Optimization and Depletion Potential

USGS
science for a changing world

UW Extension
Wisconsin Geological and Natural History Survey

How do wells interact with streams?

USGS
science for a changing world

UW Extension
Wisconsin Geological and Natural History Survey

Original System

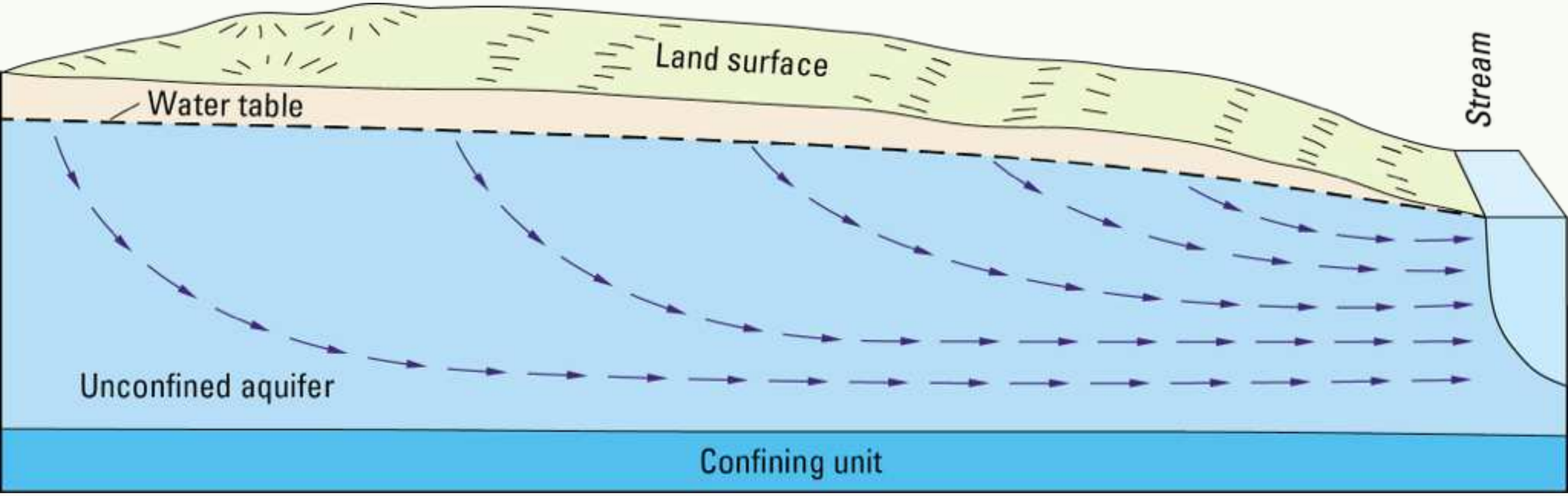


image adapted from http://pubs.usgs.gov/circ/circ1139/

USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

interception

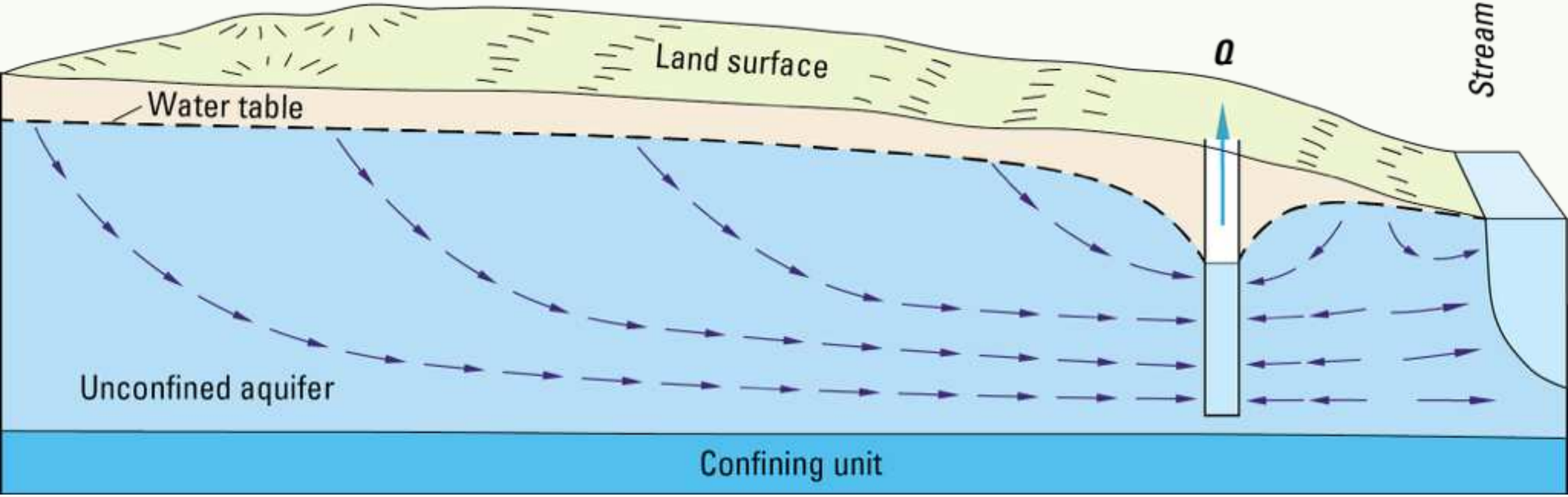


image adapted from http://pubs.usgs.gov/circ/circ1139/

USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

diversion

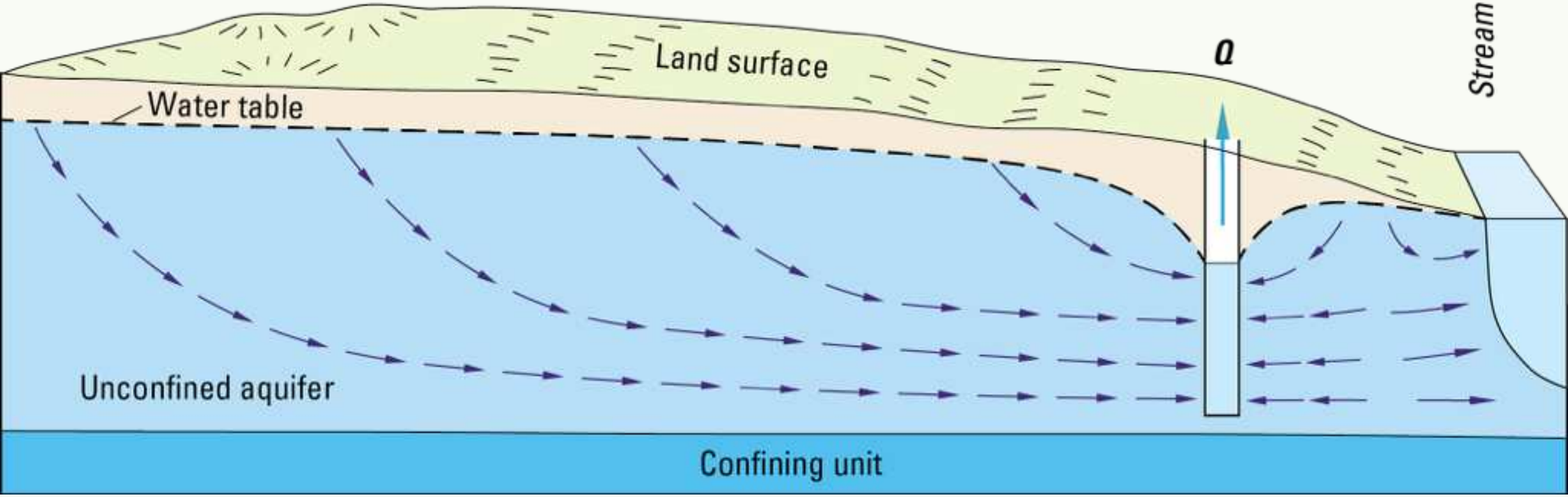


image adapted from http://pubs.usgs.gov/circ/circ1139/

USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

induced infiltration

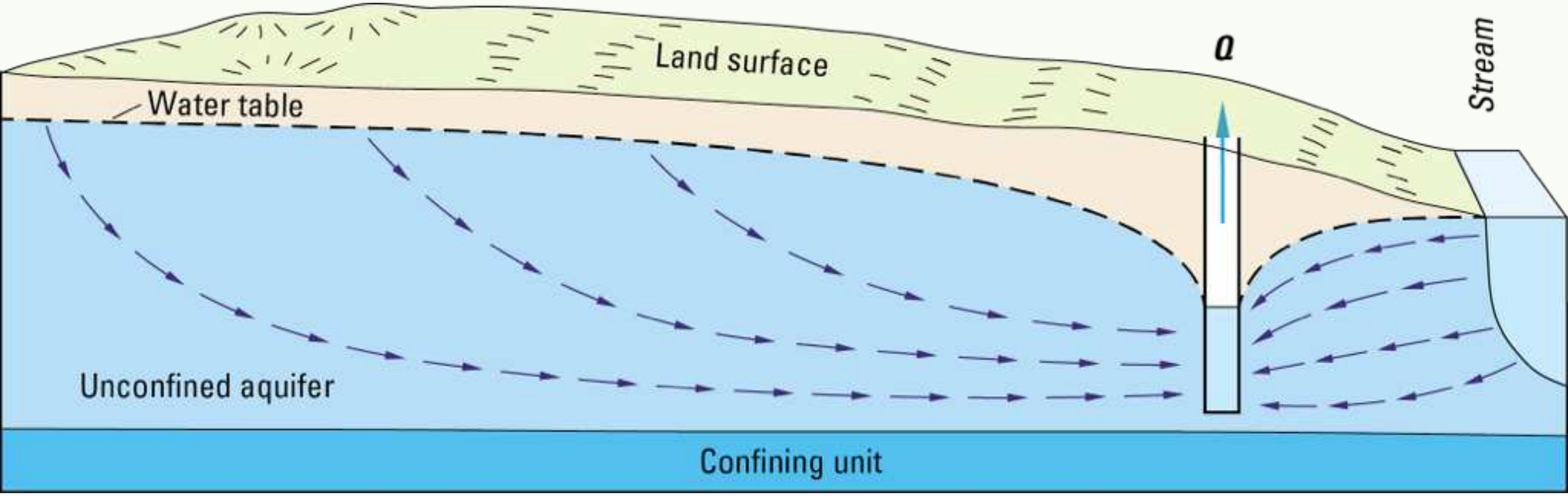


image adapted from http://pubs.usgs.gov/circ/circ1139/

USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

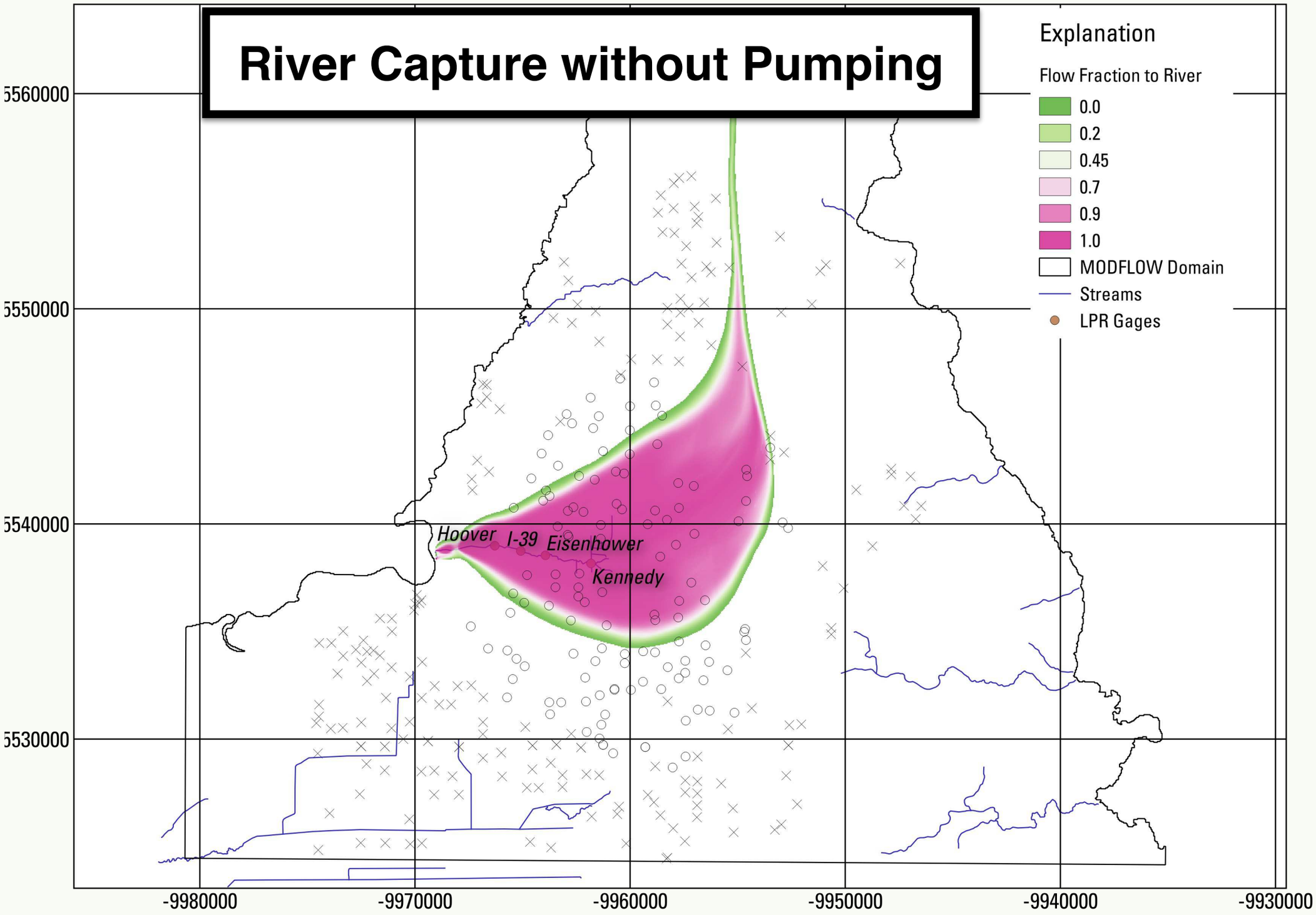
interception
diversion
induced infiltration

“depletion”

USGS
science for a changing world

UW Extension
Wisconsin Geological and Natural History Survey

Flowfield Visualization with FlowSource*

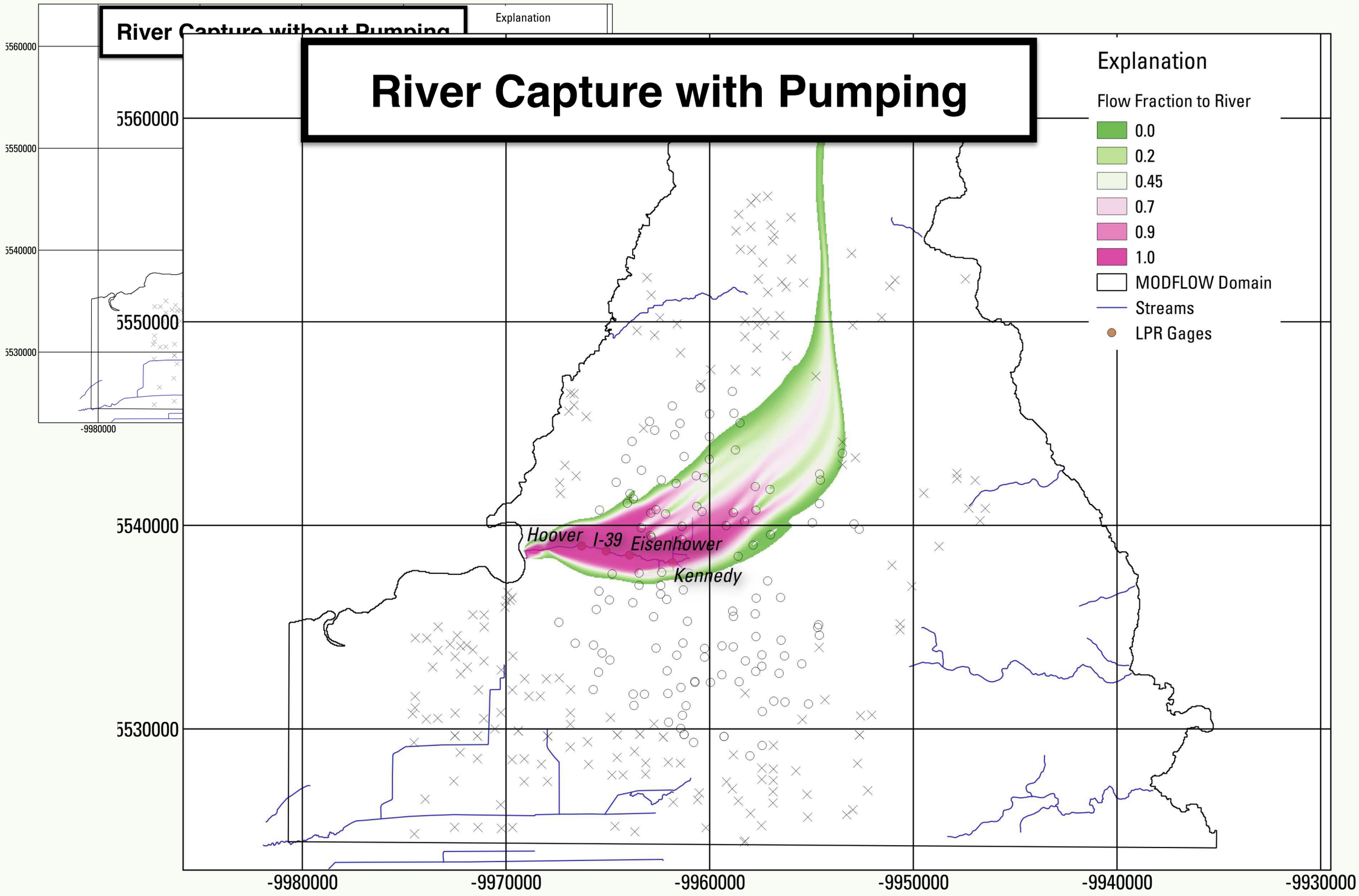


USGS science for a changing world

*Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government

UW Extension
Wisconsin Geological and Natural History Survey

Flowfield Visualization with FlowSource*



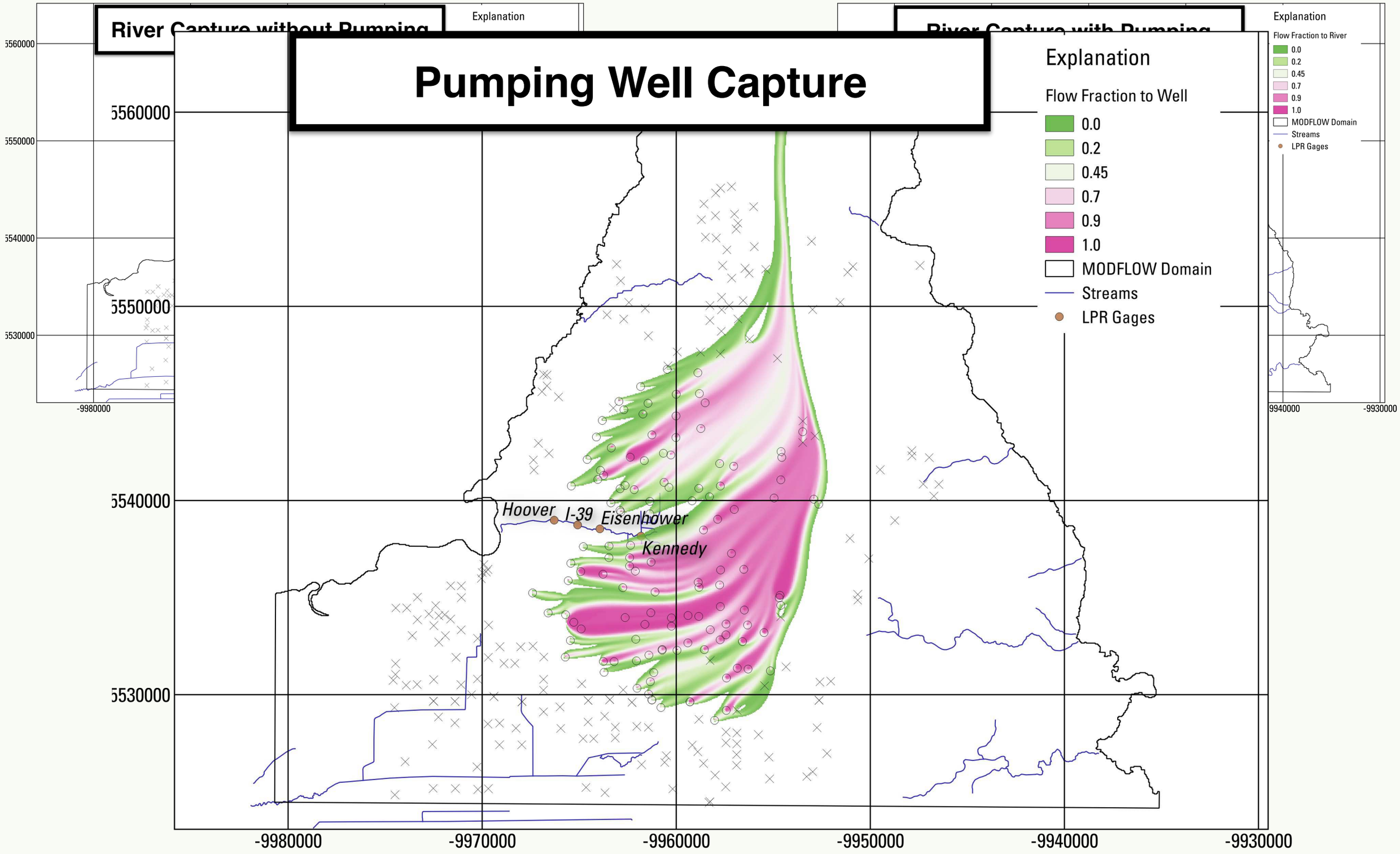
*Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government

USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

Preliminary Information-Subject to Revision. Not for Citation.

Flowfield Visualization with FlowSource*



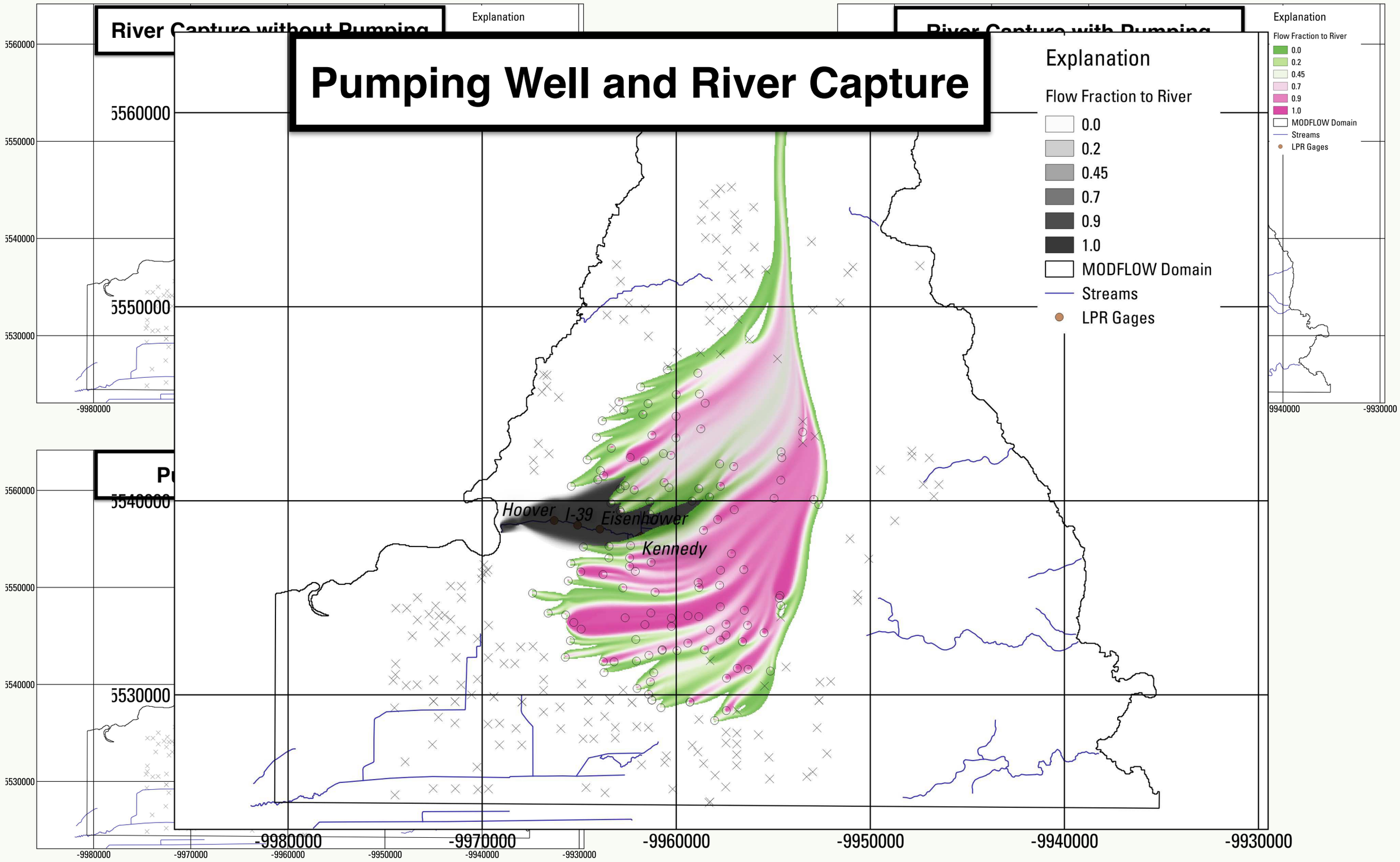
*Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government

USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

Preliminary Information-Subject to Revision. Not for Citation.

Flowfield Visualization with FlowSource*



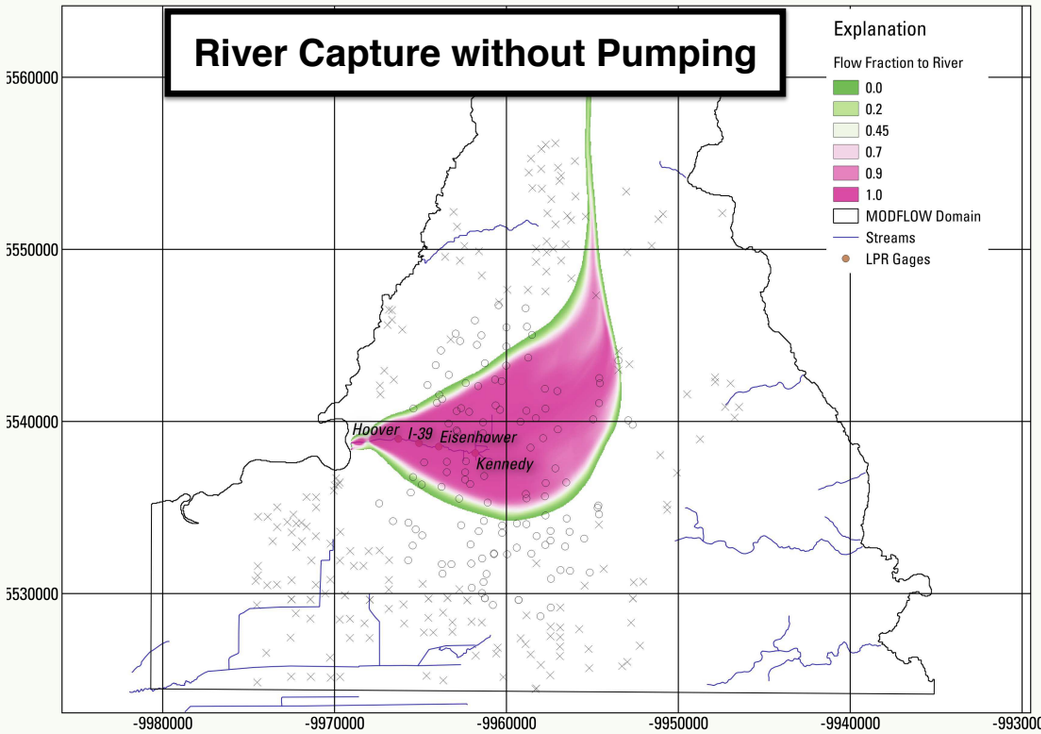
*Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government

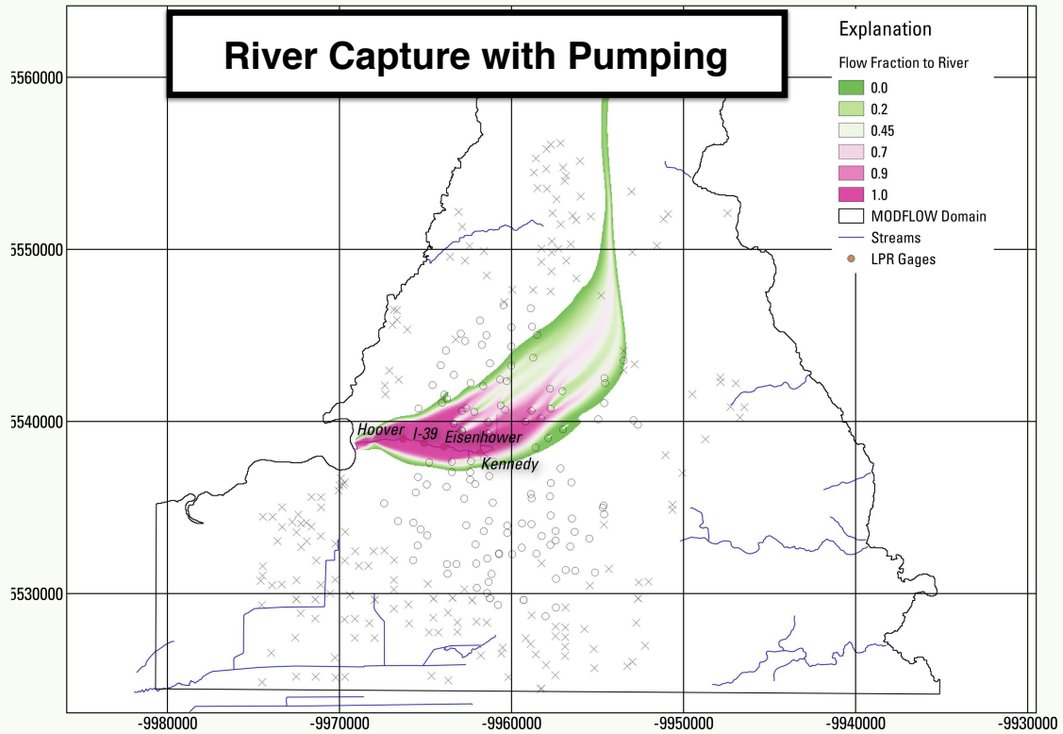
USGS science for a changing world

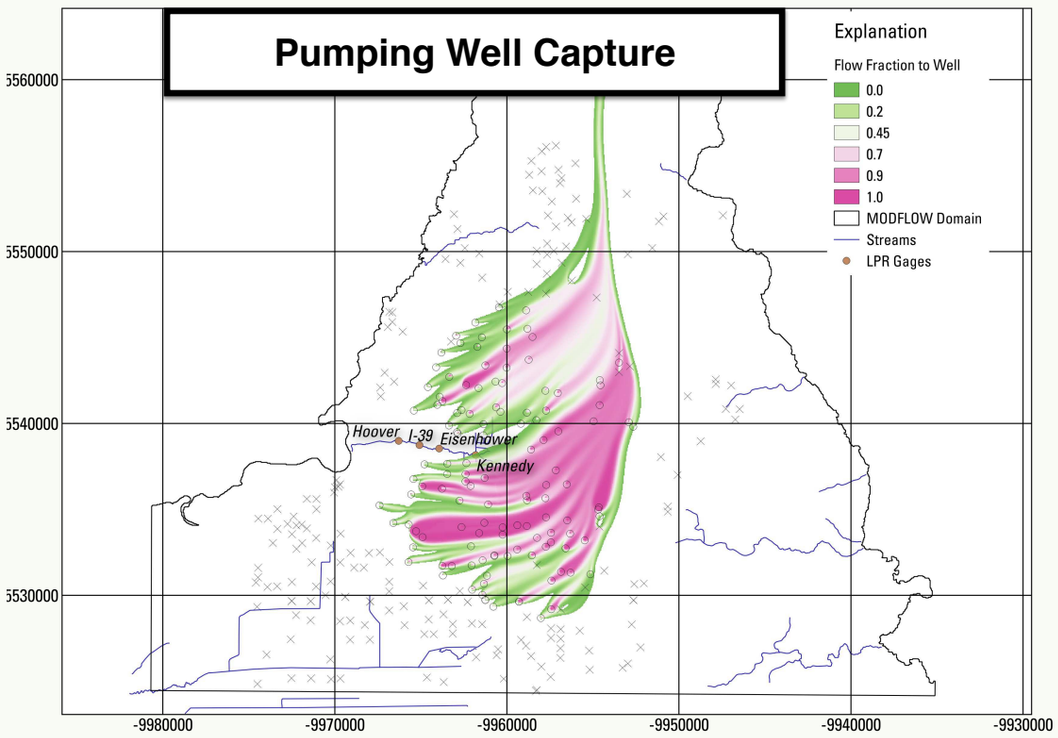
UW Extension Wisconsin Geological and Natural History Survey

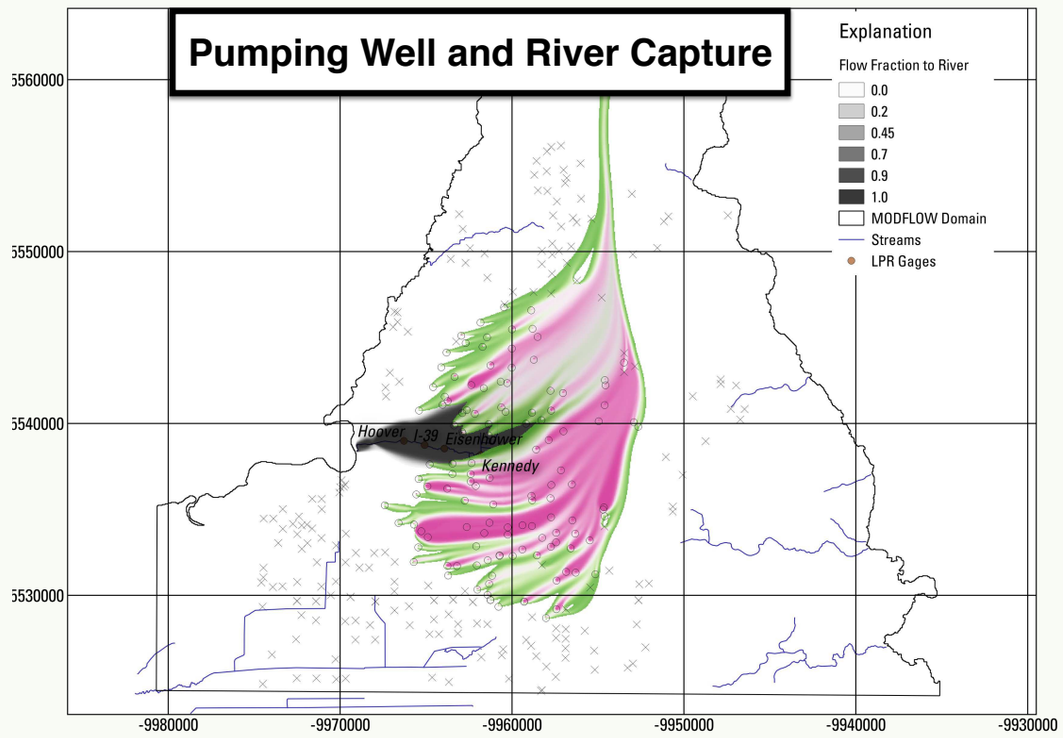
Preliminary Information-Subject to Revision. Not for Citation.

Flowfield Visualization with FlowSource*









USGS science for a changing world

*Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government

UW Extension
Wisconsin Geological and Natural History Survey

Calculating Depletion Potential

USGS
science for a changing world

UW Extension
Wisconsin Geological and Natural History Survey

Depletion Potential

$$\frac{\Delta Qstream}{\Delta Qwell}$$

USGS
science for a changing world

UW Extension
Wisconsin Geological and Natural History Survey

Depletion Potential

$$\frac{\Delta Qstream}{\Delta Qwell}$$

The reduction in flow at a stream location due to new pumping

USGS
science for a changing world

UW Extension
Wisconsin Geological and Natural History Survey

Depletion Potential

$$\frac{\Delta Qstream}{\Delta Qwell}$$

The reduction in flow at a stream location due to new pumping

Evaluated by:

running the model without new pumping

running the model again with new pumping

calculating the difference in stream flow

USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

Depletion Potential

$$\frac{\Delta Qstream}{\Delta Qwell}$$

The reduction in flow at a stream location due to new pumping

Evaluated by:

running the model without new pumping

running the model again with new pumping

calculating the difference in stream flow

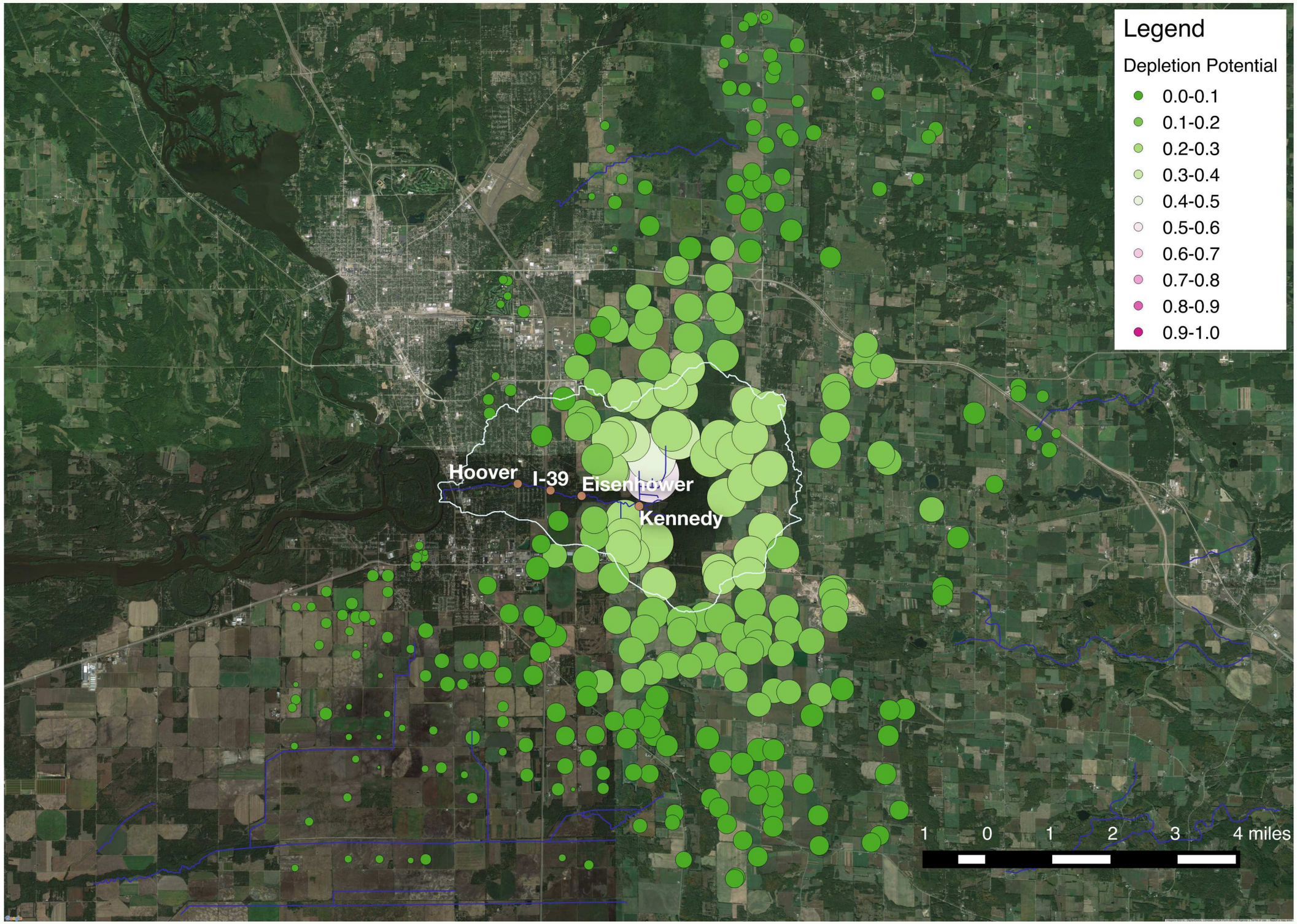
Since both have units of flow, express as a ratio

$$\frac{\Delta Qstream}{\Delta Qwell} \times Qwell = \text{ predicted depletion}$$

USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

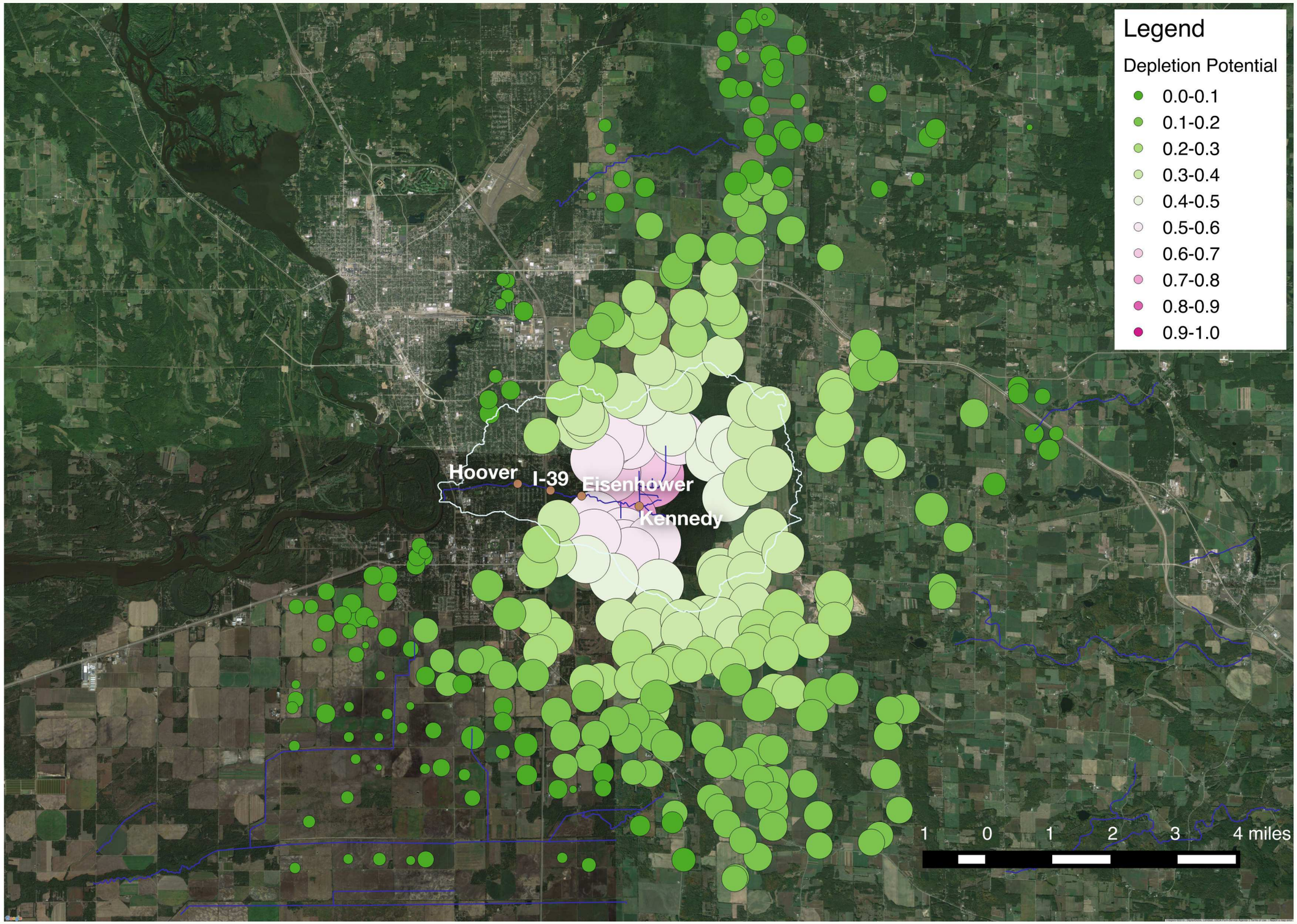
Depletion Potential: Kennedy



USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

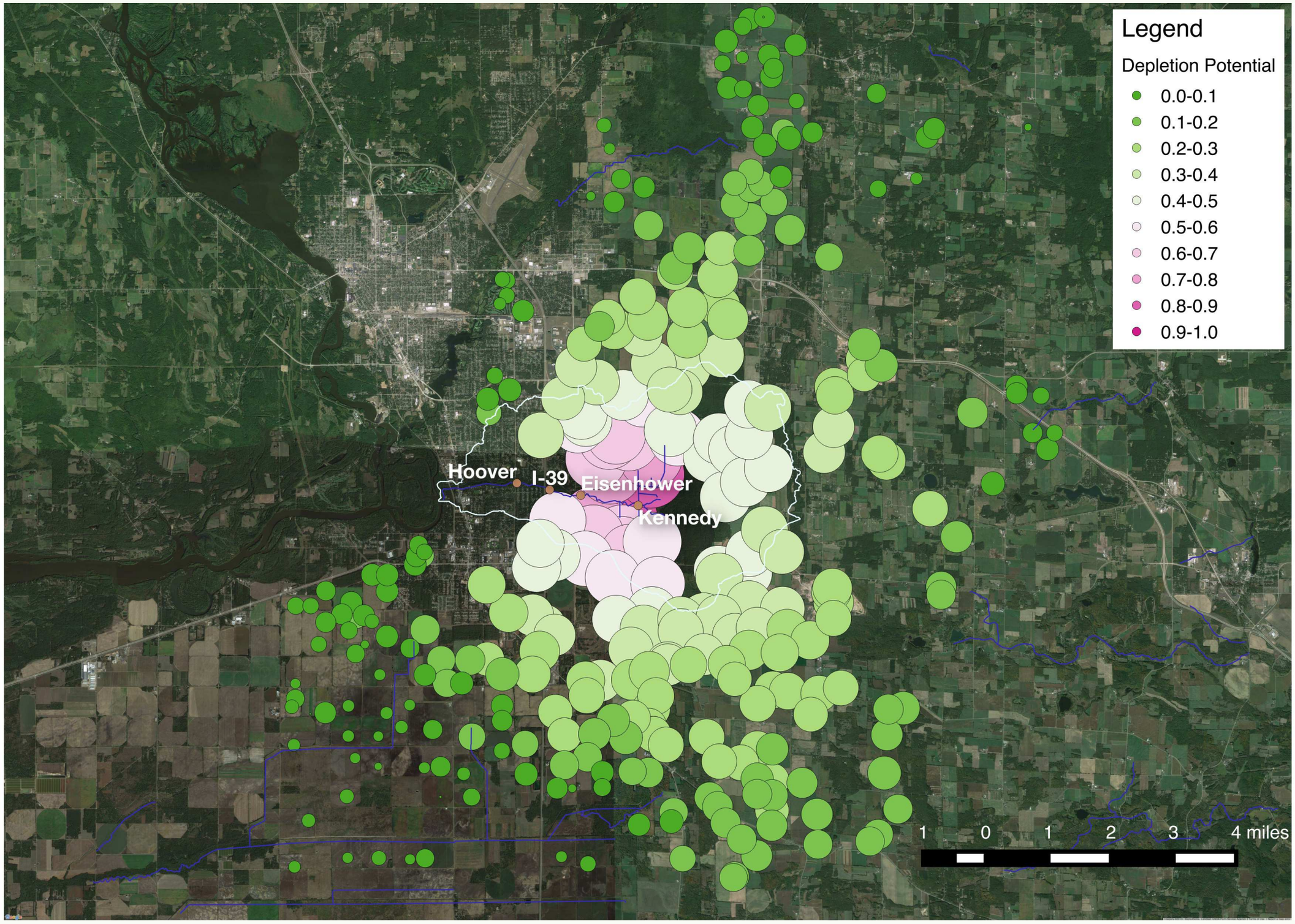
Depletion Potential: Eisenhower



USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

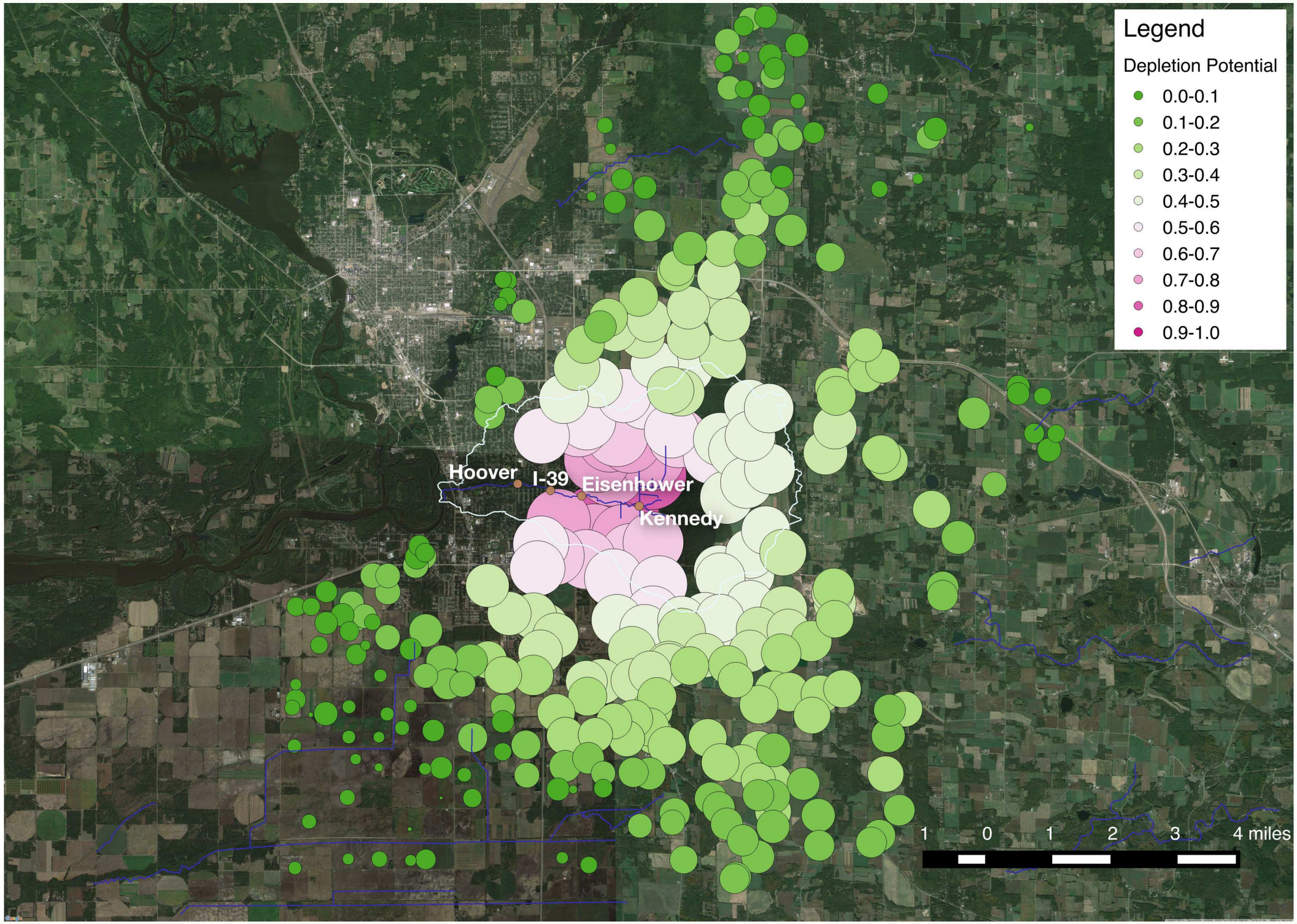
Depletion Potential: Interstate 39



USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

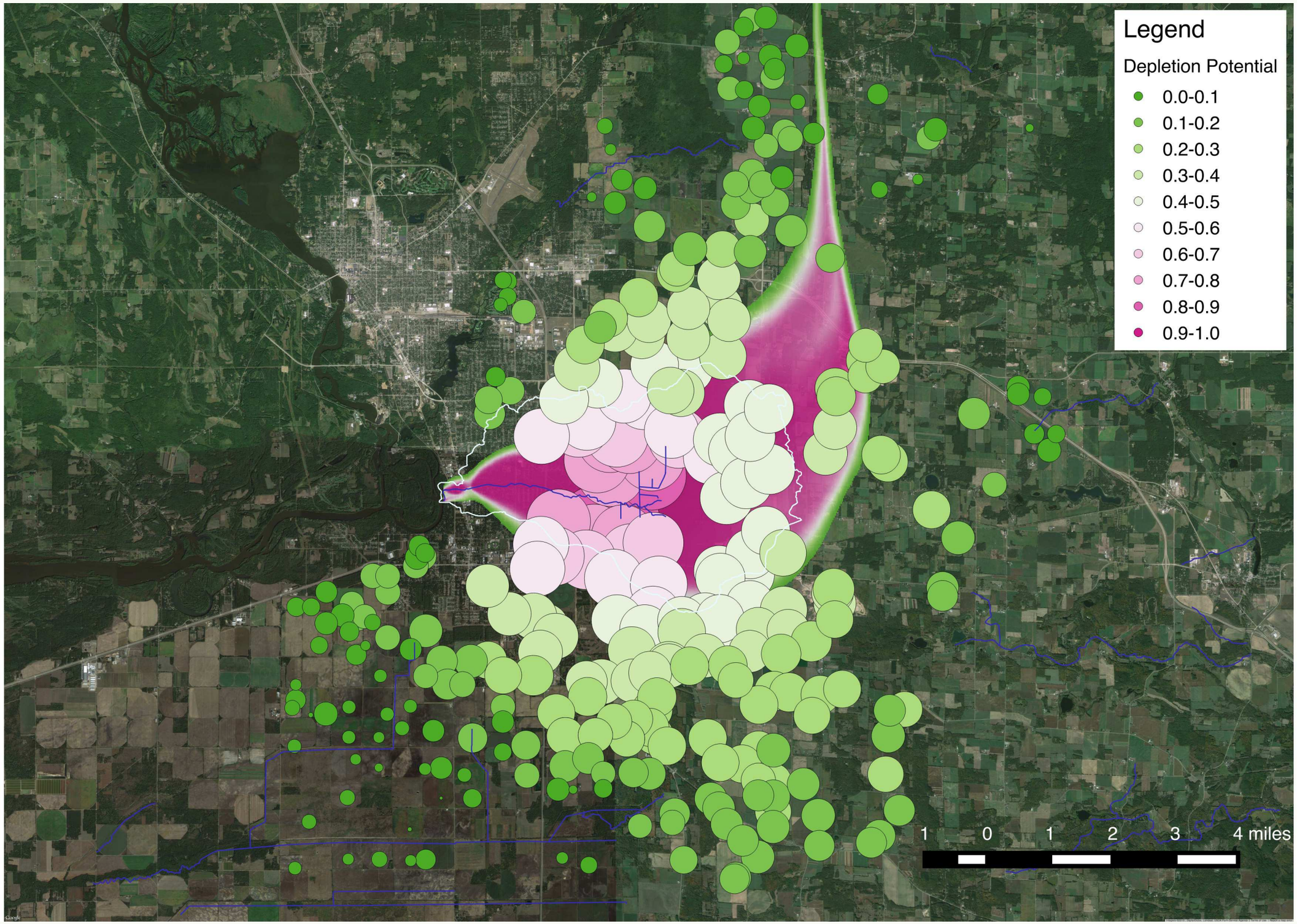
Depletion Potential: Hoover



USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

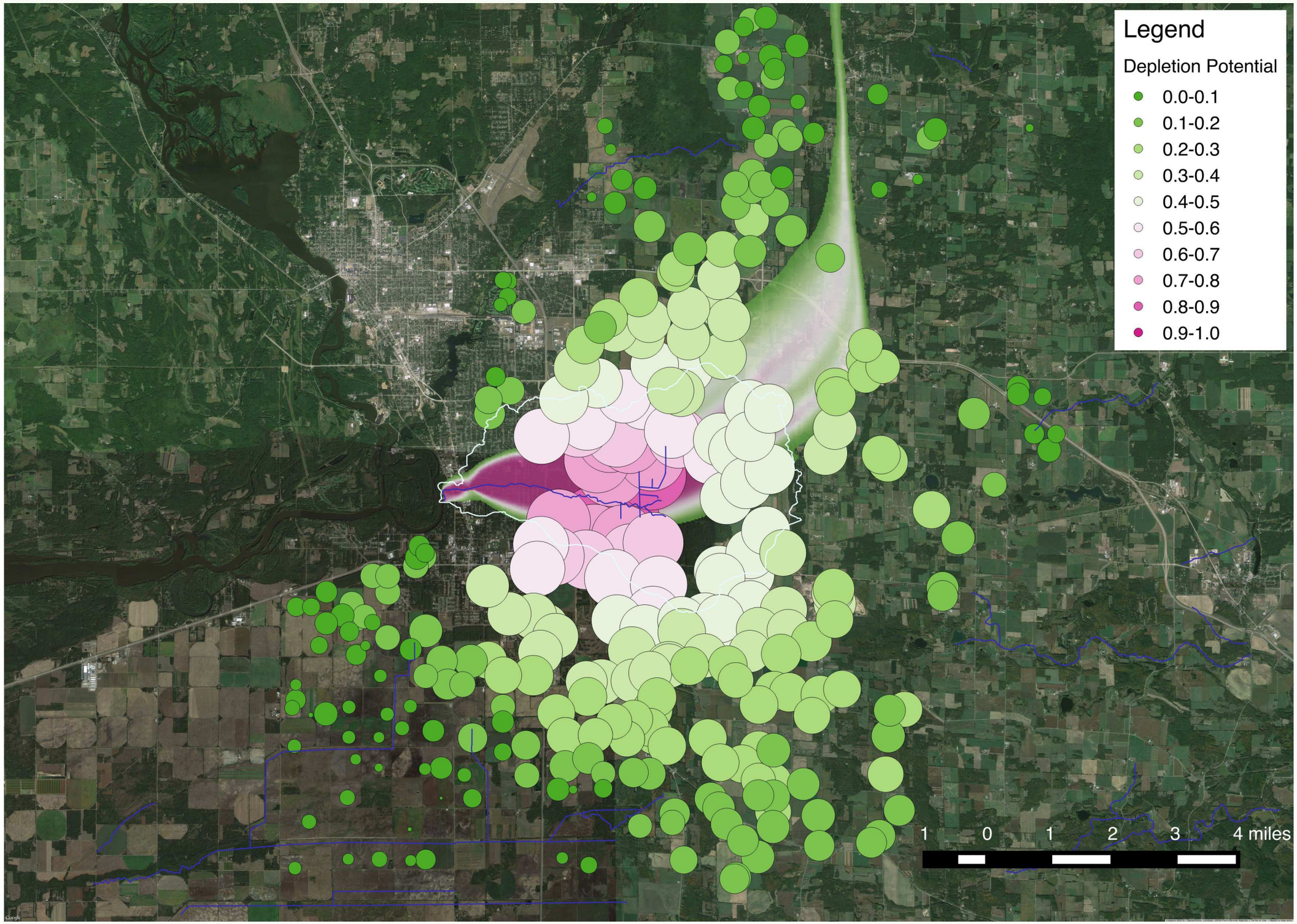
Depletion Potential: Hoover



USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

Depletion Potential: Hoover



USGS science for a changing world

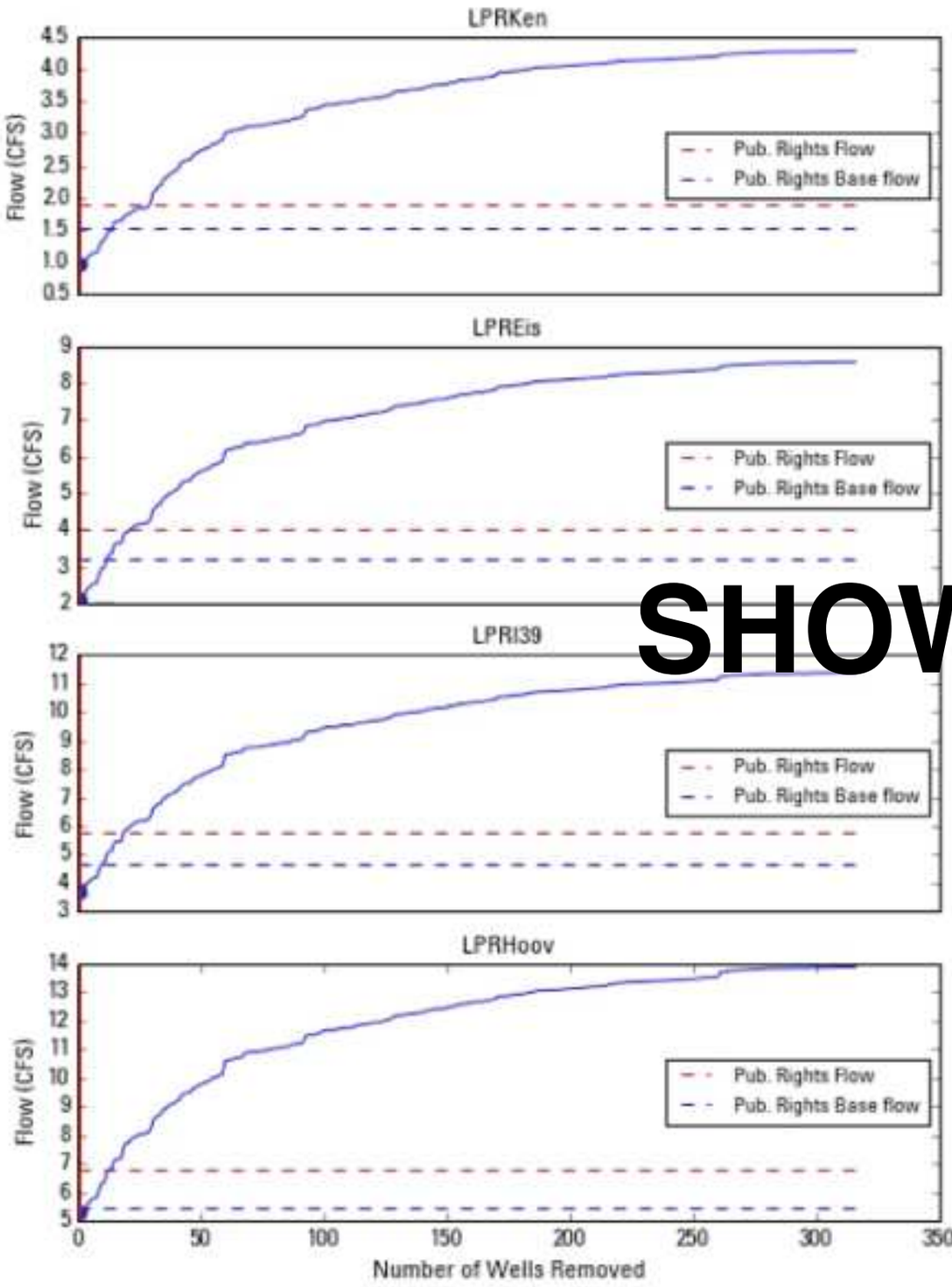
UW Extension Wisconsin Geological and Natural History Survey

Using Depletion Potential to Evaluate Streamflow and Pumping Changes

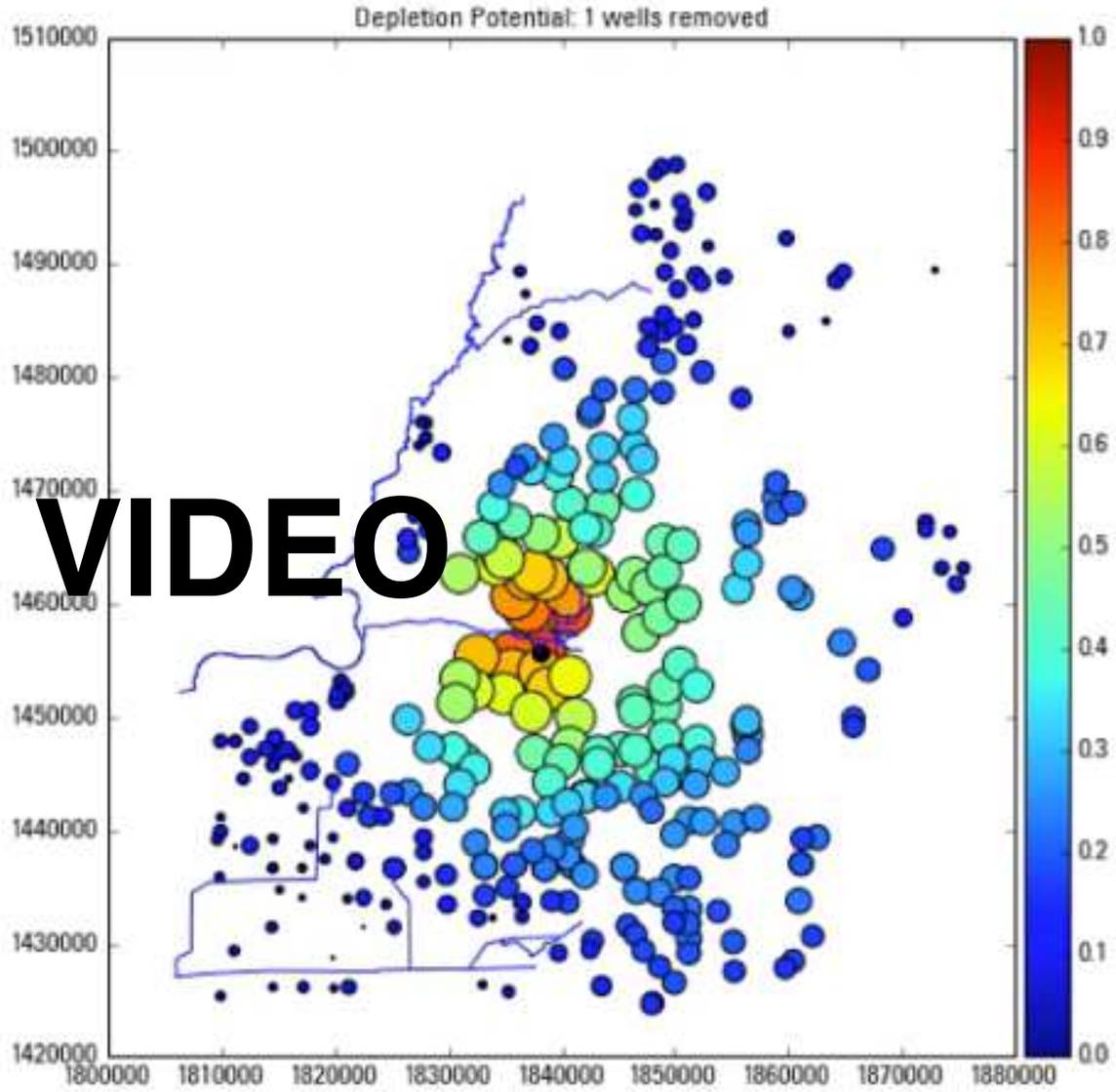
USGS
science for a changing world

UW Extension
Wisconsin Geological and Natural History Survey

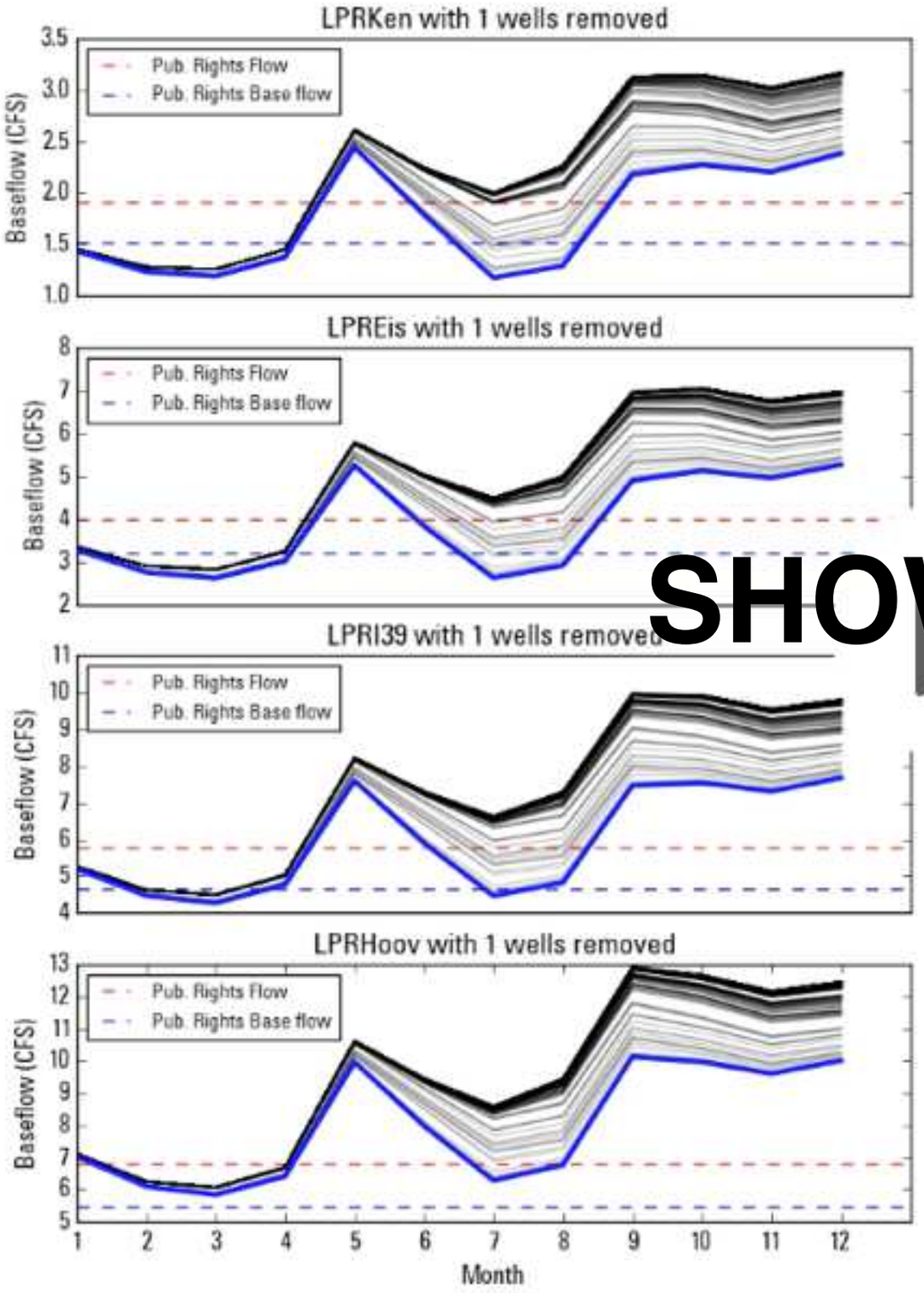
Steady State: Remove wells and recover streamflow



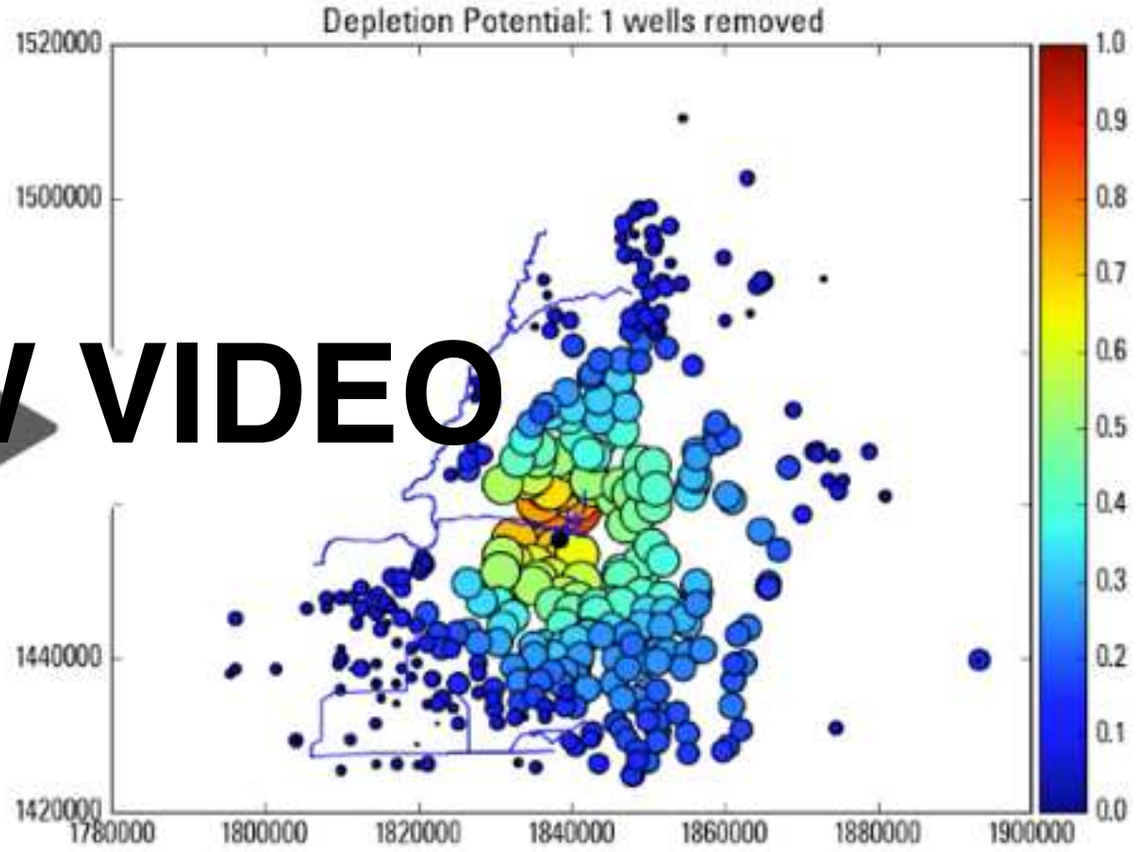
SHOW VIDEO



Transient: Remove wells and recover streamflow



SHOW VIDEO



USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

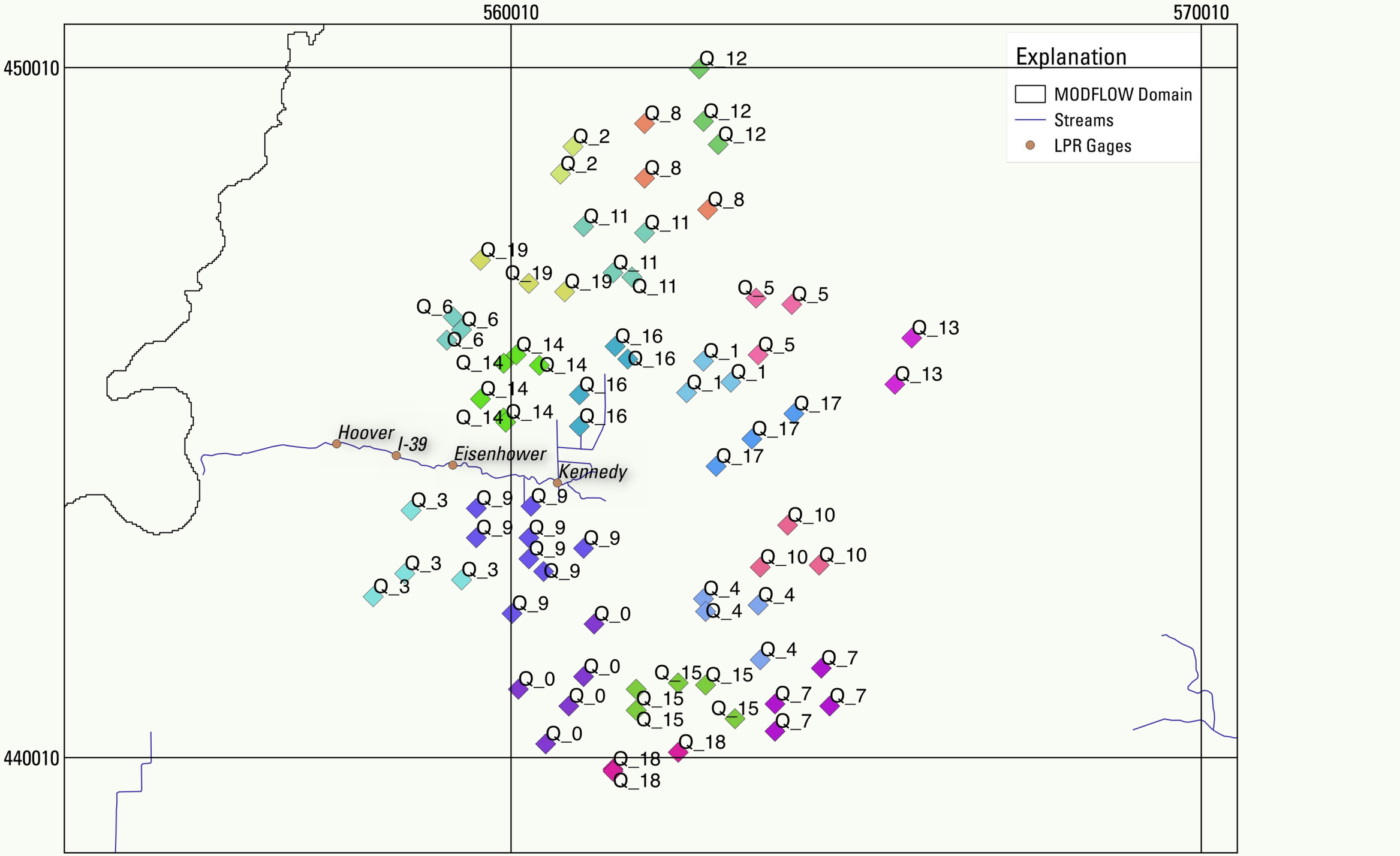
Constrained Optimization

Can we *minimize* reduction in pumping meeting the *constraint* of the public rights streamflow condition?

USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey

Use *k*-means clustering on location and depletion potential to define management groups: 20 Groups



The GWM (Groundwater Management) Tool for MODFLOW

Two main variables that can be adjusted:

1. Number of clusters in each management group
2. Maximum reduction of pumping allowed per group

The GWM (Groundwater Management) Tool for MODFLOW

Two main variables that can be adjusted:

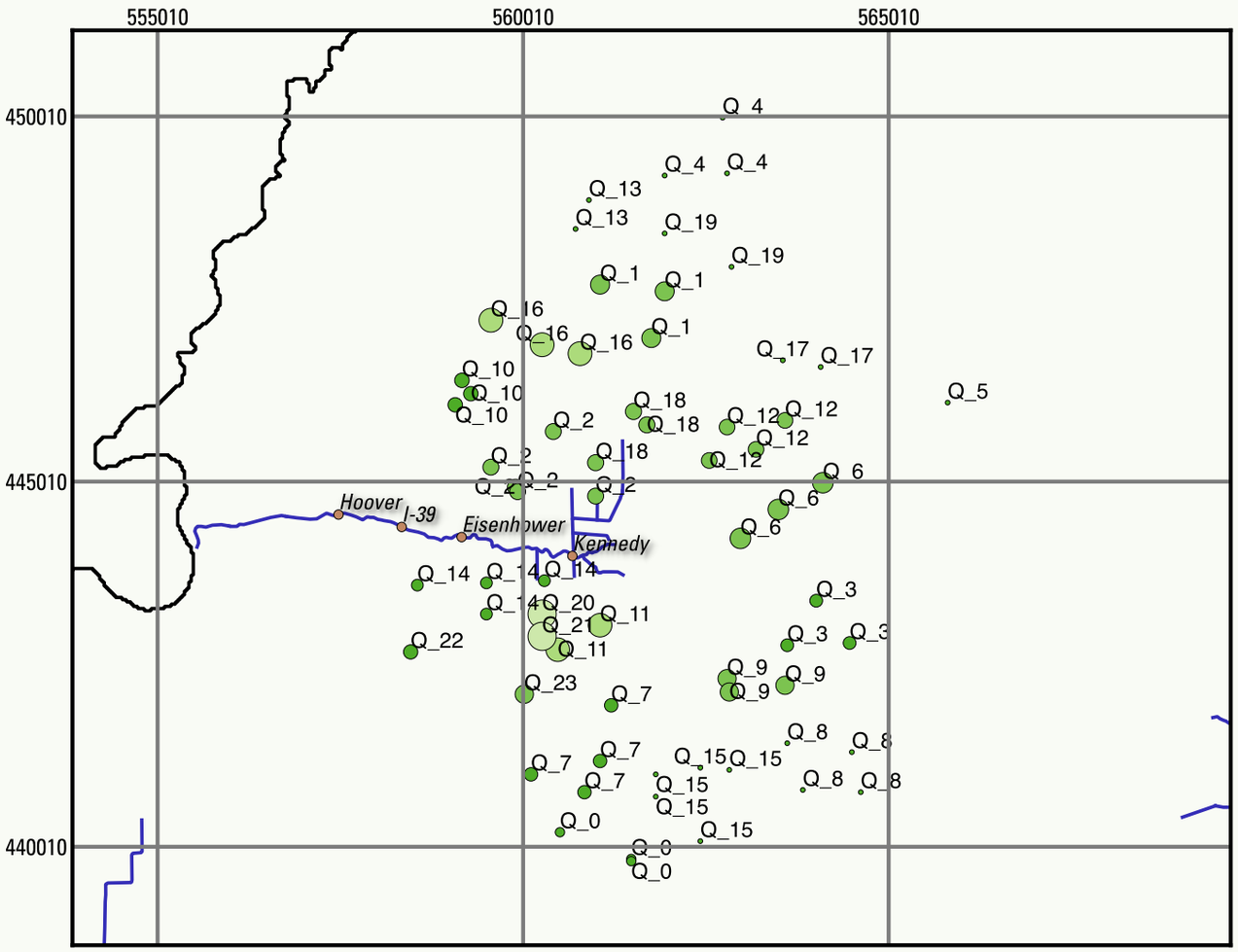
1. Number of clusters in each management group
2. Maximum reduction of pumping allowed per group

Scenario	***Total Pumping Reduction***
All wells equal reduction	30%
Maximum reduction per well 35%	26%
Maximum reduction per well 100%	20%

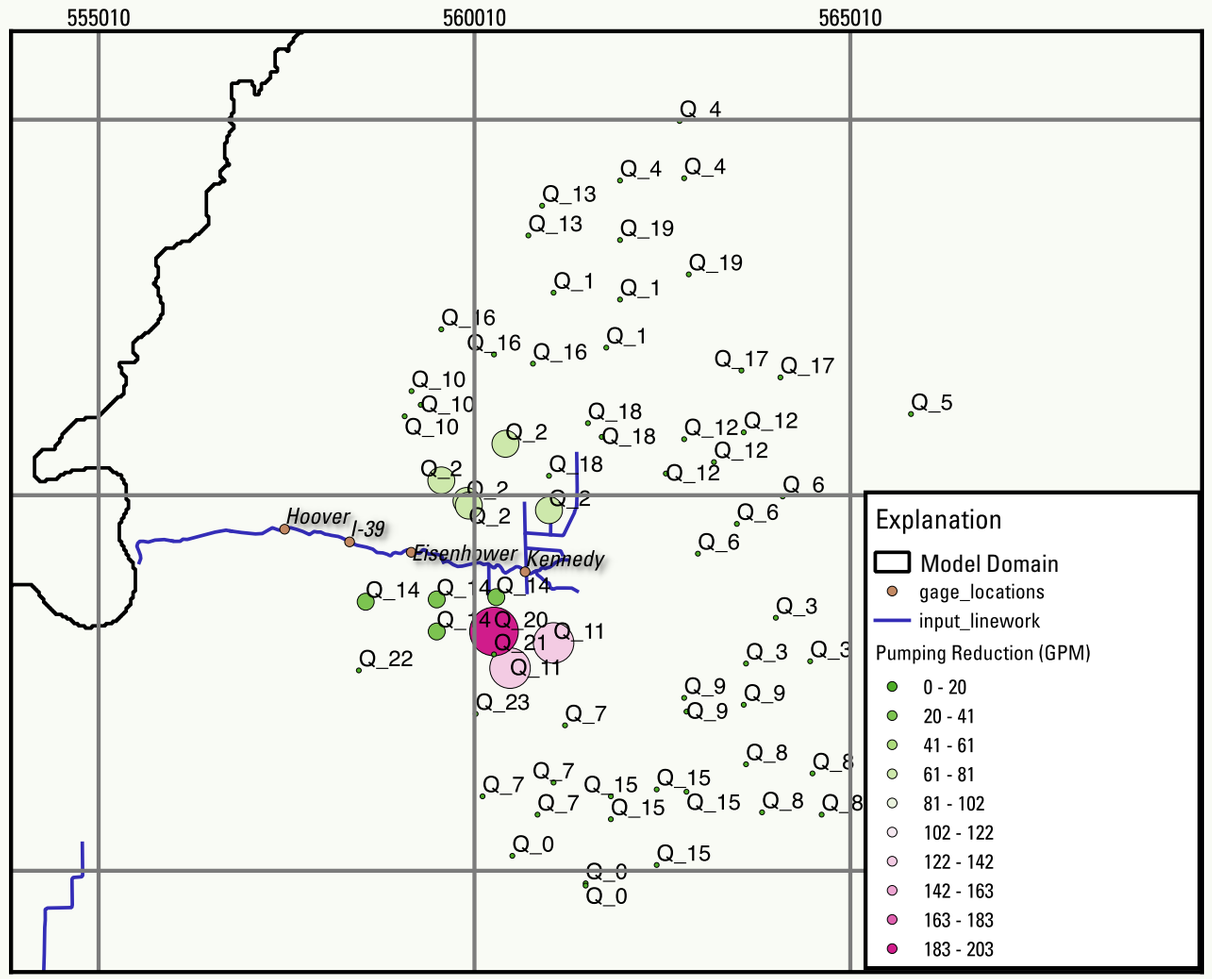
GWM Results:
20 Clusters with non-irrigation separated out

Clusters and Optimal Pumping Reduction

20 Clusters with 35% Maximum Reduction



20 Clusters with 100% Maximum Reduction



USGS science for a changing world

UW Extension Wisconsin Geological and Natural History Survey