Grouse Reach, Vermilion River.
Photo by Dan Armstrong

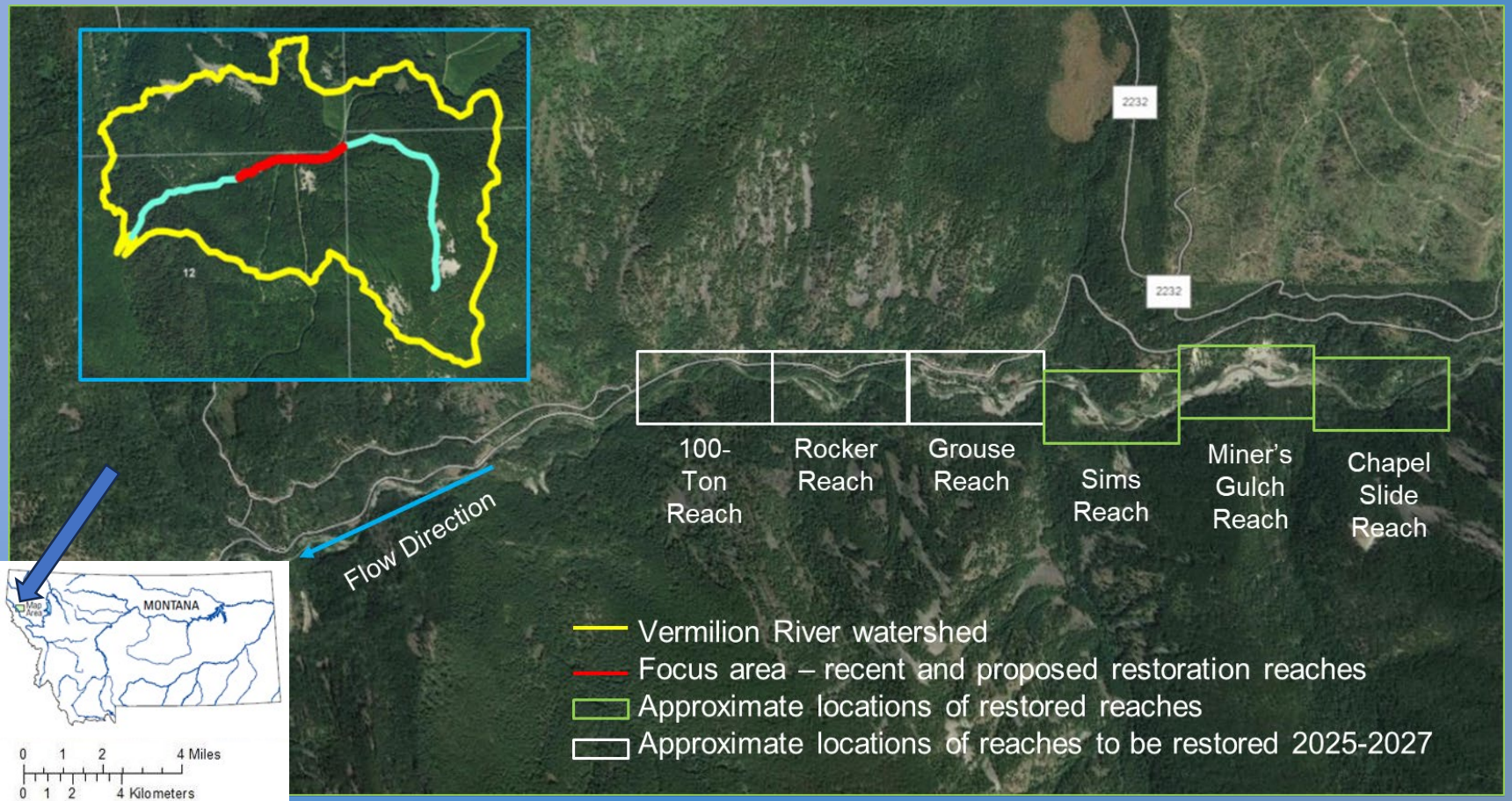
Vermilion River Restoration

Presented by Sara Eldridge and Dan Armstrong of the U.S. Geological Survey

2024 Montana Chapter of the American Water Resources Association

Site Locations and History

1874: Historic placer, hydraulic, and dredge mining destabilized the stream channel.
1950-1970: Commercial clear-cutting and road building elevated peak flows.



Example of conditions prior to restoration: absence of pool features, in-channel woody debris, and the adjacent riparian area void of mature trees and vegetation. *Photo source: public domain*

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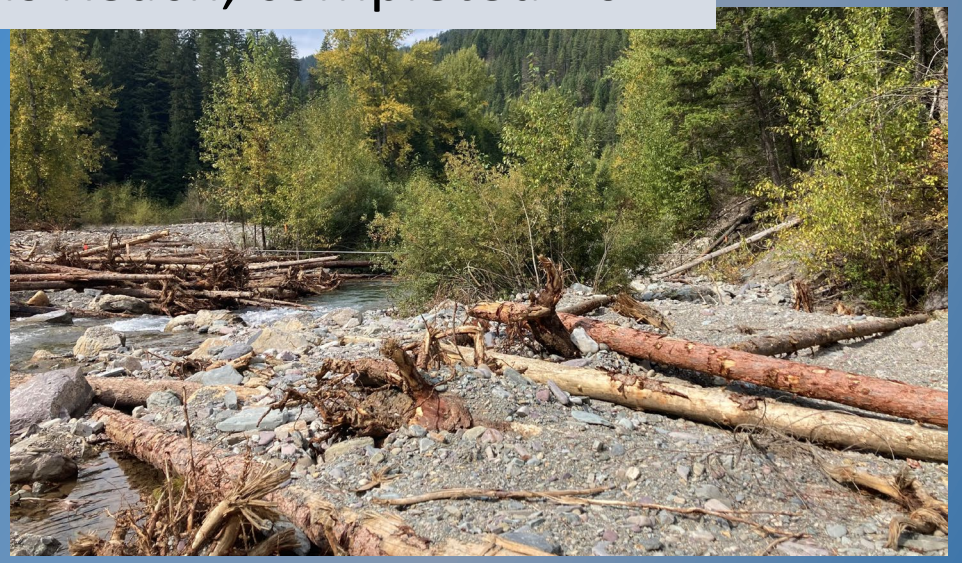
U.S. Forest Service Restoration since 2012

Goals

- Restore degraded stream channel and floodplain
- Regenerate native riparian vegetation
- Increase habitat complexity with large woody debris
- Improve the stability of the stream channel

Pre-restoration

Sims Reach, completed 2021



Post-restoration

Photos by US Forest Service, public domain.

Study Phases

Phase 1

Hydrologic Connectivity

Develop and integrate a monitoring plan for hydrologic connectivity.

Phase 2

Biogeochemical Cycling

Develop and integrate a monitoring plan for biogeochemical cycling recovery to support cold-water fisheries.

Phase 3

Preliminary Analysis of Foundational Data

Begin preliminary data analysis, combining results from Phase 1 and Phase 2. Identify gaps/opportunities for further understanding.

Phase 4

Integration and Assessment

Place results in context with previous watershed restoration plans, fisheries recovery plans, and conservation strategies.

Phase 5

Dissemination

Develop story and key findings, takeaways, and recommendations for further restoration plans.

Hydrologic Setting - Phase 1

Establish groundwater monitoring network

Well sampling

Identify additional groundwater inputs, such as springs

Determine groundwater and surface water interactions and hyporheic zones along the restoration reaches.

Photos by Rod Caldwell and Dan Armstrong, USGS

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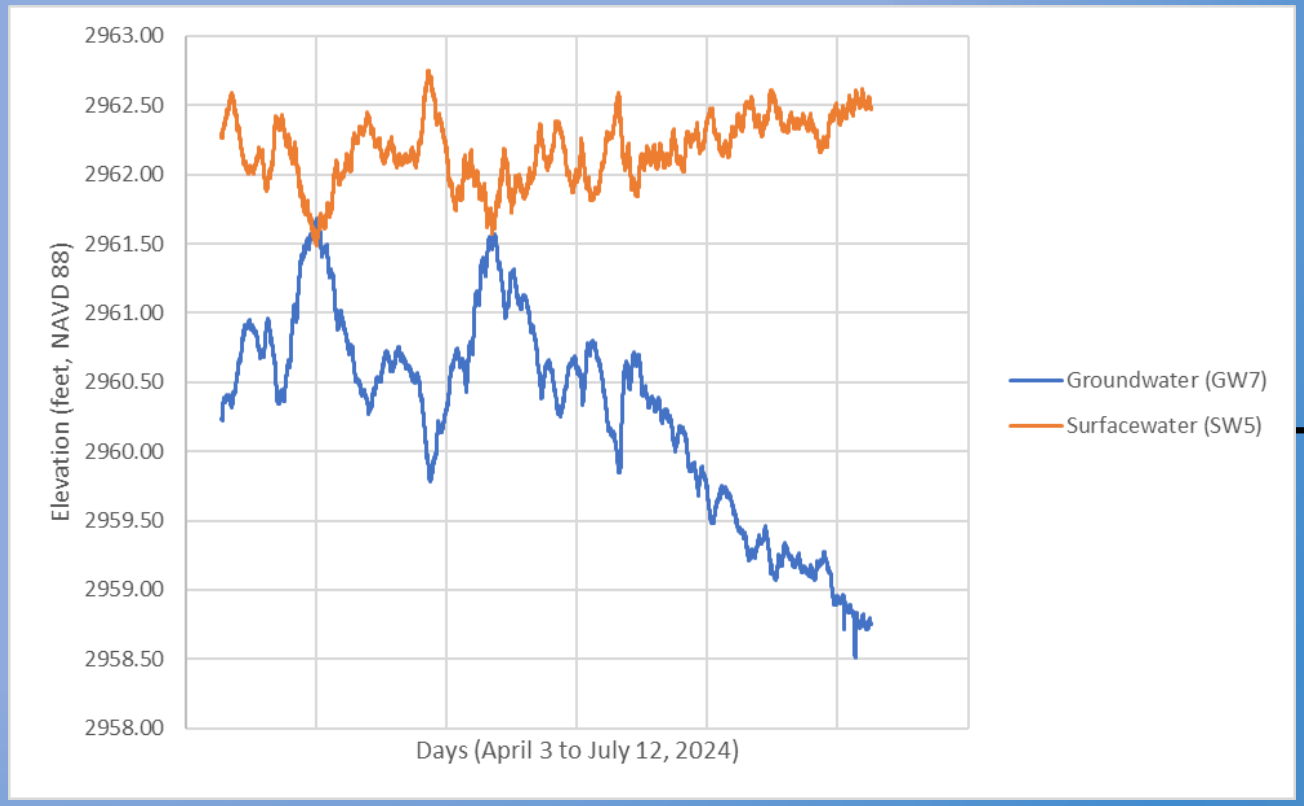
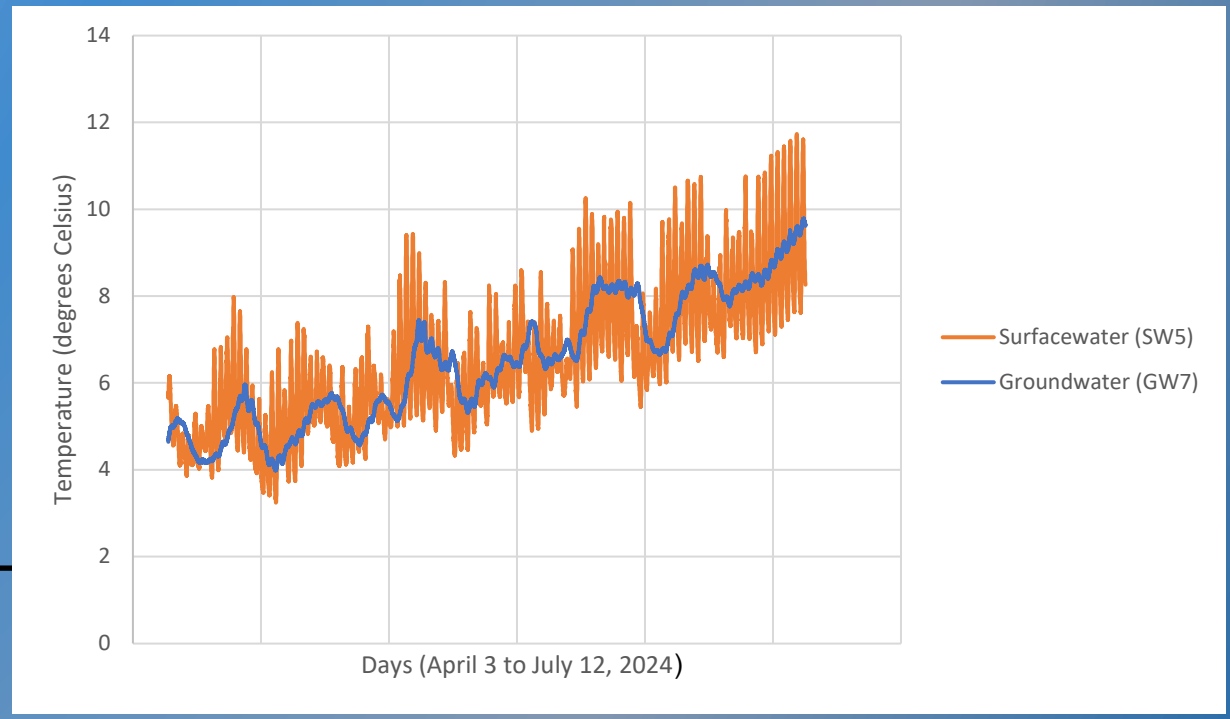
Hydrologic Setting - Phase 1

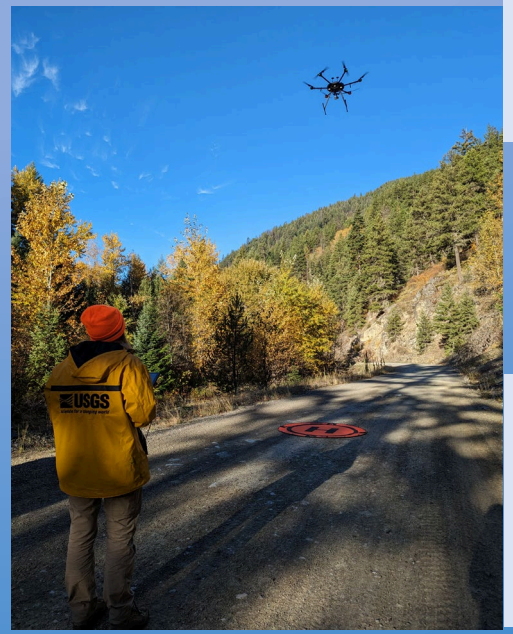


Groundwater and surface water gaining and losing reaches and interchange



Temperature flux between groundwater, surface water, and downstream between river reaches.

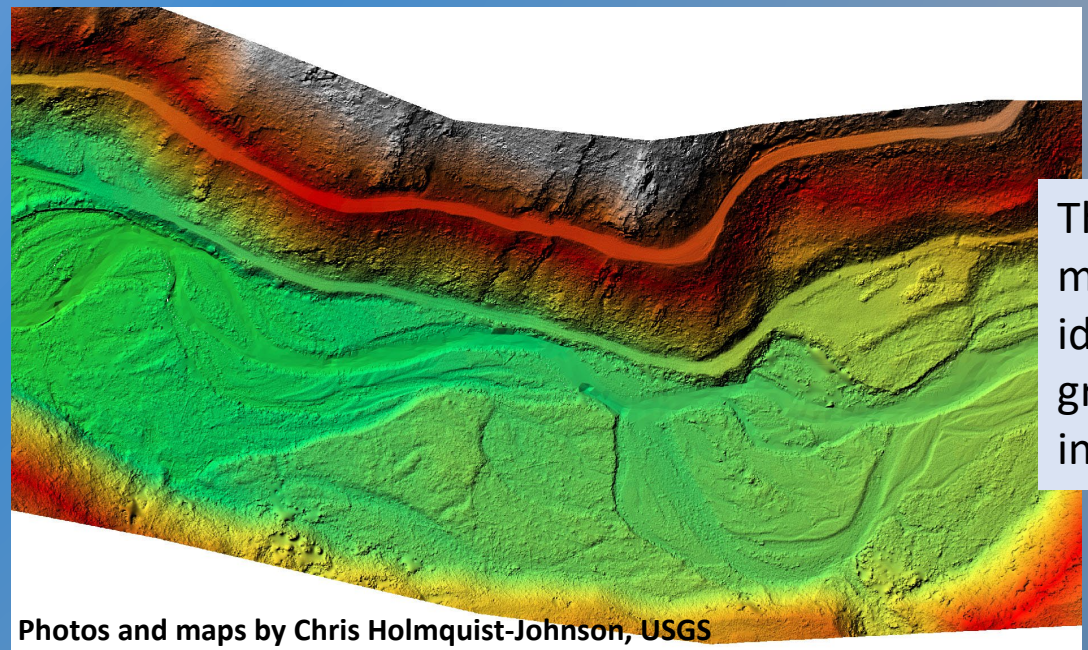
Top: The U.S. Forest Service restoration engineers and USGS drone surveyors.



Site Surveying

Bottom: LiDAR drone flights mapped the area and thermal cameras mapped temperatures.

Color-corrected LiDAR point cloud



Thermal mapping helps identify groundwater inflows.

Photos and maps by Chris Holmquist-Johnson, USGS

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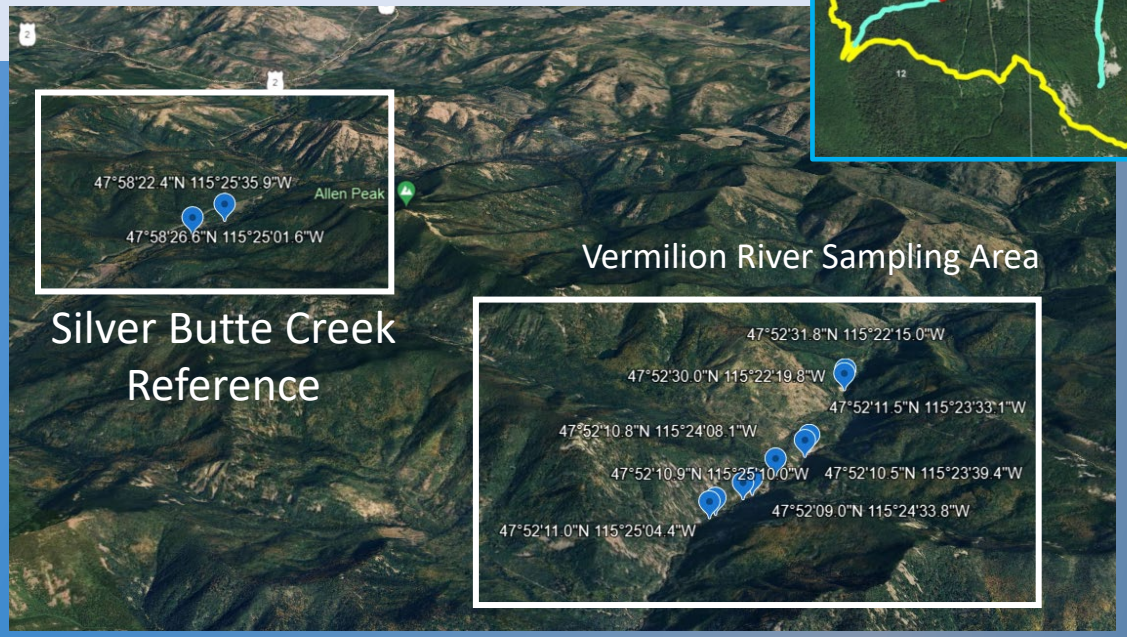
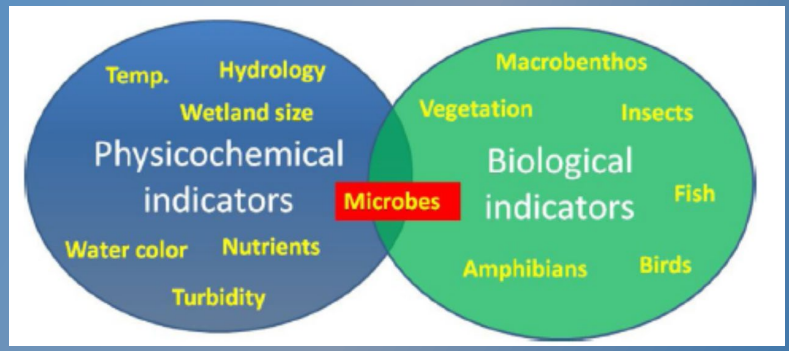
Phase 2: Assessments of water quality, microbiological indicators, and groundwater/surface-water interactions

Objectives

- Examine water levels and temperatures at the groundwater/surface-water interface.
- Compare water quality of near-stream groundwater to nearby surface water.
- Describe the microbial community as indicators in hyporheic and within-channel areas.
- Evaluate stream carbon production and mineralization.



Photos by USGS



Urakawa et al.(2017) *Ecol Engr* **108**, 456-476

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Phase 2 sampling, July 2024

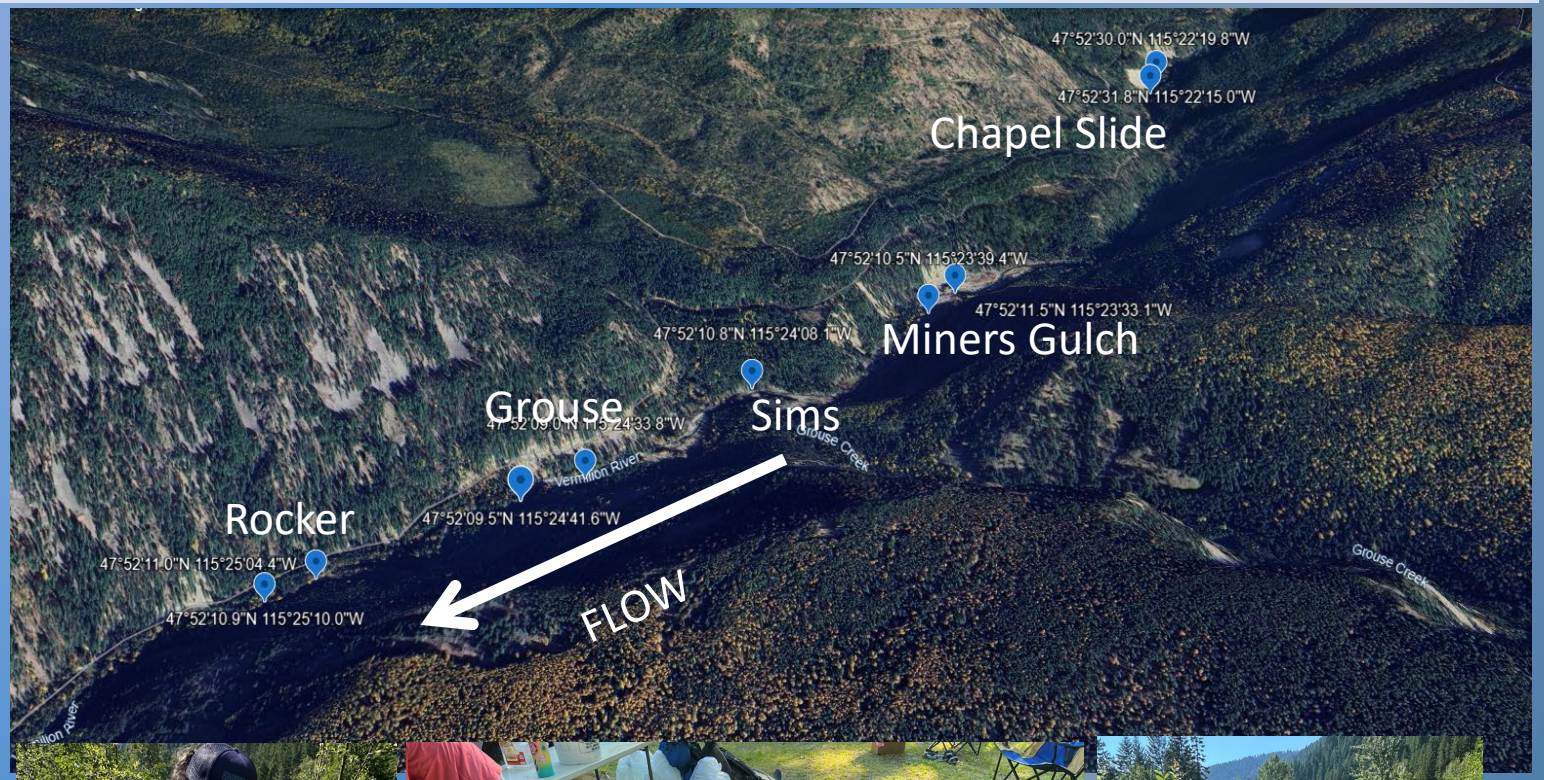
11 sites, 5 reaches, 2 reference reaches

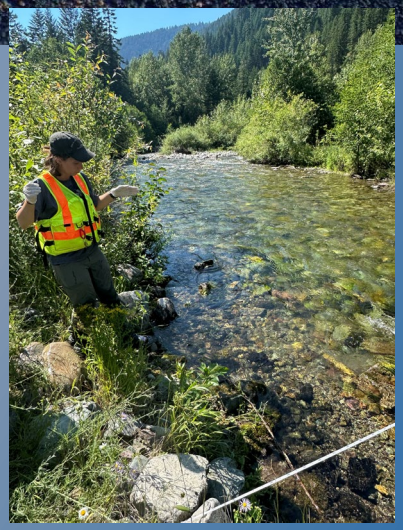
Samples

- Total and dissolved nutrients: SW/GW
- Major cations: SW/GW
- Major anions: SW/GW
- Chlorophyll *a*: SW
- Microbial community (DNA): SW
- Soil nutrients, moisture

Data

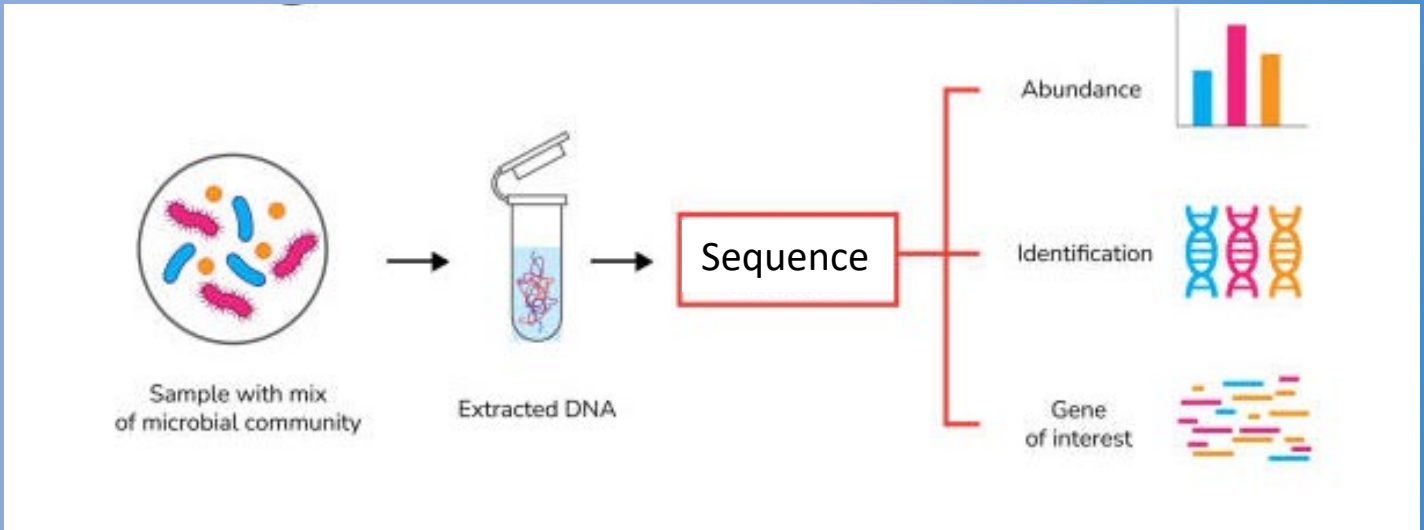
- Instantaneous discharge
- Instantaneous water temperature, pH, dissolved oxygen, specific conductance
- GW levels
- PAR (light), barometric pressure, air temperature





Photos by USGS

Analysis: Microbial Communities



- Describe communities based on 16S taxonomic sequencing
- Compare diversity, richness between reaches and conditions
- Relate to water quality and other environmental parameters

Goals:

- Use community differences to analyze restoration progress
- Identify gradients indicative of physicochemical changes
- Compare communities and growth to nutrients levels, water chemistry
- Implications for ecosystem health and conditions for fish

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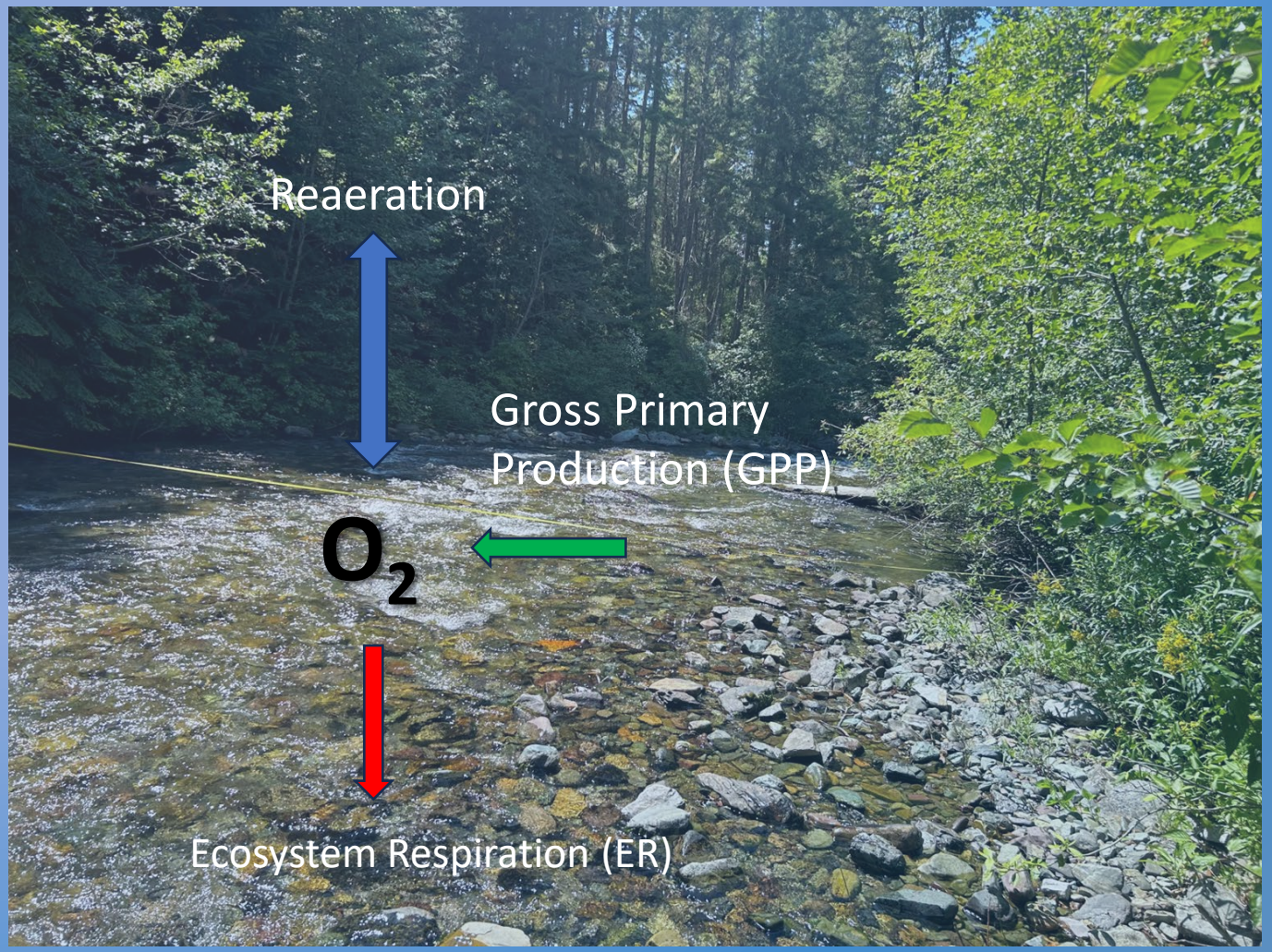
Analysis: Stream ecosystem metabolism



Grouse Reach, July 2024. Photo by USGS

Determine the river's trophic and energetic base

- High-frequency dissolved oxygen measurements
- Collect covariate data: PAR (light), barometric pressure, discharge

Goals

- Estimate daily GPP and ER
- Compare GPP and ER seasonally and between reaches
- Estimate relative capacity to transport vs. produce, mineralize, and retain carbon
- Determine how biogeochemical processes influence carbon availability to the food web

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Cooperators and Questions

Cooperators

Lower Clark Fork Watershed Group

U.S. Forest Service

Sanders County, MT

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