

# WATER QUALITY CHALLENGES IN GROUNDWATER INFLUENCED STREAMS

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## Collaborators and Students:

- Dr. Marty Briggs (USGS, Hydrogeophysics Branch)
- Dr. Janet Barclay and Dr. Jeff Starn (USGS, NE Water Science Center)
- Eric Moore, Kevin Jackson, Adam Haynes (UConn, NRE grad students)
- Becky Thielman, Kenny Bell, Huayile Zhang, Fiona Liu (field assistants)

## Funding Sources:

- NSF-EAR Hydrologic Sciences grant 1824820
- USDA National Institute of Food and Agriculture, Hatch project CONS00938
- CT Institute of Water Resources 104b grant (2016CT306B)



# Groundwater discharge to streams

- Maintains streamflow
- Critical habitat for temperature sensitive species
- Provides nutrients

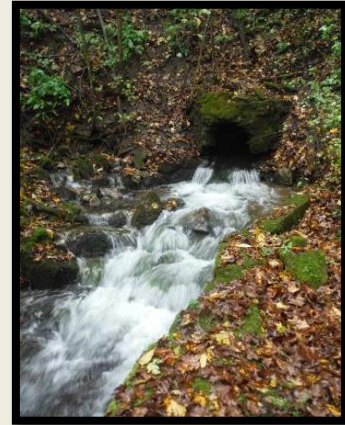
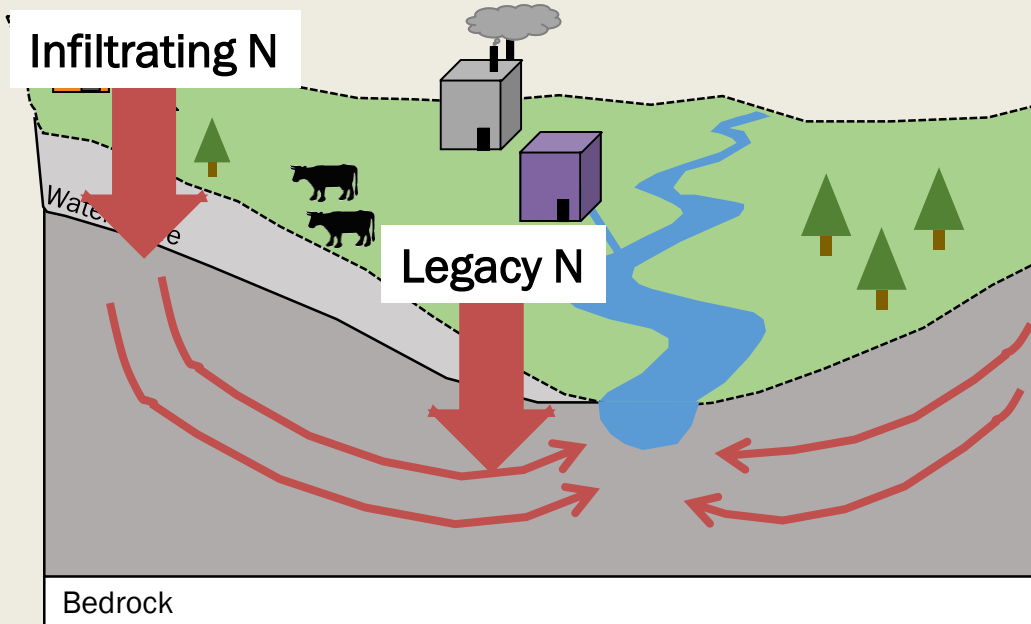


Photo credit: WI Geological & Natural History Survey



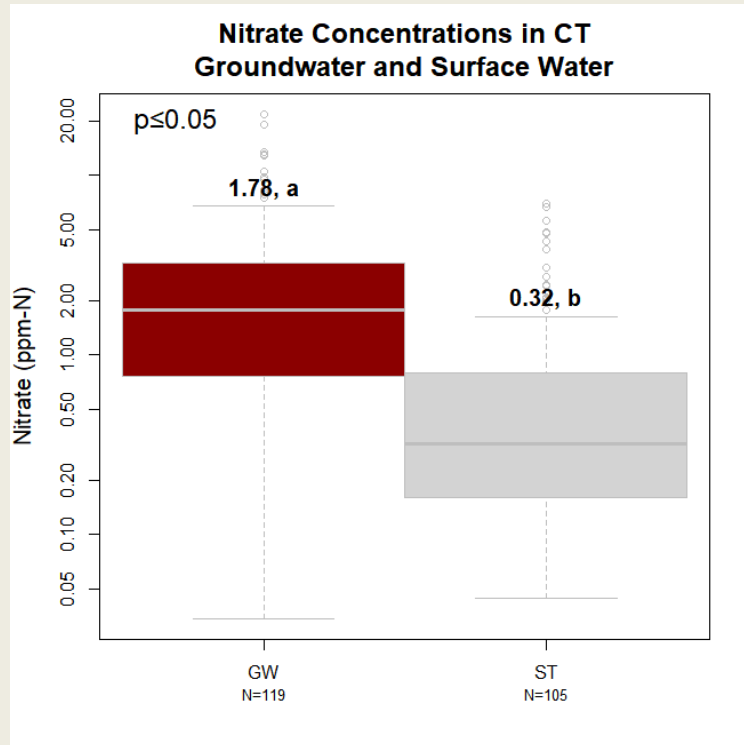
Photo credit: VT Fish & Wildlife Service

# Legacy nutrients & contaminants in groundwater discharge to streams



E.g., 55% of contemporary nitrogen loads from the Mississippi River are > 10 years old<sup>1</sup>

# Examples in CT – Nitrogen



# Examples in CT – Forever chemicals

UConn HEALTH MINUTE

COVID-19 Precautions

EXPAND  
▽

## What Are The PFAS Chemicals Involved In The Farmington River Spill?

By DIANE ORSON & HARRIET JONES • JUN 18, 2019

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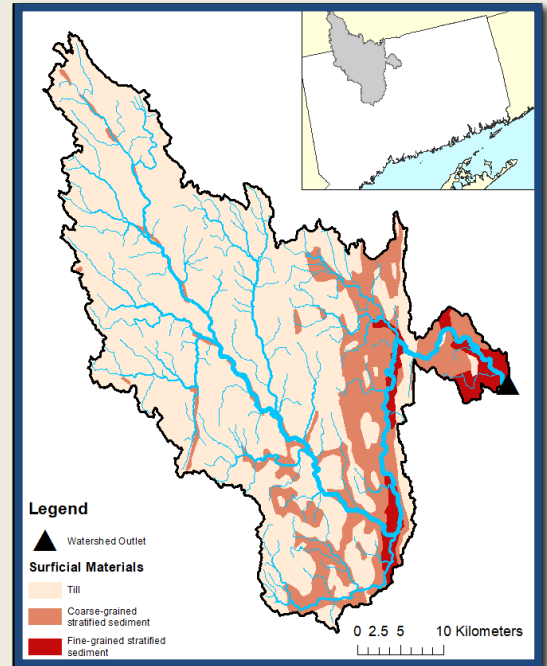


*Firefighting foam that spilled into the Farmington River June 9, 2019.*

COURTESY: CT DEPARTMENT OF ENERGY AND ENVIRONMENTAL PROTECTION

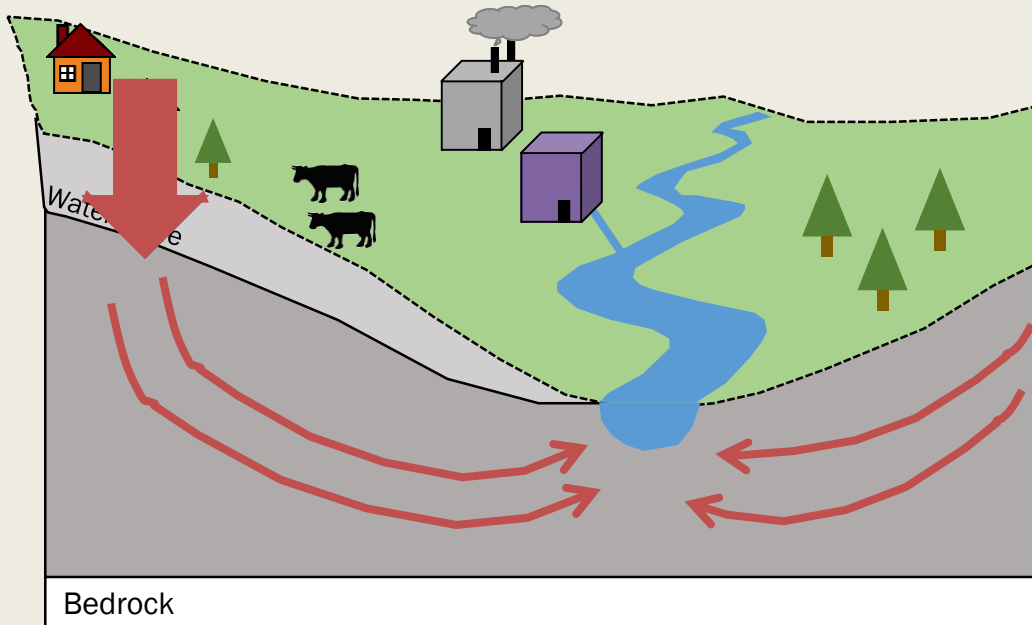
# Focal Watershed: Farmington River Watershed

- 1571 km<sup>2</sup>
- Primarily forested, with areas of development and agriculture
- Primarily glacial till, with areas of fine and coarse sediments



# Challenges

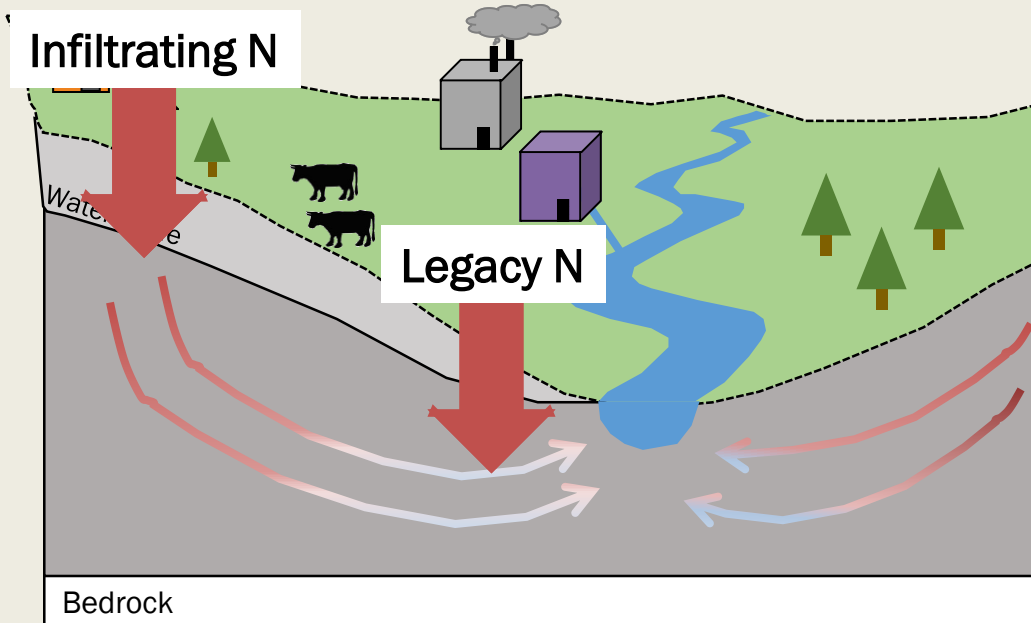
1. Where is groundwater discharging?



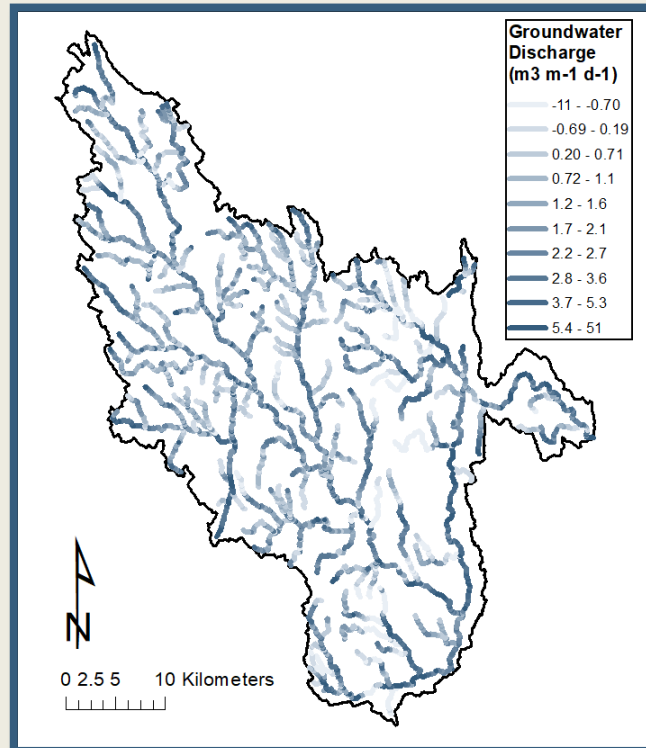


# Challenges

1. Where is groundwater discharging?
2. What is the water quality of groundwater discharge?



# Basin-scale groundwater models – Groundwater discharge Patterns



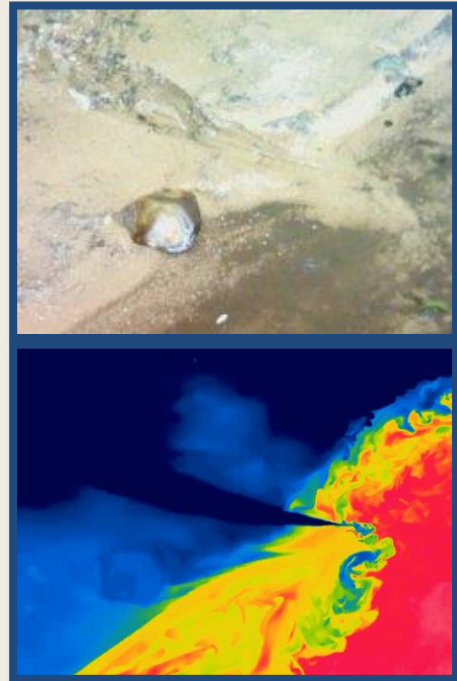
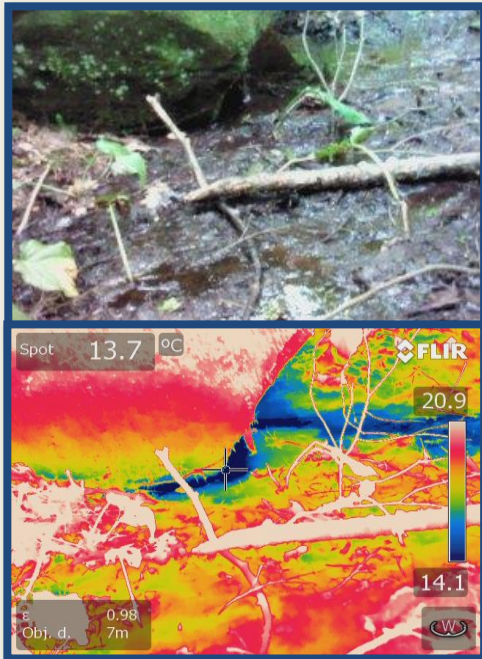
Barclay et al In Revision

# “Seeing” Groundwater Discharge



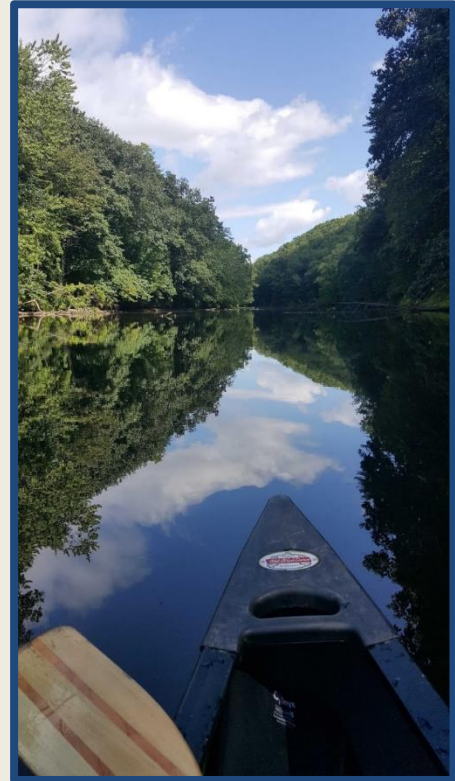
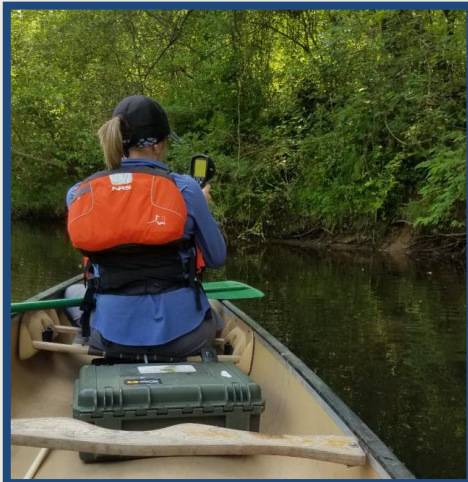
# “Seeing” Groundwater Discharge

Thermal Infrared (TIR) gives a **picture of the surface temperature**



# “Seeing” Groundwater Discharge

Thermal Infrared (TIR) gives a **picture of the surface temperature**



## Large River (Paddling)

Length: 31 km (2017) & 27 km (2019)

Stream Order: 5 (main stem)

## Small Streams (Wading)

Length: 5.6 km (2017) & 2019/2020 ongoing

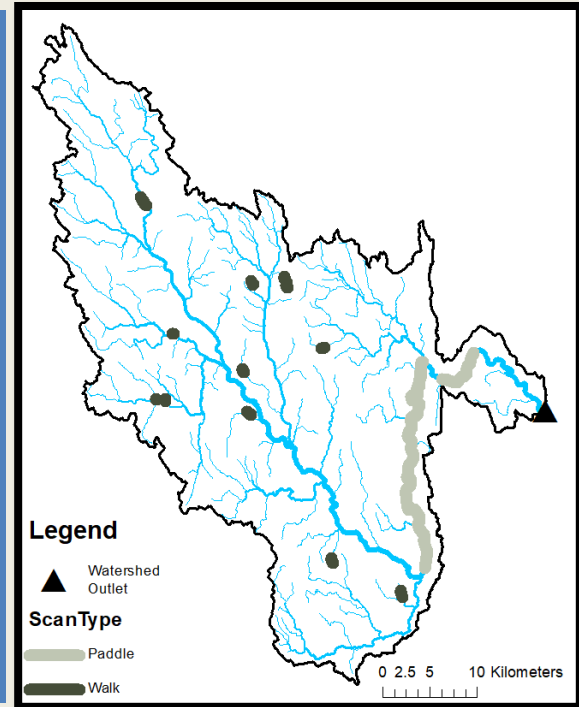
Stream Order: 1-4

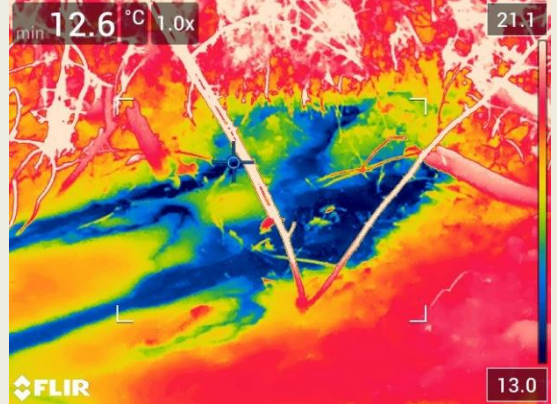
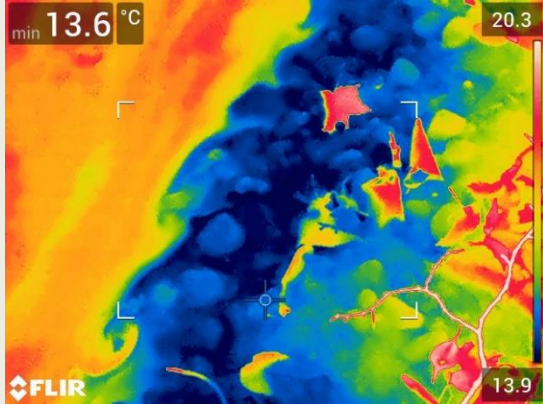
Number of Streams: 10 (2017)

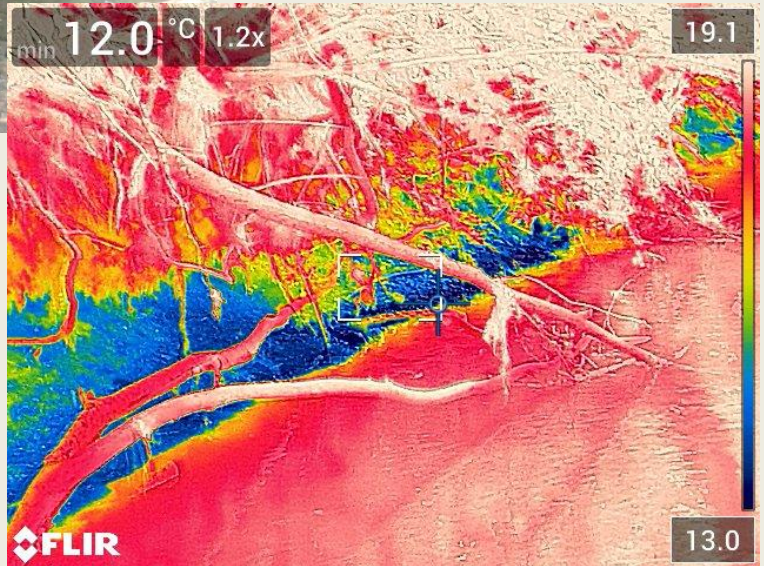
## Conditions

Time: Late Summer / Early Fall

Flow: Low Flow



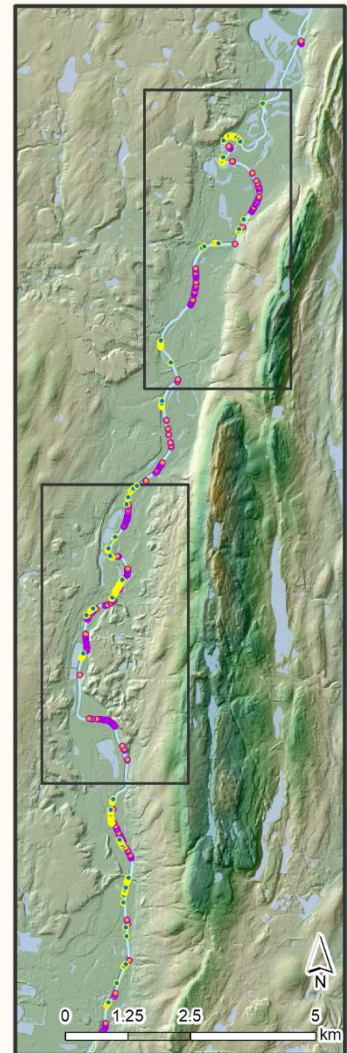






# Survey Results – Map of Groundwater Discharge Zones

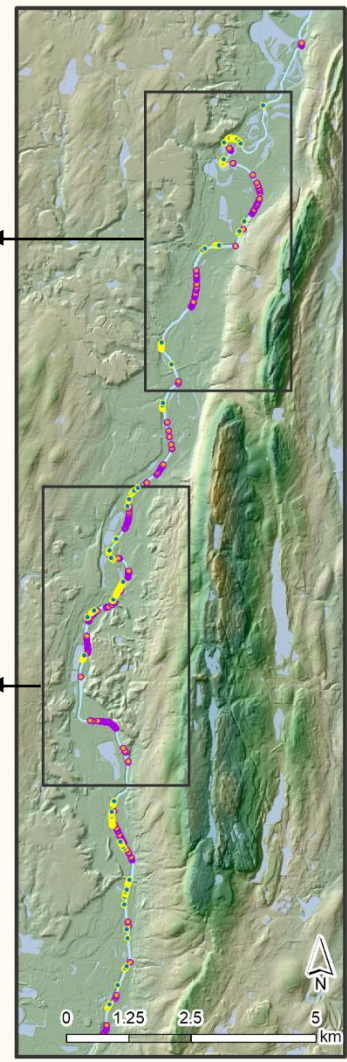
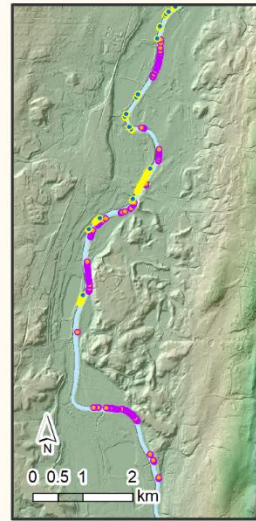
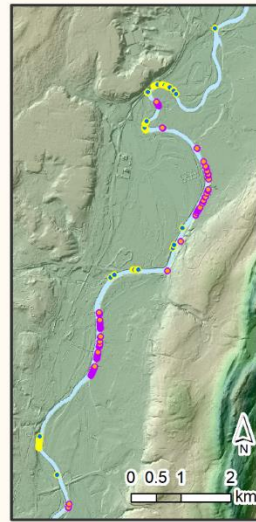
- 27 km, 162 groundwater discharge locations (2019)
- GW discharged occurred along 1.52 km of river left and 2.43 km of river right



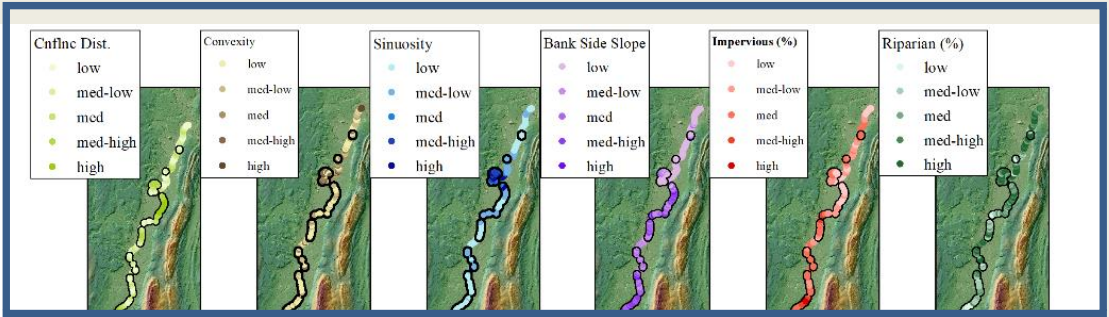
# What determines where discharge occurs?

Local Curvature

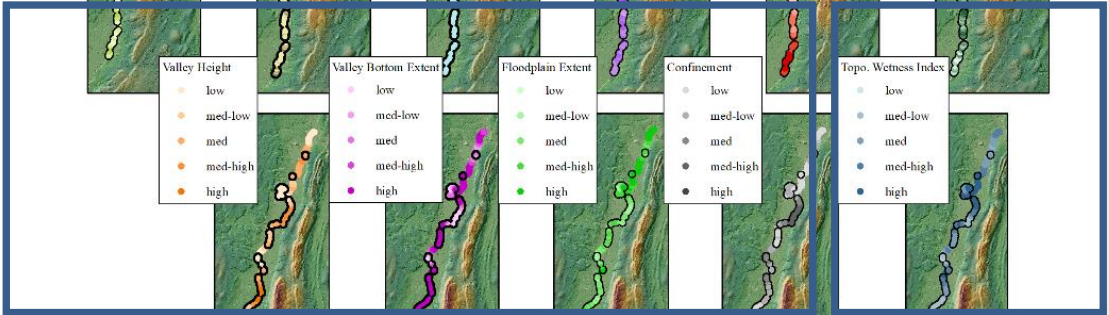
Valley Confinement



LOCAL

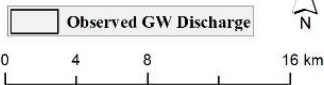


VALLEY

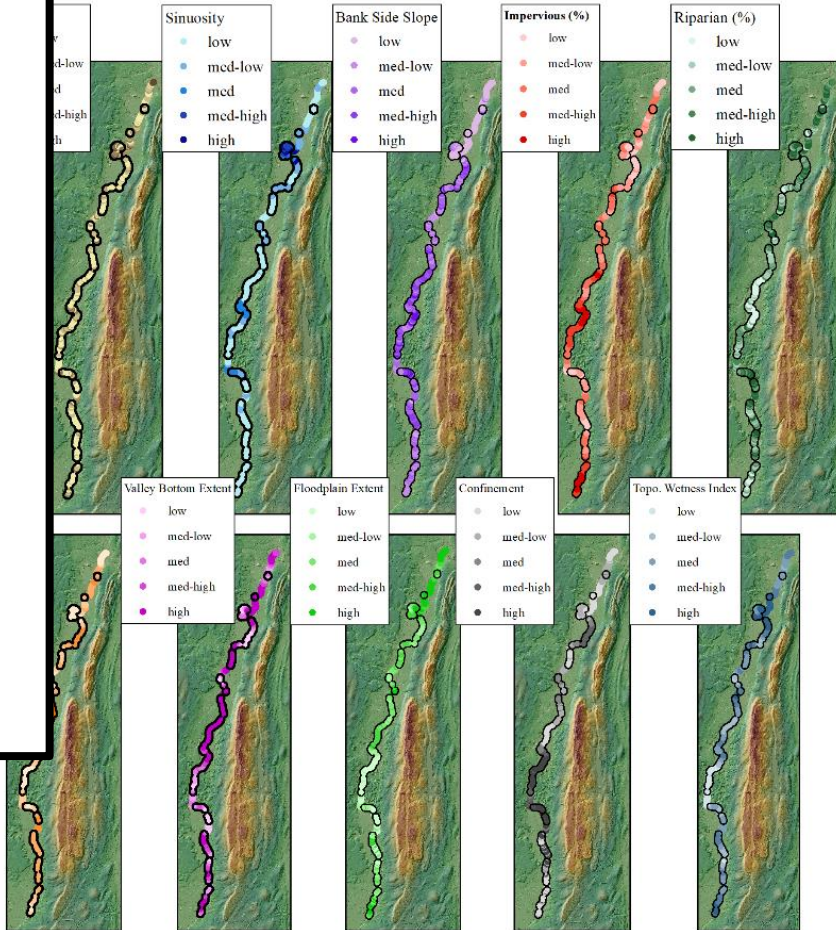
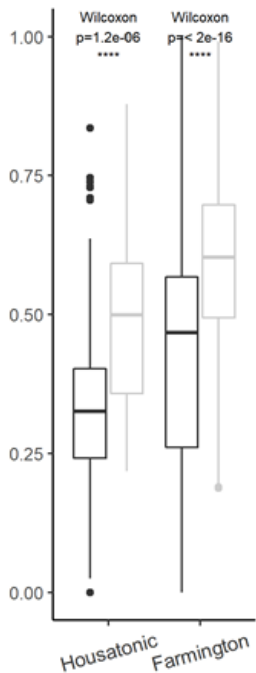


SUBSURFACE

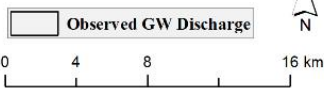
### Farmington River

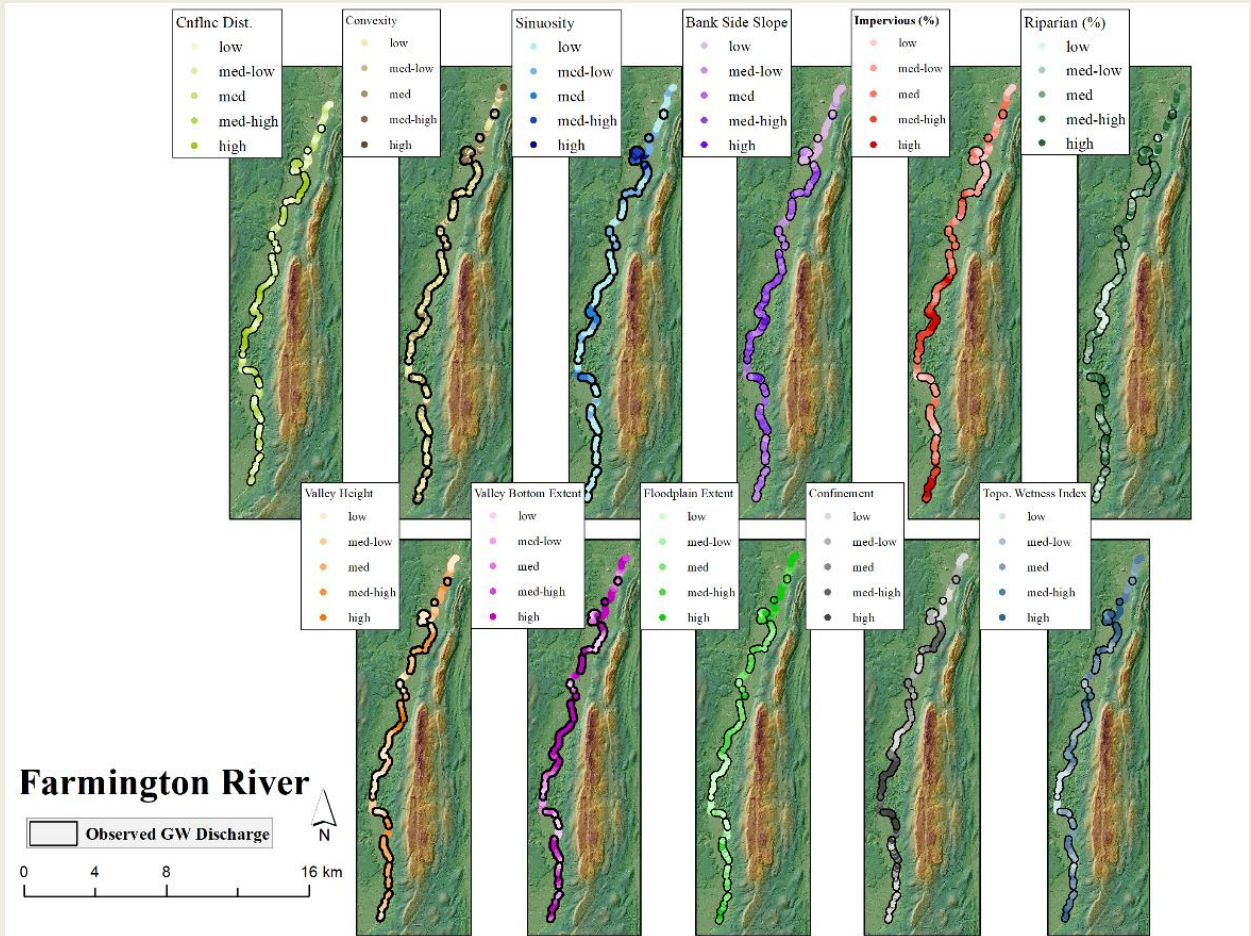


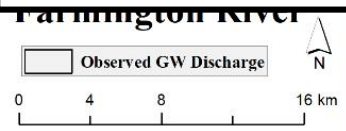
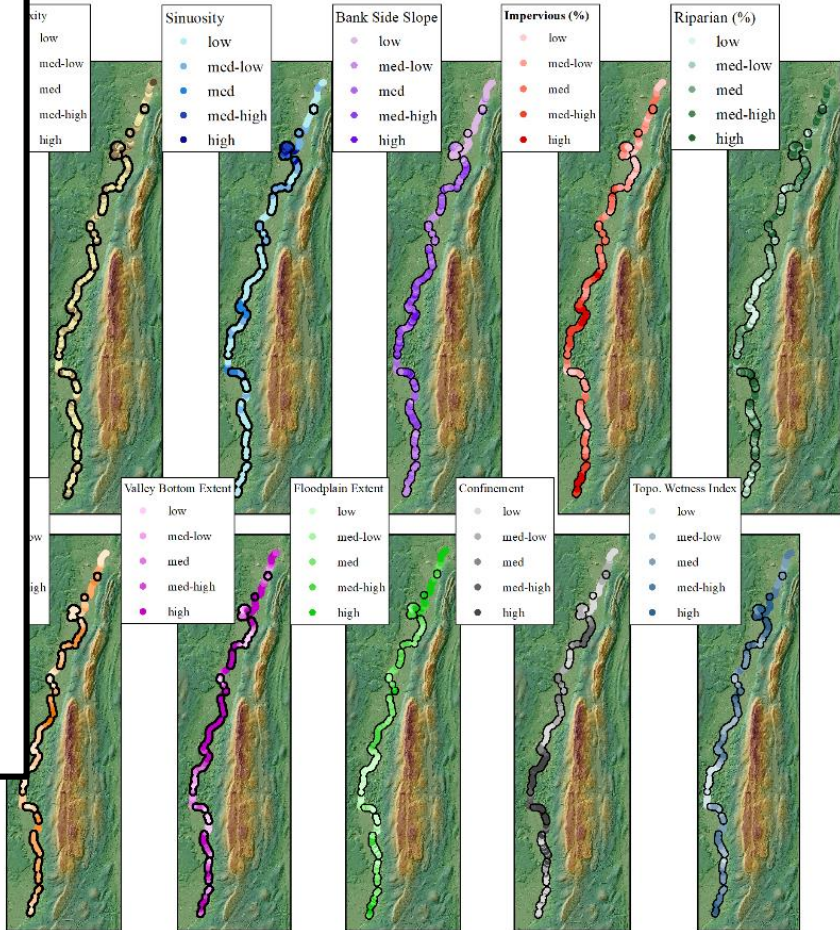
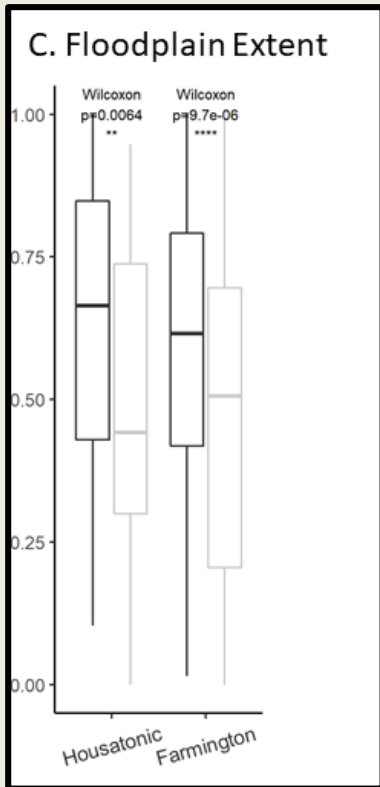
# A. Bank Side Slope



## Farmington River

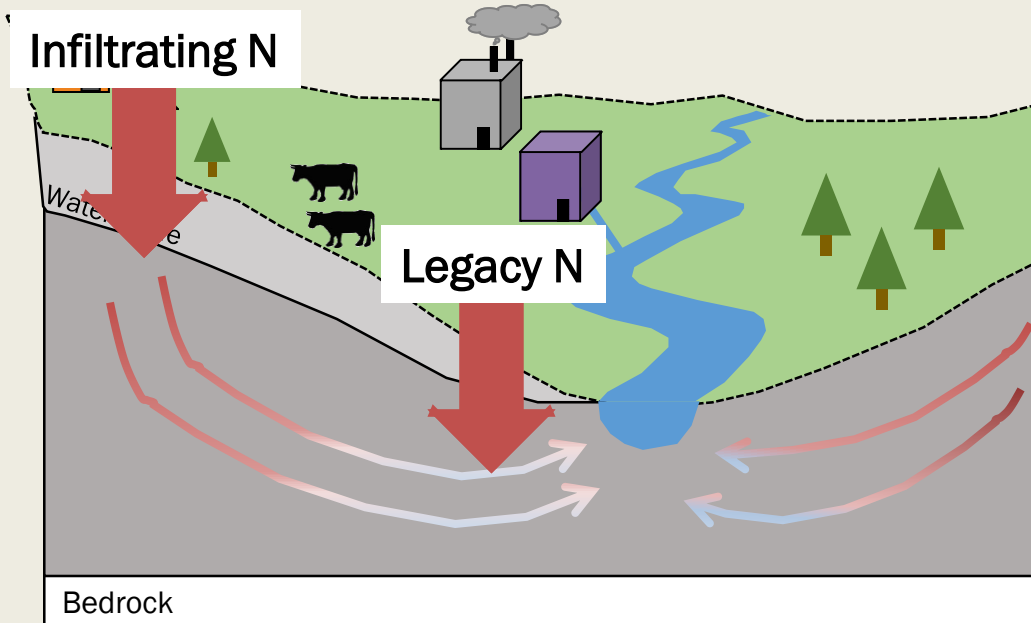




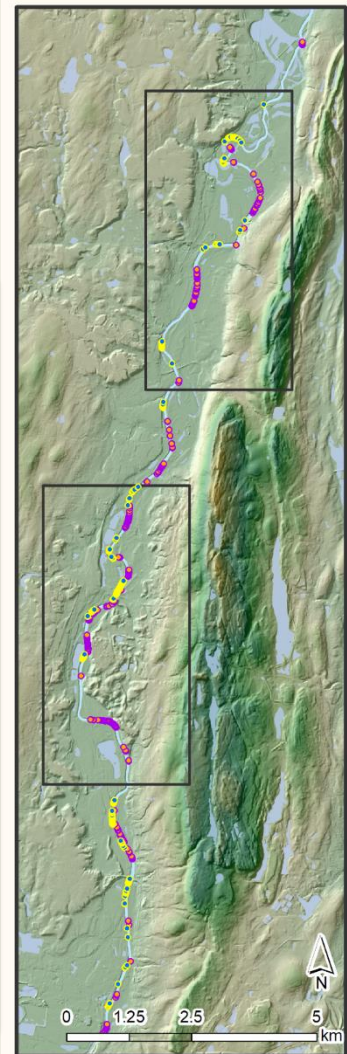


# Challenges

1. Where is groundwater discharging?
2. What is the water quality of groundwater discharge?



# Water sampling

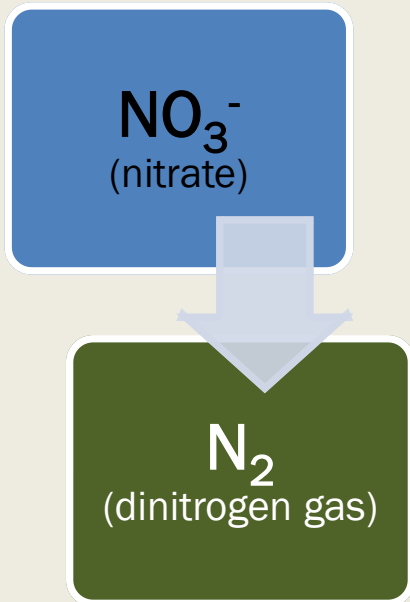


## Variables:

- Nitrogen species
- Dissolved oxygen
- Chloride, sulfate
- Dissolved OC
- GHGs
- Ar/N<sub>2</sub> (Denitrification)

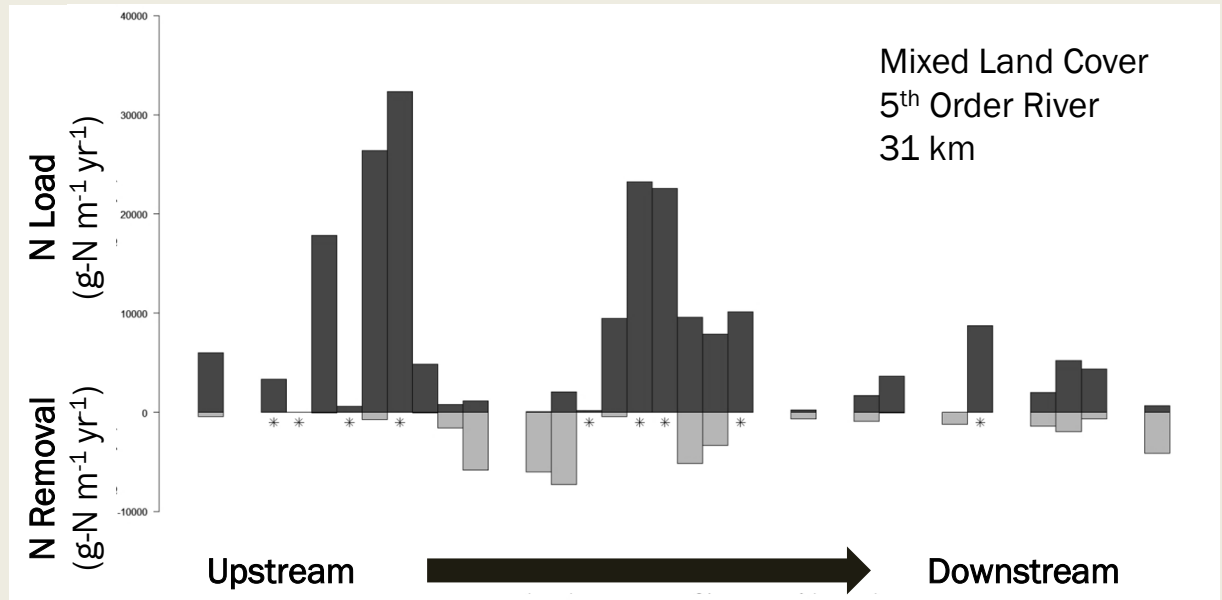


# Denitrification (N Removal)

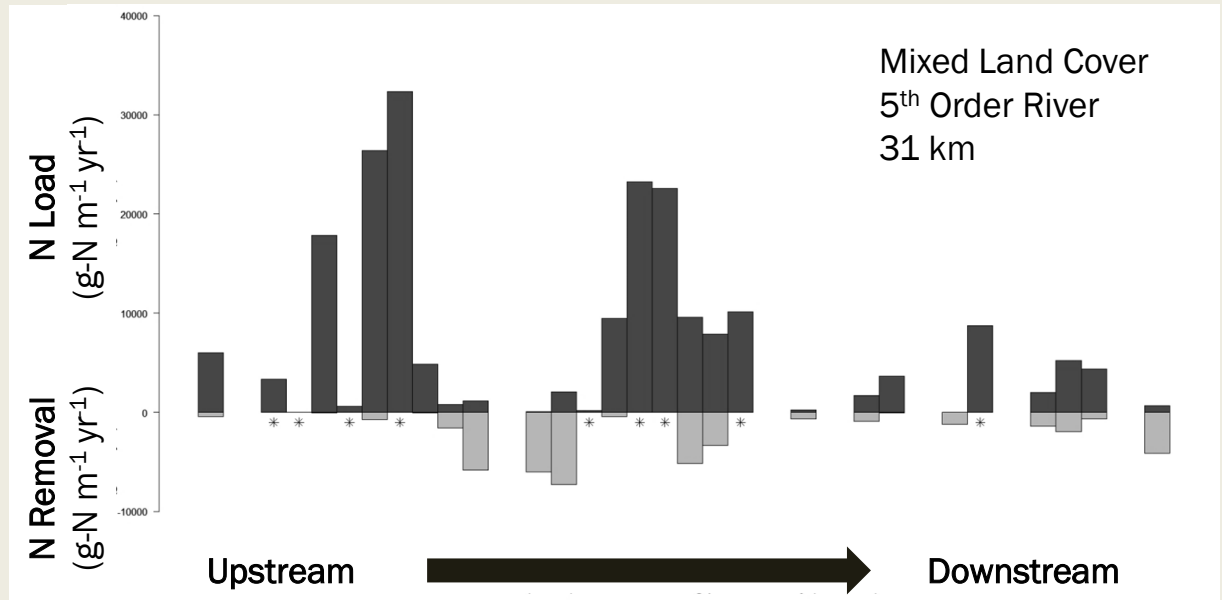


- Reaction rates vary widely
- Rates are driven by reaction conditions in the subsurface

# Nitrogen loading and removal is spatially heterogeneous

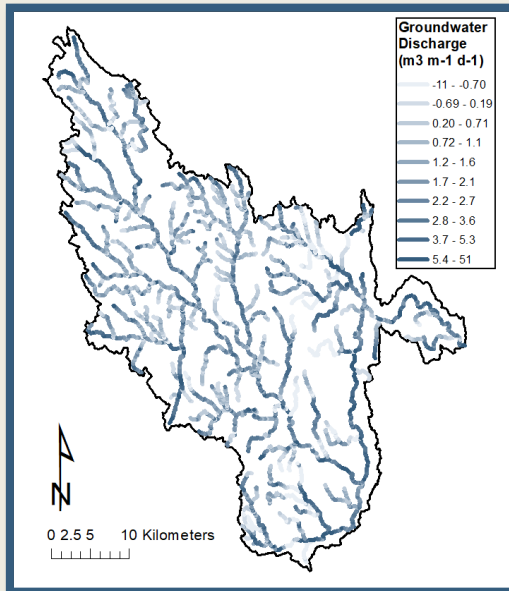


# Nitrogen loading and removal is spatially heterogeneous.. Why?

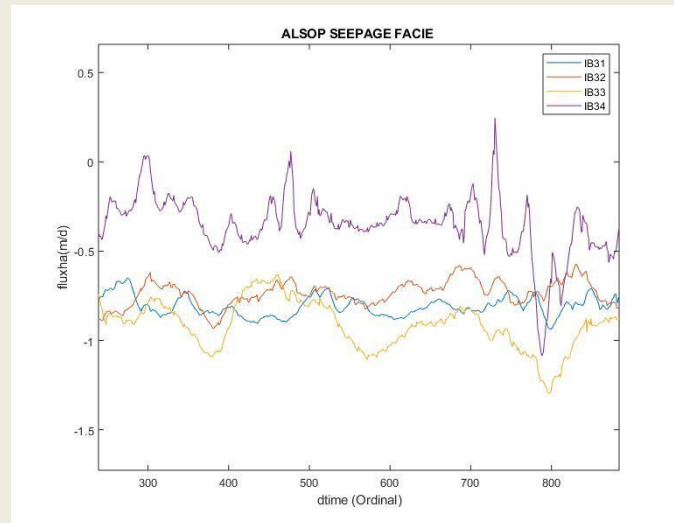


# Nitrogen loading and removal is spatially heterogeneous.. Why?

1. Groundwater fluxes vary a lot!



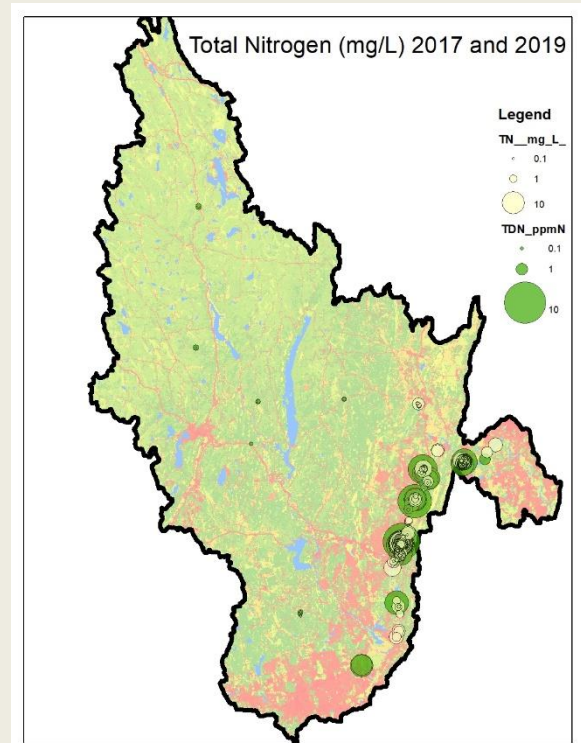
Barclay et al. In Revision



Haynes et al. In Preparation

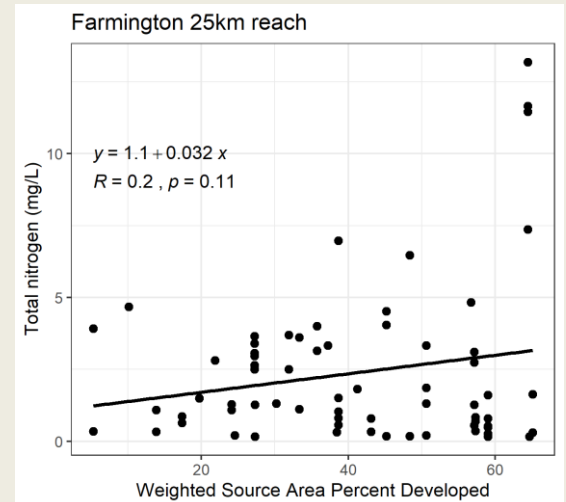
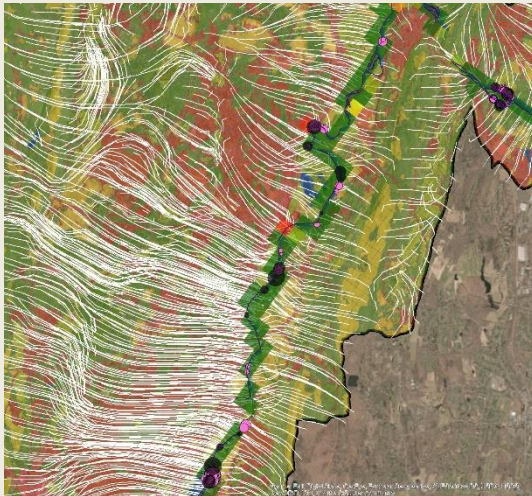
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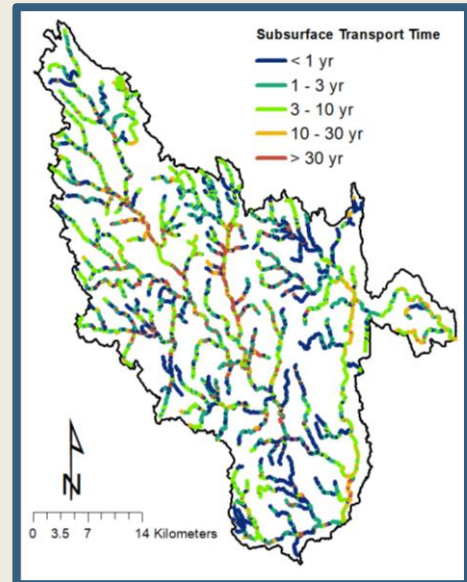
1. Groundwater fluxes vary a lot!
2. So do nitrogen concentrations
  - a) Infiltration
  - b) Removal

Modeling Denitrification with Sulfate and Carbon:

Variable	Coefficient	p - value
$\ln(\text{SO}_4^{2-})$	0.45	2.22E-03
$\ln(\text{DOC})$	0.47	8.24E-04

p-value: 1.90E-05; Adj. R<sup>2</sup>: 0.39

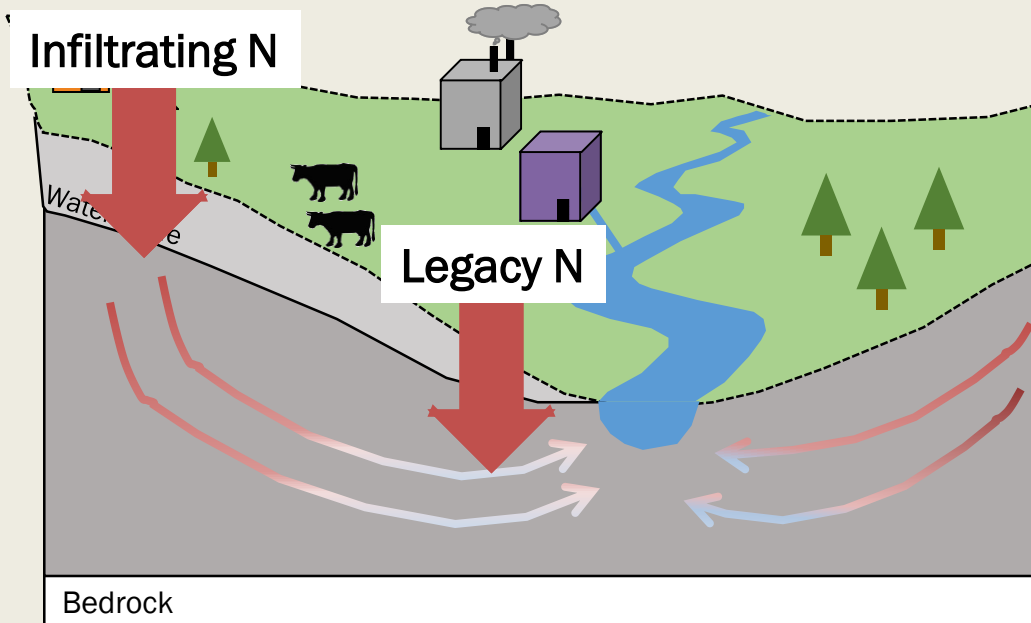
## Residence Time



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Questions?

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