Can we restore ecological processes and recover salmon populations below a dam?

Lesson learned from the Trinity River Restoration Program

REM – 631; February 5, 2016.

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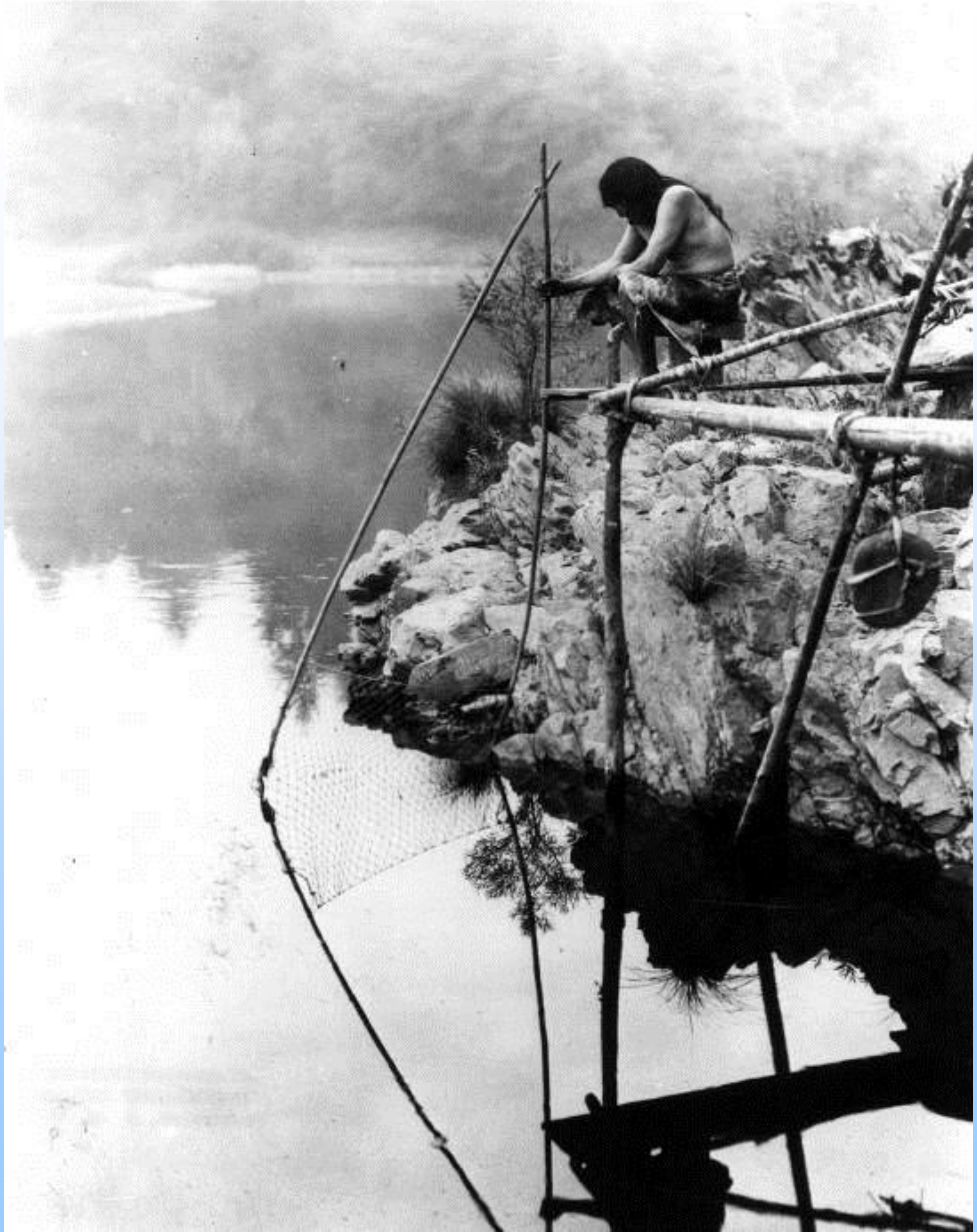
with help from ESSA and TRRP scientists

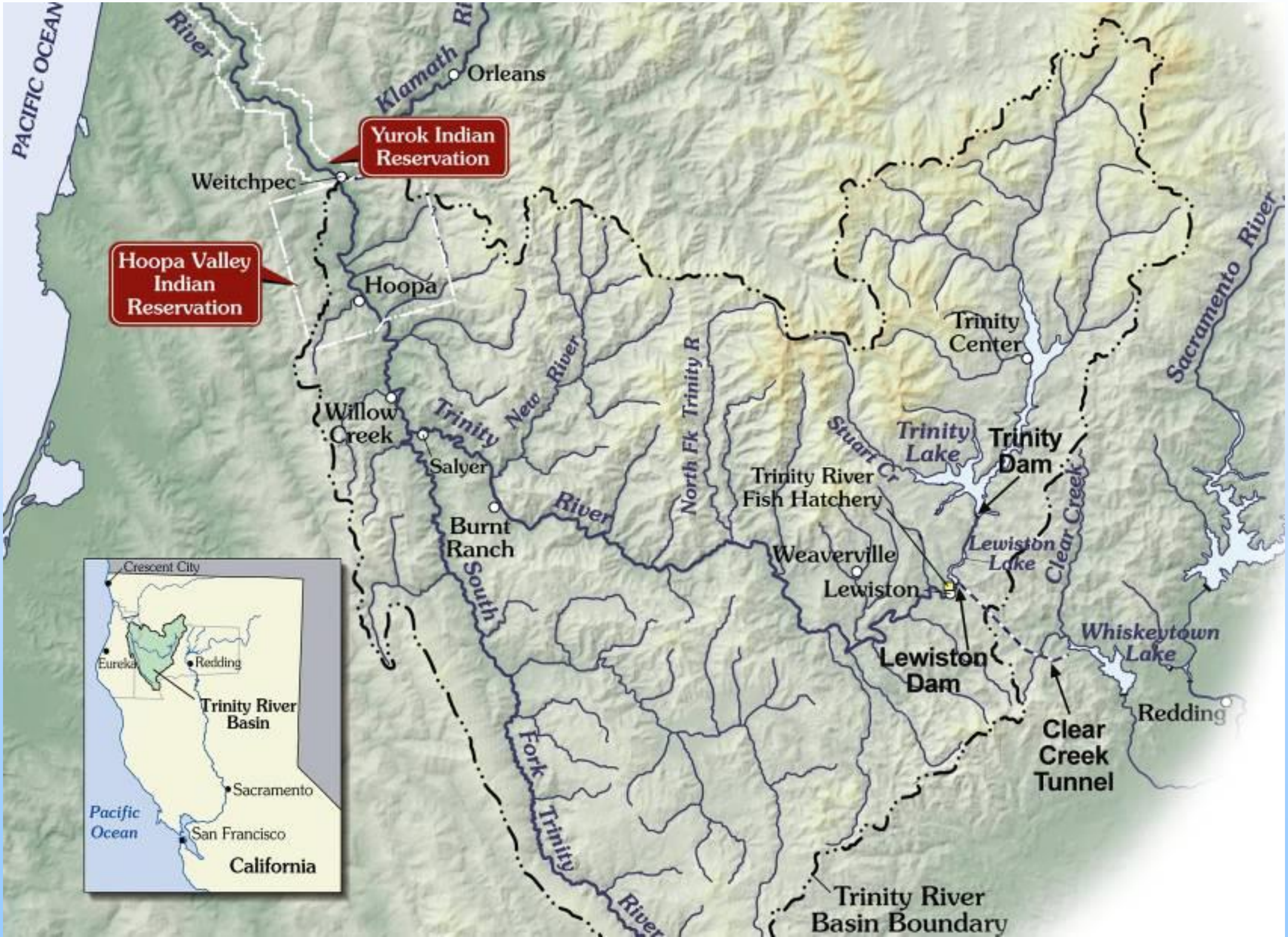
Outline

- History of changes in the Trinity River
- Restoration strategy
- Monitoring, evaluation and adaptive management
- Implementation challenges
- Future uncertainties

Hoopa, Yurok, and Wintu tribes depended on Trinity River salmon



Trinity River Geography & Plumbing




Weaverville, CA
N
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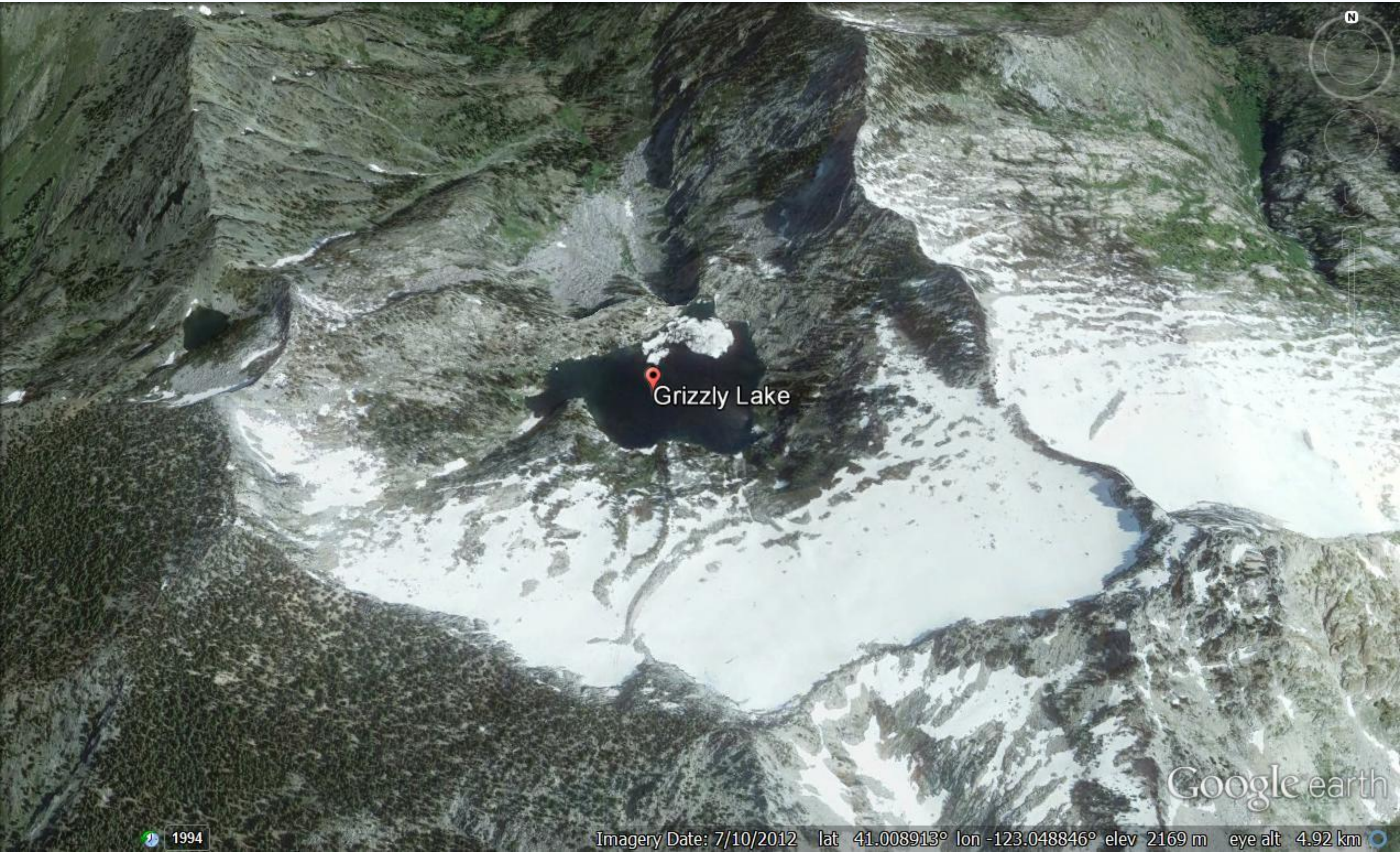
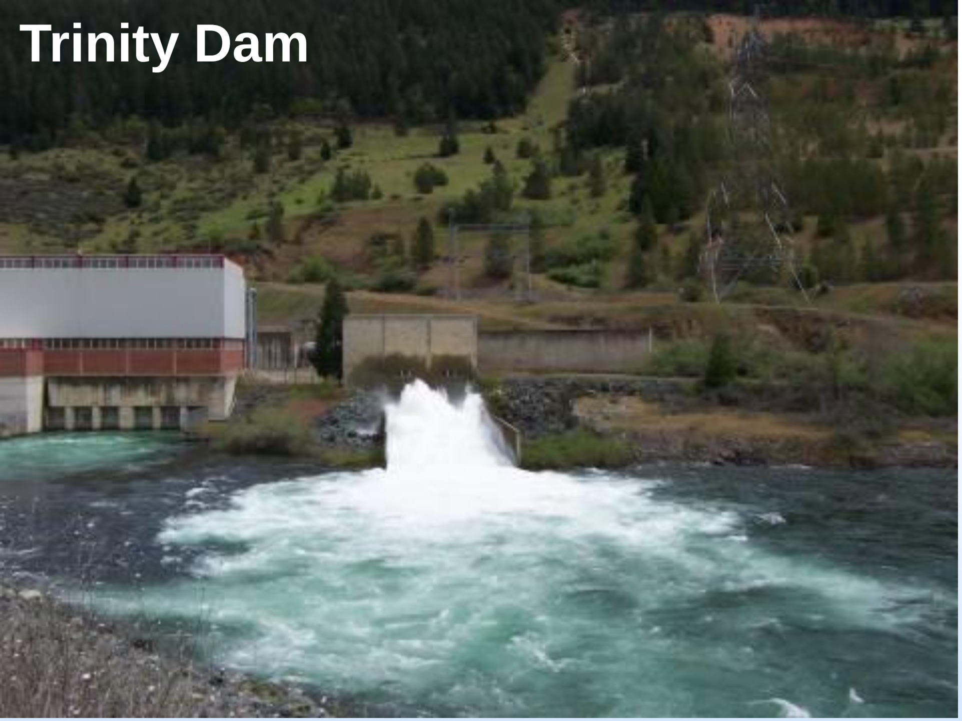
Snowpack from the Trinity Alps very important to hydrology

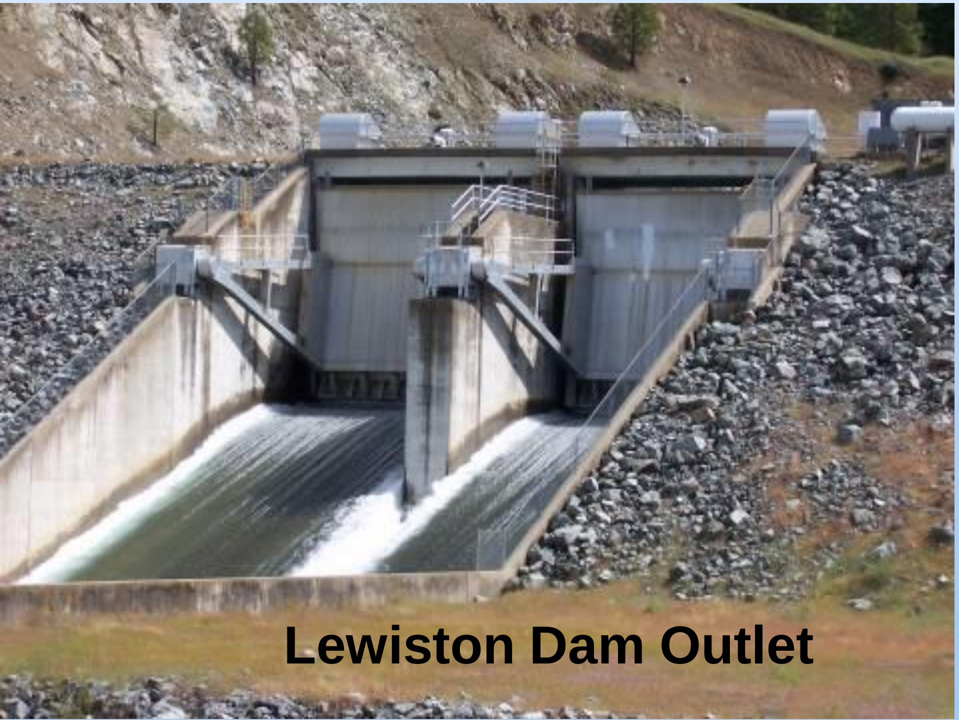
Ken Lertzman was here

(studying hummingbirds 1979-80)

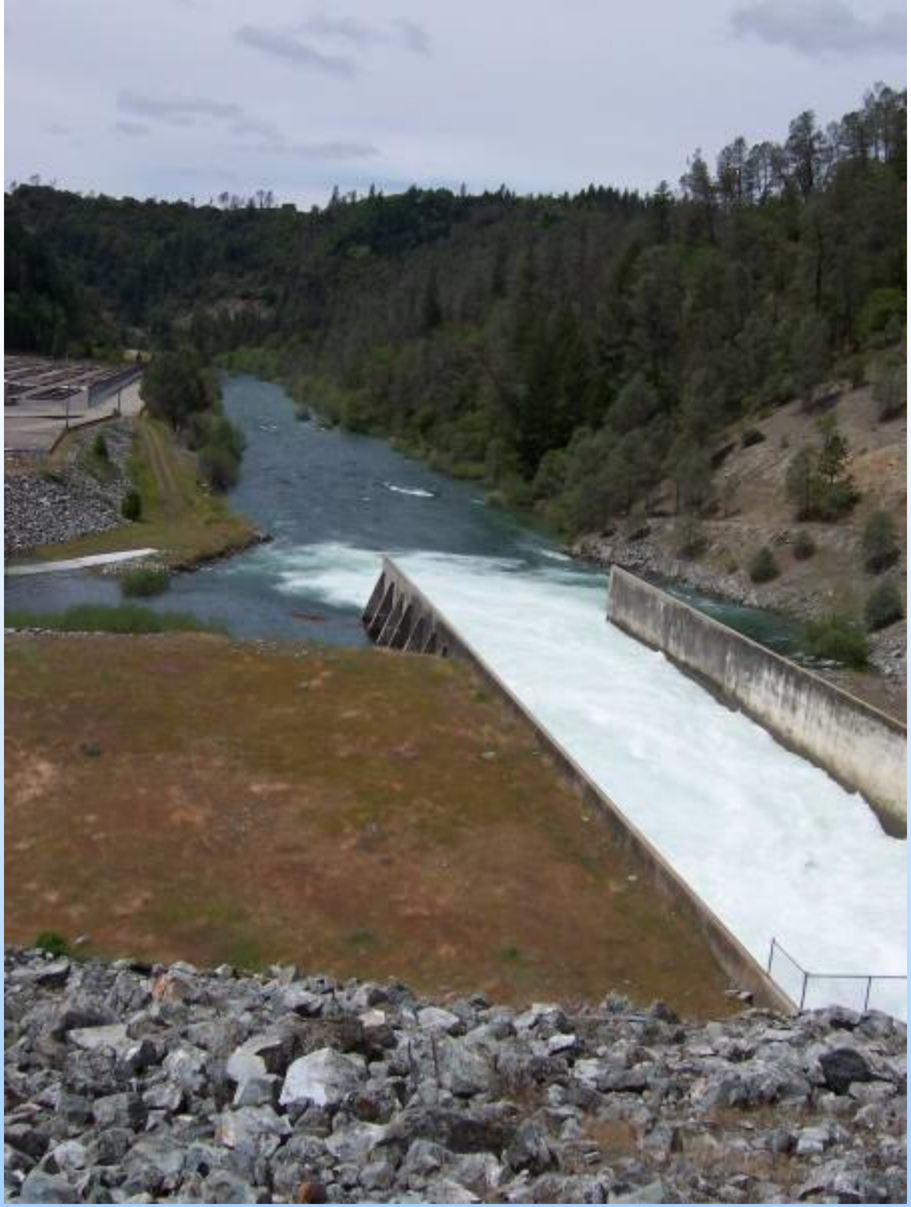




Trinity Dam

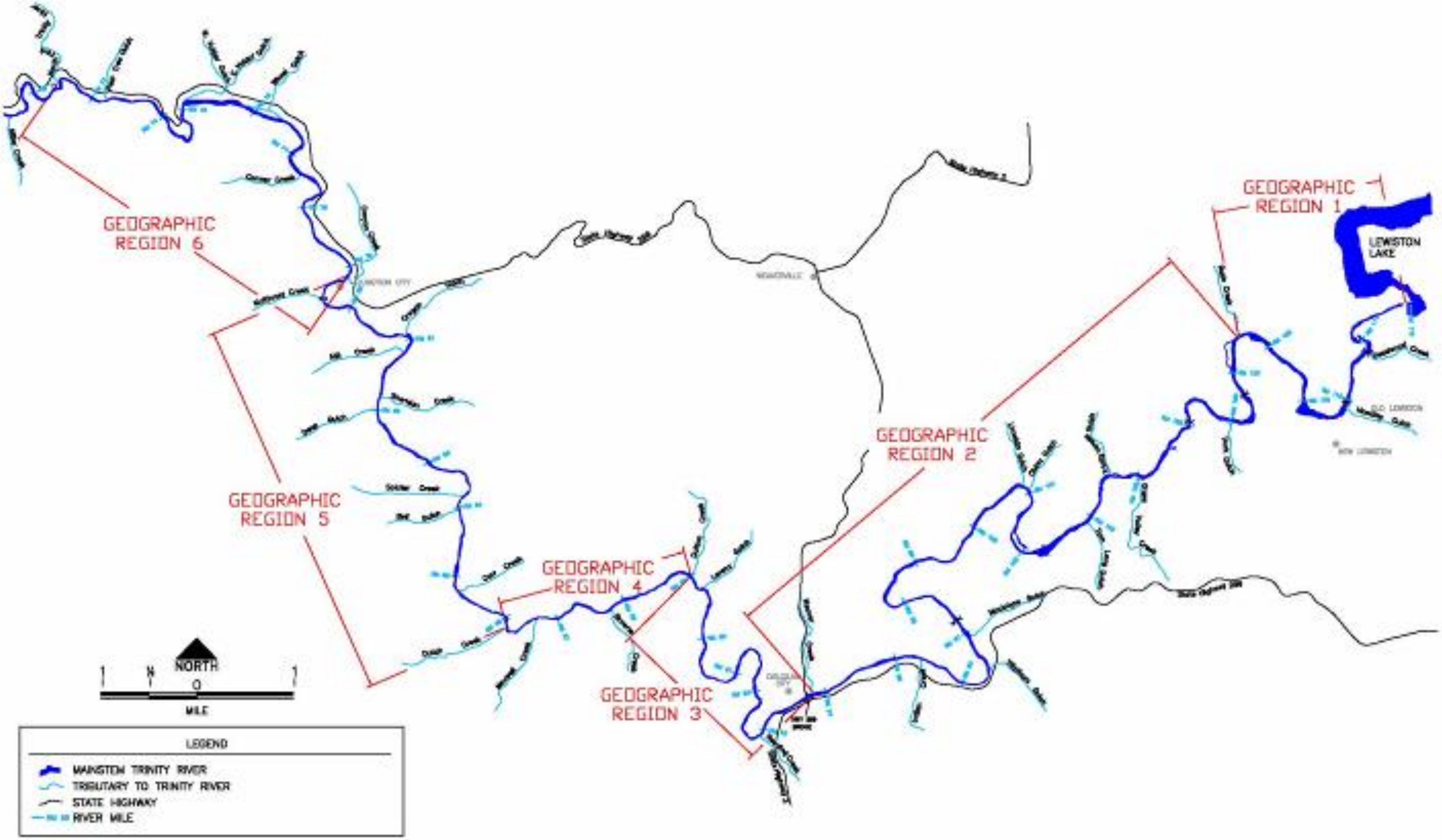


Lewiston Dam Outlet

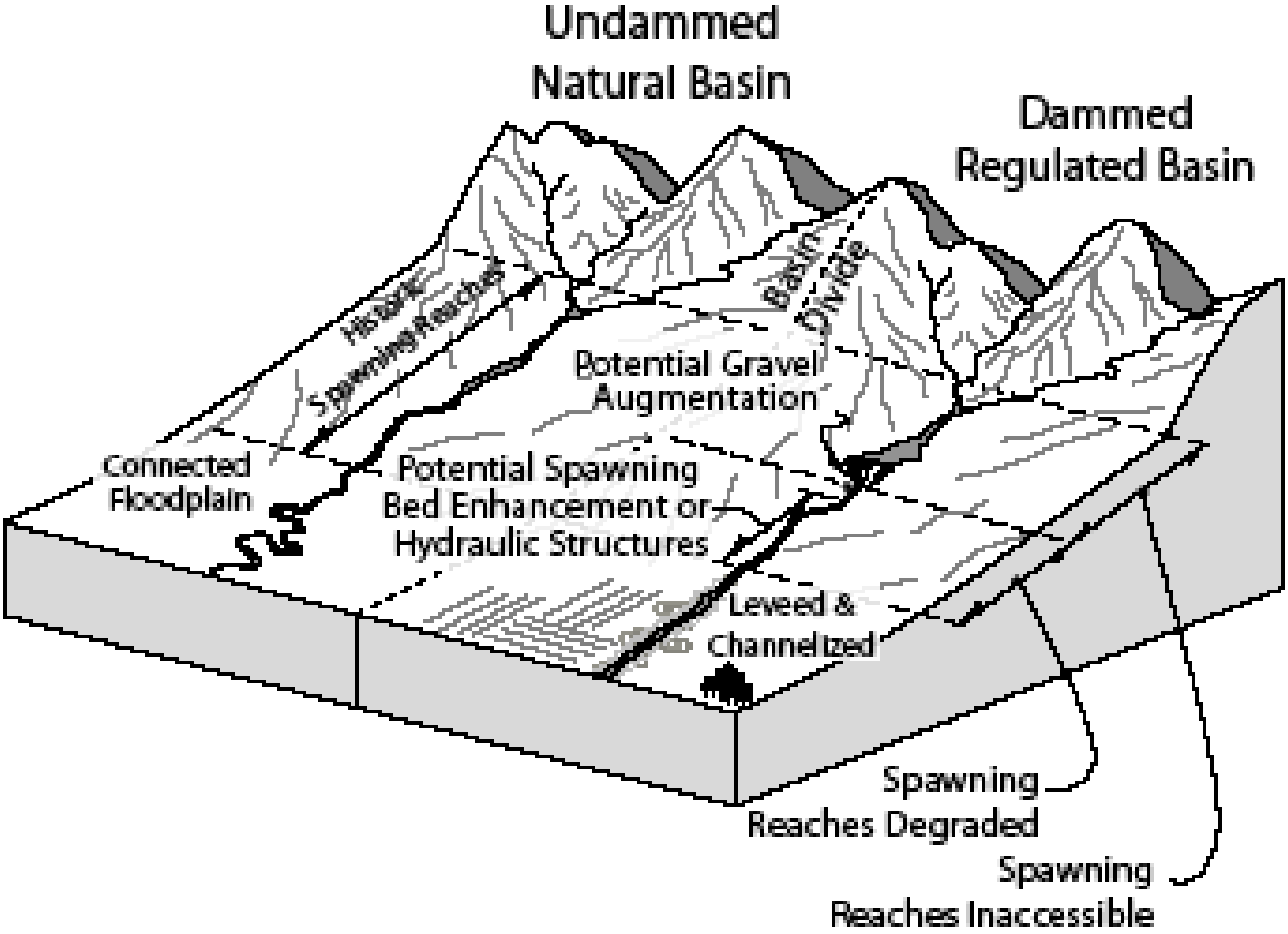


Looking downstream from Lewiston Dam

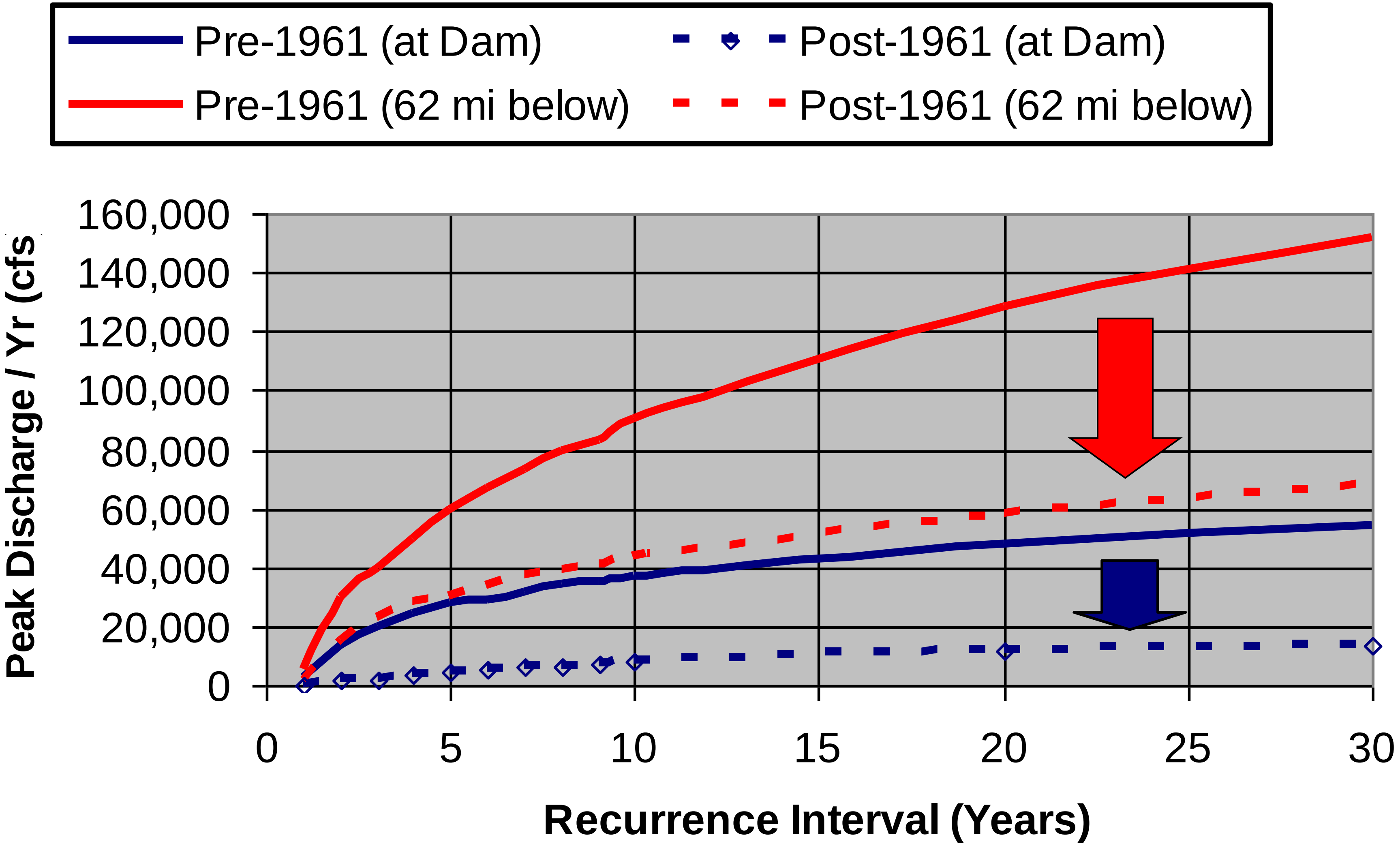
The First 40 Miles Below the Dam



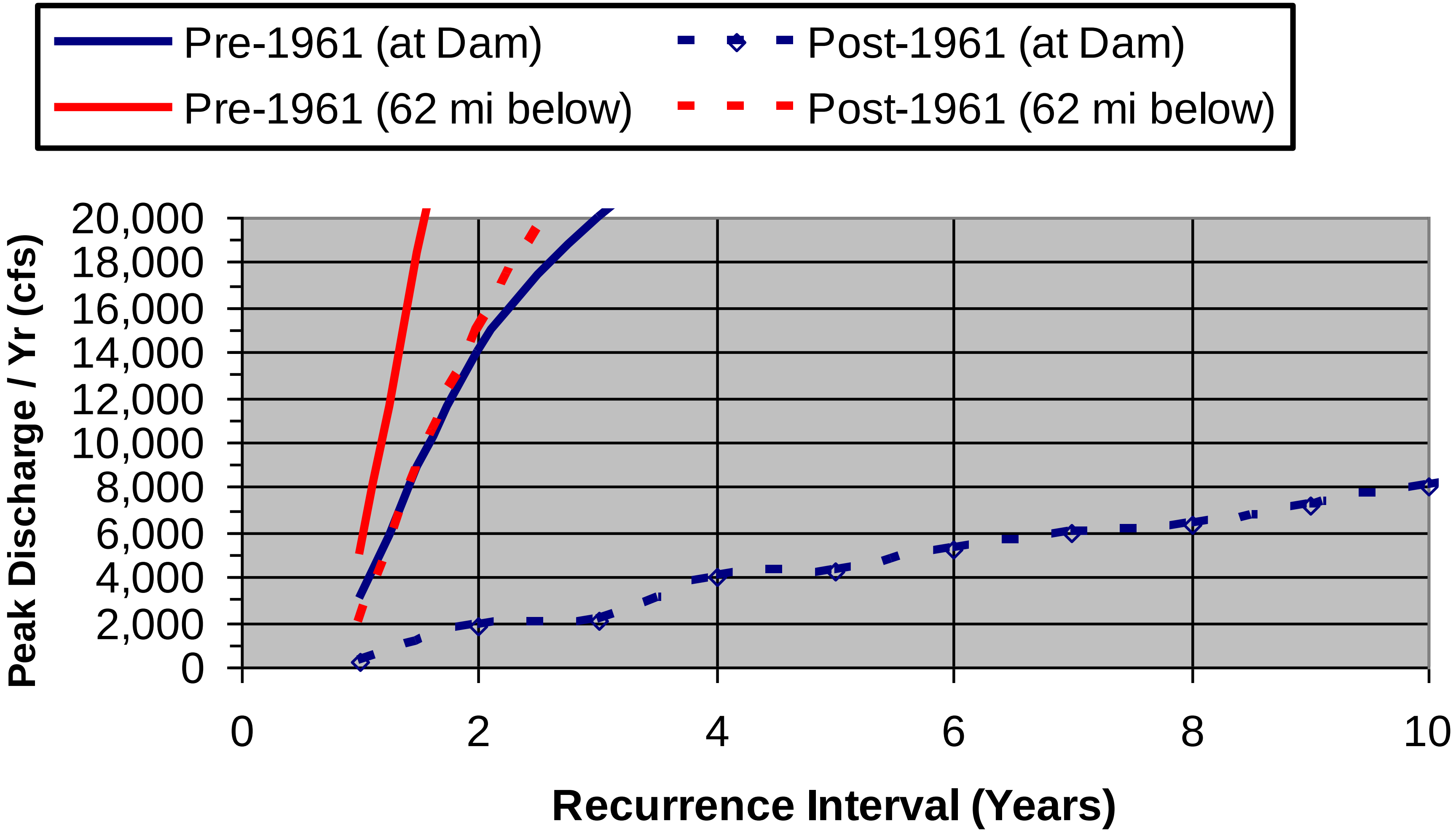
Trinity River Geographic Regions


Undammed
Natural Basin
Dammed
Regulated Basin
Historic
Spawning Reaches
Basin
Divide
Potential Gravel
Augmentation
Connected
Floodplain
Potential Spawning
Bed Enhancement or
Hydraulic Structures
Leveed &
Channelized
Spawning
Reaches Degraded
Spawning
Reaches Inaccessible

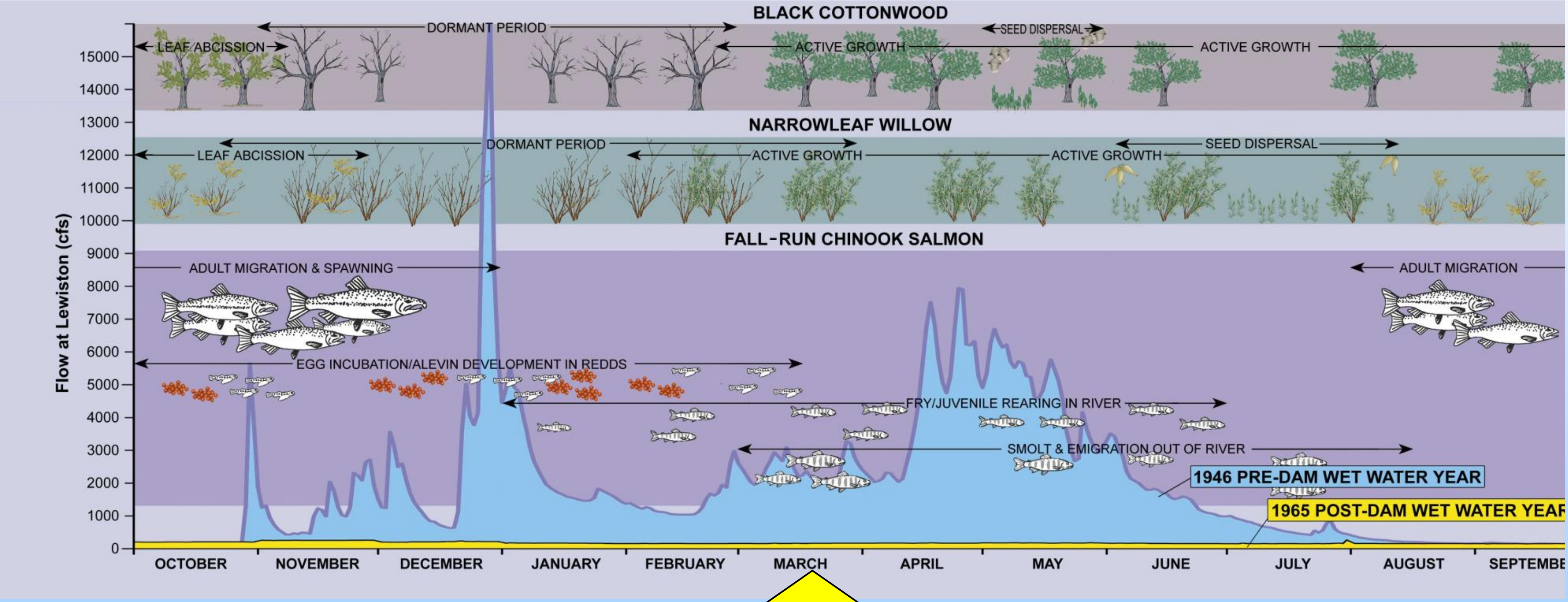
Changes in Peak Flows



Changes in Moderate Peak Flows

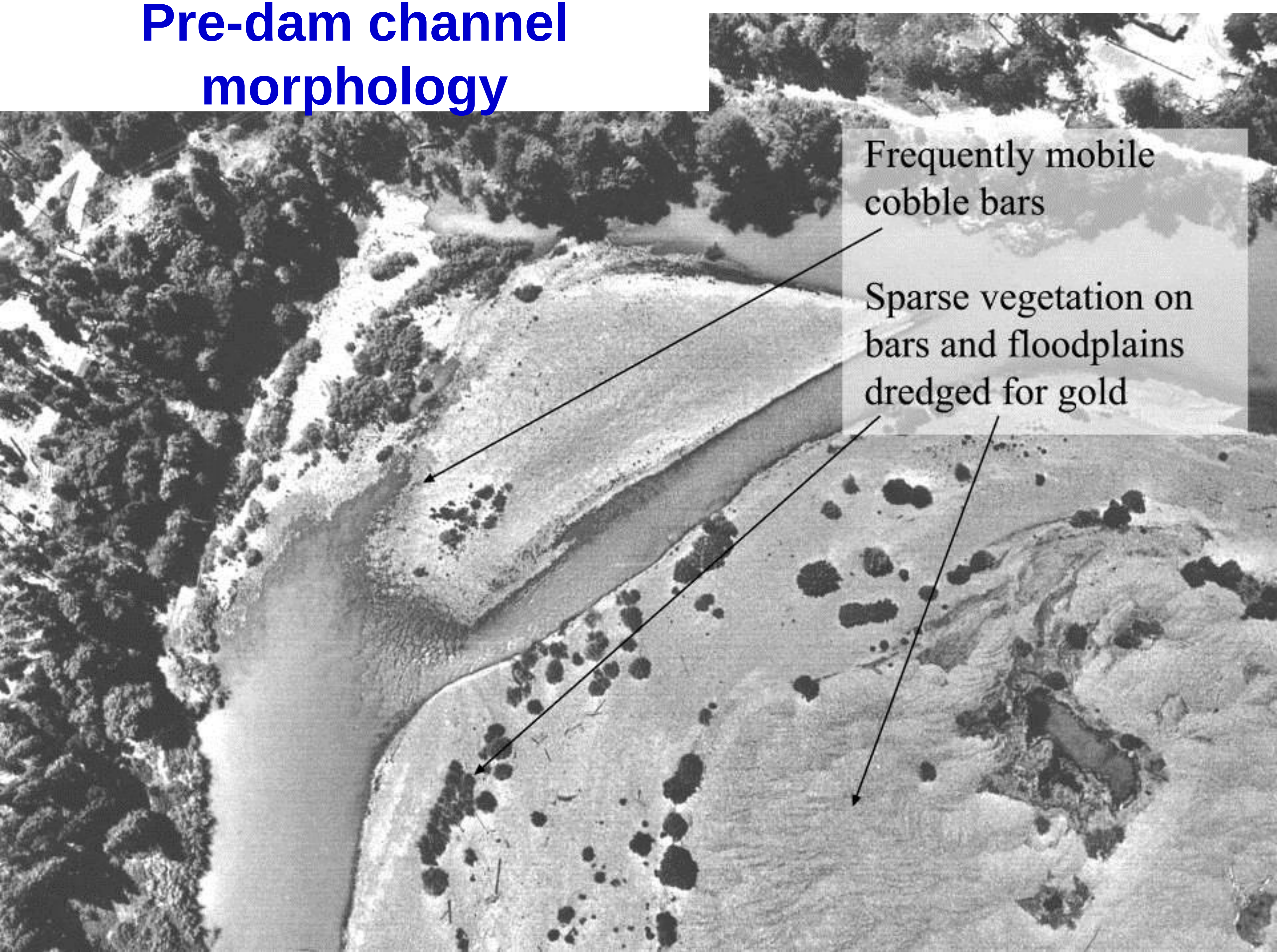


Flow and Life History Timing



Yes, the flow really was this low! Except for storm safety releases

Pre-dam channel morphology



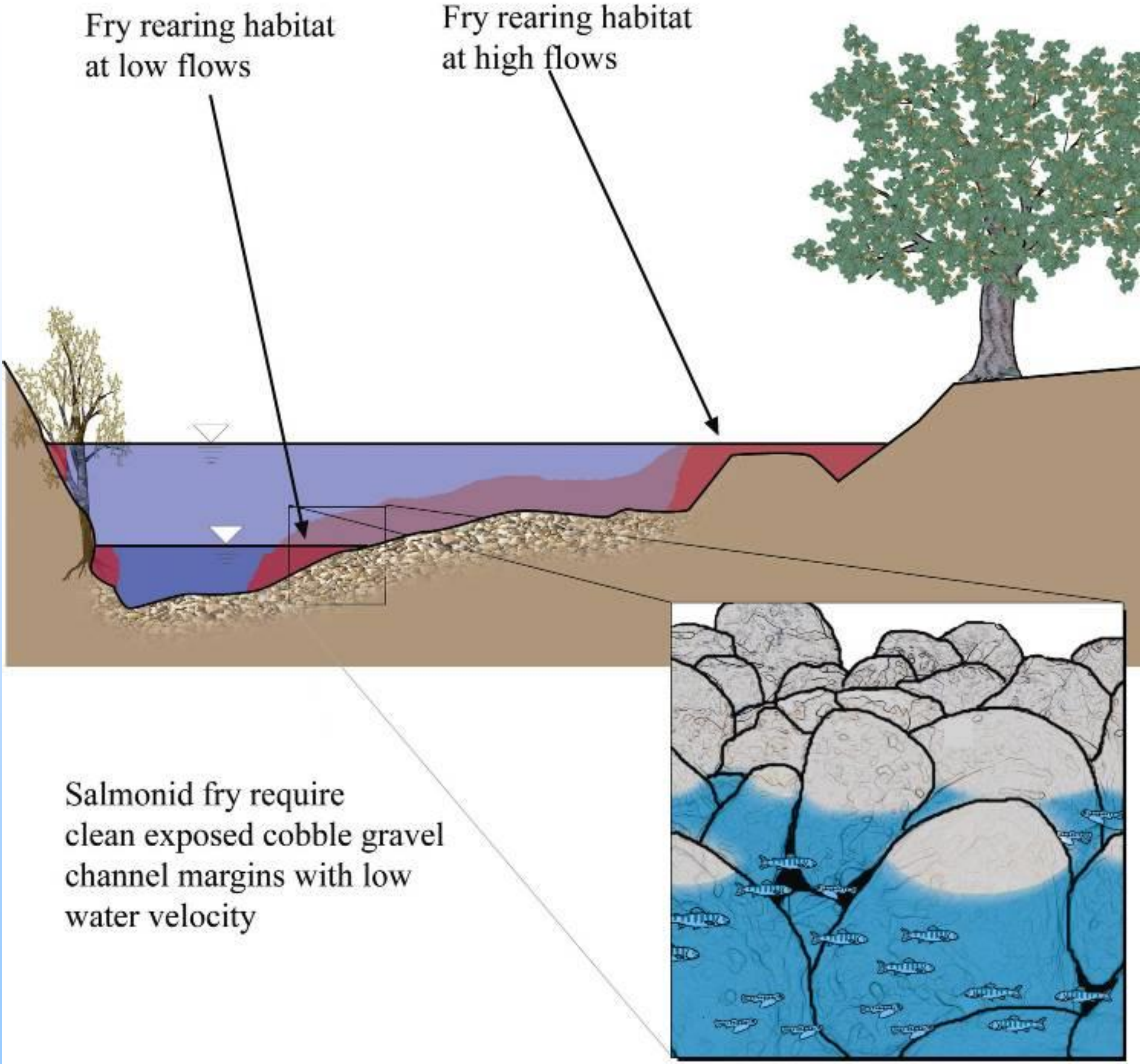
Frequently mobile cobble bars

Sparse vegetation on bars and floodplains dredged for gold

Post-dam channel morphology

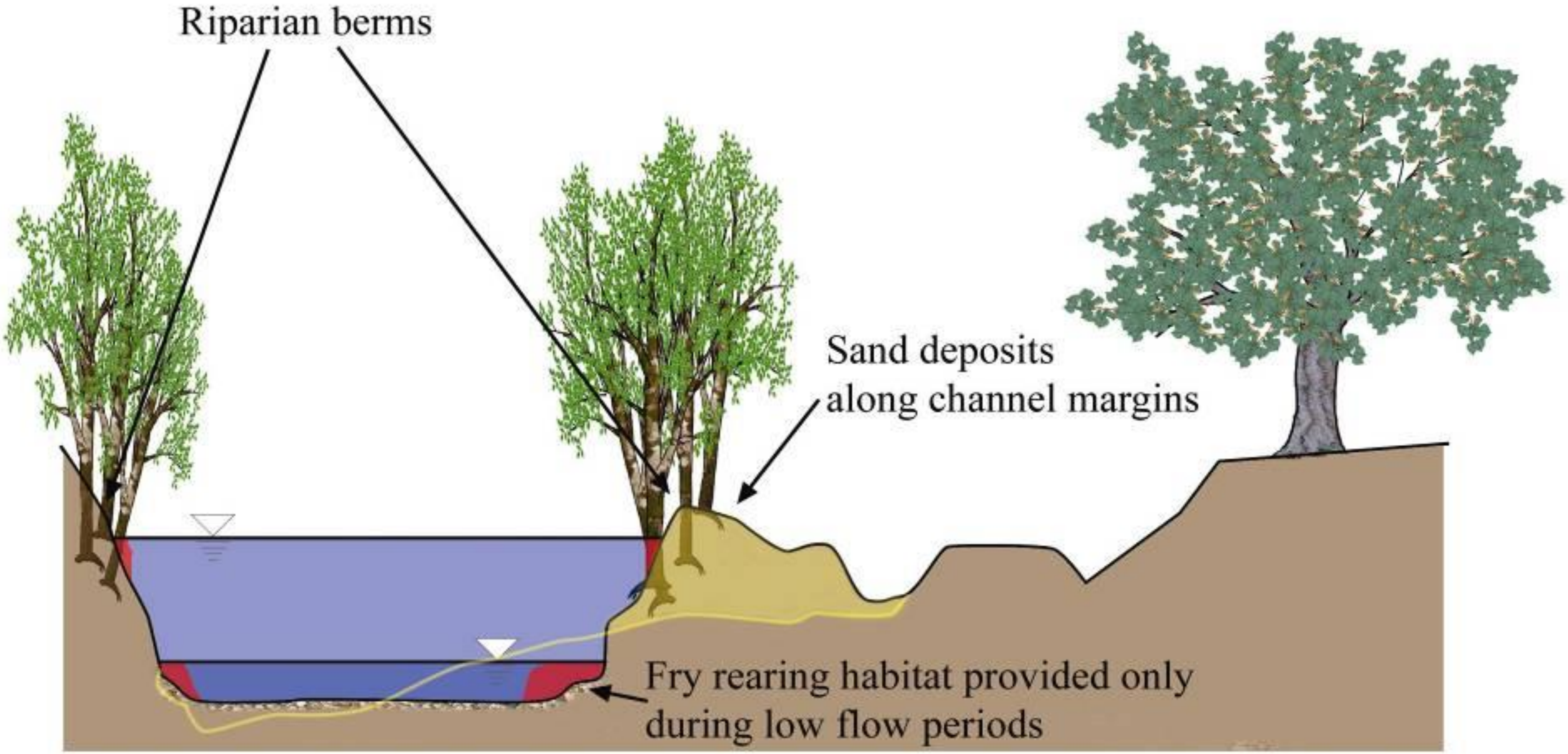
Thick riparian berms have armored previously mobile bars and have simplified channel morphology 40 miles downstream of Lewiston Dam

Pre-dam channel morphology and salmonid habitat



Salmonid fry require clean exposed cobble gravel channel margins with low water velocity

Impacts of modified channel morphology on salmonid habitat



Effects on Salmon

Fall-run chinook

- Pre-dam: 19,000 to 75,000 spawners
- Post-dam: 4,000 to 15,000
- Hatchery created, now 80% of in-river spawning are hatchery origin fish

Spring-run chinook, coho, steelhead

- Similar declines, coho a listed species

2000 Record of Decision: culmination of two Congressional actions, 16 years of study, and many lawsuits

- Sets the policy for restoring the Trinity River
  - Specifies total volumes in each of 5 Water Year types (369,000 ac-ft to 815,000 ac-ft)
  - Allows flexibility in future scheduling within <u>fixed</u> annual volume (appx 48% of historical volume); *recreate a river half the size*
  - Guideline for annual flow schedules based upon best available science
  - Mechanical rehabilitation of the channel
  - Coarse and fine sediment management
  - Establishes new adaptive management organization and process

TRRP Program Goal & Strategy {simplified}

Program Goal

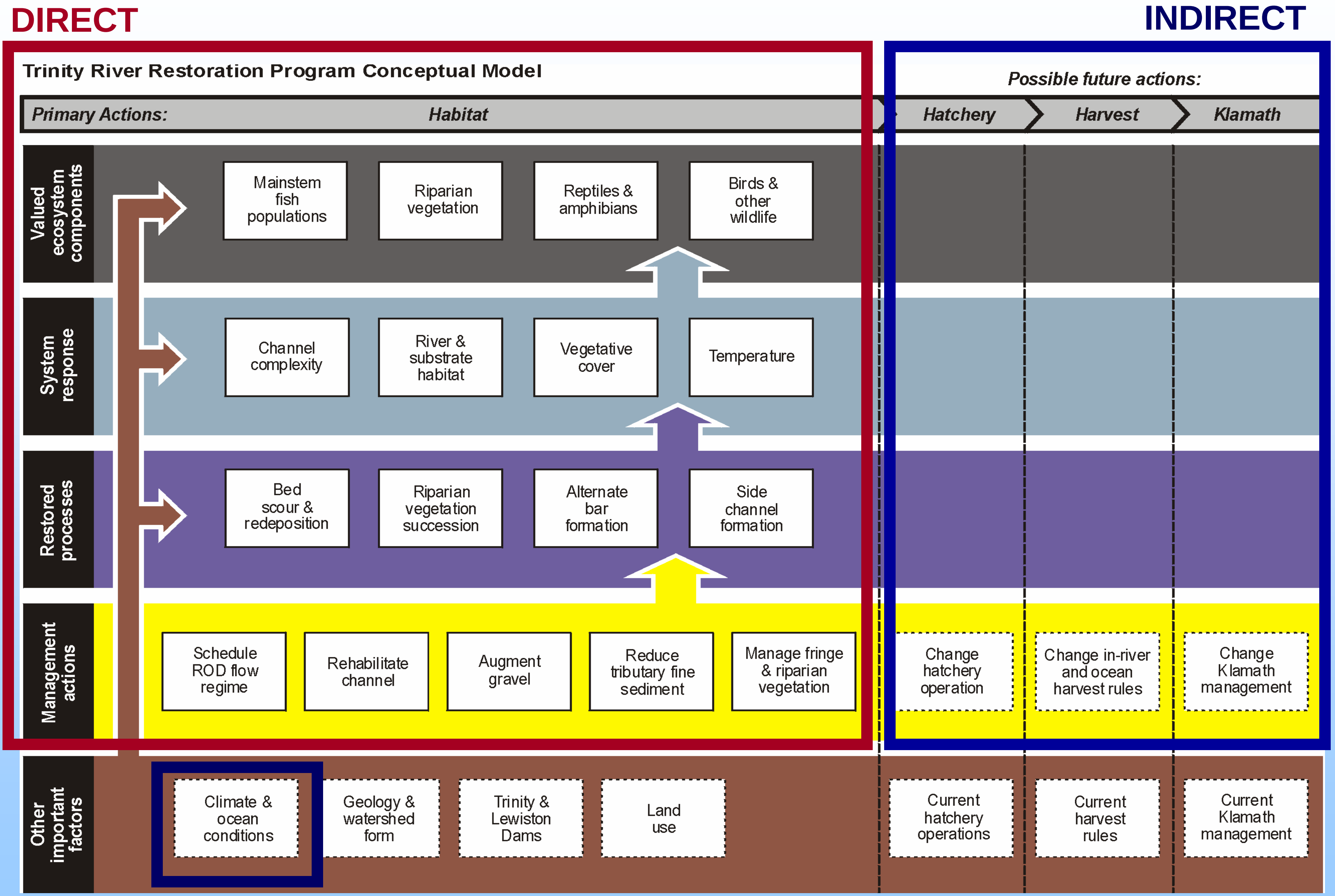
Restore and sustain **natural production** of anadromous fish populations downstream of Lewiston Dam **to pre-dam levels**,

to facilitate dependent tribal, commercial, and sport **fisheries**' full participation in the benefits of restoration via enhanced harvest opportunities.

Program Strategy

Restore **the processes** that produce a healthy alluvial river ecosystem, implementing management actions in a **science-based adaptive management** program.

Testing Program Hypotheses

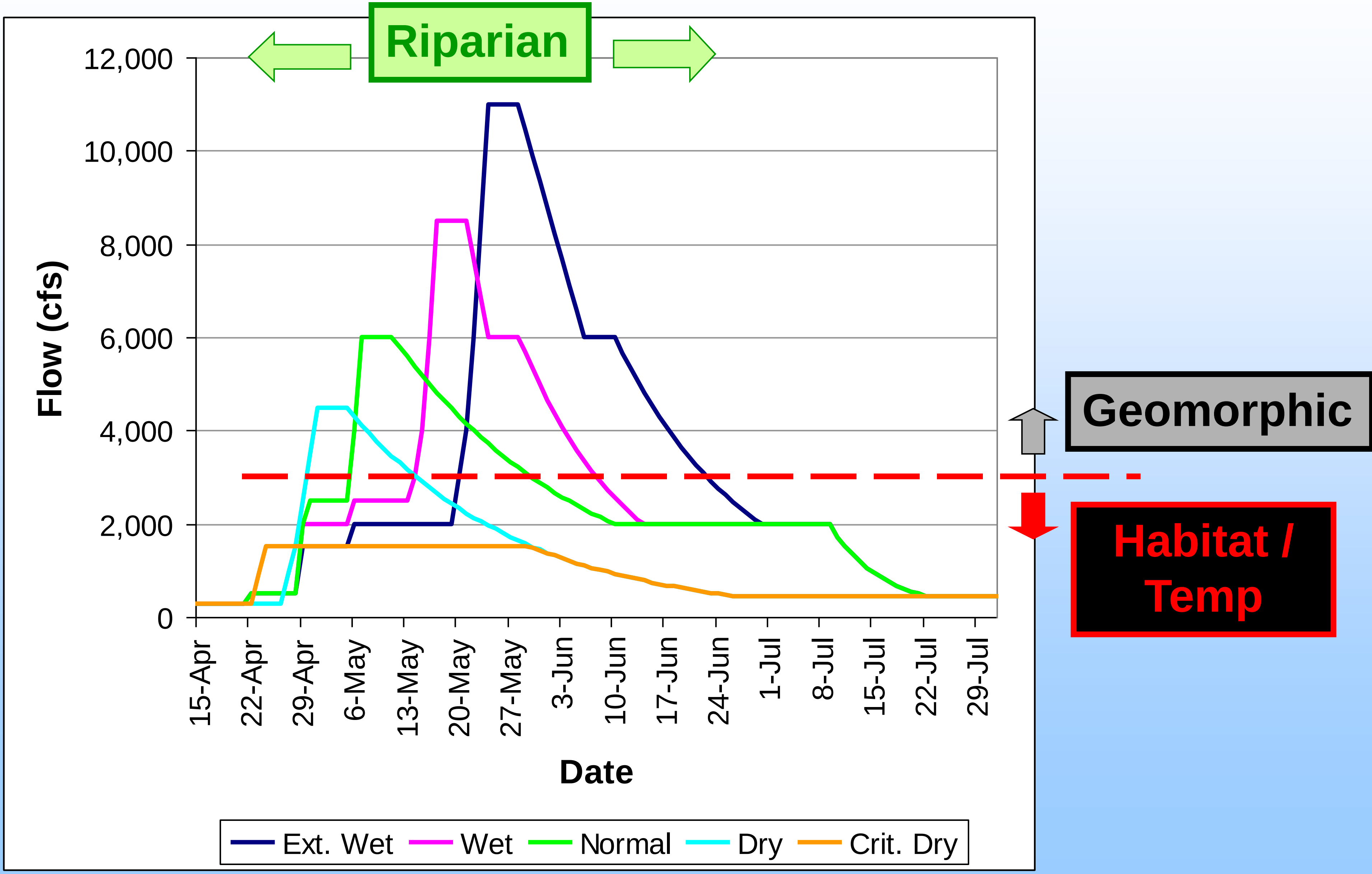


Variable Annual Flow Schedule

Water year type	**Frequency of occurrence**	**Volume (AF)**	**Peak Release (cfs)**
Critically dry	(12%)	369,000	1,500
Dry	(28%)	453,000	4,500
Normal	(20%)	647,000	6,000
Wet	(28%)	701,000	8,500
Extremely wet	(12%)	815,000	11,000

Average volume post-dam but before Record of Decision was only 369,000 AF

ROD Flows

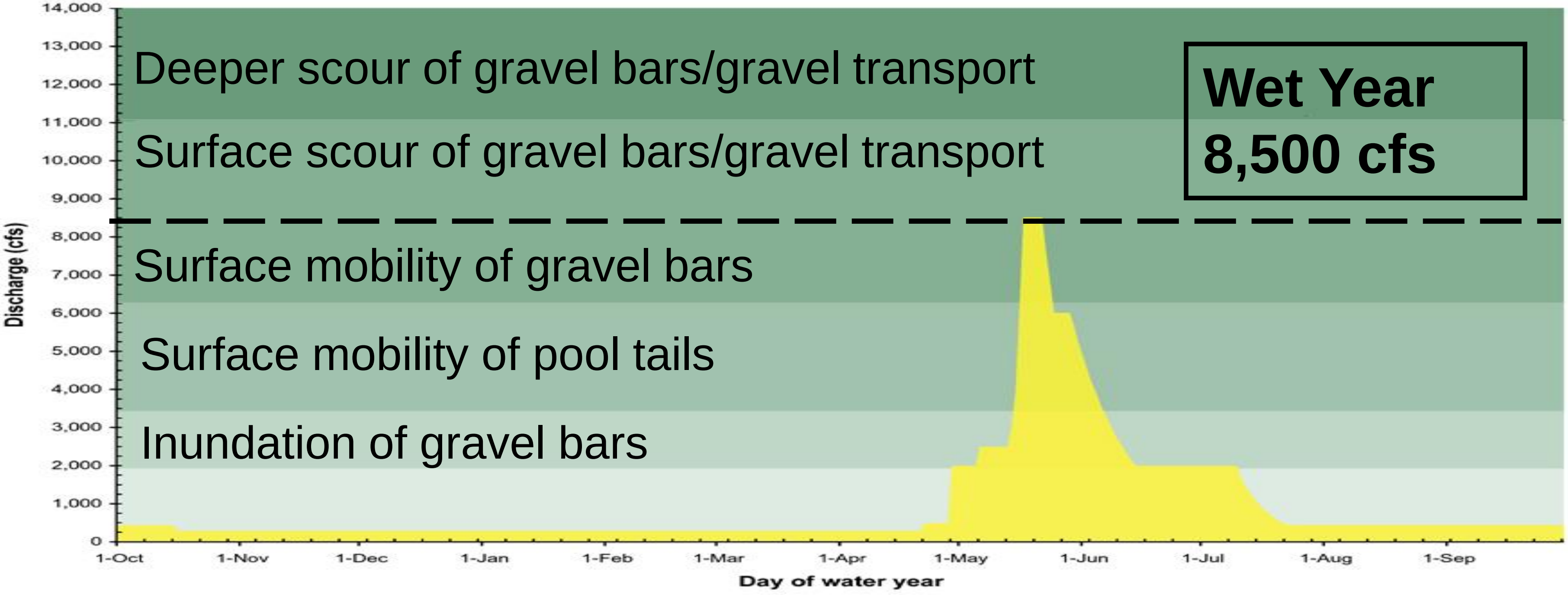


Riparian

Geomorphic

Habitat / Temp

Restoration Tools: Flow Management



Deeper scour of gravel bars/gravel transport

Surface scour of gravel bars/gravel transport

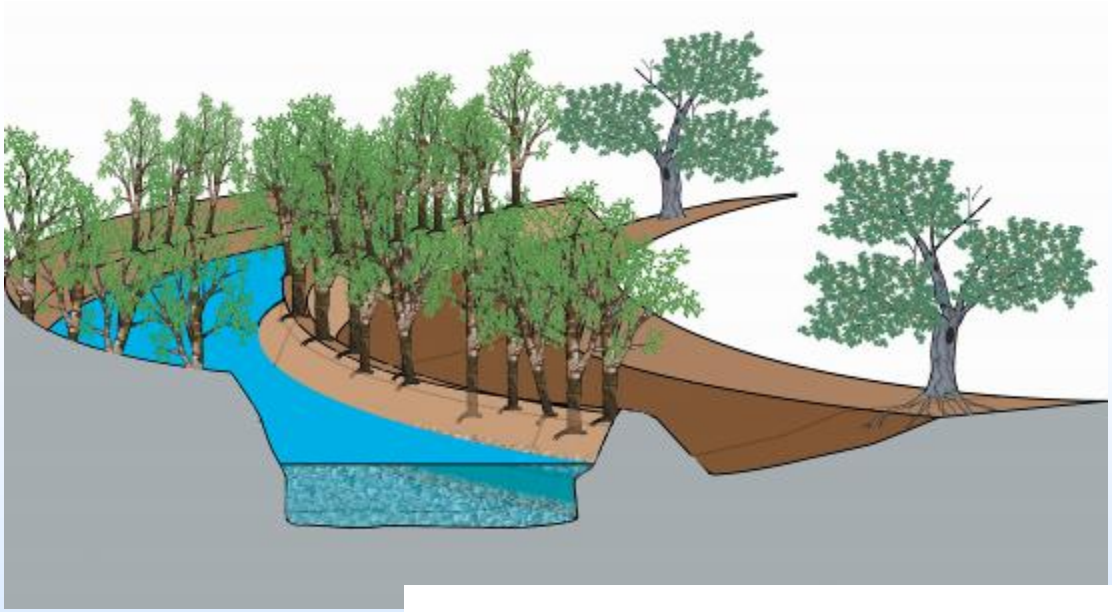
Surface mobility of gravel bars

Surface mobility of pool tails

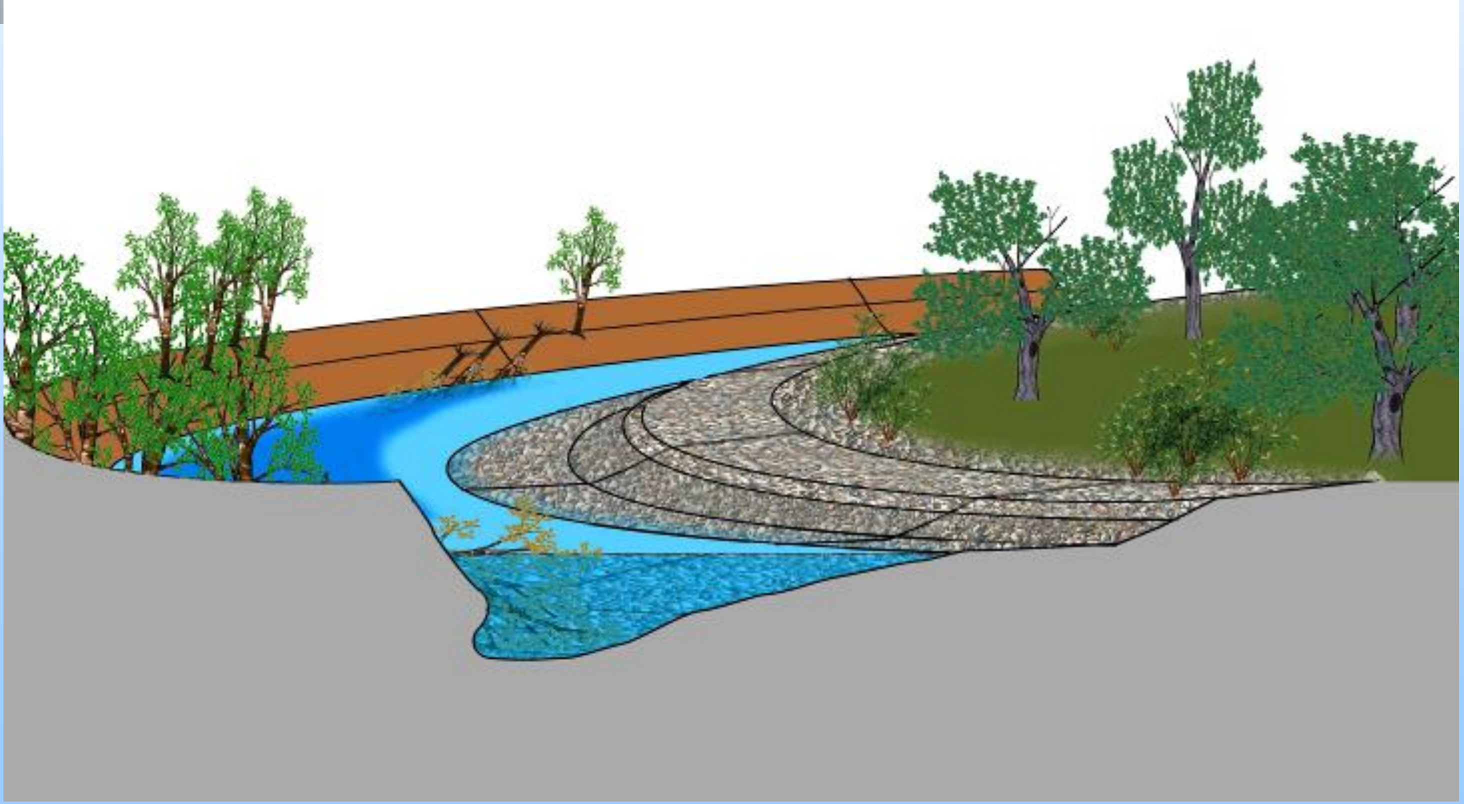
Inundation of gravel bars

Wet Year
8,500 cfs

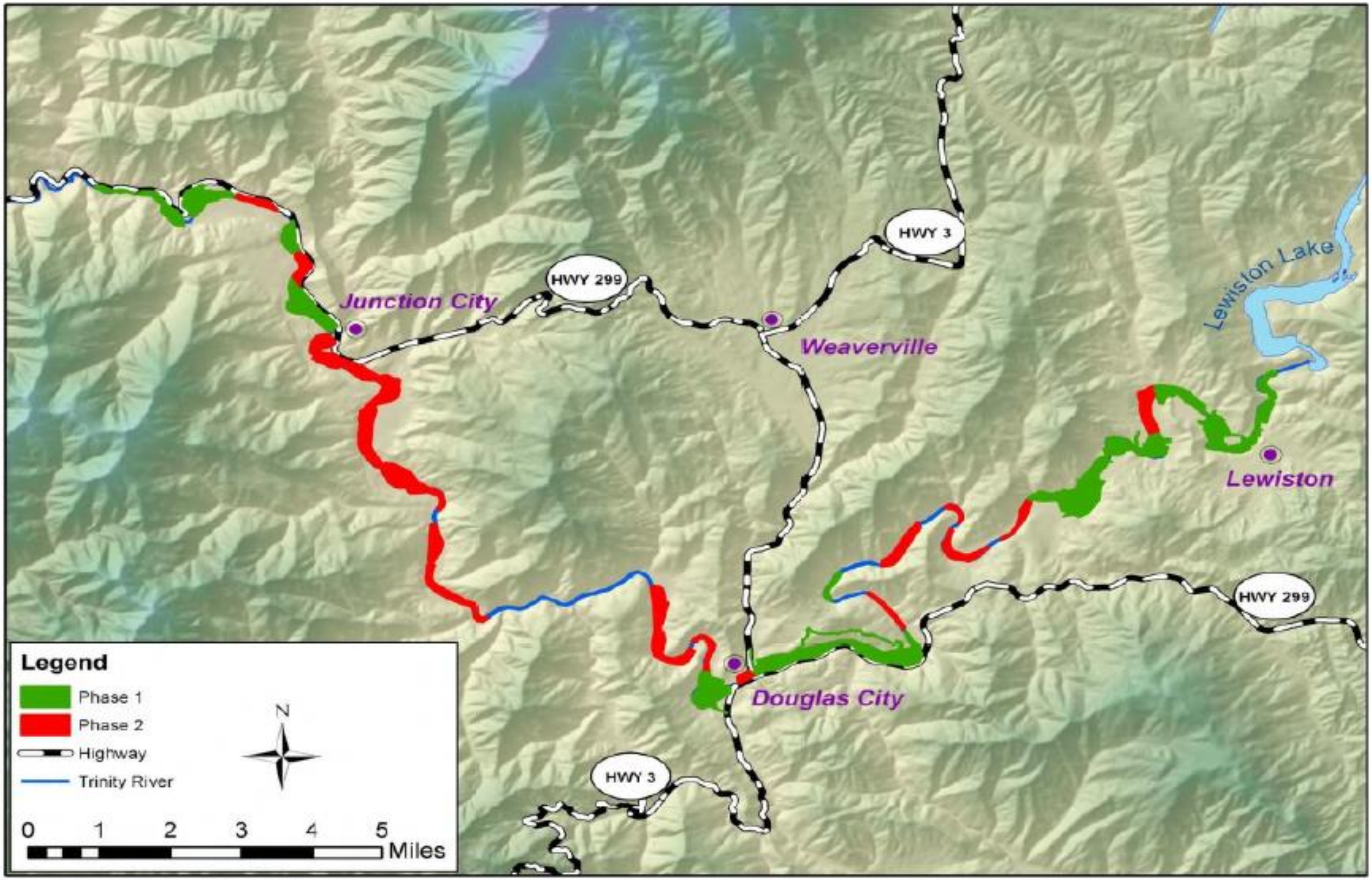
Restoration Tools:
Mechanical Channel Bank Restoration



Bank Rehabilitation Sites

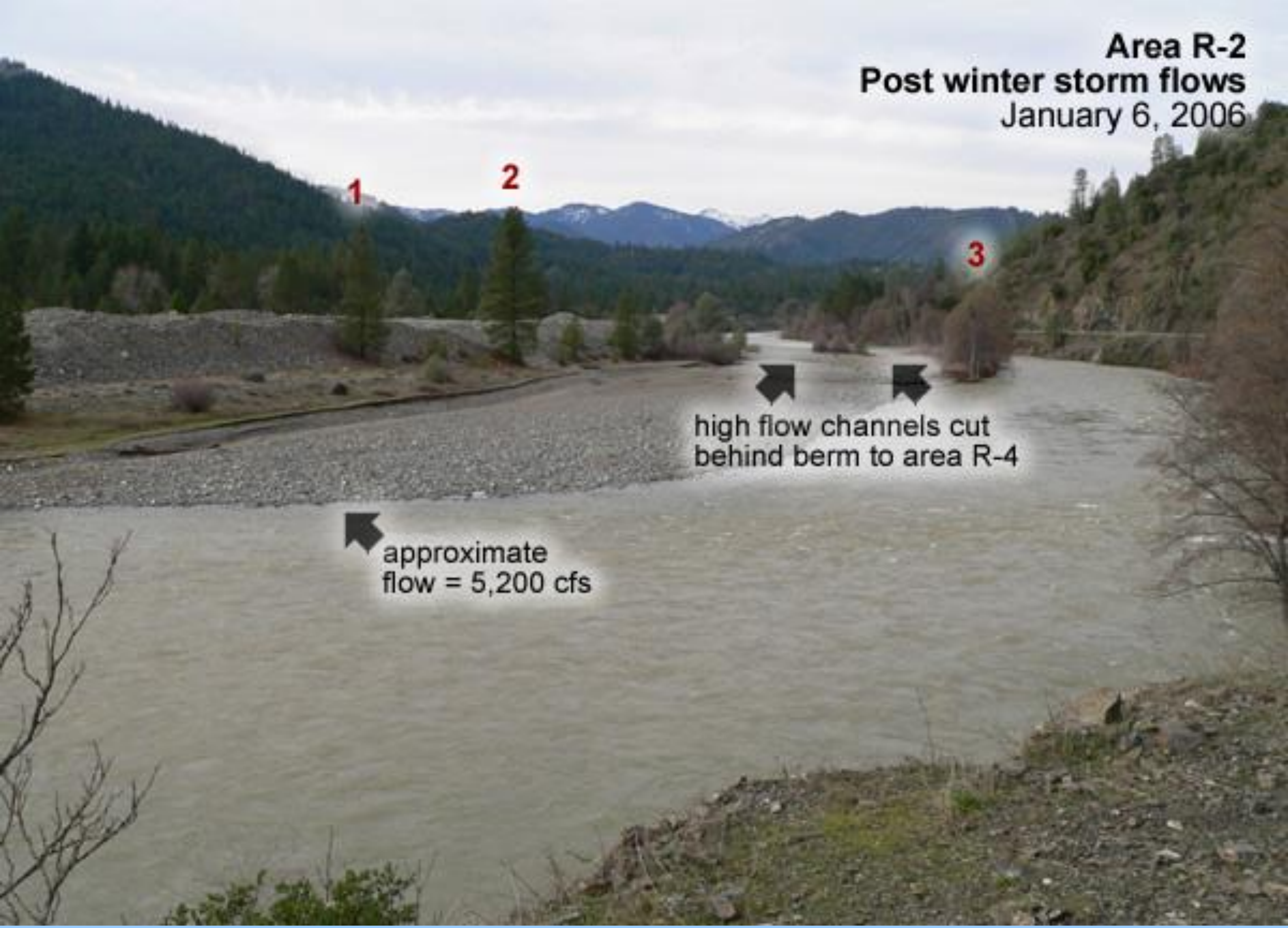


Channel Rehabilitation Sites




Area R-2
Post-construction
September 12, 2005
1
2
3
approximate
flow = 450 cfs


1
2
3
Area R-2
Winter storm flows
December 28, 2005
flow across floodplain
to area R-4
approximate
flow = 14,000 cfs



Area R-2

Post winter storm flows

January 6, 2006

high flow channels cut
behind berm to area R-4

approximate
flow = 5,200 cfs

Area R-4
Pre-construction
April 3, 2003

approximate flow = 600 cfs

Area R-4
Post-construction
October 13, 2005

Area R-4
Winter storm flows
December 28, 2005

flow across floodplain
from area R-2

approximate
flow = 14,000 cfs

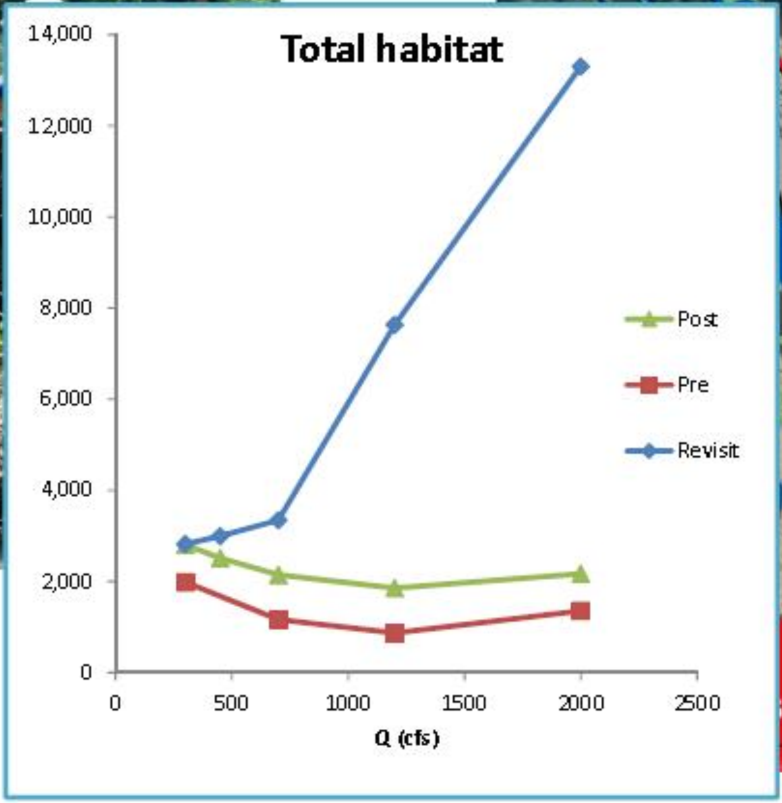
Interdisciplinary learning at Rehab Sites

- First few sites designed by geomorphologists
  (*Trees are the enemy – trap fine sediment)*
- Fish biologists then got involved in dialogue
  (*Trees provide cover for juvenile salmon)*

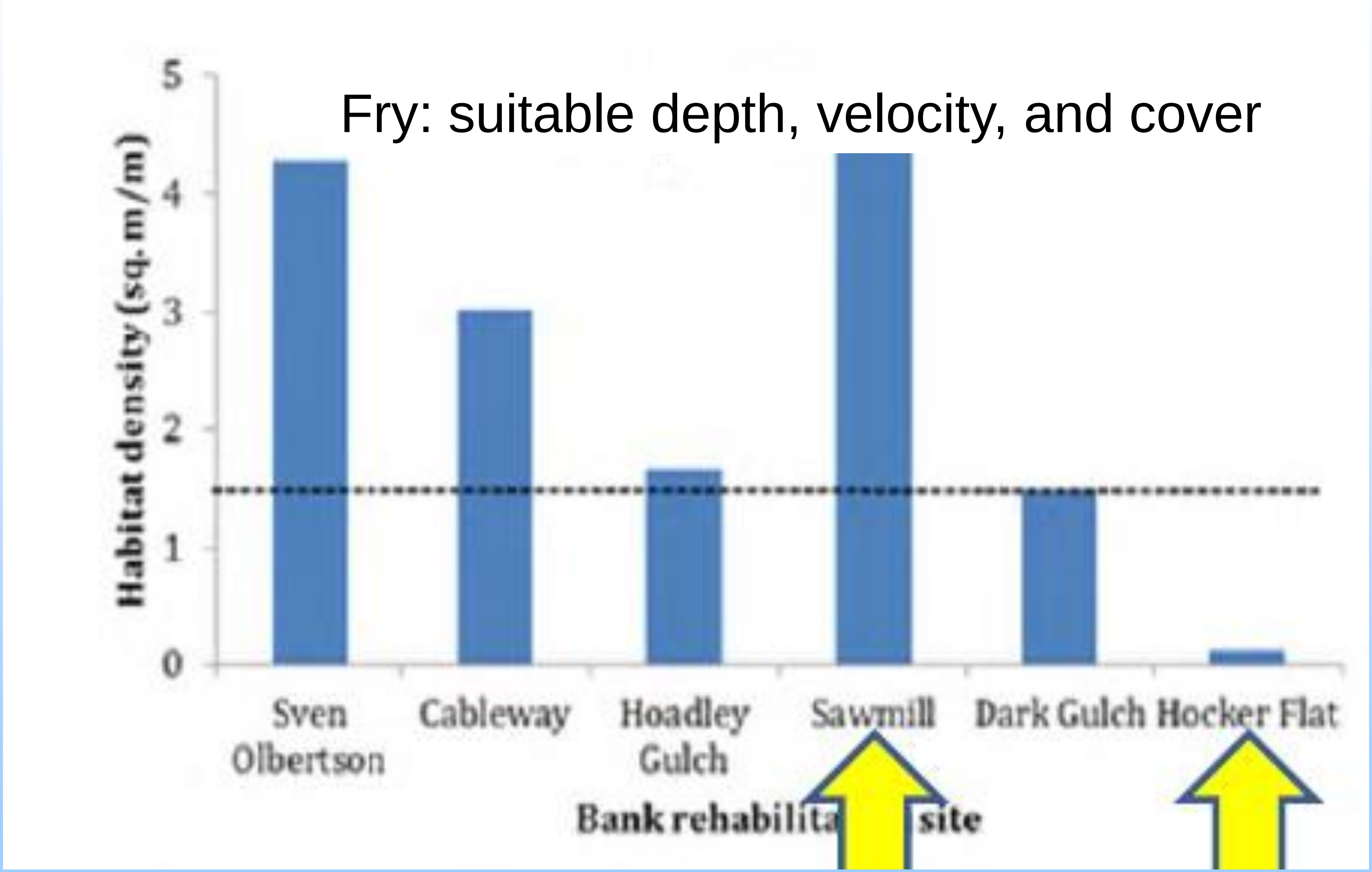
UTILIZATION OF LARGE WOOD FOR COVER & COMPLEXITY

Channel rehabilitation

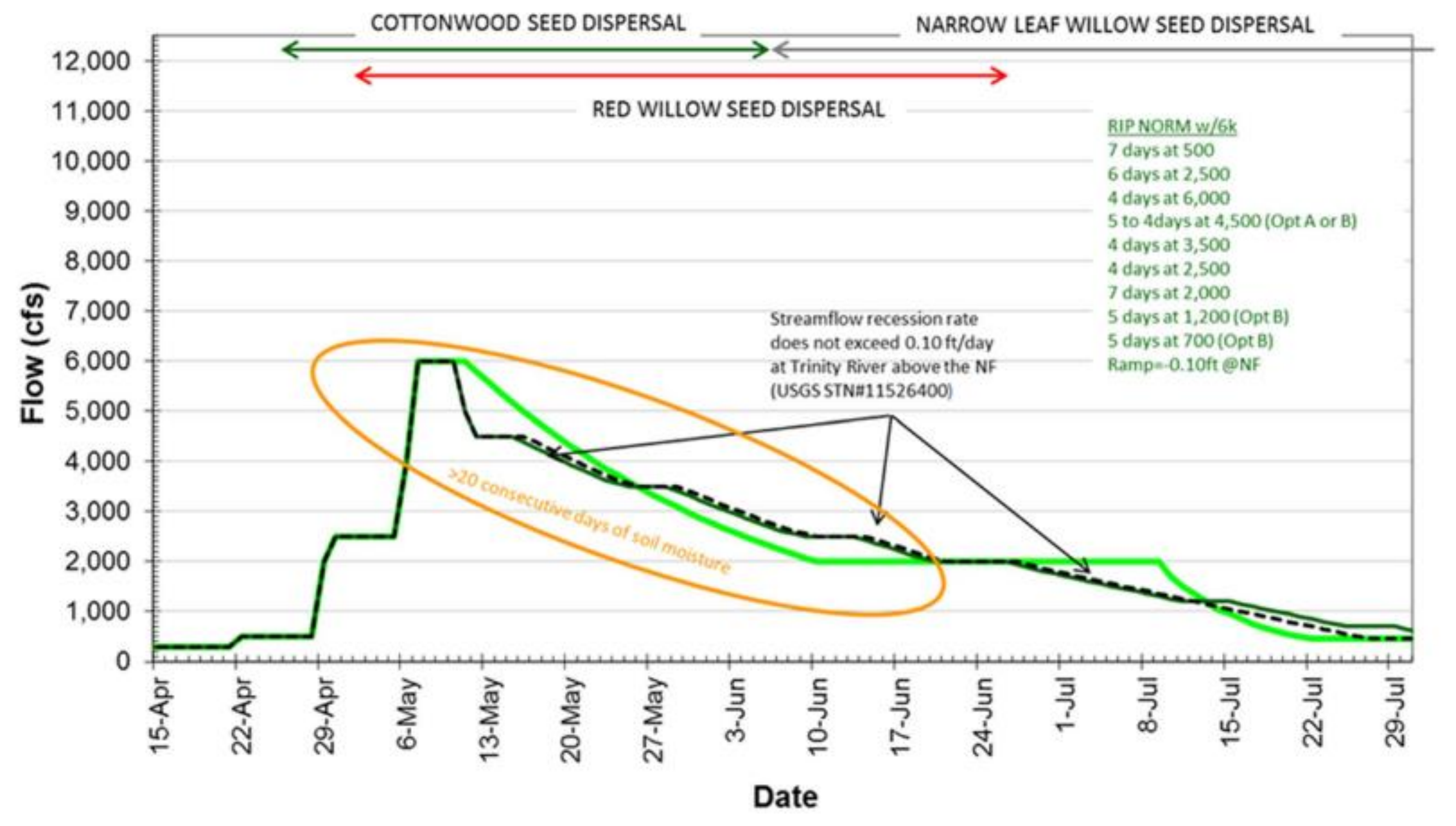
Rearing habitat assessment



Design improvements ⇒ More suitable fry and smolt habitat per length of river


Fry: suitable depth, velocity, and cover

Learning to restore vegetation in upland areas



Streamflow recession rate does not exceed 0.10 ft/day at Trinity River above the NF (USGS STN#11526400)

RIP NORM w/6k
7 days at 500
6 days at 2,500
4 days at 6,000
5 to 4days at 4,500 (Opt A or B)
4 days at 3,500
4 days at 2,500
7 days at 2,000
5 days at 1,200 (Opt B)
5 days at 700 (Opt B)
Ramp=-0.10ft @NF

Just flows ⇒ Solar-powered drip irrigation

Restoration Tools:
Coarse Sediment Augmentation

Short Term

- 3 years
- ~ 100,000 yd^3

Long Term

- Annually
- Up to 67,000 yd^3

Based on multi-year average sediment budget

Restoration Tools:
Watershed Sediment Source Control

- Reduce fine sediment delivery
- Encourage coarse sediment delivery
- Reduce delivery of oversize material

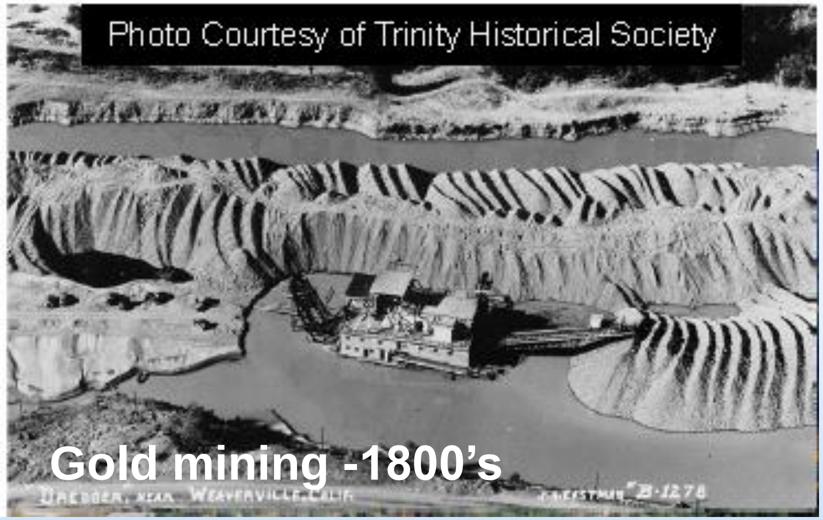
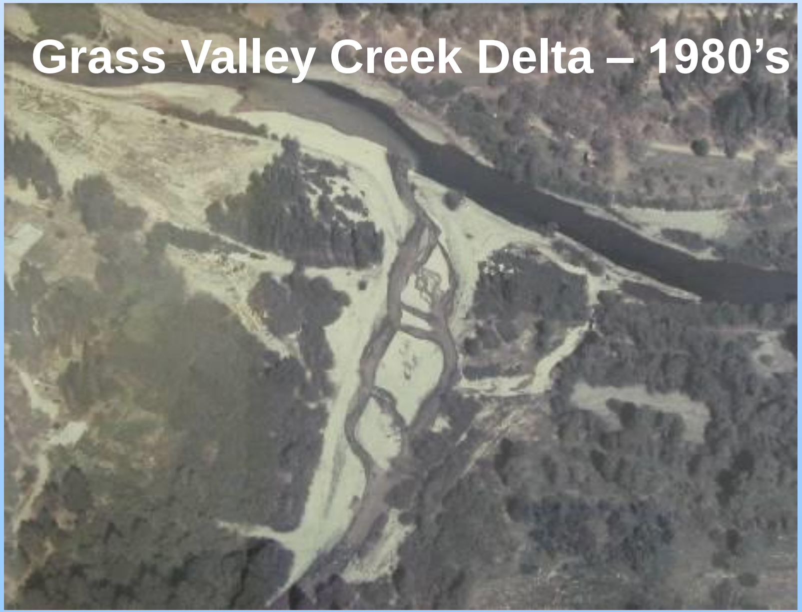


Photo Courtesy of Trinity Historical Society

Gold mining -1800's


Grass Valley Creek Delta – 1980's


Decomposed Granite

What are the attributes of dynamic alluvial rivers?

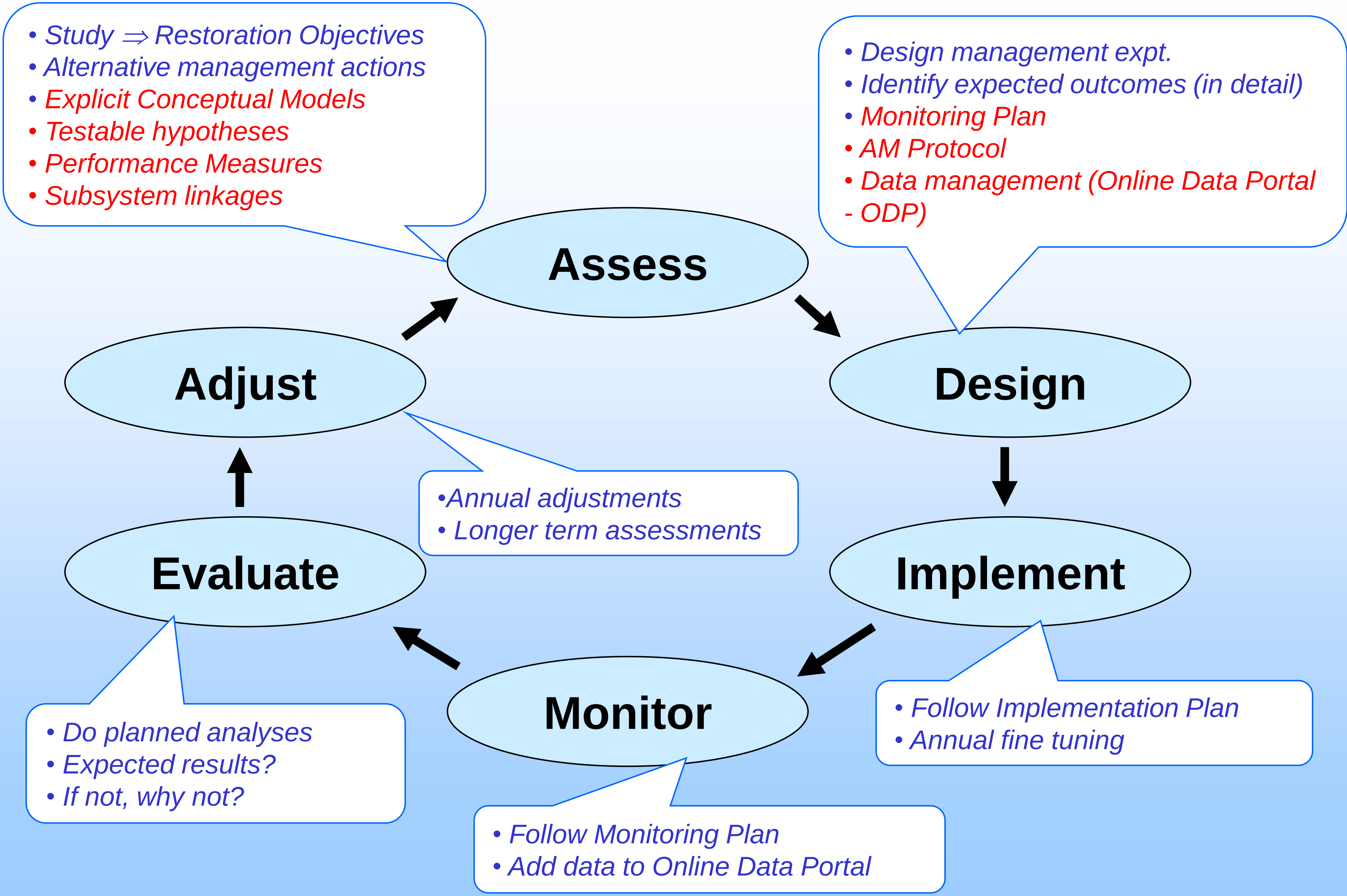
1) Spatially complex morphology and habitat
2) Variable flow and temperature regime
3) Frequent mobilization of gravel bed
4) Periodic scour and redeposition of gravel bed
5) Balanced sediment budget (fine and coarse)
6) Periodic channel migration
7) Frequently inundated floodplain
8) Infrequent very large floods to re-organize channel and riparian vegetation
9) Self-sustaining and diverse riparian vegetation
10) River often connected with adjacent water table

General geomorphic restoration objectives

- Restore inter-annual flow variability
- Restore intra-annual flow variability
- Mobilize bed surface particles every 1-2 years
- Scour/redeposit bar surfaces every 4-8 years
- Reduce fine sediment supply
- Balance and route coarse sediment
- Restore alternate bar morphology, floodplains, and dynamic riparian vegetation
- Different objectives for each water year
- Evolution over time in these objectives as Program learns

Restoration Tools

Adaptive Environmental Assessment and Management (AEAM)



Assess

- *Study ⇒ Restoration Objectives*
- *Alternative management actions*
- *Explicit Conceptual Models*
- *Testable hypotheses*
- *Performance Measures*
- *Subsystem linkages*

Design

- *Design management expt.*
- *Identify expected outcomes (in detail)*
- *Monitoring Plan*
- *AM Protocol*
- *Data management (Online Data Portal - ODP)*

Implement

- *Follow Implementation Plan*
- *Annual fine tuning*

Monitor

- *Follow Monitoring Plan*
- *Add data to Online Data Portal*

Evaluate

- *Do planned analyses*
- *Expected results?*
- *If not, why not?*

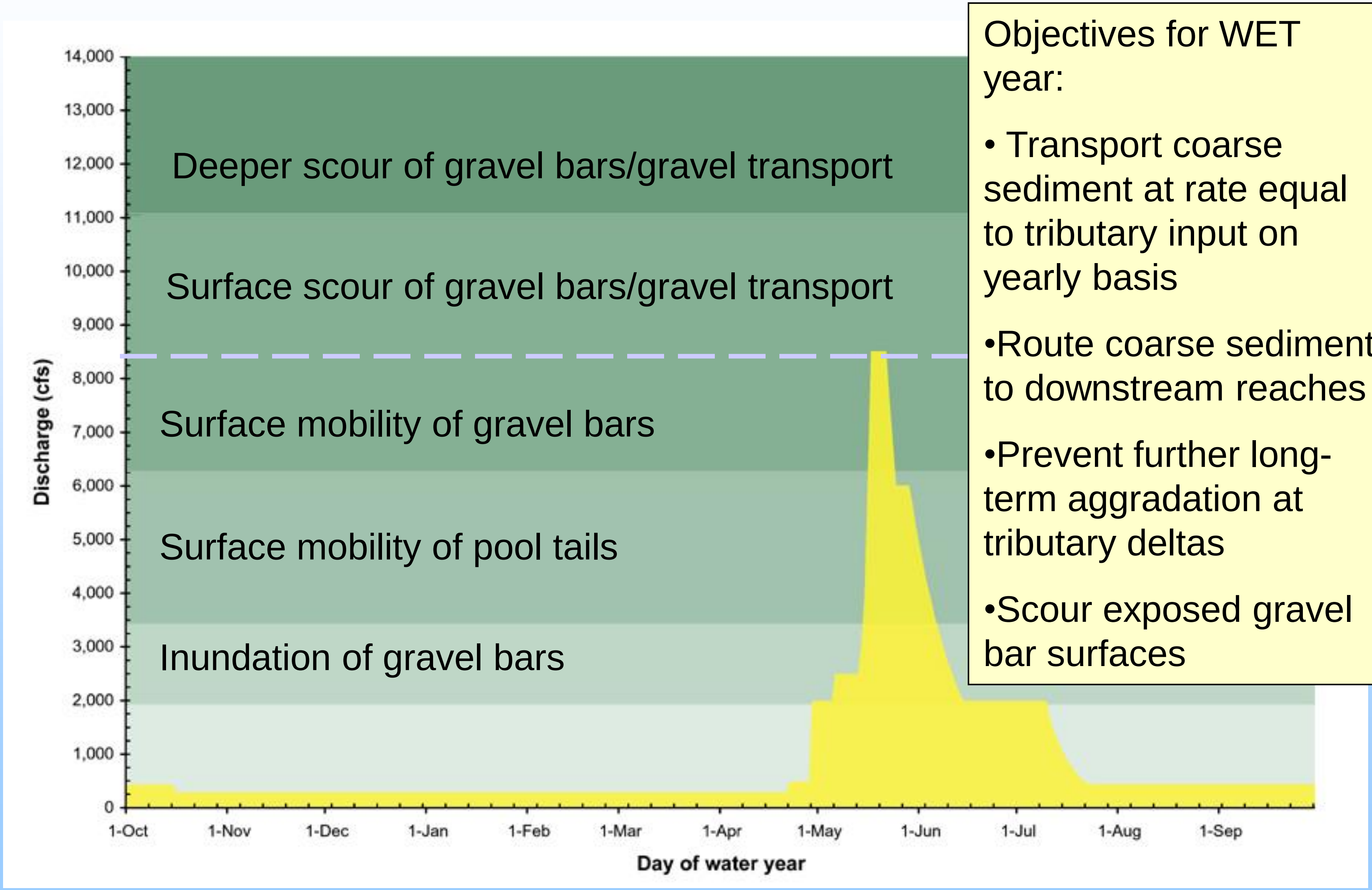
Adjust

- *Annual adjustments*
- *Longer term assessments*

AEAM Example: Coarse Sediment Transport on Trinity River during WET water year

- Define quantitative/measurable goals and objectives
- Document baseline conditions
- Develop testable hypotheses
- Develop management action and predict response
- Implement and monitor action
- Re-evaluate objectives and hypotheses; improve management action
- Conduct external peer review

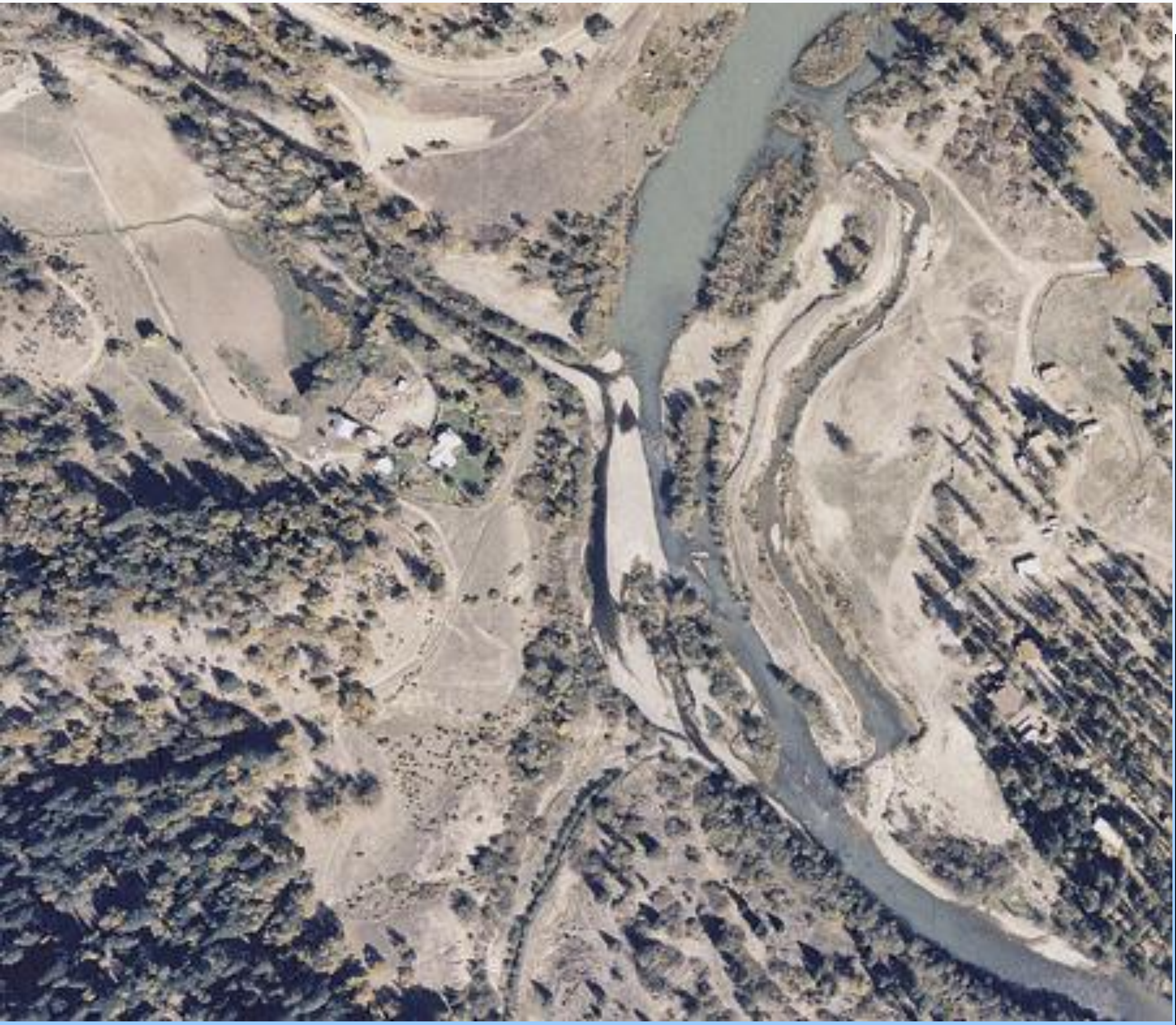
WET water year hydrograph and geomorphic objectives / thresholds



Objectives for WET year:

- Transport coarse sediment at rate equal to tributary input on yearly basis
- Route coarse sediment to downstream reaches
- Prevent further long-term aggradation at tributary deltas
- Scour exposed gravel bar surfaces

Example of a Coarse Sediment Management Target: Rush Creek Delta

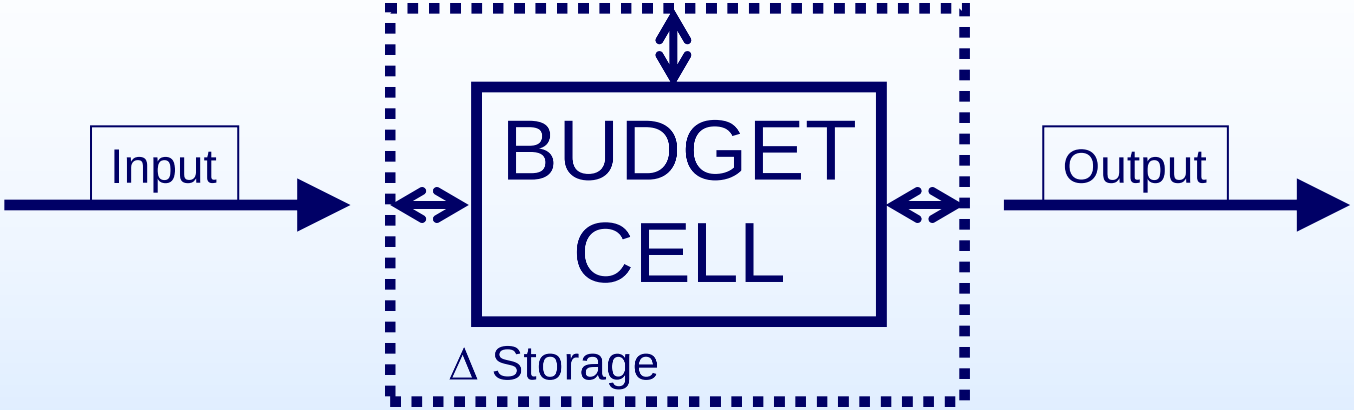


Rush Creek delivers coarse sediment to Trinity River; reduced flow regime caused coarse sediment to accumulate

Aggradation occurs at delta, backwater occurs upstream of delta

Hypothesis: Downstream distribution of coarse sediment will create and maintain salmonid habitat quantity and quality

Sediment Budget – *Dynamic* Equilibrium

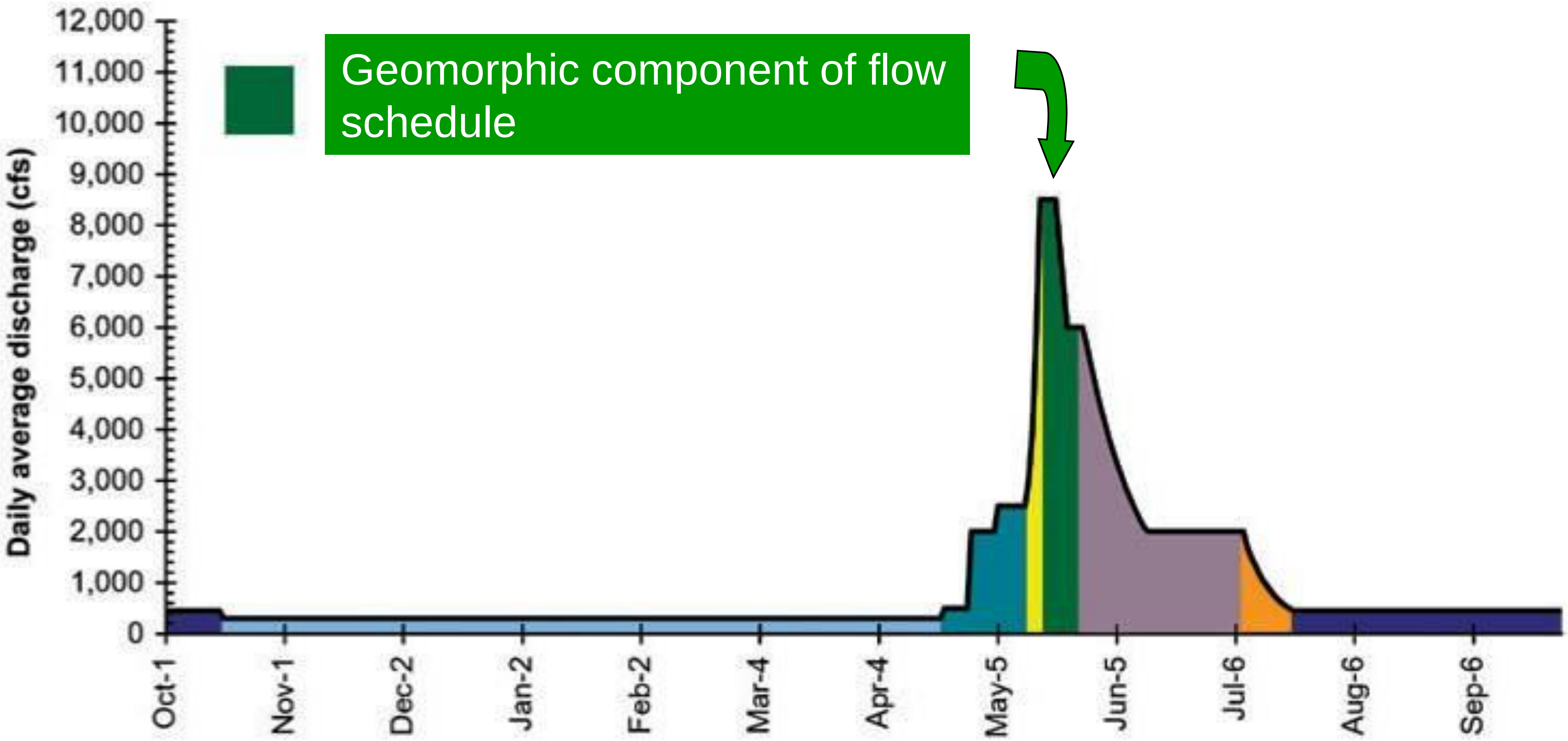


Goal: Input – Output + Δ Storage ≅ 0

(*Measurable? At equilibrium over what time frame?*)

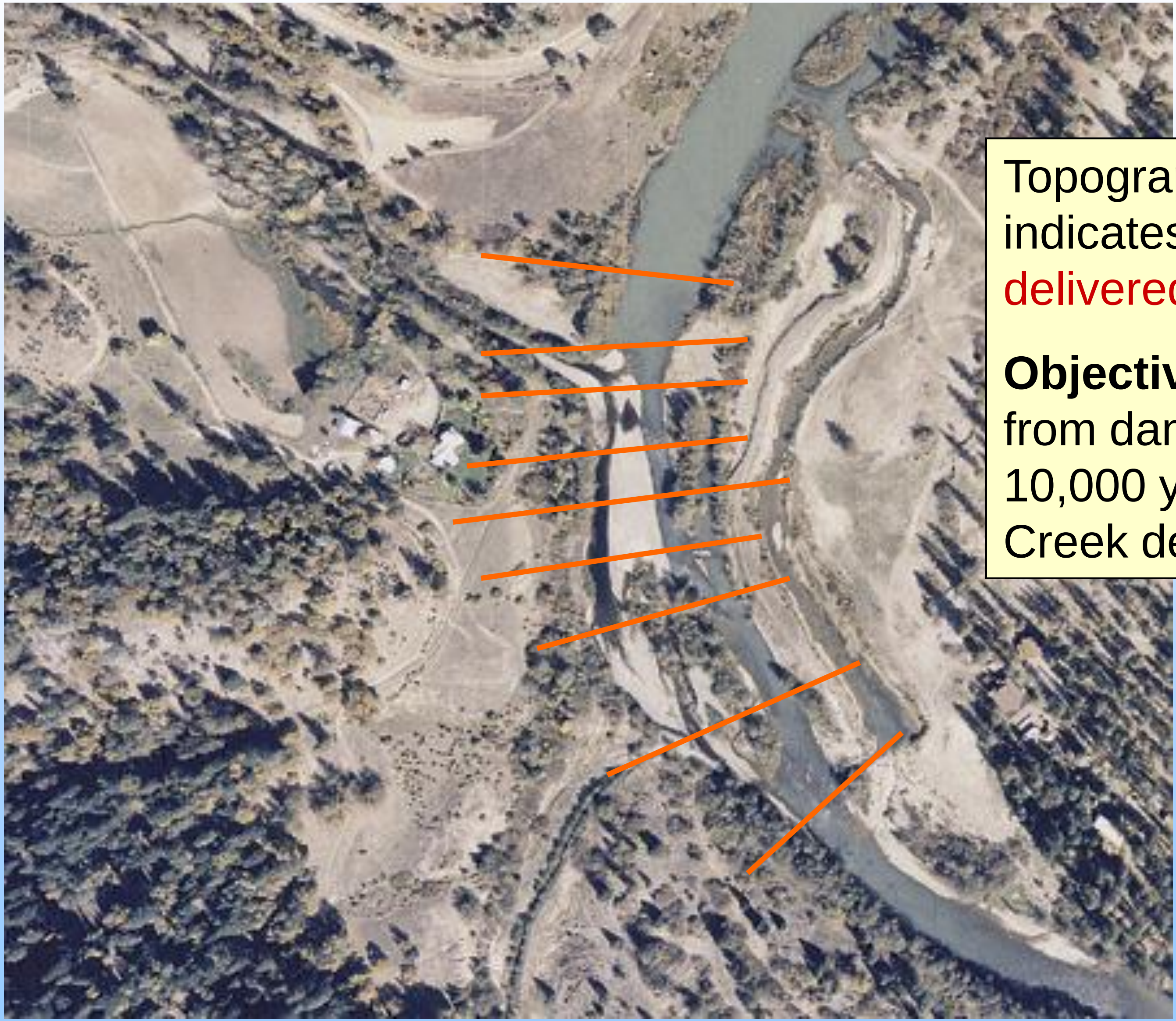
Uncertainty: How long to maintain geomorphic flows in a WET water year?

We know MAGNITUDE (8,500 cfs); need to know DURATION to transport coarse sediment delivered by Rush Creek and maintain equilibrium



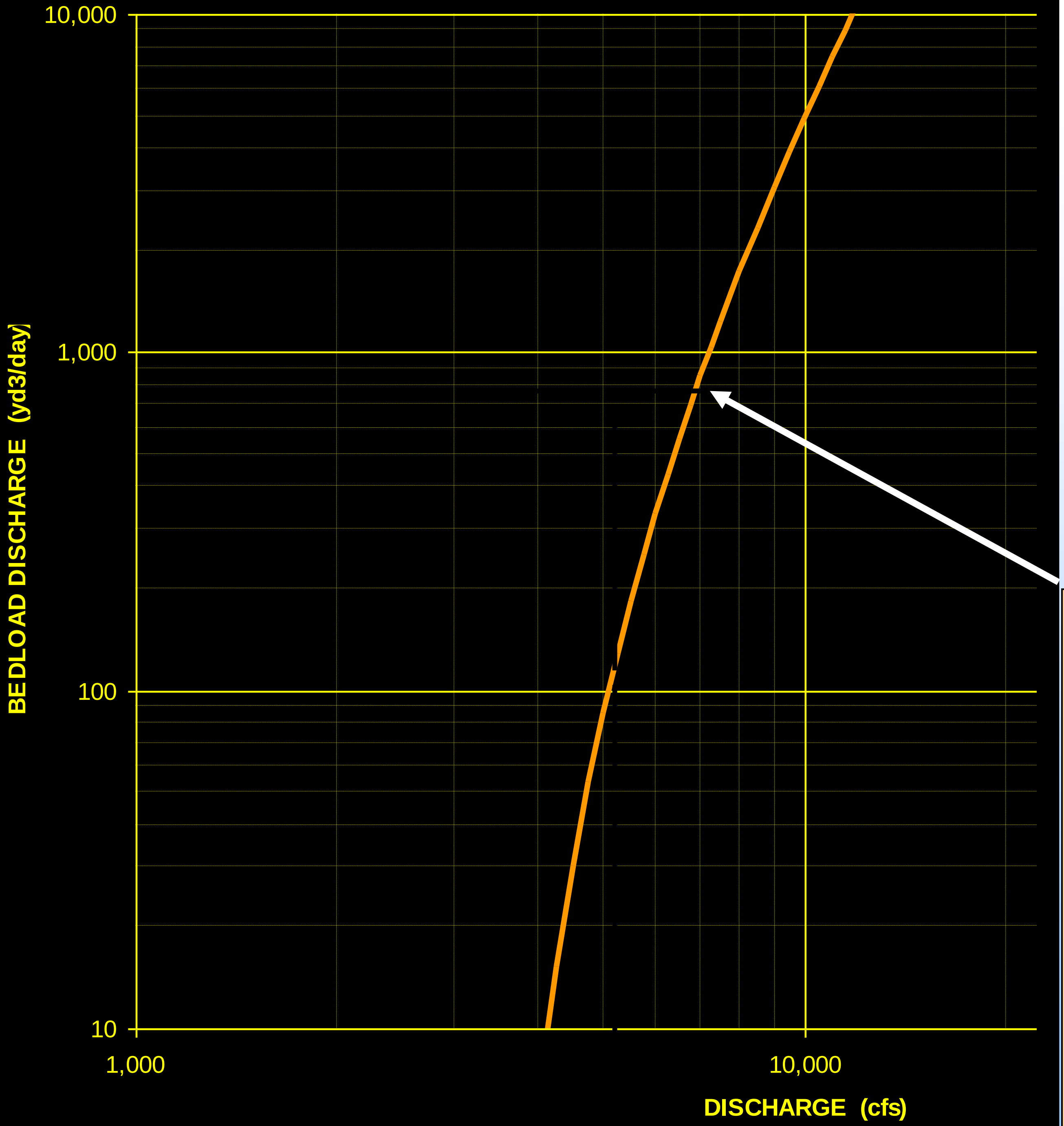
🟩 Geomorphic component of flow schedule

Measure coarse sediment delivery: survey Rush Ck delta after tributary flow season (late May)



Topographic surveying indicates 10,000 yd^3 delivered at mouth

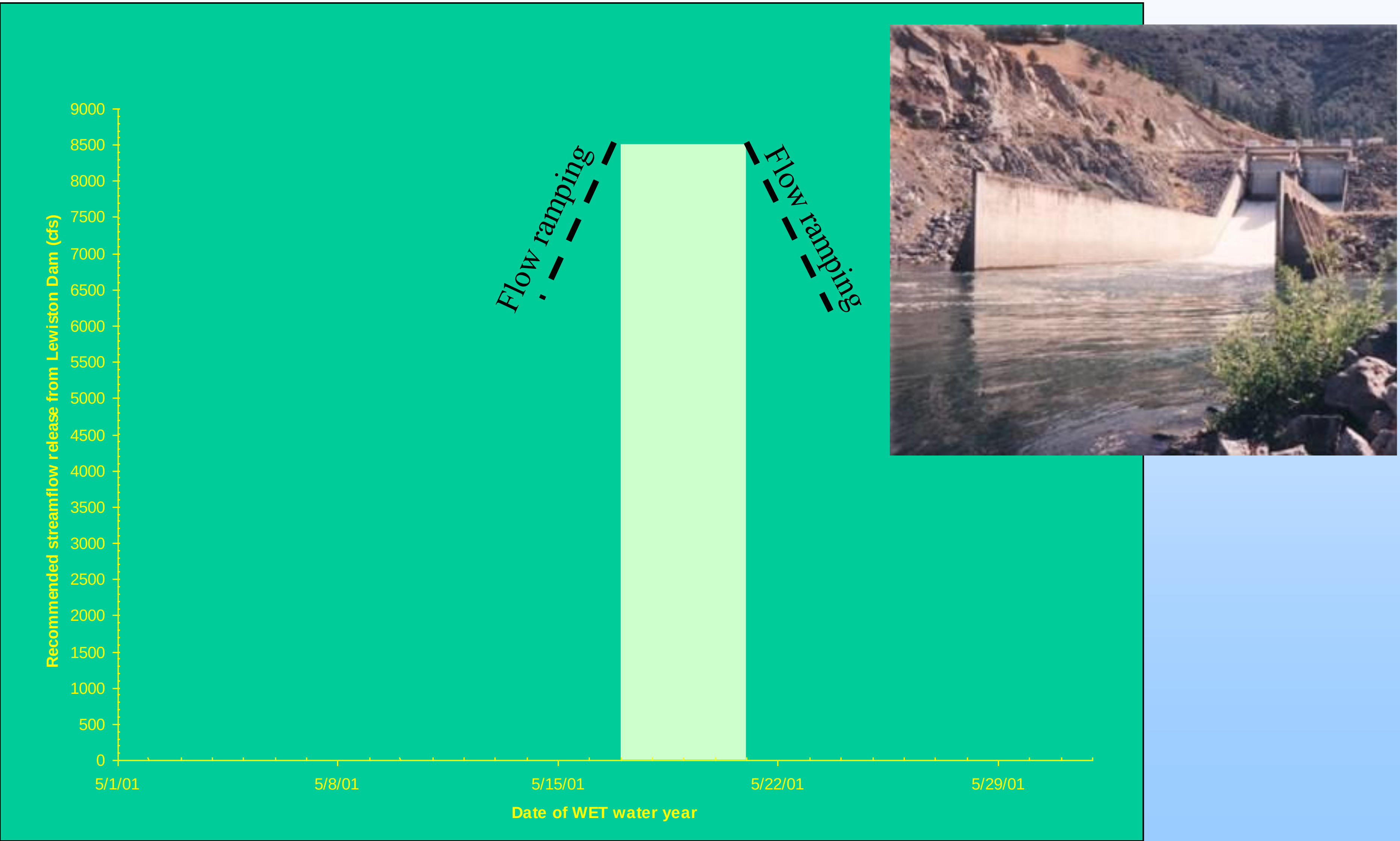
Objective: Release flows from dam to transport 10,000 yd^3 from Rush Creek delta



Hypothesis and Prediction: Sediment transport measurements and models

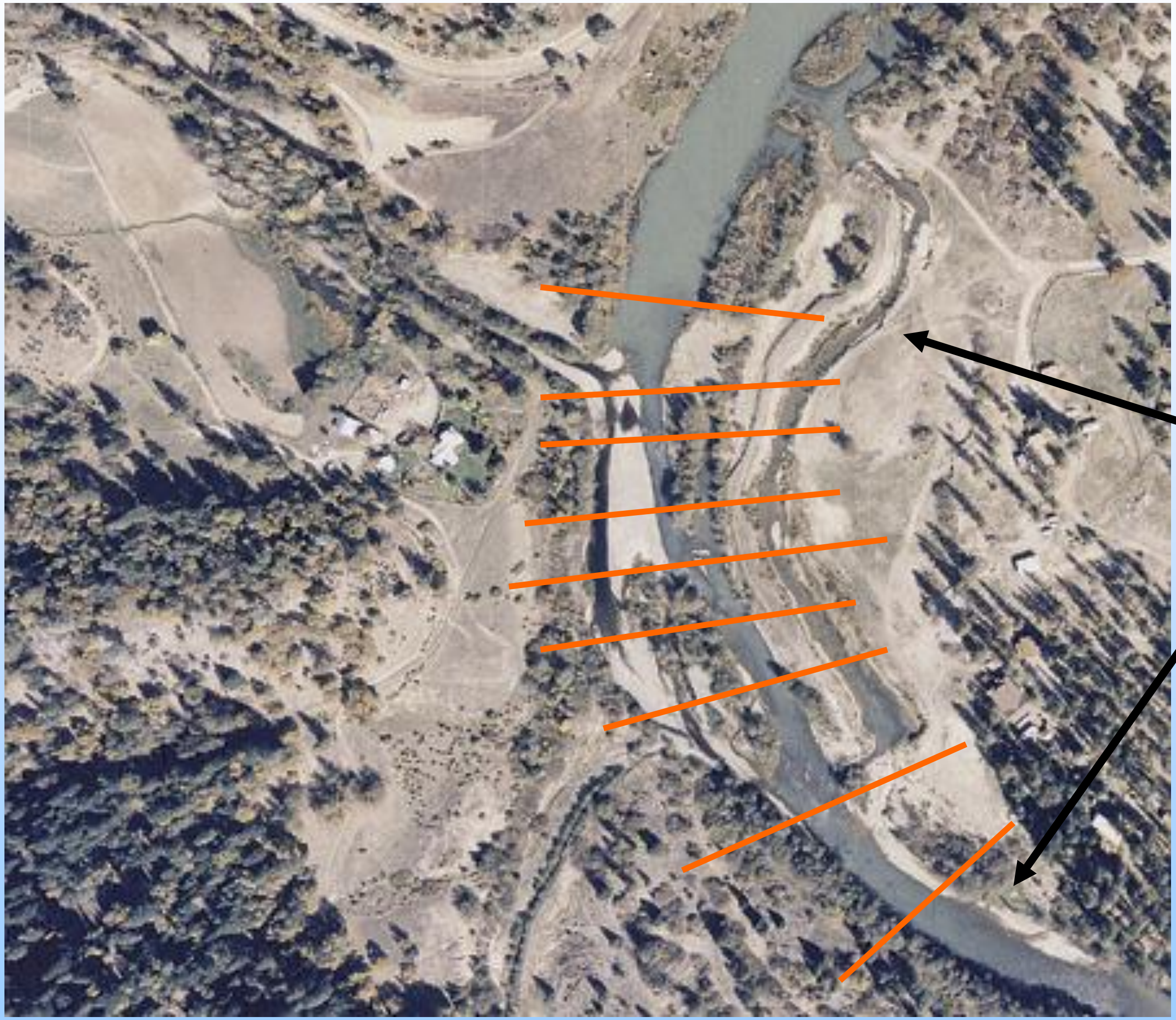
Sediment transport model predicts that 8,500 cfs transports 2,300 yd^3 of coarse sediment per day; Therefore, we can estimate that it requires 4.3 days to transport 10,000 yd^3

<u>Implement</u> experimental management action: Release 8,500 cfs from May 17-21 (5 days)



<u>Monitor</u> coarse sediment transport to calibrate predictive models

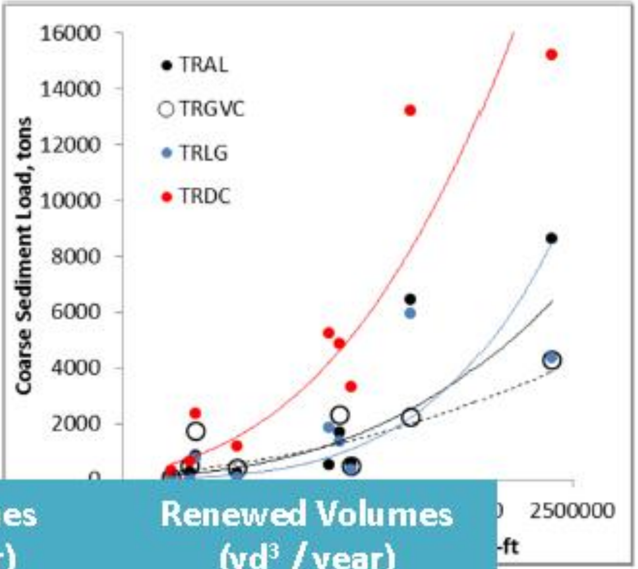
Monitor delta topography to see if 10,000 yd^3 is transported downstream from delta to maintain equilibrium



Survey with cross sections or total station after flow release: we measure that 15,000 yd^3 is transported by 5-day release of 8,500 cfs (5,000 yd^3 more than needed). **Use 3.3 day release instead of 5 day.**

Sediment management

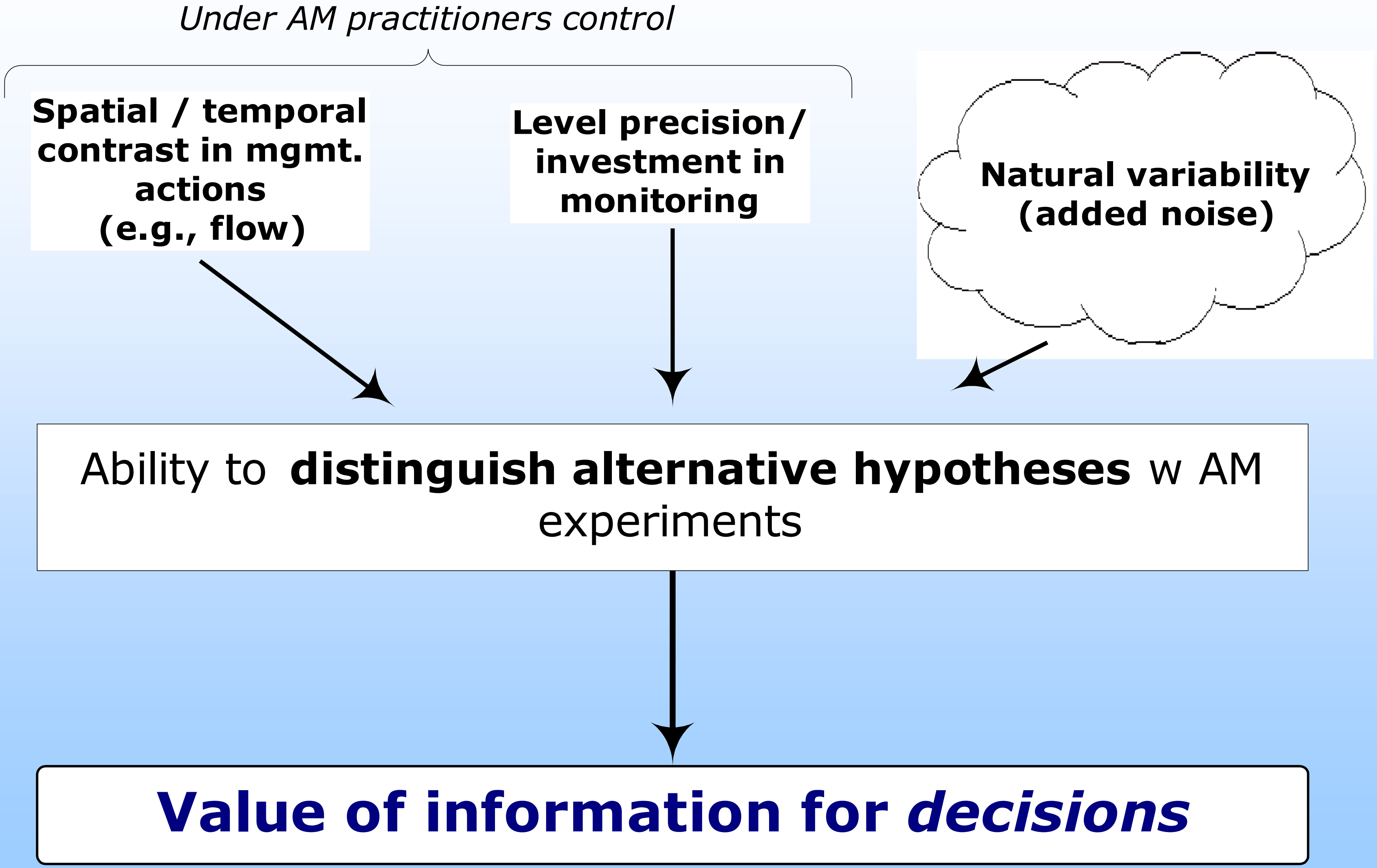
Sediment transport monitoring



Water Year Type	ROD Volumes (yd^3 / year)	Renewed Volumes (yd^3 / year)
Extremely Wet	31,000-67,000	5000
Wet	10,000-18,000	3000
Normal	1,800-2,200	1670
Dry	150-250	670
Critically Dry	0	0

- **much less** gravel required in **wet** and **very wet** years than in ROD, but
- **more** gravel required in **dry** years.

Learning from AM experiments is a function of what the practitioner can and cannot control



Under AM practitioners control

Spatial / temporal contrast in mgmt. actions (e.g., flow)

Level precision/ investment in monitoring

Natural variability (added noise)

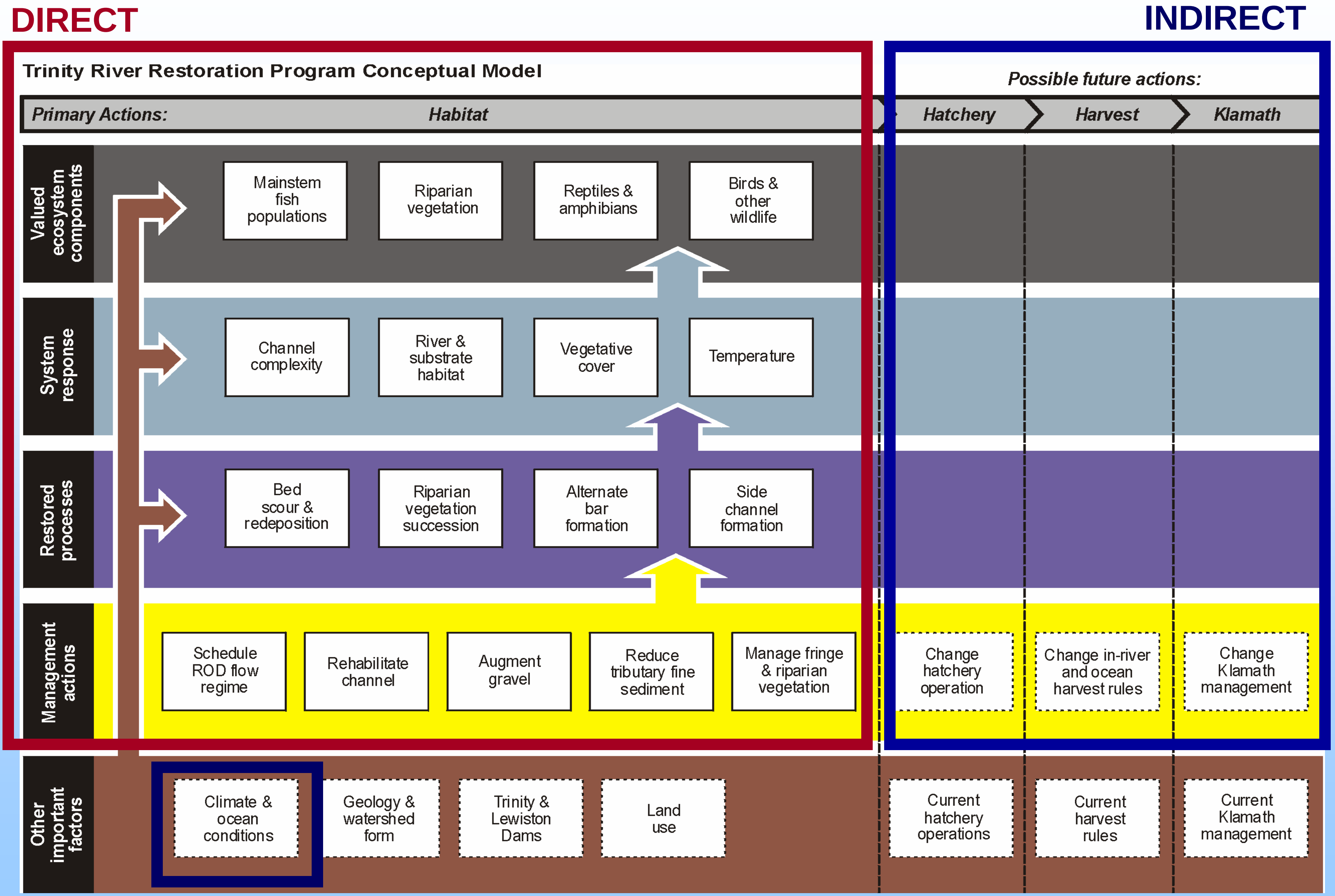
Ability to **distinguish alternative hypotheses** w AM experiments

Value of information for *decisions*

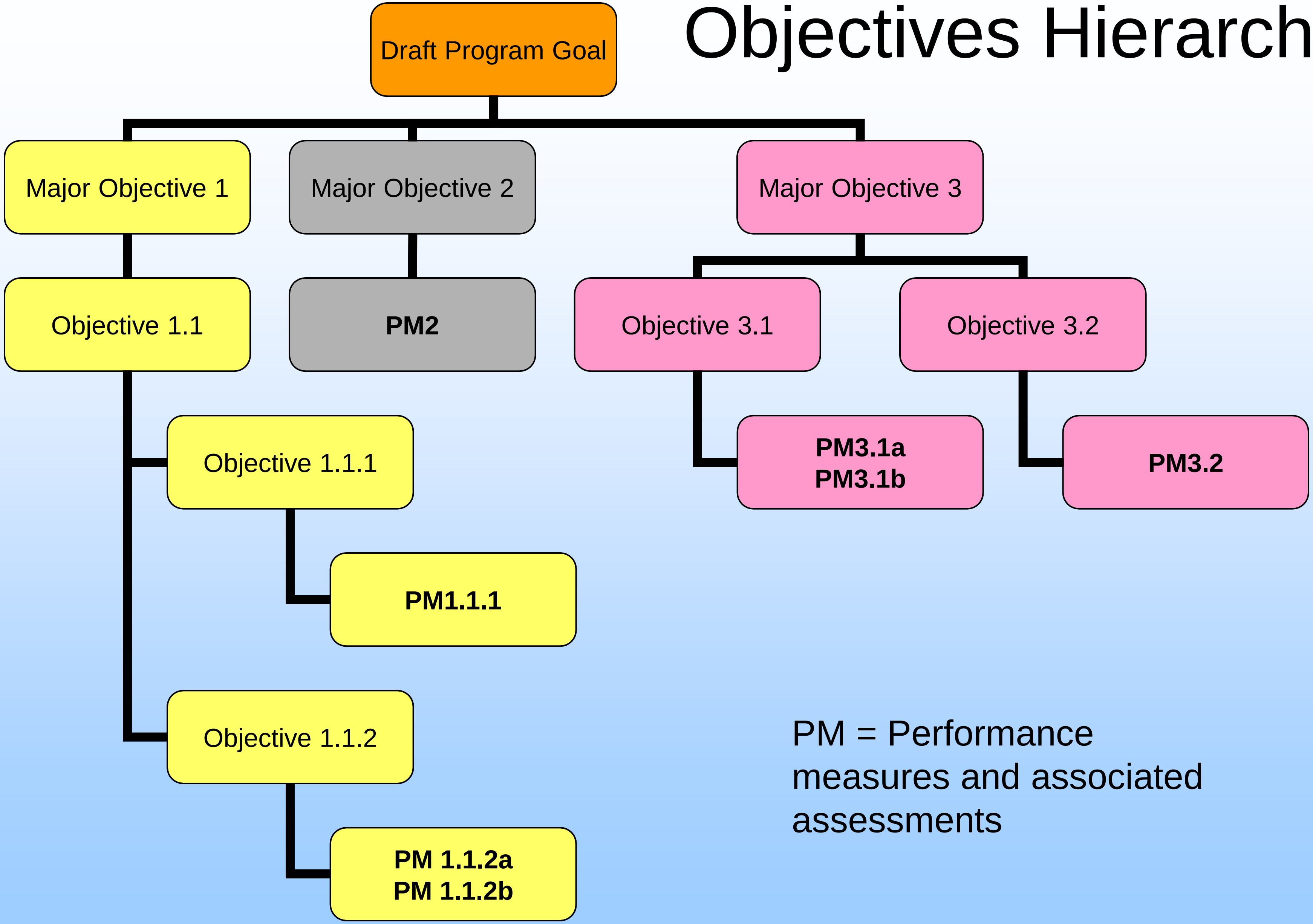
Monitoring Challenges

- *Evaluation design:* how will you analyze the data to answer the question of interest?
- *Sampling design:* where and when will you sample?
- *Monitoring protocol:* what will you measure at those places and times, and how?
- *Prioritization:* What should you do first? What's required level of reliability for each component?

Using a conceptual model to allocate effort



Objectives Hierarchy



Draft Program Goal

Major Objective 1

Major Objective 2

Major Objective 3

Objective 1.1

PM2

Objective 3.1

Objective 3.2

Objective 1.1.1

PM3.1a
PM3.1b

PM3.2

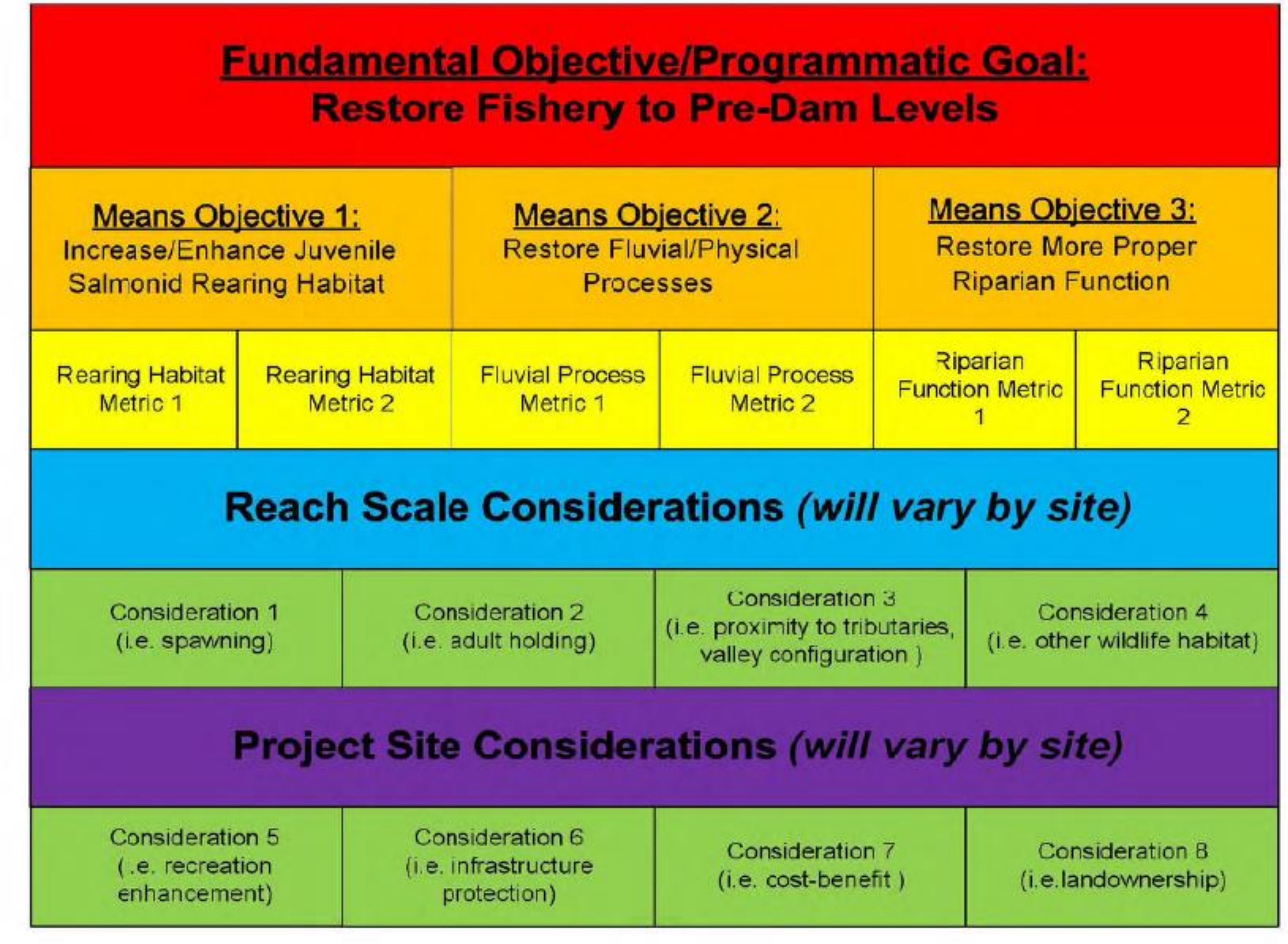
PM1.1.1

Objective 1.1.2

PM 1.1.2a
PM 1.1.2b

PM = Performance measures and associated assessments

Trinity Objectives Hierarchy (2014)



Fundamental Objective/Programmatic Goal:
Restore Fishery to Pre-Dam Levels

Means Objective 1:
Increase/Enhance Juvenile Salmonid Rearing Habitat

Means Objective 2:
Restore Fluvial/Physical Processes

Means Objective 3:
Restore More Proper Riparian Function

Rearing Habitat Metric 1	Rearing Habitat Metric 2	Fluvial Process Metric 1	Fluvial Process Metric 2	Riparian Function Metric 1	Riparian Function Metric 2

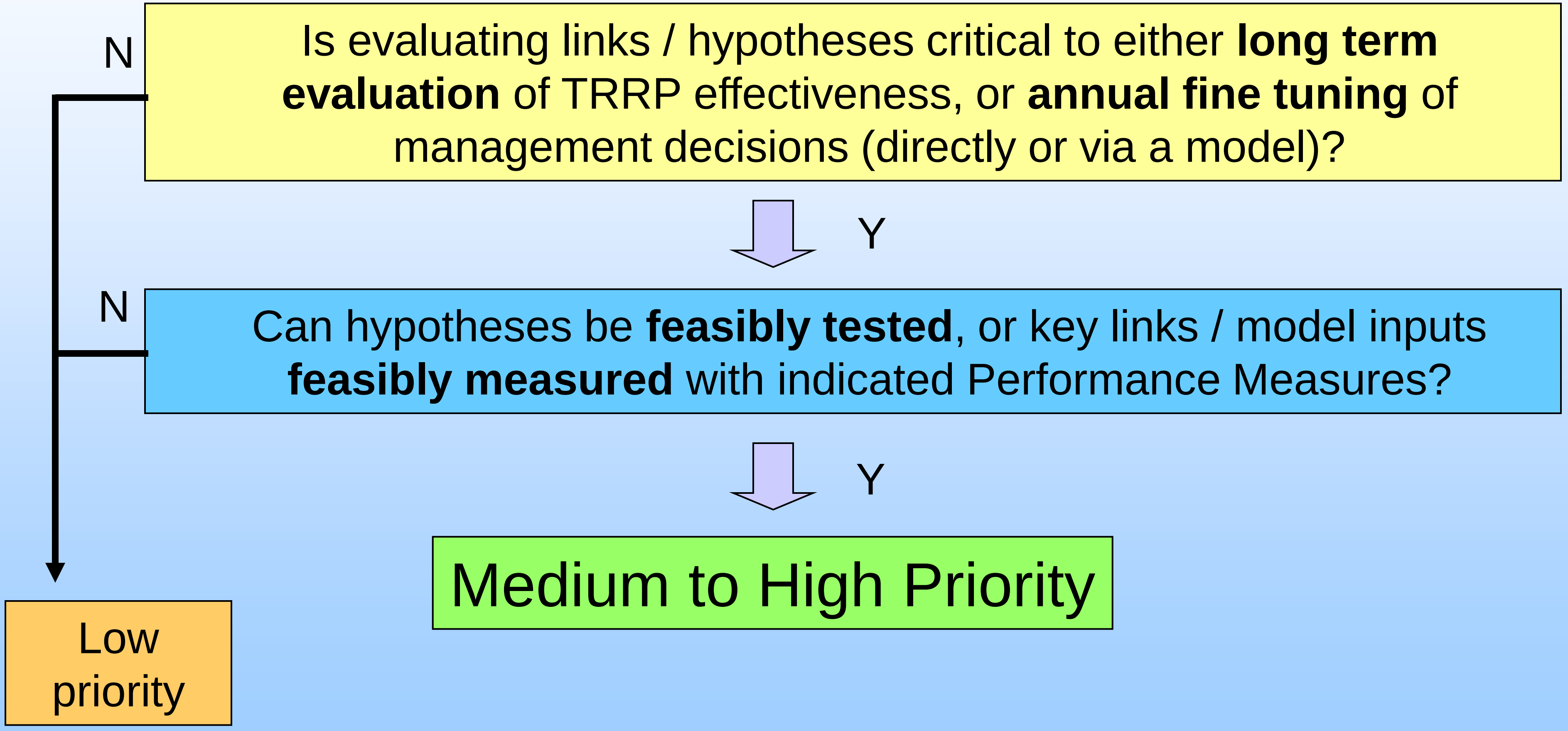
Reach Scale Considerations ***(will vary by site)***

Consideration 1 (i.e. spawning)	Consideration 2 (i.e. adult holding)	Consideration 3 (i.e. proximity to tributaries, valley configuration)	Consideration 4 (i.e. other wildlife habitat)

Project Site Considerations ***(will vary by site)***

Consideration 5 (.e. recreation enhancement)	Consideration 6 (i.e. infrastructure protection)	Consideration 7 (i.e. cost-benefit)	Consideration 8 (i.e.landownership)

Prioritization of limited resources
For each group of links / hypotheses, assess:



N

Is evaluating links / hypotheses critical to either **long term evaluation** of TRRP effectiveness, or **annual fine tuning** of management decisions (directly or via a model)?

Y

N

Can hypotheses be **feasibly tested**, or key links / model inputs **feasibly measured** with indicated Performance Measures?

Y

Medium to High Priority

Low priority

Data Quality Objectives

1. What are critical annual management decisions, effectiveness evaluation questions/hypotheses?
2. What are key inputs to these decisions and evaluation methods to be used?
3. What is tolerance of error in decisions and evaluations, desired detectable effect sizes?
4. What are implied precision requirements in inputs?
5. What are alternative designs (sampling & response) that could meet these precision requirements?
6. Optimize design and cost both within and across all components; examine tradeoffs across monitoring objectives (e.g. precision, cost, error rates)

Annual AM decisions involve evaluations both within and across domains

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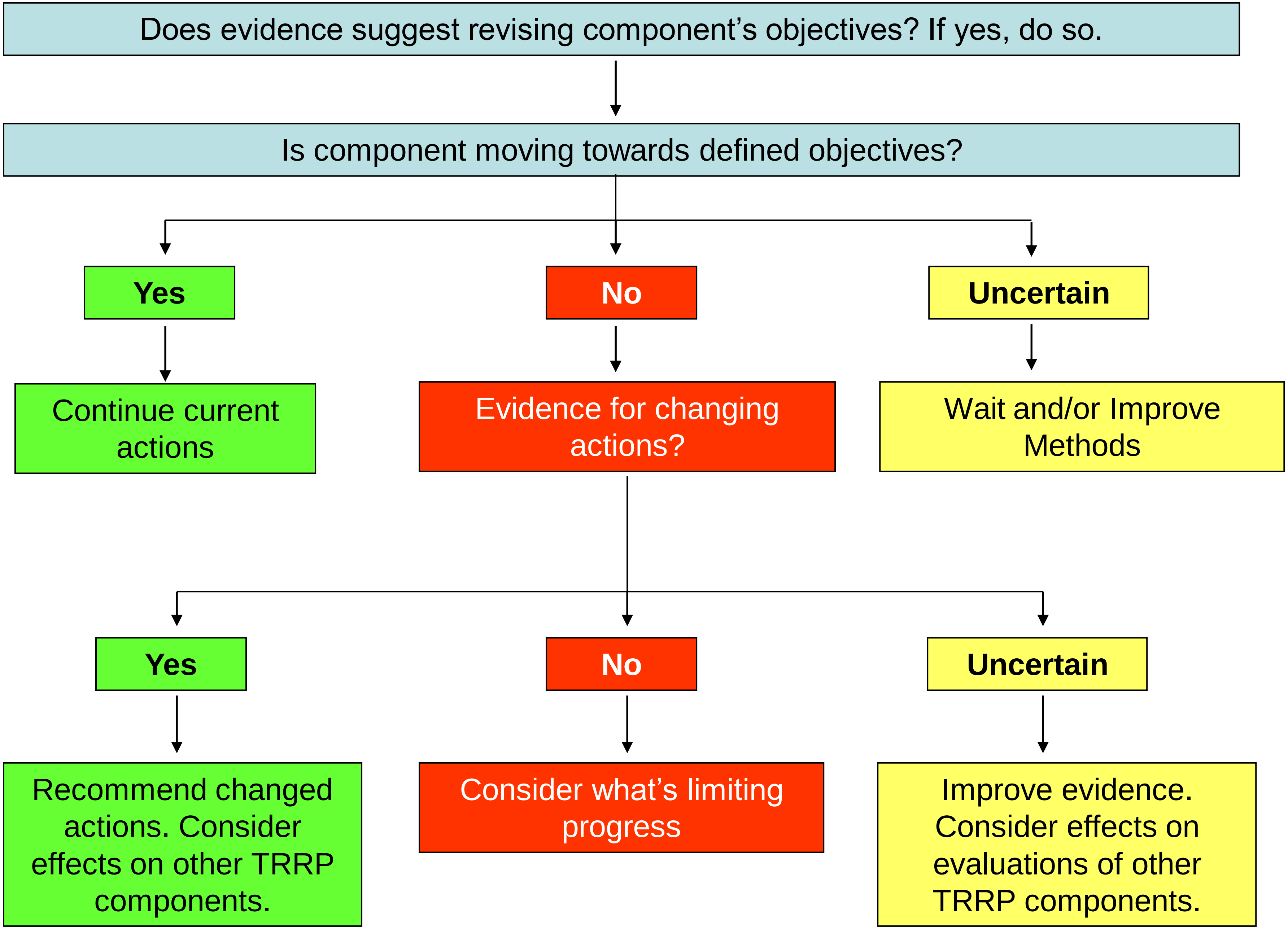
Adaptive Management evaluation of Trinity ecosystem components



Does evidence suggest revising component's objectives? If yes, do so.

Is component moving towards defined objectives?

Yes

Continue current actions

No

Evidence for changing actions?

Uncertain

Wait and/or Improve Methods

Yes

Recommend changed actions. Consider effects on other TRRP components.

No

Consider what's limiting progress

Uncertain

Improve evidence. Consider effects on evaluations of other TRRP components.

B. Whole system level (inter-disciplinary evaluation)

B1. Examine rationales for all proposed changes in actions

B2. Is each proposed action change:

1) consistent with TRRP strategy (and not confound its evaluation)?
2) supportive of other components (won't undermine them)?
3) addressing factors most limiting fish production in short term (1-2 yrs)?
4) addressing factors most limiting fish production in long term (10 yrs)?

B3. Score proposed actions vs 4 criteria & assess tradeoffs

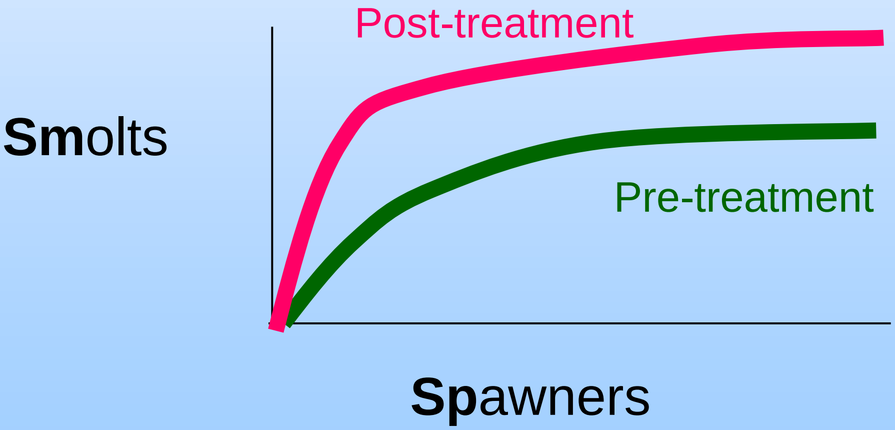
Converge to action plan for next year


CAUTION
STAY FAR LEFT
1. 1. 1997


11. 7. 1999

How long do you need to monitor?

- How long will it take to demonstrate overall effects of restoration program on each subsystem?
- Can you in the meantime test hypotheses / models relating to restoration tactics ⇒ inform annual management decisions?



Recent trends in Trinity R natural fall Chinook smolts and spawners

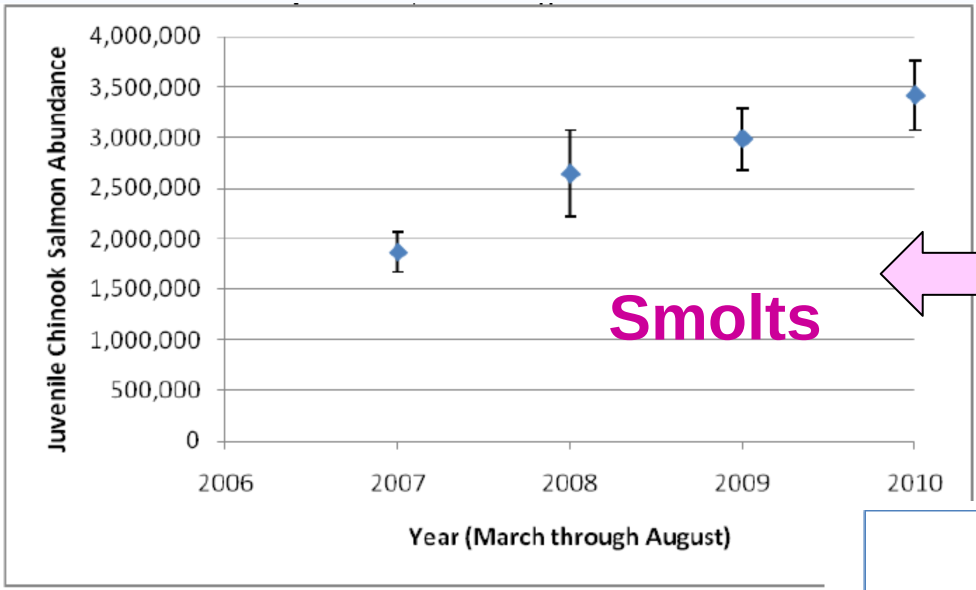
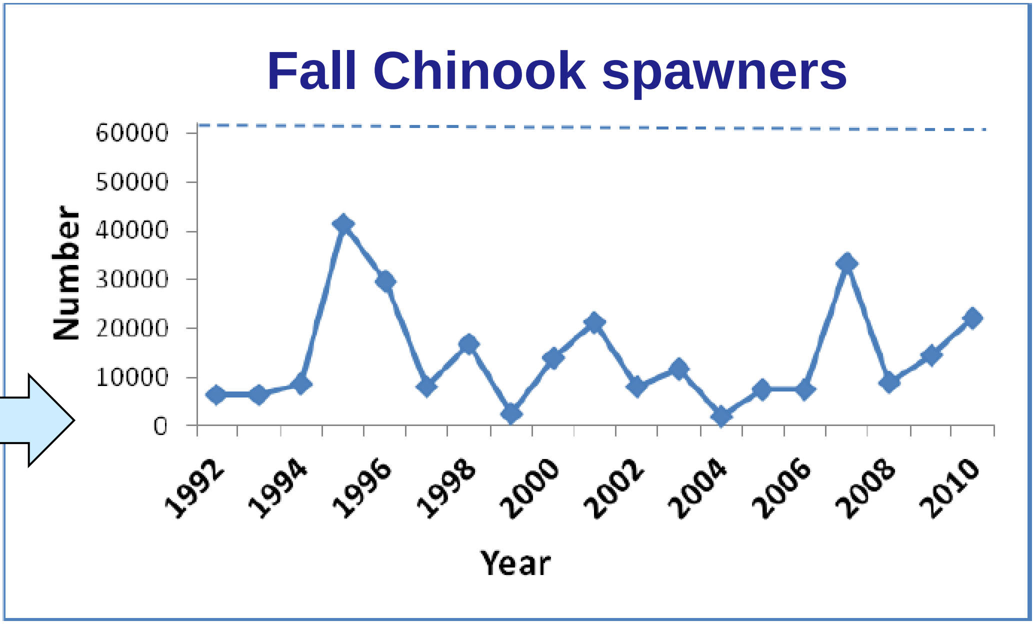


Figure 1. Abundance of naturally produced juvenile Chinook Salmo
March through August, 2007-2010. Error bars represent 95% confi

Smolts

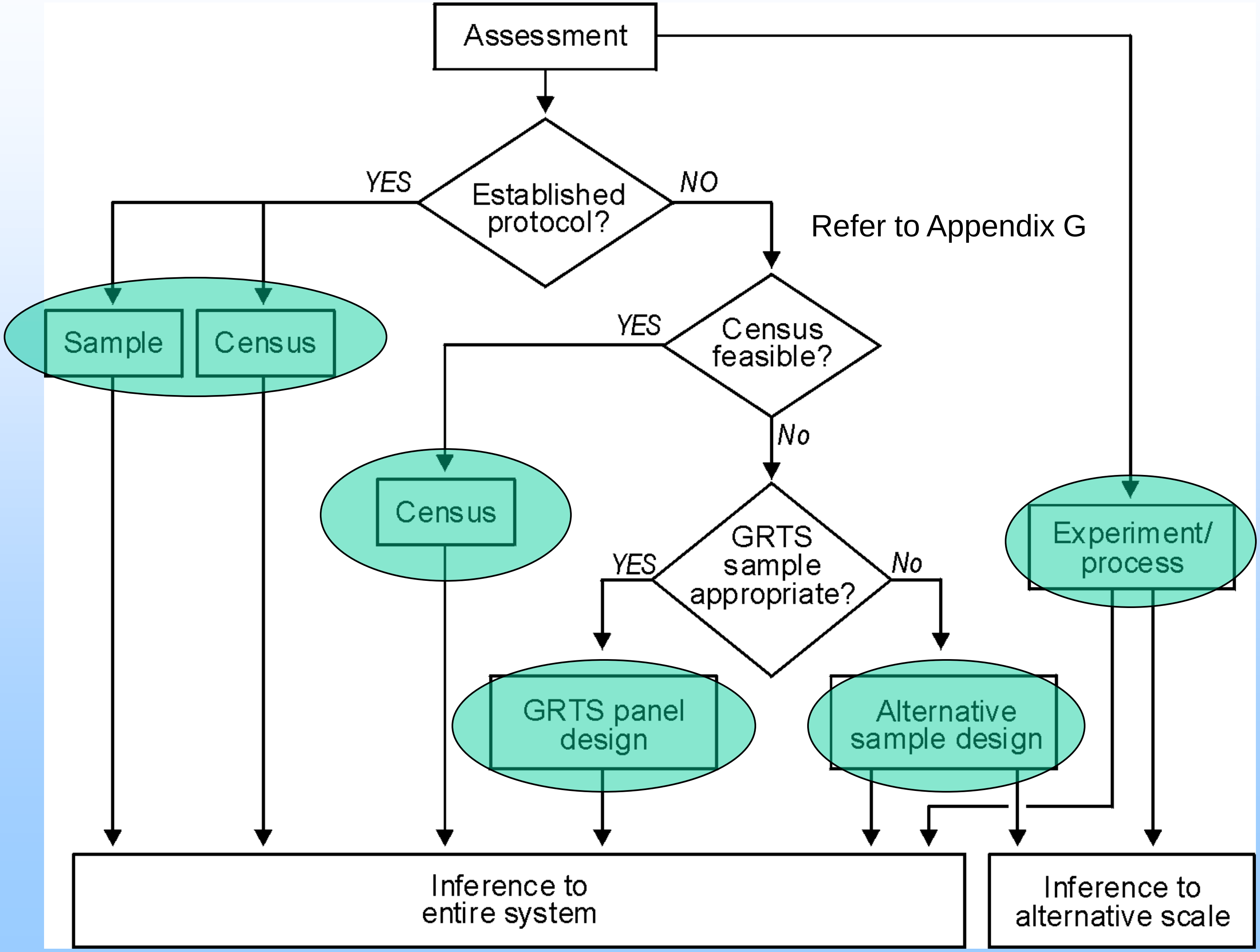
- **Smolts** are the most important performance measure of Program actions.
- Also the hardest (and most expensive) to measure.



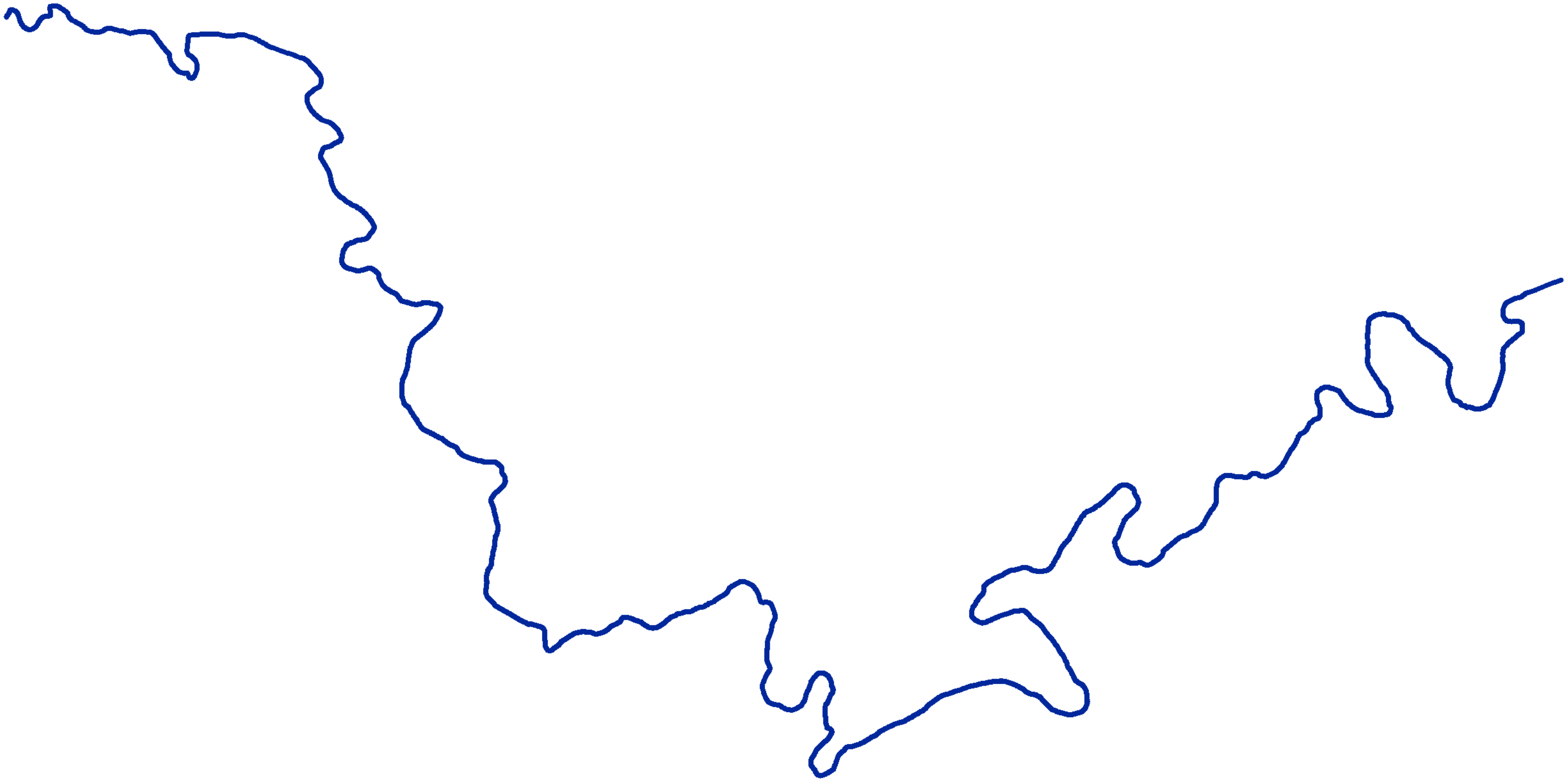
Spawners have strongest connection to overall goal (increased harvest) but can vary 10-fold with ocean survival, so hard to see trends.

Where and when should you sample?

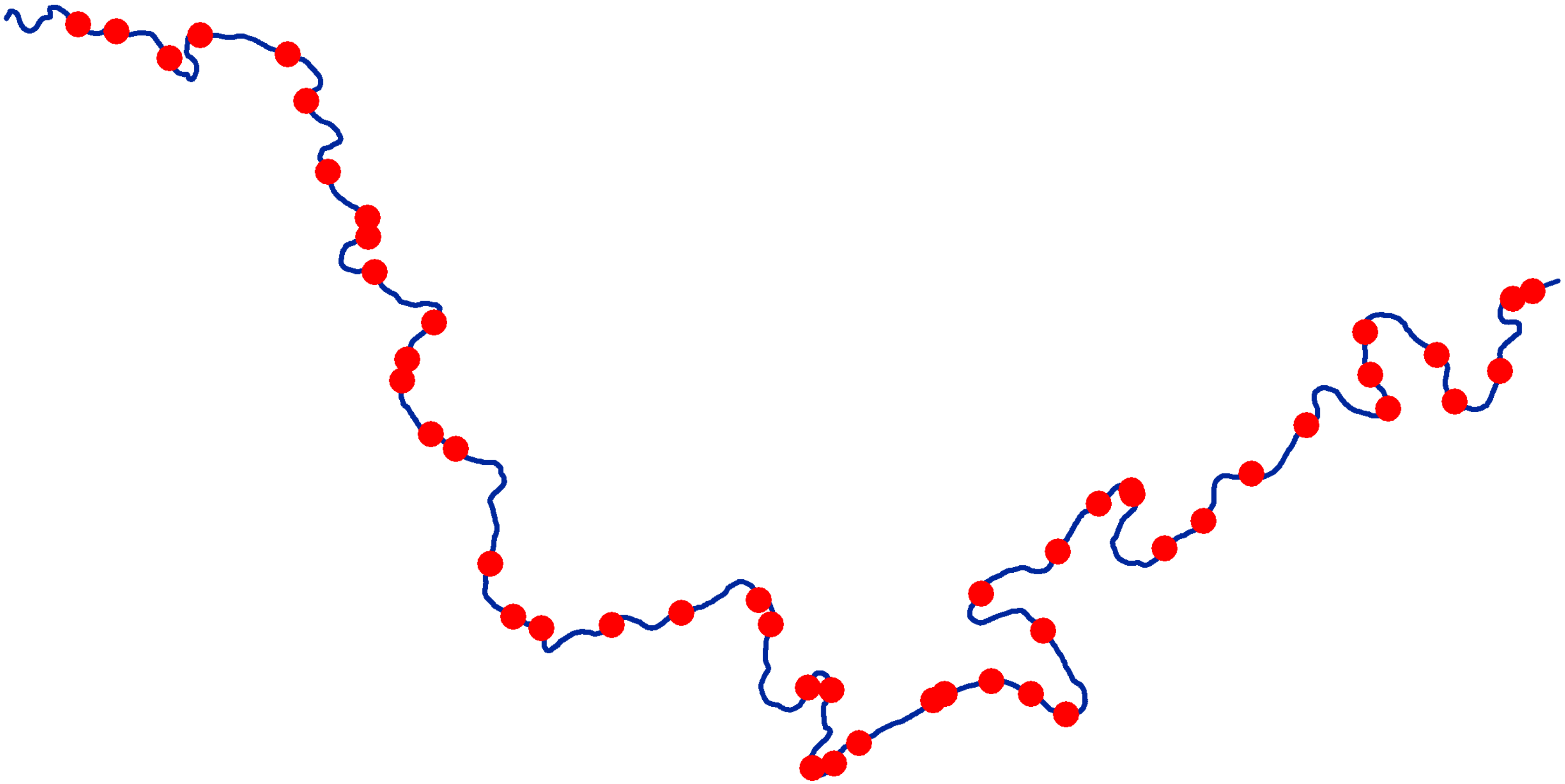
Sampling Framework



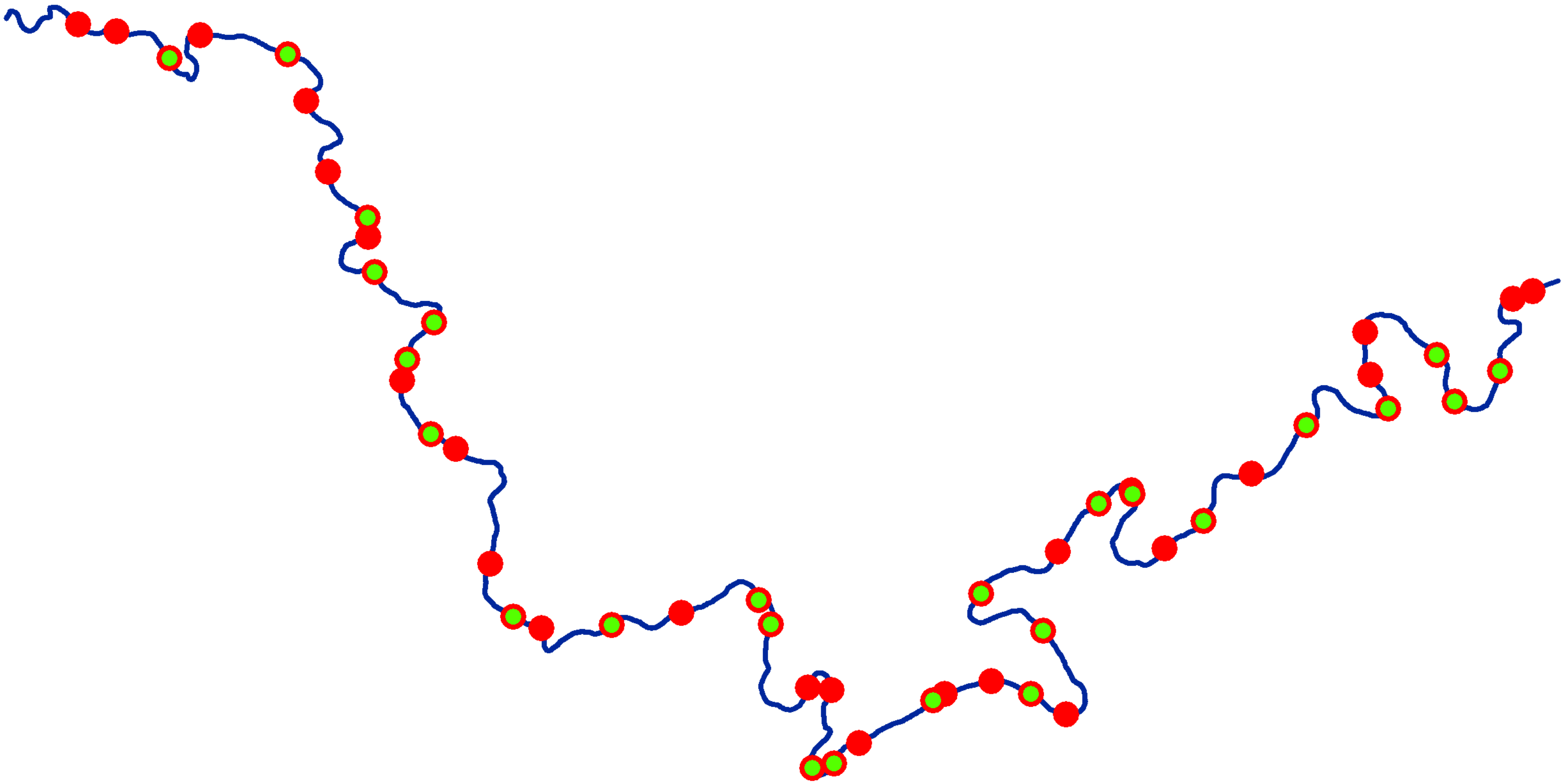
Trinity River Program Area



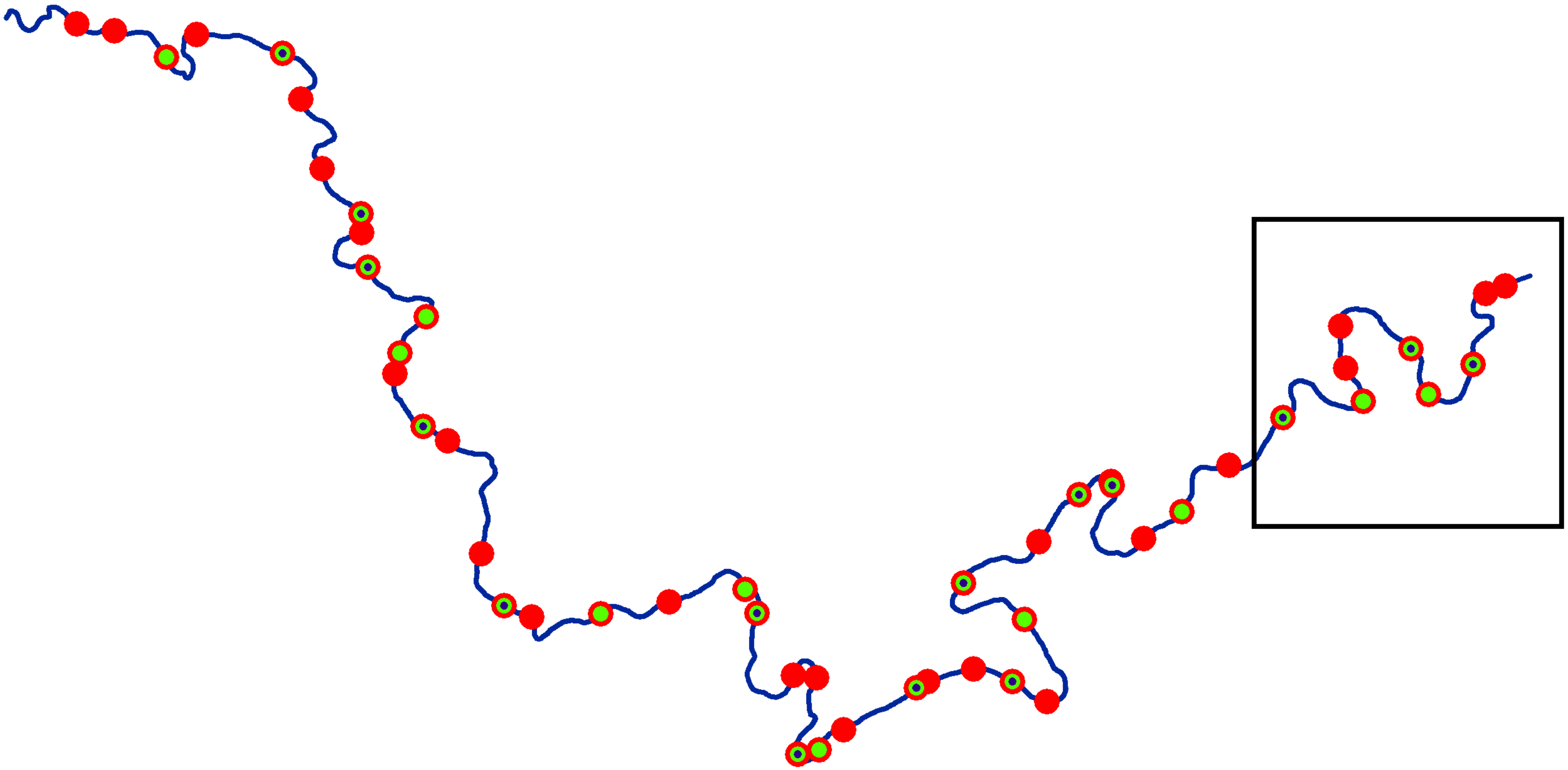
Protocol 1 - GRTS selected sampling (50 sites)

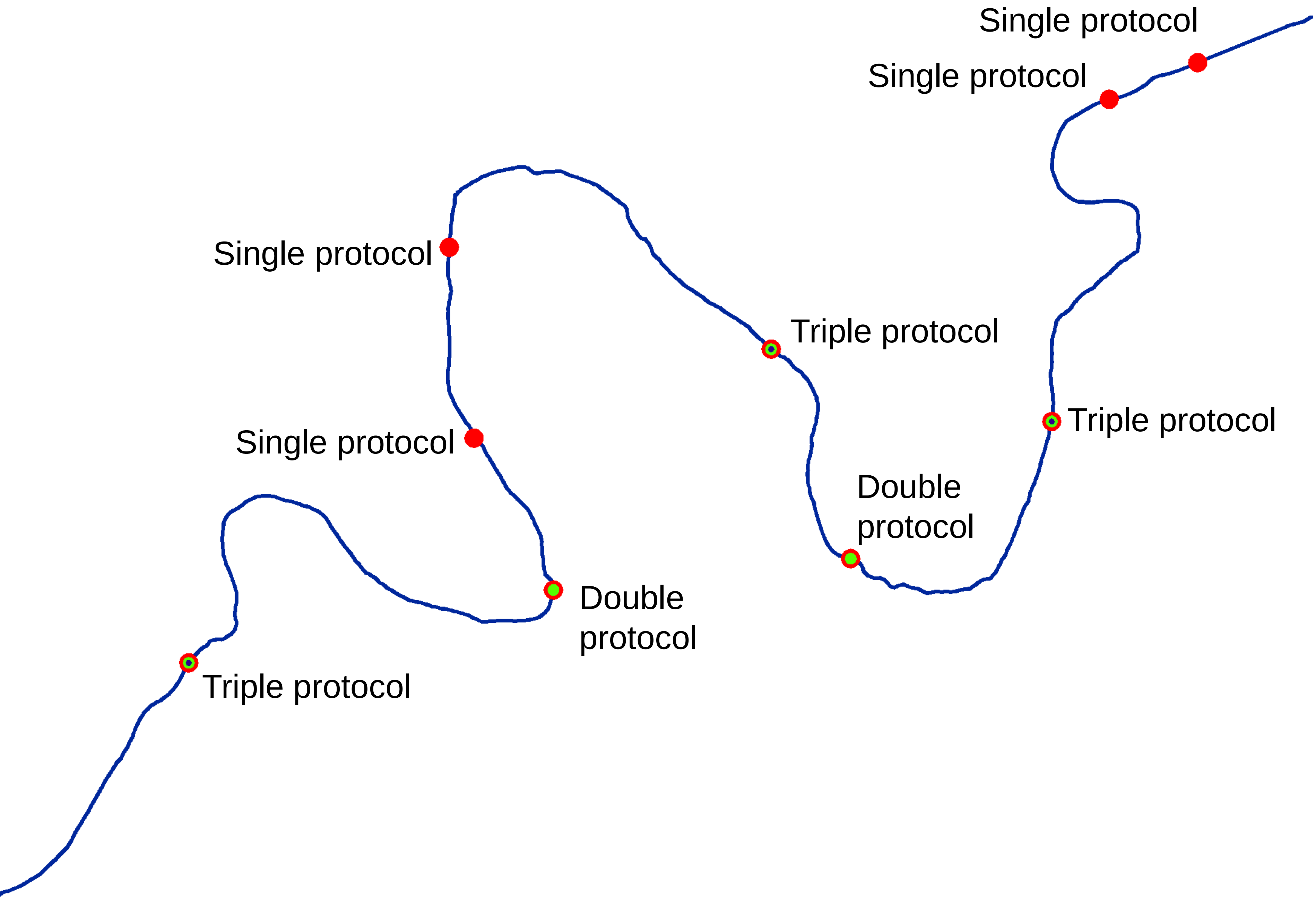


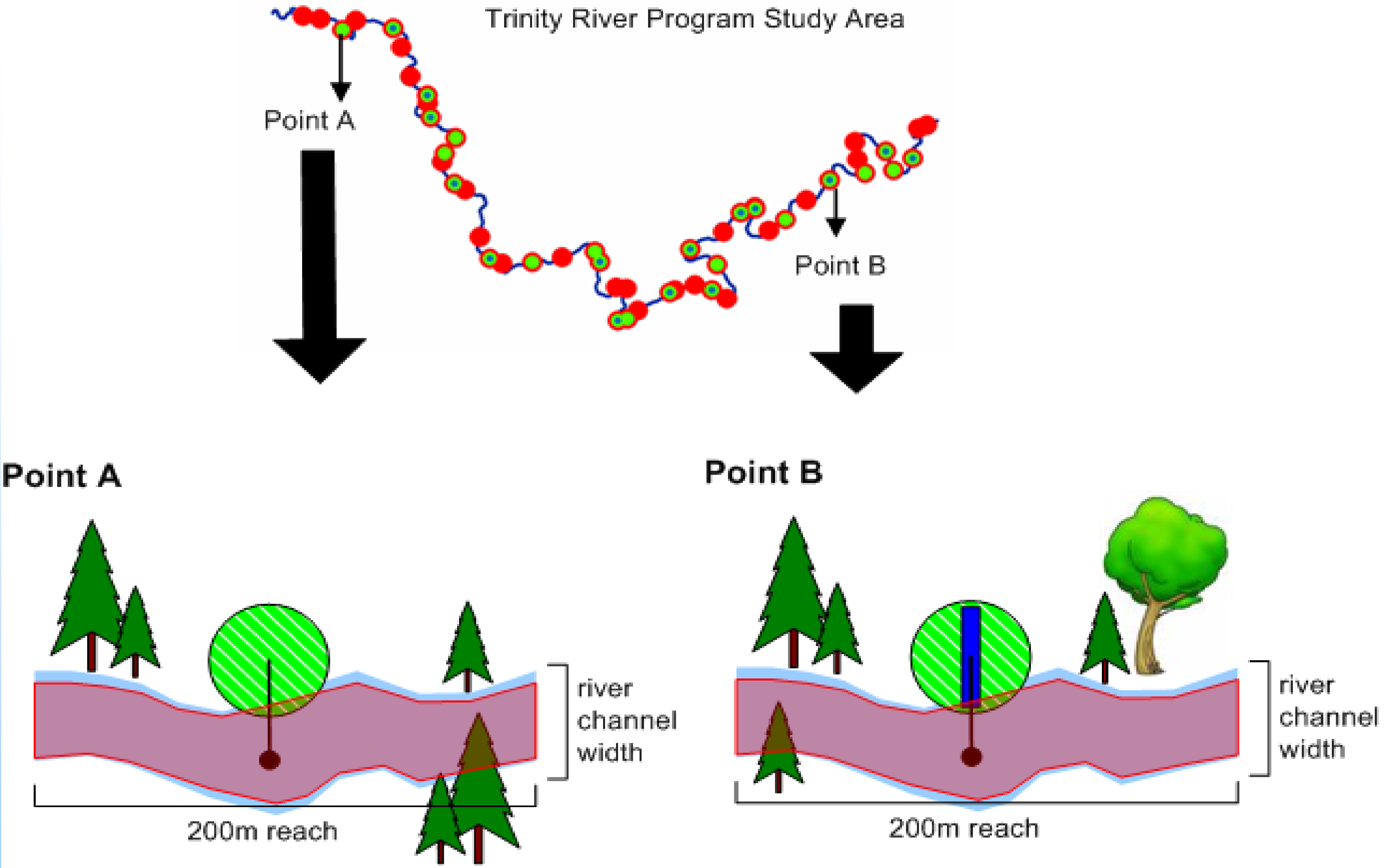
Protocol 2 - GRTS selected sampling (25 sites - green) overlapped with Protocol 1 sites



Protocol 3 - GRTS selected sampling (15 sites - black) overlapped with Protocol 1 & 2 sites




Single protocol
Single protocol
Single protocol
Triple protocol
Single protocol
Triple protocol
Double
protocol
Double
protocol
Triple protocol



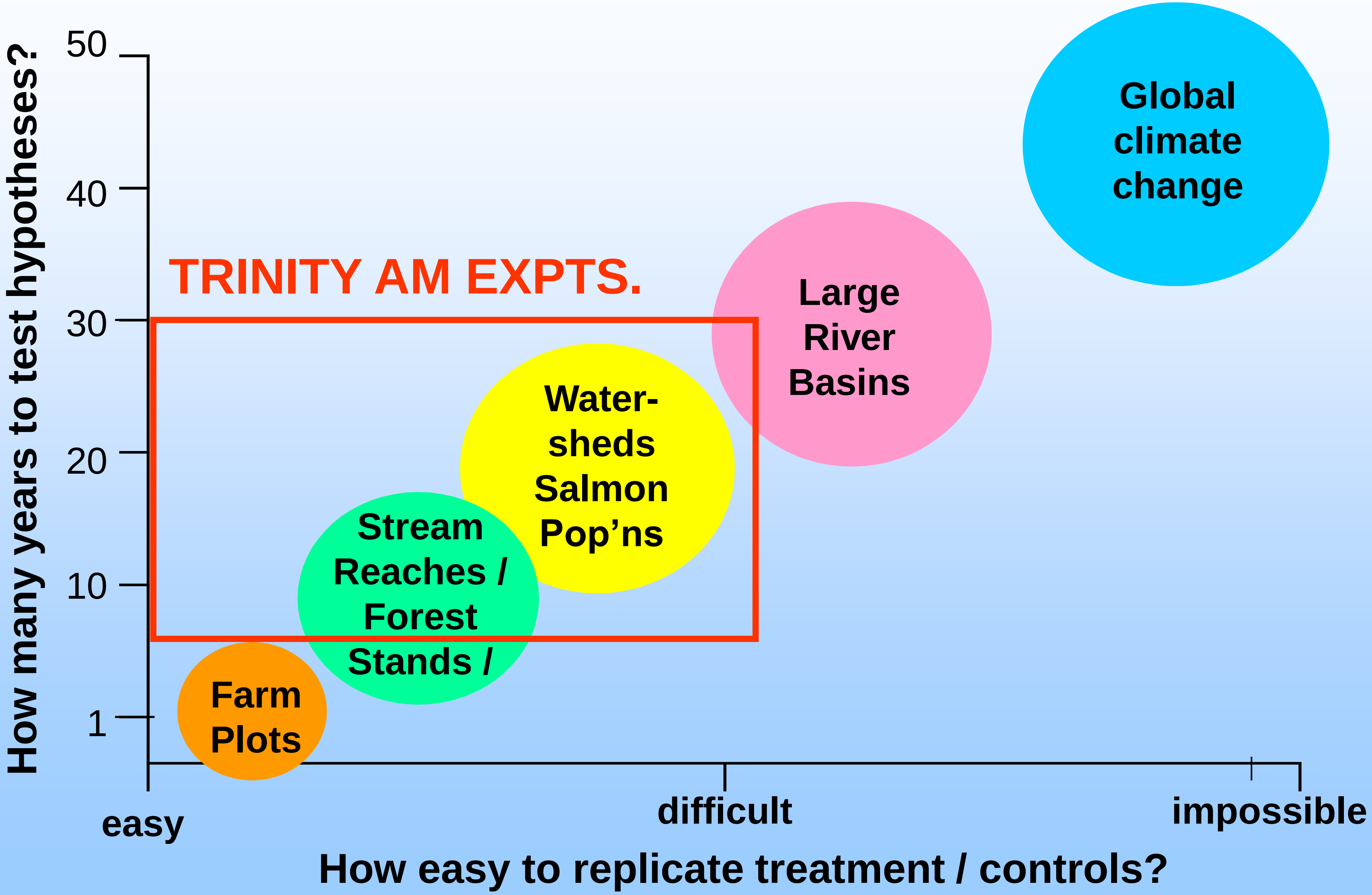
● GRTS point for monitoring site

🟥 Protocol 1 – Fish habitat mapping (SBHM)

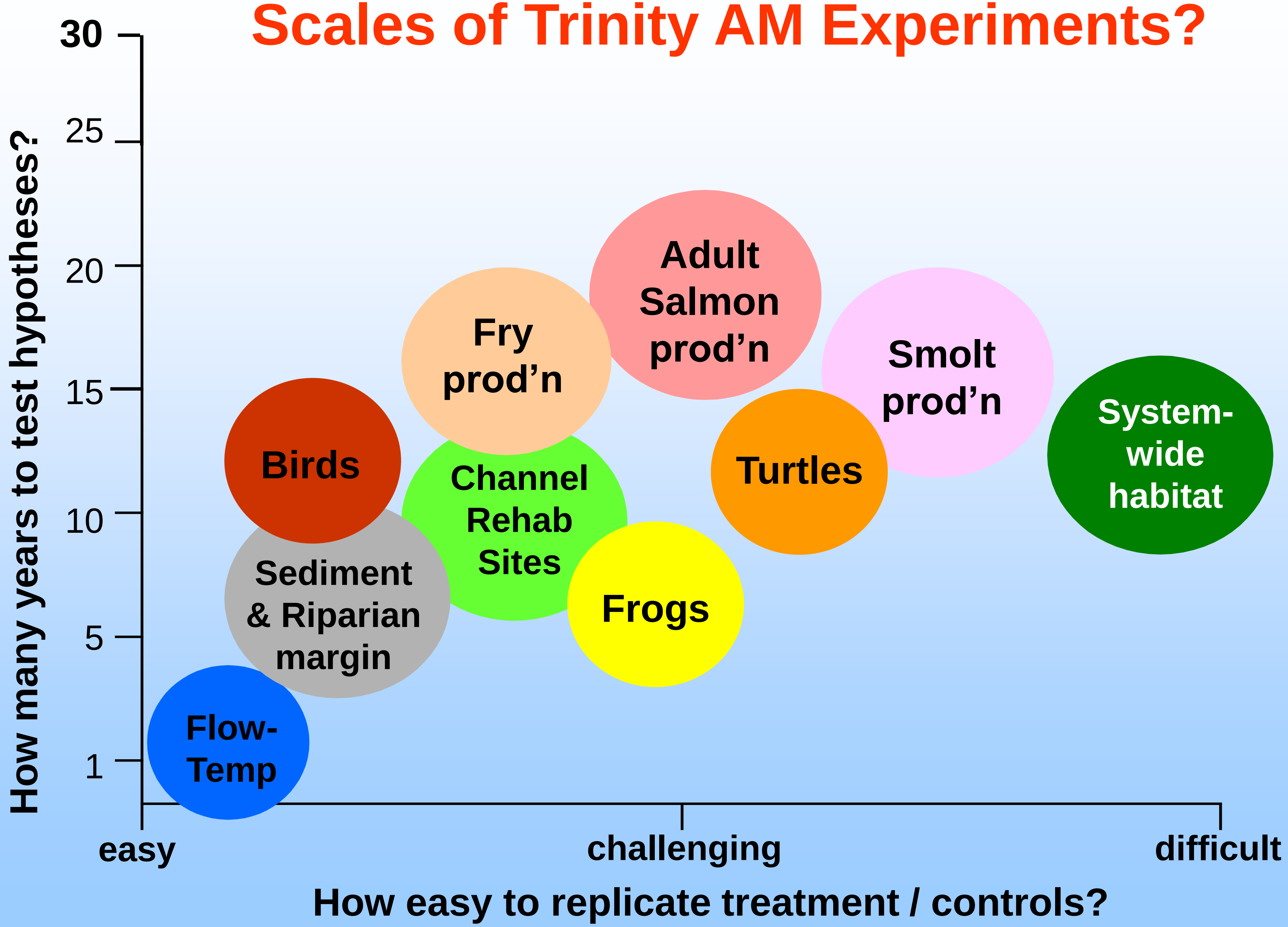
▨ Protocol 2 – Riparian bird point count

🟦 Protocol 3 – Riparian vegetation transect

Feasibility of AM Experiments



Scales of Trinity AM Experiments?



Implementation Challenges

- Buying back houses; replacing bridges

Old Biggers Road Bridge at 6000 cfs

Implementation Challenges

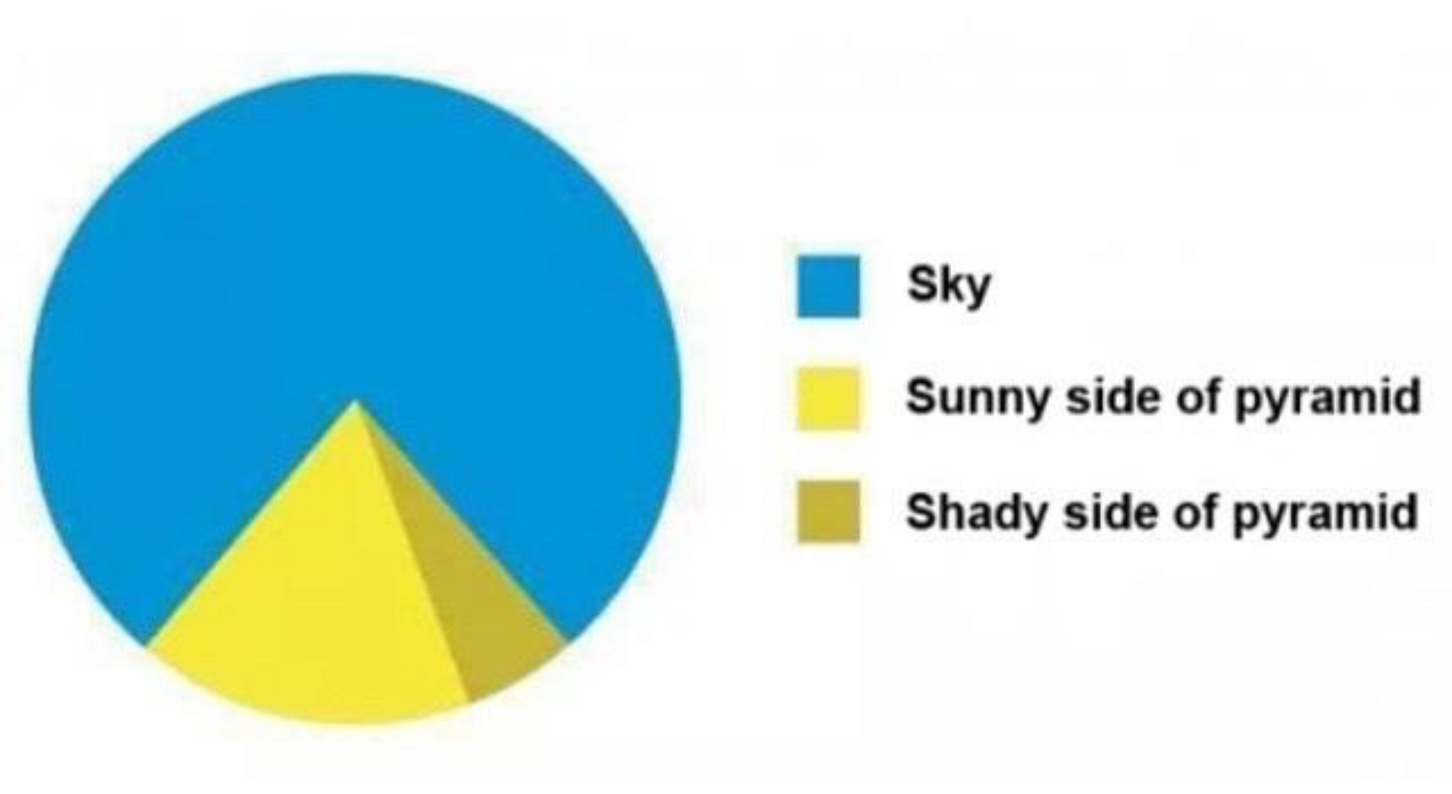
- History of development means low level of trust between Hoopa and Bureau of Reclamation, inertia in monitoring
- Multiple agencies, disciplines, objectives
- Cheap mechanical restoration in many places vs. fancier restoration in a few places (*resolved – cheap doesn't work)*
- Predicting design evolution *(beyond current tools)*
- Public use vs. restoration actions (*e.g., trout pools filling up with added gravel)*
- Staging implementation to learn more vs. going quickly to have greater impact *(adaptive management tradeoff)*
- Differing visions (*Physical scientists vs Biologists; Tribes vs Bureau of Reclamation)*
- Klamath temperature problems forcing fall flows in Trinity
- Climate change likely to reduce snow pack by 80% by 2050 *(happening sooner? 2014 snowpack 80% below normal)*

Questions???

Check out *trrp.net*

THANKS TO: Scott McBain, John Bair, Andreas Krause, Darcy Pickard, Marc Porter, Katherine Wieckowski, Ernie Clarke, DJ Bandrowski

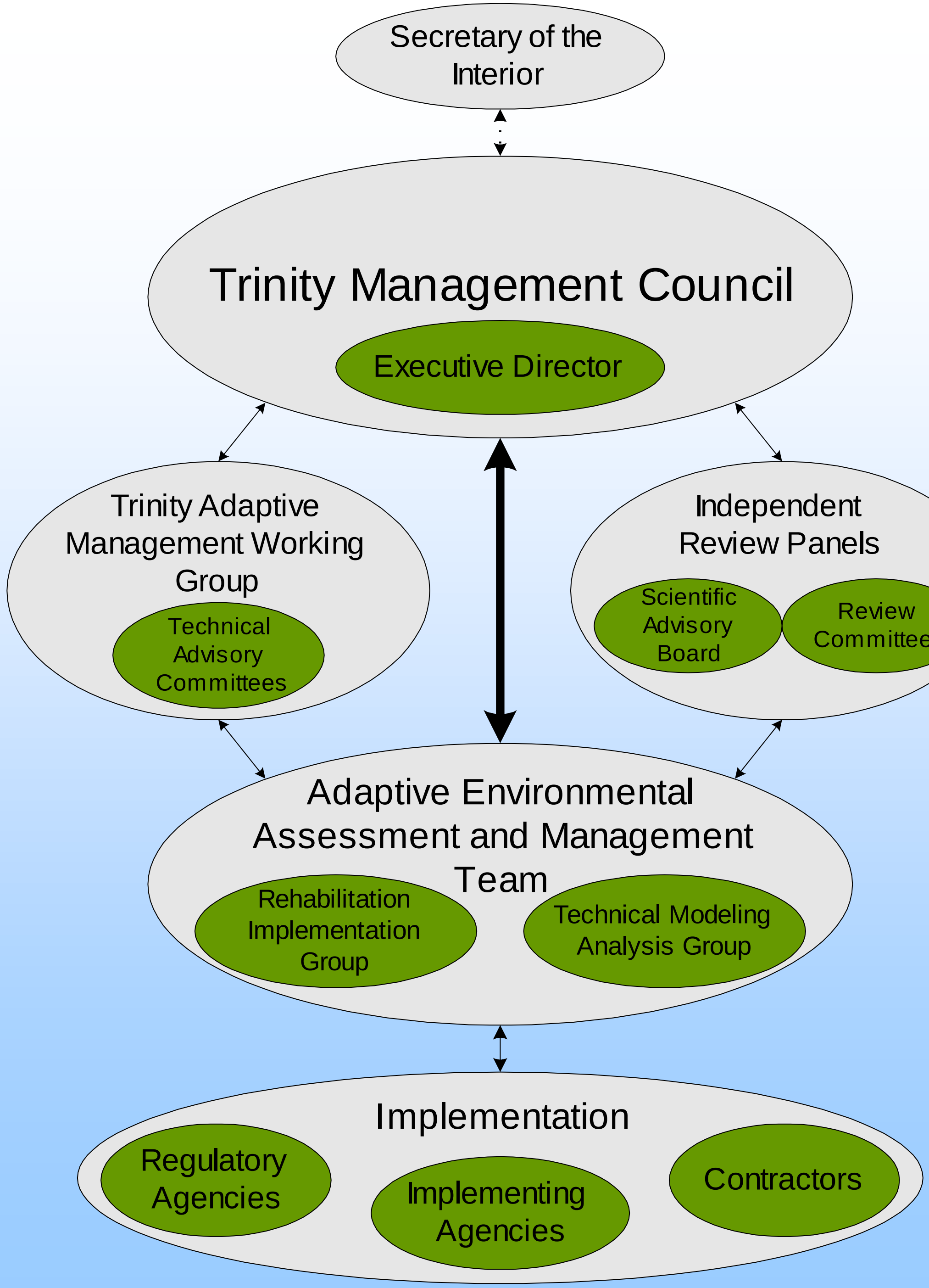
EXTRA SLIDES



Organizational Structure & Implementation Challenges

Trinity River Restoration Program

Restore • Adapt • Improve



Secretary of the Interior

Trinity Management Council

Executive Director

Trinity Adaptive Management Working Group

Technical Advisory Committees

Independent Review Panels

Scientific Advisory Board

Review Committees

Adaptive Environmental Assessment and Management Team

Rehabilitation Implementation Group

Technical Modeling Analysis Group

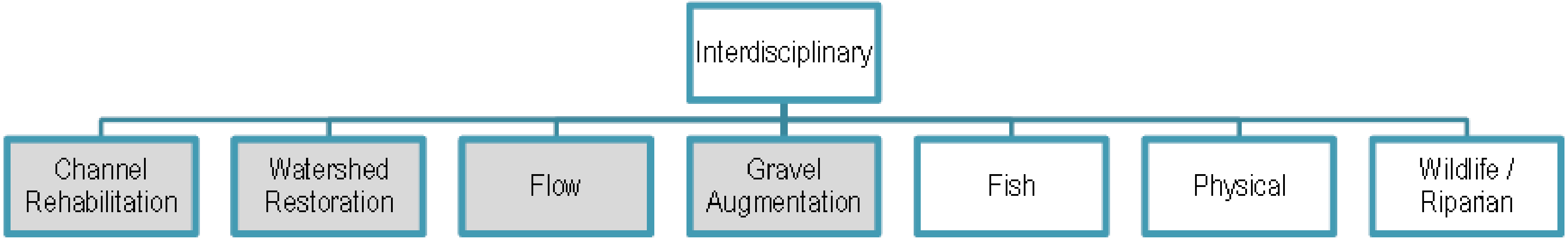
Implementation

Regulatory Agencies

Implementing Agencies

Contractors

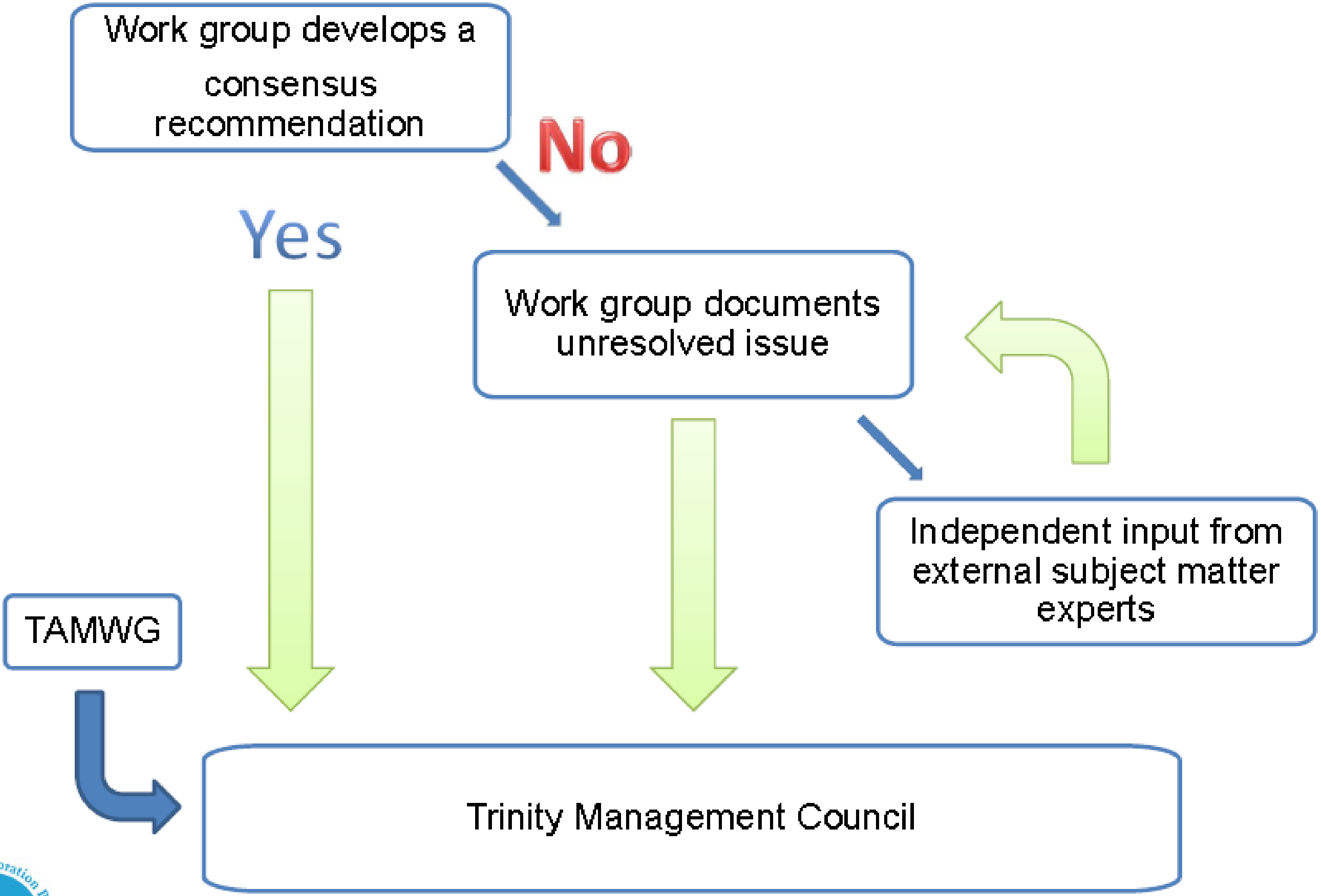
Technical Work Groups



Interdisciplinary

- Channel Rehabilitation
- Watershed Restoration
- Flow
- Gravel Augmentation
- Fish
- Physical
- Wildlife / Riparian

Issue Resolution



Work group develops a consensus recommendation

No

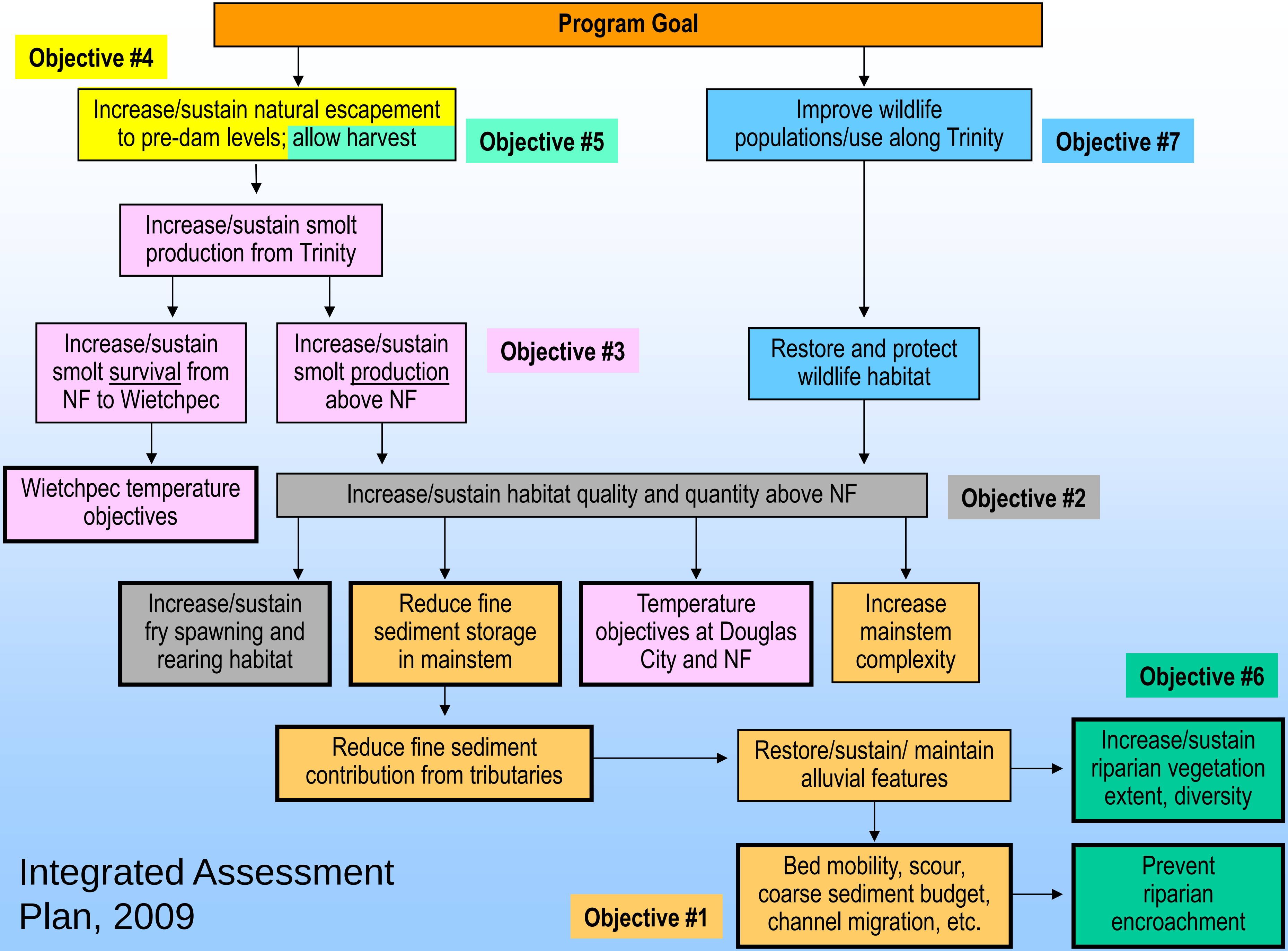
Yes

Work group documents unresolved issue

Independent input from external subject matter experts

TAMWG

Trinity Management Council



Program Goal

Objective #4

Increase/sustain natural escapement to pre-dam levels; allow harvest

Objective #5

Improve wildlife populations/use along Trinity

Objective #7

Increase/sustain smolt production from Trinity

Increase/sustain smolt survival from NF to Wietchpec

Increase/sustain smolt production above NF

Objective #3

Restore and protect wildlife habitat

Wietchpec temperature objectives

Increase/sustain habitat quality and quantity above NF

Objective #2

Increase/sustain fry spawning and rearing habitat

Reduce fine sediment storage in mainstem

Temperature objectives at Douglas City and NF

Increase mainstem complexity

Objective #6

Reduce fine sediment contribution from tributaries

Restore/sustain/ maintain alluvial features

Increase/sustain riparian vegetation extent, diversity

Bed mobility, scour, coarse sediment budget, channel migration, etc.

Prevent riparian encroachment

Objective #1

Integrated Assessment Plan, 2009

What scales of measurement?

(courtesy of Greg Pasternack)

Hydraulic Unit
Microhabitat
(0.1 - 1 Channel Widths)
Provide higher quality habitat for existing populations

Geomorphic Unit
Mesohabitat
(10 Channel Widths)
Provide greater quantity of habitat to increase population size

Reach Unit
(100-1000 Channel Widths)
Provide a mechanism for self-sustainability of the river system