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Assessing groundwater availability of the Williston and Powder River structural basins, Northern Great Plains

Jennifer M. Bednar[1], Andrew J. Long[1], Joanna N. Thamke[2], Kyle W. Davis[1], Katherine R. Aurand[1], Timothy T. Bartos[2], Gary D. LeCain[3], Derek W. Ryter[4], Roy Sando[2]

[1] U.S. Geological Survey South Dakota Water Science Center, Rapid City, SD
[2] U.S. Geological Survey Wyoming-Montana Water Science Center, Helena, MT
[3] U.S. Geological Survey Office of Groundwater, Denver, CO
[4] U.S. Geological Survey Oklahoma Water Science Center, Oklahoma City, OK

Groundwater availability in the lower Tertiary, Upper Cretaceous, and glacial aquifer systems in the Williston and Powder River structural basins is currently being assessed by the U.S. Geological Survey (USGS). The Williston structural basin is located in parts of North Dakota, South Dakota, and Montana in the United States and Manitoba and Saskatchewan in Canada. The Powder River structural basin is located in parts of Montana and Wyoming. A large amount of water is needed for energy development in these basins, and the primary accessible aquifers are glacial sand and gravel aquifers and the lower Tertiary and Upper Cretaceous aquifer systems. These aquifers commonly are the shallowest, most accessible, and in some cases, provide the only potable groundwater within the Northern Great Plains aquifer system. The USGS currently is conducting a 4-year groundwater availability study of these regional aquifer systems, which will include conceptual and numerical models of groundwater flow. Both of these models include a quantification of recharge and discharge components. In addition, the numerical model will be used to assess groundwater sensitivity to water withdrawals and climatic effects.

The components of groundwater recharge consist of recharge from direct precipitation on aquifer outcrops, infiltrating streams, and excess irrigation water; components of groundwater discharge to the land surface consist of discharge to streams and well withdrawals. Recharge from direct precipitation was estimated by using a soil-water balance model, with additional estimates from the water-table fluctuation and chloride mass-balance methods. The interaction between groundwater and surface water was quantified by analyzing streamflow records, using hydrograph separation methods, and implementing a water-budget analysis for major reservoirs in the study area. Groundwater withdrawals were quantified by analyzing Federal and State well databases and assessing previously published information. Estimated stream recharge accounts for 74% of total recharge, and direct precipitation and excess irrigation account for 23% and 3% of recharge, respectively. Discharge from groundwater is dominated by discharge to streams (96%) and well withdrawals (4%).

Locating sinkholes in LiDAR coverage of a glacio-fluvial karst, Goodhue County, Minnesota

Author: Caitlin Castner

Faculty Mentor: Calvin Alexander

Department: Earth Sciences University of Minnesota College of Science and Engineering 117 Pleasant Street SE Minneapolis, MN 55455

This project is systematically mapping karst sinkholes in Goodhue County, Minnesota. Mapping of karst features in south east and south central Minnesota is becoming more important because of land use interests and urban sprawl. Mapping karst features, such as sinkholes in Minnesota, can be used for the public good in land use planning and zoning regulations. Groundwater pollution is a major concern with sinkholes because they are direct highways to the groundwater system. LiDAR (Light Detection And Ranging) is an aerial tool that allows high-resolution imaging of small depressions in an active karst landscape. One strong advantage of LiDAR is that it can "see through" trees and vegetation and directly image the land surface. The resulting high resolution elevation and location data can be processed into various kinds of Digital Elevation Models (DEM) in a GIS (Geographic Information System) environment. The individual LiDAR pixels have dimensions of 1.5m horizontal and about 20cm vertical. I used the Hillshade function with the LiDAR DEMs to further illuminate the depressions. The smallest sinkholes visually identifiable in the Hillshade DEMs are about 5 to 7 pixels across. In Goodhue County, Minnesota 383 sinkholes had been mapped since the 1980's without aerial imaging using surface field mapping but many areas had been inaccessible for a variety of reasons. The use of LiDAR allowed a synoptic survey of the whole county in great detail. I am in the process of determining if the 383 mapped sinkholes are in the right location or it they still exist – many are known to have been filled by the land owners. LiDAR use in Goodhue County, Minnesota, has uncovered more than 700 features, although false identification does occur. Common false identifiers that appear as sinkholes are tree tip-ups, old farm foundations, cattle wallows, and slumps along hillsides. Once the features are tagged using LiDAR and GIS they will need to be reviewed and if necessary field checked to eliminate false positives.

Roads, Fish, and Peat: The Underlying Groundwater Story to Road Development in Wetland Habitats

Megan J. Haserodt, University of Wisconsin – Madison, Department of Geoscience, Madison, WI, *haserodt@wisc.edu*

Jean M. Bahr, University of Wisconsin – Madison, Department of Geoscience, Madison, WI, *jmbahr@geology.wisc.edu*

Groundwater inputs are important habitat features in streams, providing cool water during the warm summer months. Many aquatic species are sensitive to stream temperature. Salmon, like trout, have strict thermal thresholds. Well over a million salmon return to streams on the Kenai Peninsula, AK. As the human population continues to grow, so does the road network. Numerous roads now bisect wetlands. Groundwater contribution from wetlands to salmon rearing streams has been identified by local agencies as an important but poorly studied habitat feature. This study integrated physical and chemical hydrogeologic methods to study road impacts on shallow groundwater movement in a wetland and on baseflow to a stream.

Two sites, one with a road perpendicular to the stream and one with a ditched road parallel to the stream, were instrumented with water table wells, piezometers, and a stilling well. From this monitoring network regular water level measurements, field chemistry sampling, and $\delta^{18}O$ and $\delta^{2}H$ stable isotope analyses were utilized to assess hydrogeologic processes and flowpaths. Slight pooling of the water table was observed on the upgradient side of the road relative to the downgradient side. Conversely, road ditching lowered the water table and increased the temperature of the intercepted groundwater prior to stream entry. Reduced hydraulic head in streambed minipiezometers was observed at the road crossing. These field results were used to develop a conceptual model and constrain a numerical model of groundwater flow though the study section. The numerical model allowed for estimates of baseflow reduction. Together, this information will provide the basis for more general management tools for local land managers, stakeholders, and policy makers.

Evaluating aquifer flow conditions using heat as an in-well tracer

Stephen M. Sellwood, University of Wisconsin – Madison, Department of Geoscience, Madison, WI, s*ellwood@wisc.edu*

Jean M. Bahr, University of Wisconsin – Madison, Department of Geoscience, Madison, WI, *jmbahr@geology.wisc.edu*

David J. Hart, Wisconsin Geological and Natural History Survey, Madison, WI, *djhart@wisc.edu*

Understanding aquifer flow conditions, including the presence or absence of preferential flow paths or aquitards, is critical for developing accurate conceptual models and numerical simulations of groundwater supply and contaminant transport problems. Boreholes that intersect multiple formations with different heads often have ambient flow in response to the vertical gradients. Variations in ambient borehole flow direction and magnitude are caused by varying head gradients over the open well interval. Head gradients are set up by heterogeneities in the aquifer, including aquitards and preferential flow paths. As a result, borehole flow measurements are a valuable tool for assessing aquifer flow conditions and identifying heterogeneities that can significantly affect groundwater flow.

We used heat as an in-well tracer to evaluate borehole flow characteristics in four bedrock wells in south-central Wisconsin. Heat tracer tests were initiated using an electric downhole heater and monitored using a distributed temperature sensing (DTS) system. DTS measurements of borehole fluid temperature provide a record of heat movement in the well with time.

Heat tracer tests revealed a number of distinct flow regimes in the tested wells, including intervals with upward flow and others with downward flow, reflecting variations in local vertical gradients. Measured borehole flow velocities ranged from approximately 0.01 m/min to 30 m/min, and a well with no ambient vertical flow was also identified. Heat tracer testing also identified discrete preferential flow paths in some of the tested wells, while in another well changes in borehole flow appeared to reflect porous media flow. These borehole flow characteristics provide valuable information about the flow regimes in the aquifers adjacent to the boreholes, including the presence or absence of hydraulically active fractures that serve as preferential flow paths.