Fish Passage Design and Implementation Lessons Learned

A Concurrent Session at the 40th Annual Salmonid Restoration Conference held in Fortuna, California from April 25−28, 2023

Session Coordinators:

- Jason Q. White, Environmental Science Associates
  P. Travis James, Michael Love & Associates
  Luke Walton, Prunuske Chatham, Inc.

Fish passage remains a significant issue for salmonids throughout California. Salmonids' life history strategy to move about and utilize various habitats within a watershed is critical to their survival as a species, particularly in the face of climate change. Barriers that prevent fish movement can break the salmonid life cycle with dire consequences to a population in a given watershed. The California Department of Fish and Wildlife collects barrier data from various agencies and organizations in California and compiles them into the Passage Assessment Database (PAD). The PAD currently lists thousands of total, partial, and temporal barriers in the State in need of removal. The PAD also lists hundreds of barriers that have been remediated. Though there is much work to do when it comes to addressing fish passage in California, many barriers have already been successfully removed, with a wide range of successes and setbacks that can be learned from.

This session focuses on fish passage design and implementation lessons learned. It's been over 13 years since the release of the Part XII of California Salmonid Stream Habitat Restoration Manual: Fish Passage Design and Implementation. The work that has been performed under the guidance of this manual and beyond has much to offer in the way of lessons learned. This session will cover recent innovations, practical experiences, and challenges encountered in designing and implementing fish passage projects throughout the State of California.

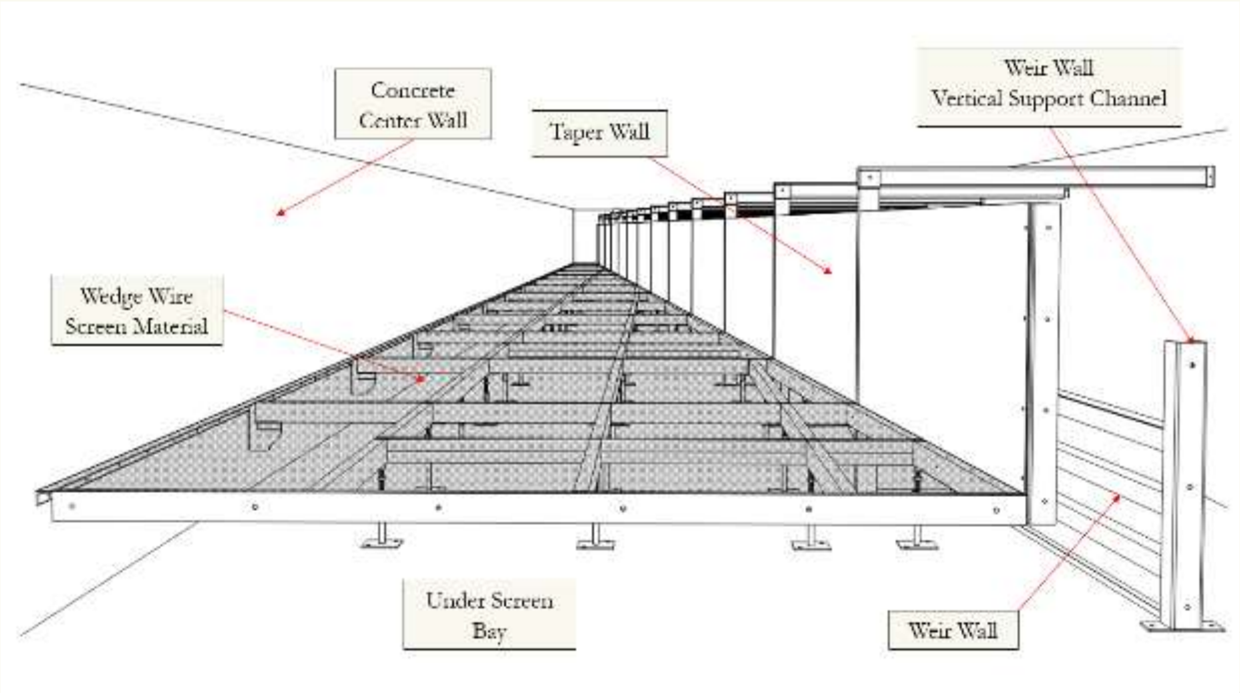
Presentations

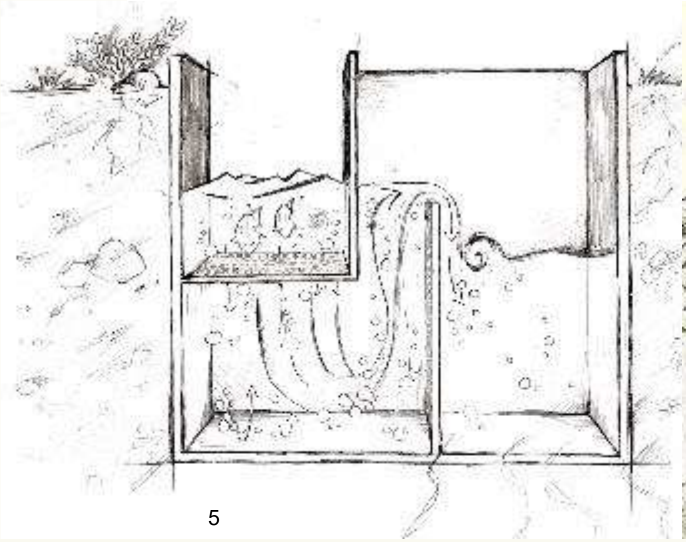
- Slide 4, **Lesson Learned Constructing a Horizontal Fish Screen at Derby Dam,** Dan Kaler, PE, *Farmers Conservation Alliance*
- Slide 21, **Carmel River Reroute and Dam Removal Project: Challenges in Design and Construction of a Step-pool Channel,** Robert Mussetter, Program Manager, *Tetra Tech, Inc.*
- Slide 47, **Mill Creek Fish Passage Project: Design, Construction & Lessons Learned,** Justin Bodell RLA, Landscape Architect, PCI
- Slide 62, **Embrace Change: Combining Engineering and Geomorphic Principles to Design Resilient Fish Passage on San Geronimo Creek**, Jason Q. White, Hydrologist, *Environmental Science Associates*
- Slide 111, **Implementation When Design Cannot Progress Past a Conceptual Level: North Fork Battle Creek Fish Passage Improvement Project**, P. Travis James, P.E., Senior Project Engineer, *Michael Love & Associates, Inc.*
- Slide 178, **Beale Lake Dam Removal and Roughened Ramp**, Mark Gard, Senior Hydraulic Engineer, *California Department of Fish and Wildlife*
- Slide 229, **Final Design, Material Sourcing, and Construction Methods of the Nelson Dam Roughened Channel Fishway**, Michael C. Garello, PE , *HDR Engineering, Inc.*

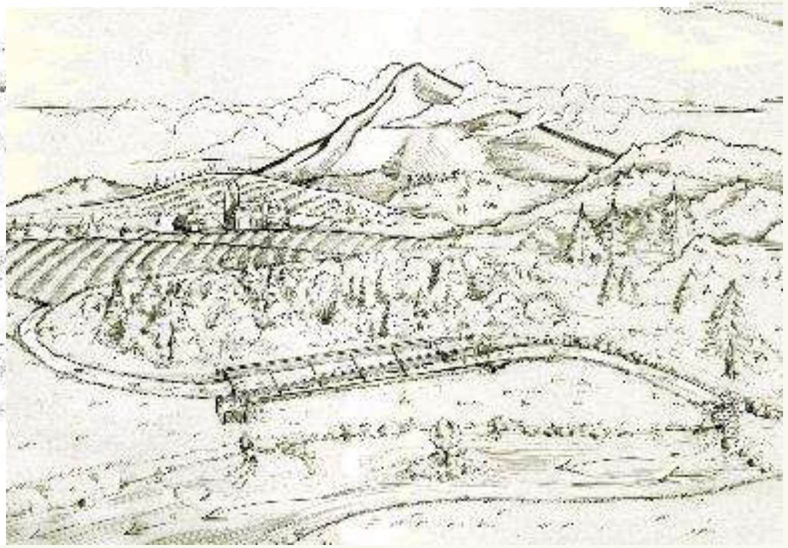
Derby Dam Horizontal Fish Screen
Farmers Conservation Alliance

Farmers Screen

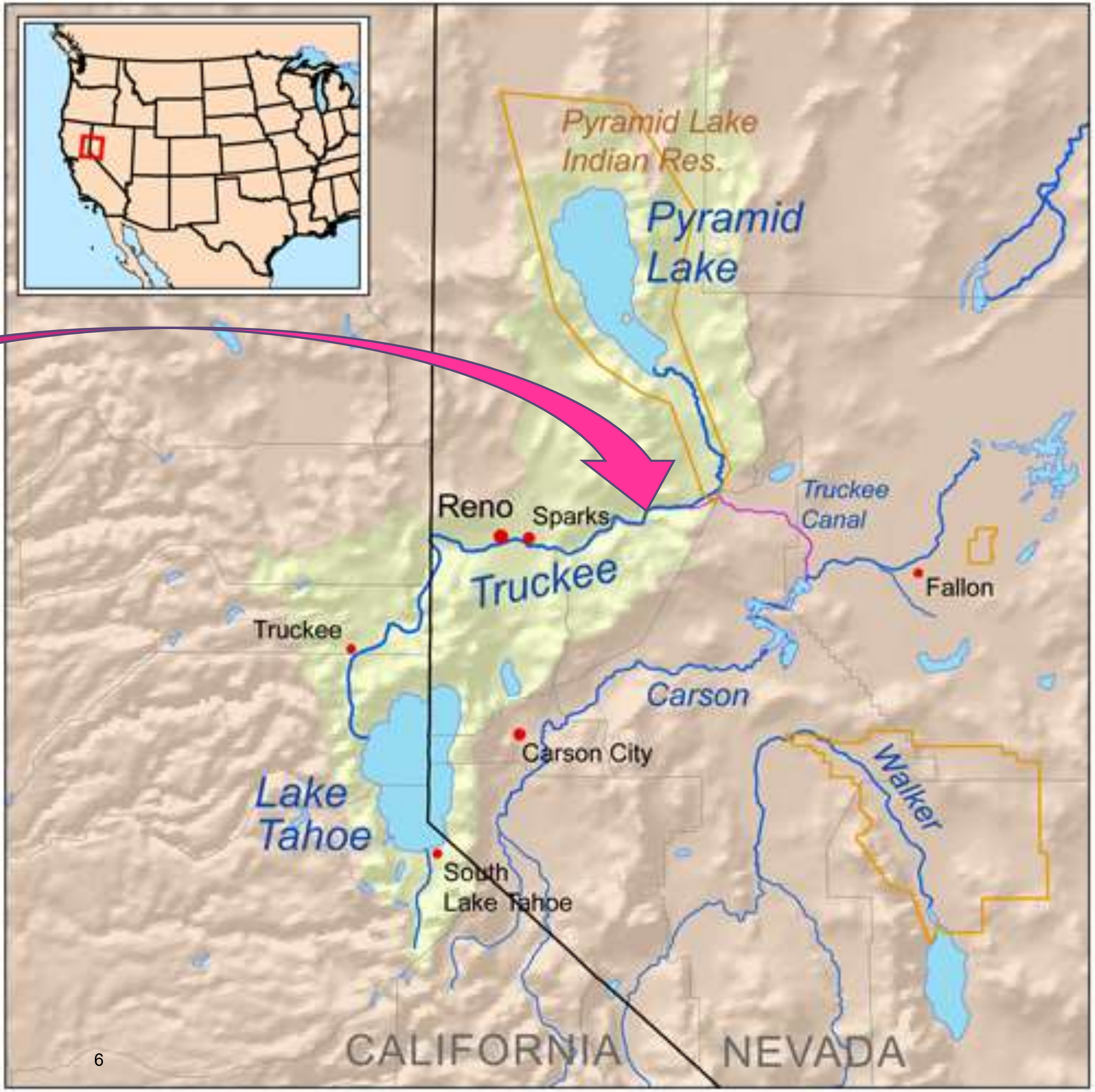
- Horizontal Fish Screen
  - Bypass flow required
  - Uses energy of the river to operate
  - No continuous moving parts
  - Passive cleaning properties
  - Low operation and maintenance
  - NMFS Approved
- Derby Dam – Largest Horizontal Screen in the World
- 52 Screens installed across 8 states
  - UT, CO, MT, OR, WA, NV, ID, WY







Truckee River



Source: https://en.wikipedia.org/wiki/Truckee_River

Lahontan Cutthroat Trout (LCT)

- Extirpated from Truckee River in 1940's
- 1970s Out-of-Basin Population Found
- Rehabilitation Efforts
- 2014 – First Observed Spawning

Source: Western Native Trout Association

Fish Passage

- Upstream fish passage
- Down stream fish passage

Derby Dam Fish Screen

- Five screen array
- 40 – 600 cfs
- Stainless steel
- Fish return

November 4, 2019

March 10, 2020

August 13, 2020

September 25, 2020

Lessons Learned

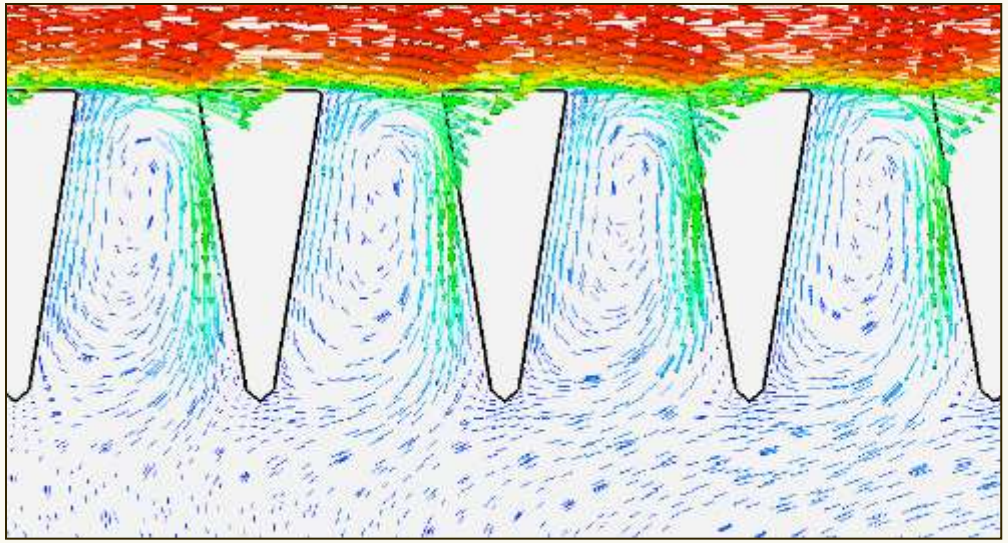
- Team Collaboration
  - Team Building
    - Formal and Informal
  - CMAR Process
  - Pre-Construction Collaboration
  - What are the pieces you remember?

Lessons Learned

- Construction
  - Define success
  - Construction meetings
  - QA/QC representative
  - Clear line of communication
  - Construction camera

Lessons Learned

- Screen Design/Operation
  - Over 20 years of experience
  - Over 50 installations
  - Physical and theoretical models
  - Optimization study



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Carmel River Reroute and Dam Removal: *Challenges in Design and Construction of a Step-pool Channel*

Robert Mussetter, Tetra Tech

Shawn Chartrand, Simon Fraser University

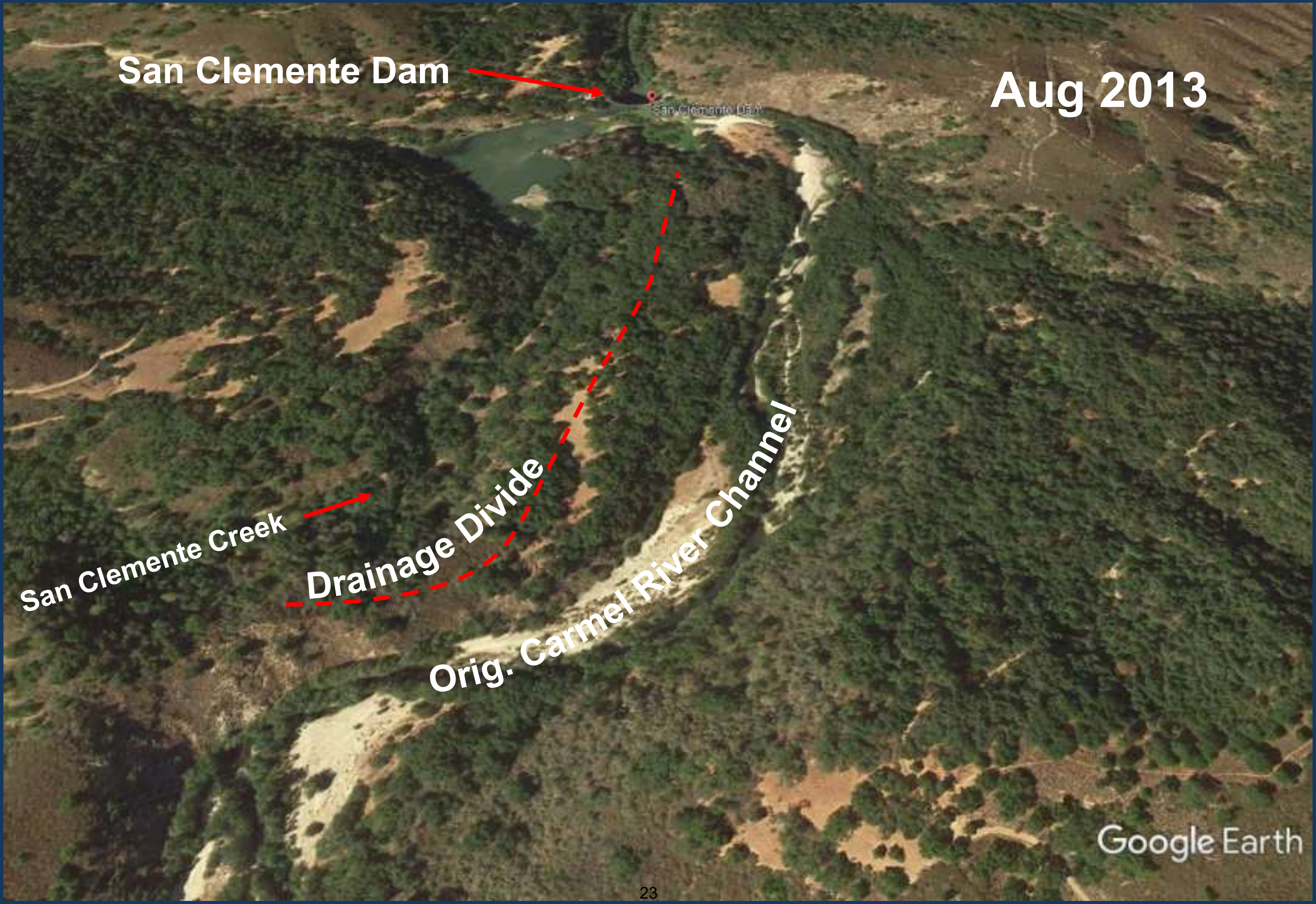
Brian Cluer, NOAA Fisheries

Michael Burke, Interfluve

Marcin Whitman, CDFW

San Clemente Dam

Site Conditions



Site Conditions

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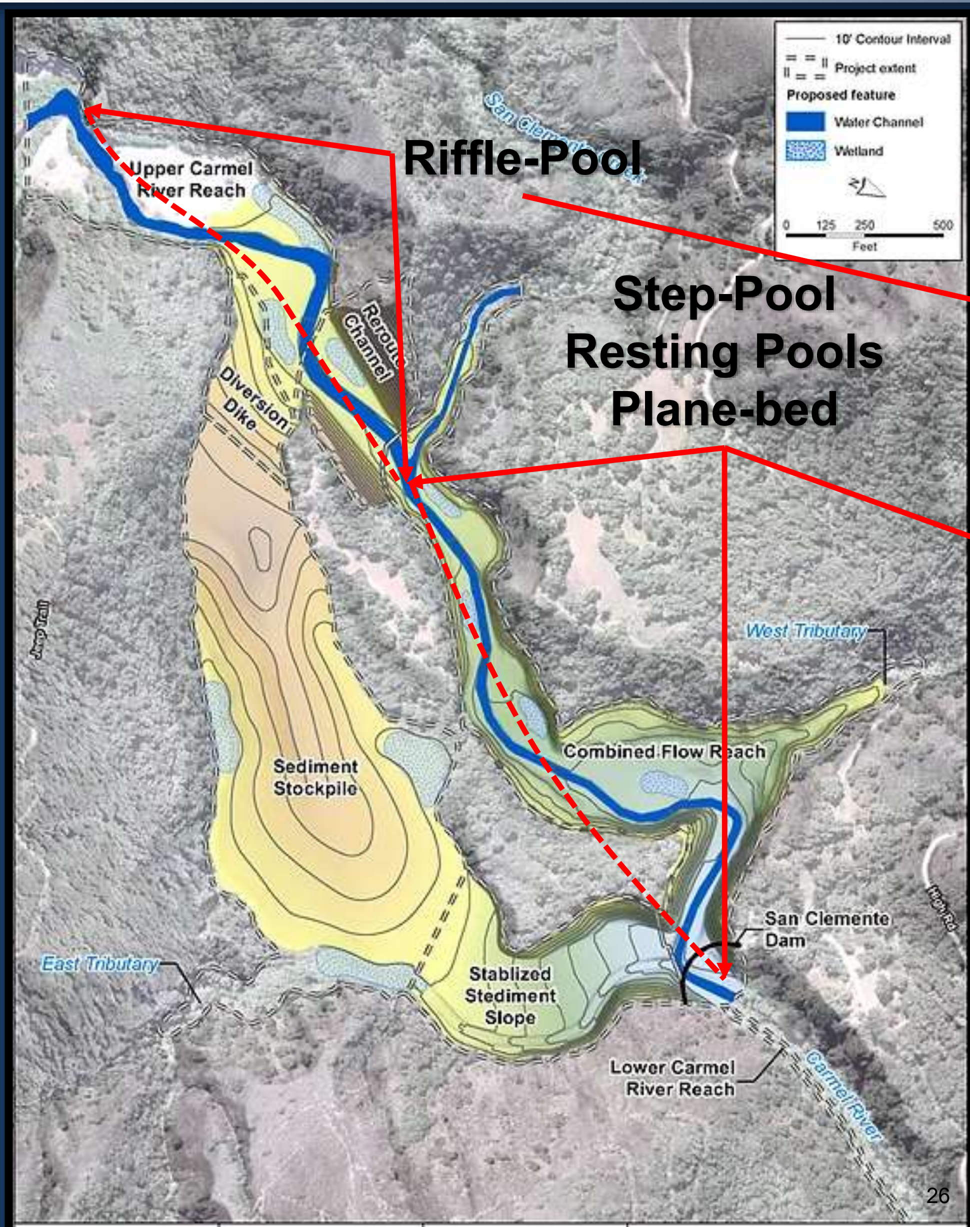
Channel Reconstruction Objectives

1. Fish Passage
   - Short-term:
     - Provide immediate passage
     - Focused on low flows
   - Long-term:
     - Resiliency for future storms
2. Restore and sustain high quality aquatic habitat
3. Sustainable long-term river processes and function
4. Emulate natural variability in channel form

Design Concept



Design Criteria – Combined Flow Reach

Variable design level by feature:

- In-channel: Q_5 - Q_{50}
- Overbanks:
  - Q_{10} (no avulsion 1st 5 yrs)
  - Boulder and substrate recruitment ($Q_{25,}$ Q_5)

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Design Criteria

In-channel hydraulic criteria

- **16 cfs to 1,260 cfs**
  (~5%-95% Mean daily FDC)
- **Details highly prescribed**
- **Bankfull capacity Q_1-Q_2**

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Design Criteria – Step Pools

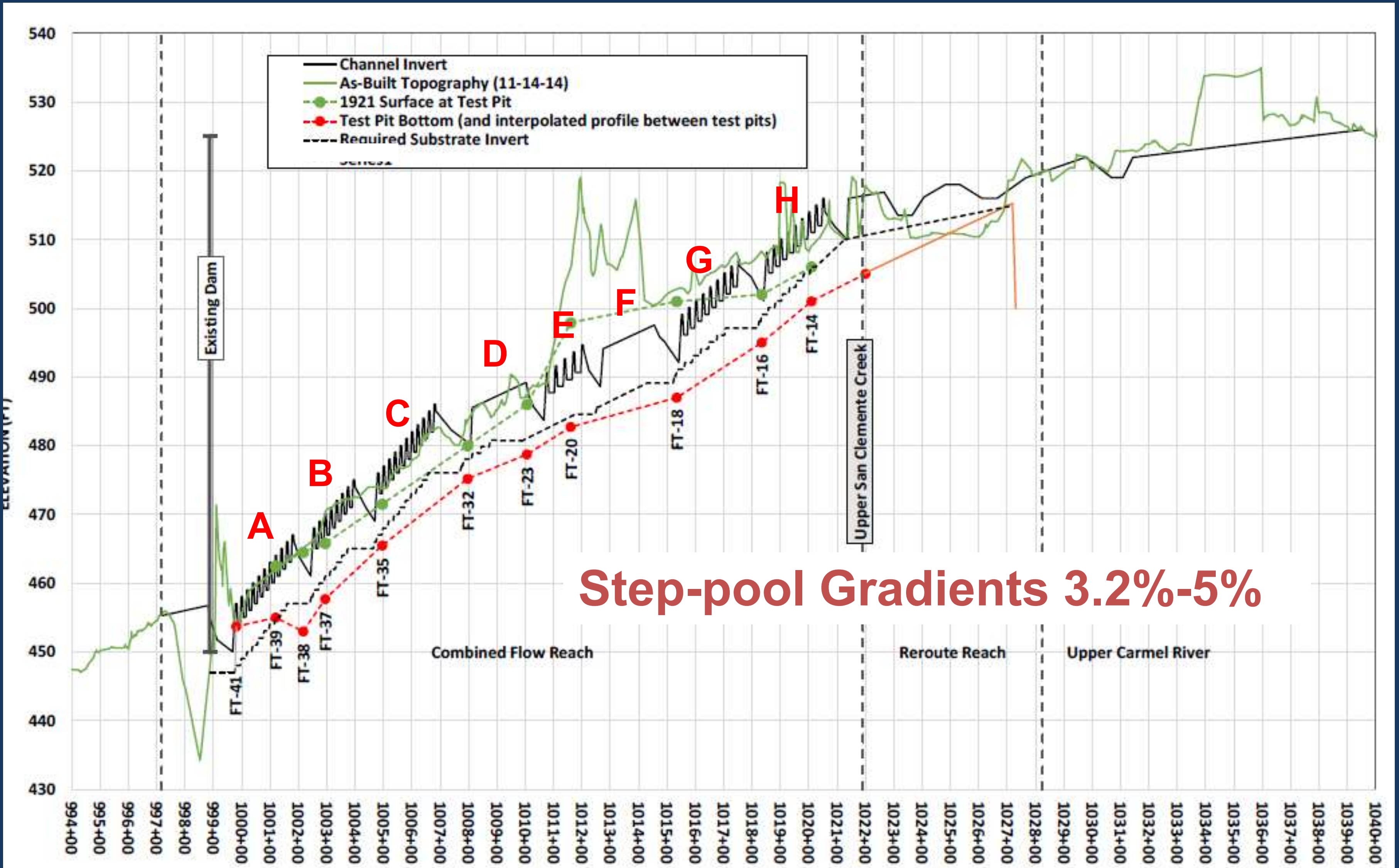
Step-pools

- Max Drop Height: 1'
- Min 2' depth downstream from steps

Resting Pools

- LWD>=40% pool margin for cover habitat:

Channel Profiles



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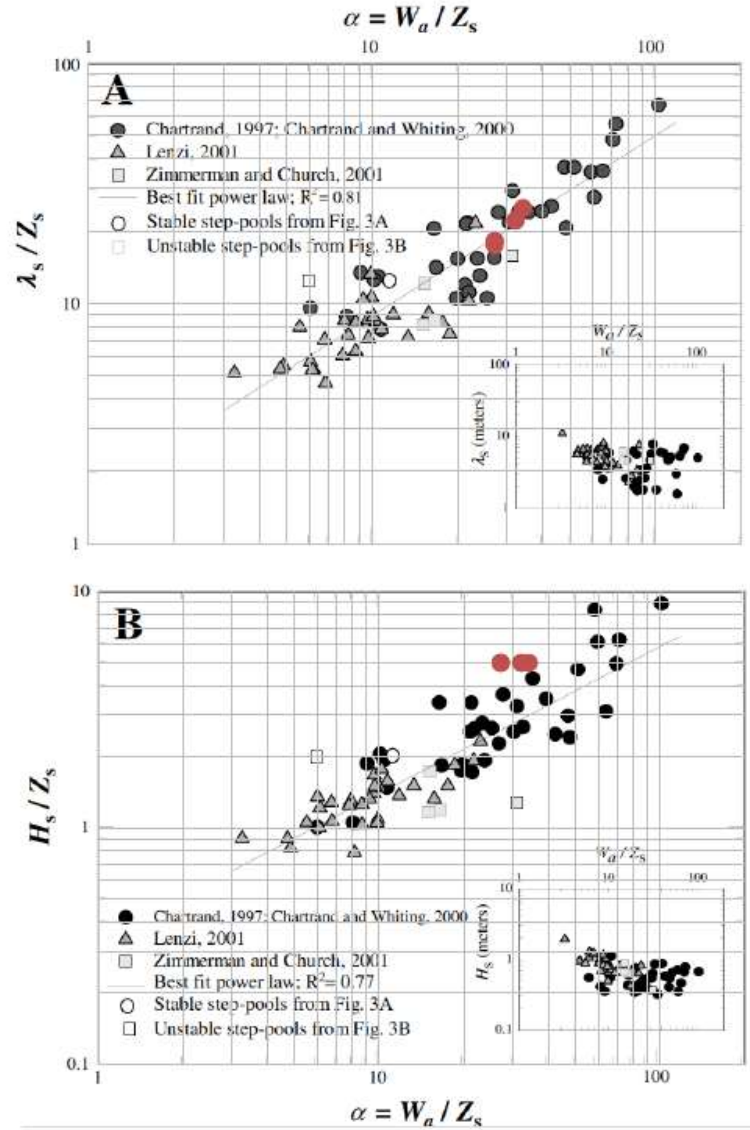
Chartrand (2011)



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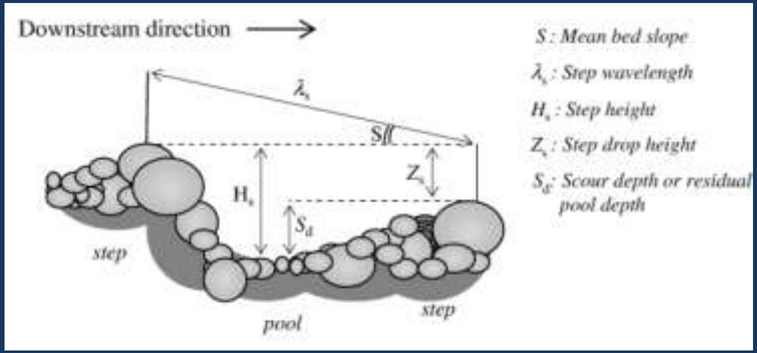
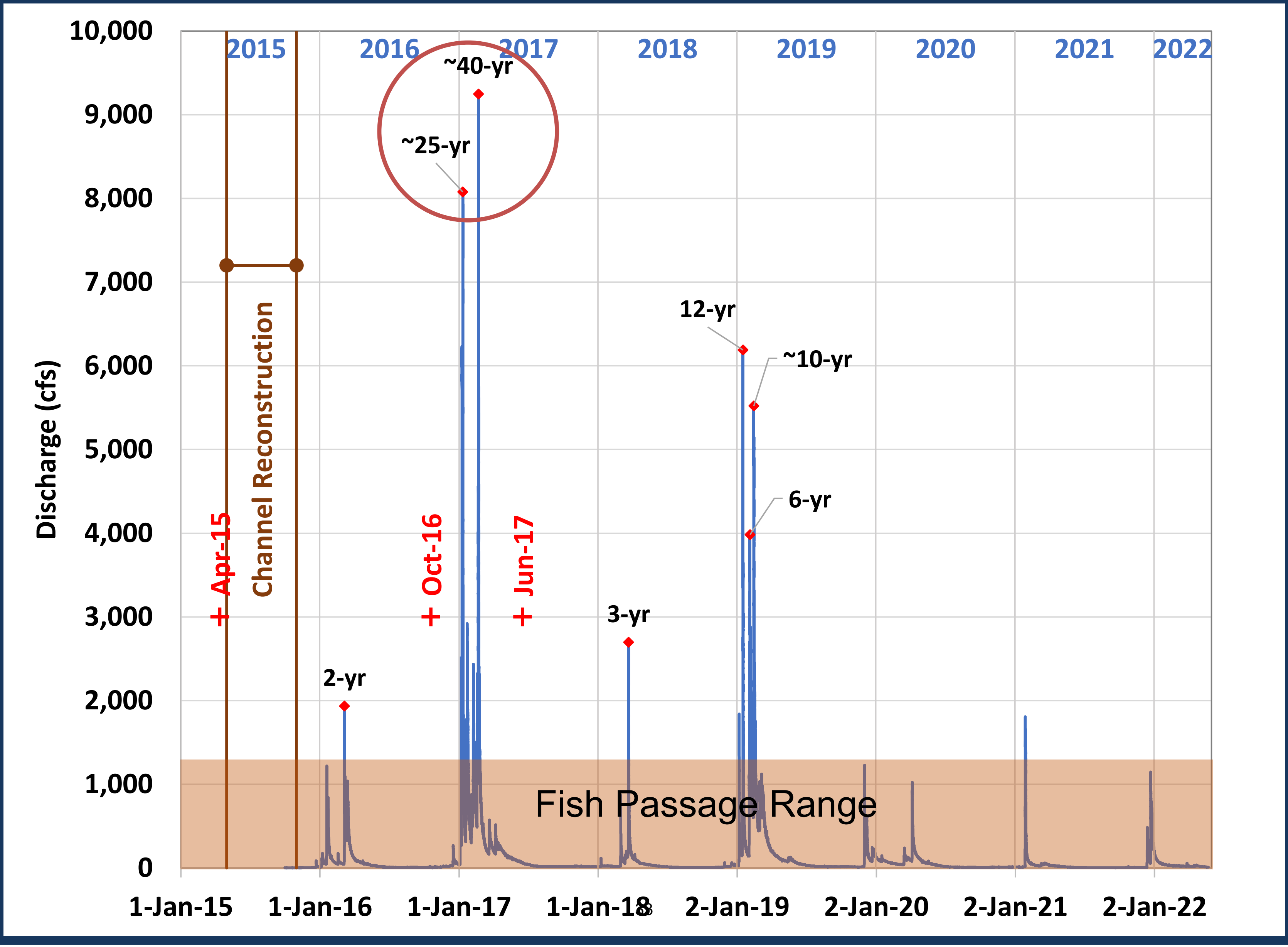
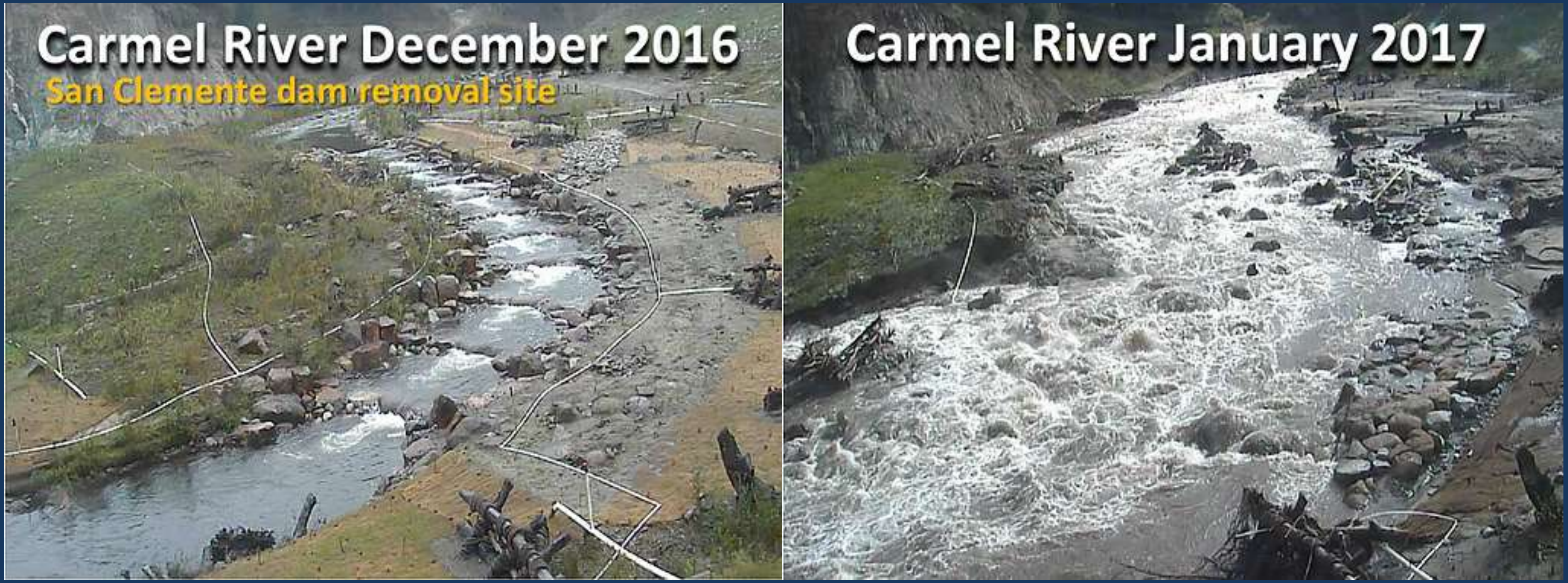


After 1st Const. Season and Small Events

And Then the Floods Came!



Then the Floods Came!



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Then the Floods Came!

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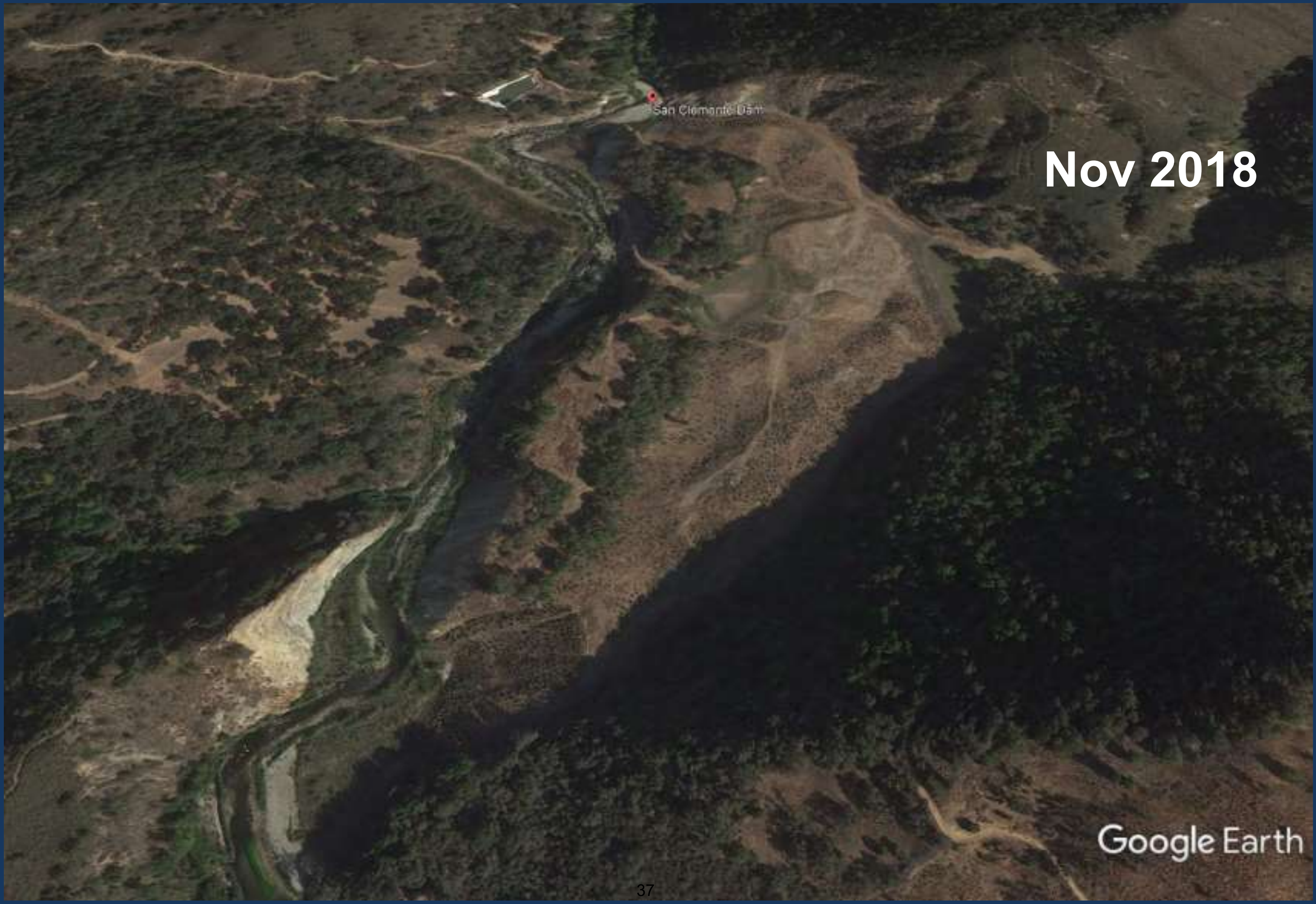

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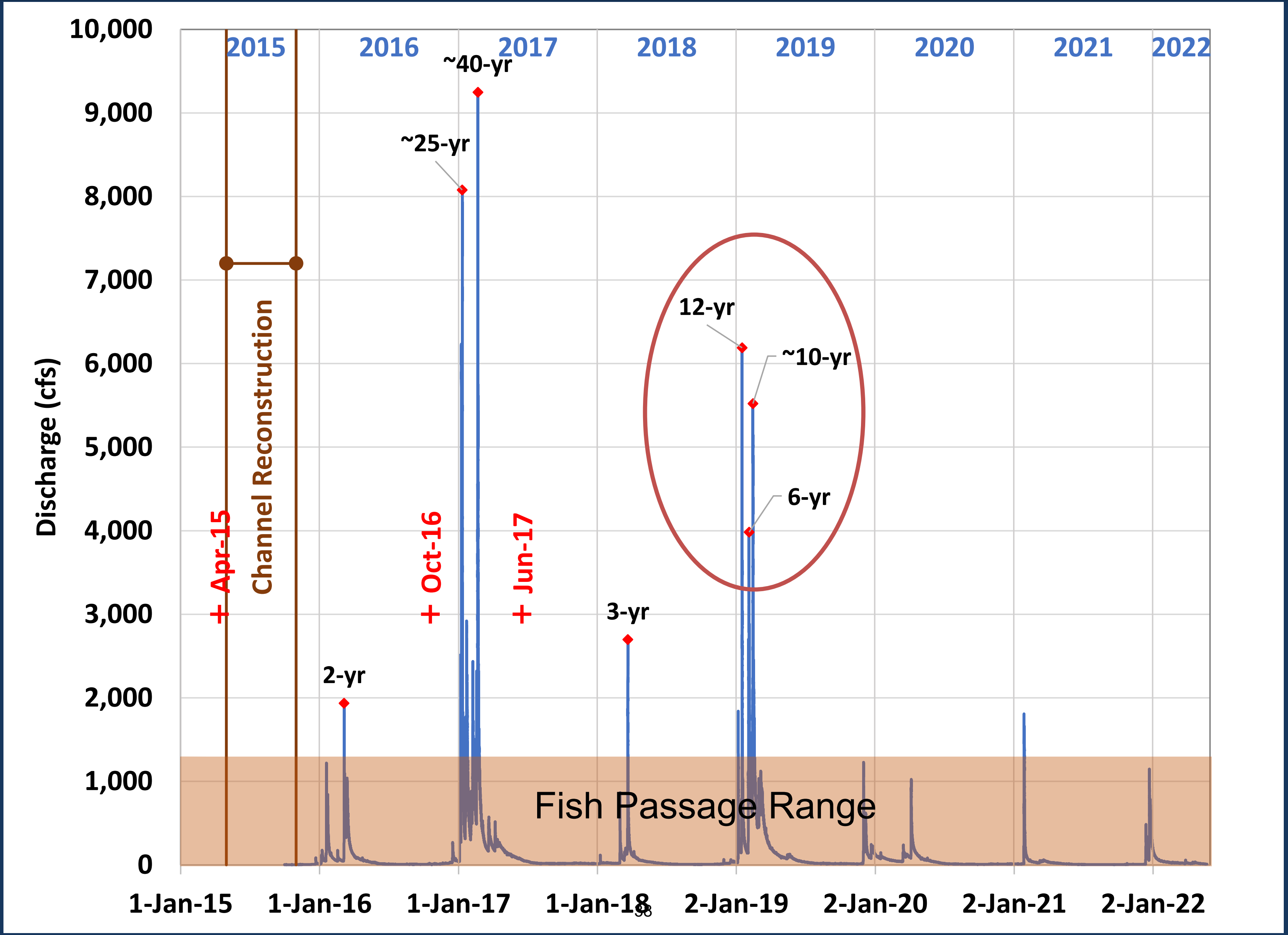
Then the Floods Came!



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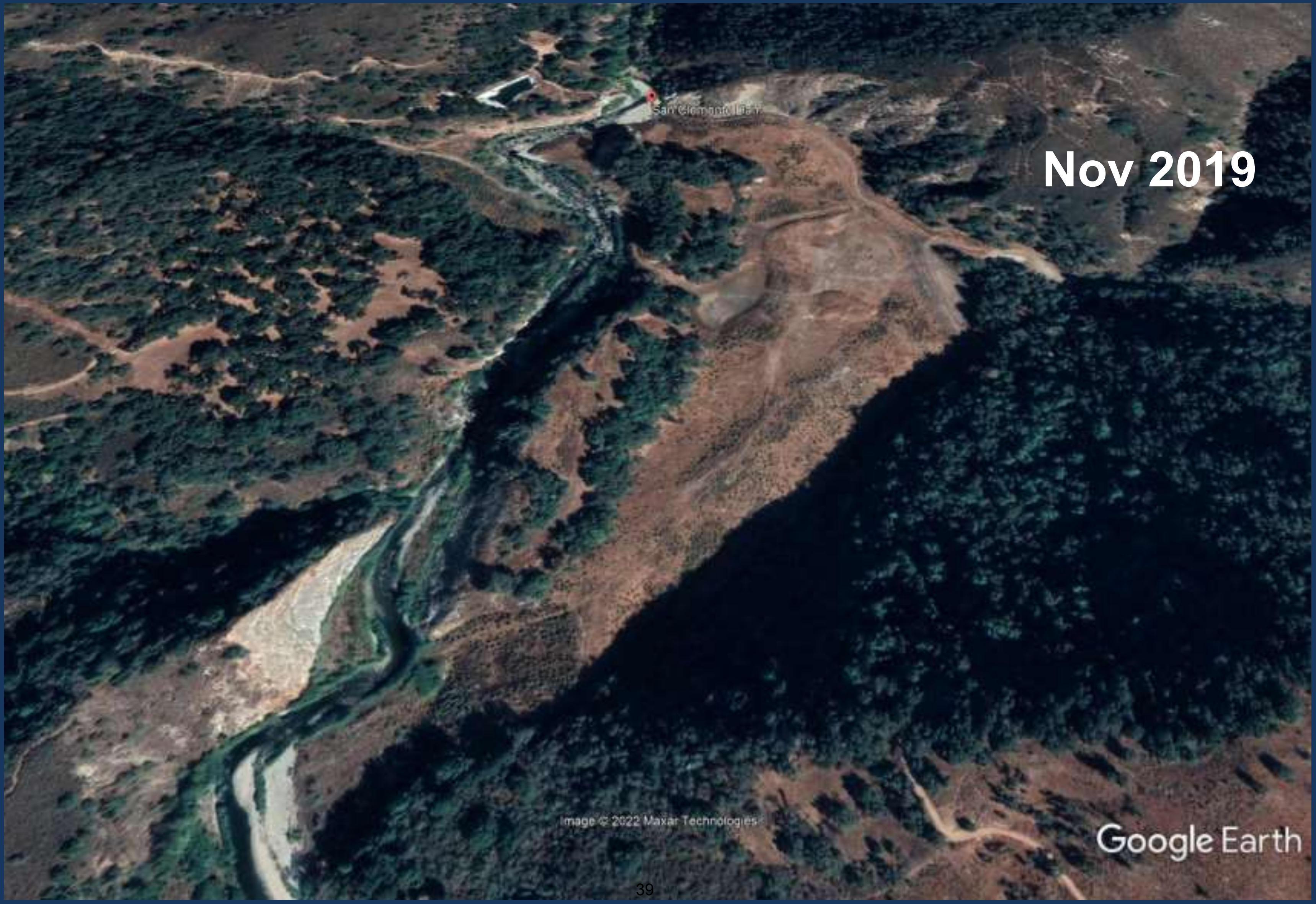

Channel continues to evolve

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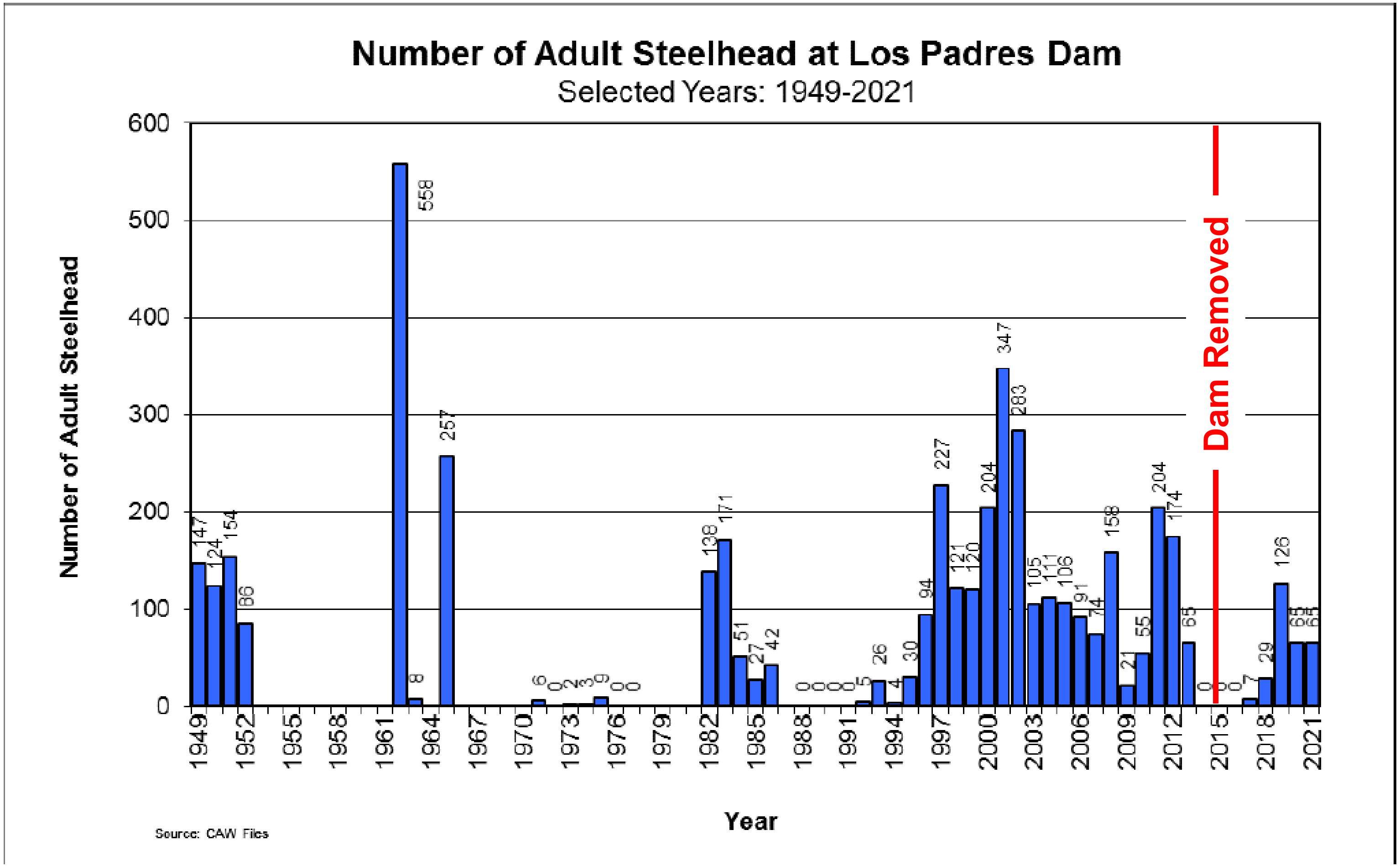
November 2021 – Step-Pool/Plane Bed Reach

November 2021 – Upper Riffle-Pool Reach

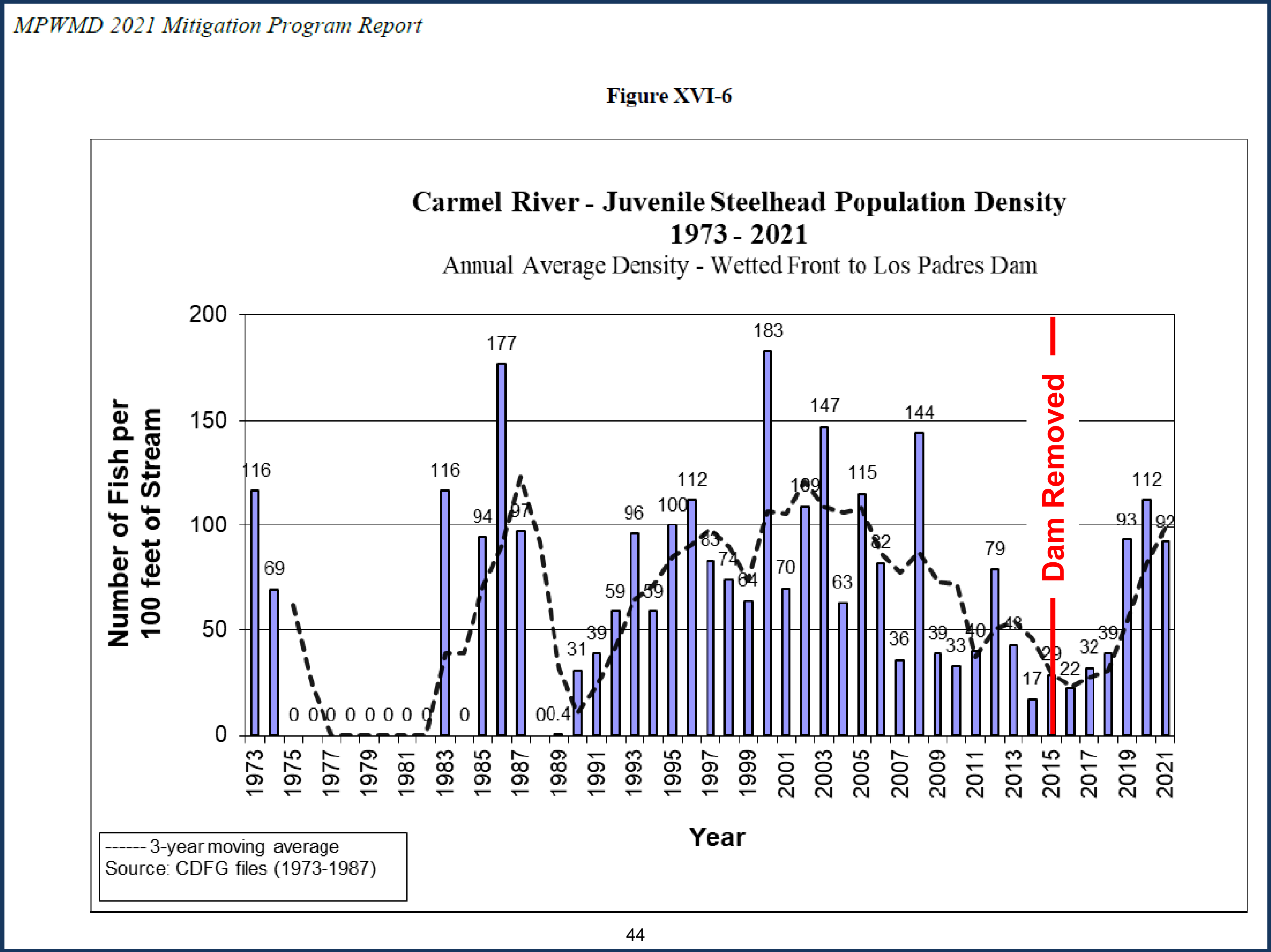
Fish Response

MPWMD 2021 Mitigation Program Report

Figure XVI-5



Fish Response



Lessons Learned

- **Very difficult (maybe impossible) to design for all possibilities considering highly-variable hydrology and geology**
- **High cost and highly prescriptive design substantially tied to low biological risk tolerance**
- **Prescriptive design, compounded by project delivery complexities, led to significant construction challenges**
- **Current status looks like a real evolving river with only minor, if any, fish passage constraints**
- **Project meets objectives even though some design criteria not currently met**
- **Perhaps the river knows best! We gave the river the materials it needed to evolve to the smaller, steeper SCC valley. It seems be doing just that.**

Carmel River Reroute and Dam Removal: *Challenges in Design and Construction of a Step-pool Channel*

Questions/Comments?

Robert Mussetter, Tetra Tech
Shawn Chartrand, Simon Fraser University
Brian Cluer, NOAA Fisheries
Michael Burke, Interfluve
Marcin Whitman, CDFW

Mill Creek Dam
Fish Passage Project
Design, Construction & Lessons Learned

Justin Bodell, RLA (PCI)
Luke Walton, PE (PCI)

SRF Conference – Fortuna

4/27/23

Background

- Instream Dam:
  - Historic flashboard dam built around 1910 for recreation and irrigation uses;
  - ~7.5-foot tall concrete apron caused a significant passage barrier during all flows.
- Project Objectives:
  - Remediate the highest priority barrier for coho salmon within the Russian River (NMFS recovery plan, 2012);
  - Restore juvenile and adult coho salmon and steelhead access to approximately 11.2 miles of high-quality spawning and rearing habitat.

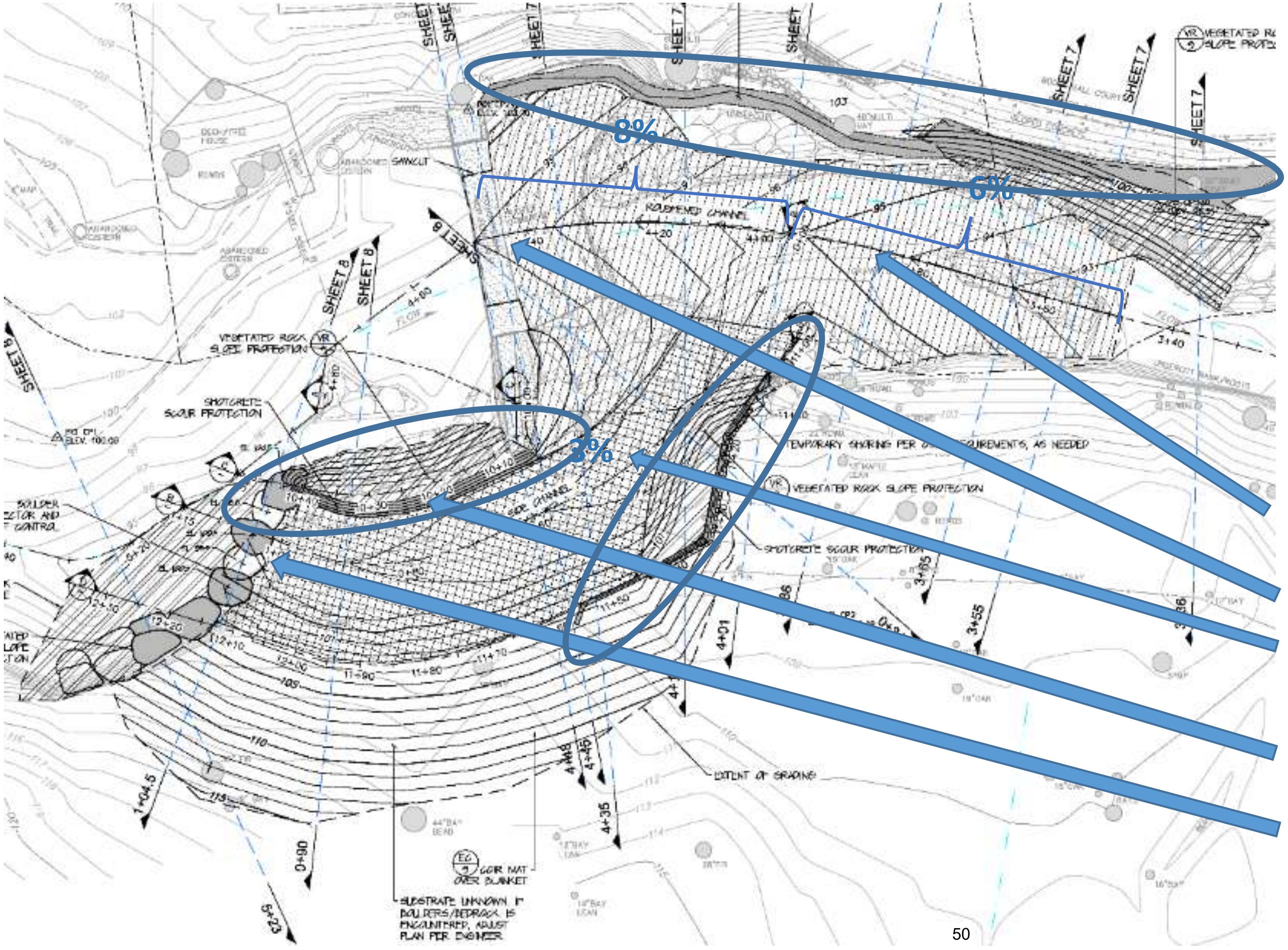
1945 . Mill Creek Dam

2009. Mill Creek dam apron

Design Constraints

- Significant infrastructure adjacent to the creek:
  - Adjacent buildings and terraced landscape areas;
  - Water supply wells within the dam impoundment as well as upstream and downstream of the dam.
- ❑ Prevented removal of the dam and stream simulation design.
- Mature redwood trees armoring banks;
- ❑ Prevented laying back banks or side channels through adjacent forest.
- Very high energy/very flashy stream with headwaters in one of the highest intensity rainfall locations in California (Venado rain gauge);
- ❑ Significant engineering required to maintain flood capacity and very large rock to maintain channel stability.
- Landowner’s desire to maintain aesthetics and beneficial use.
- ❑ Prevented significant modifications to dam that could change the upstream pool or “character” of site.

Final Design – Overall



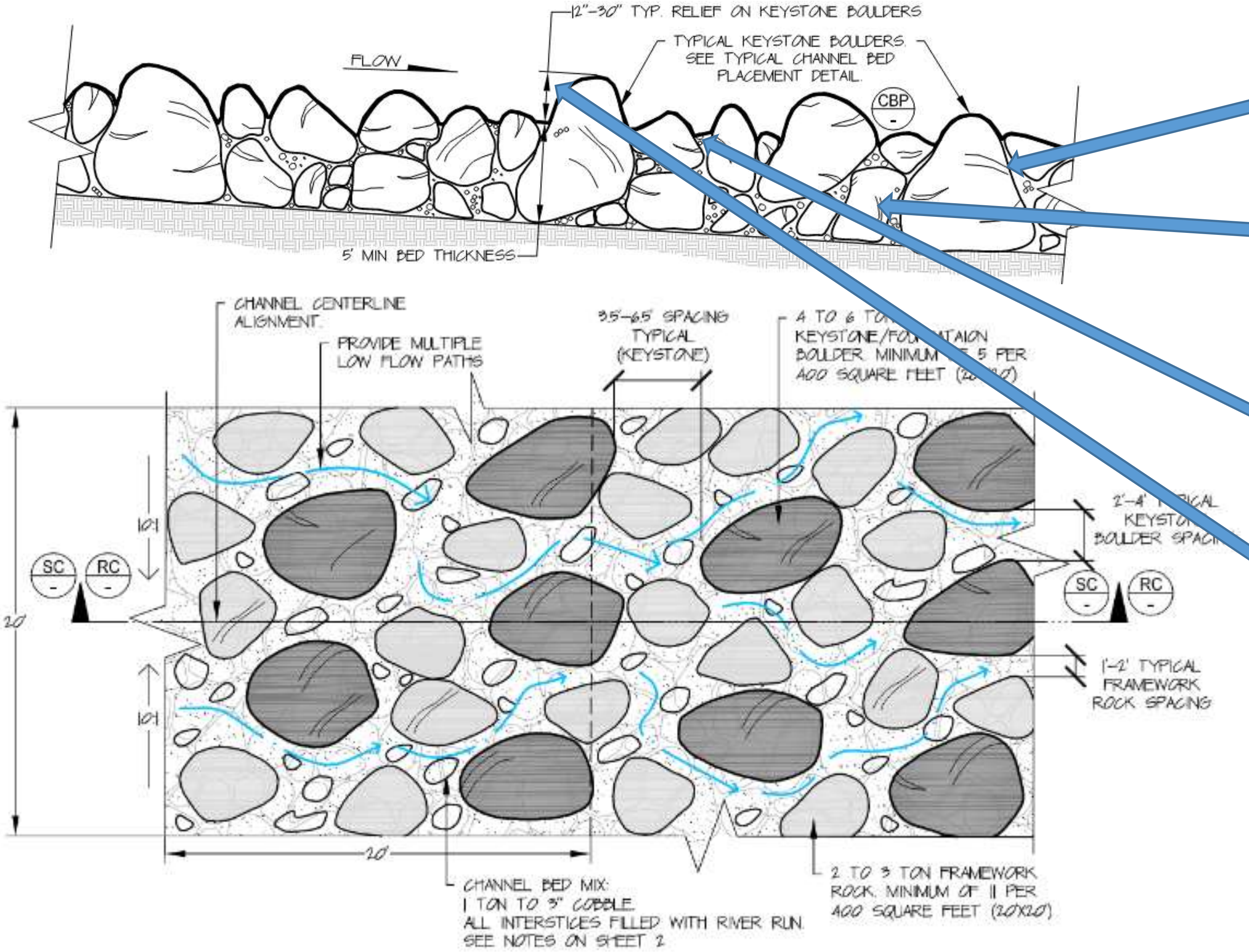
After analyzing 5 alternative designs, a roughened ramp over the dam with a lower gradient side channel around the dam was selected as a balance between project constraints and drastically improved fish passage conditions.

Worked with Dave White (NOAA Fish Passage Engineer) for variance to fish passage guidelines based on very steep reference reach downstream of the site.

Key design components are:

- Roughened boulder channel fill in mainstem to dam crest (6% lower 50’, 8% upper 50’);
- Dam elevation lowered 6”;
- Side channel excavated into hillside around dam into the middle of roughened ramp (3% channel slope for 100’);
- Shotcrete used for bank scour protection and weir inlet control.
- Side channel entrance set 6” lower than dam. Designed to take low flows, but exclude higher flows to maintain lower velocities through side channel.

Final Design – Roughened Chute



CBP CHANNEL BED PLACEMENT - PLAN VIEW
1"=5"

<u>Construction Sequence:</u>

1. Install large keystone boulders (D84 and larger from Engineered Streambed Material);
2. Install bed material in lifts with largest material first, making sure to hand chink all gaps. This will lock the keystone boulders in place;
3. Install river run and use water jet to completely fill all voids until water pools on surface of lift;
4. Ensure the tops of the keystone boulders project above bed finish grade with enough relief to account for scour of bed material;
   - In high energy systems, the smaller surface material will mobilize and leave the finish grade profile lower than designed.

Construction – Roughened Chute

Construction Challenges

- Construction began in June, 2016.
- Very limited site access and staging areas.
- All trucking with 10-wheelers backing down narrow driveway.
- A single 4-6 ton boulder would fit into the truck.

Finished Project

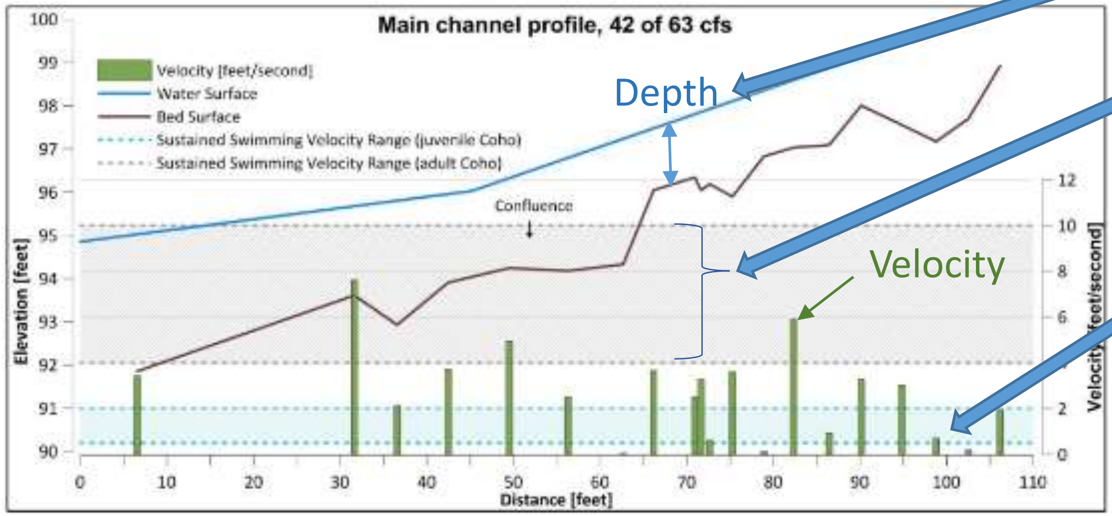
Construction finished October 2016

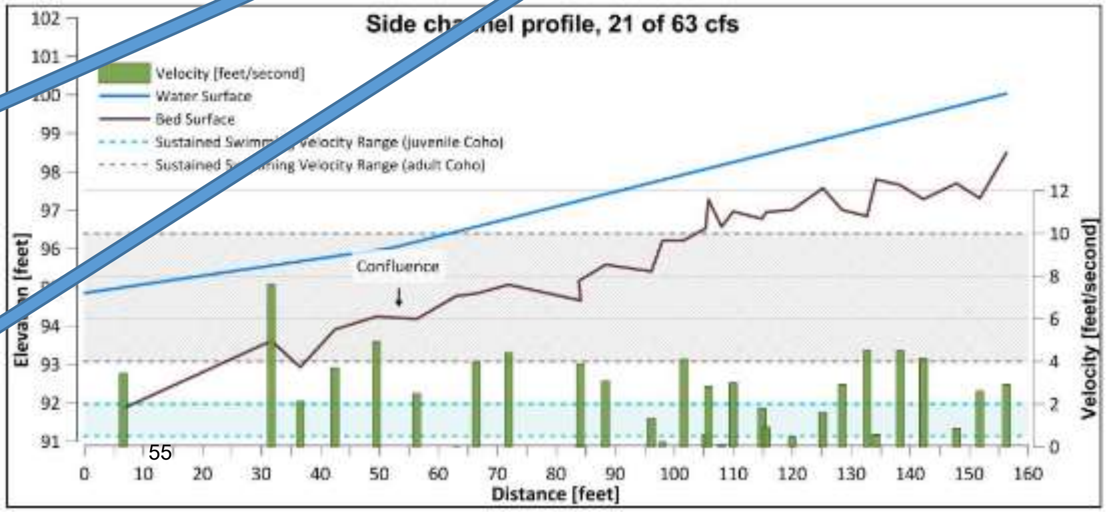
Physical Monitoring

Main Channel (looking upstream)

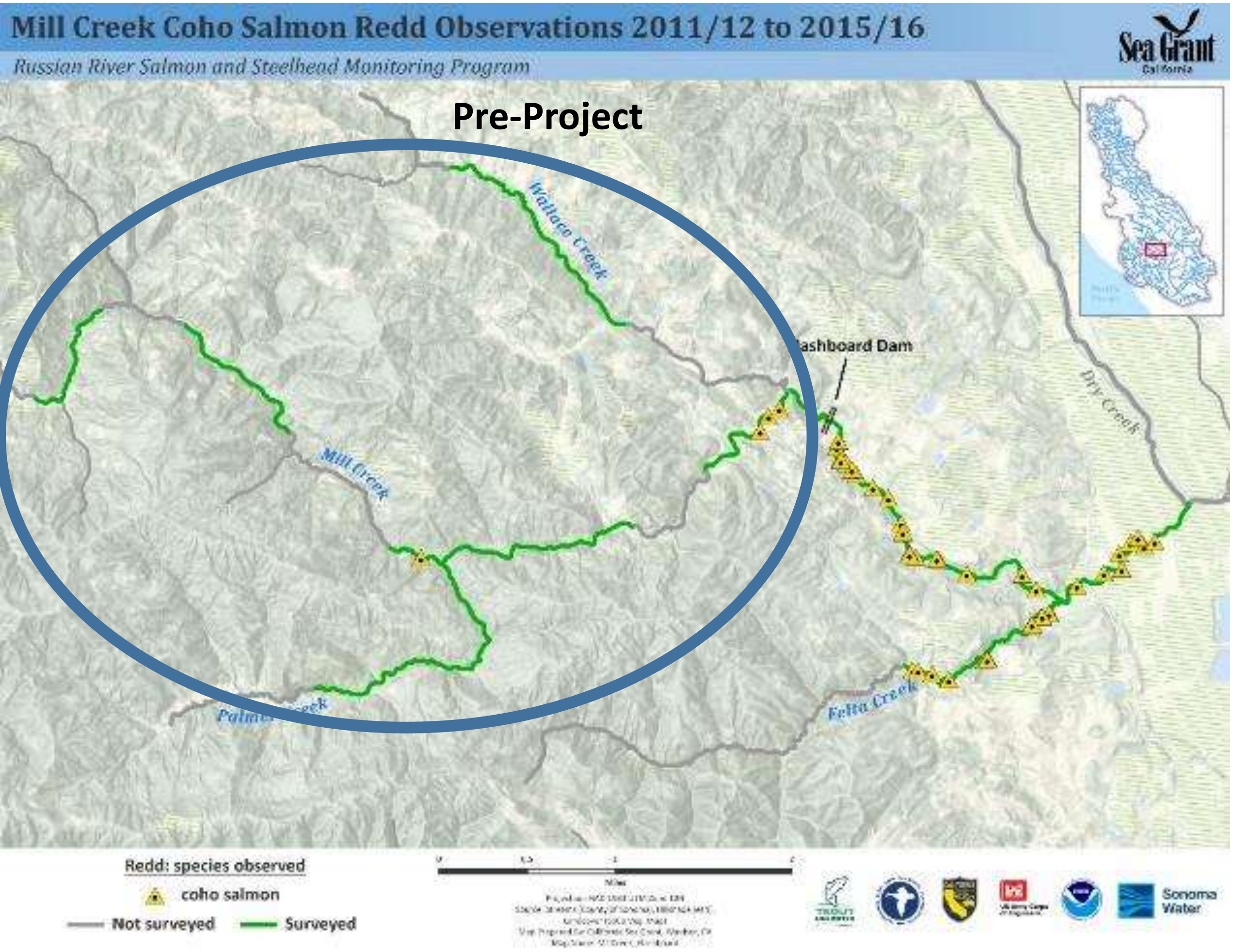
Side Channel (looking downstream)

- Measured depth and velocities at multiple points along profiles that represent a reasonable path for fish to take through the roughened channels.
- Fish passage flows range from 1cfs (juvenile low) to 770 cfs (adult high). One mid-range flow of 63 cfs, near the end of wadeability, was measured. This flow corresponded to coho transiting from nearby PIT tag detections.
- Results show that the two channels create an array of velocity and depth conditions to accommodate passage for both adults and juveniles over a wide range of flows.
    - Depths are acceptable for adult passage;
    - Max velocities are within range of adult coho sustained swimming speed;
    - Channel has abundant resting pools (pocket water).

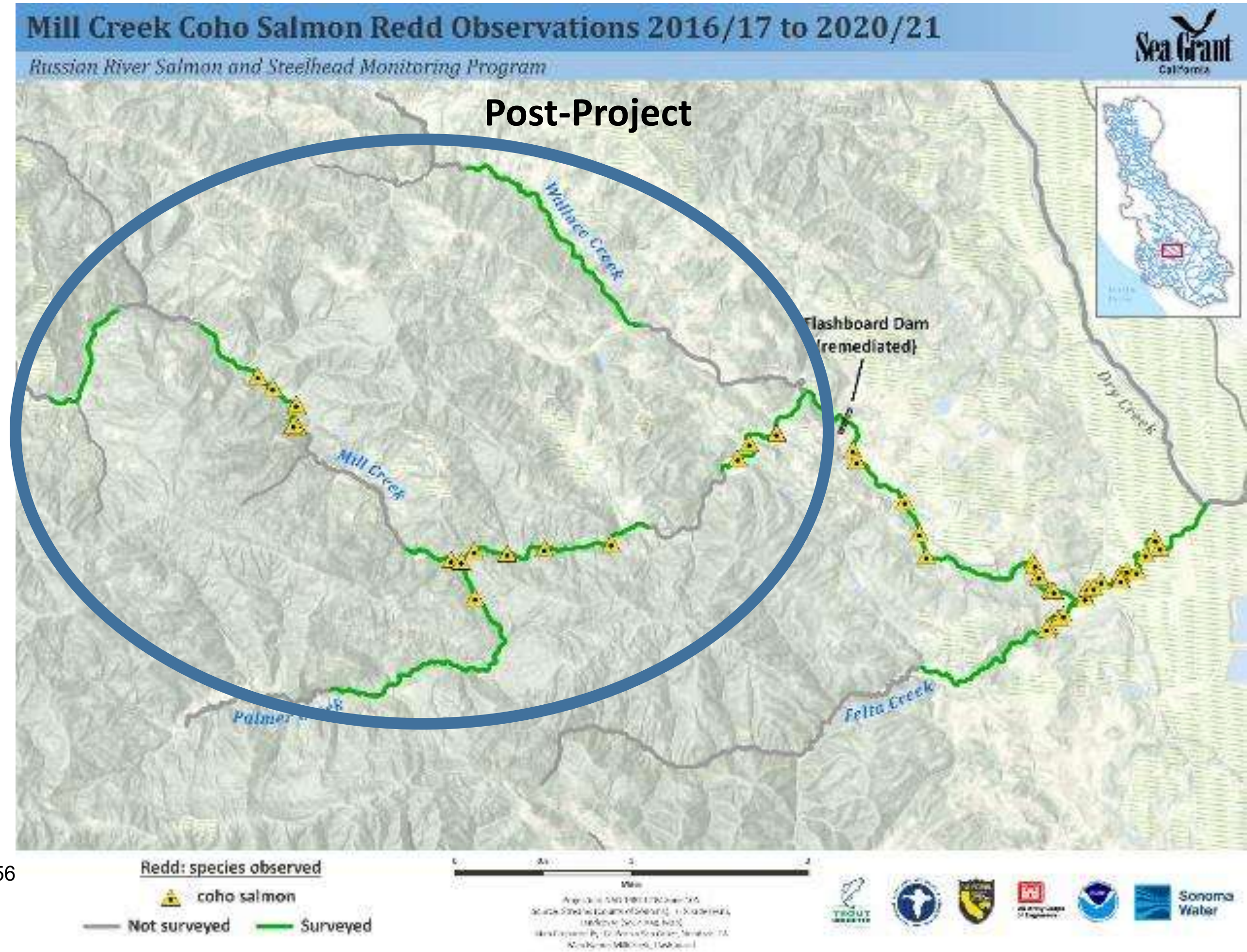




Coho Redd Observations



- **4** coho reds observed upstream of dam in four year period **before** project.
- **14** coho reds observed upstream of dam in four year period **after** project.



Lessons Learned

- **Pins vs. wood stakes.** Pins take a long time to decay. Wood stakes are more expensive.
- **Lessons learned:**
  - Rusty exposed pins can create a future safety hazard. Exposed pins should be removed during monitoring.
  - Don’t let leashed dogs run wild!

- **Kevlar strips in shotcrete.** Adds shear strength to concrete, but when exposed can become environmental microplastic.

- **Lessons learned:** Consider only adding strips to interior of shotcrete and omit on surface layer.

Lessons Learned




- **Gravity dewater systems** are challenging to implement, costly, and often need to run through the work area.
- **Lessons learned:**
  - Account for lots of extra time to install.
  - Use streamgage data to predict flows during construction window.

- **Pumped dewater systems** require an energy source and have a higher potential of failing.
- **Lessons learned:**
  - Landowners don't like diesel generators near their house.
  - Pumps require lots of monitoring.

Lessons Learned

- **High energy stream** caused scour around all the rock work.
  - Vegetation pockets on island between side channel and main channel was washed out.
  - Smaller material (1/4 ton minus) on surface was mobilized.

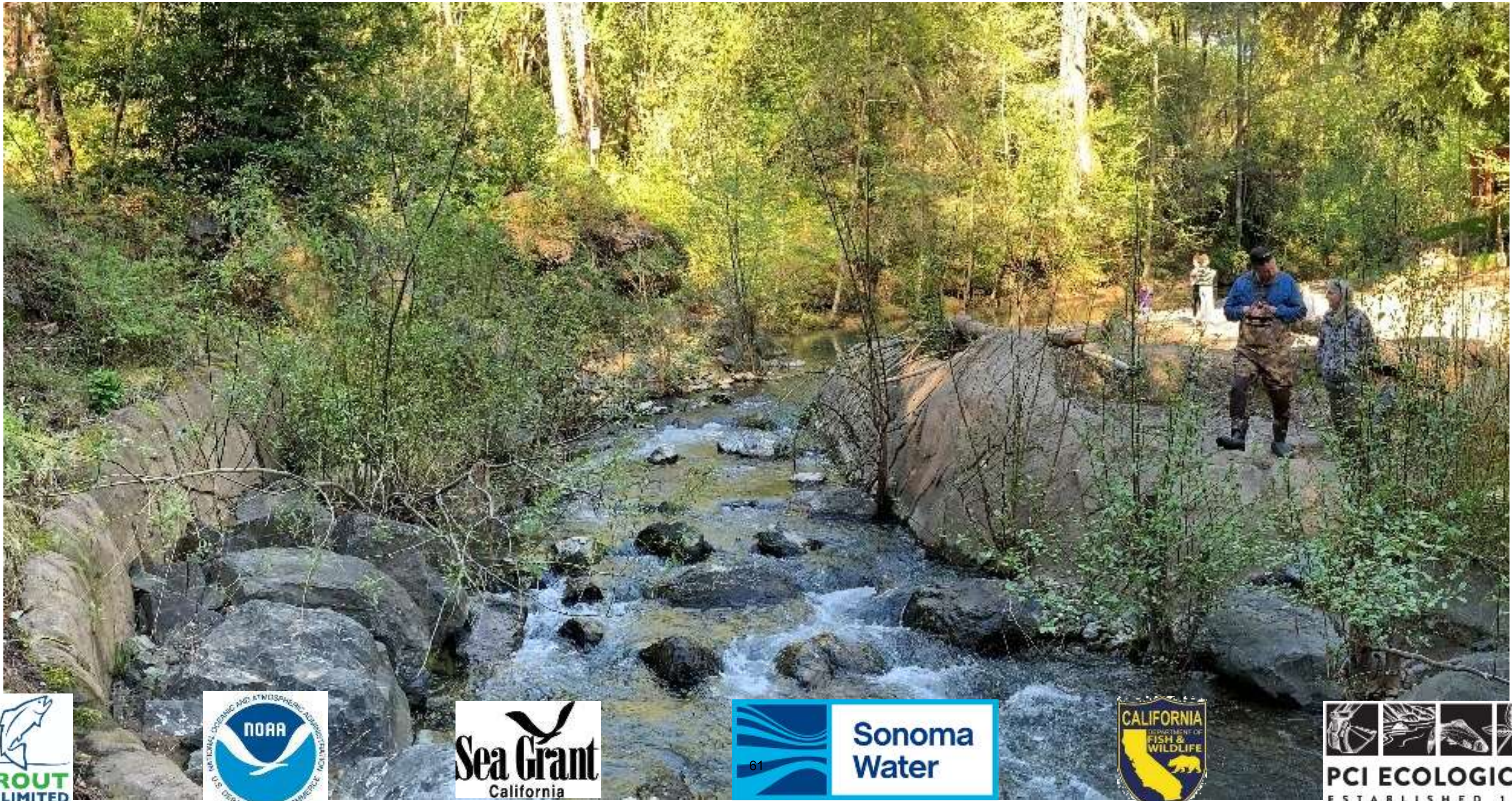
- **Lessons learned:**
  - Account for scour in design by projecting keystone boulders above finish grade and locking smaller material in place with larger rocks.
  - Consider biotechnical methods to protect new vegetation in high energy areas.

Lessons Learned

- **Excavations into hillsides** come with risk. Decision was made to reduce extent of wall during design phase in order to minimize concrete in project.

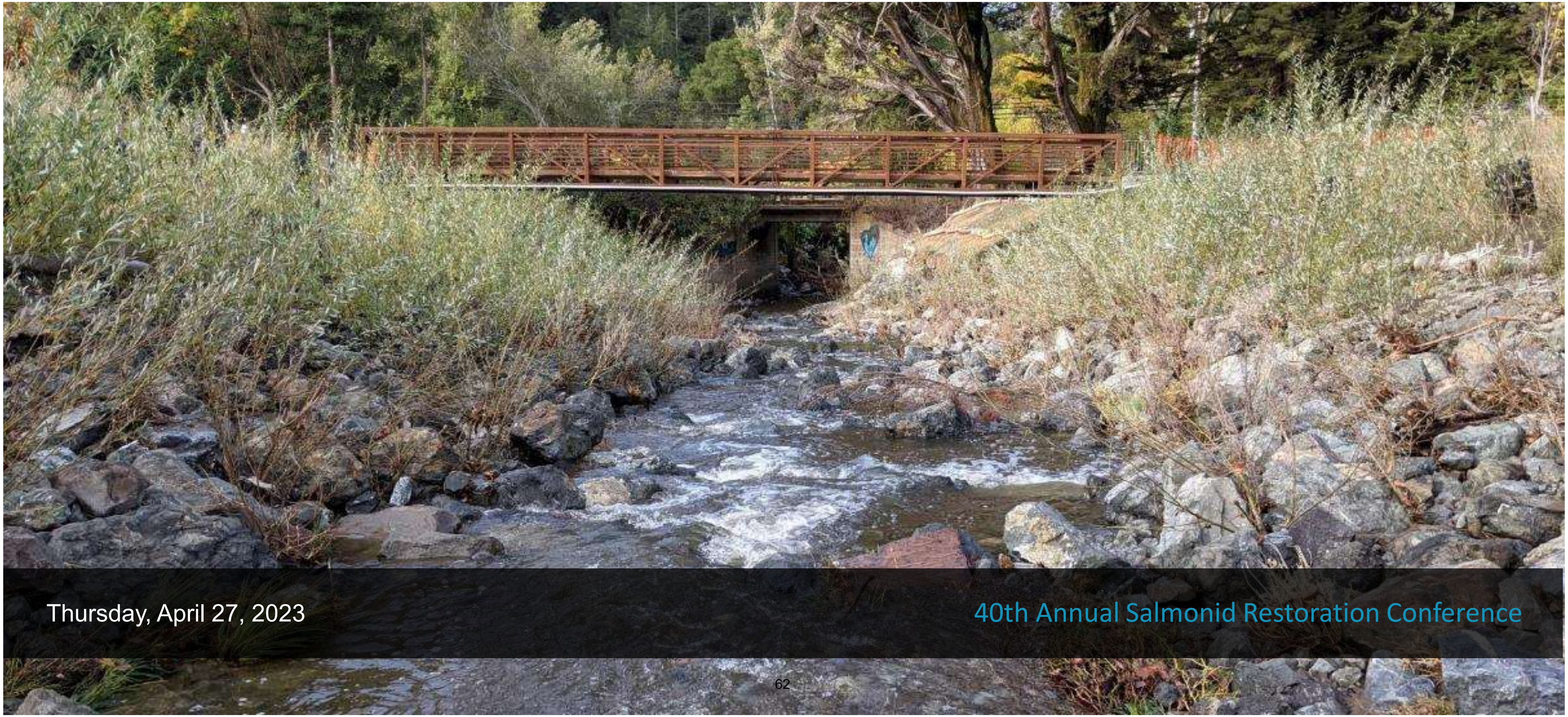
- **Lessons learned:**
  - Make sure geotechnical investigation analyzes potential for landslides.
  - If possible and no infrastructure is threatened, allow time for nature to re-establish an equilibrium.

Thanks to all project partners!!!



Embrace Change:

Combining Engineering and Geomorphic Principles to Design Resilient Fish Passage on San Geronimo Creek



Thursday, April 27, 2023

40th Annual Salmonid Restoration Conference

Embrace Change:

Combining Engineering and Geomorphic Principles to Design Resilient Fish Passage on San Geronimo Creek

- Presentation Overview
  - Project Team
  - Design
  - Implementation
  - Geomorphic Change

Project Team

Project Team

Project Leader

TURTLE ISLAND RESTORATION NETWORK

Salmonid
Protection
And
Watershed
Network

Design Team

ESA

Subconsultants

Geotechnical Engineer

A3GEO

Project Manager/Designer/Hydrologist
Jason White

Engineer of Record
Marisa Landicho

Permitting Support
Jill Sunahara

Project Director
Jorgen Blomberg

Chief Engineer
Ann Borgonovo

Structural Engineer

MARK THOMAS

Land Surveyor

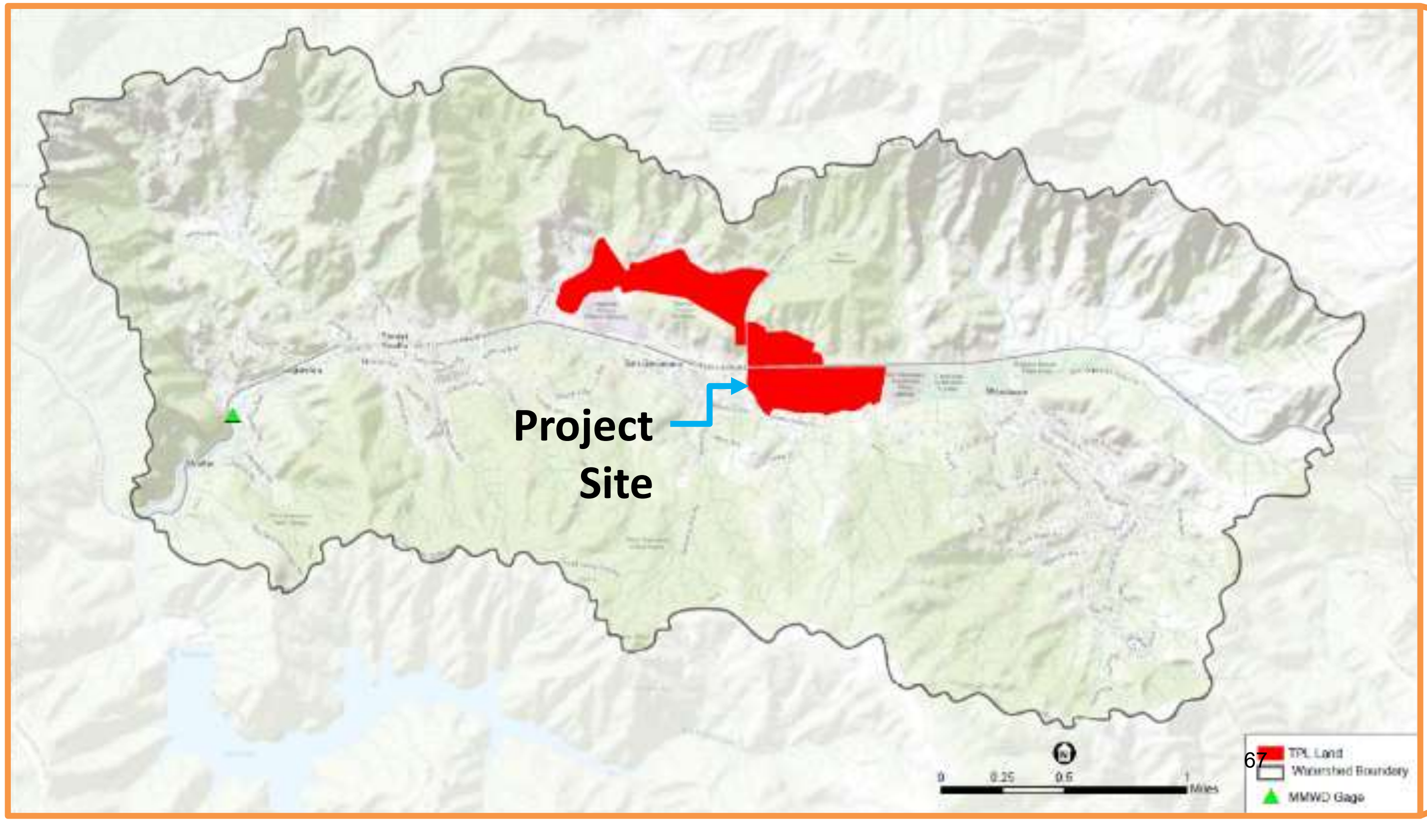
LACO

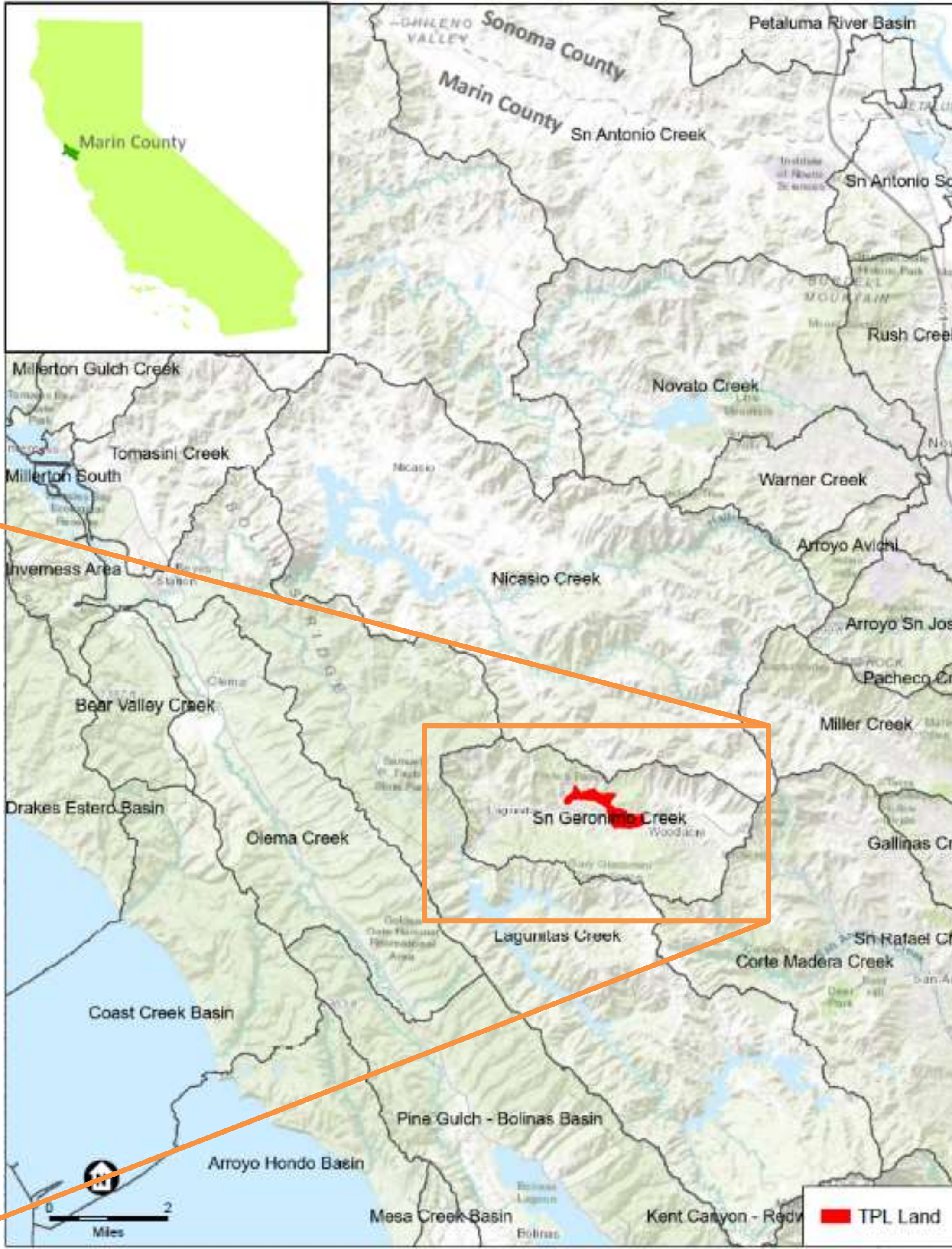
Past ESA Contributors:
Scott Stoller
Barry Tanaka
Rocko Brown
Phil Luecking

Background

Background

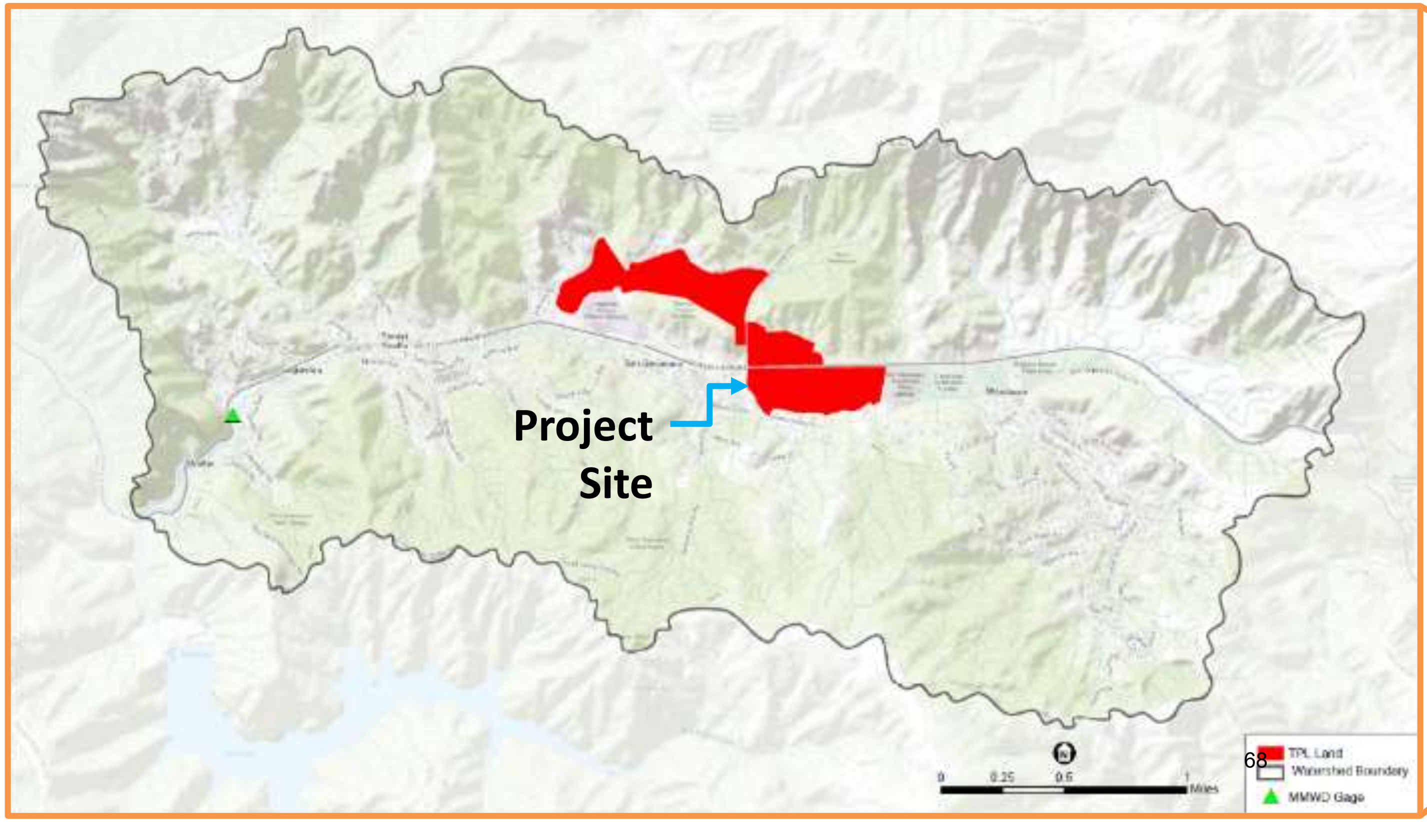
- Project Location
  - Marin County
  - Lagunitas Creek watershed
    - Drains to Tomales Bay near Point Reyes Station
  - Landowner: Trust for Public Land

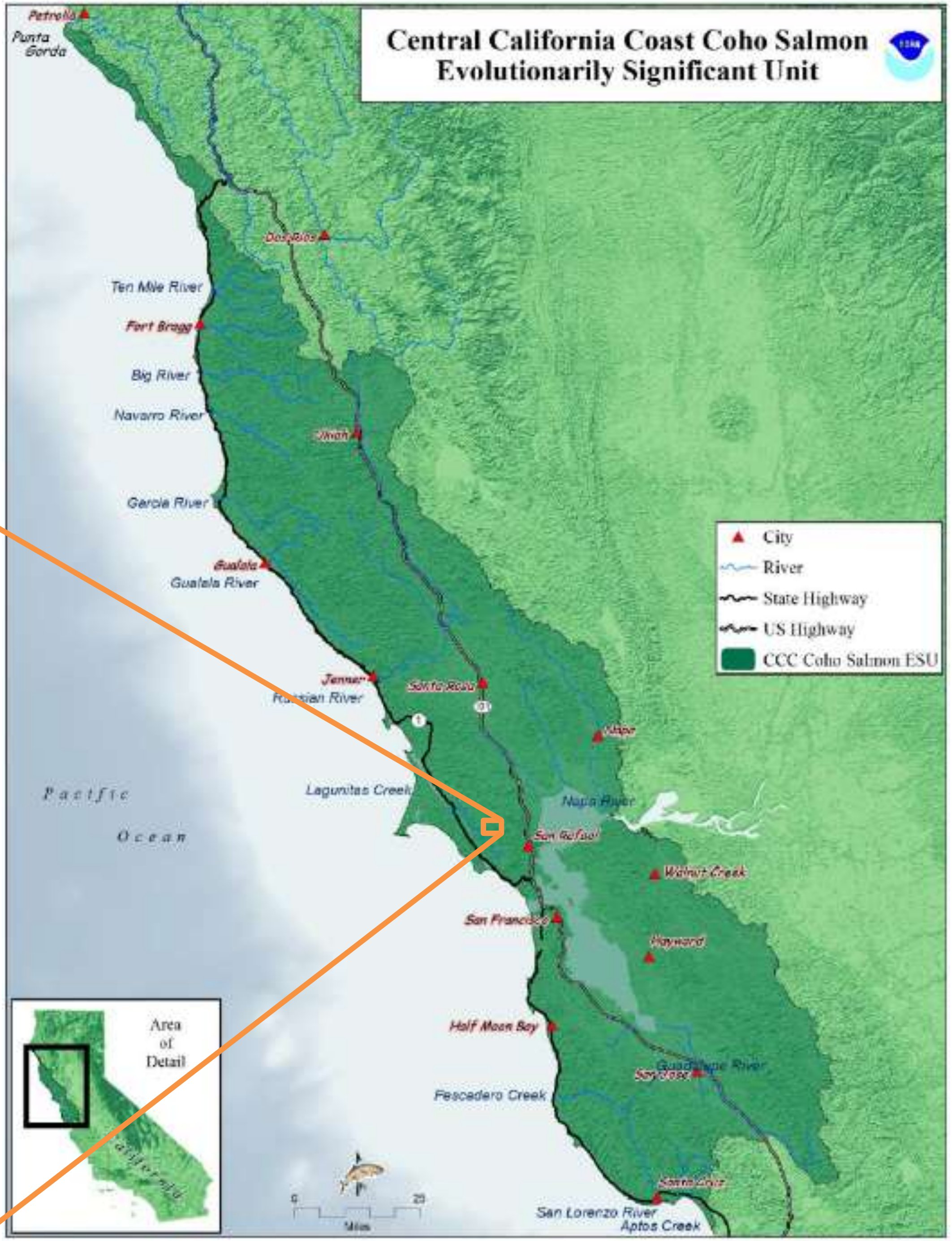




Background

- Project Need
  - Central California Coast Coho Salmon ESU
    - Federally listed Endangered Species under Endangered Species Act
  - CDFW Priority Barriers
    - Barrier to >4 square miles of watershed





Background

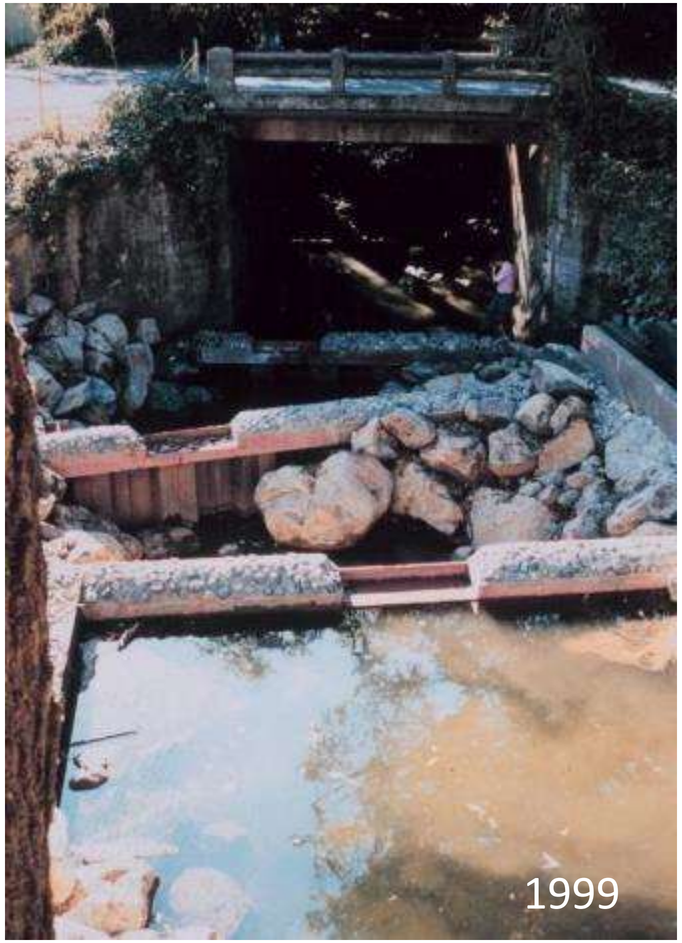
- Site Conditions
  - Dam built early 1900s for cattle ranching
  - Dam retrofitted with fish ladder in 1960s
  - Dam replaced in 1999 with steel and concreate weirs

ESA

Background

- Site Conditions
  - Fish Passage Barrier
  - Fish stranding

"Roy's Pools"


1999


2018

Background

- SPAWN teamed with ESA
  - Preston Brown with Ayano Hayes
- – Partnered with Landowner(s)
  - Current: Trust for Public Land
- – Secured funding
  - Fisheries Restoration Grant Program
    - ➢ Grant Manager: Matt Erickson
    - ➢ Engineer: Marjorie Caisely

Project Leader

TURTLE ISLAND RESTORATION NETWORK
SPAWN

Landowner

TRUST FOR PUBLIC LAND

Project Funder, Permitting, CEQA and Engineering Review

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Fisheries Restoration Grant Program

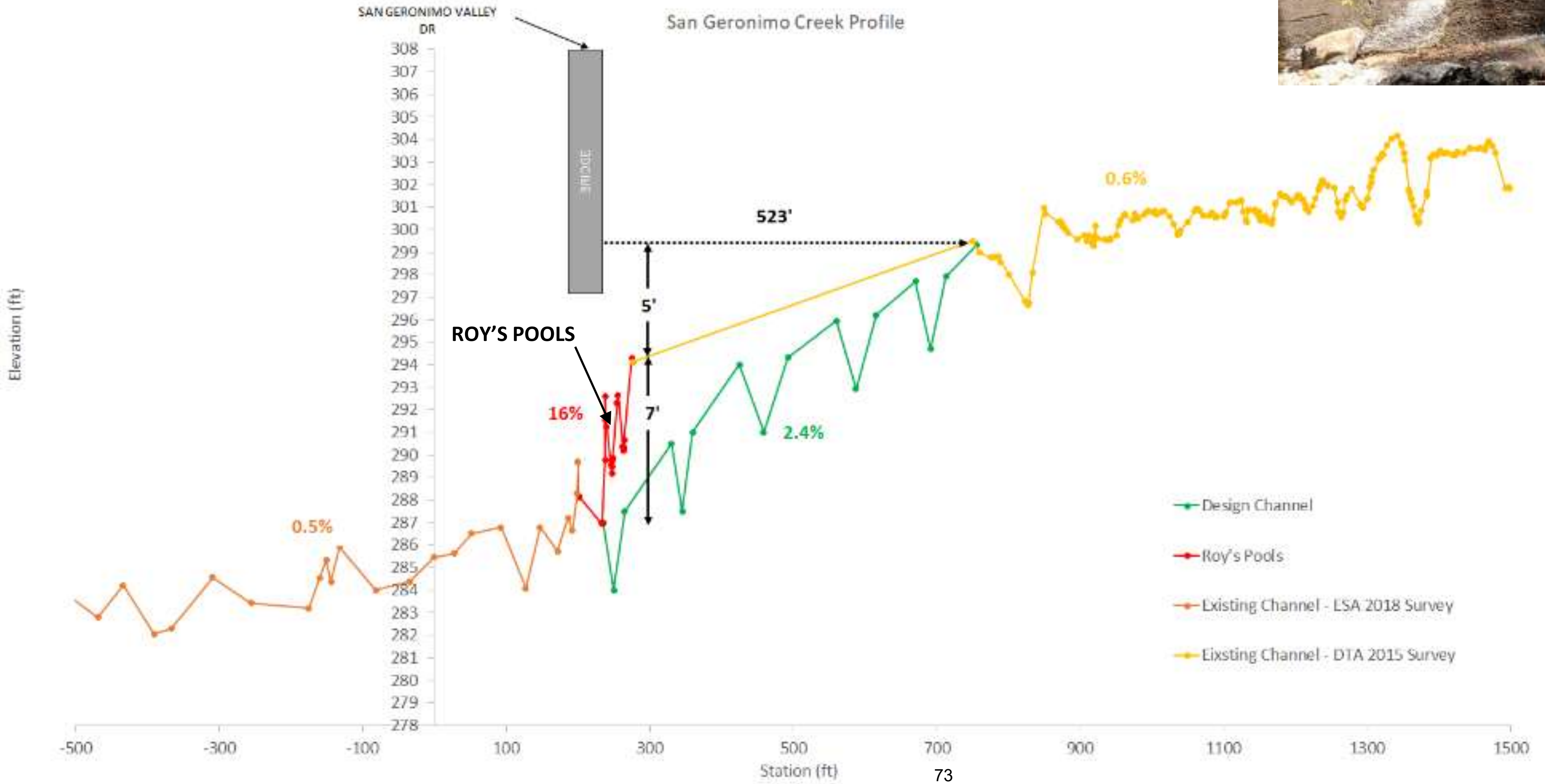
CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

Figure 1. Geographical Areas and Fourth Field Hydrologic Units Covered by CDFW's Fisheries Restoration Grants Program.

Design

Design

- Problem: large drop at Roy's Pools



Key Design Considerations:

- Fish Passage
- Grade Control

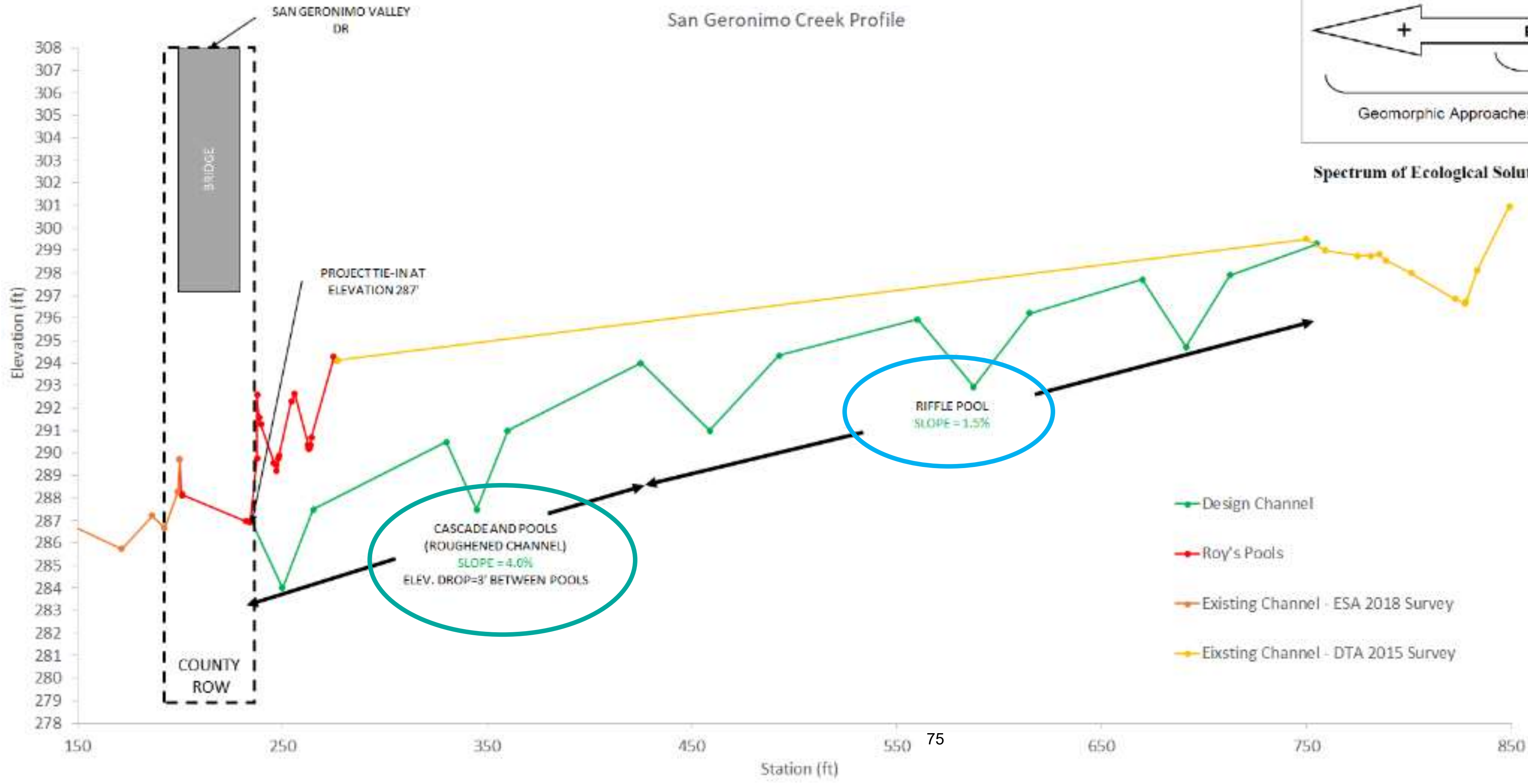
ESA

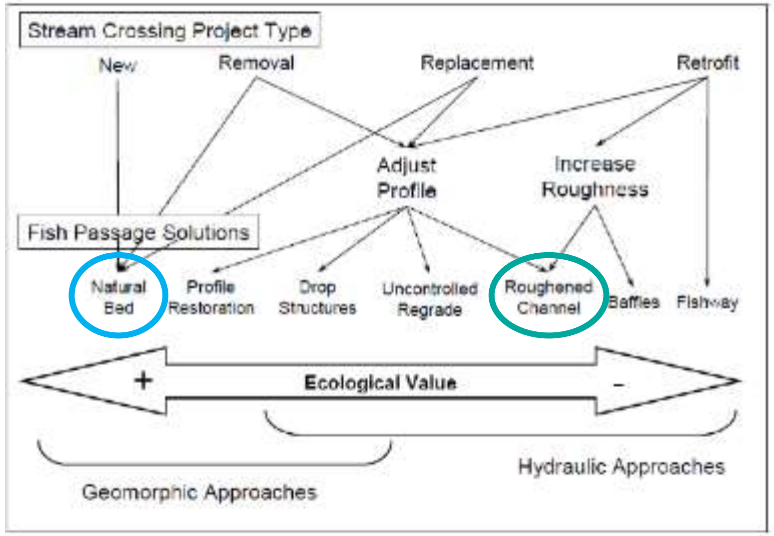
Design

- Design Guidance:
  - California Salmonid Stream Habitat Restoration Manual
    - Part XII: Fish Passage Design and Implementation (CDFW, 2010)

Design

- Project Profile Design: broken into two design approaches





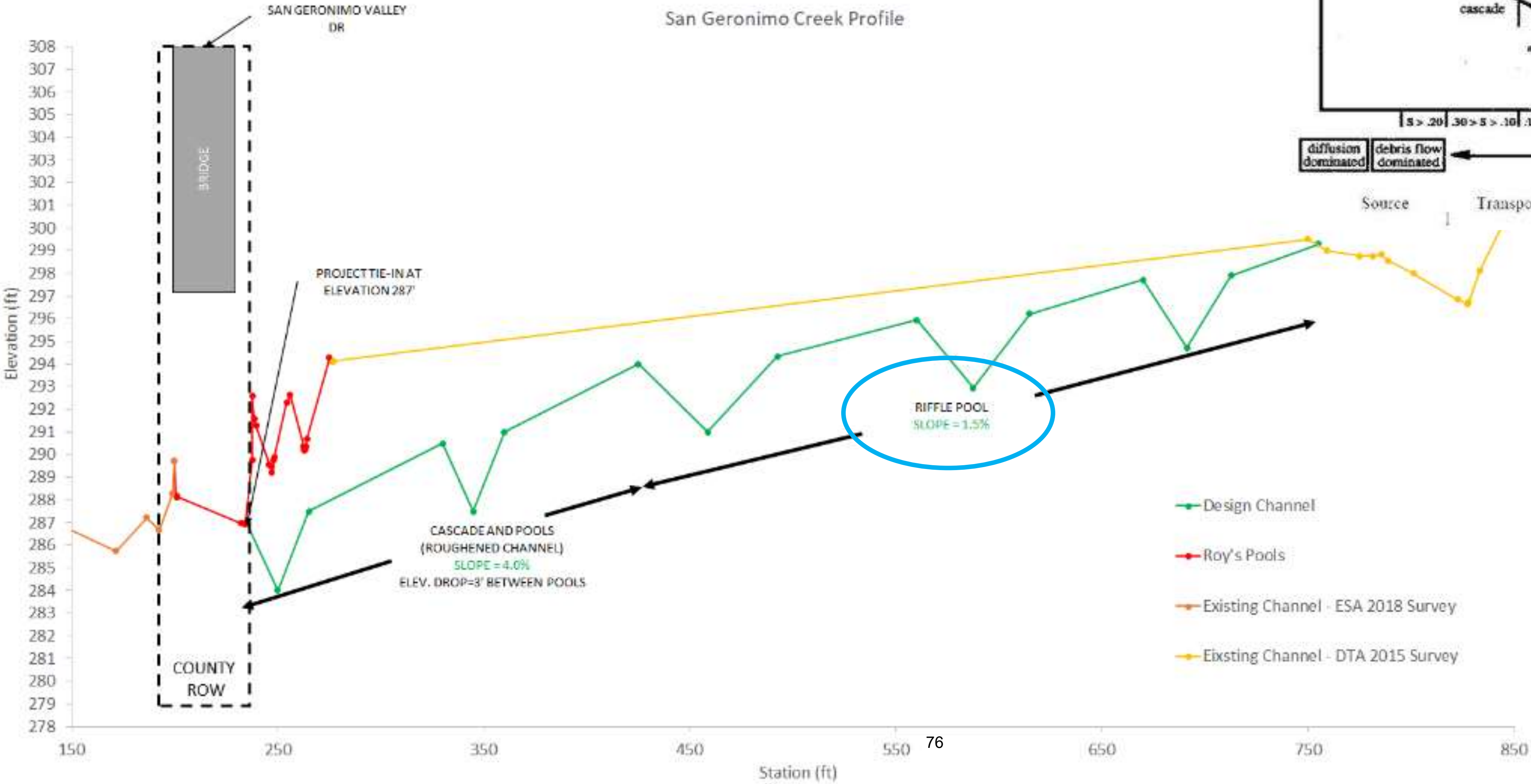
Spectrum of Ecological Solutions for Fish Passage.

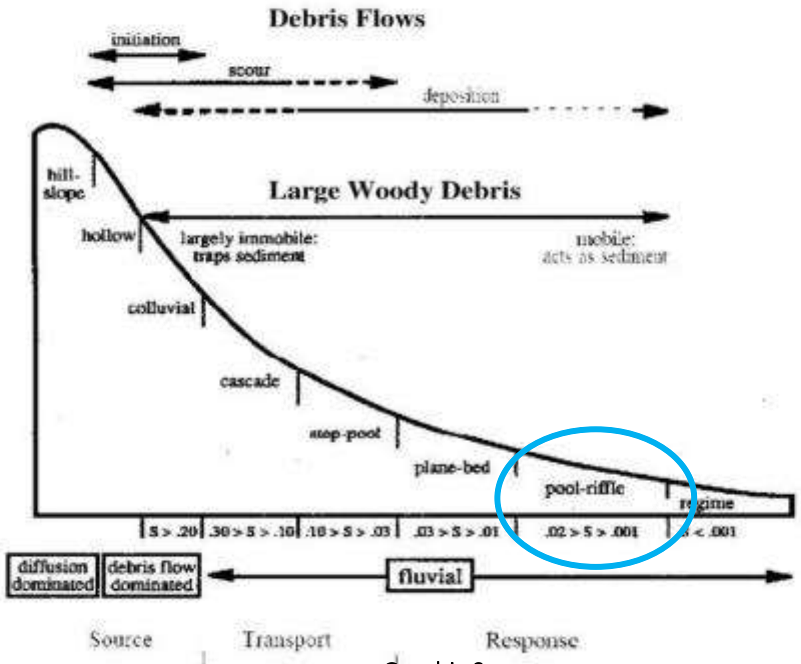
Graphic Source: CDFW (2010)

ESA

Design

- Geomorphic Design Approach: Riffle Pool Natural Bed





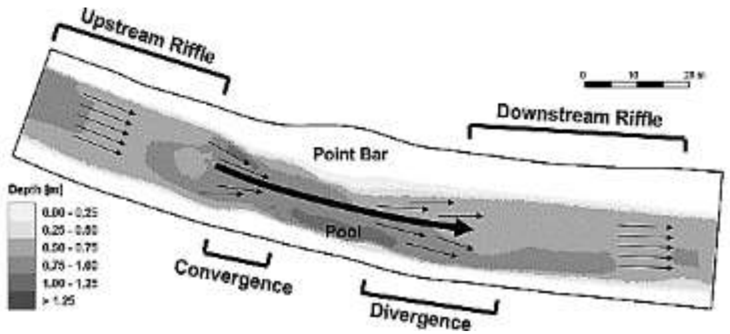
Graphic Source:
Montgomery and Buffington (1997)

CDFW (2010):
"A channel that simulates characteristics of the natural channel, will present no more of a challenge to movement of organisms than the natural channel."

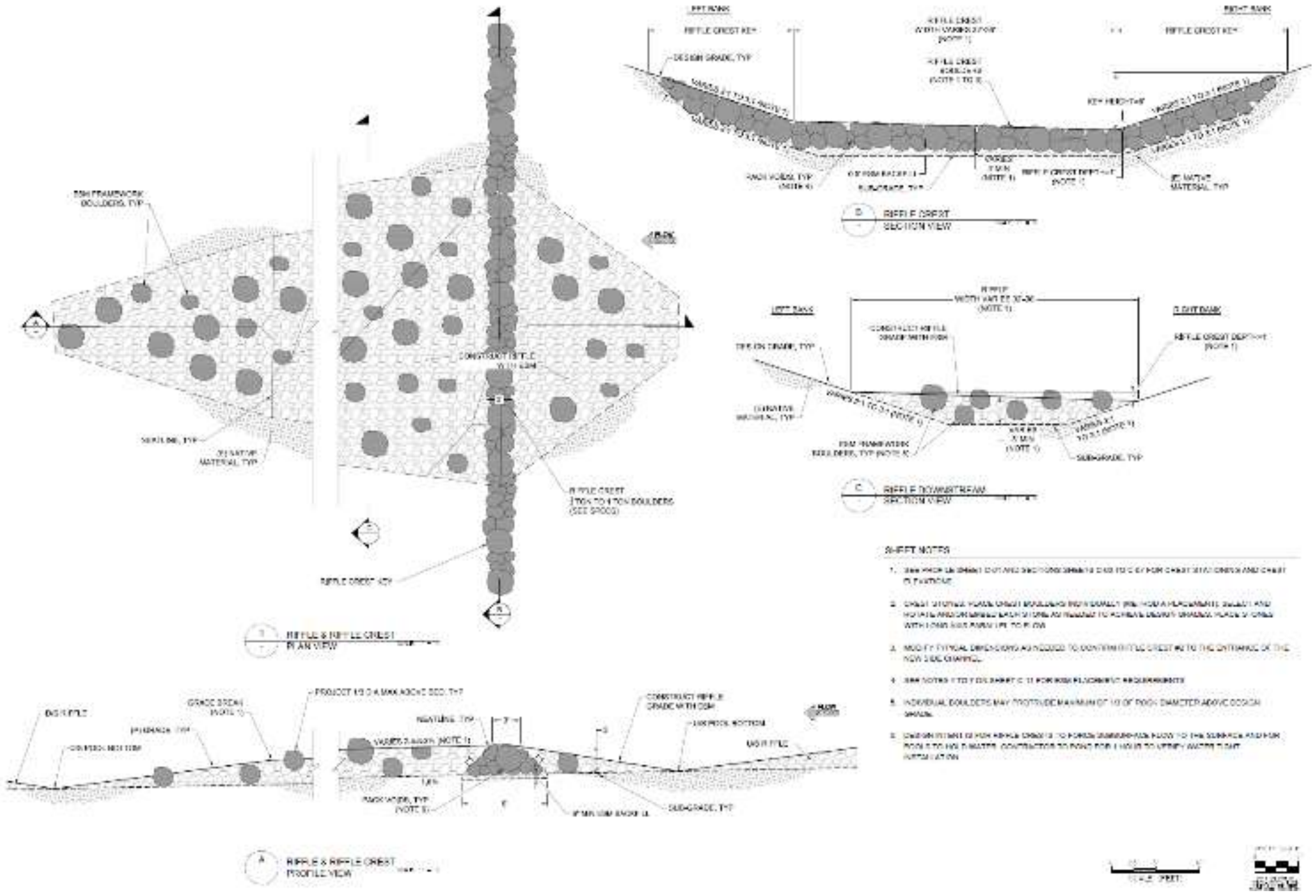
ESA

Design

- Riffle Pool Natural Bed
  - Variable width to promote natural riffle pool processes
    - Wide at riffle crest to encourage deposition
    - Narrow at pool to encourage scour

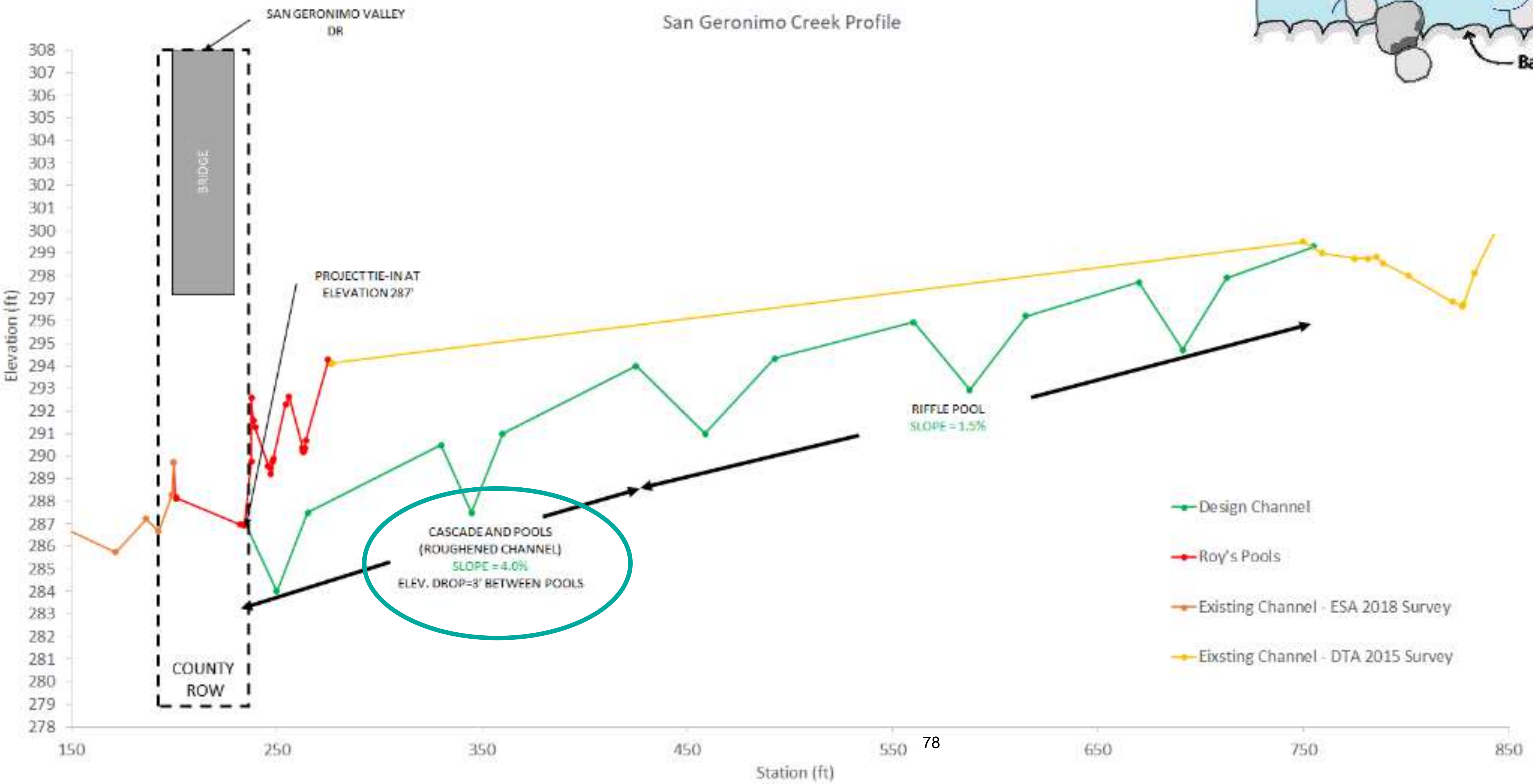


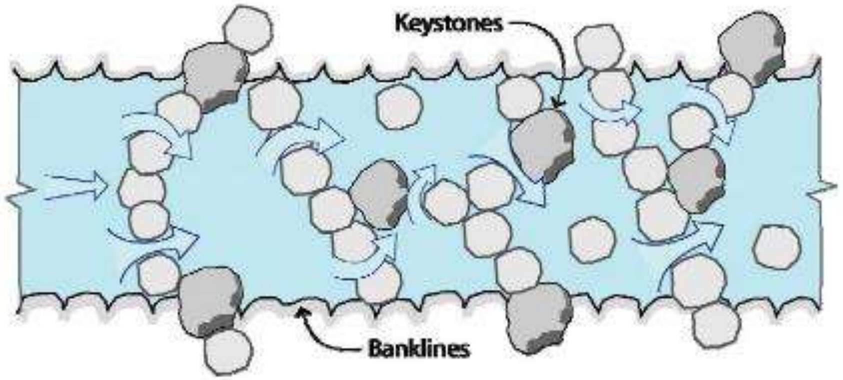
Graphic Source:
MacWilliams et all (2006)



Design

- Hydraulic Design Approach: Cascade Roughened Channel





Graphic Source: CDFW (2010)

CDFW (2010):

"The geomorphic characteristics of natural channel** types, along with hydraulic fish passage design criteria for water depths and velocities, turbulence, hydraulic drops and minimum pool depths, can be used to **guide design of a roughened channel."

Design

- Cascade Roughened Channel

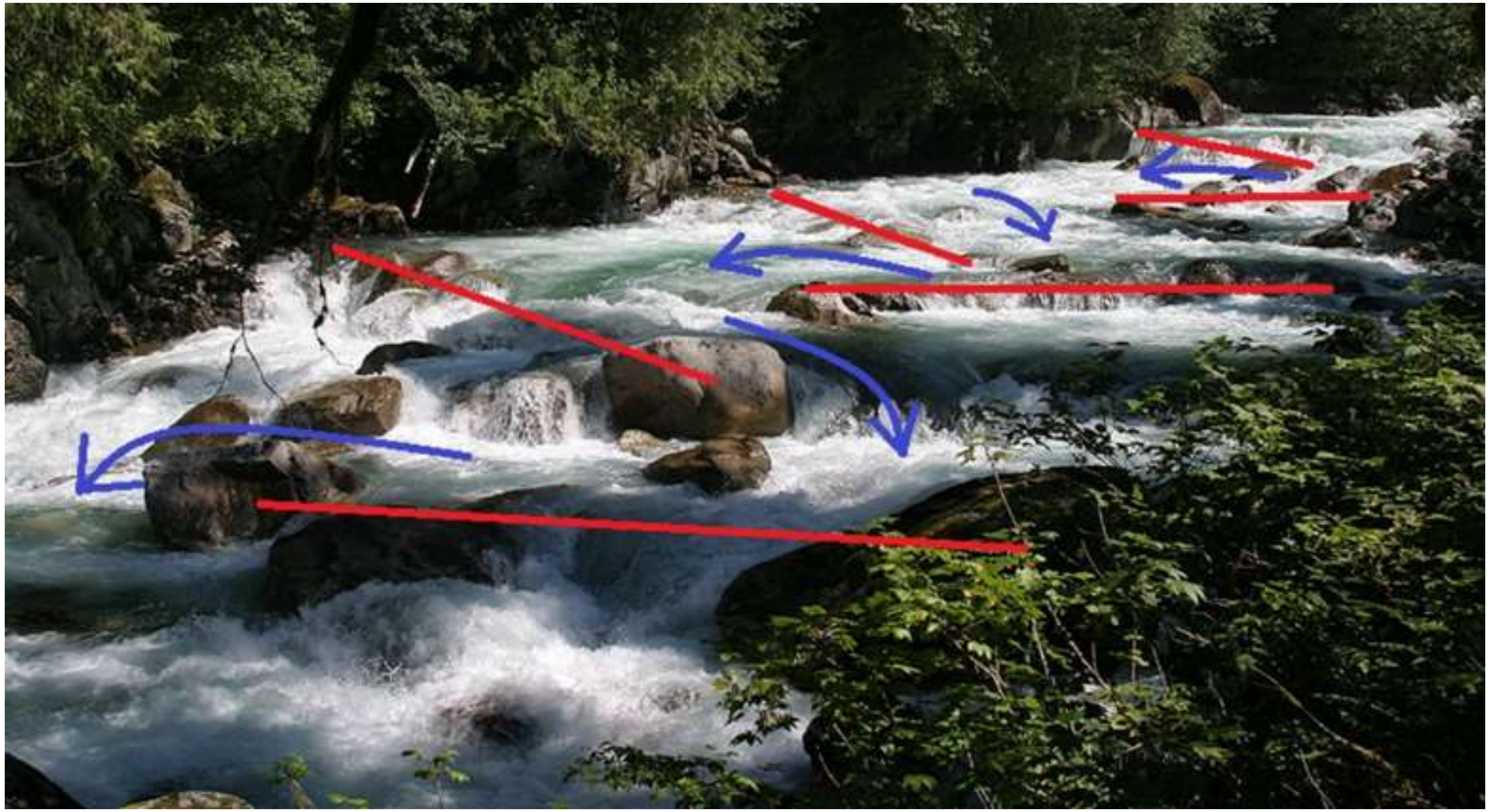


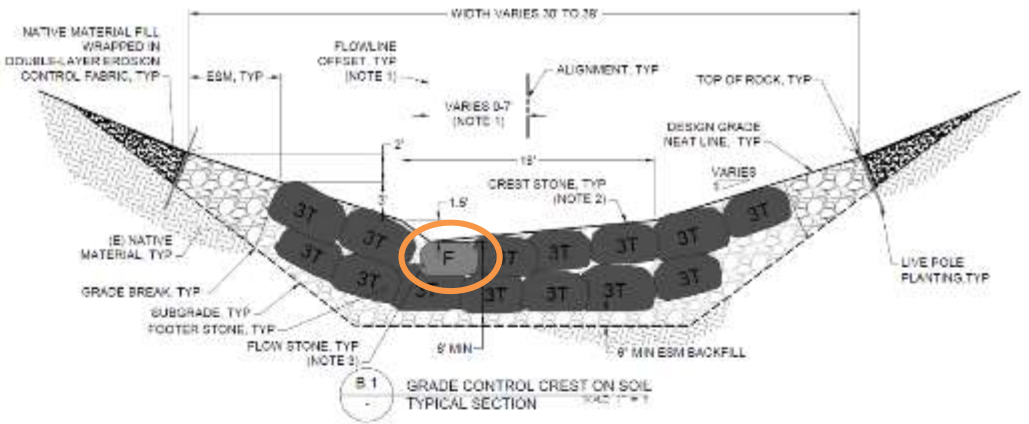
Photo: Ryan Cole (https://www.oregonkayaking.net/rivers/cascade/cascade.html)

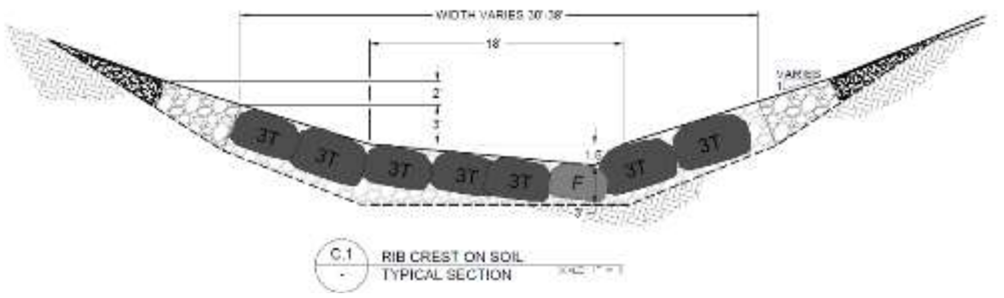
CDFW (2010):

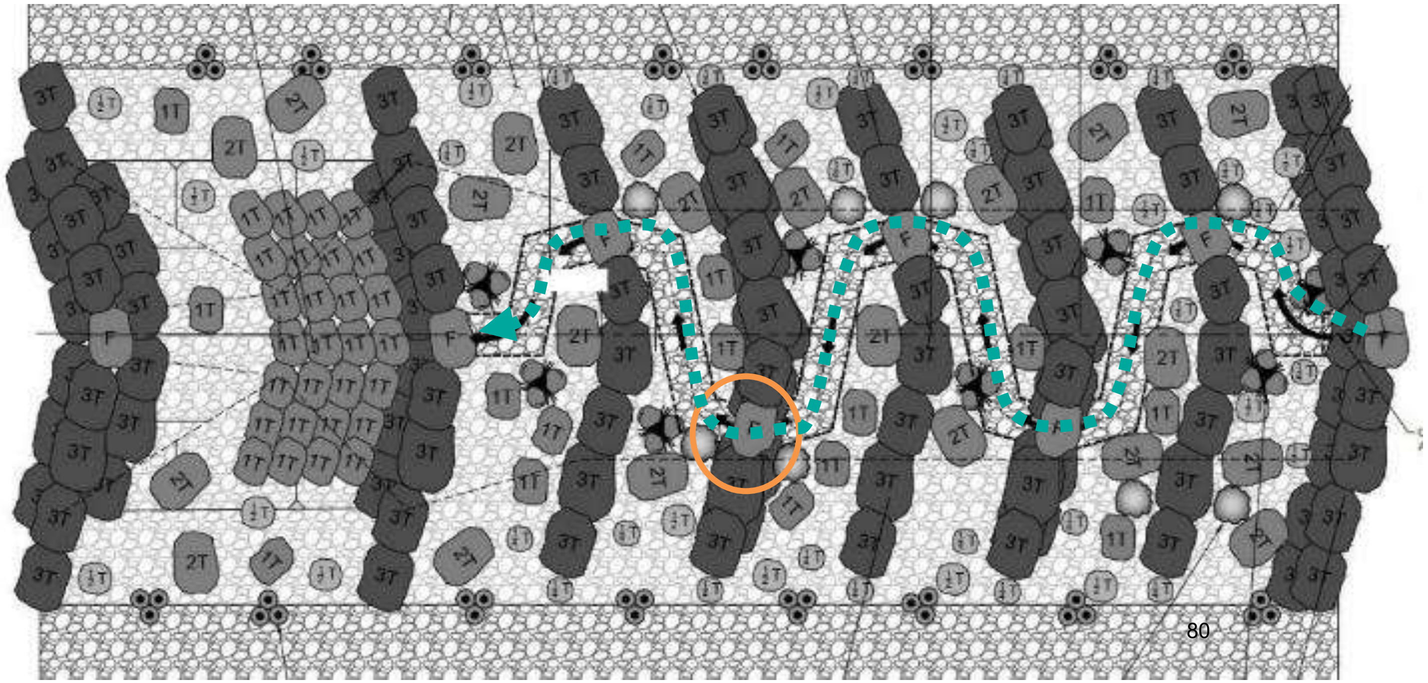
"A roughened channel can only approximate the characteristics of a cascade *channel. Individual rocks are expected to adjust position but the larger rocks are sized to be stable and not move out of the roughened channel reach. The bed material must remain fixed because, unlike stream simulation, if a rock within the roughened channel becomes mobile it will not be replaced by natural recruitment."*

Design

- Cascade Roughened Channel
  - Grade Control Crest
    - Resist mobility to maintain grade
  - Rib Crest
    - Provide structure but allowed to adjust
  - Flow Stone & Cascading Flow Path
    - Flow stone establishes low flow path
    - Low flow path excludes larger rock to allow for natural scour and deepening







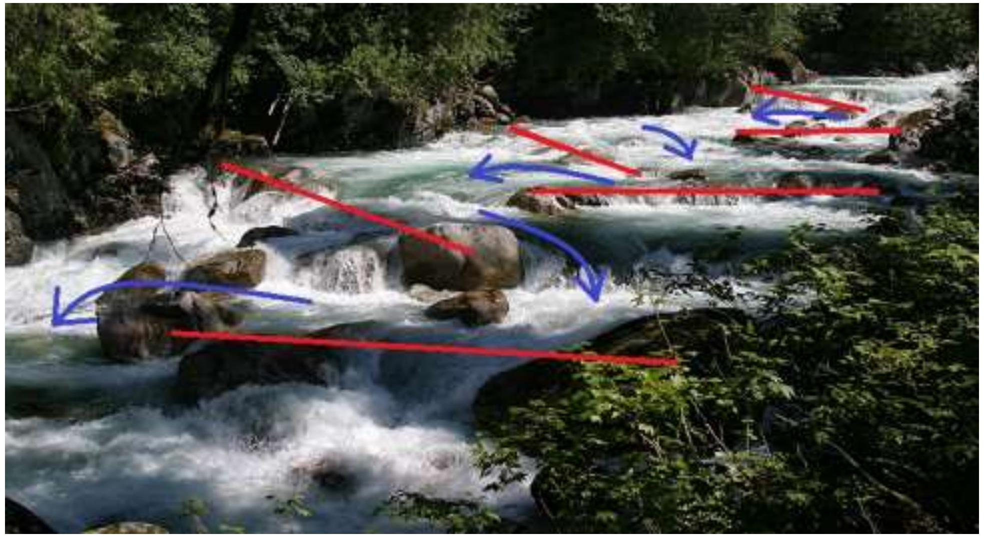
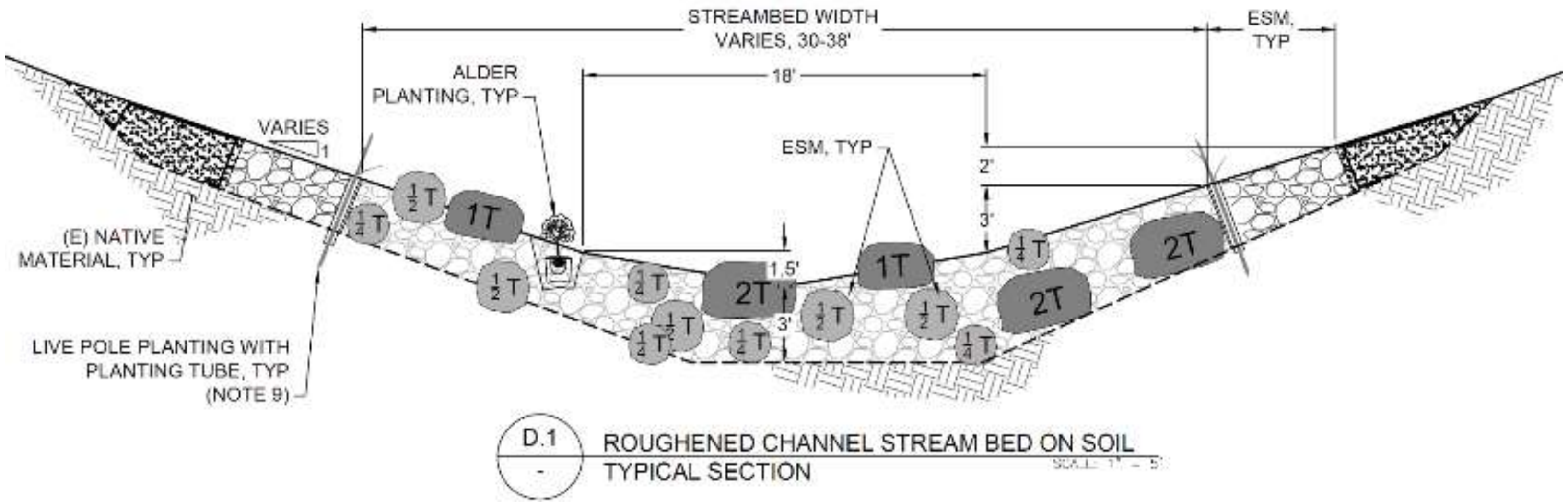


Photo: Ryan Cole (https://www.oregonkayaking.net/rivers/cascade/cascade.html)

Design

- Cascade Roughened Channel
  - Key element: Engineered Streambed Material



CDFW (2010):

"A roughened channel can only approximate the characteristics of a cascade channel. Individual rocks are expected to adjust position but the larger rocks are sized to be stable and not move out of the roughened channel reach. The bed material must remain fixed because, unlike stream simulation, ***if a rock within the roughened channel becomes mobile it will not be replaced by natural recruitment."***

ESA

Design

- Engineered Streambed Material (ESM)
  - Rock sizing and gradation
    - Design flow 100-year Peak Flow (2231 cfs)
    - Starts with stable rock sizing methods by USACE (21994)
    - Gradation methods by CDFW (2010) to create “stable bedform while filling the interstitial voids”

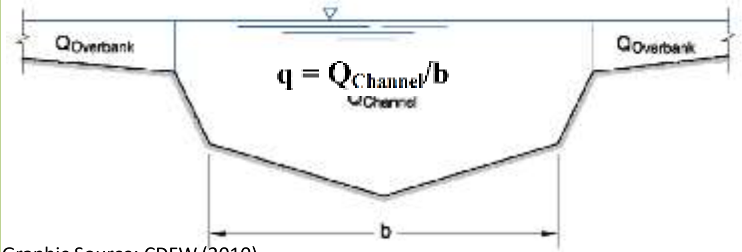
STABLE ROCK

$$D_{30-ACOE} = \frac{1.95 S^{0.555} (1.25q)^{\frac{2}{3}}}{g^{\frac{1}{3}}}$$

S Hydraulic slope (ft/ft)

q unit discharge

flow concentration factor of 1.25



Graphic Source: CDFW (2010)

FRAMEWORK

$$D_{84\text{-}ESM} = 1.5\, D_{30\text{-}ACOE}$$

$$D_{50\text{-}ESM} = 0.4\, D_{84\text{-}ESM}$$

$$D_{100\text{-}ESM} = 2.5\, D_{84\text{-}ESM}$$

FILL VOIDS

$$D_{16-ESM} = 0.32^{\frac{1}{n}} D_{50-ESM}$$

$$D_{8-ESM} = 0.16^{\frac{1}{n}} D_{50-ESM}$$

Design

- Engineered Streambed Material (ESM)
  - Roughened Channel rock sizing and gradation
    - Expand gradation to 12 classes + crest stones (3 tons)

ENOUGH LARGE ROCK TO ALLOW FOR GEOMORPHIC CHANGE AND REMAIN FUNCTIONAL

	Material Specification	Sub-Mix Ratio (by weight)	Specifications Reference
ESM Backfill Sub-Mix	Native Material (soil)	1	02300 Earthwork
	Native Alluvium	1	02300 Earthwork
	3/4" Class 2 Aggregate Base	1	Standard Section 26
	Small RSP 4" Thick	1	Standard Section 72-4
	Small RSP 7" Thick	1	Standard Section 72-4
	Class I (20 lb)	1	Standard Section 72-2
	Class II (60 lb)	1	Standard Section 72-2
	Class IV (300 lb)	2	Standard Section 72-2
	Subtotal	9	
ESM Framework Sub-Mix	Class V (1/4 ton)	1	Standard Section 72-2
	Class VII (1/2 ton)	1	Standard Section 72-2
	Class VIII (1 ton)	1	Standard Section 72-2
	Class IX (2 ton)	2	Standard Section 72-2
	Subtotal	5	

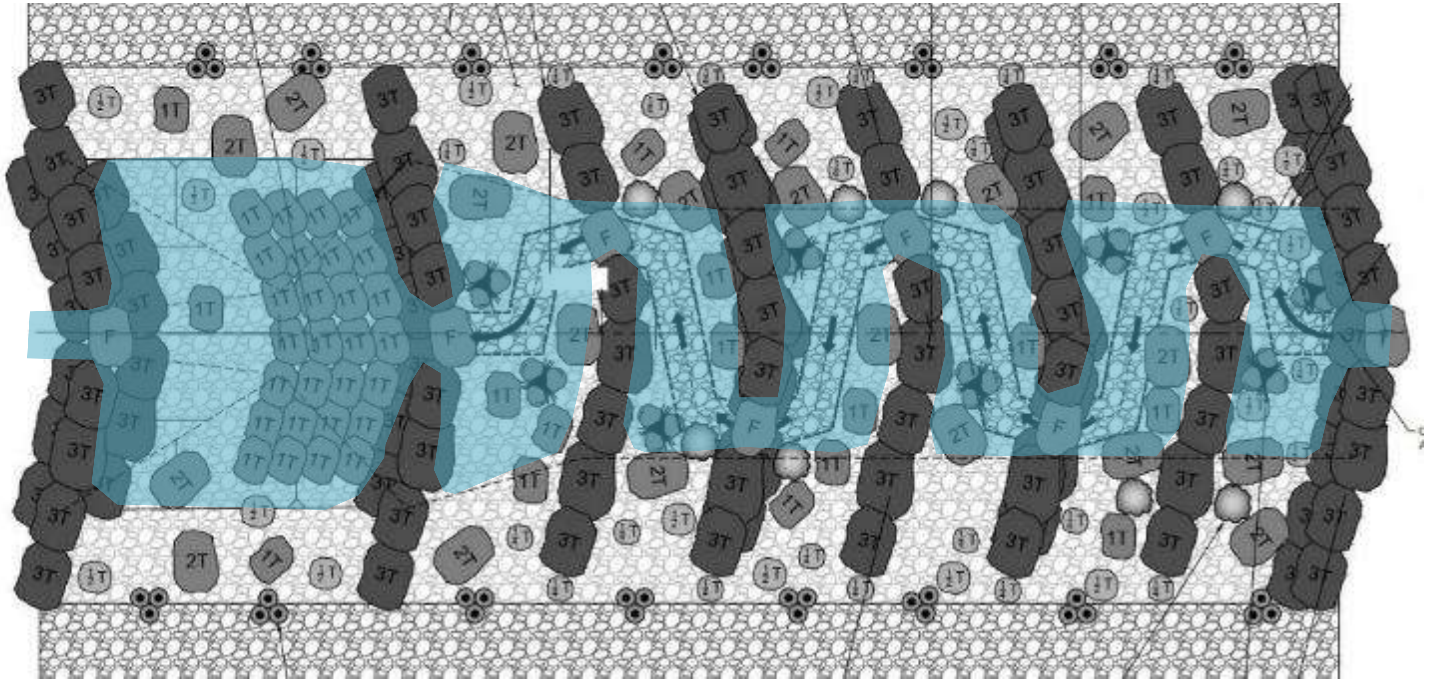
Back fill mix used to construct riffle

Design

- Cascade Roughened Channel
  - Hydraulic Design Approach
    - Requires evaluating hydraulic fish passage design criteria
  - High flow velocity criteria met along channel edges
  - Low flow depth criteria met through flow path

CDFW (2010):

*"The geomorphic characteristics of natural channel types, along with **hydraulic fish passage design criteria** for water depths and velocities, turbulence, hydraulic drops and minimum pool depths, can be used to **guide design of a roughened channel**."*



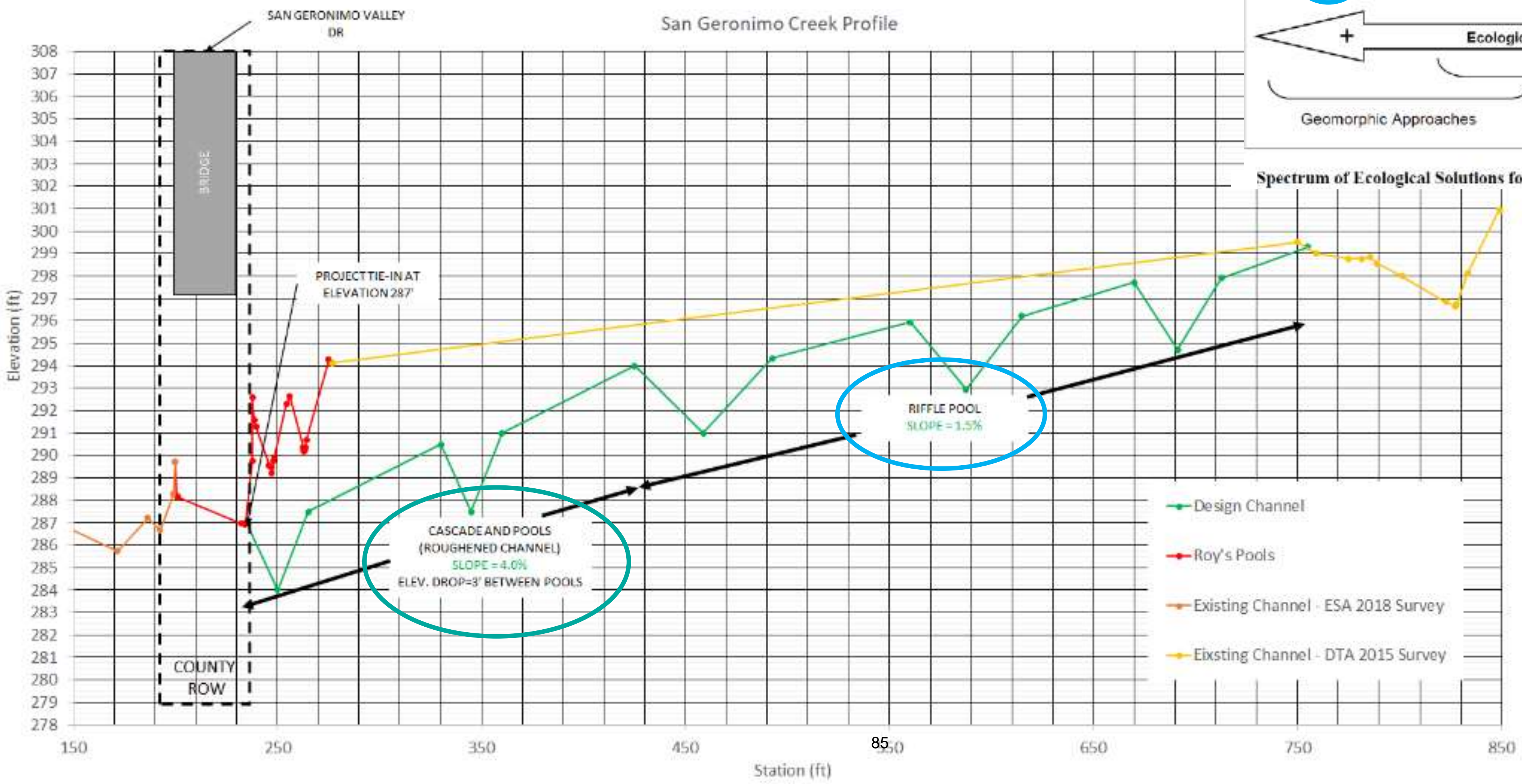
	Design Flow	Left Edge Velocity	Channel Velocity	Right Edge Velocity	CDFW Criteria Maximum Average Water Velocity
	(cu ft/s)	(ft/s)	(ft/s)	(ft/s)	(ft/s)
Juvenile Salmonids					
U/S Cascade	30	1.2	2.4	1.2	1
D/S Cascade	30	1.3	3.0	1.4	1
Adult Salmonids					
U/S Cascade	337	3.9	6.8	3.9	5
D/S Cascade	337	3.6	6.4	3.6	5

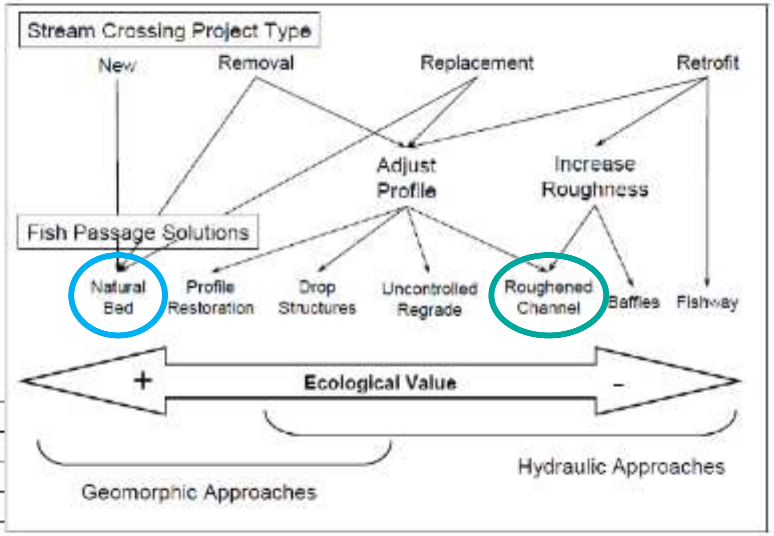
Design Flow	Flow Depth	CDFW Criteria Minimum Flow Depth
(cu ft/s)	(ft)	(ft/s)
Juvenile Salmonids		
1	0.8	0.5
Adult Salmonids		
3	1.2	1

ESA

Design

- Project Profile Design: broken into two design approaches





Spectrum of Ecological Solutions for Fish Passage.

Graphic Source: CDFW (2010)

ESA

Implementation

Implementation

Construction Manager and Revegetation Planning & Implementation

TURTLE ISLAND RESTORATION NETWORK
SPAWN

Construction Contractor

HANFORD

Engineer Observation

ESA

with support from

A3GEO

MARK THOMAS

Project Funder

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

Project Partner

COUNTY OF MARIN

Implementation

- Demolition

Implementation

- Water Control





89

ESA

Implementation

- Staging, review, and mixing of rock





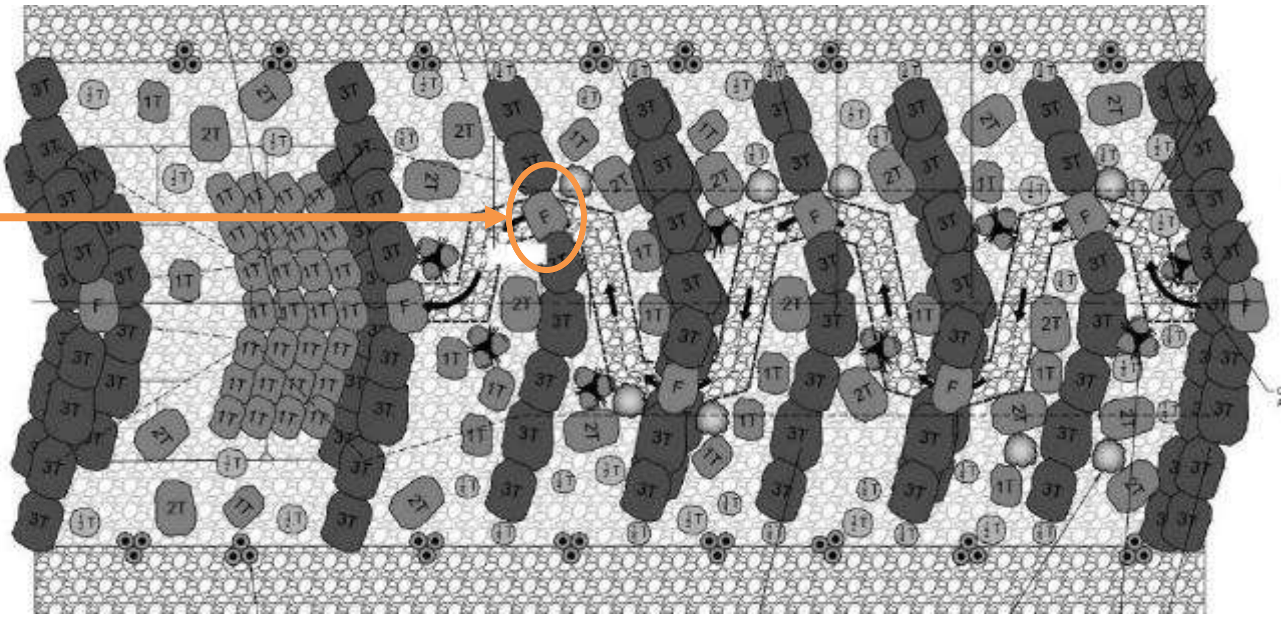
ESA

Implementation (Year 1: 2020)

- Cascade Roughened Channel Construction

Implementation (Year 1: 2020)

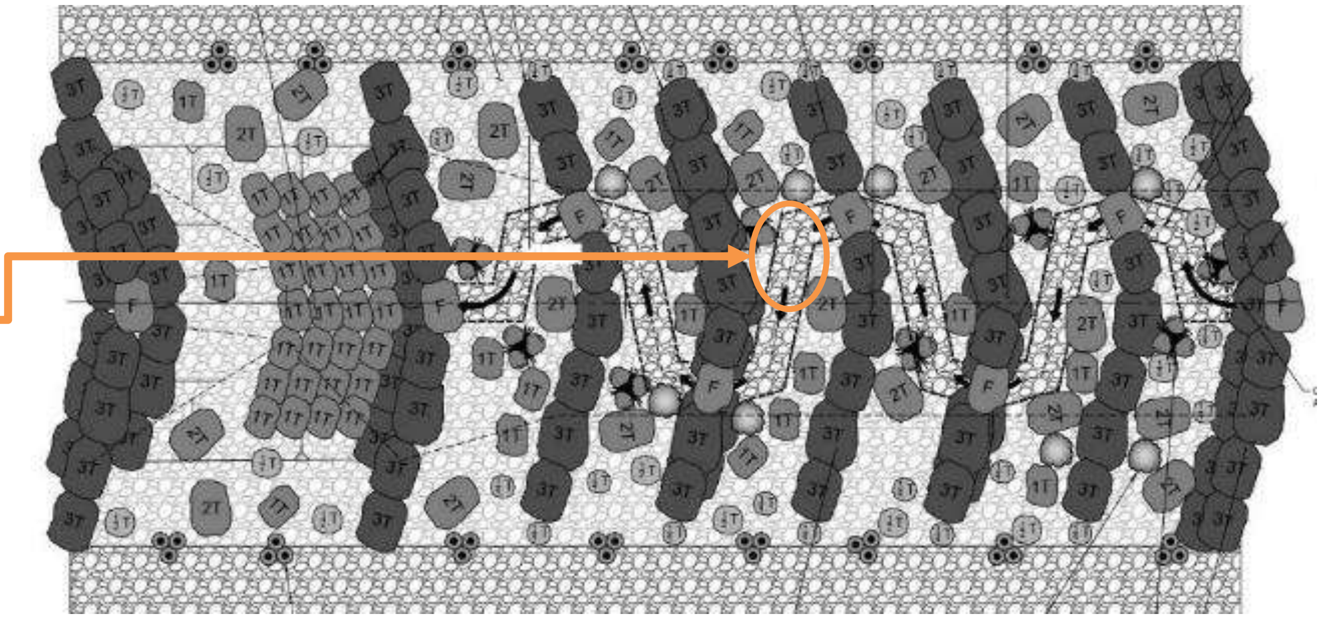
- Cascade Roughened Channel Construction: Flow Stone



ESA

Implementation (Year 1: 2020)

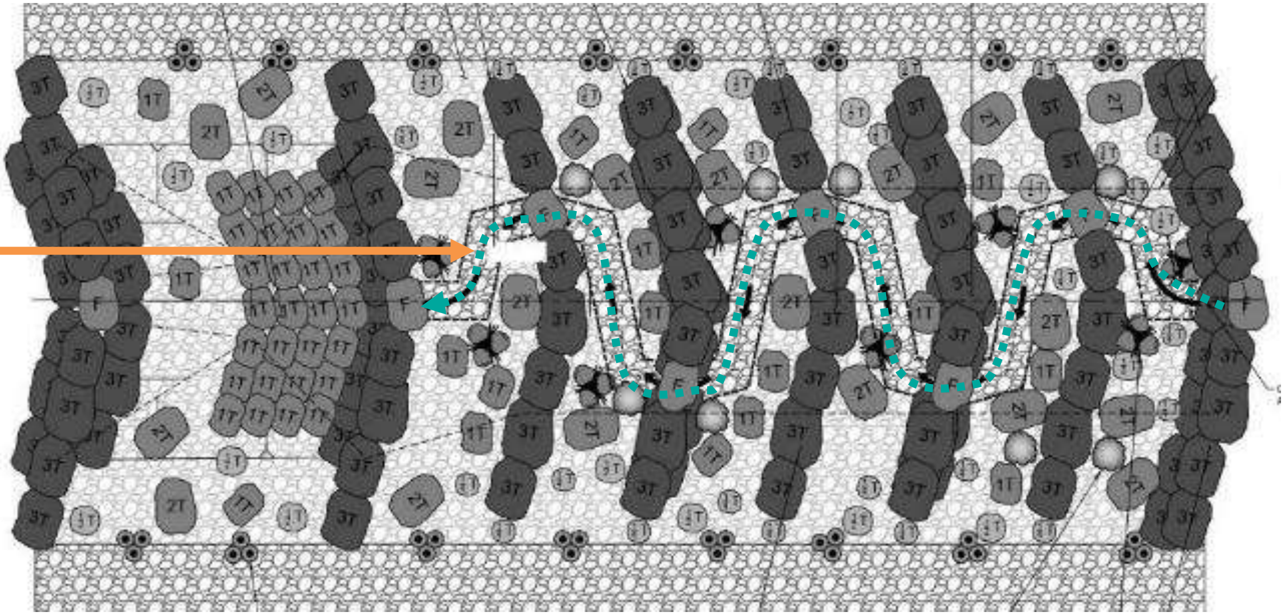
- Cascade Roughened Channel Construction: Tamp and Jet to Seal



ESA

Implementation (Year 1: 2020)

- Cascade Roughened Channel Construction: Low Flow Path Established

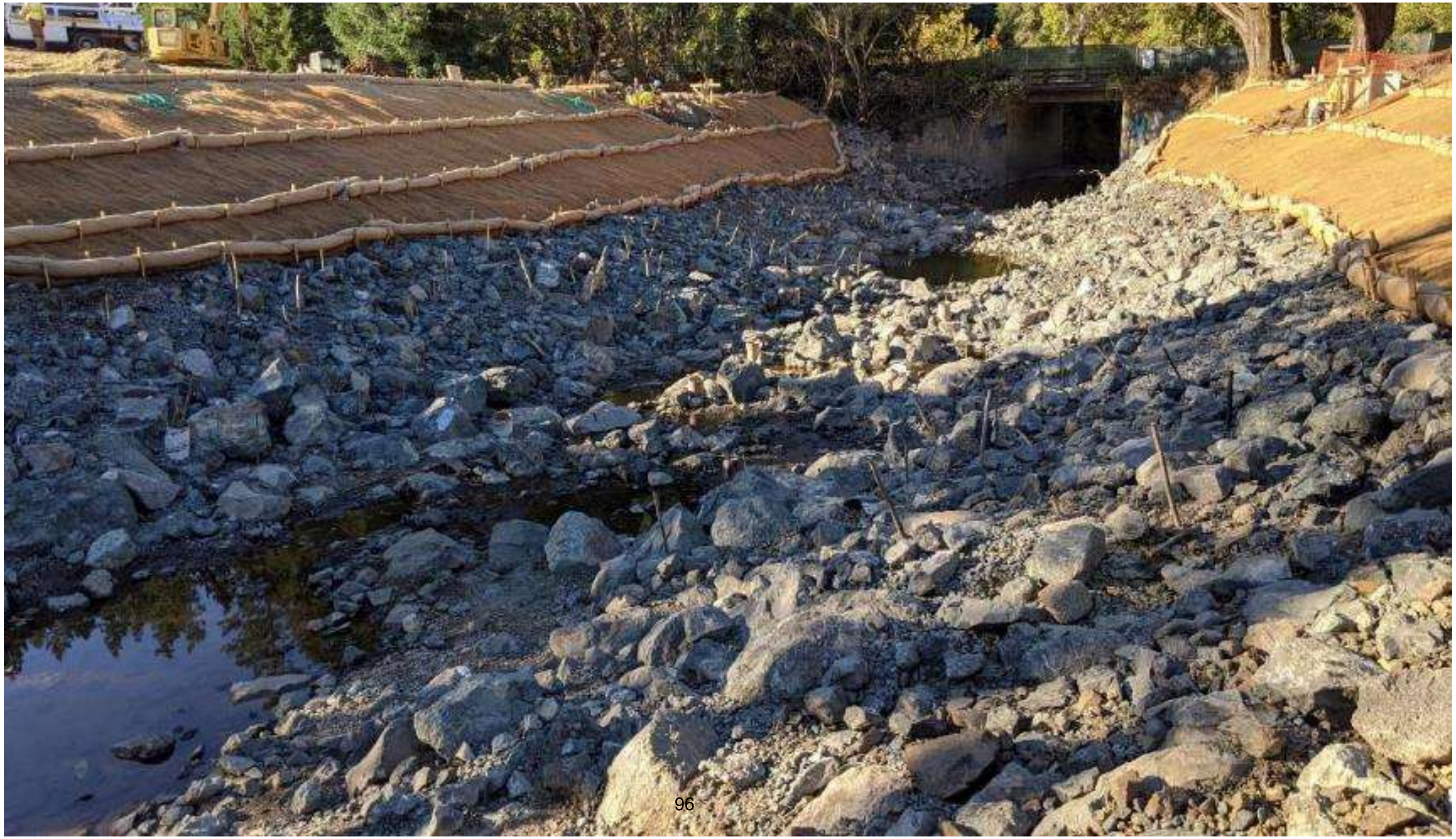


Implementation (Year 1: 2020)

- Cascade Roughened Channel Construction: Willow Pole Plantings

Implementation (Year 1: 2020)

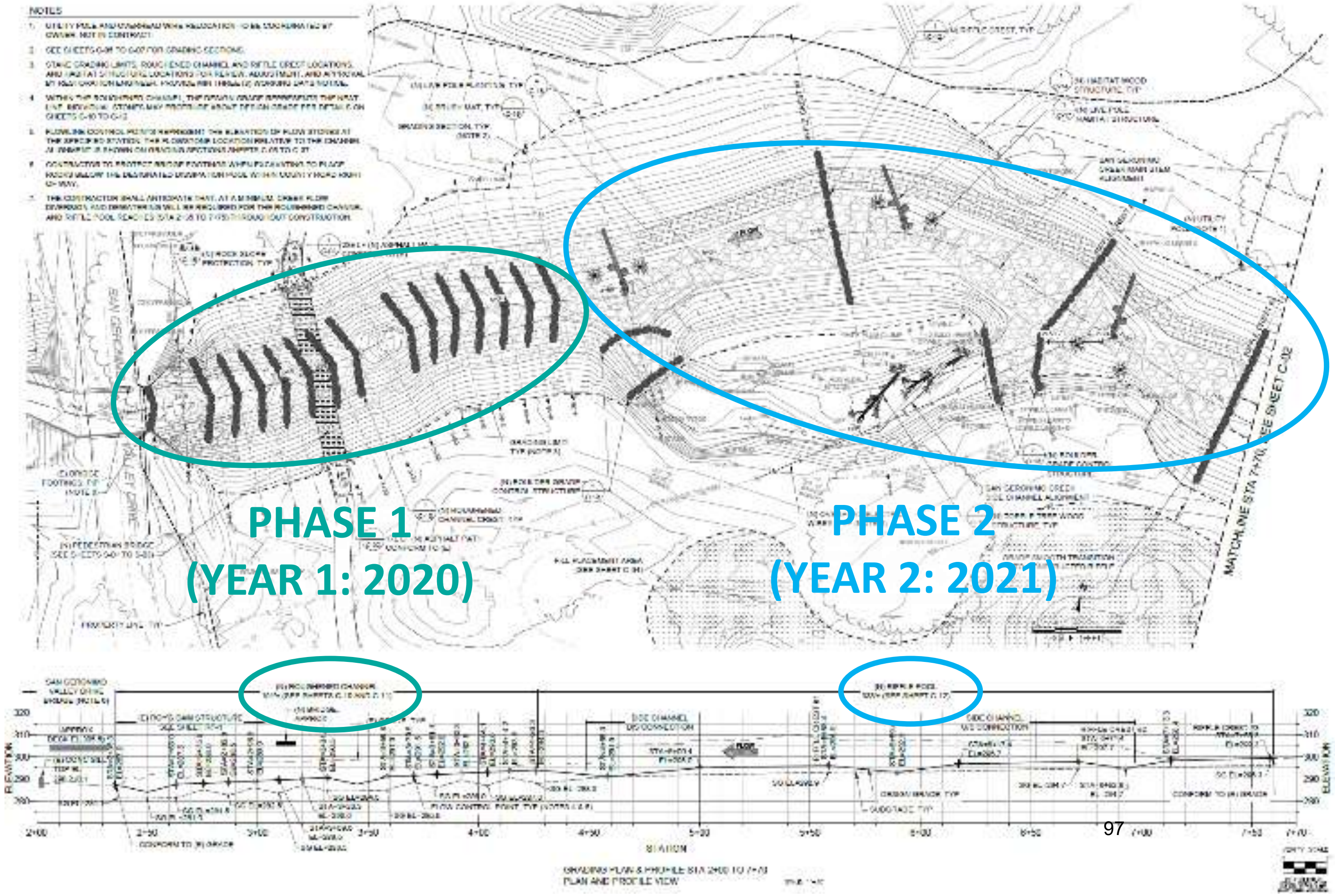
- Cascade Roughened Channel Construction



ESA

Implementation (Year 1: 2020)

- Phasing



Implementation (Year 2: 2021)

- Riffle Pool

Implementation (Year 2: 2021)

- Riffle Pool

Implementation (Year 2: 2021)

- Under the Bridge

Geomorphic Change

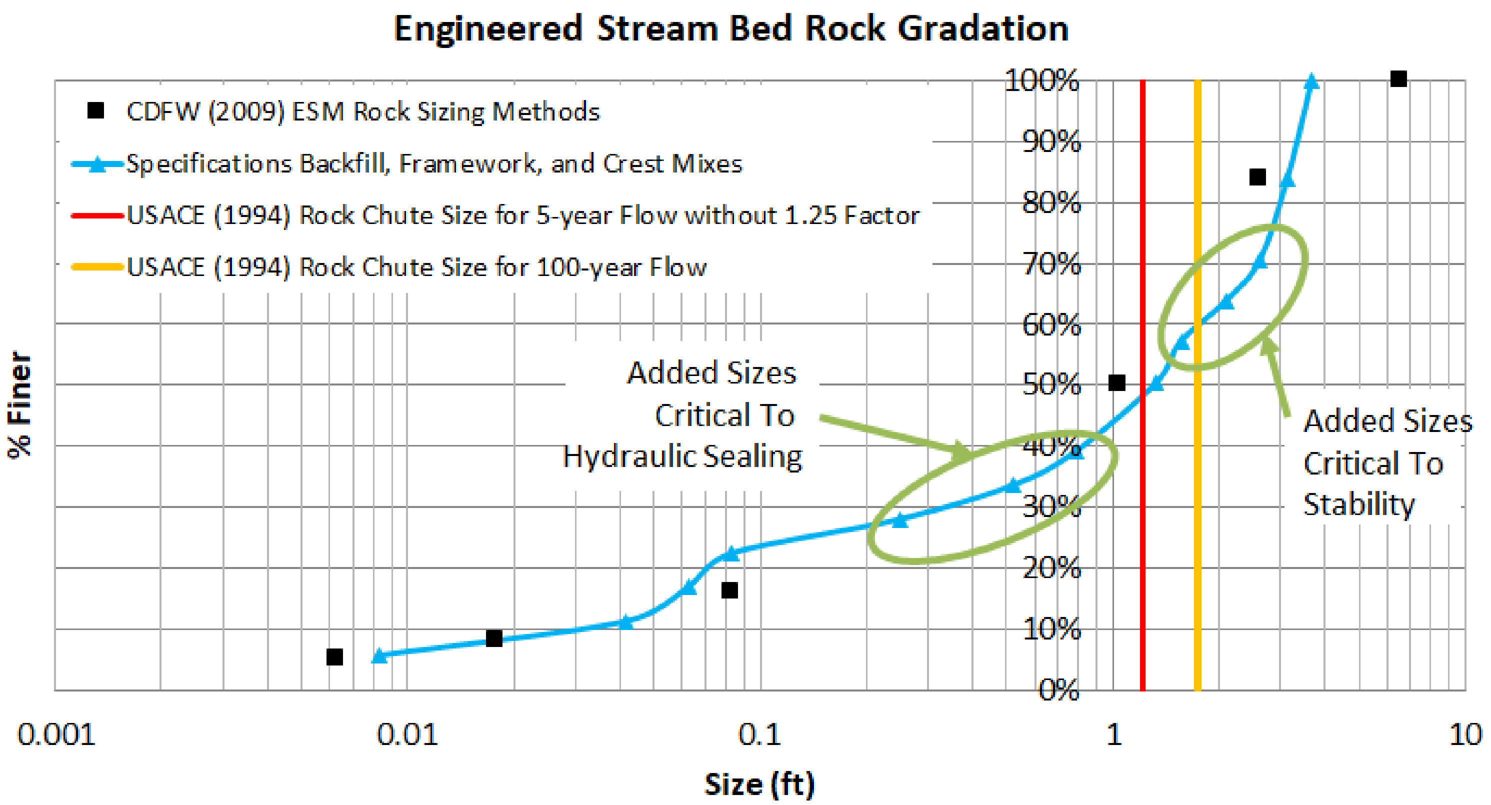
Geomorphic Change

- October 24th, 2021: 9 inches of rain in 24 hours
- Flows estimated to be 1,200 cfs (>5-year event)

Photo: SPAWN

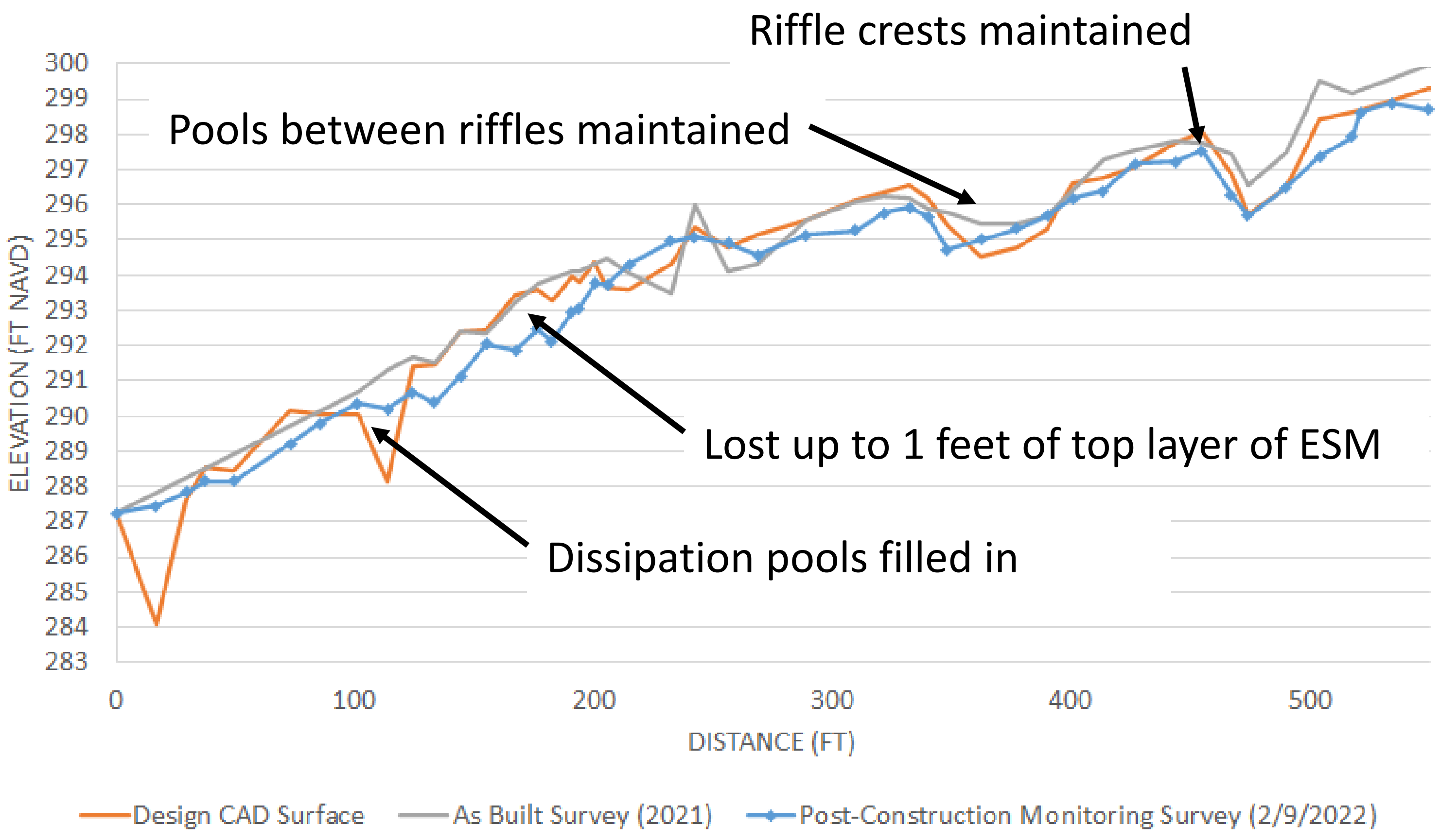
Geomorphic Change

- For 5-year event (~1,140 cfs)
  - ➢ 1.2 ft (or 250 lb) and smaller rock expected to be mobile



Geomorphic Change

- Post construction surveys before and after the October 2021 storm



ESM DEPOSIT DOWNSTREAM

Geomorphic Change

- Riffle Pool looking downstream

Geomorphic Change

- Cascade Roughened Channel Cascade looking downstream

Geomorphic Change

- Cascade Roughened Channel looking upstream from pedestrian bridge

Geomorphic Change

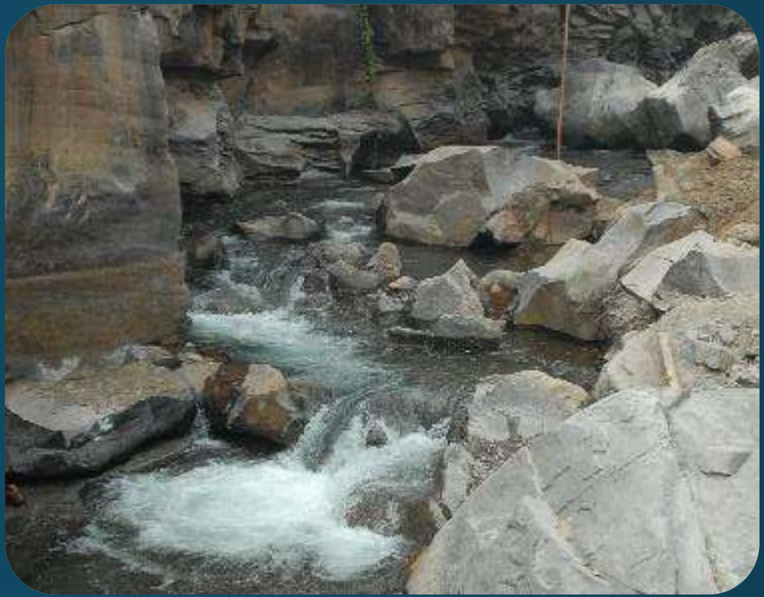
- Cascade Roughened Channel looking upstream from San Geronimo Valley Dr

ESA

Geomorphic Change

- Embrace change!

Questions



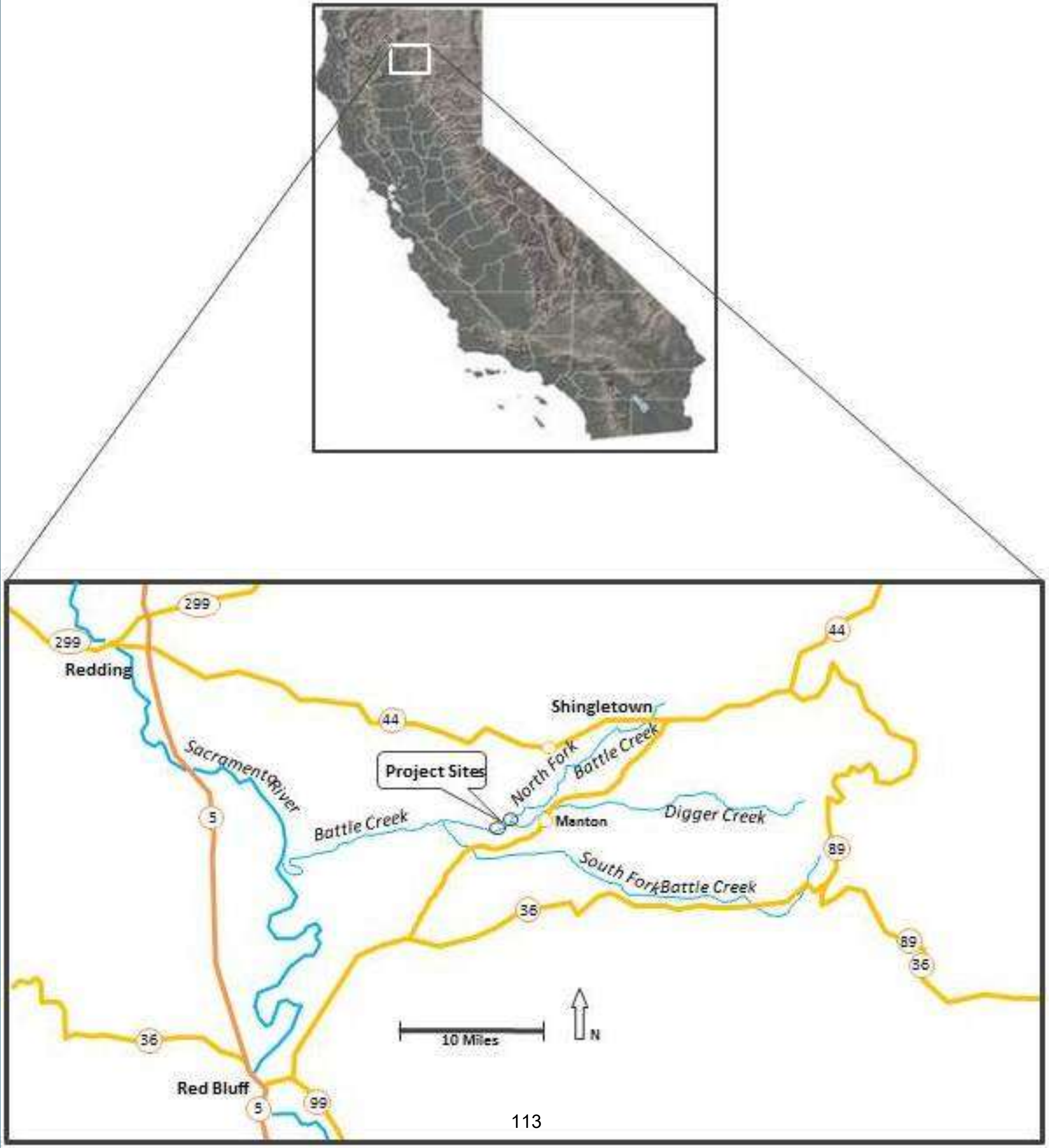
North Fork Battle Creek Fish Passage Improvement Project

Implementation Lessons Learned When Design Cannot Progress Past a Conceptual Level

Michael Love & Associates
Hydrologic Solutions

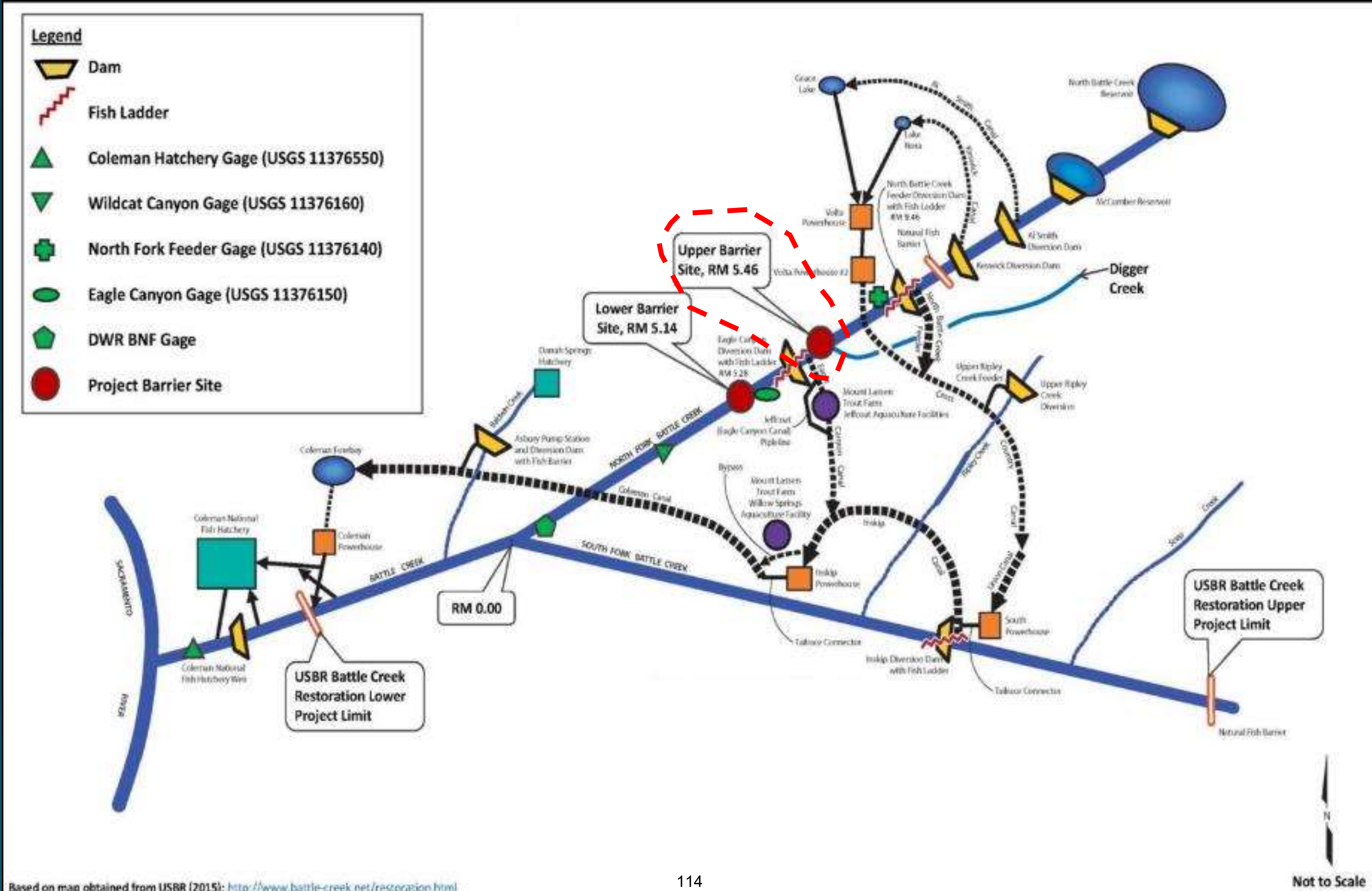
Salmonid Restoration Conference
P. Travis James, P.E.
April 27, 2023

Project Location

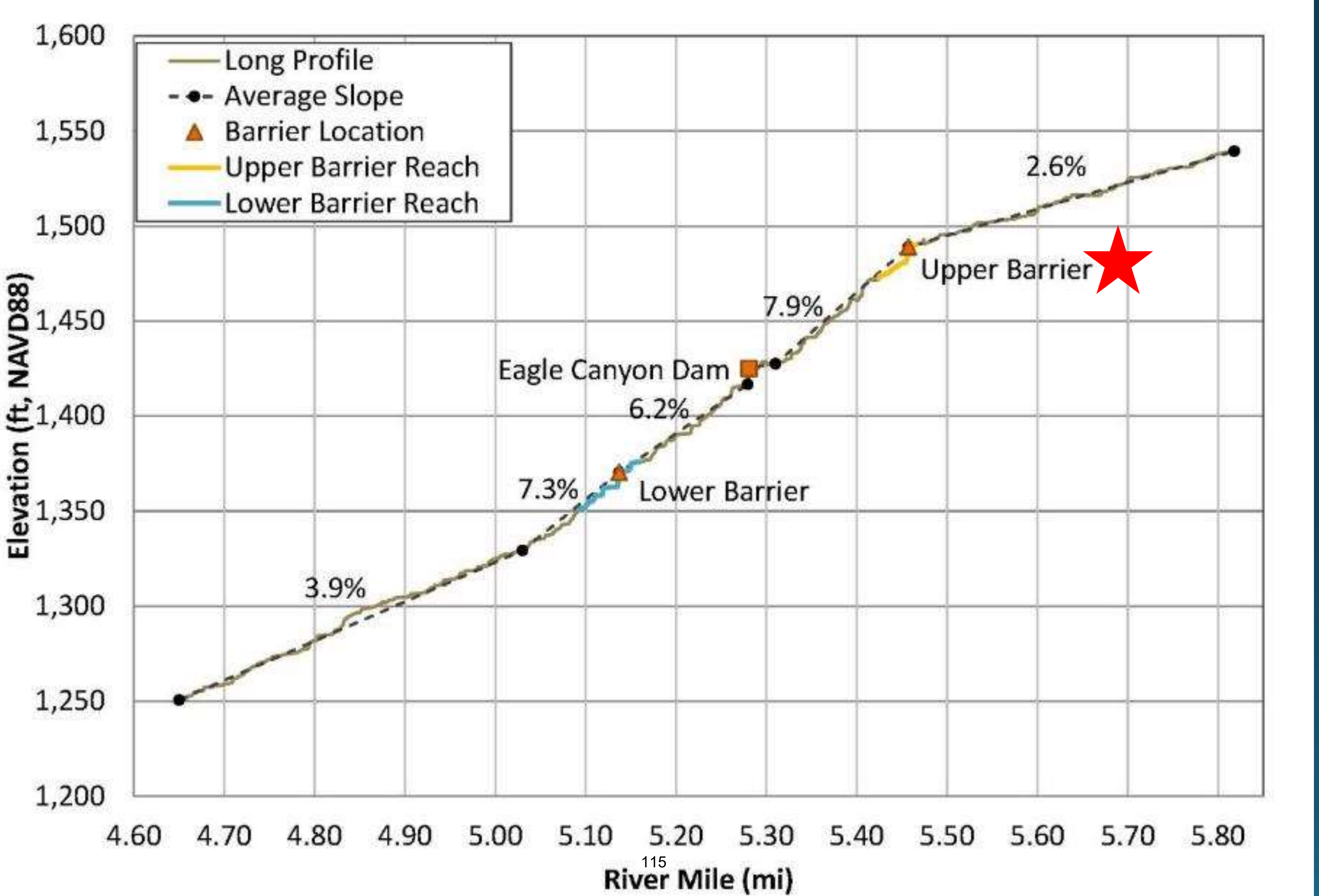


299
299
Redding
44
44
Shingletown
Project Sites
North Fork
Battle Creek
Sacramento River
5
Battle Creek
Manton
Digger Creek
89
South Fork Battle Creek
36
89
36
10 Miles
N
36
Red Bluff
5
99

Battle Creek Schematic with Lower and Upper Barriers



Profile of Eagle Canyon Reach



Design Overview

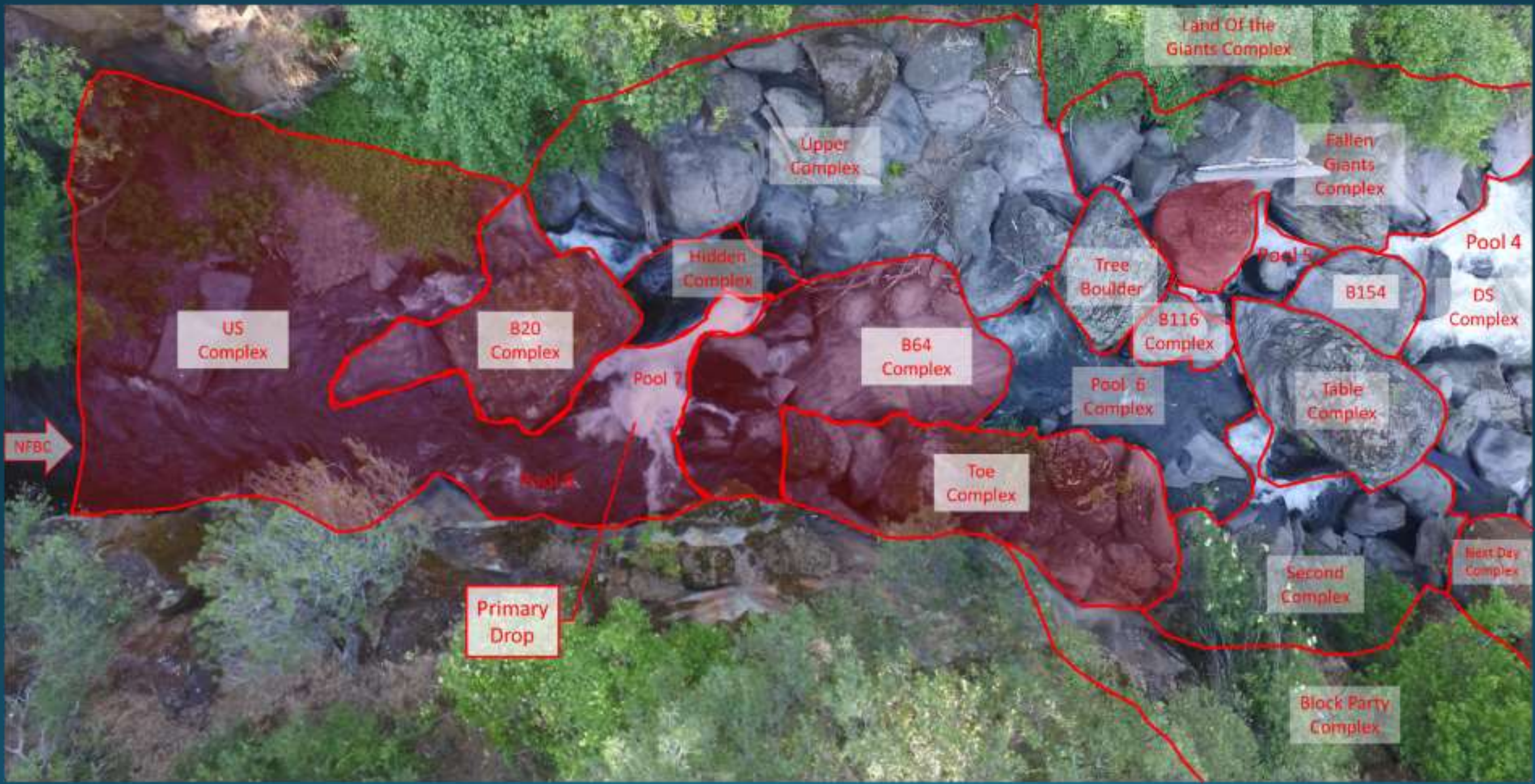
Site Characterization

- Survey (total station, sonar, laser scan)
- Geotechnical investigation
- Boulder mapping
- Flow lines mapping
- Sieve mapping
- Pressure transducers
- Timelapse cameras
- Flow measurements

Upper Barrier Site Flow Paths and Sieves

Scan point cloud

UBS Alternative C: Natural Channel Regrade
Boulders and Bedrock to be Removed



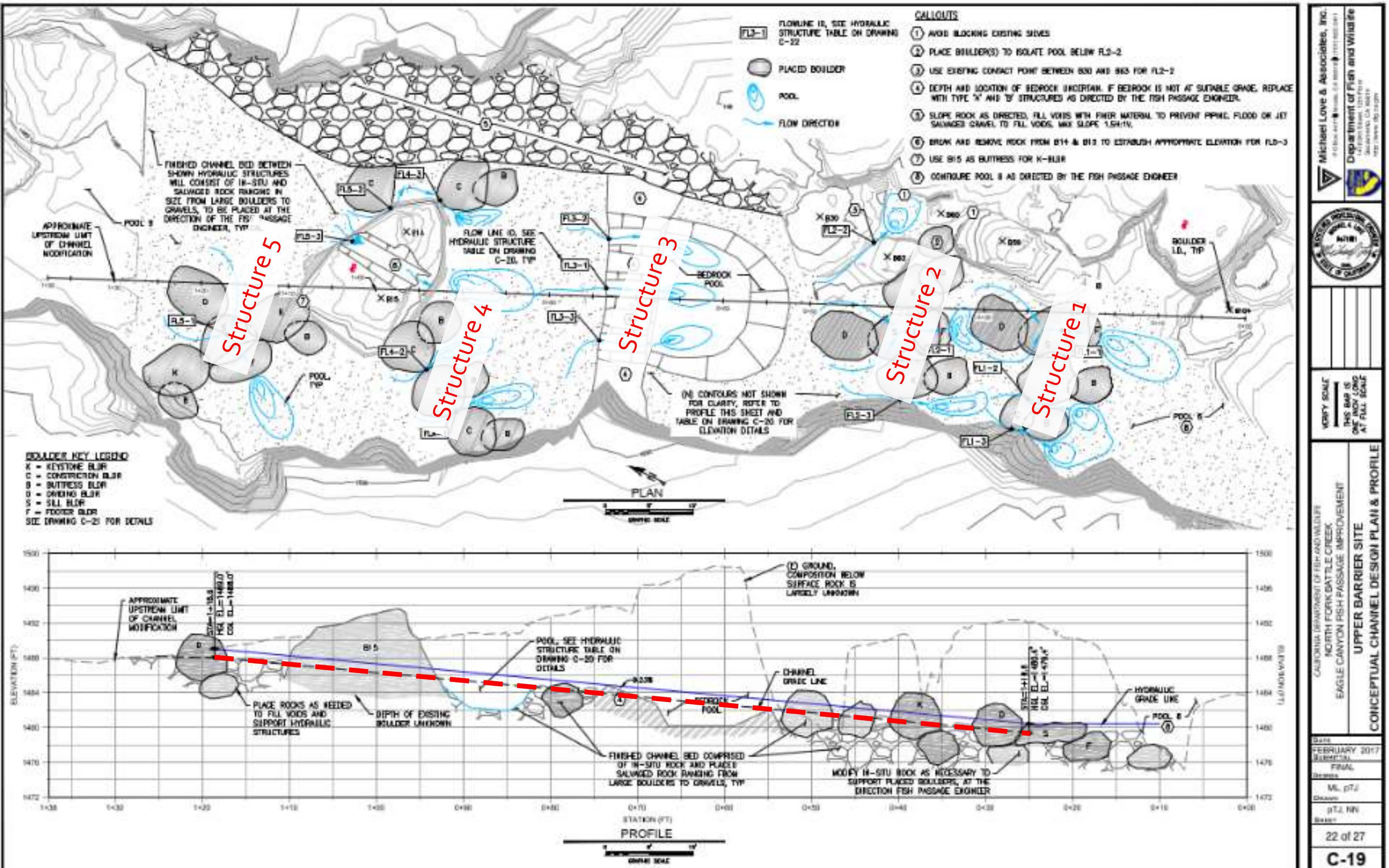
Design Documents

Lesson: Be clear about uncertainties

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT

UPPER BARRIER SITE

CONCEPTUAL CHANNEL DESIGN PLAN & PROFILE



Overall Slope = 9.2%

Implementation

Eagle Canyon Implementation Team

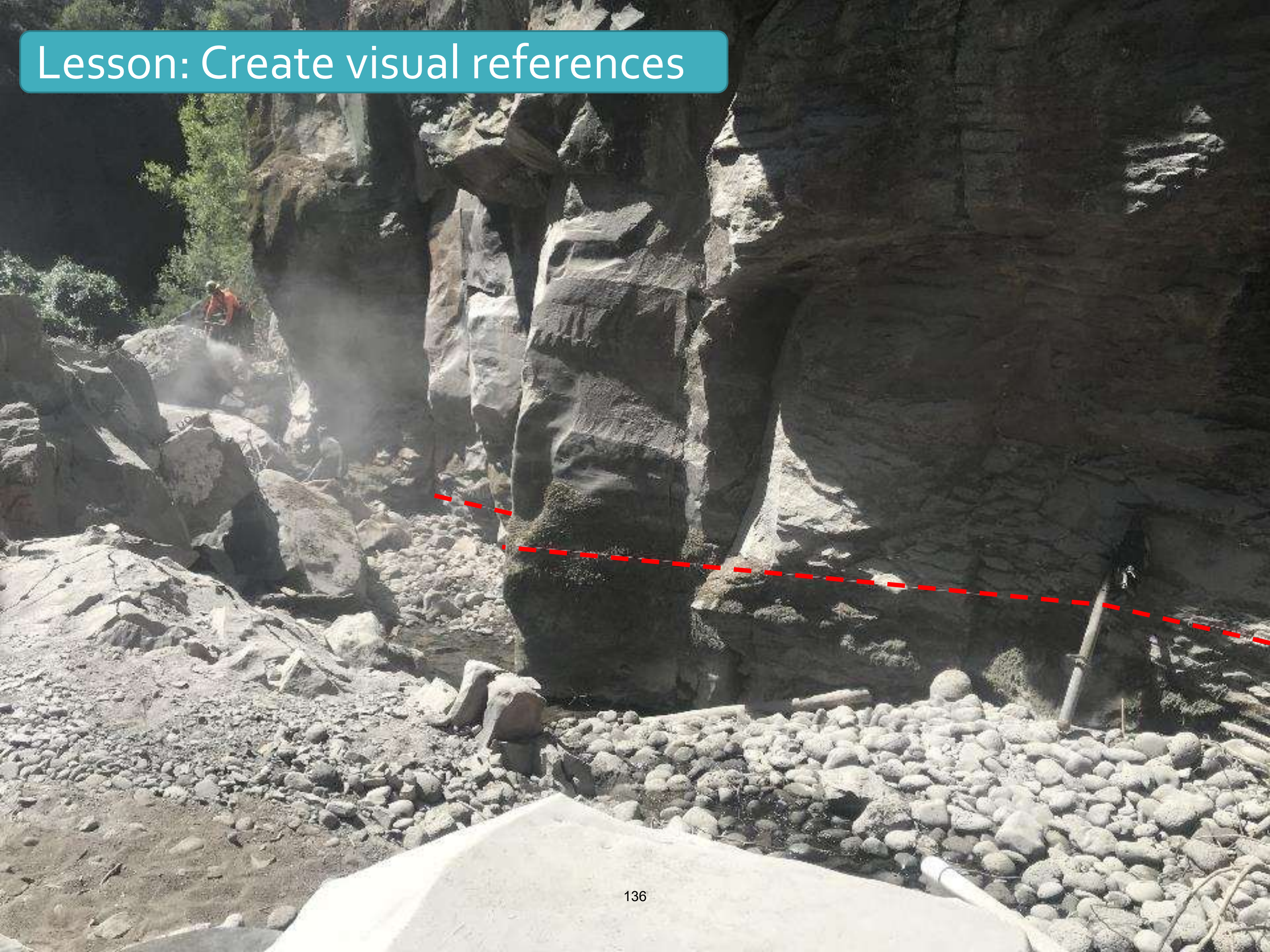
Implementation: Access & Water Management

Boulder Removal

Lesson: Label what you know

Lesson: Know how to use survey tools

Lesson: Create visual references



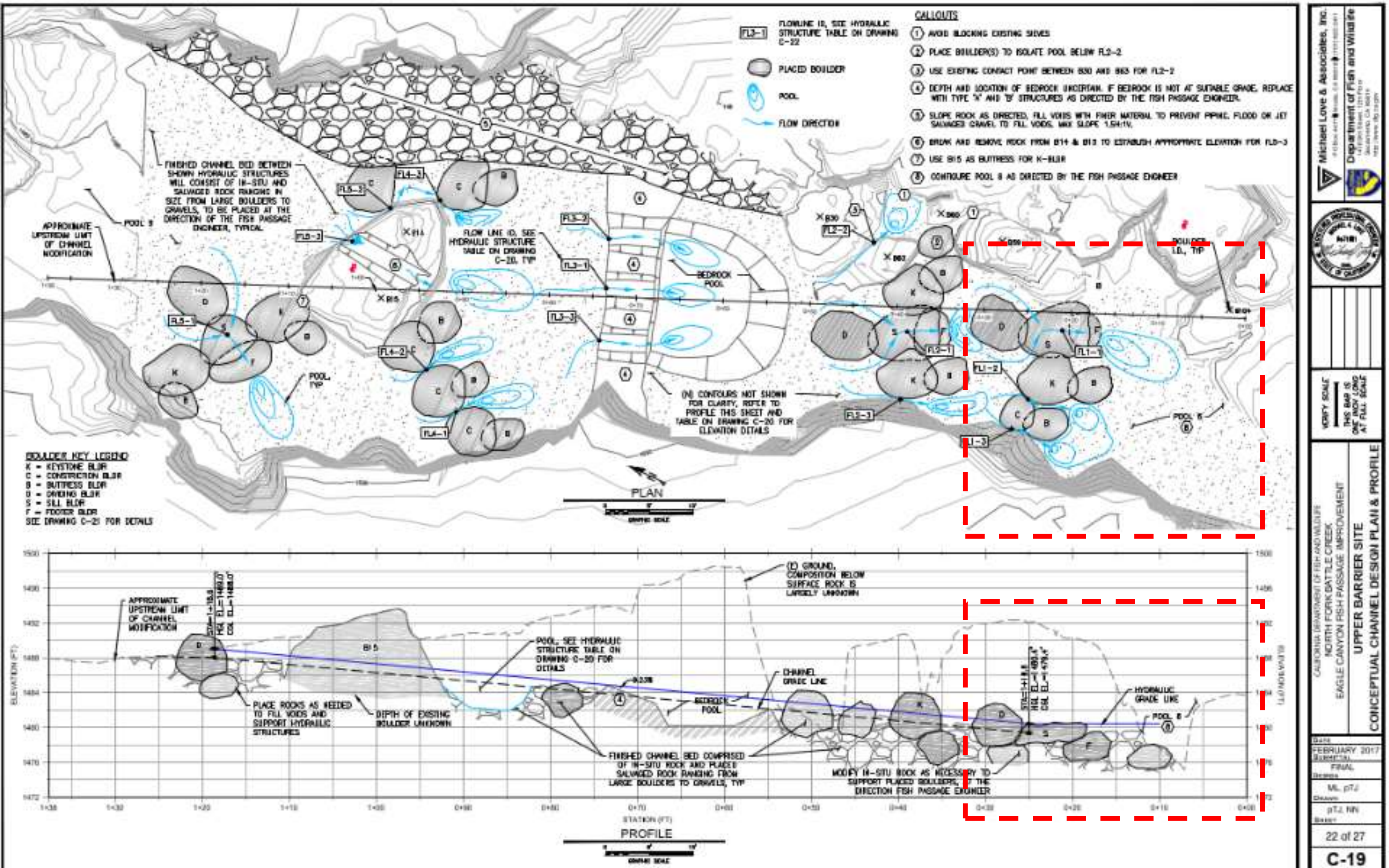

July 2, 2021

July 15, 2021

July 20, 2021

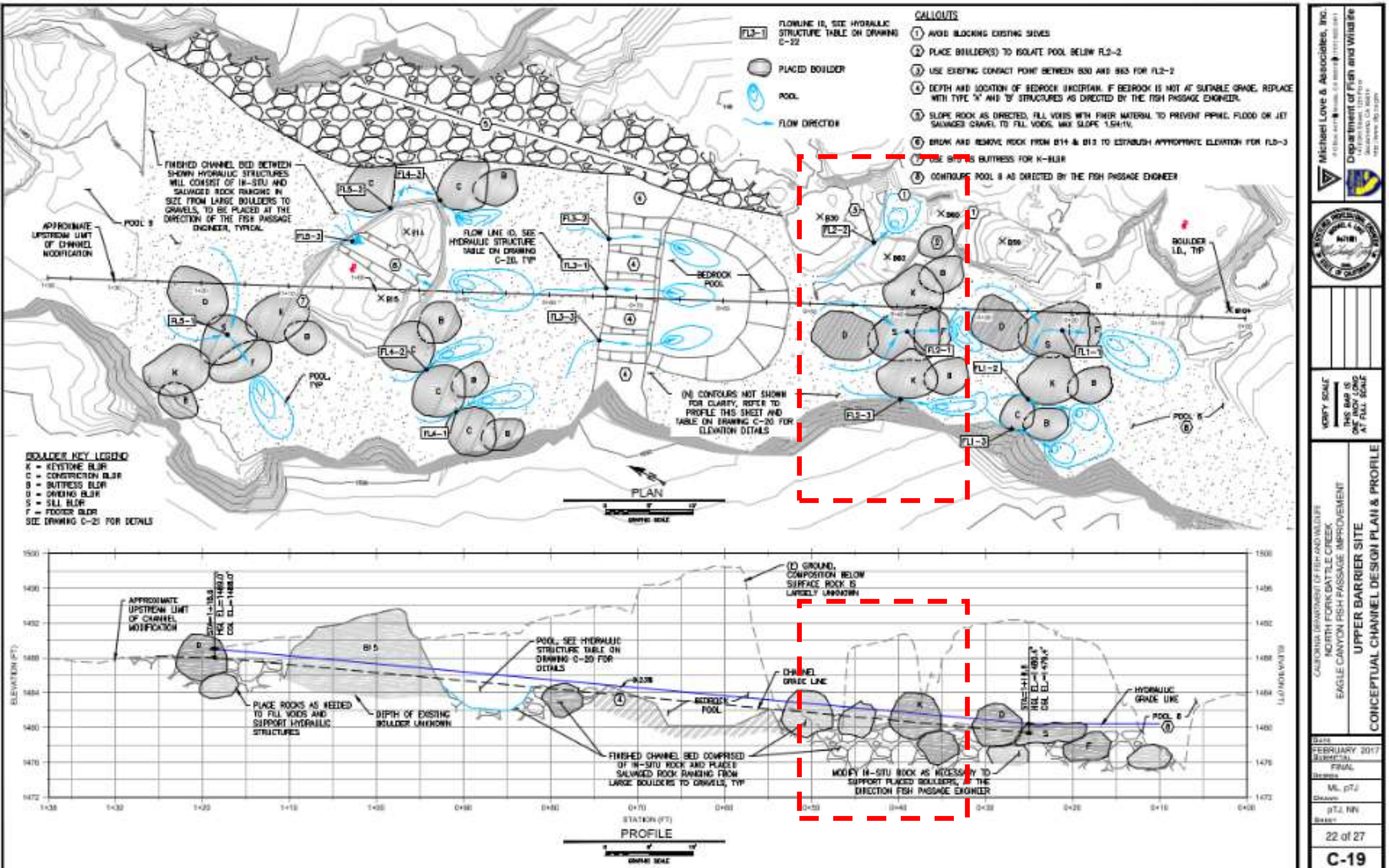

1,800 tons of rock removed
(3,600,000 lbs)

Reconstruction: Structure 1


CALLOUTS
1 AVOID BLOCKING EXISTING SIEVES
2 PLACE BOULDER(S) TO ISOLATE POOL BELOW FL2-2
3 USE EXISTING CONTACT POINT BETWEEN B30 AND B63 FOR FL2-2
4 DEPTH AND LOCATION OF BEDROCK UNCERTAIN. IF BEDROCK IS NOT AT SUITABLE GRADE, REPLACE WITH TYPE 'A' AND 'B' STRUCTURES AS DIRECTED BY THE FISH PASSAGE ENGINEER.
5 SLOPE ROCK AS DIRECTED. FILL VOIDS WITH FINER MATERIAL TO PREVENT PIPING. FLOOD OR JET SALVAGED GRAVEL TO FILL VOIDS. MAX SLOPE 1.5H:1V.
6 BREAK AND REMOVE ROCK FROM B14 & B13 TO ESTABLISH APPROPRIATE ELEVATION FOR FL5-3
7 USE B15 AS BUTTRESS FOR K-BLDR
8 CONTOURE POOL 8 AS DIRECTED BY THE FISH PASSAGE ENGINEER
FLOWLINE ID, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-22
PLACED BOULDER
POOL
FLOW DIRECTION
FINISHED CHANNEL BED BETWEEN SHOWN HYDRAULIC STRUCTURES WILL CONSIST OF IN-SITU AND SALVAGED ROCK RANGING IN SIZE FROM LARGE BOULDERS TO GRAVELS, TO BE PLACED AT THE DIRECTION OF THE FISH PASSAGE ENGINEER, TYPICAL
APPROXIMATE UPSTREAM LIMIT OF CHANNEL MODIFICATION
FLOW LINE ID, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20, TYP
BEDROCK POOL
BOULDER I.D., TYP
POOL, TYP
(N) CONTOURS NOT SHOWN FOR CLARITY, REFER TO PROFILE THIS SHEET AND TABLE ON DRAWING C-20 FOR ELEVATION DETAILS
POOL 8
BOULDER KEY LEGEND
K = KEYSTONE BLDR
C = CONSTRICTION BLDR
B = BUTTRESS BLDR
D = DIVIDING BLDR
S = SILL BLDR
F = FOOTER BLDR
SEE DRAWING C-21 FOR DETAILS
PLAN
(E) GROUND, COMPOSITION BELOW SURFACE ROCK IS LARGELY UNKNOWN
POOL, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20 FOR DETAILS
CHANNEL GRADE LINE
HYDRAULIC GRADE LINE
BEDROCK POOL
PLACE ROCKS AS NEEDED TO FILL VOIDS AND SUPPORT HYDRAULIC STRUCTURES
DEPTH OF EXISTING BOULDER UNKNOWN
FINISHED CHANNEL BED COMPRISED OF IN-SITU ROCK AND PLACED SALVAGED ROCK RANGING FROM LARGE BOULDERS TO GRAVELS, TYP
MODIFY IN-SITU ROCK AS NECESSARY TO SUPPORT PLACED BOULDERS, AT THE DIRECTION FISH PASSAGE ENGINEER
ELEVATION (FT)
STATION (FT)
PROFILE
Michael Love & Associates, Inc.
Department of Fish and Wildlife
VERIFY SCALE
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT
UPPER BARRIER SITE
CONCEPTUAL CHANNEL DESIGN PLAN & PROFILE
FEBRUARY 2017
FINAL
ML, pTJ
pTJ, NN
22 of 27
C-19

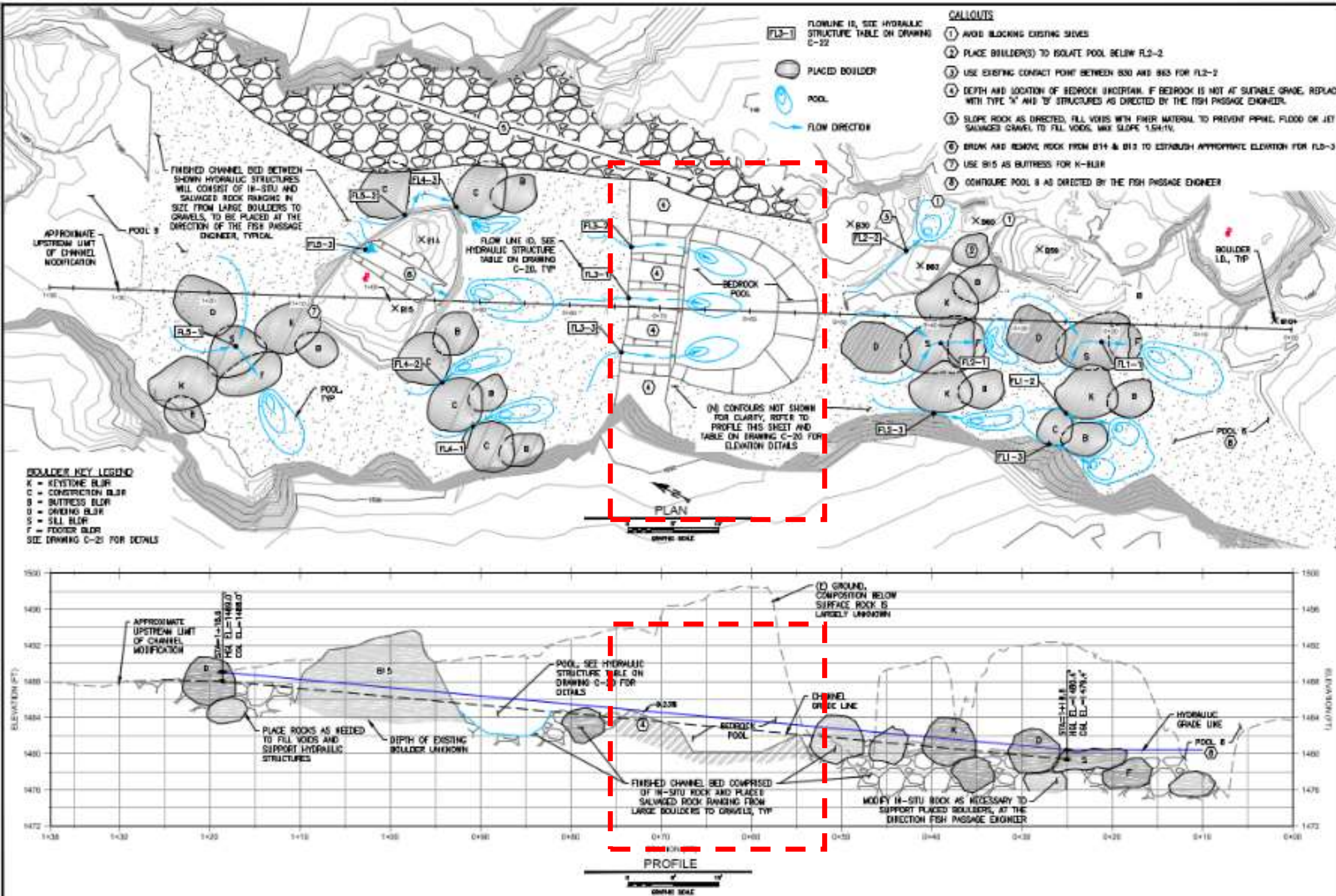
Lesson: Plan as far in advance as possible

Reconstruction: Structure 2

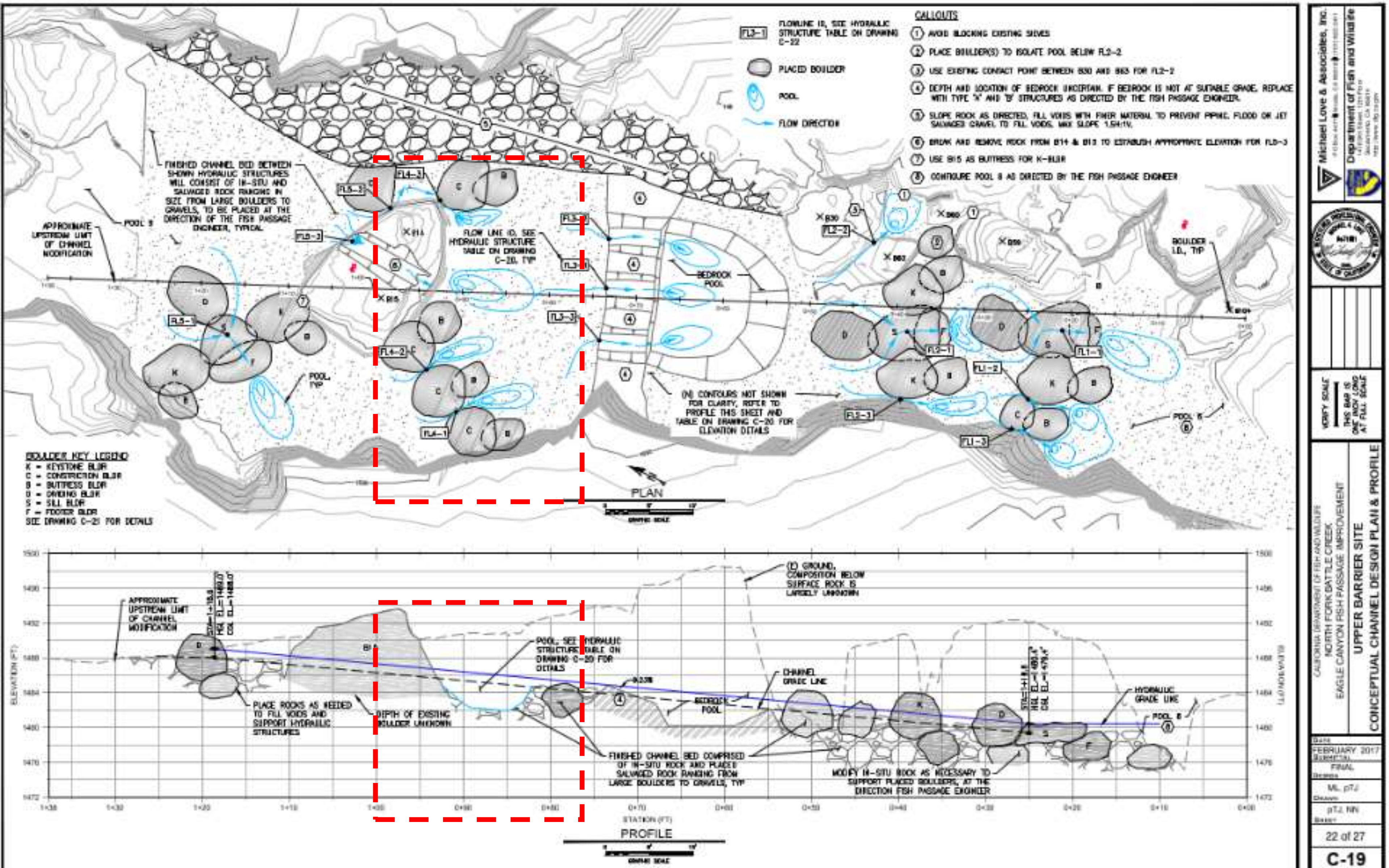

FLOWLINE ID, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-22
FL3-1
PLACED BOULDER
POOL
FLOW DIRECTION
CALLOUTS
1 AVOID BLOCKING EXISTING SIEVES
2 PLACE BOULDER(S) TO ISOLATE POOL BELOW FL2-2
3 USE EXISTING CONTACT POINT BETWEEN B30 AND B63 FOR FL2-2
4 DEPTH AND LOCATION OF BEDROCK UNCERTAIN. IF BEDROCK IS NOT AT SUITABLE GRADE, REPLACE WITH TYPE "A" AND "B" STRUCTURES AS DIRECTED BY THE FISH PASSAGE ENGINEER.
5 SLOPE ROCK AS DIRECTED. FILL VOIDS WITH FINER MATERIAL TO PREVENT PIPING. FLOOD OR JET SALVAGED GRAVEL TO FILL VOIDS. MAX SLOPE 1.5H:1V.
6 BREAK AND REMOVE ROCK FROM B14 & B13 TO ESTABLISH APPROPRIATE ELEVATION FOR FL5-3
7 USE B15 AS BUTTRESS FOR K-BLDR
8 CONTOUR POOL 8 AS DIRECTED BY THE FISH PASSAGE ENGINEER
FINISHED CHANNEL BED BETWEEN SHOWN HYDRAULIC STRUCTURES WILL CONSIST OF IN-SITU AND SALVAGED ROCK RANGING IN SIZE FROM LARGE BOULDERS TO GRAVELS, TO BE PLACED AT THE DIRECTION OF THE FISH PASSAGE ENGINEER, TYPICAL
APPROXIMATE UPSTREAM LIMIT OF CHANNEL MODIFICATION
POOL 9
FLOW LINE ID, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20, TYP
BEDROCK POOL
POOL, TYP
(N) CONTOURS NOT SHOWN FOR CLARITY, REFER TO PROFILE THIS SHEET AND TABLE ON DRAWING C-20 FOR ELEVATION DETAILS
BOULDER I.D., TYP
POOL 8
FL5-1 FL5-2 FL5-3 FL4-1 FL4-2 FL3-1 FL3-2 FL3-3 FL2-1 FL2-2 FL2-3 FL1-1 FL1-2 FL1-3
BOULDER KEY LEGEND
K = KEYSTONE BLDR
C = CONSTRICTION BLDR
B = BUTTRESS BLDR
D = DIVIDING BLDR
S = SILL BLDR
F = FOOTER BLDR
SEE DRAWING C-21 FOR DETAILS
PLAN
GRAPHIC SCALE
(E) GROUND, COMPOSITION BELOW SURFACE ROCK IS LARGELY UNKNOWN
APPROXIMATE UPSTREAM LIMIT OF CHANNEL MODIFICATION
POOL, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20 FOR DETAILS
CHANNEL GRADE LINE
BEDROCK POOL
HYDRAULIC GRADE LINE
POOL 8
PLACE ROCKS AS NEEDED TO FILL VOIDS AND SUPPORT HYDRAULIC STRUCTURES
DEPTH OF EXISTING BOULDER UNKNOWN
FINISHED CHANNEL BED COMPRISED OF IN-SITU ROCK AND PLACED SALVAGED ROCK RANGING FROM LARGE BOULDERS TO GRAVELS, TYP
MODIFY IN-SITU ROCK AS NECESSARY TO SUPPORT PLACED BOULDERS, AT THE DIRECTION FISH PASSAGE ENGINEER
ELEVATION (FT)
STATION (FT)
PROFILE
GRAPHIC SCALE
Michael Love & Associates, Inc.
Department of Fish and Wildlife
VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT
UPPER BARRIER SITE
CONCEPTUAL CHANNEL DESIGN PLAN & PROFILE
FEBRUARY 2017
FINAL
ML, pTJ
pTJ, NN
22 of 27
C-19


YANMAR

Reconstruction: Structure 3


FLOWLINE ID, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-22
PLACED BOULDER
POOL
FLOW DIRECTION
CALLOUTS
1 AVOID BLOCKING EXISTING SIEVES
2 PLACE BOULDER(S) TO ISOLATE POOL BELOW FL2-2
3 USE EXISTING CONTACT POINT BETWEEN B30 AND B63 FOR FL2-2
4 DEPTH AND LOCATION OF BEDROCK UNCERTAIN. IF BEDROCK IS NOT AT SUITABLE GRADE, REPLACE WITH TYPE "A" AND "B" STRUCTURES AS DIRECTED BY THE FISH PASSAGE ENGINEER.
5 SLOPE ROCK AS DIRECTED. FILL VOIDS WITH FINER MATERIAL TO PREVENT PIPING. FLOOD OR JET SALVAGED GRAVEL TO FILL VOIDS. MAX SLOPE 1.5H:1V.
6 BREAK AND REMOVE ROCK FROM B14 & B13 TO ESTABLISH APPROPRIATE ELEVATION FOR FL3-3
7 USE B15 AS BUTTRESS FOR K-BLDR
8 CONTOURE POOL 8 AS DIRECTED BY THE FISH PASSAGE ENGINEER
FINISHED CHANNEL BED BETWEEN SHOWN HYDRAULIC STRUCTURES WILL CONSIST OF IN-SITU AND SALVAGED ROCK RANGING IN SIZE FROM LARGE BOULDERS TO GRAVELS, TO BE PLACED AT THE DIRECTION OF THE FISH PASSAGE ENGINEER, TYPICAL
APPROXIMATE UPSTREAM LIMIT OF CHANNEL MODIFICATION
POOL 9
FLOW LINE ID, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20, TYP
BEDROCK POOL
POOL, TYP
(N) CONTOURS NOT SHOWN FOR CLARITY, REFER TO PROFILE THIS SHEET AND TABLE ON DRAWING C-20 FOR ELEVATION DETAILS
BOULDER I.D., TYP
POOL 8
BOULDER KEY LEGEND
K = KEYSTONE BLDR
C = CONSTRICTION BLDR
B = BUTTRESS BLDR
D = DIVIDING BLDR
S = SILL BLDR
F = FOOTER BLDR
SEE DRAWING C-21 FOR DETAILS
PLAN
(E) GROUND, COMPOSITION BELOW SURFACE ROCK IS LARGELY UNKNOWN
POOL, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20 FOR DETAILS
CHANNEL GRADE LINE
BEDROCK POOL
HYDRAULIC GRADE LINE
PLACE ROCKS AS NEEDED TO FILL VOIDS AND SUPPORT HYDRAULIC STRUCTURES
DEPTH OF EXISTING BOULDER UNKNOWN
FINISHED CHANNEL BED COMPRISED OF IN-SITU ROCK AND PLACED SALVAGED ROCK RANGING FROM LARGE BOULDERS TO GRAVELS, TYP
MODIFY IN-SITU ROCK AS NECESSARY TO SUPPORT PLACED BOULDERS, AT THE DIRECTION FISH PASSAGE ENGINEER
PROFILE
Michael Love & Associates, Inc.
Department of Fish and Wildlife
VERIFY SCALE
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT
UPPER BARRIER SITE
CONCEPTUAL CHANNEL DESIGN PLAN & PROFILE
FEBRUARY 2017
FINAL
22 of 27
C-19

Reconstruction: Structure 4



FLOWLINE ID, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-22
PLACED BOULDER
POOL
FLOW DIRECTION
CALLOUTS
1 AVOID BLOCKING EXISTING SIEVES
2 PLACE BOULDER(S) TO ISOLATE POOL BELOW FL2-2
3 USE EXISTING CONTACT POINT BETWEEN B30 AND B63 FOR FL2-2
4 DEPTH AND LOCATION OF BEDROCK UNCERTAIN. IF BEDROCK IS NOT AT SUITABLE GRADE, REPLACE WITH TYPE "A" AND "B" STRUCTURES AS DIRECTED BY THE FISH PASSAGE ENGINEER.
5 SLOPE ROCK AS DIRECTED. FILL VOIDS WITH FINER MATERIAL TO PREVENT PIPING. FLOOD OR JET SALVAGED GRAVEL TO FILL VOIDS. MAX SLOPE 1.5H:1V.
6 BREAK AND REMOVE ROCK FROM B14 & B13 TO ESTABLISH APPROPRIATE ELEVATION FOR FL5-3
7 USE B15 AS BUTTRESS FOR K-BLDR
8 CONTOURE POOL 8 AS DIRECTED BY THE FISH PASSAGE ENGINEER
FINISHED CHANNEL BED BETWEEN SHOWN HYDRAULIC STRUCTURES WILL CONSIST OF IN-SITU AND SALVAGED ROCK RANGING IN SIZE FROM LARGE BOULDERS TO GRAVELS, TO BE PLACED AT THE DIRECTION OF THE FISH PASSAGE ENGINEER, TYPICAL
APPROXIMATE UPSTREAM LIMIT OF CHANNEL MODIFICATION
POOL 9
FLOW LINE ID, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20, TYP
BEDROCK POOL
BOULDER I.D., TYP
POOL, TYP
(N) CONTOURS NOT SHOWN FOR CLARITY, REFER TO PROFILE THIS SHEET AND TABLE ON DRAWING C-20 FOR ELEVATION DETAILS
POOL 8
BOULDER KEY LEGEND
K = KEYSTONE BLDR
C = CONSTRICTION BLDR
B = BUTTRESS BLDR
D = DIVIDING BLDR
S = SILL BLDR
F = FOOTER BLDR
SEE DRAWING C-21 FOR DETAILS
PLAN
(E) GROUND, COMPOSITION BELOW SURFACE ROCK IS LARGELY UNKNOWN
APPROXIMATE UPSTREAM LIMIT OF CHANNEL MODIFICATION
POOL, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20 FOR DETAILS
CHANNEL GRADE LINE
BEDROCK POOL
HYDRAULIC GRADE LINE
POOL 8
PLACE ROCKS AS NEEDED TO FILL VOIDS AND SUPPORT HYDRAULIC STRUCTURES
DEPTH OF EXISTING BOULDER UNKNOWN
FINISHED CHANNEL BED COMPRISED OF IN-SITU ROCK AND PLACED SALVAGED ROCK RANGING FROM LARGE BOULDERS TO GRAVELS, TYP
MODIFY IN-SITU ROCK AS NECESSARY TO SUPPORT PLACED BOULDERS, AT THE DIRECTION FISH PASSAGE ENGINEER
ELEVATION (FT)
STATION (FT)
PROFILE
Michael Love & Associates, Inc.
Department of Fish and Wildlife
VERIFY SCALE
THIS BAR IS ONE INCH LONG AT FULL SCALE
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT
UPPER BARRIER SITE
CONCEPTUAL CHANNEL DESIGN PLAN & PROFILE
FEBRUARY 2017
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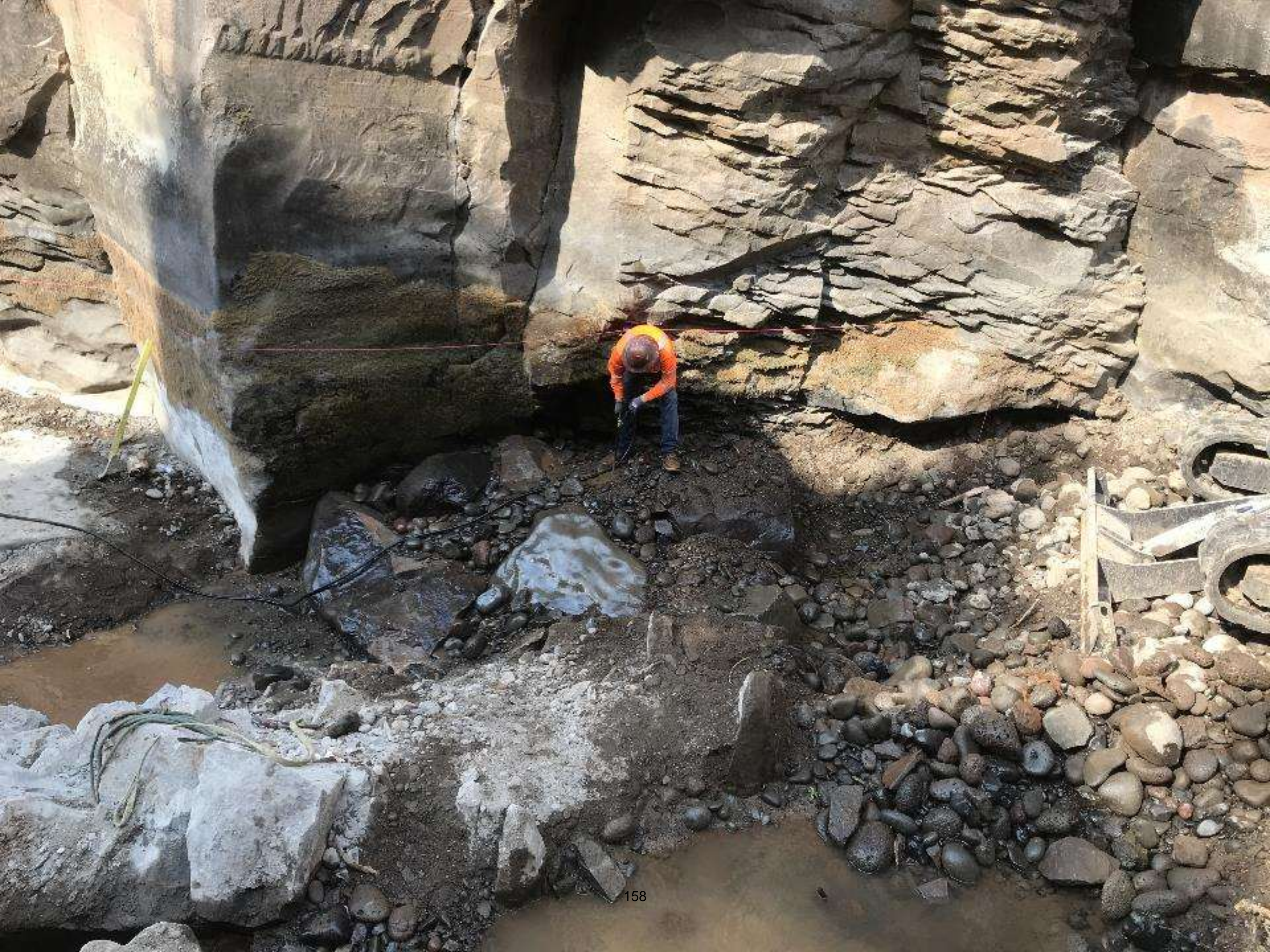
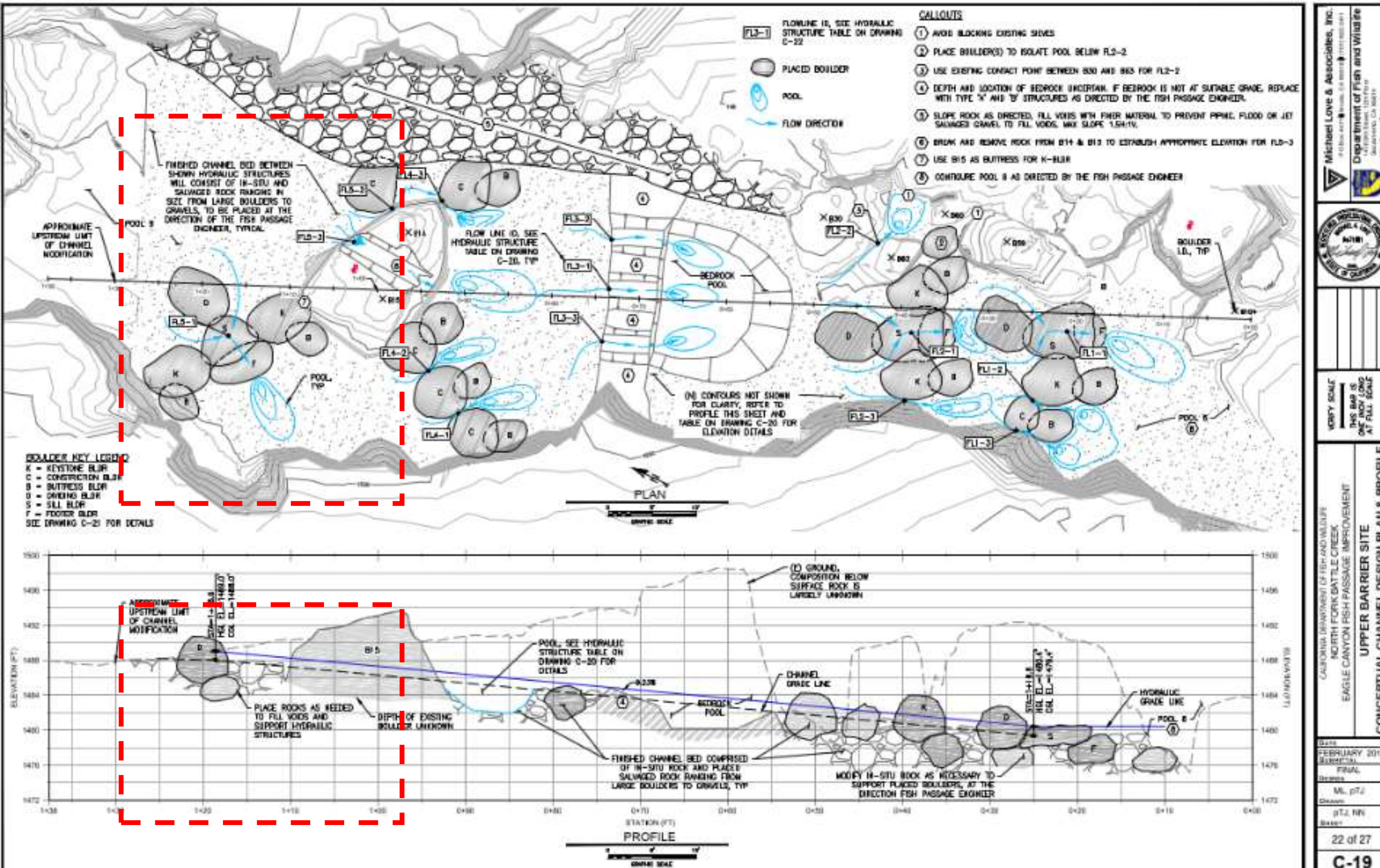
22 of 27
C-19



Reconstruction: Structure 5, Part 1


CALLOUTS
1 AVOID BLOCKING EXISTING SIEVES
2 PLACE BOULDER(S) TO ISOLATE POOL BELOW FL2-2
3 USE EXISTING CONTACT POINT BETWEEN B30 AND B63 FOR FL2-2
4 DEPTH AND LOCATION OF BEDROCK UNCERTAIN. IF BEDROCK IS NOT AT SUITABLE GRADE, REPLACE WITH TYPE 'A' AND 'B' STRUCTURES AS DIRECTED BY THE FISH PASSAGE ENGINEER.
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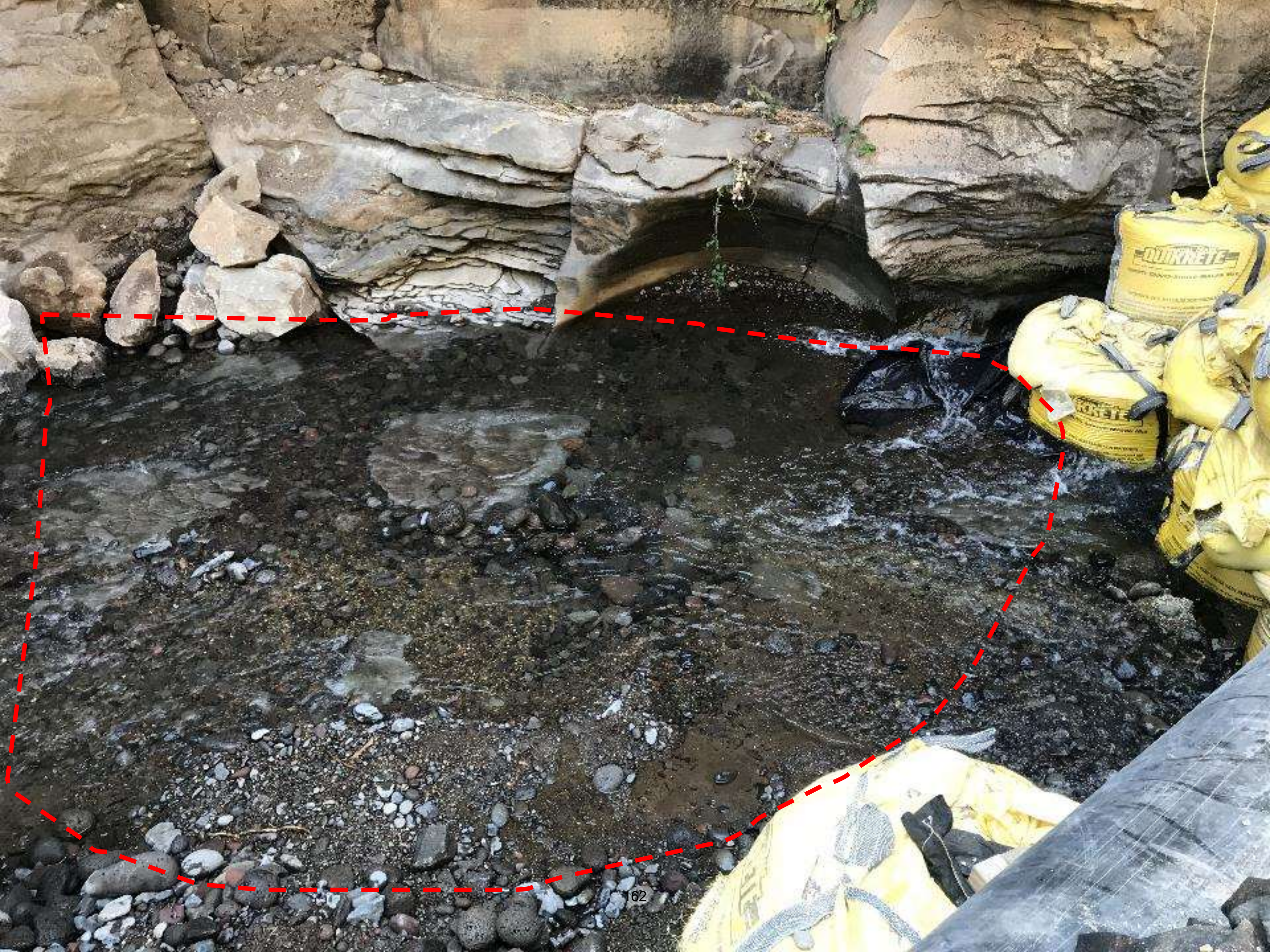
6 BREAK AND REMOVE ROCK FROM B14 & B13 TO ESTABLISH APPROPRIATE ELEVATION FOR FL5-3
7 USE B15 AS BUTTRESS FOR K-BLDR
8 CONFIGURE POOL 8 AS DIRECTED BY THE FISH PASSAGE ENGINEER
FLOWLINE ID, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-22
PLACED BOULDER
POOL
FLOW DIRECTION
FINISHED CHANNEL BED BETWEEN SHOWN HYDRAULIC STRUCTURES WILL CONSIST OF IN-SITU AND SALVAGED ROCK RANGING IN SIZE FROM LARGE BOULDERS TO GRAVELS, TO BE PLACED AT THE DIRECTION OF THE FISH PASSAGE ENGINEER, TYPICAL
APPROXIMATE UPSTREAM LIMIT OF CHANNEL MODIFICATION
POOL 9
FLOW LINE ID, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20, TYP
BEDROCK POOL
POOL, TYP
(N) CONTOURS NOT SHOWN FOR CLARITY, REFER TO PROFILE THIS SHEET AND TABLE ON DRAWING C-20 FOR ELEVATION DETAILS
BOULDER I.D., TYP
POOL 8
BOULDER KEY LEGEND
K = KEYSTONE BLDR
C = CONSTRICTION BLDR
B = BUTTRESS BLDR
D = DIVIDING BLDR
S = SILL BLDR
F = FOOTER BLDR
SEE DRAWING C-21 FOR DETAILS
PLAN
(E) GROUND, COMPOSITION BELOW SURFACE ROCK IS LARGELY UNKNOWN
POOL, SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20 FOR DETAILS
CHANNEL GRADE LINE
HYDRAULIC GRADE LINE
BEDROCK POOL
PLACE ROCKS AS NEEDED TO FILL VOIDS AND SUPPORT HYDRAULIC STRUCTURES
DEPTH OF EXISTING BOULDER UNKNOWN
FINISHED CHANNEL BED COMPRISED OF IN-SITU ROCK AND PLACED SALVAGED ROCK RANGING FROM LARGE BOULDERS TO GRAVELS, TYP
MODIFY IN-SITU ROCK AS NECESSARY TO SUPPORT PLACED BOULDERS, AT THE DIRECTION FISH PASSAGE ENGINEER
STATION (FT)
PROFILE
ELEVATION (FT)
Michael Love & Associates, Inc.
Department of Fish and Wildlife
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT
UPPER BARRIER SITE
CONCEPTUAL CHANNEL DESIGN PLAN & PROFILE
FEBRUARY 2017
FINAL
22 of 27
C-19

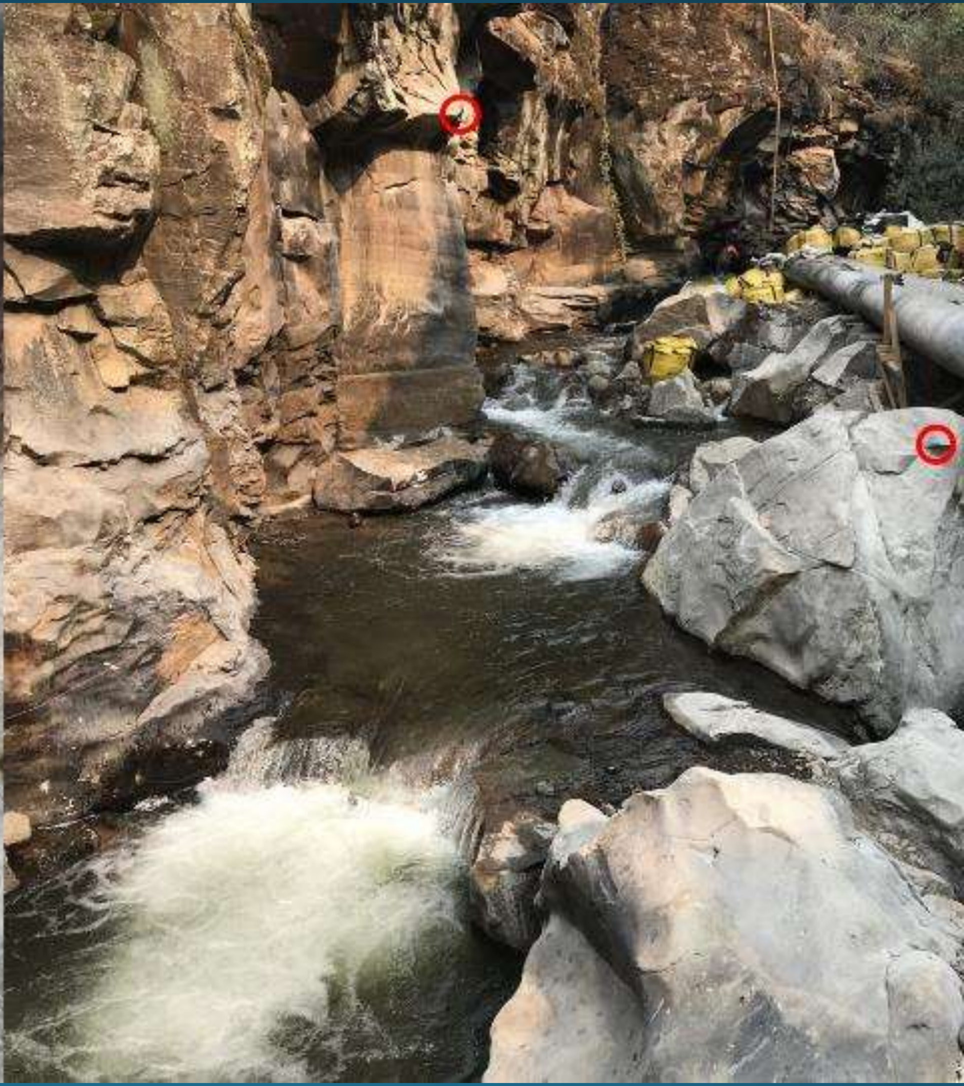

YANMAR

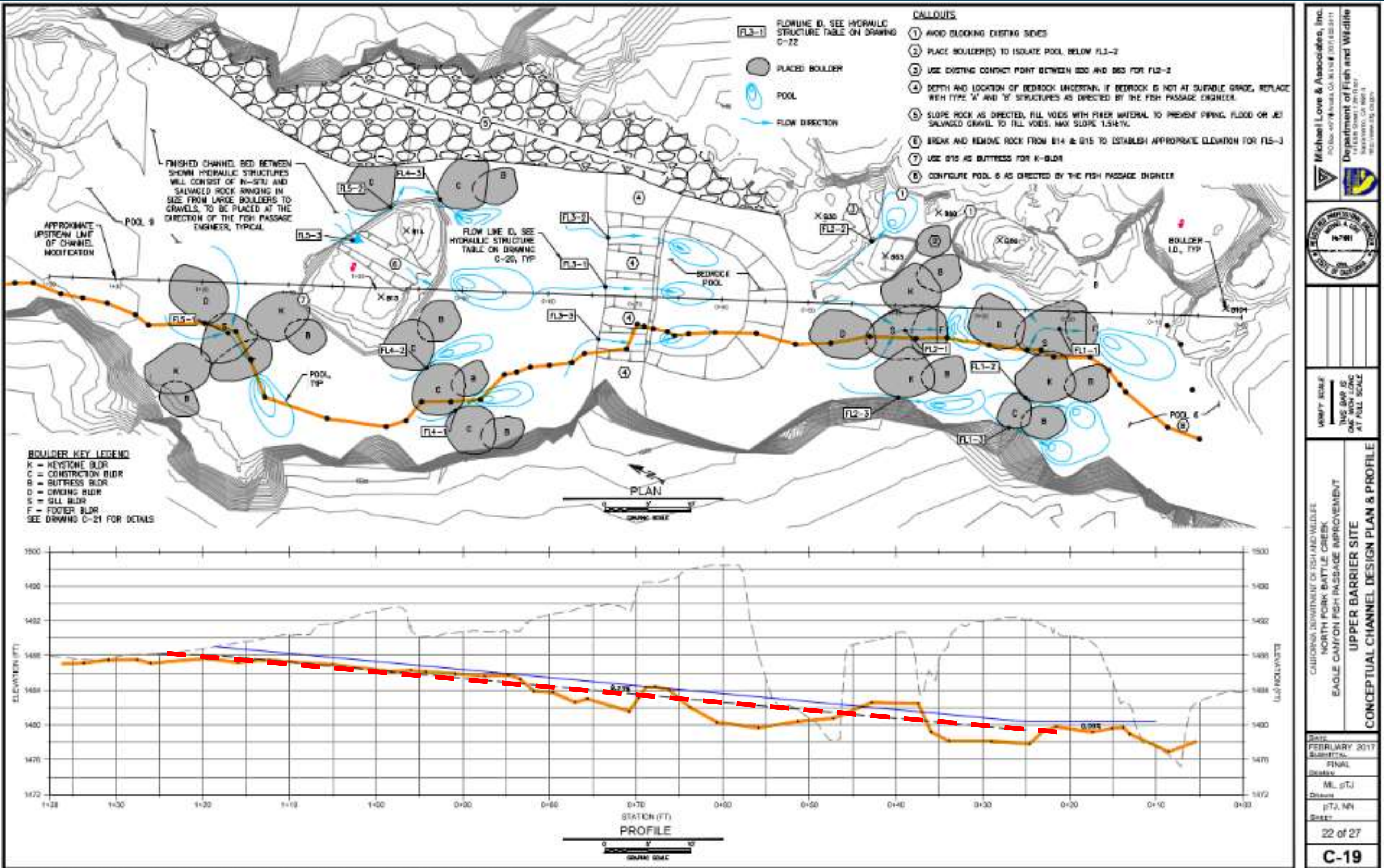

QUIKRETE

Reconstruction: Structure 5, Part 2

Implementation: Final Outcome







FLOWLINE ID. SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-22
PLACED BOULDER
POOL
FLOW DIRECTION
CALLOUTS
1 AVOID BLOCKING EXISTING SIEVES
2 PLACE BOULDER(S) TO ISOLATE POOL BELOW FL1-2
3 USE EXISTING CONTACT POINT BETWEEN B30 AND B63 FOR FL2-2
4 DEPTH AND LOCATION OF BEDROCK UNCERTAIN. IF BEDROCK IS NOT AT SUITABLE GRADE, REPLACE WITH TYPE 'A' AND 'B' STRUCTURES AS DIRECTED BY THE FISH PASSAGE ENGINEER.
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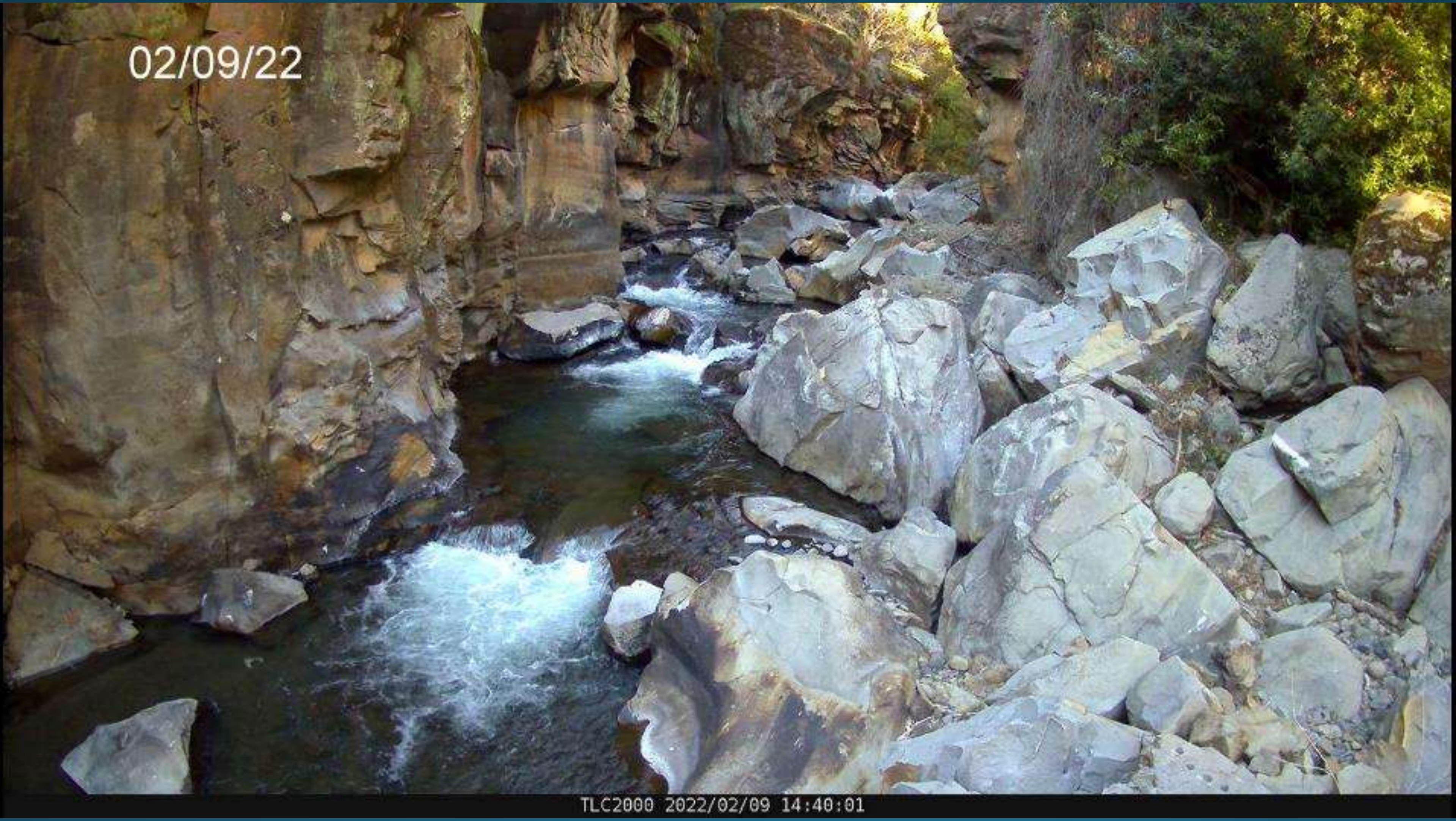
FINISHED CHANNEL BED BETWEEN SHOWN HYDRAULIC STRUCTURES WILL CONSIST OF IN-SITU AND SALVAGED ROCK RANGING IN SIZE FROM LARGE BOULDERS TO GRAVELS, TO BE PLACED AT THE DIRECTION OF THE FISH PASSAGE ENGINEER, TYPICAL
APPROXIMATE UPSTREAM LIMIT OF CHANNEL MODIFICATION
POOL 9
FLOW LINE ID. SEE HYDRAULIC STRUCTURE TABLE ON DRAWING C-20, TYP
BEDROCK POOL
BOULDER I.D., TYP
POOL, TYP
POOL 8
BOULDER KEY LEGEND
K = KEYSTONE BLDR
C = CONSTRUCTION BLDR
B = BUTTRESS BLDR
D = DIVIDING BLDR
S = SILL BLDR
F = FOOTER BLDR
SEE DRAWING C-21 FOR DETAILS
PLAN
PROFILE
ELEVATION (FT)
STATION (FT)
Michael Love & Associates, Inc.
Department of Fish and Wildlife
CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE
NORTH FORK BATTLE CREEK
EAGLE CANYON FISH PASSAGE IMPROVEMENT
UPPER BARRIER SITE
CONCEPTUAL CHANNEL DESIGN PLAN & PROFILE
FEBRUARY 2017
FINAL
ML, pTJ
pTJ, NN
22 of 27
C-19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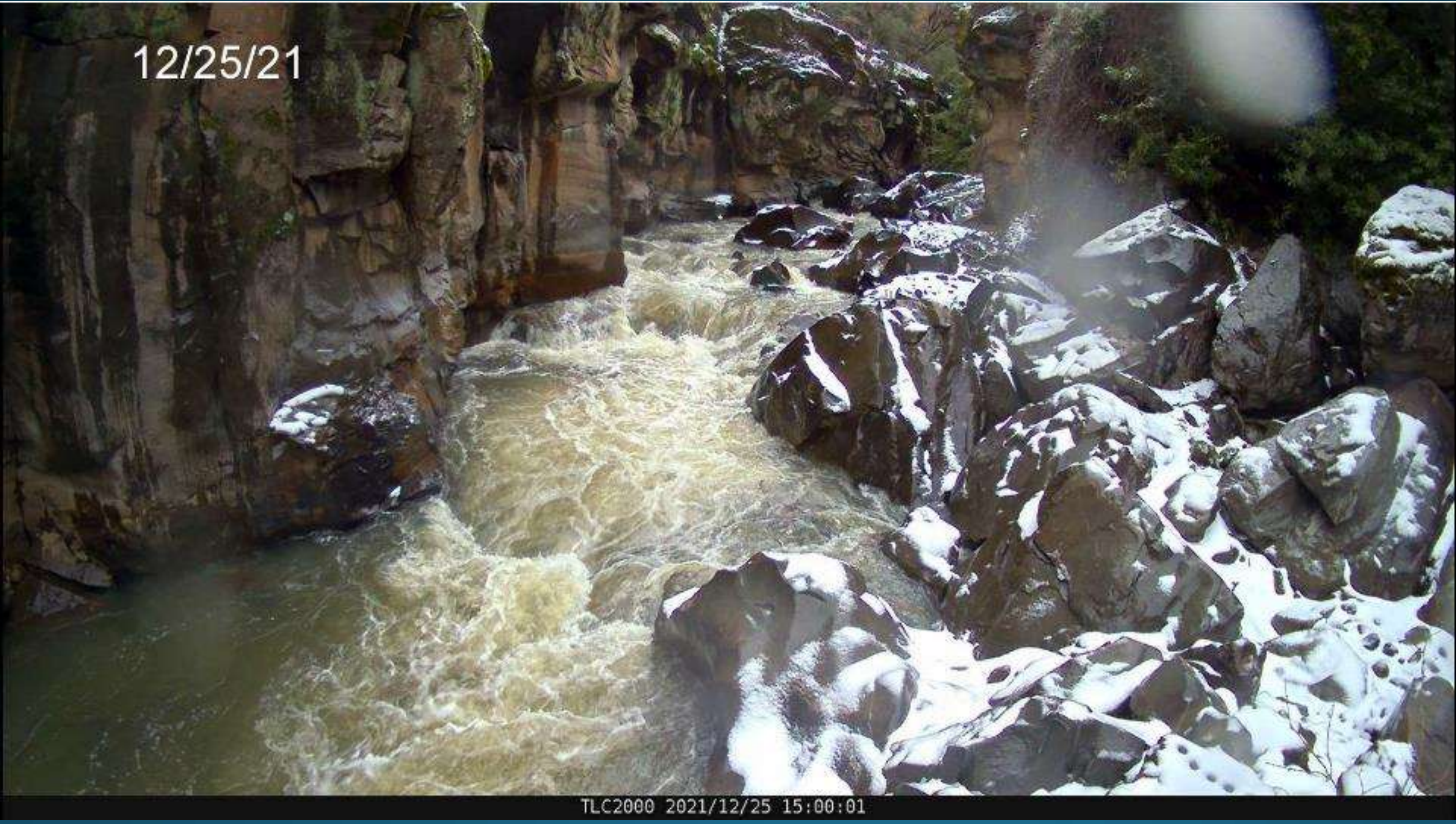
12/16/21
TLC2000 2021/12/16 10:10:01


12/25/21
TLC2000 2021/12/25 15:00:01

Lesson: Take time to enjoy your hard work

Questions?

Beale Lake Dam Removal and Roughened Ramp

Mark Gard

California Department of Fish and Wildlife,

West Sacramento, CA, USA

Heather Hanson, Jessica Pica and Paul Cadrett

U.S. Fish and Wildlife Service

Acknowledgments

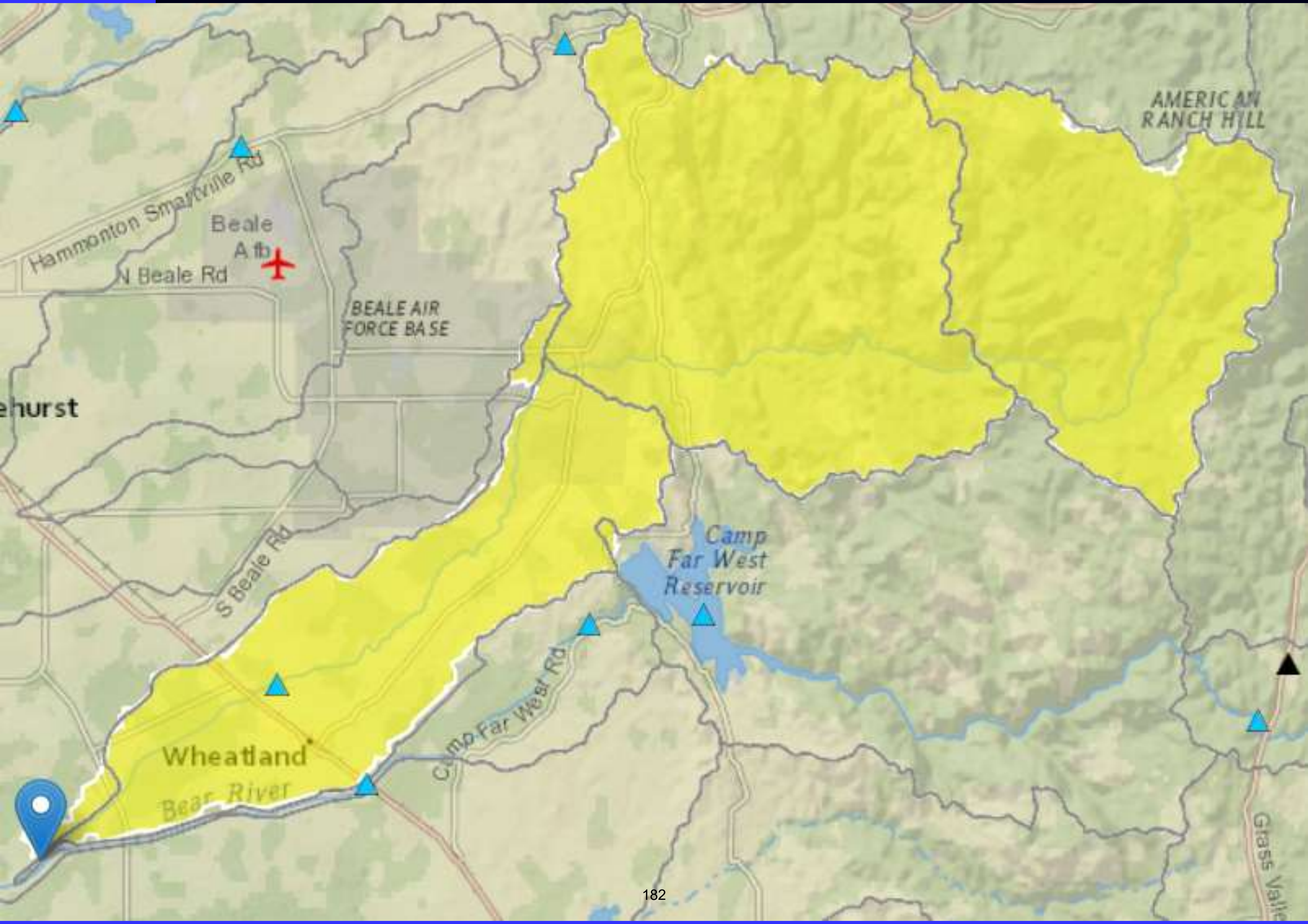
- Funded by U.S. Air Force

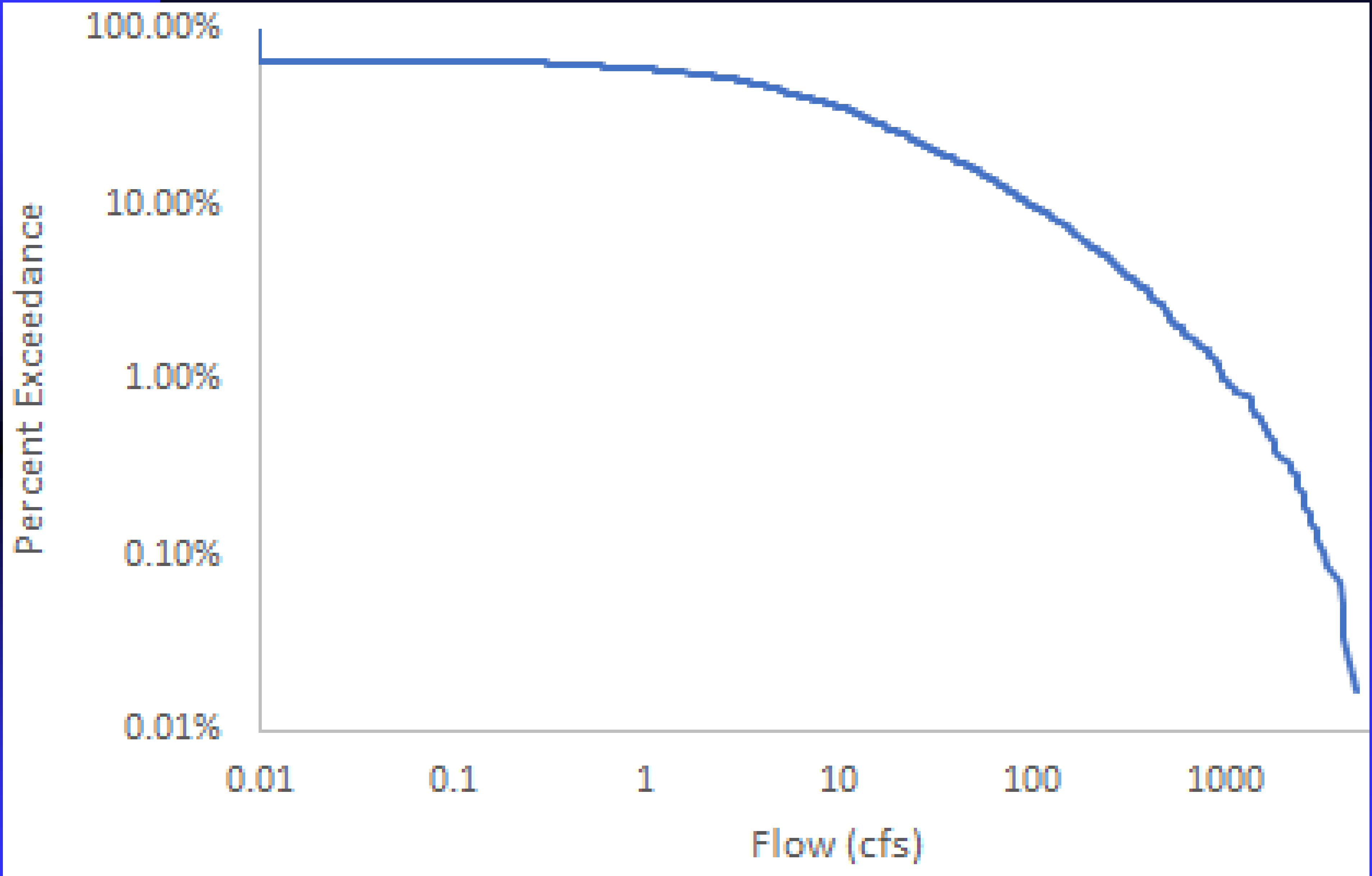
Introduction

- Dam removal is an increasingly common method being used to provide fish passage
- For Beale, dam removal was selected because it was more cost-effective than constructing a new pool and chute fish ladder

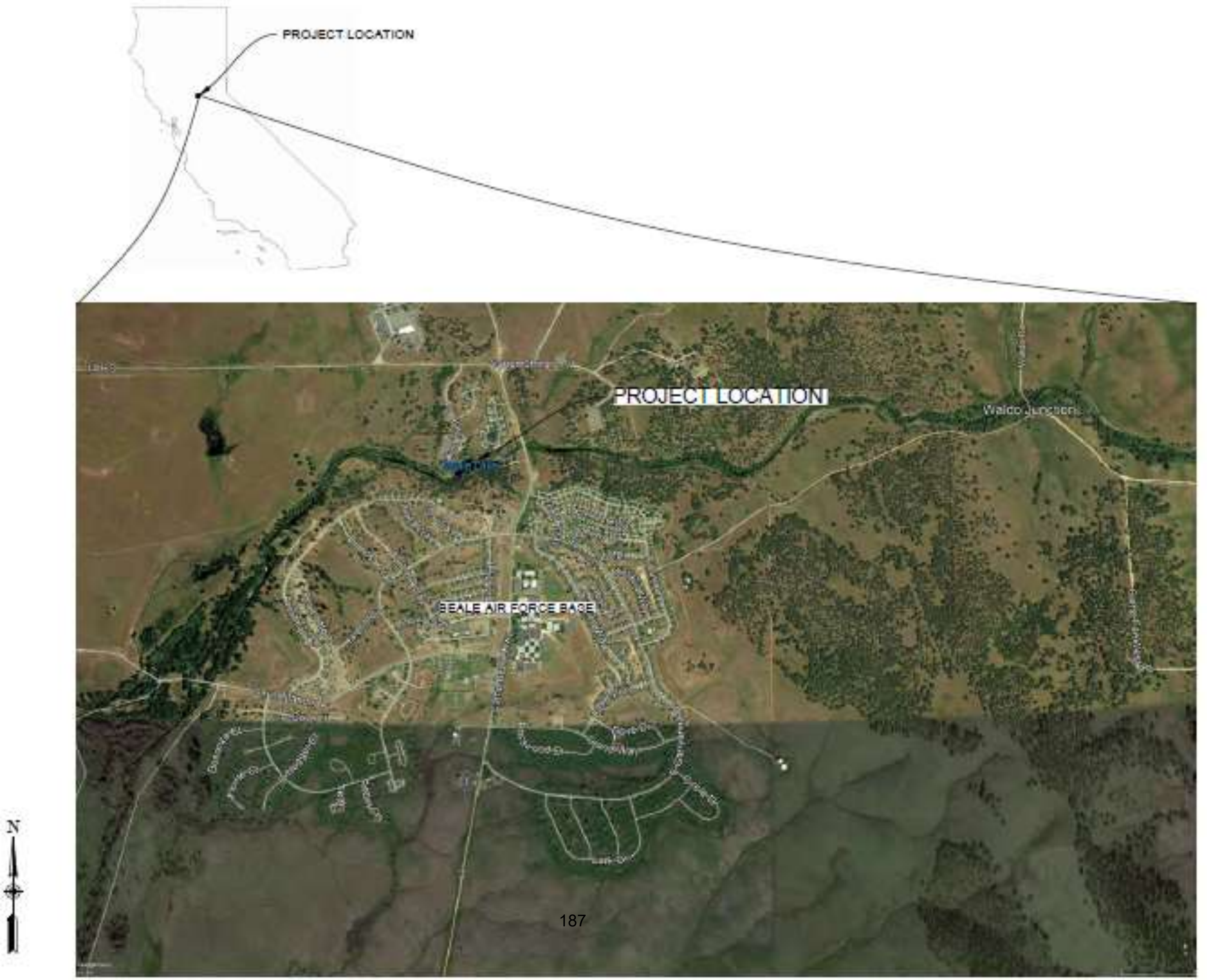
Questions to be addressed

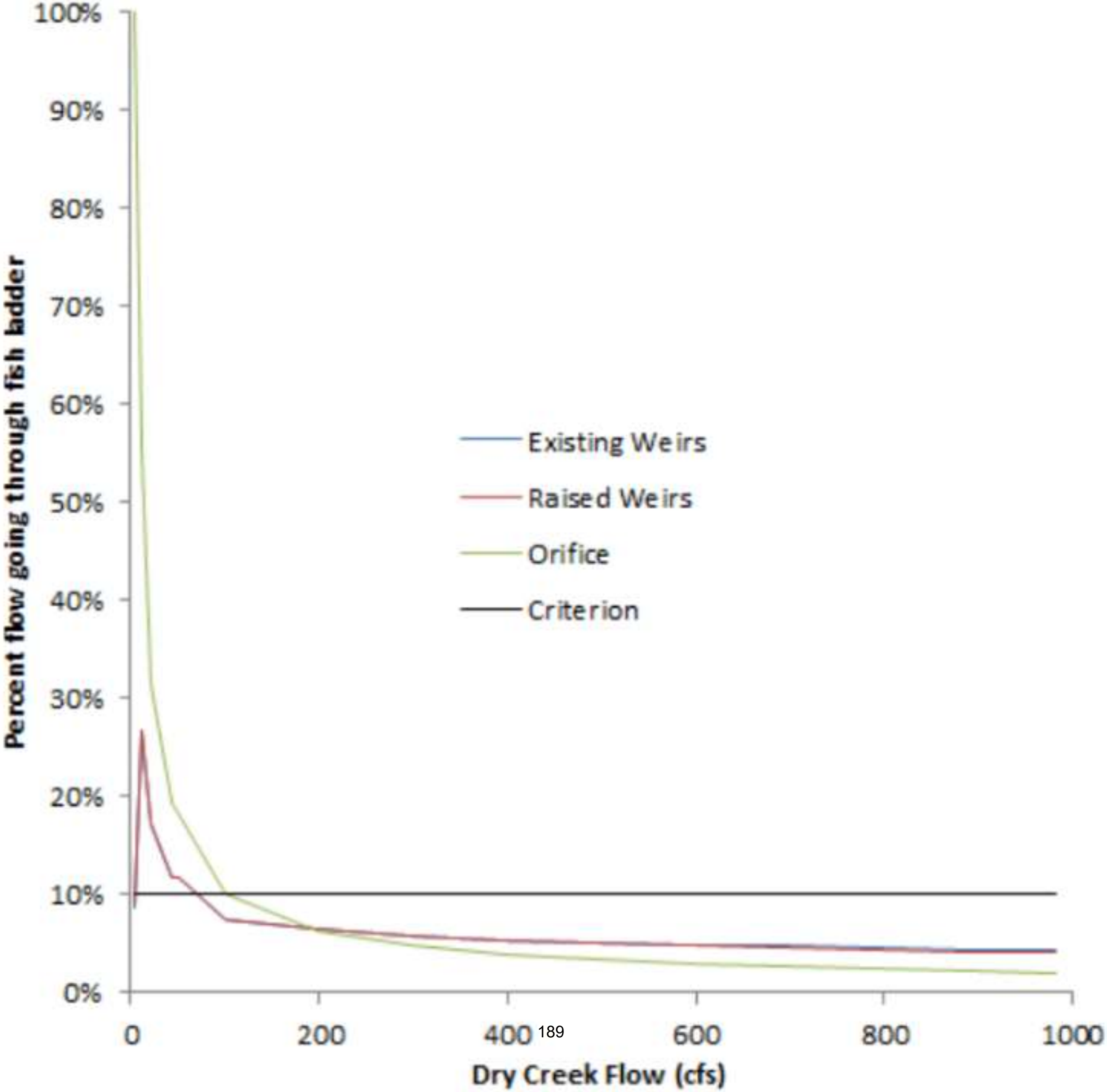
- How should the channel in the impoundment area be restored?
- How should fish passage be provided at a waterfall at the upstream end of the impoundment?


AMERICAN RANCH HILL
Hammonton Smartville Rd
Beale
A fb
N Beale Rd
BEALE AIR FORCE BASE
ehurst
S Beale Rd
Camp Far West Reservoir
Camp Far West Rd
Wheatland
Bear River
Grass Valle


100.00%
10.00%
1.00%
0.10%
0.01%
Percent Exceedance
0.01
0.1
1
10
100
1000
Flow (cfs)

Study Area

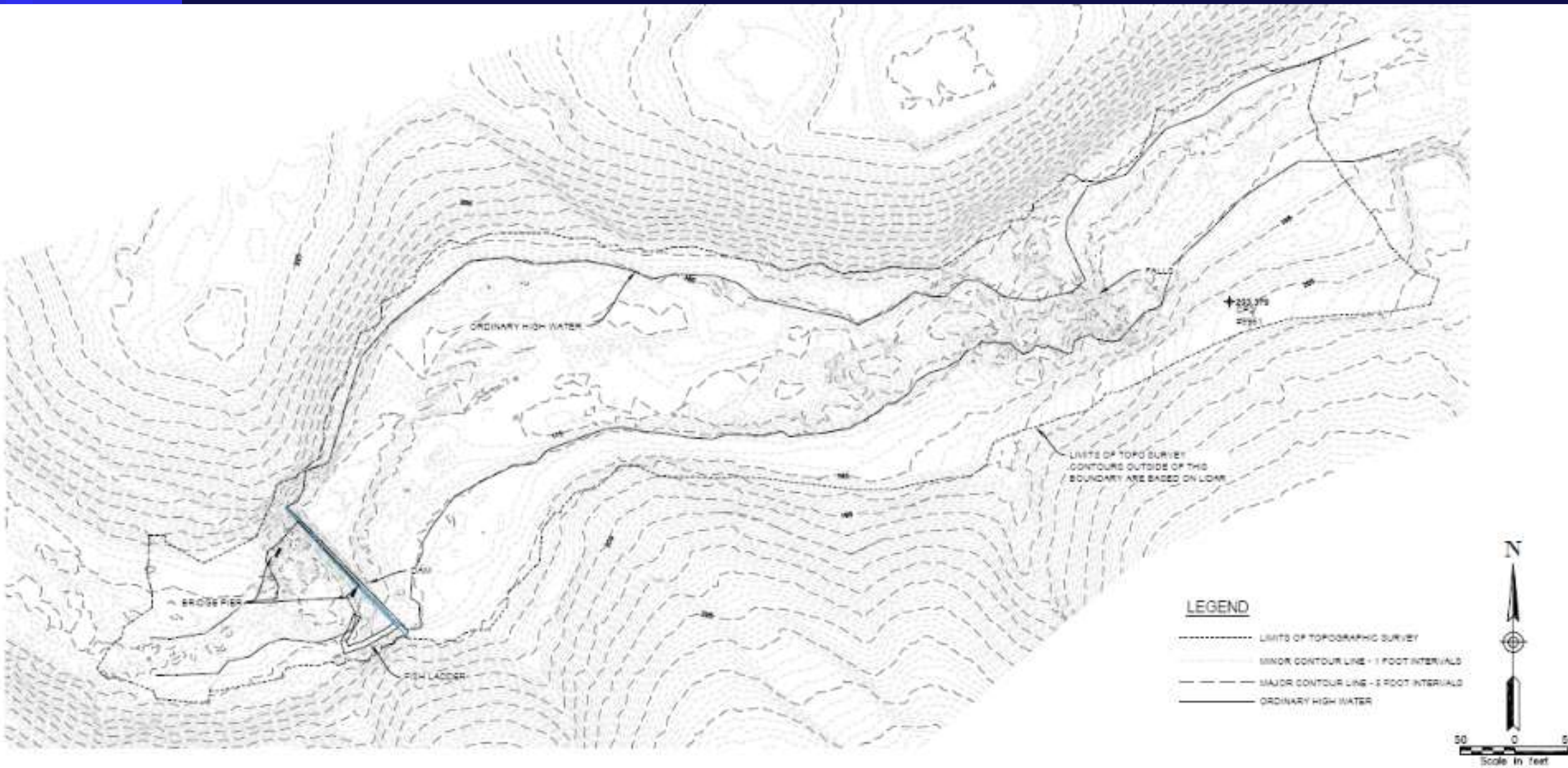

PROJECT LOCATION
PROJECT LOCATION
Waldo Junction
BEALE AIR FORCE BASE
N


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent flow going through fish ladder
Existing Weirs
Raised Weirs
Orifice
Criterion
0
200
400
600
800
1000
Dry Creek Flow (cfs)

Methods

- Topographic and sediment surveys
- Reference reach
- Design of channel and rocky ramp
- Hydraulic modeling

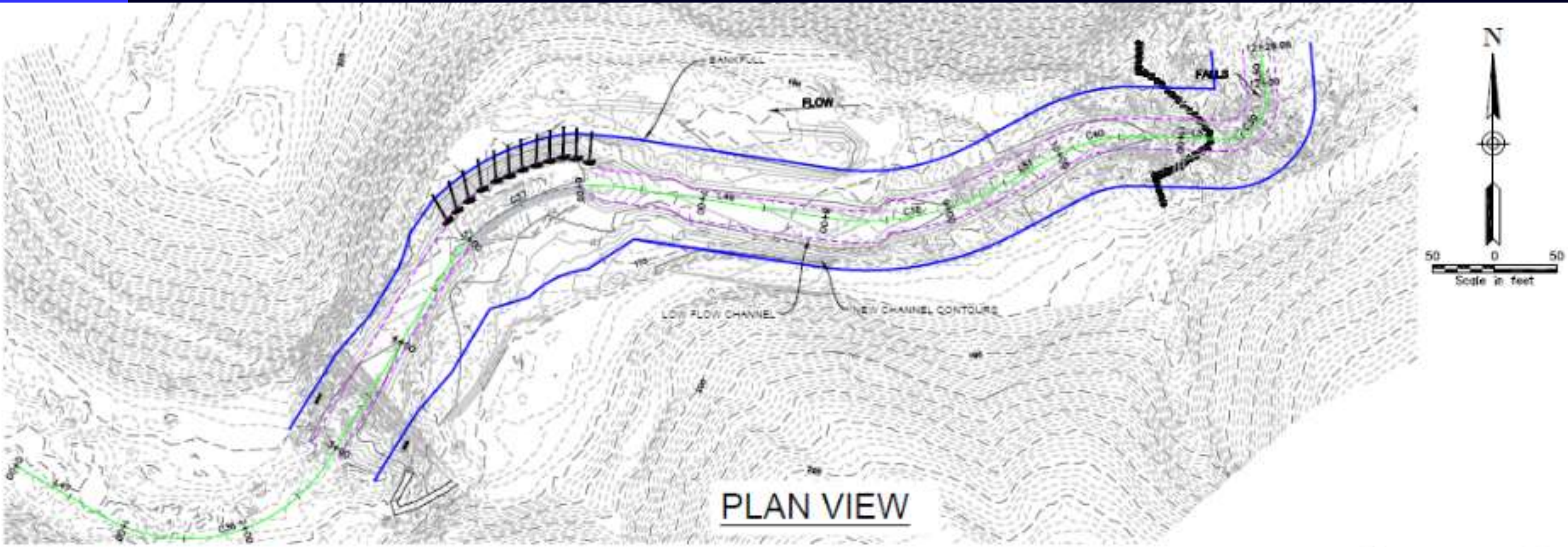

U.S. FISH & WILDLIFE SERVICE
SIMMS


ORDINARY HIGH WATER
FALLS
LIMITS OF TOPO SURVEY
CONTOURS OUTSIDE OF THIS
BOUNDARY ARE BASED ON LIDAR
DAM
BRIDGE PIER
FISH LADDER
LEGEND
LIMITS OF TOPOGRAPHIC SURVEY
MINOR CONTOUR LINE - 1 FOOT INTERVALS
MAJOR CONTOUR LINE - 5 FOOT INTERVALS
ORDINARY HIGH WATER
N
50
0
50
Scale in feet

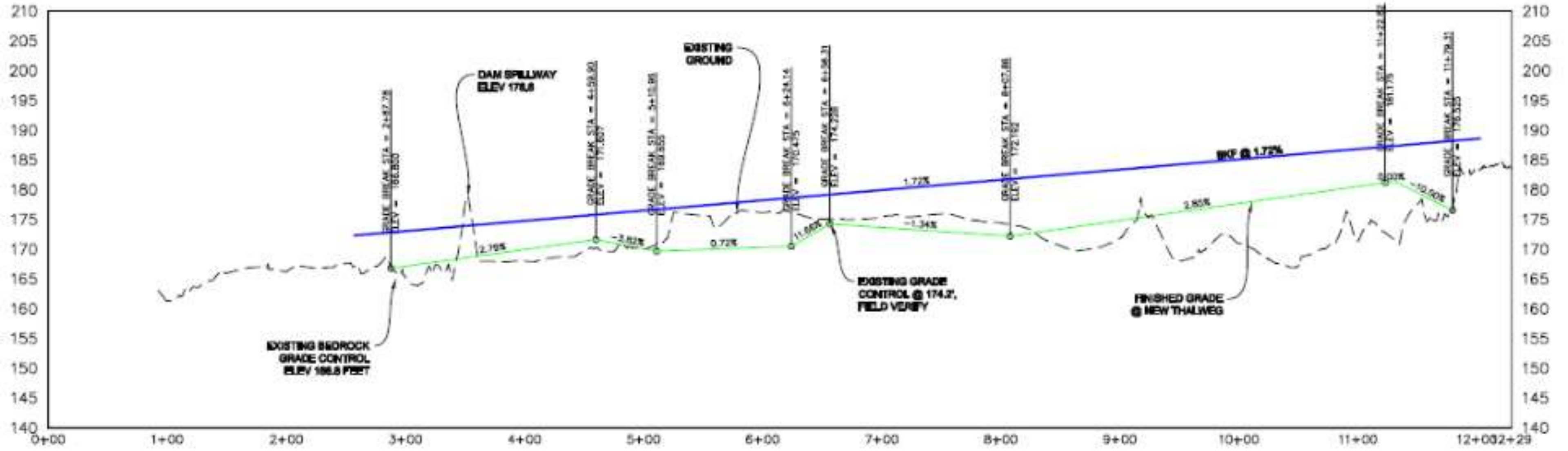
Design Criteria

- Flow range 60 – 1900 cfs
- Minimum depth 0.9 feet
- Maximum velocity 8 ft/s
- Minimum pool depth 3 feet or 1.25 times jump height
- Maximum jump height 5.6 feet

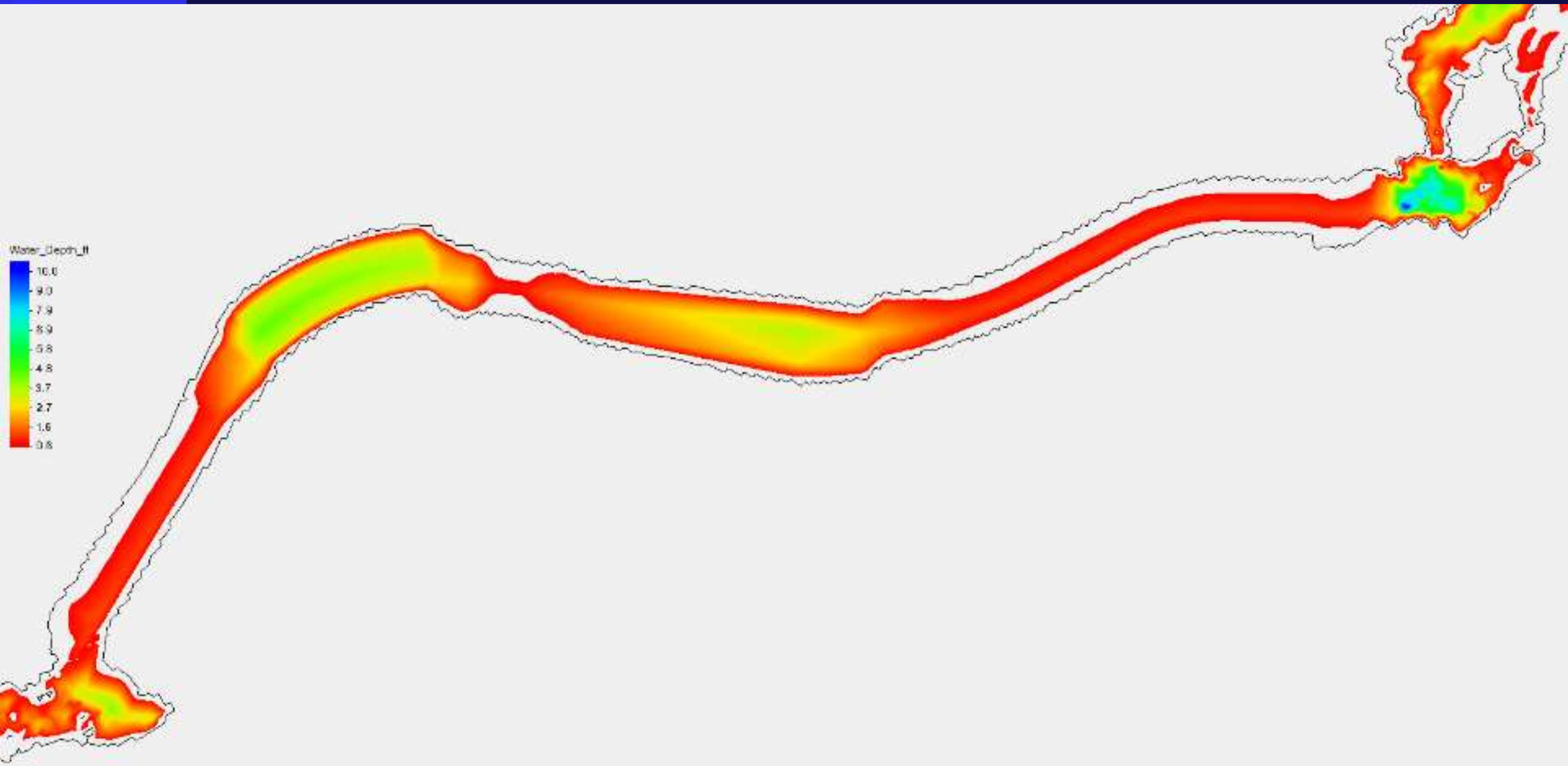
Results

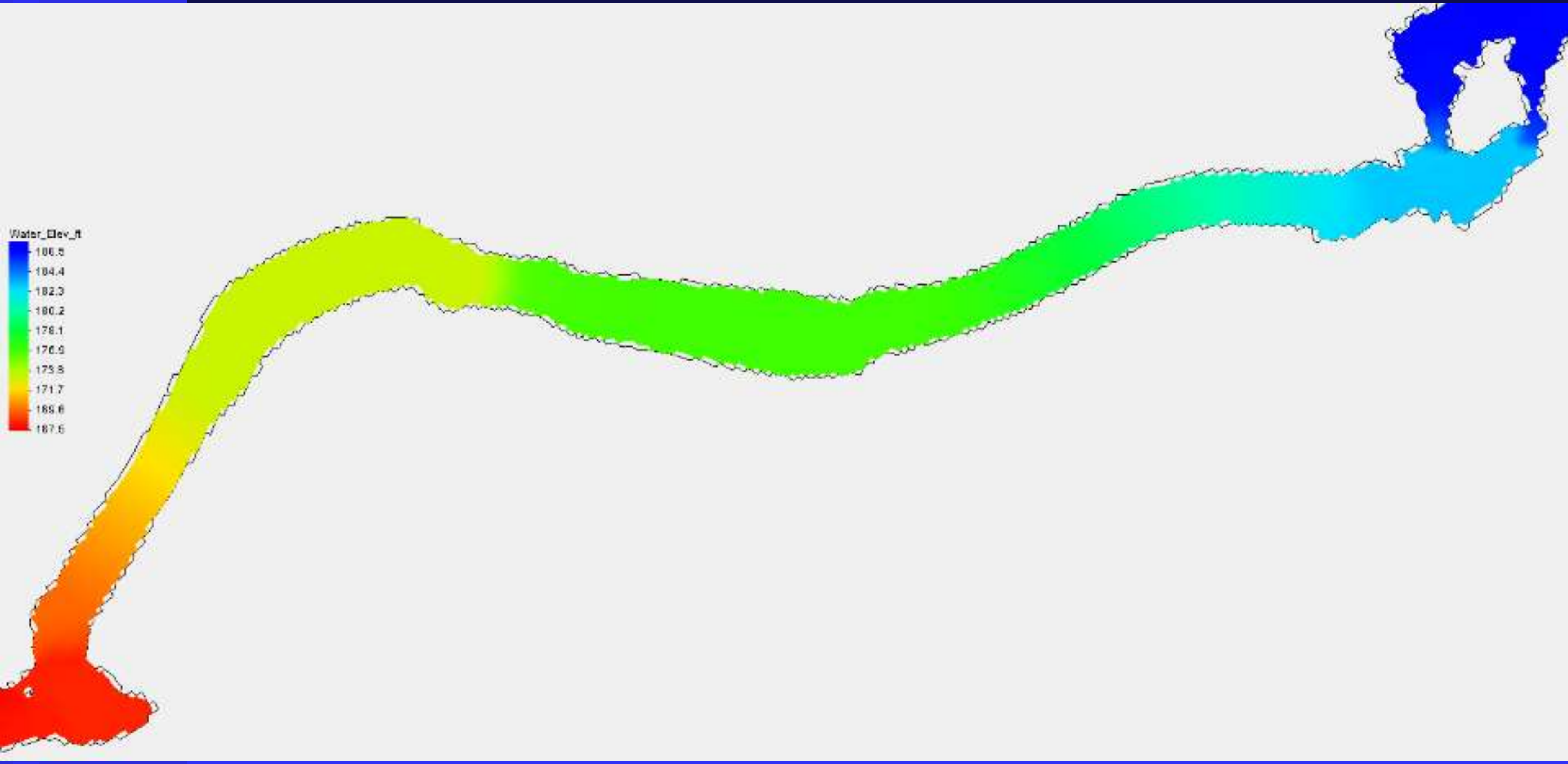


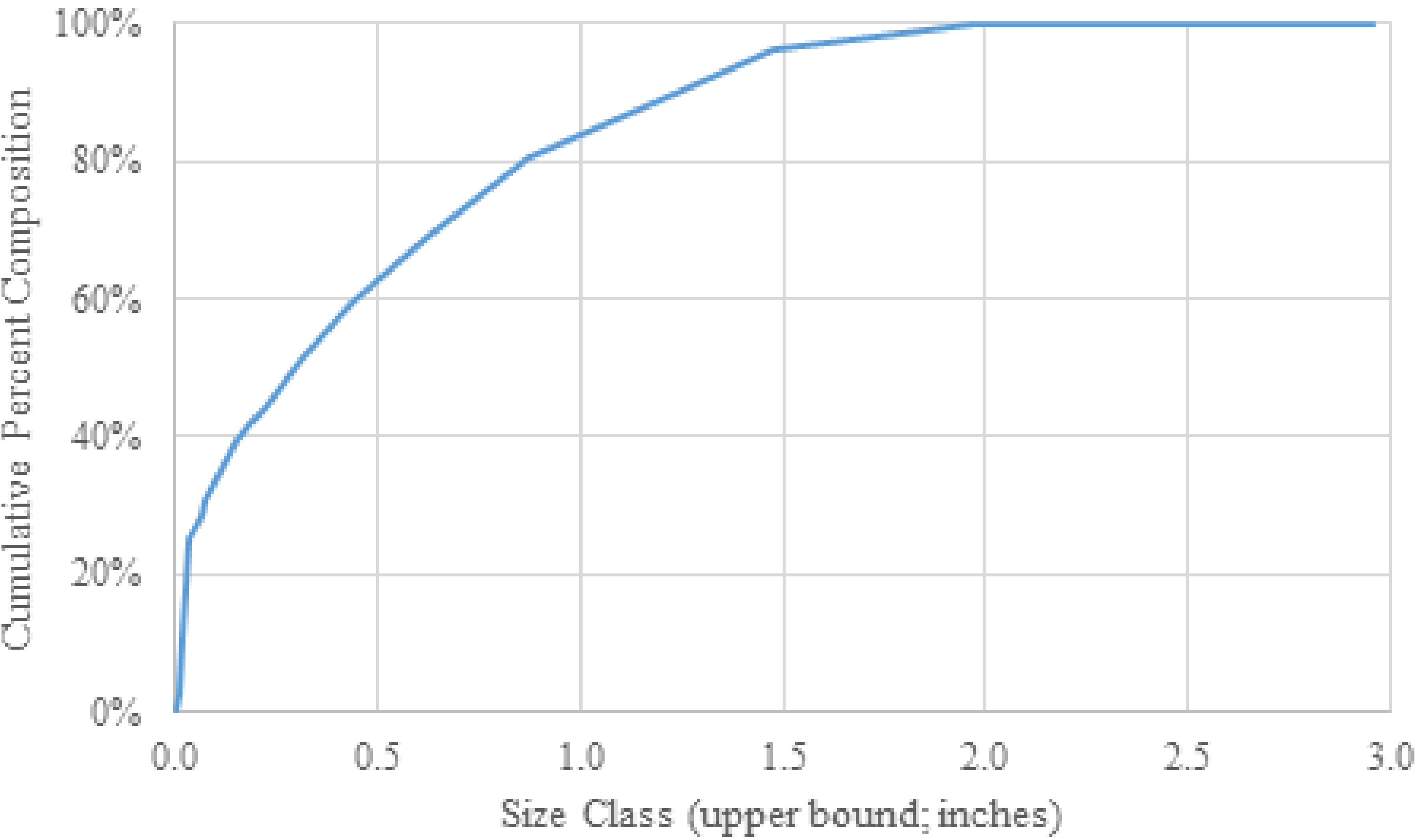
PLAN VIEW



LONGITUDINAL PROFILE

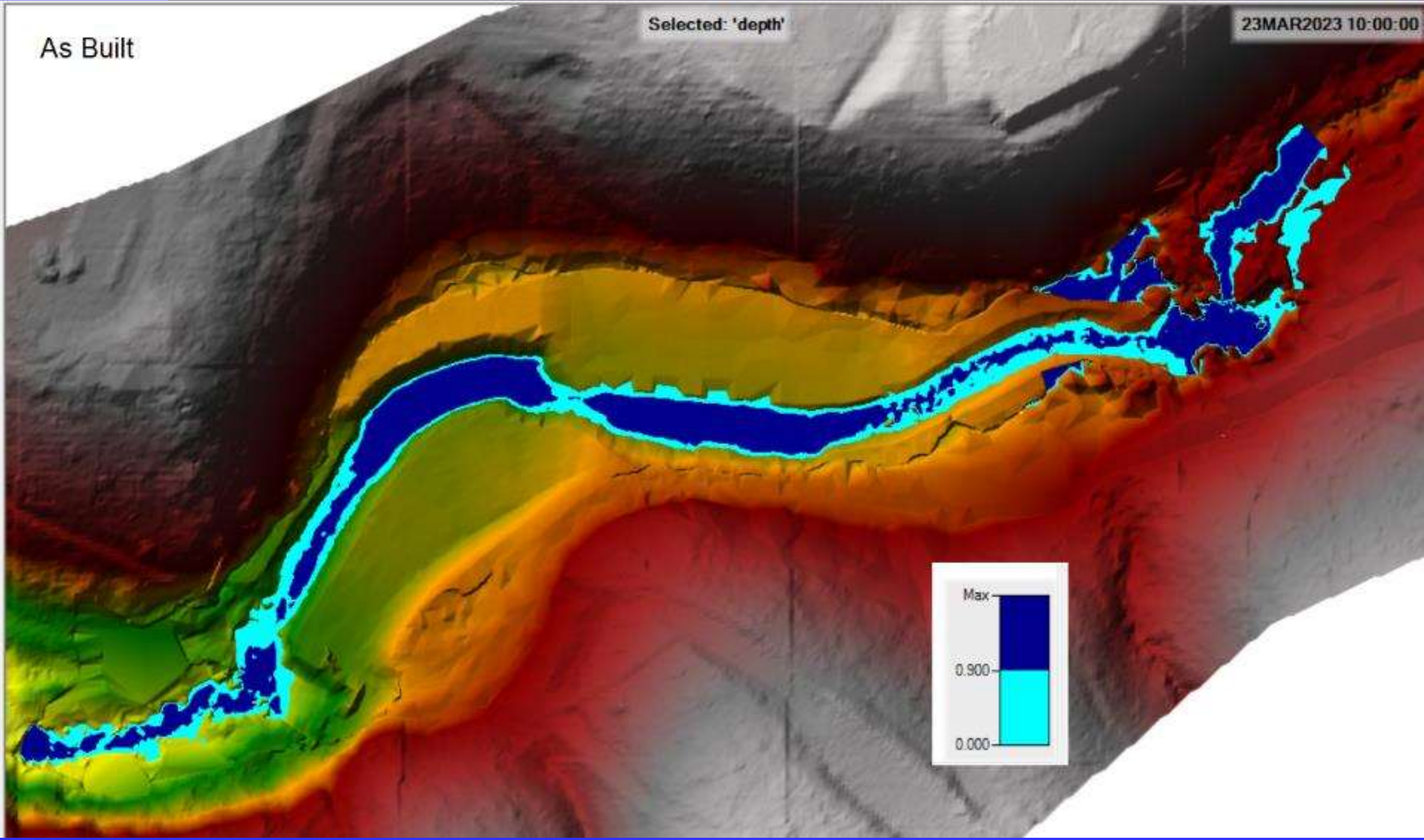

Water_Depth_ft
10.0
9.0
7.9
6.9
5.8
4.8
3.7
2.7
1.6
0.6

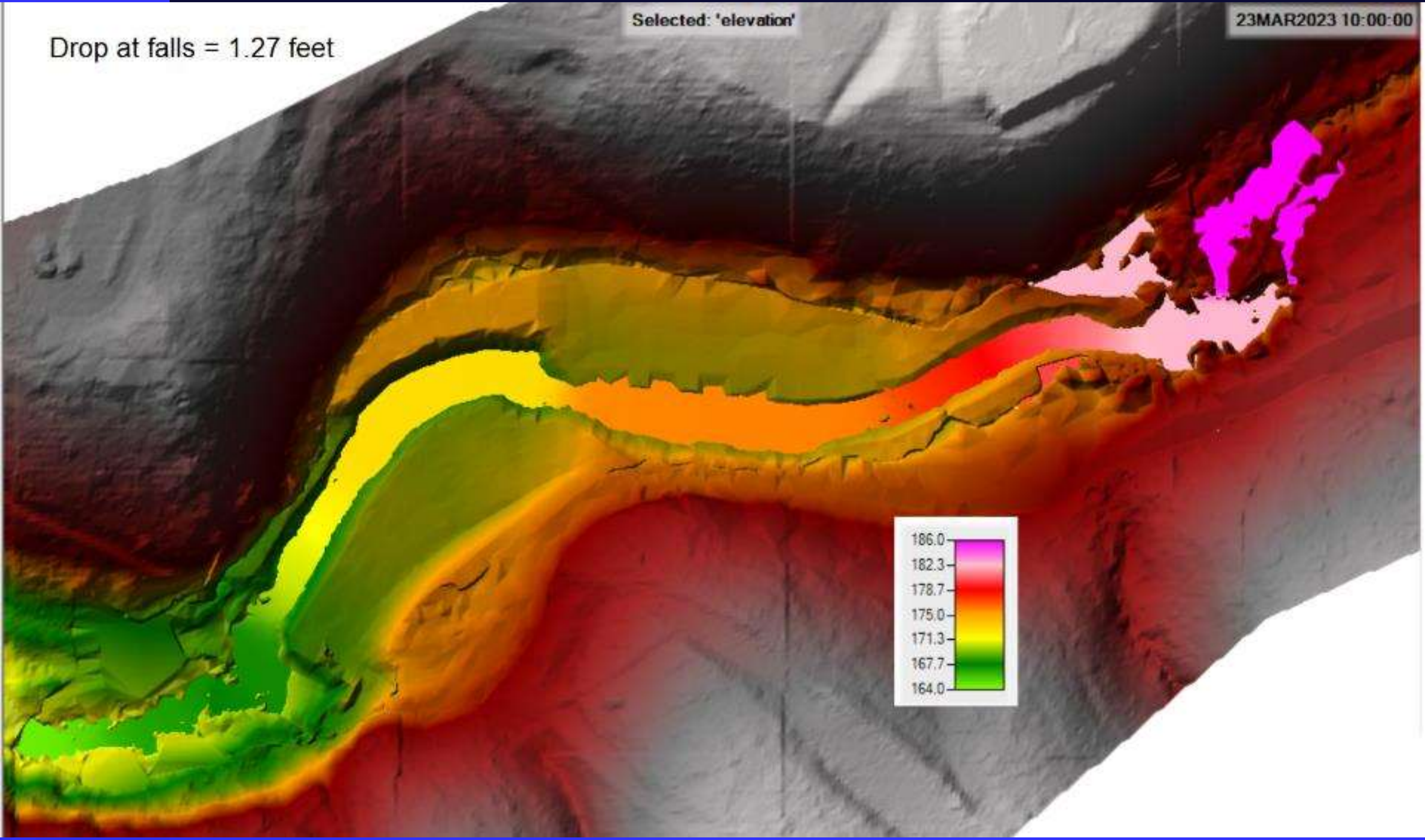

Water_Elev_ft
186.5
184.4
182.3
180.2
178.1
176.0
173.9
171.7
169.6
167.5

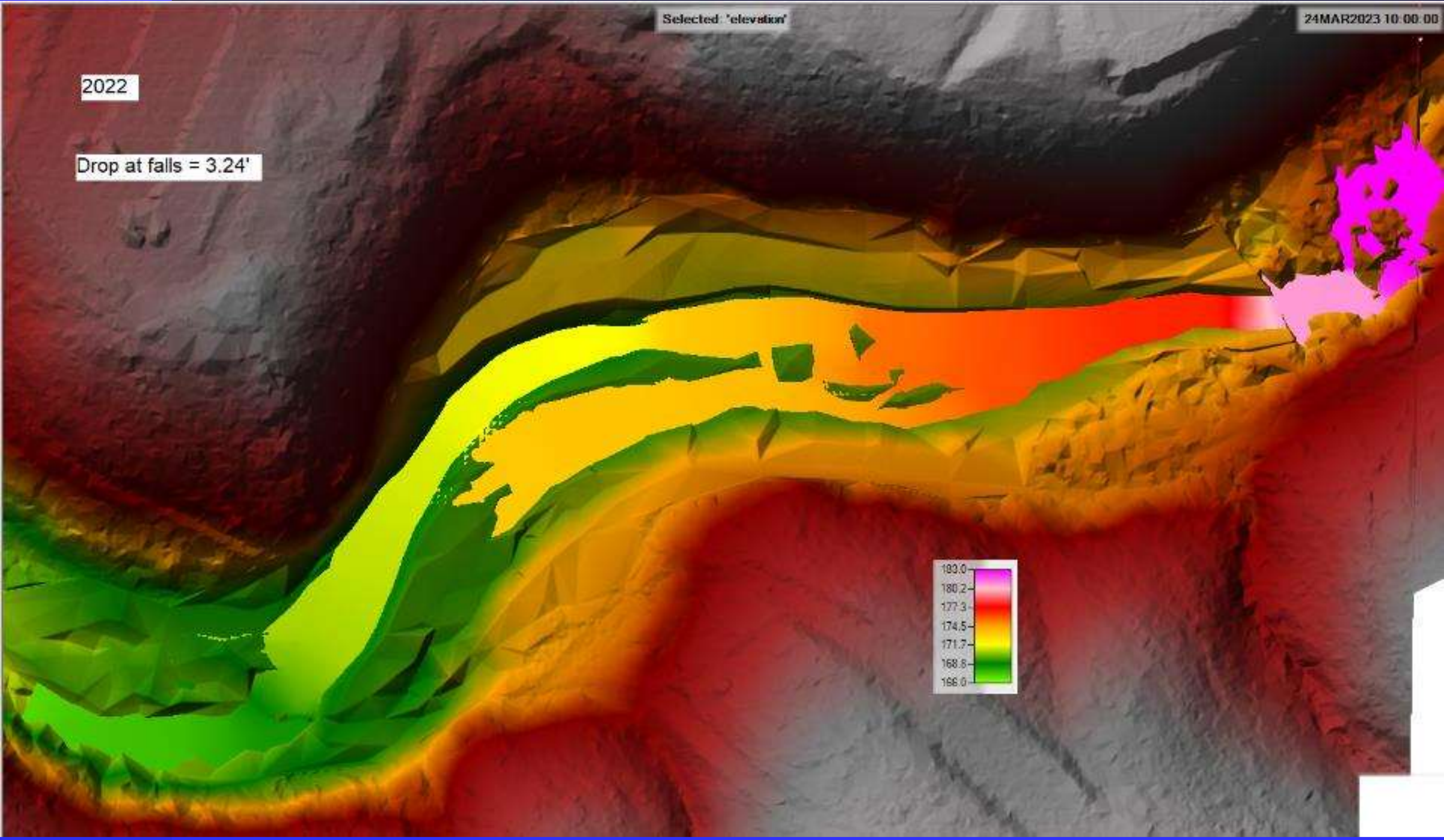


100%
80%
60%
40%
20%
0%
Cumulative Percent Composition
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Size Class (upper bound; inches)


Date & Time: Thu, Aug 20, 2020, 10:45:54 PDT
Position: +039.109024° / -121.336364° (±23.1ft)
Altitude: 185ft (±58.6ft)
Datum: WGS-84
Azimuth/Bearing: 247° S67W 4391mils True (±18°)
Elevation Angle: -01.9°
Horizon Angle: -00.4°
Zoom: 1.0X
Beal_AFB_Dam_Project


As Built
Selected: 'depth'
23MAR2023 10:00:00
Max
0.900
0.000


Drop at falls = 1.27 feet
Selected: 'elevation'
23MAR2023 10:00:00
186.0
182.3
178.7
175.0
171.3
167.7
164.0



Selected: 'elevation'
24MAR2023 10:00:00
2022
Drop at falls = 3.24'
183.0
180.2
177.3
174.5
171.7
168.8
166.0

Discussion

- Most of the design process focused on recreating a channel in the inundation area and design of the rocky ramp
- Cost of the project rose substantially due to permitting requirements (to remove accumulated sediment) and dewatering
- Data collected during lake drawdown was crucial for refining the design

Conclusions

- Dam removal can be a cost-effective way of providing fish passage

Questions?

Email: Mark.Gard@wildlife.ca.gov

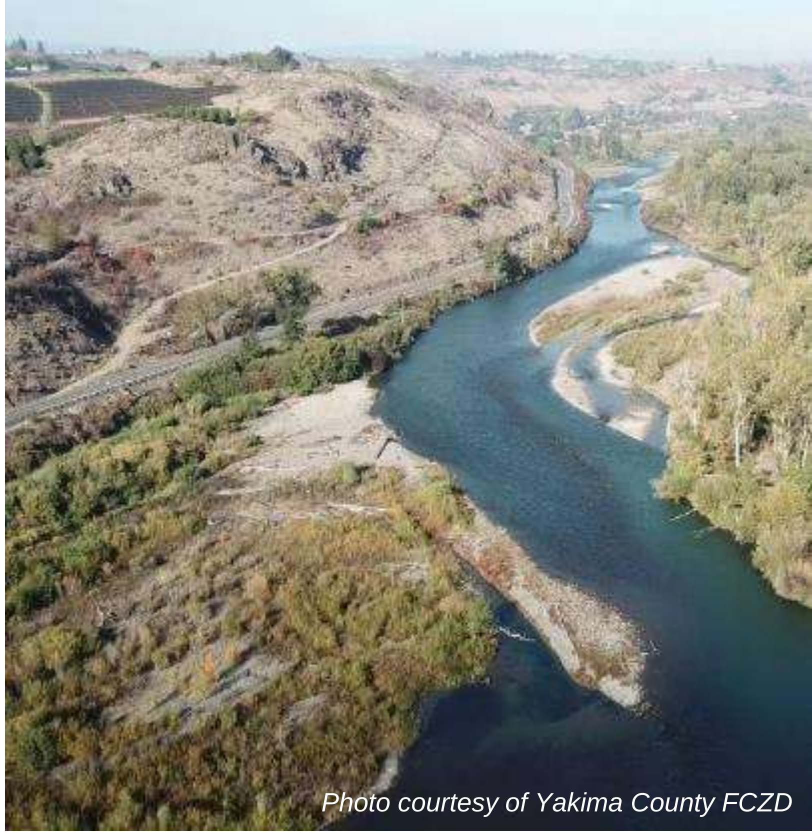


Photo courtesy of Yakima County FCZD

Nelson Dam Removal:
Final Design, Material Sourcing, and Construction Methods

Michael Garello, PE
40th Annual SRF Conference 2023

Fish Passage Design and Implementation
Lessons Learned

HDR

Presentation Agenda

Provide an overview of major final design, material sourcing, and construction methods used for the Nelson Dam Removal Project on the Naches River, Yakima, WA.

Project Background

Project Development

Design

Construction

01 Pre-Project Conditions

Project Location

- Naches River is the largest tributary to the Yakima River
- 8-foot-high by 140-foot-long irrigation diversion dam
- Provides water to four individual diversions (>8,000 customers)

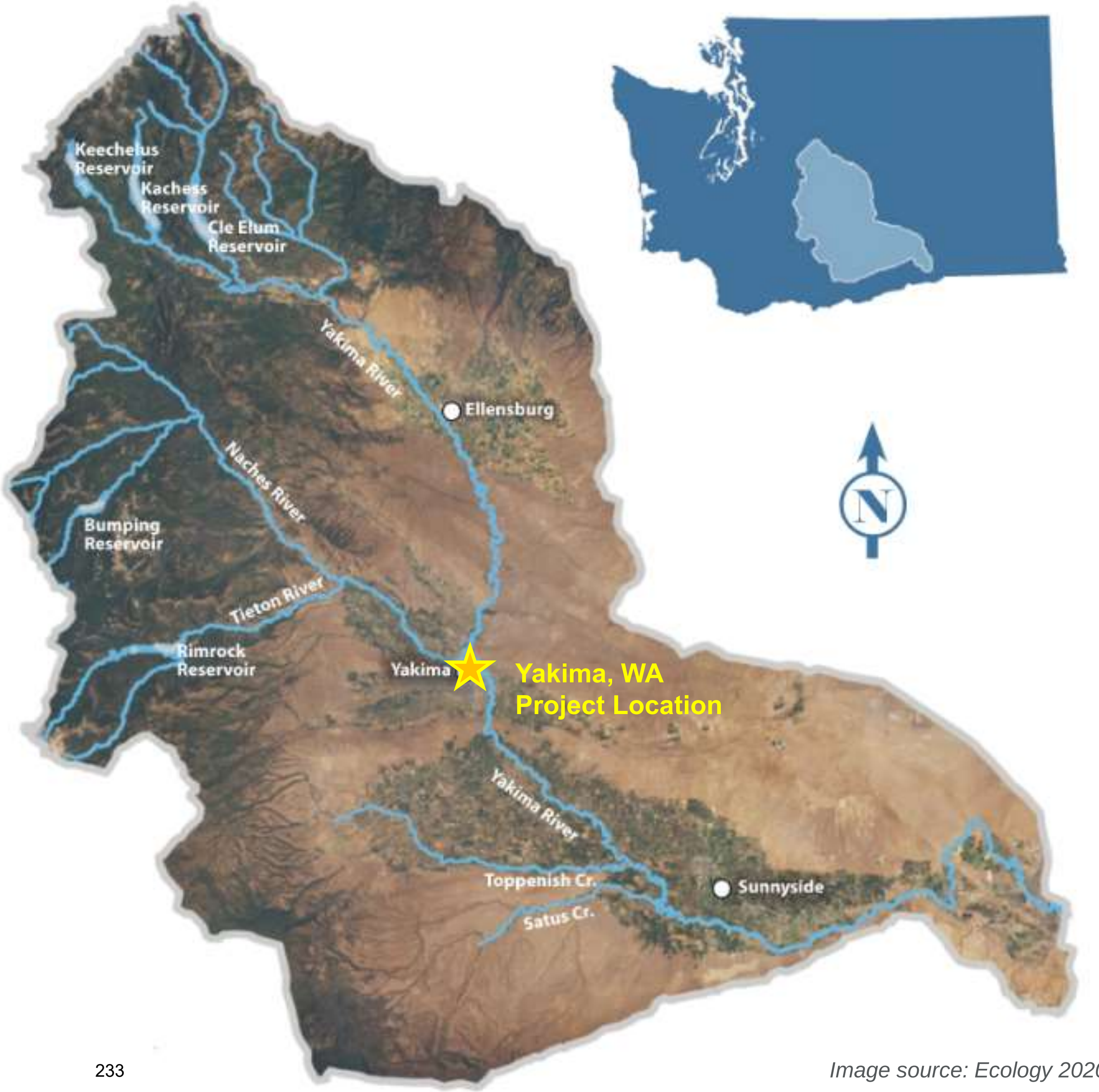


Image source: Ecology 2020

Pre-Project Infrastructure

What's the Problem?

Aging Infrastructure
- Dam built in 1920s
- Exposed rebar
- Needs replacement

Sediment Accumulation Upstream
- Decreased flood conveyance capacity
- Increasing flood events
- Potential damage to life/property

Fish Passage
- Low effectiveness of current ladder

Diminished Geomorphic Process
- Lower sediment continuity
- Fixed elevated floodplains
- Lower potential for dynamic habitat redevelopment

Intake Maintenance
- Requires high level of maintenance
- Instream manipulation needed to clear accumulated sediment, create check dams, maintain adequate water levels

Project History

1920s – 1985

Nelson Dam was built and operated, refurbished in 1985 but no significant changes were made to structure's design

Continued **sediment accumulation** upstream of Nelson Dam, causing **increased water surface elevation** for miles upstream

1996

Major **Flood** Event

2010

City and County FCZD **agreed to identify, fund, and implement solution** for Nelson Dam (modification, replacement, removal, etc.)

Collaboration with project stakeholders; Design Development: preliminary to final design, bid packages

2021

Construction begins!

2023

Implementation of project

02 Project Vision

Project Benefits

Overall reduction in WSELs, resulting in **less frequent flood-induced infrastructure damage**

Increased stability of bridge piers and roadway embankments

Opportunity for **sediment continuity** through and past the Project reach

Greater **reliability of water supply** systems

Decreased level of effort associated with facility **maintenance**

Creation of **fish passage** corridors to allow volitional upstream and downstream migration

Increased habitat potential for rearing and spawning fish

Three Primary Project Goals

Public Infrastructure

Water Supply

Ecological Habitat Restoration

Project Participants

Major Funding Partners

DEPARTMENT OF ECOLOGY
State of Washington

Washington Department of FISH AND WILDLIFE

Implementation Team

CITY OF YAKIMA
INCORPORATED 1886

YAKIMA COUNTY

HDR

nhc

HLA
Engineering and Land Surveying, Inc.

NORTHBANK
Civil & Marine

Other Project Participants

TROUT UNLIMITED

Bonneville
POWER ADMINISTRATION

Natural Resources

THE WILDERNESS SOCIETY

NOAA

NOAA FISHERIES

03 Project Elements

Removal of Pre-Project Infrastructure

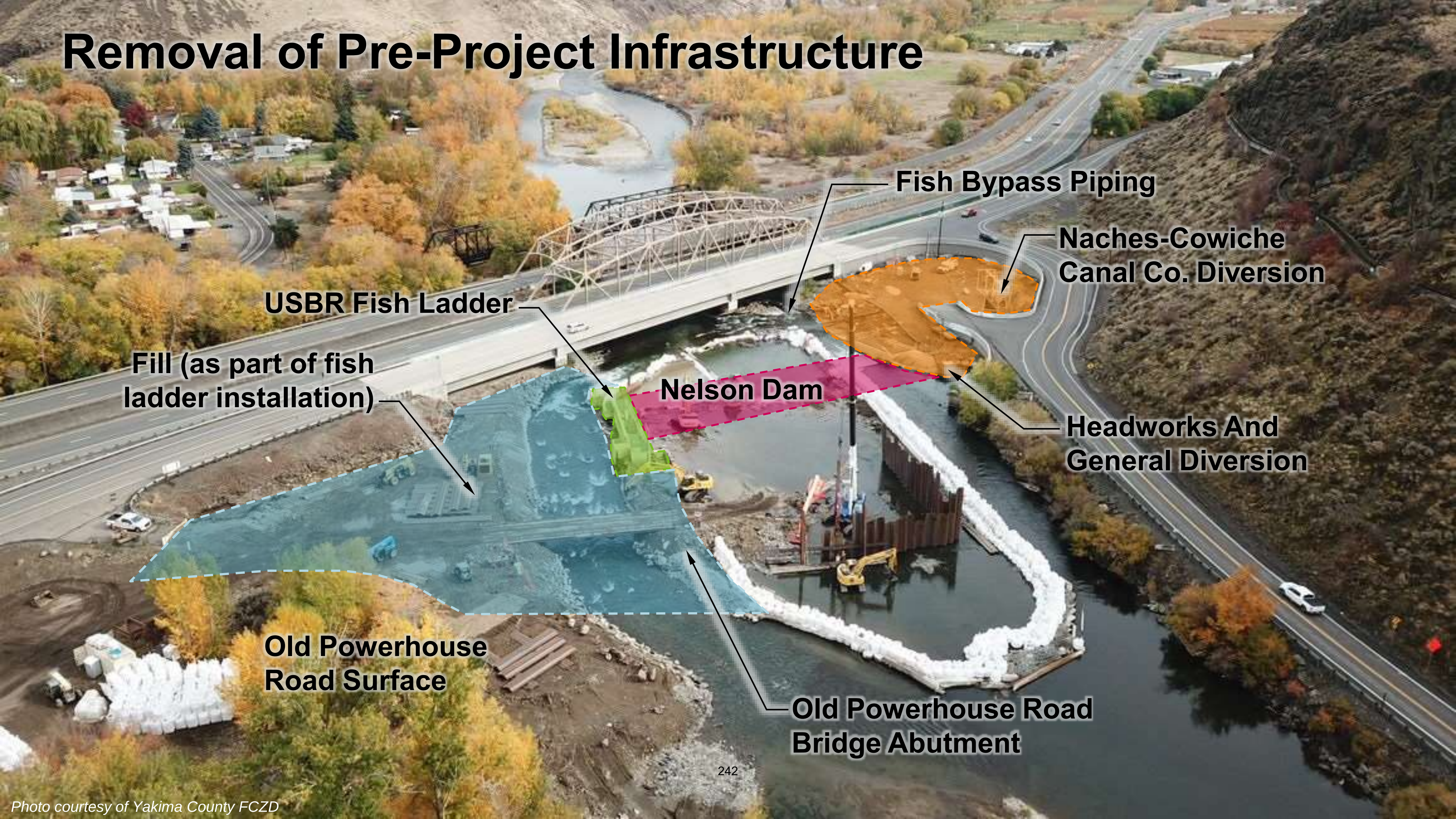
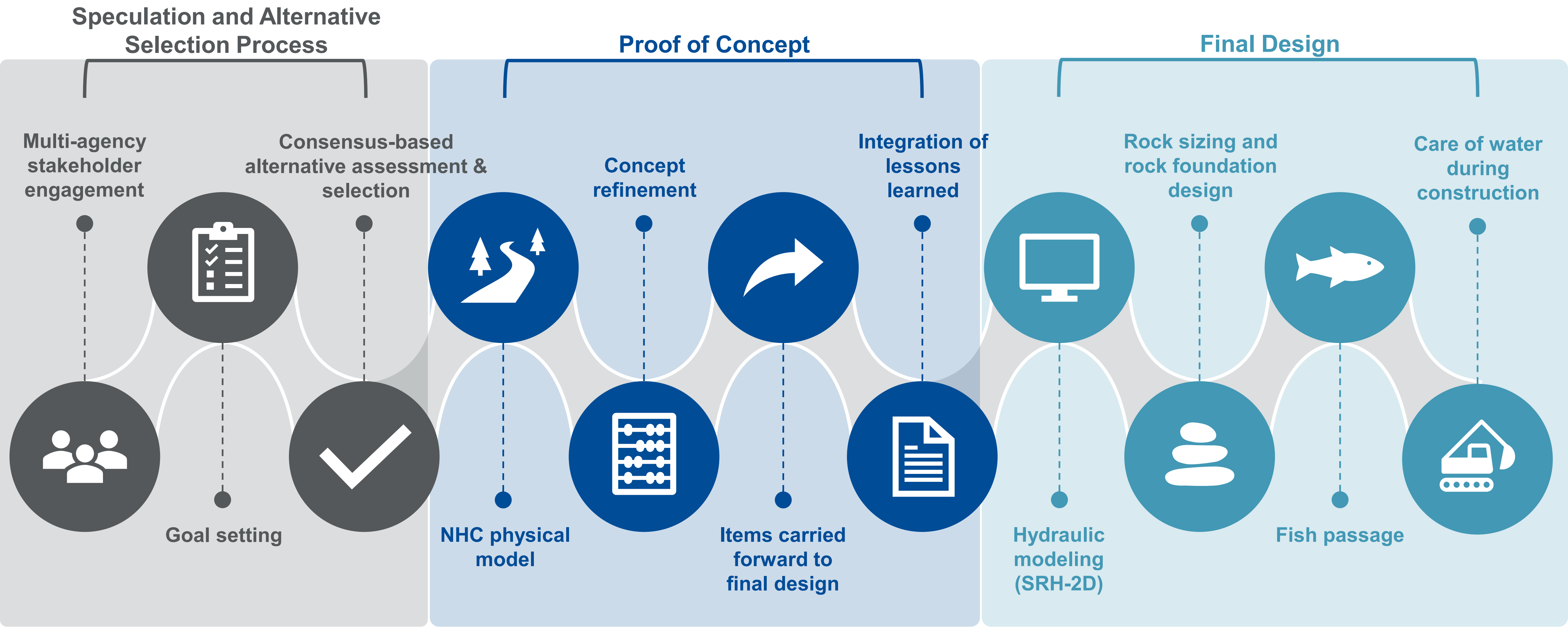


Photo courtesy of Yakima County FCZD

New Project Elements

04 Project Design

Design Techniques



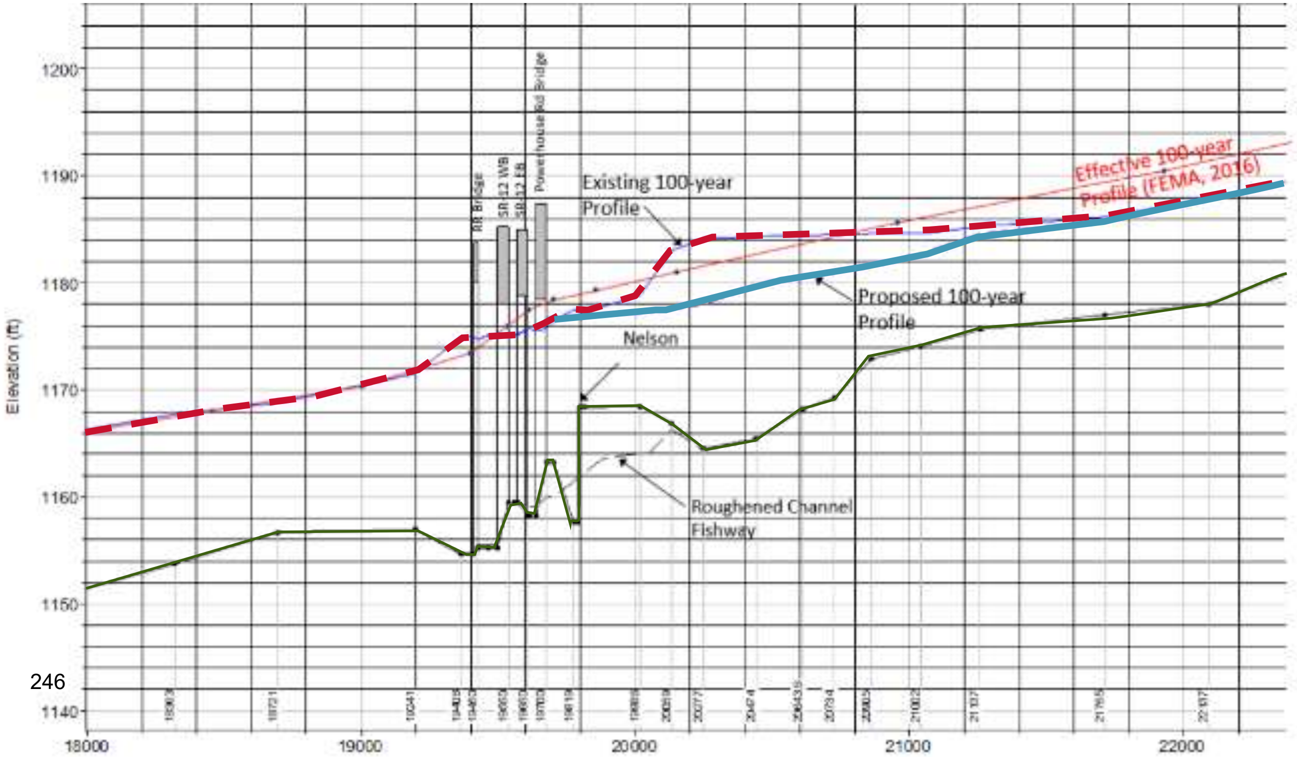
Hydraulic Design

Physical Modeling

- Bypass channel and sluiceway design & testing

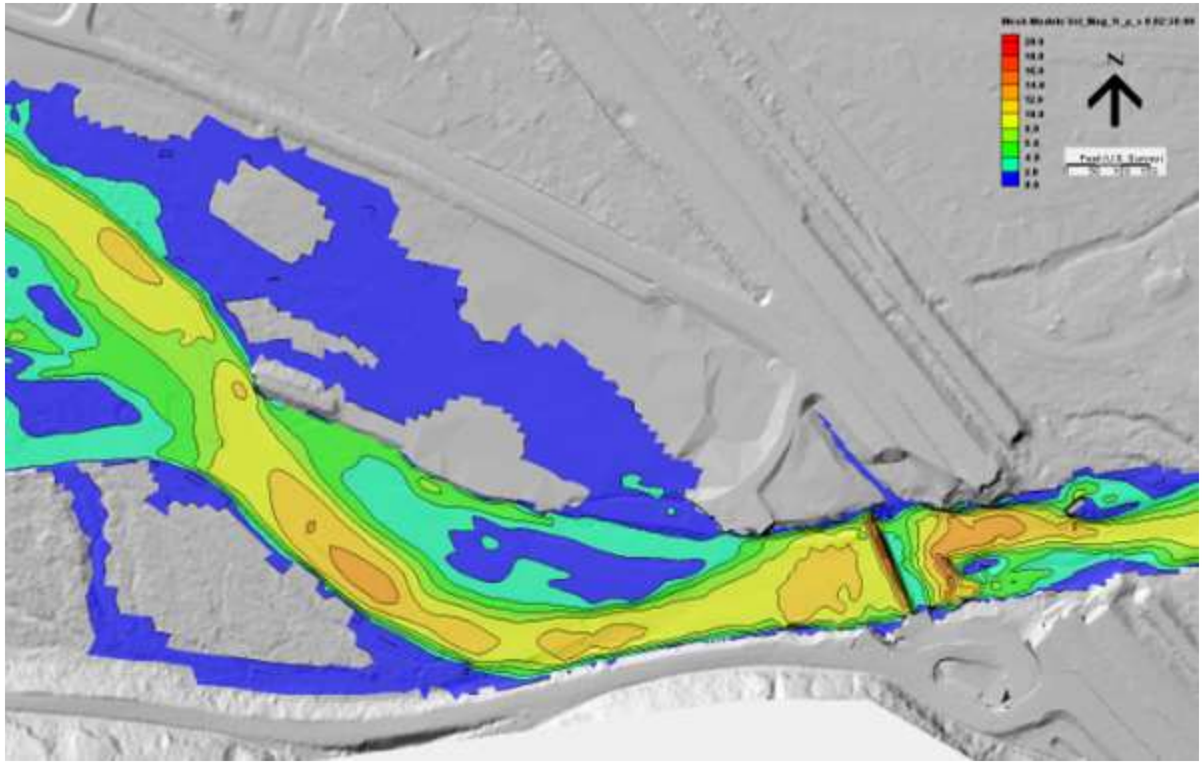
Numerical Modeling

- 1-Dimensional
  - HEC-RAS
  - 2- to 100-year flood profiles
  - Document flood level reduction
- 2-Dimensional
  - SRH-2D
  - Development of hydraulic design parameters for key assessments

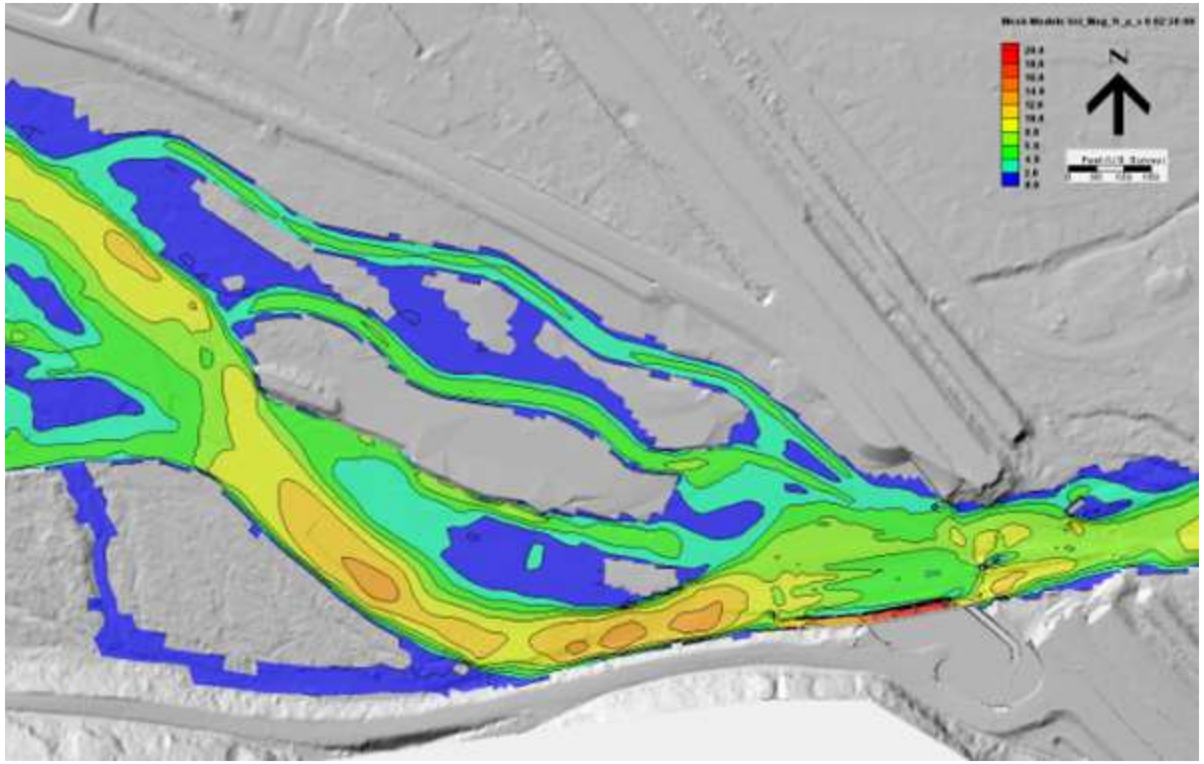


Final Design: SRH-2D

- Example analysis – velocity at 6,520 cfs
- Modeled velocity, depth, WSEL, shear



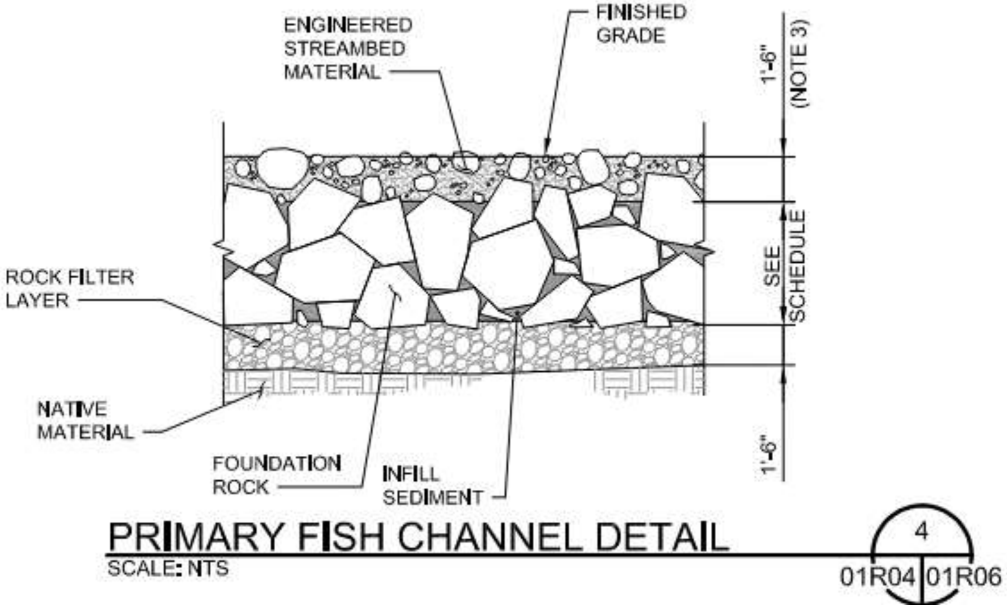
Pre-Project Conditions

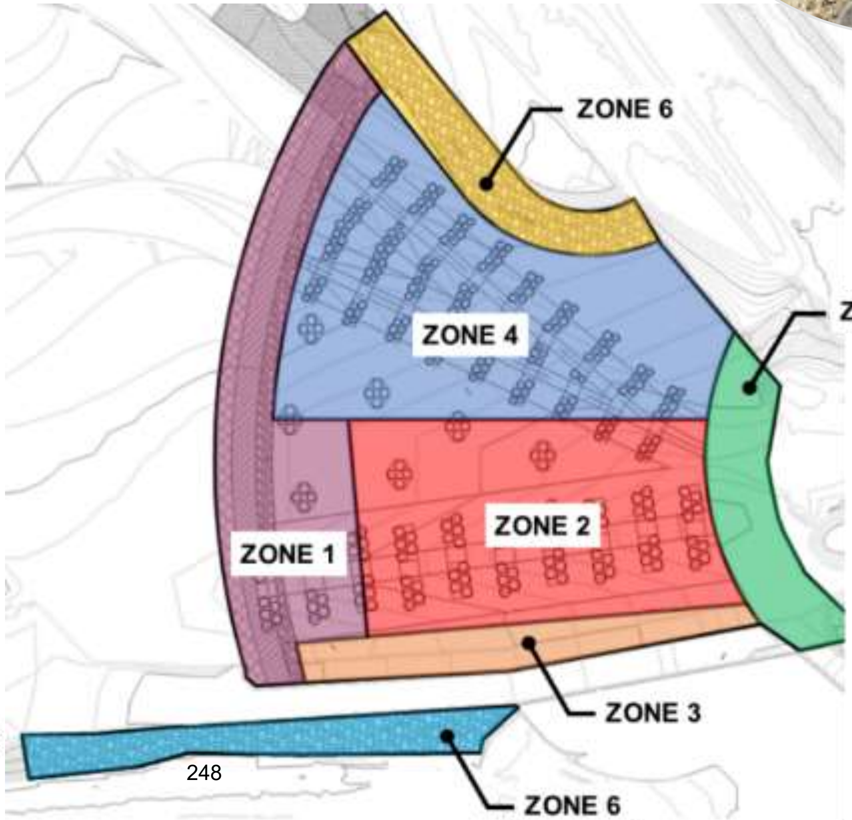


Post-Project Conditions

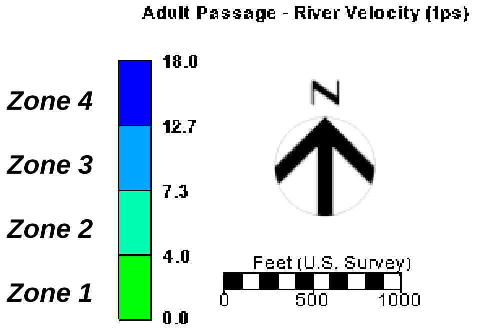
Final Design: Rock Sizing

- Rock filter layer
- Structural foundation rock layer
- Mobile bed layer

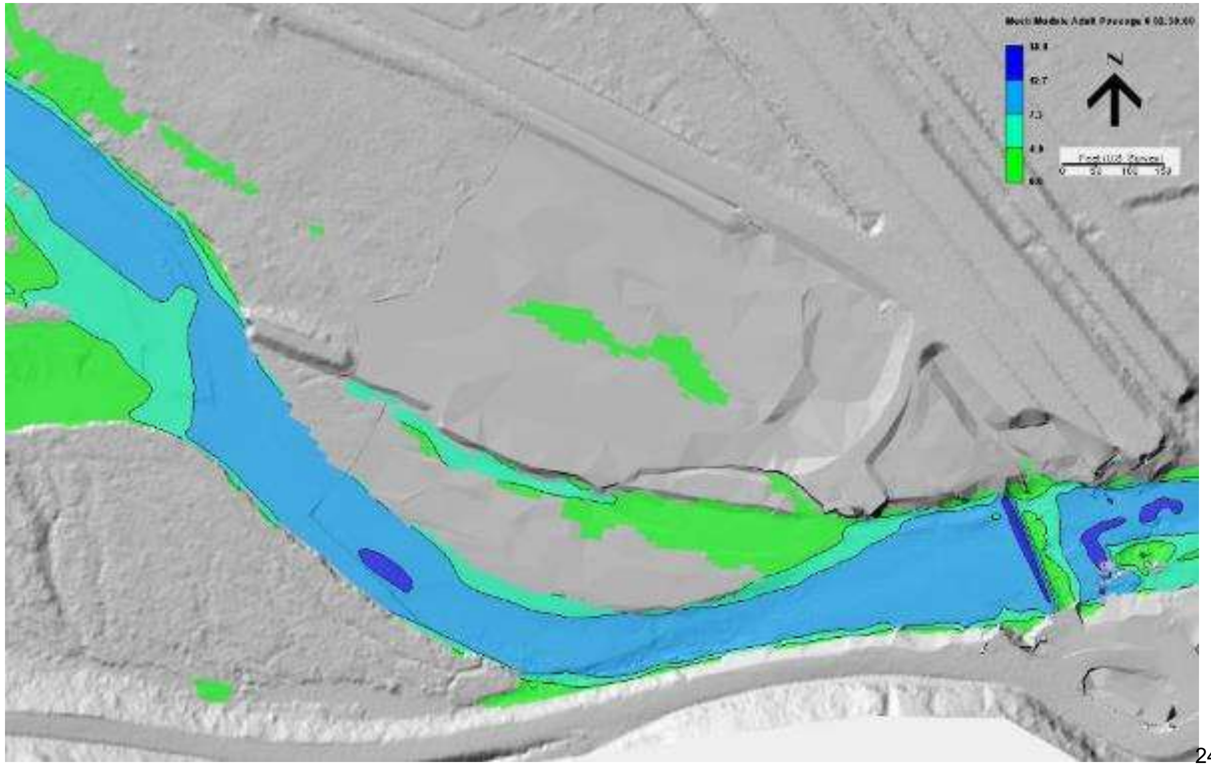




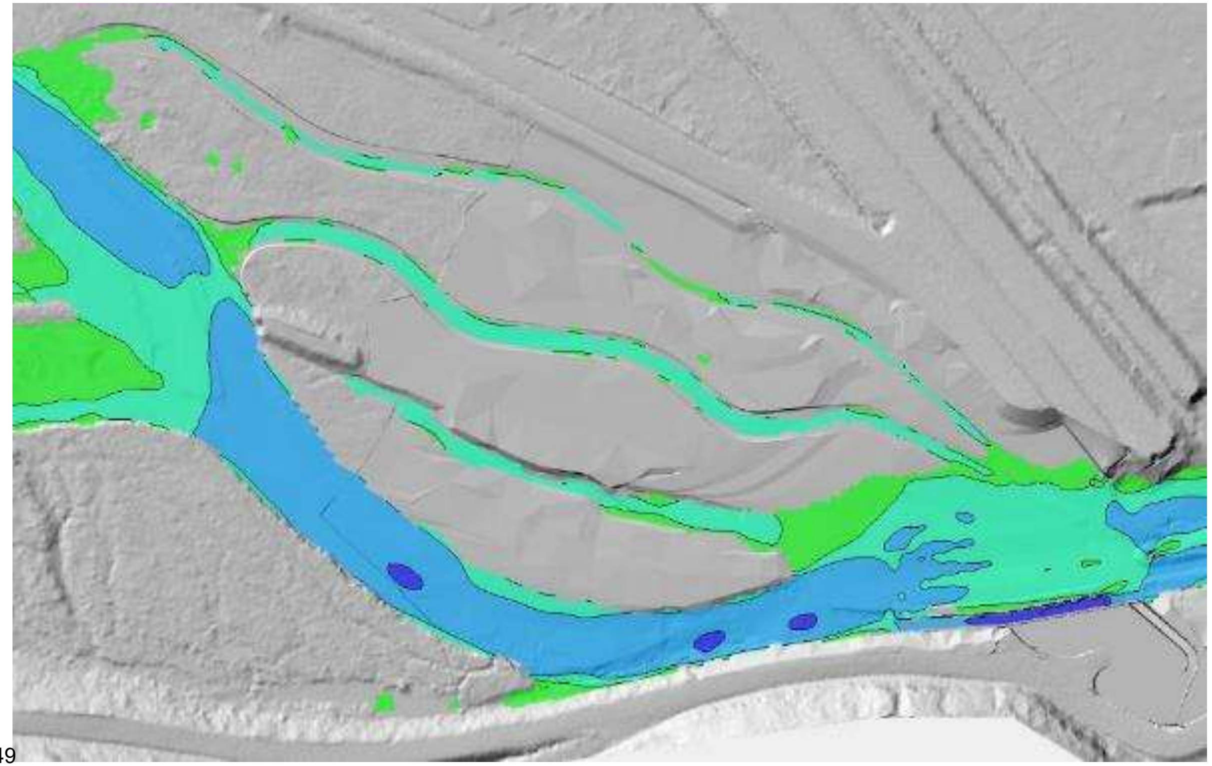
Final Design: Fish Passage



- Biometric comparison to 2D hydraulic modeling results
- Flow velocity vs. time to exhaustion vs. fish swimming distance adapted from Katopodis and Gervais, 2016
- Adult fish passage at 6,520 cfs, depth 0.9 feet or greater



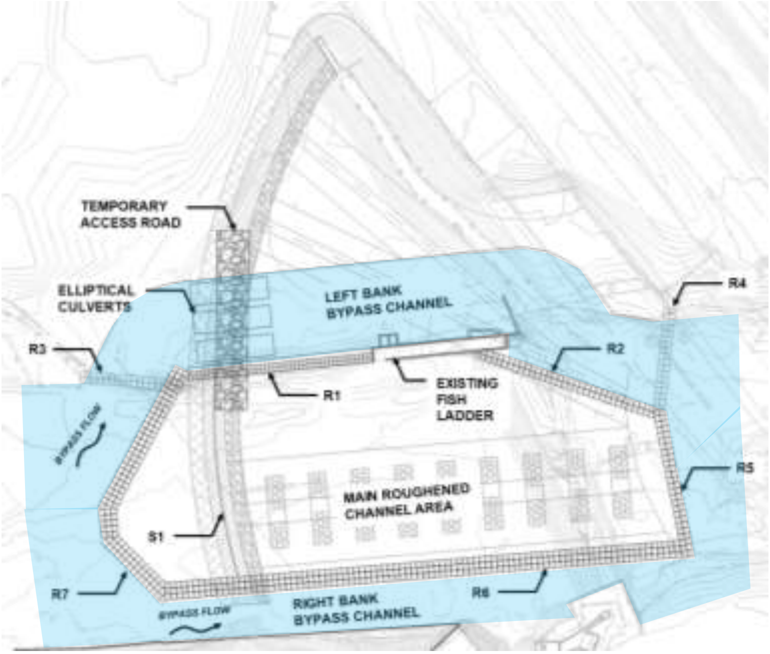
Pre-Project Conditions

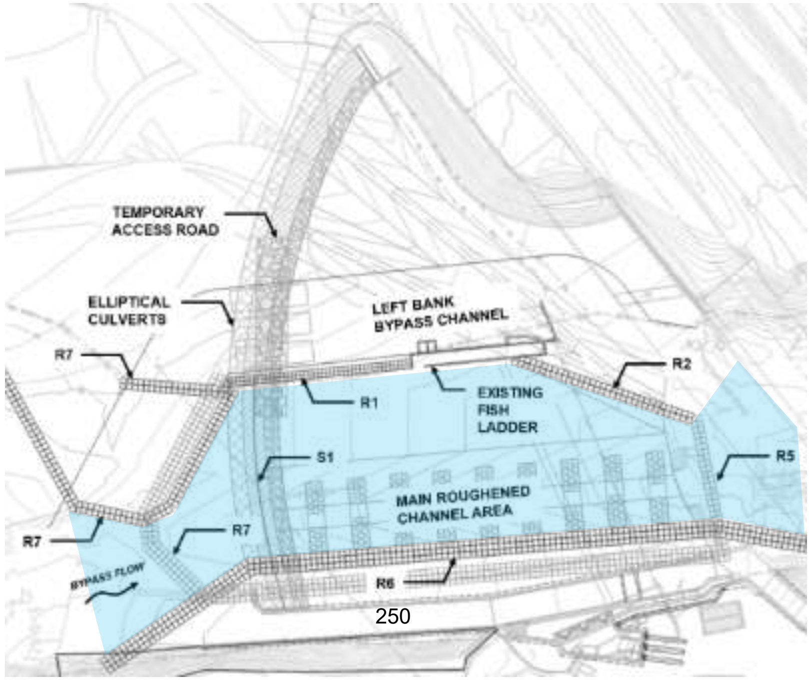


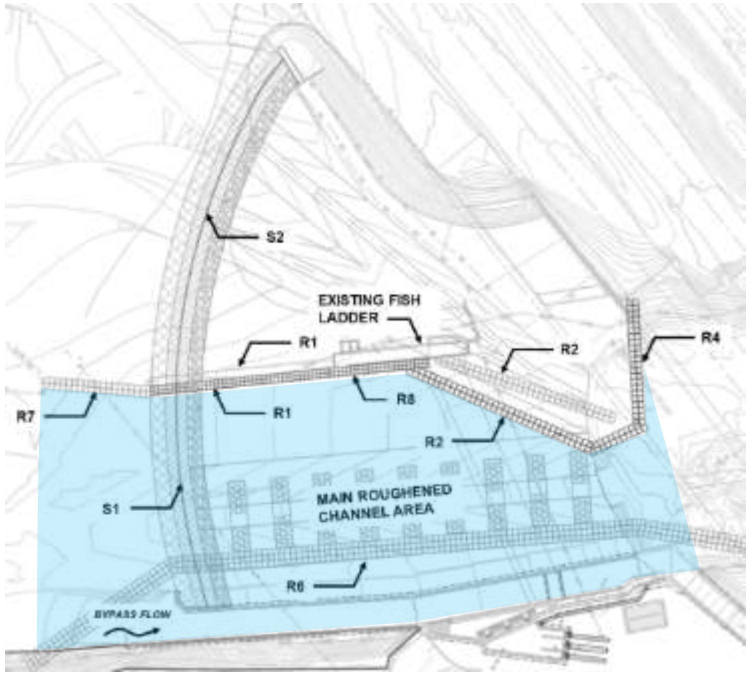
Post-Project Conditions

Final Design: Care of Water During Construction

- Major project component:
  - Cost
  - Risk
- Three phase strategy focused on construction of:
  - Main roughened channel area
  - Sluiceway and intake
  - Pilot channels

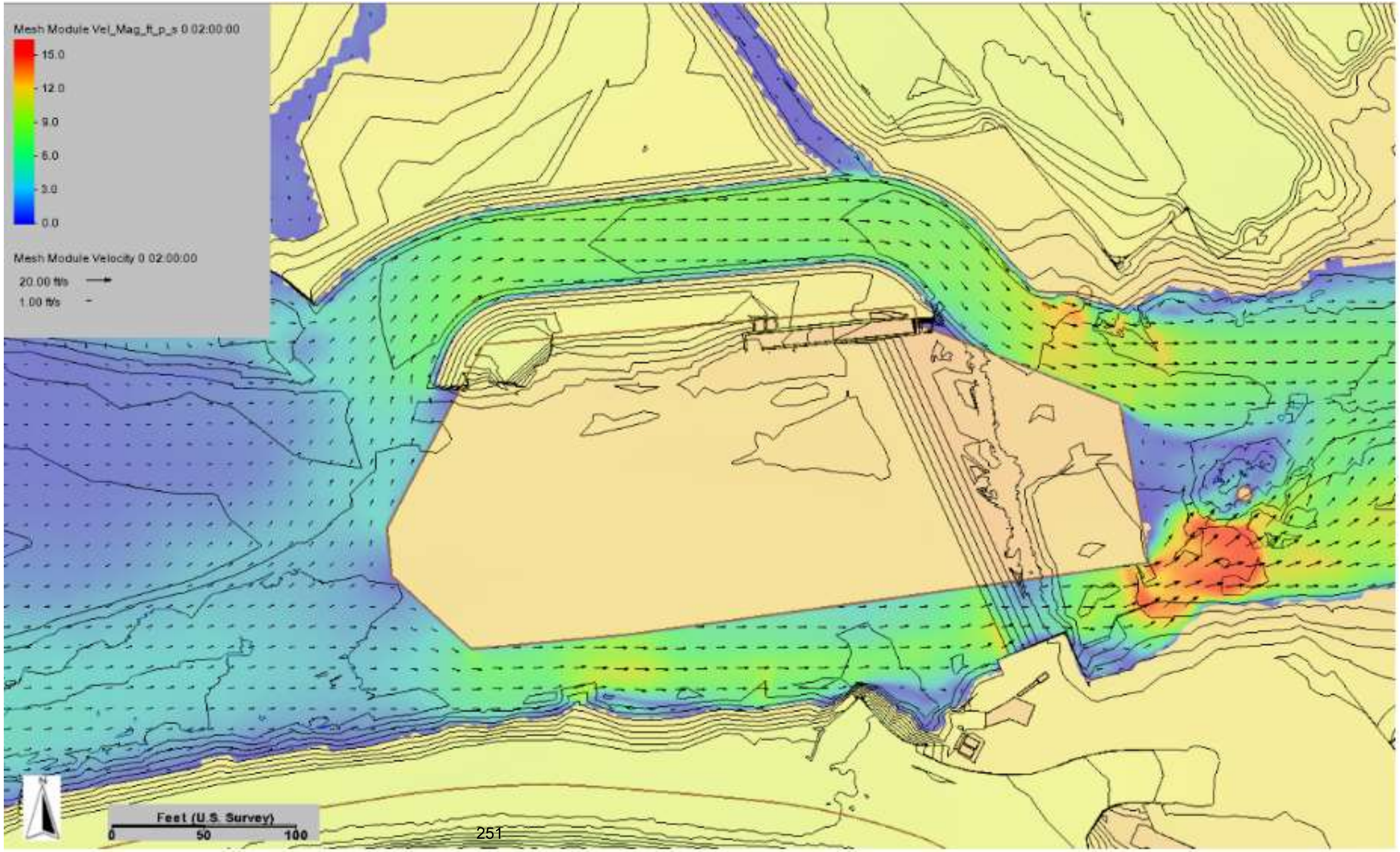






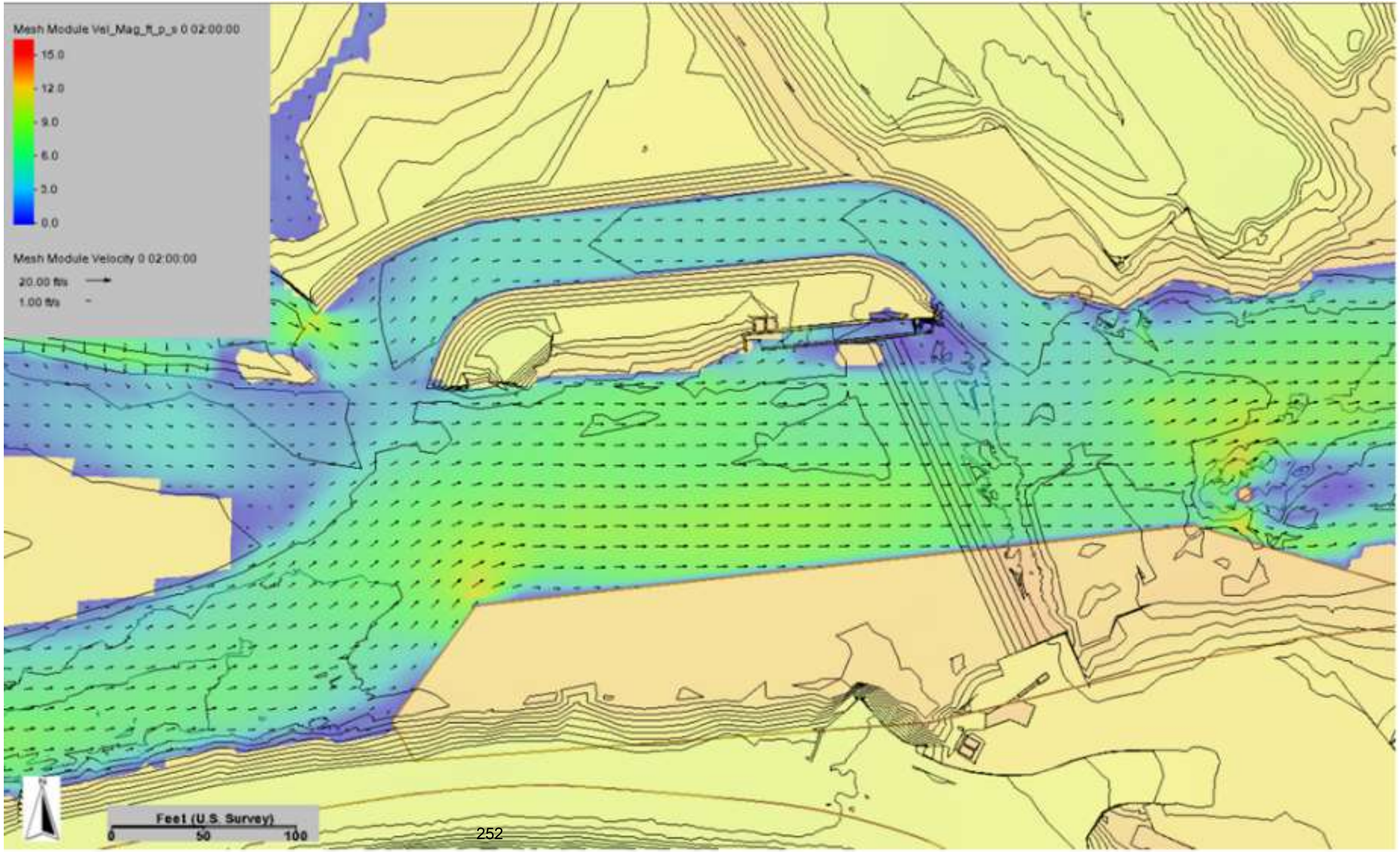
Final Design: Care of Water During Construction

- Phase 1
- 2,500 cfs



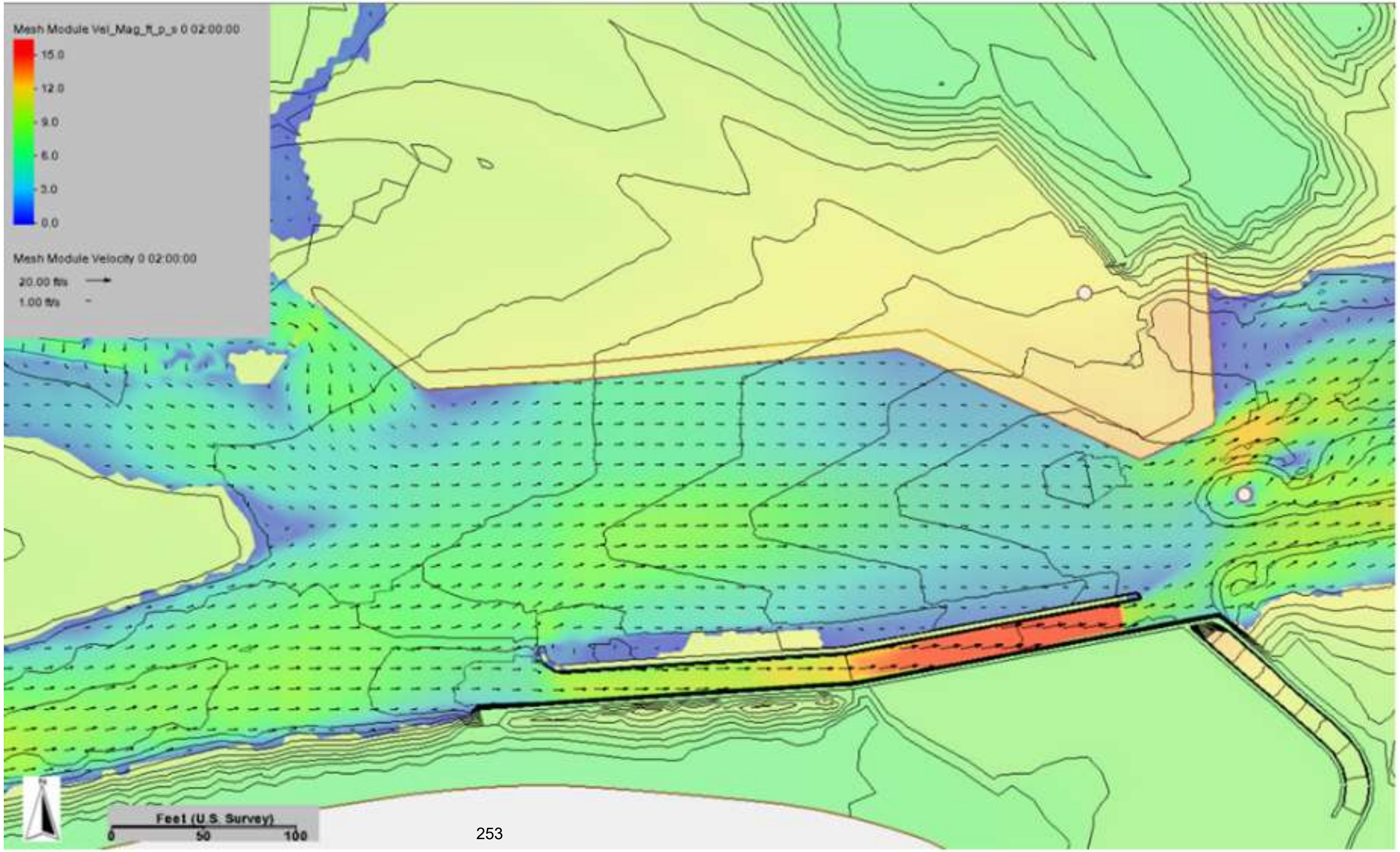
Final Design: Care of Water During Construction

- Phase 2
- 2,500 cfs



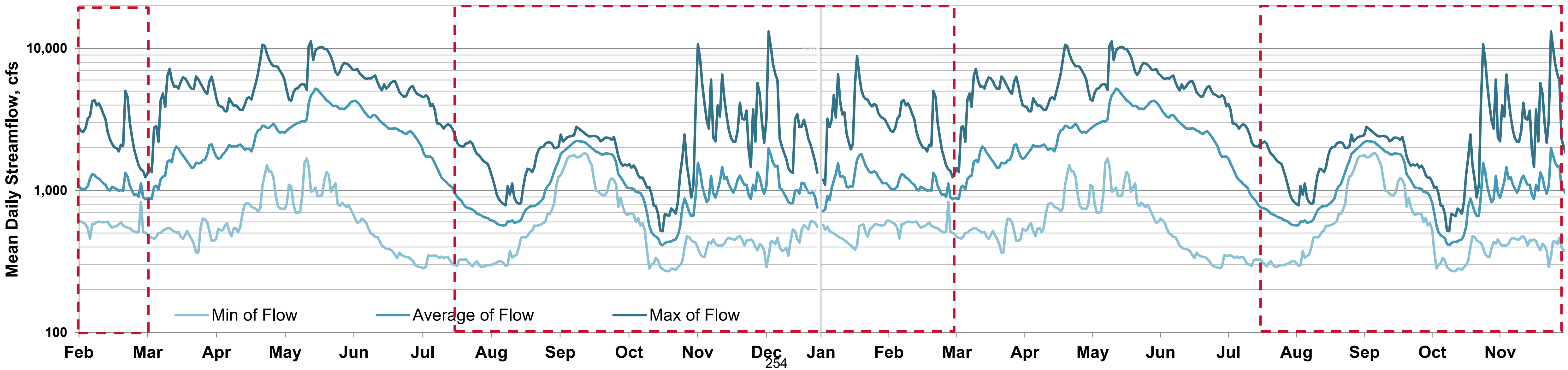
Final Design: Care of Water During Construction

- Phase 3
- 2,500 cfs



Summary of Construction Sequence

Step	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
1																						
2																						
3																						
4																						



05 Construction Methods

Material Sourcing

- Bid solicitation through City of Yakima Public Works
- Selection of three local quarries to produce material meeting design requirements
- Stockpile select material and deliver as requested by contractor during construction
- Total select rock deliveries to the project site – 39,000 tons

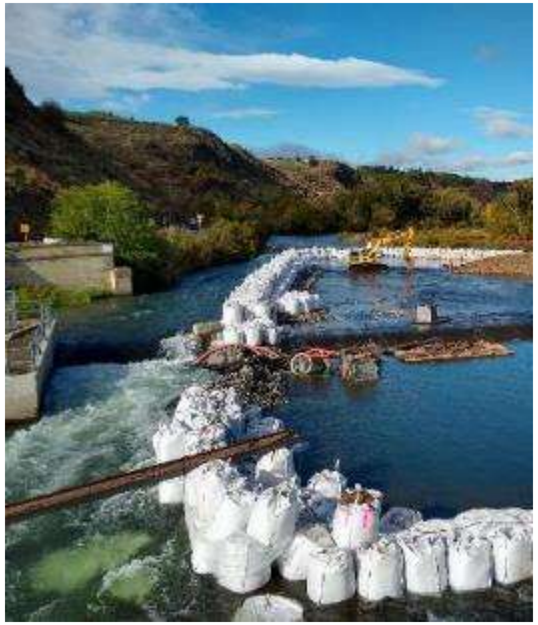
Onsite Material Receiving, Sorting, and Handling

Large Rock Handling

Phased Care of Water

Over 2,700 supersacks used for cofferdams

Temporary and permanent sheet pile walls



Multiple river diversion strategies

Networks of dewatering pumps, and conveyance techniques

Phased Care of Water

Phase 1:

- Bypass channel construction
- Existing dam isolation
- September 23, 2021

Phased Care of Water

Phase 1:

- Existing dam removal
- Permanent sheet pile wall
- Temporary sheet pile wall installation
- October 22, 2021

Phased Care of Water

Phase 1:

- Temporary sheet pile wall installation
- Construct middle roughened channel
- February 1, 2022

Phased Care of Water

Phase 2:

- Construct sluiceway and intake
- April 4, 2022

Phased Care of Water

Phase 2:

- Construct sluiceway and intake
- Temporary gravity irrigation diversion established
- June 9, 2022

Phased Care of Water

Phase 3:

- Construct sluiceway and intake
- Construct left bank floodplain and roughened channel
- October 24, 2022

Phased Care of Water

Phase 3:

- Construct sluiceway and intake
- Construct left bank floodplain and roughened channel
- November 22, 2022

Phased Care of Water

Phase 3:

- Construct sluiceway and intake
- Construct left bank floodplain and roughened channel
- January 27, 2023

Phased Care of Water

- April 19, 2023 Phase 1 project complete

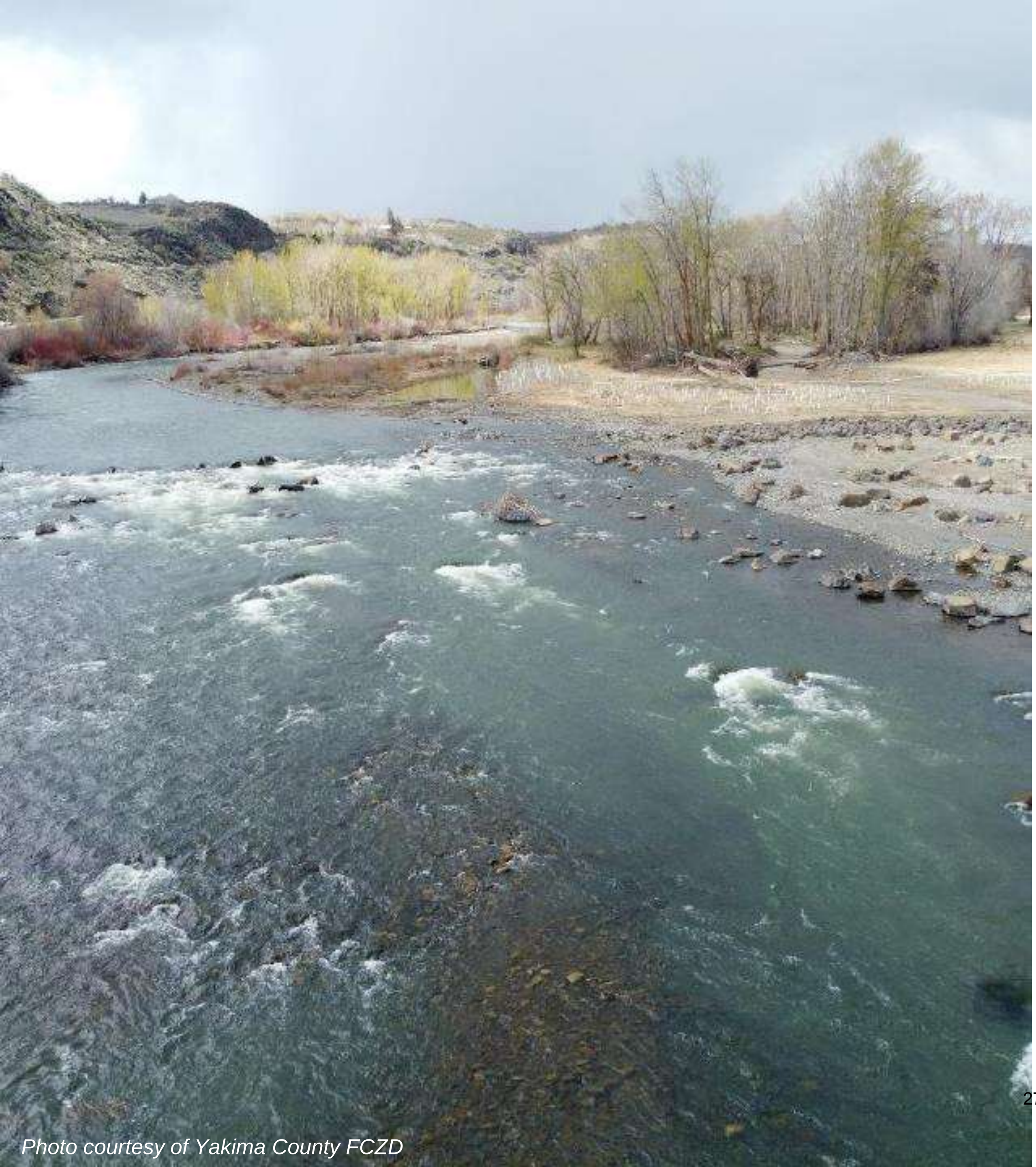


Photo courtesy of Yakima County FCZD

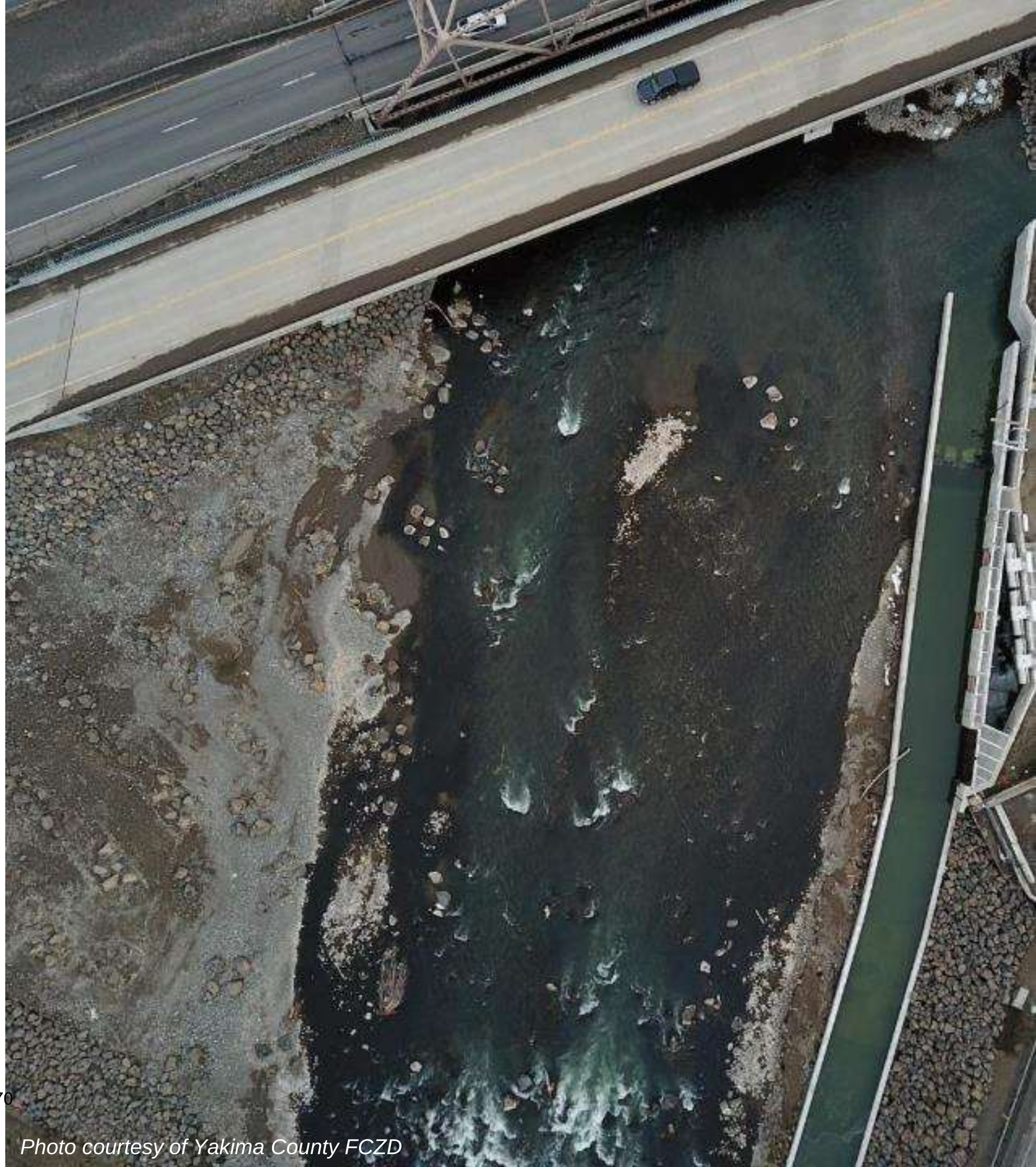


Photo courtesy of Yakima County FCZD

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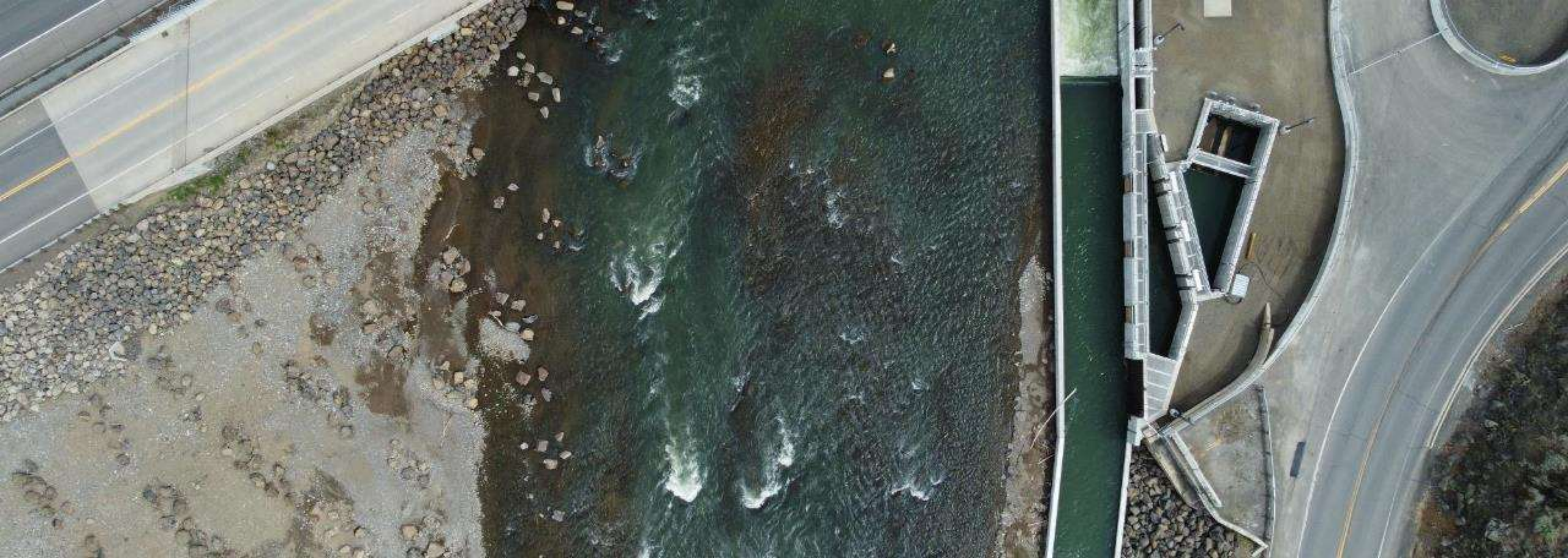

06 Next Steps

Anticipated Project Future

Phase I – Construction Complete: April 2023

Operation, Testing, and Monitoring: April – October 2023, then ongoing…

Phase II – Begin / End of Construction: June 2024

Diversion Decommissioning: Fruitvale and Old Union Diversions will be decommissioned

Future Work: Habitat / Floodplain Restoration, Set-Back Levees, and Flood Damage Reduction Efforts

Nelson Dam Project and associated Phases of Work complete 2027

Questions?

Thank You for Attending!

HDR

Special thanks to the City of Yakima, Yakima County Flood Control Zone District, and Northwest Hydraulic Consultants

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