

# Detecting and Monitoring Cold- and Warm-Water Inputs to the Lower Big Hole River near Glen, MT

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Montana Bureau of Mines and Geology – Ground Water Investigation Program (GWIP)



# Background

GWIP Project  
Proposed by:



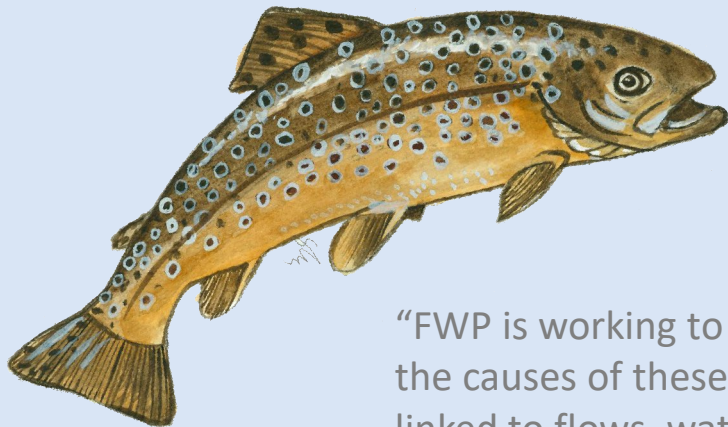
**BIG HOLE**  
WATERSHED COMMITTEE  
*Conservation Through Consensus.*

25  
YEARS

**Purpose:** Determine the hydrogeologic influences that most affect water supply and temperature on the lower Big Hole River near Glen. Stakeholders can use this information to better understand which land management practices most benefit the water resources in this area.

## Recreation/Fish Health:

- >120,000 anglers in 2020 (Montana FWP, 2022).
- Hoot Owl and River Closures

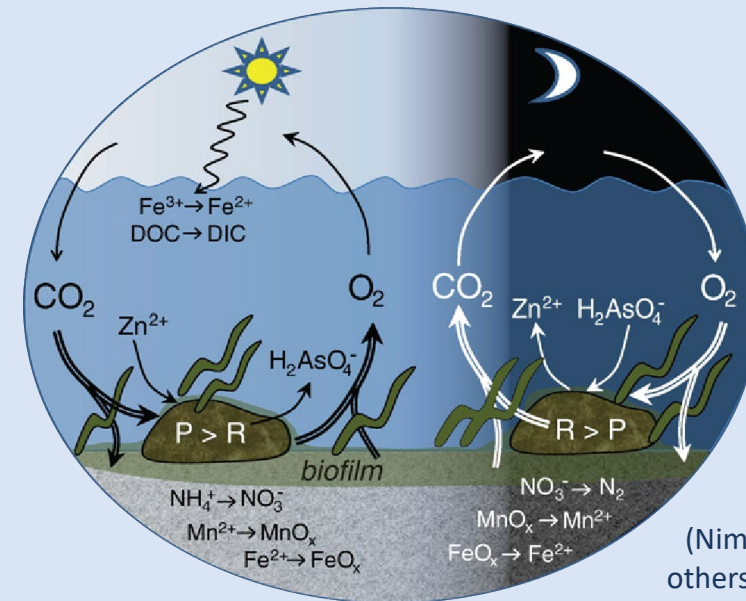


“FWP is working to better understand the causes of these declines, which are linked to flows, water temperatures and other factors.”

- Montana FWP (July, 2023)

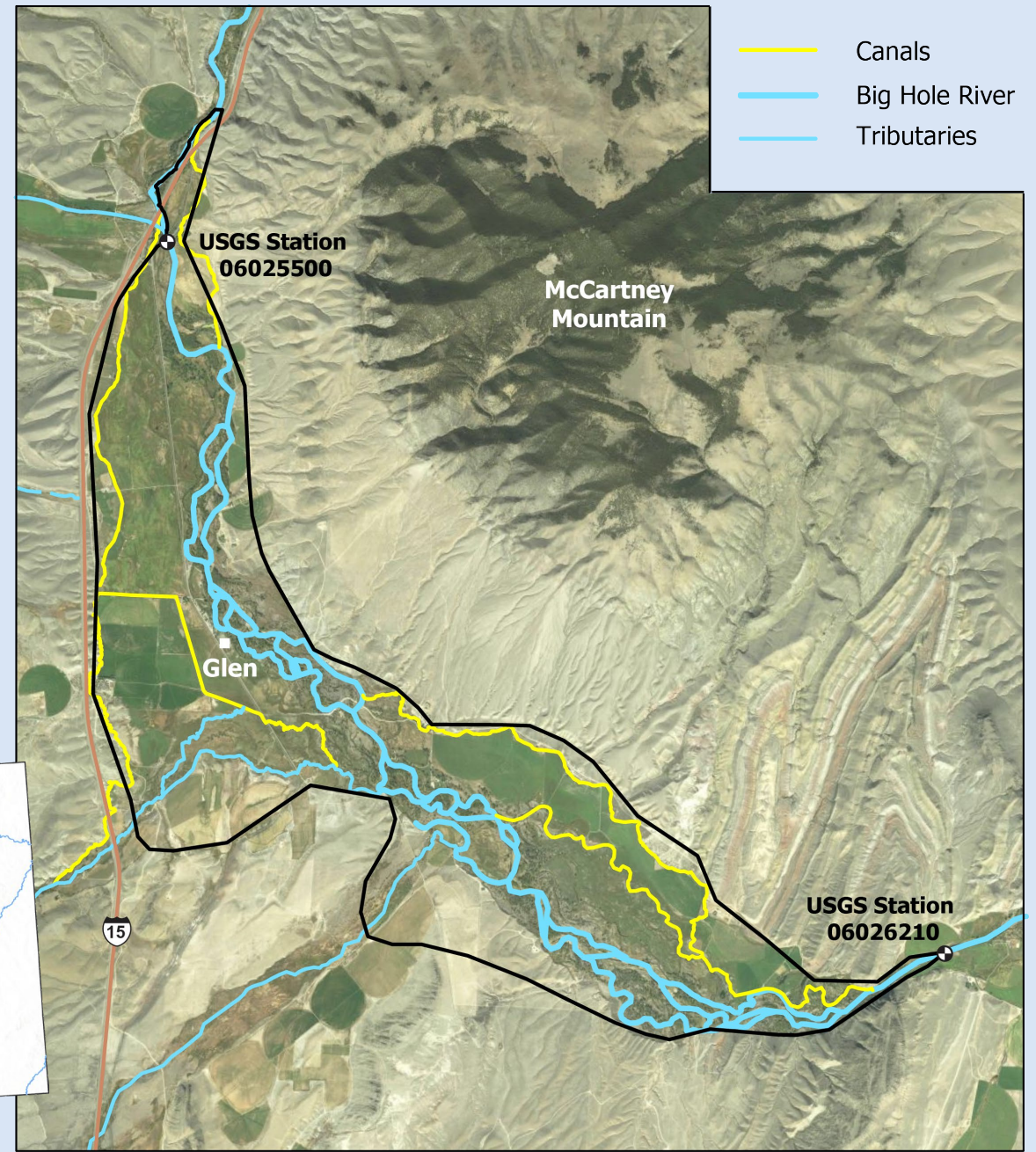
## Nutrient Cycling:

↑ temperatures = ↑ nutrient solubility and  
↑ biogeochemical rates



# Background

- Big Hole River near Glen, MT is anabranching river
- Flows:
  - High flow is ~4,000-6,000 cfs (May-June)
  - Low flow is generally 100-300 cfs (Aug-Sept)



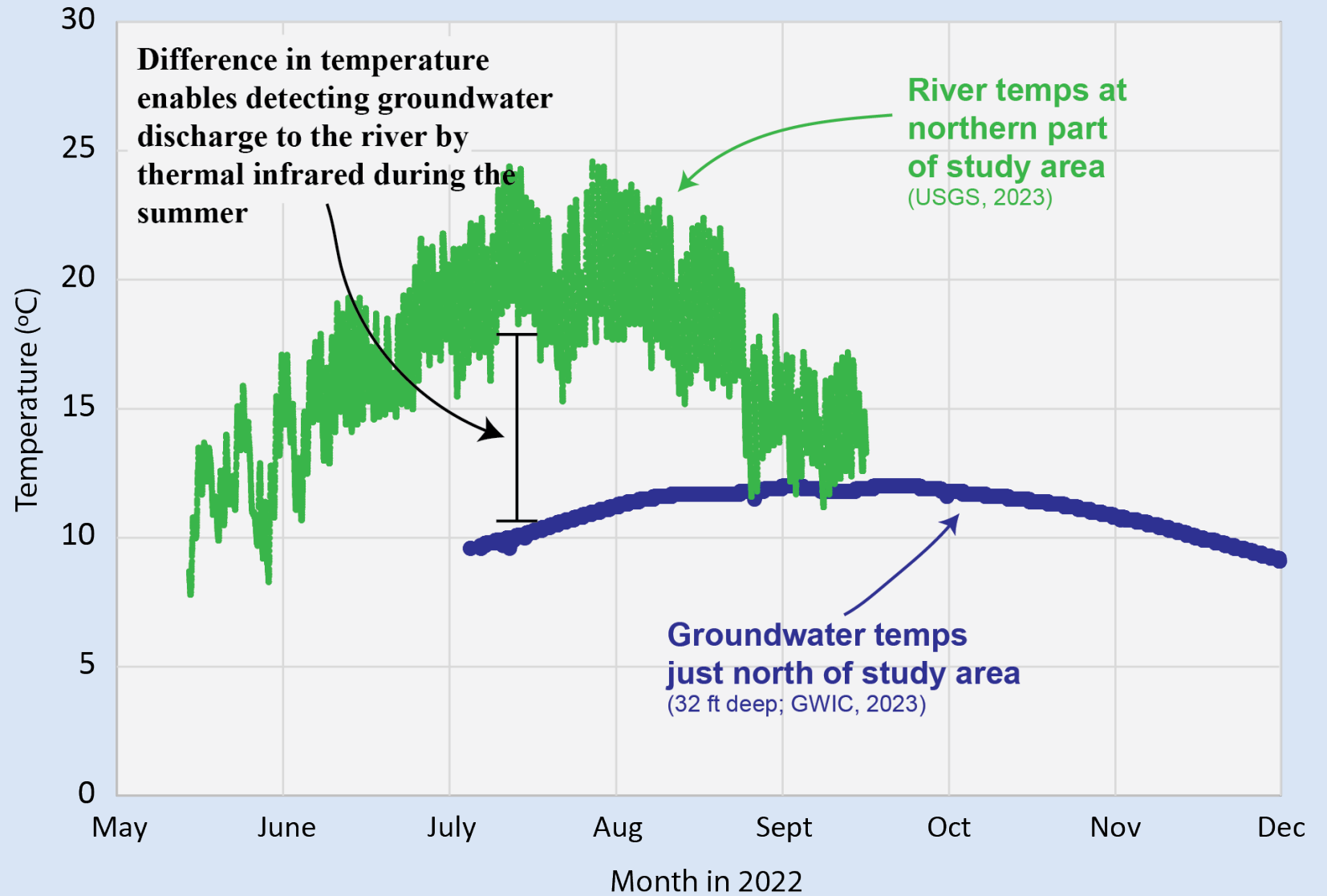
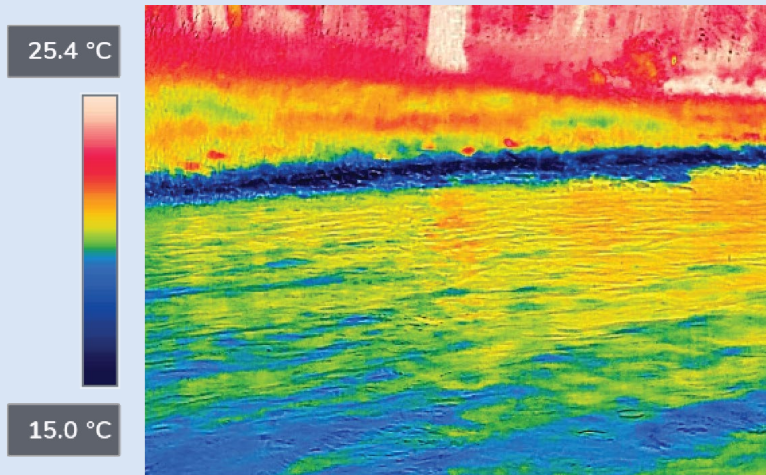
# Approach

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- 1) Float trip with handheld thermal infrared
- 2) Temperature loggers in:
  - groundwater discharge,
  - tributaries,
  - hyporheic, and
  - tail-water return
- 3) Water Quality Parameters
  - pH
  - SC
  - ORP
  - DO



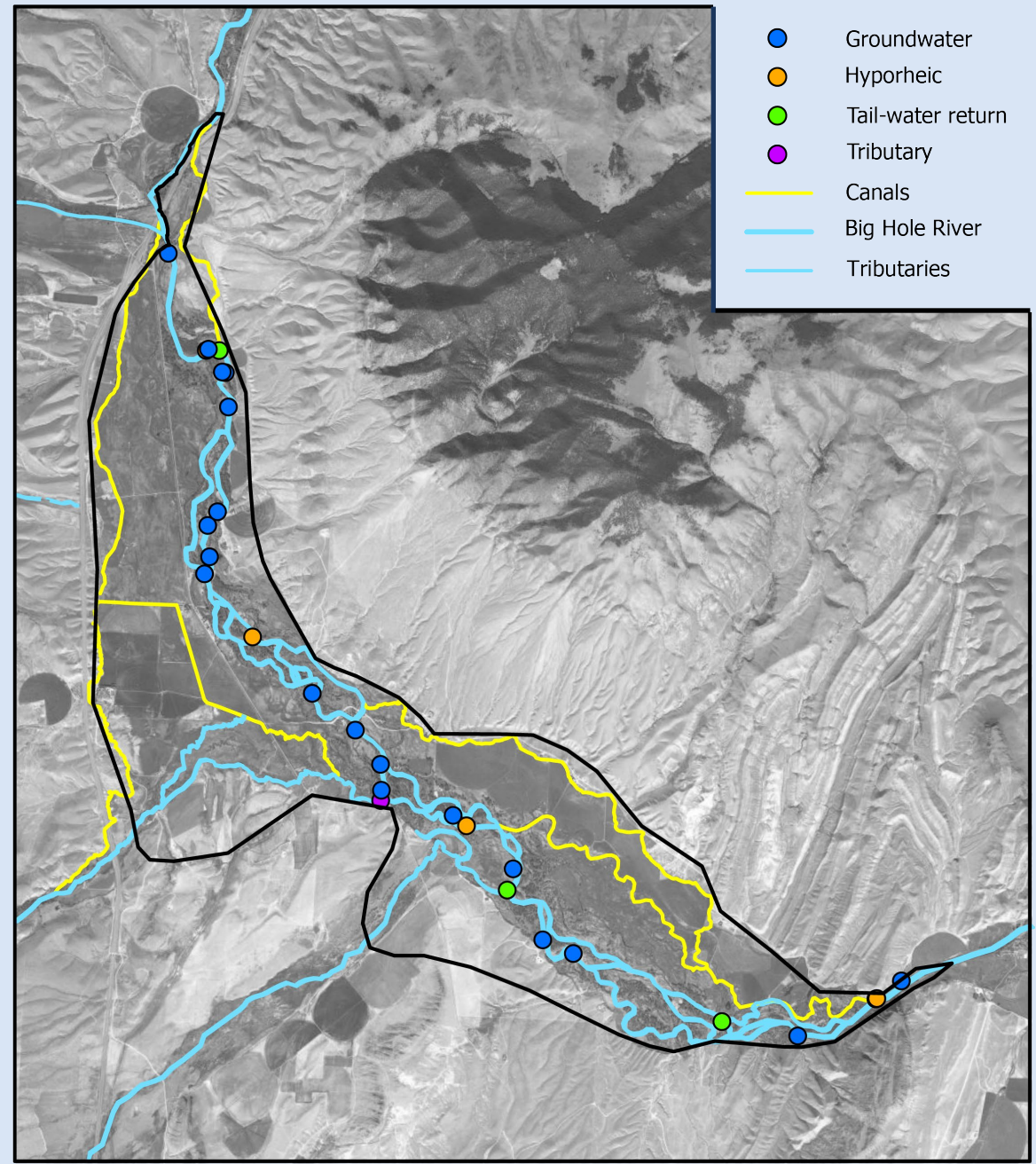
# Approach



# Field Data from 2023

## Monitoring:

- 19 Groundwater discharge sites
- 3 Hyporheic
- 3 Tail-water returns sites
- 1 Tributary

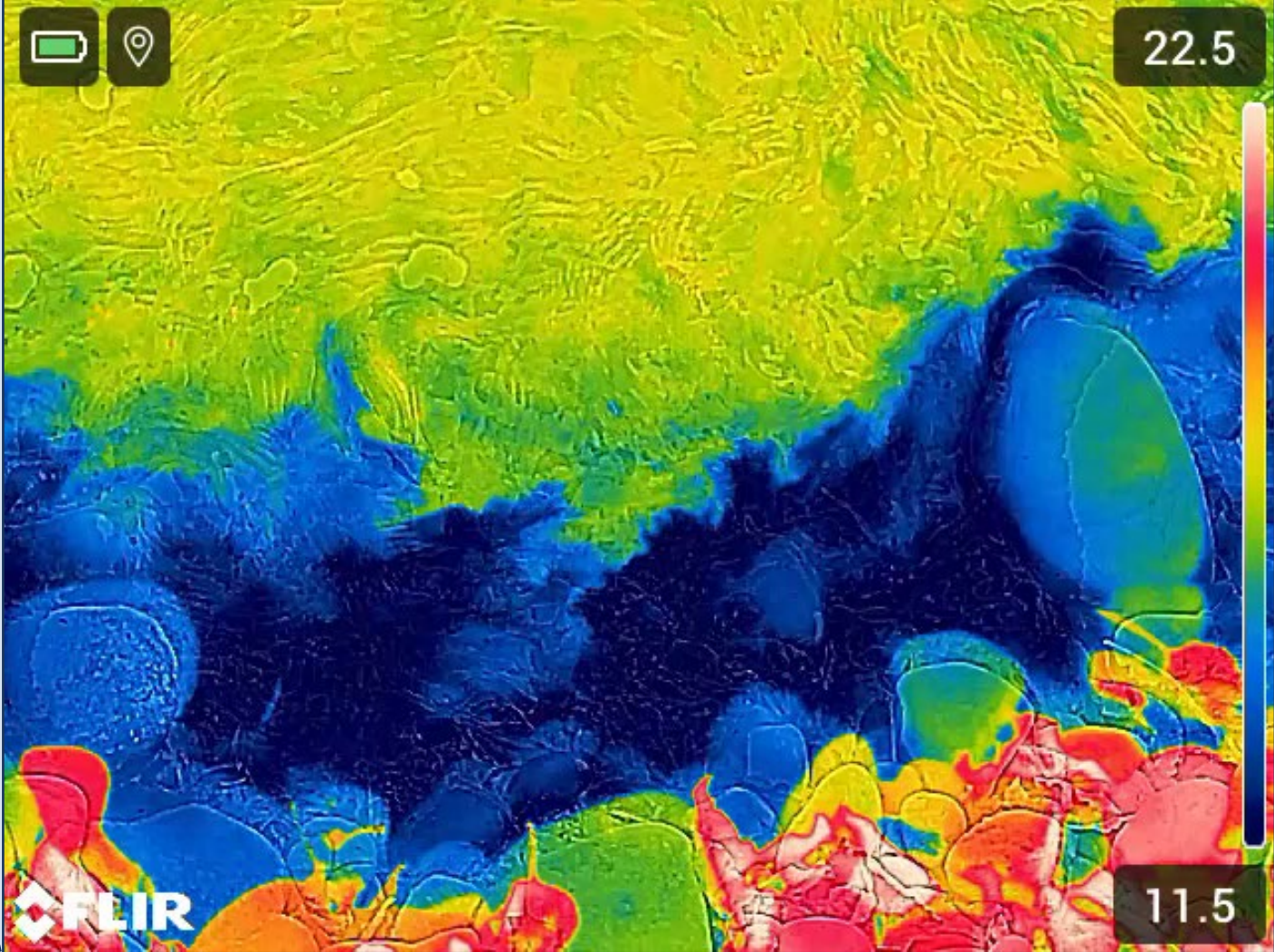


# Field Data from 2023

What did the groundwater discharge sites look like?



Bank discharge (10's of ft)

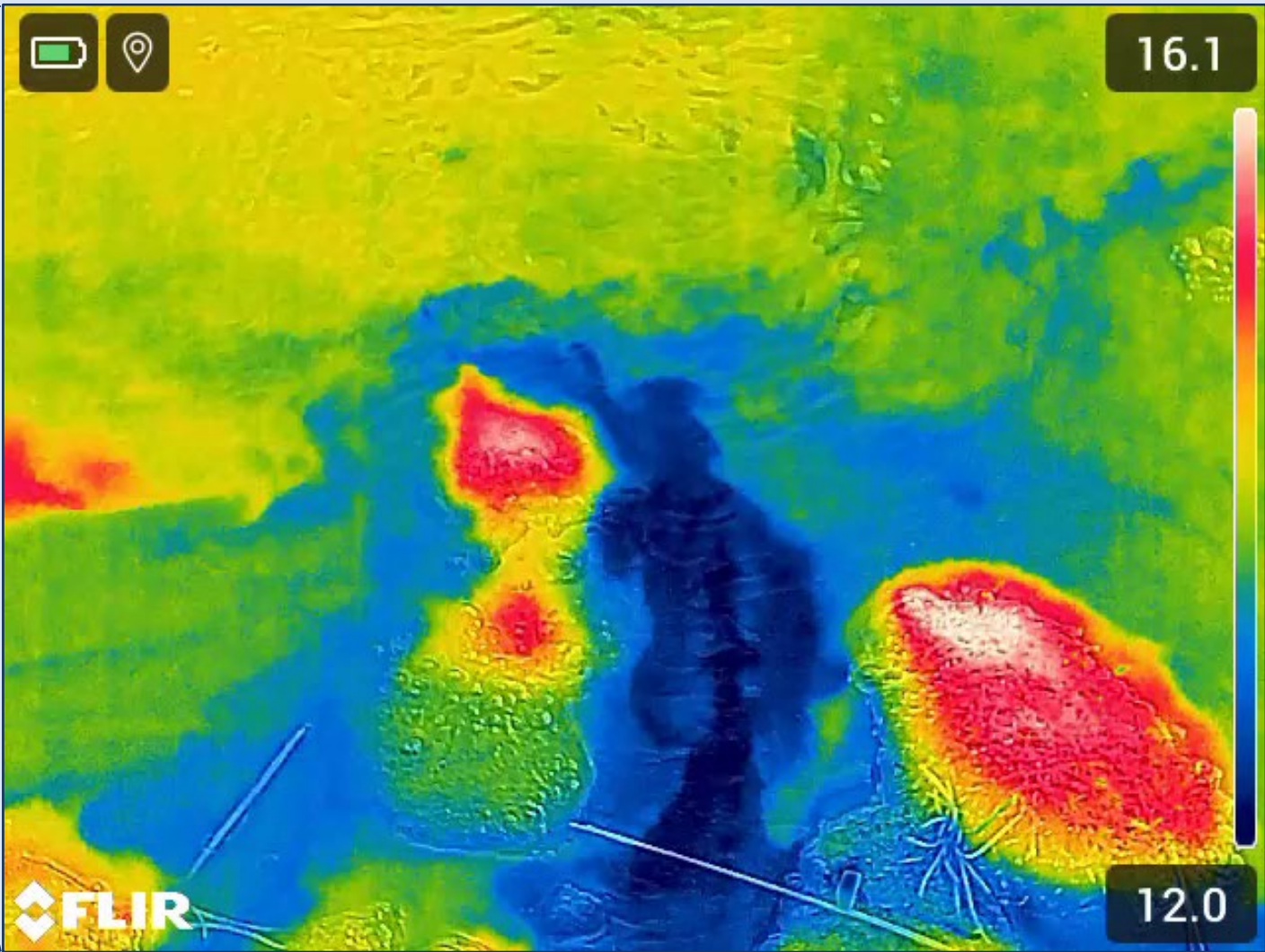


# Field Data from 2023

What did the groundwater discharge sites look like?

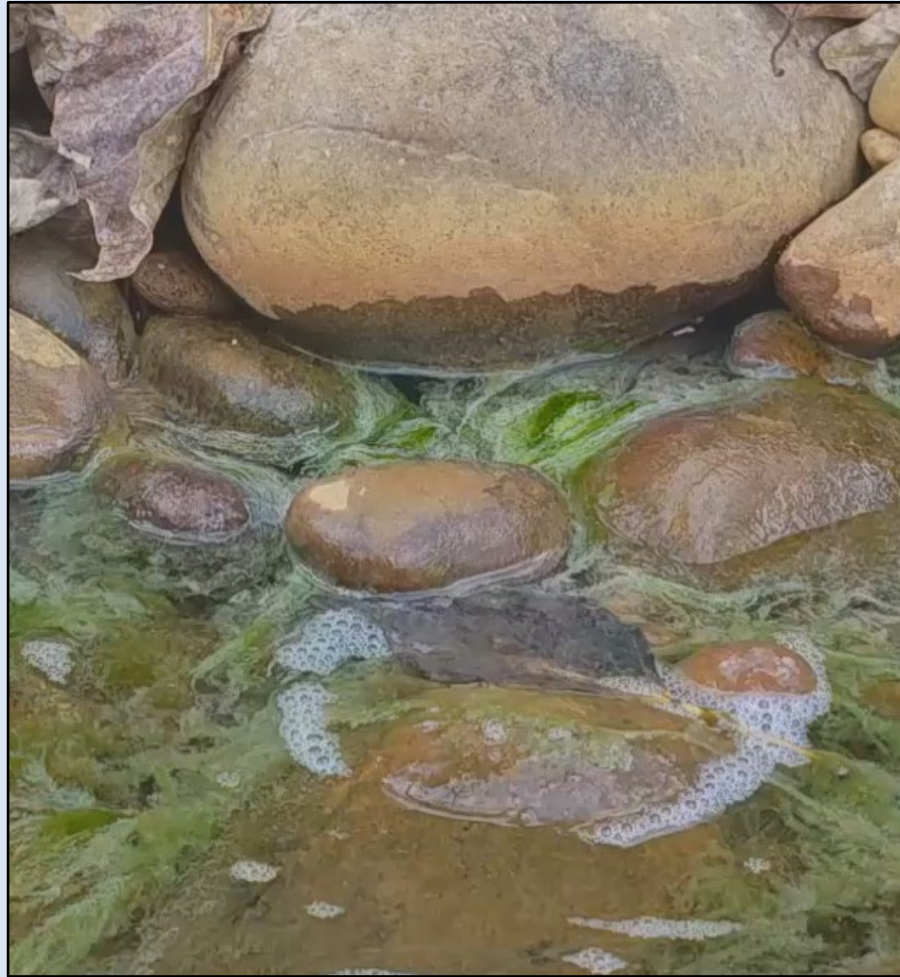


Patches of discrete flow



# Field Data from 2023

Precipitated iron hydroxides and iron-oxidizing bacteria (Brooks and Field, 2020)



Visual groundwater flowing out of banks



Iron and manganese staining

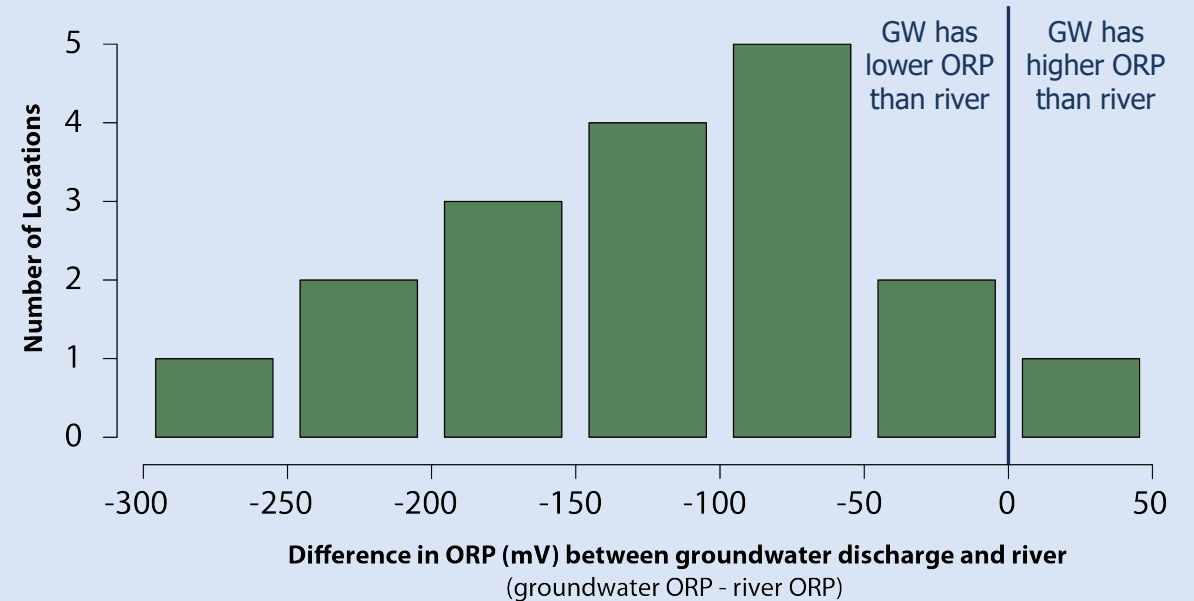
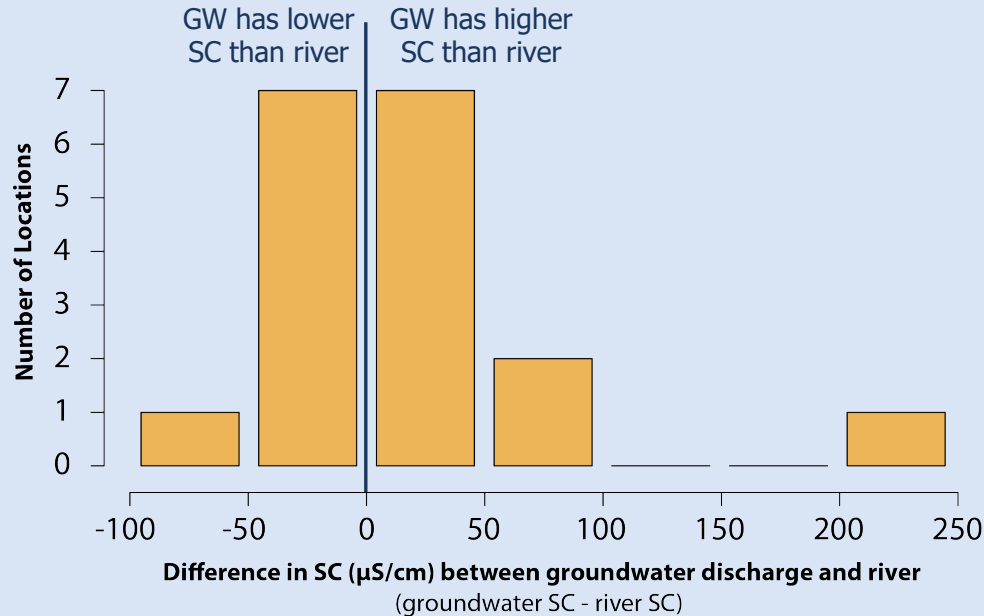
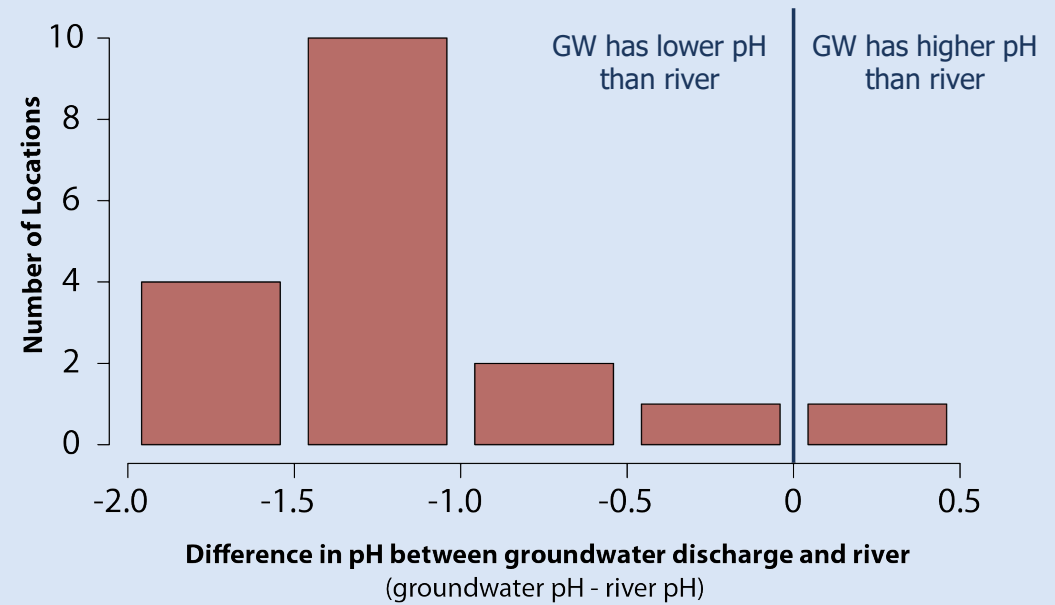


Oil-like sheen indicative of iron oxidation (Stanton and others, 2007)

# Field Data from 2023

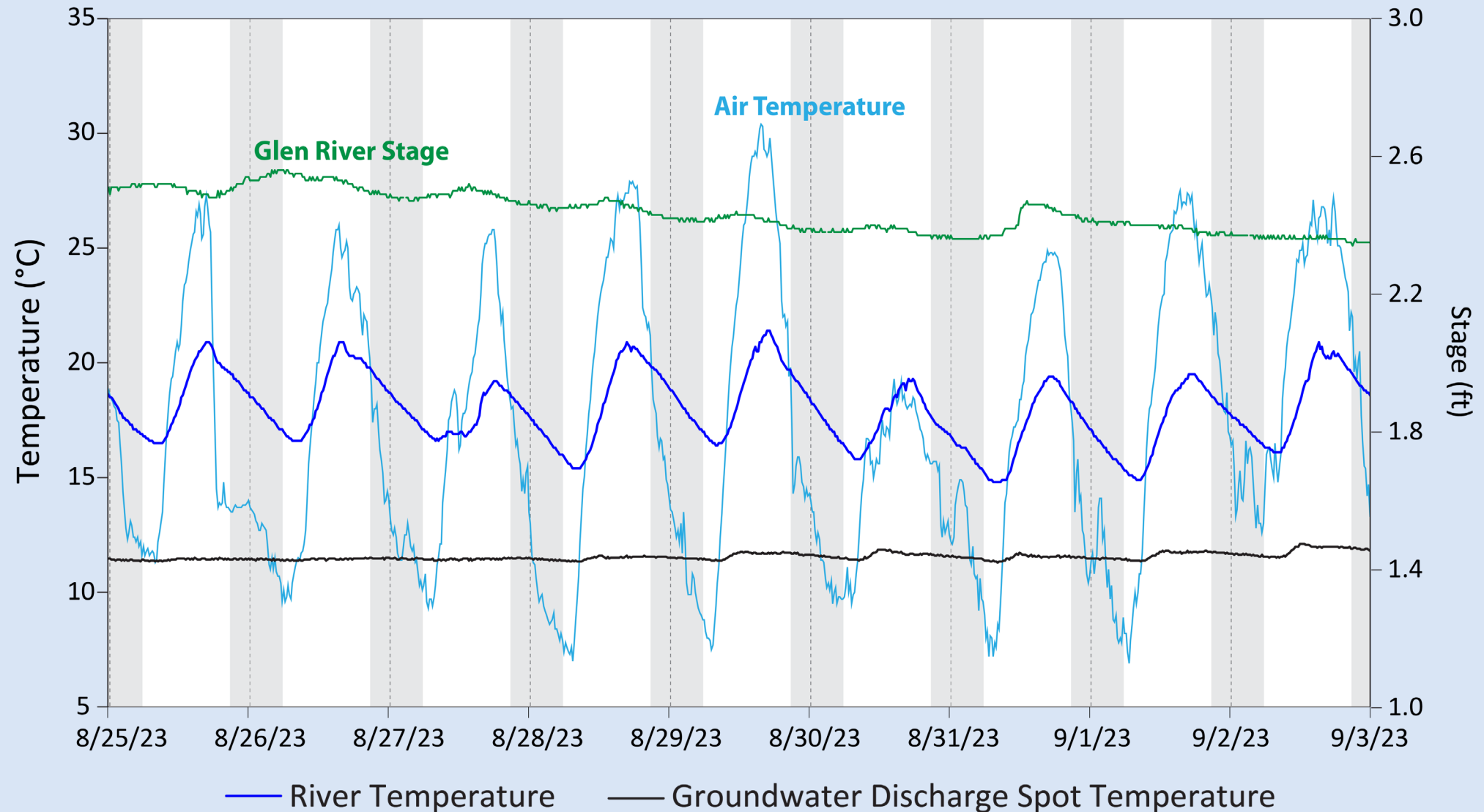
Groundwater discharge generally has lower pH and lower ORP, but similar SC to the river.

Data from late August float	GW Discharge	River
Median pH	7.26	8.57
Median ORP (mv)	-26.1	72.3
Median SC ( $\mu\text{S}/\text{cm}$ )	192	195



# Preliminary Results

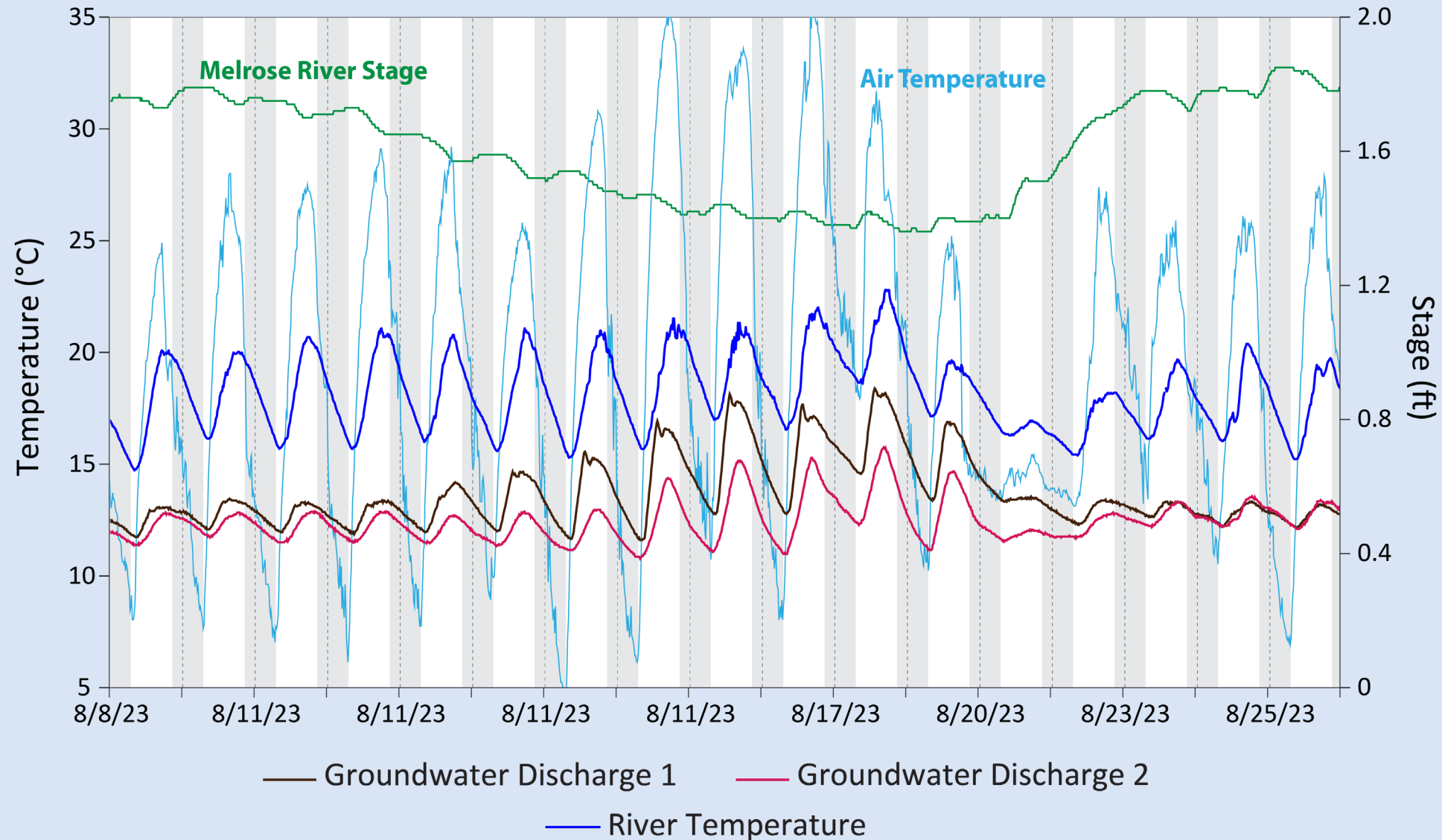
Groundwater diel cycles are colder, muted and influenced by stage.



# Preliminary Results

Why there is greater diel swings during lower river stage?

- Different groundwater discharge paths become preferential
- Bank storage

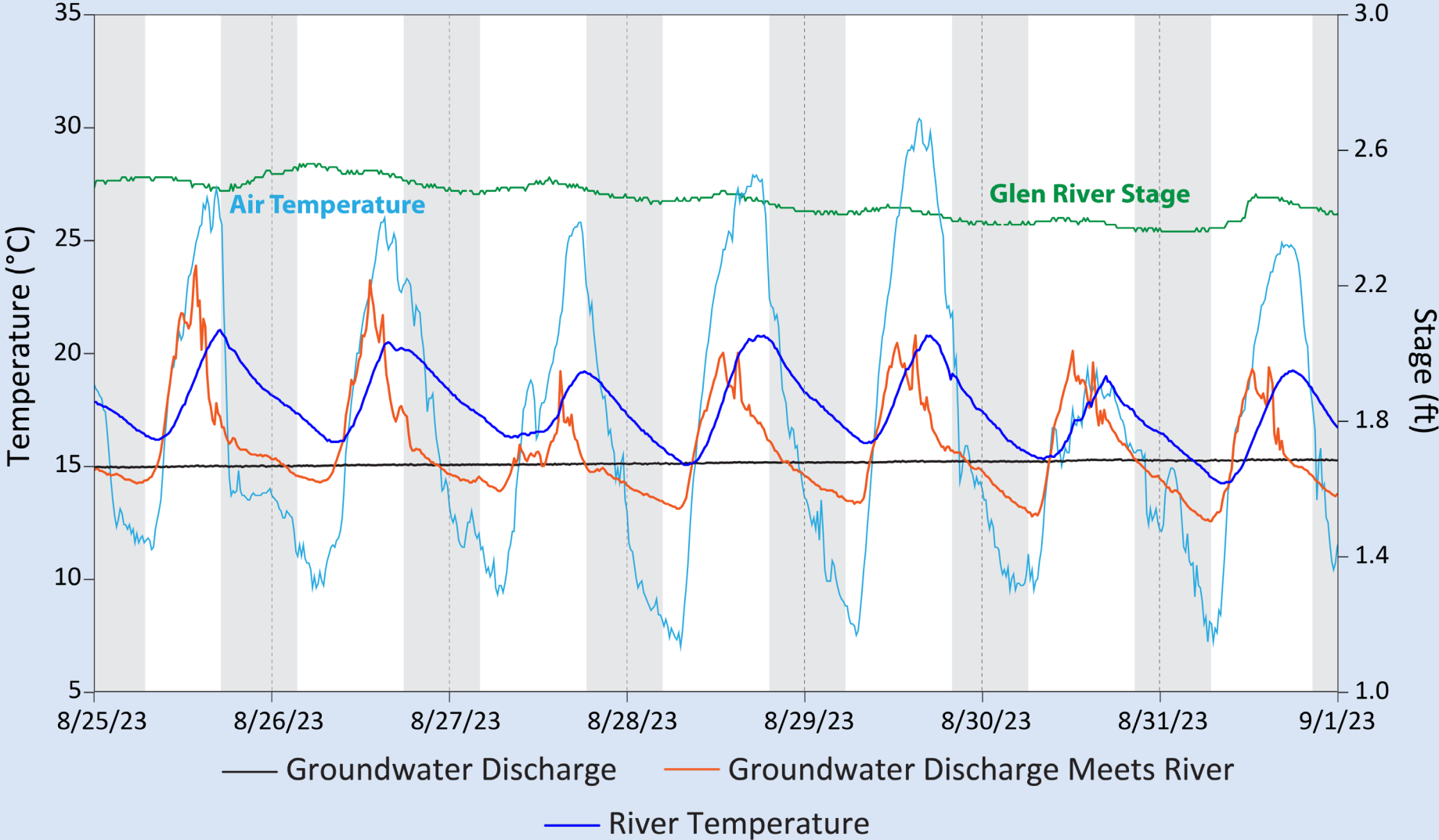


# Preliminary Results

The path the groundwater takes to the river matters: the groundwater can warm up before it reaches the river.

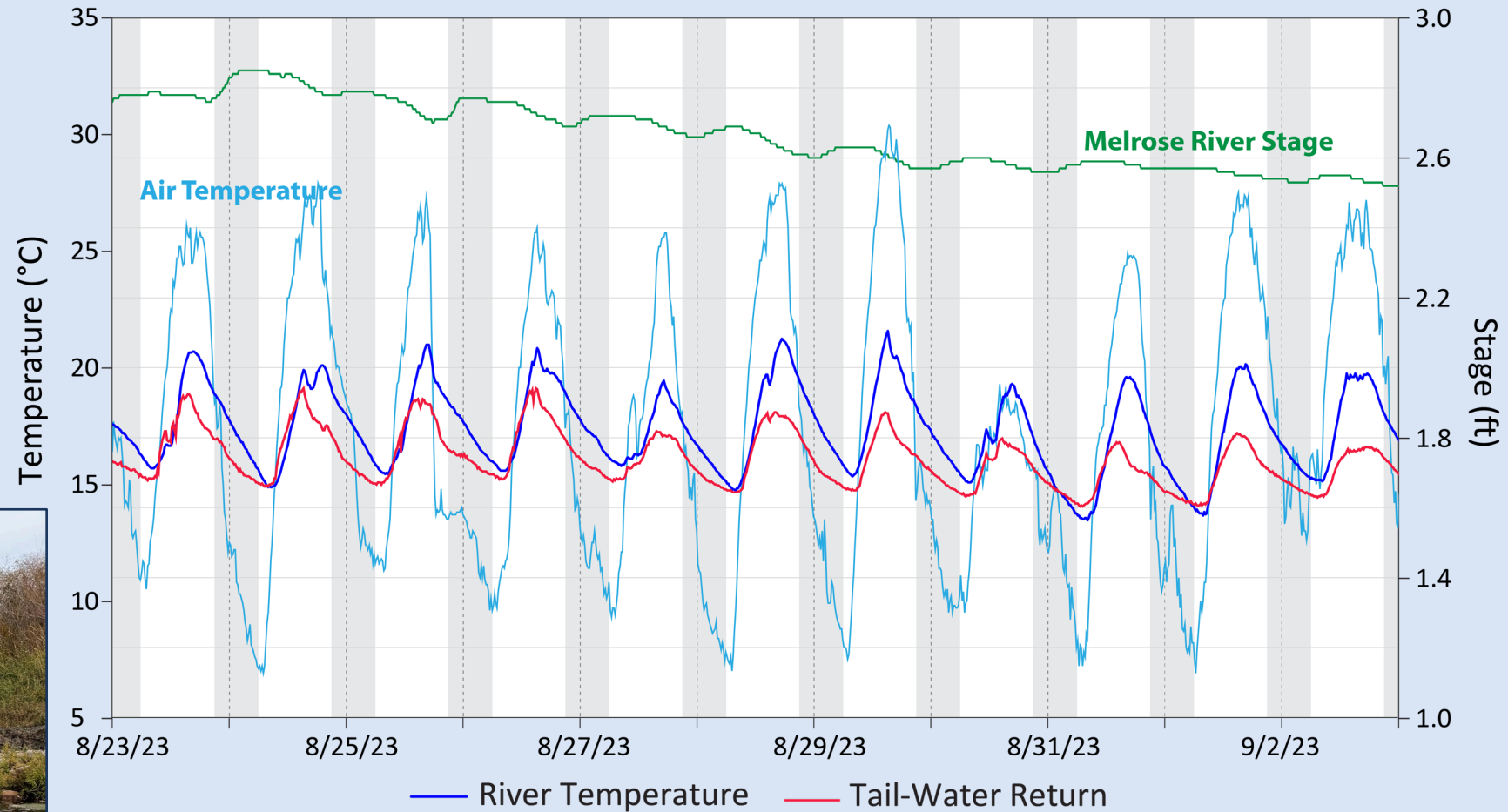


~100 ft long path



# Preliminary Results

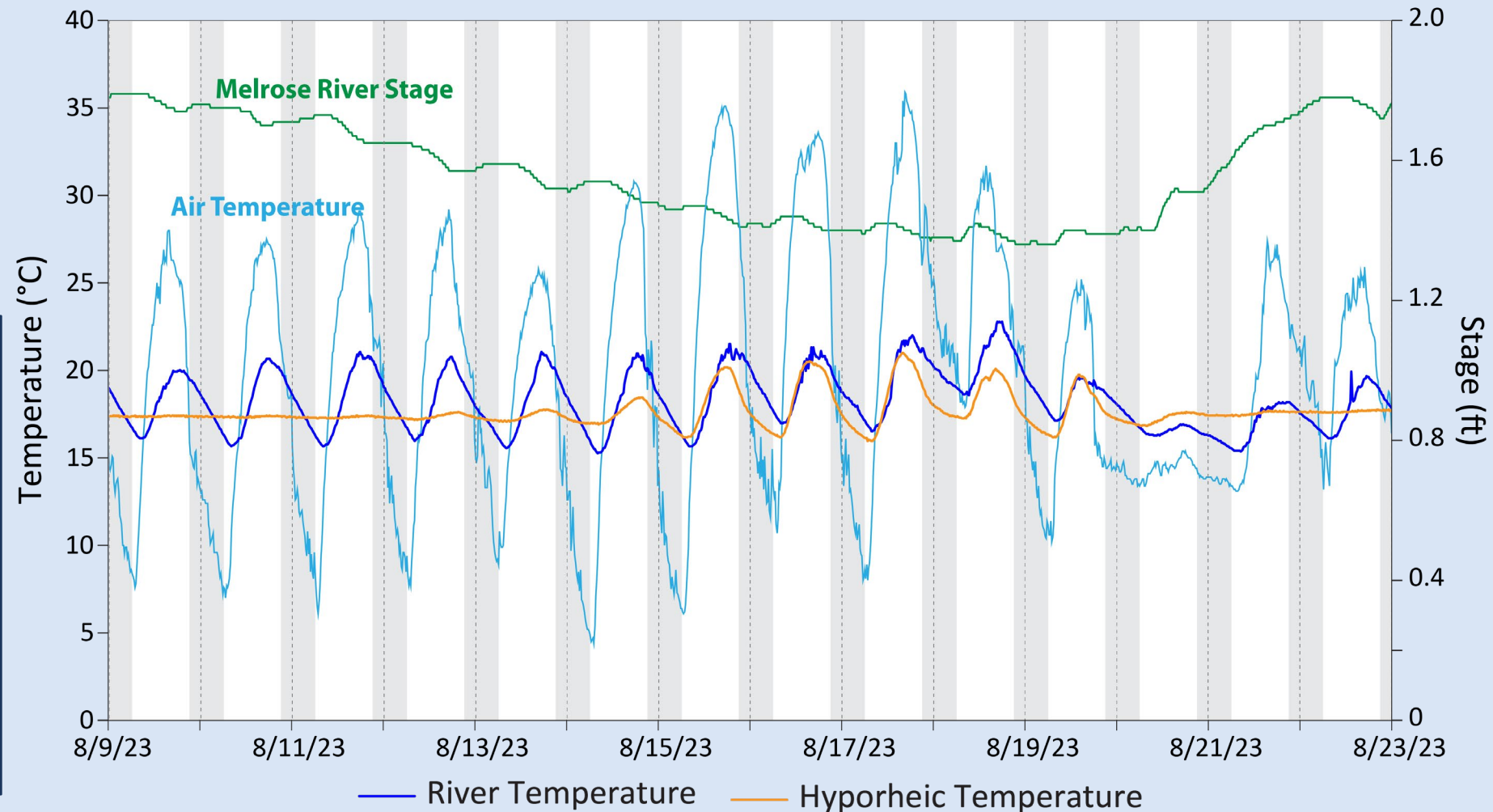
Temperatures from tail-water return sites appear to be at the same temperature as the river or slightly lower.



# Preliminary Results

## Hyporheic flow buffers the river temperature

When river stage gets too low, hyporheic flow show greater diel temperature swings.



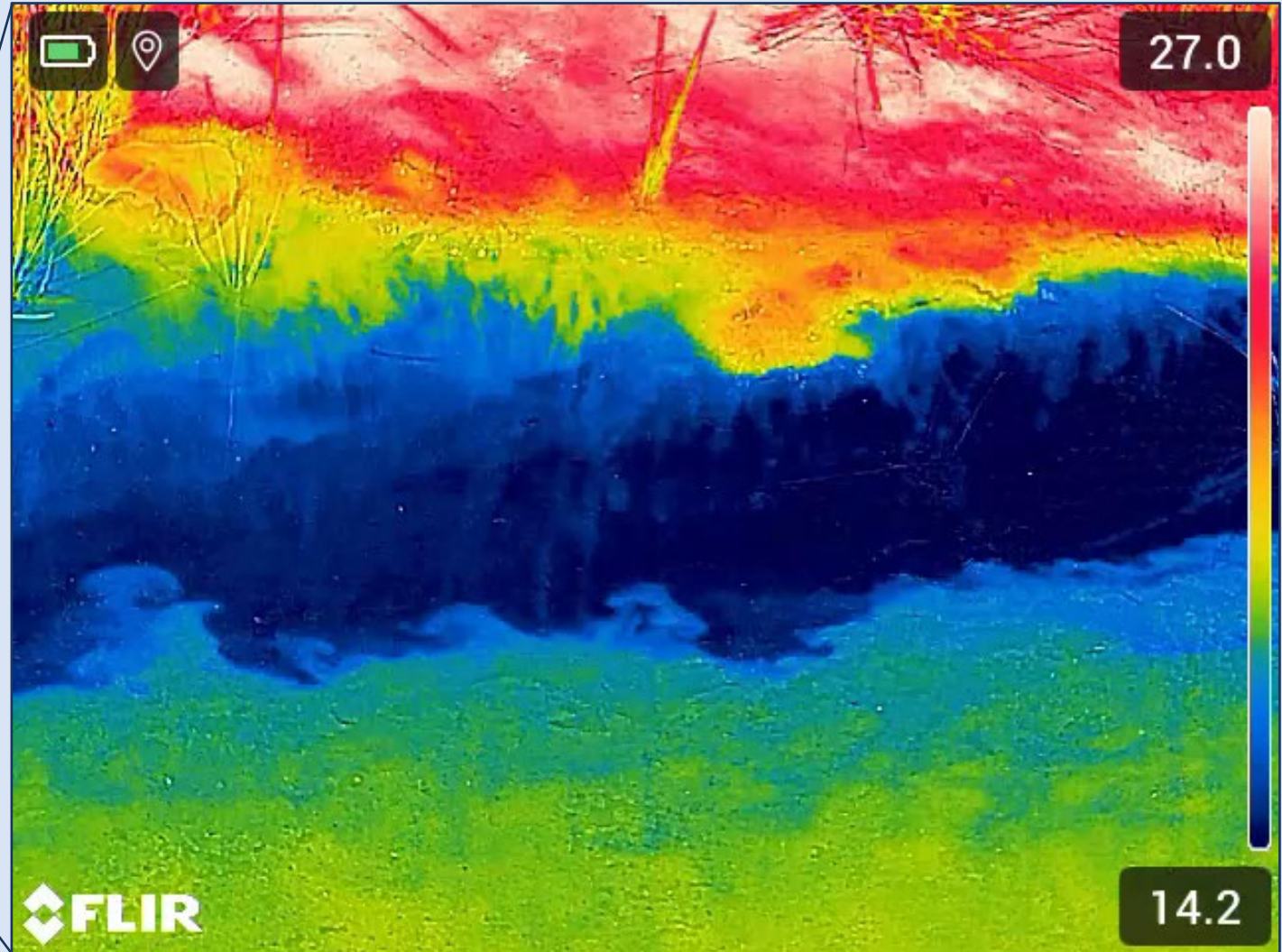
# Preliminary Conclusions

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- Groundwater discharging into river is a cooling source, unless it warms up before reaching the river.
- Canals generally have temperatures that are cooler or equal to the river temperature
- Hyporheic flow buffers the river temperature until river stage drops low enough that the hyporheic flow path is cut off.
- Things to consider when river sampling
  - Nearby groundwater discharge can impact “river” samples and result in non-representative samples
  - Diel cycles in temperature, pH, DO, and the biogeochemical processes that are associated with these parameters can result in isolated readings being non-representative (e.g., Nimick and others, 2005; Arrigoni and others, 2008)

# Questions?

Call for GWIP proposals  
this spring!



**MBMG**

Ground Water Investigation Program

Background

Approach

Field Data

Preliminary Results

Conclusions

# References

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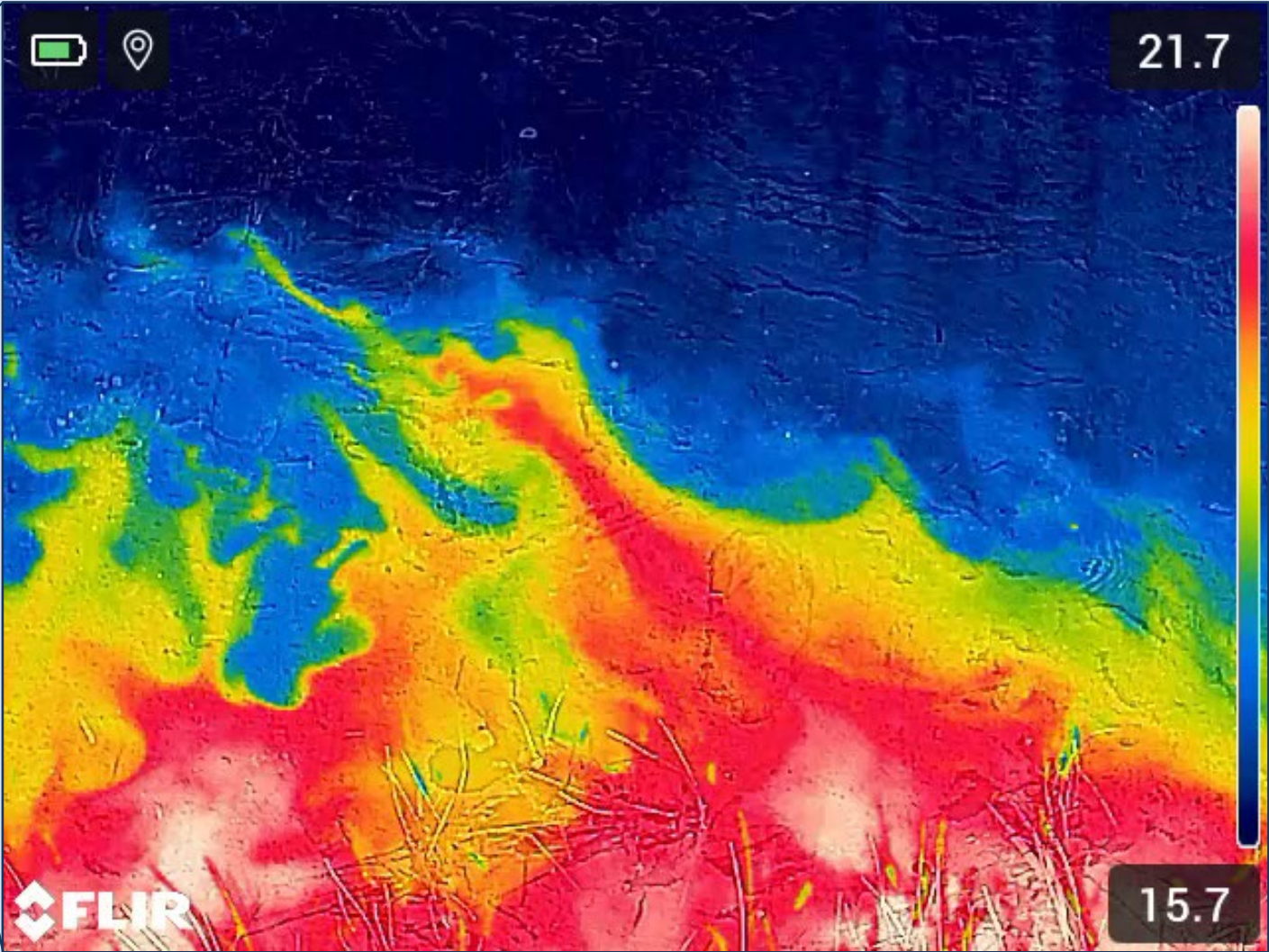
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# Field Data from 2023

What did the groundwater discharge sites look like?



Slow groundwater discharge warming before reaching the river