Presenter Responses to Questions Not Answered During the Webinar

Note: Some of the responses to questions below refer to USGS Circular 1376, Streamflow Depletion by Wells. That publication can be accesses electronically at http://pubs.usgs.gov/circ/1376/ . For paper copies of that publication, and further questions, please contact Paul Barlow, pbarlow@usgs.gov.

Is this analysis currently being used in California that you are aware of?
We do not know of applications in California to date.

How does modeling one well at a time affect model output and consequent water management decisions?

Think of the capture maps as a way to look at sources of water to a particular pumping well at a particular pumping time, based on the location of that well. Water managers could use that information for understanding the individual effect of an existing or new well at that location on a stream, for example. For an understanding of the combined effects of many wells pumping at different locations in an aquifer, we would not use capture maps, but would run a model simulation that included all of the pumping.

How would Aquifer Storage Recovery (ASR) impact streamflow depletion?

The effects of ASR on a stream would depend on how far the facility is from a stream. For an ASR facility that is at a great distance from the nearest stream, perhaps several miles or more, the effect on the stream would be minimal if the storage and recovery amounts were equal when averaged over time. If the facility is very close to the stream, streamflow would be enhanced during periods of injection, and depleted during periods of withdrawal. This behavior can be inferred from the discussion of "Variable and Cyclic Pumping Effects," starting on page 26 of USGS Circular 1376. Figure 21 shows how depletion from a well pumping cyclically is damped with distance from a stream.

How do these capture maps compare with Streamflow Depletion Factor (SDF) maps from analytical models, i.e., Jenkins & Glover?

For the case of a straight stream and uniform aquifer properties, results from capture maps made with a groundwater model would be identical to maps made using the Jenkins and Glover approach. The real world, however, is never that ideal and groundwater models allow us to represent complex geometry of stream systems and aquifer boundaries, as well as aquifer properties that vary both vertically and horizontally. Analytical models cannot address these types of complexity.

How was ET calculated for the model?

ET (evapotranspiration) from the groundwater system was simulated in the Elkhorn and Loup Rivers model by use of MODFLOW's ET Package. A full explanation of the details of how ET was simulated is given on pages 20-21 of the USGS report SIR 2010-5149 "Simulation of Groundwater Flow and Effects of Groundwater Irrigation on Stream Base Flow in the Elkhorn and Loup River Basins, Nebraska, 1895-2055—Phase Two." The report is available online at: http://pubs.usgs.gov/sir/2010/5149/

Were pumping rates used in the models based on steady production or varying production rates?

We use a constant pumping rate, and make a map showing capture as a fraction of that rate. Alternatively, the maps can be made to show capture as a fraction of the volume of water pumped over a time period, as was done in our Nebraska example. The pumping rate used in either case, is constant.

What software is being used to build these models?

The models in our examples were constructed with the USGS MODFLOW groundwater model program. To make the capture maps, a separate program is needed to run the model repeatedly. For each model run, that program must first construct the Well Package for the current pumping location, run the model using that Well Package input, and extract and save information on the effects of that added well. When the model has been run for all well locations of interest, results for a particular pumping time can be contoured, usually within a Geographic Information System. A formal program to run the model does not exist. Stan has made the repeated model runs with FORTRAN programs, custom-tailored for each model being run repeatedly. Others have used scripting languages to accomplish the same set of steps.

Why wasn't the Elkhorn River downstream of Norfolk included in the ELM?

While the area downstream of Norfolk is considered part of the High Plains aquifer system (see map at http://pubs.usgs.gov/ds/543/), glacial deposits dominate the area east of the North Fork of the Elkhorn River. The glacial area does contain lenses of sand and gravel but only incomplete information exists with regard to the distribution and extent of the sands and gravels, and how groundwater in those deposits, does or does not interact with the rest of the High Plains aquifer. In 2005, the ELM technical committee, consisting of representatives from all collaborators involved in the project, agreed to limit the eastern edge of the model to the approximate edge of the glacial deposits.

Does the model just use historical hydrology, or are climate change scenarios also analyzed?

The process uses historical hydrology. Climate change would not influence the effect of a well on a stream except in cases where it caused streams to disappear entirely, other major changes to the distribution of boundary conditions within an aquifer (such as changes in the areal distribution of evapotranspiration), or where it caused large changes in aquifer saturated thickness.

For the Nebraska model, what is the effect of surface water pumping on aquifer depletion?

If the amount of water stored in the aquifer was dependent upon losing stream reaches that contributed water to the aquifer and pumping in the stream was large enough to cause the stream to go dry, thereby reducing the amount of surface water that would enter the aquifer, there might be an effect. However, the streams in the study area are gaining water from the aquifer, not losing water to the aquifer, and therefore there is no effect of surface water pumping on aquifer depletion.

Is there enough water to support all the surface water rights if groundwater pumping was stopped completely?

Yes. The State only grants new surface water rights if there is an expected long term supply of water available to meet the extra demand. Additional information about how surface water rights are evaluated and granted is available at: http://dnr.ne.gov/ .

Are there existing documented impacts from streamflow depletion such as trend of reduced annual streamflow rates?

For the ELM area, with respect to whether past impacts of pumping on stream depletion, we are not aware that any have been documented though it is generally accepted within the state that impacts are occurring. Several approaches could be used to quantify impacts, including but not limited to using the ELM model. With respect to future impacts, estimates of the impacts of changes in irrigation on streamflow were provided in http://pubs.usgs.gov/sir/2010/5149/ (fig. 32-33) and http://pubs.usgs.gov/sir/2008/5143/ (figure 33), though as with any model, the future estimated impacts largely depend upon the assumptions used to construct the model of future conditions, such as climate, land use, and the ability to irrigate with groundwater.

Have you measured reduced flow in streams due to pumping? If so what is the magnitude?

See the example of the Beaver-North Canadian River Basin in Oklahoma, as described on pages 52-54 of USGS Circular 1376. There are more extreme examples where perennial streamflow and riparian evapotranspiration have been eliminated entirely by groundwater pumping.

Can you explain how depletion occurs when a well is located on the opposite side of a groundwater divide?

This is discussed in the section “Depletion and rates and directions of groundwater flow,” starting on page 40 of Circular 1376. Depletion is not affected by rates and directions of groundwater flow and groundwater divides have no effect on depletion. To understand the physical mechanism for depletion across a groundwater divide, refer to figure 45 in USGS Circular 1376. Let us assume that a groundwater divide exists between the location of well A and the streams in watershed 3. That divide would be maintained by groundwater recharge. The effect of pumping well A would be to move that divide away from the pumping well, and the cone of depression moves into the area of the divide. As that divide moves away from the well, recharge that formerly went to watershed 3 will now be going to the pumping well. This means that less water will be discharging to streams in watershed 3, even though the pumping well is not in that watershed.

Why was a 50-year timeframe ran for capture zone analyses?

The 50-year timeframe was selected because it is a key management variable in Nebraska. The Nebraska Department of Natural Resources defines hydrologically connected areas of an aquifer as those areas within which pumping of a well at a constant rate for 50 years will deplete base flow by at least 10 percent of the pumped volume. Additional information on this topic can be found on page 5 of the USGS report

"Simulation of Ground-Water Flow and Effects of Ground-Water Irrigation on Base Flow in the Elkhorn and Loup River Basins, Nebraska," which is available at: http://pubs.usgs.gov/sir/2008/5143/ .

Did you say that the Nebraska aquifer is modeled as a one-layer system? Do you model confined or unconfined conditions? Do aquifer tests in the local well tests reflect the condition represented in the model?

Yes, the aquifer was modeled using a single unconfined layer (page 4, USGS SIR 2010-5149, http://pubs.usgs.gov/sir/2010/5149/). At the time scales used in that model, groundwater gradients are predominantly horizontal and vertical gradients only for much shorter times. Therefore, it was appropriate to simulate the groundwater flow system as horizontal; see the 'Assumptions' section of http://pubs.usgs.gov/sir/2010/5149/ for discussion of this and other assumptions.

Calibrated hydraulic conductivity values were compared against expected values that were derived from lithologic material and texture descriptions at test holes and several aquifer tests within the study area. Calibrated conductivity was generally close to expected values derived from test-hole texture/lithology. An aquifer test only measures responses over time scales of a few days and distances of tens of feet, whereas the Elkhorn-Loup Model represents the groundwater flow system at time scales of years and decades and distances of hundreds of miles. Therefore, regional patterns and values of hydraulic conductivity used in model calibration may differ from values estimated from aquifer tests.