Regenerative Stormwater Conveyance Performance: The Groundwater Connection

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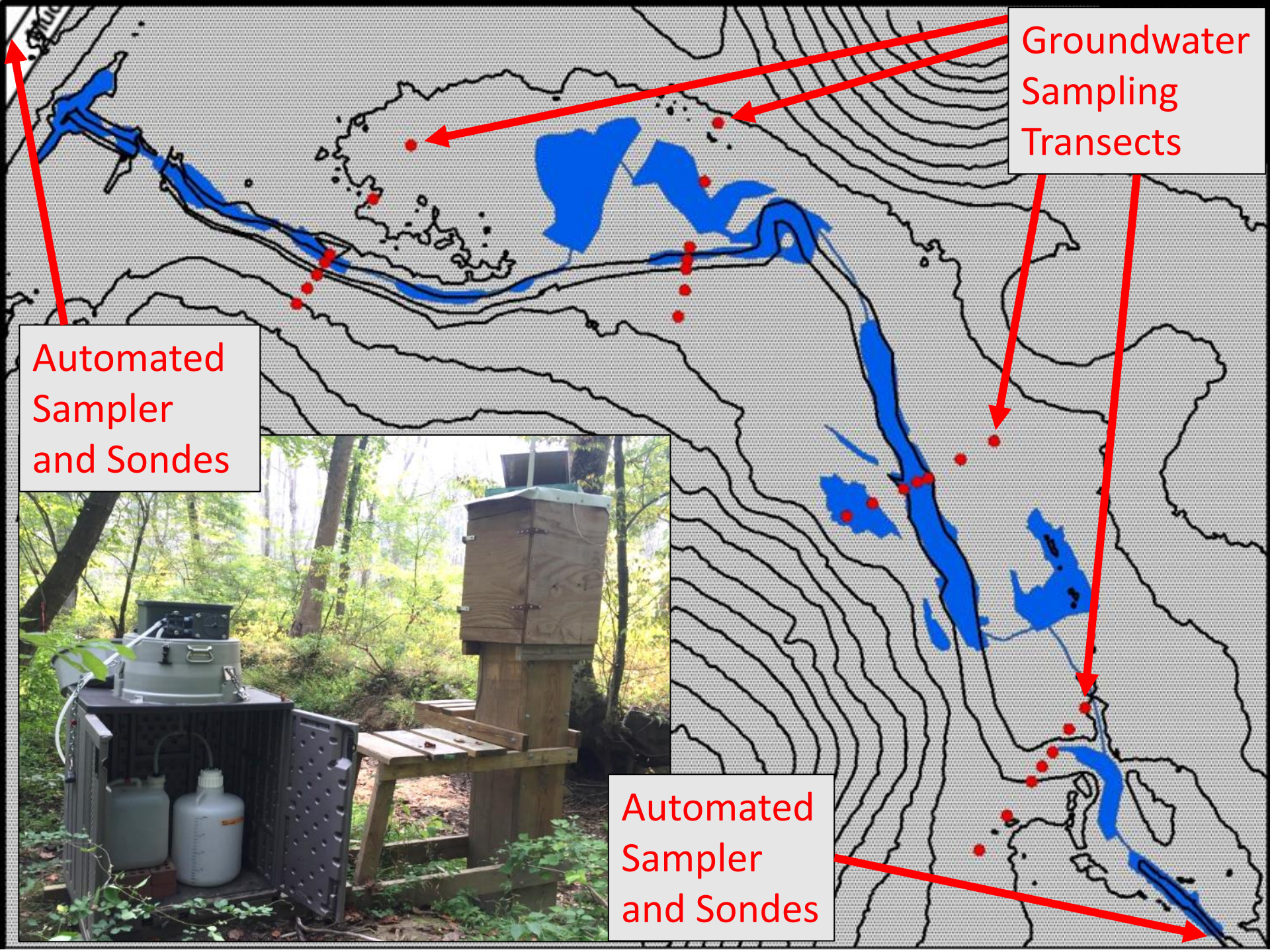
Muddy Creek Restoration

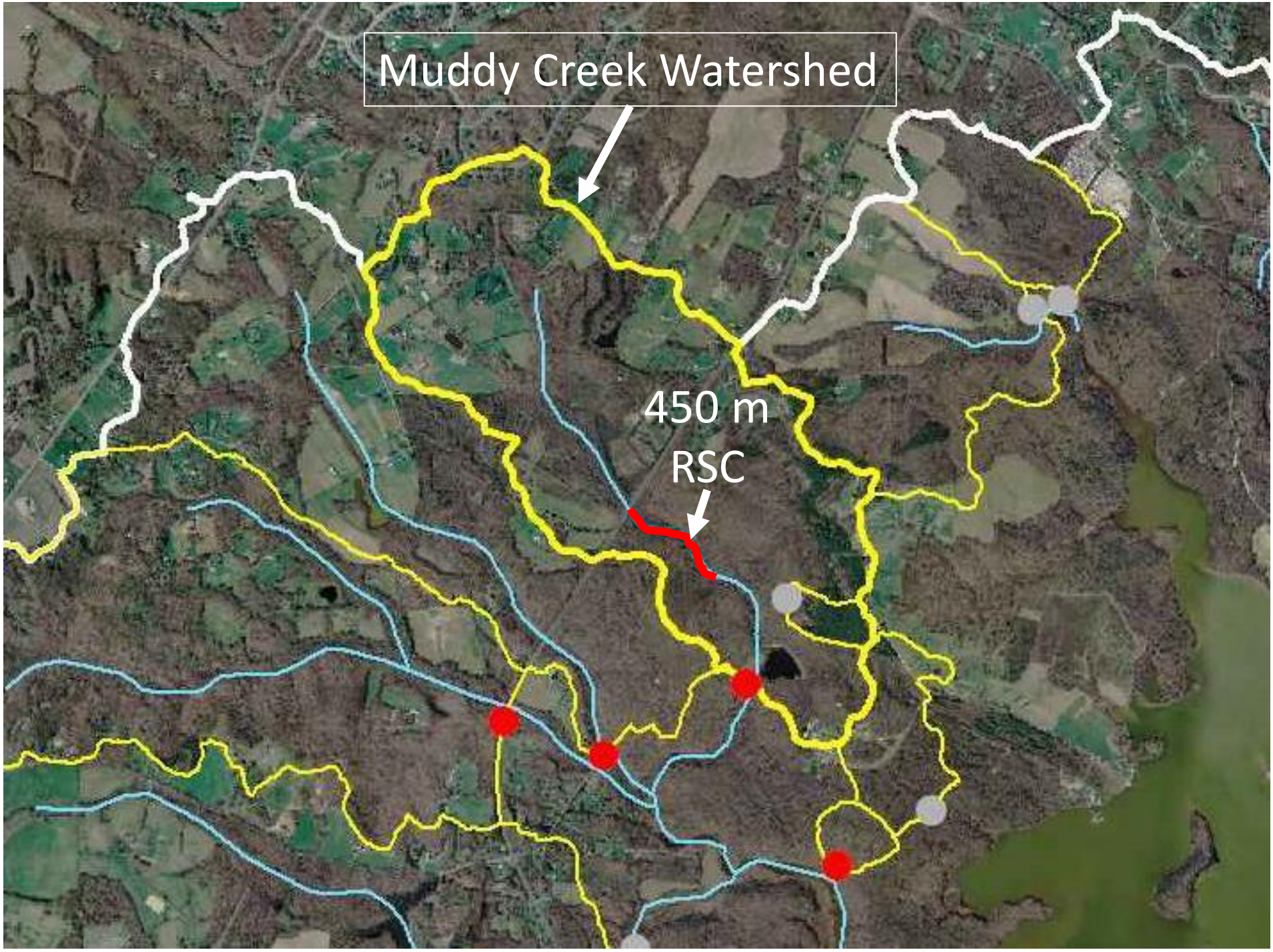
RSC:

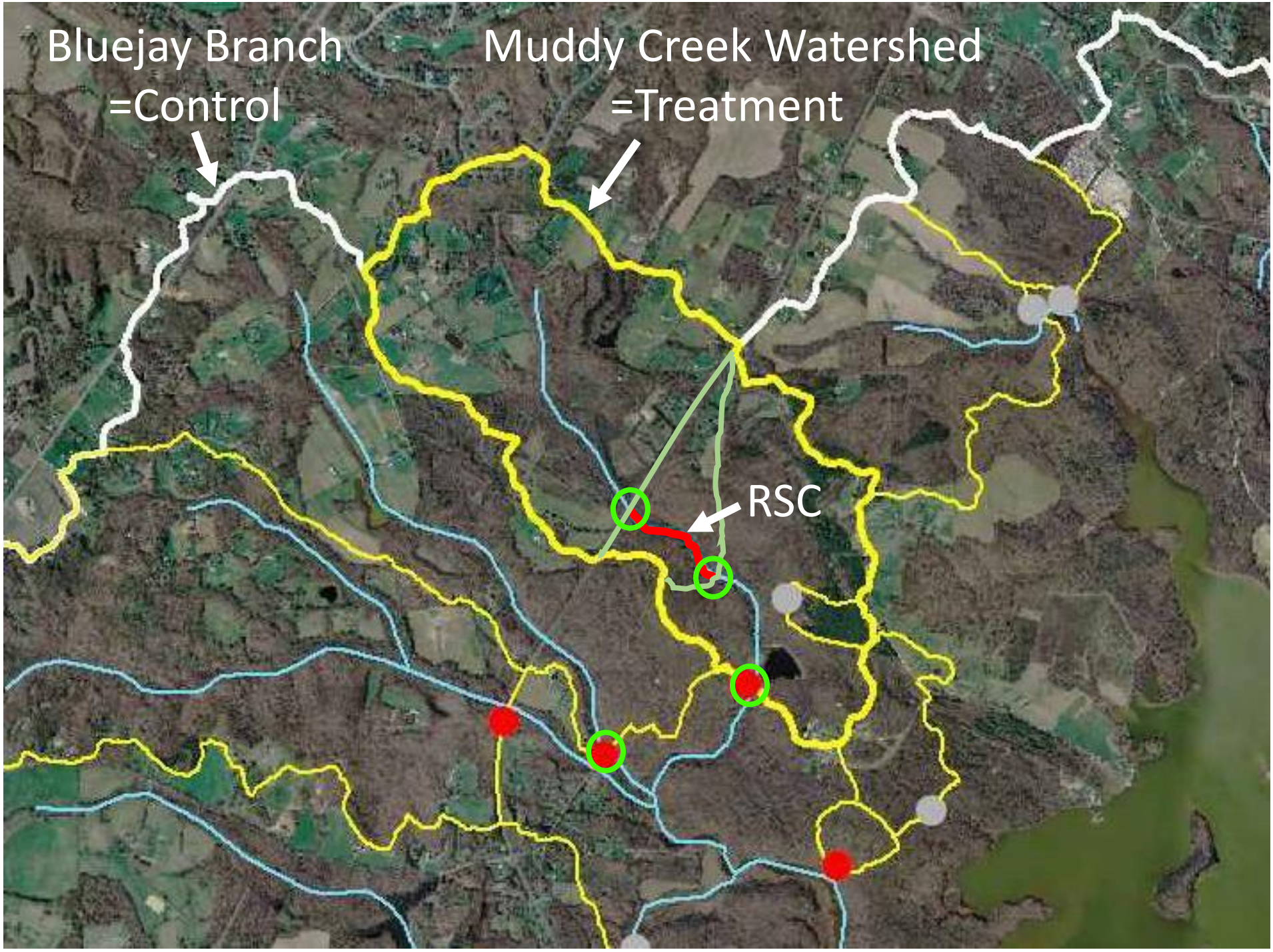
Regenerative Stormwater Conveyance

Research Goals

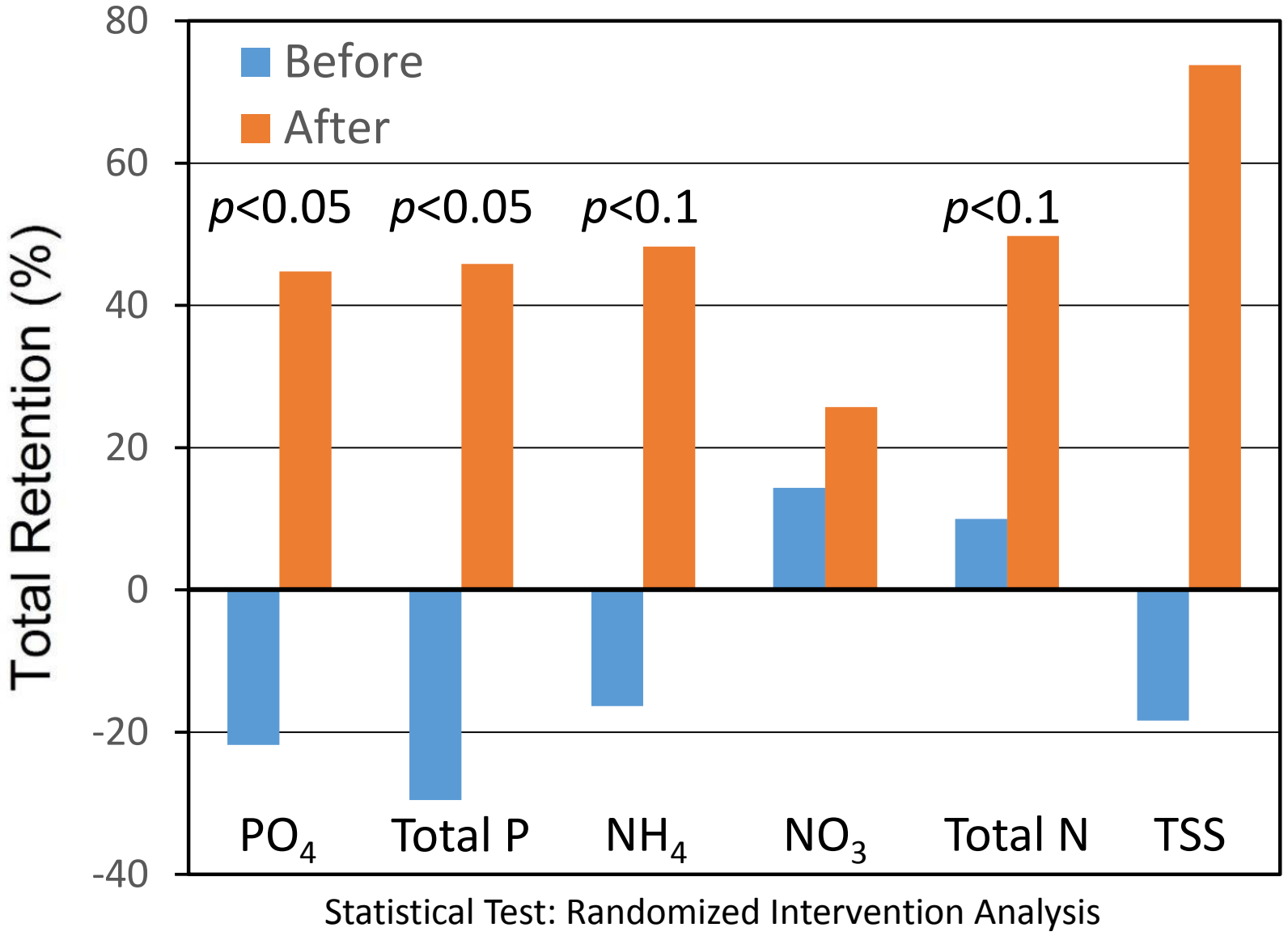
- Assess the effects of the stream restoration:
  - On the removal of suspended solids and nutrients from surface water; and...
  - On the chemistry and flow of groundwater as they may impact removal of nutrients and precipitation of iron in the stream.


Groundwater Sampling Transects
Automated Sampler and Sondes
Automated Sampler and Sondes

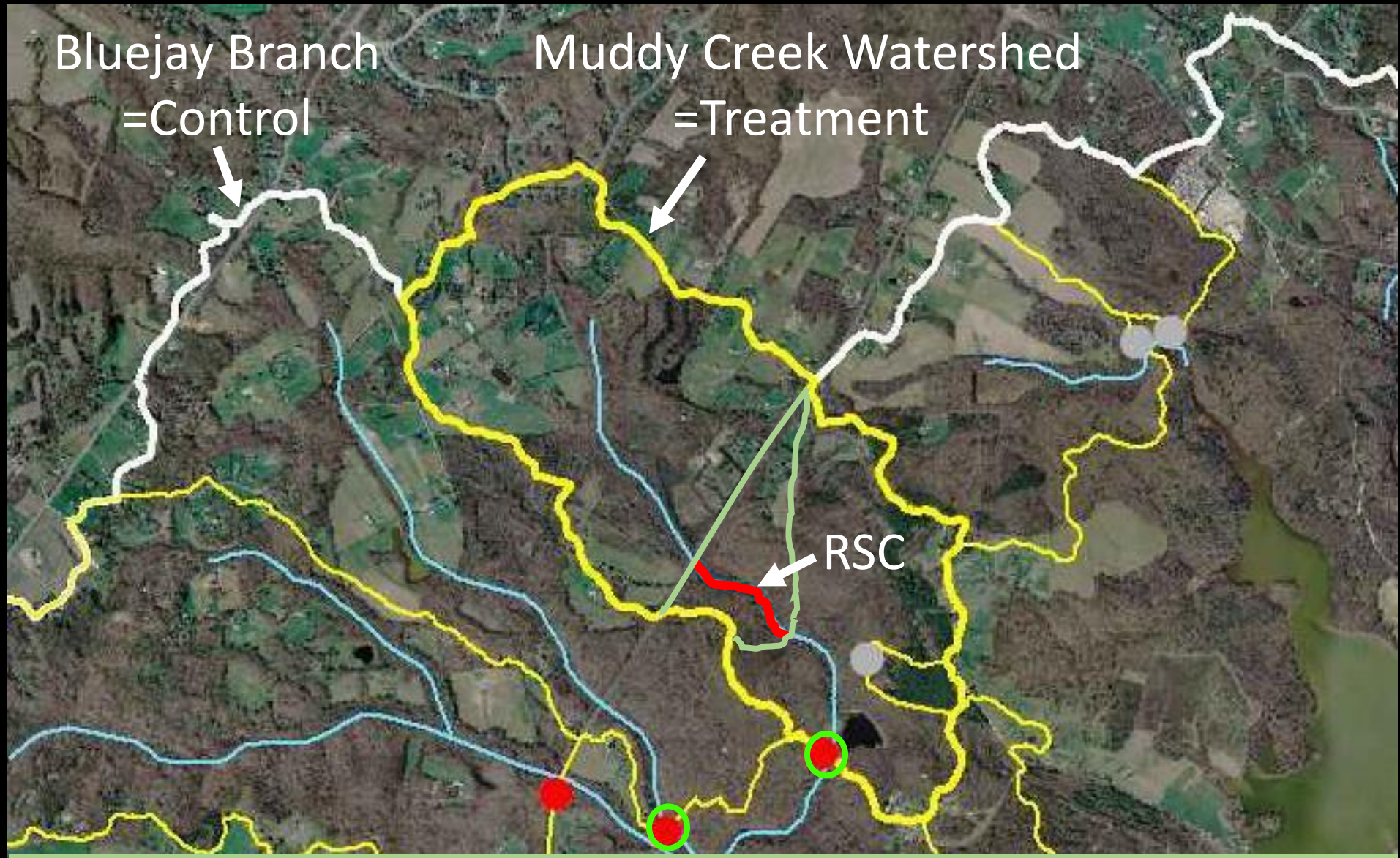

Muddy Creek Watershed
450 m
RSC


Bluejay Branch
=Control
Muddy Creek Watershed
=Treatment
RSC

Comparing the inlet and outlet of the restored reach: Percentage of inflow retained increased after restoration



Statistical Test: Randomized Intervention Analysis



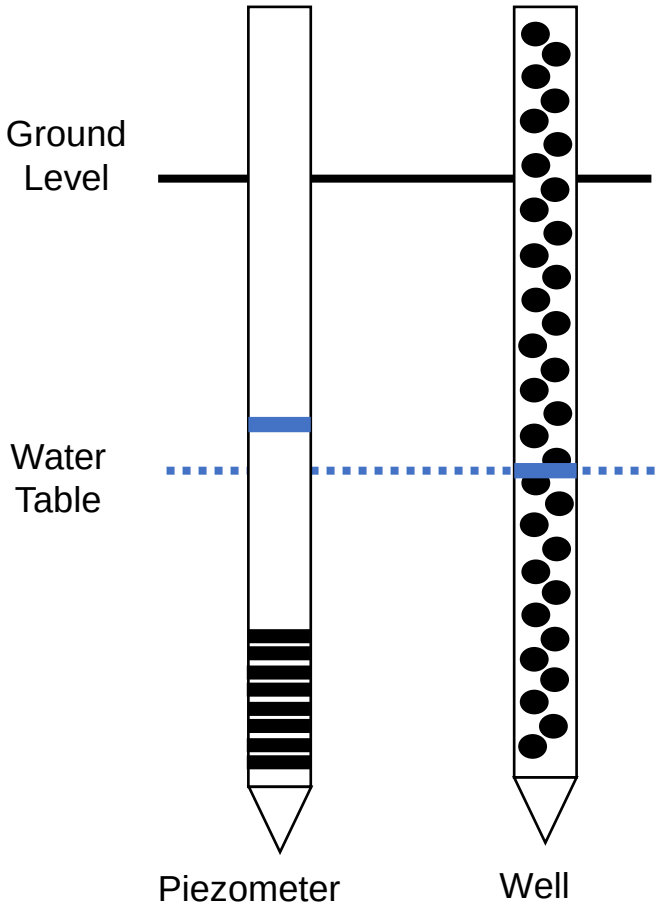
Comparing the treatment and control watersheds:

No statistically significant changes in loads could be attributed to the restoration.

The effects may have been masked by the effects of beaver ponds downstream of the restoration.

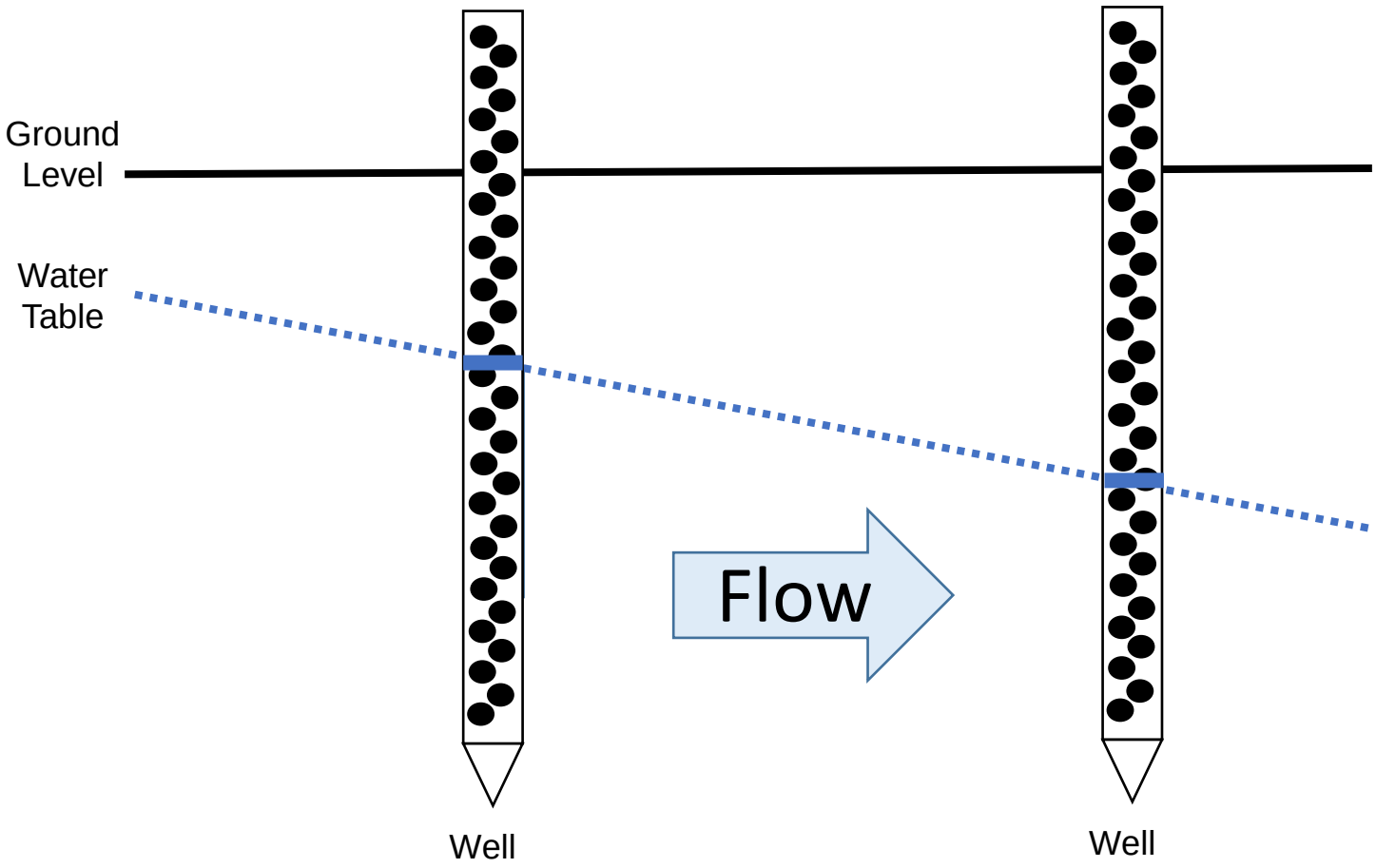
Transect of Wells and Piezometers

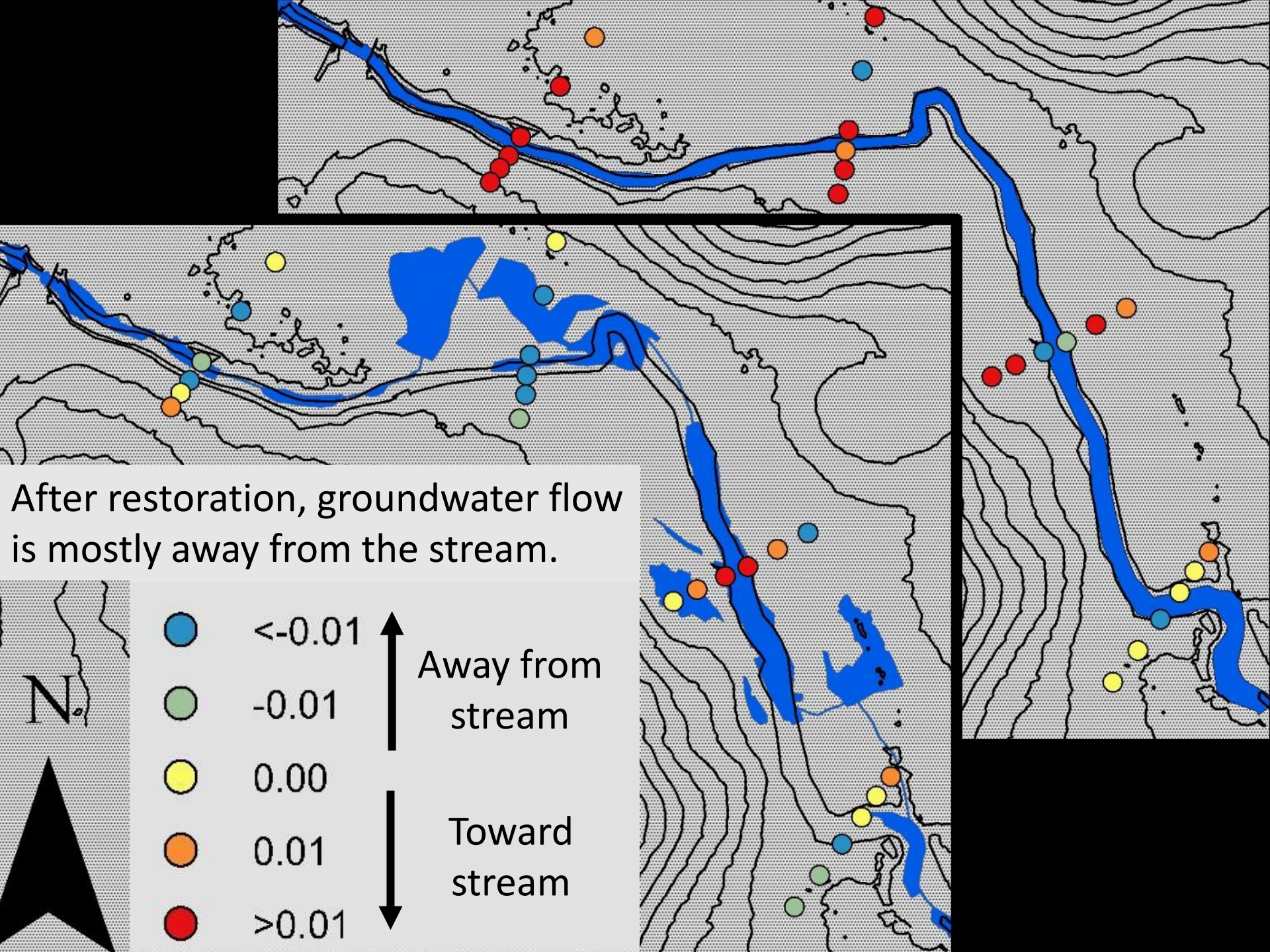
Groundwater Monitoring



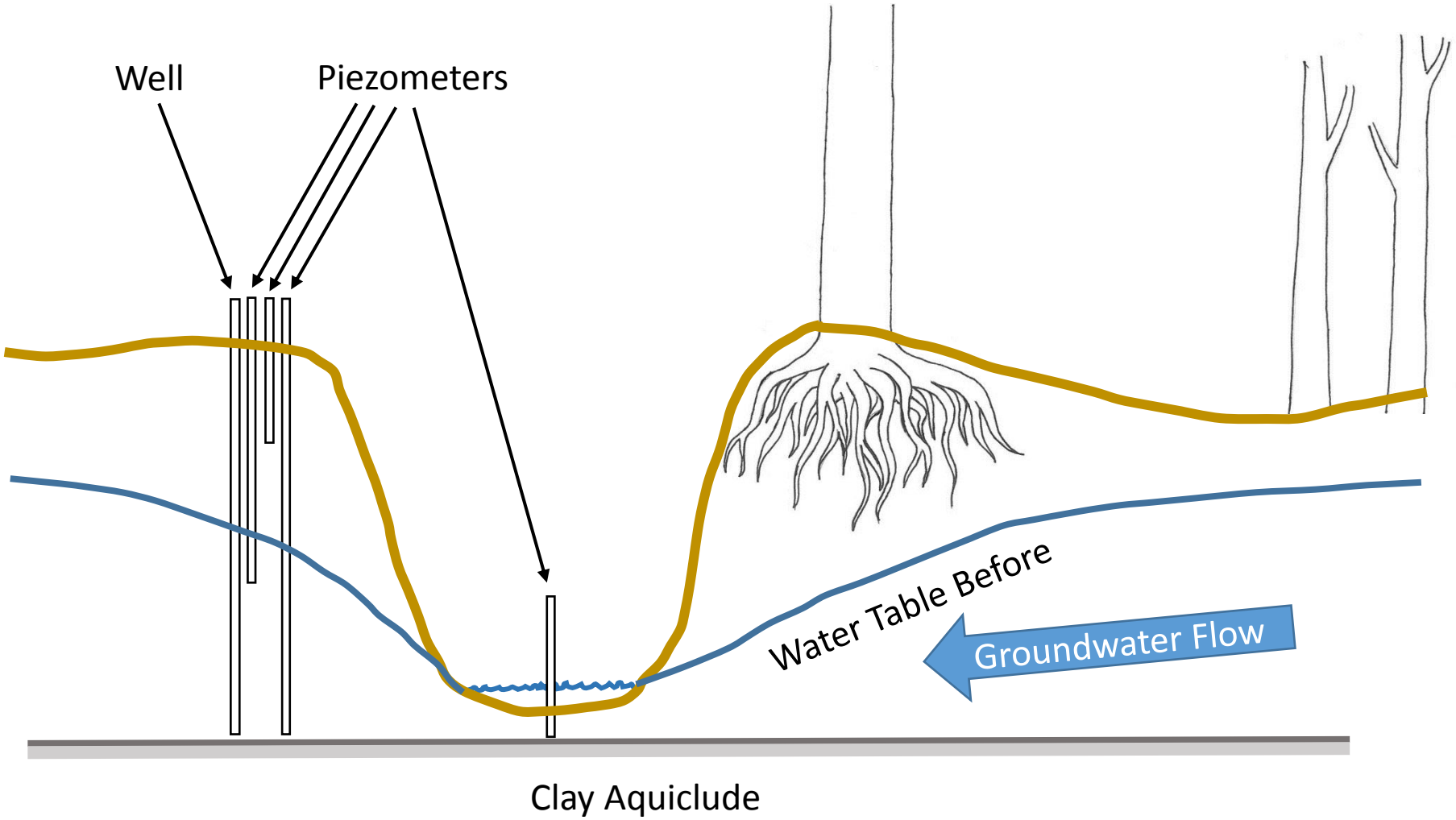
- Groundwater levels monitored within 4 transects, with 7 wells in each transect.
- Groundwater chemistry sampled within 52 piezometers at three depths, spaced 0.6 m apart.
- Groundwater levels monitored weekly, with chemistry monitored each month for 2 years.

Horizontal Pressure Gradient

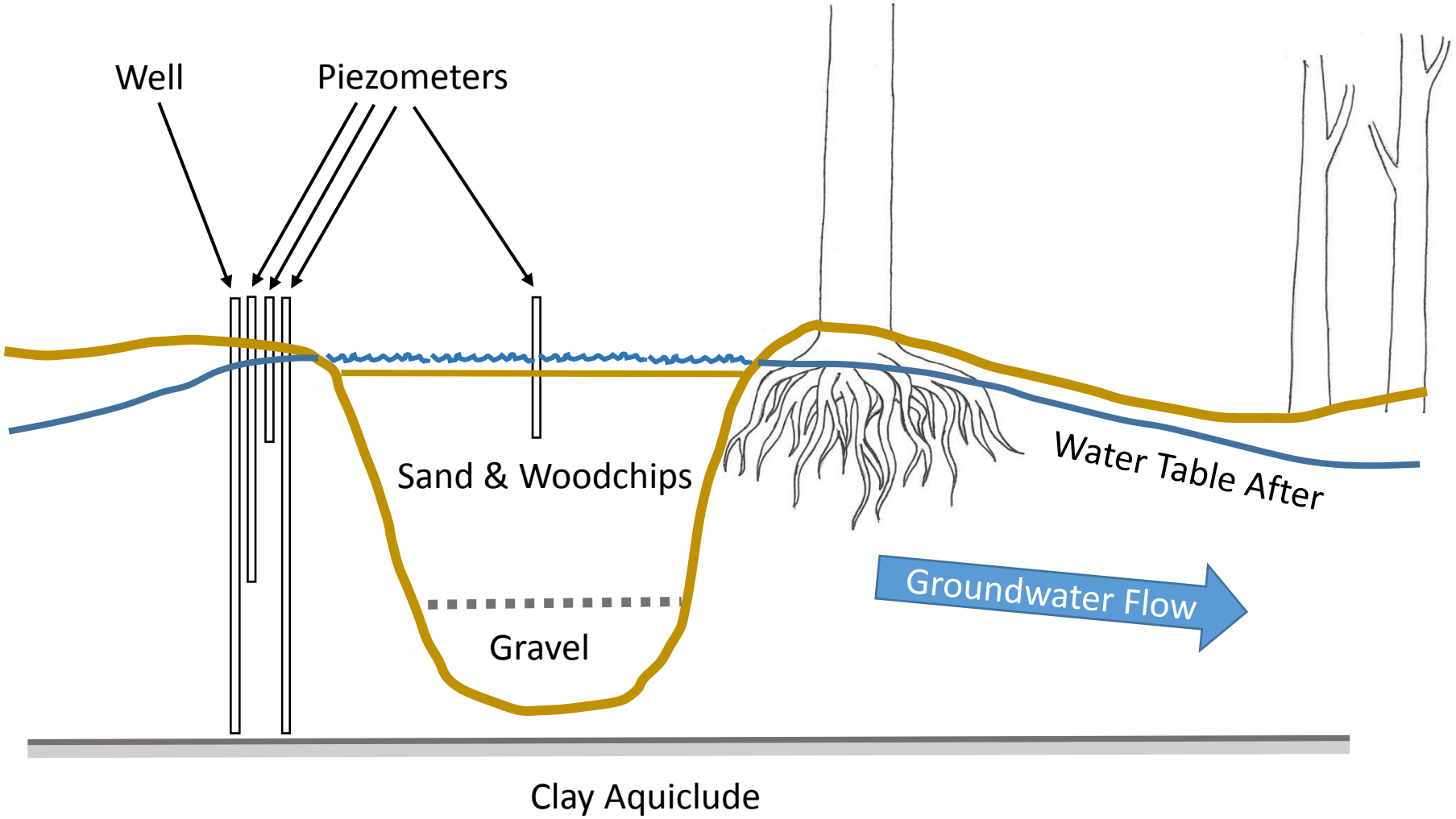



After restoration, groundwater flow is mostly away from the stream.
N
<-0.01
-0.01
0.00
0.01
>0.01
Away from stream
Toward stream

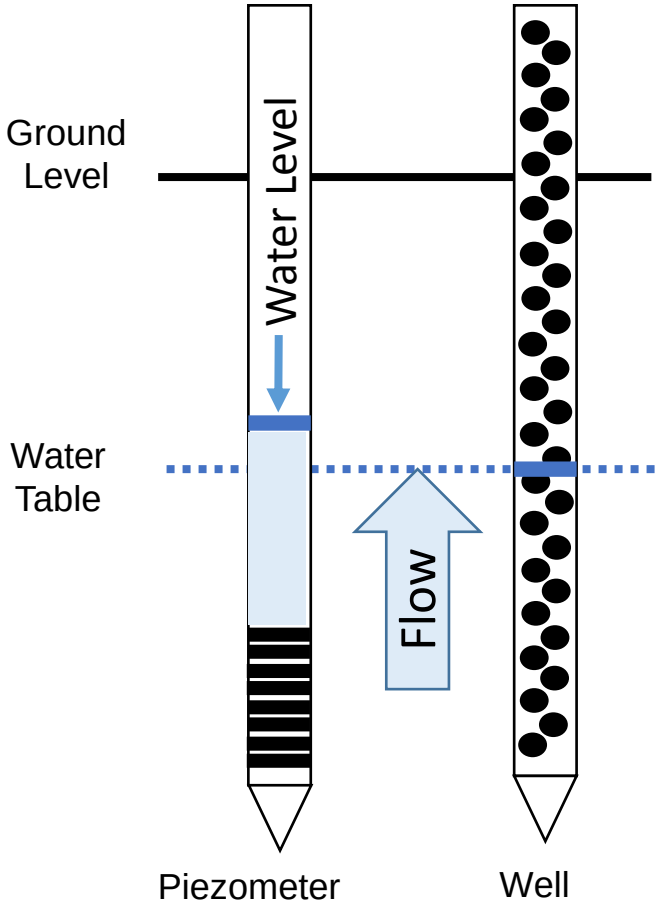
Before restoration, the eroded channel drained the banks.

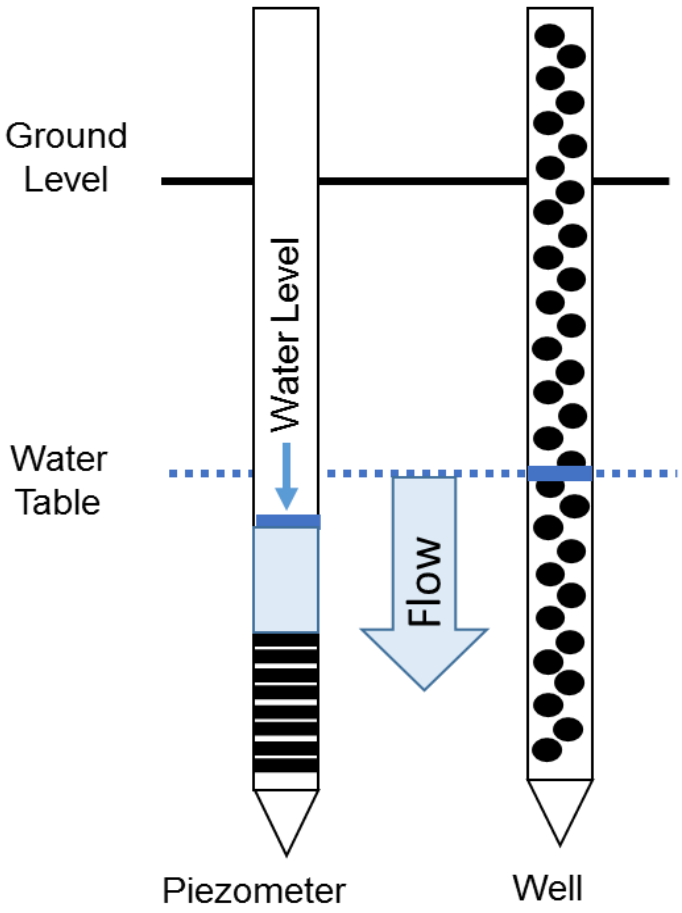


After restoration, the water table elevation increased.



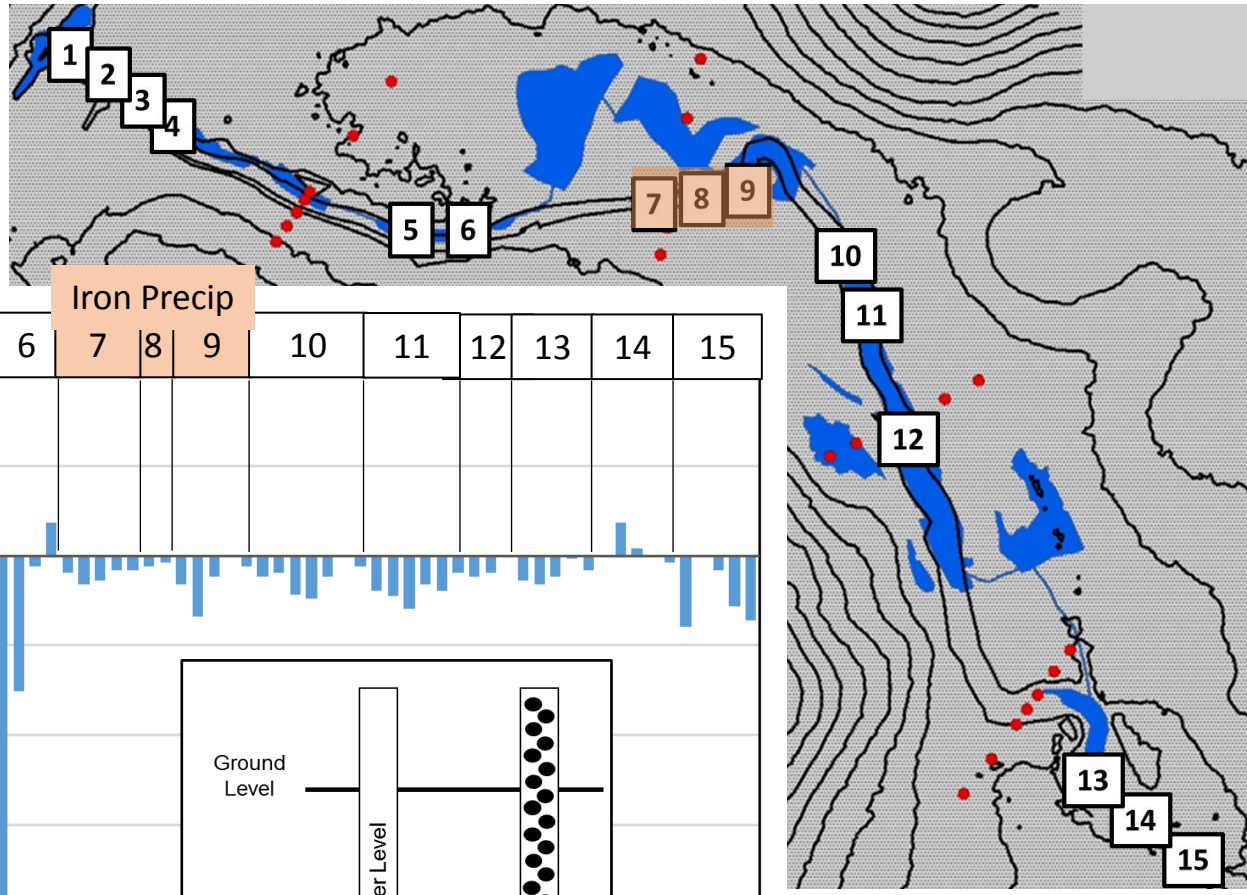
Vertical Pressure Gradients

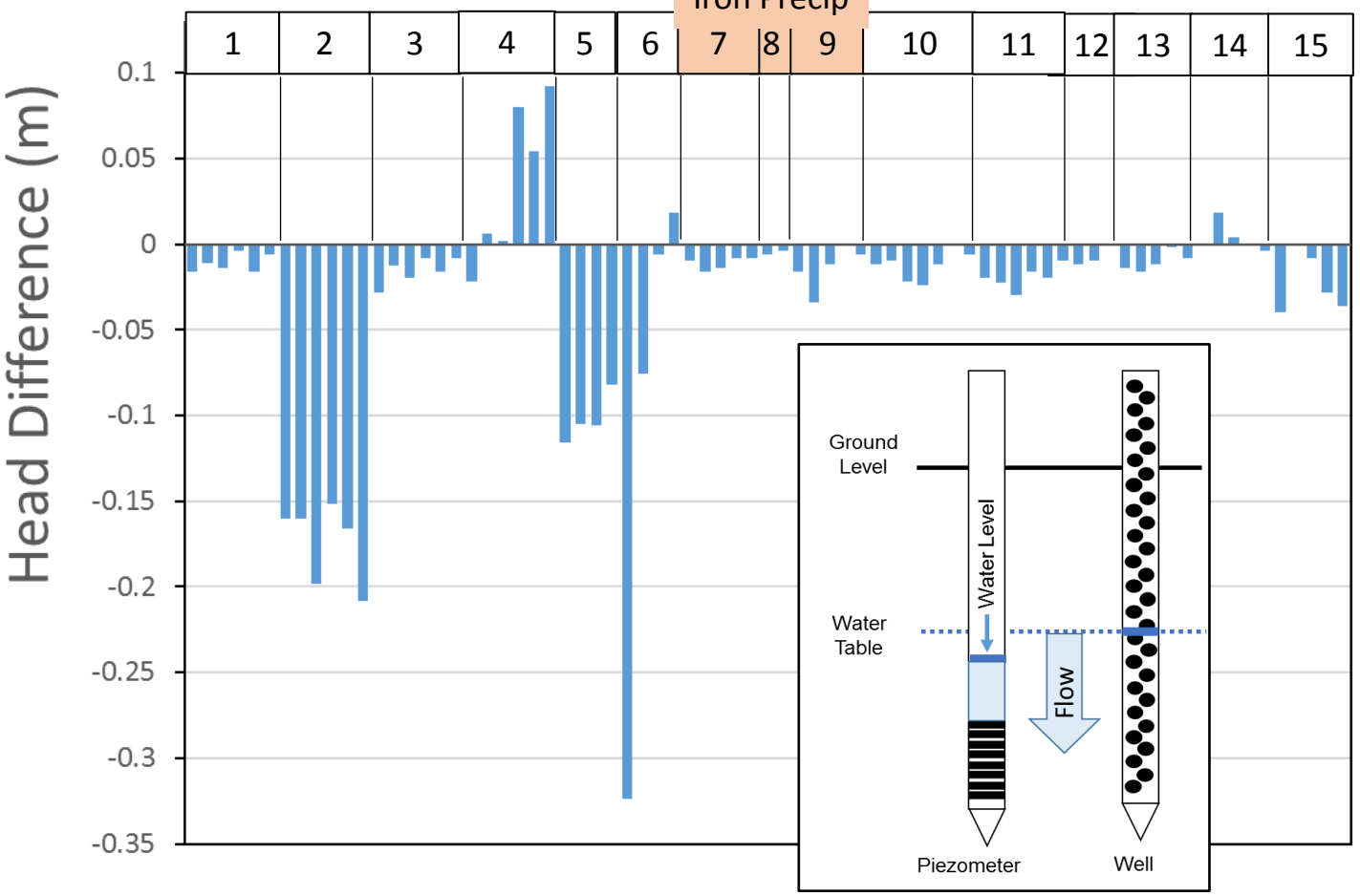




Vertical pressure gradients in streambed groundwater: Negative values suggest infiltration

May-June 2018 data from SERC intern Christina Klein:



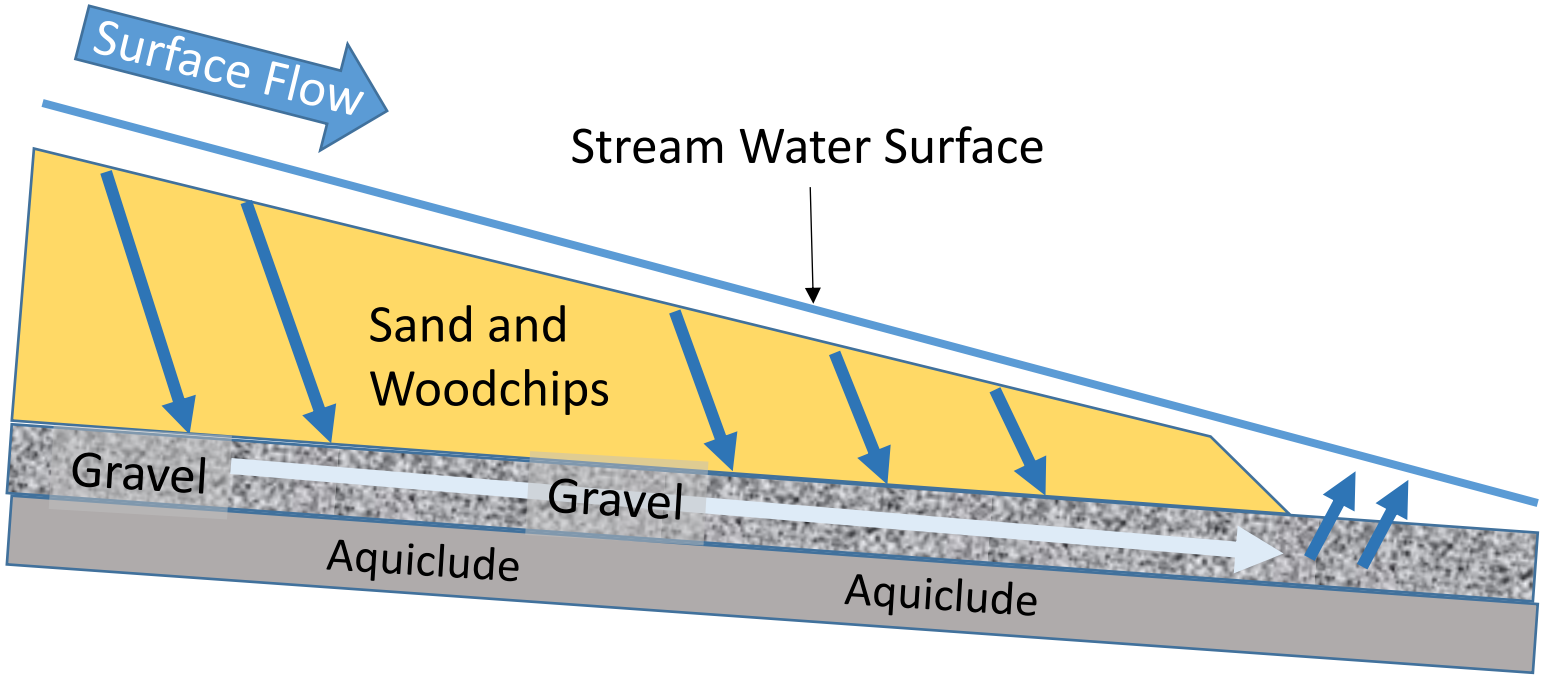


Sand Filter Concept:

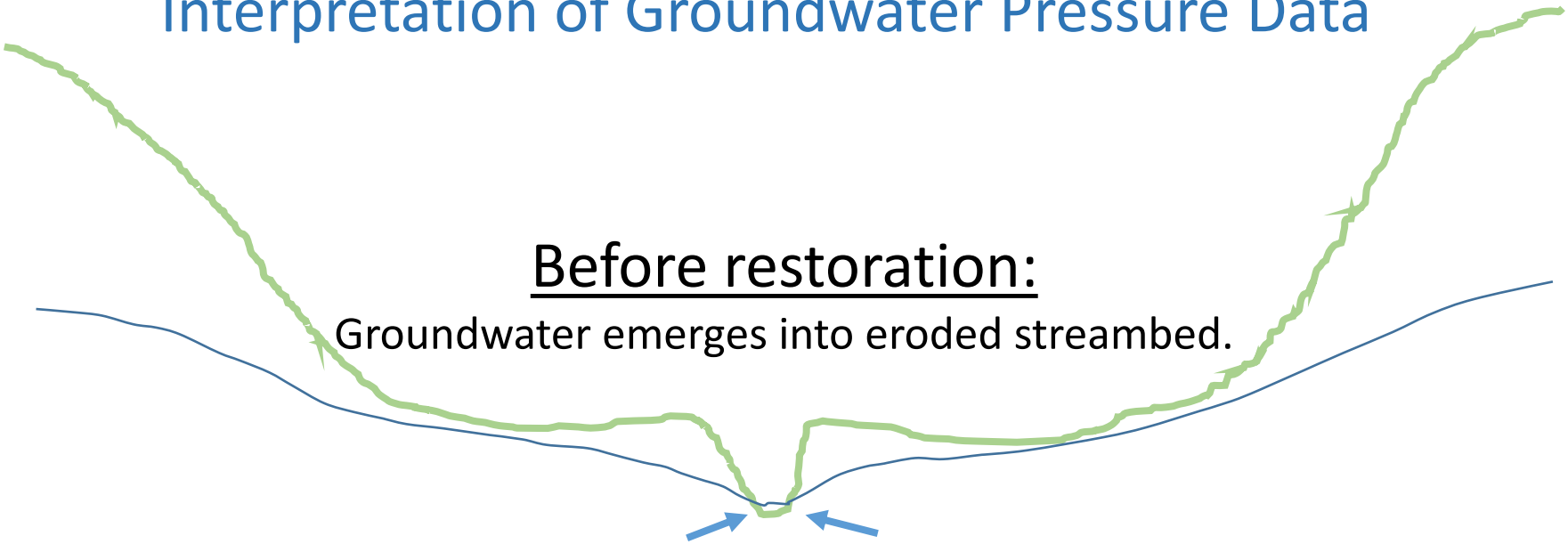
-The gravel layer allows faster groundwater flow than the overlying sand.

-This pulls water downward through the sand.

-At the end of the restored reach groundwater carried through the gravel is released back into the surface flow.



Interpretation of Groundwater Pressure Data

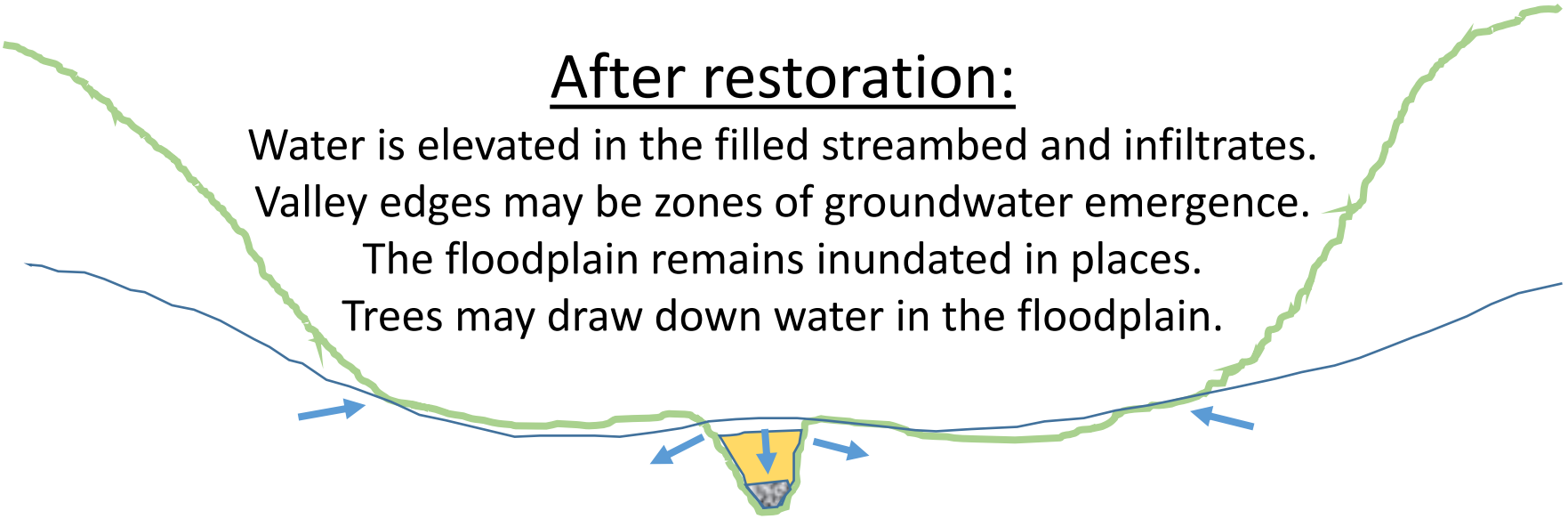


Before restoration:

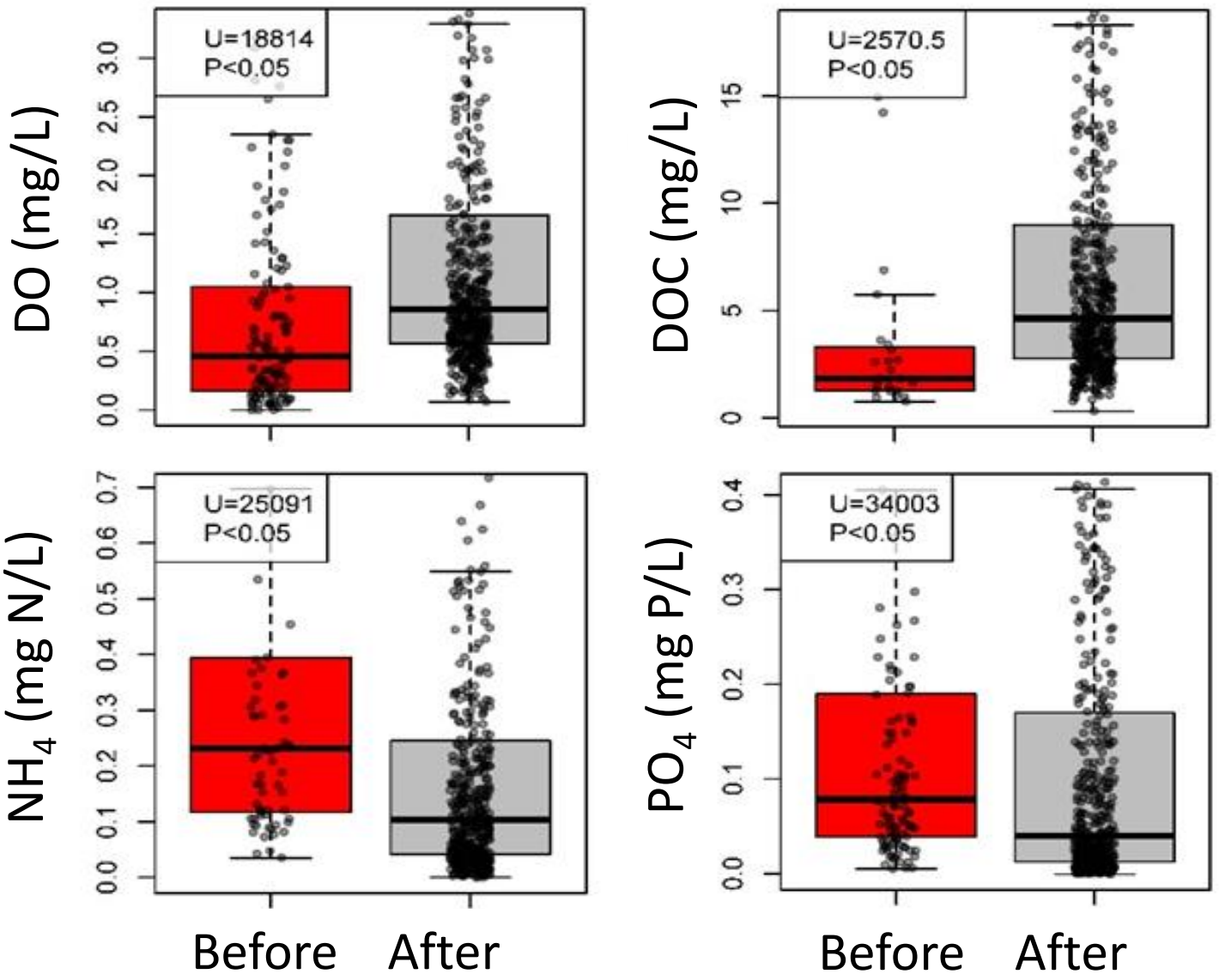
Groundwater emerges into eroded streambed.

After restoration:

Water is elevated in the filled streambed and infiltrates.
Valley edges may be zones of groundwater emergence.
The floodplain remains inundated in places.
Trees may draw down water in the floodplain.



Concentrations in Groundwater Before and After Restoration



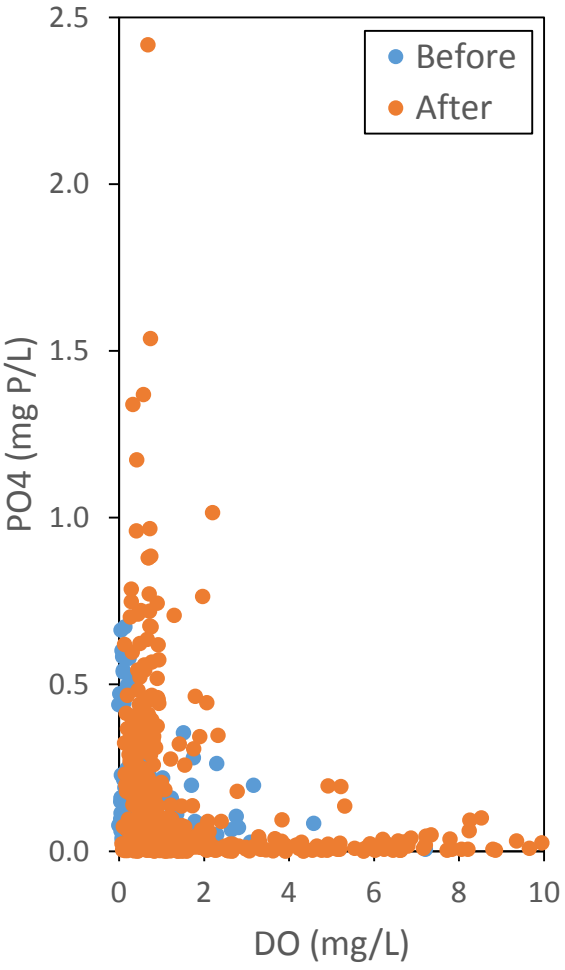
Groundwater chemistry after restoration: Statistically significant changes in dissolved concentrations

Decreased:	Increased:	No change:
Phosphate	Organic C	Nitrate
Ammonium	Iron	
Sulfate	Oxygen	
pH	Conductivity	

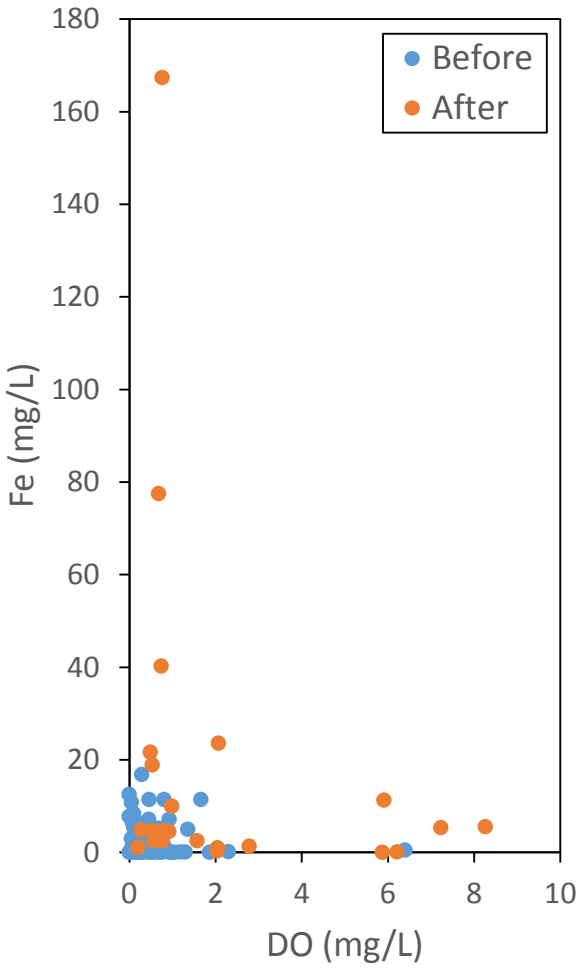
Groundwater chemistry before and after restoration:

Concentrations that were high when dissolved oxygen was low:

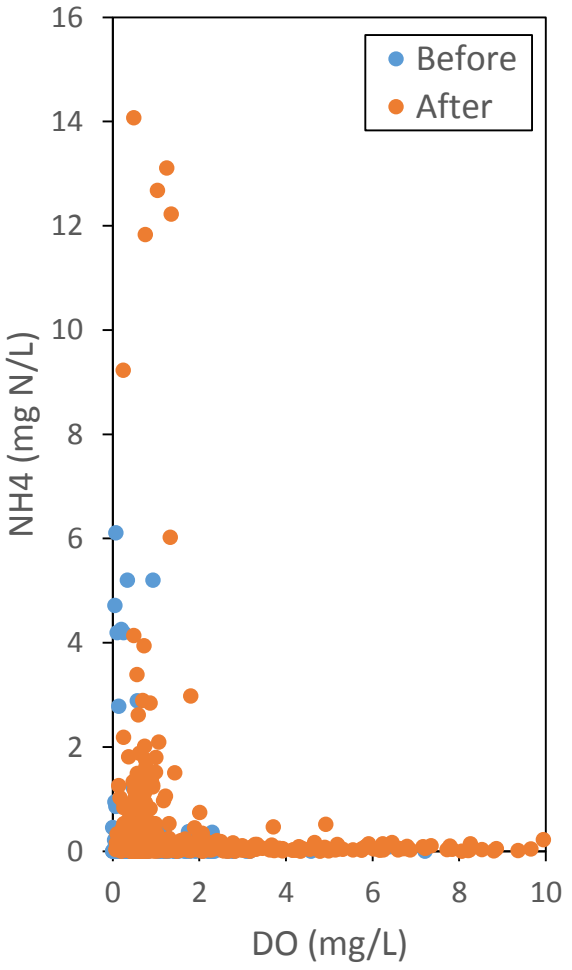
Phosphate



Iron



Ammonium



Summary: Surface Water

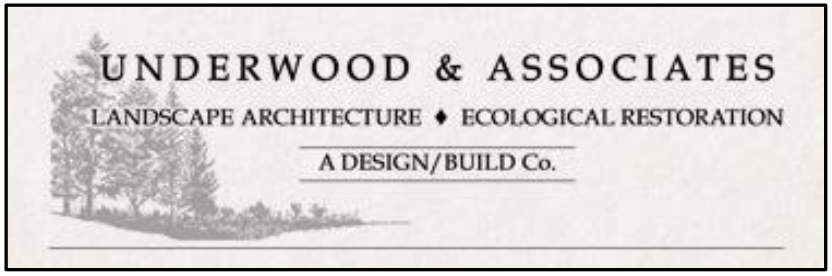
- Comparing loads entering and leaving the restored reach before and after restoration:
  - Significant retentions of: phosphate, total P, ammonium, and total N.

- Comparing control and treatment watersheds:
  - No significant effects of restoration.
  - Effects may have been masked by retentions in beaver ponds downstream of the restored reach.

Summary: Groundwater

- The restoration altered the distribution and flow of groundwater around the restored reach.
- Groundwater chemistry changed after the restoration.
- Enhanced exchanges of surface water and groundwater may contribute to nutrient retention.
- Predominance of infiltration makes it difficult to explain iron precipitation in stream.

We thank these organizations for support:



Rathmann Family Foundation

SERC
Translation Slides

What does this mean for me?

- The RSC performed as expected: nutrient retention increased after restoration (PO_4, TP, NH_4, TN).

- Groundwater dynamics were dramatically altered after restoration; higher groundwater elevation in the floodplain, and increased hyphoreic exchange.

- The gravel layer pulled groundwater through the above sand/woodchip layer, shunting the groundwater to the end of the restoration, where it emerges as surface flow.

- The impact of the beaver pond suggests that beaver ponds/dams can potentially serve as natural nutrient and sediment sinks.

What does this mean for me?

What do I take from this if I am a practitioner?

- Maximizing Hyporheic and ground water interaction may amplify nutrient reductions in stream restorations.

- Consider incorporating design features which mimic the effects of beaver ponds and/or dams (e.g. beaver dam analogs) as cost effective additions to stream restoration designs.

What do I take from this if I am a regulator?

- Consider the above design features when reviewing designs.

- Pre-restoration water quality data can be extremely valuable in the design of stream restorations to maximize water quality uplift.