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Restoring Complexity: Design of Large Wood Structures and Off-Channel Habitats

A Concurrent Session at the 34th Annual Salmonid Restoration Conference held in Fortuna, CA from April 6-9, 2016.

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Session Overview

- Session Coordinators:
  - Michael Love, P.E., Michael Love & Associates
  - Steve Allen, P.E., GHD Inc.

Many of our streams and rivers have become over-simplified through removal of large wood and stream encroachment and confinement, often resulting from pressures to reduce flooding at the expense of biological diversity. This trend commonly results in the disconnection and loss of complex backwater habitats and deep pools that once provided productive nurseries for rearing salmonids. This workshop focuses on developing and constructing projects aimed at restoring geomorphic processes that create and maintain channel complexity while working within current-day constraints. Presentations will describe approaches to identify and characterize site suitability for restoring off-channel habitat and creating high-flow and thermal refugia, available tools and analyses to support design development, use of large wood structures (LWS) to create desired geomorphic responses, approaches to mitigate potential project risks, and engineering and construction techniques for installing LWS and connecting off-channel habitat. The workshop will include instruction on these various topics and presentations of example projects.

Presentations

(Slide 5) Geotechnical Characterization and Construction Techniques for Creating Off-channel Habitats and Post-assisted Wood Structures
Rocco Fiori, Fiori GeoSciences

(Slide 55) Constructed Wood Jams and Off-Channel Habitats on the Trinity River, CA
Aaron Martin, DJ Bandrowski, Kyle DeJuilio, and Andreas Krause, Yurok tribe

(Slide 122) Installation of LWD from a Contractor's Perspective
Mark Cederborg, Hanford ARC

(Slide 149) LWS Construction Considerations for Publically Bid and Contracted Restoration Projects
Steve Allen, GHD

(Slide 167) Integrating Off-channel Estuary Slough Restoration in the Mattole, with Riparian Revegetation and Terrace Margin treatments for Climate Change resiliency
Sungnome Madrone and Drew Barber, Mattole Salmon Group

(Slide 211) Jacoby Creek Off-Channel Habitat: Site Characterization, Design, and Construction
Michael Love and Antonio Llanos, Michael Love & Associates

Presentations

(Slide 233) Channel Surfing by Juvenile Salmonids: Fish and Water Quality Responses to Off-channel Habitat Restoration Projects in the Stream-estuary Ecotone of Humboldt Bay
Mike Wallace, California Department of Fish and Wildlife

(Slide 270) Coho, Cows, and Collaboration: Creating Coho Rearing Habitat in an Anthropogenic Landscape
Charles Wickman, Mid Klamath Watershed Council

(Slide 283) Design and Engineering of Off-Channel Habitat and Large Wood Projects
Toz Soto, Karuk Tribe

(Slide 330) The Effectiveness of Large Wood Enhancement in Lagunitas Creek over 15 Years
Eric Ettlinger, Marin Municipal Water District

(Slide 351) Design and Implementation of Fine Woody Material for Juvenile Salmonid Habitat
Brian Wardman, Northwest Hydraulic Consultants

(Slide 370) Models for Cranberry Bog Stream and Wetland Restoration
Caitlin Alcott, Inter-Fluve

Geotechnical Characterization and Construction Techniques for Creating Off-Channel Habitats and Post-Assisted Wood Structures: Examples from Lower Klamath Tributaries

Rocco Fiori, Fiori GeoSciences
Sarah Beesley, Yurok Tribe Fisheries Service

Discussion Topics

Why Post-Assisted Wood Structures

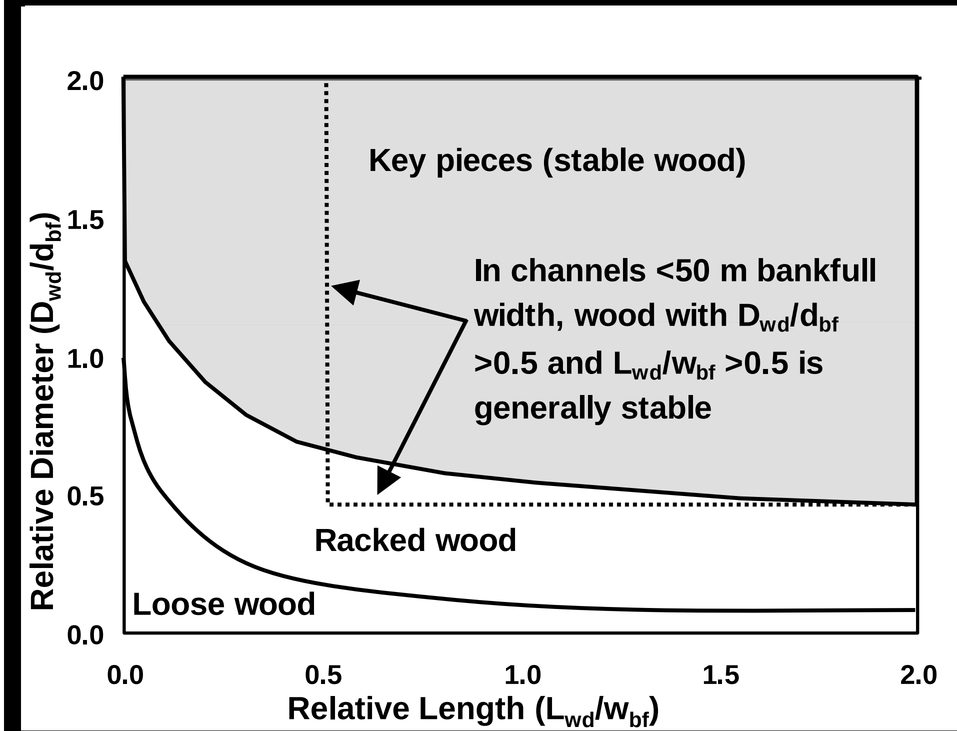
Key Design Equations and Selection of Input Parameters

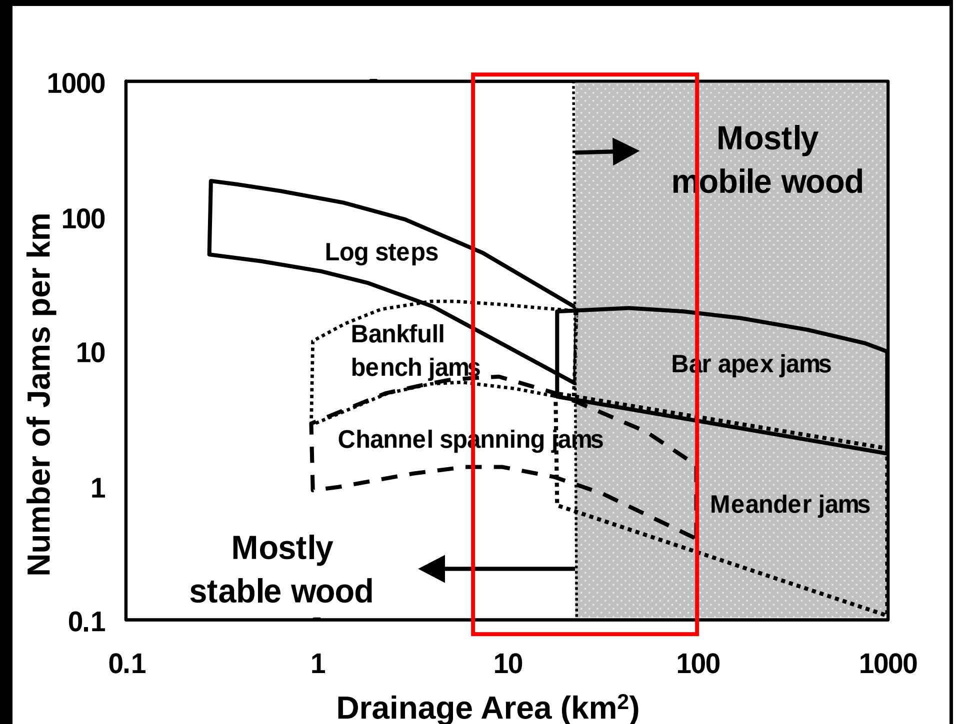
Construction Techniques and Failure Mechanisms

Conceptual Model For Estimating ELJ Design Life

Guiding Concepts

Wood Dynamics and Function





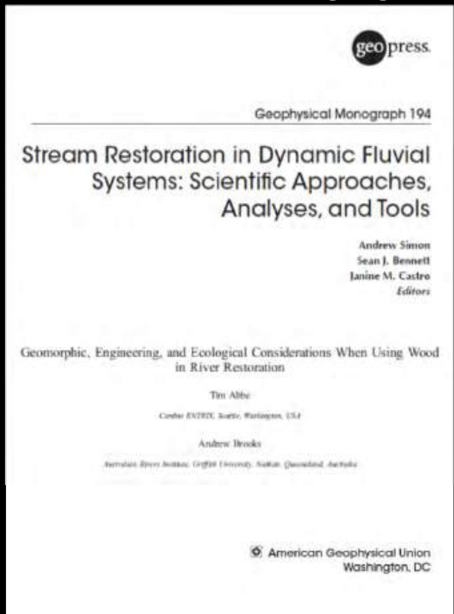
Abbe and Montgomery (2003) Patterns and processes of wood debris accumulation in the Queets River basin, Washington.

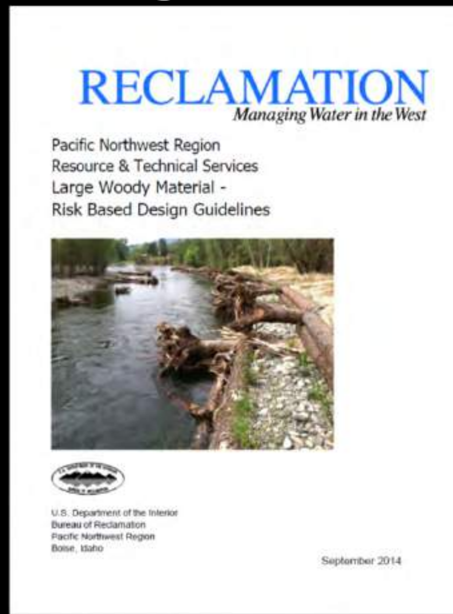
Wohl (2013) Floodplains and Wood.

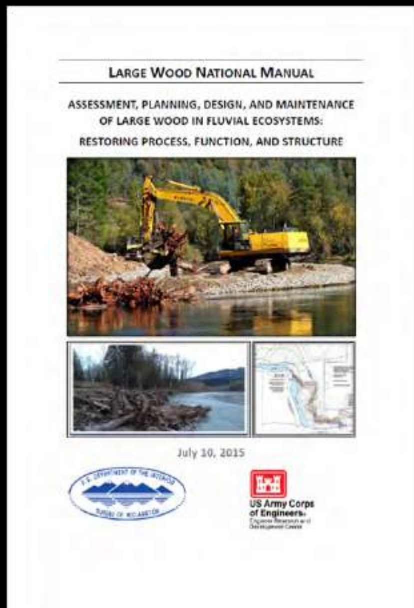
Roni et al. (2015) Wood placement in river restoration: fact, fiction, and future direction.

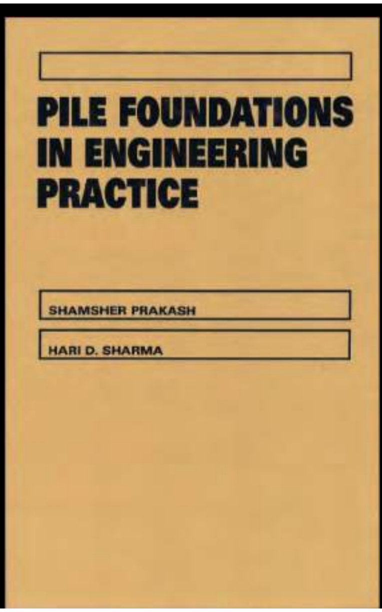
USACE & BOR (2015) Large Wood National Manual.

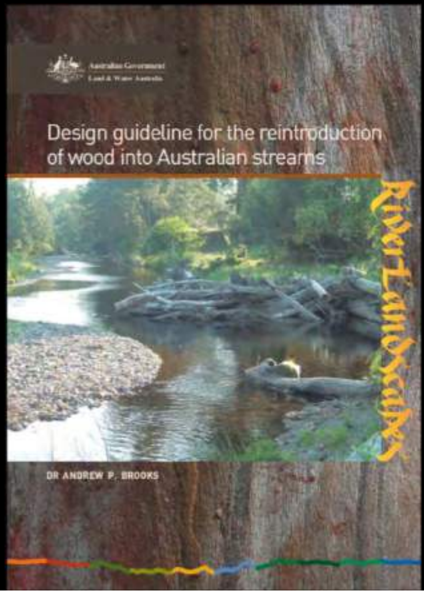
Design Resources For Post & Pile Supported Large Wood Structures

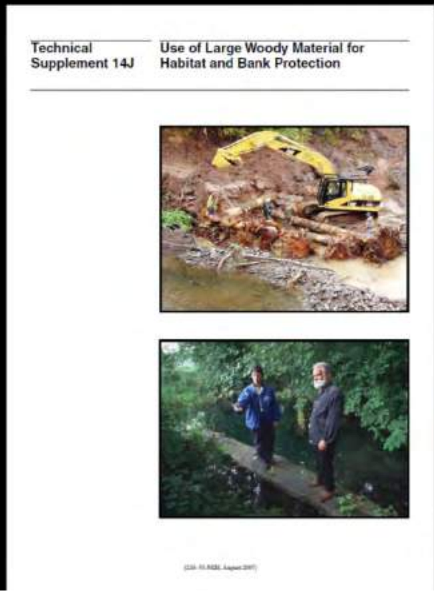












Key Post & Pile Design Equations

Pullout Resistance

$$F_{piles-v} = N_{piles} * \pi * d_{piles} * L_{piles}(k_s * \tan\frac{2}{3}\emptyset * \sigma' + \frac{d_{piles}}{4} * (\gamma_{wood} - \gamma_w))$$

Equation 15

N_{piles} = number of piles

d_{piles} = diameter of piles

L_{piles} = embedded length of piles

k_s = coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density) Should be multiplied by 2/3 for pullout Prakash and Sharma (1990)

ϕ = internal angle of friction of soils

$$\sigma' = L_{piles} * (\gamma_{sat} - \gamma_w)$$

Equation 16

= effective vertical stress over pile length

Broms Ks and δ values for driven timber piles

Material	δ	Ks	
		low density soil	high density soil
timber	**2/3ϕ**	**1.5**	**4**

Knudson and Fealko 2014

Key Post & Pile Design Equations

Lateral Resistance

$$F_{piles-h} = -N_{piles} * \frac{L_{pile}^{3} * \frac{1}{2} * \gamma_e * d_{pile} * K_p}{h_{load} + L_{pile}}$$ **Equation 36**

N_{piles} = *number of piles*

L_{pile} = *length of pile embedded below potential scour depth*

$$\gamma_e = \gamma_s - \gamma_w$$ *effective unit weight of soil* **Equation 37**

γ_s = *dry unit weight of the soil*

γ_w = *unit weight of the soil*

d_{pile} = *diameter of the pile*

h_{load} = *height above the potential scour depth the load is applied*

$$K_p = \frac{1 + \sin \emptyset}{1 - \sin \emptyset}$$ **Equation 38**

Knudson and Fealko 2014

Key Post & Pile Design Equations

Embedment Depth

$$L_{pile}^3 = \frac{|F_{piles-h}| * (L_{pile} + h_{load})}{N_{piles} * \gamma_e * d_{pile} * {}^{K_p}/_4}$$

Equation 40

$$L_{pile}^3 = \frac{|F_{piles-h}| * (L_{pile} + h_{load})}{N_{piles} * \gamma_e * d_{pile} * {}^{K_p}/_2}$$

Corrected Eq 40

Knudson and Fealko 2014

Geotechnical Properties Earth Materials

FHWA (1993) after Meyerhof (1956)

Description	SPT N'60* value (blows/ft.)	Approximate Angle of Internal Friction (Φ)**	Moist Unit Weight (pcf)	Field Approximation
Very Loose	0 – 4	< 30	70 – 100	Easily penetrated many inches (>12) with ½ inch rebar pushed by hand.
Loose	4 – 10	30 – 35	90 – 115	Easily penetrated several inches (>12) with ½ inch rebar pushed by hand.
Medium	10 – 30	35 – 40	110 – 130	Easily to moderately penetrate with ½ inch rebar driven by 5 lb. hammer.
Dense	30 – 50	40 – 45	120 – 140	Penetrated one foot with difficulty using ½ inch rebar driven by 5 lb. hammer.
Very Dense	> 50	> 45	130 – 150	Penetrated only a few inches with ½-inch rebar driven by 5 lb. hammer.

* N'_{60} is corrected for overburden pressure and energy

** Use the higher phi angles for granular material with 5% or less fine sand and silt.

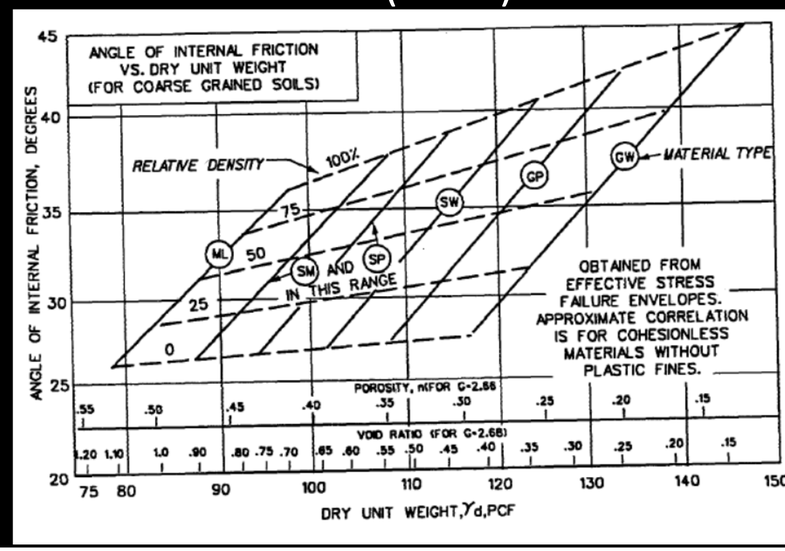
K and F (2014) from Rafferty (2013)

Grain size (mm)	Sediment Class	Average Dry Unit Weight (lb/ft^3)	Internal Friction Angle (degrees)
Bedrock	Bedrock	165	-
256-2048	Boulder	146	42
128-256	Large Cobble	142	42
64-128	Small Cobble	137	41
32-64	Very coarse gravel	131	40
16-32	Coarse gravel	126	38
8-16	Medium gravel	120	36
4-8	Fine gravel	115	35
2-4	Very fine gravel	109	33
1-2	Very coarse sand	103	32
0.5-1	Coarse sand	98	31
0.25-0.5	Medium sand	94	30
0.125-0.25	Fine sand	93	30
0.063-0.125	Very fine sand	92	30
0.004-0.063	Silt	82	30
<0.004	Clay	78	25

Teng (1962)

Compactness	Relative Density (%)	SPT N (blows per ft)	Angle of Internal Friction (deg)	Unit Weight: Moist (pcf)	Unit Weight: Submerged (pcf)
Very Loose	0-15	0-4	<28	<100	<60
Loose	16-35	5-10	28-30	95-125	55-65
Medium	36-65	11-30	31-36	110-130	60-70
Dense	66-85	31-50	37-41	110-140	65-85
Very Dense	86-100	>51	>41	>130	>75

NAVFAC DM 7.2 (1986)



Geotech Investigation and FOS

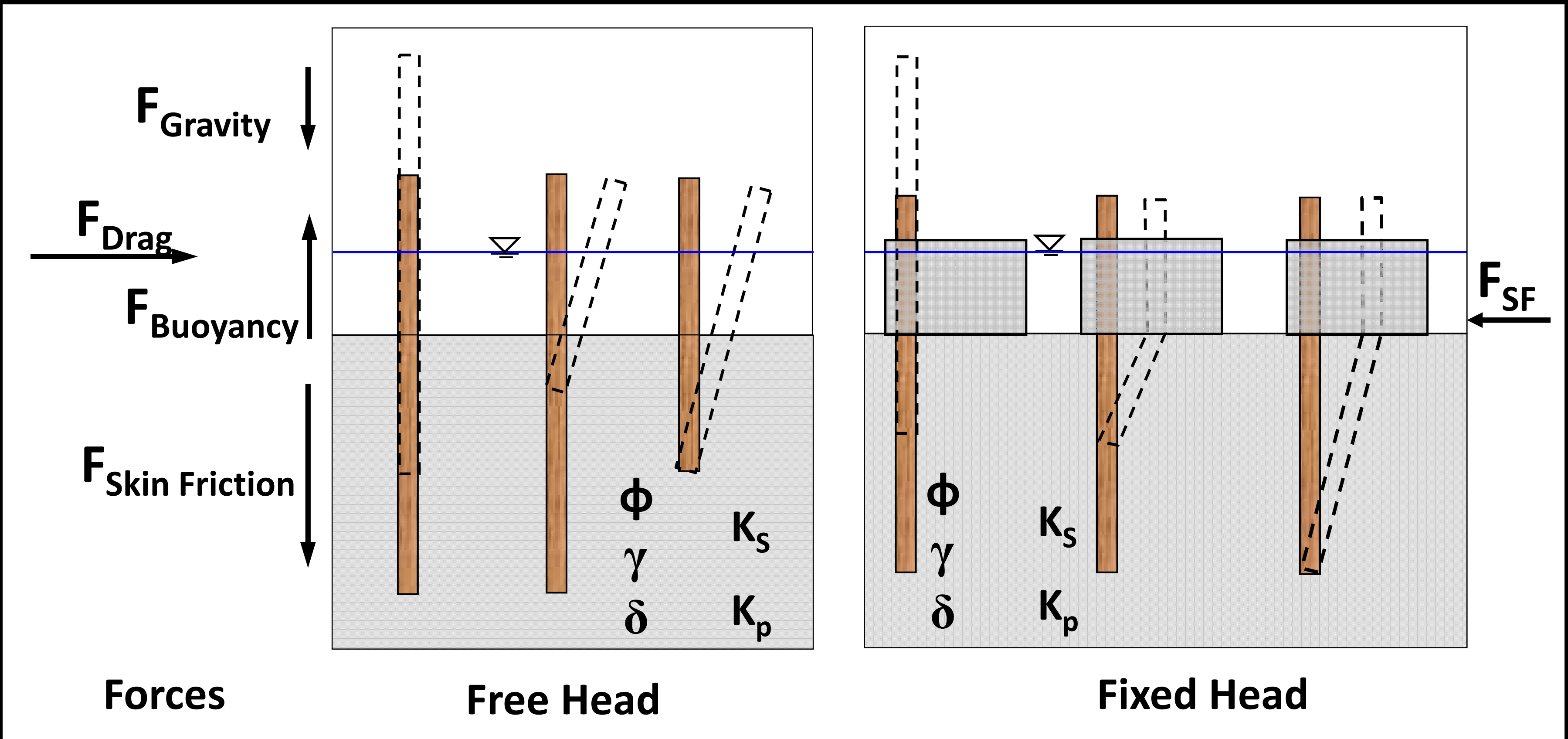
In the past, only two methods have been used for coping with the inevitable uncertainties: either to adopt an excessive factor of safety, or else to make assumptions in accordance with general, average experience. The designer who has used the latter procedure has usually not suspected that he was actually taking a chance.

The first method is wasteful; the second is dangerous. Soil mechanics, as we understand it today, provides a third method which could be called the experimental method. The procedure is as follows:

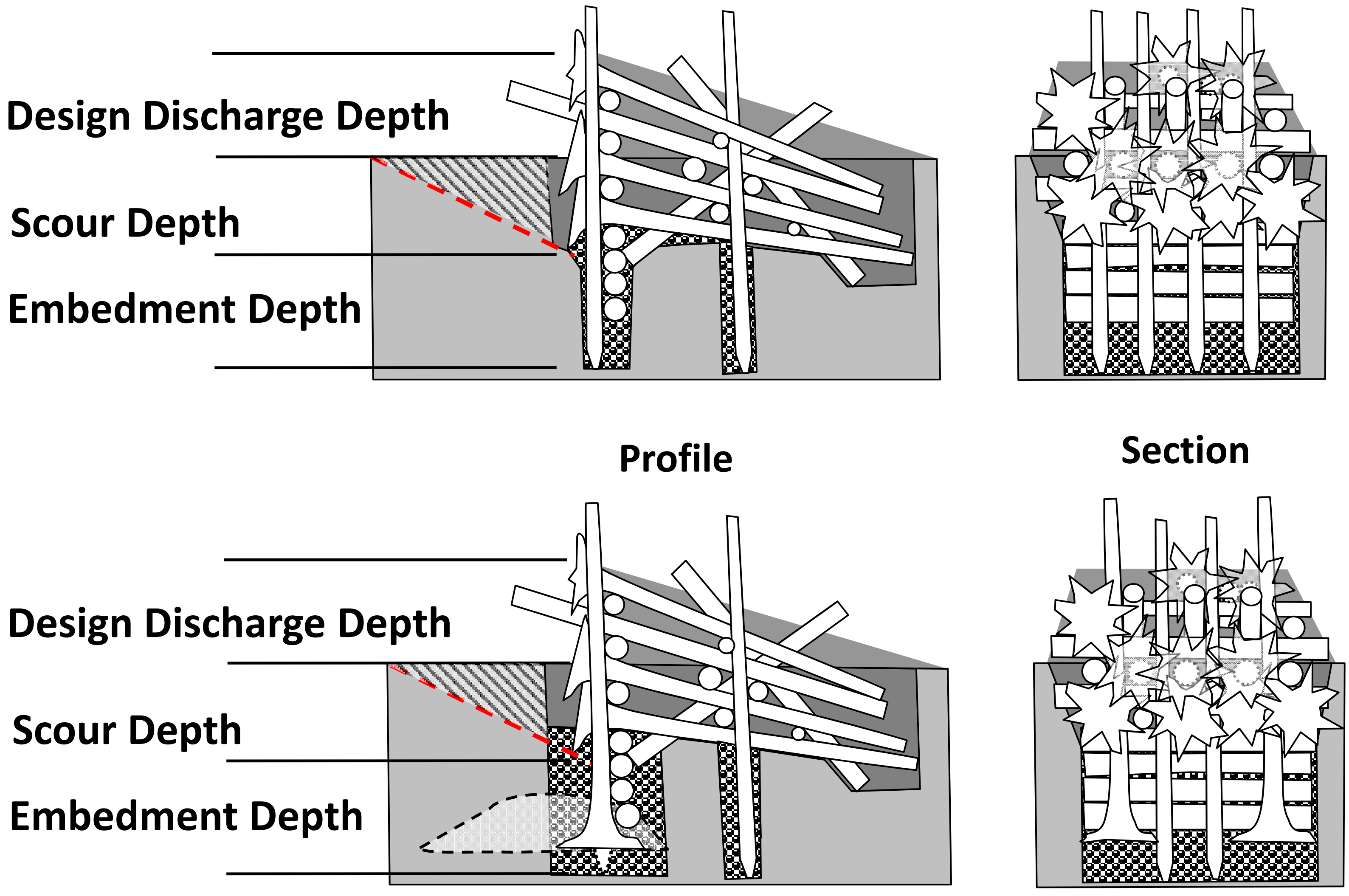
1. Exploration sufficient to establish at least the general nature, pattern and properties of the deposits, but not necessarily in detail.
2. Assessment of the most probable conditions and the most unfavourable conceivable deviations from these conditions. In this assessment geology often plays a major role.
3. Establishment of the design based on a working hypothesis of behaviour anticipated under the most probable conditions.
4. Selection of quantities to be observed as construction proceeds and calculation of their anticipated values on the basis of the working hypothesis.
5. Calculation of values of the same quantities under the most unfavourable conditions compatible with the available data concerning the subsurface conditions.
6. Selection in advance of a course of action or modification of design for every foreseeable significant deviation of the observational findings from those predicted on the basis of the working hypothesis.
7. Measurement of quantities to be observed and evaluation of actual conditions.
Modification of design to suit actual conditions.

Karl Terzaghi, quoted in Peck (1969)

Post and Pile Failure Modes

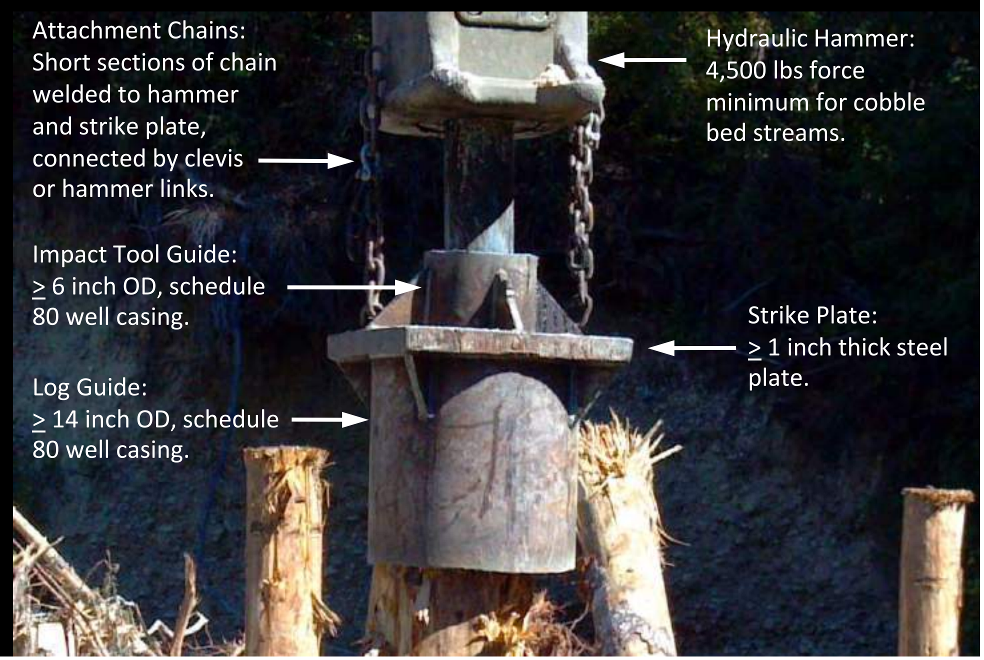


Basic ELJ Architecture



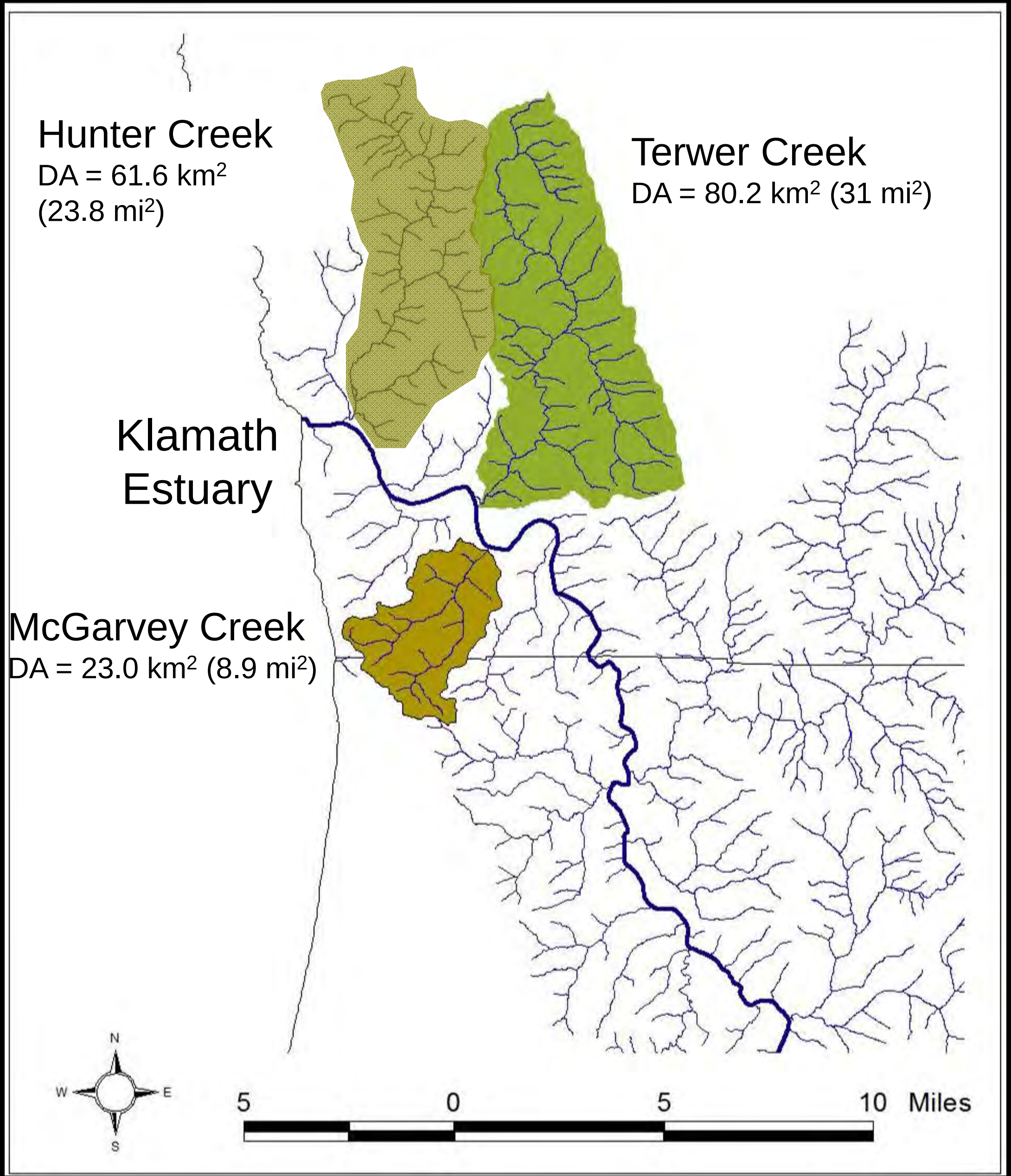
Pile Drivers

Pile Drivers

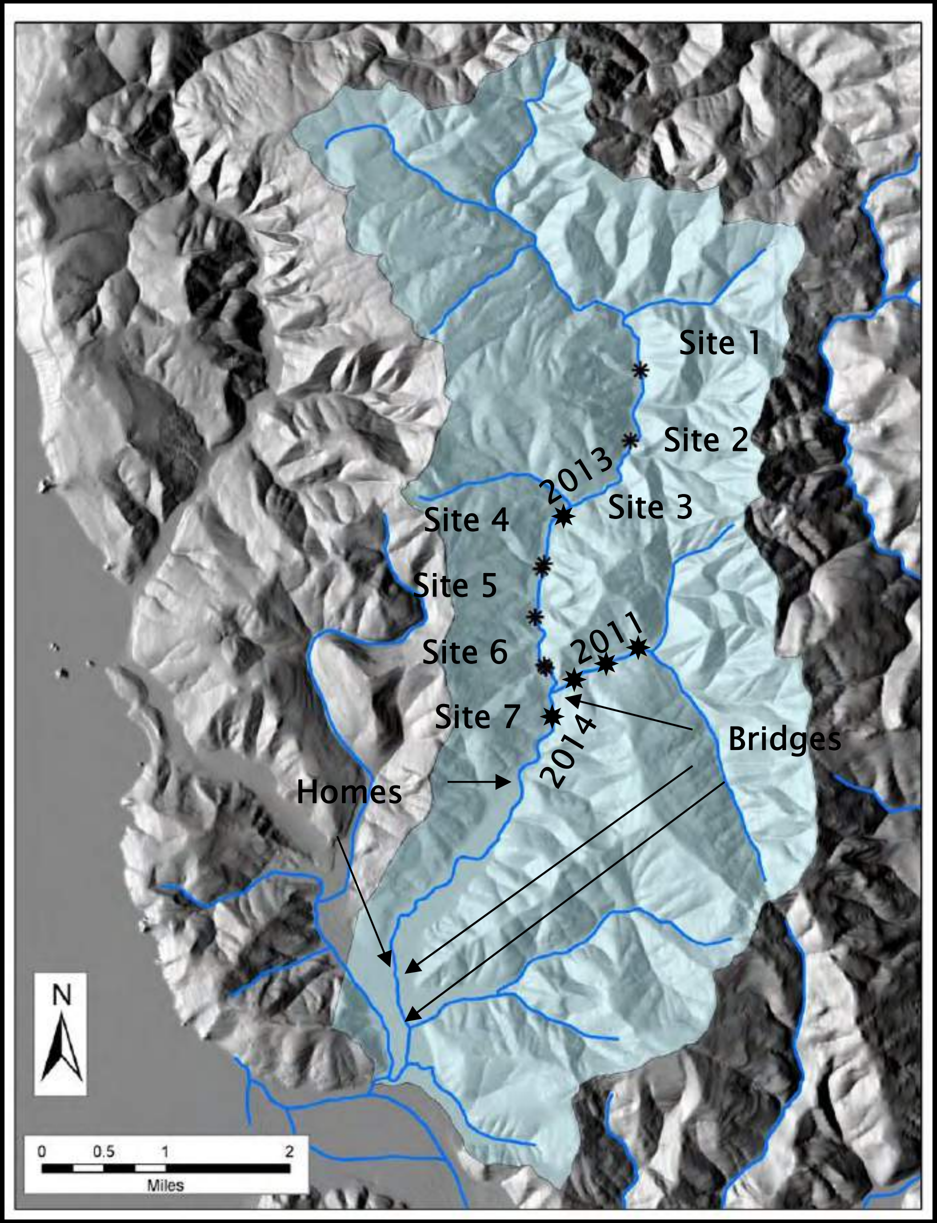


Wood Handling Techniques

Project Locations



Hunter Creek Watershed



Hunter Creek Site 6 – BAJ 1

Side channel flowing under LWD fence

Hunter Creek Site 6 – BAJ 1

Hunter Creek Site 7 - BAJ 1

Post 5-yr
RI flood
WY15

Post x-yr
RI flood
WY16
Mar
2016

Hunter Creek Site 7 - BAJ 2

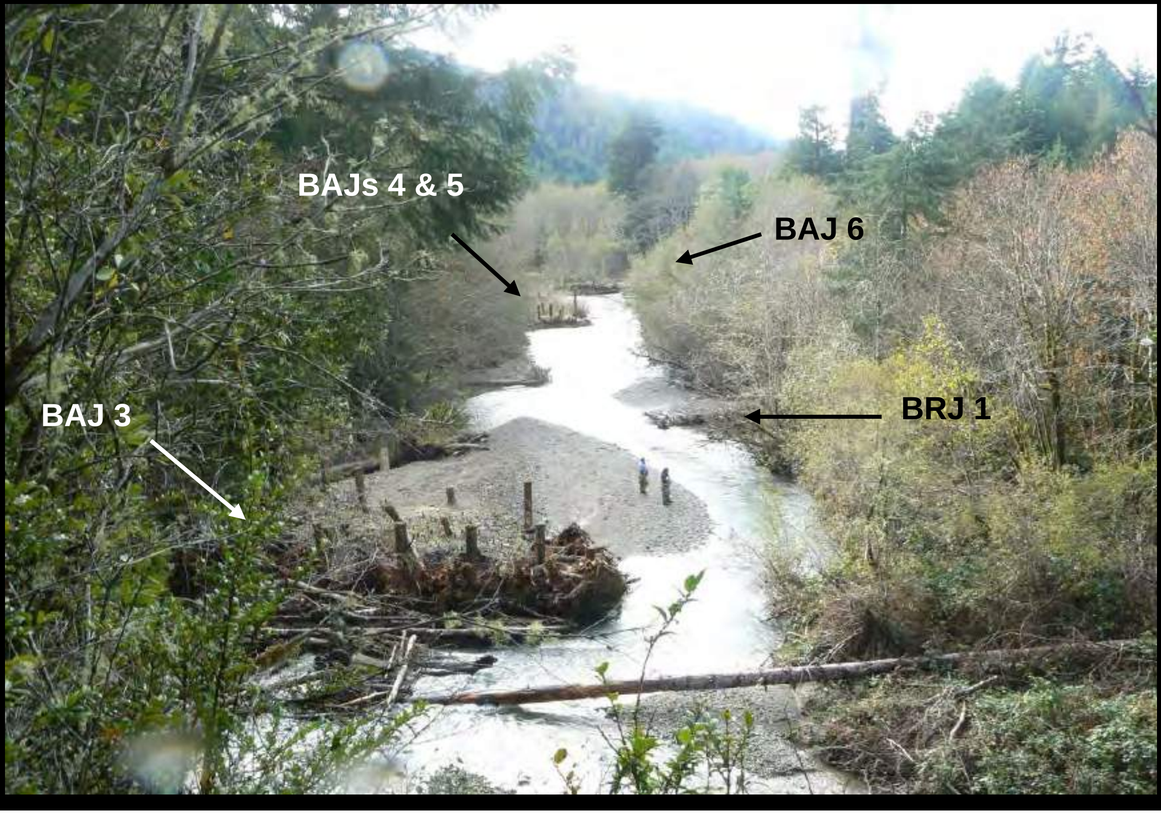
First flows WY15

Hunter Creek Site 7 - BAJ 2

Hunter Creek Site 7 – Multiple ELJs in Series

~As-Built
Sept 2014

First flows
Nov 2014



Hunter Creek Site 7 – Multiple ELJs in Series

Hunter Creek BAJ 3 - Chaos Jam

Pre-Project
2012

Construction
2014

Hunter Creek BAJ 3 - Chaos Jam

As-Built 2014

First flows 2014

Hunter Creek BAJ 3 - Chaos Jam

As-Built
First flows
Oct 2014

High flows - Dec 20, 2014

January
2016

March
2016

Redwood
Recruit

Hunter Creek Site 7
BAJ 6

Hunter Creek Site 7 - BAJ 6

Hunter Creek Site 7 – PADR 1-2


During Construction Oct 2014

PADR 1-2 - First flows Oct 2014

PADR 1-2 – January 2016

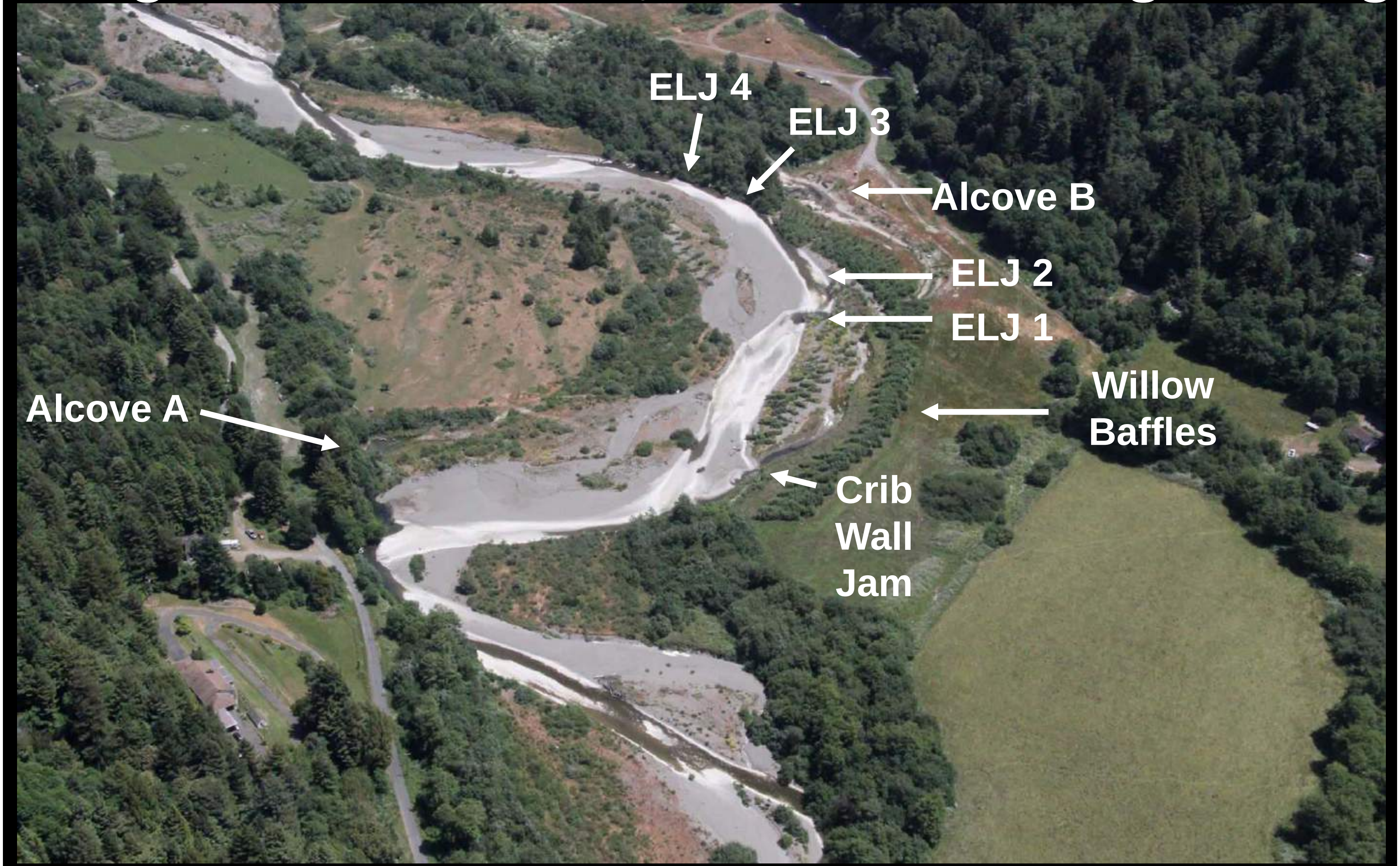
PADR 1-2 – April 2016

PADR 1-2 – April 2016

Terwer Creek

Terwer Creek

Terwer Creek
Integrated Use of ELJs, Alcoves & BioEngineering



Terwer Creek

Pre-Construction 2008

Post-Construction 2009

Terwer Creek ELJ 2

Terwer Creek ELJs 1-3

As-Built ELJ 3
Oct 2012

Dec 2012

April 2016

Terwer Creek ELJ 1

As-Built ELJ 1 2010

ELJ 1 2012


ELJ 1 – Sumer 2015
5-yrs Post-Construction

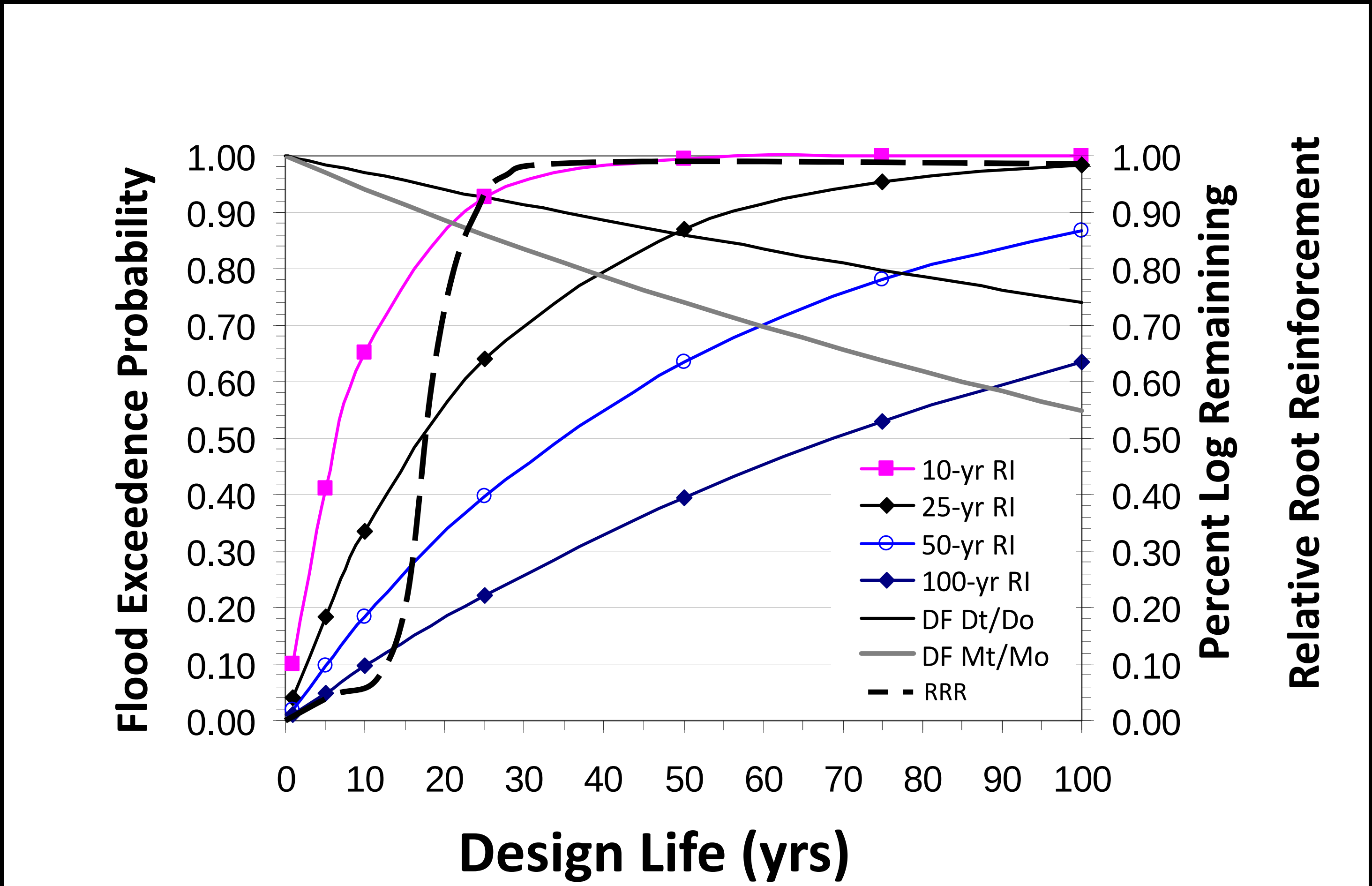

ELJ 1 – April 2016
6-yrs Post-Construction

ELJ Durability

Location	Constructed	Remaining
Hunter Cr	15	14
McGarvey Cr	2	2
Terwer Cr	7	7
Total	**24**	**23**

96% remain after multiple > 5 yr RI floods

Conceptual Model For Estimating ELJ Design Life

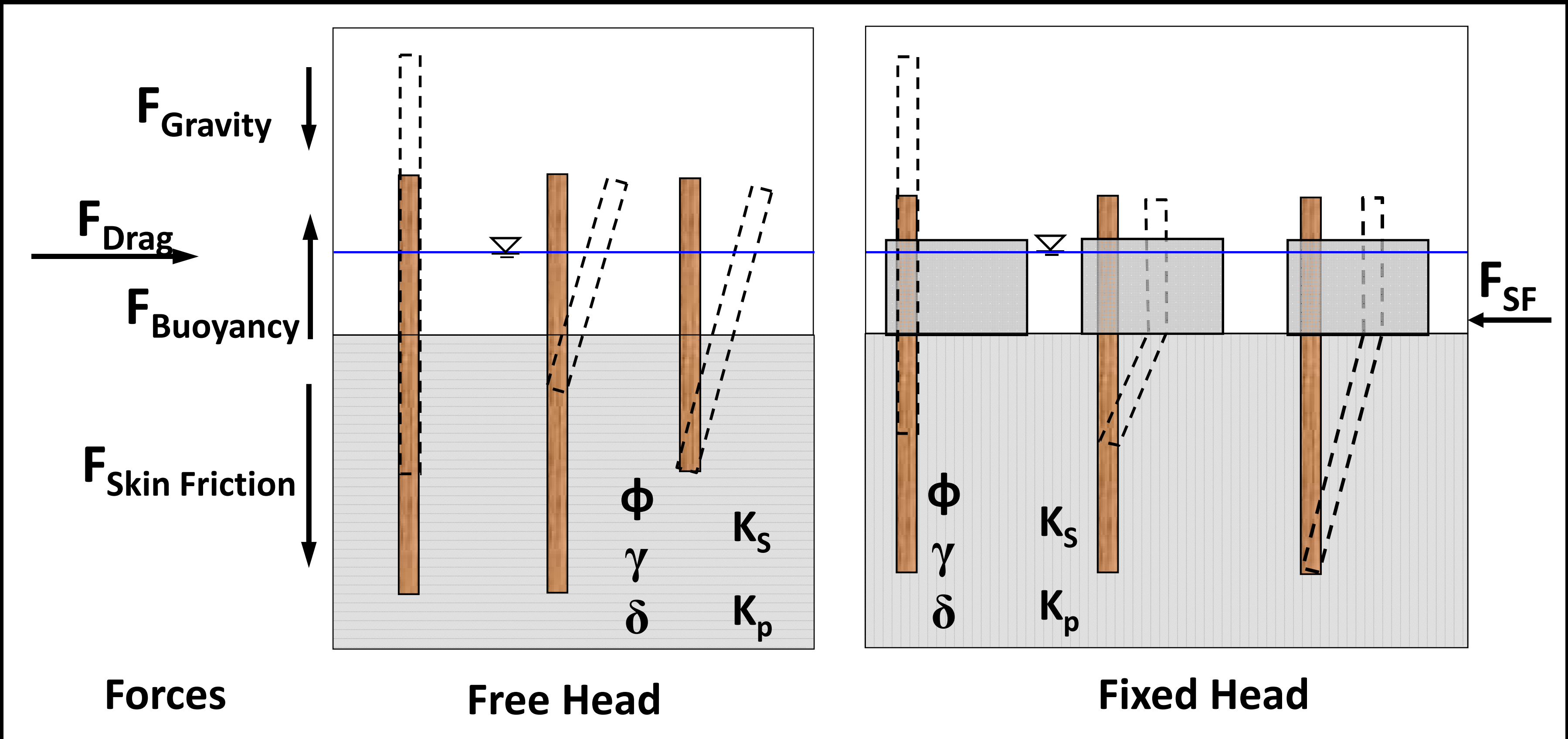


Probability of flood exceedence of various flood levels. (Arneson et al. 2012)

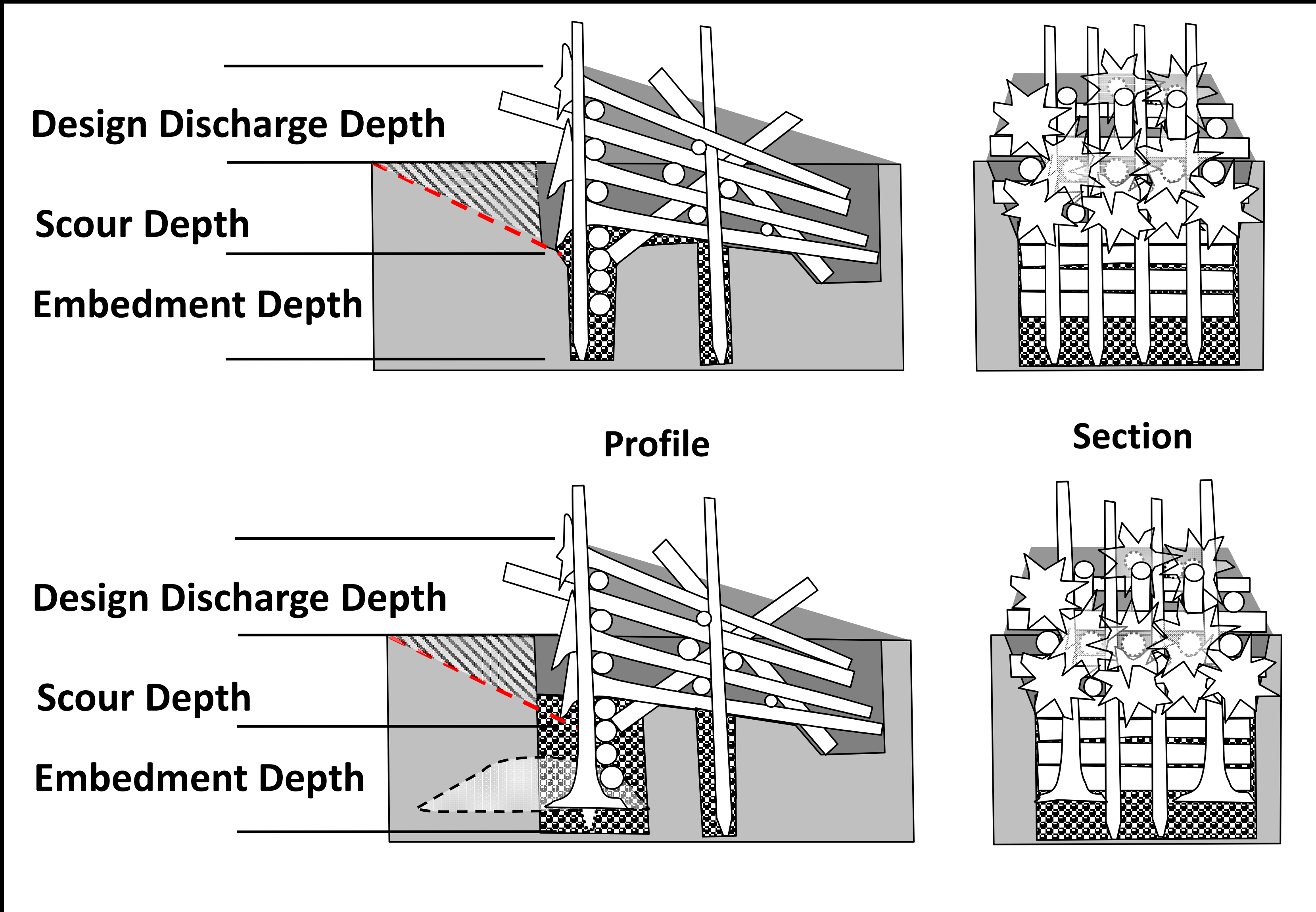
Log decay for Douglas fir (Harmon et al. 1986)

Relative Root Reinforcement (Ziemer 1981)

Post and Pile Failure Modes



Basic ELJ Architecture



Salmon Need Habitat – We Need Salmon

Contributors

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- Scott Silloway – Fisheries Biologist, Yurok Tribal Fisheries Program
- Andrew Antonetti – Fisheries Biologist, Yurok Tribal Fisheries Program
- Walter Mecklenburg – Fisheries Biologist, Yurok Tribal Fisheries Program

Funding Partners, Landowners and Cooperators

- U.S. Fish and Wildlife Service
- U.S. Bureau of Reclamation
- National Oceanic and Atmospheric Administration
- CA Dept of Fish and Wildlife
- Green Diamond Resources Company
- Yurok Tribe Watershed Restoration Dept.
- Yurok Tribe Environmental Program

Restoring Complexity:
Design of Large Wood Structures and Off-Channel Habitats Workshop
"Constructed Wood Jams on the Trinity River"

Salmon Restoration Federation (SRF)
April 7, 2015

David (DJ) Bandrowski P.E., Aaron Martin,
Andreas Krause P.E., Kyle De DeJuilio
Yurok Tribe – Fisheries Division

The Washington Post

Business

States, federal agencies will seek removal of Klamath dams

By Jonathan J. Cooper | AP April 4

SACRAMENTO, Calif. — Oregon, California, the federal government and others have agreed to go forward with a plan to remove four hydroelectric dams in the Pacific Northwest without approval from a reluctant Congress, a spokesman for dam owner PacifiCorp said Monday.

The dam removal is part of an announcement planned Wednesday in Klamath, California, by the governors of both states and U.S. Interior Secretary Sally Jewell.

Two New Klamath Basin Agreements Carve out Path for Dam Removal and Provide Key Benefits to Irrigators

4/6/2016
Last edited 4/6/2016

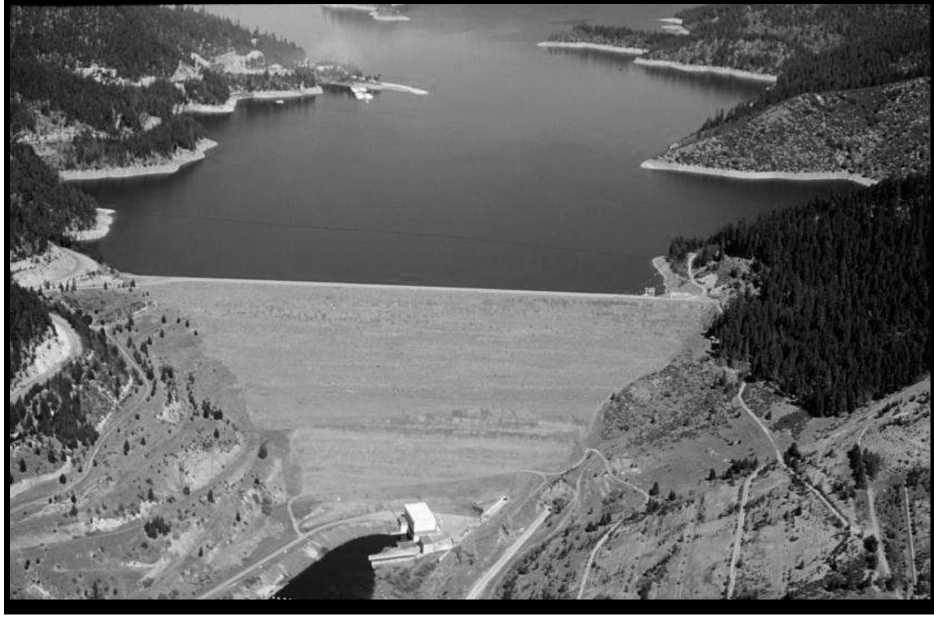
DISCUSSION TOPICS

- Trinity River Restoration Program - Historical Background
- Large Wood and General Restoration Philosophy
- Evolution in Design and Implementation Approach
- Wood Loading – How Much is Enough?
- Current Design Guidance and Design Tools
- Types of Large Wood Structures
- Construction and Contracting Recommendations
- Example/Case Study Large Wood Geomorphic Structures

Aaron Martin

- Continued Trinity Large Wood Topics, including Hydraulic and Habitat Structures

THE TRINITY'S EARLY YEAR – REFERENCE CONDITION….?



Photos Courtesy of Trinity County Historical Society

Historic conditions within the Trinity

Historic conditions within the Trinity

Figure 2. ***Trinity River circa 1910-1930 near Trinity Center near Swift Creek confluence (see Figure 1) prior to impoundment of Trinity Lake. The alluvial valley is clearly covered in a mixed stand of multi-age coniferous trees. Photo is believed to be looking upstream. Photo from Rocco Fiori courtesy of Trinity Valley Historical Society. Interpretations by Tim Abbe.***

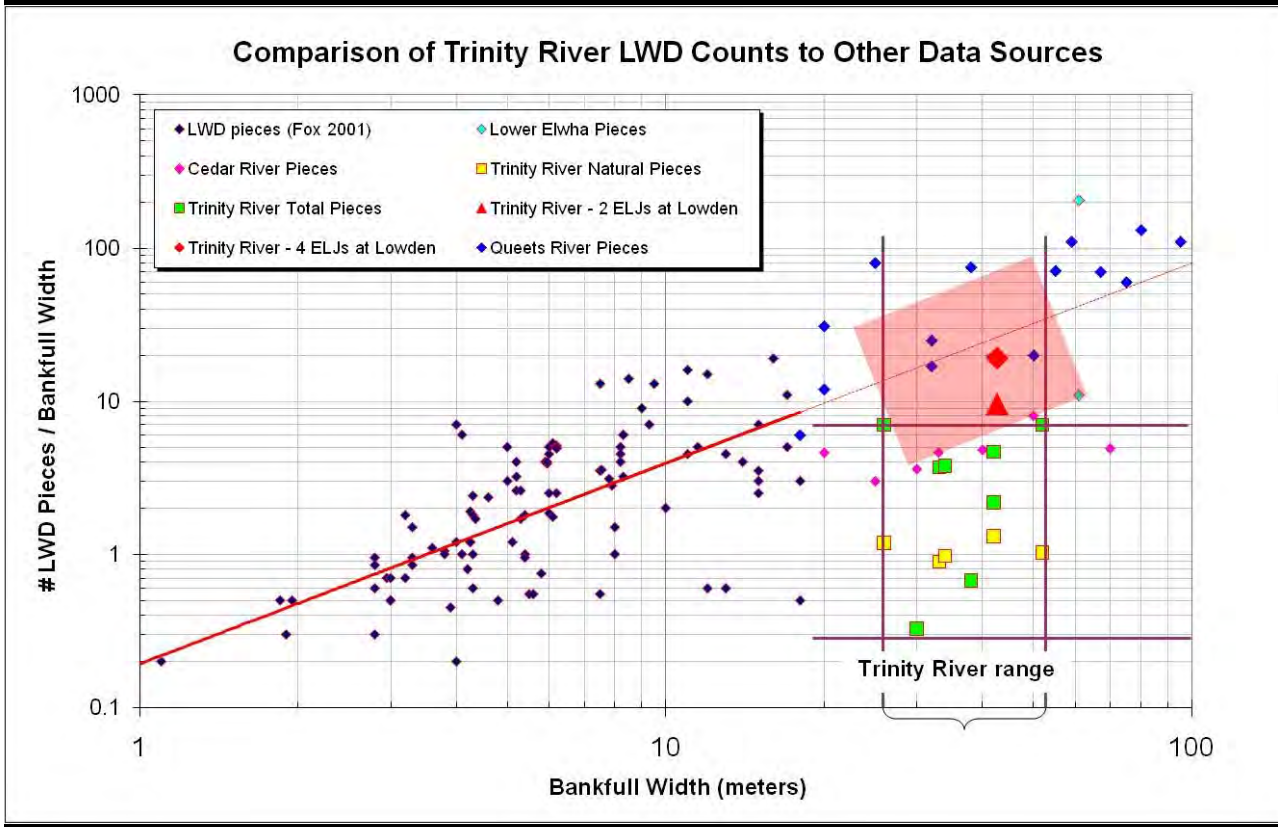
PROCESSED BASED PRINCIPLES – RESTORATION PHILOSOPHY
BALANCING STABILITY VS. DYNAMISM

EVOLUTION OF WOOD PLACEMENT (2006 – CANYON CREEK SUITE)

EVOLUTION OF WOOD PLACEMENT (2009 - SAWMILL)

2015 – Limekiln Gulch Chanel Rehab Project

How Much Wood is Enough?...



Final Report

Trinity River Large Wood Analysis and Recommendation Report

Prepared for

Trinity River Restoration Program

1313 South Main Street
Weaverville, CA 96093

January 2011

Prepared by:

Cardno ENTRIX
1048 Ski Run Blvd.
South Lake Tahoe, CA 96150

CH2MHILL
322 East Front Street, Suite 200
Boise, ID 83702

Fox, M., S. Bolton, and L. Conquest. 2003.

Site	Reach Start (RM)	Reach End (RM)	Length (miles)	Length (meters)	Total Number of LWD Pieces	Total Number of ELJ Structures
Wheel Gulch	75.9	76.4	0.5	805	443	3.6
Upper Junction	79.8	80.4	0.6	966	531	4.3
Sky Ranch[1]	80.4	80.9	0.5	805	443	3.6
Oregon Gulch	80.9	81.6	0.7	1126	620	5.1
Sheridan Creek	81.6	82.1	0.5	805	443	3.6
Deep Gulch[2]	82.1	82.9	0.8	1,287	708	5.8
Chapman Ranch[3]	82.9	83.7	0.8	1,287	708	5.8
Lorenz Gulch	89.4	90.2	0.8	1,287	708	5.8
Limekiln Gulch	99.6	100.4	0.8	1,287	708	5.8
Total for Phase II Projects				9,656	5,311	43

Historic conditions within the Trinity

Figure 3. **Trinity River in the Minersville area circa 1910-1930, an area also inundated by Lake Trinity. Flow is from right to left based on wood accumulation at head of point bar in lower left. Floodplain clearings are interpreted as homestead farms. Photo from Rocco Fiori courtesy of Trinity Valley Historical Society. Interpretations by Tim Abbe.**

As-Built Quantities of Wood on the Trinity

Project Year	Rehabilitation Site Name	Large Wood – Approximate (Pieces)
2005	Hocker Flat	0
2006	Canyon Creek Sites	100
2007	Indian Creek Sites	200
2008	Lewiston and Dark Gulch Sites	200
2009	Sawmill and Steel Bridge Day Use	260
2010	Lowden Ranch, Trinity House Gulch, and Reading Creek	300
2011	Wheel Gulch	200
2012	Upper Junction City Lower Steiner Flat	400
2013	Lorenz Gulch and Lower Douglas City	600
2014	Lower Junction City	250
Total		**2,435**

National Large Wood Manual – Design Guidance

National Large Wood Manual

Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure

January 2016

U.S. Department of the Interior
Bureau of Reclamation

US Army Corps of Engineers®
Engineer Research and Development Center

Chapter 1. Large Wood Introduction

Chapter 2. Large Wood and the Fluvial Ecosystem Restoration Process

Chapter 3. Ecological and Biological Considerations

Chapter 4. Geomorphology and Hydrology Considerations

Chapter 5. Watershed-Scale and Long-Term Considerations

Chapter 6. Engineering Considerations

Chapter 7. Risk Considerations

Chapter 8. Regulatory Compliance, Public Involvement, and Implementation

Chapter 9. Assessing Ecological Performance

Chapter 10. Large Wood Bibliography

Recent Large Wood Design Documents

RECLAMATION
Managing Water in the West

Pacific Northwest Region
Resource & Technical Services
Large Woody Material -
Risk Based Design Guidelines

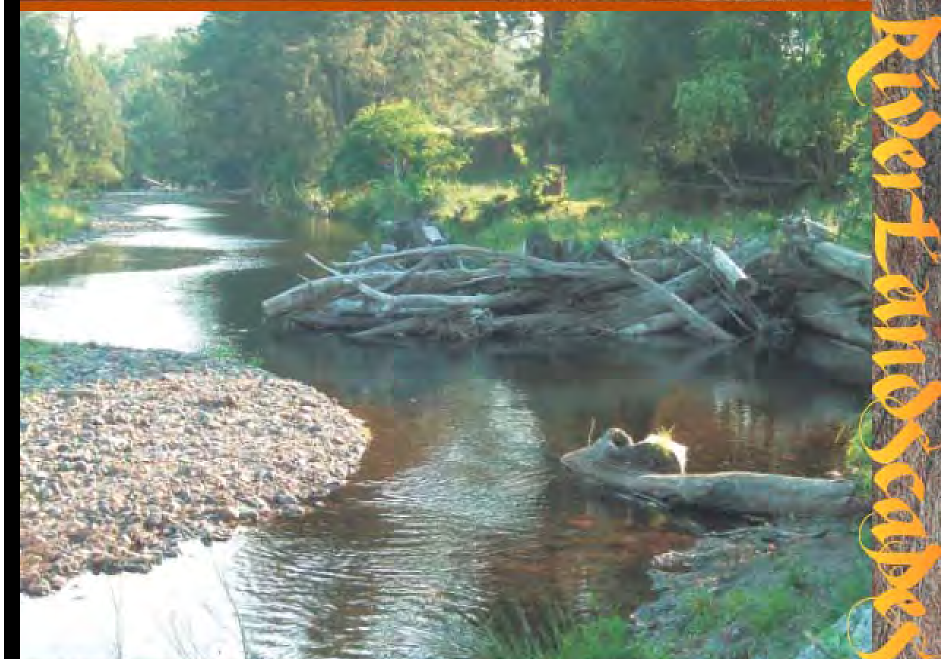
U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Boise, Idaho

September 2014

Knutson and Fealko 2014

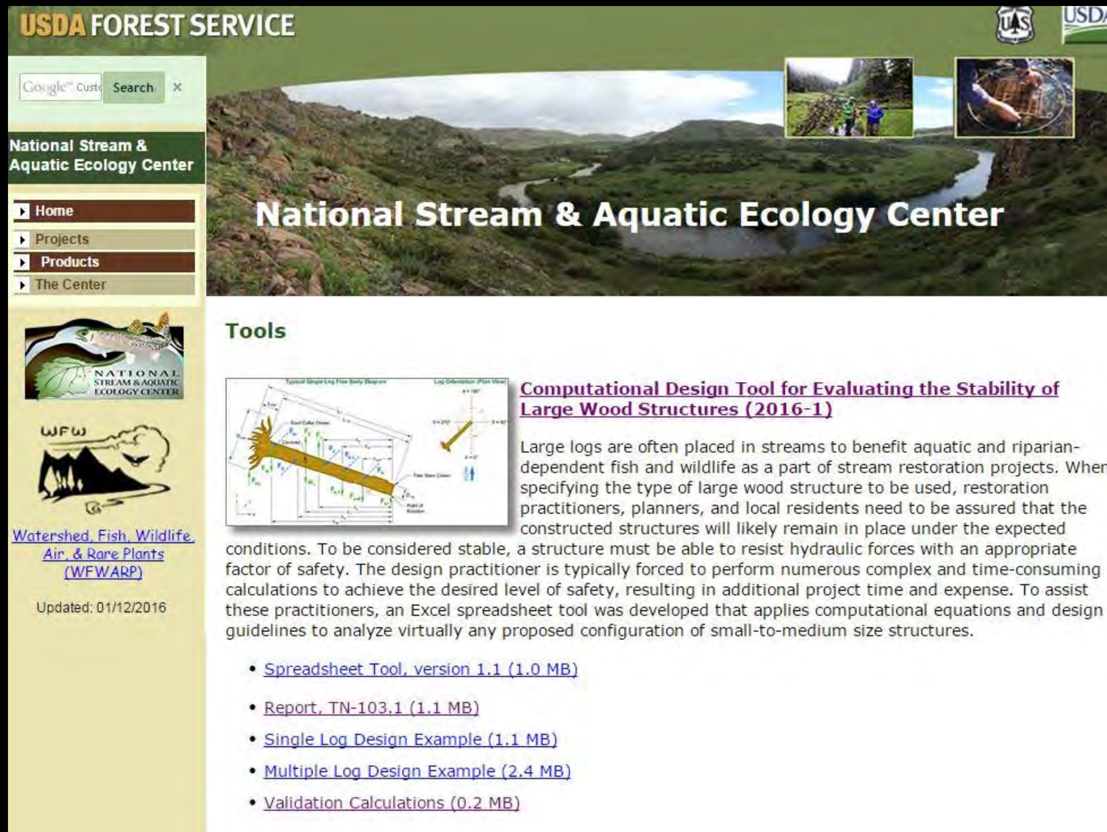
Australian Government
Land & Water Australia

Design guideline for the reintroduction of wood into Australian streams



DR ANDREW P. BROOKS

RECENT LARGE WOOD DESIGN TOOLS



Engineered Log Jam Calculations

Spreadsheet developed by Scott Wright, P.E. – revision 1.4

Methodology based on a standard force balance approach and information adapted from D'aoust & Millar (2000). The designer should attain a minimum factor of safety of 2.0 for the ELJ.

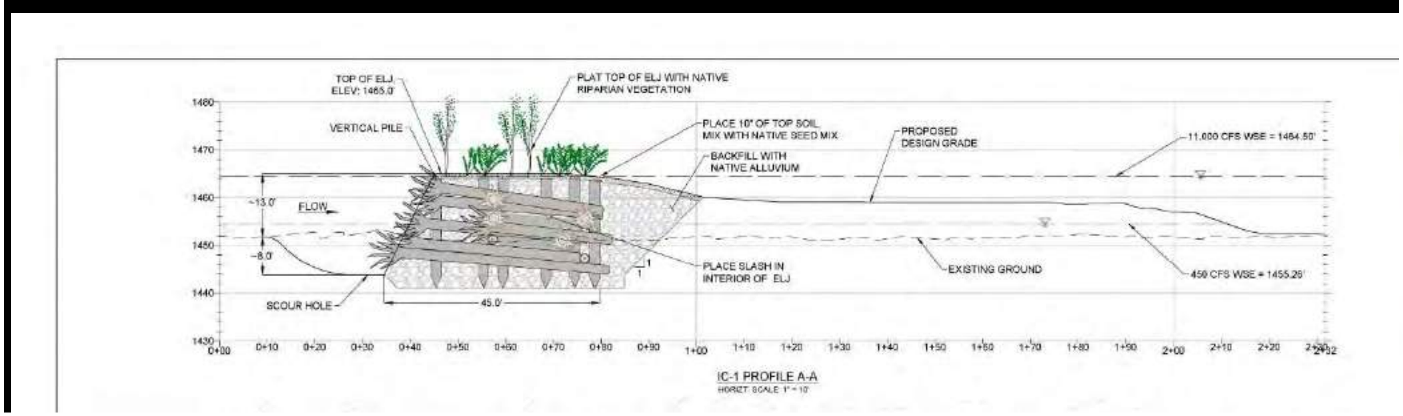
KEY "BASE" MEMBERS

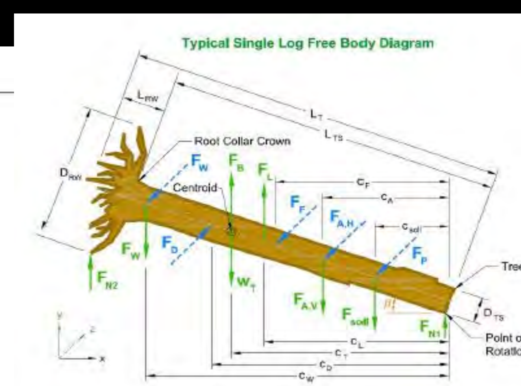
Number of Logs with Rootwads	N_L =	1				
cottonwood, black	S_L =	0.35	specific gravity			
Average Rootwad Fan Diameter	D_{RW} =	2	feet	Wood Volume =	772	cubic feet per member
Average Rootwad Length	L_{RW} =	1	feet			
Proportion of Voids in Rootwad	p =	0.2	decimal %			
Tree Stem Average Diameter	D_{TS} =	7	feet			
Tree Stem Average Length	L_{TS} =	20	feet	F_{BL} =	31,315	pounds

$$F_{BL} = \left(\frac{\pi D_{TS}^2 L_{TS}}{4} + \frac{\pi D_{RW}^2 L_{RW}}{4} \cdot (1-p) \right) \cdot \rho_w g (1 - S_L) \cdot N_L$$

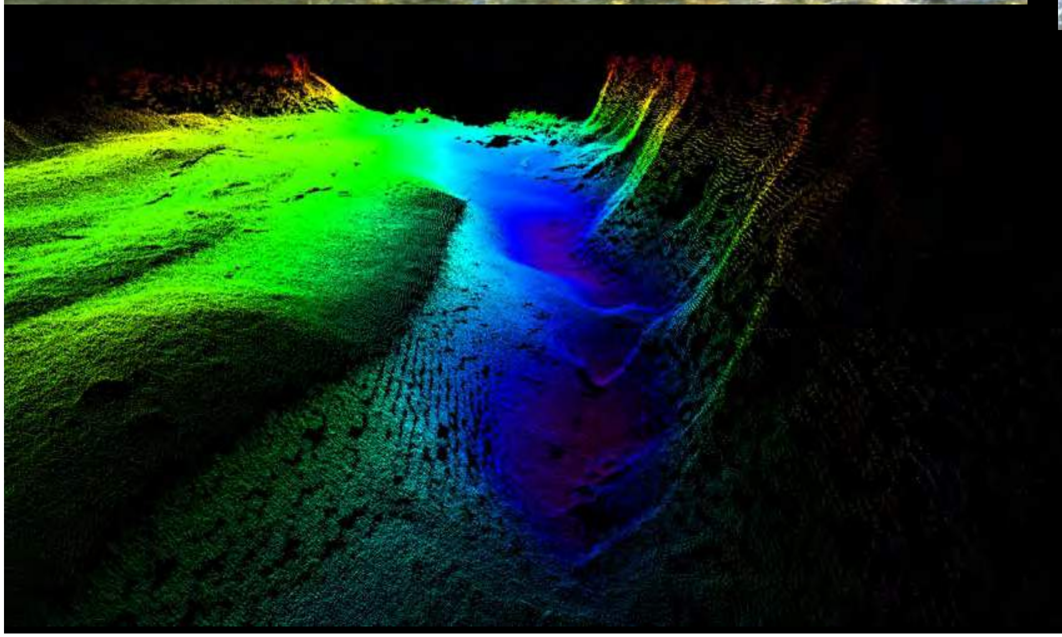
Types of Large Wood Elements

- Geomorphic structures
  - primary goal – interact with river flow and sediment
  - secondary goal – provide habitat
  - larger structures with larger scour potential
  - flow splitting, abutment, bar apex jam
- Hydraulic structures
  - similar to geomorphic structures but smaller with less scour potential
  - purpose to guide flow or create hydraulic complexity (side channels)
- Habitat structures
  - simple, smaller structures suited to typical design details
  - not intended to provide structural stability
  - primary goal – habitat, cover, floodplain roughness

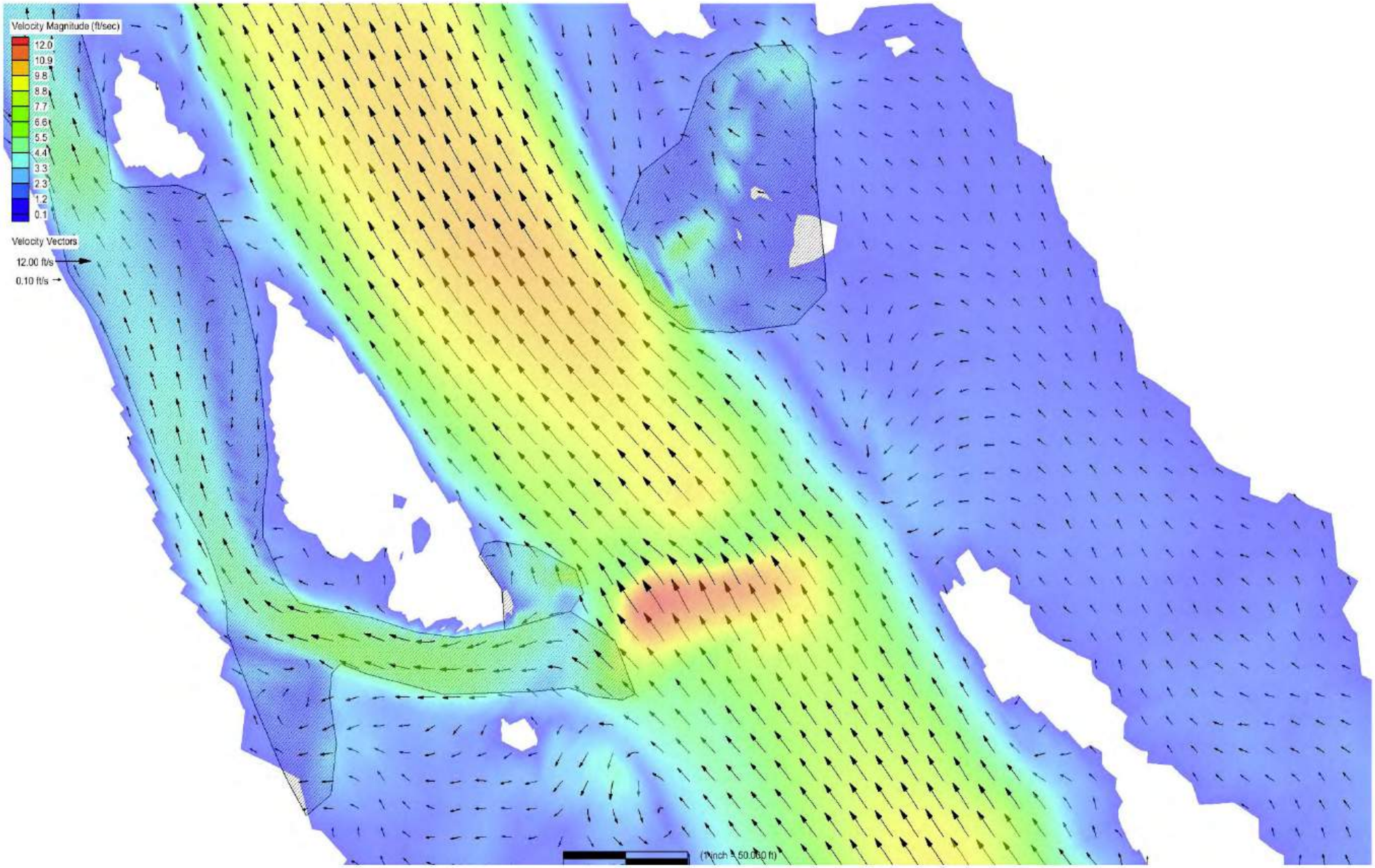




TERRAIN MODEL DATA COLLECTION – BATHYMETRY AND LIDAR



2D Hydraulic Output – 9000 cfs – Velocity Vectors at Large Wood Jams at Deep Gulch



RECLAMATION

Managing Water in the West

Technical Report No. SRH-2013-09

Coupled 2D Morpho-Dynamic and Bank Erosion Modeling at the Upper Junction City Channel Rehabilitation Project Site, Trinity River, CA

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

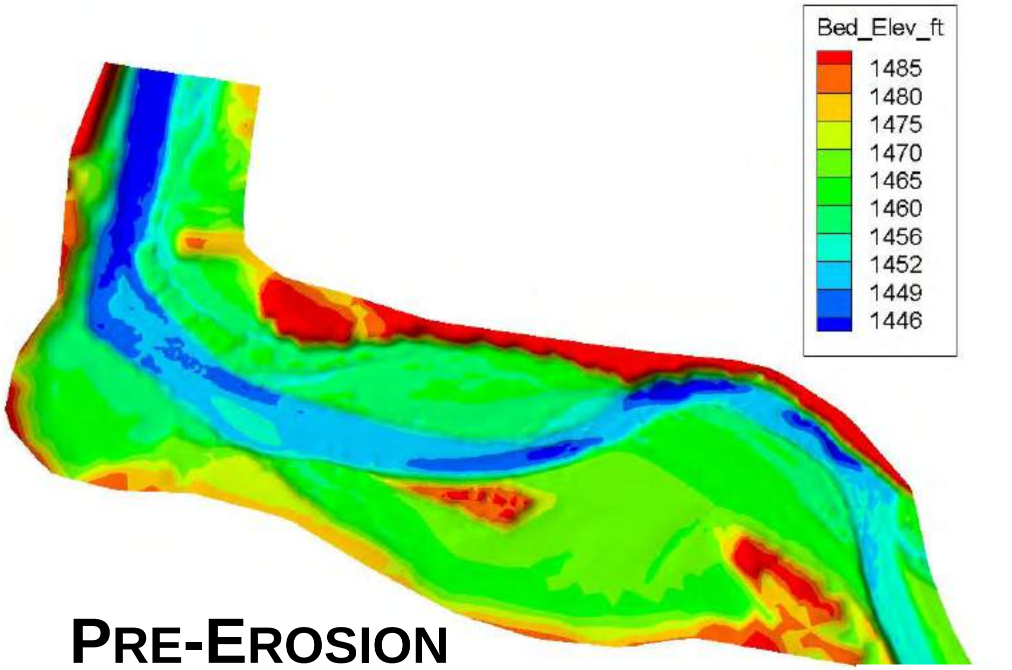
March 2013

Upper Junction City Morphodynamic Modeling

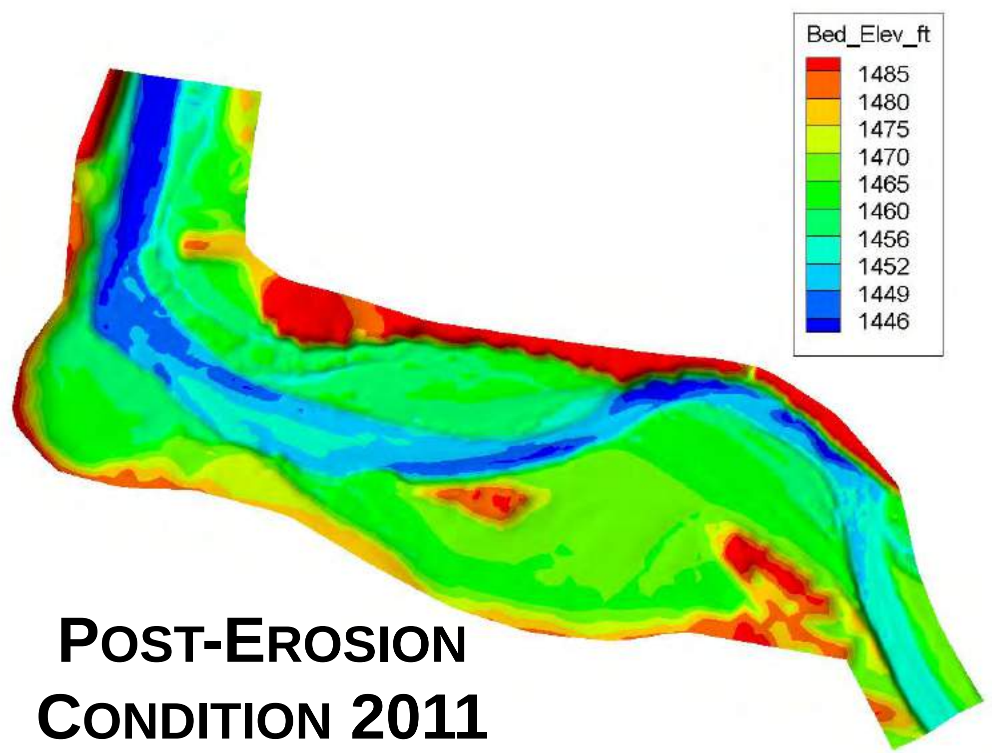
Sediment Transport and Erosion/Deposition Evolution Modeling

Developed by Bureau of Reclamation – Technical Service Center (TSC) Yong Lai

Comparing Two Know Topographic DTM Datasets and Known Hydrograph from Gage Records

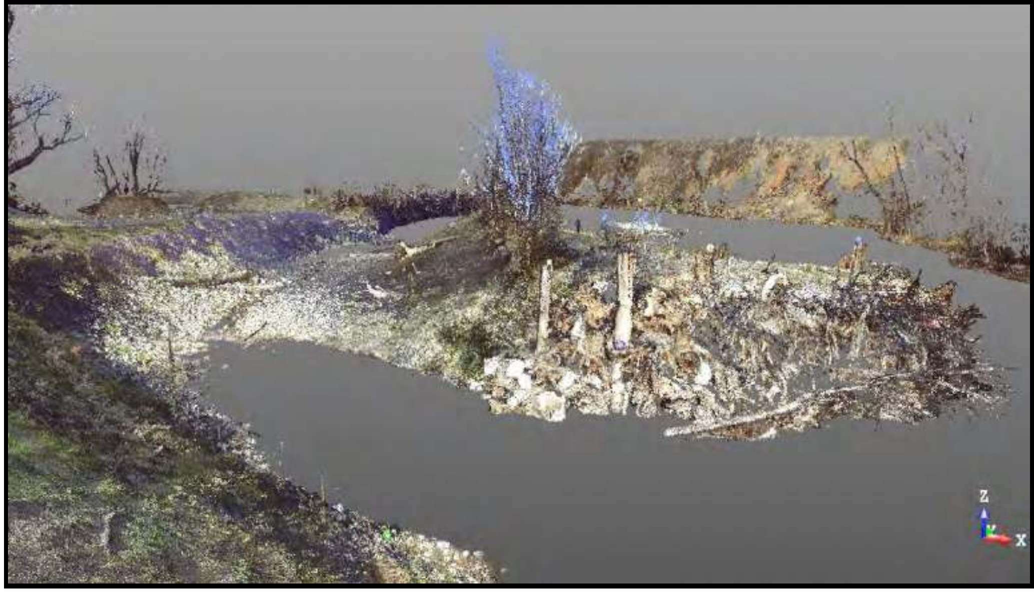


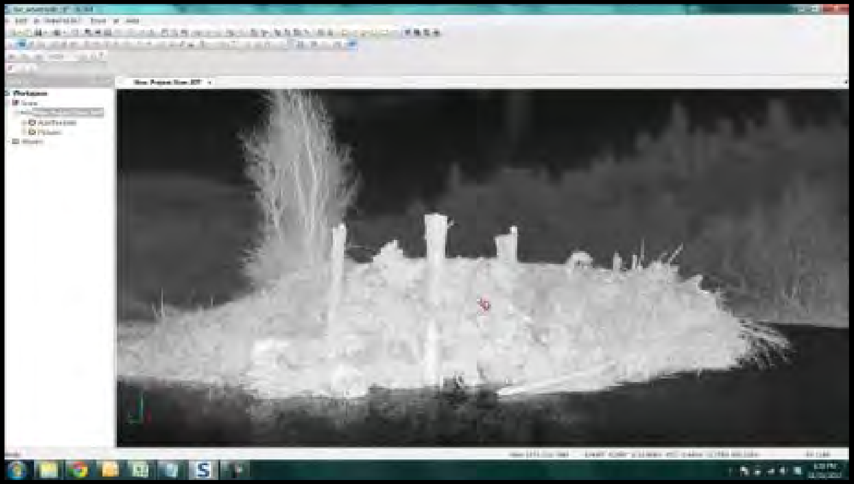
Pre-Erosion Condition 2009



Post-Erosion Condition 2011

POST CONSTRUCTION – 3D LASER SCANNING OF WOOD





CONSTRUCTION AND IMPLEMENTATION ON THE TRINITY

PILE DRIVING EQUIPMENT

CONTRACTING AND BID SCHEUDLE

Bid Schedule

Table A-1 below contains an example bid schedule for a hybrid contract.

Table A-1. Sample Bid Schedule for Fixed Price Contract with Time-and-Materials Items[1]

Item No.	Supplies/Services	Est. Qty	Unit	Unit Price	Amount
CLIN 001	Task A1 – Reporting, Signage & Mobilization & Demobilization	1	Lump Sum	$_____	$_____
CLIN 002	Tasks A2 through A4	1	Lump Sum	$_____	$_____
CLIN 003	Task B – Project Layout & Site Surveys	1	Lump Sum	$_____	$_____
CLIN 004	Task C – Site Preparation	1	Lump Sump	$_____	$_____
CLIN 005	Task D – In-Channel (IC) Features Excavation Cut estimate: 12,200 cubic yards (cy) Boulder Estimate: 180 cy; Clean Gravel and Cobble estimate: 1,550 cy; Pit Run estimate: 3,030 cy	1	Lump Sum	$_____	$_____
CLIN 006	Task E – Riverine (R) Features Excavation Cut estimate: 40,765 cy Infiltration Gravel Fill: 900 cy	1	Lump Sum	$_____	$_____
CLIN 007	Task F – Upland (U) Features Fill & Spoil placement estimate: 47,300 cy	1	Lump Sum	$_____	$_____
CLIN 008	Task G – Final Site Preparation	1	Lump Sum	$_____	$_____
CLIN 009	Task H – Rock Material Supply Pit Run estimate: 3,030 cy; Clean Gravel and Cobble estimate: 1,550 cy; Infiltration Rock estimate: 900 cy; Boulder estimate: 180 cy	1	Lump Sum	$_____	$_____
CLIN 010	Task I – Stockpiled Material Installation Hours assume crew	300	Hours	$_____	$_____
CLIN 011	Task J – Contour Grading	60	Hours	$_____	$_____
CLIN 012	Task K – Haul Large Wood	1	Lump Sum	$_____	$_____
CLIN 013	Task L – Turbidity Control	1	Lump Sum	$_____	$_____
CLIN 014	Task M – Plant Materials Supply	1	Lump Sum	$_____	$_____
CLIN 015	Task N – Riparian Planting	1	Lump Sum	$_____	$_____
CLIN 015	Task O (Optional) – Additional Rehabilitation Services	1	Lump Sum	$_____	$_____

[1] Shaded rows are for time-and-materials items. Specific contract language for Task I is provided below.

Scope of Work

Below is an excerpt from the scope of work for an actual LW placement contract for the Trinity River Restoration Program (TRRP). Content below corresponds to items I, J and K of the example bid schedule depicted in Table A-1 above. Note that Tasks I and J are time-and-materials types, while K is a fixed-price task.

Stockpiled Materials Installation – Task I

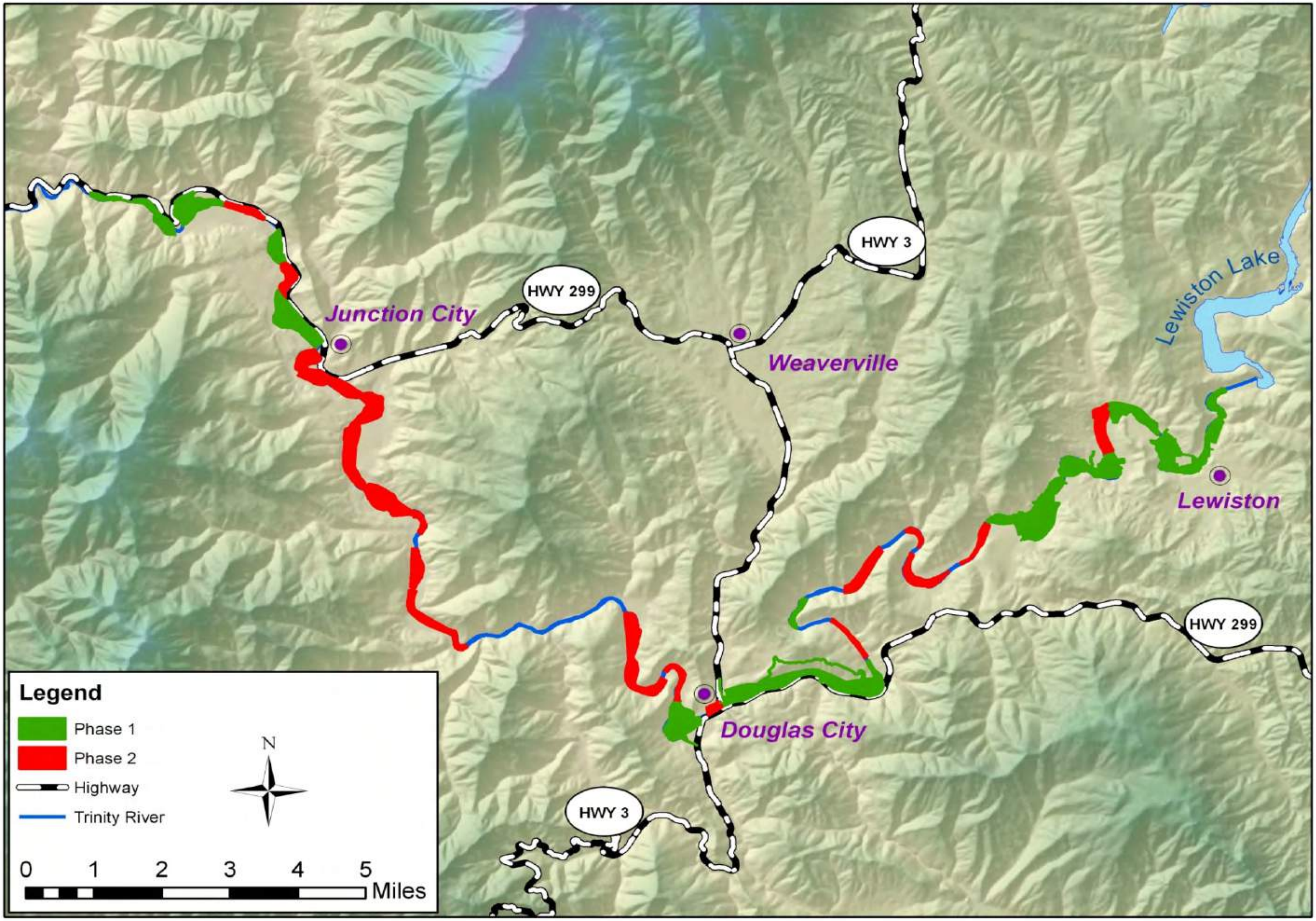
Contractor shall notify the Onsite Government Representative (OGR) at least 2 weeks before installing stockpiled materials. Stockpiled materials including Large Wood (LW), slash, boulders, willow clumps, topsoil, and other materials shall be placed by Contractor at locations marked by the OGR with assistance from TRRP staff, or at locations otherwise indicated in the Performance Work Statement (PWS). An accounting of stockpiled material installation per feature is included in Table A-2, Table A-3, and Table A-4. Locations can be referenced per Technical Exhibit *X* (plan view). Measurement and payment will be based on percentage completion as determined by measurement of hours.

Stockpiled materials shall be utilized to create habitat areas for the fishery, geomorphic, or riparian revegetation purposes. Typical equipment and crew composition utilized on past projects has included a Class 300 excavator with operator, a front end loader with operator, and an off-road dump truck with operator/laborer. The above typical crew/equipment is the basis for estimation in determining hourly units for this task, and each hour includes three pieces of equipment operating for each individual hourly unit. Contractor must have available all applicable support equipment available during the implementation of Task I. Examples of support equipment and hand tools are: chainsaw, choker cable, chaps, gas/oil, etc.

Table A-2. Wood Material Accounting per Feature

Location	12"–24" dbh tree stems w/ rootwad (each)	12"–24" diameter tree stem (log only) (each)	Tree Tops with Limbs (12" diameter and smaller) (each)	Wood Slash (stems, branches, brush < 4" diameter) (cubic yards)	Estimated Installation time (3-piece crew) (hours)
IC-2	25	25	25	125	40
IC-4 @ head	20	20	20	100	40
IC-3 upper	4	6	6	25	8
IC-3 middle	5	8	8	32	8
IC-3 middle	4	6	6	25	8
IC-3 end	8	10	10	45	8
R-1 entrance	8	12	12	50	8
R-1 upper	8	10	8	45	8
R-1 mid	5	6	6	28	8
R-1 outlet	8	12	12	50	8
R-2 (multiple locations loose placements)	40	60	60	250	40
W-1 Pond (multiple loose placements)	20	20	20	100	40

42 Mile Reach-Scale Approach - Projects Begin in 2005



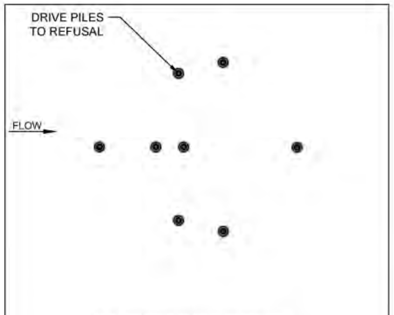
UPPER JUNCTION CITY PROJECT REACH – 1944, 1960, 2011, 2012
LOW FLOW CONDITIONS

UPPER JUNCTION CITY PROJECT REACH
DIGITAL TERRAIN MODELING (DTM) – ALTERNATIVE ANALYSIS

UPPER JUNCTION CITY PROJECT – POST CONSTRUCTION (~4500CFS)

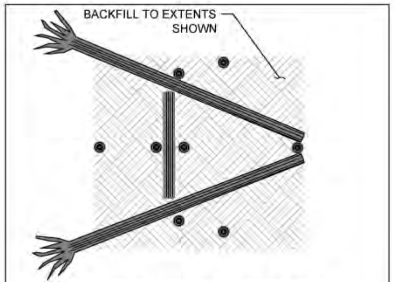
MODELING FOR DESIGN PERFORMANCE – UPPER JC 2012

LARGE WOOD DESIGN DRAWINGS



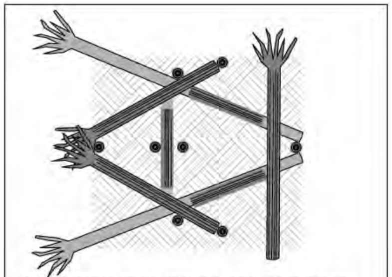
CUT AND DRIVE PILES (8) TO REFUSAL.

LAYER 1



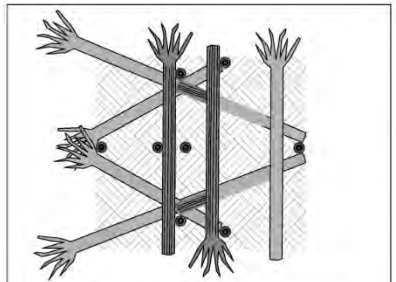
ADD TWO HORIZONTAL LOGS PARALLEL TO FLOW ANGLED TOWARDS THE CENTER OF THE ELJ AND ONE FILLER LOG PERPENDICULAR TO FLOW AS SHOWN. PLACE SLASH AND NATIVE ALLUVIUM AROUND LOGS TO TOP OF LAYER.

LAYER 2



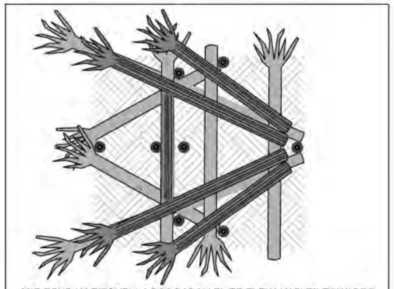
ADD ONE HORIZONTAL LOG PERPENDICULAR TO FLOW. ADD TWO HORIZONTAL LOGS PARALLEL TO FLOW ANGLED DOWNSTREAM AWAY FROM CENTER OF ELJ AS SHOWN. ADD 3 SHORT FILLER LOGS AS SHOWN. PLACE SLASH AND NATIVE ALLUVIUM AROUND LOGS TO TOP OF LAYER.

LAYER 3



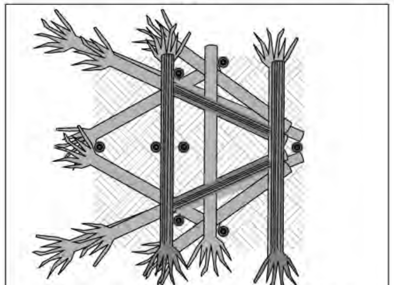
ADD TWO LOGS PERPENDICULAR TO FLOW. ADD 2 SHORT FILLER LOGS AS SHOWN. PLACE SLASH AND NATIVE ALLUVIUM AROUND LOGS TO TOP OF LAYER.

LAYER 4



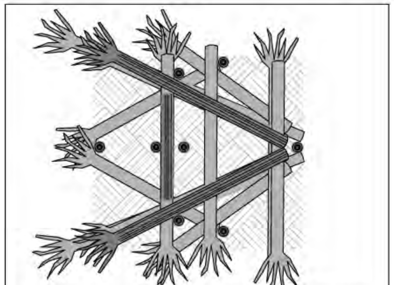
ADD FOUR HORIZONTAL LOGS PARALLEL TO FLOW ANGLED TOWARDS THE CENTER OF THE ELJ AS SHOWN. ADD ONE FILLER LOG PERPENDICULAR TO FLOW AS SHOWN. PLACE SLASH AND NATIVE ALLUVIUM AROUND LOGS TO TOP OF LAYER.

LAYER 5



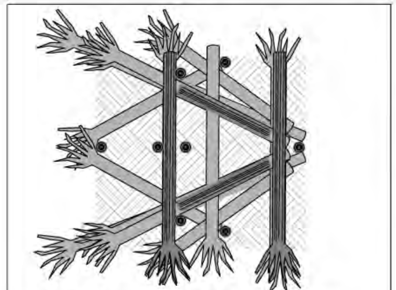
ADD TWO HORIZONTAL LOGS PERPENDICULAR TO FLOW. ADD 2 SHORT FILLER LOGS AS SHOWN. PLACE SLASH AND NATIVE ALLUVIUM AROUND LOGS TO TOP OF LAYER.

LAYER 6



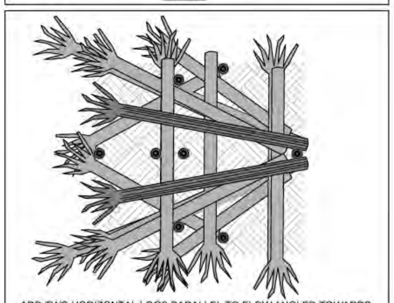
ADD TWO HORIZONTAL LOGS PARALLEL TO FLOW ANGLED TOWARDS THE CENTER OF THE ELJ AS SHOWN. ADD 1 SHORT FILLER LOG AS SHOWN. PLACE SLASH AND NATIVE ALLUVIUM AROUND LOGS TO TOP OF LAYER.

LAYER 7



ADD ONE HORIZONTAL LOG PERPENDICULAR TO FLOW. PLACE SLASH AND NATIVE ALLUVIUM AROUND LOGS TO TOP OF LAYER.

LAYER 8



ADD TWO HORIZONTAL LOGS PARALLEL TO FLOW ANGLED TOWARDS THE CENTER OF THE ELJ AS SHOWN. PLACE SLASH AND NATIVE ALLUVIUM AROUND LOGS TO TOP OF PROPOSED FINISH GRADE, ELEV. 1465.0'

LAYER 9

LOG SCHEDULE (ELJ)

LAYER	TYPE	DIAMETER	LENGTH	ROOTWAD	NUMBER
LAYER 1	VERTICAL POST	24"	32'	NO	8
LAYER 2	HORIZT. LOG	24"	50'	YES	2
	FILLER LOG	24"	~20'	YES	1
LAYER 3	HORIZT. LOG	24"	40'	YES	1
	HORIZT. LOG	24"	32'	YES	2
	FILLER LOG	24"	~15'	NO	3
LAYER 4	HORIZT. LOG	24"	40'	YES	2
	FILLER LOG	24"	~5'	NO	2
LAYER 5	HORIZT. LOG	24"	32'	YES	2
	HORIZT. LOG	24"	40'	YES	2
	FILLER LOG	24"	~20'	NO	1
LAYER 6	HORIZT. LOG	24"	40'	YES	2
	FILLER LOG	24"	~20'	NO	2
LAYER 7	HORIZT. LOG	24"	32'	YES	2
	FILLER LOG	24"	~20'	NO	1
LAYER 8	HORIZT. LOG	24"	40'	YES	2
	FILLER LOG	24"	~20'	NO	1
LAYER 9	HORIZT. LOG	24'	40'	YES	1
				TOTAL	37

NOTES:

1. SEE SHEETS 04, 05, 06 FOR PLAN AND PROFILE INFORMATION.
2. THE FIRST HORIZONTAL LOG LAYER (LAYER 2) SHALL BE PLACED 8.0' BELOW EXISTING BED SURFACE.
3. BACKFILL CONSISTING OF NATIVE ALLUVIUM AND SLASH SHALL BE PLACED AT LAYERS 2-9 TO EXTENTS SHOWN BY GRAY HATCHING.
4. TOPOGRAPHIC INFORMATION WAS GENERATED FROM A DIGITAL TERRAIN MODEL (DTM) DEVELOPED BY TRRP.
5. PILES REFER TO VERTICAL STRUCTURAL MEMBERS.

Cardno ENTRIX
295 HWY 50, SUITE 1
STATELINE, NV 89449
TEL (775) 588-9069
WWW.CARDNOENTRIX.COM

Trinity River Restoration Program
Restore • Adapt • Improve

REGISTERED PROFESSIONAL ENGINEER
R. CHARLES MILLER
C 72591
EXP.
CIVIL
STATE OF CALIFORNIA

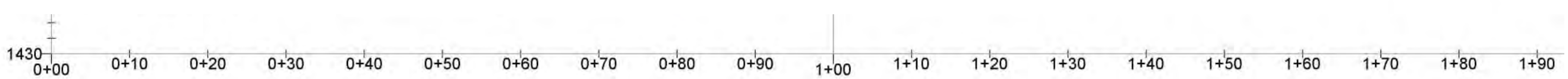
UPPER JUNCTION CITY IC-1
SEQUENCING

TRINITY RIVER RESTORATION PROGRAM

TRINITY COUNTY, CALIFORNIA

DATE	06/26/12
DESIGNED BY	CM/ZL
DRAWN BY	ZL
CHECKED BY	CM
ENTRIX JOB NO.	30088130
PLAN NO.	09

SHEET 09 of 24

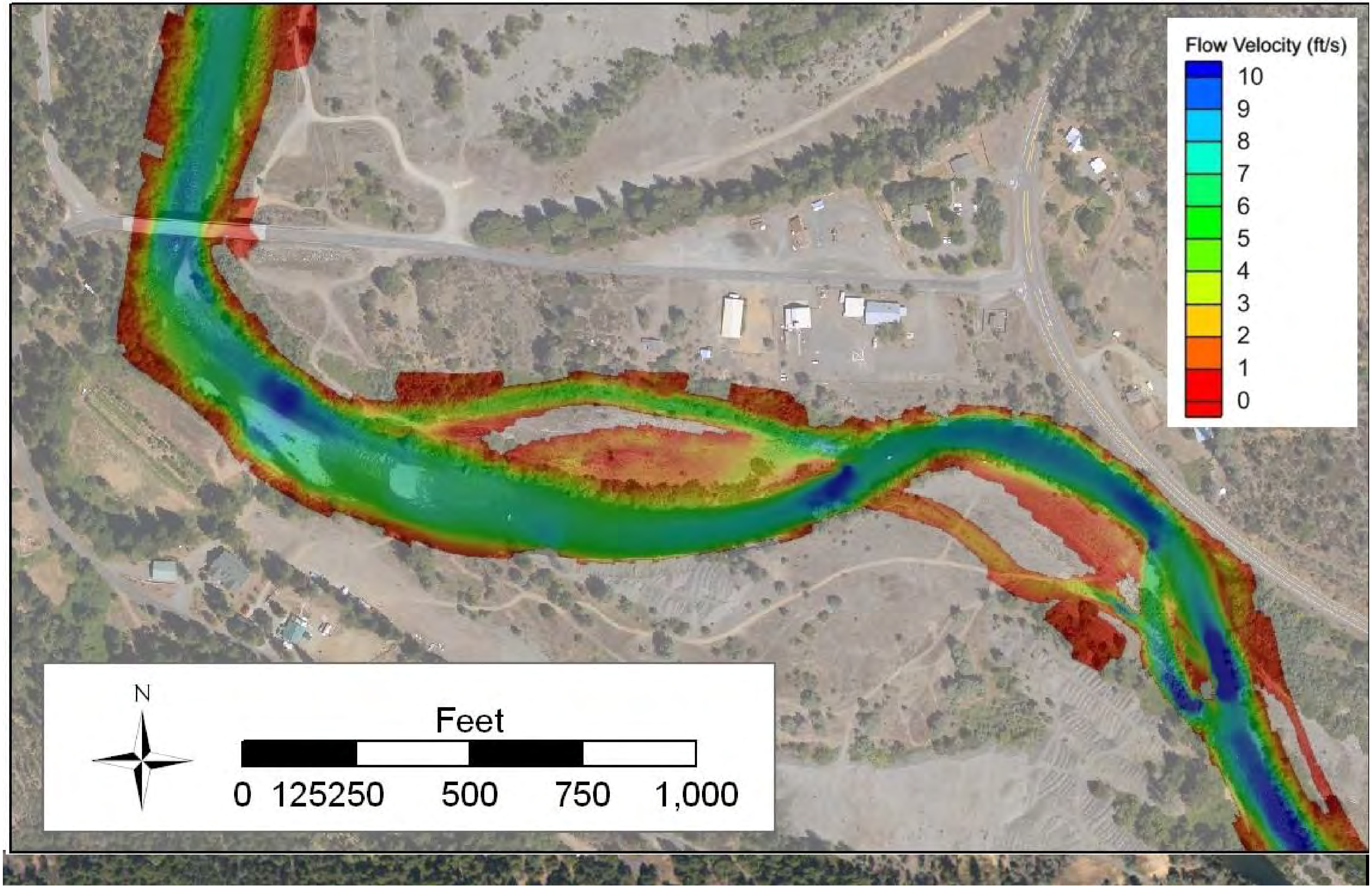


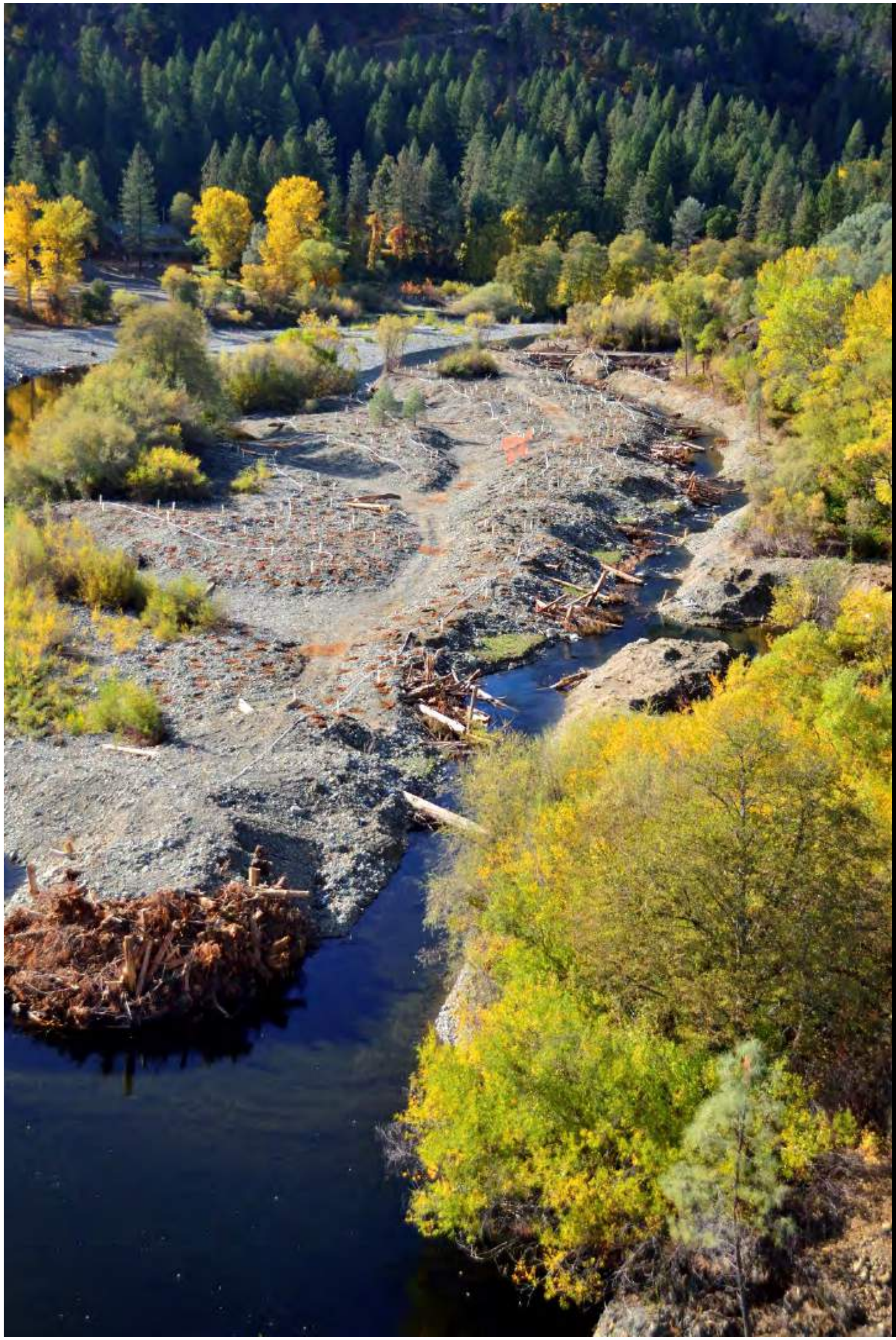
UPPER JUNCTION CITY – DESIGN OBJECTIVES

<u>Design Performance Goals (from the Upper Junction City Design Report):</u>

1. Double shoreline rearing habitat with cover through the length of the flow split.
2. Create 350m2 of new low velocity eddy habitat at 450 ft3/s.
3. Create 6000m^2 of new side-channel & connected pond rearing habitat at flows of ~2500 ft3/s.
3. Limit flow velocities at 7500 ft3/s to less than 1 ft/s over at least 4600 m2 of floodplain
4. Retain 95% of bankfull flow in mainstem through the upstream third of the site at 7500 ft3/s.
5. Limit conveyance of the R-5/R-6 side channel to 6% of the total flow at 7500 ft3/s.
6. Reduce floodplain conveyance adjacent to the R-4 flow split to near zero at 7500 ft3/s

2D HYDRAULIC MODELING – DESIGN CONDITIONS
FLOWS = 450, 2700, 7500 CFS

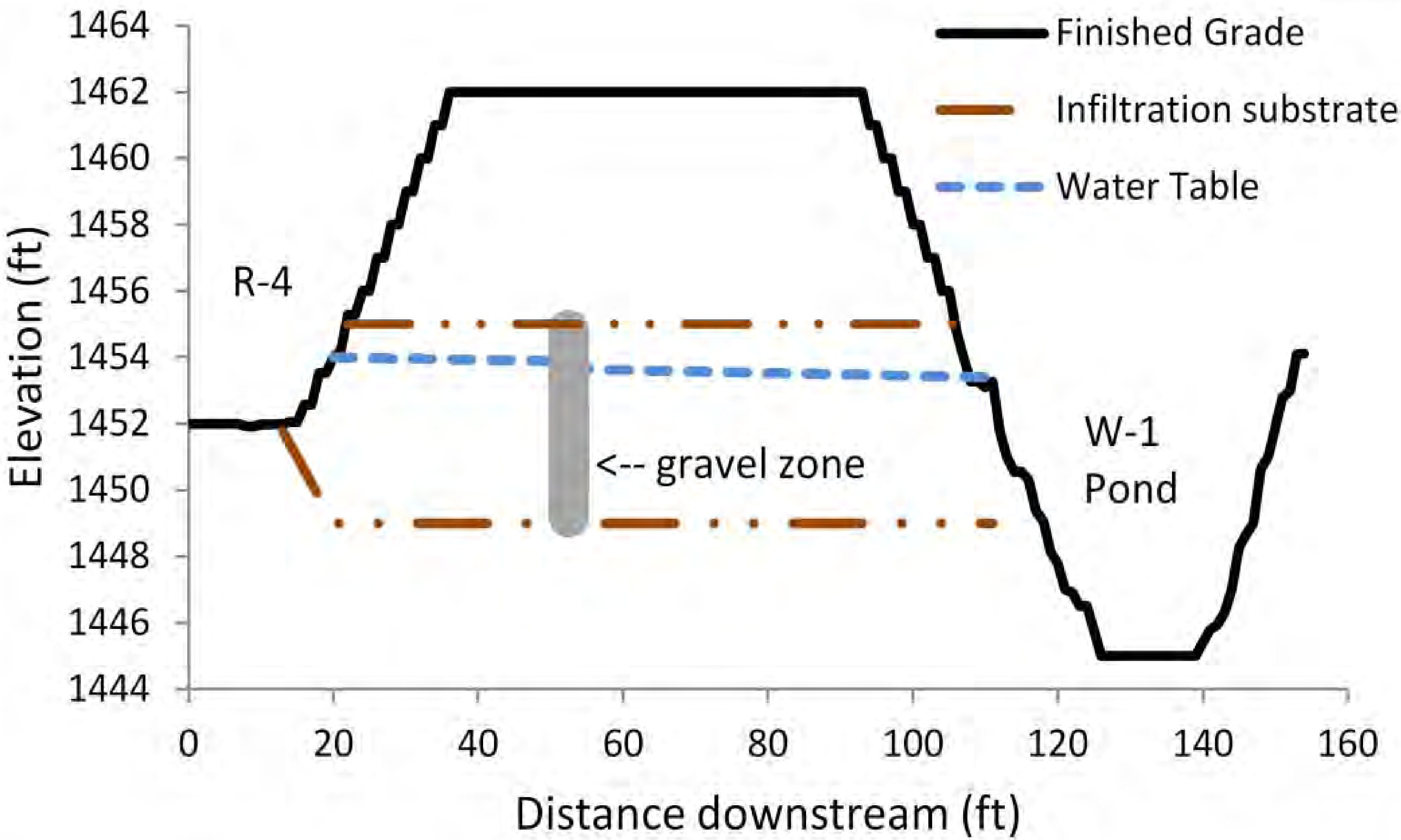




Post Construction – Asbuilt Condition (300 cfs)

POST CONSTRUCTION AT ~4500CFS

“Infiltration Gallery” - Hyporheic Inlet to Pond Reduces Loss of Conveyance and Risk of Inlet Filling



OTHER GEOMORPHIC FEATURES
LOWDEN RANCH REHAB SITE 2010

OTHER GEOMORPHIC FEATURES
LORENZ GULCH REHAB SITE 2013

TRINITY RIVER RESTORATION PROGRAM
COLLABORATIVE PARTNERSHIP

Tell me and I'll forget. Show me, and I may not remember. Involve me, and I'll understand.

- Native American Saying -

DJ Bandrowski P.E., Project Engineer
djbandrowski@yuroktribe.nsn.us
906-225-9137




Constructed Wood jams and off channel habitats – part 2

Aaron Martin – Yurok Tribal Fisheries Program

Outline:

Hydraulic Structures

Habitat Structures

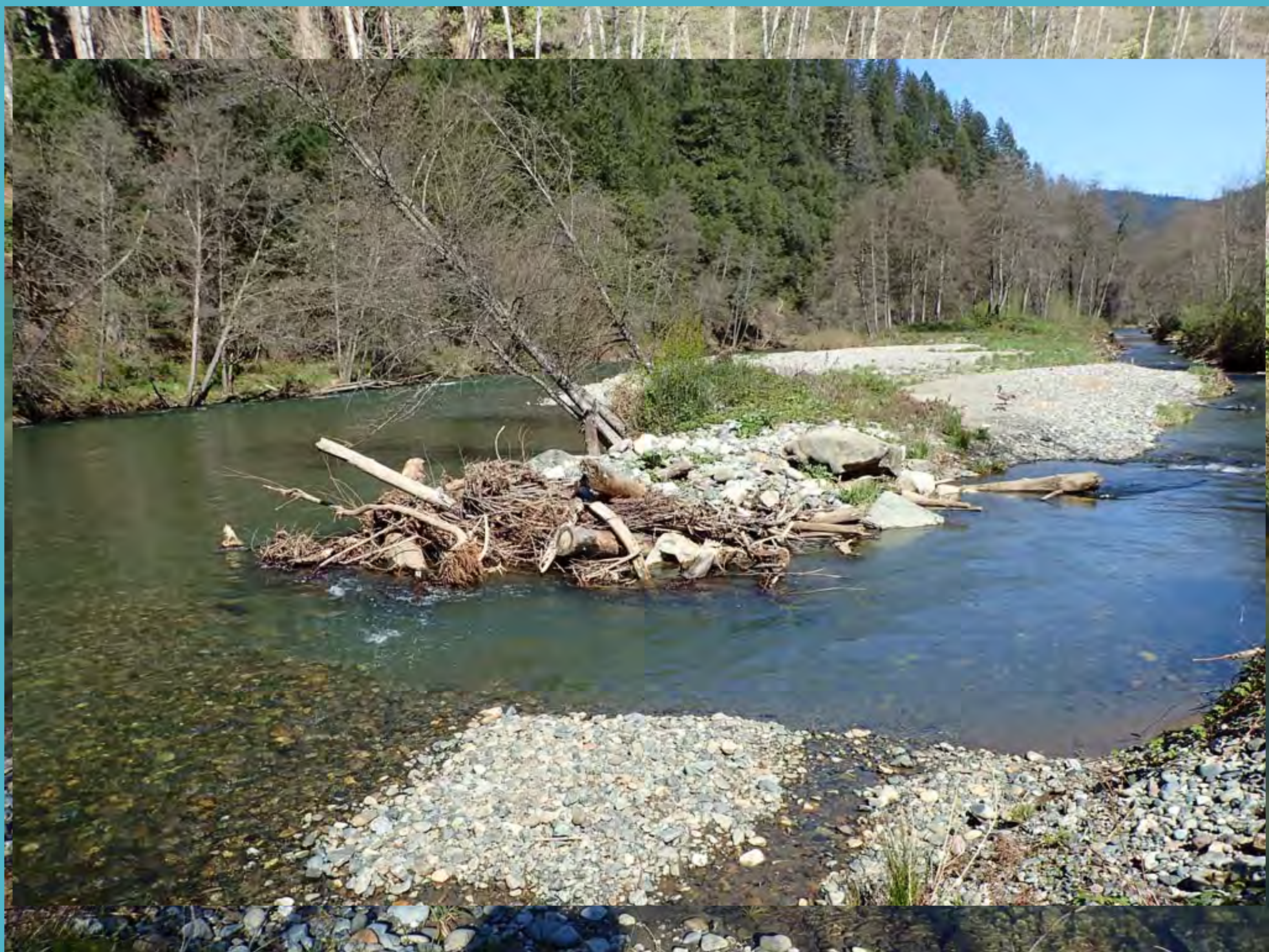
Monitoring

- habitat
- fish use

Construction related lessons and tips

Hydraulic Structures

- Widely used to help maintain side channel openings at a range of flows
- Needs to interact with high flows, want it in the flow path
- Should be well ballasted, or anchored
- We use larger rocks/boulders, or existing vegetation/banks and native material
- Don’t forget the slash!



Hydraulic Structures - examples

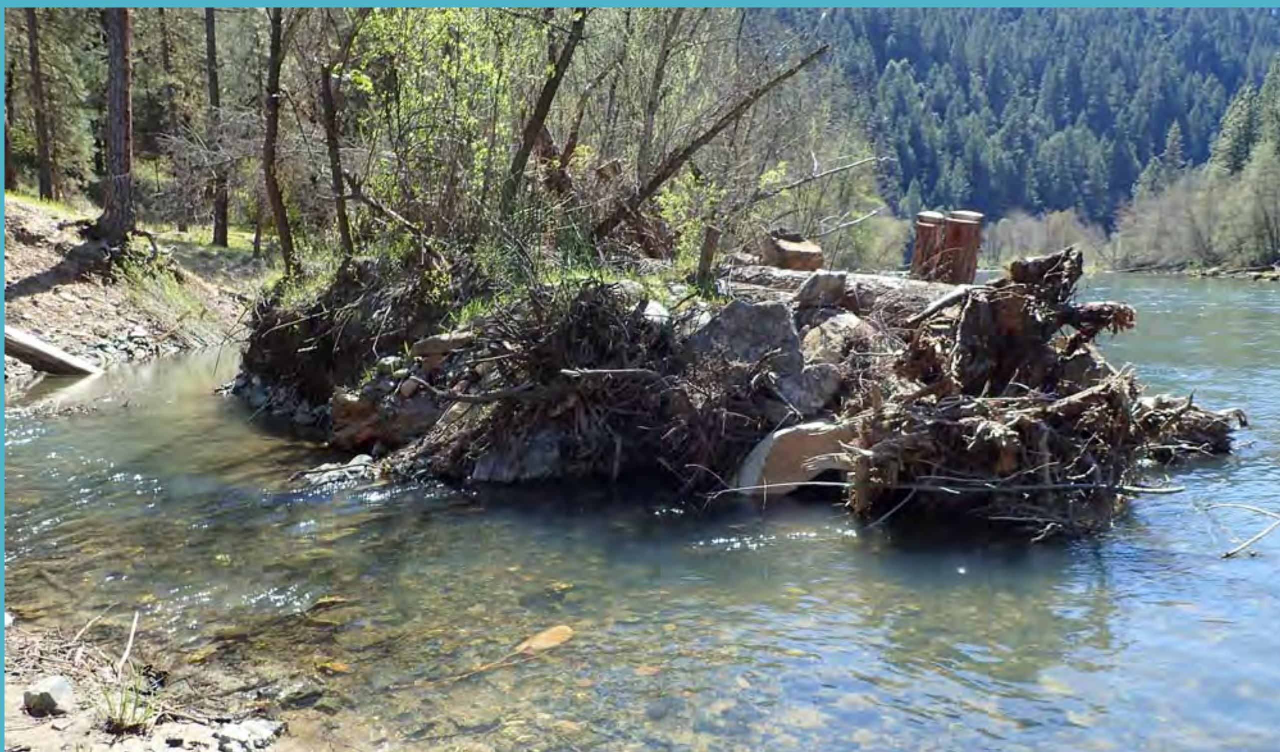
- Usually excavate entire footprint
- Used large boulders and/or native material as ballast
- Entrance would be filled in without structure

Hydraulic Structures - examples

- No wood jam requested
- Filled within 2 years

Hydraulic Structures - examples

- Goal was to raise WSEL, slow down water upstream
- 2 logs and some boudlers
- Huge increase in habitat diversity



Hydraulic Structures - examples

- Keep you veg, and have your wood too!
- Convinced designer to not excavate footprint, rather build into existing bank and vegetation

Habitat Structures

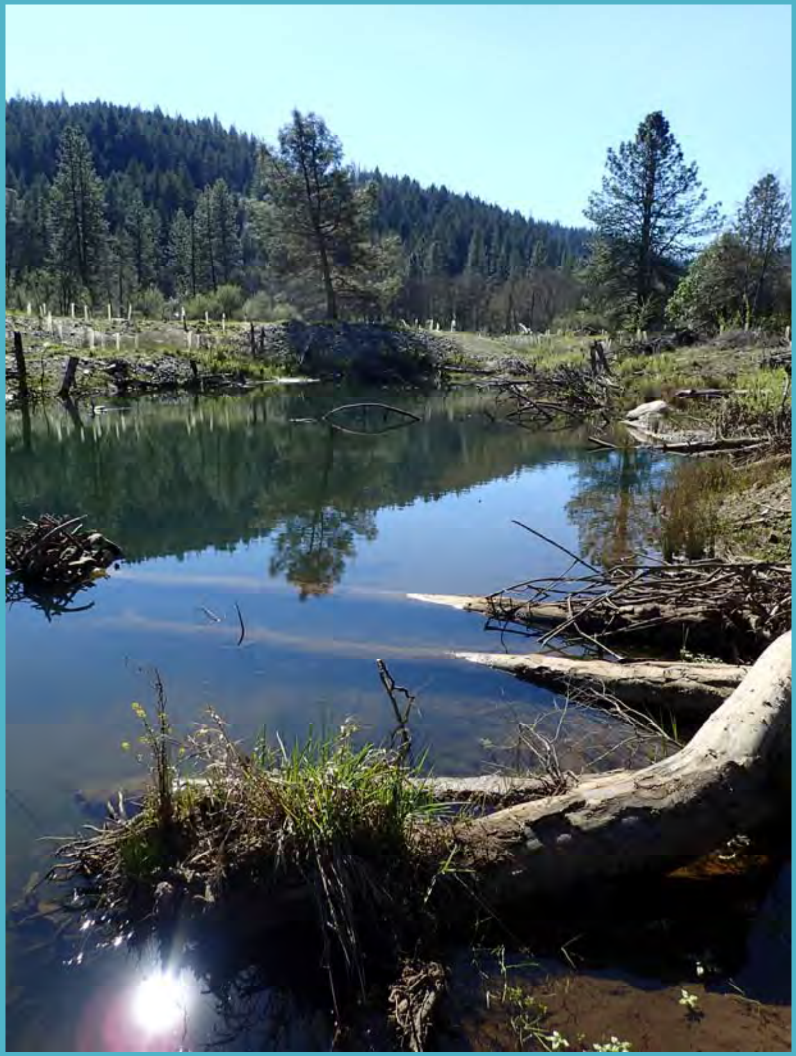
- Usually less than 10 logs/trees
- Majority target low – medium flows to increase habitat
- Heavy use of slash with all features, this is what the juvenile fish respond to
- Excavate ‘cavity’, place slash/wood, fill with native material
- Have placed 1000’s of habitat features. Vast majority are still in place.

Habitat Structures - examples

- Heavy wood loading, but careful not to affect hydraulics in sc
- Try to vary orientation, size, spacing etc.

Habitat Structures - examples

- Use wood to create pool/riffle morphology
- Diversity of habitat=diversity of critters



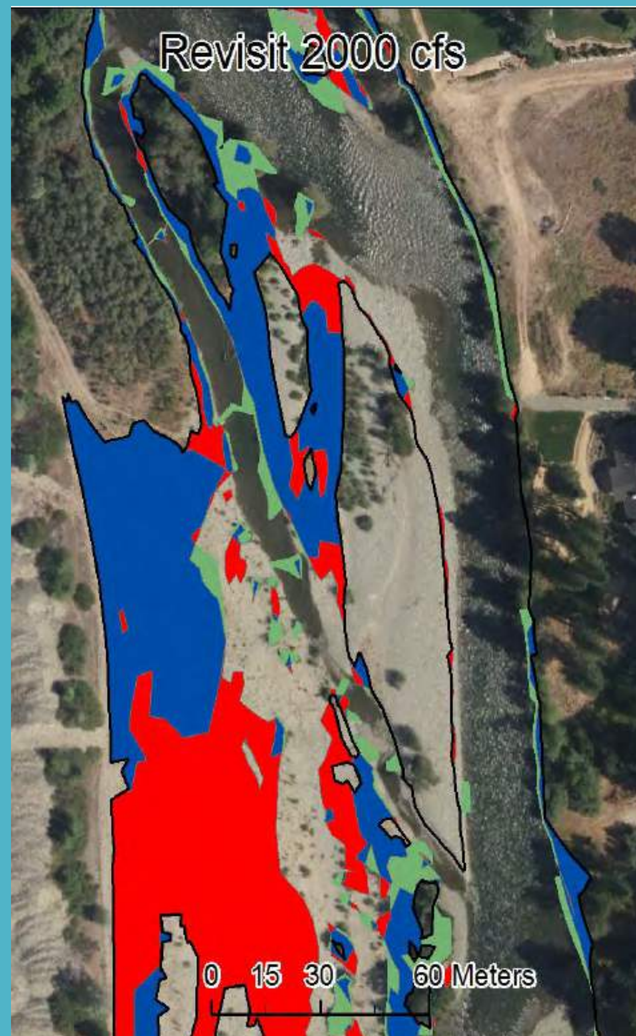
Habitat Structures - diversity

- Pond construction
- Wood heavy!
- Off channel features favor Coho, some Chinook
- Turtles, ducks/geese, lamprey etc

Monitoring – Feedback to restoration

Habitat mapping at rehab sites

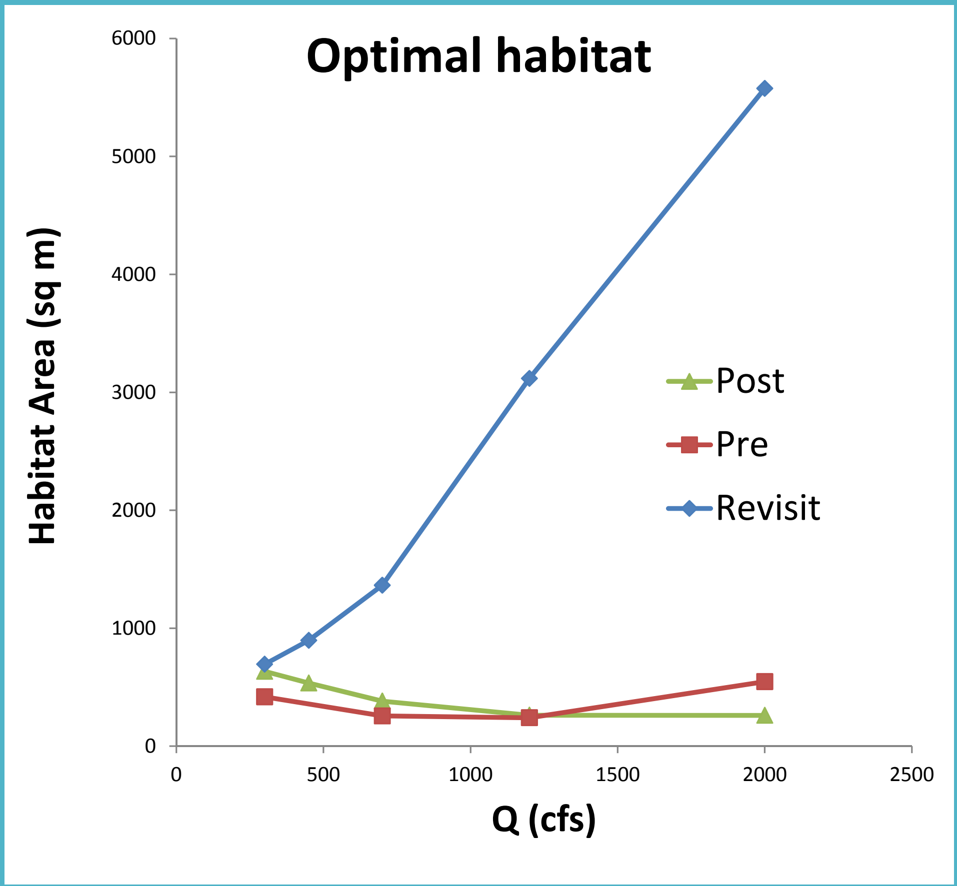
- Survey habitat at a range of flows before and after construction, and over time
- Measure specific depth/velocity and cover to describe available habitat



Habitat mapping at rehab sites

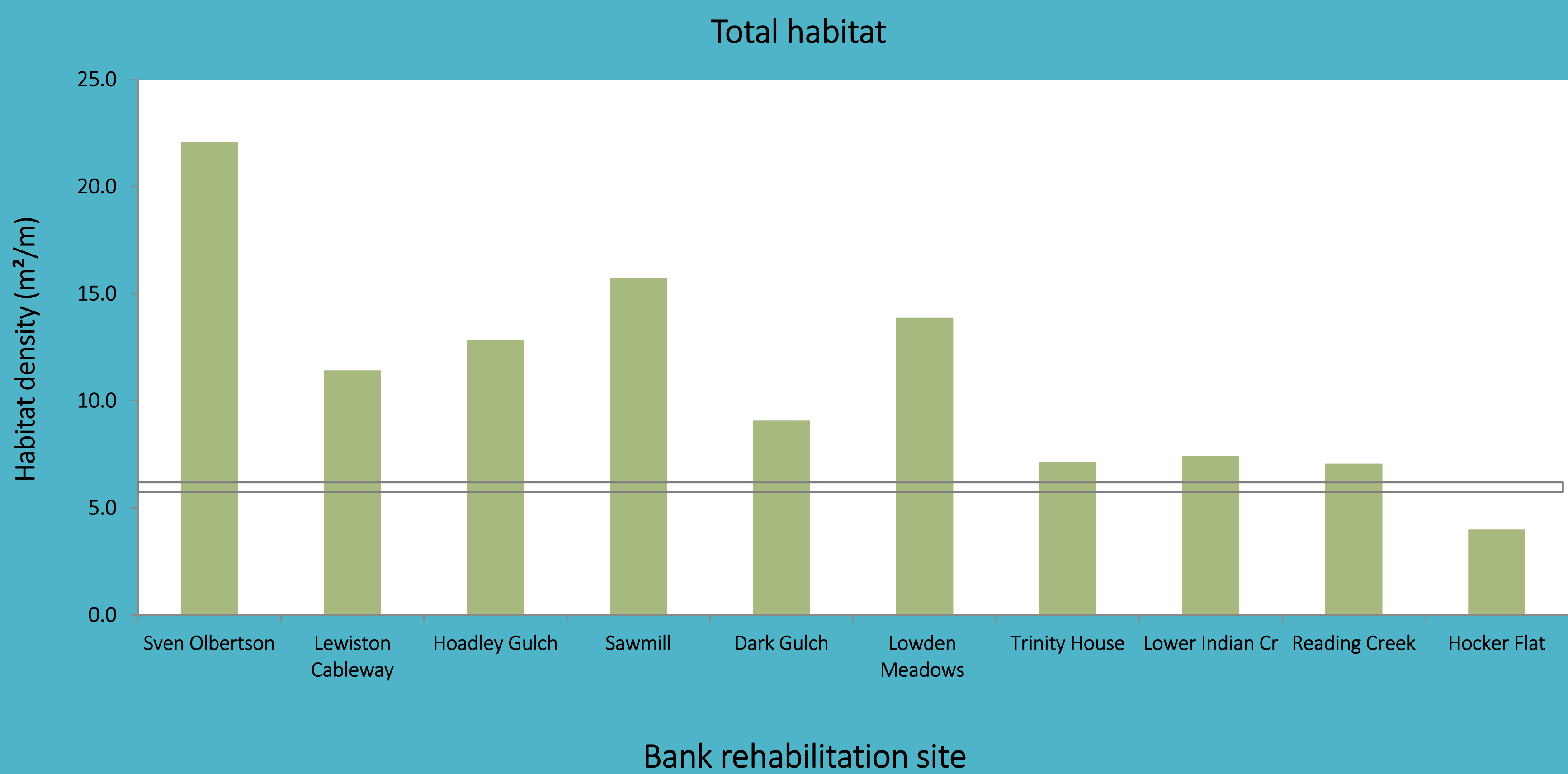
- Example of habitat mapping results at a site on Upper Trinity
- Reduced optimal habitat immediately after construction
- Huge increases at flows above baseflow (water on floodplain, in vegetation)

Habitat mapping at rehab sites



- Important to monitor over time
- Understand more by looking at a range of flows
- Combination of bar deposition and re-vegetation provided huge increases at higher flows
- Process takes time!

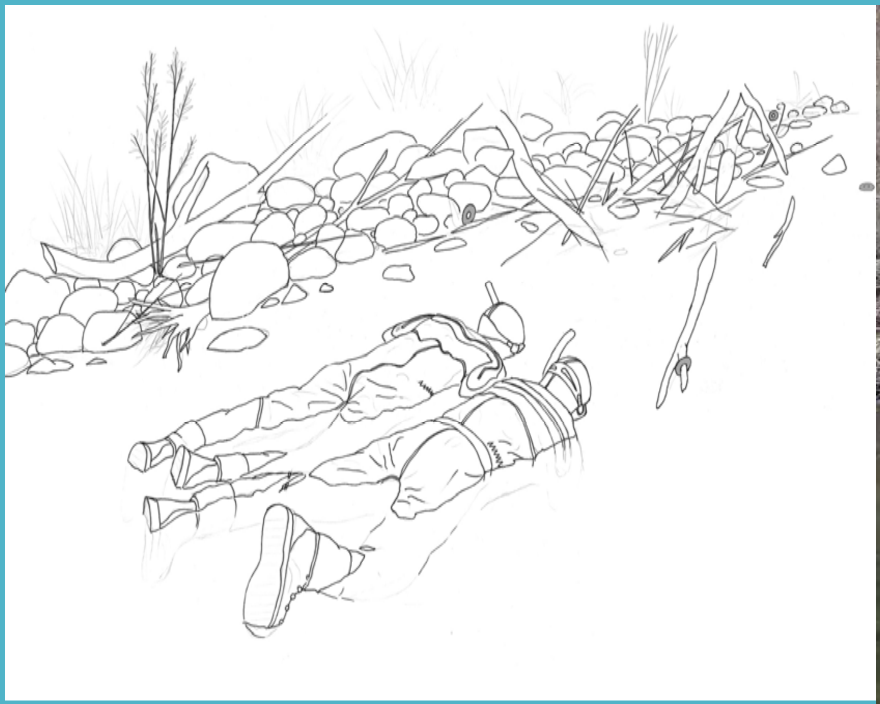
Comparison of sites



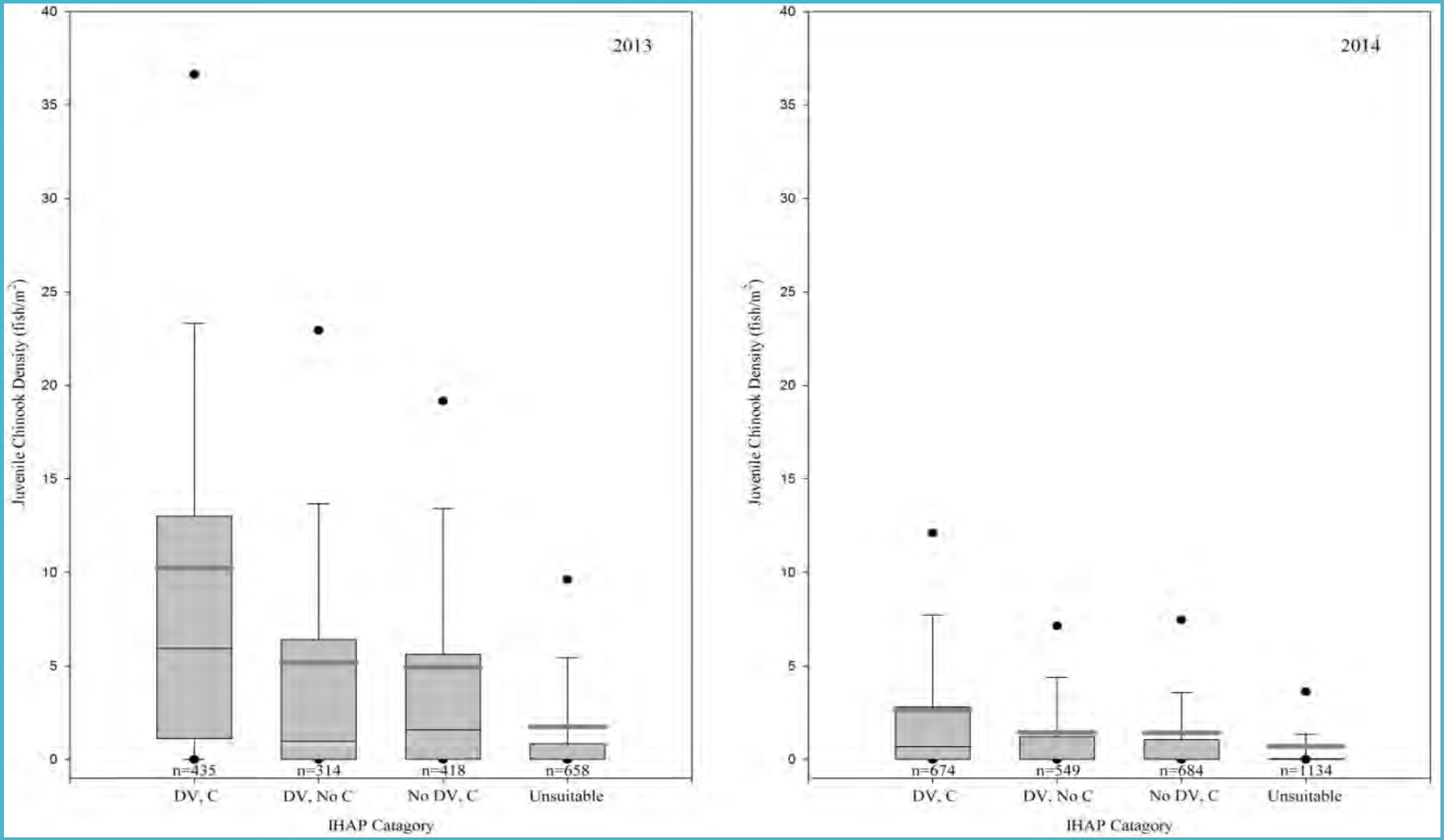
What do the fish say?

-Conducted snorkel surveys for 2 years, describing habitat use by fry and juvenile salmonids

-Over 4500 observations



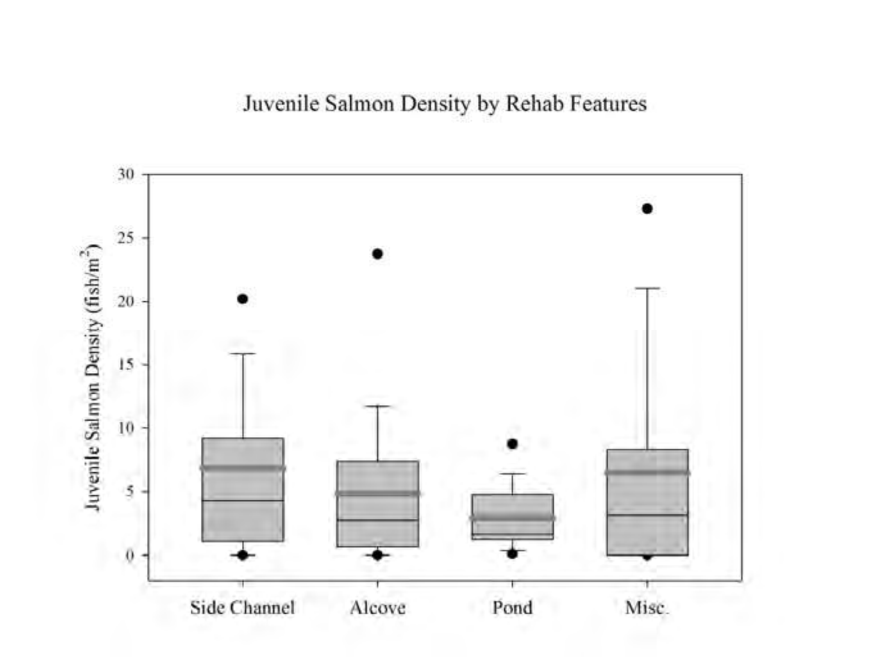
Shallow/slow areas with cover had the highest densities of fish

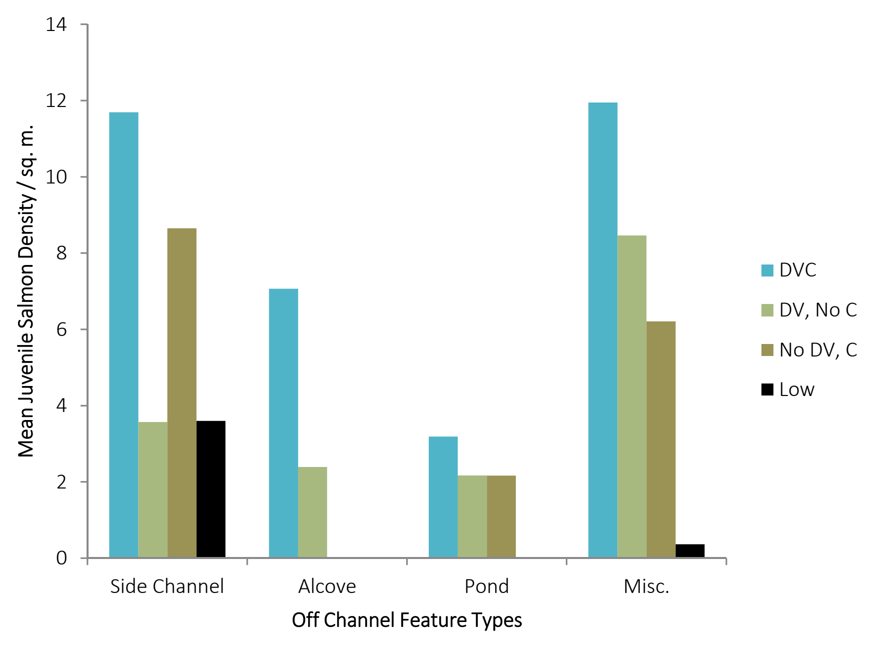


New studies directed at providing additional feedback to Design Team

- What design elements are most heavily utilized by juvenile fish (i.e., LWD, ponds, alcoves, flow)?
- When constructed, a specific feature will be highly utilized by Chinook and Coho salmon.
- “Juvenile salmonids use all identified rearing habitat equally”
- How do juvenile fish densities differ between similar kinds of habitat within different types of constructed features?”

How Fish Use Different Feature Types





- Fish densities vary among feature types
- Fish densities vary among categorical habitat types between features

Construction/Wood implementation lessons from the Trinity

- Flexibility is key! Can't design a perfect channel on your computer
- Need ability to 'field fit'
- Don't overdesign if you don't have to
- Time and materials contract

Lessons continued..

Lessons continued..

- Use straps/chockers to drive/weave logs into existing banks and trees

Lessons continued..

- Combination of pins and boulders
- Sharpened logs and drove into bank
- Fine substrate, but root cohesion

Building a living wood jam

- Used fresh cottonwood cuttings (branches)
- Tied to piles
- Placed fines around them
- Built jam around them

Get the best operator!

- Must have the best operator available
- Makes a huge difference in what/how much can be accomplished
- Get them involved, make them take ownership
- Work as a team, listen to their ideas

Questions?

Habitat Mapping Citation

Goodman DH, NA Som, J Alvarez and A Martin. 2015. A mapping technique to evaluate age-0 salmon habitat response from restoration. Restoration Ecology doi: 10.1111/rec.12148

Large Woody Debris Installation: A Contractor’s Perspective

Hanford ARC

About Hanford ARC

- Established in 1984 in Sonoma, Ca.
- Growth of Company based on industry growth and client needs
- Employment now ranges from 40 to 90 seasonally
- Service area includes Western States, primarily California
- Specialty is stream, wetland and heavy civil construction in sensitive habitat
- Clients: Federal, State, Regional, Local Agencies, Utilities, Private Landowners

Our Approach to Contracting

- Approach project with intent to work as a team with owner and designer
- Understand design ‘intent’, site and permit restrictions. This helps us to determine means and methods relative to desired outcome.
- All parties must remember that we are typically working in a dynamic system. Changed conditions should come as expected rather than a surprise. Our goal is to have all tools readily available to address conditions.
- We assess potential risk factors during bidding, and always aim for flexibility during construction.

Recommendations for Contracting

- PREQUALIFY
- RFP Process, with approach narrative required = vested contractor and best value
- Establish bid items that allow for evaluation of bids and create a basis for evaluating whether bids are balanced
- Specify performance criteria, rather than means and methods
- Do not guarantee site conditions, and provide full permit text with bid package
- Since LWD structures are typically below top of bank, water control methods should be discussed immediately with contractor, preferably during bid/proposal analysis

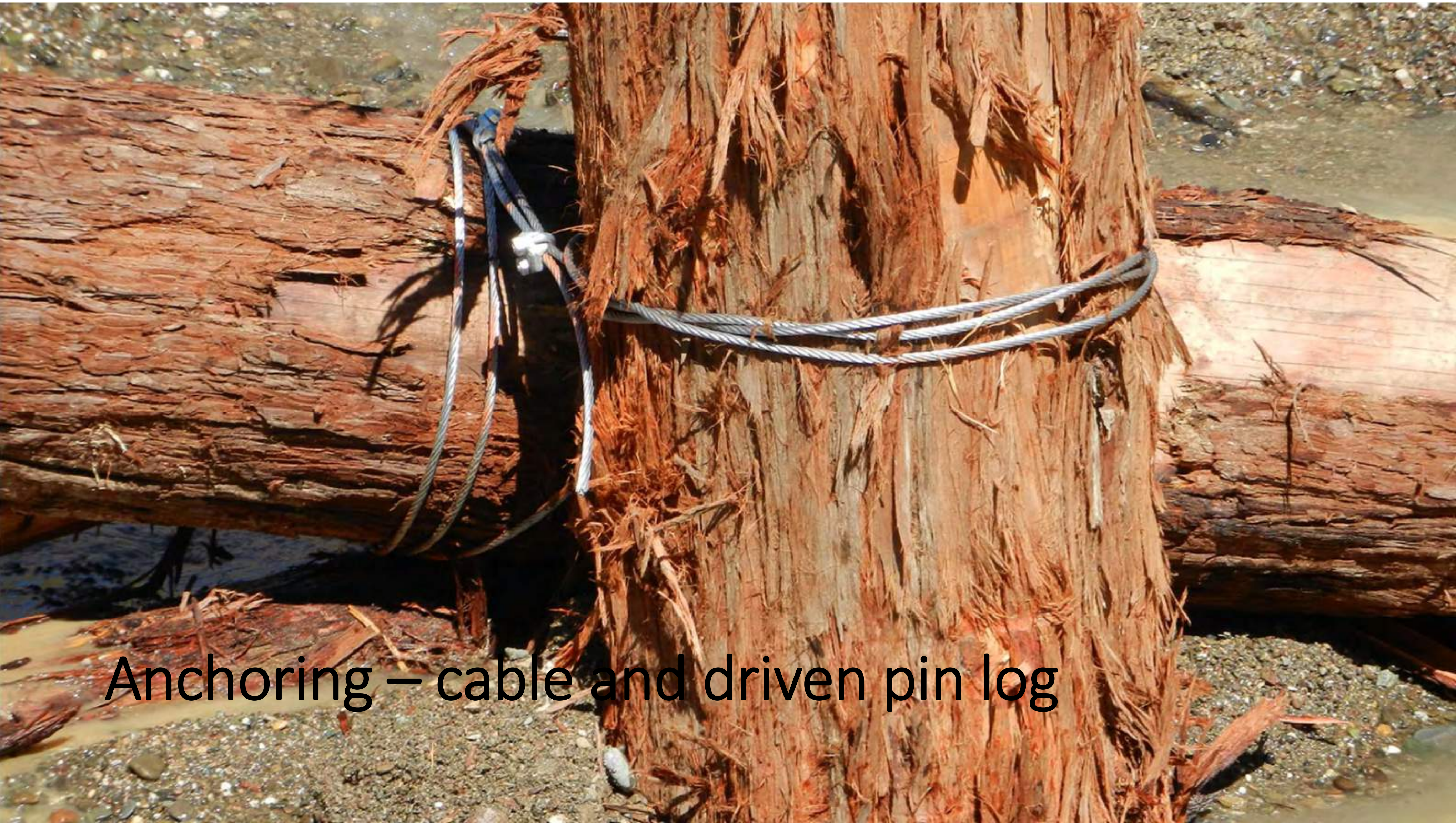
Installation Equipment

- Excavator (critical and typically primary equipment)
- Wheel loader with log forks or skid steer with grapple (secondary, log handling)
- Heel Boom (very effective for log handling and setting)
- Excavator or crane mounted pile driver (for driven logs)
- Excavator mounted vibra-plate (for driven logs)
- Chainsaw (for notching, cutting tip, trimming clean rootballs)
- Machetti, Hand Saw (trimming dirty rootballs)
- Hand Tools (wrenches, ratchets, torch, cable cutter, rock drill, wood drill. Tools to work with cable and bolts)

Log Anchoring

- Rock only, relying on rock weight, or drilled rock with cables or bolt
- Pin logs, relying on friction, or cable, bolt together
- Anchoring: duckbill, helical, tied to cable
- Other Materials: epoxy, cable, cable clamps, bolts, washers, nuts
- Anchoring tools: gas or electric drill, rock drill, equipment for setting anchors, pull tester
- All tools should be on-hand; contractor should be focused on efficient and effective installation, owner/inspector should be focused on testing for effective installation and end result

Anchoring – cable and rock



Anchoring – cable and driven pin log

Anchoring – duckbill earth

Types of Structures

- Single rootwad, rock anchor – equipment only
- Rootwad series with header/footer logs, cable/bolt – equipment, labor
- Solo pin logs – equipment only
- Log weirs – equipment only unless cable/anchor is required
- Debris jams – equipment and labor required
- Crib walls – equipment and significant labor force required

Example 1 – Brush Creek (1999), single root wad

Example 2 – Redwood Creek (2003), weirs and complex bank structures

Example 3 – Peyton Slough (2004), logs in tidal environment

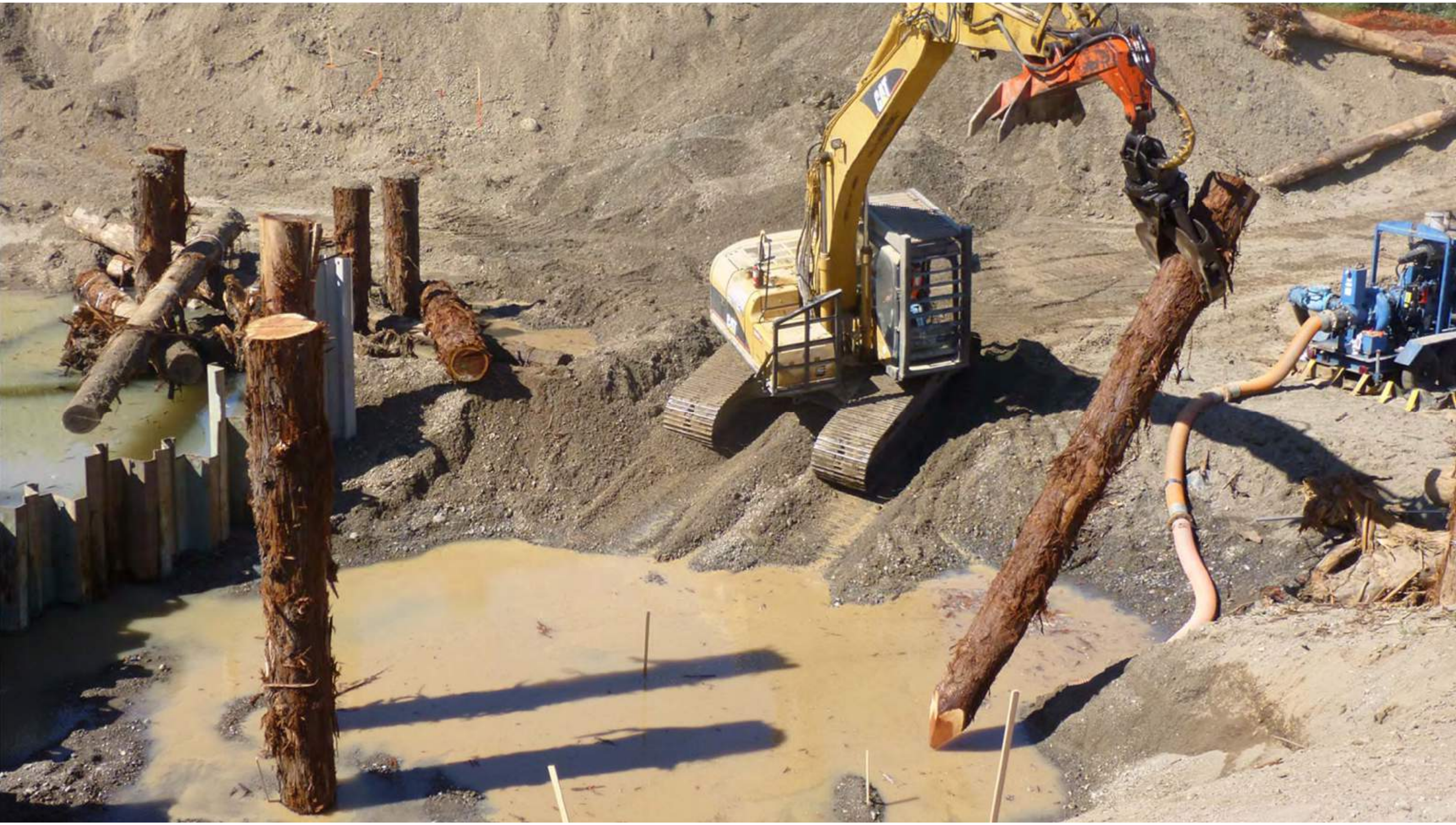
Example 4 – Arroyo de la Laguna (2006) pin logs

Example 5 – Angora Creek (2006), floodplain logs, rootwad toe series

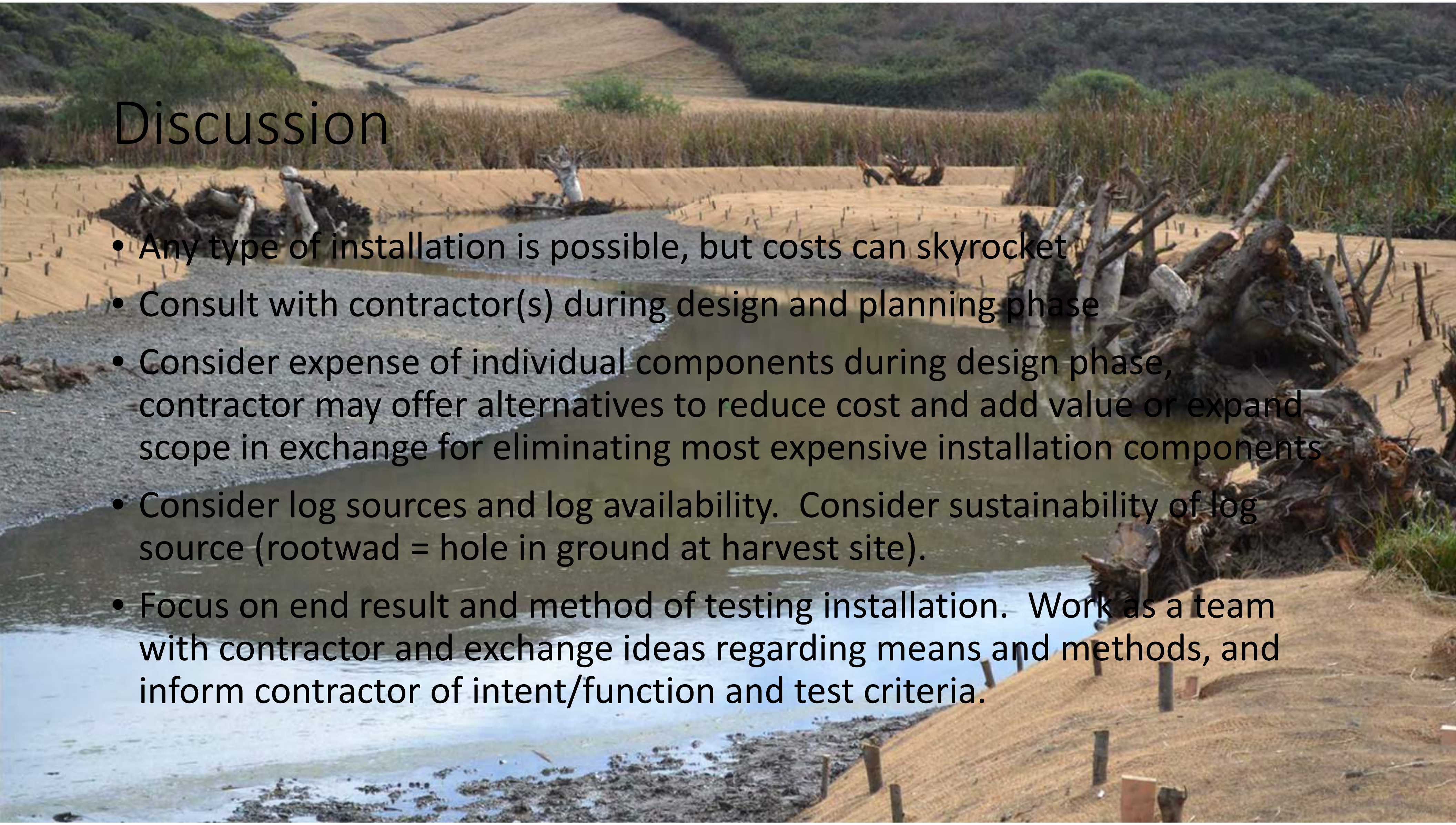
Example 6 – Inman Creek (2009), simple LWD introduction below TOB

Example 7 – Redwood Creek (2009-11), comlex LWD bank structures

Example 8 – Dry Creek (2013-14), complex LWD structures


CAT


KOMATSU
WA320
CAT
KOMATSU



Discussion

- Any type of installation is possible, but costs can skyrocket
- Consult with contractor(s) during design and planning phase
- Consider expense of individual components during design phase, contractor may offer alternatives to reduce cost and add value or expand scope in exchange for eliminating most expensive installation components
- Consider log sources and log availability. Consider sustainability of log source (rootwad = hole in ground at harvest site).
- Focus on end result and method of testing installation. Work as a team with contractor and exchange ideas regarding means and methods, and inform contractor of intent/function and test criteria.

Large Wood Structure **Construction Considerations for Publically Bid and Contracted Restoration Projects**

Presented By:
Steven Allen, Jeremy Svehla

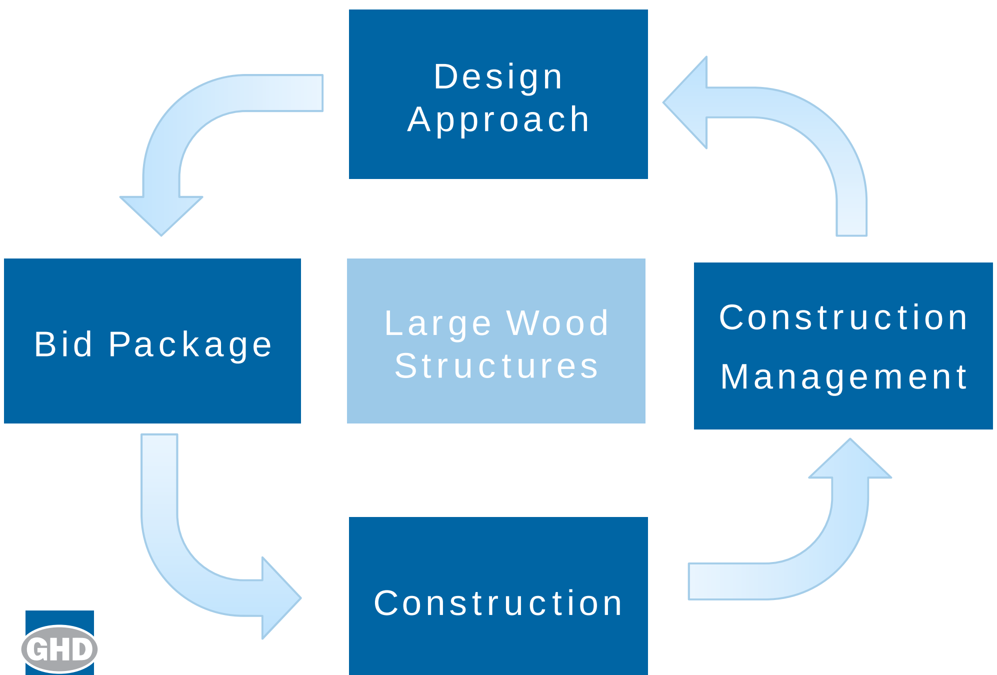
Salmonid Restoration Federation
34th Annual Conference
April 7, 2016

Presentation Overview

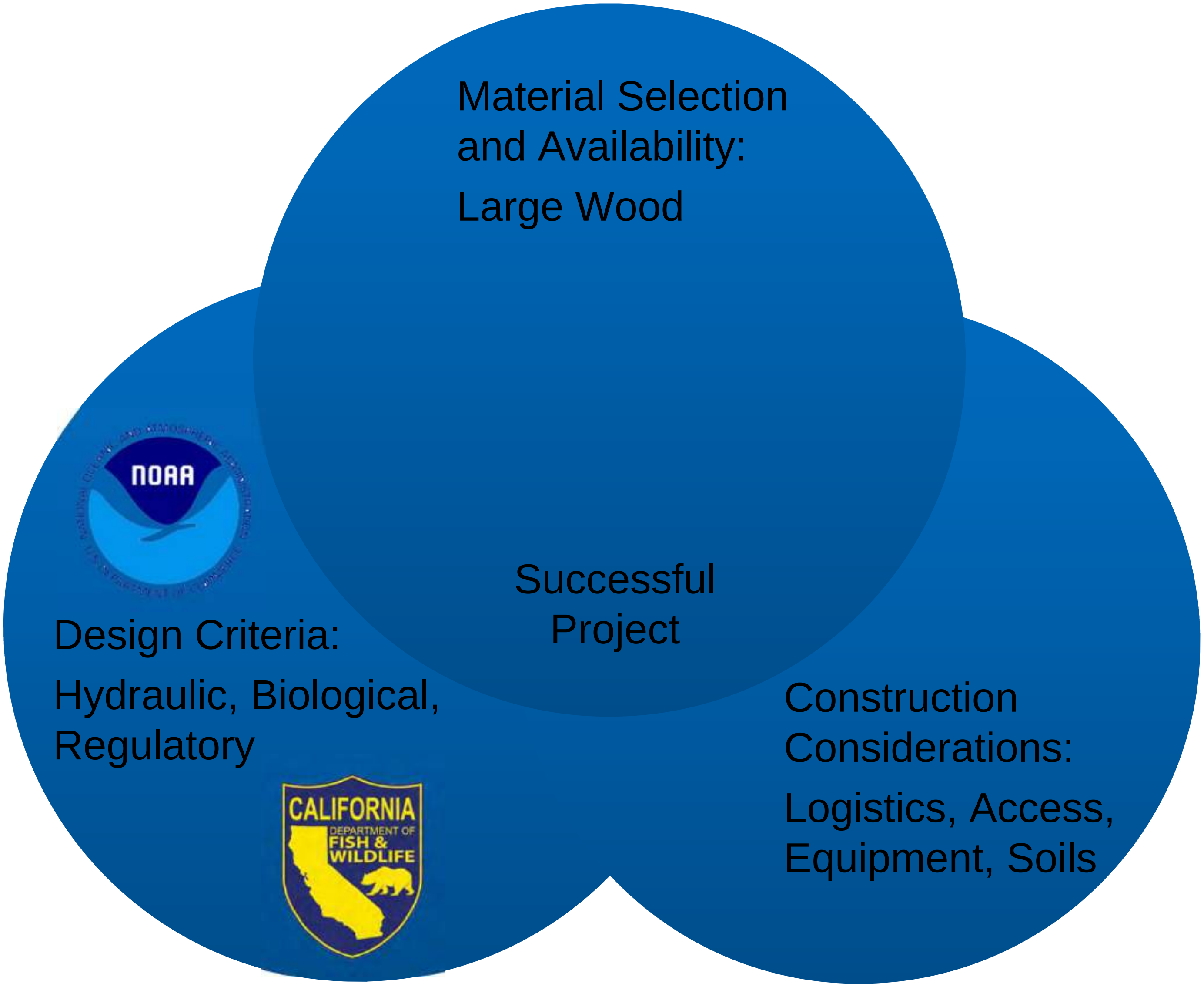
This presentation will focus on the construction of large wood projects to create specific hydraulic conditions desired by the project design.

Stakeholders

- **Landowners**
- **Clients**
- **Regulatory agencies**
- **Contractors**
- **Salmonids and other organisms**



Design Approach - Process



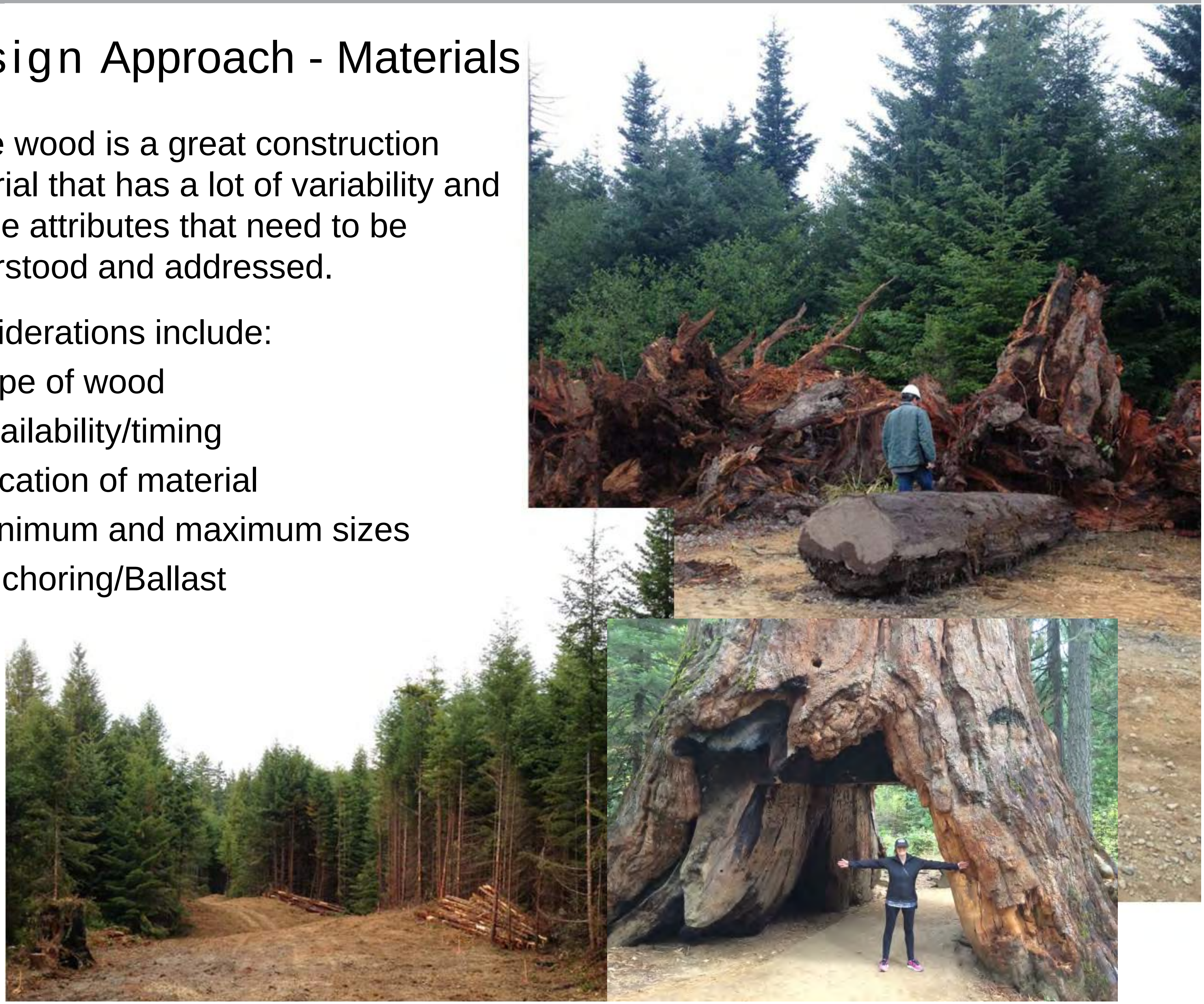
GHD

Design Approach - Materials

Large wood is a great construction material that has a lot of variability and unique attributes that need to be understood and addressed.

Considerations include:

- Type of wood
- Availability/timing
- Location of material
- Minimum and maximum sizes
- Anchoring/Ballast



Design Approach - Goal

Design goals must be understood in order to develop a design that meets those goals.

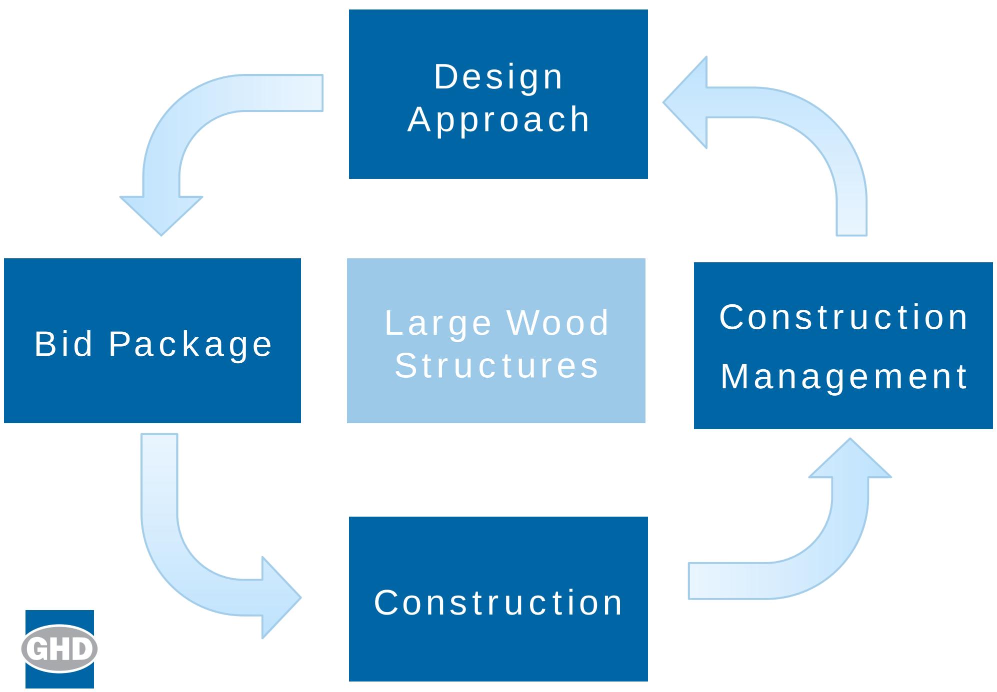
Goals could include:

- Hydraulic conditions
  - Velocities, roughness
  - Grade control, jump heights
  - Refugia, cover, hydraulic variability
- Regulatory set number of structures
- Re-using material on-site

Bid Package

Public Bidding

- **Public contract code sections 20161 and 20162 requires competitive bidding**
- **Lowest responsible bidder who submits a responsive bid**
- **Responsible bidder typically a licensed contractor how has not been barred**
- **Responsive bid that complies with all the bid procedures**
- **Bid protests, waiving irregularities, rejection of all bids**
- **Prevailing wage and the California Department of Industrial Relations**



Invitation for Bids

BORDER COAST REGIONAL AIRPORT AUTHORITY
150 DALE RUPERT ROAD
CRESCENT CITY, CALIFORNIA 95531

Sealed proposals for the work described in the specifications and contract documents entitled:

TERMINAL OFF-SITE MITIGATION AT PACIFIC SHORES IN DEL NORTE COUNTY

AIP NO: 03-06-0057-032-2016

will be received by the Border Coast Regional Airport Authority located at 150 Dale Rupert Road, Crescent City, California 95531, until:

WEDNESDAY, MARCH 16, 2016 AT 4:00 PM

at which time they will be publicly opened and read aloud at said address.

PRE-BID MEETING

The non-mandatory pre-bid meeting will be held and begin at the **Jack McNamara Field administrative offices on FRIDAY, MARCH 3, 2016 at 10:30 AM** for an informational meeting, then proceed to the TERMINAL OFF-SITE MITIGATION AT PACIFIC SHORES project site off of Kellogg Road to the north, west of Lake Earl, and south of Tolowa Dunes State Park. All interested bidders are invited to attend. Bidder's questions will be accepted until **4:00 PM** on **FRIDAY, MARCH 11, 2016**. Notice is given to all prospective bidders that the project includes unique construction and construction permitting/monitoring requirements, and access limitations. Prospective bidders are highly encouraged to attend the Pre-Bid Meeting to raise their understanding and increase their confidence in their bids.

Bidders who elect not to attend the Pre-Bid Meeting must complete their own due diligence sufficient to become familiar with the project site and unique requirements of the construction, permitting and coastal geographic configuration. It shall be the bidder's sole responsibility to complete a site visit and otherwise investigate and become familiar with the project requirements including permit conditions.

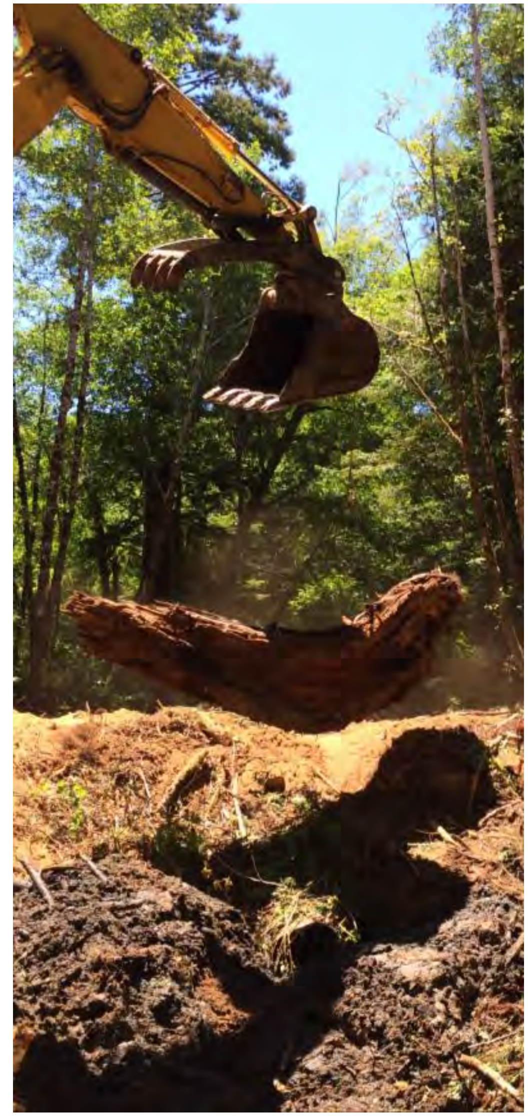
Bid Package

A good bid package defines the project so that contractors understand the work to be done and can develop competitive bids.

Bid package considerations:

- Include plans, front end contract documents and technical specifications
- Define funder, client, and regulatory requirements
- Define materials
- Define measurement and payment
- Define testing requirements and anticipated soil conditions
- Define schedule

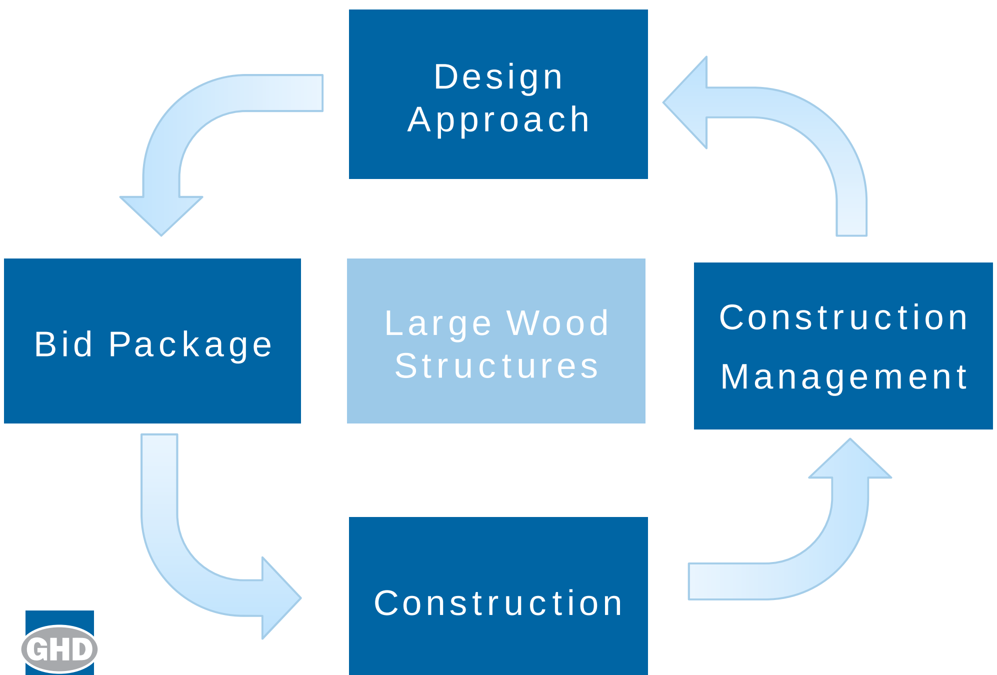


Construction Considerations

Contractors

- **Have “won” the work and now are obligated to complete the work**
- **Have many responsibilities from insurance to staffing, materials, and equipment**
- **Want to have a successful project**
- **Need to make money on a project**
- **May have good ideas on how to approach certain elements**
- **They may be juggling other projects**



Construction Considerations

Success will depend on many factors, and really takes a team focused on project success!

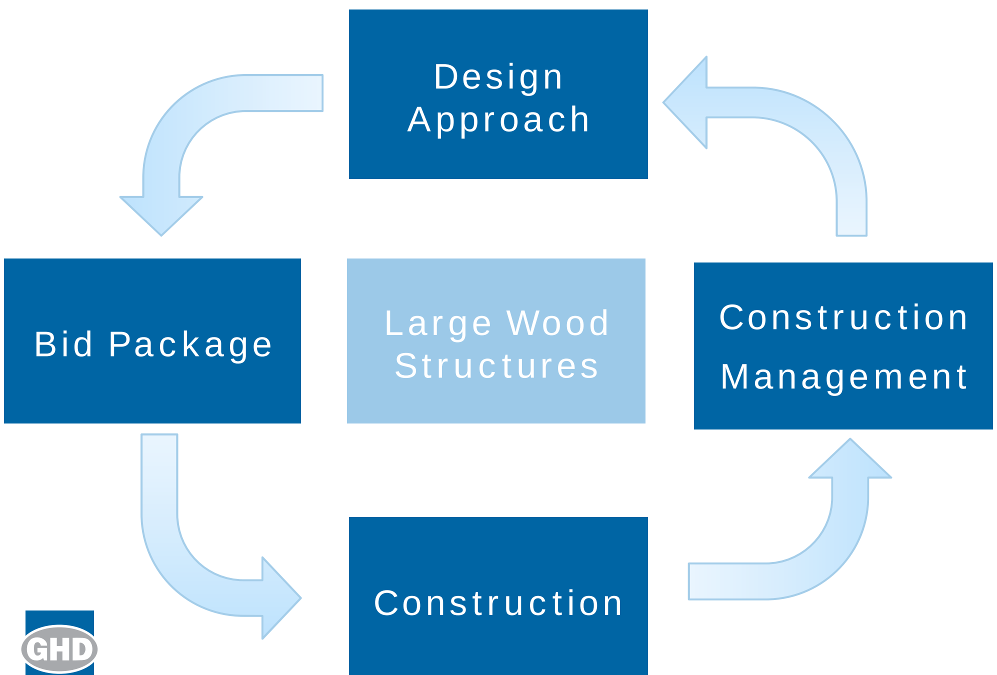
Construction considerations:

- Do your part, control what is in your control
- Communicate regularly (weekly construction meetings)
- Identify and address potential issues early
- Be open to new ideas and different approaches
- Be clear on expectations
- Ask questions
- Be a good listener and communicate clearly
- Be proactive to avoid claims and litigation

Construction Management

Roles

- **Construction manager, Engineer of Record**
- **Inspector is defined by the California Department of Industrial Relations**
- **Special inspections, materials testing, construction surveying**
- **Review of submittals, responding to requests for information**
- **Clients representative to see that project is built per contract documents**
- **Goal is to work with all parties to end up with a successful project**



Construction

Construction

Construction

Construction

Construction

Construction

Questions?

www.ghd.com

Exciting Details

PUBLIC CONTRACT CODE
SECTION 20160-20174

20160. The provisions of this article shall apply to contracts awarded by cities subject to Title 4 (commencing with Section 34000) of the Government Code.

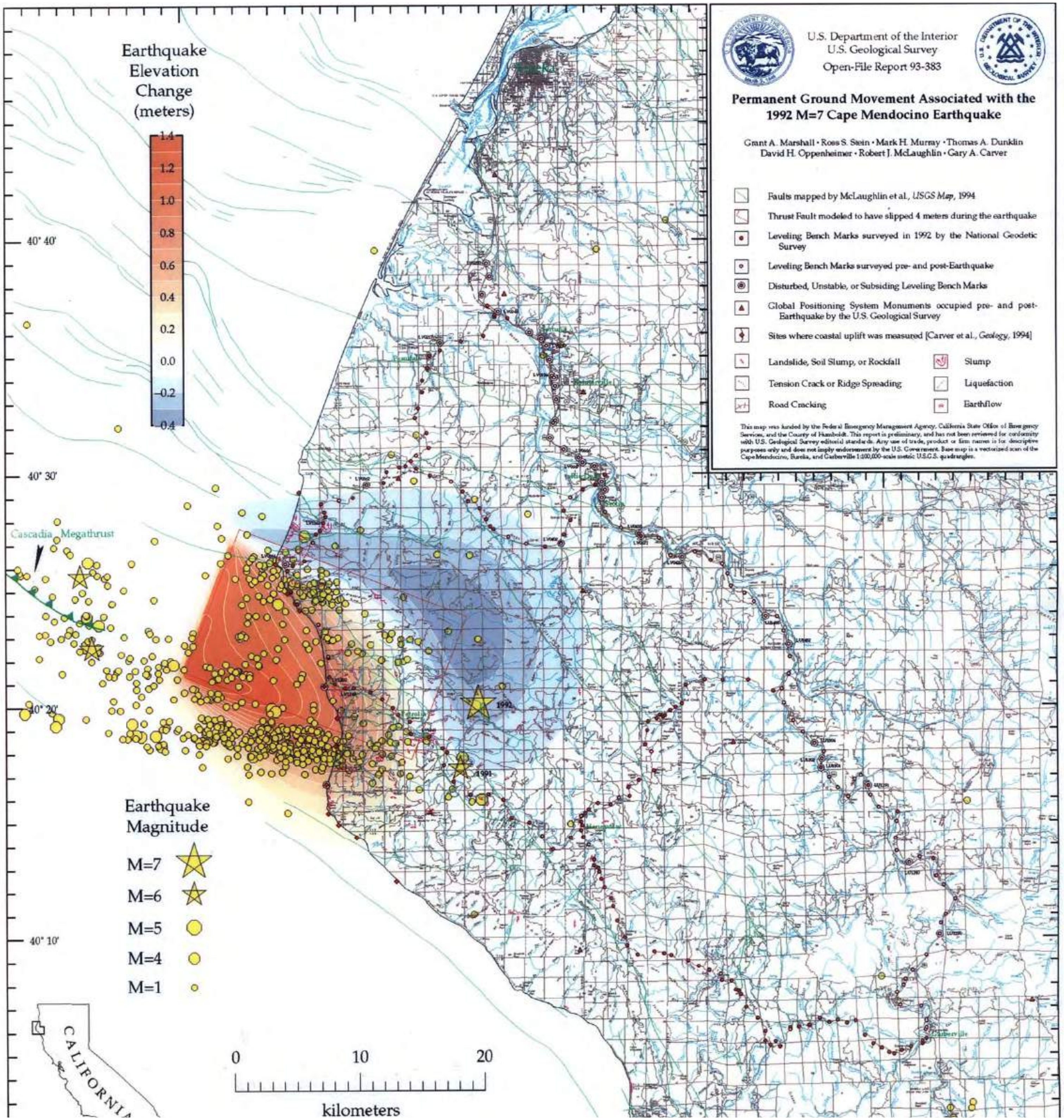
20161. As used in this chapter, "public project" means:
(a) A project for the erection, improvement, painting, or repair of public buildings and works.
(b) Work in or about streams, bays, waterfronts, embankments, or other work for protection against overflow.
(c) Street or sewer work except maintenance or repair.
(d) Furnishing supplies or materials for any such project, including maintenance or repair of streets or sewers.

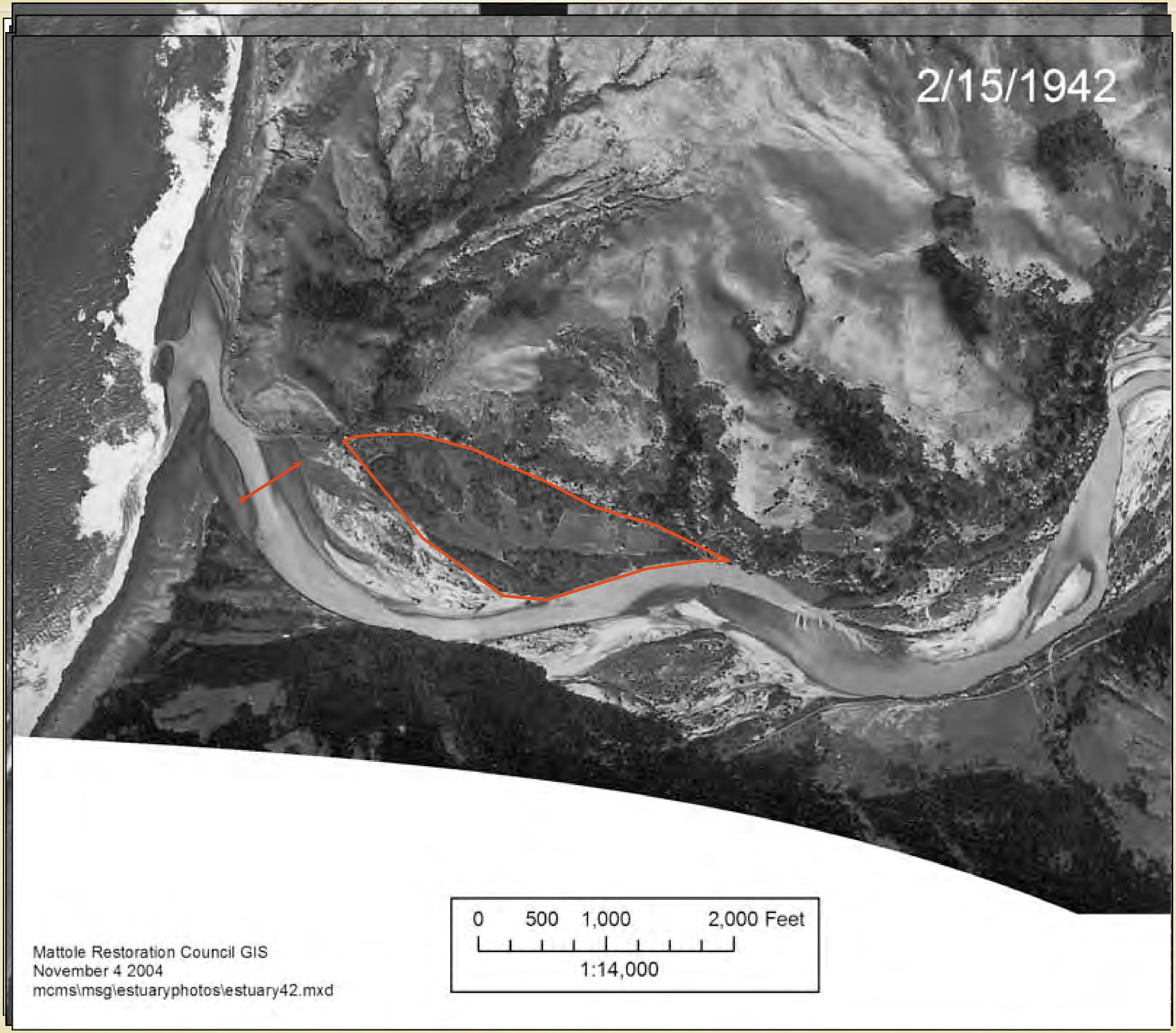
20162. When the expenditure required for a public project exceeds five thousand dollars ($5,000), it shall be contracted for and let to the lowest responsible bidder after notice.

Integrating off channel slough restoration in the Mattole Estuary with riparian revegetation and terrace margin treatments for climate change resiliency


Towards a restoration perspective
•Prolonged observation
•Adaptive management
•Integrated approach
•Mimic natural process
•Humility

Prolonged observation



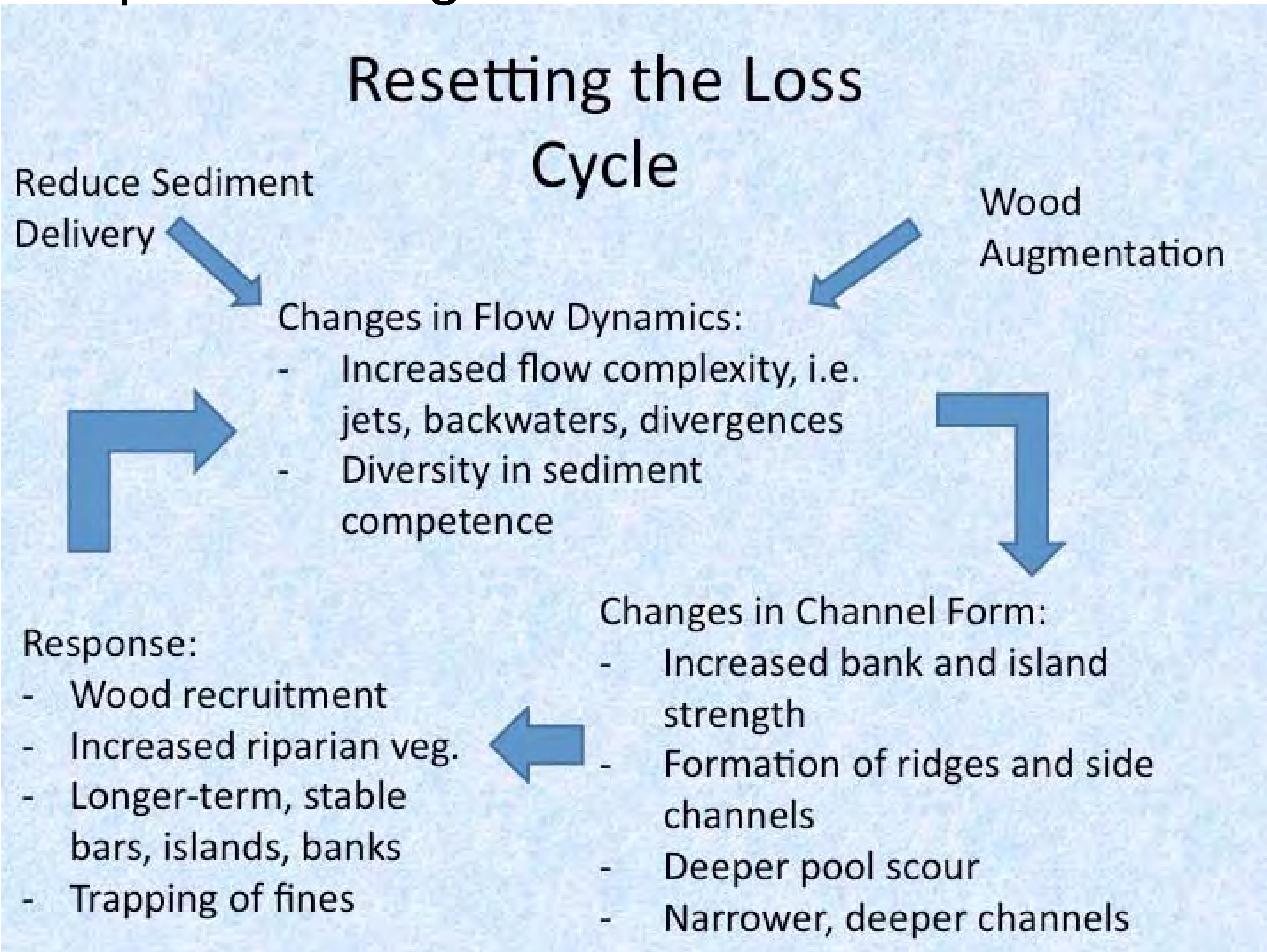

2/15/1942
0 500 1,000 2,000 Feet
1:14,000
Mattole Restoration Council GIS
November 4 2004
mcms\msg\estuaryphotos\estuary42.mxd


1979


1987


2009

Adaptive management

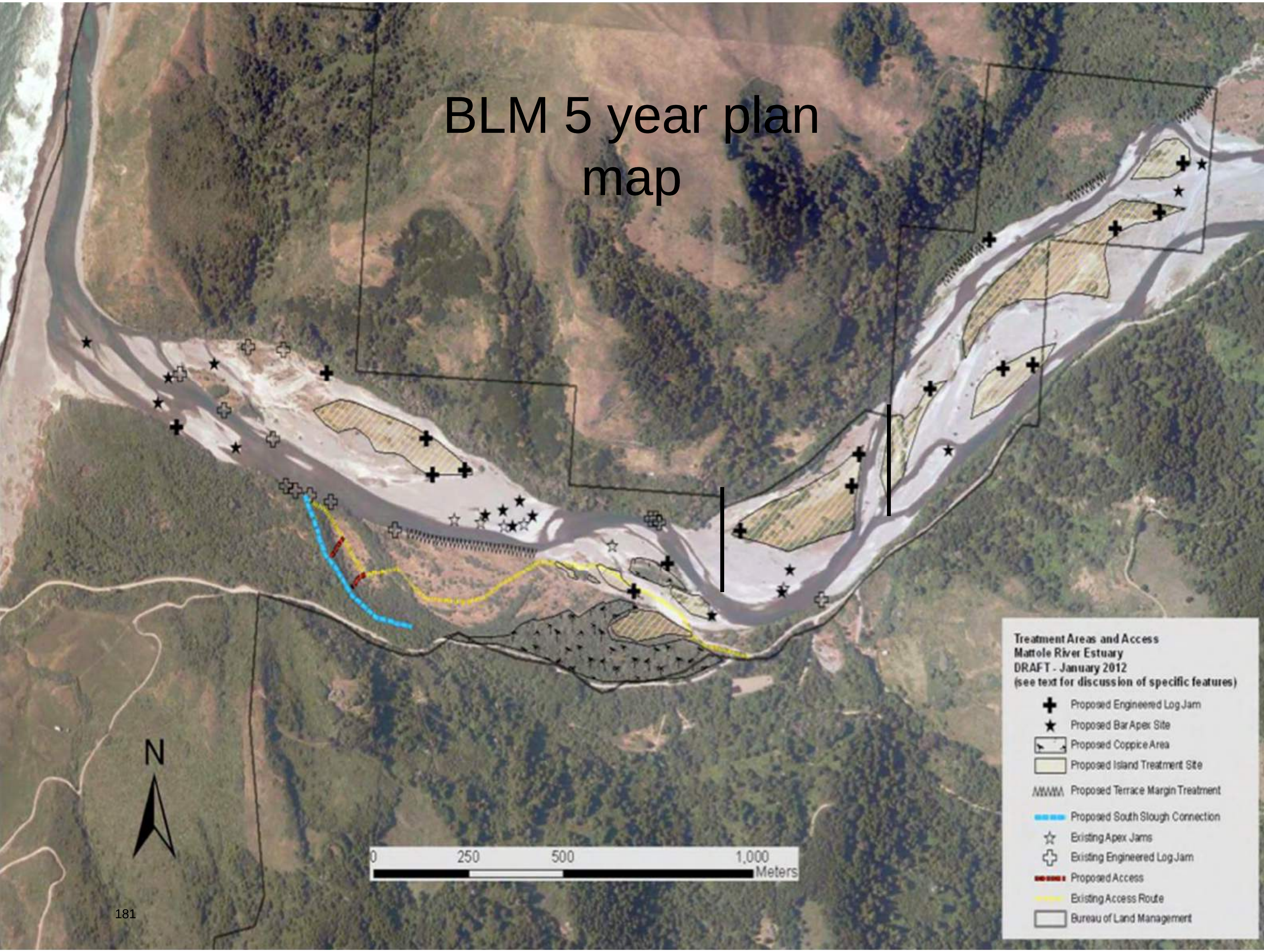



Mimic natural
process:
use only the finest ingredients

Integrated approach

TAC

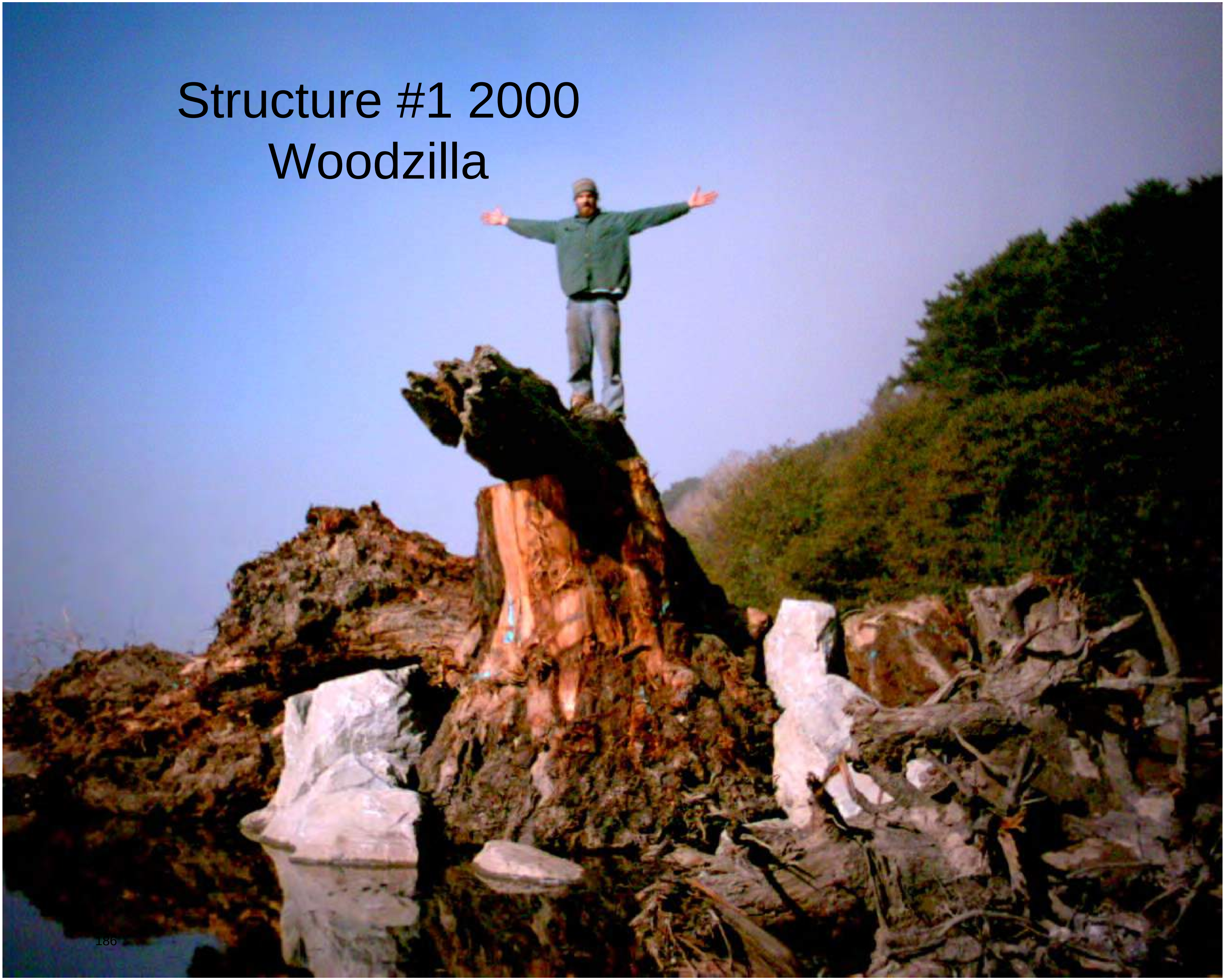
BLM 5 year plan map

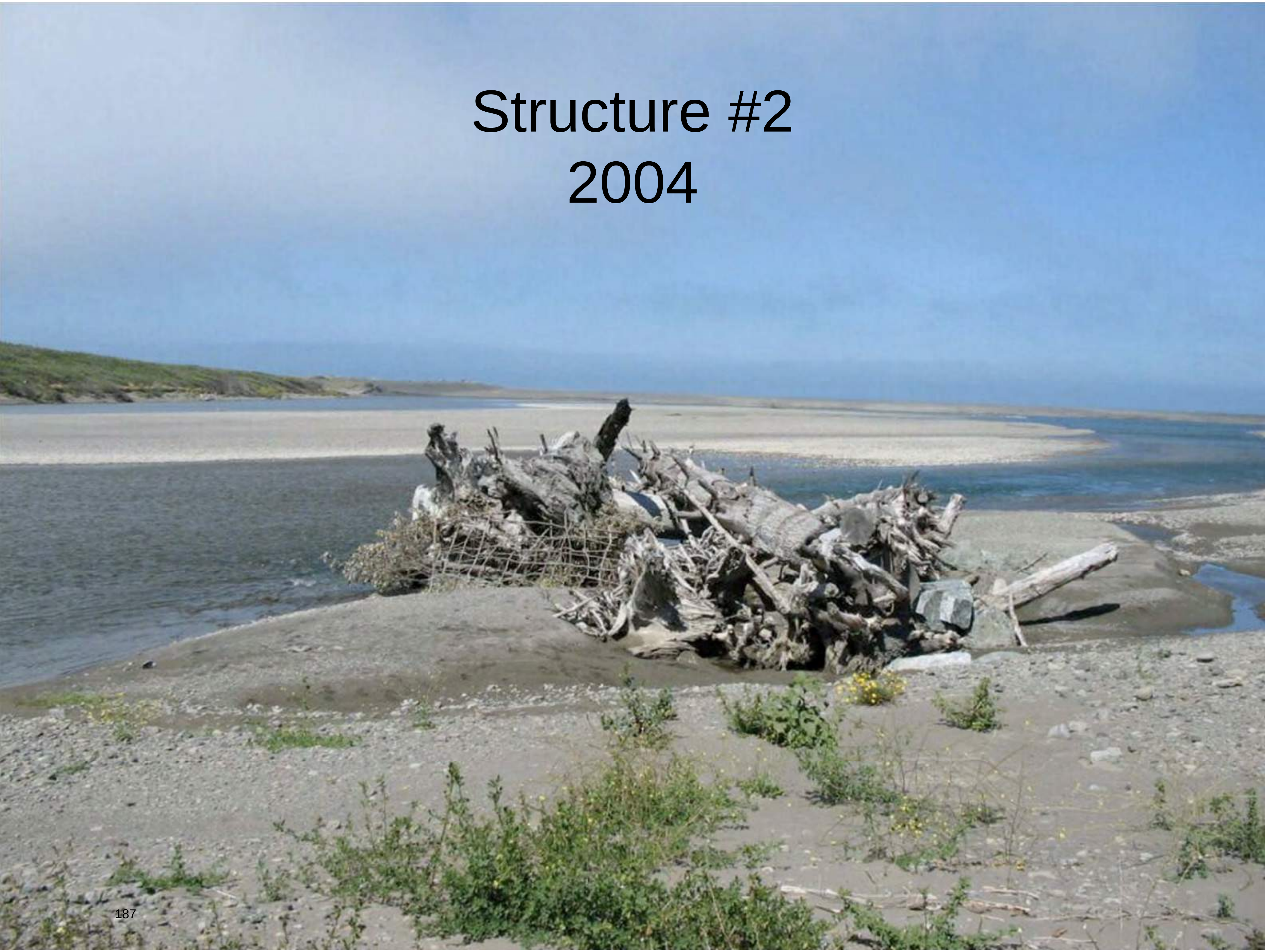



Humility

An LWD journey
1990-Present

Early LWD: circa 1990


Structure #1 2000
Woodzilla


Structure #2
2004


Structures #3 & #4
2007


Structure #5
2010

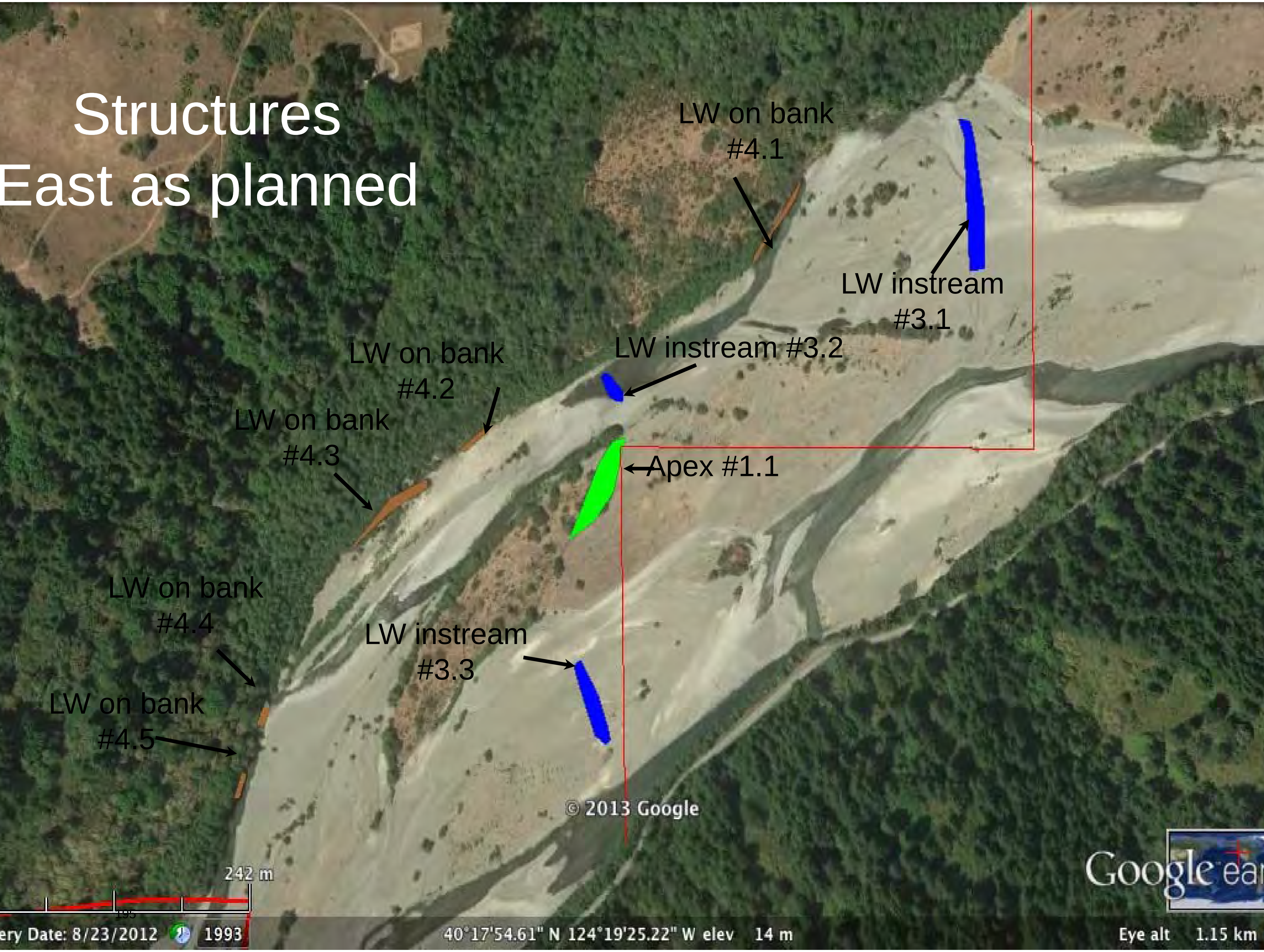

Structure #6
2010


The first apex jams
2010

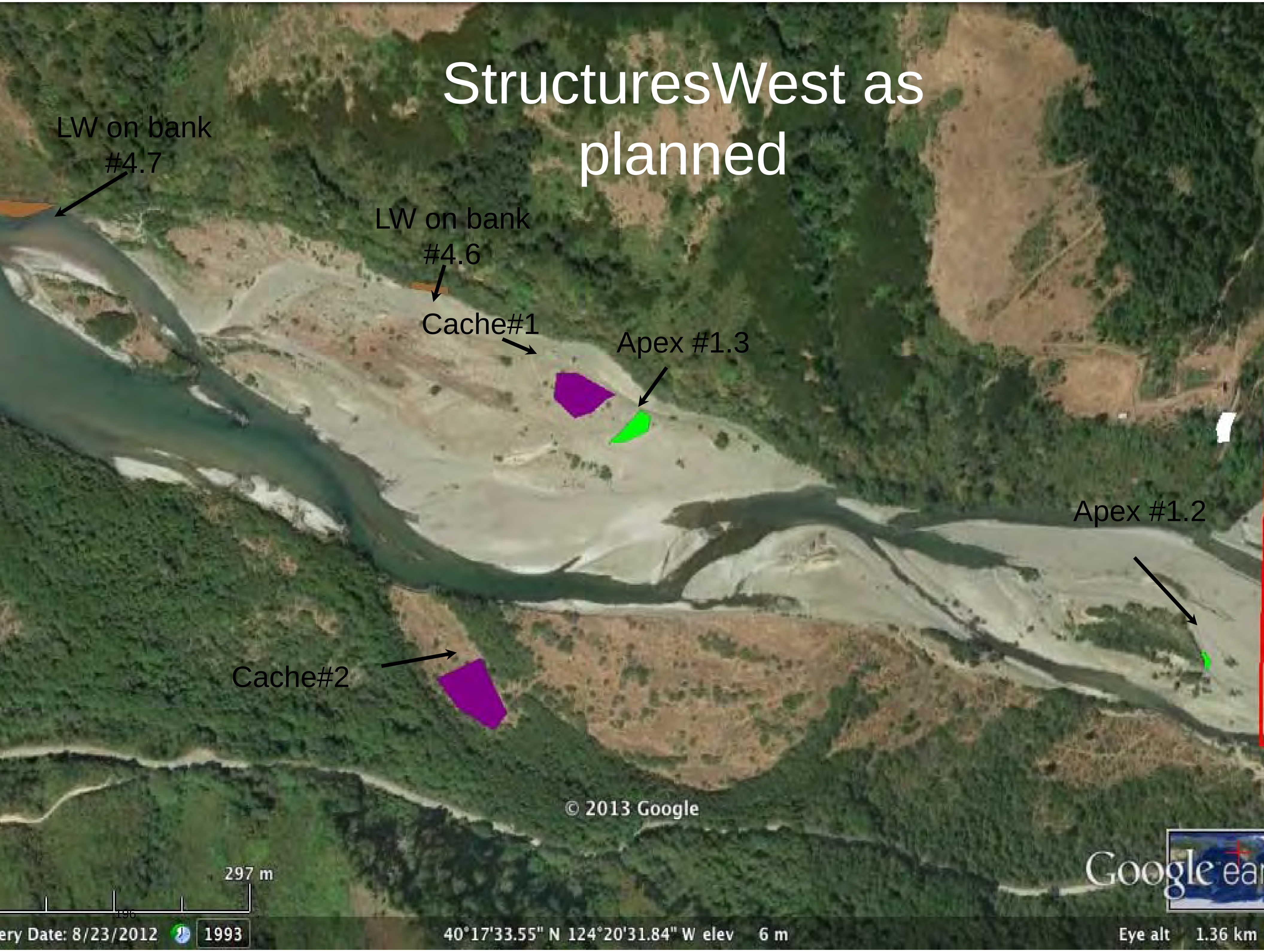

Structure #7
2011


#1
#2
#3
#4
#5
#6
#7

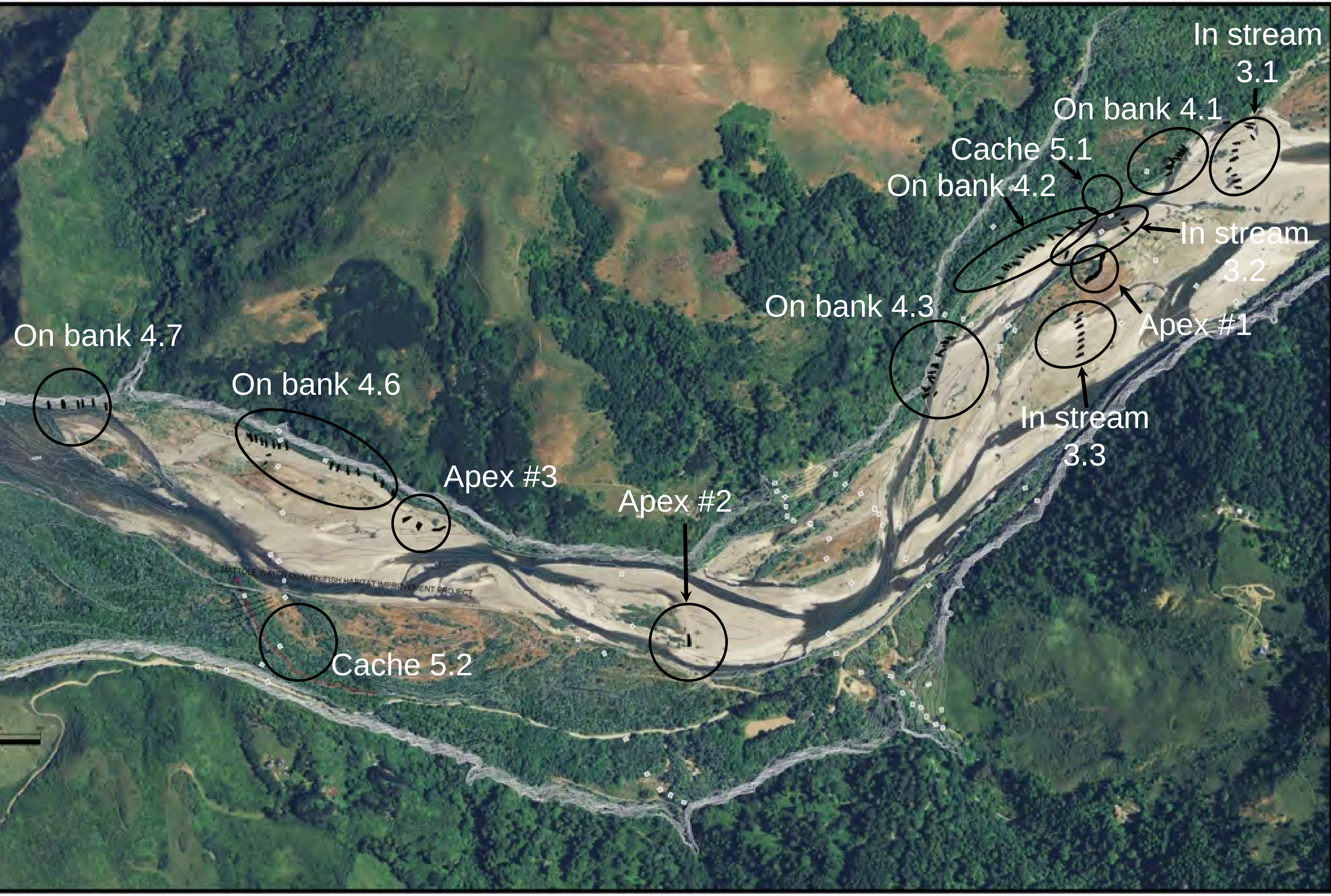

Heliwood 2013
Tipped tree sites
East structure sites
West structure sites
No Fly
© 2013 Google
Google earth
630 m
te: 8/23/2012
1993
40°17'38.34" N 124°20'13.77" W elev 86 m
Eye alt 2.73 km


Structures
East as planned
LW on bank
#4.1
LW instream
#3.1
LW instream #3.2
LW on bank
#4.2
LW on bank
#4.3
Apex #1.1
LW on bank
#4.4
LW instream
#3.3
LW on bank
#4.5
© 2013 Google
242 m
ery Date: 8/23/2012
1993
40°17'54.61" N 124°19'25.22" W elev 14 m
Eye alt 1.15 km

StructuresWest as planned




Apex #1-3
2013


In stream 3.1
On bank 4.1
Cache 5.1
On bank 4.2
In stream 3.2
On bank 4.3
Apex #1
On bank 4.7
On bank 4.6
In stream 3.3
Apex #3
Apex #2
Cache 5.2


N
W
E
S

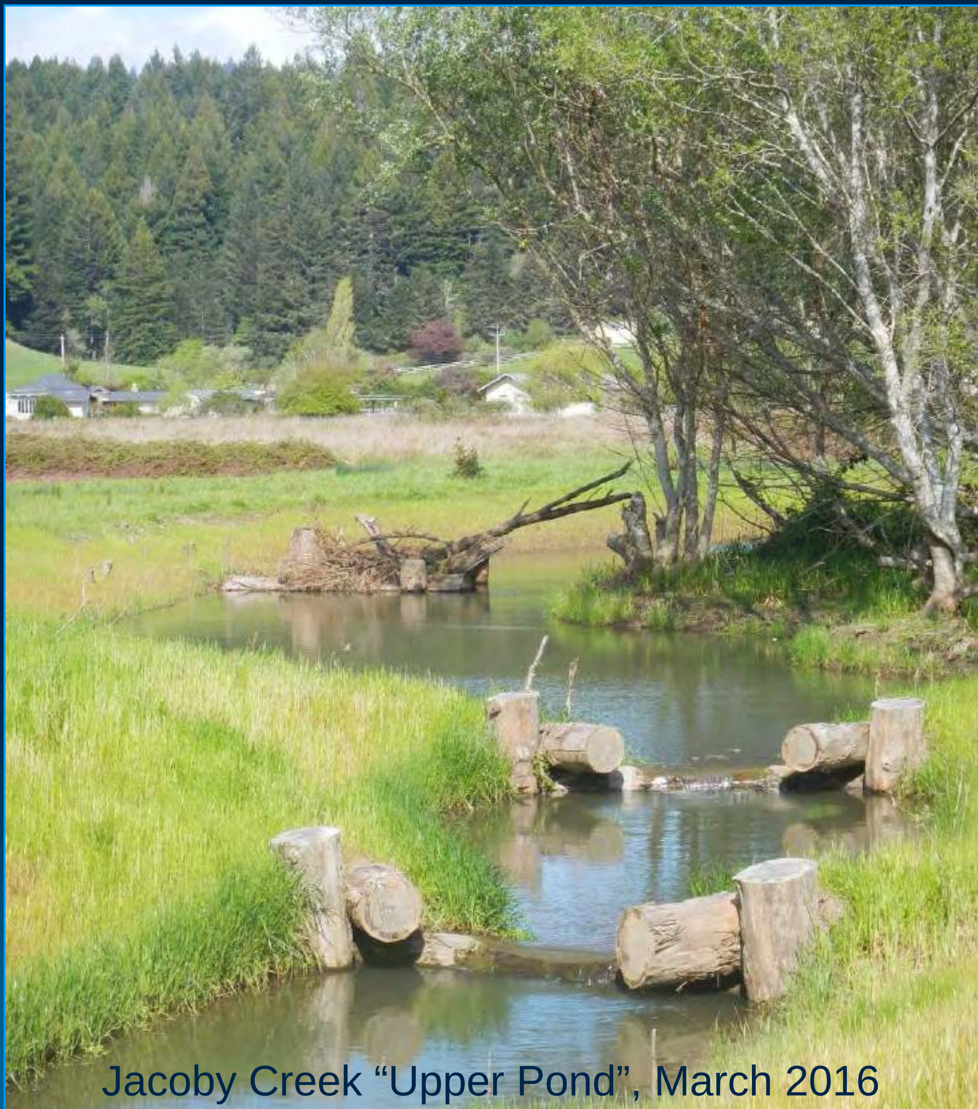

MATTOLE WATER QUALITY/FISH HABITAT IMPROVEMENT PROJECT
SCALE, ft
150
300
600

MATTOLE ESTUARY RESTORATION PROJECT HELIWOOD MOVEMENT 3/14 &10/14

Slough Excavation

Revegetation

Jacoby Creek Off-Channel Ponds: Site Characterization, Design, and Construction


Jacoby Creek "Upper Pond", March 2016

Michael Love P.E.
Antonio Llanos P.E.

Michael Love & Associates, Inc.
Arcata, California

Jacoby Creek Land Trust

Michael Love & Associates
Hydrologic Solutions

California Department of Fish & Wildlife

Pacific Watershed Associates

Pacific Coast Fish, Wildlife & Wetlands Restoration Association

California Conservation Corps Est. 1976

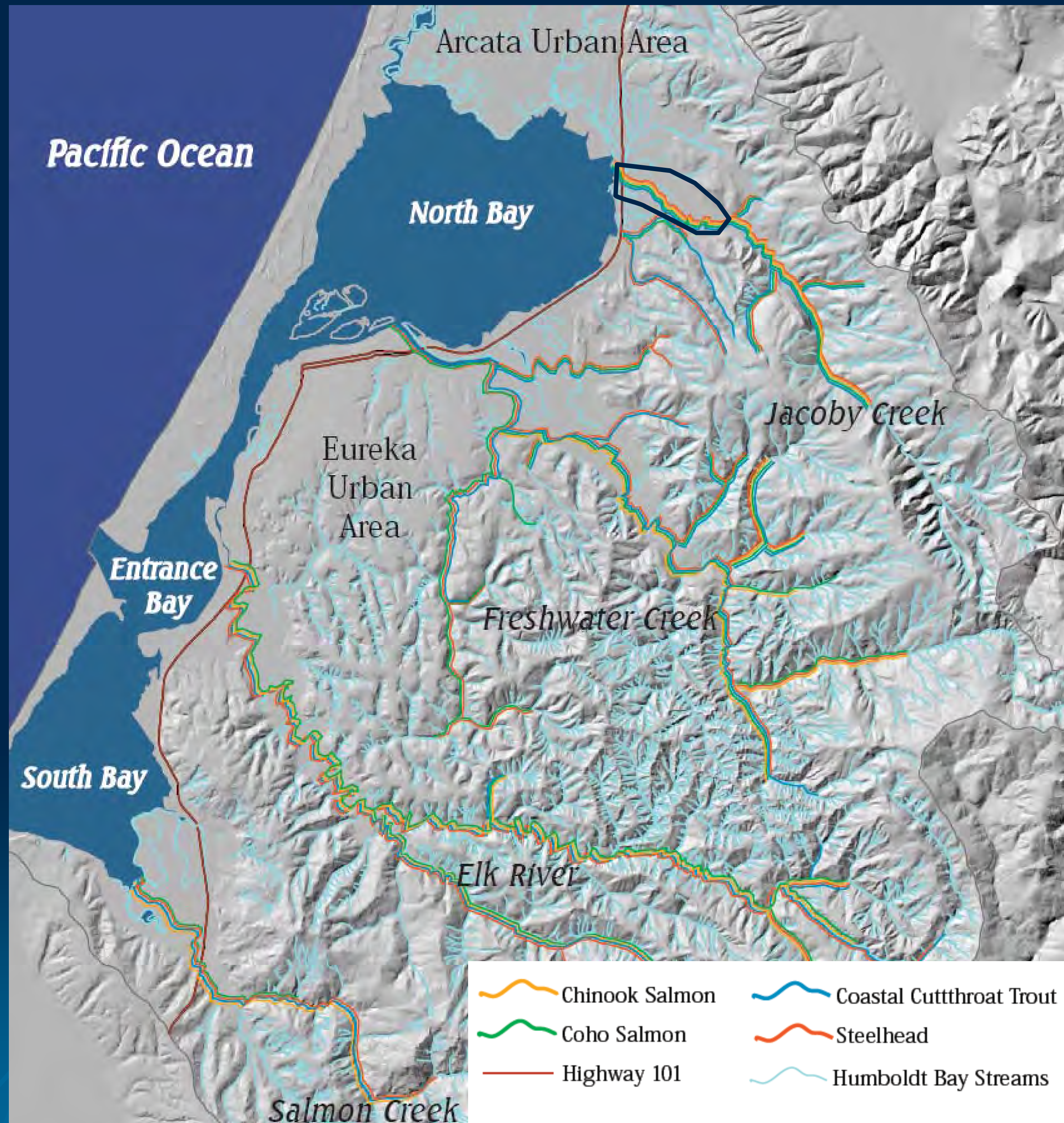
Wallace Structures

Presentation Overview

1. Site Overview and Project Objectives
2. Site Characterizations
3. Biological Criteria and Considerations
4. Design Development
5. Construction
6. Post-Project Physical Monitoring

The Barntini Fundraiser
at Jacoby Creek Land Trust

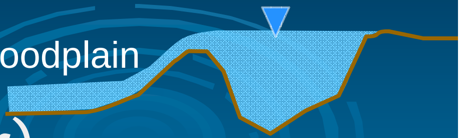
Jacoby Creek
A Key Humboldt Bay Tributary for Salmonids



Map from RCAA Natural Resources Services

Lower Jacoby Creek Floodplain

Channel/Floodplain Condition:



Perched channel (floodplain flows does not re-enter)

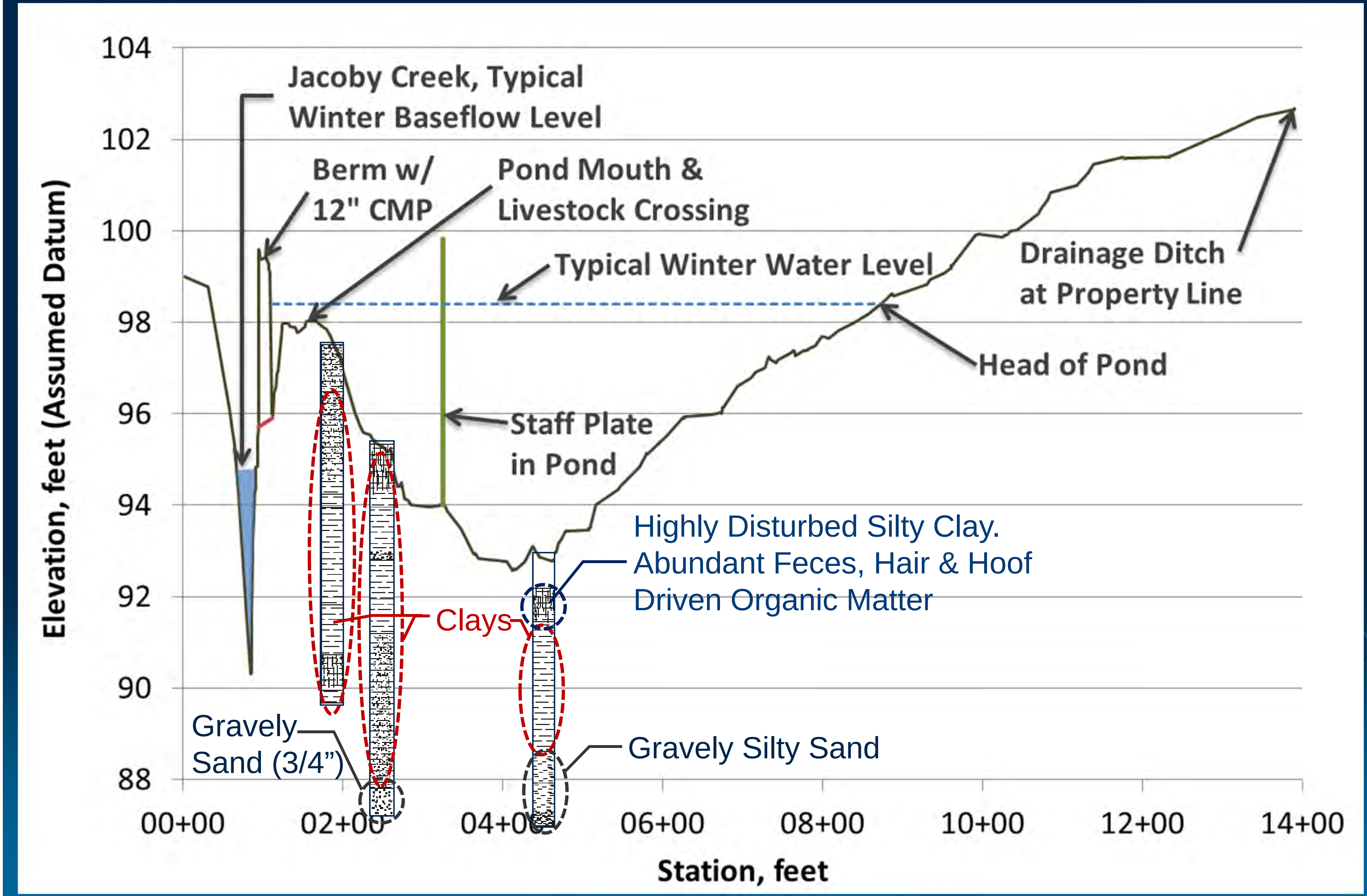
Oversimplified / Oxbows and Side-channels Disconnected

Jacoby Creek Pre-Project Conditions

Project Goals and Objectives

- Improve access for juvenile salmonids to existing Lower Pond site to provide over-wintering off-channel habitat
- Create more persistent off-channel over-wintering habitat and provide juvenile salmonid access to this habitat

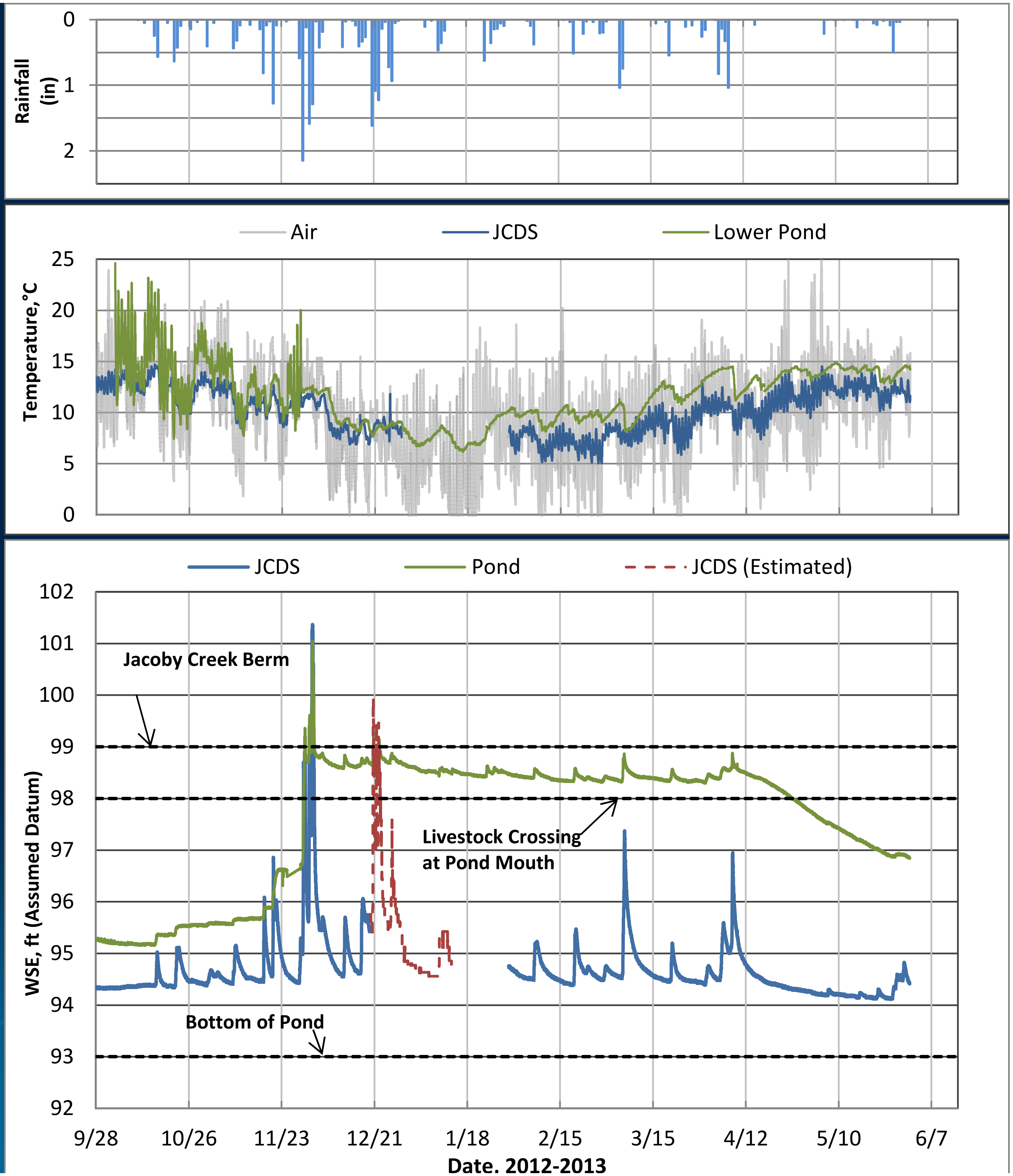
Jacoby Creek Lower Pond Site - Profile



Jacoby Creek Lower Pond Site

2012-2013 Monitoring

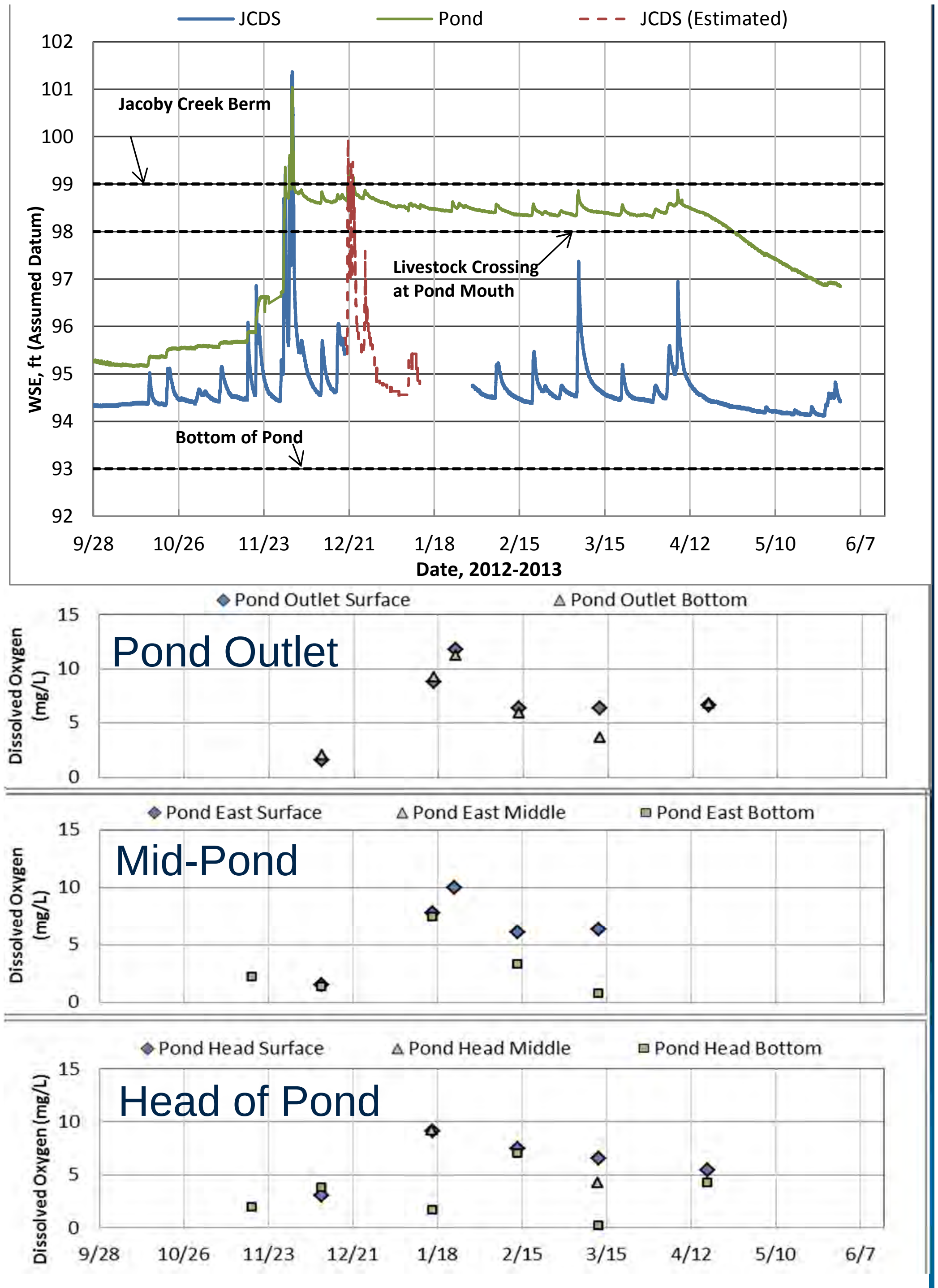
- Daily Rainfall
- Temperature
  - o Air
  - o Pond
  - o Jacoby Creek
- Water Levels
  - o Pond
  - o Jacoby Creek



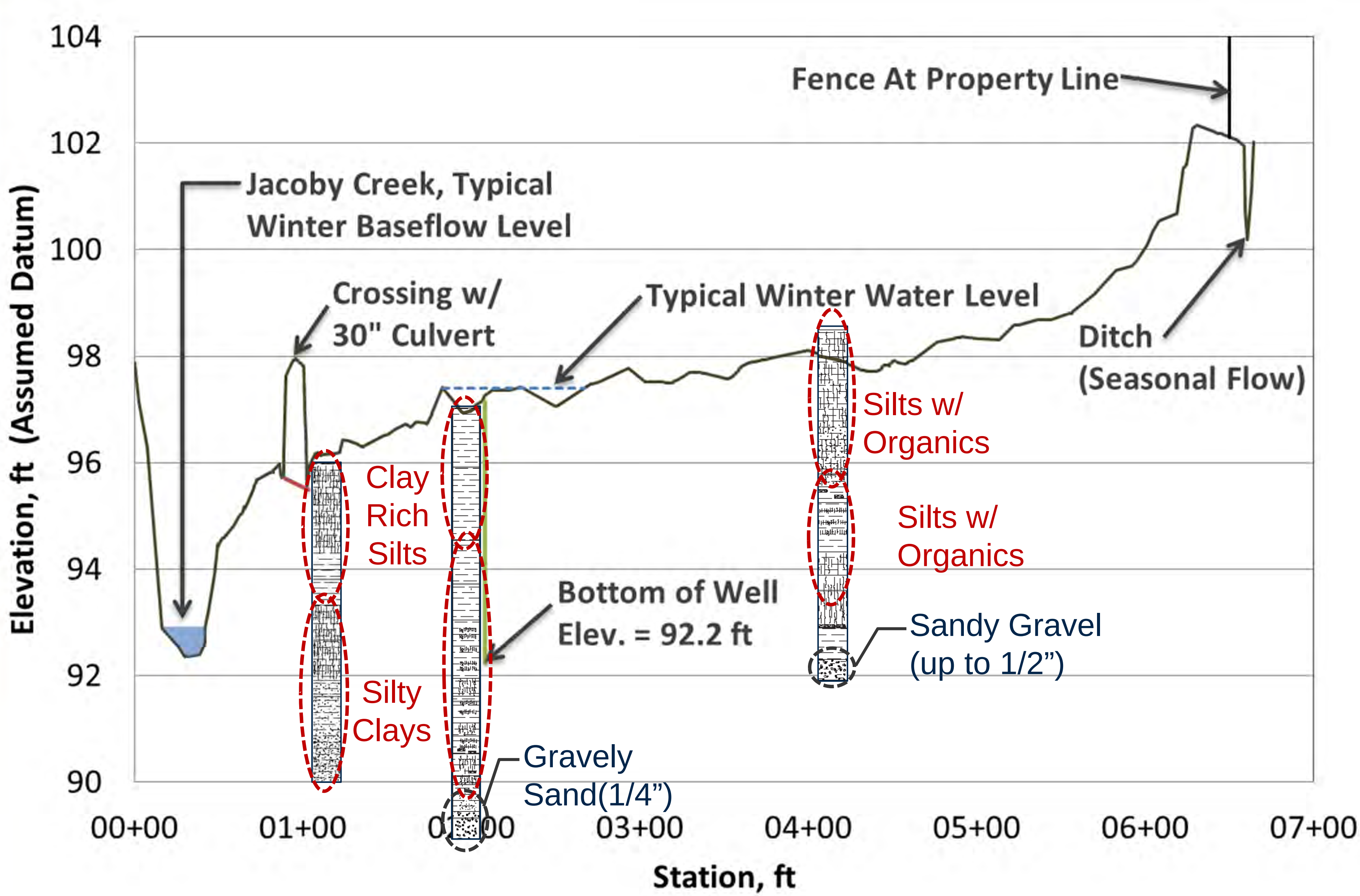
Jacoby Creek Lower Pond Site

DO Monitoring (CDFW)

- DO very low during dry season
- Required two backwater events and substantial rainfall to improve DO.
- DO remained low along pond bottom



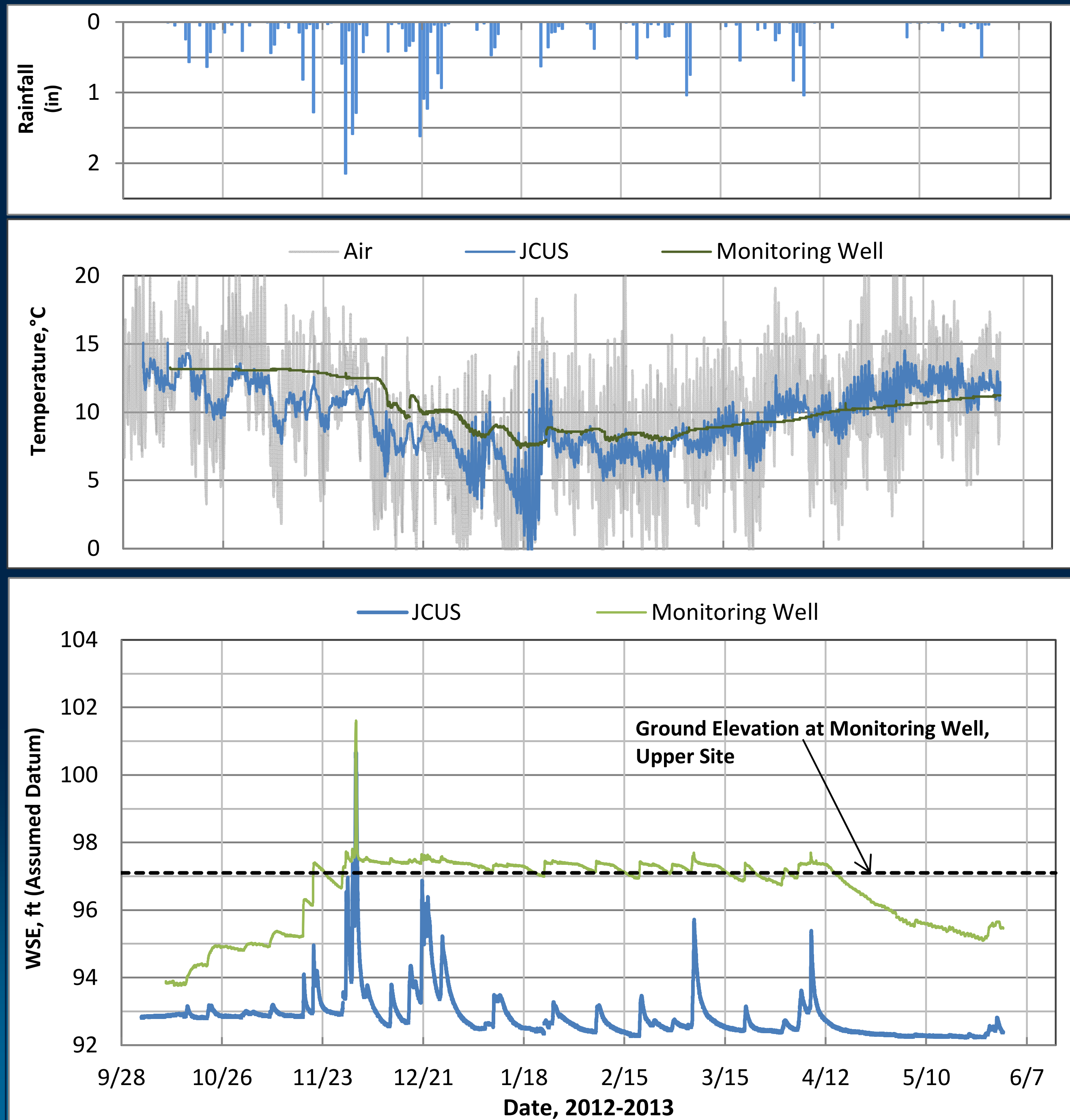
Jacoby Creek Upper Pond Site - Profile



Jacoby Creek Upper Pond Site

2012-13 Monitoring

- Daily Rainfall
- Temperature
  - Air
  - Monitoring Well
  - Jacoby Creek
- Water Levels
  - Monitoring Well
  - Jacoby Creek



Biological Objectives and Considerations

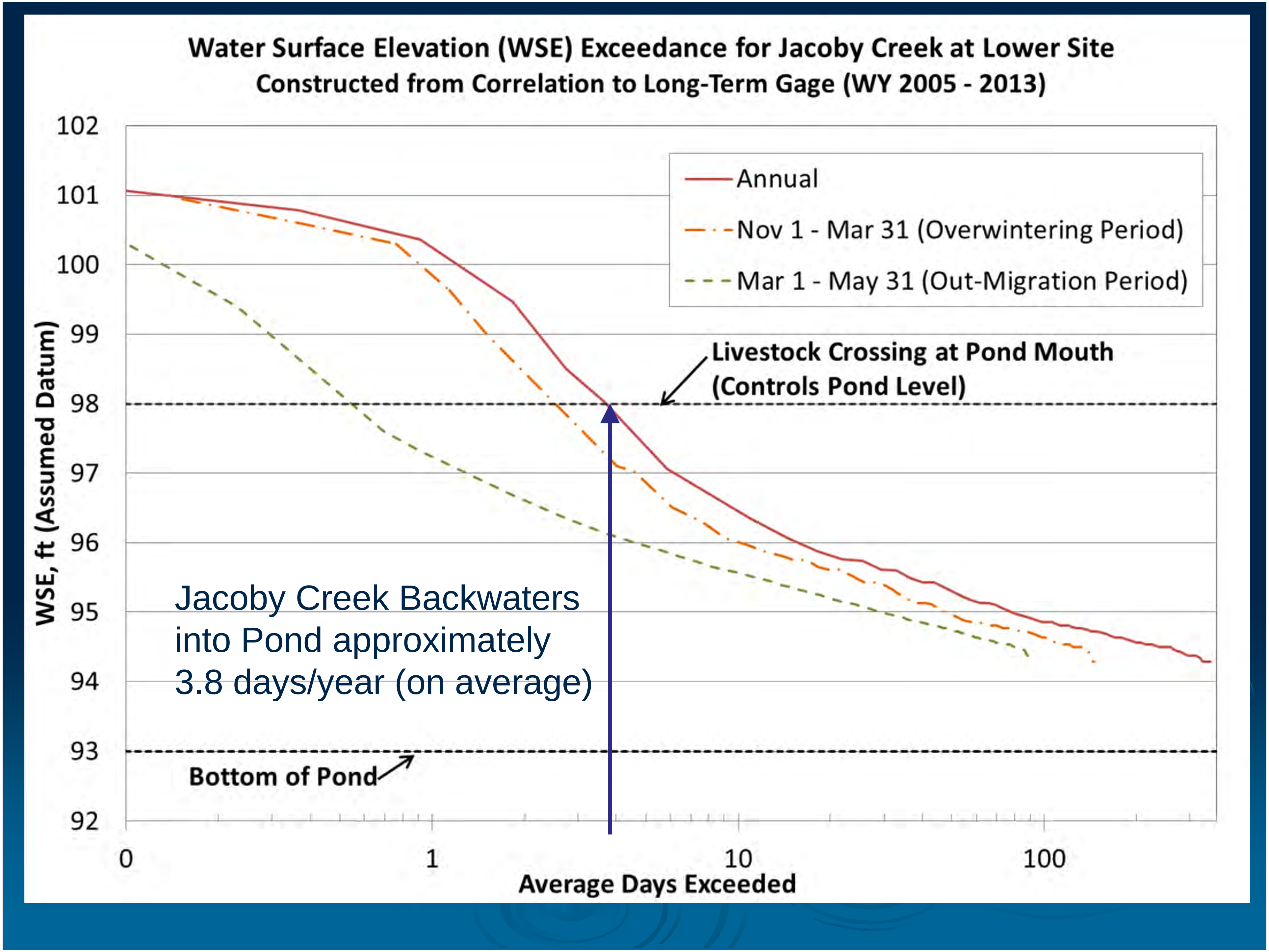
Developed by Technical Advisory Group

- Focus on overwintering refugia for juvenile salmonids
  - Overwintering Period: Nov. 1 – Mar. 31 (juvenile winter foraging)
  - Out-Migration Period: Mar. 1 – May 31 (smolts on way to tidal waters)
  - "Ponds" do not need to be suitable for summer habitat
- Provide fish access to ponds during high flows in Jacoby Creek.
  - Access 10 to 15 days per year is sufficient
  - Access during winter baseflow conditions is not necessary
  - Provide for out-migration
- Suitable rearing conditions for Humboldt Bay Trib.
  - Temperatures less than 17° C (Wallace, 2007)
  - DO as low as 5 to 6 mg/l
  - Minimum water depth set at 2 feet for rearing
- Will juvenile salmonids leap over log weirs to access a pond?

Other Considerations

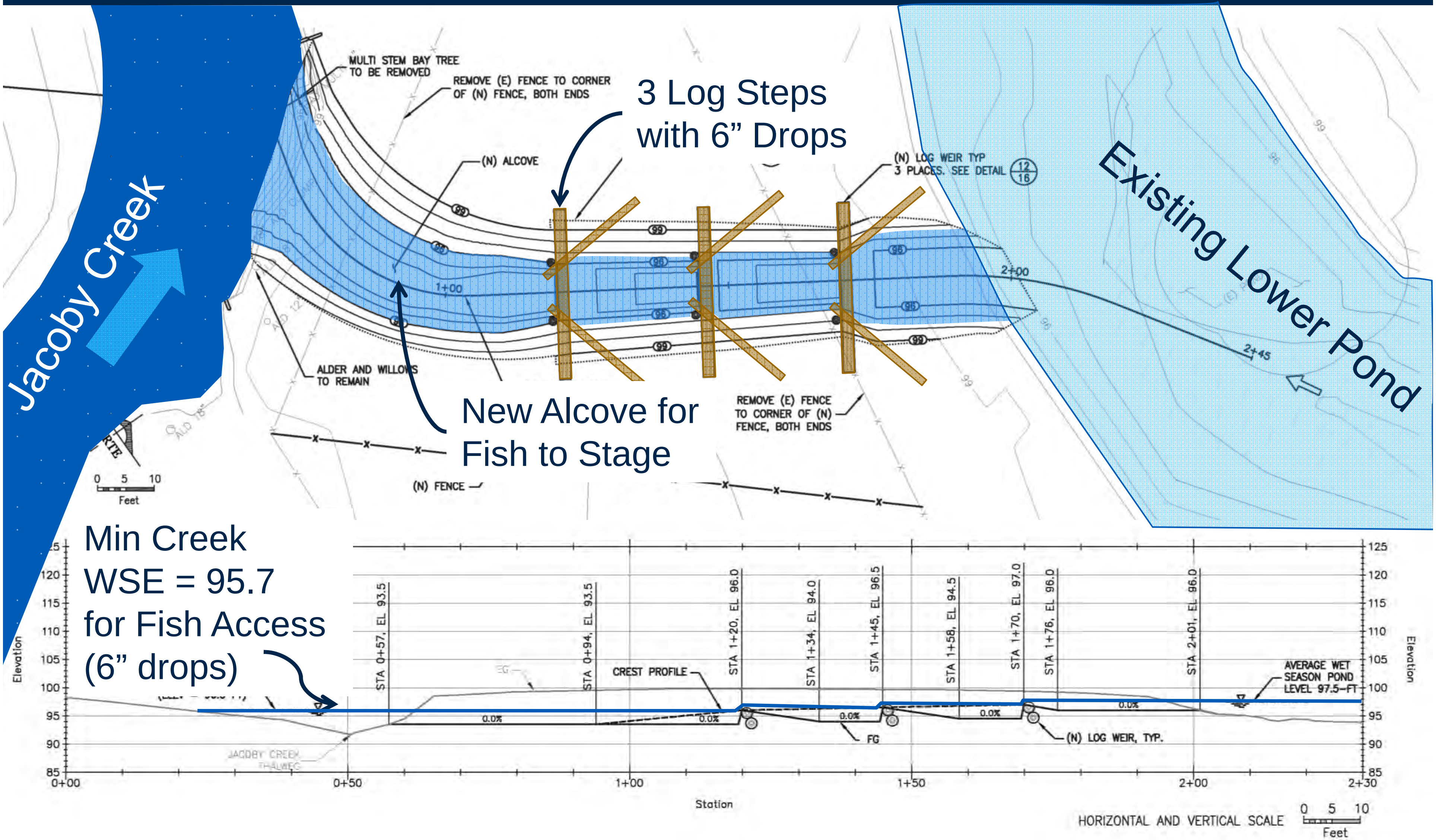
Developed by Technical Advisory Group

- Avoid increasing FEMA Base Flood Elevations (real and perceived)
- Avoid creating new Bullfrog habitat (no new perennial ponds)
- Preserve existing Lower Pond Waterfowl Habitat Value
- Anchor all wood to resist buoyancy and drag
- Reliability of Future In-Flow from Existing Ditches
    - Contributing "ditches" considered watercourses and under jurisdiction of CDFW.
    - Landowners would require 1600 permit to modify

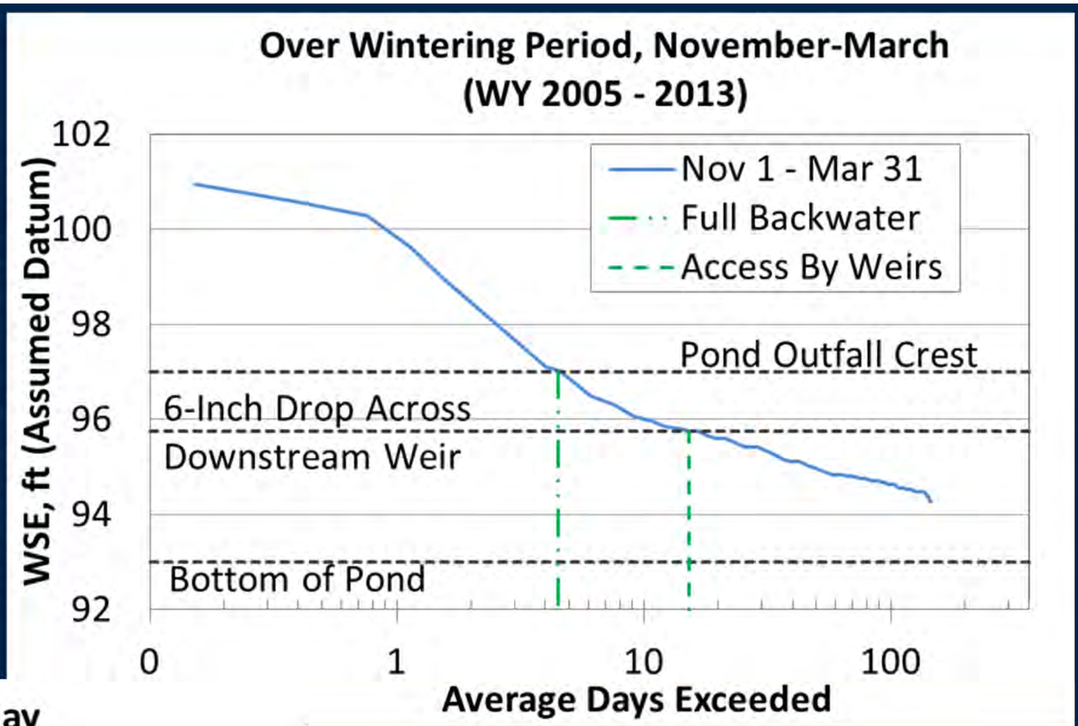

Water Surface Elevation (WSE) Exceedance for Jacoby Creek at Lower Site
Constructed from Correlation to Long-Term Gage (WY 2005 - 2013)
WSE, ft (Assumed Datum)
102
101
100
99
98
97
96
95
94
93
92
0
1
10
100
Average Days Exceeded
Annual
Nov 1 - Mar 31 (Overwintering Period)
Mar 1 - May 31 (Out-Migration Period)
Livestock Crossing at Pond Mouth
(Controls Pond Level)
Jacoby Creek Backwaters
into Pond approximately
3.8 days/year (on average)
Bottom of Pond

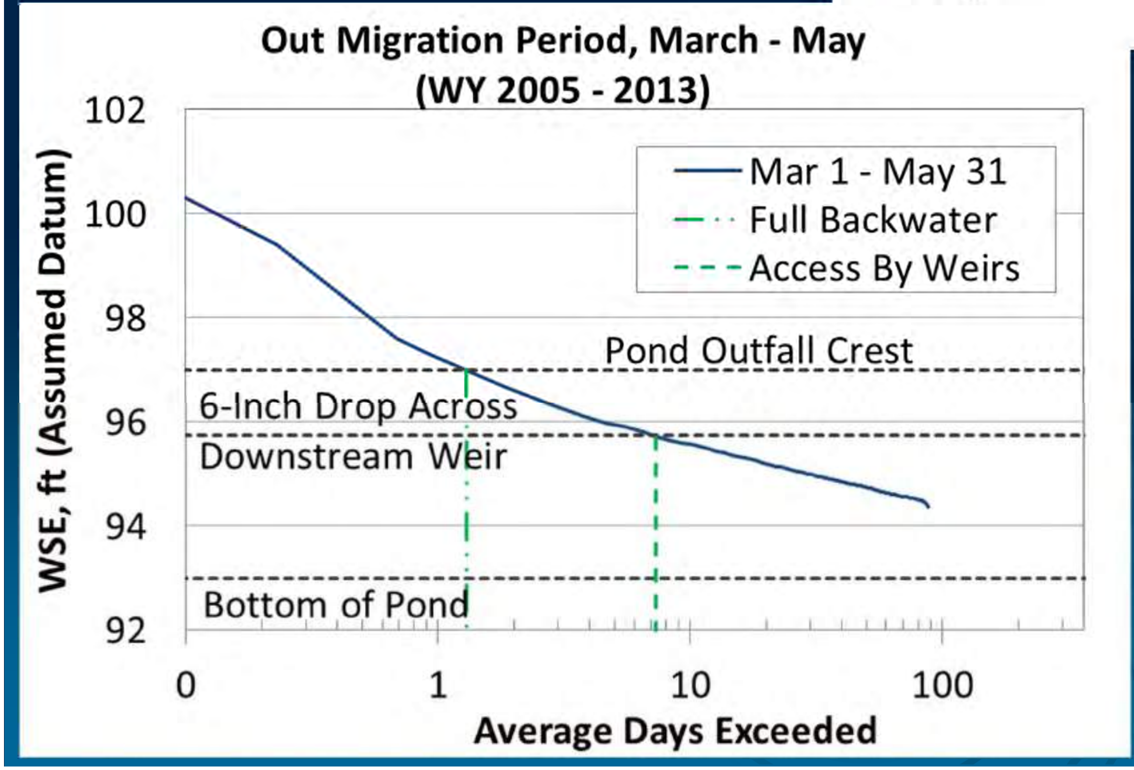
Lower Pond Fish Access

Proposed Design



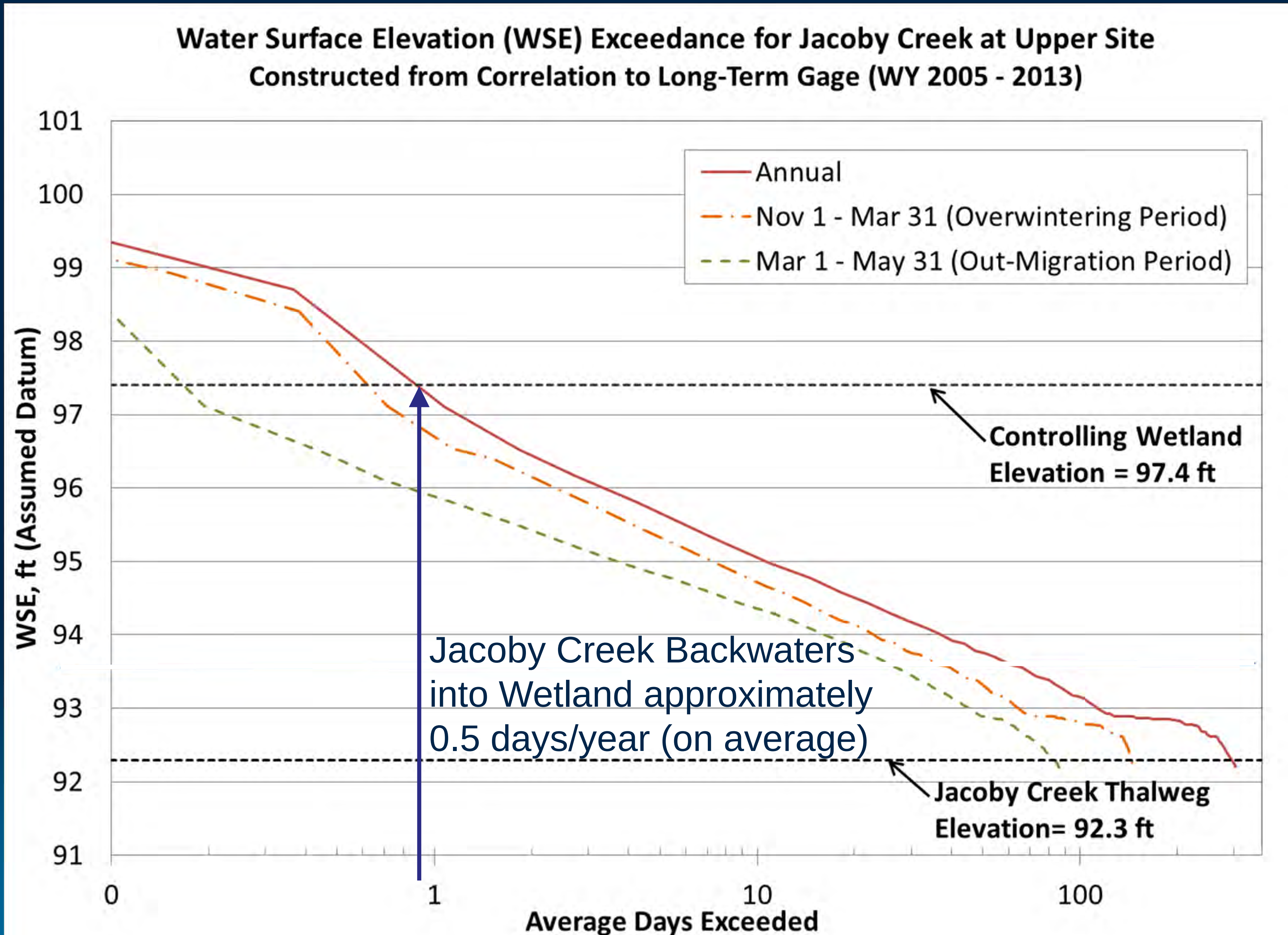
Lower Pond
Fish Access
Proposed Design



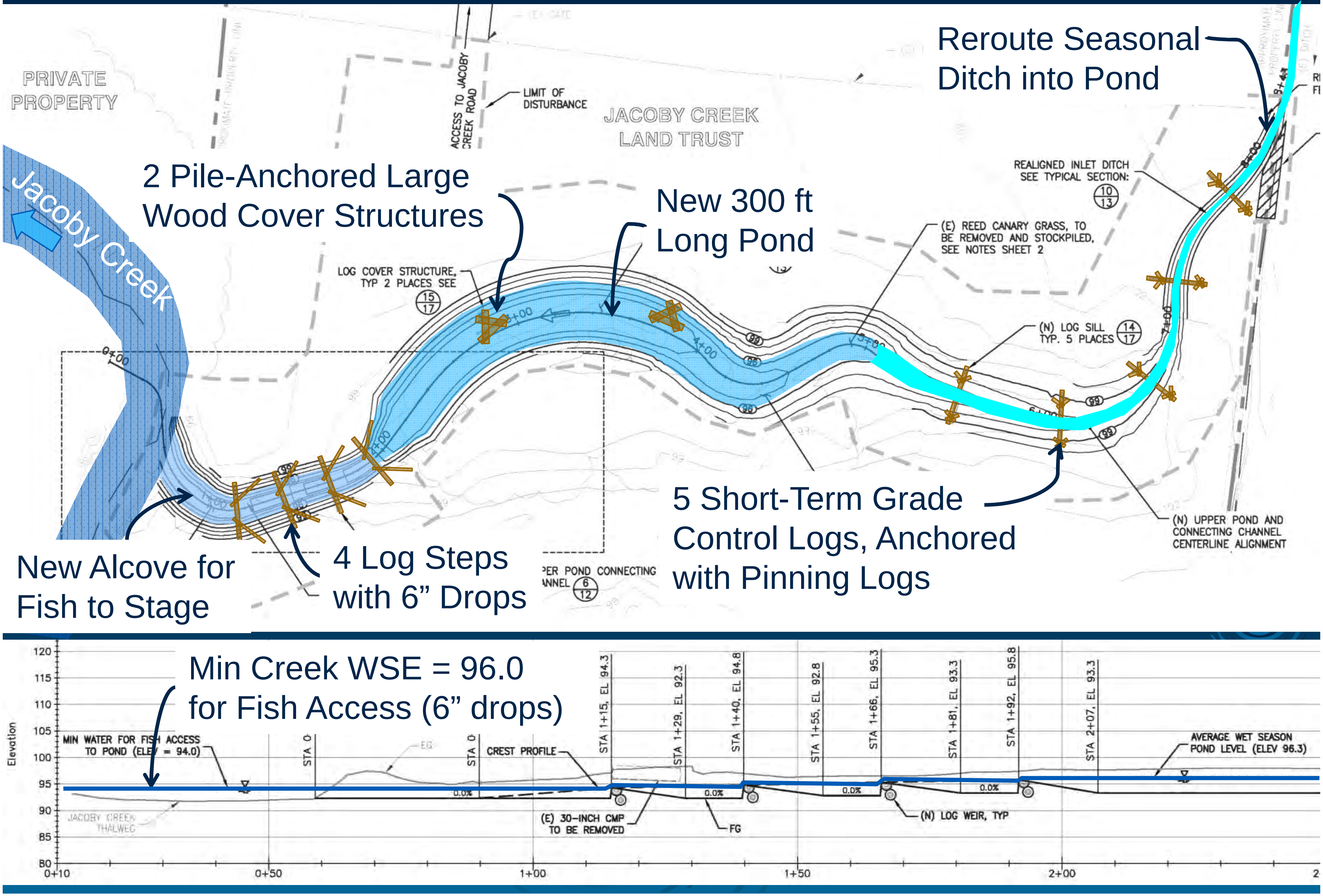


Lower Pond Characteristics & Fish Access

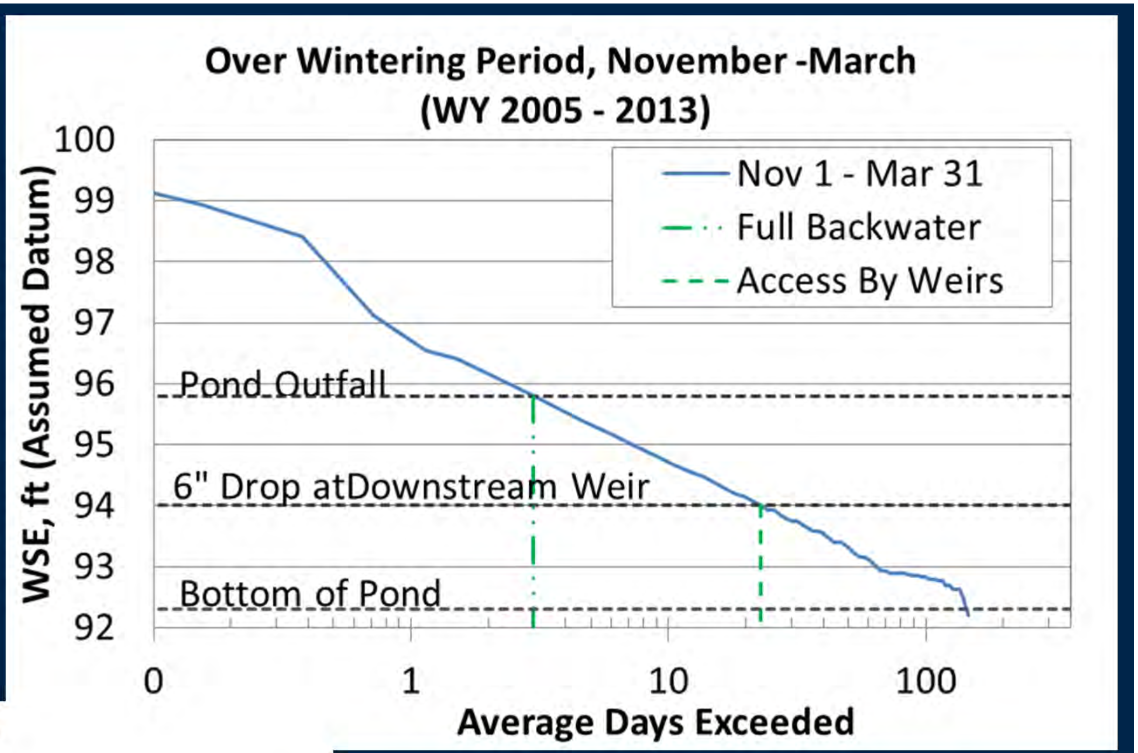
Metric	Existing Conditions	Proposed Conditions
Wetted Area of Pond (During Wet Season)	0.77 acres	0.55 acres
Maximum Residual Depth in Pond	5 feet	4 feet
Fenced Riparian Area	4.6 acres	5.0 acres
Average Annual Duration of Jacoby C. Backwatering into Pond	3.7 days	6.5 days
Number of Backwatering Events per Year	Average: 6 Min: 1 Max: 13	Average: 8 Min: 3 Max: 16
Annual Fish Access	3.7 days	28 days
Fish Access During Overwintering Period (Nov. 1 – Mar. 31)	2.3 days	15.2 days
Fish Access During Out-Migration Period (Mar. 1 – May. 31)	<1 days	7.4 days

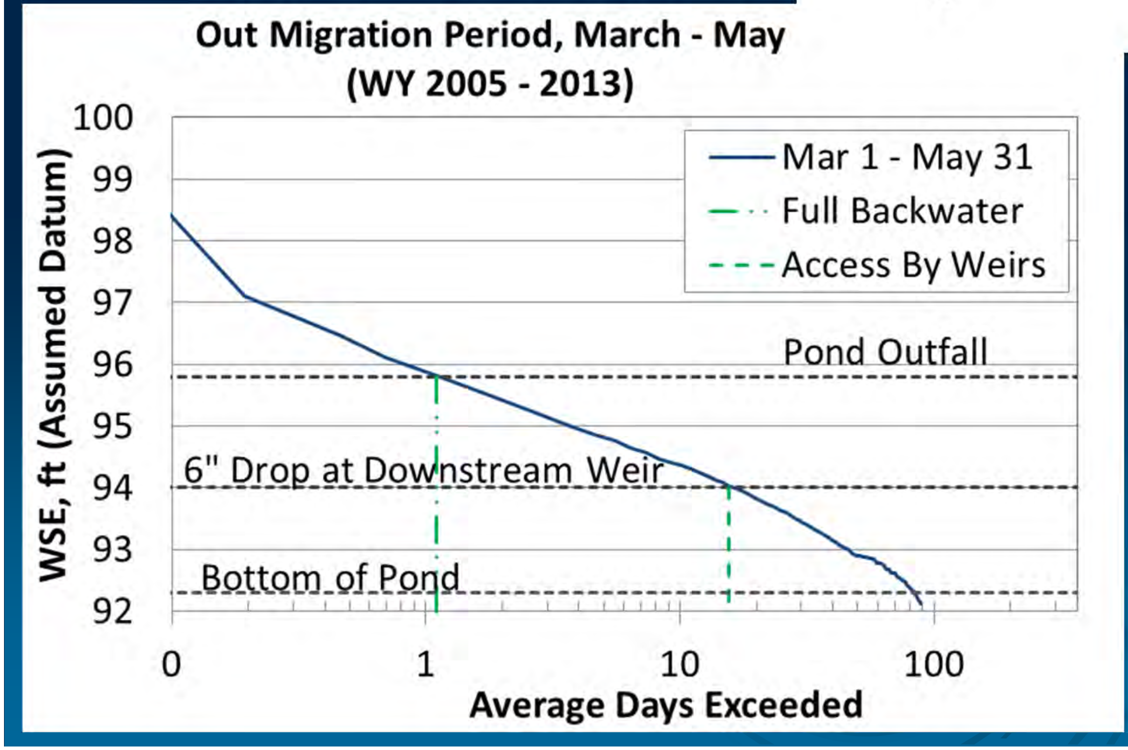

Water Surface Elevation (WSE) Exceedance for Jacoby Creek at Upper Site
Constructed from Correlation to Long-Term Gage (WY 2005 - 2013)
WSE, ft (Assumed Datum)
101
100
99
98
97
96
95
94
93
92
91
0
1
10
100
Average Days Exceeded
Annual
Nov 1 - Mar 31 (Overwintering Period)
Mar 1 - May 31 (Out-Migration Period)
Controlling Wetland Elevation = 97.4 ft
Jacoby Creek Thalweg Elevation= 92.3 ft
Jacoby Creek Backwaters into Wetland approximately 0.5 days/year (on average)

Upper Pond - Proposed Design



Upper Pond Fish Access
Proposed Design

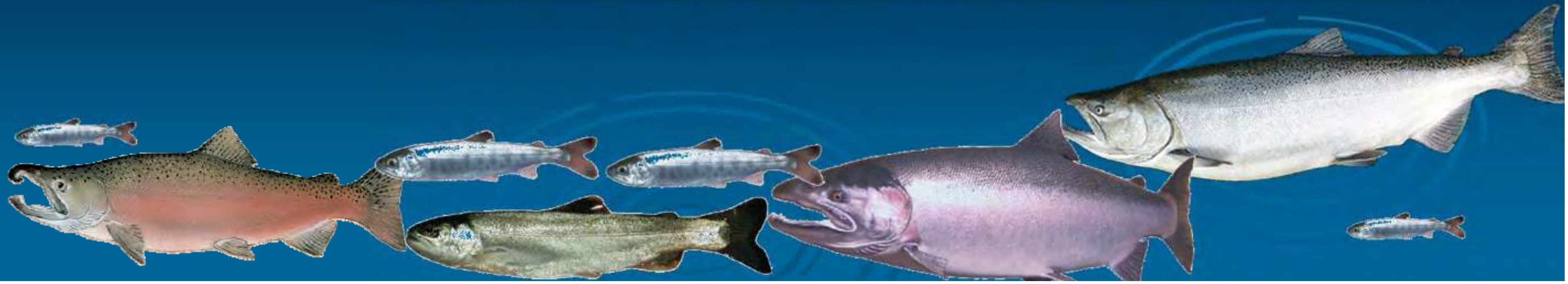




Upper Pond Characteristics & Fish Access

Metric	Existing Conditions	Proposed Conditions
Wetted Area of Pond (During Wet Season)	0.05 acres	0.18 acres
Maximum Residual Depth in Pond	0.4 feet	2.5 feet
Average Annual Frequency of Fish Access	< 1 day	36 days
Frequency of Jacoby Creek Backwatering into Pond (Ave. Annual)	<1 day	4.3 days
Number of Backwatering Events per Year	Average: 3 Min: 0 Max: 6	Average: 5 Min: 1 Max: 12
Fish Access During Overwintering Period (Nov. 1 – Mar. 31)	0.7 days	22.8 days
Fish Access During Out-Migration Period (Mar. 1 – May. 31)	0.2 days	15.6 days

Constructed Project Aerial Video



Channel Surfing by Juvenile Salmonids:

Fish and water quality responses to off channel habitat restoration projects in the stream-estuary ecotone of Humboldt Bay, CA

Michael Wallace
California Department of Fish and Wildlife

Image by Ray Troll

Stream-Estuary Ecotone: Loss of Channel Complexity



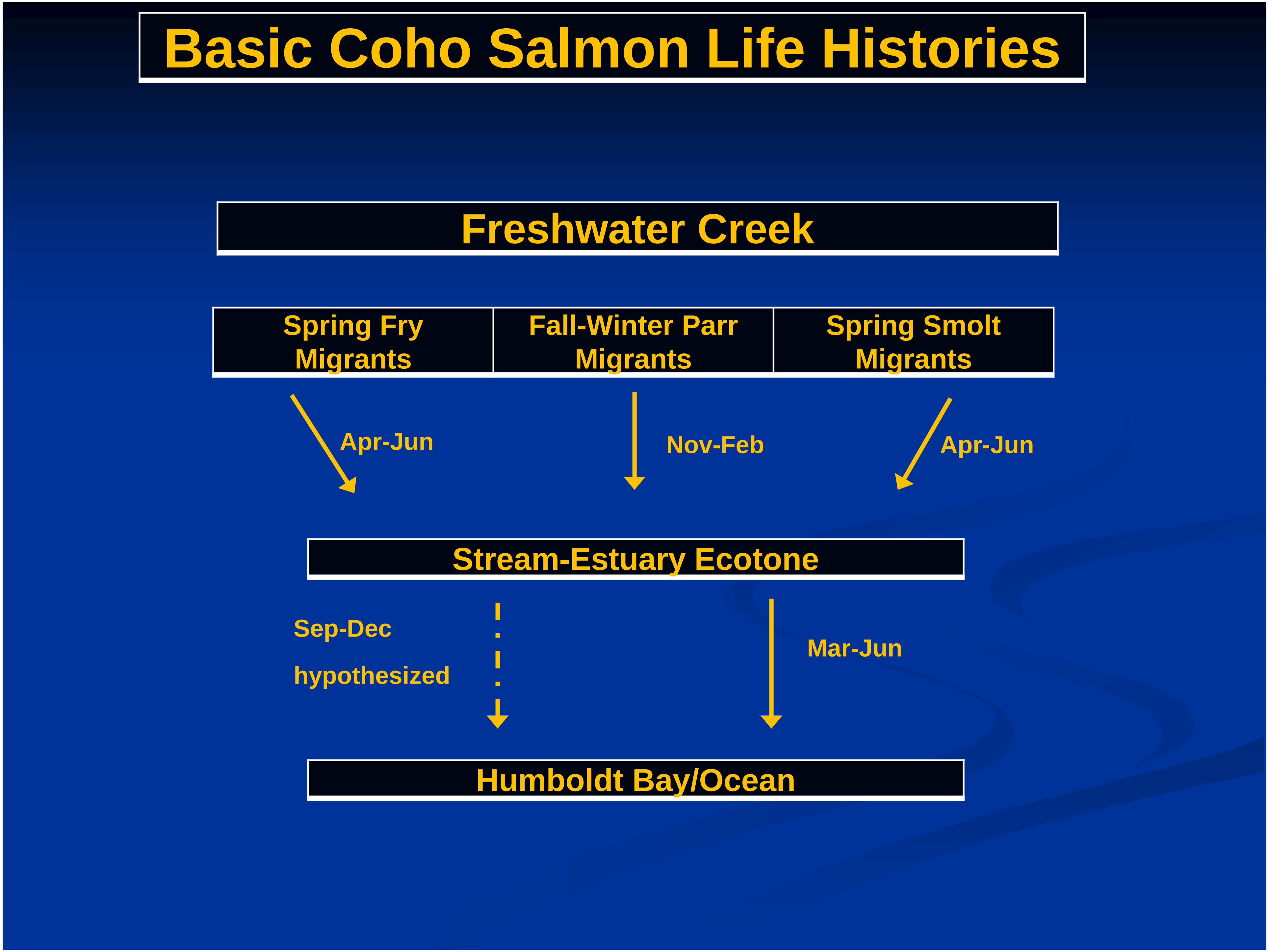


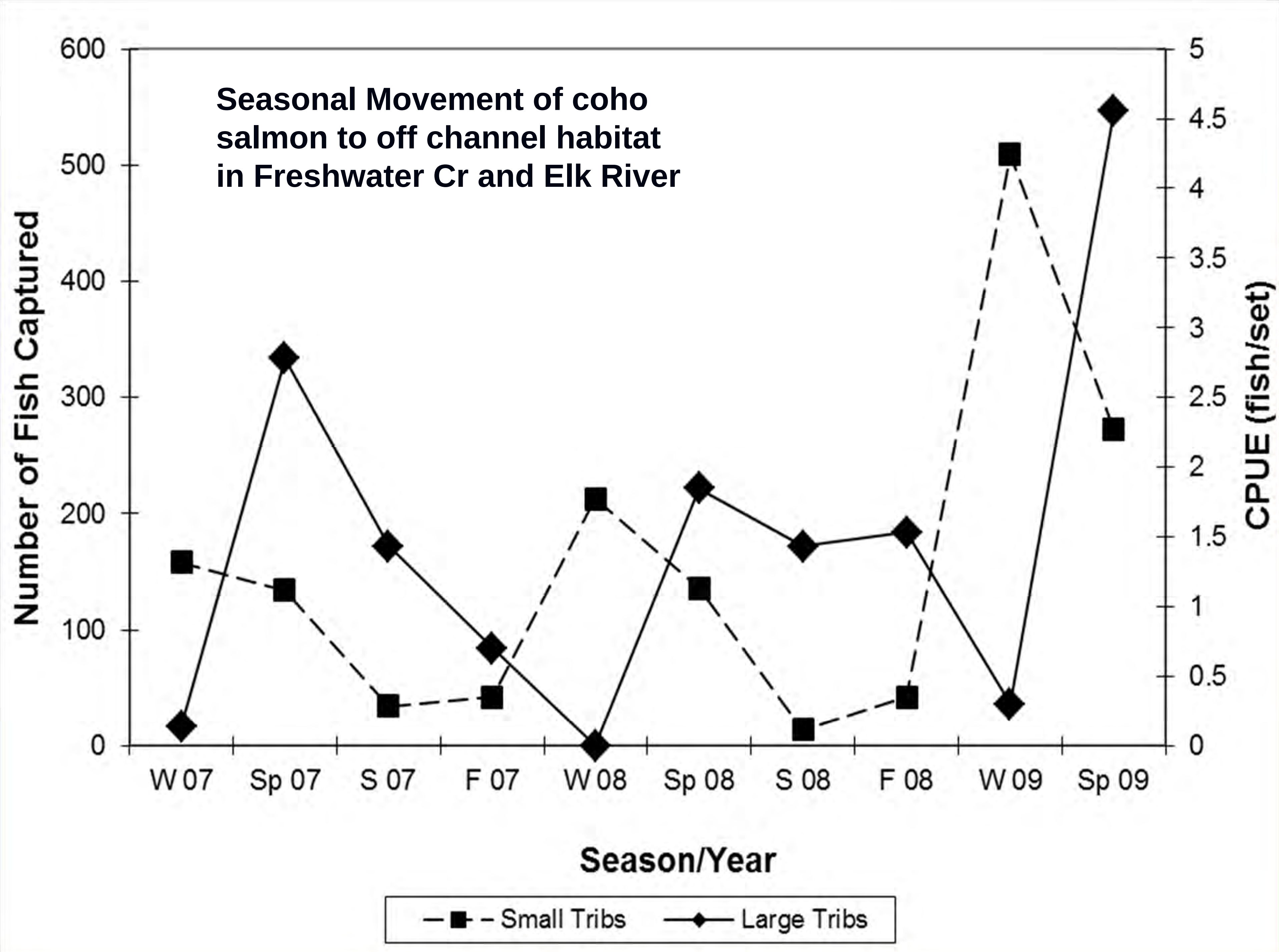


We’ve done the Science!

Stream-estuary ecotone importance

- Prolonged residence
- Used by multiple life stages
- Good growth/survival
- Substantial portion of population uses habitat
- Provides habitat during stressful periods


Basic Coho Salmon Life Histories
Freshwater Creek
Spring Fry Migrants
Fall-Winter Parr Migrants
Spring Smolt Migrants
Apr-Jun
Nov-Feb
Apr-Jun
Stream-Estuary Ecotone
Sep-Dec
hypothesized
Mar-Jun
Humboldt Bay/Ocean


Seasonal Movement of coho salmon to off channel habitat in Freshwater Cr and Elk River
Number of Fish Captured
CPUE (fish/set)
0
100
200
300
400
500
600
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
W 07
Sp 07
S 07
F 07
W 08
Sp 08
S 08
F 08
W 09
Sp 09
Season/Year
Small Tribs
Large Tribs

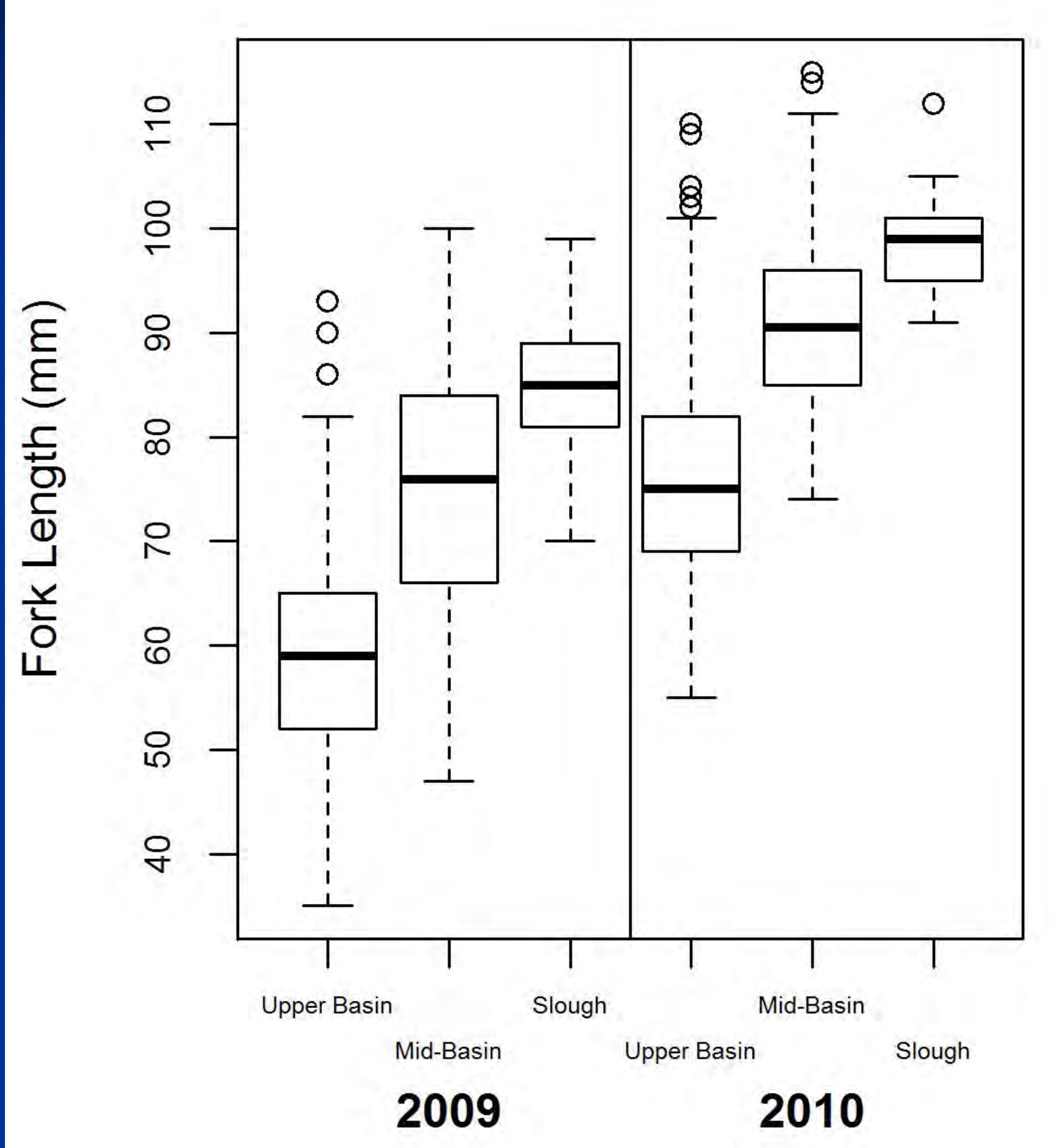
Salmon Creek March 21, 2012 **Water Quality Site**	**Depth (feet)**	**Water Temperature (° C)**	**Salinity (ppt)**	**Dissolved Oxygen (mg/l)**
Pond 1 (time 1020 hrs)				
West Transect				
surface	0.5	10.1	0.1	9.92
middle	2.3	10.0	0.1	9.25
bottom	4.5	10.0	0.1	9.74
Pond 2 (time 1145 hrs)				
West Transect				
surface	0.5	10.7	0.1	7.98
middle	2.0	10.5	0.1	9.23
bottom	4.0	10.4	0.1	8.42
Pond 4 (time 1030 hrs)				
Inside Transect				
surface	0.5	10.3	0.1	9.13
middle	2.0	10.2	0.1	9.46
bottom	4.0	10.3	0.1	8.83
Salmon Creek July 26, 2012 **Water Quality Site**	**Depth (feet)**	**Water Temperature (° C)**	**Salinity (ppt)**	**Dissolved Oxygen (mg/l)**
Pond 1 (time 1115 hrs)				
West Transect				
surface	0.5	18.5	19.2	6.15
middle	1.5	19.1	25.4	5.98
bottom	3.0	19.8	27.0	4.12
Pond 2 (time 1210 hrs)				
West Transect				
surface	0.5	19.7	16.5	6.79
middle	-	-	-	-
bottom	2.25	24.4	25.8	10.56
Pond 3 (time 1350 hrs)				
Inside Transect				
surface	0.5	18.9	15.5	7.32
middle	-	-	-	-
bottom	2.0	20.1	28.6	6.65


Photo by Thomas Dunklin


4


2
3
8
9

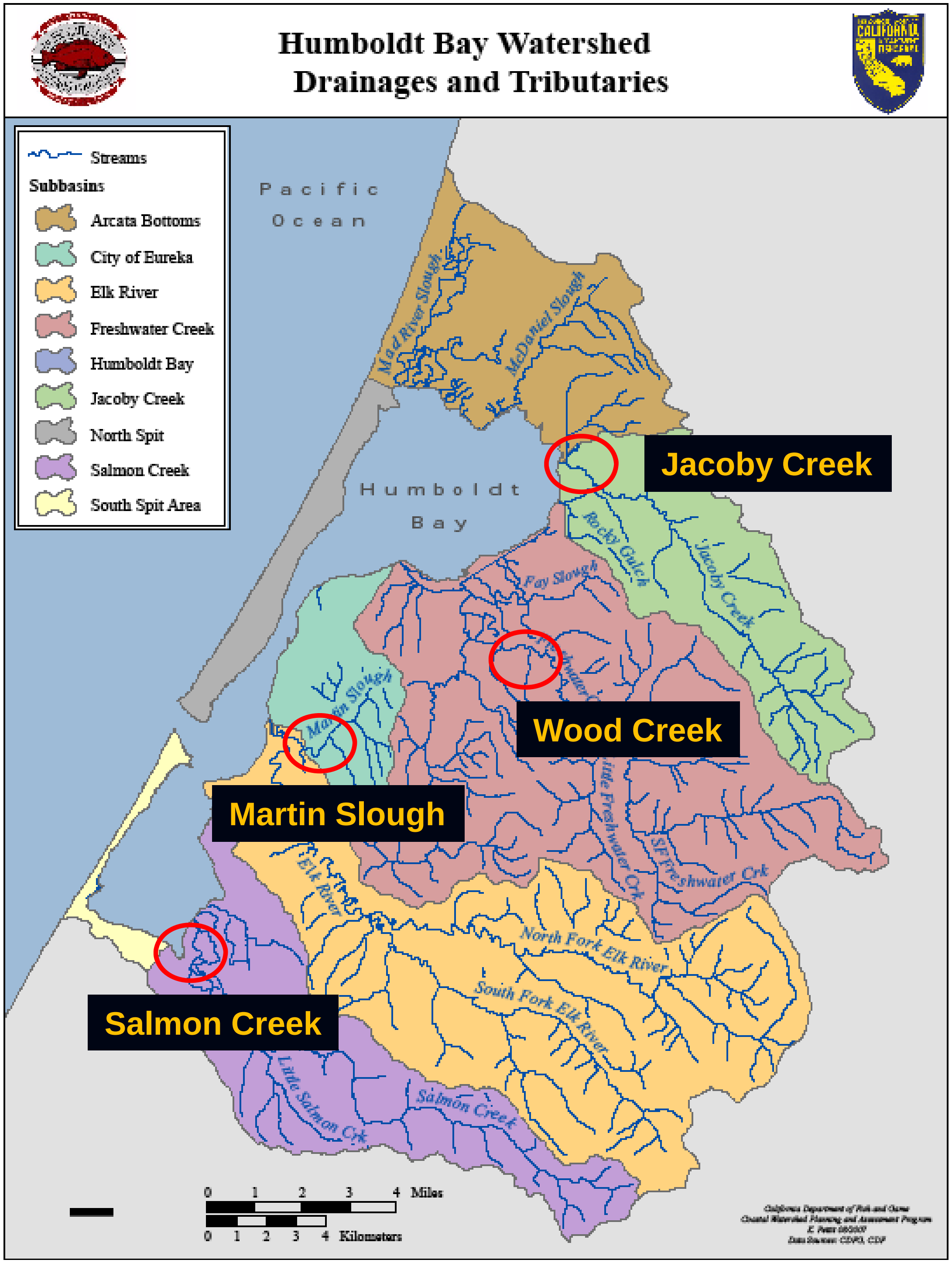
Size of Sub-Yearling Coho in the fall Freshwater Cr



Growth Rate of Juvenile Coho Salmon Ponds vs. Stream (Feb-May)

Location	Year	Pond Growth Rate	Stream Growth Rate
Wood Creek	2013-2015	0.39	0.28
Martin Slough	2015	0.48	0.21
Jacoby Creek	2016;14/15	0.28	0.12
Salmon Creek	2013-2015	0.82	n/a
Freshwater Sl	2013-2015	n/a	0.18-0.31
Ryan Slough	2013-2015	n/a	0.19-0.42

Estuarine Habitat Restoration


Humboldt Bay Watershed
Drainages and Tributaries
Streams
Subbasins
Arcata Bottoms
City of Eureka
Elk River
Freshwater Creek
Humboldt Bay
Jacoby Creek
North Spit
Salmon Creek
South Spit Area
Pacific Ocean
Humboldt Bay
Mad River Slough
McDaniel Slough
Jacoby Creek
Rocky Gulch
Fay Slough
Wood Creek
Martin Slough
Little Freshwater Crk
SF Freshwater Crk
Elk River
North Fork Elk River
South Fork Elk River
Salmon Creek
Little Salmon Crk
0 1 2 3 4 Miles
0 1 2 3 4 Kilometers


Martin Slough
Coho Habitat?

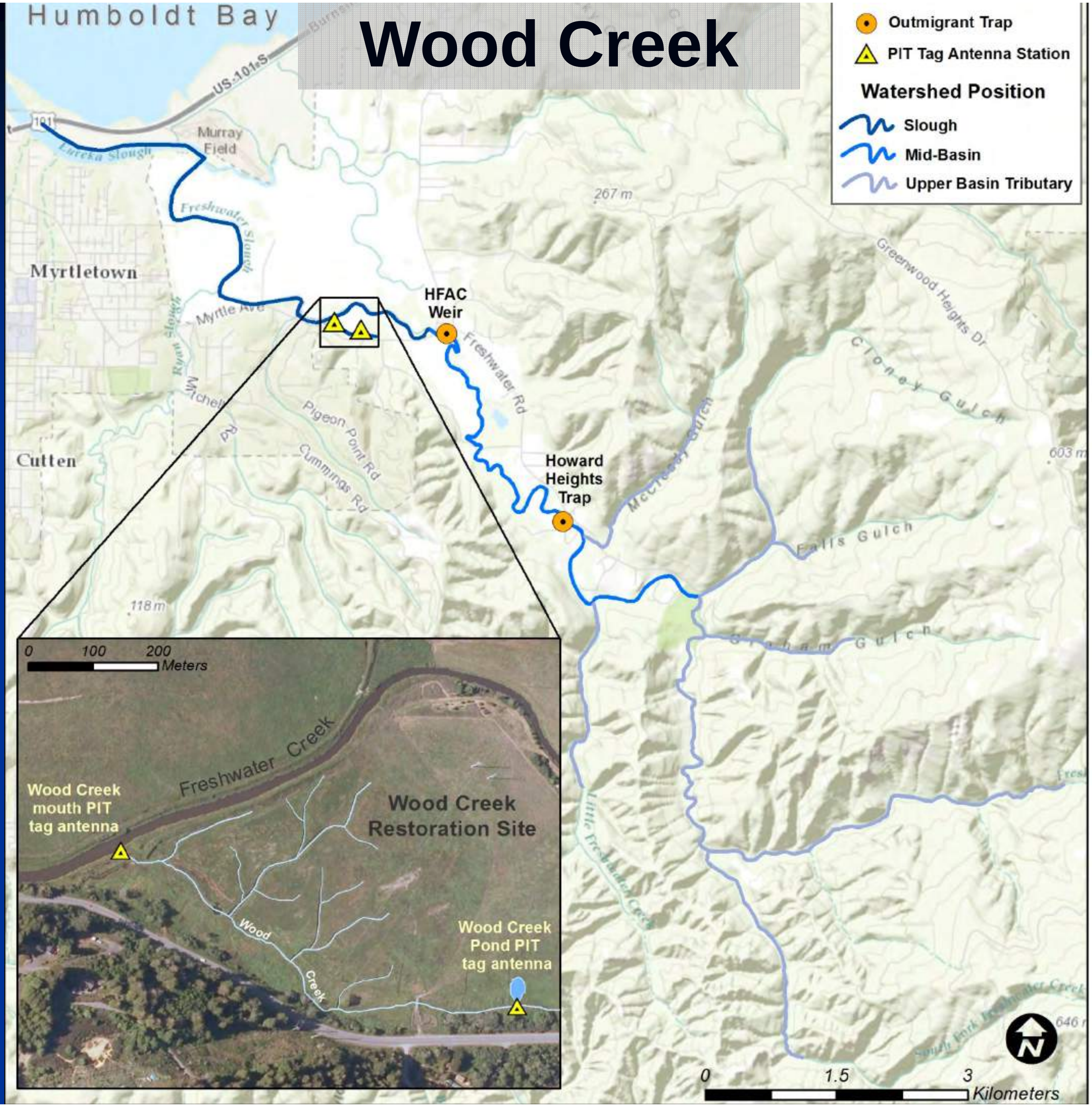
Martin Slough Pond




Catches of juvenile salmonids and TWG in Martin Sl, 2008-2016

Date	1+ Coho	0+ Coho	Steelhead	Cutthroat	TWG
Winter 2008	68	0	0	0	0
Spring 2008	70	0	0	5	0
Winter 2009	435	0	0	0	0
Spring 2009	246	1	1	11	0
Winter 2010	198	0	0	1	0
Spring 2010	83	0	0	3	0
Spring 2011	66	33	0	24	2
Summer 2011	0	97	0	19	158
Fall 2011	0	121	0	20	411
Winter 2012	553	0	0	6	25
Spring 2012	74	1	0	1	5
Winter 2013	80	0	1	0	46
Spring 2013	159	2	0	6	119
Summer 2013	0	0	0	1	0
Fall 2013	0	4	0	0	0
Spring 2014	10	0	0	7	189
Summer 2014	0	15	0	7	16
Fall 2014	2	1	0	0	132
Winter 2015	38	0	0	0	24
Spring 2015	51	0	1	5	157
Summer 2015	0	1	0	0	39
Fall 2015	0	6	2	1	82
Winter 2016	136	0	0	2	2

Wood Creek



Humboldt Bay
Outmigrant Trap
PIT Tag Antenna Station
Watershed Position
Slough
Mid-Basin
Upper Basin Tributary
Murray Field
Eureka Slough
Freshwater Slough
Myrtletown
Cutten
Myrtle Ave
Ryan Slough
Mitchell Rd
Pigeon Point Rd
Cummings Rd
HFAC Weir
Freshwater Rd
Howard Heights Trap
McCready Gulch
Greenwood Heights Dr
Cloney Gulch
Falls Gulch
Graham Gulch
Little Freshwater Creek
267 m
118 m
603 m
646 m
0 1.5 3 Kilometers
0 100 200 Meters
Freshwater Creek
Wood Creek mouth PIT tag antenna
Wood Creek Restoration Site
Wood Creek
Wood Creek Pond PIT tag antenna


2009
2010
Wood Creek Pond
2013
2014

Number of juvenile salmonids captured by season during opportunistic seining in Wood Creek Pond, January 2011 to December 2014. Winter is January-March, Spring is April-June, Summer is July-September, and Fall is October-December.

Date	1+ Coho	0+ Coho	Steelhead	Cutthroat
Winter 2011	11	1	0	1
Spring 2011	1	46	0	1
Summer 2011	0	0	0	0
Fall 2011	0	1	0	0
Winter 2012	211	0	1	0
Spring 2012	26	73	0	1
Summer 2012	0	2	0	0
Fall 2012	0	15	0	0
Winter 2013	61	0	0	0
Spring 2013	3	0	0	0
Summer 2013	0	0	0	0
Fall 2013	0	10	0	0
Winter 2014*	1	0	0	0
Spring 2014*	4	0	0	0
Summer 2014*	0	0	0	0
Fall 2014*	0	2	0	0
Winter 2015*	2	0	0	0
Spring 2015*	2	1	0	0
Summer 2015*	0	1	0	0
Fall 2015*	0	8	0	0

*reduced effort due to heavy algae growth; used small 10X4 ft. seine designed to capture tidewater goby.

Origin of PIT tagged juvenile coho salmon tagged in Freshwater Creek basin detected at Wood Creek pond antennas, 2010-2015

Fish Origin	2010	10/11	11/12	12/13	13/14	14/15
Stream Estuary Ecotone	7	1	-	1	0	1
Lower Mainstem Freshwater Creek	11	6	26	2	0	6
Middle Mainstem Freshwater Creek	-	11	16	1	1	4
Upper Mainstem Freshwater Creek	7	6	12	4	0	4
Little Freshwater Creek	12	-	-	-	0	-
Cloney Gulch	9	4	6	4	0	1
South Fork Freshwater Creek	-	0	10	2	0	1
Freshwater Creek (total)	46	28	70	14	1	17
Wood Creek Pond	74	8	199	42	5	2
Wood Creek	27	19	20	11	11	13
Ryan Slough/Creek	0	0	7	2	0	0
Freshwater Creek Slough	5	0	8	6	0	2
HFAC Weir	1	0	2	0	4	1
Estuary Ecotone (total)	107	27	236	61	20	18
Grand Total	153	55	306	75	21	35


Salmon Creek Ponds
Photo by David Kenworthy

Juvenile Coho Salmon, Steelhead Trout and Tidewater Goby Catches in Cattail Creek and Off Channel Ponds of Salmon Creek 2011-2015

	Pond 0			Pond 1			Pond 2			Ponds 3&4[a]			Cattail Cr		
Date	**CO**	**SH**	**TG**	**CO**	**SH**	**TG**	**CO**	**SH**	**TG**	**CO**	**SH**	**TG**	**CO**	**SH**	**TG**
Fall 11	-	-	-	0	1	3	0	0	20	0	0	3	-	-	-
Win 12	-	-	-	59	10	22	6	3	143	1	0	0	-	-	-
Spr 12	-	-	-	31	1	1	9	1	46	0	0	0	-	-	-
Sum 12	-	-	-	0	0	462	0	0	168	0	0	0	-	-	-
Fall 12	0	0	37	0	0	2163	0	0	0	0	0	1	-	-	-
Win 13	1	0	7	1	0	8	0	0	77	0	0	0	-	-	-
Spr 13	6	0	73	2	0	96	2	0	171	0	0	0	0	0	108
Sum 13	0	0	130	0	0	190	0	0	180	0	0	0	0	0	148
Fall 13	0	0	56	0	1	36	0	0	139	0	0	0	0	0	36
Win 14	0	3	26	7	20	10	0	0	7	0	0	0	0	0	42
Spr 14	0	0	33	3	3	60	0	0	9	0	0	0	0	0	65
Sum 14	0	0	109	0	0	17	0	0	285	0	0	0	0	0	390
Fall 14	0	0	24	0	0	130	0	0	371	0	0	0	0	0	311
Win 15	2	0	56	0	0	25	0	0	32	0	0	1	0	0	57
Spr 15	0	1	57	20	5	37	1	0	35	0	0	0	0	0	6
Sum 15	0	0	5	0	0	30	0	0	60	0	0	0	0	0	128
Fall 15	0	0	2	0	0	18	0	4	18	0	0	0	0	0	375
Win 16	2	2	5	7	10	41	2	14	35	0	0	0	0	0	29
Total	**11**	**6**	**620**	**130**	**51**	**3349**	**20**	**22**	**1796**	**1**	**0**	**5**	**0**	**0**	**1695**

Pre-Project Coho Catch 2005-2010 = 9

Post-Project Coho Catch 2011-2015/6= 162

[a] Sampled only with minnow traps

Upper Jacoby Cr Pond

Lower Jacoby Cr Pond


Photo by Travis James

Number of Juvenile Salmonids Captured in Jacoby Creek Ponds and Stream

Month	Upper Pond		Lower Pond		Jacoby Cr	
	CO	SH	CO	SH	CO	SH
Jan-Nov 2015	n/a	n/a	0	0	19	16
December 2015	0	0	0	0	high flow	high flow
January 2016	67	1	3	0	0	2
February 2016	91	7	2	0	0	0
March 2016	90	6	1	0	0	0
Total	248	14	6	0	19	18


Upper Jacoby Cr Pond

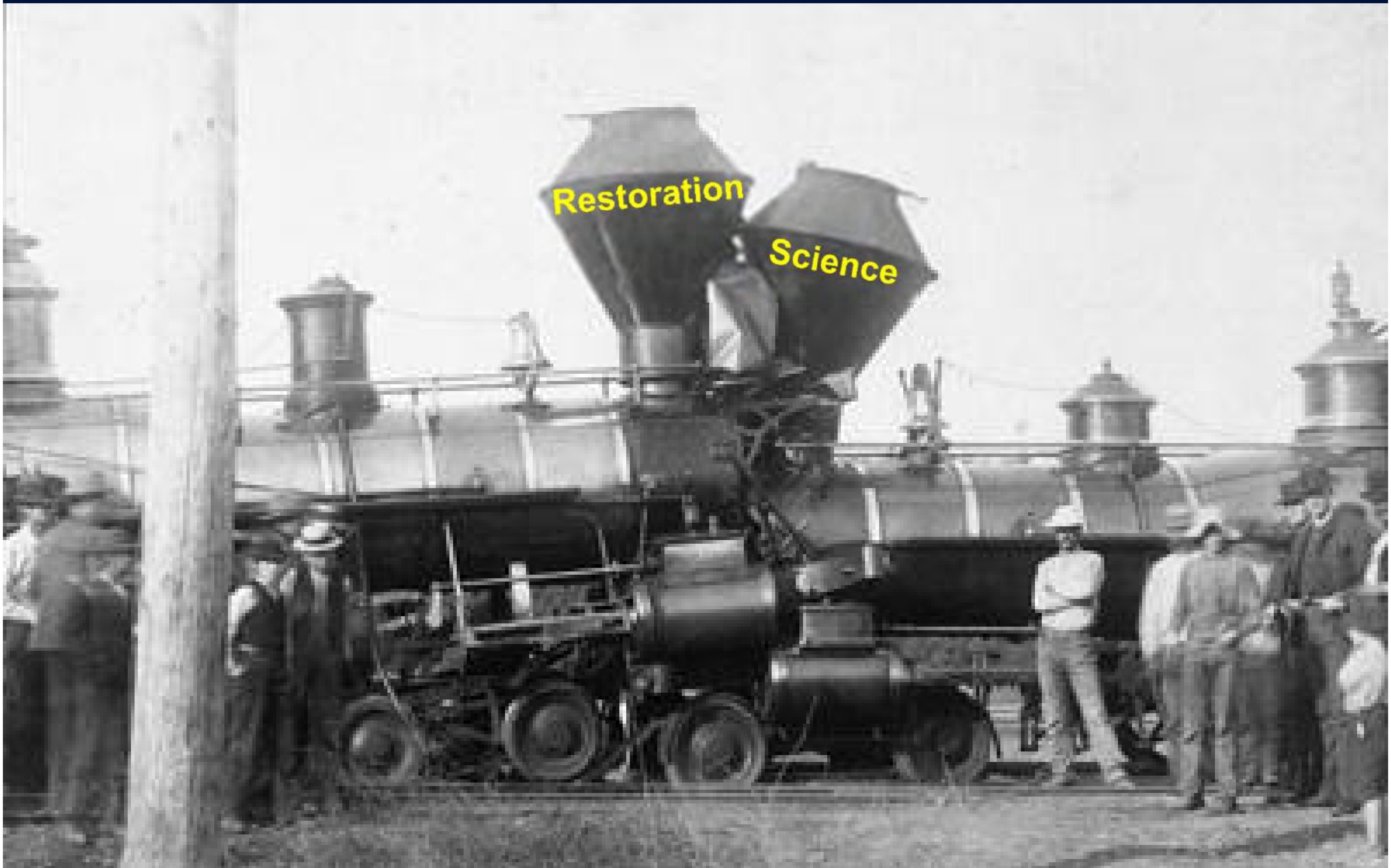

Lower Jacoby Cr Pond

Potential Reasons for Disparate Catches

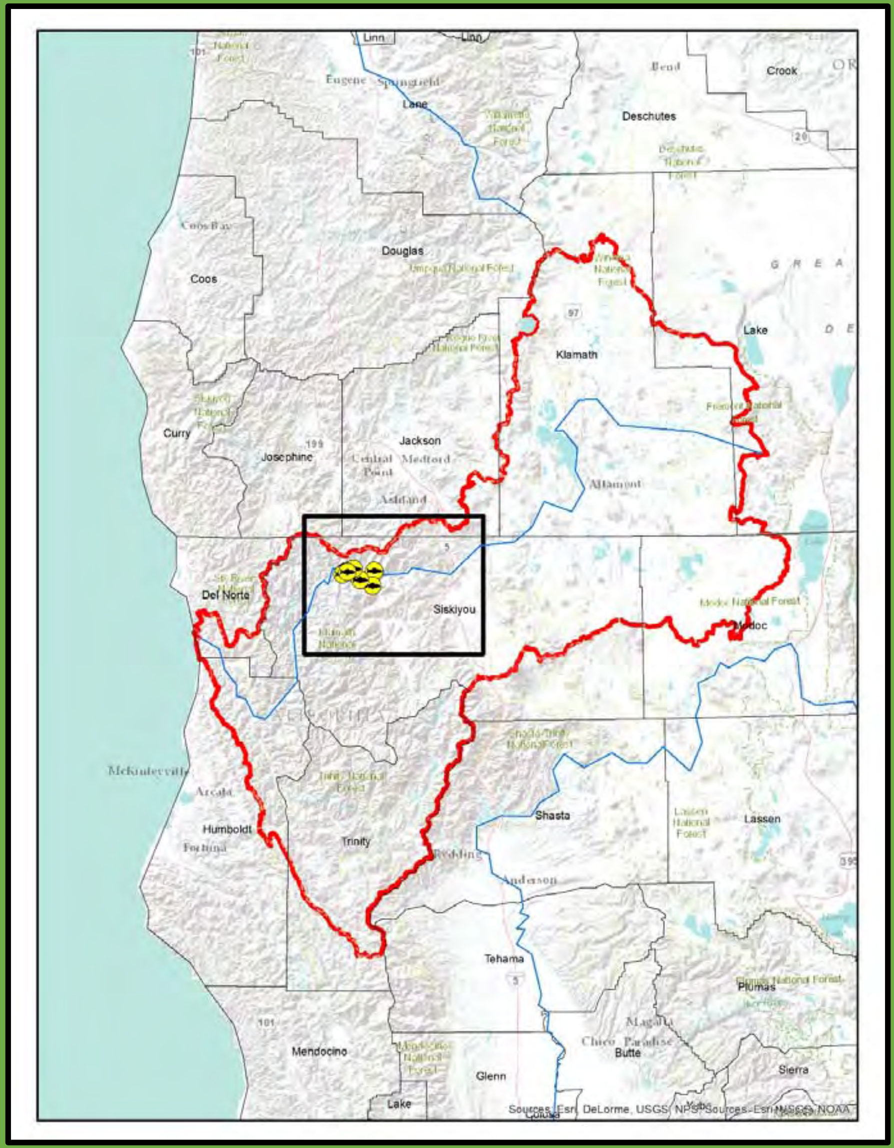
- **Heavy vegetation in lower pond; less DO?** No obvious difference in WQ between ponds
- **Diurnal fluctuations in DO in lower pond?** DO levels at first light similar between ponds
- **Lower catch efficiency in lower pond?** Seining not possible but traps very different; 24 hr soak produced 2 coho in lower pond
- **Differences in connections to creek?** No obvious difference in connections of ponds
- **Other reasons?**

Conclusions

- Appears at least three juvenile coho salmon life history patterns in stream-estuary ecotone of Humboldt Bay
- Juvenile coho rear in non natal freshwater stream-estuary ecotone for months
- Juvenile coho use mainstem channels in summer/fall and smaller off channel tributaries in winter/spring
- Juvenile salmonids move into newly created ponds as soon as they become available and WQ conditions are adequate to support them
- Growth rates of juvenile coho salmon appear to be higher in off channel pond habitat than adjacent stream habitat

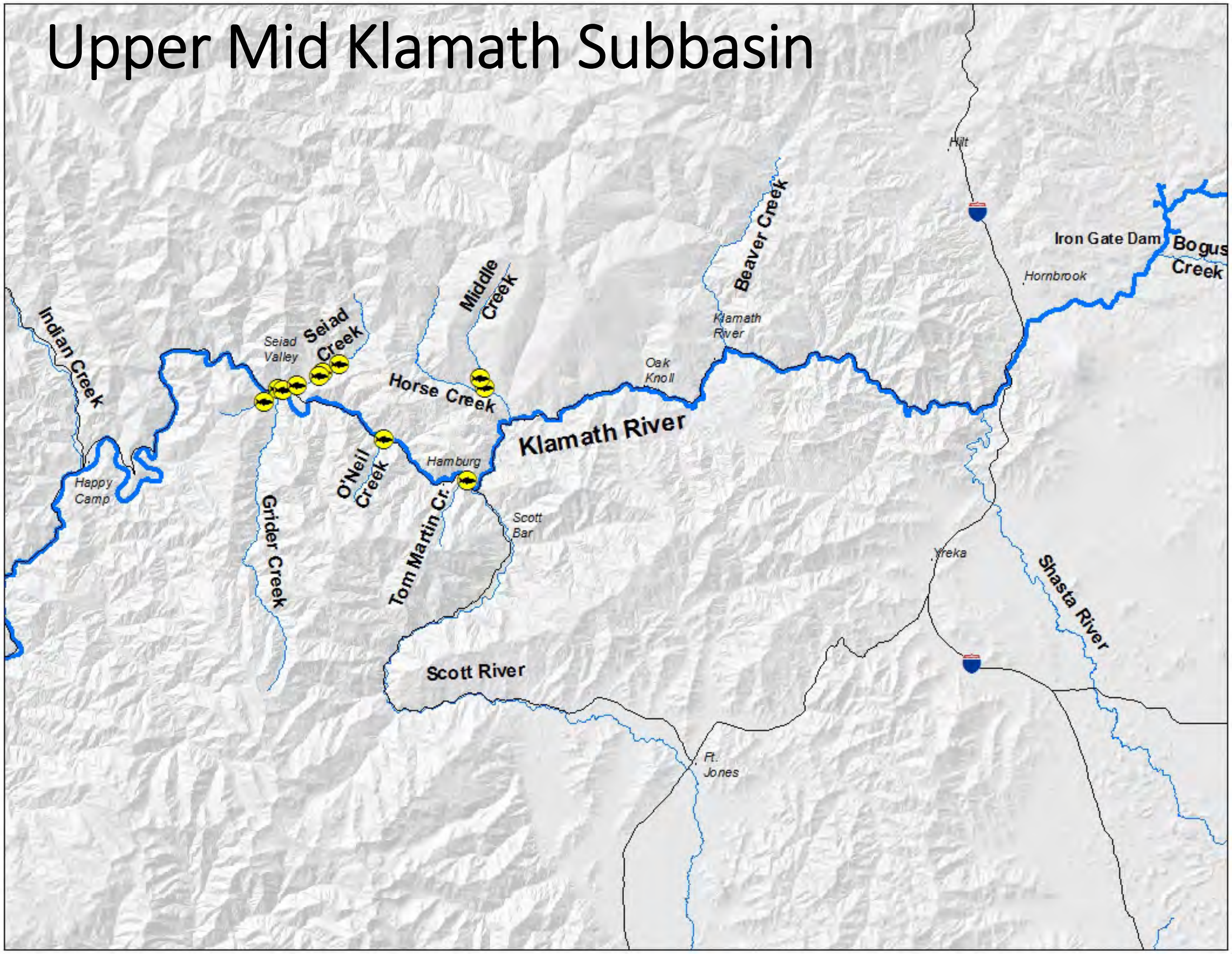

Restoration
Science


Coho, Cows, and Collaboration
Creating Coho Habitat in a Bovine Landscape

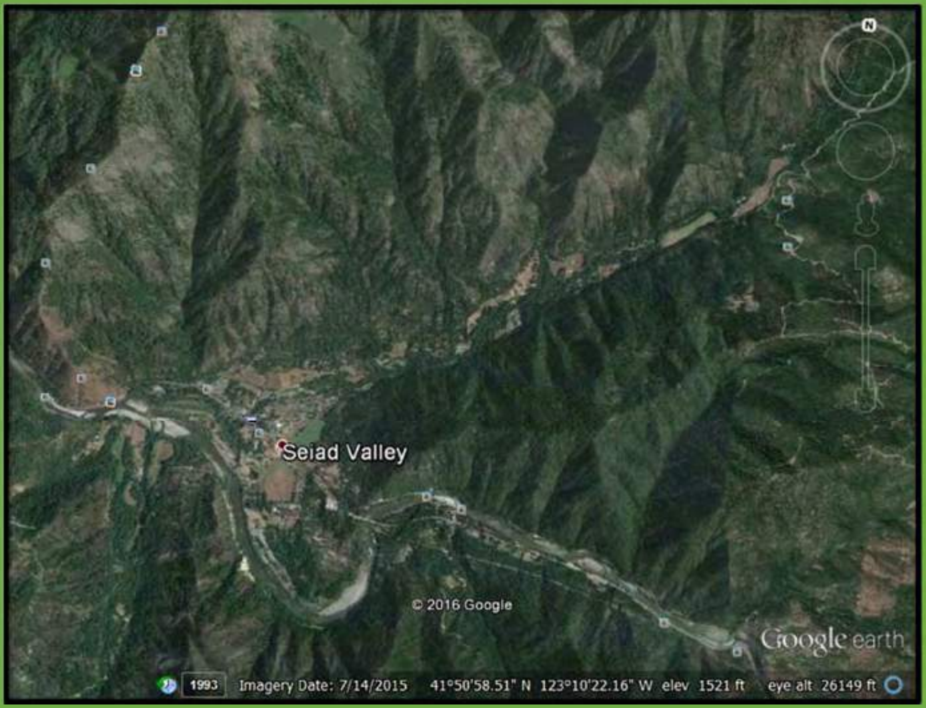


Linn
Eugene
Springfield
Lane
Bend
Crook
Deschutes
Coos Bay
Coos
Douglas
Klamath
Lake
Curry
Josephine
Jackson
Central Point
Medford
Ashland
Altamont
Del Norte
Siskiyou
Modoc
Mckinleyville
Arcata
Humboldt
Fortuna
Trinity
Shasta
Lassen
Redding
Anderson
Tehama
Plumas
Chico
Paradise
Butte
Mendocino
Glenn
Sierra
Lake
Sources: Esri, DeLorme, USGS, NPS

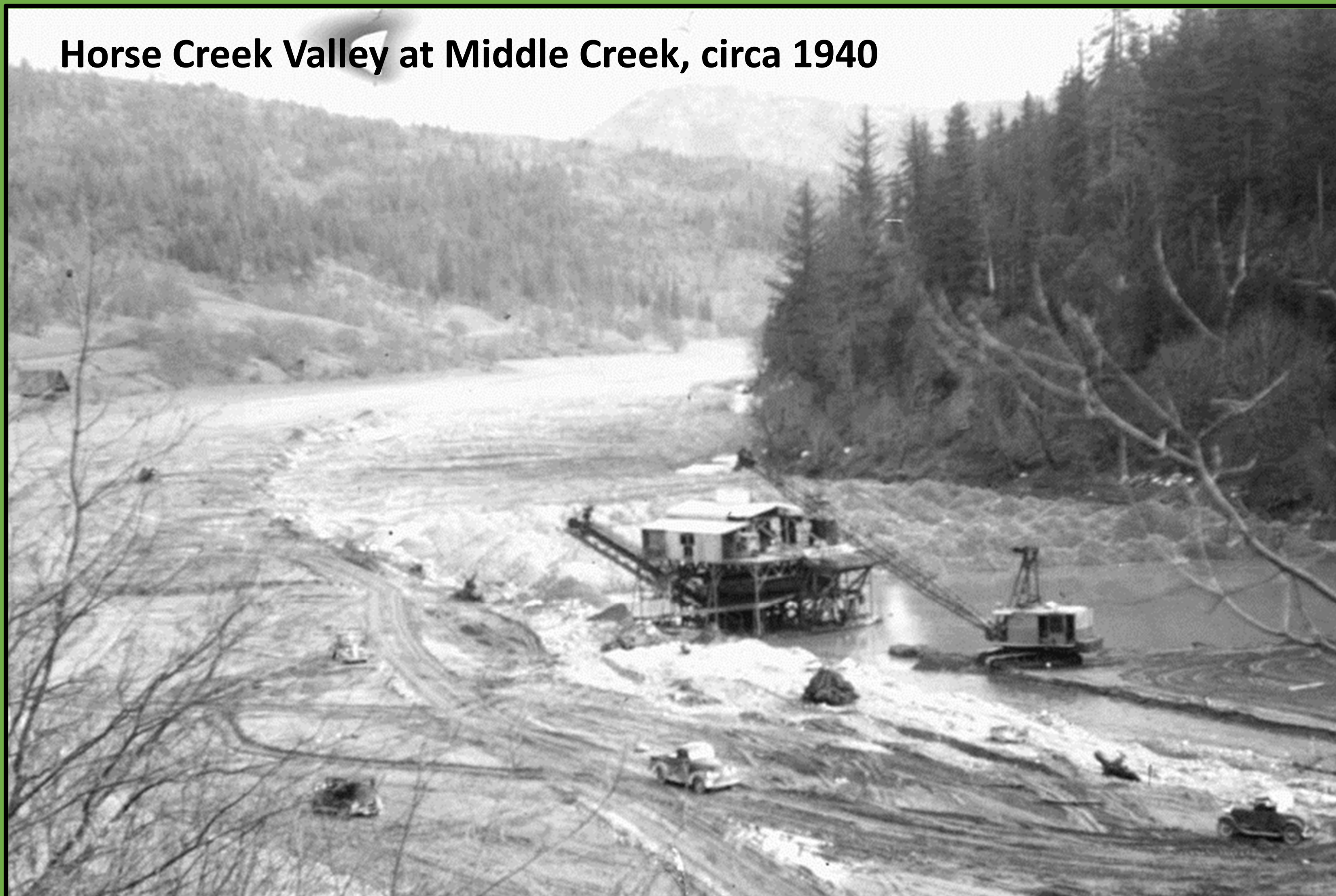
Upper Mid Klamath Subbasin

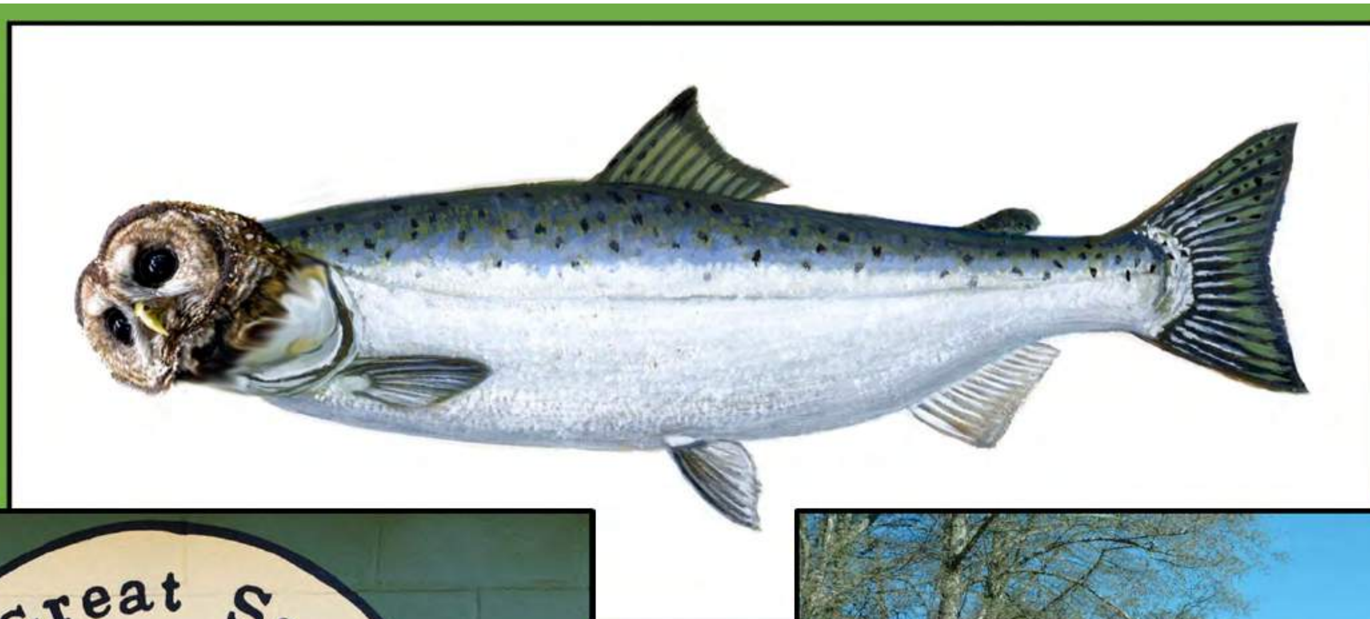


Seiad Valley



Horse Creek


Horse Creek Valley at Middle Creek, circa 1940




The Great Seal Of
XX
State Of Jefferson

The Contractors


DEERE


DEERE

The Landowners

The Public

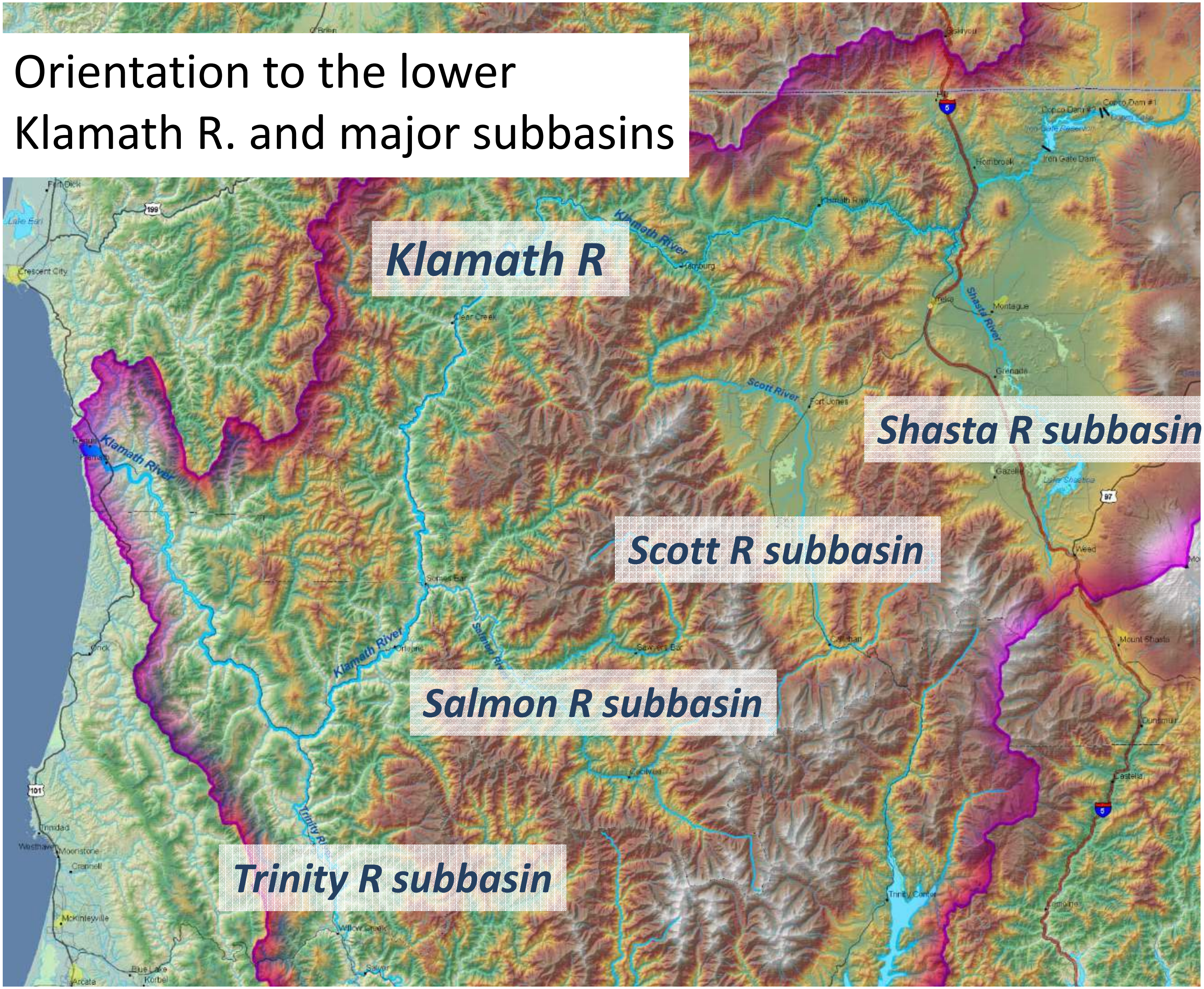
The Payoff

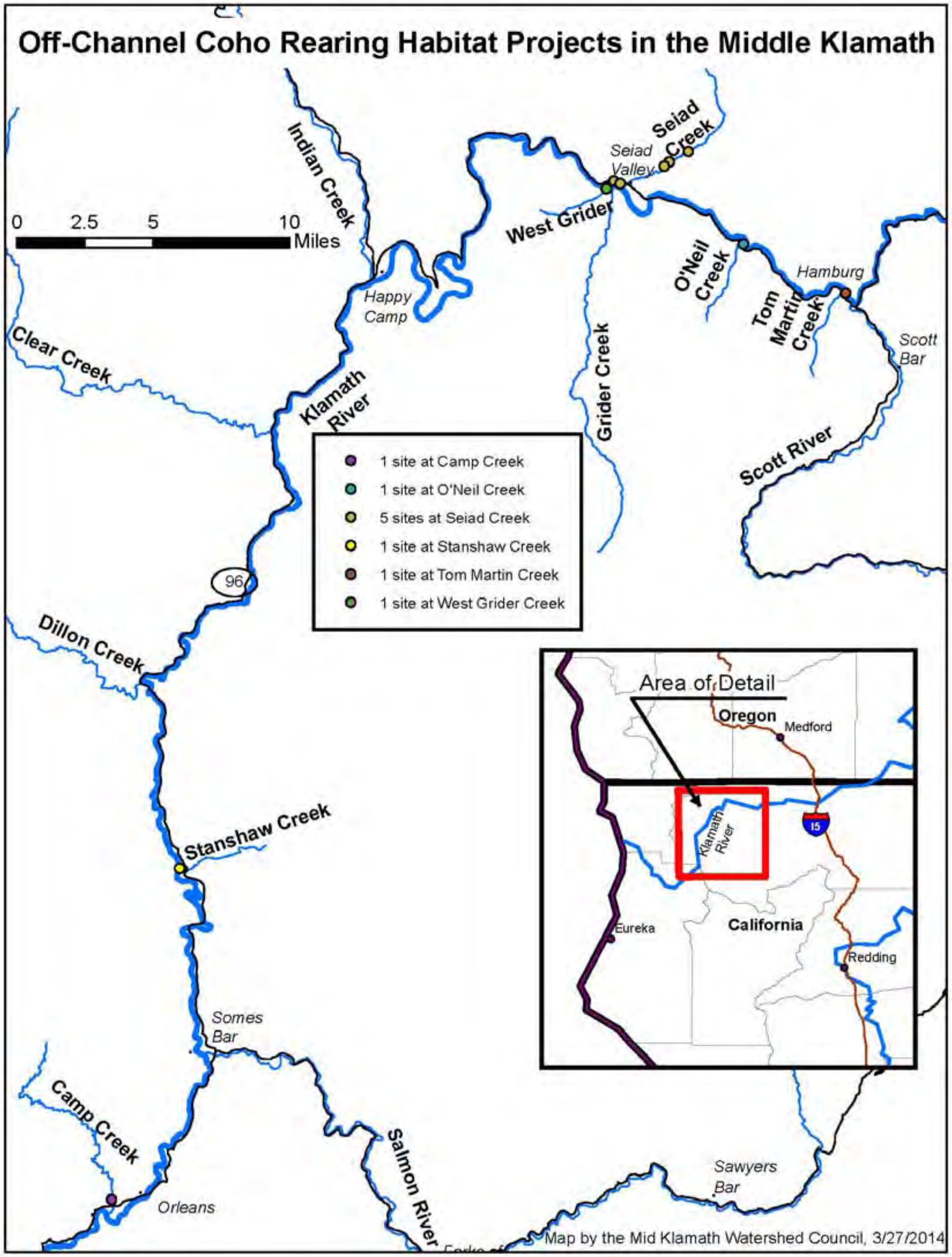
The Partners

- The Karuk Tribal Fisheries Program
- Fiori GeoSciences
- Biostream Environmental
- US Fish and Wildlife Service
- California Department of Fish and Wildlife
- NOAA Fisheries
- Klamath National Forest
- Six Rivers National Forest
- PacifiCorp
- Fish America Foundation
- Humboldt State University

Coho Salmon Utilization of Off-Channel Habitats along Seiad Creek and other Middle Klamath Tributaries

Orientation to the lower Klamath R. and major subbasins





Off-Channel Coho Rearing Habitat Projects in the Middle Klamath
0 2.5 5 10 Miles
Indian Creek
Seiad Creek
Seiad Valley
West Grider
O'Neil Creek
Hamburg
Tom Martin Creek
Happy Camp
Clear Creek
Klamath River
Grider Creek
Scott Bar
Scott River
1 site at Camp Creek
1 site at O'Neil Creek
5 sites at Seiad Creek
1 site at Stanshaw Creek
1 site at Tom Martin Creek
1 site at West Grider Creek
96
Dillon Creek
Area of Detail
Oregon
Medford
I5
Klamath River
California
Eureka
Redding
Stanshaw Creek
Somes Bar
Camp Creek
Salmon River
Sawyers Bar
Orleans
Map by the Mid Klamath Watershed Council, 3/27/2014

Common Coho life history theme:

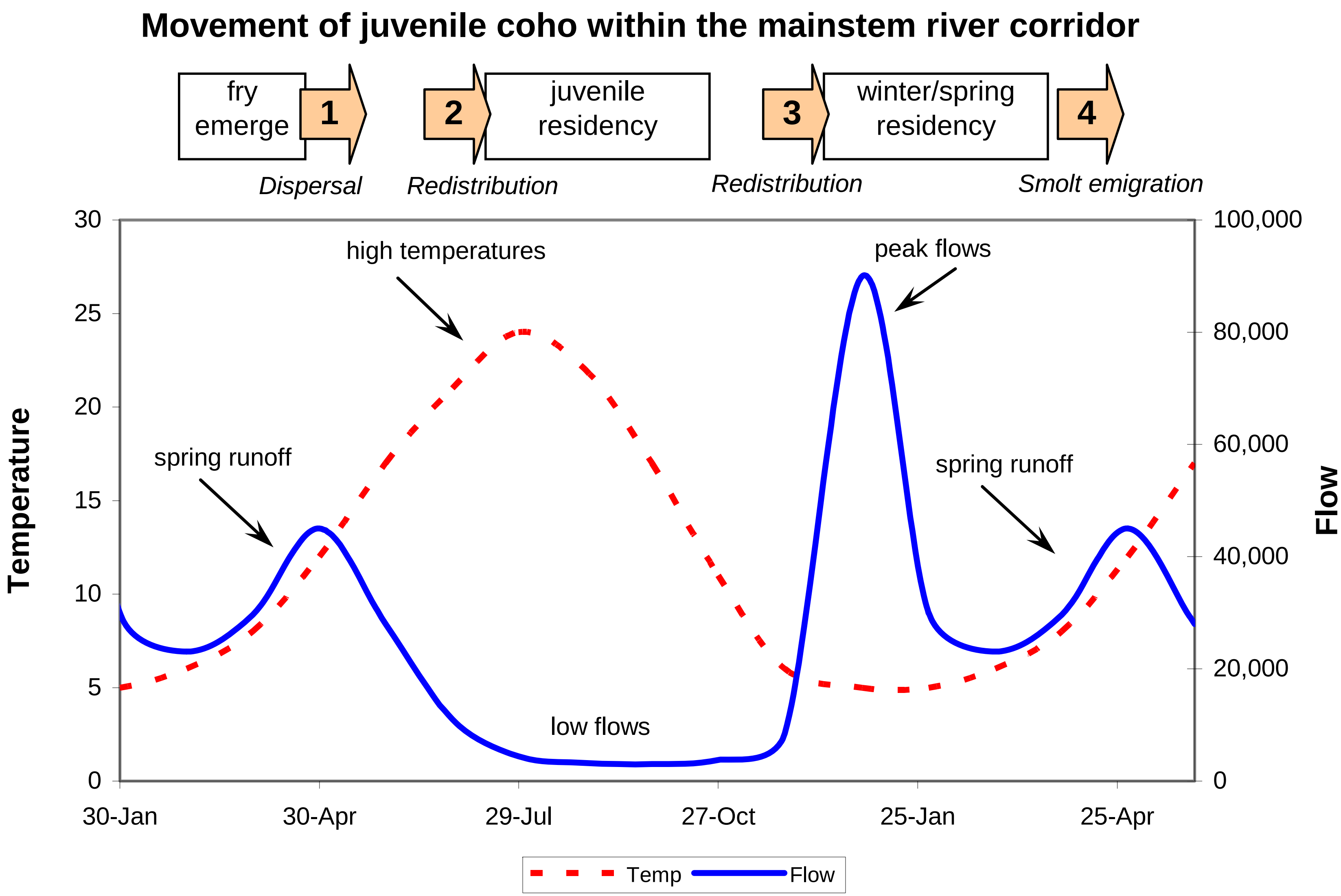
Life in the slow lane!

- Slow water velocities preferred (> 1 yr in fw)
- Coho < Chinook < Steelhead

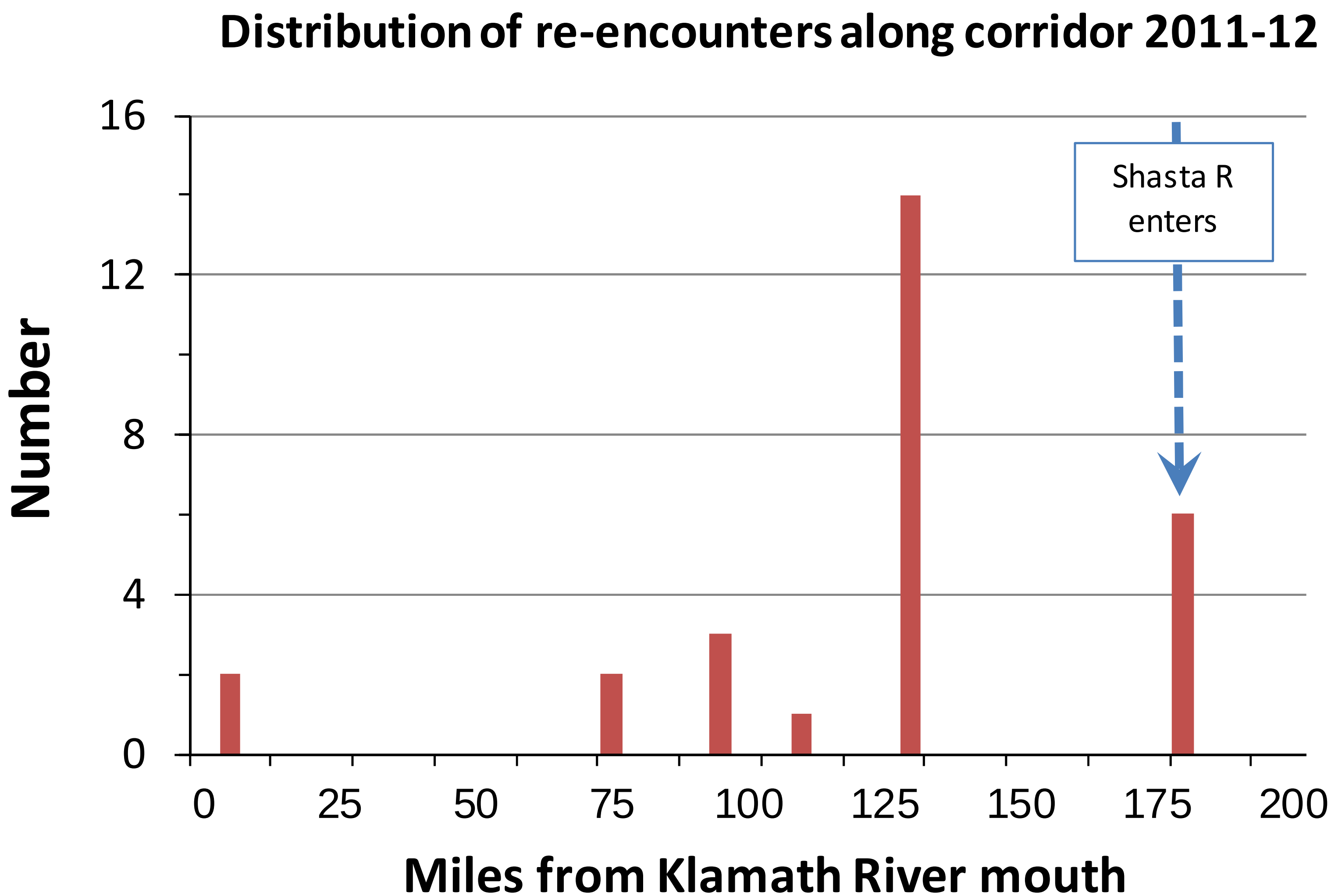
Coho Ecology Study Findings

- Summer redistribution to cold water refuges (when mainstem Klamath River is > 19C)
- Fall redistribution to overwinter habitat is significant (up to 144 miles traveled documented)
- Largest overwintering area in very lower river corridor and tributaries to the Estuary
- Most mid Klamath winter rearing habitats support only low densities of Coho salmon
- Flood plains are degraded and beaver ponds are rare and natural off-channel habitat are reduced in number and function

Another theme: Seasonal redistributions
(Klamath River)



Shasta River PIT Tagged Age 0 Coho Out-Migrants



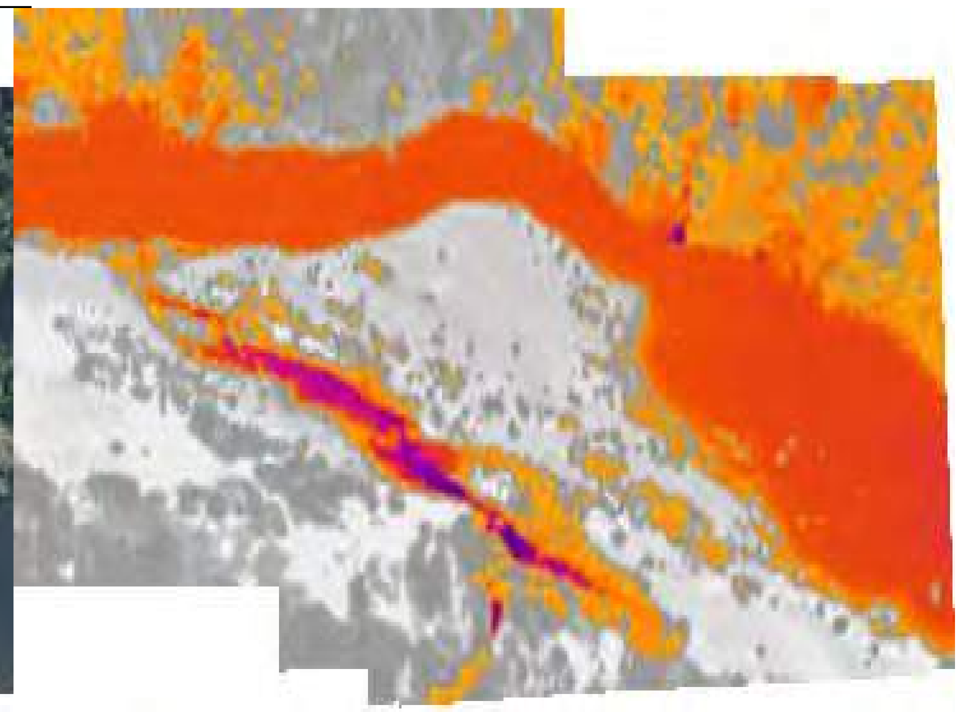
Natal Shasta River age 0 Coho seek out non-natal summer rearing opportunities along the mainstem corridor

Data: CDFW and Karuk Tribe

Off-Channel Thermal Refuge Habit

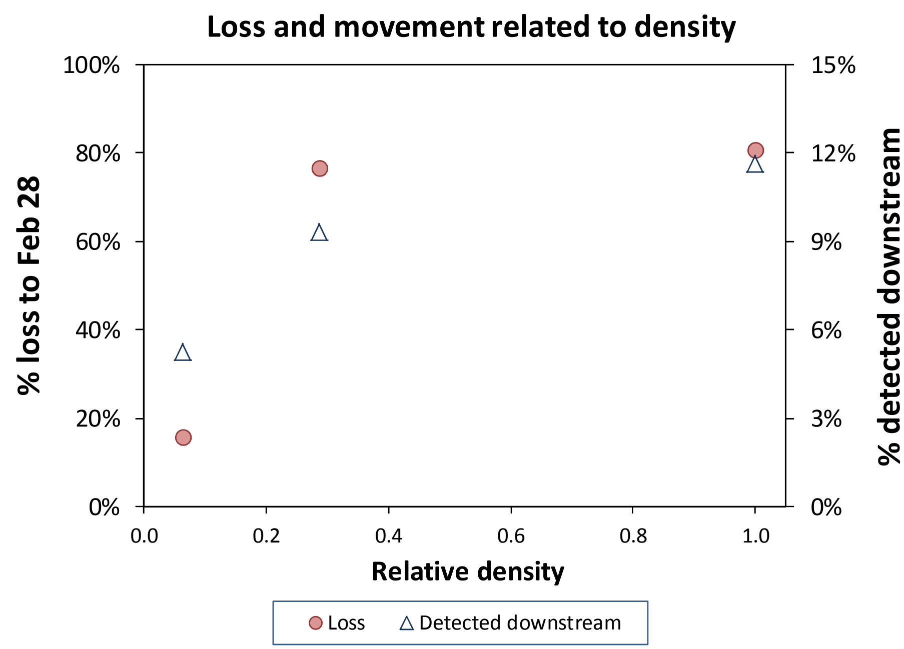
Sandy Bar Creek

Mainstem side channels fed by cold water tributaries



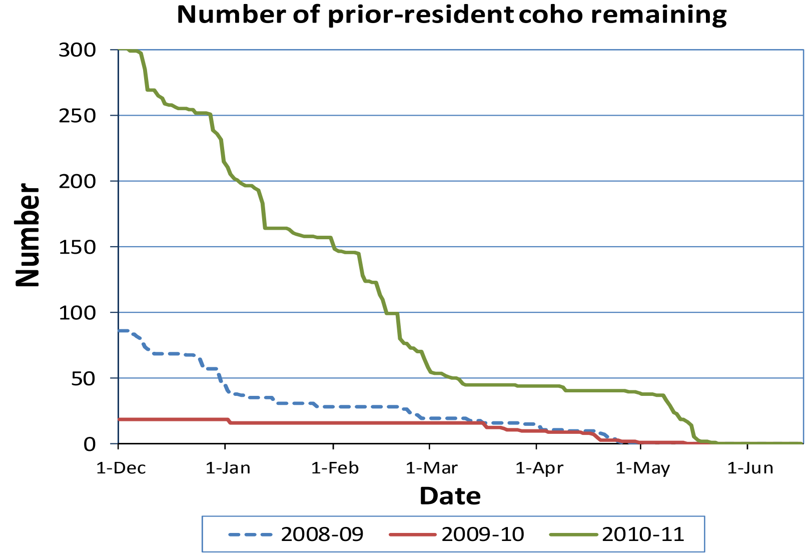
Winter Density and Movements out of Sandy Bar Off-Channel Habitat

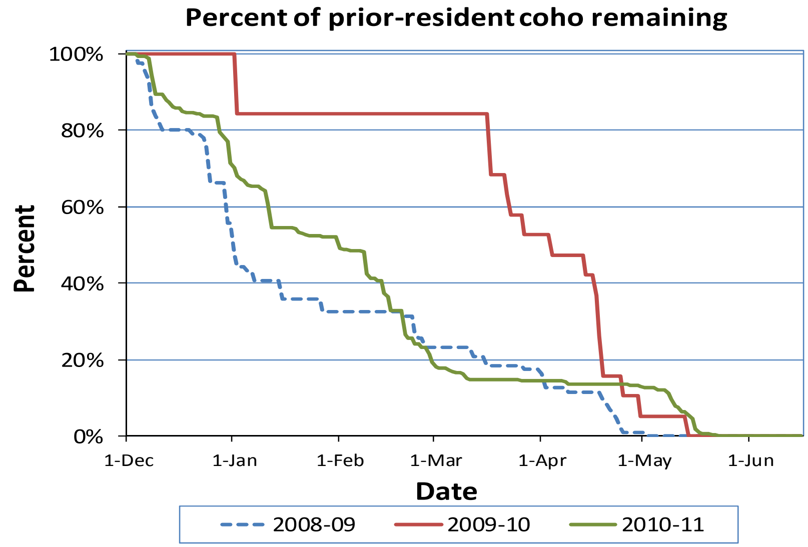
- High Density= More Movements Downstream
- Low Density = Less Movements Downstream



Data: Karuk Tribe

Winter Rearing Densities at Sandy Bar Creek





Most winter habitats were found to have low capacity and support low densities.

Data: Karuk Tribe

3


Klamath River at Humbug Creek - Today

Floodplain Loss = Off Channel Habitat Loss

Seiad Creek Gravel Push-up Levees (Sugar Levee)

Downstream View

Upstream View

Humans and Coho are in direct competition for wide floodplains, wetlands and flat valleys. The same tools that developed and destroyed these habitats can be used to restore them.

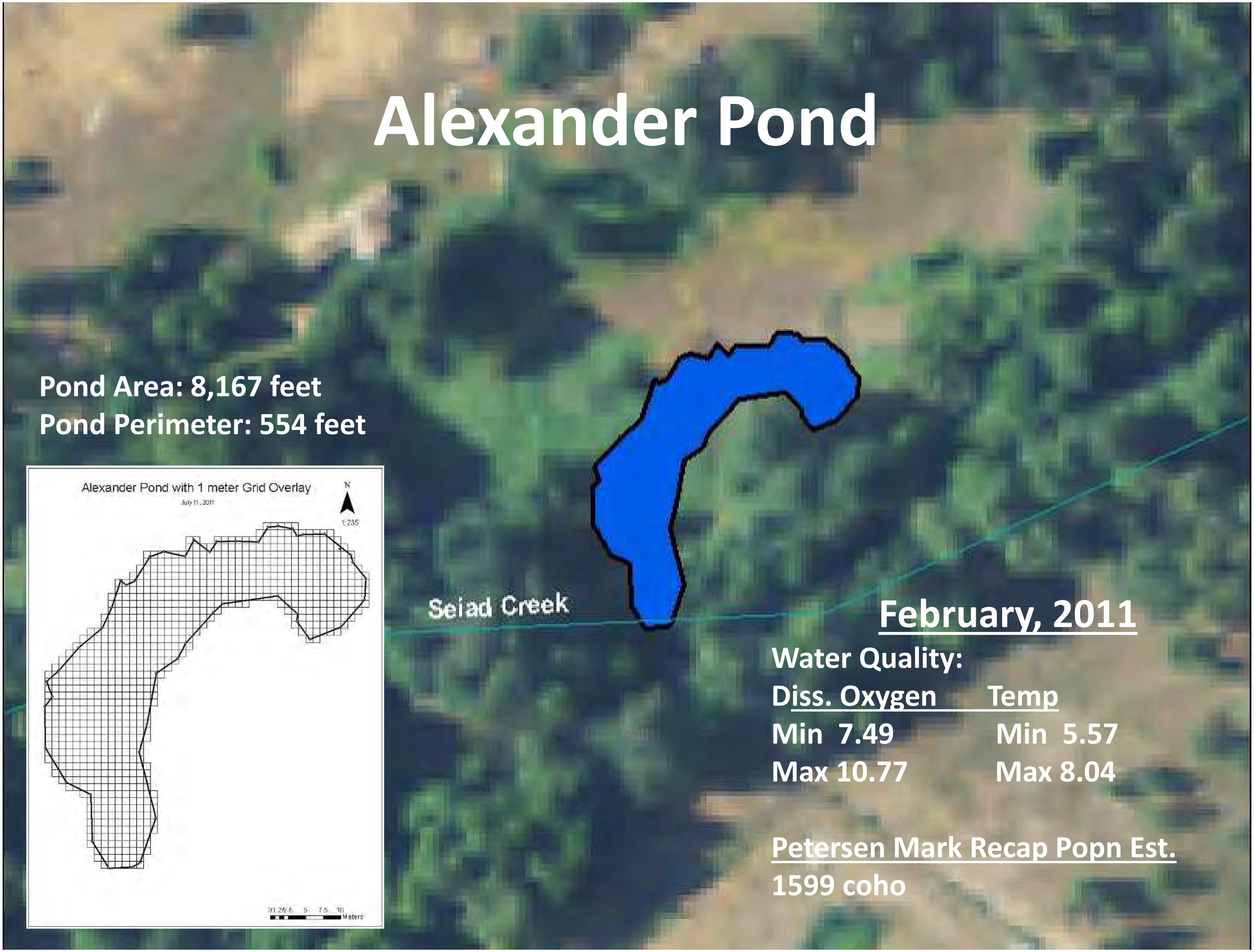
Constructed Habitat….?????

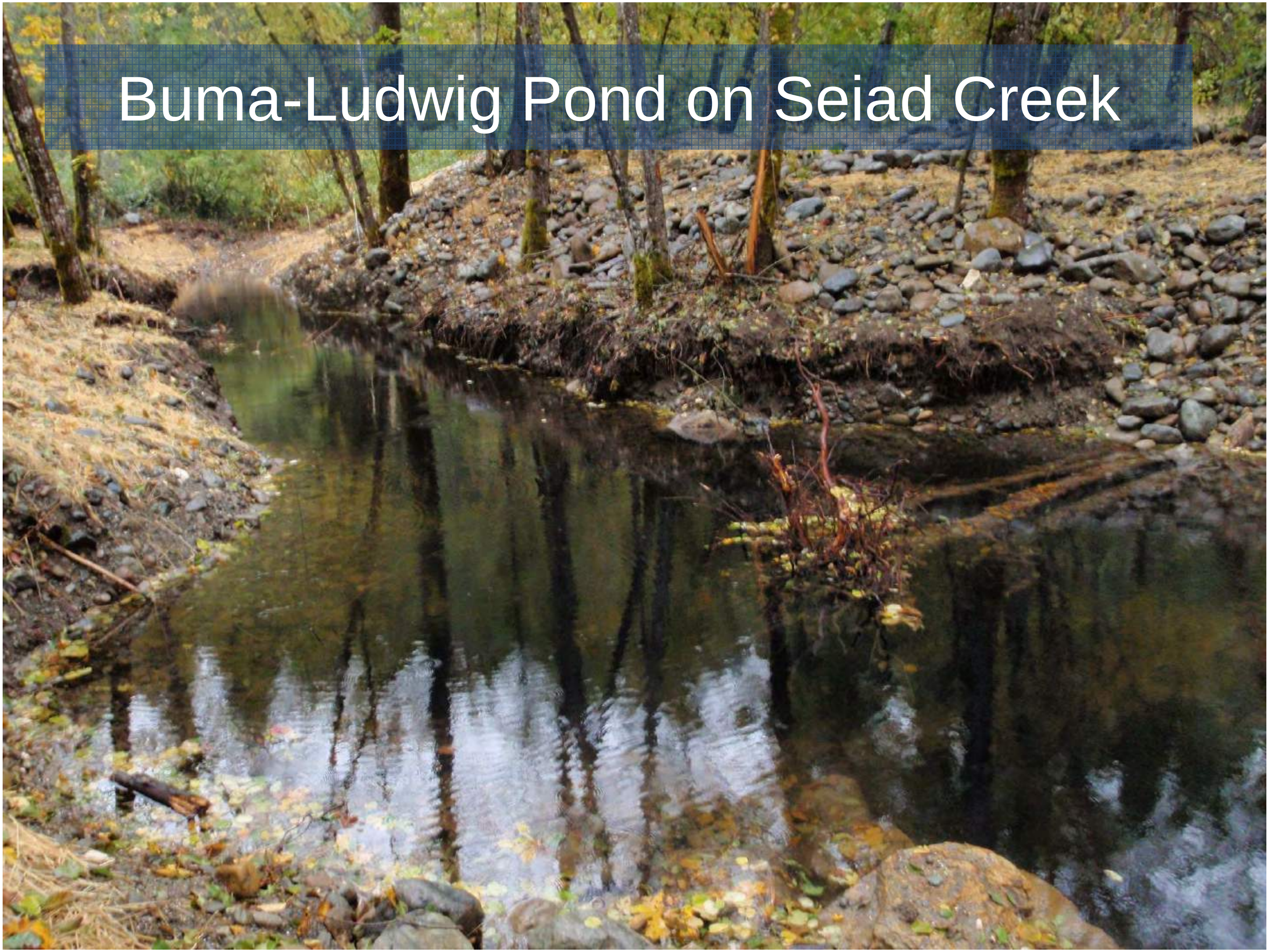
Are mechanically excavated habitats designed to attract juvenile salmon for specific rearing habitat objectives.

- Winter rearing
- Cold water refuge
- Increase growth & survival

Why constructed habitats?

- Provide juvenile Coho salmon access to complex off channel habitats associated with the floodplain (i.e. beaver ponds, alcoves, groundwater channels)…especially for winter growth and survival.
- Replace the loss of floodplain habitat caused by human development.
- Replace natural beaver pond type habitat until beaver populations rebound
- Coho need **immediate benefits** to slow population decline.


Alexander Pond
Pond Area: 8,167 feet
Pond Perimeter: 554 feet
Alexander Pond with 1 meter Grid Overlay
July 11, 2011
N
Meters
Seiad Creek
February, 2011
Water Quality:
Diss. Oxygen Temp
Min 7.49 Min 5.57
Max 10.77 Max 8.04
Petersen Mark Recap Popn Est.
1599 coho


Buma-Ludwig Pond on Seiad Creek

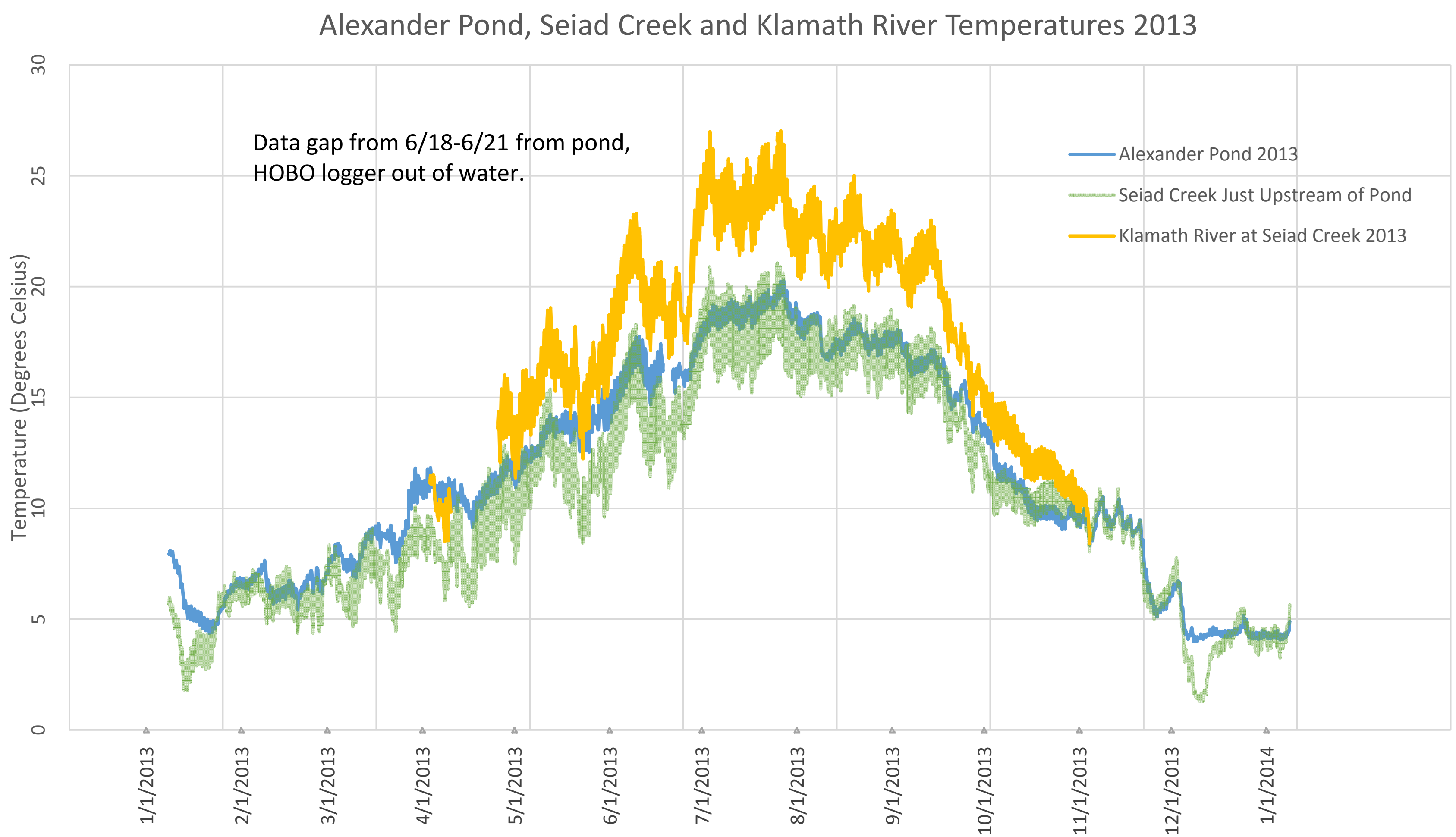
Lower Seiad Creek Pond-2014

May Pond-at source spring

PIT Tag Detection Antennas in May Pond

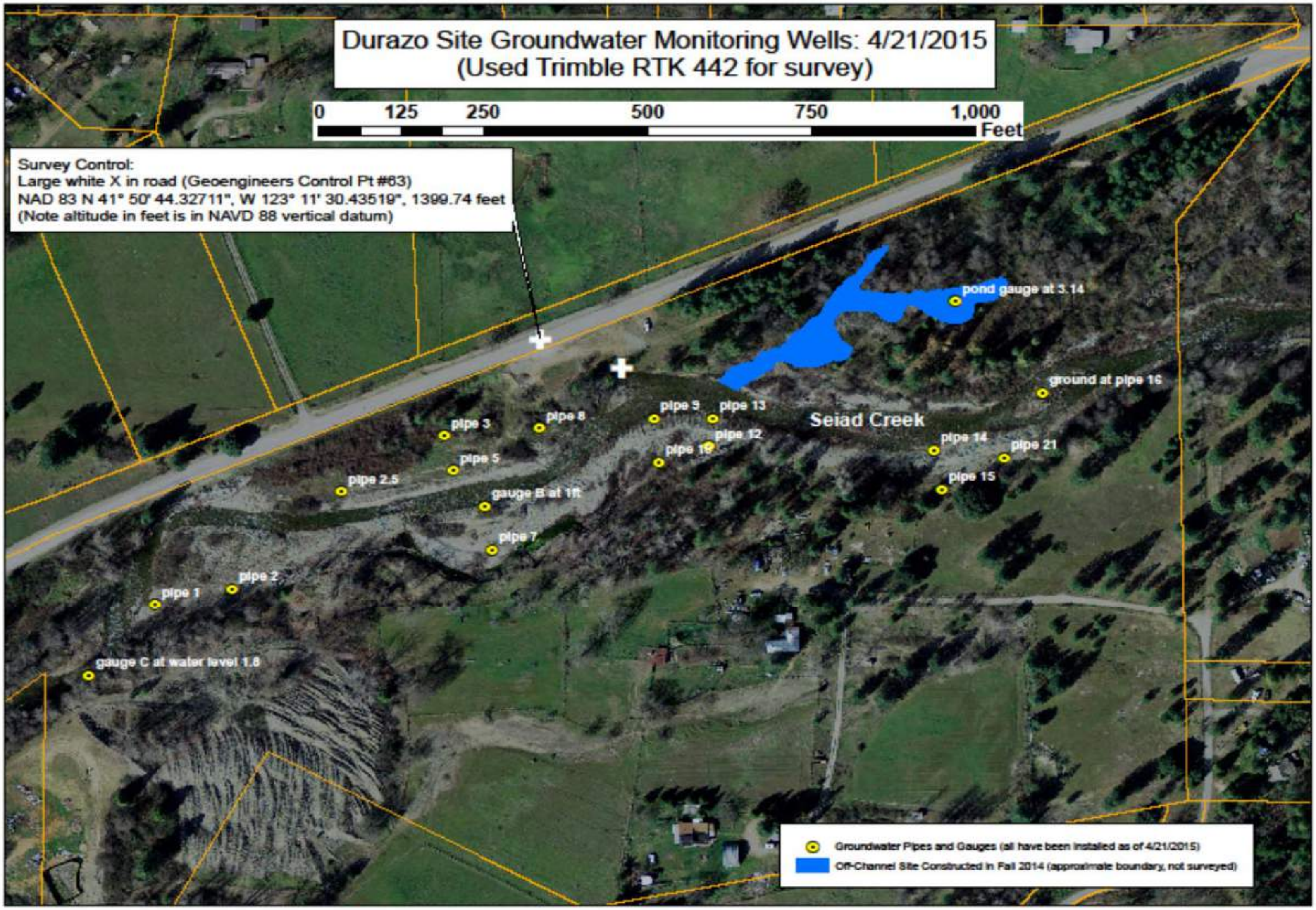
Lower Seiad and May Pond (Under Construction) From Space!

Water Temperature

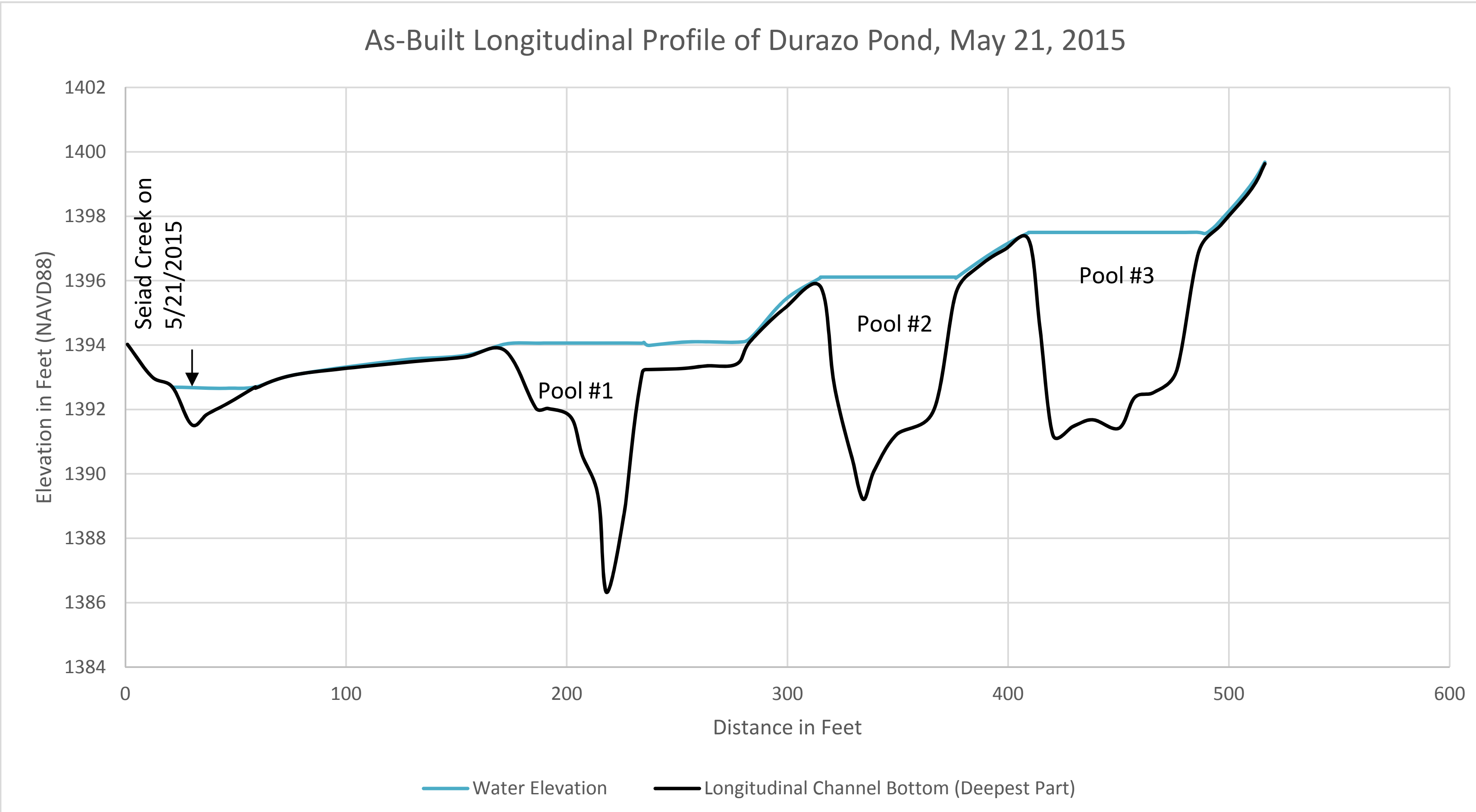


Data: MKWC

Aerial View of Durazo Pond Complex and Seiad Creek Groundwater Monitoring Wells



Durazo Pond Profile

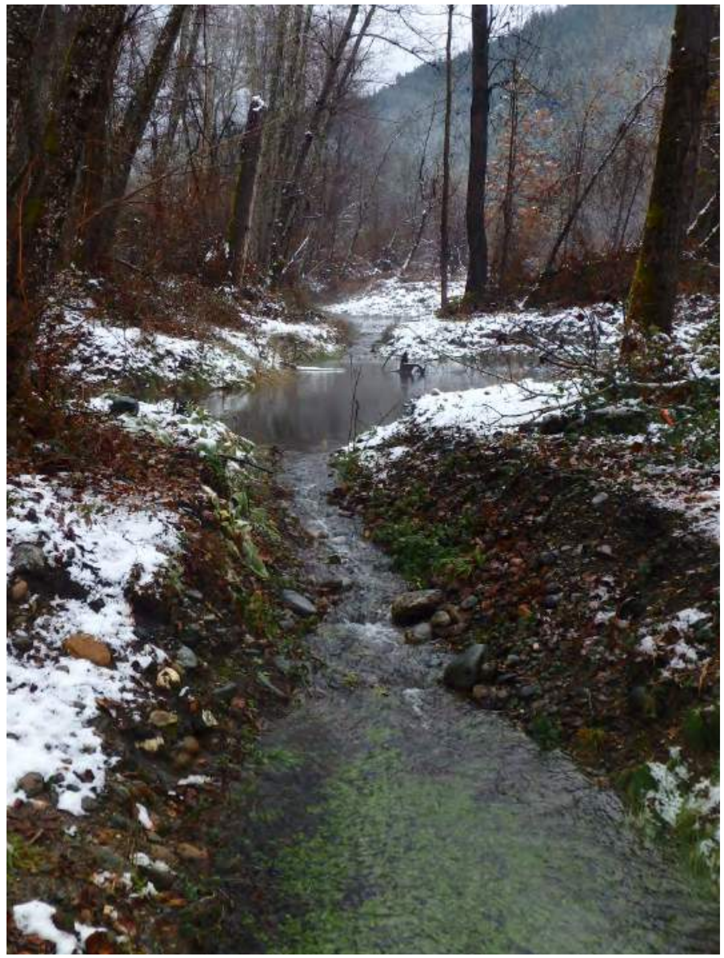


Data: MKWC

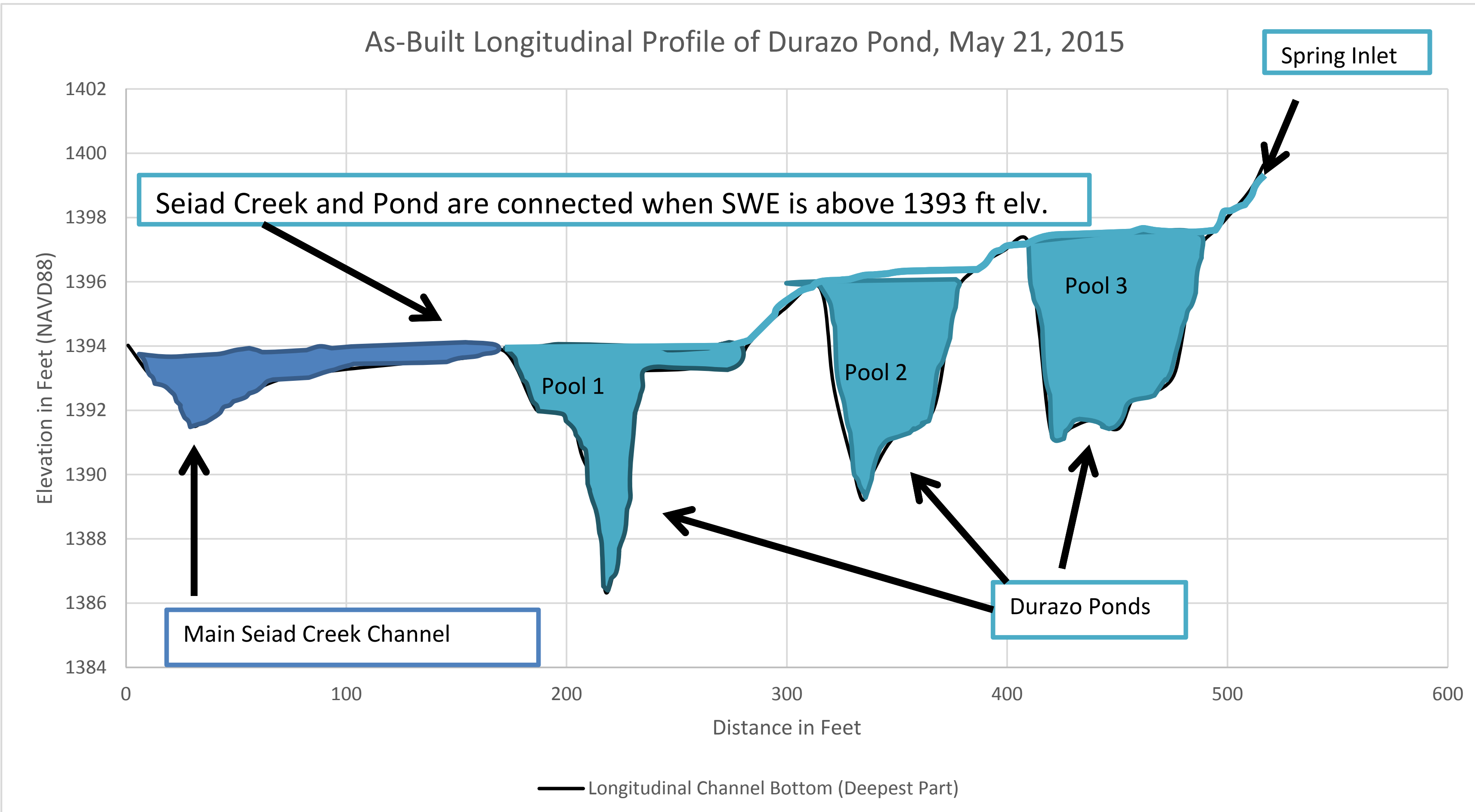
Durazo Pond inlet meets Seiad Creek- up stream view

Durazo Pond-Pool #1

Durazo Pond-up stream view Pool #2 and Pool #3



Durazo Pond Profile

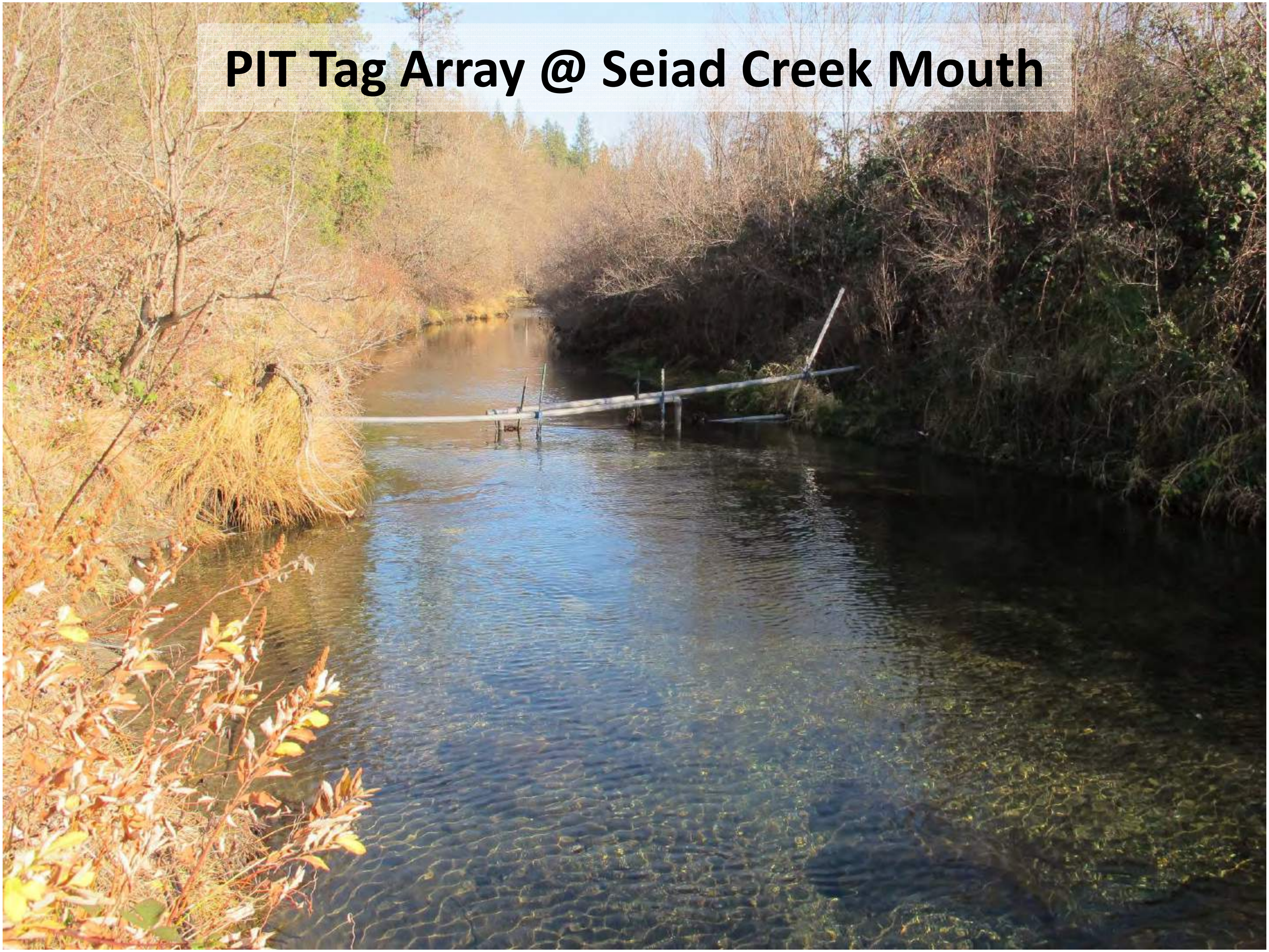


Durazo Pond Inlet Channel

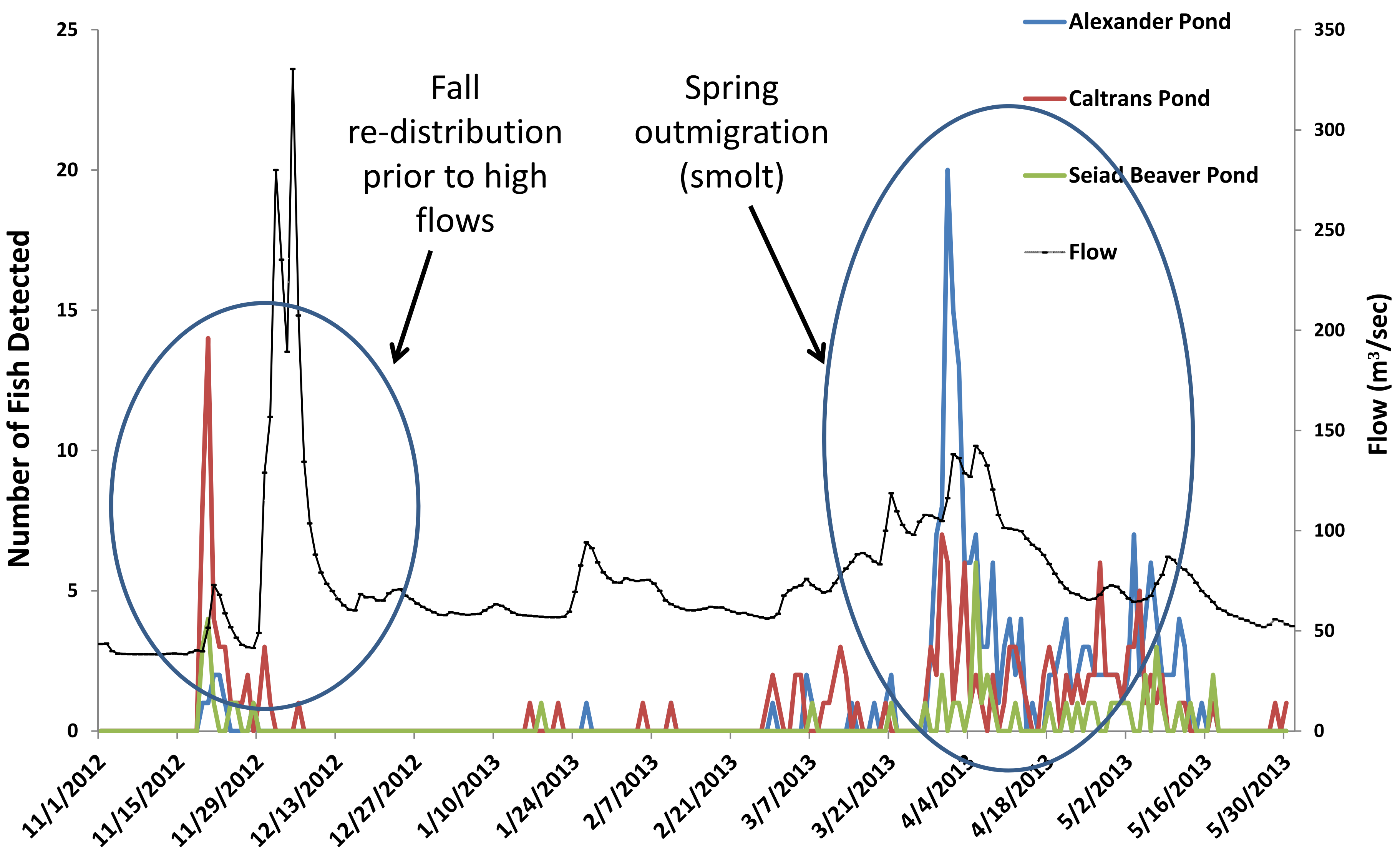
Durazo Pond meets Seiad Creek

Remote PIT Tag Detection Systems

PIT Tag Array @ Seiad Creek Mouth



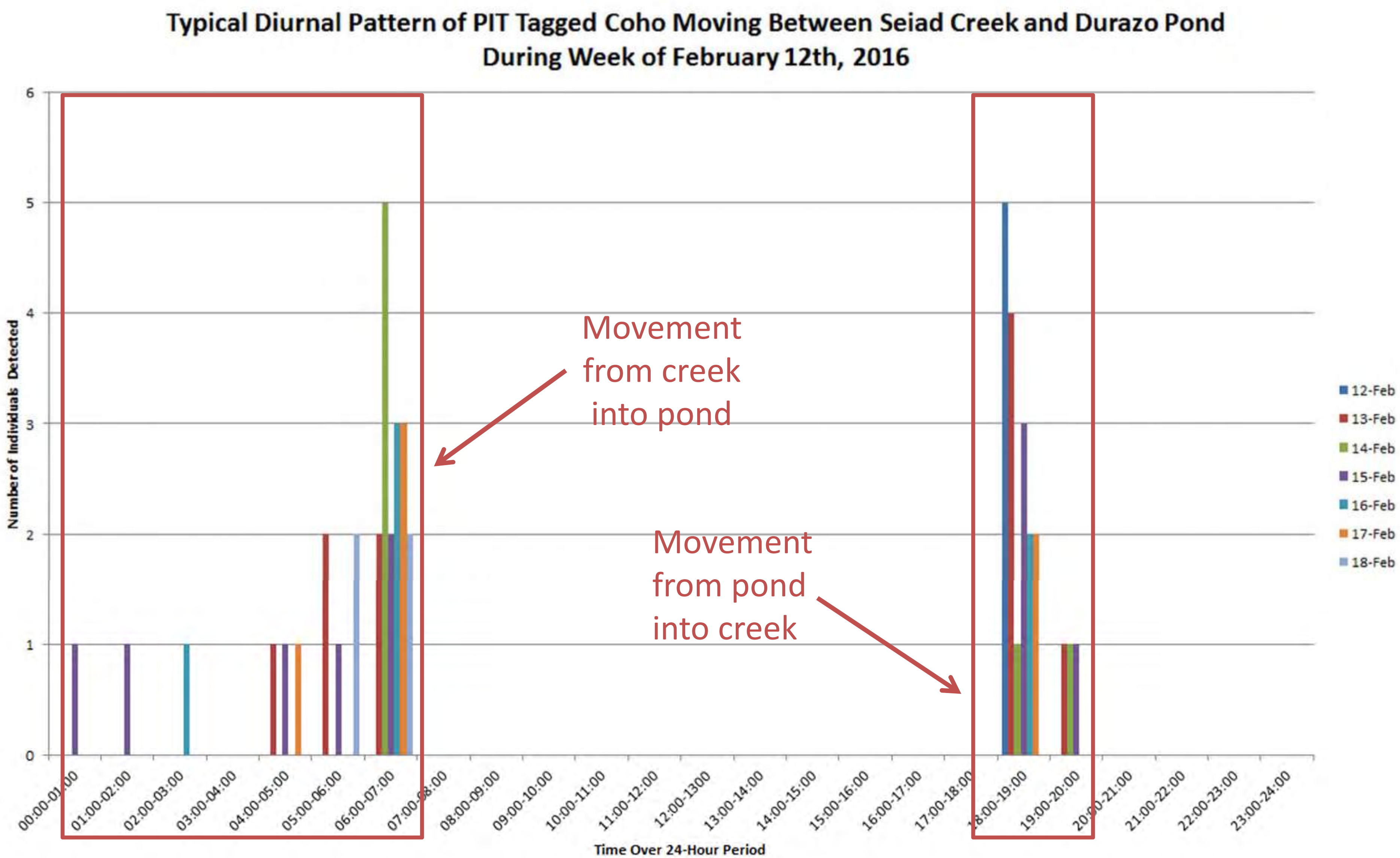
Seasonal Movement



Data: Karuk Tribe and Shari Whitmore

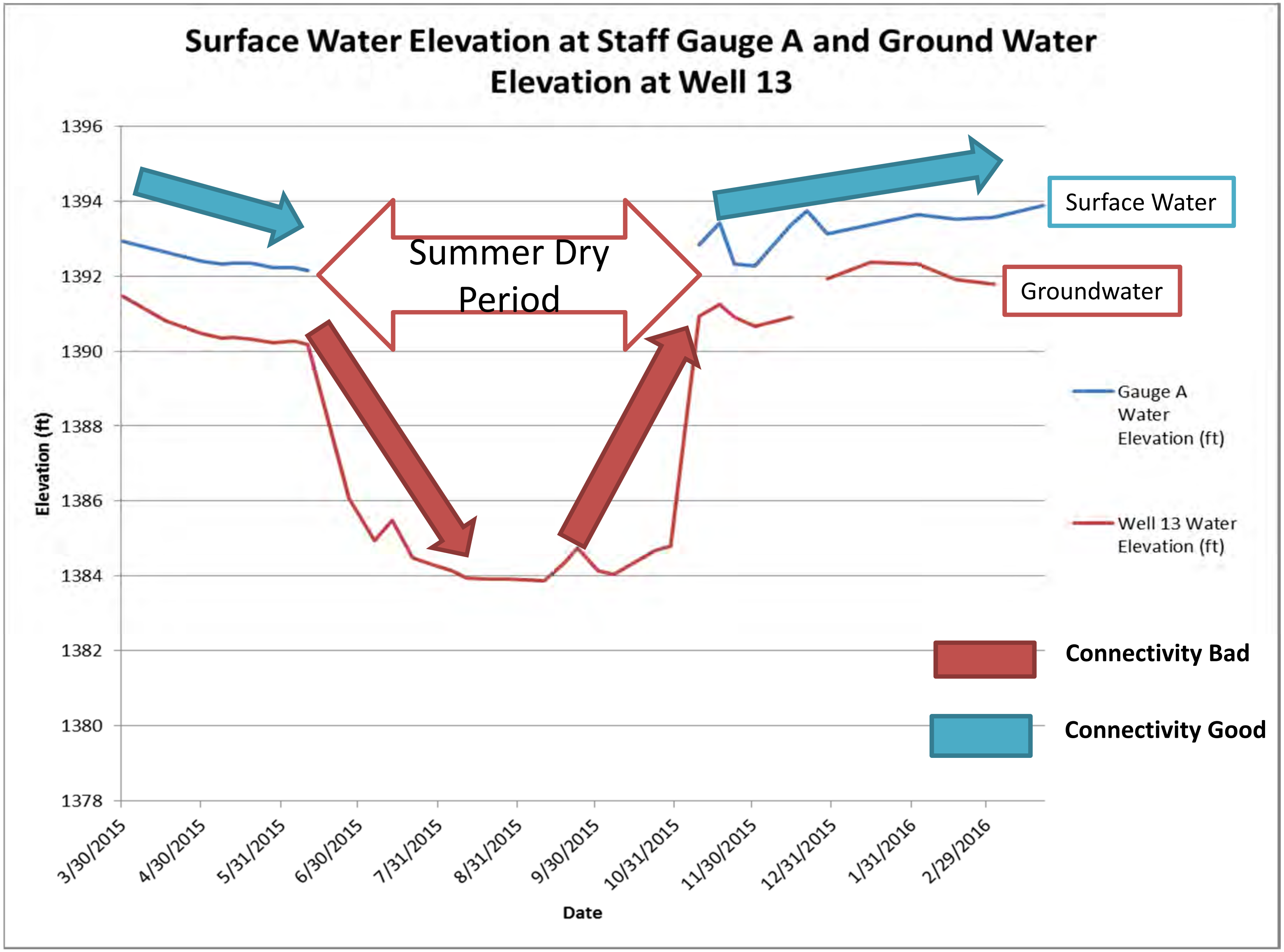
Date Detected at Mouth of Seiad Creek

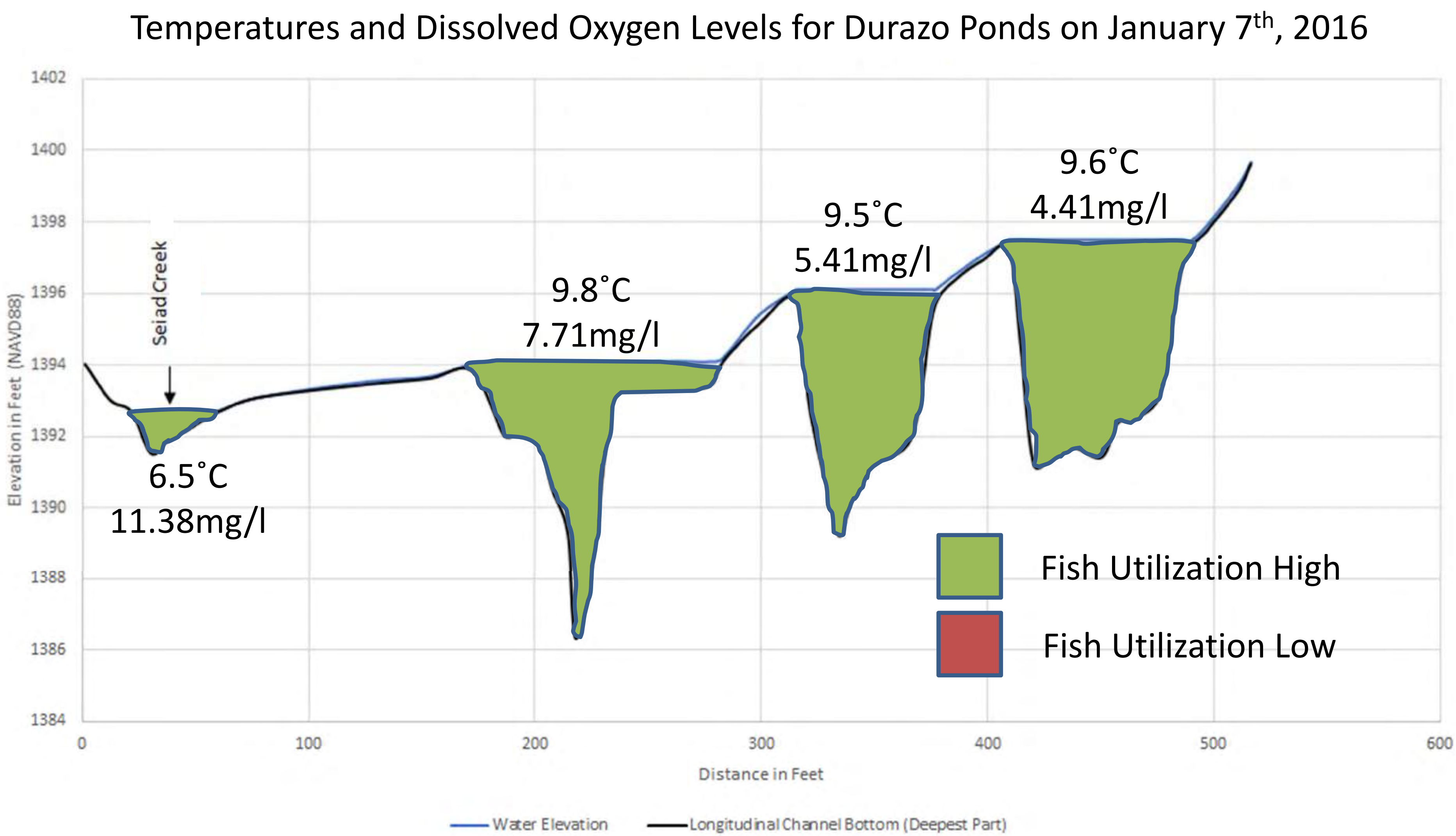
Diurnal Movements

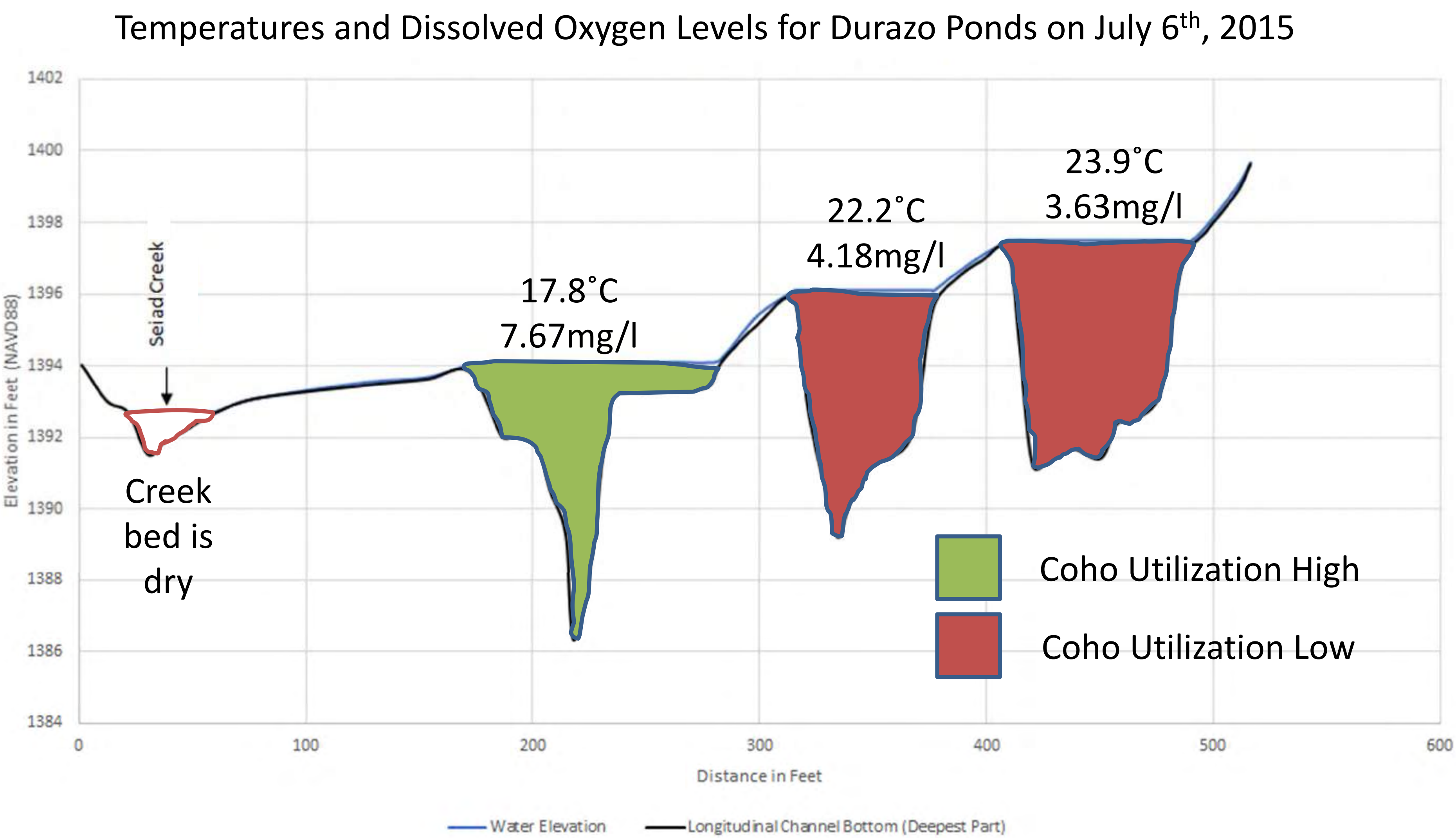


Staff Gauge at Durazo Pond Inlet

Seasonal Connectivity of Durazo Pond to Seiad Creek

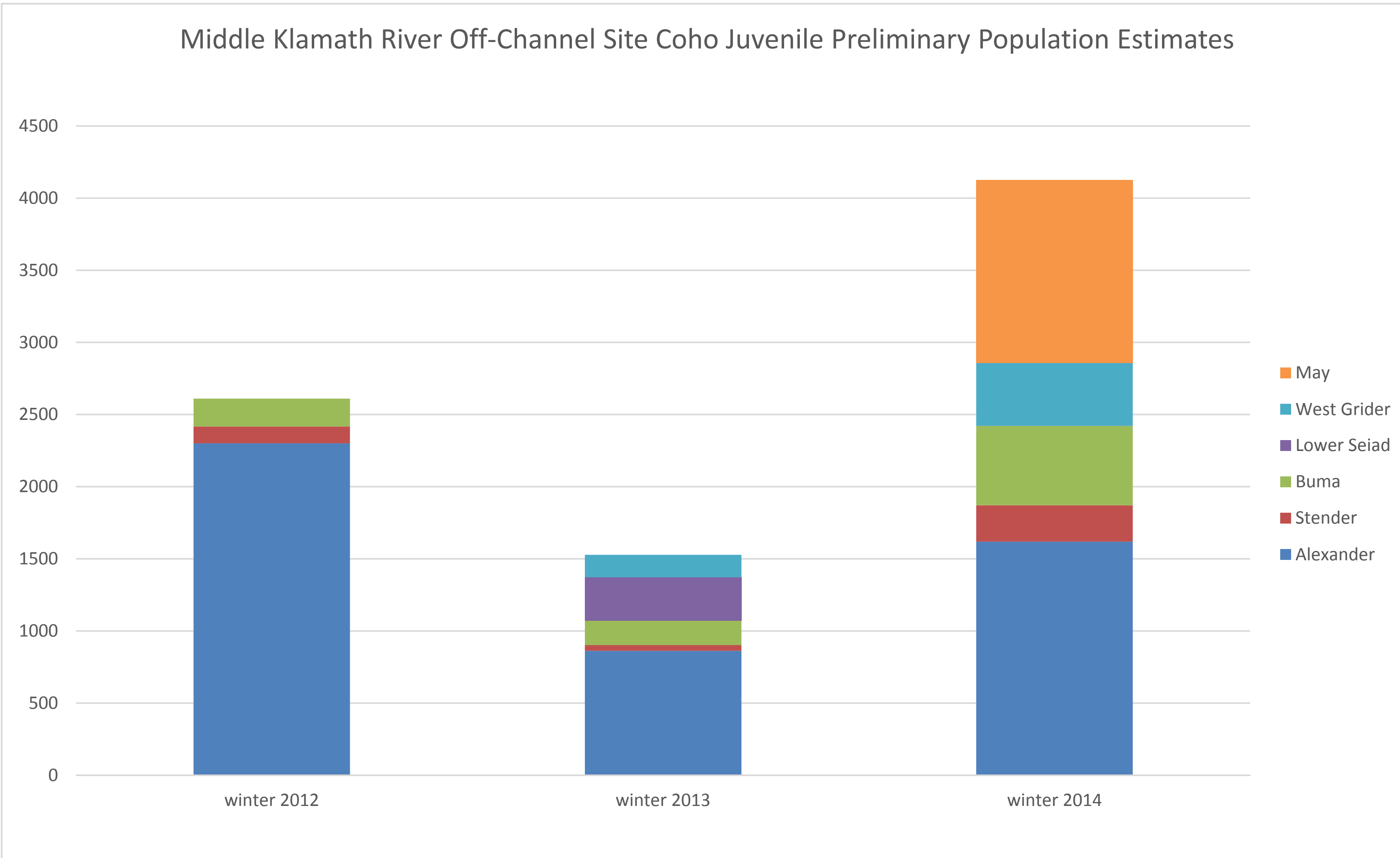



Temperatures and Dissolved Oxygen Levels for Durazo Ponds on January 7th, 2016
Elevation in Feet (NAVD88)
1402
1400
1398
1396
1394
1392
1390
1388
1386
1384
Seiad Creek
6.5˚C
11.38mg/l
9.8˚C
7.71mg/l
9.5˚C
5.41mg/l
9.6˚C
4.41mg/l
Fish Utilization High
Fish Utilization Low
0
100
200
300
400
500
600
Distance in Feet
Water Elevation
Longitudinal Channel Bottom (Deepest Part)

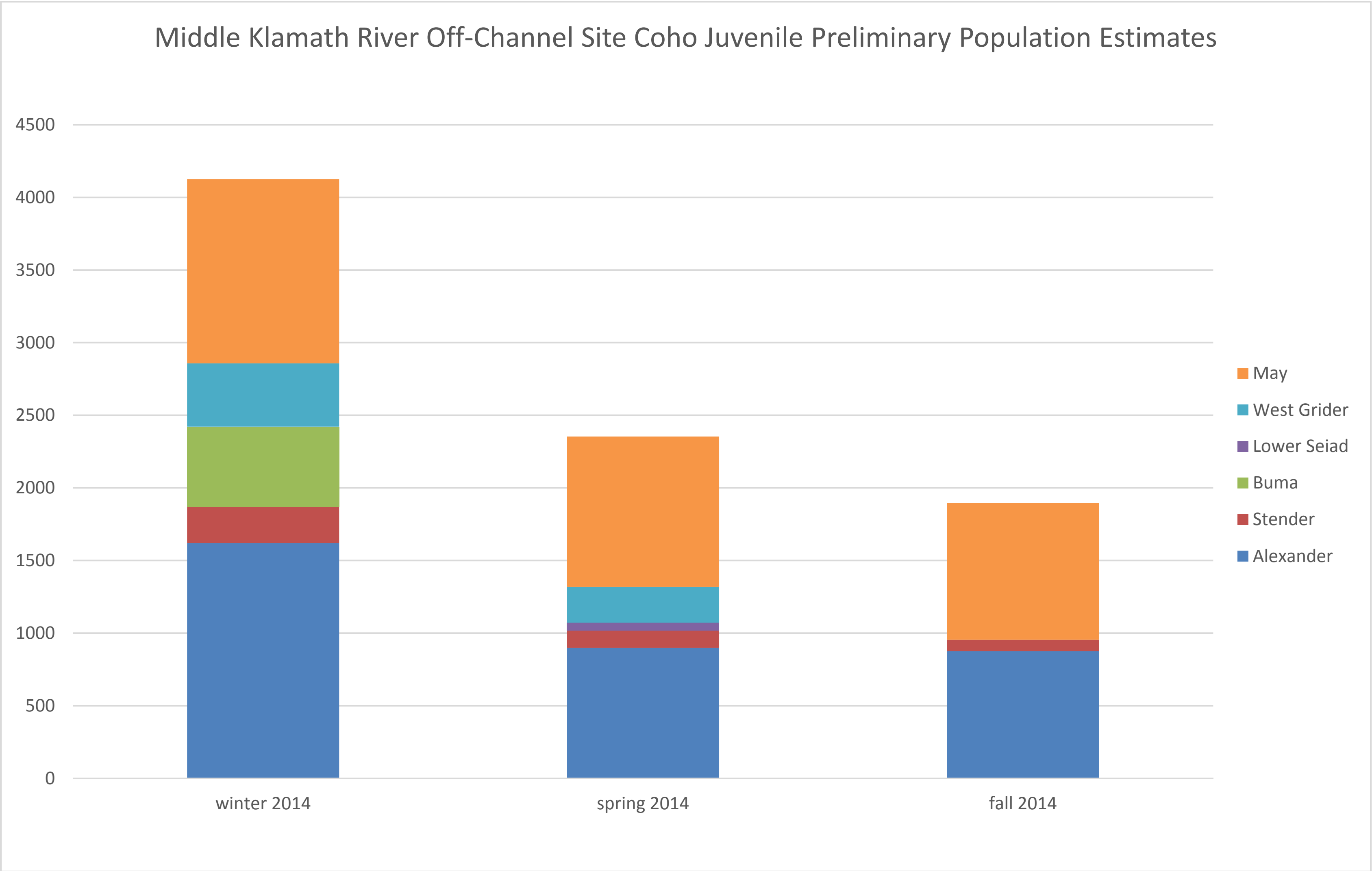

Temperatures and Dissolved Oxygen Levels for Durazo Ponds on July 6th, 2015
Seiad Creek
Creek bed is dry
17.8˚C
7.67mg/l
22.2˚C
4.18mg/l
23.9˚C
3.63mg/l
Coho Utilization High
Coho Utilization Low
Elevation in Feet (NAVD88)
1402
1400
1398
1396
1394
1392
1390
1388
1386
1384
0
100
200
300
400
500
600
Distance in Feet
Water Elevation
Longitudinal Channel Bottom (Deepest Part)

Population Estimates

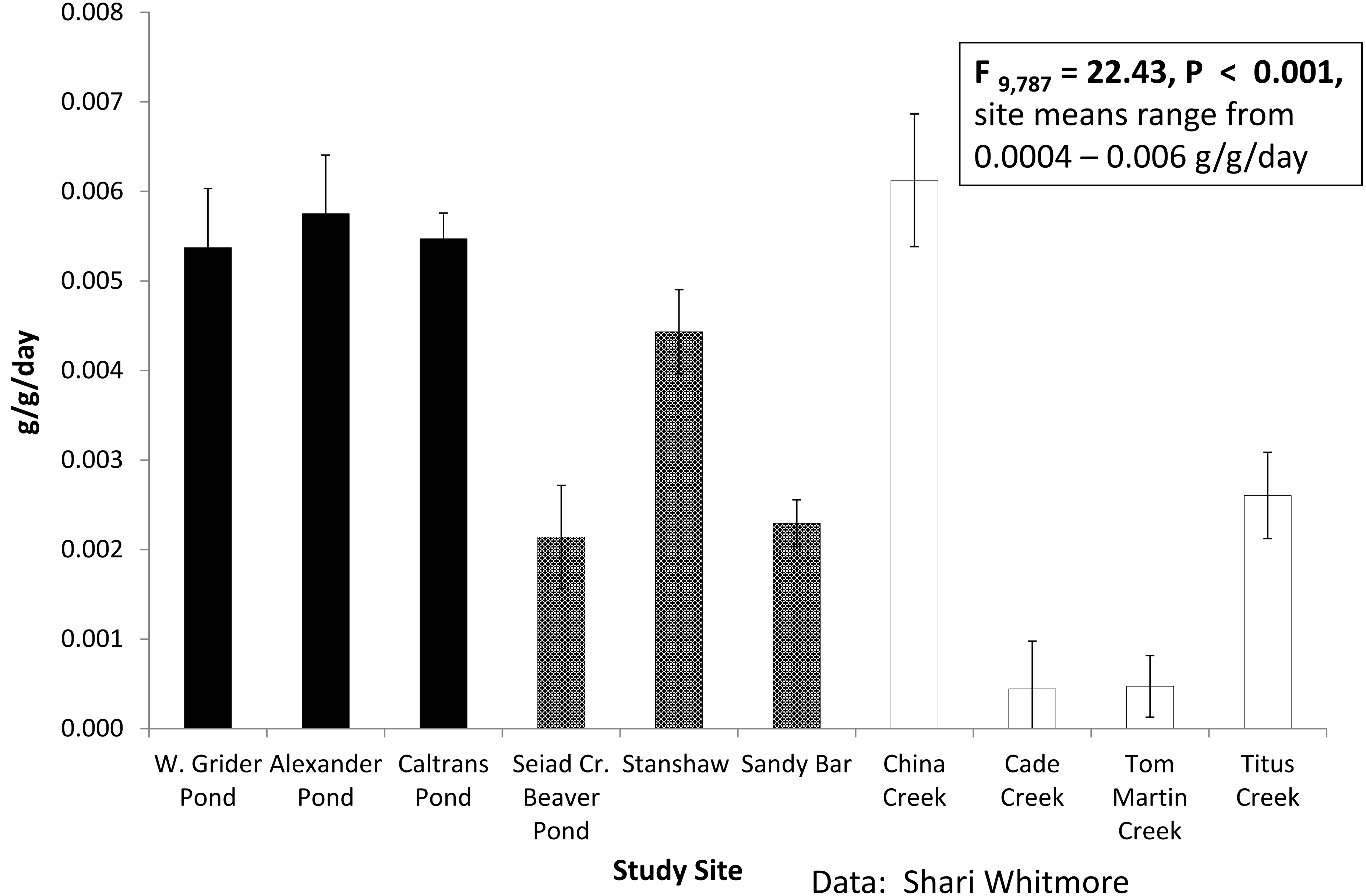
Winter Population Estimates



Population Estimates by Season

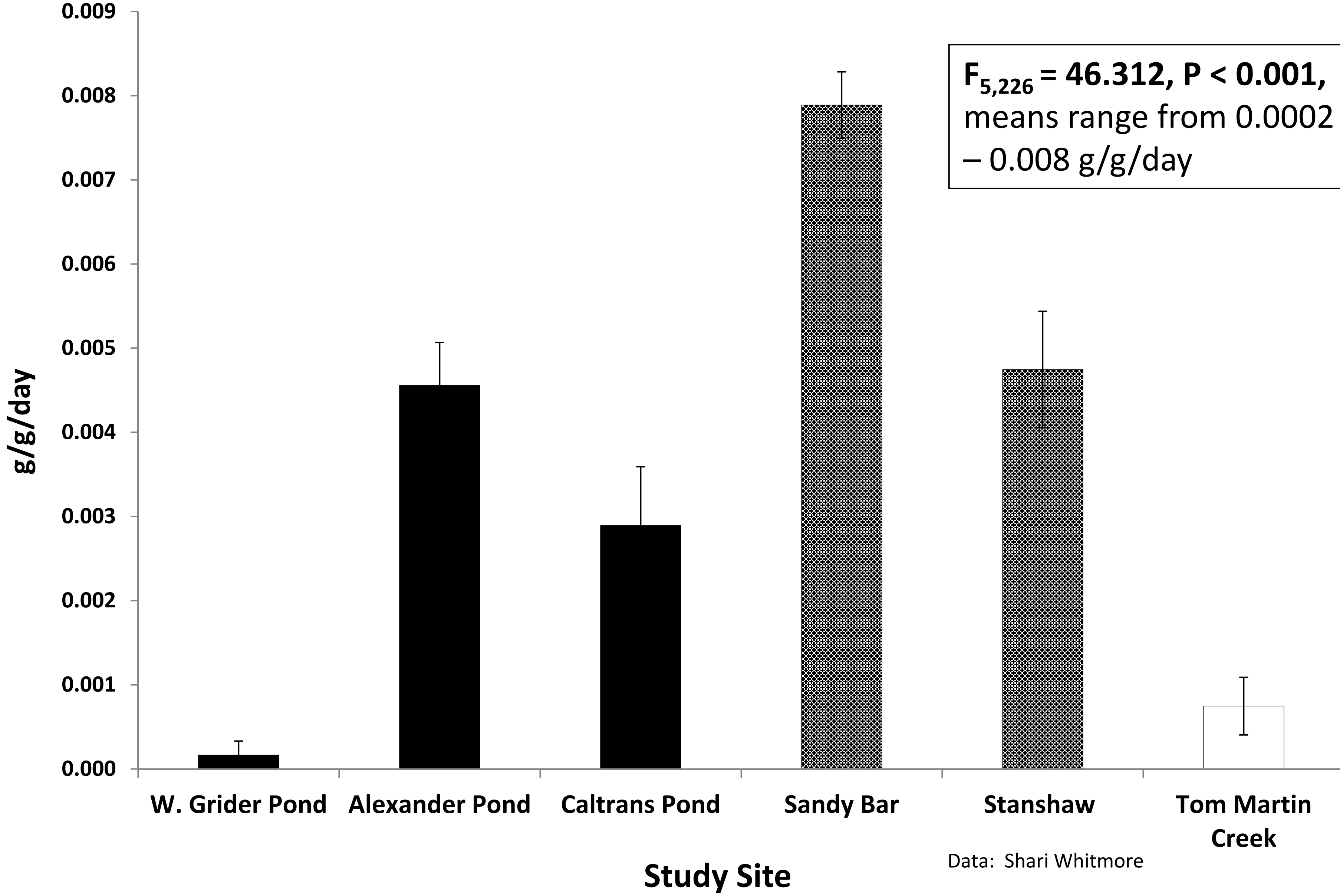


Summer Growth Rates



Data: Shari Whitmore

Winter Growth Rates



$F_{5,226}$ = 46.312, P < 0.001, means range from 0.0002 – 0.008 g/g/day

Data: Shari Whitmore

Conclusions

- Each site is unique
- Utilization during all seasons, but water quality and connectivity are limiting factors during summer
- Winter has highest utilization and residency
- Pond inlet design and location matters
- Growth and survival opportunities
- Maximize pond depth and complexity
- Groundwater influence is important for summer cooling and winter warming especially inland zones
- Location…Location…Location

Acknowledgement's

- Karuk Fisheries Program
  - Ken Brink
  - Sophie Price
  - Mike Polmateer
  - Alex Corum
  - Emilio Tripp
- Middle Klamath Watershed Council
  - Charles Wickman
  - Mitzi Wickman
  - Will Harling
  - Jimmy Peterson
- Humboldt State Grade Students
  - Michelle Krall
  - Shari Whitmore

- Consultants
  - Rocco Fiori
  - Larry Lestelle

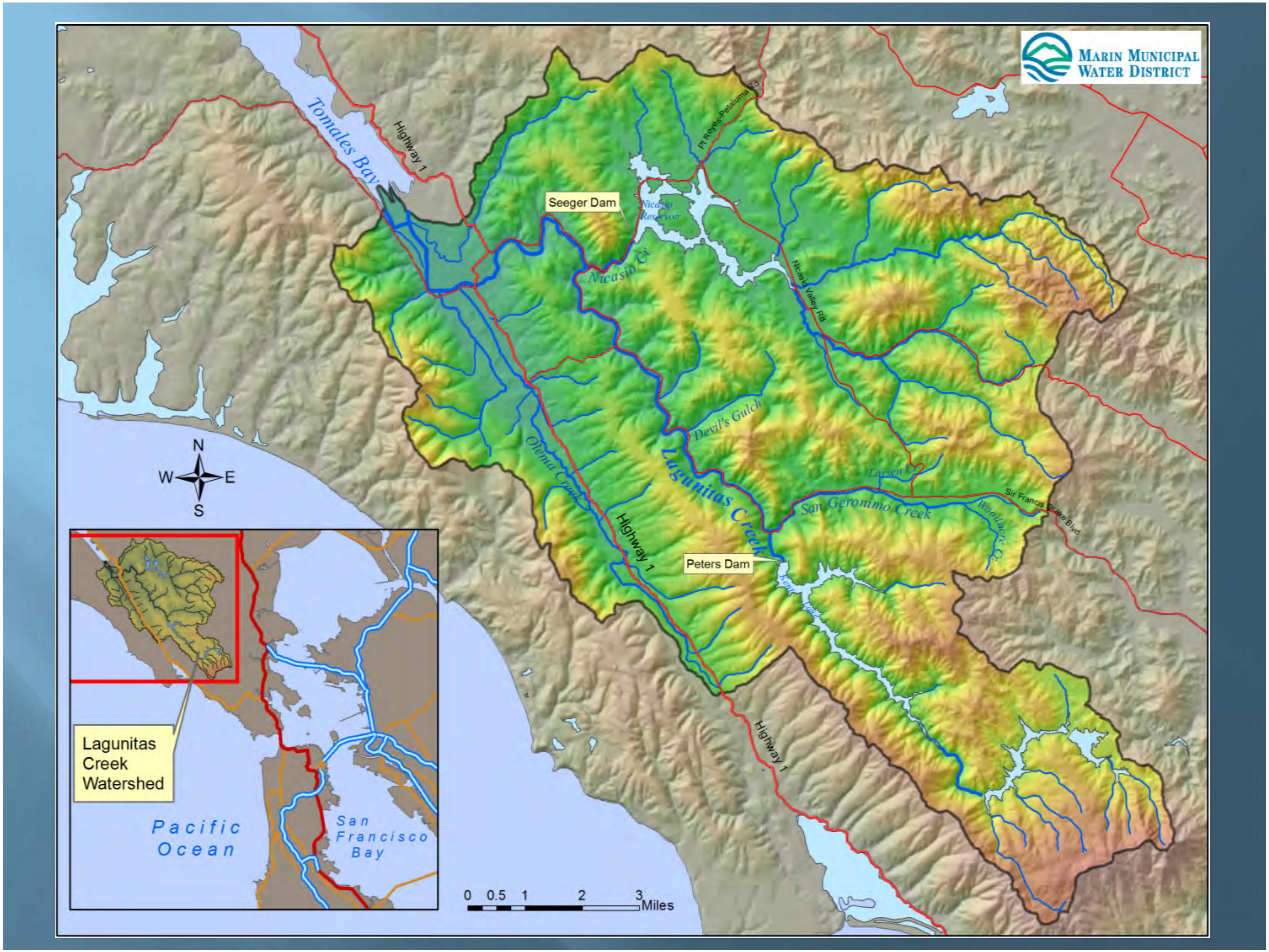
- Funding Provided by the Nation Fish and Wildlife Foundation and US Bureau of Reclamation

Questions???

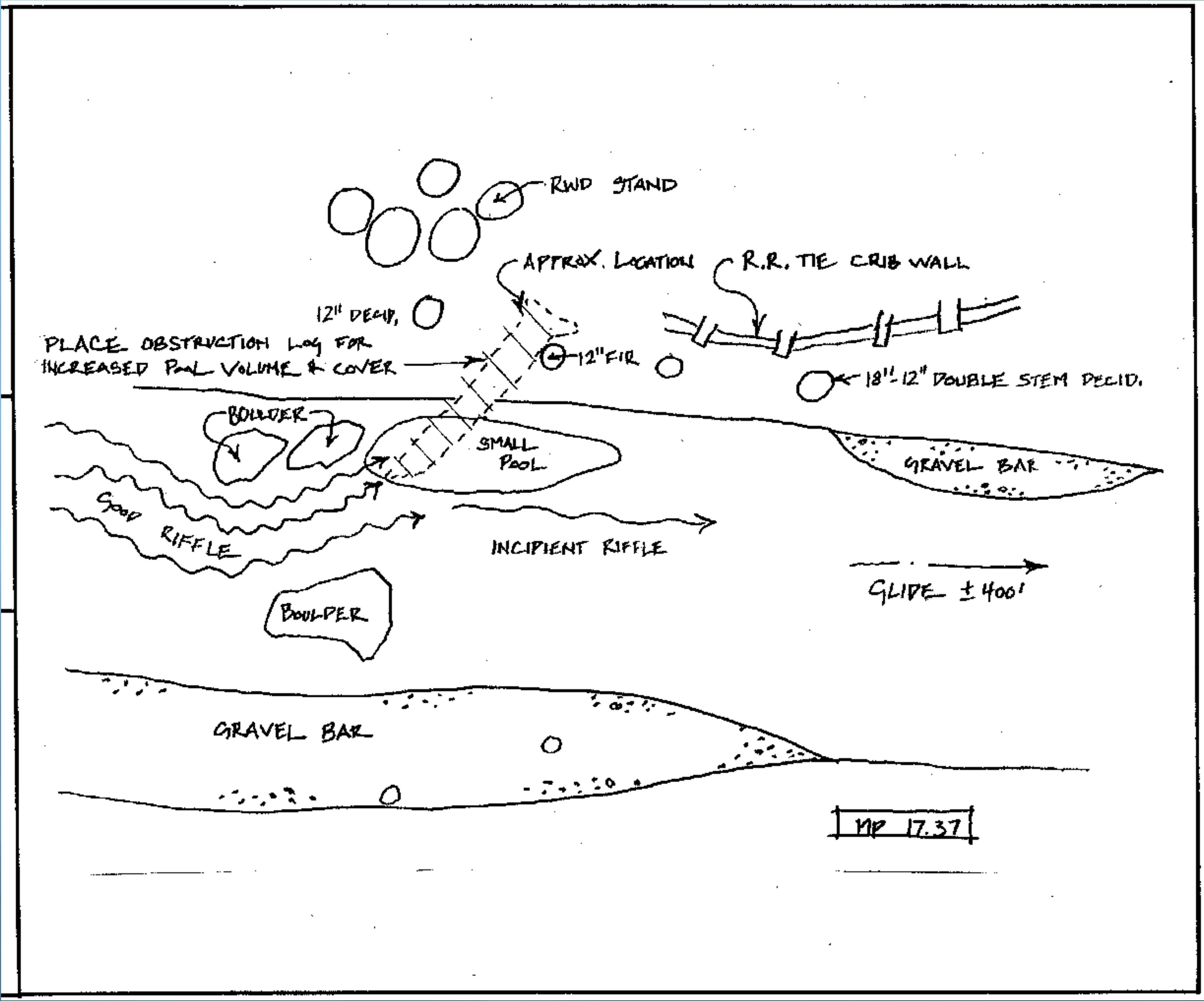
Salmon River

THE EFFECTIVENESS OF LARGE WOOD ENHANCEMENT IN LAGUNITAS CREEK 2000-2015

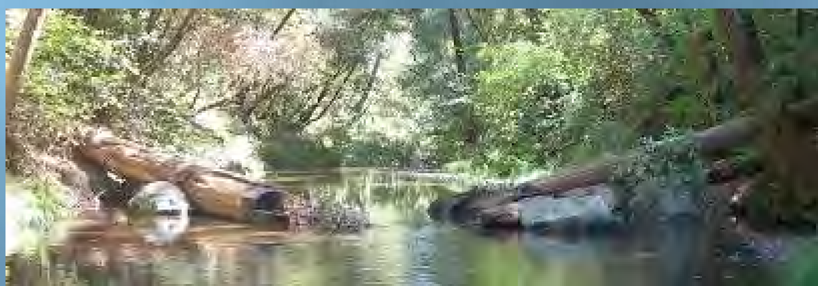
Eric Ettlinger, Aquatic Ecologist
Marin Municipal Water District

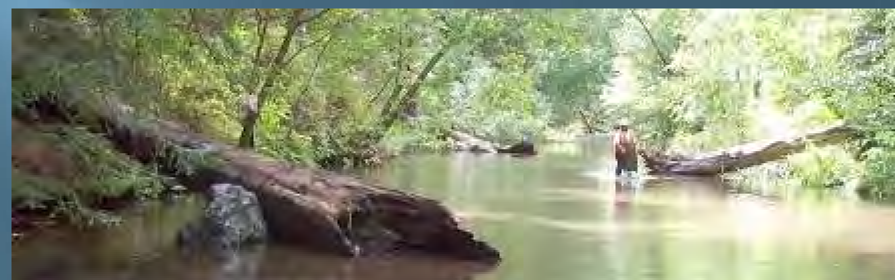

Marin Municipal Water District
Tomales Bay
Highway 1
Pt Reyes-Petaluma Rd
Seeger Dam
Nicasio Reservoir
Nicasio Cr.
Nicasio Valley Rd
Devil's Gulch
Lagunitas Creek
Olema Creek
Larsen Cr.
San Geronimo Creek
Woodacre Cr.
Sir Francis Drake Blvd
Peters Dam
Kent Lake
N
W
E
S
Lagunitas Creek Watershed
Pacific Ocean
San Francisco Bay
0 0.5 1 2 3 Miles

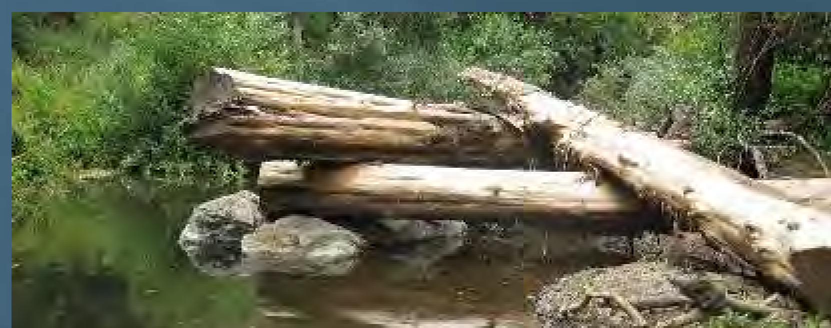
Lagunitas' Lack o' Wood


RWD STAND
APPROX. LOCATION
R.R. TIE CRIB WALL
12" DECID.
PLACE OBSTRUCTION LOG FOR
INCREASED POOL VOLUME & COVER
12" FIR
18"-12" DOUBLE STEM DECID.
BOULDER
SMALL
POOL
GRAVEL BAR
GOOD RIFFLE
INCIPIENT RIFFLE
GLIDE ± 400'
BOULDER
GRAVEL BAR
MP 17.37

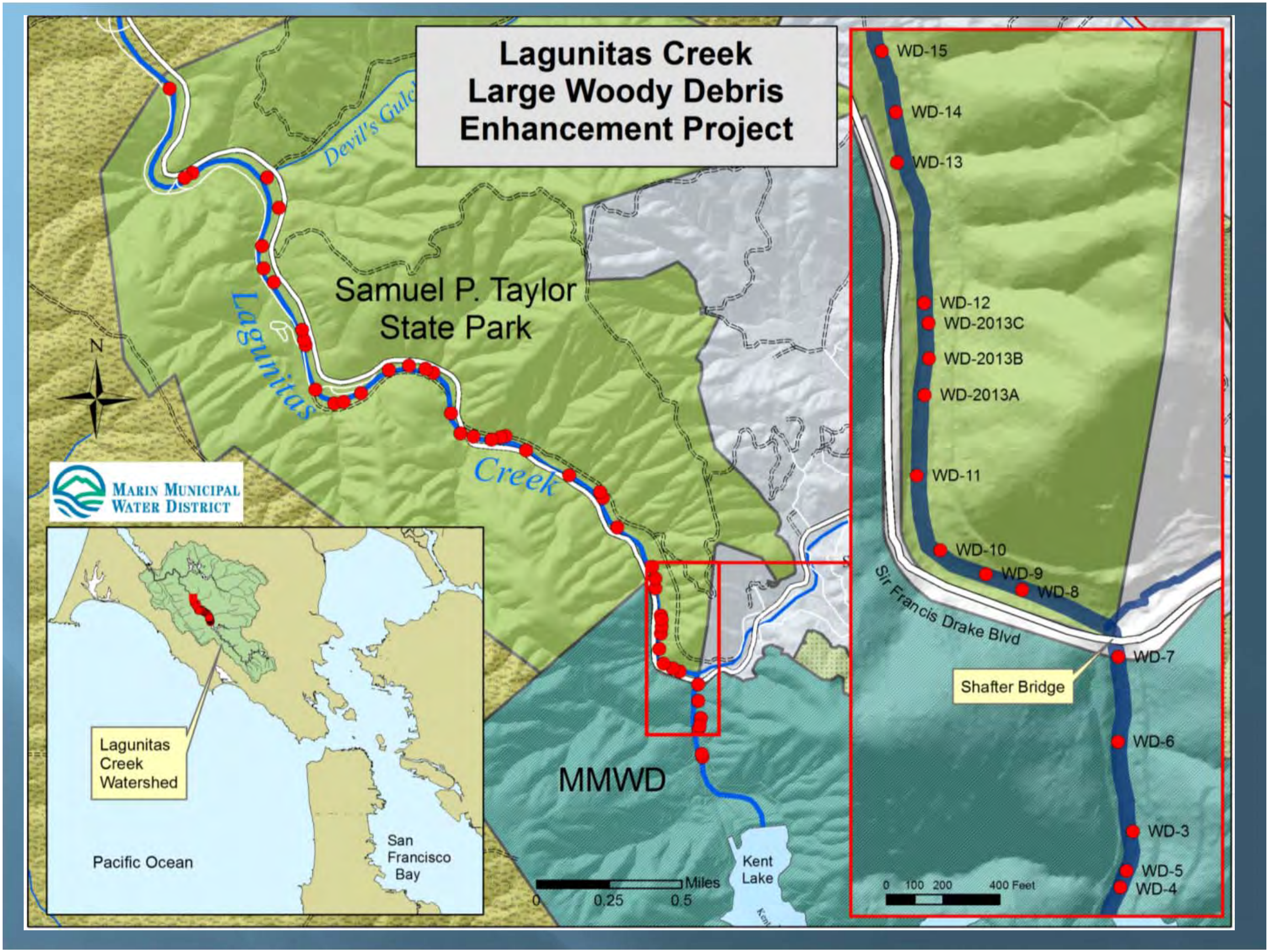
Structure Designs



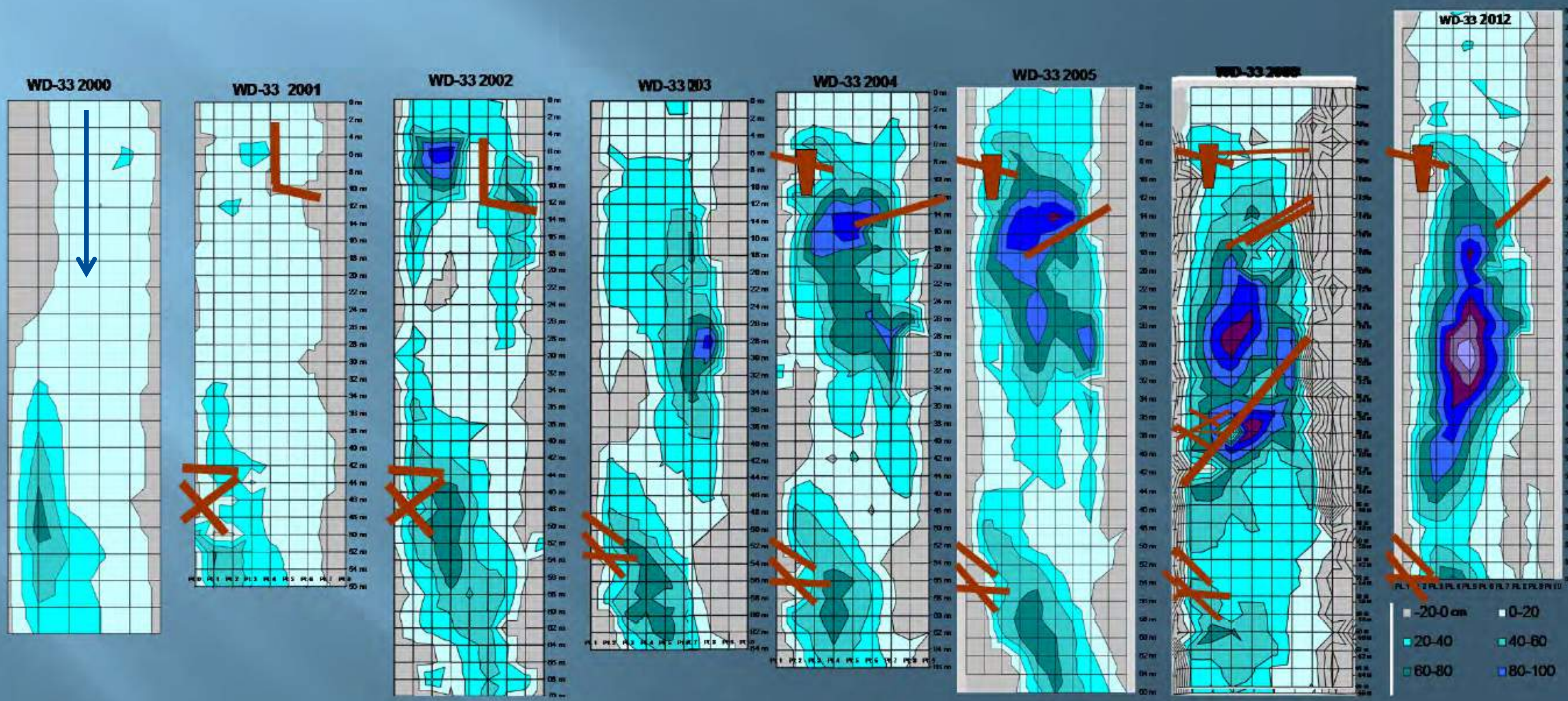




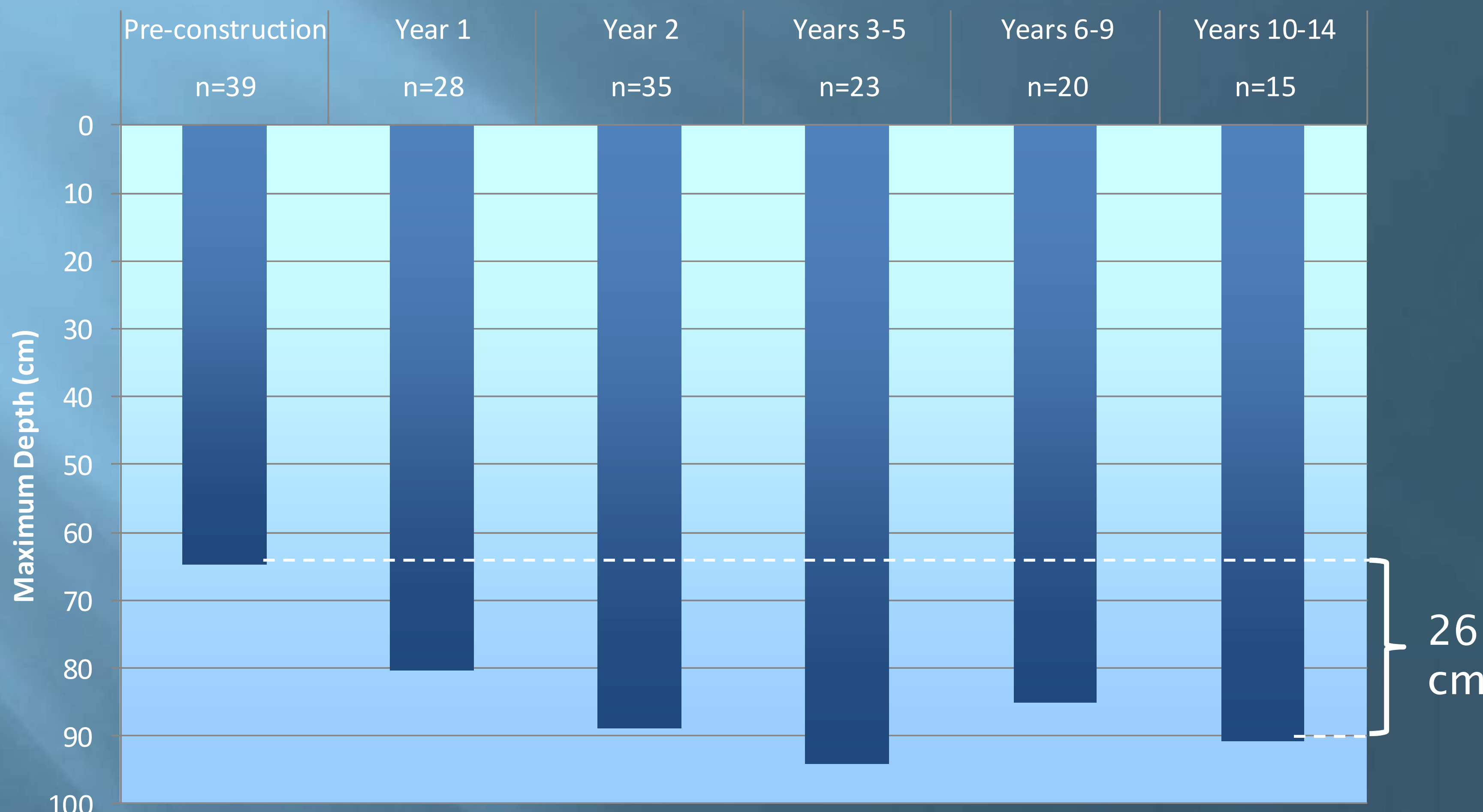

CAT
MMWD


Lagunitas Creek
Large Woody Debris
Enhancement Project
Samuel P. Taylor
State Park
Devil's Gulch
Lagunitas
Creek
N
Marin Municipal
Water District
MMWD
Kent
Lake
Miles
0
0.25
0.5
Lagunitas
Creek
Watershed
Pacific Ocean
San
Francisco
Bay
WD-15
WD-14
WD-13
WD-12
WD-2013C
WD-2013B
WD-2013A
WD-11
WD-10
WD-9
WD-8
Sir Francis Drake Blvd
Shafter Bridge
WD-7
WD-6
WD-3
WD-5
WD-4
0
100
200
400 Feet

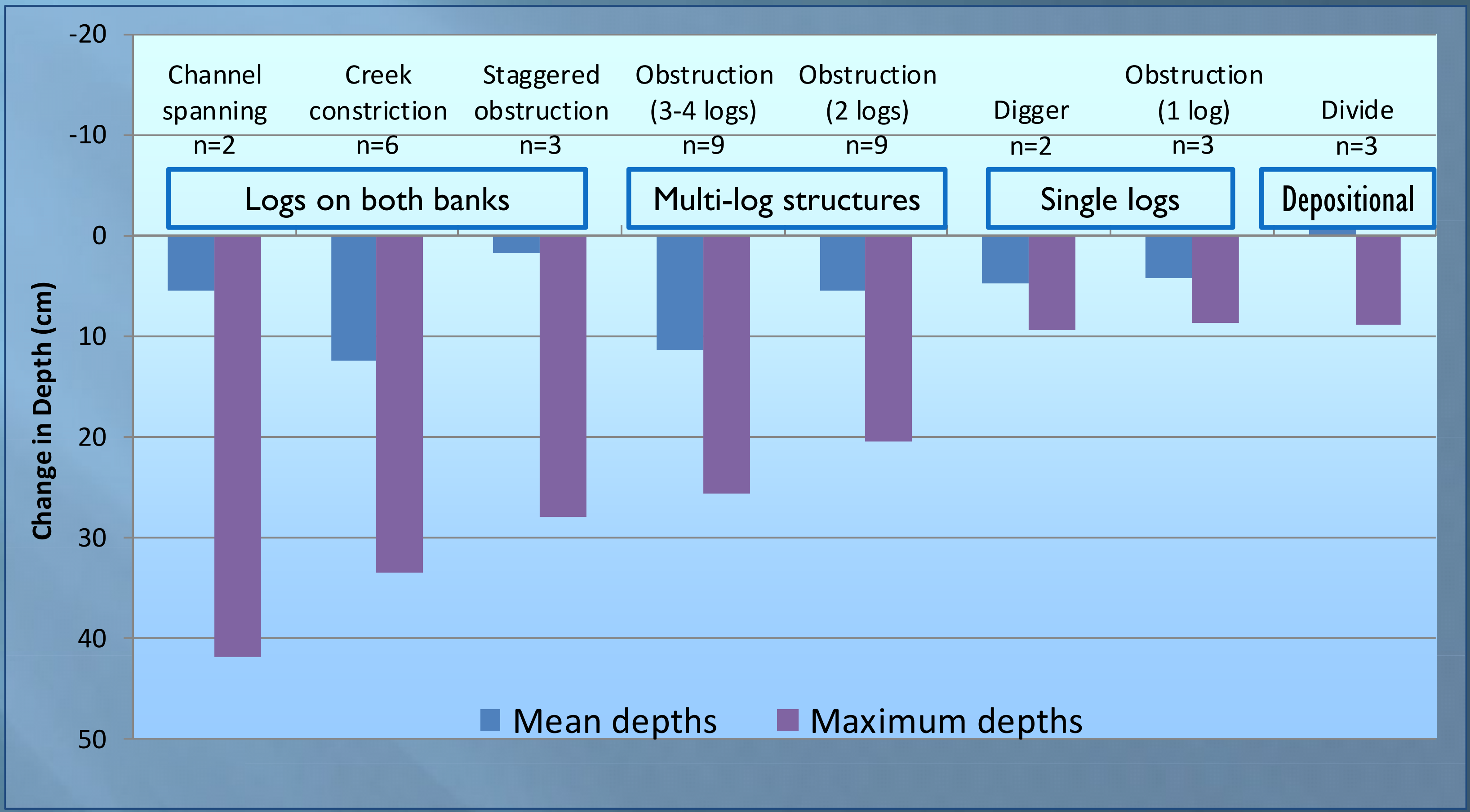
Creating and Enhancing Pools



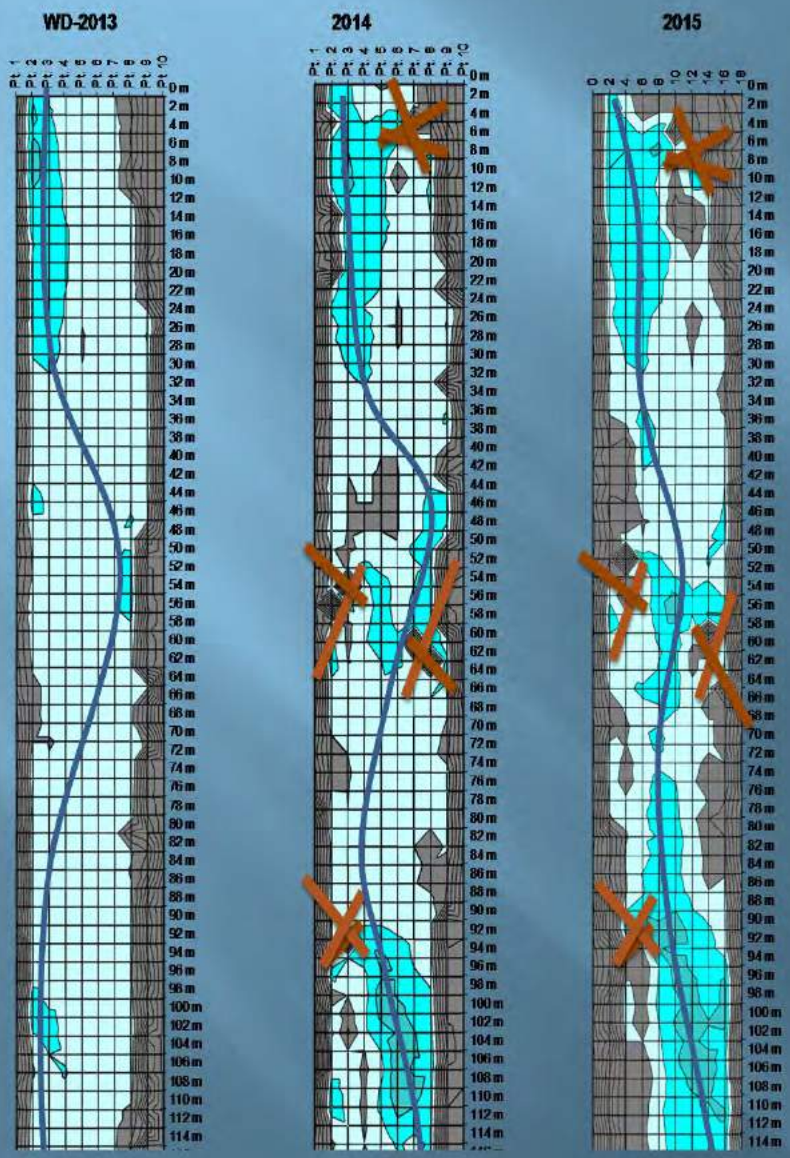
Increasing Stream Depth

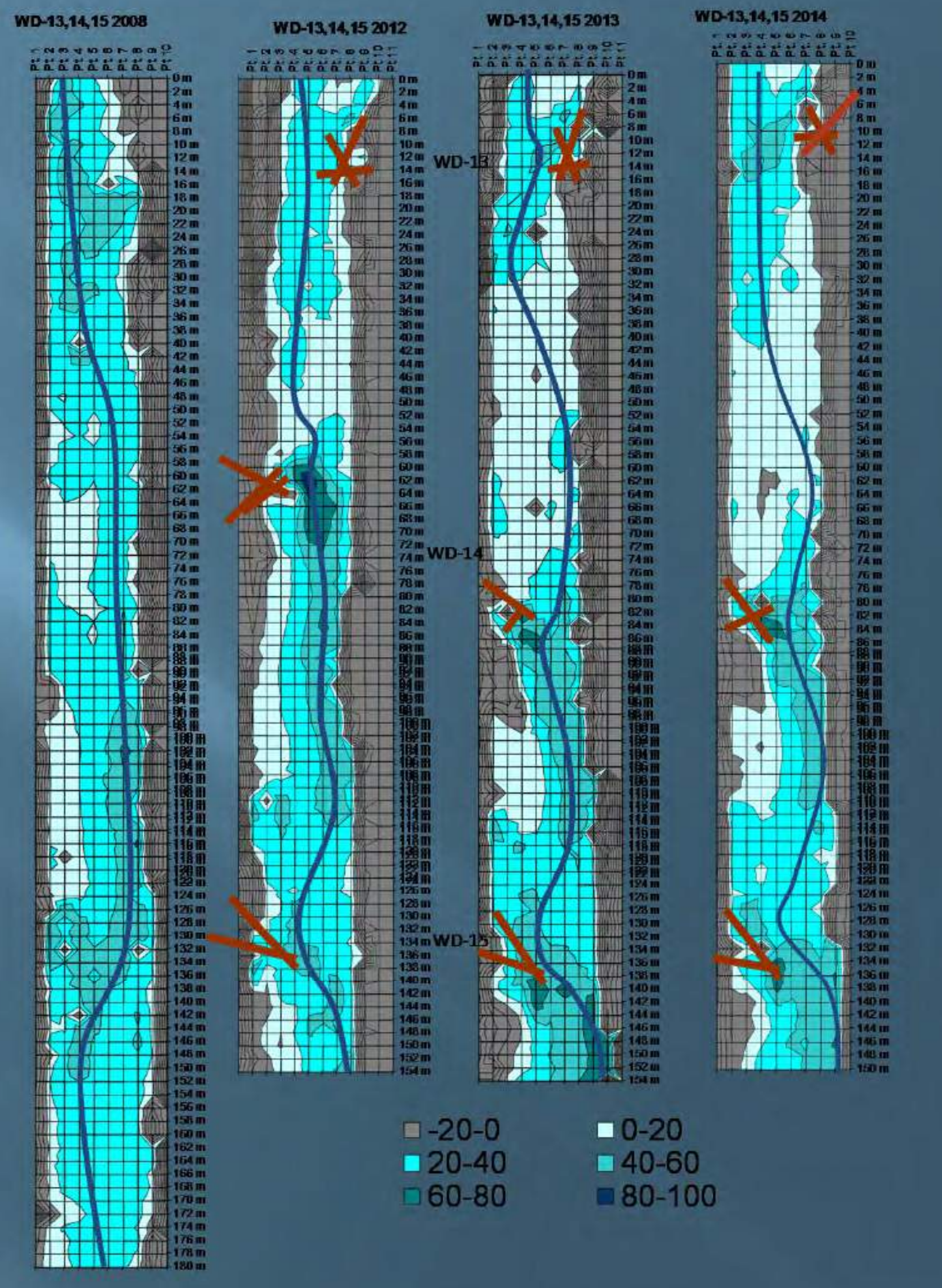


Best Structures for Increasing Depth



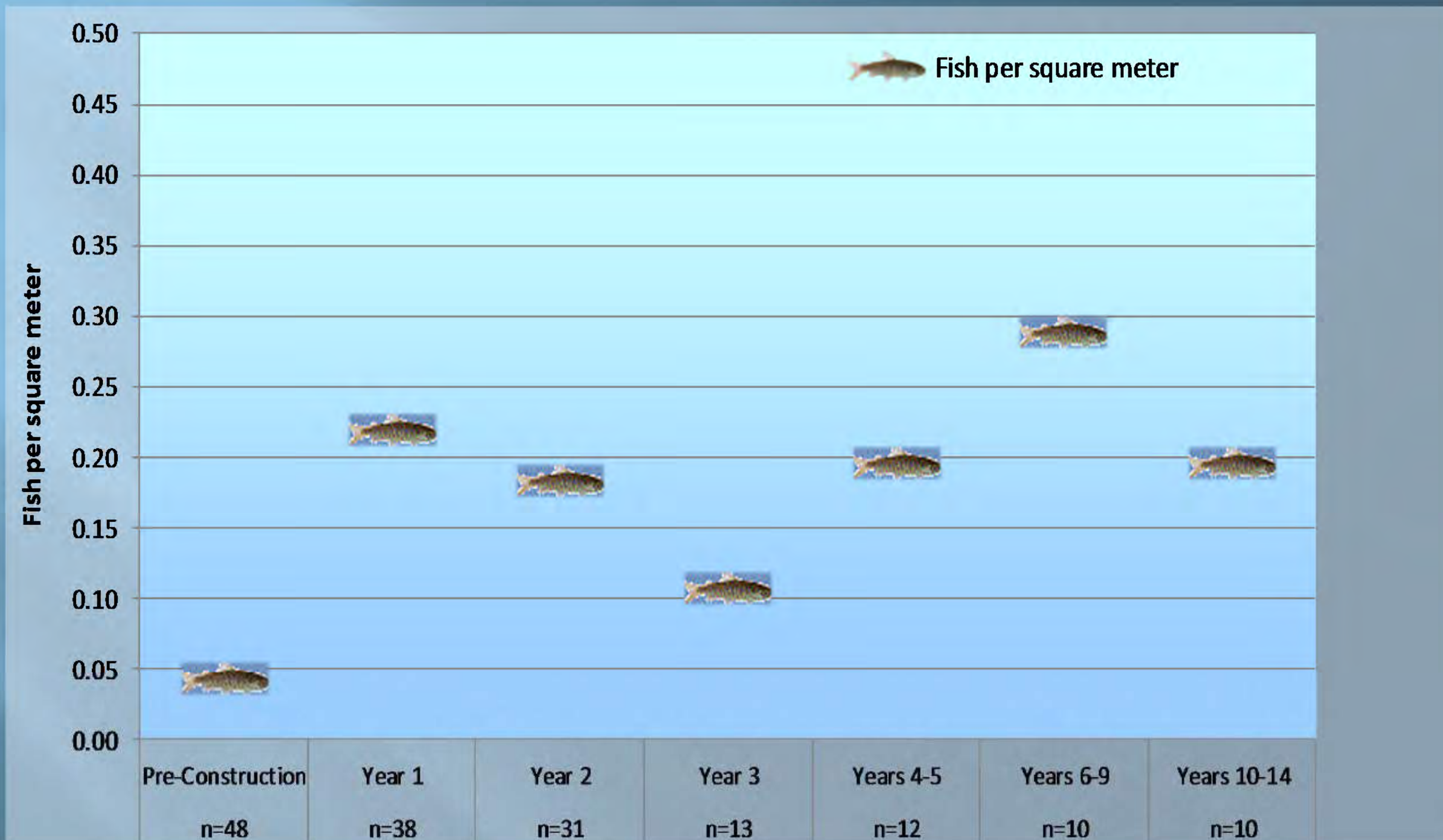
Channel Complexity



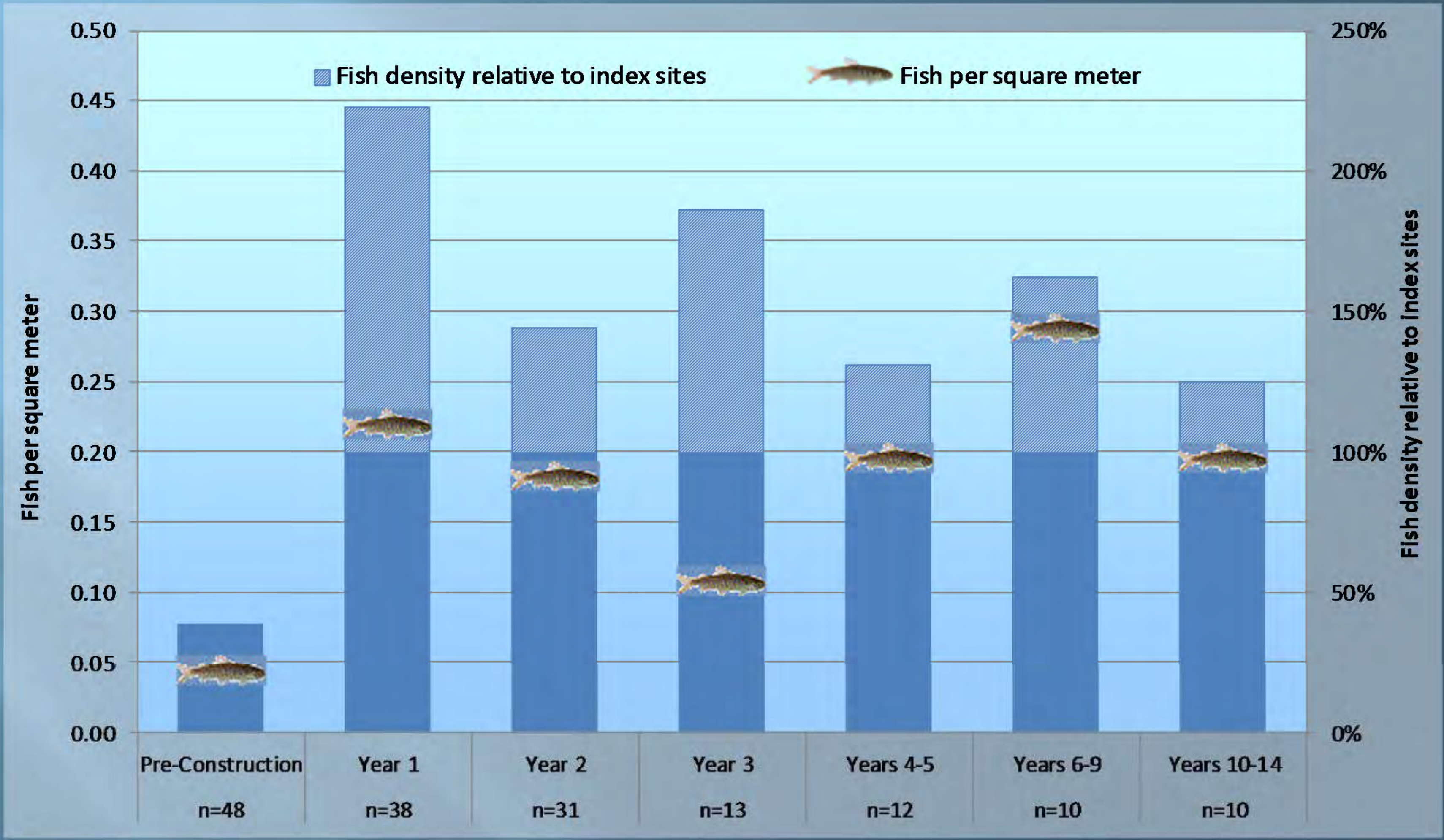


Coho in the Wood

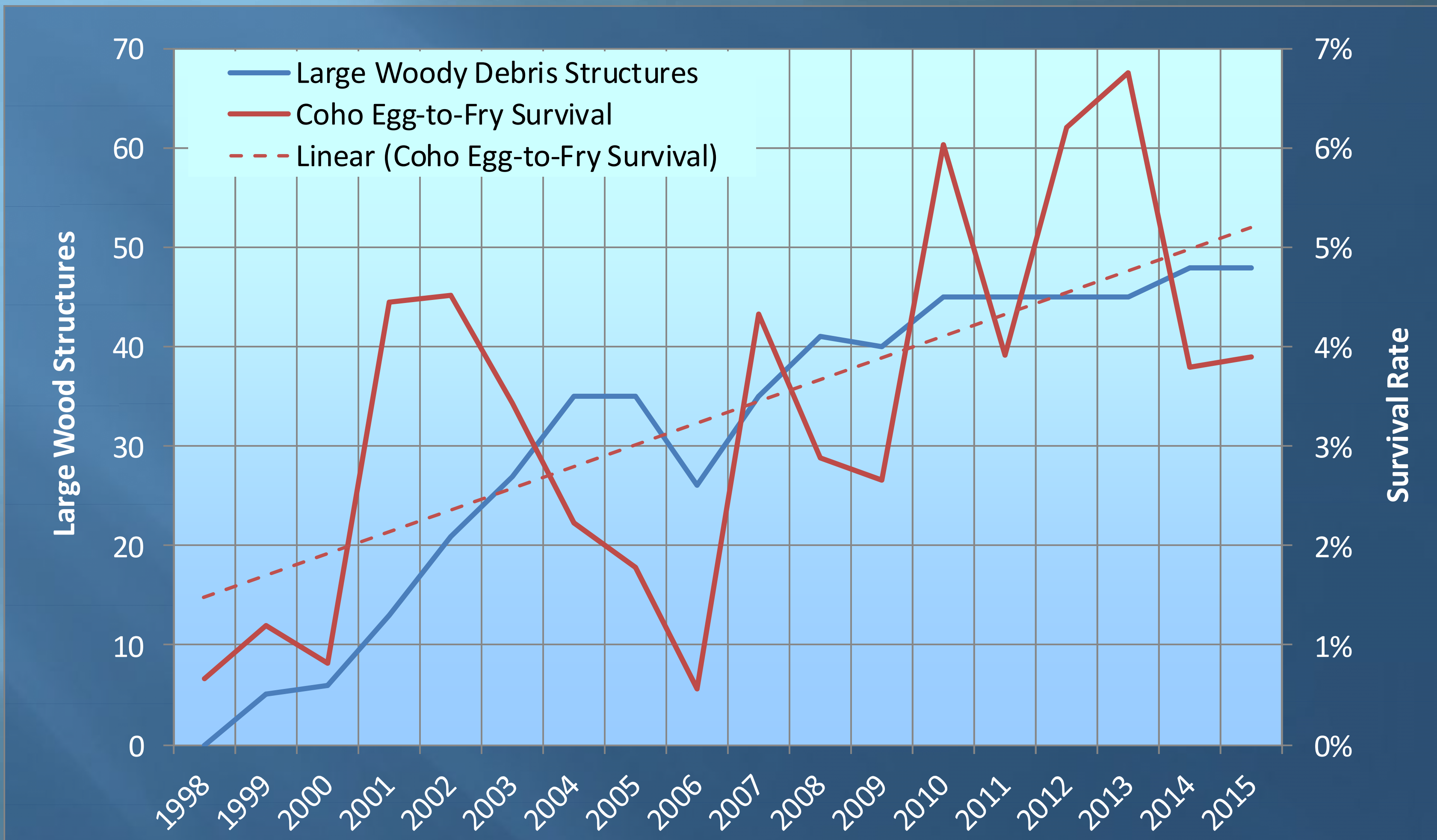
Coho in the Wood



Coho in the Wood

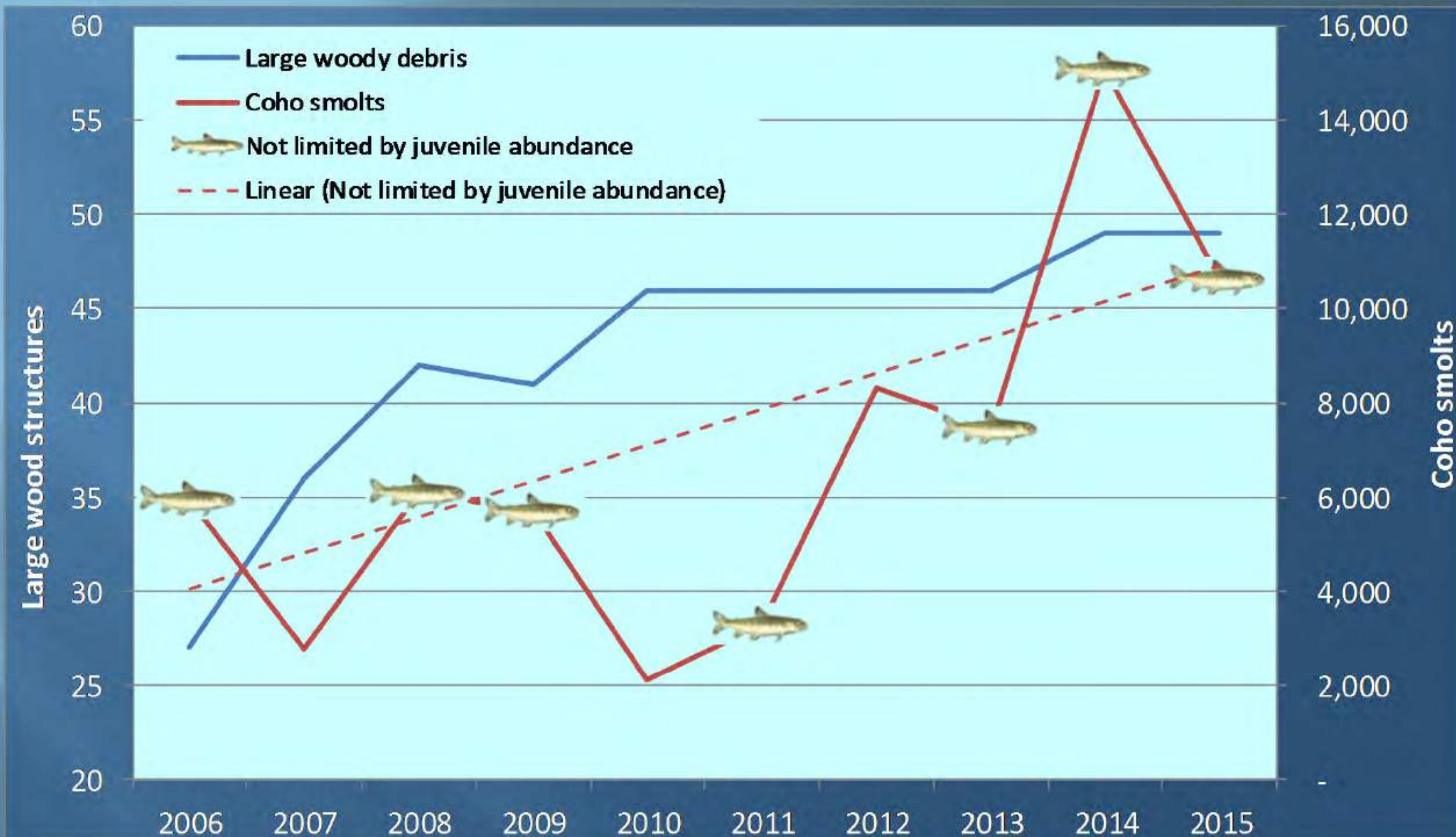


Increasing Fry Survival?



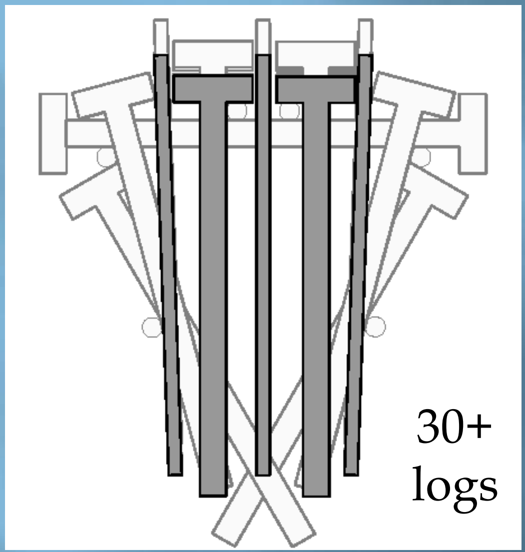
Disclaimer: Correlation is not causation

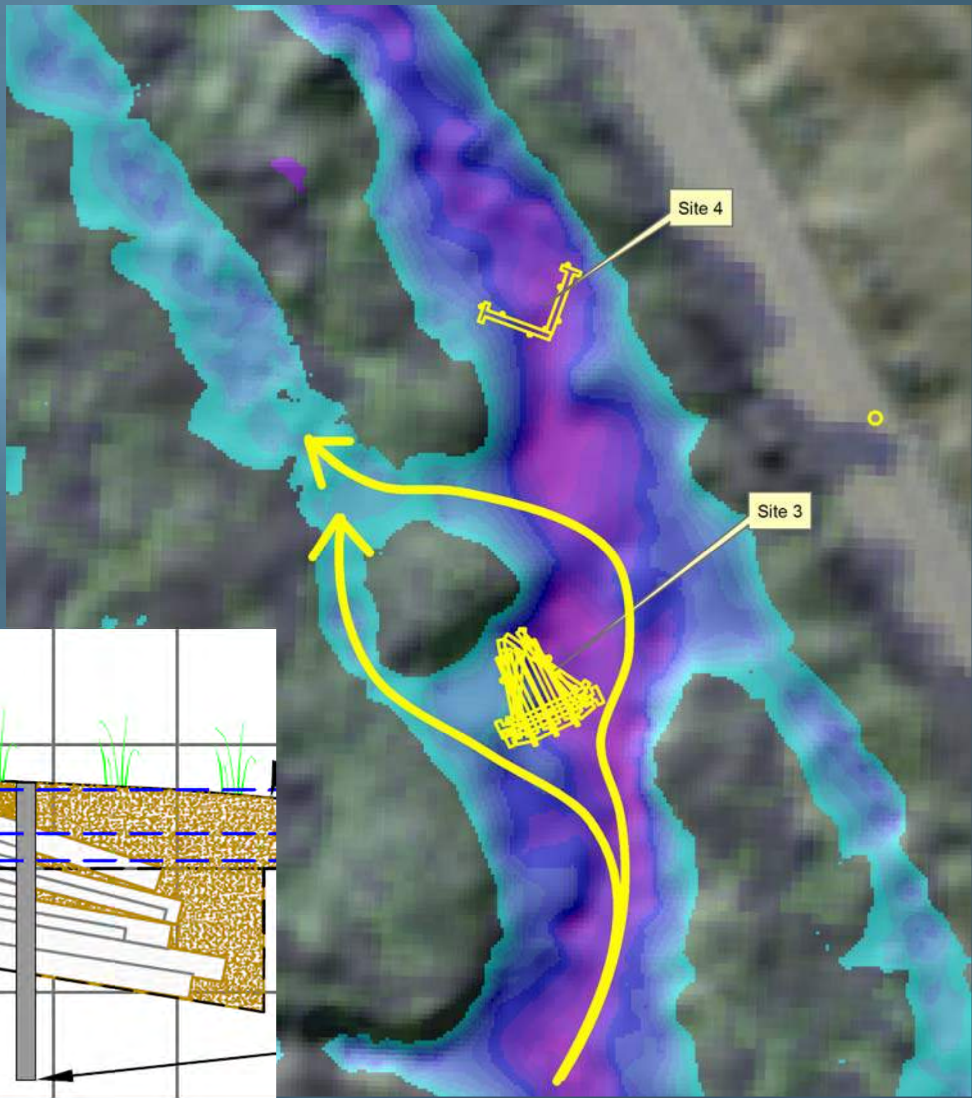
Increasing Smolt Survival?

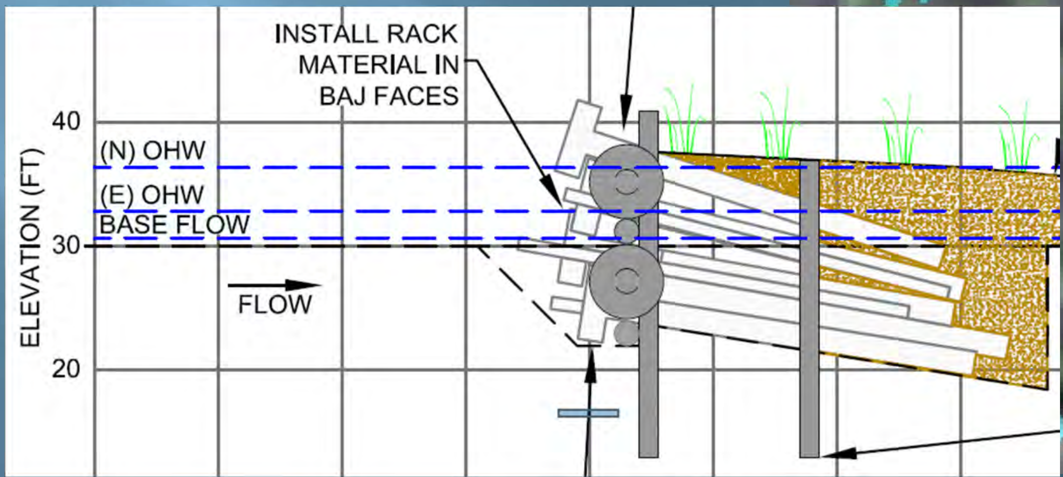


Disclaimer: Correlation is not causation

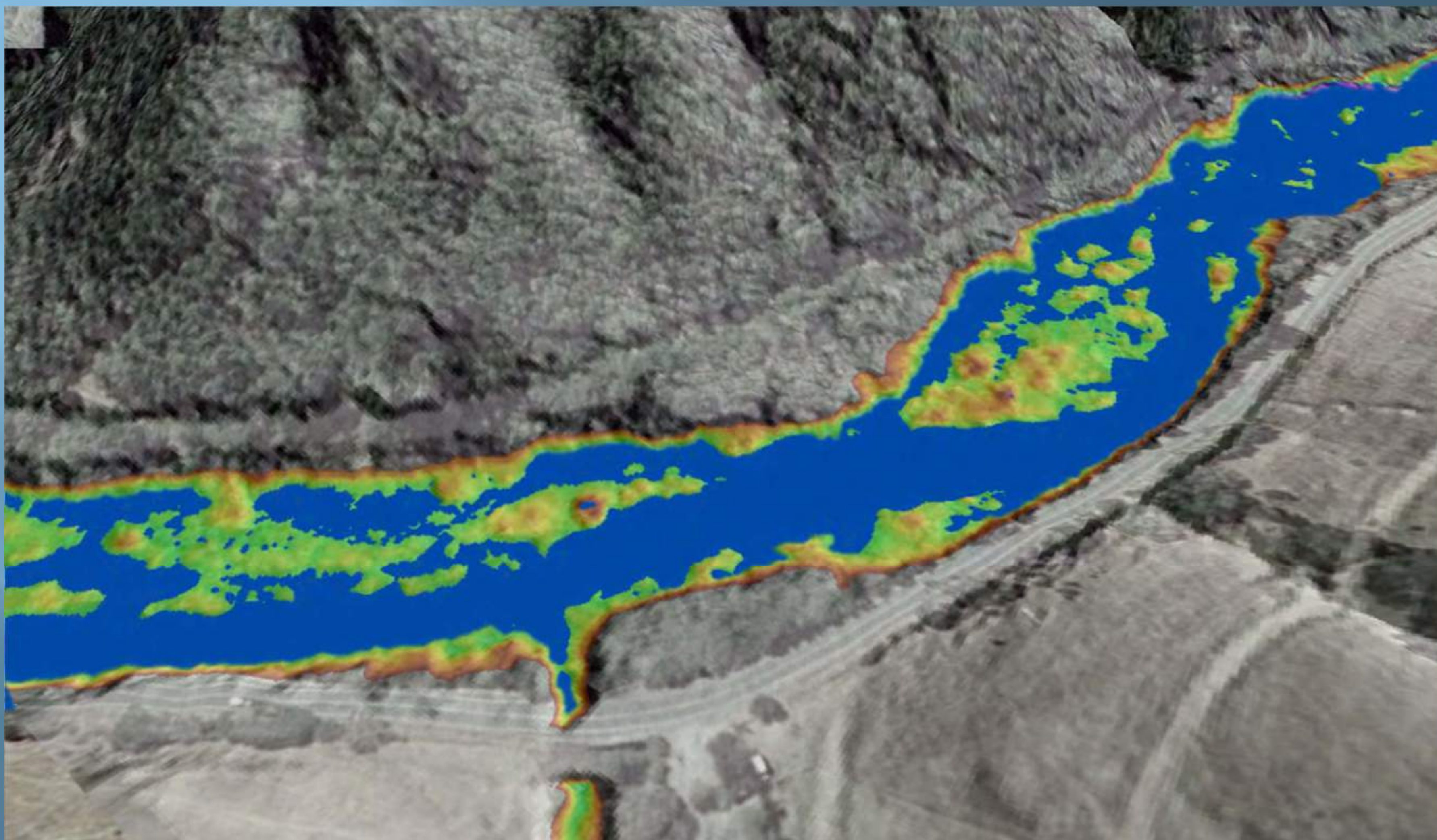
Next Up: Winter Habitat







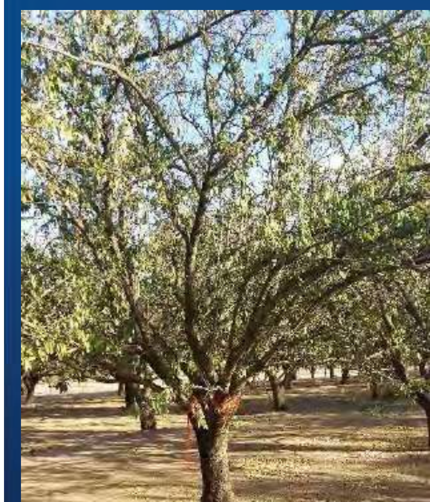
Next Up: Winter Habitat



Design and Implementation of Fine Woody Material for Juvenile Salmonids In the Levee Corridor

April 7th, 2016

Fortuna, CA



nhc
northwest hydraulic consultants

water resource specialists

Overview

- Project Setting
- Project Need
- Overall Design
- Purpose of Wood
- Design/Specification of Wood
- Implementation
- Monitoring

Project Setting

- American River RM 0.5 near Sacramento River RM 60
- Downstream of Major Dams (Folsom, Oroville, Shasta)
- Federal Project Levees/Urban encroachments

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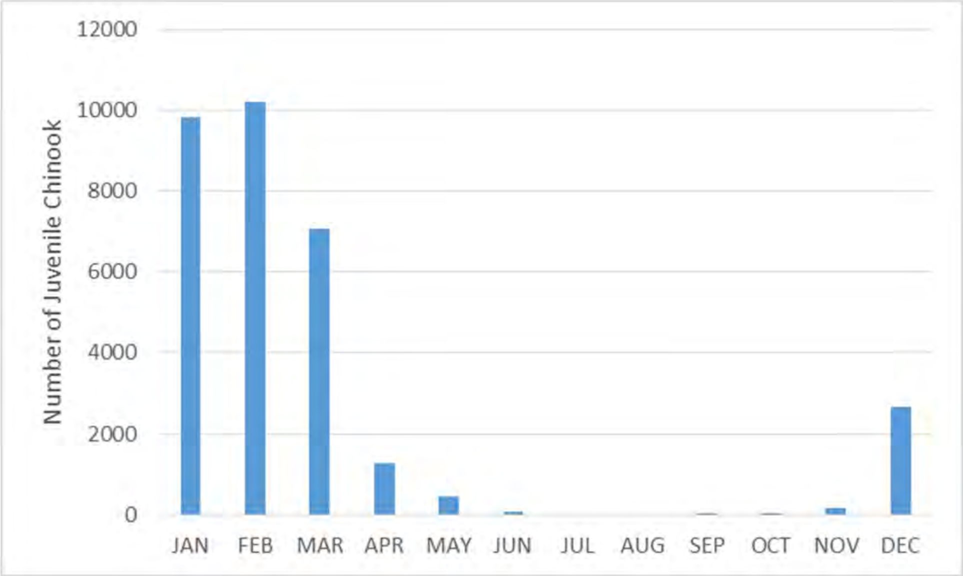
Juvenile Presence

- Sacramento River supports 4 runs of Chinook and Central Valley Steelhead
- American River supports fall-run Chinook
- Sacramento is a pass-through reach



Number of Chinook Salmon Captured per month with USFWS beach sine surveys 1976-2011 at Elkhorn Slough (RM 71)

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Project Need

- Artificial physical (levees) and hydrologic (water management) constraints have removed shallow floodplain and off-channel habitat from the main stem of the Sacramento River (Lufkin 1996).
- Off-channel habitat provide refuge, reduced competition, reduced predator encounters, and increased prey densities.

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water resource specialists

Project Need

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water resource specialists

Overall Design Objectives

- Shallow Water Habitat when Juvenile are present

- Native Planting to provide food and refuge (cover, food)

Project Overview

- ~2.5 acre Restoration Site
- Naturally perched floodplain lowered ~20 feet
- 60,000 cy off-haul
- Graded Planting benches, instream wood

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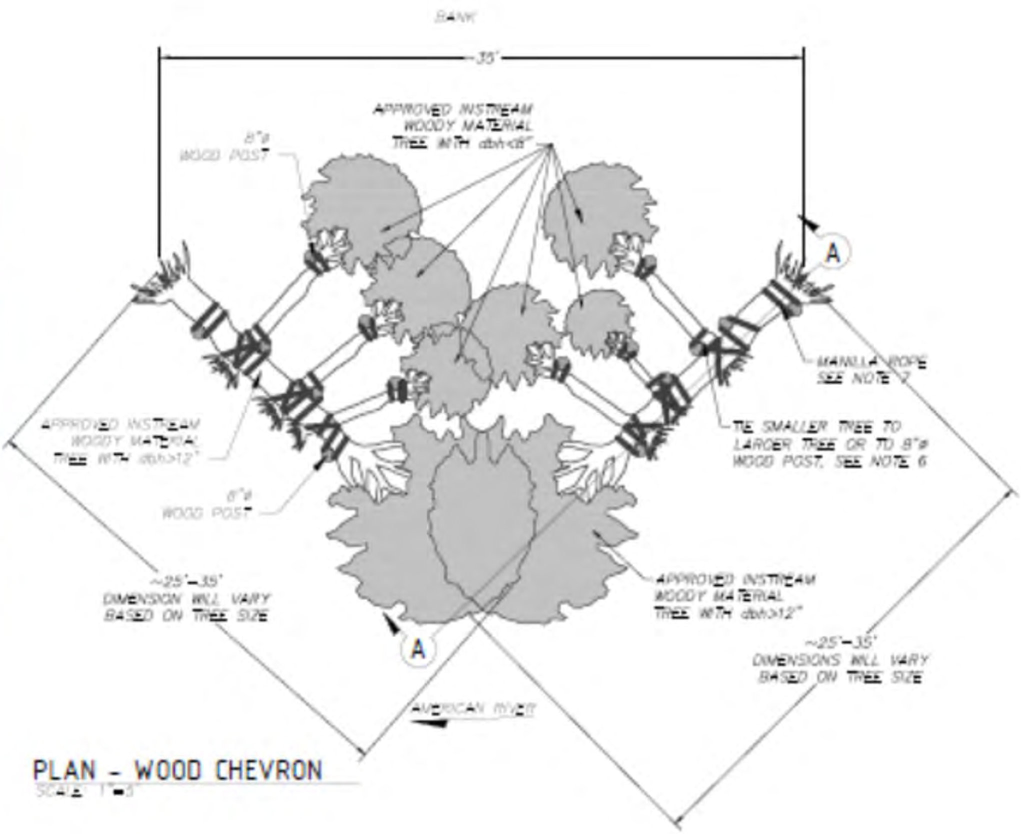
Purpose of Wood

- Functional Design
  - To provide cover at fall water levels
  - To provide protection to planting berms from boat wakes
  - To reduce shear stress and allow Tule to establish

Design of Wood

- Based on observations of wood placed at bank protection sites.
- Fine Woody Material
- Wood must be anchored but
  - Leave no trace
  - No shipwrecks
  - Constructability

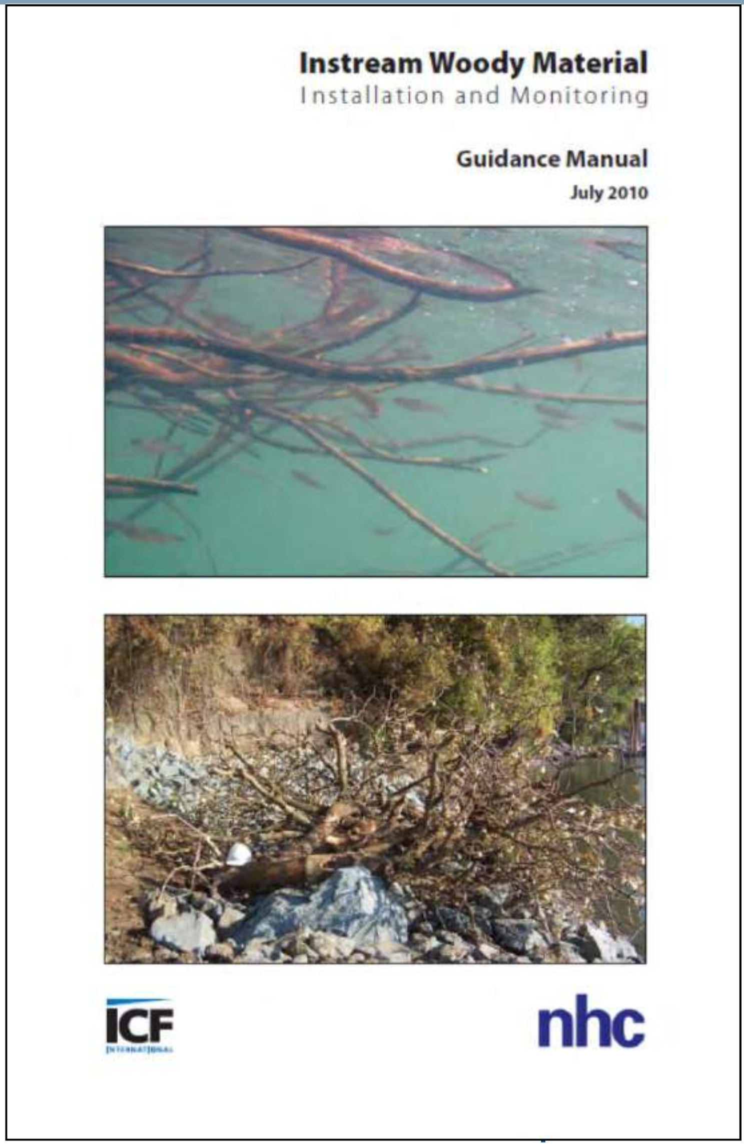
IWM Design



BANK
35'
APPROVED INSTREAM WOODY MATERIAL TREE WITH dbh<8"
8"ø WOOD POST
A
MANILLA ROPE SEE NOTE 7
TIE SMALLER TREE TO LARGER TREE OR TO 8"ø WOOD POST. SEE NOTE 6
APPROVED INSTREAM WOODY MATERIAL TREE WITH dbh>12"
8"ø WOOD POST
~25'-35' DIMENSION WILL VARY BASED ON TREE SIZE
APPROVED INSTREAM WOODY MATERIAL TREE WITH dbh>12"
~25'-35' DIMENSIONS WILL VARY BASED ON TREE SIZE
AMERICAN RIVER
PLAN - WOOD CHEVRON

IWM Manual

- SAFCA funded-Bill Mitchell (ICF) authored
- Identifies wood types (almond, walnut, olive trees) and size
- How to select, transport, handle, and install


Instream Woody Material
Installation and Monitoring

Guidance Manual
July 2010

ICF
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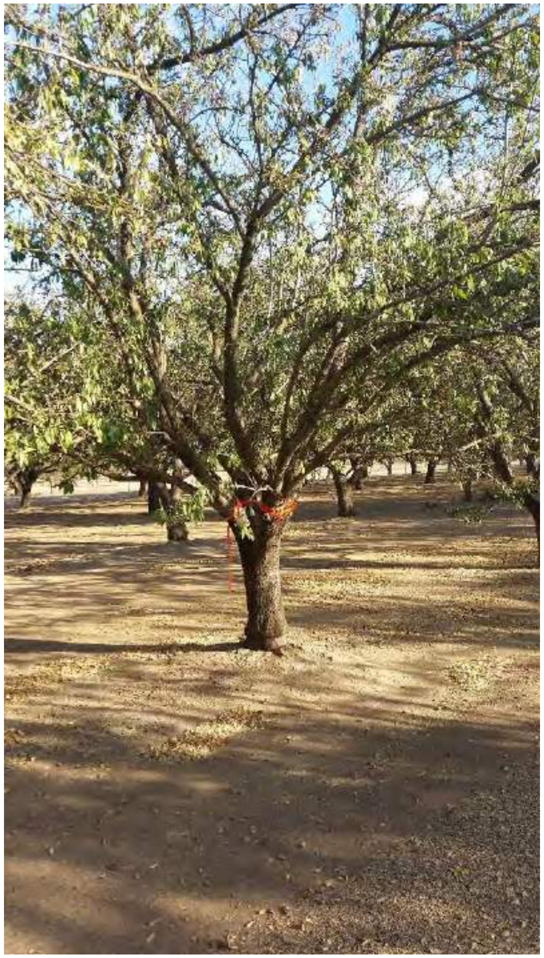
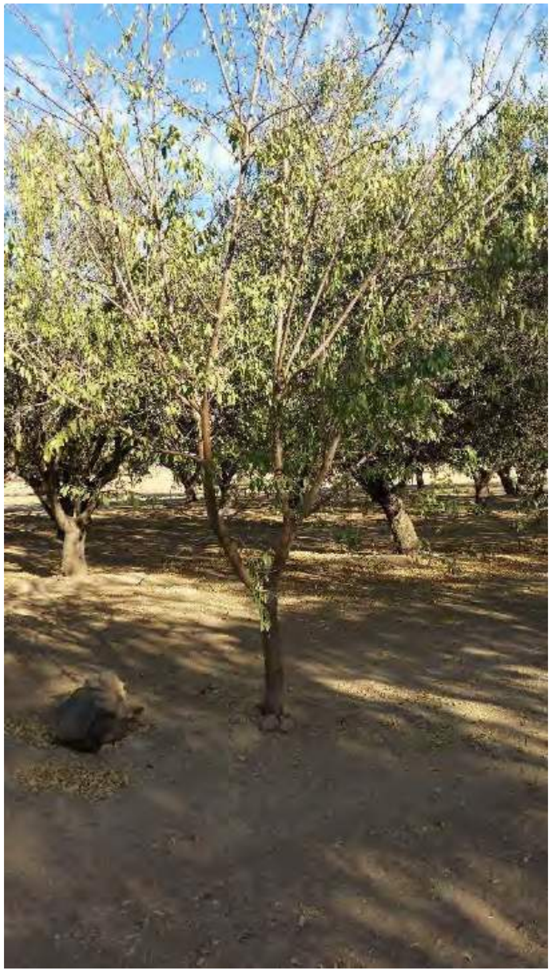
nhc

IWM Selection





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IWM Transport and Handling

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IWM Installation

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Planting

- Tule were planted in late Fall 2015
- Currently planted with native grass
- Riparian Planting is to occur in Fall 2016

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Things to Evaluate

- Wood as a wave break
- Hemp rope, oak post, fine woody material relative design lives
- Ability of tule to survive

Questions?

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water resource specialists

Models for Cranberry Bog Stream & Wetland Restoration

Caitlin Alcott, Marty Melchior,
Nick Nelson

April 7, 2016

inter·fluve

Inter-fluve.com

Outline

1. Cranberry cultivation
2. Eel River project
3. Tidmarsh Farms project

1. CRANBERRY CULTIVATION

Image: oregoncranberrygrowers.com

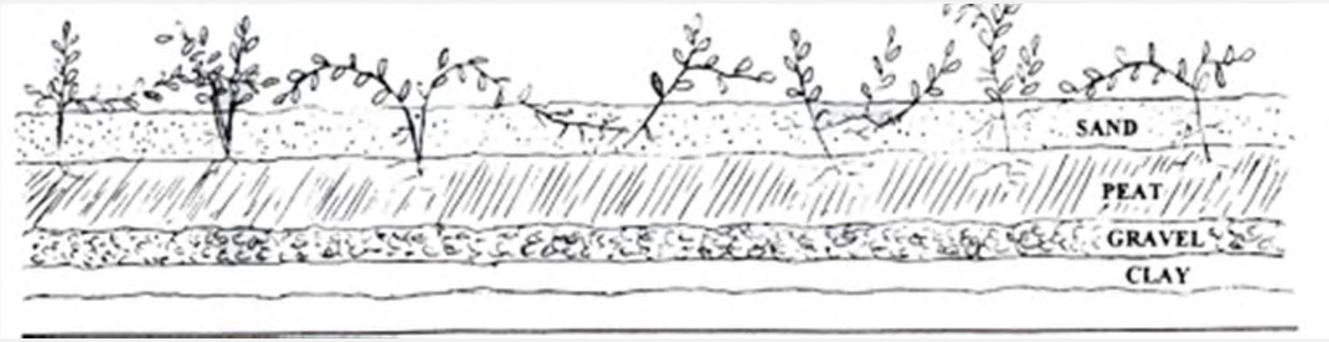

Image: Tidmarsh Farms 1987

CRANBERRY CULTIVATION

Cranberry "bog" recipe:

- Acidic, sandy soil
- Impermeable layer
- ~April-Nov growing season
- Sand supply
- Fresh water

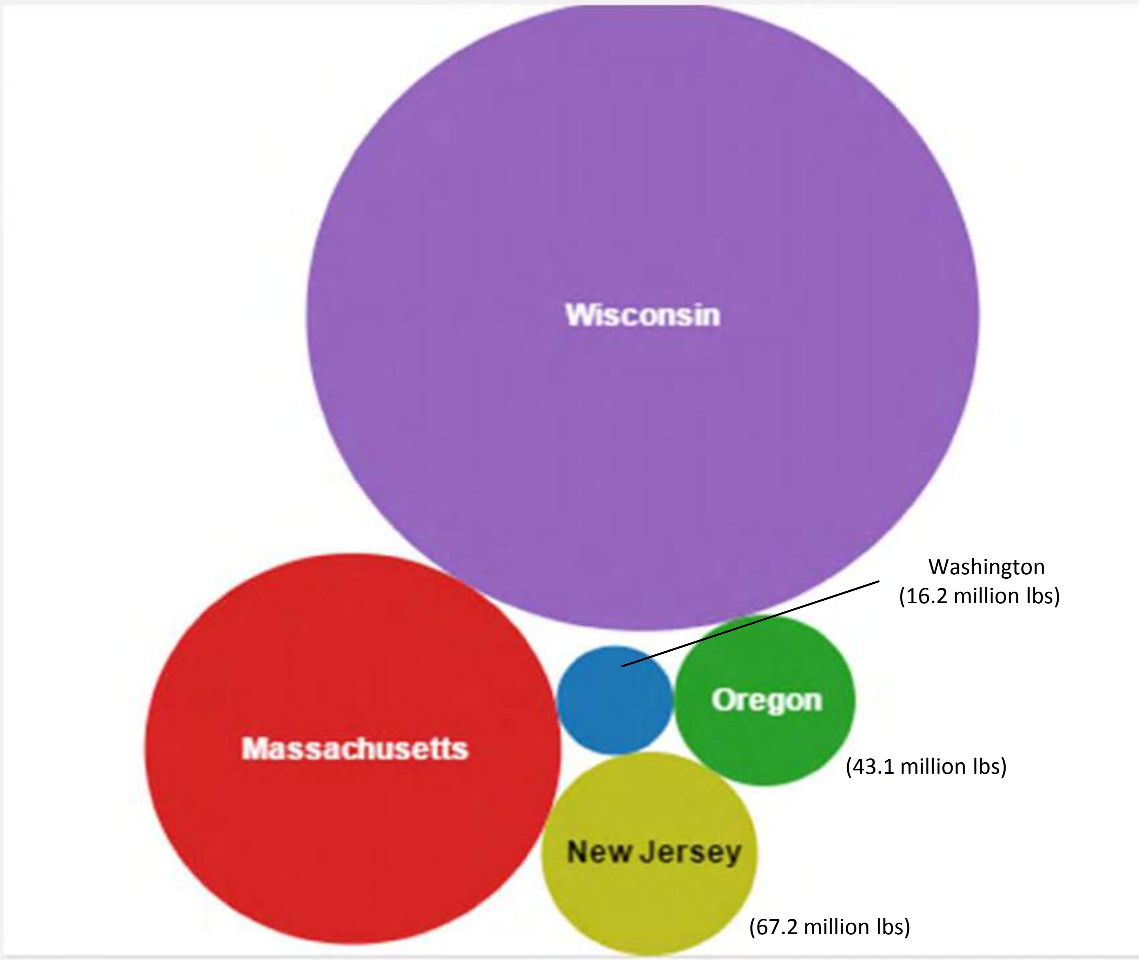
oregoncranberrygrowers.com



Cape Cod Cranberry Growers' Association

Image: oregoncranberrygrowers.com

CRANBERRY CULTIVATION



2014 cranberry production by state (USDA, 2014)

Image: Tidmarsh Farms 1983

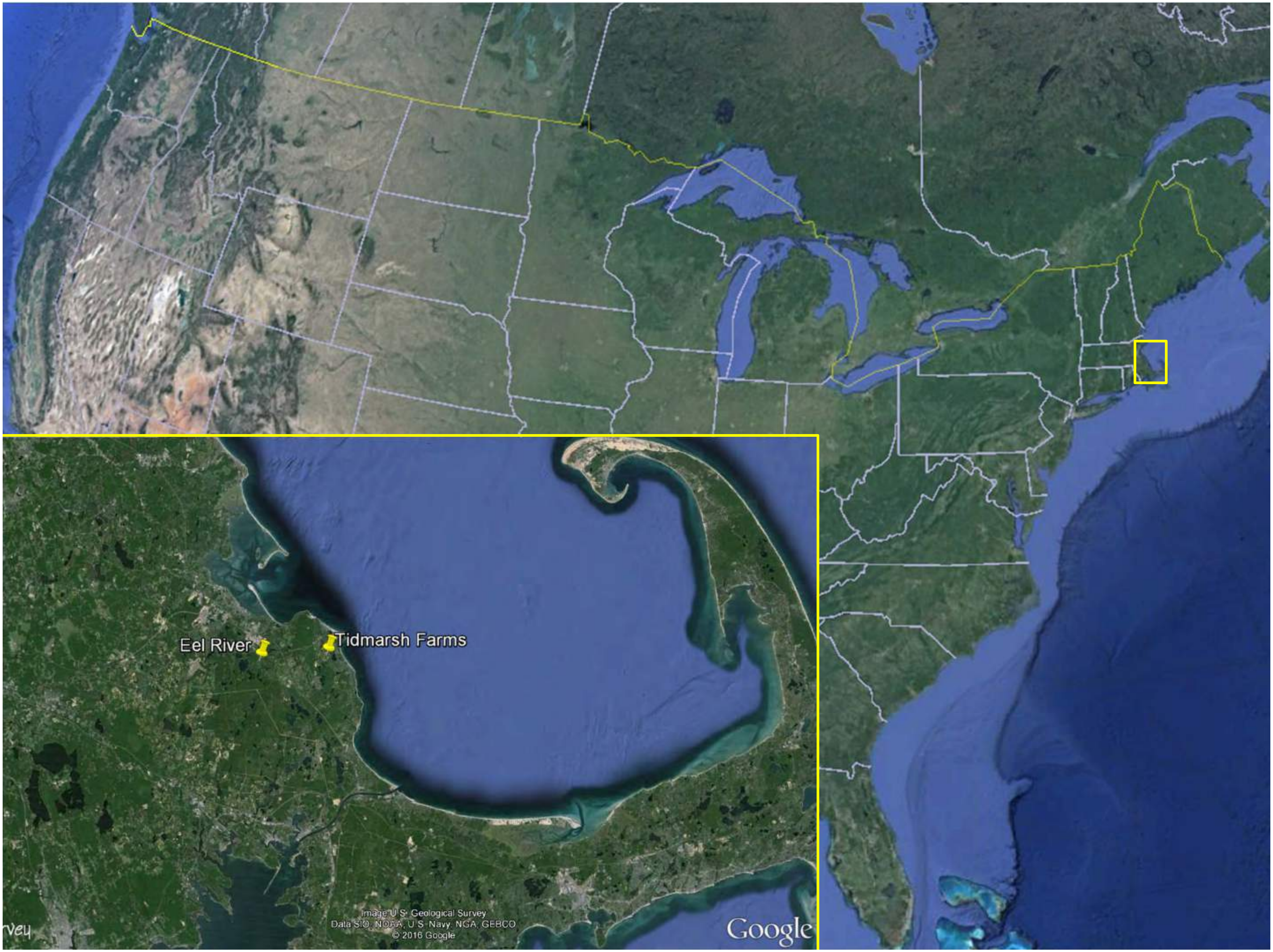
Cranberry Bog Restoration Considerations

- Water table depth
- Excess sand
- Channel uniformity
- Ditches and berms
- Flow control structures
- Sediment balance
- Plant species uniformity
- Pesticides/herbicides/
- Fertilizers

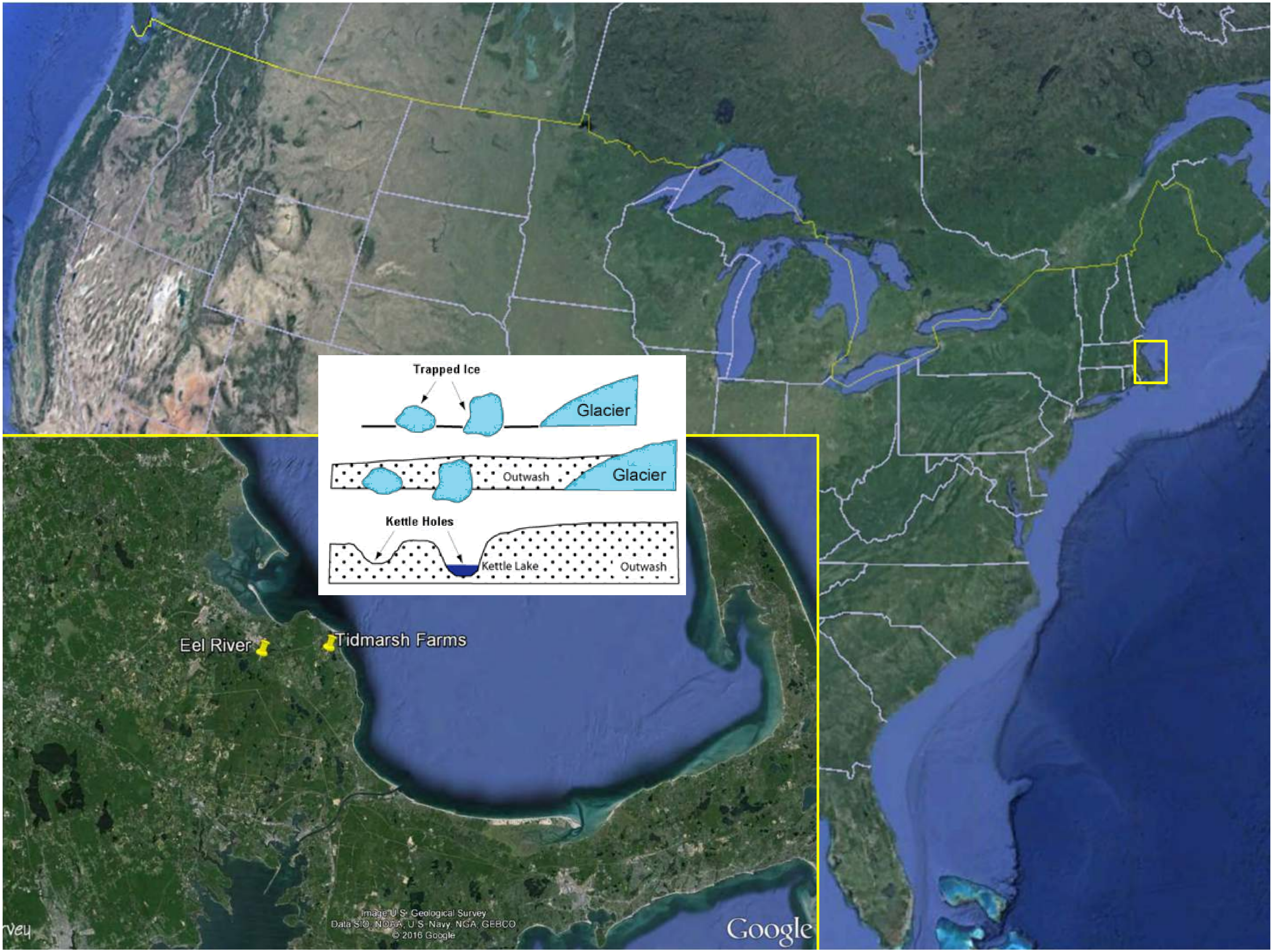
Species of Interest

- Alewife
- Blueback herring
- Brook trout
- American eel
- Atlantic White Cedar
- Red maple
- Sphagnum moss

11



Eel River
Tidmarsh Farms
Image U.S. Geological Survey
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2016 Google
Google


Trapped Ice
Glacier
Outwash
Glacier
Kettle Holes
Kettle Lake
Outwash
Eel River
Tidmarsh Farms
Image U.S. Geological Survey
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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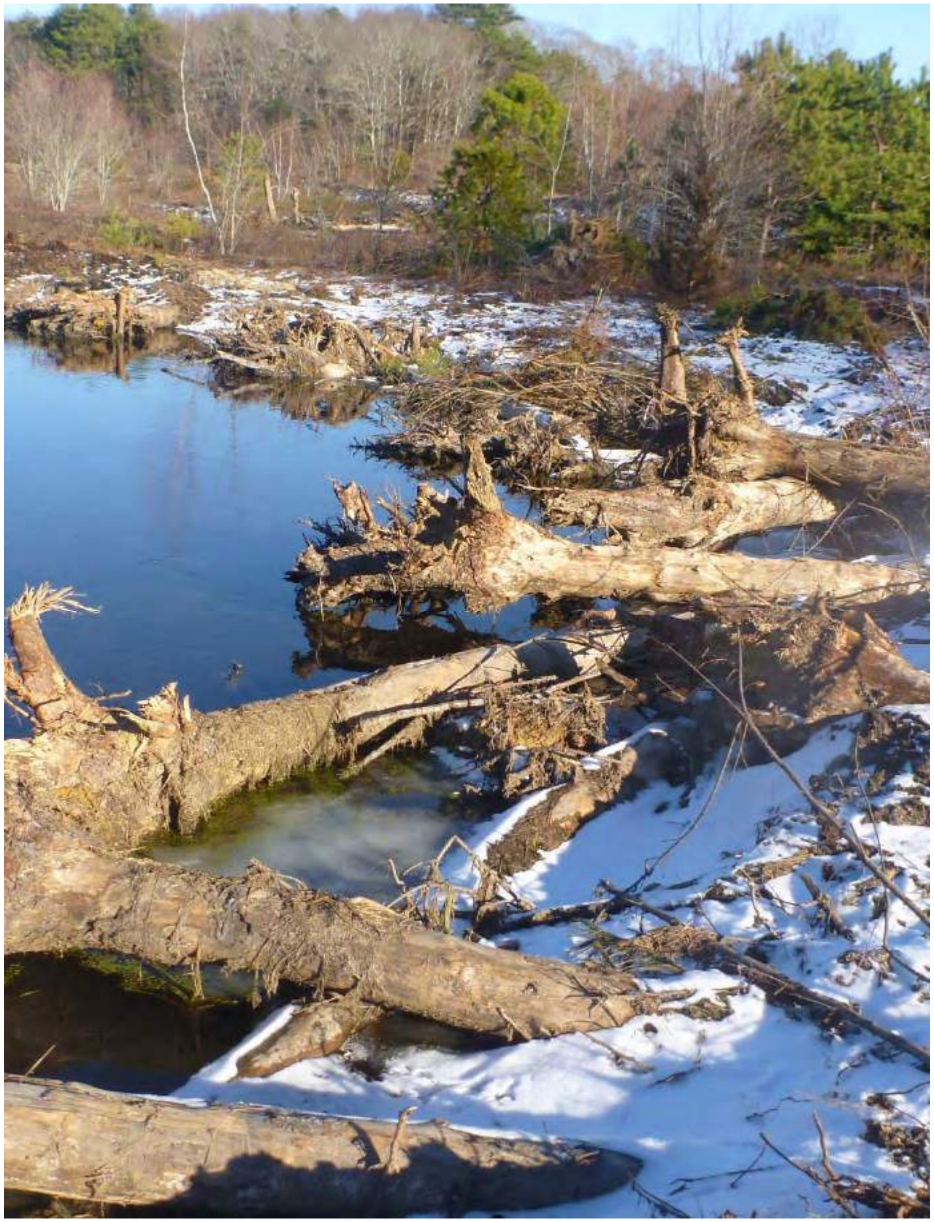
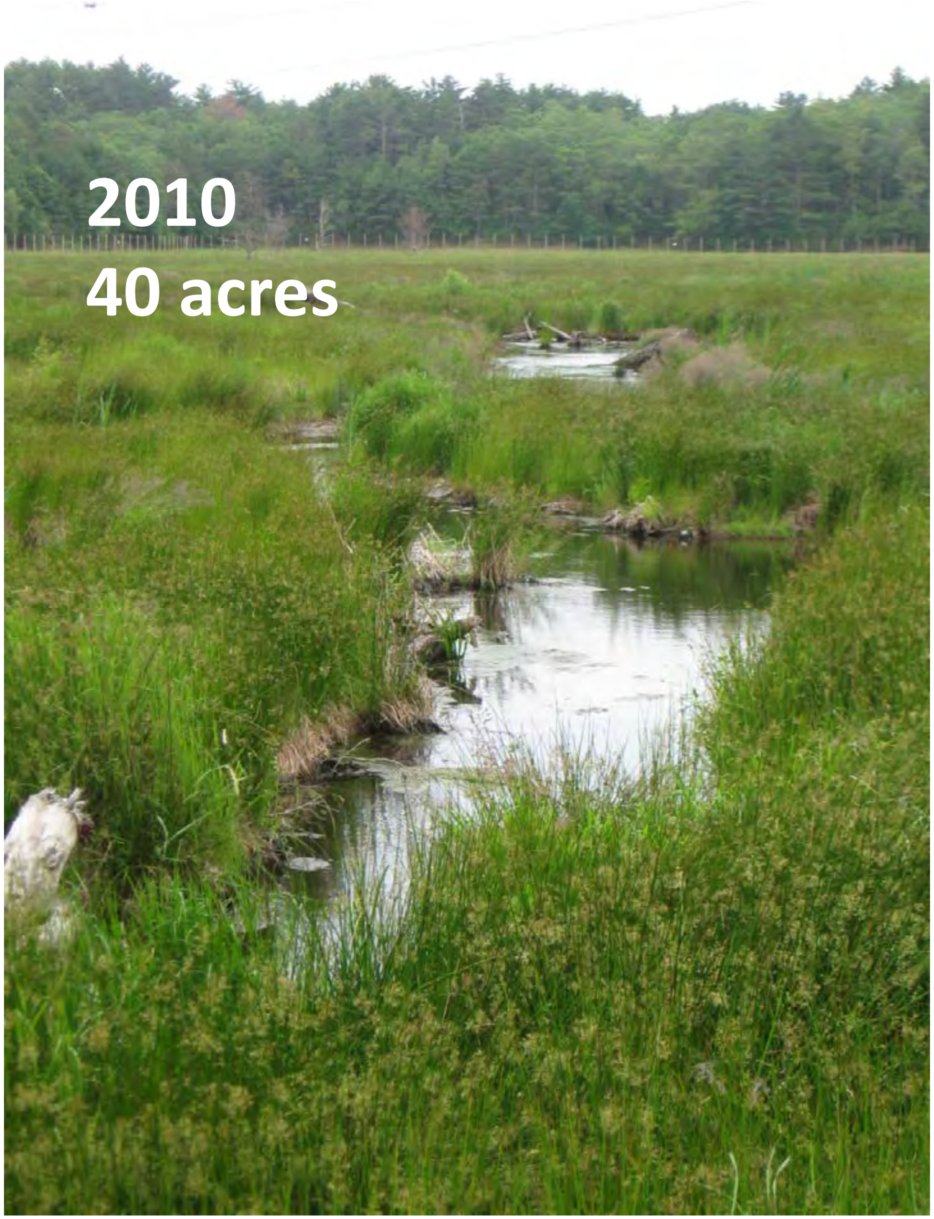
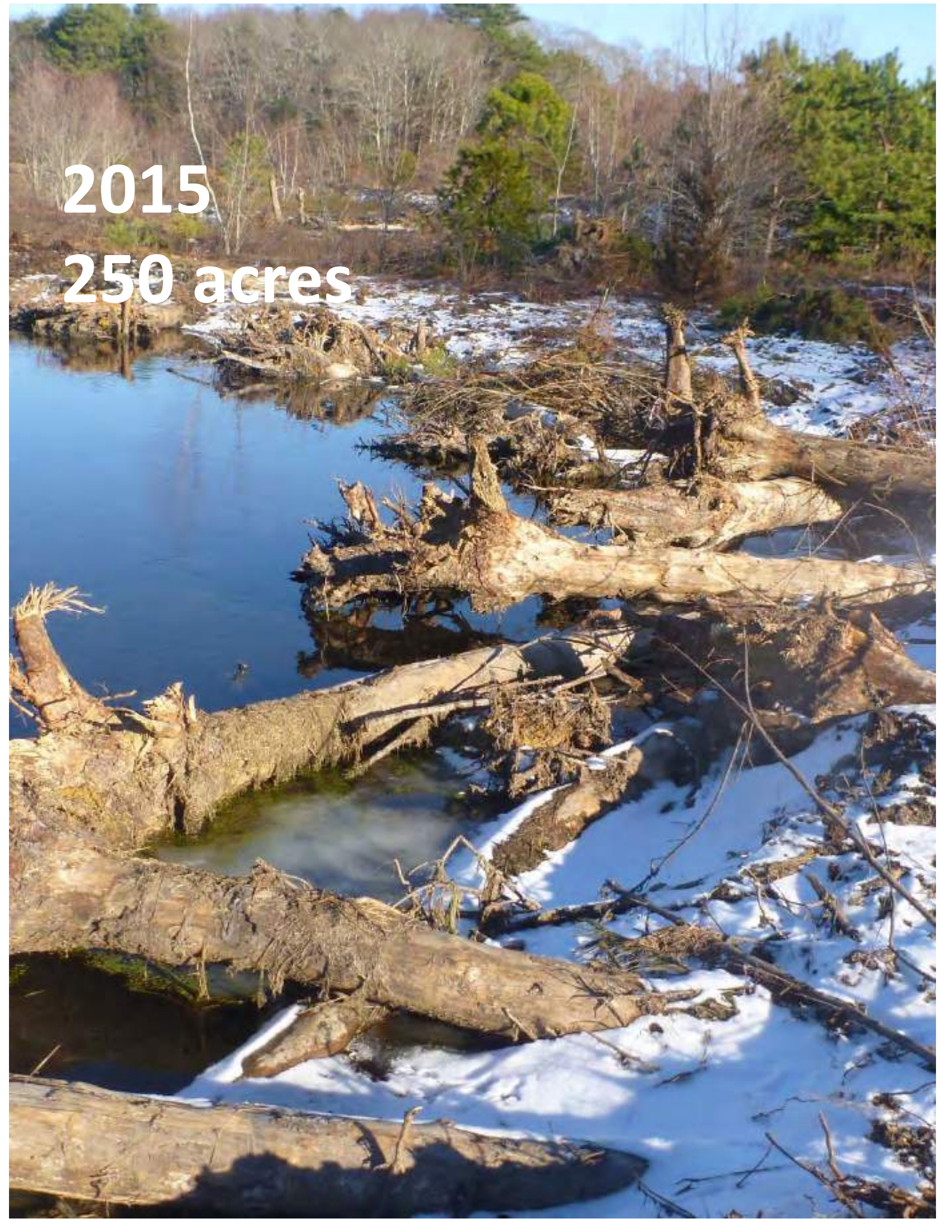
Google

Eel River



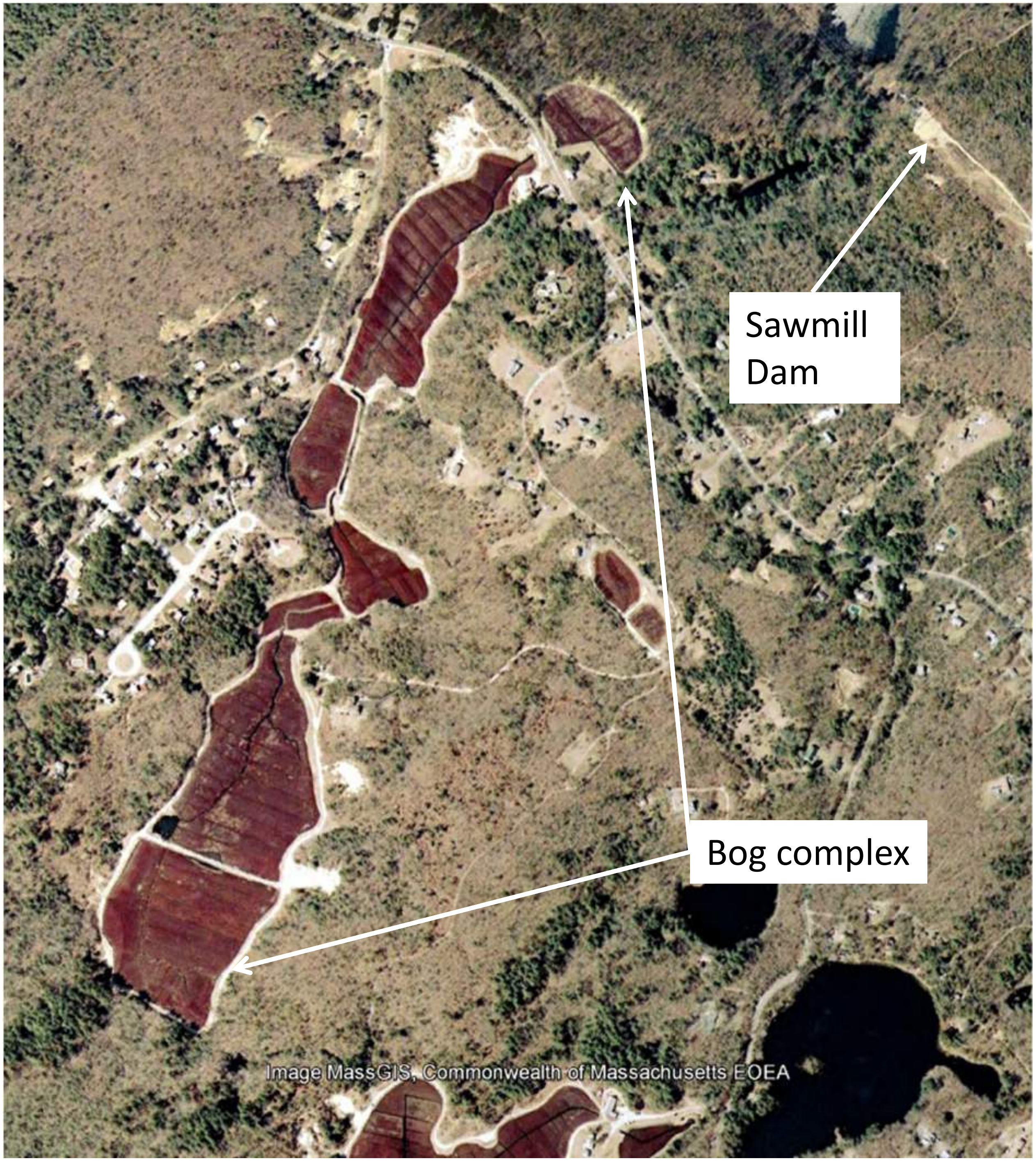
Tidmarsh



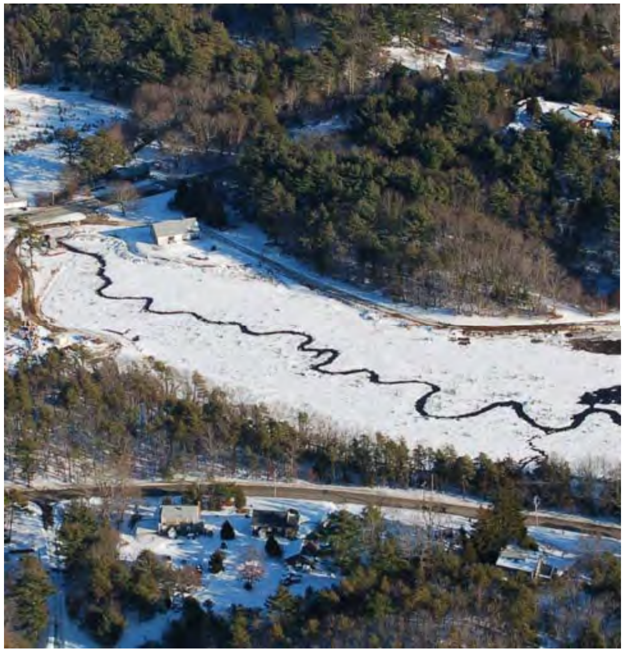


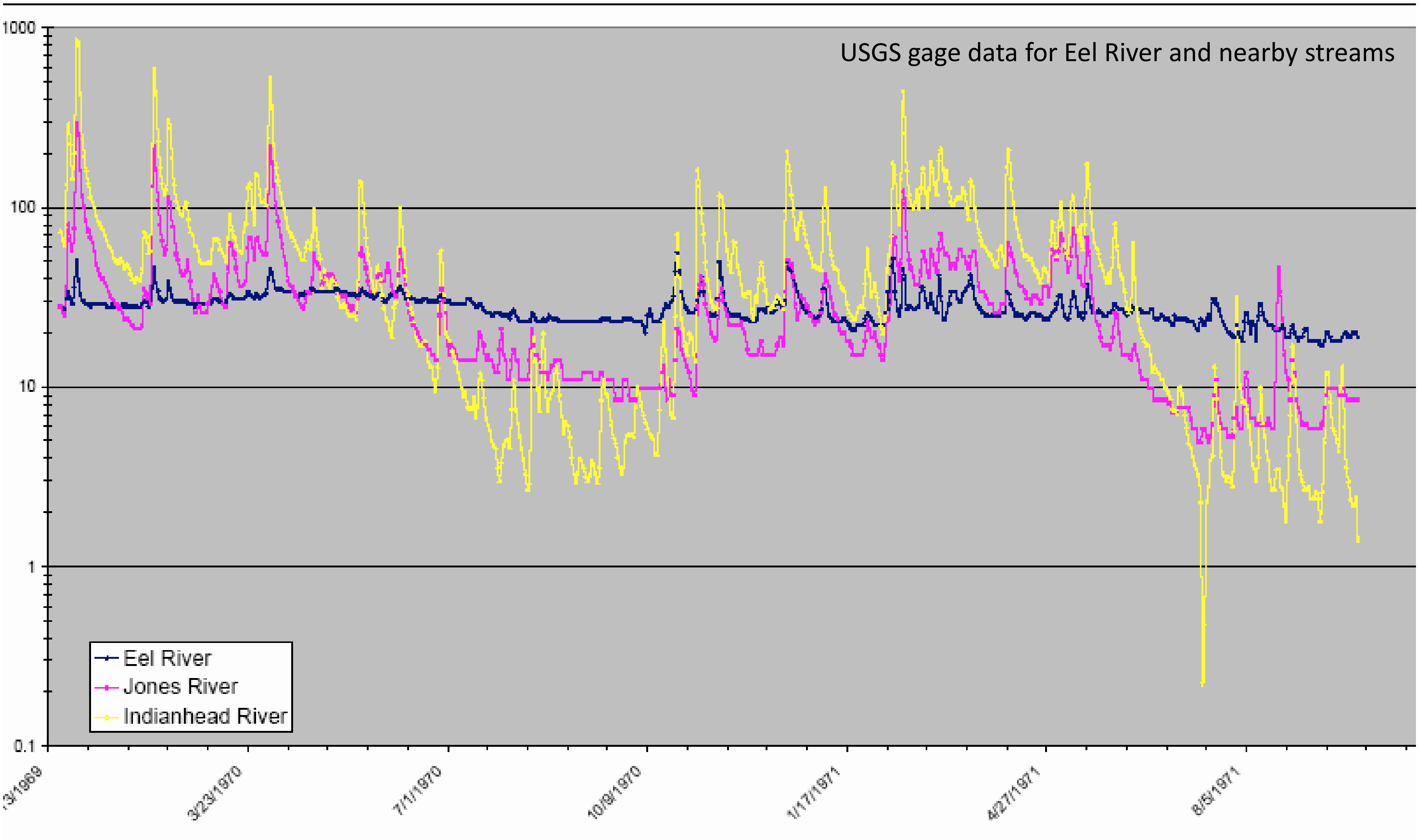
Eel River | **Tidmarsh**

2. EEL RIVER



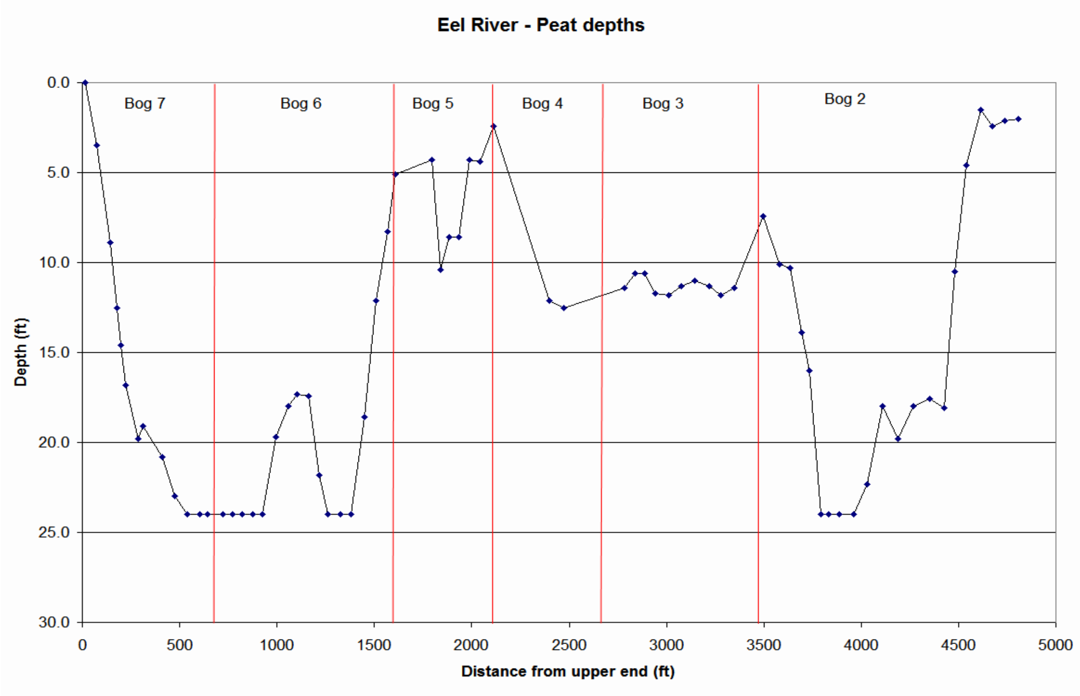
EEL RIVER SITE



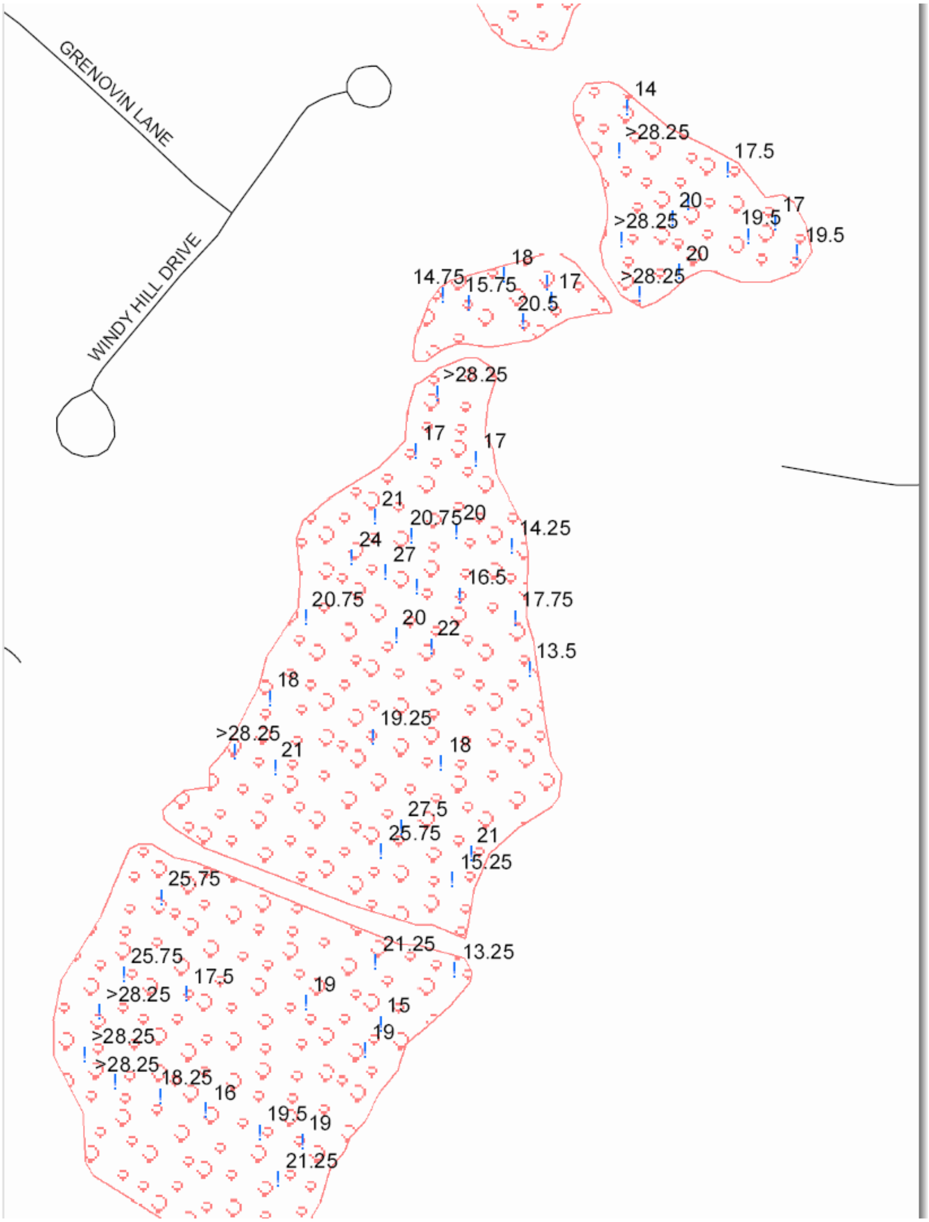


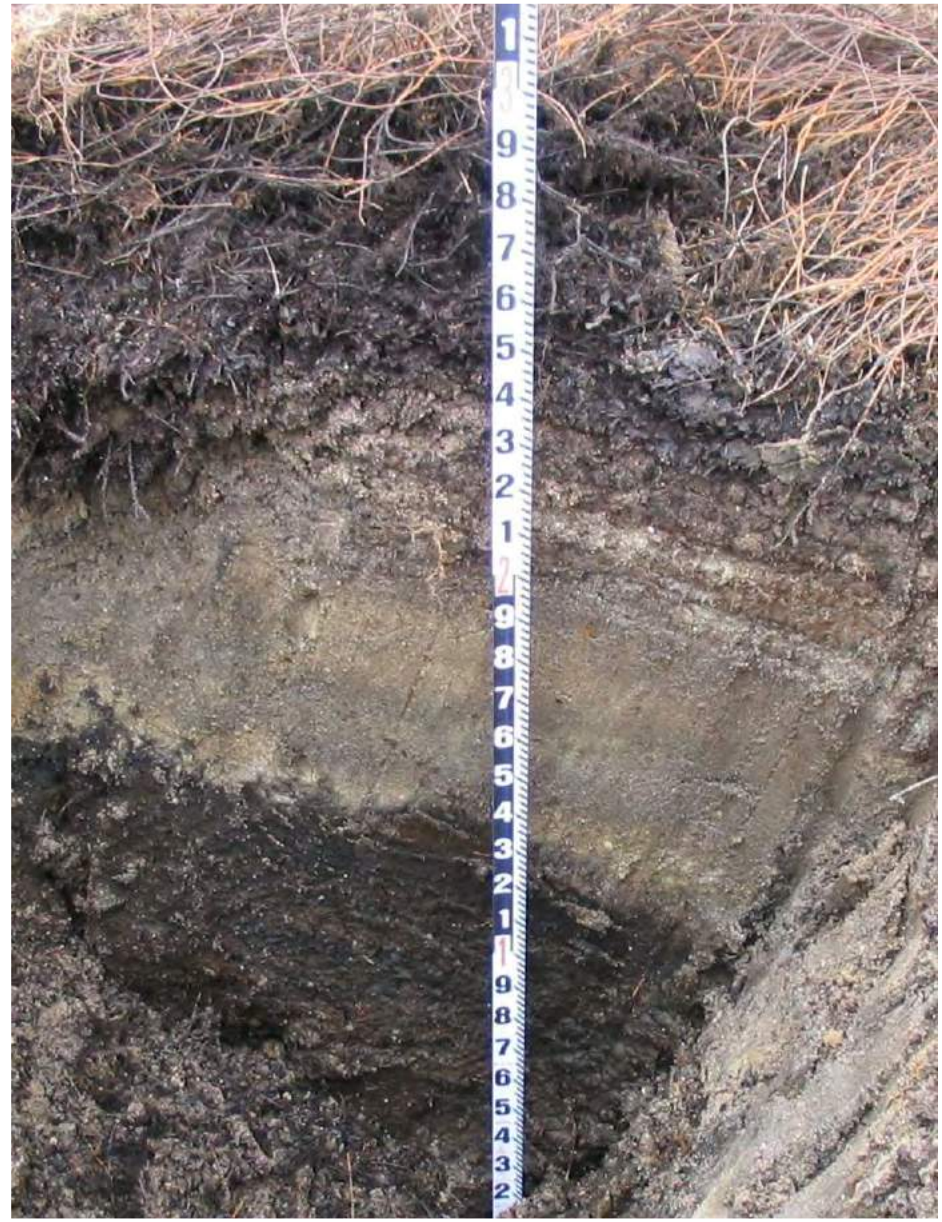
Eel River Hydrology: Eel River is dominated by groundwater flow

Peat depth through bog complex (ground penetrating radar)



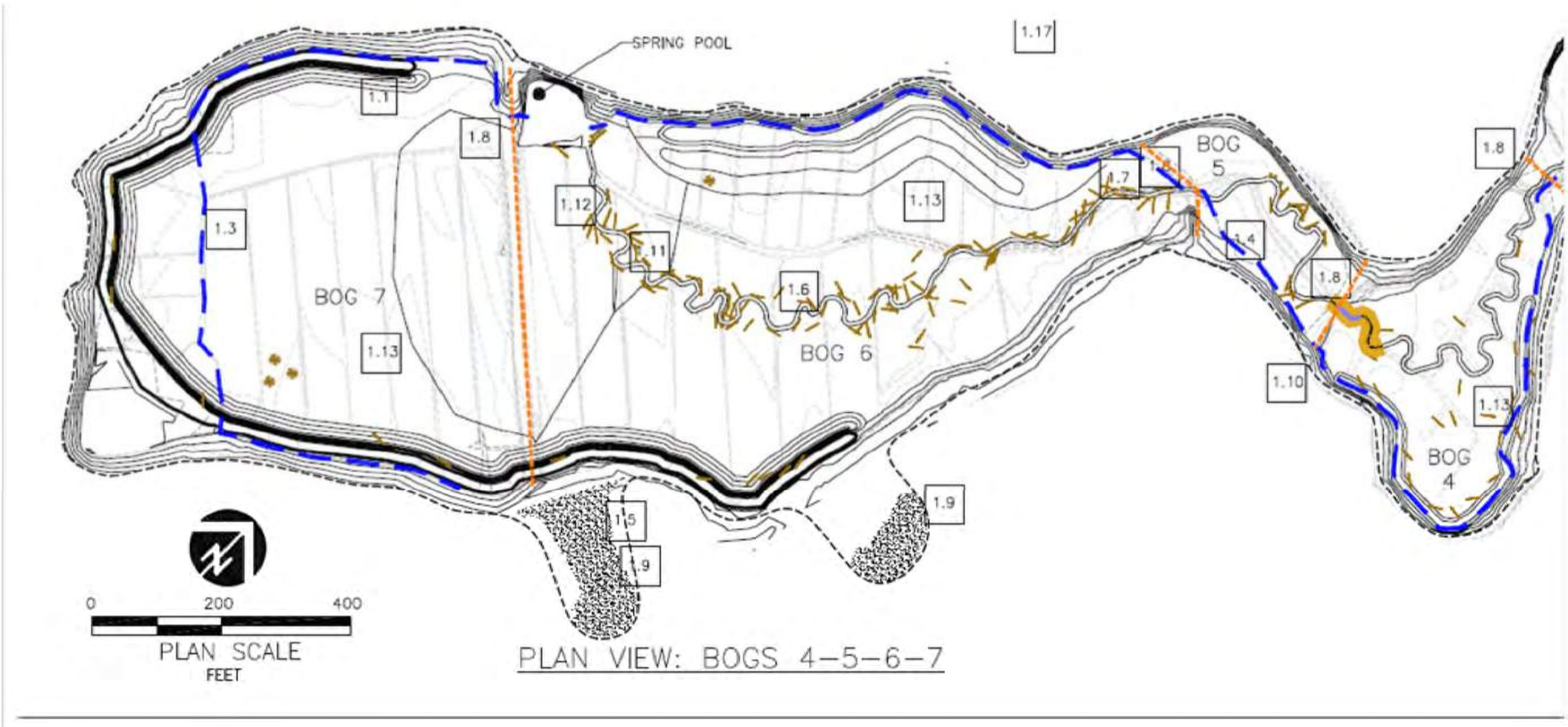
Eel River Soil





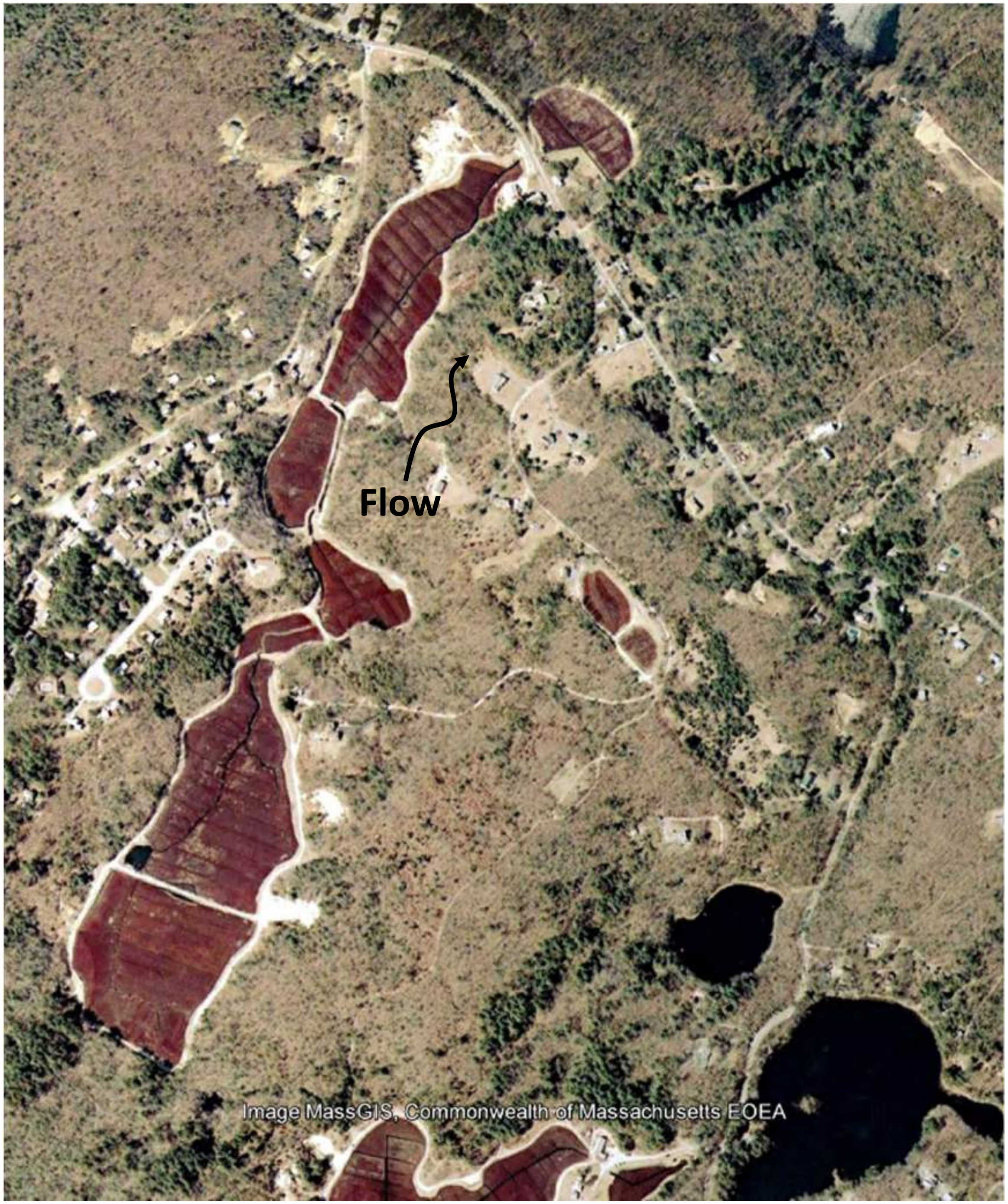
Eel River Sand Depth: 100 Probes, 9 test pits; Average depth of sand 20 inches

Existing seed bank



Key Restoration Components

- 6000 feet of low gradient wetland stream channel
- 2000 feet of gravel riffle-pool stream channel
- 1200 feet of steep (3%) boulder step pool channel restoration
- Large wood to define channel and create habitat
- Grade control riffles
- Some sand removal
- Dam, berm, flow control structure removal
- Wetland microtopography
- Atlantic White Cedar restoration


Flow
Image MassGIS, Commonwealth of Massachusetts EOEA

Restoration Elements


Google Earth 5/23/15


Grade control riffles


Constructed channel


Constructed channel

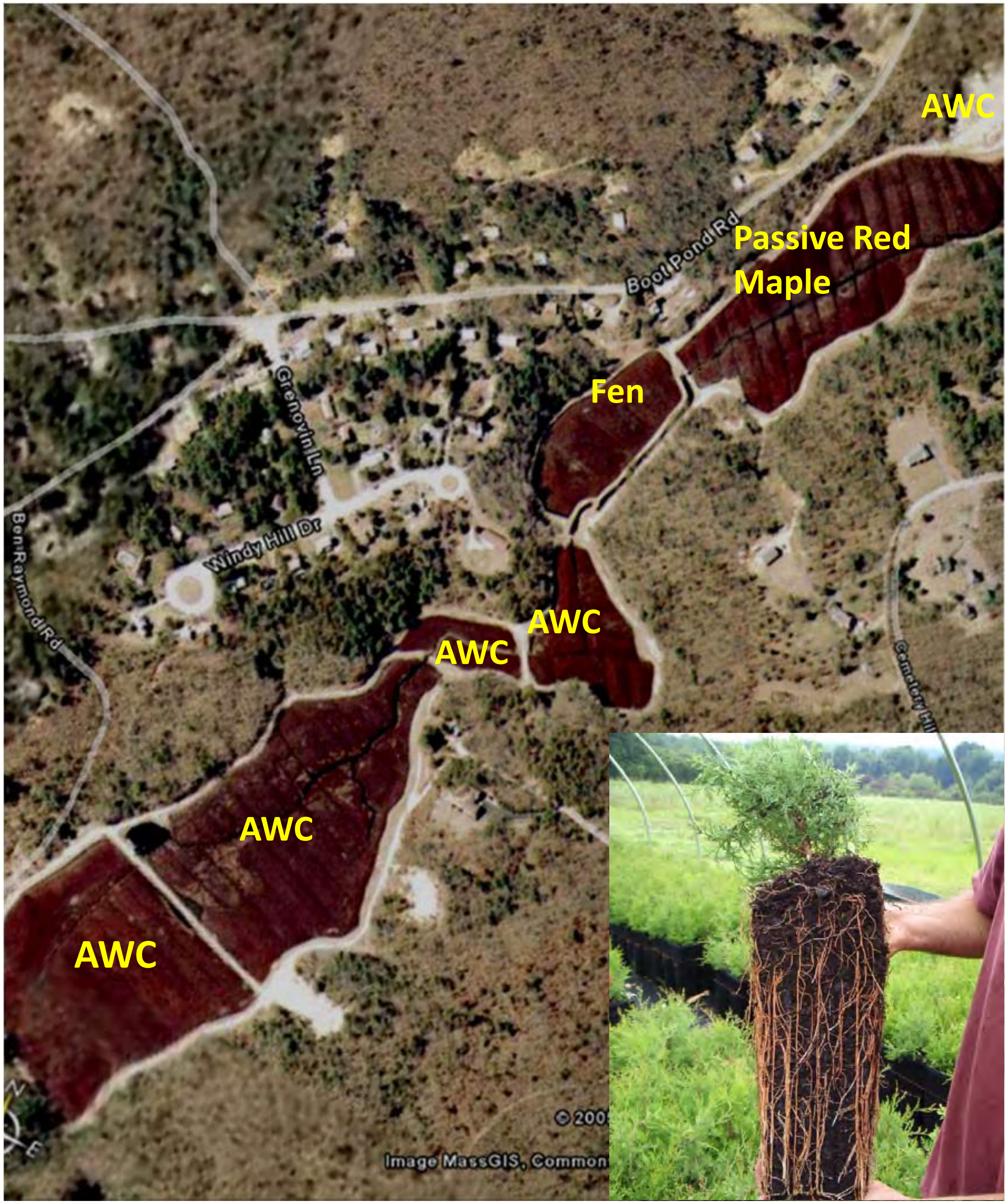
Restoration Elements

- Constructed channels

Large woody habitat

Microtopography

Culvert replacement



Restoration Elements

- Atlantic White Cedar Swamp
  - (Bogs 4-7) – 20 acres
  - Forested riparian wetlands (Bog 1, dam) 15 acres
- Fen meadow
  - (Bog 3) 4 acres
- Red Maple swamp
  - (Bog 2) 10 acres

Atlantic White Cedar Seed Collection

- Broadest possible genome from local populations
- 4 sites within 10 miles of Plymouth
- Private lands, public sites

- Enclosed bog 4-7 (22 acres)
- 6,000 feet of 9 ft reusable fencing

Deer Browse Protection

The Nature Conservancy
Protecting nature. Preserving life.™

TOWN OF PLYMOUTH MASSACHUSETTS 1620

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

COMMONWEALTH OF MASSACHUSETTS
Division of Ecological Restoration

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

Massachusetts Department of ENVIRONMENTAL PROTECTION

CWRP
CORPORATE WETLANDS RESTORATION PARTNERSHIP

American Rivers
Thriving By Nature

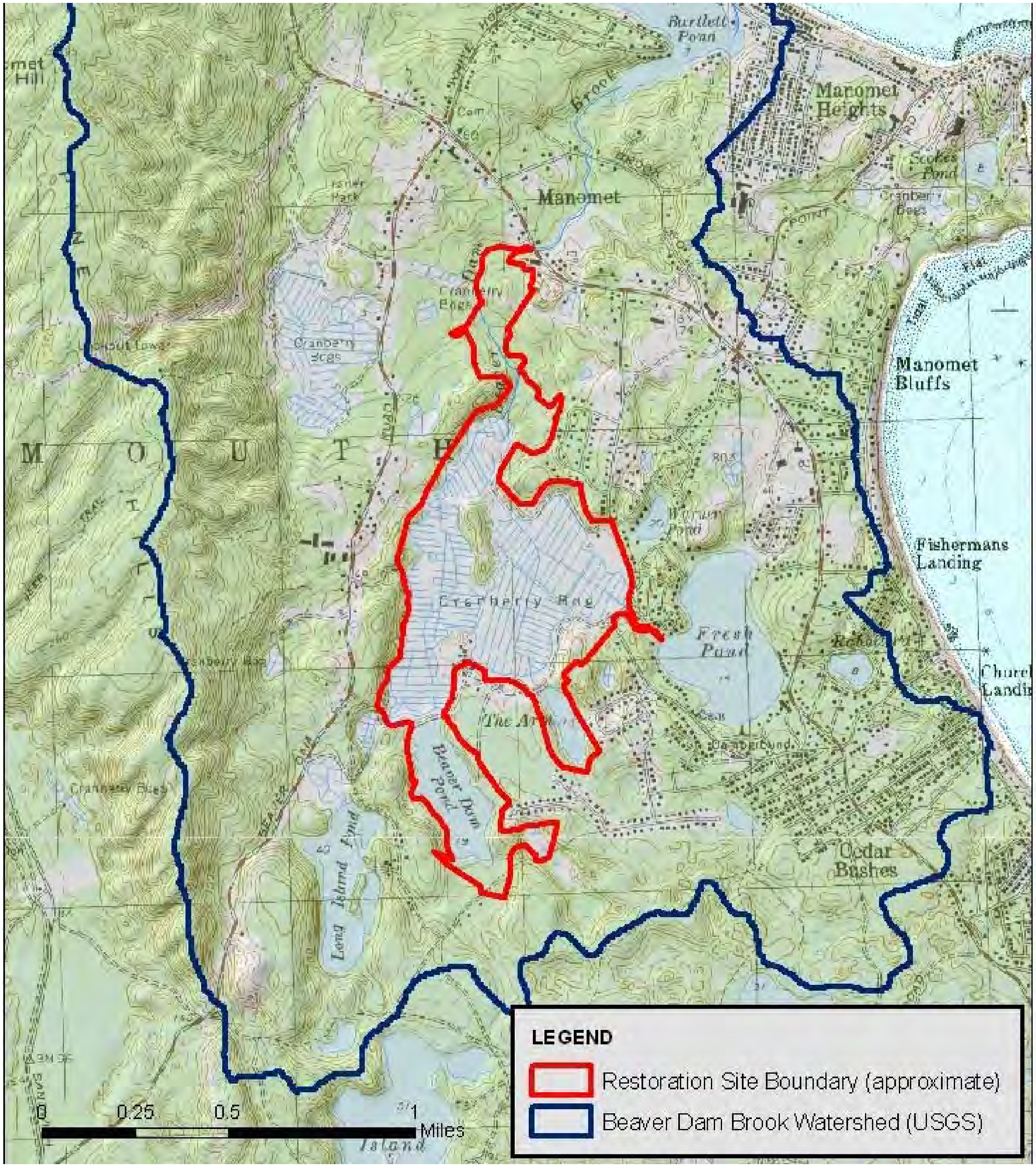
Eel River Project Partners

Eel River

Lessons Learned

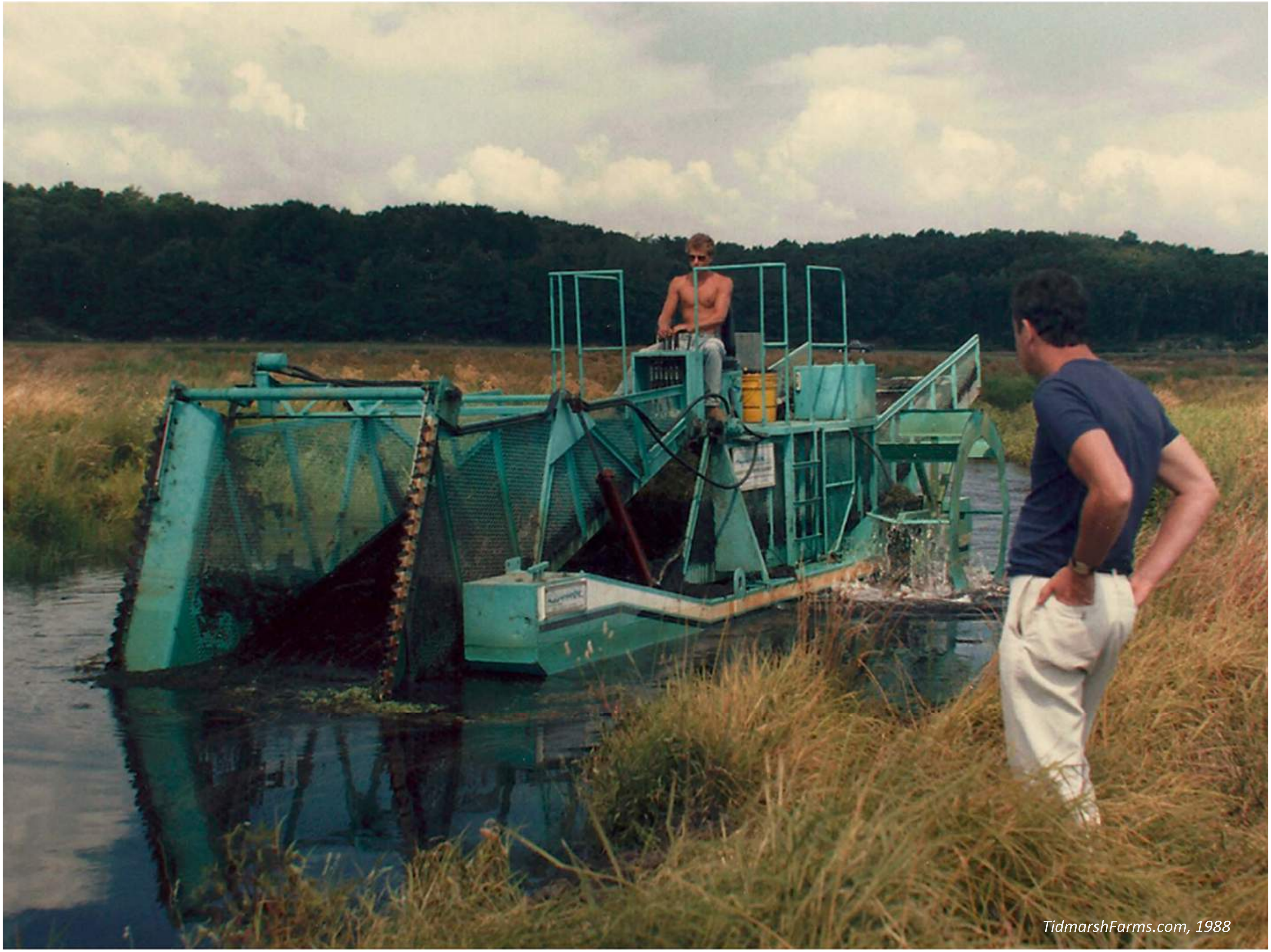
- Raising the water table through grade control
- Minimal sand removal
- Sand reuse in old borrow pits as Eastern Box turtle habitat (bare sandy slopes)
- Natural channel design
- Large wood placement for wetland and in-stream habitat
- Largely passive planting plan
- Active Atlantic White Cedar plantings
- Microtopography grading
- Separation of wetland ecosystems by bog cell
- Dam removal
- Water control structure removal
- Pedestrian walk paths and footbridge
- Wildlife passage at culverts
- Raptor habitat

3. TIDMARSH FARMS



TIDMARSH FARM SITE


TidmarshFarms.com, 1987


TidmarshFarms.com, 1988

Tidmarsh Living Observatory | **Overview** | Projects | Live Data | Downloads

Tidmarsh is a 600-acre property near Plymouth, Massachusetts. After over a century as a large operational cranberry farm, Tidmarsh is now being restored to natural wetland. Researchers in the Media Lab's Responsive Environments group are developing sensor networks that document ecological processes and allow people to experience the data at different spatial and temporal scales. Small, distributed, low-power sensor devices capture climate, soil, water, and other environmental data, while others stream audio from high in the trees and underwater. Visit any time from dawn till dusk and again after midnight; if you're lucky you might just catch an April storm, a flock of birds, or an army of frogs.

Many current projects in the group are making use of the Tidmarsh site and the data. The flagship project is a cross-reality sensor data browser constructed using the Unity game engine to experiment with presence and multimodal sensory experiences. We're looking for new ways to explore and experience data about the environment. Built on LIDAR-scanned terrain data, the virtual Tidmarsh experience integrates real-time data from the sensor networks with real-time audio streams and other media. The soundtrack is based on real-time sensor data—flashes and ukulele notes occur when new data comes from each sensor. The music is driven by the sensor readings: higher pitches indicate warmer temperatures, for example. You can visit Virtual Tidmarsh yourself on Mac, Windows, or Linux by grabbing the app from our downloads page.

Media

TidmarshFarms.com

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Tidmarsh Farms Restoration Elements

- Channel creation
- Restoring relic channels (1)
- New channel (2, 3, 4, 6, 7)
- Large wood within channels
- Microtopography, depressions
- Expose peat/seed
- Onsite spoils
- Spring connections
- Raise groundwater with grade controls
- Atlantic white cedar (cell 3, 4, beaver brook headwaters)
- Open shrub fen
- Ditch plugs
- Access/crossings

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Tidmarsh Project Partners

Partners

- American Rivers
- USDA NRCS (Natural Resources Conservation Service), Wetland Reserve Program
- USFWS (U.S. Fish & Wildlife Service)
- GOMC-NOAA Habitat Restoration Partnership
- Massachusetts Environmental Trust (MET)
- Town of Plymouth
- Mass Audubon
- Inter-Fluve, Inc.
- Saliciola
- Public Lab

Supporters

- Manomet Center for Conservation Sciences
- Manomet Village Steering Committee

Research Institutions *affiliated with the* Living Observatory

- University of Massachusetts-Amherst, Department of Geosciences
- University of Massachusetts-Boston, Freshwater Ecology Laboratory (FEL)
- Mt Holyoke College, Restoration Ecology Program
- Massachusetts Institute of Technology, Media Laboratory

- 40 acres
- 2010 construction
- Alternative cranberry bog reclamation
  - Channel
  - Wetland
  - Multi-species

Eel River

- 250 acres
- 2015-2016 construction
- Apply experience from Eel River
- Multi-stakeholder process
  - Private landowner participation, MIT Media Lab, agencies, etc

Tidmarsh

(541) 386-9003

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