Scott River Watershed Council

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Scott Watershed Informational Forum

Hydrogeomorphic Study

April Sawyer, Scott Wright, Toby Stegman, Chris Hammersmark (cbec)

Thursday, February 20, 2025

Agenda

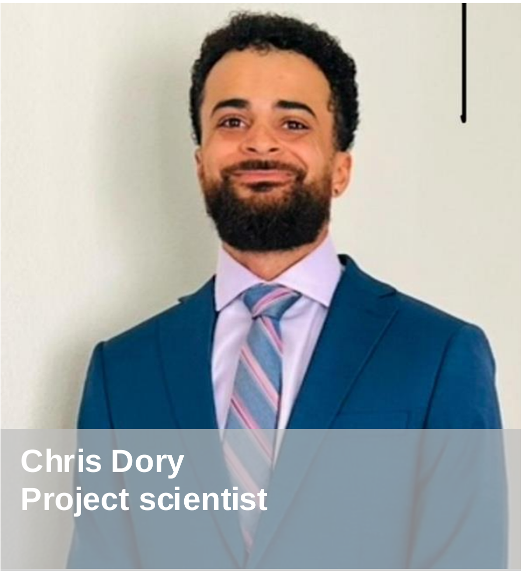
- Introduction to Team
- Background and Objectives
- Hydrogeomorphic Study Approach
- Schedule
- Q & A Discussion

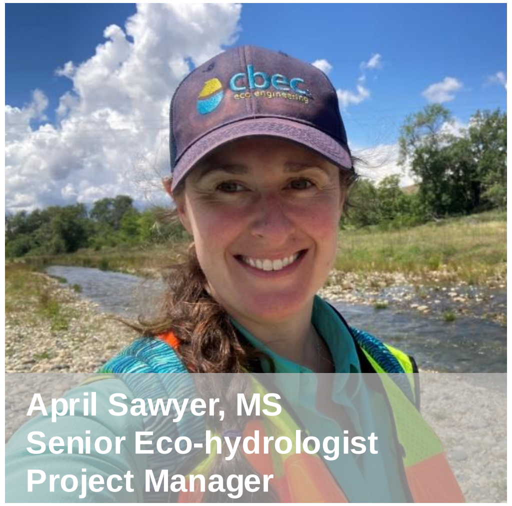
INTRODUCTION TO TEAM

Who We Are


Laura Foglia, PhD
Vice President, Hydrologist
Project Manager for the Groundwater Sustainability Agency


Katrina Arredondo, PhD, PG
Project scientist and modeler


Chris Dory
Project scientist


April Sawyer, MS
Senior Eco-hydrologist
Project Manager


Chris Hammersmark, PhD, PE
Director, Eco-Hydrologist
Project Director


Toby Stegman, MS
Senior Eco-hydrologist
Modeling Tech. Advisor


Scott Wright, PhD
Senior Eco-Hydrologist
Geomorphic Tech. Advisor

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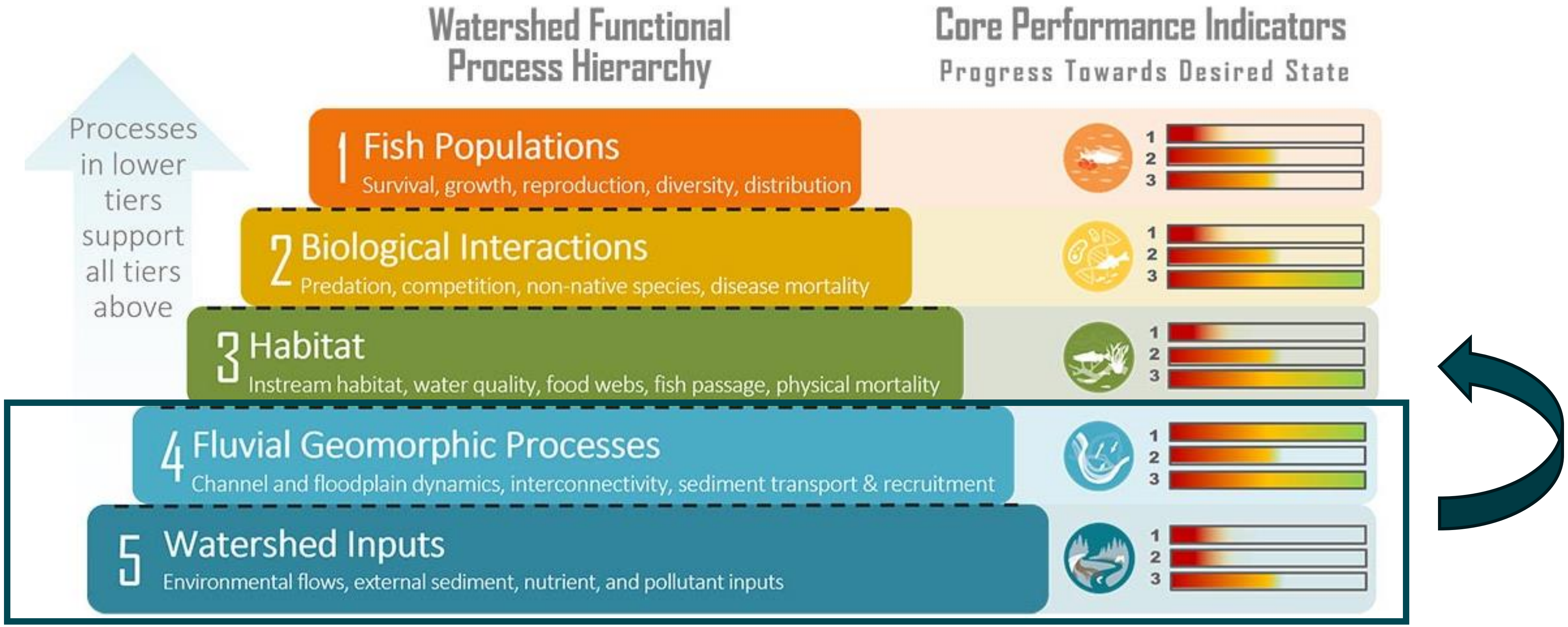
Integrated Background



Klamath IFRMP Plan Document (2023)

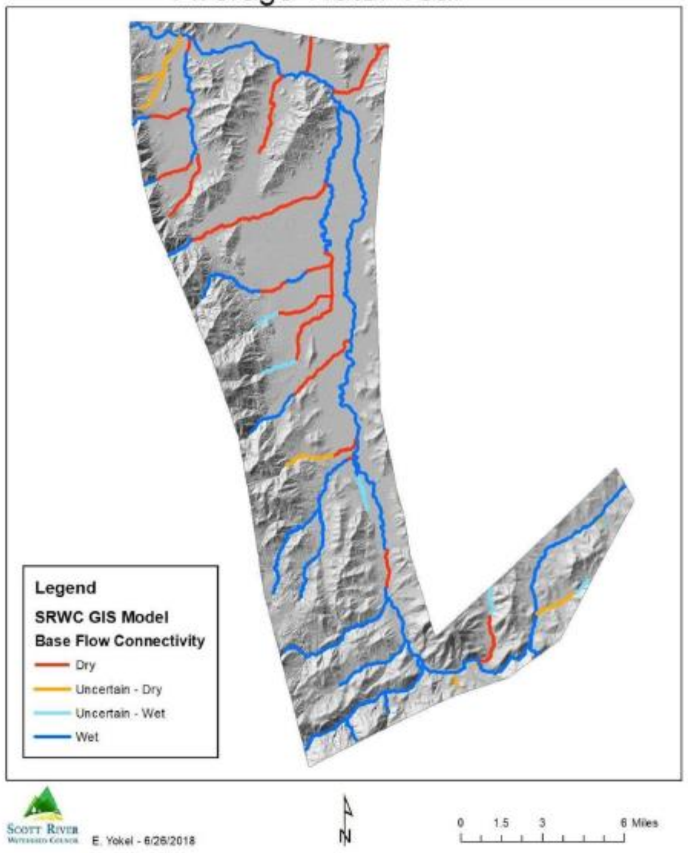
Integrated Background

Priority Project Concepts (2023-2024)	Key Action Classes	Watershed Processes Benefiting	Species Benefiting
Scott 15 - Callahan dredge tailings remediation			
Scott 1 - Acquire water rights from willing sellers within priority areas of the Scott River sub-basin to help maintain instream flows for fish			
Scott 10 - Restore floodplain connectivity and create refuge habitats across Scott River sub-basin streams as identified in the SRWC plan			
Scott 8 - Remove or reconfigure priority river/stream levees and dikes identified in the SRWC plan to restore channel form and floodplain connectivity			

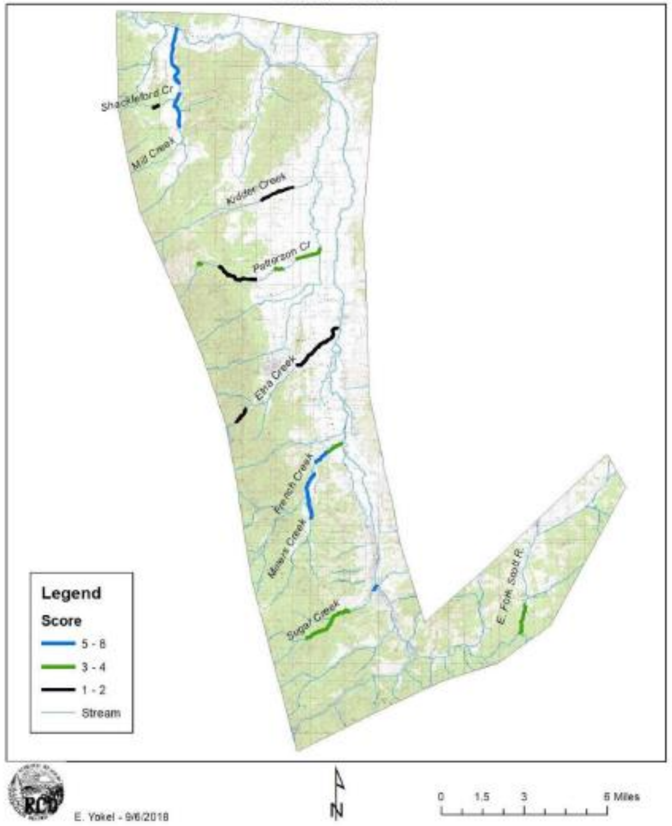
Klamath IFRMP RAA (2023-2024)

Integrated Background

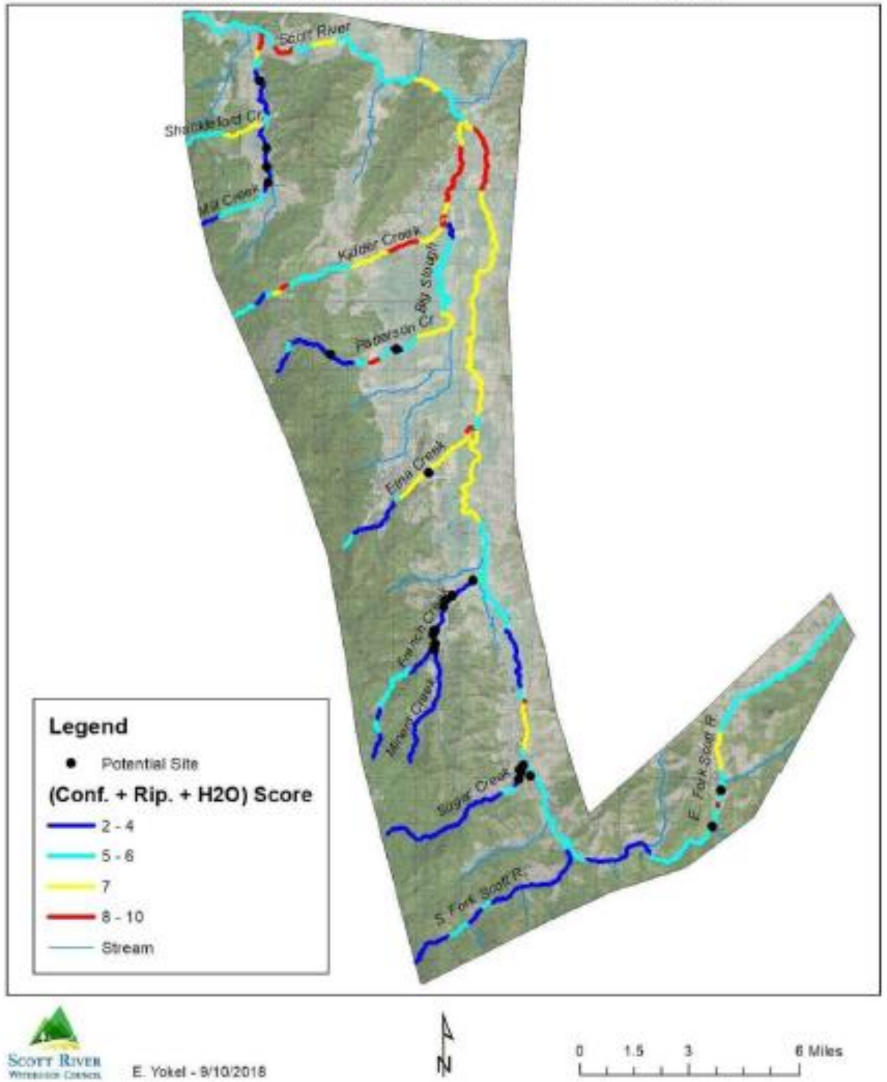
Stream Connectivity at Base Flow
Average Water Year



Scott River - Surveyed Reaches with Highest Coho Redd Density
2004 - 2016



Potential Sites in Reaches with
Identified High Density of Coho Spawning



SRWC (2018)

Objectives

- Assess **groundwater-surface water interactions** by coupling existing SVIHM groundwater modeling and hydrology as inputs to varying resolution hydraulic and sediment transport models.
- Assess **upland impacts on water budget** and impacts of fires and land use changes.
- Evaluate **watershed wide geomorphic processes** and sediment routing patterns, define geomorphic process reaches and perform field and desktop based geomorphic assessments.
- **Identify and prioritize specific restoration actions** that consider watershed wide sediment conditions and hydraulic connectivity by overlaying geomorphic process assessment with coupled groundwater-surface water model, and an understanding of agricultural and fish utilization.
- **Integrate** and leverage multiple existing planning and design efforts into the larger watershed understanding to gain momentum toward project implementation phase.
- Support development of a comprehensive, holistic **river action plan** with prioritized actions with identified benefits and challenges.
- Model area of interest: **Main stem Scott River** from SVID Young's Dam to Fort Jones USGS gage, **select tribs** in that reach (Shackleford, Mill, Kidder, Patterson, Etna, **French**)

Guiding Questions

- How does the hydrology of the entire watershed function and impact water balance in the Scott River, and what are the best locations for upland and edge valley water retention?
- What are the surface and subsurface conditions on the Scott River and its tributaries sufficient to recover flow for fish and supply human water requirements?
- How much incision reversal is needed to increase processes that support groundwater recharge, provide for improved sediment deposition and retention, and enhance overall conditions within the Scott River?
- How is sediment routed from the tribs and through the mainstem Scott River?
- What reaches are going dry and are those reaches perched due to previous disturbances resulting in profile changes (e.g. mining, roads)?
- Where in the watershed, exactly, should projects be focused and/or directed using a targeted and **prioritized list of actionable restoration strategies**?

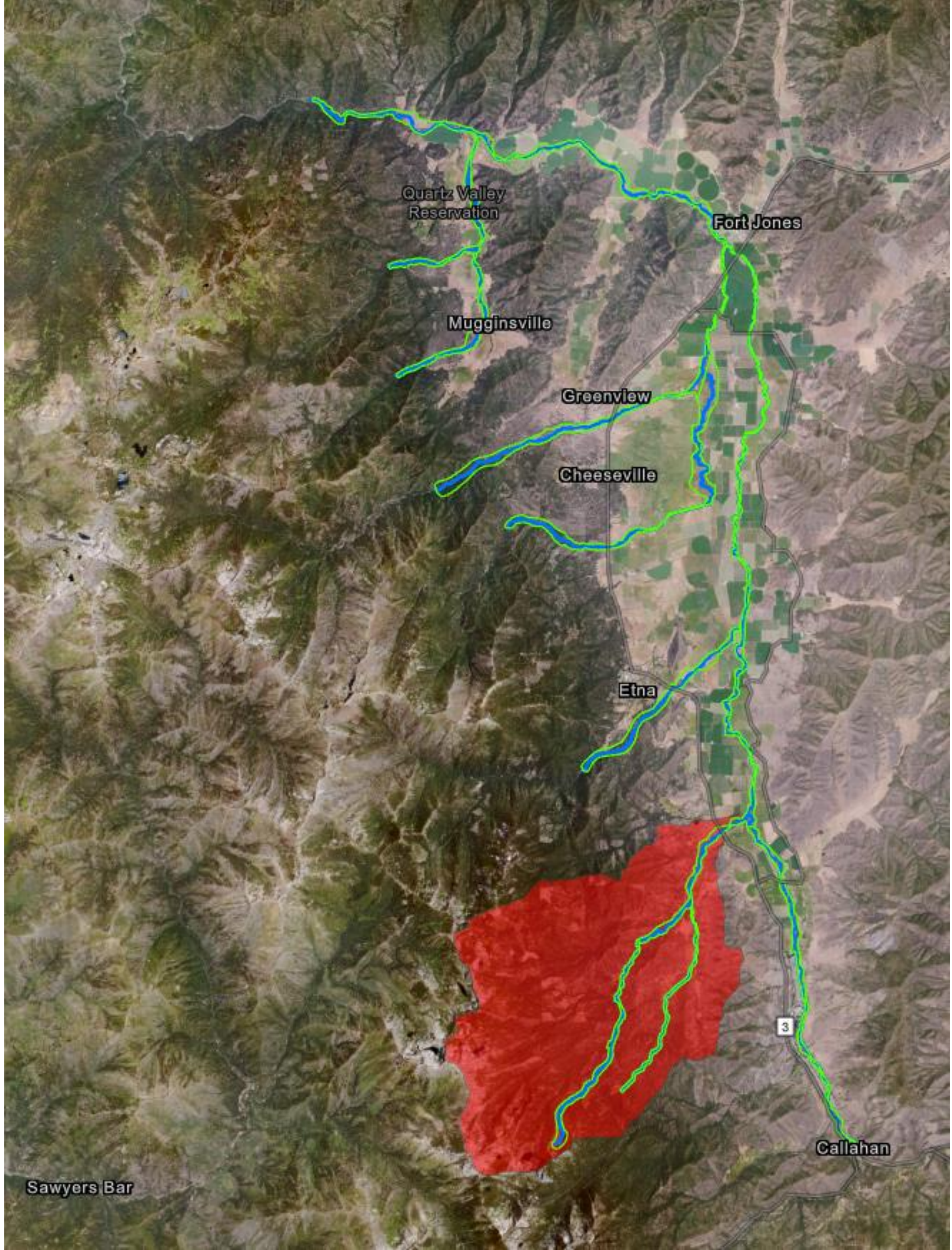
Hydrogeomorphic Study Elements

- **Geomorphic Assessments**
  - Existing conditions – new lidar/imagery acquisition
  - Historical conditions – air photos
  - Delineate geomorphic features and changes through time

- **Predictive Tool Development**
  - Hydraulic models – depth and velocity, groundwater interaction
  - Sediment transport models – erosion and deposition
  - Habitat quantification

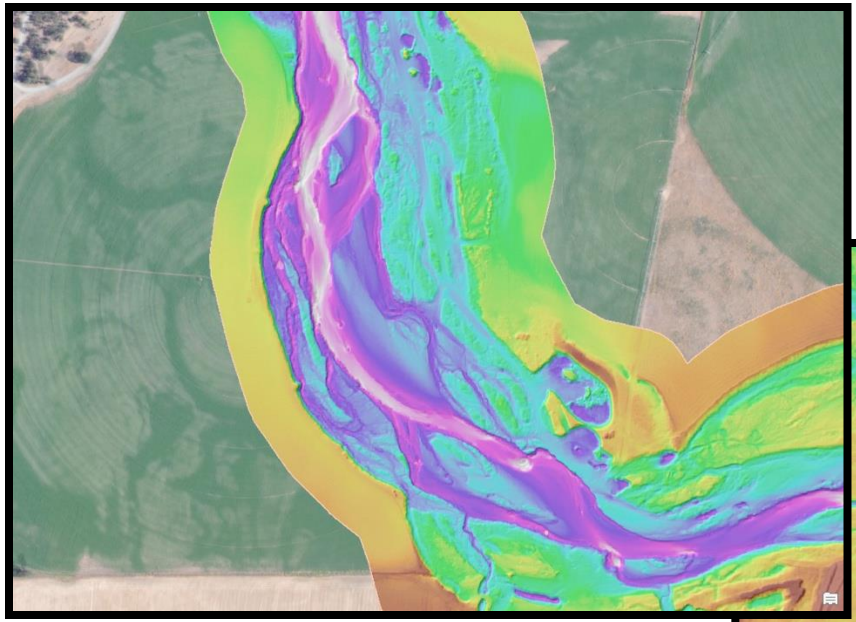
Bathymetric LiDAR

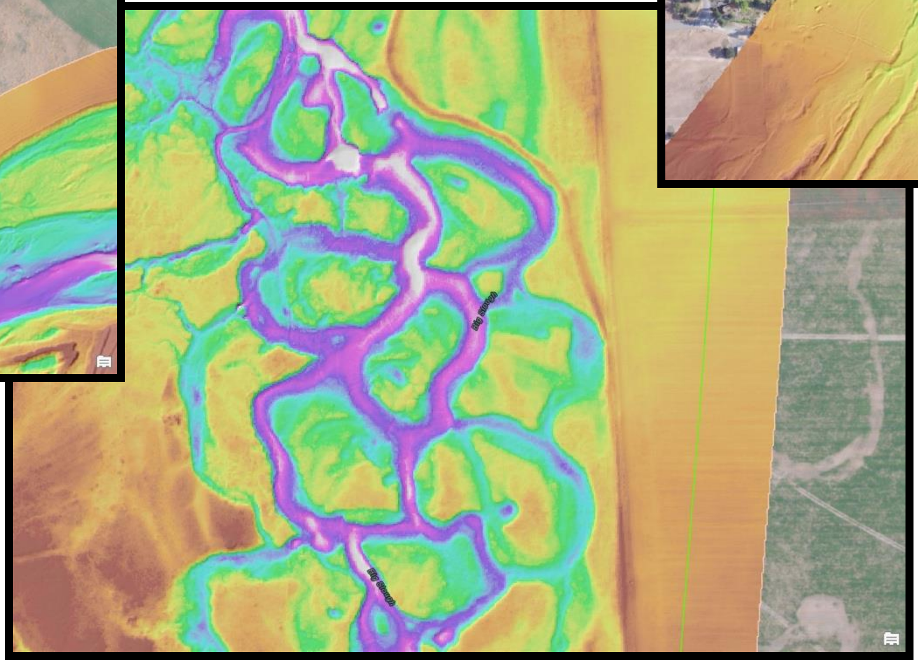
- 5,697 acres of topo-bathy (green lidar) collected in early October 2024
- Topo-bathy = 99.5 miles of river channel
- Ortho images (3” pixel, 4-band)
- Topo (red lidar) for French Creek in coordination with Mid French Restoration Design Development

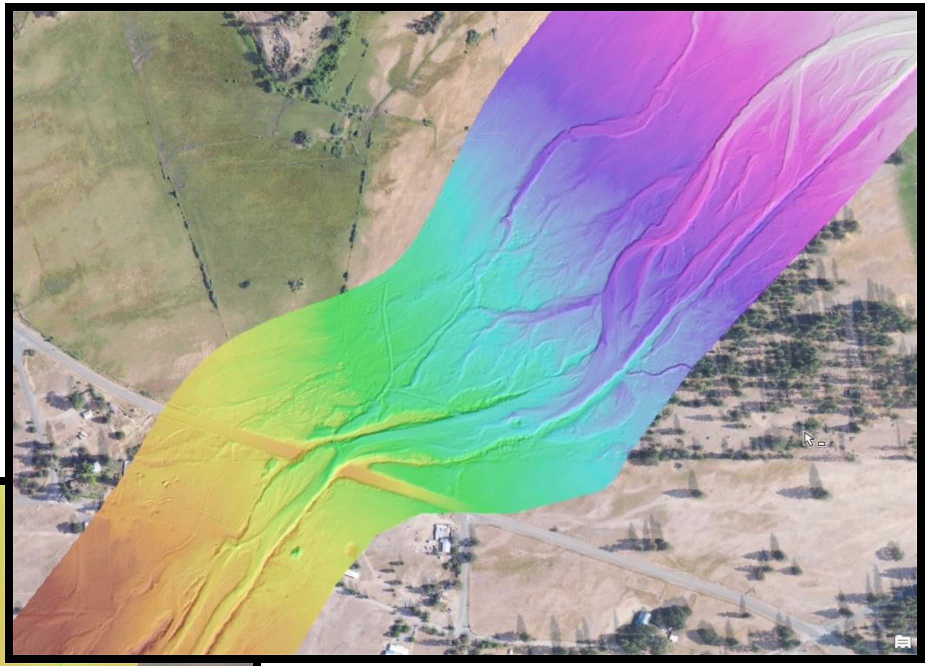


HYDROGEOMORPHIC STUDY APPROACH

Bathymetric LiDAR



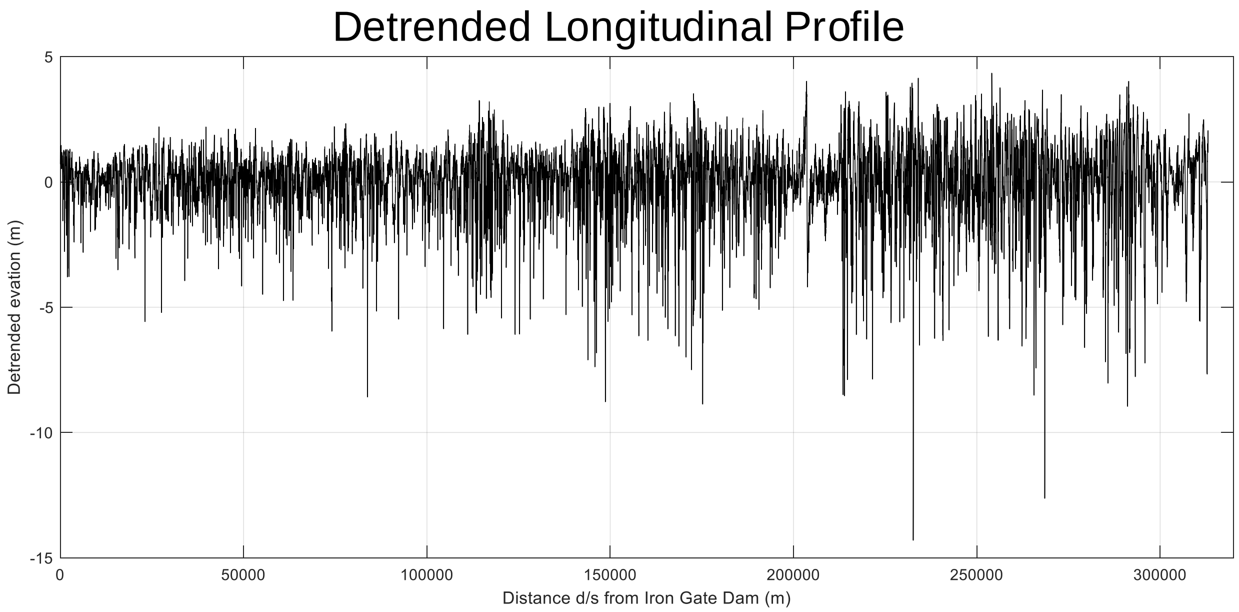


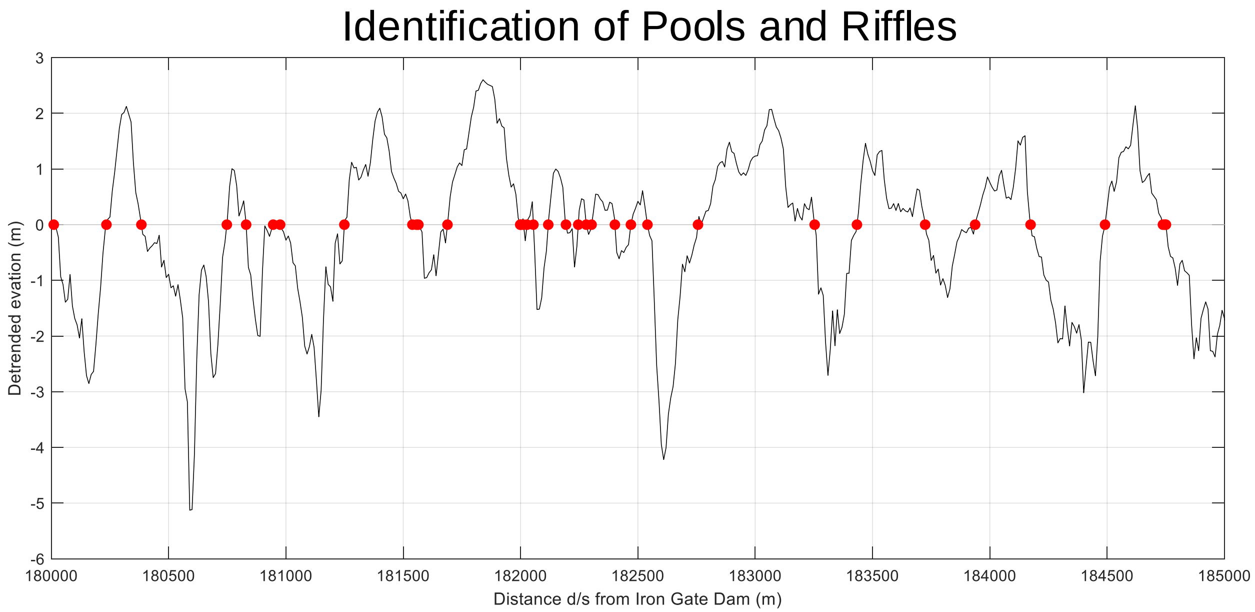


HYDROGEOMORPHIC STUDY APPROACH

Bathymetric LiDAR

- Lidar dataset allows for evaluation of the elevation profile of the entire river (e.g. locations of pools and riffles)
- Examples shown from the Klamath River
- Lidar and imagery can also be used to estimate sediment storage in the channel, by reach





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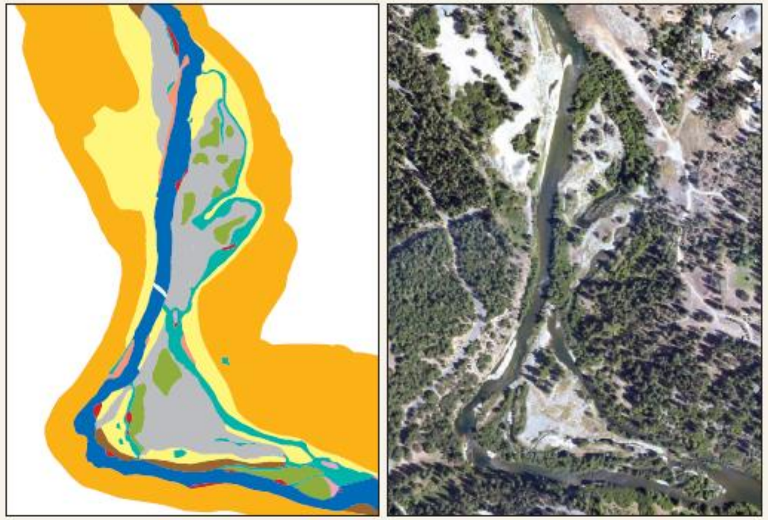
Geomorphic Assessment

- Adapt geomorphic mapping protocol from other, regional efforts
- Ortho images used to digitize geomorphic features.

Coded value	Features
	Environments
1	Main channel
2	Tributary
3	Terrestrial
	Terrestrial
1	Other
2	Floodplain
3	Island
4	Post-dam topographic bench
5	Surface-water feature
6	Uplands
	Channel
1	Wetted channel
2	Secondary water features
3	Bedrock
4	Bar
5	Other
	Secondary water features
1	Alcove
2	Wetland
3	Side channel
4	Split-flow channel

	Additional feature attributes
	Bar type
1	Lateral
2	Medial
	Vegetation
1	Bare to sparse
2	Moderate
3	Dense
	Bar stability
1	Stable
2	Active
	Restoration
1	Constructed

Geomorphic Mapping to Support River Restoration on the Trinity River Downstream from Lewiston Dam, California, 1980–2011



Geomorphic features along the Trinity River, California, downstream from Lewiston Dam, 2011

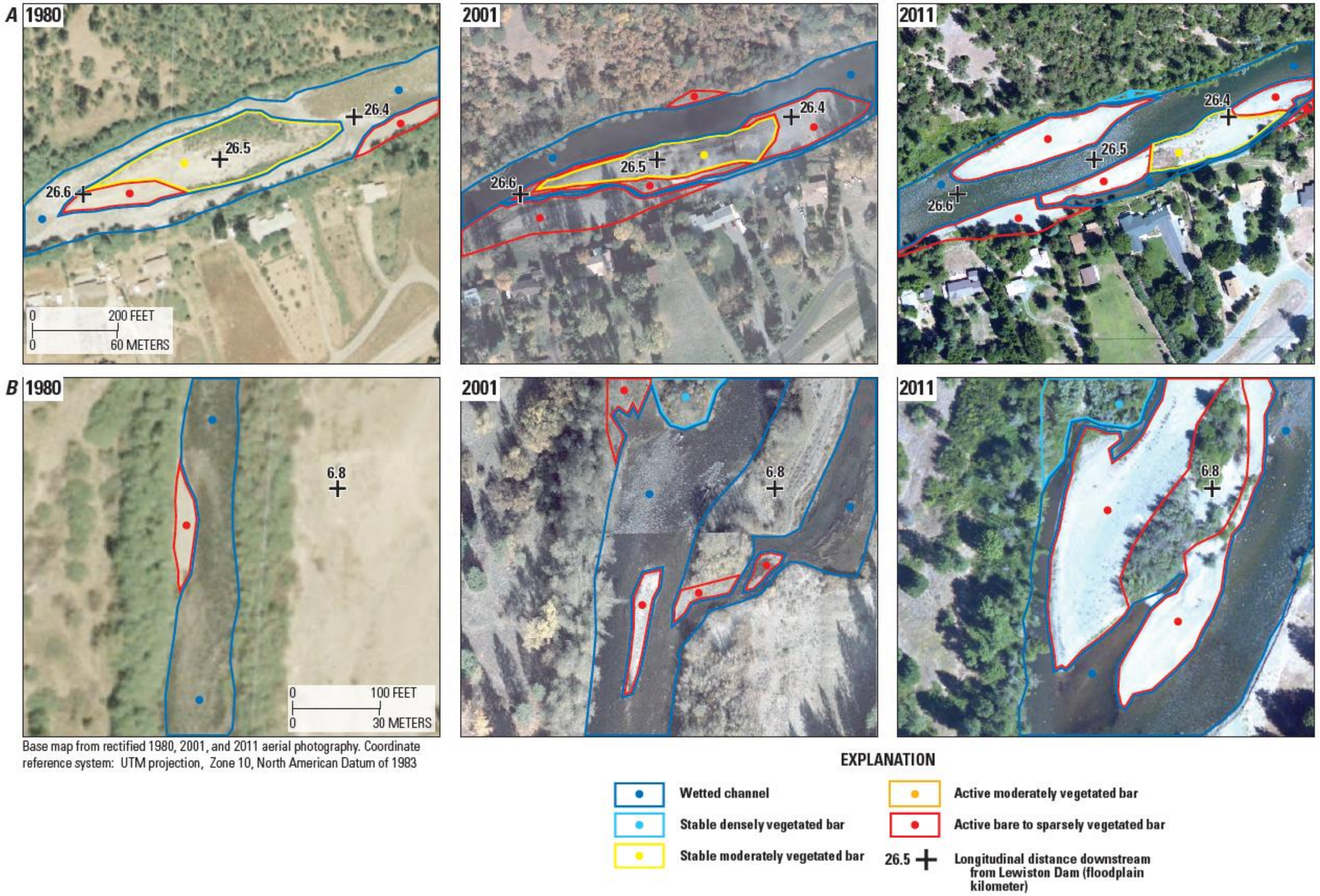
USGS science for a changing world

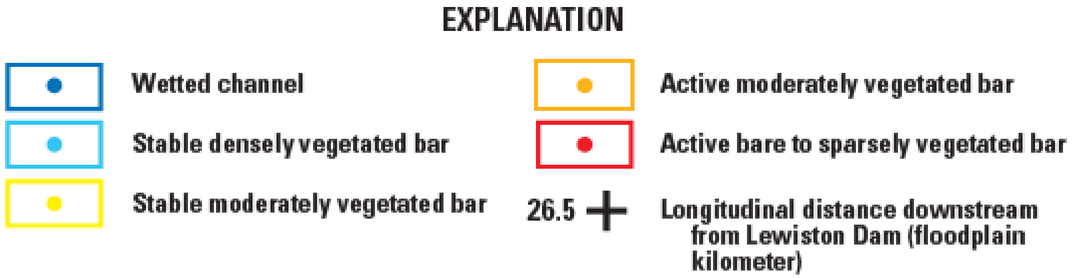
- Uplands
- Pre-Dam Floodplain
- Island
- Constructed Floodplain
- Post-Dam Bench
- Stable Bar
- Active Bar
- Constructed Bar
- Secondary Water Feature
- Primary Wetted Channel

Open File Report 2015–1047

By Jennifer A. Curtis and Timothy M. Guerrero

Geomorphic Assessment

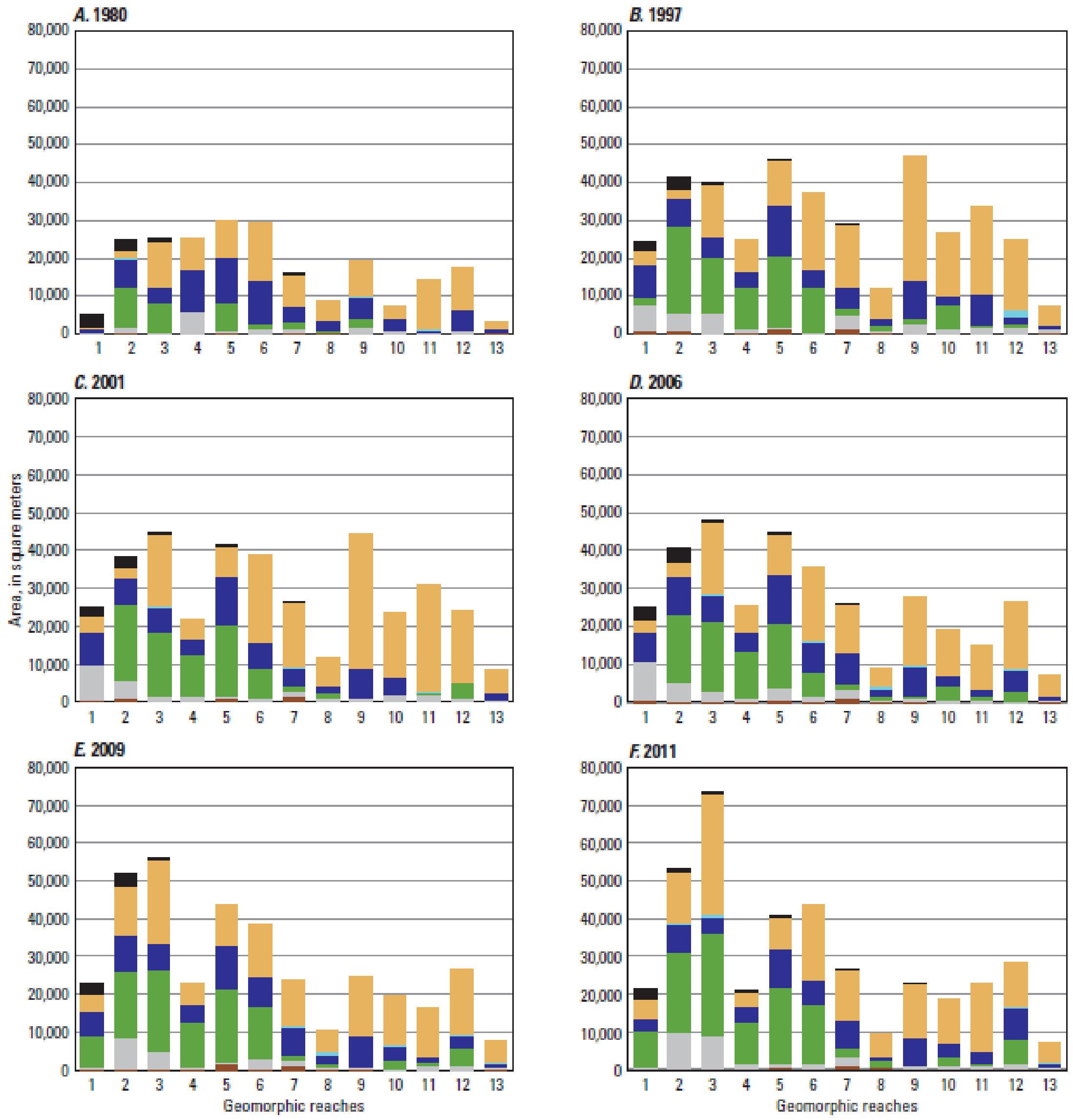




Geomorphic Assessment

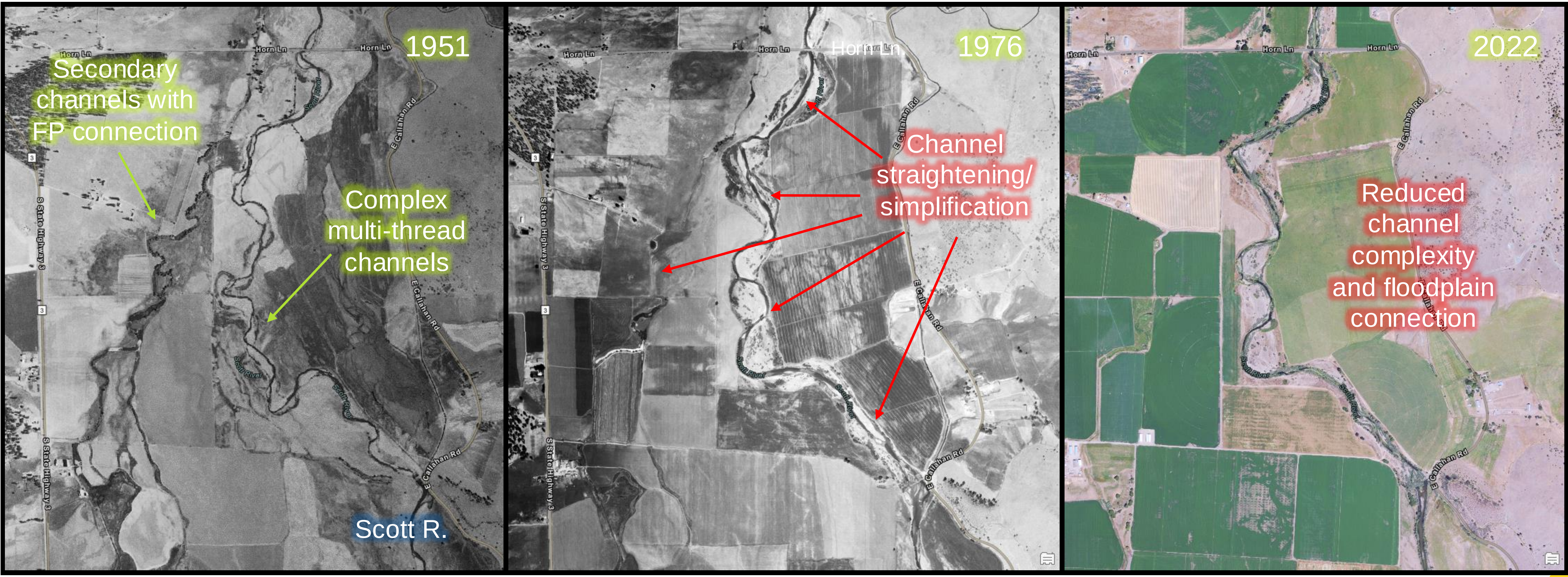
- Geomorphic feature mapping allows for an assessment of how the river has changed through time, at a chosen spatial scale (i.e. reaches)

- Example from the Trinity River shown at right



HYDROGEOMORPHIC STUDY APPROACH

Historical Images



Historical Images

Geomorphic Assessment

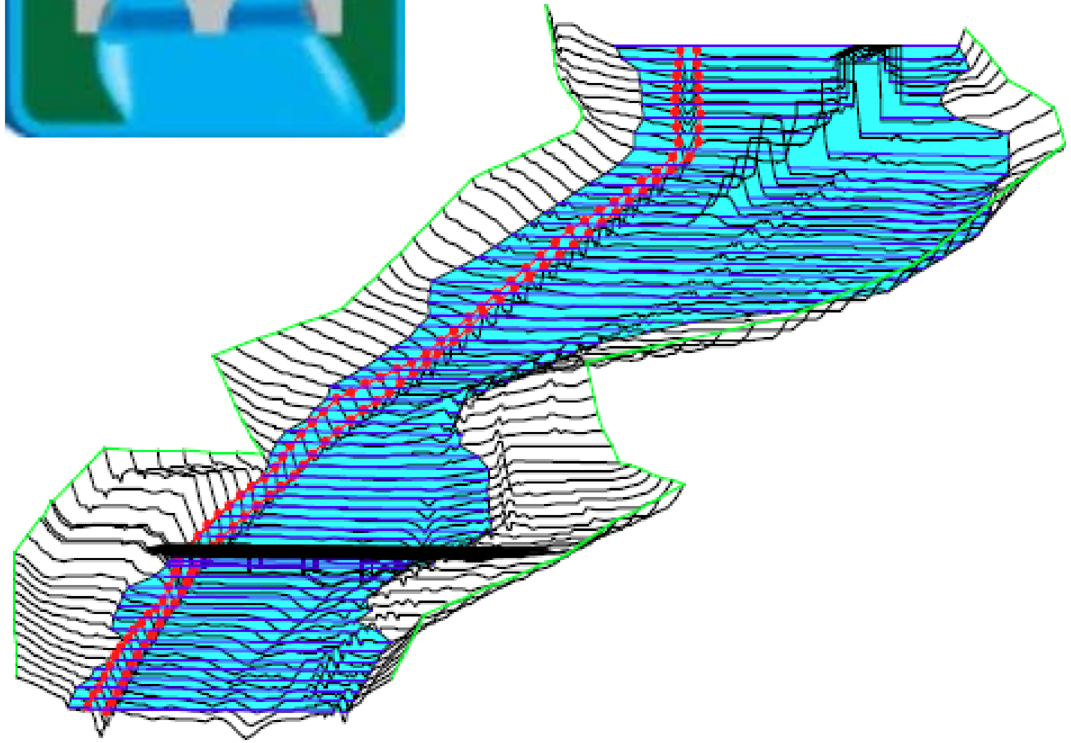
Scott River Models

US Army Corps of Engineers®

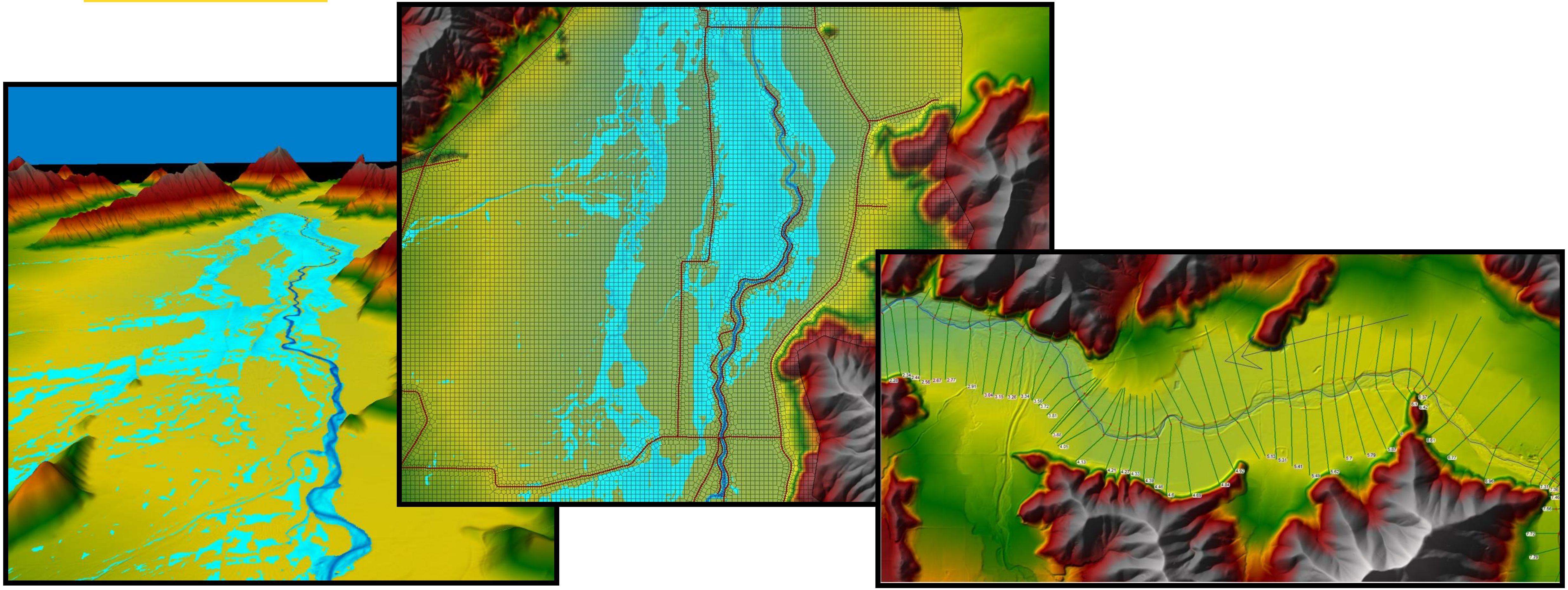
Hydrologic Engineering Centers River Analysis System (HEC-RAS)

- Simulates hydraulic processes (depth & velocity)
- Can simulate one-dimensional steady flow
- Can simulate one and two-dimensional unsteady flow
- Boundary conditions from PRMS
- Can simulate sediment transport and bed changes

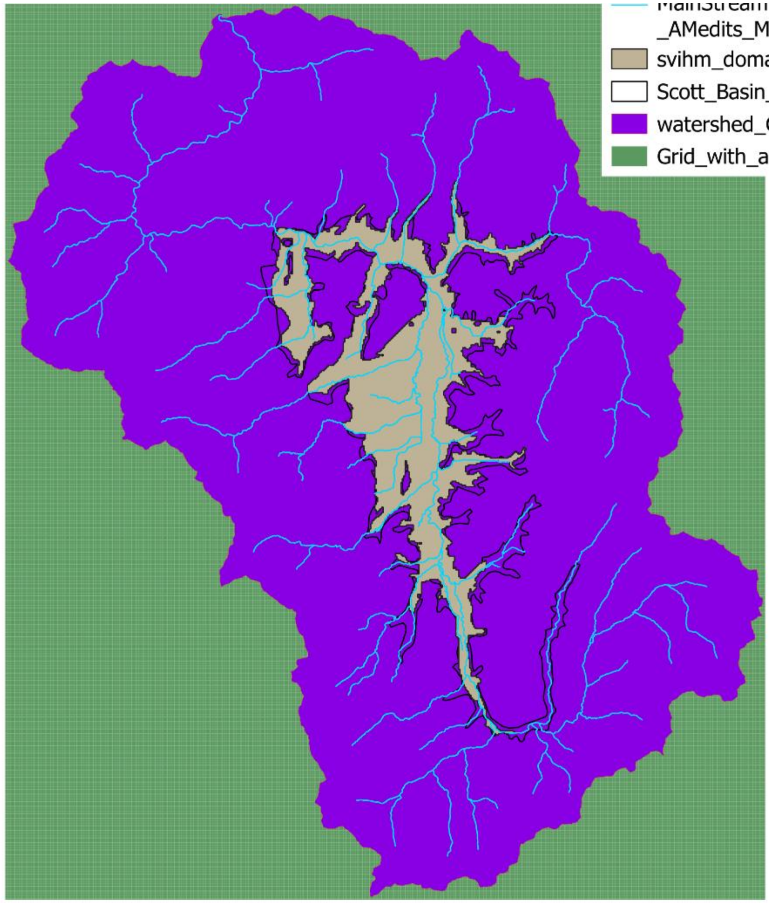
- Green LiDAR data will be used to develop the model with accurate channel topography.
- Models will be calibrated to observed data
- Models used to understand baseline and future conditions.
- Coupled models will be used to simulate groundwater surface water interactions.



Hydraulic Modeling in HEC-RAS



HEC-RAS to MODFLOW Integration



HEC-RAS model output

→ Post-processing by cbec to return WSE, wetted area/fraction/volume by MODFLOW cell

→ Calculate river and floodplain conductance based on Tier 2 unsaturated recharge rates and wetted area

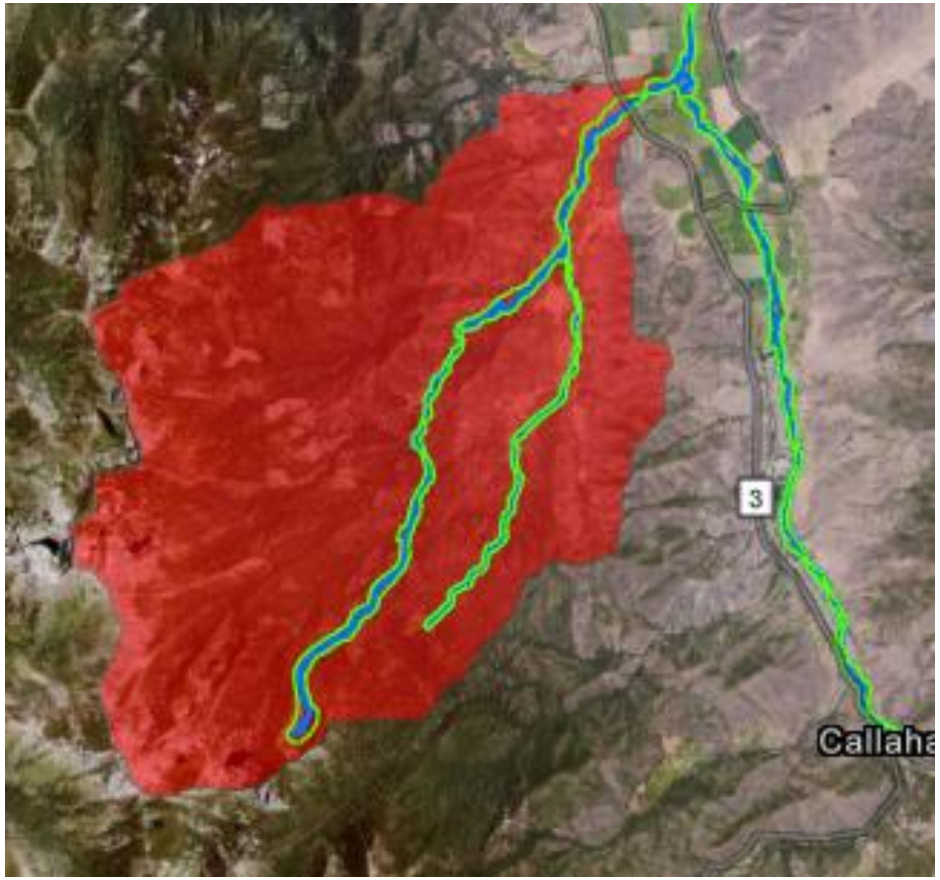
→ MODFLOW model input :

- River and floodplain boundary condition
- Reduce recharge/pumping at concept locations

→ Post-process MODFLOW output to review changes in water budget, groundwater level, flow exchanges

French Creek

- Classify reaches based on geomorphic characteristics.
- Estimate sediment loads from the various tributaries to French Creek, develop a reach-based sediment budget.
- Construct a conceptual, semi-quantitative diagram showing transport pathways from the source areas through the channel reaches to the confluence with the Scott.
- Support project design by PCI.



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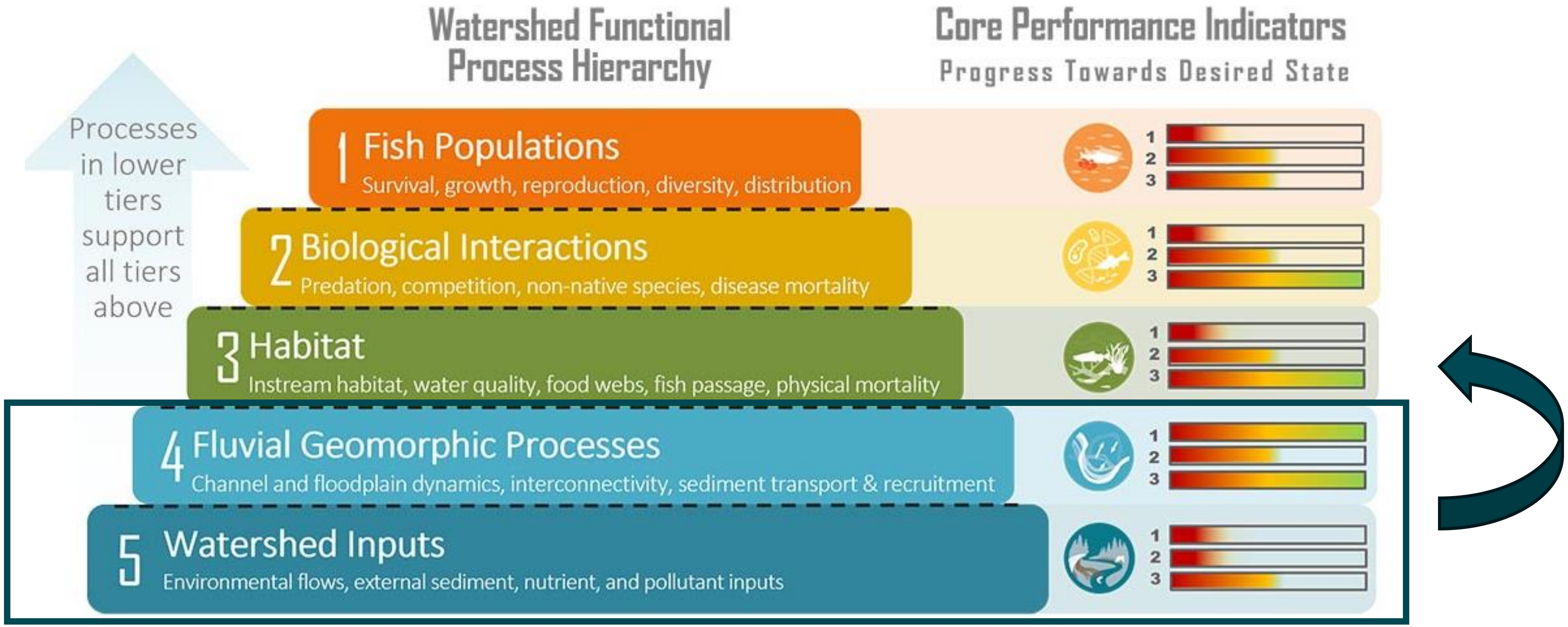
Integrated Background



Klamath IFRMP Plan Document (2023)

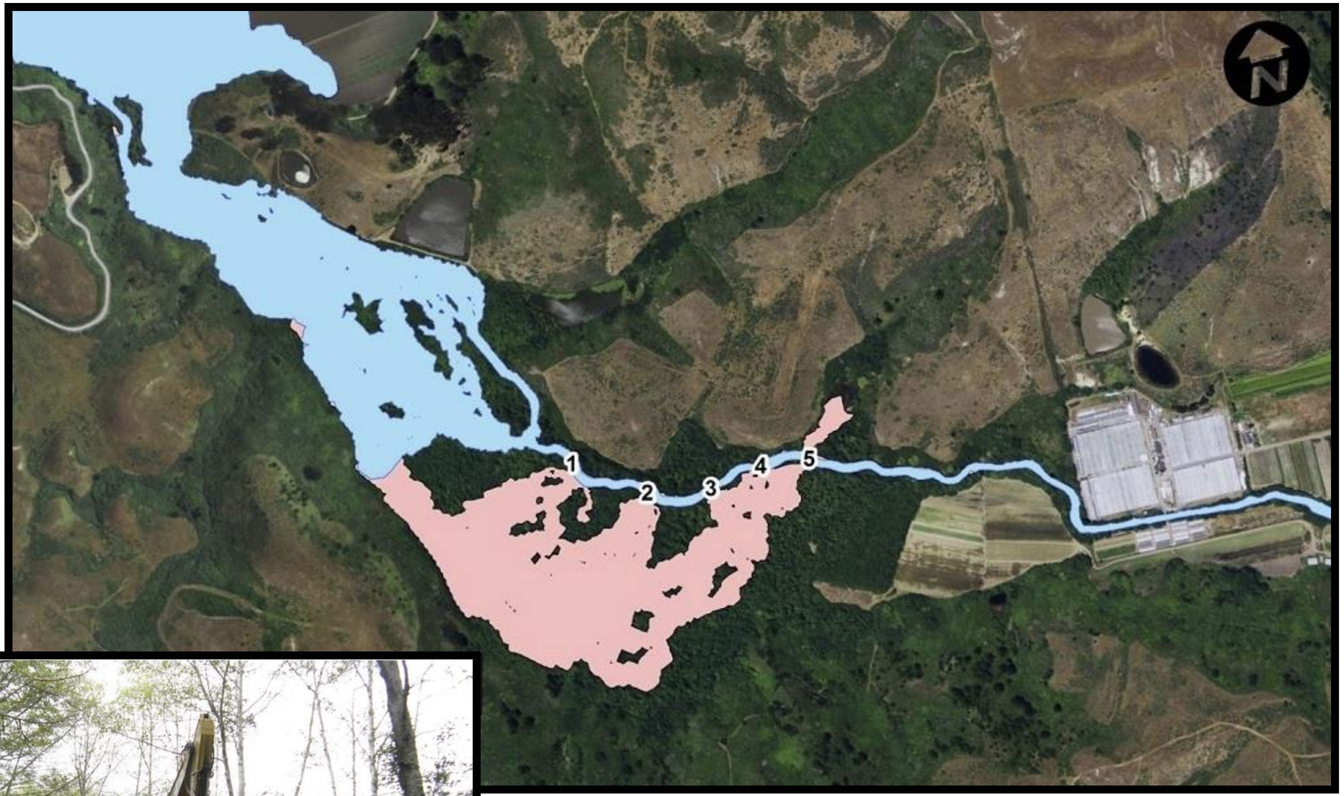
Recovery Approach

Beechie et al. 2010

Table 2. Summary of the four process-based principles.

Principle	Description
1. Target root causes of habitat and ecosystem change	Restoration actions that target root causes of degradation rely on assessments of processes that drive habitat conditions, and actions are designed to correct human alterations to those driving processes.
2. Tailor restoration actions to local potential	Each reach in a river network has a relatively narrow range of channel and riparian conditions that match its physiographic and climatic setting, and understanding processes controlling restoration outcomes helps design restoration actions that redirect channel and habitat conditions into that range.
3. Match the scale of restoration to the scale of the problem	When disrupted processes causing degradation are at the reach scale (e.g., channel modification, levees, removal of riparian vegetation), restoration actions at individual sites can effectively address root causes. When causes of degradation are at the watershed scale (e.g., increased erosion, increased runoff due to impervious surfaces), many individual site-scale actions are required to address root causes. Recovery of wide-ranging fishes (e.g., Pacific or Atlantic salmon) requires restoration planning and implementation at the scale of population ranges.
4. Be explicit about expected outcomes	Process-based restoration is a long-term endeavor, and there are often long lag times between implementation and recovery. Ecosystem features will also continuously change through natural dynamics, and biota may not improve dramatically with any single individual action. Hence, quantifying the restoration outcome is critical to setting appropriate expectations for river restoration.

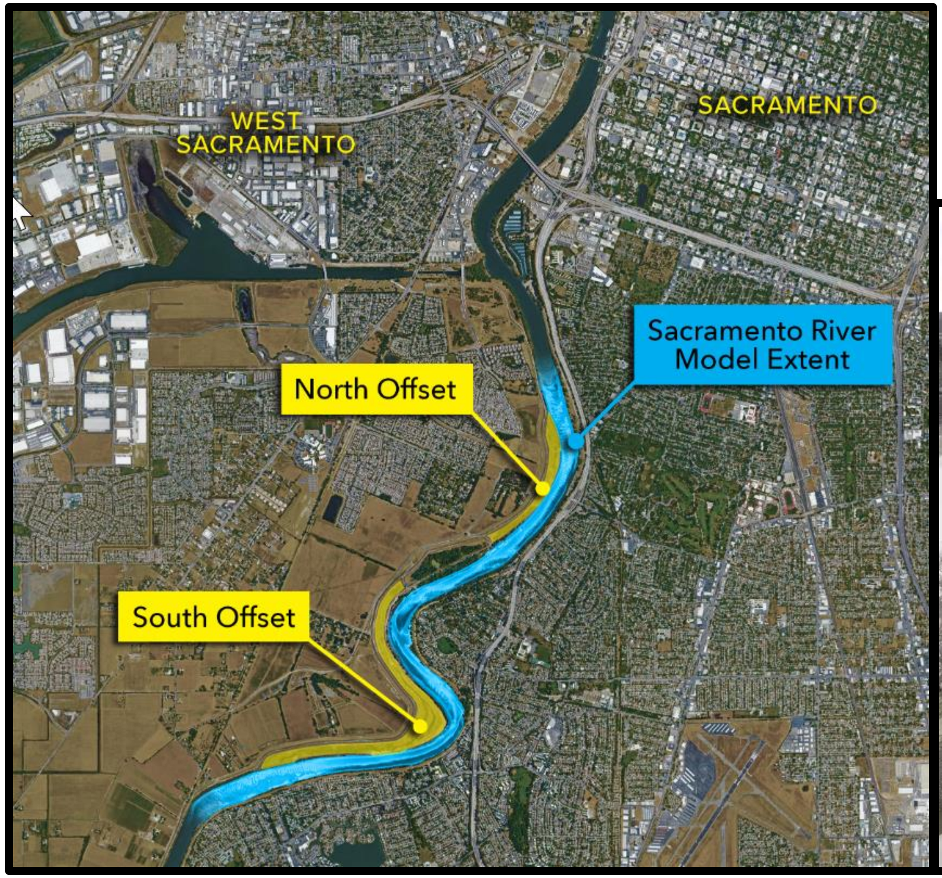
Recovery Concepts



Butano Floodplain Reconnection Project

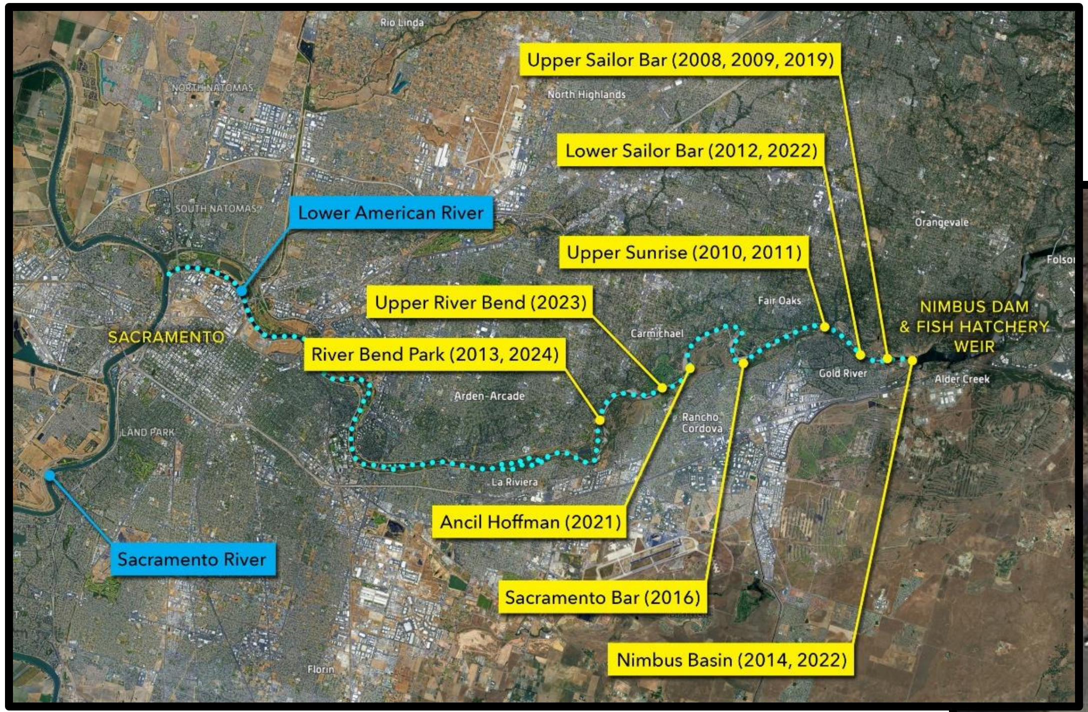
Recovery Concepts

Southport Levee Setback Project



HYDROGEOMORPHIC STUDY APPROACH

Recovery Concepts



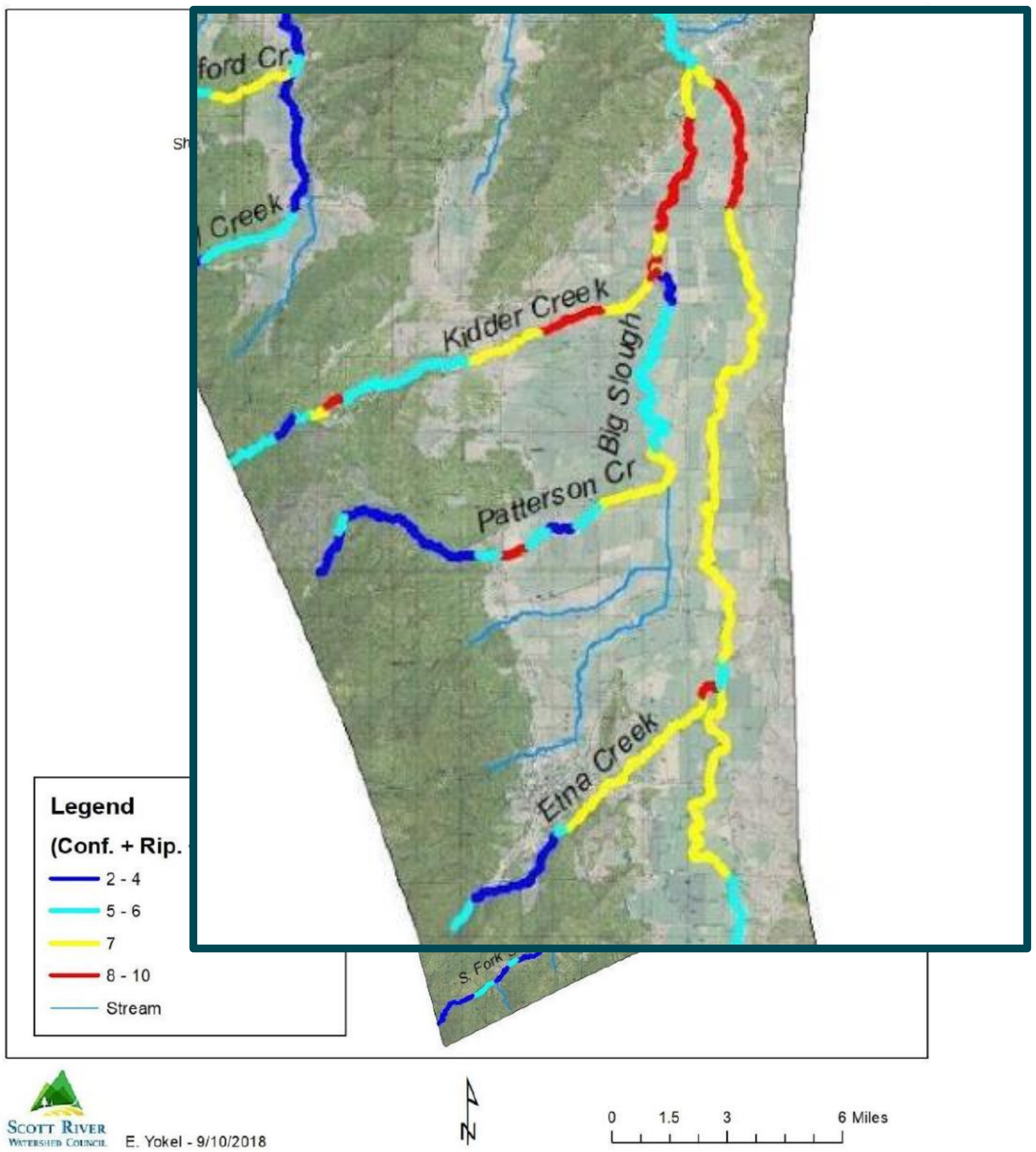
Lower American River Salmonid Habitat Enhancement Program

HYDROGEOMORPHIC STUDY APPROACH

Recovery Concepts

- Watershed scale approach
- Many small, cumulative actions
- Opportunistic channel modifications to augment complexity along migration corridor
  - Levee setbacks, variable field levels along riparian margins?
  - Small benches on field margins or outside of pivot coverage?

(Confinement + Riparian + Water at Base Flow) = Total Score



Concept Identification and Prioritization

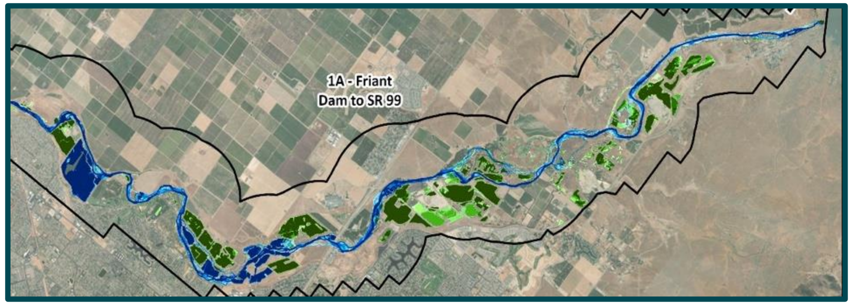
Tier 1:
Large-scale inundation potential

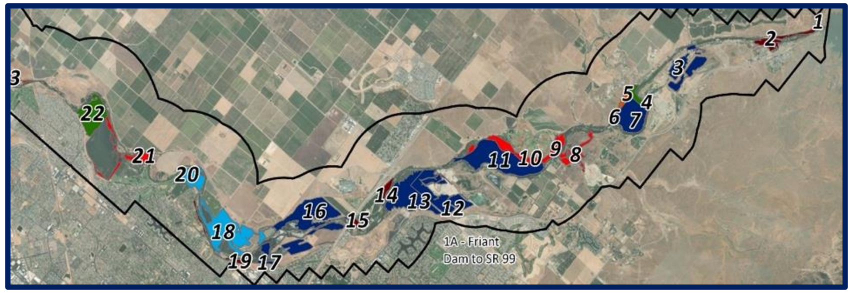
Tier 2:
Multi-objective Site Identification & Prioritization

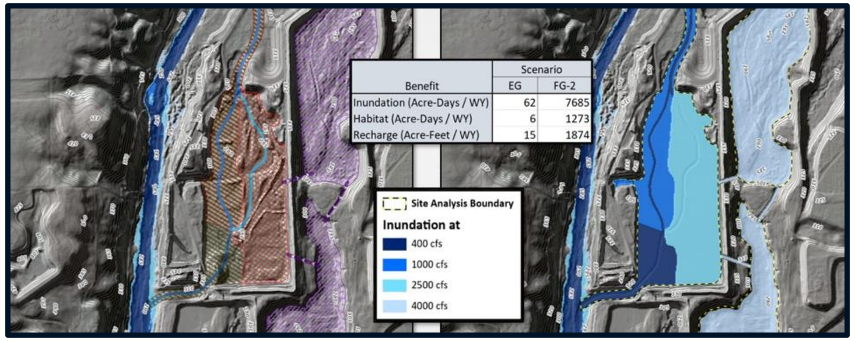
Tier 3:
Conceptual Design

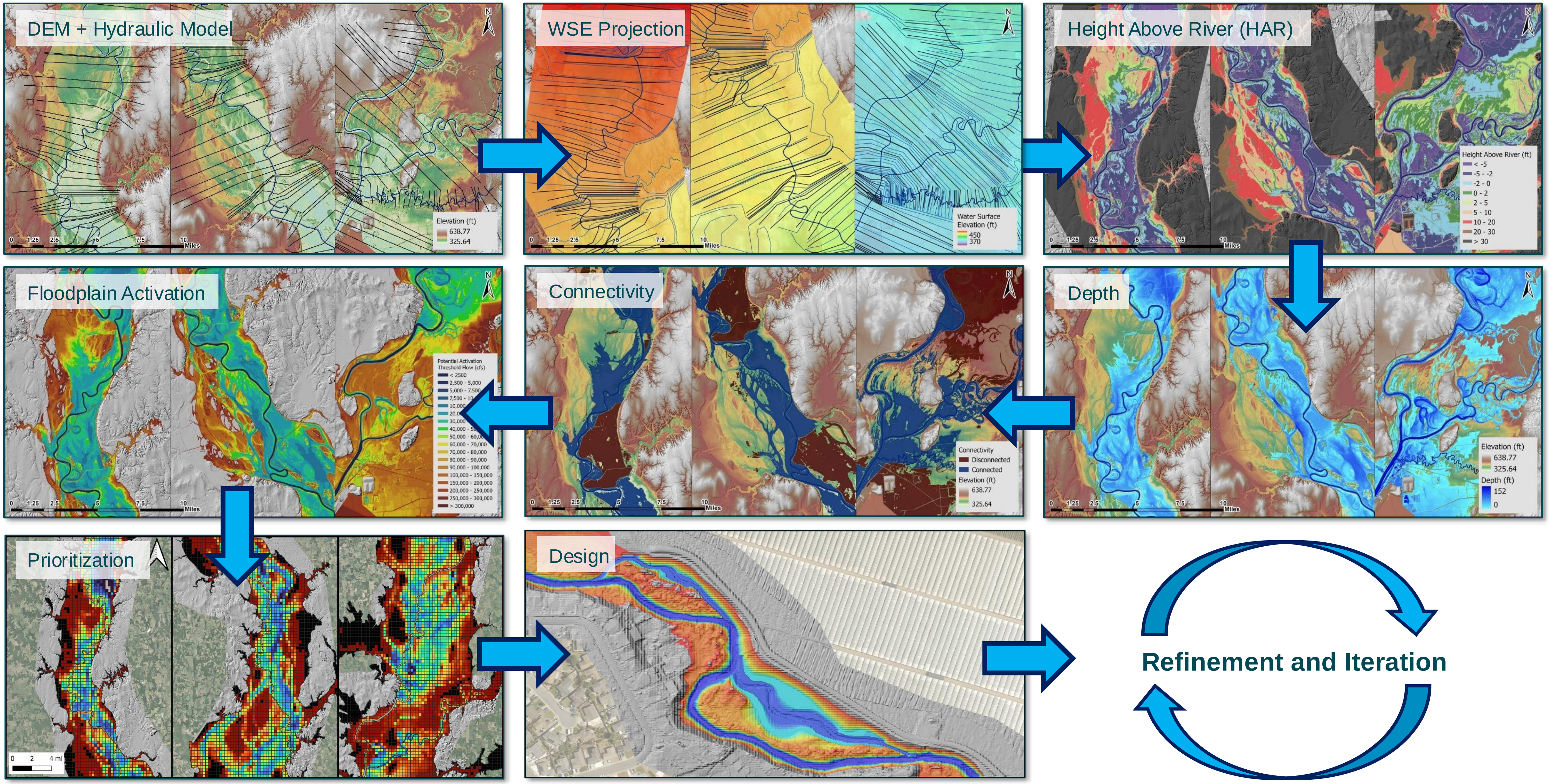
Analysis Dimensions

Temporal	Spatial
Individual flows	*River reach*
WY-based accumulated stats	*Boundaries for Existing Topography (parcels, river miles, gridded)*
WY-based accumulated stats	*Site Concept For Design Topography*








DEM + Hydraulic Model
Elevation (ft)
638.77
325.64
WSE Projection
Water Surface Elevation (ft)
450
370
Height Above River (HAR)
Height Above River (ft)
< -5
-5 - -2
-2 - 0
0 - 2
2 - 5
5 - 10
10 - 20
20 - 30
> 30
Floodplain Activation
Connectivity
Disconnected
Connected
Elevation (ft)
638.77
325.64
Depth
Elevation (ft)
638.77
325.64
Depth (ft)
152
0
Prioritization
Design
Refinement and Iteration

SCHEDULE

Hydrogeomorphic Study Timeline

Task	Description	2024		2025				2026			
		Year 1		Year 2				Year 3			
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	Refine Hydrogeomorphic Study Plan										
2	Data Compilation										
3	Historical Channel Changes										
4	Existing Conditions Assessment										
5	Identification of Potential Projects										
6	Future Conditions Assessment										
7	Reporting										
8	Project and Quality Management										
9	Interested Party Outreach										

Q & A Discussion

Reach out with further questions to Hydrogeomorphic Study PM April Sawyer (a.sawyer@cbecoeng.com) or

Laura Foglia (lauraf@lwa.com) for groundwater/hydrologic inputs.

Recovery Approach

Beechie et al. 2010

Table 4. Examples of process-based restoration actions designed to correct causes of ecosystem degradation at both watershed and reach scales, or to restore migration pathways.

Cause of degradation	Restoration action	Purpose
Watershed scale		
Increased surface erosion and sediment delivery	Resurface or remove forest roads	Reduce erosion of fine sediments, and reduce delivery of fine sediments to streams
Flow regulation has reduced peak and low flows	Environmental flow restoration	Restore a range of critical flows, including channel-forming flows, maintenance flows, and low flows
Reach scale		
Levees prevent flooding and secondary-channel habitat formation	Levee set-back or removal	Restore lateral channel migration, floodplain patch turnover, riparian forest succession, habitat diversity, movement of biota
Loss of wood delivery and stream shading	Replant or thin riparian forests	Restore wood recruitment, restore shade functions, restore nutrient inputs
Loss of in-channel sediment retention prevents recovery of incised channels	Reintroduce beaver to help aggrade incised river channels	Restore natural sediment retention mechanism, accelerate aggradation, raise water table, and increase spatial extent of riparian vegetation
Habitat connectivity		
Dams block fish access to spawning and rearing habitats	Remove dams or build passage structures	Restore ability of fishes to migrate among habitats that are critical to their life cycles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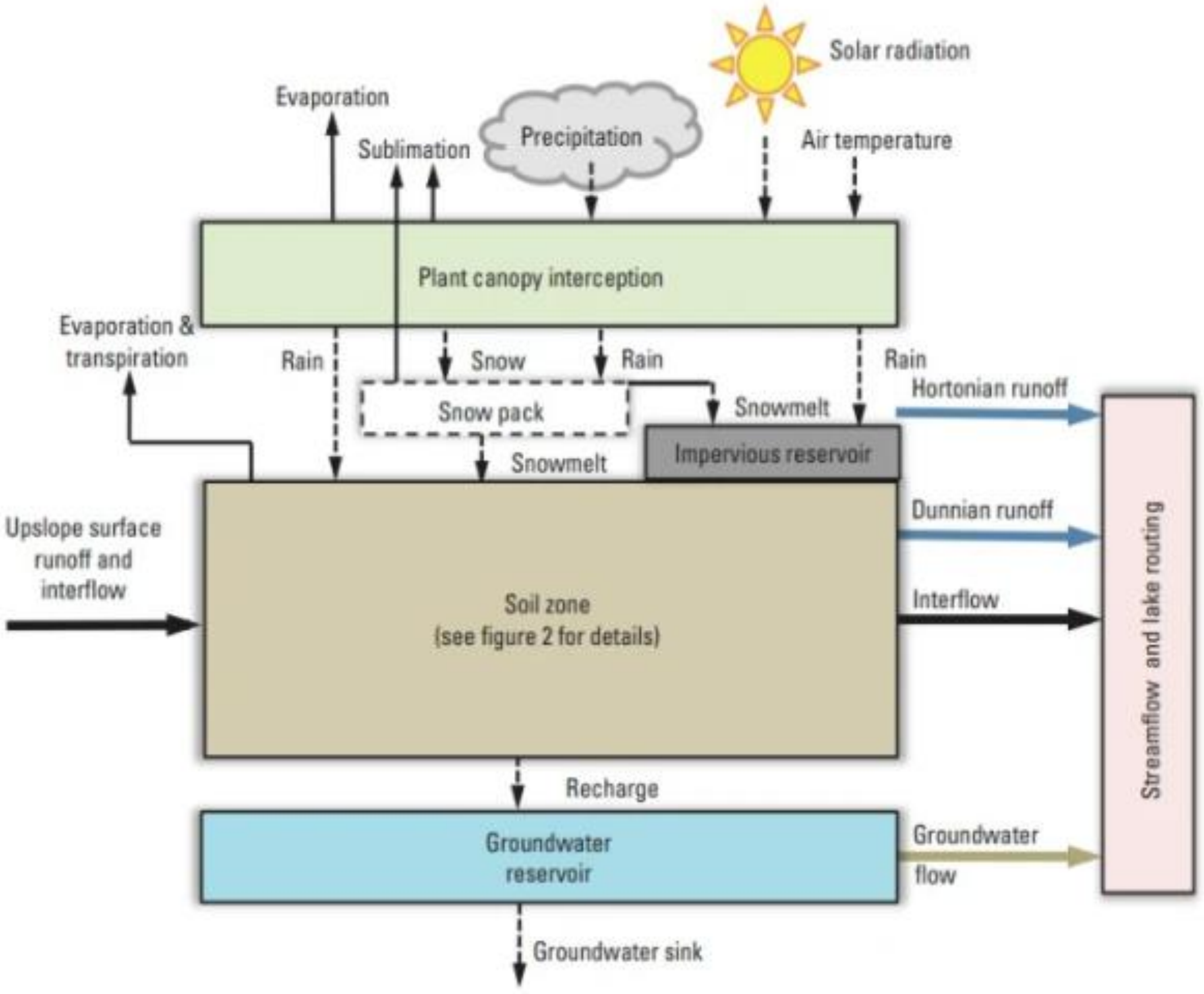
Scott River Models

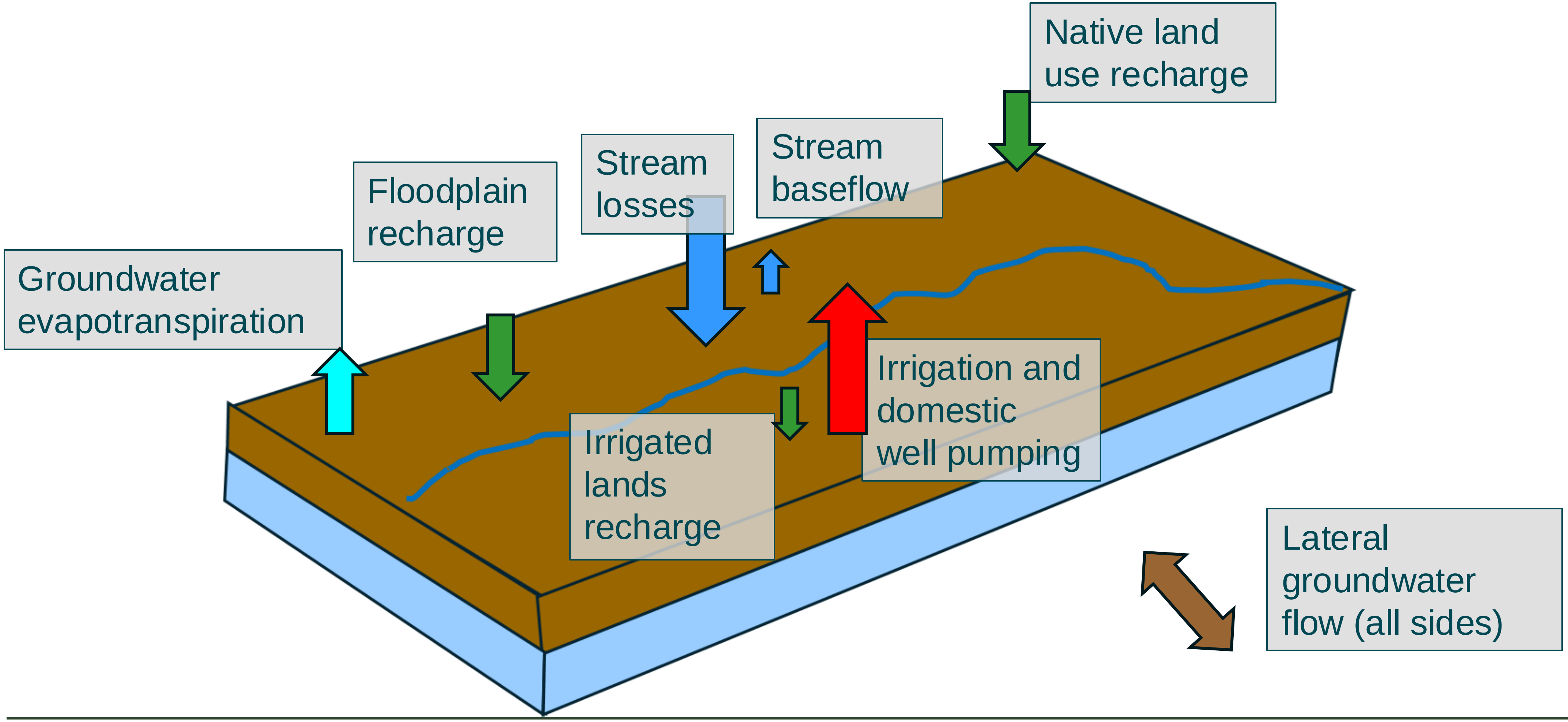
Precipitation Runoff Modeling System (PRMS)

- Simulate hydrologic processes including evaporat the energy and water budgets of the plant canop information (temperature, precipitation, and sola
- Simulate hydrologic water budgets at the watersh
- Can simulate hydrographs for use in a hydraulic m
- Can simulate groundwater interactions



https://www.usgs.gov/software/precipitation-runoff-modeling-system-prms

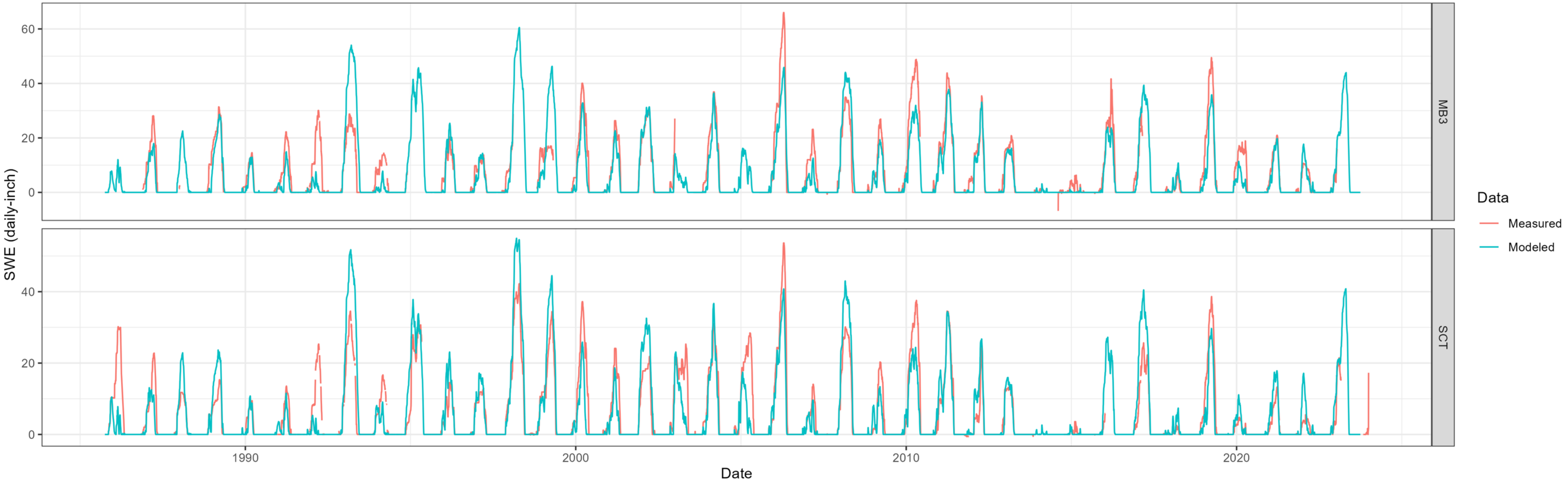
Groundwater Model Boundary Conditions



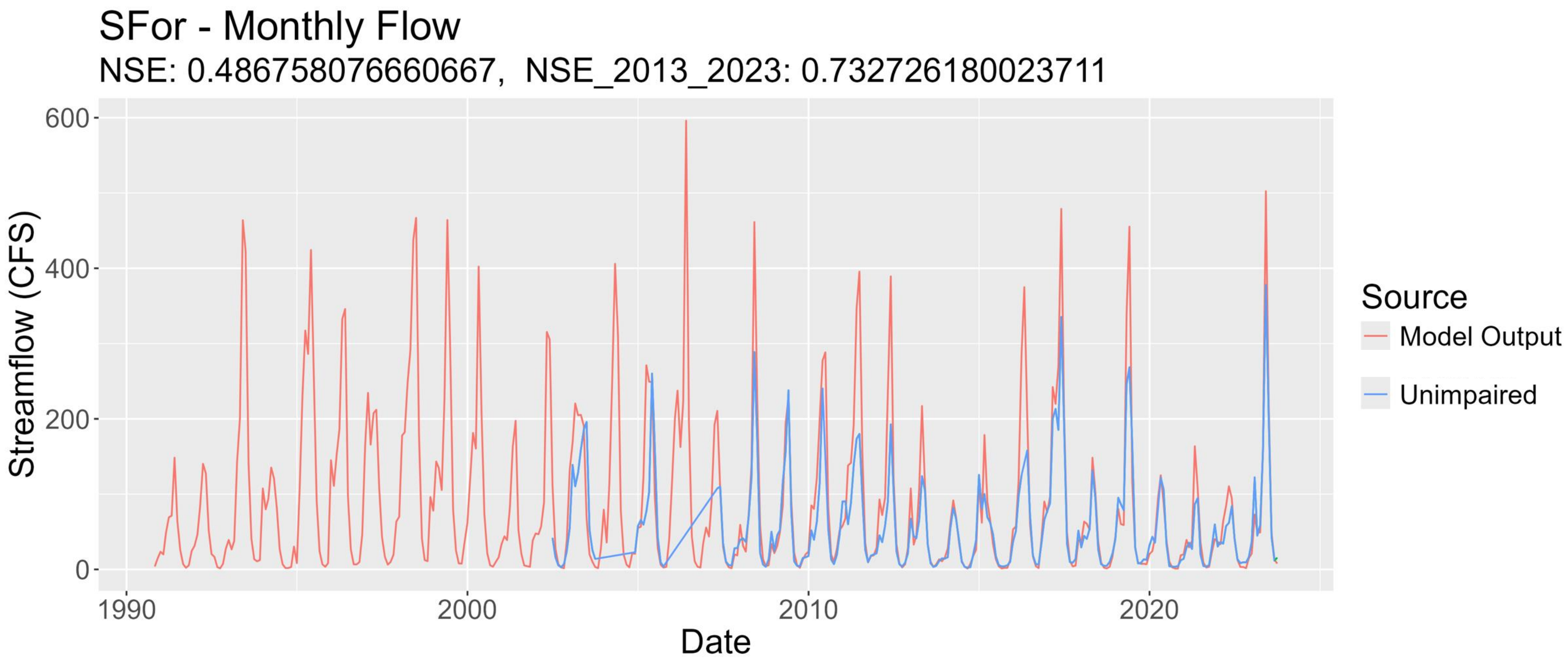
Scott Valley PRMS

Scott Valley Precipitation-Runoff Modeling System (PRMS)

- Determines whether precipitation falls as rain or snow, creating a snowpack



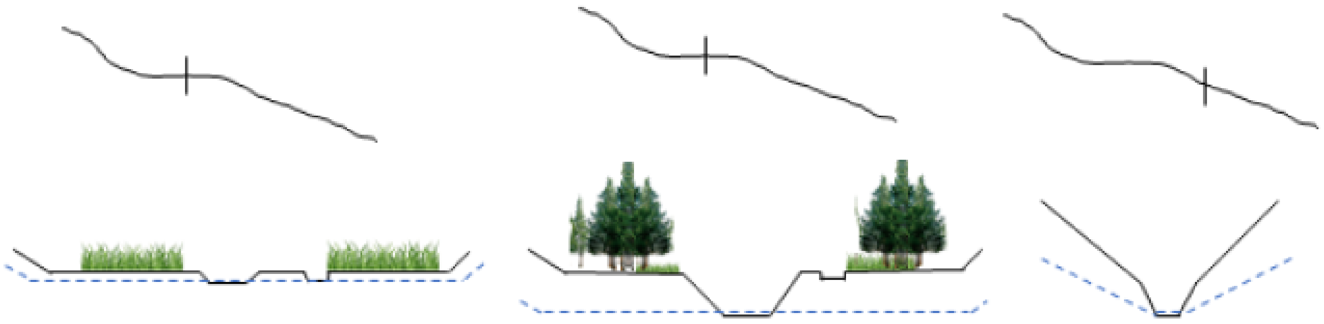
Scott Valley PRMS – South Fork of Scott River



Upland Management- Model Integration

Couple the Scott Valley Precipitation Runoff Modeling System (PRMS) and USDA Lost Meadow Model

- Identify promising meadow restoration projects from the USDA Lost Meadow Model, then use the PRMS model to simulate the potential impact to streamflow, ET, interflow, and baseflow.
- Simulate restoration of meadow vegetation, (i.e., removal of juniper) and changes to water accumulation from restored floodplains and shallow channels.

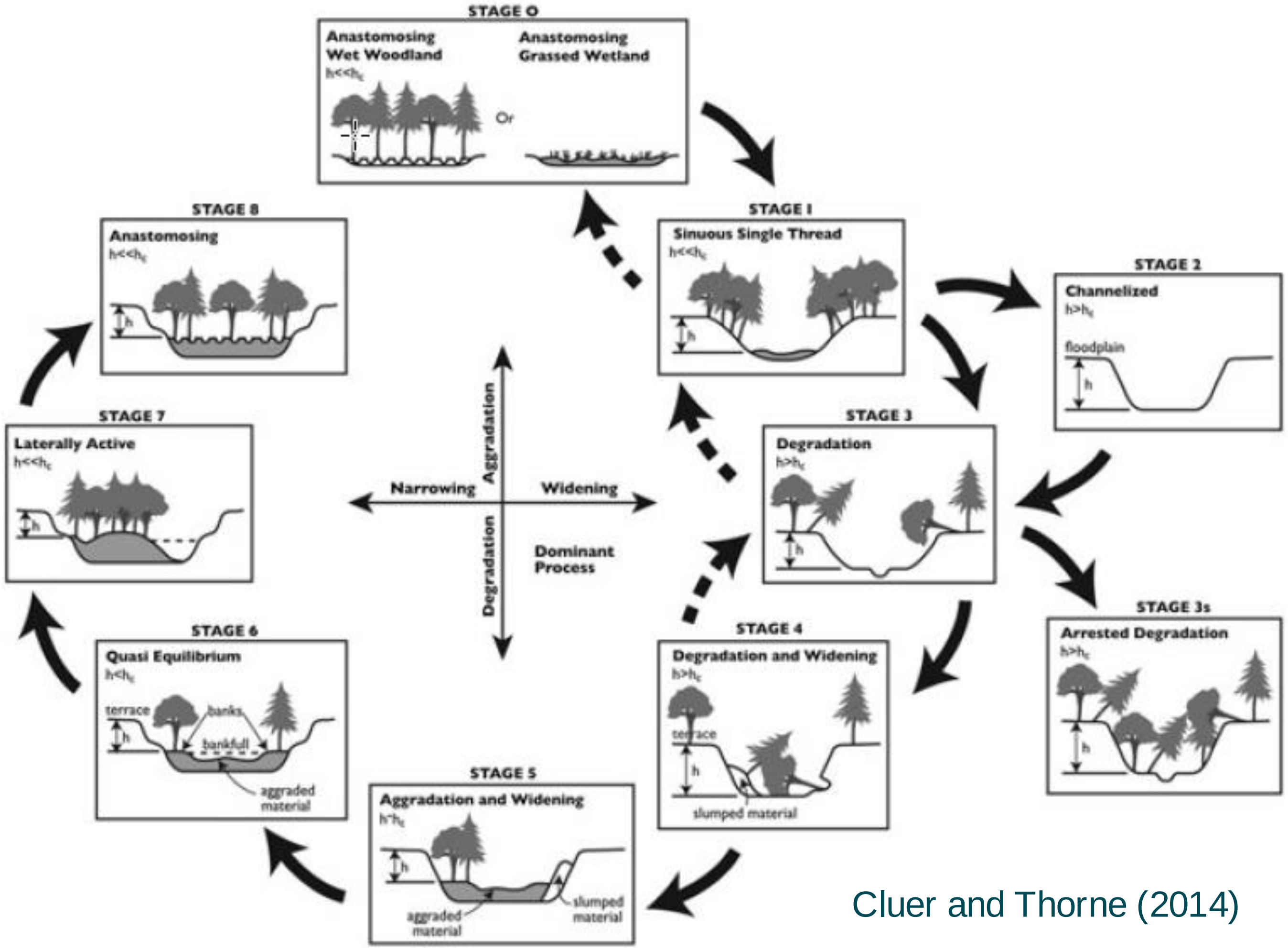


Existing meadow: Wide, flat floodplain where water accumulates. Expect shallow channels, high groundwater elevation, and predominantly graminoids and forbs.

Model-predicted potential meadow: Wide, flat floodplain where water accumulates. Expect deeper channels, lower groundwater elevation and predominantly shrubs and trees.

Not predicted as meadow: Steep channel without a flat floodplain.

Geomorphic Assessment



Cluer and Thorne (2014)

Preliminary Results

Difference Between Meadow Models and Base Model – South Fork (left) and Shackleford Creek (right)