Minnesota Ground Water Association
www.mgwa.org
Newsletter

September 2008
Volume 27, Number 3

Featured:

MGWA President Stu Grubb

Inside:

President's Letter

I recently returned from a vacation to Yellowstone National Park. This was the classic road trip where we put the kids and the tent in the family car and headed west. The picture at left was taken at one of the many sulphurous, boiling springs in the area.

The last time I visited Yellowstone was when my parents put me in the back of the car and drove west, complaining continually about having to pay thirty-five cents per gallon for gasoline. Back then, my parental tour guides and I had little understanding of geology and ground water. So on this trip, I saw Yellowstone in a different light. I made sure that my kids knew about all the incredible geologic features we were seeing. They expressed their appreciation by rolling their eyes and pretending not to know me.

Yellowstone is America's ground water amusement park. For a hydrogeologist, it is one of those places you should visit before you die. The Yellowstone caldera has produced a spectacular collection of ground water features. Not just geysers shooting water hundreds of feet in the air, but also basins of boiling mud, hot springs with mineral deposits in fantastic colors, and fumaroles.

Recently, MGWA volunteers were asked to organize a ground water field trip for the Legislative and Citizens Committee on Minnesota Resources (LCCMR). A ground water field trip, especially one intended to highlight regulatory issues, is always a challenge. There just is not much to see at places with ground water

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MDH Evaluation of Point-of-Use Devices for Removal of PFCs

By the Well Management Section, Minnesota Department of Health

Figure 1: Field test station setup to allow side-by-side evaluation of point-of-use devices.

Perfluorochemicals (PFCs) are a family of organic chemicals used in products resistant to heat, oil, grease, and water, including nonstick cookware, stain- and water-resistant fabrics, fire suppression foams, film coatings, and other consumer and commercial products. PFCs were produced by the 3M Company at its Cottage Grove facility. Production wastes were disposed of at four sites in Washington County, including the Oakdale disposal site and the former Washington County Landfill.

Beginning in 2003, the initial environmental and public health investigations focused on two specific PFCs in groundwater – perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). These investigations revealed groundwater contamination of five Oakdale municipal wells and many private wells in Lake Elmo with PFOA and PFOS.

In the spring of 2006, the Minnesota Department of Health (MDH) Public Health

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Newsletter Deadlines

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MGWA NEWS

Member News

Amanda Strommer (formerly Amanda Goebel) has been promoted to Program Manager at the Washington County Department of Public Health & Environment in Stillwater. Amanda provides supervision and program direction to staff in the ground water/surface water, food/beverage/lodging, pools, manufactured home park and recreational camping area, radon, septic, and public health nuisance programs. Amanda was the coordinator of the ground water and surface water program at the county prior to being promoted to program manager.

Don Rosenberry, MGWA member who works in Denver for the U. S. Geological Survey (USGS), became a Geological Society of America (GSA) Fellow this year. The published citation reads: "Don Rosenberry's work in ground water/surface water interactions has been both innovative and influential. He has collected and interpreted some of the key data sets that have provided new understanding of the influence of ground water on ecology and water-resource management. His leadership has advanced research in the field."

Jim Stark is now Center Director for the USGS Water Science Center in Minnesota. He manages water-resources data programs and investigations for the USGS in the state in collaboration local, state and federal agencies.

Jim has also worked in Michigan and Utah. He has been the author, or co-author, of more than 60 scientific reports, abstracts, and journal articles that have primarily focused on ground water and ground-water and surface-water interactions.

Jim had been the Center's Ground Water Specialist and served as the Center's Data Chief. Jim holds MS degrees in geology, and in water resources, from the University of Wisconsin, and has an MBA from the University of St Thomas.

President's Letter, cont.

shortages and poor ground water quality. It would be a lot easier if Minnesota had streams of boiling water shooting out of the ground at regular intervals. Sure, we have a few small caves and gurgling springs, but most of the action takes place far underground and very slowly.

We all appreciate ground water as a resource for domestic, agricultural, and industrial use. But it is easy to overlook, especially compared to air, surface water, and forests. Most of the time, our interactions with ground water require extraordinary efforts, like drilling expensive wells or collecting data using sophisticated instruments. Thankfully, even I don't have to think about my own ground water resource very often. My household well is out of sight and out of mind in my front yard, and it has reliably delivered good quality water for over a decade.

Minnesota ground water tends to be a shy and unassuming resource that needs professional help to get noticed. We can help by educating people and by collecting copious amounts of data. Educational efforts such as the display at the Science Museum of Minnesota's Big Back Yard and the annual Children's Water Festival are helpful, and we should all take advantage of opportunities to talk about ground water at public meetings.

We need to encourage federal, state, and local agencies to collect ground water data on an ongoing, regular basis. We all rely on data collected over many years. When it comes time to make decisions or take action regarding a ground water issue, we usually have to rely to some extent on past measurements. Often there was no immediate or obvious need for the data at the time it was collected. We are indebted to people who had the foresight to collect and store boring logs, water levels, and chemistry data years or decades before it was put to our particular use. Will future generations thank us for our current data collection efforts, or will they disparage us for not investing enough to enable future resource management?

MGWA has planned two events that focus on data collection. In October, we will sponsor a pump test training session at the University of Minnesota field station near Hackensack. In November, the MGWA Fall Conference will highlight recent advances in data collection. The conference will feature both indoor presentations and outdoor demonstrations of equipment and techniques. I encourage everyone to attend one or both events and sharpen your data gathering skills.

Looking for a New Newsletter Editor

After over six years as your newsletter editor, it's time for me to step down and give someone else the chance to fill this position. The December issue will be my last issue as your newsletter editor. Over the past six years, we have seen the publication move to an electronic format; a change in its look, including color; the 25th Anniversary edition; and the posting of all past issues on the MGWA web site. It has been a rewarding experience and I have enjoyed working on every issue.

I would like to thank the members of the newsletter team, Jan Falteisek, Tom Clark, Kurt Schroeder, Steve Robertson, and Eric Tollefsrud, for their involvement in the publication. It is the team concept that really makes the newsletter editor position an enjoyable one. The issue editor coordinates the selected articles and is rotated among the members of the newsletter team. The layout is handled by our publisher, the Watershed Research, Inc. with Jennie Leete and Sean Hunt providing a great service to our organization through their involvement with this publication. Jim Aiken, our advertising manager, does a great job of contacting companies to advertise in the newsletter.

With so many people involved in the publication, the newsletter editor is not a position that gets overworked or burnt out. It's an opportunity to work with people from different state agencies and private companies to make a difference in communicating to our members about important ground water issues. The newsletter editor chairs the monthly newsletter team meetings and attends the MGWA Board meetings as an appointed official. If you would be interested in this position, please contact one of the MGWA Board members or a member of the newsletter team.

Norm Mofjeld, MGWA Newsletter Editor

Two MGWA Officer Positions Open for 2009

The MGWA membership needs to fill two officer positions — Treasurer and President-Elect — for 2009. The Treasurer oversees MGWA financial matters and assists with meeting planning. The President-Elect takes a leadership role in the planning of one or more of the MGWA meetings while "learning the ropes" of MGWA leadership. Here's a chance for you or someone you nominate to get in on the front end of ground water resource protection in Minnesota.

The Treasurer serves a two-year term, and the President-Elect serves a year before becoming President in 2010, followed by a year as Past-President. Send nominations by November 1 to MGWA, 4779 126th St. North, White Bear Lake, MN 55110, or send an e-mail to office@mgwa.org.

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The primary objectives of the MGWA are:

- Promote and encourage scientific and public policy aspects of ground water as an information provider;
- Protect public health and safety through continuing education for ground water professionals;
- Establish a common forum for scientists, engineers, planners, educators, attorneys, and other persons concerned with ground water;
- Educate the general public regarding ground water resources; and
- Disseminate information on ground water.

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Save the Date!

MGWA's Fall Conference Advances in Field Data Collection

November 13, 2008

Point of Use Study, cont.

Laboratory expanded their testing to include five additional PFC compounds, most notably perfluorobutanoic acid (PFBA). Further investigation through the course of 2006 and 2007 revealed widespread contamination of 50 municipal wells and over 1100 private wells with PFCs, mostly PFBA, throughout southern Washington County, including the communities of Cottage Grove, Grey Cloud Island, Lake Elmo, Newport, Oakdale, St. Paul Park, and Woodbury. The total area affected is approximately 100 square miles.

Although the PFBA levels were generally below the current Health Based Value (HBV) of seven micrograms/liter (µg/L), many residents were interested in water treatment to reduce their exposure to PFCs as much as possible. However, there was very limited information on PFOA and PFOS removal by common water treatment technologies, and virtually no information on the other PFCs, especially PFBA. In fact, the little information that was available indicated that PFBA was problematic for activated carbon (AC) filter treatment. The 2007 Legislature directed the MDH to evaluate the effectiveness of point-of-use (POU) water treatment devices in removing PFCs.

In the fall of 2007, MDH retained Water Science & Marketing, LLC (WSM) of Cedar, Minnesota, and the Water Quality Association (WQA) to conduct this study. The investigation started by surveying over 450 manufacturers of POU devices for their recommendations on devices with potential to remove PFCs. A panel consisting of representatives of MDH, WQA, WSM, and the U.S. Environmental Protection Agency selected 14 devices from those "nominated" by manufacturers for laboratory testing. The selected devices had to be rated to treat at least 500 gallons, be available to the public, and meet relevant industry standards and be certified by one or more of the organizations that certify these devices.

The 14 devices, including six AC filter devices and eight reverse osmosis (RO) devices were then tested at the Water Quality Association facility in Lisle, Illinois. Typical industry practice is for RO devices to be equipped with AC pre- and post-filters. In this first phase of laboratory testing, the AC pre-filters on the RO devices were removed in order to evaluate the performance of the RO membrane. The devices were fed three different challenge solutions, prepared by the MDH Public Health Laboratory, at concentrations meant to simulate the highest levels found in Washington County. The three solutions were:

(1) 10 micrograms/ liter (µg/L) PFBA,
(2) PFOA and PFOS at 3 µg/L each, and
(3) PFBA, PFOA, and PFOS at the concentrations noted in (1) and (2).

Of the 14 devices, one AC device and five RO devices were found to be effective for PFC removal and progressed to field testing in Washington County. Three AC devices and two RO devices went through a second round of laboratory testing to simulate conditions of more normal use patterns. Also, the AC-prefilters were now kept with the RO devices for this second round of laboratory testing. One RO device and two AC filters individually were not effective in removing PFCs and did not progress to further testing. In general, the RO devices proved to be very effective at removing PFCs in the finished water. The AC filters did remove PFCs, but PFBA tended to be problematic and was always the first PFC to break through.

The 11 devices that progressed through laboratory testing were then tested in the field during March-April 2008 at two locations – Oakdale Well #5 (with multiple PFCs present) and at St. Paul Park Well #3 (with only PFBA present). PFC concentrations at these two sites are lower than those concentrations in the laboratory challenge solutions, but are fairly representative of groundwater conditions in southern Washington County. The field test stations (see Figure 1) were designed, constructed, and installed by WSM. All RO devices proved effective at reducing PFC concentrations to below the analytical detection limit of 0.05 µg/L. One AC filter, the Kinetico MACguard, did show some PFBA breakthrough at 500 gallons of production, but below the analytical reporting limit of 0.2 µg/L. Interestingly, the Aquion Rainsoft Hydrefiner did show some PFBA breakthrough (below reporting limit) initially at one site, but then performed fine afterwards. This behavior may have been due to air entrainment, which effectively reduced the volume available for flow until the air was either dissolved or displaced. For comparison, the HBV for PFBA is 7 µg/L.

The 11 devices that were tested in the field and found to reduce PFCs to below reporting limits through 500 gallons of treated water are:

continued on next page

Amendments to the Rules Relating to Wells and Borings

Minnesota Rules, Chapter 4725

By Well Management Section, Minnesota Department of Health

The Minnesota Department of Health (MDH) has adopted amendments to the Rules Relating to Wells and Borings, Minnesota Rules, Chapter 4725, effective August 4, 2008. The rules, sometimes referred to as the "well code" establish minimum standards for the construction and sealing of water-supply wells, dewatering wells, monitoring wells, vertical heat exchangers, elevator borings, and environmental boreholes. The rules contain requirements for licensing and certification of persons who construct and seal wells and borings, and set requirements for permits and notifications. The rules also contain the minimum isolation or "setback" distances between wells and borings, and sources of contamination and utilities.

The following contains a brief summary of some rule changes.

- "Bedrock" is defined for the purposes of the rules to:
  - include specific examples, such as the St. Peter and Jordan Formations;
  - exclude Cretaceous deposits;
  - and exclude weathered portions of bedrock where 50 percent of the parent material is altered.
- "Remedial well" definition is amended to exclude trenches, sumps, or pits less than 10 feet deep.
- "Sensitive water-supply well" is defined as a well with less than 50 feet of casing that does not penetrate a confining layer (typically 10 feet of clay, silty clay or sandy clay), or multiple layers of confining materials with a total thickness of 10 feet or more.
- The definition of "potable water-supply well" is broadened to include use for drinking, cooking, bathing, processing of food, drink, or pharmaceuticals, or supplying water to plumbing fixtures accessible to humans.
- A community or noncommunity public water supply operator may disinfect their public well without having a well contractor or limited license.
- Depths on well and boring permits and records must be reported from the ground surface.
- A written agreement detailing responsibilities for the well is required when a well is drilled on property owned by someone other than the well owner.
- Interconnection of an unconsolidated aquifer and a bedrock aquifer is prohibited except for monitoring or remedial wells in some circumstances.
- The 25-foot well and boring setback to an electric line over 50kV is reduced to 10 feet; however the OSHA standard is referenced.
- The following are exempt from the utility setbacks when Occupational Safety and Health Administration requirements are followed: portable Liquid Propane tanks, low voltage electric lines, overhead electric lines when repairing or sealing that does not involve use of a drilling machine or hoist, or buried electric lines or gas pipes when repairing or sealing that does not involve excavation.
- Multiple wells or borings are not permitted in a single bore hole.
- The 30-foot minimum grouting requirement is increased to 50 feet.

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Point of Use Study, cont.

AC Devices:
Aquion Rainsoft Hydrefiner (P-12 9878)
Culligan RC-EZ-4
Kinetico MACguard 7500
Sears Kenmore (Elite 625.385010)

RO Devices:
Culligan Aqua Cleer
3M/CUNO/Water Factory SQC-3 (04-045)
EcoWater ERO-375E-CP
GE Smartwater (GXRM10GBL)
Kinetico Plus Deluxe VX
Pentair RO 3500-EX w/GS *
Watts Premier (WP-4V)

* The Pentair RO 3500-EX w/GS is also equipped with a resin filter in addition to a AC post-filter. The resin was never really challenged with PFCs because of the previous treatment train.

An AC filter device is relatively easy to install and simple to operate. Water simply flows through the activated carbon media and is dispensed for use. In the field tests, flow rates were 0.2 – 0.9 gallons per minute. Flow rates can vary depending on general water quality and usually decline gradually with use. Manufacturers typically recommend that AC filters be replaced every six months (~500 gallons of water treated).

RO devices available on the market typically include AC pre- and post-filters and may include a sediment pre-filter. Additional treatment is obviously provided because of the multiple treatment technologies, a plus when dealing with PFCs. However, RO devices are a more complicated installation, in part, because they generate a wastewater stream and the treated water must be stored for later use. Standard storage tank sizes are 1.5 – 3.0 gallons, but larger sizes may be available. In the study, the RO devices produced 10.5 – 40 gallons of water per day. The amount of wastewater generated ranged from 1.5 to 4.7 gallons per gallon of treated water.

The full report, Performance Evaluation – Removal of Perfluorochemicals with Point-of-Use (POU) Water Treatment Devices, can be found at: www.health.state.mn.us/divs/eh/wells/waterquality/poudevicefinal.pdf.

A summary is available at: www.health.state.mn.us/divs/eh/wells/waterquality/poudevicefinalsummary.pdf.

Case Study of a Salt-Contaminated Well

By James Walsh and Scott Longanecker, MDH

Reprinted from Minnesota Well Management News, Volume 23, No.1

In the spring of 2005, the Minnesota Department of Health (MDH) was notified by the owners of a residential housing development in Crow Wing County that their existing well had become contaminated with salt (sodium chloride). A water sample from the well had been taken for analysis after several complaints that the water had a salty taste. The lab analysis showed that chloride was present at a concentration of 837 milligrams per liter (mg/L), more than three times the secondary drinking water standard of 250 mg/L. (The typical background concentration of chloride in Minnesota wells is generally less than 20 mg/L.)

The contaminated well had been constructed in 1997 to a depth of 62 feet with a 10-foot well screen. The geology at the well site consists of sand from the land surface to the bottom of the well, with a static water level approximately 11 feet below the land surface (Figure 1). Possible sources of chloride contamination that were identified in the vicinity of the well included water softener discharge located approximately 35 feet from the well, a sewage lift station located approximately 60 feet from the well, buried sewer pipes located 50 feet from the well, a residential road located approximately 70 feet from the well, and a pond located 85 feet away.

The management of the housing development reported that in July of 2003 they hired a local company to install a commercial water softener. The regeneration discharge from the water softener was estimated to be 400 gallons per day at peak water demand. The regeneration discharge was piped to a French drain located 35 feet from the well.

In December 2004 residents of the development began reporting a salty taste in the drinking water. The water treatment discharge was relocated 85 feet from the well; however, the contamination continued to increase. In March 2005 an analysis of a water sample reported chloride was present at a concentration of 837 mg/L.

After going through the site inspection and plan review process, a new community well was installed in May 2005 to replace the salt-contaminated well. Considerations involved in the plan review process for the new well included: (1) constructing the well in a geologically-protected sand M below the aquifer impacted by the salt plume, and (2) placing the well a sufficient distance away and up-gradient from the plume. The direction of groundwater flow at the site is not well known, but is regionally thought to be southeasterly towards a major lake chain. In May 2005 the replacement well (Well Number 2) was completed at 85 feet deep and penetrated a clay confining unit.

A water sampling study was conducted on July 18, 2007, to assess the chloride concentration at both Well Number 1, Well Number 2, and at a pond near the location where the softener waste is currently discharged. Water samples were collected and analyzed for chloride and bromide. The ratio of chloride to bromide has been found to be useful for determining when groundwater has been impacted from anthropogenic (human or animal) activities, and even for pinpointing particular sources of salinity such as road salt, fertilizer, or wastewater (Alexander, et al., 2005). The results showed that water from Well Number 1 had a high chloride level of 1,940 mg/L and had a high chloride/bromide ratio of 29,305, which is a clear indication of contamination by sodium chloride used in water softeners or on roadways (Figure 2). Although a residential road does go through the development, it is situated to the east (downgradient) and is not heavily salted. The most likely source of contamination for Well Number 1 is the water softener effluent that was discharged near the well. This is corroborated by the sample collected from the pond which is currently receiving discharge from the softener. The chloride level in the pond was 74.3 mg/L. Bromide was not detected in the water sample from the pond. However, if one assumes that bromide is present at some minute concentration, then a minimum chloride/bromide ratio of approximately 18,575 would be indicated, which would be consistent with sodium chloride derived from

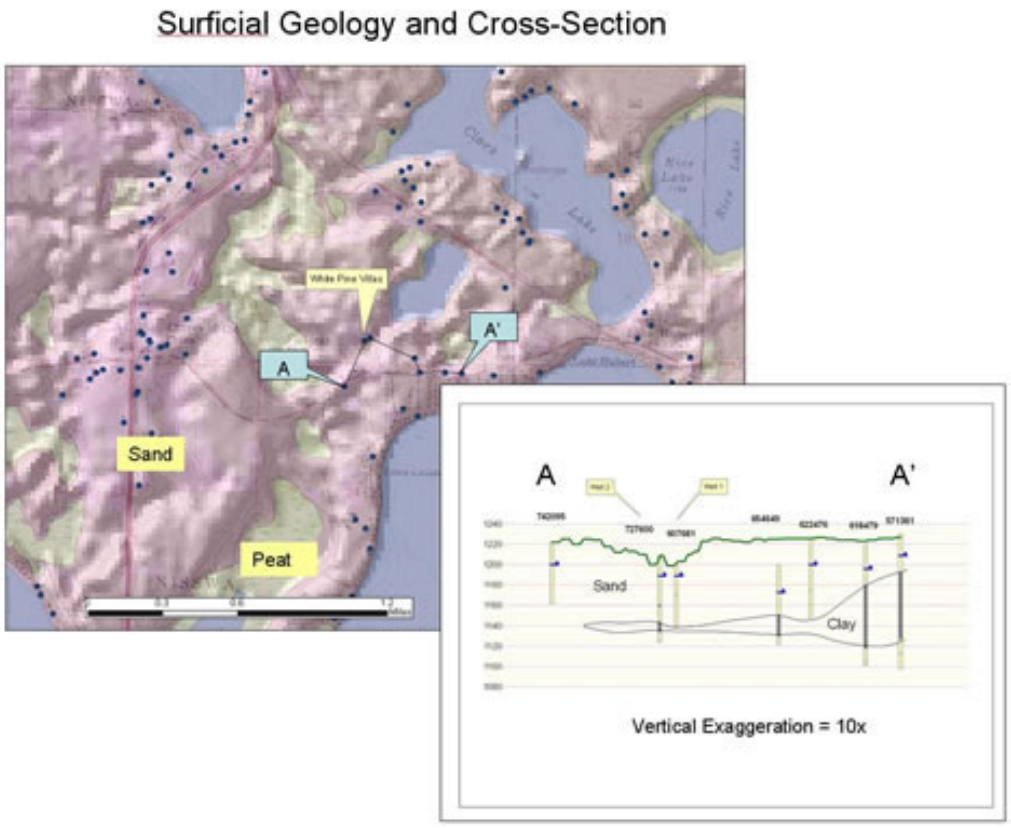

Figure 1. Surficial geology (after MGS, 2004) and geologic cross-section.

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Salt Contaminated Well, cont.

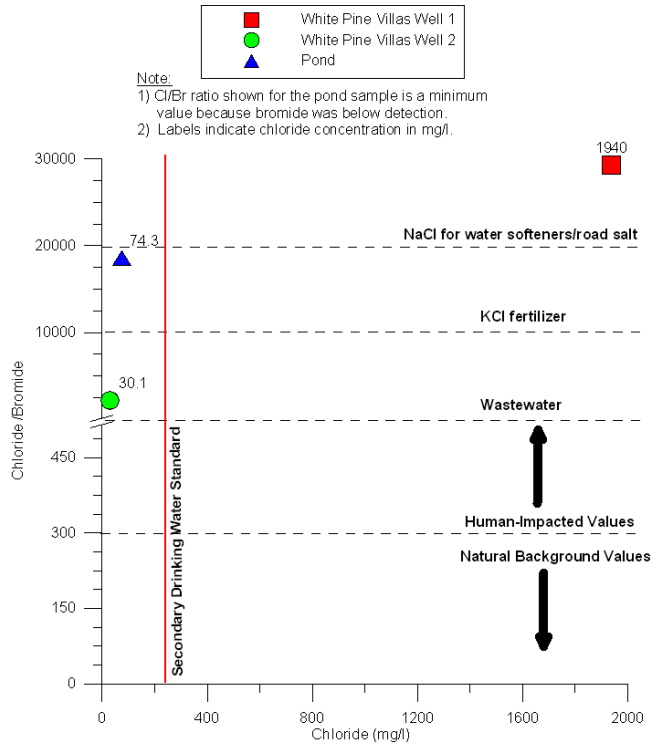

Figure 2. Chloride and bromide data.

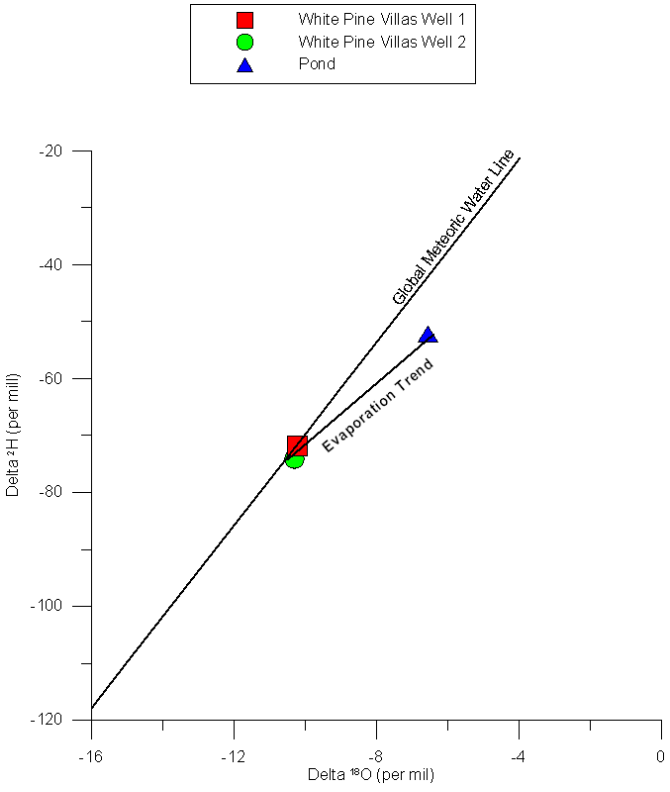

Figure 3. Stable isotope data.

the softener. Finally, Well Number 2 had a chloride value of 30 mg/L and a chloride/bromide ratio of 2,213. Although these values exceed those one would expect for pristine groundwater, the chloride value is well within drinking water standards and the ratio is significantly different than that indicated by the softener effluent. Apparently, the location and construction measures employed for Well Number 2 succeeded in avoiding the salt plume.

As a final check on whether the wells might be receiving recharge from the pond, samples from all three sources were analyzed for the stable isotopes of oxygen and hydrogen (Figure 3). The results showed that the pond water plots far off the global meteoric water line, indicating significant evaporative fractionation. Both well samples plot on the line, showing no evidence of pond water capture. Apparently, the contamination observed at Well Number 1 resulted from direct infiltration of water softener effluent into the ground.

References:

Alexander, S.C., Alexander, E.C., Jr., and Pfannkuch, H., 2005, Hydrogeology of the St. Paul Campus.

Minnesota Geological Survey, 2004, Geologic Atlas of Crow Wing County, Plate 3 - Surficial Geology.

New Rules, cont.

- Alternative welded or threaded casing connections and bolted sleeve-type (Dresser-type) couplings are allowed for sounding tubes, vents, and vacuum lines at or above the frost line.
- Borings are regulated in special well and boring construction areas, and water treatment may be required in special construction areas when necessary to ensure a safe drinking water supply.
- Well or boring treatment chemicals must meet National Sanitation Foundation Standard 60, except that chlorine may meet Federal Insecticide, Fungicide, and Rodenticide Act standards.
- Isolation or “setback” distances between a water-supply well and a source of contamination are measured horizontally from the closest part of the well to the closest part of the contamination source. The distances apply to an unused or abandoned source unless the contaminants and visibly contaminated soil are removed.
- A number of contamination source isolation distances are amended including adding a 300-foot isolation distance to: a subsurface dispersal system with a flow greater than 10,000 gallons per day; a mixed municipal solid waste landfill or dump; a permitted demolition debris landfill; a municipal or industrial rapid infiltration basin; a municipal wastewater stabilization pond with leakage of 500 gallons/acre/day or more; and a manure storage basin or lagoon that is not permitted or certified.
- Standards are established for hydrofracturing.
- A new potable water-supply well must be tested for arsenic.
- Additional requirements are added for public wells, including full-length grouting.

Additional information and copies of the amendments may be viewed on the MDH website at www.health.state.mn.us/divs/eh/wells/rules/propamend.html. For questions, please contact the Well Management Section of the MDH at (651)201-4600.

Truth or Fiction: Water restrictions can help to reduce outdoor water use

By Sara Bertelsen, Metropolitan Council

Mandatory watering restrictions can effectively shave peak water use, this we know. The effectiveness, however, of watering restrictions to reduce total outdoor water use depends on the intensity of the restrictions.

In the Twin Cities metropolitan area, residential customers use about 60 gallons of water per day outdoors during the summer months (May through September), which is about 50% of total residential summer water use. Most water supply systems are built to meet outdoor water use demands, specifically peak day demands, which means during the winter months only about half to a third of the water supply system capacity is used. While the level of outdoor water use is highly dependent on temperature and precipitation, targeting outdoor water use is the most effective way for water suppliers to reduce demand and minimize costs.

In an attempt to reduce outdoor water use, about 75% of metropolitan area communities with water supply systems have implemented mandatory year-round or summer watering restrictions, which include odd/even and time of day restrictions. About 18% of the communities implement mandatory watering restrictions only during especially dry periods. Odd/even and time of day watering restrictions are the most common outdoor water conservation programs implemented by metropolitan area communities with municipal supply systems. The odd/even watering schedule alternates between allowing odd numbered properties water one day, even numbered properties water the next and so on. Time of day watering restrictions generally prohibit outdoor watering during the peak water use period, which is generally between 10AM to 6PM. These watering restrictions have effectively reduced peak demands throughout the metropolitan area; however, there is less evidence to suggest that the watering restrictions alone have reduced total outdoor water use.

An article published in the Journal of the American Water Resources Association[1] following the 2002 drought in the Denver, Colorado area, concluded that mandatory watering restrictions can effectively reduce total outdoor water use, but that the water savings is highly dependent on the intensity of the restrictions. For instance, communities that implemented mandatory watering restrictions saw greater water savings than those with voluntary restrictions. In addition, communities that restricted water use to three-days, two-days and one-day per week saw savings of about 17, 31, and 55 per capita, respectively. The article also noted a greater likelihood of public acceptance and cooperation with the watering restrictions when the region is facing water supply limitations due to drought.

Similarly, communities in states in the South and West have found watering restrictions to be most effective when implemented along with education and water waste restrictions. Water waste is defined, generally, as any water other than natural precipitation that flows or sprays into a public right-of-way, city storm drain, or adjacent private property. If implemented together, the watering restrictions will limit the frequency residents water and prohibiting water waste may lower the amount of water residents use.

In general, restrictions such as odd/even or time of day watering restrictions can help communities reduce peak day demands. Communities, however, should consider implementing a variety of water conserving programs to reduce total outdoor use. Water suppliers should also realize that with any conservation program, it is important that they provide information to customers about the benefits of implementing any specified practice.

For more information about water conserving programs and practices please visit the Metropolitan Council's water conservation toolbox www.metrocouncil.org/environment/WaterSupply/conservationtoolbox.htm.

1 Kenney, Douglas, Roberta Klein and Martyn Clark. Use and Effectiveness of Municipal Water Restrictions During Drought in Colorado, Journal of the American Water Resources Association, 2004.

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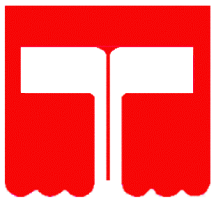

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Crow Wing County Geologic Atlas, Part B

Hydrogeology, Pollution Sensitivity, and Lake and Ground Water Interaction

By Todd Petersen, DNR Waters

Part B of the Crow Wing County Geologic Atlas is now available (Figure 1). This report, recently published by DNR Waters includes three map plates that describe the county's ground-water conditions and pollution sensitivity. Because of Crow Wing County's many lakes the report also includes a special fourth plate discussing the interaction of lakes and ground water. This report joins the previous published portion of the report, Part A, prepared by the Minnesota Geological Survey that contains six map plates describing the county's surficial and bedrock geology.

Most ground-water supplies in Crow Wing County are pumped from the surficial sand aquifer and several buried sand aquifers. More than 99 percent of wells in the county are completed in Quaternary sediments; less than 1 percent of the wells are completed in bedrock. Of the wells in Quaternary sediments, 72 percent are completed in buried sand aquifers under confined conditions, 24 percent are completed in surficial sands, and 3 percent are completed in buried sands under unconfined conditions.

Quaternary buried artesian (i.e. confined) sand aquifers are the most important ground-water source where till is at the surface. However, the buried artesian aquifers are also heavily used in areas where the surficial sand aquifer is present. Where sufficient well log data exist, the buried sand aquifers were individually mapped.

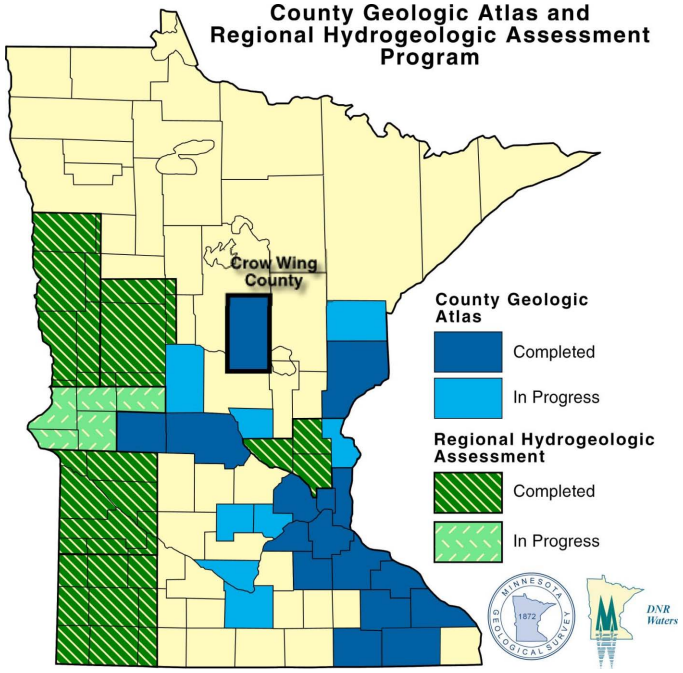

Figure 1. Location of Crow Wing County and status of County Geologic Atlas series.

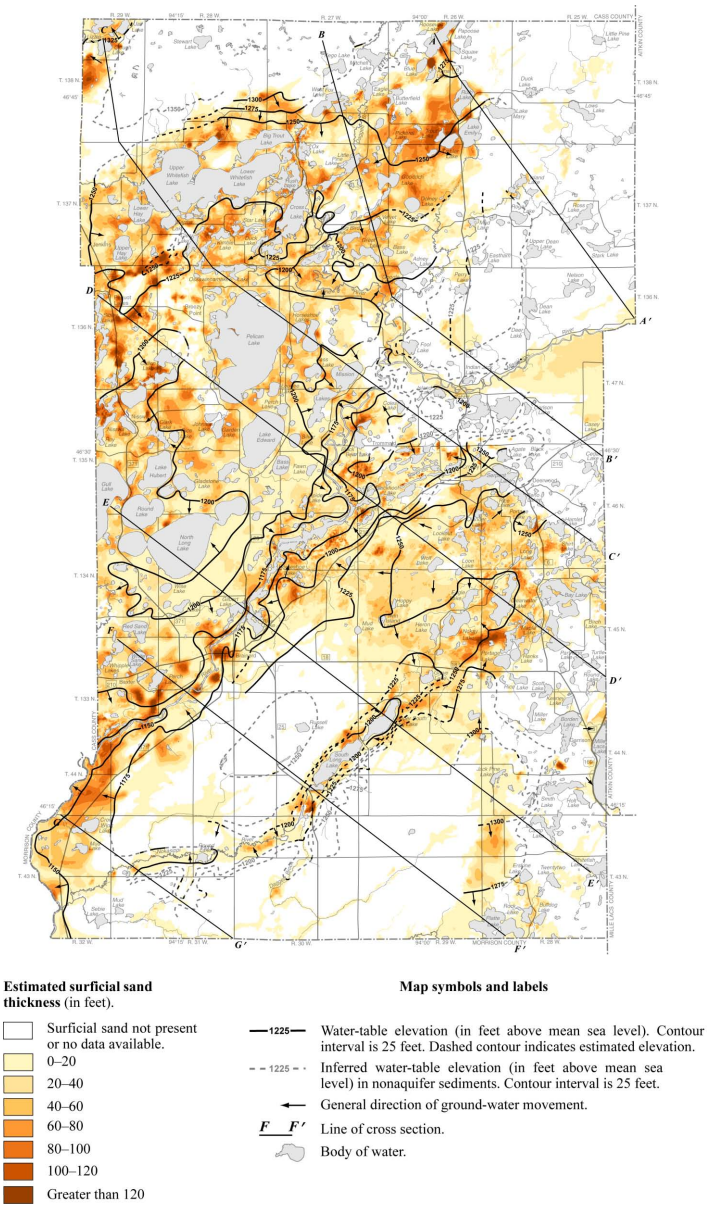

Figure 2. Surficial sand thickness and water-table elevation. Arrows show direction of ground-water flow.

Characteristics of Major Aquifers

Surficial Sand Aquifer

The surficial sand aquifer largely consists of glacial outwash, lacustrine sand from glacial lakes Brainerd and Aitkin, and terrace sediments. The thickness of surficial sand deposits, shown in Figure 2, was determined by first mapping the approximate bottom elevation of the surficial sand deposits and then subtracting this elevation from the surface elevation. The surficial sand aquifer is widely used in western and central Crow Wing County.

The water-table elevation contours indicate ground-water flow in the surficial aquifer. They are based on static water-level data from water-table wells collected by well drillers immediately

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Crow Wing County Atlas, cont.

after the wells were constructed (from data in the County Well Index) and on lake surface elevation and river elevation data (from topographic maps) in the county's three river drainages. A depth to water table map is included in Part B, but is not discussed here.

Buried Sand Aquifers

Buried sand aquifers are present throughout most of the county. The aquifers (in the upper 100 feet to 200 feet below land surface) were mapped where sufficient stratigraphic information from well records was available (Figure 3). The mapped aquifers were correlated with the surficial deposits shown on Surficial Geology, Plate 3, Part A; the correlation is shown on Figure 4. Deeper sand units are also present and form good aquifers, but the available well data were insufficient to determine their stratigraphic relationship or map their extent.

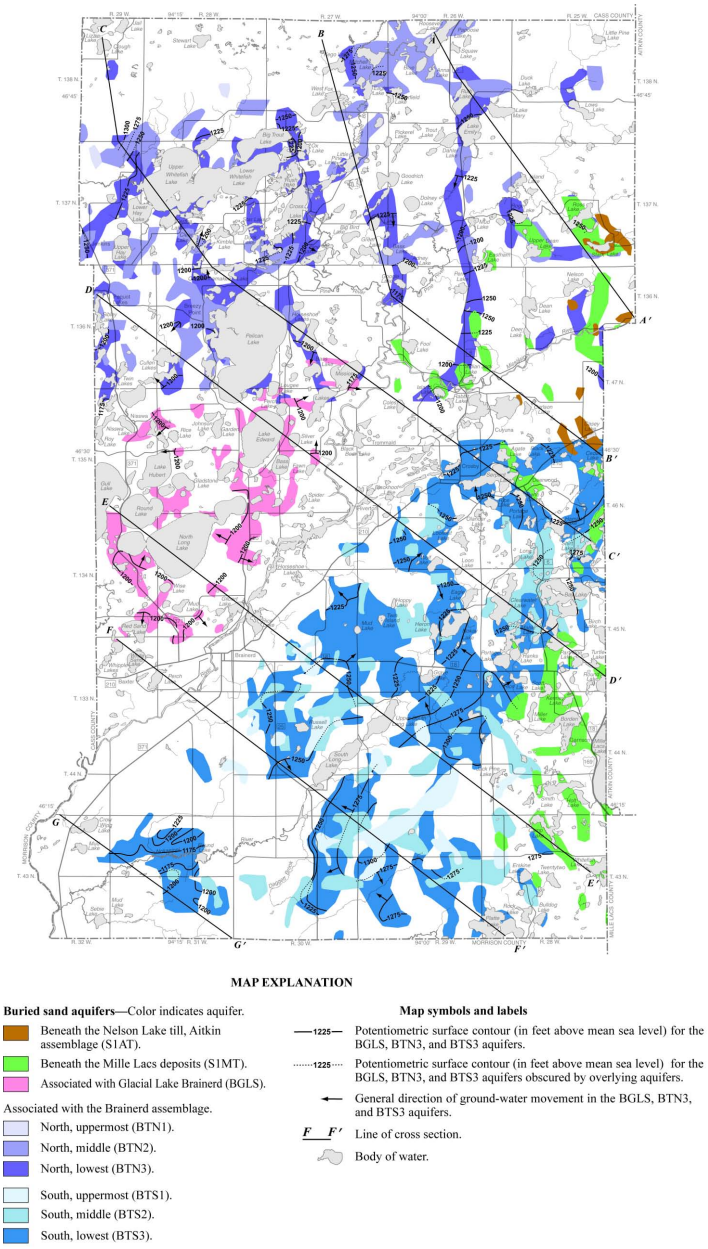

Figure 3. Extent and distribution of nine buried sand aquifers in Crow Wing County. Contours and arrows show direction of ground-water movement in the BGLS, BTN3, and BTS3 aquifers.

Hydrogeology and Ground-Water Residence Time Illustrated by Cross Sections

Two hydrogeologic cross sections from the published atlas (A-A' and C-C') show much of the hydrogeologic variation found in Crow Wing County (Figure 5; only the northwestern two-thirds of C-C' is shown). Cross section locations are shown in Figures 2 and 3.

Ground-Water Residence Time

The pink, dark pink, green, and blue areas shown on the cross sections represent the estimated age of the ground water, also known as ground-water residence time). This is the approximate time that has elapsed from the moment the water infiltrated the land surface to the time it was pumped from the aquifer. Tritium is a naturally occurring radioactive isotope of hydrogen whose presence in water samples indicates that the water has infiltrated

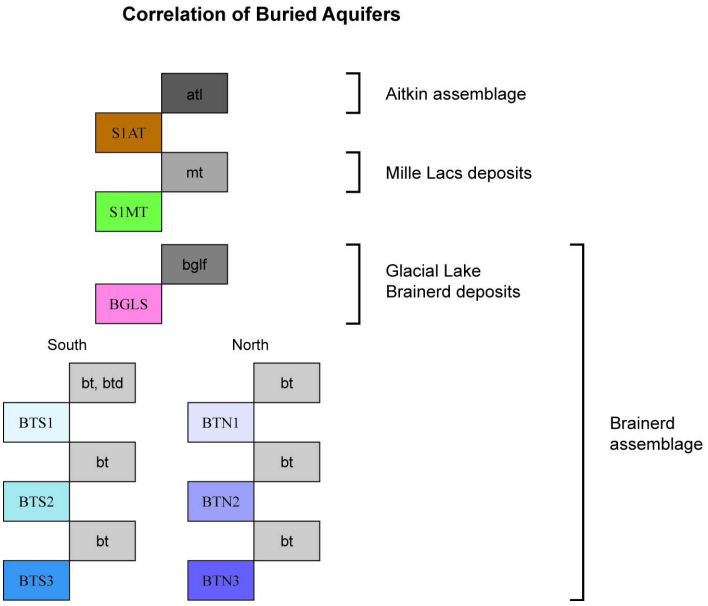

Figure 4. Correlation of buried aquifers and till units in Crow Wing County. The till units are shown in shades of gray. The aquifers are shown in color and labeled in capital letters.

the land surface within about the last 50 years. Concentrations of this isotope were greatly increased between about 1953 and 1963 by above-ground nuclear tests (Alexander and Alexander, 1989). This isotope decays at a known rate (half-life of 12.43 years). Because of this, the proportion of recently recharged water in a sample can be estimated by its tritium content.

Water samples with tritium concentrations of 10 or more tritium units (TU) are considered to be recent water, entering the ground within about the last 50 years. Water samples with tritium concentrations of 20 or more TU are a special subset of recent water that entered the ground primarily during the cold war era. During 1958–1959 and 1961–1972, the original tritium concentration was so high that, even after radioactive decay, ground water that entered the subsurface during the cold war era can still have tritium values of 20 or more TU. Ground-water samples collected for this study with 20 or more TU probably entered the ground

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Crow Wing County Atlas, cont.

during this period of atmospheric bomb testing. Water samples with tritium concentrations of 1 TU or less are classified as vintage water; the water in these samples entered the ground before approximately 1953. Water samples with tritium concentrations greater than 1 TU and less than 10 TU are considered mixed waters. They are a mixture of vintage and recent waters.

Hydrogeology Illustrated by the Cross Sections

The north end (left side) of cross-section A–A' crosses surficial outwash sand; otherwise, it mostly crosses areas with thick till at the land surface. This thick till generally protects the Brainerd assemblage sand aquifers very well. Most of the water samples from wells completed in those aquifers had no detectable tritium. Two of the samples from wells in shallower sands, which were less than 50 feet below land surface, had recent and mixed waters. One sample from a well in the BTN2 aquifer had no detectable tritium but one had 13.3 TU (recent water). The water sample collected from the S1AT aquifer immediately below the Nelson Lake till (atl) on the southeast side of the cross section had a mixed tritium value; deeper sand units had vintage water. The thick till and limited surficial sand provide better hydrogeologic protection than other areas where the surficial sand is thicker.

Cross-section C–C' starts in the Brainerd outwash sands in the northwestern corner of the county; crosses South Long Lake till (bt), more Brainerd outwash, and a small area of Glacial Lake Brainerd sand. Vintage water was found in well samples from the buried sands beneath the South Long Lake till (bt), sometimes less than 50 feet below land surface. The abrupt contact between recent and vintage waters at shallow depths indicates that in this area the shallow ground water is flowing mostly laterally and not penetrating very deeply. This suggests shallow, local flow systems where ground water and lakes are linked. The water chemistry, in particular stable isotope data, indicates a strong connection between the surface water and the ground water in the surficial aquifer. Ground-water temperature and the stable

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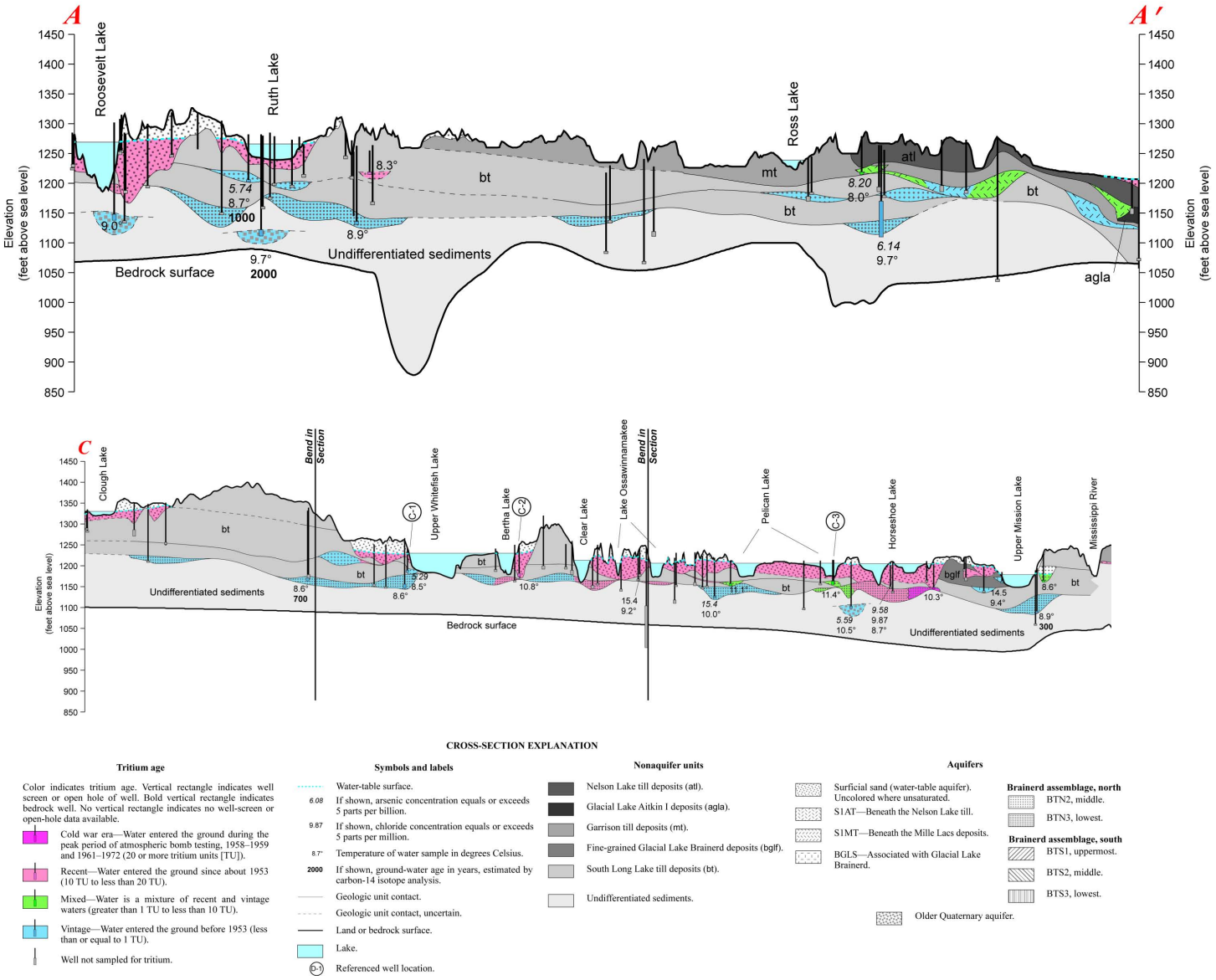

Figure 5. Selected hydrogeologic cross sections showing ground water residence time. All of cross section A-A' and the northwest two-thirds of cross section C-C' are shown. See Figures 2 and 3 for cross section location.

Crow Wing County Atlas, cont.

isotopes of oxygen and hydrogen indicate that ground water flows into some area lakes on one side and flows out the other.

Sensitivity to Pollution of the Surficial Aquifer

The surficial sand aquifer has very little protective cover and the water table is generally shallow, so sensitivity to pollution of the surficial aquifer is very high to high (Figure 6). The sensitivity model is based on the simplified surficial sediment material, as mapped in Part A. The surficial sand aquifer comprises lacustrine sand of glacial lakes Brainerd and Aitkin, outwash of the Brainerd assemblage and of the Mille Lacs deposits of the Cromwell Formation, and terrace sediments. The lacustrine sand is fine grained and has very little gravel, while the outwash and terrace sediments are coarser grained sand and gravel. The time of travel is estimated to be fairly rapid through the sand and gravel of both the outwash and the terrace sediments. Time of travel through the lacustrine sand, which is less permeable, is estimated to be longer than the time of travel through the sand and gravel. Thus, the sensitivity to pollution of the sand and gravel is estimated as very high, and the sensitivity to pollution of the lacustrine sand is estimated as high.

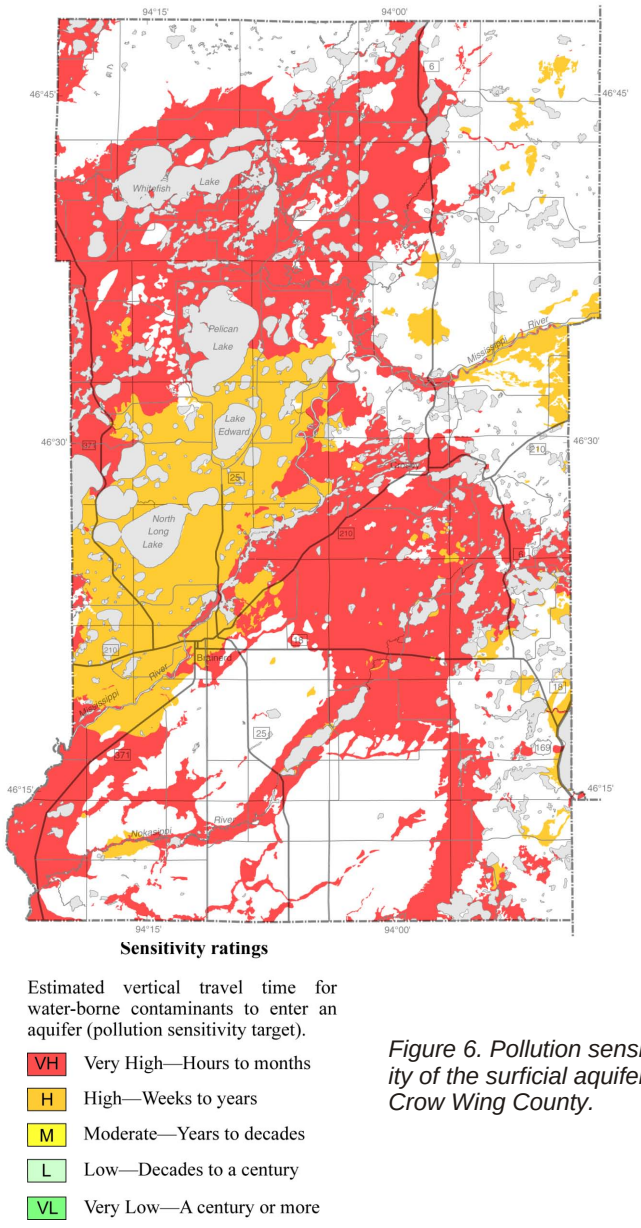

Figure 6. Pollution sensitivity of the surficial aquifer in Crow Wing County.

Sensitivity to Pollution of the Buried Aquifers

The first step in creating a sensitivity model for buried aquifers was to map the subsurface geology. A map was made of the bottom elevation and thickness of the surficial sand and then of buried sand units (aquifers). By using geographic information system (GIS) software, 30-meter grids were calculated for the base of the surficial sand and the top and bottom of buried sand units that could be mapped. The fine-grained material between the sand bodies (e.g., clay or till) is considered during mapping, but it does not have its own grid surface. The volume of sediment between the bottom of one sand body and the top of the next lower sand body is assumed to consist of fine-grained material that acts as an aquitard, restricting the ground-water movement to the sand below.

Next, creation of pollution sensitivity maps for buried aquifers was based on the method of vertical recharge surfaces of Berg (2006). Recharge surfaces were derived from the distribution and thickness of sand (and intervening low permeability) layers mapped on Figure 3. The uppermost recharge surface (RS1) starts at the land surface (Figure 7). Where surficial sand or a lake is present, RS1 extends to the base of this sand unit or lake. The assumption is that precipitation can quickly reach this shallow recharge surface.

If less than 10 feet of fine-grained sediment such as clay or till is present between RS1 and the top of a buried sand below, then the assumption is that a buried sand is probably recharged vertically from water at RS1. Thus, water will travel vertically to the bottom of this buried sand body, which is labeled recharge

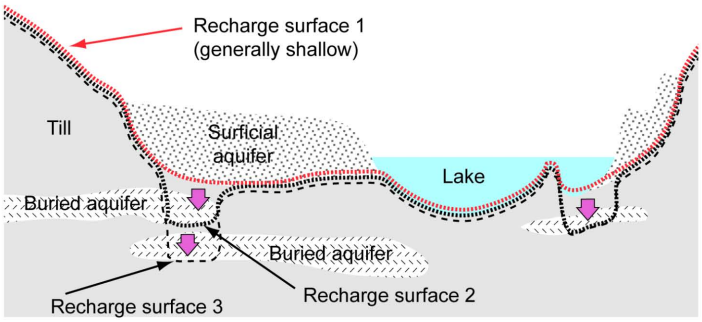

Figure 7. Generalized cross section showing recharge concepts for buried aquifers considered in the sensitivity evaluations.

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Crow Wing County Atlas, cont.

surface 2 (RS2). RS2 is the same as RS1 where more than 10 feet of fine-grained sediment exists immediately below RS1.

Deeper recharge surfaces (below RS2) are calculated similarly. If a deeper buried sand has less than 10 feet of clay between RS2 and the top of a deeper sand, then a third recharge surface (RS3) will be defined as the bottom of this sand. Horizontal movement of ground water is not accounted for in this method although it is often important. Finally, the sensitivity estimates for the buried aquifers are calculated by comparing the elevation of the upper surface of each buried aquifer with the nearest overlying recharge surface (Figure 8). The distance between the top of the aquifer and the overlying recharge surface is used to determine the sensitivity to pollution.

The sensitivity to pollution of the two lowest buried aquifers (BTN3 and BTS3) is shown in Figure 9. The aquifer has low sensitivity in areas where thick till overlies the aquifer. In the central part of the county, where the aquifer is overlain by surficial sand and very little clay till, the sensitivity to pollution is much higher. The water sample chemistry and tritium values were generally consistent with the pollution sensitivity ratings.

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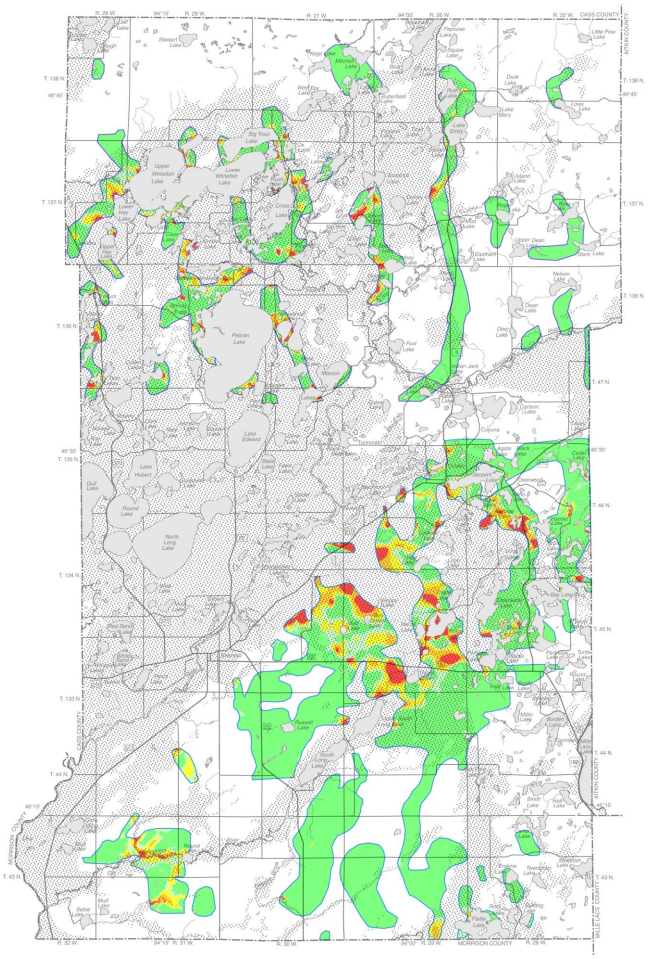
Thickness of protective layer between the aquifer and the nearest overlying recharge surface (in feet)				
0 to 10	10 to 20	20 to 30	30 to 40	Greater than 40
VH	H	M	L	VL

Figure 8. Pollution sensitivity rating matrix.



Sensitivity ratings

Estimated vertical travel time for water-borne contaminants to enter an aquifer (pollution sensitivity target).

- VH — Very High—Hours to months
- H — High—Weeks to years
- M — Moderate—Years to decades
- L — Low—Decades to a century
- VL — Very Low—A century or more

- Surficial sand aquifer.
- Body of water.

Figure 9. Pollution sensitivity of two lowest buried sand aquifers (BTN3 and BTS3).

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Crow Wing County Atlas, cont.

Interaction of Lakes and Ground Water

Geologic Settings of Lakes

Most lakes in Crow Wing County are found in distinct geologic environments (Figure 10). The number of lakes and their size and depth are a result of the geology and the topography. The geologic settings of most lakes in the county are Glacial Lake Brainerd deposits and outwash. Lakes cover about 29 percent of the surface area formerly occupied by Glacial Lake Brainerd (the highest percentage in the county) and about 27 percent of the surface area where outwash is present. In these two geologic settings, the lakes vary in size from small ponds to the largest lakes in the county (some deeper than 100 feet) and are a vital part of the landscape. Because of the low topographic gradient, generally poor surface drainage, and the coarse-grained sediments (sand or sand and gravel) that surround most lakes in this area, ground-water inflow and outflow in the lakes is a significant part of the water balance.

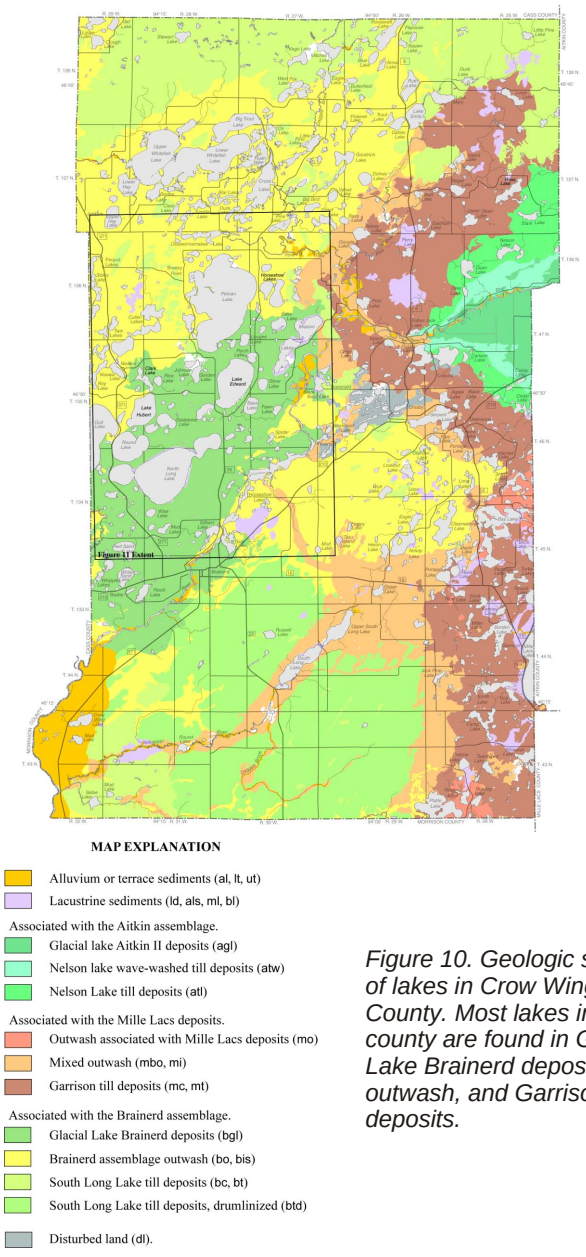

Figure 10. Geologic settings of lakes in Crow Wing County. Most lakes in the county are found in Glacial Lake Brainerd deposits, outwash, and Garrison till deposits.

The Garrison till deposits are also the geologic setting of many lakes that formed after stagnant ice blocks melted. About 24 percent of the surface area dominated by Garrison till deposits is covered by lakes. The Aitkin assemblage sediments are the geologic setting of fewer lakes than the settings previously described. The topographically high areas north of Whitefish Lake and south of the Mississippi River are mostly underlain by South Long Lake till deposits and have very few lakes.

Interaction Between Lake and Ground Water

Ground water and surface water flow directions into and out of lakes can be significantly different. Lake Hubert, in west central Crow Wing County is a good example (Figure 11). Water table elevation contours mapped from the static water level in wells and information from the stable isotopes of hydrogen and oxygen indicate that ground water flows into Lake Hubert from the east and Lake Hubert water exits to ground water to the west and south. However, surface water flows north out of Lake Hubert to Clark Lake.

For More Information

The Crow Wing County Geologic Atlas, Parts A and B can be purchased at the Minnesota Geological Survey, Publications Office, 2642 University Avenue, St. Paul, Minnesota 55114, (612) 627-4782. Portable document file (.pdf) images of the plates are available for download. Please see the DNR Waters web site at: www.dnr.state.mn.us/waters/groundwater_section/mapping/status.html for Part B access and download instructions. Data files for Part B will be posted soon. PDF images and data files for part A of the report can be downloaded from the MGS ftp site at: ftp://mgssun6.mngs.umn.edu/pub3/c-15/.

For additional information, contact Todd Petersen (651) 259-5698, Jan Falteisek (651) 259-5665, or Dale Setterholm (612) 627-4780.

References cited

Alexander, S.C., and Alexander, E.C., Jr., 1989, Residence times of Minnesota groundwaters: Minnesota Academy of Sciences Journal, v. 55, no. 1, p. 48–52.

Berg, J.A., 2006, Sensitivity to pollution of the buried aquifers [Plate 9], in Geologic Atlas of Pope County, Minnesota: St. Paul, Minnesota Department of Natural Resources County Atlas Series, C-15, Part B, Scale 1:150,000.

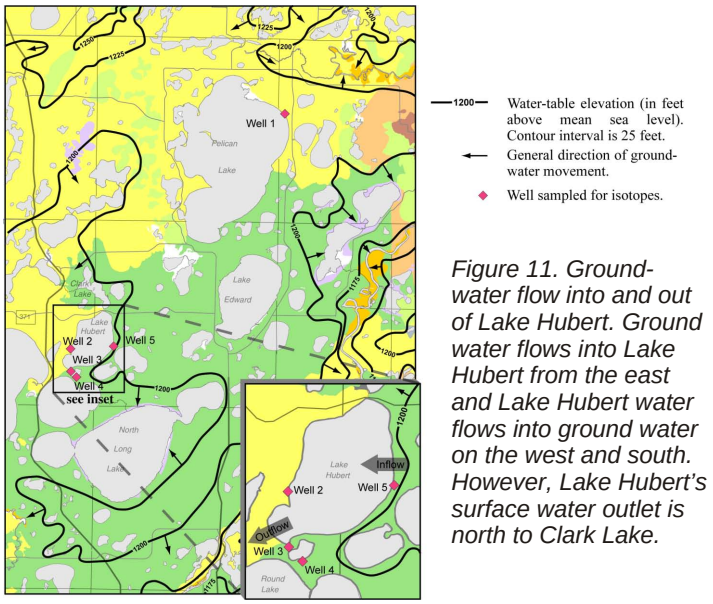

Figure 11. Ground-water flow into and out of Lake Hubert. Ground water flows into Lake Hubert from the east and Lake Hubert water flows into ground water on the west and south. However, Lake Hubert's surface water outlet is north to Clark Lake.

MPCA to Study Solid Waste Policy Changes

The Minnesota Pollution Control Agency (MPCA) received an appropriation from the general fund as a result of the 2008 legislative session to conduct several studies concerning solid waste policy, recycling and product stewardship. By January 1, 2009, the MPCA must submit a report to the legislature that recommends options for achieving the following goals by 2020:

- an increase in county recycling rates to 60 percent of the weight of total solid waste generation (currently, that figure is closer to 40 percent); and
- the diversion, prior to delivery to landfills, waste-to-energy plants, and recycling and reuse, of an amount of source-separated compostable materials equal to 15 percent of total solid waste generation.

In preparing the report, the MPCA is directed to obtain input from counties inside and outside the seven-county metropolitan area, recycling and composting facilities, waste haulers, environmental organizations and other interested parties. The MPCA has recently convened a work group to assist in this effort.

In addition, the MPCA must prepare a separate report, due December 1, 2008, analyzing the availability of collection and processing capacity in the seven-county metropolitan area for the recycling of construction and demolition waste. The report must recommend a percentage of the total weight of construction and demolition waste generated in the seven-county metropolitan area that represents an achievable but aggressive goal that can be reached in 2012 and must include an analysis of the economic and environmental costs and benefits of achieving that goal.

Finally, the MPCA must develop recommendations for establishing a comprehensive product stewardship approach to reduce environmental and health risks posed by the use or disposal of products by January 15, 2009.

Further details of these requirements are contained in Minnesota Statutes, Chapter 363, Section 3. The primary staff contact at the MPCA is Jim Chiles, 651-296-7273.

Legislative Outcomes for DNR

2008 Legislative Bonding for Ground Water Monitoring

The bonding bill passed by the 2008 Legislative session included $500,000 to DNR Waters for ground water monitoring and observation wells. The funds will allow installation of new ground water level observation wells in the metropolitan and adjoining areas and several new monitoring wells in the south central regions of the state to monitor the Mt. Simon aquifer. Priority sites in Dakota and Hennepin counties have been identified in collaboration with the Metropolitan Council. Additional priority sites have been identified in Brown and Nicollet counties. Drilling and installation of monitoring wells will begin this fall and continue into 2009.

$1.6M for South-Central MN Ground Water Project

The 2008 Legislature, as recommended by the Legislative-Citizens Commission on Minnesota Resources, has provided $1.6 million from the Environment and Natural Resource Trust Fund for a three-year ground water project in south-central Minnesota. The project provides funding to the Minnesota Geological Survey and DNR Waters for collection and interpretation of subsurface geological information and acceleration of the county geologic atlas program. Three new atlases will begin this year including Blue Earth, Nicollet, and one other to be named. The project will also investigate the physical and recharge characteristics of the Mt. Simon aquifer by installing ground water level monitoring wells in south-central Minnesota where very few wells in the Mt. Simon exist.

Clean Water, Land and Legacy Amendment Set for Vote on November Ballot

This November 4, every Minnesotan who votes has a chance to make his or her voice heard through a proposed amendment to the Minnesota Constitution. The Clean Water, Land and Legacy Amendment will be on the ballot, asking if citizens want to invest in clean water, open areas, arts and parks and trails. If you leave the question blank, it is considered a "no" vote. The specific ballot language will read as follows:

Shall the Minnesota Constitution be amended to dedicate funding

- to protect our drinking water sources;
- to protect, enhance and restore our wetlands, prairies, forests and fish, game and wildlife habitat;
- to preserve our arts and cultural heritage;
- to support our parks and trails; and
- to protect, enhance, and restore our lakes, rivers, streams and groundwater

by increasing the sales and use tax rate beginning July 1, 2009, by three-eights of one percent on taxable sales until the year 2034?

To learn more about this ballot initiative, visit: www.YesforMN.org

MDH Publishes Report on Flooded Wells in Southeast Minnesota

The Well Management Section of the Minnesota Department of Health has published the "Assessment of Chemical Contamination of Flooded Wells in Southeast Minnesota, Flooded Well Testing Project Report."

Executive Summary

Following the record flooding in southeast Minnesota in August 2007, the Minnesota Legislature appropriated funds to conduct expanded testing of flooded wells found to be contaminated with bacteria. In response, the Minnesota Department of Health (MDH), with support from the Minnesota Department of Agriculture (MDA), initiated a special project to test flooded public and private wells in seven counties (Dodge, Fillmore, Houston, Olmsted, Steele, Wabasha, and Winona) for chemical contaminants.

Eighty (80) wells were known to have been impacted by floodwater. All 65 wells that were available for testing were tested for nitrate, chloride, disinfection by-products, volatile organic chemicals (VOCs), and selected pesticides and pesticide breakdown products. Test results indicated that chemical contamination of wells that may have been due to floodwater was generally minimal and short-lived.

Twenty-one of the 65 tested wells contained nitrate at more than 1 milligram per liter (mg/L) as nitrogen. Four wells (approximately 6 percent) exceeded the state Health Risk Limit of (10 mg/L) for nitrate-nitrogen, which is consistent with statewide data on nitrate occurrence in groundwater.

Chloride, a possible indicator of road salt, animal wastes, or septic systems, exceeded 20 mg/L in ten wells. No well exceeded 250 mg/L, the aesthetic limit for chloride in drinking water.

Thirty-one of the 65 tested wells contained at least one disinfection by-product, most commonly chloroform, with 21 of these 31 wells having levels less than 1 microgram per liter (*u*g/L). The ten wells having more than 1 *u*g/L were re-sampled within six weeks, and all the follow-up samples had significantly lower levels, ranging from not detected to 7.9 *u*g/L (the Health Risk Limit for chloroform is 60 *u*g/L).

Ten of the 65 tested wells contained at least one volatile organic chemical (VOC), common components of fuels and cleaners, usually at levels less than 1 *u*g/L. Confirmation re-samples typically contained lower levels of VOCs than the initial samples.

Twenty-one of the 65 tested wells contained at least one pesticide or pesticide breakdown product, most at levels below

continued on page 17

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Report Announcements from the MGS

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Carbon Sequestration

Thorleifson, L.H., ed., 2008, Potential capacity for geologic carbon sequestration in the Midcontinent Rift System in Minnesota, Minnesota Geological Survey Open File Report OFR-08-01, 138 p.

Paleozoic stratigraphic nomenclature

Mossler, J.H., 2008, Paleozoic stratigraphic nomenclature for Minnesota: Minnesota Geological Survey Report of Investigations 65, 76 p., 1pl. Abstract follows.

Abstract

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Several significant revisions are proposed for the stratigraphic nomenclature of the Paleozoic rock formations of Minnesota. These changes reflect new information acquired from sedimentological and biostratigraphic studies conducted since this report was last published in 1987.

Biostratigraphic and sedimentological studies conducted on several Cambrian formations including the Ironton Sandstone, Galesville Sandstone, Franconia Formation, St. Lawrence Formation, and Jordan Sandstone result in the following recommendations:

1. The St. Lawrence Formation and Jordan Sandstone are no longer divided into formal members. The formations instead are informally divided into lithofacies.

2. The interbedded sandstone, sandy dolostone, and shale beds formerly assigned to the Coon Valley Member of the Jordan Sandstone are no longer included in that formation. Instead, the Coon Valley Member is classified as the basal member of the Lower Ordovician Oneota Dolomite. The heterolithic nature of interbedded siliclastics and carbonates better fits with the Prairie du Chien Group than with the siliclastic Jordan Sandstone. Additionally, the formation break now corresponds with a major unconformity, with the Coon Valley Member above it grading transitionally into overlying silty Oneota Dolomite dolostone.

3. The Ironton Sandstone and Galesville Sandstone are classified together as the Wonewoc Sandstone. Lithostratigraphic studies have shown that it is not possible to consistently distinguish the two formations, and it has never been deemed practical to map them separately in Minnesota at any scale. Use of the term Wonewoc also makes Minnesota terminology consistent with neighboring states.

4. The Franconia Formation is renamed the Tunnel City Group. The Mazomanie Member of the Franconia Formation is elevated to formation rank. The Reno, Tomah, and Birkmose Members of the Franconia Formation are grouped together in the Lone Rock Formation. A prominent carbonate unit that intertongues with the Lone Rock Formation in the subsurface of southwestern Minnesota is interpreted to be a tongue of the Davis Formation that extends into Minnesota from Iowa. This revision of nomenclature reflects outcrop and subsurface stratigraphic and sedimentological studies that demonstrate the Mazomanie Member is distinguishable from the rest of the Franconia Formation as a mappable unit. It is as distinct from other parts of the Franconia Formation as other formations historically differentiated in other parts of the Paleozoic section are from one another. The Carimona Member, formerly included in the Upper Ordovician Platteville Formation as its uppermost member, is moved into the Decorah Shale in order to place the contact between the Platteville Formation and Decorah Shale at a recognizable regional discontinuity surface rather than subjectively placing the formation contact where Carimona Member limestone beds are predominant over interbedded Decorah Shale beds. Additionally, moving the contact to the base of the Carimona Member makes the geologic contact between the Platteville Formation and Decorah Shale consistent with the way it is drawn in neighboring states. For the same reason, the Upper Ordovician Galena Group is redefined to include the Decorah Shale and the Dubuque Formation. In neighboring states, those formations are included in the Galena Group.

The Devonian Wapsipinicon Formation has been raised to group status and expanded to include the Spillville Formation. The Cedar Valley Formation has also been raised to group status and divided into three formations, the Little Cedar, Coralville, and the Lithograph City. This makes Minnesota nomenclature for the Devonian consistent with that used in Iowa. In addition, the revised nomenclature recently was applied in geologic mapping and found to be usable in southern Minnesota.

Flooded Wells Report, cont.

1.0 *u*g/L. Re-samples collected within six to eight weeks confirmed most of these initial pesticide detections at similar levels, suggesting ongoing low-level pesticide contamination of the aquifer, rather than flood impacts.

All well owners were provided copies of their test results, and given individual consultations on the meaning of the test results and any further actions that might be recommended.

The full report is available on the Minnesota Department of Health web site at www.health.state.mn.us/divs/eh/wells/waterquality/floodtestreport.pdf.

New USGS Publications

A new report, **USGS Circular 1323** titled, "Ground-Water Availability in the United States," has just been released. This report examines what is known about the Nation's ground-water availability and places the regional studies by the USGS Ground-Water Resources Program as a long-term effort to understand ground-water availability in major aquifers across the Nation. The report is written for a wide audience interested or involved in the management, protection, and sustainable use of the Nation's water resources. The report is available online at: pubs.usgs.gov/circ/1323/.

Tornes, L.H, Stark, J. R., Hoard, C. J., and Smith, E. A., **Anthropogenic Organic Compounds in Ground Water and Finished Water of Community Water Systems in the Greater Twin Cities Metropolitan Area, Minnesota and Wisconsin, 2004-05: U. S. Geological Survey Scientific Investigations Report 2007-5273**, 42p. (product of the USGS National Water Quality Assessment (NAWQA) Program). Two source-water quality assessments (SWQAs) were conducted by the NAWQA Program in unconfined parts of the glacial aquifer system and in unconfined parts of the Prairie du Chien-Jordan aquifer in the Greater Twin Cities metropolitan area of Minnesota and Wisconsin. The SWQAs consisted of evaluating the occurrence of 258 anthropogenic organic compounds (AOCs) in source water and in finished waters from larger community water-supply wells completed in these aquifers. Human-health benchmarks for these compounds (Maximum Contaminant Levels for regulated compounds or Health-Based Screening Levels for unregulated compounds, when they existed), typically were not exceeded. The hydrogeologic setting of the aquifers was important in explaining the occurrence of AOCs in community water system wells. The report is available online at: pubs.usgs.gov/sir/2007/5273/.

Healy, R. W., Winter, T. C. . LaBaugh , J. W, and Franke, O. L., **Water Budgets: Foundations for Effective Water-Resources and Environmental Management: U. S. Geological Survey Circular 1308**, 90 p. Water budgets provide a means for evaluating availability and sustainability of a water supply. An understanding of water budgets and underlying hydrologic processes provides a foundation for effective water-resource and environmental planning and management. This report provides an overview and qualitative description of water budgets as foundations for effective water-resources and environmental management of freshwater hydrologic systems. The report is available online at: pubs.er.usgs.gov/usgspubs/cir/cir1308.

Other publication of interest

Christensen, V.G. and Lee, K.E., 2008, **Effects of Agricultural Land Retirement in the Minnesota River Basin: Proceedings of the American Water Resources Specialty Conference, June 30-July 2, 2008, Myrtle Beach, South Carolina,** 6p. (Prepared in cooperation with the Minnesota Board of Water and Soil Resources and the Legislative and Citizens Committee on Minnesota Resources). The effects of agricultural land retirement on nutrient concentrations and biological conditions of three streams in the Minnesota River Basin were assessed using data collected during 2005-2007. The Chetomba Creek, West Fork Beaver Creek, and South Branch Rush River subbasins, which range in size from 52,500 to 96,031 acres, have similar geologic and hydrologic settings, but differ with respect to the amount, type, and location of retired land. Preliminary results show that nitrite plus nitrate concentrations were highest in South Branch Rush River, the subbasin with little to no land retirement, and lower in Chetomba Creek and West Fork Beaver Creek, subbasins with more riparian or upland land retirement. Fish data indicate better resource quality for the West Fork Beaver Creek than other streams likely due to a combination of factors including habitat quality, food resources, and dissolved oxygen characteristics. Index of biotic integrity (IBI) scores increased as local land retirement percentages increased. Data and analysis from this study can be used to evaluate the success of agricultural best management practices (BMPs) and land retirement programs for improving stream quality.

Environmental Quality Board Water Availability Project Update

In December 2007, the Minnesota Pollution Control Agency (MPCA) requested that the Environmental Quality Board (EQB) establish an interagency work group to consider water availability issues in Minnesota. The MPCA was seeking a broader framework in which the state might evaluate current and future water uses, especially related to the increasing demand for ground water caused by the siting of current and potential future biofuel refineries.

The EQB identified three project components:

- Take a broad look at water availability and appropriations, including but not limited to issues specific to the biofuels industry, finding a way to put consideration of proposed water uses into a broader framework and perspective;
- Consider how the state might establish protective and achievable standards to quantify and address the environmental impacts of proposed water uses; and
- Summarize the need and options for collecting additional data important to comprehensive and timely analysis of proposed water uses.

The project will attempt to answer:

- What do and don't we know about Minnesota's ground water resources?
- Can we estimate water availability in the broad sense?
- What is our water resources management strategy?
- Do we have a sustainable management strategy? What is it?
- What do we want to know from a resource management and planning perspective?
- Can we identify the data gaps and develop tools that would improve our understanding in any of the areas we would like to know more about?

The EQB has established a strong web presence for the water availability project, where it hosts information for the work group and a technical sub-group, meeting agendas and minutes, supporting documents and items for which group input is being sought, including results of several surveys that were conducted of work group members. For further details, visit:

www.eqb.state.mn.us/resource.html?Id=19502

The primary contacts for the project are Princesa VanBuren at EQB (651-201-2478) and Jeanette Leete at the Department of Natural Resources (DNR) at 651-259-5687.

The Jordan River Pipe Dream in the Red Wing Catacombs

By Greg Brick

Some years ago, the *Goodhue County Historical News* carried a brief article titled, "The Catacombs of Red Wing's Sewer System" (Anonymous, 1991). The author had explored two storm drains with outfalls (exit points) in Levee Park, along the Mississippi River, in Red Wing, Minnesota. I was able to visit the stormwater "catacombs" on several occasions in the company of a long-time Red Wing employee. Several points of ground-water interest emerged from our expeditions.

It turned out that the "catacombs" were twice as extensive as reported: there are in fact four stormwater outfalls in Levee Park. They are sumped (flooded) in spring, and the river is cold in winter, which limits when visits can comfortably take place. Most of the passages appeared to have been hand-carved in the Franconia Sandstone, which has a greenish color owing to its glauconite content, and as the tunnels are mostly unlined, bedrock is exposed in their walls. Each of the four tunnels had its own unique features.

Starting at the south end of Levee Park, near Barn Bluff, is the Bluff Street tunnel, which ran directly under the street of that name, with tributaries at East 5th and East 7th Street, where the main trunk passage ends. The storm drain, though straight overall, meanders about somewhat, giving it the appearance of a snaking cave passage, especially in the tributaries. The cave-like experience was enhanced by the abundant mineral deposits, because the walls are decorated with creamy white flowstone and the ceiling is covered with countless short soda-straw stalactites, and there are even nests of cave pearls (Figure 1). The overlying paved concrete surfaces are probably the source of the minerals in the cave formations. The tunnel acoustics are such that the dripping water mimics the sound of muffled speech, a creepy circumstance for which my friend refused to explore alone!

Figure 1. Flowstone deposits in the Bluff Street tunnel.

Most of the dry-weather flow in the Bluff Street tunnel appeared to be ground-water seepage from the exposed bedrock walls. This cold water, together with inputs of organic matter, such as leaves, makes an ideal environment for the amphipod Gammarus pseudolimnaeus, found very commonly in Minnesota springs. Also known as scuds or freshwater shrimp, these crustaceans swim on their sides. As noted by Muck & Newman (1992), this species is "restricted to springs and spring-fed waters with maximum temperatures less than 20°C." Reaching densities up to 10 individuals per square foot in the upstream tributaries of the storm drain, the scuds probably hide in crevices and under stones during peak flows to avoid getting swept away.

The Bluff Street tunnel is perhaps most unusual from a tectonic standpoint, however. Consulting Tony Runkel's (1998) bedrock map in the Goodhue County Geologic Atlas, I noticed that the Red Wing Fault crosses the tunnel along the line of US Highway 61, a point that would be easy to locate given the noisiness of the highway manholes, with all the traffic passing overhead. Would fault offset be visible in the tunnel?

The Red Wing Fault has a maximum 150 feet of vertical displacement and can be seen on the surface in the Barn Bluff outcrops (Ojakangas & Matsch, 1982). Entering the tunnel, I found that the actual location where the fault is expected was bricked over for a distance of 60 feet, perhaps because there was a zone of instability that required shoring. The bedrock on either side of the brick segment appeared different, as would be expected if there was fault offset in between. Moreover, fault breccia was visible in the bedrock walls of the tunnel just upstream from the brickwork (Figure 2).

Figure 2. Red Wing fault breccia in the Bluff Street tunnel.

The Plum Street tunnel, exiting just to the north of the Bluff Street tunnel, is by far the longest tunnel under Red Wing, and also highly decorated. It ran back under the hills behind the downtown as far as 22nd Street, a distance of one mile, with a tributary running under 12th Street another half mile. The tunnel gains a total of 175 feet of elevation along its course, and we

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ascended the Cambrian stratigraphic column as we hiked upstream, passing through the Eau Claire formation, Ironton and Galesville formations, thence into the St. Lawrence and Franconia formations. This tunnel has the deepest shafts, as well as the most frequent changes of building materials and cross-section, almost every city block, providing a lot of variety for the weary explorer. At one point, the tunnel had a mushroom-shaped cross-section. Eventually, in the uplands behind town, it ran directly under the streets as a cut-and-cover through the surficial glacial deposits. Despite our usual meteorological precautions, it began to rain during our expedition, but the ominous sound of water rushing into the tunnel alerted us to the perilous situation and we were able to exit safely (Brick, 2005).

Our next adventure under Red Wing, and our chief historical quest, involved finding the so-called Jordan River. Visible as a surface stream in the earliest landscape paintings of Red Wing, such as that by the German artist Henry Lewis, made in 1848 (Lewis, 1967), the Jordan River bisected the town but was later made to run through storm drains under the streets. A bronze historical plaque at Jordan Court, a plaza located along West 3rd Street, states in part that "the village of Chief Red Wing lay along the banks of a stream called Cold Water Creek by the local Dakota Indians of the Mdewakanton division. Fed by springs near the bluffs…Jordan Creek continues to flow under the streets and buildings of downtown Red Wing. Its course begins beyond Fifth and Plum, carries through the city hall basement area, crosses beneath Jordan Court and enters the Mississippi at Levee Park through storm sewers and general seepage." The historical marker, which I photographed, included a map of the stream (Figure 3). The Goodhue County Historical Society, with its impressive museum, had a file of old newspaper clippings on the Jordan River, which provided additional information. But we began our quest with the persistent local rumor that the Jordan River could be seen in the basement of a certain building in Red Wing.

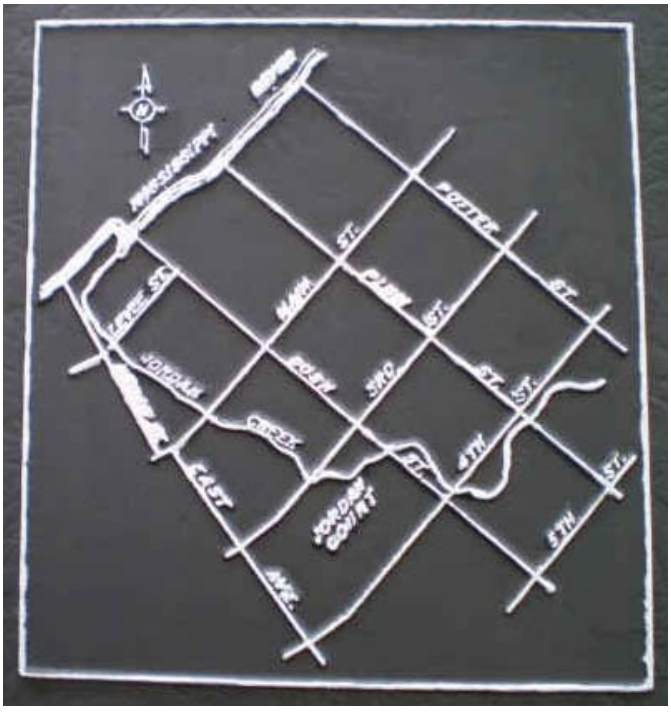

Figure3. Map of the Jordan River before it flowed through storm drains.

This building, which we soon identified, had many different tenants over the years, but at the time of our visit in 2006 it was the Cornerstone Community Church (420 West 3rd Street). The owner kindly allowed us to visit the "Jordan River" in the church basement, which you could supposedly see by looking down a "well" in the floor. I confess I was not very impressed, as it appeared to be merely a somewhat unusual basement floor drain (Figure 4).

Figure 4. Basement floor drain, a supposed window into the Jordan River.

But it was indisputable that the building had been originally constructed in a ravine, as I could tell by examining the underground parking ramp behind the storefront church. Finding a manhole at the low point of the parking lot, I figured that this would reveal the "true" Jordan River, if anywhere. I peered down the shaft but was disappointed to see that it was dry at the bottom and did not lead to further passages that appeared humanly enterable.

We next attempted to trace the Jordan River from its downstream end. Going back to Levee Park, we followed the Bush Street tunnel, which ran in the direction of the Cornerstone Church. Hiking upstream, we found this greensand tunnel to be the roomiest yet, up to 8 feet in diameter, but it was devoid of cave formations. The left fork of the tunnel changed to a reinforced concrete pipe (RCP) at West 3rd Street. In the block running under Bush Street between West 3rd and West 4th Street, near City Hall, we encountered a row of gushing tunnel springs. Here, the tunnel lining had been pierced by dozens of one-inch diameter drill holes, apparently to allow ground water to drain into the tunnel, and some of the holes were coated with black manganese deposits. The word "sample" had been spray painted on the wall at several places, but whether a concrete sample or a ground water sample

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was intended, was not clear. This whole area of gushing tunnel springs could possibly be considered the headwaters of the Jordan River, judging from the bronze map, or at least as close as we cared to get, considering how fast the RCP was telescoping downwards as we advanced upstream. Springs like this led to the piping out of large voids under Red Wing buildings years ago (Ladd, 1966).

The right fork of the Bush Street tunnel, on the other hand, was much smaller and ran under East Avenue. This fork came closest to where the Cornerstone Church was located and seemed to embrace the former middle reaches of the Jordan River. The stooping-height passage hunkered down to a wet crawlway before dead ending at a brick wall. Painfully cold water boiled up through a gravel deposit at this point—another tunnel spring. At no point were we able to look up into the church basement, however.

Just for the sake of completeness, the northernmost outfall in Levee Park is the discharge point for the Broad Street tunnel, a low, boring stoopway lined with masonry throughout, no bedrock being visible along its course. The only fun thing about it was the acoustics, the whole tunnel reverberating with church bells on a regular basis, because the tunnel ended at West 3rd Street, where another church was located. It must be the world's largest "pipe" organ!

Acknowledgement

Thanks to Tony Runkel for reading over a previous draft of this article. Any misinterpretations are my own fault!

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53rd Annual Midwest Ground Water Conference, *Grand River Center Dubuque, Iowa.* Abstracts due June 6, 2008.
Website: www.igwa.org

October 3-5, 2008

MGWA 2008 Field Trip Minnesota Ground Water Association will sponsor a Field Trip focused on aquifer testing techniques. Accommodations and meals will be provided at the Deep Portage Conservation Reserve near Hackensack, MN. Contact Scott Alexander alexa017@umn.edu

October 22-23, 2008

"Water then and now" 2008 Eastern South Dakota Water Conference,Swiftel Center, Brookings, SD, Information: wri.sdstate.edu/esdwc

October 27-28, 2008

2008 Minnesota Water Resources Conference
Rivercentre, St. Paul. Information is posted at: wrc.umn.edu/waterconf/index.html

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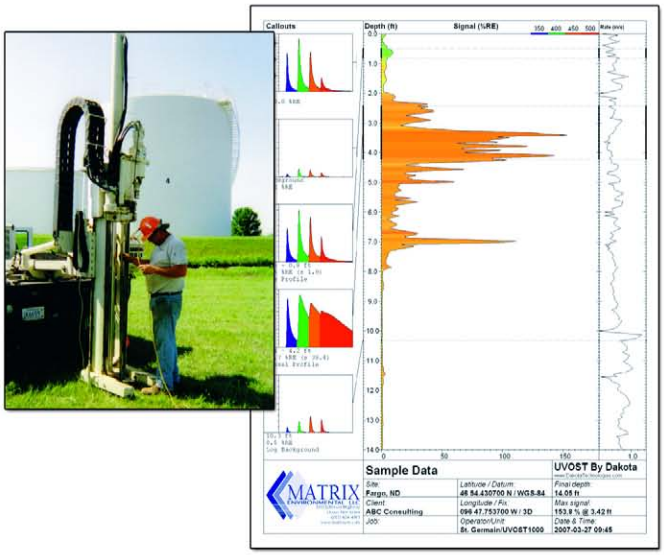

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Guidelines for Submission of Newsletter Articles

The newsletter team appreciates the efforts of article contributors, without whom our newsletter would not be possible. To make the process easier on the author, the newsletter team and production staff, we have established some guidelines we would like authors to follow. For a complete list of guidelines, please see the MGWA web site:

- Submittals should be complete and ready for publication.
- The text of the article should be submitted as a Microsoft Word document in an attachment to an e-mail or on disk.
- Tables, captions, figures and graphics should be submitted as separate high quality files.
- A version of the article with embedded tables, figures, and graphics may be submitted as an additional file to indicate the preferred layout of the tables, figures and graphics within the article.
- The contributor should include the contributor's name and affiliation following "By" below the title of the article.
- The contributor should secure permission to print or reprint if applicable and provide the required text to be included with the article.
- Materials should be submitted before the deadline.
- If there is any question about the suitability of a proposed article's content for the MGWA newsletter, it is advisable for the contributor to call the editor before investing significant time in article preparation.

Have an idea for an article?
Contact the editor at editor@mgwa.org

MGWA 2008 Newsletter Advertising Policy

Advertising Rates to Increase in MGWA Newsletter

The MGWA Board has voted to increase advertising rates for display ads in the MGWA Newsletter beginning with the March 2008 issue. The increase is due to increasing costs for the production and publication of the newsletter. The new rates are for four issues and will be as indicated below. Advertisers provide significant support in the publication of this newsletter. With their support we are able to produce a higher quality newsletter of which we can all be proud. The MGWA Board has also voted to increase advertising rates in the MGWA Directory as indicated below.

Display ads:

Size	Inches Horiz. x Vert.	Quarterly Newsletter 4 issues	Membership Directory 2 issues
Business Card	3.5 x 2.3 or 1.9 x 3.5	$100	$50
Quarter Page	3.5 x 4.8 or 5.4 x 3.5	$150	$100
Half Page	7.5 x 4.8	$250	$200
Full Page	7.5 x 9.75	$500	$400
Inside Cover	7.5 x 9.75	not available	$500

Many thanks for the support of MGWA newsletter advertisers

There are no commissions on ads. Advertising copy must be received by the publication deadlines as published in the newsletter. Advertisers should submit material as a digital file in TIFF, GIF, JPEG or PCX format at 300 to 600 dpi.

Please make checks payable to "Minnesota Ground Water Association" or "MGWA." Direct your orders and questions concerning advertising rates to Jim Aiken, Advertising Manager, c/o MGWA, 4779 126th Street, White Bear Lake MN 55110-5910; (952)832-2740; jaiken@barr.com. The complete advertising policy is available on the MGWA web site at www.mgwa.org/newsletter/adrates.html.
Questions concerning advertising policy should be directed to the MGWA President.

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MGWA Foundation Grant Request Deadlines are quarterly:
March 1
June 1
September 1
December 1

MGWA FOUNDATION NEWS

Minnesota Ground Water Association Foundation Board Meeting Minutes

Meeting Date: Tuesday, June 10, 2008
Location: USGS Office, 2289 Woodale Dr., Mounds View
From: Cathy Villas-Horns (Secretary)
Attending: Gilbert Gabanski, Amanda Goebel, Jeff Stoner, Chris Elvrum, David Liverseed and Cathy Villas-Horns, Board Members, Sean Hunt and Jeanette Leete, MGWA Management Staff
Minutes: The meeting minutes for the March 11, 2008 meeting were unanimously approved on March 26, 2008 and provided via e-mail to the MGWAF Board and the MGWA Newsletter staff.
Treasurer's Report: Foundation balance to date is $79,589.21. There were no credits for the period from 3/11/08 to 6/3/08. Interest in the amount of $940.36 was accrued in this period and was swept into the endowment, which now totals over $70,000. Debits were $2,100 for this period.
No new certificates of deposit will be needed until May of 2009.
Old Business: Science Museum of Minnesota (SMM) Big Backyard (BBY) – The Ground Water Display is now open for the 2008 season. The acknowledgement panel should be on display next week. Gil will request that the SMM website contain a link to the Ground Water Display. Gil already requested that all upcoming publications advertising the BBY also mention the Ground Water Display as a feature of the BBY. Cathy will draft an article on the Ground Water Display for possible inclusion in a National Ground Water Association publication.
MGWA Board Meeting report – Jeff stated that the fall 2008 MGWA conference will have a field focus and will be held on November 13. The fall field trip will be in September or October at Deep Portage.
Bylaws of the MGWAF – Chris moved that the revised MGWAF Bylaws be approved. David seconded the motion. Motion passed.
New Business: MGWA website server – Sean reported that the new system provides more space, that MGWAF board members can set up e-mail accounts and that the approved bylaws can be posted. A lot of time was spent researching and setting up the new system, but Jennie is sanguine that the results will be worth the effort. The online ordering system is still under review.
Grant requests:
1) Metro Children's Water Festival for $1,000. Discussion on high value of this event and the poignant questions raised by the 5th grade attendees. Jeff moved that the request be approved; Cathy seconded the motion. Motion passed.
2) Request by the MGWA for $1,050 for student registration fees for the fall field trip. Discussion on giving students priority over others for registration fee grant. Chris moved that the request be approved with the statement "Approve with the stipulation that students be given priority over professors." Amanda seconded the motion. Motion passed.
Legislative Citizen Commission on Minnesota Resources (LCCMR) member tour – David and Gil will be participating in the field trip for the LCCMR board on June 24, 2008.
Grant request inquiry – Jim Lundy of MDH contacted Gil about an inquiry Jim received from a Ph.D. student on the East Coast who wondered if the MGWAF would be willing to partially fund some research on radium concentrations in Minnesota's ground water. Gil responded that in general MGWAF doesn't support research, but if the person engaged some MN students in the work, that the MWGAF may be able to fund some of the work. The MGWAF will not pay for the analytical work.

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MGWA BOARD MINUTES

Minnesota Ground Water Association Board Meeting Minutes

The MGWA Board of Directors meets once a month.

All members are welcome to attend and observe.

Meeting Date May 23, 2008
Place Fresh Grounds, 1362 West 7th Street, St. Paul, Minnesota
Attending Stu Grubb, President; Scott Alexander, President Elect; Jeff Stoner, Past President; Jon Pollock, Secretary; Norm Mofjeld, Newsletter Editor

Past Minutes The April 25, 2008 minutes were approved as written.
Treasury Net income to date $27,248. MGWAF will be sent $3500.00, the net income for 2007.
Newsletter Draft of President's Letter passed out. Issues are getting longer than 20-30 pages. Can save articles that are not time dependent for future issues. Discussed listing of feature articles with newsletter notification to increase readership.
WRI Report Received draft of Newsletter from issue Editor that morning.
Old Business Legislative: Trying to set up another meeting with LCCMR. Stu is looking for ideas prior to meeting. Scott has several ideas for the meeting.
New Business Spring Conference: Evaluations indicated an overall good response to conference.
Fall Conference: Advances in Field Techniques. Conference to include outdoor demonstrations. Possibly have conference at the U of M. Could put out email to membership requesting planning help and ideas for new techniques to include. Stu will take the lead on setting the conference up.
Summer field trip: Narrowing down dates to mid September or early October for aquifer test day near Deep Portage Conservation Reserve near Hackensack. Scott and Jeff to work on this.

Meeting Date June 27, 2008
Place Fresh Grounds, 1362 West 7th Street, St. Paul, Minnesota
Attending Stu Grubb, President; Scott Alexander, President Elect; Jeff Stoner, Past President; Craig Kurtz, Treasurer; Norm Mofjeld, Newsletter Editor; Jennie Leete and Sean Hunt, WRI management team

Past Minutes The May 23, 2008 minutes were approved as modified.
Treasury On April 30, 2008, Treasurer and WRI conducted and informal audit for 2007 and placed summary-results letter into MGWA files. Treasurer reviewed 2008 fiscal books through June 27, 2008, which are summarized as gross income of $51,389.49, total expenses of $27,743.28, for net income of $23,646.21.
Newsletter Average newsletter size for past several years was 24 pages. Ads took up 5 pages in June 2008 issue. Have a number of articles for the September issue. Newsletter Editor reminded the Board that September issue commonly announces vacancies for MGWA officers and appointed officials for the following year, which will be President Elect, Treasurer, and Newsletter Editor.
Web Page New server will provide more space and improved browsing performance.
WRI Report June newsletter published via web and mail. Business journal entries made and initial tax return completed.
MGWAF Foundation approved MGWA request for supporting students to attend 2008 Field Trip attendance. College students will be given priority over college professors.
Old Business LCCMR outreach planning meeting: Participants President and President–Elect reported that a southeastern Minnesota tour is planned for October, a possible trip to peatlands areas near Nevis in August, and maybe a 1-day tour of Washington County, all of which could include discussion about ground water.
MGWA Field trip planning: Scott and Jeff will draft and short announcement for getting the word out to Members in early July.
Fall Conference Planning: Three MGWA members responded with ideas. Theme will be "recent advances in field techniques," which will complement the 2008 field trip on aquifer testing. Board and Management members volunteered to contact various MGWA Members to participate.
New Business Water Sustainability Conference: President received a call from Deb Swackhamer, acting Director of the U. of Minnesota Institute of the Environment, about MGWA interest in co-sponsoring such a conference. Board discussed value and timing and suggested that MGWA respond by encouraging such an event in late winter or coincide with MGWA Spring Conference
Spring 2008 Conference issue: President received a request to post all power points from Spring 2008 conference onto the MGWA Web site. The Board agreed to do this with a reminder that such postings are at the permission of the author and content does not necessarily express the views of the MGWA.

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Minnesota Ground Water Association Board Meeting Minutes, cont.

Meeting Date	July 22, 2008
Place	USGS 1345 Corporate Center Curve, Suite 200, Eagan, Minnesota
Attending	Stu Grubb, President; Jeff Stoner, Past President; Craig Kurtz, Treasurer; Jon Pollock, Secretary; Norm Mofjeld, Newsletter Editor; Jennie Leete and Sean Hunt, WRI management team
Past Minutes	The June 27, 2008 minutes were approved as modified.
Treasury	Taxes being completed. $29,776.18 cash on hand. $23,526.64 net income
Newsletter	Deadline for September issue is August 8. Topics for newsletter were discussed.
Web Page	Updating items after server change over.
WRI Report	Received tax extension. One new advertiser added.
MGWAF	Foundation approved MGWA request for supporting students to attend 2008 Field Trip attendance with stipulation that college students are given priority over college professors.
Old Business	LCCMR outreach planning meeting: No update over the last two weeks. Trip to peat area North of Red Lake and Walker area in August. Working on setting up stops for Red Lake and Walker areas. Ground water trip late September/early October to SE MN. No stops set yet for SE MN trip, looking at Rochester area (Decorah edge), trout streams, Washington County – stormwater management and infiltration. MGWA Field trip planning: Date set for October 3-5, 2008 (Deep Portage). Scott and Jeff will write short announcement for emailing to members. Fall Conference Planning: Stu will be working coming up with and looking for ideas for new techniques conference
New Business	None
Next Meeting	August 21, 11:30 a.m. at Fresh Grounds at 1362 West 7th Street, St. Paul, Minnesota. Meeting adjourned at 1236.

Members can access the current year's newsletters in the 'Members Only' area of the web page.

The user name is mgwa and the password is emailed to members with each announcement of newsletter availability.