Restoring to Stage Zero, Recent Innovations in Restoration Science: Reports From the Field

A Concurrent Session at the 36th Annual Salmonid Restoration Conference held in Fortuna, California from April 11 – 14, 2018.

Session Overview

- Session Coordinators:
  - Brian Cluer, Ph.D., NOAA Fisheries

During the first decade of the new millennium, conventional thinking that the single-thread, meandering channel represented the 'natural' course for an alluvial stream, and that the return period for a flood large enough to inundate the floodplain was between 1.5 and 3 years, was increasingly questioned. During the second decade of the new millennium, river restoration theory and practice has started to apply new thinking based on the principles that, prior to human modification, most alluvial streams had channels that were multi-threaded and that they overflowed on to their floodplains several times a year. Recognizing this, the Stream Evolution Model (SEM; Cluer and Thorne 2013) extended existing Channel Evolution Models (Schumm et al. 1984, Simon and Hupp, 1986) to include multi-thread channels, highly connected to their floodplains as precursor (Stage 0) and successor (Stage 8) forms, genetically related to the single-thread, incised channels featured in Stages 1 to 7. This expanded continuum of alluvial channel patterns was linked to published habitat and ecosystem benefits using 26 common biological and hydro-physical attributes. The analysis of the links between physical processes, stream form, and ecosystem services revealed clear distinctions between streams that are fully-connected with their floodplains (i.e., in Stages 0 and 8) and those that have become disconnected due to channelization (Stage 2) and/or incision (Stages 3 to 7), spotlighting the poor performance of >1 yr RI bankfull channels. Insights gained by practitioners who have applied the SEM in the contexts of stream problem assessment and restoration design has led to a number projects aimed at restoring multi-thread or anastomosed patterns (i.e., Stage 0) instead of single-thread meandering channels (i.e., Stage 1) in historic deposition zones.

This session will first set out the historic, geomorphic, and biotic basis for restoring to Stage 0, and, second, will provide a platform for restoration practitioners to share their first-hand experiences of Stage 0 projects, from inception, through to design, construction, and effectiveness monitoring. The sessions will feature consideration of the advantages and risks of restoring to Stage 0, focusing particularly on concerns expressed by some stakeholders and regulators, including issues such as fish passage, stranding risks, and provision of deep pools.

Presentations

(Slide 4) Session Introduction - Restoring to Stage Zero, Recent Innovations in Restoration Science: Reports From the Field
Brian Cluer and Michael Pollock, NOAA Fisheries, West Coast Region

(Slide 11) Historical Basis for Restoring to Stage Zero
Sean Baumgarten, San Francisco Estuary Institute-Aquatic Science Center (SFEI-ASC)

(Slide 69) Embracing Chaos, Stage Zero Experience from the Sierra Foothills
Damion Ciotti and Jared McKee, U.S. Fish and Wildlife Service

(Slide 116) Stage 0 Restoration Approach, Design, and Construction
Paul Powers, U.S. Forest Service, Deschutes National Forest

(Slide 162) Five-mile Bell Restoration Project: A Stage 0 Restoration Case Study in Coastal Oregon
Paul Burns, Fisheries Biologist, U.S. Forest Service, Siuslaw National Forest

(Slide 217) Design and Implementation of Secondary Channels in Dry Creek, Sonoma County, California
Jason Q. White, River Scientist, ESA

(Slide 263) Winter Habitat and Floodplain Enhancement in Lagunitas Creek - Phase 1 Project Construction
Gregory Andrew, MS, Marin Municipal Water District

Restoring to Stage 0
Recent Innovations In Restoration Science: Reports From The Field

Brian Cluer
and Michael Pollock
NOAA Fisheries
West Coast Region

perspective

- Stream Evolution Model:

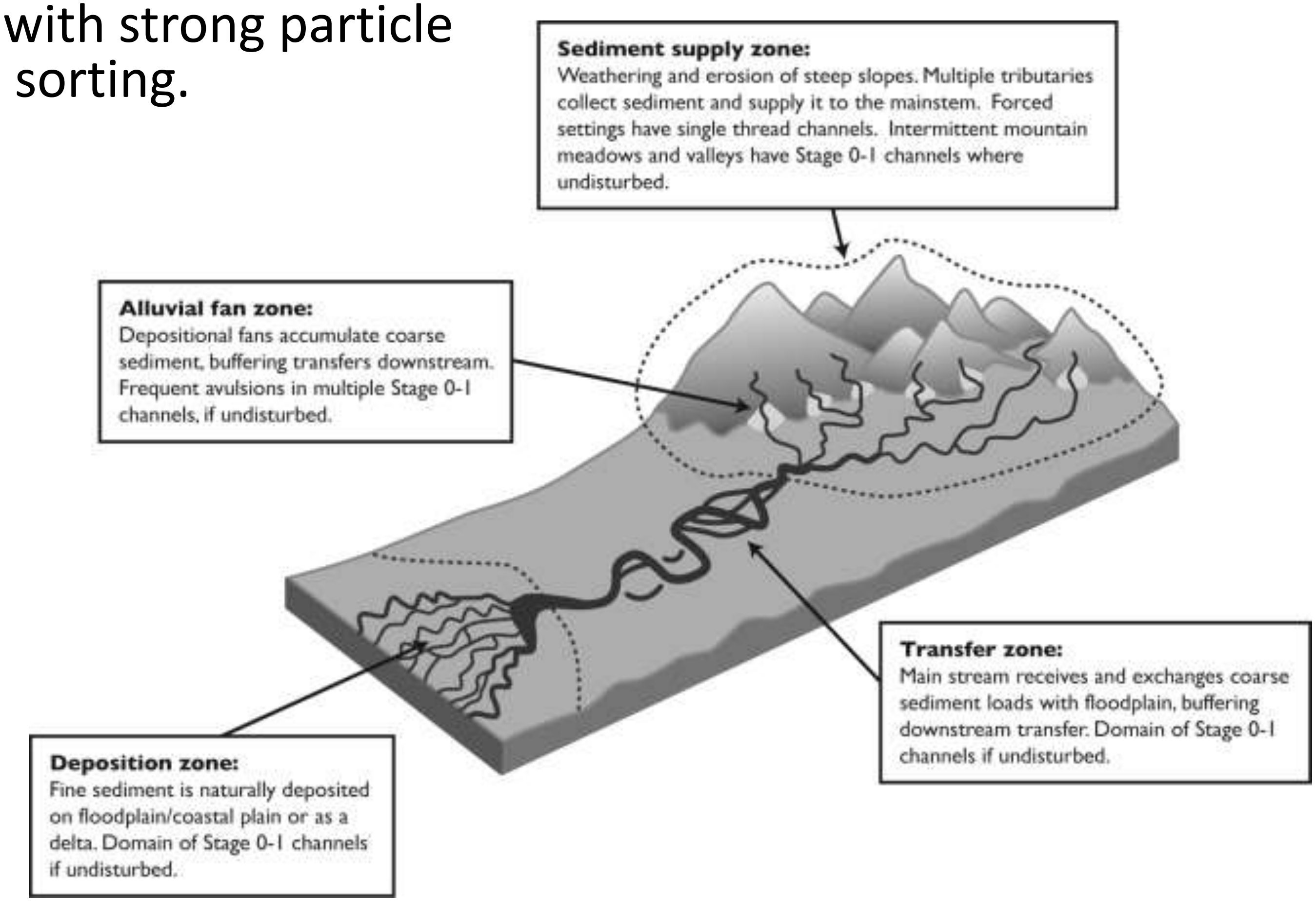
a way to relate physical and biological processes that puts into perspective the history of streams and their possible futures, allowing us to guide effective restoration.

- Stage 0:

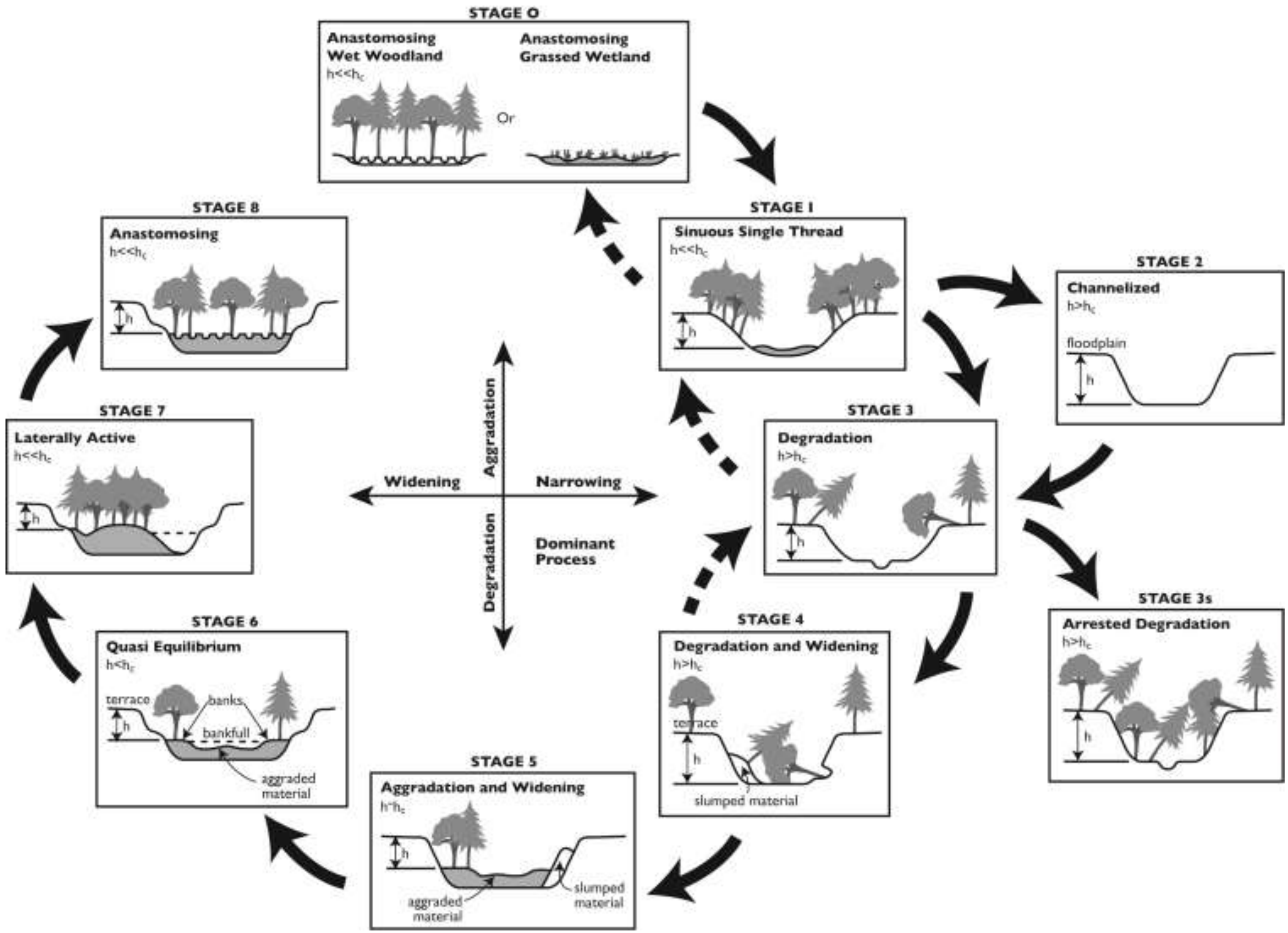
is the end member of the SEM cycle - fully developed depositional zone wetland-stream complex that delivers the greatest habitat and ecosystem benefits. Salmonids evolved with and are adapted to thrive in Stage 0 streams.

Process Domains and Stream Types

- DEPOSITION ZONES = Stage 0
  - Transport capacity limited.
  - When mature, supply and capacity may balance, with strong particle exchange and sorting.

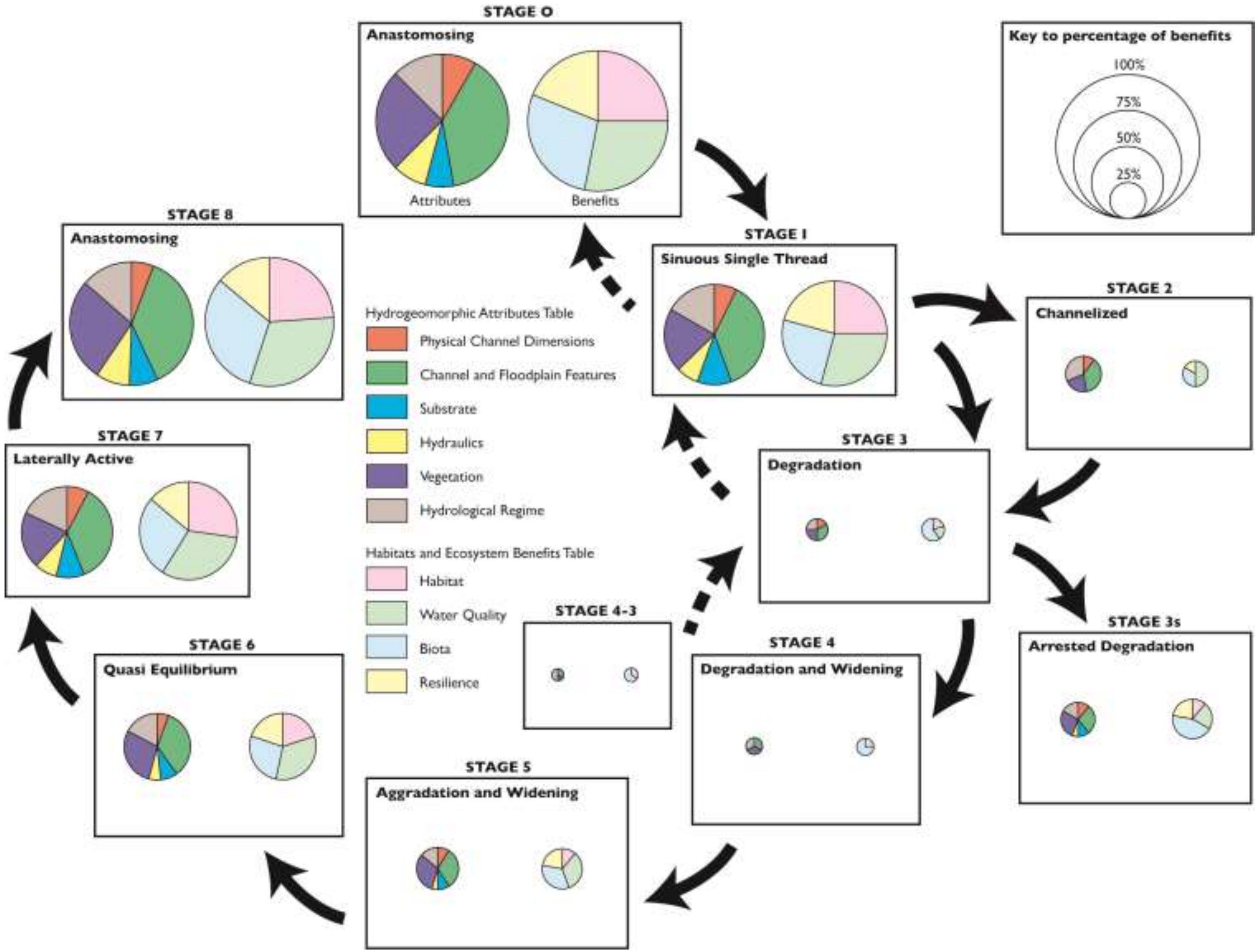


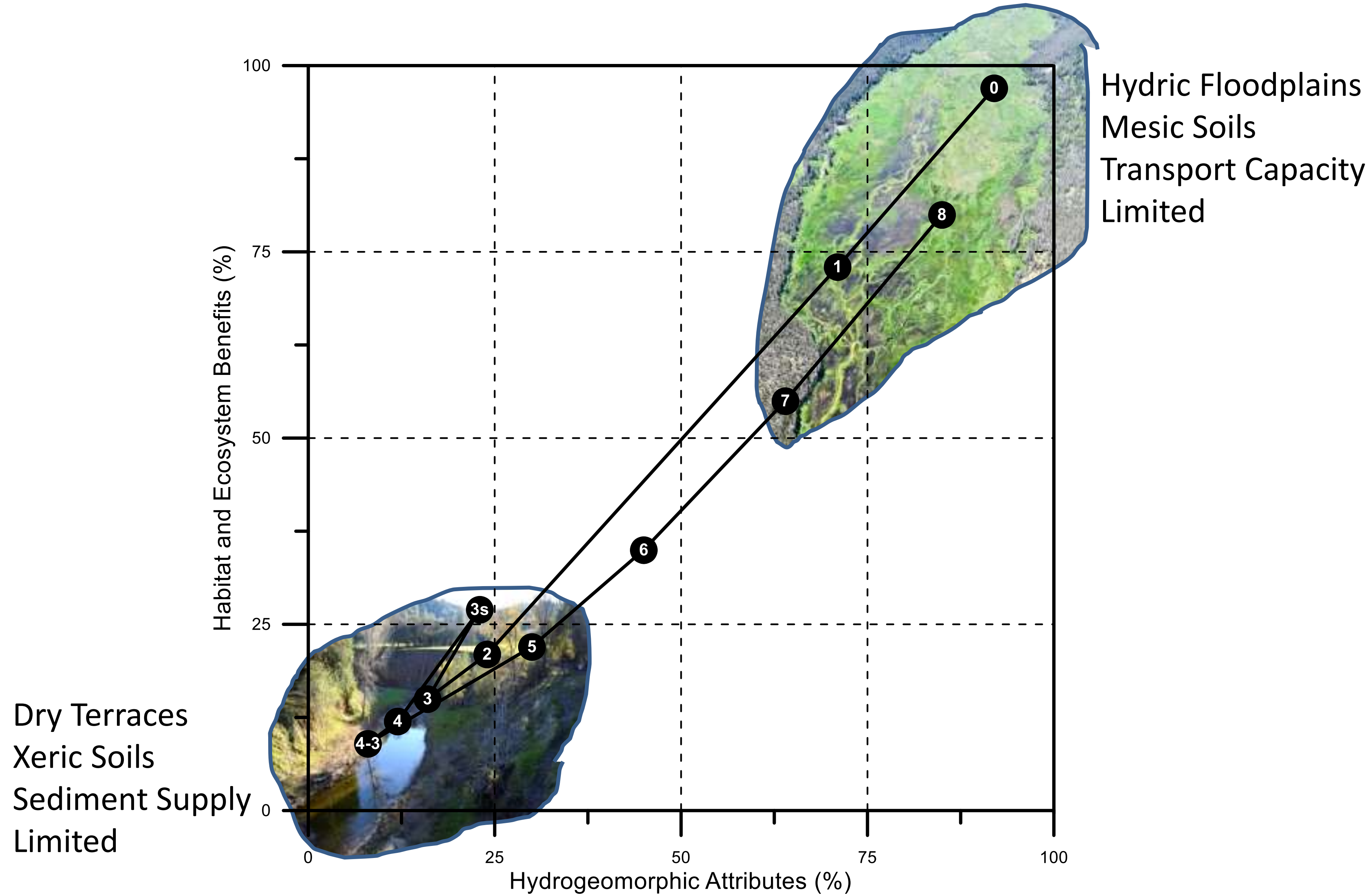
SEM: biogeomorphic template



Cluer and Thorne 2013

Ecosystem overlay




Hydric Floodplains
Mesic Soils
Transport Capacity
Limited
Dry Terraces
Xeric Soils
Sediment Supply
Limited
Habitat and Ecosystem Benefits (%)
Hydrogeomorphic Attributes (%)
0
25
50
75
100
0
1
2
3
3s
4
4-3
5
6
7
8

Stage 0 session:

Historical Basis for Restoring to Stage Zero
Sean Baumgarten, San Francisco Estuary Institute-Aquatic Science Center (SFEI-ASC)

Embracing Chaos, Stage 0 Experience from the Sierra Foothills
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Winter Habitat and Floodplain Enhancement in Lagunitas Creek – Phase 1 Project Construction
Gregory Andrew, MS, Marin Municipal Water District

HISTORICAL BASIS

FOR RESTORING TO STAGE 0

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Land Case Map B-128, courtesy of The Bancroft Library

Sean Baumgarten

Resilient Landscapes Program
San Francisco Estuary Institute

Salmonid Restoration Federation
Conference

April 13, 2018

SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

CO-AUTHORS

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Land Case Map B-128, courtesy of The Bancroft Library

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Historical Ecology Studies by SFEI and partners

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Maps

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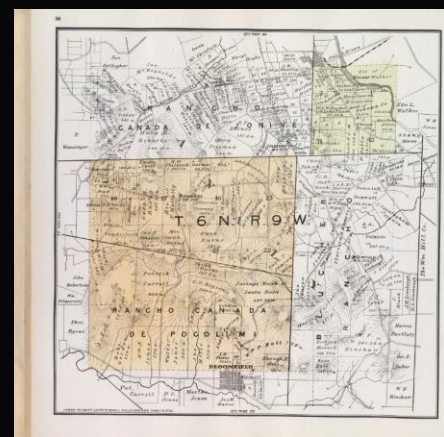

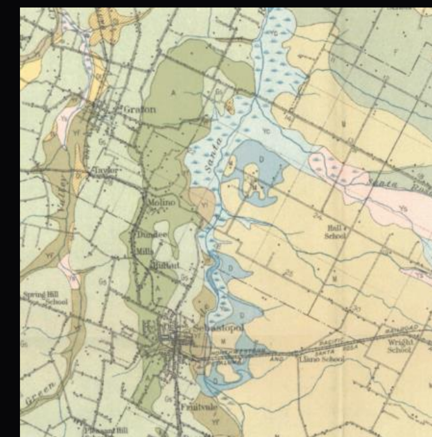

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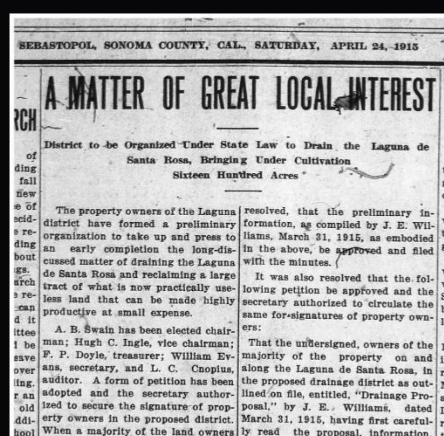


SEBASTOPOL, SONOMA COUNTY, CAL., SATURDAY, APRIL 24, 1915

A MATTER OF GREAT LOCAL INTEREST

District to be Organized Under State Law to Drain the Laguna de Santa Rosa, Bringing Under Cultivation Sixteen Hundred Acres

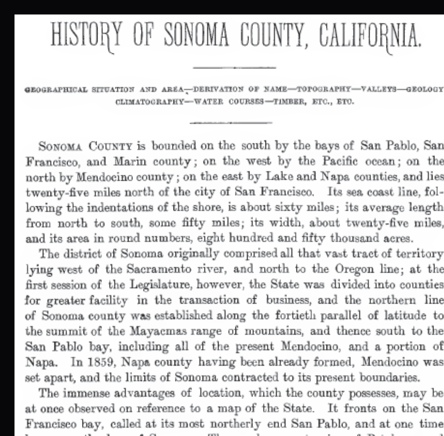
The property owners of the Laguna district have formed a preliminary organization to take up and press to an early completion the long-discussed matter of draining the Laguna de Santa Rosa and reclaiming a large tract of what is now practically useless land that can be made highly productive at small expense.

A. B. Swain has been elected chairman; Hugh C. Ingle, vice chairman; F. P. Doyle, treasurer; William Evans, secretary, and L. C. Cnopius, auditor. A form of petition has been adopted and the secretary authorized to secure the signature of property owners in the proposed district. When a majority of the land owners have signed up another meeting will

resolved, that the preliminary information, as compiled by J. E. Williams, March 31, 1915, as embodied in the above, be approved and filed with the minutes.

It was also resolved that the following petition be approved and the secretary authorized to circulate the same for signatures of property owners:

That the undersigned, owners of the majority of the property on and along the Laguna de Santa Rosa, in the proposed drainage district as outlined on file, entitled, "Drainage Proposal," by J. E. Williams, dated March 31, 1915, having first carefully read the proposal, information, probable cost of the scheme and line



HISTORY OF SONOMA COUNTY, CALIFORNIA.

GEOGRAPHICAL SITUATION AND AREA—DERIVATION OF NAME—TOPOGRAPHY—VALLEYS—GEOLOGY CLIMATOGRAPHY—WATER COURSES—TIMBER, ETC., ETC.

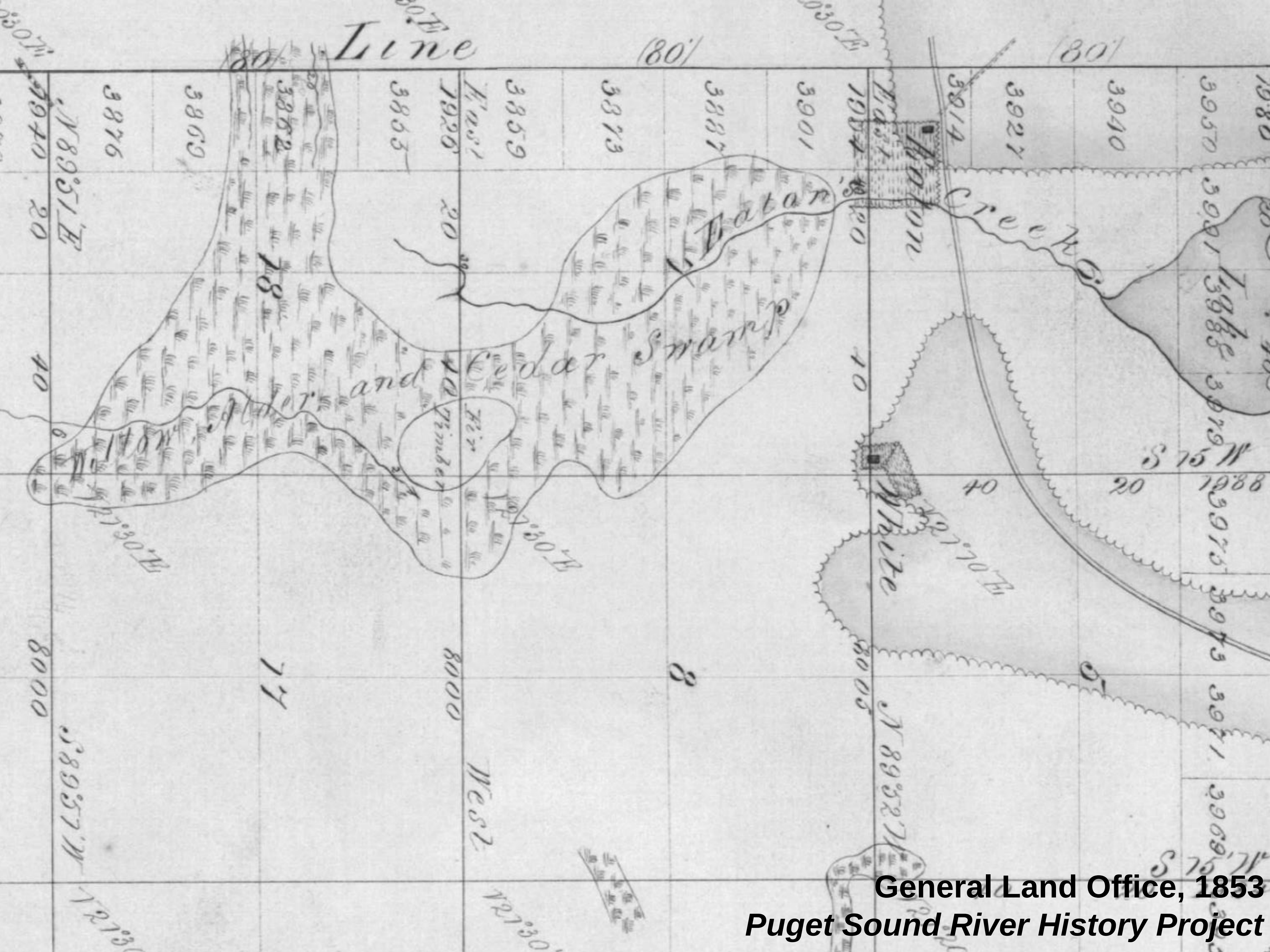
Sonoma County is bounded on the south by the bays of San Pablo, San Francisco, and Marin county; on the west by the Pacific ocean; on the north by Mendocino county; on the east by Lake and Napa counties, and lies twenty-five miles north of the city of San Francisco. Its sea coast line, following the indentations of the shore, is about sixty miles; its average length from north to south, some fifty miles; its width, about twenty-five miles, and its area in round numbers, eight hundred and fifty thousand acres.

The district of Sonoma originally comprised all that vast tract of territory lying west of the Sacramento river, and north to the Oregon line; at the first session of the Legislature, however, the State was divided into counties for greater facility in the transaction of business, and the northern line of Sonoma county was established along the fortieth parallel of latitude to the summit of the Mayacmas range of mountains, and thence south to the San Pablo bay, including all of the present Mendocino, and a portion of Napa. In 1859, Napa county having been already formed, Mendocino was set apart, and the limits of Sonoma contracted to its present boundaries.

The immense advantages of location, which the county possesses, may be at once observed on reference to a map of the State. It fronts on the San Francisco bay, called at its most northerly end San Pablo, and at one time known as the bay of Sonoma. The creeks, or estuaries, of Petaluma and

Texts

Thomas Doughty, ca. 1825 – 1830
View on the Brandywine River: Gilpin's Paper Mill
Brandywine River Museum

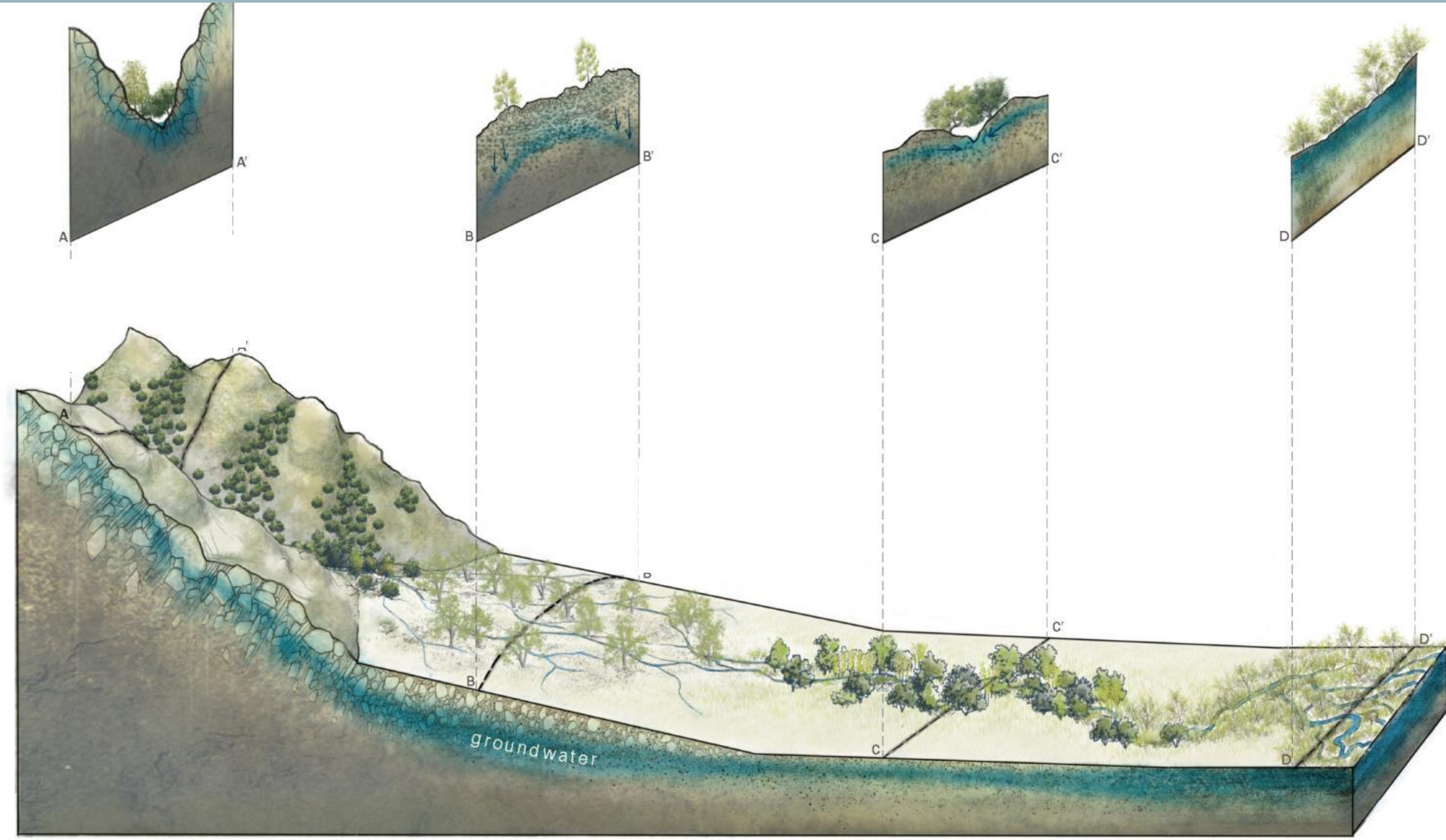


General Land Office, 1853
Puget Sound River History Project

Geographic/Historical Setting: CA Coastal Range

- Mediterranean climate; less wet, intermittent streamflow
- Not forested valleys: oak savannas, meadows
- Different land use history: later development

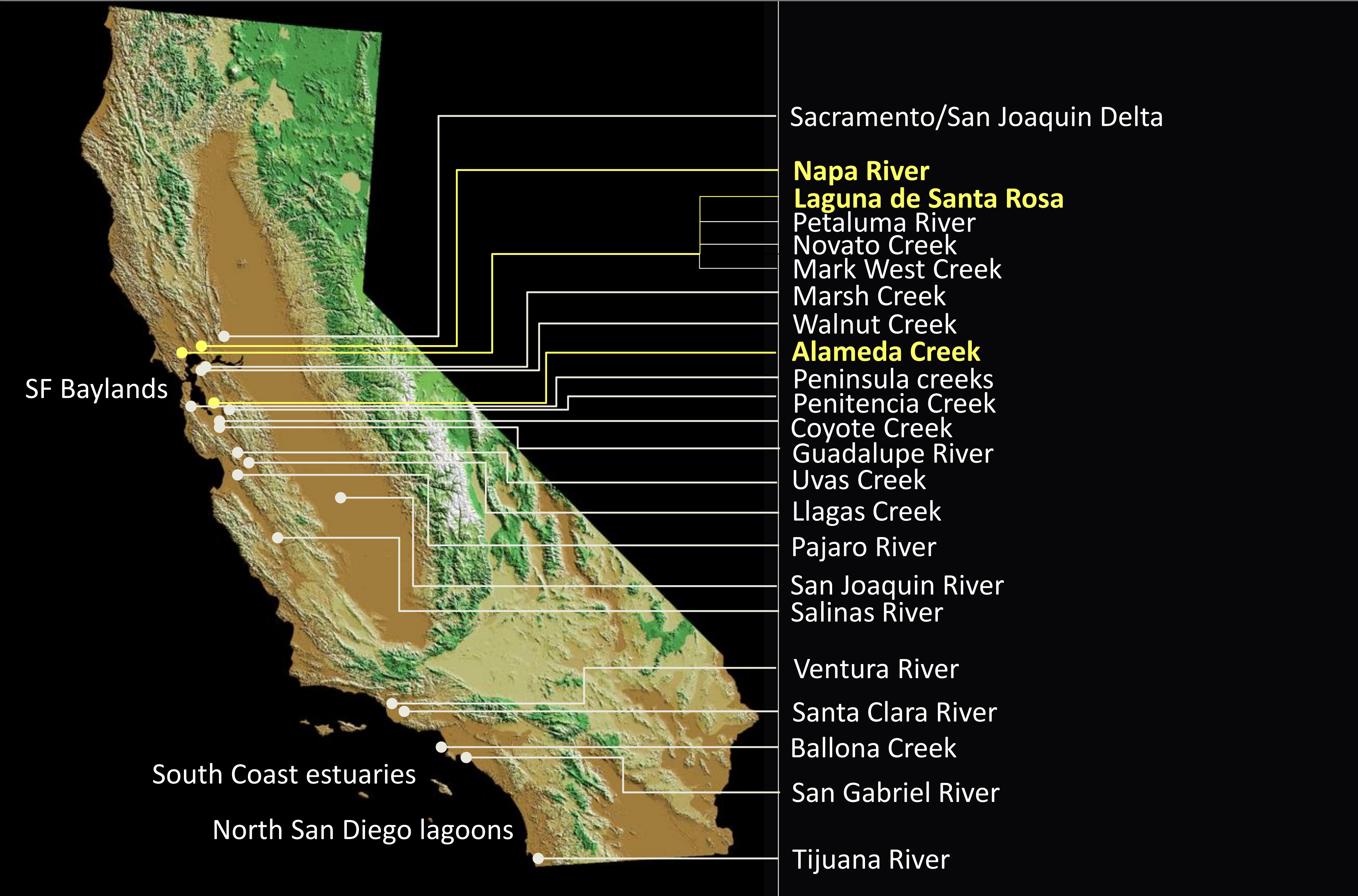
Conceptual model of channel type diversity: CA streams (Alameda Creek HE Study, Stanford et al. 2013)



Source: Stanford et al. 2013

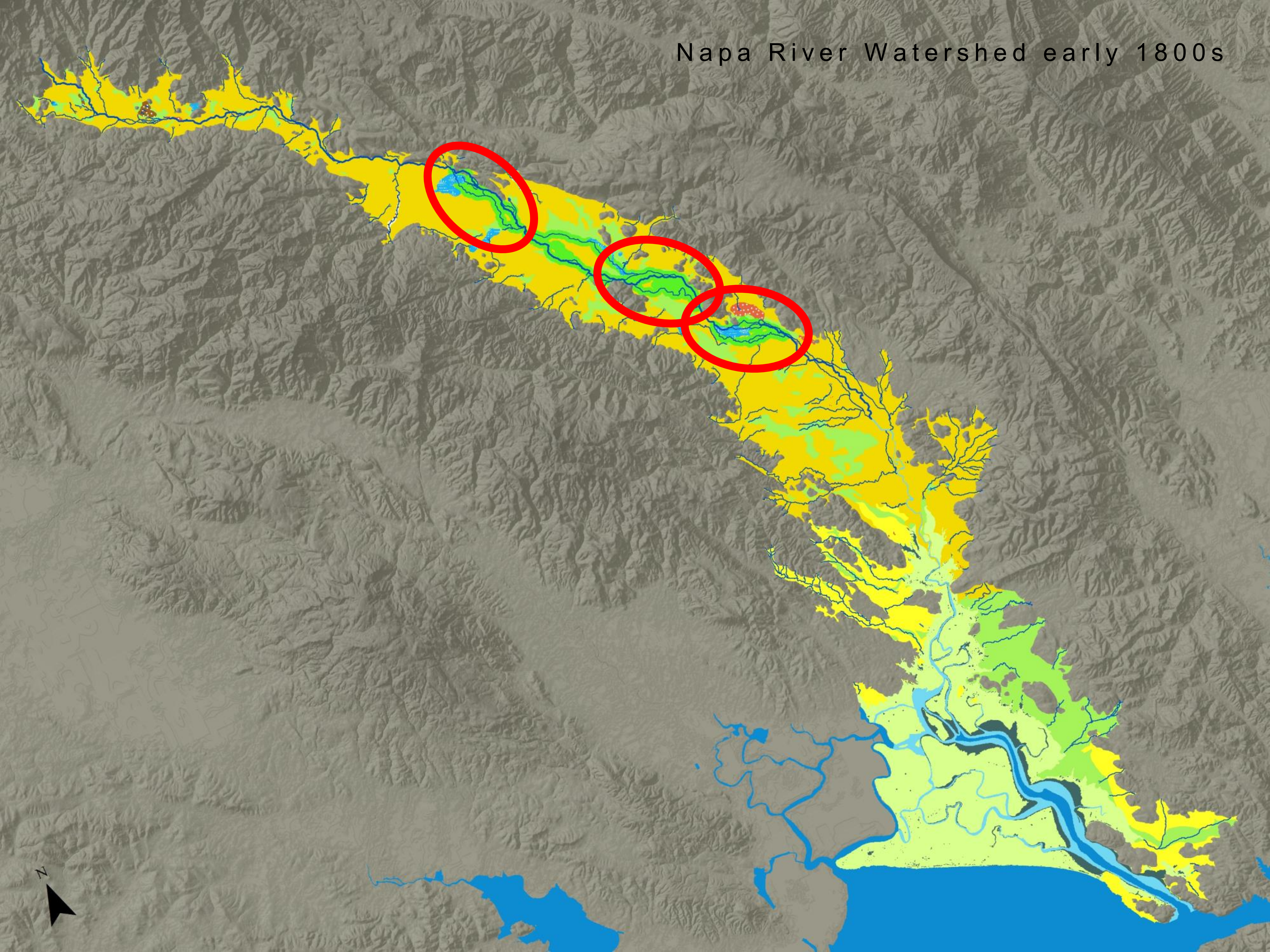
Historical Ecology Studies by SFEI and partners

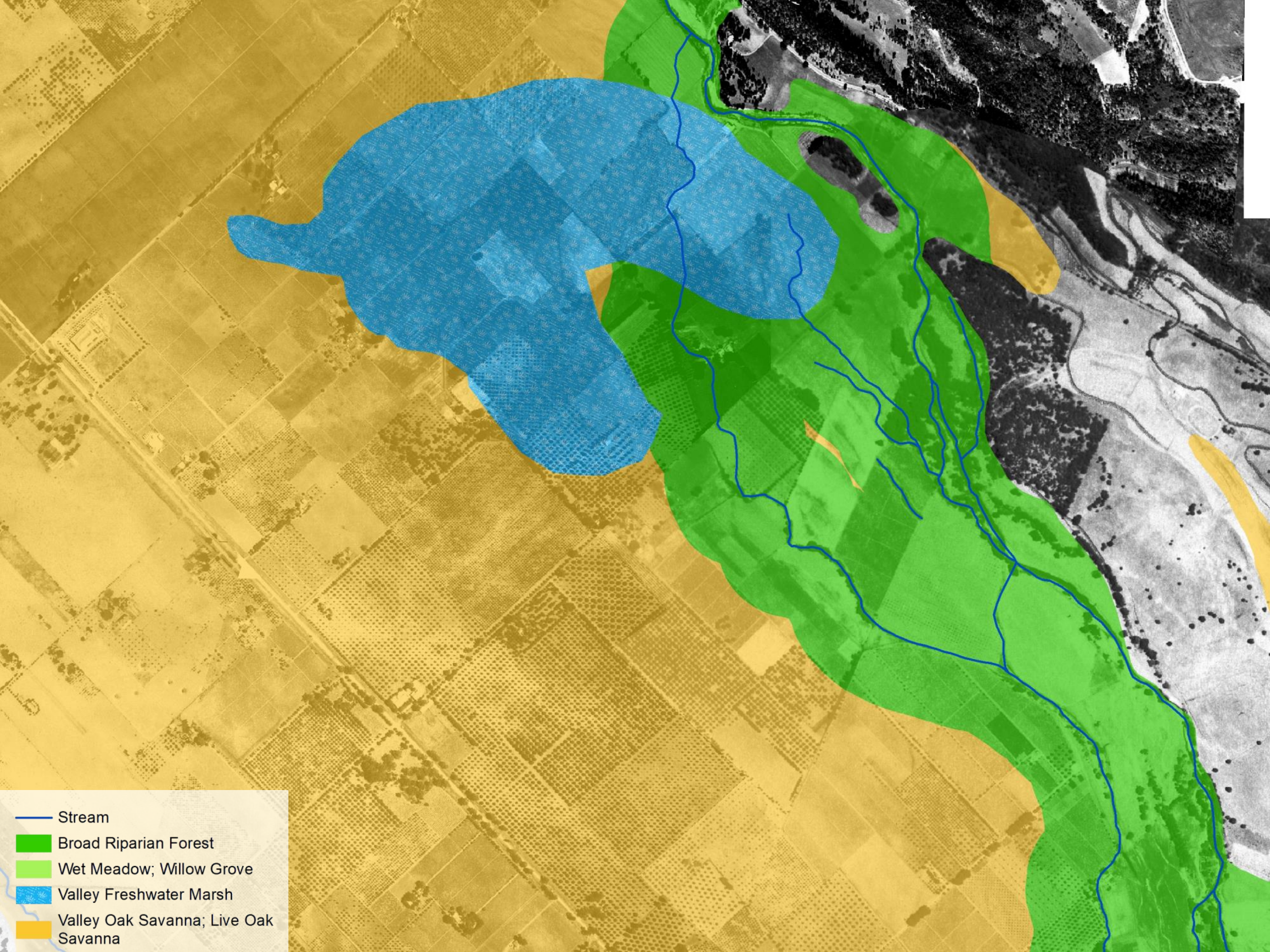
Historical Ecology Studies by SFEI and partners



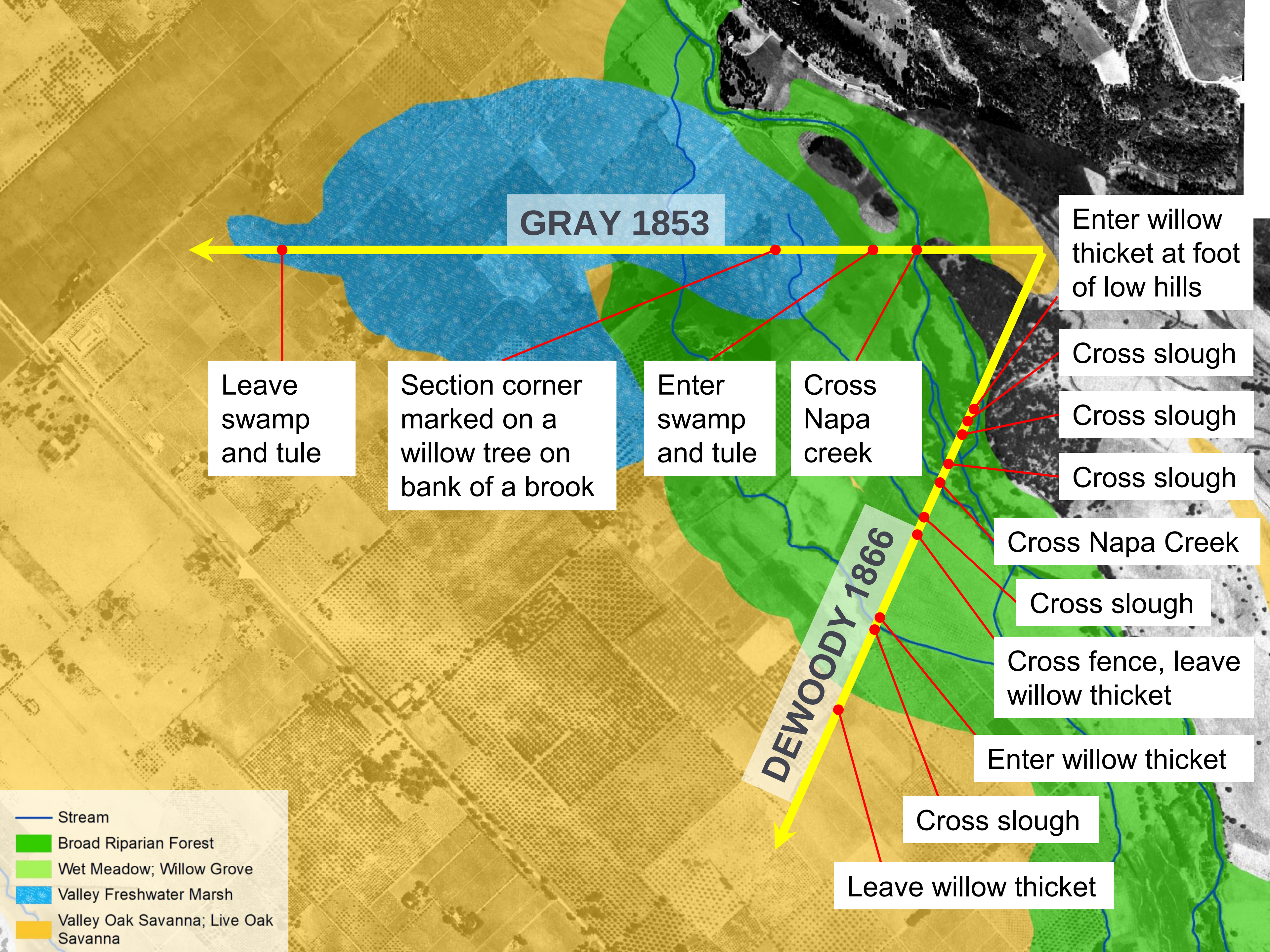
Napa River

Napa County

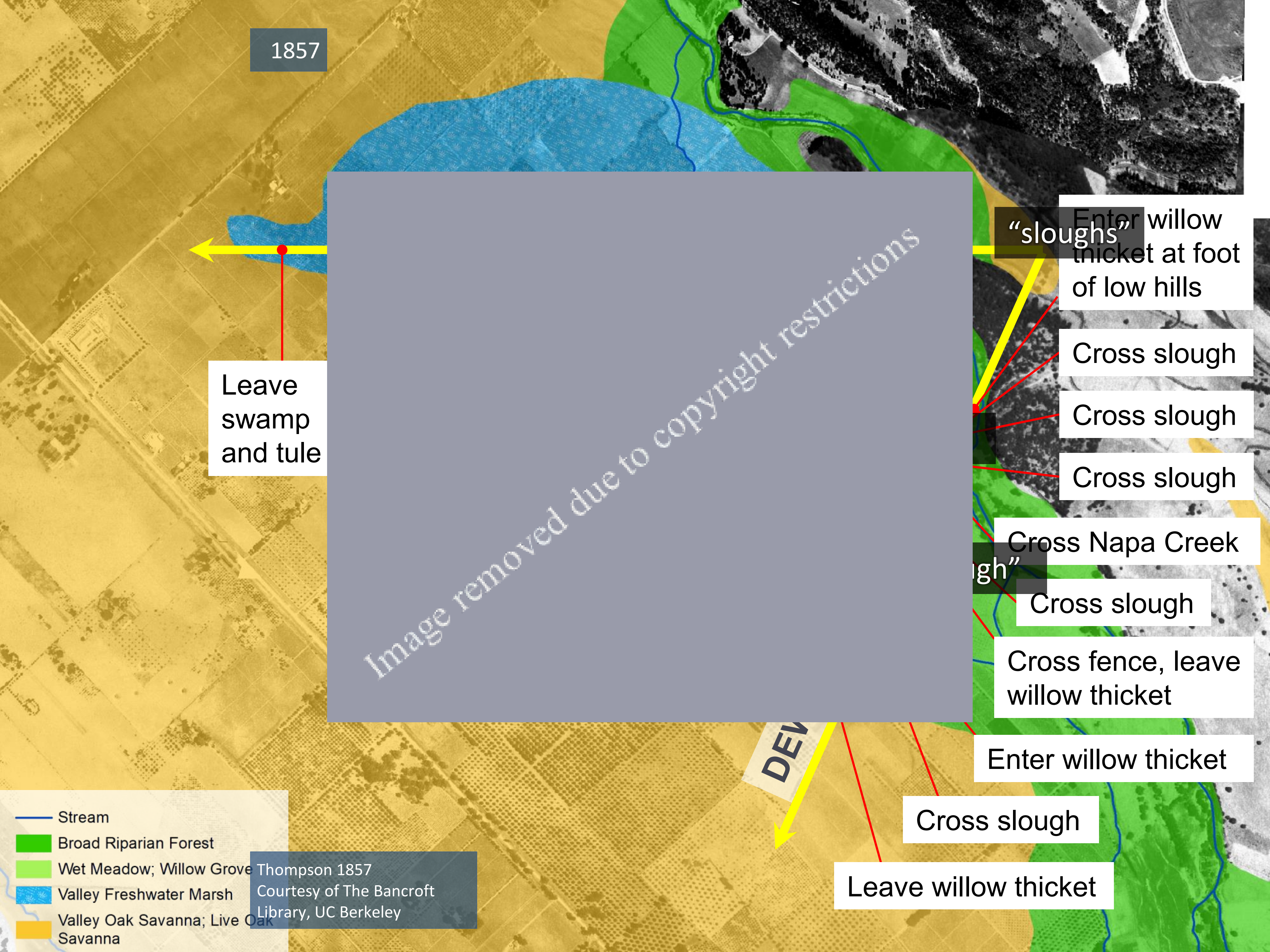

Napa River Watershed early 1800s
N

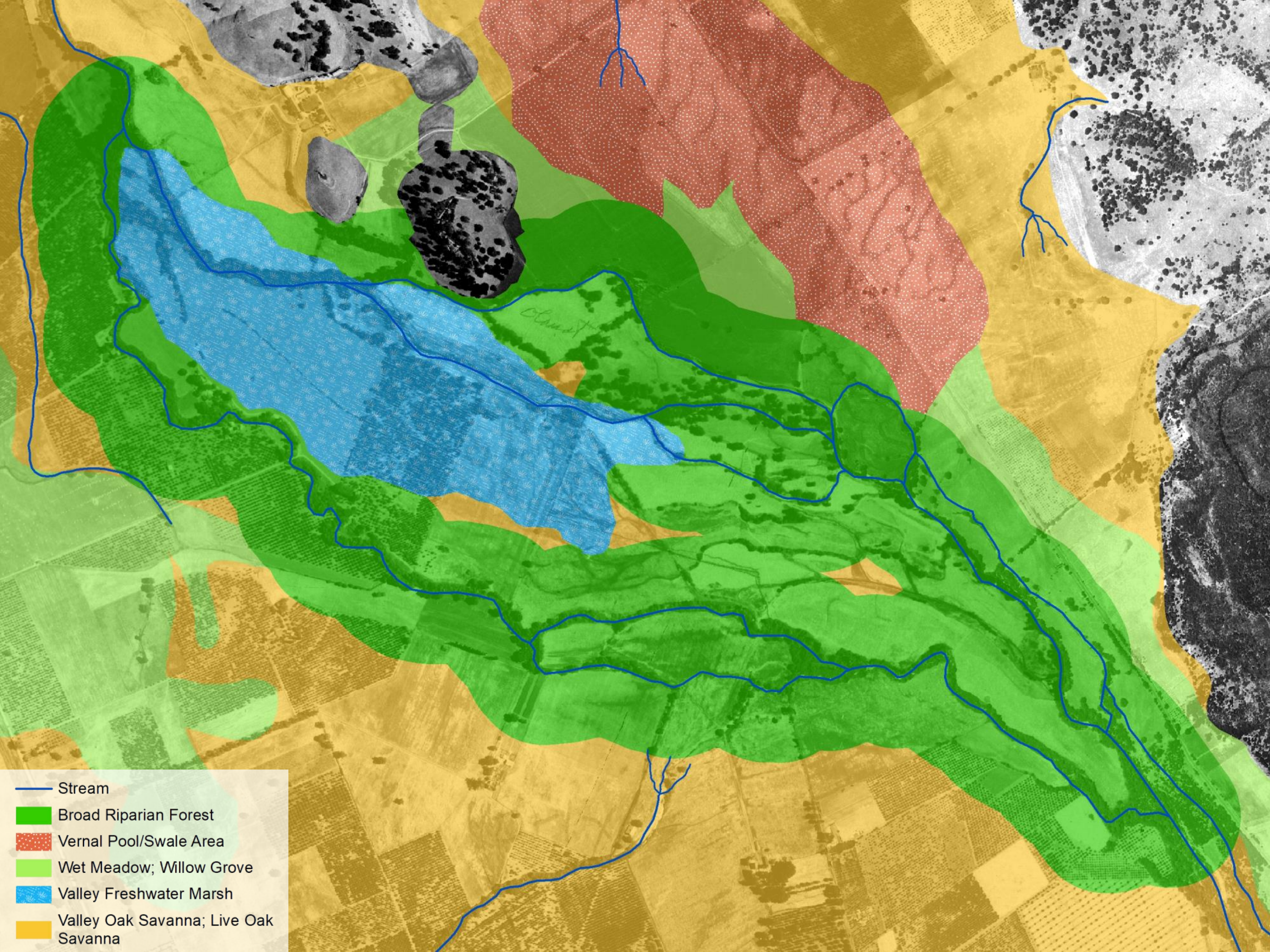


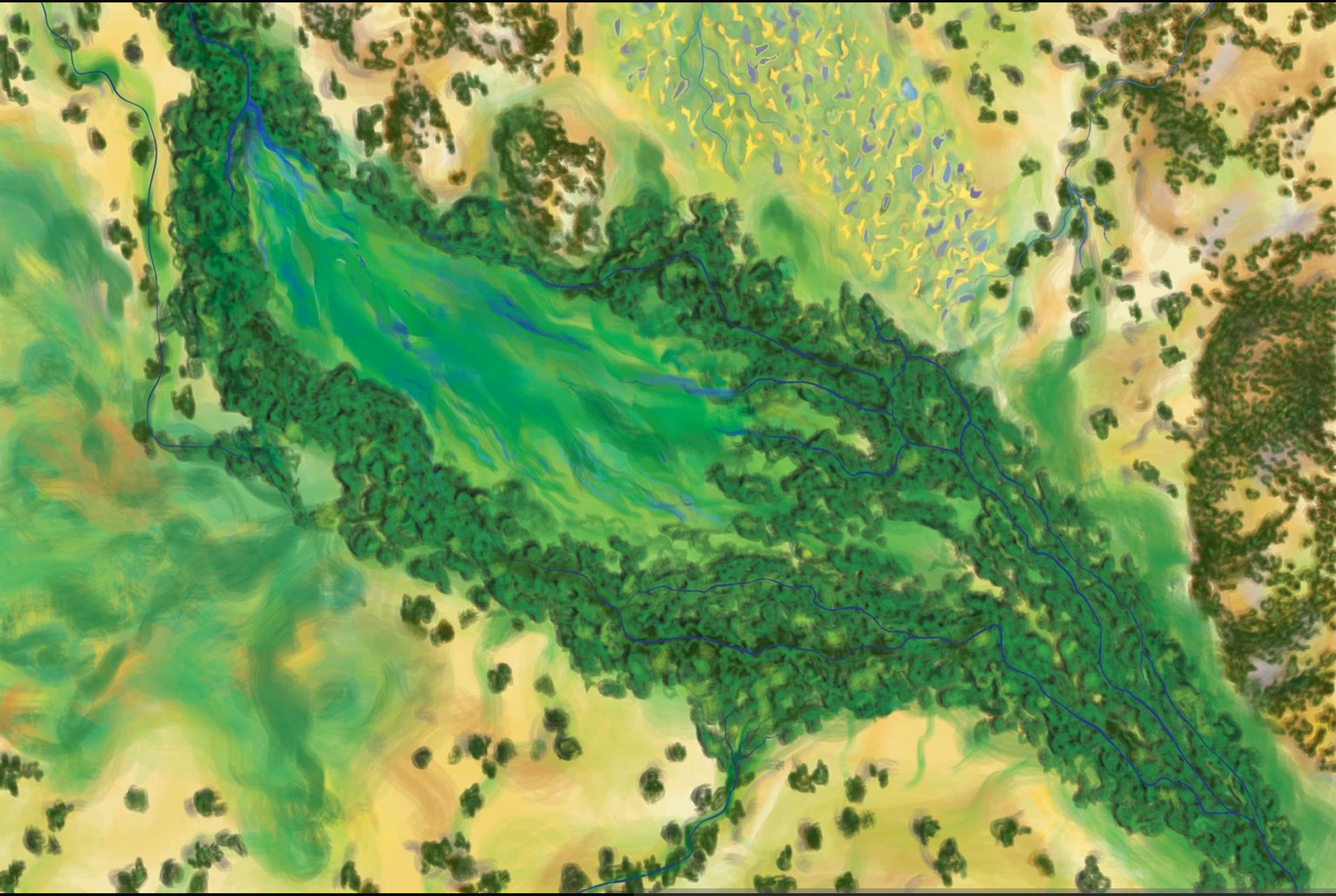
Stream
Broad Riparian Forest
Wet Meadow; Willow Grove
Valley Freshwater Marsh
Valley Oak Savanna; Live Oak Savanna



GRAY 1853
DEWOODY 1866
Leave swamp and tule
Section corner marked on a willow tree on bank of a brook
Enter swamp and tule
Cross Napa creek
Enter willow thicket at foot of low hills
Cross slough
Cross slough
Cross slough
Cross Napa Creek
Cross slough
Cross fence, leave willow thicket
Enter willow thicket
Cross slough
Leave willow thicket
Stream
Broad Riparian Forest
Wet Meadow; Willow Grove
Valley Freshwater Marsh
Valley Oak Savanna; Live Oak Savanna


1857
“sloughs”
Enter willow thicket at foot of low hills
Cross slough
Cross slough
Cross slough
Cross Napa Creek
Cross slough
Cross fence, leave willow thicket
Enter willow thicket
Cross slough
Leave willow thicket
Leave swamp and tule
Image removed due to copyright restrictions
Stream
Broad Riparian Forest
Wet Meadow; Willow Grove
Valley Freshwater Marsh
Valley Oak Savanna; Live Oak Savanna
Thompson 1857
Courtesy of The Bancroft Library, UC Berkeley

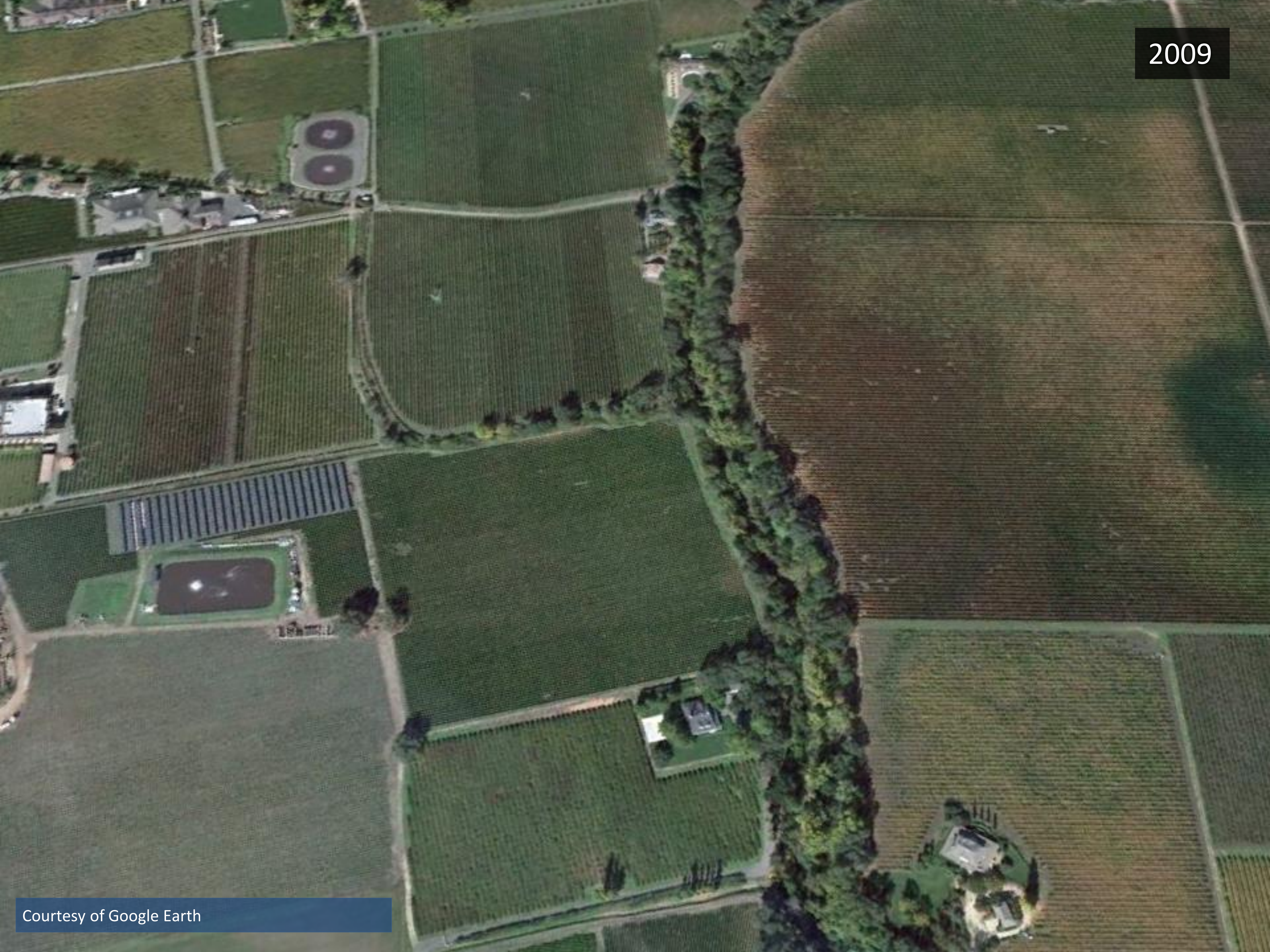

Stream
Broad Riparian Forest
Vernal Pool/Swale Area
Wet Meadow; Willow Grove
Valley Freshwater Marsh
Valley Oak Savanna; Live Oak Savanna



SFEI and Brian Mabeus, Bay Nature


1942
USDA 1942
Courtesy of Napa County Resource Conservation
District and Natural Resources Conservation Service


2009
USDA 2009
Courtesy of National Agricultural Imagery Program

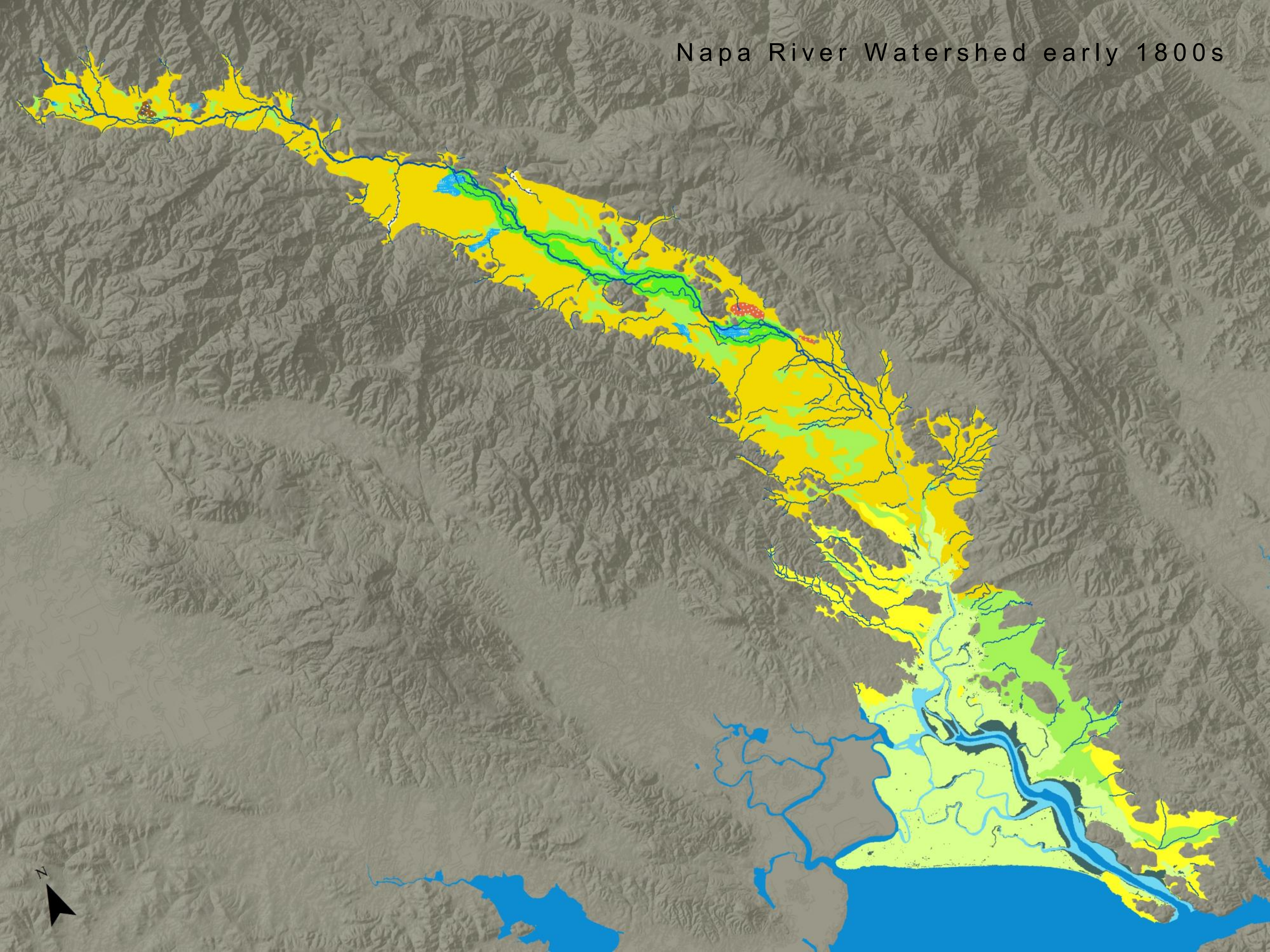

2009
Courtesy of Google Earth

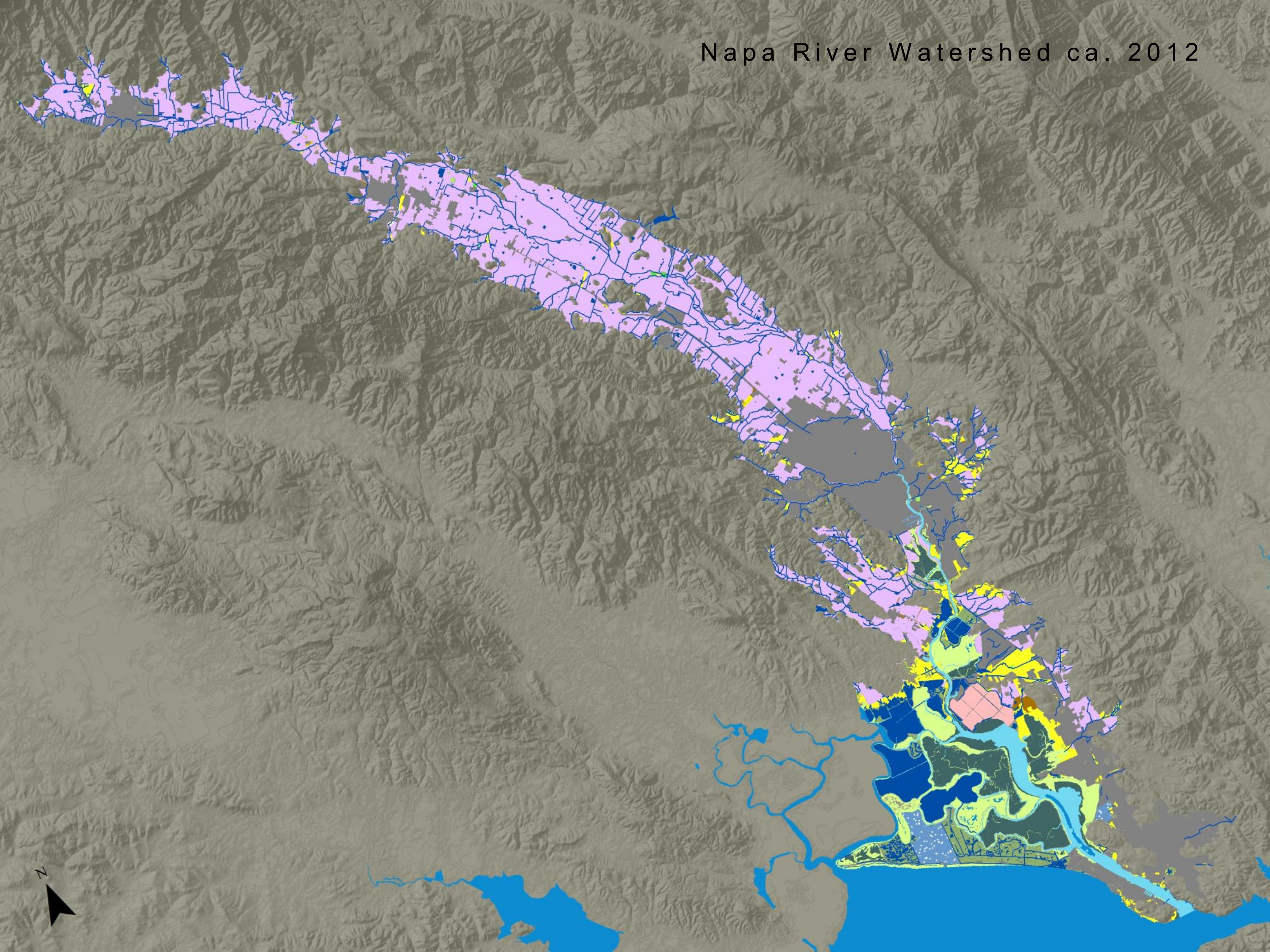
Early 1800s

SFEI and Jen Natali

Channel Incision

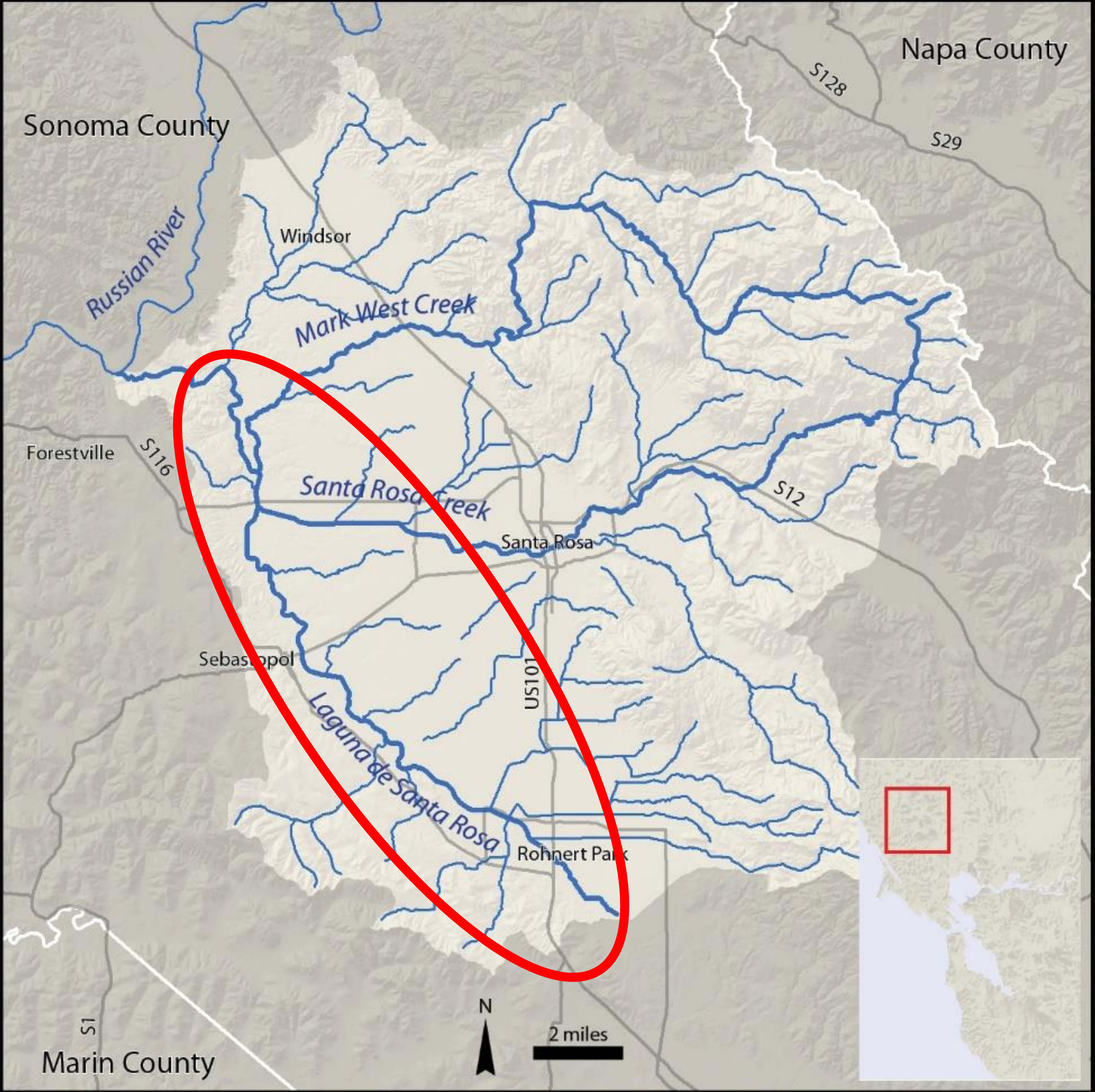
SFEI and Jen Natali


Napa River Watershed early 1800s
N


Napa River Watershed ca. 2012
N

Laguna de Santa Rosa

Sonoma County


Napa County
S128
S29
Sonoma County
Russian River
Windsor
Mark West Creek
Forestville
S116
Santa Rosa Creek
S12
Santa Rosa
Sebastopol
US101
Laguna de Santa Rosa
Rohnert Park
S1
Marin County
N
2 miles

1858

ca. 1840

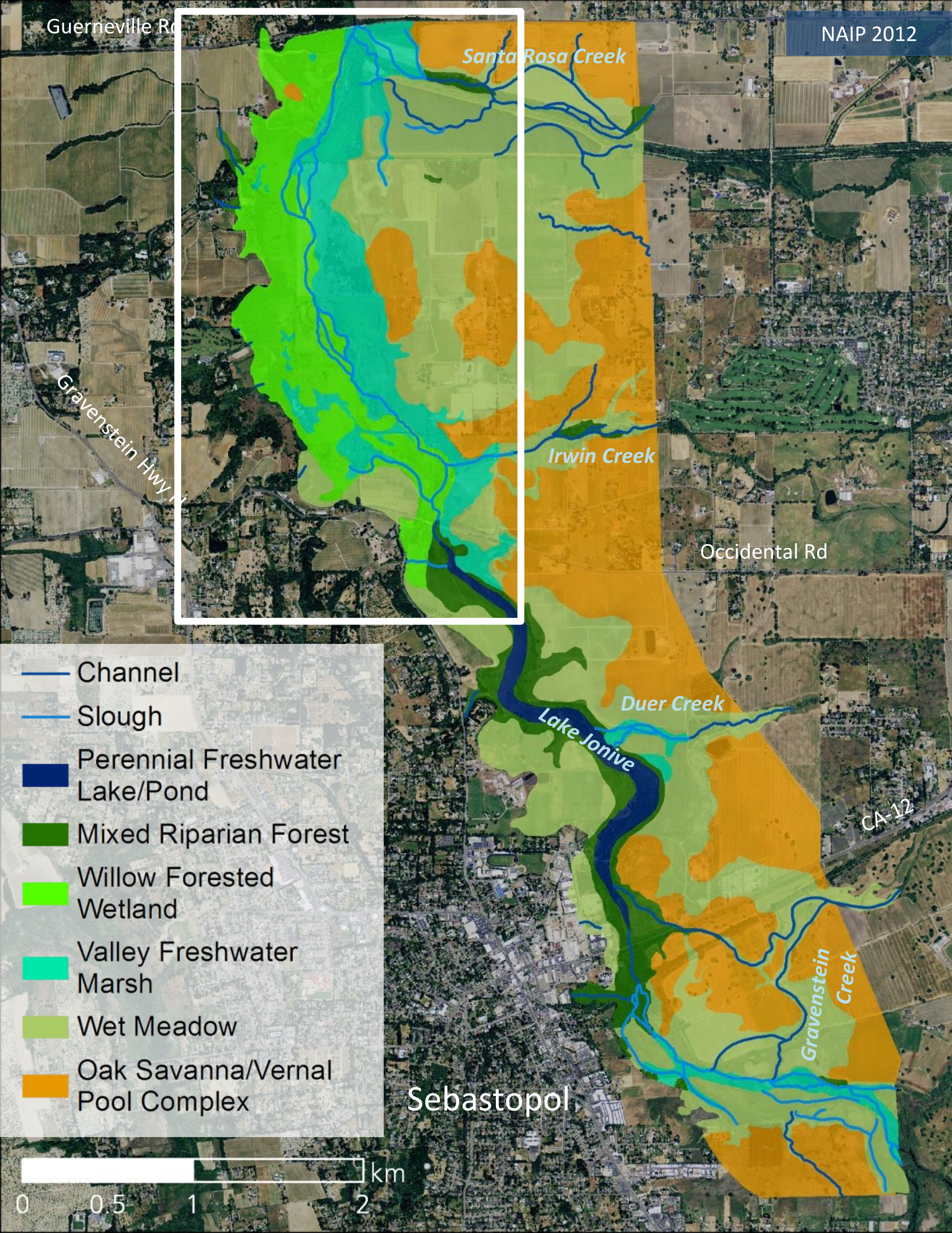
"A lagoon and a stream with **many pools of retained water** [*una laguna y una arroyo con muchas posas de agua retenida*]" (Moraga 1810, September)

"Great **tulare lakes** teaming with beaver [*grandes lagunas tulares, y abunda de castores*]" (Vallejo 1833)

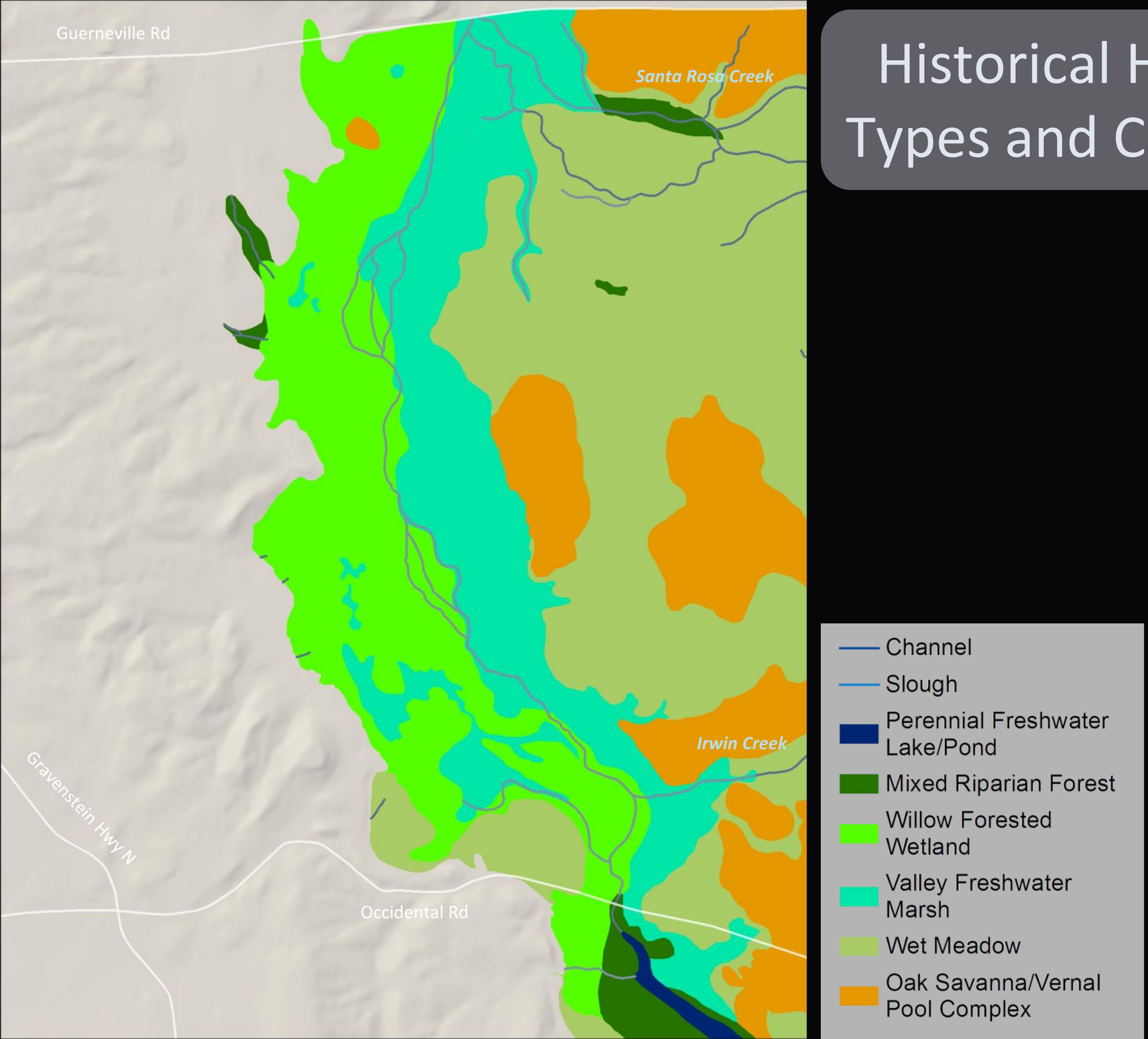
USDC 1858, Rancho El Molino (B-492)
Courtesy of The Bancroft Library

USDC ca. 1840, Rancho Llano de Santa Rosa (B-128)
Courtesy of The Bancroft Library

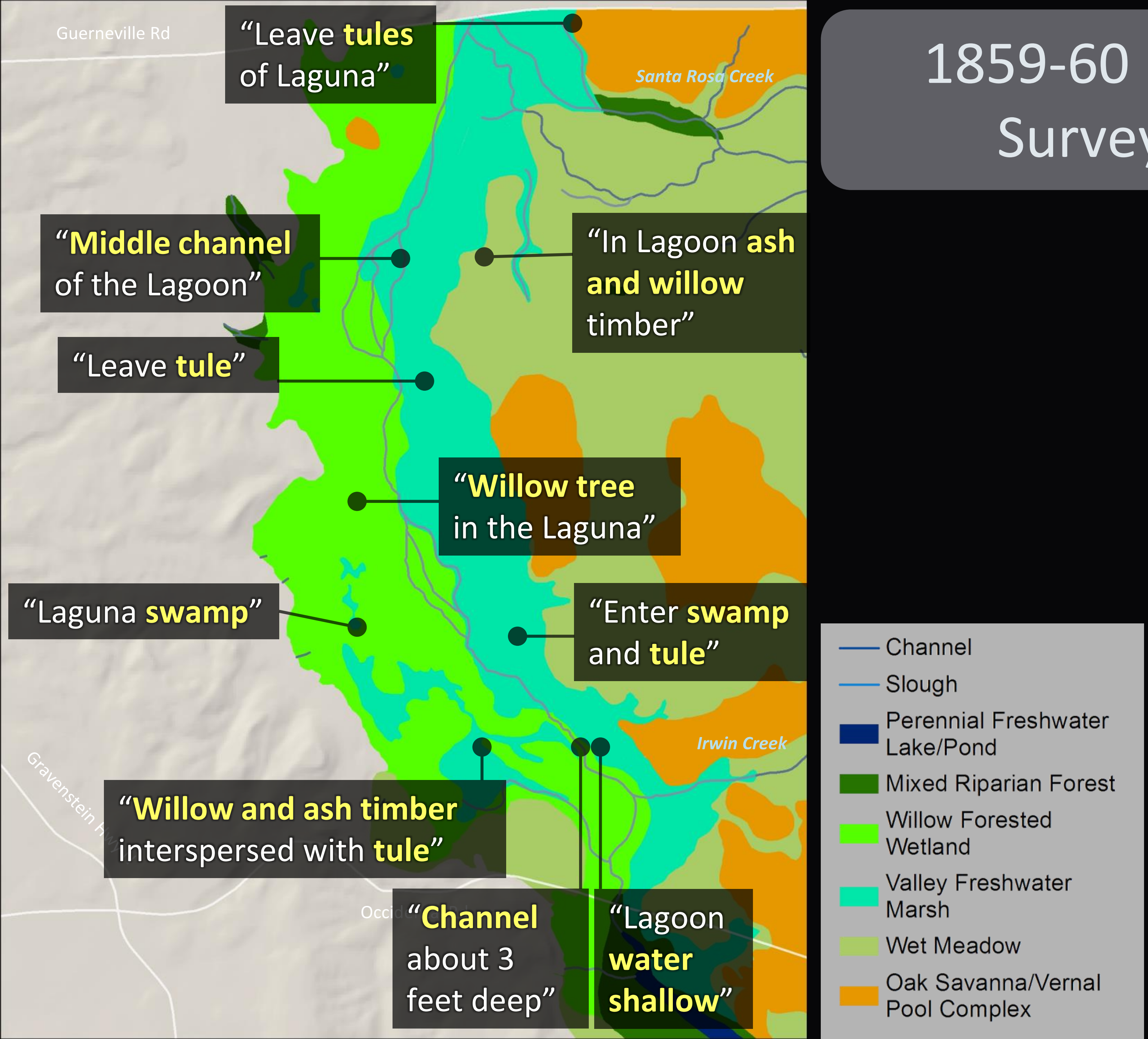
Historical Habitat Types and Channels



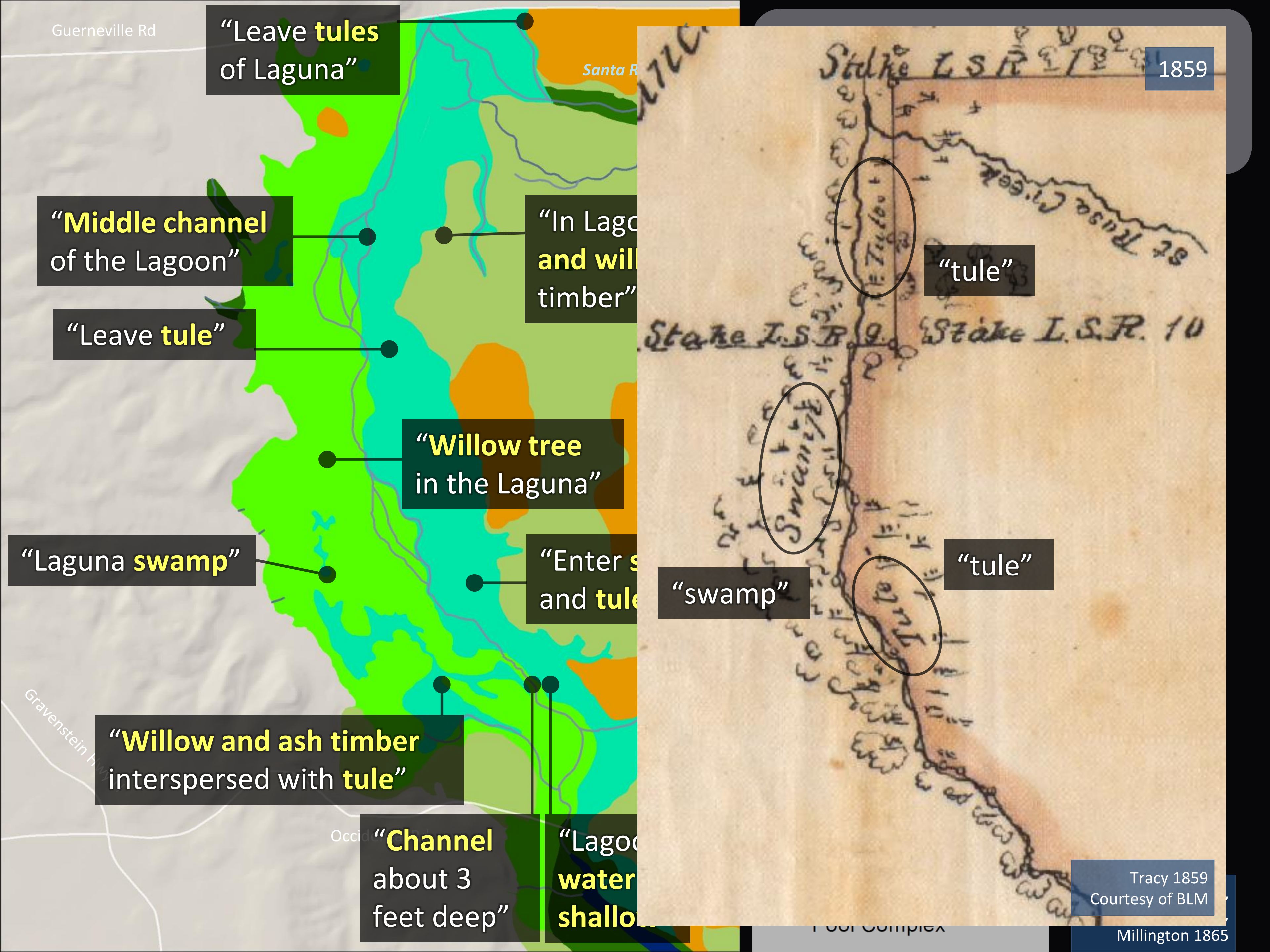
Historical Habitat Types and Channels



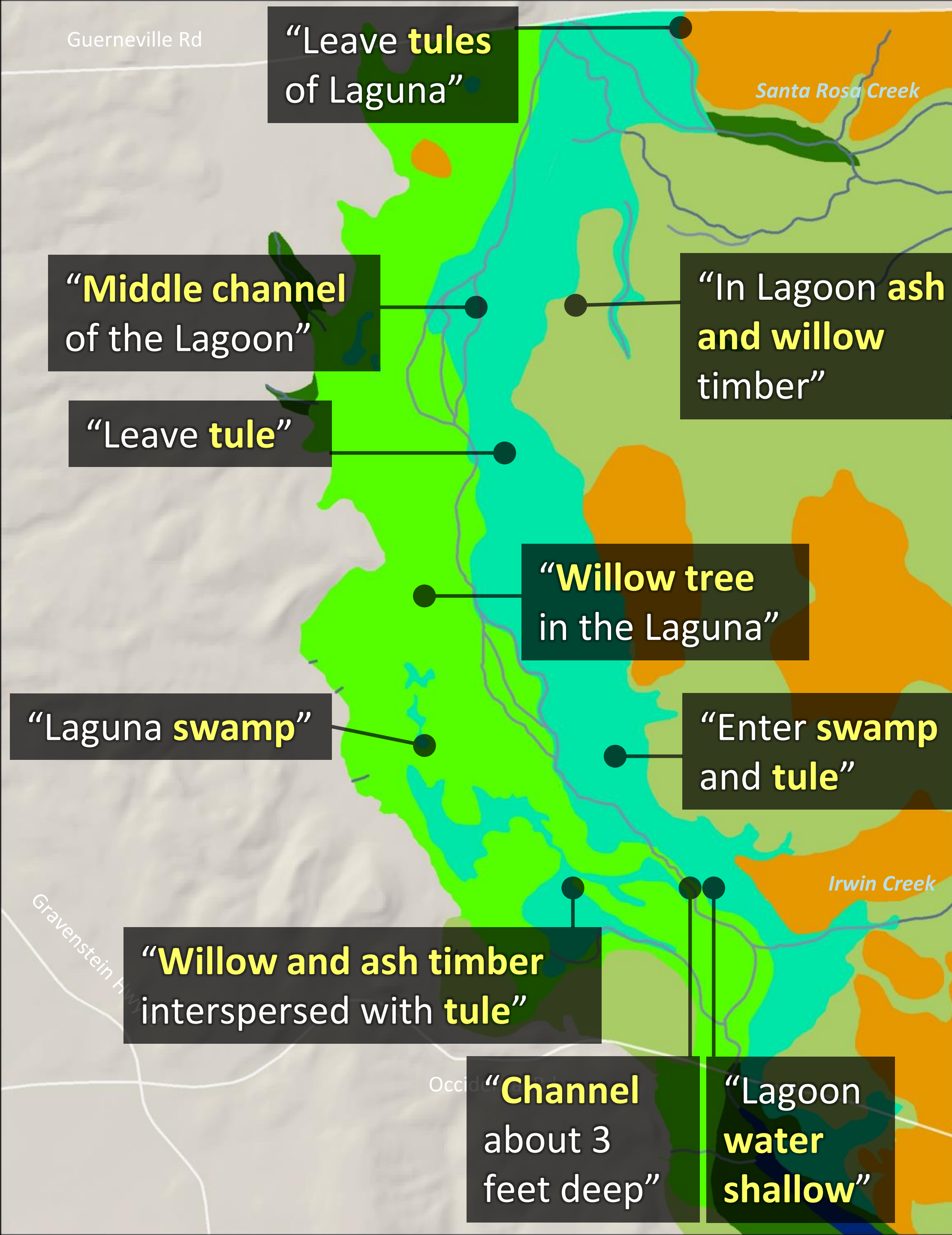
1859-60 Field Surveys



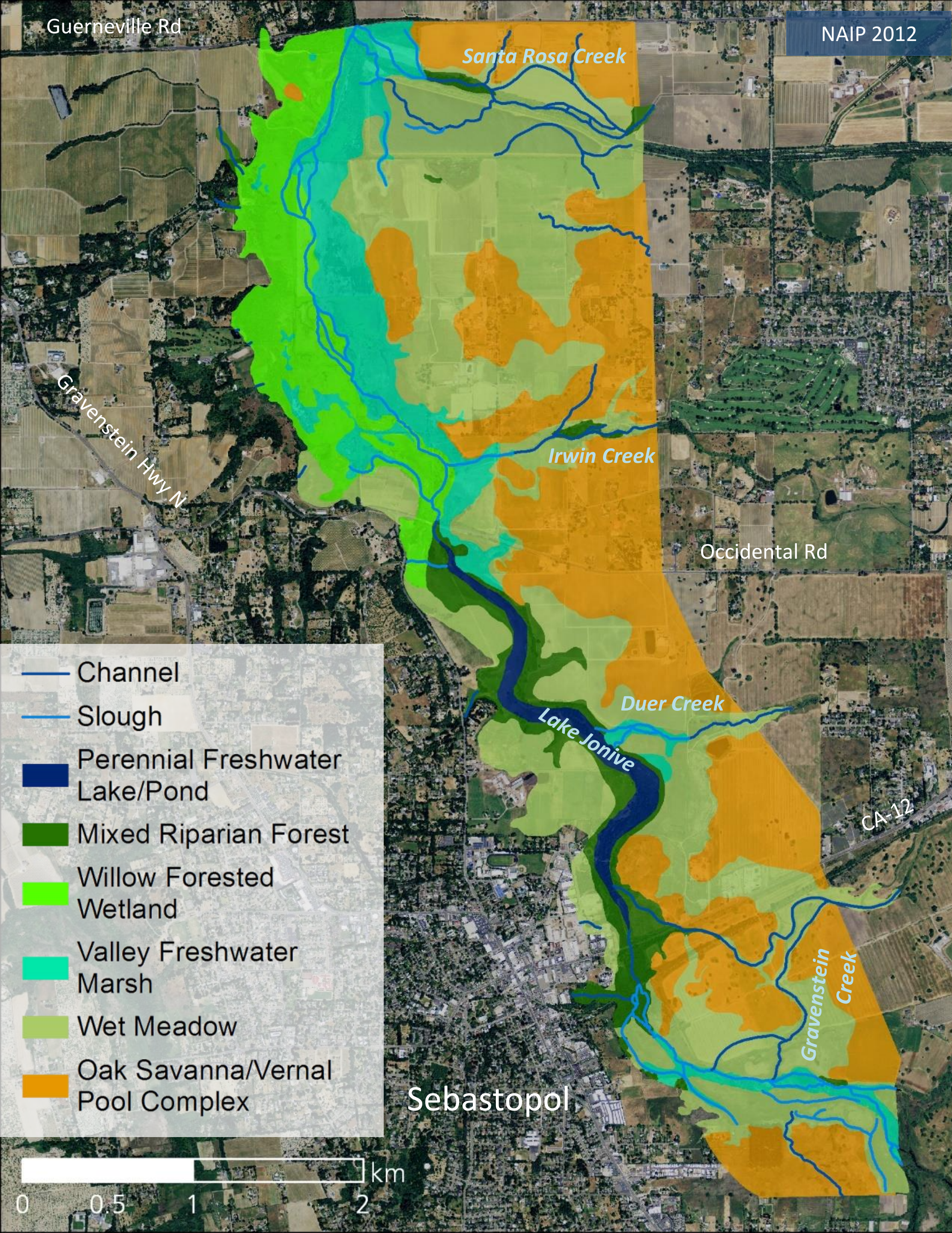
Sources: Tracy 1859, Eliason 1861, Millington 1865



Guerneville Rd
"Leave **tules** of Laguna"
Santa R
"**Middle channel** of the Lagoon"
"In Lago
and wil
timber"
"Leave **tule**"
"**Willow tree** in the Laguna"
"Laguna **swamp**"
"Enter s
and **tule**
Gravenstein Hw
"**Willow and ash timber** interspersed with **tule**"
Occid
"**Channel** about 3 feet deep"
"Lagoo
water
shallo
1859
Stake L.S.R.
"tule"
Stake L.S.R. 9
Stake L.S.R. 10
"swamp"
"tule"
Tracy 1859
Courtesy of BLM
Millington 1865



Millington 1865



Historical Habitat Types and Channels

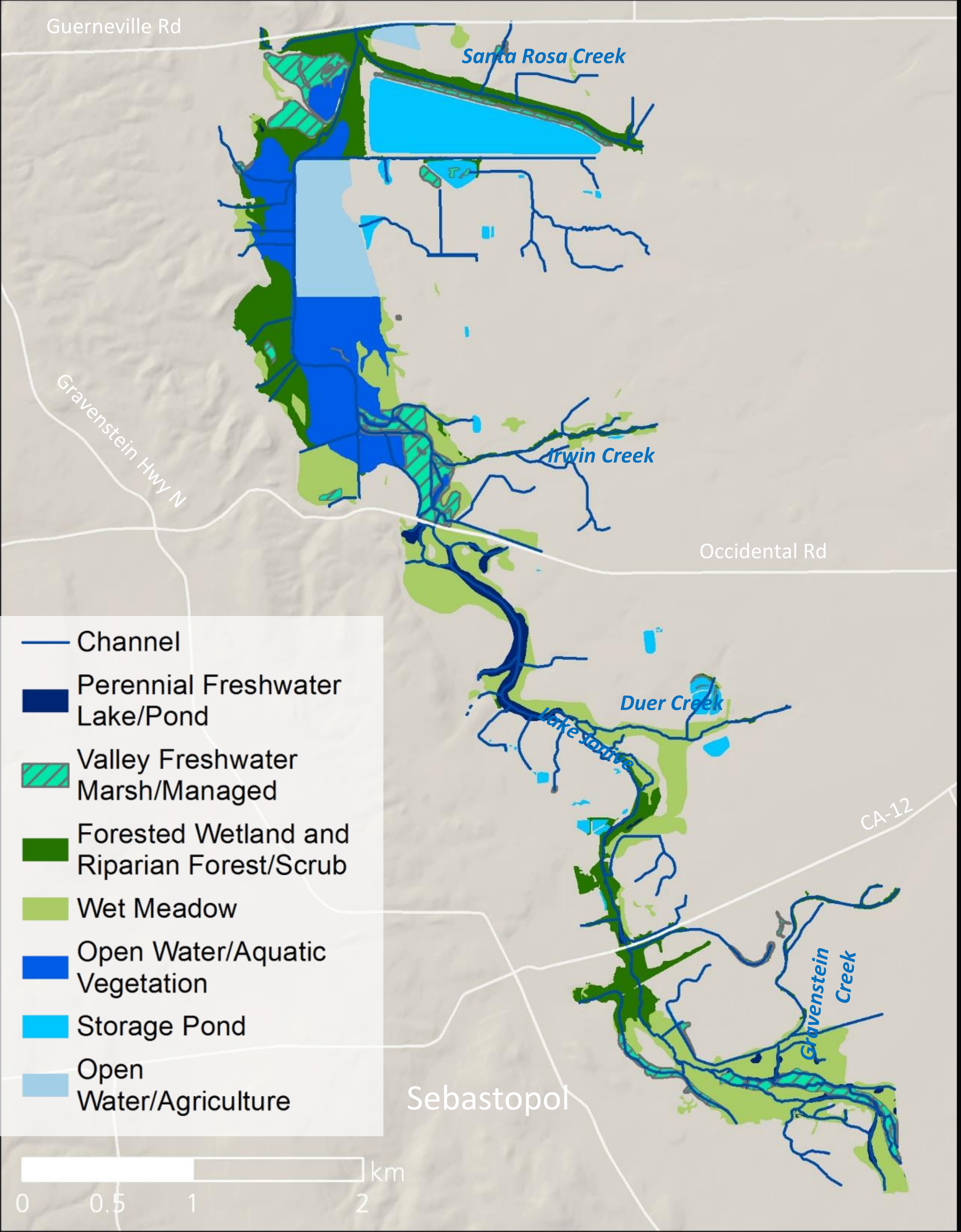
"**From the clear waters of [Lake Jonive] have been caught salmon-trout** that filled the sportsman's heart with joy" (*Sebastopol Times* 1/2/1903)

"In the high hills which form the eastern boundary of Santa Rosa Township three large creeks rise... **The salmon trout run up these streams nearly to their source to spawn**" (*Sonoma Democrat* 1/2/1875)

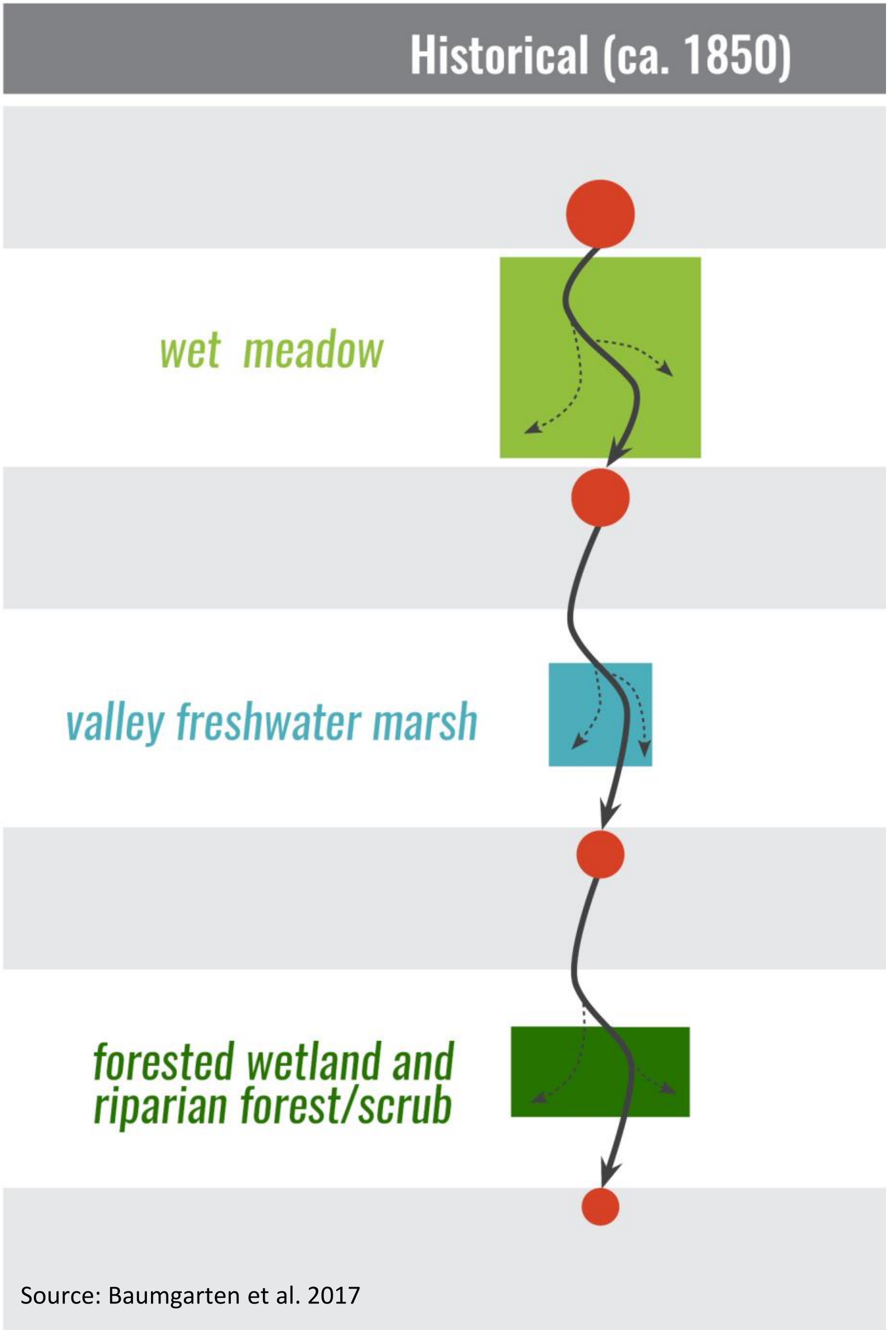
"**Salmon trout** are plentiful in **Mark West Creek**" (*Sonoma Democrat* 2/18/1882)

Modern Habitat Types and Channels

"The Laguna de Santa Rosa does continue to provide **abundant potential winter refugia** for coho salmon" (NMFS 2010)

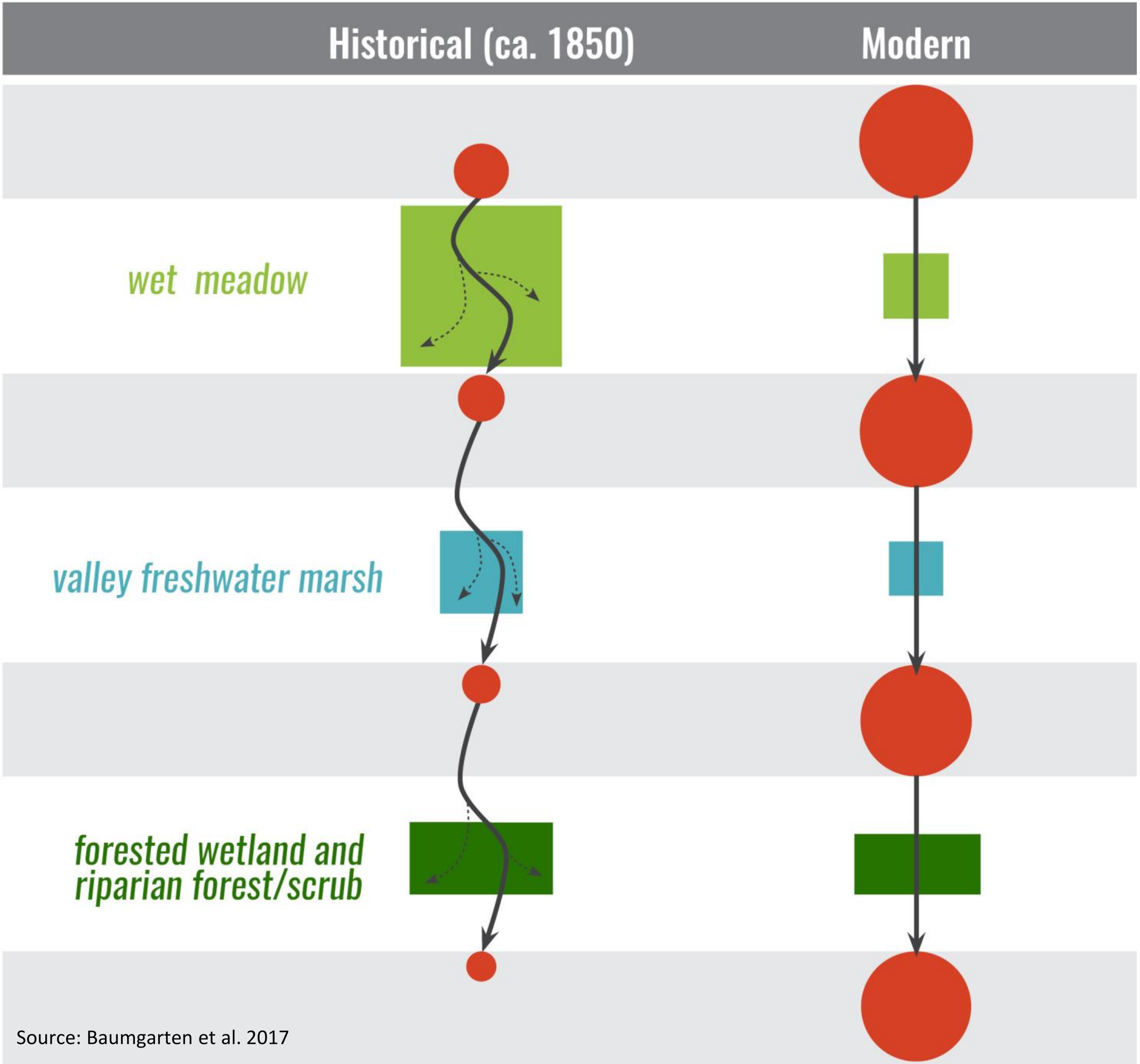


NUTRIENT TRANSPORT AND ASSIMILATION (CONCEPTUAL)



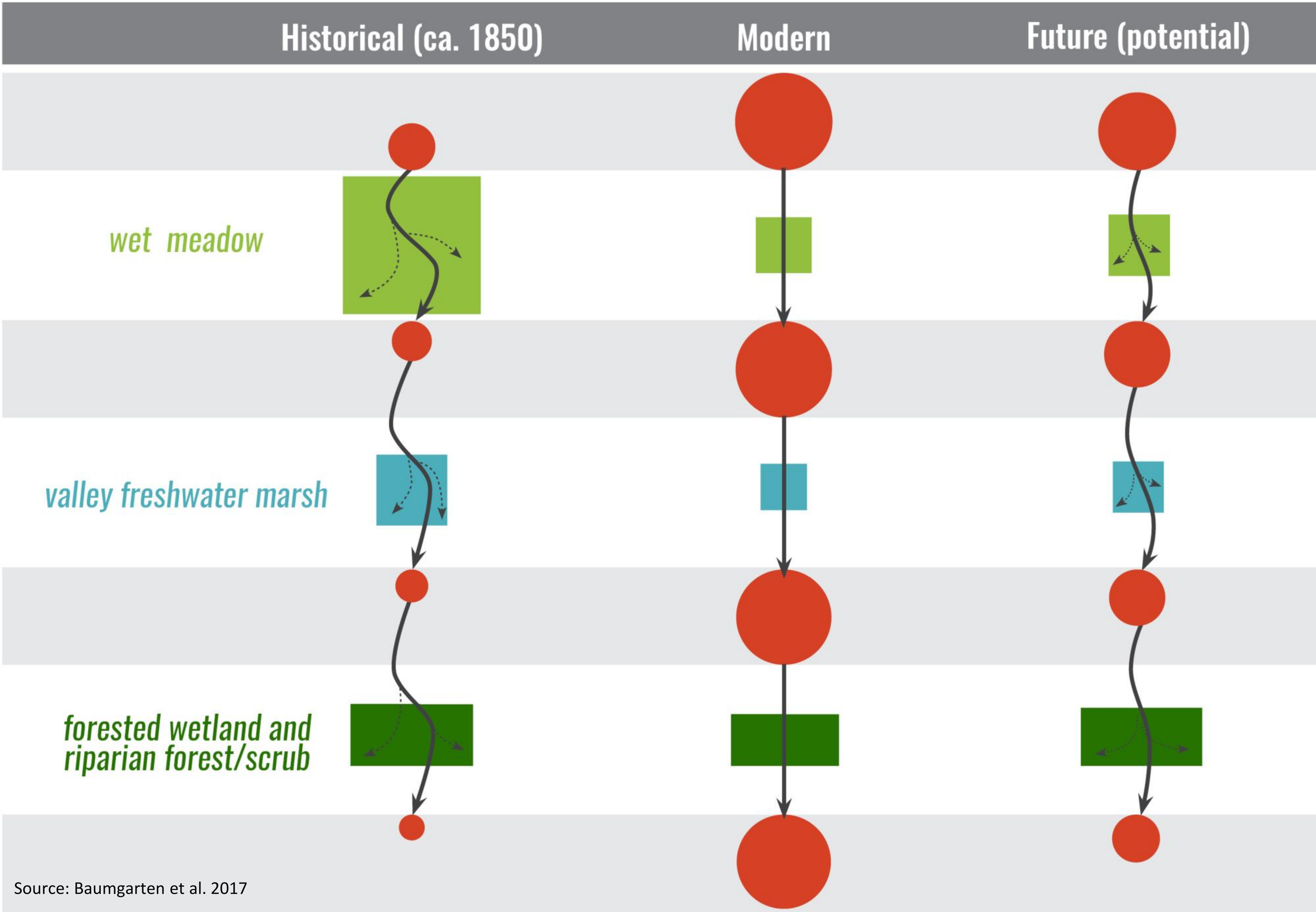
Source: Baumgarten et al. 2017

NUTRIENT TRANSPORT AND ASSIMILATION (CONCEPTUAL)



Source: Baumgarten et al. 2017

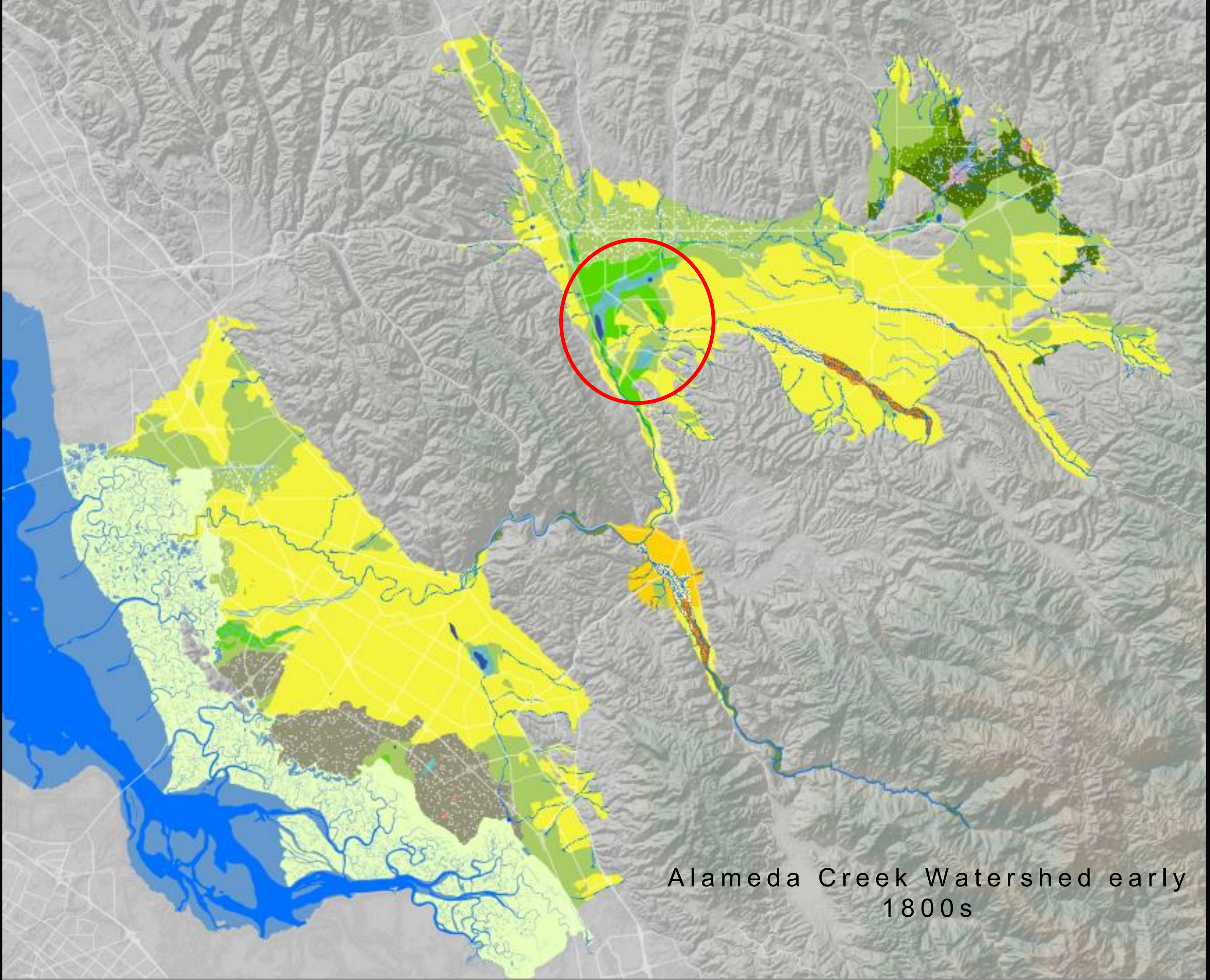
NUTRIENT TRANSPORT AND ASSIMILATION (CONCEPTUAL)



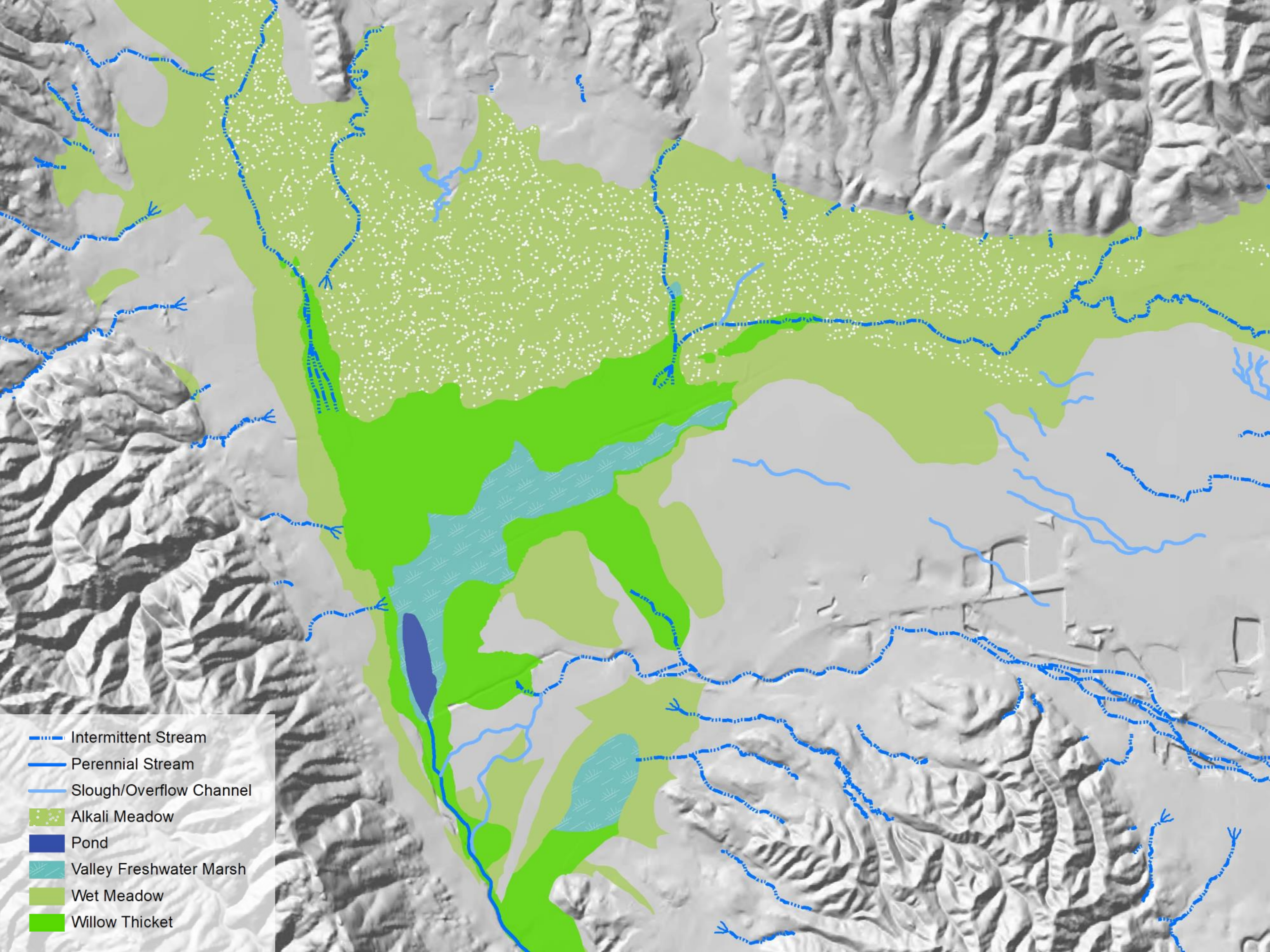
Source: Baumgarten et al. 2017

Pleasanton Marsh and Arroyo de la Laguna

Alameda County



Alameda Creek Watershed early 1800s


Intermittent Stream
Perennial Stream
Slough/Overflow Channel
Alkali Meadow
Pond
Valley Freshwater Marsh
Wet Meadow
Willow Thicket

1860

Image removed due to copyright restrictions

La Croze 1860 (E-346)
Courtesy of The Bancroft Library

1880

Image removed due to copyright restrictions

Allardt 1880
Courtesy of The Bancroft Library

"Tule swamp abounding
with copious living springs"

“Many tulares and lakes” (Fages 1772)

1880

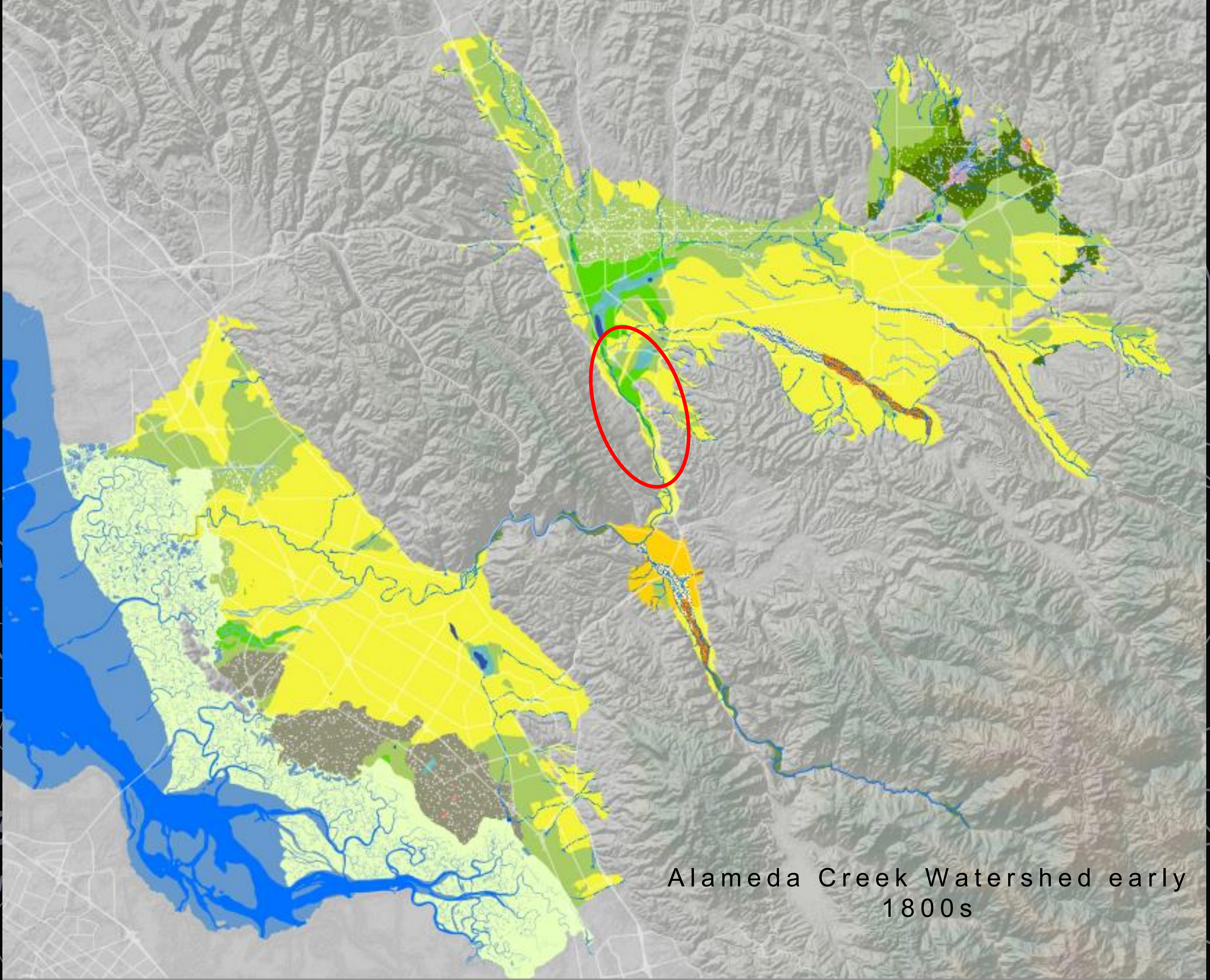
“Tule”

“Willows”

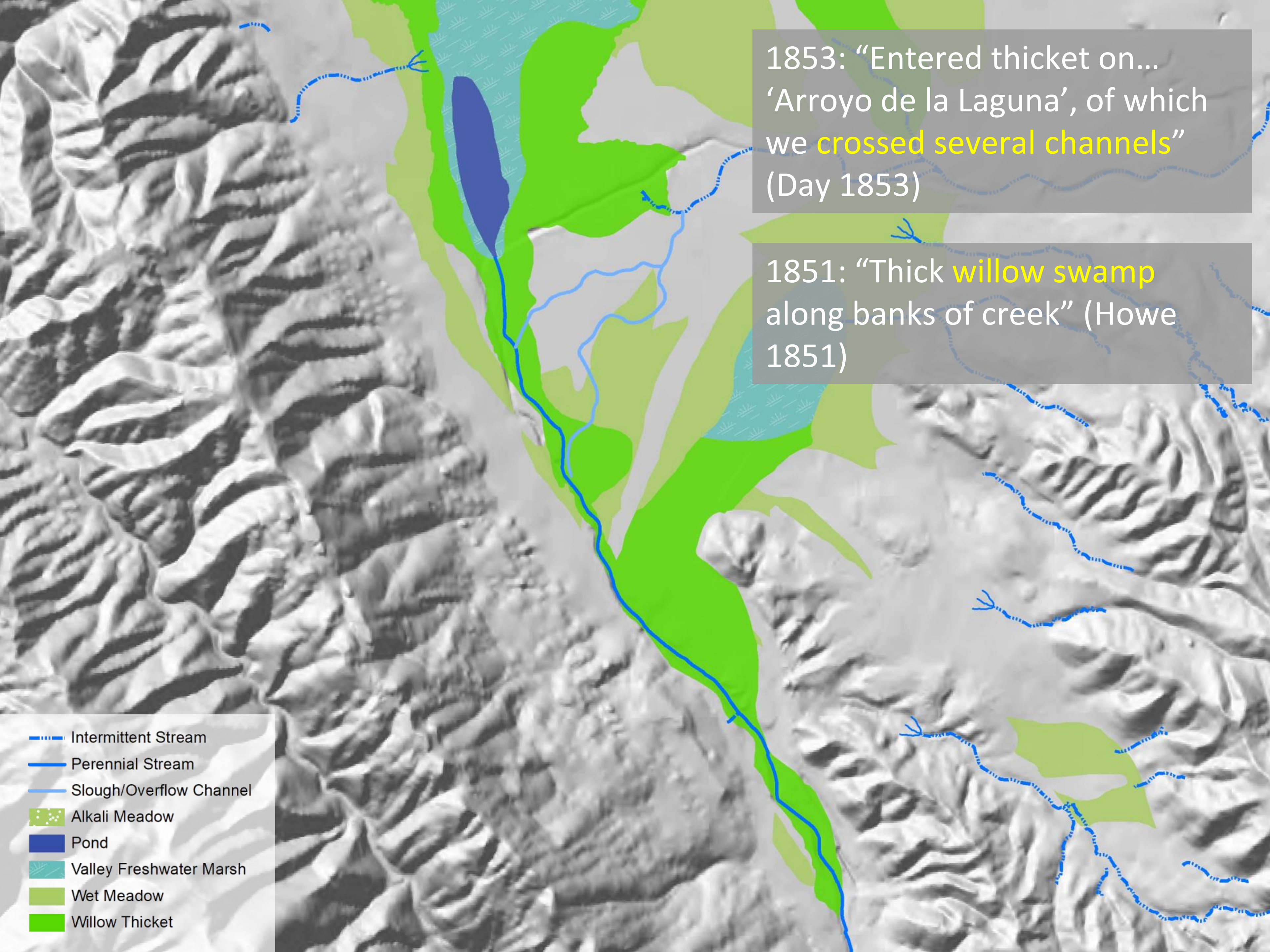
Image removed due to copyright restrictions

“Lagoon”

Allardt 1880
Courtesy of The Bancroft Library

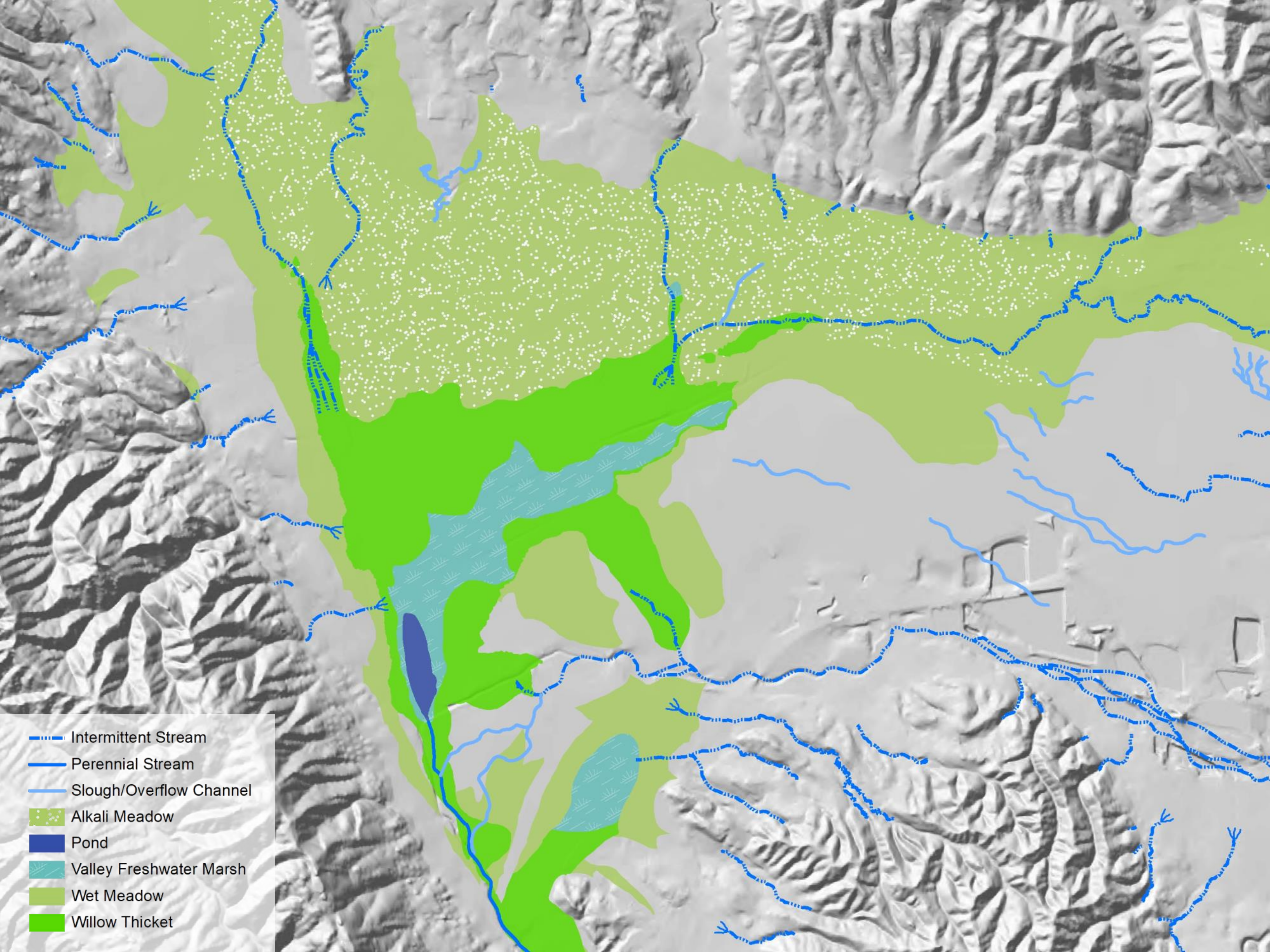


Alameda Creek Watershed early 1800s



1853: “Entered thicket on… ‘Arroyo de la Laguna’, of which we crossed several channels” (Day 1853)

1851: “Thick willow swamp along banks of creek” (Howe 1851)



Intermittent Stream
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Slough/Overflow Channel
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Valley Freshwater Marsh
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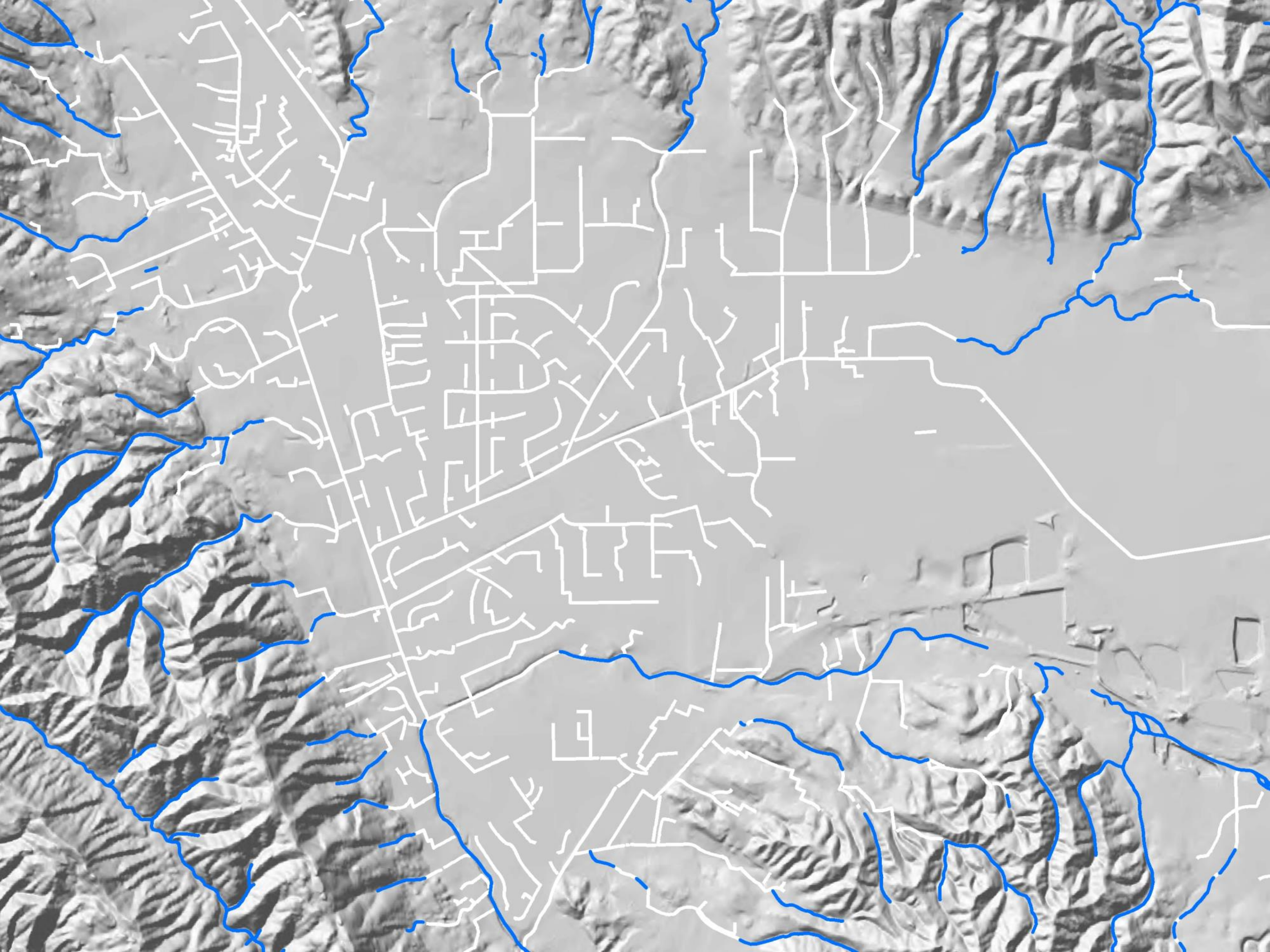
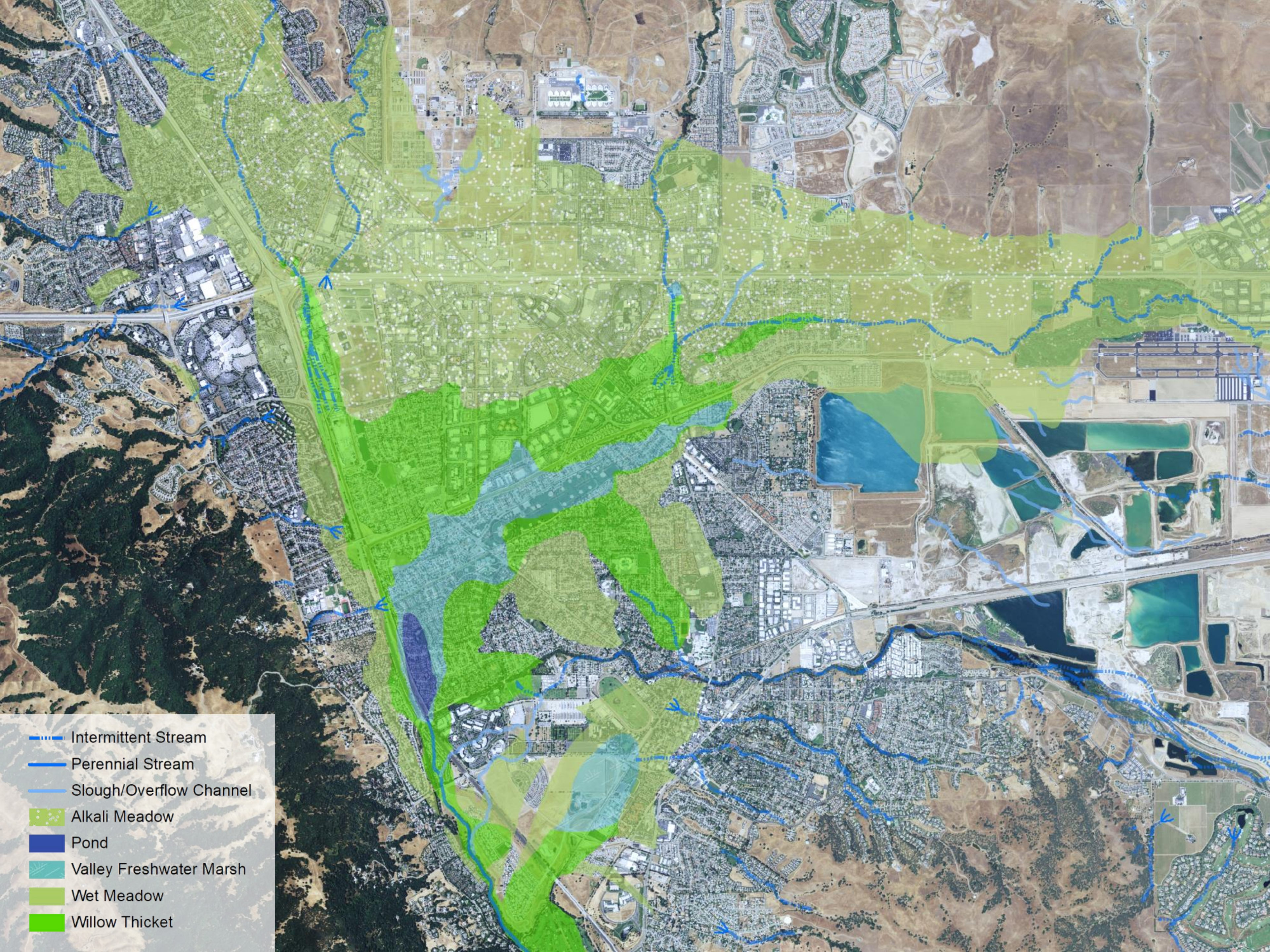
Willow Thicket





Intermittent Stream
Perennial Stream
Slough/Overflow Channel
Alkali Meadow
Pond
Valley Freshwater Marsh
Wet Meadow
Willow Thicket

Image removed due to copyright restrictions

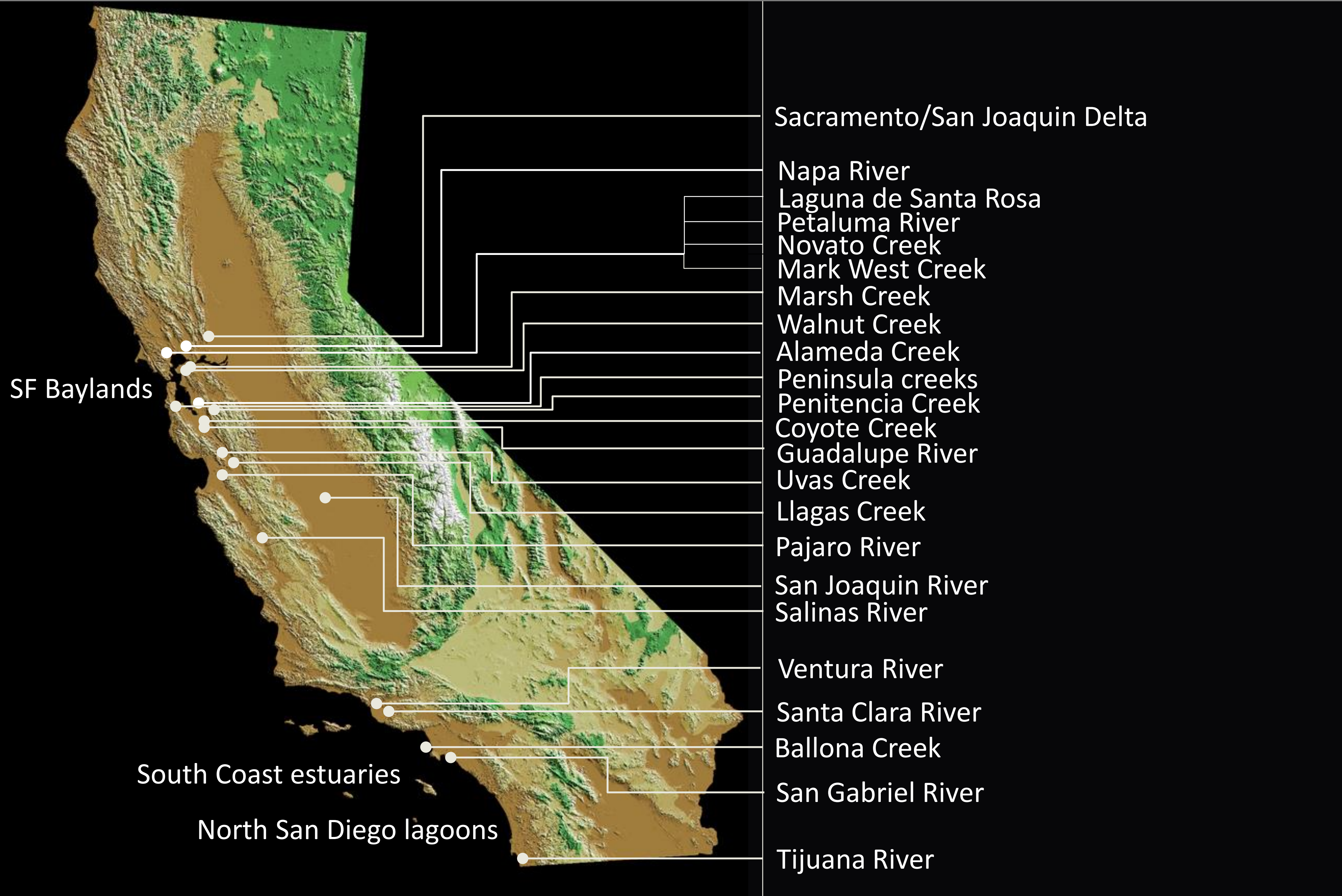
…the channel of the Laguna Creek, less than 30 years ago, followed a very **indefinite course** at a much higher elevation than at present…Since the clearing of Laguna channel the creek has worn its bed down at a rapid rate, the erosion having lowered the bed of this creek…**3 feet in 10 years**…

(Williams 1912)

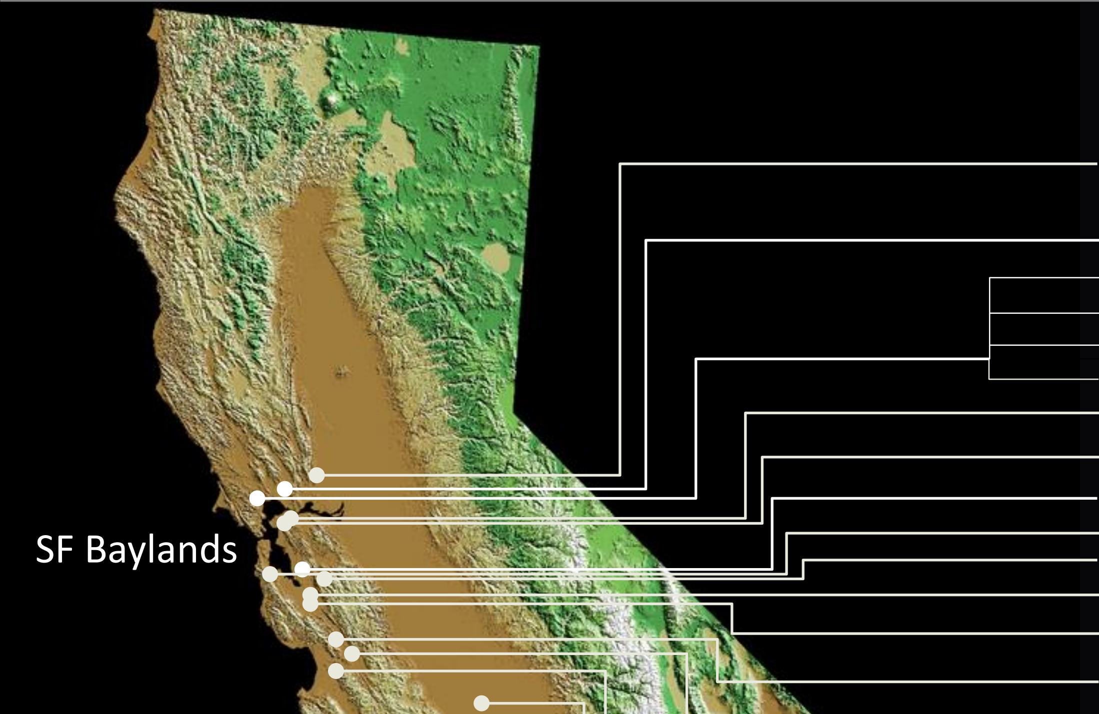
Photo by Julie Beagle

Photo by Julie Beagle

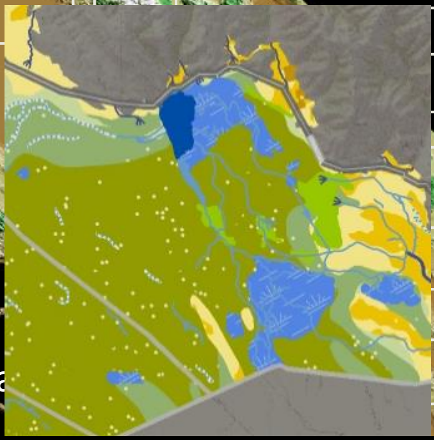
Historical Ecology Studies by SFEI and partners



Historical Ecology Studies by SFEI and partners



Llagas Creek



Pacheco Creek

Walnut Creek

San Joaquin River

Source: Google Earth

Summary

- Stage 0 part of diversity of California stream types historically
- Occupy particular low-gradient, high-groundwater settings
- Ecological oases; rare perennial wetland-slough mosaics; salmonid rearing, red-legged frog, neotropical migrants, waterfowl
- Many other ecosystem benefits: nutrient cycling, sediment storage, flood attenuation, etc
- Rapid conversion and homogenization to confined, single thread
- Not generally recognized as stream restoration opportunity and target

Thank You

seanb@sfei.org
www.sfei.org

Embracing Chaos Stage Zero Experience from the Sierra Foothills

Damion Ciotti and
Jared McKee

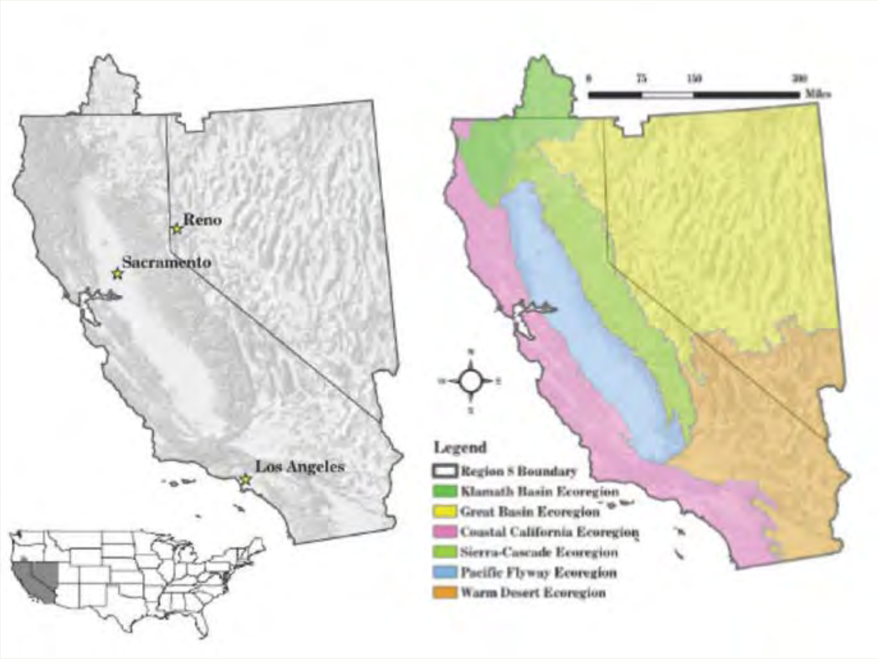
Audience Check-In

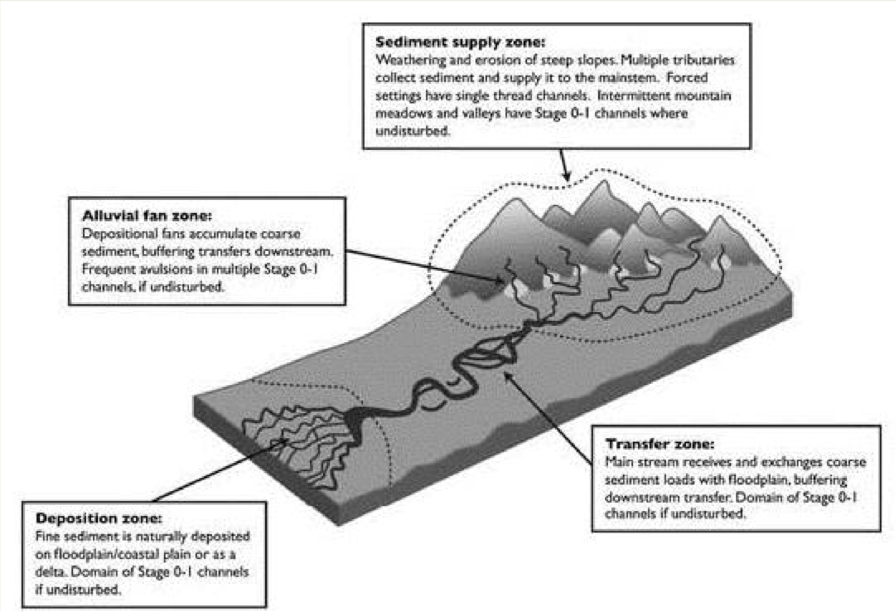
- What's your role in the restoration world?
  - Permitter, Funder, Researcher, Land Manager, Restoration Practitioner?
- Do the projects you are seeing meet the stated goals?
- Does the current pace and scale of restoration match the needs?
- Will resources for restoration go up or down in the future?

Partners for Fish and Wildlife Program

Mission Statement

"working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American People"





Cluer , Thorne. 2012.

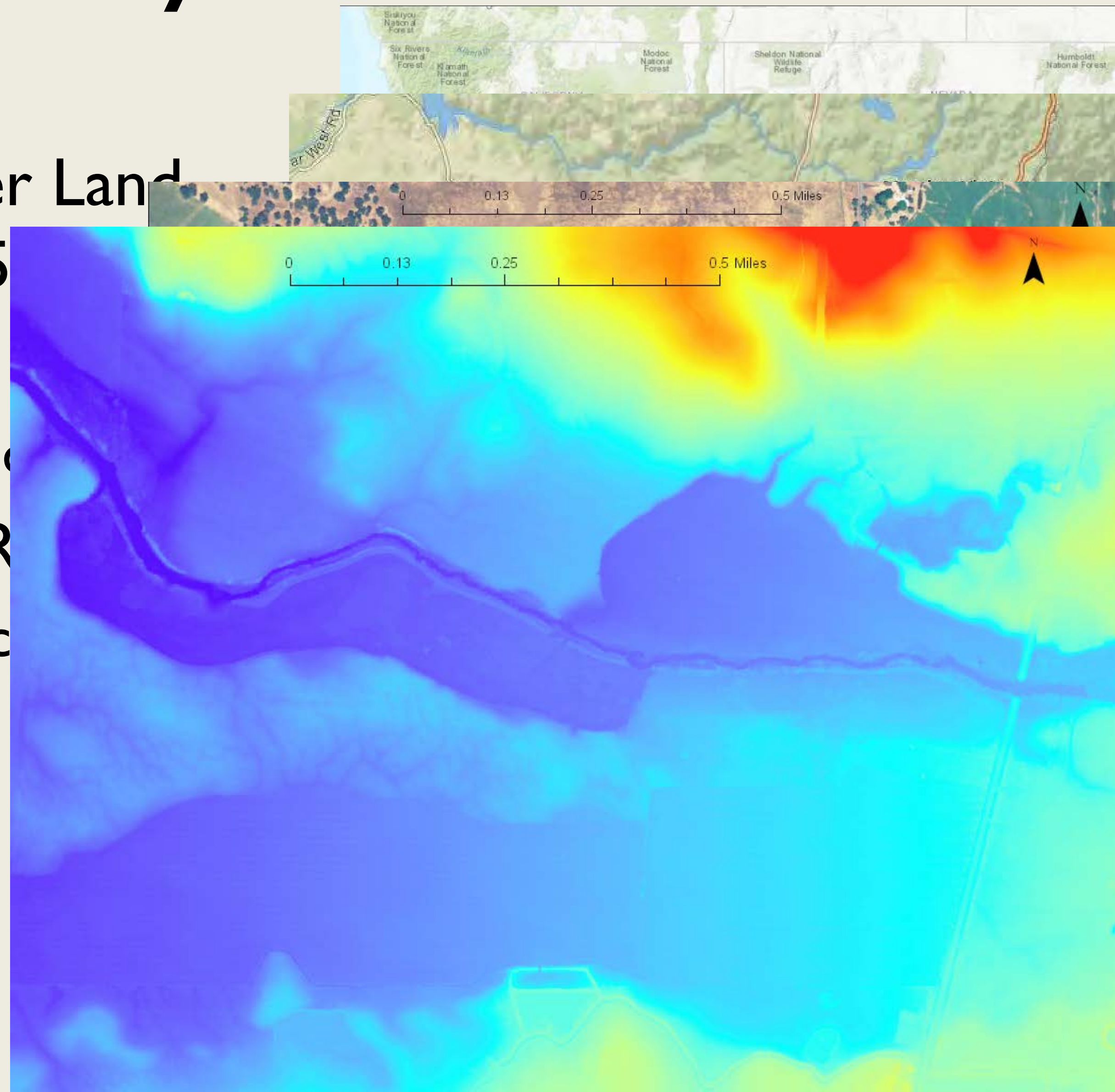
U.S. Fish and Wildlife Service Partners for Fish & Wildlife

U.S. FISH & WILDLIFE SERVICE

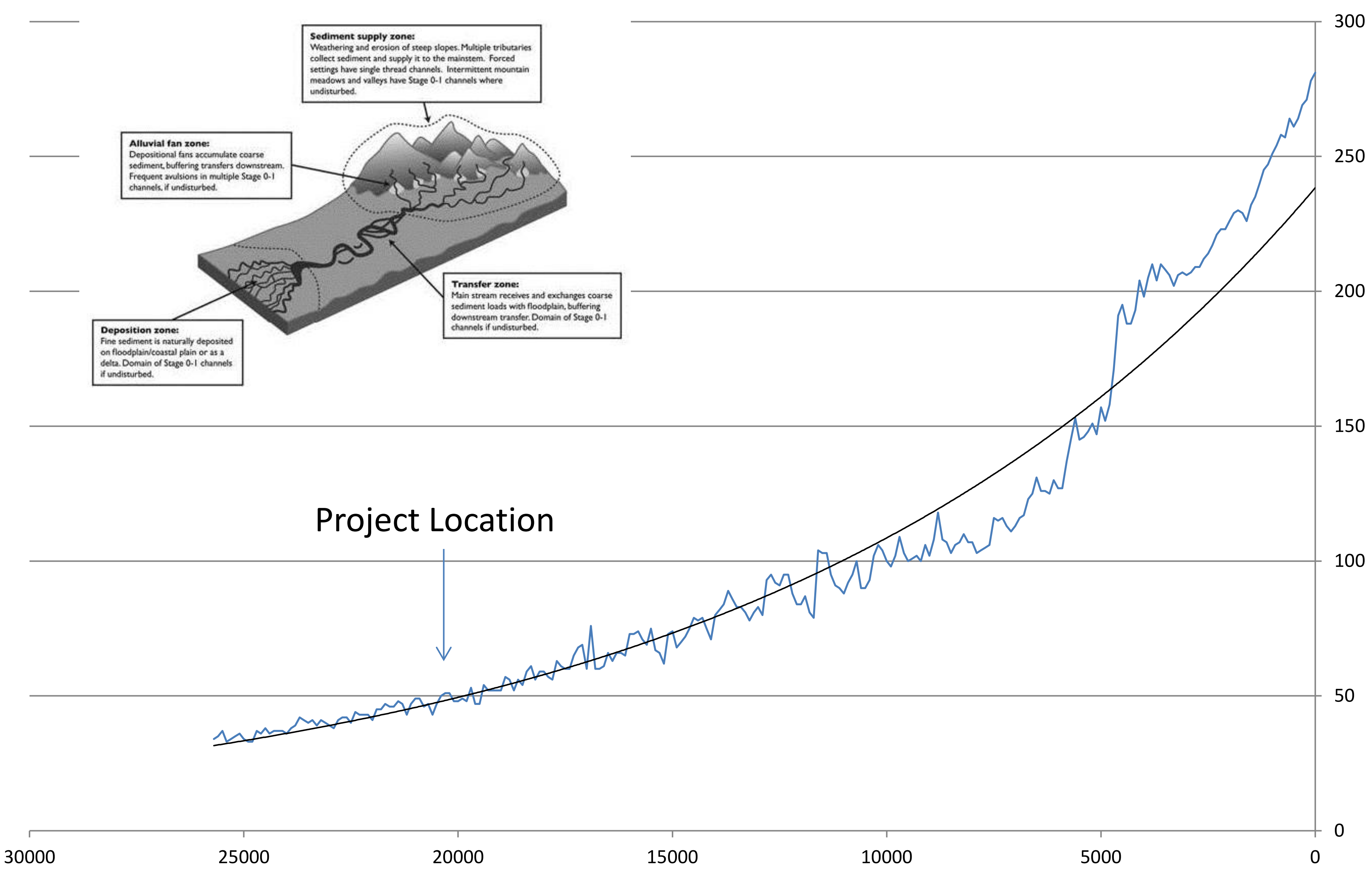
Since 1990 - 62,000 acres of voluntary wetland and wildlife habitat restoration

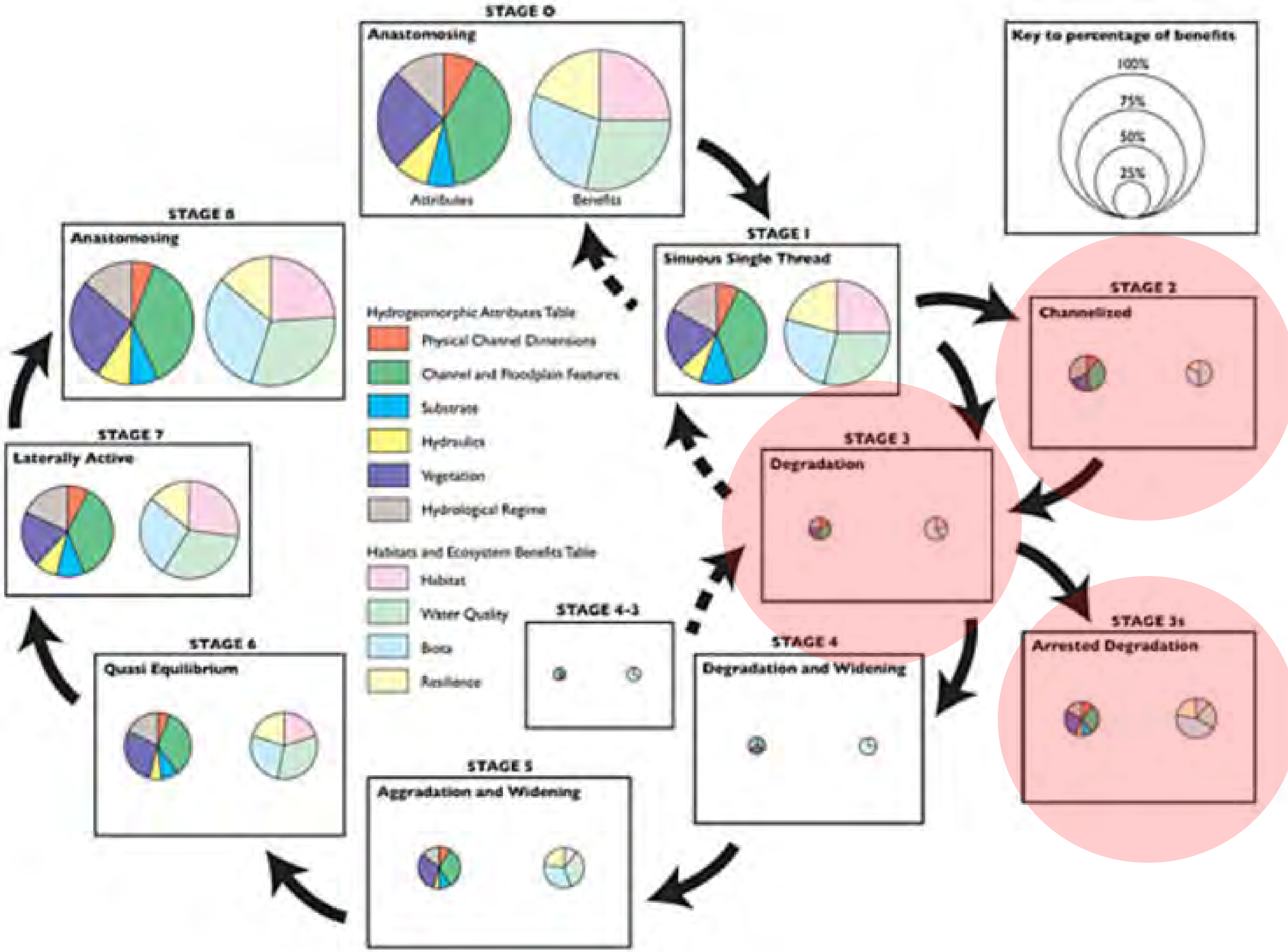
Doty Ravine

- Fast Facts
  - Owned by Placer Land
    Trust since 2005
  - 427 acres total
    - 55 acres of flooc
  - 1 mile of Doty R
    - Steelhead Critic



Watershed Long Pro




STAGE 0
Anastomosing
Attributes
Benefits
Key to percentage of benefits
100%
75%
50%
25%
STAGE 8
Anastomosing
STAGE 1
Sinuous Single Thread
STAGE 2
Channelized
Hydrogeomorphic Attributes Table
Physical Channel Dimensions
Channel and Floodplain Features
Substrate
Hydraulics
Vegetation
Hydrological Regime
STAGE 7
Laterally Active
STAGE 3
Degradation
Habitats and Ecosystem Benefits Table
Habitat
Water Quality
Biota
Resilience
STAGE 4-3
STAGE 3s
Arrested Degradation
STAGE 6
Quasi Equilibrium
STAGE 4
Degradation and Widening
STAGE 5
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Foundational Goal – Restore fluvial processes that create and maintain dynamic, complex, high quality habitat

- *Improve and increase instream habitat for native aquatic fauna*
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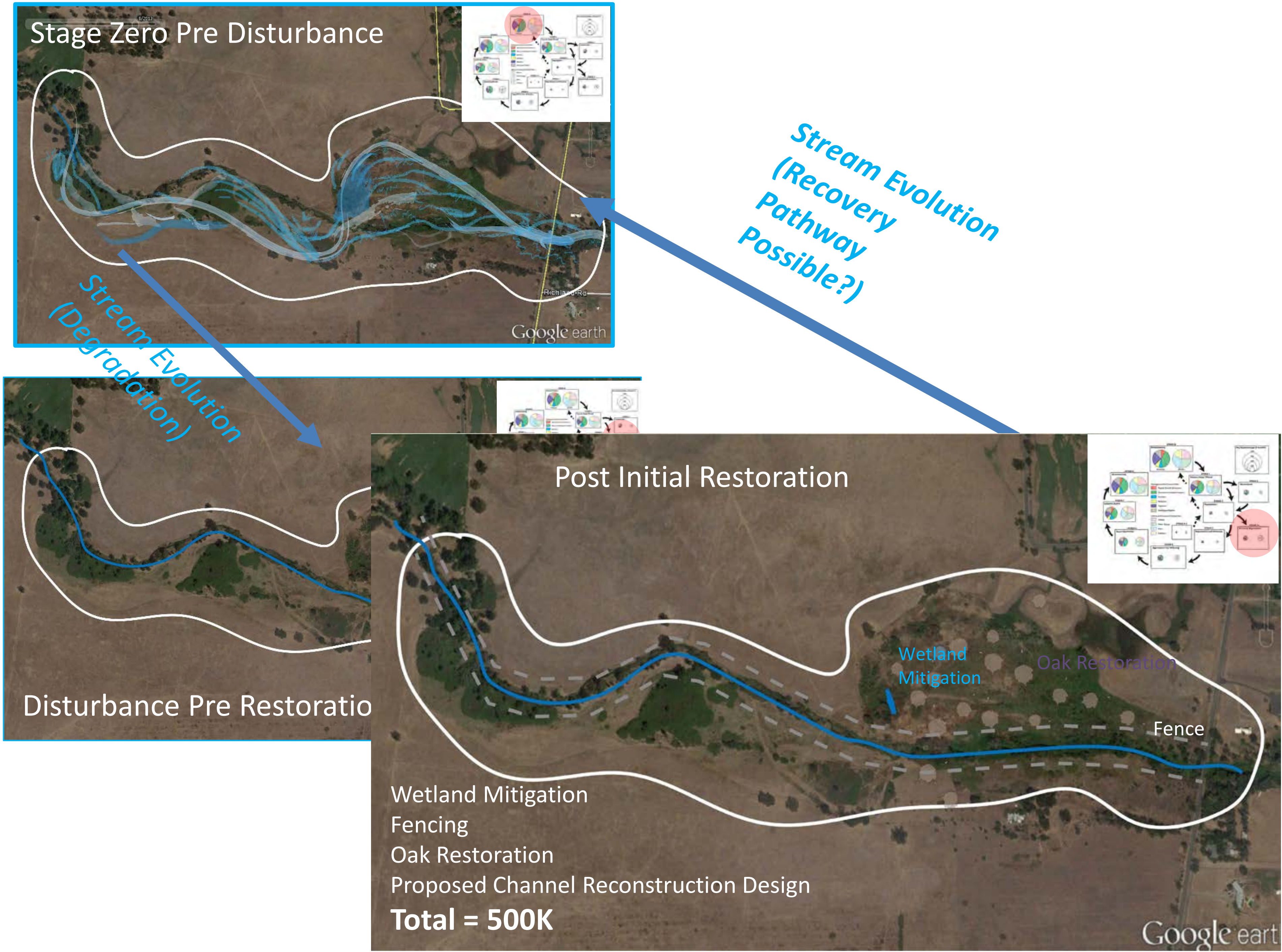
- *Integrate active livestock operation within restoration plan*

Restoration Actions

- Wetland Mitigation
- Riparian Planting / Oak Planting
- Riparian Fencing and Off Stream Water Structures


Stage Zero Pre Disturbance
Stream Evolution (Recovery Pathway Possible?)
Stream Evolution (Degradation)
Disturbance Pre Restoratio
Post Initial Restoration
Wetland Mitigation
Oak Restoration
Fence
Wetland Mitigation
Fencing
Oak Restoration
Proposed Channel Reconstruction Design
Total = 500K
Google earth

Aerial Time Series 2003 - 2013

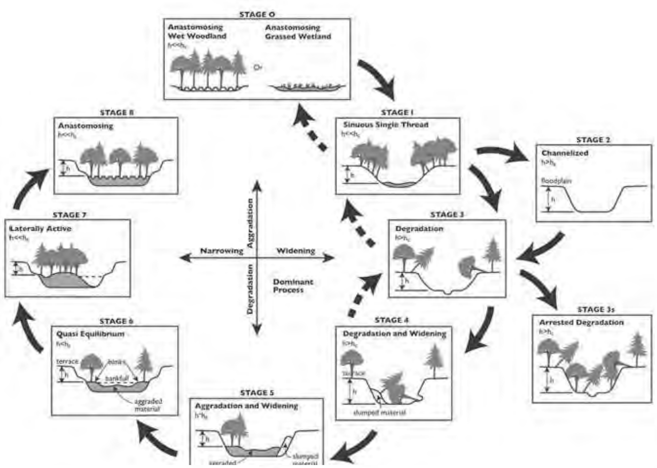
Were our goals realized?

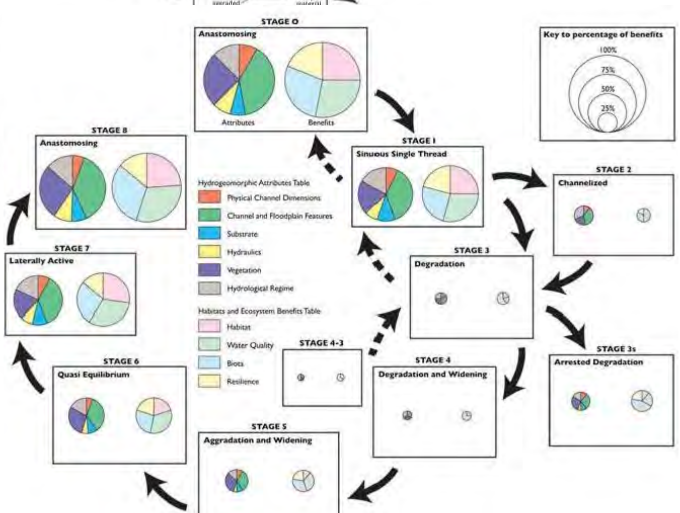
- Improve and increase instream habitat for native aquatic fauna
- Improve and increase riparian habitat
- Increase stream length and complexity of channelized and leveed Doty Ravine

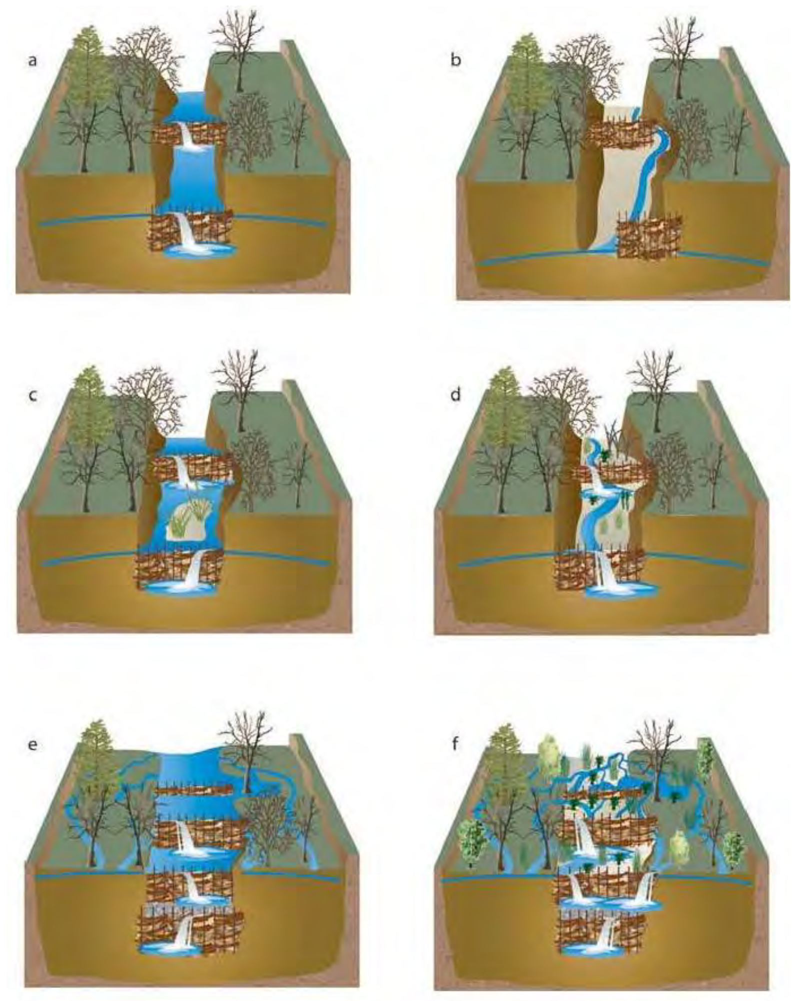
- Integrate active livestock operation within restoration plan
- Increase groundwater recharge
- Control invasive plant species

And then 2014 happened

- Cluer and Thorne - A Stream Evolution Model Integrating Habitat and Ecosystem Benefits
- Pollack et al. - Using Beaver Dams to Restore Incised Stream Ecosystems







Plus what we were already thinking about

Palmer 2005: "Standards"

1. A <u>dynamic ecological endpoint</u> is initially identified and used to guide the restoration.
2. The ecological conditions of the stream are measurably improved.
3. Through <u>the use of natural fluvial and ecological processes</u>, the restored stream must be more self-sustaining and resilient to perturbations than pre-restoration conditions, so that minimal maintenance is needed.
4. The implementation of the restoration <u>does not inflict lasting harm</u>.
5. Pre- and post-project assessments are completed and the data are made publically available so that the restoration community as a whole can benefit from knowledge learned.

Beechie 2010: "Principles"

1. Restoration actions should <u>address the root causes of degradation</u>
2. Actions must be consistent with the physical and biological potential of the site
3. Actions should be at a scale commensurate with environmental problems
4. Actions should have clearly articulated outcomes for <u>dynamics</u>

Problem with Ecological Restoration standards

- somewhat subjective
- many designers funders and regulators don't understand ecological science or how to apply ecological science to on the ground management and design of fluvial systems

Current standard is to apply engineering/construction criteria such as deformability and stabilization, threshold channel design, "Natural" Channel design

Limited guidance for integrating ecological science with design.

We propose at least 2 Criteria that provide a vehicle for transferring 20 years of ecological science into restoration practice:

Maximum Space and Zero Energy Design Criteria

encourage practitioners to:

1. *Open space for fluvial process*
2. *Use stream energy to do geomorphic work*

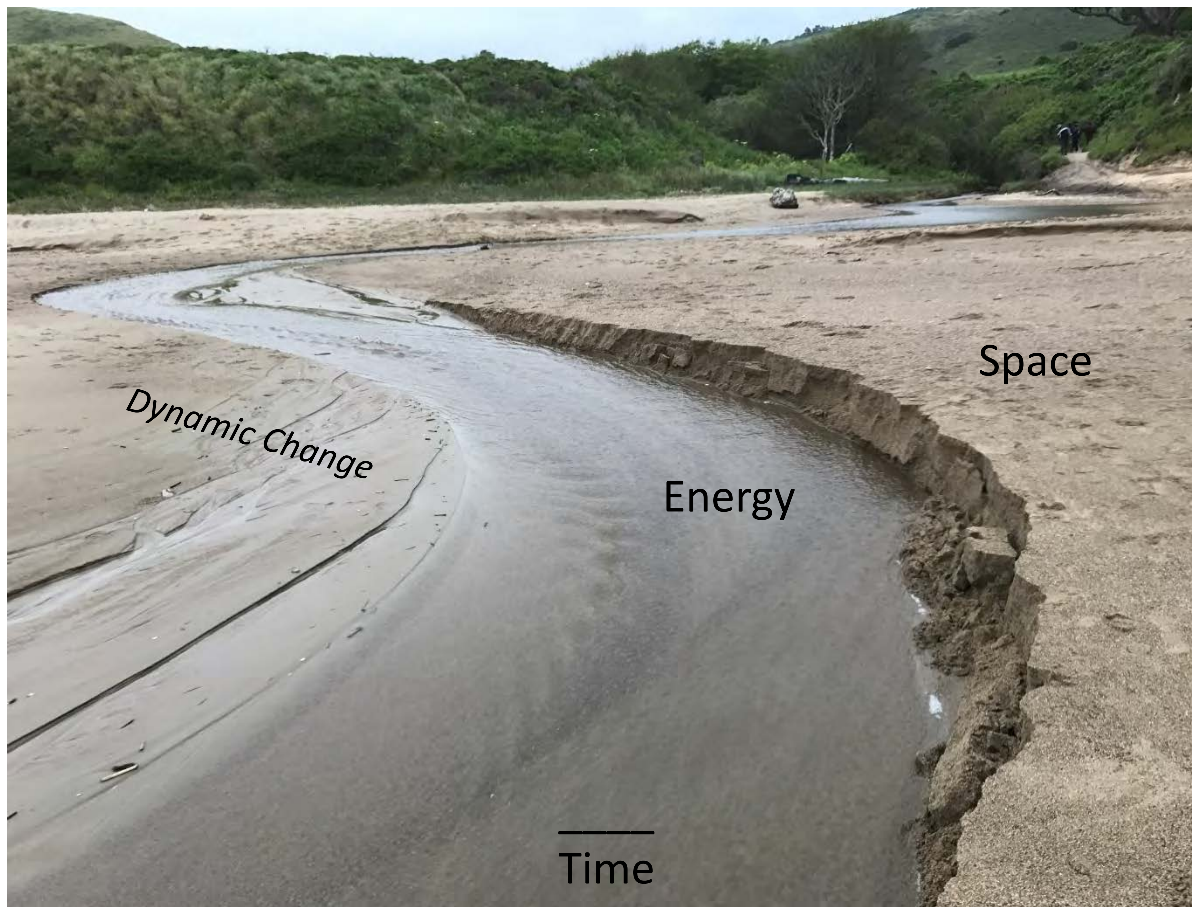
Ecologically based design criteria for low gradient alluvial stream and river systems

MAX SPACE Performance based criteria (What is the project to achieve?):

1. Maximize space for fluvial energy (Does the action increase or decrease space for habitat forming energy to operate?)
2. Reconnect fluvial energy with open space (Channel migration space and source sediment and energy connections)

ZERO ENERGY (MAX STREAM ENERGY) Prescriptive Based Criteria (How will the project be undertaken?):

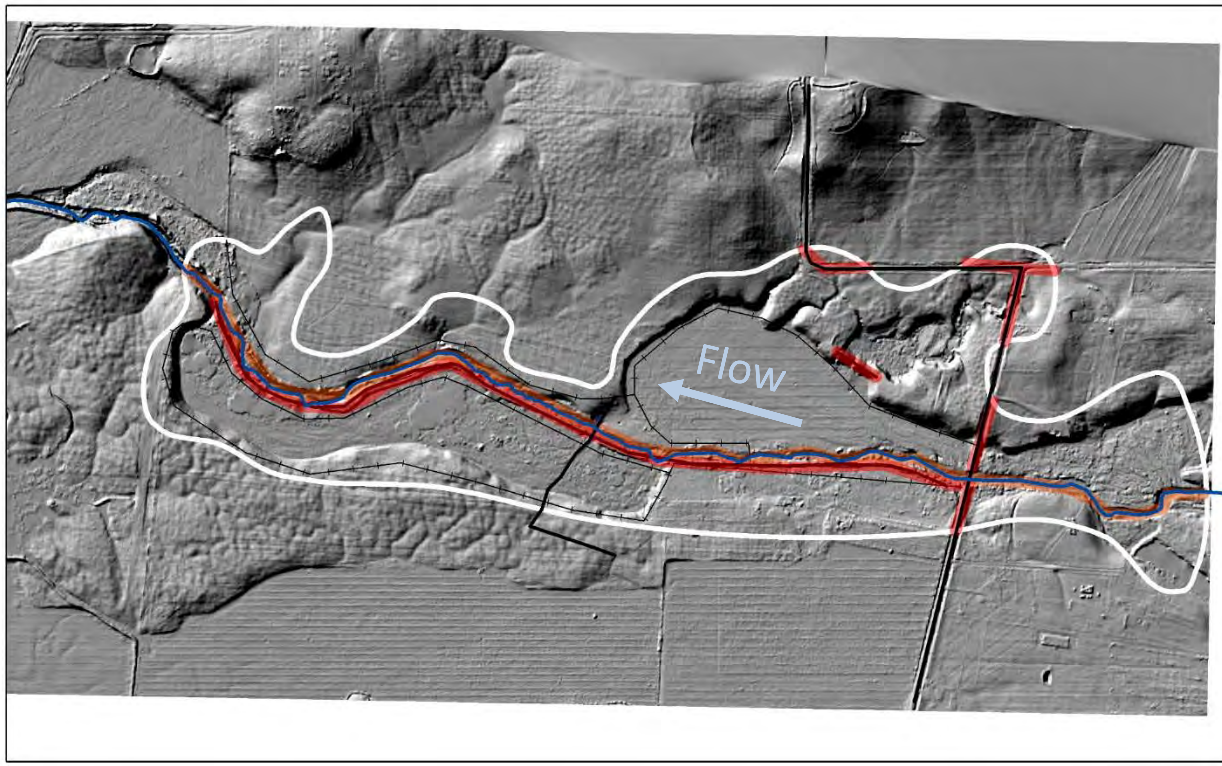
1. Maximize use of stream energy to do geomorphic work
2. Minimize diesel energy inputs unless modifying infrastructure
3. Use geomorphically appropriate material to create hydraulic resistance



#1 Criteria SPACE

Design process that leads to actions that increase space for habitat forming energy to operate.

- Delineate an area Stream Evolution Corridor (SEC)
- Management unit where you try to restore fluvial energy and sediment conveyance that will
- Creates and maintains habitat over the long term



SEC is already in the literature…. Kind of

Design focused on removing infrastructure and management constraints to dynamic system is in the literature
Erodible Corridor Concept, Process Zone, “Channel Migration Zone” River Styles, Restore Eco-geomorphic Process (Pollock et al 2014)

Vs

“Natural” Channel Design focused on stabilizing system around arbitrary boundaries or old infrastructure is most commonly used
Rosgen or common stream or river engineering practices

IMPORTANT to do it up front and have stakeholder agreement on it

Criteria 1: Maximum Space

Ecological design is removing system constraints so fluvial energy can expand, create, and maintain habitat

1. What is the natural extent of fluvial dynamic space?
2. What is the current extent of dynamic fluvial space?
3. What are the anthropogenic impacts to fluvial dynamics?
4. What modifications can be made to infrastructure and management to expand fluvial space now or in the future?

Answering these questions gets at source problems and ecosystem scale restoration instead of addressing site specific symptoms

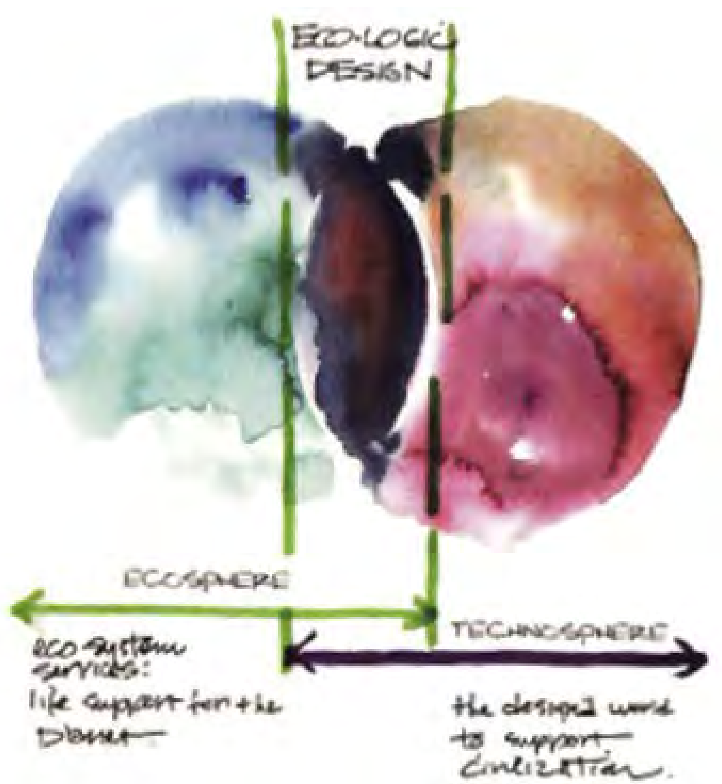
Fundamental questions for stream design but rarely analyzed and presented to stakeholders

Criteria 2: ZERO ENERGY

Prescriptive Based

Tells practitioner HOW they have to implement project and ensures ecological approach

1. "Net Zero Energy" Maximize use of stream energy for meeting form objective (aim for C neutral) unless you are modifying infrastructure
2. Use geomorphically appropriate material (Pollock et al 2003, 2007, 2012; Manga and Kirchner 2000)



This criteria is well established in Green Architecture

Ecological Design is strongly rooted in Architecture

Ecological design – *"any form of design that minimizes environmentally destructive impacts by integrating itself with living processes"*

Sim Van der Ryn
Architect/Ecologist

ZERO ENERGY Criteria Borrowing from Eco Architectural Design

Eco Architecture

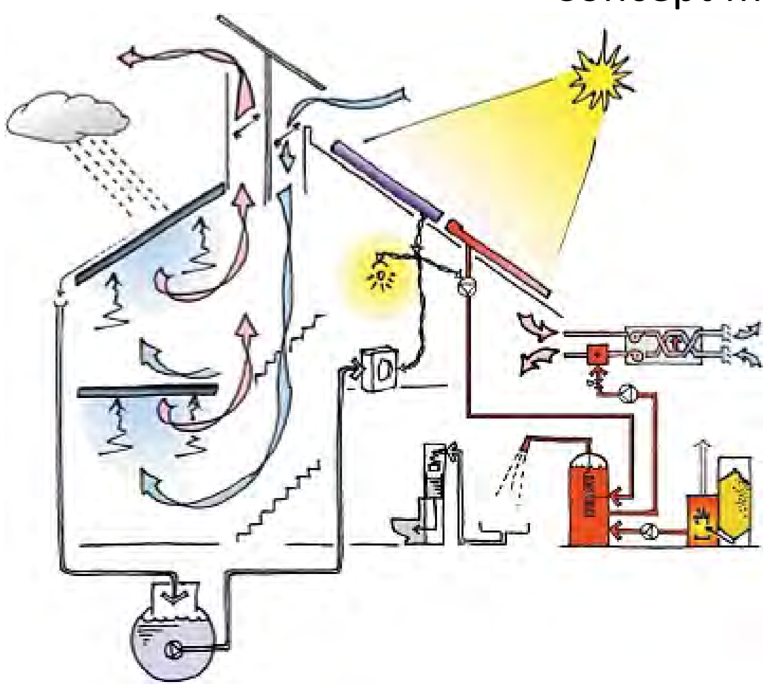
1. Focus on energy available (solar and wind) to meet heating, cooling and space objectives over time
2. Design optimizes passive strategies
3. Situate house to maximize energy need

Eco stream design

1. Focus on Stream energy hillslope/channel gradients, discharge and sediment supply to meet form and habitat objectives over time
2. Design should optimize passive strategies
3. Modify infrastructure to maximize stream energy need

Concept models on Energy Flow

Home vs SEC



Do we want anthropogenic habitat or naturally formed habitat?

If we construct in this space we take away space for Natural process formation and again we lower the return on our investment and risk further degrading to natural processes.

"Rosgen" channel vs Stage Zero channel

Hint – Embrace the Chaos


Lat, Lon: 41.195302, -121.719335
Alt: 3990ft MSL WGS84
CEP: 10ft
-30°
-15°
0°
-1.0°
-10.2°
-5°
NE
E

Criteria #2 Maximize Stream Energy Minimize Fossil Fuel Input

When working in the stream channel this prescriptive criteria places bounds on how the practitioner can work and requires them to:

Exhaust all stream energy before using diesel energy

- Doesn’t apply to infrastructure modification
- Reduces habitat disturbance
- Requires practitioner to build habitat using prevailing sediment and energy
- Very low risk of constructing forms that are overwhelmed or non compatible with system dynamic or scale

1. **Opening dynamic fluvial space is low risk**
2. **Using stream energy to meet form objective is low risk**

Project Risk Screening Matrix 2011

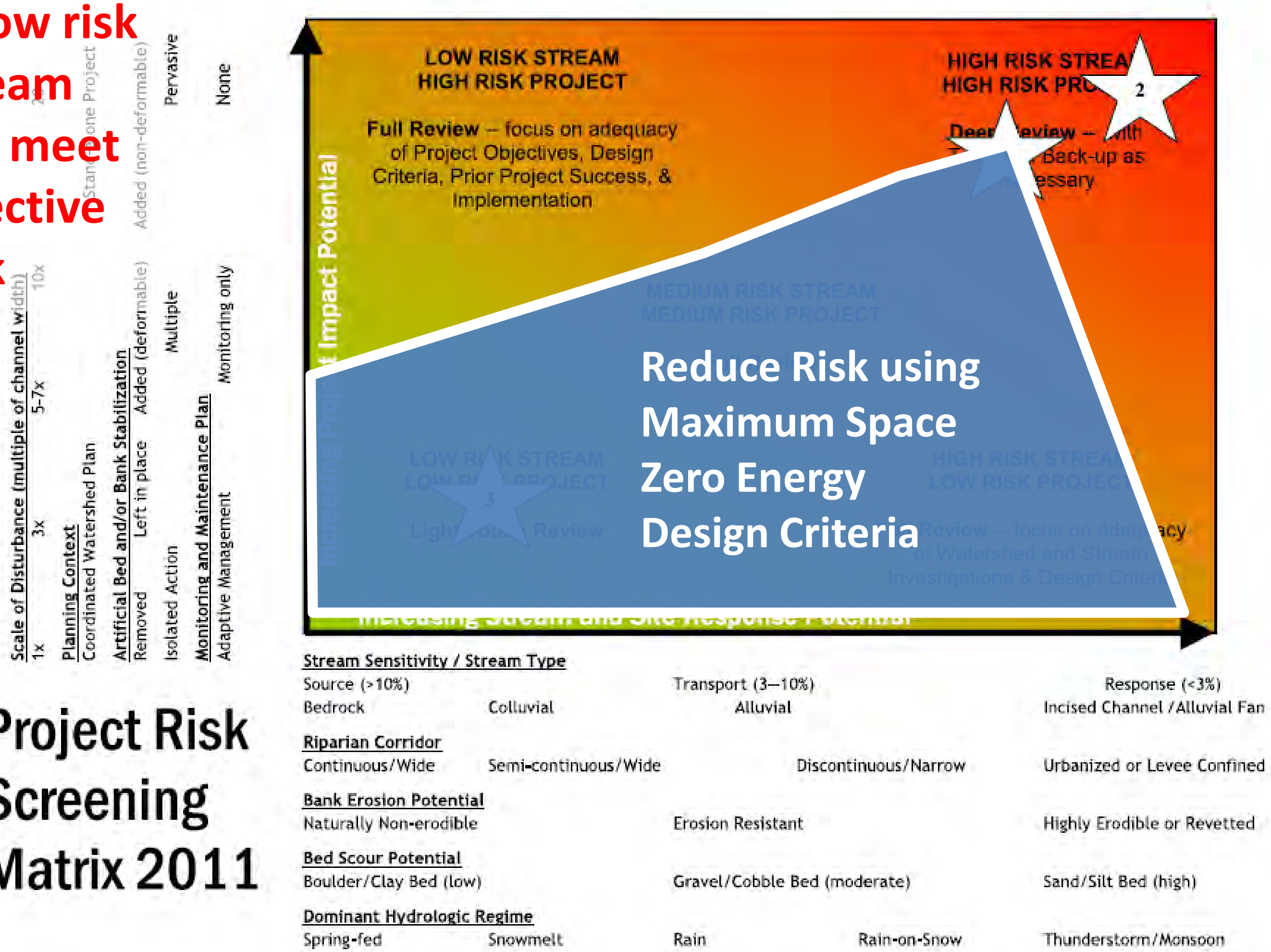


Figure 7. 2011 matrix with three example proposals for restoration projects plotted in their appropriate review categories based on evaluation of risks to aquatic species and in-stream habitat: 1. culvert replacement, 2. channel construction and 3. large wood placement. This figure is available in colour online at wileyonlinelibrary.com/journal/rra

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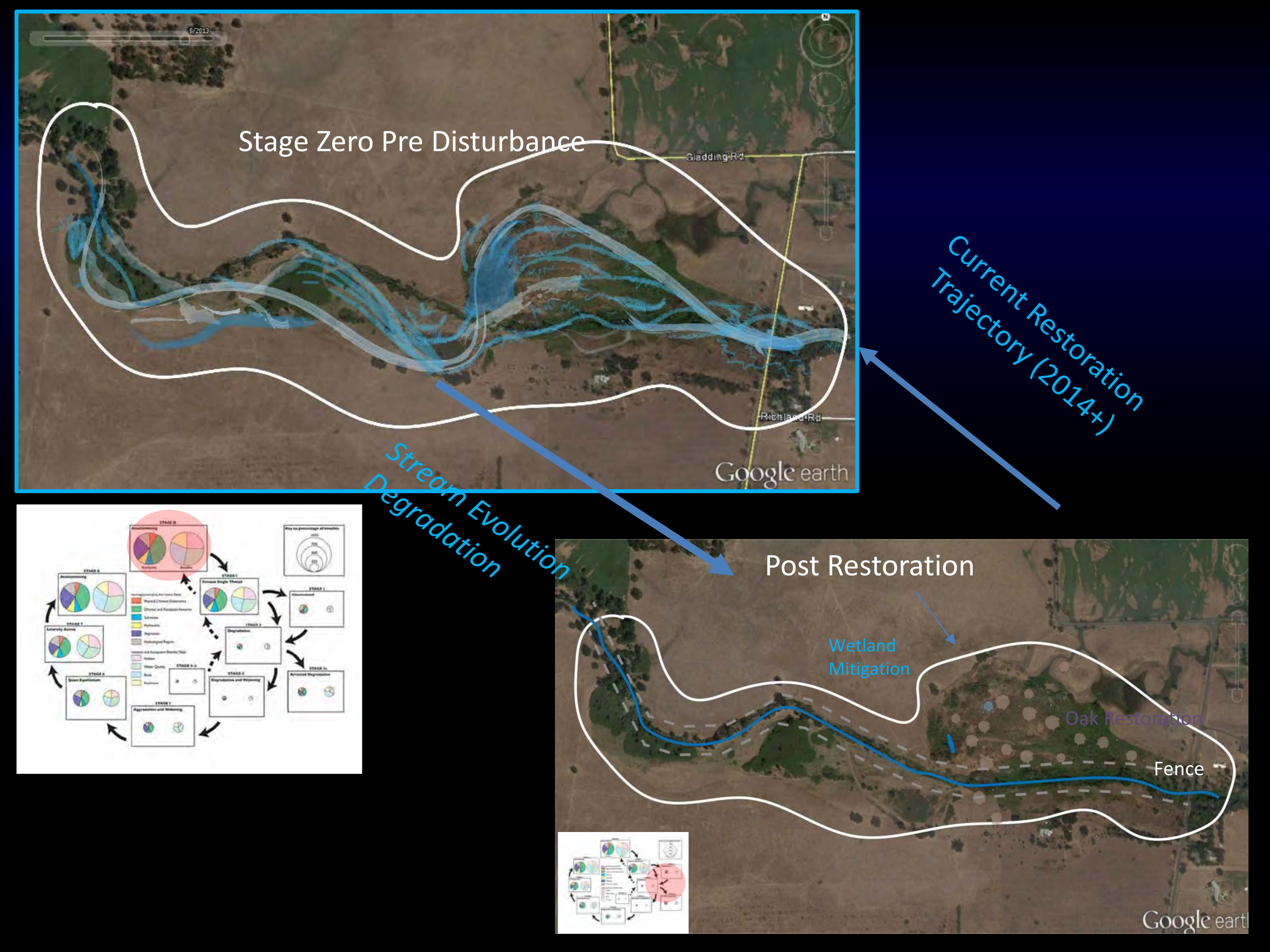
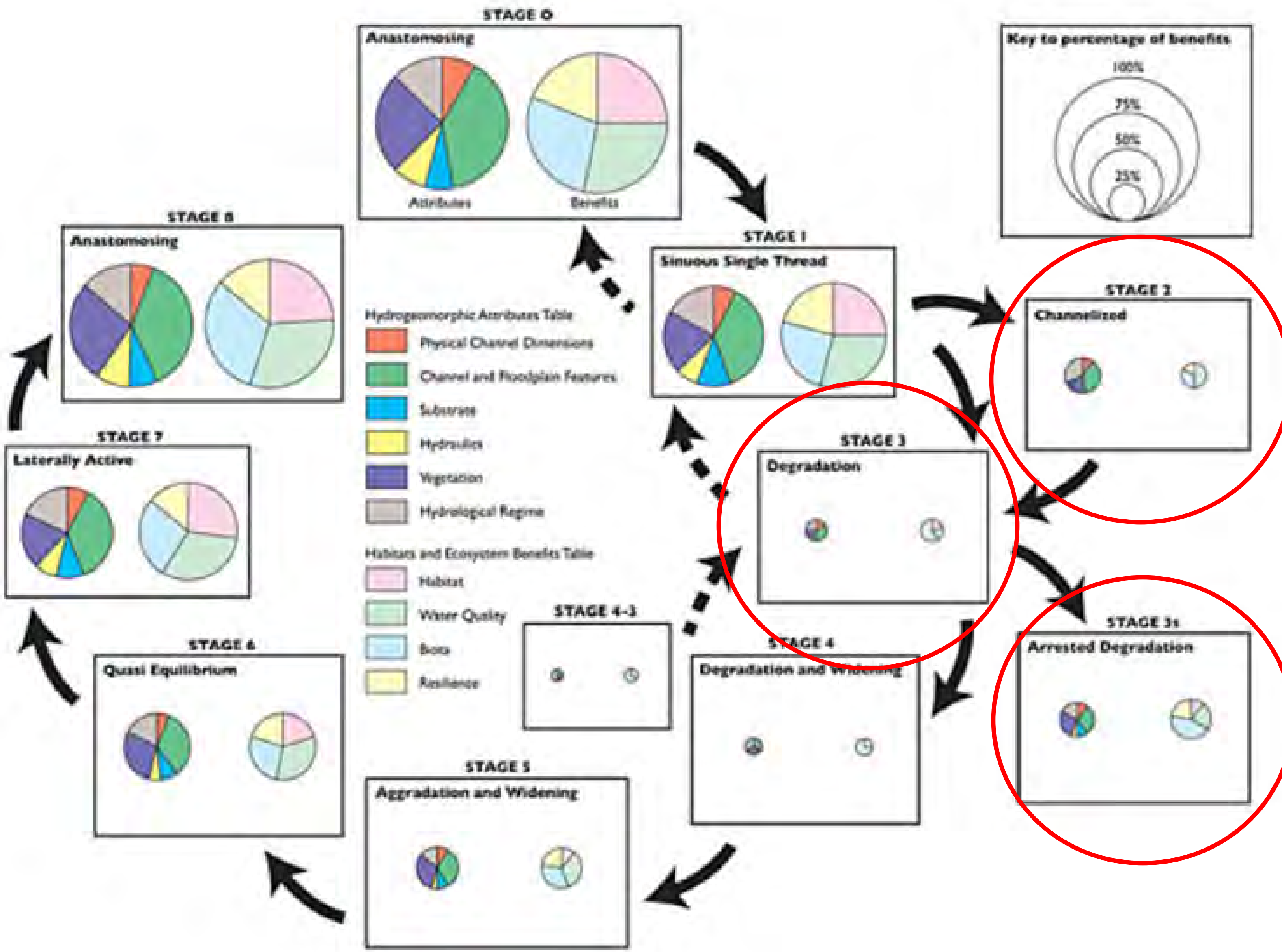


Stage Zero Pre Disturbance
Gladding Rd
Richland Rd
Google earth
Current Restoration Trajectory (2014+)
Stream Evolution Degradation
Post Restoration
Wetland Mitigation
Oak Restoration
Fence



STAGE 0
Anastomosing
Attributes
Benefits
Key to percentage of benefits
100%
75%
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Channelized
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Substrate
Hydraulics
Vegetation
Hydrological Regime
Habitats and Ecosystem Benefits Table
Habitat
Water Quality
Biota
Resilience

Restoration Actions

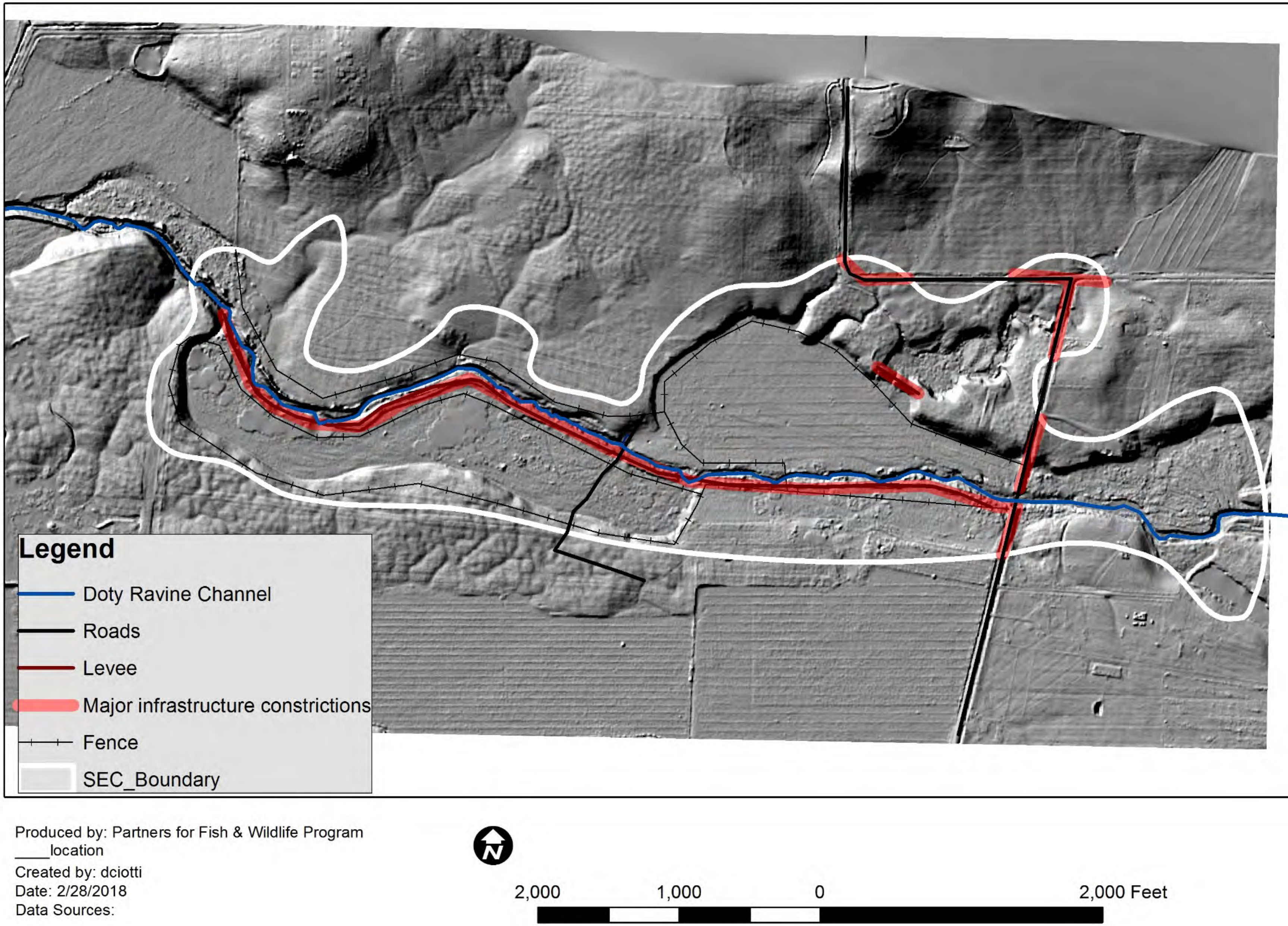
- ~~Wetland Mitigation~~
- ~~Riparian Planting / Oak Planting~~
- ~~Riparian Fencing and Off stream Water Structures~~
- Beaver Peace Treaty
- Levee Removal
- Beaver Dam Support and Beaver Dam Analogues
- Constriction Dam – Tree Blaster – Complex Small Wood Jams

U. S. Fish & Wildlife Service

_____Office Name ____

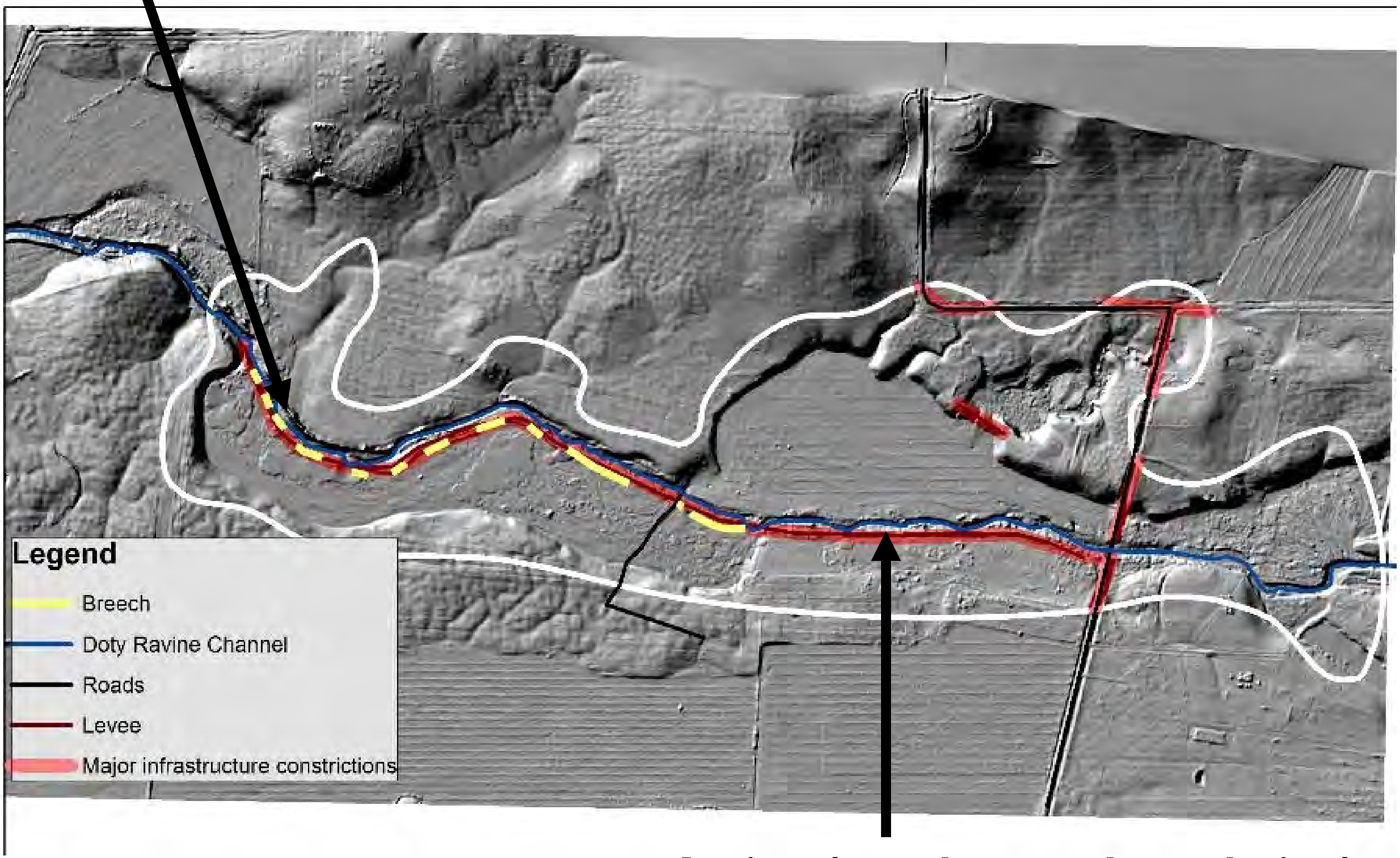
________ County, California

Doty Ravine Stream Evolution Corridor (SEC) Constrictions



Produced by: Partners for Fish & Wildlife Program
____location
Created by: dciotti
Date: 2/28/2018
Data Sources:

Action (levee Breach)
Opens SEC space



Action (stop beaver depredation)
Reconnects SEC space with stream energy

Levee breaching will be about 40K
Redo fencing 20K
BDAs 5K

Beaver Dam Support

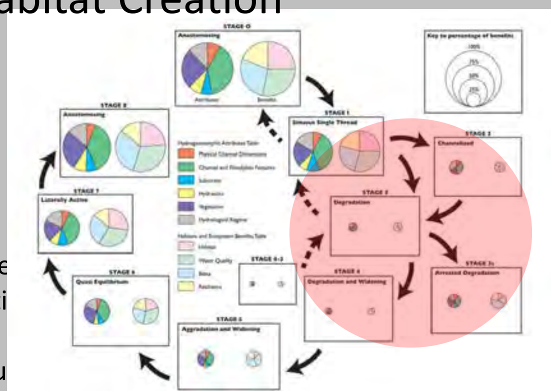
Beaver Dam Analogue

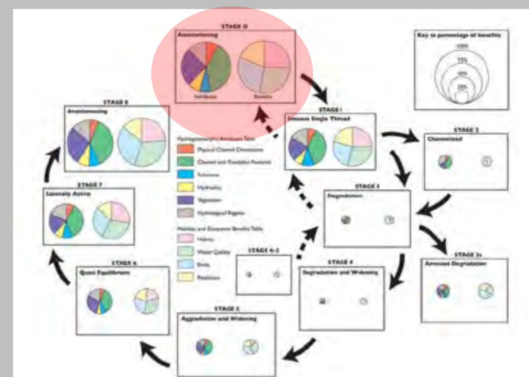
Constriction Dam

Accelerate Process –widening and tree recruitment using stream energy

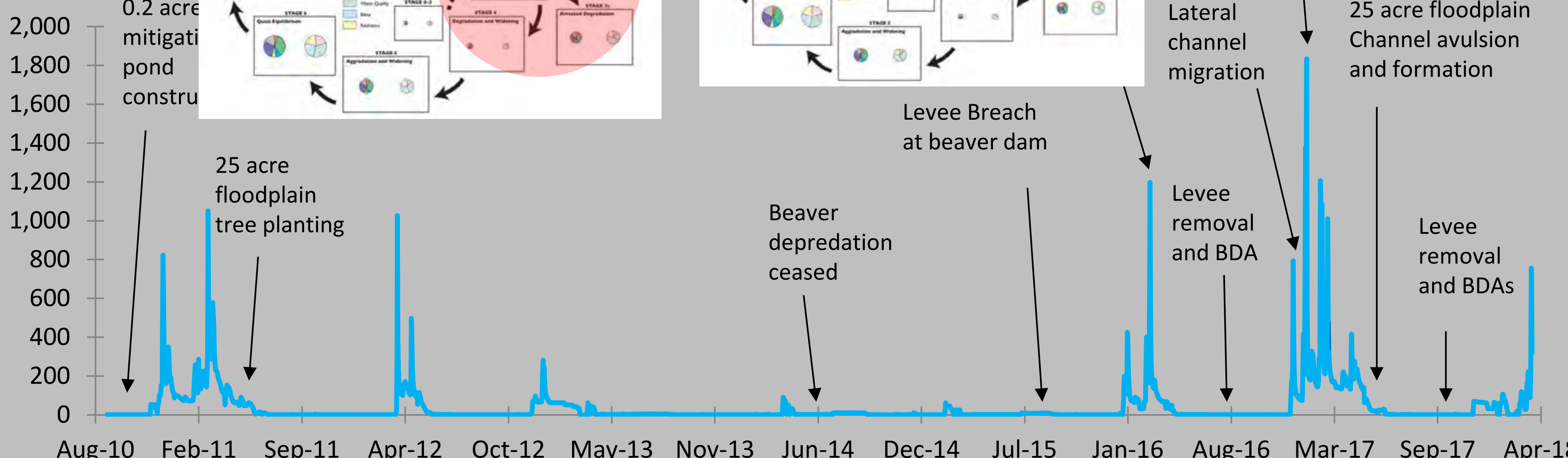
Gauging system recovery to stage zero

Habitat Creation





Habitat Restoration



Aerial Time Series 2014 – 2018

Before / After

Before / After

Stage Zero Area

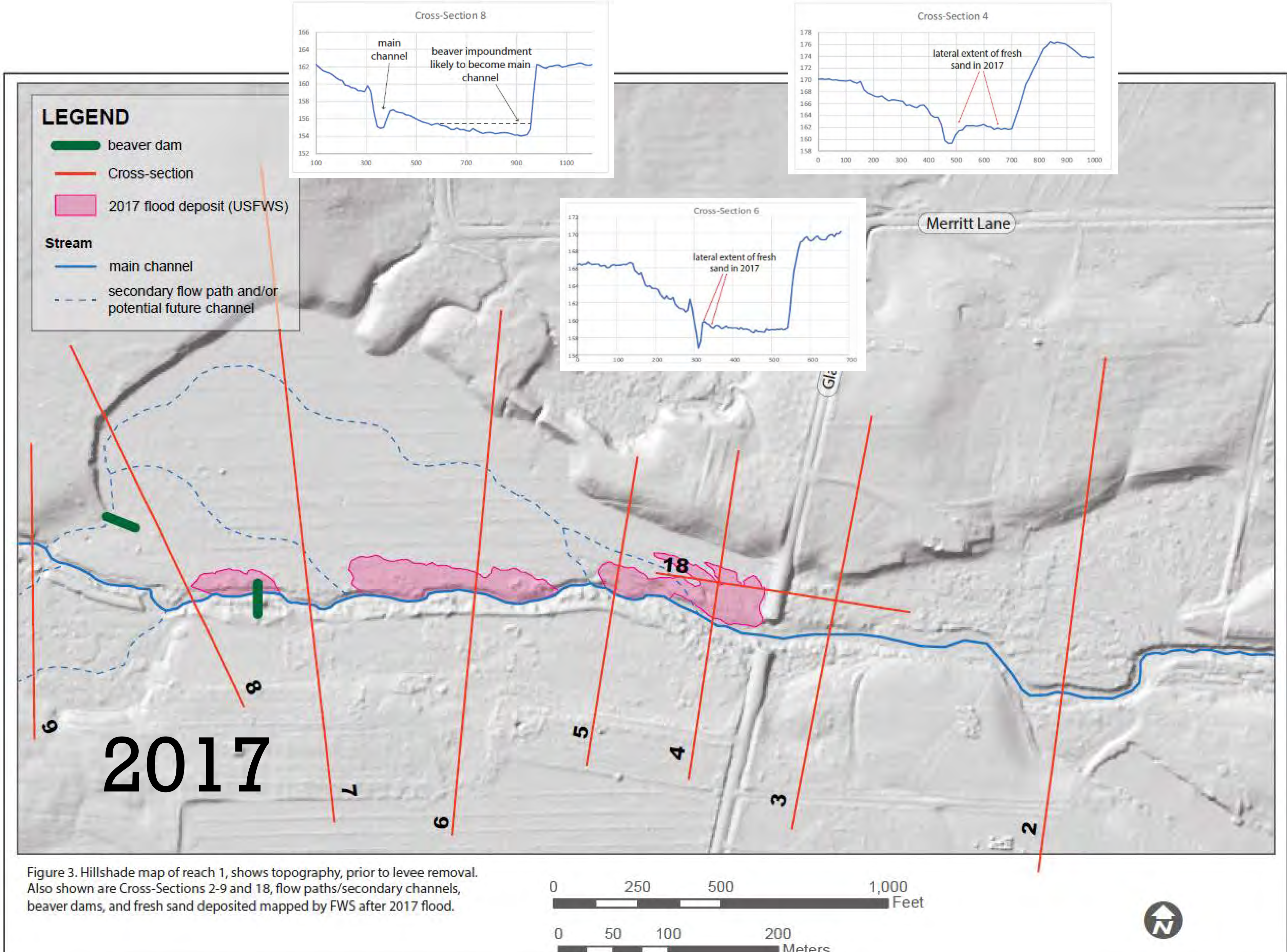
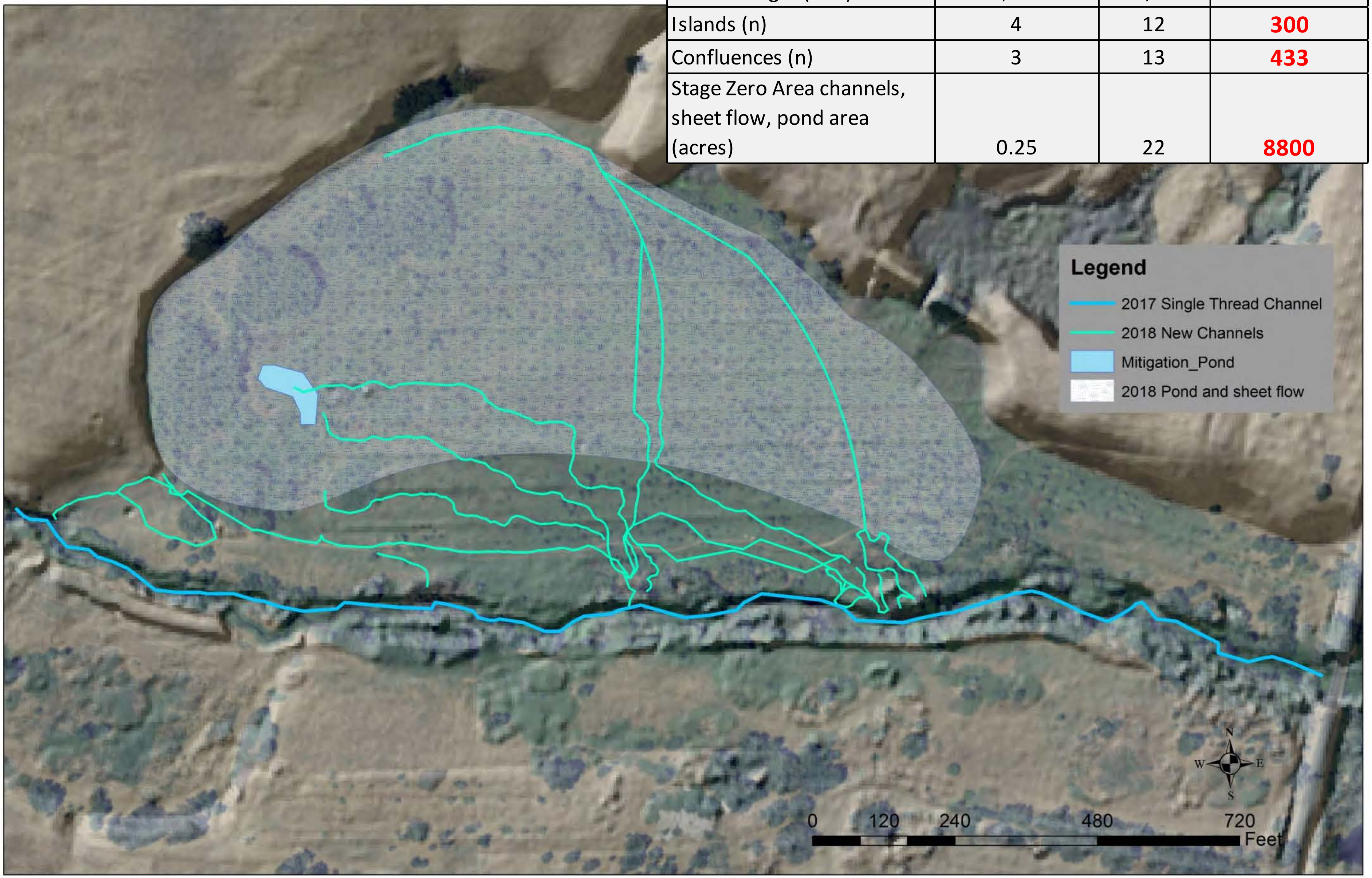
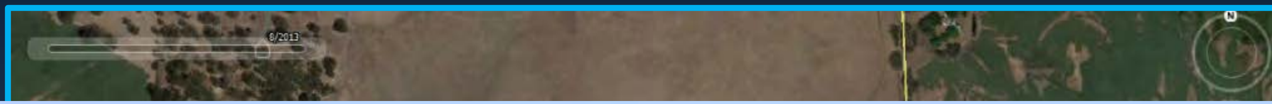
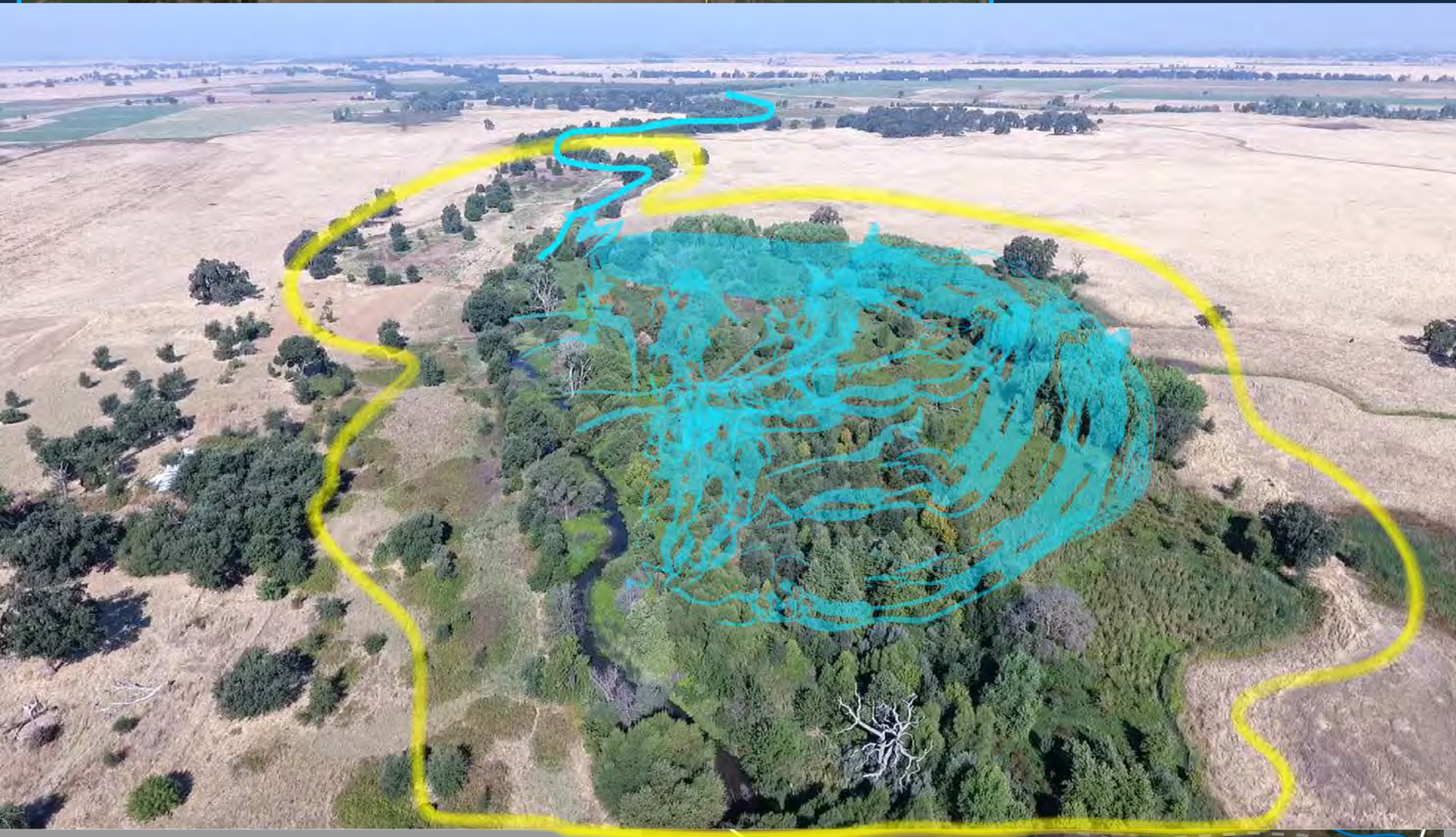


Figure 3. Hillshade map of reach 1, shows topography, prior to levee removal. Also shown are Cross-Sections 2-9 and 18, flow paths/secondary channels, beaver dams, and fresh sand deposited mapped by FWS after 2017 flood.

2018

Gauging Evolution to Stage Zero			
Habitat Attributes	**2017**	**2018**	**% Increase**
Stream length (feet)	2,383	10,478	**440**
Islands (n)	4	12	**300**
Confluences (n)	3	13	**433**
Stage Zero Area channels, sheet flow, pond area (acres)	0.25	22	**8800**




8/2013


Google earth

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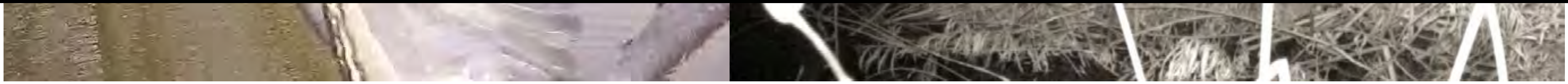
Habitat Use

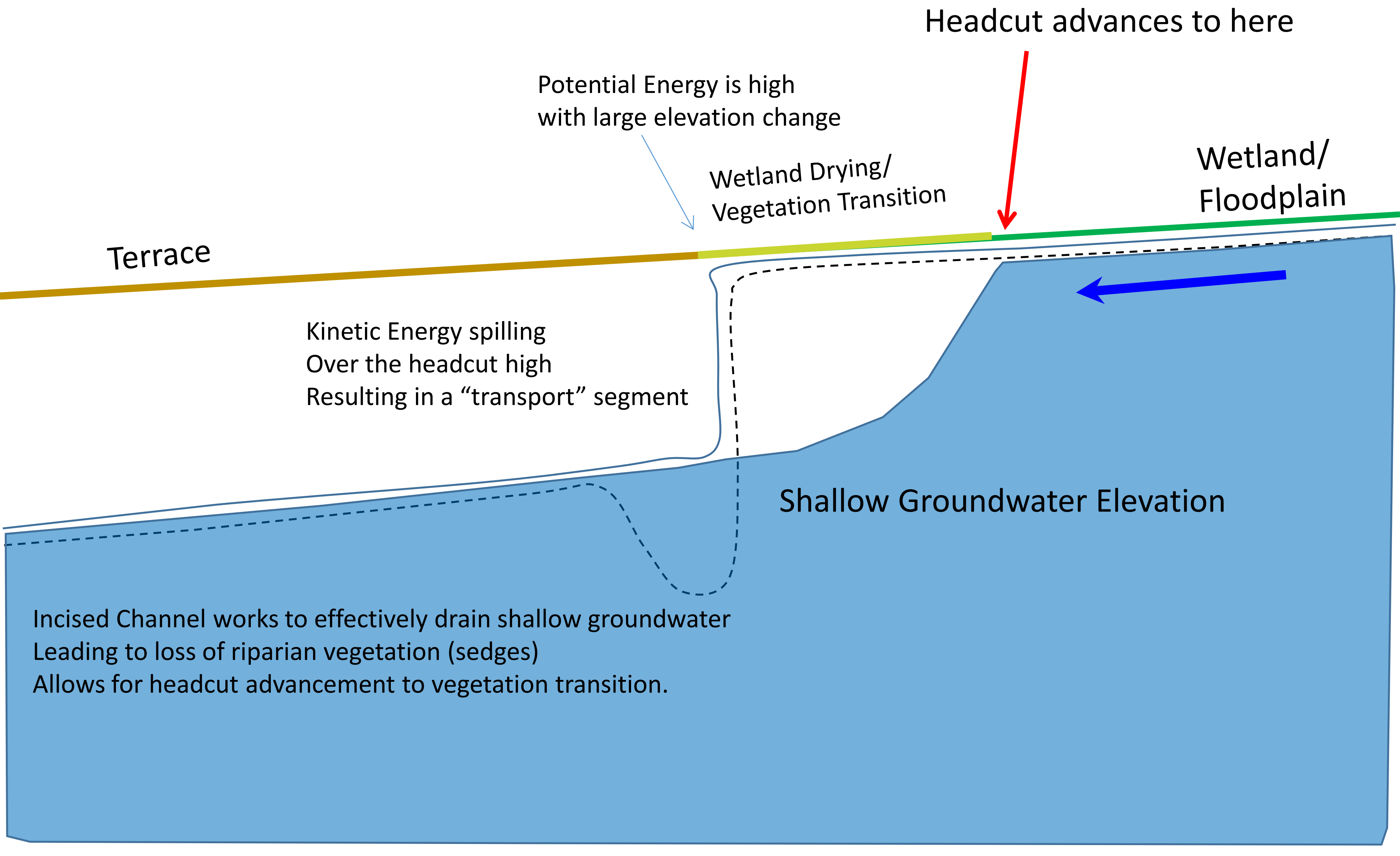


QUESTIONS

Stage 0 Restoration Approach, Design and Construction

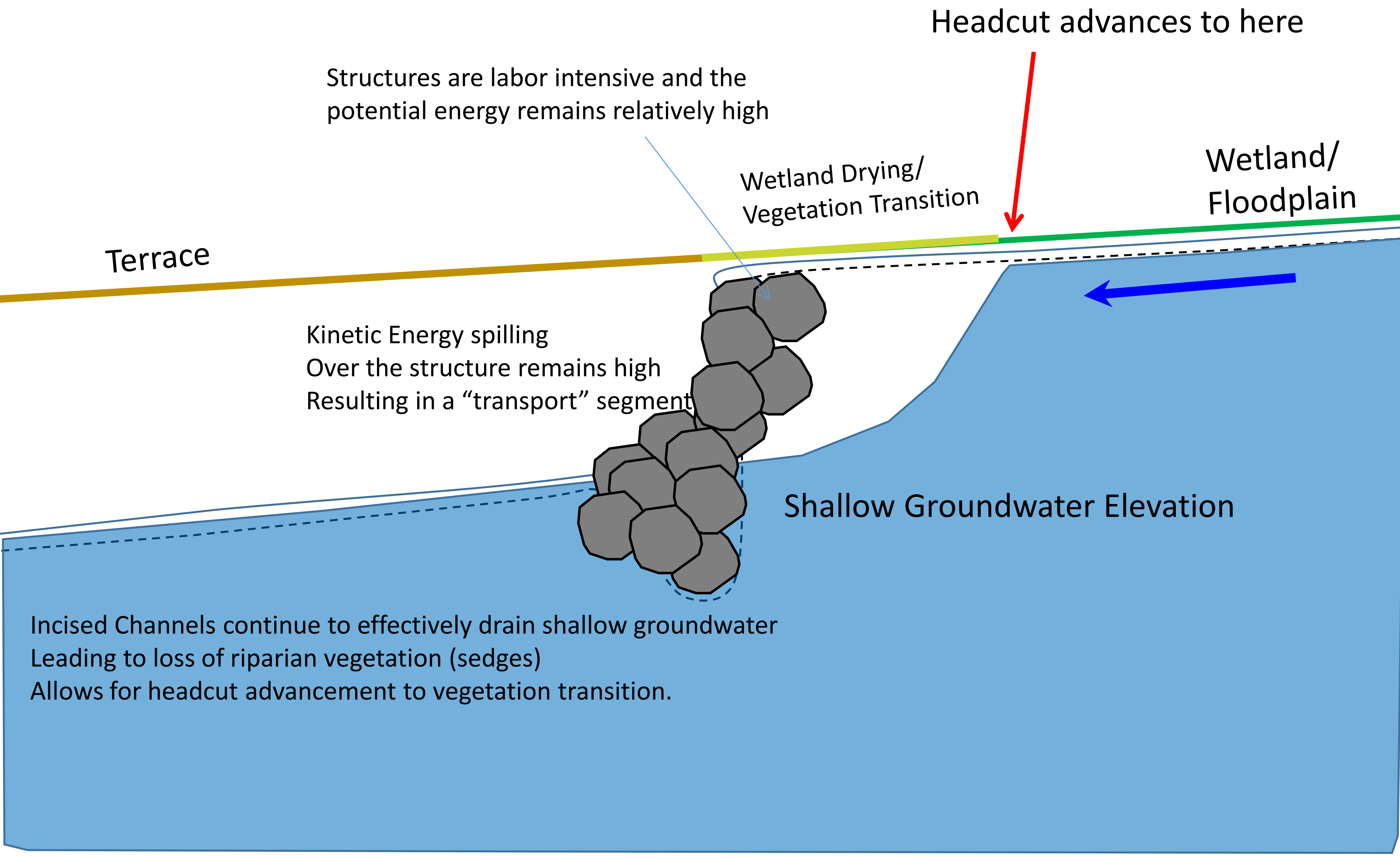
Paul Powers-Deschutes National Forest

Typical Valley Profile of Meadow Headcut



Traditional Treatment of Typical Meadow Headcut

Construct a rock/log vane structure (step-pools) at headcut in an attempt to prevent cutting of soils/bed

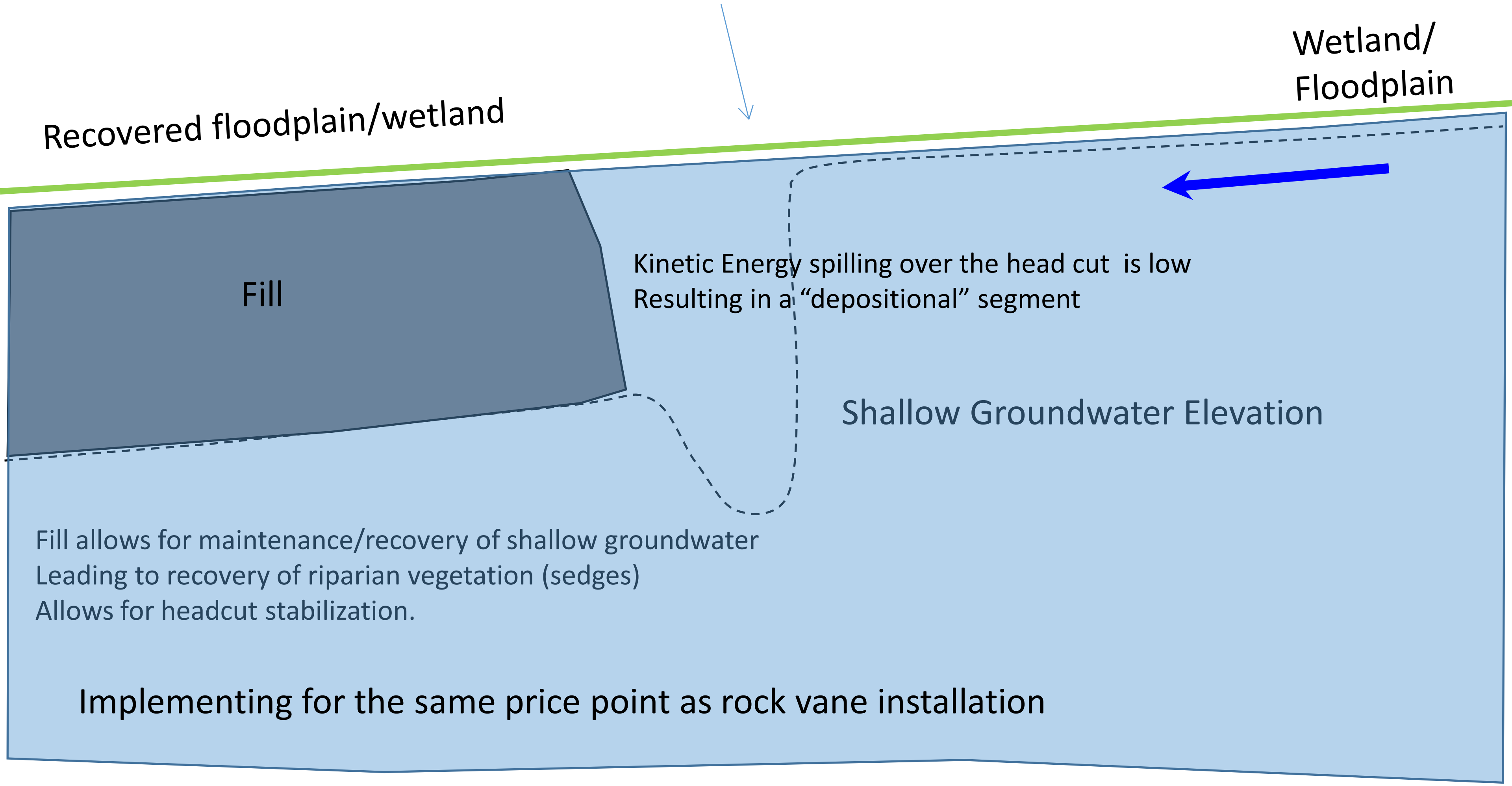


Lost Cr – The Nature Conservancy
Pre-Construction
Pre- 2012

Contemporary Technique for Meadow Headcut

Fill in the incised channel to restore shallow groundwater elevation and
Remove the hydraulic jump and potential energy.

- Potential Energy Is low
- Hydraulic Jump has been eliminated with backwater effect from fill



Lost Cr- During Construction
View of the Upper Meadow
(HC#6)
October 2012

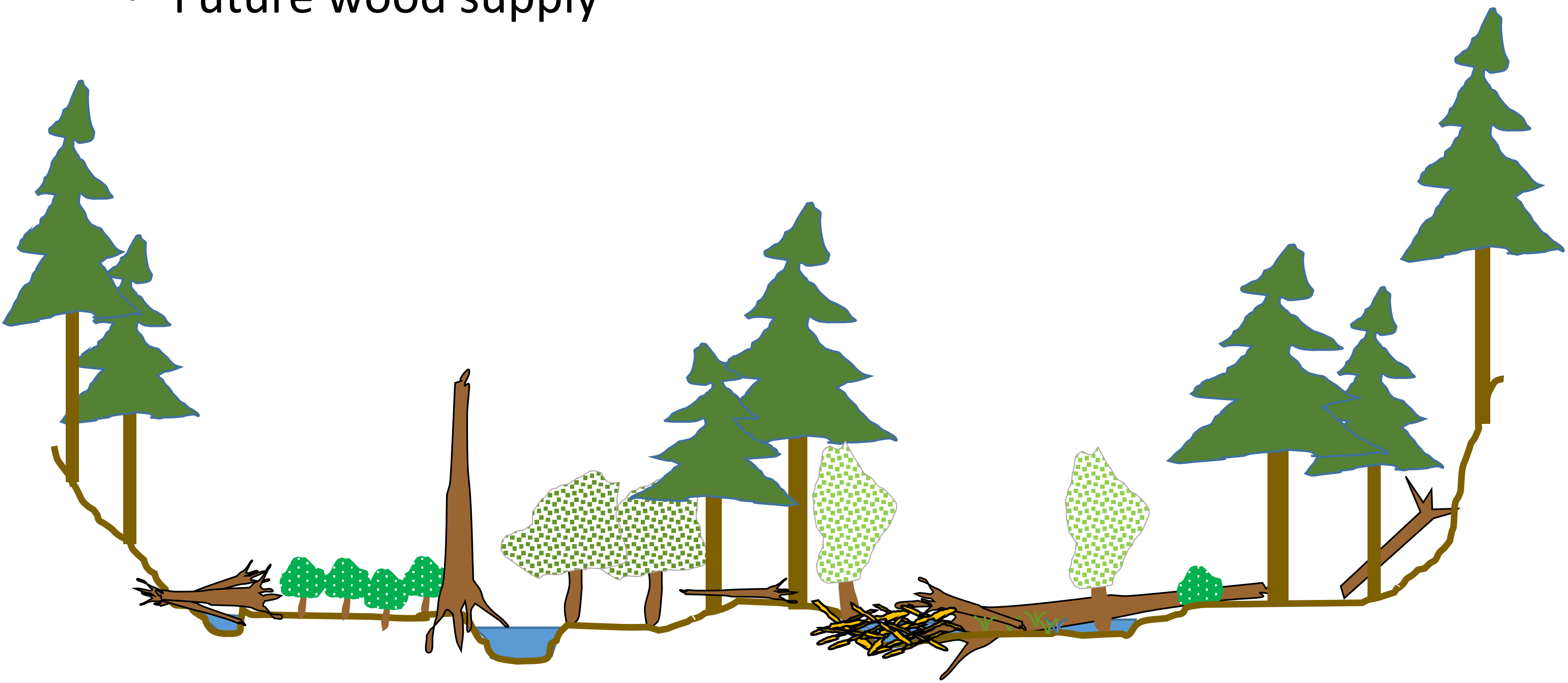
8,000 cubic yards fill

Fall of 2012

Summer 2013

Historic Floodplain Condition in Depositional Environments

- Vegetation diversity
- Elevational diversity
- Multiple flow paths
- Downed wood
- Future wood supply
- High water table
- Beaver dams
- Frequent floodplain wetting
- Maximum patch complexity



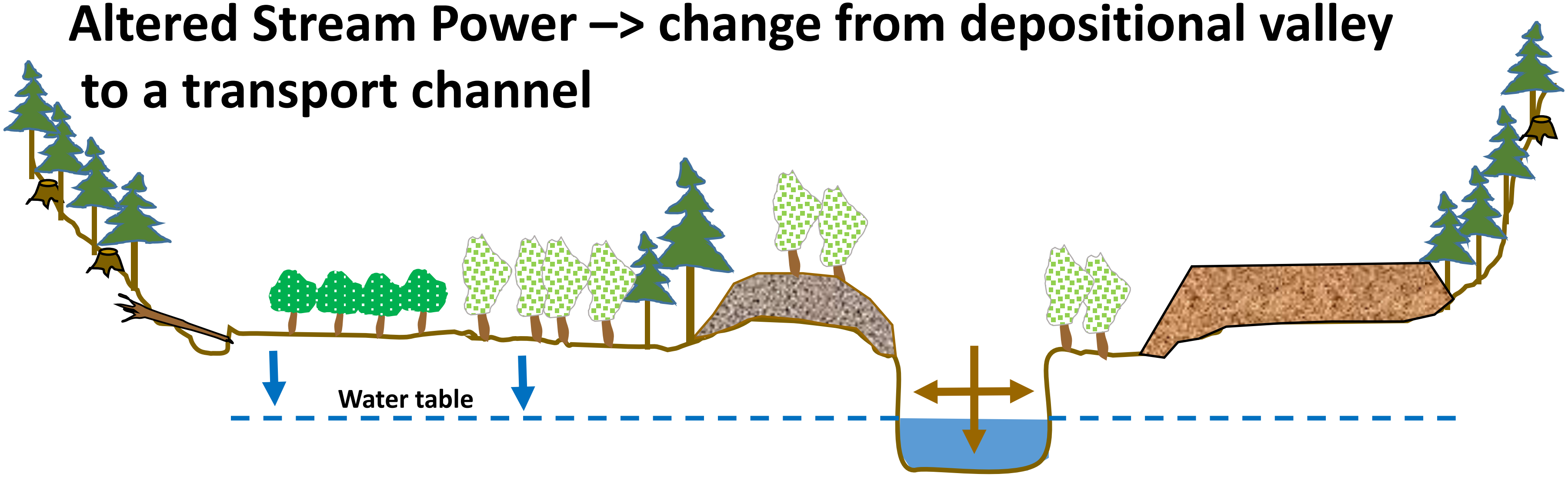
Changed Condition in Depositional Environments

- Road building
- Conifer harvest
- Diking and channelization
- Blocking or filling side channels
- Grazing and farming

Leads to:

- Single incised channel
- Loss of water table/wetlands
- Altered vegetation types
- Minimal large wood

Altered Stream Power –> change from depositional valley to a transport channel

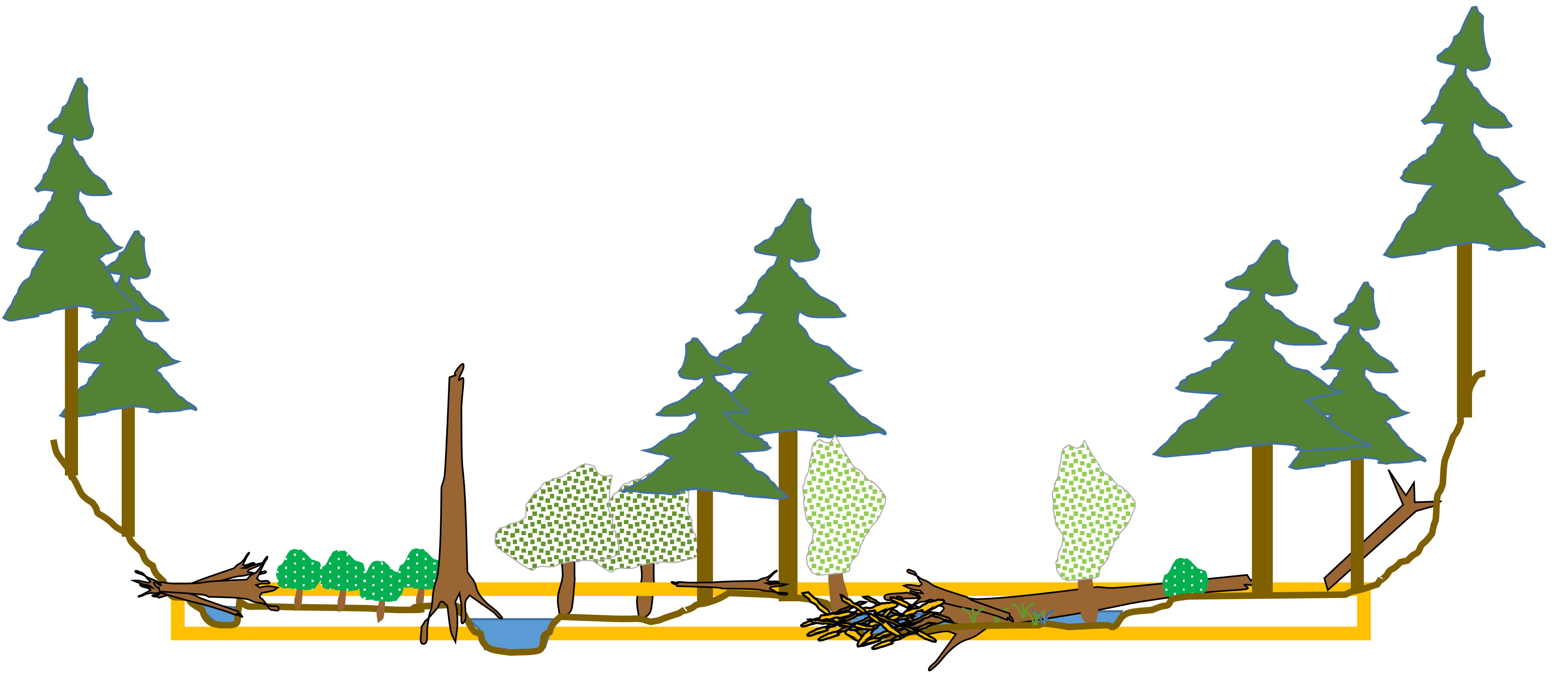


Stream Evolution Model, Stages 2-5
Cluer and Thorne, 2013

Restoration History:

Stream Power Per Unit Width

Historic Floodplain Condition in Depositional Environments

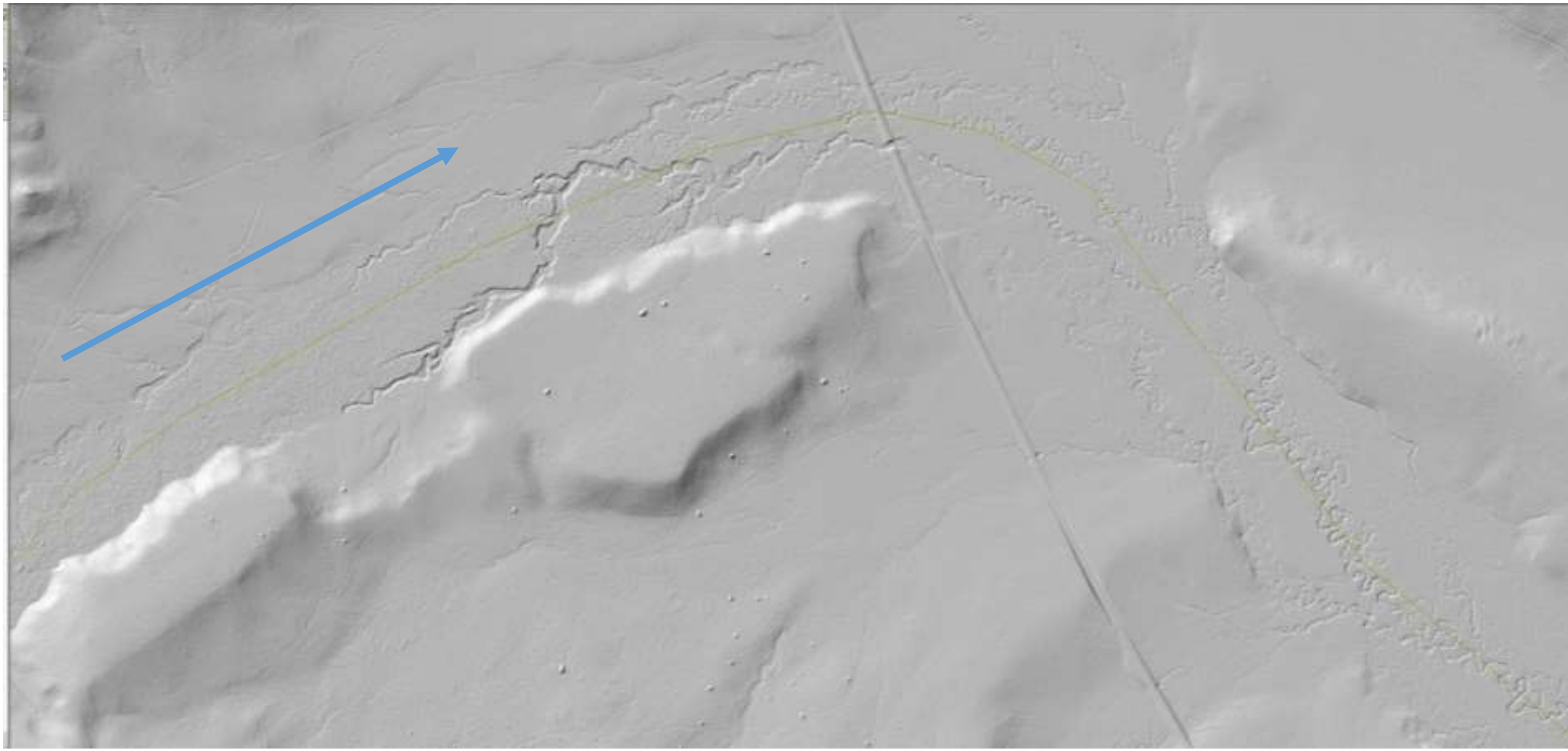


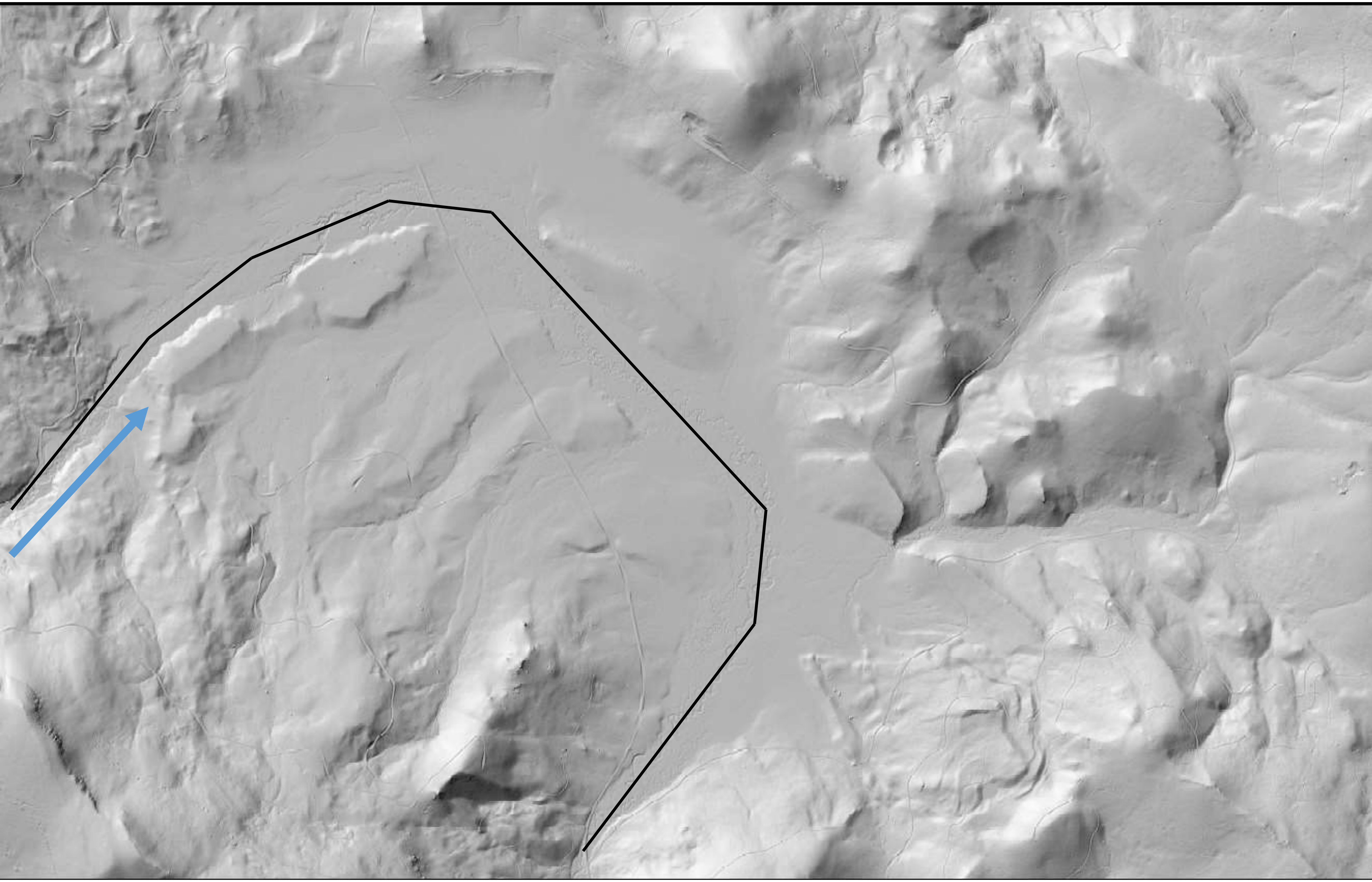
Stream Power Per Unit Width - Low

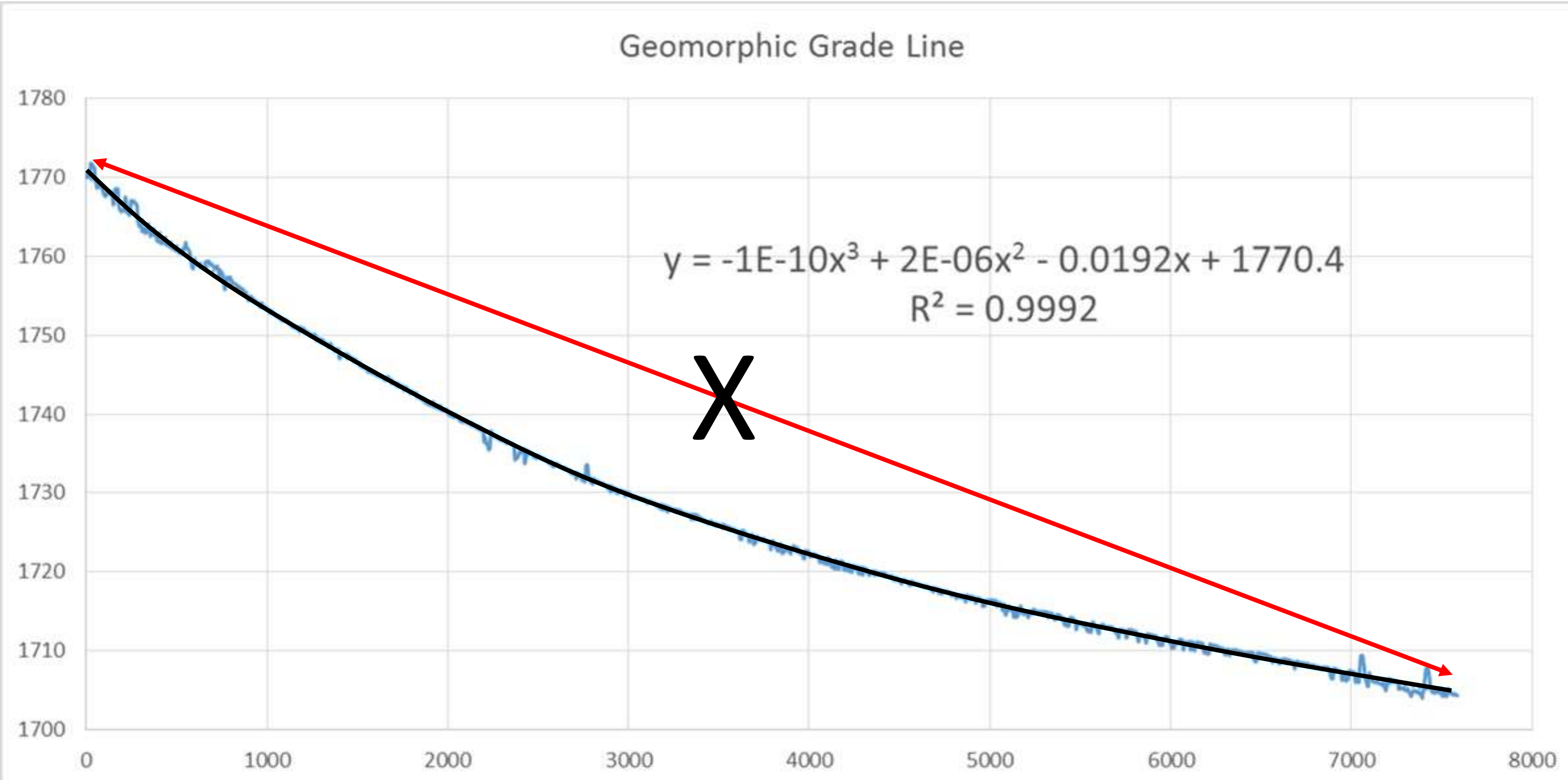
- Flow distributed throughout a roughened surface

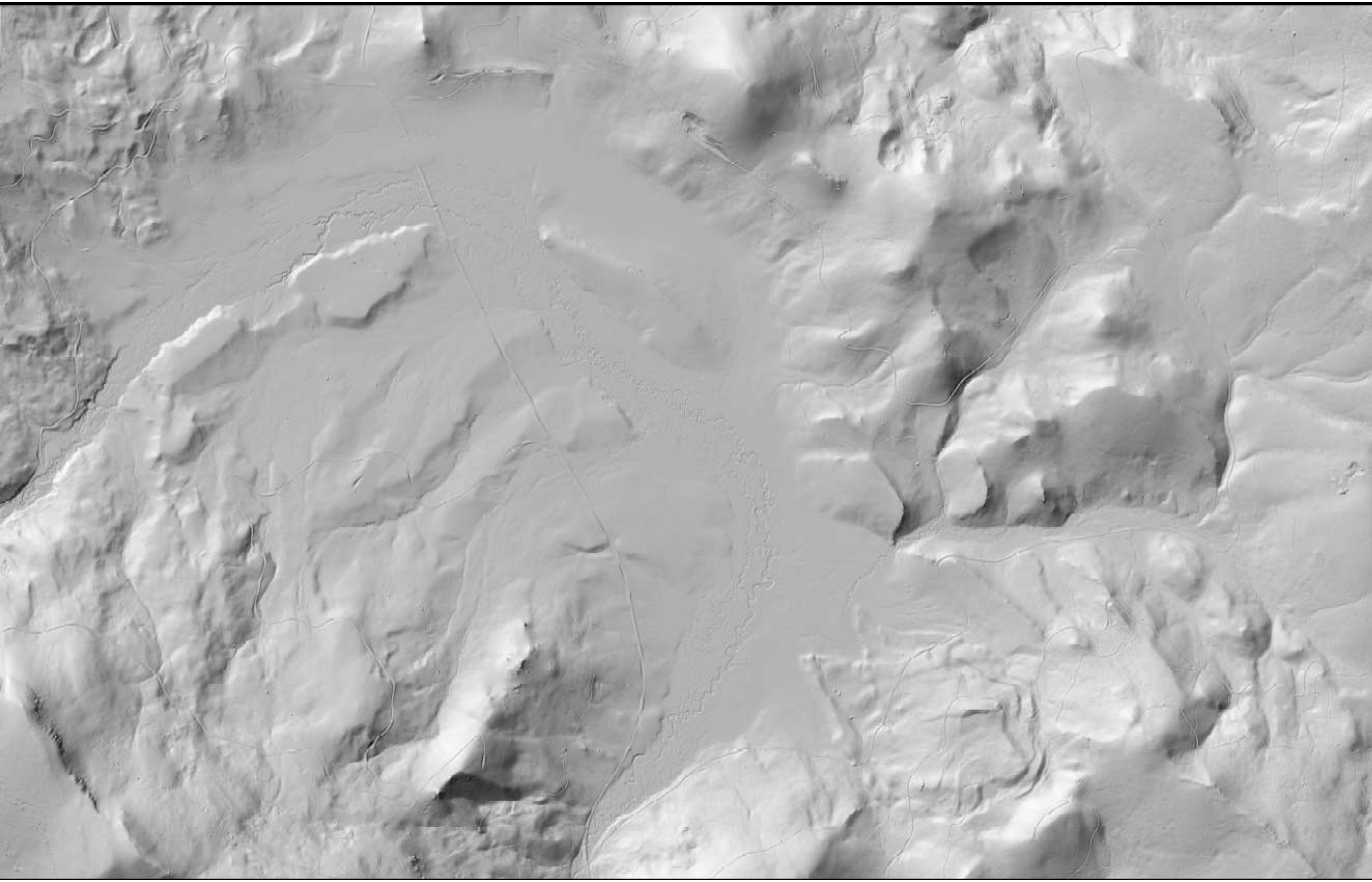


© 2015 Richard Scott Nelson

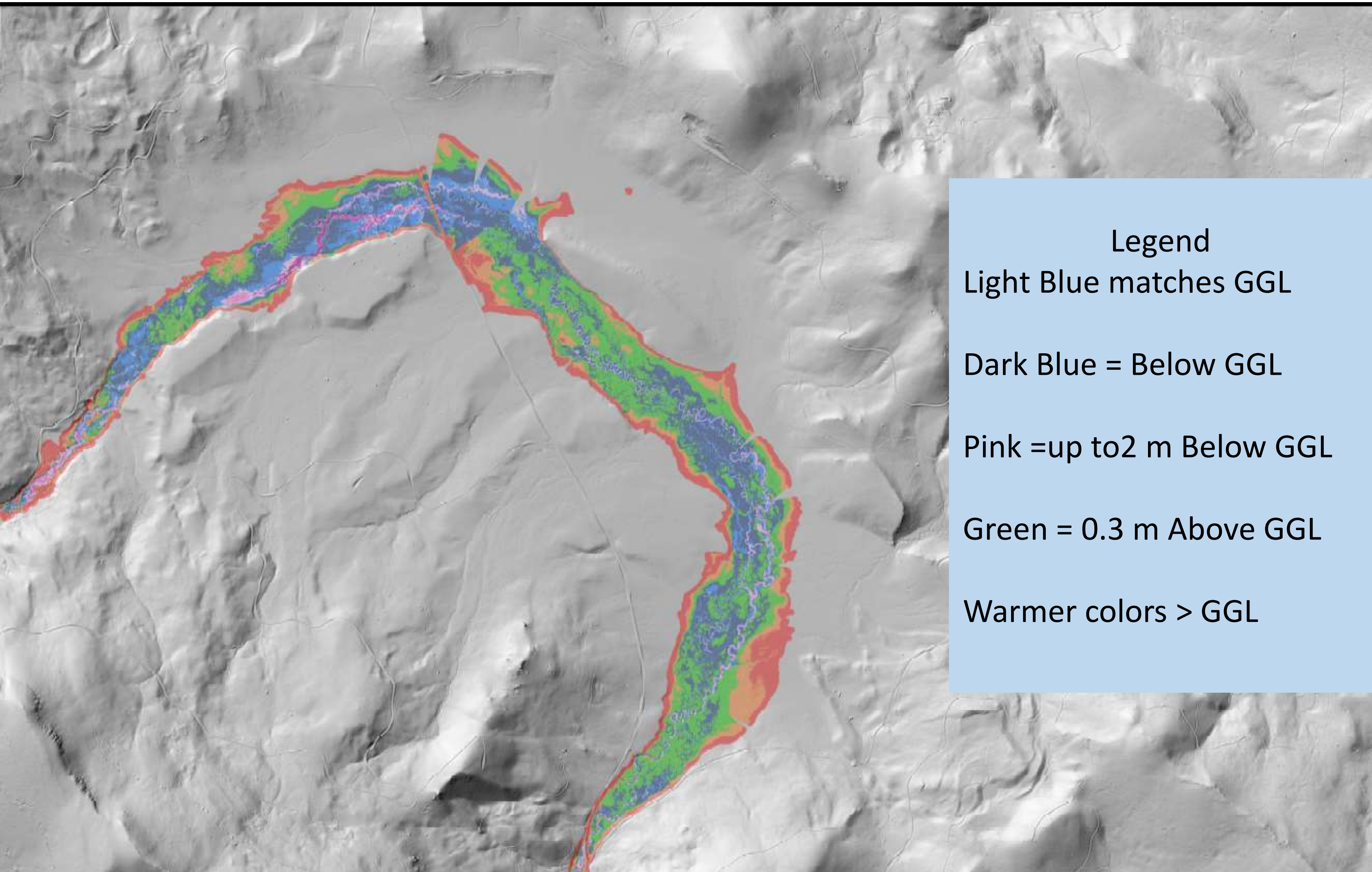


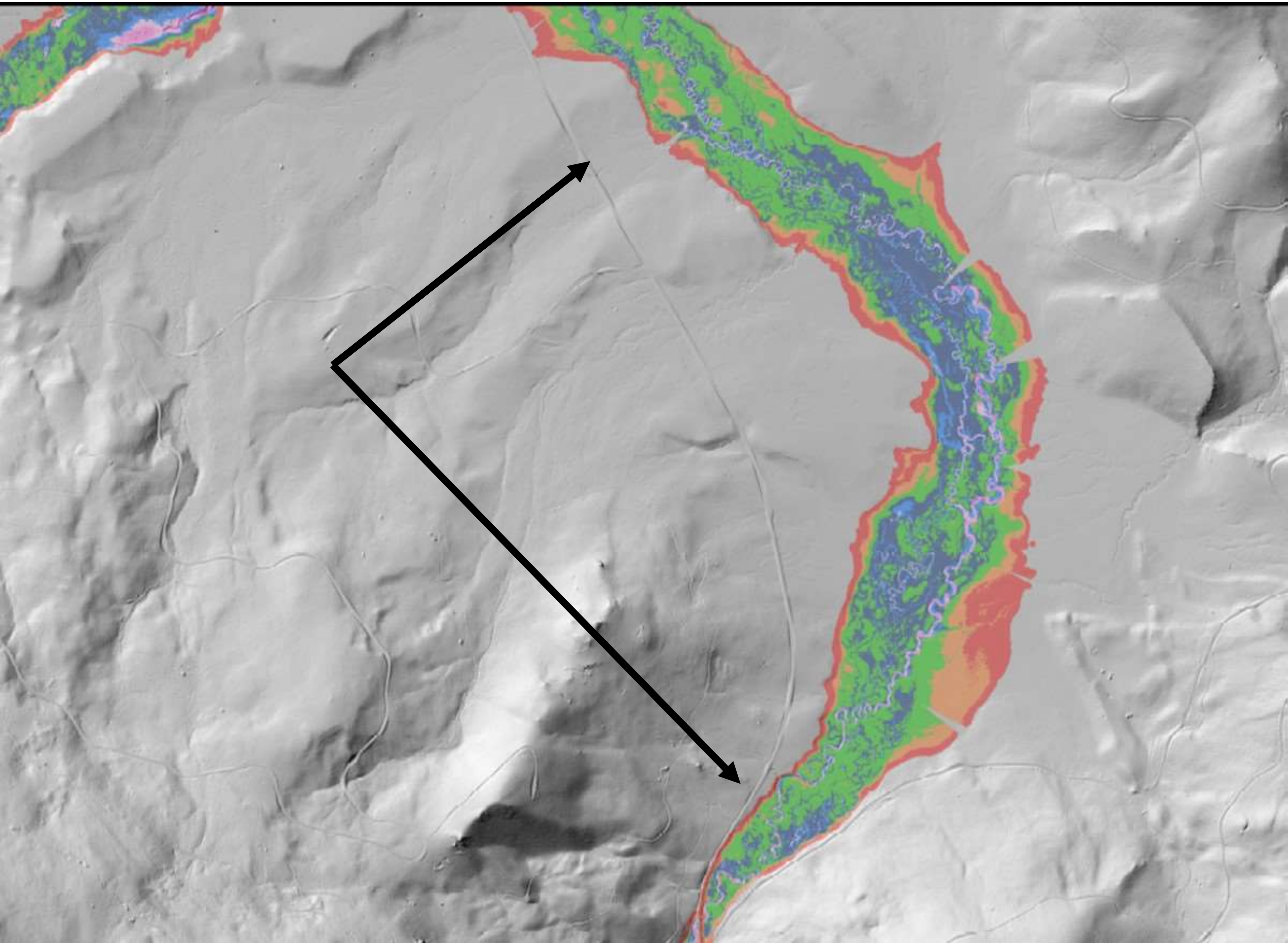


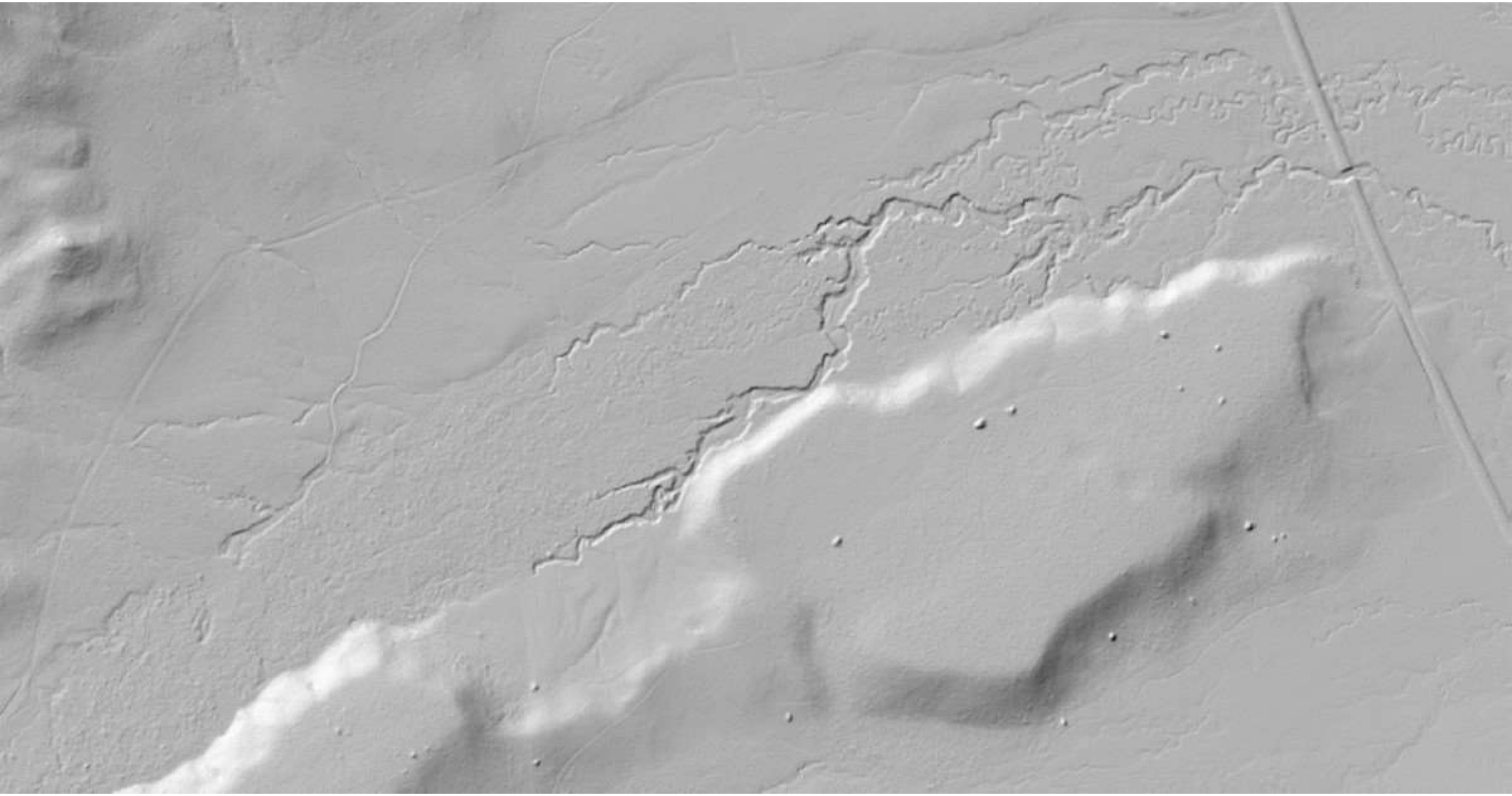

Geomorphic Grade Line
1780
1770
1760
1750
1740
1730
1720
1710
1700
0
1000
2000
3000
4000
5000
6000
7000
8000
y = -1E-10x³ + 2E-06x² - 0.0192x + 1770.4
R² = 0.9992
X

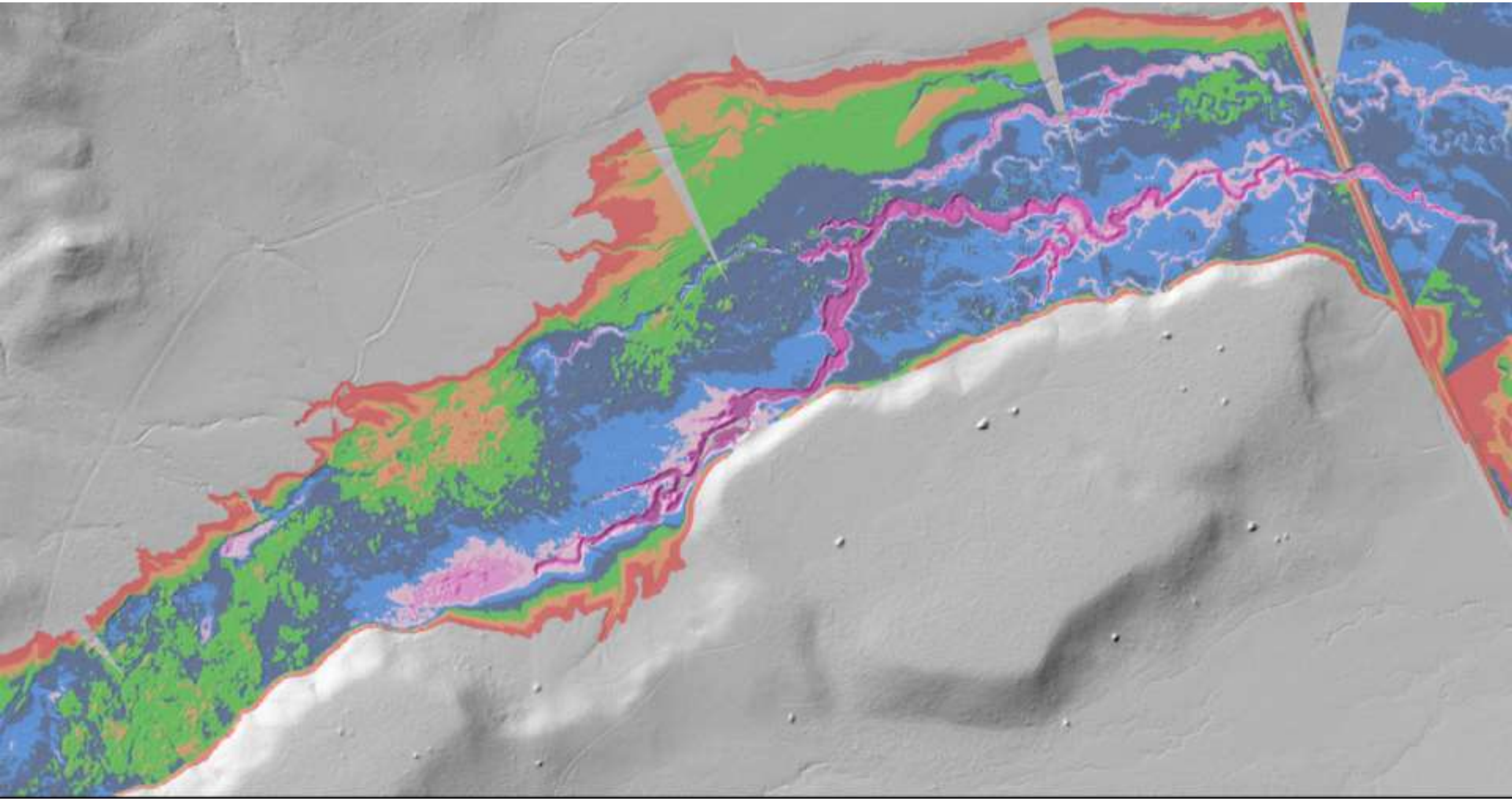


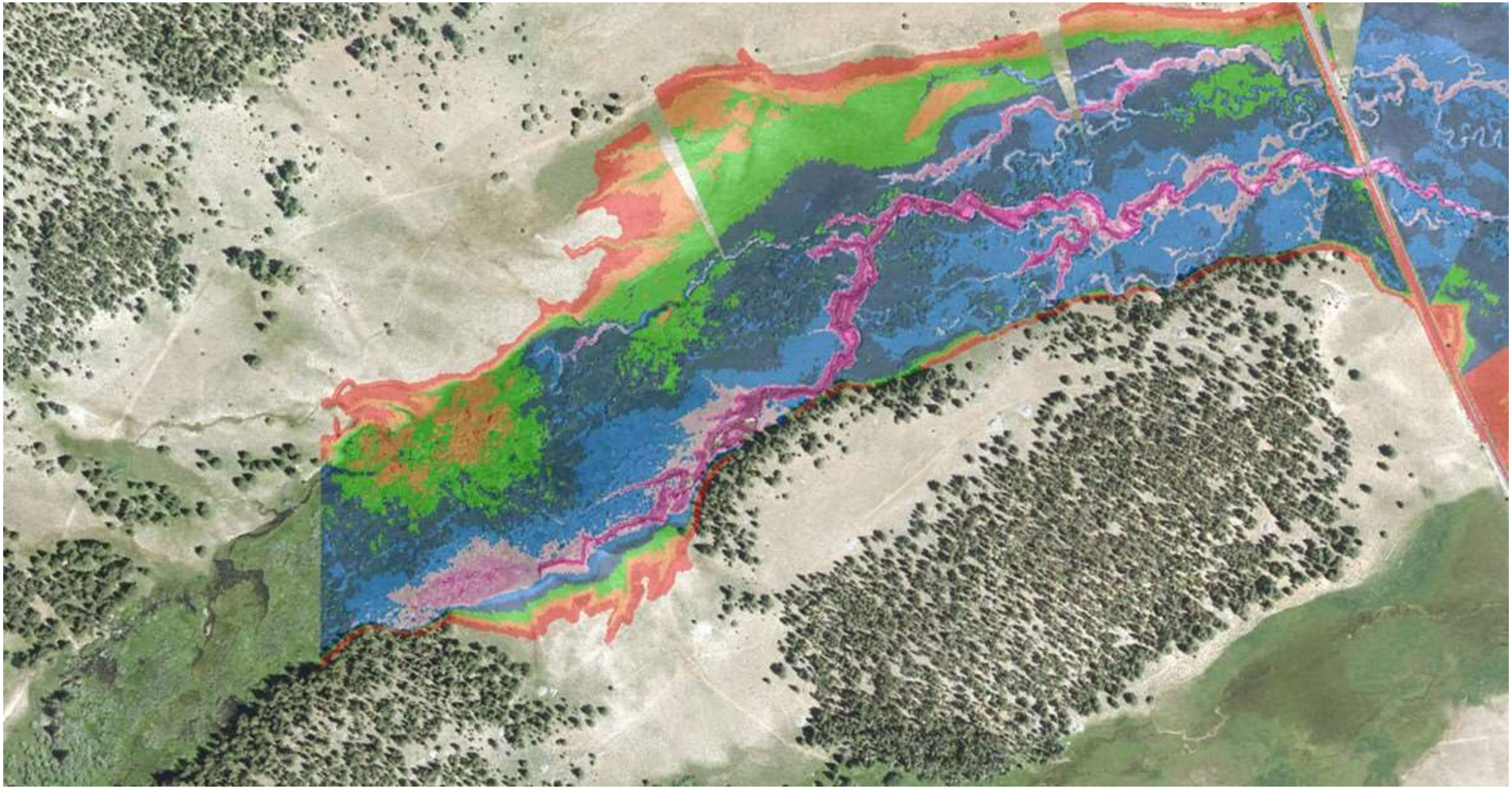
Relative Elevation Map Built Around the Geomorphic Grade Line











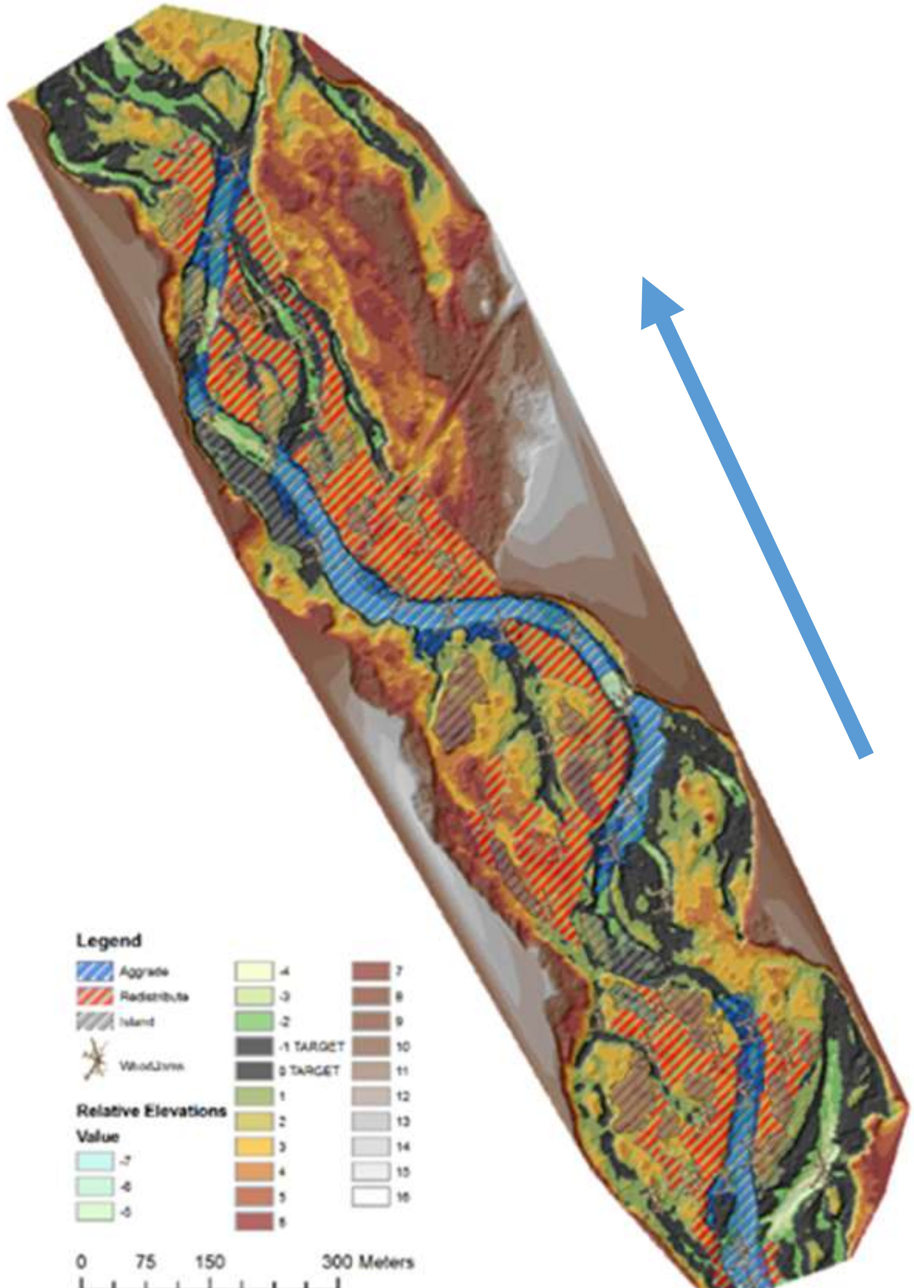
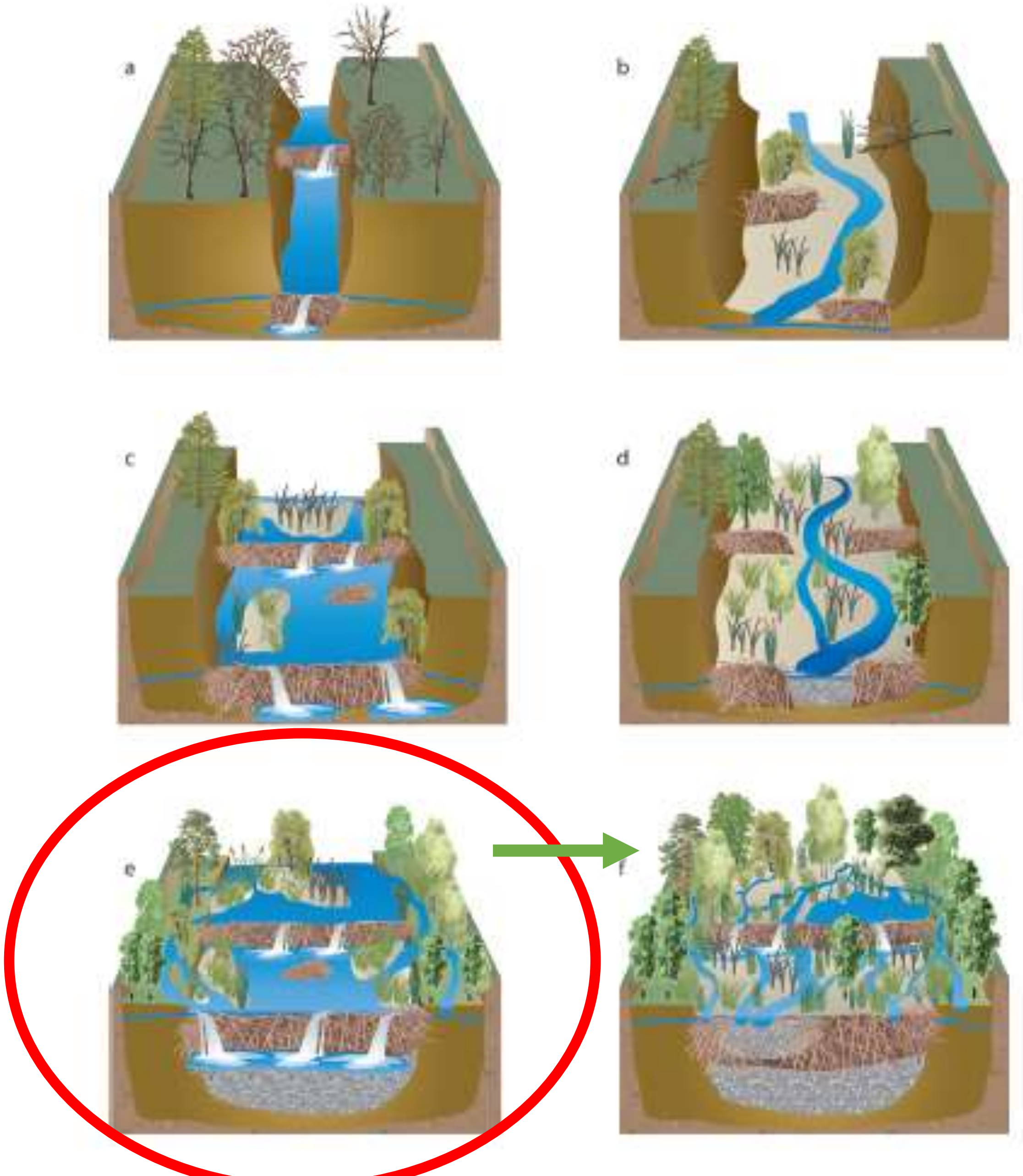

Legend
Aggrade
Redistribute
Island
Relative Elevations
Value
-7
-6
-5
-4
-3
-2
-1 TARGET
0 TARGET
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
0
75
150
300 Meters

Photo credit Johan Hogervorst


DEERE
DEERE



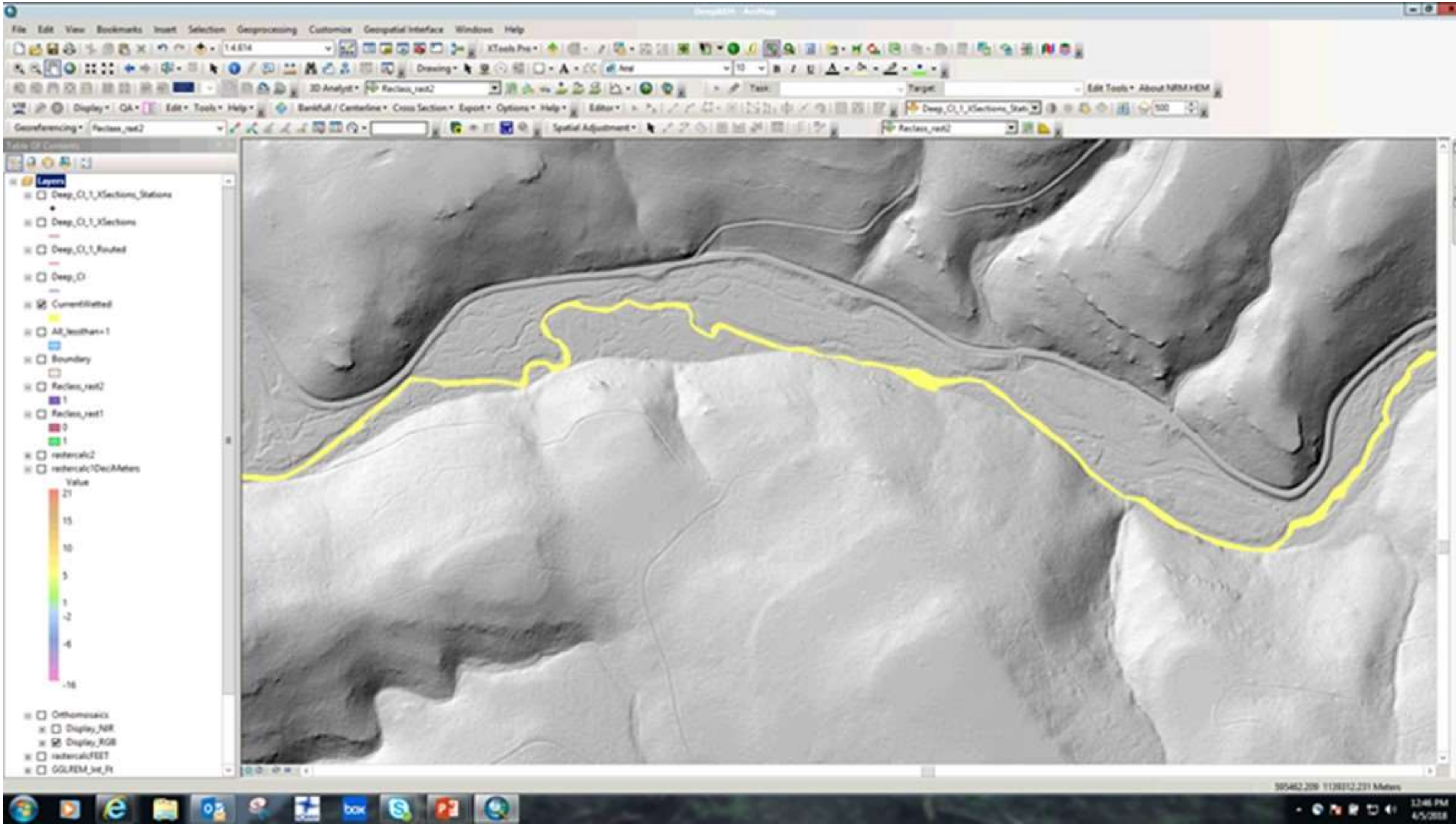
Pollok et al, 2014

Photo credit Johan Hogervorst

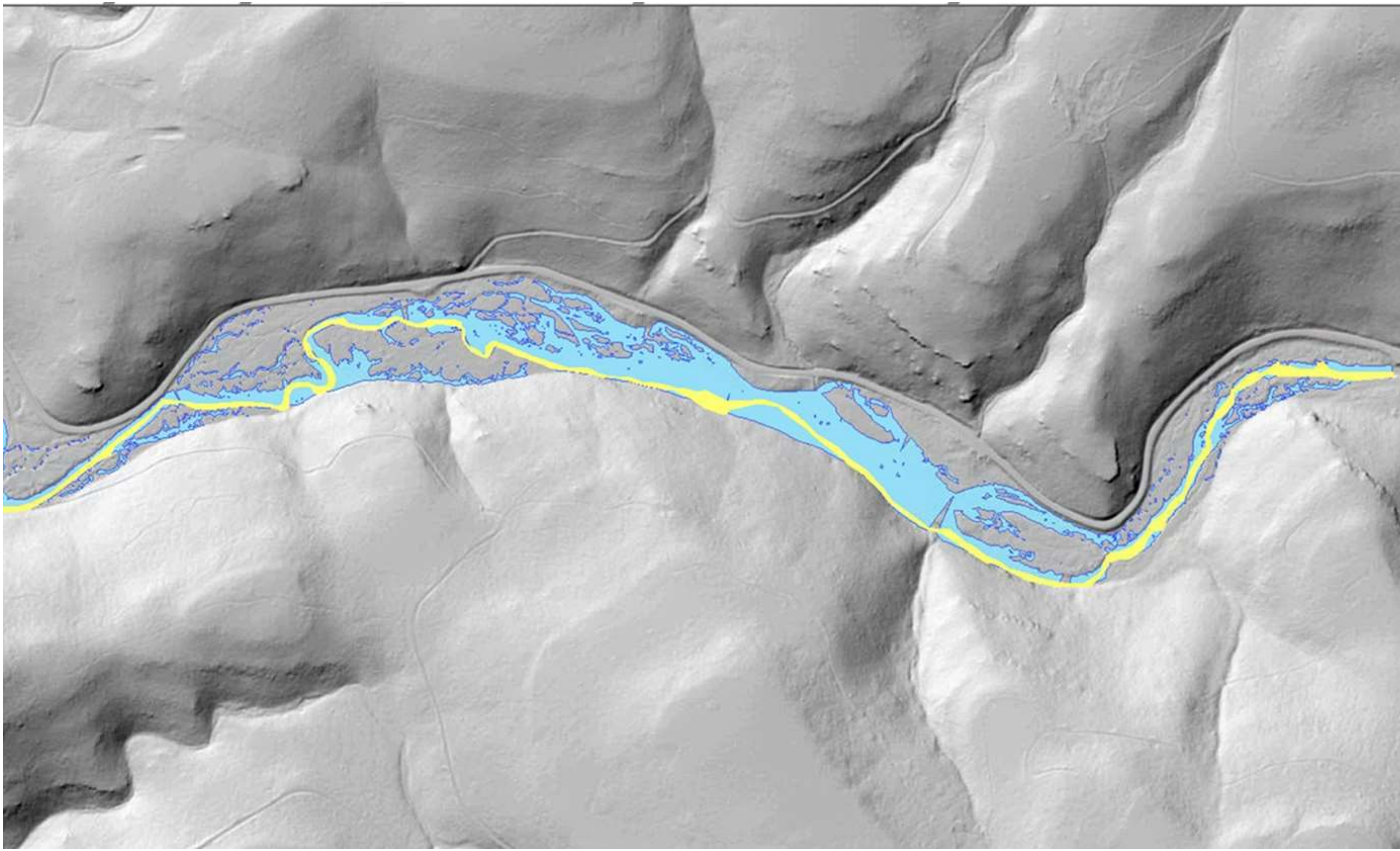

Photo credit: Kate Meyer


Photo credit: Kate Meyer

Photo credit: Kate Meyer

File Edit View Bookmarks Insert Selection Geoprocessing Customize Geospatial Interface Windows Help
Layers
Deep_CI_1_XSections_Stations
Deep_CI_1_XSections
Deep_CI_1_Routed
Deep_CI
CurrentWetted
All_lessthan=1
Boundary
Reclass_rast2
Reclass_rast1
rastercalc2
rastercalc1DeciMeters
Value
21
15
10
5
1
-2
-6
-16
Orthomosaics
Display_NIR
Display_RGB
rastercalcFEET
GGLREM_Int_Ft



Fivemile-Bell Restoration Project: A Stage 0 Restoration Case Study in Coastal Oregon

Paul Burns
Fisheries Biologist
Siuslaw National Forest
United States Forest Service

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

SIUSLAW
INSTITUTE

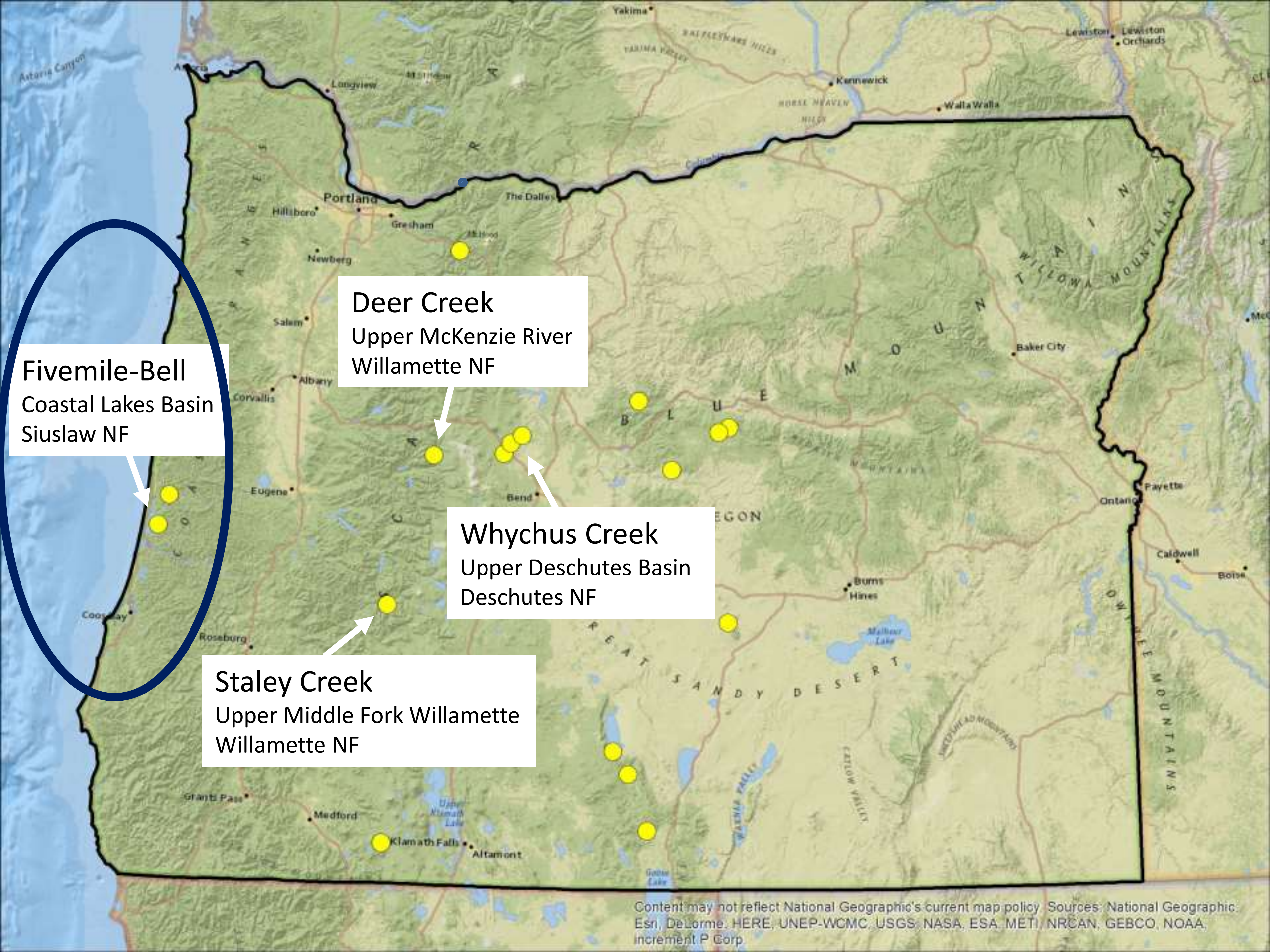
SWC

ELKTON COMMUNITY
EDUCATION CENTER

Confederated Tribes of
Siletz Indians

CONFEDERATED TRIBES
OF COOS-LOWER UMPQUA-SIUSLAW

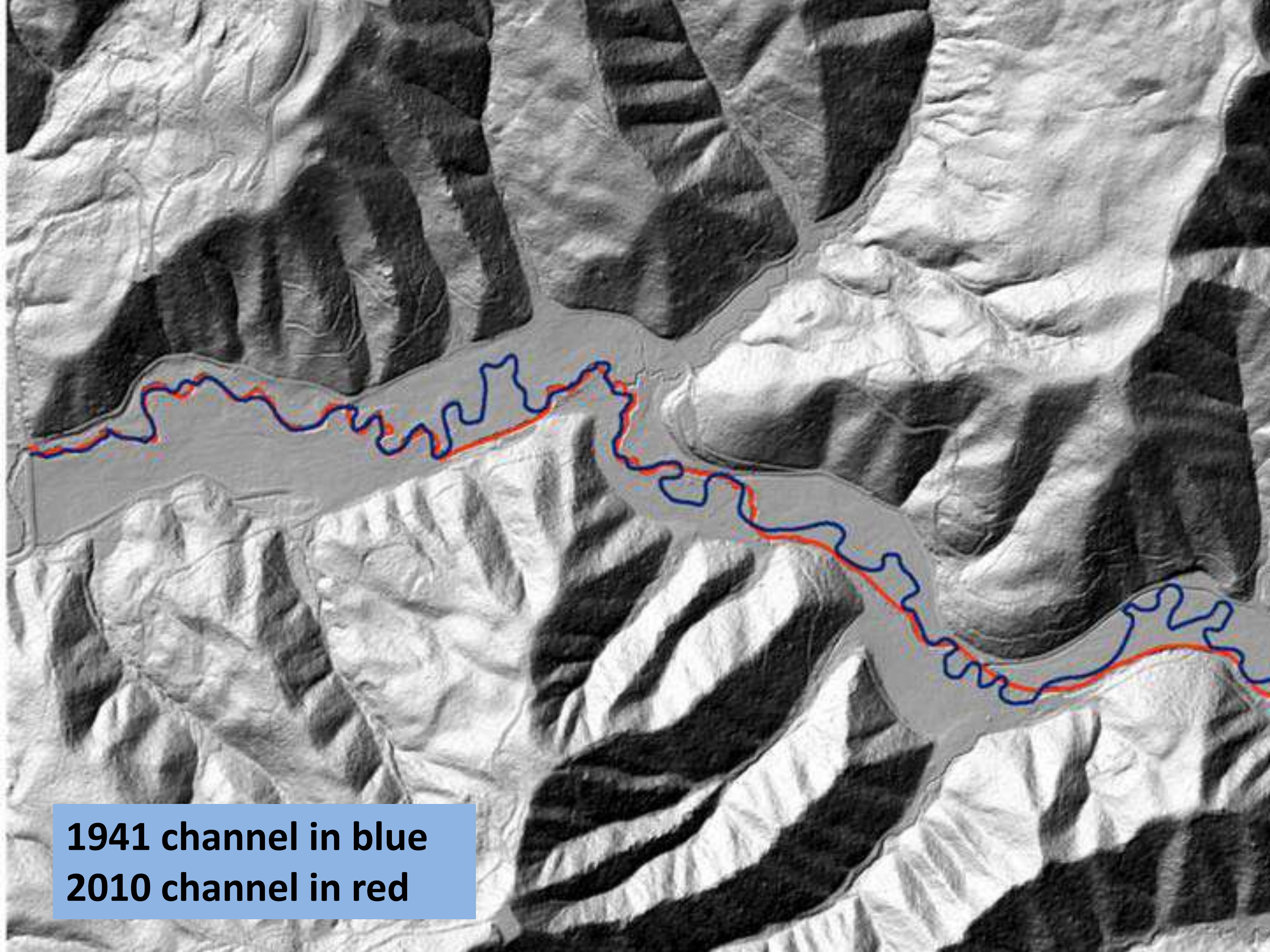
ecotrust



Deer Creek
Upper McKenzie River
Willamette NF
Fivemile-Bell
Coastal Lakes Basin
Siuslaw NF
Whychus Creek
Upper Deschutes Basin
Deschutes NF
Staley Creek
Upper Middle Fork Willamette
Willamette NF
Portland
Salem
Eugene
Bend
Corvallis
Albany
Newberg
Hillsboro
Gresham
The Dalles
Longview
Yakima
Kennewick
Walla Walla
Lewiston
Lewiston Orchards
Baker City
Ontario
Payette
Caldwell
Boise
Burns
Hines
Roseburg
Coos Bay
Grants Pass
Medford
Klamath Falls
Altamont
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

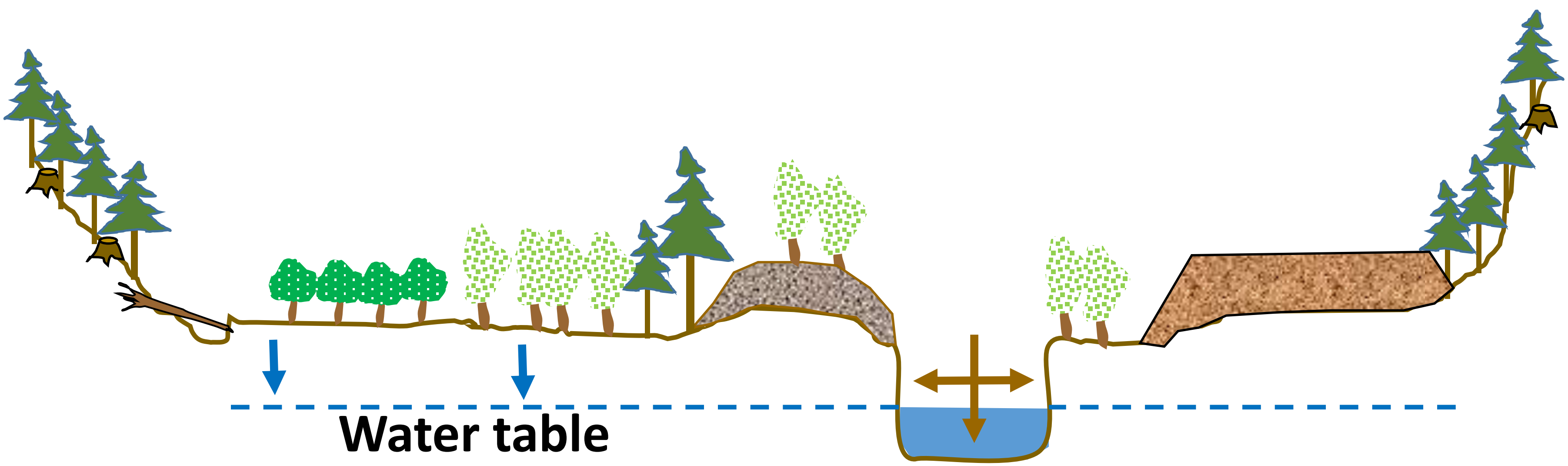
- Fivemile Creek is the largest tributary to Tahkenitch Lake on the Central Oregon Coast.


Fivemile Creek


1941 channel in blue
2010 channel in red

Leads to:

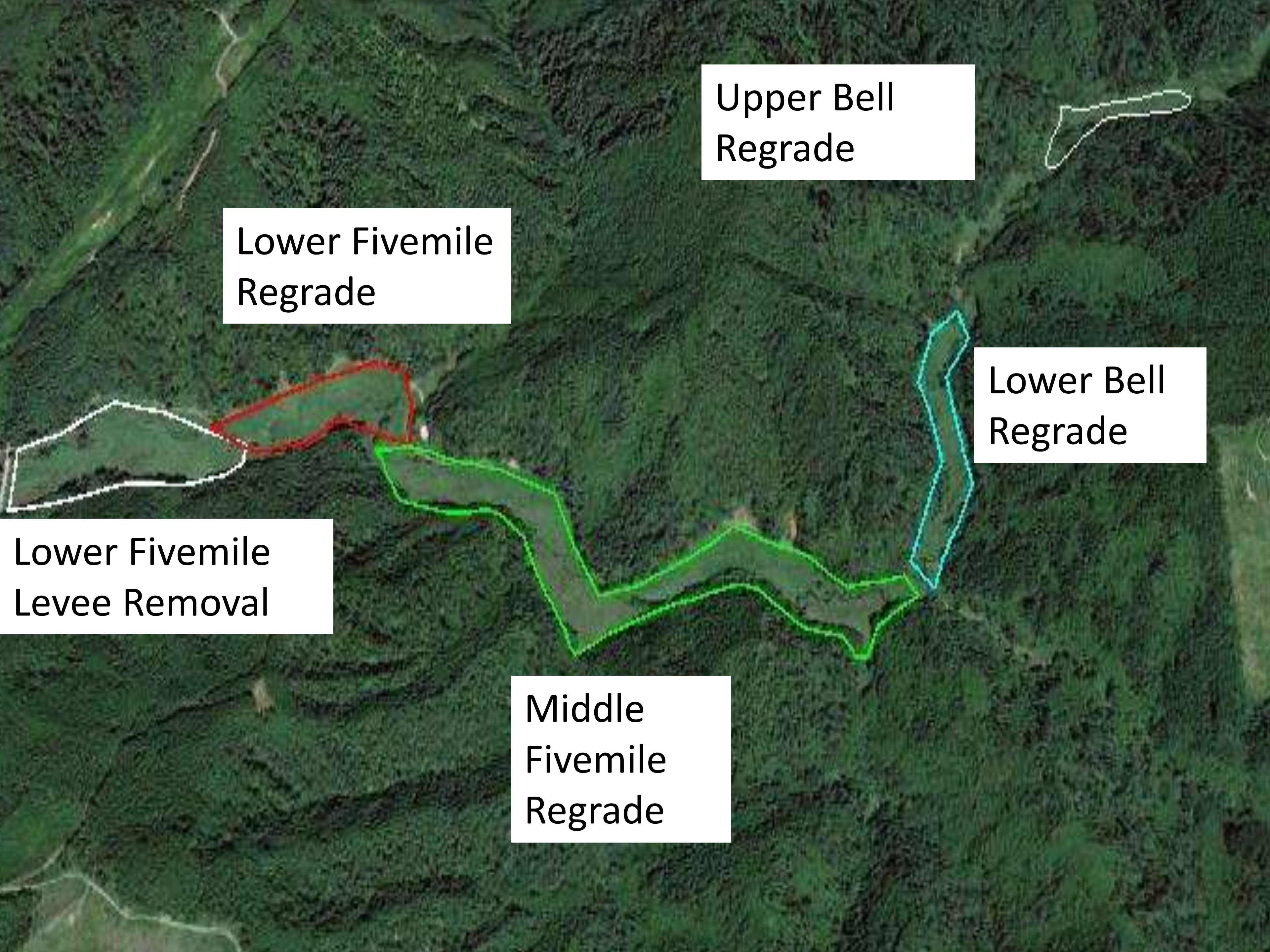
- Single incised channel
- Loss of water table/wetlands
- Altered vegetation types
- Minimal large wood
- **Altered Stream Power –> change from deposition to transport – even in extremely low gradient valleys**



Channel Evolution Model, Stages 2-4
Cluer and Thorne, 2013

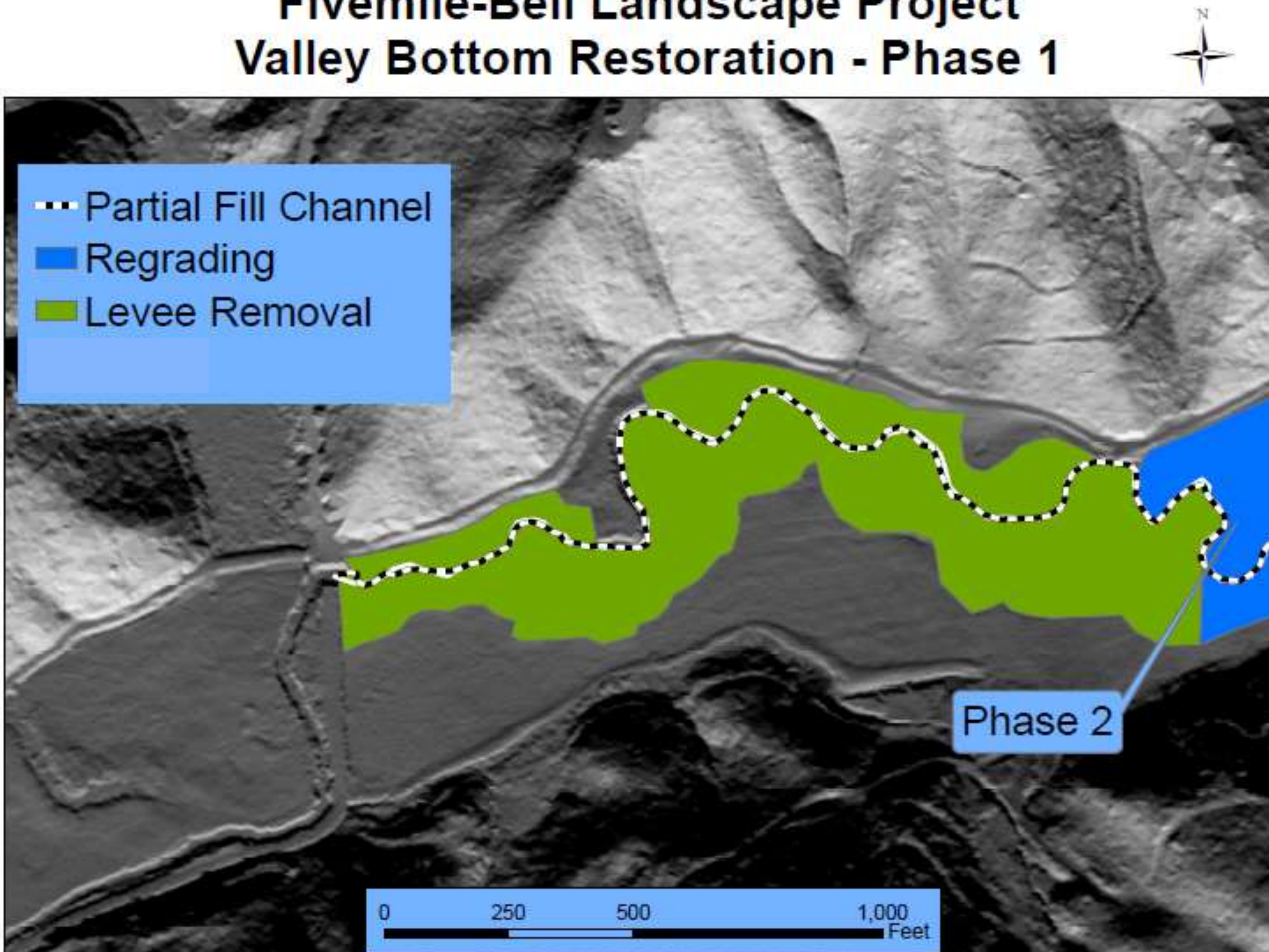
Watershed Processes to Restore

- Valley Bottom: Floodplain Function
  - Native Plant Species Re-introduction
    - Approximately 100 acres
  - Floodplain Interaction
    - Removal of Levees (2 miles)
    - Regrading of floodplain
    - Stream Channel construction (4 miles)
    - Decommission Roads (2 miles)
    - Enhance Passage at stream/road intersections

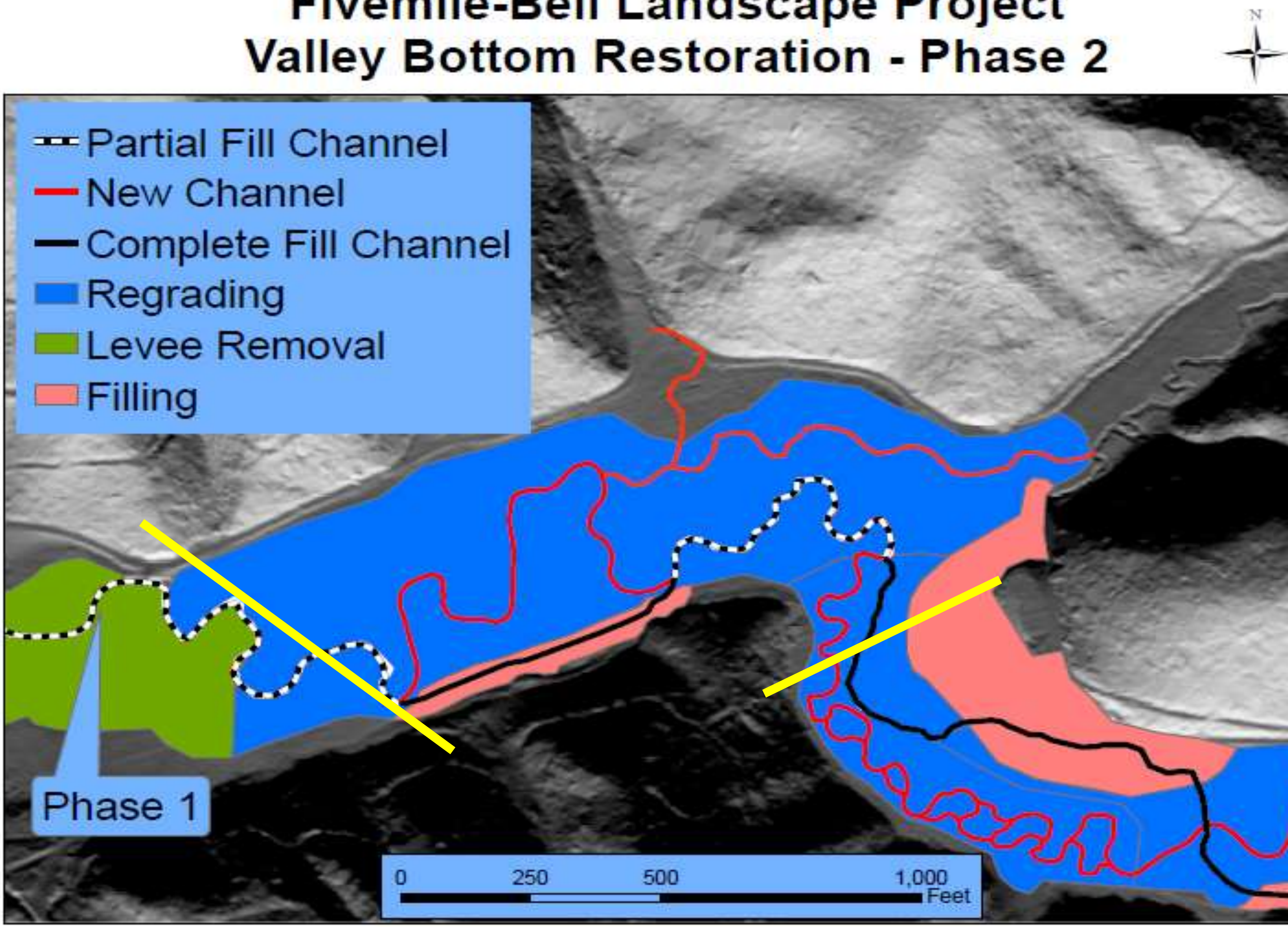

Upper Bell Regrade
Lower Fivemile Regrade
Lower Bell Regrade
Lower Fivemile Levee Removal
Middle Fivemile Regrade

Phase I – 2013/2014
Phase II – 2014/2015
Phase III – 2016/2017
Phase IV – 2018
Phase V - 2020

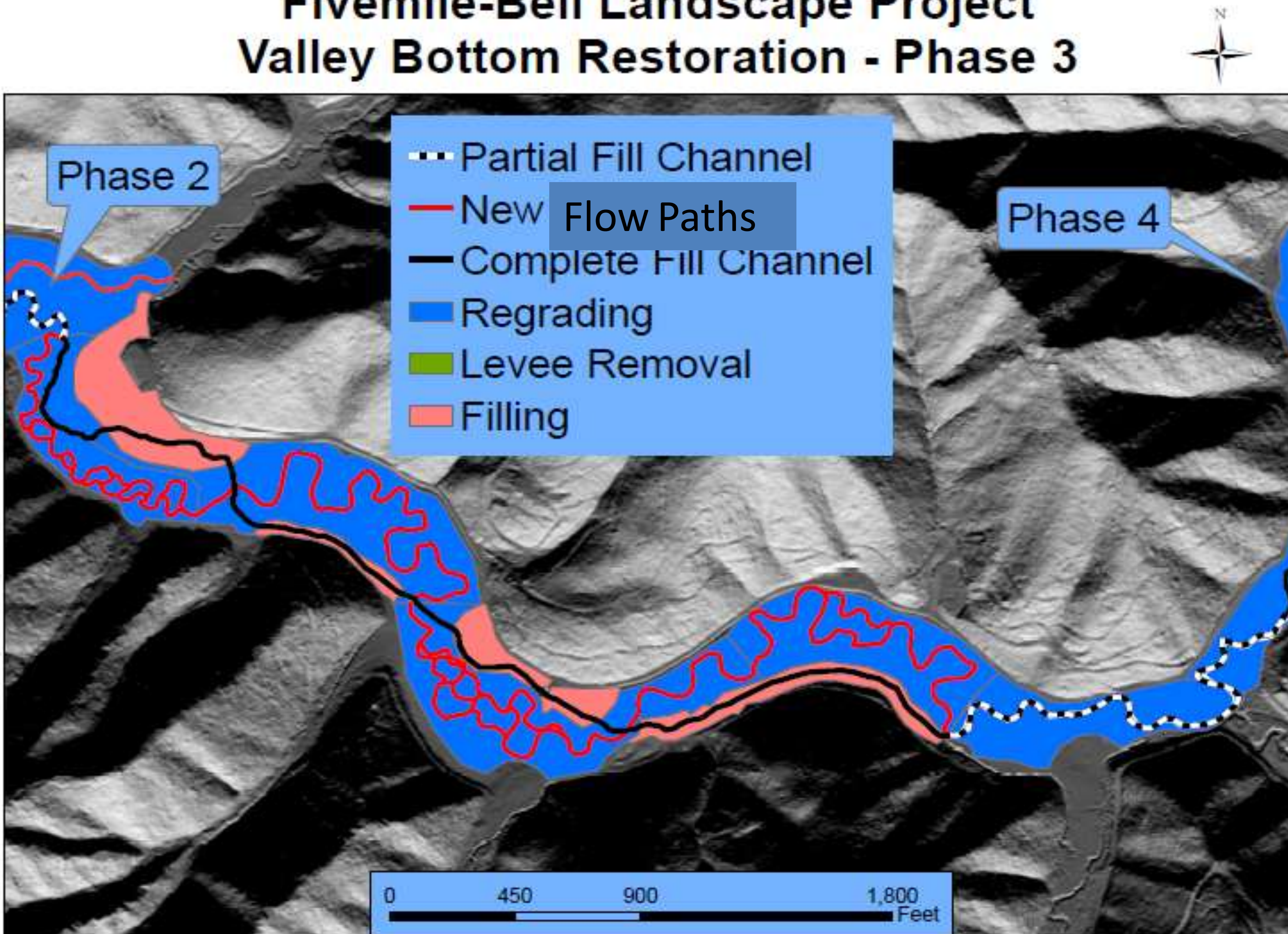
Fivemile-Bell Landscape Project
Valley Bottom Restoration - Phase 1



Fivemile-Bell Landscape Project
Valley Bottom Restoration - Phase 2



Fivemile-Bell Landscape Project
Valley Bottom Restoration - Phase 3



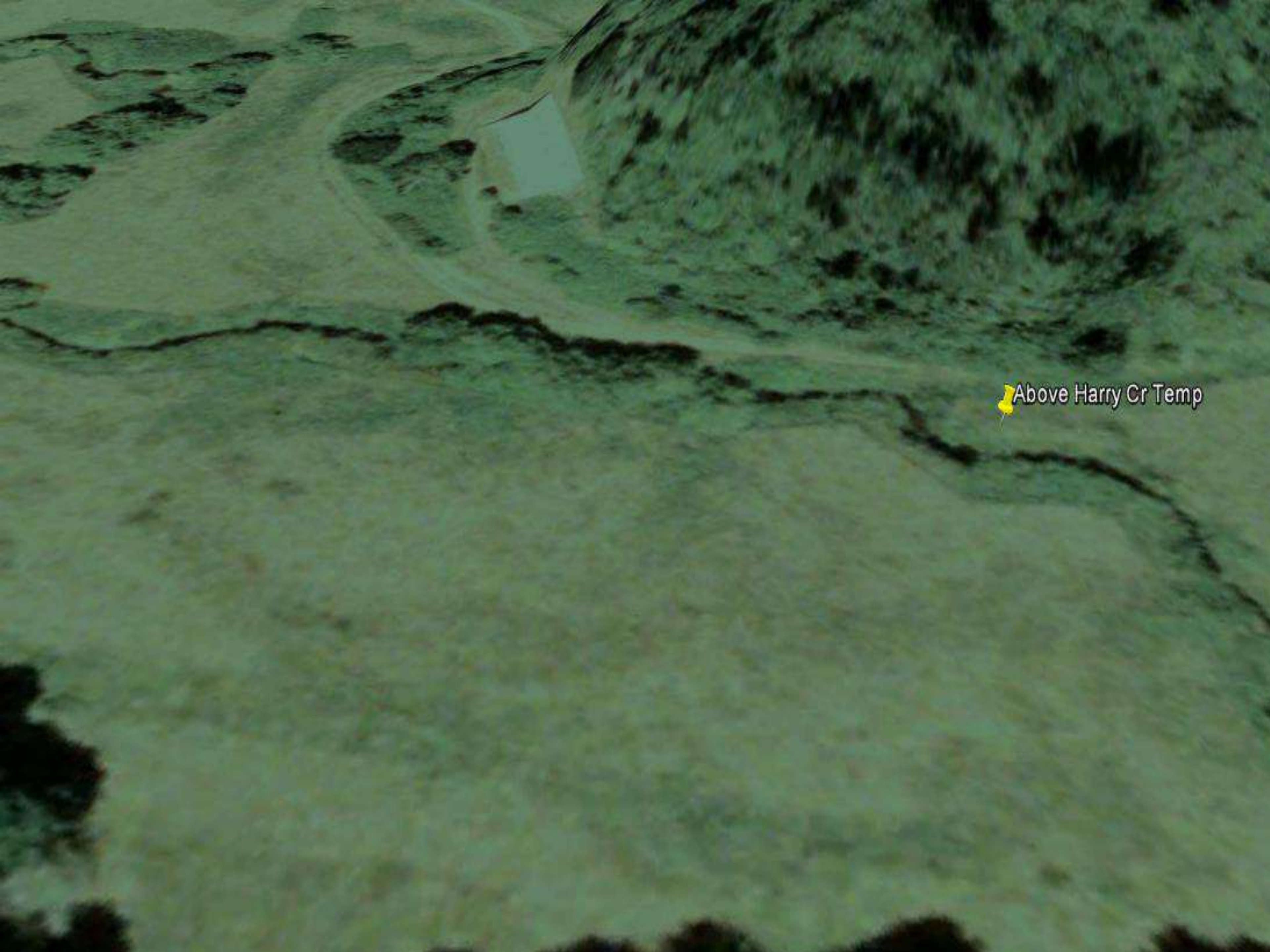

KOBELCO

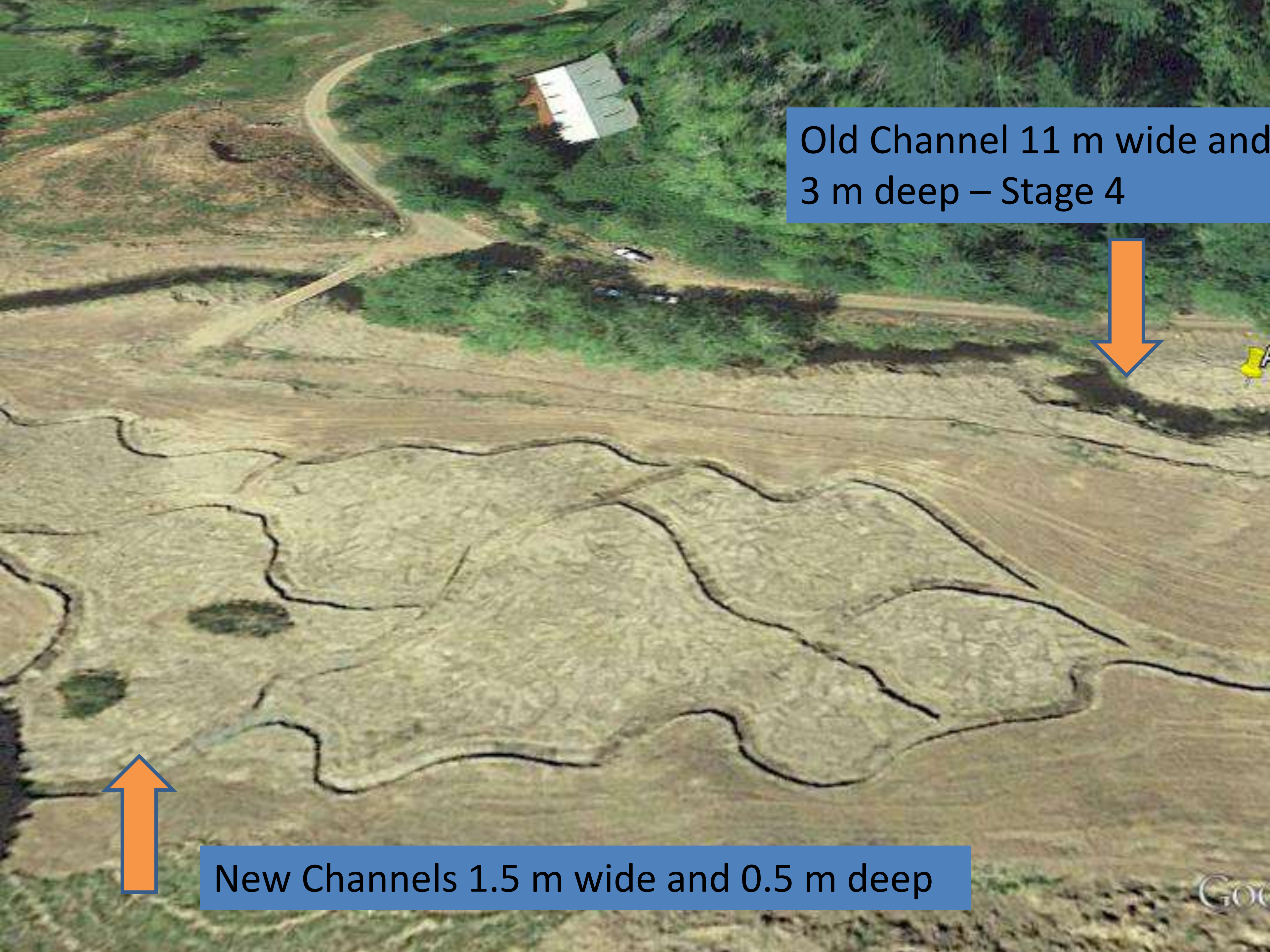

KOBELCO


2014-10-14 09:46:51 M 1/3 13°C
PC900 PROFESSIONAL
RECONYX


2014-10-22 12:00:00 T
15°C
PC900 PROFESSIONAL
RECONYX

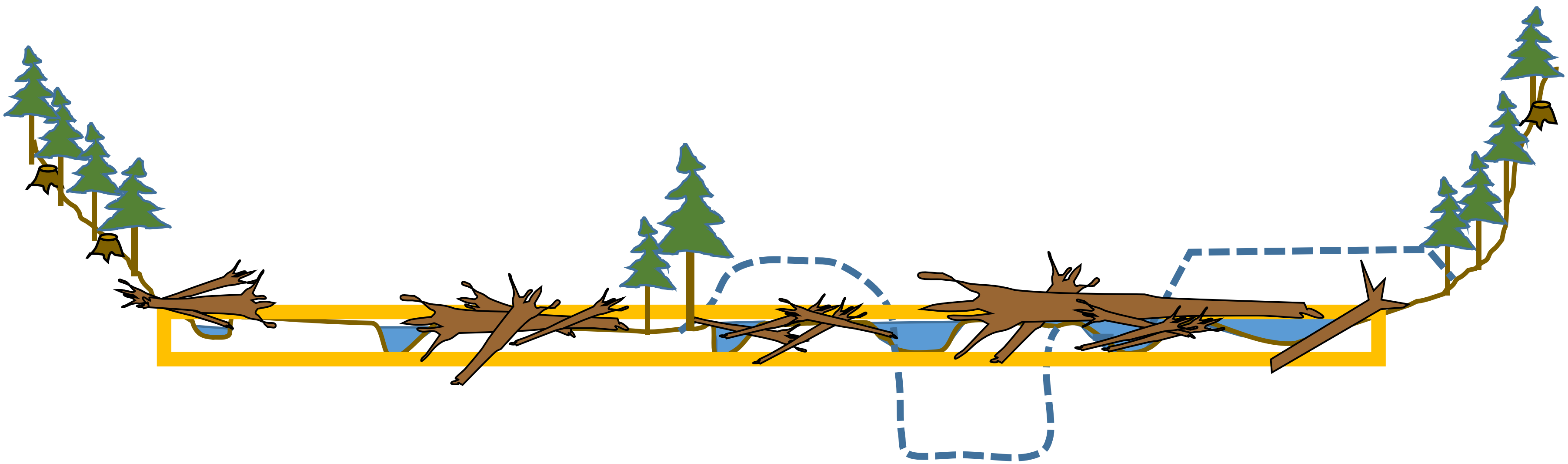

2014-12-20 17:00:00 T
13°C
PC900 PROFESSIONAL
RECONYX


Above Harry Cr Temp


Old Channel 11 m wide and
3 m deep – Stage 4
New Channels 1.5 m wide and 0.5 m deep

Return to Stage 0

Reduction of Stream Power Per Unit Width




KOMATSU


2017-04-06 11:11:14 AM M 2/5
55°F
PC900 PROFESSIONAL
RECONYX

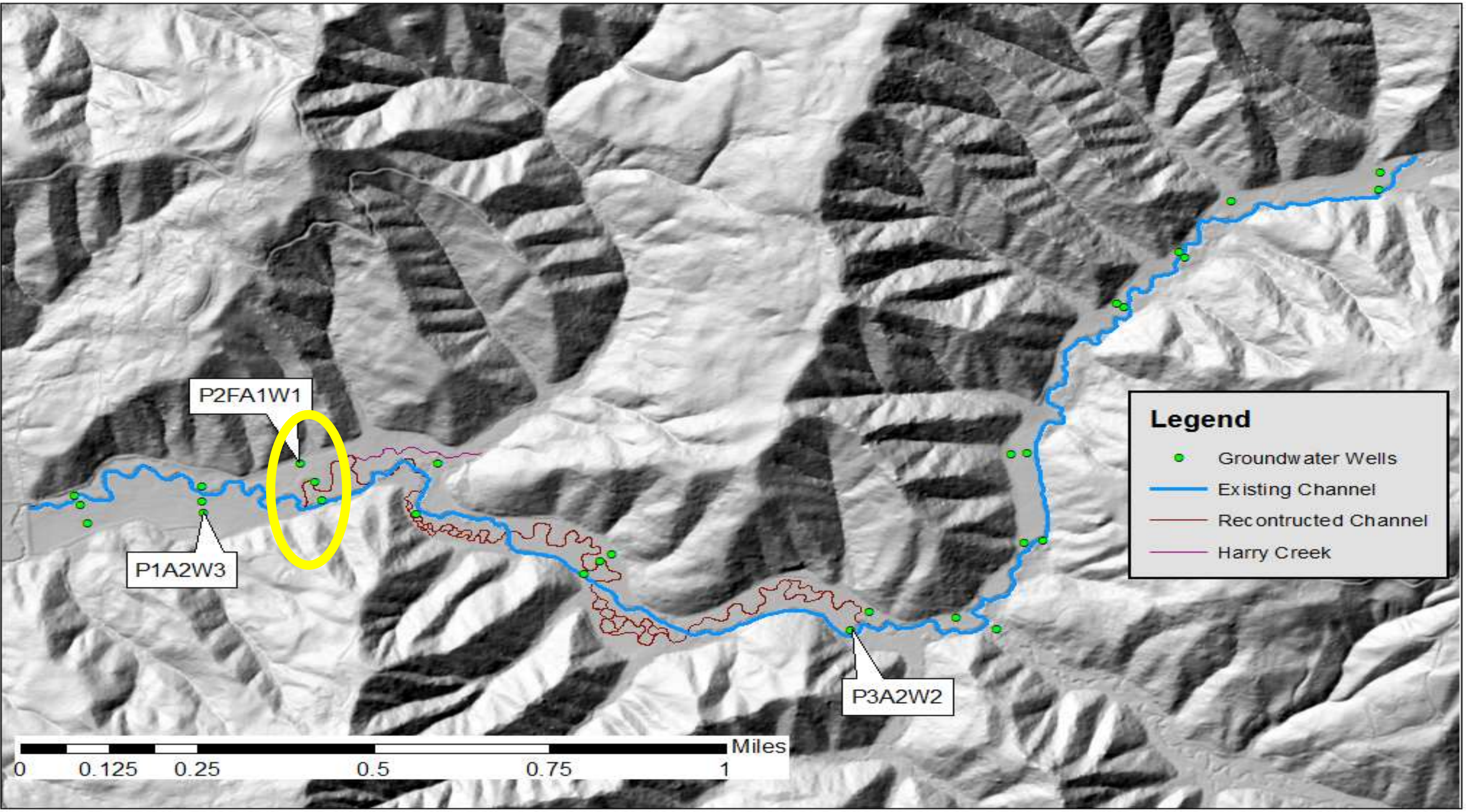

2017-06-07 10:45:00 AM T
68°F
PC900 PROFESSIONAL
RECONYX

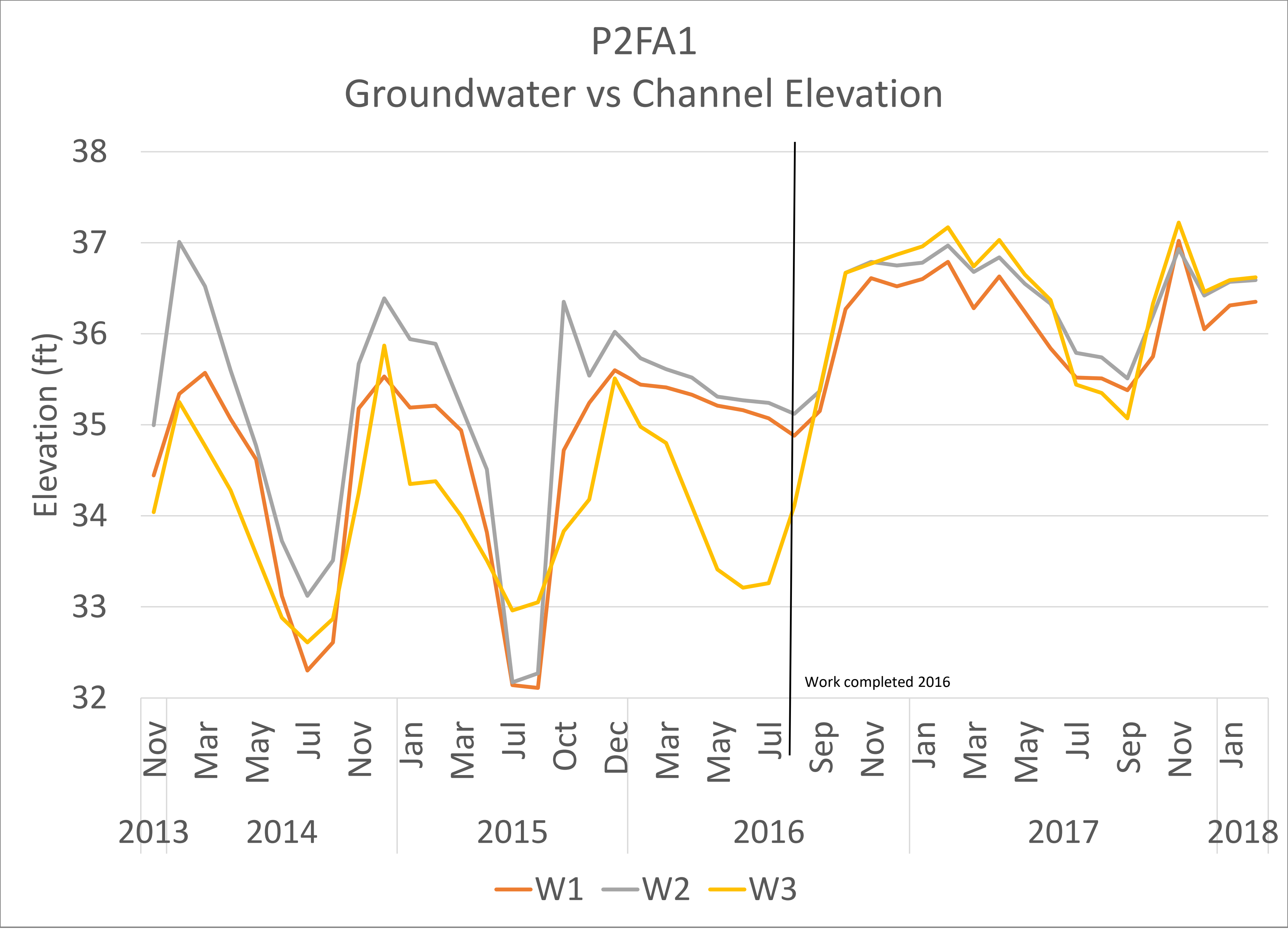

2017-07-27 6:48:46 PM M 1/5
62°F
PC900 PROFESSIONAL
RECONYX


2017-07-27 4:00:00 PM T
74°F
PC900 PROFESSIONAL
RECONYX

- 30,000 lamprey ammocetes
- 15,000 sculpin sp
- 14,000 Western Pearlshell mussels
- 14,000 3 spine stickleback
- 10,000 coho juveniles
- Plus 10 other species

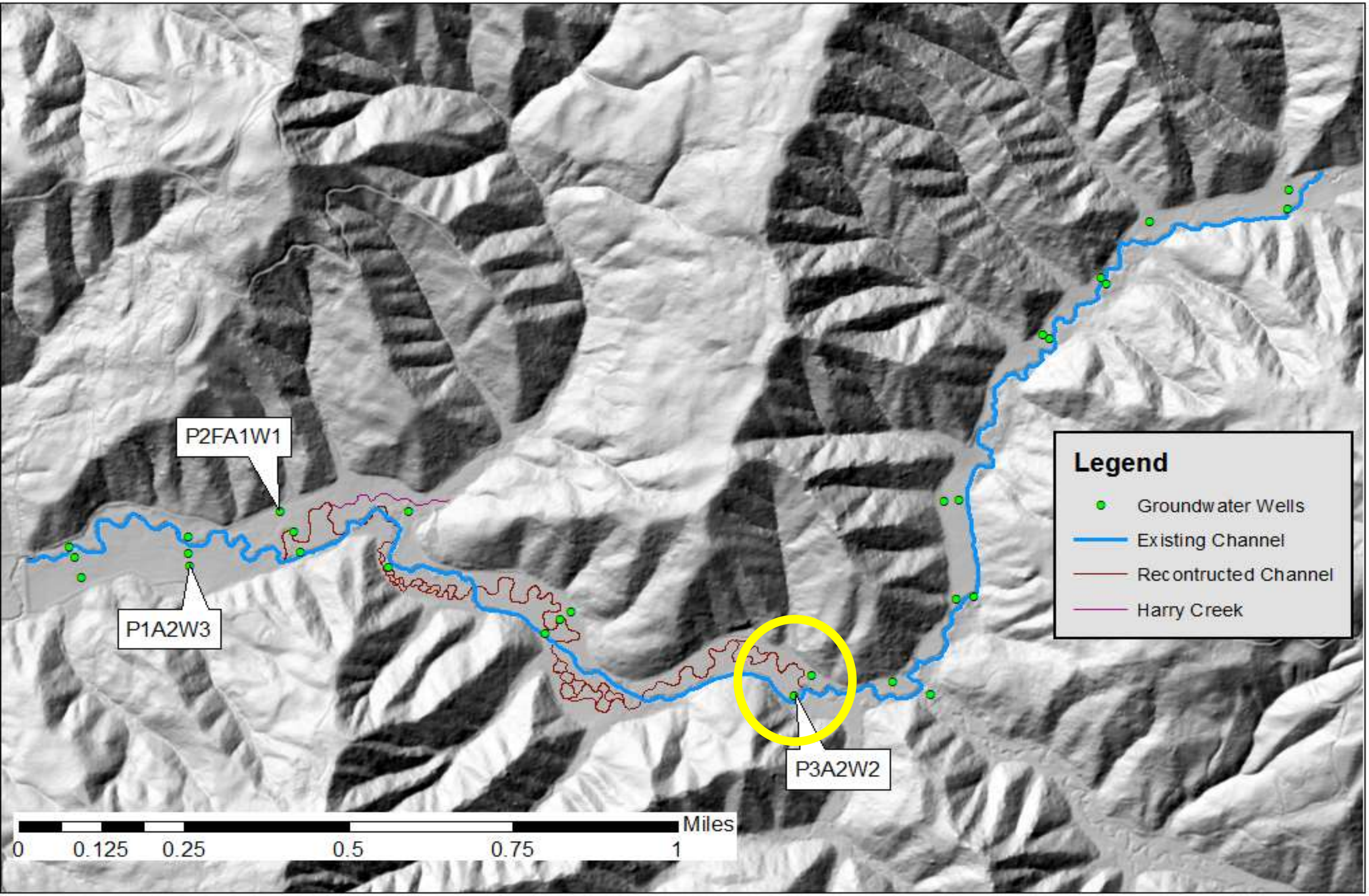
Fivemile/ Bell Groundwater Wells

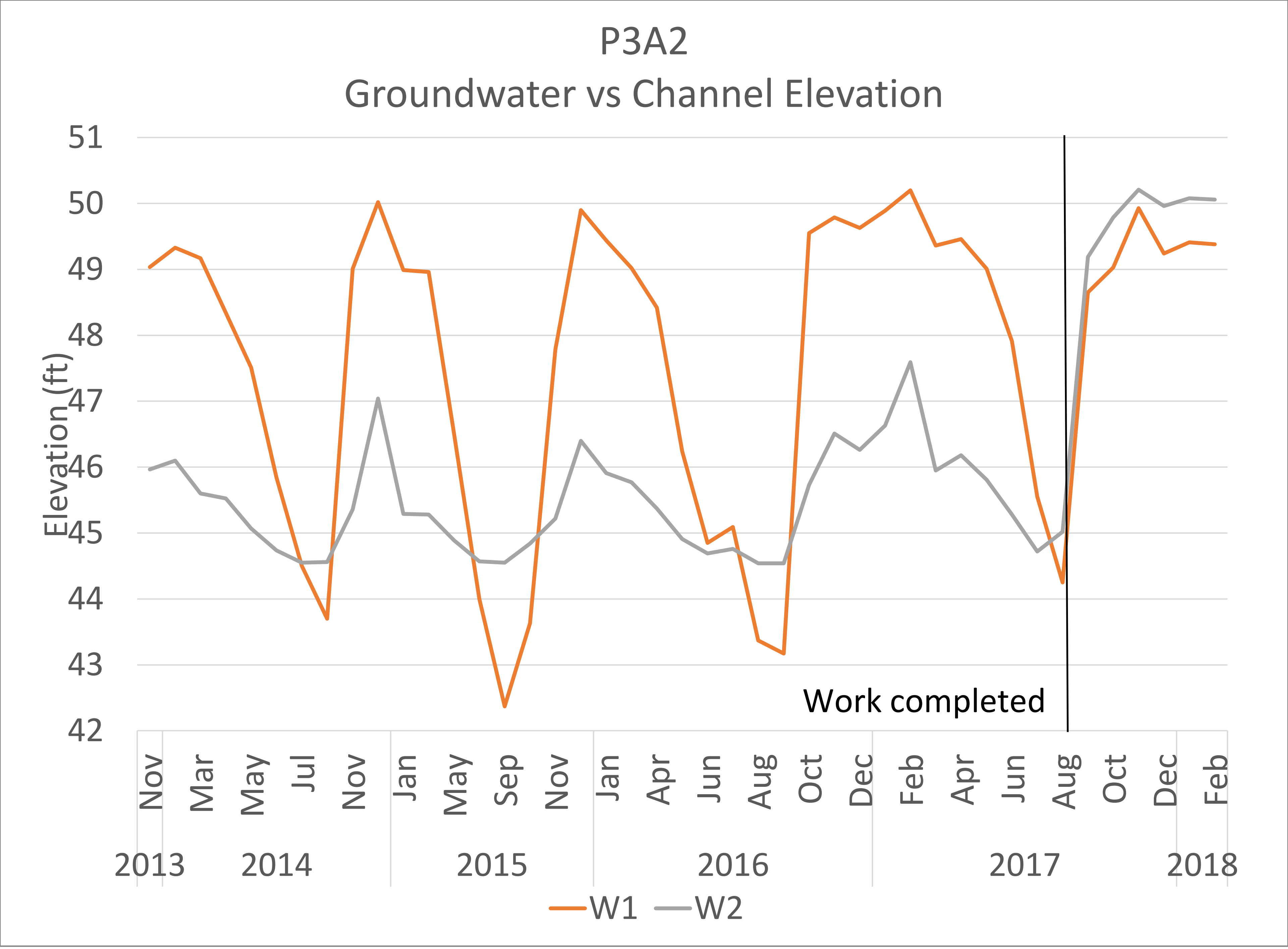




P2FA1
Groundwater vs Channel Elevation
Elevation (ft)
38
37
36
35
34
33
32
Work completed 2016
Nov
Mar
May
Jul
Nov
Jan
Mar
Jul
Oct
Dec
Mar
May
Jul
Sep
Nov
Jan
Mar
May
Jul
Sep
Nov
Jan
2013
2014
2015
2016
2017
2018
W1
W2
W3

Fivemile/ Bell Groundwater Wells





P3A2
Groundwater vs Channel Elevation
Elevation (ft)
51
50
49
48
47
46
45
44
43
42
Work completed
Nov
Mar
May
Jul
Nov
Jan
May
Sep
Nov
Jan
Apr
Jun
Aug
Oct
Dec
Feb
Apr
Jun
Aug
Oct
Dec
Feb
2013
2014
2015
2016
2017
2018
W1
W2


CASE

Main Funders:

USFS: Appropriated $ and Stewardship Retained Receipts

Oregon Watershed Enhancement Board

Pacific Coast Salmon Recovery Funds

Session: Restoring to Stage Zero, Recent Innovations in Restoration Science: Reports from the Field

Design and Implementation of Secondary Channels

in Dry Creek, Sonoma County, California

April 13, 2018

Presented by

Jason Q. White

Restoration Hydrologist

Environmental Science Associates

Session: Restoring to Stage Zero, Recent Innovations in Restoration Science: Reports from the Field

Design and Implementation of Secondary Channels

in Dry Creek, Sonoma County, California

Purpose of Presentation

Share what we've learned about creating perennial secondary channels

Dry Creek Habitat Enhancement Project

Mile 3 Team

ESA

Jason White
ESA

Aaron Fulton
ESA

Ann Borgonovo, PE
ESA

Jorgen Blomberg
ESA

SONOMA COUNTY WATER AGENCY

US Army Corps of Engineers

PRUNUSKE CHATHAM, INC.

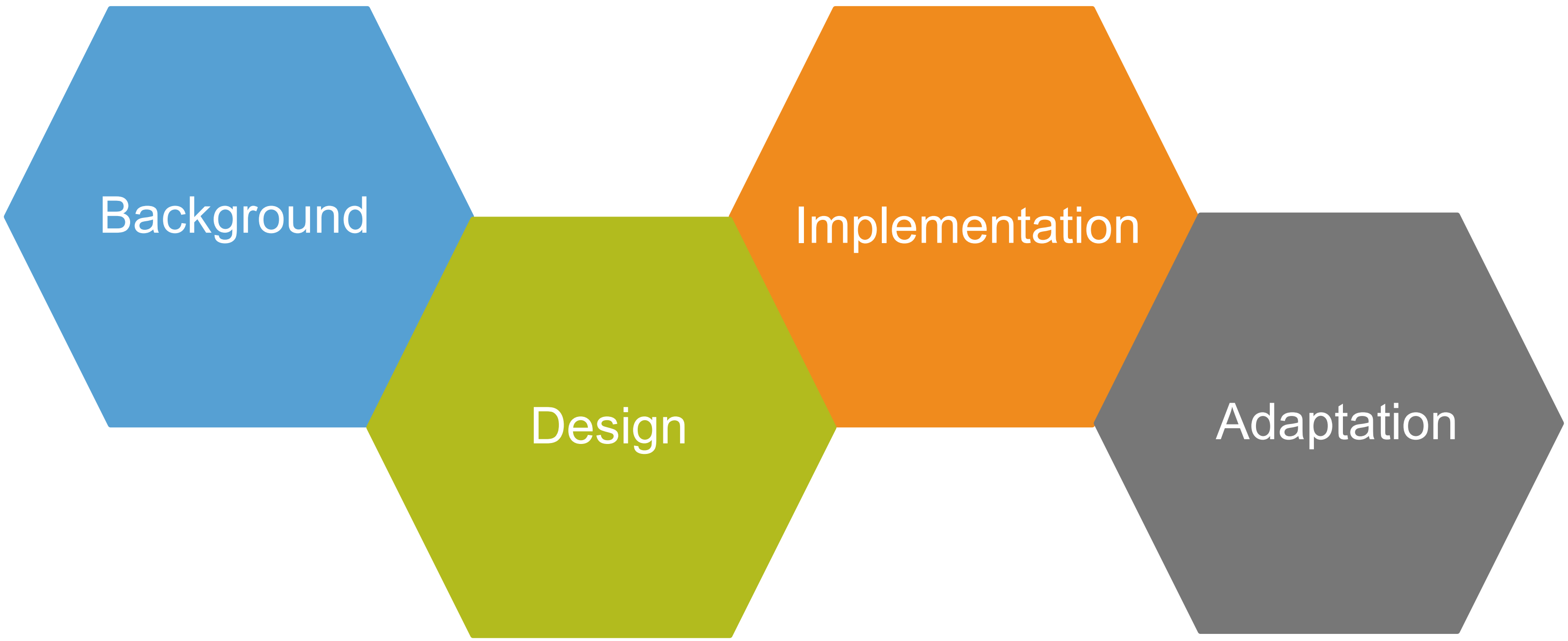
CRAMER FISH SCIENCES
Oregon • California • Washington • Idaho • Alaska

A3GEO

Session: Restoring to Stage Zero, Recent Innovations in Restoration Science: Reports from the Field

Design and implementation of secondary channels

in Dry Creek, Sonoma County, California



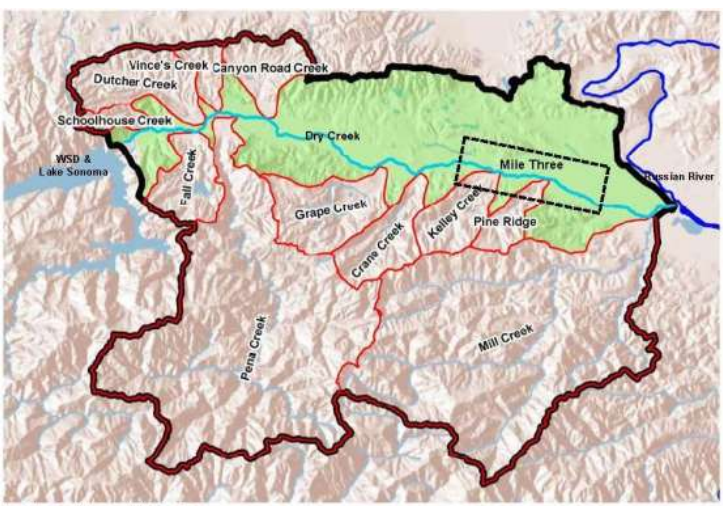
Project Location and Setting

Background

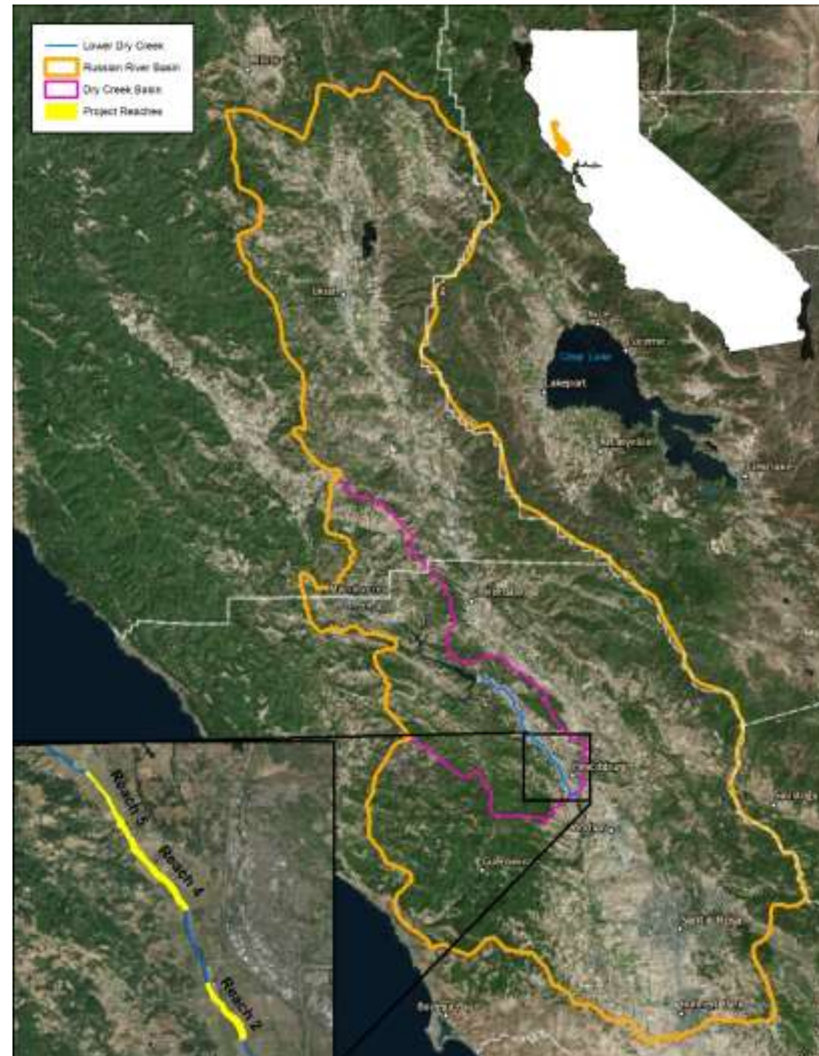
Located in Sonoma County near Healdsburg, California.

Dry Creek is the largest tributary to the Russian River

- Total watershed area of 217 square miles
- Upper 130 square miles dammed by Warm Springs Dam
- Lower 87 square miles undammed



Graphic source: Inter-fluve (2010; 2011)



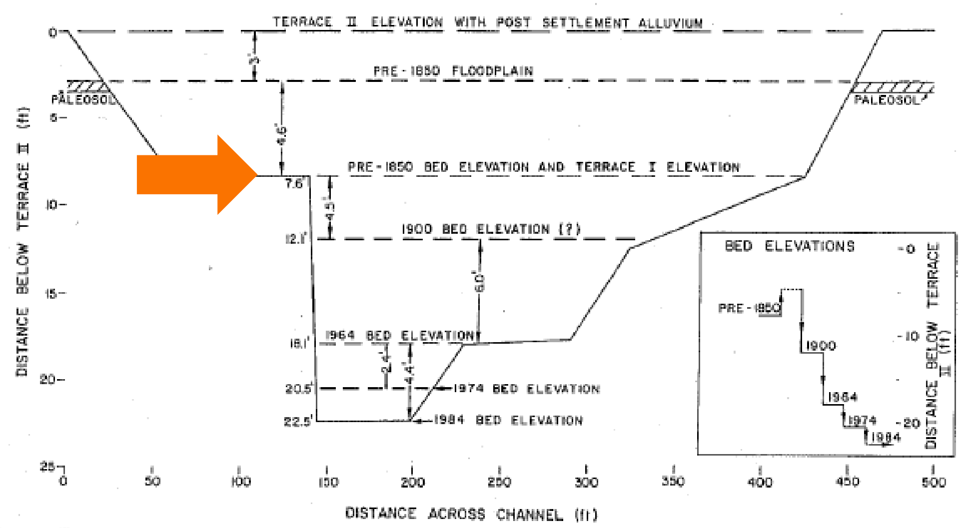
Evolution of Dry Creek:

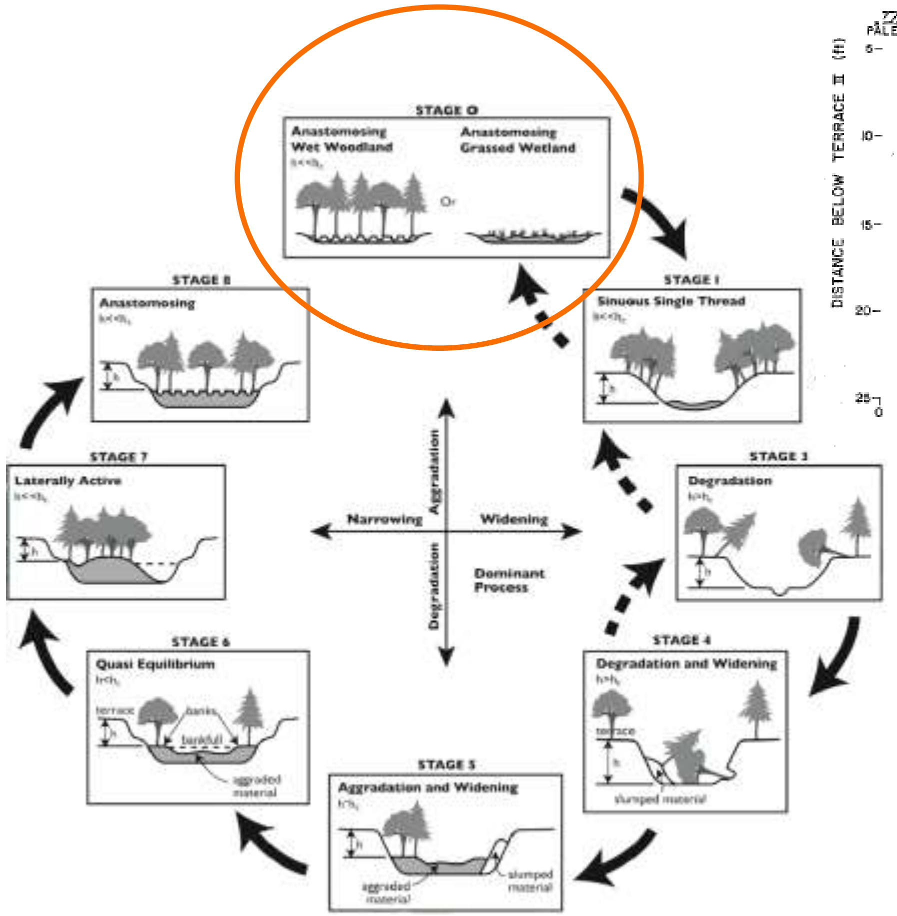
Pre-1850's:

Undisturbed Alluvial Valley Stage 0?

Background

Harvey and Schumm (1985)





Cluer and Thorne (2013)

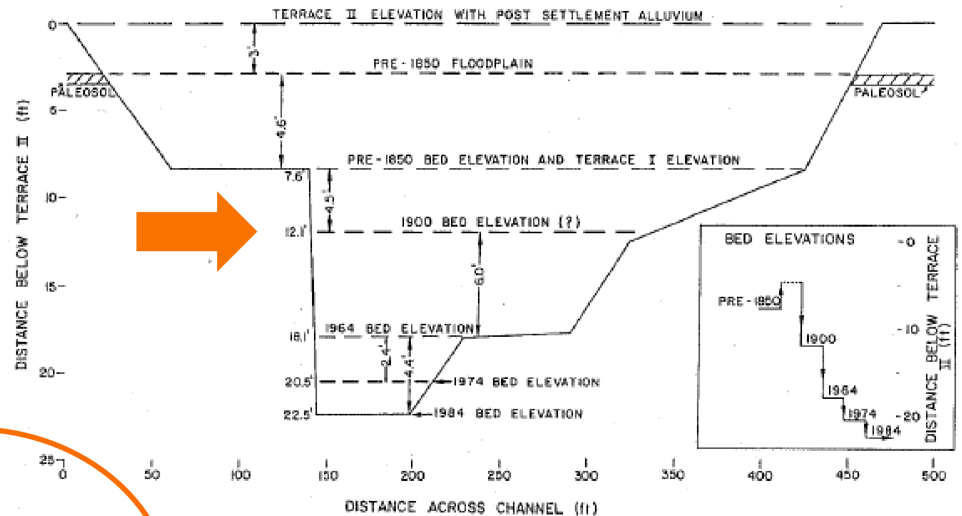
Evolution of Dry Creek:

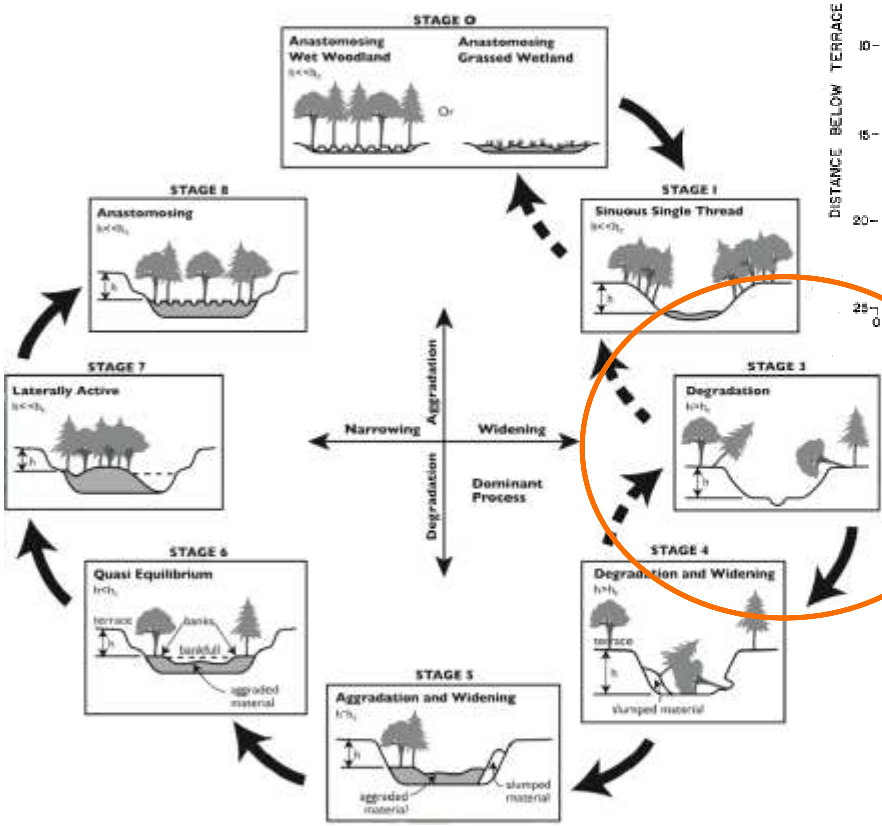
1850's-1900's:

Cattle grazing ⇨ Increased runoff ⇨ Degredation

Background

Harvey and Schumm (1985)





Cluer and Thorne (2013)

Evolution of Dry Creek:

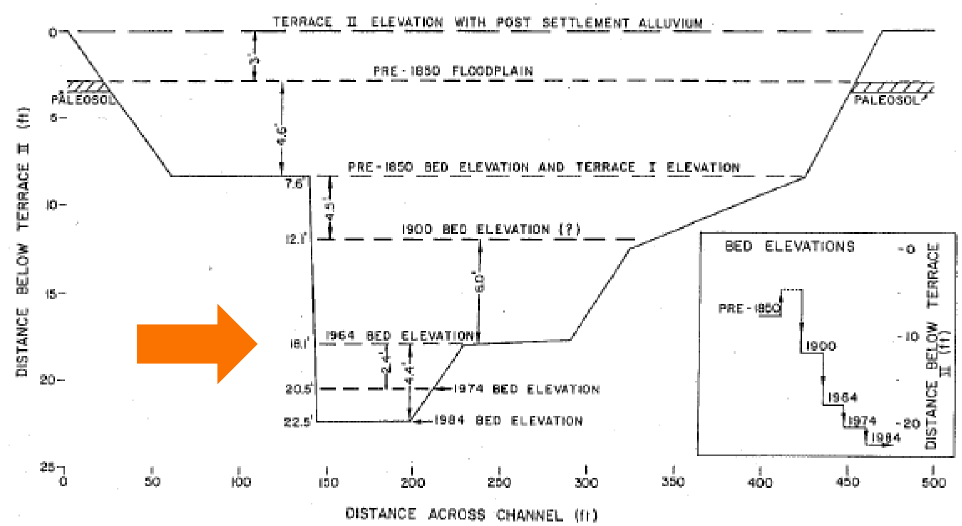
1900's-1980's:

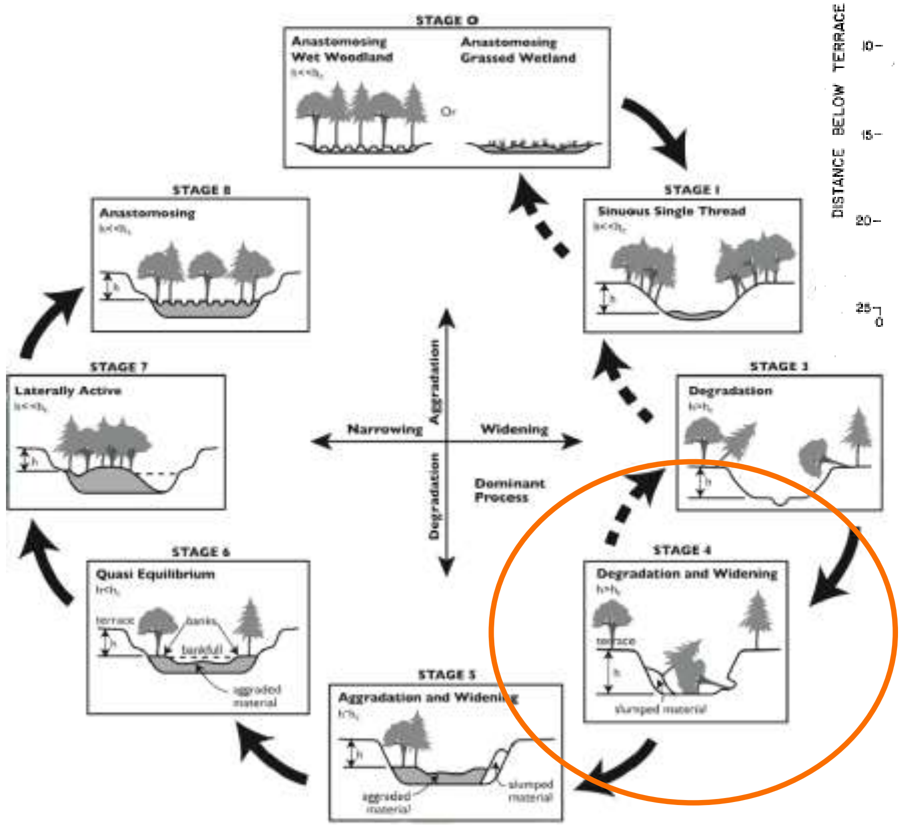
Gravel mining ⇨ Base level lowering ⇨

Degradation & widening

Background

Harvey and Schumm (1985)



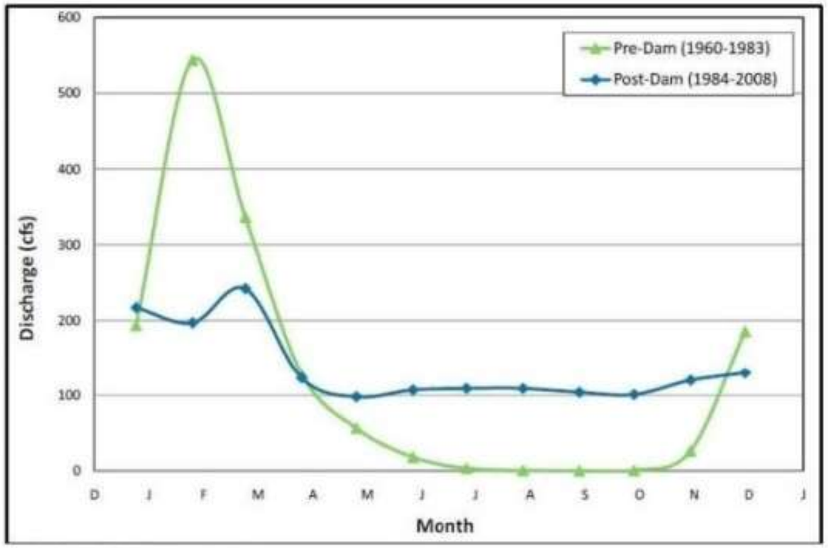


Cluer and Thorne (2013)

1984 - Warm Springs Dam Built

Change in hydrology ⇨ Vegetation

Background



Reprinted from Inter-Fluve, 2010

Comparison of Monthly Median Discharges for Pre- and Post-dam Periods at Yoakim Bridge (USGS No. 11465200)

Dry Creek Pre-Dam

Dry Creek 1981 (image source: USACE, 1981)

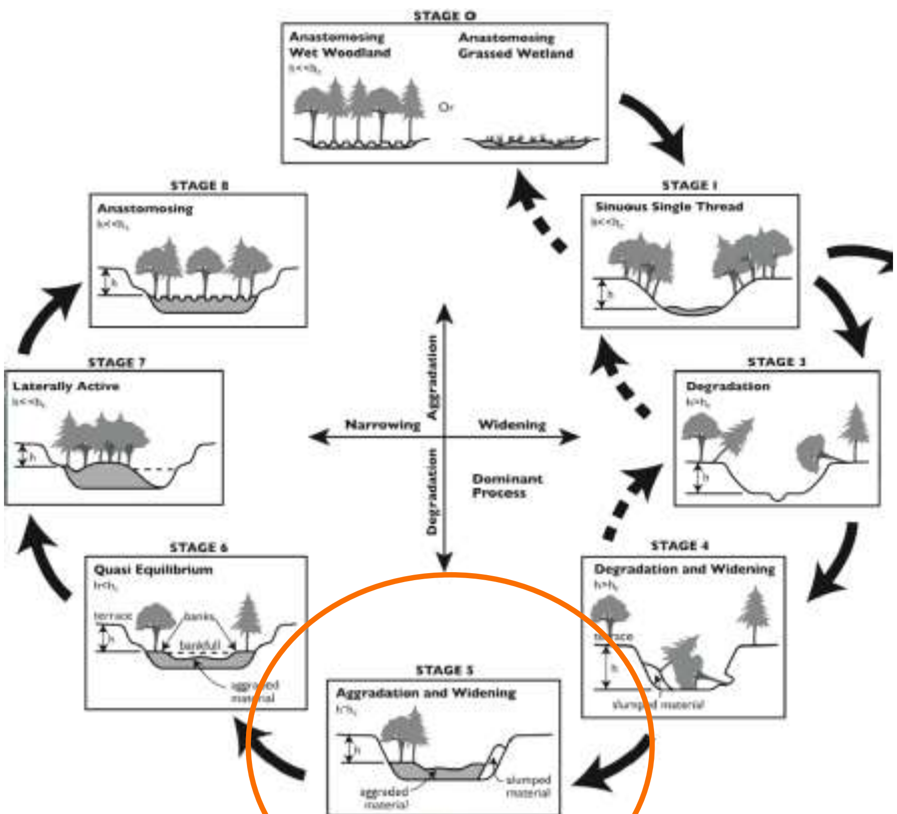
Dry Creek Post-Dam

Dry Creek Present (image source: Google Earth)

Evolution of Dry Creek:

1984-Present Day:
Vegetation establishment ⇨ Aggradation

Background



Stream Evolution Model: Cluer and Thorne (2013)

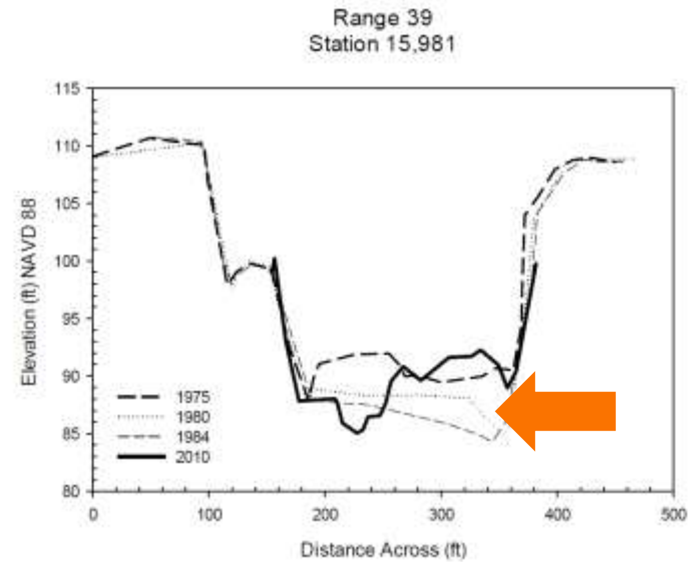


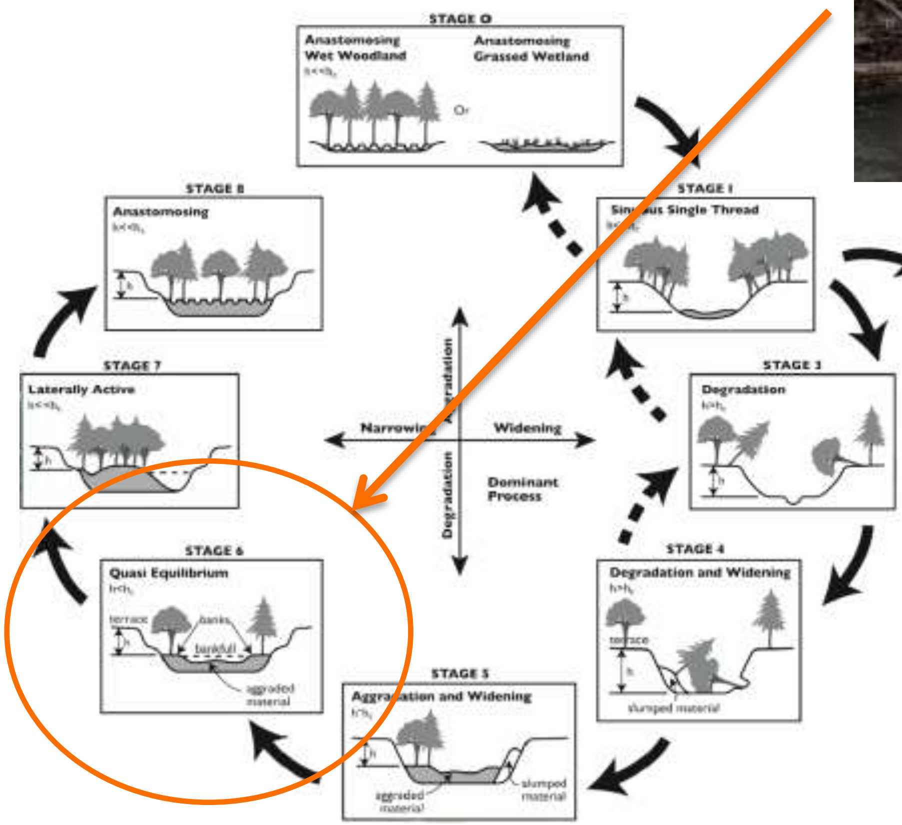
Figure 14a-b. Repeat surveys of degradation ranges 27 and 39. Station is distance upstream of the Russian River confluence, in feet.

Evolution of Dry Creek:

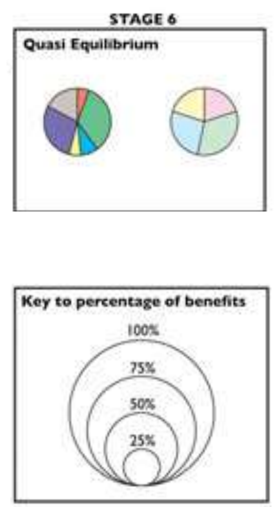
Present Day Conditions:

Aggradation stabilized by vegetation ⇨ Stage 6

Background



Stream Evolution Model: Cluer and Thorne (2013)



- Poorly connected off-channel habitat
- Channel is long, uniform glides
- Lacks bedform and hydraulic complexity
- Less than ideal habitat conditions for rearing Coho and Steelhead

Dry Creek Habitat Enhancement Project

Background

Biological Opinion:

- Important to the recovery of Coho salmon and Steelhead in the region
- Lacks riffle-pool habitat

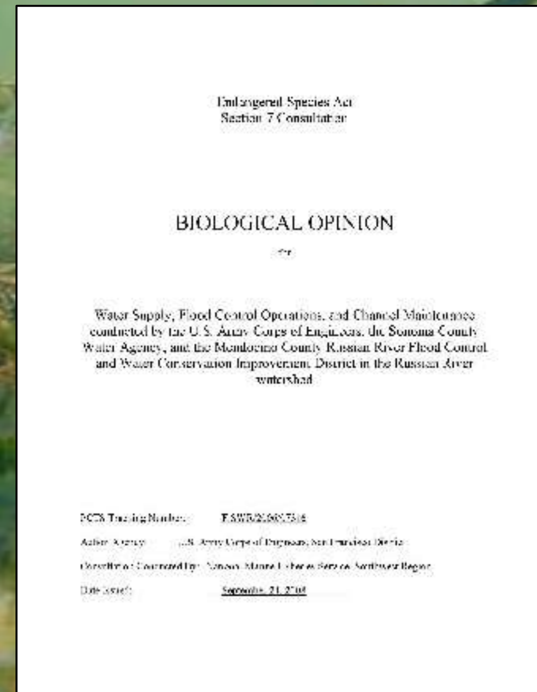
Enhancement more cost effective than water supply pipeline

Project Goal:

Enhance lower Dry Creek for summer rearing juvenile Coho salmon and Steelhead trout

Project Objective:

Increase pool-riffle habitat that meets ‘near-ideal’ conditions for Coho salmon and Steelhead


Endangered Species Act
Section 7 Consultation

BIOLOGICAL OPINION

Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed

SONOMA COUNTY WATER AGENCY

US Army Corps of Engineers

(Photo courtesy of SCWA)

BO and AMP “Near Ideal” Coho Rearing Conditions

Background

Habitat Conditions

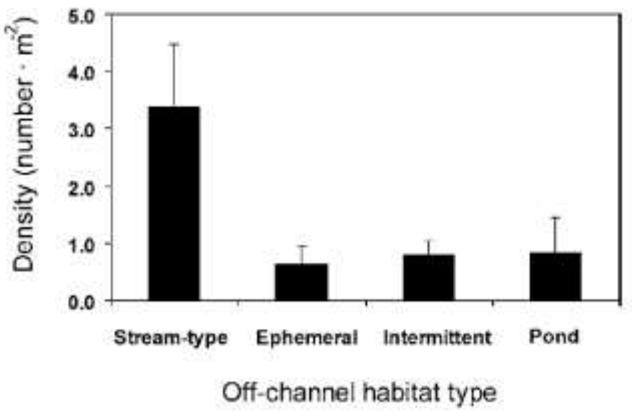
- Depth 0.5 – 4 feet
- Velocity 0 – 0.5 feet/sec
- Adequate shelter/cover
- Good water quality (DO & Temp)

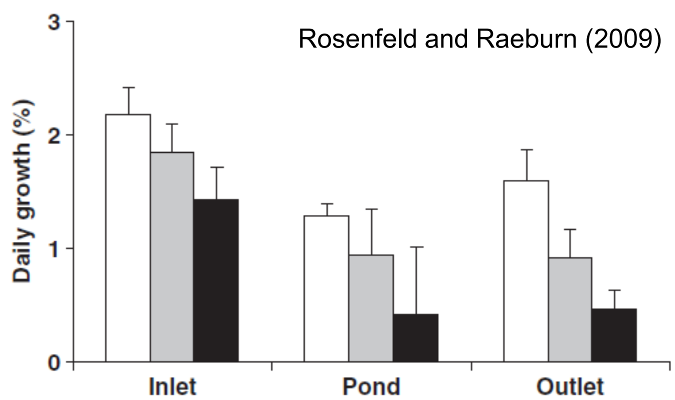
Habitat Type

- Pool to riffle ratio 1:2 to 2:1
- Off-channel
  - Summer preference
    - **Stream type habitat**
    - **Flowing inlet**

➡ **Secondary Channel**

Rosenfeld et al. (2008)





Dry Creek Habitat Potential

Background

- Multiple channels, known as anabranching, were once common in Dry Creek
- Dense vegetation limits natural disturbance and geomorphic processes that form secondary channels

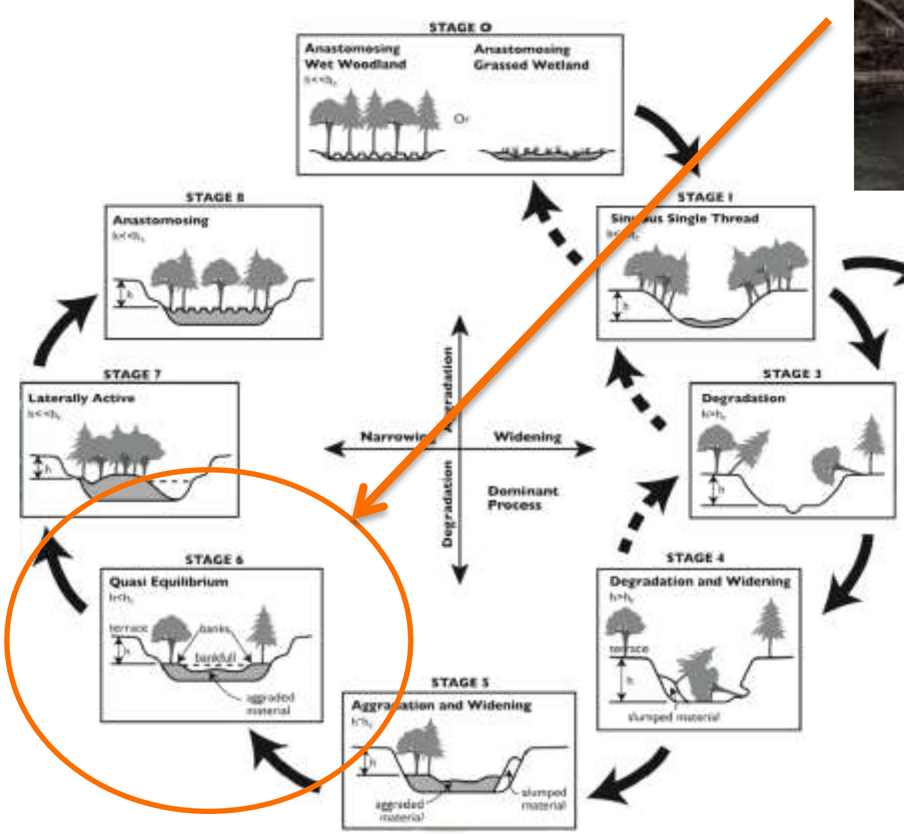
Dry Creek 1981 (image source: USACE, 1981)

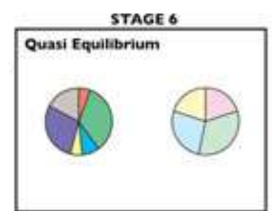
Dry Creek Present (image source: Google Earth)

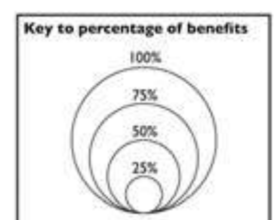
Dry Creek Evolution:

Enhancement Concept → Jump Start from Stage 6

Background





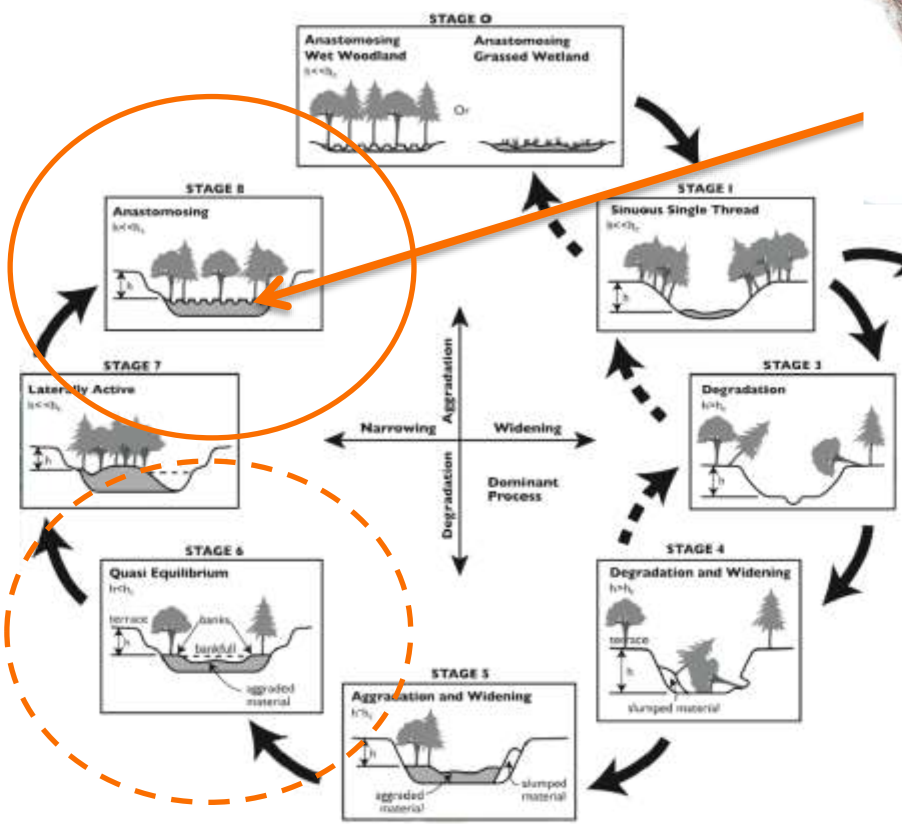


Cluer and Thorne (2013)

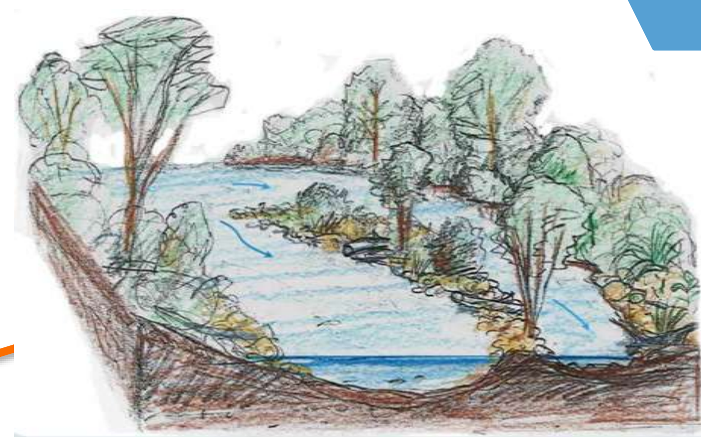
Dry Creek Evolution:

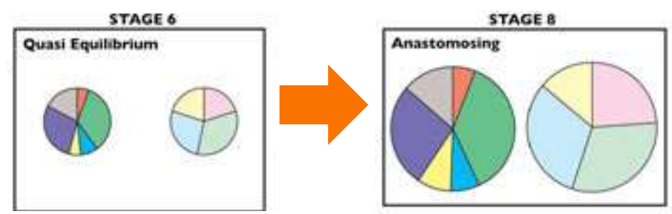
Enhancement Concept → to Stage 8

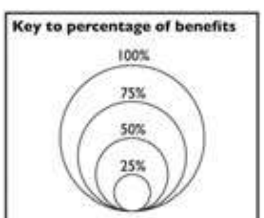
Background



Stream Evolution Model: Cluer and Thorne (2013)







Design

Geomorphic Design Approach

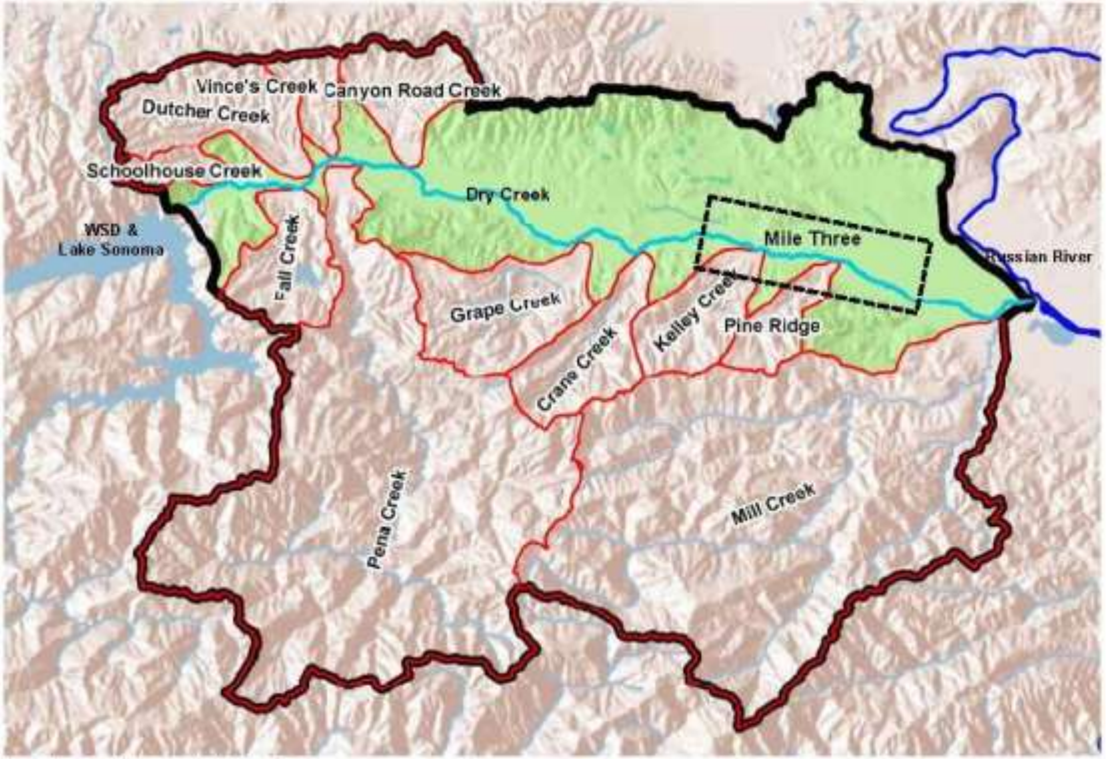
- Unlock geomorphic processes by actively removing dense vegetation and carving new secondary channels
- Secondary channels designed to provide dynamic and complex riffle-pool habitat that meets project objectives through diverse hydraulic conditions
- Secondary channels designed using an approach that applies geomorphic processes at various scales

Watershed Scale: Sediment Supply

Design

Process: *High sediment supply from undammed watershed*

- **Application**: Create dynamic features that route and utilize sediment



Reprinted, with modifications, from Inter-Fluve, 2012

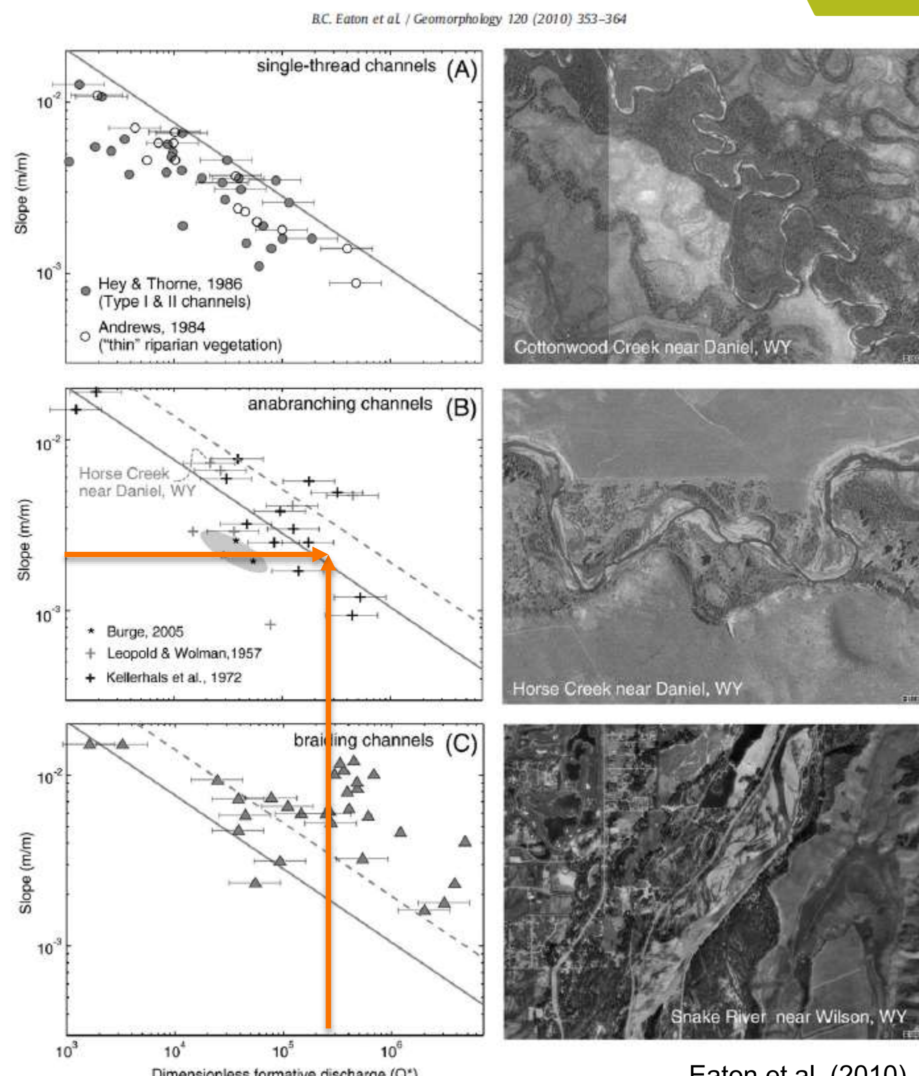
graphic from Inter-fluve (2010; 2011)

Segment Scale: Anabranching

Design

Process: *Lower segment of Dry Creek falls within the anabranching threshold*

- **Approach**: Use available space to create multi-threaded channels



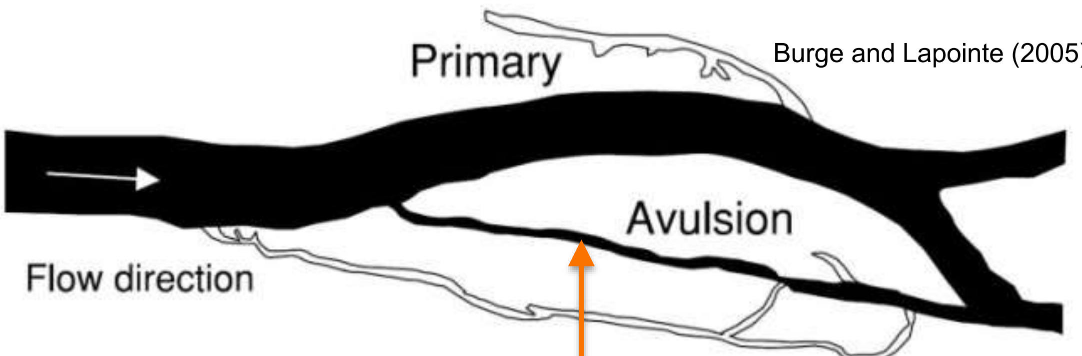
Eaton et al. (2010)

Reach Scale: Secondary Channel

Design

Process: *Secondary channels form through avulsion into abandoned channels*

- **Approach**: Align through existing abandoned channels and low lying areas

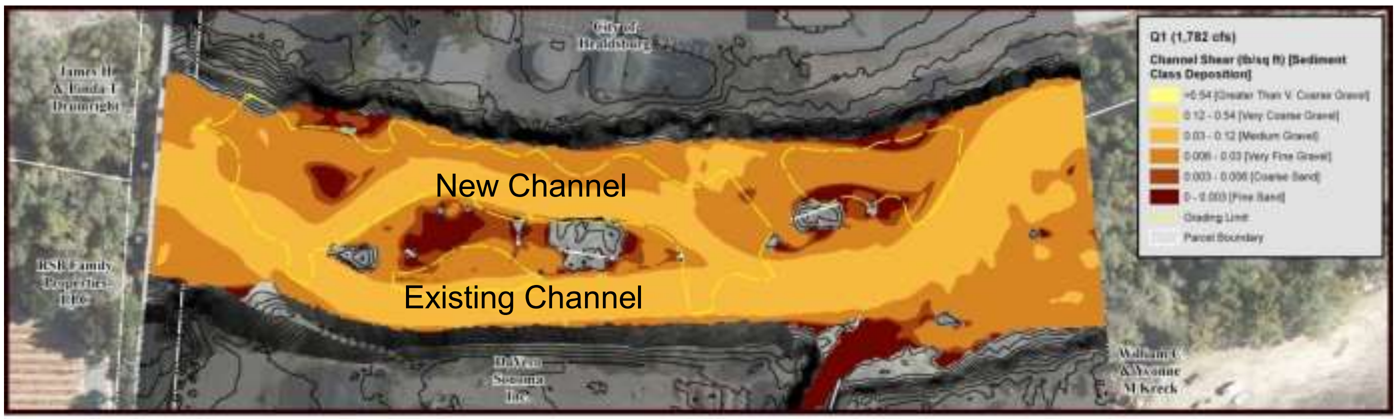


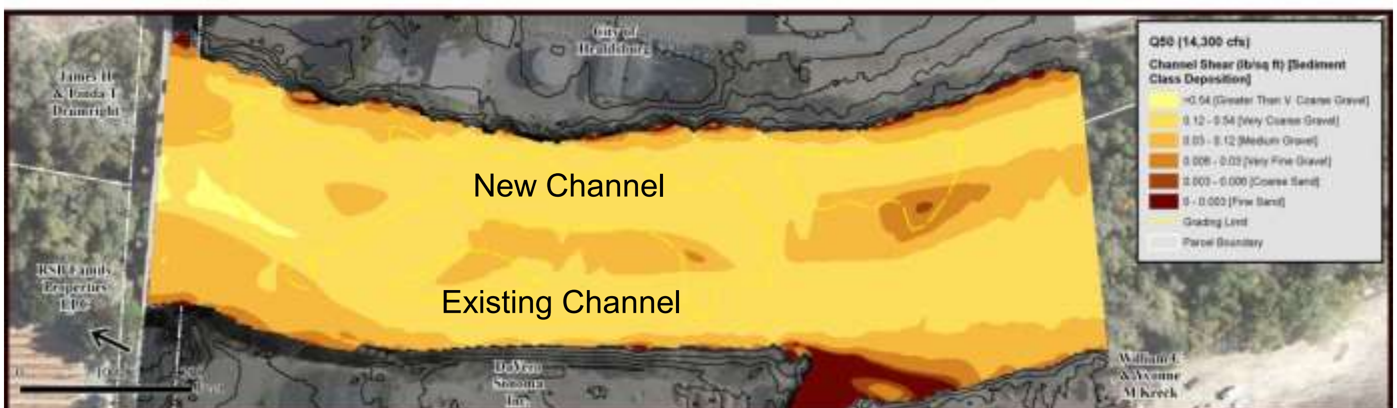
Reach Scale: Secondary Channel

Design

Process: *Secondary channels adjust until sediment transport energy equilibrates*

- **Approach**: Match sediment transport energy between branches for high flows (1-year through 100-year)





Morphologic Unit Scale: Bifurcation

Design

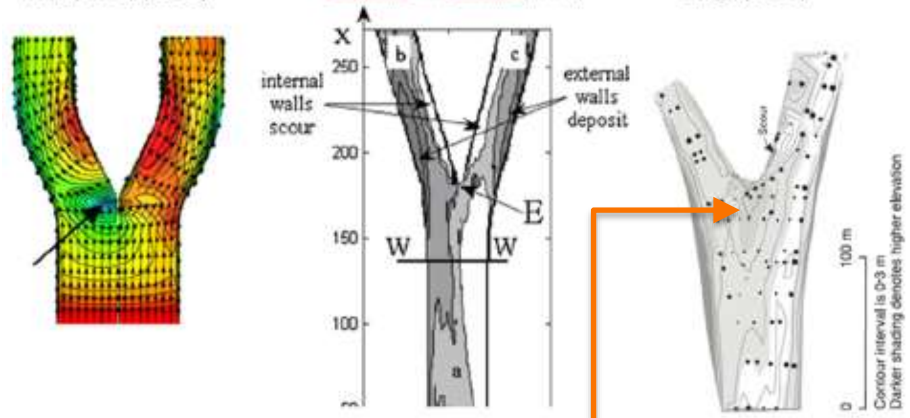
Process: *Bifurcations experience deposition upstream of the flow split*

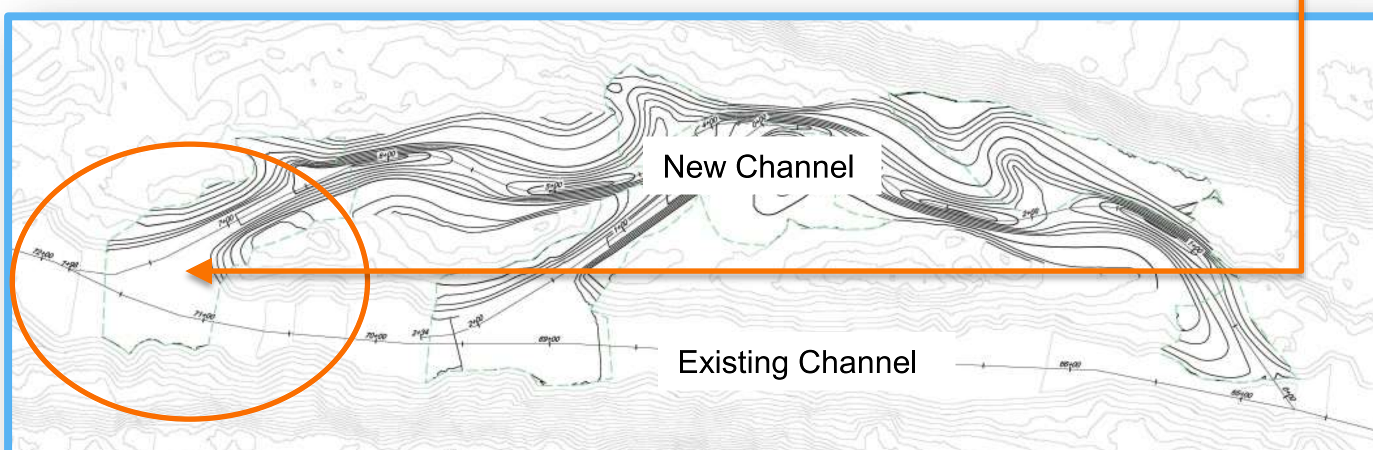
- **Approach**: Create expansive bifurcation at main channel riffle

Hydrodynamics
Hardy et al. (2011)

Morphodynamics
Bertoldi and Tubino (2007)

Topo Survey
Burge (2006)





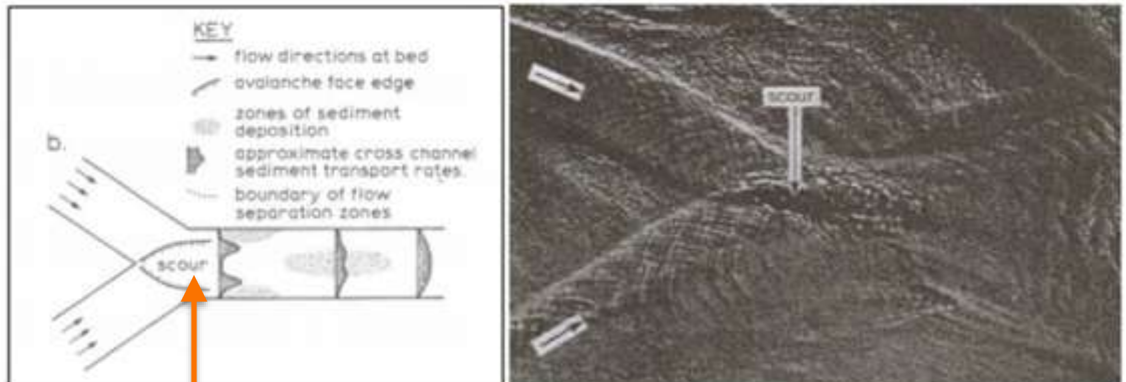
Morphologic Unit Scale: Confluence

Design

Process: *Confluences cause scour with deposition downstream*

- **Approach**: Return secondary channel into main channel at a pool just upstream of riffle

Best (1986)



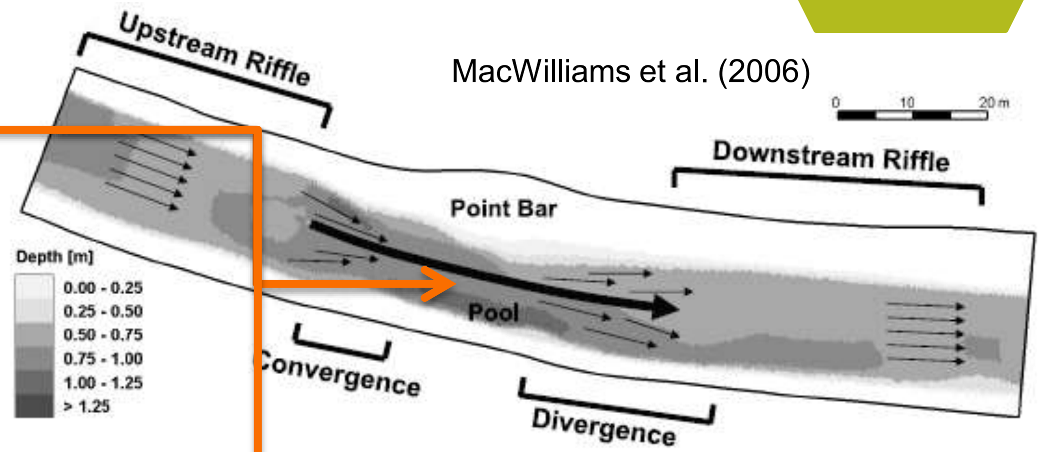
Morphologic Unit Scale: Pool

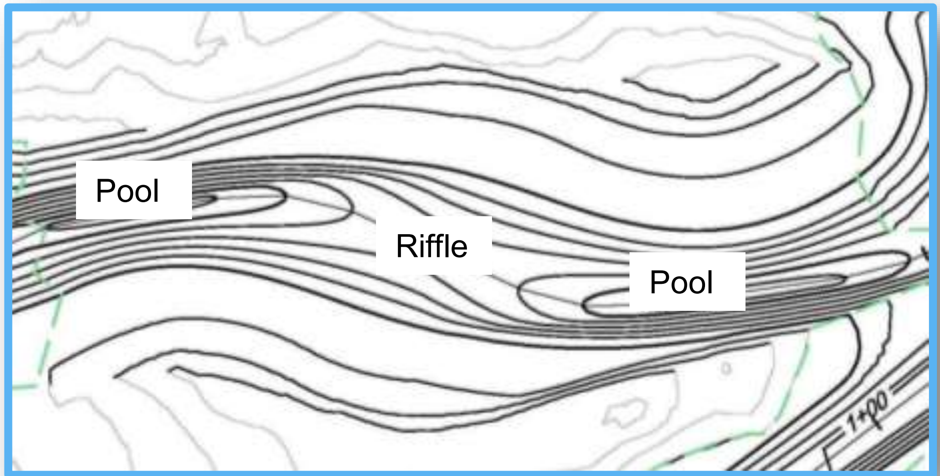
Design

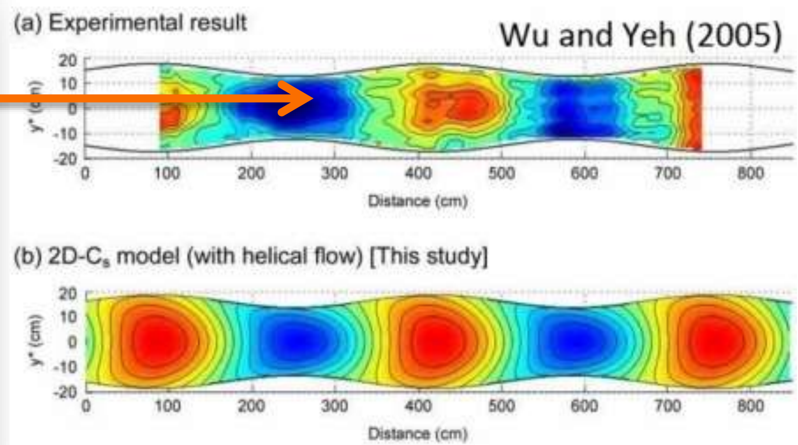
***Process:** Pools are maintained where channel narrows through flow convergence*

- **Approach**: Constrict channel width at pools

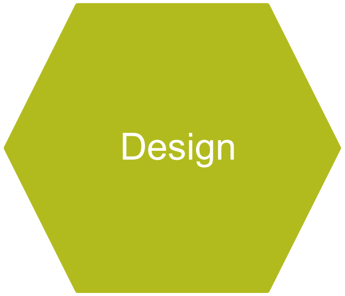
MacWilliams et al. (2006)







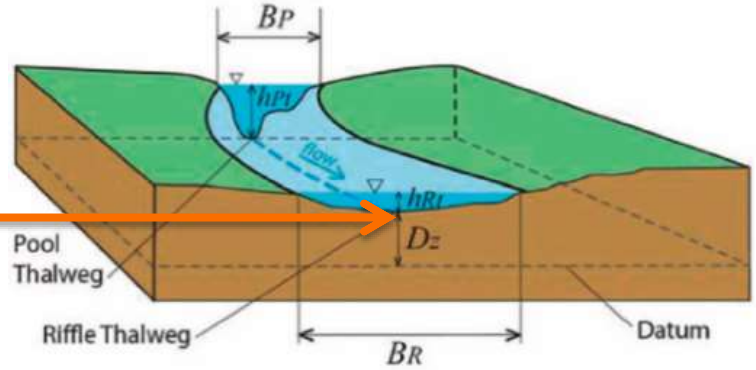
Morphologic Unit Scale: Riffle

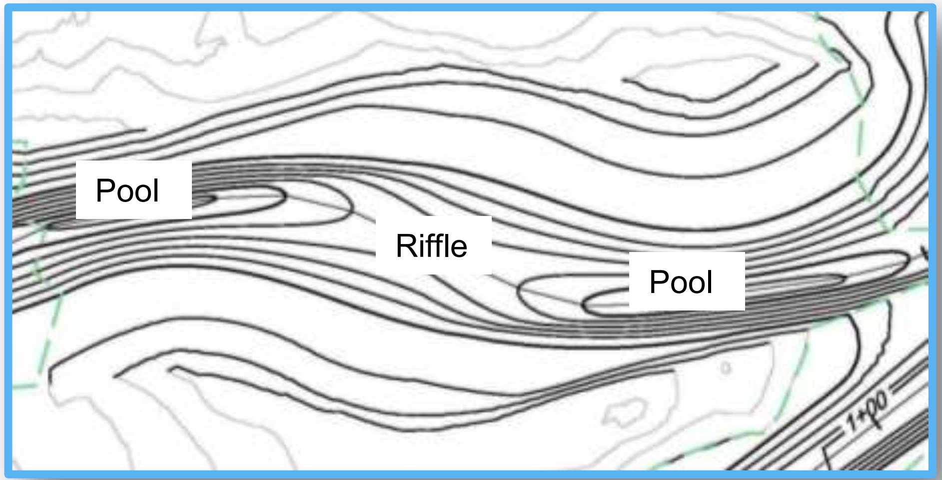


Process: *Riffles are maintained where channel widens relative to pools through flow divergence*

- **Approach**: Widen channels at riffles

Caamano et al. (2009)



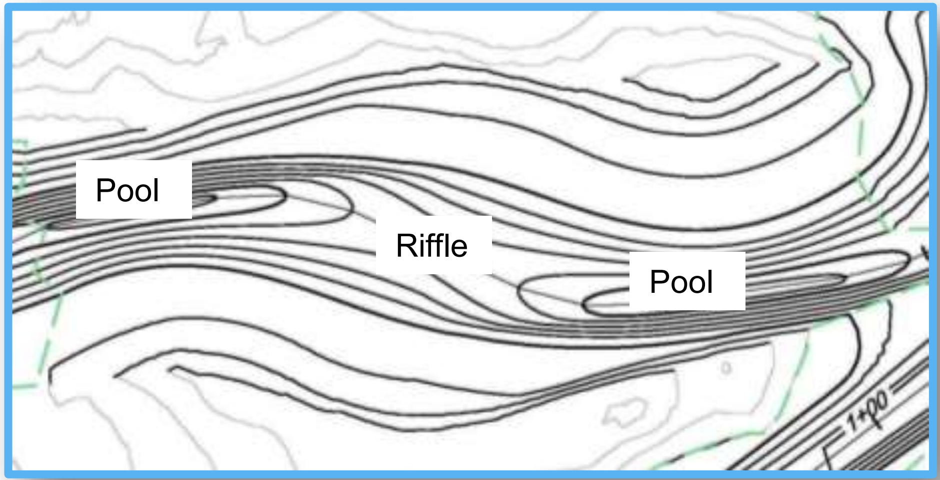


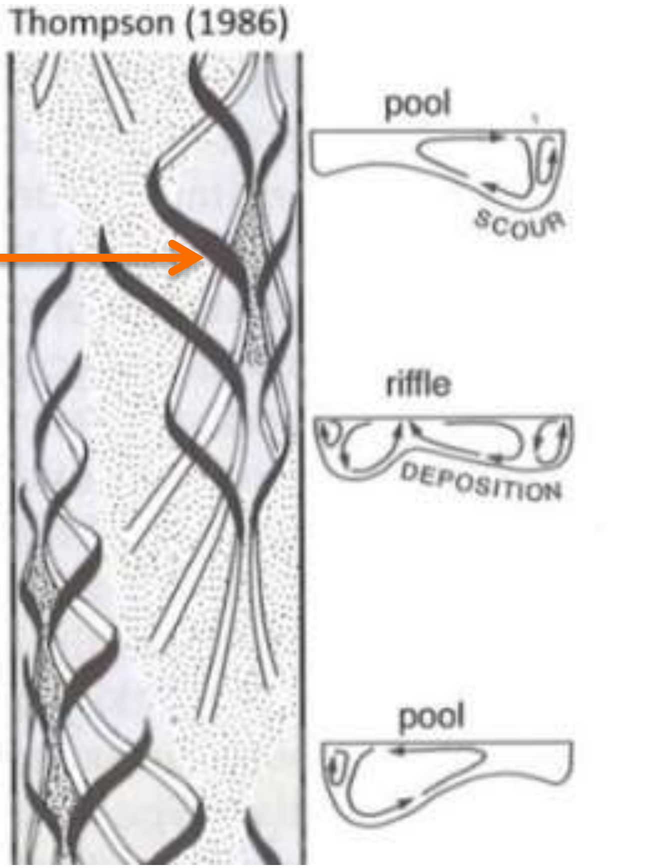
Morphologic Unit Scale: Meander Bend

Design

Process: *Meandering creates helical flow cells that route sediment away from pools and deposits on riffles.*

- **Approach:** Meander channel in synch with riffles and pools





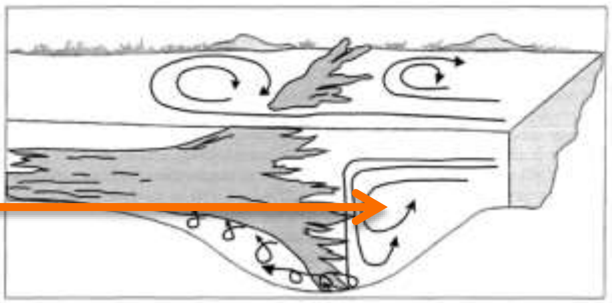
Hydraulic Unit Scale: Large Wood

Design

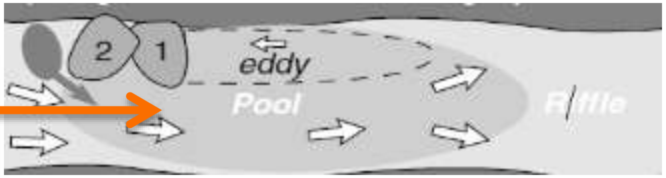
Process: *Large Wood creates scour through turbulence and constriction*

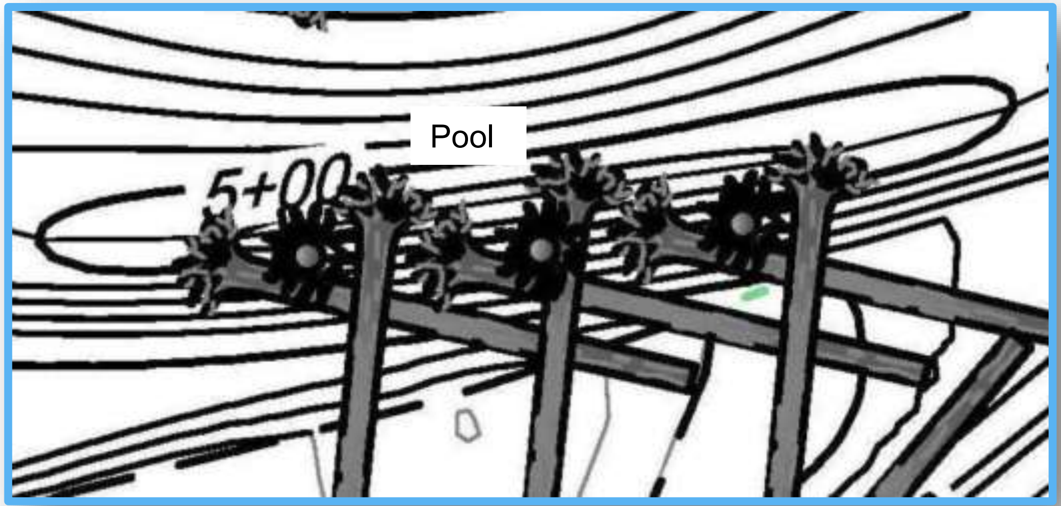
- **Approach**: Place large wood in pools

Woodsmith and Hassan (2005)



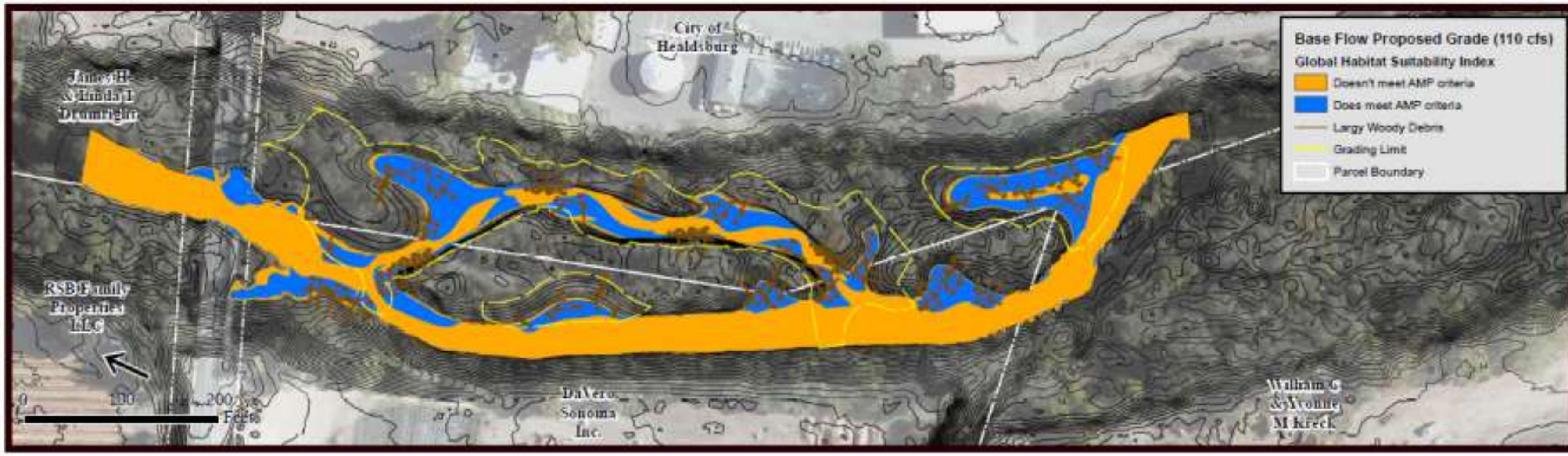
Thompson (2001)





Enhancement Final Design

Design



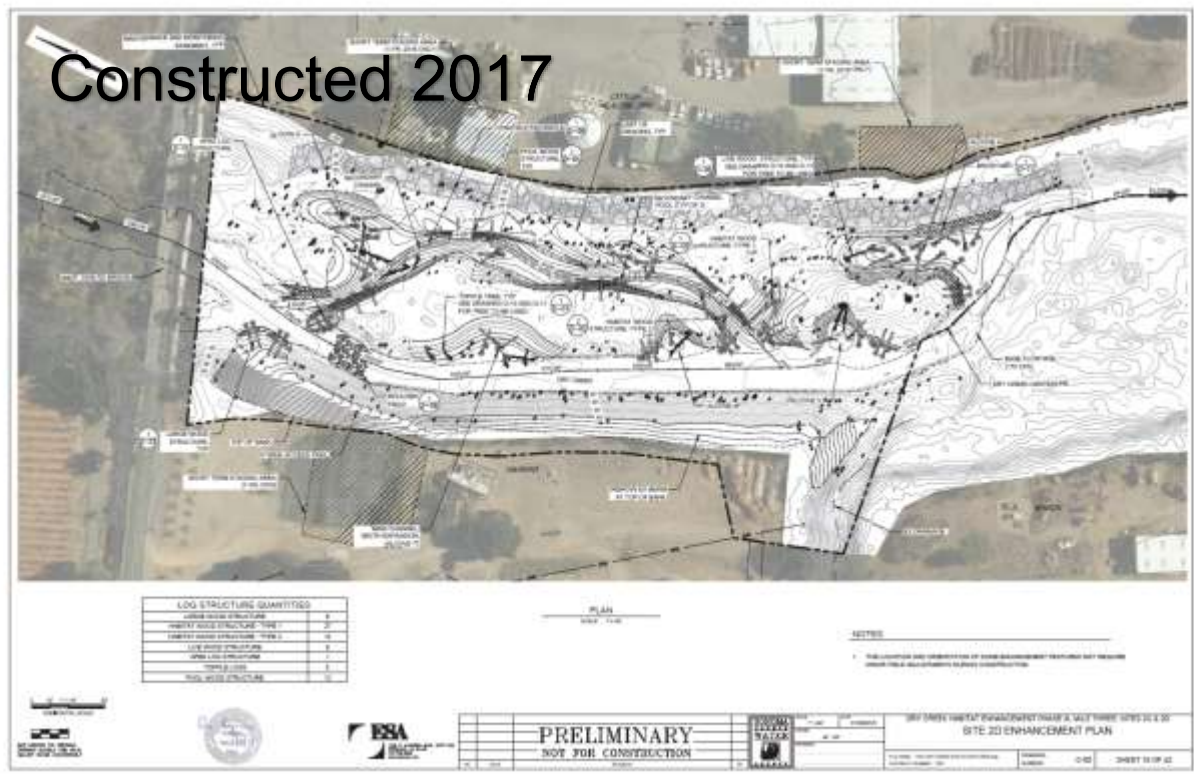
<u>Stage 8 Channel</u>

Adds complex pool-riffle habitat ⇨ diverse hydraulics ⇨ 'near-ideal' conditions for Coho salmon and Steelhead

Dry Creek Sites 2C & 2D

Constructed Perennial Secondary Channels

Implementation



Dry Creek Site 2C

Before and After Construction

2016

Implementation

Dry Creek Site 2C

Before and After Construction

2016

Implementation

Dry Creek Site 2D

Before and After Construction

Implementation

2017

Dry Creek Site 2D

Before and After Construction

Implementation

2017

Dry Creek Site 2C

WET winter following construction of first site

Adaptation

Dry Creek Site 2C

Response to first high flow event

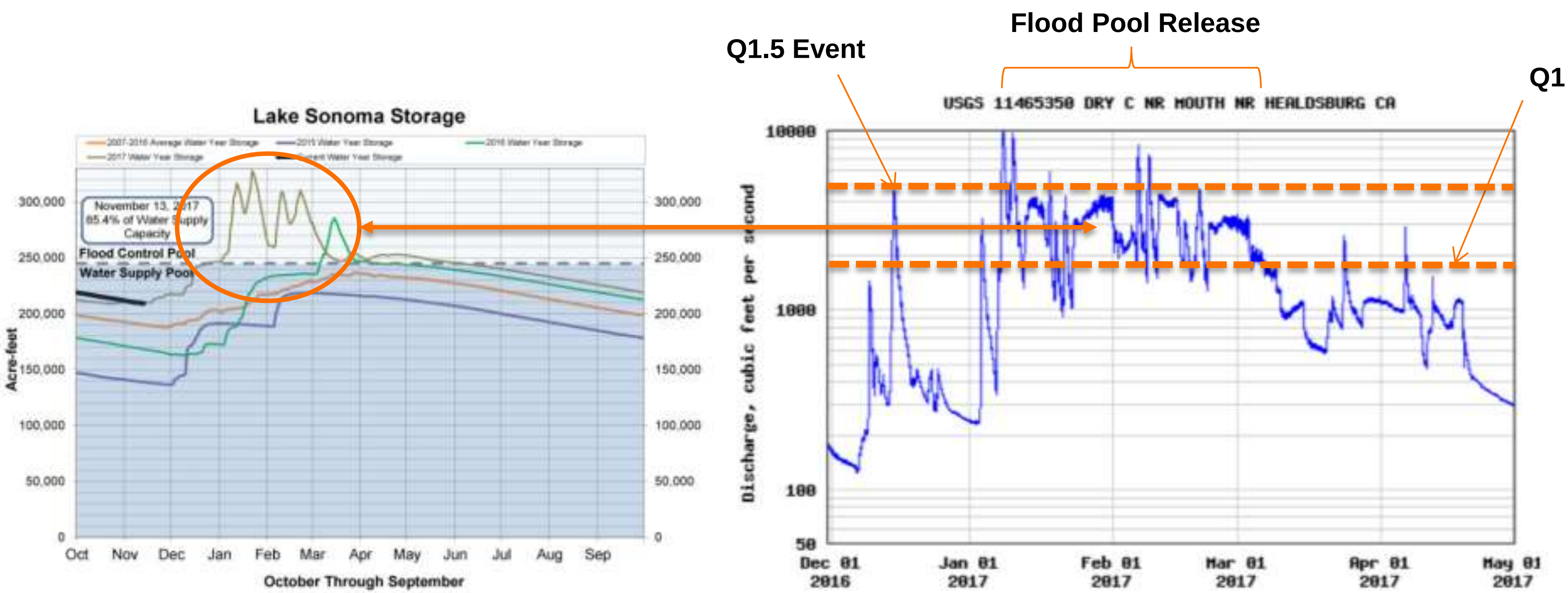
Adaptation

Dry Creek Site 2C

Wet Winter 2017

Adaptation

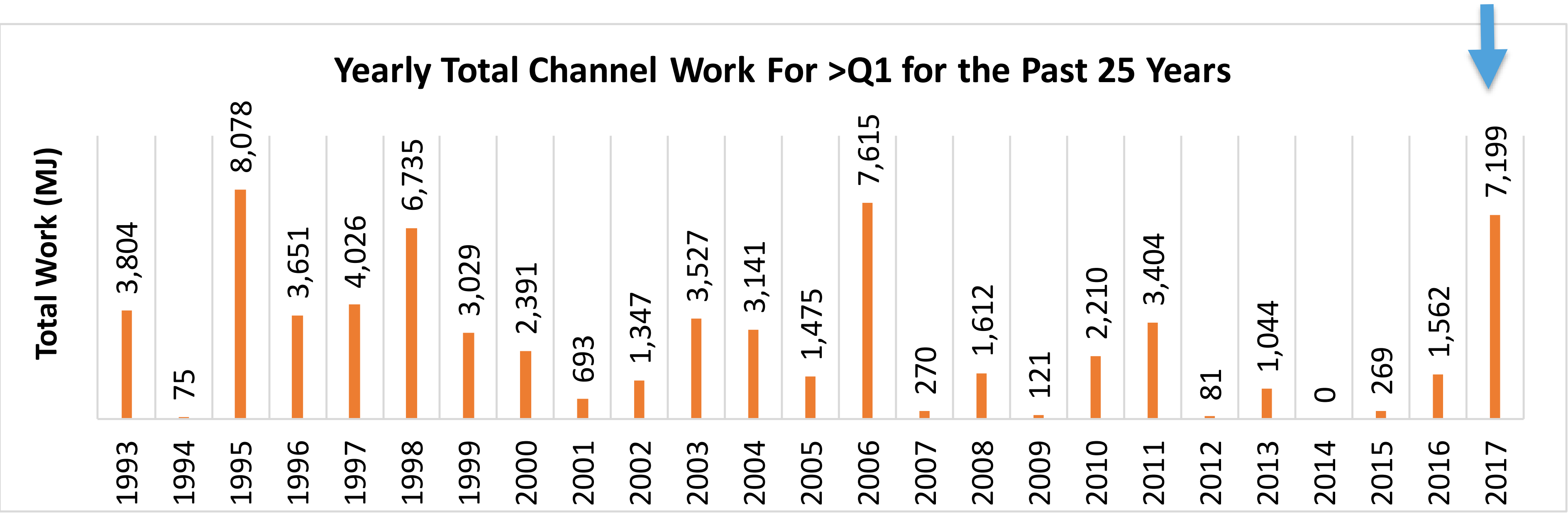
70 inches in rain resulted in a 9-week sustained release 1- to 1.5-year event



http://www.scwa.ca.gov/current-water-supply-levels/

https://waterdata.usgs.gov/ca/nwis/uv/?site_no=11465200

Winter 2017 resulted in 41% of work over past 10 years



Dry Creek Site 2C

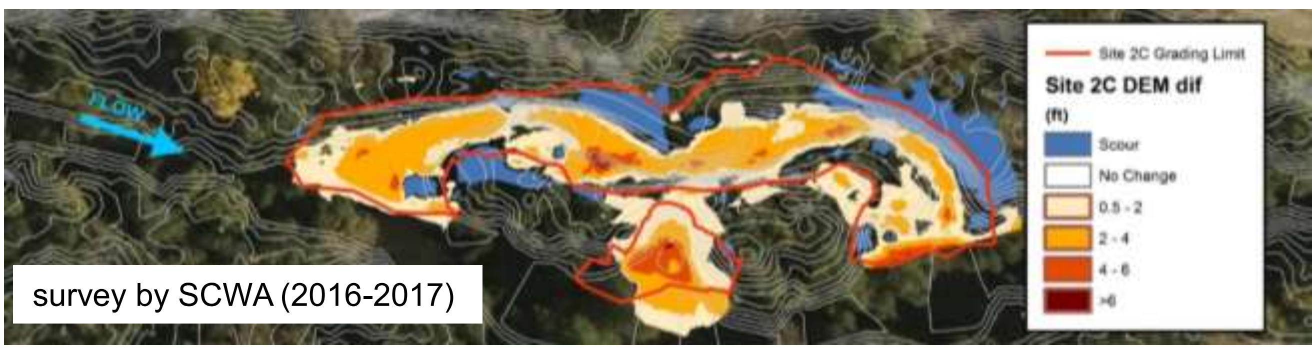
Response to Wet Winter 2017

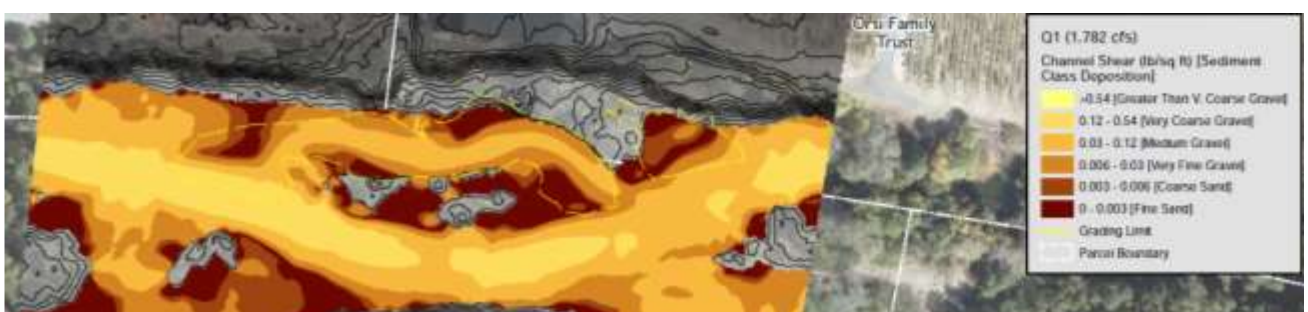
Adaptation

Response and Hypothesis

Adaptation

- Monitoring: Secondary channel filled with 2-4 feet of gravel
  - ➢ Depositional pattern as expected
- High flow field observations:
  - ➢ Flows “bypassing” secondary channel
  - ➢ Low velocities in secondary channel during high flows
- Modeling:
  - ➢ Q10-Q100 balance in sediment transport energy
  - ➢ Q1 shows an imbalance
- **<u>Hypothesis:</u>** Inlet and mid-channel bar was not large enough to split off sufficient flow and energy during 9 weeks of Q1-Q1.5

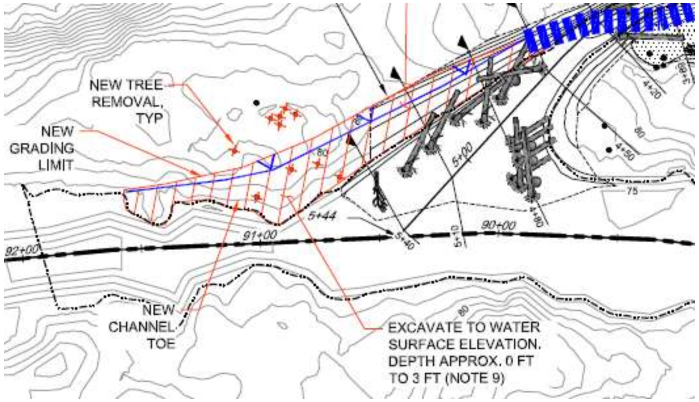




Dry Creek Site 2C

Adaptations

Adaptation



Vegetation removed and grading expanded
Mid-channel island more in center of flow

Dry Creek Site 2C

Adaptations

Adaptation

Apex jam enlarged


Expanded inlet grading and placed island in middle of flow
Adaptation
Dry Creek Site 2D
Field adjustments

Dry Creek Site 2D

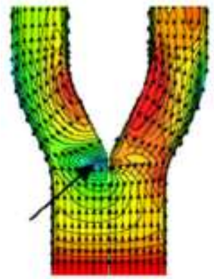
Field adjustments

Dry Creek Site 2D

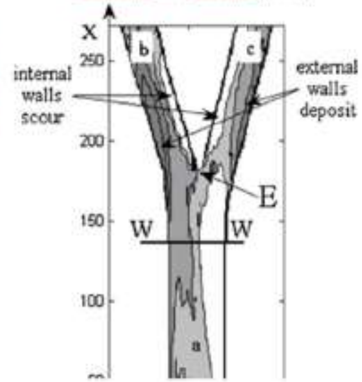
Adaptation

Response to
Winter 2018 high flow event
(1500 cfs, ~1-year)

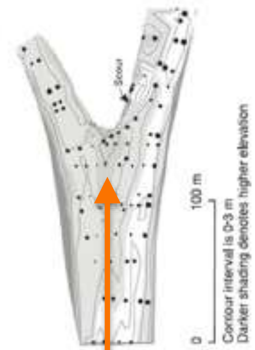
Hydrodynamics
Hardy et al. (2011)



Morphodynamics
Bertoldi and Tubino (2007)



Topo Survey
Burge (2006)



What did we learn?

Adaptation

- Inlet needed to be more expansive
- Mid-channel bar needed to be in center of flow
- Needed more equal balancing of energy during lower flow events (1- to 10-year)
- Needed to consider flow management anomalies
- Low margin of error for perennial habitat in a dynamic setting
- Maintenance may be necessary to sustain perennial conditions
- Be careful to no overly prescribe objectives

Session: Restoring to Stage Zero, Recent Innovations in Restoration Science: Reports from the Field

Design and Implementation of Secondary Channels

in Dry Creek, Sonoma County, California

April 13, 2018

Presented by
Jason Q. White
Restoration Hydrologist
Environmental Science Associates

Lagunitas Creek Winter Habitat and Floodplain Enhancement – Phase 1

Salmonid Restoration Federation, Fortuna, Ca. April 13, 2018

Gregory Andrew, Marin Municipal Water District

in association with

Kamman Hydrology & Engineering, Inc.

and

Balance Hydrologics, Inc.

Acknowledgements

Funders:

- California Department of Fish & Wildlife, Fisheries Restoration Grant Program
- California State Water Board, 319(h) Program
- U.S. Fish & Wildlife Service, Coastal Program

Land Owners:

- National Park Service
- California State Parks

Project Team

- Project Lead:

  Marin Municipal Water District

- Design & Engineering:

  Kamman Hydrology & Engineering, Inc. (KHE)

  with Fiori GeoSciences and Dr. Bill Trush

  Balance Hydrologics, Inc.

- Environmental/NEPA:

  Dudek

- Construction Management:

  The Covello Group

- Construction:

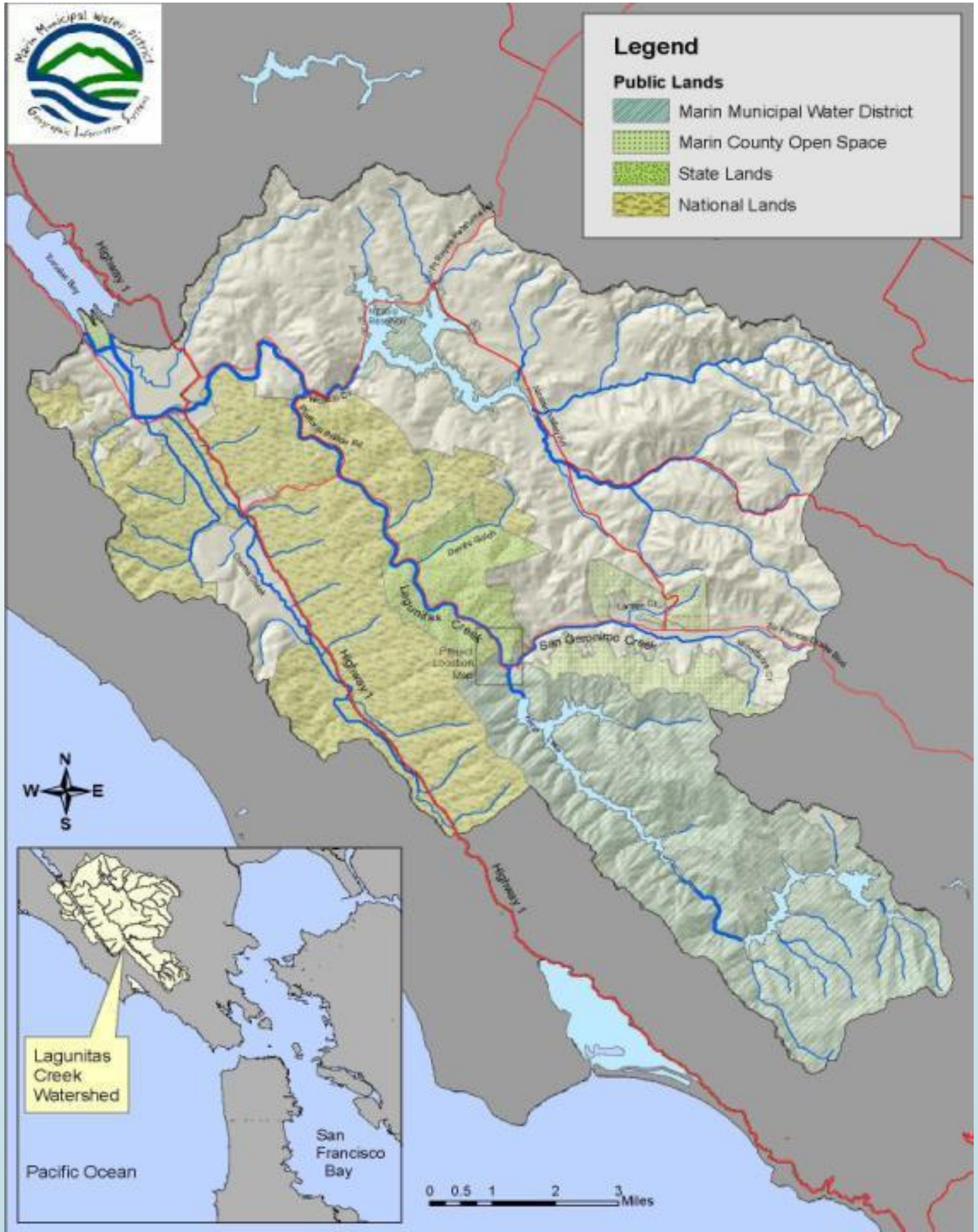
  Hanford Applied Restoration and Conservation (ARC)

Lagunitas Creek Watershed

Coho
Steelhead
Ca. Freshwater Shrimp

109 sq. mi. watershed

52 miles accessible to salmonids
50% of historic



Assessment, Site Identification & Initial Design Work 2010 - 2014

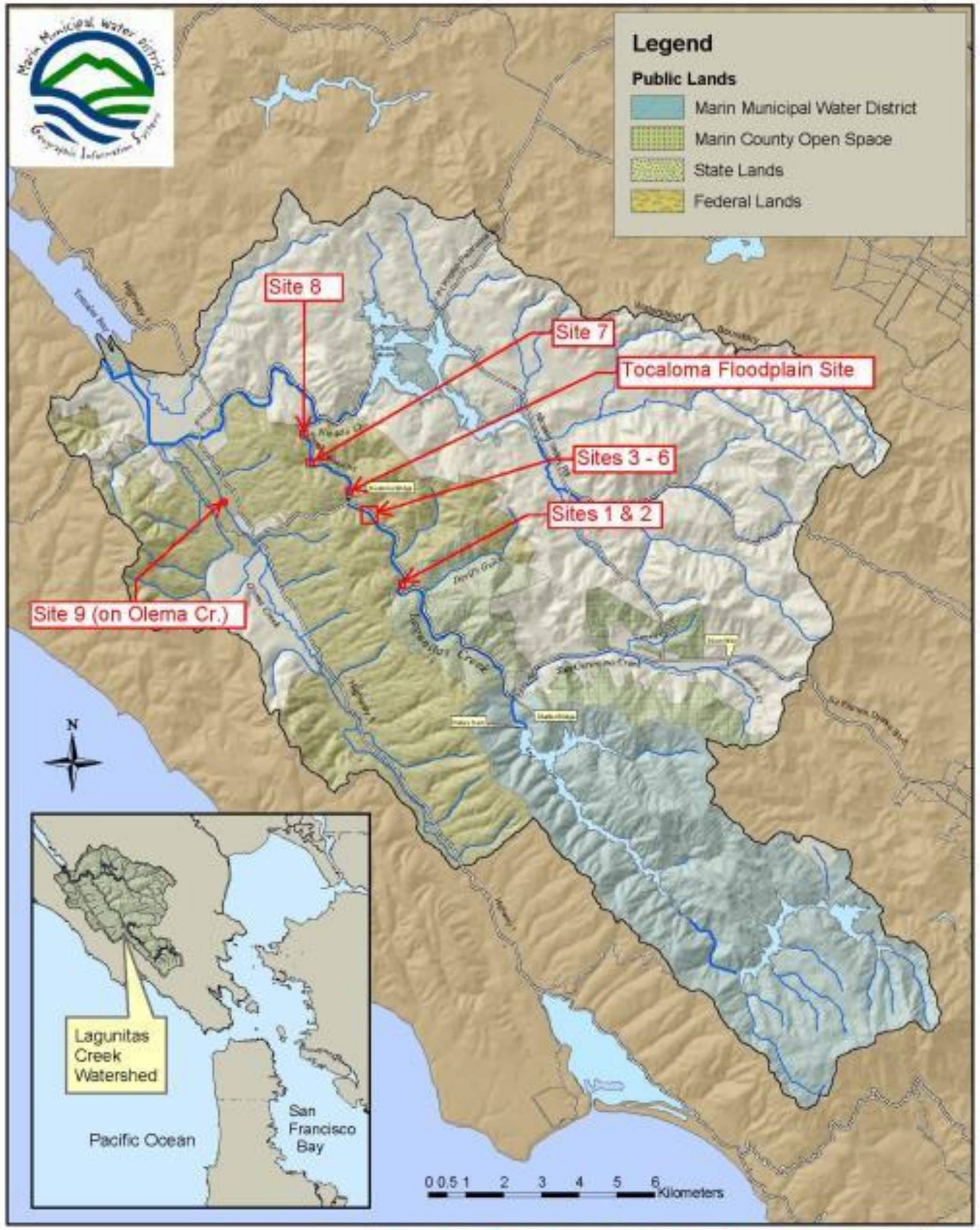


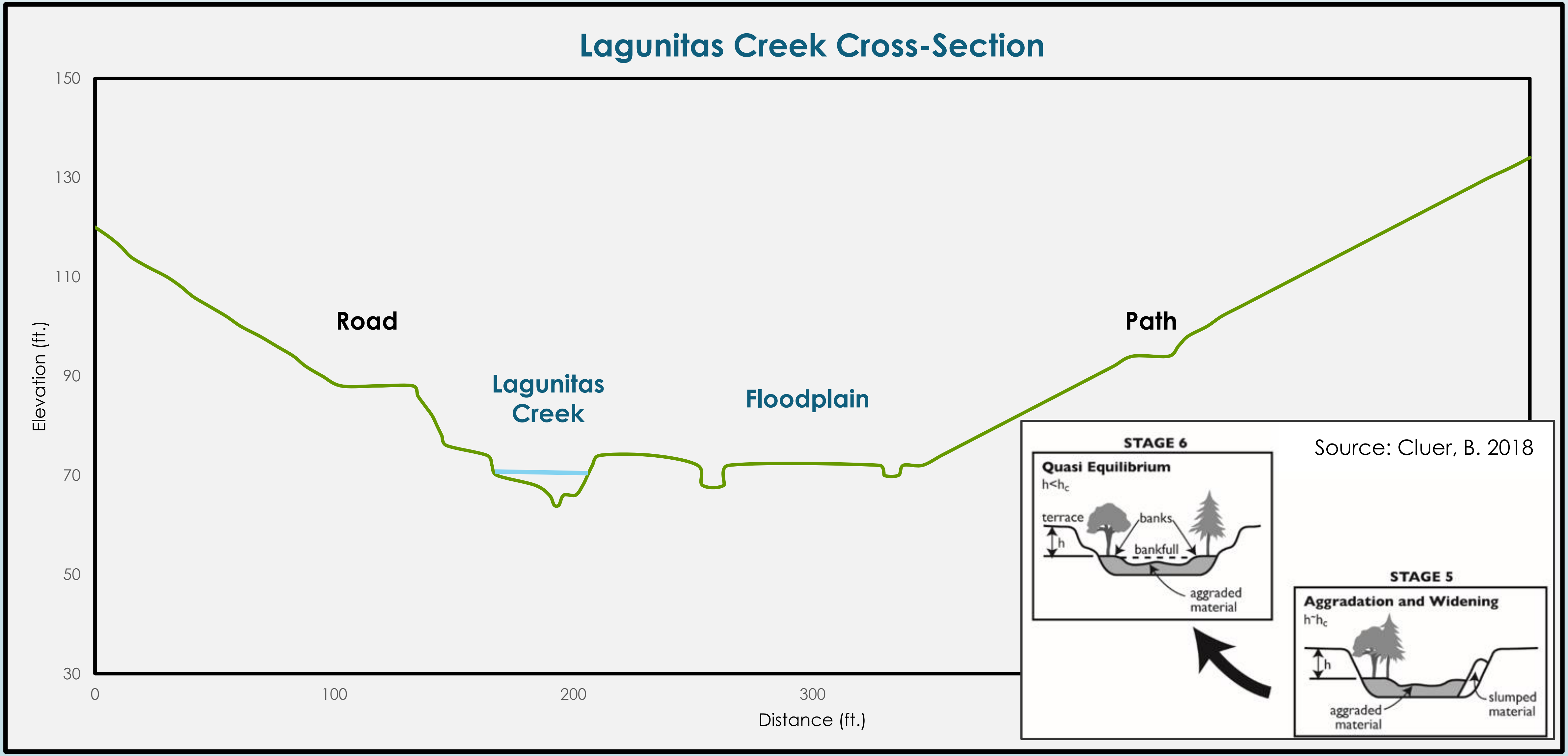
Figure 1. Lagunitas Creek Watershed

Lagunitas Creek Winter Habitat Enhancement Sites: Sites 1 - 9 and the Tocaloma Floodplain site.

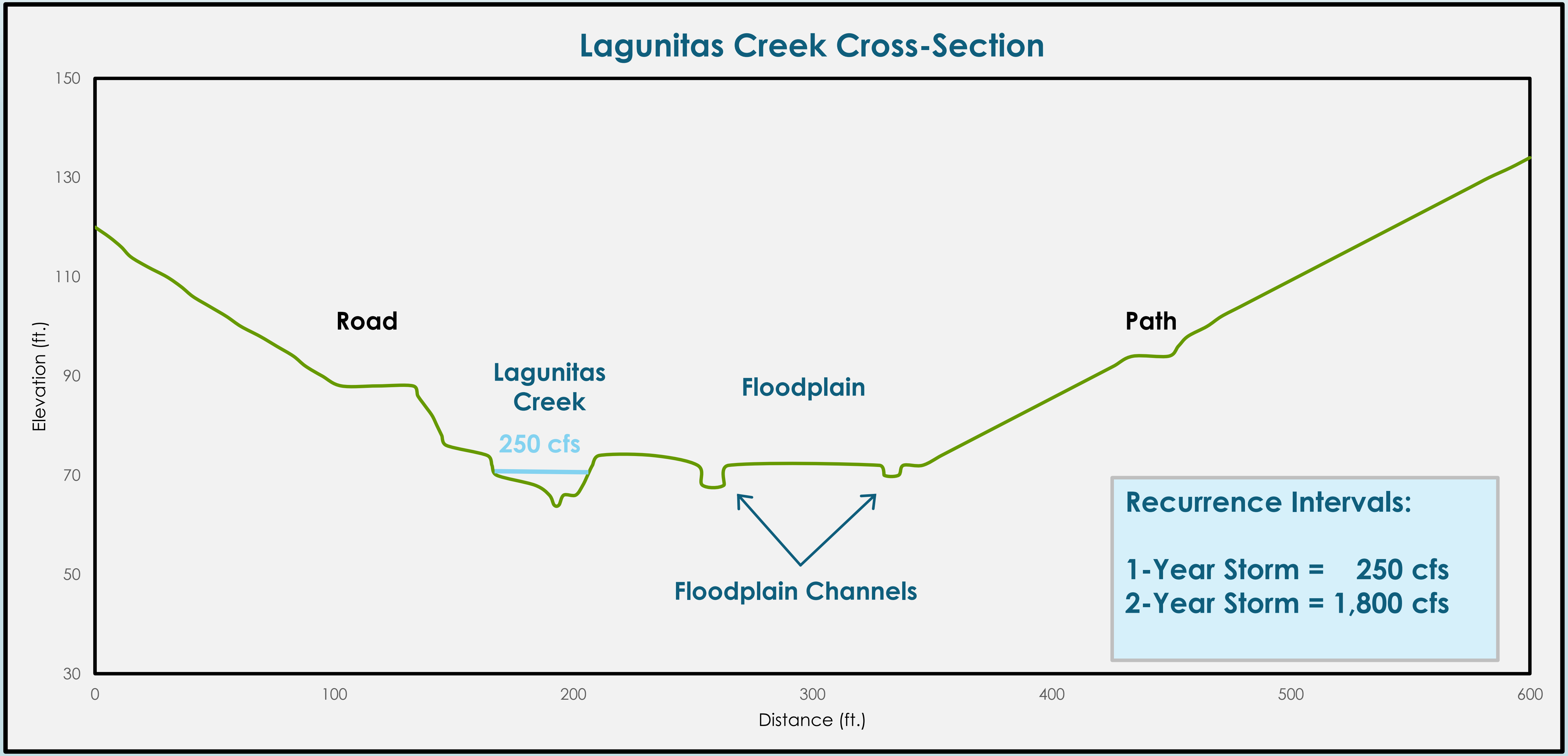
Goals & Objectives

- Goal - increase the winter carrying capacity for coho and steelhead ⇨ more and larger smolts.
- Goal - improve water quality in accordance with the Lagunitas Creek sediment TMDL.
- Reconnect Lagunitas Creek to the floodplain.

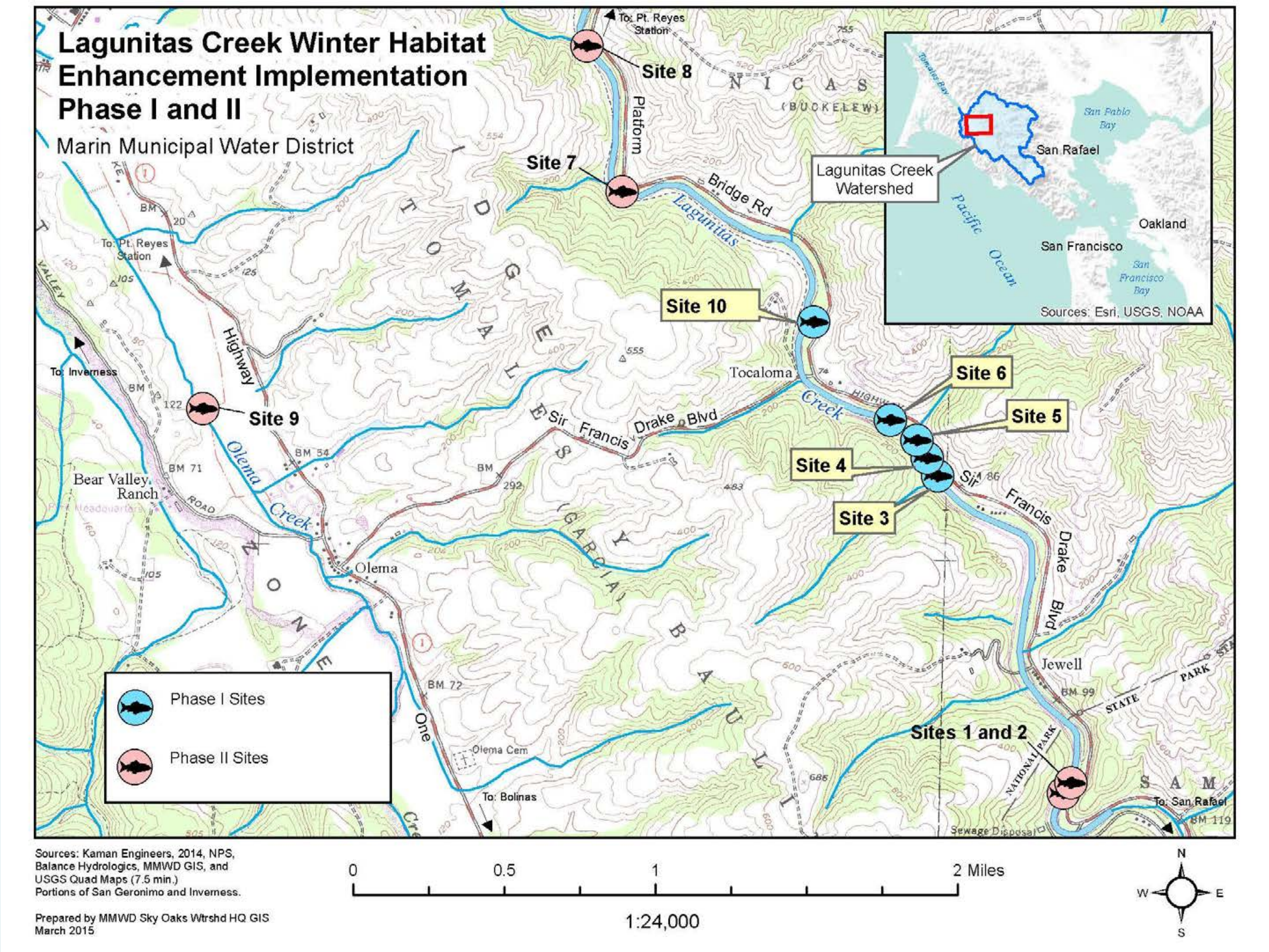
Lagunitas Creek Channel Geomorphology



Lagunitas Creek Channel Geomorphology



Plans & Specifications, Permitting, and Construction 2015 - 2018



Lagunitas Creek Winter Habitat Enhancement Implementation Phase I and II
Marin Municipal Water District
Site 8
Site 7
Site 10
Site 6
Site 5
Site 4
Site 3
Site 9
Sites 1 and 2
Lagunitas Creek Watershed
San Pablo Bay
San Rafael
Oakland
San Francisco
San Francisco Bay
Pacific Ocean
Sources: Esri, USGS, NOAA
Phase I Sites
Phase II Sites
To: Pt. Reyes Station
To: Inverness
To: Bolinas
To: San Rafael
Platform Bridge Rd
Lagunitas Creek
Sir Francis Drake Blvd
Highway One
Olema Creek
Bear Valley Ranch
Olema
Tocaloma
Jewell
Olema Cem
Sewage Disposal
Sources: Kaman Engineers, 2014, NPS, Balance Hydrologics, MMWD GIS, and USGS Quad Maps (7.5 min.)
Portions of San Geronimo and Inverness.
Prepared by MMWD Sky Oaks Wtrshd HQ GIS
March 2015
0
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1
2 Miles
1:24,000
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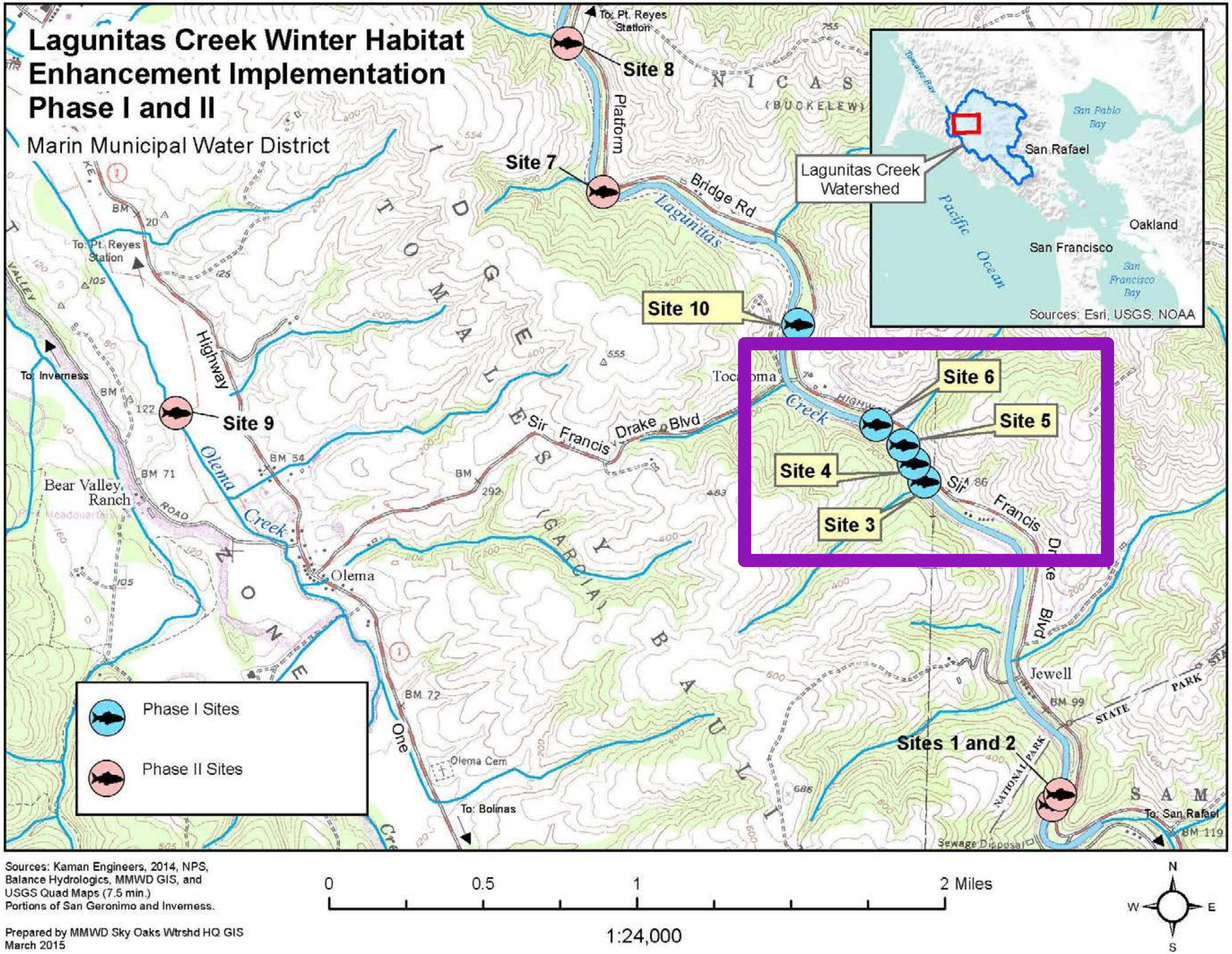
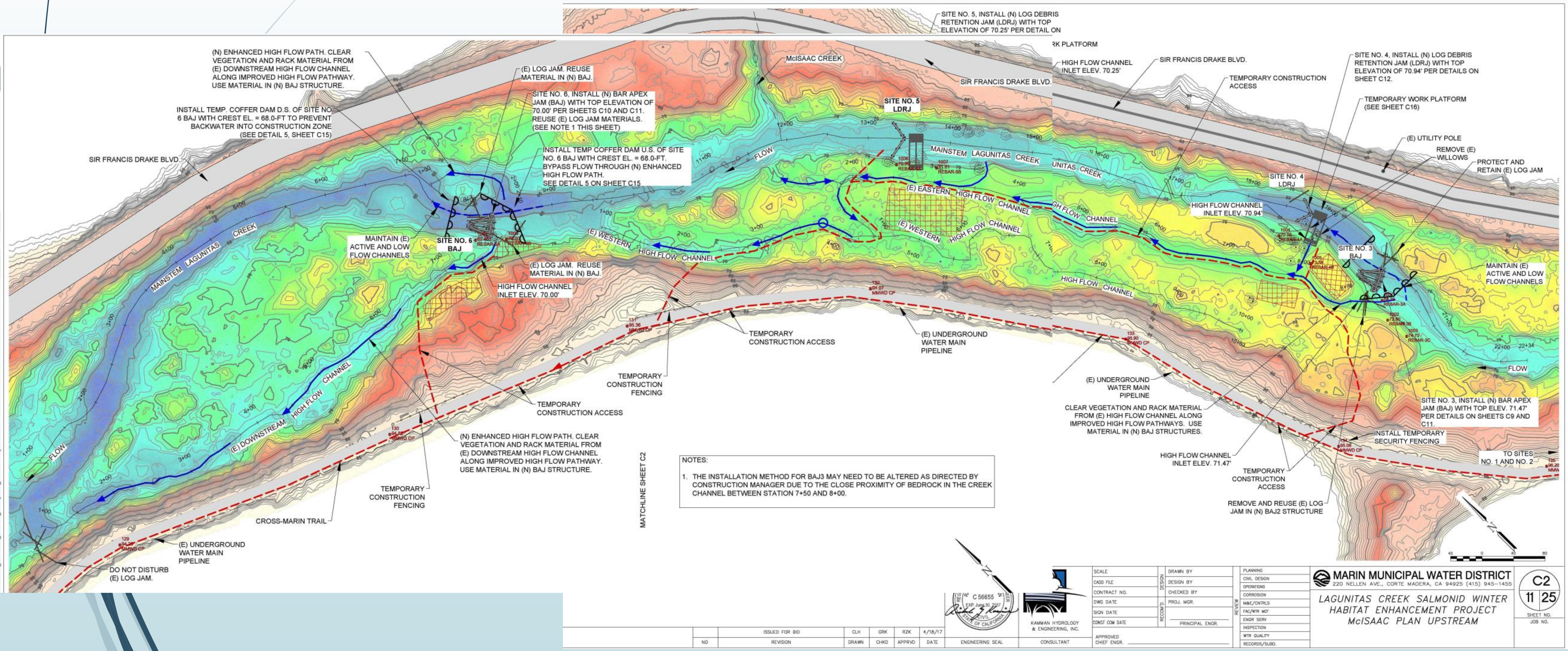
W
E
S

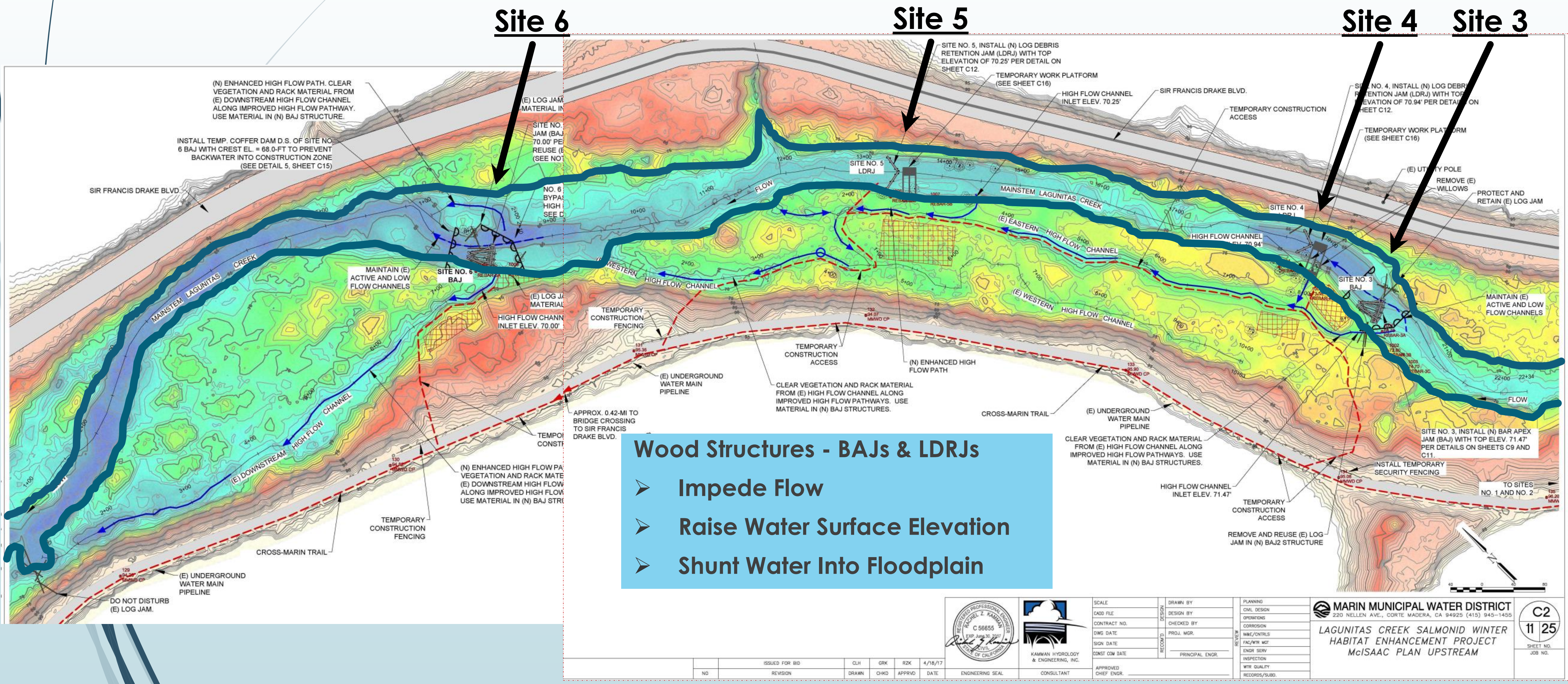
Phase 1: Sites 3 - 6



Sites 3 - 6: Bar Apex Jams & Log Debris Retention Jams for Floodplain Inundation



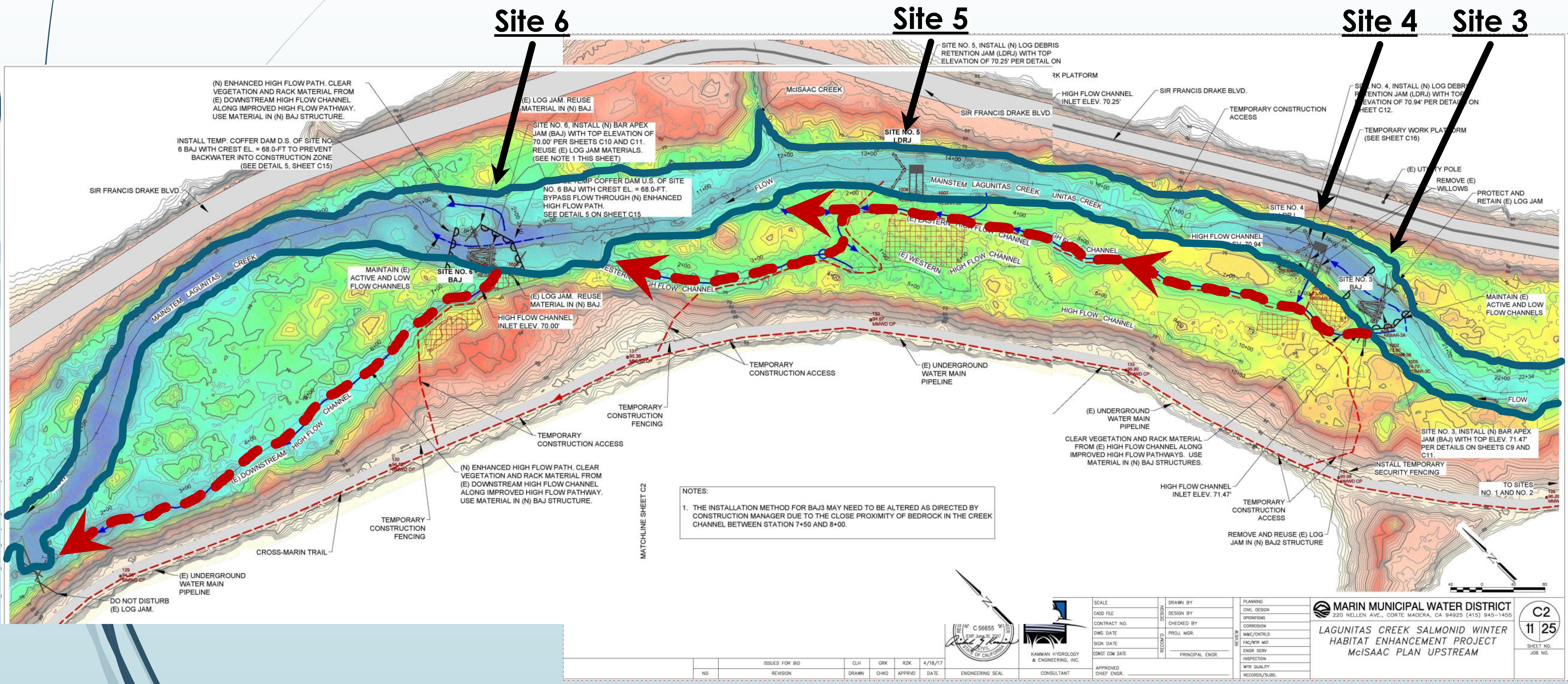
Sites 3 - 6: Bar Apex Jams & Log Debris Retention Jams for Floodplain Inundation



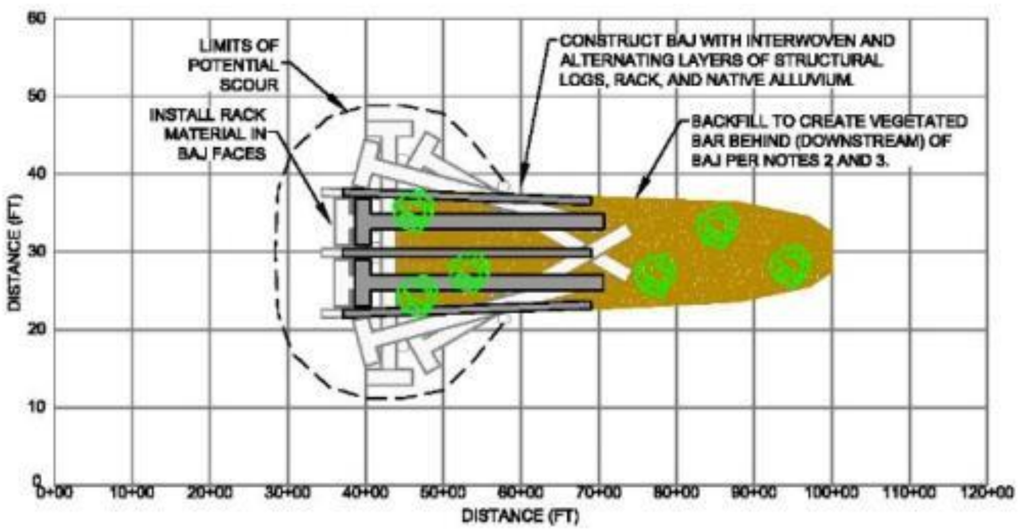
Wood Structures - BAJs & LDRJs

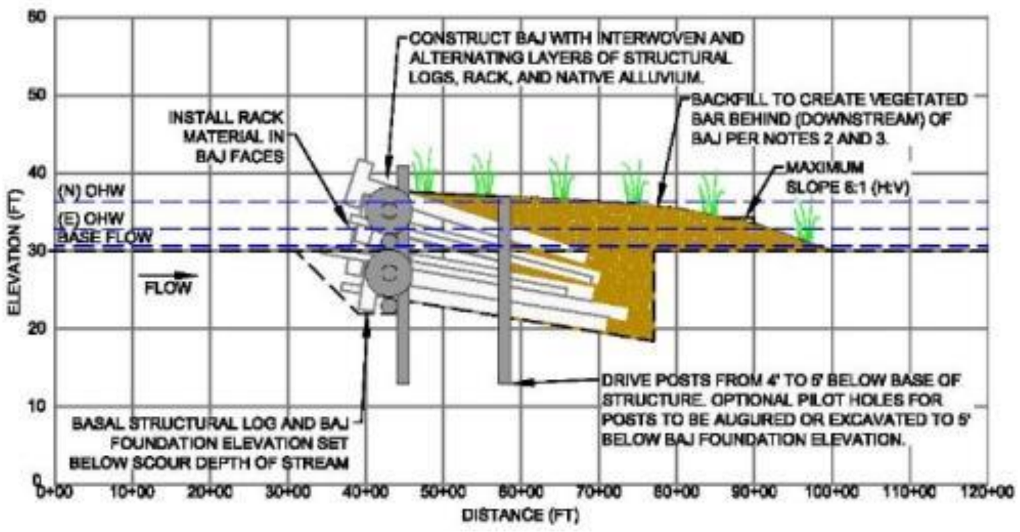
- Impede Flow
- Raise Water Surface Elevation
- Shunt Water Into Floodplain

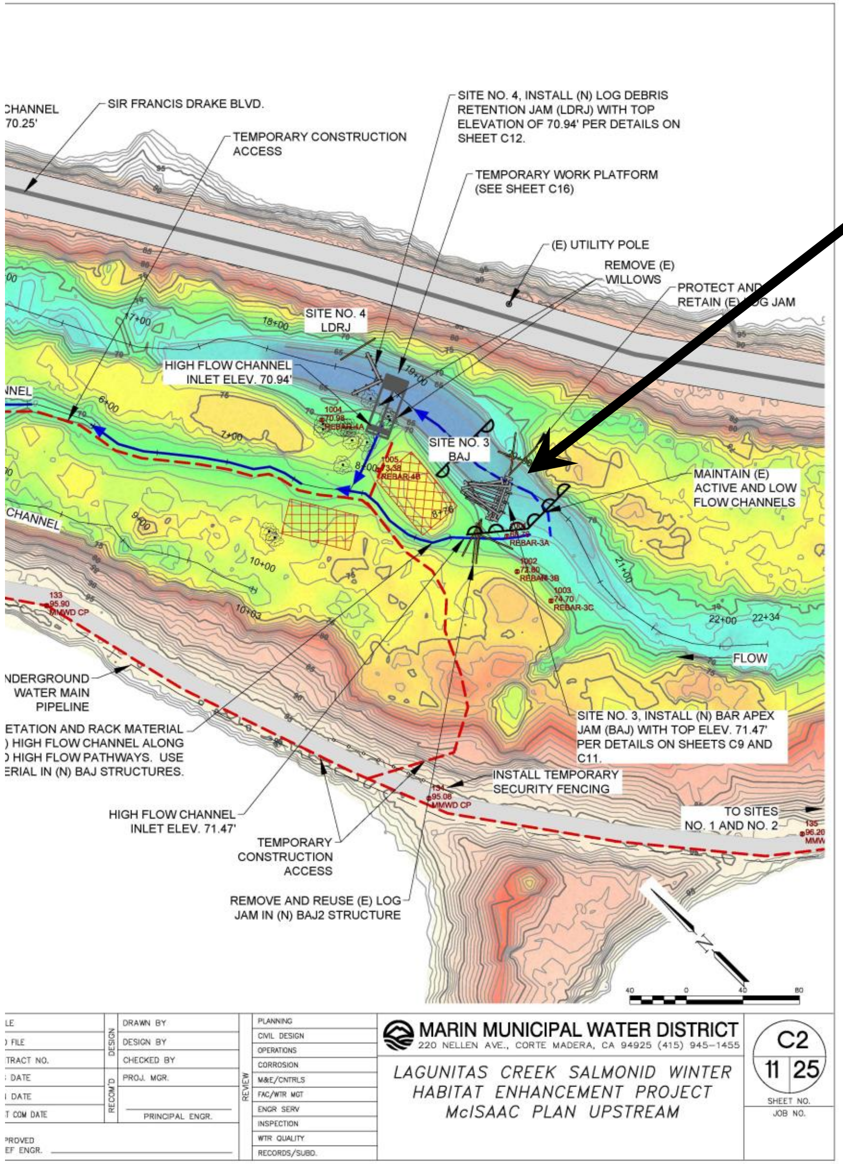
Sites 3 - 6: Bar Apex Jams & Log Debris Retention Jams for Floodplain Inundation



Bar Apex Jam (BAJ)







Site 3

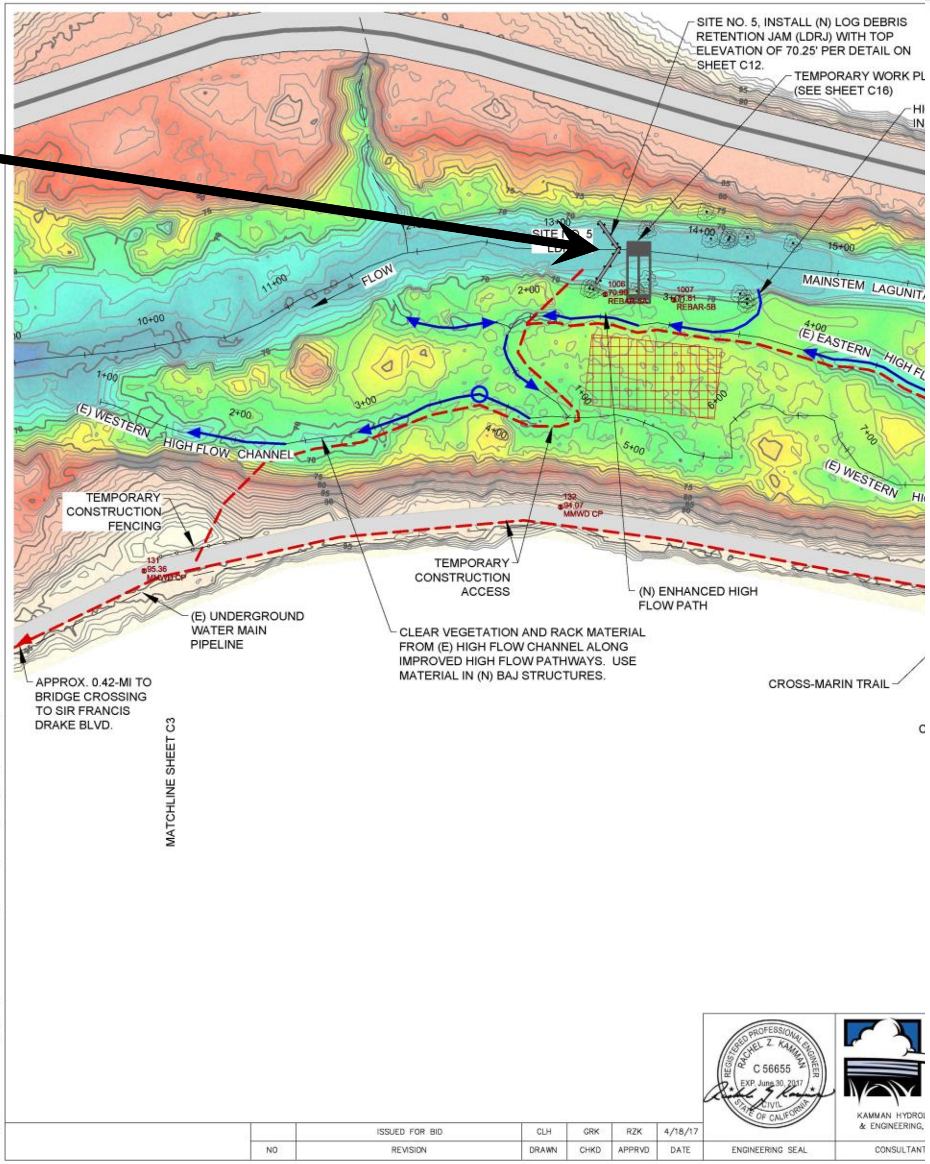
Site 3: Bar Apex Jam (BAJ)

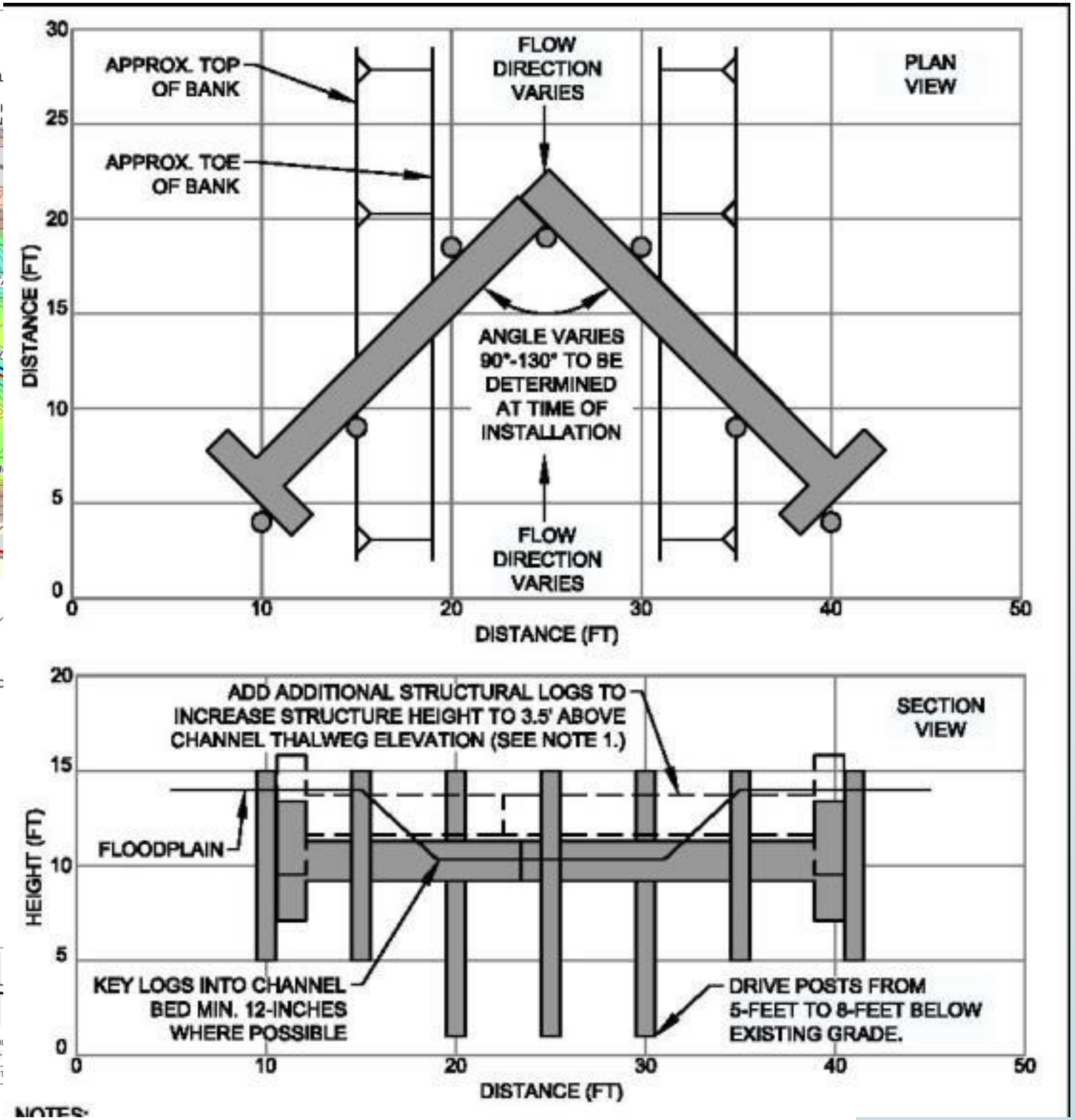
Site 3: Bar Apex Jam (BAJ)


CAT
TLC200 PRO 2017/08/22 07:00:05

Log Debris Retention Jam (LDRJ)

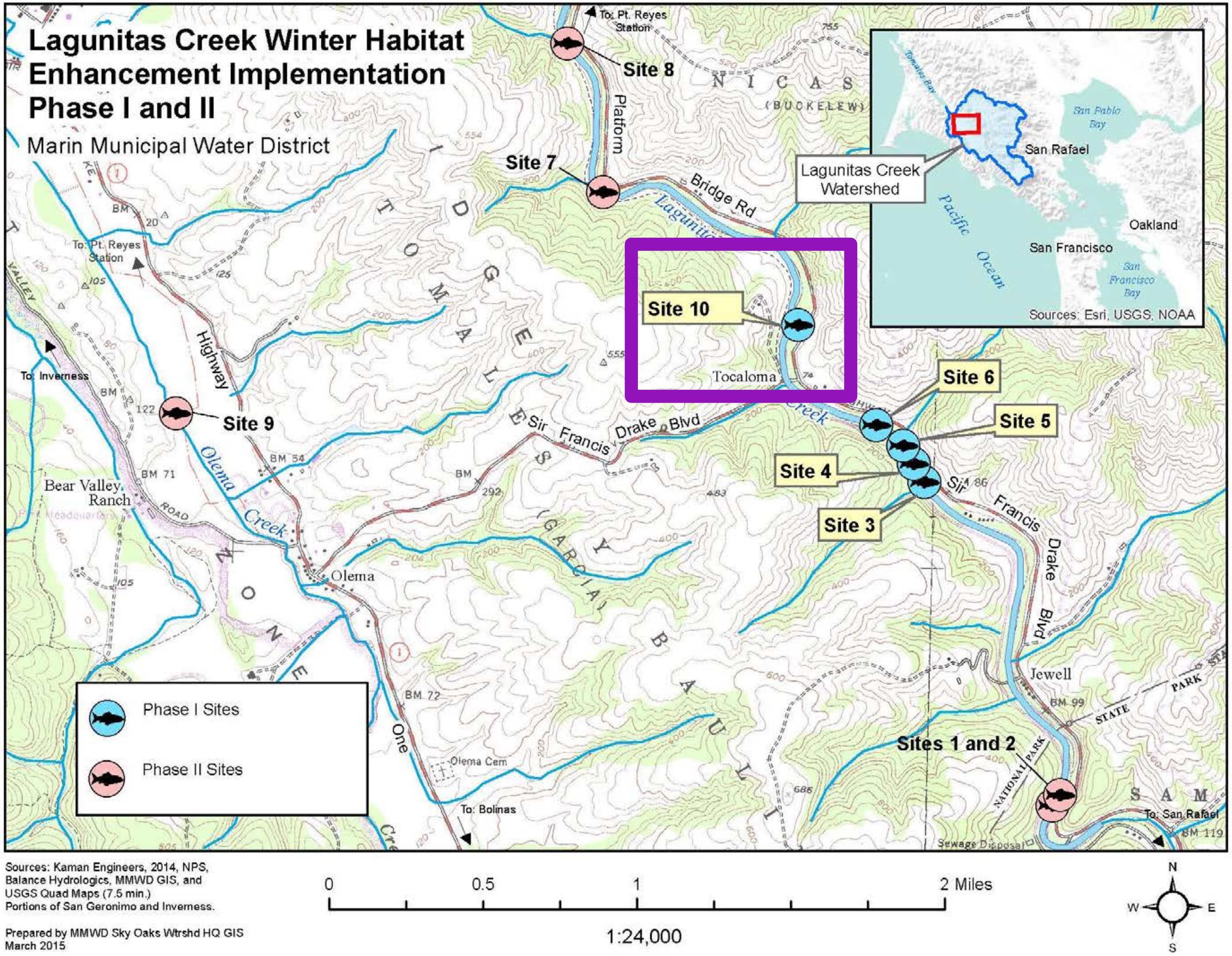
Site 5



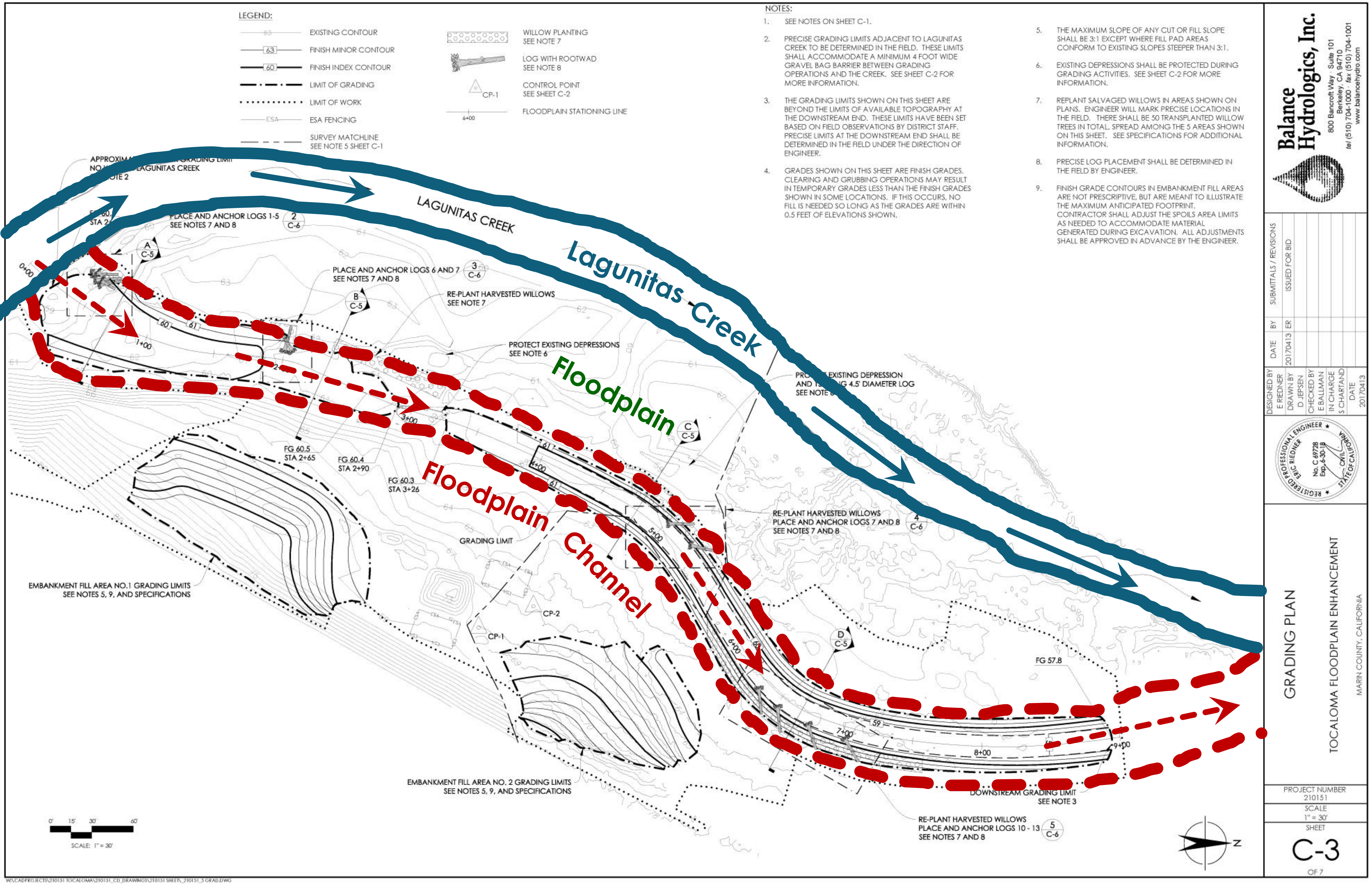


Site 5: Log Debris Retention Jam (LDRJ)

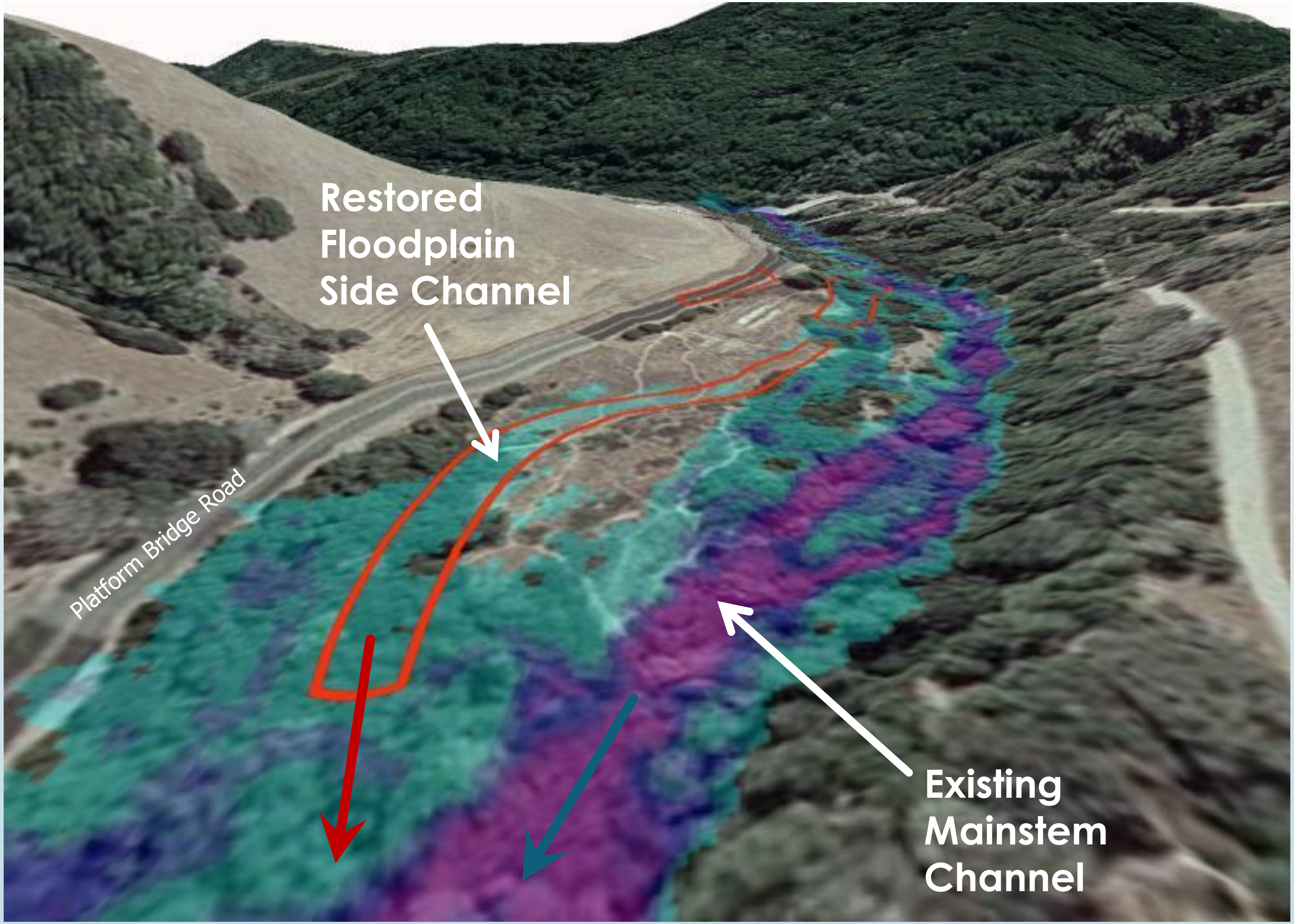
Phase 1: Tocaloma (Site 10)



Tocaloma Floodplain Side Channel Excavation



Tocaloma Floodplain Channel (rendering)



Tocaloma Floodplain Side Channel

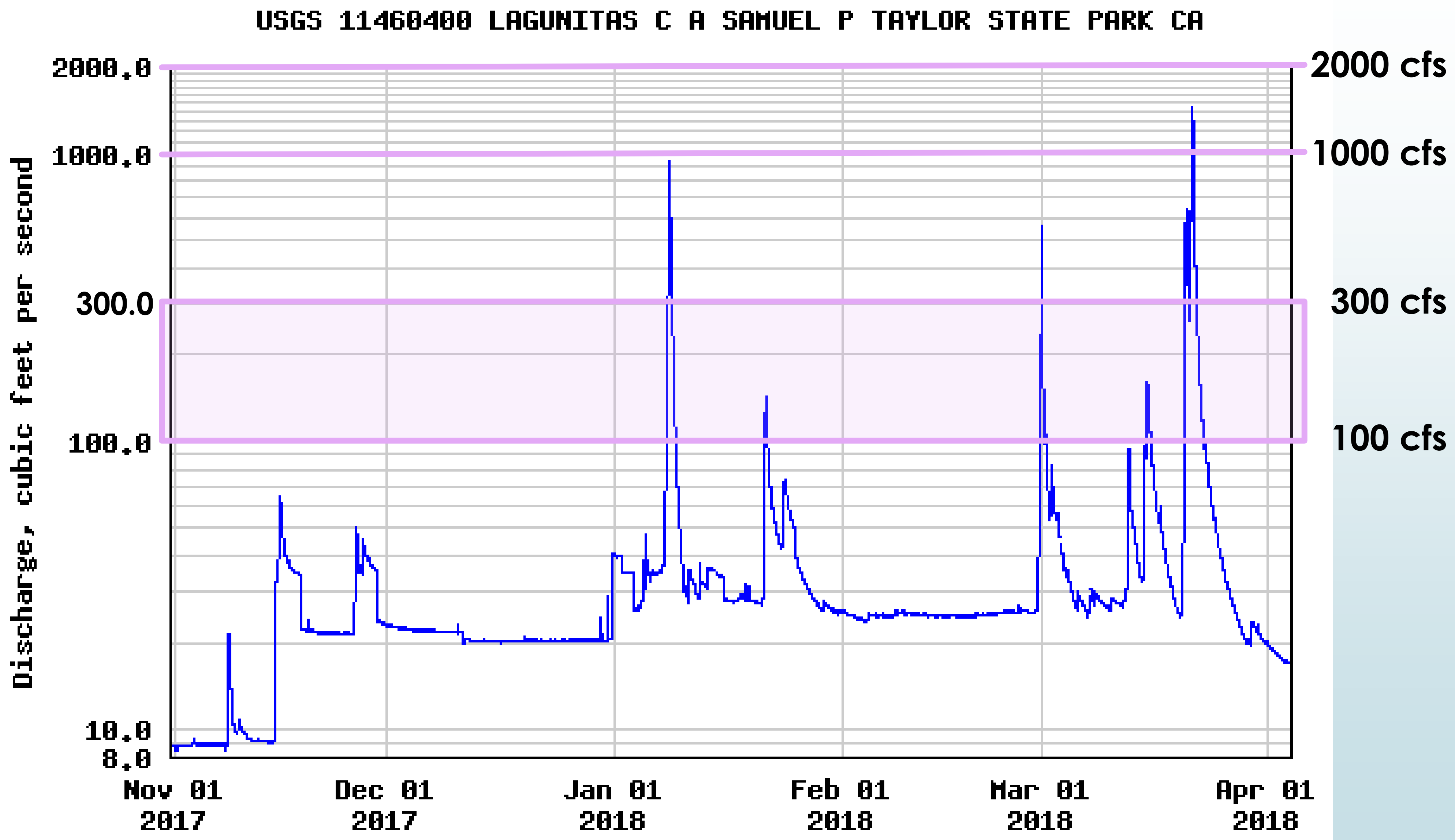
Excavated Channel; Rootballs; and transplanted willows

Objectives for Winter Habitat and Floodplain Enhancement

- Reconnect Lagunitas Creek to its floodplain.
- Impede Mainstem Flow and Divert Water into Floodplain Channels.
- Inundate Floodplain Channels at 100 – 300 cfs.

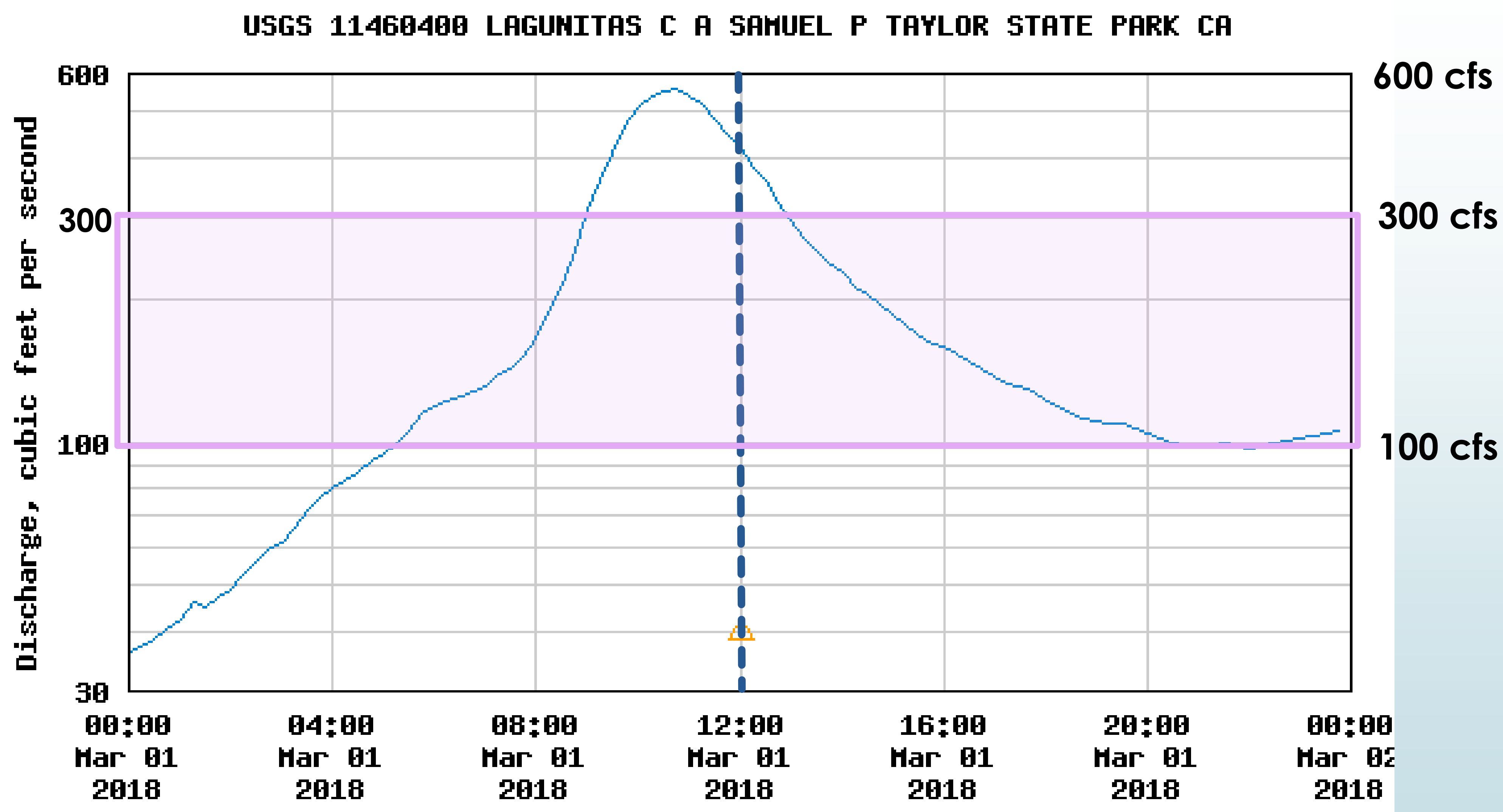
- Provide Flow Refuge for Juveniles and Adults - Slower Water in Floodplain Channels.
- Provide Additional Rearing Habitat for Juveniles.
- Trap Fine Sediments - Spread Water Across Floodplain.
- Enhance Habitat for Salmonids – At Large Wood Structures and in the Floodplain Channels.

Lagunitas Creek Stream Flows – Winter 2017/2018



Projects are designed for floodplain inundation at between 100 cfs and 300 cfs

Lagunitas Creek Stream Flows – Winter 2017/2018



March 1, 2018: Peak Flow = 560 cfs

Video

Floodplain Inundation

Floodplain Inundation (Flow ~ 300 cfs)

Floodplain Inundation (Flow ~ 300 cfs)

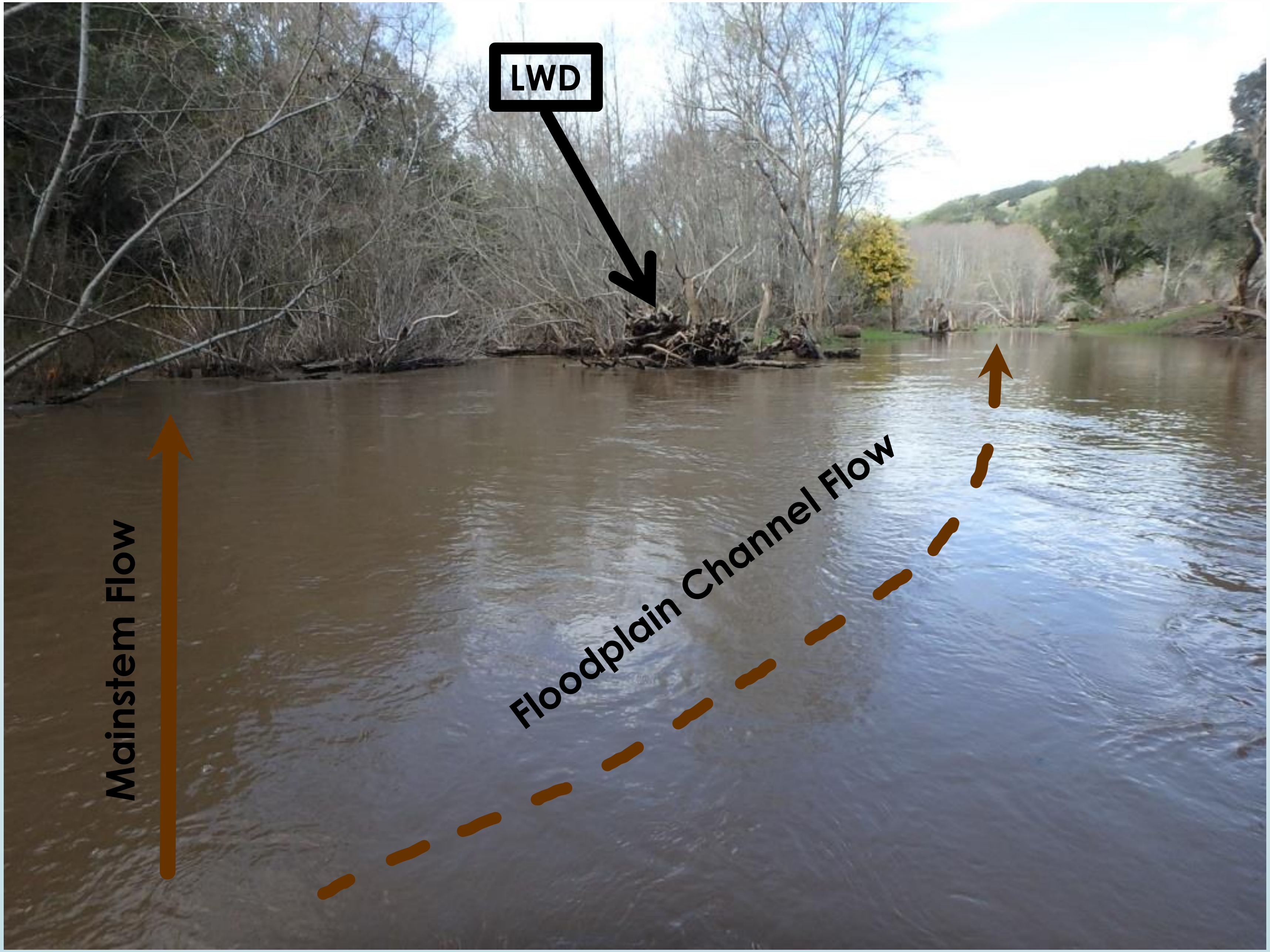
Floodplain Inundation (Flow ~ 300 cfs)

Floodplain Inundation (Flow ~ 300 cfs)

Site 5 LDRJ

Floodplain Inundation (Flow ~ 300 cfs)

Tocaloma Floodplain Channel Inundation



Tocaloma Floodplain Channel Inundation

Tocaloma Floodplain Channel Inundation

Floodplain Morphology and Habitat

Floodplain Morphology and Habitat – Sediment Sorting

Floodplain Morphology and Habitat – Sediment Sorting

Floodplain Morphology and Habitat – Sediment Sorting

Floodplain Morphology and Habitat – Instream Enhancement

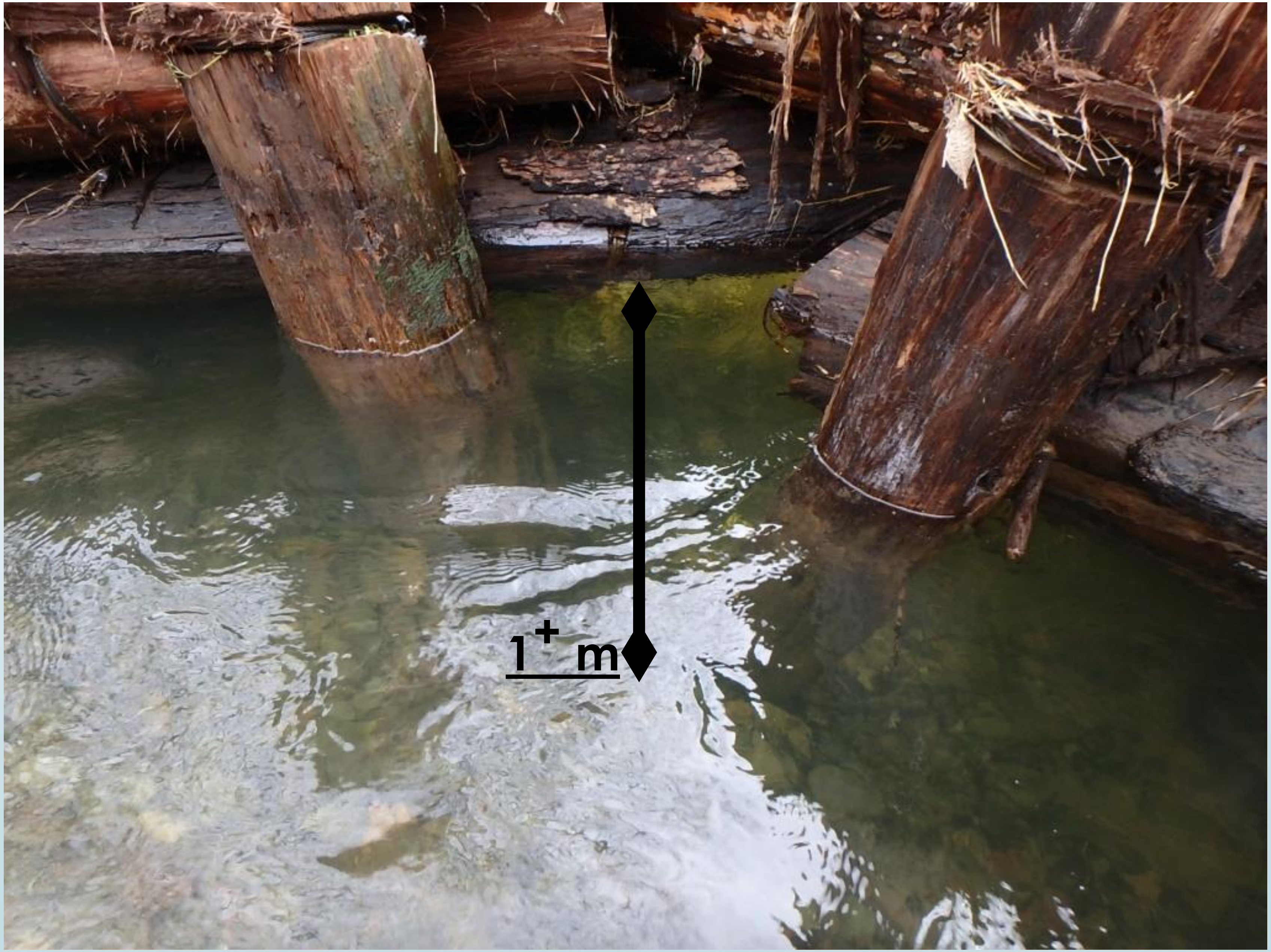
Wood
<u>Recruitment</u>

Floodplain Morphology and Habitat – Instream Enhancement

Wood
<u>Recruitment</u>

Floodplain Morphology and Habitat – Instream Enhancement

Pool
Scour



Floodplain Morphology and Habitat – Instream Enhancement

Gravel
Accumulation

Monitoring

- Water Level/Stage Data Loggers.
- Time-Lapse Cameras.

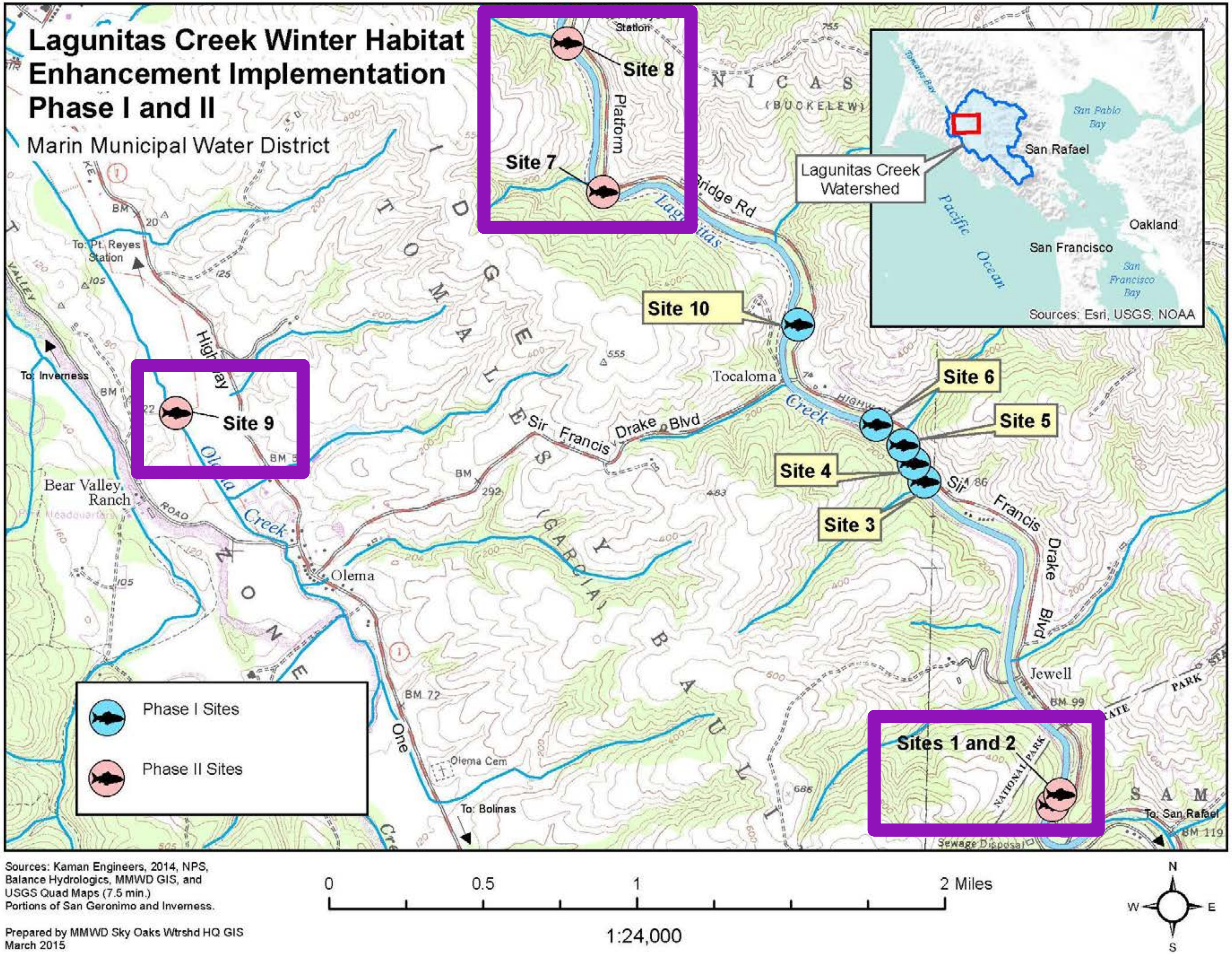
  Both Coupled with USGS Stream Gages.
- As-Built Survey, including

  Longitudinal Profile Survey.
- Salmonid Trends Surveys –

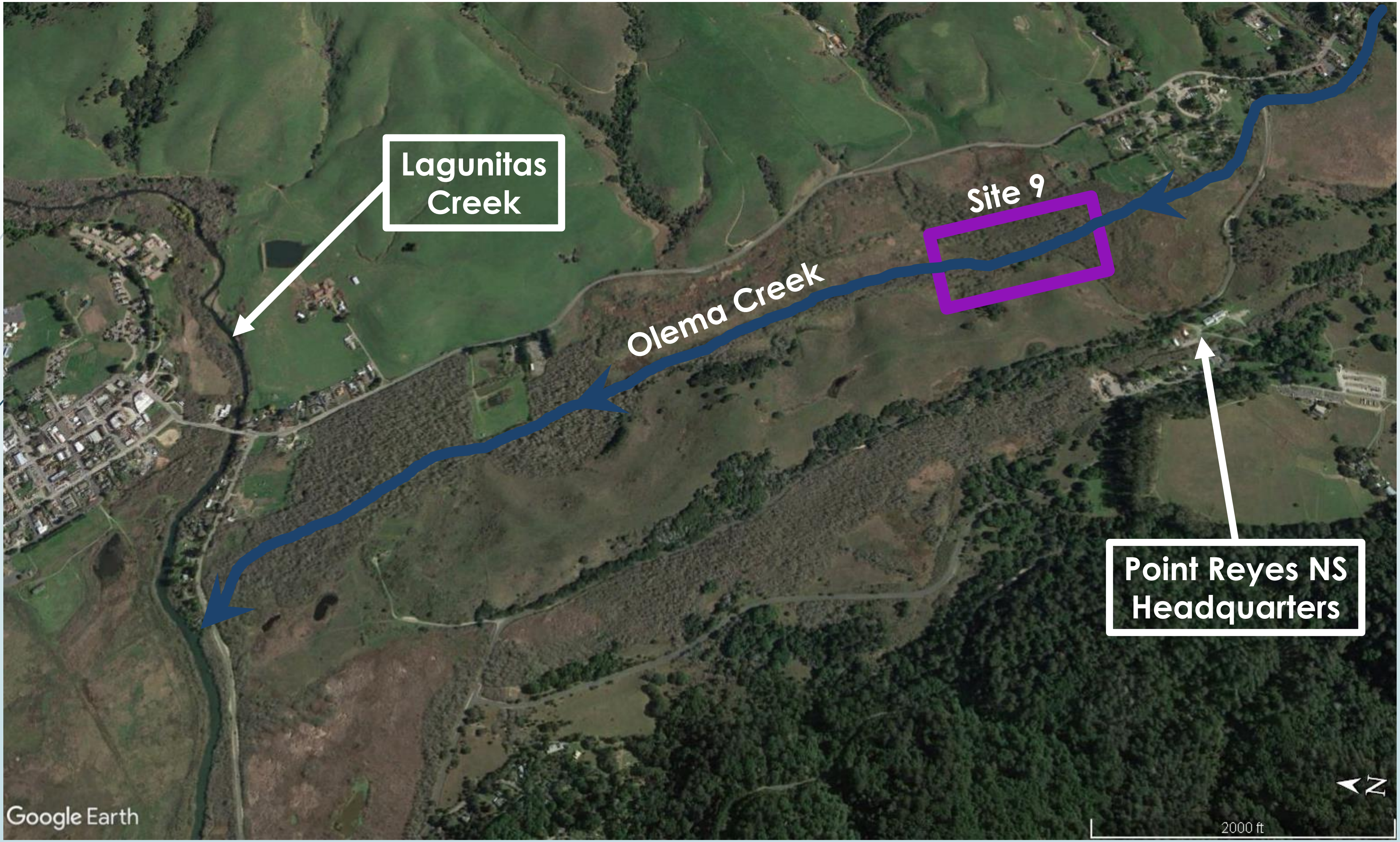
  Juvenile, Adult, Smolt

Coming Summer 2018

Phase 2:
Sites 1&2;
Sites 7-9

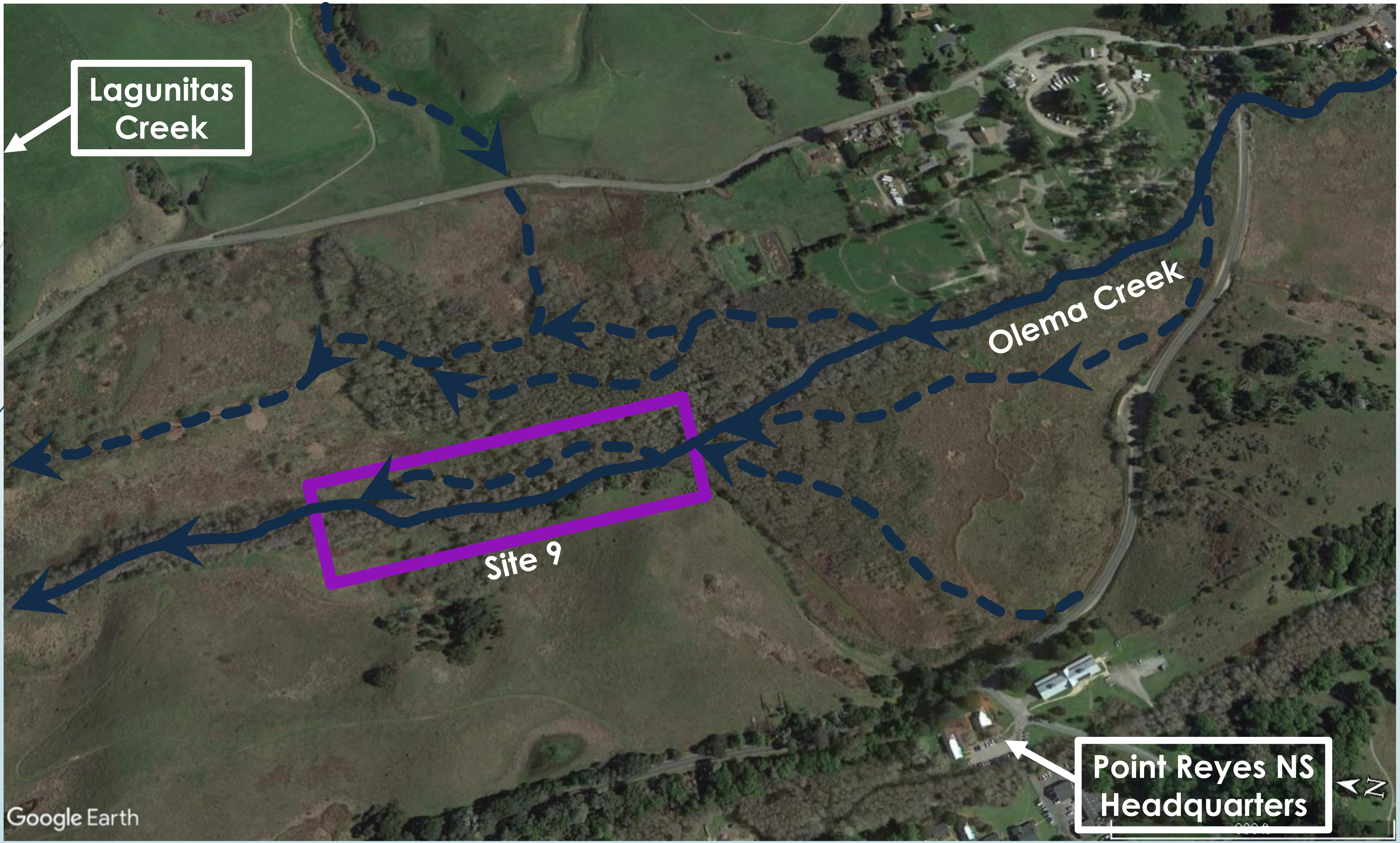


Olema Creek



Lagunitas Creek
Site 9
Olema Creek
Point Reyes NS Headquarters
Google Earth
N
2000 ft

Olema Creek


Lagunitas Creek
Olema Creek
Site 9
Point Reyes NS Headquarters
Google Earth
N


Fluvial
Intern

Thank you

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