Arbuckle-Simpson aquifer study confirms worst fears

Large-scale pumping of groundwater would have depleted area springs and streams

The attempt by a group of communities based in Canadian County to pump more than 80,000 acre feet of water from the Arbuckle-Simpson aquifer and transport it to central Oklahoma in 2002 would have depleted area springs and streams if allowed to proceed, a study recently completed by the Oklahoma Water Resources Board reveals.

Passage of Senate Bill 288 in 2003 established a moratorium prohibiting any municipality or other political subdivision outside the Arbuckle-Simpson basin from entering into a contract which would lead to municipal or public water supply use of groundwater from the basin. The moratorium has remained in effect since that time until the present comprehensive study of the aquifer conducted by the OWRB could be completed.

Results of the Arbuckle-Simpson aquifer hydrological study were summarized during an informal public meeting August 18 at the Pontotoc Technology Center in Ada.

As the OWRB works to establish a tentative maximum annual yield for the aquifer, the study shows landowners leasing or pumping groundwater for other than domestic use will be forced to reduce the amount of water pumped per acre in order to protect streams and springs in the area.

"The outcome of this study confirms what many of us already knew," Amy Ford of Durant and president of Citizens for the Protection of the Arbuckle-Simpson Aquifer (CPASA) said. "Without the help of State Senators Jay Paul Gumm and Johnnie Crutchfield and Rep. Paul Roan in the House to pass Senate Bill 288, the results of over-pumping the aquifer would have been devastating to this part of the state."

Project coordinator and OWRB geologist Noel Osborn said the five-year study focused on the eastern portion of the aquifer overlaying Johnston, Pontotoc and Murray counties, and was completed at a cost of $4.2 million. It will narrow the groundwater permitting process by the OWRB to grant permits that are "not likely to degrade or interfere with springs or streams emanating from the aquifer."

Surface Water Study

During the meeting in Ada, Derek Smithee, OWRB water quality division chief, discussed the results of surface water studies relating to the protection of streams and springs.

The charge to the surface water technical advisory group was (1) to determine what is not likely to degrade or interfere with springs or streams; and, (2) determine what will not reduce the *natural* flow of water from springs or streams emanating from said basin or sub-basin.

The working group recommendation was that groundwater management should be based upon a target of 10 to 25 percent maximum reduction in base flow.

Smithee said the initial discussion of surface water considered recreation, water supply, fishing, ecological integrity, water quality, spring and stream flow.

As a part of the surface water study, the group analyzed indicators of hydrologic alteration using Blue River and Pennington Creek, and examined the least altered flow regimes, existing alterations and trends to evaluate impacts from flow alteration. As a part of the study, the group recommended continued monitoring of stream flows.

One of the questions addressed was how groundwater withdrawal affects spring-dependent fish species. For an answer, they took field measurements of the quality and quantity of fish habitat and modeled impacts of different stream flow scenarios.

The surface study focused upon four spring fish species found in Pennington Creek and Blue River: the Southern redbelly dace, the Redspot chub, the Orangethroat darter and the Least darter.

The conclusion drawn from this part of the study stated that from a technical perspective, it was generally agreed that no substantial impact would occur if the 75 percent exceedance of total stream flow were reduced between 10 and 25 percent.

The group encouraged adaptive management and a spring, stream and groundwater monitoring program to assure that these resources react as expected after implementation of the management plan. There was also some discussion about possibly establishing buffer zones or special protection areas.

In simple terms, Smithee concluded, a maximum of 25 percent reduction in base flow should result in limited impact to spring and stream habitat.

Groundwater Flow and Management Simulations

Scott Christenson with the U.S. Geological Survey discussed the hydrogeology of the aquifer, how the groundwater flow model was developed, and the results of the management simulations.

This part of the study considered the geology, the aquifer hydraulic properties (especially storage coefficient), watersheds (surface and subsurface), and recharge.

To simulate groundwater flow, the study used a computer program known as MODFLOW and developed a model based upon the eastern portion of the Arbuckle-Simpson aquifer overlaying northern Johnston and southern Pontotoc counties and the eastern part of Murray County.

By using the MODFLOW model, the group created simulations of distributed groundwater withdrawals (pumpage); simulated the effects of groundwater withdrawals on streams and springs; and, compared distributed groundwater withdrawals to concentrated groundwater withdrawals.

Storage Capacity

Christenson noted that aquifer hydraulic (storage) properties are related to the geology found in the aquifer. As an example, he used a diagram showing an aquifer with permeable material compared to a rock-based aquifer with fractures for storage areas (such as the Arbuckle-Simpson).

Of particular interest to the study was the storage coefficient of an aquifer, demonstrated by the amount of water taken from the aquifer and its effect on the aquifer's water table.

Christenson displayed a graph that took one cubic foot of aquifer material and showed the amount of water that it held. For an Alluvial aquifer, the storage coefficient was set at 0.2. By comparison, for the Arbuckle-Simpson the storage coefficient was a mere 0.008. While the model showed an Alluvial aquifer would produce 1.5 gallons of water per cubic foot, the Arbuckle-Simpson would only produce one cup (8 ounces) of water per cubic foot.

Another slide showed that for an Alluvial aquifer with a storage coefficient of 0.2, a withdraw of 1.0 foot of groundwater would produce a five feet drawdown on one cubic foot of land. For the Arbuckle-Simpson, the drawdown would be 25 times that amount, or a 125 feet drop in one cubic foot of land.

Methods used to determine storage coefficients included earth tides and the decline in water tables.

Recharge Rates

Next Christenson's presentation focused on the aquifer's recharge, or the amount of annual precipitation that actually seeps into the aquifer.

A preliminary study conducted by the USGS published in 1990 and known as Circular 91, reported the Arbuckle-Simpson aquifer had a recharge rate of 4.7 inches of water per year.

Christenson emphasized that the 4.7 inches is misleading however, as recharge varies in time and space, and urged those present at the meeting to stop thinking of recharge as a constant. In other words, the recharge varies from year to year, based upon annual rainfall amounts for various locations and watersheds over the aquifer.

He then compared surface watersheds with sub-surface watersheds (springs) and illustrated the differences between the two, and also how the recharge for Blue River, Pennington Creek and Honey Creek varied during the study period (2004-2008) based upon average precipitation.

For example, during the dry year of 2006 when only 20.94 inches of rain was recorded for this area, the recharge rates for the eastern part of the aquifer totaled just over two inches per year.

During an unusual wet year in 2007, however, when 56.11 inches was recorded, the recharge rate for the eastern part of the aquifer climbed to approximately 12 inches.

The recharge rate calculated for the entire eastern Arbuckle-Simpson Aquifer based upon a five-year average was set at 5.58 inches per year, up from the Circular 91 estimate of 4.7 inches.

Groundwater Flow Models and Flow Paths

From there, Christenson discussed groundwater flow models and why they are used in a study such as this one of the Arbuckle-Simpson.

A calibrated groundwater-flow model enables users to test the effects of different management options on a hydrologic system, including the effects of groundwater withdrawals on stream discharge.

Data used in the groundwater flow model included geology and a hydrogeologic model; hydraulic properties (hydraulic conductivity and storage coefficient); fluxes (stream flow, recharge and water use); and head observations.

The model was calibrated to match observations made during the study (head and stream flow).

The model results showed the observed water table compared to the computerized water table, and the monthly observed stream flow on Blue River near Connerville and Pennington Creek near Reagan compared to a monthly computerized stream flow for those same locations.

In illustrating the flow paths of groundwater through the aquifer using MODPATH flow path simulation, Christenson showed that groundwater movement may or may not stay within the drainage basin in which it is absorbed. The simulation showed that much of the groundwater for Travertine Creek near Sulphur, for example, actually comes out of the Blue River drainage basin in northern Johnston and southern Pontotoc counties.

Impact of Withdrawals from the Aquifer

Next Christenson looked at the hydrologic effects of hypothetical distributed withdrawals. The simulations tested by the model kept the withdrawals less than the Circular 91 recharge (4.7 inches/year or 0.392 acre-feet per year), and used the recharge distribution (not rate) for 2004-2008, with the withdrawals simulated as an equal proportionate share.

The model results assume the aquifer is completely developed at some future time; in other words, the model assumes 100 percent of the equal proportionate share is being pumped.

Christenson then showed various graphs calculating the stream flow of Blue River near Connerville during the study period based on groundwater withdrawals distributed as an equal proportionate share.

In what was perhaps the most revealing part of the presentation, Christianson showed a graph illustrating the amount stream flow for Blue River near Connerville would be reduced by varying amounts using distributed withdrawals (spread out over the aquifer) and maximum annual yields of 0.125, 0.250 and 0.392 acre-feet per year.

While the graph shows as the amount of water pumped increases, the stream flow decreases, it also reveals that when the maximum annual yield is set at 0.392 acre feet (the aquifer's original recharge rate and far below the 2.00 acre feet allowed before the study) there were periods during the study when Blue River would have ceased to flow near Connerville.

Another graph showed both Pennington Creek and Blue River ceasing to flow in all but their southern most regions using the 0.392 maximum annual yield figure.

Using another comparison, Christenson showed the amount of acre-feet per year that could be withdrawn from the aquifer resulting in a 25 percent decrease of base flow (groundwater discharge) and total stream flow (runoff+baseflow) for Pennington Creek and Blue River.

In that comparison, a 25 percent reduction in base flow for Blue River and Pennington Creek would occur with an equal proportionate share set just above 0.10 acre feet of water per acre per year. When looking at the total stream flow of both streams, that amount increases to between 0.15 and 0.20 per acre feet, but is still only a mere fraction of the two acre feet per acre of land rule for other aquifers in the state that do not have a hydrological study completed. The amount of groundwater that could be withdrawn from the aquifer that would include a 25 percent stream reduction was estimated at approximately 30,000 acre feet per year. By comparison, the amount of water proposed to be pumped and transferred to central Oklahoma before the passage of Senate Bill 288 totaled in excess of 80,000 acre feet.

In another comparison, Christenson showed concentrated withdrawals (straw in the bucket theory) would have a significantly reduced negative impact on the average base flow of streams in the study area as opposed to (equally) distributed withdrawals.

In conclusion, Christenson said the study showed groundwater withdrawals will cause depletion of flow of the streams and springs that discharge from the aquifer. It is significant in that a scientific study of an aquifer in Oklahoma has now proven the hydrological connection between ground and surface water as asserted in SB 288.

Developing a Management Plan

Duane Smith, executive director of the OWRB, says that even though the study proves a hydrological connection between ground and surface water in Oklahoma, there are no plans to take the results forward on a statewide basis.

"We didn't have to do this study to determine a connection between groundwater and surface water," Smith said. "The only books you read that don't make that connection are our (Oklahoma's) law books.

"I'm not prepared to say at this time that there is going to be a broad, statewide implementation plan starting with the Arbuckle-Simpson aquifer."

Smith did say, however, that the results of the study would figure heavily in the OWRB setting the maximum annual yield of the Arbuckle-Simpson and developing a management use plan. Also to be considered are recommendations made by the public that can be posted on the OWRB website, *www.owrb.ok.gov*. Recommendations should be made by the end of September to be considered, he said.

Ford said CPASA looks forward to working with the OWRB to develop a management plan that protects springs and streams in the area. During a CPASA meeting in Tishomingo prior to the meeting in Ada, the citizens group drafted a set of recommendations as to how that plan might best be implemented.

"The gravity of this decision is so important," Smith said. "We have to consciously make some philosophical decisions on how we can move forward.

"What is fair?" Smith continued. "How do we balance between the environment and economic development? There is groundwater that can be pumped, otherwise, Senate Bill 288 would say water could not be pumped. When we look at landowners and tell them they have to reduce their pumpage, fairness needs to come into play.

"This is going to be a very time consuming process for us to determine the likelihood of degradation of springs and streams," Smith said. "This is not a choice of the Oklahoma Water Resources Board. We are doing what the legislature told us to do. They told us springs have a higher priority than groundwater usage. Our directions are pretty clear."

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