

**SUMMARY OF REPORT  
CITY OF MADISON WATER UTILITY  
UNIT WELL 29 MANGANESE ASSESSMENT**

**Study Objectives**

Based on the background conditions at UW 29 the following objectives were developed for this project:

1. Assess the probable source and cause of manganese and probable migration pathways to Well 29; and
2. Provide recommendations on whether manganese treatment or re-drilling UW 29 at a nearby location will provide the greater likelihood for providing a reliable source of water with acceptable manganese concentrations.

**Activities Performed**

The completed activities that were described in our scope of work for this project, including approved modifications include the following:

1. Review of UW 29 pumping and drawdown records;
2. Review of the Wellhead Protection Plan for UW 29 and other data to identify contaminant sources that have the potential to affect UW 29;
3. Review of the literature on elevated manganese in groundwater from other states;
4. Review of geologic logs, well construction report and downhole videos for UW 29;
5. Review of well construction reports for the UW 29 area;
6. Review of aquifer hydraulic parameters developed by the Wisconsin Geological and Natural History Survey, the University of Wisconsin, and other researchers;
7. Collaboration with WGNHS to select and analyze rock cuttings taken during well drilling for selected and organic parameters;
8. Groundwater flow modeling and particle tracking analysis focused on potential contaminants source areas relevant to UW 29;
9. Review of existing water quality data for UW 29;
10. Review of available water quality data for the Sycamore Landfill;
11. Collection of composite (well head) samples at UW 29, and analysis for field parameters and detailed laboratory analyses. Data collected in the field included pH, dissolved oxygen, temperature, conductivity and oxidation-reduction potential (referred to as "redox"). Laboratory analyses included major ions, total organic carbon, total dissolved

solids, redox-related water quality parameters (Mn, Fe, NO<sub>3</sub>, Nitrate-N, Total Kjeldahl-N, and ammonia-N), bromide and iodide, low level Volatile Organic Compounds, tritium, and stable isotopes of water, including hydrogen ( $\delta D$ ) and oxygen ( $\delta^{18}O$ ).

12. Collection of composite (well head) field parameters ((pH, dissolved oxygen, temperature, conductivity and redox) at UW 30 and UW 12 during normal production pumping operations;
13. Review of well construction reports and water level data for monitoring wells installed at Sycamore Landfill;
14. Coordination with the City Health Department for the removal of permanent water quality sampling pumps and temporary installation of pressure transducers at two Sycamore Landfill monitoring wells; and
15. Review and analysis of Fe and Mn groundwater concentrations at UW 29 during the well pumping for pilot testing for manganese treatment conducted by Earth Tech in January and February 2007.

## Conclusions

The primary conclusions of this study are:

1. **The water supply aquifer for UW 29 is relatively isolated from the surface.** The aquifer supplying UW 29 (the lower sandstone aquifer, below the Eau Claire Shale) appears to be isolated from near-surface conditions. The aquifer is dominated by water older than approximately 50 years, but still of meteoric (rainfall/snowmelt) origins. The water shows no contaminant or organic loading indicative of a near-surface connection. This conclusion is based on both chemical and radiological analysis of water drawn from the well, as well as the results of pump test monitoring and groundwater modeling.
2. **Continued operation of UW 29 is not likely to be affected by surficial contamination sources.** Groundwater modeling analyses indicate that it is not likely that long-term operation of UW 29 will draw water into the well from the most significant nearby source of contamination, the Sycamore Landfill. Potential unidentified surficial sources of contamination do not appear to be likely, and do not appear to pose a significant threat, due to the isolation of the surface from the aquifer supplying UW 29. However, these conclusions must be qualified in that they are based on the results and underlying accuracy of the Dane County groundwater model.
3. **Conditions allowing release of manganese into solution from naturally occurring minerals exist at UW 29, and are expected to continue in the future.** Observed pH and oxidation/reduction conditions favor dissolution of manganese dioxide, and the aquifer contains sufficient mass of manganese dioxide to allow continued dissolution far into the future. The presence of iron sulfide in the aquifer provides a mechanism for the long-term continuation of reducing conditions that will dissolve manganese. A zone of high manganese content exists in the bedrock at a depth of approximately 480 ft, near a zone of

fractures and the area of well development by blasting observed in the borehole video. This data suggests that the concentration of manganese in the well water may vary with depth in the borehole.

4. **Manganese is soluble at UW 29, UW 30 and UW 12 based on pH and redox, but concentrations are probably limited by its availability.** The rock cutting sample analyses and the composite well head pH and oxidation/reduction (Eh) data from UW 12, UW 29, and UW30 indicate that manganese is present in the aquifer bedrock, and can dissolve into the water in the aquifer. Solution of manganese into the aquifer may be limited by the isolation of manganese dioxide within the much larger mass of iron oxide that coats many of the silica sand grains of the sandstone. Elevated manganese concentrations at UW 29 suggest that near-well aquifer disturbance and variations in permeability, fractures and aquifer water chemistry may be very important in understanding the manganese levels variations from well to well.
5. **We do not have the data at this time to recommend a specific alternative location for UW 29 that will have lower manganese concentrations.** At UW 29, the water supply aquifer is isolated from the surface, and human-induced contamination impact does not control reducing conditions and hence manganese release. Aquifer geochemistry determining natural release mechanisms for the relatively low levels of manganese is complex, and we do not have data on the spatial variability of these mechanisms.
6. **A Draft Protocol for new pilot well testing has been developed based on the results of this study.** The draft recommended pilot testing protocol for new production well locations based on the observations in this project, is included in Appendix A. These recommendations could be refined in the test well /pilot well evaluation program.

## Recommendations

Based on the conclusions of this study, we recommend the following:

1. **Development of a manganese treatment design for UW 29 should proceed.** Given our conclusions on water quality at UW 29, and the goal of the end of 2008 for UW 29 to be on-line with acceptable water quality, continuing design for well head water quality treatment is appropriate.
2. **A test well sampling and analysis program should be conducted.** This study identified the possibility that near-well disturbance and variations in permeability, aquifer mineralogy and water chemistry with depth in the borehole may be very important in understanding manganese levels. However, we have not been able to sample water from individual depths of the aquifer, which has limited our ability to identify the cause of the composite manganese concentrations observed at the well head. The best way to address this data gap would be by conduct of a test well drilling and sampling program.

3. **Assessment of additional Water Utility wells based on the conclusions and recommendations of the study should continue.** This work should include collection of field parameters as well as laboratory water quality and rock cuttings analyses, and will extend our understanding of sources and causes of manganese.
4. **The Water Utility should work with City Engineering to continue monitoring the Sycamore Landfill.** Although we do not expect landfill-related effects at UW 29, periodic landfill monitoring well observations should be conducted as part of long-term operation of UW 29.