MINNESOTA GROUND WATER ASSOCIATION

NEWSLETTER v.5 n.3 September 1986

RICK JOHNSTON AND PAT BLOOMGREN WIN MGWA ELECTIONS

DR. JOHN CHERRY TO SPEAK AT FALL MEETING

Congratulations to Rick Johnston (MPCA) and Pat Bloomgren (DNR-Waters), the new President-Elect and the new Treasurer/Membership Chairman for the Minnesota Ground Water Association. Rick Johnston will start his term in November and Pat Bloomgren will begin hers immediately.

It was announced at the summer meeting that our fall meeting will be held in Duluth, and our guest speaker will be Dr. John Cherry. There are more details regarding the fall meeting later in the newsletter. However, the next time any of you see Kevin Powers (LBG), tell him what a great idea he had to get Dr. Cherry here for the fall meeting. Also thank Jim Stark (USGS) for following up with additional contacts and Glenn Evavold (RREM) for coordinating the whole show in Duluth. I'm really looking forward to a fine meeting. The leaves should be turning colors about that time, and the UMD Geology Club is preparing a post-meeting party as only college geologists can. You had better plan on having a designated driver for your vehicle or staying overnight. Since we are having the 1986 fall meeting in Duluth at UMD this year, maybe the folks at Winona State can host the fall meeting in 1987.

Several new national consulting firms have opened offices in the Twin Cities. Since last year, Conastoga-Rovers, ERT, IT Corp., and several other firms have opened offices here. Let's all make an effort to invite ground water professionals from these firms to our next meeting, and encourage them to join MGWA.

Good news from Congress this month -- they passed the Federal Superfund Bill for $8.6 billion. That should help all of us keep our jobs for at least a couple more years. Regarding jobs, remember in college when Petroleum Geology was the **in thing** and ground water was **un-cool**? With the price of oil dropping off the table and Superfund being reauthorized, it's ironic how many of the petroleum geologists that we went to school with have suddenly become "enlightened" to just how interesting ($) hydrogeology is after all.

A big thanks to Dave Kill and Dave Schaffer for the tremendous job they did in organizing and presenting our summer meeting on aquifer tests. We are very lucky to have Johnson UOP located here in the Twin Cities. They are a class company and make a tremendous contribution to the ground water profession in Minnesota.

Why doesn't the MGWA have more student members from the U of M, St. Thomas, Macalester, Gustavus, UMD, Winona State and that other school that Kelton Barr and Jane Willard went to? Next time you visit your alma mater, invite your major professor to the next MGWA meeting and ask him (or her) to bring a couple of students along.

Getting back to petroleum geology, did you know that banks in Texas are giving people who open new account for over $100.00 a choice of a free toaster or a free oil drilling rig? Word has it that they're running out of toasters.

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MINNESOTA GROUND WATER ASSOCIATION

FALL MEETING
Friday, October 3, 1986

Dr. John A. Cherry
Professor, Department of Earth Sciences
University of Waterloo
Waterloo, Ontario
Distinguished Lecturer Sponsored by the National
Water Well Association

Topic: GROUND WATER CONTAMINATION

Time: 7:30 P.M.
7:00 P.M. registration

Place: Life Science Building, Room 175
University of Minnesota Duluth

Cost: $5.00

Reception immediately following the lecture - UMD Campus Club

Meeting and reception co-sponsored by UMD Geology Dept.

For further information call Glenn Evavold, 218/722-3915

Registration for the MGWA Fall Meeting
Professor John A. Cherry: "Ground Water Contamination"

Name(s) _____

_____

Amount enclosed: _____

Make checks payable to: Minnesota Ground Water Association

Mail to: MGWA, P.O. Box 3362, St. Paul, Minnesota 55165

RITA PAQUETTE MEMORIAL SCHOLARSHIP FUND

As most of you probably know, Rita Paquette, a hydrogeologist at the Minnesota Pollution Control Agency and member of MGWA, died in a car accident on May 22. Those of you who knew Rita personally, or had the opportunity to work with her, will remember her as a warm, friendly person with a deep commitment to preserving our environment.

As a memorial to Rita, several of her friends have made arrangements with the University of Minnesota Foundation to establish a scholarship fund at the "U" in her name. Such a memorial is enthusiastically supported by Rita's family.

We intend to raise enough funds to endow an annual award to an undergraduate female geology student with an expressed career interest in environmental geology of hydrogeology. The recipient would be selected during fall quarter by a three-member committee consisting of one person from the Geology Department, one of her coworkers from the MPCA and one other person who may be interested such as a family member or friend.

Contributions to this scholarship fund will be very much appreciated by her friends and certainly by the recipient. Most of us aren't so old that we don't remember how much a few hundred dollars can mean to a poor college student.

The University will acknowledge all contributions and provide receipts. For those of you in the private sector, many corporations will match donations to organizations such as the University.

Contributions should be sent to the:
University of Minnesota Foundation
P.O. Box 70870
St. Paul, Minnesota 55170-0034

Please note that it is for the Rita Paquette Memorial Scholarship Fund.

If you have any questions, please feel free to call Rick Johnston at (612) 296-7734 or Paul Book at (612) 296-7337. You may also contact Ed Tickner at the University Foundation at (612) 624-3333.

ST. ANTHONY FALLS HYDRAULIC LABORATORY

FALL SEMINAR SERIES

All seminars are held on Thursdays 3:30 - 4:30 p.m. in the St. Anthony Falls Hydraulic Laboratory Auditorium, Mississippi River at 3rd Avenue S.E. in Minneapolis. For more information call (612) 373-2782.

ELECTION OF OFFICERS

Rick Johnston and **Pat Bloomgren** won the spring election for President-Elect and Treasurer. Rick will serve a one-year term and then will serve a one-year term as President. Pat's term is two years in length. Congratulations to both Rick and Pat.

MGWA SUMMER MEETING

Approximately 60 people attended the July 24 MGWA summer meeting on aquifer test design and analysis at the Plaza Best Western Hotel in Shoreview. Dave Kill and Dave Schaffer, both with the Johnson Division of Universal Oil Products, presented a two-hour seminar on test design, methodology, data collection and data analysis. An aquifer test demonstration and plant tour followed at the Johnson plant site. Thanks to both Daves and the Johnson Division for a very successful meeting.

MGWA WINTER CONFERENCE

The MGWA is considering the possibility of hosting a Minnesota Ground Water Conference in the spring. This conference would give local ground water professionals an opportunity to exchange information and ideas. Abstracts from papers presented would be published. If you have any ideas or would like to be involved and help with the planning please write to the MGWA or call Jim Stark at (612) 725-7841.

SPRING SEMINAR

The geophysical exploration seminar in May was a great success. In the morning session Dr. Robert Taylor presented a short overview of geophysical exploration methods including a unique application of electrical resistivity methods using miscellaneous odds and ends picked up at season-end lawn and garden sales. The roving resistivity array powered by a lawn tractor and equipped with circular saw contact probes had to be seen to be believed.

The afternoon session was held outdoors under cooperating skies. Attendees were able to see various geophysical instruments demonstrated in the field. Bison, R. J. Ikola and Associates, Minnesota Department of Natural Resources, and Donahue and Associates all provided demonstrations of various geophysical methods. The informal atmosphere was conducive to questioning and discussion of the pros and cons of the different techniques.

Our hats off to the people who organized this meeting and to the people and organizations who provided the expert demonstrations!

The Effects of Lake Level Lowering on Lake-Ground Water Interaction at School Section Lake, Stearns County, Minnesota.

by Eric Mohring, Division of Waters, Minnesota Department of Natural Resources. 500 Lafayette Rd., St. Paul, MN, 55155-4032

A complete report on this study is available from the Division of Waters, Minnesota DNR.

School Section Lake is located in southeastern Stearns County, Minnesota, approximately 60 miles northwest of the Twin Cities metropolitan area. (Fig. 1). The lake is one of over 25 landlocked lakes within glaciated terrain in Minnesota that are currently experiencing high water level problems. These lakes have no active natural outlets and are susceptible to large natural water level fluctuations. The lakes are part of larger ground water flow systems and ground water often plays a dominant role in the lake level fluctuations.

The Department of Natural Resources (DNR), with the aid of local volunteers, has monitored ground water levels and the level of School Section Lake since before the installation of a lake outlet in September, 1984. The work is an interesting case study in lake-ground water interaction before and after artificial lake level manipulation. It shows that ground water inflow was a major component of the lake water budget after the outlet was installed, accounting for much of the outlet outflow.

GEOLOGIC SETTING

School Section Lake is situated in outwash sands and gravels within the St. Croix moraine complex, near its boundary with Des Moines Lobe drift (Fig. 1). Along its southeast shore, the lake borders on red till of the St. Croix moraine. The saturated thickness of the outwash varies from less than 20 feet on the eastern side of the lake to 60 feet at its western edge (Lindholm, 1980). Bedrock is about 100 feet deep in the area and consists of Pre-cambrian granite, argillite, and graywacke.

From School Section Lake, the regional ground water flow direction is to the northeast toward the Mississippi River (Fig.2). Several miles west of the lake the ground water flow direction is to the east toward the lake. Local flow systems exist around the lake and around other lakes in the outwash plain.

BACKGROUND

School Section lake has a meandered area of 206 acres, based on the original Government Land Office Survey of 1857. It was planimetered at 183 acres on 1951 air photos and 201 acres on 1982 air photos. A 1969 fisheries map of School

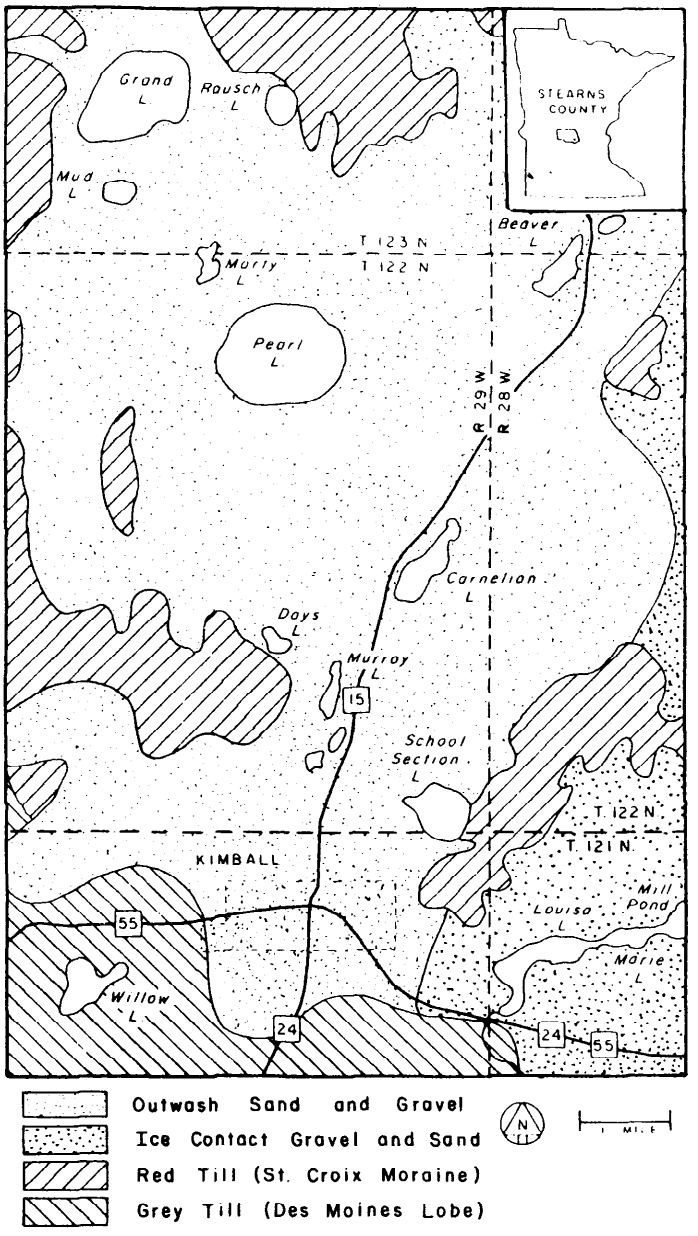


FIGURE 1: LOCATION AND GEOLOGY

Section Lake shows an area of 188 acres and a maximum depth of 12 feet. At that time the lake was approximately 7 feet lower than its maximum level in 1984. The drainage area for the lake (excluding the lake itself) is about 1000 acres. A 1967 USGS quadrangle map shows the lake at an elevation of 1131 feet above sea level. This is the earliest recorded lake level elevation, though local residents recall the lake being considerably lower in the 1930's. The lake level was approximately 1132.7 feet in the spring of 1983. Following heavy rainfalls during June, 1983, the lake level rose rapidly. There were reports of rising lake levels in the spring of 1984. By June, 1984, the lake level had reached 1137.9 and 14 houses and cabins were flooded.

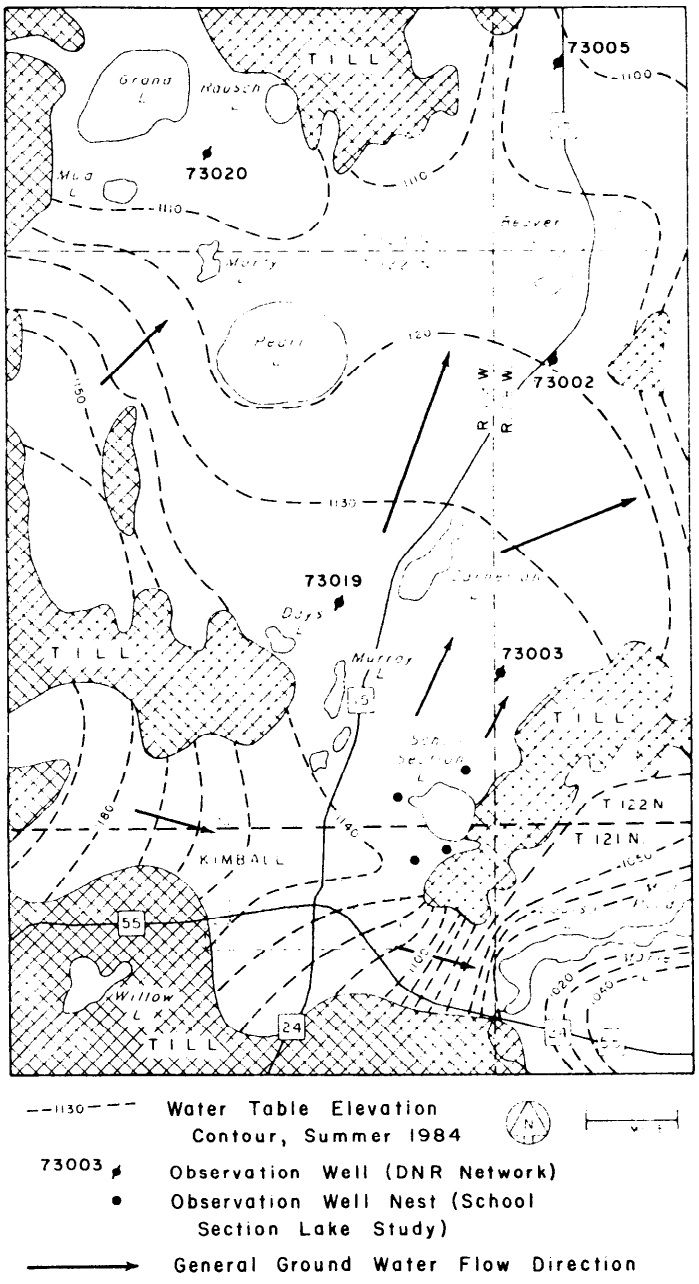


FIGURE 2: GROUND WATER FLOW PATTERNS (MODIFIED FROM LINDHOLM, 1980)

The lakeshore owners petitioned the Clearwater River Watershed District to construct an outlet. The outlet structure was installed at the southeast corner of the lake. Its runout level was set at an elevation of 1135.4 feet, and later lowered to 1133.9 ft. The outlet conveys lake water by a series of culverts, open ditches, and marshes to the Clearwater River at Lake Marie. Flow from the outlet began on 17 September, 1984 at approximately 5 cfs. The outlet was closed from 2 July to 10 July, 1985, and again from 8 September to 9 October, 1985 because of high lake levels in the Clearwater Chain of Lakes, but otherwise has been flowing continuously. By August, 1985, the lake level had been lowered 3 ft.

METHODS

The DNR installed 9 observation wells around the lake ten weeks prior to the completion of the lake outlet. These consisted of 3 nests of wells near the lake and a single well 1/4 mile southwest of the lake (Fig. 2). A lake level gauge was also installed. The wells and lake gauge have been read weekly by local volunteers since July, 1984. There are 5 water table observation wells to the north of the lake which are read monthly by the Stearns County Soil and Water Conservation District (Fig. 2). The well nests provide information about the vertical and horizontal components of ground water flow near the lake.

RESULTS

Lake Level

The lake level was declining in the 2 months prior to the installation of the outlet (Fig. 3), as were ground water levels in the area. After the outlet was installed, the rate of lake level decline increased significantly. By August, 1985, the lake level elevation had declined to just over 1134 feet. The lake level rose approximately 0.8 feet from 8 September to 9 October, 1985 when the outlet was closed, and resumed its decline after the outlet was reopened.

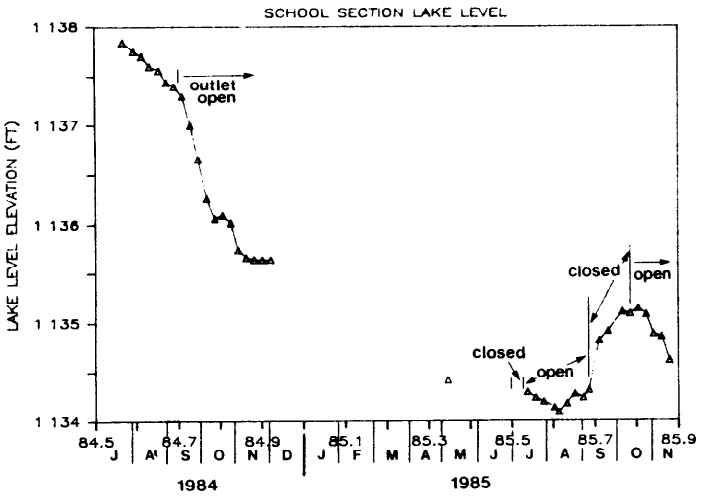
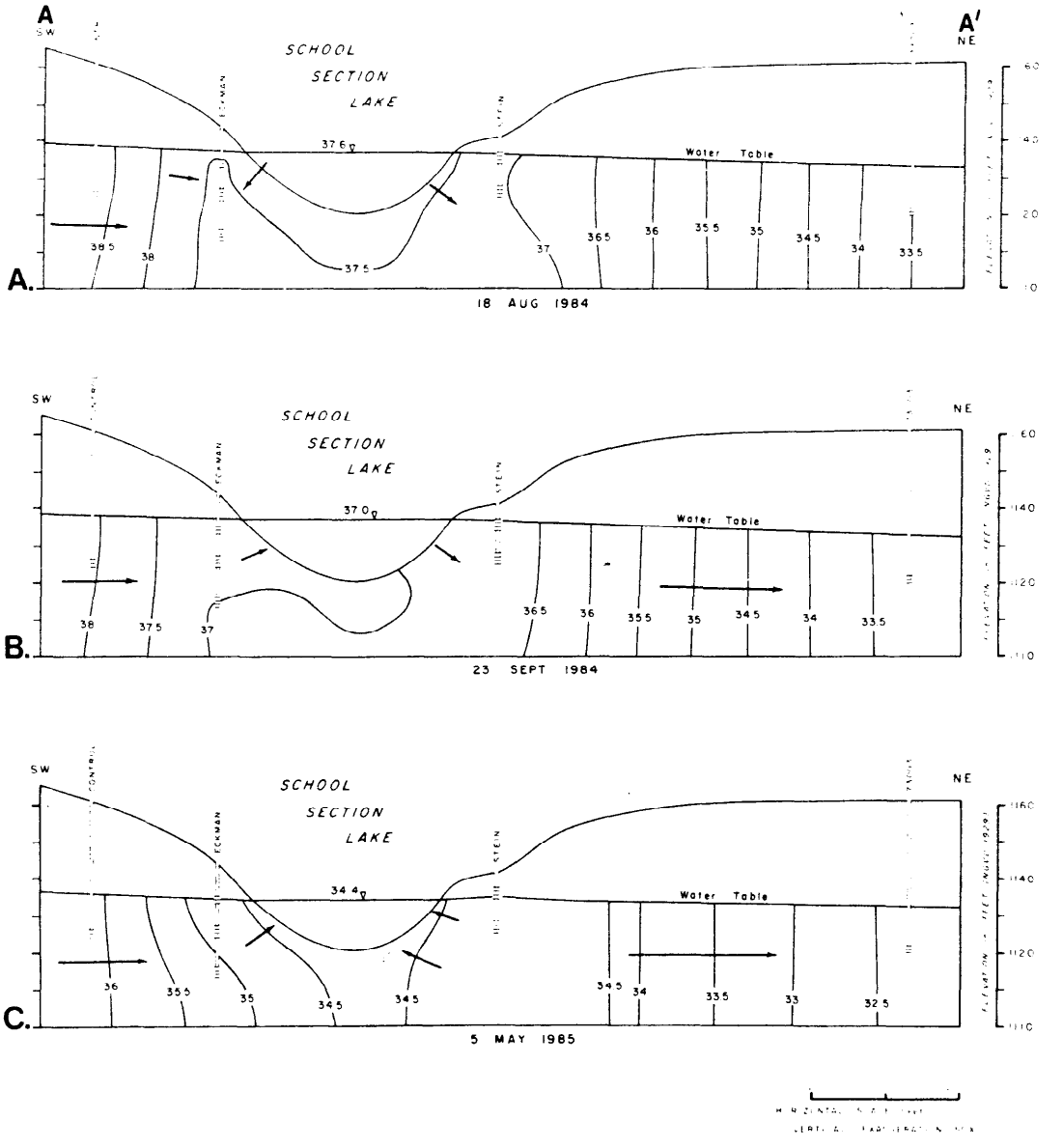


FIGURE 3: LAKE LEVEL HYDROGRAPH

Ground Water Flow

Figure 4 shows water table configurations and head distributions for different times along a southwest-northeast cross-section through the lake. Before the outlet was installed, regional flow was from the southwest to the northeast, and outflow was occurring along the northeast shore of the lake (Fig. 4a). There was also outflow to the southwest against the regional gradient. One week after the outlet was installed (Fig. 4b), the outflow to the southwest had reversed, and ground water was flowing into the



lake from the southwest and out of the lake to the northeast. By the spring of 1985, the northeast outflow had reversed, and ground water was flowing into the lake from all directions (Fig 4c). A ground water mound had developed on the northeast (down gradient) side of the lake with a local flow system toward the lake. The situation persisted through the summer and fall of 1985. When the outlet was closed during the period 8 September to 9 October, ground water inflow to the lake from the northeast decreased, but then increased after the outlet was reopened.

The observation well data show increased ground water inflow to the lake as a result of lowering the lake level. The amount of the ground water contribution was calculated using lake water budget calculations and Darcy's Law calculations.

Water Budget Calculations

The lake water budget can be expressed by the following:

(P + RO + GW) - (OF + E) - delta S = 0

where:

P = precipitation on lake
RO = direct runoff into lake
GW = net ground water inflow
OF = outflow through outlet
E = evaporation from lake
delta S =change in storage associated with lake level change

The net ground water contribution can be calculated as a residual if all the other terms are known:

GW=-P - RO + OF + E + delta S.

Much attention has been focused on the errors associated with estimating the ground water component of a lake's water budget as a residual (Winter, 1981). The errors associated with the other terms in the equation can be additive and produce a large error in the estimate of the ground water contribution. While not an exact calculation, the water budget technique is useful as an estimate as long as the errors are taken into account. In this analysis, the terms used in the calculation were bracketed by maximum and minimum values which were used to calculate maximum and minimum estimates for the ground water contribution for the period September, 1984 to September, 1985.

Lake storage changes, delta S, were calculated by interpolating between planimetered areas of the USGS quadrangle map.Precipitation over the lake was calculated using daily gauge data from a rain gage adjacent to the lake. Runoff was calculated using the precipitation data and applying runoff coefficients of 0.1 to 0.25 to the 1000 acre drainage basin. A coefficient of 0.18 was taken as the median value based on regional average annual runoff data. High, medium and low estimates for outlet outflow were calculated using the outlet discharge history provided by consultants for the Clearwater River Watershed District. Lake evaporation for May-October was calculated using daily pan evaporation data from the Becker agricultural experiment station 20 miles northeast of the lake.

The terms in the water budget equation were adjusted to their upper and lower error limits to obtain a maximum, minimum, and medium value for net ground water inflow. The medium estimate for net ground water inflow for the period 17 September, 1984 to 8 September, 1985 is 2158 acre-feet which is equivalent to an average inflow rate of approximately 3.1 cfs over the period. The maximum estimate is 3443 acre-feet, equivalent to an average inflow rate of approximately 4.9 cfs. The minimum estimate is 906 acre-feet, or approximately 1.3 cfs.

Darcy's Law Calculations

The lake was divided into three shoreline units to compute ground water inflow. Flow through the till on the southeast shore was assumed to be negligible. The three well nests were used to determine gradients along the shoreline units. A hydraulic conductivity of 250 feet per day was used, based on tranmissivity maps in Lindholm, 1980. A flow depth of 15 feet was assumed. A net ground water inflow rate was computed for each available water table configuration. The net ground water inflow rate versus time curve was integrated numerically to produce ground water inflow.

The calculated net ground water inflow for the period 17 September, 1984 to 8 September, 1985 was 3300 acre-feet, equivalent to an average inflow rate of 4.7 cfs. These values are toward the upper end of the range of ground water flow values produced by the water budget calculations. The Darcy's Law calculations probably overestimate ground water inflow by ignoring the potential effects of lower permeability lake sediments. The calculations do indicate that the water budget estimates for ground water inflow are not physically unrealistic.

Regional Effects

The data show an area of water table depression around School Section Lake as a result of lake level lowering. The precise areal extent of the depression is difficult to determine using data from observation wells to the north because these wells were showing a declining trend prior to the installation of the outlet. However, the hydrographs from wells 73003 and 73009, 1 and 2 miles north of the lake respectively (see Fig. 2). more closely match the lake level decline than do the hydrographs from more distant wells. Analytical modeling using a water table mounding equation (Hantush, 1967) and assuming ground water inflow rates to the lake of 3-5 cfs for a year indicates that water table depression would be negligibly small beyond 2 miles away from the lake .

SUMMARY AND CONCLUSIONS

The observation well data show changing ground water inflow patterns and increased ground water flow to School Section Lake as a result of lake level lowering. Seepage out of the lake to the northeast and south was reversed. A local ground water flow system on the original down-gradient (northeast) side of the lake was created with flow toward the lake. Water budget and Darcy's Law calculations indicate that ground water was a major inflow component to the lake, accounting for much of the outlet outflow for the period September, 1984 to September, 1985.

The study emphasizes the need to consider lake-ground water interaction as a major factor in lake water budgets. When a lake's level is artificially dropped, increased net ground water inflow to the lake is to be expected. This additional inflow should be taken into account in designing lake water control structures. The hydrogeologic setting of a lake should be given thorough consideration before lake level manipulation is attempted.

REFERENCES

Hantush, M.S., 1967. Growth and decay of ground water mounds in response to uniform percolation. Water Resources Research, Vol. 3. No. 1.

Lindholm, G.F., 1980. Ground Water Appraisal of Sand Plains in Benton, Sherburne, Stearns, and Wright Counties, Central Minnesota. U.S. Geological Survey Water Resources Investigations. Open-File Report 80-1285.

Winter, T.C., 1981. Uncertainties in estimating the water balance of lakes. Water Resources Bulletin, Vol. 17, No. 1.

SAFETY RISKS OF OPEN BOREHOLES

by Michael Convery
Minnesota Pollution Control Agency

Boreholes are drilled for a variety of purposes, including conducting geotechnical tests (i.e. percolation tests), obtaining geological samples, or installing wells. In recent years, attention has focused upon the need to seal boreholes and annular spaces around wells in order to prevent migration of contaminants from one geologic zone to another and, in the case of monitoring wells, to ensure valid samples are collected from the zone being sampled.

Open boreholes also pose a safety risk. This risk may go well beyond simply an instance of someone stepping into an open borehole and twisting a leg. A more dramatic case occurred April 24, 1986, in Colts Neck, New Jersey. A 21 month-old child fell into a 12-foot deep borehole (12 inches in diameter) and remained trapped for over 3 hours. The borehole was drilled for soil analysis and percolation tests for a proposed housing development. There were 80 such boreholes on the 443-acre site, most filled with water. Fortunately, the hole in which the child fell was on a high point of the property and the hole was initially dry.

Rescuers first on the scene could only see the boy's hair with his two hands over his head. He was down approximately 12 feet. Efforts to loop a rope around the boy's hands were unsuccessful. His hands were too small and he could not either hear or understand calls to grab the rope. An oxygen line was dropped to supply the boy with air. Rescuers using shovels and a backhoe slowly and carefully excavated a rescue shaft adjacent to the borehole. Once the shaft was below the level of the boy, the rescuers tunneled across to the borehole using an ice cream scoop, spatula and coffee can. Unfortunately, a compacted clay slowed progress. Water was also beginning to fill both the shaft and the borehole. Eventually, rescuers broke into the borehole at the boy's feet and were able to pull him into the rescue shaft. Nothing was wrong with the boy.

The rescue effort involved the combined effort of various police, fire, and first-aid squads, private contractors (supplying two backhoes and a crane) and numerous government agencies (including the U.S. Army Corps of Engineers). A number of factors prevented a more tragic ending. These included the facts that the child fell into one of few dry boreholes on the site, his mother quickly discovered him in the hole, and the closest fire station was across the street from the site.

The environmental and safety risks posed by open boreholes are clear. The open holes may also represent a legal liability to the geotechnical contractor responsible for the conditions.

UNIVERSITY OF MINNESOTA - CIVIL AND MINERAL ENGINEERING

October 27-31, 1986 *Computer Modeling of Groundwater Flow and Transport* in Minneapolis Minnesota. A one-week short course will be offered on the application of computer models to regional groundwater flow and transport. The program is summarized as follows:

Day 1: Basic concepts.
Day 2: Elementary analytic solutions.
Day 3: The analytic element method.
Day 4: Finite element and finite difference methods.
Day 5: Contaminant transport.

The lectures will be accompanied by computer demonstrations, utilizing large-screen projectors. Participants will have continuous access to 15 IBM personal computers, and will follow the examples given by the instructors on their own machines. The lectures will be interspersed with problem-solving sessions. All evenings will be dedicated to hands-on computer modeling; the instructors will remain available for individual assistance for as long as the demand requires.

Participants will receive complete sets of lecture notes on all material covered, as well as five diskettes with various computer programs, including an analytic element model and several finite element programs.

The instructors are Professor Arnold Verruijt, Delft University of Technology, The Netherlands, and Professor Otto D. L. Strack, University of Minnesota.

The course is intended for engineers and scientists active in the field of groundwater flow and transport modeling. Participants are expected to have a working knowledge of elementary algebra, and should have some familiarity with differential equations and computer programming. The course is intended primarily to provide the participants with a working knowledge of powerful modeling techniques that are not as commonly used in the US as the finite element method. However, the finite difference method will be covered as well.

For further information call or write to:

Mrs. Rita Mendenhall,
Program Coordinator
University of Minnesota
Department of Civil and Mineral Engineering
500 Pillsbury Drive, S. E., Room 292
Minneapolis, MN 55455
(612) 376-7630 or (612) 727-1703

NEW PUBLICATION FROM THE FRESHWATER FOUNDATION

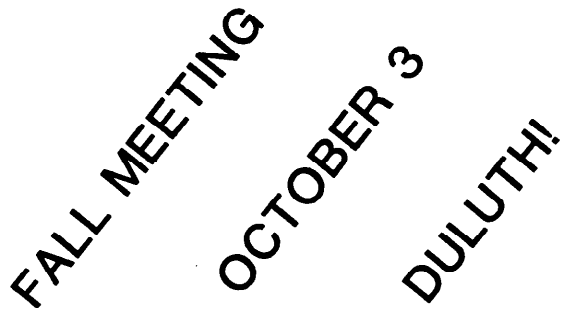
Water Values and Markets: Emerging Management Tools is the title of the Freshwater Foundation's 1986 Special Report, just published and now available.

This 56-page document examines the implications of treating water as a valued commodity and provides a national perspective on the changing economics of a new era in water management.

This report brings together commentaries from governors, lawyers, economists and policymakers on the challenges we face in moving from an era of water management marked by political subsidy to one of water management guided increasingly by water values and market mechanisms.

This Report seeks to provide insight into this time of transition by examining issues of concern, highlighting examples of emerging state responses, and challenging water managers of today to prepare for the changing economics of a new era in water management.

Copies of this Special Report are available from the Freshwater Foundation for $11 ($10 plus $1 postage), 2500 Shadywood Road, Box 90, Navarre, MN 55392. Bulk discounts are available.



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Possible future seminar topics which have been suggested include landfill hydrogeology, underground storage tanks, contaminated ground water treatment, professional liability insurance, and the effects of the moon's gravitational force on ground water flow.

Did you know that there is a **PEOPLE** section in this newsletter? Use it to share information about promotions, new employees, job changes and other news about MGWA members. For the next newsletter, just send your news about people to MGWA Newsletter, P.O. Box 3362, St. Paul, MN 55165.

Jim Stark (USGS) has a great idea for an annual winter meeting. Ask him about it the next time you see him.

The last time I wrote an introduction for the newsletter, Kevin Powers (editor of the newsletter) told me I had to make it a little longer. Since I have run out of important things to write about, I thought I'd share a few impartial observations about life at the MPCA. How many of you have noticed the stylish blue stereo headphones being worn by those trendsetters at the MPCA this fall? Very hip. Rumor has it that double-decker desks (bunk desks?) are being considered for their new offices over in St. Paul if they continue to add staff as fast as they have in the past.

Also in regards to the MPCA offices, I heard that a consultant sent a new hydrogeologist over there 6 weeks ago to deliver a proposal on the second floor. Well, that young man got lost in the maze of walls, desks, and piles of files and maps and hasn't been heard from since. But the owner of the consulting firm is happy; the proposal made it in on time.

See you all at the fall meeting in Duluth.!- *Jerry Rick.*

MGWA MEMBERSHIP APPLICATION

Annual Membership Dues: _____ Individual-$10/Year, _____ Student-$5/Year
Make checks payable to: Minnesota Ground Water Association
P.O. Box 3362, St. Paul, MN 55165

Name: _____

Mailing Address: _____

City, State, Zip: _____

Telephone Number: (_____) _____

CALENDAR

October 16-17, 1986 *Pesticides and Ground Water Conference.* St. Paul, Minnesota. This conference will focus on the growing Midwestern and national concern about pesticides in ground water, the drinking water source for 97% of rural America. Discussions will include factors influencing pesticide leaching, chronic health effects of pesticides, pesticide regulation and standard setting, regulatory and innovative approaches to protection of ground water resources, and Changing responsibilities in the agricultural and agribusiness community. Contact the Health and Environment Network, 2500 Shadywood Road, Box 90, Navarre, Minnesota, 55392 or call (612) 471-8407.