Minnesota Ground Water Association

Volume 14, Number 4: December, 1995

## Twin Cities Metropolitan Area Groundwater Model

*—Andrew Streitz and John Seaberg, Minnesota Pollution Control Agency*

Staff from the Minnesota Pollution Control Agency (MPCA) have recently begun leading the development of a regional analytic element groundwater computer flow model known as the Metropolitan Area Groundwater Model (Metro Model). The Metro Model will be used along with local-scale modeling to predict groundwater contaminant movement in the seven-county Metropolitan area. The Metro Model will simulate flow through and between aquifers comprised of both glacial materials and bedrock units using the software program Multi-Layer Analytical Element Model (MLAEM). MLAEM was selected for ease of use, speed, adaptability to multiple scales, and familiarity to the metropolitan area groundwater community. This software was discussed in the December 1994 MGWA Newsletter, in conjunction with the Hennepin Conservation District's (HCD) County Model.

The Metro Model is a Legislative Commission on Minnesota Resources (LCMR) project funded by the Legislature for the 1995 - 1997 biennium. The project team is staffed with personnel from the Ground Water and Solid Waste Division of the MPCA. The team includes Ground Water Unit supervisor Don Jakes, project manager Andrew Streitz, principal modeler John Seaberg, geologic support from Markell Lanpher and Geographical Information System (GIS) support from Hsu Yuan-Ming.

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## President's Letter

This year has passed quickly. With 1996 ready to leap out at us, the MGWA is in able hands. Please remember to vote for a President Elect and a Secretary by completing the 1996 Officer Ballot enclosed with this newsletter.

Since becoming President last January, I believed it would be necessary to increase MGWA membership dues and/or conference fees to ensure a stable financial base for our organization. This belief came from the realization that 1994 MGWA income (dues, advertising revenue) covered only about two-thirds of our administrative and publishing (newsletter, directory) costs. Fortunately, MGWA's 1994 fall and spring conferences helped offset the imbalance.

This year too, the MGWA fall and spring conferences were well attended, yielding additional revenue that helped cover our expenses, even though the conference fees are set only high enough to make it likely the conference will break even. Yet our most recent financial report indicates that cash inflows are barely enough to cover our operating costs.

There appear to be two factors involved in the MGWA's negative cash flow. The first is inflationary cost increases for postage and paper. With a large portion of our revenues going into production and distribution of our quarterly newsletter and directory, these increases have had a significant effect on our expenses.

The second factor is increased administrative costs. The MGWA has long contracted Watershed Research Inc. (WRI) headed by Jeanette Leete, to publish our newsletter and directory and maintain our membership database. For the past two years, the MGWA Board has also directed WRI to computerize and maintain our financial records. This has been a very positive change for the MGWA, as our handwritten ledger system meant it required hours of labor to review cash flow and provide a financial report to the board (just ask Rita O'Connell, past treasurer and the last to go through this exercise). And with our future change in status to 501(c)(3), we need to maintain a strong financial record to ensure we are complying with the financial requirements for educational non-profit organizations. But the bottom line is that keeping these records added to our expenses.

On December 7, 1995 the MGWA Board voted to raise dues, to charge for the membership directory, and to directly ask for voluntary contributions toward our scholarships. This change will help meet our expenses and allow us to continue our programs at their current levels. As this was my last meeting as President, I'd like to say it has been a privilege to serve and work with the other board members and editorial staff. Thank you very much for the opportunity. I look forward to seeing good things happen under Gretchen Sabel's presidency.

*—Cathy O'Dell, MGWA President*

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**Metro Groundwater Model, cont.**

The University of Minnesota, Civil Engineering Department is under contract to work with the MPCA in the Metro Model's development. University personnel include Professor Otto Strack and Dr. Mark Bakker. Additionally, Wim de Lange began working on the project in October, and will continue to work in a half-time capacity through March 1996. Wim is on leave from his job in The Netherlands as project manager of a similar groundwater model developed for that country.

### Project Background

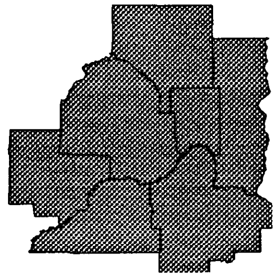
Initial planning for this project began back in 1990, during conversations between MPCA scientists and Dr. Otto Strack of the University of Minnesota about developing a state-wide groundwater simulation. By early 1991, several state agencies and some private consultants had become involved in the planning discussions. Several unsuccessful attempts at funding preceded the 1995 Legislature's decision to fund the MPCA proposal. The project principals are the MPCA and the University of Minnesota Department of Civil Engineering.

On May 9, 1995, over 40 representatives of government, industry and private consulting met with the Metro Model team to hear about the proposed project. The response was very supportive. Since that meeting many outside parties have contributed resources and time to the many technical issues addressed by this project.

The first meeting of the technical advisory work group is planned for late January 1996. Participation in the work group is open to all interested parties, though the focus will be highly technical. Expected topics of discussion: the conceptual model; database organization; spatial location standards; interaction between geographical control of data and the new graphical analytic interface; and more traditional modeling issues.

### Hydrogeologic Conceptual Model

This summary is taken from a larger, more detailed document which is available on request.



Twin Cities Seven County Metropolitan Area

The Metro Model's hydrogeologic conceptual model of the aquifer system of the Twin Cities metropolitan area was developed from information gathered in meetings held from May 22 to 26, 1995, and from assorted literature sources. In attendance were local groundwater scientists representing the public and private sectors.

Both the geologic conceptual model and the Metro Model will be in a continuous state of development, as new information from geologic sources and output from the groundwater simulation itself require a modification of our databases. The project team will apply multiple working hypotheses and maintain flexibility in the development of the conceptual and computer models in order to develop the most technically defensible interpretation and robust understanding of the groundwater system with the information at hand.

MLAEM simulates groundwater flow within aquifers as horizontal flow, and Flow between the aquifers as vertical flow through leaky layers. Modeling the groundwater flow system requires breaking it down into discrete units of aquifers and separating leaky layers. Assignment of units to either of these two categories requires that they fulfill appropriate criteria, including horizontal extent, variation in piezometric head throughout the unit's vertical extent, and the presence of hydraulic connection within the unit. Although the groundwater flow simulation in the Metro Model will focus on the seven-county Twin Cities Metropolitan area, boundary conditions outside this area that impact flow will be incorporated as well.

The first step in developing a computer groundwater flow model is to develop a conceptual model of the groundwater flow. The conceptual model is expressed as a set of assumptions, including identification of the system's geometry, boundary conditions, type of flow, composition of the system, aquifer recharge and discharge zones, and hydraulic properties of the media. These assumptions represent a simplified perception of the real system, and include only those features that are relevant to the problems being solved and that meet the objectives of the modeling effort.

The Metro Model tentatively consists of six aquifer layers and five leaky layers that separate them:

**Layer 1**: Glacial drift aquifer, optional, to be used locally where two significant glacial aquifers exist.

Leaky Layer 1-2: An optional leaky layer associated with Layer 1, representing a till with significant vertical hydraulic resistance.

**Layer 2**: Global glacial drift aquifer

Leaky Layer 2-3: Leaky layer beneath lowest glacial aquifer. Can represent glacial tills, Decorah Shale, Platteville Limestone, and the Glenwood Shale.

**Layer 3**: St. Peter Sandstone aquifer

Leaky Layer 3-4: Basal St. Peter Sandstone, a silty, hydraulically resistant layer.

**Layer 4**: Prairie du Chien/Jordan aquifer

Leaky Layer 4-5: St. Lawrence Formation and Franconia Formation

**Layer 5**: Ironton-Galesville aquifer

Leaky Layer 5-6: Eau Claire Formation

**Layer 6**: Mt. Simon-Hinckley aquifer

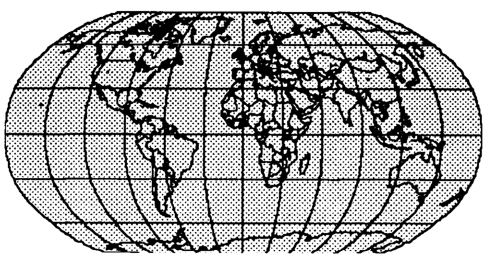
In addition to the above groupings, water can enter or leave the system through the top of the upper-most aquifer or the bottom of the lower-most aquifer.

Management of the layers through the use of aquifer inhomogeneities and reassignment of aquifers to layers could allow flexibility to model some of the lumped bedrock units as separate aquifers if there is a need to do so.

**Metro Groundwater Model, cont.**

### GIS

The Metro Model Project is using GIS for database management and manipulation of conceptual models. The project is also planning for direct data transfer from GIS to MLAEM data files. The GIS software used is ARC/INFO (version 7.0) and ARCVIEW (version 2.1). Following the lead of Dr. James Piegat at the Hennepin Conservation District and staff at the Minnesota Department of Health (MDH) working on the Hennepin County model, we are building a GIS structure based on a variety of database layers. The layers contain information on metropolitan cultural features (Topographic Integrated Geographic Encoded Records -TIGER), surface hydrography (Department of Natural Resources' National Wetland Inventory), county geologic atlases, and USGS Digital Elevation Model files.



Robinson Projection

It was very important to select an accurate map projection and coordinate system, and the project team sought broad input on this question. Essentially, this involves locating specific points in three-dimensional space and transforming them onto a two-dimensional map. Such a transformation always leads to some distortion of an earth surface feature such as area, direction, distance, or shape.

The project team has selected the Universal Transverse Mercator (UTM) projection, utilizing a combination of conic and cylindrical projections of the earth's surface. This system (in Minnesota, zone 15) places the 93 degree meridian at its center and projects coordinates 3 degrees east and west. There is no distortion of distance in the direction parallel to the meridian, and only small distortion in the east-west direction (a maximum of 0.1 percent across the state of Minnesota). Distortion from the use of UTM is less than that for other Cartesian systems such as State Plane Coordinate System or Public Land Survey. Ultimately, if the Metro Model expands to include Greater Minnesota, all model input will be stored in the spherical coordinates of latitude/longitude, and then retrieved and converted via GIS into UTM coordinates.

Databases (including hydraulic conductivities, well construction, observed heads, etc.) will be directly accessed by the team using ARCVIEW, from prepared databases layers created with ARC/INFO. Data attribute tables will be stored locally in DBF (data base) formatted files. The association between the attribute value and graphic feature will be done "on the fly" using ARCVIEW, ensuring maximum flexibility in data manipulation. For example, the team can use a stand-alone geostatistical program to analyze the data and transport the result back to ARCVIEW for display and plotting. Using this technique, many scenarios can be explored in a relative short period of time. This will greatly shorten the time necessary to refine the conceptual model.

This system will continue to be modified as connections between the new graphical version of MLAEM are joined to GIS over the next year.

### Standards

There are issues that need to be discussed by the larger modeling community during the development of the Metro Model including the possibility of:

1) designating common GIS locations for DNR-permitted high-capacity wells, major rivers, lakes, and buried river valleys;

2) recommending protocols for estimating $T_{horizontal}$ from specific capacity data, and estimating bed resis-

—*continued beneath officer listing*

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**Metro Groundwater Model, cont.**

tance in streams; and

3) setting standards for point locations, calibration factors, sensitivity analyses, and GIS file nomenclature.

Assuming that the Metro Model is successful in its goals, there are other issues that must be settled

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## 1995 MGWA- AIPG- MRGS Fall Field Trip a Big Success

The fall field trip was held September 8-9 this year and was attended by over 70. MGWA and AIPG were joined this year by the Mesabi Range Geological Society (MRGS) in sponsoring the trip, which was headquartered at the Holiday

*Part of the group views an exposure of glacial stratigraphy, north face of the Embarrass Mine*

Inn in Eveleth. The perfect fall weather added to a beautiful trip which began at the Peter Mitchell taconite mine south of Babbitt. The mine moves 40,000 tons per day (averaging 26 percent magnetic iron) and employs 120. Mark Severson of the Natural Resources Research Institute in Duluth was our guide for much of this part of the trip and we benefited from his detailed knowledge of the Virginia and Biwabik Iron Formations and the Duluth Complex.

A highlight of the stop for many included garnet hunting in the Lower Slaty Member of the Biwabik Iron Formation. Box lunches were served at the north rim of the ten- mile long pit, from which a panoramic view of active mining operations at several levels of the mine could be had. Following a stop to examine an unusual conglomerate complete with algal stromatolites which comprises part of the Upper Cherty Member of the Biwabik, it was on to an inactive mine near Embarrass for a look at the glacial stratigraphy of this part of the Iron Range. Here, J. D. Lehr of the Minerals Division of DNR gave an overview of the history of the mine site and discussed the origin of the glacial tills in the Laurentian Divide area.

Following a happy hour and hearty dinner back at the Holiday Inn, John Adams, Mining Hydrologist with DNR in Grand Rapids, gave a stimulating talk on the water balance of abandoned mine pits on the Mesabi Iron Range. His slides showed how important an understanding of the water budget of mine pits is both during operation and reclamation. Anyone wanting more information on this topic can consult John's article in the April 1994 MGWA Newsletter, which was reprinted in the field trip guidebook. After John's talk, Barry Frye gave a brief discussion on the interpretation of cores from the Tower- Soudan Mine which was to be one of the next day's field trip stops.

Saturday dawned clear and crisp as the buses departed for the DNR core storage facility in Hibbing. Here, over two million feet of cores from mineral exploration and highway and bridge construction projects are stored, representing 79 of Minnesota's 87 counties. Rick Ruhanen and his staff displayed and explained some examples of the holdings of the core library. Also under construction at the site is a demonstration project which will show how the environmental impacts of mine waste storage can be minimized.

From Hibbing, we traveled to the Tower- Soudan area and another box lunch on the scenic south shore of Lake Vermilion. From there, it was on to Soudan Underground Mine State Park and an adventurous elevator ride down to the 27th level of the old mine and a trip by electric train to the workings of the Montana ore body in the northwest part of the mine. Tours are conducted by former miners who either worked or have family who worked in the mine. The mine closed

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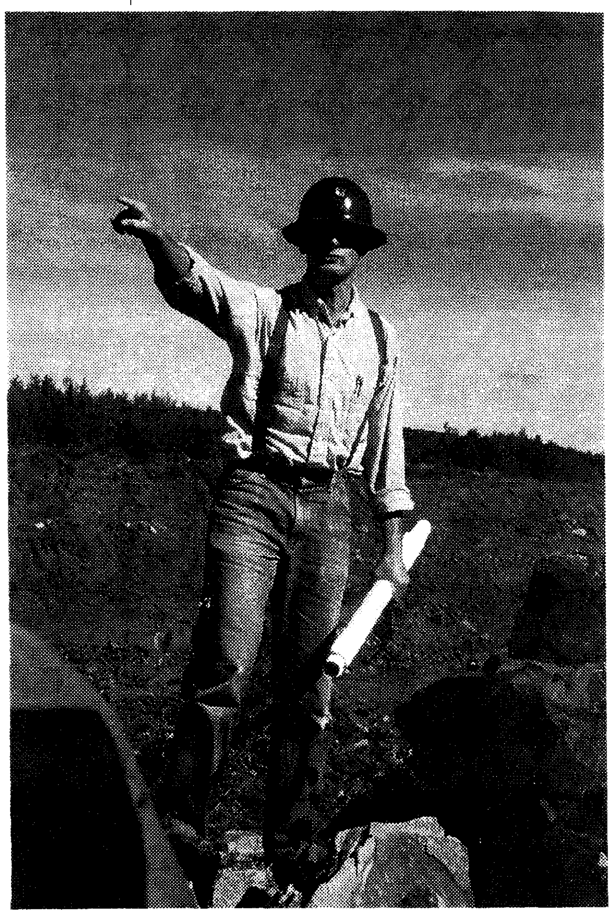

*Mark Severson of the Natural Resources Research Institute, Duluth, points out features of an outcrop of the Biwabik Iron Formation, Peter Mitchell Mine, near Babbitt* in late 1962, a victim of the new economics of ore mining afforded by taconite and open pit mines.

Thanks to the many who contributed to making this a successful trip. Once again Sean Hunt of DNR did an excellent job of capturing some of the field trip highlights on film. It was hard to choose which ones to print!

*—Tom Clark, Editor*

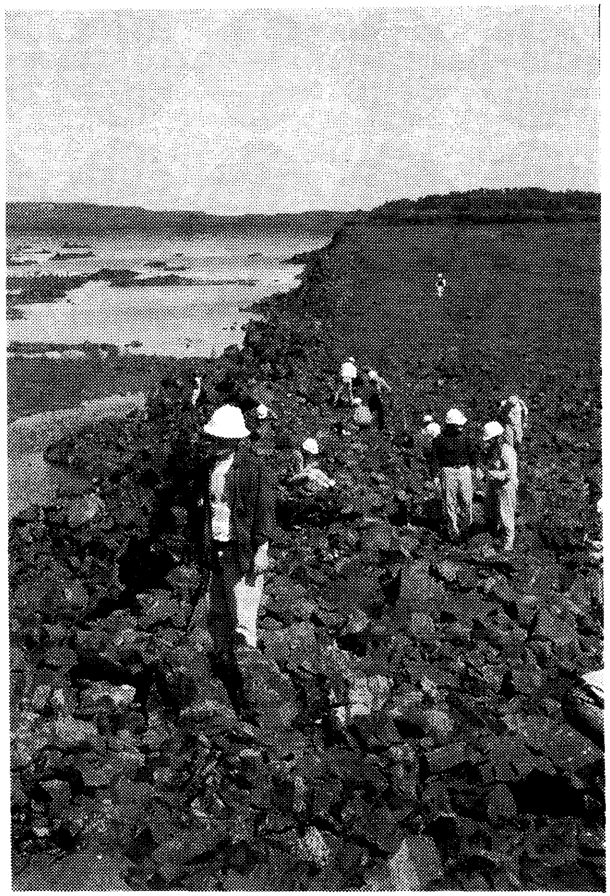

*Photo to right:*

*Hunting for garnets and other minerals, Peter Mitchell Mine*

## Carlson Appoints Two to Licensing Board

Governor Arne Carlson has appointed Jane Willard of St. Paul and Dr. James Balogh of Duluth to the two geoscientist positions created by the 1995 Legislature on the Board of Architecture, Engineering, Land Surveying, Landscape Architecture, Geoscience and Interior Design.

Ms. Willard, a 1971 graduate of Carleton College, has a Masters degree in Geology from the University of Kansas and a Masters of Science from the State University College at Buffalo. She is a consulting environmental geologist in practice in the Twin Cities for more than 15 years and has been President and Principal Geologist of EnPro Assessment Corp. for the last eight years. Ms. Willard has been active on the boards of several state and national professional societies, including a term as national president of the Association for Women Geoscientists (AWG), past president of the Minnesota Chapter of the American Institute of Professional Geologists (AIPG), and past president of the Minnesota Chapter of AWG. She is currently the AIPG representative to the national ASTM Committee E50 on commercial real estate transactions.

Dr. Balogh, a Ph.D. soil scientist in Duluth, is chief executive officer and research and development director of Spectrum Research, Inc. in Duluth, a company he has headed for more than a decade. He has worked on numerous natural resource contracts, environmental and soil impact assessments, and non-point source pollution remediation projects from Hawaii to Maine. Dr. Balogh has written a book on the environmental effects of turfgrass management and is working on another on turfgrass and water quality. He has likewise been active in several local and national professional organizations including the Soil Science Society of America (SSSA), American Society of Agronomy (ASA), and the Minnesota Association of Professional Soil Scientists (MAPSS). He sits on SSSA's Soil Competency Committee and is editor of *The Auger*, the MAPSS newsletter.

## St. Lawrence Formation Investigation

The Minnesota Department of Health (MDH) is completing the evaluation of the integrity of the St. Lawrence formation as a confining unit. Jim Walsh has had the technical lead on the study. The last rule revision, May 1993, lists the St. Lawrence formation as a confining layer. Wells through the confining layer require oversize hole, and grouting, and prohibit completion in more than one aquifer. Contractors in south central Minnesota questioned the confining character of the St. Lawrence. They were using the St. Lawrence for water supply. The other difficulty encountered was the ability to distinguish the St. Lawrence clearly from the underlying Franconia sandstone. Difficulty in identifying the St. Lawrence from the surrounding formations is not unique to that area. Similar difficulties occur in Washington County and western Hennepin County. The region is overlain by clay-rich till, so there are not many water supply alternatives.

This investigation involved sampling 13 pairs of wells (26 altogether). Jim Walsh led that effort to evaluate water chemistry, water level measurements, well construction practices, and geology (working with the Minnesota Geological Survey) to better characterize the St. Lawrence there and to see if it is in fact functioning as a confining layer. The St. Lawrence consists of two or three units The upper unit tends to be shaley. The middle unit is the more classical St. Lawrence siltstone. This lower part tends to be a mixed zone with the underlying Franconia. The Franconia is a green sandstone. Another difficulty for the drillers is rotary drilling mixes the cuttings, losing the ability to pick up some of these distinctions.

Water level measurements indicate a distinction between wells completed above and below the St. Lawrence. Water quality also shows differences across the St. Lawrence, including the presence of nitrate. All "recent" water, based on tritium analysis, is above the St. Lawrence. The St.

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# Vacuum Vaporizer Wells (UVB) Restore Ground Water at a Perchloroethylene Site in St. Louis Park

*— **James R. Lundy**, Minnesota Pollution Control Agency*

Many hydrogeologists can cite failure stories involving pump and treat (P/T) for ground water restoration. Potential drawbacks of P/T include: failure to achieve regulatory standards due to diminishing effectiveness with time; operation expense for the extended period commonly necessary to complete cleanup; diffusion limited contaminant transport; unintentional recovery of previously clean formation water, greatly increasing effluent disposal costs; limited use of naturally occurring bioremediation of volatile organic compounds (VOCs); removing large ground water volumes may constitute poor resource management.

The perceived difficulties with P/T have encouraged the development of innovative techniques, including induced ground water circulation cells. Vacuum vaporizer wells, sometimes called UVBs (or in German, *Unterdruck-Verdampfer Brunnen*; used in Germany since the mid-1980s to restore VOC contaminated ground water). This strategy, gaining acceptance in the United States, circulates contaminants to the treatment well with ground water.

This article describes the UVB/ground water circulation cell technique and presents a case study in Minnesota. The MPCA installed a UVB system in St. Louis Park just over one year ago. Data collected during the first year of operation suggest the system is effectively restoring ground water contaminated by perchloroethylene (PCE). This article highlights the UVB technique, and demonstrates MPCA is receptive to potentially beneficial innovative remedial techniques.

### *Vacuum Vaporizer Wells, or UVB*

**Well construction is unusual, consisting of two screened intervals.** Two screens of a specially constructed treatment well, one across the water table and a deeper one (within the same aquifer) to the maximum depth of ground water contamination, bracket the vertical extent of the dissolved phase plume (Figure 1; Figures are on next page). Blank casing separates the two screens. The borehole annulus is sandpacked, and bentonite placed between the two screen-ed sections blocks short-circuit flow. The airtight wellhead allows development of reduced pressure within the well casing, with appropriate connections for a blower, sampling ports, and other equipment.

**Downhole equipment: packer, stripping unit and piping.** A packer regulates water flow from lower to upper screened sections of the UVB well. The plastic stripping unit floats above the packer, attached to a drop pipe that supplies fresh air (figure 1). A second pipe delivers ground water from the lower screened section across the packer to the bottom of the air stripper.

**Effect of Operating the UVB.** Starting the blower activates the system. Because the casing is sealed except for upper screen openings above the capillary fringe, casing pressure decreases. This causes a small rise in water level near the well (figure 1), and vadose zone air enters the upper screen. This condition offers vadose zone remediation similar to results expected from a soil vapor extraction (SVE) system.

Reduced casing pressure causes fresh air intake at the wellhead (figure 1). Air descends the drop pipe, entering the submerged stripper. Inside the stripping unit, fresh air is forced against contaminated water, resulting in countercurrent air stripping. Bubbles exit the stripper, continuing to strip contaminants from water in the upper screened section, and oxygenating the water. Bubbles ascend, dragging water upwards ("airlift effect"). The bubbles burst at the water table, and the airborne contaminants are collected (e.g., across a carbon filter) or discharged to the atmosphere. The oxygenated, cleaned water moves outward from the upper screen, and into the aquifer. There is no need to pump water to the surface. Ascension of cleaned water in the upper well section causes contaminated water in the lower screened section to enter the stripper via the pipe connecting the two (figure 1).

**Development of ground water circulation cell.** Because ground water enters the UVB via the lower screened section and re-enters the formation via the upper screened section, a ground water circulation cell with a radius, S, develops in the aquifer. Herrling et al. (1991) have developed a family of curves to predict the capture zone for the circulation cell, based on the following: screen length (a); aquifer thickness (H); flow rate within the UVB well (Q); ground water flow velocity (v); and horizontal ($K_H$) and vertical ($K_V$) hydraulic conductivity.

Figure 2a depicts the theoretical lozenge shape of an induced ground water circulation cell where no natural flow of ground water exists, and little anisotropy is present. The symmetrical shape deforms and S decreases if ground water flows at some natural velocity (Figure 2b, 2c). The shape deforms further and S is further reduced at higher velocities. Aquifer anisotropy (reflected by changes in grain size or stratigraphy, for example) may increase S somewhat.

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**St. Lawrence Formation, cont.**

Lawrence is functioning as a confining layer. MDH staff will spend more time with the contractors to better characterize these cuttings during drilling. The conclusion is that contractors must drill through the St. Lawrence and complete a legal well. This will, in some cases, require deeper wells and will perhaps require some bigger equipment to drill these wells. MDH will have a meeting with the contractors later in the year and MDH field staff will work with contractors on site.

*Mike Convery and Jim Walsh, Minnesota Department of Health From Minutes of the MDH Water Well Advisory Council, June 14, 1995*

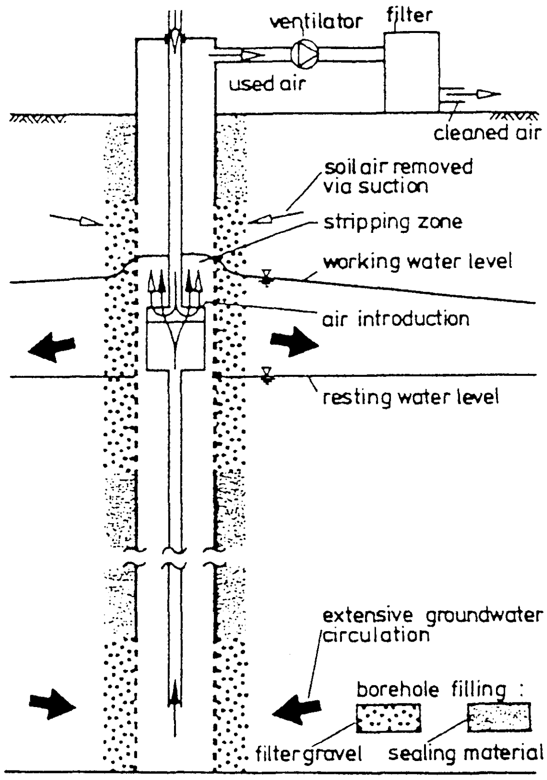


**Figure 1.** Effect of operating the UVB. A ground water circulation cell develops in the aquifer. From Herrling, et al., 1991.

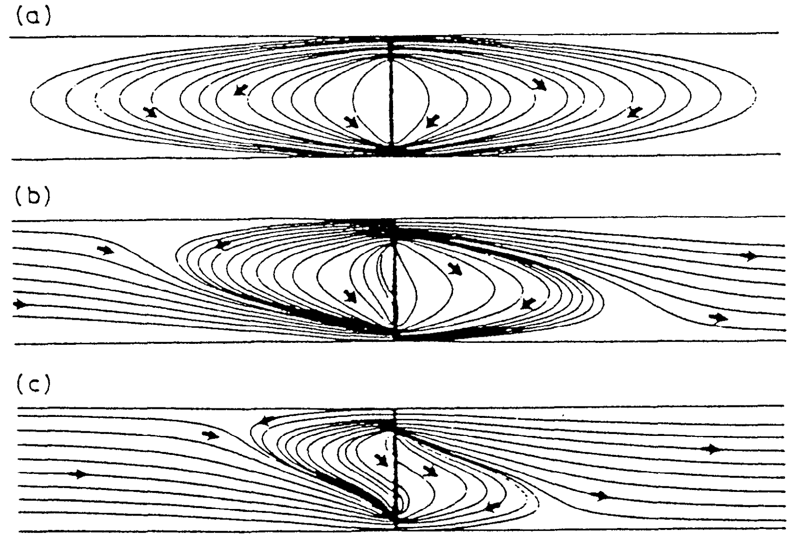


**Figure 2.** Cross section of ground water circulation cell for natural velocities: a) 0.0 m/day; b) 0.3 m/day; c) 1.0 m/day. From Herrling, et al., 1991.

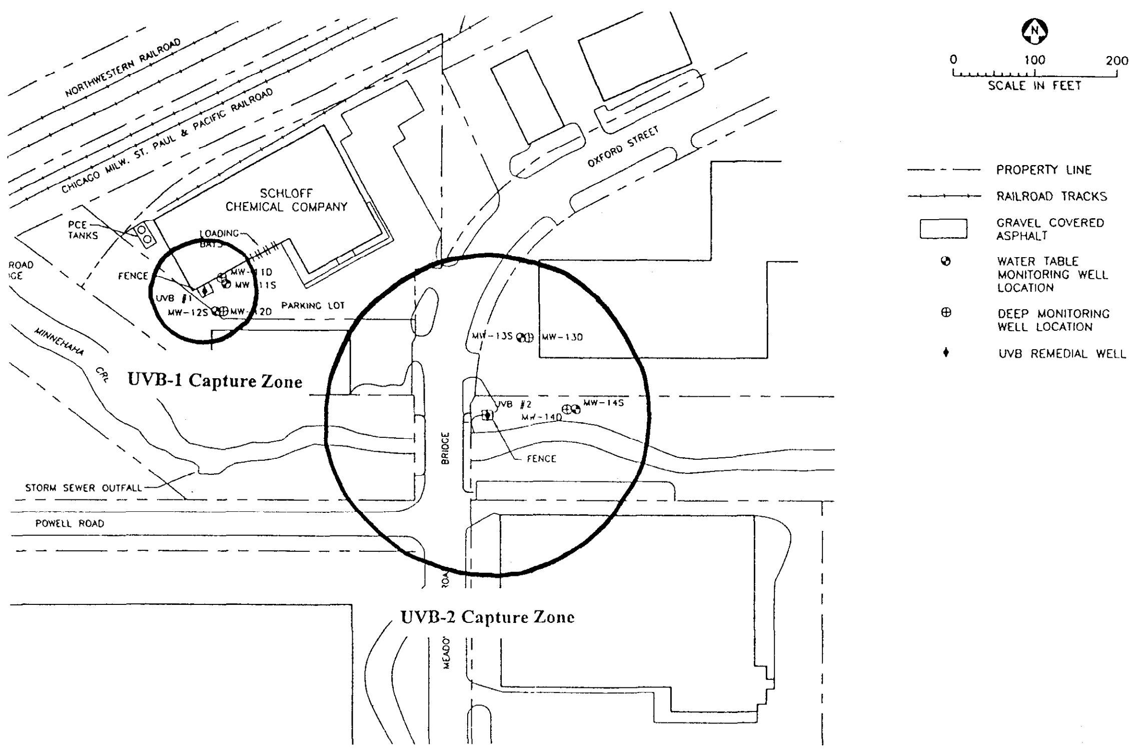


**Figure 3.** Schloff UVB well locations and capture zones. Modified from Barr (1994).

**UVB Wells, cont.**

If targeting a dissolved plume near the water table, adding a downhole pump and reversing the flow of water in the well reverses the direction of flow in the ground water circulation cell. Reversing the cell flow direction causes contaminated water to enter the upper screen, where it is treated before discharge from the lower screen.

***Case Study: Schloff Chemical Supply Company, St. Louis Park Minnesota***

The MPCA installed a UVB system at a former dry-cleaner chemical supply company located in St. Louis Park, Minnesota to address a dissolved PCE ground water plume discovered in 1990.

The Site remedial investigation (RI) found that PCE released during bulk handling has contaminated a glacial outwash aquifer composed of medium sands and gravel (upper zone, K=1E-02 cm/sec), and sandy lean clay with silty sand and gravel (lower zone, K=1E-04 cm/sec). Ground water flow direction is southeasterly, concurrent with the plume in both units. Although no free phase (dense non-aqueous phase liquid, DNAPL) PCE has been detected, the RI defined a dissolved VOC (primarily PCE) plume at least 500 feet long and approximately 200 feet wide, migrating downward with a natural vertical gradient of about 0.030.

On the basis of the RI data, MPCA staff determined a PCE cleanup goal (7.0 ug/l). A variety of factors contributed to the failure of the P/T system subsequently installed by the responsible party (RP). In 1991 the MPCA board determined project eligibility for state funds, resulting in transfer of project management to MPCA staff .

**Re-evaluating the alternatives.** Because the P/T system became ineffective, MPCA staff evaluated alternate ground water restoration strategies for the Site. We considered and rejected air sparging because that technique is not well suited to contaminant plumes with a significant downward component.

On the other hand, the UVB/ground water circulation cell technique was attractive for several reasons. It depends to a greater degree than other approaches on ambient hydrogeologic conditions. It makes use of research showing natural biodegradation of VOCs is an important (often unintentional) benefit of many remedial efforts. Although new in the United States, UVB has successfully remediated VOC plumes in Germany since about 1986. With capital costs for installation similar to a P/T or air sparging system, but low operating/maintenance (O/M) costs (and zero disposal costs), UVB is an effective and low cost alternative over the life of the project.

**UVB system design and installation.** The system design consists of two 8-inch diameter treatment wells (permitted by Minnesota Department of Health variance as environmental boreholes) placed at the source area and the downgradient extent of the plume. UVB-1, located near the source area, is 29 feet deep, screened entirely within the upper sandy aquifer zone (Figure 3). Screened sections were placed across the water table (approximately 12-20 feet deep) and at 25-29 feet deep. The design predicted a maximum capture zone width of about 140 feet.

UVB-2, located approximately 450 feet downgradient from the source area, has a total depth of 51 feet. Screened sections were placed across the water table (upper zone, approximately 10-18 feet deep) and in the lower zone, 46-50 feet deep. The design predicted a maximum capture zone width of about 400 feet.

Installing downhole strippers, connecting the blowers and effluent stacks, and providing security fenc-

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## Join the Minnesota Ground Water Association!

If you are reading this newsletter second-hand, we'd like to take this opportunity to invite you to become a member of **MGWA** for 1996. Annual dues are $20 for professional members and $15 for students.Members are entitled to purchse the annual membership directory for $7. Additional donations toward our scholarships and/or the use of recycled paper will be gratefully accepted.

Just complete the form below and mail to: MGWA, c/o WRI, 4779 126th St. N, White Bear Lake, MN 55110-5910.

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Which Address should we use for Directory Listing? ______________________

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## Fall Conference Report

The MGWA Fall Conference, held October 27 at the Earle Brown Center on the University of Minnesota's St. Paul Campus was a short course on isotope hydrology. The featured presenters were Dr. Carol Kendall of the U.S. Geological Survey, Menlo Park, California, and Dr. Calvin Alexander of the Department of Geology and Geophysics, University of Minnesota. Over 40 ground water professionals representing consulting firms, government agencies and academia attended. The morning lecture by Dr. Kendall included a discussion of terms and definitions common to isotope studies, isotopic fractionation, and the applications of deuterium, oxygen-l 8, and tritium to tracing water sources. In the afternoon, Dr. Kendall's discussion of isotope biogeochemistry was followed by a presentation by Dr. Alexander on age dating techniques including carbon- 14 and tritium, drawing on examples from his years of experience studying Minnesota ground water. The day concluded with a panel discussion which brought in several other Minnesota researchers who use isotopes in their studies. In addition to Drs. Kendall and Alexander were Dr. Emi Ito of the University of Minnesota, Dr. Steve Komor of the local U.S. Geological Survey office, Mr. Chuck Regan, hydrologist with the Minnesota Pollution Control Agency, and Mr. Jim Walsh, hydrologist with the Minnesota Department of Health. By all accounts, the conference was a big success and many attending commented that the gained a better understanding and appreciation for how isotopes could be used in their own ground water work.

*—Tom Clark, Editor*

**UVB Wells, cont.**

ing and power completed the treatment well installations.

**Monitoring the UVB/ground water circulation cell system.** Upon system activation in September 1994, MPCA staff followed agency guidance outlining air monitoring to be conducted following activation of SVE systems. System startup air effluent monitoring determined a PCE emission rate of approximately 1.50 ug/sec, within the applicable standard (65,200 ug/sec). Therefore no air effluent treatment is required. Air effluent sampling has continued on a regular schedule to provide estimates of PCE removal rates from ground water.

MPCA staff conducted baseline ground water sampling prior to system activation, with subsequent rounds performed: one hour after system activation; one week after system activation; two weeks after system activation; quarterly thereafter. All samples were analyzed for a VOC list including PCE and daughter products. Other measurements included water levels, dissolved oxygen (DO), specific conductivity (SC), and ground water temperature (T). Additional measurements are made monthly during routine operation/maintenance (O/M) visits to assure proper operation of the blowers and downhole equipment.

**Monitoring results.** We attempted to track the ground water circulation cell development with some of the above measurements. SC and T measurements were not

*—continued on next page*

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## New Publications

### New from U.S. Geological Survey

G. L. Amos, 1995, Water-Related Publications of the U.S. Geological Survey in Minnesota 1946-94, USGS Open-File Report 95-297, 150p.

M. K. Landon and G. N. Delin, 1995, Ground-Water Quality in Agricultural Areas, Anoka Sand Plain Aquifer, East-Central Minnesota. USGS Water Resources Investigations Report 95-4024, 25p.

### New From Minnesota Geological Survey:

1. Rice County Geologic Atlas, 1995; County Atlas Series C-9, Part A. Plate 1, Database map; Plate 2, Bedrock geology; Plate 3, Surficial geology; Plate 4, Quaternary stratigraphy; Plate 5, Depth to bedrock and bedrock topography; Plate 6, Geologic resources
Howard C. Hobbs, Project Manager

2. Fillmore County Geologic Atlas, 1995; County Atlas Series C-8, Part A. Plate 1, Database map; Plate 2, Bedrock geology; Plate 3, Surficial geology; Plate 4, Depth to bedrock and bedrock topography; Plate 5, Geologic resources
John H. Mossler, Project Manager

3. Regional Hydrogeologic Assessment; Quaternary Geology - Southwestern Minnesota, 1995; Regional Hydrogeologic Assessment Series RHA-2, Part A. Plate 1, Surficial geologic map; Plate 2, Quaternary stratigraphy
Dale R. Setterholm, Project Manager

### Regional Ground-Water Profiles

The MPCA has created a series of regional ground-water profiles that feature large sections of Minnesota, such as the Southwest and South Central areas. The profiles give general information on ground water within a region. They focus on hydrogeology and the quantity and quality of ground water in a region, and point out areas where specific action is needed to improve our understanding of Minnesota's underground water resources. For a copy of a profile, contact MPCA at (612)296-7789.

### Ground Water Primer Available

Groundwater - A Primer provides basic facts about groundwater: occurrence, use, contamination risk, and protection. It was prepared by the American Institute of Hydrology (AIH) in cooperation with the American Geological Institute and the International Association of Hydrogeologists.

The Primer is available from AGI Publications Center, PO Box 205, Annapolis Junction, MD 20701; (301)953-1744, FAX: (301)953-2838. Soft cover; 6"x9"; 53 pp.: price $9.95 includes shipping and handling.

### Free Directory of Ground-Water Information Resources

The MPCA, in conjunction with several other state agencies and the U.S. EPA, recently published a directory of ground-water information resources. "Ground Water: A Directory of Minnesota's Programs and Resources" provides citizens with an easy-to-use guide on many vital ground-water issues, such as well-water testing, sealing old wells, installing new wells or reporting abandoned wells, plus many other important ground-water topics. For a free copy of this booklet, please contact the MPCA at (612)296-7789.

### UVB Wells, cont.

meaningful. Under certain conditions, changes in [DO] will delimit the ground water circulation cell. However the error in our measurements was apparently larger than the changes we were trying to demonstrate. In addition, DO is non-conservative in many subsurface environments, making data interpretation difficult.

Vertical gradients measured in nested monitoring wells did not vary systematically with time, and (assuming circulation does occur), we therefore suspect the gradient necessary to drive the cell is too small to measure. In finer grained aquifers (silt, sandy silty clay, etc.) measured vertical gradients may be more pronounced.

The best evidence that ground water circulation is occurring is provided by changes in [VOCs]. The cell near UVB-1 has developed most completely, and plots of [VOCs] vs. time for two monitoring wells in the UVB-1 circulation cell are shown in figure 4. These are radially non-aligned water table wells about 30 feet from UVB-1.

Upon activation of a UVB system, a continuous pulse of cleaned

*—continued on next page*

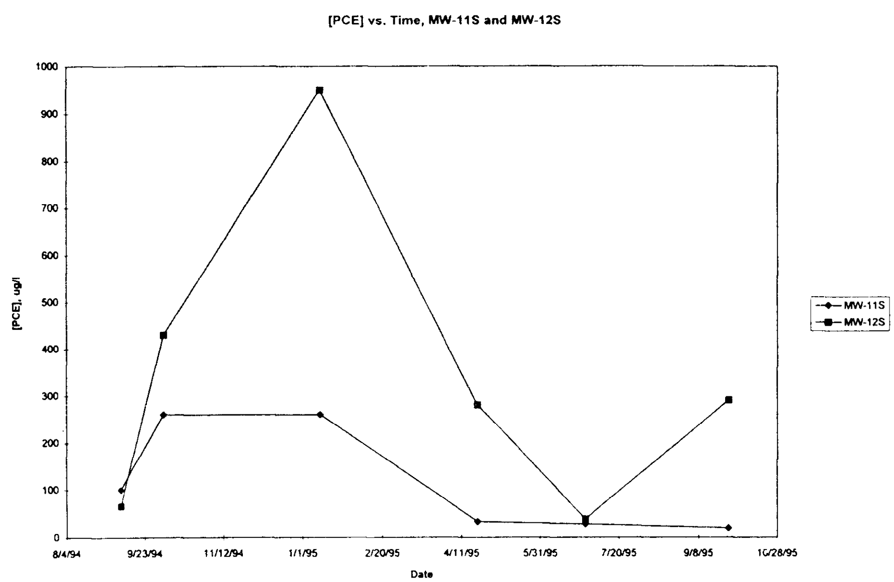


Figure 4

## Wellhead Protection Rule Development

The Minnesota Department of Health is proceeding with the development of a state rule addressing the implementation of wellhead protection measures for public water supply wells. The department published formal notification of its intent to develop the wellhead protection rule in the February 8, 1993, printing of the State Register. Since then, draft rule language has been prepared with the assistance of a number of advisory groups. The wellhead protection rule focuses on land-use practices and other activities that could contaminate groundwater — the underground source of the water used by many public water supply systems. The draft rule requires public water suppliers to develop and implement a wellhead protection plan. The plan must identify the wellhead protection area and strategies to manage the potential sources of contamination in this area. The public water supplier would only be responsible for implementing the plan in the area which is under their jurisdictional authority.

The department anticipates that the proposed rule and the rationale in support of the proposed rule (statement of need and reasonableness) will be available for public review and comment in early 1996.

If you want to receive a copy of the draft rule or be placed on the mailing list to receive a copy of the proposed rule and the statement of need and reasonableness, please contact:

Art Persons
Minnesota Department of Health
Southeastern District Office
Campus Center Building
2116 Campus Drive Southeast
Rochester, Minnesota 55904-4744
Phone Number: (507)285-7289

*—MDH Press Release, November 1995*

## Editorial Note: Ground Water or Groundwater

Many readers may have noticed inconsistencies in past issues of the newsletter in the spelling of the resource we are trying to protect. This is especially apparent in this issue where the authors of the two lead technical articles (both Hydrogeologists with the Minnesota Pollution Control Agency I might add) have chosen a different spelling. Andrew Streitz prefers "groundwater" while Jim Lundy likes "ground water". And these guys work on the same floor!

Since this is a debate that has raged for decades and will probably continue into the next century, I've chosen to take a "soft" editorial approach to the issue and follow the author's wishes. It makes the job of your volunteer editor and overworked publisher a little easier and hopefully keeps our authors happy, too. Speaking of authors, we are always looking for new ideas and discussion of emerging issues to feature in the newsletter. If you have something you'd like to see in print or an article or announcement you think would be of interest to our readers, please submit them to me at the MGWA address or to MPCA, 520 Lafayette Rd, St. Paul, MN 55155 (phone: 612-296-8580; fax: 612-296-9707; email: tom.clark@pca.state.mn.us)

**UVB Wells, cont.**

ground water exits the upper screen, and flows outward. [VOCs] in a water table monitoring well, located in the plume and in the circulation cell some distance R from the UVB well, can be expected to change due to discharge of clean water from the upper UVB screen. Prior to the arrival of the clean water front, changes in [VOC] may be erratic, but after the arrival of the clean water front, VOC concentrations should drop.

The calculated travel time of a water particle from UVB-1 to either monitoring well is about 2 months. On figure 4, the [VOC]s clearly peak approximately 3 months after system activation, declining thereafter to levels below baseline. This behavior strongly suggests the UVB system is influencing the aquifer, and that a ground water circulation cell has developed as described above. The recent [VOC] increase in MW-12S does not conform to the behavior described above, and needs to be tracked in future monitoring rounds. This result and other observations suggest development of ground water circulation cells may be sensitive to minor lateral anisotropy in the aquifer.

Air effluent results from UVB-1 and UVB-2 indicate continuous stripping of PCE from ground water. Calculations indicate about 1.86E+02 kg (400 pounds, or about 30 gallons of PCE) have been removed after one year of operation.

**Potential Limitations of the UVB Technique**

Complex stratigraphy, less permeable formations, large surface water bodies, or large aquifer anisotropy should not hamper the development of ground water circulation cells, but may affect the cell shape and size (and therefore remediation time). However, circulation cells cannot develop across confining layers, and cannot be adequately predicted where bedrock aquifer fracture patterns are undefined. In these situations, the UVB system is designed on a case by case basis. Not all are compatible with the UVB design.

At some sites, mineral encrustation on the screens or downhole equipment may limit system effectiveness. Monitoring inorganic parameters (such as calcium, iron, magnesium, carbonate alkalinity, etc.) may indicate whether encrustation is likely, and appropriate modifications can be made (e.g., re-routing air-effluent to the stripper, making a closed air flow loop).

**Conclusions**

MPCA's contractor estimates the remediation time for this project to be approximately

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## Reauthorization of the Safe Drinking Water Act: Senate Bill 1316 Introduced

On October 11. 1995, Senators Kempthorne, Chaffee, Baucus, Reid, Kerrey, Inhofe, and Jeffords introduced legislation to reauthorize the Safe Drinking Water Act. A companion House bill should be introduced soon. Some highlights of the Senate version are as follows:

1) State Revolving Loan Funds

- The bill establishes a new federal grant program to capitalize drinking water treatment revolving loan funds, similar to those now used to finance sewage treatment systems.
- Authorizations for the federal grants are $ 1 billion for each year 1995-2003.

2) Standard Setting Authority

- The mandate to promulgate standards for 25 additional contaminants every 3 years is repealed and a new mechanism to identify contaminants for future regulation is established.
- If EPA determines that the benefits of a standard issued under current law would not justify the costs to systems that must comply with the standard, EPA may issue a less -stringent standard that maximizes health risk reduction at a cost that is justified.

3) Monitoring

- Systems serving up to 10,000 persons can skip repeat testing for many contaminants that do not present acute health risks, if the first sample in a quarterly series does not detect them.

4) Small System Variances

- States are authorized to grant variances from federal health standards for systems serving up to 10,000 people.
- Consumers may participate in the decision to grant a variance.

5) Source Water Quality Protection

- States are to delineate areas that provide source water for drinking water systems and are to conduct vulnerability assessments for high priority areas.

6) New Drinking Water Standards

- States and water systems are to monitor for up to 20 unregulated contaminants to collect information for future standards.
- Every 5 years, EPA is to reach a determination as to whether federal health standards are needed for at least 6 of the contaminants that have been listed and studied.
- EPA is to promulgate an enhanced surface water treatment rule including standards for cryptosporidium.
- EPA is to conduct additional research on the cancer risks from exposure to low levels of arsenic; a revised arsenic standard reflecting these cancer risks is to be promulgated no later than 2001.

*Abstracted from Technical Assistance Times, Minnesota Rural Water Association, November 1995*

**UVB Wells, cont.**

5-7 years, based on other similar projects. Experience at UVB sites in Europe indicates VOC plume remediation times between several months and eight years can be expected.

Experience at the Schloff site indicates direct development of ground water circulation cells is difficult; tracer injection would conclusively determine cell size, but this practice is limited in Minnesota (although it has been performed elsewhere). However, if aquifer restoration occurs, conclusively demonstrating the development of a ground water circulation cell becomes secondary. The [VOC] data from the Schloff site indicate this occurring, primarily near the source area (UVB-1). A larger predicted cell, tighter aquifer material, and a deeper well completion at UVB-2 contribute to a greater expected travel time, and results there will become clearer with time. Air effluent results further demonstrate PCE removal from the aquifer at a significant rate. With these points in mind, we conclude that the UVB/ground water circulation cell is a practical approach to ground water restoration.

**References**

Barr Engineering, 1994. *Remedial Action Construction Report, Schloff Chemical Supply Company.* Prepared for the Minnesota Pollution Control Agency.

Herrling, B., Stamm, J., Alesi, E.J., Brinnel, P., Hirschberger, F., and Sick, M.R. 1991. *In situ ground water remediation of strippable contaminants by vacuum vaporizer wells (UVB): Operation of the well and report about cleaned industrial sites.* Presented at the Third Forum on Innovative Hazardous Waste Treatment Technologies: Domestic and International, June 11-13, 1991, Dallas, TX.

*James R. Lundy, can be reach at the Minnesota Pollution Control Agency, Site Response Section, 520 Lafayette Road, St. Paul, MN 55155 (612)296-7822 or (fax) (612)296-9707*

**Metro Groundwater Model, cont.**

before the model is distributed, including:

1) settling on a format for file notation and size;

2) incorporating Super Block functions within MLAEM to manage model run time while allowing the incorporation of detail;

3) designation of a "home" for the model databases; and

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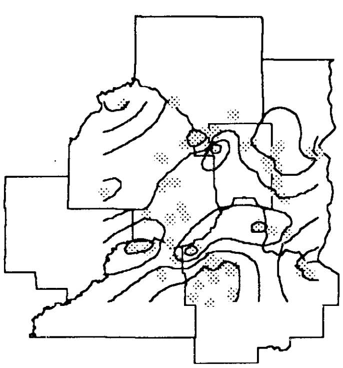
## Metro Groundwater Model, cont.

4) investigating funding for further development and maintenance of the model.

### Synoptic Network

The Metropolitan Synoptic Ground Water Network is a joint effort of the MPCA, MDH, community water suppliers, and the Metro Area Ground Water Alliance (MAGWA), which is made up of representatives of the seven Twin Cities Metropolitan counties, various state agencies and boards and the Minnesota Geological Survey (MGS). Synoptic refers to the measuring of an aquifer's water level over a broad area within a prescribed period of time. As one of their groundwater initiatives, MAGWA undertook the coordination of the monitoring schedules of existing groundwater networks, such as those operated by the Hennepin Conservation District and Department of Natural Resources, with the goal of taking groundwater elevations from the greatest number of wells on a single day across the region.

In both March and August of 1995, water elevations were taken on the first Wednesday of the month at over 400 wells across the seven county area. Staff at the MPCA and MDH have collected the field notes, entered the resulting data into databases and are currently organizing the distribution of the databases and graphical displays to interested parties.



Prairie du Chien/Jordan Heads for March 1995

The Metro Model team was motivated to participate in this network by the project's need for a synoptic database for model calibration purposes. Other participants are interested in the data for other reasons. The Metro Model project plans to continue this association with the synoptic network at least until the end of the two-year project. Due to the interest expressed by the county planners and hydrogeologists of MAGWA, it is quite likely that the network will continue in some fashion for the foreseeable future. The Synoptic network in 1996 will be focused on non-pumping wells and wells near rivers and buried river valleys.

Results from the first measuring event in March 1995 are now available from the MPCA in a DBF format (suitable for spreadsheet or ARCVIEW import) as well as a graphical display. Eventually the information will also be available via County Well Index (CWI) through the MGS.

### Related Work by the MGS

The MPCA Ground Water Unit hopes to contract with the MGS this fall to update CWI database files for selected metropolitan counties. This will include adding new records and correcting existing records. They also will produce digitized upper surfaces of several geologic units. Work is scheduled to be completed in the spring of 1996. This work will be valuable to the Metro Model team in developing the most current interpretation of the hydrostratigraphy to serve as the basis for the Metro Model.

The latest version of the CWI database and software program is available to users who have access to the State Novell network. Connection may be made by typing the following commands, though most likely with some modification depending upon the user's system:

**`login mgs-nova\cwi`**
`CWI%95` (at password prompt)
**`map j:=mgs-nova\sys:`** ("j" or other available `drive name`)
**`cd j:\open\cwi`**
**`j:`**
**`logout mgs-nova`** (after data has been gathered)

Due to memory constraints it may be impossible for your system to run CWI while connected to the MGS. If this is the case you can copy relevant database files to your local hard drive and run the program under a reduced RAM boot-up. A good procedure to follow would be to delete original CWI database files from your hard drive after use, returning to mgs-nova for new copies as needed.

For answers to questions directly related to CWI and network access, call the MGS CWI coordinator Tim Wahl at (612) 627-4798.

### Coordination with County-scale Models

The project team has been working closely with technical staff associated with the other large-scale metropolitan analytic element modeling projects, specifically the Hennepin and Dakota County groundwater models. The Hennepin County model was begun in 1993, while the Dakota County model was started in the spring of 1995. The Metro Model project team has two goals: 1) to encourage the development of a common hydrogeologic conceptual model, and 2) to share information. In this way we hope to gain from the experiences of these other projects and increase the compatibility of results from the different groundwater models.

HCD staff have finished an analytical element model for the Prairie du Chien/Jordan for Hennepin County, achieving a high level of communication between their GIS system (ULTIMAP) and the AEM software loaded on a PC. Though the ULTIMAP GIS system is incompatible with the ARC/INFO GIS system, many of the data management ideas and databases themselves are directly transferable to the Metro Model. A similar model for the glacial deposits is currently under development.

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### Metro Groundwater Model, cont.

Because of the coincidental start of the Dakota County and Metro Models, close coordination between the two teams has benefited both projects. The Dakota County model is a joint effort of the County and several Dakota County Cities, and is being developed in MLAEM. The team has also been in close contact with the MDH with the goal of ensuring that the Metro Model facilitates the delineation of Wellhead Protection (WHP) areas. The policy of the Metro Model team is to develop good working relationships with all metropolitan modeling projects.

**Coming Up in the Next Few Months**

- January 1996: advisory workgroup meeting
- March 1996: next date of synoptic groundwater network
- Spring 1996: completion of coarse MLAEM Metro Model

If you would like to be kept abreast of progress made, have questions on the content of this article, or would like more information, contact Andrew Streitz at (612) 296-7791 or John Seaberg at (612) 296-0550. Alternatively, you could reach us at: MN Pollution Control Agency, 520 Lafayette Rd, St. Paul MN 55155-4194, Fax: (612) 296-9707 E-mail: andrew.streitz@pca.state.mn.us or john.seaberg@pca.state.mn.us

## Transcripts of Landfill Gases Conference Now Available

The Minnesota Department of Health's Site Assessment and Consultation Unit now has written transcripts available of our joint April 1994 conference entitled, "Landfill Gases: Genesis, Detection, and Control." The conference was very successful and requests have come in from across the country and from Canada for further information on this topic.

The transcripts cover the half-day conference, which had five topics related to landfill gases:

- Scope of the Problem
- Movement of Gases
- Fate of Gases
- Distribution of Gases
- Gas Control

This material is being offered at no charge. Transcripts can be obtained by contacting Lisa Pogoff at (612)215-0916, or by calling toll free at 1-800-657-3908, and pressing "4" on a touch tone phone to leave a message.

## Reminder of 1996 newsletter editorial and publication submittal deadlines:

**Volume 15, Number 1; March 1996**
Submission of articles to the editor—2/9/96
Submission of copy to the publisher—2/16/96

**Volume 15, Number 2; June 1996**
Submission of articles to the editor—5/10/96
Submission of copy to the publisher—5/17/96

**Volume 15, Number 3; September 1996**
Submission of articles to the editor—8/9/96
Submission of copy to the publisher—8/16/95

**Volume 15, Number 4; December 1996**
Submission of articles to the editor—11/8/96
Submission of copy to the publisher—11/15/95

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