Title: Report on the Preliminary Investigation of Arsenic in Groundwater near Lake Geneva, Wisconsin

Project I.D.: DNR #163

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Background: This project was designed to meet the need for information about arsenic in well water in southeastern Wisconsin. In 1998, in response to elevated arsenic levels in the Wood School well (located approximately 2 miles west of Lake Geneva), WDNR personnel analyzed water from selected private and public water supply wells located near the school. Of the fifteen wells sampled, only four wells did not contain arsenic above the laboratory detection limit. The WDNR has supported significant efforts to document and investigate the causes of naturally occurring arsenic impacts to wells in the Fox River Valley, where oxidation of a sulfide-rich horizon in rock appears to contribute arsenic to well water. This preliminary study in the area of the Wood School was designed in part to compare the water quality conditions in the area to those in the Fox River Valley.

Objectives: The purpose of this preliminary investigation is to characterize the hydrogeologic and groundwater quality conditions prevalent in the vicinity of the Wood School, between the towns of Lake Geneva and Williams Bay, Wisconsin (Figure 1). The main objective of this project was to evaluate the nature and extent of arsenic in well water in this limited area. Additional objectives were to determine 1) if well chlorination was the cause of the apparent increase in arsenic levels, and if so, the duration of the effect and 2) if oxidation or reduction of arsenic-bearing sulfides is a primary cause of arsenic contamination of groundwater.

Methods: Methods include evaluation of geologic and hydrogeologic conditions using water well construction reports, geologic logs, and available rock samples from drill cuttings. Water quality samples were collected and analyzed to evaluate groundwater geochemistry of the area.

Results and Discussion: Based on the results of this study, groundwaters in all three of the aquifers (unlithified sands and gravel, shallow bedrock (Silurian), and Cambrian-Ordovician sandstones) in the study area are, to some extent, impacted by arsenic. Levels exceeding the current federal maximum contaminant limit (M.C.L.) of 50 µg/L were found only in wells that are open to the shallow bedrock aquifer. Each of the eight wells completed in shallow bedrock that were tested during this study contain arsenic. Concentrations in excess of the proposed M.C.L. of 5 µg/L were found in the unconfined sand and gravel aquifer that overlies the Silurian bedrock, and in the deep Cambrian sandstone aquifer. However, concentrations exceeding 5 µg/L do not appear to be widespread within either the sand and gravel or the deep sandstone aquifers.

Hydrogeologic conditions in the study area suggest that arsenic in groundwater in the sand and gravel and shallow bedrock aquifers do not have the same geologic source as the arsenic that occurs in the confined, deep sandstone aquifer. Examination and limited analytical testing of drill cuttings from the study area did not reveal evidence of pyrite mineralization in sediments from any of the three aquifers. Extensive mineralization has been observed within the deep sandstone aquifer in a well in Lyons, Wisconsin, located about seven miles northeast of the study area.

The water quality conditions in the study area are significantly different than those documented in the arsenic-impacted areas of the Fox River Valley. The *maximum* arsenic concentration found in the Lake Geneva area (on the order of 100 µg/L) is significantly less than the *maximum* levels present in the Fox River Valley (on the order of 1000s µg/L). In the Fox River Valley, sulfide oxidation is believed to be the cause of high (>100 µg/L) arsenic concentrations in wells, while a mechanism causing the more prevalent, lower arsenic concentrations has not yet been identified. In this study area, data show generally reducing conditions, pH range between 7 and 8, and very low sulfate, iron, and trace metal concentrations. Static and pumping water levels in wells do not cause exposure of the aquifer matrix to the air-water interface. These conditions do not support sulfide oxidation or reduction of iron- oxyhydroxides as a mechanism for arsenic release to groundwater. Transport of dissolved or colloid-associated arsenic could occur under these conditions.

The well chlorination experiment carried out in this study showed that batch chlorination causes oxidizing conditions within the borehole, but it did not trigger a subsequent increase in arsenic concentration. The experiment provides further evidence that in the Lake Geneva area, oxidation of arsenic-bearing minerals *exposed at the borehole* is not a mechanism of arsenic release to groundwater. However, the result of this chlorination experiment should not be generalized to wells in the Fox River Valley, where wells with high (>100 µg/L) arsenic concentrations are likely open to sulfide-rich horizons.

Conclusions/ Implications/Recommendations: Based on the results of this study, a public education effort in the Lake Geneva area is necessary to alert residents, well drillers, and real estate developers to the need to test for arsenic in well water. New wells drilled in the vicinity of the Wood School should be completed above, or cased through, the Silurian dolomite aquifer. This preliminary study could be followed by additional investigation to determine the source of arsenic and mechanism for its release to groundwater in the study area. Methods of investigation should include the collection of continuous samples through the sand and gravel deposits and the Silurian dolomite, subsequent characterization of the aquifer mineralogy, and leaching tests with geochemistry similar to the water quality of the study area. A well chlorination experiment should be conducted at an arsenic-impacted well in the Fox River Valley where the borehole is known to intersect the sulfide-cement horizon.

Key Words: arsenic, groundwater, Lake Geneva, chlorination

Funding: Groundwater Section, Bureau of Drinking Water and Groundwater, Wisconsin Department of Natural Resources

Final report: A final report containing more detailed information on this project is available for loan from Wisconsin's Water Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.