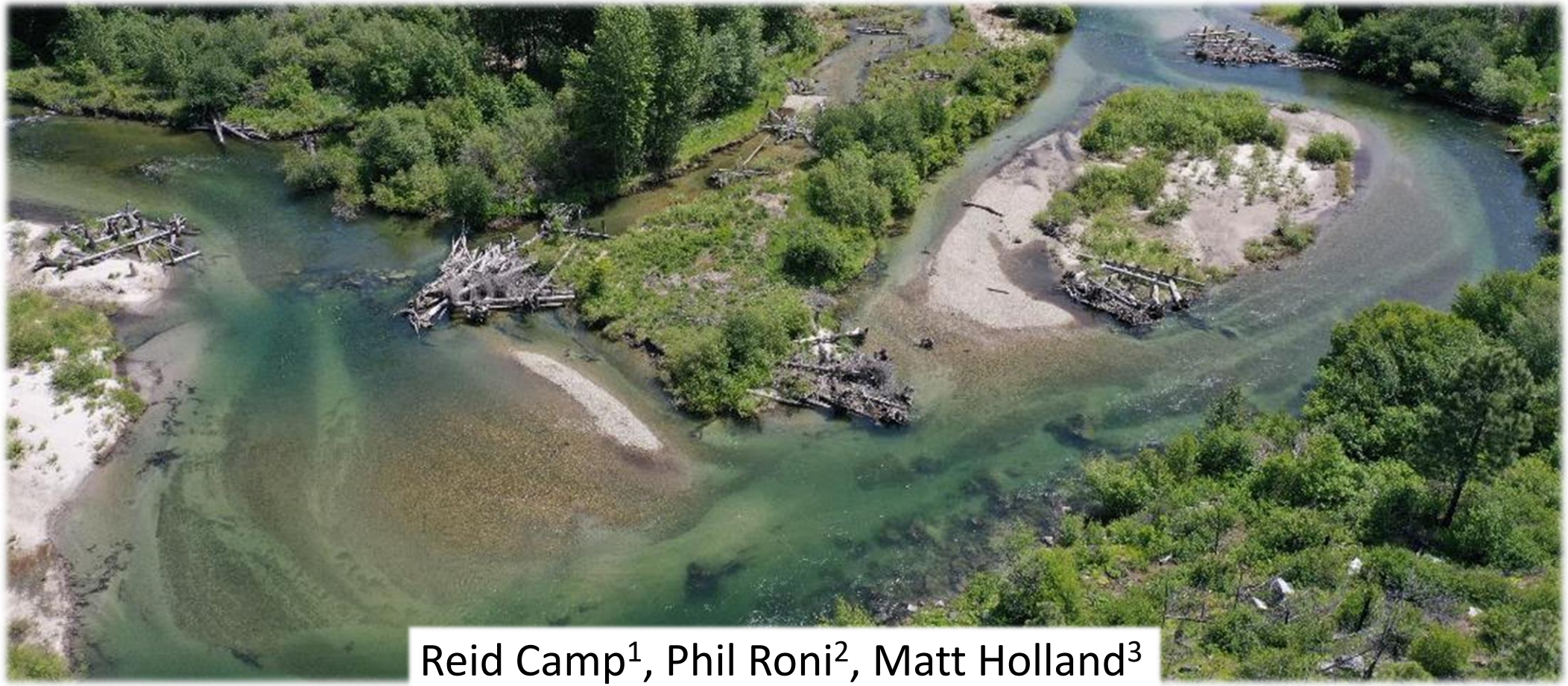
Restoration Effectiveness on the Entiat River



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Evaluating Large Floodplain Restoration Projects

2013 to 2023 – 128 Projects

CRAMER FISH SCIENCES

ACTION EFFECTIVENESS MONITORING

2022 Annual and Final Report

Project Number 2016-001-00
Report covers work performed under BPA contract #71969, 74809, 78579
Report was completed under BPA contract #78579
Report covers work performed from March 1, 2022 – September 30, 2023

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Report created: August 23, 2023

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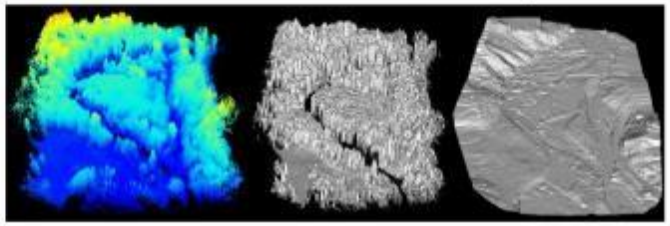
Applied Research in Fisheries, Restoration, Ecology, and Aquatic Genetics

2004 to 2018 – 58 Projects

Future Monitoring Guidance

CRAMER FISH SCIENCES

USING REMOTE SENSING AND OTHER TECHNIQUES TO ASSESS AND MONITOR LARGE FLOODPLAIN AND RIPARIAN RESTORATION PROJECTS



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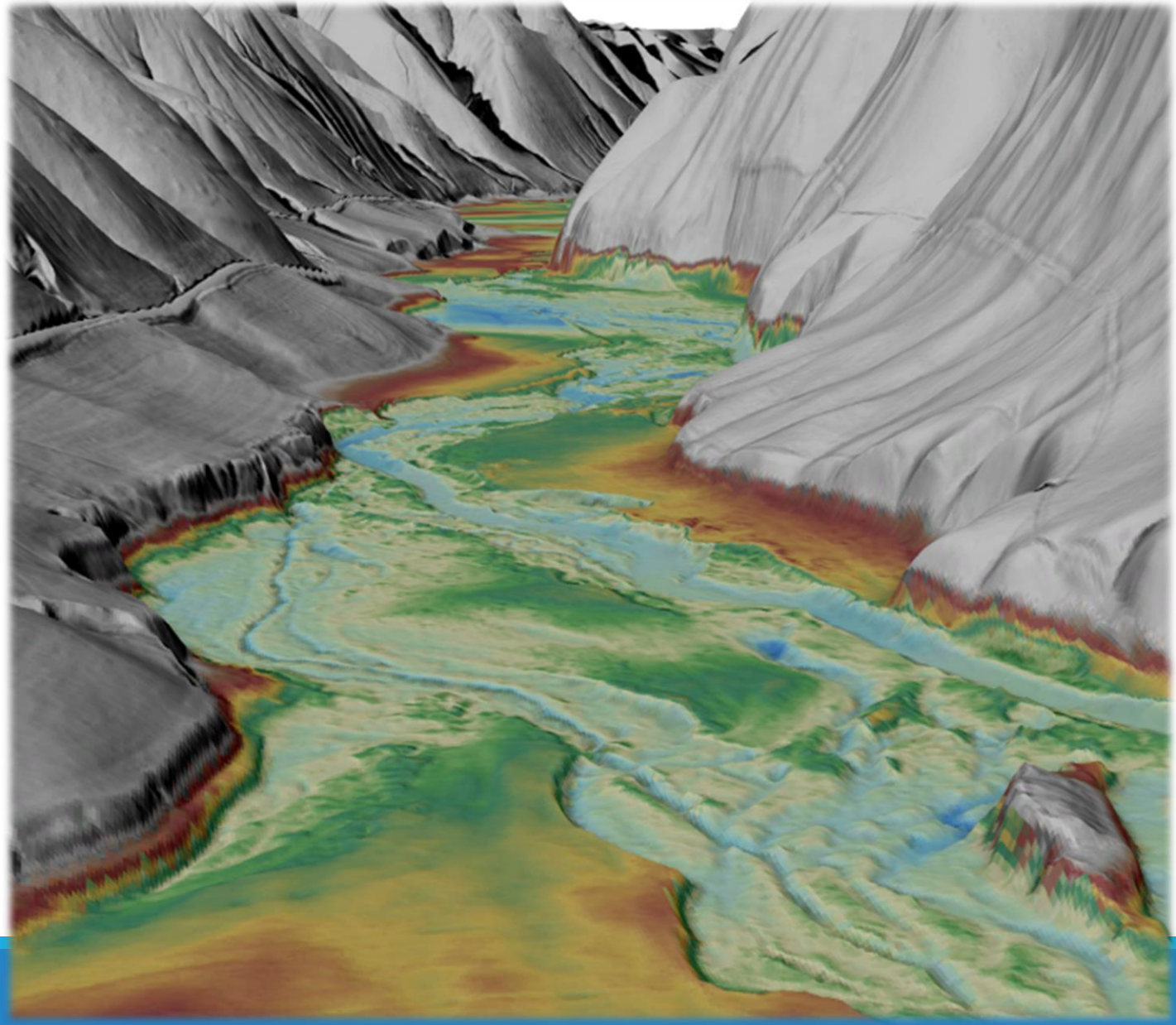
Applied Research in Fisheries, Restoration, Ecology, and Aquatic Genetics

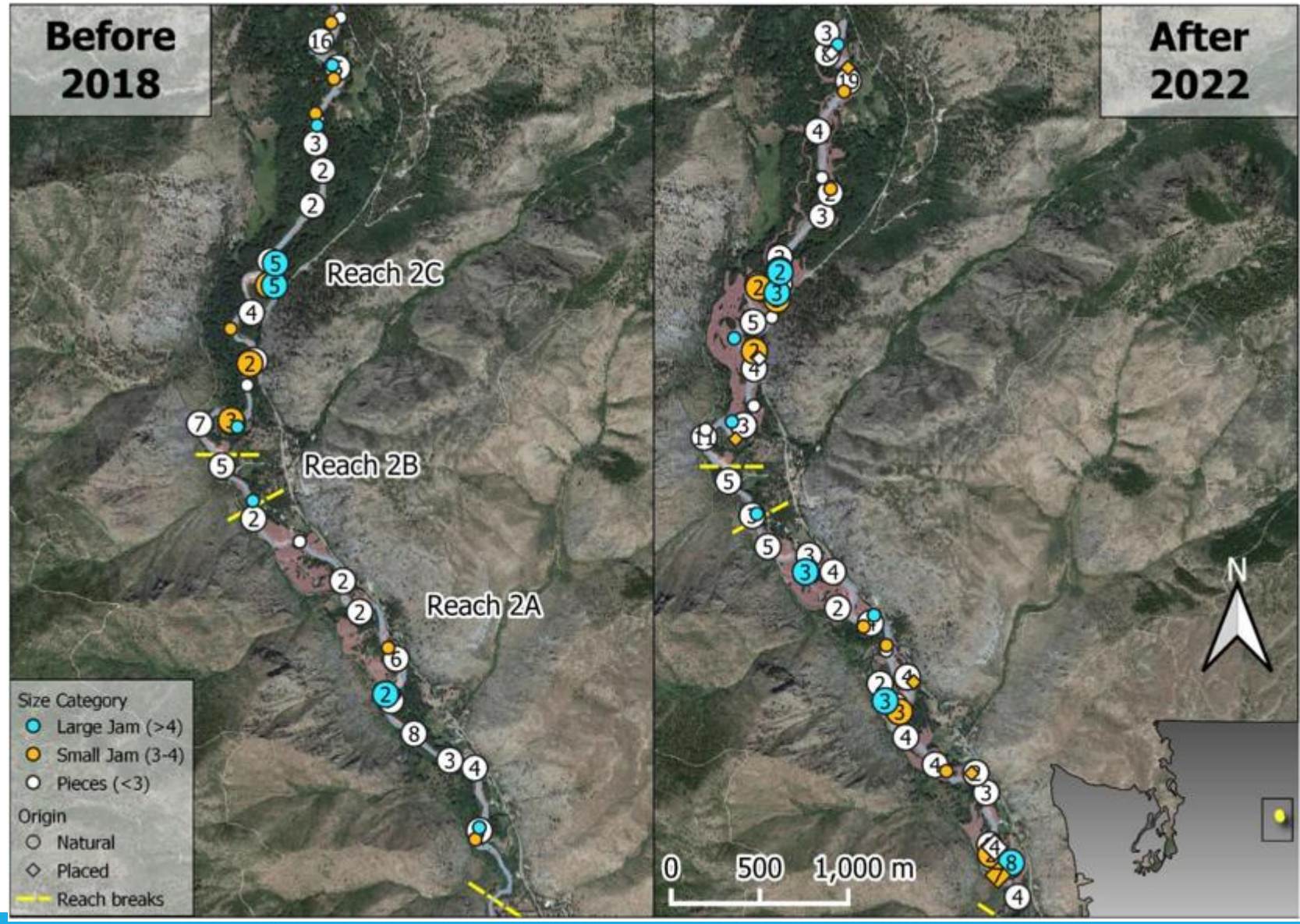
Effectiveness Evaluation – Tools/Methods

- Topobathymetric LiDAR before and after
  - Elevation, basis for other derivatives
- Hydraulic model (BOR)
  - Water depth and velocity
- Habitat Suitability Index modeling
  - Habitat quality by species and life stage
- Geomorphic Unit Toolkit (GUT)
  - Morphologic units derived from LiDAR
- Geomorphic Change Detection (GCD)
  - Before/after elevation change
- Aerial imagery
  - NAIP, satelite, fixed-wing, drones
- Field Data
  - RTK, jam details, habitat, snorkel, eDNA



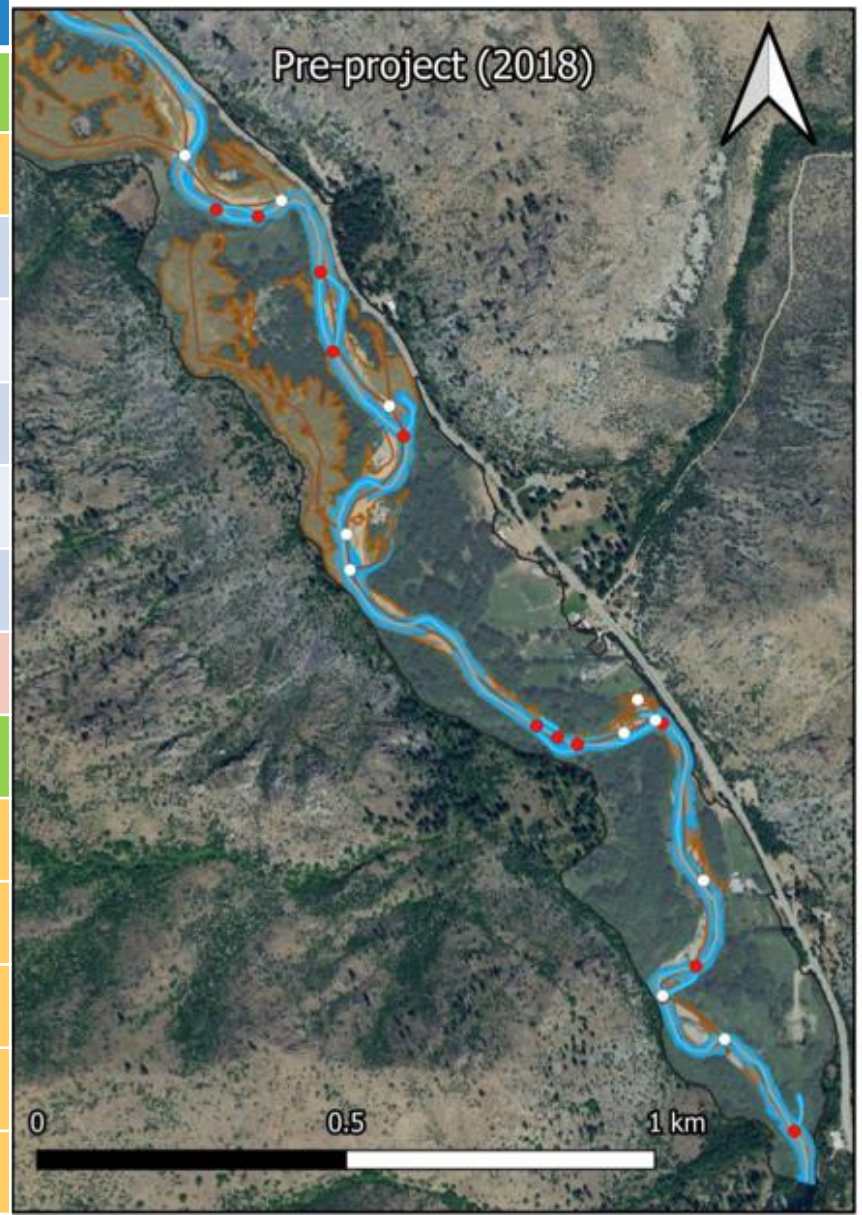
Effectiveness Evaluation – Study Design

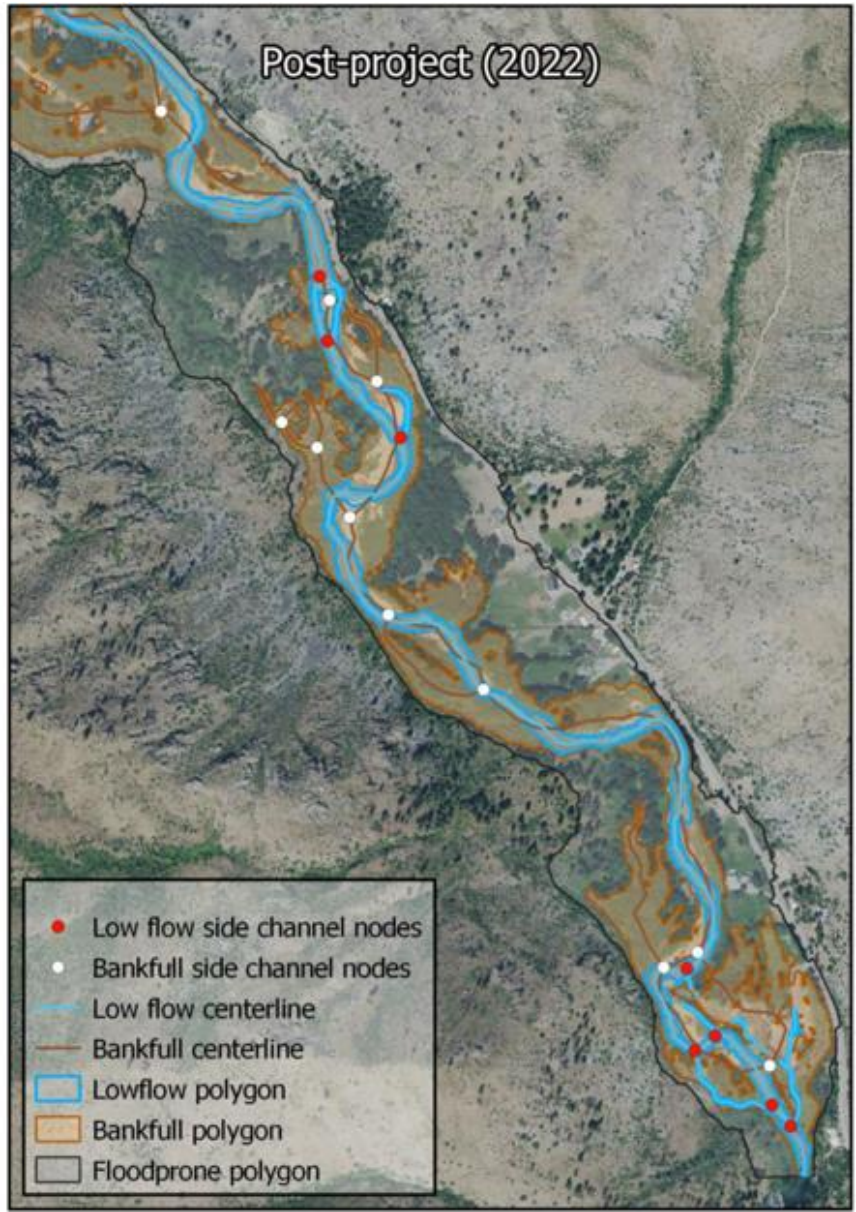
- Before/After monitoring
- Pre-Project:
  - All methods ~1 year before (2018)
- As-Built:
  - Topographic surveys (2019/2020)
- Post-Project:
  - All methods ~3 years after (2023)
  - *Also flow-based trigger for earlier monitoring that was not met



Effectiveness Evaluation – Whole Project Results

Metric/Measurement	Change
Bankfull area	+84%
Mean bankfull width	+31%
Mean wetted width	+20%
Wetted area	+10%
Floodplain area	+10%
Floodplain inundation index	+10%
Sinuosity	+21%
Side channel length (low flow)	+2%
Side channel length (high flow)	+79%
River complexity index	+47%
# habitat units	+32%
Pool area	+39%
# of pools	+35%
Mean pool depth	+33%





Design Element Evaluation – Example Objectives

- Objectives by element from Basis of Design Report

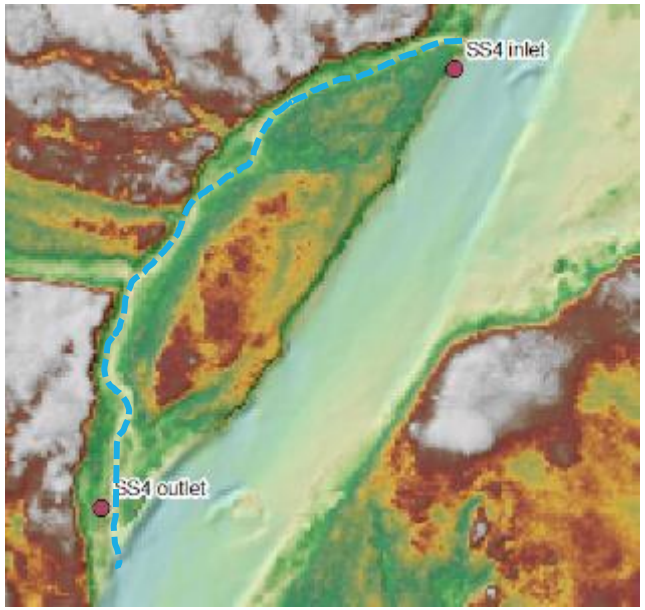
Apex Jams

1. Split Flow
2. Create and maintain pool
3. Create suitable rearing habitat

Bank-Attached Jams

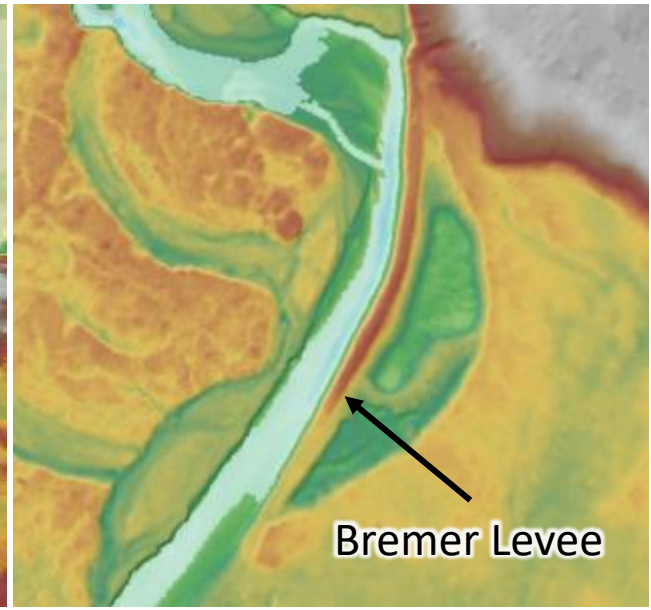
1. Stabilize banks
2. Create and maintain pool
3. Create suitable rearing habitat

Seasonal Side Channels



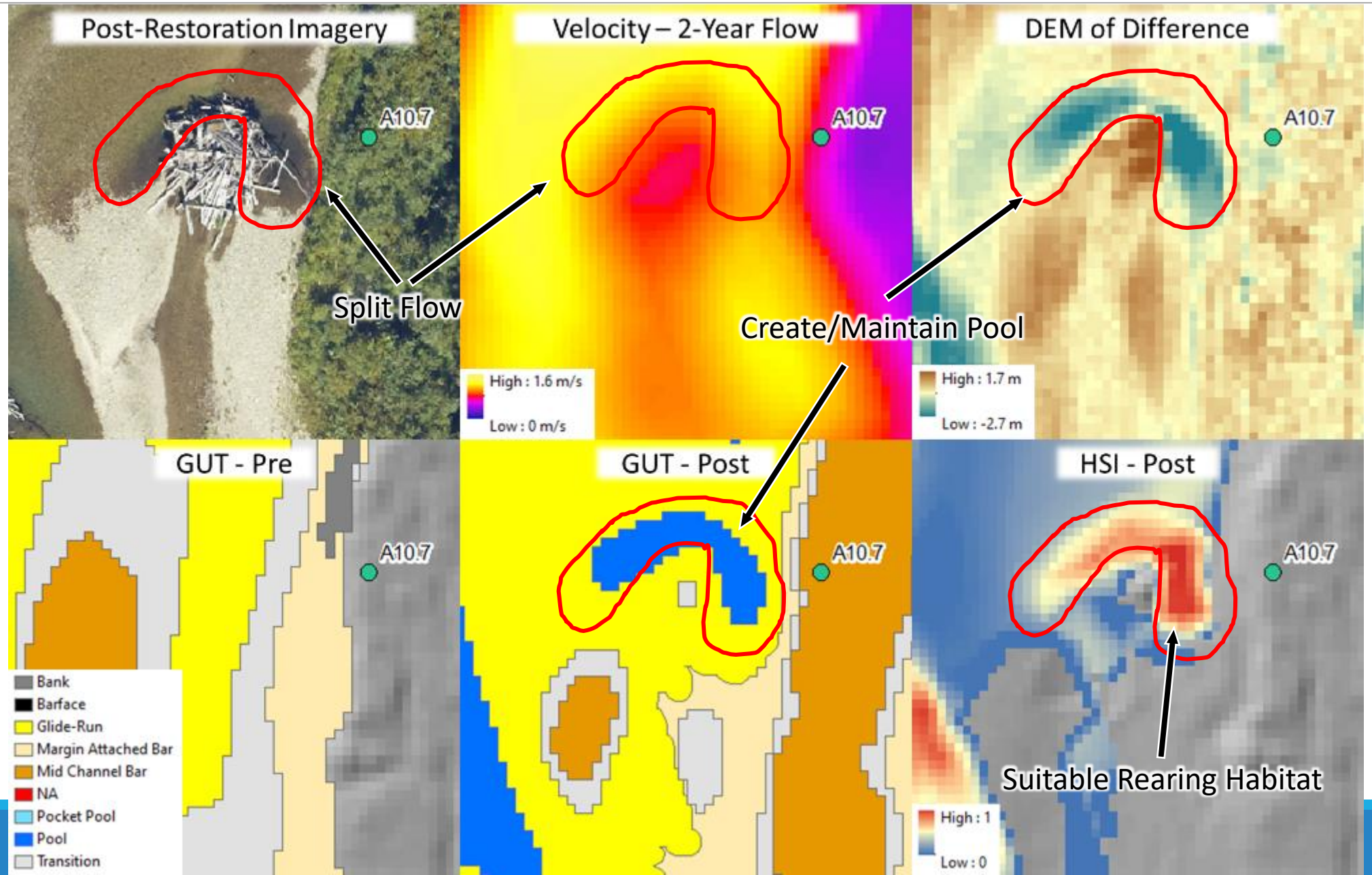
1. Seasonal flow within side channel
2. Outlet maintained as backwater at baseflow

Levee Removal

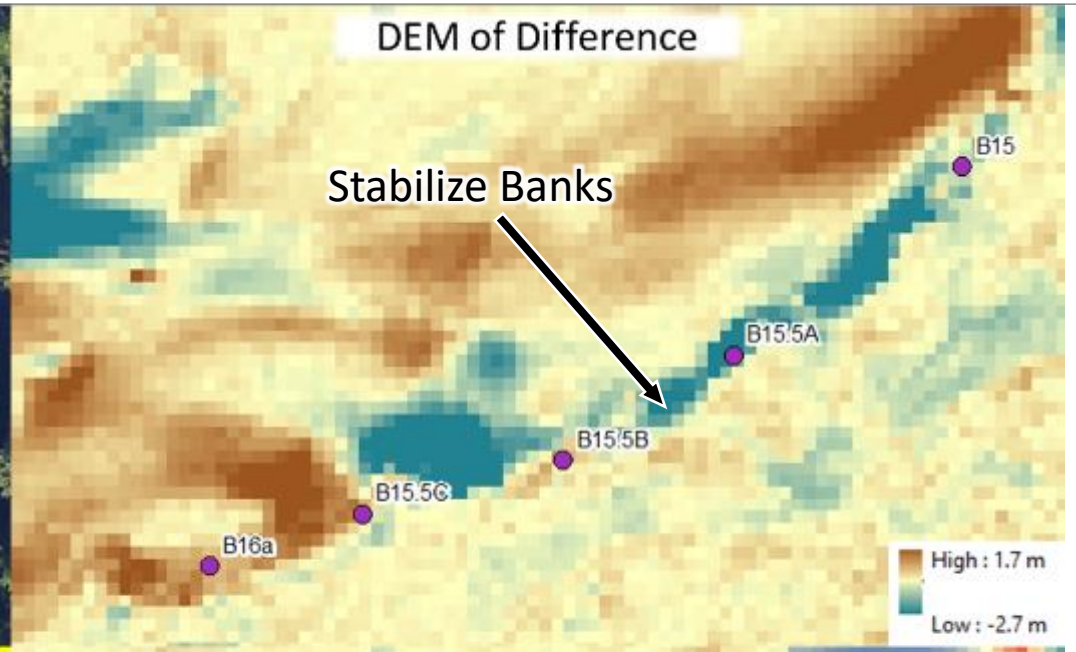


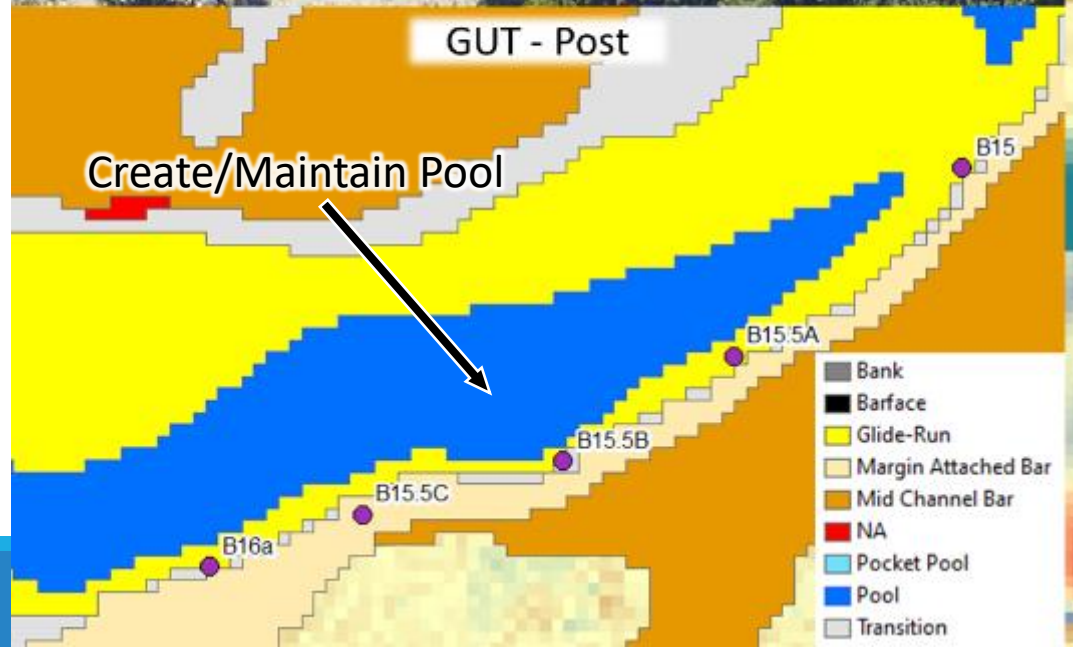
1. Increased lateral migration
2. Improved floodplain connection

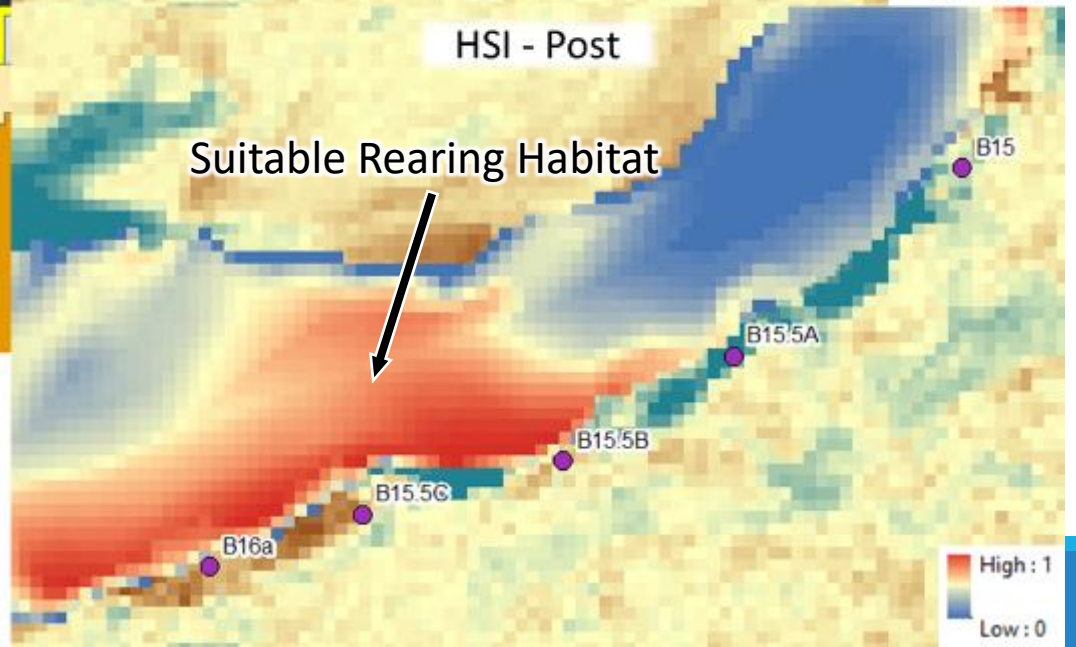
Design Element Evaluation – Apex Jams



Design Element Evaluation – Bank Attached Jams







Takeaways – Physical Responses

- Wood Jams
  - Response = flow + sediment flux + jam size
  - Interaction between jams is key
  - Helicopter jams performed very well
  - Pinned logs limit temporal response
  - Low porosity = stronger response

Takeaways – Physical Responses

- Side Channels
  - Extremely difficult to build stable side channels
  - Mimic natural side channels (no 90° entries!)
  - Bed aggradation most effective for connection
  - Wood alone likely will not maintain connection
  - Design for low flows

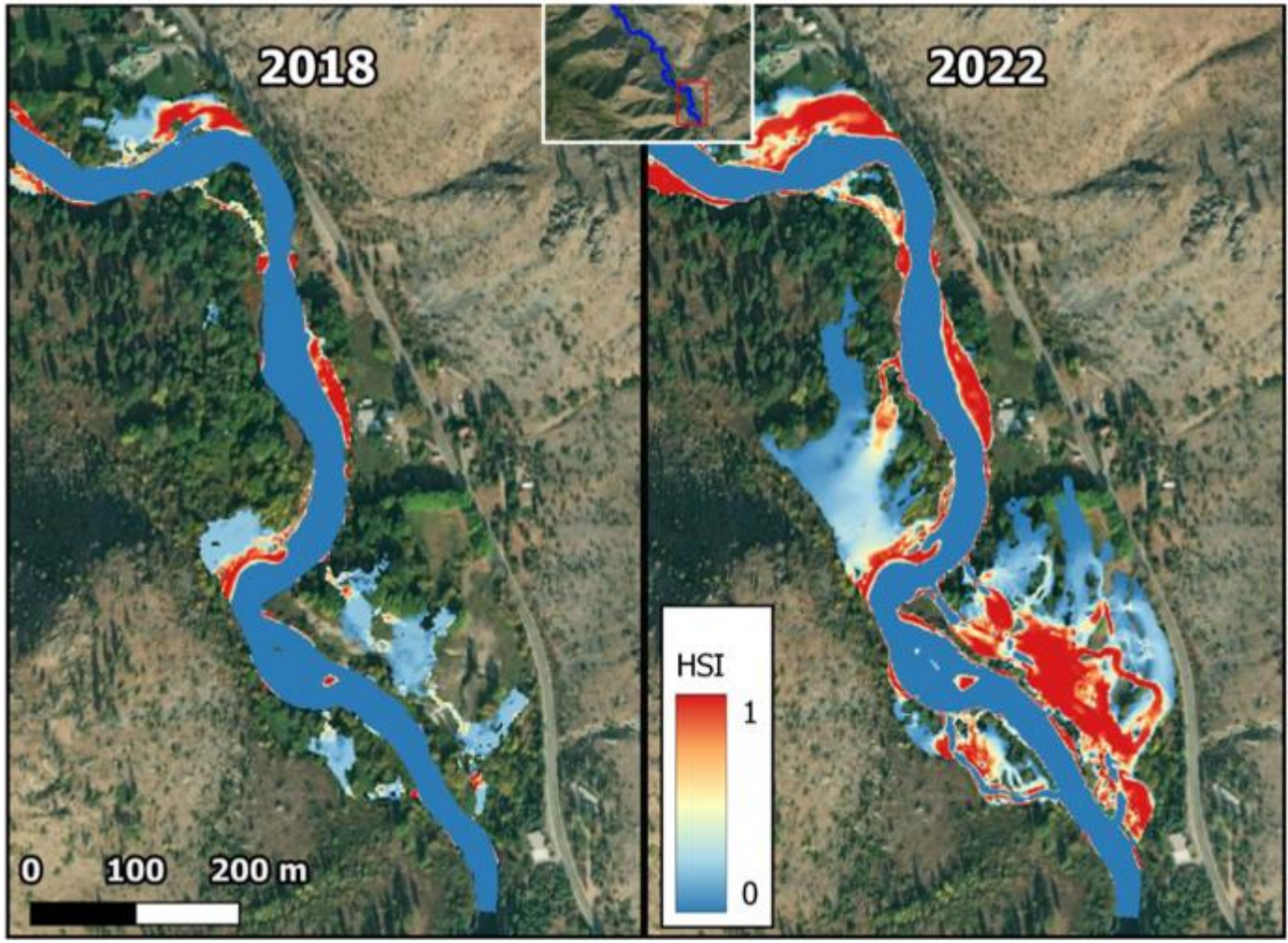
Takeaways – Physical Responses

- Levee Removal
  - Design lower elevation than models suggest
  - Use more wood to spread flows into area AND aggrade the channel bed
  - Model flow duration for floodplain areas to maximize fish benefit

Takeaways – Fish Habitat

- Fish habitat suitability has improved

Species - life stage	cfs	Before (ha)	After (ha)	change
Chinook - juvenile	130	5.86	7.2	23%
Steelhead - juvenile	130	8.86	10.36	17%
Chinook - juvenile	2,680	11.02	20.43	85%
Steelhead - juvenile	2,680	14.19	23.84	68%
Chinook - spawning	130	4.75	5.38	13%
Steelhead- spawning	600	9.59	11.73	22%



Takeaways – Fish Observations

- Fish abundance appear to have increased

Species	Number	
	Before	After
Chinook	573	2782
Coho	0	1856
Steelhead	80	544
Sockeye	23	198
Bull trout	13	4
Cutthroat	8	37
Whitefish	866	1049
Dace	880	233

Thank you!

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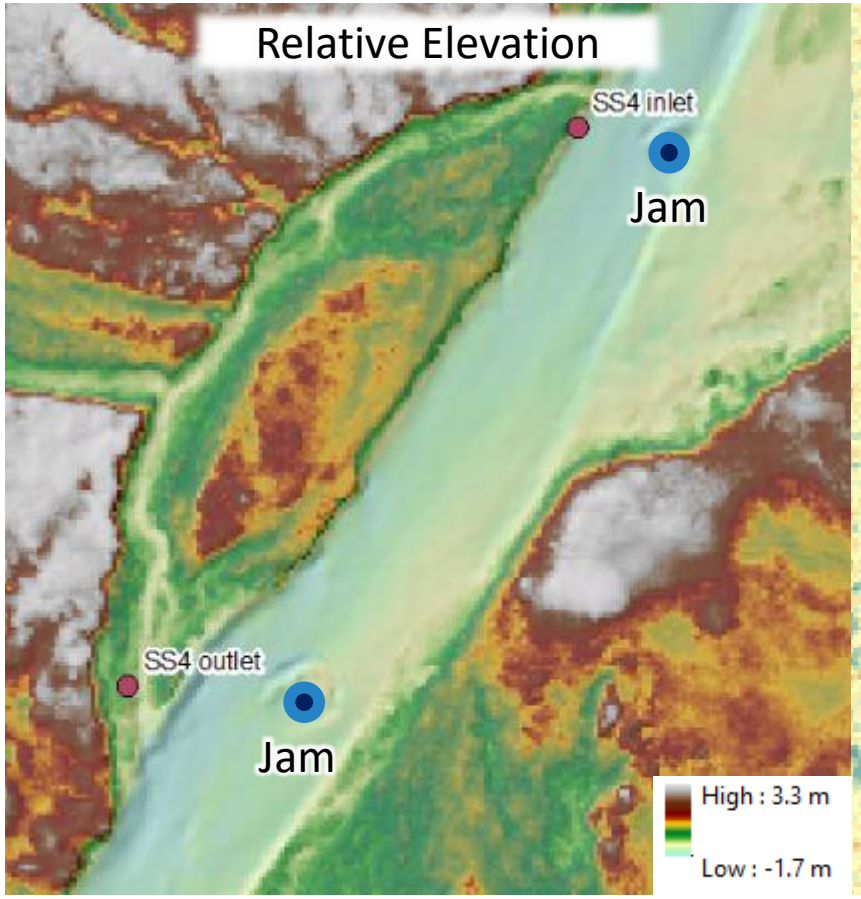
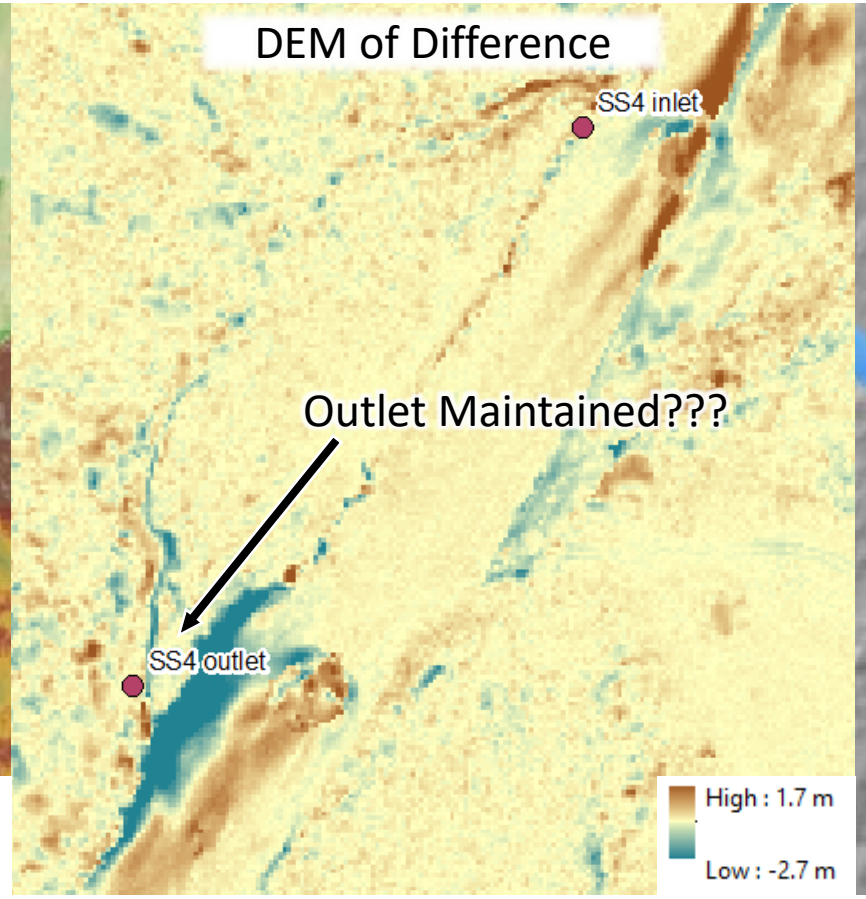
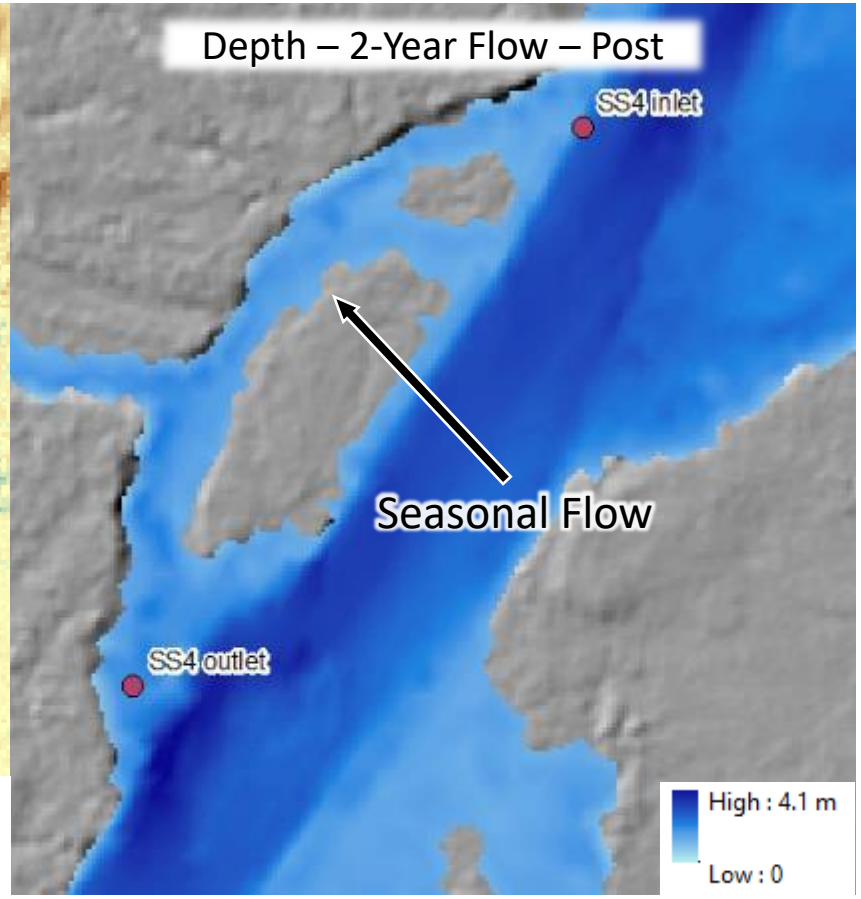
Design Element Evaluation – Side Channels







Design Element Evaluation – Levee Removal