Professor Mary C. Hill, PhD, PE
Department of Geology, University of Kansas
1475 Jayhawk Blvd, Lawrence, KS 66049
(785)864-2728 mchill@ku.edu
http://wwwbrr.cr.usgs.gov/projects/GW_ModUncert
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Testimony to Kansas Natural Resources Committee Meeting November 13, 2017
Representative Tom Sloan, Chair

Dear Representative Sloan and committee members,

Motivation

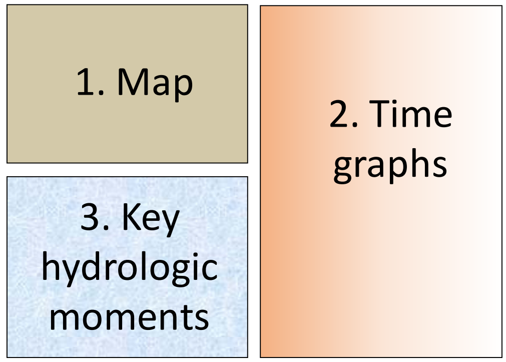
At the Governor's Water Conference last week in Manhattan, Tracy Streeter talked about the difficulty of motivating action on slow moving crises such as those related to groundwater depletion in western Kansas. In this testimony, I seek to show you ways my project at the University of Kansas has been addressing this issue. We use visualization of hydrologic data that is more interactive than most other efforts that have reached legislators and the public thus far. Here, we use our new approach to tell the story of the Arkansas River in western Kansas.

We will focus on what happens when pumping causes the water table to drop regionally. In general, we expect to see springs dry up and stream baseflows (low flows) to diminish and possibly go to zero flow. Indeed, this has occurred across the landscape. Here we focus on the data at and around one stream gage on the Arkansas River.

There are a lot of data related to the Arkansas River in Kansas and the hydrologic system in which it exists. An overwhelming amount of data. There are 60 years or more of streamflow data from at least 12 gages along the river. Other locations have precipitation and temperature data, pumping data, and groundwater level data. There are data, but many stakeholders (including legislators, administrators, residents, and scientists) do not understand how the data relate to their interests. Can more people obtain more knowledge and understanding from this data, in hopes of motivating better resource management?

DiscoverWater and Example Results

Our approach combines data and interactive visualization in a widely accessible web site called DiscoverWater. We organize our web site into the three main components shown here.



The DiscoverWater web site is at **discover-energy.ku.edu/interact.** The example presented there shows results from the Syracuse gage station in Hamilton County. Static images derived from the interactive web site are used below to describe its features and utility.

Using static images to show how an interactive web site works is tricky. In the image below, item 3 (Key Hydrologic Moments) is replaced by a second item 1 (map) to show in these static images how the map's interactive time slider works.

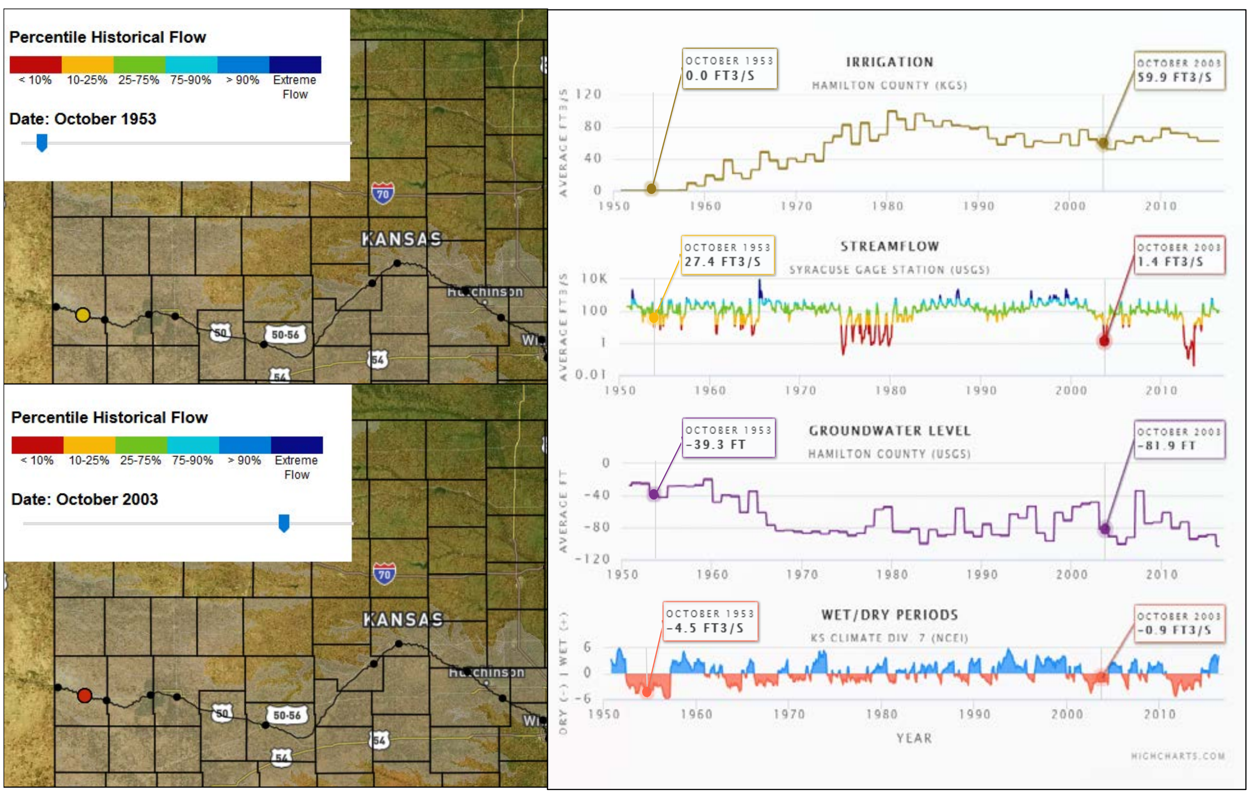
- Looking more closely at the maps, we see
- county boundaries,
- satellite imagery,
- white shading of the Ogallala aquifer, and
- the Arkansas River (black line) with gaging stations marked by mostly black dots.

The Syracuse gage station dot is larger and colored; the color reflects streamflow intensity with categories shown in the legend. The time slider shows the user-chosen year; display of values for October focuses attention on annual low streamflows. Here, we see that in October 1953 flow at the Syracuse station was low and in October 2003 it was very low. The maps alone cannot be used to place the streamflows into a broader hydrologic perspective.

In the graphs on the right, a second set of leaders is inserted to show in these static images how the interactive leaders work on the map. Looking more closely at the graphs, we see

1. Groundwater pumped for irrigation increasing and then levelling off.
2. Streamflow at the Syracuse gage with colors that match the legend in the map.
3. County average groundwater levels that fall as pumping increases, and then level off.
4. Wet and dry periods defined.

The leaders point to data from the two times shown on the two maps. Because streamflow is shown on the left, the same data for that month are shown in the streamflow graph on the right. The graphs enable the streamflows on the maps to be placed in context. This include in historical context and the context of irrigation pumpage and groundwater level in the surrounding county, and the history of wet and dry periods. This relational context allows consequences of irrigation pumping to be understood.



What do these results tell us about this system?

First, look at selections from item 3, Key Hydrologic Moments, as listed on the web site.

KEY HYDROLOGICAL MOMENTS:

1954: Before extensive pumping, major droughts cause declines in streamflow and groundwater level. These impacts are not as extreme as when the aquifer is heavily pumped later.

…

1974-1979: Modest dry period produces extremely low streamflows. The consequences of pumping on streamflow are revealed.

Sept - Nov 1983: At this site, second highest recorded pumping corresponds with the second lowest groundwater level. Streamflow remains normal, which demonstrates how data from natural systems can be confusing. Some situations like this are worth further study.

1992-2001: Long mostly wet period allows streamflow and groundwater to recover.

2003-2006: Pumping during a moderate drought is associated with smaller streamflows than occurred in the more severe 1950's drought. The rate of irrigation pumping in the county is nearly as large as average streamflow.

2010-2014: Pumping during a severe drought is associated with the lowest measured streamflows to date, which is essentially a dry stream. The stream is no longer perennial at this location. It has become ephemeral – a stream for which flow is no longer supported by groundwater during dry periods.

The above clearly illustrates how streamflow has become less resilient to drought conditions as pumping has increased.

Second, the graphs make it clear why people get confused about hydrology. There are many variables involved and the timeframes are decades long, or more. Without images like this to provide clear historical and relational perspectives, it is simply not possible for anyone to understand what is happening.

Future Advances

This work establishes a base point. The presentation today shows the multivariate data storage and interactive visualization system we have developed being used to promote popular understanding of a hydrologic system with inherently long timeframes. There are rich ways to build on this foundation in relation to hydrologic data and data related to other issues. Here are some examples.

- Hydology
    - dynamically choose other gaging stations
    - dynamically include other kinds of data sets (e.g., precipitation and temperature, releases from upstream reservoirs such as the John Martin Reservoir, and so on)
    - dynamically choose other areas (movable window)
    - enrichments of Key Hydrologic Moments section based on data correlations, wikipaedia access, and user entries
    - improve cell phone accessibility
- Blue-green algae (Cyanobacterial harmful algal blooms CyanoHABs)
    - Submitted KU Research Excellence grant proposal with Ted Harris of KBS (who I met here at the last meeting of this committee).
    - We proposed to use the DiscoverWater data organization and display system to
        - organize the currently poorly organized data related to CyanoHABs
        - produce the kind of visualizations shown here for hydrologic systems
        - use the developed resources to address scientific questions.
    - We can then use the results to correlate algal blooms with climatic conditions and upstream agricultural practices.
        - This will support subsequent investigation of causes and remediation, and suggestions for future legislation.
    - Coordinate with KSU, The Nature Conservancy, and others.
- Reservoir sedimentation
    - Organize reservoir sedimentation data
    - Relate it to data on upstream erosion of riverbanks and agricultural practices.
    - Coordinate with KSU, The Nature Conservancy and others.

Our progress in these efforts will be expedited with added funding. We are applying for funds from various sources. Expressions of interest from state legislators make us more competitive. We hope that our presentation today is a constructive start to building that interest.

Thank you for your consideration. I will stand for questions.

Prepared by Professor Mary C Hill and PhD Aspirant Misty Porter