs. Examples of such factors include but are not limited to seasonal timing of adult and juvenile migration, target species to consider in the assessment and their source, escapement goals, and expected adult and juvenile abundance. Although all of these factors require careful consideration, certain ones are needed to directly support the development of facility alternatives for both upstream and downstream passage. Examples include:

- target species identification and source,
- life stages proposed for collection at each type of facility,
- migration timing of these species specific to the Tuolumne River,
- environmental conditions associated with adult and juvenile collection, handling, transport, and release, and
- population goals and expected peak return numbers (linked to habitat availability, suitability, and carrying capacity).

The review of materials in advance of the September 17 workshop is encouraged. Please come prepared to provide input and pertinent discussion to information needs to further the study program.

5.0 REFERENCES

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_____. 2013b. Don Pedro Project FERC No. 2299 Draft License Application. Transmittal Letter Exhibits A Through H. Prepared November 2013.

_____. 2013c. Salmonid Population Information Integration and Synthesis Study Report (W&AR-05). Attachment to Don Pedro Hydroelectric Project Draft License Application. December 2013.

From: Peter Drekmeier [mailto:peter@tuolumne.org]
Sent: Thursday, September 17, 2015 8:00 PM
To: Byrd, Larry; Devine, John; John Holland
Subject: Historic Salmon Articles

Gentlemen,

Nice seeing you this morning.

I'm following up on the historic articles that reference salmon in the upper Tuolumne. Attached are a few things. The first is a summary prepared by Bob Hackamack. The second is the actual article from the Tuolumne Independent, and the third is the front page of the edition the article appeared in.

I hope these are helpful.

-Peter

Bob Hackamack's summary was as an attached document; the second and third items were inserted here in the text of the email. They have been removed and given their own pages, so that the scanned images could be rotated and enlarged for easier viewing.

–Rose Staples 09/18/2015

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Policy Director
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(415) 882-7252

Tuolumne River Trust

Editor: I have presented the texts I copied as close to the actual pages appearance in quotation marks as I can including Font, but not type size. Please take care how you change margins at sides, top and bottom. Bob H

A number of sources of historical data on salmon in the Tuolumne River are relevant to La Grange Dam licensing:

"THE TUOLUMNE INDEPENDENT SONORA, TUOLUMNE CAL. SEPT 15, 1883. NUMBER 24.
Published every Saturday Morning by DUCHOW BROTHERS."

Two years of this newspaper are at the Tuolumne County Museum Archive in Sonora CA. In the Sept 15 issue the INDEPENDENT wrote on the fifth page, top of the second column:

"We Want a Fish-Ladder.—Considerable complaint is manifested, from time to time, regarding the dam that retards the fish from ascending the Tuolumne at La Grange. This dam is thrown across the river from bank to bank, 40 feet high, and one hundred feet wide, and belongs to the La Grange Hydraulic Mining Company in operation near by. The worthless fish-ladder that was put in, some two years ago, washed out. It was impossible for salmon to go up—nothing but very small fish. The ladder was put in about 200 feet below the dam, and the little fish that ascended were compelled to go into a by-ditch before getting into the river above. We are informed that the water at the foot of the dam is now literally alive with salmon trying to ascend the river—and sometimes jumping twenty to thirty feet into the air in the vain endeavor to get over. This is the time of year for them to hunt the head waters of steams for spawning purposes, and after passing this dam there is no further obstruction offered. A man by name of Wheaton, who resides in San Francisco, owns the property, and the Fish Commissioner should see to it at once that a proper fish-ladder is put in the stream where the water *flows over* the dam, and no toy arrangement in a by-ditch as heretofore."

The second source of salmon information is from "Land, Water and Power A History of the Turlock Irrigation District 1887-1987" by Alan M. Paterson", published by Arthur H Clark Company, Spokane, WA, in 2004, now in its third printing. A copy of Mr. Paterson's book was purchased recently at the TID central offices. Pertinent salmon information begins at chapter and page:

"New Don Pedro 319"

"Before Wheaton dam blocked the Tuolumne, salmon spawned above La Grange, perhaps as far upstream as Wards Ferry. In the right conditions of water temperature, depth and velocity the salmon scooped out the gravel of the riverbed to make their nests, or redds, and deposited their eggs. The eggs hatched in late winter or early spring and the young salmon went down to the sea with the spring freshets. The effect of Wheaton's dam was described in 1877.

> Immense quantities of salmon have been prevented from reaching their breeding grounds further up the stream in consequence, and much indignation is expressed regarding the obstruction. The ranchers and others have been taking wagon loads of salmon from the river below the dam during several months past, killing the fish with clubs as they passed over the riffles. The Fishery Commissioners should compel the construction of a fish ladder to the dam, as the law requires.[15]

Although the salmon did spawn in the stretch of the river below La Grange, M. A. Wheaton was twice brought before the courts for failing to provide a fish ladder. The last time in 1889, his attorneys included C. C. Wright and P. J. Hazen, and the jury delivered a rapid verdict of not guilty.[16] Illegal salmon "fences" in the San Joaquin River erected by poachers impeded the annual migration in some years, but around the turn of the century, more determined enforcement of the fish and game laws reduced the practice and there were reports of thousands of salmon at La Grange Dam. Salmon were commonly caught with spears, and some people were said to be gathering great numbers of fish to be salted down.[17]

Until 1940 there seem to have been no estimates of how many salmon spawned in the gravel riffles above Waterford, and the number varied considerably from year to year. Salmon numbers between 1940 and 1960 ranged from a high of 130,000 fish in 1944 to a low of 3,000 in 1951, although after 1944 there were only four years of 45,000 fish or more, and none above 61,000.[18] The salmon run on the San Joaquin River itself was eliminated by the construction of Friant Dam in the mid-1940s, and runs in San Joaquin tributaries like the Tuolumne may have suffered as well.[19] As early as 1946, the California Department of Fish and Game (DFG), in commenting on a federal water development report recognized that more dams and additional diversions from valley rivers could endanger the salmon population. To save the salmon the department recommended that controlled minimum flows be required to provide enough water for migration and spawning. On the Tuolumne River the 1946 report recommended flows below La Grange Dam ranging from at least 750 second–feet during the spawning season, down to 100 second-feet in the late spring and summer.[20]"

"CHAPTER 13-FOOTNOTES"

"[15] *Modesto Herald,* Dec. 27, 1877

[16] *Modesto Daily* Evening News, June 6, 7, 1886, Oct 24, 28, 1889.

[17] *Stanislaus County Weekly News,* Dec. 18, 1903, Dec 2, 1904.

[18] Fall-Run Chinook Salmon Stocks in the Tuolumne River, 1940-," (ca. 1970), in Meikle files, vol. 1970, item 56.

[19] Author interview with Tim Ford, June 24, 1985.

[20] U.S. Dept of the Inter., *Central Valley Basin,* Sen. Doc. 113, 81st. Cong., 1st. Sess. (1949), p 413."

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We Want a Fish Ladder.—Considerable complaint is manifested, from time to time, regarding the dam that retards the fish from ascending the Tuolumne at La Grange. This dam is thrown across the river from bank to bank, 40 feet high, and one hundred feet wide, and belongs to the La Grange Hydraulic Mining Company in operation near by. The worthless fish-ladder that was put in, some two years ago, washed out. It was impossible for salmon to go up—nothing but very small fish. The ladder was put in about 200 feet below the dam, and the little fish that ascended were compelled to go into a by-ditch before getting into the river above. We are informed that the water at the foot of the dam is now literally alive with salmon trying to ascend the river—and sometimes jumping twenty or thirty feet into the air in the vain endeavor to get over. This is the time of year for them to hunt the head waters of streams for spawning purposes, and after passing this dam there is no further obstruction offered. A man by the name of Wheaton, who resides in San Francisco, owns the property, and the Fish Commissioner should see to it at once that a proper fish ladder is put in the stream where the water *flows over* the dam, and no toy arrangement in a by-ditch as heretofore.

— Ah Kuen was arrested on the 12th inst. for keeping an opium den, at the Tigre, and on the 14th was fined $20 by Justice Cooper. At the time Marshal Keeffe kicked

Pops.

Dave Levy is about t
"Old Tuolumne" quartz
below Summit Pass, nor
A small portion of the
paid down. Our honest
this will be the making of
mine....M. B. Harriman
surfeiting with delights of
turned. The Judge gaine
day....In the way of
Sears has just finished pai
on the school house. He
tract for a number of fine
San Francisco....Hattie
gone a-herding sheep....
gossip at Bald Mountain
got our measure. For his
will state, that we do n
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to exist by such means, we
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cheaper than that class
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that the public call and
as to prices. Give him
is opposite Divoll's mi
the corner. Those out of
shopping here, will save
on Brescia....The bla

THE TUOLUMNE INDEPENDENT.

An Independent Newspaper, Devoted to Local Affairs, the Interests of Tuolumne County, and to Miscellaneous, Family Reading.

VOLUME XII. SONORA, TUOLUMNE COUNTY, CAL., SEPT. 15, 1883. NUMBER 24.

The Tuolumne Independent

What to Wear to the Photographer's

Tried Her Own Remedy

Remedy for Consumption

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT
WORKSHOP NO. 3

NOVEMBER 19, 2015

FINAL MEETING NOTES AND MATERIALS

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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 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 11th 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) a. Summary review of the Reintroduction Decision Framework b. Participant comments on Framework, preferences and potential process implementation concepts c. Decision regarding Reintroduction Decision Framework implementation
11:30 am – 12:00 pm	Next Steps (All) a. Schedule: Further opportunities for collaboration and incorporation of feedback b. Action Items

Modesto Irrigation District

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

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PLEASE SIGN IN

	Name	Organization	Telephone No.	E-mail	Time In
13.	Brandon McMillan	TID			
14.	Bill Ketscher	Farmer			
15.	Peter Drekmeier	TRT			
16.	Gavin Bruce	Stanislaus Business Alliance			
17.	Fred Souza	YFC			
18.	Adrianne Carr	BAWSCA			
19.	Tim Heyne	DFW			
20.	John Holland	Bee			
21.					
22.					
23.					
24.					

MID
Modesto Irrigation District

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

TID WATER & POWER
Serving Central California since 1887

PLEASE SIGN IN

	Name	Organization	Telephone No.	E-mail	Time In
1.	Bill Paris	MID			
2.	Jennifer Carlson	MCCV			
3.	Gretchen Murphey	CDFW			
4.	JOSH WEIMER	TID			
5.	Tom Levic	SCFB			
6.	Calvin Curtin	TID			
7.	DANA FERREIRA	REP. DENHAM			
8.	John Buckley	CSERC			
9.	[illegible]	Asm Kristin Olsen			
10.	Jim Alves	City of Modesto			
11.	RAY DIAS	Public			
12.	Anna Eddings	Senator Cannella			

TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

Overview of Tuolumne River Reintroduction Structured Decision-Making Framework

TURLOCK IRRIGATION DISTRICT | MODESTO IRRIGATION DISTRICT

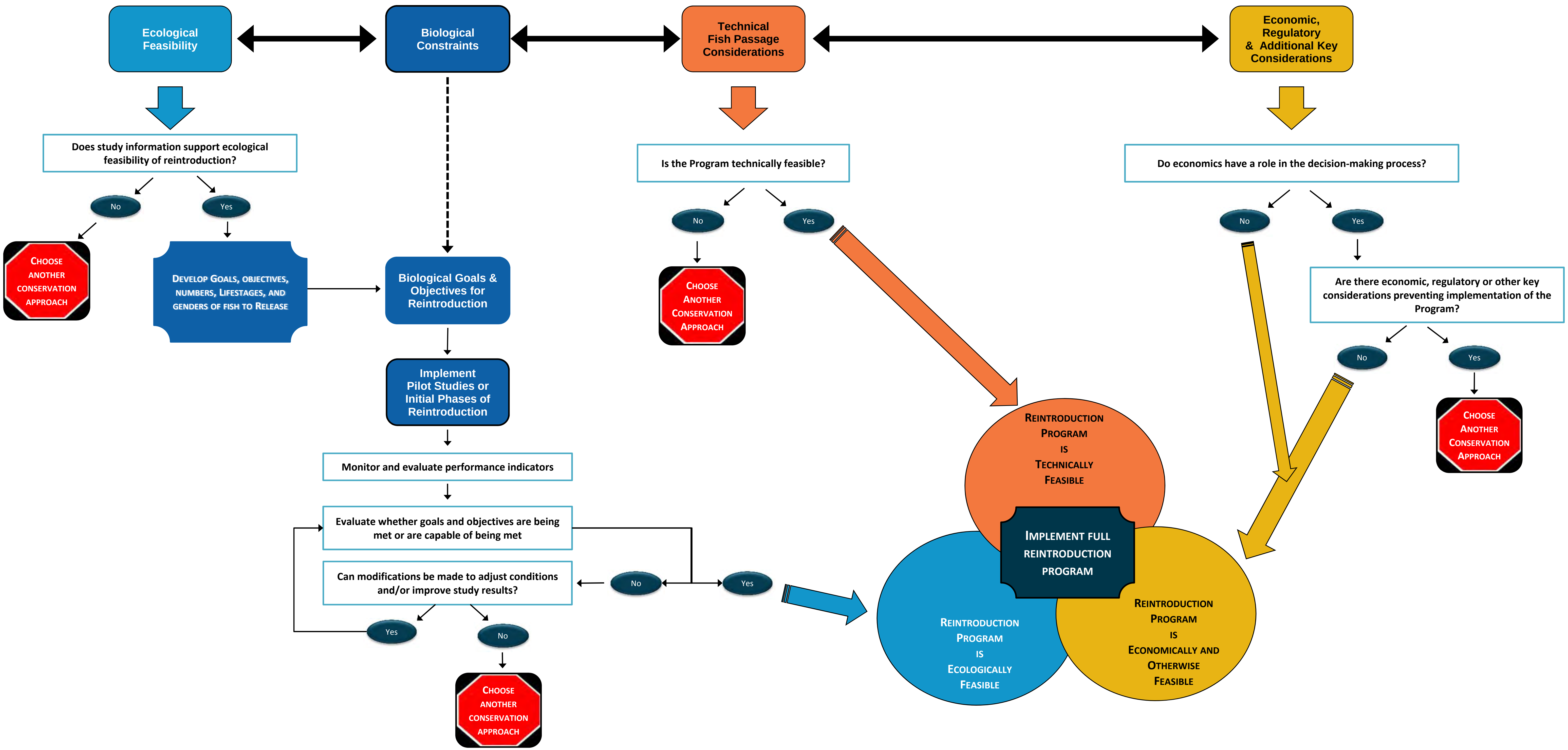
Reintroduction Decision-Making

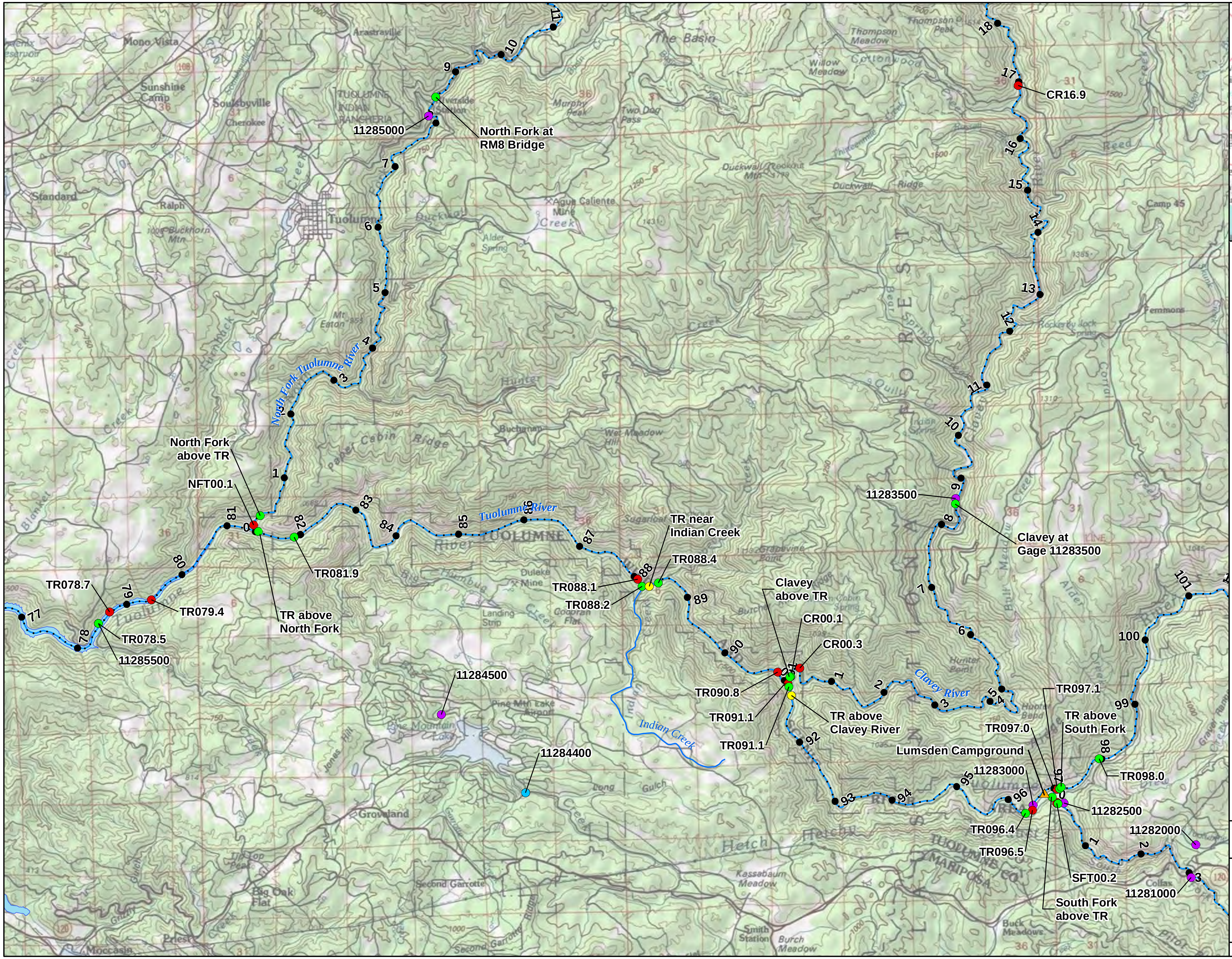
- Fish reintroduction involves numerous complex considerations
- There are extensive and complicated interactions among reintroduction considerations
- Structured decision-making requires careful analysis of complex interactions
- Identify the numerous issues to develop an agreed-upon framework for structured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

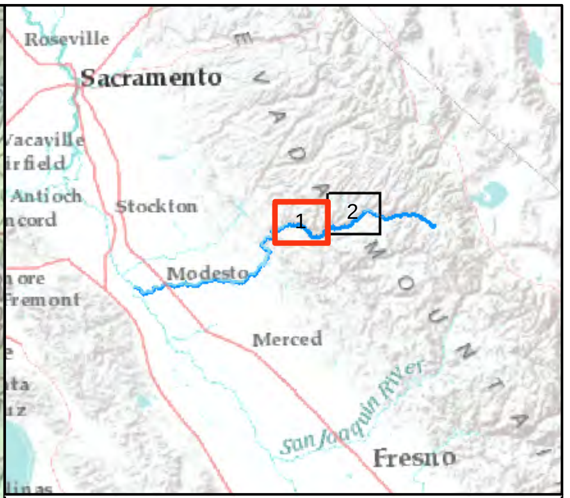
Integrated Decision Tree

- 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	M 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
11284400	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 Campgorund
TR096.5	CDFG	NO	Tuolmune 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.

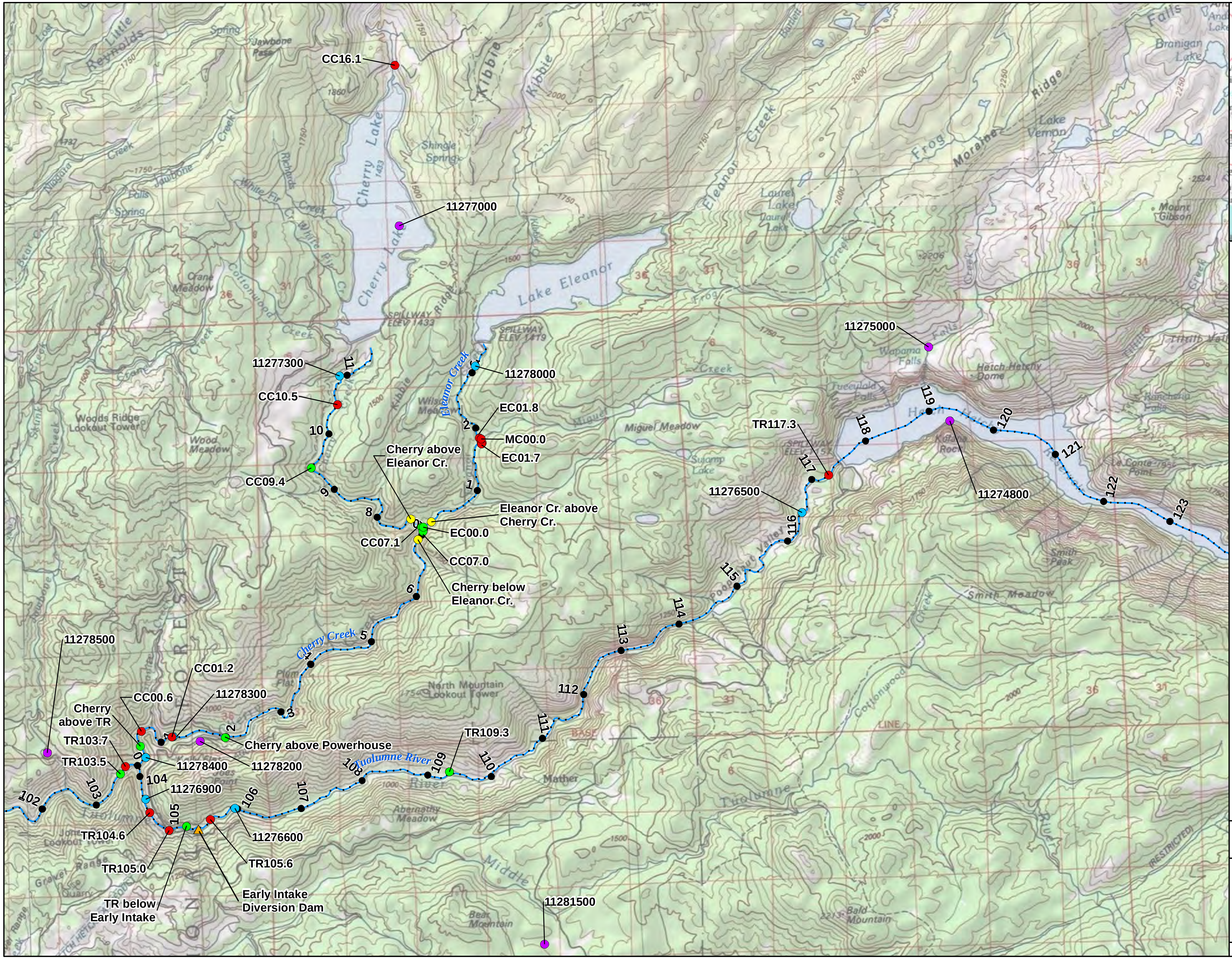
0 0.5 1 2 Miles

N

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

Sources: Esri, DeLorme, USGS, NPS
Sources: Esri, USGS, NOAA
Data is CA SPCS, Zone III, ft.



Stream / Flow Gage

Active Inactive

Label	Agency	Active	Site Name
11274800	USGS	Inactive	TUOLUMNE R AT HETCH HETCHY NR SEQUOIA CA
11275000	USGS	Inactive	FALLS C NR HETCH HETCHY CA
11275500	USGS	Active	HETCH HETCHY RES A HETCH HETCHY CA
11276500	USGS	Active	TUOLUMNE R NR HETCH HETCHY CA
11276600	USGS	Active	TUOLUMNE R AB EARLY INTAKE NR MATHER CA
11276900	USGS	Active	TUOLUMNE R BL EARLY INTAKE NR MATHER CA
11277000	USGS	Inactive	CHERRY C NR HETCH HETCHY CA
11277200	USGS	Active	CHERRY LK NR HETCH HETCHY CA
11277300	USGS	Active	CHERRY C BL VALLEY DAM NR HETCH HETCHY CA
11277500	USGS	Active	LK ELEANOR NR HETCH HETCHY CA
11278000	USGS	Active	ELEANOR C NR HETCH HETCHY CA
11278200	USGS	Inactive	CHERRY C CN NR EARLY INTAKE CA
11278300	USGS	Active	CHERRY C NR EARLY INTAKE CA
11278400	USGS	Active	CHERRY C BL DION R HOLM PH, NR MATHER CA
11278500	USGS	Inactive	JAWBONE C NR TUOLUMNE CA
11281500	USGS	Inactive	M TUOLUMNE R NR MATHER CA

Water Temperature Logger

Active Inactive Proposed*

Label	Agency	Active	Site Locations
CC00.6	TID/MID	YES	Cherry above TR
CC00.6	CDFG	NO	Cherry Creek Power House
CC01.2	CCSF	NO	Cherry Creek, upstream of Dion Holm Powerhouse
CC07.0	CCSF	YES	Cherry Creek, downstream of confluence with Eleanor Creek
CC07.1	CCSF	YES	Cherry Creek, upstream of Eleanor Creek confluence
CC09.4	CCSF	YES	Cherry Creek, downstream of Cherry Dam
CC01.2	TID/MID	YES	Cherry above Powerhouse
CC10.5	CCSF	NO	Cherry Creek, downstream of Cherry Dam
CC16.1	CCSF	NO	Upstream of Cherry Lake
EC00.0	CCSF	YES	Eleanor Creek, upstream of Cherry Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.7	CCSF	NO	Eleanor Creek, downstream of Miguel Creek confluence
EC01.8	CCSF	NO	Eleanor Creek, upstream of Miguel Creek confluence
MC00.0	CCSF	NO	Miguel Creek, upstream of Eleanor Creek confluence
TR103.5	CCSF	YES	Tuolumne River, downstream of Cherry Creek confluence
TR103.7	CCSF	NO	Tuolumne River, downstream of Cherry Creek confluence
TR104.6	CCSF	NO	Tuolumne River, downstream of Early Intake Diversion Dam
TR105.0	CDFG	NO	Tuolumne River at Early Intake
TR105.2	TID/MID	YES	TR below Early Intake
TR105.6	CCSF	NO	Tailrace of Kirkwood Powerhouse
TR109.3	CCSF	YES	Tuolumne River, downstream of Preston Falls
TR117.3	CCSF	NO	Tuolumne River, downstream of O'Shaughnessy Dam

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

0 0.5 1 2 Miles

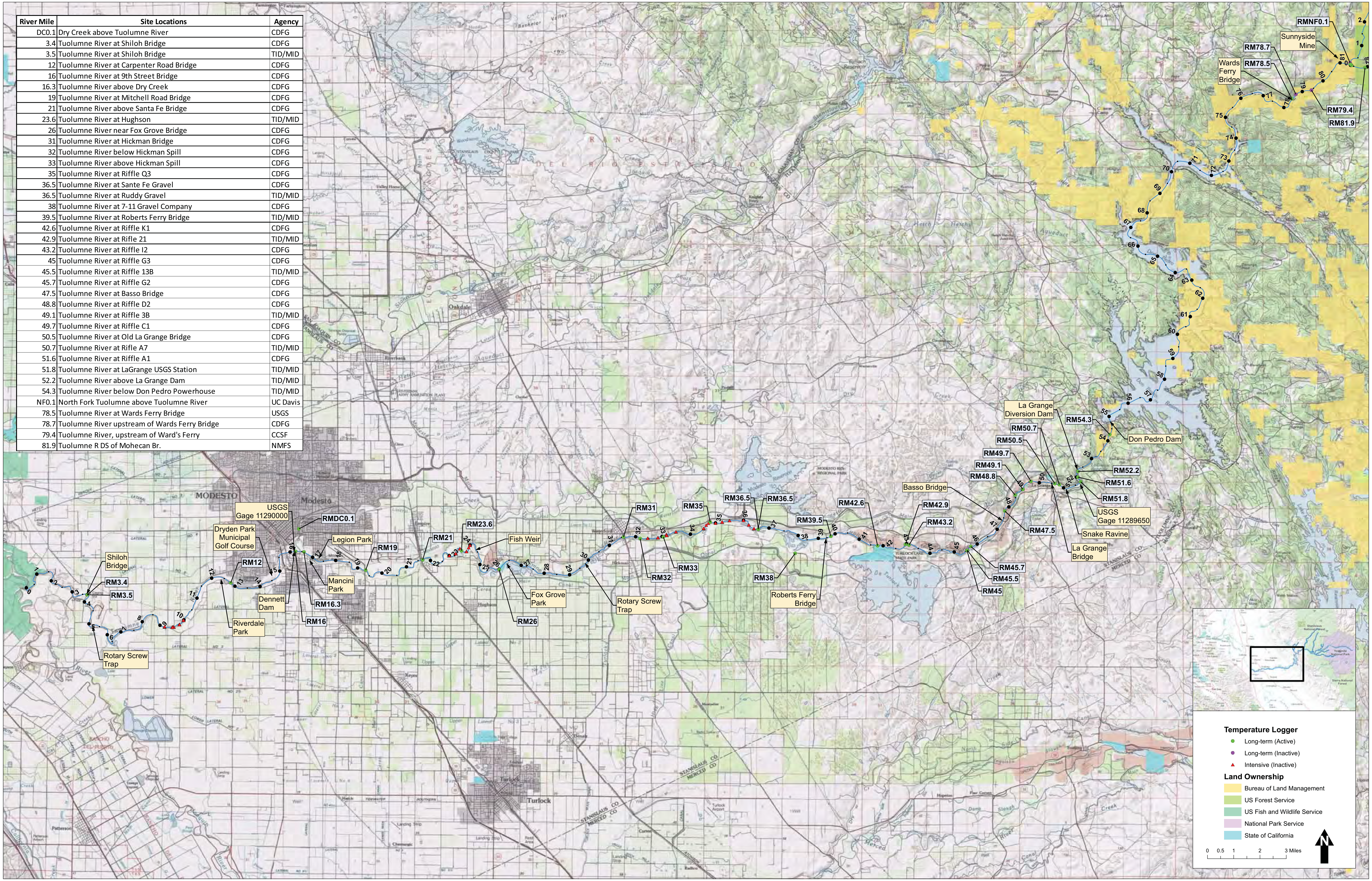
N

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

Sources: Esri, DeLorme, USGS, NPS
Sources: Esri, USGS, NOAA
Data is CA SPCS, Zone III, ft.

River Mile	Site Locations	Agency
DC0.1	Dry Creek above Tuolumne River	CDFG
3.4	Tuolumne River at Shiloh Bridge	CDFG
3.5	Tuolumne River at Shiloh Bridge	TID/MID
12	Tuolumne River at Carpenter Road Bridge	CDFG
16	Tuolumne River at 9th Street Bridge	CDFG
16.3	Tuolumne River above Dry Creek	CDFG
19	Tuolumne River at Mitchell Road Bridge	CDFG
21	Tuolumne River above Santa Fe Bridge	CDFG
23.6	Tuolumne River at Hughson	TID/MID
26	Tuolumne River near Fox Grove Bridge	CDFG
31	Tuolumne River at Hickman Bridge	CDFG
32	Tuolumne River below Hickman Spill	CDFG
33	Tuolumne River above Hickman Spill	CDFG
35	Tuolumne River at Riffle Q3	CDFG
36.5	Tuolumne River at Sante Fe Gravel	CDFG
36.5	Tuolumne River at Ruddy Gravel	TID/MID
38	Tuolumne River at 7-11 Gravel Company	CDFG
39.5	Tuolumne River at Roberts Ferry Bridge	TID/MID
42.6	Tuolumne River at Riffle K1	CDFG
42.9	Tuolumne River at Rifle 21	TID/MID
43.2	Tuolumne River at Riffle I2	CDFG
45	Tuolumne River at Riffle G3	CDFG
45.5	Tuolumne River at Riffle 13B	TID/MID
45.7	Tuolumne River at Riffle G2	CDFG
47.5	Tuolumne River at Basso Bridge	CDFG
48.8	Tuolumne River at Riffle D2	CDFG
49.1	Tuolumne River at Riffle 3B	TID/MID
49.7	Tuolumne River at Riffle C1	CDFG
50.5	Tuolumne River at Old La Grange Bridge	CDFG
50.7	Tuolumne River at Rifle A7	TID/MID
51.6	Tuolumne River at Riffle A1	CDFG
51.8	Tuolumne River at LaGrange USGS Station	TID/MID
52.2	Tuolumne River above La Grange Dam	TID/MID
54.3	Tuolumne River below Don Pedro Powerhouse	TID/MID
NF0.1	North Fork Tuolumne above Tuolumne River	UC Davis
78.5	Tuolumne River at Wards Ferry Bridge	USGS
78.7	Tuolumne River upstream of Wards Ferry Bridge	CDFG
79.4	Tuolumne River, upstream of Ward's Ferry	CCSF
81.9	Tuolumne R DS of Mohecan Br.	NMFS



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.

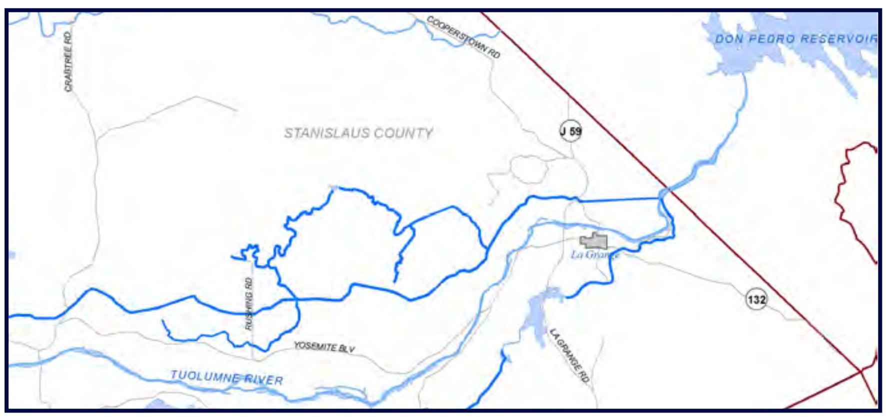
Providing fish passage on the Tuolumne River would be a major undertaking for MID, TID and its customers, both financially and logistically. Fish passage has become one of the key issues in the La Grange licensing process.

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.



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.

$$$

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.

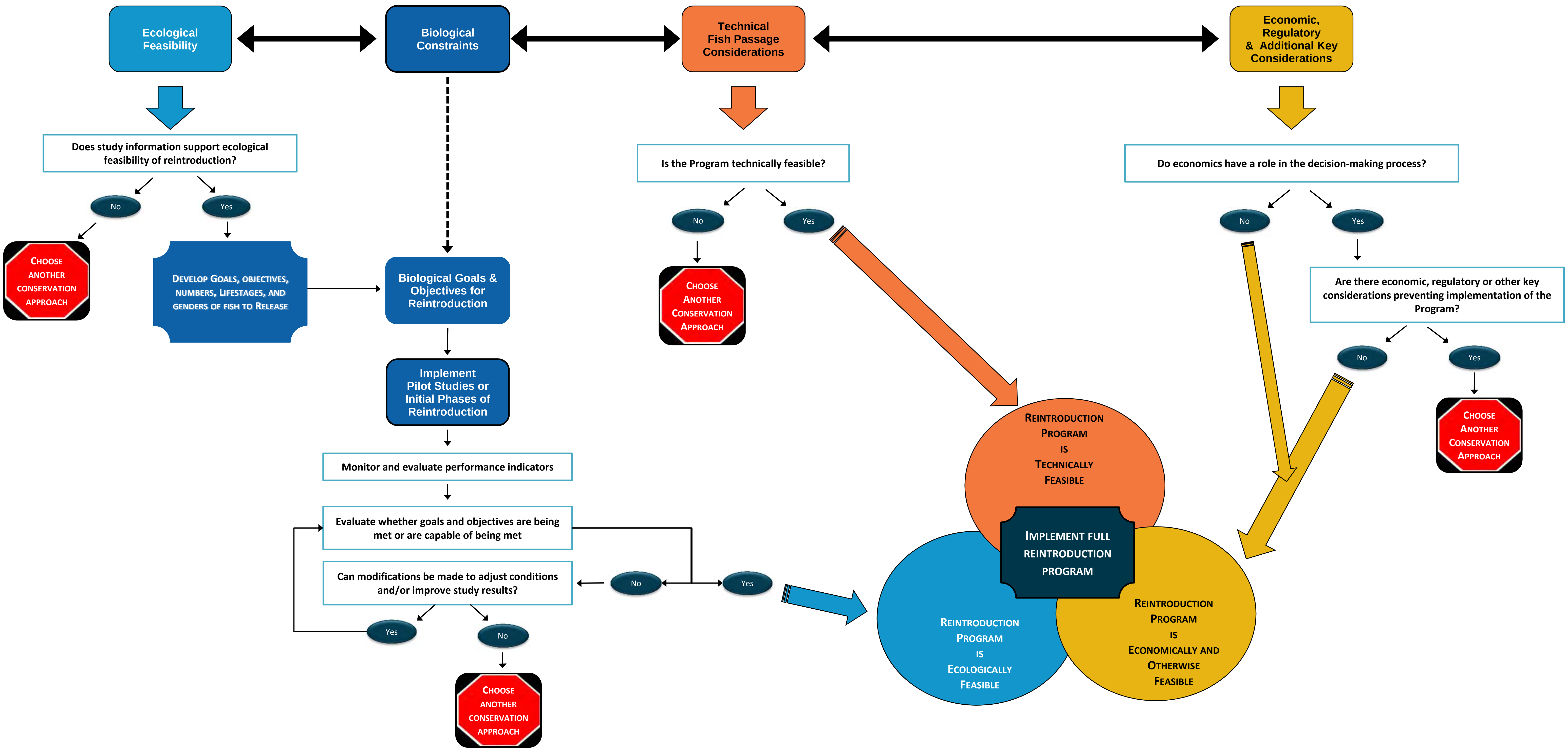
Currently, little information exists to know what fish facilities might be appropriate or if the habitat above Don Pedro Dam is sufficient to support reintroduction goals. To encourage a collaborative process, a series of workshops are being held to identify, collect and share information.

MID Modesto Irrigation District
Water and Power

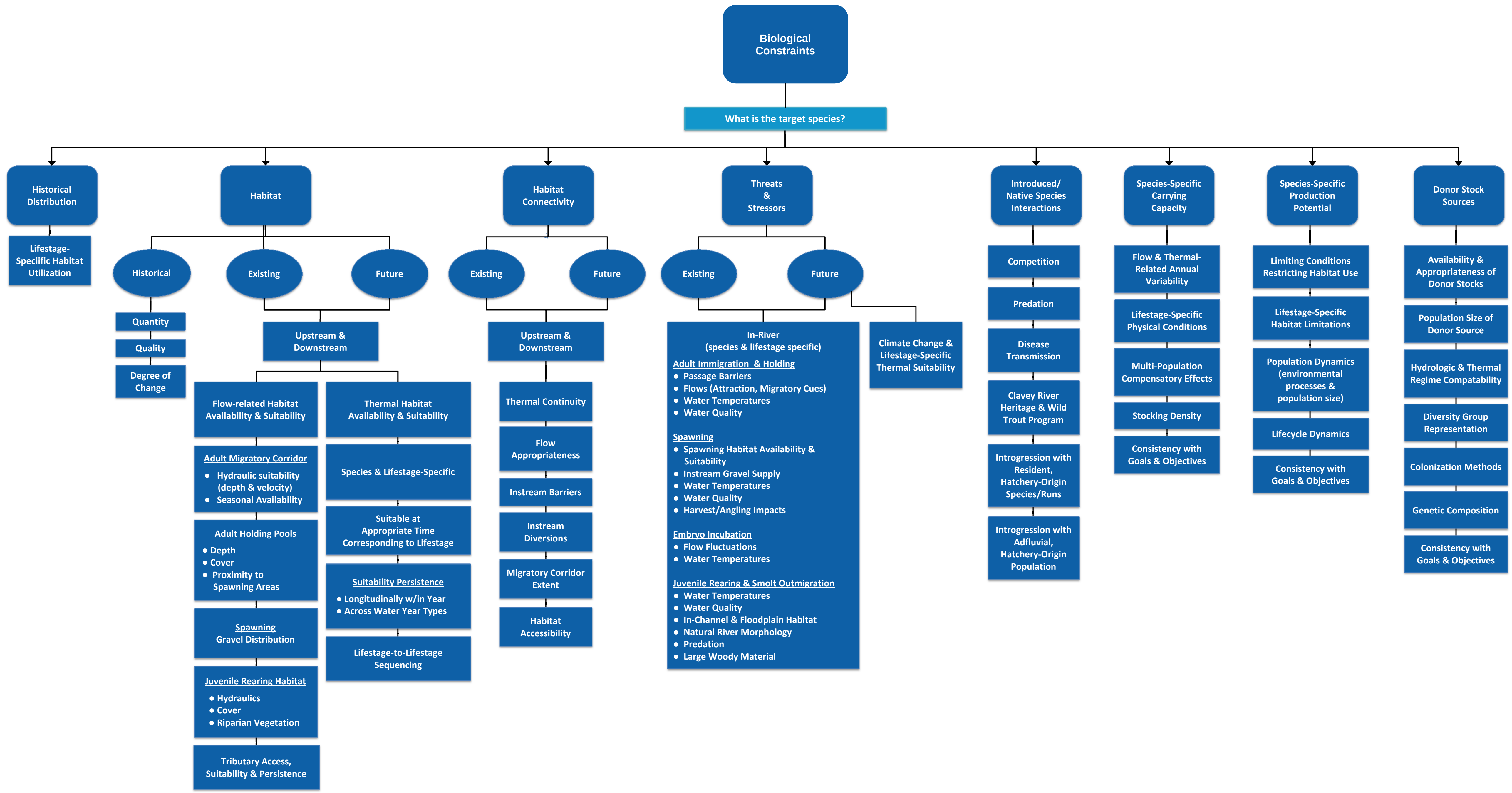
TID WATER & POWER
Serving Central California since 1887

For more information on the La Grange Project licensing or the fish passage study, visit *www.lagrange-licensing.com*.

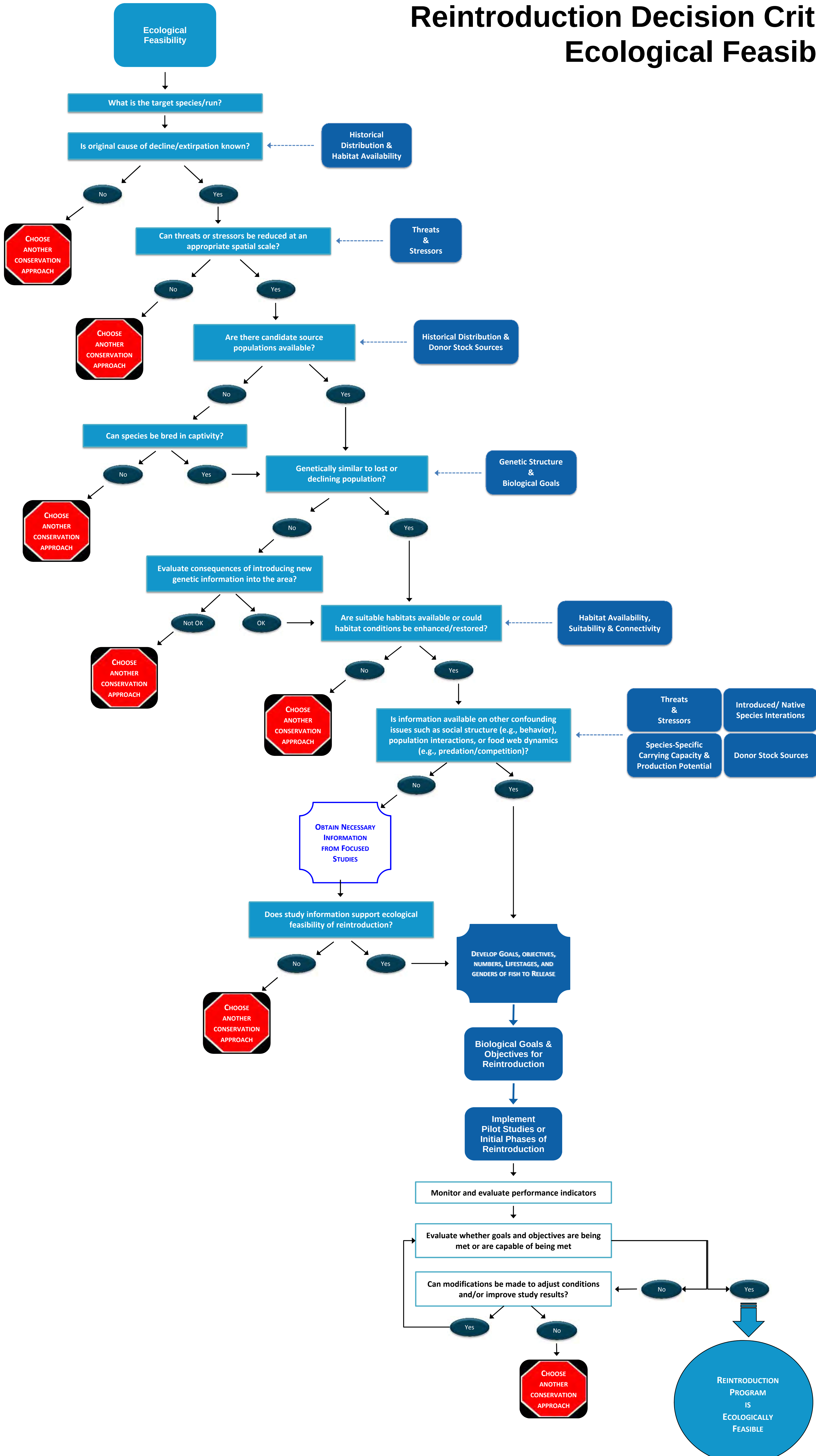
Reintroduction Decision Criteria
Decision Tree Overview



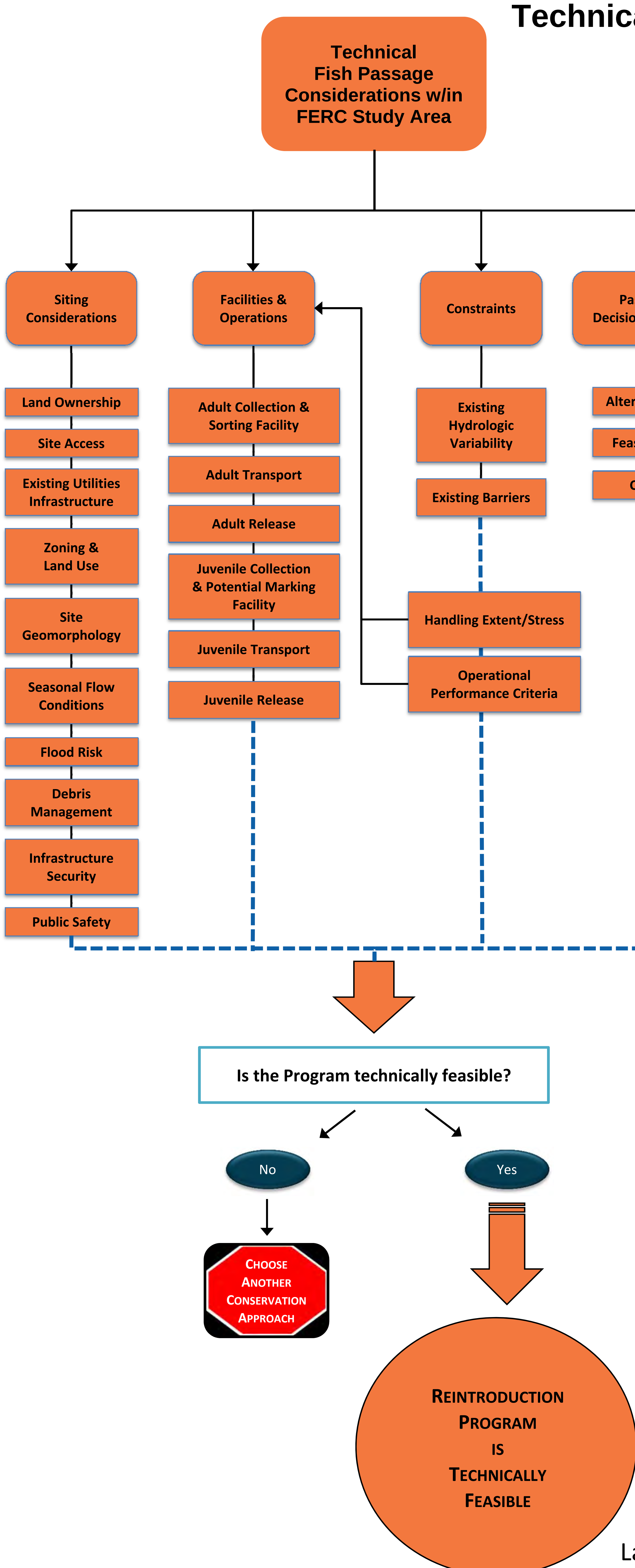
Reintroduction Decision Criteria
Biological Constraints



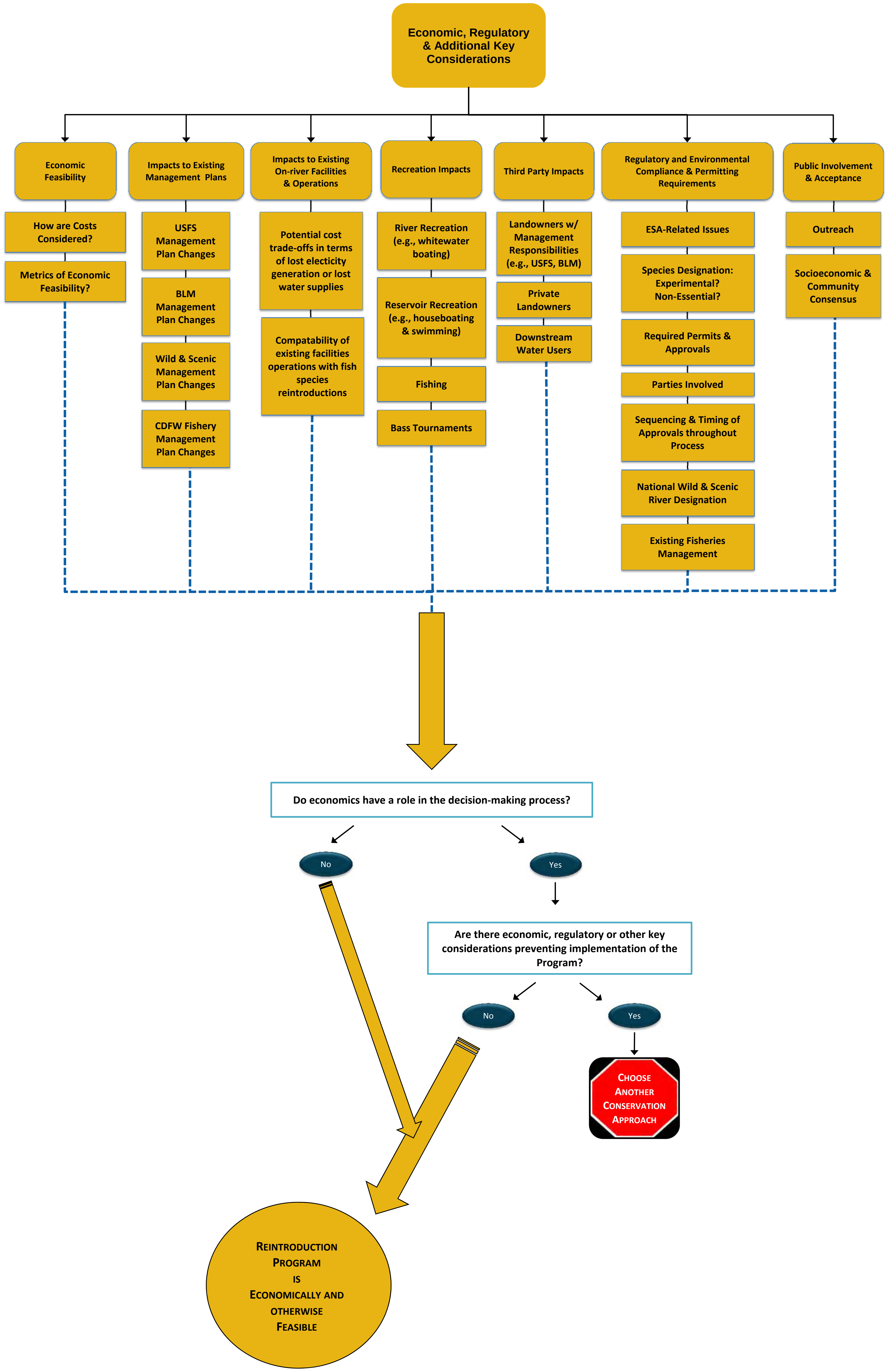
Reintroduction Decision Criteria
Ecological Feasibility



Reintroduction Decision Criteria
Technical Passage Feasibility



Reintroduction Decision Criteria
Economic, Regulatory and Other Considerations



La Grange Hydroelectric Project
Fish Passage Alternatives Assessment
Workshop No. 3 – November 19, 2015

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT
WORKSHOP NO. 4

JANUARY 27, 2016

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project Licensing (FERC No. 14581)
Fish Passage Facilities Alternatives Assessment
Workshop No. 4

Wednesday, January 27, 2016
9:00 am to 12:00 pm

Meeting Notes

On January 27, 2016, Turlock Irrigation District (TID) and Modesto Irrigation District (MID) (collectively, the Districts) hosted the fourth Workshop (Workshop No. 4) for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives 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 sheets, presentation slides, and handouts.

Mr. John Devine (HDR, Inc. [HDR]), consultant to the Districts, welcomed Workshop participants. Attendees in the room and on the phone introduced themselves. The following individuals participated remotely: (1) Mr. Peter Barnes (State Water Resources Control Board); (2) Ms. Adrianne Carr (Bay Area Water Supply and Conservation Agency); (3) Ms. Jesse Deason (HDR); (4) Mr. Steve Edmondson (National Marine Fisheries Service [NMFS]); (5) Mr. Tim Heyne (California Department of Fish and Wildlife [CDFW]); (6) Mr. Tom Holley (NMFS); (7) Ms. Trudi Hughes (California League of Food Processors) and; (8) Mr. John Wooster (NMFS).

Mr. Devine asked if any Workshop participants would like to make opening remarks. No participants volunteered. Mr. Devine reviewed the meeting agenda. He stated that today's meeting is a follow-up to Workshop No. 3 (held on November 19, 2015; meeting notes and materials are available here on the La Grange Project Licensing Website), in which attendees agreed to begin implementation of an Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework (Framework) as described and discussed at Workshop No. 2 (held on September 17, 2015; meeting notes and materials available here). Mr. Devine said that in Workshop No. 3, the Districts proposed a plan to implement the Framework; one of the items on today's agenda is to discuss and reach consensus on implementing that process.

Mr. Devine said implementing the Framework will require a fair amount of technical work, including preparing study plans and reviewing study reports. As such, the Districts are suggesting that a Technical Committee, made up of volunteers from this larger group (Plenary Group), be formed to assume some of the technical responsibilities of implementing the Framework. The Technical Committee would report to the Plenary Group (i.e., all Framework participants).

Mr. Devine said another purpose of today's meeting is to discuss studies to complete in 2016 to support the Framework. The Districts prepared a list of potential studies and had provided a list with abstracts prior to the Workshop. Mr. Devine added that this list of studies is intended to jump-start discussion about which studies would be most relevant to support the Framework. It is not intended that all studies be conducted. Mr. Devine said today's meeting also includes a presentation of what data exist for the reach under consideration for reintroduction, which is defined as the mainstem Tuolumne River upstream of the Don Pedro Reservoir to Early Intake and associated tributaries (accessible reaches of these tributaries) within this reach.

Mr. Devine asked for thoughts or comments on his remarks. There were none.

Mr. Devine summarized the discussions at Workshops No. 2 and No. 3 and noted that consensus had been reached on implementing the Framework. The Framework considers fish passage engineering to be but one of several key components of assessing fish reintroduction. The other components are ecological feasibility; biological constraints; and economic, regulatory, and effects on other uses.

Mr. Devine introduced Mr. Bao Le (HDR). Mr. Le presented slides on the goals of and schedule for the Framework. Mr. Le said the overarching goal of the Framework is to evaluate the feasibility of reintroducing anadromous salmonids into the upper Tuolumne River by applying a structured assessment process. The process is an integrated evaluation of ecological, biological, engineering, economic, regulatory, and other key considerations related to reintroduction. Mr. Le said that HDR estimates that implementing the Framework would require considerable effort and entail a phased approach. In order to be respectful of the level of effort asked of all participants, the Framework considers the use of a Technical Committee that reports to the Plenary Group. Mr. Le summarized activities proposed for Phase 1 and Phase 2. Mr. Le said the Districts would like to arrive at a consensus at today's meeting on use of the Framework implementation plan, the associated schedule, and use of a Technical Committee.

Mr. Devine said one goal of the Framework is to arrive at an information base that was developed through studies where all parties agreed on the study scope, methods, and data collected. Mr. Devine said the goal is to achieve this by providing all parties the opportunity to participate in study development, implementation, and reporting.

Mr. Le reviewed the Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework Flow Chart (Flow Chart). Phase 1 and Phase 2 would each occur over approximately a one-year period.

Ms. Dana Ferreira (Office of U.S. Congressman Jeff Denham) asked who would participate on the Technical Committee. Mr. Le said all are welcome to participate on the Technical Committee. Individuals who are interested in participating should email Ms. Rose Staples (HDR) (Rose.Staples@hdrinc.com). Ms. Ferreira asked how a diverse and representative Technical Committee could be ensured if it is made up only of volunteers. Mr. Le said that, depending on who volunteers, the Districts may ask additional individuals to participate to ensure a broad representation.

Mr. John Buckley (Central Sierra Environmental Resource Center [CSERC]) said participation on the Technical Committee may not be possible for small organizations, such as CSERC, that have small staff sizes and do not have the resources to fund consultants to participate on their behalf. Mr. Buckley asked if support will be available for such groups to participate. Mr. Devine said the Technical Committee would meet via conference call, instead of in person, to help minimize the time commitment. Mr. Buckley said participation on the Technical Committee will require working with and discussing highly technical subject matter, such as PHABSIM and weighted usable area, and individuals who are considering participating on the Technical Committee should be aware of this.

Mr. Le reviewed the Flow Chart, Information Needs, and Potential Studies Table (Studies Table). In the beginning of 2016, the Plenary Group would identify which studies would be completed and which entity(ies) would be responsible for completing each study. Mr. Le stated that study plans would be developed and the studies would be completed from spring through fall. Also in 2016, the Technical Committee would need to develop reintroduction goals. Mr. Le said by the end of 2016, the results from the studies would be available to begin evaluating whether the reintroduction goals identified could be met (i.e., is reintroduction feasible?).

Mr. Edmondson asked how decisions will be made in the Technical Committee, such as by unanimous or majority vote, and what the relationship will be between the Technical Committee and the Plenary Group. Mr. Edmondson asked if the findings of the Technical Committee will be considered as binding or as recommendations. Mr. Devine said the Technical Committee will provide technical feedback to the Plenary Group and will make decisions internally by majority vote. The Technical Committee is a venue for collaboration; it cannot compel agreement, nor can it require or limit any parties' activities. Mr. Devine said there will likely be differences of opinion among Technical Committee members and it will be important that those differing opinions be documented. Mr. Devine said feedback from the Technical Committee would be considered by the Plenary Group as information sharing and there would not be a formal governance structure. Mr. Edmondson asked how the role and structure of the Technical Committee will be documented. Mr. Devine suggested that the Workshop No. 4 meeting notes be used to document this discussion. No individuals disagreed with Mr. Devine's suggestion.

An individual asked if the final Study Report will include a decision about fish reintroduction or if the report will simply present the issues and document the process. Mr. Devine said the latter is a more likely outcome, but the former would be ideal.

Mr. Le resumed his presentation. He noted that in order to remain on the proposed Framework schedule, the next Plenary Group meeting will be in mid-April.

Mr. Edmondson suggested that the Technical Committee's discussions and decisions be documented so that individuals who do not participate may still be kept aware of what happens on the Technical Committee. Mr. Devine agreed. Mr. Shelton (CDFW) said his staff is spread thin and completing some of the work via Technical Committee may make for more efficient meetings, but may also make it more difficult for small organizations to participate. Ms. Jennifer Shipman (Manufacturer's Council of the Central Valley) agreed with Mr. Shelton. Ms. Shipman said she supports the Framework and believes having a Technical Committee will result in a more transparent and efficient approach. Ms. Shipman suggested that individuals be allowed to provide written comments after Technical Committee meetings, to allow individuals unable to attend a chance to provide input to the process. No party disagreed with this.

Mr. Wooster asked Mr. Devine to summarize the relationship between the Framework and the Study. Mr. Devine explained that Technical Memorandum (TM) No. 1 issued in September 2015 (available online here) identified a number of information gaps that are required to move forward with developing engineering alternatives and reliable cost estimates. Mr. Devine provided examples of data gaps described in TM No. 1, such as what target fish species and population sizes should be considered when developing engineering alternatives. Mr. Devine said that by the end of 2016, the goal is to have all the information needed to produce the concept-level facility layouts that are realistic and defensible. In 2017, more detailed engineering alternatives assessments could be produced and modified if there were additional studies needed in 2017. Mr. Wooster asked how completing engineering alternatives analyses in 2017 will align with the La Grange Project Federal Energy Regulatory Commission (FERC) schedule. Mr. Devine said that once the Districts were provided the basic information requested in TM No. 1, issued to licensing participants in September 2015, they could begin conceptual engineering of alternatives. These could be sufficiently complete in 2016 to determine if a reservoir transit study is warranted. The FERC study schedule, as outlined in FERC's February 2, 2015 Study Plan Determination (SPD), adopted a two-year (2015 and 2016) study schedule, but also acknowledged that additional studies may be needed, presumably in 2017. Mr. Devine pointed out that the FERC-approved two-year La Grange barrier study already extends to September 2017 (see page B-6 of the SPD). Mr. Devine said the proposed schedule for implementing the Framework is not inconsistent with that FERC study schedule. Mr. Devine noted that FERC has not issued a schedule yet for submittal of a Draft or Final License Application. Mr. Devine said the Districts anticipate that FERC would be amenable to this process if the collaborative group is in agreement and working together. Mr. Devine indicated that he believes FERC is seeking cost estimates and concepts for fish passage that are realistic, reliable, and not built simply on a series of assumptions.

Mr. Wooster said the schedule in the Study Plan states engineering alternatives will be developed in 2016. Mr. Wooster said now that the engineering alternatives will not be developed until 2017, and therefore the reservoir transit study may not occur until 2018, this would be at odds with the schedule in the SPD. Mr. Devine said the reservoir transit study may possibly occur in 2018 but it is more likely that engineering alternatives can be sufficiently far along by the end of 2016/early 2017 to allow any reservoir transit study to take place in 2017, possibly along the same schedule as the FERC-approved La Grange barrier study. .

Mr. Edmondson said he sees a risk in FERC not concurring with a change to the schedule and the Plenary Group should have a good reason for changing the schedule. Mr. Devine stated that there currently is no FERC-specified schedule for filing a Draft and Final License Application for the La Grange Project. Mr. Devine pointed to the December 7, 2015 letter the Districts filed with FERC noting the inconsistency between the schedule in Scoping Document 2 and the SPD. He added that one reason for holding Workshop No. 4 prior to the La Grange Project Initial Study Report (ISR) meeting, scheduled for February 25, is to have the Plenary Group potentially come to agreement on an implementation schedule and then be able to document this agreement in Workshop No. 4 meeting notes and present the agreed-upon path forward at the ISR meeting and in the ISR meeting notes, which will all be filed with FERC. Mr. Devine said this would create an opportunity for FERC to accept this process and for FERC to understand the level of support for this process by the Workshop participants. Mr. Wooster said he believes the engineering-related Study should remain on track to reach a decision in 2017, regardless of whether a reservoir transit study is completed. Mr. Wooster said many studies proposed for 2016 will help refine the engineering analysis, but will not prevent the engineering analysis from moving forward at least conceptually. Mr. Devine said the Districts would entertain continuing to move ahead with engineering where possible, but that key questions remain, for example, the performance standards and expectations for the passage facilities. Mr. Devine said he believes the Plenary Group can arrive at answers based on good information prior to 2017 so that the Districts can move forward with all aspects of the engineering. Mr. Wooster reiterated he believes that the conceptual engineering can move forward without having to deviate from the schedule in the SPD.

Mr. Buckley said a challenging aspect of this schedule is the current lack of reintroduction goals. Mr. Buckley said the Districts would like an end result that minimizes cost and the amount of water that must be provided downstream, while other entities, such as the fish agencies, would like a significant improvement to the viability of salmon and steelhead in the Tuolumne River and increased flows. Mr. Buckley said that without a consensus on goals, it is difficult to come to agreement on schedule. Mr. Devine said the Districts agree with that, and hope that reintroduction goals will be established by mid-2016.

Mr. Edmondson said it may be helpful for some individuals at this meeting if Mr. Devine reviewed the steps in the engineering design process. Mr. Devine provided an overview of the engineering design process that will occur for the Study and described different types of volitional and non-volitional fish passage facilities.

Ms. Shipman asked when in the process the issue of predation will be considered. Mr. Devine said that if a floating surface collector was considered for Don Pedro Reservoir, predation in the reservoir would be evaluated to help estimate the likely success of the facility. Predation in the river below La Grange Diversion Dam would also be considered when estimating the likelihood of successful outmigration.

Ms. Shipman asked if fall-run Chinook salmon, spring-run Chinook salmon, and steelhead could use the same fish passage facilities. Mr. Devine said different species may be able to use the same facilities, but the facilities would need to be able to operate at different flow conditions because different species would arrive to the facilities at different times of the year. Mr. Devine said because fish size varies among species, the facilities would also need to be able to accommodate different fish sizes and run sizes.

Mr. Larry Byrd (MID) asked for clarification on the difference between "volitional" and "non-volitional" fish passage facilities. 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 active intervention. Mr. Byrd said it may not be necessary to consider volitional upstream passage facilities, such as a fish ladder, because the fish that arrive at La Grange Diversion Dam do not have the energy to use such a facility. Mr. Devine said different species of upstream migrating fish will likely arrive at the facility in different conditions, which is another consideration of facilities design. Workshop participants discussed the possibility of using a combination of volitional and non-volitional facilities at a single project.

Mr. Buckley said the results of 2016 studies may be affected by the ongoing drought and effects of the Rim Fire. Mr. Buckley said because of the current anomalous conditions, study results may not be representative of what could be expected to occur over the course of a FERC license period. Mr. Devine said he agreed and that all parties would need to be cognizant of current conditions.

Mr. Devine reviewed the Flow Chart and Studies Table. Studies with an "X" are ongoing and studies with a "P" are suggested by the Districts' technical team. Mr. Le said the table does not differentiate between Phase 1 and Phase 2 studies, but the Districts think that studies deemed to be high priority for Phase 1 would be accomplished in 2016. Mr. Devine said the cost estimates are not firm but only indicative of the effort required to collect these data. Regarding the Habitat Typing and Characterization Study, Mr. Wooster said NMFS is conducting a study using remote sensing data and that some of the remote sensing depth data will be ground-truthed. Given NMFS' study, Mr. Wooster thought the Studies Table could be revised to state that this study is ongoing, and not proposed, with the caveat that depending on the study results, more habitat ground-truthing may be recommended. Mr. Wooster said the NMFS LiDAR study will assess the availability of holding pools and results will be available by the end of August 2016. While the NMFS LiDAR study will also complete a cursory assessment of spawning gravels, Mr. Wooster recommended that the Plenary Group still consider a separate spawning gravel study, as proposed by the Districts. Mr. Devine said that Workshop participants agreed to try to keep to a two-year timeframe. Workshop participants also agreed to implement the Technical Committee.

Mr. Patrick Koepele (Tuolumne River Trust [TRT]) said the question of what studies to complete seems like a question for the Technical Committee. Mr. Devine said the intent of the Technical Committee is to flesh out in greater detail the technical components of agreed-to studies through study plan development and, ultimately, review of study reports. Mr. Devine said the Plenary Group should consider the Studies Table and discuss what studies should occur in Phase 1.

Mr. Chris Shutes (California Sportfishing Protection Alliance) asked if there is existing data about benthic macroinvertebrates (BMI) for the study reach. Mr. Devine said there is very little information available and the information that does exist is dated.

Mr. Peter Drekmeier (TRT) said the City and County of San Francisco (CCSF) has completed many studies on the Early Intake stretch of the Tuolumne River and that results from those studies may be helpful for this effort. Mr. Devine said he has reviewed some of these studies and he believes that most of CCSF's work was completed upstream of Early Intake which is beyond the scope of the reintroduction assessment area. Mr. Bill Sears (CCSF) agreed with Mr. Devine's statement.

Mr. Buckley asked if the resource agencies requested the Swim Tunnel Study noted in the Studies Table. Mr. Devine said the study was placed in the list by the Districts' technical team and resource agency input was welcome. Mr. Le reiterated that the list of studies is not intended to be anything more than a set of ideas for discussion, not study recommendations from the Districts. Mr. Shelton said that while the Swim Tunnel study completed for the Don Pedro Project was good scientific research, it would not be used to inform decision-making in the relicensing proceeding. Mr. Shelton said performing similar swim tunnel studies on other rivers and tributaries would help to create a database of good scientific information, which then may help to give the results broad applicability.

Workshop participants agreed to have the first Technical Committee conference call on Tuesday, February 16, at 11:00 am Pacific. Mr. Devine said the purpose of this call will be to try to decide on what studies will be completed in 2016. Workshop participants decided against reserving the same day each month for Technical Committee calls.

Mr. Wooster proposed that an assessment of the potential impacts of climate change to the upper and lower Tuolumne River be added to the Studies Table. Mr. Wooster agreed to provide an abstract for this study.

Meeting breaks for 15 minutes.

Mr. Devine presented slides on the information currently available on the study reach. Mr. Shutes said the Technical Committee should research the historical presence of the target species in the upper Tuolumne River, as part of consolidating the existing information for the study reach. Mr. Shutes said this issue will likely come up in the future and it would be helpful to know which target species originally inhabited this stretch of river. Mr. Shutes and Mr. Lonnie Moore (citizen) volunteered to lead this effort. Workshop participants discussed the validity and value of using anecdotal historical information to determine historical presence and the importance of documenting how decisions are made regarding whether or not a species existed historically. Mr. Devine said that regardless of whether species may or may not have been present in the reach in the distant past, and in what numbers, the reintroduction success depends on the current and future conditions of the reach under study. Many changes have occurred in the watershed over the last 150 years, so anecdotal information would not be very useful. There was no objection to compiling that information and Mr. Devine asked Mr. Shutes if he would take the lead, and Mr. Shutes agreed.

Mr. Devine asked what target species NMFS thinks should be considered. Mr. Edmondson said NMFS believes fall-run Chinook salmon, spring-run Chinook salmon, and steelhead should be considered. Mr. Edmondson said there is no evidence to suggest that fall-run Chinook were not historically in the study reach, and the extent of demarcation between fall-run Chinook and spring-run Chinook is unknown, therefore NMFS could not find a reason to not include fall-run Chinook. Mr. Devine asked if NMFS had considered the generally poor condition fall-run Chinook are in at the end of their upstream migration to the Lower Tuolumne River and what additional effects the stress of collecting and trucking the fish may have on survival and/or productivity. Mr. Shelton said CDFW agrees that the condition of fall-run Chinook at the end of their upstream migration is indicative of the condition of Tuolumne River. Mr. Shelton said CDFW believes that in most years, fall-run Chinook at the end of the run are in poor condition; however, with more water and non-flow measures, the condition of the fish will improve. Mr. Shelton said CDFW agrees that this process should look at all three fish species. Mr. Shelton said CDFW is cognizant that the Districts do not have unlimited funding and CDFW would like to help defer costs. Mr. Shutes said he had spoken with commercial fishermen and they are interested in reintroducing fall-run Chinook to the upper Tuolumne River. Mr. Shutes said the study should consider capturing fall-run Chinook further downstream than the other two species and should consider passing only those fish in good condition. Mr. Shutes said the study should also consider that fall-run Chinook will likely spawn further downstream than spring-run Chinook, which means that fall-run Chinook will not have to travel as far to get to the downstream passage facility. Mr. Devine stated that in order to more fully explore this proposal, it may be appropriate to move this item into the Technical Committee. Mr. Devine asked if there were concerns about interbreeding between fall-run and spring-run Chinook and competition for limited spawning habitat. Mr. Wooster indicated the resource agencies had meetings on this subject and decided that all three species should be considered. The basic reasoning came down to "why wouldn't we consider" fall-run.

Ms. Ferreira asked NMFS to describe how the agency considers economics and cost when deciding to require fish passage at a project. Mr. Edmondson said that NMFS requests studies through the FERC process and that licensees generally conduct the studies as part of the proceeding. Mr. Edmondson said NMFS provided a summary of how it considers economics in the July 7, 2015 letter to California State Assembly Member Kristin Olsen. Mr. Edmondson said in these types of processes, NMFS first determines whether there is a barrier to fish passage and whether providing passage around the barrier would produce a benefit. Mr. Edmondson said the next step is studying the availability of suitable habitat and whether fish passage is necessary for species recovery, recreational or commercial fishing purposes, or to prevent species extinction. Mr. Edmondson said NMFS's analysis is qualitative in nature. Mr. Edmondson said NMFS performed an economic analysis for the Klamath Project (FERC No. 2802) but that this analysis was part of a Secretarial Determination and different from the FERC process. He will provide a link to reports.

Mr. Devine presented slides describing the information the Districts have been able to locate relevant to the resources and conditions in the study reach (Attachment A). After the presentation, the Workshop adjourned.

ACTION ITEMS

1. Mr. Wooster will provide an abstract for the proposed assessment of climate change impacts to the Tuolumne River.
2. Mr. Shutes will take the lead on compiling information about the historical presence of target species in the upper watershed.
3. Mr. Edmondson will provide a link to the Klamath Project economic analysis and the Districts will send this link to Workshop participants (complete; link to Klamath Project economic analysis).

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Modesto Irrigation District
The Power to Grow

La Grange Hydroelectric Project
Reintroduction/Fish Passage Assessment Framework
Workshop No. 4

Wednesday, January 27, 2016 -- 9:00 am to 12:00 pm
MID Office, 1231 11th Street, Modesto, California
Conference Line: 1-866-583-7984; Passcode: 814-0607
Join Lync Meeting: https://meet.hdrinc.com/jenna.borovansky/3D64F0F5

Meeting Objectives:

1. Discuss and approve the proposed Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework (Reintroduction Framework) goals and schedule.
2. Present and discuss existing information, information needs, and potential preliminary studies for 2016.

TIME	TOPIC
9:00 am – 9:10 am	Introduction of Participants (All)
9:10 am – 9:30 am	Opening Remarks (All) Review Agenda and Meeting Objectives (All) Overview of Upper Tuolumne River Reintroduction Framework (Districts)
9:30 am – 10:00 am	Reintroduction Assessment Framework Goals and Schedule (All) a. Proposed goals by year (2016-2017) b. Summary of 2016 proposed schedule, meetings, and potential use of a technical subcommittee c. Discuss and decide: -Assessment Framework goals, schedule and meetings -Use of a technical subcommittee
10:00 am – 10:45 am	Potential 2016 Studies and Discussion of Biological Goals and Objectives of the Reintroduction Program (All) a. Potential 2016 studies discussion b. Schedule for identifying reintroduction program biological goals and objectives
10:45 am – 11:00 am	Break
11:00 am – 11:45 am	Upper Tuolumne River: Existing Information and Information Gaps Discussion (Districts) a. NMFS studies – schedule of availability b. Barriers, temperature, habitat, and hydrology summaries c. Other information
11:45 am – 12:00 pm	Next Steps (All) a. Schedule b. Action items

Modesto Irrigation District

La Grange Fish Passage Workshop No. 4
Wednesday, January 27, 2016
9:00 a.m. – 12:00 p.m.

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PLEASE SIGN IN

	Name	Organization	Telephone No.	E-mail	Time In
1.	Ron Yoshiyama	San Francisco			
2.	George Morrow	Jim Brisco Ent			46
3.	Gretchen Murphey	CDFW			08Y
4.	Brandon McMillan	TID			96
5.	Scott Wilcox	Stillwater			47
6.	Jennifer Shipman	MCCV			3
7.	Jay Dixon	Public			53
8.	W. Sears	SF.			55
9.	John Buckley	CSERC			55
10.	Peter Drekmeier	TRT			57
11.	Garth Stapley	BEE			9
12.	Connie Moore	Citizen			

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Modesto Irrigation District

La Grange Fish Passage Workshop No. 4
Wednesday, January 27, 2016
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	Name	Organization	Telephone No.	E-mail	Time In
13.	Marco Moreno	WCR			
14.	Joe Sallaberry				
15.	Paul Zeek	Asm. Kristin Olsen			
16.	Allen Zanker	Zanker Farms			
17.	John Shelton	CDFW			
18.	Dana Ferreira	Congr. Denham			'4
19.	Chris Shutes	CSPA			
20.	David White	Alliance			com
21.	Helen Condit	Senator Cannella			
22.	[illegible]	Farmer			
23.	Zac Jackson	USFWS			05
24.	Patrick Koepele	TRT			45

Information Needs and Potential Studies to Inform Reintroduction Assessment Framework
For Discussion and Review by Collaborative Group

Framework Category	Studies	On-going and Potential Studies for 2016[1]	Cost Estimate	Schedule for Draft Report
Ecological	Limiting Factors Analysis and Carrying Capacity		$340,000	December 2017
Ecological	Reservoir Transit Study		$500,000	
Ecological	Interactions with Existing Aquatic Communities		$250,000	
Ecological	Source Population Assessment		NMFS lead?	
Ecological	Method of Colonization		$60,000	
Ecological	Genetics Assessment of Existing and Source Populations (NMFS has study on-going)	X	NMFS lead	April 2017
Biological	Habitat Typing and Characterization[2]	P	$240,000	Nov/Dec 2016
Biological	Upstream Migration Barriers	X	$220,000	Nov/Dec 2016
Biological	Instream Flow – Habitat Assessment: PHABSIM		$300,000[3]	
Biological	Water Temperature Monitoring and Modeling	X	$350,000	Nov/Dec 2016
Biological	Spawning Gravel Study	P	$140,000	Nov/Dec 2016
Biological	Macroinvertebrate Study		$220,000	
Biological	Swim Tunnel Study of Upper River *O. mykiss*		$450,000	
Economic, Regulatory, and Other Key Considerations	Regulatory Evaluation of Reintroduction (ESA Status, BLM/USFS Management Plans, Wild and Scenic, etc)	P	$50,000	October 2016
Economic, Regulatory, and Other Key Considerations	Socioeconomic Scoping and Issues Identification/ Preliminary Evaluation of Impacts on Tuolumne River Uses/Users	P	$50,000	October 2016
Economic, Regulatory, and Other Key Considerations	Hatchery Practices Review, including current Don Pedro related practices.		$50,000	

Draft Study Abstracts

Limiting Factors Analysis and Carrying Capacity

A limiting factors analysis (LFA) is a useful tool to identify and fill information gaps related to physical and biological factors controlling population dynamics of one or more target species. This type of analysis has been used extensively in California and the Pacific Northwest to identify habitat conditions, ecological interactions, and other factors that constrain salmonid population production potential. The LFA proposed herein would test hypotheses regarding potential factors that that could limit the ability of the upper Tuolumne River to support viable populations of reintroduced Chinook salmon and O. mykiss. The data analyzed and synthesized as part of a LFA can also include an analysis of carrying capacity, to determine the number of individuals of each freshwater life stage that can be supported by the available habitat. The results of a LFA provide valuable insight into possible effects of current or historical riverine habitat conditions on salmonid populations (or reintroduced populations), allowing managers evaluate

[1] X = Ongoing study; P = Potential additional 2016 study for consideration by collaborative group
[2] Habitat typing and characterization study proposal does not explicitly include habitat components being collected by NMFS; however, the NMFS data should be discussed in overall Assessment Framework.
[3] The geographic scope and amount of available information needs to be confirmed to refine scope and cost estimate.

reintroduction potential, focus future management activities, help prioritize actions, and/or refine the current understanding of limitations of the ecosystem.

Reservoir Transit Study

As detailed in FERC's study plan determination, if the fish passage facilities assessment indicate that the most feasible concept alternative for fish passage would involve either upstream or downstream passage through the project reservoirs (i.e., La Grange or Don Pedro reservoirs), a study would be required to evaluate the technical and biological feasibility of upstream (adults) or downstream (juvenile) movement of anadromous fish (as appropriate) through the project's reservoirs. Until feasible concept alternatives have been selected, the scope of this study cannot be accurately identified.

Interactions with Existing Aquatic Communities

Evaluating potential interactions with existing species in the target area is a factor that can impact reintroduction success. This constraint includes predatory and competitive interactions with other species and populations. Often times, habitat in target areas have changed from historic conditions. Consequently, aquatic communities present in target reintroduction areas may be comprised of non-native species or native invaders that have filled these available niches. Furthermore, intraspecific competition is possible if a population of the target species is already present in the target reach (i.e., *O. mykiss*). This assessment would identify the potential interactions of target reintroduction species with the existing aquatic community in the target reach and characterize the potential risks/benefits to the reintroduction program.

Source Population Assessment

Consideration of genetic and ecological characteristics of a source population is important to assessing the probability of a successful reintroduction. Ecological factors such as life history, morphological, and behavioral traits compatible with the target area will increase the probability of a successful reintroduction. Source populations that are genetically similar to the historic population may also maximize the benefits and reduce the risks of reintroduction. This assessment would identify factors that should be considered when identifying viable source populations, potential sources, associated pros and cons of each, and constraints of utilizing each source, if any.

Method of Colonization Assessment

Colonization approaches (i.e., natural, transplants, and hatchery releases) differ in the effects on the parameters that are used to assess the success or failure of a reintroduction. Method of colonization also has implications for the infrastructure and operations needed to support a reintroduction program. As such, identifying early in the process the lowest-risk strategy for colonization will be a critical component of assessing risks, constraints, and benefits of any reintroduction program.

Genetics Assessment of Existing and Source Populations

NMFS is conducting a study of the upper river *O. mykiss* fishery genetics. Request a schedule and information update for the group.

Habitat Typing and Characterization

Habitat mapping quantifies the type, amount, and location of river habitat types available to reintroduced anadromous salmonids of all life stages. Habitat mapping would be conducted in the field and remotely using standardized methodologies. The frequency and area of each habitat type (e.g., pool, riffle, run) would be tabulated and where potential holding pools for spring-run salmon occur, the size, depth, and vertical thermal profile of the pools will be measured to determine possible holding capacity, stratification of the pools (if any), and thermal suitability. Additional (remote) mapping tasks will include assessments of channel gradient, width, habitat areas, etc. This baseline information provides the template for many other evaluations and is critical for assessing the feasibility of reintroduction. For example, data on habitat type, area, and distribution are required to assess potential Chinook salmon and steelhead adult holding capacity, spawning habitat potential, and juvenile rearing capacity.

Upstream Migration Barriers

Little information exists to reliably assess the current quantity and quality of suitable habitat for the adult, egg, fry and juvenile life stages of anadromous salmonid species that may be considered for reintroduction in the Upper Tuolumne River watershed (i.e., above the Don Pedro Project). Prior to assessing the quality/suitability of habitat for target species, an assessment of barriers (both complete and partial) to upstream anadromous salmonid migration must first be conducted to identify the quantity of habitat that is accessible. This assessment would utilize relevant prior studies, desktop analyses, and field surveys to characterize and document the physical structure of barriers in the mainstem Tuloumne River and its tributaries upstream of the Don Pedro Project Boundary. Note that this study was requested by NMFS but per FERC's determination, was not required to be conducted by the Districts as part of the La Grange licensing process. However, to more fully support licensing participants in their development of information to supplement fish passage and reintroduction assessments, and to foster collaboration among all parties, the Districts have opted to conduct an upstream migration barriers assessment.

Instream Flow – Habitat Assessment: PHABSIM

Hydraulic models such as the Physical Habitat Simulation (PHABSIM) system are widely used and accepted tools used to produce quantitative estimates of the amount (quantity and quality) of habitat available to fish at a range of stream flows. Using measured physical channel characteristics for representative habitat types or reaches, PHABSIM modeling incorporates habitat suitability relationships for the target fish species and life stage to produce estimates of weighted usable area (WUA) in relation to stream flow. Results of PHABSIM modeling can be combined with data from habitat mapping and water temperature modeling to provide estimates of habitat availability and suitability for target species and associated life stages throughout the project area at a range of flows. Additionally, the analysis would include an evaluation of the effect of fluctuating flows on habitat value, due to the frequent peaking operations in the upper Tuolumne River. This could be evaluated by comparing habitat values on a small time-step using the high and low flows within the fluctuation range. Water temperature data would also be overlaid with the PHABSIM results to evaluate how the total amount of habitat is affected by thermal rather than physical habitat conditions.

Water Temperature Monitoring and Modeling

The assessment of suitable habitat quality for the adult, egg, fry and juvenile life stages of anadromous salmonid species that may be considered for reintroduction in the Upper Tuolumne River watershed (i.e., above the Don Pedro Project) is dependent upon both physical and thermal characteristics. This study would use existing and additional data to characterize the thermal regimes of the upper Tuolumne River and tributaries from the Don Pedro Project Boundary to CCSF's Early Intake to characterize locations where temperatures may be suitable for anadromous salmonid species considered for reintroduction. The study would include the development of a computer model to simulate existing thermal conditions in the study area. Note that this study was requested by NMFS but per FERC's determination, was not required to be conducted by the Districts as part of the La Grange licensing process. However, to more fully support licensing participants in their development of information to supplement fish passage and reintroduction assessments, and to foster collaboration among all parties, the Districts have opted to conduct an upstream migration barriers assessment.

Spawning Gravel Study

Spawning gravel mapping quantifies the amount, location, and suitability of gravel available for spawning by reintroduced anadromous salmonids. In a confined, high gradient river channel dominated by large substrates (boulder, cobble, bedrock) like the upper Tuolumne River, spawning gravel distribution is typically patchy and overall abundance may be low. Initial evaluation of aerial photographs and an on-river reconnaissance survey indicate this is may be the case in portions of the Tuolumne River between Wards Ferry and Early Intake. Because successful spawning and fry production are dependent on the abundance and suitability of accessible spawning gravel, spawning gravel mapping is a critical component for assessing the feasibility of reintroduction. This information is a key part of any evaluation of the factors likely to limit production and viability of an existing or reintroduced salmonid population (i.e., a limiting factors or carrying capacity analysis).

Macroinvertebrate Study

Drifting and benthic macroinvertebrates (BMI) are the primary food source for rearing salmonids in fresh water habitats. Growth of juvenile anadromous salmonids during their freshwater rearing period is critical for their survival during outmigration and ocean phases, as well as to the overall viability of the population. Studies have shown a strong relationship between the size at which juvenile salmon and steelhead migrate to the ocean and the probability that they return to fresh water to spawn. Macroinvertebrate sampling provides a measure of food availability during this important life history period. Information on macroinvertebrate prey resource availability is therefore a key component of any evaluation of the factors likely to limit production and viability of an existing or reintroduced salmonid population (i.e., a limiting factors analysis).

Swim Tunnel Study of Upper River O. mykiss

Thermal acclimation among fish species dates back to the 1940's and since 2001, thermal adaptation at the population level and among a wide variety of fish species has been convincingly supported in the peer-reviewed scientific literature. Included in this evidence base are salmon and trout species. The objective of this study would be to determine the thermal performance of the subadult *O. mykiss* population inhabiting the upper Tuolumne River to assess any local adjustments in thermal performance. The study would test the hypothesis that the *O.mykiss* population in the Upper Tuolumne River (i.e., above the Don Pedro Project Reservoir) is locally adjusted to relatively warm thermal conditions that may exist during the summer. Results of the study would be used to support habitat suitability and temperature modeling assessments.

Hatchery Practices Review, including current Don Pedro related practices

Assessing historic and current hatchery practices in the upper Tuolumne River will be necessary to evaluate potential risks to reintroduction. Risks include but are not limited to evolutionary (homogenization or reduced fitness), ecological (competition, predation, etc.) and disease issues. Results of the review will identify past and current hatchery practices in the reintroduction area as well as connected areas (i.e., Don Pedro Reservoir), potential risks of past/present hatchery programs to a reintroduction program, and recommendations to address identified risks.

Regulatory Evaluation of Reintroduction

The Upper Tuolumne River watershed spans several land management agencies' jurisdictions and there are management plans and regulations in place based on established resource management objectives (e.g., Wild and Scenic Management Plan, Forest Plan, BLM Management Plan). The compatibility of the potential reintroduction of *O.mykiss* and/or spring run Chinook will be evaluated relative to these current management objectives. The potential reintroduction of Endangered Species Act (ESA) listed species may overlay additional management objectives and a new regulatory framework in the upper Tuolumne River. This evaluation will include compiling and reviewing all relevant and potentially relevant existing management plans for the upper Tuolumne River and the Don Pedro Reservoir. In addition, applicable recovery plans and ESA regulations and potential population status classifications for the reintroduced species will be summarized. Responsible resource management agencies will be contacted to determine the most recent guidance documents for the study area.

<u>Socioeconomic Scoping and Issue Identification/Preliminary Evaluation of Impacts on Tuolumne River Uses/Users</u>

Current management of the Don Pedro Reservoir and upper Tuolumne River supports a wide range of resources, uses, and users. The upper watershed includes the Tuolumne Wild & Scenic River segment managed for several outstanding resource values and is utilized by commercial and private recreational boaters. Other uses include the City and County of San Francisco's Hetch Hetchy Project operations, private timber practices, and a recreational fishery. Don Pedro Reservoir has an active house boating and recreational fishery; county government and businesses rely upon the economic activities supported by the upper watershed. This evaluation will conduct a comprehensive survey of uses in the upper watershed and identify potential issues for consideration in the reintroduction assessment. A literature survey and review of existing information from the Don Pedro Recreation Agency, county and federal land management agencies and other sources will be conducted. Surveys and/or focus groups will be used to verify and expand upon available information on the multiple existing uses of the watershed that could be impacted by a fish reintroduction program.

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La Grange Hydroelectric Project

Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework

Goals and Schedule

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Overarching Framework Goal

Evaluate feasibility of reintroducing anadromous salmonids into the Upper Tuolumne River by applying a structured assessment process. The process is an integrated evaluation of ecological, biological, engineering, economic, regulatory, and other key considerations related to the reintroduction.

Framework Implementation

- Framework implementation over 2.5 years
- Phased approach to information/data collection and analysis
- Phased approach allows for key assessment points over the implementation period
- Use of technical subcommittee

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Framework Goals By Year

- **2016 (Phase 1)**
  - Compile and share existing information, identify data gaps and needed studies
  - Implement 2016 studies – ecological, biological, regulatory and potential uses/user impacts
  - Develop overall reintroduction goals related to ESA Recovery planning
  - Develop Phase 1 evaluation approach

Framework Goals By Year

- **2017 (Phase 1/2)**
  - 2016 studies information available
  - Conduct Phase 1 reintroduction evaluation using study results and developed reintroduction goals
  - **Key Assessment Milestone** – can ESA reintroduction goals be met (i.e., can success be achieved?)

Framework Goals By Year

- **2017 (Phase 2)**
  - If reintroduction deemed achievable based on Phase 1 (i.e., no fatal flaws), move to Phase 2.
  - Scope/conduct 2017 studies – additional biological, ecological studies, re-engage fish passage engineering, socioeconomics, other resource/user impacts
  - Develop Phase 2 evaluation approach

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Framework Goals By Year

- **2018 (Phase 2 continued)**
  - 2017 studies information available
  - Conduct Phase 2 reintroduction evaluation
  - **Key Assessment Milestone** – can ESA reintroduction goals be met (i.e., can success be achieved?)
  - Final reporting

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Discussion and Decisions

- **Framework implementation approach**
- **Schedule and meetings**
- **Use of a technical subcommittee**

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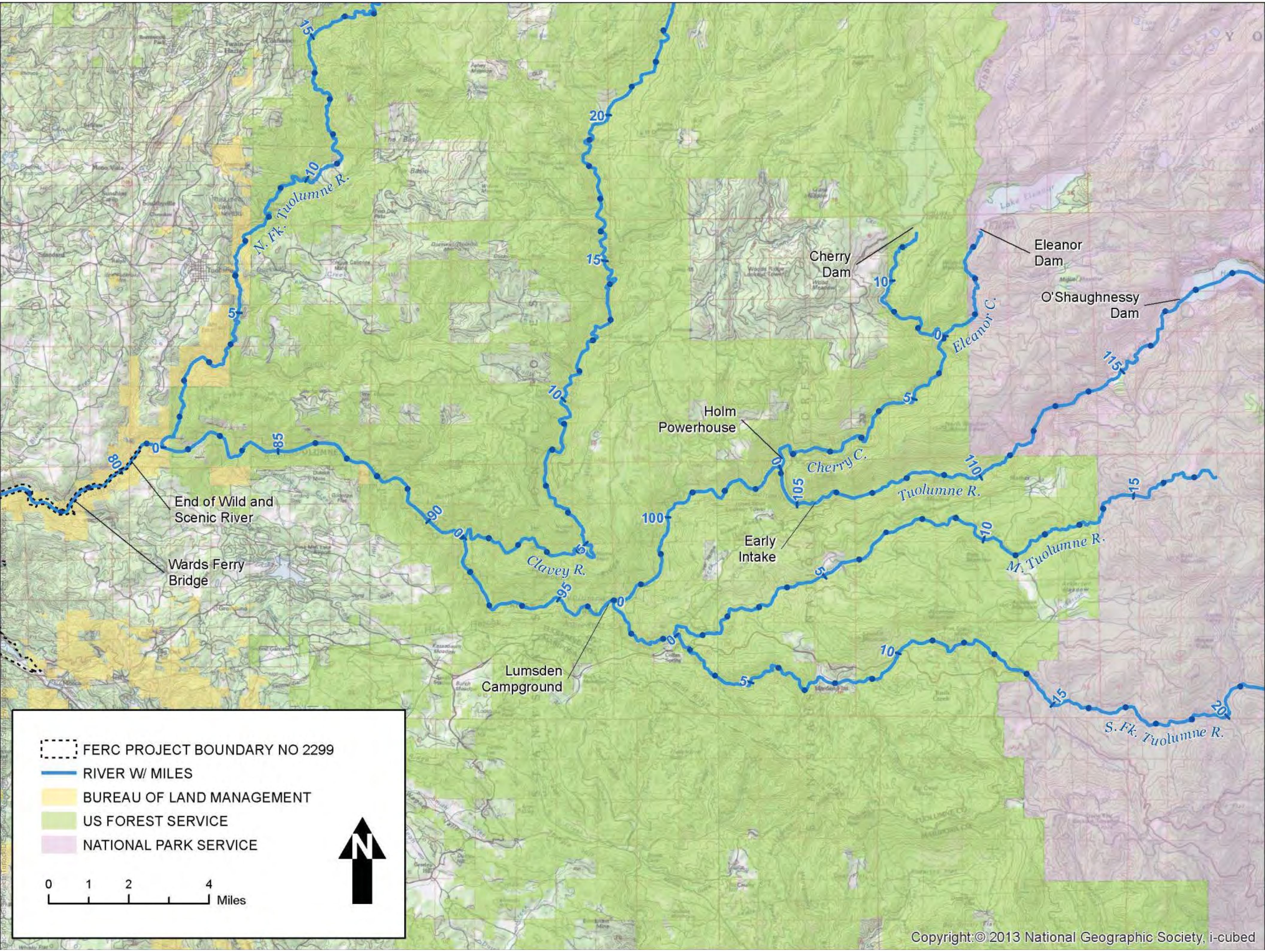
La Grange Hydroelectric Project
FERC No. 14581

Description of Existing Environment


N. Fk. Tuolumne R.
Cherry Dam
Eleanor Dam
O'Shaughnessy Dam
Eleanor C.
Holm Powerhouse
Cherry C.
Tuolumne R.
End of Wild and Scenic River
Early Intake
M. Tuolumne R.
Wards Ferry Bridge
Clavey R.
Lumsden Campground
S. Fk. Tuolumne R.
FERC PROJECT BOUNDARY NO 2299
RIVER W/ MILES
BUREAU OF LAND MANAGEMENT
US FOREST SERVICE
NATIONAL PARK SERVICE
0 1 2 4 Miles
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Copyright:© 2013 National Geographic Society, i-cubed

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Geomorphology

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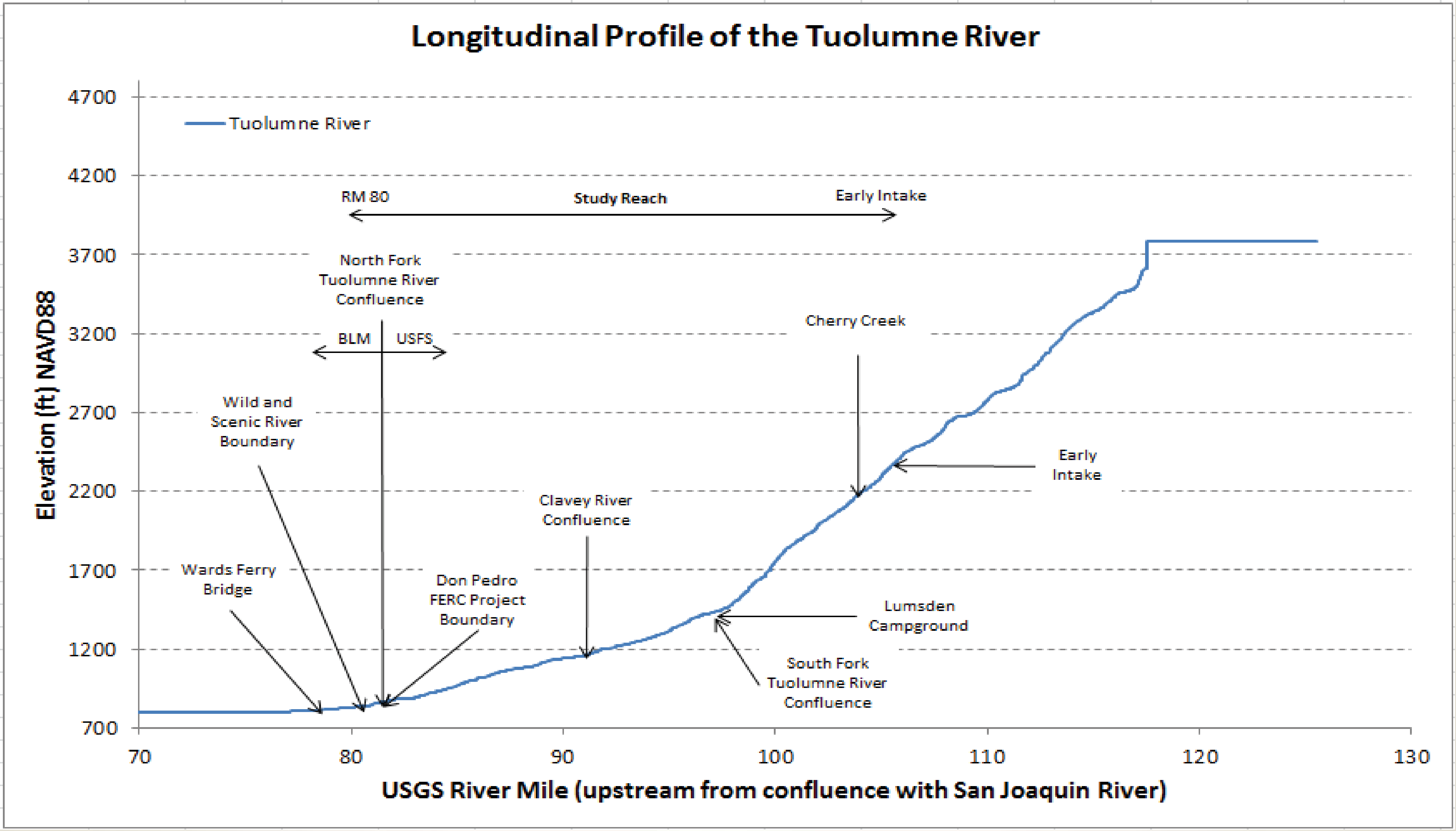

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Mainstem TR Geomorphological Zones Table

Main Stem Tuolumne River Geomorphological Zones					
Subreach	**RM**	**Length (mi)**	**Approx Change in Elev**	**Channel Gradient (%)**	**Description**
Wards Ferry to Clavey River	78.4 - 91	12.6	400 ft	0.6	Channel becomes semi-alluvial; large boulder bars and side channels are more common here than in upstream reaches.
Clavey River to South Fork Tuolumne River	91 - 97	6	300 ft	0.9	Boulder cascades separated by medium-length pools.
South Fork Tuolumne River to Early Intake	97 - 105.5	8.5	1100 ft	2.5	Deep pools separated by boulder cascades; confined by steep, bedrock canyon walls; some boulder alternate bars and few side channels.

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Hydrology

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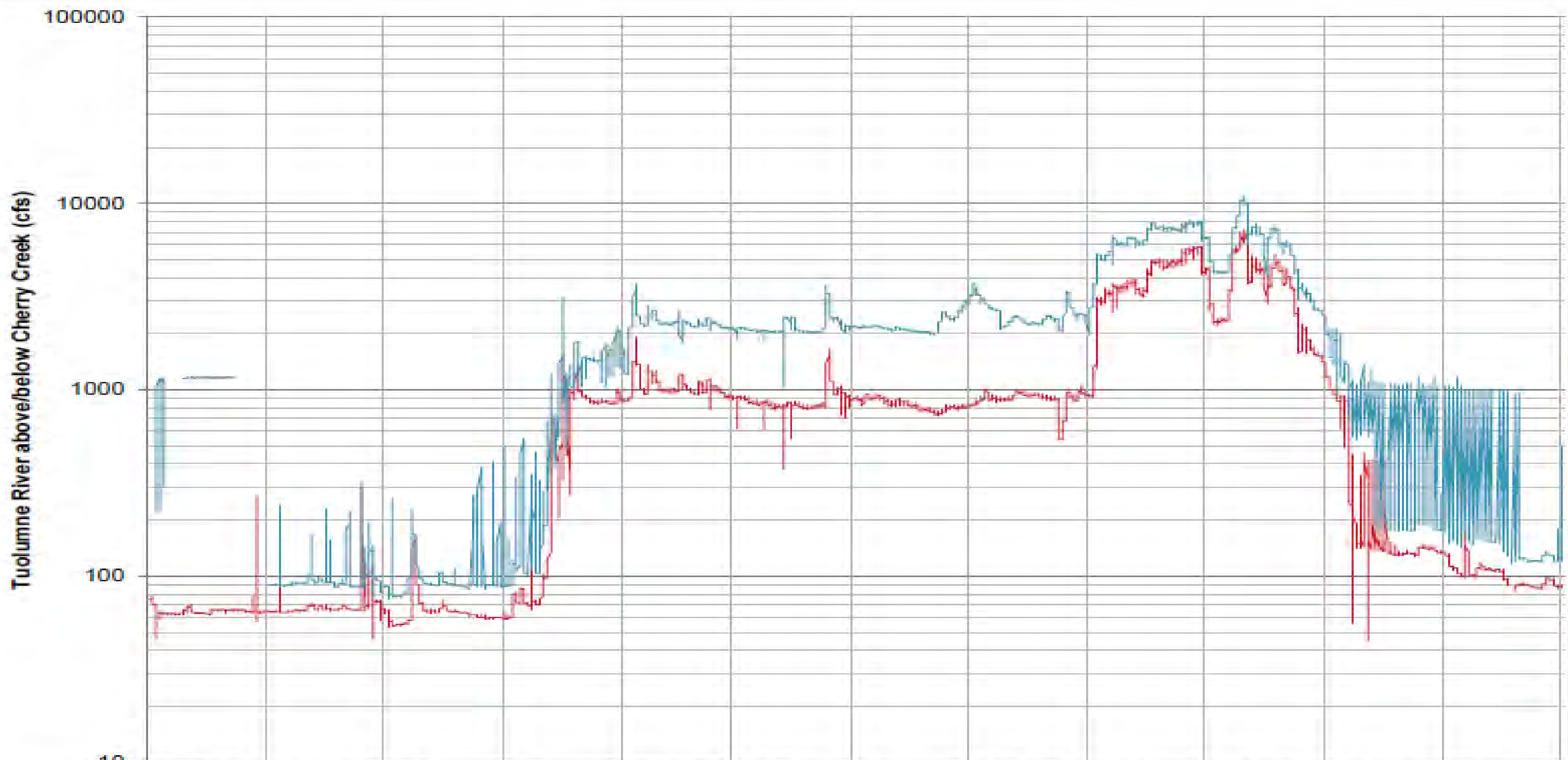
Mainstem TR Hydrology – Wet Year (WY 1998)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Above	4,001AF	4,085 AF	3,961AF	34,560 AF	57,717 AF	53,619 AF	49,670 AF	55,435 AF	242,666 AF	218,828 AF	18,939 AF	5,736 AF
Below	32,936 AF	5,936 AF	6,625 AF	58,303 AF	128,050 AF	133,769 AF	133,505 AF	156,443 AF	389,723 AF	335,667 AF	51,260 AF	17,580 AF

Water Year 1998 - 749,215 AF Above and 1,449,797 AF Below Cherry Creek

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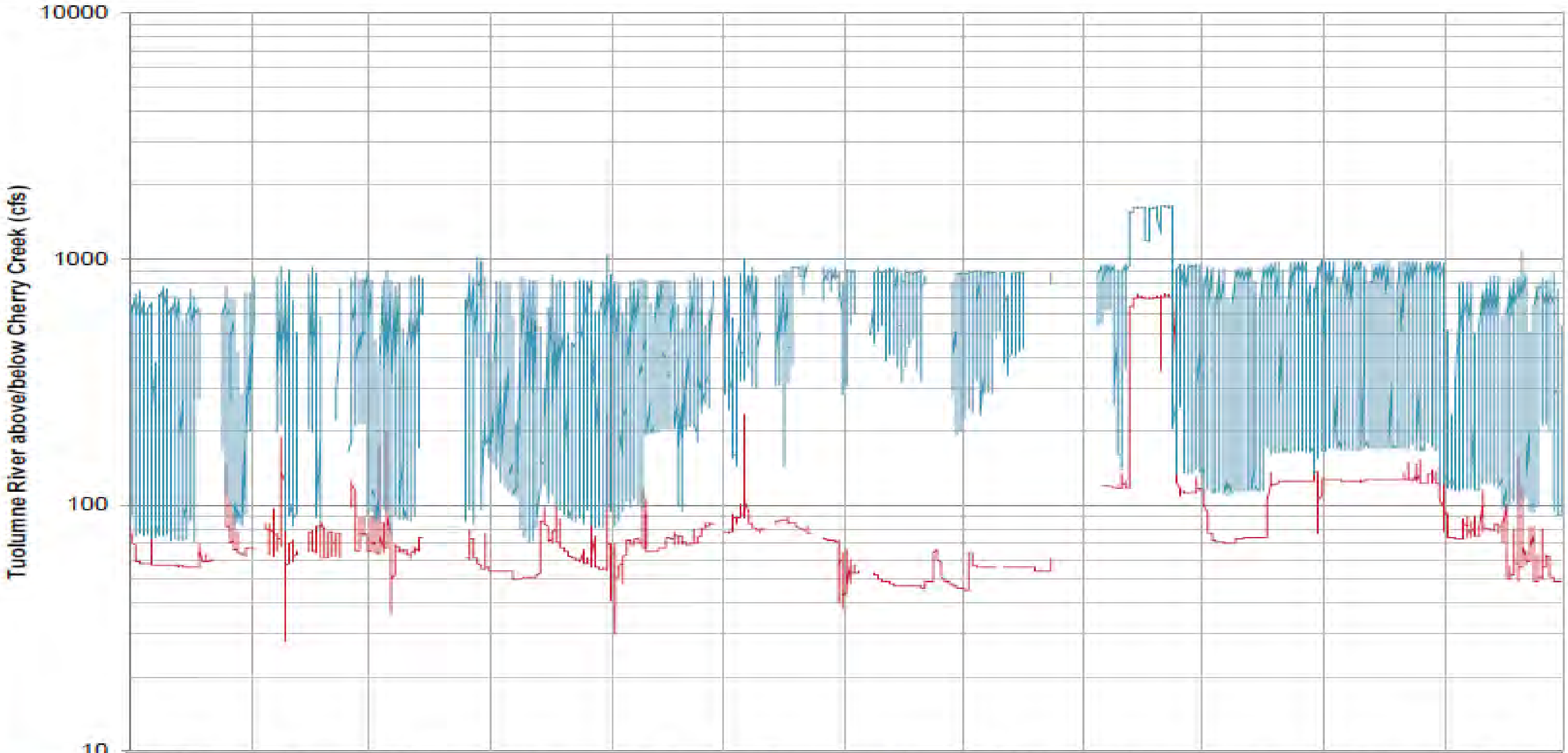
Mainstem TR Hydrology – Dry Year (WY 1990)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Above	3,515 AF	3,180 AF	2,713 AF	3,794 AF	3,589 AF	3,825 AF	2,647 AF	2,414 AF	19,020 AF	5,944 AF	7,734 AF	4,053 AF
Below	20,756 AF	16,088 AF	18,995 AF	27,515 AF	23,193 AF	30,834 AF	26,708 AF	20,286 AF	54,756 AF	34,719 AF	37,040 AF	28,241AF

Water Year 1990 - 62,428 AF Above and 339,133 AF Below Cherry Creek

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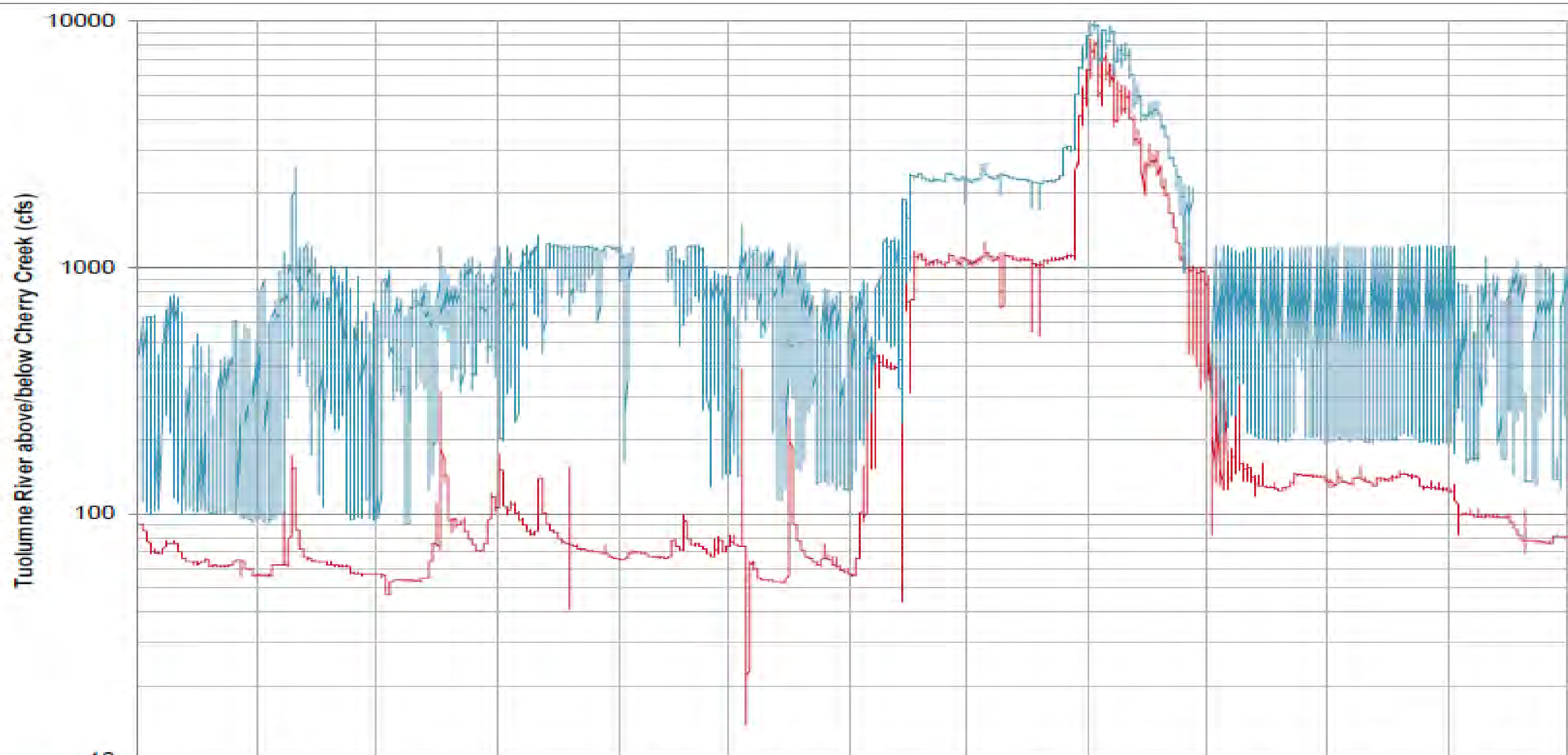
Mainstem TR Hydrology – Normal Year (WY 2003)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Above	4,081 AF	3,911 AF	4,878 AF	5,171 AF	3,978 AF	4,117 AF	42,832 AF	97,516 AF	190,194 AF	9,694 AF	8,329 AF	5,355 AF
Below	22,125 AF	39,352 AF	41,473 AF	63,332 AF	33,095 AF	42,842 AF	94,437 AF	189,684 AF	264,308 AF	32,092 AF	28,804 AF	32,047 AF

Water Year 2003 - 380,056 AF Above and 883,592 AF Below Cherry Creek

CCSF Minimum Flow Regimes

1982 Streamflow Stipulation for Eleanor Creek below Lake Eleanor Dam

Month	Minimum Flow (cfs)	
	Pumping	Not Pumping
Jan	5	5
Feb	5	5
Mar	10	5
April 1 - 14	10	5
April 15 - 30	20	5
May	20	5
June	20	5
July	20	15.5
Aug	20	15.5
Sept 1 - 15	20	15.5
Sept 16 - 30	10	15.5
Oct	-	5
Nov	5	5
Dec	5	5

1950 Streamflow Stipulation for Cherry Creek below Cherrry Valley Dam

Month	Minimum Flow (cfs)
Jan	5
Feb	5
Mar	5
April	5
May	5
June	5
July	15.5
Aug	15.5
Sept	15.5
Oct	5
Nov	5
Dec	5

1985 Streamflow Stipulation for the Tuolumne River below O'Shaughnessy Dam

Month	Minimum Flow (cfs)				
	A (60%)	A (60%)	B(32%)	B (32%)	C (8%)
Jan	50	114	40	104	35
Feb	60	124	50	114	35
Mar	60	124	50	114	35
April	75	139	65	129	35
May	100	164	80	144	50
June	125	189	110	174	75
July	125	189	110	174	75
Aug	125	189	110	174	75
Sep 1 - 15	100	164	80	144	75
Sep 16 - 30	80	144	65	129	50
Oct	60	124	50	114	35
Nov	60	124	50	114	35
Dec	50	114	40	104	35

Source: RMC Water and Environment and McBain & Trush, Inc. 2007.

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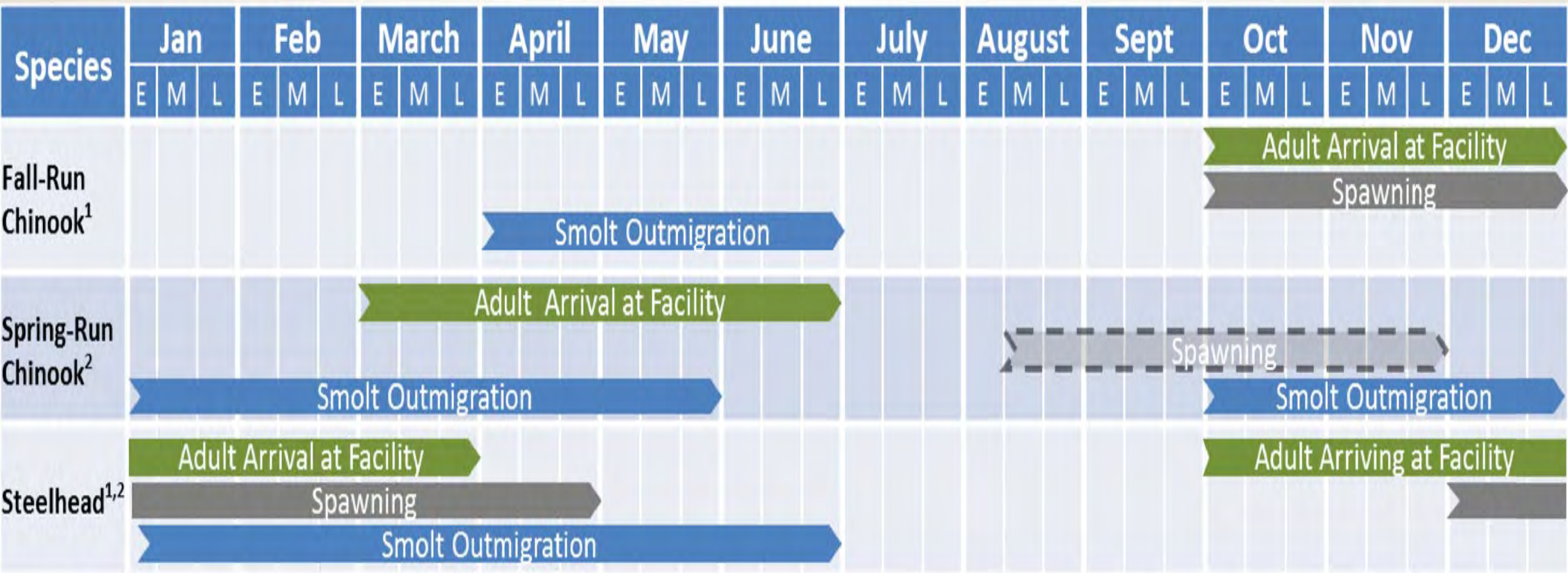
Anadromous Fish Species Being Considered For Reintroduction

Species of Interest

Steelhead	Spring-run Chinook	Fall-run Chinook
✓	✓	?

Species of Interest
Anticipated Life History Timing



[1] TID/MID 2013b.
[2] BOR et al. 2013 and NMFS 2014

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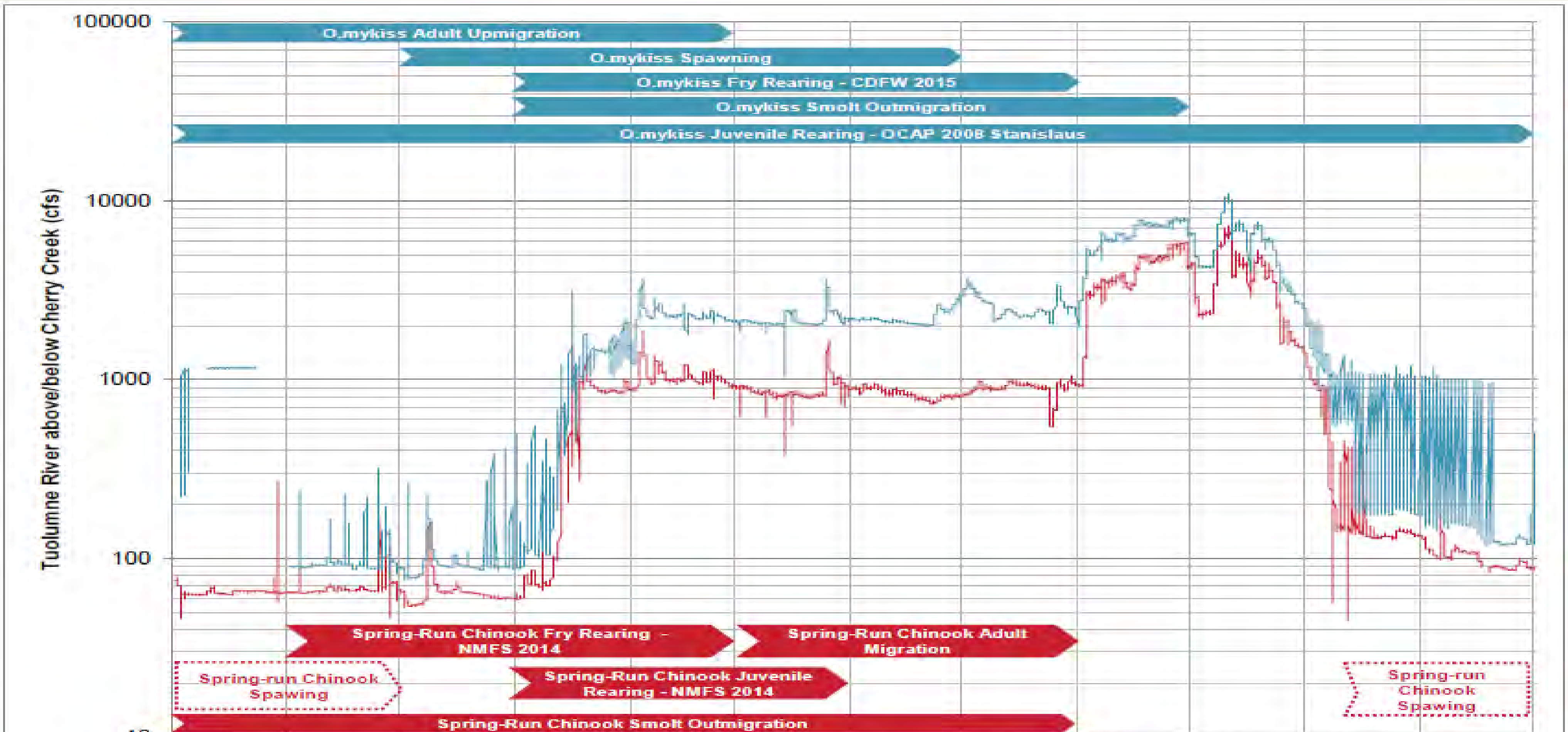
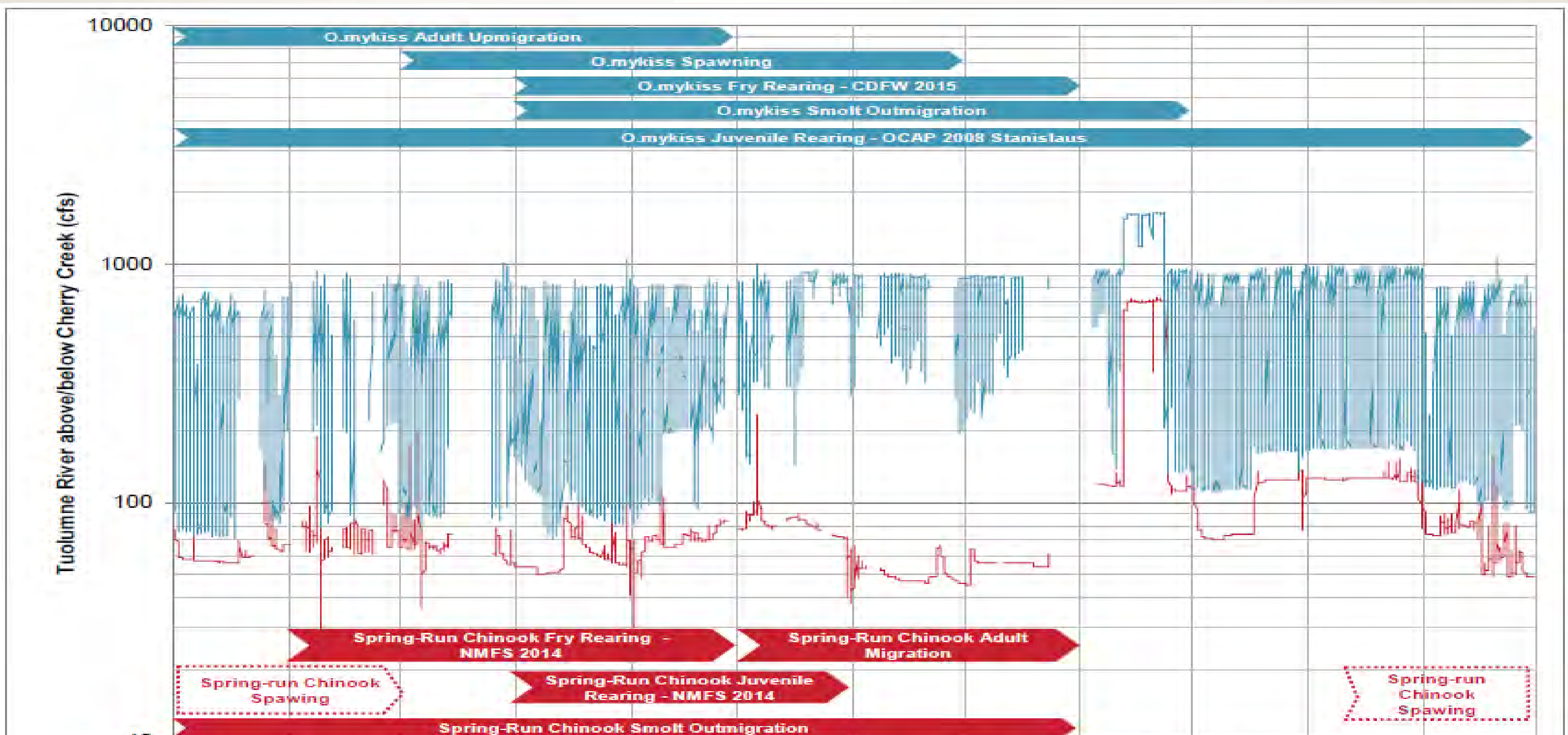
TR Abv/Bel Cherry Creek – Wet WY (WY 1998)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Above	4,001 AF	4,085 AF	3,961AF	34,560 AF	57,717 AF	53,619 AF	49,670 AF	55,435 AF	242,666 AF	218,828 AF	18,939 AF	5,736 AF
Below	32,936 AF	5,936 AF	6,625 AF	58,303 AF	128,050 AF	133,769 AF	133,505 AF	156,443 AF	389,723 AF	335,667 AF	51,260 AF	17,580 AF

Water Year 1998 - 749,215 AF Above and 1,449,797 AF Below Cherry Creek

TR Abv/Bel Cherry Creek – Dry WY (WY 1990)



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Above	3,515 AF	3,180 AF	2,713 AF	3,794 AF	3,589 AF	3,825 AF	2,647 AF	2,414 AF	19,020 AF	5,944 AF	7,734 AF	4,053 AF
Below	20,756 AF	16,088 AF	18,995 AF	27,515 AF	23,193 AF	30,834 AF	26,708 AF	20,286 AF	54,756 AF	34,719 AF	37,040 AF	28,241AF

Water Year 1990 - 62,428 AF Above and 339,133 AF Below Cherry Creek

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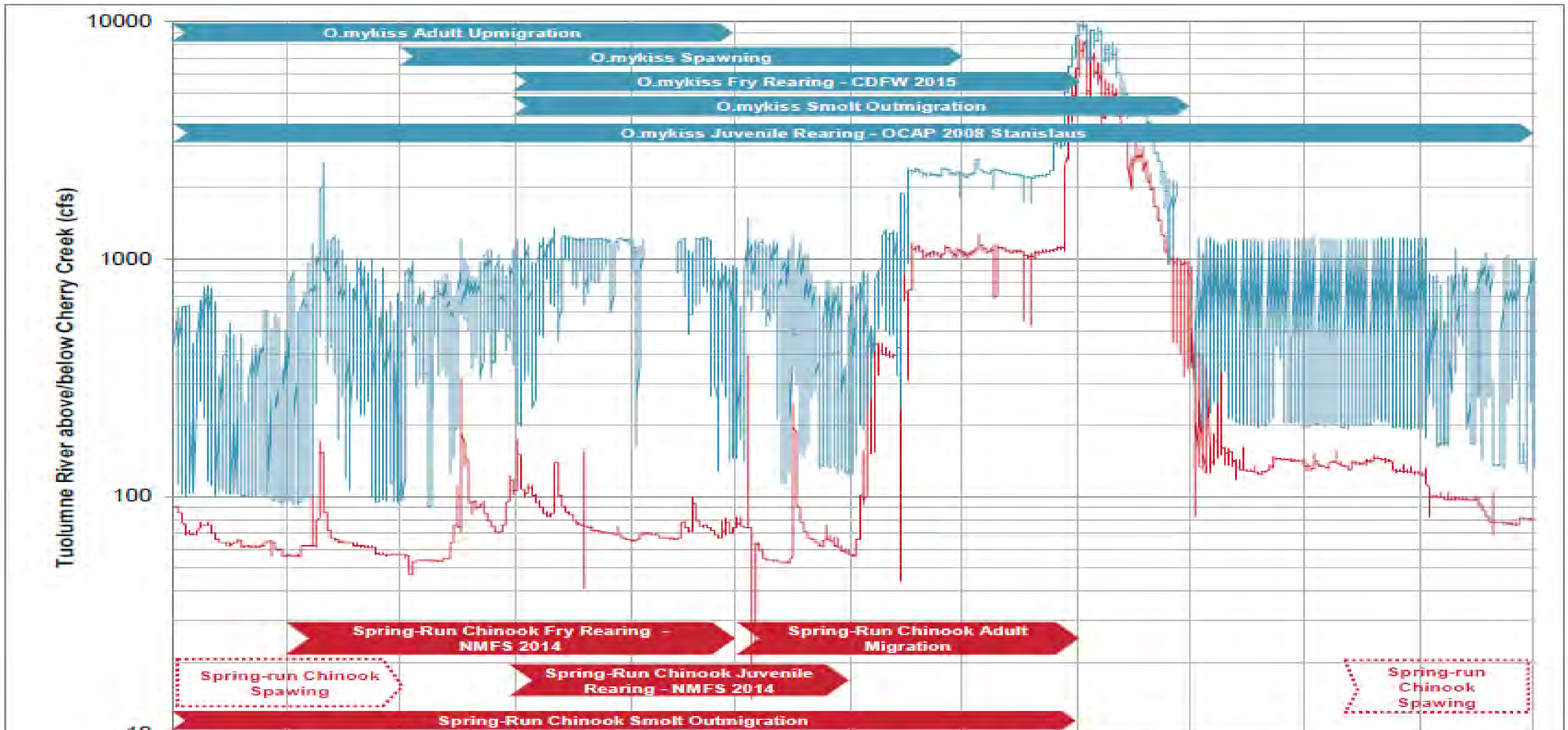
TR Abv/Bel Cherry Creek – Normal WY (WY 2003)



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Water Year 2003 - 380,056 AF Above and 883,592 AF Below Cherry Creek

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Upper Tuolumne River Studies

Goals of Upper Tuolumne River Studies

Upper River Barriers Study	Water Temp. Monitoring and Modeling	Anadromous Fish Habitat Reconnaissance

• Determine potential limits of anadromy by identifying physical features classified as total barriers on TR mainstem and tribs upstream of Don Pedro Project Boundary	• Use existing data and collect additional data (as necessary) to characterize thermal regimes of upper TR and tribs from Early Intake to above DP Reservoir
	• Develop and test a computer model to simulate existing thermal conditions in TR from below Early Intake to above DP Reservoir
		• Reconnaissance level investigation of habitat suitability for anadromous fish
		  • TR (downstream of Meral's Pool), S.F. Tuolumne River, Clavey River
		• Habitat elements for consideration
		  • Holding pools (mainstem)
		  • Spawning gravel (tributaries)
		  • Habitat unit diversity
		  • Summer thermal conditions
		  • Stranding potential (mainstem)

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Upper River Barriers Study

- Observed via watercraft on August 2 – 4 and observed by foot on August 5 – 6 and October 26 – 27
- Surveys conducted on mainstem TR (downstream of Lumsden Falls and upstream of Cherry Creek confluence), South Fork TR, Clavey River, and Cherry Creek
- Each observed during lower flow of about 350 cfs and two-unit Holm powerhouse flow of about 1,000 cfs
- More information available in ISR

Temp. Monitoring and Modeling Study

Summary of 2015 Activities

- Existing data through 2014 compiled and evaluated
- 2015 monitoring locations for additional data identified
- Loggers deployed in spring 2015 and downloaded fall 2015
- QA/QC of 2015 field data is near completion
- Additional data will be presented in ISR

Anadromous Fish Habitat Reconnaissance

- Habitat reconnaissance conducted in concert with barriers work in similar locations and reaches
- Habitat elements for consideration
  - Holding pools (mainstem)
  - Spawning gravel (tributaries)
  - Habitat unit diversity
  - Summer thermal conditions
  - Stranding potential (mainstem)
- Preliminary observations downstream of barriers suggest limited habitat in tributaries
- Additional mainstem habitat information (e.g. thermal regime, flow regime, spawning gravel, holding pools) is needed to evaluate suitability for anadromous salmonids

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Next Steps For Upper Tuolumne River Studies

Upper River Barriers Study	Water Temp. Monitoring and Modeling	Anadromous Fish Habitat Reconnaissance

• Complete remaining initial field surveys on North Fork and Tuolumne River mainstem between Lumsden and Cherry Creek Confluence (RM 97.3 to 104.0)
• Perform more detailed assessment of barriers identified in 2015.
	• Coordinate with barrier study team to identify potential limits to upstream migration
	• Confirm life history presence/absence in space and time through study area
	• Characterize temperature on a reach-by-reach basis
	  • Field data
	  • Models
		• Select studies for 2016 calendar year

Benthic Macroinvertebrates

Benthic Macroinvertebrates

- Data Availability
  - Numerous BMI samples were collected in study reach for Ponderosa Project
  - A limited number of samples were analyzed

- Preliminary Results (from McBain & Trush 2007)
  - "Species diversity (richness) downstream of Early Intake to Wards Ferry was moderate overall but low when compared to sites above Early Intake in the tributaries to the mainstem, probably due to hypolimnial releases from Holm PH"
  - "Plecoptera (stoneflies) and Elmidea (riffle beetles) were notably absent from the samples in the Lumsden Reach, which could be an indicator of environmental stress"
  - BMI "abundance was low at all sites in the reach"

Other Water Uses/ Affected Resources/ Potential Impacts

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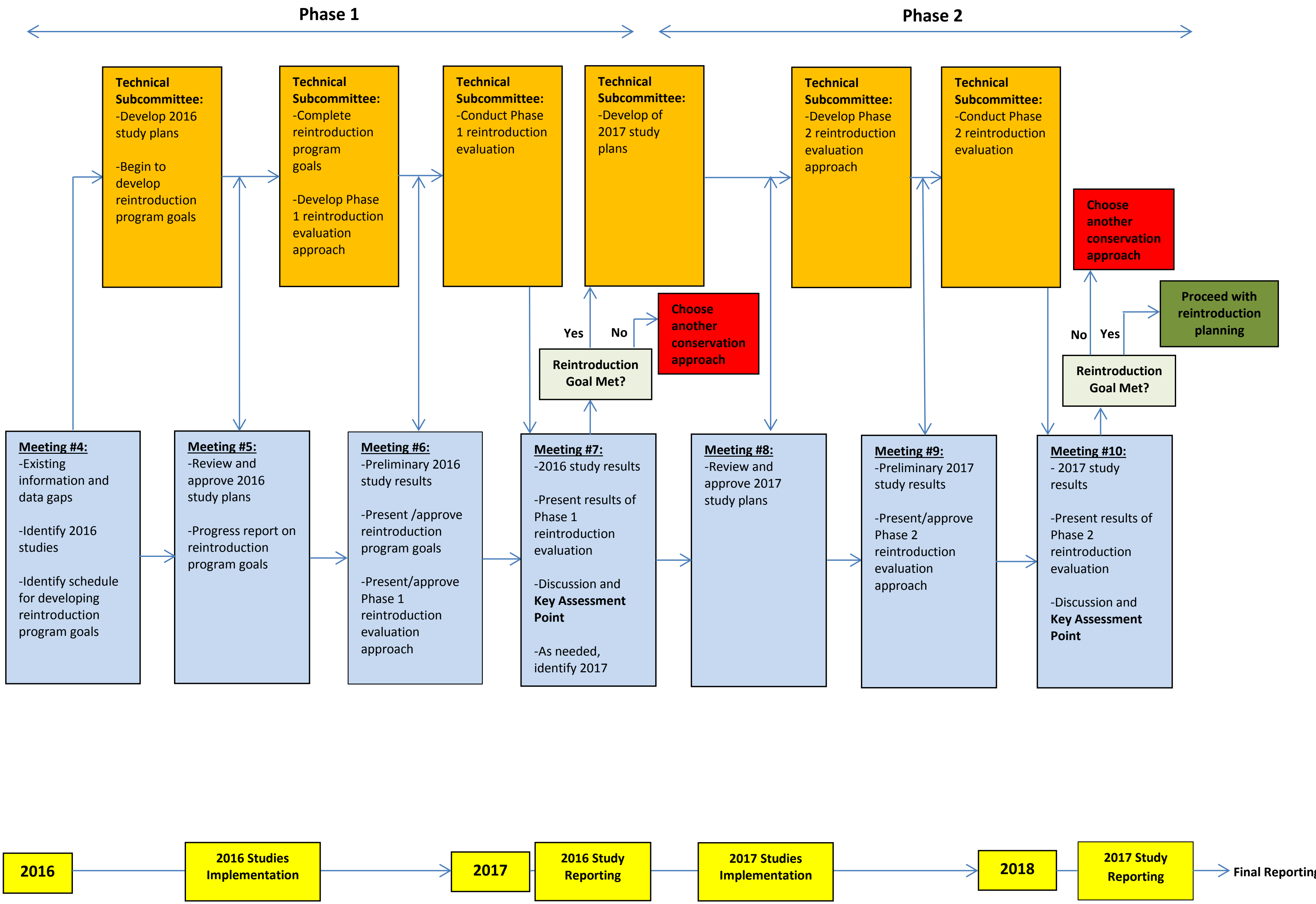
Other Water Uses/ Affected Resources/ Potential Impacts

Environmental Issues		Regulatory Issues
• Impacts caused by or to other fish species: river and reservoir predator abundance (rainbow trout; pikeminnow; smallmouth bass); Clavey River Wild Trout and Heritage Trout designation; competition for spawning habitat; interbreeding resident/ anadromous *O. mykiss;* interbreeding stocked Chinook and introduced Chinook; • Impacts to/effects of Don Pedro stocking of salmonids (kokanee; Chinook; coho; rainbows)	• *O. mykiss* genetic considerations • Impacts caused by or to whitewater boating • Impacts caused by or to recreational fishing • Fishing regulations in affected reaches and Don Pedro Reservoir • Effects on watershed forest harvest practices • Juvenile mortality in lower Tuolumne River	• Designations under ESA • USFS whitewater boating annual permits (need ESA protection – each year?, BiOps, NEPA compliance) • USFS Forest Plan changes due to introduction of listed species • BLM Mngt Plan changes • W&S River designation compatibility • Installation of passage facilities in W&S reaches? • CCSF operations – need ESA authorization and "take" permits?

Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework – Flow Chart



La Grange Hydroelectric Project Licensing
Upper Tuolumne River Reintroduction Assessment Framework
Proposed Meetings/Schedule 2016-2017

DRAFT Programmatic Process Steps and Goals by Year

2016 (Phase 1):

- Share and assess existing information relevant to assessing reintroduction in the upper Tuolumne River (includes past studies/information, ongoing studies related to licensing, and agency-led studies).
- Identify data gaps/additional information needs and scope priority studies in 2016 to address data gaps. 2016 studies constitute Phase 1 of the assessment framework with a focus on preliminary biological/ecological, regulatory, and other uses/user impact information needs.
- Conduct 2016 studies.
- Develop reintroduction program goal (i.e., criteria for success) in order to evaluate reintroduction (in combination with available/collected information).
- Develop Phase I reintroduction evaluation approach that addresses biological/ecological and regulatory areas (last quarter of 2016).

2017 (end Phase 1, begin Phase 2):

- Review and finalize 2016 study reporting and make information available for Phase I reintroduction evaluation.
- Conduct Phase I reintroduction evaluation using relevant program goal (developed in 2016) and existing/collected information. Collaborative discussion of evaluation results and whether reintroduction program goal can be met (i.e., key assessment point).
- If Phase I reintroduction evaluation results and subsequent discussions support proceeding forward with assessment framework, scope 2017 studies that constitute Phase 2 and are focused on additional biological/ecological information (as needed), re-engaging fish passage engineering design (using more accurate biological information), socio-economic and cost-benefit analysis, etc.).
- Reservoir Transit Study as identified in FERC's Study Plan Determination.
- Conduct 2017 studies.
- Develop Phase II reintroduction evaluation approach that addresses additional biological/ecological, engineering, and social and economic areas of consideration (last quarter of 2017).

2018:

- Review and finalize 2017 study reporting and make information available for Phase II reintroduction evaluation.
- Conduct Phase II reintroduction evaluation using relevant program goal (developed in 2016) and existing/collected information. Collaborative discussion of evaluation results and whether reintroduction program goal can be met (i.e., key assessment point).

2016 Phase 1 Schedule:

1. **Workshop 4 - January 27, 2016 (Wednesday): 9am to 12pm.**
    a. Objectives:
        i. Present and reach agreement upon framework and schedule (Phased approach including 2016 meetings).
        ii. Discuss and identify approach/schedule for developing goals of reintroduction program.
        iii. Summarize existing information and begin scoping potential 2016 studies that address key Phase 1 elements of assessment framework and can be used to assess reintroduction program success (goal).
        iv. Approve the use of a technical subcommittee as a means to implement technical tasks approved by the plenary group to minimize the numbers of workgroup meetings.
    b. Materials to be distributed in advance:
        i. Agenda
        ii. Draft Reintroduction Framework schedule and flow diagram
        iii. Studies list

2. **Workshop 5 – April 13 or 20, 2016**

a. Objectives:
    i. Review and approve 2016 study plans developed by technical subcommittee.
    ii. Progress report on task to develop reintroduction program goals.
b. Materials to be distributed in advance:
    i. 2016 study plans – for review/approval as identified from meeting 1
    ii. Reintroduction goal materials - TBD

3. May 2016 to November 2016 – Implementation of 2016 studies

a. No meetings planned until November during study implementation but could have a progress update via optional conference call, if desired.
b. June/July: complete development of reintroduction program goals.
c. July/August: begin technical subcommittee development of Phase I reintroduction evaluation approach.

4. Workshop 6 – November 17, 2016 (Thursday)

a. Objectives:
    i. 2016 study updates.
        1. Share preliminary information.
        2. Reporting schedule.
    ii. Present reintroduction program goal (completed in June/July 2016).
    iii. Present/approve Phase I reintroduction evaluation approach.
b. Materials to be distributed in advance:
    i. Agenda
    ii. TBD

2017 End Phase 1/Phase 2 Schedule: Detailed meeting schedule TBD; high level ideas for consideration below:

- 2016 study reporting will likely be final in first quarter of 2017 depending upon specific study scope and schedule.
- Priority in 1st quarter of 2017 is to conduct Phase I reintroduction evaluation to inform next steps of reintroduction assessment framework. – **Key Assessment Point.**
- If information shows that reintroduction goal can be met, 2017 Phase 2 studies would focus on additional biological/ecological information (if needed), and non-biological/ecological considerations such as socio-economics, impacts to other uses, etc. 2017 study scoping and study plan development would occur in the late first quarter/early second quarter of 2017.
- If reintroduction from a biological, ecological and regulatory perspective is supported, information could be available to re-engage in a more detailed concept-level fish passage engineering design process so this could occur in 2017.
- 2017 study updates.
- Development of a Phase 2 reintroduction evaluation approach to inform next key assessment point will be required toward the end of the year.

2018 – Detailed schedule TBD

- 2017 reporting completed.
- Complete Phase II reintroduction evaluation, second **Key Assessment Point** and final conclusion developed.

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT
TECHNICAL COMMITTEE CONFERENCE CALL

FEBRUARY 16, 2016

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project Licensing (FERC No. 14581)
Fish Passage Facilities Alternatives Assessment
Technical Committee Conference Call

Tuesday, February 16, 2016
11:00 am to 1:00 pm

Final Meeting Notes

Conference Call Attendees		
No.	**Name**	**Organization**
1	Jenna Borovansky	HDR, Inc., consultant to the Districts
2	Steve Boyd	Turlock Irrigation District
3	John Buckley	Central Sierra Environmental Resource Center
4	Larry Byrd	Modesto Irrigation District
5	Adrianne Carr	Bay Area Water Supply and Conservation Agency
6	Jesse Deason	HDR, Inc., consultant to the Districts
7	John Devine	HDR, Inc., consultant to the Districts
8	Greg Dias	Modesto Irrigation District
9	Art Godwin	Turlock Irrigation District
10	Chuck Hanson	Hanson Environmental, consultant to the Districts
11	Steve Holdeman	U.S. Forest Service
12	Zach Jackson	U.S. Fish and Wildlife Service
13	Bao Le	HDR, Inc., consultant to the Districts
14	Ellen Levin	City and County of San Francisco (CCSF)
15	Lonnie Moore	Citizen
16	Gretchen Murphy	California Department of Fish and Wildlife (CDFW)
17	Bill Paris	Modesto Irrigation District
18	Bill Sears	City and County of San Francisco (CCSF)
19	Chris Shutes	California Sportfishing Protecting Alliance
20	John Wooster	National Marine Fisheries Service (NMFS)
21	Ron Yoshiyama	City and County of San Francisco (CCSF)

On February 16, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted a Technical Committee conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Passage/Reintroduction Assessment Framework. 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 meeting agenda and read-ahead materials.

Meeting attendees introduced themselves. Mr. Le said there are two objectives for this conference call: (1) determine what studies will be completed in 2016 for the Upper Tuolumne River Fish Passage/Reintroduction Assessment Framework (Reintroduction Framework) and (2) begin discussing an approach for developing the reintroduction program goals.

Mr. Devine said one additional meeting objective is to discuss how this conference call and Workshop No. 4 (held on January 27) interface with the upcoming La Grange Project Initial Study Report (ISR) meeting (to be held on February 25) and the overall ISR process. Mr. Devine said the Districts will file a summary of the ISR meeting and then licensing participants will have an opportunity to comment on the meeting summary and request new studies and study modifications. The Districts will then have an opportunity to respond to those comments and then the Federal Energy Regulatory Commission (FERC) will make a determination on new studies and study modifications. Mr. Devine said part of the rationale of having Workshop No. 4 and this conference call prior to the ISR meeting was to allow time to come to a decision on what studies will be completed in 2016 so that this decision can be documented in the ISR meeting notes, which FERC will review.

Mr. Wooster asked if the Districts have been in communication with FERC about the Plenary Group's (individuals participating in the Reintroduction Framework) activities, given that FERC has not been participating in the Workshops. Mr. Devine said he recently had a call with Mr. Jim Hastreiter (FERC) and briefed Mr. Hastreiter on the Plenary Group's Workshops and recent decisions. Mr. Devine said he told Mr. Hastreiter the Plenary Group is trying to come to a decision on 2016 studies and, if a decision is made, the decision will be discussed at the ISR meeting. Mr. Devine said Mr. Hastreiter had no comment.

Mr. Wooster asked if the 2016 studies to be discussed today will be implemented within the licensing process or outside the licensing process, similar to the upper Tuolumne River studies the Districts are currently conducting voluntarily. Mr. Devine said he envisioned the latter because the 2016 studies will not be held to the licensing process criteria for new studies and conducting the studies outside the licensing process allows for more freedom to collaborate amongst the Plenary Group. Mr. Wooster said he agreed, but there may come a point in the licensing process where a due date arises and the 2016 study results are not yet available. Mr. Devine said that was a good point and it will be important for the Plenary Group to keep FERC informed of its progress and schedule.

Mr. Le reviewed the table of potential studies to inform the Reintroduction Framework (Studies Table). He said the Studies Table was developed by the Districts' technical team and studies included were identified as potential studies that could support reintroduction evaluation. Mr. Le stated that not every study in the Studies Table should or would be completed. As agreed to at the January 27, 2016 Workshop, implementation of the Reintroduction Framework would be phased. Mr. Le said Phase 1 would include completing the 2016 studies and comparing the 2016 study results with the reintroduction goals (also to be developed in 2016). If the study results suggest the reintroduction goals can be met, studies in 2017 (Phase 2) may be implemented.

Mr. Wooster provided an update on the genetics study being completed by NMFS. In 2015, 17 sites were sampled in the upper Tuolumne River for resident *O. mykiss*. A total of 634 samples were collected from those 17 sites. The National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Science Center (NOAA Lab) processed the samples and is currently running the samples through algorithms. Mr. Wooster said the NOAA Lab is happy with the results so far. Mr. Wooster said the NOAA Lab will be presenting the results at a conference in June 2016, so he expected the study results will be available at that time. Mr. Wooster said the second year of sampling will take place this summer and will be informed by the first year of sampling. Samples will also be collected from the Merced River to both compare samples from the Merced River to the Tuolumne River samples and to inform a possible reintroduction program in the upper Merced River. NMFS also intends to collect samples from the lower Tuolumne River. Although NMFS received lower Tuolumne River samples from CDFW, these samples are somewhat older and NMFS is interested in collecting additional samples. The NOAA Lab will analyze the second-year samples over the winter 2016. A final report will be available by May 2017, and may be available as early as March 2017.

Mr. Wooster said NMFS has some funding for the second year of sampling, but most of the funding will be spent on the lab work, leaving little money for collecting the samples. Mr. Wooster said sample collection will rely heavily on volunteers and the National Park Service may help with sampling on the Merced River.

Mr. Devine asked what the NOAA Lab will present on at the June conference. Mr. Wooster said he did not know much about the June presentation, but he thinks the presentation will include analyses similar to analyses the NOAA Lab completed recently for the upper American River. Mr. Wooster said he did not think a final report had been released on the upper American River analyses.

Mr. Devine asked if Mr. Wooster had a sense of the scope of conclusions or recommendations that may be in the NOAA Lab's Tuolumne River genetics study report. Mr. Wooster said the study includes isolating genetic markers to determine whether there is a propensity toward anadromy and the study report will likely include this analysis. Mr. Wooster said he also expects the report will describe how the Tuolumne River samples might relate to samples from other nearby rivers and to samples from within the larger Central Valley, as well as to known hatchery strains (i.e., hatchery influence or introgression). Mr. Wooster said the report will likely not make recommendations on where to capture fish for broodstock.

Mr. Devine asked if NMFS has received the CDFW permits necessary for collecting samples on the lower Tuolumne River. Mr. Wooster said the NOAA Lab has received the necessary permits. However, due to time and funding constraints, at this time there is not an active plan to sample the lower Tuolumne River. Mr. Wooster said it would be great if individuals volunteered to help collect samples.

Mr. Wooster gave an update on an action item from Workshop No. 4, which was for NMFS to provide an abstract for the climate change study they proposed for consideration. Mr. Wooster said the study would assess the likely effects of climate change on the Tuolumne River. Mr. Wooster said he had been in communication with Ms. Andrea Ray at the NOAA Center for Dynamics in Colorado about producing an abstract for this study but so far an abstract has not been developed. Mr. Wooster said many climate change models predict changes in snow pack and water supply for the region including the Tuolumne River, and these changes would likely influence environmental conditions over the new license period. Mr. Wooster said he anticipated developing an abstract for a risk assessment approach with Ms. Ray, but that this approach would not be specific to the Tuolumne River. Instead, the abstract would describe the methodology and approach for completing a climate change study that could apply more broadly to any FERC licensing proceeding. Meeting attendees decided to table future discussions of a climate change study until an abstract is available for review.

Mr. Wooster asked if the Districts or CCSF have conducted climate change analyses and if these climate change analyses can be translated to flow or temperature impacts for use in this effort. There were no responses. Mr. Moore asked if the Districts or CCSF have ongoing studies related to the drought that could relate to climate change. Mr. Devine said a climate change study was proposed during the Don Pedro Project relicensing process, but FERC did not require the Districts to complete the study. Mr. Devine said the Districts have not completed any work during the Don Pedro Project relicensing process related to climate change.

Mr. Moore asked about the ability to model changes to the Don Pedro Project's releases and operations. Mr. Devine said the Districts produced several models (e.g., an operations model, reservoir model, lower river model, fish models) that can be used to run different outflow scenarios. The Districts provided training on how to use these models and the models are available for use by the public. Mr. Devine said he is unsure how helpful the models would be for modeling climate change impacts because the models do not include the necessary climatological inputs.

Mr. Shutes asked if CCSF has studies looking at climate change and predicting future water availability and surface runoff patterns. Ms. Levin said CCSF has done some basic sensitivity analysis of the effect of changing temperatures on inflow to the Hetch Hetchy Project Reservoir, but the analysis is dated and does not look at water supply. Ms. Levin said CCSF has a study plan that includes more downscaled work, but CCSF is unlikely to take the analysis further and the analysis will not be used to inform decision-making. Mr. Wooster asked if information on the scenarios is available. Ms. Levin said the work was not completed due to insufficient funding and CCSF will revisit the study if funding becomes available.

Mr. Shutes asked if CCSF has a temperature model for the CCSF reservoirs. Mr. Sears said CCSF has a stream temperature model of O'Shaughnessy Dam to Early Intake that was produced by Mr. Mike Deas as part of the Upper Tuolumne River Ecosystem Program (UTREP). Also as part of UTREP, McBain & Trush produced a water storage versus outflow temperature model. Mr. Sears said that is the extent of CCSF's temperature work.

Mr. Shutes asked what the NMFS habitat analysis entails. Mr. Le said the study includes collecting hyperspectral LiDAR data and some ground-truthing. Mr. Le said one of the primary reasons the Districts propose to conduct a separate habitat study is that results from the NMFS study will not be available until late summer, and when the results do become available it may be that additional habitat work including further ground-truthing is necessary. Logistically, it may be extremely challenging to complete any additional fieldwork in the fall, which would require that this study then be conducted in 2017. With regards to the overall Reintroduction Framework schedule, delaying a habitat study to 2017 is of concern to the Districts. Mr. Le said the Technical Committee has already agreed on the importance of having the habitat work completed in 2016 as part of Phase 1, therefore the Districts are interested in doing a habitat study to complement the work being completed by NMFS. Mr. Wooster agreed with Mr. Le's characterization of the NMFS study and said he expects the habitat typing data to be available in August or possibly the end of September. Mr. Devine also agreed with Mr. Le and said the habitat data is essential information. Mr. Devine said the Districts have researched the type of hyperspectral work being used in the NMFS study and reported that the experts the Districts consulted with believe the hyperspectral technique is somewhat experimental. Mr. Wooster asked what would be the scope of the Districts' habitat study since his primary concern is that this study might be duplicative as opposed to complementary to NMFS' effort. Mr. Devine said the scope is not yet determined and the Districts are open to discussing this during development of the study plan.

Mr. Le suggested that as a first step, the Districts develop a study plan for the habitat study in collaboration with the Technical Committee. Mr. Moore agreed. Mr. Wooster disagreed and said from his perspective the money would be better spent collecting data where no data is currently being collected. Mr. Wooster said the NMFS study is a 100 percent census of the study area and the data resolution is on par with data collected in the field. Mr. Devine said part of the Districts' concern with relying on the NMFS data is that a study plan or any other detailed information of NMFS's work is unavailable. Mr. Devine said the NMFS study LiDAR report had only one page about the spectral analysis and did not include anything about accuracy or penetration. Mr. Devine said the Districts are hopeful the NMFS study will produce solid information.

Mr. Wooster clarified that the NMFS study is using hyperspectral LiDAR to assess grain size for sediment out of the water. Mr. Wooster said images were taken in the field to conduct pebble counts. There has been good agreement between the hyperspectral data and the calibration data. Mr. Wooster said he does not have any other written descriptions of the hyperspectral work than what he has previously provided to the Districts.

Mr. Shutes asked for how the spawning gravel study in the Studies Table might overlap with the habitat typing work. Mr. Le said in general a spawning gravel study can be completed as part of a habitat characterization study, but given the importance of the spawning gravel study to the overall evaluation of reintroduction, the Districts decided to propose it as a separate study. Mr. Le said at Workshop No. 4, Mr. Wooster agreed with keeping the spawning gravel study separate. Mr. Wooster said the NMFS habitat study is primarily looking at bar features at 150 cfs in the mainstem and additional work in the tributaries would be helpful.

Mr. Shutes asked which study or studies NMFS would prefer be completed instead of the Districts' habitat study. Mr. Wooster said he believes the benthic macro-invertebrate (BMI) study is a high priority study and goes hand-in-hand with the habitat typing work and the spawning gravel work. Mr. Wooster said the reservoir transit study should also be a priority and he believes the cost estimate provided by the Districts is low, based on a conversation he had with a NMFS engineer about the study. Mr. Wooster said he will get additional details about why it appears the reservoir transit study cost estimate is low and provide these details to the Technical Committee.

Mr. Le said the Districts at this time are not proposing to undertake a detailed BMI study in 2016. Mr. Le stated that from an ecological feasibility perspective, Phase 1 is designed to focus on physical habitat. If the 2016 study results suggest adequate habitat is available, limiting factor studies, such as the BMI study, could possibly be conducted in 2017 even within the current FERC schedule. Mr. Wooster believes understanding the availability of food (i.e., the BMI study) is just as important as understanding the availability of habitat and spawning gravel and thermal suitability, all of which are being studied in 2016. Mr. Shutes said he agrees the BMI study is a high priority study. Mr. Shutes said conducting the study in 2016 would provide the opportunity to conduct additional sampling in 2017, if 2016 results appear anomalous. Mr. Shutes said it would be helpful to determine upfront which riffles the BMI sampling would focus on. Mr. Shutes believes the study could be done for reasonable cost and noted that on the Feather River, they used high resolution aerial imagery to identify eight or nine riffles from which to sample BMI that effectively informed productivity. Mr. Wooster said from an economies-of-scale perspective, it may make sense to collect the BMI data at the same time as the other 2016 fieldwork. Mr. Devine said the Districts will consider today's discussion about the BMI study, explore alternatives, and will provide feedback on whether they have an interest in conducting this study in 2016.

Mr. Le summarized study decisions made thus far on the call. The Districts will develop a habitat typing study plan and discussions will continue on whether or not the Districts should conduct this study. The Technical Committee agreed the spawning gravel study should be conducted. The Districts will give further consideration to whether or not the BMI study should be completed in 2016. Mr. Le described the regulatory evaluation and socioeconomic scoping studies and asked if anyone on the phone objected to conducting these studies in 2016. There were no responses.

Mr. Devine described the hatchery practices review. Mr. Devine said there have been reports of a self-sustaining kokanee population in Don Pedro Reservoir and anecdotal evidence of self-sustaining populations of resident Chinook and rainbow trout, both of which have been stocked in the past. Mr. Devine said these populations may hamper the successful reintroduction of spring-run Chinook and/or steelhead. Ms. Murphy said a recent paper by Moyle and others mentioned the existence of juvenile Chinook in Don Pedro Reservoir. Ms. Murphy said she would send the paper to Rose Staples (HDR) for distribution to the group. Mr. Devine said the subject of hatchery practices is likely to come up in the future and that it seems advantageous to start collecting the information now. Mr. Wooster agreed that information on hatchery practices would be useful to have and, especially given the relatively low cost of completing the study, there is value in beginning the study this year. Mr. Le said he will revise the Studies Table to have a "p" for the hatchery practices review.

Mr. Shutes asked if any thought had been given to the risk of a reintroduction program introducing pathogens into the upper watershed. Mr. Shutes said it would be helpful to determine whether or not this is something to be concerned about. Mr. Le agreed and said that collecting information on disease profiles can be incorporated into the hatchery practices review. Mr. Devine also agreed.

Mr. Le asked if others have thoughts or input on 2016 studies. There were no responses.

Mr. Devine said the Districts have spoken with their technical team about whether or not it is prudent to consider fall-run Chinook in these studies. Mr. Devine said there are several reasons not to include fall-run Chinook:

1. Fall-run Chinook are not included in the NMFS Recovery Plan. If one of the main reasons for the reintroduction program is to advance the Recovery Plan, then the Reintroduction Framework should only consider species in the Recovery Plan (i.e., spring-run Chinook and steelhead).
2. There are concerns about the effects of stress from non-volitional passage on fall-run Chinook. CDFW previously expressed concern over the amount of stress placed on fall-run Chinook from passing Dennett Dam.
3. There may be adverse interactions between fall-run and spring-run Chinook, such as increased competition. Maintaining genetic separateness is also a concern.
4. The risk of predation in the lower Tuolumne River to outmigrating smolts is a significant concern.
5. Plenty of habitat for fall-run Chinook already exists in the lower Tuolumne River.
6. Passing fall-run Chinook to the upper river may create a population sink.

Mr. Wooster said the issue of whether or not to consider fall-run Chinook in the Reintroduction Framework was discussed by the fish agencies over several months. Mr. Wooster said the issues Mr. Devine raised are reasonable and Mr. Wooster does not have the answers. However, there are many unknowns with reintroducing spring-run Chinook and steelhead and we are still moving forward with those species so it does not seem unreasonable to continue to consider fall-run Chinook. Mr. Devine said the Districts would like meeting attendees to reconsider their position on including fall-run Chinook.

Mr. Le said that with regard to the objective of developing an approach for developing reintroduction program goals, the Districts propose a separate subcommittee be formed. Mr. Le said this Reintroduction Goals Subcommittee would be smaller than the Technical Committee and would develop goals independently from the information collected by 2016 study program. The Technical Committee agreed to form a Reintroduction Goals Subcommittee. Mr. Devine said all are welcome to participate and those who are interested should email Rose Staples (HDR) at Rose.Staples@hdrinc.com.

Mr. Le said the next steps for the Technical Committee are to develop draft study plans, with the goal of discussing these study plans on a conference call in mid-March, ahead of the next Plenary Group meeting (to be held on April 13) where approval of final study plans would be an objective. The Districts will send around a Doodle poll for the date of the next Technical Committee call. Mr. Le said the Districts will prepare notes from this meeting and send these around to the group.

ACTION ITEMS

1. The Districts will prepare a habitat typing study plan in collaboration with the Technical Committee.
2. Mr. Wooster will provide additional details about why it appears the reservoir transit study cost estimate is low.
3. The Districts will consider today's discussion about the BMI study and will provide feedback to the Technical Committee.
4. Ms. Murphy will send to Ms. Staples the paper by Moyle and others mentioning the existence of juvenile Chinook in Don Pedro Reservoir. Ms. Staples will send this paper to the Technical Committee (complete).
5. Mr. Le will revise the Studies Table to state the upstream hatchery practices study is a suggested study (complete).

6. The Districts will send around a Doodle poll for the date of the next Technical Committee call (complete; the next Technical Committee call will be on March 18 from 10:00 am to 12:00 pm Pacific).
7. The Districts will prepare notes from this meeting (complete).

Technical Committee Conference Call
February 16, 2016

Meeting Notes

ATTACHMENT A

WATER & POWER
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Modesto Irrigation District
The Power to Grow

La Grange Hydroelectric Project
Reintroduction/Fish Passage Assessment Framework
Technical Subcommittee Conference Call

Tuesday, February 16, 11:00 am to 1:00 pm
Conference Line: 1-866-583-7984; Passcode: 814-0607

Meeting Objectives:

1. Identify and decide on 2016 studies for the Upper Tuolumne River Reintroduction/Fish Passage Assessment Framework (Reintroduction Framework).
2. Prepare schedule for study plan development of identified 2016 studies.
3. Identify and decide on a schedule for the development of reintroduction program goals.

TIME	TOPIC
11:00 am – 11:10 am	Introduction of Participants (All) Review Agenda and Meeting Objectives (Districts)
11:10 am – 12:20 pm	2016 Studies to Support Reintroduction Framework (All) a. General studies list b. Discuss feedback/comments from Workshop #4 c. Updates on studies in progress d. Discuss and decide: - 2016 studies -Study plan development schedule for 2016 studies
12:20 pm – 12:50 pm	Reintroduction Program Goals to Support Reintroduction Framework (All) a. Purpose of development of program goals (i.e., metrics for success) in the Reintroduction Framework b. Relationship to Recovery Plan c. Discuss and decide: - Development schedule - Participants
12:50 pm – 1:00 pm	Next Steps (All) a. Schedule next call and agenda topics (e.g., review 2016 draft study plans, etc.) b. Action items

Potential Studies to Inform Reintroduction Assessment Framework For Discussion and Review by Technical Subcommittee

Framework Category	Studies	On-going and Potential Studies for 2016[1]	Cost Estimate	Schedule for Draft Report
Ecological	Limiting Factors Analysis and Carrying Capacity		$340,000	December 2017
Ecological	Reservoir Transit Study		$500,000	
Ecological	Interactions with Existing Aquatic Communities		$250,000	
Ecological	Source Population Assessment		NMFS lead?	
Ecological	Method of Colonization		$60,000	
Ecological	Genetics Assessment of Existing and Source Populations (NMFS has study on-going)	X	NMFS lead	April 2017
Ecological	Climate Change Assessment (proposed by NMFS)		NMFS lead?	
Biological	Habitat Typing and Characterization[2]	P	$240,000	Nov/Dec 2016
Biological	Upstream Migration Barriers	X	$220,000	Nov/Dec 2016
Biological	Instream Flow – Habitat Assessment: PHABSIM		$300,000[3]	
Biological	Water Temperature Monitoring and Modeling	X	$350,000	Nov/Dec 2016
Biological	Spawning Gravel Study	P	$140,000	Nov/Dec 2016
Biological	Macroinvertebrate Study		$220,000	
Biological	Swim Tunnel Study of Upper River *O. mykiss*		$450,000	
Economic, Regulatory, and Other Key Considerations	Regulatory Evaluation of Reintroduction (ESA Status, BLM/USFS Management Plans, Wild and Scenic, etc)	P	$50,000	October 2016
Economic, Regulatory, and Other Key Considerations	Socioeconomic Scoping and Issues Identification/ Preliminary Evaluation of Impacts on Tuolumne River Uses/Users	P	$50,000	October 2016
Economic, Regulatory, and Other Key Considerations	Hatchery Practices Review, including current Don Pedro related practices.		$50,000	

Draft Study Abstracts

Limiting Factors Analysis and Carrying Capacity

A limiting factors analysis (LFA) is a useful tool to identify and fill information gaps related to physical and biological factors controlling population dynamics of one or more target species. This type of analysis has been used extensively in California and the Pacific Northwest to identify habitat conditions, ecological interactions, and other factors that constrain salmonid population production potential. The LFA proposed herein would test hypotheses regarding potential factors that that could limit the ability of the upper Tuolumne River to support viable populations of reintroduced Chinook salmon and O. mykiss. The data analyzed and synthesized as part of a LFA can also include an analysis of carrying capacity, to determine the number of individuals of each freshwater life stage that can be supported by the available habitat. The results of a LFA provide valuable insight into possible effects of current or historical riverine habitat

[1] X = Ongoing study; P = Proposed additional 2016 study for consideration by collaborative group

[2] Habitat typing and characterization study proposal does not explicitly include habitat components being collected by NMFS; however, the NMFS data should be discussed in overall Assessment Framework.

[3] The geographic scope and amount of available information needs to be confirmed to refine scope and cost estimate.

conditions on salmonid populations (or reintroduced populations), allowing managers evaluate reintroduction potential, focus future management activities, help prioritize actions, and/or refine the current understanding of limitations of the ecosystem.

Reservoir Transit Study

As detailed in FERC's study plan determination, if the fish passage facilities assessment indicate that the most feasible concept alternative for fish passage would involve either upstream or downstream passage through the project reservoirs (i.e., La Grange or Don Pedro reservoirs), a study would be required to evaluate the technical and biological feasibility of upstream (adults) or downstream (juvenile) movement of anadromous fish (as appropriate) through the project's reservoirs. Until feasible concept alternatives have been selected, the scope of this study cannot be accurately identified.

Interactions with Existing Aquatic Communities

Evaluating potential interactions with existing species in the target area is a factor that can impact reintroduction success. This constraint includes predatory and competitive interactions with other species and populations. Often times, habitat in target areas have changed from historic conditions. Consequently, aquatic communities present in target reintroduction areas may be comprised of non-native species or native invaders that have filled these available niches. Furthermore, intraspecific competition is possible if a population of the target species is already present in the target reach (i.e., *O. mykiss*). This assessment would identify the potential interactions of target reintroduction species with the existing aquatic community in the target reach and characterize the potential risks/benefits to the reintroduction program.

Source Population Assessment

Consideration of genetic and ecological characteristics of a source population is important to assessing the probability of a successful reintroduction. Ecological factors such as life history, morphological, and behavioral traits compatible with the target area will increase the probability of a successful reintroduction. Source populations that are genetically similar to the historic population may also maximize the benefits and reduce the risks of reintroduction. This assessment would identify factors that should be considered when identifying viable source populations, potential sources, associated pros and cons of each, and constraints of utilizing each source, if any.

Method of Colonization Assessment

Colonization approaches (i.e., natural, transplants, and hatchery releases) differ in the effects on the parameters that are used to assess the success or failure of a reintroduction. Method of colonization also has implications for the infrastructure and operations needed to support a reintroduction program. As such, identifying early in the process the lowest-risk strategy for colonization will be a critical component of assessing risks, constraints, and benefits of any reintroduction program.

Genetics Assessment of Existing and Source Populations

NMFS is conducting a study of the upper river *O. mykiss* fishery genetics. Request a schedule and information update for the group.

Climate Change Assessment

At the January 27th, 2016 Upper Tuolumne River Reintroduction Assessment Framework Workshop #4, NMFS requested that a climate change assessment be added to this potential studies list. An action item was noted at this workshop for NMFS to develop an abstract.

Habitat Typing and Characterization

Habitat mapping quantifies the type, amount, and location of river habitat types available to reintroduced anadromous salmonids of all life stages. Habitat mapping would be conducted in the field and remotely using standardized methodologies. The frequency and area of each habitat type (e.g., pool, riffle, run) would be tabulated and where potential holding pools for spring-run salmon occur, the size, depth, and vertical thermal profile of the pools will be measured to determine possible holding capacity, stratification of the pools (if any), and thermal suitability. Additional (remote) mapping tasks will include assessments of channel gradient, width, habitat areas, etc. This baseline information provides the template for many other evaluations and is critical for assessing the feasibility of reintroduction. For example, data on habitat type, area, and distribution are required to assess potential Chinook salmon and steelhead adult holding capacity, spawning habitat potential, and juvenile rearing capacity.

Upstream Migration Barriers

Little information exists to reliably assess the current quantity and quality of suitable habitat for the adult, egg, fry and juvenile life stages of anadromous salmonid species that may be considered for reintroduction in the Upper Tuolumne River watershed (i.e., above the Don Pedro Project). Prior to assessing the quality/suitability of habitat for target species, an assessment of barriers (both complete and partial) to upstream anadromous salmonid migration must first be conducted to identify the quantity of habitat that is accessible. This assessment would utilize relevant prior studies, desktop analyses, and field surveys to characterize and document the physical structure of barriers in the mainstem Tuloumne River and its tributaries upstream of the Don Pedro Project Boundary. Note that this study was requested by NMFS but per FERC's determination, was not required to be conducted by the Districts as part of the La Grange licensing process. However, to more fully support licensing participants in their development of information to supplement fish passage and reintroduction assessments, and to foster collaboration among all parties, the Districts have opted to conduct an upstream migration barriers assessment.

Instream Flow – Habitat Assessment: PHABSIM

Hydraulic models such as the Physical Habitat Simulation (PHABSIM) system are widely used and accepted tools used to produce quantitative estimates of the amount (quantity and quality) of habitat available to fish at a range of stream flows. Using measured physical channel characteristics for representative habitat types or reaches, PHABSIM modeling incorporates habitat suitability relationships for the target fish species and life stage to produce estimates of weighted usable area (WUA) in relation to stream flow. Results of PHABSIM modeling can be combined with data from habitat mapping and water temperature modeling to provide estimates of habitat availability and suitability for target species and associated life stages throughout the project area at a range of flows. Additionally, the analysis would include an evaluation of the effect of fluctuating flows on habitat value, due to the frequent peaking operations in the upper Tuolumne River. This could be evaluated by comparing habitat values on a small time-step using the high and low flows within the fluctuation range. Water temperature data would also be overlaid with the PHABSIM results to evaluate how the total amount of habitat is affected by thermal rather than physical habitat conditions.

Water Temperature Monitoring and Modeling

The assessment of suitable habitat quality for the adult, egg, fry and juvenile life stages of anadromous salmonid species that may be considered for reintroduction in the Upper Tuolumne River watershed (i.e., above the Don Pedro Project) is dependent upon both physical and thermal characteristics. This study would use existing and additional data to characterize the thermal regimes of the upper Tuolumne River and tributaries from the Don Pedro Project Boundary to CCSF's Early Intake to characterize locations where temperatures may be suitable for anadromous salmonid species considered for reintroduction. The study would include the development of a computer model to simulate existing thermal conditions in the study area. Note that this study was requested by NMFS but per FERC's determination, was not required to be conducted by the Districts as part of the La Grange licensing process. However, to more fully support licensing participants in their development of information to supplement fish passage and reintroduction assessments, and to foster collaboration among all parties, the Districts have opted to conduct an upstream migration barriers assessment.

Spawning Gravel Study

Spawning gravel mapping quantifies the amount, location, and suitability of gravel available for spawning by reintroduced anadromous salmonids. In a confined, high gradient river channel dominated by large substrates (boulder, cobble, bedrock) like the upper Tuolumne River, spawning gravel distribution is typically patchy and overall abundance may be low. Initial evaluation of aerial photographs and an on-river reconnaissance survey indicate this is may be the case in portions of the Tuolumne River between Wards Ferry and Early Intake. Because successful spawning and fry production are dependent on the abundance and suitability of accessible spawning gravel, spawning gravel mapping is a critical component for assessing the feasibility of reintroduction. This information is a key part of any evaluation of the factors likely to limit production and viability of an existing or reintroduced salmonid population (i.e., a limiting factors or carrying capacity analysis).

Macroinvertebrate Study

Drifting and benthic macroinvertebrates (BMI) are the primary food source for rearing salmonids in fresh water habitats. Growth of juvenile anadromous salmonids during their freshwater rearing period is critical for their survival during outmigration and ocean phases, as well as to the overall viability of the population. Studies have shown a strong relationship between the size at which juvenile salmon and steelhead migrate to the ocean and the probability that they return to fresh water to spawn. Macroinvertebrate sampling provides a measure of food availability during this important life history period. Information on macroinvertebrate prey resource availability is therefore a key component of any evaluation of the factors likely to limit production and viability of an existing or reintroduced salmonid population (i.e., a limiting factors analysis).

Swim Tunnel Study of Upper River O. mykiss

Thermal acclimation among fish species dates back to the 1940's and since 2001, thermal adaptation at the population level and among a wide variety of fish species has been convincingly supported in the peer-reviewed scientific literature. Included in this evidence base are salmon and trout species. The objective of this study would be to determine the thermal performance of the subadult *O. mykiss* population inhabiting the upper Tuolumne River to assess any local adjustments in thermal performance. The study would test the hypothesis that the *O.mykiss* population in the Upper Tuolumne River (i.e., above the Don Pedro Project Reservoir) is locally adjusted to relatively warm thermal conditions that may exist during the summer. Results of the study would be used to support habitat suitability and temperature modeling assessments.

Hatchery Practices Review, including current Don Pedro related practices

Assessing historic and current hatchery practices in the upper Tuolumne River will be necessary to evaluate potential risks to reintroduction. Risks include but are not limited to evolutionary (homogenization or reduced fitness), ecological (competition, predation, etc.) and disease issues. Results of the review will identify past and current hatchery practices in the reintroduction area as well as connected areas (i.e., Don Pedro Reservoir), potential risks of past/present hatchery programs to a reintroduction program, and recommendations to address identified risks.

Regulatory Evaluation of Reintroduction

The Upper Tuolumne River watershed spans several land management agencies' jurisdictions and there are management plans and regulations in place based on established resource management objectives (e.g., Wild and Scenic Management Plan, Forest Plan, BLM Management Plan). The compatibility of the potential reintroduction of *O.mykiss* and/or spring run Chinook will be evaluated relative to these current management objectives. The potential reintroduction of Endangered Species Act (ESA) listed species may overlay additional management objectives and a new regulatory framework in the upper Tuolumne River. This evaluation will include compiling and reviewing all relevant and potentially relevant existing management plans for the upper Tuolumne River and the Don Pedro Reservoir. In addition, applicable recovery plans and ESA regulations and potential population status classifications for the reintroduced species will be summarized. Responsible resource management agencies will be contacted to determine the most recent guidance documents for the study area.

Socioeconomic Scoping and Issue Identification/Preliminary Evaluation of Impacts on Tuolumne River Uses/Users

Current management of the Don Pedro Reservoir and upper Tuolumne River supports a wide range of resources, uses, and users. The upper watershed includes the Tuolumne Wild & Scenic River segment managed for several outstanding resource values and is utilized by commercial and private recreational boaters. Other uses include the City and County of San Francisco's Hetch Hetchy Project operations, private timber practices, and a recreational fishery. Don Pedro Reservoir has an active house boating and recreational fishery; county government and businesses rely upon the economic activities supported by the upper watershed. This evaluation will conduct a comprehensive survey of uses in the upper watershed and identify potential issues for consideration in the reintroduction assessment. A literature survey and review of existing information from the Don Pedro Recreation Agency, county and federal land management agencies and other sources will be conducted. Surveys and/or focus groups will be used to verify and expand upon available information on the multiple existing uses of the watershed that could be impacted by a fish reintroduction program.

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT
TECHNICAL COMMITTEE CONFERENCE CALL

MARCH 18, 2016

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project
Reintroduction Assessment Framework
Technical Committee Conference Call

Friday, March 18, 10:00 am to 12:00 pm
Conference Line: 1-866-583-7984; Passcode: 230-0743

Meeting Objectives:

1. Review and discuss 2016 study plans for the Upper Tuolumne River Reintroduction Assessment Framework (Reintroduction Framework).
2. Identify schedule for study plan finalization in advance of April 13, 2016 Plenary Group meeting.
3. Discuss next steps on Reintroduction Program Goals subgroup.

TIME	TOPIC
10:00 am – 10:15 am	Introduction of Participants (All) Review Agenda and Meeting Objectives (Districts) Review Action Items from Last Call (All)
10:15 am – 11:30 am	2016 Study Plans to Support Reintroduction Framework (All) a. Present and discuss study plans b. Identify schedule for study plan finalization (for presentation at April 13, 2016 Plenary Group meeting)
11:30 am – 11:50 am	Reintroduction Program Goals to Support Reintroduction Framework (All) a. Purpose of developing program goals (i.e., metrics for success) in the Reintroduction Framework Assessment b. Relationship to Recovery Plan c. Update: - Schedule - Participants - Next steps
11:50 am – 12:00 pm	Next Steps (All) a. Schedule next call and agenda topics b. Action items from this call

La Grange Hydroelectric Project Licensing (FERC No. 14581)
Fish Passage Facilities Alternatives Assessment
Technical Committee Conference Call

Friday, March 18, 2016
10:00 am to 12:00 pm

Final Meeting Notes

Conference Call Attendees		
No.	**Name**	**Organization**
1	Leigh Bartoo	U.S. Fish and Wildlife Service
2	Jenna Borovansky	HDR, consultant to the Districts
3	Steve Boyd	Turlock Irrigation District
4	Paul Bratovich	HDR, consultant to the Districts
5	Adrianne Carr	Bay Area Water Supply and Conservation Agency
6	Jesse Deason	HDR, consultant to the Districts
7	John Devine	HDR, consultant to the Districts
8	Art Godwin	Turlock Irrigation District
9	Jason Guignard	FishBio, consultant to the Districts
10	Tom Holley	National Marine Fisheries Service
11	Zach Jackson	U.S. Fish and Wildlife Service
12	Patrick Koepele	Tuolumne River Trust
13	Ellen Levin	City and County of San Francisco
14	Lonnie Moore	Citizen
15	Marco Moreno	Latino Community Roundtable
16	Gretchen Murphy	California Department of Fish and Wildlife
17	Bill Paris	Modesto Irrigation District
18	Bill Sears	City and County of San Francisco
19	Jay Stallman	Stillwater Sciences, consultant to the Districts
20	Cory Warnock	HDR, consultant to the Districts
21	Scott Wilcox	Stillwater Sciences, consultant to the Districts
22	Alison Willy	U.S. Fish and Wildlife Service
23	John Wooster	National Marine Fisheries Service
24	Ron Yoshiyama	City and County of San Francisco

On March 18, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted a Technical Committee conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Reintroduction Assessment Framework (Framework). 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 meeting agenda and draft study plans.

Mr. John Devine (HDR, consultant to the Districts) provided background on why the Technical Committee was formed. Mr. Devine said at Workshop No. 4 (held on January 27, 2016; meeting notes and materials are available on the La Grange Project licensing website here), the Plenary Group (i.e., all Framework participants) agreed to form a Technical Committee to try to come to agreement on what studies would be completed in support of implementing the Framework. On the first Technical Committee conference call (held on February 16, 2016; draft meeting notes and materials available here), the Technical Committee agreed to draft study plans for several studies to be conducted in 2016. The

Districts drafted five study plans and on March 16, 2016, sent these study plans to the Technical Committee for review and comment.

Mr. Devine said the objective of today's meeting is to discuss each study plan with the Technical Committee. The Districts hope that providing an overview of each study plan will help expedite the Technical Committee's study plan review. Mr. Devine said a second objective of this call is to discuss the schedule for reviewing the study plans and, if necessary, schedule another conference call prior to the study plan comment due date, to allow individuals an opportunity to ask questions or get clarification on the study plans before comments are due.

Mr. Devine reviewed the status of the action items from the February 16 Technical Committee call. All action items from that call are complete except for one; Mr. John Wooster (National Marine Fisheries Service [NMFS]) will provide additional details about why it appears the reservoir transit study cost estimate provided by the Districts appears to be low.

Mr. Jay Stallman (Stillwater Sciences, consultant to the Districts) summarized his professional background and reviewed the goals, study area, and methodology for the Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study (Spawning Gravel Study). Mr. Tom Holley (NMFS) said Chinook salmon currently exist in Don Pedro Reservoir and these fish swim upstream to spawn. Mr. Holley asked if there is existing information on where those fish spawn and said he believes snorkel studies may have been performed in the area where Chinook spawn. Mr. Devine said he has also heard that resident Chinook salmon may exist in Don Pedro Reservoir, as well as Kokannee salmon, but he is unaware of any documented observations. Mr. Holley said he believes the California Department of Fish and Wildlife (CDFW) completed snorkel surveys in the Lumsden reach and documented adult Chinook salmon during those surveys. Ms. Gretchen Murphy (CDFW) said she is unaware of snorkel surveys being done in that reach. Mr. Patrick Koepele (Tuolumne River Trust) said Mr. Steve Holdeman (U.S. Forest Service) may have information on the presence of Chinook salmon in that reach of the river. Mr. Devine said the Districts will contact Mr. Holdeman about information the U.S. Forest Service may have relevant to resident Chinook salmon or other reservoir species using the upper Tuolumne River.

Mr. Jason Guignard (FishBio, consultant to the Districts) summarized his professional background and reviewed the goals, study area, and methodology for the Upper Tuolumne River Habitat Mapping and Macroinvertebrate Assessment (Habitat Mapping Study). Mr. Guignard noted that the Habitat Mapping Study Plan and Spawning Gravel Study Plan were developed in close coordination as both studies will be completed on the same rafting trips.

Mr. Lonnie Moore (citizen) asked if the Habitat Mapping Study will collect data on both drifting macroinvertebrates and benthic macroinvertebrates. Mr. Guignard confirmed the study will collect data about both types of macroinvertebrates.

Mr. Wooster said significant stage changes will likely occur during the Habitat Mapping Study fieldwork. He asked how the study will accommodate for those stage changes. Mr. Guignard said the flow schedule is not yet available for when the fieldwork will be completed. At this point, the study team is planning to complete the fieldwork at the end of the summer and/or early fall, when low flows and less flow fluctuation is anticipated. Mr. Guignard said the study team is cognizant that peaking flows may make it more difficult to collect detailed habitat mapping data.

Mr. Wooster asked if the study team will use depth sounders to collect water depth information and how the study team will account for daily flow fluctuations when water depths are measured. Mr. Guignard said depth sounders will be used. As much as possible, the study team is intending to collect data in each reach during off-peak, low flows conditions, not at on-peak flow conditions. Mr. Guignard said the study team is still determining whether the logistics associated with this approach is realistic. Mr. Wilcox (Stillwater Sciences, consultant to the Districts) said fluctuations in flow will likely not impact depth measurements at deep pools because any fluctuations in flow will likely be a small percentage of the total pool depth. Mr. Wooster said fluctuations of two or three feet could create significant variability regarding depth measurements at shallow pools. Mr. Devine said the study team is still working out the logistics and will aim to collect data during non-peaking flows. Mr. Devine reiterated that the intent of the study is to collect data during base flow conditions. Mr. Devine said the study team will be very careful to document field and flow conditions when data is collected.

Mr. Wooster asked if the Districts can provide the model number and other specifications for the depth finders that will be used. Mr. Wooster said in his experience, the amount of fine sediment in the water seems to impact a depth finder's performance. Mr. Guignard said he does not know the model numbers or specifications offhand. Mr. Guignard said several different models will likely be used during the fieldwork. Mr. Guignard said he has experience using each model and in his previous fieldwork, each model performed well, even in the presence of fine sediment. Mr. Guignard said a stadia rod will be used to measure depths where possible and depth finders will only be used for deep pools where the stadia rod is too short. Mr. Wooster asked if a depth finder was used during the 2015 mesohabitat data collection. Mr. Wilcox said a depth finder was used for the 2015 data collection and the depth finder provided consistent measurements. Mr. Devine asked if Mr. Wooster has recommendations on what depth sounders should be used, or avoided. Mr. Wooster said he did not have specific recommendations. Mr. Wooster said depending on the hydrograph at the time of data collection, sediment from the Rim Fire may or may not create turbidity and affect the depth sounder readings, and this is something that should be considered. Mr. Devine agreed. Mr. Wilcox said turbidity was not a problem during the 2015 data collection, but that likely had to do with the dry water year. Conditions may be different for the 2016 data collection.

Mr. Wooster asked if the Districts will provide additional information on the mesohabitat mapping that was completed last summer, as part of the Upper River Barriers Study. Mr. Wilcox said the Upper River Barriers Study researchers opportunistically collected data on gravel, large woody debris, and pool depth. This data collection was unrelated to the Upper River Barriers Study and was thus not included in the Upper River Barriers Study Progress Report. Mr. Devine said the mesohabitat data is currently being summarized and will be provided to licensing participants when the summary is complete. Mr. Wooster said receiving the summary soon would be helpful for informing NMFS's comments on the study plans. Mr. Wilcox said the data can be made available, but cautioned the data may not be ready for scientific analysis. Once the data undergoes necessary internal reviews, it can be made available to the public.

Mr. Moore asked if the Habitat Mapping Study will include surveys of the riparian habitat. Mr. Wilcox said the study will only look at stream habitat. Mr. Moore said there are a number of studies recognizing the benefit of riparian habitat to salmon and steelhead and asked if a study can be done on the riparian habitat in the lower Tuolumne River and upper Tuolumne River. Mr. Devine said a riparian study of the lower Tuolumne River was completed for the Don Pedro relicensing and he will send out a link to the study report. Mr. Devine said a study of the riparian habitat in the upper river is not planned, but collecting general observations about riparian habitat could be added to one of the studies being completed. Mr. Guignard noted the Habitat Mapping Study Plan includes documenting the percent total canopy, which is the amount of riparian habitat that is shading the river. Mr. Wilcox said there is not much riparian shading in the upper river.

Ms. Borovansky (HDR) reviewed the goals, study area, and methodology for the Hatchery and Stocking Practices Review. Ms. Borovansky said the study plan includes research into the disease profiles of hatchery stocks, per discussions on the February 16 Technical Committee call.

Ms. Borovansky reviewed the goals, study area, and methodology for the Regulatory Context Study. Ms. Borovansky requested that meeting attendees submit ideas for additional plans that should be reviewed as part of this study. Mr. Bill Sears (City and County of San Francisco) requested that the Stanislaus National Forest Wild and Scenic River Plan be added to the list of plans to be reviewed. Mr. Sears said he can provide a copy of the plan if the Districts do not already have a copy.

Ms. Borovansky reviewed the goals, study area, and methodology for the Socioeconomic Scoping Study. Mr. Wooster asked if the objective of the study is to only develop a list of activities that could potentially be affected by fish passage and reintroduction, and not to assess how these activities may be affected. Ms. Borovansky confirmed Mr. Wooster is correct. Ms. Borovansky said the study is a scoping exercise to identify existing uses and activities. Once conceptual fish passage alternatives are available, the study team can begin to assess how uses and activities may be affected. Mr. Moore asked if the study team would consider expanding the study area to include the lower Tuolumne River. Mr. Devine agreed the lower river may be impacted by fish passage. He said the Hatchery and Stocking Practices Review Study Plan, Regulatory Context Study Plan, and Socioeconomic Scoping Study Plan will be reviewed, and revised if necessary, to adequately consider effects to the lower river.

Mr. Devine reviewed the schedule. The Districts are hoping to receive any comments on the study plans by March 29. The Districts will address any comments received and provide revised versions of the study plans to the Plenary Group ahead of Workshop No. 5, scheduled for April 13. Mr. Devine suggested the Technical Committee may like to have another conference call between now and March 29, perhaps on March 24, to allow individuals an opportunity to ask questions or get clarification on the study plans prior to March 29. Mr. Devine said individuals are welcome to submit questions ahead of the March 29 deadline, and study leads would do their best to quickly provide answers. All questions should be sent to Ms. Rose Staples (HDR) (rose.staples@hdrinc.com).

Mr. Wooster said given that the deadline for comments on the La Grange Initial Study Report (ISR) is April 4, it will be nearly impossible for him to provide comments on the study plans by the March 29 deadline and he likely will not have time to participate on a call on March 24. Mr. Wooster said a call the week of April 4 would work much better for his schedule. Mr. Koepele said it will be difficult for him to make the March 29 study plan comment deadline, given the April 4 deadline for ISR comments. Mr. Devine said the Districts will convene on the schedule and get back to the Technical Committee.

Mr. Wooster asked if future fish passage engineering feasibility meetings will be separate from the Plenary Group meetings. Mr. Devine said the Districts do not envision separate meetings for fish passage engineering feasibility and any technical items that arise can likely be handled by the Technical Committee or via individual communications.

Mr. Devine discussed the importance of having reintroduction program goals and how the results of the 2016 studies will be measured against those goals. Mr. Devine said the Reintroduction Goals Subcommittee (Goals Subcommittee) will take the lead on developing reintroduction program goals. Mr. Devine said eight people have volunteered to participate on the Goals Subcommittee and, based on the results of a Doodle poll, the first Goals Subcommittee call will be on Friday, April 1, from 10:00 am to 12:00 pm.

Mr. Devine said no agency personnel volunteered to participate on the Goals Subcommittee and asked what is preventing agency personnel from participating. Mr. Wooster said his schedule is already full and he does not have time to participate in another committee or on a call on April 1. Mr. Devine asked if moving the meeting until after April 4 would allow Mr. Wooster to participate. Mr. Wooster said he would likely be able to participate if the meeting is after April 4. Ms. Gretchen Murphy (CDFW) said she does not have time to participate in the Goals Subcommittee given her upcoming field season. Ms.

Alison Willy (U.S. Fish and Wildlife Service) said she is also too busy to participate. Mr. Devine said it may be that at the first Goals Subcommittee meeting on April 1, a rough schedule is developed and then the broader group is canvased to determine the date for the second meeting. Mr. Wooster said he may be able to attend the second meeting or, if he is unable to attend, he can provide his comments after the meeting.

Mr. Devine reviewed action items from today's call and said the Districts will send out meeting notes.

Meeting adjourned.

ACTION ITEMS

1. Incomplete action item from February 16 Technical Committee call: Mr. Wooster will provide additional details about why it appears the reservoir transit study cost estimate provided by the Districts appears to be low.

2. Mr. Sears will provide a copy of the Stanislaus Forest Wild and Scenic River Plan. (complete)

3. Mr. Devine will send to the Technical Committee the snorkel survey report provided by Mr. Holley. (complete)

4. The Districts will contact Mr. Steve Holdeman (U.S. Forest Service) about information the U.S. Forest Service may have relevant to resident Chinook salmon or other reservoir species using the upper Tuolumne River.

5. The Habitat Practices Study Plan, Regulatory Context Study Plan, and Socioeconomic Study Plan will be revised to consider effects on the lower Tuolumne River (as well as Don Pedro Reservoir and the upper Tuolumne River).

6. HDR will send out a link to the Lower Tuolumne River Riparian Information and Synthesis Study Report (W&AR-19). (Rose to complete on 3/22)

7. The Habitat Mapping Study Plan will be revised to include completing general observations of riparian habitat, in addition to the percent total canopy which is already included in the study plan.

8. Given scheduling constraints discussed at the meeting, the Districts will revisit the current schedule including the March 29 due date for comments on the study plans and will report back to the Technical Committee. (complete)

9. The Districts will provide results from the 2015 habitat data collection work. This should be completed, with QA/QC done, by mid-April.

10. The Districts will provide notes from today's meeting. (complete)

DRAFT STUDY PLAN

TURLOCK IRRIGATION DISTRICT
AND
MODESTO IRRIGATION DISTRICT

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

Upper Tuolumne River Habitat Mapping and Macroinvertebrate Assessment

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which 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. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Upper Tuolumne River Habitat Mapping and Macroinvertebrate Assessment is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to characterize habitat distribution, abundance, and quality in the upper Tuolumne River.

2.0 STUDY AREA

The study area will include the mainstem of the upper Tuolumne River from the upstream limit of the Don Pedro Project (approximately RM 81) to Early Intake (approximately RM 105).

3.0 STUDY GOALS

The primary goal of this study is to provide information on habitat distribution, abundance, and quality in the upper Tuolumne River. This information will inform evaluations in the Framework and is critical for assessing the feasibility of anadromous salmonid reintroduction, estimating potential population size and developing engineering alternatives for the upper Tuolumne River. Specific objectives include:

- document the number, size and distribution of mesohabitats available in the upper Tuolumne River;
- collect detailed data on habitat attributes in representative reaches of the upper Tuolumne River;

- documenting potential pool holding habitat for over-summering adult Chinook salmon; and
- collect drift and substrate samples of macroinvertebrates (salmonid prey organisms).

4.0 STUDY METHODS

For this assessment, habitat mapping will quantify the type, amount, and location of habitat types available to potentially reintroduced anadromous salmonids during their riverine life stages (adult holding/spawning, incubation and rearing). Habitat mapping will be conducted in the field and remotely using standardized methodologies. The frequency and area of each habitat type (e.g., pool, riffle, run) will be tabulated and where potential holding pools for adult Chinook occur, the size and depth of the pools will be measured to determine possible holding capacity. Additional mapping tasks will include assessments of channel gradient, width, habitat areas, etc.

Habitat mapping will consist of mapping all mesohabitat units between Early Intake (RM 105) and the upstream limit of the Don Pedro Project (approximately RM 81), and collecting detailed habitat data in a sub-set of the mapped mesohabitat units.

4.1 Task 1. Mesohabitat Mapping

Reconnaissance level mapping in the summer of 2015 consisted of mesohabitat classifications (Table 1.0) for portions of the reach between Lumsden (Merals Pool at RM 96) and approximately RM 81. In 2016, habitat mapping will be extended up to Early Intake (RM 105), and gaps in mapping between RM 96 and approximately RM 81 will be comprehensively assessed to obtain a more complete dataset. Habitat units will be identified visually by a boat-based survey crew and mapped on pre-existing high-resolution color aerial photographs. Boundaries of mesohabitat units will also be geo-referenced in the field with a handheld GPS unit.

Table 1.0 Mesohabitat mapping units and criteria for the mainstem Tuolumne River.

Mesohabitat types	Definitions/ Criteria
Deep Pool	>6 ft max depth
Shallow Pool	<6 ft max depth
Glide/ Pool tail	Typically in the downstream portion of a pool with negative bed slope where converging flow approaches the riffle crest. Wide, shallow, flat bottom with little to no surface agitation. Substrate type is typically smaller than riffle, but coarser than pool and often provides best salmonid spawning habitat.
Run	Long, smoothly flowing reaches, flat or concave bottom, and deeper than riffles with less surface agitation. Higher velocities than pools.
Boulder Garden/Pocket Water	Moderate to low gradient riffles, runs, and glides with numerous large boulders/obstructions that create scour pockets and eddies with near zero velocity. Often no clear thalweg present due to multiple flow paths.
Cascade/ Chute	>10% gradient, and with air entrainment (particularly in cascades), very large boulders and/or bedrock. Consisting of alternating small waterfalls and can have shallow pools in middle and margin of channel at low flows.
High Gradient Riffle	>4% gradient. Substrate is usually large boulder and bedrock (>24”)
Low Gradient Riffle	<4% gradient. Substrate is usually small boulder and large cobble(6-24”)
Side Channel	Contains < 20% of total flow. Connected at top and bottom to main channel at low flow.
Backwater	Low to zero velocities. Only connected to main channel from one end.

Mapped habitats will be digitized and added to the project GIS layer for mapping, as well as for quantitative and spatial analysis. Color maps will be created to depict the type and location of habitats throughout the study area and in relation to important features such as tributaries, potential passage barriers, access points, and water temperature monitoring locations. The frequency and area of each habitat type (e.g., pool, riffle, run) will also be tabulated.

4.2 Task 2. Habitat Inventory Mapping

Additional (remote) mapping tasks will include assessments of channel gradient, width, habitat areas, etc. following the CDFW Level III habitat typing methodology (CDFG 2010). Methods will be similar to habitat typing conducted in the lower Tuolumne River (TID/MID 2013). Sampling units selected for detailed habitat measurements will encompass approximately 10 to 20 percent of the study reach, as recommended in CDFG (2010). The habitat typing field effort will consist of a team of three biologists surveying the river by raft. The study area will be divided into seven sampling reaches, based on length of river rafted daily (two reaches from Early Intake to Lumsden and five reaches from Lumsden to Wards Ferry). Within each individual sampling reach, a one mile section will be randomly selected for habitat typing. Prior to the field assessment, the team will use maps and existing aerial photographs to delineate the specific reaches to be surveyed.

A suite of measurements consistent with the Level III CDFW criteria (Table 2.0) will be made within each mesohabitat type along each of the selected one-mile reaches. Data will be recorded on standardized datasheets to ensure all data are collected in a consistent manner. A photograph of each and GPS coordinates will be recorded at the bottom of each habitat unit. Unit length and width will be measured with a laser range finder. Depths will be measured using a stadia rod or handheld depth finder. Large woody debris (LWD) count will include a count of LWD pieces with a diameter greater than one foot and a length between six and twenty feet, as well as pieces greater than twenty feet in length, within the bankfull width. Percent total canopy will be measured using a spherical densiometer at the upstream end of each habitat unit in the center of the wetted channel. The remaining habitat parameters including substrate composition, substrate embeddedness, shelter complexity, and bank composition types will be visually estimated. Within each sampling reach, stream gradient will also be measured using a clinometer over a distance of at least 20 bankfull channel widths. In addition, the size and depth of each pool will be collected throughout the study reach to help quantify the amount of potential Chinook salmon adult holding habitat.

Table 2.0 List of data collected as part of Level III CDFW habitat mapping.

Data	Description
Form Number	Sequential numbering
Date	Date of survey
Stream Name	As identified on USGS (U.S. Geological Survey) quadrangle
Legal	Township, Range, and Section
Surveyors	Names of surveyors
Latitude/Longitude	Degrees, Minutes, Seconds from a handheld GPS
Quadrant	7.5 USGS quadrangle where survey occurred
Reach	Reach name or river mile range
Habitat Unit Number	The habitat unit identification number
Time	Recorded for each new data sheet start time
Water Temperature	Recorded to nearest degree Celsius
Air Temperature	Recorded to nearest degree Celsius
Flow Measurement	Available from USGS monitoring stations
Mean Length	Measurement in feet of habitat unit
Mean Width	Measurement in feet of habitat unit wetted width
Mean Depth	Measurement in feet of habitat unit
Maximum Depth	Measurement in feet of habitat unit
Depth Pool Tail Crest	Maximum thalweg depth at pool tail crest in feet

Data	Description
Pool Tail Embeddedness	Percentage in 25% interval ranges
Pool Tail Substrate	Dominant substrate: silt, sand, gravel, small cobble, large cobble, boulder, bedrock
Large Woody Debris Count	Count of LWD within wetted width and within bankfull width
Shelter Value	Assigned categorical value: 0 (none), 1 (low), 2 (medium), or 3 (high) according to complexity of the shelter.
Percent Unit Covered	Percent of the unit occupied
Substrate Composition	Composed of dominant and subdominant substrate: silt, sand, gravel, small cobble, large cobble, boulder, bedrock
Percent Exposed Substrate	Percent of substrate above water
Percent Total Canopy	Percent of canopy covering the stream
Percent Hardwood Trees	Percent of canopy composed of hardwood trees
Percent Coniferous Trees	Percent of canopy composed of coniferous trees

Results to be reported include the following:

- Ground-mapped habitat units
  - Total number of habitat units, by type
  - Total length of habitat units, by type
  - Number of habitat units (frequency)
  - Average width of habitat units, by type
  - Number and relative frequency of dominant instream cover types
  - Reach summary data (e.g., average bankfull width and depth, LWD density (within wetted and bankfull))
- Pool holding habitat
  - Total number of pools identified as potential holding habitat (and the criteria of determination)
  - Average and maximum pool depth
  - Percentage of pools with ≥ 5% cover
  - Map showing the suitable holding pools in each 1-mile sampled reach of the upper Tuolumne River
- Tributary mapping data and reconnaissance level mainstem Upper Tuolumne River habitat data collected in 2015

4.3 Task 3. Macroinvertebrate Assessment

If time and logistics allow as the final field schedule is developed, a macroinvertebrate assessment will be conducted following the methods outlined below.

4.3.1 Study Goals

Drifting and benthic macroinvertebrates typically comprise the primary food source for rearing salmonids in fresh water habitats (Allan 1978, Fausch 1984, Harvey and Railsback 2014). Information on macroinvertebrate prey resource availability is a component of an evaluation of the factors affecting production and viability of an existing or introduced salmonid population. The density and taxonomic composition of drifting macroinvertebrates can provide a relative measure of food availability for drift-feeding salmonids. To provide a relative measure of food availability for salmonids within the water column, a literature search of similar streams and macroinvertebrate studies in the region (Sierra foothill region) will be conducted. Substrate sampling for benthic macroinvertebrates will provide data that can be used in a standardized bioassessment approach to evaluate the potential for physical habitat impairment. The objectives of the macroinvertebrate assessment are to:

- collect and analyze macroinvertebrate drift samples to determine whether the taxonomic composition and density of drift is consistent with other regional systems currently supporting healthy salmonid populations; and
- collect and analyze benthic macroinvertebrate samples from the substrate to develop metrics for bioassessment and comparison with similar streams and data sets.

4.3.2 Study Methods

4.3.2.1 Sampling Site Selection

The study area for macroinvertebrate sampling within the upper mainstem of the Tuolumne River is from RM 81 to Lumsden Bridge (RM 98). The location and number of sampling sites and sampling frequency will represent the seasonal variability of macroinvertebrate populations and related seasonal variability of food resources for stream-dwelling salmonids during the primary salmonid rearing and growth period (spring-fall), as well as the variability of physical habitat characteristics in each study reach.

<u>Number of sites</u>
Depending on opportunities encountered during stream habitat mapping, drift and benthic macroinvertebrate samples will be collected at five sites, equating to approximately one site per 3.5 river miles.

<u>Locations</u>
Drift sampling will occur in the vicinity of Lumsden and at four additional downstream locations corresponding to locations selected for overnight camping during each five-day (four-night) rafting trip. Drift samples will be collected in riffle or run habitats selected opportunistically in the vicinity of overnight camping locations along each study reach. At each overnight camping location, drift sampling locations will be selected based on suitable depth, velocity, substrate, and accessibility/safety considerations, with two sites per location and two replicates (net placements) per site.

Benthic macroinvertebrate sampling will occur at suitable riffles initially identified in the office using aerial photographs and verified in the field. One composite sample will be collected daily from a suitable riffle or combination of suitable fast-water habitat types during the five-day raft-based sampling.

<u>Sample timing and frequency</u>
Macroinvertebrate sampling will be conducted daily during the five-day raft-based sampling effort. Drift sampling in late summer (September) will characterize food resources available to rearing juvenile anadromous salmonids prior to overwintering. Spring sampling may also occur if scheduling allows in conjunction with other field efforts. In many temperate streams, aquatic macroinvertebrate diversity and abundance peak during spring and summer and are reduced in late summer and fall. Peak feeding and growth by rearing salmonids occur when prey availability and water temperatures are relatively high, maximizing net energy gain (Rundio and Lindley 2008, Stillwater Sciences 2007, Wurtsbaugh and Davis 1977). Exact sampling dates for this study may be adjusted within the general seasonal period to coincide with other sampling efforts in order to maximize efficiency and accommodate river flow levels. However, macroinvertebrate sampling should not occur during periods of very high flows or when river discharge is changing rapidly due to safety and access concerns and the potential effects of flow fluctuations on invertebrate drift (Brittain and Eikland 1988).

Drift sampling will begin each afternoon by 1700 hours and proceed until approximately 2000 hours. This sample timing is intended to collect drifting macroinvertebrates during the daily period when feeding activity is often greatest for juvenile Chinook salmon and trout (Sagar and Glova 1988, Johnson 2008) and to avoid pre-dawn and post-dusk peaks in drifting macroinvertebrates that may not be available to drift-feeding salmonids at low light levels. The timing and duration of drift sampling can be adjusted if needed to accommodate rafting safety concerns or logistical constraints. All drift sampling should occur during the peak afternoon-evening feeding period and have the same start and end time.

The timing of the benthic macroinvertebrate sampling is not seasonally dependent, but will be coincident with the drift sampling effort to maximize efficiency and reduce the amount of field sampling time required for the study. Benthic macroinvertebrate samples will be collected once per day during the raft-based sampling effort, typically during mid-day or as determined by the location of suitable sampling riffles and logistics of the habitat mapping study.

4.3.2.2 Sampling Protocols

Invertebrate drift sampling

Drift samples will be collected using stationary nets with rigid rectangular openings and tapered, nylon mesh bags with a collection jar fitted at the downstream end – similar to drift nets used by other researchers (Brittain and Eikeland 1988), including the 1987–1988 drift studies in the lower Tuolumne River (Stillwater Sciences 2010). All drift nets will be identical, with a mesh size small enough to capture small invertebrates such as immature chironomids that may be important salmonid prey, while also large enough to minimize clogging (e.g., 250–500 μ). There is no standard mesh size for drift nets, with mesh size instead chosen according to study objectives, and to represent a compromise between filtration efficiency and clogging (Svendsen et al. 2004).

At each sampling location two transects will be selected perpendicular to the river and two drift nets will be placed at each transect: one near shore and one in the thalweg or as close to the thalweg as water depth and velocity will safely allow. Each drift net will be anchored in the water column using steel (e.g., rebar stakes or fence posts) driven into the stream bed, with the bottom of the net at least 10 cm above the river bottom and the top of the net at least 4–5 cm above the water surface. This vertical net placement ensures capture of terrestrial-origin organisms originating from outside the stream (Leung et al. 2009), which may be an important diet component for anadromous salmonids (Tiffan et al. 2014, Leung et al. 2009, Rundio and Lindley 2008) while avoiding capture of organisms crawling on the substrate. Because drift composition is not uniform across the channel (Waters 1969), placement of near-shore and mid-channel drift nets allows sampling of each portion of the channel to represent potential differences in taxonomic composition, origin (aquatic vs. terrestrial), density, or other factors. During sampling, the drift nets will be attended by one or more field crew members to monitor for approaching rafts or other safety hazards. If needed, field personnel will verbally warn rafters of the potential hazard and assist rafts in avoiding the nets.

Drift nets will be deployed for three hours each day (1700–2000 hours). The width and depth of the submerged portion of each net will be measured upon installation to calculate the effective net area (i.e., the area being sampled). Water velocity will be measured at the midpoint of each net mouth immediately after net installation, at the midpoint of sampling (after 1.5 hours), and immediately before retrieving the net. The three velocity values will be used to calculate the average water velocity at the mouth of each net during sampling, and the average velocity will be multiplied by the sampled area to determine the total volume of water passing through each net during the sampling event. Because net clogging during sampling can gradually reduce the velocity of water passing through the net, an average of several water velocities measured over the course of sampling provides a more accurate measure of volume than a single velocity measure.

After removing each drift net from the water, the contents will be carefully washed to the end of the net and into the collection bottle using river water. The bottle will then be removed and all contents will be transferred to a sample container, labeled, and preserved with 95% ethanol for later processing.

<u>Benthic sampling</u>
Benthic sampling will be conducted using a modified version of the targeted riffle composite (TRC) method described in the California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment Standard Operating Procedure (Ode 2007). The TRC has been widely used in California by state and federal water resource agencies, is consistent with the methods of EPA's Environmental Monitoring and Assessment Program (EMAP) (Peck et al. 2006), and has been adopted as the standard riffle protocol for bioassessment in California (Ode 2007). A similar methodology, the former California Stream Bioassessment Protocol (CSBP) and later the California Monitoring and Assessment Program (CMAP), produced comparable results and was used for the Districts' benthic macroinvertebrate sampling program in the lower Tuolumne River from 2001–2005 and from 2007–2009 (Stillwater Sciences 2010). The SWAMP TRC method was recently used to collect benthic macroinvertebrate samples in the upper Merced River as part of the Merced River Alliance Biological Monitoring and Assessment project (Stillwater Sciences 2008).

Due to site access constraints and non-wadeability in most habitat types, a modified version of the SWAMP protocol will be used to select riffles or other suitable fast-water habitat types for TRC sampling. Whereas the SWAMP protocol specifies that habitats (riffles or other fast-water habitats) for TRC sampling should be selected randomly from a pre-established reach 250 meters in length, riffles sampled for this study will instead be selected randomly from among all potentially wadeable riffles that are accessed during the habitat mapping study and were initially identified in the office by examining high-resolution color aerial photographs of the study reaches. During field sampling, the field crew will carry a set of the aerial photographs with potential sampling riffles identified, to enable identification of alternative sampling riffles if needed. Using the office-based method, a total of five riffles will be selected for sampling. Riffles selected for sampling will be spaced sufficiently to enable sampling of an average of one riffle per day during the five-day raft-based field effort.

In the field, riffles initially selected for benthic sampling will be evaluated individually as they are encountered during the rafting trip to determine whether substrate, depth, and velocity are suitable for sampling, and if they can be sampled safely. A riffle will be deemed suitable if it has enough gravel or cobble substrate to allow collection of up to eight non-overlapping benthic samples in areas that can be safely accessed on foot by a two-person field crew (i.e., depth and velocity do not prohibit safe access and sampling). If a riffle initially chosen for TRC sampling is unsuitable, the crew will proceed to the next suitable riffle. Ideally, a total of five riffles or other fast-water habitats will be sampled in the study reach using the TRC method. At each riffle selected for TRC sampling, physical habitat and water chemistry data will be collected following the SWAMP protocol for the "basic" level of effort (Ode 2007). These data include GPS coordinates and photographs of the site, water temperature, pH, dissolved oxygen, specific conductance, channel width, riparian canopy cover, bank stability, and channel gradient.

The TRC approach specifies collection of benthic samples at eight riffles within each 250 meter sampling reach (Ode 2007). However, preliminary examination of aerial photographs indicates that the riffles in the upper Tuolumne River are relatively infrequent and widely spaced, thus selection of a 250 meter sampling reach containing multiple riffles will likely be infeasible. A modified approach will therefore be used, which will entail collection of eight benthic samples per riffle. If additional suitable riffles or other suitable fast-water habitat types (e.g., run or pool tail) are located in close proximity to a riffle that has been selected for TRC sampling and can be safely accessed on foot, the required eight samples will be collected at locations distributed randomly among the suitable habitats. Sampling locations in each riffle or combination of fast-water habitat types at each site will be selected randomly using a digital stopwatch or random number chart, as described in Ode (2007). Samples will be collected using a standard D-frame kick net with 500-μ mesh. At each sampling location, a 0.09 m^2 (1 ft^2) area of bottom substrate will be sampled immediately upstream of the net following methods described in Ode (2007). All eight samples collected at each site (riffle or combination of fast-water habitats) will be combined into a single composite sample for the site, preserved in 95% ethanol, and labeled for laboratory processing.

4.3.2.3 Analysis and Reporting

All macroinvertebrate samples will be processed in the laboratory following standardized methods and the data will be entered into a database. Processing will enumerate and identify organisms to the taxonomic level necessary to calculate commonly reported biological metrics (numerical attributes of biotic assemblages) for each sample site from the benthic samples (i.e., TRC samples) and identify the diversity and abundance of primary salmonid prey items in the drift. Benthic macroinvertebrate metrics may include those calculated for benthic macroinvertebrate samples collected in the lower Tuolumne River from 2000–2005 and 2007–2009 (Stillwater Sciences 2010). Laboratory analysis of drift samples will also include length measurement of individual organisms, to allow calculation of biomass at a later date, if desired, to provide a relative measure of energy content and available fish food resources. Results will be included in a technical report that evaluates the adequacy of the macroinvertebrate prey resources to support healthy populations of juvenile anadromous salmonids, as indicated by comparison of the taxonomic composition and relative abundance (drift density) of the upper Tuolumne River macroinvertebrate drift samples with drift samples from other salmonid streams.

5.0 STUDY SCHEDULE

The study will be completed during the summer and fall of 2016; a detailed field schedule will be developed in conjunction with other field studies.

6.0 REFERENCES

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DRAFT STUDY PLAN

TURLOCK IRRIGATION DISTRICT
AND
MODESTO IRRIGATION DISTRICT

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

Hatchery and Stocking Practices Review

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which 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. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Hatchery and Stocking Practices Review is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to inform an evaluation of the potential for hatchery stocking practices to affect Chinook salmon and steelhead that may be introduced into the upper Tuolumne River above the Don Pedro Project.

2.0 STUDY AREA

The study area for this desktop literature review will encompass the upper Tuolumne River basin, including Don Pedro Reservoir and the mainstem Tuolumne River, and associated tributaries (North Fork Tuolumne River, Clavey River, Cherry Creek, etc.), to the extent that information is available regarding historical or current hatchery and stocking practices.

3.0 STUDY GOALS

The overall goal of this study is to assess historical and current hatchery stocking practices in the upper Tuolumne River basin and identify potential interaction of stocking activities with the reintroduction of anadromous salmonids to the reach of the Tuolumne River between the upstream end of the Don Pedro Project and the City and County of San Francisco's Early Intake. Specific objectives of this study are listed below:

- identify the species, source hatcheries and their stocking practices in the area, and time periods of fish that were historically stocked in the upper Tuolumne River, tributaries to the upper Tuolumne River, and in Don Pedro Reservoir;
- identify stocking location and seasonal timing of stocking for species currently stocked (and that may be stocked in the future) in the upper Tuolumne River, tributaries to the upper Tuolumne River, and in Don Pedro Reservoir;
- identify and describe self-sustaining potamodromous populations (species of fish that migrate [upstream or downstream] exclusively in freshwater) originating from previously stocked species, their life history characteristics, and population characteristics, as available;
- identify available information on documented incidents of disease in hatchery stocks and in the upper Tuolumne River basin;
- describe life histories of stocked species, as well as their spatial and temporal migrations and distributions to identify the potential to interact with reintroduced anadromous salmonids;
- describe potential spatial and temporal overlap of stocked species and lifestages with potentially-reintroduced species and lifestages (i.e., steelhead and spring-run Chinook salmon) in the upper Tuolumne River; and
- identify potential effects of historical and existing/future hatchery and stocking practices on efforts to reintroduce anadromous salmonids to the upper Tuolumne River.

4.0 STUDY METHODS

A desktop literature review will be conducted and is expected to include review of agency technical memoranda, fish stocking data, fish health information, journal articles, and websites to identify and describe historical, current and future fish hatchery and stocking practices in the upper Tuolumne River Basin. Agencies and organizations involved with fish hatchery and stocking activities will be contacted to gather additional information on historical and existing fish stocking activities in the study area, including the Don Pedro Recreation Agency and California Department of Fish and Wildlife.

Based on the information collected regarding historical and current/future stocking practices, existing hatchery operations, life histories of stocked fish species, and literature on interactions between stocked fish species and anadromous salmonids, potential effects of hatchery and stocking practices to an anadromous salmonid reintroduction effort will be described and evaluated. Potential risks associated with hatchery and stocking practices to an anadromous salmonid reintroduction program will be identified and described.

5.0 STUDY SCHEDULE

The anticipated schedule is to conduct the desktop literature review and contact agency staff from May to July 2016. A draft report will be provided to the Technical Committee in November and a final report will be included in the February 2017 Updated Study Report.

6.0 REFERENCES

Turlock Irrigation District and Modesto Irrigation District (TID/MID). 2016. Fish Passage Facilities Alternatives Assessment Progress Report. Prepared by HDR, Inc. Appendix to La Grange Hydroelectric Project Initial Study Report. February 2016.

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TURLOCK IRRIGATION DISTRICT
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LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

Regulatory Context for Reintroduction

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which 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. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Regulatory Context for Reintroduction review is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to evaluate federal, state, and local regulatory issues that may be associated with the reintroduction of Chinook salmon and steelhead into the upper Tuolumne River above the Don Pedro Project.

2.0 STUDY AREA

The study area will encompass the upper Tuolumne River basin, including Don Pedro Reservoir and the mainstem Tuolumne River, and associated tributaries (North Fork Tuolumne River, Clavey River, Cherry Creek, etc.), and surrounding public and private land.

3.0 STUDY GOALS

This regulatory review will evaluate federal, state, and local regulatory issues associated with the potential introduction of listed and protected fish species into the Tuolumne River upstream of the Don Pedro Project. The upper Tuolumne River basin spans the jurisdictions of several federal land management agencies (United States Forest Service [USFS], Bureau of Land Management [BLM], and National Park Service [NPS]). Current activities related to fisheries management (stocking, setting of fishing areas, seasons, limits, and catch quotas) are the responsibility of the State of California. With the potential introduction of protected anadromous salmonids, regulatory requirements related to such laws as the Endangered Species Act, Magnuson-Stevens Fishery Conservation and Management Act, Clean Water Act, National Environmental Protection Act, the Federal Land Policy and Management Act, and California Environmental Quality Act may become relevant to activities occurring in the study area. The goals of this study are to:

- identify applicable existing legal precedent, regulatory guidance and resource management plans in the study area;
- identify additional regulatory guidance and rules that may apply to or affect the reintroduction of spring-run Chinook and/or steelhead; and
- identify and define potential federal, state, and local regulatory issues associated with the potential fish passage/reintroduction program.

4.0 STUDY METHODS

The introduction of new species into the upper river may affect current uses and regulatory requirements/restrictions. A comprehensive understanding of the regulatory aspects of introducing federal- and state-listed species to the upper Tuolumne River watershed is necessary. For purposes of this evaluation, the regulatory context is defined as legal precedent, rules, regulations and guidelines in land and species management that may apply to land and species management in the study area.

State and federal resource management agencies will be contacted to confirm all relevant guidance documents and supporting materials are identified. A summary of regulations and authorities applicable and potentially applicable to activities in the watershed will be completed. This study report will include a matrix of species and land management goals, responsible authorities, and applicable laws and regulations relevant to current and future proposed activities in the watershed. An initial list of documents to be reviewed is provided below and will be expanded as necessary based on consultation with licensing participants.

- Recovery Plan for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead (National Marine Fisheries Service 2014)
- Sierra Nevada Forest and Community Initiative (SNFCI) Action Plan (Sierra Nevada Conservancy 2014)
- The State of the Sierra Nevada’s Forests (Sierra Nevada Conservancy 2014)
- Tuolumne Wild and Scenic River Comprehensive Management Plan and supporting documents (NPS 2014)
- Sierra Nevada Forest Plan and Amendments (USFS 2004, 2013)
- Stanislaus National Forest Plan Direction (USFS 2010)
- Sierra Resource Management Plan (BLM 2008)
- Steelhead Restoration and Management Plan for California (California Department of Fish and Game 1996)
- Tuolumne County General Plan (Tuolumne County 1996)
- Red Hills Management Plan (BLM 1985)

5.0 STUDY SCHEDULE

The anticipated schedule is to gather relevant plans and consult licensing participants and agencies from May through July 2016. A draft report will be provided to the Technical Committee in November 2016 with a final report included in the February 2017 Updated Study Report.

6.0 REFERENCES

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TURLOCK IRRIGATION DISTRICT
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LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

Socioeconomic Scoping Study

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which 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. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Socioeconomic Scoping Study is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to evaluate the potential socioeconomic effects of reintroducing Chinook salmon and steelhead into the upper Tuolumne River above the Don Pedro Project.

2.0 STUDY GOALS

The goal of this study is to develop a comprehensive description of the human environment, activities, and current uses of the resources and facilities in the study area that may be impacted by constructing and/or operating fish passage facilities and the introduction of anadromous fish upstream of the Don Pedro Project.

3.0 STUDY METHODS

Socioeconomic considerations are identified as a key element in assessing whether potential reintroduction methods could be successful (Andersen et al. 2014). Current management of the Don Pedro Reservoir and upper Tuolumne River supports a wide range of resources, uses, and users. The upper watershed includes the Tuolumne Wild & Scenic River segment managed for several outstanding resource values and is utilized by commercial and private recreational boaters. Other uses of the watershed include the City and County of San Francisco's operation of the Hetch Hetchy Project, private timber practices, and a recreational fishery. Don Pedro Reservoir provides numerous recreational activities, including house boating and a popular recreational fishery. County government and businesses benefit from the economic activities supported by the upper watershed.

As part of this study, a comprehensive survey of uses in the upper watershed will be conducted and potential issues will be identified for consideration in the reintroduction assessment. A literature survey and review of existing information from the Don Pedro Recreation Agency, county and federal land management agencies, and other sources will be conducted. Surveys and/or focus groups will be used to verify and expand upon available information related to existing uses of the watershed that could be impacted by a fish reintroduction program. The information collected in this study is designed to support and expand upon the socioeconomic considerations identified in the Framework, such as recreation impacts (e.g., river recreation, reservoir recreation, recreational fishing) and impacts on private resources (e.g., timber resources, private landowners), and will be considered in any socioeconomic evaluation done once reintroduction and fish passage options are further developed.

4.0 STUDY SCHEDULE

The anticipated schedule is the study team will gather available literature and consult licensing participants and agencies from April to July 2016. The literature review and data gathering will be completed over the summer, with a draft report issued to the Technical Committee by October 2016. The final report will be included in the February 2017 Updated Study Report.

5.0 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.

Turlock Irrigation District and Modesto Irrigation District (TID/MID). 2016. Fish Passage Facilities Alternatives Assessment Progress Report. Prepared by HDR, Inc. Appendix to La Grange Hydroelectric Project Initial Study Report. February 2016.

DRAFT STUDY PLAN

TURLOCK IRRIGATION DISTRICT
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LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which 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. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to characterize the distribution, quantity, and quality of suitable Chinook salmon and steelhead spawning gravel in the upper Tuolumne River.

2.0 STUDY AREA

The study area for mapping Chinook salmon and steelhead spawning gravel in the upper Tuolumne River includes the approximately 24-mile reach from the upstream limit of the Don Pedro Project (approximately RM 81) to Early Intake (approximately RM 105).

3.0 STUDY GOALS

Successful Chinook salmon and steelhead spawning and fry production are dependent on the abundance and quality of suitable spawning gravel. Information on the amount, distribution, and quality of spawning gravel are critical components in estimating habitat carrying capacity and assessing limiting factors. Limited information is available to describe the distribution, quantity, and quality of spawning gravel in the upper Tuolumne River. The goal of this study is to characterize the distribution, quantity, and quality of suitable Chinook salmon and steelhead spawning gravel in the upper Tuolumne River.

The study objectives are:

- map the distribution of potentially suitable spawning gravel available for Chinook salmon and steelhead in the upper Tuolumne River;
- assess the quality of potentially suitable spawning gravel based on gravel size characteristics, sorting, angularity, embeddedness, substrate depth, and permeability measured in a representative sample of gravel patches; and
- quantify the amount of suitable spawning gravel in the reach between RM 81 and RM 105.

Study results will help inform the feasibility of introducing Chinook salmon and steelhead into the upper Tuolumne River.

4.0 STUDY METHODS

4.1 Spawning Gravel Mapping

Probable locations of gravel patches will initially be delineated in a Geographic Information System (GIS) using the best available aerial photography. This desktop mapping step will inform field staff as to the approximate distribution of gravel deposits and the most efficient logistical process for locating and mapping those deposits in the field. Field mapping criteria and protocols will be consistent with studies in the lower Tuolumne River (TID/MID 1992, 2013), and will be refined following this initial desktop analysis, as needed.

Potentially suitable spawning gravel patches will then be delineated in the field on map tiles from high resolution orthorectified aerial imagery (e.g., 8-13-2007 photography and mapbook). A laser range finder will be used to measure the approximate dimensions of each gravel patch, if necessary to support the delineation of patch areas on field tiles. Each patch will be assigned a unique ID. Field delineation of potentially suitable spawning gravel patches will be performed by a two-person crew using whitewater raft support to access the study reach. The crew will stop frequently to locate and investigate preliminary gravel polygons obtained from desktop mapping and any other deposits that appear to meet the mapping criteria. Inflatable kayaks may also be used to navigate unwadable areas requiring investigation. To the extent feasible, mapping will be performed during low or off-peak flow conditions to optimize visibility of potentially suitable spawning gravels. Supplemental access to limited portions of the study reach are available at vehicle road crossings and by foot, depending on terrain and river flow.

4.1.1 Gravel Particle Size Criteria

Species-specific spawning gravel size criteria that will be used to delineate potentially suitable spawning gravel for Chinook salmon and steelhead in the upper Tuolumne River study reach are summarized in Table 1.0. These particle size criteria, based on D_{50} reported in the literature, may be refined in coordination with the Technical Committee prior to the field effort. Chinook salmon typically spawn in substrates with a D_{50} of 11–78 mm (0.42–3.0 in) (Platts et al. 1979, as cited in Kondolf and Wolman 1993, Chambers et al. 1954, 1955, as cited in Kondolf and Wolman 1993). Steelhead typically spawn in substrates with a D_{50} of 10–46 mm (0.4–1.8 in.) (Barnhart 1991, Kondolf and Wolman 1993). Wolman (1954) pebble counts will be conducted in selected areas to calibrate visual estimates of grain size parameters using methods developed by Bunte and Abt (2001). Patches with substantially different surface particle size characteristics will be delineated separately.

4.1.2 *Minimum Gravel Patch Size Criteria*

Minimum patch size criteria for mapping potentially suitable spawning gravel will be determined prior to the field effort based on (1) a combination of the minimum area required for a spawning Chinook salmon or steelhead pair and (2) the scale and resolution of available imagery used as a base for field mapping tiles. The minimum spawning area generally identified for Chinook salmon is approximately 12 m^2 (Healy 1991, Bjorn and Reiser 1991, Ward and Kier 1999). Steelhead typically defend a redd only during the period of active spawning, and therefore the area required for a spawning steelhead pair is approximately equal to the disturbed area of the redd. The average area encompassed by a steelhead redd is 4.4–5.4 m^2 (47–58 ft^2) (Bjornn and Reiser 1991; Orcutt et al. 1968). For mapping purposes, we assume a minimum patch size of approximately 6 m^2 is required for a steelhead pair to build and defend a redd. The minimum mappable size of potentially suitable spawning gravel patches based on the scale and resolution of available imagery will be evaluated during the desktop gravel mapping step described above.

Table 1.0 Summary of potential spawning gravel mapping criteria for Chinook salmon and steelhead in the upper Tuolumne River.

Species	Gravel D_{50} mm (in.)	Minimum Patch Size Required for Spawning, m^2 (ft^2)	References
Chinook salmon	10–78 (0.4–3)	12 (130)	Platts et al. 1979, Chambers et al. 1954, 1955, all as cited in Kondolf and Wolman 1993; Healy 1991, Bjorn and Reiser 1991, Ward and Kier 1999
Steelhead	10–46 (0.4–2)	6 (65)	Barnhart 1991, Kondolf and Wolman 1993, Bjornn and Reiser 1991, Orcutt et al. 1968

Note: D_{50} – diameter of particle (in millimeters) at which 50 percent of the sample is smaller (*e.g.*, median).

4.2 Spawning Gravel Quality

In addition to the particle size and patch size criteria described above, characteristics informing spawning habitat quality will be collected for each patch. These will include additional gravel particle size parameters (e.g., D_{16}, D_{84}); characterization of particle sorting, angularity, and embeddedness; and an estimate of the average substrate depth (where feasible).

4.2.1 *Field Observations of Gravel Quality*

Sorting describes the homogeneity of surficial particles within a patch. Spawning salmonids prefer substrates that are relatively well sorted. The degree of sorting will be visually estimated using the comparison chart in Compton (1985). Angular grains tend to pack more tightly than rounded particles and are more likely to slow intragravel flow. More loosely packed and rounded particles also increase a fish's ability to dislodge the substrate during redd construction. The degree of particle angularity within a patch will be visually estimated based on the comparison chart in Powers (1989). Substrate embeddedness describes the presence of fine sediment in the gravel interstices. Substrate embeddedness is measured by selecting a random sample of coarse surface particles within the patch and measuring the percent of the particle that is surrounded or buried by fine sediment (fines and sands <2 mm). This would be conducted concurrent with pebble count procedures. The substrate depth required for redd construction and egg deposition likely depends on the size of the spawning female and on particle size characteristics, as well as flow depth and velocity. Chinook salmon egg pocket depths range from 8 to 51 cm (3 to 20 in), with an average of 22 cm (8.5 in) (Burner 1951). Steelhead egg pocket depths range from 15 to 28 cm (6 to 11 in), with an average of 21 cm (8.4 in) (Briggs 1953).

4.2.2 Gravel Permeability

Gravel permeability will be collected to characterize incubation conditions and estimate predicted survival-to-emergence. The quality of spawning gravel will be assessed by measuring streambed permeability at select patches following the methods of Barnard and McBain (1994). Gravel inflow rate (ml/sec), which is an index of intragravel permeability (cm/hr), will be measured using a steel standpipe adapted from the Terhune Mark VI standpipe design (Terhume 1958; Barnard and McBain 1994). At select gravel patches, the standpipe will be driven into the gravel to an approximate depth of 30 cm (12 inches) using a protective end cap and sledge hammer. A battery powered peristaltic pump (e.g., IP Masterflex brand pump or equivalent) will be used to create a 2.5 cm head differential in the standpipe and the rate at which water is drawn from the pipe will be measured (Barnard and McBain 1994). While maintaining this constant pressure head, water will be drawn through the perforations in the standpipe buried in the gravel, and a stopwatch will be used to measure the time required to collect a volume of water.

Gravel permeability can be highly variable within and between patches in a reach. Therefore, a sampling plan will be developed based on the results of the spawning gravel mapping effort. The sampling plan will outline an approach and provide field protocols for characterizing the permeability of potential spawning patches throughout the study reach. The approach will generally rely on assigning patches to a morphologic unit (e.g., pool tail) and sampling from consistently similar positions within a morphologic unit. Sampling will occur in the morphological unit(s) that are best exhibit the effects of fine sediment supply on spawning gravel quality and that have the highest potential value to spawning Chinook and steelhead. Permeability sampling results may be stratified by subreach, as appropriate. Desktop and field-based mapping of potentially suitable spawning gravel patches will inform an appropriate system for delineating morphological units, appropriate permeability sampling locations within those units, and appropriate delineation of any subreaches.

4.2.3 Gravel Quality Ranking

When a gravel patch is deemed "usable" based upon initial measurements associated with particle size criteria, a qualitative ranking of overall suitability from 1 (poor) to 10 (good) will be assigned to each patch based on an overall assessment of the following physical characteristics (substrate particle size, sorting, angularity, embeddedness, gravel depth, permeability, and patch location and size). A separate ranking will be assigned for Chinook salmon and steelhead. Although reliable rankings rely heavily on the professional judgment and personal experience of the survey participants, this ranking will allow comparison of patch quality. Rankings will be summarized as follows: 1–3= low suitability, 4–7= medium suitability, and 8–10= high suitability.

4.3 Data Processing and Analysis

Potentially suitable spawning gravel patches delineated on field tiles will be digitized using GIS, and area estimates for each patch will be calculated. The quantity and quality of potentially suitable spawning gravel patches will be summarized in tabular format.

Results to be reported include the following:

- shapefiles with polygons of potentially suitable spawning gravel patches and associated patch attributes;

- a database of attributes for each mapped gravel patch (i.e., measured and/or estimated particle size parameters, sorting, angularity, embeddedness, estimated mean depth [where feasible], associated channel morphological feature, and quality score);
- mean, minimum and maximum gravel inflow rates (ml/sec) as an index of intragravel permeability (cm/hr) for each sample site, presented by river mile location; and
- derived mean permeability (cm/hr) by river mile.

5.0 STUDY SCHEDULE

The anticipated schedule is to conduct the initial office-based analysis in May-June 2016, with subsequent field surveys in August/September 2016 for gravel mapping and gravel quality assessments. Mapping of potentially suitable spawning gravel will occur over two separate five-day field trips. Permeability sampling will occur over one three-day field trip to be conducted after the gravel mapping is completed. A draft report will be provided to the Technical Committee in November 2016 with a final report to be included in the February 2017 Updated Study Report.

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LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT
REINTRODUCTION GOALS SUBCOMMITTEE CONFERENCE CALL

APRIL 13, 2016

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project
Reintroduction Assessment Framework
Reintroduction Goals Subcommittee Conference Call

Wednesday, April 13, 10:00 am to 12:00 pm
Conference Line: 1-866-583-7984; Passcode: 8140607

Meeting Objectives:

1. Review and confirm the purpose of the Reintroduction Goals Subcommittee.
2. Present and discuss examples of reintroduction assessment goal(s) development.
3. Discuss development of reintroduction assessment goal(s) relevant to the Tuolumne River Reintroduction Assessment Framework.
4. Identify next steps on Reintroduction Goals Subcommittee.

TIME	TOPIC
10:00 am – 10:15 am	Introduction of Participants (All) Review Agenda and Meeting Objectives (Districts)
10:15 am – 10:45 am	Reintroduction Assessment Framework – Development of Program Goals. Why Is It Important? What Purpose Does it Serve? (All) a. Planning Pacific Salmon and Steelhead Reintroductions Aimed at Long-Term Viability and Recovery, Andersen et al. b. NMFS Recovery Plan
10:45 am – 11:15 am	Development of Reintroduction Goals - Examples a. Yuba River (Paul Bratovich) b. San Joaquin River (Chuck Hanson)
11:15 am – 11:50 am	Process for Developing Tuolumne River Reintroduction Goals (all) a. Part 1: Narrative goal(s) statement b. Par 2: Quantitative metrics
11:50 am – 12:00 pm	Next Steps (All) a. Schedule next call and agenda topics b. Action items from this call

La Grange Hydroelectric Project Licensing (FERC No. 14581)
Fish Passage Facilities Alternatives Assessment
Reintroduction Goals Subcommittee Conference Call

Wednesday, April 13, 2016
10:00 am to 12:00 pm

Final Meeting Notes

Conference Call Attendees		
No.	**Name**	**Organization**
1	Leigh Bartoo	U.S. Fish and Wildlife Service
2	Steve Boyd	Turlock Irrigation District
3	Anna Brathwaite	Modesto Irrigation District
4	Paul Bratovich	HDR, consultant to the Districts
5	Jesse Deason	HDR, consultant to the Districts
6	John Devine	HDR, consultant to the Districts
7	Greg Dias	Modesto Irrigation District
8	Steve Edmondson	National Marine Fisheries Service
9	Art Godwin	Turlock Irrigation District
10	Chuck Hanson	Hanson Environmental, consultant to the Districts
11	Patrick Koepele	Tuolumne River Trust
12	Bao Le	HDR, consultant to the Districts
13	Ellen Levin	City and County of San Francisco
14	Bill Paris	Modesto Irrigation District
15	Bill Sears	City and County of San Francisco
16	Chris Shutes	California Sportfishing Protection Alliance
17	John Wooster	National Marine Fisheries Service
18	Ron Yoshiyama	City and County of San Francisco

On April 13, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted a Reintroduction Goals Subcommittee conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Reintroduction Assessment Framework (Framework). 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 meeting agenda and meeting read ahead materials.

Mr. Bao Le (HDR, consultant to the Districts) said there are two primary components of Framework implementation: (1) collecting site-specific technical, regulatory and socioeconomic information, and (2) assessing that information in the context of the goals for reintroduction in order to evaluate reintroduction feasibility. Mr. Le reviewed the timeline for developing reintroduction goals, noting that goals are needed by the fall of 2016. Mr. Le said this meeting is intended to initiate discussions about developing goals. On today's call meeting attendees will discuss why setting goals is important, potential sources of information for developing goals, and specific examples of goals at other Central Valley reintroduction programs. Mr. Le said if there is time, attendees may begin to discuss what goals might look like for the Tuolumne River.

Mr. Steve Edmondson (National Marine Fisheries Service [NMFS]) said HDR may be able to provide examples of other reintroduction programs the company has worked on that have used a decision matrix similar to the Framework. Mr. Le said he will inquire within HDR as to whether there are examples applicable to the Tuolumne River. Mr. John Devine (HDR) said NMFS may also have worked on projects, perhaps projects in the Pacific Northwest, which could serve as examples relevant to the effort here. Mr. Edmondson said he is not familiar with any projects that are using a decision framework, like this process. Mr. Edmondson noted there will be a workshop with fish passage experts, both from federal agencies and the private sector, to discuss designing fish passage at high head dams. Mr. Le said he encourages anyone with knowledge of projects that may be applicable to this project to provide information they think might be useful. Later in the meeting, Mr. Edmonson said he had sent an email query out to other NMFS offices about the use of a framework in other reintroduction programs, and none of the individuals who responded to his email were aware of a process similar to the Framework being used elsewhere.

Mr. Le said he thinks Anderson et al. (2014; included in Attachment A) provides a sound basis for evaluating the feasibility of a reintroduction program for the Tuolumne River. In particular, the paper describes the importance of assessing a reintroduction program's potential benefits, risks, and constraints. While the focus is often on achieving success, a reintroduction program must also manage risk associated with the effort and be cognizant of working within the program's constraints. Mr. Le encouraged meeting attendees to read the paper and provide feedback.

Mr. Le said he believes the paper is particularly relevant for the Tuolumne River because the paper approaches reintroduction planning from the perspective of recovery of salmonid species listed under the Endangered Species Act (ESA), which is also the driving motivation behind the NMFS Recovery Plan (2014; available online here). The NMFS Recovery Plan lists the upper Tuolumne River as a candidate reach for steelhead and spring-run Chinook. Mr. Le said the Recovery Plan seems like an obvious source of information to explore to inform the development of reintroduction goals. Mr. Le asked if meeting attendees had any thoughts about the Recovery Plan and using that document as a source of information for helping to craft reintroduction goals and objectives for the Tuolumne River. No one responded. Mr. Le requested that meeting attendees review the Recovery Plan and provide feedback on whether the Recovery Plan is relevant to developing reintroduction goals on the Tuolumne River.

Mr. Paul Bratovich (HDR) provided a summary of the reintroduction program on the Yuba River. Mr. Bratovich noted that several individuals on this call, including Mr. Steve Edmondson (NMFS), Mr. Chris Shutes (California Sportfishing Protecting Alliance), and Mr. John Wooster (NMFS) have participated in the reintroduction program for the Yuba River. Mr. Bratovich said the reintroduction initiative on the Yuba River has evolved over several years. Most recently, goals and objectives were agreed to in a concept plan, which accompanied the settlement term sheet. Mr. Bratovich said the goals and objectives of a reintroduction program are much different from fish passage facility operational performance criteria, and that the two must not be confused. Mr. Bratovich said there are a number of ways in which reintroduction goals may be structured. Mr. Bratovich said the NMFS Recovery Plan has a section about recovery goals and population goals. However, these goals are structured differently than goals being developed for the Stanislaus River. Goals for the Yuba River are structured differently than both goals in the NMFS Recovery Plan and goals for the Stanislaus River.

Mr. Bratovich said one possible route is to create numeric goals and objectives, such as the number of individuals needed for a viable population. "Viability" is defined in the NMFS Recovery Plan by numeric criteria and extinction risk, but "viability" would still need to be defined as it pertains to the potential river and project. Mr. Bratovich said a "simpler criteria" that has been identified by Lindley may also be used. These criteria have four parameters: abundance, productivity, spatial structure, and diversity.

Mr. Bratovich said one issue to consider when developing reintroduction goals is in-basin versus out-of-basin effects. For example, a reintroduction program with a goal tied to a species population metric such as the number of returning adults will be assuming responsibility for out-of-basin and/or non-project effects, such as predation, ocean conditions, sportfishing and commercial fishing. One approach to defining goals that can remove out-of-basin and non-project effects is to define goals based on the number of individuals at various life stages that can be supported by managing suitable habitat.

Mr. Bratovich said the Yuba River concept plan reintroduction goals are based on providing suitable habitat to support a low extinction risk, as interpreted by the simpler criteria from Lindley and others. In particular, the goals specify a number of individuals in terms of habitat, and do not assume responsibility for numbers of returning adults. Mr. Bratovich noted the project is currently in settlement negotiations.

Dr. Chuck Hanson (Hanson Environmental, consultant to the Districts) gave a summary of the reintroduction program on the San Joaquin River. Dr. Hanson said talks of reintroduction on the San Joaquin River first began in 1988 when the National Resources Defense Council sued the U.S. Bureau of Reclamation (Reclamation). After many years of litigation and many environmental studies, the parties settled in 2006. The settlement agreement had several components. In particular, the settlement agreement: (1) recommended that several projects be implemented in order to successfully re-establish spring-run Chinook; (2) provided goals for re-establishing a self-sustaining naturally reproducing population of spring-run Chinook downstream of Friant Dam, and (3) formed a Technical Advisory Committee to provide advice on what needed to be done for the program to be successful.

Dr. Hanson said one of the first tasks of the new program was to compile into a single document all the existing environmental information about the reach identified for reintroduction, so that existing conditions and problem areas could be identified. With the data compilation in hand, the Technical Advisory Committee determined that reintroduction would focus on spring-run Chinook, and a secondary focus would be on fall-run Chinook.

Dr. Hanson said in October 2007, a document entitled *Recommendations on Restoring Spring-Run Chinook to the San Joaquin River* was released. The document recommended that the reintroduction strategy be compatible with existing conditions, such as the carrying capacity of the spawning gravel and existing water temperatures. The program should be responsive to natural selection processes. The "build it and they will come" approach was eliminated from consideration because it was likely there were not enough strays to make the program feasible. The program should aim to create a founding population with life history characteristics that match the anticipated environmental conditions. The founding population should also exhibit broad genetic diversity. Genetic diversity was important for fostering natural selection and thus creating a population that was genetically suited to conditions in the San Joaquin. The document also recommended the founding population be demographically diverse, with broad life history expression for juvenile rearing, with the goal that adults would return at multiple age classes, thus building resiliency.

Dr. Hanson said given there had been no Chinook present in the system for over 50 years, it was decided that the San Joaquin River reintroduction program would be best implemented through four phases: (1) Reintroduction Period; (2) Interim Period (during this period, infrastructure would be constructed and begin operating); (3) Population Growth Period (during this period, escapement and reproduction would take place); and (4) Maintenance Period (this is the long-term period of program operation). Dr. Hanson said at the beginning of the process, the number of returning adults was selected as the metric that best reflected whether the program was accomplishing its objective (i.e., to produce a self-sustaining, naturally reproducing population). The Reintroduction Period focused on achieving a five-year running average escapement of at least 2,500 fish, with a minimum escapement of 500 fish.

Dr. Hanson said the team looked at multiple life stage strategies for the founding population to mimic populations that had been established previously in northern California. The team looked into collecting eggs, fry, and juveniles from Deer Creek and Mill Creek, but there were political sensitivities to that approach. The team, which included NMFS, USFWS, and Reclamation, among others, determined a politically feasible strategy was to build a conservation hatchery. A conservation hatchery would increase the number of juveniles available for use by the program and would be helpful in low water years. To minimize impacts to natural populations, the conservation hatchery would use surplus fish from the Feather River Hatchery.

Dr. Hanson said currently the team has permits to import eggs and fry from the Feather River. CDFW started the conservation hatchery with fall-run Chinook. Currently, CDFW is applying what has been learned from raising the fall-run Chinook and is shifting the hatchery operations to spring-run Chinook. Dr. Hanson said the program is currently introducing spring-run into the system and trapping and hauling fall-run Chinook. The program monitors reproduction, fry emergence, juvenile migration, abundance of juveniles, and survival by reach, among other metrics. The program is also currently addressing multiple problems that have arisen unexpectedly, including seepage, impacts to agricultural and other water users, levy instability, and predation issues. Due to predation, the program is not producing as many juveniles as was previously anticipated.

Dr. Hanson said the program estimated adult escapement based on an analysis of the limiting factors. The analysis provided a useful framework, but it now must be applied to site-specific factors. The team is realizing that original projections for how long it would take to implement the project were overly optimistic, in part due to interdisciplinary issues that were not anticipated. Dr. Hanson said he will send Mr. Le documents related to the reintroduction approach. Dr. Hanson said he sees many parallels between the Yuba River and Tuolumne River in terms of establishing a successful reintroduction program.

Mr. Le noted that for the programs on the Yuba River and San Joaquin River, the summaries provided by Mr. Bratovich and Dr. Hanson describe a phase of the program where the decision to reintroduce fish had already been made. However, for the Tuolumne River, NMFS has stated in a previous workshop that a decision to reintroduce fish has still not yet been made. Mr. Le asked whether in either of the processes, there was a phase of the process that focused on evaluating reintroduction feasibility toward a "go/no go" decision. Both Mr. Bratovich and Dr. Hanson noted that reintroduction programs were identified from settlement discussions and a structured evaluation framework such as that proposed for the Tuolumne River had not been implemented. Mr. Bratovich said many millions of dollars were previously spent collecting information on the Yuba River, and all that information was available to inform the reintroduction planning process. Dr. Hanson said preliminary discussions for the San Joaquin focused on what it would take to meet the requirements suggested by the limiting factor analysis. Mr. Le said it appears the process on the San Joaquin was driven by limiting factors such as thermal suitability and carrying capacity, and not independently by goals. Mr. Le noted this is different from what this group is trying to do on the Tuolumne River, which is to collect the information in parallel but independent of developing the reintroduction program goals and success criteria, and then evaluate the information and criteria hand-in-hand to evaluate whether the goals can be met (i.e., feasibility) prior to considering implementation. Mr. Le stated that careful planning and evaluation was a valuable point he took from review of the Anderson et al. (2014) since the authors had noted that in their review of the salmonid reintroduction literature, there remain large uncertainties in the success of reintroduction in establishing self-sustaining populations, particularly for programs employing active colonization strategies.

Mr. Wooster asked Dr. Hanson to highlight a few of the parallels between the situation on the San Joaquin River and the situation on the Tuolumne River. Dr. Hanson said both rivers are in the southern geographic range of the target species, and both rivers share similar hydrologic and temperature concerns. In addition, habitat features such as the availability of spawning gravel are also problematic. Dr. Hanson noted too that both rivers exhibit poor survival of juvenile outmigrants.

Mr. Yoshiyama said he believes that the genetics of spring-run and fall-run on the Feather River cannot be genetically distinguished from one another. Mr. Yoshiyama said he sees the Feather River Chinook population as a gradation of life history timings and forms, with very early migrants that would be classified as spring-run and later fish that would be classified as fall-run. Mr. Yoshiyama said that this gradation would have repercussions for the Tuolumne River. Mr. Yoshiyama asked if the group here is more interested in achieving life history diversity, as opposed to achieving a true spring-run life history. Mr. Yoshiyama said it may make it easier to achieve a spring-run life history on the Tuolumne River if genetic mixing between fall-run and spring-run is not a concern. Dr. Hanson confirmed that the Feather River spring-run do not have unique genetics. Instead, the fish are a blend. Dr. Hanson noted that on the San Joaquin River, the team had to move away from a focus on maintaining genetic diversity to a focus on life history.

Mr. Le noted that on the San Joaquin, prior to the decision to move away from fall-run, the initial program was going to use fall-run as surrogates and then move to spring-run. Mr. Le asked what consideration had been given to how to separate out the two sets of fish, given that their life histories overlap both temporally and spatially. Dr. Hanson said consideration had been given to how flows or mechanical intervention could be used to separate the two runs. Dr. Hanson said genetic testing is currently underway to better understand the issue Dr. Yoshiyama raised.

Mr. Devine asked Mr. Bratovich to describe how the Framework was developed. Mr. Bratovich said he was unaware of examples where a similar reintroduction framework had been used. However, all the components of the Framework are issues that have been addressed at other projects and/or were issues Anderson et al. (2014) recommended be addressed. Mr. Bratovich said the Framework is simply a visual representation of those components. Mr. Devine said the Framework was an attempt to systematically bring together, organize, and sequence all the biological and ecological criteria, regulatory issues, and engineering considerations. Mr. Devine said one takeaway from Anderson et al. (2014) is that failing to approach reintroduction in a systematic way often leads to problems down the road. Mr. Devine discussed the importance of having a site-specific framework that reflects the specific issues of the watershed.

Dr. Yoshiyama said one item of note in Anderson et al. (2014) is that in order to assess the success of a reintroduction program, fish generations must be monitored for several decades. Dr. Yoshiyama said this group must also consider what indicators should be monitored in order to assess whether the program is failing or has failed. Mr. Le agreed that monitoring is a key component of evaluating a program, and that he thinks it will be necessary to include an adaptive component that provides an opportunity for a programmatic course correction. Mr. Le said his takeaway from Anderson et al. (2014) is that the first step in a reintroduction program is first determining whether the program is worth doing.

Mr. Shutes said it is a good idea in the beginning to identify front-end decisions that could have dramatic consequences for the success or failure of the program. For example, if the goal is to reintroduce fall-run on the San Joaquin, and there isn't enough water to get the fall-run to move to suitable habitat, it does not necessarily mean the program is doomed to fail, only that the limiting factor must be identified.

Mr. Le summarized issues discussed by Mr. Bratovich and Dr. Hanson that may be considered while developing reintroduction goals and objectives for the Tuolumne River. Mr. Le asked if others have thoughts about what would be realistic goals for this program. There was no response. Mr. Le asked if others thought the goals should be tied to habitat availability, escapement, and/or the NMFS Recovery Plan. Mr. Le added that there did not seem like a reason to pursue reintroduction if the end goal is not to support delisting the species. Mr. Shutes said in addition to the approach of tying goals to habitat, he believes the goals should apply to a defined geographic area, so that metrics are not based on out-of-basin factors beyond the control of the program and program proponents. An example would be a goal based on juveniles per spawner. Mr. Shutes said he recommended that each meeting attendee or entity sketch out a short high-level narrative goals proposal to be shared with the rest of the Reintroduction Goals Subcommittee. With those ideas in hand, the group can begin to consider something more quantitative. Mr. Shutes noted that objectives considered for the Yuba River may be helpful to reference and attendees might also consider how goals for the Tuolumne River might relate to the NMFS Recovery Plan criteria. Mr. Le suggested each Subcommittee member or entity send HDR a short bulleted list with thoughts on goals for a Tuolumne River reintroduction program and how success might be defined. The bulleted list could be a narrative/qualitative or quantitative. HDR will combined the lists and circulate the compilation for discussion on the next subcommittee call.

Mr. Edmondson asked if there is a reason why the group is not moving forward with the engineering feasibility portion of the study. Mr. Edmondson said he does not believe this exercise in setting goals is something that needs to happen in a step-wise manner, and he wondered how long this process will continue without moving forward with the engineering feasibility. Mr. Devine said the biological criteria must be known in order to develop reliable cost estimates and accurate facility designs that are the correct size and layout and that operate at the correct times. Mr. Devine said designing facilities without this basic information is akin to asking a builder to design a house without knowing how many people will live in it. The builder can design a house, but the design and cost estimate will be meaningless because the design was not based on solid information. Mr. Devine said it is not good practice to guess what the biological criteria are that will inform the design. Mr. Devine said the Districts asked for input on the biological criteria in Technical Memorandum No. 1, and the Districts are open to having a meeting to discuss in detail what biological criteria are needed for the design. Mr. Devine said differences in expected performance standards for the facilities, biological criteria, and percent efficiencies would result in the design of very different facilities.

Ms. Ellen Levin (City and County of San Francisco) asked how NMFS would go about building a fish passage facility without first knowing the goals of the facility. Mr. Edmondson said NMFS has contracted for fish passage engineering studies for the Merced River and the Yuba River. Mr. Edmondson said these studies use the NMFS fish passage design document, which is currently being updated, and provides the basic information on what is needed to design a facility. Mr. Edmondson said NMFS would look to expectations and performance criteria at state-of-the-art fish passage facilities to determine these factors for the Tuolumne River study. Mr. Edmondson said he believes the conceptual engineering feasibility can move forward in parallel with this effort to develop goals, and does not need to be in sequence. Mr. Edmonson said his concern is delay to the schedule, and in order to keep costs down the schedule should move forward as efficiently as possible.

Ms. Levin said she agreed this process must be done right. Ms. Levin said it is very unclear what the reintroduction goals should be and what it is that this program is trying to accomplish. Ms. Levin said without those goals, it is unknown how the design can move forward. Ms. Levin said that while a generic fish passage facility can be designed, without first knowing the goals of the facility the design could be at completely the wrong scale. Ms. Levin said if state-of-the-art is what NMFS wants, a state-of-the-art facility could be what is designed, but the end results may be incredibly expensive and completely overdesigned. Ms. Levin said the better approach would be to first determine what facilities are needed. Mr. Edmondson reiterated that he believes the conceptual engineering feasibility can move forward based on information provided in the NMFS design criteria. One can decide to build a house on a lot without first knowing what color the curtains will be. Mr. Edmondson said the NMFS design criteria provides guidance on layout sizing and performance elements. Mr. Edmondson said he is taken aback to hear that engineers who design fish passage for a living are unable to move forward with the engineering. Mr. Edmondson said he would be happy to put pen to paper and provide the biological information requested in TM No. 1.

Mr. Shutes said a middle ground between no definition and complete definition is to use ranges for these types of data. In some cases, it may be instructive to see what cost differences result when assuming a range, such as the costs to build a facility that accommodates 2,000 fish compared to facility designed to accommodate 10,000 fish. Mr. Shutes said he thinks it reasonable for meeting attendees to provide some initial thoughts and ideas. Mr. Shutes said these initial thoughts would not be commitments, but just general ideas. Mr. Shutes said perhaps the group could sit down and have a conversation about these numbers so that the engineering can move forward. Mr. Shutes said he agrees that planning for a range will provide a result with wide error bars. However, planning for a range will provide a sense of the scale of facility anticipated here. Mr. Shutes said he believes it is appropriate for the development of the goals and objectives to take place in parallel with engineering at the scale NMFS is referring to.

Mr. Devine said the Districts can move forward with the engineering using a range, but the range must be based on sound information. Mr. Devine said the Districts welcome feedback on biological criteria that is based on solid science. Mr. Edmondson asked what level of engineering will be completed for the facility designs. Mr. Devine said this is a conceptual engineering study, but the engineering must still be based in fact, otherwise the results are guaranteed to be wrong. Mr. Devine questioned why money should be spent to estimate something when the estimate is based on guesses.

Mr. Le noted there are examples of fish passage projects in the Pacific Northwest that moved forward with designing conceptual-level facilities, but in those cases there were existing runs and habitat suitability data to base the designs on. Mr. Le said similar information for the Tuolumne River does not exist. Two of the target species do not currently exist in the river. Mr. Le said the carrying capacity work NMFS is completing (available in October 2016) and work the Districts will be completing this summer will be very helpful for informing the design process. Mr. Le said he agrees with Mr. Devine and Mr. Shutes that a separate call may be needed to help move this forward. Mr. Le said the Districts will take on an action item to move this forward.

Mr. Le asked if meeting attendees are amendable to providing their initial thoughts about reintroduction goals and ideas. The ideas could be narrative/qualitative or quantitative, and need not be longer than one page. Mr. Le said the ideas would be considered as draft conceptual ideas, the purpose of which would be to stimulate conversation, and would be considered and discussed without attribution. Mr. Le said HDR will consolidate the ideas and circulate the compiled document. Mr. Le asked if two weeks is enough time to provide these initial thoughts.

Mr. Edmondson proposed that instead of meeting attendees providing their ideas, HDR create a proposal and allow meeting attendees to comment on that proposal. Mr. Devine said that is a possibility. Mr. Dias said getting feedback from meeting attendees on the proposal would be important. Mr. Le asked if Mr. Edmonson proposed this alternative because two weeks is an insufficient amount of time to draft ideas. Mr. Edmondson said he thinks it will be more efficient for HDR to draft a proposal and allow others to provide their comments. Mr. Edmondson said this approach is similar to how these documents are typically created in a FERC proceeding. In such proceedings, a contractor develops the product and stakeholders provide comments on that product. Mr. Edmondson said he thinks the one-pagers could all come out very differently, and since much of that variety won't be reflected in the final product, it would not be a good use of time. Mr. Devine said the Districts will consider Mr. Edmondson's suggestion and provide feedback. Mr. Edmondson said that would be acceptable.

Mr. Le said the Districts will send out notes from this meeting.

Meeting adjourned.

ACTION ITEMS

1. Mr. Le will inquire within HDR as to whether there are examples of other reintroduction programs that have used a decision matrix similar to the Framework and that are applicable to the Tuolumne River.
2. Dr. Hanson will send Mr. Le documents related to the approach to reintroduction on the San Joaquin River. The Districts will provide these documents to the Reintroduction Goals Subcommittee. (complete)
3. Mr. Edmondson will put pen to paper and provide the biological basis the engineering needs to make progress as outlined in TM No. 1.
4. The Districts will facilitate a future meeting to discuss the biological criteria necessary to move forward the engineering study.
5. The Districts will consider and provide feedback on Mr. Edmondson's suggestion that the Districts provide a one-pager about goals, and circulate this one pager for comment, instead of individual attendees and entities providing their own one-pagers.
6. The Districts will send out meeting notes. (complete)

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

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ARTICLE

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

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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

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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, 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

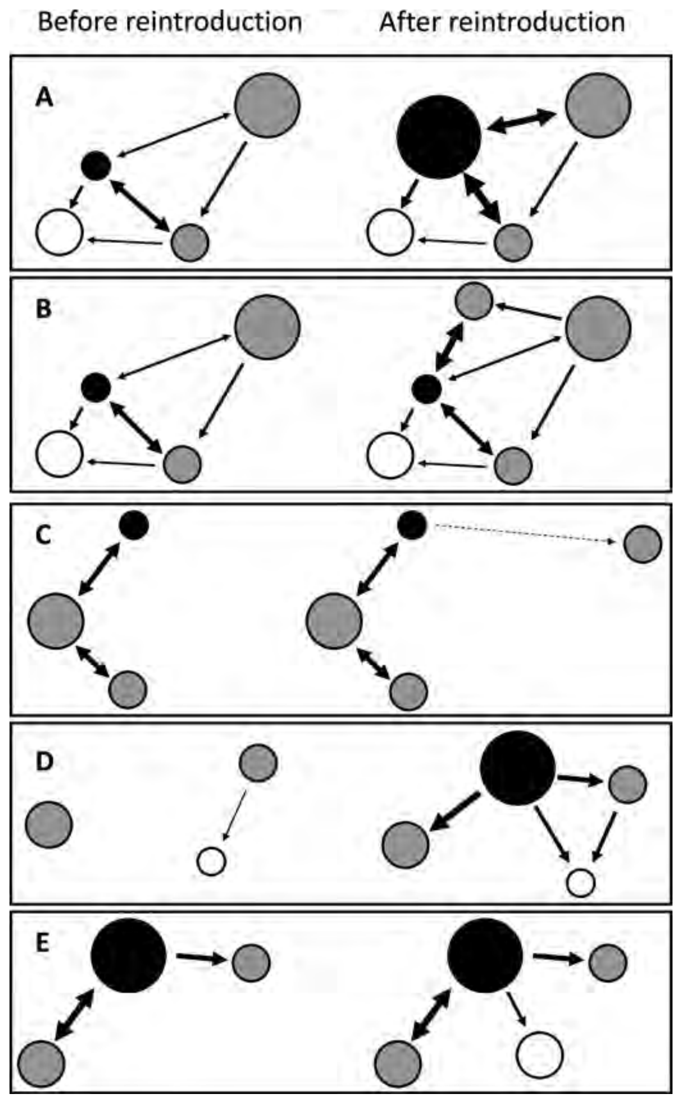

FIGURE 1. Possible effects of reintroduction on metapopulation structure are as follows: **(A)** increase the abundance of the existing population, **(B)** establish a new, independent population well connected to the metapopulation, **(C)** establish a new, independent population isolated from the other 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.

(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 metapoulation models useful for guiding salmonid management (Cooper 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).

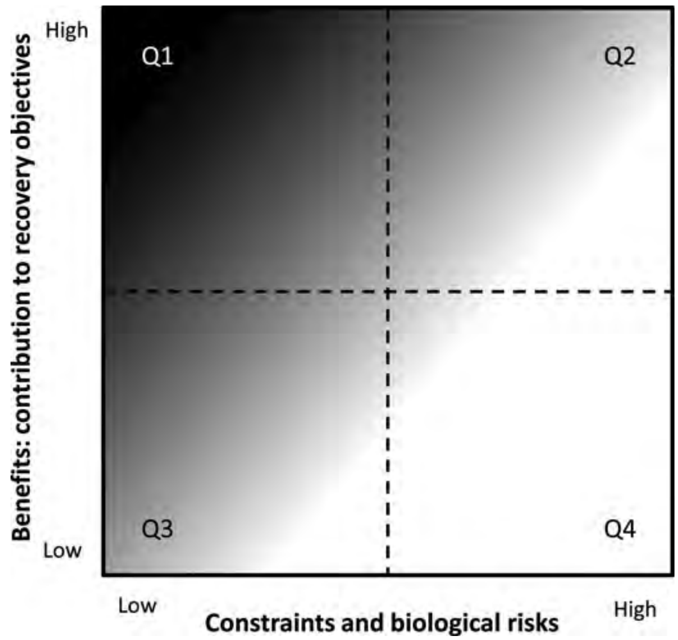

FIGURE 2. Framework for gauging the net benefit of reintroduction options, with darker colors representing a higher likelihood of contributing to conservation and recovery goals. In each case, the benefits are weighed against the constraints and risks of the project. In quadrant 1 (Q1), the benefits 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.

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 depensatory 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 currently 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 Pikeminnow *Ptychocheilus oregonensis*), species that consume a considerable quantity of salmonids (Sanderson et al. 2009; Carey et al. 2012). Competition and predation 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

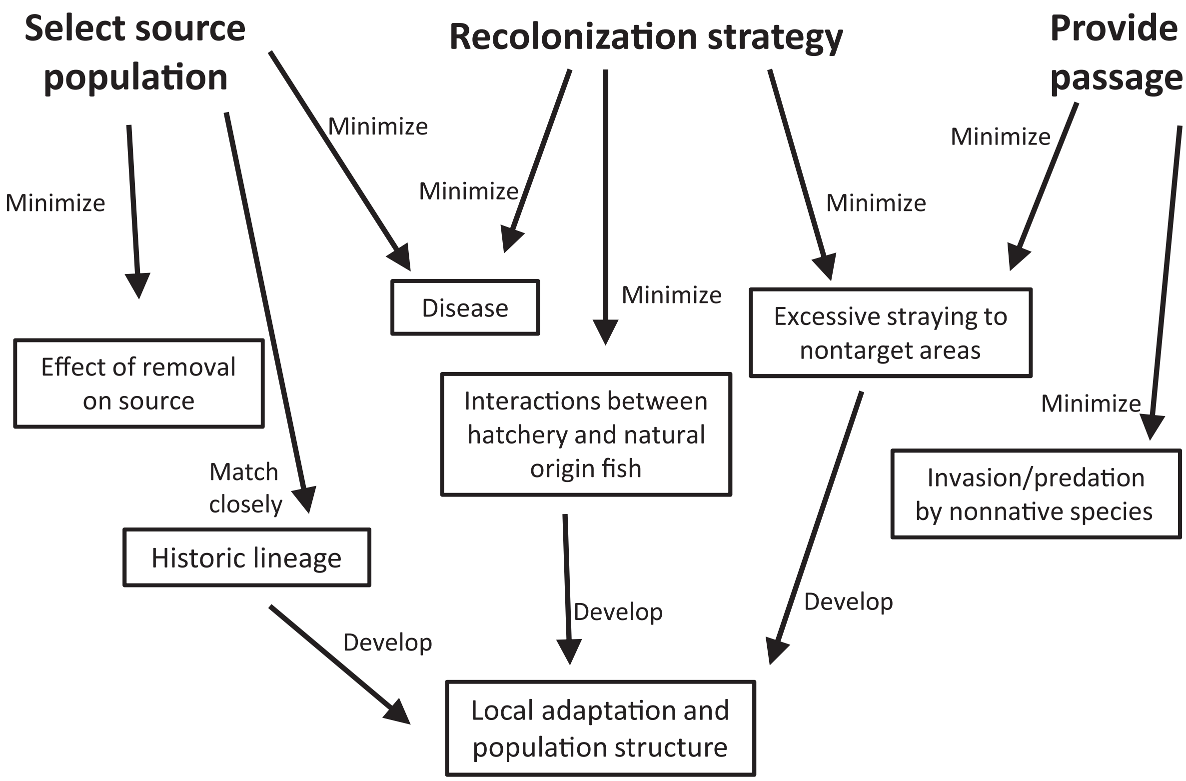

FIGURE 3. Minimizing biological risks in reintroduction planning. Biological risks are unintended negative consequences that may harm nontarget species, other populations, spawning areas, or life history types of the reintroduced species.

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 reintroductions 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

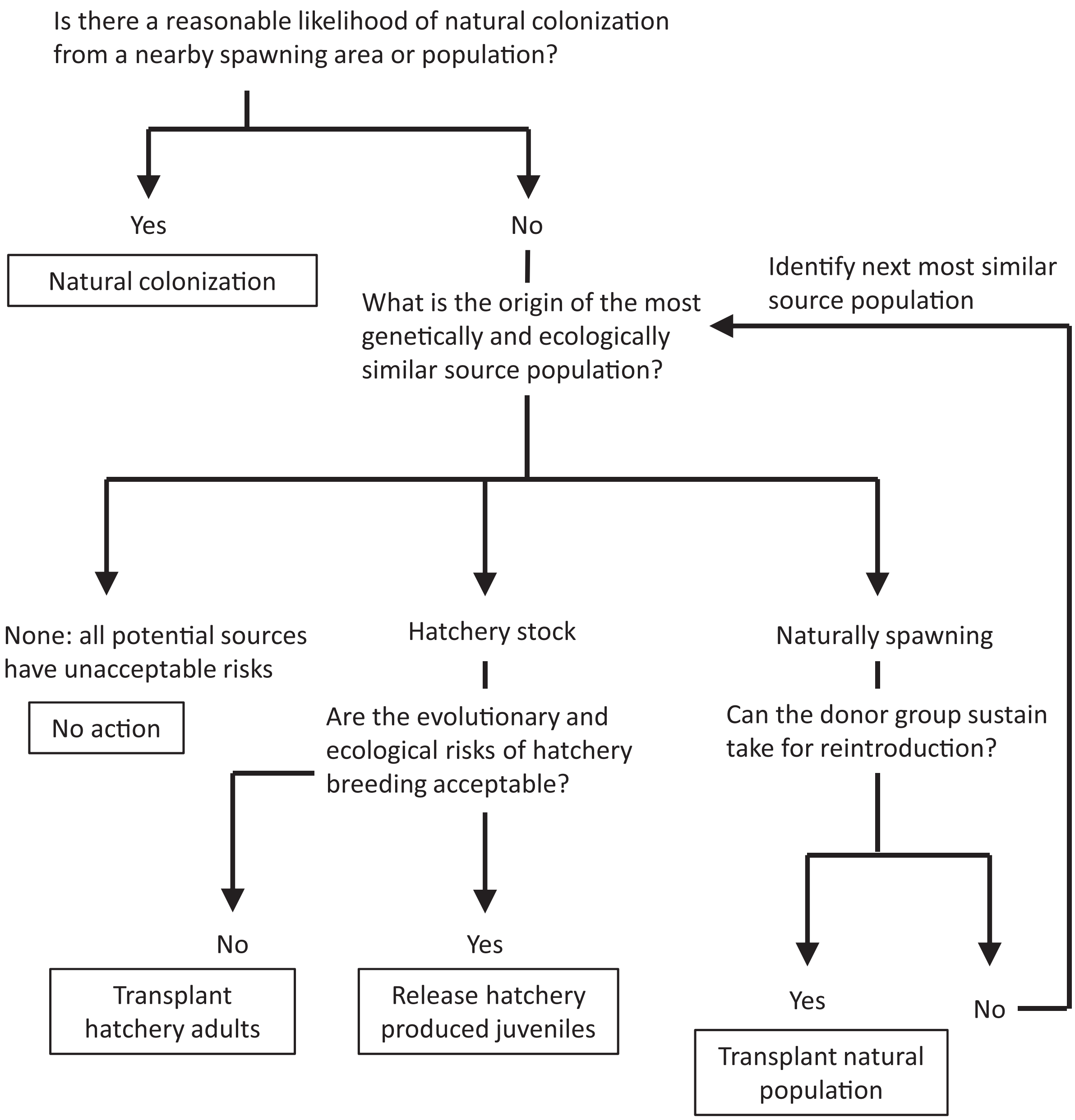

FIGURE 4. Decision framework for selecting a low-risk colonization strategy and source population. This diagram does not encompass every possibility but is intended to highlight the key decisions affecting reintroduction risks. Boxes indicate decision endpoints.

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, depensatory 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 dispersal 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[a]	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[b]	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[c]	None	Kesler et al. 2011
Beaver Creek, Washington	2005	Steelhead	Natural colonization	Fishways	Weigel et al. 2013

[a]Colonization strategy varied by river.
[b]Genetic analysis indicates that natural dispersal, not hatchery releases, were primarily responsible for colonization.
[c]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 *O. keta*, 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; Kostow 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 (Mobrand 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, impoundments 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).

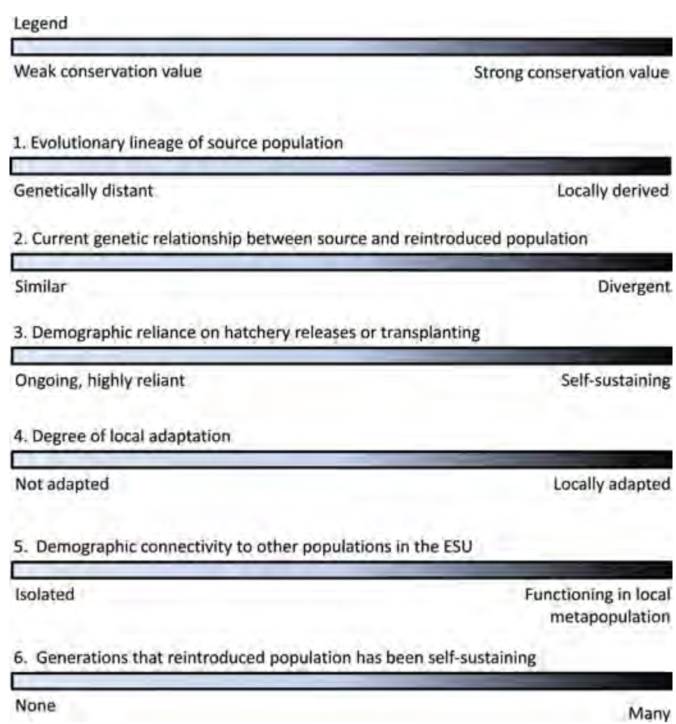

FIGURE 5. Factors to consider in evaluating the conservation value of reintroductions. Each bar is intended to represent a gradient of outcomes in between the extremes described at either end. The extent to which natural demographic, ecological, and evolutionary processes operate uninterrupted will strongly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

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LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

FISH PASSAGE FACILITIES ALTERNATIVES ASSESSMENT
TECHNICAL COMMITTEE CONFERENCE CALL

APRIL 18, 2016

FINAL MEETING NOTES AND MATERIALS

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La Grange Hydroelectric Project Licensing (FERC No. 14581)
Fish Passage Facilities Alternatives Assessment
Technical Committee Conference Call

Monday, April 18, 2016
11:00 am to 12:00 pm

Final Meeting Notes

Conference Call Attendees		
No.	**Name**	**Organization**
1	Alison Boucher	Tuolumne River Conservancy
2	Steve Boyd	Turlock Irrigation District
3	Anna Brathwaite	Modesto Irrigation District
4	Larry Byrd	Modesto Irrigation District
5	Jarvis Caldwell	HDR, consultant to the Districts
6	Jesse Deason	HDR, consultant to the Districts
7	John Devine	HDR, consultant to the Districts
8	Greg Dias	Modesto Irrigation District
9	Jason Guignard	FISHBIO, consultant to the Districts
10	Chuck Hanson	Hanson Environmental, consultant to the Districts
11	Bao Le	HDR, consultant to the Districts
12	Lonnie Moore	Citizen
13	Gretchen Murphy	California Department of Fish and Wildlife
14	Bill Sears	City and County of San Francisco
15	Chris Shutes	California Sportfishing Protection Alliance
16	Niccola Ulibarri	Stanford University
17	Scott Wilcox	Stillwater Sciences, consultant to the Districts
18	John Wooster	National Marine Fisheries Service
19	Ron Yoshiyama	City and County of San Francisco

On April 18, 2016, Turlock Irrigation District and Modesto Irrigation District (collectively, the Districts) hosted a Technical Committee conference call for the La Grange Hydroelectric Project (La Grange Project) Fish Passage Facilities Alternatives Assessment and Upper Tuolumne River Fish Reintroduction Assessment Framework (Framework). This document summarizes discussions during the meeting. It is not intended to be a transcript of the meeting.

Mr. Bao Le (HDR, consultant to the Districts) noted the deadline for Technical Committee comments on the study plans has been extended from April 22 to April 29. The Districts will revise the study plans based on comments received and will provide revised study plans to the Technical Committee for final comments. Mr. Le said the Districts plan to send final study plans to the Plenary Group ahead of Workshop No. 5, which is scheduled for May 19.

Mr. Le provided an overview of the draft study plans discussed on the March 18 Technical Committee call. Mr. Le noted that last week, the Districts sent the draft Upper Tuolumne River Instream Flow Study Plan to the Technical Committee for review and comment. Mr. Le said the lead for this study, Mr. Jarvis Caldwell (HDR), will be providing a summary of this study plan on today's call. In addition, the study leads for the other draft study plans are also on this call and available to answer any questions attendees may have on those studies.

Mr. Caldwell reviewed the goals, study area, and methodology for the Upper Tuolumne River Instream Flow Study (Instream Flow Study). Mr. John Wooster (National Marine Fisheries Service) asked if the fieldwork for this study will be completed in tandem with the fieldwork for the Upper Tuolumne River Habitat Mapping and Macroinvertebrate Assessment (Habitat Mapping Study), or if the Habitat Mapping Study will be completed first. Mr. Caldwell said the Districts plan to complete the Habitat Mapping Study first and use information collected from that study to inform study site selection for the Instream Flow Study.

Mr. Wooster asked if the Instream Flow Study will be completed in 2016. Mr. Caldwell said the study will be completed in the fall of 2016. Mr. Wooster asked if, given that schedule, the necessary flows will be available. Mr. Wooster noted that higher flows associated with rafting are generally unavailable after Labor Day. Mr. Caldwell said based on the hydrology he has reviewed, standard operations upstream of the study reach provide a range of flows on a daily basis. Mr. Caldwell said that during the five or seven days at an Instream Flow Study site, he expects the study team will be able to capture a range of flows. Mr. Caldwell noted the study team is still working out the fieldwork logistics.

Mr. Wooster said the Instream Flow Study Plan states there will be two or three study sites, but it is unclear whether that means two or three sites per river reach or two or three sites for the entire study. Mr. Caldwell said there will be two or three sites identified between Lumsden Falls and the upstream end of the Don Pedro Project.

Mr. Larry Byrd (Modesto Irrigation District) asked if there is particular reason why the study cannot be completed before Labor Day, when higher flows are available. Mr. Caldwell said it is important that the Habitat Mapping Study first be completed, as information from that study is required to help select study sites for the Instream Flow Study. Mr. Caldwell said a range of flows at each site is necessary to calibrate the model. Mr. Caldwell reiterated that the study team is still working on the schedule logistics. Mr. Byrd asked when the study site locations will be determined. Mr. Le responded that the study team had been waiting for the summer flow schedule to be released in order to finalize the summer fieldwork schedule. Mr. Le said the study team anticipates fieldwork for the Habitat Mapping Study and the Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study (Spawning Gravel Study) will be completed in late June or early July, in time to compile the results for consideration in the Instream Flow Study.

Mr. Chris Shutes (California Sportfishing Protection Alliance) said the Middle Fork American River Project relicensing instream flow model provided output in a series of tables that depicted how habitat changed from one flow to another. Mr. Shutes asked if the Districts' two dimensional (2D) model (i.e., River 2D) will be able to capture changes in habitat during flow fluctuations. Mr. Caldwell said he is familiar with the analysis Mr. Shutes is referring to, and in that project, model output was depicted using effective habitat tables, which are also known as wedge tables. Mr. Caldwell said at the site level, these tables provide some indication of how total habitat suitability (i.e., WUA) for a specific life stage changes from one flow to another, which may be important for understanding how general habitat changes with flow. Mr. Caldwell said such tables, however, do not help explain or show where the habitat goes in the river with changes in flow. This may be more important for non-mobile life stages (e.g., spawning/incubation) than for mobile life stages (e.g., fry and juvenile). Mr. Caldwell said for this study, time series analysis will be completed that will use GIS to show habitat over a range of flows. This analysis is more spatial and visual than what is provided by wedge tables.

Mr. Shutes asked for an explanation why holding habitat will not be modeled. Mr. Caldwell confirmed the study plan states holding habitat will not be modeled. Mr. Caldwell said one reason holding habitat will not be modeled is that habitat suitability criteria for holding habitat are not available. Another reason is that the Habitat Mapping Study will already be evaluating pools from the perspective of habitat holding. Mr. Caldwell said habitat generated by River 2D may be used to look at variables such as depth and velocity, but habitat suitability criteria will not be used. Mr. Caldwell noted that the ongoing Upper Tuolumne River Basin Temperature Monitoring and Modeling Study is analyzing temperature, which is a driving variable in habitat suitability. Mr. Scott Wilcox (Stillwater Sciences, consultant to the Districts) said regarding spring-run Chinook holding habitat, that particular habitat is not well-suited for modeling because the habitat is specific pools, which are better characterized by taking depth and temperature measurements at those specific locations.

Mr. Shutes requested that the Districts send out the habitat suitability criteria used for spring-run Chinook on the McCloud. Mr. Wilcox said he will send out that information.

Mr. Wooster said the study plan states that habitat suitability criteria for spring-run Chinook on the McCloud were developed for the reintroduction program. Mr. Wooster said that is not quite accurate. The study was implemented as part of the relicensing proceeding at the request of the State Water Resources Control Board (SWRCB), and not at the request of the Interagency Fish Passage Steering Committee, which was the entity working on the reintroduction program. Mr. Wooster said the study plan states the Interagency Fish Passage Steering Committee stemmed from the NMFS Recovery Plan, and this is also inaccurate. Mr. Caldwell said he will revise the study plan to clarify this. Mr. Wilcox said the SWRCB requested the study on behalf of the SWRCB as well as other agencies, including NMFS, because NMFS had stated reintroduction on the McCloud was imminent. Mr. Wilcox said regardless of how the study came about, the criteria developed by the study are relevant to this effort for the Tuolumne River. Mr. Wooster agreed the study is relevant, and he only sought to clarify how the study came about.

Mr. Wooster said that if specific flow releases are arranged as part of this study, it would be helpful for NMFS to be kept informed as those flows may have implications for NMFS fieldwork. Mr. Devine said the Districts will not be arranging specific flow releases for the Instream Flow Study and that planning for field work will be under conditions dictated by CCSF's flow schedule at the time of study implementation. However, Mr. Devine stated in order to ensure the field program for the study occurs under appropriate flow conditions, the Districts would remain in close coordination with CCSF to better understand what the likely flow schedule will be in the late summer and fall and will keep licensing participants informed of what they find out.

Mr. Le reviewed the schedule for finalizing the study plans. Mr. Le said Technical Committee comments on the study plans are due by April 29. The study leads will revise the study plans based on comments received and the Districts will provide revised drafts to the Technical Committee on May 3. Final Technical Committee comments on the study plans will be due on May 6. The Districts anticipate sending final study plans to the Plenary Group on May 10. At Workshop No. 5, which will take place on May 19, an objective will be to get approval from the Plenary Group on the study plans in time to begin implementing the studies this summer.

Mr. Le said the Districts will provide notes from this meeting.

Meeting adjourned.

ACTION ITEMS

1. The Districts will send out the habitat suitability criteria used for spring-run Chinook on the McCloud River. (complete)

2. Mr. Caldwell will revise the Instream Flow Study Plan to clarify how the McCloud River habitat suitability study came about and that the Interagency Fish Passage Steering Committee was not a result of the NMFS Recovery Plan. (complete)

DRAFT STUDY PLAN

TURLOCK IRRIGATION DISTRICT
AND
MODESTO IRRIGATION DISTRICT

LA GRANGE HYDROELECTRIC PROJECT
FERC NO. 14581

Upper Tuolumne River Instream Flow Study

March 2016

1.0 BACKGROUND

As part of the La Grange Hydroelectric Project licensing proceeding, the Districts are undertaking the Fish Passage Facilities Alternatives Assessment (Fish Passage Assessment), the goal of which 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. In September 2015, the Districts provided to licensing participants Technical Memorandum No. 1, which identified a number of information gaps critical to informing the biological and associated engineering basis of conceptual design for the Fish Passage Assessment. In November 2015, licensing participants adopted a plan to implement the Upper Tuolumne River Reintroduction Assessment Framework (Framework) intended to develop the information needed to undertake and complete the Fish Passage Assessment and to assess the overall feasibility of reintroducing anadromous salmonids into the upper Tuolumne River (TID/MID 2016). As part of implementing the Framework, a number of environmental studies are planned.

The Upper Tuolumne River Instream Flow Study is one of several studies to be implemented in 2016 in support of the Framework. Information collected during this study will be used to evaluate existing aquatic habitat and provide quantifiable metrics of aquatic habitat suitability in the upper Tuolumne River.

2.0 STUDY AREA

The study area for the Instream Flow Study is the main stem of the Tuolumne River extending from the upstream end of the Don Pedro Project (RM 81 +/-) to Early Intake (RM 105).

3.0 STUDY GOALS

The goals of this study are (1) to model existing aquatic habitat for spring-run and fall-run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (O. *mykiss*); (2) to evaluate the existing aquatic habitat over a representative range of observed water years and operations of the City and County of San Francisco's Holm powerhouse; and (3) to provide quantifiable metrics of aquatic habitat suitability in the context of potential reintroduction of Chinook salmon and steelhead.

4.0 STUDY METHODS

The following instream flow study methods are consistent with normal and customary 2-dimensional (2D) instream flow methodologies, and will provide data that are comparable to data collected and used at other salmonid-bearing streams and rivers in California and elsewhere.

The study will be performed in five steps: (1) reach and site selection; (2) field data collection; (3) hydraulic modeling; (4) aquatic habitat modeling; and (5) report preparation. Each of these steps is described below.

Step 1 – Reach and Site Selection

The establishment of study reaches and the location of a study site within each reach will be based on five primary sources of information: (1) upper Tuolumne River geomorphology; (2) watershed hydrology; (3) habitat mapping study results; (4) spawning gravel mapping study results; and (5) existing aerial imagery. Based on current information, it is expected that two or three study sites will be selected throughout the study area.

Reach segmentation in the study area will be based on geomorphic characteristics (e.g., gradient, channel width, substrate composition) and hydrologic contributions (e.g., accretion, percent contribution to overall streamflow from tributaries, effects of hydropower peaking). Based on these characteristics and results from detailed mesohabitat mapping and gravel surveys, one or more study sites will be selected in each reach. Lastly, study site selection will focus on selecting both low gradient mesohabitats (pool, run and low gradient riffle) and likely short high gradient transition mesohabitats (e.g., high gradient riffle, cascade).

Study sites will be selected of a sufficient size and habitat composition to adequately characterize, and be indicative of, the range of habitat attributes (e.g., spawning, rearing and holding) documented through previous and concurrent field data gathering efforts conducted as part of the Framework. The final length of each site will be dependent on the geomorphic characteristics and lengths of mesohabitats contained within the selected study location. The number and types of mesohabitats selected will also depend on the length and variability of mapped units in the vicinity.

While study sites will initially be developed using field and aerial imagery data sources, final site selection may also be influenced by (1) proximity to camping locations, an important logistical consideration in this remote river canyon, and (2) safety considerations, which are influenced by gradient, channel configuration, hydraulic conditions, and availability of downstream recovery/safety zones.

Step 2 – Field Data Collection

Given the remoteness and limited access to the upper Tuolumne River, field data collection at each site will be completed in one continuous five to seven day period. It is anticipated that most of the out-of-water topography will be developed using airborne Light Detection and Ranging (LiDAR) data collected by NMFS in 2015 along the upper Tuolumne River. Before use, the LiDAR data will be evaluated by a remote sensing expert for quality and study utility.

Additional topographic data will be collected using a variety of methods depending on site conditions. Initially, LiDAR coverage will be evaluated and used to describe the majority of each study site not submerged at the time of the data collection. The remaining in-water and out-of-water topographic data collection will be completed utilizing a number of survey techniques. Given the steep nature of the canyon, standard Real Time Kinematic (RTK) Global Positioning System (GPS) survey will likely not be practical. Therefore, the primary survey instruments used will be Robotic Total Stations (RTS), surveyed into a RTK GPS network. The RTS units will be used for topographic surveys conducted on foot and for single beam bathymetric surveys conducted to collect unwadable in-channel topography. Depending on river conditions and safety considerations during each survey, a variety of manned and unmanned craft may be used for bathymetric data collection. Field staff will record all relevant survey information into predefined survey log sheets throughout each survey day.

After each data collection period, the RTK static GPS data files collected by the base station will be submitted to the National Oceanic and Atmospheric Administration's (NOAA) Online Positioning User Service (OPUS). OPUS returns a position corrected and mapped into the high accuracy National Spatial Reference System (NSRS). Using Trimble Business Center software, the OPUS-corrected position will then used to correct the network of RTS collected points from each survey instrument.

Habitat modeling for certain lifestages will require that substrate classification be consistent with habitat suitability criteria (HSC). Once final HSC are defined for this study, substrate classification tables and codes will be developed for use in the field. Similarly, and if applicable, cover types will correspond to cover codes defined in HSC selected for each species.

Prior to field work, detailed substrate information from the *Upper Tuolumne River Chinook Salmon and Steelhead Spawning Gravel Mapping Study* will be reviewed and, as appropriate, used for field reference. Additionally, if aerial photos are of suitable resolution, preliminary substrate polygons will be digitized throughout each model domain. In the field, crews will use an iPad loaded with aerial photos and GIS mapping software to either validate and refine the desktop delineation or develop substrate polygons and cover features throughout each study site.

Water surface elevations (WSE), discharges, and calibration depths and velocities will be collected throughout each study site at two calibration flows. The final measured flows will ultimately depend on the hydropower peaking operations and the duration of stable flows observed at each study site. Flow stability for data collection and modeling purposes is defined as a 'steady' discharge that results in minimal fluctuation in stage (e.g., no more than +/- 0.05 ft) for a long enough duration to measure discharge, WSEs, depths and velocities throughout the study site. It is anticipated that target flows will range from approximately 200 cfs to 1,200 cfs but will be dictated by upstream hydropeaking operations during each survey period. Based on these targets, hydraulic-habitat relationships modeled in each study site will extend from approximately 50 cfs to 2,000 cfs. The final range will be determined by the overall quality of site specific rating curves and model performance.

WSE's will be surveyed using a RTS in approximately 50 locations throughout the wetted channel for each calibration flow. In addition, spatially referenced depth and velocity validation data will be collected in at approximately 50 locations by an acoustic Doppler current profiler (ADCP) or manual velocity meter depending on location and hydraulic condition. Spot velocities depths and WSE measurements will span the entire longitudinal profile of model site.

Study site discharge measurements will be made using a combination of manual velocity meters and an ADCP mounted on an OceanSciences™ trimaran or similar vessel. ADCP measurements will follow standard USGS procedures (Mueller and Wagner 2009) for measuring discharge.

On-site rating curves will be developed using a combination of stage and discharge measurements and stage recording pressure transducers. At a minimum, three stage and discharge measurements will be made at each site. To supplement these data, stage recorders, which also record temperature, will be deployed at the top and bottom of the each study site to passively record stage over the data collection period. Stage recorders may also be deployed at various locations throughout the site to monitor the rate of stage change at specific mesohabitats. To relate WSE to discharge, the WSE will be measured directly above each installed logger at the time of deployment and again when the units are retrieved. A barometric pressure transducer will also be installed at the site to compensate for changes in atmospheric pressure. For validation purposes, WSEs will be measured during calibration flow surveys in the vicinity of each recorder. In addition to providing stage data for rating curve development, stage and temperature data from the recorders will be used to inform habitat and peaking analyses, discussed in Step 5 below.

Study site photographs will be collected to document site conditions during each survey. A representative collection of site photos, arranged by calibration survey flow will provided in a report attachment.

Step 3 – Hydraulic Modeling

Surface and Mesh Development

Hydraulic modeling for the study site will use River2D (Steffler and Blackburn 2002). The River2D model uses the finite element method to solve the basic equations of vertically averaged 2D flow incorporating mass and momentum conservation in the two horizontal dimensions (Steffler and Blackburn 2002).

The main input parameters for the River2D model include channel surface topography, bed roughness (in the form of an effective roughness height), and upstream and downstream hydraulic boundary conditions (i.e., water levels and discharge). Accurate topography is the primary variable that allows for the development of a well calibrated model.

Topographic surfaces will be constructed by combining the total station survey data, RTS and RTK GPS standard survey data, bathymetric data, and the LiDAR ground return data. In order to increase the definition in areas of topographic gradient and variability, breaklines will be defined within the topographic surface. Breaklines enforce the topographic surface to 'snap' to the entire length of the line and are used to define features with large vertical gradient changes, such as cascades, toe of slopes, and boulders.

Before entering the data into the River2D model, topographic data from the site will be reviewed for errors in ArcMap and ArcScene. Triangulated Irregular Networks (TINs) will be developed to visualize the data in two and three dimensions

Mesh development will follow procedures outlined in the R2D_Mesh User's Manual (Waddle and Steffler 2002). When building a computational mesh, it is important to optimize for computational performance without sacrificing mesh quality. Using the topographic surface nodes to define the mesh is not recommended as the computational requirements for such a model exceed the limits of the software and currently available computer hardware. Instead, a low density uniform mesh is developed and then refined using a variety of techniques.

As recommended by the R2D_Mesh User's Manual, a balance between mesh density and computational burden will be addressed in part by applying a procedure called 'wet refinement' which places nodes at the centroid of each mesh element. This process ensures the appropriate mesh density in wetted areas only, while limiting mesh density in dry areas.

Another method used to refine the mesh is to review mesh-generated elevation contours as compared to bed elevation contours at an interval of 0.82-foot with a goal of close contour approximation. Since the topographic points and mesh nodes are not in the same location, the contours will not be exactly the same. Therefore, to increase contour agreement, additional nodes may be added in topographically complex areas. To achieve the appropriate mesh density over all simulation flows, the mesh will be iteratively refined in the context of the full range of possible wetted areas.

A third method used to refine the mesh will be to identify large elevation differences between topographic data points and the interpolated elevation of each mesh triangle. Most often, large elevation differences exist in areas of high gradient (e.g., cascade) or significant localized topographic relief (e.g., cliff or vertical bank). Mesh triangles that exceed a 0.82-ft difference threshold are highlighted yellow in the mesh development software and further refined until the difference is no longer detected.

QI is a mesh quality index where a value of 1.0 represents a mesh comprised of perfect equilateral triangles. The goal minimum triangle quality index (QI) for each computational mesh is 0.15. Low QI values (i.e., <0.10) do not necessarily compromise model quality, but will increase computational run times. Tools in the mesh development software are used to improve geometry to achieve the minimum goal QI value.

One initial base mesh used for model calibration will be used for all simulation runs. However, it will be necessary to make small changes if model run time errors (i.e., eddy shedding velocity oscillation, extremely high velocity, or Froude number) occur.

Model Calibration

Model parameters such as bed roughness (Ks, in the form of an effective roughness height), substrate transmissivity (tr) and eddy viscosity can be adjusted during model calibration to reflect field conditions. A stage-wise approach with target criteria for model performance will be used to guide calibration. The specific stages and criteria are discussed below.

For the initial hydraulic model, hydraulic calibration tests will be conducted using the target calibration flows of 200 cfs and 1,200 cfs. Bed roughness (Ks) and transmissivity (tr) will be varied as necessary to match observed WSEs and wetted area. As part of normal calibration, Ks and tr values are incrementally adjusted through an integrative sensitivity analysis until modeled WSEs calibrate well to observed WSEs. In addition to the WSE comparisons, velocity and depth predictions will be compared to field measured data to evaluate changes made to Ks.

The term "Ks" is scientific notation for bed roughness factor (in meters) and the term refers to gradation of material in the river. Compared to traditional one-dimensional models, where many two-dimensional effects are abstracted into the resistance factor, the 2D resistance term accounts only for the direct bed shear (Steffler and Blackburn 2002). Ks is iteratively varied as necessary to match observed water surface elevations using the default transmissivity of tr = 0.1. In general, the initial Ks value entered is 1-3 times the grain size documented during field data collection. Multiple regional Ks values (i.e., heterogeneous substrate material and/or large elevation changes) may be selected for each study site based on model performance.

Groundwater transmissivity (tr) is a user-defined variable which corresponds to groundwater flow and the relationship to surface flow. The default value is 0.1 which ensures that groundwater discharge is negligible. Because subsurface flow through gravel or cobble may be present at the study site, it may be necessary to modify the default value of tr to aid in the wetting and drying function throughout the model domain.

The target criterion for mean error in WSE between simulated versus observed data is, to a large extent, based on the accuracy of the survey equipment used to measure WSE. It is also important to recognize the influence of highly heterogeneous or high gradient topography (e.g., cascades and high gradient riffles) habitats on differences between field data and model data. Given the expected range of site characteristics in the upper Tuolumne River an average of 0.10 ft difference between simulated and observed WSE will be targeted.

Similarly, no specific target calibration criteria exist for velocity or depth parameters as these variables are greatly influenced by the differences in topographic detail between the field conditions, initial bed file detail, and the final bed detail resulting from the interpolated mesh. Using professional judgment and standard industry practice, velocity and depth variables are reviewed for reasonableness and significant errors in depth (i.e., > 0.33 ft mean error) and velocity (i.e., > 0.5 fps mean error) are evaluated. For all sets of model calibration variables, the correlation coefficient (r) and the coefficient of determination (r2) (i.e., percent of variance in an indicator variable explained by a factor and the measure of the proportion of variance of model results, respectively) will be calculated. In general, coefficients greater than 0.7 are expected while coefficient of determination values for velocity magnitude are expected to be within a range of 0.4 and 0.8 (Pasternack 2011).

Flow field velocity vectors (i.e., the direction and magnitude) are used to evaluate velocity prediction reasonableness during the calibration process but are otherwise not incorporated into the statistical review process.

Model convergence for a given hydraulic simulation is achieved and accepted when the inflow (Qin) equals outflow (Qout) and the solution change is nominal. Solution change is the relative change in the solution variable over the last time step. Specific criteria thresholds do not exist for these parameters and are largely based on the magnitude of the simulation discharge and the professional judgment of the modeler. The target solution change goal will be 0.0001. This target value is consistent with recommendations made in the River2D User's Manual (Steffler and Blackburn 2002).

Step 4 – Aquatic Habitat Modeling

Habitat Suitability Criteria

HSC define the range of microhabitat variables that are suitable for a particular species and lifestage of interest. HSC provide the biological criteria input to the River2D model which combines the physical habitat data and the habitat suitability criteria into a site-wide habitat suitability index (i.e., Weighted Usable Area or WUA) over a range of simulation flows. Variables typically defined with HSC include depth, velocity, instream cover and bottom substrate. HSC values range from 0.0 to 1.0, indicating habitat conditions that are unsuitable to optimal, respectively. WUA is defined as the sum of stream surface area within a nodal area model domain or stream reach, weighted by multiplying area by habitat suitability variables, most often velocity, depth, and substrate or cover, which range from 0.0 to 1.0 each.

Spring-run Chinook salmon HSC information compiled for the McCloud River, a tributary of the Sacramento River, will be used for habitat modeling. The HSC were recently developed for use in a PHABSIM study related to the Interagency Fish Passage Steering Committee's draft recovery plan (NMFS 2009) for reintroduction of Chinook salmon upstream of Shasta Lake. The PHABSIM study was conducted for PG&E's McCloud Pit Hydroelectric Project (FERC No. 2106) (PG&E 2012). Using the best available HSC information and professional judgment, composite curves were developed for spawning, fry and juvenile lifestages. Holding HSC were not developed in the process. Holding habitat will be evaluated in the *Upper Tuolumne River Habitat Mapping and Macroinvertebrate Assessment*. Model results from this study may, however, inform the suitability of holding habitat. Spring-run periodicity information will rely upon information provided in Technical Memorandum No. 1 (TID/MID 2015).

Steelhead and fall-run Chinook salmon HSC information developed for the lower Tuolumne River instream flow study (Stillwater Sciences 2013) will be used to model habitat suitability in this study. Spawning and juvenile lifestages will be modeled. The Districts note that the lower Tuolumne River HSC may require some modification to appropriately be used in the upper Tuolumne River channel. Modifications to HSC will be made by a regional HSC expert familiar with the proposed curves and any changes will be thoroughly documented in the final report. Periodicity information for these species will rely upon information provided in Technical Memorandum No. 1 (TID/MID 2015).

Model Simulation

Approximately 18 discharges will be simulated for each study site resulting in an expected flow range of 50 cfs to 2,000 cfs. Habitat suitability and WUA for all fish species and lifestages will be calculated for each simulation flow. In order to calculate habitat suitability, four data inputs are required: a fish preference file (i.e., HSC), a channel index, depth, and velocity. A fish preference file is loaded into River2D as a text file. Depth and velocity values are provided from the model once a simulation has converged and is at a steady state. Channel index files are a River2D model file equivalent to a substrate and/or cover map of the entire study site. Substrate may only be applicable to the spawning lifestages and possibly fry/juvenile lifestages (as a cover component) but will depend on the HSC used.

For this study, the habitat suitability calculation will use the standard triple product function which multiplies depth, velocity, and channel index suitability together at each model node. Channel index interpolation will be defined using discrete node selection (i.e., nearest node rather than a continuous linear interpolation of the channel index values from surrounding nodes). Discrete node selection is typically applied to substrate classifications such that the original substrate code value is maintained. If cover codes are defined for the proposed HSC, continuous interpolation will be applied to cover indices where a gradient of cover may be best described by the interpolation function.

Hydropeaking Analysis – Habitat Persistence

It is of particular importance to evaluate and understand the potential effect of hydropeaking operations on the habitat utilized by various lifestages of aquatic organisms. For example, an area with suitable depth, velocity and substrate for spawning adults at one flow may become unsuitable as flows rise or recede over a large range of hydropeaking operations. At some point, if redds were developed at a high flow, they may become dewatered at lower flows. Similarly, it is important to understand the spatial and temporal distribution of habitat for fry and juvenile salmonids. Suitable rearing habitat at one flow may quickly become unsuitable and shift in location when flows rapidly increase or decrease. These analyses are often termed habitat effectiveness, or habitat persistence. These terms relate to the temporal and spatial change in habitat suitability and distribution under changing flow conditions.

Within each model domain, regions of special interest (e.g., spawning gravel patches) will be identified. The areas of interest (AOI) will be areas that could provide suitable spawning and rearing habitat under a range of flow conditions. Polygons representing the AOI regions will be digitized in ArcGIS in order to extract data from model nodes in the computational mesh.

Relying on information generated from each of the model simulation runs, model parameters such as suitability, WSE, velocity and depth will be extracted at each model node such that changes in each parameter, per unit discharge, can be calculated and evaluated. These analyses will be conducted using Geographic Information System (GIS) and spreadsheet tools.

Effects on aquatic habitat from daily changes in power plant operation will be modeled for time periods specified by species and lifestage periodicity and will be initially conducted at 15-minute to 1-hr time intervals using data collected at each site by stage recorders. Additional longer duration analyses will focus on weekly or monthly time steps and rely on hydrologic time series data from representative water years (e.g., dry, normal and wet). Results for the selected AOI regions in each model domain will be reported in both tabular and spatial form.

Step 5 – Reporting

A detailed technical memorandum will be provided that includes the following sections: (1) Study Goals and Objectives; (2) Methods; (3) Results; (4) Discussion; and (5) Description of Variances from the study plan, if any. A number of report attachments will include, but not be limited to, additional data such as representative site photographs and, habitat suitability maps. Models and interactive spreadsheets will be made available on CD.

5.0 STUDY SCHEDULE

Final study sites will be selected once data from habitat mapping and spawning gravel surveys are completed and data evaluated. Field data collection is anticipated to commence in the fall of 2016. Hydraulic and habitat modeling and associated analyses will be conducted in the fall of 2016 and winter of 2017. A progress report will be included in the February 2017 Updated Study Report.

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