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Data from slug tests in the Silurian dolomite using a short-interval straddle-packer assemblage

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INTRODUCTION

This Open File Report presents the data and methodology for slug tests conducted in the Silurian dolomite of Door County using a straddle-packer assemblage. The data collection was initiated for a project entitled "Correlation of High-Permeability Zones with Stratigraphic Features in the Silurian Dolomite, Sturgeon Bay, Wisconsin". The final report for this project (Gianniny and others, 1996) contains a summary plot of data collected from corehole DR-394, located at the Jarmen Road research site. Subsequent to the completion of the above project, additional data were collected from a corehole (Dr-439) located in Bissen Quarry. Summary data from both coreholes can be found in Muldoon and others (1998), Muldoon (1999), and Muldoon and others (in review)

The purposes of this Open File report are to 1) document the field methodology, 2) outline the analytical procedures, 3) provide a summary of the calculated hydraulic conductivity values, and 4) archive the raw slug test data so that it will be available for analysis by other researchers. The packer testing of the Jarmen Road and Bissen coreholes was quite intensive both in terms of equipment preparation and actual test procedures. Several people, in addition to the author, conducted the field tests including Ken Bradbury, Ron Hennings, Wylie Linquist, Eric Oelkers, Pete Roffers, and Diane Stocks. A detailed set of instructions was written in order to insure uniformity in test procedures and those instructions have been included in this report. A field notebook and the slug test data sheets, used to record water levels and other details of the field data collection, are on file in the WGNHS project files. Analysis of the slug tests was completed by the author and those procedures are outlined in this report along with a summary of calculated hydraulic conductivity values.

A straddle-packer assemblage (figure 1) with an open-interval of 2.8 ft (0.85 m) was used to complete rising-head slug tests at 1.5-ft (0.46-m) increments in corehole DR-394. The open interval was shortened to 2.1 ft (0.64-m) and tests were completed at 2-ft (0.61-m) intervals in hole DR-439. Water-levels were monitored using pressure transducers and recorded with a datalogger. Tests were initiated 10 to 15 minutes after packer inflation and recovery was recorded for 10 to 15 minutes. Recoveries varied from 2 to 100%. A total of 258 slug tests were conducted in corehole DR-394 and 60 tests in DR-439. The raw data files from these tests are 577 pages in length. One hard copy has been included as Appendix I of this report. The data are also available on computer diskette and are contained in the following files:

DR394all.txt -- ASCII text file of the data from the individual slug tests from DR-394 (tab delimited),
DR394all.xls -- MicroSoft Excel 97 spreadsheet file of the same data,

DR439all.txt -- ASCII text file of the data from the individual slug tests from DR-439 (tab delimited),
DR439all.xls -- MicroSoft Excel 97 spreadsheet file of the same data

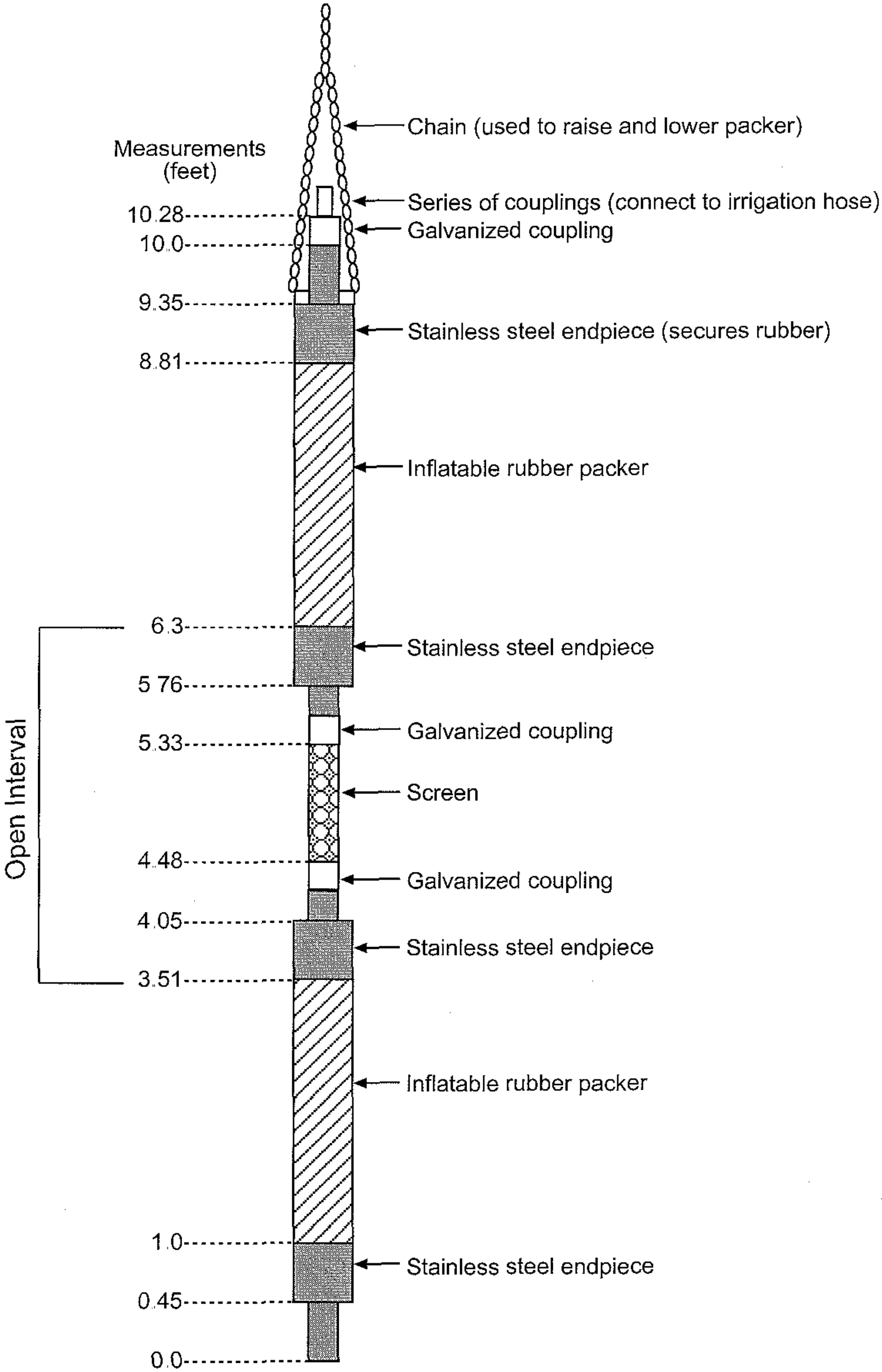

Figure 1. Diagram of straddle-packer assemblage (diameter 2-1/2 inches). Measurements (on left) show packer configuration for the Jarmen Road corehole (DR-394). The open interval was shortened (by reducing the length of the galvanized couplings and the screen segment) prior to the testing of corehole Bissen 19 (DR-439).

MEMO DESCRIBING SLUG TEST PROCEDURES

Instructions for Slug Tests at Jarmen Road Site Using Baski Packers and PST3 Datalogger 10/9/95 (revised 5/9/96)

Background

Mark Harris from UW-Milwaukee had this corehole drilled in May 1995. He performed some injection tests using straddle packers with a 10-ft spacing. We will be conducting slug tests using straddle packers with a 2.8-ft open interval. Water-levels at this site are quite variable. The depth to water for the deeper system ranges from approximately 90 to 180 ft below ground surface annually.

System overview

Packers were lowered to near the bottom of the hole (middle of open interval at 425 ft depth) and we'll conduct slug tests at 1.5-ft increments as we move the packers up the hole. 1-1/2" black plastic hose connects the packers to the surface and functions as the "well" in which we conduct the slug tests. 1/4" inflation tube also runs from the packers to the ground surface (this is external to the black plastic hose). The whole assembly (packers, black plastic hose, inflation line) is suspended by (and raised using) a safety chain and a winch/pulley system. Depths are marked in 5-ft increments on the safety chain

During the slug test, water levels will be monitored using an INW pressure transducer and recorded using a CR10 datalogger and Campbell Scientific's PST3 software.

Necessary equipment

•INW pressure transducer (pressure transducer with blue cable on spool)
•PST3 datalogger system (plastic case)
•laptop computer with PST software (AST 386)
    •power cord for computer that has cigarette lighter plug-in
    •extra 3-1/2" diskettes
•water-level tape (at least 180-ft long)
•slug attached to a rope/cable that's at least 180 ft long
    slug can't be much bigger than 1/2"-diameter or else both it and the transducer cable won't fit through the hose connectors for the black plastic pipe
•tool box (hack saw, electrical tape, Sharpie marker, screw driver, pliers)
•field book (yellow, "rite in the rain" notebook specifically for this project)
•slug test data sheets
•tank of compressed nitrogen
•2-stage regulator, set-up to connect tank of compressed nitrogen with inflation hose
•graph showing inflation pressure (psi) versus packer submergence (ft)
•geophysical log of the hole
•tape measure or folding wooden ruler at least 5 feet long, with markings in tenths and

hundredths of feet
•extra 12-volt battery and jumper cables (in case car battery runs down)

Beginning of day:

1. Determine if packers have been moved after the last test (should be recorded in field notebook); if not move packers to next position (see test procedure instructions below).

2. Measure water level and record in notebook

3. Connect computer and PST3 system.

•computer is powered from car battery using the power cord that plugs into the cigarette lighter. I have started using a 12 V marine battery rather than the car battery. This is because I have sometimes ended up draining the car battery after a day of testing (started 10:00 am, battery died about 4:30 pm). By using a marine battery, you won't end up with a dead vehicle at the end of the day.

•connect computer and datalogger using the cable that goes from the RS-232 port on the PST to the serial port on the back of the laptop

4 Set switches on PST system. There are 6 switches, 4 on left, 2 on right; set them as follows:

LEFT

method of recording data:	logarithmic
recording time:	elapsed time
time format:	min.00
water-level reference:	unadjusted level

RIGHT

scan:	**off** until you put transducer in the water **on** after putting transducer in water **off** while "recording" (see below)
recording:	**off** unless you want to record data to a file (turn **on** for slug tests and possibly for packer inflation)

Now skip ahead to **test procedures**, then come back and do the following step.

5. Set-up laptop for monitoring transducer (complete this step **after** installing transducer, see **test procedure** below)

•turn laptop on;

•kill the "metashell" program used with the geophysical logger
C:>metashell/k, enter

•get into the PST directory which is on the C drive:

C>cd pst, enter

•start the pst program
C:\pst>pst3, enter

•This brings up the main menu

•At the start of the day, you need to clear off files from the previous day Do this by choosing menu option D -- *Utilities*

•This brings up another menu; you want option H -- *erase all data from PST* Clearly you want to make sure that you have successfully downloaded data from the previous day before you do this or else you loose the previous day's work

Now ESC back to the main menu. Now you want option A -- *monitor wells in real time*

•this switches you to a screen that lists the current values for the transducers. It will only read if you have either SCAN or RECORDING in the **on** position and the transducer plugged into the PST box.

> -I like to read head to the hundredth of a foot. PST automatically reads this way if the head is in the 0 to 9 ft range. For heads > 10 ft, it only reads one decimal digit. You can change this by hitting **d** when you are in this screen.

•After installing transducer at beginning of day get into the graphical display in the following manner (I tend to stay in graphical mode almost all day.)

> hit **g** to switch to graphical mode. It will have a default display that automatically comes up. The graph range is -10 to 10 ft. This is not convenient for the range of water levels that we'll be monitoring so you need to changes levels
>
> hit **l**, this switches you to a screen where you can set parameters for the graph. The first line names the default parameter file which is "well". Scroll to that place; delete "well"; type in "JARMEN" instead, then hit enter. Then use ESC key to get back to graph.

Test procedure:
The steps for each test are summarized in the following list and then explained more fully below

- •install pressure transducer and slug
- •inflate packers
- •once pressure has stabilized, start test
- •record for 10 to 15 minutes (minimum .02 ft recovery)
- •let packers deflate while lowering slug into hole

•mark test position, then raise packers approximately 1 5 ft
•after running 3 to 4 tests, pull slug and transducer and cut off hose

1. Install pressure transducer and slug. -- This is pretty straightforward Put the transducer in first. The transducer is a 15 psi transducer and so it can measure about a 30 ft head range. You want to put it at a depth so that when the pipe is flush with the top of casing the transducer reads about 13 to 14. This way you can pull it up 3 tests worth (4.5 ft) and both the transducer and slug are still fully submerged I marked a spot with yellow electrical tape that worked pretty well when the depth to water was about 87 ft.

After lowering the transducer for the first time, connect the cable end to port 1 on the PST3 box. The pins are somewhat hard to see, but it only goes one way so just play around with it until you get it Once you've installed transducer, turn the SCAN switch on the PST box to **on** and go up and complete step 5 under Beginning of Day

The slug sometimes catches on the hose couplings that hold 100-ft lengths of the black hose together. If you get caught going down, just bounce the slug up and down a few times until it falls free As you get close to the slug SLOW DOWN. It's not good for the slug to go whipping into the transducer, so lower it slowly until you feel it go slack as it rests on top of the transducer. Pull it back a foot or so and then secure it using the pipe clamps on the pipe on the left hand side of the trailer.

NOTE: When you get close to the top of the water column, you need to pay more attention to depths The slug is about 5 ft long; the transducer should be about 1 foot below this. So when you get near the measured water level; lower the slug as far as it will go (but without any slack in cable) and make sure you always have enough water to cover the slug Eventually you won't have enough water to submerge the slug and then stop testing

You should see a pressure response after installing the slug; this tends to be an oscillating response that eventually dames out (after a minute or two). Once oscillations have stopped, **record** the "uninflated" water level on data sheet and the time (read time from the computer, it's in the upper right-hand corner of the screen when you're using the graphical interface).

2. Inflate packer -- When you first get to site, you'll need to attach the 2-stage regulator to the tank of compressed nitrogen; tighten it with a wrench so that there's no gas leak At the end of day you should probably take the regulator home with you.

•Make sure the "T-valve" is unscrewed (out rather than In) and then open the valve on top of the tank, the pressure will be recorded on the high pressure gauge.
•Connect the air line from the regulator to the inflation line from the packer This is a "quick-connect" couple and should snap into place.
•The inflation line from the packer also has a valve and gauge on it. Open that valve (unscrew in counter-clockwise direction).
•Use the T-valve on the regulator to let air into the inflation line; as you screw-in this

valve, air will start to flow into the inflation line. You can set the inflation pressure anywhere up to approximately 200 psi (the valve doesn't go higher than that). Determine inflation pressure using the graph of inflation pressure vs packer submergence. Air will continue to flow until the pressure in the packers and inflation line is equal to the pressure on the low-pressure gauge of the 2-stage regulator.
•Once inflation is complete; shut the valve on the inflation line, unscrew the T-valve on the two-stage regulator, disconnect quick connect coupling

3. Wait for pressure to stabilize -- Packer inflation causes a somewhat sinusoidal pressure response where pressure initially goes up and then drops to a lower value. For most of the tests that I ve run the pressure stabilizes within 2 to 3 minutes of inflation, however, for a few tests pressure continued to change over 5 to 10 minutes. For these, I waited until pressure was changing less than .01 ft in a minute and then I started slug test; maximum wait time should be in the 10 to 12 minute range.

Record the "inflated water level" on data sheet along with the time.

4. Run slug test -- Once pressure has stabilized; start slug test. The next four steps need to be completed as quickly as possible

- •**Record** start time on data sheet
- •Turn SCAN **off** and RECORDING **on**
- •Quickly but smoothly, pull slug approximately 10 ft out of hole. Glance over and note the starting water level and then secure slug cable to chain so that it doesn't fall back down (I tend to pin it down with the tool box which is heavy) It's not a good idea to pull it all the way out at this point because it tends to catch the transducer cable on the way out and so would artificially change the water-level reading.
- •**Record** "starting water level" for slug test.
- •Let test run approximately 10 minutes; I've been trying to wait for at least .02 ft recovery, but will only wait for 15 minutes and will then end test
- •Stop test by turning RECORDING **off**.
- •**Record** "ending water level" for slug test.

5. Move packer up approximately 1.5 ft -- Let the packers deflate as you drop slug back into the hole.

- •Deflate packer by opening valve on inflation line.
- •Before moving packer, mark the position of the top of casing (TOC) on the chain using a Sharpie marker, if possible also mark the position using a piece of colored electrical tape. When using tape, note if top or bottom of tape is the TOC position by drawing an arrow in the appropriate direction.
- •Use the winch to raise the packers. I measure 1.5 ft from the winch reel and use a piece of colored electrical tape to mark that distance on the nylon strap so that I know how far to lift the packers.

NOTE The packers can be difficult to lift and it is exceedingly important not to overstress the chain; if the chain snaps we loose everything down the hole Eric set-up a nice system with the vice grips so that the black plastic hose pulls up evenly as you raise the packers and this had made things go smoothly.

Once the packers are at the right position,

- mark position of TOC on chain
- measure
  - distance from previous mark
  - distance from 5-ft tape mark
- calculate the depth to the mid-point of the open interval and **record** this on the data sheet. So far these measurements have always been within .01 to .02 ft for me and I just average the two depths

Now you're ready to go back up to step 1 of test procedure and start again.

<u>6. Cutting black plastic hose</u> --After three tests, I pull the slug and transducer; raise the packers one more time and use the hacksaw to cut off black hose approximately level with TOC (being careful not to cut inflation line) This is also a good time to move the winch hook further back on the chain. To do this you need to support the packers by shoving a screwdriver through the chain. Flip the switch on the winch and give the chain enough slack so that the weight shifts off the chain and onto the screwdriver. Then pull out a length of strap and move the hook further back on the chain. I can't quite reach high enough, when standing on the trailer, to get the hook far enough for a full 4 packer moves. I've taken to climbing up and hooking it in further back on chain so that I can have enough strap for 4 moves (i.e. little over 6 feet).

Downloading the datalogger to PC

At the end of the day, download the data from the PST3 to the laptop.

From the graphical interface, use ESC key to get back to main menu

At the main menu choose option B - *Collect well.dat from PST and convert to RPT/ PRN files.*

This generates 3 files for each test They are automatically placed in the C:\PST\DATA directory. The default names are

TSTxxWLS.dat
TSTxxWLS.rpt
TSTxxWLS.prn

where the xx is a number starting with 01 and continuing until the last test.

When the files are downloaded, ESC from PST3 interface and return to DOS prompt. Use Quikfiler to create a new directory and copy the day's files into it.

NOTE
This is very important, because if you download again without copying the old files to a new directory, it will write over them because the program always uses the same default file names.

C:\PST>cd data, enter
C:\PST\DATA>qf, enter

This loads Quikfiler, a file management program The files in C:\PST\DATA are displayed on the left.

hit F1 key to create a subdirectory At the bottom of the screen, you'll see a place to type in the name of the subdirectory Type in the date (i.e. Sept27 or Oct11, etc).

Use arrow key to scroll up so that the cursor is on the new directory, **hit F4**, a new file list for the directory you just created should appear on the right hand side of the screen (at this point it's empty).

Use the arrow key to go back to the left-hand side of the screen.

Hit **T**, to "tag" all files. At the bottom of the screen it asks if you want to do this; use **Y** for yes.

Hit **M**, to move all files from the left-hand directory to the right-hand directory It will ask if you want to move files, again say **Y** for yes.

Now all the files are safely in a new directory If you're feeling ambitious (and comfortable with DOS or Quikfiler) you could rename them in the following format:

- keep the extensions as named by the PST system but change the first part of the filename to reflect the depth of the test

  for example a test at 409.54 ft depth would have three files named
  409-54.dat
  409-54.rpt
  409-54.prn

I tend to rename things at the DOS prompt using the following command

C:\PST\DATA\SEPT27>rename TSTxxWLS.* 409-54.*

This changes all three file names at once, you just need to insert the appropriate numbers for xx and the appropriate depth instead of 409-54.

SLUG TEST DATA SHEET

Location: Jarmen Road **Depth to Water TOCasing** (ft) ____________
Date: ______________

Test Depth	Uninflated Static water level	Inflated static water level	Time of start	Starting water level	Ending Water level (time)

ANALYSIS METHOD

Slug test data were analyzed using the Hvorslev (1951) method. Since data recording was initiated prior to slug removal the first step in the analysis procedure was to determine the start time and initial head displacement. Initial head displacement varied between tests for a variety of reasons. A smaller-diameter slug (approximately 0.6-inch diameter) was used in DR-394 (Jarmen Road) Connections between the 100-ft lengths of the black plastic hose narrowed the diameter of the standpipe. As the transducer cable also had to pass through the connectors, a narrow slug was used. In most cases, the initial head displacement was on the order of 1.0 to 1.4 feet (see Appendix I). In DR-439 (Bissen hole 19), a larger diameter slug (approximately 1-inch diameter) was used when possible. Calculated initial head displacements were approximately 2.4 feet for the larger-diameter slug and 1.1 ft for the narrower slug (see Appendix I).

Start times were chosen by examining the data files and noting when the head displacement reached it's maximum value; in cases where the start point was somewhat ambiguous the head data were plotted versus elapsed time in order to chose the most appropriate point. Once the start point was chosen, elapsed test time was calculated by subtracting the start time from the elapsed time recorded in the data files. The initial head reading (H) and the initial displacement (H_o) were noted in the data file and used to calculate

$$\frac{H-h}{H-H_o}$$

where

H is the undisturbed initial head reading,
H_o is the head reading at the start of the test (t=0),
h is the head reading at time t > 0.

The geometry of borehole and the packer assemblage allowed use of the simplified version of the Hvorslev equation which is applicable when the length of the open interval is more than eight times the radius of the borehole (L/R > 8):

$$K = \frac{r^2 \ln(L/R)}{2LT_o}$$

where K is hydraulic conductivity,
r is the radius of the standpipe,
R is the radius of the borehole,
L is the length of the open interval,
T_o is the time is takes for the water level to recover to 37% of the initial change.

T_o was calculated from a semilog plot of elapsed test time (x-axis, arithmetic) versus $H-h/H-H_o$ (y-axis, logarithmic). Data were plotted using the Golden Software's *Grapher* ™ program and an exponential line of the form

$$Y = exp\ (c1*x) * c2,$$

where c1 and c2 are fitting coefficients, was fit to the data Copies of the semilog graph for each test can be found in WGNHS project files.

T_o was calculated as

$$(-1 - \ln c2)/c1.$$

The next section contains summary data for each test including:

- field-measured depth from top of casing,
- corrected depth from top of casing,
- depth from ground surface,
- coefficient c1,
- coefficient c2,
- calculated T_o (min),
- calculated T_o (sec),
- hydraulic conductivity, K (ft/sec),
- hydraulic conductivity, K (cm/sec).

In some cases, most often in zones were test recovery was extremely rapid, several tests were conducted over the same interval. In these cases, the geometric mean of tests from the same interval was used in the summary plots in Gianniny and others (1996), Muldoon and others (1998), Muldoon (1999), and Muldoon and others (in review).

SUMMARY SPREADSHEETS

Calculating K for slug tests on corehole at Jarmen Road site

Tests conducted 9/95-5/96

Length of test interval 2.8 ft

Hole diameter = 3 inches (.25 ft)

Subtract 3.35 to get depth (ft) relative to TOC (corrects for depth error while installing packer)

Subtract 4.75 to get depth (ft) relative to ground surface (TOC to ground surface = 1.4)

Using Hvorslev analysis

Calculating T_o from best-fit exponential line

$T_o=[(-1)-\ln C2]/C1$

Calculating K from Hvorslev (since L/R>8 can used simplified form)

$K=[r^2\ln(L/R)]/2LT_o$

r=.75" or .0625'

R=1.5in or .125 ft

L=2.8 ft

$K=0.002168709/T_o$

Depth to TOC (ft)	Corr Depth to TOC (ft)	Corr Depth to GS (ft)	C1	C2	T_o(min)	T_o(sec)	K(ft/sec)	K(cm/sec)
423.54	420.19	418.79	-0.00821604	0.836753	100.02	6001.24	3.614E-07	1.101E-05
422	418.65	417.25	-0.0080267	0.858113	105.52	6331.22	3.425E-07	1.044E-05
420.48	417.13	415.73	-0.00871159	0.871437	98.99	5939.59	3.651E-07	1.113E-05
419	415.65	414.25	-0.00617101	0.956546	154.85	9290.93	2.334E-07	7.115E-06
417.47	414.12	412.72	-0.00759055	0.882436	115.27	6915.95	3.136E-07	9.558E-06
415.97	412.62	411.22	-0.00743524	0.945739	126.99	7619.48	2.846E-07	8.675E-06
414.47	411.12	409.72	-0.00763335	0.950536	124.36	7461.50	2.907E-07	8.859E-06
412.95	409.6	408.2	-0.0048648	0.92708	189.99	11399.66	1.902E-07	5.799E-06
411.42	408.07	406.67	-0.00436448	0.909399	207.36	12441.74	1.743E-07	5.313E-06
409.92	406.57	405.17	-0.00466767	0.97815	209.51	12570.40	1.725E-07	5.259E-06
408.4	405.05	403.65	-0.00069758	0.903932	1288.75	77324.81	2.805E-08	8.549E-07
406.9	403.55	402.15	-0.067748	0.933002	13.74	824.22	2.631E-06	8.020E-05
405.39	402.04	400.64	-0.0635843	0.892367	13.94	836.17	2.594E-06	7.905E-05
403.87	400.52	399.12	-0.0156373	0.950955	60.73	3644.02	5.951E-07	1.814E-05
402.37	399.02	397.62	-0.00338564	0.955741	281.99	16919.67	1.282E-07	3.907E-06
400.87	397.52	396.12	-0.00348627	0.96218	275.78	16546.85	1.311E-07	3.995E-06
399.37	396.02	394.62	-0.00688365	0.947403	137.42	8245.36	2.630E-07	8.017E-06
397.87	394.52	393.12	-0.00513197	0.940162	182.83	10970.02	1.977E-07	6.026E-06
396.34	392.99	391.59	-0.00431161	0.930496	215.22	12913.45	1.679E-07	5.119E-06
394.89	391.54	390.14	-0.00511934	0.909491	176.81	10608.36	2.044E-07	6.231E-06
393.38	390.03	388.63	-0.00752506	0.939785	124.64	7478.18	2.900E-07	8.839E-06
391.83	388.48	387.08	-0.0102727	0.93152	90.44	5426.40	3.997E-07	1.218E-05

Depth to TOC (ft)	Corr Depth to TOC (ft)	Corr Depth to GS (ft)	C1	C2	T_o(min)	T_o(sec)	K(ft/sec)	K(cm/sec)
390.35	387	385.6	-0.00582904	0.96772	165.93	9955.54	2.178E-07	6.640E-06
390.34	386.99	385.59	-0.00749727	0.962958	128.35	7700.84	2.816E-07	8.584E-06
388.8	385.45	384.05	-0.00411696	0.971239	235.81	14148.56	1.533E-07	4.672E-06
387.25	383.9	382.5	-0.00363346	0.981692	270.13	16208.06	1.338E-07	4.078E-06
384.2	380.85	379.45	-0.00307269	0.968905	315.17	18910.04	1.147E-07	3.496E-06
382.72	379.37	377.97	-0.00283546	0.951572	335.17	20110.18	1.078E-07	3.287E-06
381.2	377.85	376.45	-0.00206016	0.975168	473.19	28391.61	7.639E-08	2.328E-06
379.66	376.31	374.91	-0.0134627	0.976612	72.52	4351.29	4.984E-07	1.519E-05
378.14	374.79	373.39	-0.00575954	0.965798	167.58	10054.96	2.157E-07	6.574E-06
376.64	373.29	371.89	-0.00634305	0.963665	151.82	9109.07	2.381E-07	7.257E-06
375.15	371.8	370.4	-0.00854183	0.964219	112.81	6768.31	3.204E-07	9.766E-06
373.61	370.26	368.86	-0.00669964	0.963381	143.69	8621.60	2.515E-07	7.667E-06
372.15	368.8	367.4	-0.010919	0.954491	87.32	5239.07	4.139E-07	1.262E-05
370.65	367.3	365.9	-0.0281577	0.969206	34.40	2064.21	1.051E-06	3.202E-05
369.16	365.81	364.41	-0.0152303	0.972268	63.81	3828.72	5.664E-07	1.726E-05
367.62	364.27	362.87	-0.0057104	0.907872	158.19	9491.61	2.285E-07	6.964E-06
366.09	362.74	361.34	-0.00463052	0.975125	210.52	12631.11	1.717E-07	5.233E-06
364.56	361.21	359.81	-0.00330836	0.953654	287.92	17275.25	1.255E-07	3.826E-06
363.07	359.72	358.32	-0.00639906	0.937558	146.20	8771.82	2.472E-07	7.536E-06
361.58	358.23	356.83	-0.00472391	0.91708	193.37	11601.91	1.869E-07	5.698E-06
360.05	356.7	355.3	-0.00572458	0.927647	161.57	9693.94	2.237E-07	6.819E-06
358.56	355.21	353.81	-0.00570402	0.968084	169.63	10177.70	2.131E-07	6.495E-06
357.06	353.71	352.31	-0.044748	0.925416	20.62	1236.91	1.753E-06	5.344E-05
357.06	353.71	352.31	-0.0663654	0.918613	13.79	827.34	2.621E-06	7.990E-05
355.55	352.2	350.8	-0.0290704	0.908072	31.08	1864.92	1.163E-06	3.544E-05
355.55	352.2	350.8	-0.0821457	0.949914	11.55	692.88	3.130E-06	9.540E-05
354.04	350.69	349.29	-0.16548	0.950978	5.74	344.36	6.298E-06	1.920E-04
352.53	349.18	347.78	-0.17904	0.98058	5.48	328.55	6.601E-06	2.012E-04
351.01	347.66	346.26	-1.26277	0.978386	0.77	46.48	4.666E-05	1.422E-03
349.49	346.14	344.74	-1.60082	0.950615	0.59	35.58	6.095E-05	1.858E-03
347.96	344.61	343.21	-1.67317	1.01222	0.60	36.30	5.975E-05	1.821E-03
346.47	343.12	341.72	-1.26697	0.942127	0.74	44.53	4.870E-05	1.484E-03
344.91	341.56	340.16	-0.32134	2.79033	6.31	378.32	5.732E-06	1.747E-04
344.91	341.56	340.16	-0.148631	0.916915	6.14	368.67	5.883E-06	1.793E-04
343.39	340.04	338.64	-0.0718052	0.922007	12.80	767.74	2.825E-06	8.610E-05
341.86	338.51	337.11	-0.0436322	0.971533	22.26	1335.42	1.624E-06	4.950E-05
340.36	337.01	335.61	-0.0820391	0.965966	11.77	706.03	3.072E-06	9.362E-05
338.83	335.48	334.08	-0.158276	0.981478	6.20	372.00	5.830E-06	1.777E-04
337.31	333.96	332.56	-0.151469	0.97692	6.45	386.87	5.606E-06	1.709E-04
335.76	332.41	331.01	-0.19749	0.913427	4.61	276.30	7.849E-06	2.392E-04

Depth to TOC (ft)	Corr Depth to TOC (ft)	Corr Depth to GS (ft)	C1	C2	T_o(min)	T_o(sec)	K(ft/sec)	K(cm/sec)
334.28	330.93	329.53	-0.270431	0.957454	3.54	212.22	1.022E-05	3.115E-04
332.74	329.39	327.99	-0.263552	1.05532	4.00	239.92	9.039E-06	2.755E-04
328.3	324.95	323.55	-0.0702493	0.935726	13.29	797.36	2.720E-06	8.290E-05
325.32	321.97	320.57	-0.0454919	0.89354	19.51	1170.45	1.853E-06	5.648E-05
323.81	320.46	319.06	-0.0391872	0.907044	23.03	1381.73	1.570E-06	4.784E-05
322.32	318.97	317.57	-0.014864	0.910442	60.96	3657.86	5.929E-07	1.807E-05
320.81	317.46	316.06	-0.27046	0.93753	3.46	207.53	1.045E-05	3.185E-04
319.3	315.95	314.55	-0.330195	0.912643	2.75	165.10	1.314E-05	4.004E-04
317.8	314.45	313.05	-0.00653951	0.916155	139.53	8371.55	2.591E-07	7.896E-06
316.28	312.93	311.53	-0.00981424	0.935316	95.08	5704.75	3.802E-07	1.159E-05
314.76	311.41	310.01	-0.00969444	0.984126	101.50	6090.08	3.561E-07	1.085E-05
313.25	309.9	308.5	-0.00882743	0.982043	111.23	6673.83	3.250E-07	9.905E-06
310.24	306.89	305.49	-0.0169955	0.92901	54.51	3270.39	6.631E-07	2.021E-05
308.75	305.4	304	-4.77532	0.992463	0.21	12.47	1.739E-04	5.301E-03
307.25	303.9	302.5	-4.85233	1.01249	0.21	12.52	1.732E-04	5.280E-03
305.73	302.38	300.98	-0.00314011	0.96273	306.36	18381.86	1.180E-07	3.596E-06
304.23	300.88	299.48	-0.00133153	0.973243	730.65	43838.83	4.947E-08	1.508E-06
302.71	299.36	297.96	-0.458015	1.11195	2.42	144.90	1.497E-05	4.562E-04
301.19	297.84	296.44	-0.434878	0.969602	2.23	133.71	1.622E-05	4.944E-04
298.19	294.84	293.44	-0.228682	1.02324	4.47	268.40	8.080E-06	2.463E-04
296.69	293.34	291.94	-0.304696	0.904461	2.95	177.14	1.224E-05	3.732E-04
295.19	291.84	290.44	-0.396522	0.975399	2.46	147.55	1.470E-05	4.480E-04
293.67	290.32	288.92	-0.00649861	0.98892	152.16	9129.87	2.375E-07	7.240E-06
292.15	288.8	287.4	-0.633605	0.980738	1.55	92.85	2.336E-05	7.119E-04
290.61	287.26	285.86	-0.632264	0.963578	1.52	91.38	2.373E-05	7.234E-04
289.11	285.76	284.36	-0.00382689	0.98436	257.19	15431.38	1.405E-07	4.284E-06
287.65	284.3	282.9	-0.00384849	0.961978	249.77	14986.18	1.447E-07	4.411E-06
286.15	282.8	281.4	-0.00707983	0.978875	138.23	8293.83	2.615E-07	7.970E-06
284.64	281.29	279.89	-0.00712555	0.964178	135.22	8113.23	2.673E-07	8.147E-06
283.17	279.82	278.42	-0.0046592	0.952462	204.18	12250.54	1.770E-07	5.396E-06
281.65	278.3	276.9	-0.00427482	0.962827	225.07	13503.99	1.606E-07	4.895E-06
280.17	276.82	275.42	-0.397873	0.917778	2.30	137.86	1.573E-05	4.795E-04
278.65	275.3	273.9	-0.367601	0.928714	2.52	151.15	1.435E-05	4.373E-04
277.15	273.8	272.4	-0.00396774	0.960768	241.95	14516.74	1.494E-07	4.554E-06
275.66	272.31	270.91	-0.00329231	0.965311	293.01	17580.88	1.234E-07	3.760E-06
274.15	270.8	269.4	-0.152831	0.961358	6.29	377.12	5.751E-06	1.753E-04
272.65	269.3	267.9	-0.174511	0.92521	5.28	317.09	6.839E-06	2.085E-04
271.13	267.78	266.38	-0.500383	0.960888	1.92	115.12	1.884E-05	5.742E-04
269.65	266.3	264.9	-0.603007	0.953215	1.58	94.73	2.289E-05	6.978E-04
268.25	264.9	263.5	-0.00562431	0.962241	170.96	10257.36	2.114E-07	6.444E-06

Depth to TOC (ft)	Corr Depth to TOC (ft)	Corr Depth to GS (ft)	C1	C2	T_o(min)	T_o(sec)	K(ft/sec)	K(cm/sec)
266.74	263.39	261.99	-0.00549986	0.951518	172.79	10367.21	2.092E-07	6.376E-06
265.26	261.91	260.51	-58.2855	1.07179	0.02	1.10	1.970E-03	6.005E-02
263.76	260.41	259.01	-62.4129	1.28465	0.02	1.20	1.804E-03	5.499E-02
263.76	260.41	259.01	-128.015	0.851052	0.01	0.39	5.517E-03	1.682E-01
262.25	258.9	257.5	-0.0171204	0.960815	56.08	3364.50	6.446E-07	1.965E-05
260.74	257.39	255.99	-0.102584	0.943166	9.18	550.66	3.938E-06	1.200E-04
259.25	255.9	254.5	-0.0414757	0.960518	23.14	1388.36	1.562E-06	4.761E-05
257.75	254.4	253	-0.00538281	0.965209	179.20	10751.89	2.017E-07	6.148E-06
256.25	252.9	251.5	-0.00458595	0.972126	211.89	12713.57	1.706E-07	5.199E-06
254.72	251.37	249.97	-0.00506157	0.952405	187.93	11275.97	1.923E-07	5.862E-06
253.26	249.91	248.51	-0.349664	0.945068	2.70	161.90	1.340E-05	4.083E-04
251.72	248.37	246.97	-0.347314	0.9507	2.73	164.02	1.322E-05	4.030E-04
250.21	246.86	245.46	-21.7744	1.20788	0.05	3.28	6.620E-04	2.018E-02
250.21	246.86	245.46	-20.4813	1.09801	0.05	3.20	6.770E-04	2.063E-02
250.21	246.86	245.46	-22.9544	1.17083	0.05	3.03	7.167E-04	2.184E-02
248.71	245.36	243.96	-22.6773	1.11356	0.05	2.93	7.401E-04	2.256E-02
248.71	245.36	243.96	-23.7385	1.08777	0.05	2.74	7.914E-04	2.412E-02
248.71	245.36	243.96	-34.7603	0.861508	0.02	1.47	1.477E-03	4.500E-02
247.2	243.85	242.45	-23.9257	1.17581	0.05	2.91	7.443E-04	2.269E-02
247.2	243.85	242.45	-24.0046	1.08924	0.05	2.71	7.993E-04	2.436E-02
247.2	243.85	242.45	-35.1195	0.903472	0.03	1.54	1.413E-03	4.306E-02
245.65	242.3	240.9	-3.68961	0.953487	0.26	15.49	1.400E-04	4.268E-03
244.09	240.74	239.34	-1.28593	0.970763	0.75	45.27	4.790E-05	1.460E-03
242.57	239.22	237.82	-2.18509	1.00776	0.46	27.67	7.837E-05	2.389E-03
241.06	237.71	236.31	-2.4679	1.02425	0.41	24.89	8.712E-05	2.655E-03
239.45	236.1	234.7	-0.00744146	0.981495	131.87	7912.33	2.741E-07	8.354E-06
236.42	233.07	231.67	-39.2203	0.96055	0.02	1.47	1.477E-03	4.502E-02
234.91	231.56	230.16	-13.529	0.971623	0.07	4.31	5.035E-04	1.535E-02
233.39	230.04	228.64	-5.87313	1.0081	0.17	10.30	2.106E-04	6.419E-03
233.39	230.04	228.64	-7.67149	0.964269	0.13	7.54	2.878E-04	8.771E-03
231.89	228.54	227.14	-3.58338	0.953425	0.27	15.95	1.360E-04	4.146E-03
231.89	228.54	227.14	-4.58036	1.02625	0.22	13.44	1.614E-04	4.919E-03
230.37	227.02	225.62	-6.48667	1.11246	0.17	10.24	2.119E-04	6.458E-03
230.37	227.02	225.62	-8.00402	1.03727	0.13	7.77	2.791E-04	8.507E-03
228.83	225.48	224.08	-10.9469	1.35202	0.12	7.13	3.040E-04	9.266E-03
228.82	225.47	224.07	-6.44742	1.04337	0.16	9.70	2.236E-04	6.814E-03
228.82	225.47	224.07	-11.8662	0.914018	0.08	4.60	4.713E-04	1.436E-02
227.33	223.98	222.58	-0.00786004	0.979593	124.60	7476.16	2.901E-07	8.842E-06
225.8	222.45	221.05	-0.0516221	0.976543	18.91	1134.70	1.911E-06	5.826E-05
224.26	220.91	219.51	-0.0477714	0.968311	20.26	1215.54	1.784E-06	5.438E-05

Depth to TOC (ft)	Corr Depth to TOC (ft)	Corr Depth to GS (ft)	C1	C2	T_o(min)	T_o(sec)	K(ft/sec)	K(cm/sec)
222.74	219.39	217.99	-0.190596	0.990049	5.19	311.65	6.959E-06	2.121E-04
221 21	217 86	216.46	-0.155513	1 01568	6.53	391 82	5.535E-06	1.687E-04
219.71	216 36	214.96	-0.0209035	0.968201	46.29	2777 58	7.808E-07	2.380E-05
216.73	213.38	211.98	-0.0971626	0.958527	9.86	591.36	3.667E-06	1.118E-04
215 21	211.86	210 46	-0 0897472	0.97335	10.84	650.49	3 334E-06	1.016E-04
213 71	210.36	208.96	-0.858034	1.00146	1 17	70.03	3 097E-05	9 439E-04
212 23	208.88	207.48	-0.626664	0.962237	1 53	92.06	2.356E-05	7 180E-04
210.74	207 39	205.99	-0.00294772	0.979704	332.29	19937.35	1.088E-07	3.315E-06
209.24	205.89	204.49	-0.00205039	0.988408	482.03	28921.53	7.499E-08	2.286E-06
207.71	204.36	202.96	-0.0117458	0.954561	81 18	4870.66	4.453E-07	1.357E-05
206.21	202.86	201 46	-0 00303943	0.982758	323.29	19397.21	1.118E-07	3.408E-06
204 68	201.33	199.93	-0.00281251	0.976446	347 08	20824.76	1.041E-07	3.174E-06
203.18	199 83	198.43	-4.06816	0.884104	0.22	12.93	1 677E-04	5.112E-03
201.69	198 34	196.94	-4.87414	0.953912	0 20	11.73	1 849E-04	5.636E-03
200 2	196.85	195.45	-0.00392018	0.9854	251.34	15080.31	1 438E-07	4.383E-06
198 7	195.35	193 95	-0 00521232	0.974503	186.90	11213.88	1.934E-07	5 895E-06
197 18	193 83	192.43	-0 0996655	0.981124	9.84	590 54	3.672E-06	1 119E-04
195.67	192 32	190.92	-0.055062	0.9937	18.05	1082.79	2.003E-06	6.105E-05
195.57	192 22	190.82	-0.121236	0.975417	8.04	482.58	4.494E-06	1.370E-04
194 09	190.74	189.34	-0.0417608	0.962259	23.02	1381 48	1 570E-06	4.785E-05
192 57	189.22	187 82	-0.0316575	0.978817	30 91	1854 71	1 169E-06	3 564E-05
191.07	187.72	186.32	-20.4721	1.14593	0.06	3.33	6.513E-04	1 985E-02
191.07in	187.72	186.32	-18 1925	0.90479	0.05	2.97	7.307E-04	2.227E-02
191.07ot	187 72	186.32	-21 1893	1.02247	0.05	2.89	7.492E-04	2.284E-02
189 55	186.2	184.8	-22.8291	1.19901	0.05	3 11	6.984E-04	2.129E-02
188 03	184.68	183 28	-0 0168573	0.985256	58.44	3506.42	6.185E-07	1.885E-05
186.56	183.21	181 81	-0.0218361	0.963792	44 11	2646.41	8 195E-07	2.498E-05
185.07	181.72	180.32	-0.00890568	0.987202	110.84	6650.49	3 261E-07	9 939E-06
189.58	186 23	184.83	-19.4933	1.1265	0.06	3.44	6.296E-04	1 919E-02
189.58in	186.23	184.83	-28.4447	0.990481	0.03	2.09	1.038E-03	3.164E-02
189 58ot	186.23	184.83	-26.138	1 11963	0.04	2 55	8.488E-04	2.587E-02
188.08	184.73	183.33	-0 0788976	0.973679	12.34	740.19	2.930E-06	8.930E-05
186 4	183.05	181.65	-0.0938124	0.985952	10 51	630.53	3.440E-06	1.048E-04
184 92	181 57	180.17	-0.0430788	0.992259	23 03	1381.97	1 569E-06	4.783E-05
183.4	180 05	178.65	-7.95366	1	0.13	7.54	2 875E-04	8.763E-03
183.4in	180 05	178.65	-10.1435	1	0.10	5.92	3.666E-04	1 118E-02
183.4ot	180 05	178.65	-9.61413	1	0.10	6.24	3.475E-04	1 059E-02
181.84	178.49	177.09	-8.49662	1	0.12	7.06	3.071E-04	9.361E-03
181.84in	178.49	177.09	-8 37304	1	0.12	7.17	3.026E-04	9.225E-03
181.84ot	178.49	177 09	-7 95366	1	0.13	7 54	2.875E-04	8.763E-03

Depth to TOC (ft)	Corr Depth to TOC (ft)	Corr Depth to GS (ft)	C1	C2	T_o(min)	T_o(sec)	K(ft/sec)	K(cm/sec)
180 38	177 03	175.63	-8.31258	1	0.12	7.22	3.005E-04	9.158E-03
180.38in	177 03	175 63	-10.055	1	0 10	5.97	3.634E-04	1.108E-02
180.38ot	177.03	175.63	-9 02975	1	0 11	6.64	3.264E-04	9 948E-03
178 87	175.52	174.12	-0 0290046	0 953222	32.83	1969.53	1 101E-06	3 356E-05
175 81	172.46	171.06	-0.0769348	0.981816	12.76	765.57	2 833E-06	8.634E-05
174.29	170 94	169 54	-0.0580027	0.956252	16.47	988.16	2.195E-06	6.689E-05
172.75	169.4	168	-0.121365	0.996156	8.21	492.47	4.404E-06	1.342E-04
171.25	167.9	166.5	-0.0975796	1 01134	10 36	621.82	3.488E-06	1.063E-04
169 75	166.4	165	-0.142903	0 957265	6.69	401.53	5.401E-06	1.646E-04
168.24	164 89	163.49	-0.196842	1.00082	5.08	305 06	7.109E-06	2 167E-04
168.24a	164 89	163.49	-0.169494	0.996387	5.88	352.71	6 149E-06	1.874E-04
166 77	163.42	162.02	-0 0196513	0.949157	48.23	2893.91	7.494E-07	2.284E-05
165.26	161.91	160.51	-0.0309646	0.989474	31 95	1917.19	1.131E-06	3 448E-05
163.76	160.41	159 01	-0.029502	0.984327	33.36	2001.63	1.083E-06	3 302E-05
162.24	158.89	157.49	-0.0301536	0.980044	32.50	1949 70	1 112E-06	3 390E-05
160 73	157.38	155.98	-0.0199773	0 963827	48 21	2892 75	7 497E-07	2.285E-05
159.22	155 87	154 47	-0 0199137	0 961403	48 24	2894 40	7.493E-07	2.284E-05
157 71	154 36	152 96	-0.0142859	0.942466	65 85	3951.08	5.489E-07	1.673E-05
156.21	152 86	151.46	-13.3911	1.15543	0.09	5.13	4.229E-04	1 289E-02
156 21in	152.86	151.46	-15.5159	1.05196	0.07	4 06	5 338E-04	1.627E-02
156.21ot	152.86	151.46	-14.3141	1 0445	0.07	4.37	4.958E-04	1.511E-02
154.7	151 35	149 95	-46.6499	1.13278	0.02	1.45	1.499E-03	4 570E-02
154.70in	-3.35	-4.75	-93.5618	1.00609	0.01	0.65	3.361E-03	1.025E-01
154 70ot	-3.35	-4.75	-40.9369	1.14012	0.03	1.66	1.308E-03	3 987E-02
153.21	149.86	148.46	-34.0047	1.07509	0 03	1.89	1 146E-03	3.493E-02
153.21in	-3.35	-4.75	-84 3482	1 0815	0 01	0.77	2.827E-03	8.618E-02
153 21ot	-3.35	-4.75	-34.7851	1.14907	0.03	1.96	1.104E-03	3.365E-02
151 71	148.36	146.96	-16.3885	1	0.06	3.66	5.924E-04	1.806E-02
151.71in	-3.35	-4.75	-17.7806	1	0.06	3.37	6.427E-04	1 959E-02
151.71ot	-3.35	-4.75	-16.6252	1	0 06	3 61	6 009E-04	1.832E-02
150 18	146 83	145 43	-16 3885	1	0 06	3 66	5.924E-04	1.806E-02
150 18in	-3 35	-4 75	-17.9889	1	0.06	3.34	6.502E-04	1.982E-02
151 18ot	-3 35	-4.75	-12.5481	1	0.08	4.78	4.536E-04	1.382E-02
148.67	145 32	143.92	-0 0282506	0.970197	34.33	2059.59	1.053E-06	3.209E-05
147.15	143.8	142.4	-0.0329783	0 970303	29.41	1764.53	1 229E-06	3 746E-05
145.67	142 32	140 92	-0.0140019	0.983583	70.24	4214 20	5.146E-07	1.569E-05
144.15	140.8	139.4	-0.0478367	0.975189	20.38	1222 75	1.774E-06	5.406E-05
142.65	139.3	137.9	-0.0491872	0.93176	18 89	1133.61	1.913E-06	5.831E-05
141 07	137.72	136.32	-0.0390435	0.961498	24.61	1476.41	1.469E-06	4.477E-05
139 56	136.21	134.81	-0.0372472	0.956882	25.66	1539.86	1.408E-06	4 293E-05

Depth to TOC (ft)	Corr Depth to TOC (ft)	Corr Depth to GS (ft)	C1	C2	T_o(min)	T_o(sec)	K(ft/sec)	K(cm/sec)
138.06	134 71	133.31	-0.0310941	0.961131	30.89	1853 13	1.170E-06	3 567E-05
136 56	133 21	131.81	-0 0261734	0.954446	36.43	2185.52	9.923E-07	3 025E-05
135 08	131 73	130.33	-0.136048	0.953184	7.00	419.88	5.165E-06	1.574E-04
133 57	130.22	128 82	-0.117425	0 992238	8 45	506 98	4 278E-06	1.304E-04
132.05	128.7	127.3	-0.0164675	0.976874	59 30	3558.29	6 095E-07	1.858E-05
129.04	125.69	124.29	-0.0179409	0.961445	53.55	3212 82	6 750E-07	2.057E-05
127.52	124.17	122.77	-0.0170369	0.989881	58.10	3485.95	6 221E-07	1.896E-05
125.99	122 64	121.24	-0.0159547	0.985256	61.75	3704.79	5.854E-07	1 784E-05
124 46	121 11	119.71	-0.0179661	0.962157	53.51	3210 79	6.754E-07	2.059E-05
122.97	119.62	118.22	-0.0190121	0 943396	49.53	2971.99	7.297E-07	2.224E-05
121.45	118.1	116.7	-0.0654913	0.992899	15.16	909.62	2.384E-06	7 267E-05
119.92	116.57	115.17	-0.0642919	0.994224	15 46	927.84	2.337E-06	7 124E-05
118 44	115.09	113.69	-0.0240922	0.980792	40.70	2442.13	8.880E-07	2.707E-05
116 92	113.57	112.17	-0 0281202	0.970036	34 48	2068.79	1.048E-06	3.195E-05
115 42	112.07	110.67	-0.023873	0.971969	40.70	2441.84	8 881E-07	2.707E-05
113.91	110.56	109.16	-20.0327	0 81526	0.04	2.38	9 099E-04	2.773E-02
113.92a	-3.35	-4.75	-3.313	0.889072	0 27	15.98	1.357E-04	4 136E-03
113.92in	-3 35	-4.75	-7.37333	0.969661	0 13	7 89	2.750E-04	8.381E-03
113 92ot	-3 35	-4.75	-7.77588	0.844712	0.11	6.41	3.381E-04	1 031E-02
112.4	109 05	107.65	-19.6696	0.866777	0.04	2.61	8.296E-04	2.529E-02
112 40in	-3.35	-4 75	-41.4287	1.06867	0.03	1.54	1.404E-03	4.280E-02
112 40ot	-3.35	-4.75	-28.7565	0.929293	0.03	1.93	1 122E-03	3.419E-02
110.87	107.52	106.12	-0.0973968	0.982776	10.09	605.33	3 583E-06	1.092E-04
109.34	105.99	104.59	-0.017447	0.985824	56.50	3389 89	6 398E-07	1.950E-05
109.34b	-3.35	-4.75	-0.0137044	0.980113	71.50	4290.21	5.055E-07	1 541E-05
107 85	104 5	103.1	-0.0325855	1.00126	30.73	1843.63	1.176E-06	3.585E-05

Calculating K for slug tests on corehole 19 at Bissen Quarry
Tests conducted 9/27-9/28 1997 by Diane Stocks
Length of test interval 2.1 ft
Hole diameter = 3 inches (.25 ft)
Subtract 1.1 to get depth relative to ground surface
Using Hvorslev analysis
Calculating T_o from best-fit exponential line
$T_o=[(-1)-\ln C2]/C1$
Calculating K from Hvorslev (since L/R>8 can used simplified form)
$K=[r^2\ln(L/R)]/2LT_o$
r=.75" or .0625'
L=2.1 ft
R=1.5in or .125 ft
$K=0.00262405/T_o$

Depth from TOC (ft)	Depth from GS(ft)	Depth from GS(m)	C1	C2	To(min)	To(sec)	K(ft/sec)	K(cm/sec)
13.08	11.98	3.651504	-31.9683	0.987041	0.03	1.85	1.417E-03	4.318E-02
15	13.9	4.23672	average of 2 tests				1.176E-03	3.584E-02
17.03	15.93	4.855464	-0.106549	0.947587	8.88	532.80	4.925E-06	1.501E-04
19.11	18.01	5.489448	-10.3235	0.967365	0.09	5.62	4.670E-04	1.423E-02
21.17	20.07	6.117336	-7.35977	0.999109	0.14	8.15	3.222E-04	9.819E-03
23.2	22.1	6.73608	-35.597	1.05499	0.03	1.78	1.478E-03	4.504E-02
25.09	23.99	7.312152	-0.142267	0.952946	6.69	401.42	6.537E-06	1.992E-04
27.21	26.11	7.958328	-0.1465	0.942125	6.42	385.14	6.813E-06	2.077E-04
29.21	28.11	8.567928	-0.131431	0.983296	7.48	448.82	5.847E-06	1.782E-04
31.27	30.17	9.195816	-0.185794	0.96375	5.18	311.01	8.437E-06	2.572E-04
33.24	32.14	9.796272	-0.174016	0.961795	5.52	331.36	7.919E-06	2.414E-04
35.2	34.1	10.39368	average of 2 tests				7.413E-05	2.259E-03
37.15	36.05	10.98804	-0.266198	0.975243	3.66	219.75	1.194E-05	3.640E-04
39.13	38.03	11.591544	-0.136163	0.973659	7.15	428.89	6.118E-06	1.865E-04
41.23	40.13	12.231624	-1.35006	0.968151	0.72	43.00	6.102E-05	1.860E-03
43.15	42.05	12.81684	-1.42603	0.939997	0.66	39.47	6.648E-05	2.026E-03
45.15	44.05	13.42644	-0.450526	0.975893	2.17	129.93	2.020E-05	6.156E-04
47.01	45.91	13.993368	-0.148281	1.00485	6.78	406.59	6.454E-06	1.967E-04
49.05	47.95	14.61516	-0.123625	0.991133	8.02	481.02	5.455E-06	1.663E-04
51.04	49.94	15.221712	-5.14057	0.77624	0.15	8.72	3.011E-04	9.177E-03
53.04	51.94	15.831312	-0.136138	1.00014	7.35	440.79	5.953E-06	1.814E-04
55.04	53.94	16.440912	-0.126747	0.994483	7.85	470.77	5.574E-06	1.699E-04
57.04	55.94	17.050512	-0.120924	0.998536	8.26	495.45	5.296E-06	1.614E-04
58.96	57.86	17.635728	-0.169263	0.99397	5.87	352.33	7.448E-06	2.270E-04
61.13	60.03	18.297144	-0.38695	0.955165	2.47	147.95	1.774E-05	5.406E-04

Depth from TOC (ft)	Depth from GS(ft)	Depth from GS(m)	C1	C2	To(min)	To(sec)	K(ft/sec)	K(cm/sec)
65	63.9	19.47672	-0.234611	0.997257	4.25	255.04	1.029E-05	3.136E-04
67.15	66.05	20.13204	-0.391905	0.984418	2.51	150.69	1.741E-05	5.308E-04
69.3	68.2	20.78736	-2.82932	0.99903	0.35	21.19	1.239E-04	3.775E-03
71.28	70.18	21.390864	-0.240056	0.940172	3.91	234.52	1.119E-05	3.410E-04
73.29	72.19	22.003512	-0.390302	0.939816	2.40	144.19	1.820E-05	5.547E-04
75.32	74.22	22.622256	-0.13007	0.969701	7.45	447.10	5.869E-06	1.789E-04
77.27	76.17	23.216616	-0.129894	0.951003	7.31	438.71	5.981E-06	1.823E-04
79.25	78.15	23.82012	-0.160184	0.96075	5.99	359.57	7.298E-06	2.224E-04
81.33	80.23	24.454104	-0.143134	0.979647	6.84	410.57	6.391E-06	1.948E-04
83.35	82.25	25.0698	-0.13661	0.975007	7.13	428.09	6.130E-06	1.868E-04
85.3	84.2	25.66416	-0.136347	0.978083	7.17	430.30	6.098E-06	1.859E-04
87.28	86.18	26.267664	-0.139195	0.965329	6.93	415.84	6.310E-06	1.923E-04
89.05	87.95	26.80716	-0.131644	0.98221	7.46	447.59	5.863E-06	1.787E-04
91.31	90.21	27.496008	-0.248531	0.956643	3.85	230.72	1.137E-05	3.467E-04
93.31	92.21	28.105608	-0.26105	0.963381	3.69	221.27	1.186E-05	3.615E-04
95.31	94.21	28.715208	-0.204284	0.944207	4.61	276.85	9.478E-06	2.889E-04
97.31	96.21	29.324808	-0.221441	0.972	4.39	263.26	9.968E-06	3.038E-04
99.35	98.25	29.9466	-0.240283	0.917517	3.80	228.21	1.150E-05	3.505E-04
101.31	100.21	30.544008	-0.249277	0.943241	3.78	226.63	1.158E-05	3.529E-04
103.31	102.21	31.153608	-0.227926	0.986304	4.33	259.61	1.011E-05	3.081E-04
105.43	104.33	31.799784	-0.666659	0.962457	1.44	86.56	3.032E-05	9.240E-04
107.49	106.39	32.427672	-0.498974	1.00732	2.02	121.12	2.166E-05	6.603E-04
109.46	108.36	33.028128	-0.433009	0.975937	2.25	135.19	1.941E-05	5.916E-04
111.49	110.39	33.646872	-0.389735	1.01195	2.60	155.78	1.684E-05	5.134E-04
113.48	112.38	34.253424	-0.415449	1.00899	2.43	145.71	1.801E-05	5.489E-04
115.52	114.42	34.875216	-0.464086	1.01003	2.18	130.58	2.010E-05	6.125E-04
117.5	116.4	35.47872	-3.59896	1.03615	0.29	17.26	1.520E-04	4.633E-03
119.47	118.37	36.079176	-0.404339	1.01031	2.50	149.91	1.750E-05	5.335E-04
121.43	120.33	36.676584	-2.57454	0.958874	0.37	22.33	1.175E-04	3.582E-03
123.43	122.33	37.286184	-35.6383	1.14283	0.03	1.91	1.375E-03	4.191E-02
125.42	124.32	37.892736	-18.4072	1.19699	0.06	3.85	6.823E-04	2.080E-02
127.37	126.27	38.487096	-24.1615	1.04959	0.04	2.60	1.008E-03	3.072E-02
129.43	128.33	39.114984	-34.054	1.11647	0.03	1.96	1.342E-03	4.089E-02

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APPENDIX I -- DATA FROM INDIVIDUAL SLUG TESTS