

A Lecture Tutorial on the Mahomet Aquifer in central Illinois

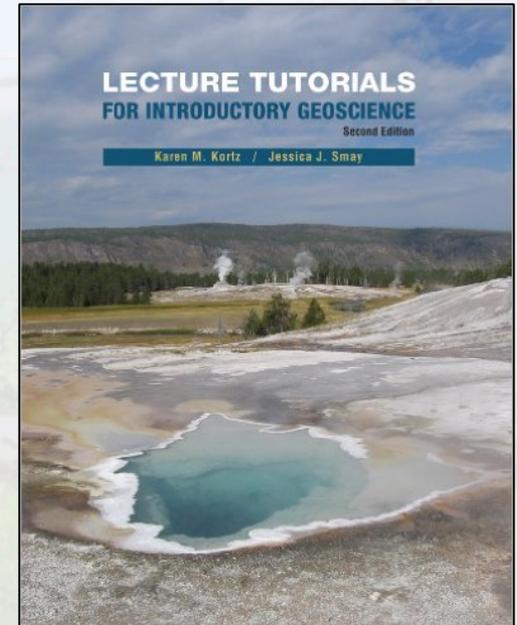
Earth Educators' Rendezvous 2016

Eileen A. Herrstrom
Geology Department
University of Illinois at Urbana-Champaign

*Center pivot irrigation system using
water from the Mahomet Aquifer*

What is a Lecture Tutorial?

- ***Lecture Tutorials for Introductory Geoscience*, K. M. Kortz and J. J. Smay, 2012, W.H. Freeman & Co., New York**
 - “A short worksheet that students complete in class, making the lecture more interactive”
 - May be done individually or in groups
 - Graded or not



Book cover on Amazon.com

Tutorial Learning Objectives

- **Make lecture more interactive**
 - Research shows this improves attention, learning, and retention
- **Introduce lab exercise**
 - Students draw contour lines for the 1st time
- **Increase attendance at lecture**
 - Tutorials are not announced in advance

A Tutorial in the Context of Groundwater



Iron-oxide staining in sandstone

- Define basic terms:
 - Porosity, permeability, water table, aquifer
 - Recharge, discharge, flow direction

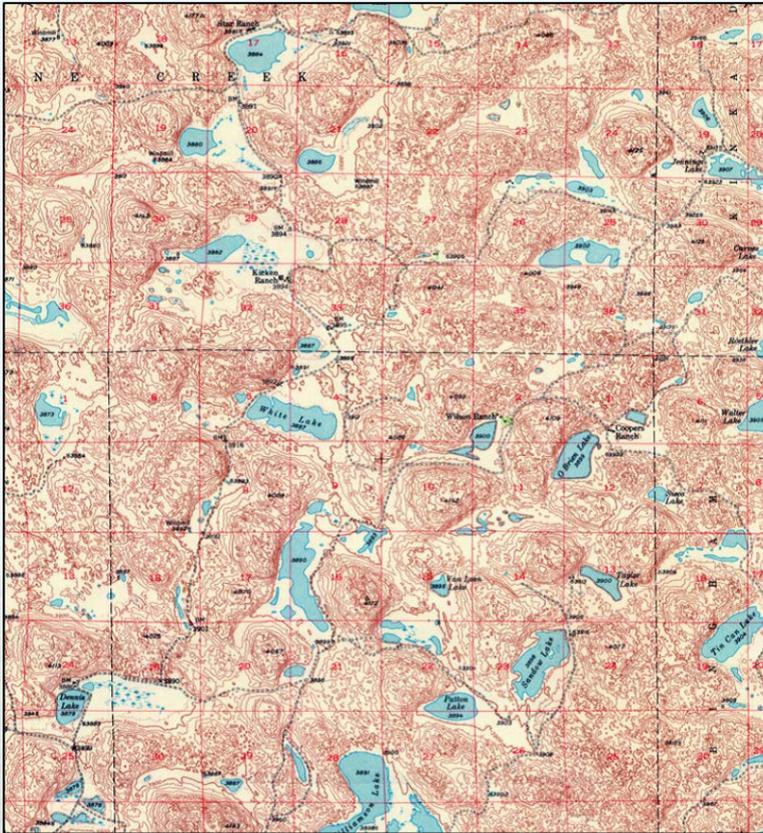


Saalfeld Fairy Grottoes, Germany

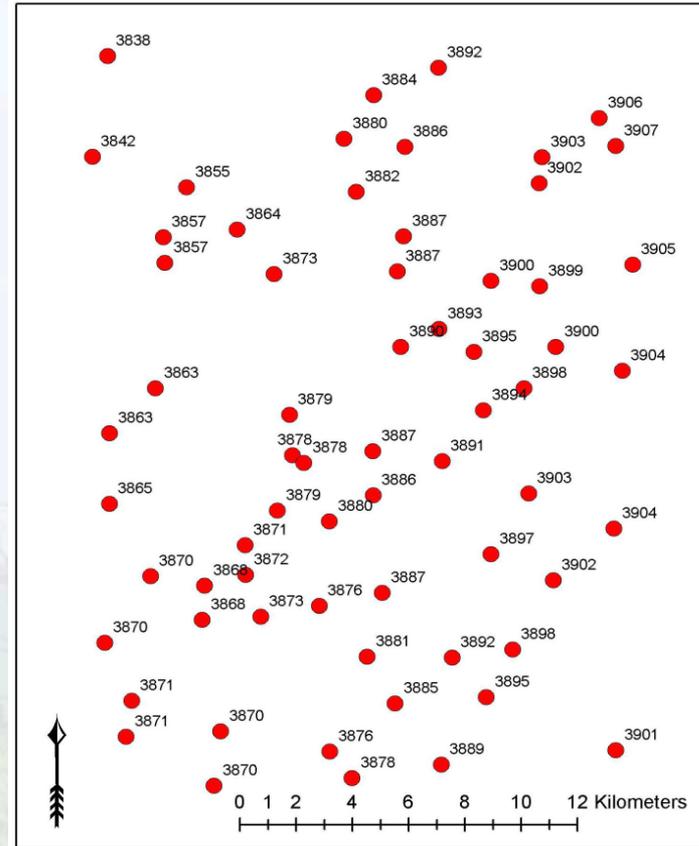


Three Sisters Spring, Florida

On the Cutting Edge Activity



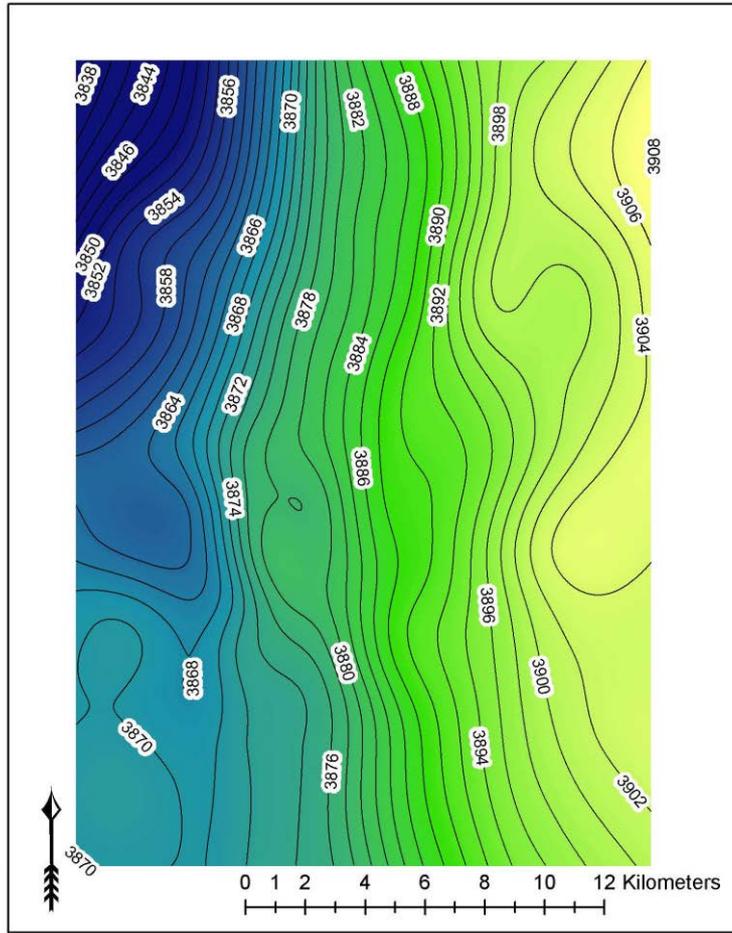
Part of Lakeside NE 15-minute quadrangle (USGS 1948)



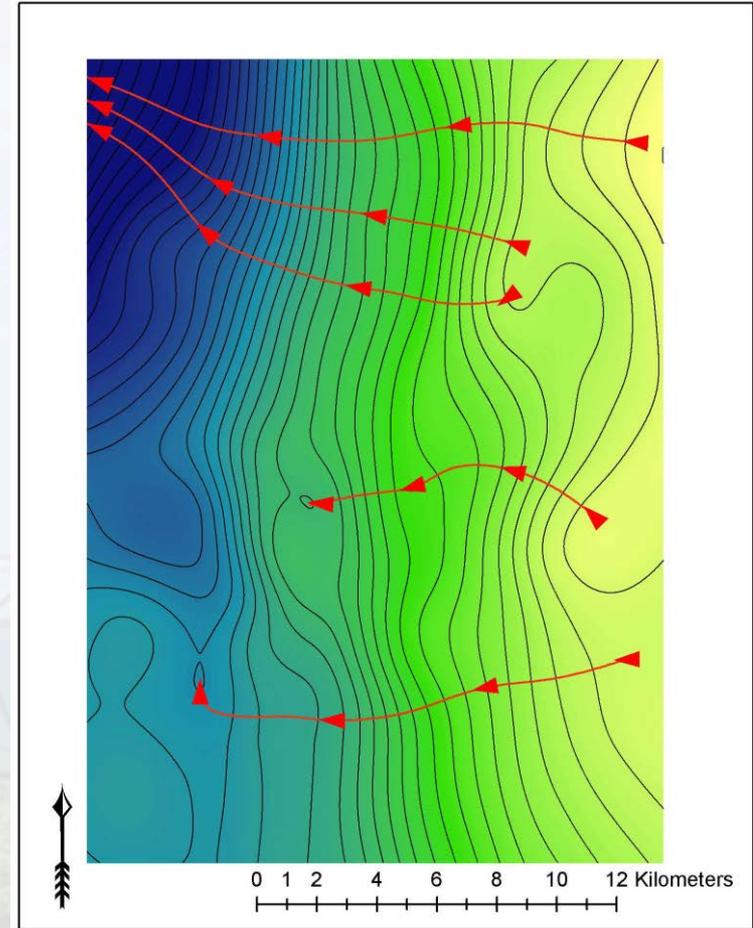
Map of lake elevations

- **Lake surfaces mark the elevation of the water table**

Groundwater Flow in Map View



Contour map of water table

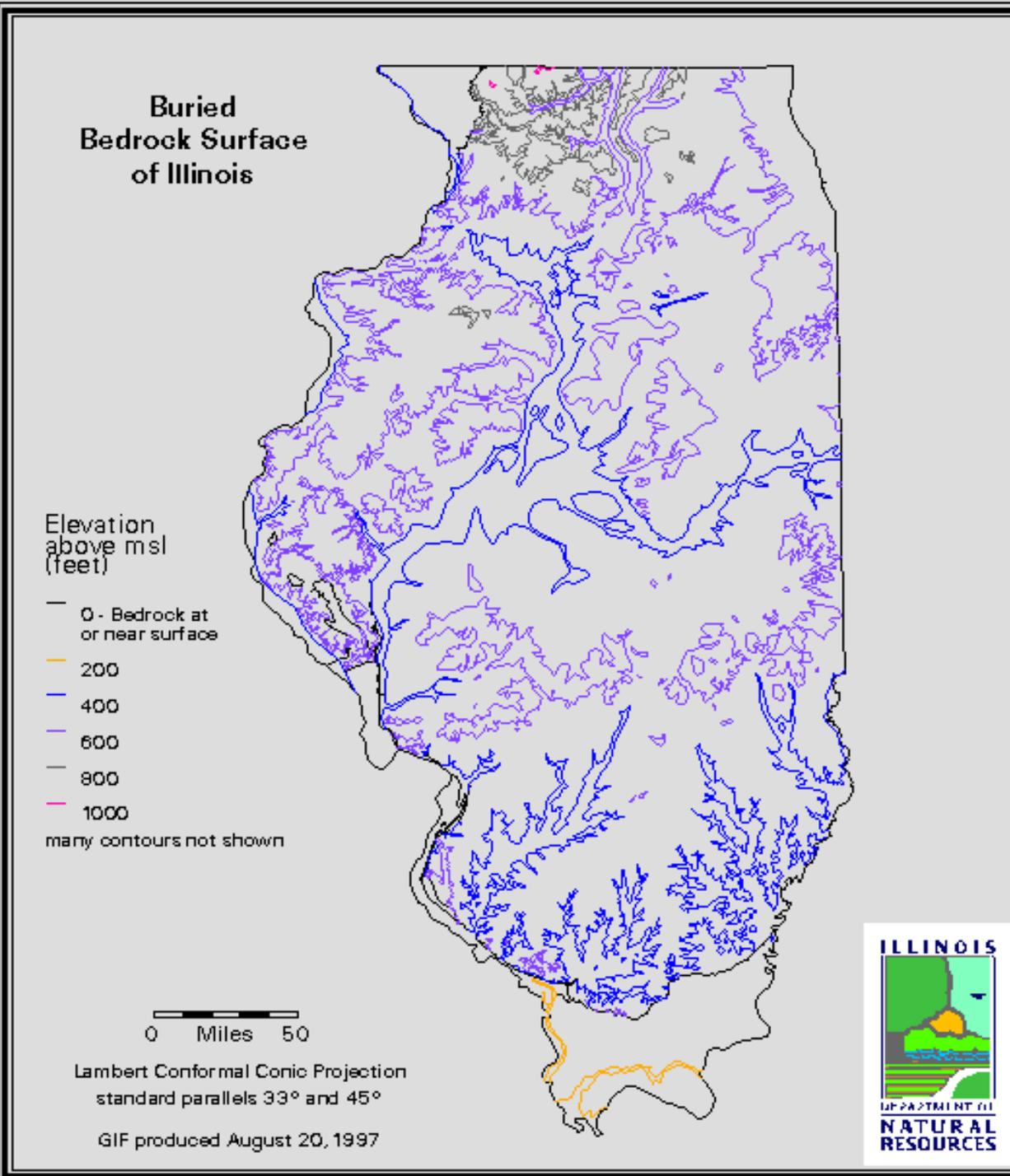


Groundwater flow directions

- **Contour the water table and draw arrows showing direction of flow**

Bedrock Valleys

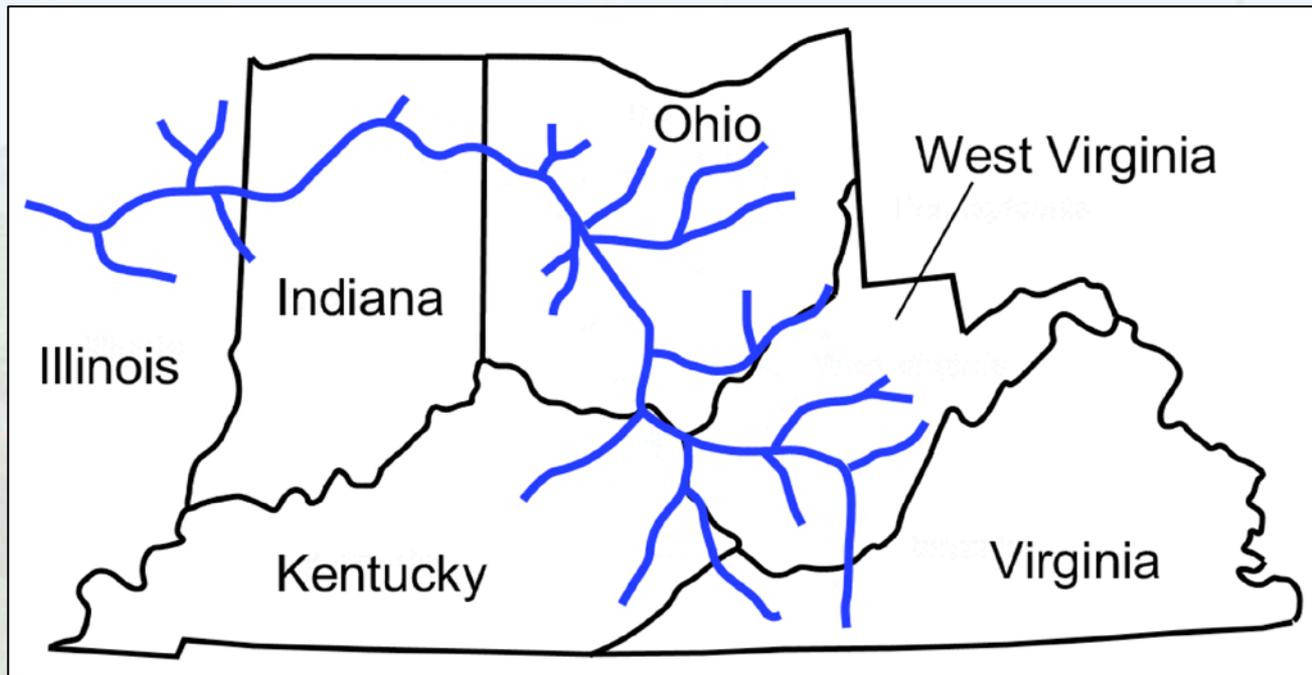
- Several valleys in bedrock are now buried by glacial sediments.



This colored contour map of Illinois (from Hansel and McKay 2010) shows the topography of the bedrock surface. The map was modified from mapping completed by Herzog et al. (1994). The major bedrock valleys shown are from Horberg (1950). ©2010 University of Illinois Board of Trustees. Used with permission of the Illinois State Geological Survey.

Mahomet-Teays River Valley

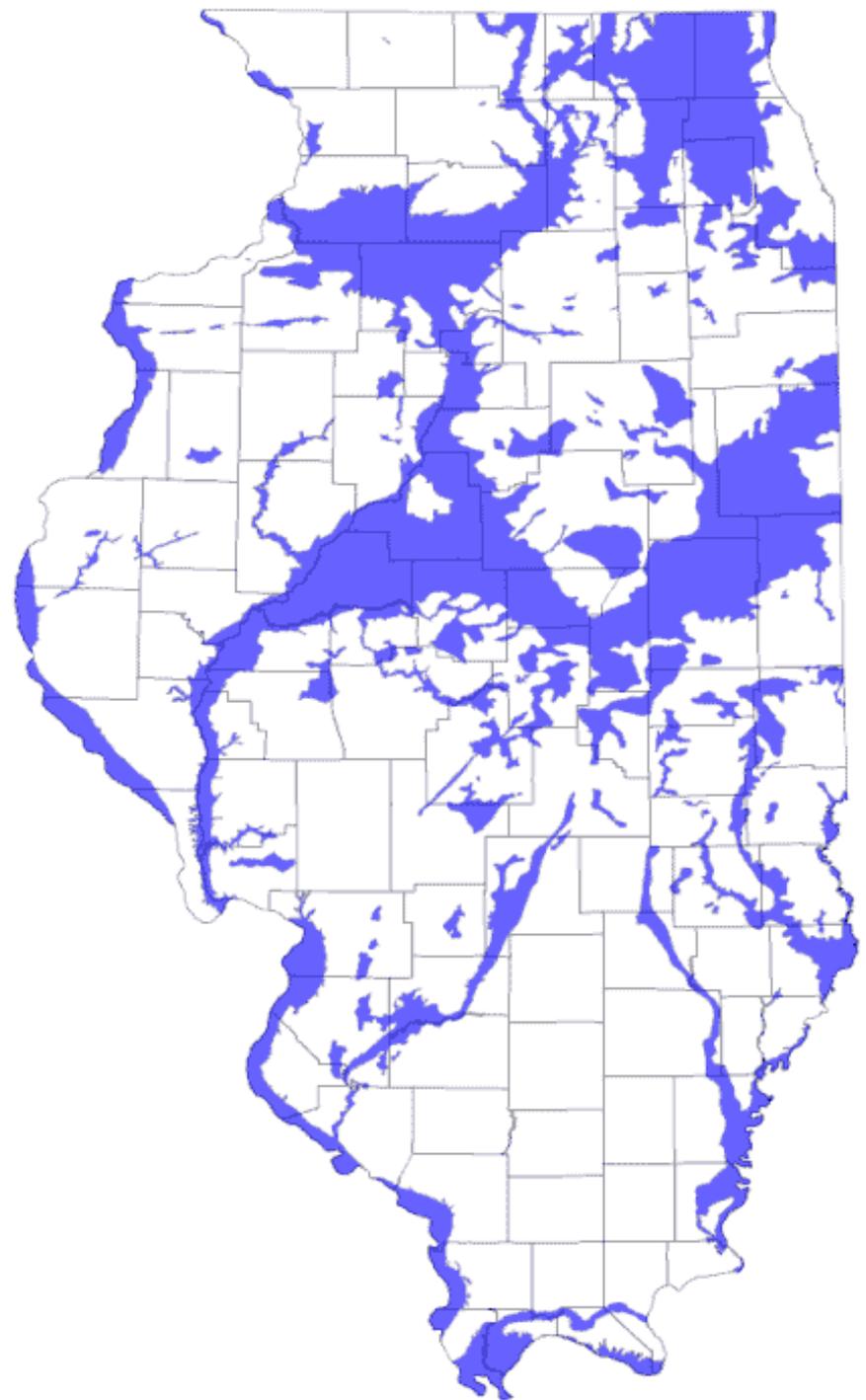
- **A major, mature stream extending from Virginia to Illinois**
 - **Formed during the Neogene**
 - **Buried during the Pleistocene**



Course of the Mahomet-Teays River

Aquifers in Illinois

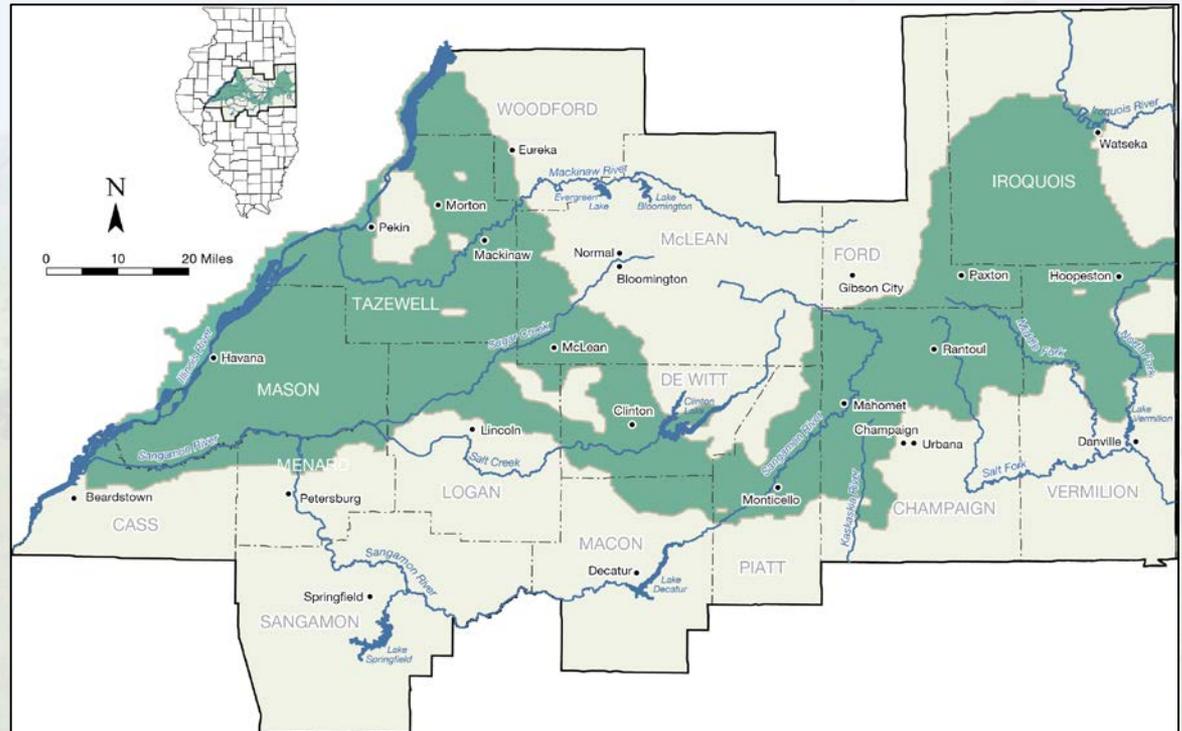
- Major aquifers occupy buried valleys
 - The Mahomet Aquifer is located in the middle of the state.



Map showing the distribution of major sand and gravel aquifers in Illinois (from ISGS 1996). Generally, the tops of such aquifers lie within 300 feet of the surface and the bases occur within 500 feet. In Illinois, major sand and gravel aquifers are defined as geologic units capable of yielding 70 gallons of potable water per minute. Potable water is defined as containing less than 2,500 mg/l of total dissolved solids. Major sand and gravel aquifers are generally Quaternary deposits found within preglacial bedrock valleys or along modern streams and rivers. They are commonly separated from shallower aquifers by layers of less permeable till or fine-grained lacustrine sediments.

The Mahomet Aquifer

- **Bedrock is 100-200 m below the surface in the area shaded green.**
- **Aquifer consists of saturated glacial outwash that filled the valley.**



Boundary of the Mahomet aquifer taken from a numerical groundwater flow model (from Roadcap et al. 2011), which was developed using the U.S. Geological Survey's three-dimensional (3-D) finite-difference groundwater model, MODFLOW (McDonald and Harbaugh 1988).

Use of the Mahomet Aquifer

- 68% of population in this area depends on aquifer for drinking water.
- >200 million gallons withdrawn daily for industry, agriculture, and public use.



Drilling into the Mahomet Aquifer. Photographer: Andrew J. Stumpf. ©2016 University of Illinois Board of Trustees. Used with permission of the Illinois State Geological Survey.



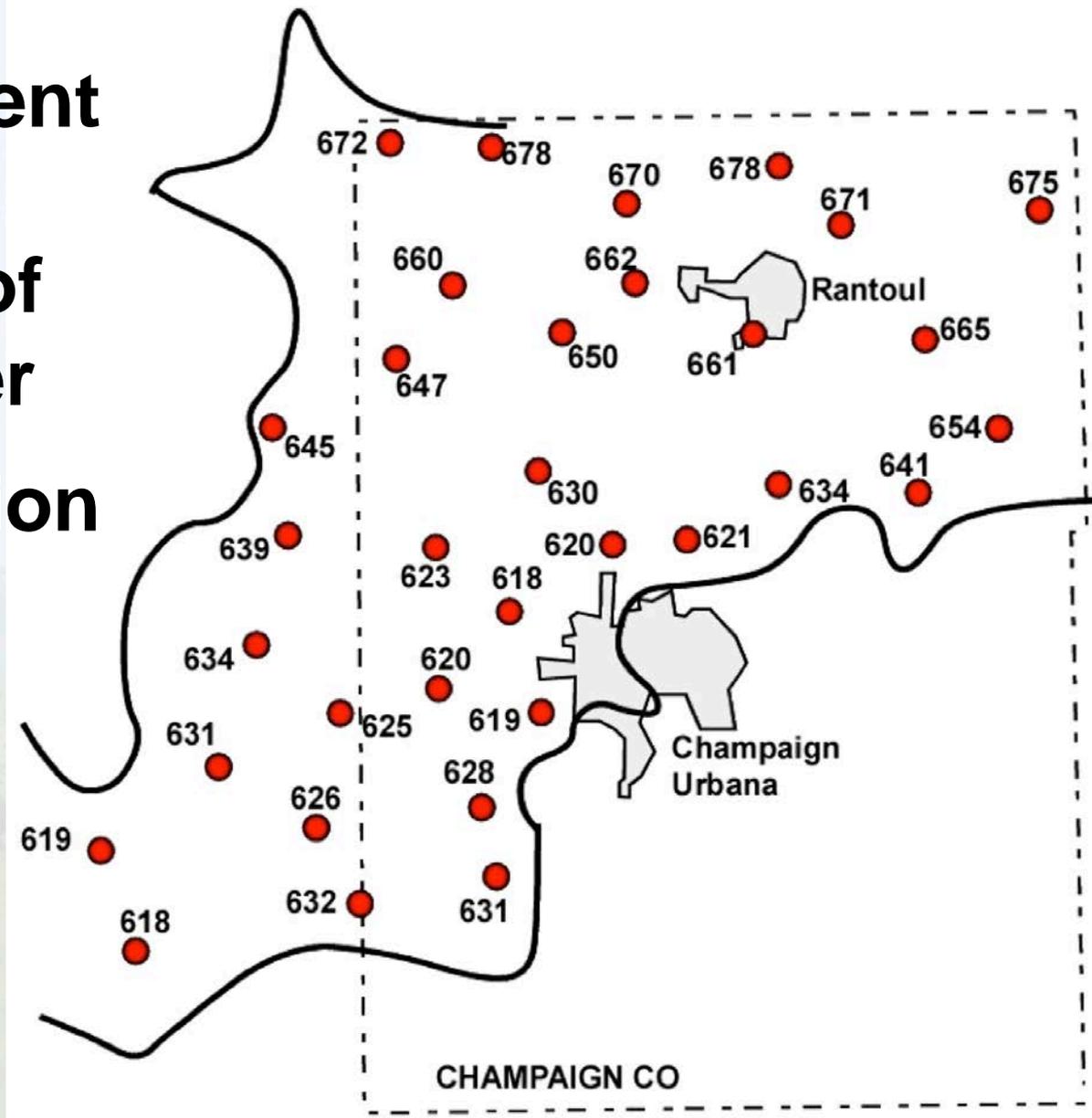
Center pivot irrigation system using water from the Mahomet Aquifer

Lecture Tutorial

1.a. Dots represent elevation of hydraulic head of Mahomet Aquifer

1.b. Land elevation ≈ 750 ft in Champaign County

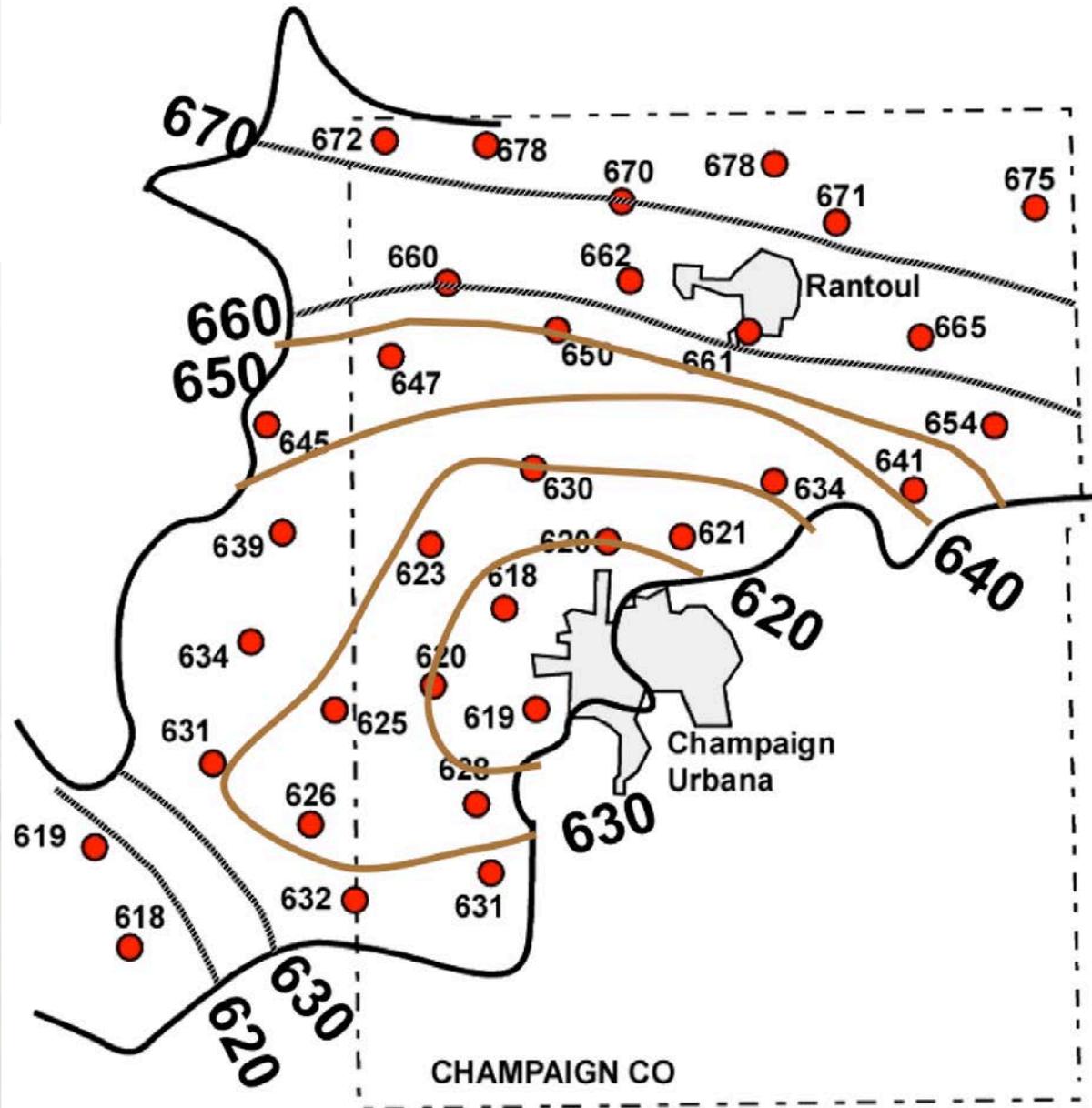
1.c. Water table depth $\approx 5-10$ ft



Contouring the Aquifer

2.a. Four lines are drawn in gray in the northern and southern parts of the map.

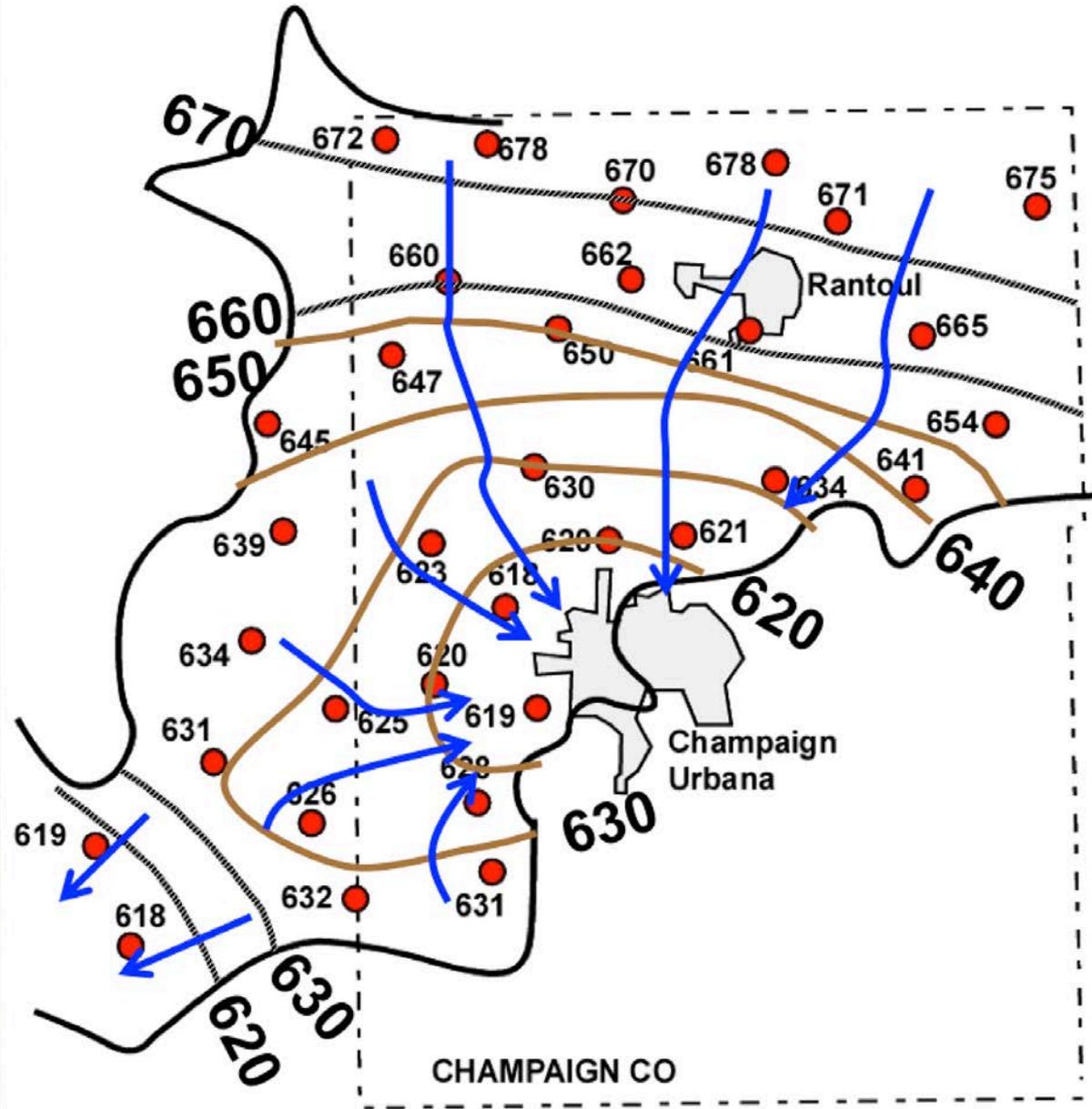
2.b. Draw 4 more contour lines on the map (brown).



Groundwater Flow

3.a. Draw several arrows showing the direction of GW flow.

3.b. Arrows cross contours at right angles.



Approximate Top of Aquifer around 1850

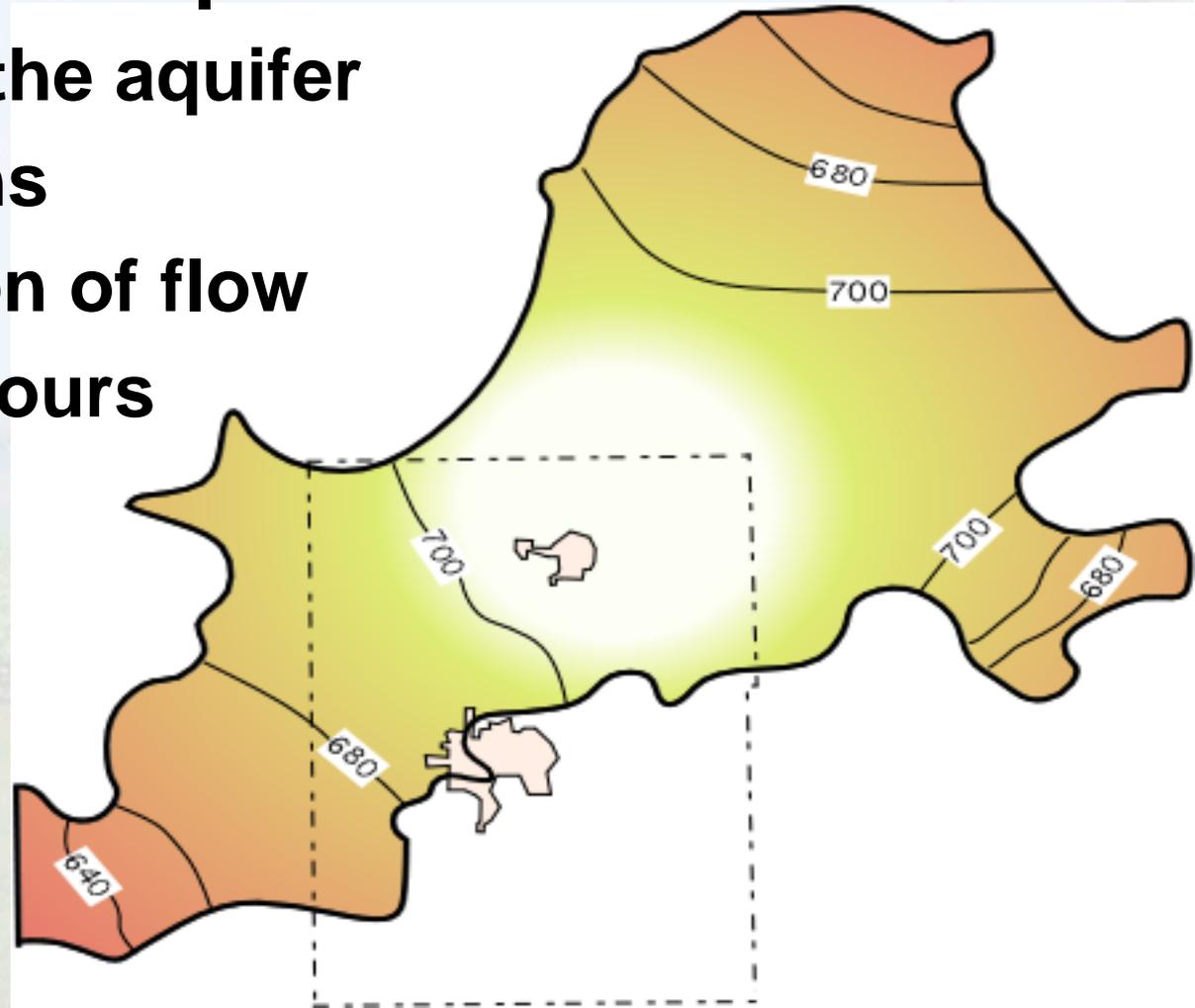
4. How does your map differ from this one?

Shows more of the aquifer

Higher elevations

Uniform direction of flow

No circular contours



Effects on the Aquifer since 1850

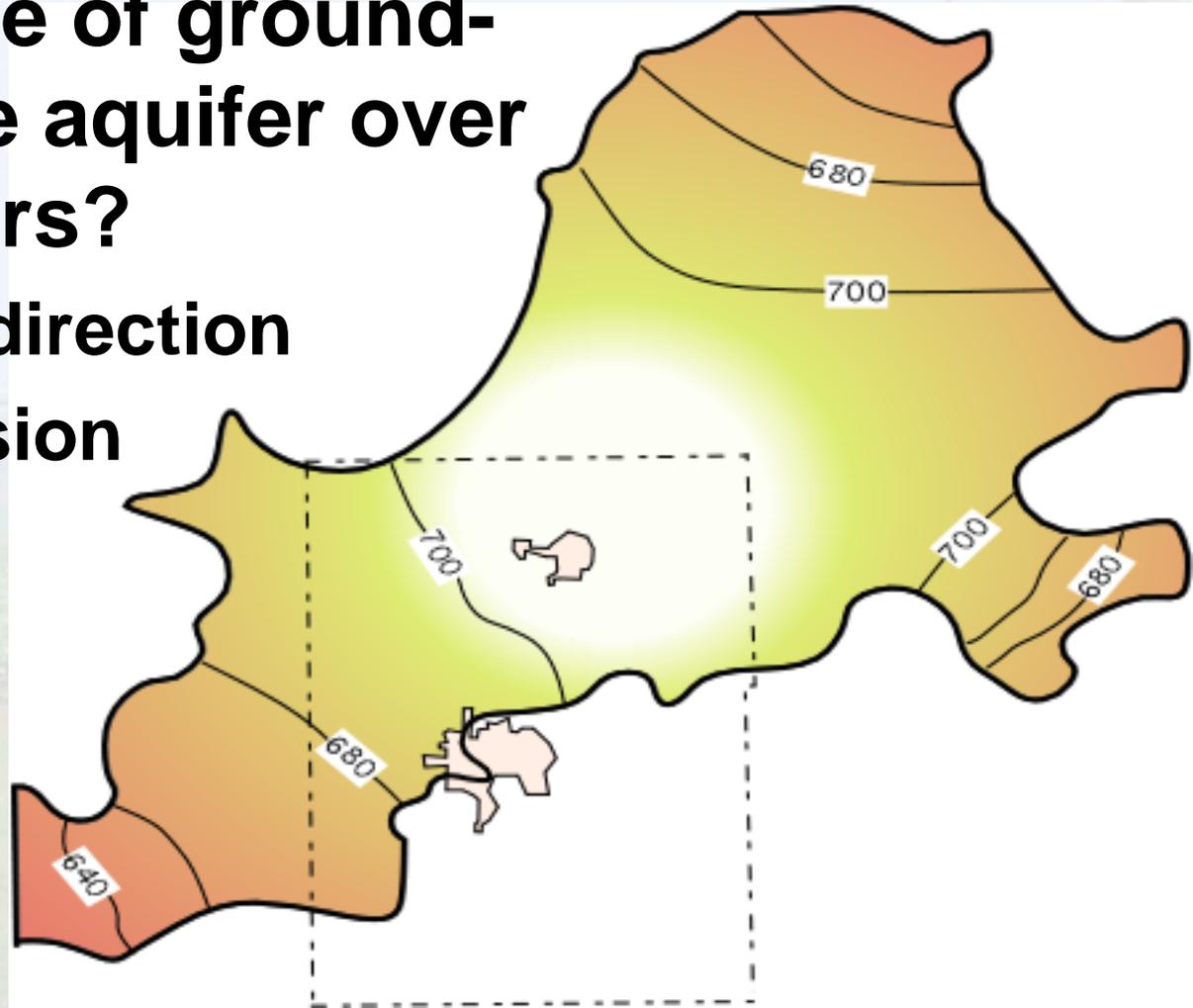
5. What effects has Urbana-Champaign's use of groundwater had on the aquifer over the past 150 years?

Change in flow direction

Cone of depression

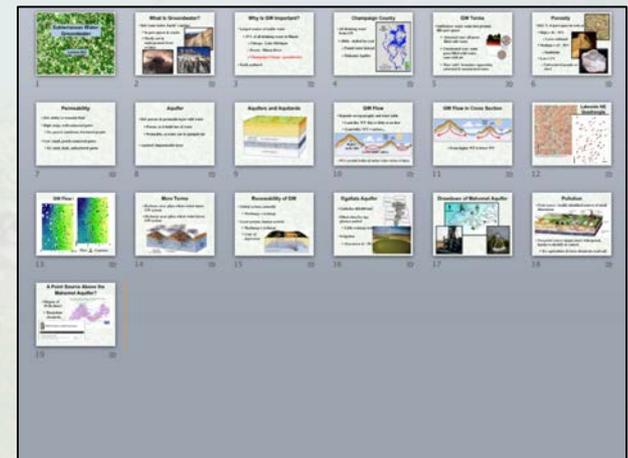
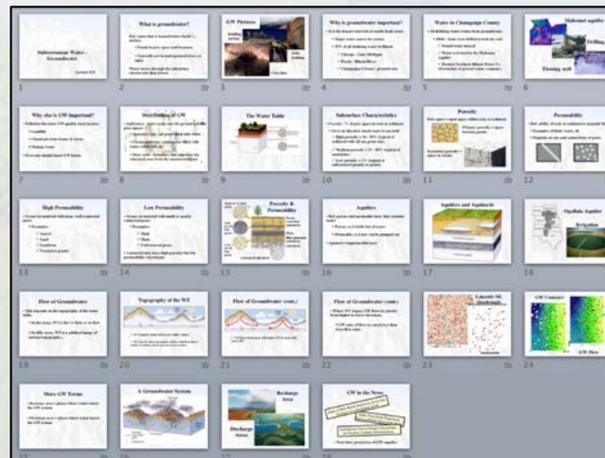
Drawdown

GW divide



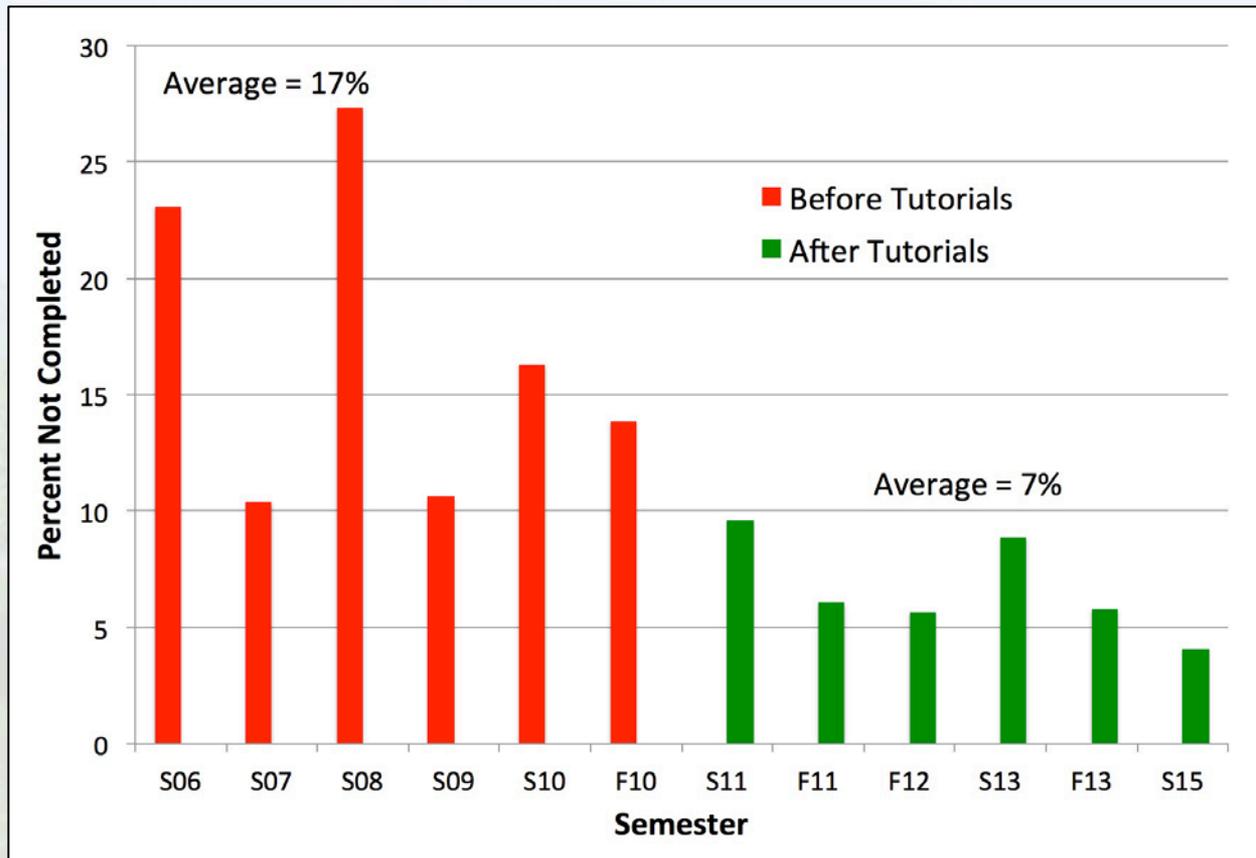
Objective: Interactive Lecture

- Students refer to information on screen to do tutorial
- Tutorial applies lecture topic
 - Addresses topic relevant to students' lives
- Content slides:
 - 28 → 19



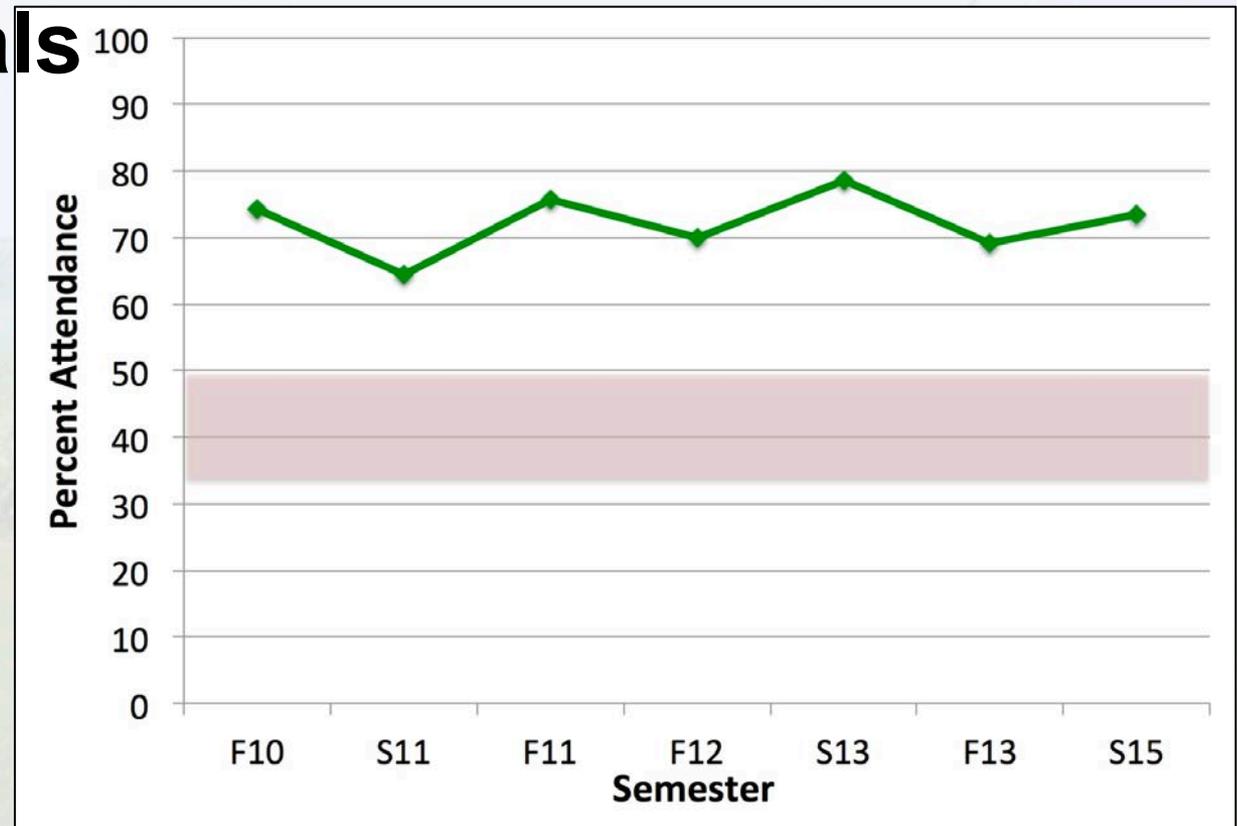
Objective: Improve Understanding

- Non-completion rate for lab associated with this lecture dropped with the addition of tutorials



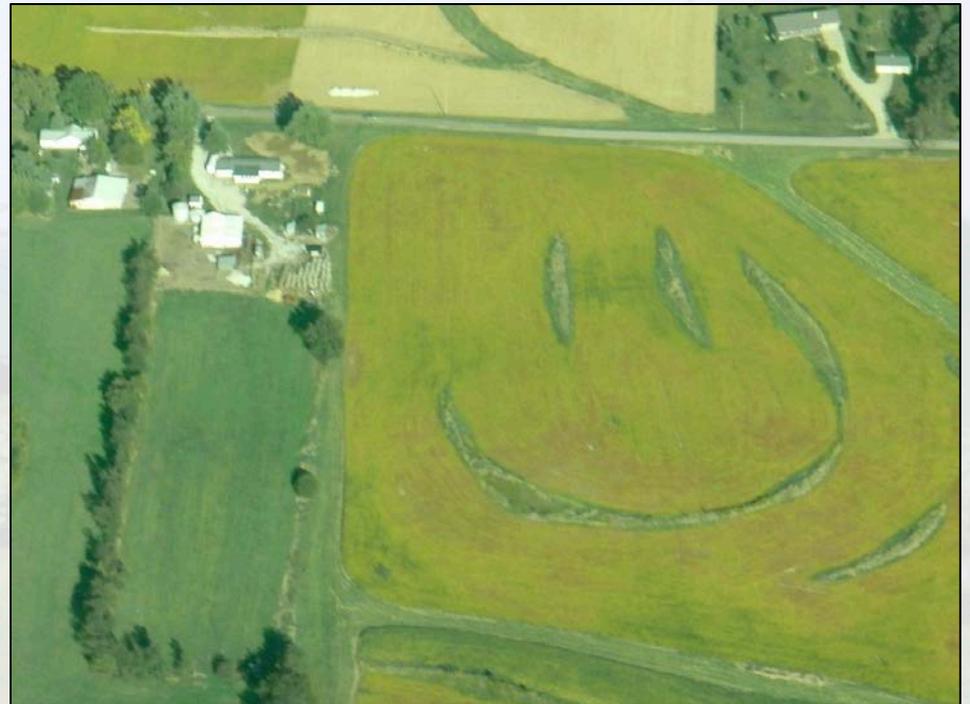
Objective: Increase Attendance

- Pink indicates approximate attendance before tutorials
- Green line shows increased attendance after tutorials



Conclusions

- **Objectives are largely met by the tutorial**
 - **Lecture interactivity increased**
 - **Lab performance improved**
 - **Attendance increased**



Aerial view of swales in farm field

References 1

- Franziskaschreyer, 2009, Saalfeld Fairy Grottoes, Germany [Online image]. CC BY-SA 3.0. Retrieved January 11, 2016, from https://commons.wikimedia.org/wiki/File:Feengrotten_1.JPG
- Hansel, A.K., and E.D. McKay III, 2010, Quaternary Period, *in* D.R. Kolata and C.K. Nimz, eds., *Geology of Illinois: Champaign, Illinois State Geological Survey*, p. 225. *Bedrock topography of Illinois*, ©2010 University of Illinois Board of Trustees. [Online image]. Used with permission of the Illinois State Geological Survey. Retrieved January 13, 2016, from <http://clearinghouse.isgs.illinois.edu/data/geology/bedrock-topography>
- Herrstrom, E., 2016, Mahomet-Teays river valley (modified from Teays river watershed, 2004 [Online image]. Public domain. Retrieved June 9, 2016, from https://commons.wikimedia.org/wiki/File:Teays_River_watershed;geo2.gif)
- Herzog, B.L., B.J. Stiff, C.A. Chenowith, K.L. Warner, J.B. Sieverling, and C. Avery, 1994, *Buried bedrock surface of Illinois (3rd ed.)*: Champaign, Illinois State Geological Survey, Illinois Map 5, 1:500,000, at http://clearinghouse.isgs.illinois.edu/sites/clearinghouse.isgs/files/Clearinghouse/data/ISGS/Geology/zips/IL_Bedrock_Topography_1994_Ln.zip

References 2

- Horberg, C.L., 1950, Bedrock topography of Illinois: Illinois State Geological Survey, Bulletin 73, 111 p., at <http://hdl.handle.net/2142/43648>
- Illinois State Geological Survey (ISGS), 1996, Major sand and gravel aquifers: Illinois State Geological Survey, 1:500,000, at http://isgs.illinois.edu/nsdihome/browse/statewide/zips/IL_Major_Aquifers.zip. [Online image]. Retrieved March 1, 2011, from <http://www.isws.illinois.edu/wsp/faq/addl/q1aquiferssandgravel.gif>
- Keith, R., Three Sisters spring, Florida [Online image]. Public domain. Retrieved January 11, 2016 from https://commons.wikimedia.org/wiki/File:Three_sisters_springs_near_crystal_river_national_wildlife_refuge.jpg
- Kortz, K.M. and J.J. Smay, 2012, Book cover on amazon.com [Online image]. Retrieved June 20, 2016, from <http://www.amazon.com/Lecture-Tutorials-Introductory-Geoscience-Karen/dp/1464101051>

References 3

- McDonald, M.G., and A.W. Harbaugh, 1988, A modular three-dimensional finite-difference groundwater flow model: Reston, Virginia, U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 6, Chapter A1, <http://pubs.usgs.gov/twri/twrt6a/pdf/TWRI-A1.pdf>. Boundary of the Mahomet aquifer taken from a numerical groundwater flow model [Online image]. Retrieved January 11, 2016, from <http://ci.champaign.il.us/departments/public-works/residents/the-mahomet-aquifer/>
- Newton, R., 2005, Topographic map, lake elevations, contour map of water table, and groundwater flow direction, from “Using GIS to construct water table maps and flow nets,” *On the Cutting Edge*. Retrieved March 1, 2011, from <http://serc.carleton.edu/NAGTWorkshops/hydrogeo/activities/9937.html> (Instructors Notes)
- Paulen, R., 2005, Iron-oxide staining in sandstone [Online image]. Used by permission. Retrieved June 9, 2016, from <https://www.cointalk.com/threads/mixing-work-and-pleasure.241265/>
- Roadcap, Andrew, Aerial view of swales in farm field [Online image]. Used by permission. Retrieved January 13, 2016, from <http://www.rwspc.org/meetings/2b-Roadcap-gwmodel-MahometAquifer.pdf>

References 4

- Roadcap, G.S., and H.A. Wehrmann, 2009, Impact of Future Water Demand on the Mahomet Aquifer, Institute of Natural Resource Sustainability, University of Illinois. Retrieved March 1, 2011, from http://www.isws.illinois.edu/iswsdocs/wsp/ppt/Mahomet_March_2009.pdf
- Roadcap, G.S., H.V. Knapp, H.A. Wehrmann, and D.R. Larson, 2011, Meeting east-central Illinois water needs to 2050: Potential impacts on the Mahomet aquifer and surface reservoirs: Illinois State Water Survey, Contract Report, 188 p., <http://www.sws.uiuc.edu/pubs/pubdetail.asp?CallNumber=ISWS+CR+2-11-08>. Map of the Mahomet Aquifer [Online image]. Retrieved January 11, 2016, from <http://ci.champaign.il.us/departments/public-works/residents/the-mahomet-aquifer/>
- Stumpf, A., 2014, Drilling into the Mahomet Aquifer. ©University of Illinois Board of Trustees. Used by permission of the Illinois State Geological Survey
- Winstanley, D., 2014, Center-pivot irrigation system using water from the Mahomet Aquifer [Online image]. Used by permission of the Mahomet Aquifer Consortium. Retrieved June 9, 2016, from <http://www.mahometaquiferconsortium.org/teacher.html> (World of Water PPT, slide #22)