

# MINNESOTA GROUND WATER ASSOCIATION

NEWSLETTER v.2 n.2

JANUARY 1984

Early morning, first cup of coffee, phone rings!

"Good morning, Mr. Ground Water speaking, may I help you?"

"Morning, my name is Mr. A. Tourney and I represent a client who has a water problem. We are looking for an expert witness to help us present our case in court. My client's well water is being contaminated by a large firm which is recklessly pumping hazardous wastes into an underground river which feeds my client's well. The company is over in the next county. Would you be interested in working with us?"

"Uh, sure! I have never been an expert witness before and I'm not too familiar with hazardous waste though I know something about it. Let's meet, I am an expert on ground water, we need to talk about that underground river theory!"

If you do not know what is in store for Messrs. Ground Water and A. Tourney, then you should attend our next meeting and learn about: "The Professional as an Expert Witness." The legal profession and the people they represent are relying more today than ever on the expert witness, particularly in litigation involving ground water. But do we know what is expected and how to present a convincing and simple explanation to a complex subject? Are you familiar with the language that an attorney uses; and are attorneys familiar with our vocabulary? How do you prepare, what will happen when you testify, who can see your preliminary data and reports? This will be a half-day seminar at the Earle Brown Center on the St. Paul campus. There will be three speakers: an attorney, Steve Halverson; a professional geologist, Terry Swor; and a hearing examiner, Myron Greenberg. Please send in the advance registration form, there is no fee except to non-members, details of the meeting are inside. I wish to thank the Minnesota-Wisconsin chapter of the American Institute of Professional Geologists for introducing me to this topic at their annual meeting in 1982.

There are several other events occurring and details for all of them are inside the newsletter. I particularly would like to point out the noon hour presentation by Mr. Edward Krinsky of The Institute for Environmental Mediation. If you are not familiar with the mediation process or the Institute, I suggest you attend this presentation. This is an informal meeting for MGWA members, we are co-sponsoring Mr. Krinsky presentation with the Environmental Law group at William Mitchell. By now I hope you have received a brochure for the short course "Computer Modeling of Regional Groundwater Flow." I would like to thank Drs. Strack and Haitjema for organizing the class and Kelton Barr who was the MGWA contact with the University of Minnesota. If you have any questions please call Cheryl Jones at the University 612/373-3173. There is also a short course on geophysical well logging at Winona State University in March. The fee is so unbelievably cheap you simply can't pass it up, details are inside. The MGWA will be one of many co-sponsors working with the Minnesota Environmental Education Board (MEEB) for a Ground Water Conference in Brainerd this April. The conference will be for the general public and local decision makers. If you are interested, please call me at 612/296-0431. Pat Leonard-Mayer will be anxiously awaiting for all of you to submit your research articles for the spring newsletter. I hope to see you at the seminar in March.

Gil Gabanski, President

A paper written by Thomas C. Chamberlin and published nearly a century ago is important today as an early record in the history of hydrology. The paper, "The requisite and qualifying conditions of artesian wells"<sup>1</sup>, was well-known according to Meinzer (1942) and is still cited today as a statement of the classical theory of artesian flow.<sup>2</sup> Chamberlin's work is important for another reason. From today's perspective, we can appreciate that he was laying the foundation for the profession of hydrogeology: he showed how to combine the science of geology with a practical knowledge of drilling and resource management, for the purpose of obtaining ground water to meet the needs of society. The purpose of an article now being prepared is to recognize the contribution made by Chamberlin to the field of hydrogeology, as it is reflected in his paper, and to encourage hydrogeologists to read and re-evaluate the early work accomplished in their field. Although we share a common perspective with Chamberlin, almost everything else has changed since his day. The purpose of this short article is to share some of the interesting information, from Chamberlin's paper and other sources, about hydrology a century ago.

From 1870 through the end of the century, there was a great deal of activity around the country in the development of ground water supplies, and many of the artesian basins of the country were discovered during those three decades.<sup>3</sup> It is not difficult to appreciate the value of artesian aquifers at that time. Artesian wells provided a constant source of good quality water that did not need pumping and that would not freeze in pipes in the winter. Thompson (1929) commented on the early development of artesian wells and provided some surprising data. According to Thompson, an artesian well at Hitchcock, South Dakota, drilled in 1885, had a flow of 1.8 million gallons per day when it was measured in 1891; a well at Springfield was also measured in 1891 and had a flow of 4.75 million gallons per day. The Springfield well was used to furnish power to a flour mill.

Chamberlin provided information about drilling methods (p. 169) and the cost of drilling (p. 170). He reports that the cable tool method of drilling was used most often to drill water wells ("modifications of the ancient chisel drill, which, by being lifted and let fall, cuts its way into the rock"). To a limited extent, the diamond drill was coming into use ("an iron tube, armed at its lower extremity with cutting diamonds so placed that when rotated the tube cuts its way into the rock"). In shallow drift, however, the cheaper and simpler drive points were used ("a tube, armed with a conical point, and a section of perforated pipe, forced into the ground ... until the perforated section reached the porous stratum"). Drilling rates for sedimentary rocks were approximately \$2 to \$3 per foot for the first 1000 feet, with an increase of \$.50 per foot for each 500 feet below that down to the limits practicable for drilling; rates were higher for crystalline rocks. These rates did not include the cost of "tubing" (casing).

1. The paper was published in the Fifth Annual Report U.S. Geological Survey (1885), pp. 125-173.
2. See, for example, the 1979 Groundwater text by Freeze and Cherry, p. 199.
3. O.E. Meinzer summarized the history of surface and ground water hydrology through the early 20th Century in Chapters I and X (a. and b.) of Hydrology, Meinzer, O.E., ed., Dover Publications, Inc., N.Y., 1942, 712 pp.

Chamberlin acknowledged that when a bed under artesian pressure is encountered during drilling, it might be noticed by a change in the feel of the drill or by a change in the cuttings, but he argued that the only reliable check is to test each water-bearing stratum as it is encountered. For this he recommended packer tests. Chamberlin described the two types of packers in use, the seed-bag packer and the rubber packer. The seed-bag was apparently going out of use by 1885, but is the more ingenious device:

"A long, stout, leather bag is made in the form of a cylinder, open at both ends, and just the size of the well-bore. This is slipped on the lower end of the pipe, and the bottom of the bag securely fastened about the tube by wrapping with marline. A thimble just above the line will aid in preventing slipping. It is then filled with dried flax-seed, and the upper end likewise closed around the tube. When thus adjusted it is lowered into the well to the point determined upon, and supported there until the seeds swell by absorbing water. This enlarges the bag so as to fit the bore tightly and shut off all water from rising outside the pipe, and so all is compelled to ascend through the tube to the surface, or, at least, as high as the pressure is competent to force it." (p. 157)

The rubber packer consisted of a series of washer-like rings of rubber that could be screwed together causing the rings to expand and fill the bore.

Finally, Chamberlin emphasized the importance of keeping accurate records, which should include "not only accurate measurements of the successive strata transversed, accompanied by careful notes on their character and a full suite of samples, but also a record of all features relating to their water-bearing nature. ... Again, when any defect in the first tubing and packing develops itself, a careful record is a valuable aid in detecting the nature and cause of the defect, and determining the means for its correction. The original driller may have thought his general observation and memory a sufficient guide for the first adjustment, but if years have passed, neither the driller nor his memory may be within available reach. The party contracting for the sinking of a well should invariably insist upon an accurate written record..." (p. 170-171)



FIG. 25.—Seed-bag: a, delivery tube, leading to the surface of the well, and terminating below the seed-bag; c, a leather bag filled with dry flax-seed; b, marline wrappings to secure the end of the seed-bag.

Thompson, D. 1929. Discussion of The Origin of Artesian Pressure, *Economic Geology*, v. 24, p. 758-771.  
Meinzer, O.E. 1942. *Hydrology*, Chapter I. Dover Publications, Inc., N.Y.

A Special MGWA Lunch-Hour Meeting  
Using Mediation to Settle Disputes  
Involving  
Natural Resources

Edward B. Krinsky, Institute for Environmental Mediation

February 9, 1984, 12:00 - 1:30, William Mitchell College of Law, Saint Paul

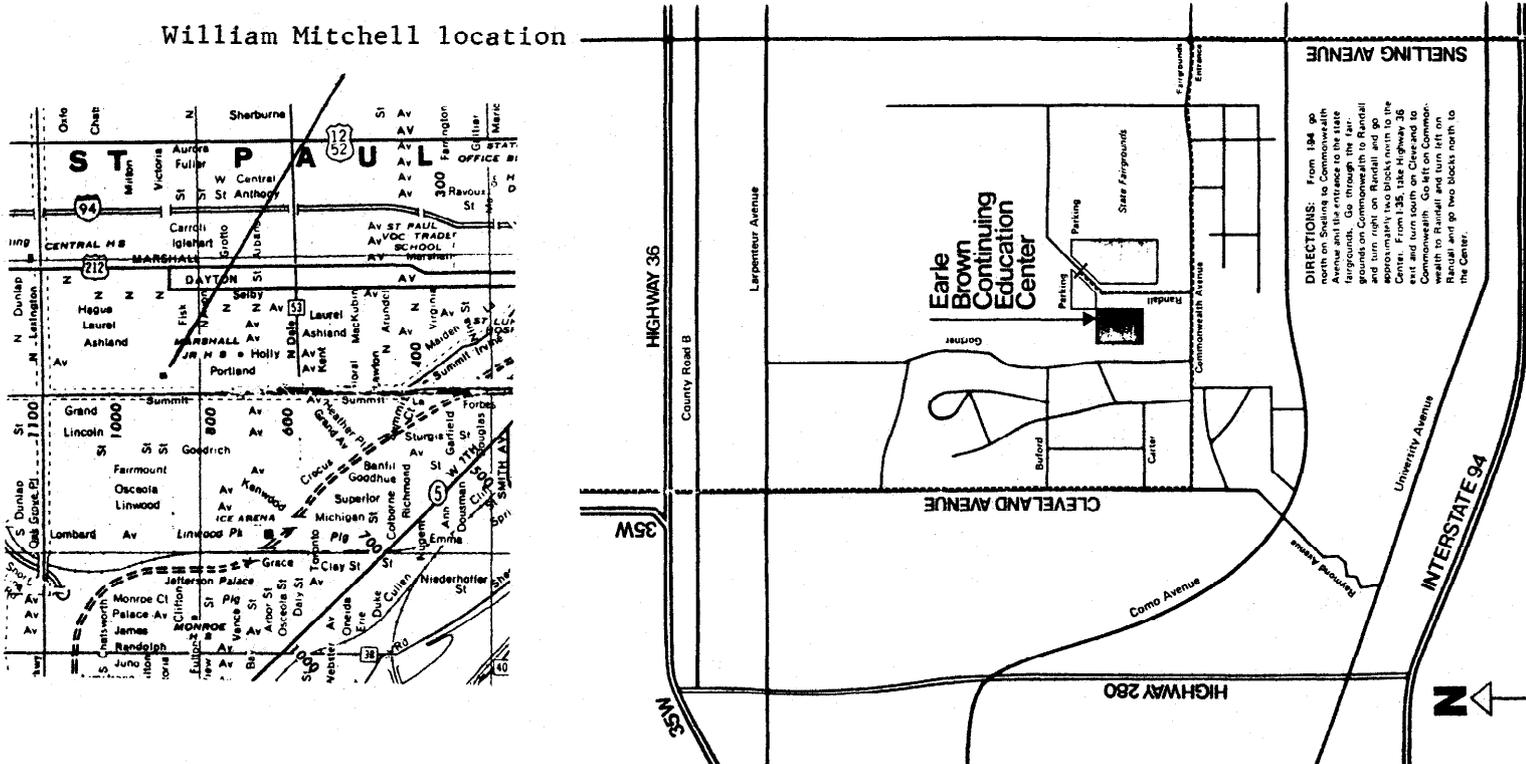
Edward Krinsky, the Director of the Institute's Madison office will explain the mediation process, when mediation can be used, and what you should ask before entering mediation. In addition, he will describe a number of case histories involving water resources.

The Institute for Environmental Mediation is a national center for the development and use of mediation to settle disputes involving natural resources. As successor to the Office of Environmental Mediation at the University of Washington, the non-profit Institute continues the effort that began in 1973. It is funded primarily by foundations and can provide, usually at no cost to the participants, mediators to help disputing parties negotiate their differences.

This presentation will be of interest to MGWA members who are likely to become involved in disputes - as lawyers, state or federal agency employees, expert witnesses.

Light refreshments will be provided; brown-baggers are welcome. Please register by mailing the form printed on a following page of the Newsletter.

William Mitchell location



MINNESOTA GROUND WATER ASSOCIATION WINTER SEMINAR

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THE PROFESSIONAL AS AN EXPERT WITNESS

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Date: March 7, 1984 (Wednesday)

Time: 1:00 to 4:00

Location: Earle Brown Continuing Education Center, St. Paul campus

The seminar is open to all members of the MGWA without charge, non-members may attend by joining the organization for \$10 (\$5 students). Please use the form in the newsletter and register by mail in advance so that arrangements and refreshments can be planned accordingly. Any questions should be addressed to Dennis Woodward (612/725-7842) or Gil Gabanski (612/296-0431)

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PROGRAM

- 1:00            Welcome.    Dennis Woodward, MGWA
- 1:10            "The Role of the Professional as an Expert Witness".  
Mr. Steve Halverson, Attorney.  
Hart and Bruner
- What is an expert witness; the use of experts in court; the function of the attorney and the expert, and fundamental rules for guiding the professional.
- 1:55            "Professional Practice Associated with the Expert Witness."  
Mr. Terry Swor, Geologist.  
Twin City Testing
- The relationship between the attorney and the expert and the necessity for upfront preparedness.
- 2:40            Break, refreshments
- 3:10            "The Hearing Examiner: the Eyes of the Beholder."  
Mr. Myron Greenberg, Asst. Chief Hearing Examiner  
Administrative Hearings Office
- The hearing process; how a hearing examiner views the expert's presentation; and what makes a presentation effective.
- 3:50            Gilbert Gabanski, questions and concluding remarks.
- 4:00            Adjourn

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Speakers will answer questions following individual presentations

## Meetings and Courses

The University of Minnesota is offering Computer Modeling of Regional Groundwater Flow, Feb. 27 - Mar. 2. The course is comprised of two parts--a three-day Basic Course and a five-day Extended Course. Detailed lecture notes will be provided for most of the lectures and there will be a limited opportunity for hands-on computer tutorials each evening. The fee for the Basic Course is \$145 and \$260 for the Extended Course. For further information, contact John Vollum, Program Director, at 612/373-3157, or call one of the MGWA Board members.

The Illinois State Water Survey and the State Geological Survey are presenting a Groundwater Monitoring Workshop in Champaign, Illinois on Feb. 27-28. The workshop is a practical course for those involved in implementing groundwater monitoring programs. The sessions are organized to take you step-by-step through the planning and execution of a monitoring program, from meeting regulatory requirements to possible remedial action. The fee is \$150. You may register by calling 217/333-8495.

A short course on Geophysical Well Logging will be held on March 23-24 at Winona State University. The course will cover the basic principles and techniques of geophysical well logging and is aimed at anyone interested in petroleum or ground water exploration or the interpretation of rock properties through geophysical data. The fee is \$15. For more information contact the WSU Geology Club, Winona State University, Winona, MN 55987 or phone 507/457-5260. You must register by Feb. 7.

The National Water Well Association's symposium Surface and Borehole Geophysics in Ground Water Investigations will be held in San Antonio, Texas on Feb. 7-9. Minnesota and Wisconsin researchers will be well represented on the program. For registration information, call David Nielsen at 614/846-9355. NWWA is also sponsoring a short course Design, Installation and Sampling of Ground Water Monitoring Wells (Mar. 19-21, Boulder, Colorado), the Second National Symposium and Exposition on Ground Water Instrumentation (Apr. 2-4, Las Vegas, Nevada), and other conferences and workshops. Call the number given above and check Ground Water for a complete schedule.

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The Minnesota Water Well Association, our sister organization, invites MGWA members to attend their annual meeting to be held at the Bloomington Marriot Motel on Feb. 6-8. For more information about the meeting or about MWWA call Gerald Ramsdell at 612/935-7100.

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A one-day conference Waste Management, Ground Water and Public Health will be held in Minneapolis late this spring. The conference, initiated by the Minnesota Public Health Association, will focus on the possibilities of ground water contamination from disposal of all types of wastes ranging from household to industrial, and the subsequent impact on public health. The program will include: overview of ground water hydrology; types of waste and disposal methods; toxicity and risk; the role of local officials. Other sponsoring organizations include the Freshwater Society, the Minnesota Department of Health, the Pollution Control Agency, the Waste Management Board, and the Minnesota Medical Association. For more information call the Freshwater Society at 612/471-7467.

Two other conferences are in the planning stage---the Crow Wing Environmental Education Council is planning a one-day conference in Brainerd in April concerning ground water in central Minnesota, and a conference hosted by a multi-county task force of county commissioners to be held in Rochester to discuss ground water protection in the southeast Minnesota karst region. For more information call Linda Bruemmer at the State Planning Agency 612/296-1424.

Bison Instruments is offering a three-day Geophysical Seminar on May 12-14. The seminar will focus on seismic refraction, seismic reflection, and earth resistivity. The cost is \$300 and includes a set of the Handbook of Engineering Geophysics, Vol. I and II and other materials. For more information call 612/926-1846.

The Environmental Law Society at William Mitchell College of Law will be sponsoring a program on Feb. 22 concerning the effects of pesticides. Planning is still underway at this time. For more information call Pat Leonard-Mayer at 612/725-4588.

#### RESEARCH ABSTRACTS

The Association invites all members to send in abstracts describing your current research projects. The abstracts will be printed in the April MGWA Newsletter. Abstracts should be approximately 200 words and should be received by MGWA before April 1st. Include the name and phone number of a contact person.

Students and those doing research in the non-science fields are encouraged to contribute as well as members of the scientific community. The response to this feature in last year's Newsletter was very enthusiastic, both on the part of readers and contributors. Share your ideas - send in your abstract and encourage your students and colleagues to do so.

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## Short Notes

A slide/tape show "Groundwater Pollution in Southeast Minnesota's Karst Region" is available; contact Roger Steinberg, Ag Extension, Rochester, MN, 612/926-6223.

U.S. EPA Region V is now publishing an Environmental Events Calendar. It will be published twice a month, on the first and the 15th and is free to interested parties. To have an event listed, send information to Editor, Environmental Events Calendar, Office of Public Affairs, SPA-14, U.S. EPA Region V, 230 S. Dearborn St., Chicago, Illinois 60604. The deadline for listing an event is 15 days preceding the publication date. (WWJ, Nov. 1983)

A guide to help AGU members communicate with legislators and government agency officials is free from AGU headquarters. AGU's Guide to Legislative Information and Contacts outlines steps in the legislative process and lists sources of information on legislation. It also gives guidelines on providing scientific testimony, and explains some of the constraints under which AGU must operate in legislative activities. To get a copy, call AGU Member Programs at 202/462-6903 x262. (EOS, Dec. 6, 1983)

If you missed the Spring MGWA Meeting, see Ground Water, v.21, n. 6, p. 666. Mary Anderson wrote the Guest Editorial, based on her talk to the Association in May.

The US Interior Dept. Office of Water Policy has published a new directory of government ground water programs and activities. Copies are available through the National Technical Information Service, US Dept. of Commerce, 5285 Port Royal Road, Springfield, VA 22161. (WWJ, Dec. 1983)

Despite a need to consolidate federal ground water activities, no national legislative or regulatory effort is likely to emerge this year or next. Most congressional and agency staffers working on ground water policy predict "a continued pecking away at the issues via slow changes in more than a dozen existing laws dealing with some aspect of water quality or quantity." (ENR, Nov. 24, 1983, p. 12)

Kelton Barr's report on certification and registration of hydrologists has not been completed because responses were not received from all interested parties. When the article is completed, it will be made available to members in the Newsletter or as a separate mailing.

The Association has obtained copies of many of the reports described in the Newsletter. Some will be available at the coming MGWA meetings so that members can look them over or borrow them. If you don't see them around at the meeting, ask.

## Lost: Earth Science

In the November 1983 Geotimes, A.G. Unklesbay writes that the long-awaited report of the National Science Board's Commission on Precollege Education is now available. The report makes many good recommendations, but leaves a very serious gap: earth science. The section on "Suggestions for course topics and criteria for selection" (p. 92-102) makes no mention of geology. There is no suggestion that knowledge of the Earth is important in any way. There is no recognition that we live in a society that has a minerals-based economy.

Unklesbay, who is the Executive Director of the American Geological Institute, makes a plea to geologists - to make your local school people aware of earth science and to help your local science teacher explain earth science to the students. He also recommends that you get a copy of the report, read it, write to the commission and tell them what you think. The report, Educating Americans for the 21st Century: a plan of action for improving mathematics, science and technology education for all American elementary and secondary students so that their achievement is the best in the world by 1995, is available from the Commission on Precollege Education, National Science Foundation, Washington, D.C., 20550. Single copies are free.

## Public Education Committee

The MGWA Public Education Committee can help you locate educational materials to prepare a presentation to your local school or civic organization. The Committee has slides and brochures and can help you to order films and contact speakers. In the past week, the Committee contributed materials for a talk to the Lions Club in Cambridge and for a presentation before the Cottage Grove City Council.

Loni Kemp is back at work on the Ground Water Project and the Committee will continue as before, reviewing newspaper articles, the drafts of the Model Ground Water Ordinance, and attending meetings of the advisory group. Very soon we will be reviewing the videotape, which is nearing completion.

The Minnesota Environmental Education Board is putting together a proposal to the Joyce Foundation for ground water educational materials. Pam Landers of the Regional Environmental Education Council in Brainerd (218/828-2663) is compiling ideas from all the regional councils. Brad Sielaff (612/296-7753) is writing a proposal for the Metro area and welcomes input from interested persons.

The DNR's Information and Education Bureau is working with the Division of Waters on a 30-second public service announcement on the importance of ground water. The script is appropriate for either TV or radio. The psa should be released in March.

Pat Leonard-Mayer  
Linda Bruemmer

## SPECIAL FEATURES

### ANALYTICAL FUNCTIONS FOR A MICROCOMPUTER

So you bought a microcomputer. You use it for word processing, and data management, but you still whip out your trusty tables whenever you have to compute a well drawdown or analyze a pump test? Shame, shame. Your microcomputer is a powerful tool for evaluating the many analytical functions commonly used in hydrogeology.

Presented below are some subroutines written in the Microsoft BASIC computer language that should run on any of the common microcomputers with little or no modification. These subroutines may be used to replace table look-ups or may be the basis of well field simulation programs.

The most common function in hydrology is the Theis well function or exponential integral. The Theis well function is used to compute the nonsteady drawdown for a constant discharge well in a confined, homogeneous aquifer of infinite extent. Drawdown is computed as:

$$s(r,t) = (Q/4\pi T) W(u)$$

where

$s(r,t)$  = drawdown at distance,  $r$  and time,  $t$ .  
 $Q$  = constant discharge rate  
 $T$  = transmissivity  
 $W(u)$  = Theis well function  
 $u = r^2 S / Tt$   
 $r$  = radial distance  
 $t$  = time  
 $S$  = storage coefficient

The short BASIC subroutine presented below calculates  $W(u)$  as a function of  $u$ . The user must write a main program in BASIC that inputs or calculates  $u$ , calls this subroutine, and finally outputs  $W(u)$ . Two different equations are used to calculate  $W(u)$ , depending on whether  $u$  is less than or greater than 1. The argument  $u$  must be greater than zero. This approach is faster than the common series representation given in many hydrogeology textbooks.

```
50000 REM THEIS WELL FUNCTION SUBROUTINE
50010 REM
50020 REM ENTER THIS SUBROUTINE WITH A VALUE ASSIGNED TO U
50030 REM WU, THE WELL FUNCTION IS RETURNED
50040 REM
50050 IF U>1 THEN 50090
50060 WU=-LOG(U)-.577216+U-.24991*U^2+.05520*U^3-.00976*U^4
+.001079*U^5
50070 RETURN
50080 TZ=U^4+8.57333*U^3+18.059*U^2+8.63476*U+.26774
50090 TY=U^4+9.57332*U^3+25.633*U^2+21.1*U+3.9585
50100 WU=TZ/TY/U/EXP(U)
```

30110 RETURN

Another common analytical function in hydrology is the Hantush-Jacob leaky well function. The leaky well function may be used to compute the nonsteady drawdown from a constant discharge well in a leaky, homogeneous aquifer of infinite extent. The overlying aquitard is assumed to have no storage and leakage is not assumed to affect the head in the aquitard. Drawdown is computed as:

$$s(r,t) = (Q/4\pi T) W(u,r/B)$$

where

$s(r,t)$  = drawdown at distance,  $r$  and time,  $t$ .  
 $Q$  = constant discharge rate  
 $T$  = transmissivity  
 $W(u, r/B)$  = leaky well function  
 $u = r^2 S / Tt$   
 $r$  = radial distance  
 $t$  = time  
 $S$  = storage coefficient  
 $B = (Tb'/K')^{.5}$   
 $K'/b'$  = leakance

The short BASIC subroutine presented below calculates  $W(u,r/B)$  as a function of  $u$  and  $r/B$ . The user must write a main program in BASIC that inputs or calculates  $u$  and  $r/B$ , calls this subroutine, and finally outputs  $W(u,r/B)$ . Two different approaches are used to calculate  $W(u,r/B)$ , depending on the relationship between  $u$  and  $r/B$ . When  $u$  is small compared to  $r/B$  squared, the leaky well function is equal to twice the value of a modified Bessel function of the second kind, order 0, with argument  $r/B$ . This is the steady state value of the leaky well function where the discharge is entirely supplied by leakage. There are two separate subroutines for the evaluation of the Bessel function depending on the value of the argument. When  $u$  is large compared to  $r/B$  squared, a little known series approximation of the leaky well function is used. This series approximation is much more efficient than a numerical integration of the function. The argument  $u$  must be greater than zero.  $r/B$  must be positive and small, say less than 5. The subroutine below calls the Theis well function subroutine that is given above.

```
60000 REM HANTUSH-JACOB LEAKY WELL FUNCTION
60010 REM
60020 REM THIS SUBROUTINE EVALUATES W(U,R/B), THE LEAKY WELL
60030 REM FUNCTION OF HANTUSH-JACOB WHICH ASSUMES NO STORAGE IN
60040 REM THE CONFINING LAYER
60050 REM
60060 REM ENTER THIS SUBROUTINE WITH VALUES OF U AND RB (R/B)
60070 REM WH- THE LEAKY WELL FUNCTION IS COMPUTED FOR EXIT
60080 REM
60090 REM IF U IS SMALL COMPARED TO RB THEN ASSUME U=0
```

```

60100 IF U<(RB*RB)/22. THEN GOSUB 60290 ELSE GOSUB 60150
60110 RETURN
60120 REM SERIES APPROXIMATION FOR HANTUSH-JACOB WELL FUNCTION
60130 REM USES APPROXIMATION OF CASE AND ADDIEGO,
60140 REM JOURNAL OF HYDROLOGY, VOL. 32 (1977)
60150 GOSUB 50000:REM CALL THEIRS WELL FUNCTION
60160 W2=WU
60170 NF!=1:SW=0
60180 REM THE FOLLOWING LOOP IMPLEMENTS THE INFINITE SERIES
60190 REM 15 TIMES THROUGH THE LOOP GIVES GOOD ACCURACY
60200 REM INCREASE FOR MORE ACCURACY, DECREASE FOR SPEED
60210 FOR NI=1 TO 15
60220 W2=(EXP(-U)-U*W2)/NI: REM REPEATED EXPONENTIAL INTEGRAL
60230 NF!=NF!*NI:REM COMPUTE N FACTORIAL
60240 SW=SW+((-RB*RB)/4./U)(NI/NF!*W2:REM INFINITE SERIES
60250 NEXT NI
60260 WH=WU+SW:REM WH IS HANTUSH-JACOB LEAKY WELL FUNCTION
60270 RETURN
60280 REM
60290 REM MODIFIED BESSEL FUNCTION OF THE 2ND KIND, ORDER 0
60300 REM FOR ARGUMENT<2
60310 REM
60320 IF RB>=2.0 THEN 60370
60330 KO!=-LOG(RB/2.)*(1.0+.25*RB*RB+0.0156*RB^4)-.5772
+.42278*RB*RB/4.+.2307*(RB/2.)^4+.034886*(RB/2)^6
+.002627*(RB/2)^8+.0001075*(RB/2)^10
60340 WH=2*KO!:REM HANTUSH WELL FUNCTION=2*KO!
60350 RETURN
60360 REM
60370 REM MODIFIED BESSEL FUNCTION OF 2ND KIND, ORDER 0
60380 REM FOR ARGUMENT >2
60390 REM
60400 IF RB>10.0 THEN WH=0:RETURN:REM LARGE RB =ZERO DRAWDOWN
60410 KO!=(1.2533-.156647/RB+.0875827/RB/RB-.1285/RB^3
+.094/RB^4)/(SQR(RB)*EXP(RB))
60420 WH=2*KO!:REM HANTUSH WELL FUNCTION
60430 RETURN

```

```

W(u)= 4.03795
u ? .005
W(u)= 4.7261
u ? 5
W(u)= 1.14829E-03

```

Now alter our little test program to read.

```

10 INPUT " u ";U
15 INPUT " r/B ";RB
20 GOSUB 60000
30 PRINT " W(u,r/B)= ";WH
40 GOTO 10
50 END

```

Now run the program and enter values of u and r/B. You should see values of W(u,r/B) correct to three or four significant figures.

```

u ? .01
r/B ? .0001
W(u,r/B)= 4.03793
u ? .1
r/B ? .0001
W(u,r/B)= 1.82292
u ? .01
r/B ? .1
W(u,r/B)= 3.81502

```

by Donald Koch  
Koch and Associates

Type the above subroutines into your microcomputer and save them (IMPORTANT STEP, ALWAYS SAVE EVERYTHING CONSTANTLY). Now let's test them. Type in the short program below.

```

10 INPUT " u ";U
20 GOSUB 50000
30 PRINT " W(u)= ";WU
40 GOTO 10
50 END

```

Now run the program and enter values of u. You will see the values of W(u), correct to about 4 significant figures.

```
u ? .01
```

Our thanks to the Colorado Ground Water Association for permission to reprint this material from their Newsletter.

## FALL 1983 MEETING SUMMARY

The fall 1983 MGWA meeting featured Dr. Tom Winter, research hydrologist with the USGS in Denver. Tom discussed his research involving ground water interaction with lakes; and, in particular, the problem of constructing, installing, and measuring piezometers to insure precise and accurate hydraulic head levels. Several references were mentioned, in addition to references of Tom's work, and various members have asked if they could be listed in the newsletter. Approximately 80 people attended the meeting at the auditorium of the St. Paul Vocational-Technical Institute. Unless we get overwhelmed with mail, we will probably use the Vo-Tech for future evening meetings.

Erickson, D. R., 1981, A study of littoral groundwater seepage at Williams Lake, Minnesota using seepage meters and wells: M.S. Thesis, Univ. of Minnesota, Mpls., 135p.

Hvorslev, M. J., 1951, Time lag and soil permeability in groundwater observations: U.S. Army Corps Engrs. Waterways Exp. Sta. Bull. 36, Vicksburg, Miss. (PLEASE NOTE: this publication is hard to find, if you want a copy please call Gil Gabanski, he has a few extra xerox copies)

Siegel, D. I., and T. C. Winter, 1980, Hydrologic setting of Williams Lake, Hubbard County, Minnesota: U. S. Geol. Survey Open-File Rept. 80-403, 56p.

Winter, T.C., 1976, Numerical simulation analysis of the interaction of lakes and ground water: U. S. Geol. Survey Prof. Paper 1001, 45pp.

Winter, T. C., 1978, Numerical simulation of steady state three-dimensional groundwater flow near lakes: Water Resour. Res., 14(2), 245-254.

Winter, T. C., 1981, Uncertainties in estimating the water balance of lakes: Water Resour. Bull., 17(1), 82-115.

Winter, T. C., 1983, The interaction of lakes with variably saturated porous media: Water Resour. Res., 19(5), 1203-1218.

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### MGWA ELECTIONS

Congratulations to Tom Clark and Gretchen Sabel. Tom was elected as Membership Director and Gretchen as Treasurer for the 1984-85 term.

REGISTER FOR COMING MGWA MEETINGS TODAY

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I will attend the MGWA Lunch-Hour presentation Using Mediation to Settle Disputes Involving Natural Resources to be held at William Mitchell College on February 9th.

Name \_\_\_\_\_

Mail to Pat Leonard-Mayer  
268 Cecelia Place  
St. Paul, MN 55105

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I will attend the MGWA Winter Meeting The Professional as Expert Witness to be held at the Earle Brown Center on March 7th.

Name \_\_\_\_\_

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

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Join the Minnesota Ground Water Association

MGWA sponsored activities are paid for with dues and contributions from our members. If you wish to attend MGWA meetings and seminars and to receive the quarterly Newsletter, please become a member of the Association.

Dues are \$10.00 (\$5.00 for students). Send to MGWA, P.O. Box 3362, St. Paul, MN 55165.

Board of Directors

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USGS, 612/725-7841

Kelton Barr, Secretary  
Barr Engineering, 612/920-0655

Gretchen Sabel, Treasurer  
MPCA, 612/296-7318

Tom Clark, Membership  
MPCA, 612/296-7791

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Material for the MGWA Newsletter can be mailed to

MGWA  
P.O. Box 3362  
St. Paul, MN 55165

or to Pat Leonard-Mayer at  
Minnesota Dept. of Health  
717 S.E. Delaware Street  
P.O. Box 9441  
Minneapolis, MN 55440

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## The Ad Hoc Minnesota Ground Water Committee

As a follow-up to the work that state agency staff did last year to coordinate ground water proposals for the Legislative Commission on Minnesota Resources, several meetings of ground water staff have been convened to discuss current projects. The committee is also an informal forum which meets whenever members feel there is a need to discuss issues and ideas relative to the state's ground water programs. Meetings tend to be called on a quarterly basis.

On January 5, a meeting was held to address activities in the area of public education. Topics included on the agenda were:

The PCA and SPA ground water report,  
A DNR public service announcement,  
A ground water public education proposal to the Joyce Foundation from the Mn Environmental Education Board,  
The Citizens League Committee on Ground Water Supply and Quality,  
County geologic atlases being prepared by the MGS,  
Upcoming regional ground water conferences.

Additional details, copies of minutes and future meeting notices may be obtained from Linda Bruemmer, Environmental Division, State Planning Agency, 297-2375.

## Groundwater cleanup is a job for professionals.

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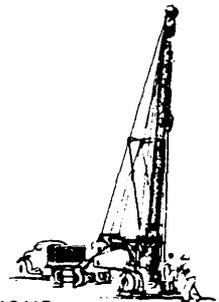
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CALENDAR \*

Feb. 6-8 Minnesota Water Well Association Annual Meeting, Bloomington  
Feb. 9 MGWA Meeting - Using Mediation to Settle Disputes Involving Natural Resources, St. Paul  
Feb. 7-9 Surface and Borehole Geophysics in Ground Water Investigations, San Antonio, Texas  
Feb. 22 Environmental Law Society Meeting - Effects of Pesticides, St. Paul  
Feb. 27-28 Groundwater Monitoring Workshop, Champaign, Illinois  
Feb. 27-Mar. 2 Short Course - Computer Modeling of Regional Groundwater Flow, U of M, Minneapolis  
Mar. 7 MGWA Winter Meeting - The Professional as Expert Witness, St. Paul  
Mar. 19-21 Design, Installation and Sampling from Monitoring Wells - Short Course, Boulder, Colorado  
Mar. 23-24 Geophysical Well Logging Course, Winona  
Apr. 1 Research Abstracts due to MGWA  
Apr. 2-4 Ground Water Instrumentation Symposium, Las Vegas, Nevada  
May 12-14 Bison Geophysics Seminar, Minneapolis  
\*\* Waste Management, Groundwater, and Public Health Conference, Minneapolis

\* see details inside



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