Availability of Hydrologic Data in SW MI

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Overview

- What do we know about the hydrogeologic architecture of aquifers in southwest Michigan and how that relates to the screening tool?
- What do we know about stream flow characterization?
- What do we know about stream type classification?
- What do we know about uncertainty in the water budget for the watershed?

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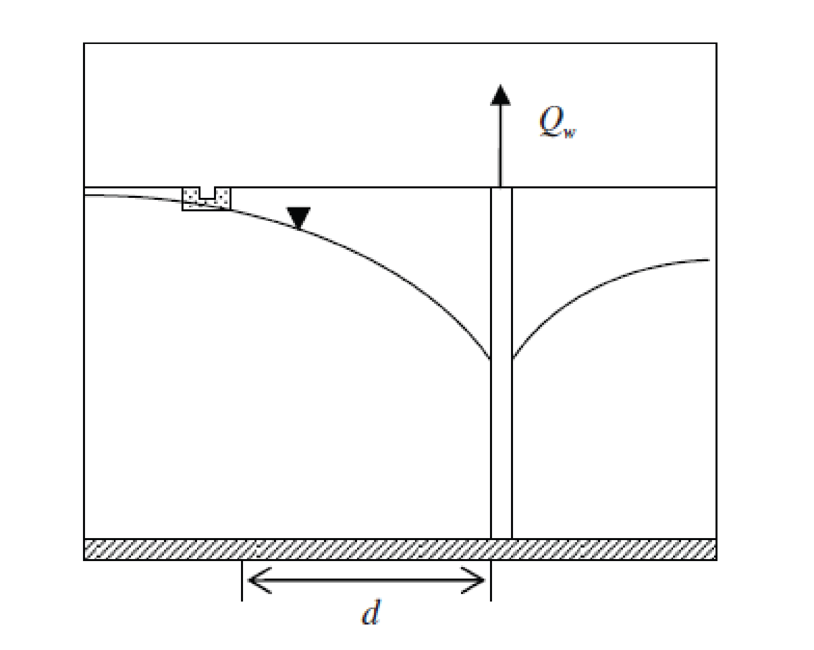
Assessment Tool

Assumptions with Analytic Solution

- Aquifer in connection with stream
- Streambed resistance is considered
- Pumping does not change recharge
- No boundaries
- Water to well from storage (drawdown) or stream
- Uniform aquifer properties



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Analytical solution

- Requires: distance from well to stream, transmissivity, storativity, streambed conductance.
- S -> typical of leaky aquifer, 0.01
- T -> from Michigan Groundwater Inventory and Map. For glacial deposits based on water-well records and glacial landforms, for bedrock based on aquifer-test analysis. Median value from 1000 m grid used for each watershed.
- d -> from web-based mapping tool
- Implementation in screening tool assumes that resistance to vertical flow between top of well screen and streambed dominates and uses an estimate based on aquifer transmissivity, aquifer thickness, and stream width for streambed conductance

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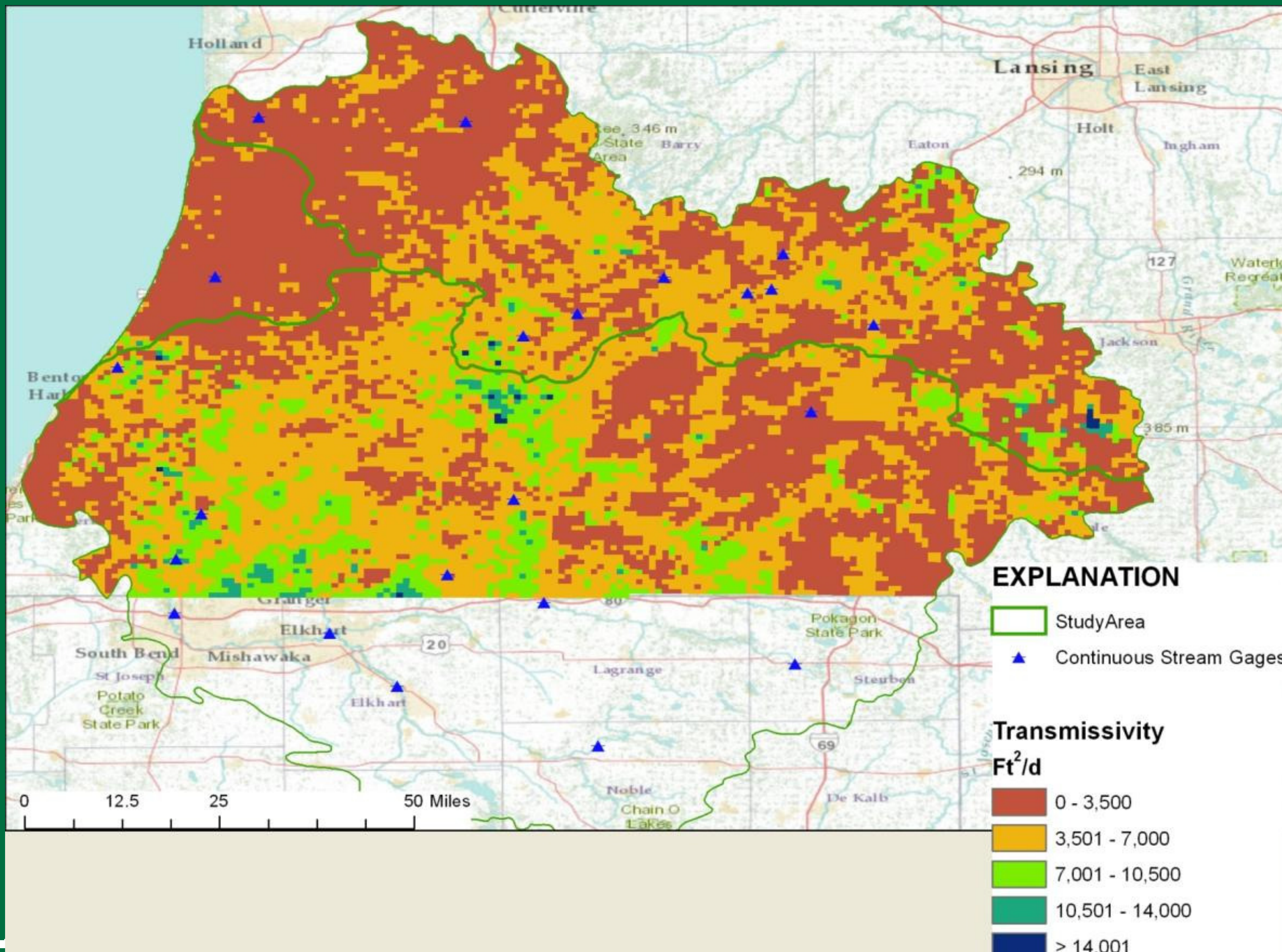
Transmissivity component of the tool



Well Pumping Illustration

- To help illustrate the effect of heterogeneity of the hydrogeologic system we can look at how a hypothetical well will behave under different conditions
  - Example situation:
  - A well in a 150 ft thick aquifer unit is turned on and pumped continuously for 90 days at a rate of 70 gpm.
    - How do the hydraulic properties of the aquifer affect movement of water to the well?

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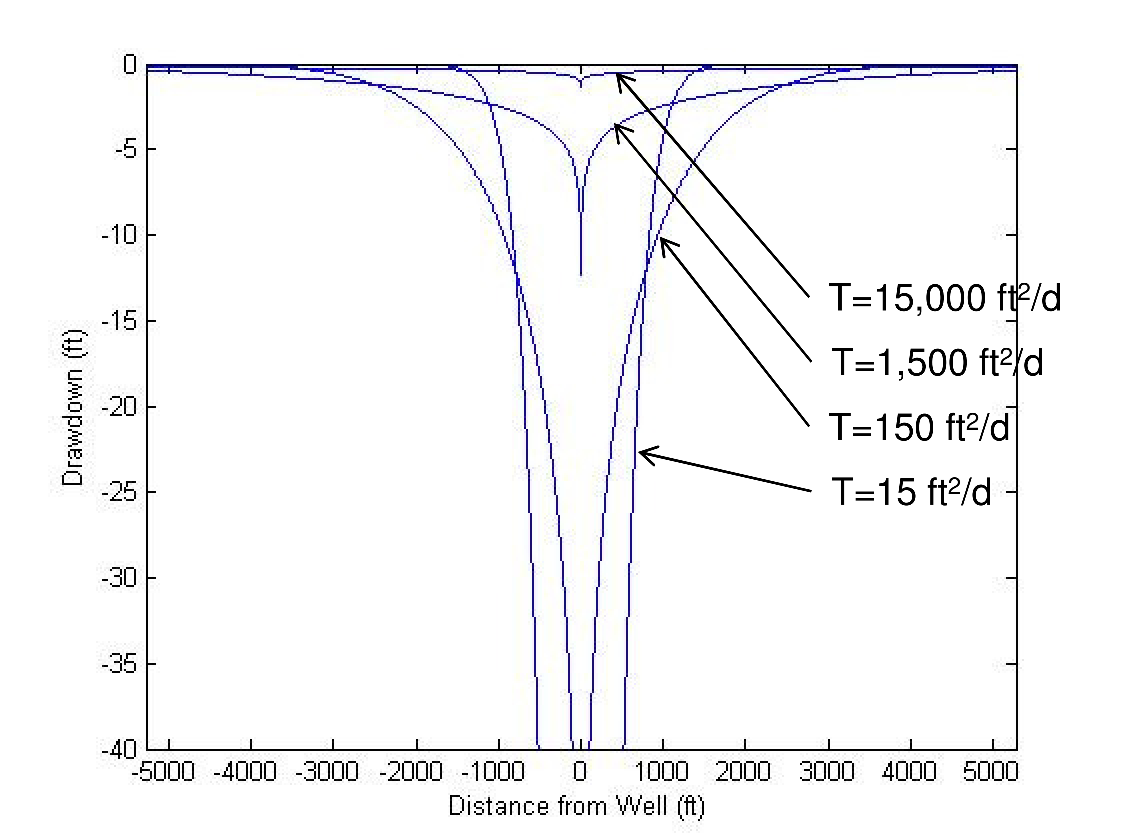
Uncertainty in Transmissivity



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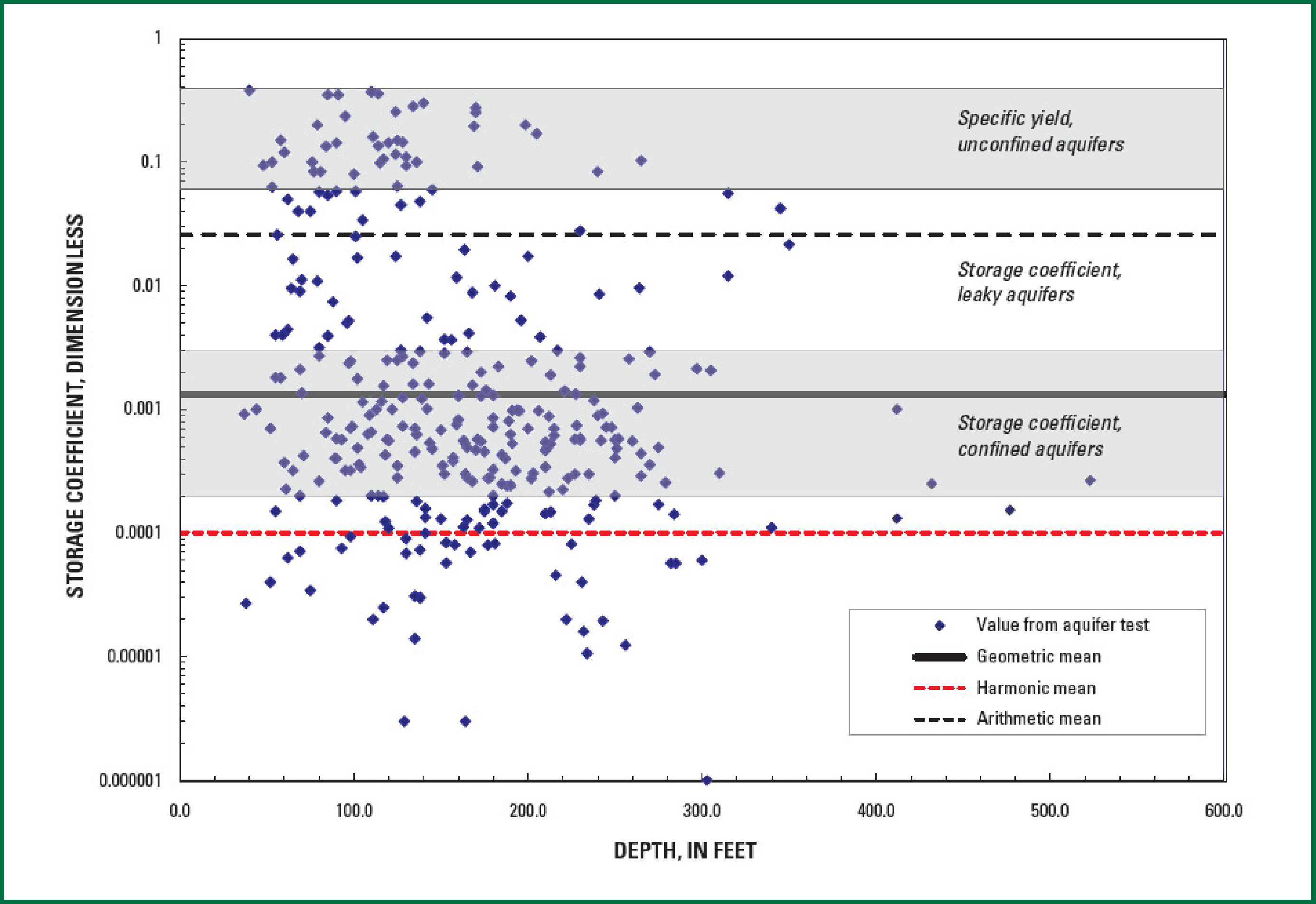
Storage coefficients from MDEQ aquifer test database



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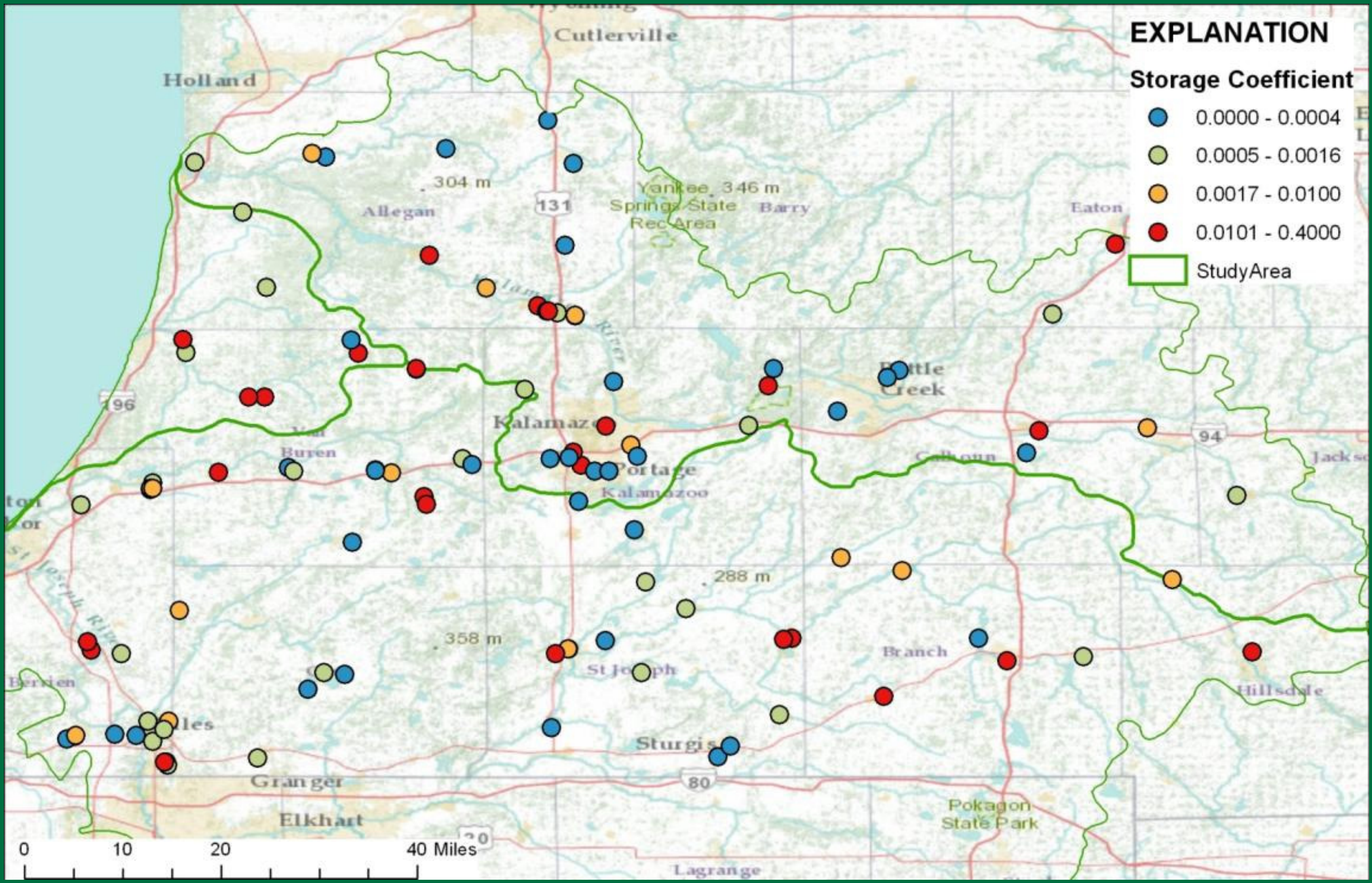
Storage coefficients from MDEQ aquifer test database in SW MI



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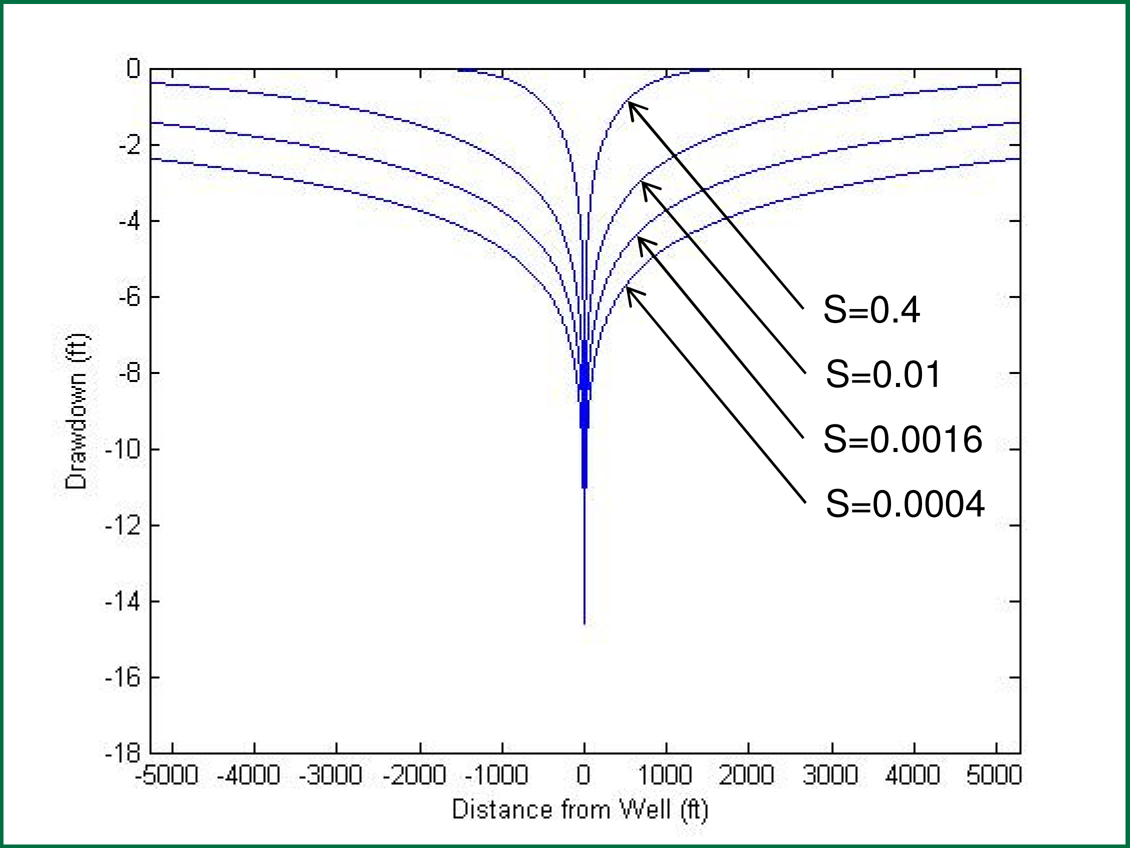
Uncertainty in Storage Coefficient



Test Case 2

- Groundwater model simulation done to highlight source of water to a well near a stream.
- Pumping was held constant for the duration of the simulation (9 yrs)
- Varied depth of the well in the model to examine the stream aquifer interaction

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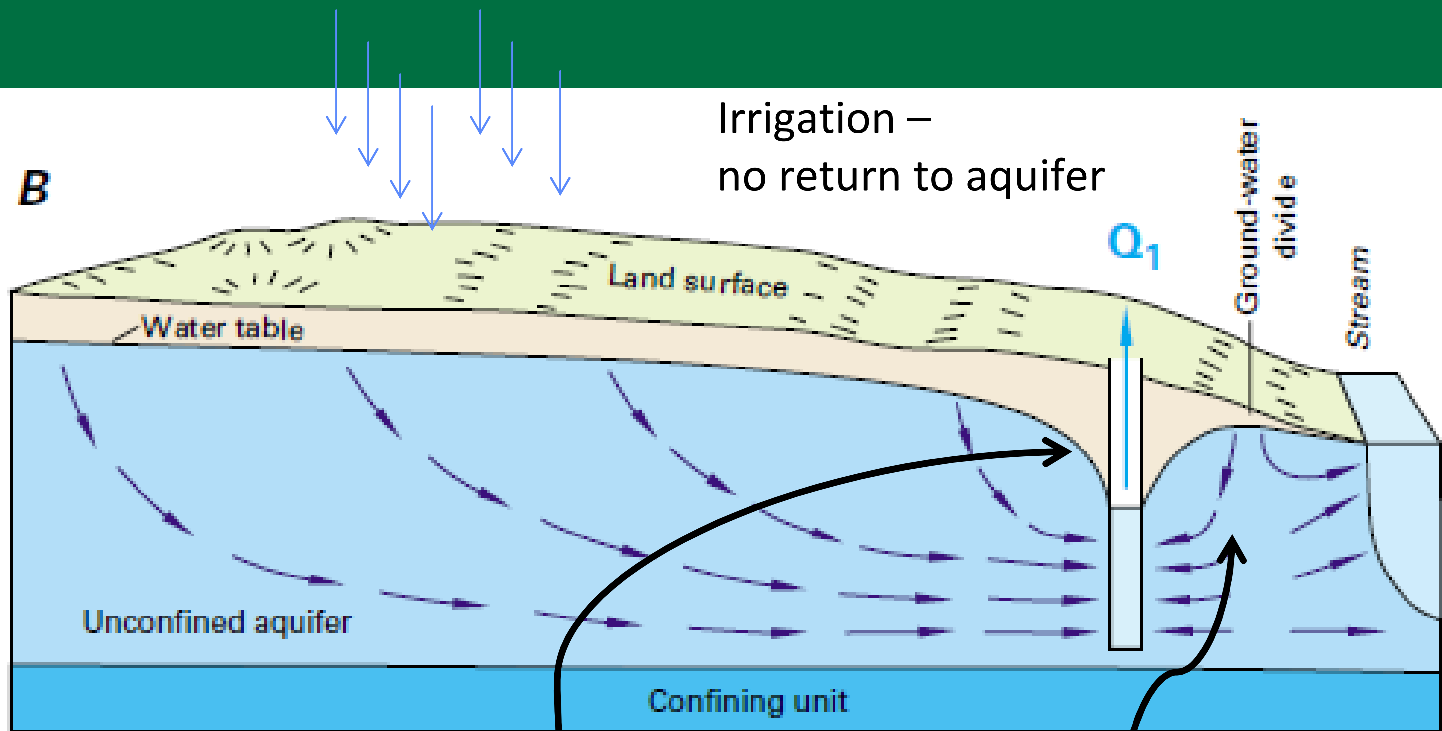
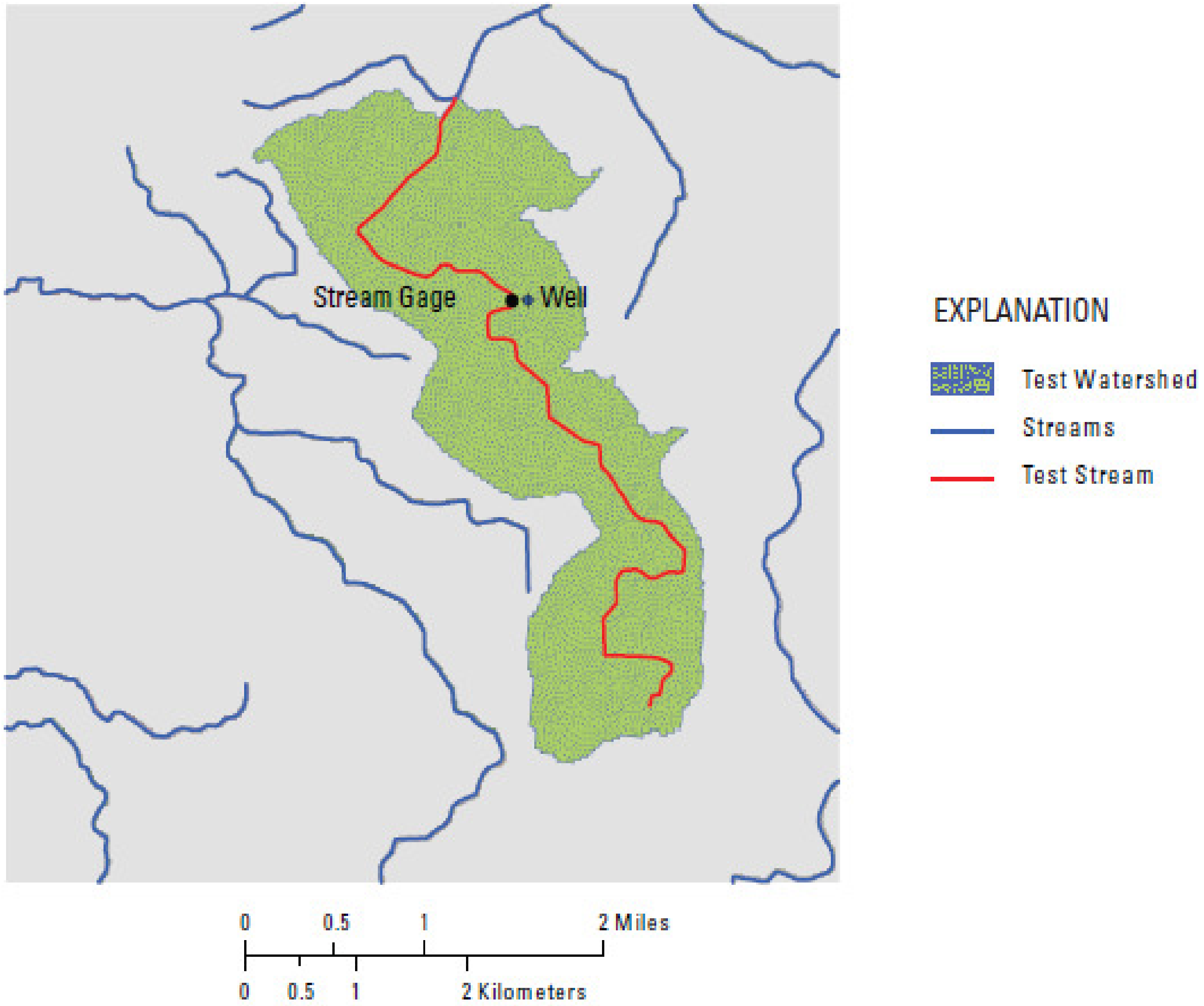
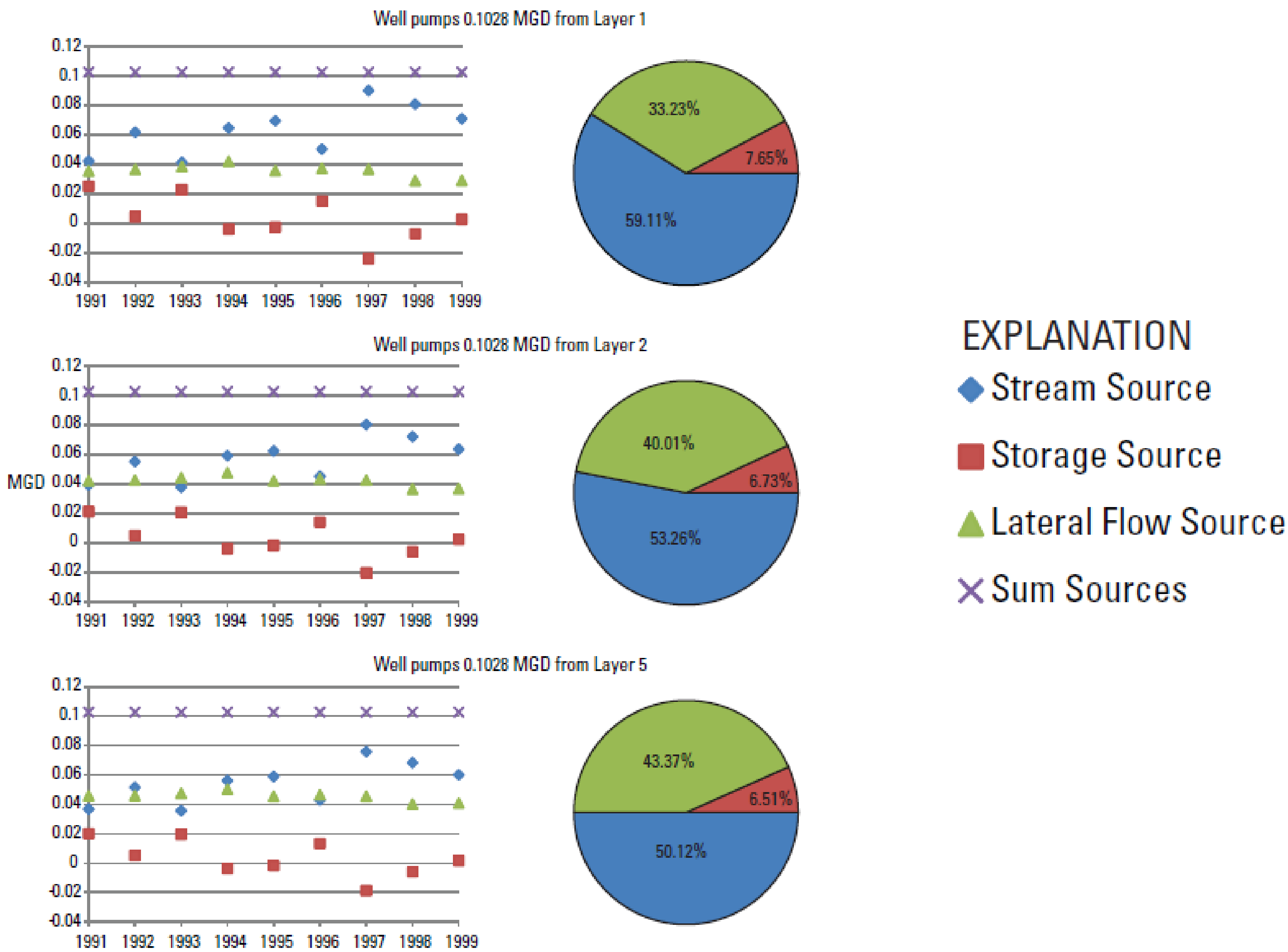
Recharge unchanged by pumping



Water from storage or from stream, either capture of water that would have discharged to stream or induced flow.


Stream Gage
Well
EXPLANATION
Test Watershed
Streams
Test Stream
0
0.5
1
2 Miles
0
0.5
1
2 Kilometers



Annual source of water to well 1991-1999

Net source of water to well 1991-1999

STREAM FLOW CHARACTERIZATION

Assumptions for index flow estimation

- Gaged areas and observed flows are representative of conditions across the state
- Variables used in the regression are relevant for flows across the state
- Range of values for regression variables for the gages are consistent with the values for ungaged areas
- Long-term average flows are appropriate for estimating current and future conditions

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Streamflow

- Linear regression on streamflow yield (Q/A) to estimate index flow
- Index flow: estimated median flow for the low-flow summer month
- Gage data used in developing the relation: minimum 10 years of record; not appreciably affected by withdrawals, diversions or augmentation; record not significantly impacted by storage in the system. 147 stations were used; record length 11 – 91 years; 88 stations in operation in 2005.
- In screening tool, estimated index flow is cut in half for the initial screening

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$$\text{Index flow} = \text{Drainage Area}^{*}\left(-0.55077 + (-0.0014132\ LT) + (0.0019883\ HT) + (0.0039675\ F) + (0.02408\ P) + (0.0023171\ A) + (0.001534\ D)\right)^2$$

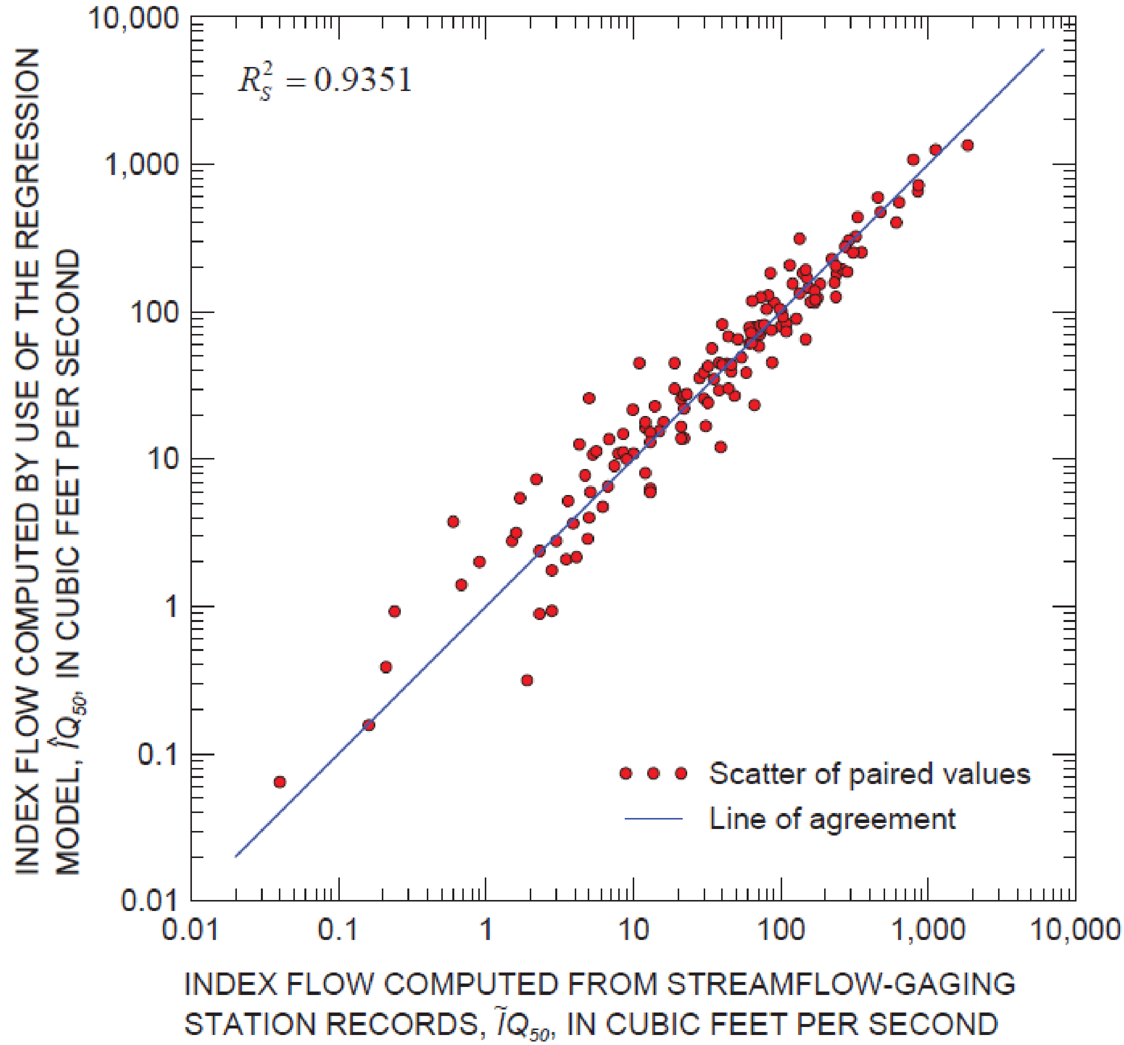
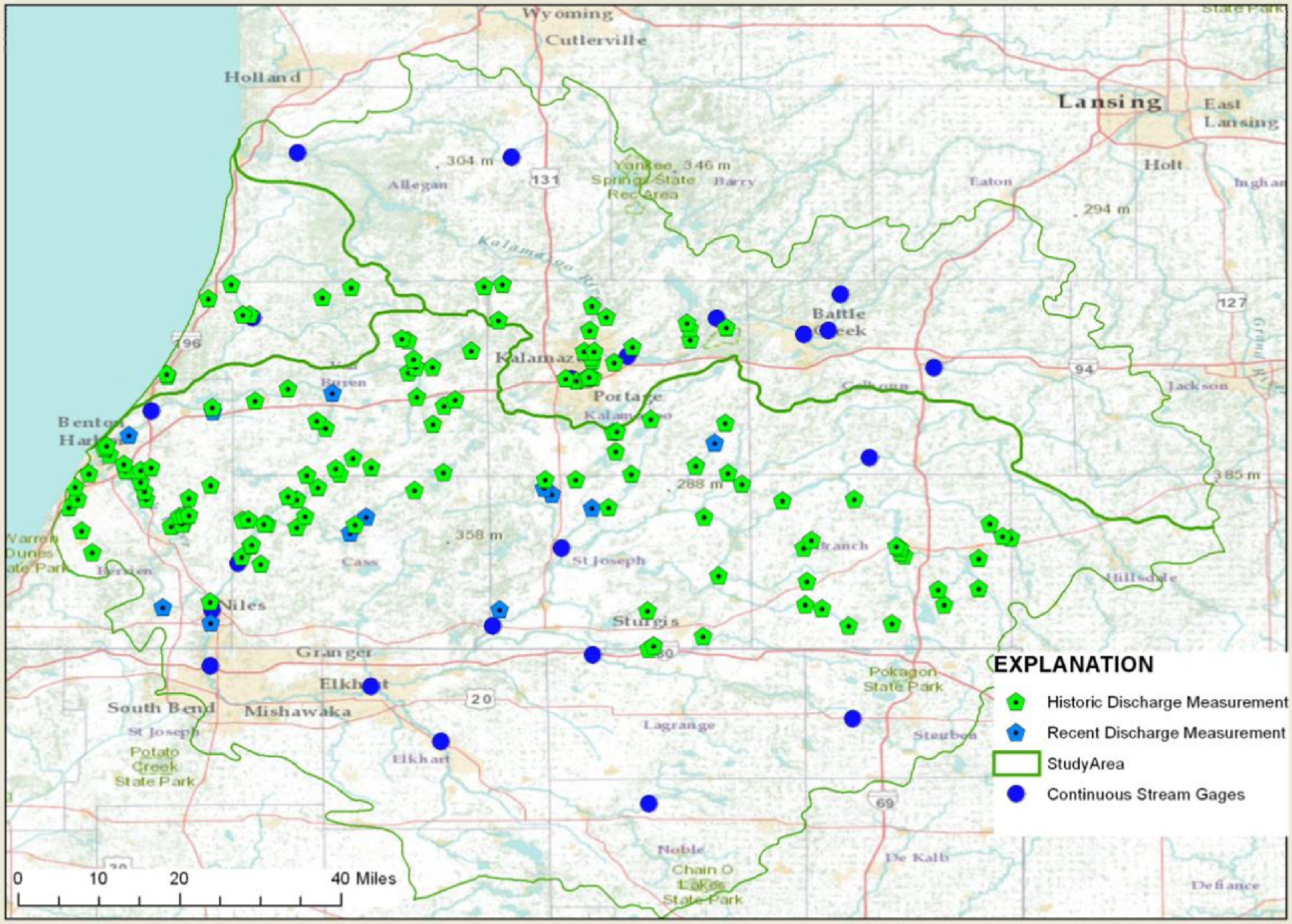


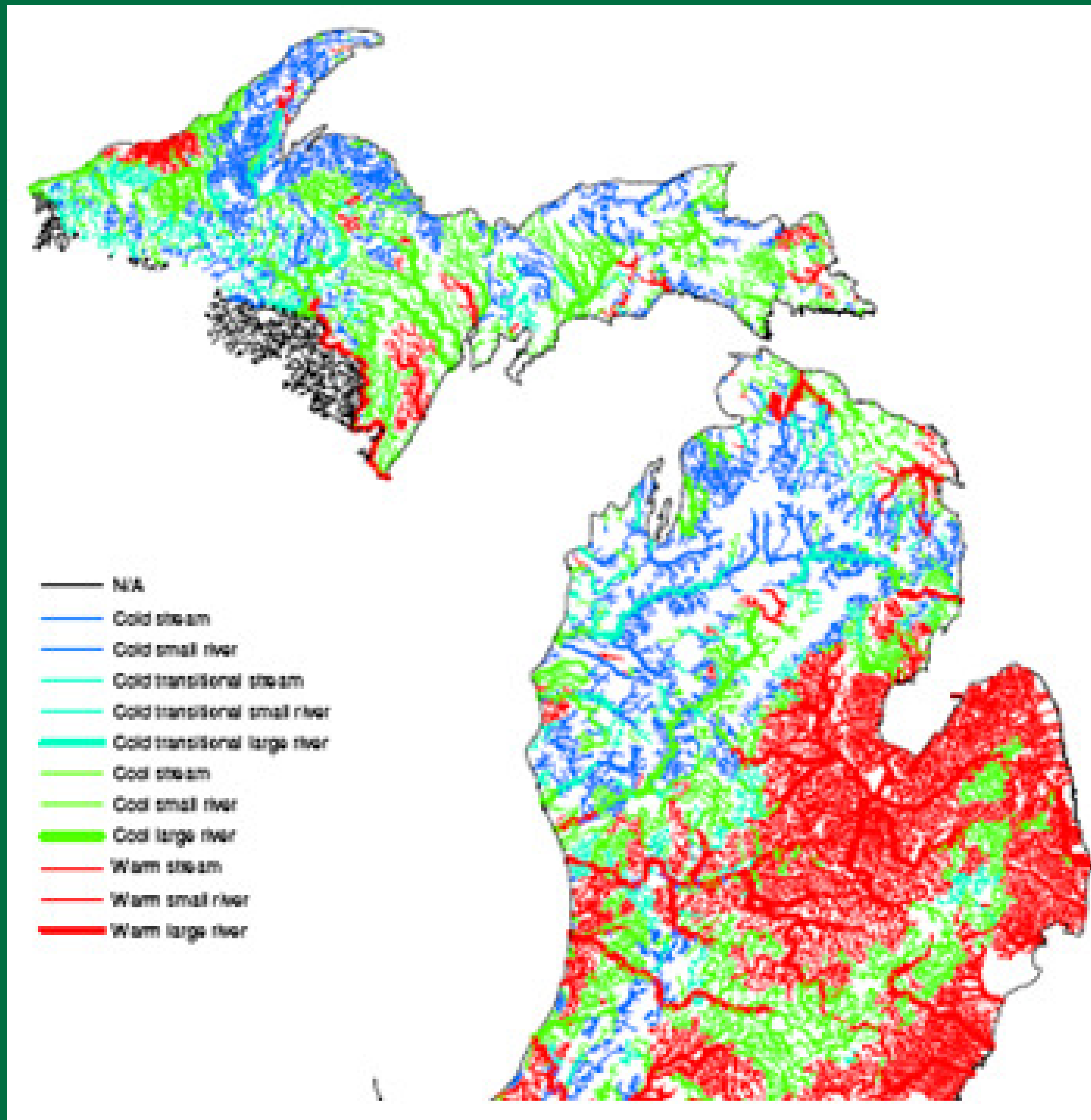
Figure 16. Relation between measured and computed index flows for selected streamflow-gaging stations in Michigan [R_S^2, the Spearman coefficient of determination].

Surface Water Analysis



Existing stream classifications

- **Streams are classified by temperature and flow**
- **Index flow: estimated median flow for the low-flow summer month**



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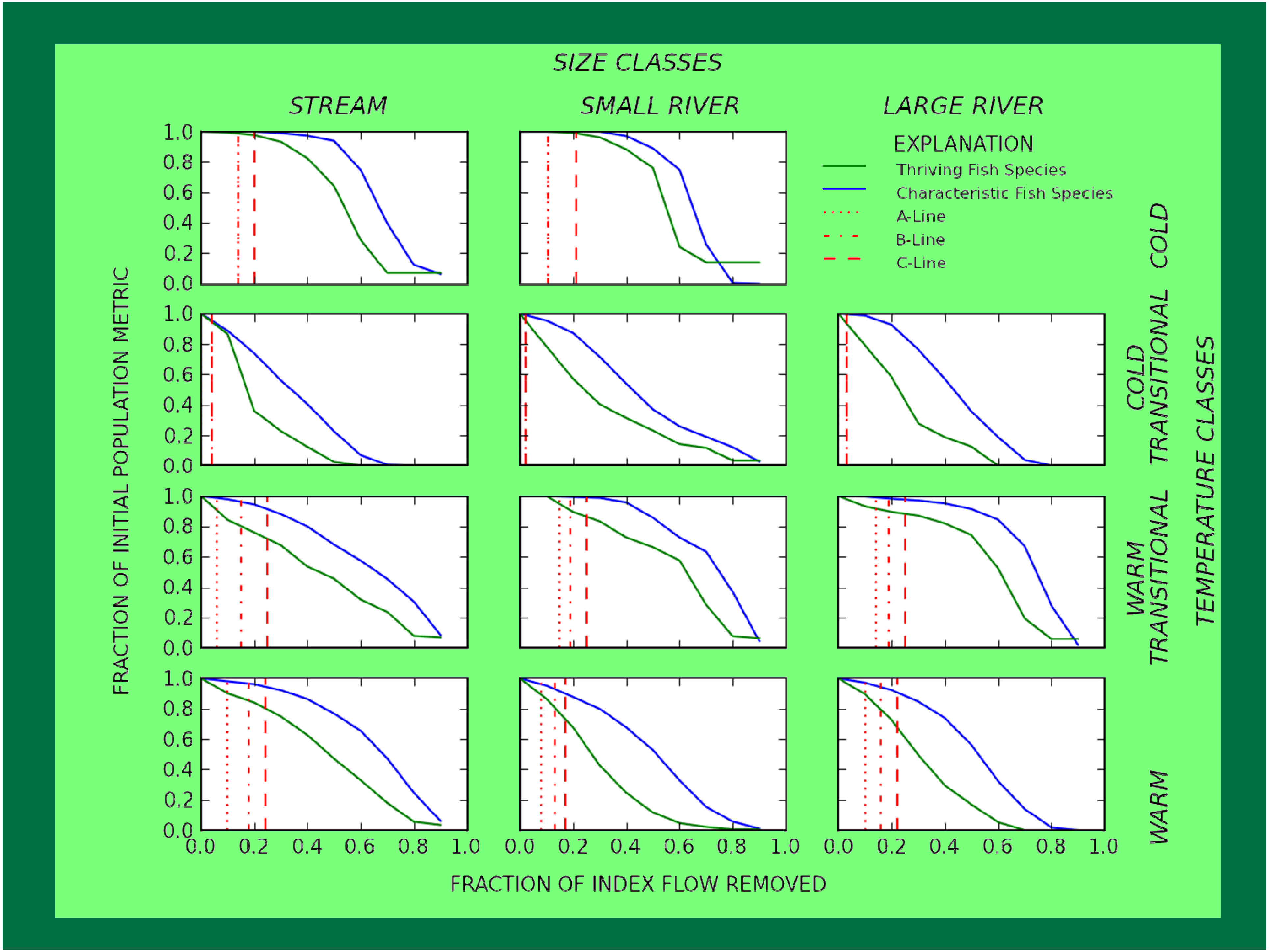
SIZE CLASSES
STREAM
SMALL RIVER
LARGE RIVER
EXPLANATION
Thriving Fish Species
Characteristic Fish Species
A-Line
B-Line
C-Line
COLD
COLD TRANSITIONAL
WARM TRANSITIONAL
WARM
TEMPERATURE CLASSES
FRACTION OF INITIAL POPULATION METRIC
FRACTION OF INDEX FLOW REMOVED
0.0
0.2
0.4
0.6
0.8
1.0

the Water Budget

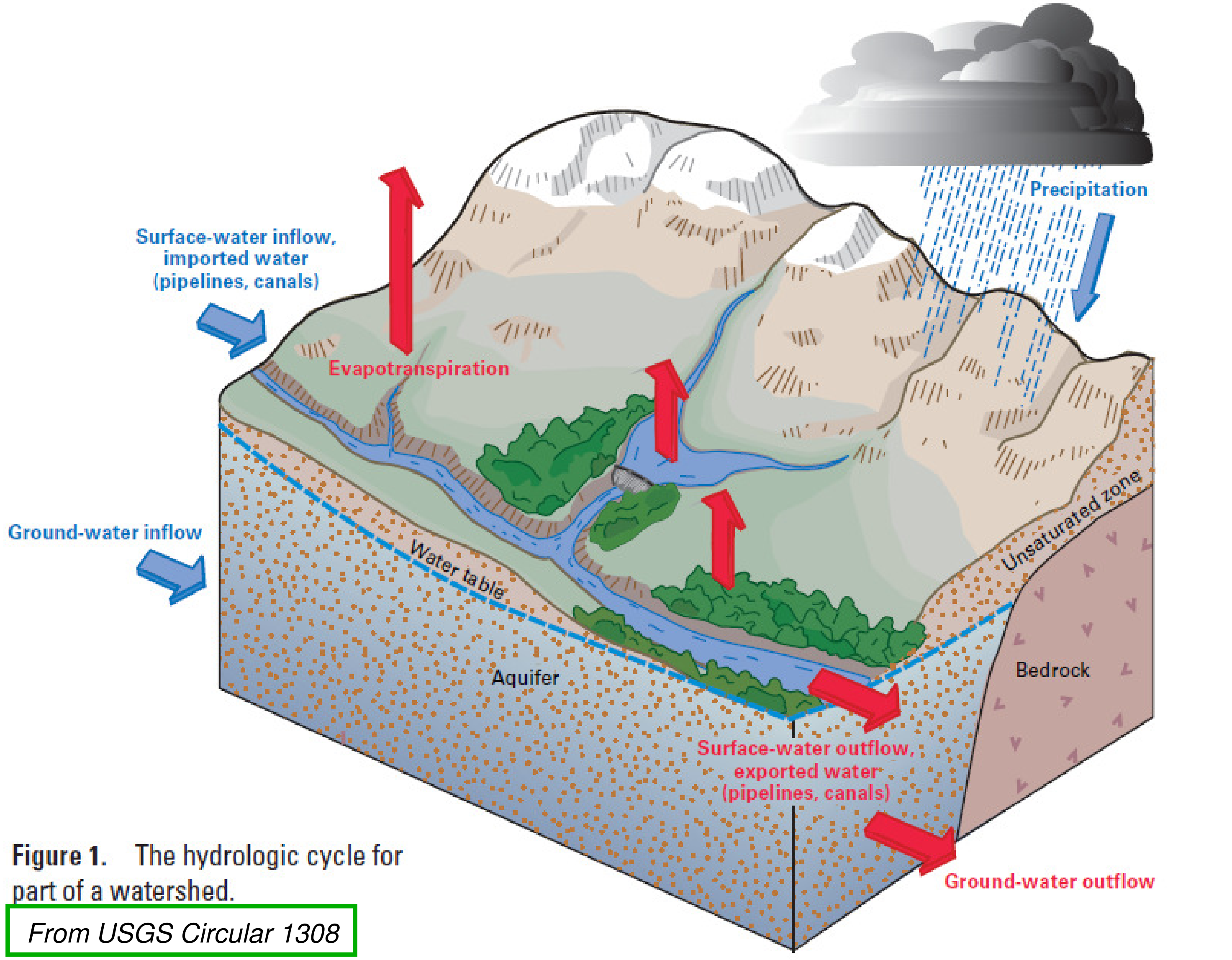

Figure 1. The hydrologic cycle for part of a watershed.

From USGS Circular 1308

Components of the Water Budget

- Inputs
  - Precipitation
  - Flow into the watershed
- Outputs
  - Runoff (Streams)
  - Evapotranspiration
  - Change in Storage
  - Flow out of the watershed (Water use, baseflow to streams)

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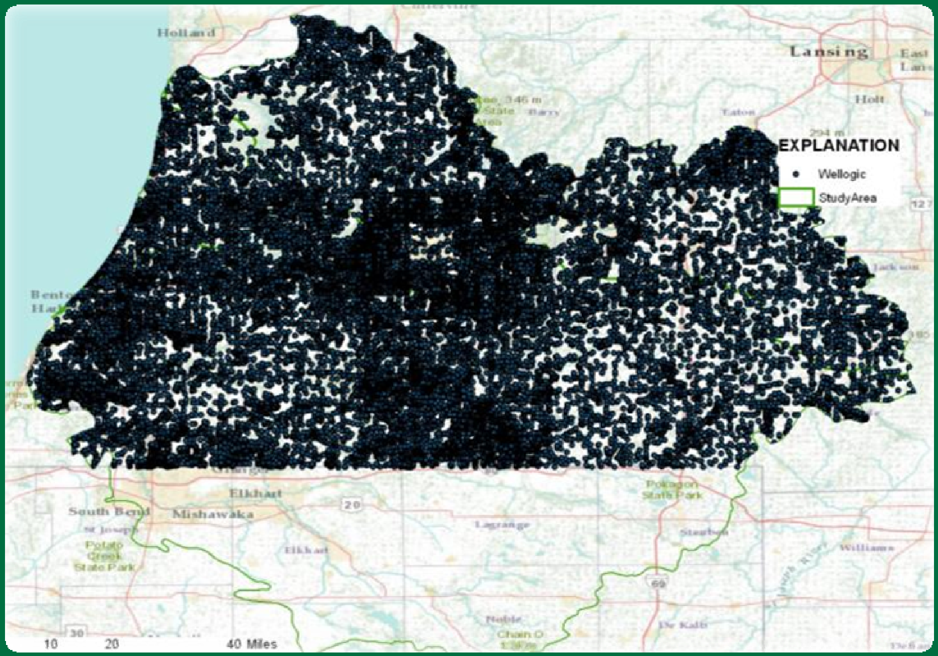
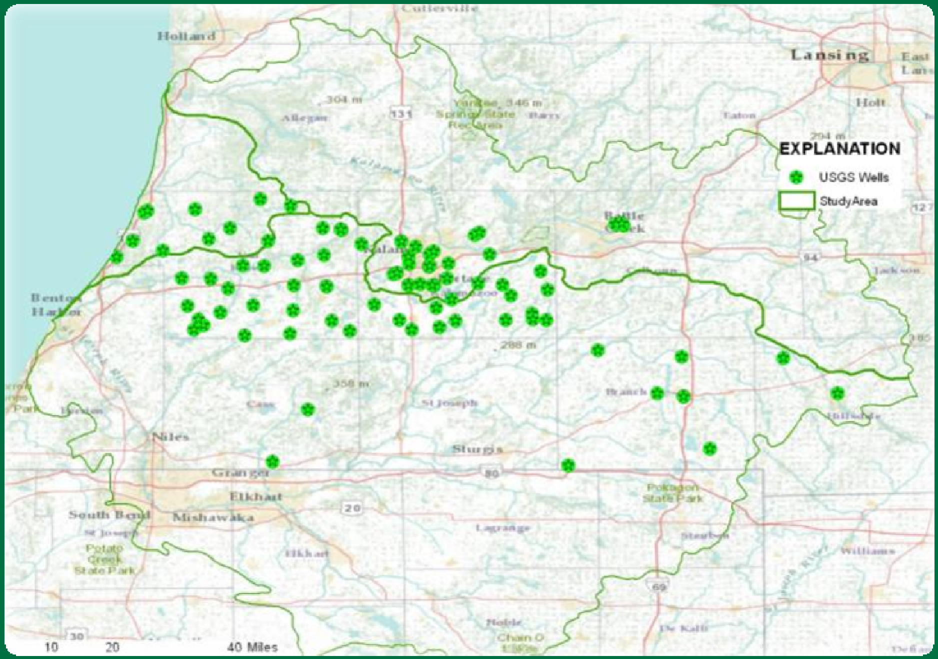
Ground water level Availability





Conclusions or next steps

- There are aspects of the hydrology in this region that we can better understand to improve the data inputs to the tool.
- A better understanding of the water resources in this region leads to better implementation of the tool and site specific review process
- Does this lead to a variation of how the tool is implemented ?

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