



WATER RESOURCES SERVICES

 **INTERA**

Presented to the City of Angola | July 27, 2022

Agenda

01

Basic Hydrology

02

Water Availability
Assessment

03

Future
Availability

04

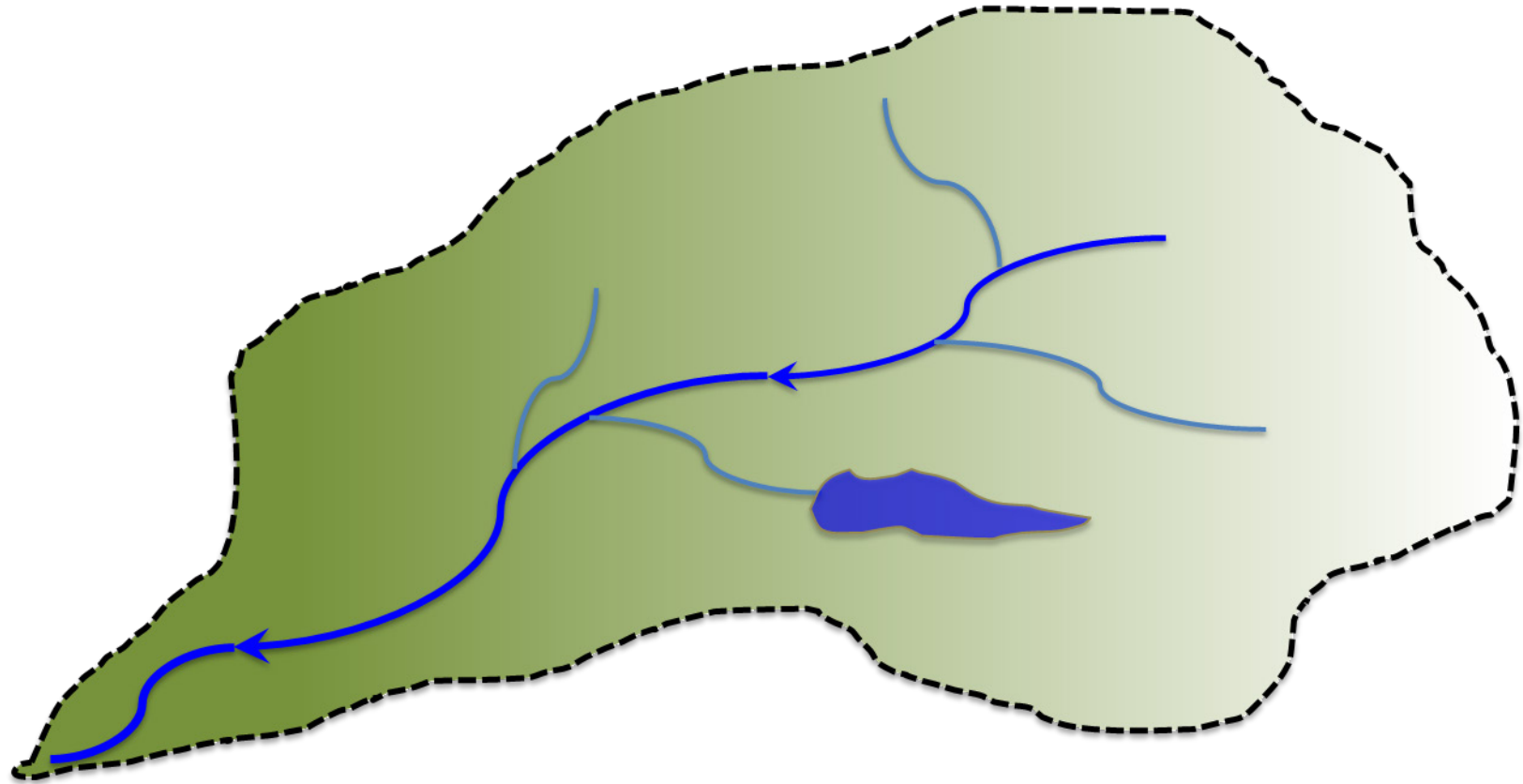
Monitoring
Network

05

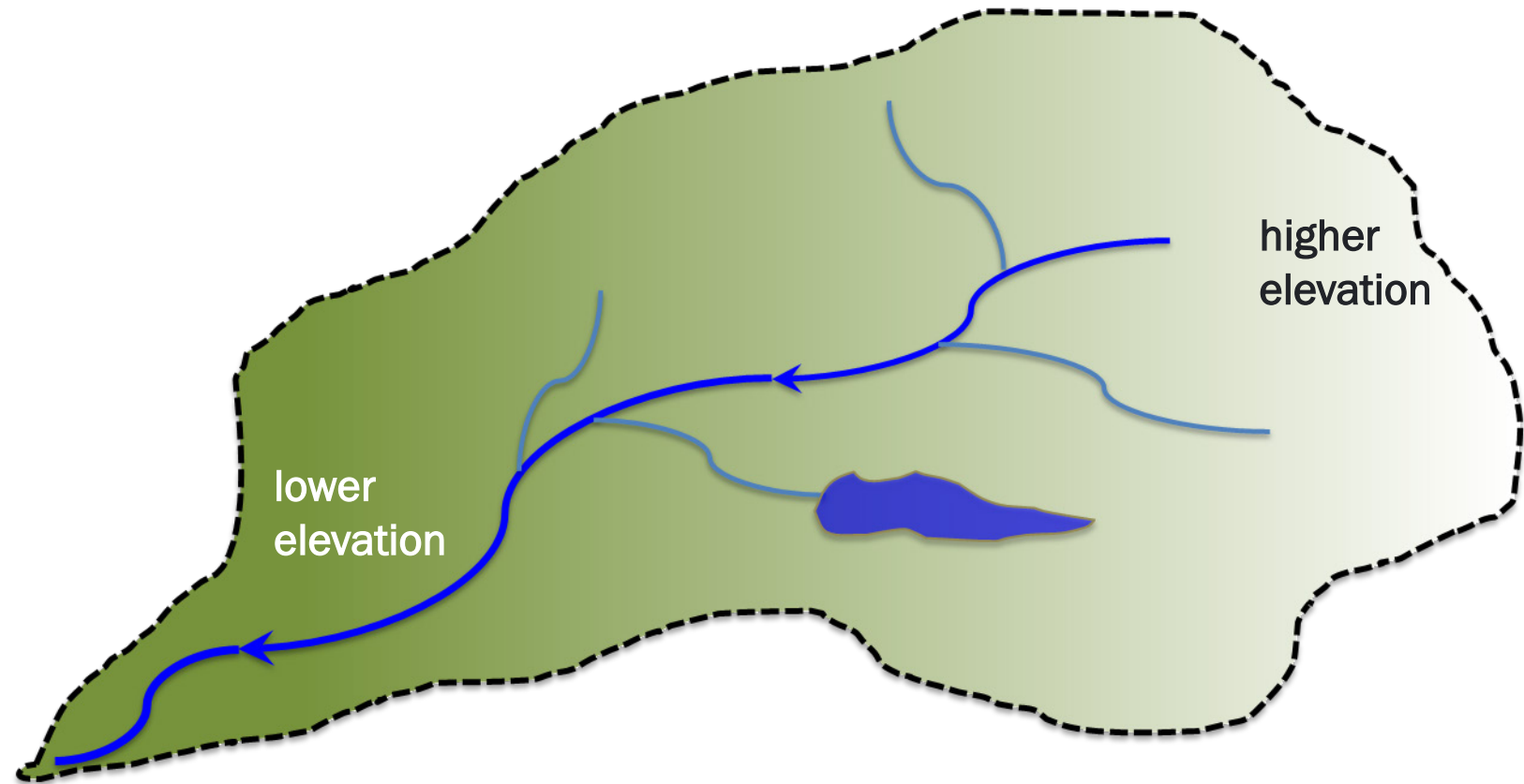
Next Steps

1. Basic Hydrology

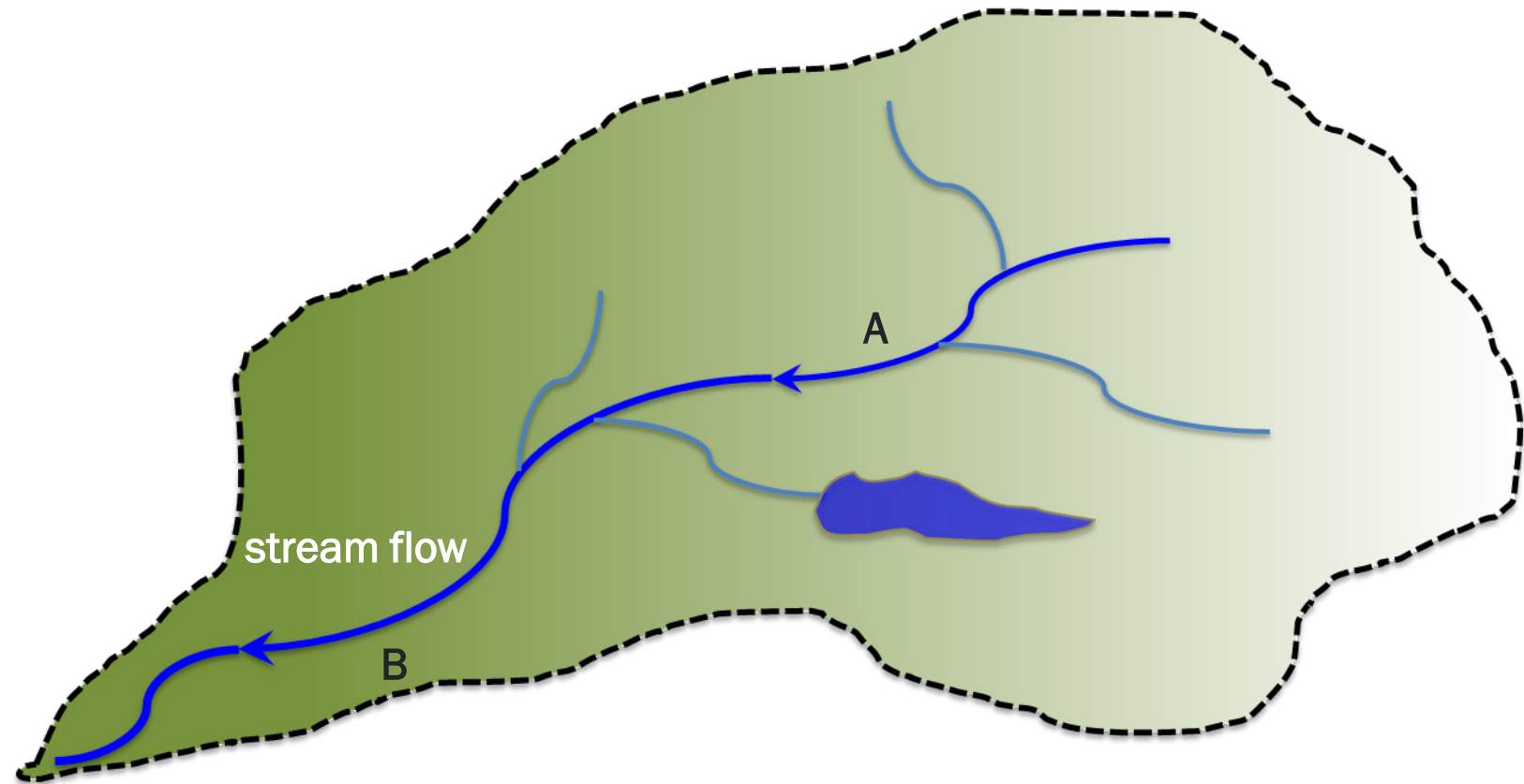
How much water is in an ideal watershed?



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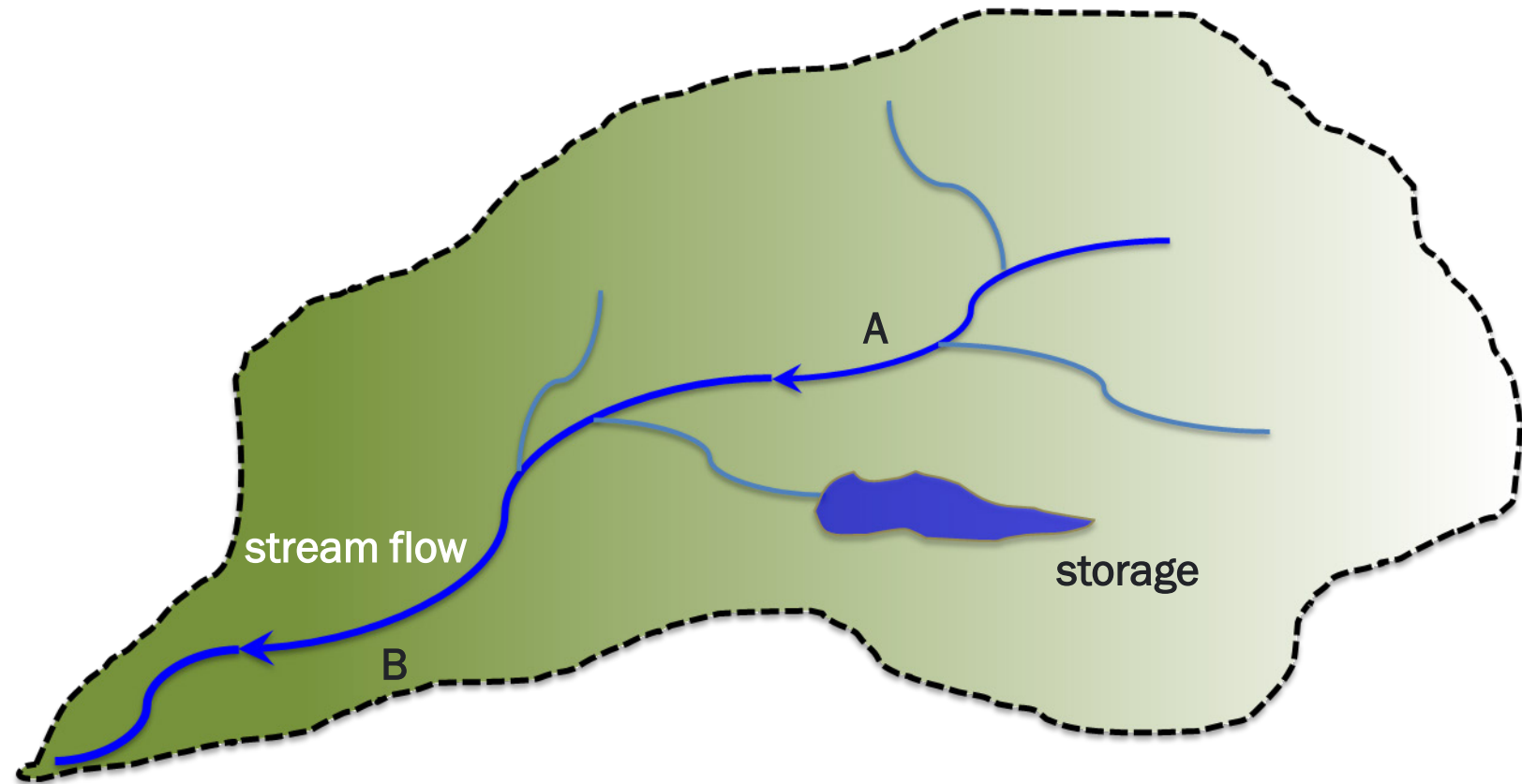


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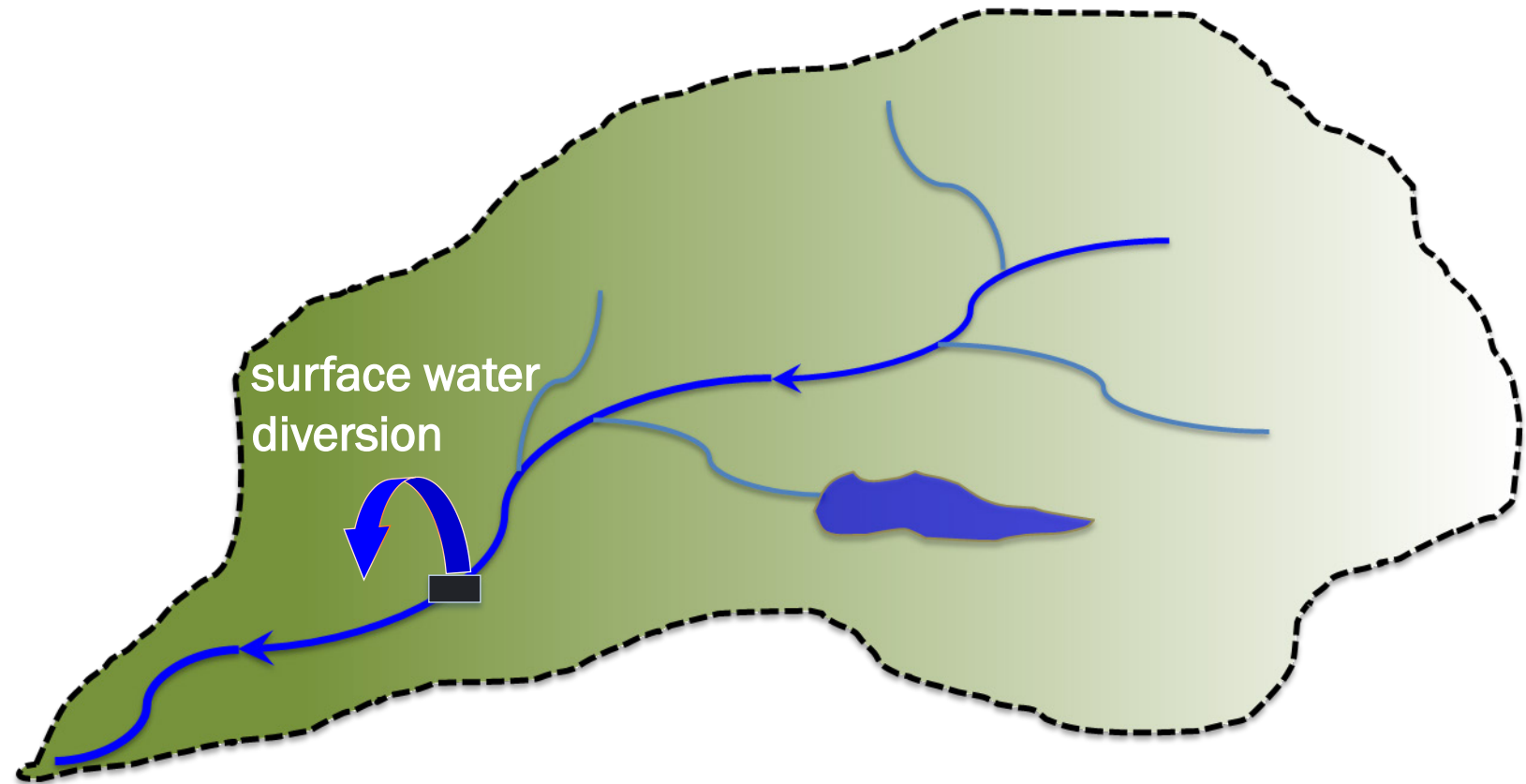


Stream flow at "A" less than the stream flow at "B"

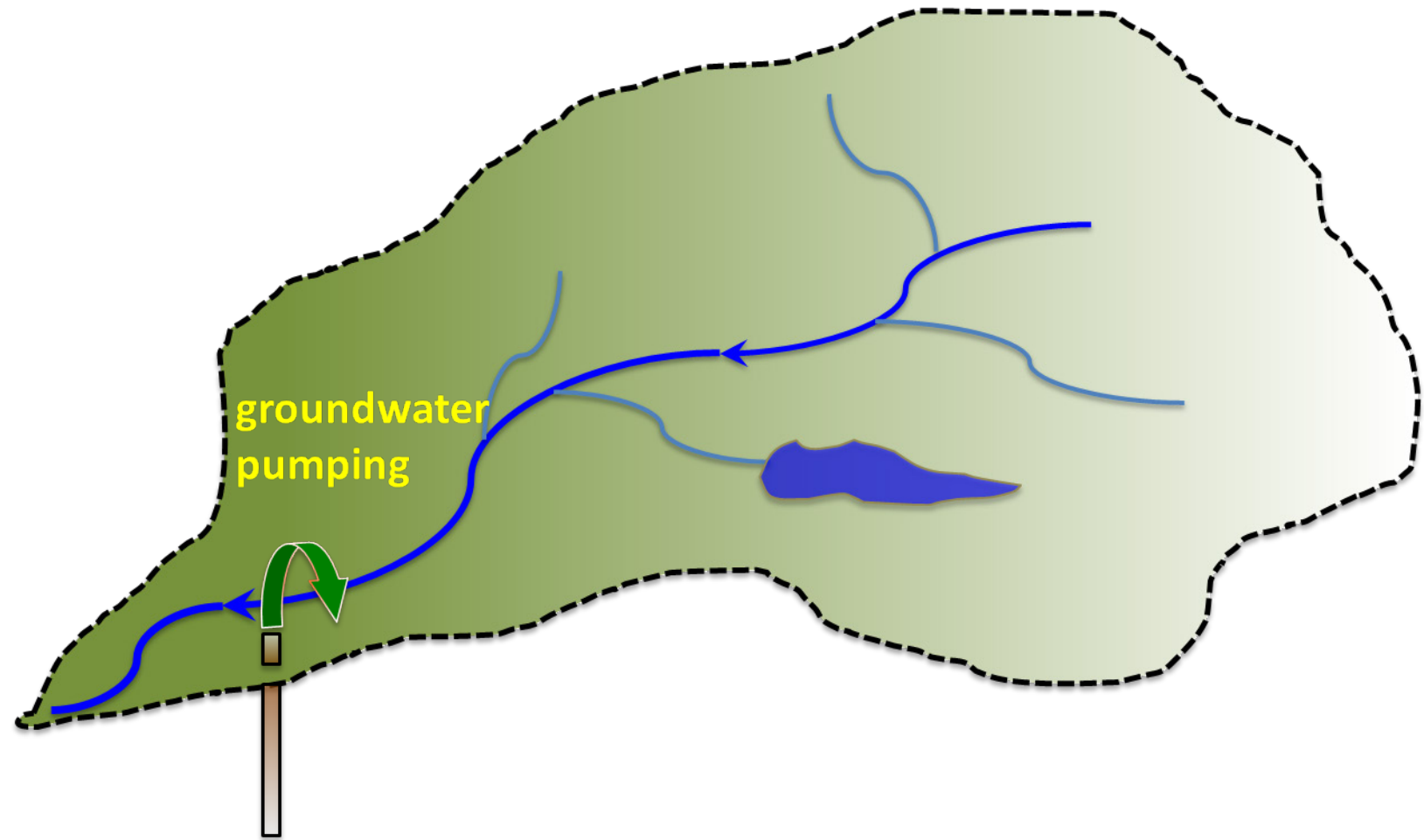
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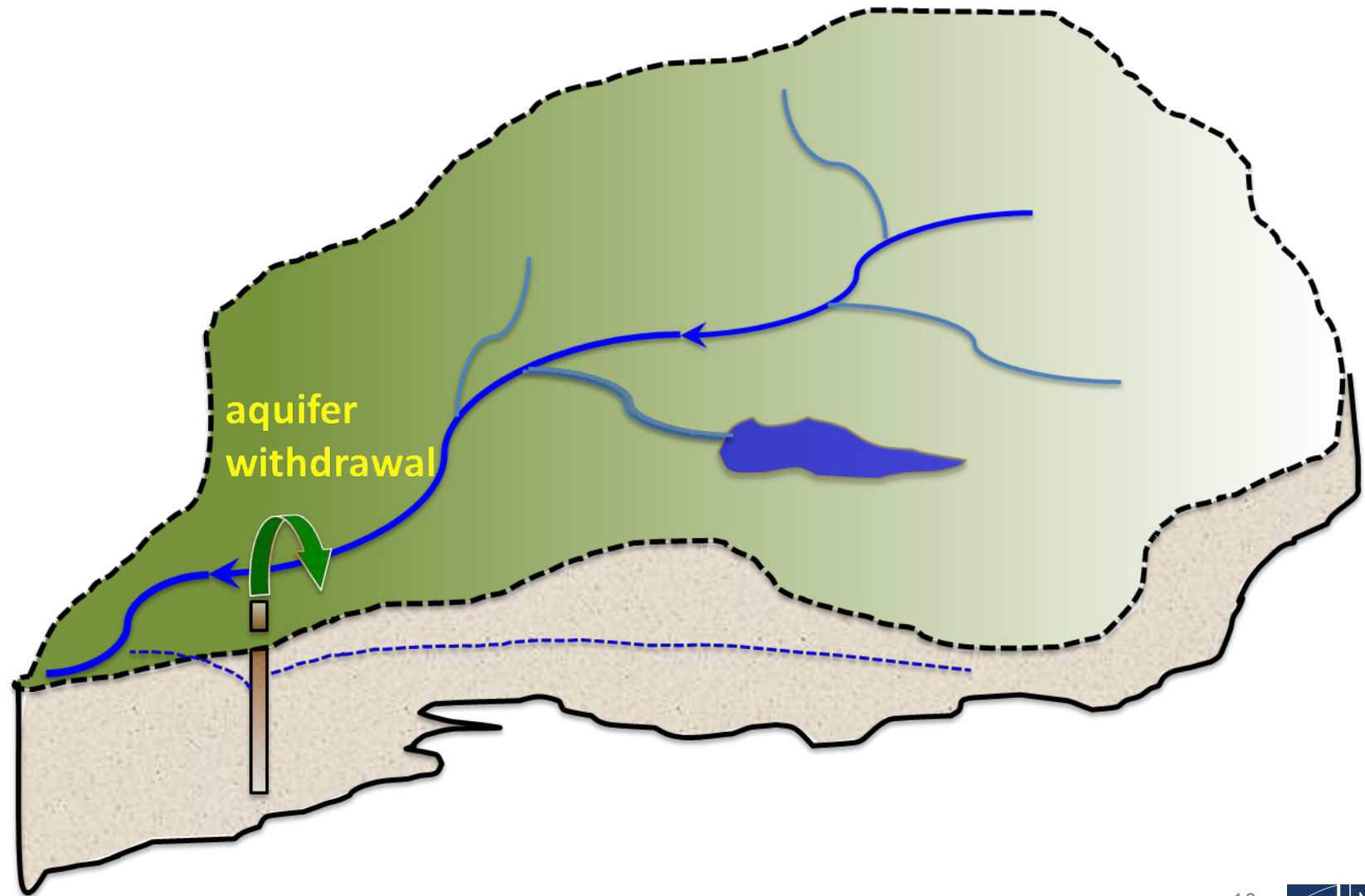
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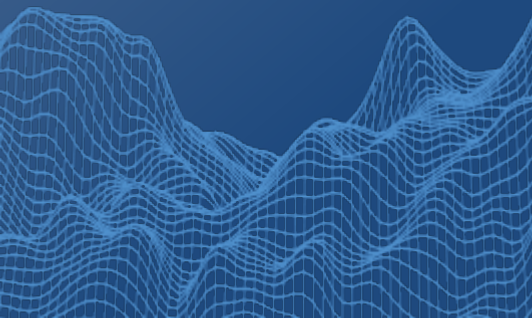


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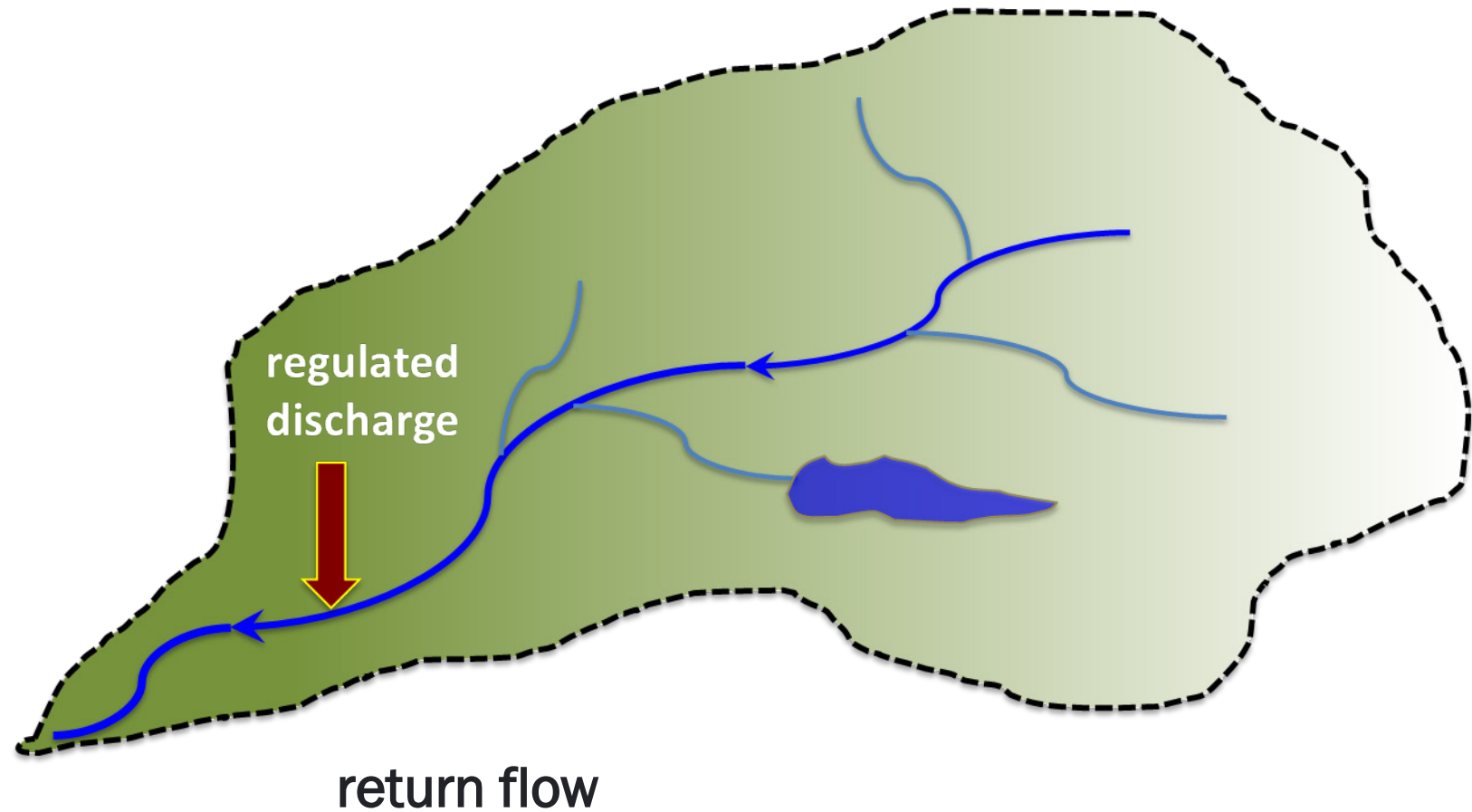


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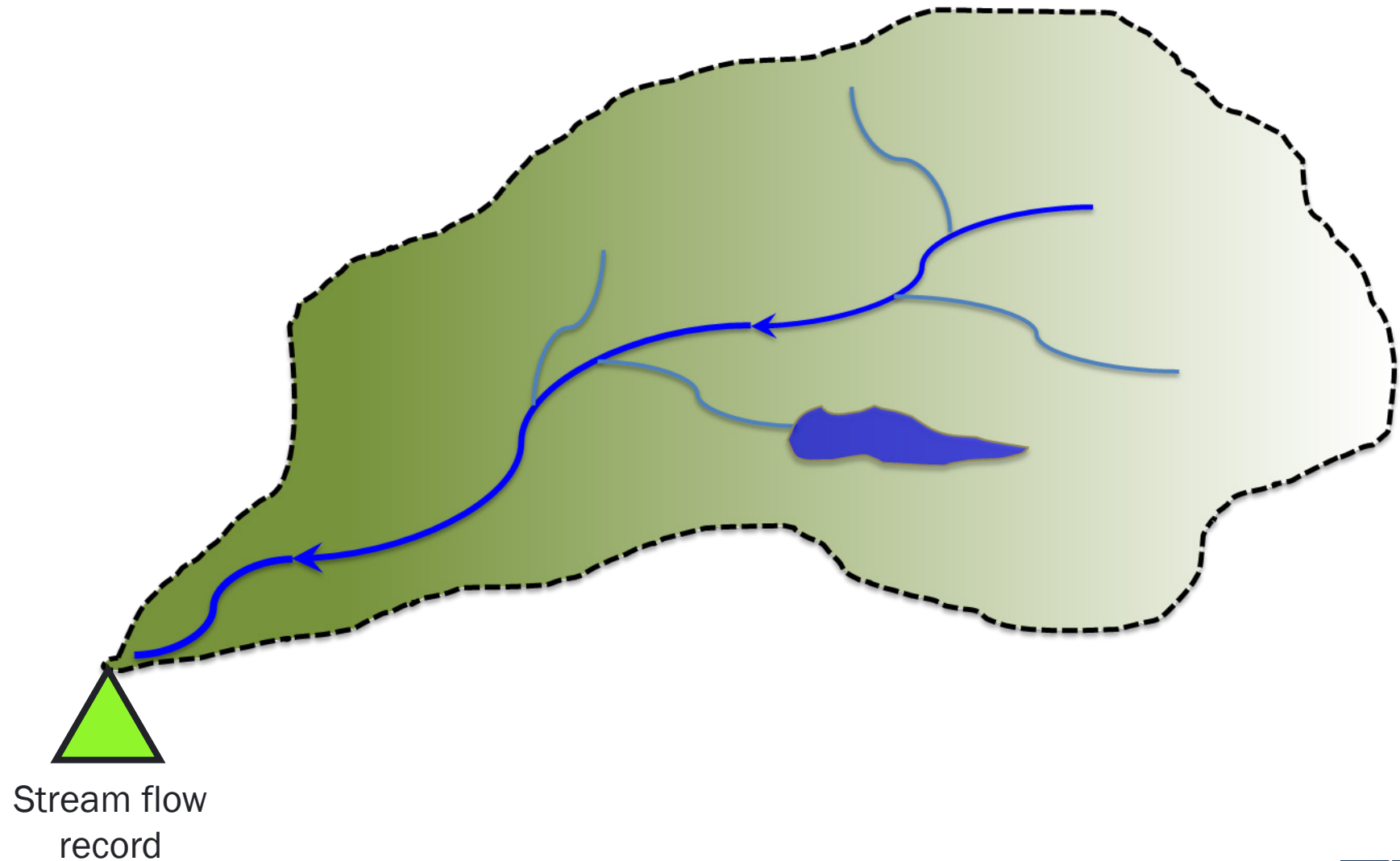




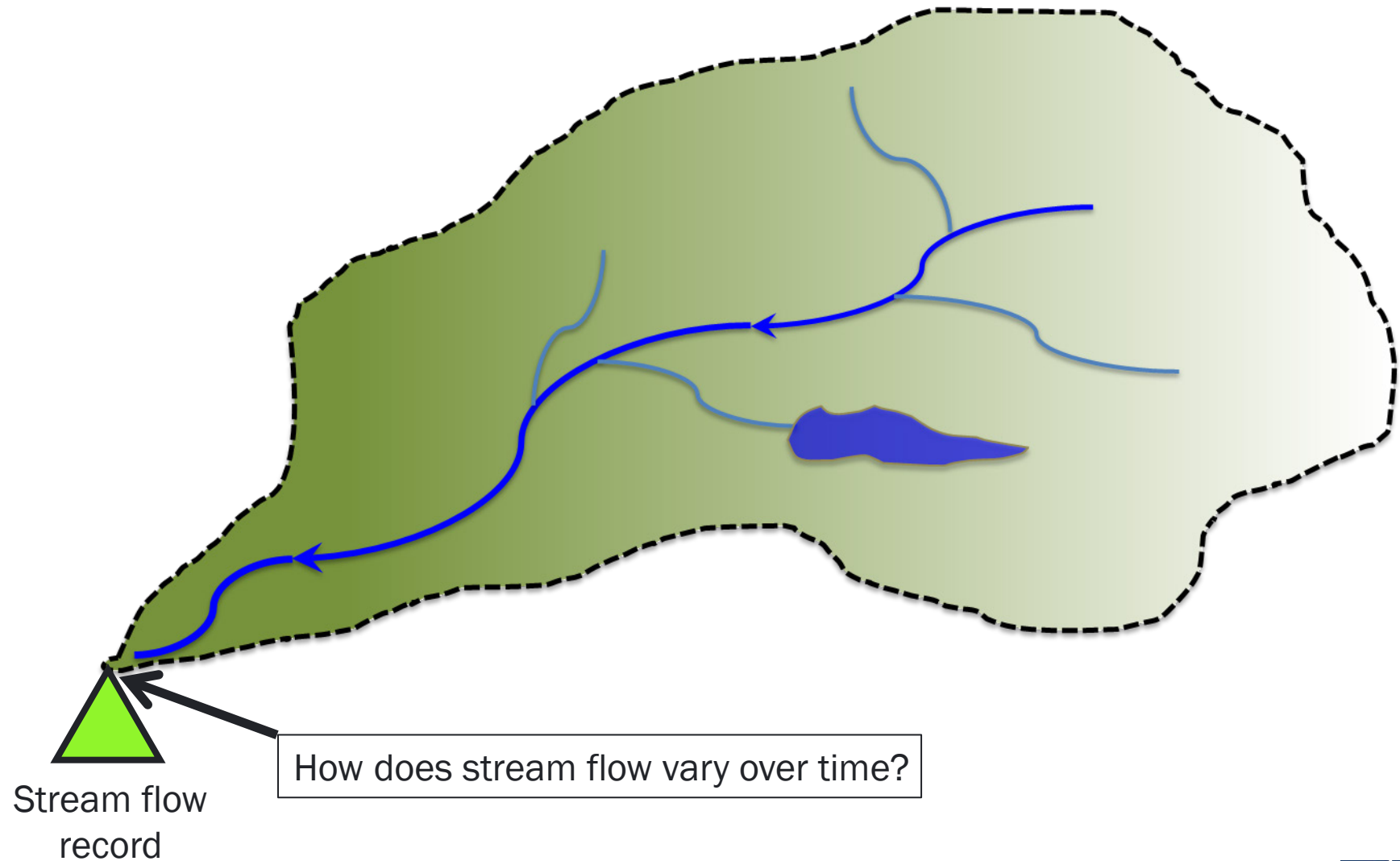
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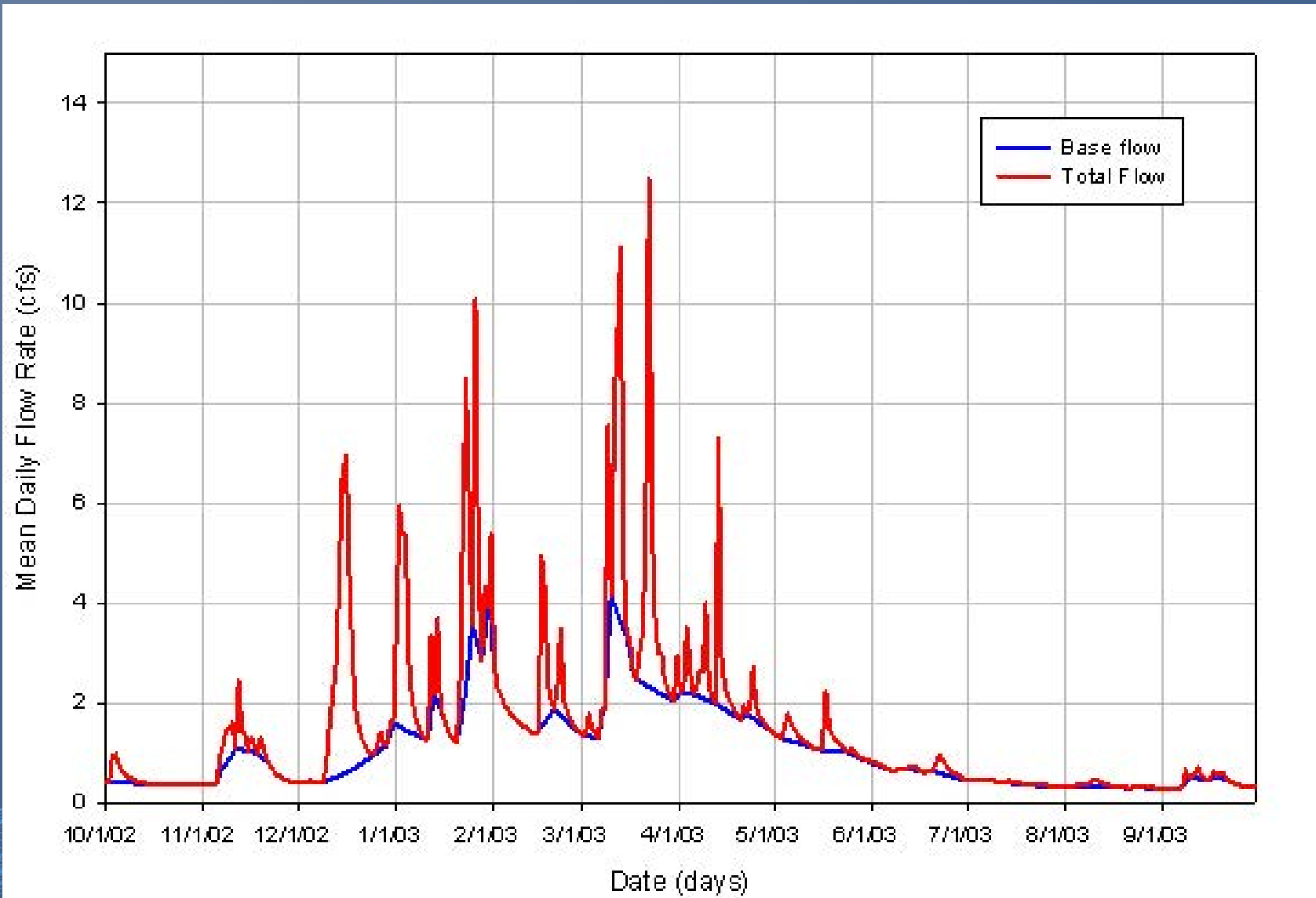
Indiana's water resources are limited only during seasonal and longer-term droughts – *demand is high when flows are low.*



Stream flow includes runoff, reservoir discharge, groundwater discharge, water withdrawals and return flows

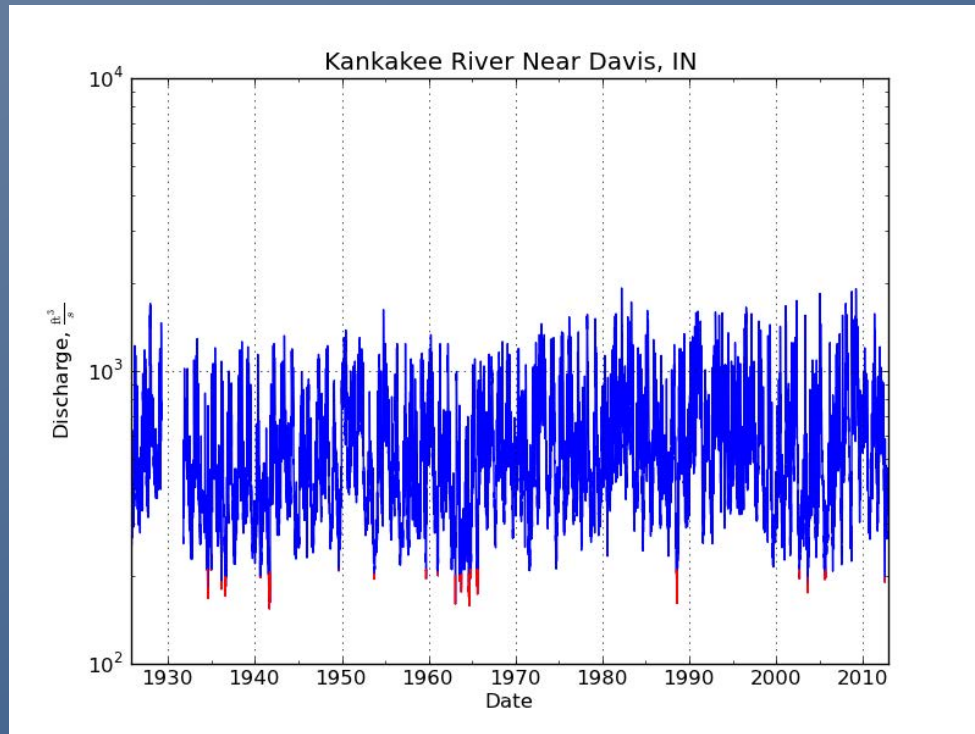


How does stream flow vary over time?

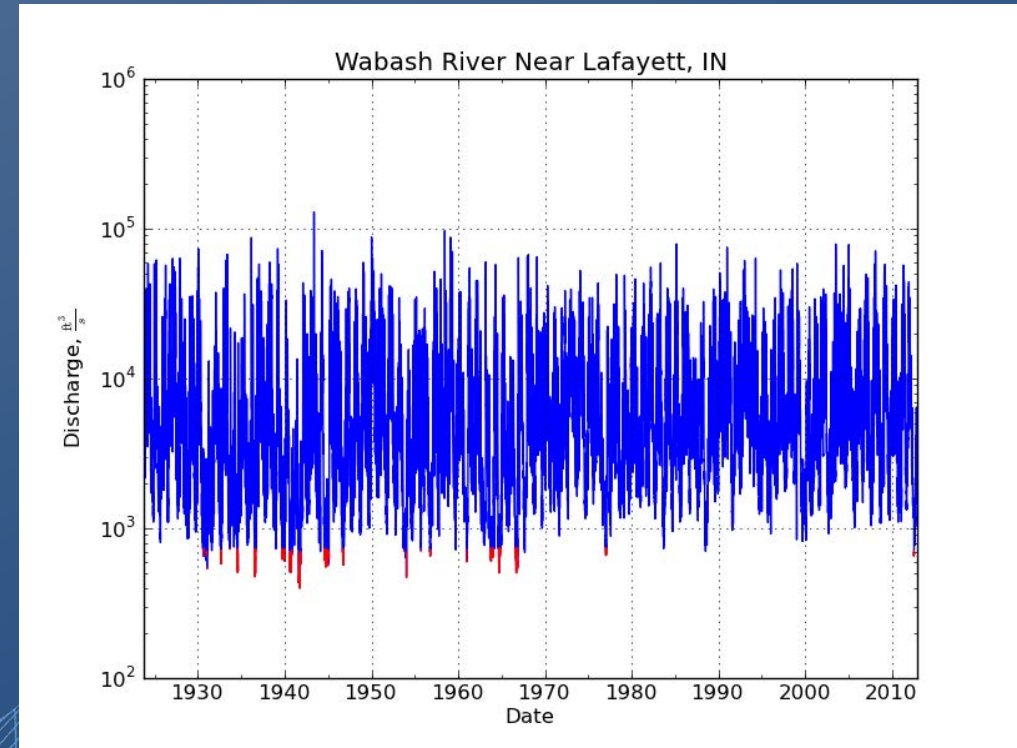


Stream Hydrograph – River Signature

Kankakee River

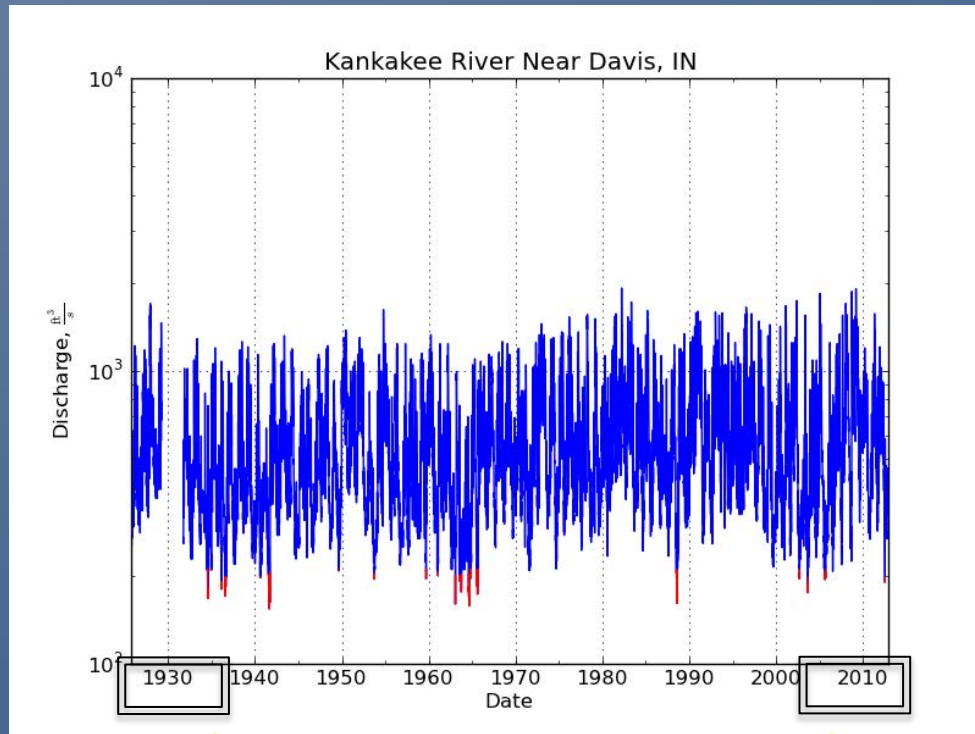


Wabash River



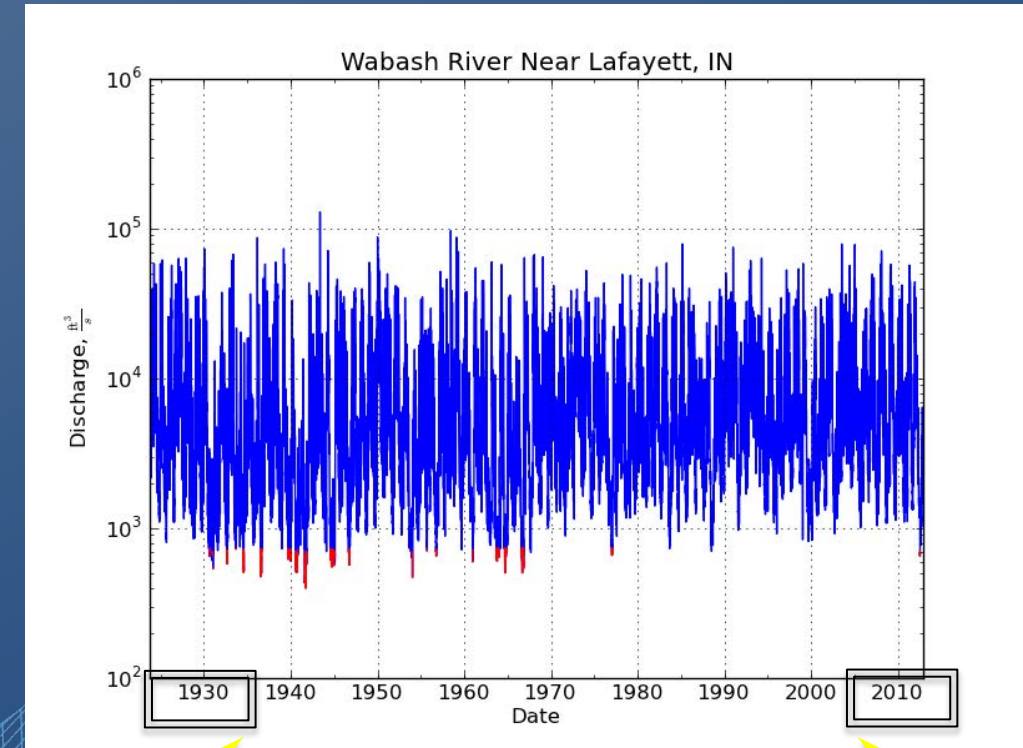
Stream Hydrograph – River Signature

Kankakee River



80 years

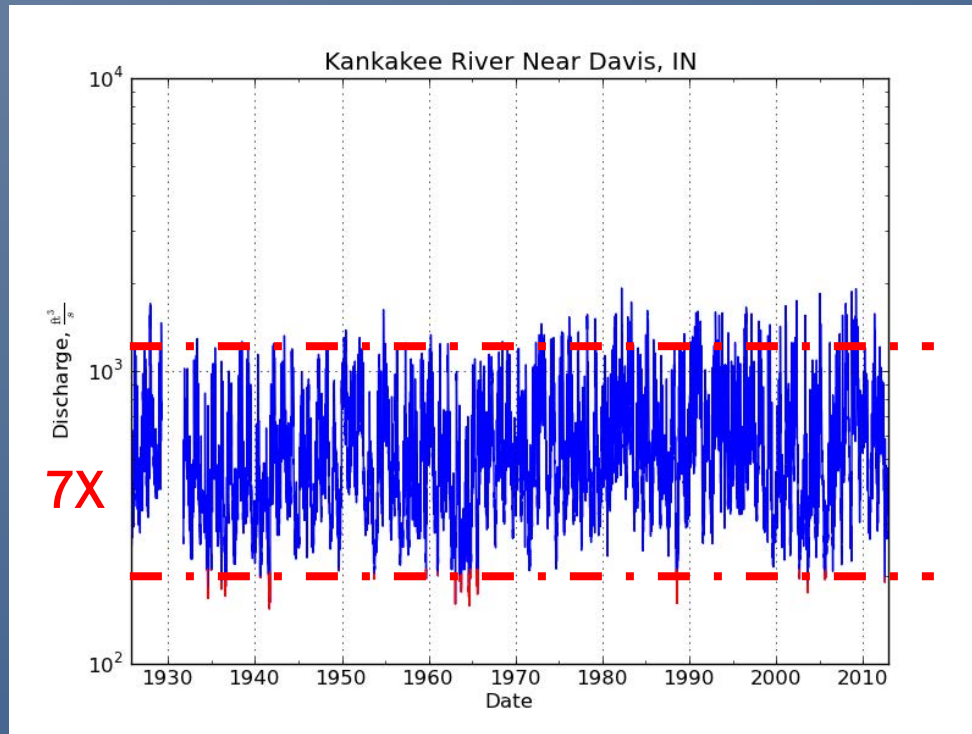
Wabash River



80 years

Stream Hydrograph – River Signature

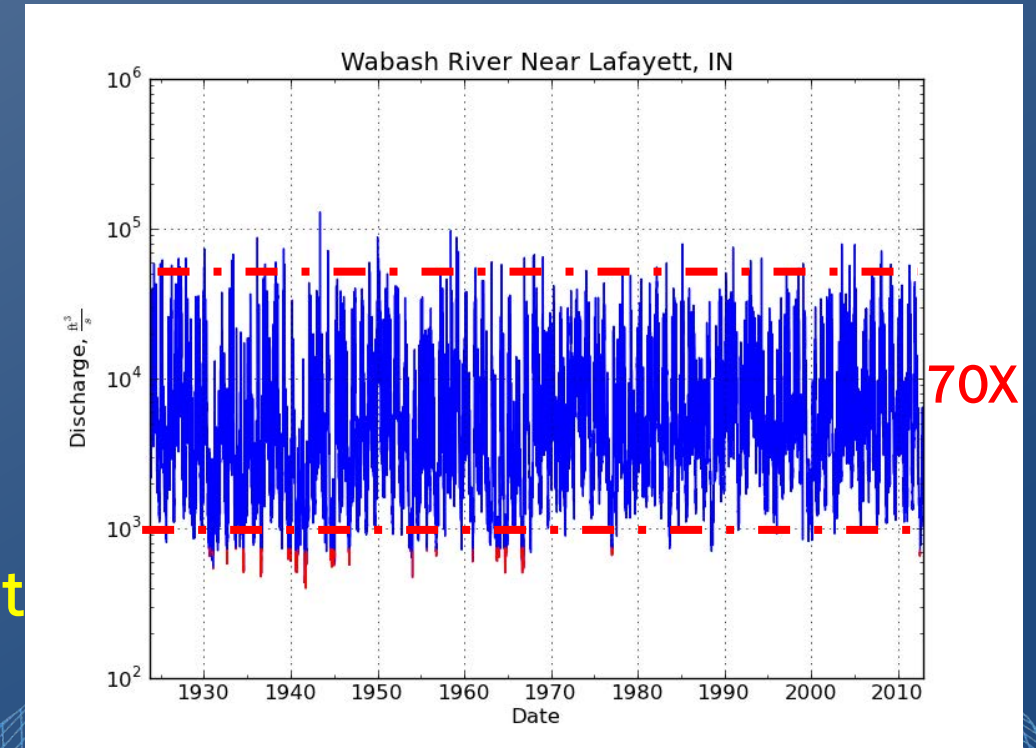
Kankakee River



flood

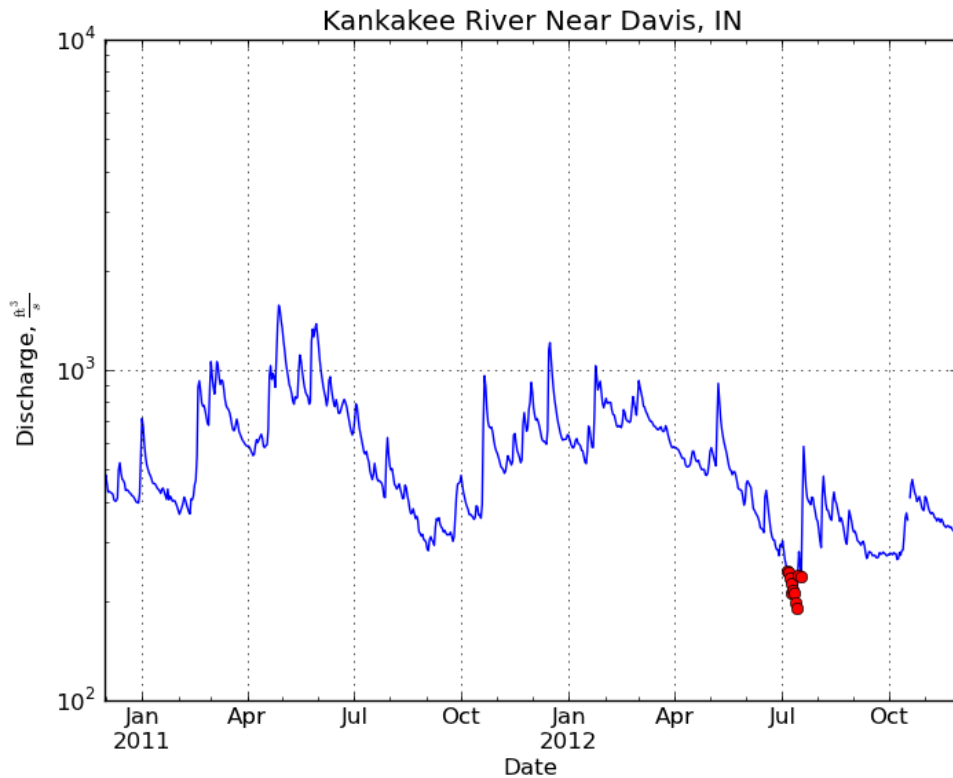
drought

Wabash River



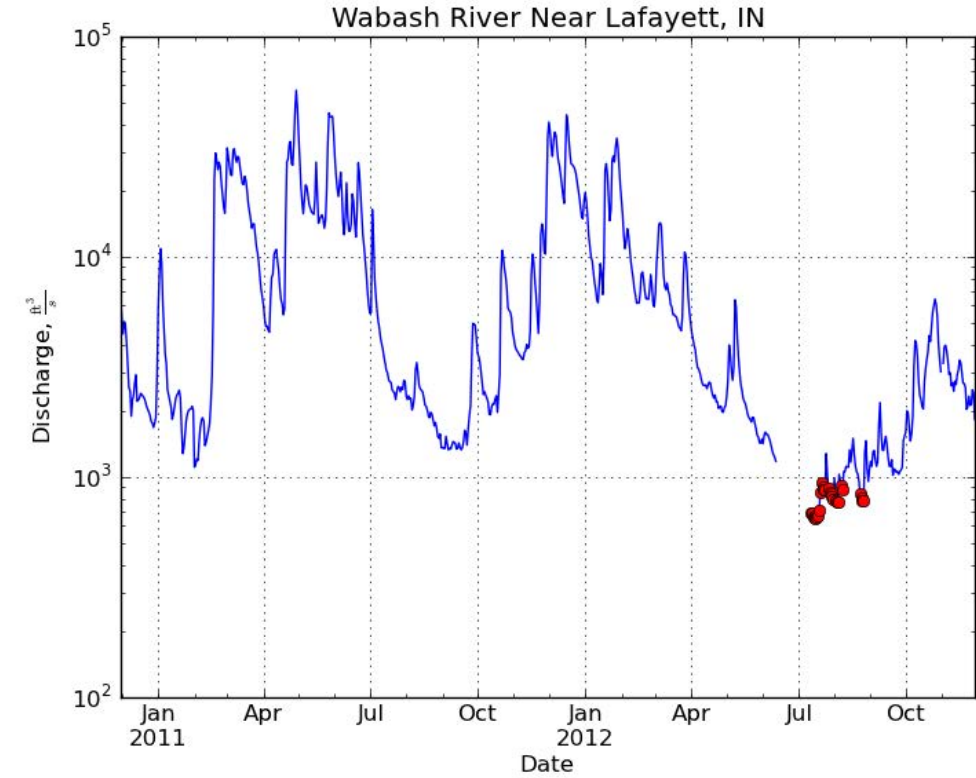
Stream Hydrograph – River Signature

Kankakee River



2 years

Wabash River

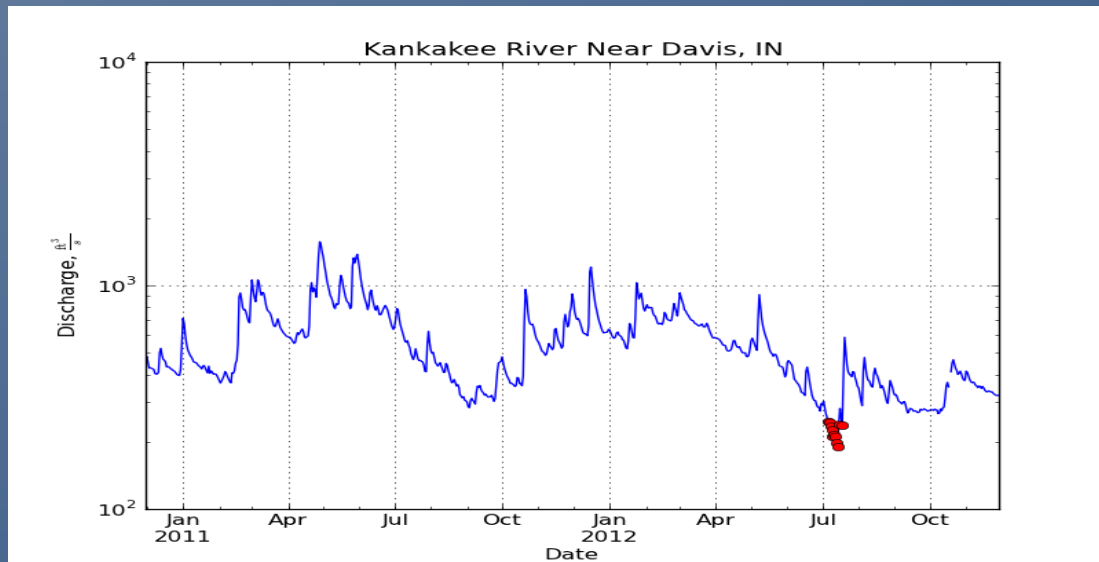


2 years

Stream Hydrograph – River Signature

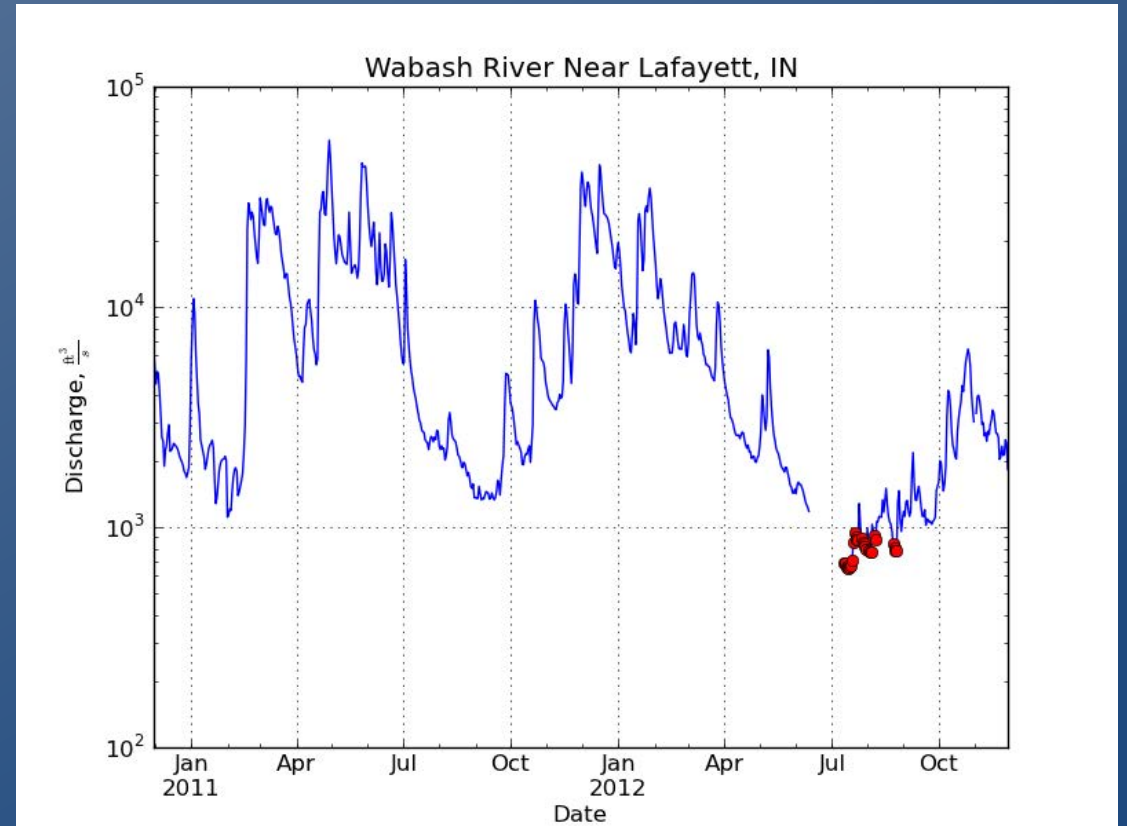
Kankakee River

same scale



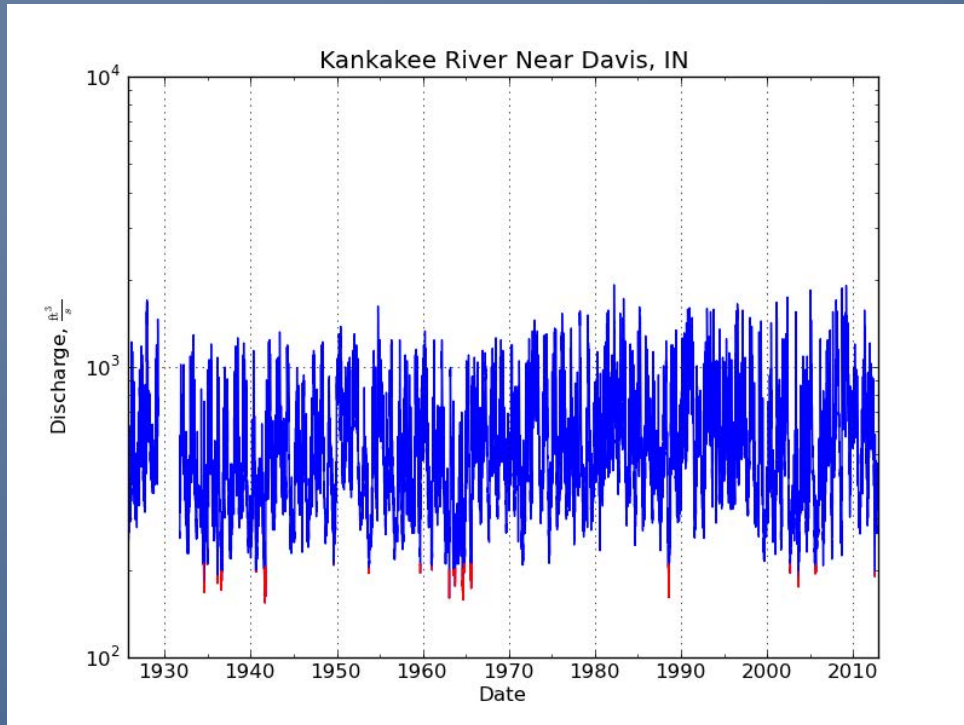
2 years

Wabash River



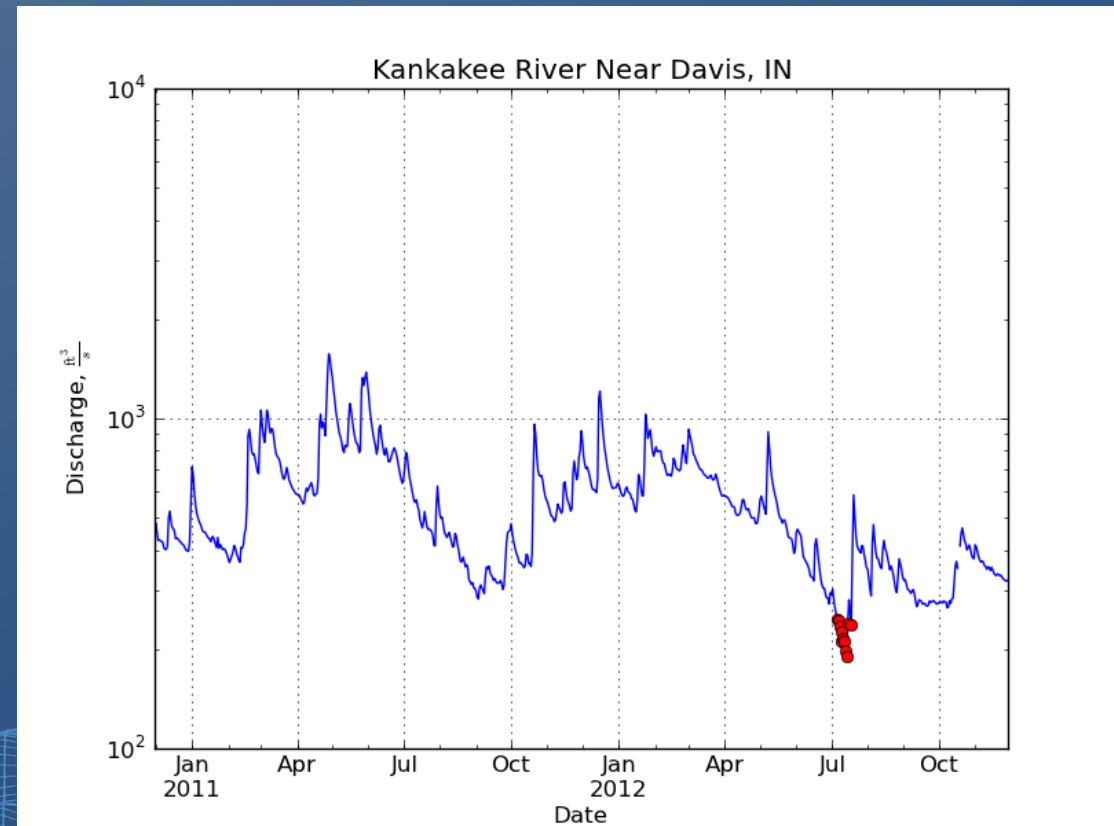
2 years

Kankakee River – Low Flows

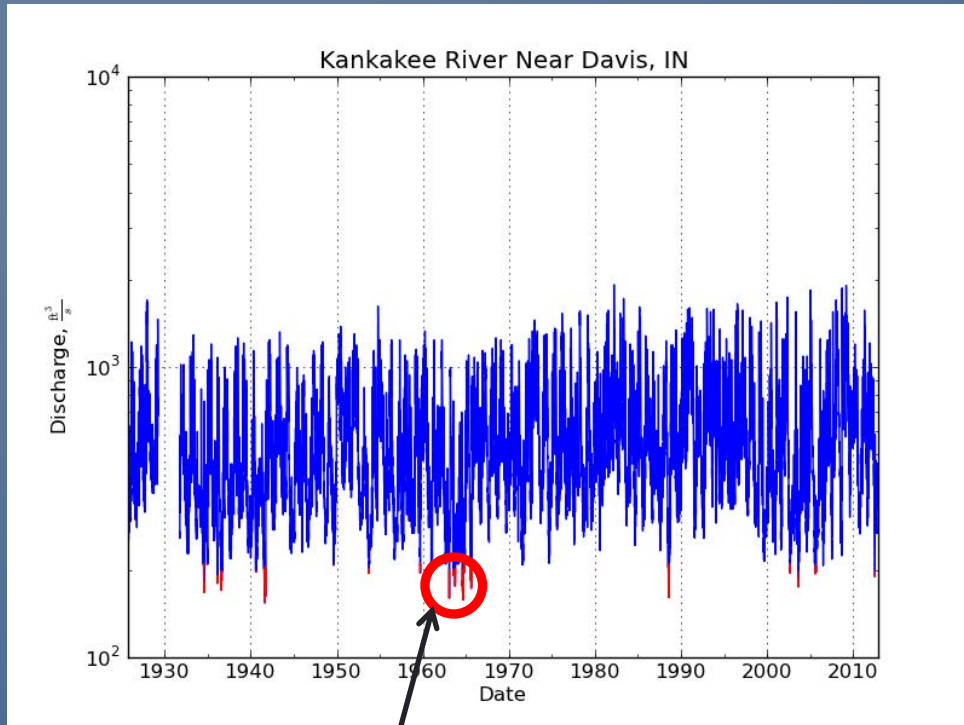


Historic flows (USGS)

2012 Summer Flows



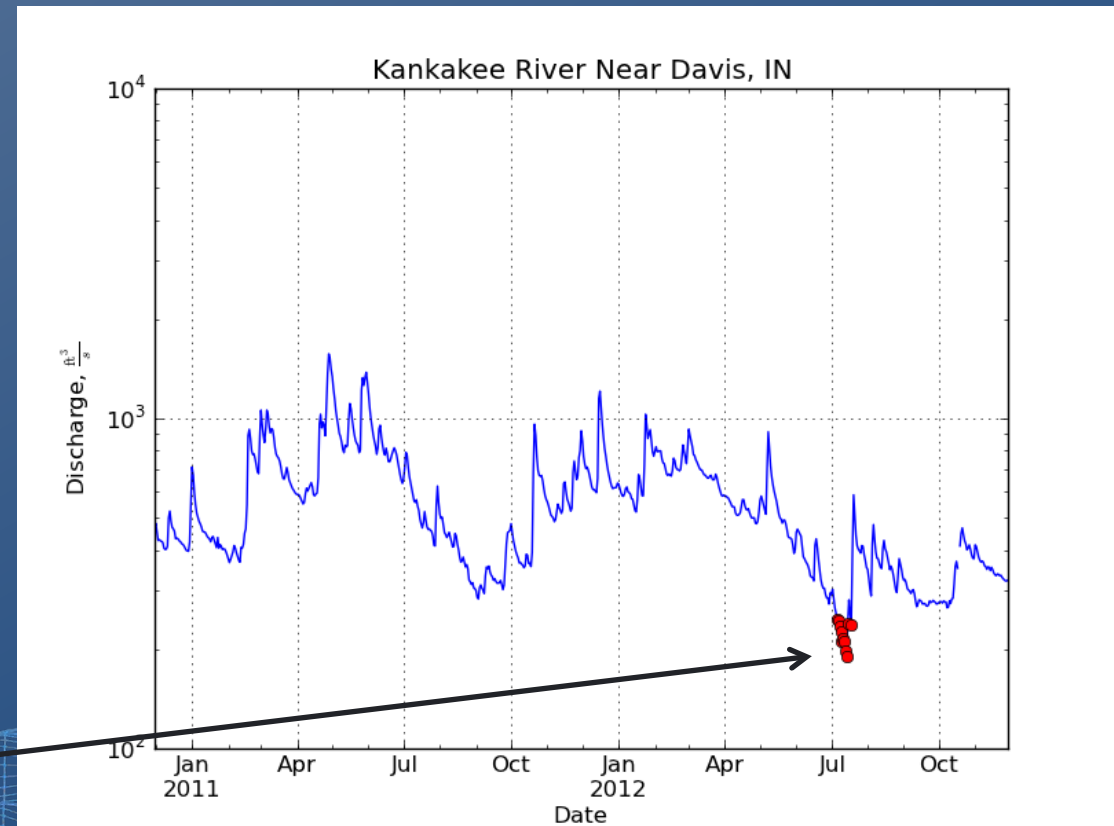
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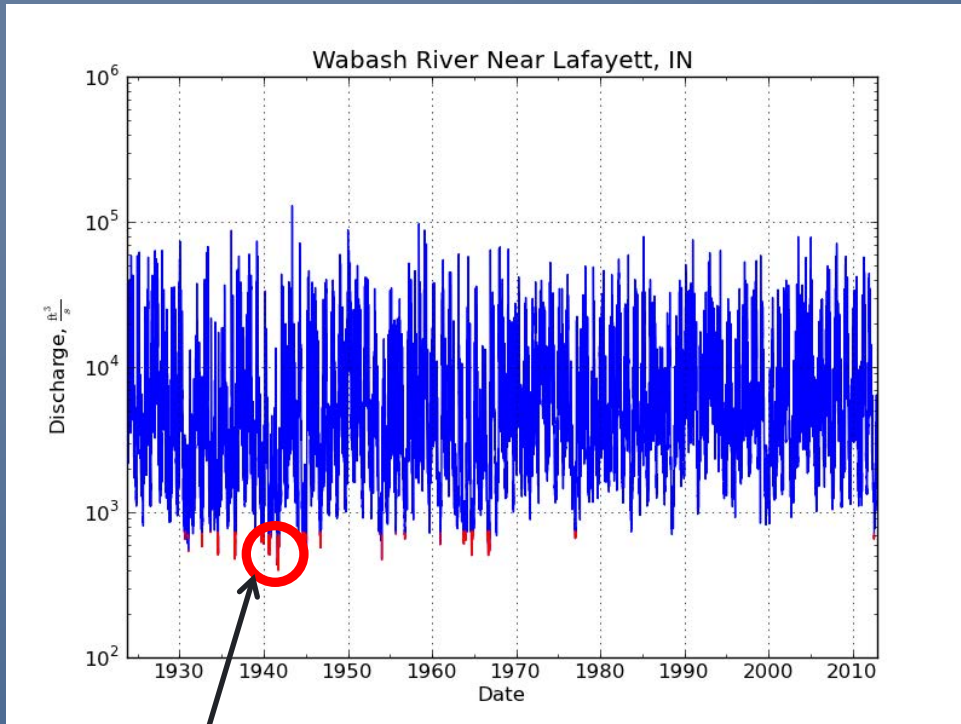
Historic flows (USGS)

Flows less than 5% on flow-duration

2012 Summer Flows



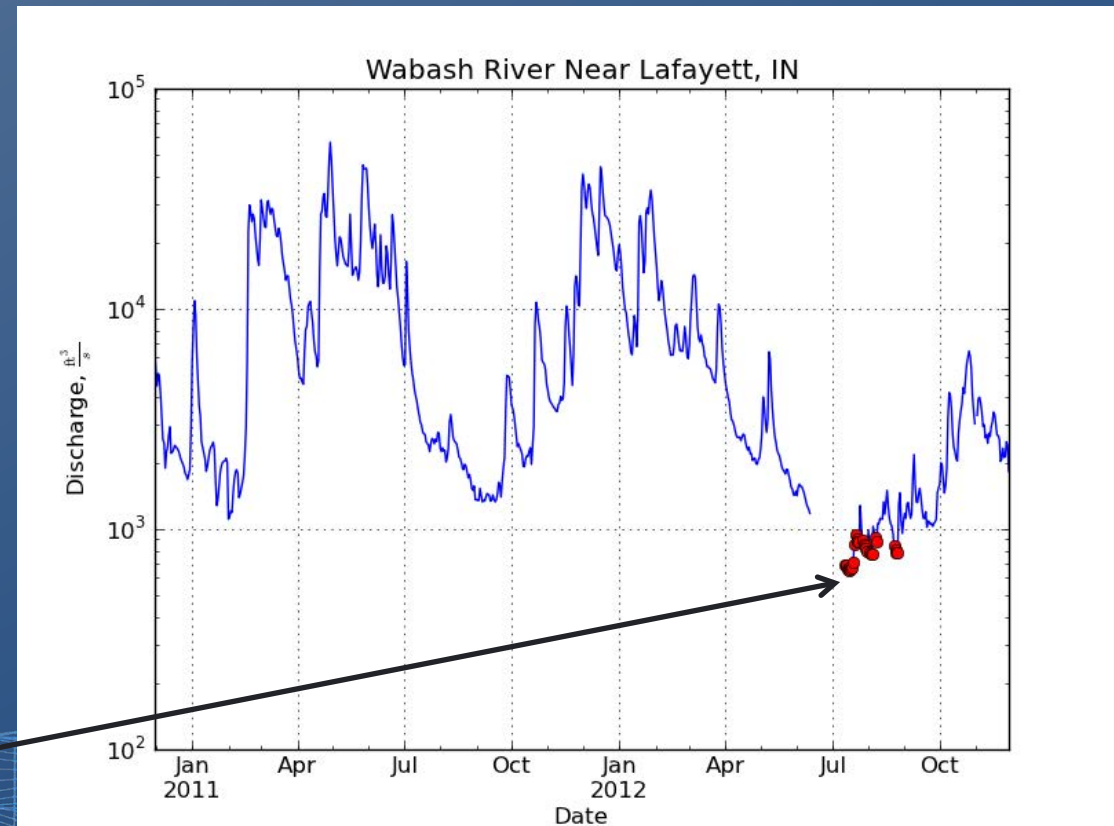
Wabash River – Low Flows



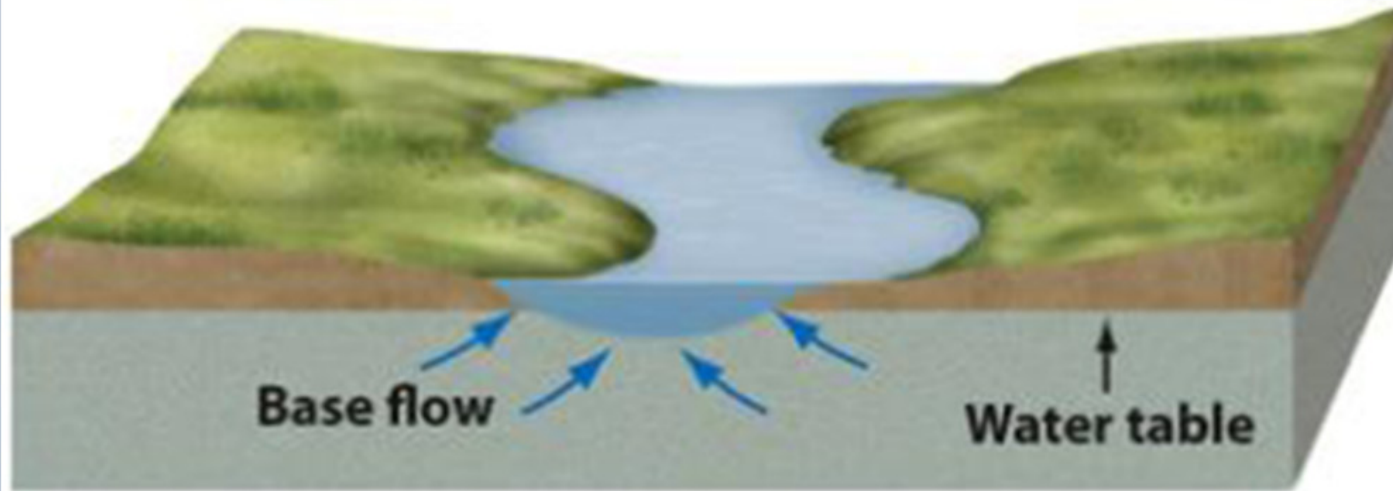
Historic flows (USGS)

Flows less than 5% on flow-duration

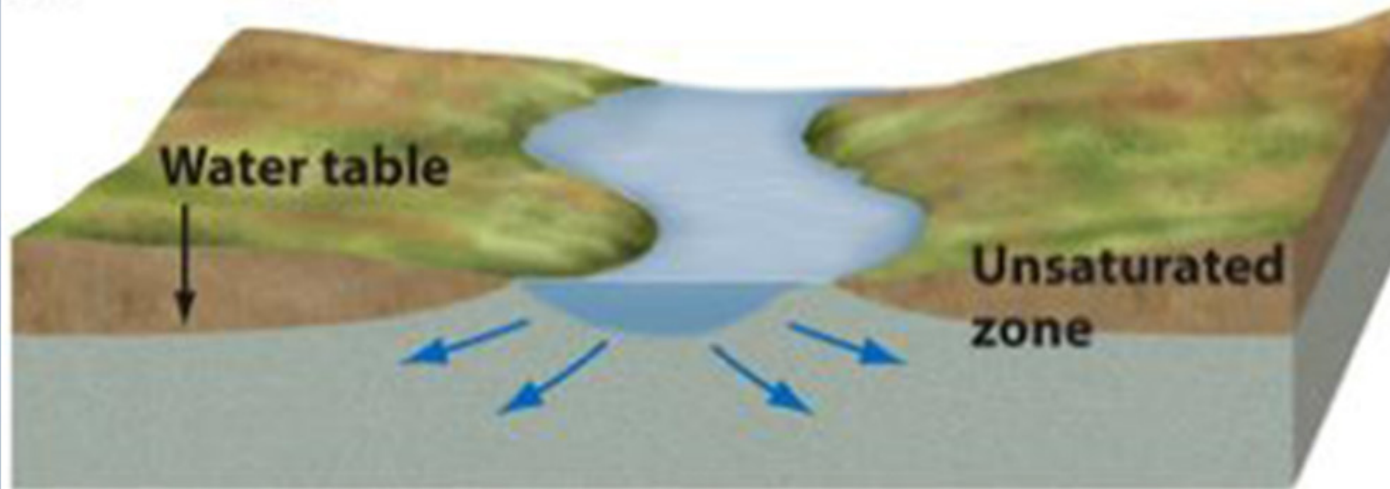
2012 Summer Flows



Gaining and losing reach

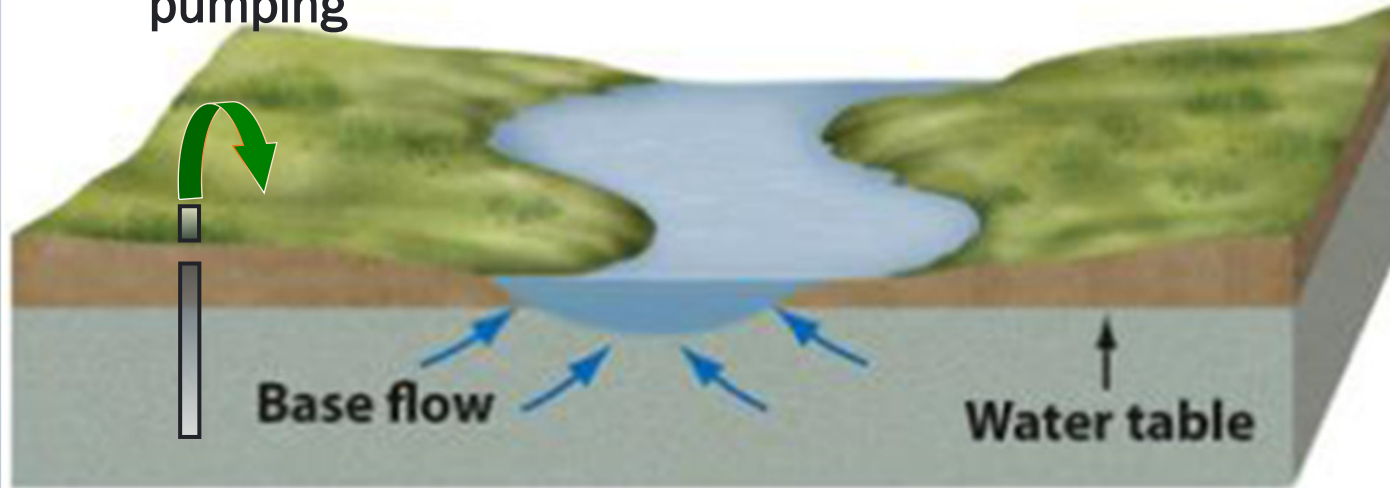


(a) Gaining stream

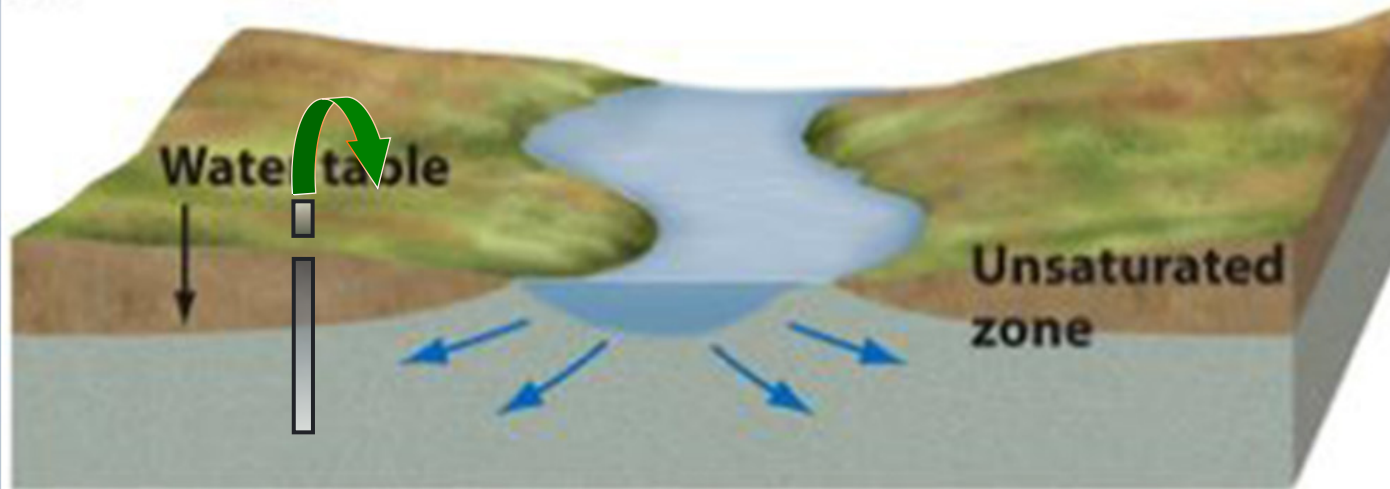


(b) Losing stream (connected)

groundwater
pumping



(a) Gaining stream



(b) Losing stream (connected)

Groundwater pumping near a gaining or losing reach reduces the flow in the stream

2. Water Availability Assessment

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“**Water Availability**” is a measure of how much water can be withdrawn from the hydrologic system without negatively impacting the system

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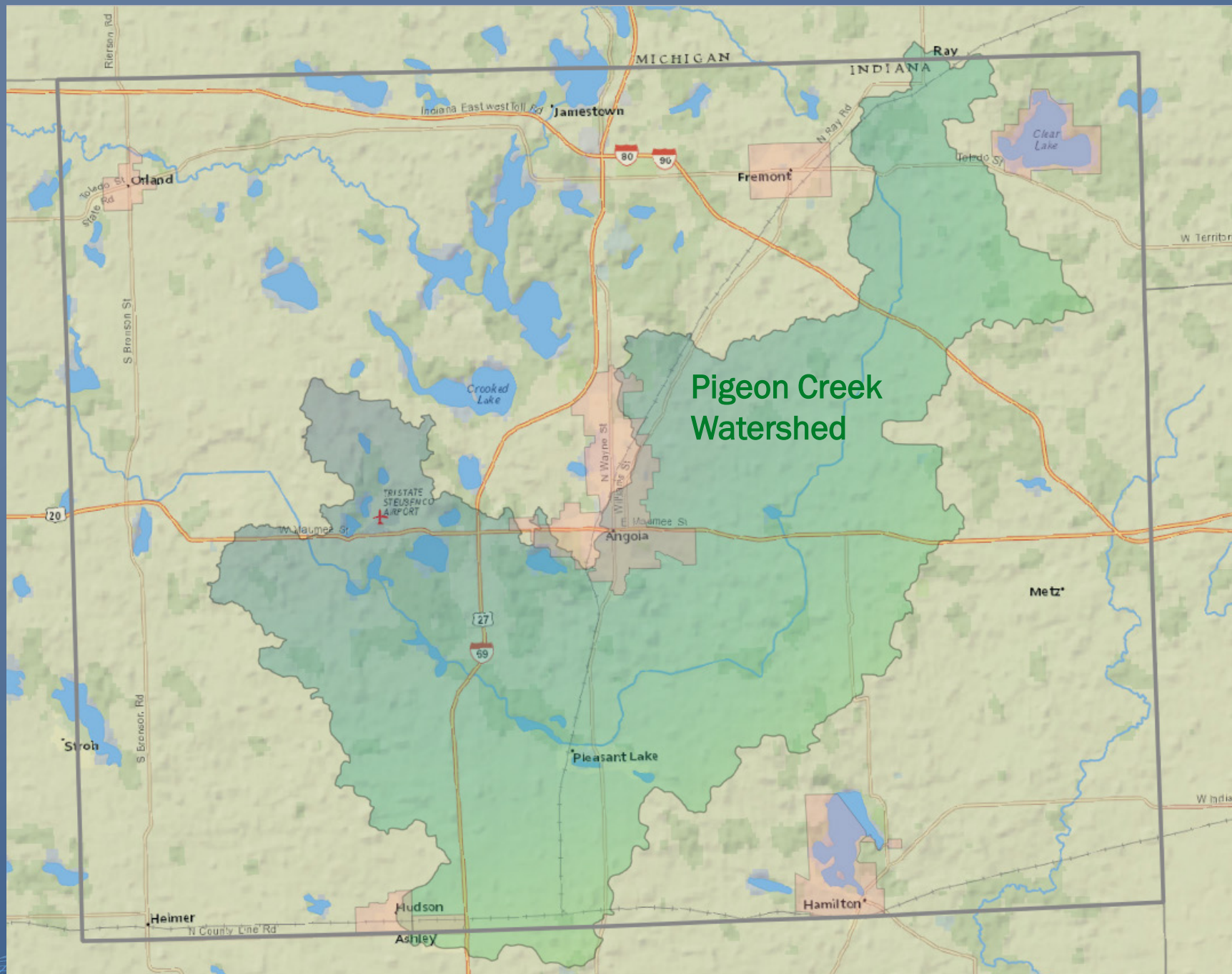
“**Excess Water Availability**” is a measure of how much *more* water can be withdrawn (above what is currently withdrawn) from the hydrologic system without negatively impacting the system

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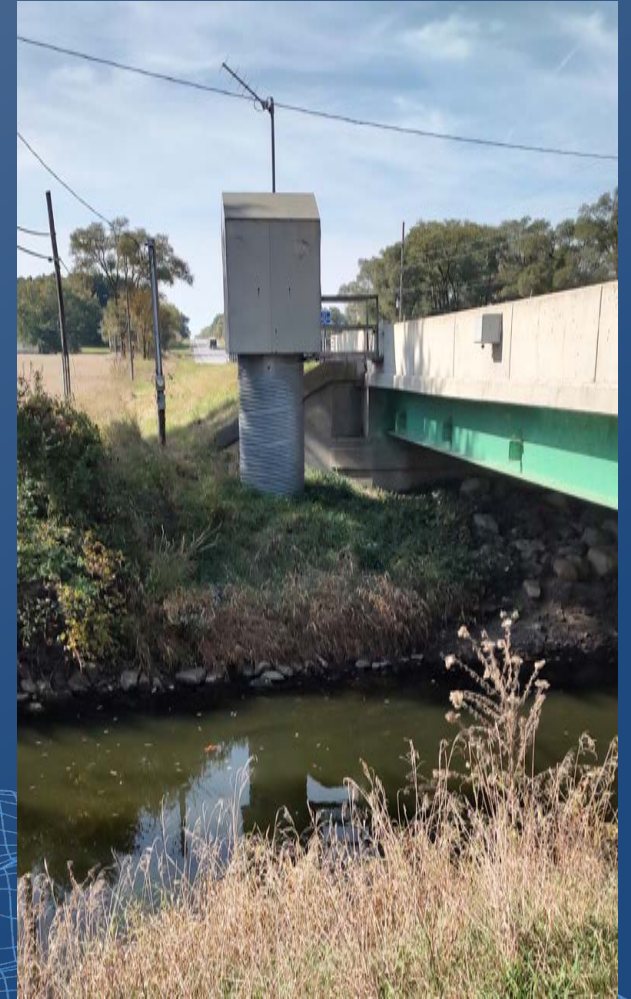
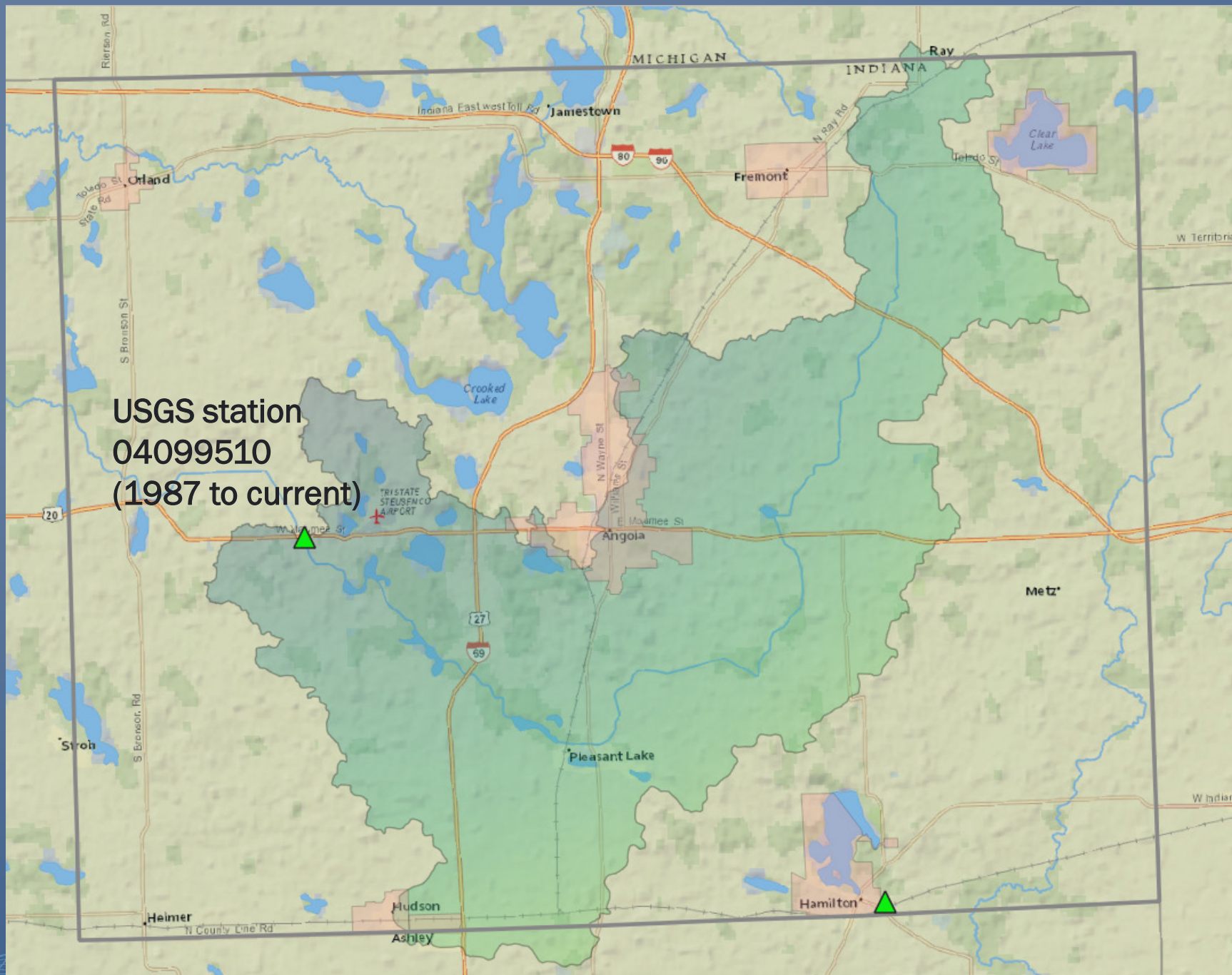
- As hydrologic conditions vary seasonally and annually, Water Availability also varies
- Water Availability in the future can only be inferred from availability in the past
- Assessment requires a water budget quantifying inflows to and outflows from the hydrologic system



Example: Pigeon Creek Watershed


Data used to assess
Water Availability

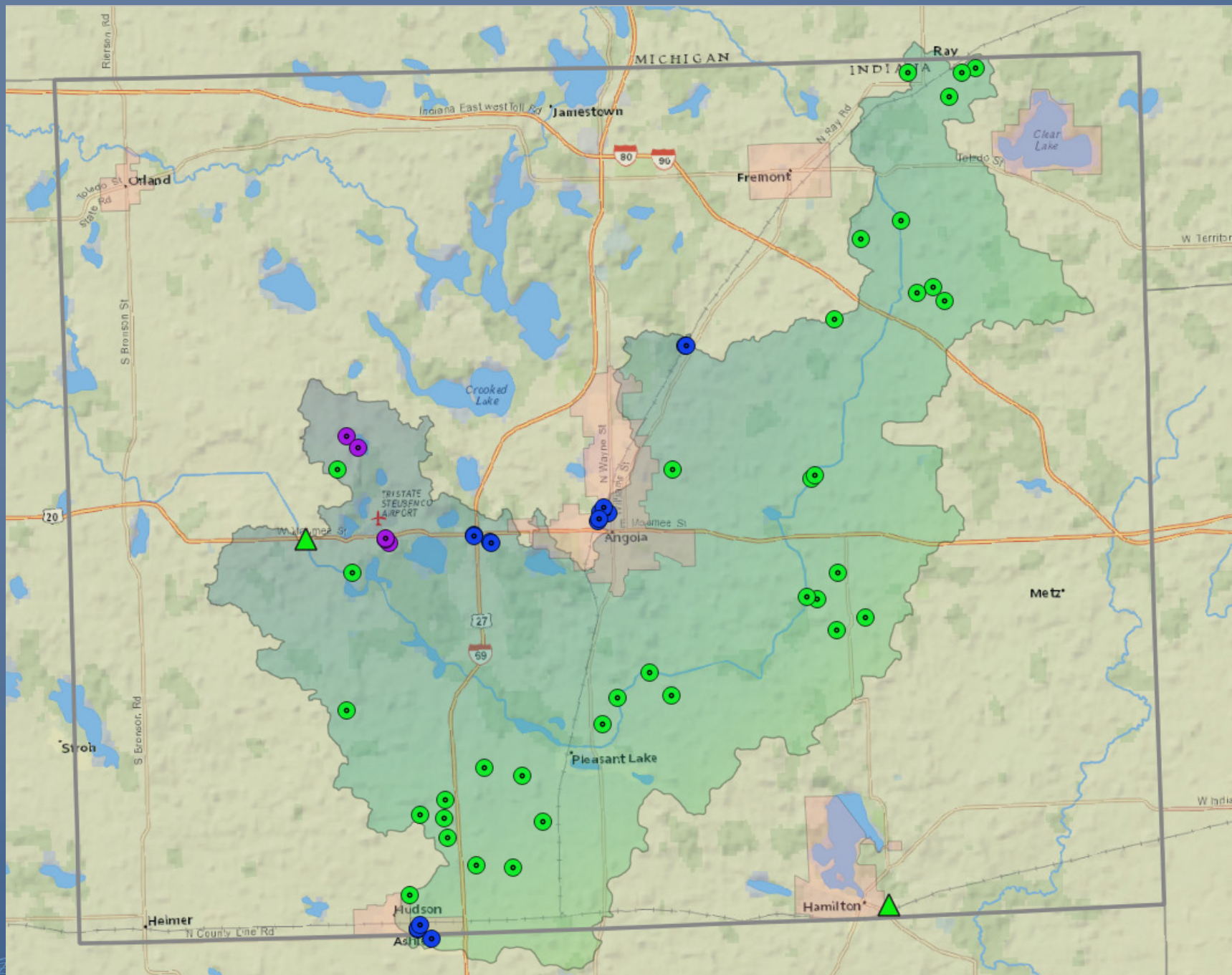
Daily stream
flow leaving
the watershed



Water Withdrawals

SIGNIFICANT WATER WITHDRAWAL POINTS

-  PUBLIC SUPPLY
-  IRRIGATION
-  INDUSTRIAL
-  MISCELLANEOUS
-  ENERGY PRODUCTION
-  RURAL USE

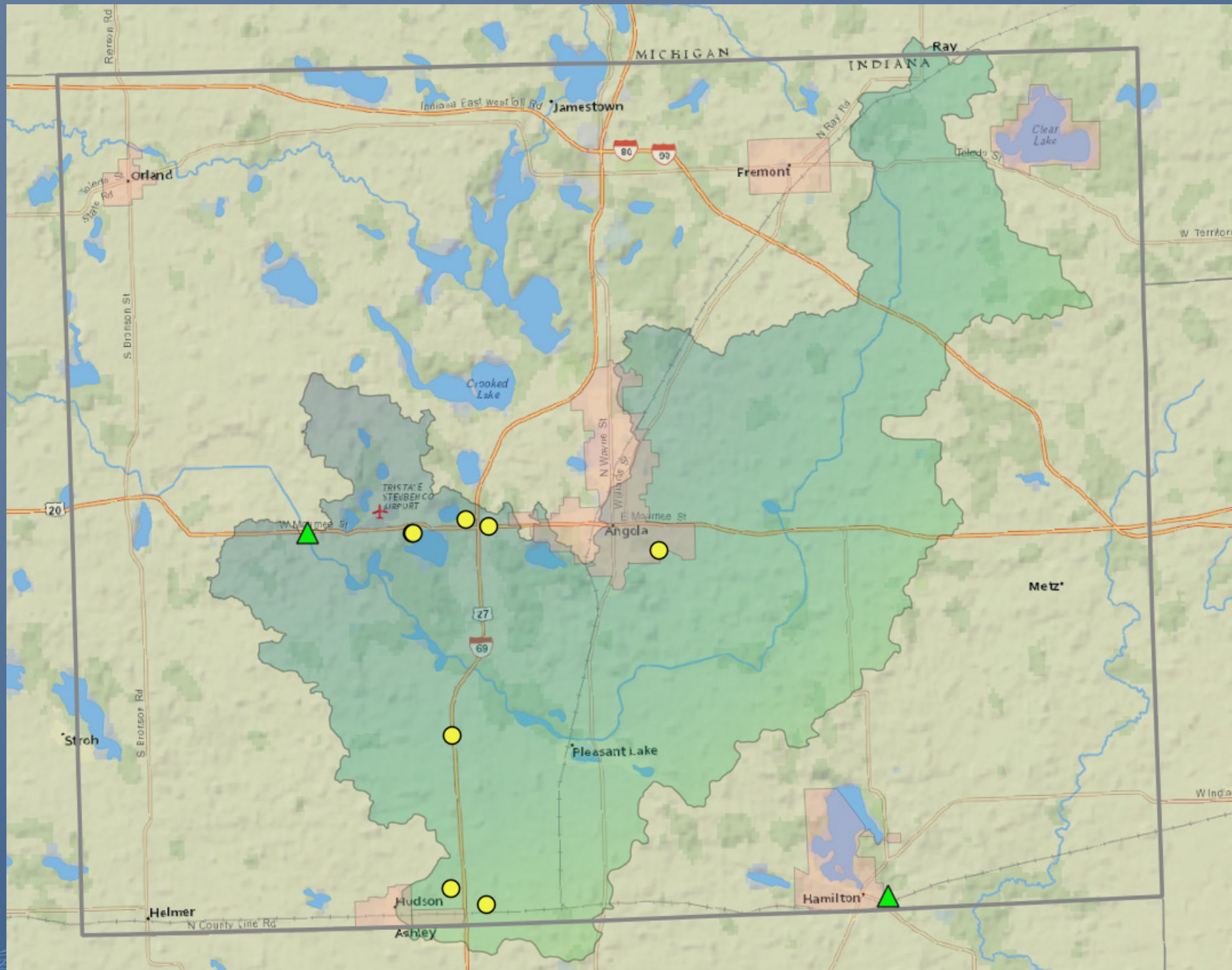


Return Flows

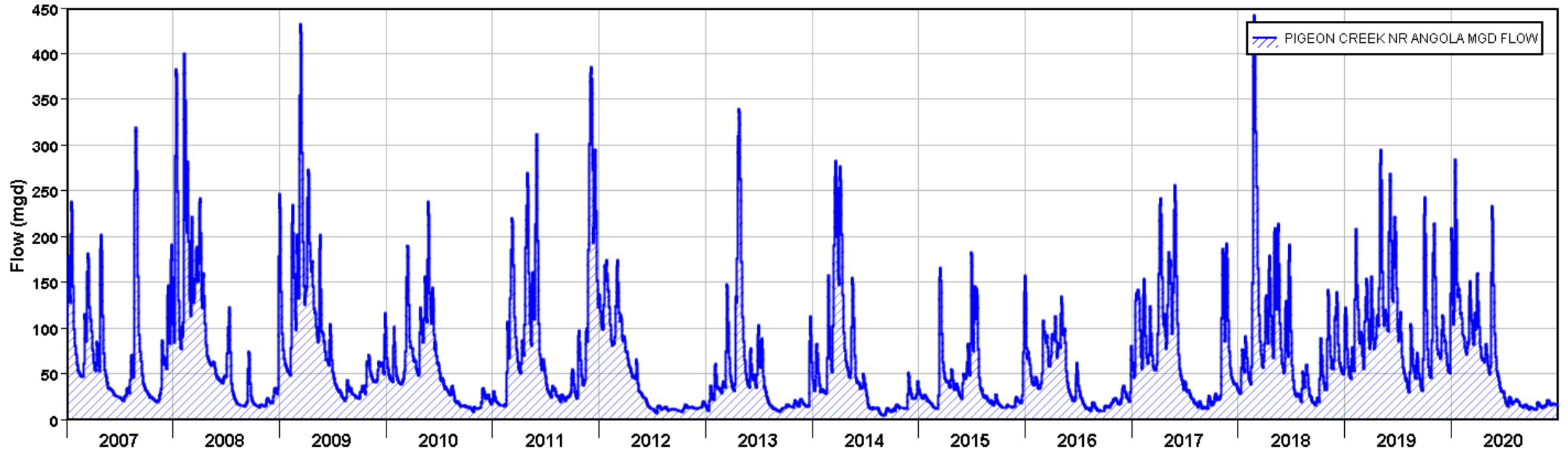
NPDES OUTFALL



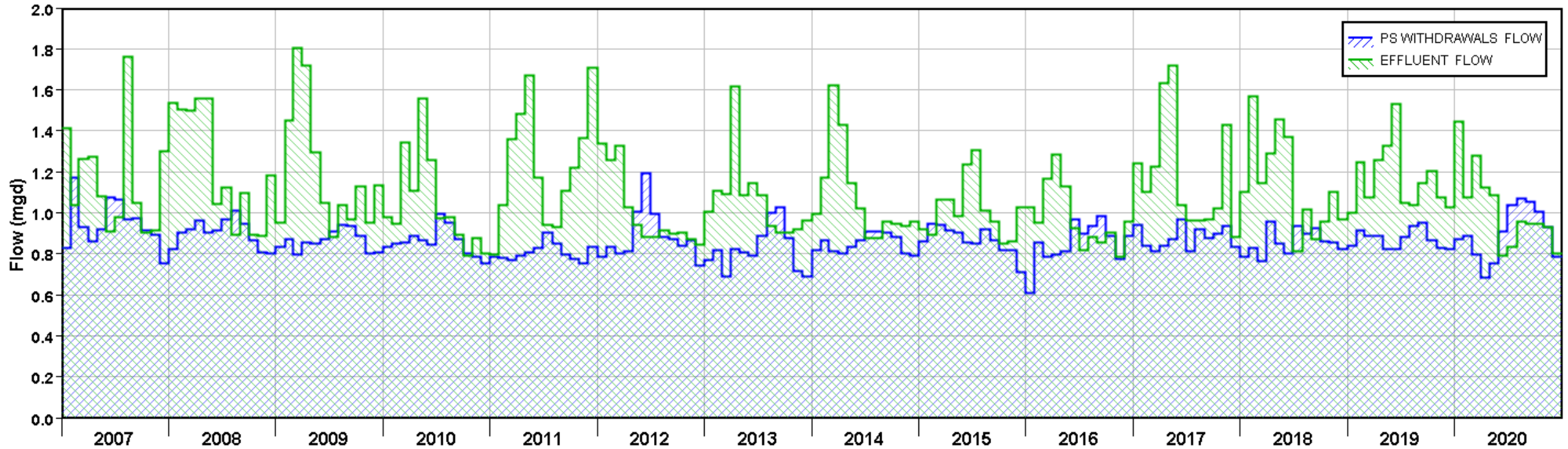
Rest Stops, Mobile
Home Parks,
Wastewater
Treatment Plants



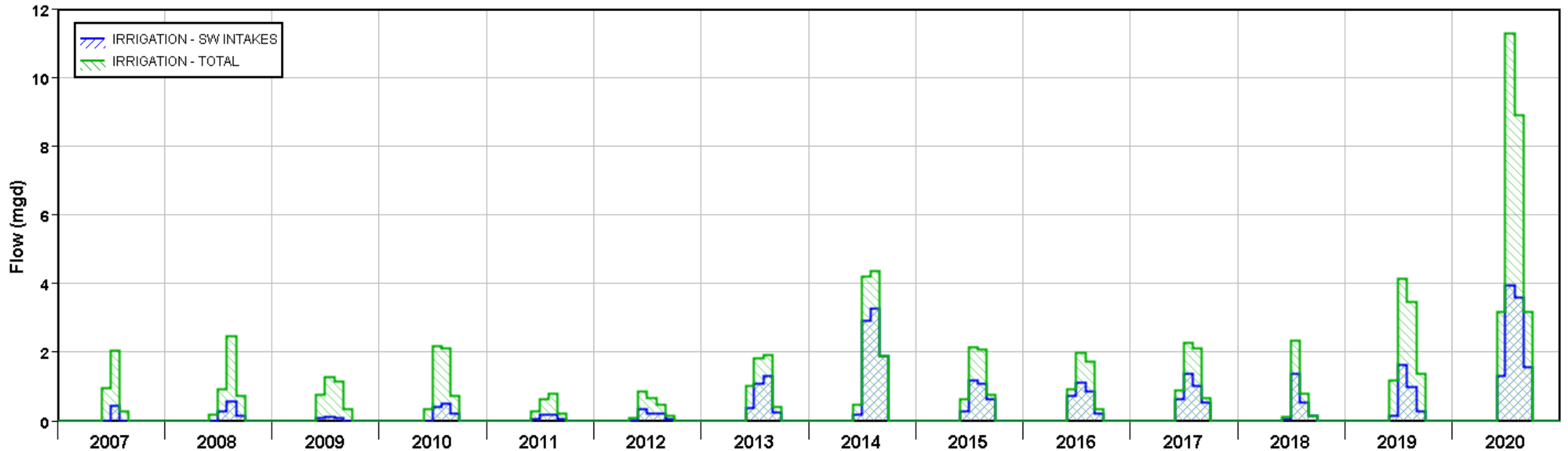
Example: Daily surface water flow from Pigeon Creek Watershed (2007-2020)



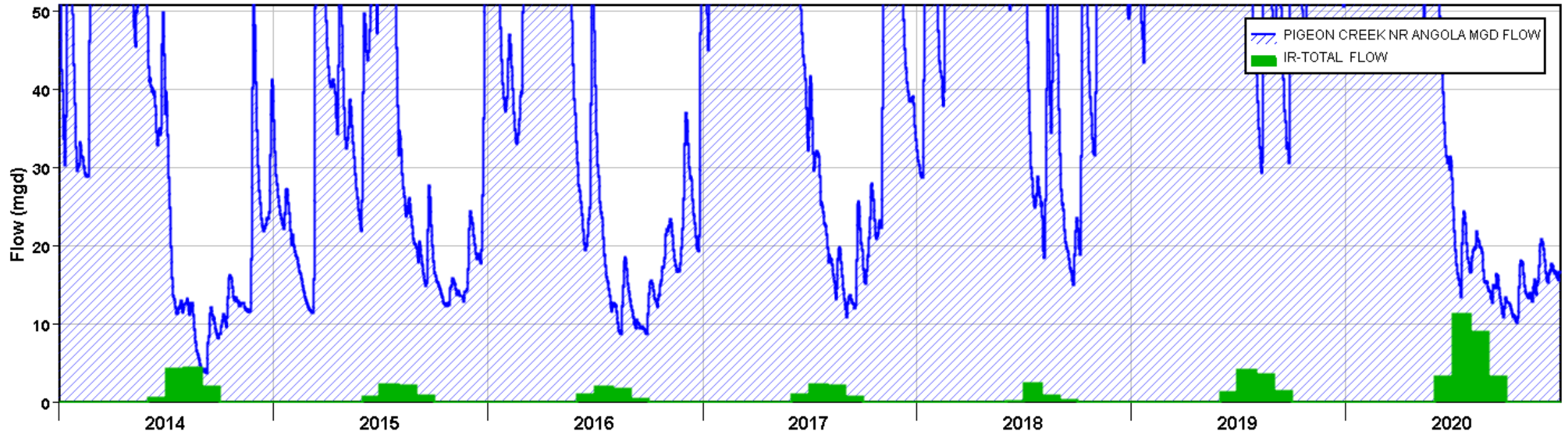
Example: Angola Public Supply withdrawals and return flows from WWTP (2007-2020)



Example: Irrigation withdrawals from surface water and groundwater (2007-2020)



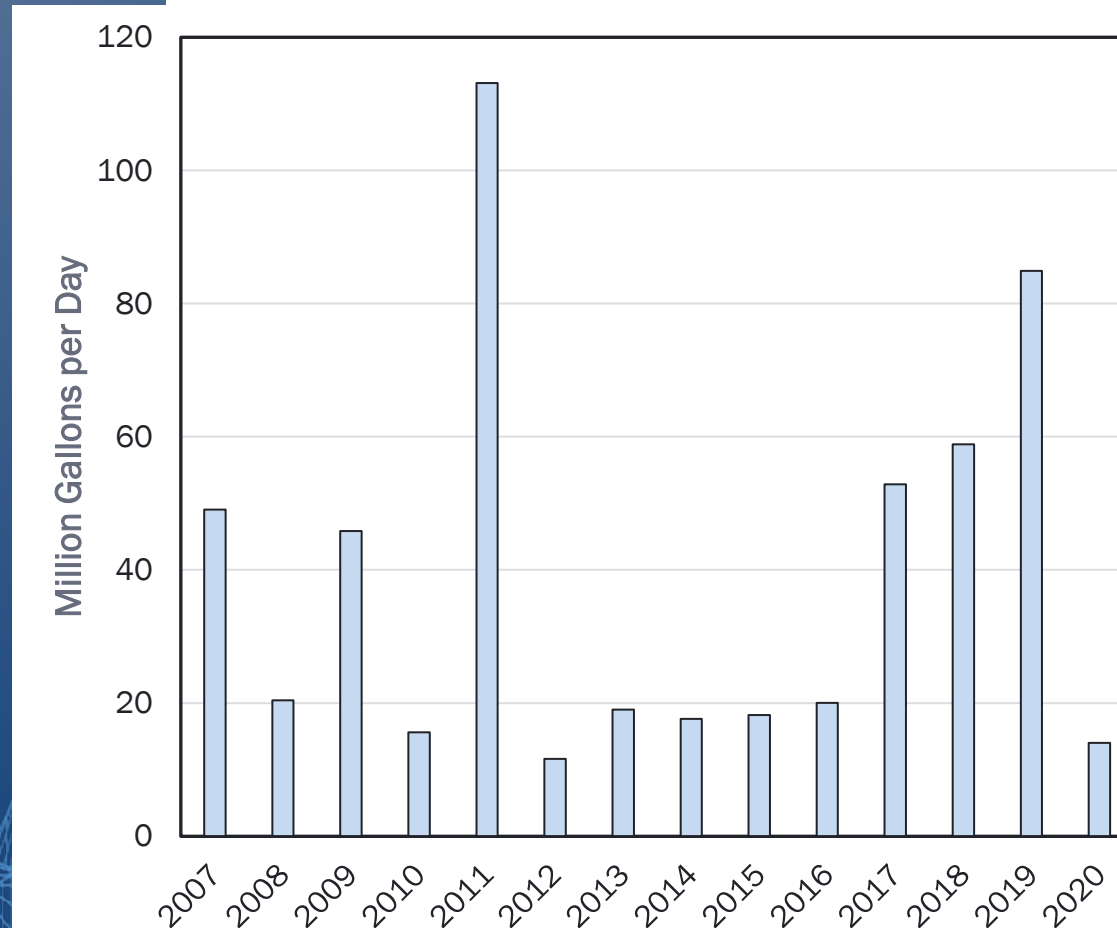
Example: Impacts of irrigation on streamflow



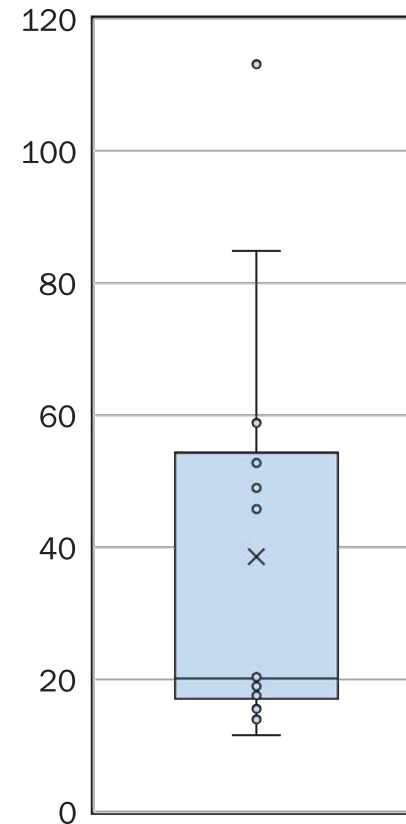
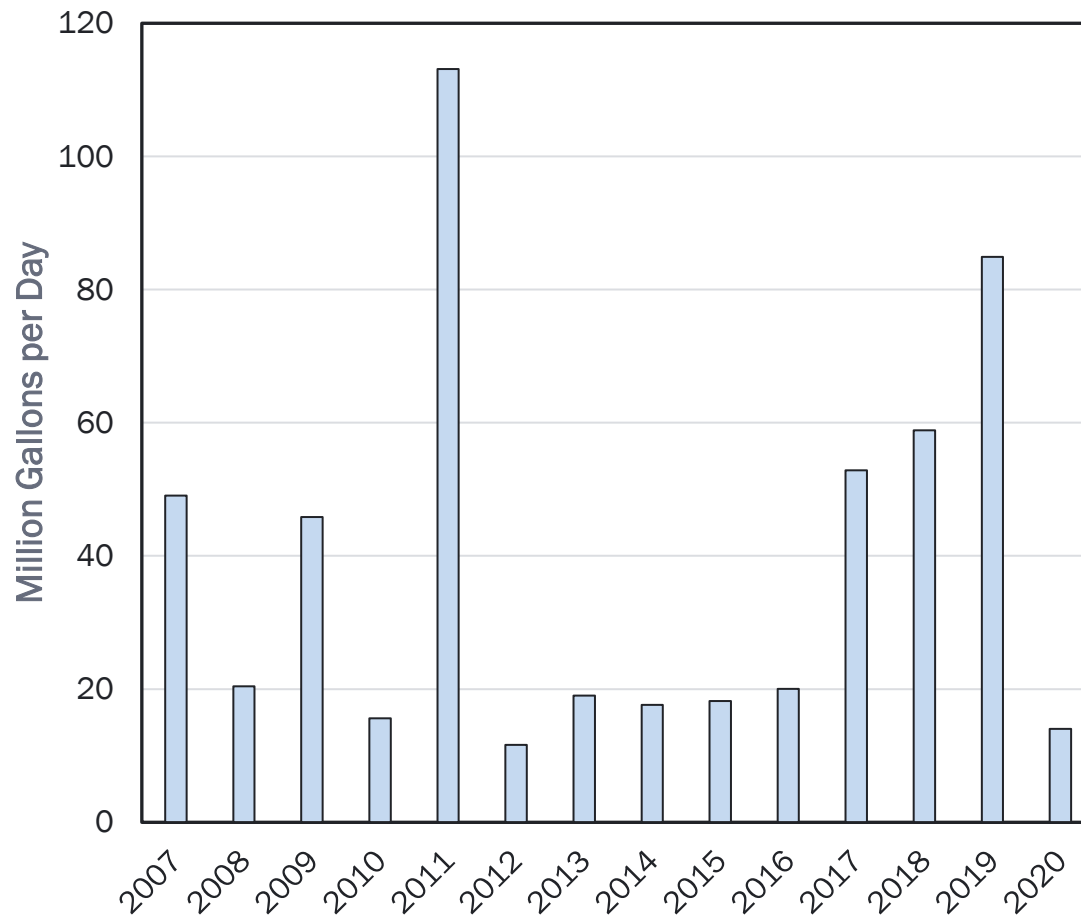
Water Availability Definitions

1. **Natural Streamflow** is the flow in the Pigeon River that would be observed if there were no withdrawals or return flows in the watershed
2. **Natural Baseflow** is the portion of Natural Streamflow derived from groundwater discharge to the River.
3. **Instream Flow** is a minimum flow in the river to maintain water quality
4. **Water Availability** = Natural Baseflow – Instream Flows. This is the portion of the natural baseflow generated in the watershed that can be used for water supply, irrigation, etc.

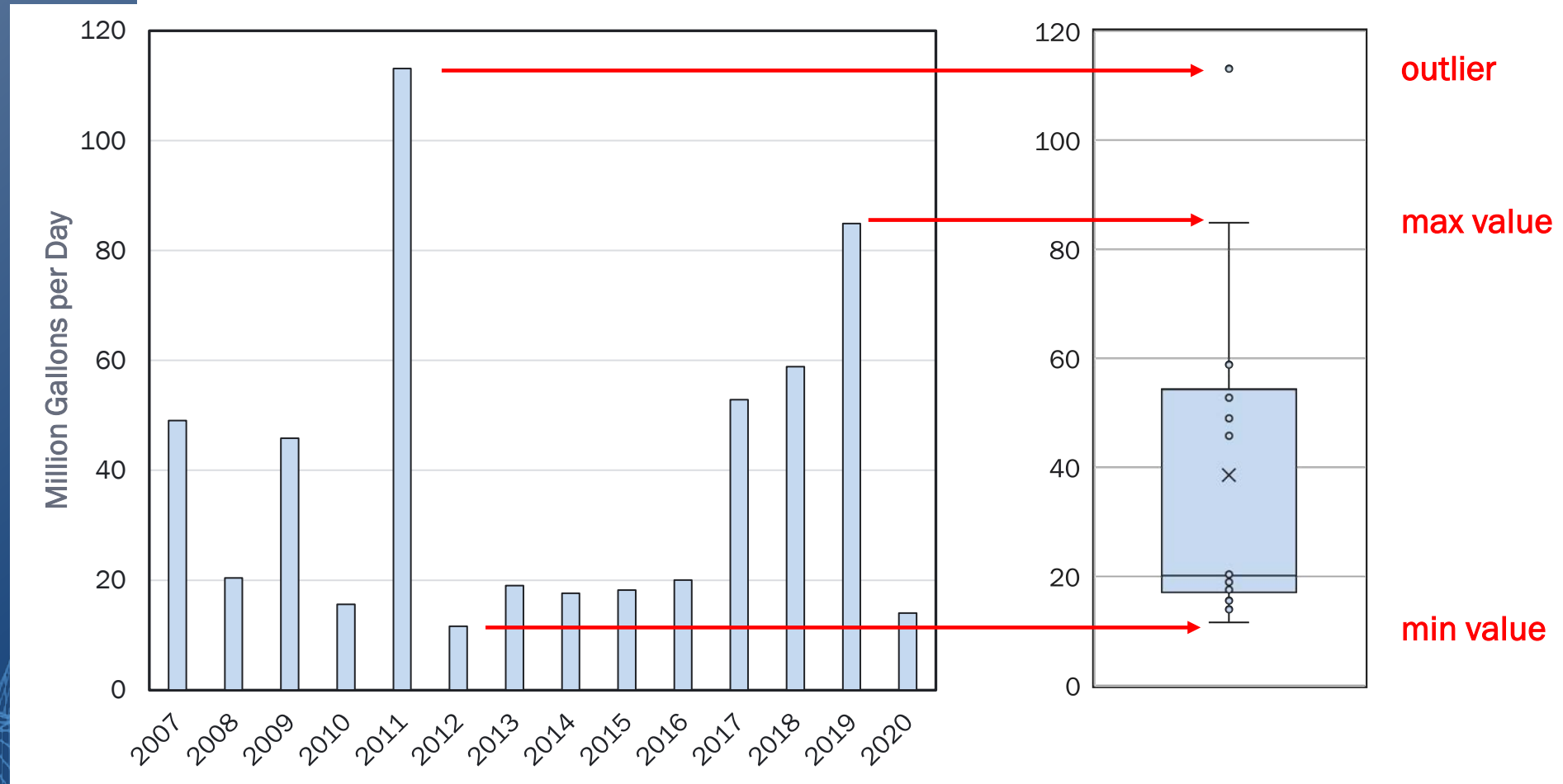
Aside: Box and Whisker Plot of timeseries data



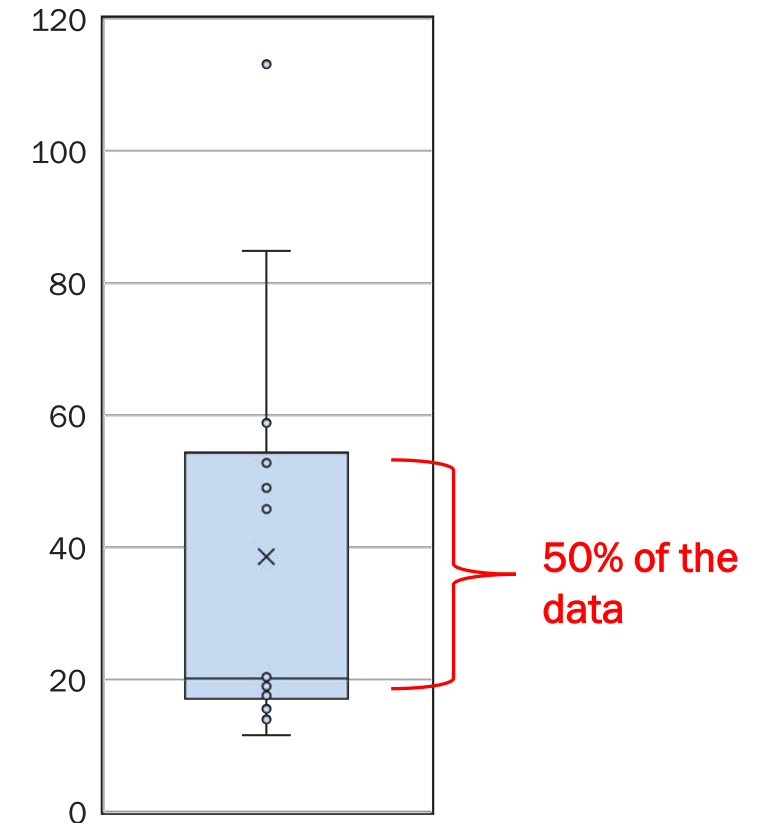
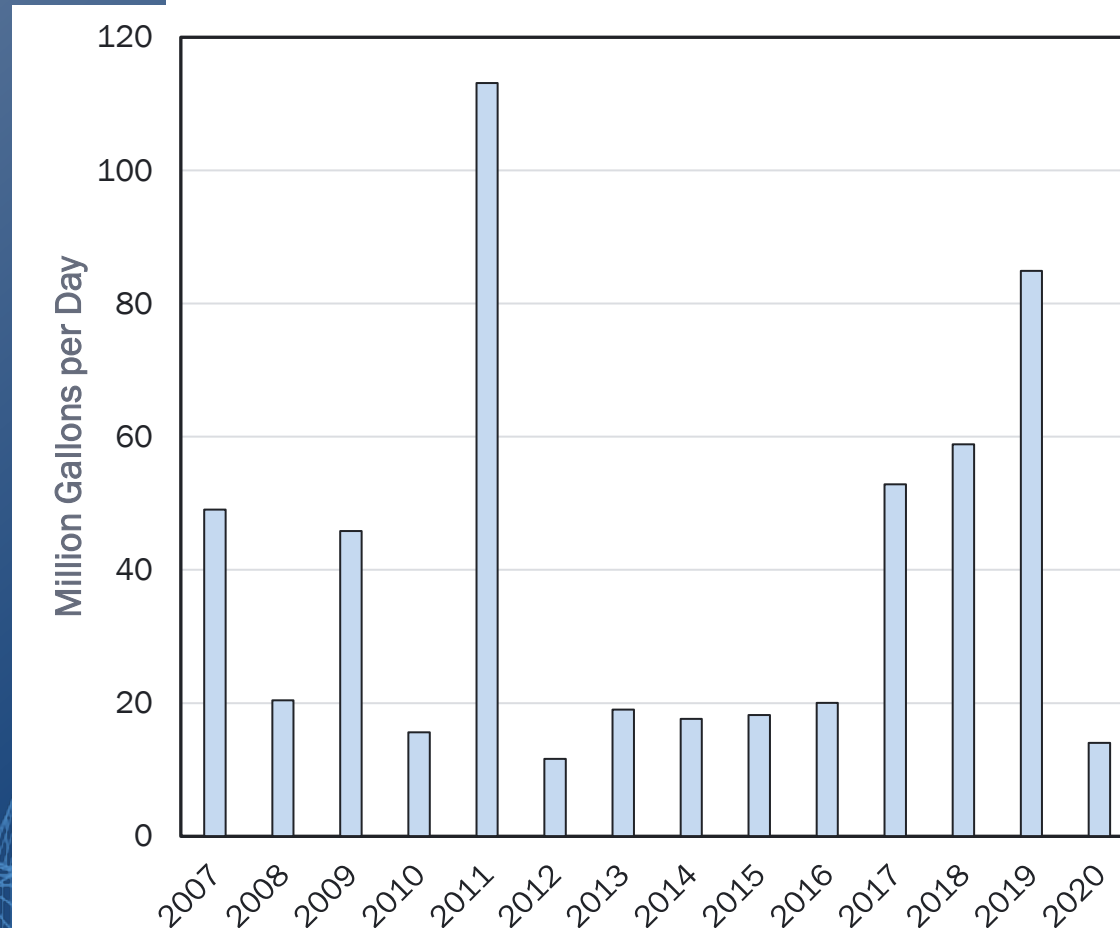
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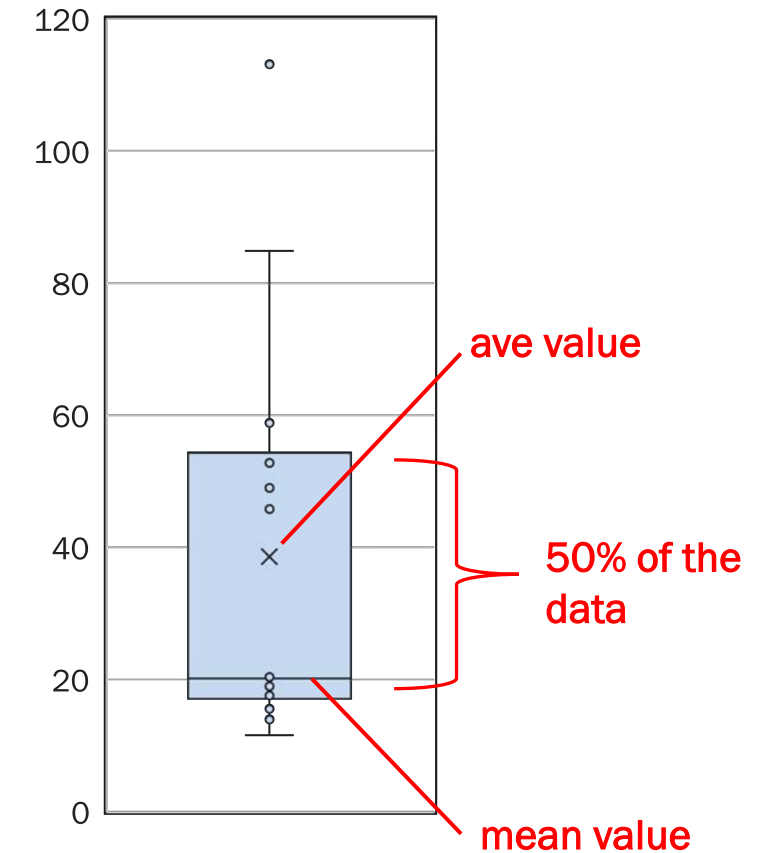
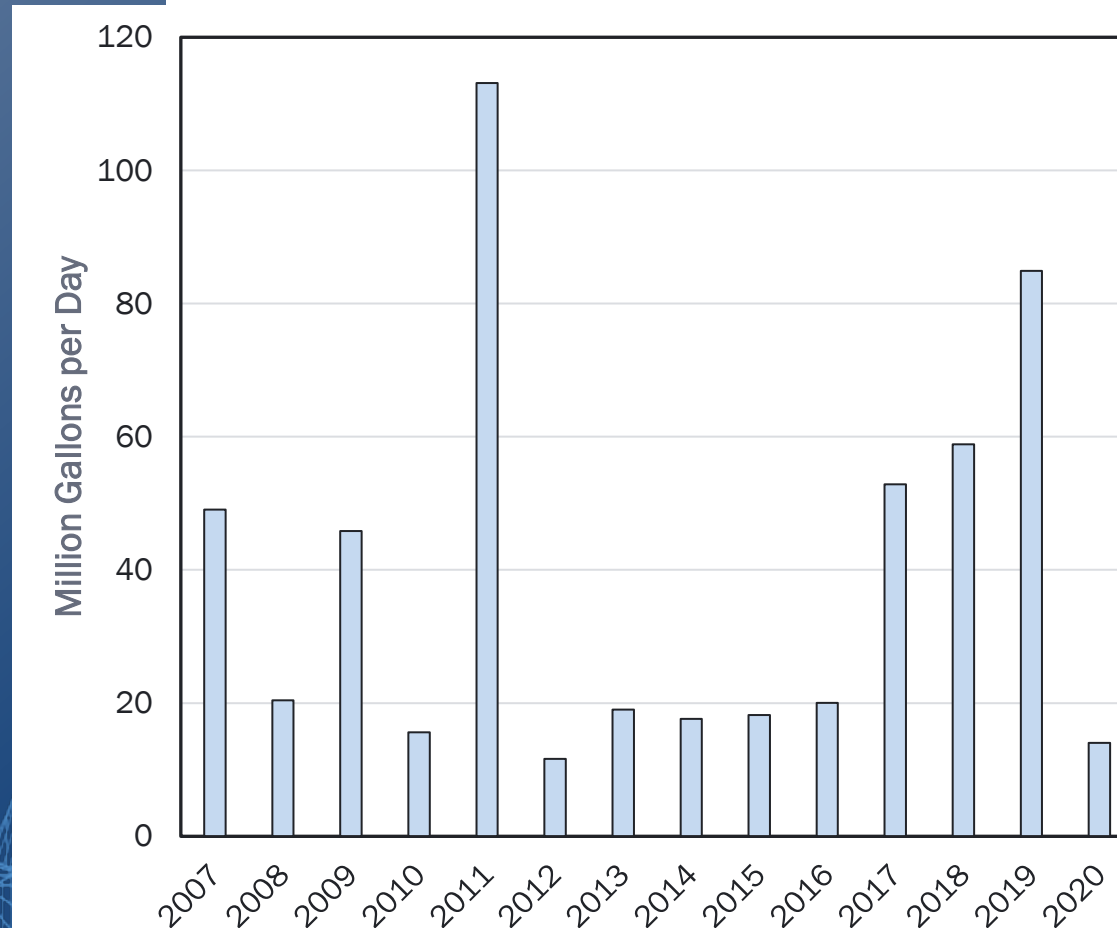
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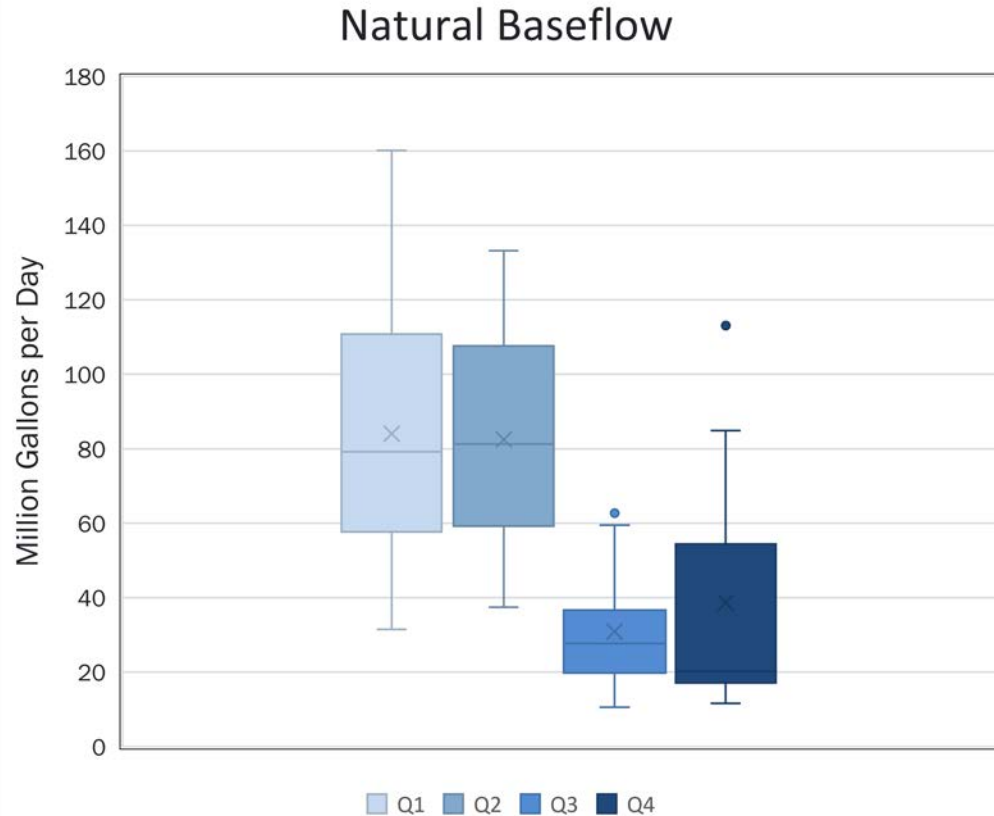
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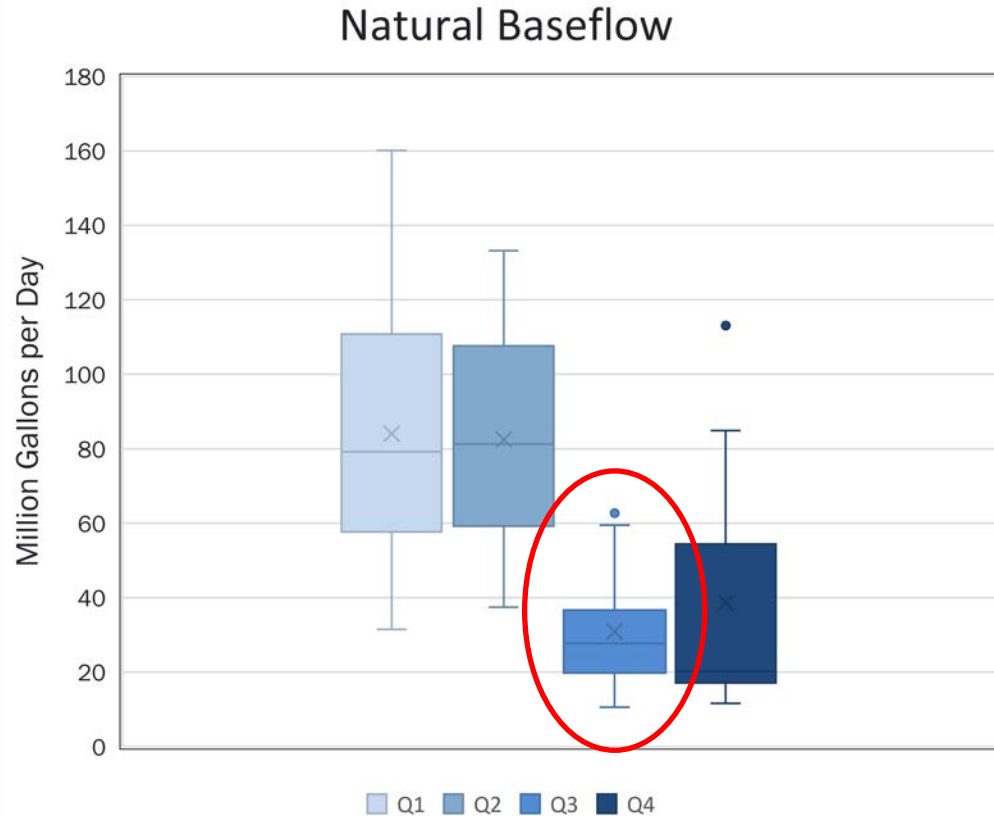
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Quarterly Averages, 2007-2020

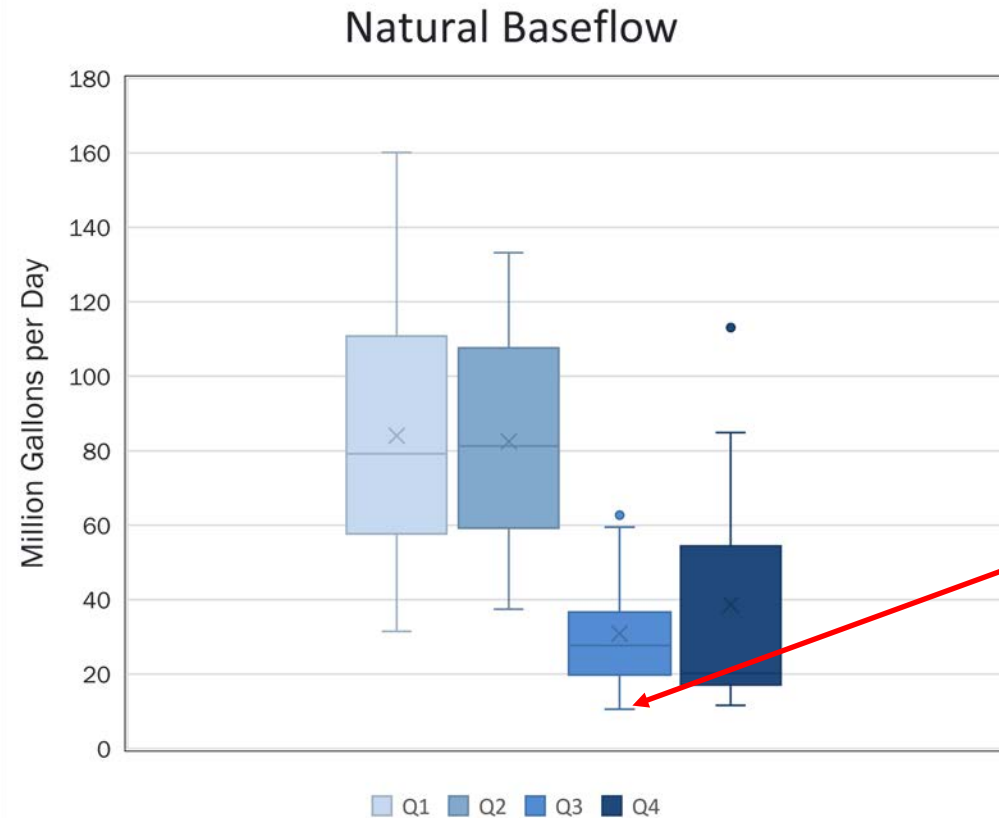


Quarterly Averages, 2007-2020



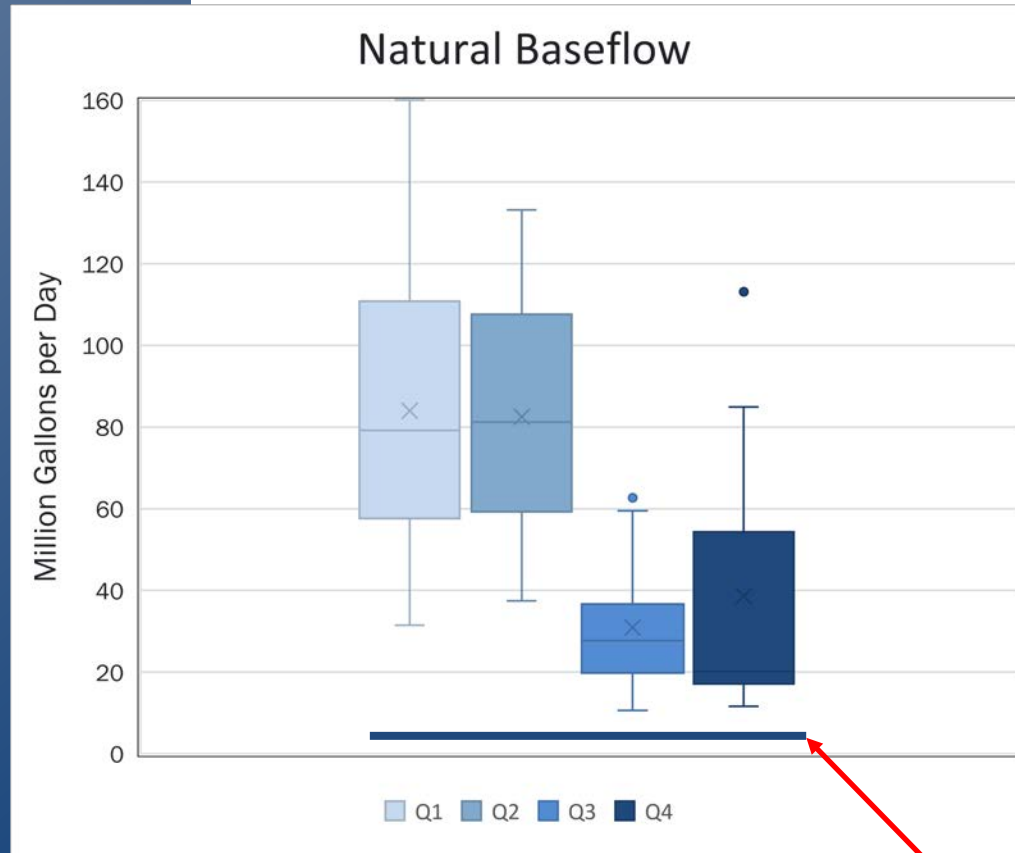
Quarter 3 (July-August-September)
is the critical quarter for water
availability

Quarterly Averages, 2007-2020

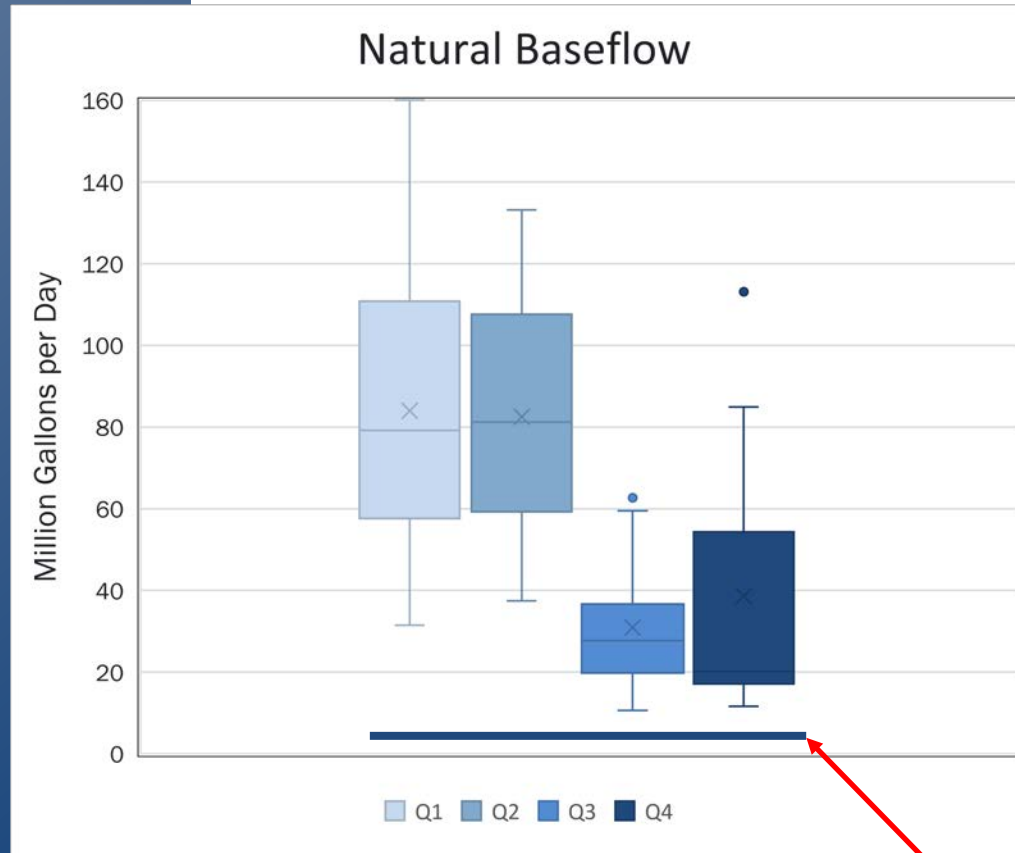


Minimum Q3 value from 2012 = 10.6 MGD

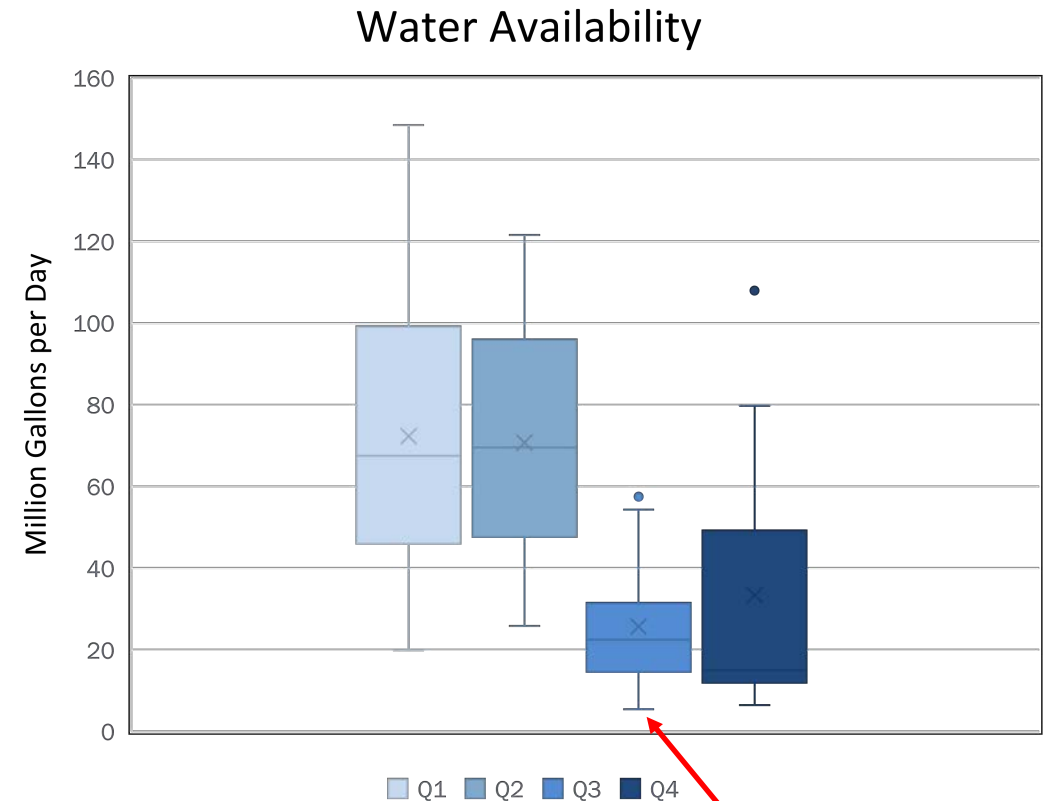
Quarterly Averages, 2007-2020



Quarterly Averages, 2007-2020



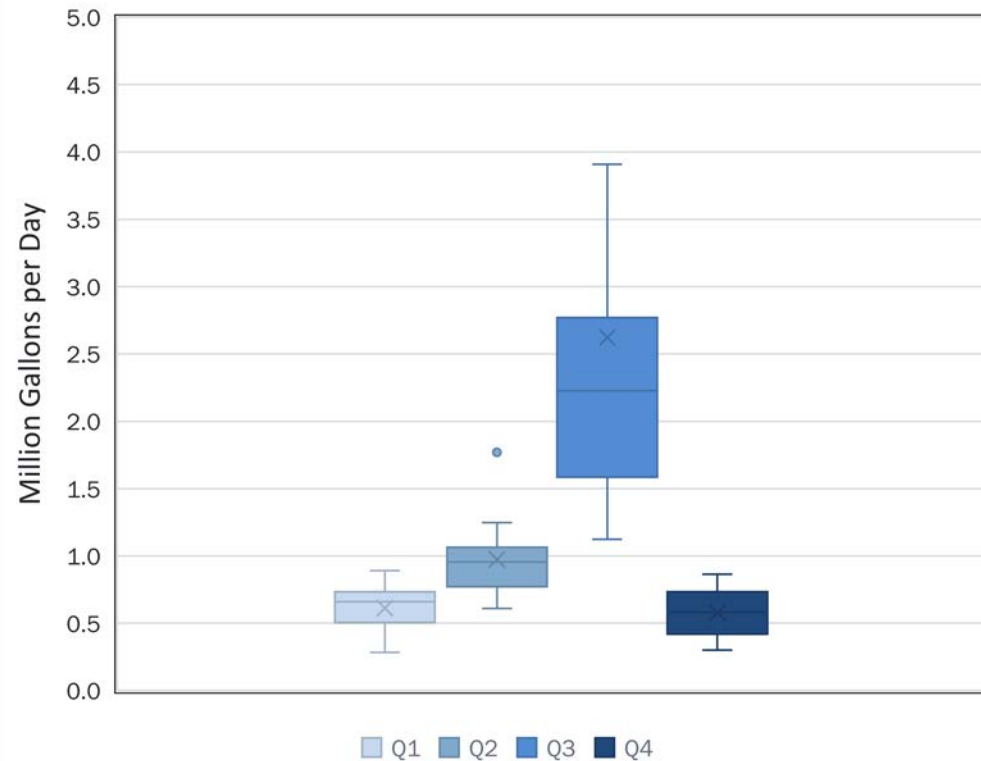
Instream Flow
 $Q_{7,10} = 5.2$ MGD



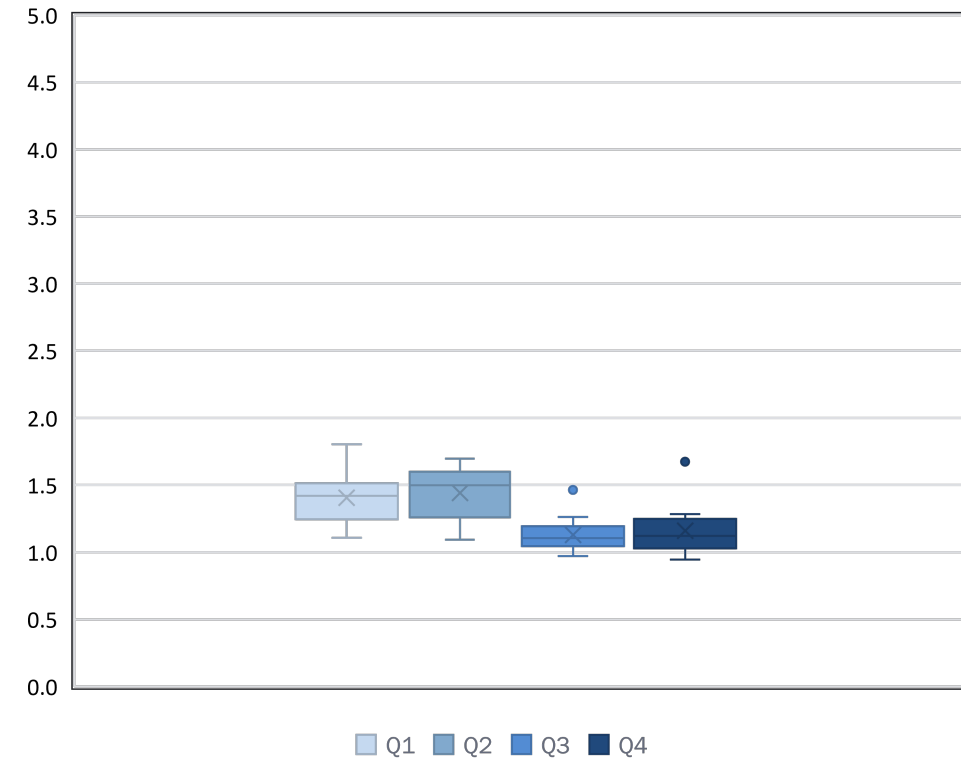
Minimum Q3 value
from 2012 = 5.4 MGD

Quarterly Averages, 2007-2020

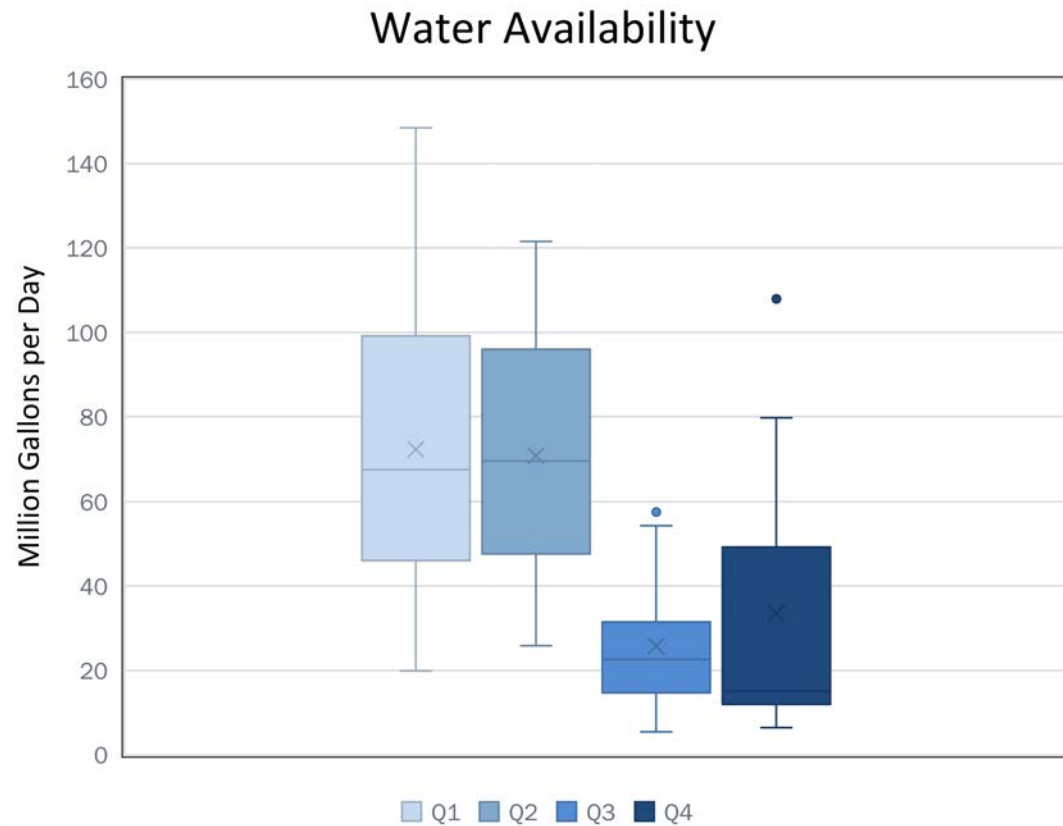
Withdrawals



Return Flows

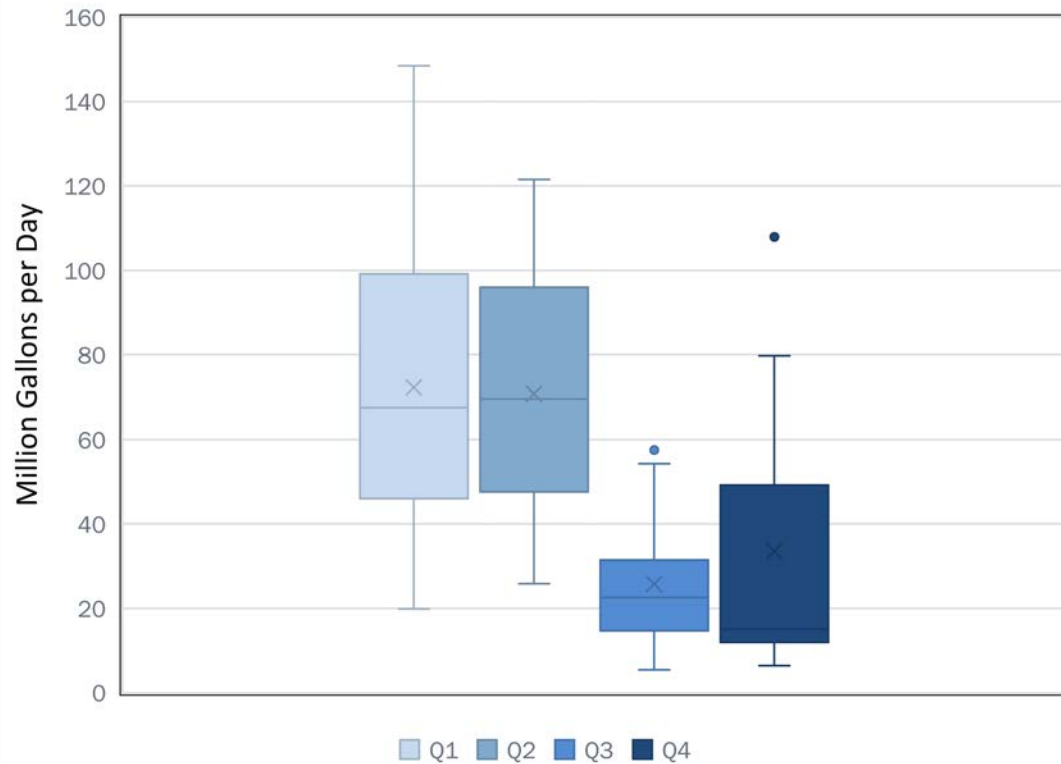


Quarterly Averages, 2007-2020

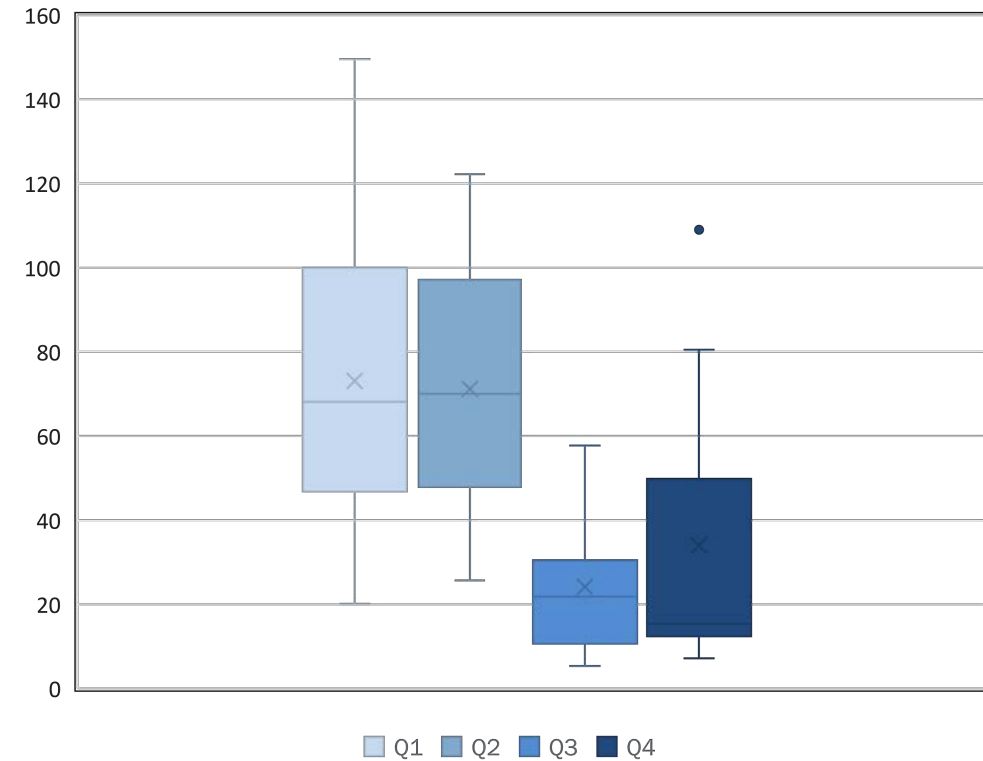


Quarterly Averages, 2007-2020

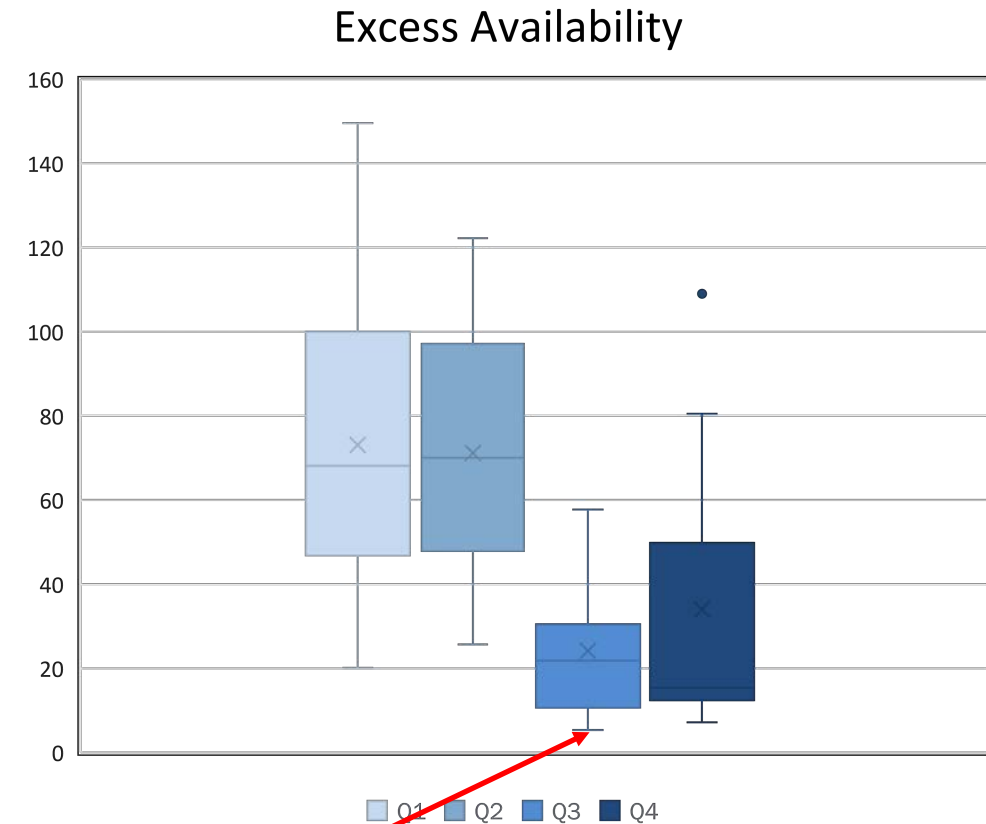
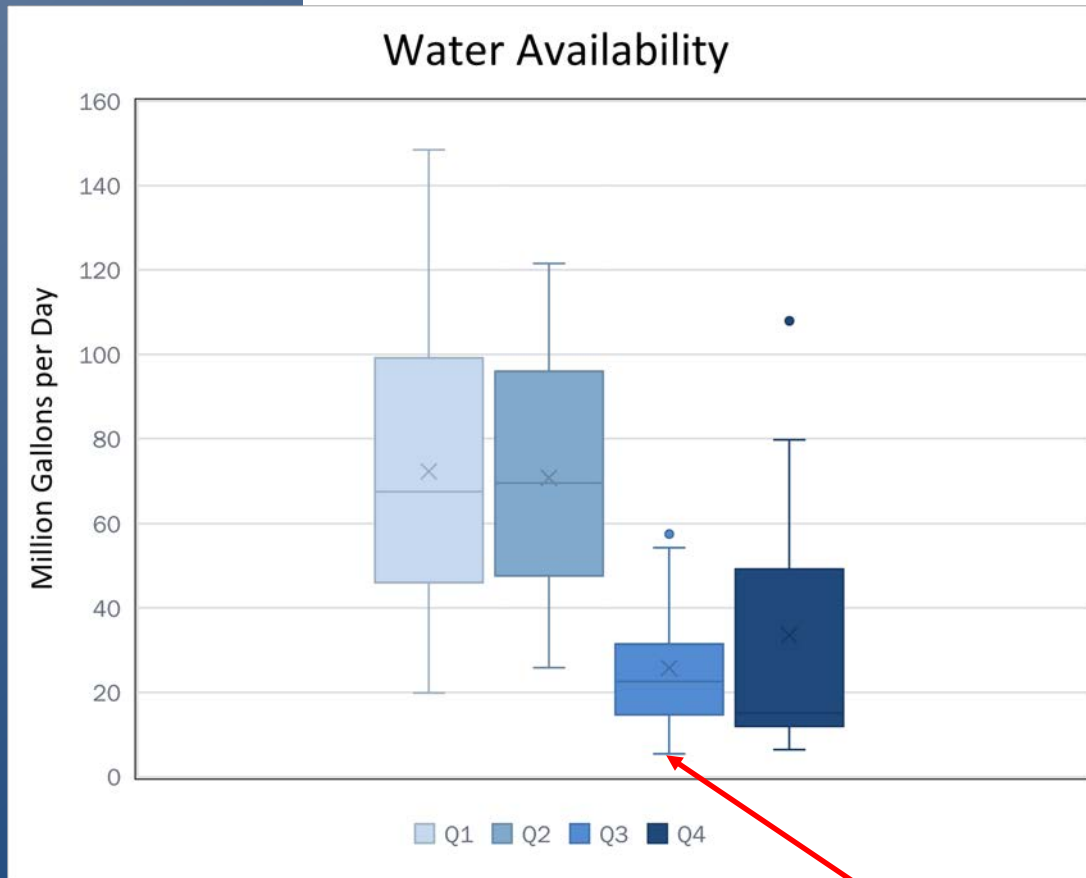
Water Availability



Excess Availability



Quarterly Averages, 2007-2020



Minimum Q3 value
from 2012 = 5.4 MGD

Conclusions from Water Availability Assessment

1. High infiltration rates in Steuben County, resulting in large, sustained Baseflows.
2. Public supply needs are small in comparison to Water Availability, and offset by WWTP discharges
3. No quarter in period of record (2007-2020) with a deficit in Water Availability.
4. No quarter in period of record with less than 5 MGD Excess Availability.
5. 5 MGD exceeds the current public supply demand in the County.
6. Irrigation is expanding in the County.

3. Future Availability

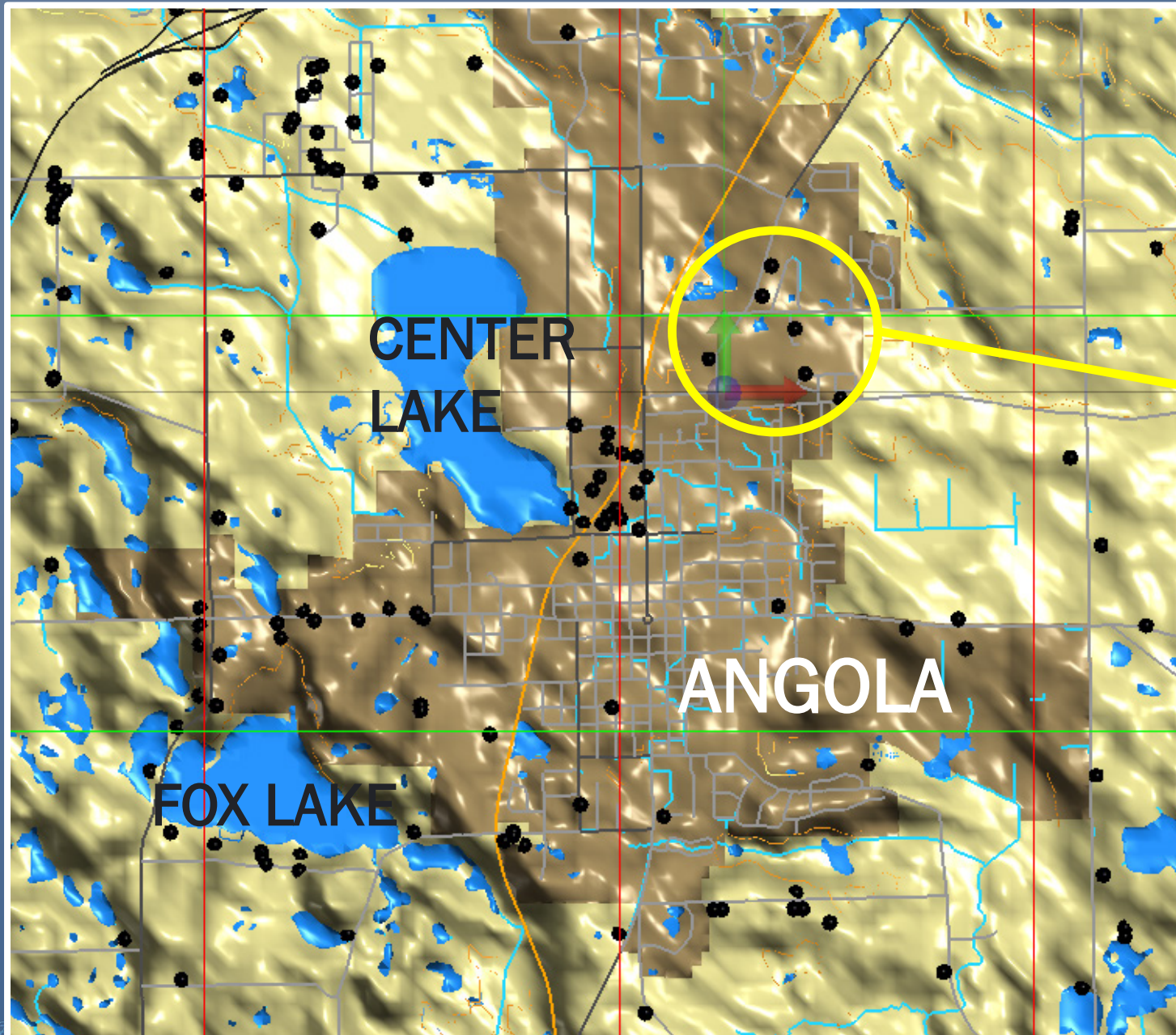
3. Future Availability

- Threat of not knowing, or not paying attention
- Industrial developments with large water requirements
- Expansion of agricultural irrigation
- Changes in climate (drier or wetter ?)

4. Monitoring Network

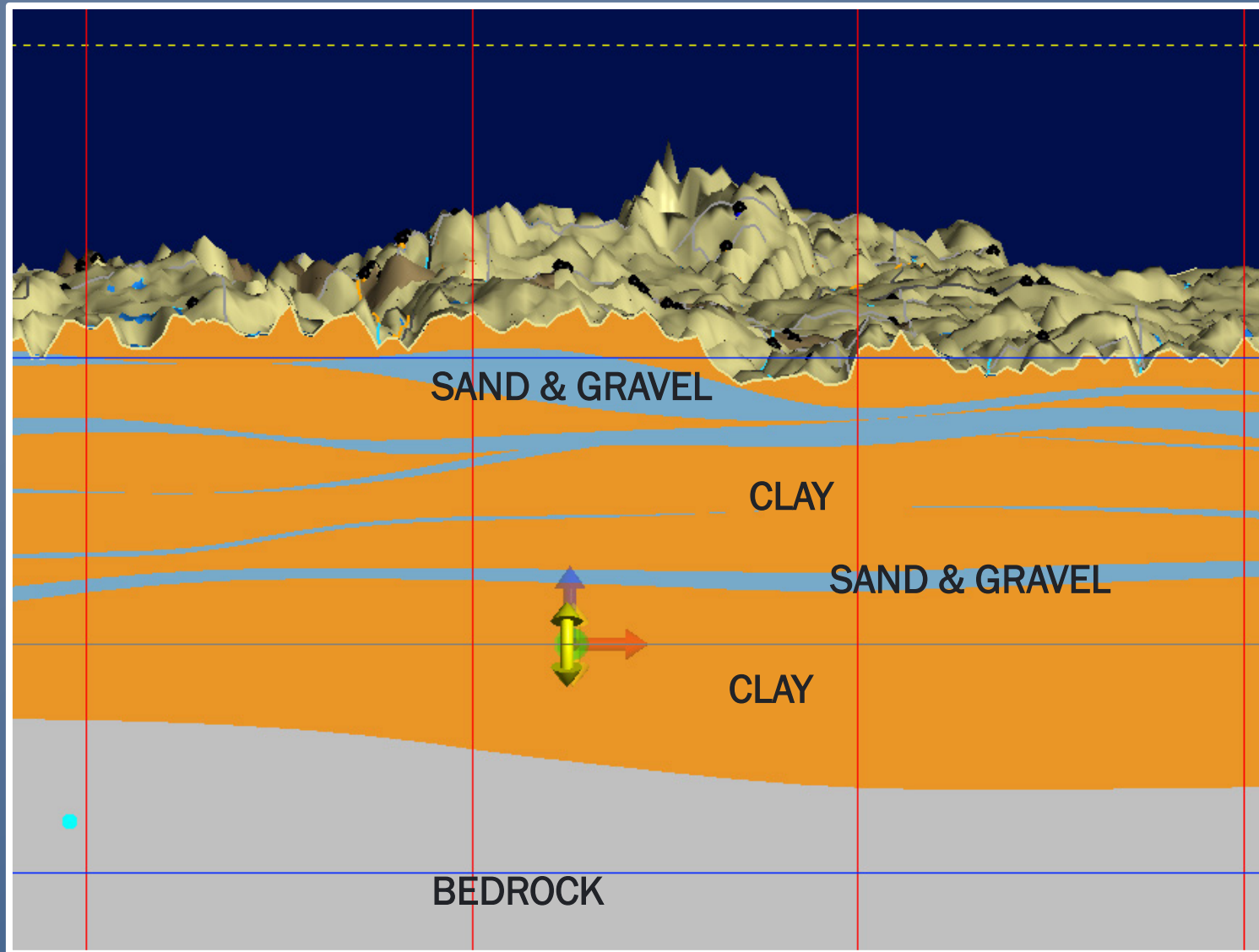
- What controls the resource? GW and SW
- What and where should we monitor?

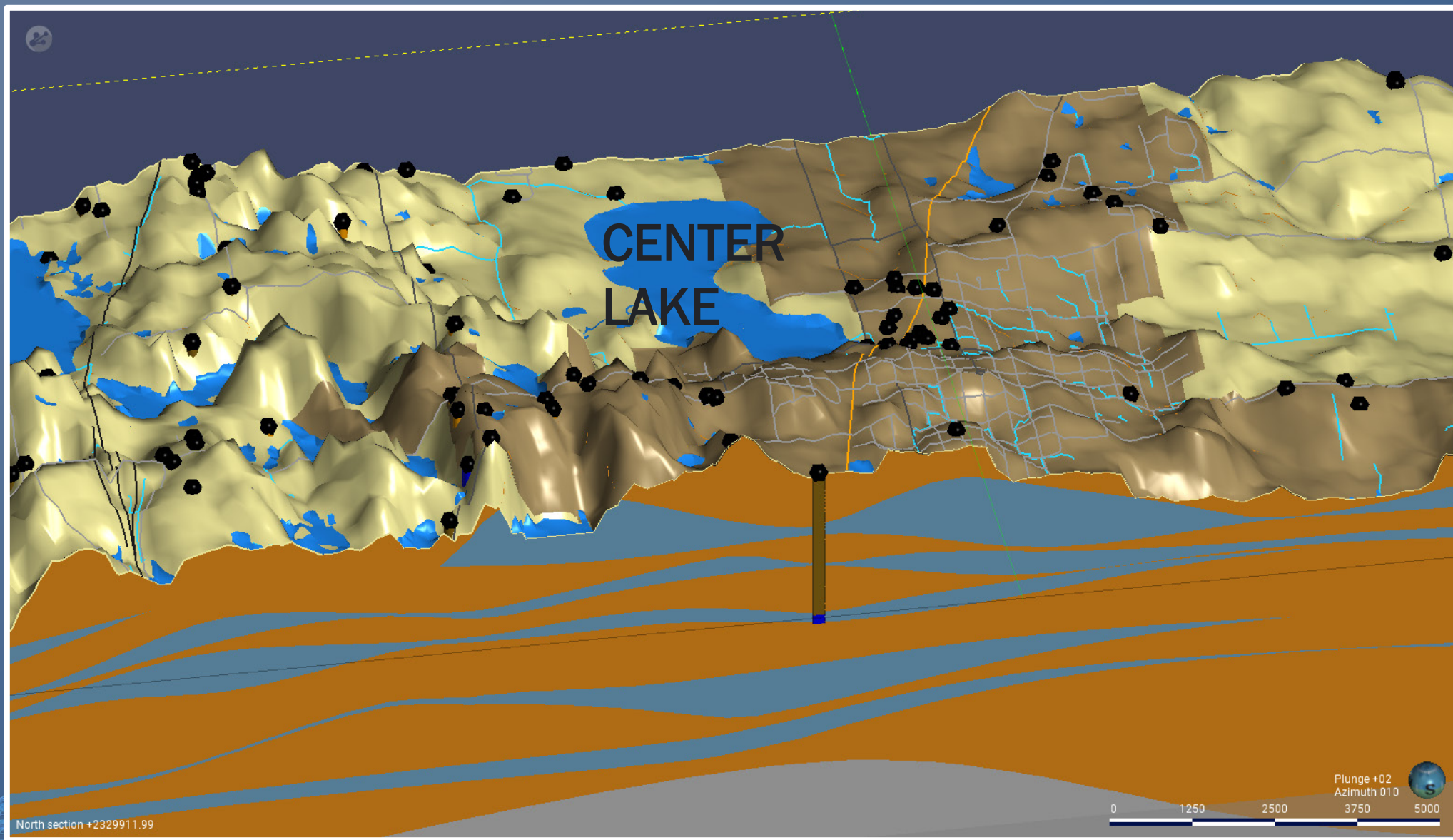
Geologic Model illustrating the aquifer system

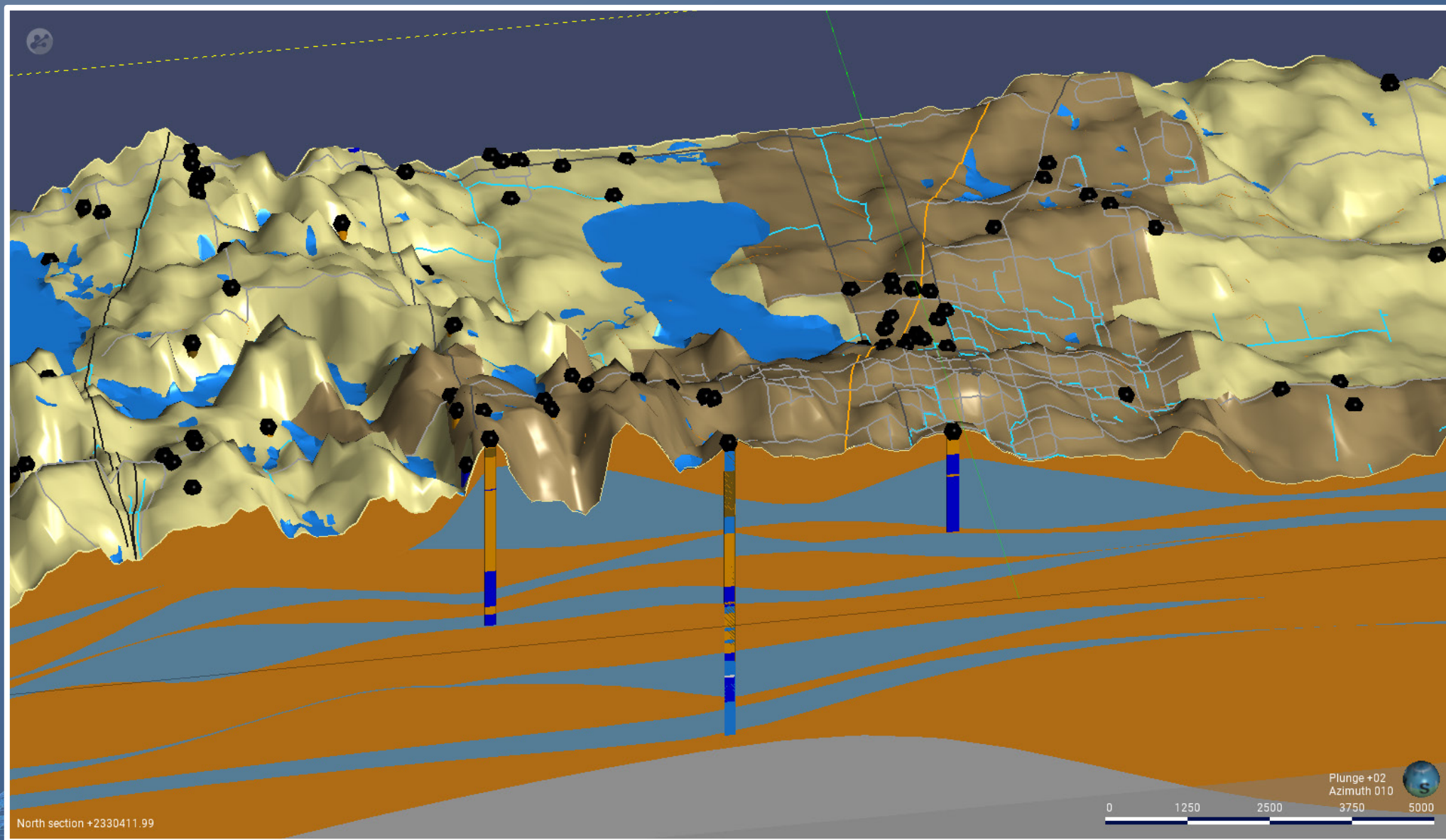


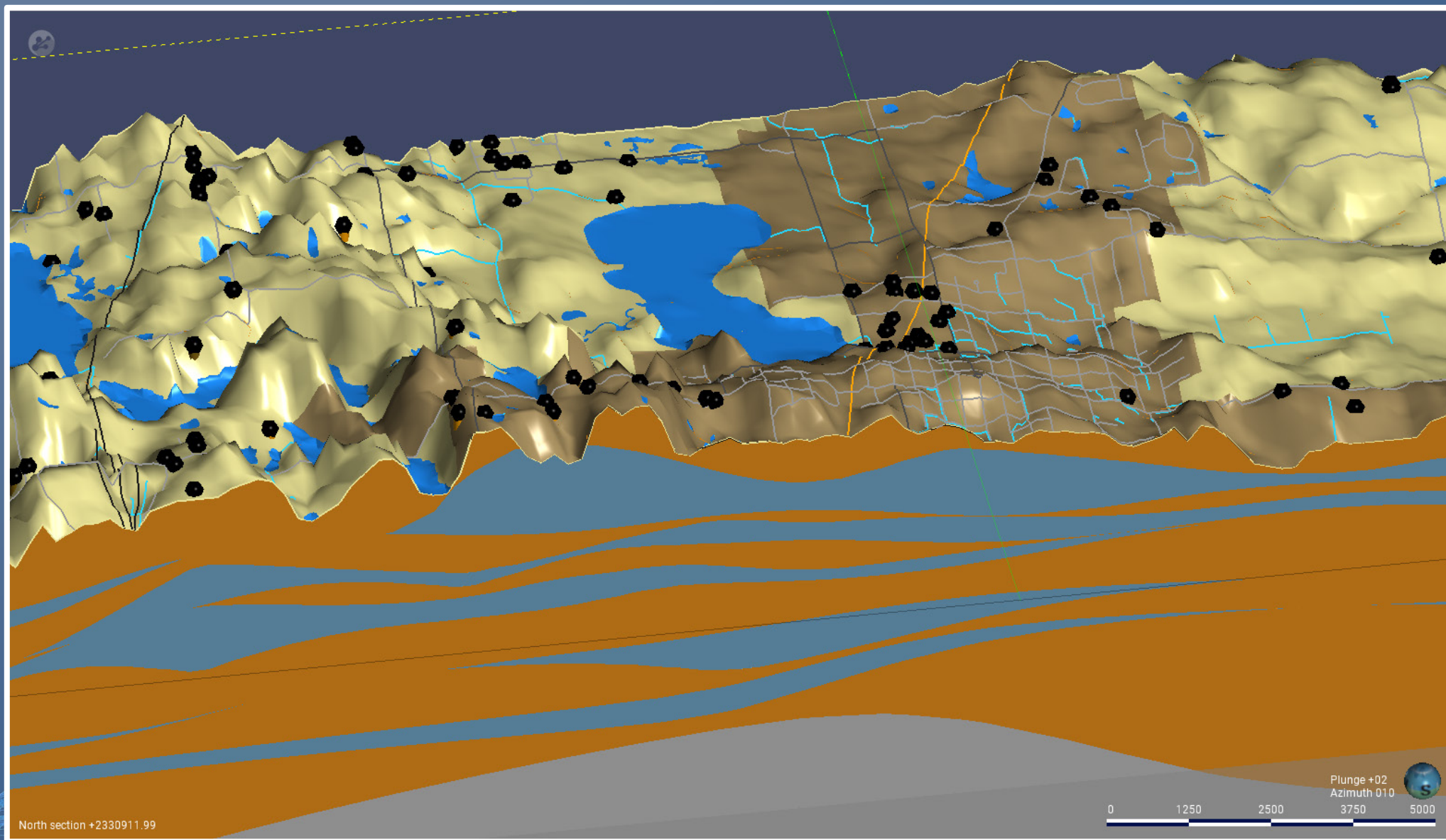
Black dots represent locations of wells with driller's logs

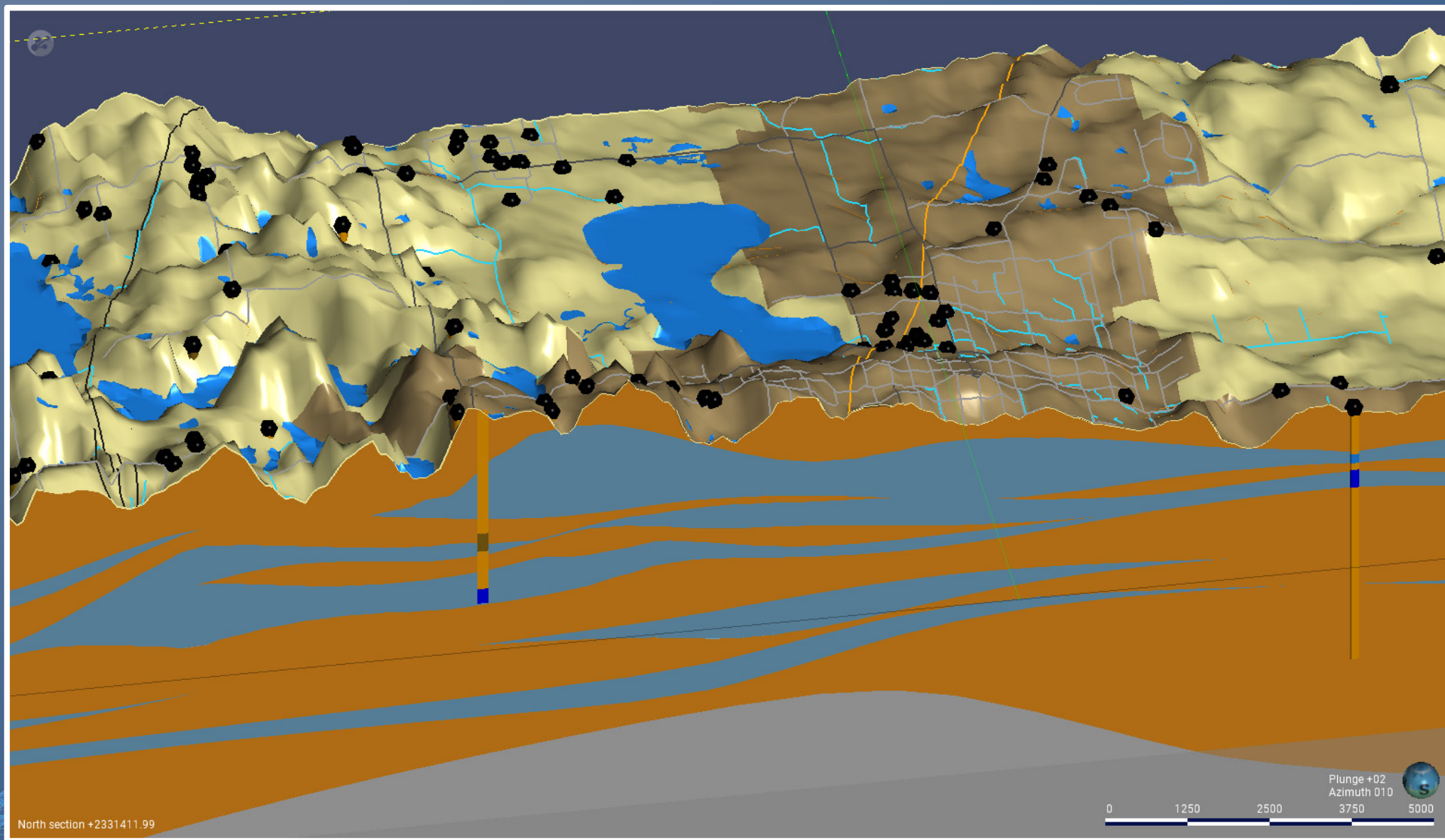
Geologic Model section view

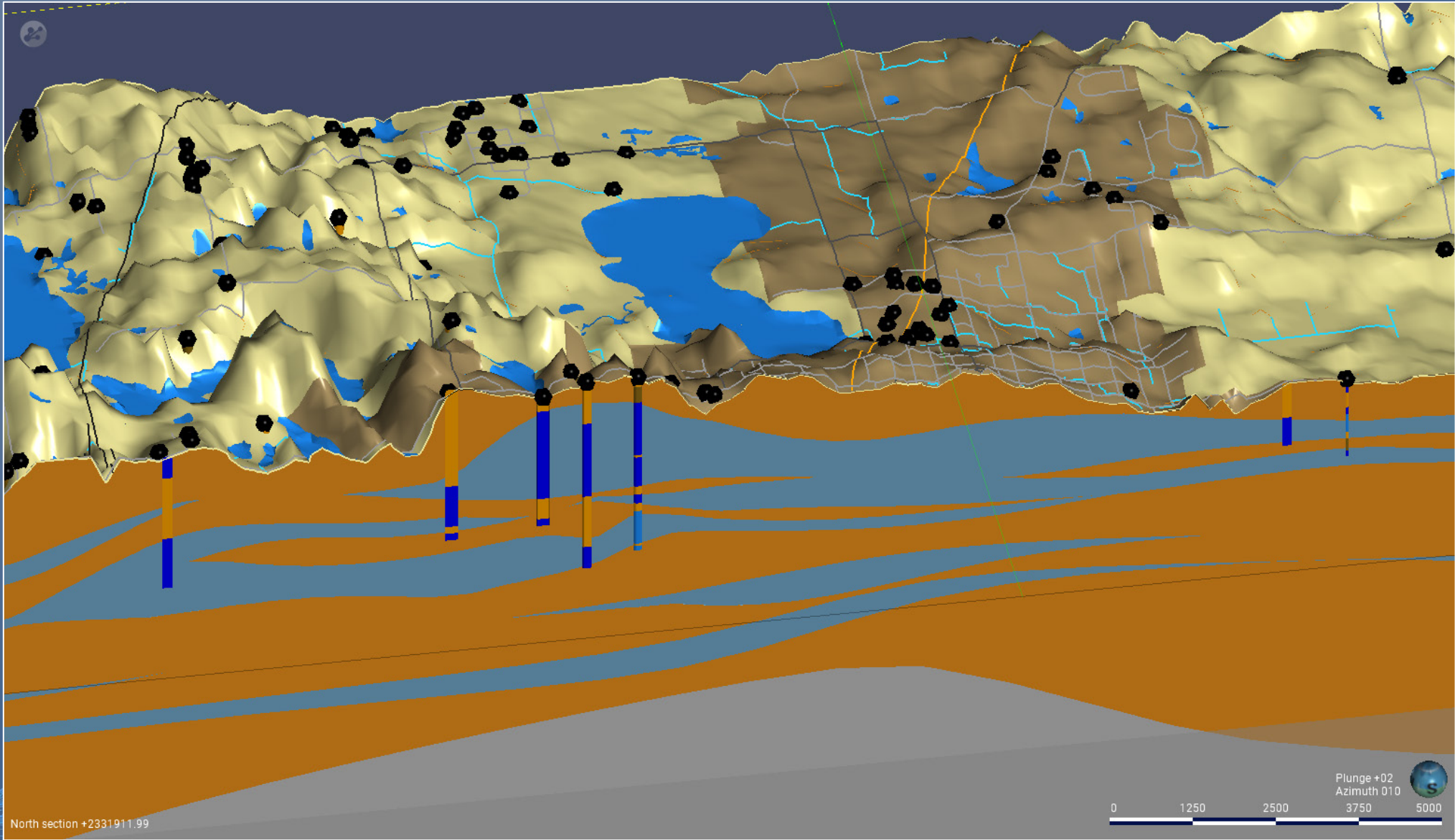


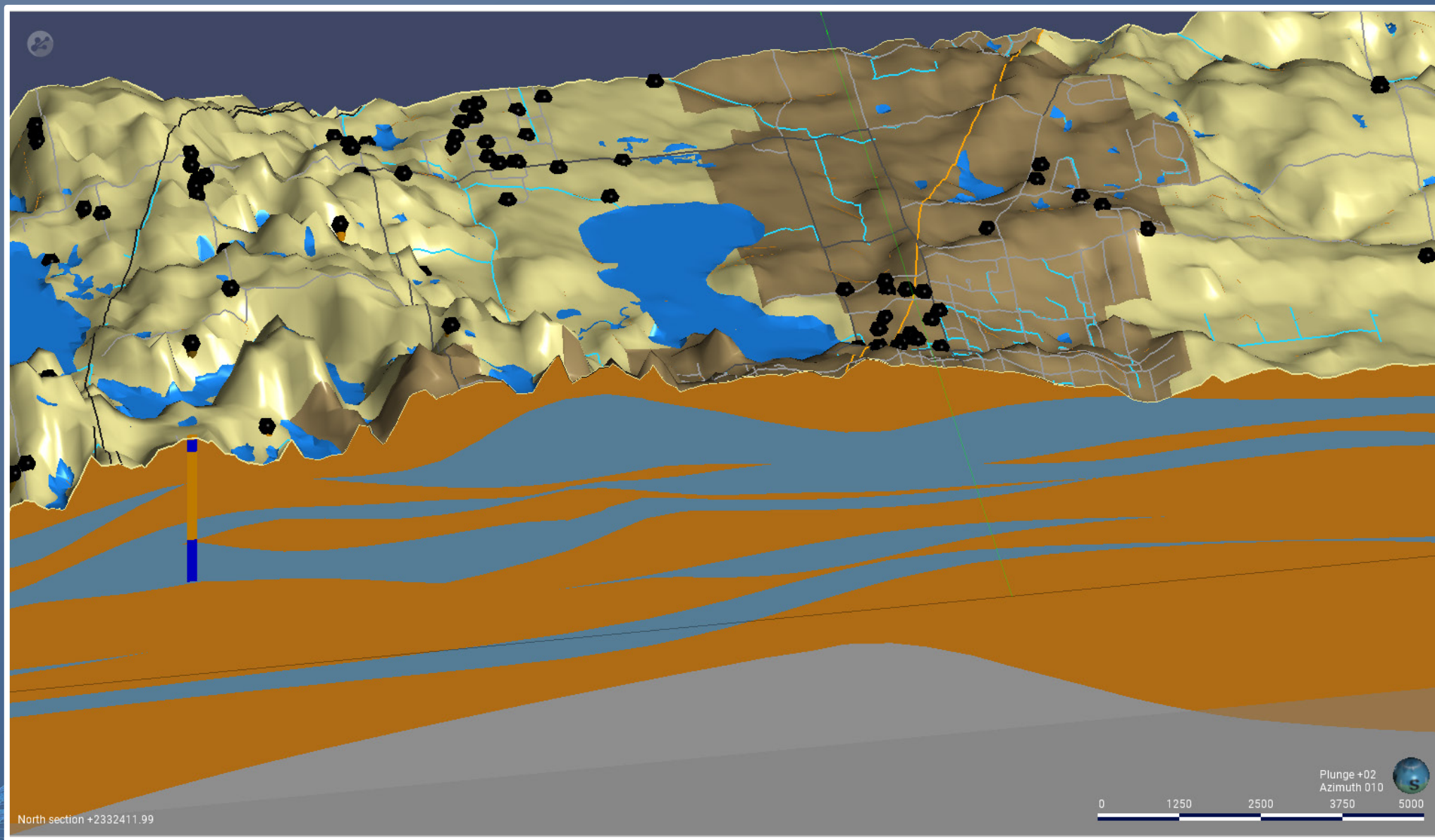


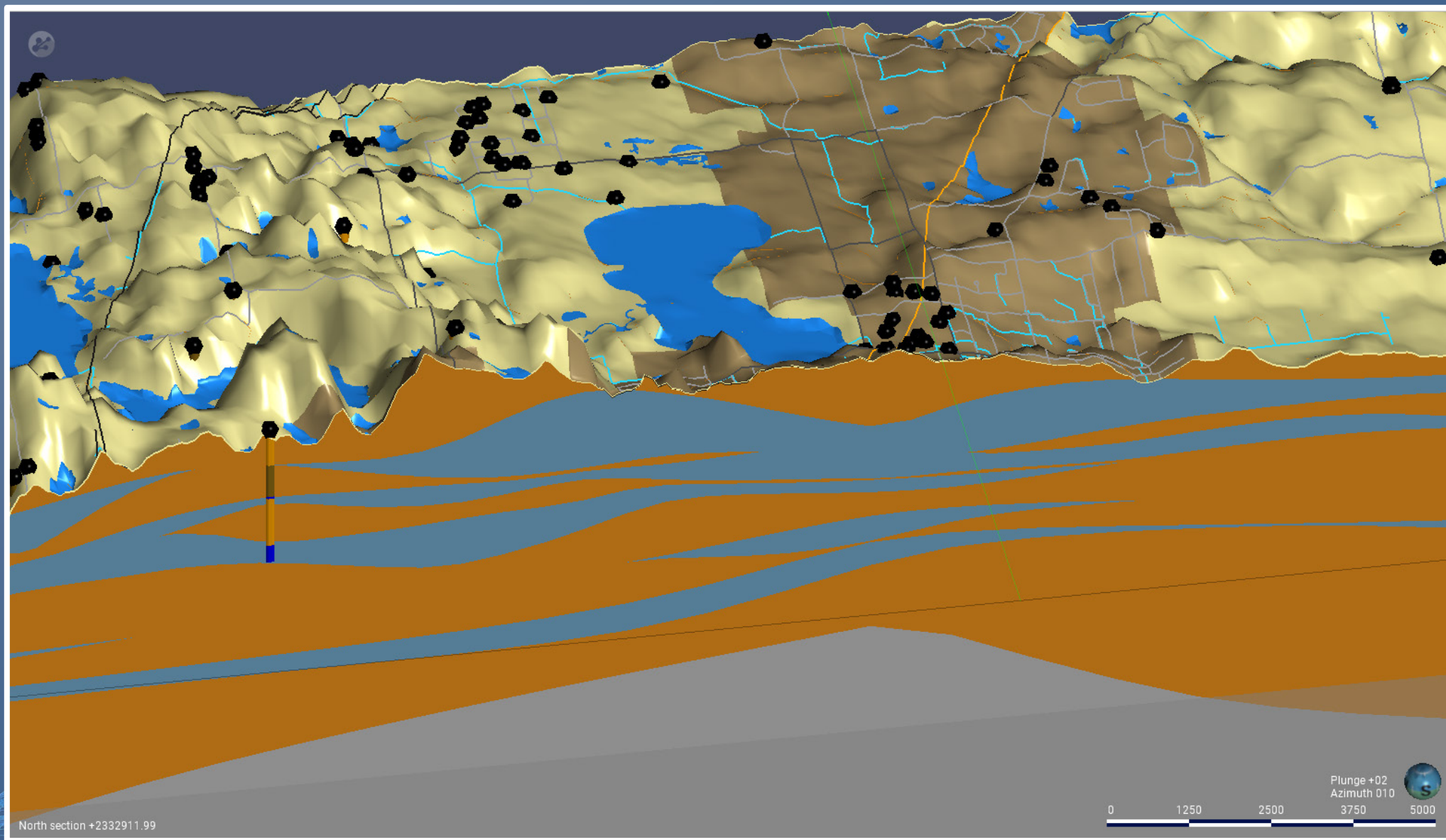


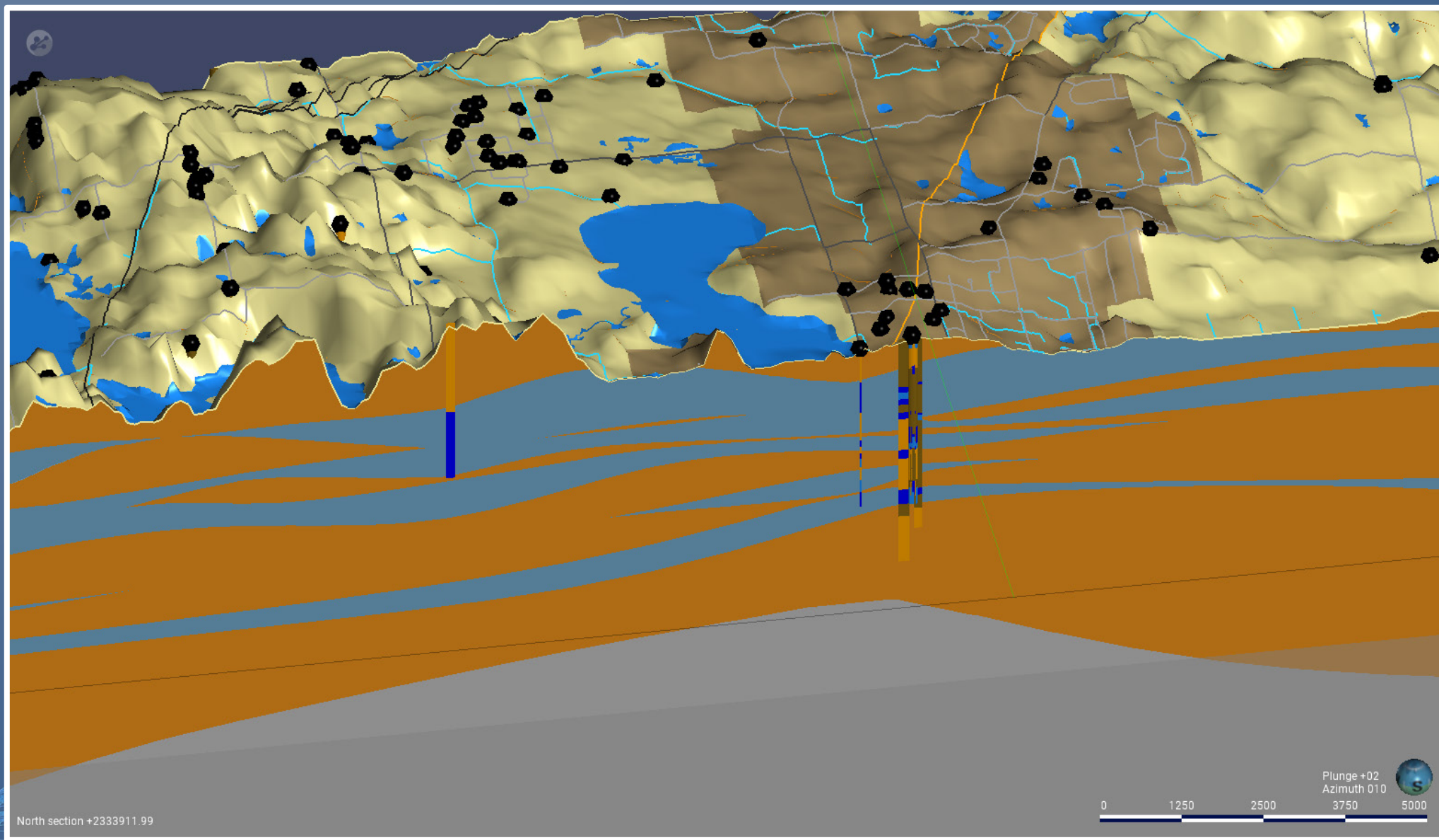


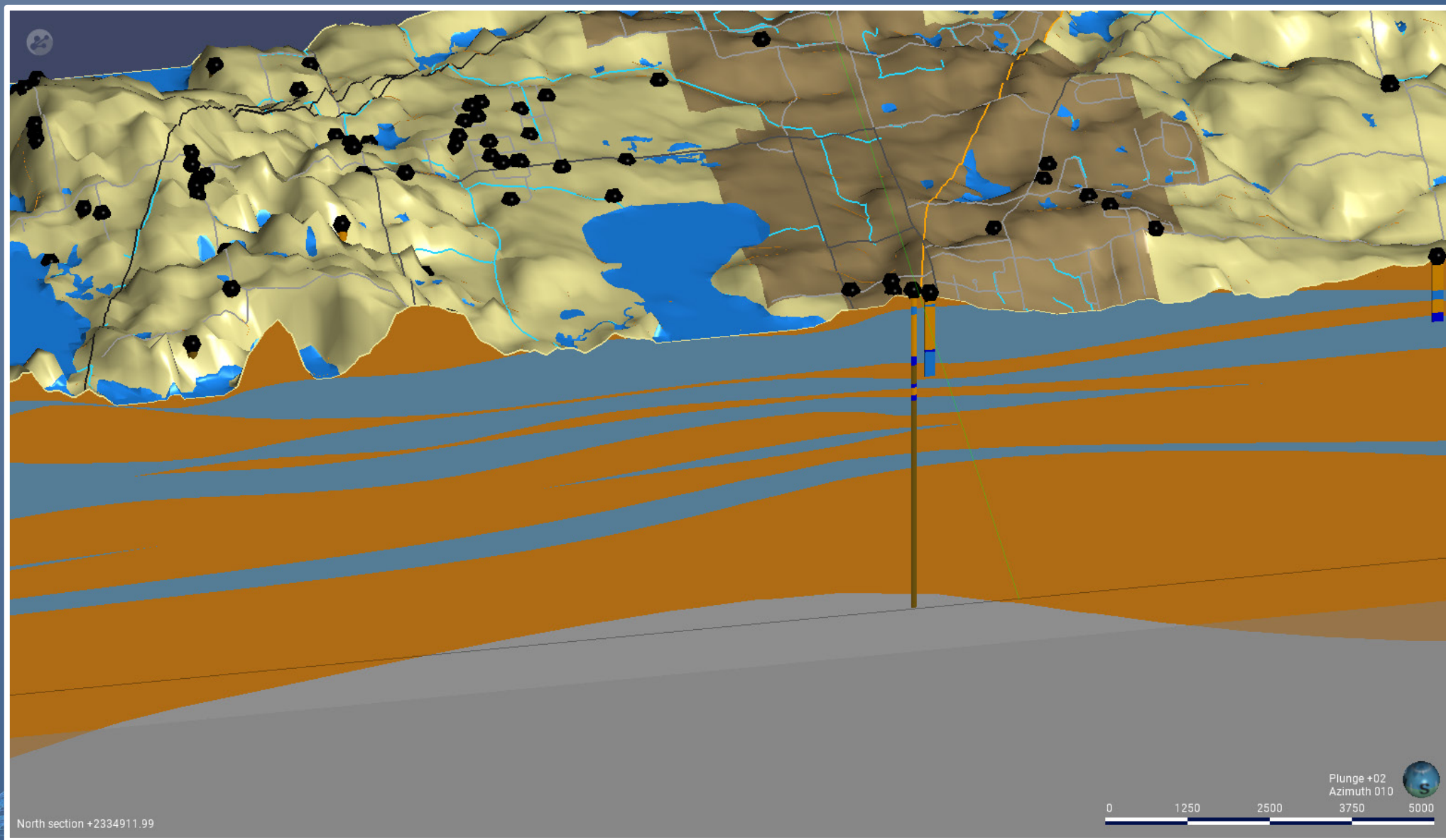








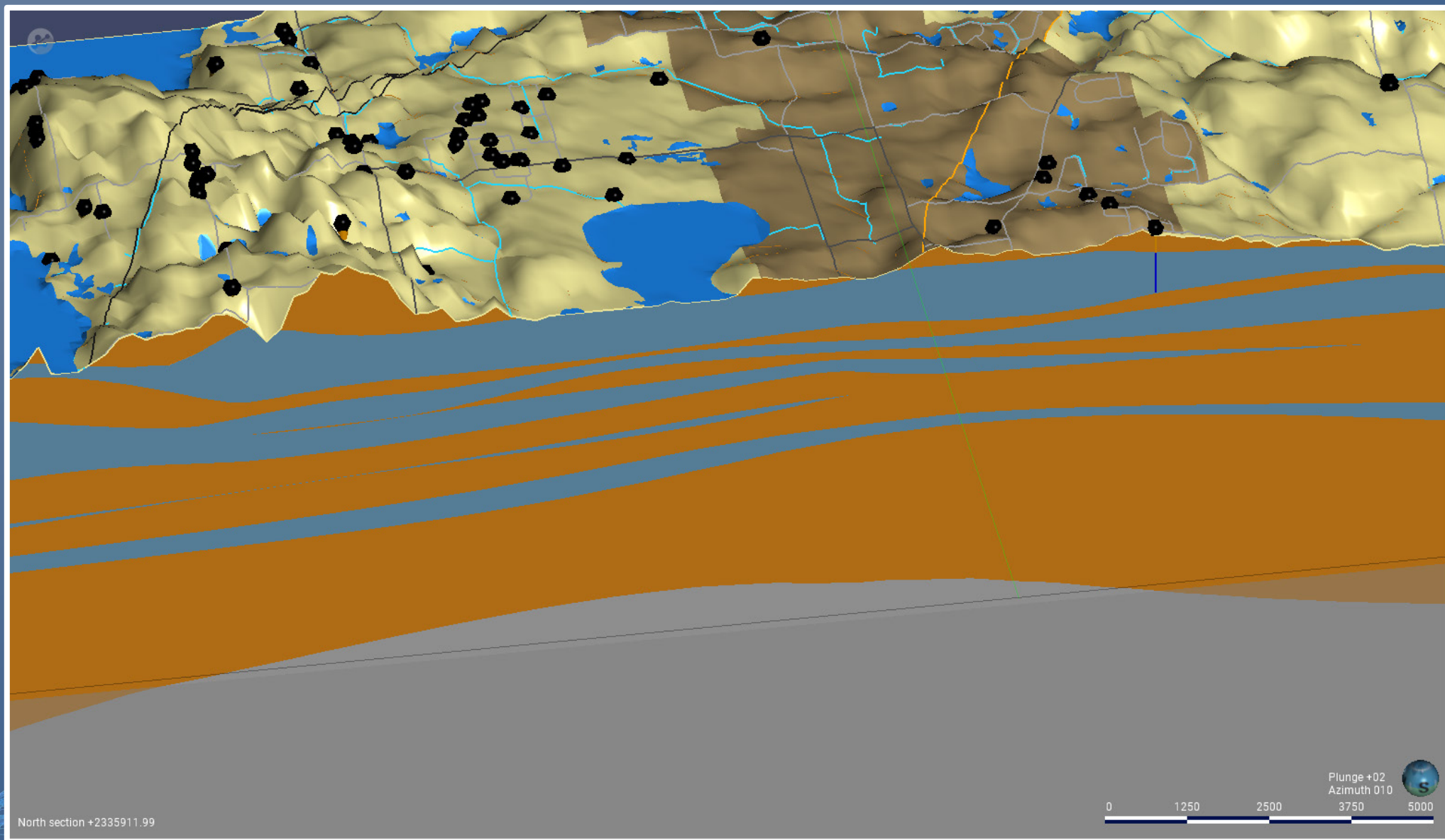




Plunge +02
Azimuth 010

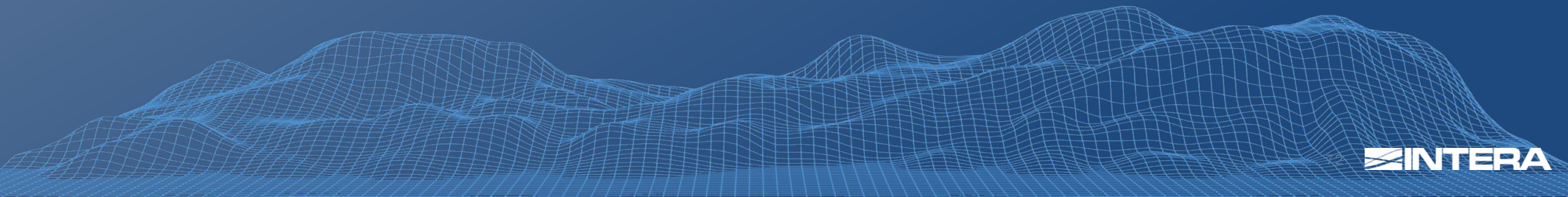
0 1250 2500 3750 5000

North section +2334911.99



- Geologic Model shows the aquifer (S&G layers) to be only locally separated
- Many lakes appear directly connected to sands and gravels
- Monitoring the aquifer means monitoring each layer

Aquifer Monitoring

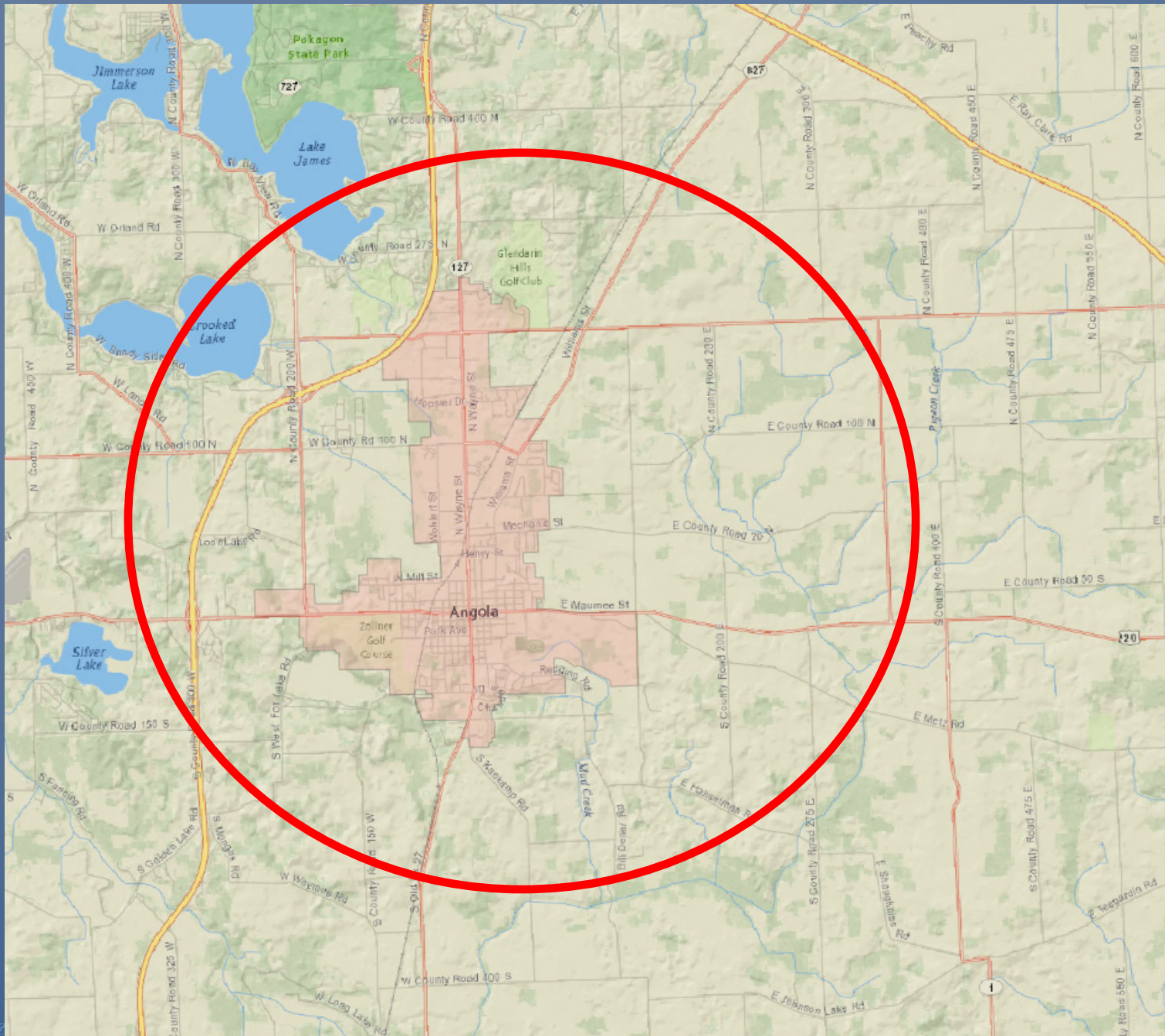


Aquifer Monitoring

- Acoustic sensors and telemetry installed on wells of volunteers
- Targeting 6-10 installations in and outside of Angola, to be monitored for 4 years
- Ideal sites would have a well drilling and construction log available, and use homeowner Wi-fi
- Network would supplement data being collected by USGS in the region

Aquifer Monitoring

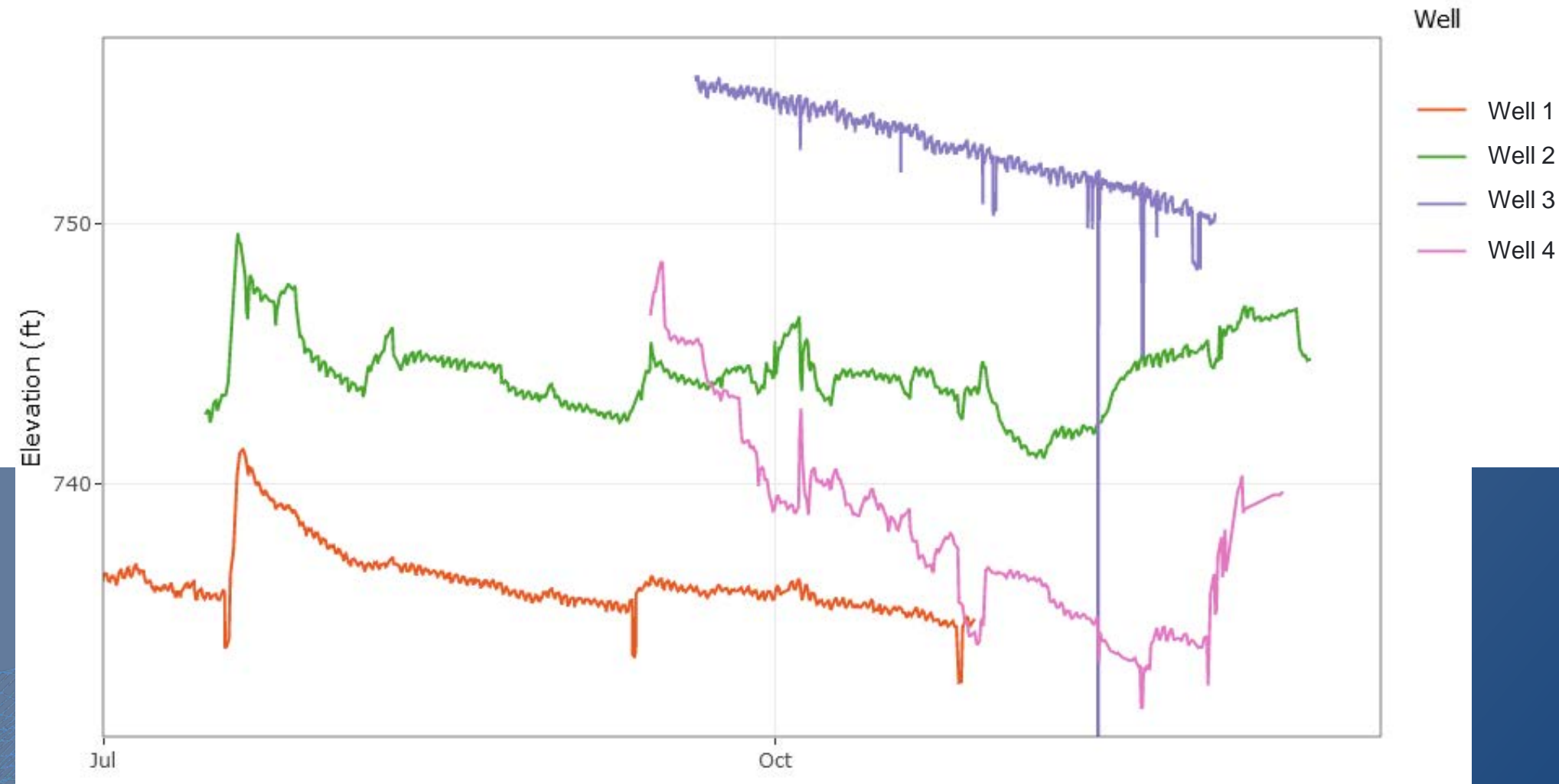
Target Area



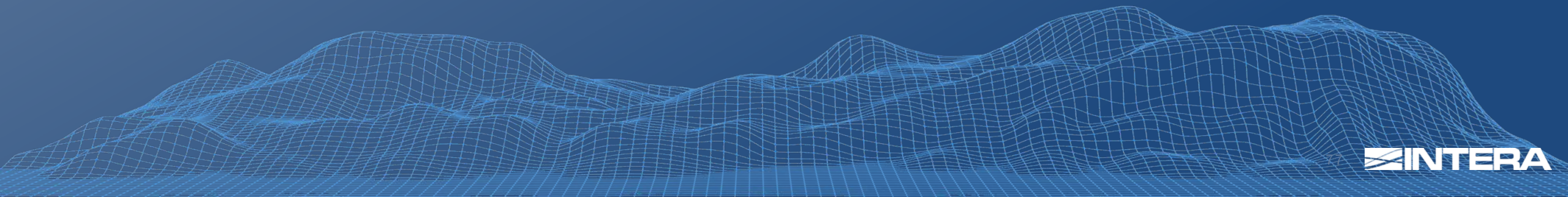
WellIntel Sensors and Telemetry



WellIntel Dashboard



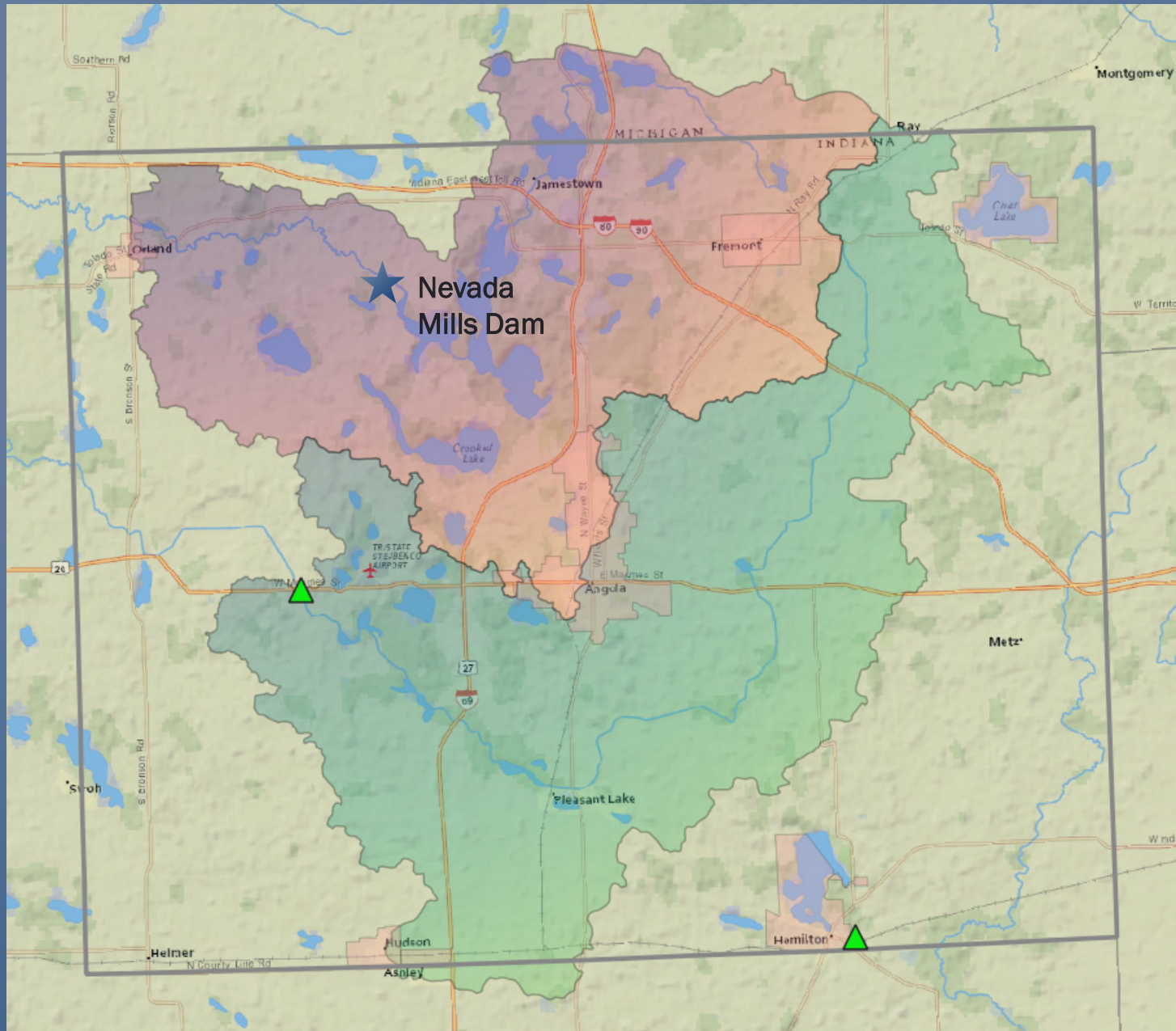
Stream Flow Monitoring



Stream Flow Monitoring

Reactivate USGS gage at Orland?

Lake level monitoring at Nevada Mills Dam?



4. Next Steps

- Solicit volunteers for Aquifer Monitoring Network
- Installation and activation of sensors
- Solicit financial support to continue monitoring beyond 4 years

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