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Analysis Package for Interpretation of 1984 H-3 Pumping Tests

ERMS 522203

STATEMENT OF CONTENT

This records package documents the analysis of hydraulic tests of the Culebra Dolomite Member of the Rustler Formation conducted by Hydro Geo Chem, Inc., on behalf of Sandia National Laboratories (SNL) at the H-3 hydropad on the WIPP site between April 17 and 20, 1984. The pumped well for these tests was H-3b3, with H-3b1 and H-3b2 used as observation wells. These analyses were undertaken to provide a defensible value of transmissivity for the Culebra at H-3 for use in WIPP-related modeling. The analyses in this records package were performed under Sandia National Laboratories Waste Isolation Pilot Plant Analysis Plan 070: Analysis Plan for Non-Salado Hydraulic-Test Interpretations under WBS 1.3.5.3.1.2.

The objectives of the test analyses were to quantify the transmissivity of the Culebra and determine the nature of the flow system at the H-3 hydropad, such as whether it behaves as a single- or double-porosity medium and whether any hydraulic boundaries are evident. The analyses assumed that only a single phase (water) was present and that flow is governed by Darcy's Law. Radial flow was assumed for all test analyses.

All tests were analyzed using the code Interpret 2000 v. 2.01.240, commercial, off-the-shelf software provided by Baker Atlas GEOScience. Interpret 2000 is the successor code to Interpret/2, and includes Interpret/2 v. 1.83 as a separate, callable module. Interpret/2 must be called to generate hardcopy plots, as well as to perform "Expert" mode file manipulations. Interpret 2000 optimizes parameter values so as to obtain the best possible fit between observed data and simulated data. For pumping tests, the comparison between observed and simulated data is typically made with log-log, semilog (Horner), and linear-linear graphs. For the log-log plots, data are normally plotted as pressure change versus elapsed time, along with the derivative of pressure change with respect to log time as defined by Bourdet et al. (1989). For semilog plots, data are plotted with pressure on a linear scale versus a superposition time function as defined by Horner (1951) on a logarithmic scale.

Data entry and preparation were performed using Excel 2000. Plotting of data was performed using Grapher 2.01. Excel and Grapher are classified as off-the-shelf software.

The analyses were all performed by Richard L. Beauheim, 6821, between December 1999 and May 2002.

This Analysis Package contains information on the DAS files recorded during the 1984 H-3 pumping tests, flow-rate data recorded in the field log books, data-reduction procedures, notes made during test interpretation, test-interpretation results, relevant pages from the

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WIPP: 1.3.5.3.1.2: TD: QA: PKG 522203

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H-3 field log books, a list of all software used, a list of all computer files used and/or generated in the analysis, copies of those computer files on disk, a list of references cited, and copies of the technical and QA reviews of this package.

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SANDIA NATIONAL LABORATORIES
WASTE ISOLATION PILOT PLANT

Analysis Plan for Non-Salado Hydraulic-Test Interpretations

WBS 1.2.01.09.02

Effective Date: 04/13/00

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QA Review:	*Original signed by David Guerin* D.C. Guerin, 6860 Quality Assurance Dept.	*04/10/00* Date
Management Review:	*Original signed by B.A. Howard* B.A. Howard, 6821 WIPP Regulatory Compliance Dept.	*4/13/00* Date

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1. INTRODUCTION AND OBJECTIVES

This Analysis Plan directs the interpretation of hydraulic tests performed in formations other than the Salado Formation at the Waste Isolation Pilot Plant (WIPP) site. Hydraulic tests are performed in support of WIPP monitoring programs to provide data needed for modeling of groundwater flow in monitored horizons. Interpretations of those tests will be used for programmatic decisions related to FEP screening and evaluation of conceptual models. The objectives of hydraulic-test interpretations are to obtain estimates of some or all of the following hydraulic properties:

- Permeability-thickness product (transmissivity);
- Storativity;
- Fracture-matrix storativity ratio;
- Interporosity flow coefficient;
- Anisotropy;
- Flow dimension; and/or
- Formation pore pressure.

Error/uncertainty in the estimation of these parameters will be assessed directly by the analysis codes used (see Section 3).

2. APPROACH

The analytical approach to be followed is well established and has been used on the WIPP project for many years. The scientific approach and assumptions are documented in Beauheim (1989; Appendix B), Beauheim et al. (1991; Appendix A), and Roberts et al. (1998; Chapter 6). The computer codes to be used for analysis include Interpret/2 v. 1.8, GTFM v. 6.2, and, when completed and qualified under NP 19-1, nSIGHTS v. 1.0. The input to these codes consists of some or all of the following:

- transient pressure data;
- transient flow-rate data;

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- well radius;
- tested thickness;
- fluid density;
- fluid viscosity;
- distance from source well;
- porosity; and/or
- rock compressibility.

3. SOFTWARE LIST

Three computer codes may be used for the analysis of hydraulic-test data:

- Interpret/2 v. 1.8 (off-the-shelf software);
- GTFM v. 6.2 (qualified under NP 19-1); and
- nSIGHTS v. 1.0 (when completed and qualified under NP 19-1).

Off-the-shelf spreadsheet programs, such as Excel 97 and Quattro Pro 8, and graphing programs, such as Grapher 2.0, will also be used for data manipulation and plotting.

4. TASKS

The tasks to be performed in connection with a hydraulic-test analysis are the following:

- Assemble data on well completion and location;
- Assemble data relevant to the performance of the test;
- Assemble data files to be used in interpretation;
- Manipulate data files in a spreadsheet to put in the proper input format for the analysis code(s);
- Plot data to evaluate data quality and develop preliminary model conceptualization;
- Analyze data with selected code(s);
- Produce hardcopy plots of final simulations;
- Make copies of input files and final output files; and

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- Prepare analysis package, obtain necessary reviews, and submit to records center.

All tasks will be documented in a scientific notebook by the analyst as the analysis progresses. The principal analyst for non-Salado hydraulic tests is Richard L. Beauheim, 6821. Analyses may also be performed by Randall M. Roberts, 6821. Analysis packages will be prepared, reviewed, and submitted by the responsible analyst according to Appendices B and C (*Analysis Records* and *Routine Calculation Requirements*, respectively) of NP 9-1 at the completion of each set of related analyses.

5. SPECIAL CONSIDERATIONS

No special considerations have been identified.

6. APPLICABLE PROCEDURES

All applicable NWMP quality-assurance procedures will be followed for these analyses. Training of personnel will be done in accordance with the requirements of NP 2-1 *Qualification and Training*. Analyses will be performed and documented in accordance with the requirements of NP 9-1 *Analyses* and NP 20-2 *Scientific Notebooks*. All software used will meet the requirements of NP 19-1 *Software Requirements*. The analyses will be reviewed following NP 6-1 *Document Review Process*.

7. REFERENCES

Beauheim, R.L. 1989. *Interpretation of H-11b4 Hydraulic Tests and the H-11 Multipad Pumping Test of the Culebra Dolomite at the Waste Isolation Pilot Plant (WIPP) Site*. SAND89-0536. Albuquerque, NM: Sandia National Laboratories.

Beauheim, R.L., T.F. Dale, and J.F. Pickens. 1991. *Interpretations of Single-Well Hydraulic Tests of the Rustler Formation Conducted in the Vicinity of the Waste Isolation Pilot Plant Site, 1988-1989*. SAND89-0869. Albuquerque, NM: Sandia National Laboratories.

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Roberts, R.M., R.L. Beauheim, and P.S. Domski. 1999. *Hydraulic Testing of Salado Formation Evaporites at the Waste Isolation Pilot Plant Site: Final Report*. SAND98-2537. Albuquerque, NM: Sandia National Laboratories.

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Introduction to 1984 H-3 Pumping Tests

Beauheim (1987; SAND86-2311) presented interpretations of two pumping tests performed on the H-3 hydropad. The first test was performed in April 1984, and consisted of the first few days of pumping for the H-3 convergent-flow tracer test. The second test was the 1985 H-3 multipad pumping test. Both tests were difficult to interpret, as no derivative stabilization was observed in log-log plots of either the pumping-well or observation-well data. The transmissivity values determined from these two tests, 2-3 ft^2/day, also appeared to be anomalously low for a location that tracer testing showed to be clearly fractured (e.g., Jones et al., 1992).

In late 1999, I reviewed the H-3 field log books (ERMS 420564) to see if any earlier tests had been performed that might be easier to interpret. I found that a number of slug tests had been performed in early 1984 that were not thought to have provided very good data. Following those slug tests and other well-development activities, four short pumping tests were conducted between April 17 and 20, 1984 in preparation for the H-3 convergent-flow tracer test. The H-3 tracer test, which began on April 23, 1984, used the equipment and well configurations set up for these tests (see ERMS 522098). Thus, the information given in Chapter 4 of Beauheim (1987) for the H-3 tracer test also applies to these tests. Beauheim (1987) is also the source of all physical parameter information used in these analyses (e.g., Culebra thickness, well spacing, well diameter; see attached figures).

Volumes I and II of the H-3 Log Book (ERMS 420564) identified HY318, HY319, and HY320 as the data files created for the four pumping tests. The original HP-9845 disks containing these data files were given to John Loukota (then in 6800), the author of the HP-9845 DAS program, who transferred the data to regular PC disks in ASCII format. Additional information about the data files and their conversion to units and format usable by Interpret/2 is given in the Data Files section of this Analysis Package.

For both of the H-3 pumping tests reported in Beauheim (1987), a packer was used in the pumping well to reduce wellbore storage. For the four tests described here, a packer was included in the tubing string for the pumping well, but was only inflated for the last test. Thus, the amount of wellbore storage was expected to be different for the first three tests as opposed to the fourth test and the two tests analyzed previously. In fact, this difference was much more important than anticipated, and proved to be the key to obtaining a good interpretation of the tests.

The H-3 pumping tests were analyzed following AP-070, Rev. 0, Analysis Plan for Non-Salado Hydraulic-Test Interpretations (Beauheim, 2000). All tests were analyzed using the code Interpret 2000 v. 2.01.240, commercial software provided by Baker Atlas GEOScience. Interpret 2000 is the successor code to Interpret/2, and includes Interpret/2 v. 1.83 as a separate, callable module. Interpret/2 must be called to generate hardcopy plots, as well as to perform "Expert"-mode file manipulations.

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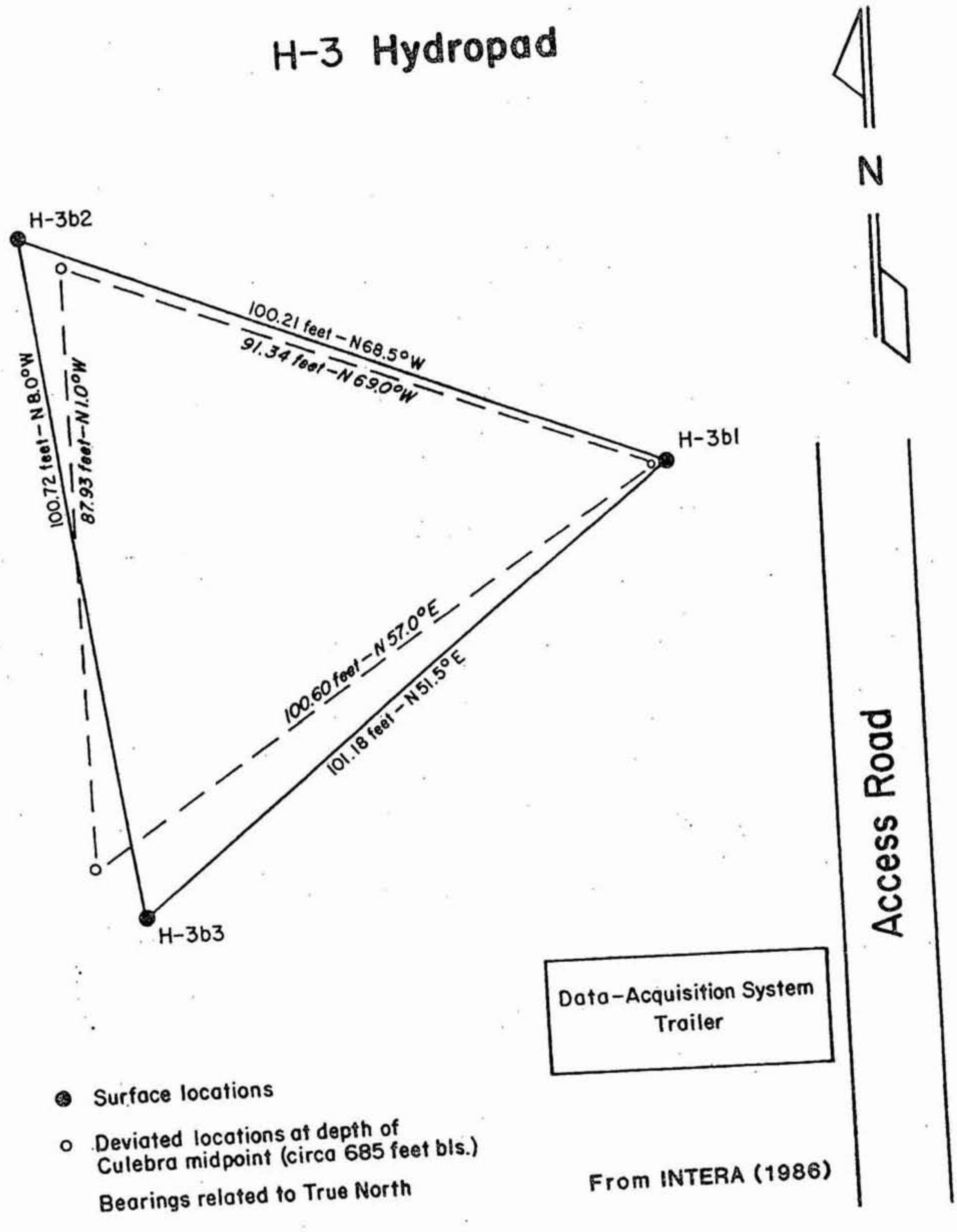

From INTERA (1986)

Figure 3-1. Plan View of the Wells at the H-3 Hydropad

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SAND86-2311

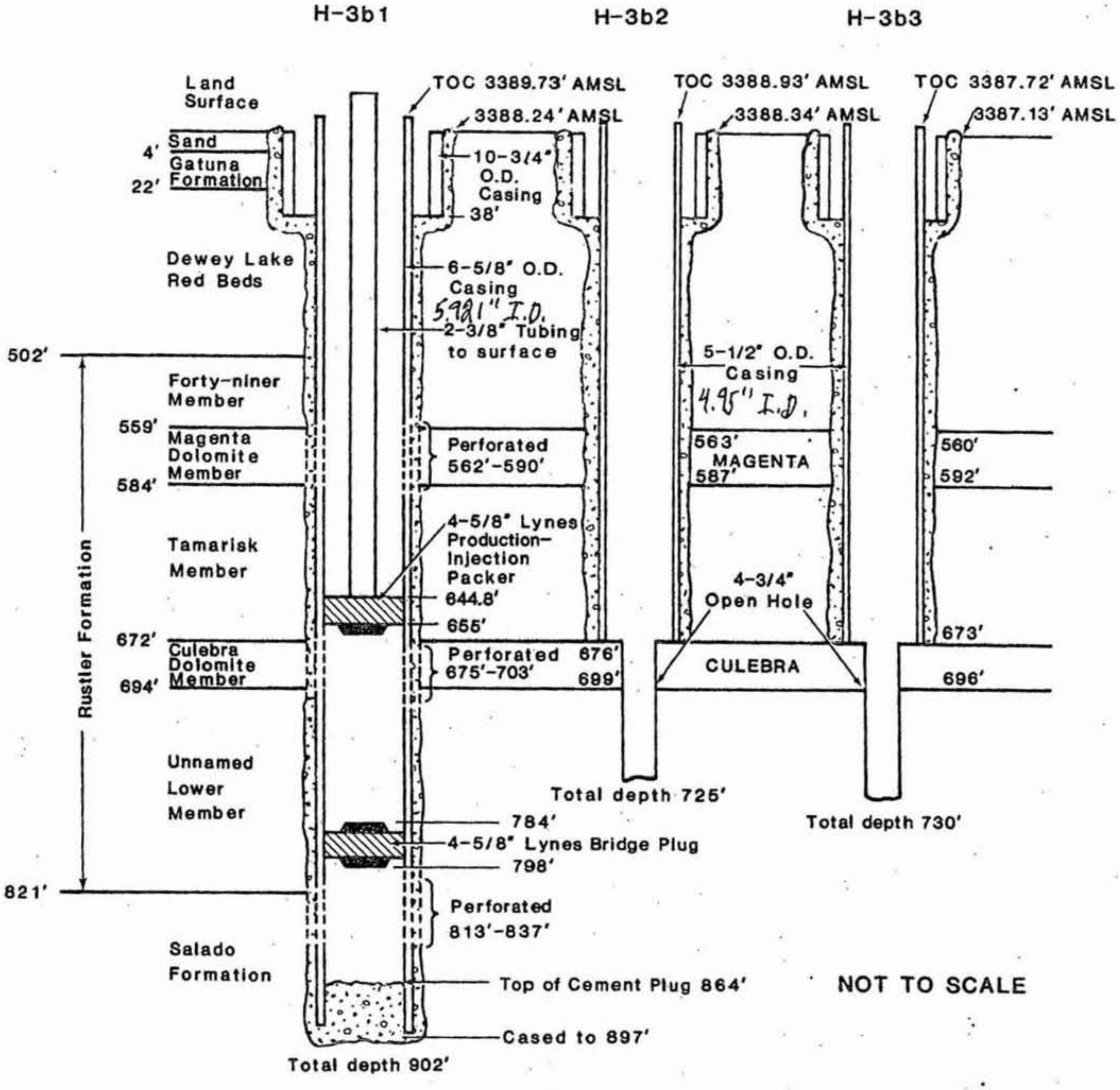

Figure 3-2. Stratigraphy and Well-Construction Details for the H-3 Hydropad

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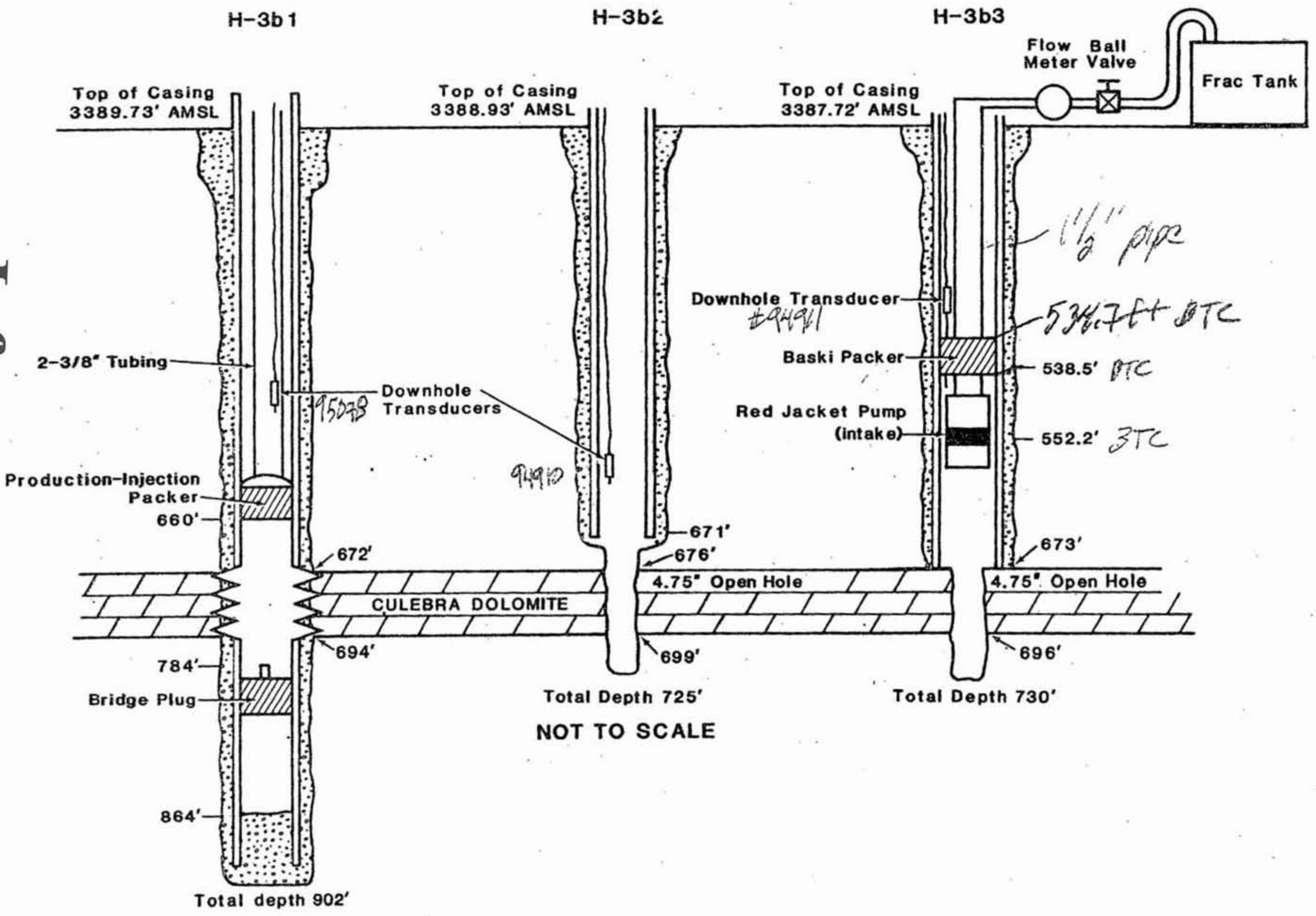

Figure 4-1. Configuration of Downhole and Surface Equipment for the 1984 Pumping Test at the H-3 Hydropad

SAND86-2311

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SAND86-2311

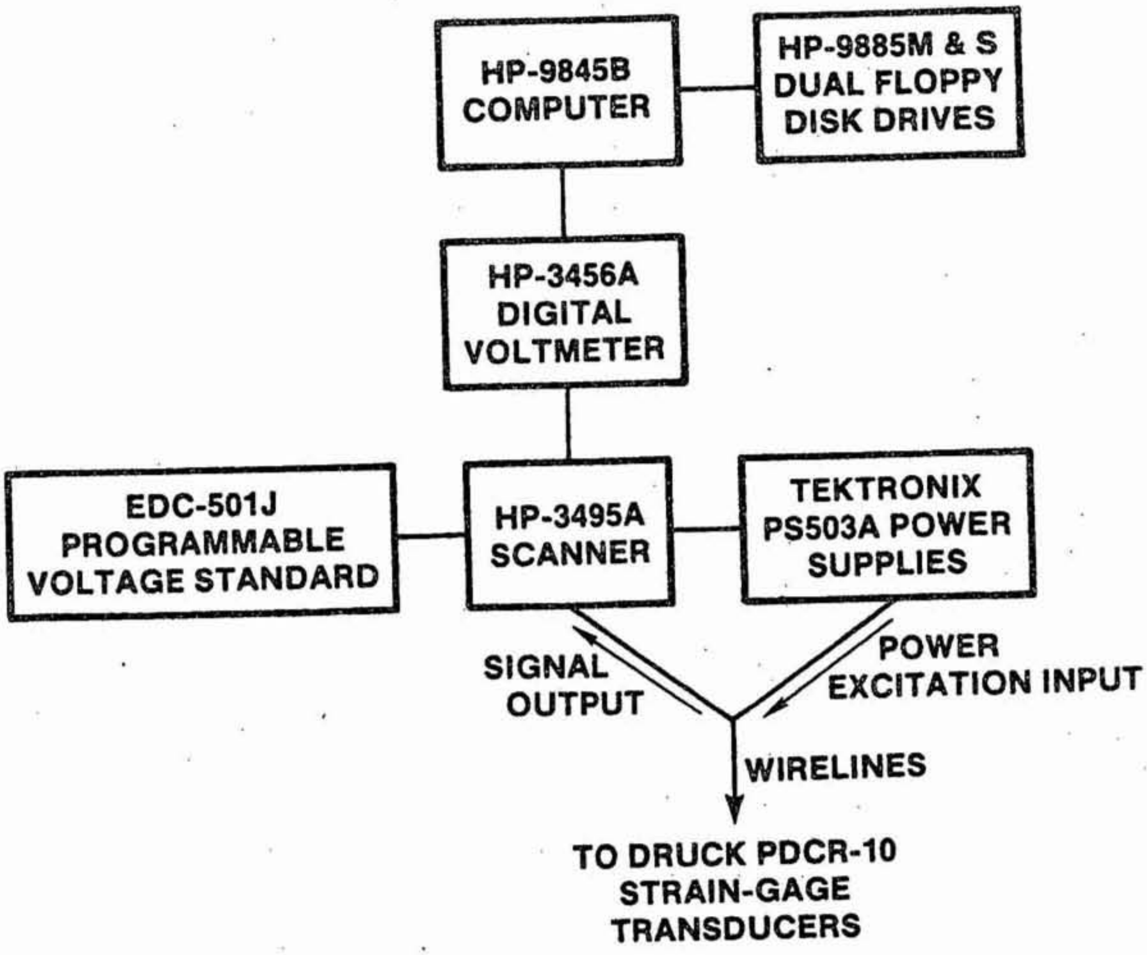

Figure 4-2. H-3 Data-Acquisition System

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Data File Conversion for 1984 H-3 Pumping Tests

John Loukota transferred data files HY318, HY319, HY320, HY321a, and HY323 from HP-9845 disks to PC disks in ASCII format. In the process, he deleted all empty fields from the matrix of fields automatically set up by the DAS. The resulting PC files were given .dat suffixes (e.g., HY319.dat). The first row in each file contains three entries: the number of lines of data, the time of the first record, and the time of the last record. The remaining rows contain twelve columns as follows:

Col. A: time (expressed in hours since 00:00 12/31/1983)
Col. B: temperature (^{o}C) measured in the instrumentation rack
Col. C: barometric pressure (psia)—defaults to 13 if no barometer on line
Col. D: calculated depth to water (ft) for first active channel
Col. E: calculated drawdown (ft) for first active channel
Col. F: calculated depth to water (ft) for second active channel
Col. G: calculated drawdown (ft) for second active channel
Col. H: calculated depth to water (ft) for third active channel
Col. I: calculated drawdown (ft) for third active channel
Col. J: power supply voltage (V) for first active channel
Col. K: power supply voltage (V) for second active channel
Col. L: power supply voltage (V) for third active channel

The DAS was programmed to record time in the format given above (hours since 00:00 12/31/1983) to facilitate reduction to a clock time. For instance, given a time of 804.566667 hours, dividing by 24 (hr/day) gives the value 33.523611. The integer part of this number, 33, identifies the day of the year of the reading (i.e., February 2). The fractional part of the number, 0.523611, can be multiplied by 24 (hr/day) to give 12.566667. The integer part of this number, 12, gives the hour of the day of the reading. Multiplying the fractional part of the number, 0.566667, by 60 (min/hr), gives the minute of the reading, 34 (and so on for seconds, if necessary). Thus, 804.566667 corresponds to 12:34 p.m. on February 2, 1984.

The DAS did not store raw millivolt readings from the transducers, but only calculated values. To calculate the depths to water (Cols. D, F, and H), each transducer was "initialized" at the start of each data file. For the initialization, the water level was measured in each well, and the depth to water was assigned to whatever millivolt value the corresponding transducer was producing at that time. From that time on, the DAS calculated new water levels using the calibration coefficients that had been entered for each transducer **and assuming that the water had a density of 1.0 g/cm^3**. Calculated depths to water are presented as negative values (depth below top of casing (BTC)). Calculated drawdowns (Cols. E, G, and I) merely represent the change in water level since the transducer was initialized.

Because the density of Culebra water at H-3 is not 1.0 g/cm^3 but approximately 1.04 g/cm^3 (Beauheim, 1987), reinitializing the transducers at the beginning of each data file introduces offsets when the data files are combined (see plots labeled "1984 H-3

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Pumping Tests, H-3b1 (or H-3b2 or H-3b3)"). These offsets were removed by determining the difference between the final calculated depth to water from the previous data file and the initialized depth to water for the new data file, and then subtracting that difference from all the data in the new data file so that the new file started at the depth to water at which the previous file ended. This process is cumulative for the total number of files. The initialization data for HY318, HY319, and HY320 and offset compensations are shown in the following table:

Data File	Well	Initialized Depth to Water (ft BTC)	Final Depth to Water in Previous File (ft BTC)	Compensation to Data in New File (ft)
HY318	H-3b1	416.26	NA	NA
	H-3b2	417.32	NA	NA
	H-3b3	417.54	NA	NA
HY319	H-3b1	416.69	418.038	-1.348
	H-3b2	418.38	418.724	-0.344
	H-3b3	418.1	418.058	+0.042
HY320	H-3b1	417.97	418.517	-1.348-0.547=-1.895
	H-3b2	419.51	419.642	-0.344-0.132=-0.476
	H-3b3	419.2	419.191	+0.042 (0.009 ignored)

The initialization data presented in the table above are found on pages 1, 2, and 10 of Volume II of the H-3 Log Book (ERMS 420564; pages included in this Analysis Package).

For analysis, the depth-to-water data were converted to pressures at the midpoint of the Culebra. From Mercer and Orr (1979), the center of the Culebra is 682 ft below ground surface (BGS) in H-3b1. Gonzales (1989) gives the ground surface elevation at H-3b1 as 3389.24 ft above mean sea level (amsl), putting the center of Culebra at 2707.24 ft amsl. Using this elevation for the center of Culebra in all wells, the initialized depths to water were converted to heights of water columns above the center of Culebra, and then converted to pressure using a fluid density of 1.04 g/cm^3 (Beauheim, 1987). Relevant data are presented in the table below:

Well	Top of Casing Elevation (ft amsl)*	Initialized Water Level Elevation (ft amsl)	Water Column Height Above Midpoint of Culebra (ft)	Initial Pressure (psig)
H-3b1	3390.64	2974.38	267.14	120.391
H-3b2	3390.03	2972.71	265.47	119.638
H-3b3	3388.67	2971.13	263.89	118.926

*Gonzales (1989)

Note that the absolute values of pressure are unimportant in the analysis process—only relative pressure changes affect the parameter estimation. Thus, errors in any of the

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elevations presented above are unimportant as long as the values are used consistently in processing the data from individual wells. The "true" density of 1.04 g/cm^3 is used only to calculate the initial pressure in each well. Subsequent calculations assume a density of 1.0 g/cm^3 when converting the changes in calculated water levels to pressures because that is the density used by the DAS to calculate the water levels.

The compensations and conversions described above are implemented in the Excel files created for each of the data files: HY318.xls, HY319.xls, and HY320.xls. These Excel files contain columns A, D, F, and H from the HY3##.dat files. The time (column A in the HY3##.xls files) is converted to elapsed time (hr) from the start of data acquisition for file HY318 in column B in HY318.xls and HY319.xls. Column B in HY320.xls is a corrected data-acquisition time (column A + 24 hr) because the person initializing the DAS for that data file forgot that 1984 was a leap year and input the wrong numerical starting day (see H-3 Log Book, Volume II, page 20). Thus, column C in HY320.xls is the elapsed time (hr) from the start of data acquisition for file HY318. The H-3b3 depth to water (column C) is converted to pressure in column D using the formula:

D#=(417.54+C#)*0.43333+118.926 in HY318.xls.

For HY319.xls and HY320.xls, the formula becomes:

D#=(417.54+C#+0.042)*0.43333+118.926 and

E#=(417.54+D#+0.042)*0.43333+118.926, respectively.

The H-3b1 depth to water (column E or F) is converted to pressure in column F or G using the formulas:

F#=(416.26+E#)*0.43333+120.391 for HY318.xls,

F#=(416.26+E#-1.348)*0.43333+120.391 for HY319.xls, and

G#=(416.26+F#-1.895)*0.43333+120.391 for HY320.xls.

The H-3b2 depth to water (column G or H) is converted to pressure in column H or I using the formulas:

H#=(417.32+G#)*0.43333+119.638 for HY318.xls,

H#=(417.32+G#-0.344)*0.43333+119.638 for HY319.xls, and

I#=(417.32+H#-0.476)*0.43333+119.638 for HY320.xls.

A comment column (I or J) was added to allow the start and stop of pumping to be noted. The calculated pressure data are shown on the plots labeled "H-3 Pumping Tests, H-3b1 (or H-3b2 or H-3b3)". More detailed views of the data from the pumping well, H-3b3, for each pumping period are shown in the plots labeled "1984 H-3b3 Pumping Test #1 (or #2 or #3 or #4)".

To provide an input file for Interpret/2, the calculated pressures for the three H-3 wells were extracted from HY318.xls, HY319.xls, and HY320.xls and combined in a single file, with time expressed as elapsed hours since the beginning of the first pumping test (2607.5 hr in HY318). This file is titled H3PINT2.xls.

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From: Loukota, John J

To: Beauheim, Richard L

Cc:

Subject: Hydrology Data

Sent: 9/29/99 2:51 PM **Importance:** Normal

Hi Rick;

Attached are copies of the data contained in the 6 files you requested. The file format of the data is: Record No. 1 contains the Number of Records in the File, the First Time of the data, and the Last Time of the data. Record No. 2 through the last record contains the data in the format: Scan Time, Data Channels 0 through 7 and Data Channels 34 through 36. The remaining data channels contained on the original diskettes contained the -9E60 data flag which indicated that they were never activated. If the data was less than -9E16 then I wrote -9999 to the file. If the data was greater than 9E16 then I wrote 9999 to the file.

I also have the data on a 3.5 inch disk that you may have if you want it.

Anything else that I can help you with, let me know.

John

HY1105.DAT HY318.DAT HY319.DAT HY320.DAT HY321A.DAT HY323.DAT

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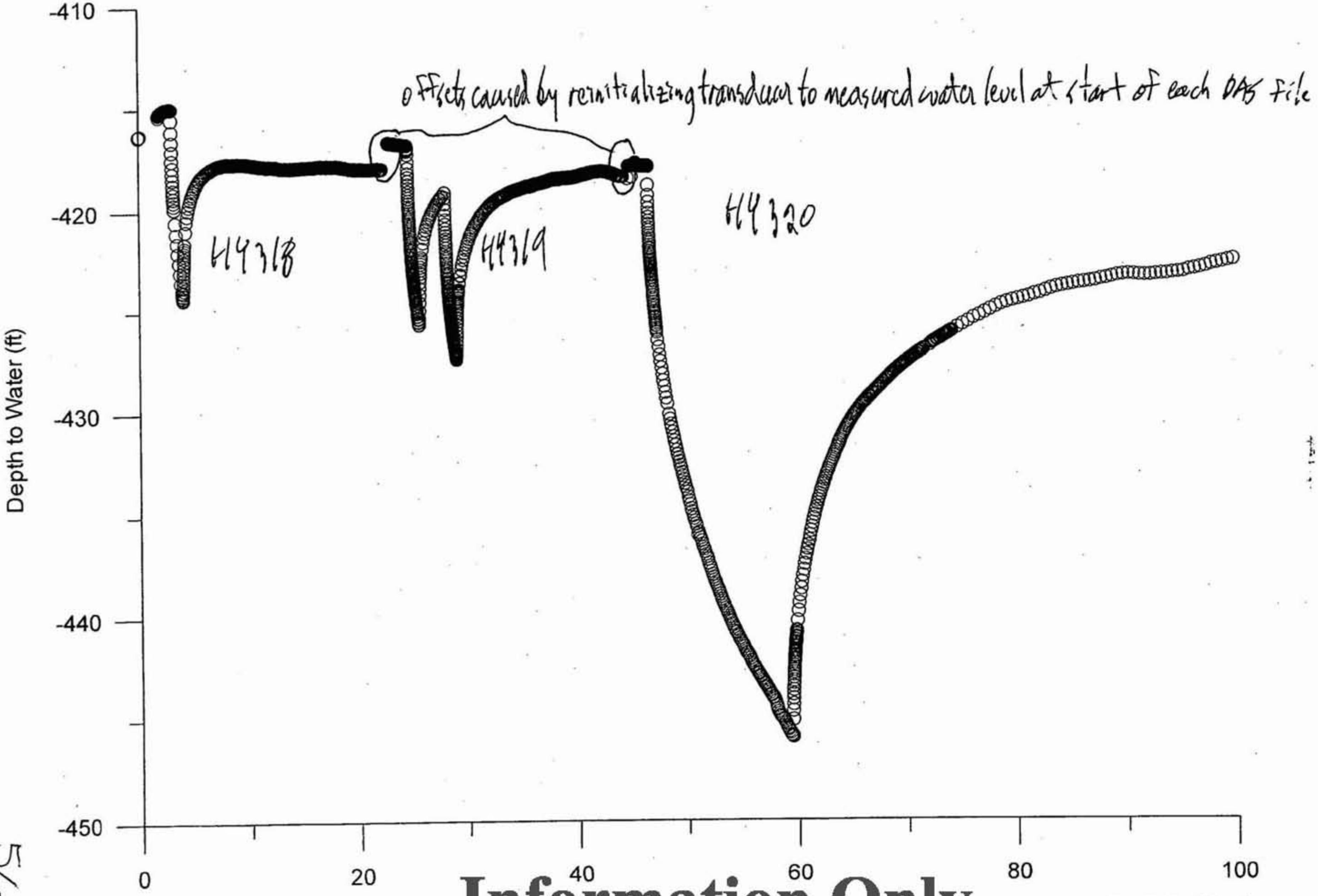
1984 H-3 Pumping Tests, H-3b1



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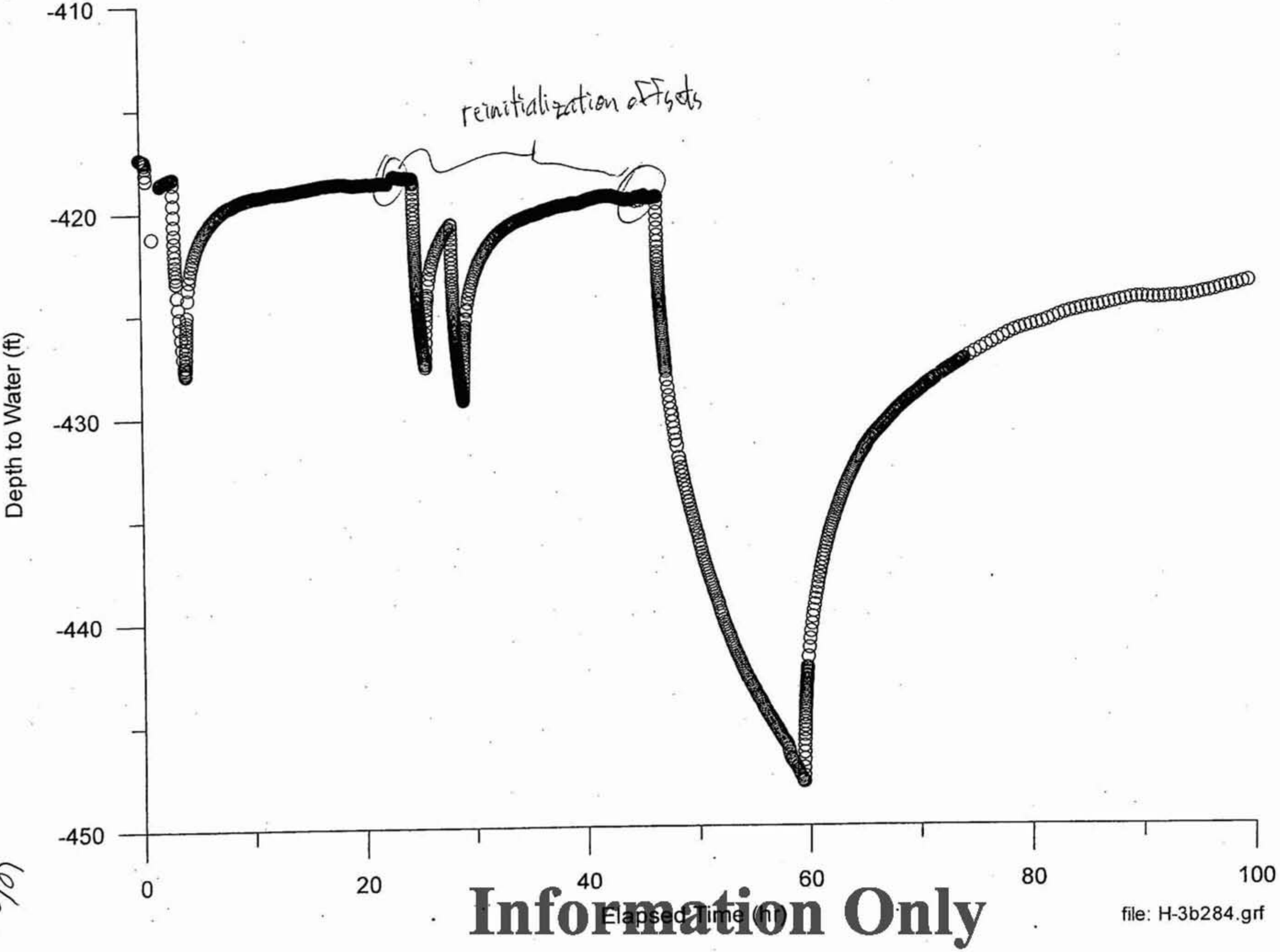
1984 H-3 Pumping Tests, H-3b2



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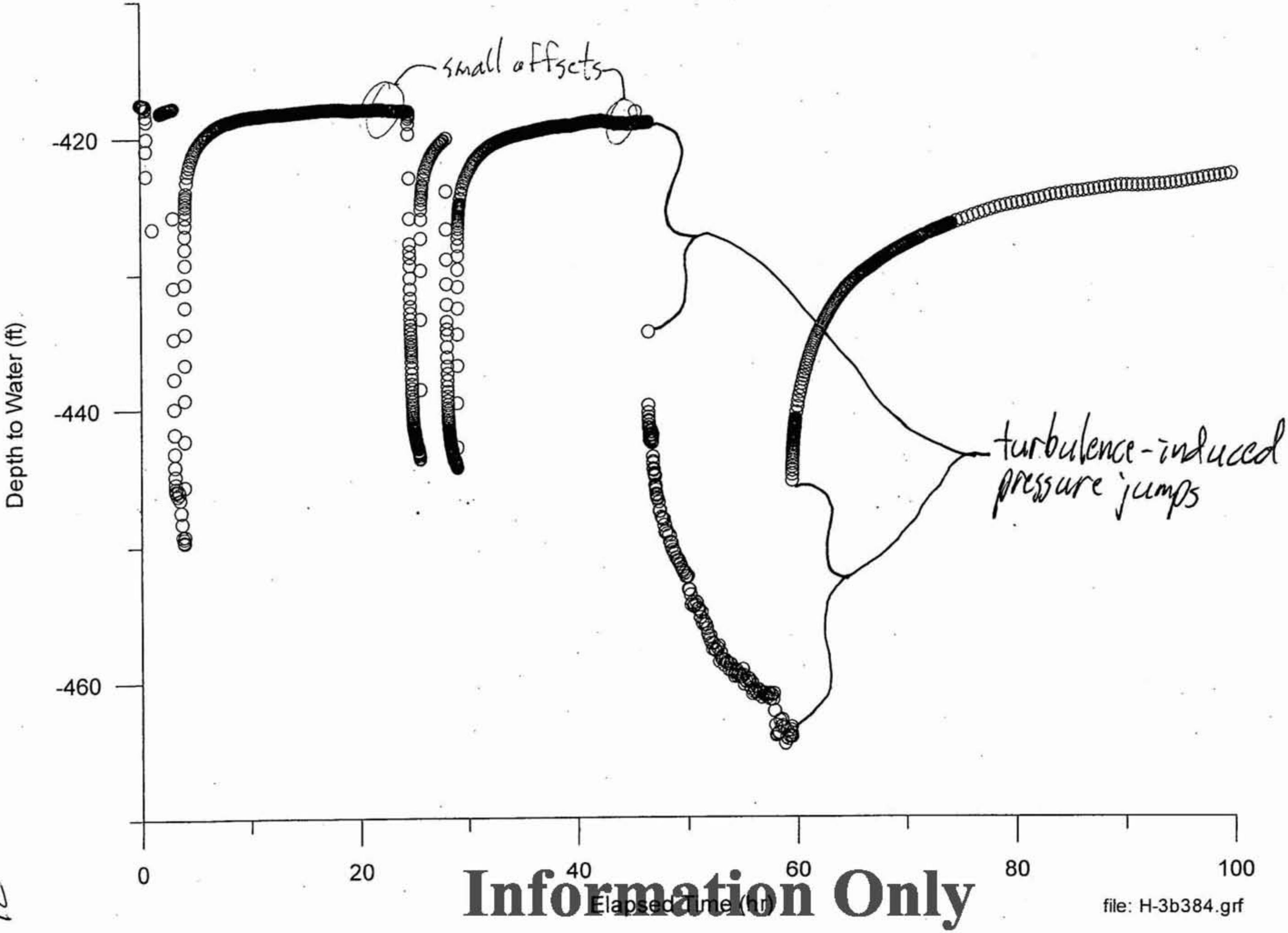
1984 H-3 Pumping Tests, H-3b3



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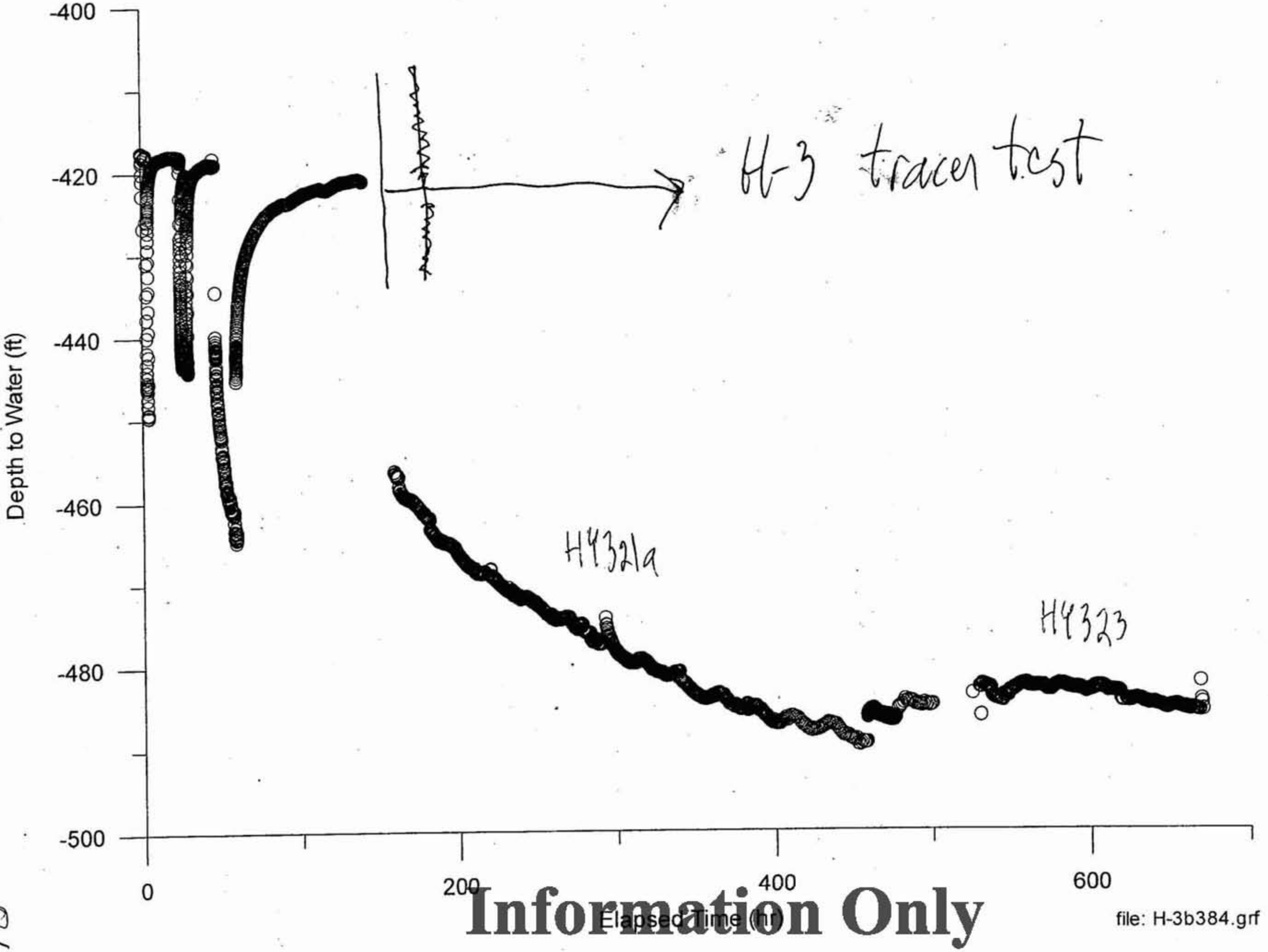
1984 H-3 Pumping Tests, H-3b3



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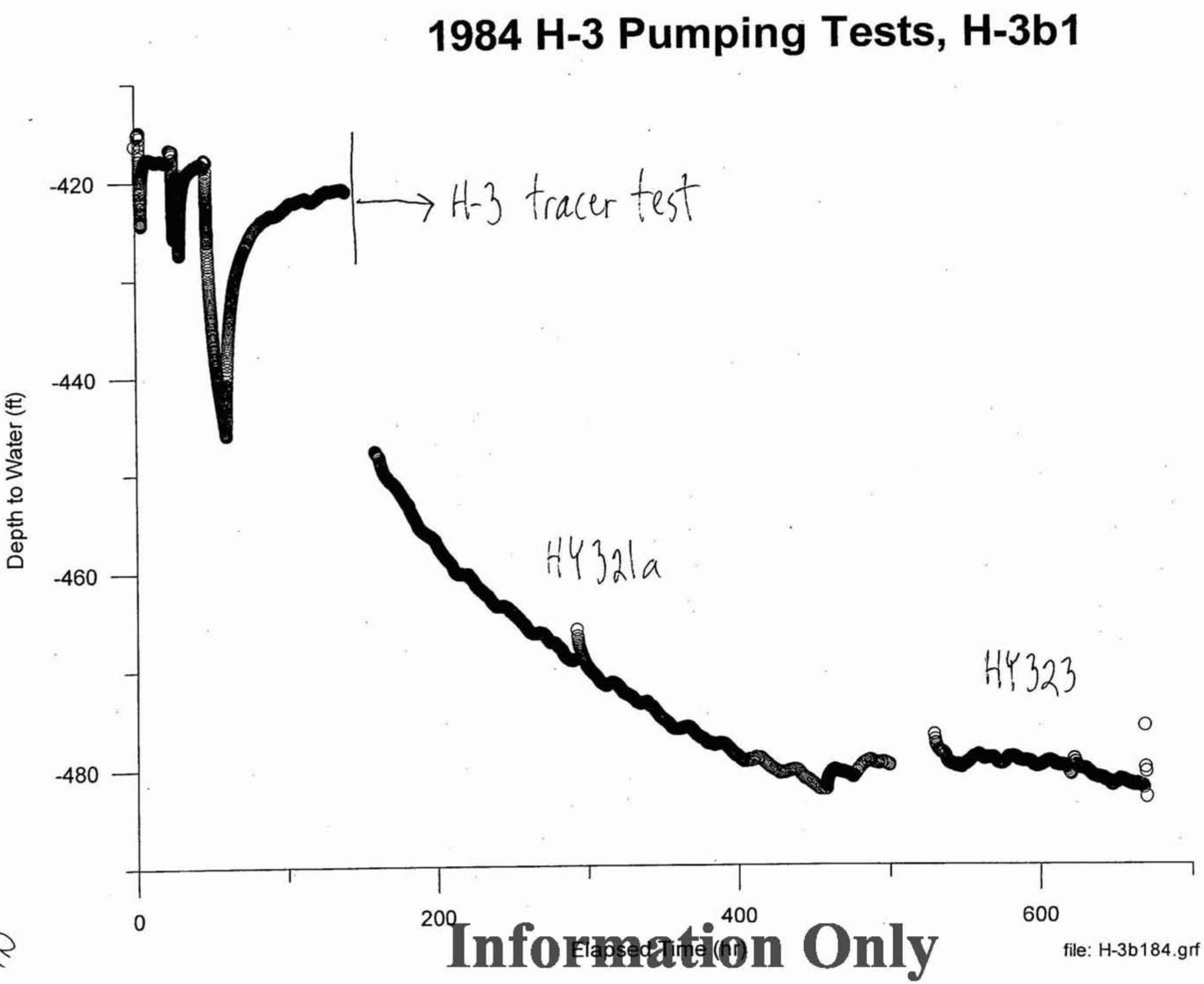

→ H-3 tracer test

HY321a

HY323

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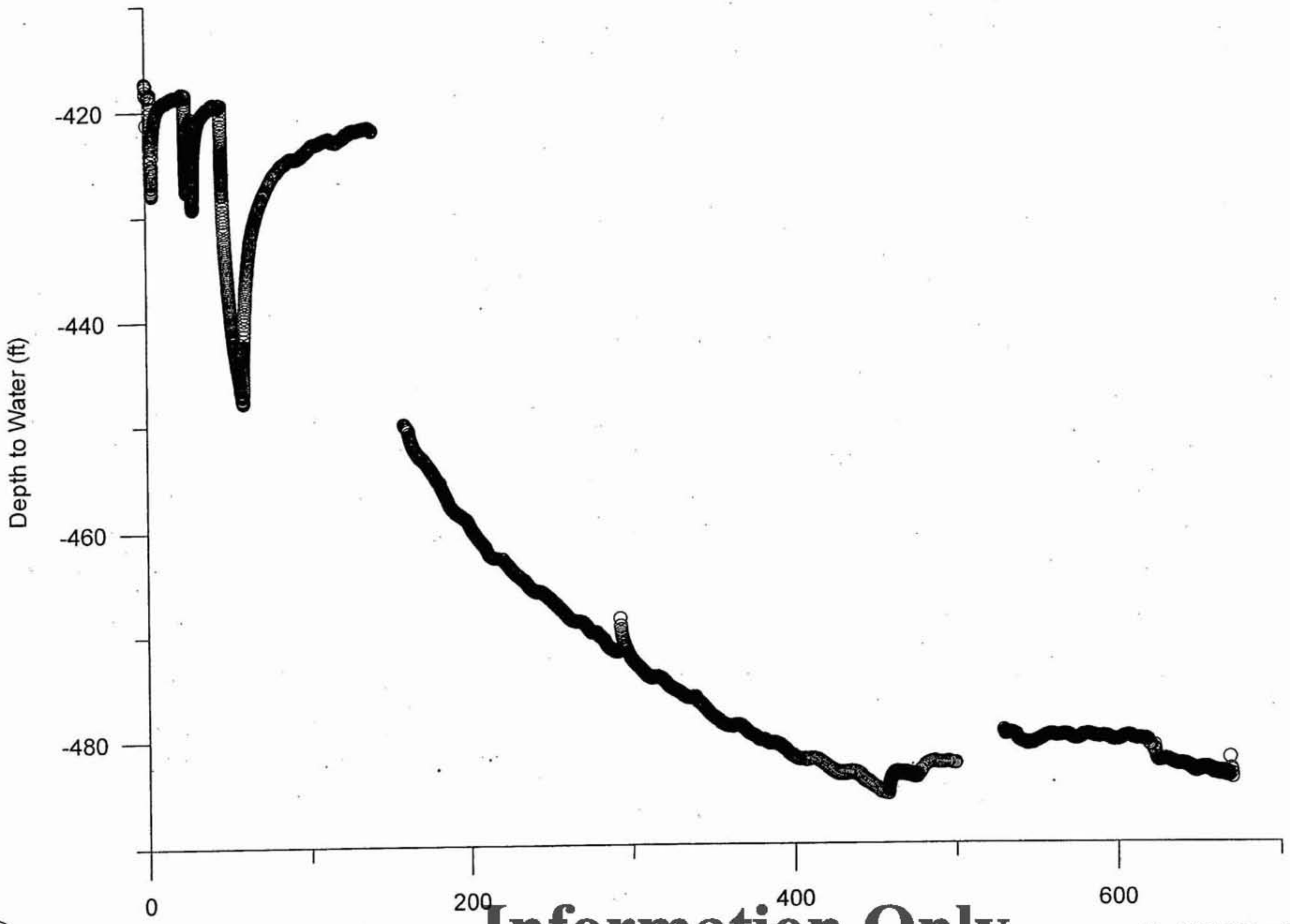
1984 H-3 Pumping Tests, H-3b2



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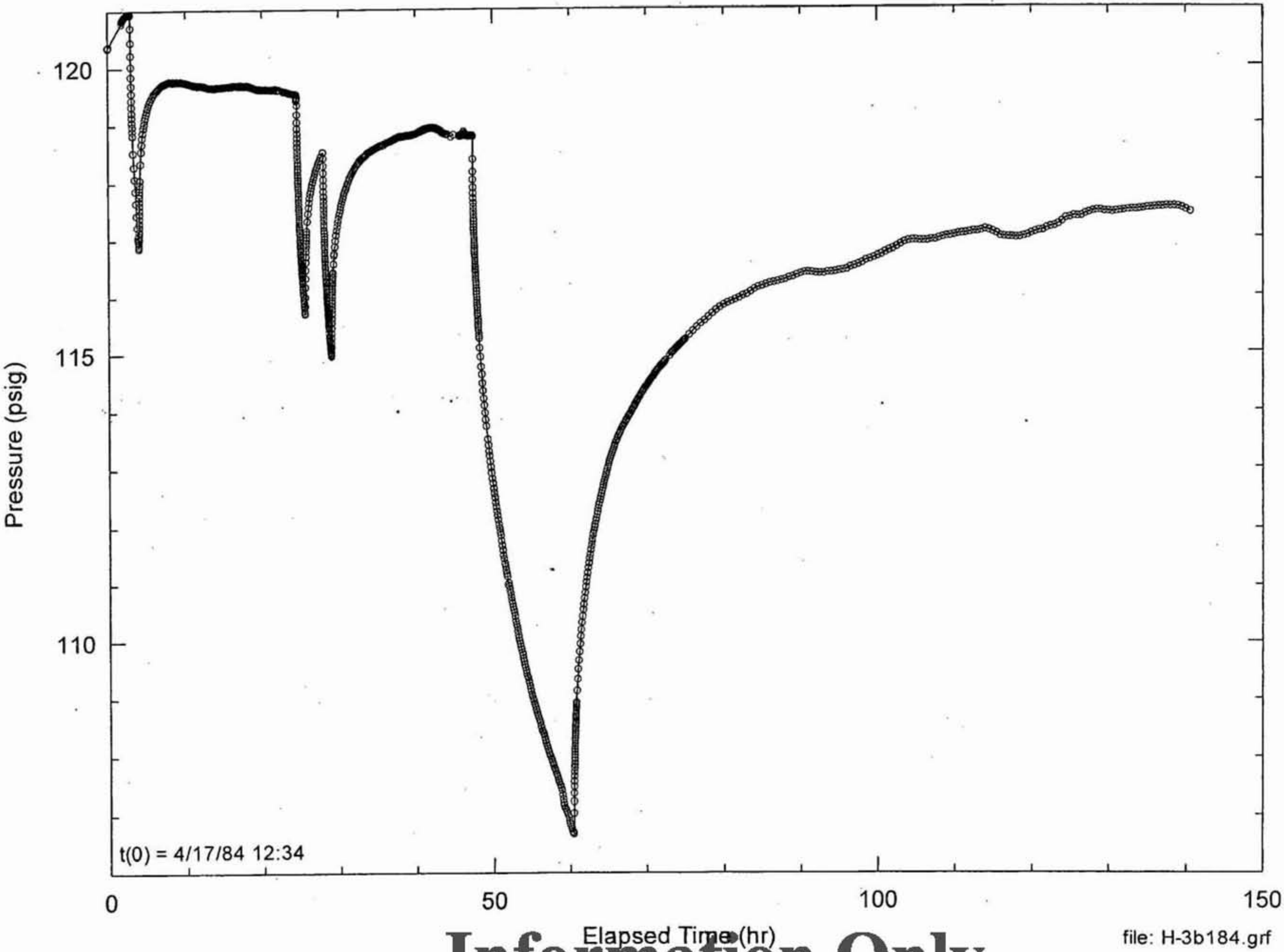
H-3 Pumping Tests, H-3b1



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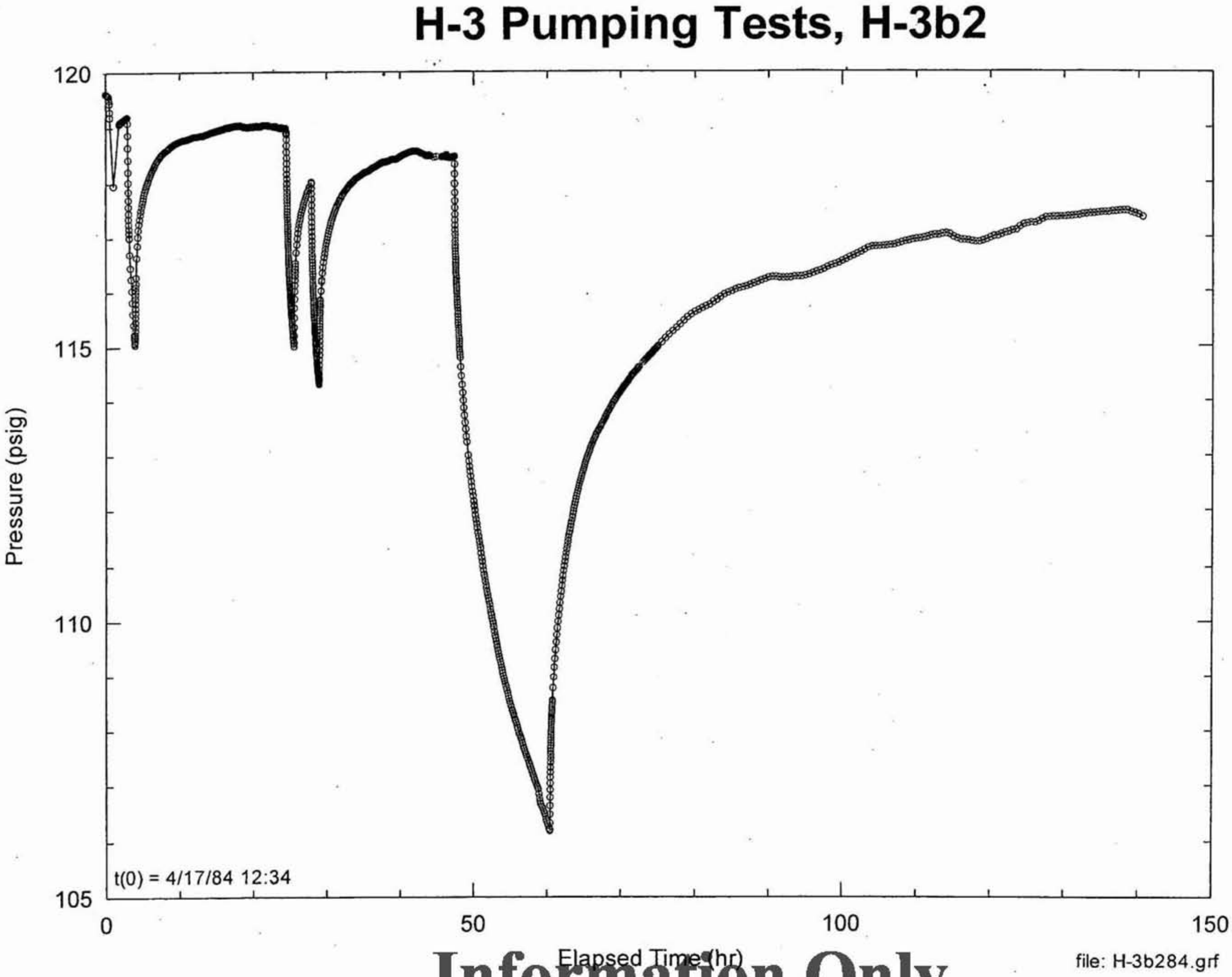

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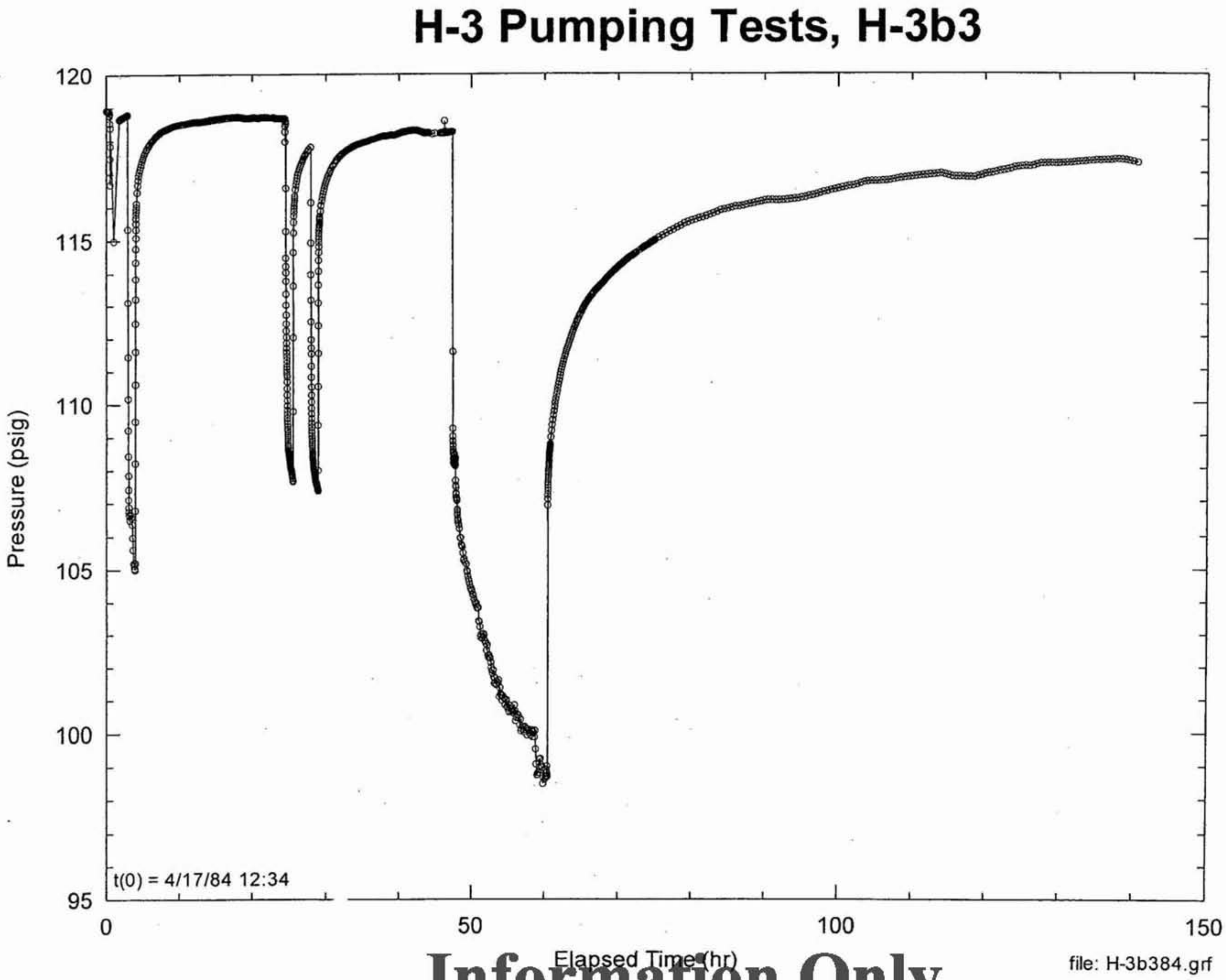

H-3 Pumping Tests, H-3b3

file: H-3b384.grf

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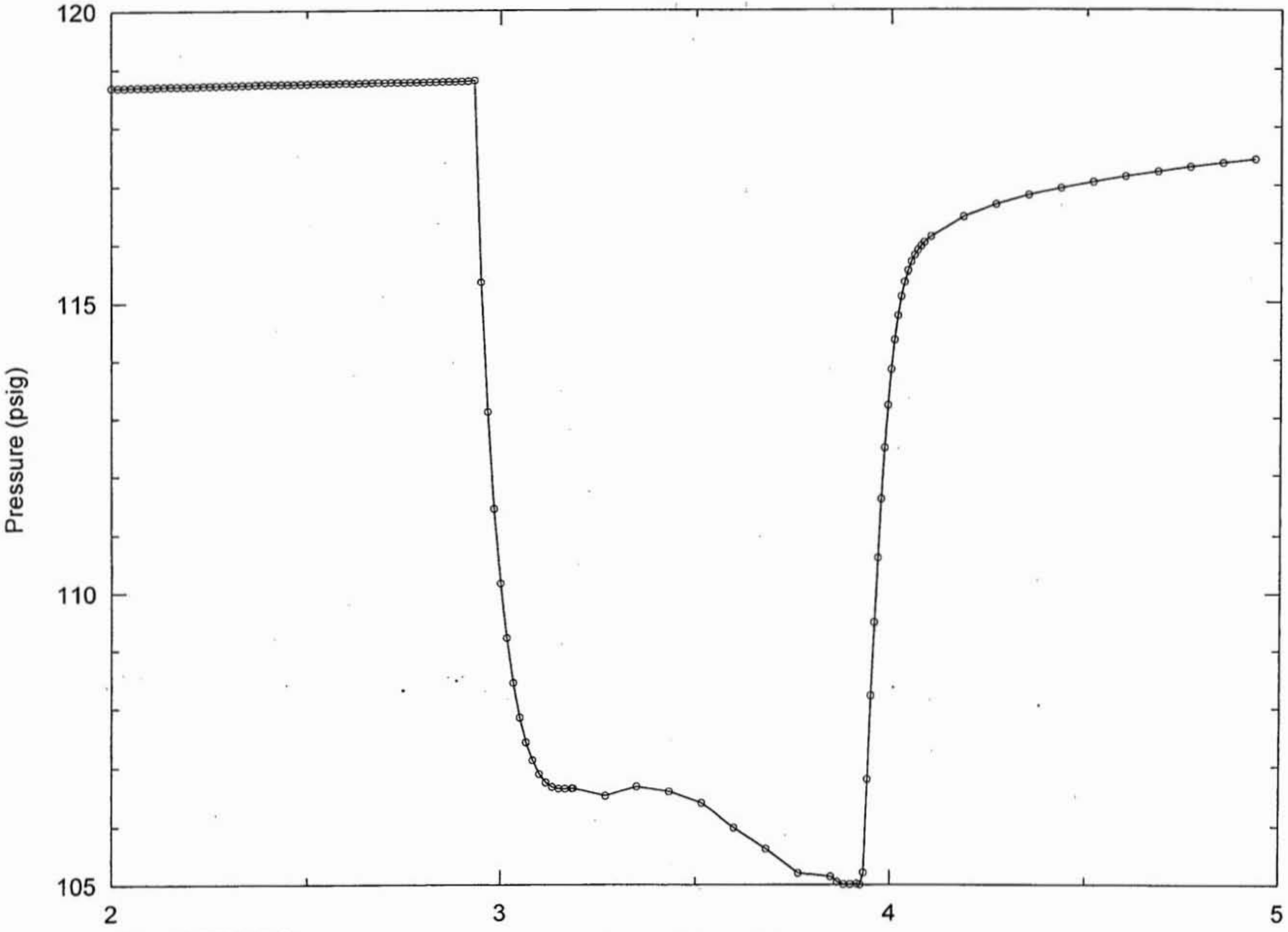
1984 H-3b3 Pumping Test #1



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file: H-3b384.grf

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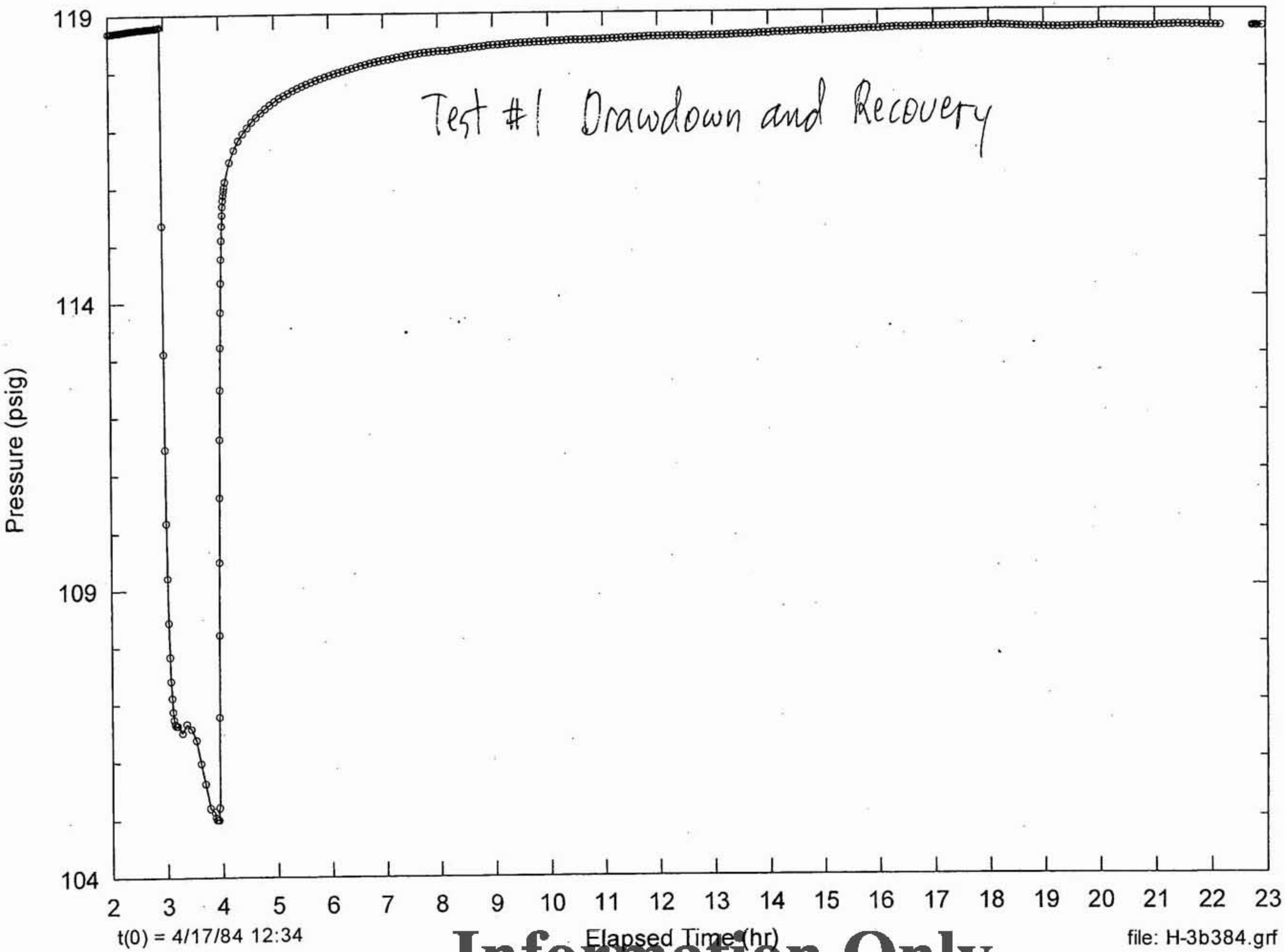
H-3 Pumping Tests, H-3b3



Test #1 Drawdown and Recovery

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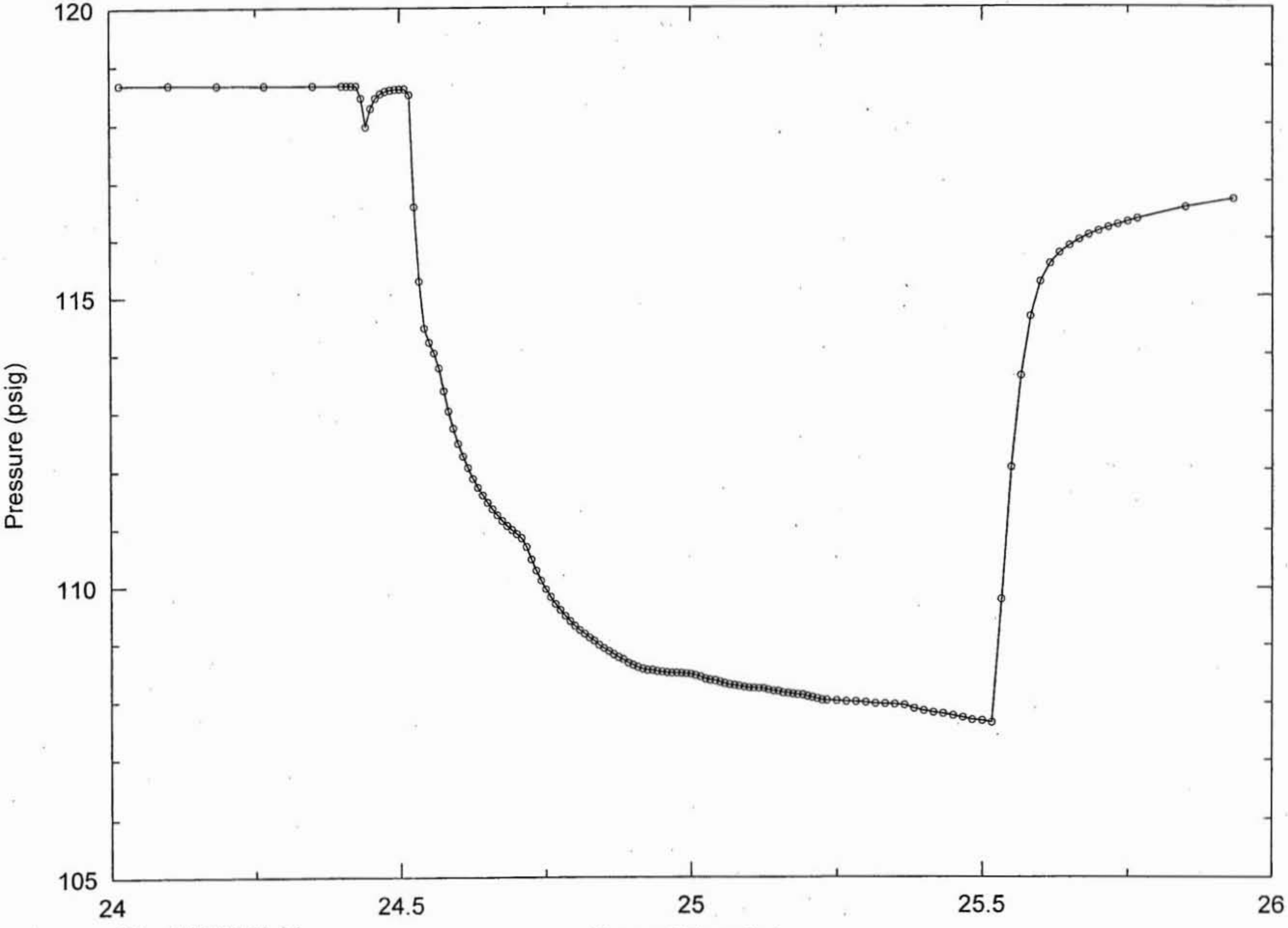
1984 H-3b3 Pumping Test #2



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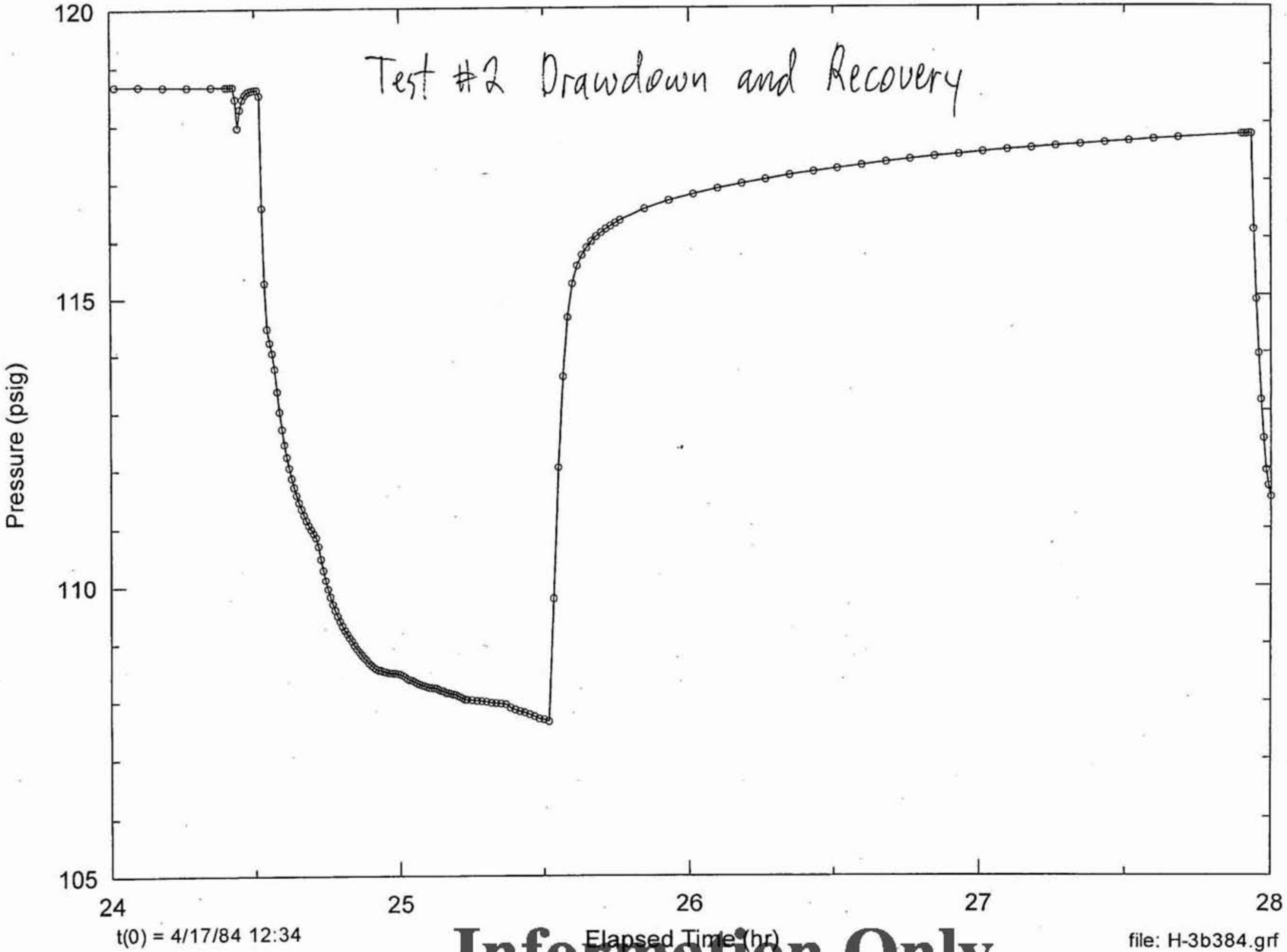
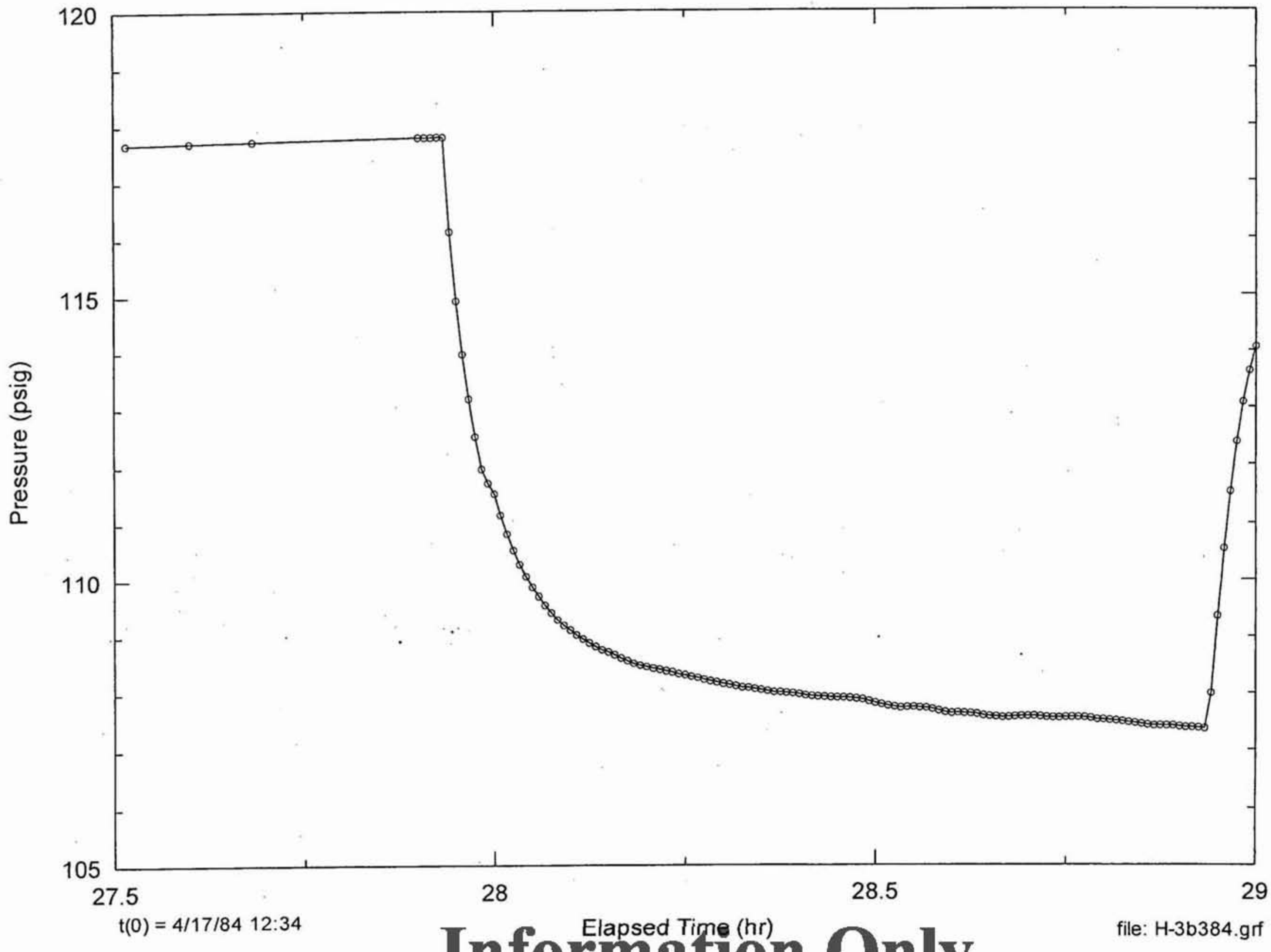
H-3 Pumping Tests, H-3b3



Information Only

1984 H-3b3 Pumping Test #3



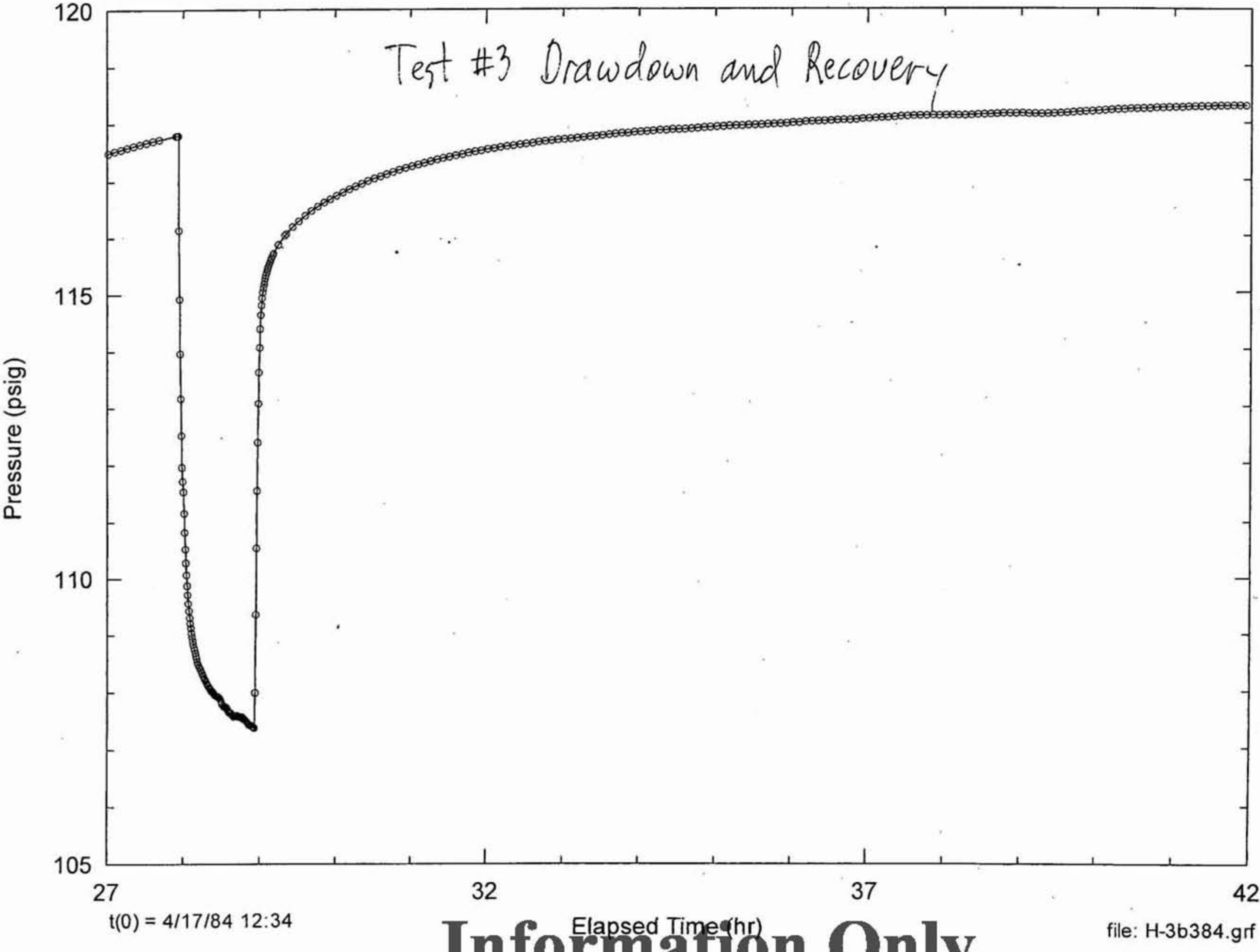
t(0) = 4/17/84 12:34

file: H-3b384.grf

Information Only

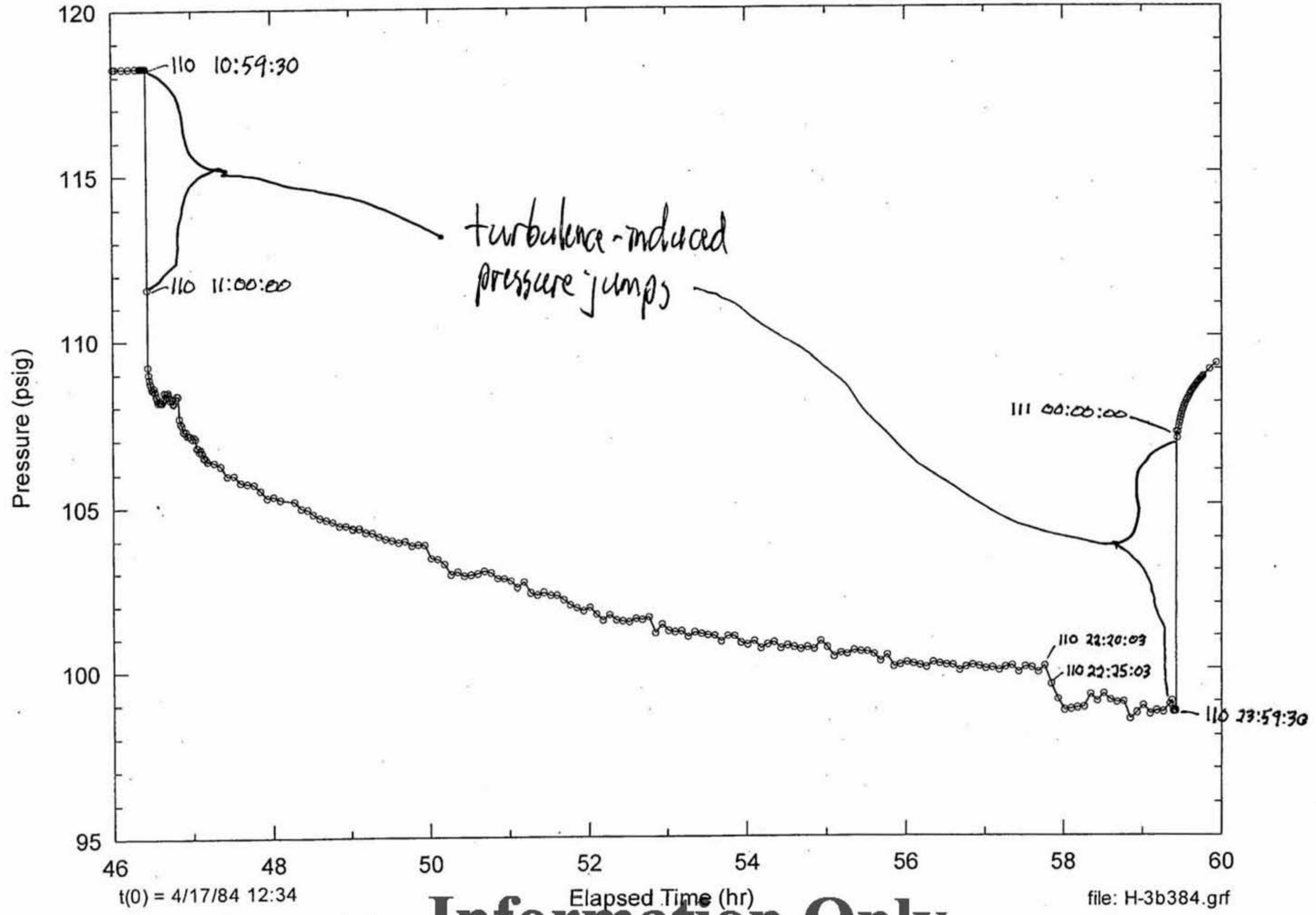
10/2/03

H-3 Pumping Tests, H-3b3



Information Only

1984 H-3b3 Pumping Test #4



packer inflated for this test only

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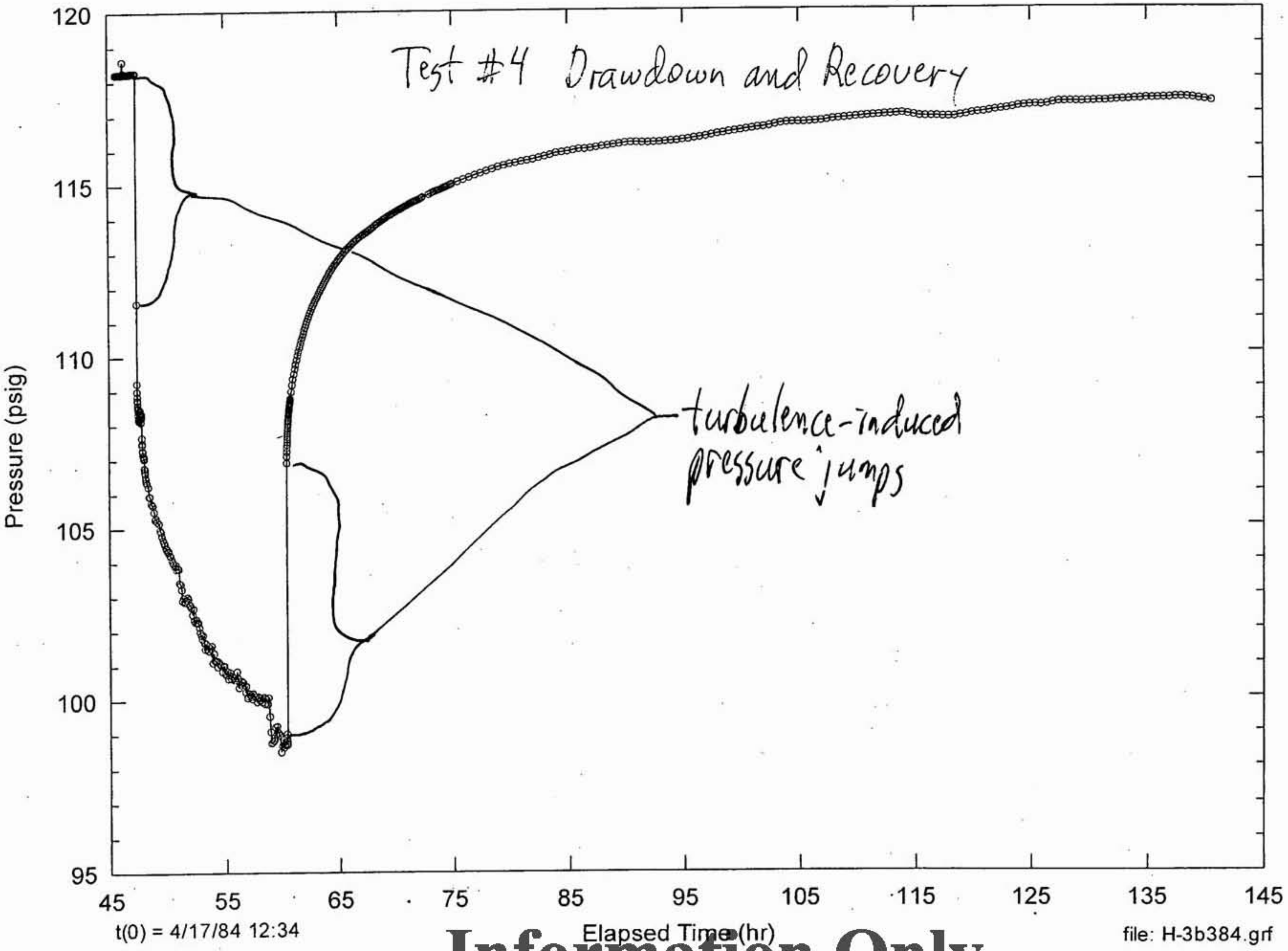
H-3 Pumping Tests, H-3b3



Test #4 Drawdown and Recovery

turbulence-induced pressure jumps

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Flow-Rate Data for 1984 H-3 Pumping Tests

The flow-rate data for the 1984 H-3 pumping tests are contained in pages 1-20 of Volume II of the H-3 Log Book (ERMS 420564; pages included in this Analysis Package). Three of the entries on p. 4, one entry on p. 7, and three entries on p. 8 of this logbook were written in a form like "7 gallons/103.56 seconds=6.60 gpm". The math appears to be incorrect until one realizes that "103.56 seconds" actually means "1 minute, 3.56 seconds (or 63.56 seconds)". This "conversion" provides data consistent with the calculated rate and previous and subsequent entries. Examination of the pressure data at the times of these entries also confirms that the pumping rate was not fluctuating as a literal reading of "103.56 seconds" would suggest. The data were entered into file H-3-Q.xls and a column (D) of elapsed time (hr) since the beginning of data acquisition for file HY318 (4/17/1984 12:34 p.m.) was calculated (see printout of H-3-Q.xls). For the first of the four pumping tests, only the total number of gallons pumped was recorded, so only a single average rate can be used to analyze that test. For the remaining three tests, the rate data were plotted using Grapher 2.0 (see plots titled 1984 H-3b3 Pumping Test #2, #3, and #4). From visual examination of these plots, a total of 53 flow periods was identified beginning with the pumping for test #1 and ending with the recovery from test #4. These flow periods and the average rates during each are demarcated on the plots and also on the printout of H-3-Q.xls. Upon further examination, flow periods 35 and 36 were combined, and 40 and 41 were combined, leaving a total of 51 flow periods.

The relationship between the flow periods (FP) and the pumping tests is as follows:

FP1 = pumping for test #1
FP2 = recovery for test #1
FP3 = aborted start for test #2
FP4 = recovery from aborted start for test #2
FP5-11 = pumping for test #2
FP12 = recovery for test #2
FP13-23 = pumping for test #3
FP24 = recovery for test #3
FP25-50 = pumping for test #4
FP51 = recovery for test #4

The data for these flow periods were then entered into file H3QINT2.xls for input into Interpret/2. File H3QINT2.xls contains four columns:

Col. A: FP#
Col. B: FP duration (minutes)
Col. C: FP rate (gallons per minute)
Col. D: FP rate (barrels per day)

Information Only

Pumping rates from 1984 H-3 tests

Date	Time	Flow Rate (gpm)	Elapsed Time (hr)		Flow Period	Rate (gpm)	(BPD)
4/17/84	12:34:00	0	0.000000				
4/17/84	15:29:59	0	2.933056				
4/17/84	15:30:00	7.12	2.933333		1	7.12	244.1
4/17/84	16:30:00	7.12	3.933333				
4/17/84	16:30:01	0	3.933611		2	0	
4/18/84	12:59:59	0	24.433056				
4/18/84	13:00:00	7	24.433333	est.	3	7	240.0
4/18/84	13:00:09	7	24.435833	est. time			
4/18/84	13:00:10	0	24.436111	est. time	4	0	
4/18/84	13:04:59	0	24.516389				
4/18/84	13:05:00	7	24.516667	est.	5	RZD 12/10/99 6 ~~7~~.82	233.8 ~~268.1~~
4/18/84	13:10:00	6.64	24.600000		6	6.535	224.1
4/18/84	13:12:00	6.43	24.633333		7	6.30	216.0
4/18/84	13:17:00	6.17	24.716667				
4/18/84	13:17:29	6.17	24.724722	est.			
4/18/84	13:17:30	6.8	24.725000	est.	8	6.76	231.8
4/18/84	13:22:00	6.72	24.800000		9	6.665	228.5
4/18/84	13:26:00	6.61	24.866667		10	6.53	223.9
4/18/84	13:32:00	6.45	24.966667		11	6.45	221.1
4/18/84	13:34:00	6.47	25.000000				
4/18/84	13:36:00	6.47	25.033333				
4/18/84	13:40:00	6.44	25.100000				
4/18/84	13:42:00	6.47	25.133333				
4/18/84	13:44:00	6.55	25.166667				
4/18/84	13:46:00	6.34	25.200000				
4/18/84	13:48:00	6.45	25.233333				
4/18/84	13:54:00	6.47	25.333333				
4/18/84	13:55:00	6.37	25.350000				
4/18/84	13:56:00	6.44	25.366667	est.			
4/18/84	14:03:00	6.44	25.483333				
4/18/84	14:05:00	6.44	25.516667	est.			
4/18/84	14:05:01	0	25.516944		12	0	
4/18/84	16:29:59	0	27.933056				
4/18/84	16:30:00	8	27.933333	est.	13	7.765	266.2
4/18/84	16:32:00	7.53	27.966667		14	7.165	245.7
4/18/84	16:37:00	6.80	28.050000		15	6.705	229.9
4/18/84	16:40:00	6.61	28.100000		16	6.59	225.9
4/18/84	16:41:00	6.61	28.116667				
4/18/84	16:44:00	6.56	28.166667		17	6.515	223.4
4/18/84	16:45:00	6.47	28.183333		18	6.45	221.1
4/18/84	16:48:00	6.45	28.233333				
4/18/84	16:52:00	6.44	28.300000		19	6.39	219.1
4/18/84	16:54:00	6.34	28.333333		20	6.32	216.7
4/18/84	16:57:00	6.31	28.383333				
4/18/84	17:00:00	6.31	28.433333				
4/18/84	17:05:00	6.33	28.516667				
4/18/84	17:09:00	6.33	28.583333		21	6.285	215.5
4/18/84	17:13:00	6.24	28.650000		22	6.19	212.2
4/18/84	17:28:00	6.14	28.900000				

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4/18/84	17:30:00	6.14	28.933333	est.	23	6.14	210.5
4/18/84	17:30:01	0	28.933611		24	0	
4/19/84	10:59:59	0	46.433056				
4/19/84	11:00:00	7	46.433333	est.			
4/19/84	11:03:00	6.84	46.483333		25	6.83	234.2
4/19/84	11:07:00	6.68	46.550000				
4/19/84	11:10:00	6.61	46.600000		26	6.50	222.9
4/19/84	11:13:00	6.39	46.650000				
4/19/84	11:16:00	6.30	46.700000				
4/19/84	11:20:00	6.31	46.766667		27	6.28	215.3
4/19/84	11:22:00	6.14	46.800000				
4/19/84	11:25:00	6.49	46.850000		28	6.39	219.1
4/19/84	11:27:00	6.53	46.883333				
4/19/84	11:28:00	6.53	46.900000		29	6.53	223.9
4/19/84	11:31:00	6.54	46.950000				
4/19/84	11:33:00	6.51	46.983333				
4/19/84	11:35:00	6.47	47.016667				
4/19/84	11:39:00	6.56	47.083333				
4/19/84	11:41:00	6.56	47.116667				
4/19/84	11:42:00	6.60	47.133333				
4/19/84	11:47:00	6.56	47.216667				
4/19/84	11:48:00	6.56	47.233333				
4/19/84	11:50:00	6.54	47.266667				
4/19/84	11:51:00	6.56	47.283333				
4/19/84	11:53:00	6.53	47.316667				
4/19/84	11:54:00	6.53	47.333333				
4/19/84	11:56:00	6.49	47.366667				
4/19/84	11:57:00	6.53	47.383333				
4/19/84	12:01:00	6.52	47.450000				
4/19/84	12:03:00	6.51	47.483333				
4/19/84	12:04:00	6.47	47.500000				
4/19/84	12:06:00	6.48	47.533333				
4/19/84	12:07:00	6.46	47.550000				
4/19/84	12:09:00	6.49	47.583333				
4/19/84	12:10:00	6.52	47.600000				
4/19/84	12:11:00	6.49	47.616667		30	6.45	221.1
4/19/84	12:17:00	6.48	47.716667				
4/19/84	12:19:00	6.46	47.750000				
4/19/84	12:20:00	6.45	47.766667				
4/19/84	12:22:00	6.44	47.800000				
4/19/84	12:23:00	6.47	47.816667				
4/19/84	12:24:00	6.42	47.833333				
4/19/84	12:26:00	6.45	47.866667				
4/19/84	12:27:00	6.42	47.883333				
4/19/84	12:29:00	6.47	47.916667				
4/19/84	12:36:00	6.43	48.033333				
4/19/84	12:41:00	6.40	48.116667				
4/19/84	12:45:00	6.37	48.183333		31	6.34	217.4
4/19/84	12:50:00	6.39	48.266667				
4/19/84	12:56:00	6.35	48.366667				
4/19/84	12:57:00	6.30	48.383333				
4/19/84	13:05:00	6.32	48.516667				
4/19/84	13:22:00	6.34	48.800000				

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4/19/84	13:50:00	6.26	49.266667		32	6.29	215.7	
4/19/84	14:06:00	6.27	49.533333					
4/19/84	14:30:00	6.19	49.933333		33	6.23	213.6	
4/19/84	14:33:00	6.33	49.983333		34	6.30	216.0	
4/19/84	14:35:00	6.37	50.016667					
4/19/84	14:45:00	6.42	50.183333		35 →	6.415		
4/19/84	14:50:00	6.49	50.266667		35		6.42 220.1	merge
4/19/84	15:00:00	6.43	50.433333		36 →	6.42		
4/19/84	15:12:00	6.36	50.633333					
4/19/84	15:44:00	6.33	51.166667		~~37~~ → 36	6.345	217.5	
4/19/84	15:50:00	6.44	51.266667					
4/19/84	15:53:00	6.41	51.316667		~~38~~ → 37	6.39	219.1	
4/19/84	15:58:00	6.36	51.400000					
4/19/84	16:00:00	6.38	51.433333					
4/19/84	16:19:00	6.30	51.750000		~~39~~ → 38	6.34	217.4	
4/19/84	16:22:00	6.43	51.800000					
4/19/84	16:23:00	6.48	51.816667					
4/19/84	16:25:00	6.45	51.850000		40 →	6.44		
4/19/84	16:27:00	6.48	51.883333					
4/19/84	16:29:00	6.55	51.916667		39		6.45 221.1	merge
4/19/84	16:45:00	6.49	52.183333					
4/19/84	17:00:00	6.42	52.433333		41 →	6.46		
4/19/84	17:15:00	6.36	52.683333					
4/19/84	17:31:00	6.37	52.950000					
4/19/84	17:45:00	6.32	53.183333					
4/19/84	18:00:00	6.33	53.433333		~~42~~ → 40	6.35	217.7	
4/19/84	18:15:00	6.37	53.683333					
4/19/84	18:30:00	6.37	53.933333					
4/19/84	18:46:00	6.32	54.200000					
4/19/84	19:00:00	6.26	54.433333		~~43~~ → 41	6.30	216.0	
4/19/84	19:15:00	6.27	54.683333					
4/19/84	19:30:00	6.15	54.933333					
4/19/84	19:45:00	6.21	55.183333		~~44~~ → 42	6.20	212.6	
4/19/84	20:00:00	6.16	55.433333					
4/19/84	20:15:00	6.29	55.683333					
4/19/84	20:30:00	6.28	55.933333		~~45~~ → 43	6.285	215.5	
4/19/84	20:45:00	6.21	56.183333		~~46~~ → 44	6.20	212.6	
4/19/84	21:00:00	6.11	56.433333					
4/19/84	21:16:00	6.16	56.700000		~~47~~ → 45	6.13	210.2	
4/19/84	21:30:00	6.10	56.933333					
4/19/84	21:45:00	6.07	57.183333					
4/19/84	22:00:00	6.08	57.433333		~~48~~ → 46	6.08	208.5	
4/19/84	22:22:59	6.07	57.816389	est.				
4/19/84	22:23:00	6.55	57.816667	est.	~~49~~ → 47	6.505	223.0	
4/19/84	22:36:00	6.46	58.033333					
4/19/84	22:40:00	6.43	58.100000					
4/19/84	22:46:00	6.38	58.200000		~~50~~ → 48	6.40	219.4	
4/19/84	22:52:00	6.33	58.300000					
4/19/84	23:08:00	6.21	58.566667		~~51~~ → 49	6.27	215.0	
4/19/84	23:59:59	6.21	59.433056	est.	~~52~~ → 50	6.21	212.9	
4/20/84	0:00:00	0	59.433333		~~53~~ → 51			

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Flow-Period Definition For 1984 H-3 Pumping Tests R.L. Beauheim 12/10/99 1/3

Source data file: H-3-Q.xls

Flow Period	Duration (min)	Pumping Rate (gpm)	Comments
1	60	7.12	no discrete data
2	1230	0	
3	0.15	7	estimated Q+T
4	4.85	0	
5	5	RLB 12/10/99 6~~7~~.82	
6	2	6.535	
7	5.5	6.30	
8	4.5	6.76	
9	4	6.665	
10	6	6.53	
11	33	6.45	
12	145	0	
13	2	7.765	
14	5	7.165	
15	3	6.705	
16	4	6.59	
17	1	6.515	
18	7	6.45	
19	2	6.39	
20	15	6.32	
21	4	6.285	
22	15	6.19	
23	2	6.14~~0~~ RLB 12/10/99	

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Flow-Period Definition For 1984 H-3 Pumping Tests R.L. Beauheim 12/10/99

Flow Period	Duration (min)	Pumping Rate (gpm)	Comments
24	1050	0	
25	7	6.83	
26	9	6.50	
27	6	6.28	
28	5	6.39	
29	43	6.53	
30	31	6.45	
31	41	6.34	
32	44	6.29	
33	24	6.23	
34	5	6.30	
35 36 > 35	15 22 > 37	6.465 6.42 > 6.42	
~~37~~ 36	32	6.345	
~~38~~ 37	16	6.39	
~~39~~ 38	19	6.34	
40 41 > 39	10 46 > 56	6.44 6.46 > 6.45	
~~42~~ 40	75	6.35	
~~43~~ 41	45	6.30	
~~44~~ 42	60	6.20	
~~45~~ 43	15	6.285	
~~46~~ 44	30	6.20	
~~47~~ 45	30	6.13	

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Flow-Period Definition for 1984 H-3 Pumping Tests R.L. Beauheim 12/10/99 3/3

Flow Period	Duration (min)	Pumping Rate (gpm)	Comments
~~48~~ 46	53	6.08	
~~49~~ 47	13	6.505	
~~50~~ 48	16	6.40	
~~51~~ 49	16	6.27	
~~52~~ 50	52	6.21	
~~53~~ 51	5000	0	

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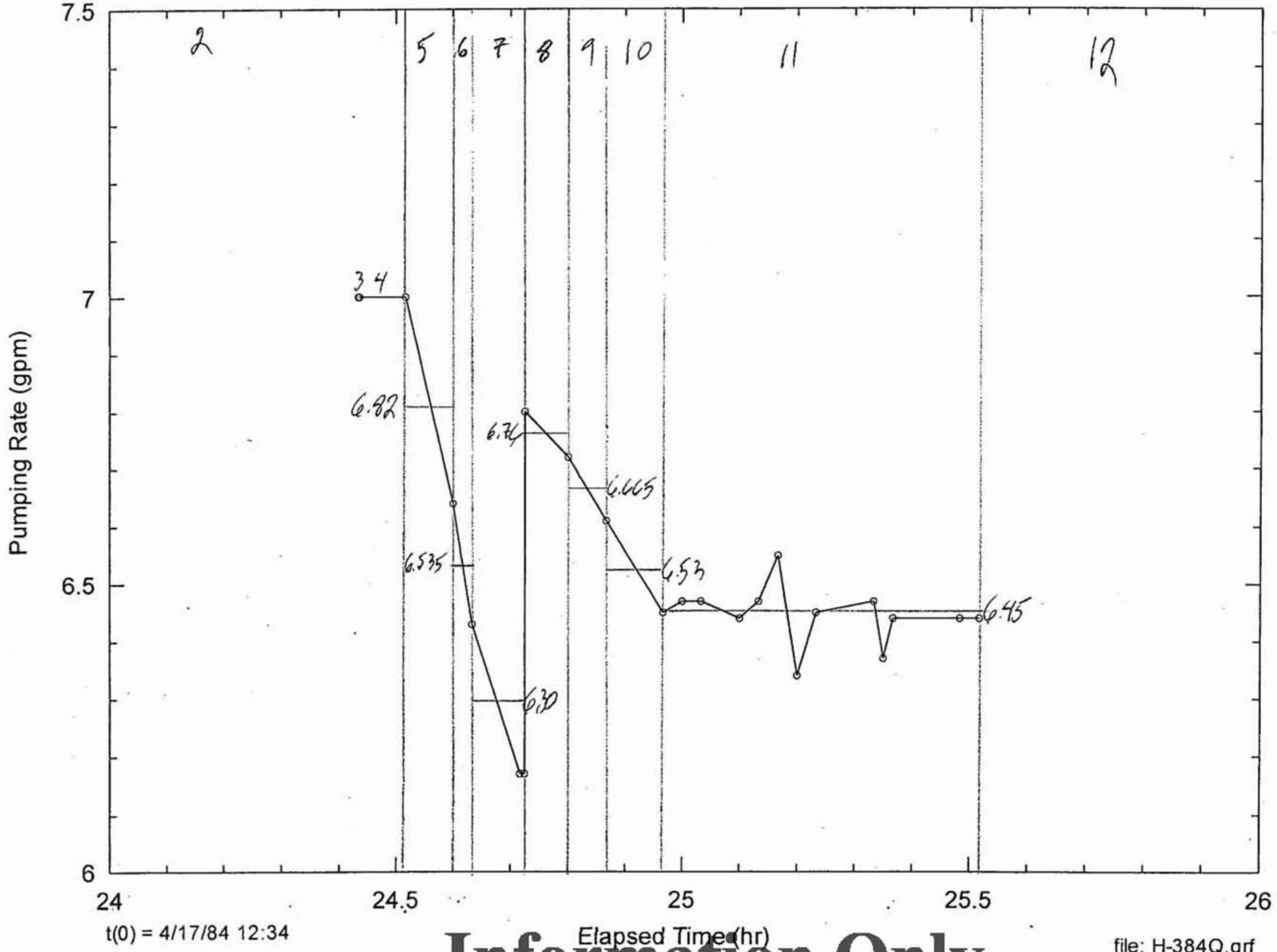
1984 H-3b3 Pumping Test #2



t(0) = 4/17/84 12:34

file: H-384Q.grf

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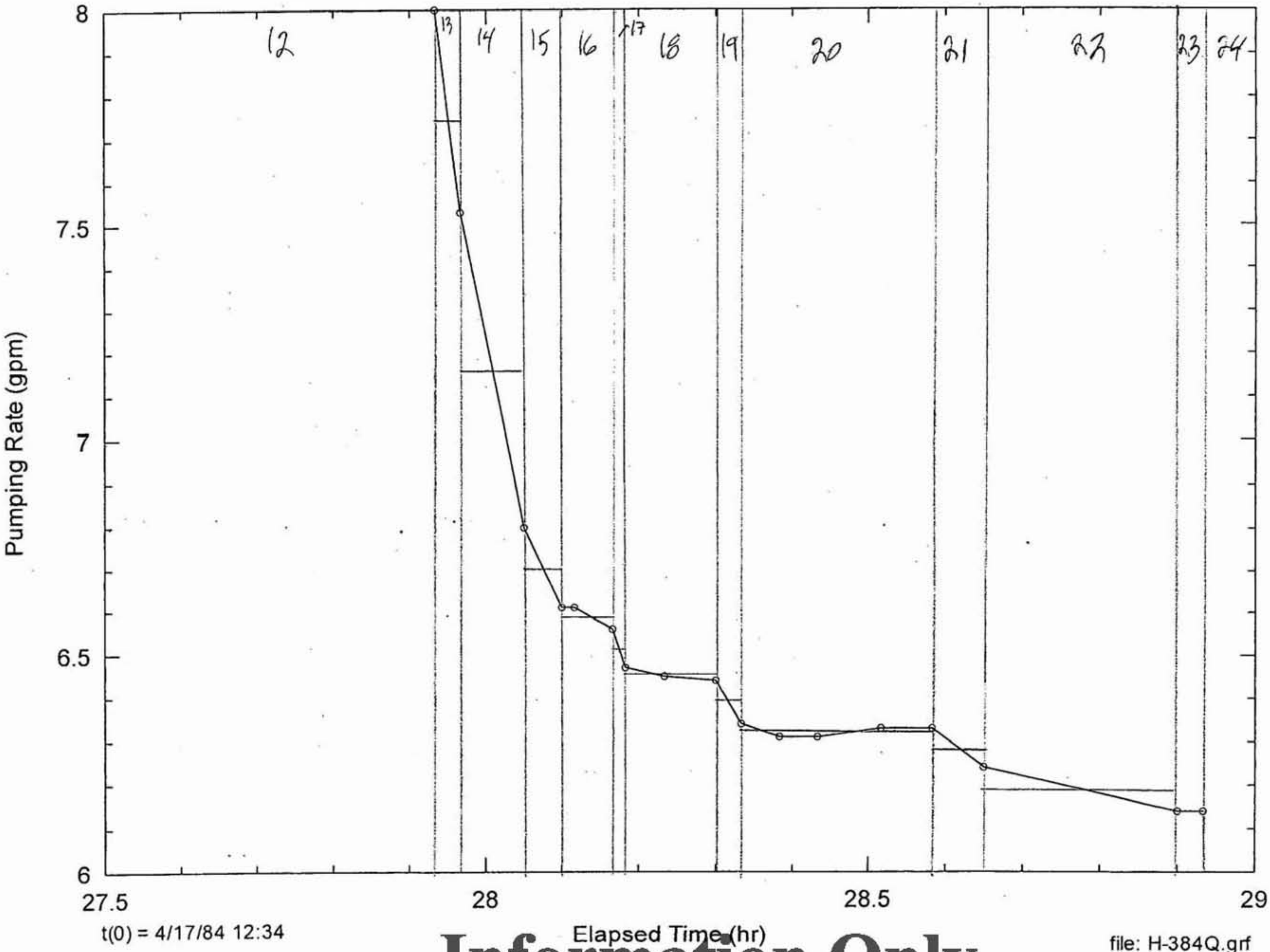
1984 H-3b3 Pumping Test #3



t(0) = 4/17/84 12:34

file: H-384Q.grf

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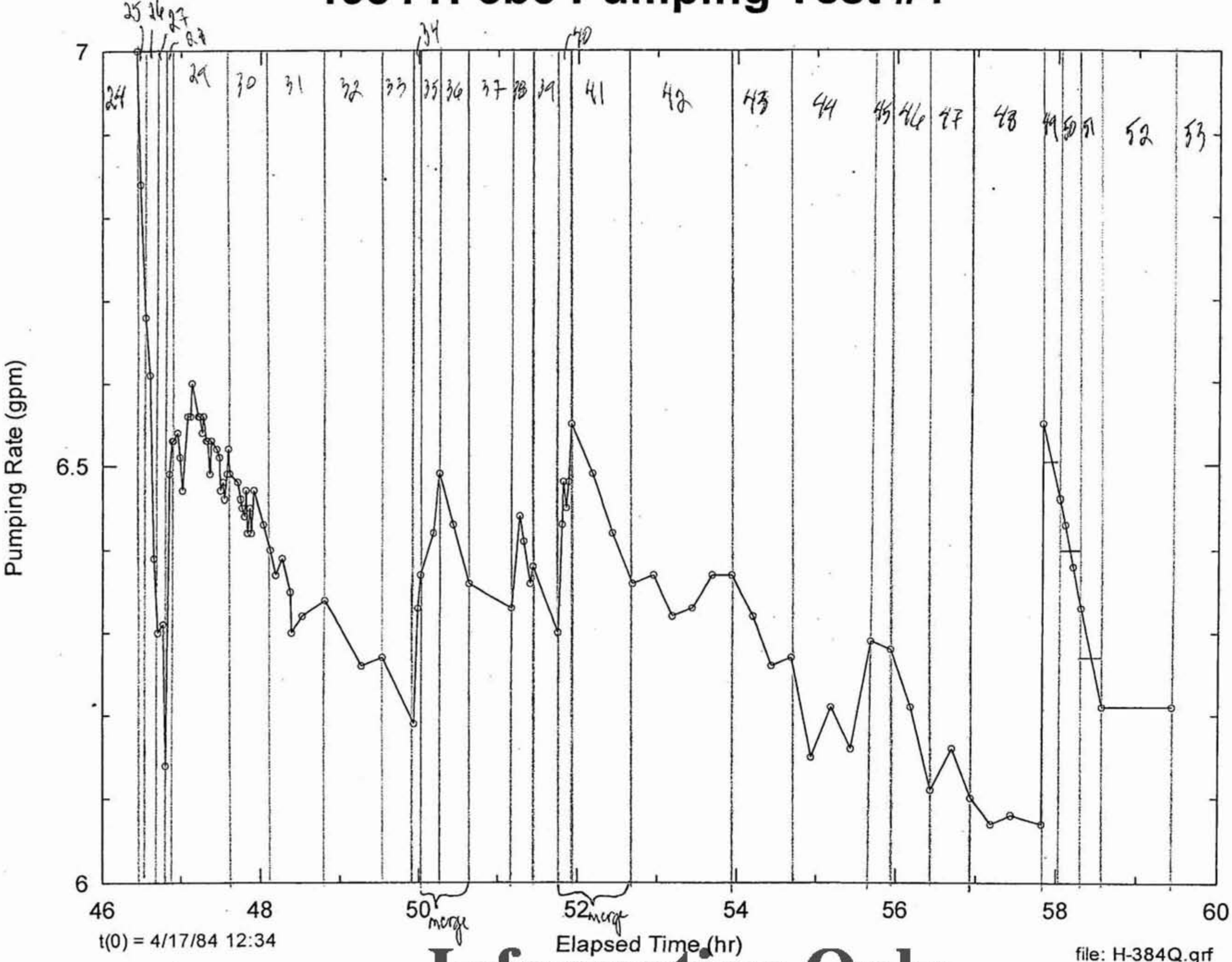
1984 H-3b3 Pumping Test #4



t(0) = 4/17/84 12:34

file: H-384Q.grf

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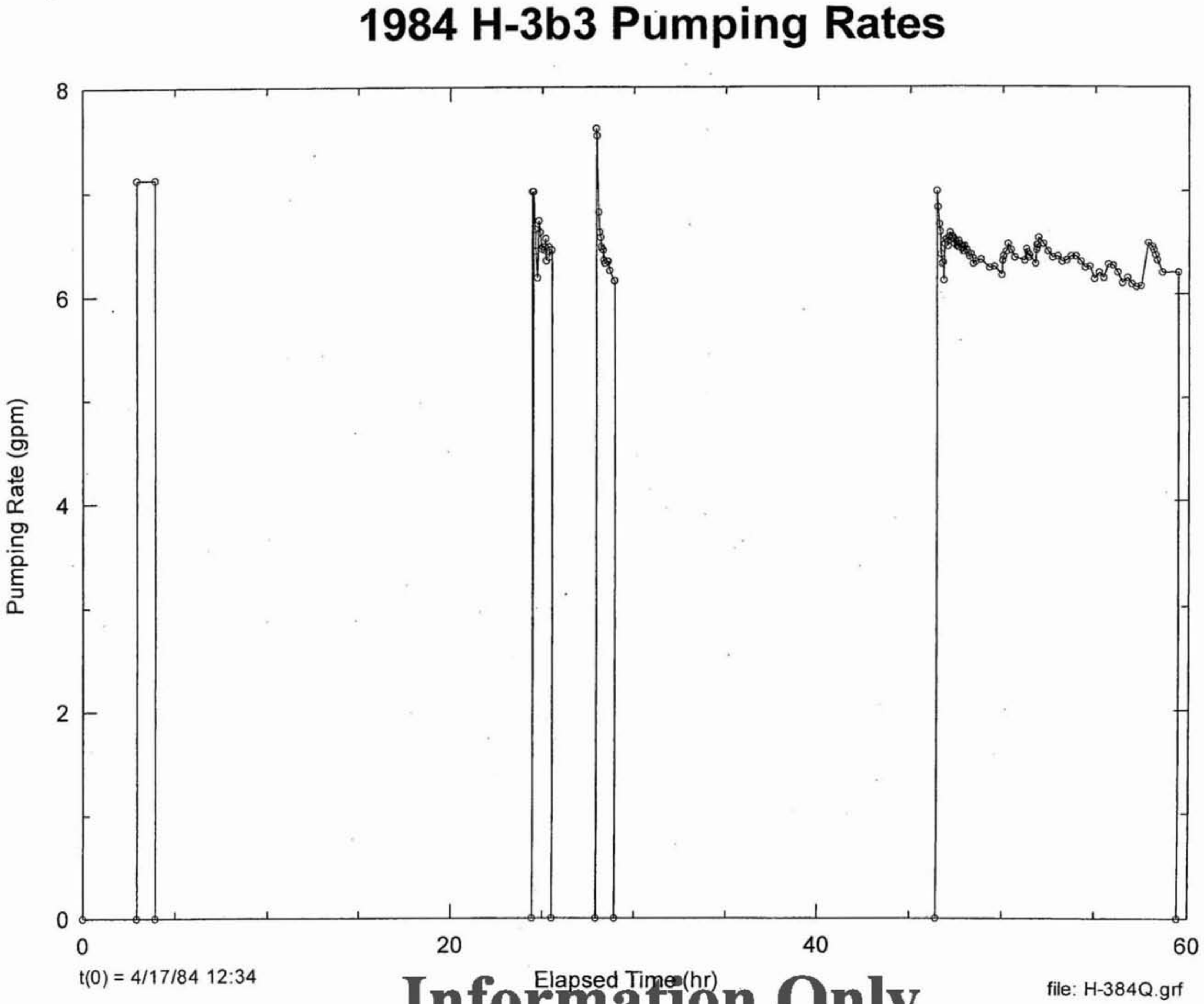

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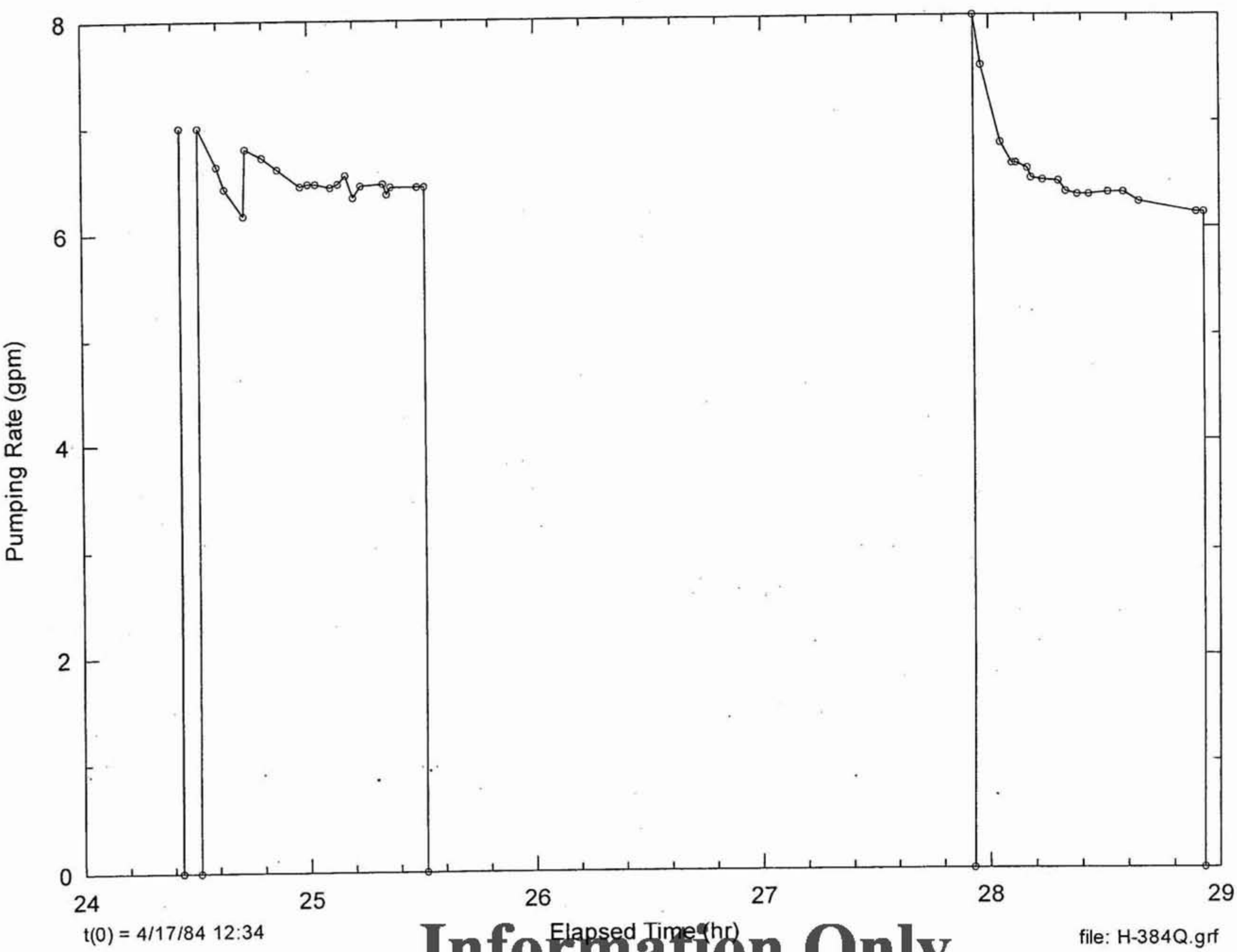
1984 H-3b3 Pumping Rates



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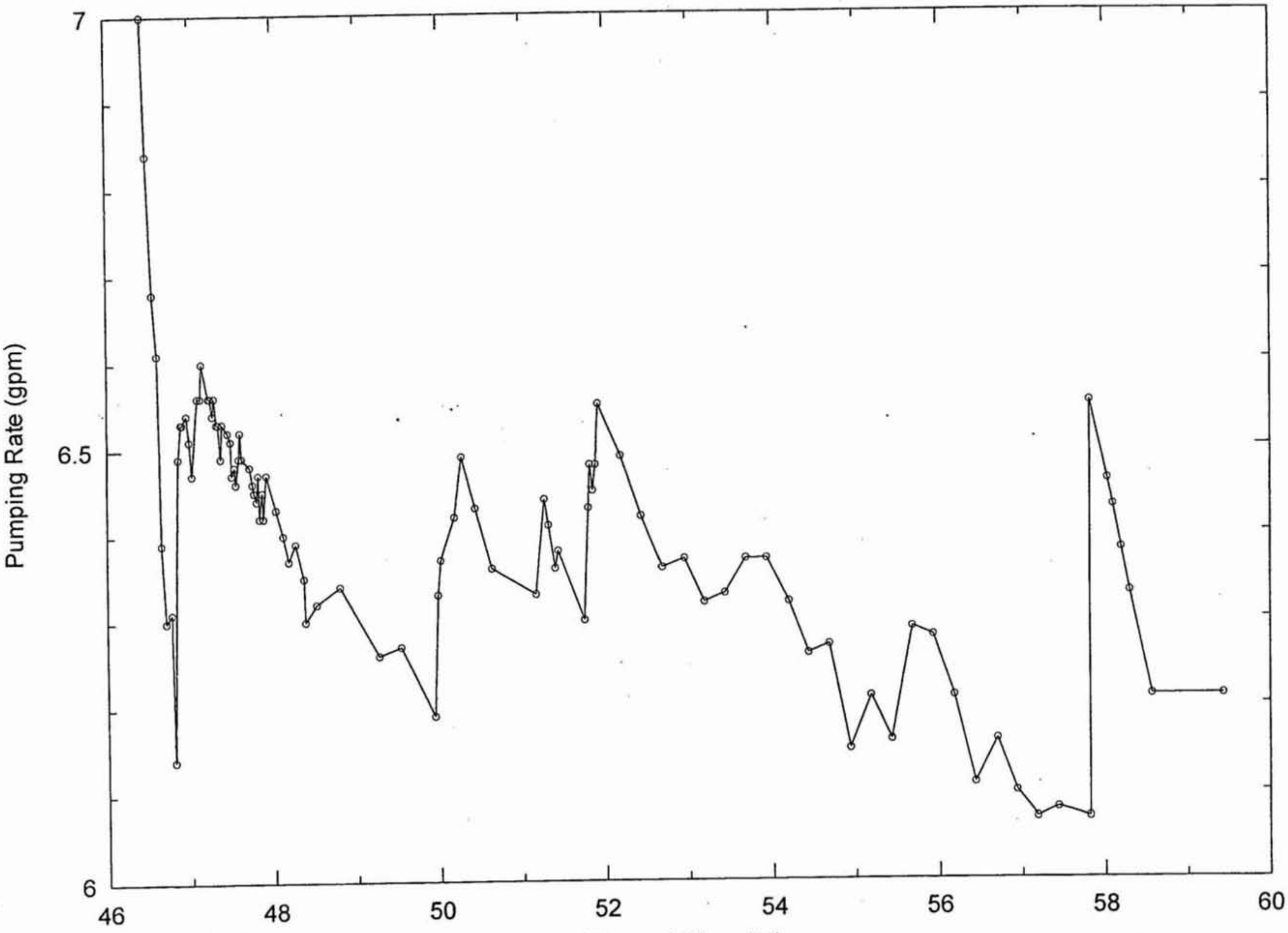
1984 H-3b3 Pumping Test #4



t(0) = 4/17/84 12:34

file: H-384Q.grf

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Analysis Notes for 1984 H-3 Pumping Tests

Examination of the calculated-pressure plots (see plots labeled "H-3 Pumping Tests, H-3b1 (or H-3b2 or H-3b3)" and "1984 H-3b3 Pumping Test #1 (or #2 or #3 or #4)" in the Data Files section of this Analysis Package) showed a number of factors affecting test interpretation. First, the recovery of H-3b1 to the first pumping period was anomalous, as the pressure reached a peak fairly quickly and then declined for the remainder of the recovery period, never approaching the pre-pumping pressure (see plot "H-3 Pumping Tests, H-3b1"). This could indicate that H-3b1 was still recovering from previously induced stresses (e.g., slug tests, well development) when the pumping tests began. Second, pressures in all wells showed parallel oscillations during the recovery periods, which likely reflect barometric effects. Because no barometer was used during these tests, no compensations can be made for these oscillations. Third, the drawdown data from H-3b3 during test #1 clearly indicate that the pumping rate was not constant (see plot labeled "1984 H-3b3 Pumping Test #1"). However, only the total number of gallons pumped during this test was recorded, so the analysis is forced to rely on a single average rate. Fourth, after the packer was inflated in H-3b3 for test #4, significant (6-8 psi) pressure jumps were noted when the pump was turned on and off (see plot labeled "1984 H-3b3 Pumping Test #4"). Such pronounced jumps did not occur when the packer was not inflated, and I believe they reflect turbulence created in the wellbore, not a formation response.

Either Interpret 2000 or GTFM 6.2 could be used to analyze these tests. I selected Interpret 2000 for two reasons. First, all other Culebra pumping tests have been analyzed using Interpret, and I wish to provide results that are directly comparable to other published results. Second, although GTFM is far superior to Interpret in being able to provide an optimized match to multiple data sets and/or data formats simultaneously, it has a difficult time optimizing to data from double-porosity systems (such as the Culebra at H-3), whereas double-porosity optimization is easy for Interpret. For these reasons, and notwithstanding the limitations of Interpret 2000 discussed below, I performed these analyses using Interpret 2000. I anticipate that these tests may be re-interpreted (along with most other Culebra tests) once the new analysis code nSIGHTS has completed QA qualification.

Interpret 2000 can fit to only a single data type from a single flow period at a time. For example, for a given flow period, it can fit to either the log-log pressure-change data, the pressure-derivative data, the Horner data, or the linear-linear pressure data, but not simultaneously to any combination of the above. Interpret 2000 cannot, by itself, find the parameter set that best matches all of the data from all of the flow periods simultaneously. For a given flow period, the analyst must iteratively regress on the matches to the different data types to find out how good a match can be obtained to a given data type in the absence of other constraints, and to determine which data type (or subset thereof) provides the best definition of a particular parameter. The final parameter set determined for a particular flow period may then represent a regression on one data type (typically the log-log pressure change, pressure derivative, or Horner data) with one or more parameters fixed (removed from the regression) based on

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regressions to different data types. This is inherently a subjective process, relying on the analyst's best judgement. My practice for reconciling the interpretation of the data from different flow periods is to seek qualitative agreement among as many parameters as possible without requiring any to be identical from flow period to flow period. If the data from one flow period are clearly of higher quality than those from other flow periods, I will attach more subjective weight to the results from the high-quality data and "steer" the analysis of the lower quality data in that direction.

Interpret 2000 provides permeability-thickness (transmissivity) estimates in standard petroleum units, milliDarcy (mD)-ft, so the following discussion will use those units. Table A includes conversion from mD-ft to the groundwater units ft^2/day and m^2/s. The conversion to ft^2/day is performed using the equation (Beauheim, 1989, Eq. B-15):

$$1\ ft^2/day = 2.7393E\text{-}3\ mD\text{-}ft \times \rho/\mu$$

where: ρ = fluid density, g/cm^3
μ = fluid viscosity, centipoise (cp)

For the H-3 tests, a value of 1.04 g/cm^3 is used for ρ, and a viscosity of 1 cp is assumed for μ.

The conversion from ft^2/day to m^2/s uses the relation:

$$1\ ft^2/day \times 0.092903\ m^2/ft^2 \times 1\ day/86400\ s = 1.07527E\text{-}6\ m^2/s$$

Interpret 2000 provides storativity estimates as the petroleum term "porosity-compressibility-thickness product ($\text{ø} c_t h$)", with porosity (ø) expressed as a decimal, total system compressibility (c_t) in units of 1/psi, and thickness (h) in ft. Beauheim (1989, Eq. B-39) relates storativity to the porosity-compressibility-thickness product by:

$$S = 0.4329\ \text{ø} c_t h \rho$$

The files H3PINT2.xls and H3QINT2.xls were read into Interpret 2000 as the pressure and rate input, respectively. Note that Interpret 2000 automatically adds 14.7 psi to all gauge pressures (psig) read as input to convert to absolute pressure (psia). Refer to the plots in the Interpret 2000 Well Test Analysis Reports for each well to understand the following discussions. Analysis began with the data from the pumping well, H-3b3.

H-3b3

The log-log plots of the data from flow periods (FP) 2, 12, and 24 (the recoveries from test #1, #2, and #3, respectively) show typical unit-slope lines at early time indicative of wellbore storage, and then clear minima in the pressure derivative indicative of double-porosity conditions. The derivative does not stabilize well after the minimum for FP2, probably reflecting pre-test pressure history that is not included in the simulation. FP12 did not last long enough for the derivative to stabilize. FP24 shows the best derivative

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stabilization, although the late-time data are affected by a pressure oscillation thought to be related to barometric effects.

In contrast, the log-log plot for FP51 (the recovery from test #4), when the packer was inflated in the pumping well, shows a completely different response. Little or no unit slope is evident at early time, no minimum is present in the pressure derivative (although a temporary decrease in slope is seen at middle time), and no derivative stabilization is seen at late time. This plot is very similar to those presented in Beauheim (1987) for the other two H-3 pumping tests in which the pumping well contained a packer. Also, whereas the starting pressures used to generate the log-log plots for FP2, 12, and 24 were the final pressures of the preceding pumping periods, the log-log plot for FP51 used as a starting pressure the second data point recorded after the pump was turned off and the pumping-induced turbulence dissipated. (The first data point seemed to represent a surge that then dropped back to the pressure of the second point.) Similar compensations for pumping-induced turbulence were made by Beauheim (1987) to analyze the other H-3 pumping tests. This treatment of the starting pressure affects only the pressure-change data, not the pressure derivative. Without this compensation, no simulation matching the pressure-derivative data will also match the pressure-change data. (This is additional evidence that the pressure jumps when the pump is turned off and on are related to turbulence, and not to formation response, because Interpret 2000 simulates only the formation response.) Additional discussion and justification of this compensation is presented at the end of this section.

The analysis results obtained for H-3b3 are shown in Table A. The parameter estimates from FP2, 12, and 24 are in good agreement and all used the same model involving wellbore storage and skin, double-porosity with restricted interporosity flow, and infinite lateral extent. But interpretation of the FP51 data resulted in somewhat different parameter values and a different model. Whereas the pumping for the first three tests lasted only approximately one hour in each case, pumping for the fourth test lasted for 13 hr and the subsequent recovery (FP51) lasted for 83 hr, much longer than any of the other recoveries. Probably because of the longer test duration, the FP51 analysis model included wedge-shaped no-flow boundaries.

As discussed above, the packer in the borehole was inflated only for the fourth test. The 5.5-inch, 15.5 lb/ft casing in H-3b3 has a capacity of 0.9997 gal/ft, or 0.0238 bbl/ft (Baker Service Tools, 1985, p. 4-8). The 1.5-inch pipe in the well would occupy a volume of 0.012 ft^3/ft, or 0.0022 bbl/ft. With a specific gravity of 1.04, one foot of water exerts a pressure of:

$$1.04 \text{ X } (62.4 \text{ lb/ft}^3) \text{ X } (1 \text{ ft}^2/144 \text{ in}^2) = 0.451 \text{ lb/in}^2\text{/ft (psi/ft)}$$

Thus, the wellbore-storage coefficient (C) with the packer deflated should be:

$$C = (0.0238 - 0.0022 \text{ bbl/ft})/(0.451 \text{ psi/ft}) = 0.048 \text{ bbl/psi}$$

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Table A. Results of Interpret 2000 Simulations of H-3 Pumping Tests.

Well	FP	kh (mD-ft)	T (ft^2/day)	T (m^2/s)	Skin	$øc_th$ (ft/psi)	S	ω	λ	d1 (ft)	d2 (ft)	Wedge θ (°)	C (bbl/psi)
H-3b3	2	6875	20	2.1E-5	-4.11	NA	NA	1.04E-4	3.34E-6	NA	NA	NA	0.047
	12	6713	19	2.1E-5	-4.53	NA	NA	5.58E-3	4.27E-6	NA	NA	NA	0.040
	24	6863	20	2.1E-5	-4.49	NA	NA	4.94E-5	4.07E-6	NA	NA	NA	0.043
	51	7531	21	2.3E-5	-6.16	NA	NA	1.42E-3	7.08E-1	175	571	107	0.156
H-3b1	2*	6588	19	2.0E-5	NA	1.17E-4	5.3E-5	0.260	7.41E-6	NA	NA	NA	NA
	12	6854	20	2.1E-5	NA	1.08E-4	4.8E-5	0.212	7.58E-6	NA	NA	NA	NA
	24	6588	19	2.0E-5	NA	1.02E-4	4.6E-5	0.224	7.83E-6	NA	NA	NA	NA
	51	6989	20	2.1E-5	NA	1.93E-4	8.7E-5	0.013	4.18E-6	768	3080	**	NA
H-3b2	2	6761	19	2.1E-5	NA	1.30E-4	5.9E-5	0.364	5.15E-6	NA	NA	NA	NA
	12	6044	17	1.9E-5	NA	1.35E-4	6.1E-5	0.232	6.81E-6	NA	NA	NA	NA
	24	6790	19	2.1E-5	NA	1.17E-4	5.3E-5	0.347	4.87E-6	NA	NA	NA	NA
	51	6862	20	2.1E-5	NA	1.06E-4	4.7E-5	0.177	6.31E-6	416	1115	**	NA

NA: not applicable

*parameters not defined from fitting to FP2 data—simulations show only that the data are consistent with a simulation using these parameters up until the time an unknown factor affects the data

**Interpret 2000 does not allow wedge boundaries for observation wells—had to switch to parallel (channel) boundaries

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The analyses of the FP2, 12, and 24 data gave values of C ranging from 0.040 to 0.047 bbl/psi, reasonably close to the calculated value.

With the packer inflated, wellbore storage would be equal to the volume of water isolated in the pumping interval multiplied by the compressibility of the materials in the pumping interval (chiefly, but not entirely, water). From the well- and equipment-configuration diagrams (Figures 3-2 and 4-1 from Beauheim (1987)) included in the section of this Analysis Package titled Introduction to 1984 H-3 Pumping Tests, the volume in the pumping interval can be calculated as:

$$V = (((673 \text{ ft}-538.5 \text{ ft}) \times \pi \times (4.95 \text{ in}/2 \times 1 \text{ ft}/12 \text{ in})^2)+((730 \text{ ft} - 673 \text{ ft}) \times \pi \times (4.75 \text{ in}/2 \times 1 \text{ ft}/12 \text{ in})^2)) \times 7.48 \text{ gal/ft}^3 \times 1 \text{ bbl}/42 \text{ gal}$$
$$= 4.45 \text{ bbl}$$

The compressibility of saline water is given by Earlougher (1977, Figures D.16 and D.17) as approximately 3E-6 psi^{-1}. Thus, the wellbore storage with the packer inflated can be calculated as:

$$C = 4.45 \text{ bbl} \times 3\text{E-6 psi}^{-1} = 1.3\text{E-5 bbl/psi}$$

Beauheim et al. (1991, Section 6.5) discuss the factors that can contribute to test-interval compressibility being higher than the compressibility of water alone, and report measured compressibilities as much as two orders of magnitude higher than that of water. Thus, the wellbore storage calculated above should be considered only a minimum value. Nevertheless, wellbore storage would be expected to decrease when the packer was inflated in the H-3b3 pumping well. Instead of wellbore storage decreasing when the packer was inflated, however, it appeared to increase by a factor greater than 3. The FP51 analysis gave a value of C of 0.156 bbl/psi. As noted by Gringarten (1984), the wellbore-storage coefficient in fissured (double-porosity) reservoirs often includes the storage volume of the fractures in direct connection with the wellbore, but why this additional contribution to wellbore storage should be more evident (indeed, even dominant) when a packer is inflated in the well is unclear.

In addition to a different value for C, the inferred value of T was slightly higher for FP51, skin was more negative, and the interporosity flow coefficient (λ) increased by nearly five orders of magnitude compared to the results from FP2, 12, and 24. Because of the absence of a clear minimum in the FP51 derivative, the double-porosity parameters λ and ω are probably poorly defined. The FP51 analysis included wedge-shaped no-flow boundaries 175 and 571 ft from H-3b3, with a wedge angle of 107° (Table A) These boundaries probably reflect the lower T's known to be present at H-1, H-2, H-15, and WQSP-5.

Given these differences between the results of the FP51 analysis and those from the FP2, 12, and 24 analyses, one might wonder if the pressure compensation made at the beginning of the FP51 recovery period was truly warranted. Included at the end of the H-3b3 Well Test Analysis Report section are three plots showing the best matches that

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could be obtained to the FP51 data without this compensation. The log-log plot begins with approximately 9 psi of immediate recovery and shows none of the early-time characteristics seen in the log-log plots of the other recovery periods. The pressure-change data can be matched quite well using a model for a finite-conductivity vertical fracture with wellbore storage and skin in an infinite, homogeneous reservoir. This model does not match the inflections in the pressure-derivative, however, that are well-matched by the double-porosity model. The Horner match is also not quite as good as that provided by the double-porosity model. The parameter values provided by this model are also inconsistent with those provided by the double-porosity analyses of the other pumping-well recovery periods and the observation-well responses. The vertical-fracture model provides a permeability-thickness estimate of 2600 mD-ft (T=7.4 ft^2/day or 8.0E-6 m^2/s), approximately three times lower than the estimates provided by the double-porosity model. It also provides a wellbore-storage estimate of 1.3E-9 bbl/psi, four orders of magnitude lower than the minimum value calculated above. Thus, the vertical-fracture model, while not requiring compensation for the jump in pressure that occurred when the pump was shut off, does not provide as good a match to the data as the double-porosity model, nor does it provide parameter estimates that are consistent with the other analyses or with the known physical properties of the well. This model is, therefore, rejected.

In general, the rate data collected during the four pumping tests appear to have been inadequate and/or inaccurate. The linear-linear plots of the pumping periods show that the simulations, which are based on the recorded rate data, do not capture the details of the observed pressure responses particularly well, although they do capture the total amount of drawdown. This inaccuracy may have led to some of the difficulties in matching to the recovery derivatives, which are generated using a superposition function based on the recorded rates.

H-3b1

The best-fitting model for the H-3b1 analyses was a line-source solution for a double-porosity aquifer with unrestricted interporosity flow and slab matrix blocks. For FP2, 12, and 24, no boundaries were in evidence. For FP51, channel no-flow boundaries were used.

As discussed above, the H-3b1 recovery response to the first pumping test was anomalous in that the pressure reached a peak after a couple hours and then declined. This may be a history effect related to the well still being in a transient state from previous slug tests and/or well-development pumping prior to the first pumping test. In any case, the FP2 data were not suitable for analysis. After fitting the FP24 data, I took the transmissivity (6588 mD-ft) from that analysis and fixed that value for FP2. I then regressed on only the first 0.8 hr of data on the FP2 log-log plot to see if a reasonable match could be obtained. All of the free parameters (everything but kh) took on values similar to those from the FP24 analysis (see Table A) and the matches look reasonable.

The analysis results from FP12 and 24 (Table A) were consistent. For FP51, the primary difference was that the storativity ratio (ω) was over an order of magnitude

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lower than for the other FP analyses. The sustained rise of the derivative required the use of two no-flow boundaries. After an elapsed time of approximately 10 hr on the log-log plot for FP51, the derivative shows signs of stabilizing. The use of wedge boundaries would allow this type of stabilization, as flow is radial at late time for such a configuration. But Interpret 2000 does not allow the use of wedge boundaries for observation wells, so I had to use parallel channel boundaries 770 and 3080 ft away to match the derivative rise. For channel boundaries, flow is linear at late time and the derivative will never stabilize.

H-3b2

The best-fitting model for the H-3b2 analyses was a line-source solution for a double-porosity aquifer with unrestricted interporosity flow and slab matrix blocks. For FP2, 12, and 24, no boundaries were in evidence. For FP51, channel no-flow boundaries were used.

All of the recoveries at H-3b2 could be simulated. For FP2, 24, and 51, the late-time derivative was affected by apparent barometric effects. All of the analysis parameters for the four recoveries were reasonably consistent (Table A). As for H-3b1, I had to use channel boundaries to match the derivative rise in FP51, although I would have preferred wedge boundaries. The estimated distances to the boundaries were 420 and 1120 ft, considerably closer than the boundaries estimated for H-3b1. I have never put much stock in the distances to boundaries provided by Interpret, particularly when I think the model used (e.g., channel boundaries) is not entirely appropriate. I put more faith in the indication that aquifer properties are changing with distance.

Summary

The analyses of the data from all three H-3 wells consistently indicate the existence of double-porosity conditions. The mean kh from the eleven interpreted flow periods (all but FP2 for H-3b1) is approximately 6800 mD-ft, giving a T of 19 ft^2/day or 2.1E-5 m^2/s. The mean øc_th is approximately 1.27E-4 ft/psi, giving an S of 5.7E-5. For the fourth and longest test, all analyses indicated the presence of multiple no-flow (reduced permeability) boundaries.

A packer was inflated in the pumping well, H-3b3, for only the last test. The pressure in the pumping well showed instantaneous jumps when the pump was turned on and off, which I believe are related to turbulence in the wellbore, not formation response. These pressure jumps were not included in the pressure-change data used for analysis because their inclusion would have necessitated the use of a vertical-fracture model that (1) was conceptually inconsistent with the double-porosity model that provided good fits to the data from the other three pumping tests and to the observation-well responses and (2) provided parameter estimates that were inconsistent with those provided by the double-porosity model and with known physical properties of the pumping well. The pumping-well results from the fourth test were more consistent with all other results when the pressure jumps were excluded and a double-porosity model was used for interpretation.

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|  Baker Atlas GEOScience                                            WorkBench |
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|                                                                              |
|                          WELL TEST ANALYSIS REPORT                           |
|                                                                              |
+------------------------------------------------------------------------------+

 Company:      Sandia National Labs
 Field:        WIPP                                Date:        14-May-02
 Formation:    Rustler                             Test No:     1-4
 Zone:         Culebra                             Test Date:   4/17-20/84
 Well:         H-3b3                               Gauge:       Gauge 1


                              ANALYSIS SUMMARY

    First three tests conducted without packer in well.  Last test
    conducted with packer inflated in well.
    FP2 = buildup from test 1; FP12 = buildup from test 2;
    FP24 = buildup from test 3; FP51 = buildup from test 4.
    No discrete flow-rate measurements during test 1.


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|  Baker Atlas GEOScience                                            WorkBench |
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|                                                                              |
|                              Results Summary                                 |
|                                                                              |
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    Near wellbore effects:   Wellbore Storage and Skin (C and S)
    Reservoir behaviour:     2 Porosity, Restricted Interporosity Flow
    Boundary effects:        Infinite Lateral Extent


  Flow Period:         1            2            4            12        Units

 (pav)i           133.567      133.586      133.468      133.401     psia
 pwf              119.705      119.705      132.664      122.348     psia
 kh                6561.9       6875.2       6417.0       6712.8     mD.ft
 k                  273.4        286.5        267.4        279.7     mD
 C                0.04184      0.04726      0.04036      0.03994     bbl/psi
 S                  -4.14        -4.11        -4.57        -4.53
 Omega           0.001118    1.039E-04    2.944E-05     0.005575
 Lambda         2.842E-06    3.341E-06    4.183E-06    4.270E-06
 xf                   0.0          0.0          0.0          0.0     ft
 ri                 1018.         963.          58.         326.     ft
 PI                 17.61        17.58        298.3        20.00     B/D/psi
 FE                 3.233        2.485        31.03        2.906     fraction
 Dp(S)               0.00       -20.62       -24.16       -21.07     psi
```

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+--------------------------------------------------------------------------+
| Baker Atlas GEOScience                                         WorkBench |
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|                                                                          |
|                            Results Summary                               |
|                                                                          |
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    Near wellbore effects:   Wellbore Storage and Skin (C and S)
    Reservoir behaviour:     2 Porosity, Restricted Interporosity Flow
    Boundary effects:        Infinite Lateral Extent


  Flow Period:        24            25        Units

 (pav)i             133.290       133.270     psia
 pwf                122.070       130.833     psia
 kh                  6862.8        7363.6     mD.ft
 k                    286.0         306.8     mD
 C                  0.04346       0.03647     bbl/psi
 S                    -4.49         -3.99
 Omega            4.935E-05      0.009778
 Lambda           4.073E-06     4.200E-06
 xf                     0.0           0.0     ft
 ri                    889.         1078.     ft
 PI                   18.76         18.79     B/D/psi
 FE                   2.732         3.070     fraction
 Dp(S)               -19.43          0.00     psi


    Near wellbore effects:   Wellbore Storage and Skin (C and S)
    Reservoir behaviour:     2 Porosity, Restricted Interporosity Flow
    Boundary effects:        Intersecting Boundaries (Wedge)


  Flow Period:        51        Units

 (pav)i             133.123     psia
 pwf                121.400     psia
 kh                  7530.7     mD.ft
 k                    313.8     mD
 C                   0.1556     bbl/psi
 S                    -6.16
 Omega             0.001419
 Lambda              0.7084
 xf                   187.4     ft
 d1                    175.     ft
 d2                    571.     ft
 Wdg Angle             107.
 Type d1            No Flow
 Type d2            No Flow
 Dinv                 1707.     ft
 PI                   18.16     B/D/psi
 FE                   3.098     fraction
 Dp(S)               -24.59     psi
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+-------------------------------------------------------------------------+
| Baker Atlas GEOScience                                        WorkBench |
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|                                                                         |
|                       Well & Reservoir Parameters                       |
|                                                                         |
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 Company:     Sandia National Labs
 Field:       WIPP                            Date:        14-May-02
 Formation:   Rustler                         Test No:     1
 Zone:        Culebra                         Test Date:   4/17-18/84
 Well:        H-3b3                           Gauge:       Gauge 1


                     WELL AND RESERVOIR DATA  (Water)

  Multiphase flow at wellbore:   NO
  Multiphase in reservoir    :   NO

  Matrix Porosity                                     0.160       fraction
  Reservoir Thickness                                 24.00       ft
  Wellbore Radius                                     0.198       ft
  Distance To Producing Well (*)                       0.00       ft

  Water Formation Volume Factor                       1.000       RB/STB
  Water Viscosity                                   1.00          cp
  Total Compressibility                           3.330E-05       1/psi

  (*) = For Interference Tests Only
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+------------------------------------------------------------------------+
|  Baker Atlas GEOScience                                      WorkBench |
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|                                                                        |
|                                 Rates                                  |
|                                                                        |
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 Flow     Start       End        Duration      Oil        Gas        Water
Period    hrs         hrs        hrs          STB/D      Mscf/D      STB/D

   1      0.0000      0.9995      0.9995      0.000      0.000      244.1
   2      0.9995     21.5000     20.5005      0.000      0.000      0.000
   3     21.5000     21.5025      0.0025      0.000      0.000      240.0
   4     21.5025     21.5833      0.0808      0.000      0.000      0.000
   5     21.5833     21.6667      0.0833      0.000      0.000      233.8
   6     21.6667     21.7000      0.0333      0.000      0.000      224.1
   7     21.7000     21.7917      0.0917      0.000      0.000      216.0
   8     21.7917     21.8667      0.0750      0.000      0.000      231.8
   9     21.8667     21.9333      0.0667      0.000      0.000      228.5
  10     21.9333     22.0333      0.1000      0.000      0.000      223.9
  11     22.0333     22.5888      0.5555      0.000      0.000      221.1
  12     22.5888     25.0000      2.4112      0.000      0.000      0.000
  13     25.0000     25.0100      0.0100      0.000      0.000      266.2
  14     25.0100     25.0800      0.0700      0.000      0.000      245.7
  15     25.0800     25.1666      0.0866      0.000      0.000      229.9
  16     25.1666     25.2333      0.0667      0.000      0.000      225.9
  17     25.2333     25.2500      0.0167      0.000      0.000      223.4
  18     25.2500     25.3666      0.1167      0.000      0.000      221.1
  19     25.3666     25.4000      0.0333      0.000      0.000      219.1
  20     25.4000     25.6500      0.2500      0.000      0.000      216.7
  21     25.6500     25.7167      0.0667      0.000      0.000      215.5
  22     25.7167     25.9667      0.2500      0.000      0.000      212.2
  23     25.9667     26.0050      0.0384      0.000      0.000      210.5
  24     26.0050     43.5000     17.4950      0.000      0.000      0.000
  25     43.5000     43.6166      0.1167      0.000      0.000      234.2
  26     43.6166     43.7666      0.1500      0.000      0.000      222.9
  27     43.7666     43.8666      0.1000      0.000      0.000      215.3
  28     43.8666     43.9500      0.0833      0.000      0.000      219.1
  29     43.9500     44.6666      0.7167      0.000      0.000      223.9
  30     44.6666     45.1833      0.5167      0.000      0.000      221.1
  31     45.1833     45.8666      0.6833      0.000      0.000      217.4
  32     45.8666     46.6000      0.7333      0.000      0.000      215.7
  33     46.6000     47.0000      0.4000      0.000      0.000      213.6
  34     47.0000     47.0833      0.0833      0.000      0.000      216.0
  35     47.0833     47.7000      0.6167      0.000      0.000      220.1
  36     47.7000     48.2333      0.5333      0.000      0.000      217.5
  37     48.2333     48.5000      0.2667      0.000      0.000      219.1
  38     48.5000     48.8166      0.3167      0.000      0.000      217.4
  39     48.8166     49.7500      0.9333      0.000      0.000      221.1
  40     49.7500     51.0000      1.2500      0.000      0.000      217.7
  41     51.0000     51.7500      0.7500      0.000      0.000      216.0
  42     51.7500     52.7500      1.0000      0.000      0.000      212.6
  43     52.7500     53.0000      0.2500      0.000      0.000      215.5
  44     53.0000     53.5000      0.5000      0.000      0.000      212.6
  45     53.5000     54.0000      0.5000      0.000      0.000      210.2
  46     54.0000     54.8833      0.8833      0.000      0.000      208.5
  47     54.8833     55.1000      0.2167      0.000      0.000      223.0
  48     55.1000     55.3666      0.2667      0.000      0.000      219.4
  49     55.3666     55.6333      0.2667      0.000      0.000      215.0
  50     55.6333     56.5001      0.8668      0.000      0.000      212.9
  51     56.5001    139.8832     83.3331      0.000      0.000      0.000
```

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+------------------------------------------------------------------------+
| Baker Atlas GEOScience                                       WorkBench |
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|                                                                        |
|                   Analysis Parameters and Results                      |
|                                                                        |
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                  ANALYSIS MODEL, FLOW PERIOD:    2

    Near wellbore effects:   Wellbore Storage and Skin (C and S)
    Reservoir behaviour:     2 Porosity, Restricted Interporosity Flow
    Boundary effects:        Infinite Lateral Extent


                ANALYSIS PARAMETERS, FLOW PERIOD:    2

    Pressure match, PM                                  0.199   1/psi
    Time match, TM                                       42.9   1/hr
    Curve Match, Log CDe2S                              0.354
    Storativity ratio, Omega                        1.039E-04
    Transition curve match, LCD                     2.817E-02


                 ANALYSIS RESULTS, FLOW PERIOD:    2

    Initial average reservoir pressure, (pav)i        133.586   psia
    Flowing pressure, pwf                             119.705   psia
    Permeability Thickness, kh                      6.875E+03   mD.ft
    Permeability, k                                      286.   mD
    Wellbore storage coefficient, C                 4.726E-02   bbl/psi
    Wellbore skin factor, S                             -4.11
    Storativity ratio, Omega                        1.039E-04
    Interporosity flow coefficient, Lambda          3.341E-06
    Half length of fracture, xf                           0.0   ft
    Radius of investigation (approx), ri                 963.   ft
    Measured Productivity Index, PI                      17.6   B/D/psi
    Flow Efficiency, FE                                  2.49   fraction
    Pressure drop due to skin, Dp(S)                    -20.6   psi
```

Information Only

5

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+----------------------------------------------------------------------------+
| Baker Atlas GEOScience                                           WorkBench |
+----------------------------------------------------------------------------+
|                                                                            |
|                     Analysis Parameters and Results                        |
|                                                                            |
+----------------------------------------------------------------------------+


                  ANALYSIS MODEL, FLOW PERIOD:   12

    Near wellbore effects:   Wellbore Storage and Skin (C and S)
    Reservoir behaviour:     2 Porosity, Restricted Interporosity Flow
    Boundary effects:        Infinite Lateral Extent


                ANALYSIS PARAMETERS, FLOW PERIOD:   12

    Pressure match, PM                                         0.215   1/psi
    Time match, TM                                              49.6   1/hr
    Curve Match, Log CDe2S                                    -0.082
    Storativity ratio, Omega                               5.575E-03
    Transition curve match, LCD                            3.043E-02


                 ANALYSIS RESULTS, FLOW PERIOD:   12

    Initial average reservoir pressure, (pav)i               133.401   psia
    Flowing pressure, pwf                                    122.348   psia
    Permeability Thickness, kh                             6.713E+03   mD.ft
    Permeability, k                                             280.   mD
    Wellbore storage coefficient, C                        3.994E-02   bbl/psi
    Wellbore skin factor, S                                    -4.53
    Storativity ratio, Omega                               5.575E-03
    Interporosity flow coefficient, Lambda                 4.270E-06
    Half length of fracture, xf                                  0.0   ft
    Radius of investigation (approx), ri                        326.   ft
    Measured Productivity Index, PI                             20.0   B/D/psi
    Flow Efficiency, FE                                         2.91   fraction
    Pressure drop due to skin, Dp(S)                           -21.1   psi
```

Information Only

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+---------------------------------------------------------------------------+
| Baker Atlas GEOScience                                          WorkBench |
+---------------------------------------------------------------------------+
|                                                                           |
|                     Analysis Parameters and Results                       |
|                                                                           |
+---------------------------------------------------------------------------+


                  ANALYSIS MODEL, FLOW PERIOD:   24

   Near wellbore effects:   Wellbore Storage and Skin (C and S)
   Reservoir behaviour:     2 Porosity, Restricted Interporosity Flow
   Boundary effects:        Infinite Lateral Extent


                ANALYSIS PARAMETERS, FLOW PERIOD:   24

   Pressure match, PM                                      0.231   1/psi
   Time match, TM                                           46.6   1/hr
   Curve Match, Log CDe2S                                 -0.007
   Storativity ratio, Omega                            4.935E-05
   Transition curve match, LCD                         3.158E-02


                  ANALYSIS RESULTS, FLOW PERIOD:   24

   Initial average reservoir pressure, (pav)i            133.290   psia
   Flowing pressure, pwf                                 122.070   psia
   Permeability Thickness, kh                          6.863E+03   mD.ft
   Permeability, k                                          286.   mD
   Wellbore storage coefficient, C                     4.346E-02   bbl/psi
   Wellbore skin factor, S                                 -4.49
   Storativity ratio, Omega                            4.935E-05
   Interporosity flow coefficient, Lambda              4.073E-06
   Half length of fracture, xf                               0.0   ft
   Radius of investigation (approx), ri                     889.   ft
   Measured Productivity Index, PI                          18.8   B/D/psi
   Flow Efficiency, FE                                      2.73   fraction
   Pressure drop due to skin, Dp(S)                        -19.4   psi
```

Information Only

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+----------------------------------------------------------------------------+
| Baker Atlas GEOScience                                           WorkBench |
+----------------------------------------------------------------------------+
|                                                                            |
|                     Analysis Parameters and Results                        |
|                                                                            |
+----------------------------------------------------------------------------+


                    ANALYSIS MODEL, FLOW PERIOD:   51

    Near wellbore effects:  Wellbore Storage and Skin (C and S)
    Reservoir behaviour:    2 Porosity, Restricted Interporosity Flow
    Boundary effects:       Intersecting Boundaries (Wedge)


                  ANALYSIS PARAMETERS, FLOW PERIOD:   51

    Pressure match, PM                                       0.250   1/psi
    Time match, TM                                            14.3   1/hr
    Curve Match, Log CDe2S                                  -0.907
    Storativity ratio, Omega                             1.419E-03
    Transition curve match, LCD                          1.966E+04
    Dimensionless distance: first boundary, (d1)D             112.
    Dimensionless distance: second boundary, (d2)D           1198.
    Wdg Angle                                                 107.


                   ANALYSIS RESULTS, FLOW PERIOD:   51

    Initial average reservoir pressure, (pav)i             133.123   psia
    Flowing pressure, pwf                                  121.400   psia
    Permeability Thickness, kh                           7.531E+03   mD.ft
    Permeability, k                                           314.   mD
    Wellbore storage coefficient, C                          0.156   bbl/psi
    Wellbore skin factor, S                                  -6.16
    Storativity ratio, Omega                             1.419E-03
    Interporosity flow coefficient, Lambda                   0.708
    Half length of fracture, xf                              187.4   ft
    Distance to first boundary, d1                            175.   ft
    Distance to second boundary, d2                           571.   ft
    Wdg Angle                                                 107.
    Type of first boundary, Type d1                     No Flow
    Type of second boundary, Type d2                    No Flow
    Distance investigated (approx), Dinv                     1707.   ft
    Measured Productivity Index, PI                           18.2   B/D/psi
    Flow Efficiency, FE                                       3.10   fraction
    Pressure drop due to skin, Dp(S)                         -24.6   psi
```

Information Only

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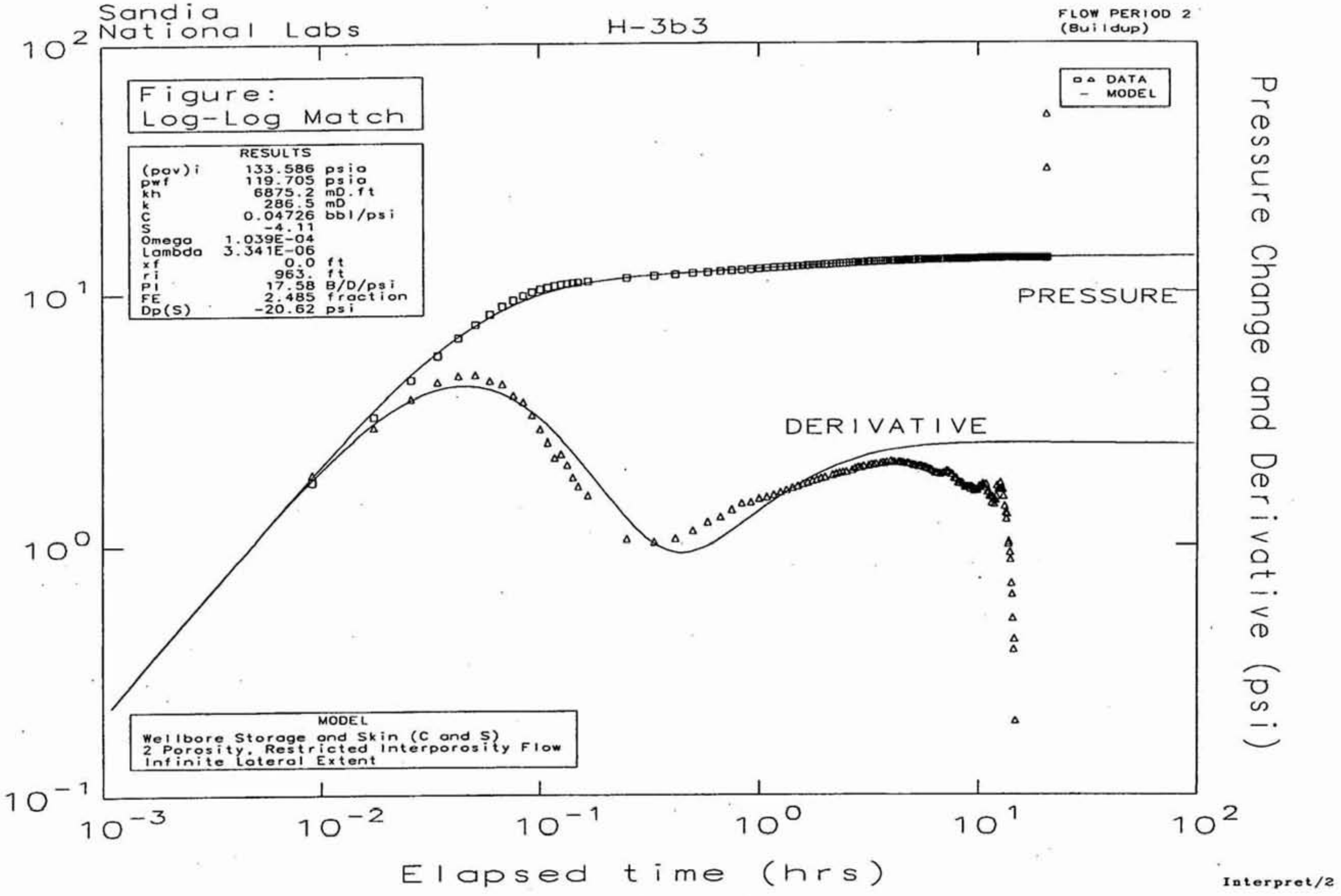
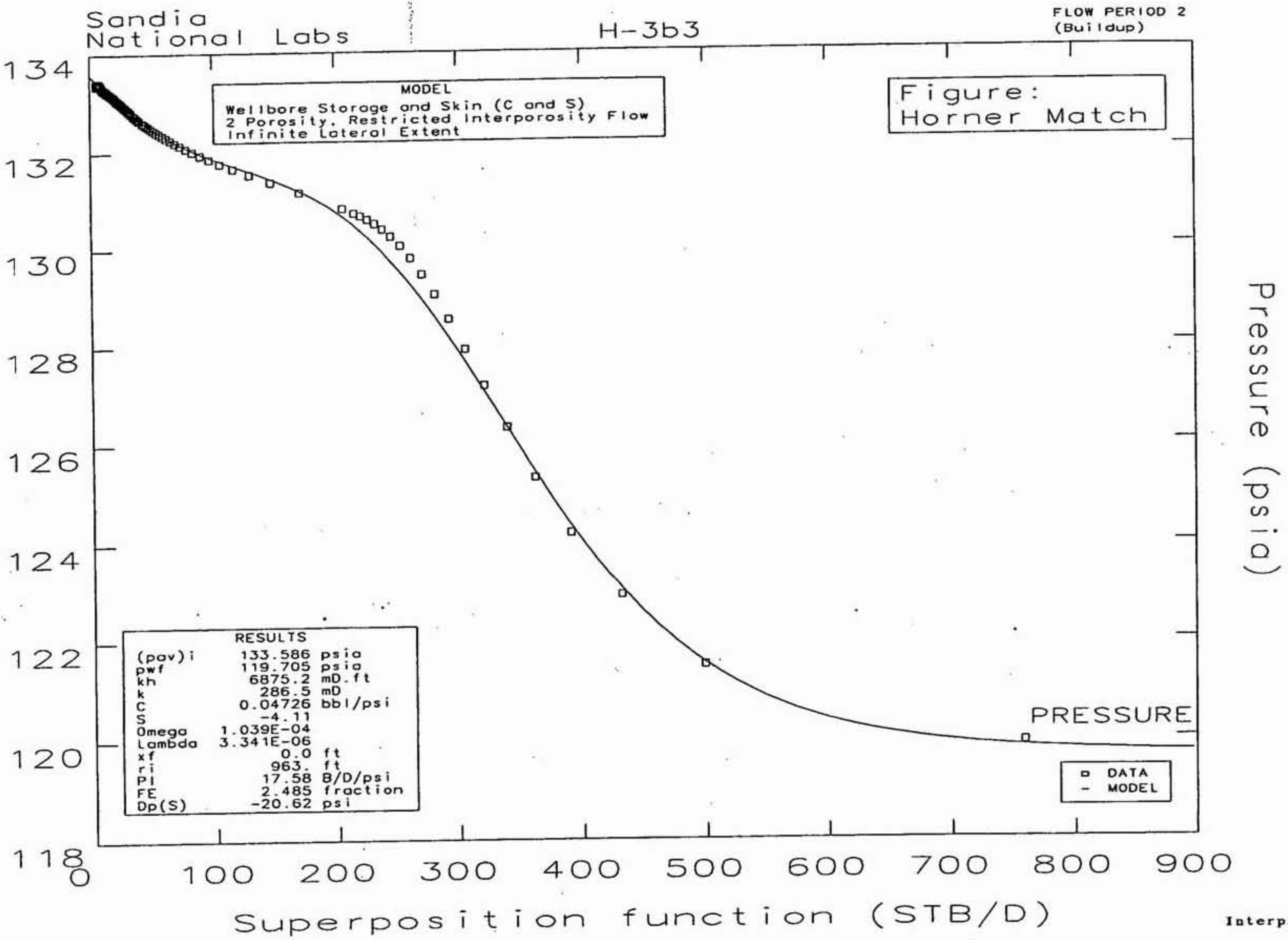


Information Only



Interpret/2

Information Only

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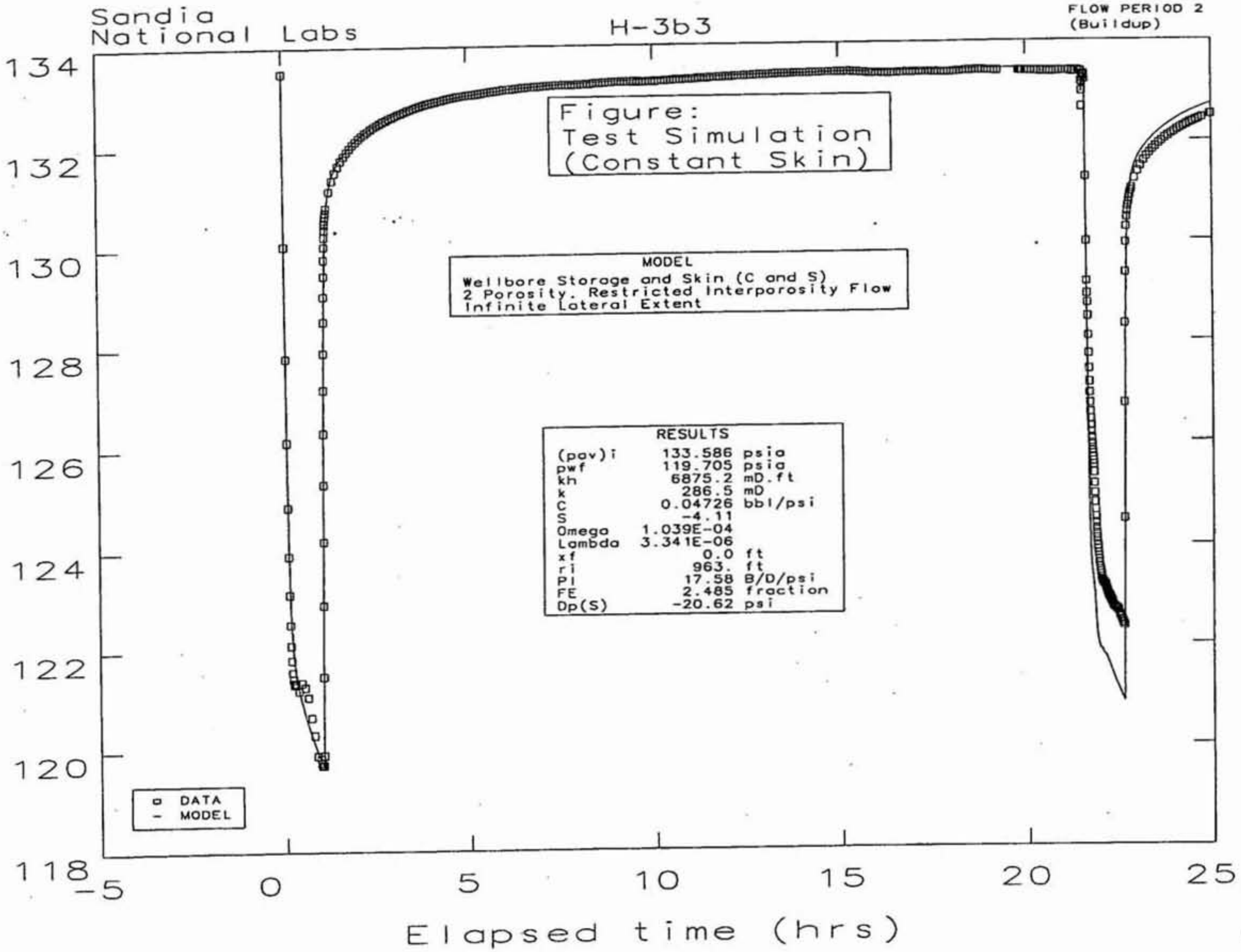


Figure:
Test Simulation
(Constant Skin)

MODEL

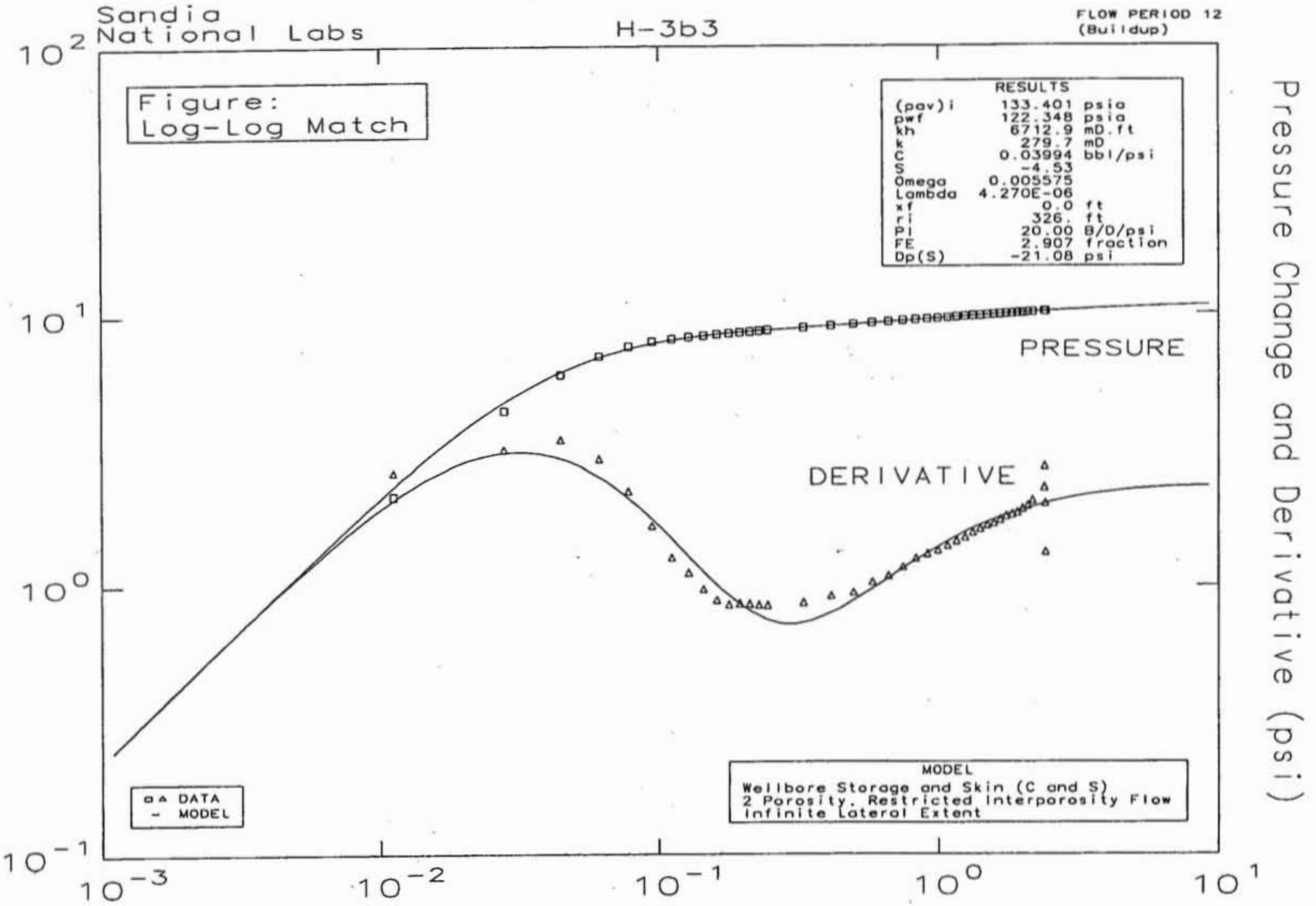
Wellbore Storage and Skin (C and S)
2 Porosity, Restricted Interporosity Flow
Infinite Lateral Extent

RESULTS

(pav)i	133.586	psia
pwf	119.705	psia
kh	6875.2	mD.ft
k	286.5	mD
C	0.04726	bbl/psi
S	-4.11	
Omega	1.039E-04	
Lambda	3.341E-06	
xf	0.0	ft
ri	963.	ft
PI	17.58	B/D/psi
FE	2.485	fraction
Dp(S)	-20.62	psi

Interpret/2

Information Only



Interpret/2

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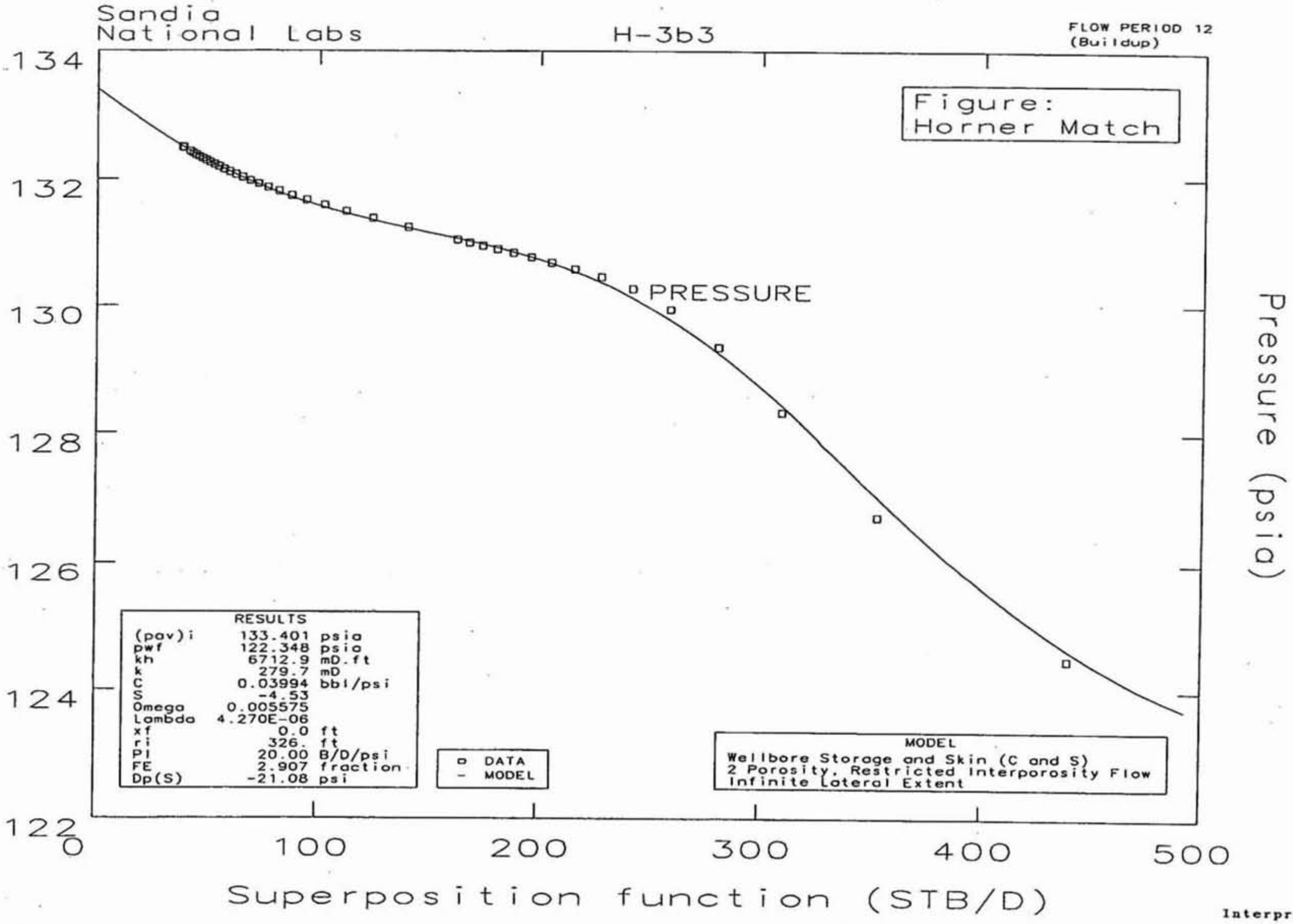
Information Only



Interpret/2

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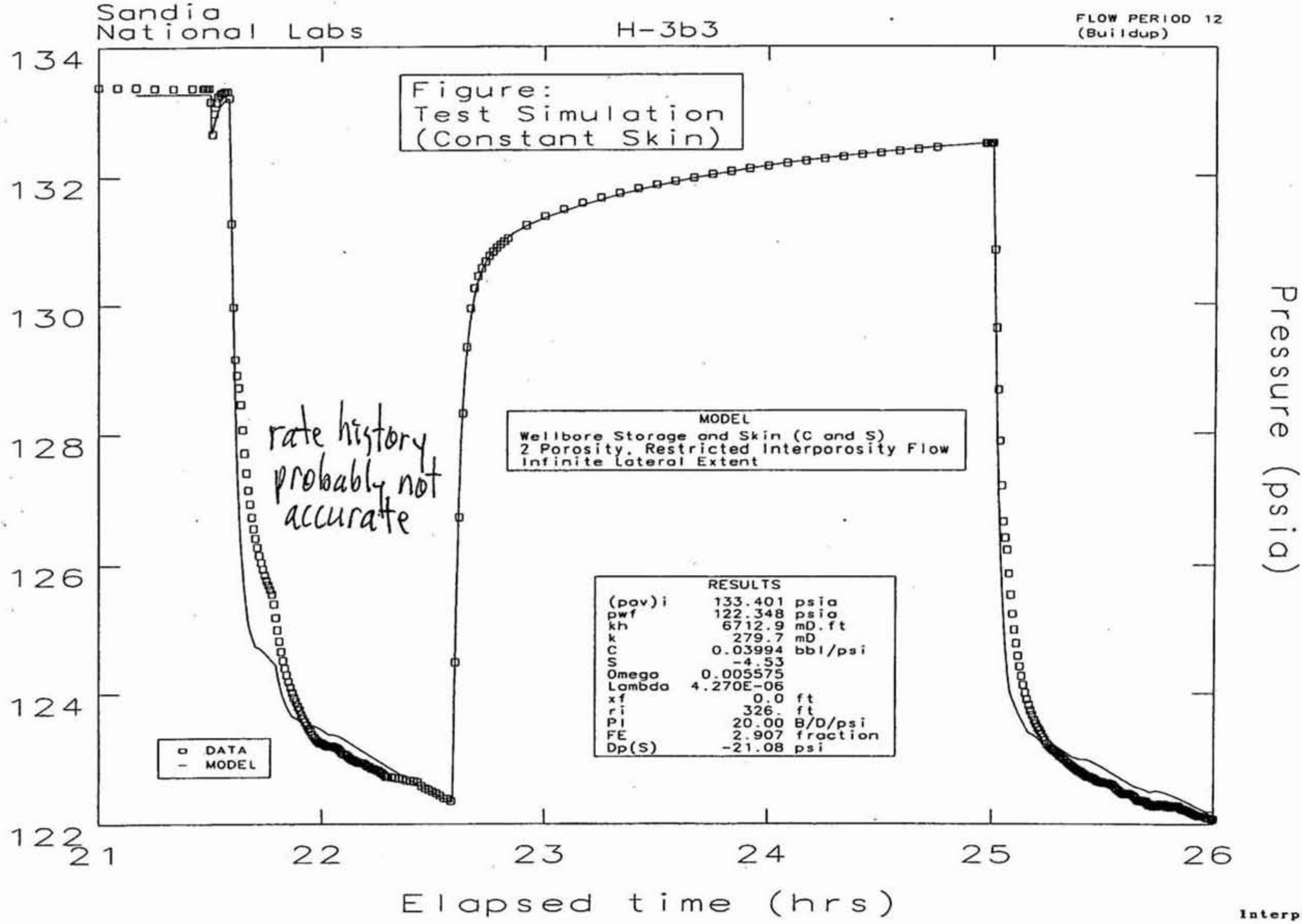
Information Only



rate history probably not accurate

MODEL

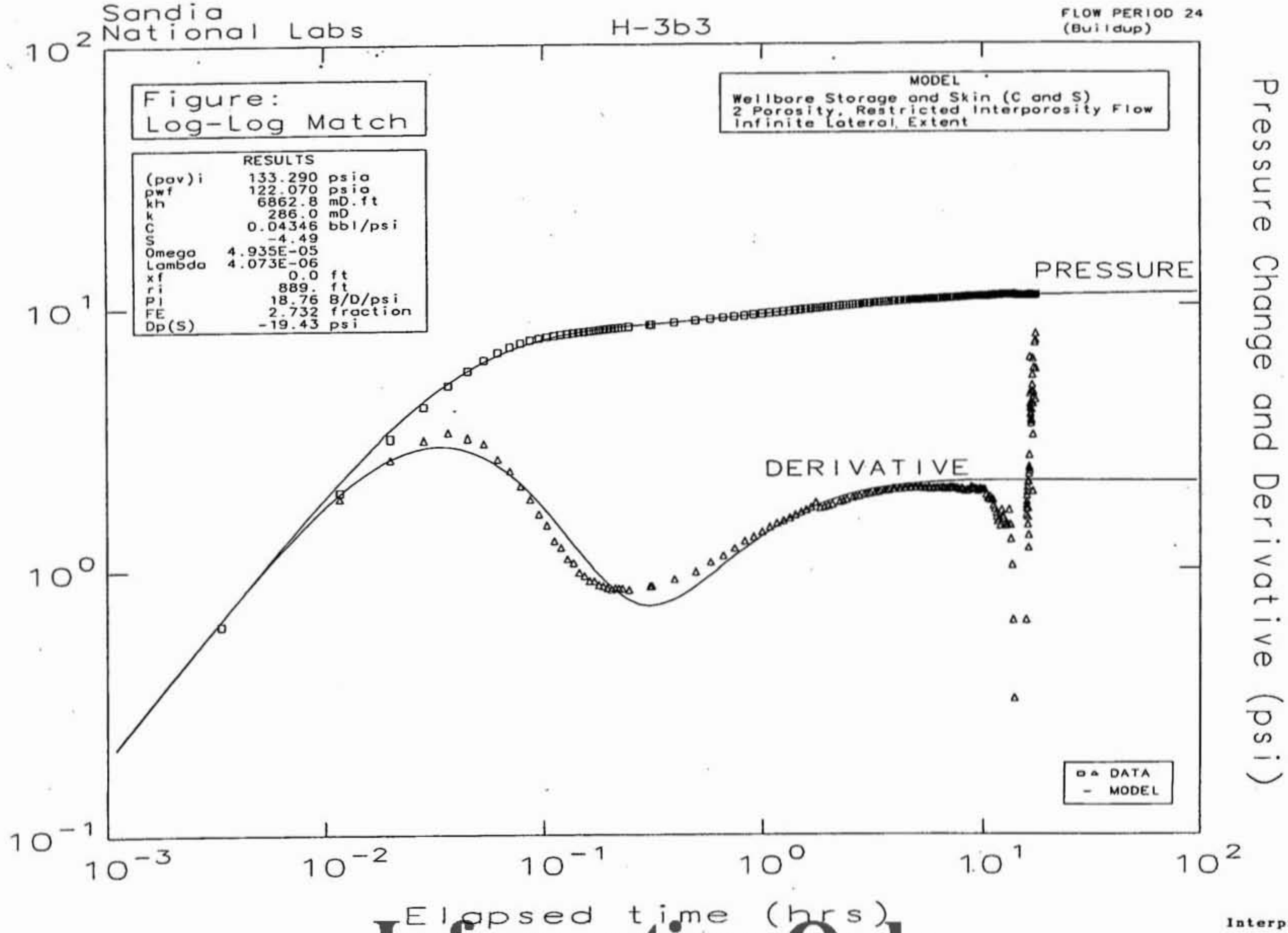
Wellbore Storage and Skin (C and S)
2 Porosity, Restricted Interporosity Flow
Infinite Lateral Extent

RESULTS

(pav)i	133.401	psia
pwf	122.348	psia
kh	6712.9	mD.ft
k	279.7	mD
C	0.03994	bbl/psi
S	-4.53	
Omega	0.005575	
Lambda	4.270E-06	
xf	0.0	ft
ri	326.	ft
PI	20.00	B/D/psi
FE	2.907	fraction
Dp(S)	-21.08	psi

Interpret/2

Information Only



Interpret/2

Information Only

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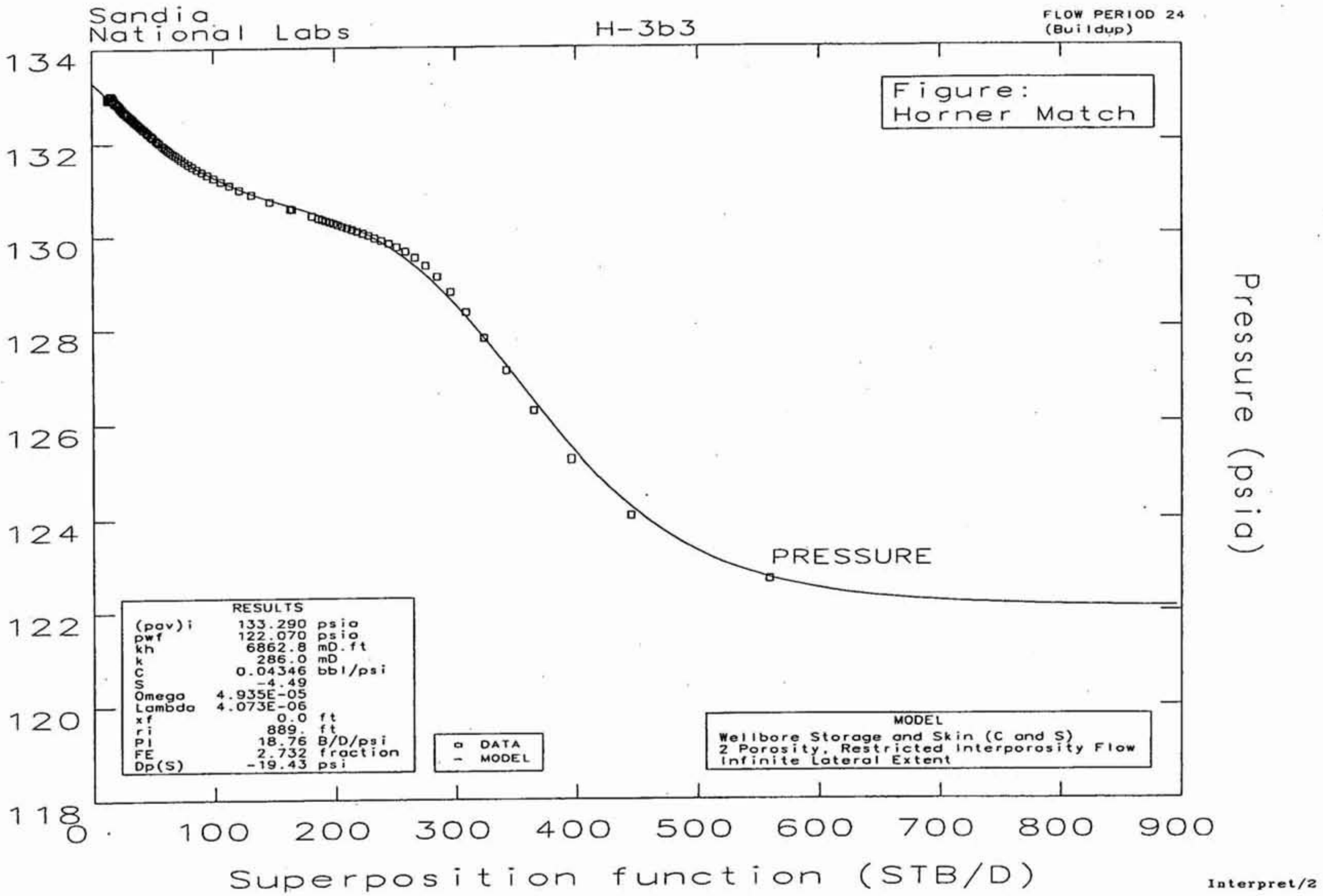
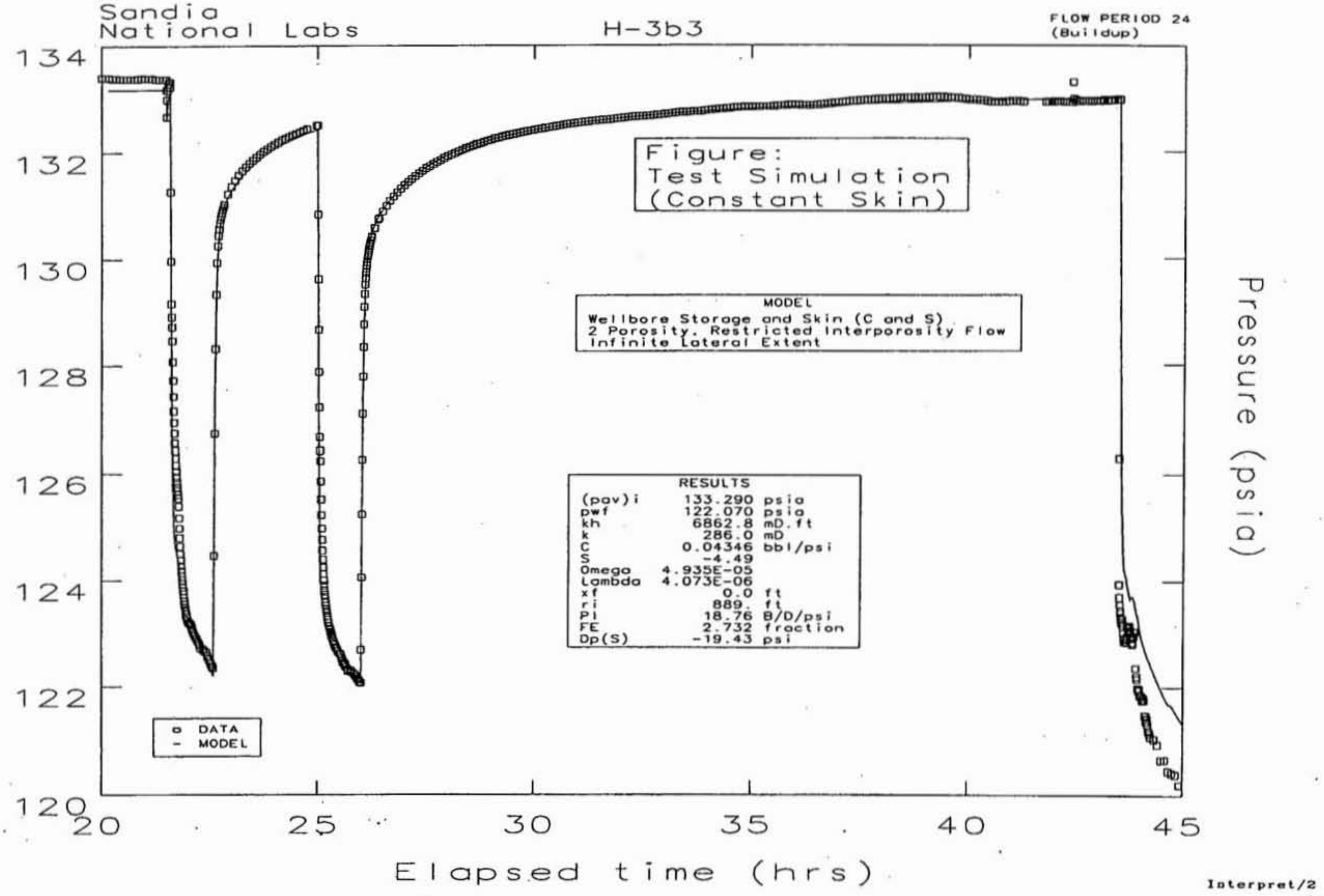


RESULTS

(pav)i	133.290	psia
pwf	122.070	psia
kh	6862.8	mD.ft
k	286.0	mD
C	0.04346	bbl/psi
S	-4.49	
Omega	4.935E-05	
Lambda	4.073E-06	
xf	0.0	ft
ri	889.	ft
PI	18.76	B/D/psi
FE	2.732	fraction
Dp(S)	-19.43	psi

Information Only



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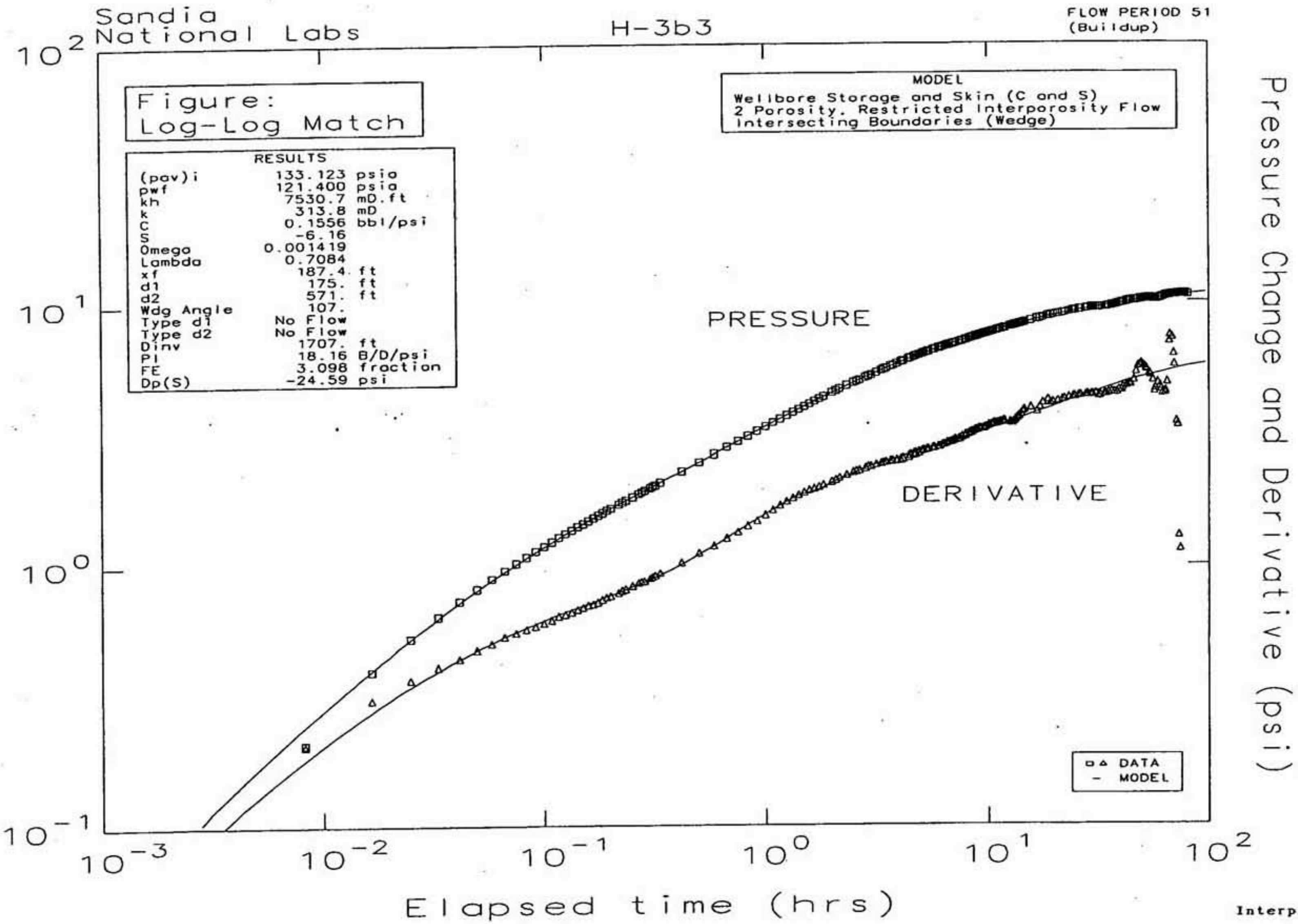
Information Only



RESULTS

(pav)i	133.123	psia
pwf	121.400	psia
kh	7530.7	mD.ft
k	313.8	mD
C	0.1556	bbl/psi
S	-6.16	
Omega	0.001419	
Lambda	0.7084	
xf	187.4	ft
d1	175.	ft
d2	571.	ft
Wdg Angle	107.	
Type d1	No Flow	
Type d2	No Flow	
Dinv	1707.	ft
PI	18.16	B/D/psi
FE	3.098	fraction
Dp(S)	-24.59	psi

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Information Only

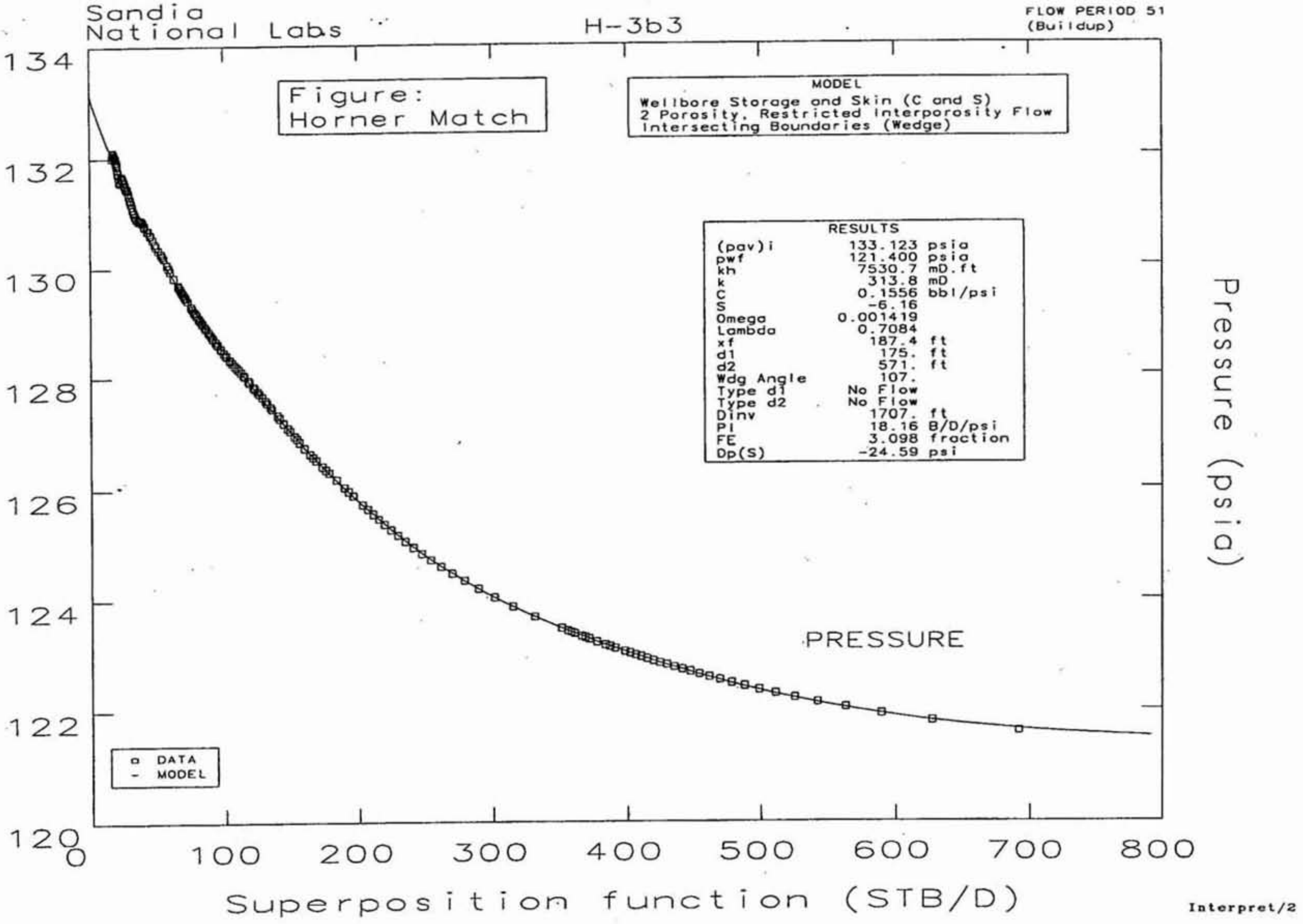


Figure:
Horner Match

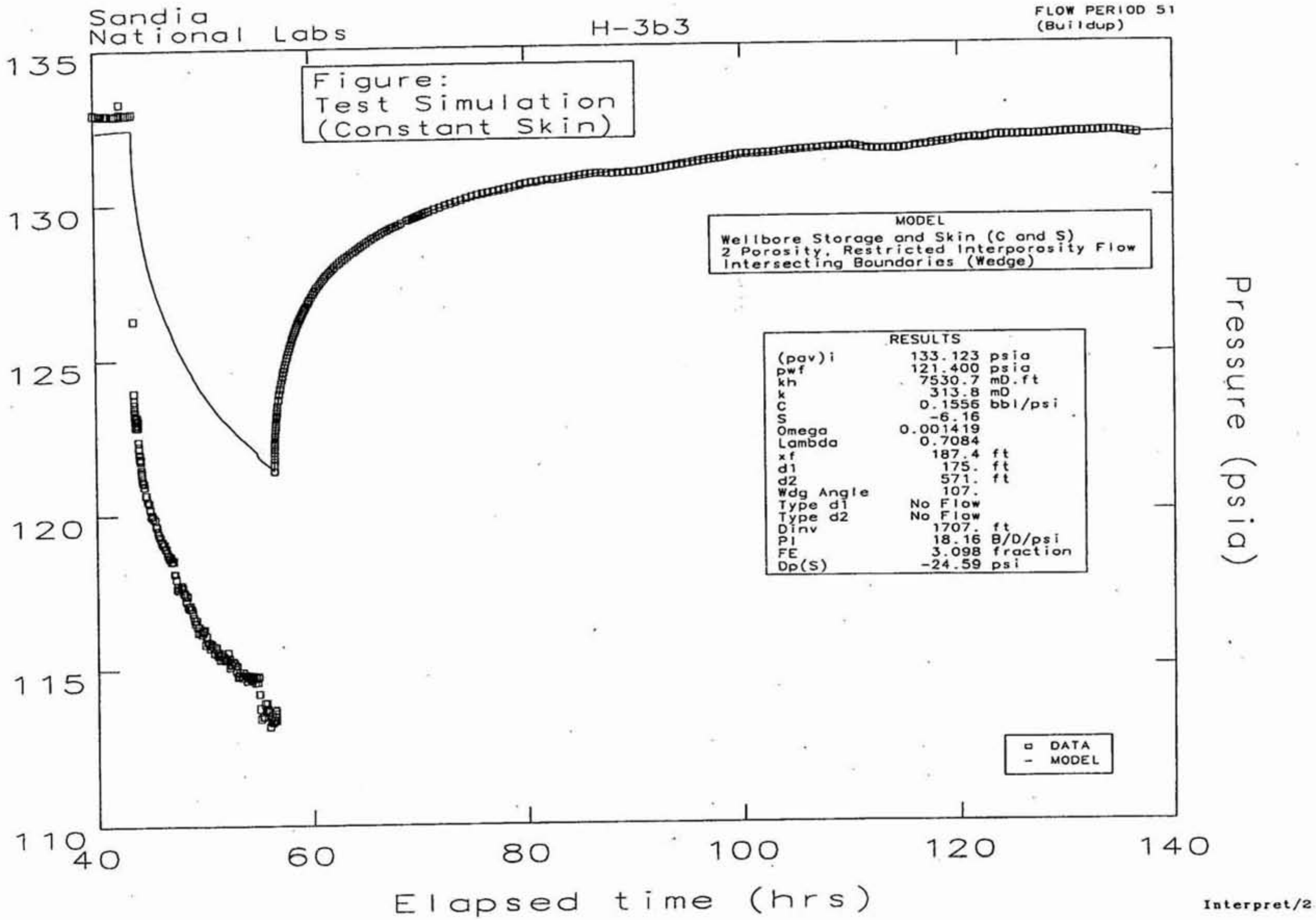
MODEL

Wellbore Storage and Skin (C and S)
2 Porosity, Restricted Interporosity Flow
Intersecting Boundaries (Wedge)

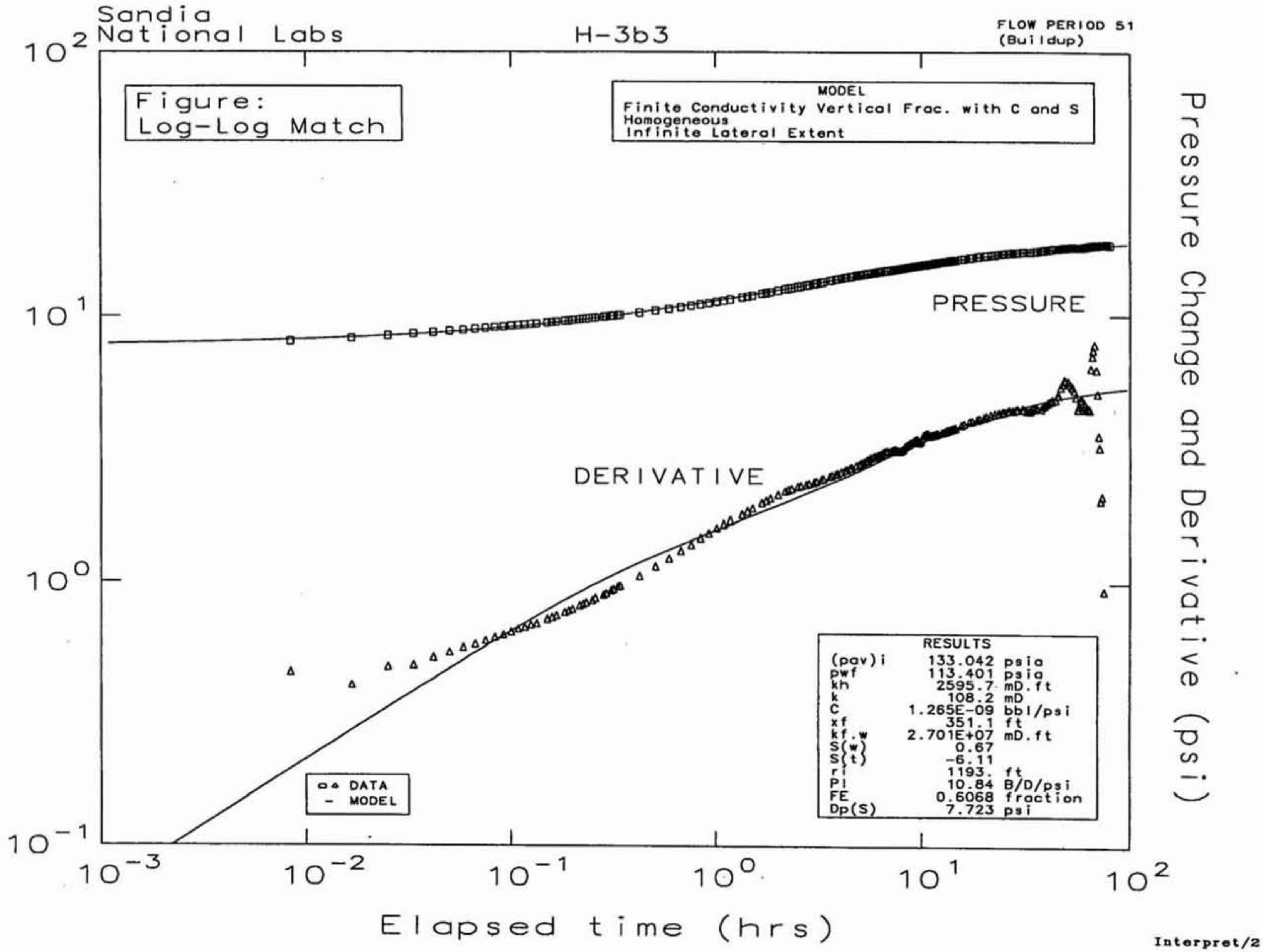
RESULTS

(pav)i	133.123	psia
pwf	121.400	psia
kh	7530.7	mD.ft
k	313.8	mD
C	0.1556	bbl/psi
S	-6.16	
Omega	0.001419	
Lambda	0.7084	
xf	187.4	ft
d1	175.	ft
d2	571.	ft
Wdg Angle	107.	
Type d1	No Flow	
Type d2	No Flow	
Dinv	1707.	ft
PI	18.16	B/D/psi
FE	3.098	fraction
Dp(S)	-24.59	psi

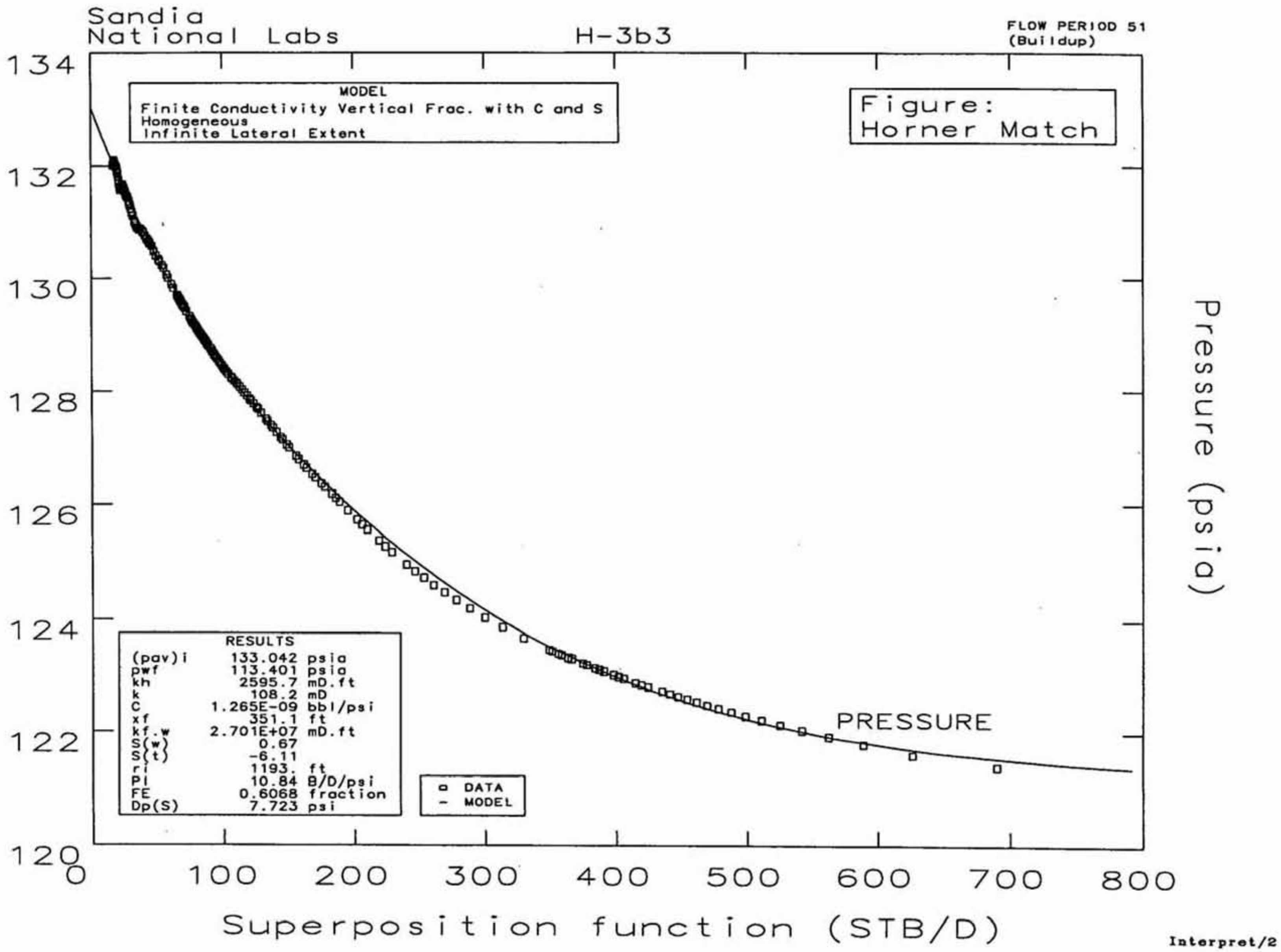
Information Only



Information Only



Information Only



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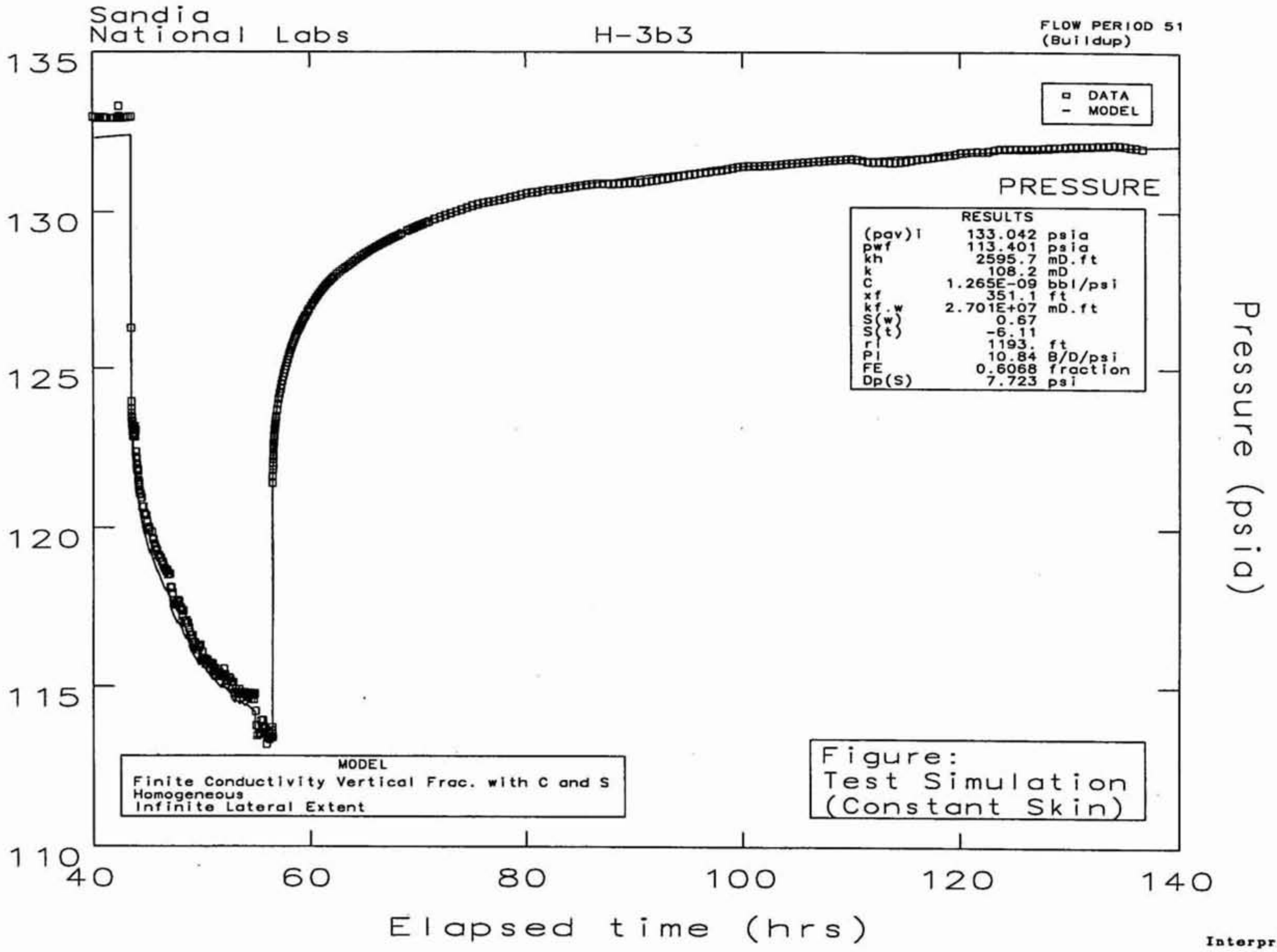
Information Only



RESULTS

(pav)i	133.042	psia
pwf	113.401	psia
kh	2595.7	mD.ft
k	108.2	mD
C	1.265E-09	bbl/psi
xf	351.1	ft
kf.w	2.701E+07	mD.ft
S(w)	0.67	
S(t)	-6.11	
ri	1193.	ft
PI	10.84	B/D/psi
FE	0.6068	fraction
Dp(S)	7.723	psi

Figure:
Test Simulation
(Constant Skin)

Interpret/2

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Information Only

```
+-----------------------------------------------------------------------------+
| Baker Atlas GEOScience                                            WorkBench |
+-----------------------------------------------------------------------------+
|                                                                             |
|                         WELL TEST ANALYSIS REPORT                           |
|                                                                             |
+-----------------------------------------------------------------------------+

 Company:     Sandia National Labs
 Field:       WIPP                               Date:        04-Mar-02
 Formation:   Rustler                            Test No:     1-4
 Zone:        Culebra                            Test Date:   April 17-23, 1984
 Well:        H-3b1                              Gauge:       Gauge 1

 Perforations:           From                         To
       1                675.00   ft                 703.00  ft

                              ANALYSIS SUMMARY

    First three tests conducted with no packer in pumping well (H-3b3).
    Last test conducted with packer inflated in pumping well.
    FP2 = buildup from test 1; FP12 = buildup from test 2
    FP24 = buildup from test 3; FP51 = buildup from test 4
    Both Magenta and Rustler-Salado contact are also perforated in this
    well, and the packer(s) above and/or below the Culebra may have been
    leaking during the tests.


+-----------------------------------------------------------------------------+
| Baker Atlas GEOScience                                            WorkBench |
+-----------------------------------------------------------------------------+
|                                                                             |
|                              Results Summary                                |
|                                                                             |
+-----------------------------------------------------------------------------+


    Near wellbore effects:   Line Source
    Reservoir behaviour:     2 Porosity, Unrestr. Interp. Flow (Slabs)
    Boundary effects:        Infinite Lateral Extent

  Flow Period:        2            12            24        Units

 (pav)i            135.380       134.062       133.980     psia
 pwf               131.571       130.405       129.663     psia
 kh                 6588.0        6854.4        6587.5     mD.ft
 k                   274.5         285.6         274.5     mD
 (pVct.h)f       3.043E-05     2.276E-05     2.268E-05     ft/psi
 (pVct)f         1.268E-06     9.483E-07     9.451E-07     1/psi
 (pVct.h)m       8.680E-05     8.481E-05     7.881E-05     ft/psi
 (pVct)m         3.617E-06     3.534E-06     3.284E-06     1/psi
 phi.ct.h        1.172E-04     1.076E-04     1.015E-04     ft/psi
 Omega              0.2595        0.2116        0.2235
 Lambda          7.414E-06     7.577E-06     7.834E-06
```

Information Only

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+------------------------------------------------------------------------------+
| Baker Atlas GEOScience                                             WorkBench |
+------------------------------------------------------------------------------+
|                                                                              |
|                              Results Summary                                |
|                                                                              |
+------------------------------------------------------------------------------+


   Near wellbore effects:   Line Source
   Reservoir behaviour:     2 Porosity, Unrestr. Interp. Flow (Slabs)
   Boundary effects:        Channel Boundaries


  Flow Period:       51     Units

 (pav)i          135.533    psia
 pwf             121.378    psia
 kh               6988.8    mD.ft
 k                 291.2    mD
 (pVct.h)f     2.579E-06    ft/psi
 (pVct)f       1.075E-07    1/psi
 (pVct.h)m     1.903E-04    ft/psi
 (pVct)m       7.930E-06    1/psi
 phi.ct.h      1.929E-04    ft/psi
 Omega           0.01337
 Lambda        4.181E-06
 Obs Angle            0.
 d1                 768.    ft
 d3                3080.    ft
 Type d1         No Flow
 Type d3         No Flow
 d1o                668.    ft
 d3o               3181.    ft
```

Information Only

2

```
+-----------------------------------------------------------------------------+
| Baker Atlas GEOScience                                            WorkBench |
+-----------------------------------------------------------------------------+
|                                                                             |
|                     Well & Reservoir Parameters                             |
|                                                                             |
+-----------------------------------------------------------------------------+


                    WELL AND RESERVOIR DATA  (Water)

  Multiphase flow at wellbore:   NO
  Multiphase in reservoir    :   NO

  Matrix Porosity                                     0.160       fraction
  Reservoir Thickness                                 24.00       ft
  Wellbore Radius                                     0.247       ft
  Distance To Producing Well (*)                     100.72       ft

  Water Formation Volume Factor                       1.000       RB/STB
  Water Viscosity                                  1.00           cp
  Total Compressibility                           1.000E-05       1/psi

  (*) = For Interference Tests Only
```

Information Only

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+-----------------------------------------------------------------------------+
| Baker Atlas GEOScience                                             WorkBench |
+-----------------------------------------------------------------------------+
|                                                                             |
|                      Analysis Parameters and Results                        |
|                                                                             |
+-----------------------------------------------------------------------------+


                  ANALYSIS MODEL, FLOW PERIOD:    2

   Near wellbore effects:  Line Source
   Reservoir behaviour:    2 Porosity, Unrestr. Interp. Flow (Slabs)
   Boundary effects:       Infinite Lateral Extent


                ANALYSIS PARAMETERS, FLOW PERIOD:    2

   Pressure match, PM                                        0.191   1/psi
   Time match, TM                                             5.63   1/hr
   Storativity ratio, Omega                                  0.260
   Transition curve match, B.rD2                              1.59


                 ANALYSIS RESULTS, FLOW PERIOD:    2

   Initial average reservoir pressure, (pav)i              135.380   psia
   Flowing pressure, pwf                                   131.571   psia
   Permeability Thickness, kh                            6.588E+03   mD.ft
   Permeability, k                                            274.   mD
   High K medium storativity, (pVct.h)f                  3.043E-05   ft/psi
   High K medium specific storativity, (pVct)f           1.268E-06   1/psi
   Low K medium storativity, (pVct.h)m                   8.680E-05   ft/psi
   Low K medium specific storativity, (pVct)m            3.617E-06   1/psi
   Total storativity, phi.ct.h                           1.172E-04   ft/psi
   Storativity ratio, Omega                                  0.260
   Interporosity flow coefficient, Lambda                7.414E-06
```

Information Only

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+-----------------------------------------------------------------------+
| Baker Atlas GEOScience                                      WorkBench |
+-----------------------------------------------------------------------+
|                                                                       |
|                   Analysis Parameters and Results                     |
|                                                                       |
+-----------------------------------------------------------------------+


                 ANALYSIS MODEL, FLOW PERIOD:   12

   Near wellbore effects:   Line Source
   Reservoir behaviour:     2 Porosity, Unrestr. Interp. Flow (Slabs)
   Boundary effects:        Infinite Lateral Extent


               ANALYSIS PARAMETERS, FLOW PERIOD:   12

   Pressure match, PM                                    0.220   1/psi
   Time match, TM                                         7.83   1/hr
   Storativity ratio, Omega                              0.212
   Transition curve match, B.rD2                          1.99


                ANALYSIS RESULTS, FLOW PERIOD:   12

   Initial average reservoir pressure, (pav)i          134.062   psia
   Flowing pressure, pwf                               130.405   psia
   Permeability Thickness, kh                        6.854E+03   mD.ft
   Permeability, k                                        286.   mD
   High K medium storativity, (pVct.h)f              2.276E-05   ft/psi
   High K medium specific storativity, (pVct)f       9.483E-07   1/psi
   Low K medium storativity, (pVct.h)m               8.481E-05   ft/psi
   Low K medium specific storativity, (pVct)m        3.534E-06   1/psi
   Total storativity, phi.ct.h                       1.076E-04   ft/psi
   Storativity ratio, Omega                              0.212
   Interporosity flow coefficient, Lambda            7.577E-06
```

Information Only

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+--------------------------------------------------------------------------+
| Baker Atlas GEOScience                                         WorkBench |
+--------------------------------------------------------------------------+
|                                                                          |
|                    Analysis Parameters and Results                       |
|                                                                          |
+--------------------------------------------------------------------------+


                   ANALYSIS MODEL, FLOW PERIOD:   24

    Near wellbore effects:   Line Source
    Reservoir behaviour:     2 Porosity, Unrestr. Interp. Flow (Slabs)
    Boundary effects:        Infinite Lateral Extent


                 ANALYSIS PARAMETERS, FLOW PERIOD:   24

    Pressure match, PM                                     0.222   1/psi
    Time match, TM                                          7.55   1/hr
    Storativity ratio, Omega                               0.223
    Transition curve match, B.rD2                           1.95


                  ANALYSIS RESULTS, FLOW PERIOD:   24

    Initial average reservoir pressure, (pav)i           133.980   psia
    Flowing pressure, pwf                                129.663   psia
    Permeability Thickness, kh                         6.587E+03   mD.ft
    Permeability, k                                         274.   mD
    High K medium storativity, (pVct.h)f               2.268E-05   ft/psi
    High K medium specific storativity, (pVct)f        9.451E-07   1/psi
    Low K medium storativity, (pVct.h)m                7.881E-05   ft/psi
    Low K medium specific storativity, (pVct)m         3.284E-06   1/psi
    Total storativity, phi.ct.h                        1.015E-04   ft/psi
    Storativity ratio, Omega                               0.223
    Interporosity flow coefficient, Lambda             7.834E-06
```

Information Only

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+------------------------------------------------------------------------------+
| Baker Atlas GEOScience                                             WorkBench |
+------------------------------------------------------------------------------+
|                                                                              |
|                     Analysis Parameters and Results                          |
|                                                                              |
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                    ANALYSIS MODEL, FLOW PERIOD:   51

    Near wellbore effects:   Line Source
    Reservoir behaviour:     2 Porosity, Unrestr. Interp. Flow (Slabs)
    Boundary effects:        Channel Boundaries


                  ANALYSIS PARAMETERS, FLOW PERIOD:   51

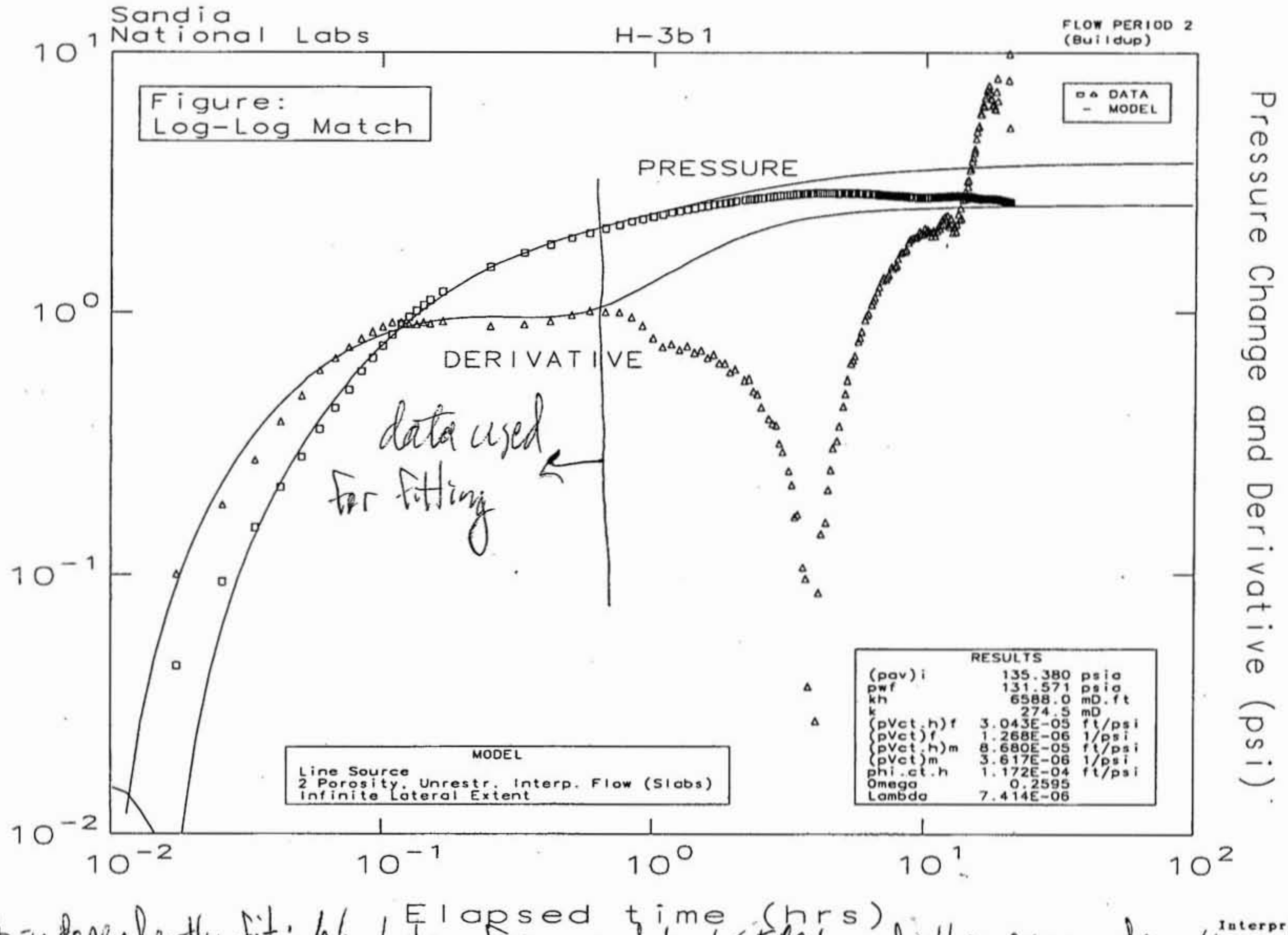
    Pressure match, PM                                          0.232   1/psi
    Time match, TM                                               70.4   1/hr
    Storativity ratio, Omega                                1.337E-02
    Transition curve match, B.rD2                                17.4
    Obs Angle                                                      0.
    Dimensionless distance: first boundary, (d1)D                233.
    Dimensionless distance: third boundary, (d3)D               3740.


                   ANALYSIS RESULTS, FLOW PERIOD:   51

    Initial average reservoir pressure, (pav)i                135.533   psia
    Flowing pressure, pwf                                     121.378   psia
    Permeability Thickness, kh                              6.989E+03   mD.ft
    Permeability, k                                              291.   mD
    High K medium storativity, (pVct.h)f                    2.579E-06   ft/psi
    High K medium specific storativity, (pVct)f             1.075E-07   1/psi
    Low K medium storativity, (pVct.h)m                     1.903E-04   ft/psi
    Low K medium specific storativity, (pVct)m              7.930E-06   1/psi
    Total storativity, phi.ct.h                             1.929E-04   ft/psi
    Storativity ratio, Omega                                1.337E-02
    Interporosity flow coefficient, Lambda                  4.181E-06
    Obs Angle                                                      0.
    Distance to first boundary, d1                               768.   ft
    Distance to third boundary, d3                              3080.   ft
    Type of first boundary, Type d1                       No Flow
    Type of third boundary, Type d3                       No Flow
    Distance of obs. well to first boundary, d1o                 668.   ft
    Distance of obs. well to third boundary, d3o                3181.   ft
```

Information Only

7



MODEL

Line Source
2 Porosity, Unrestr. Interp. Flow (Slabs)
Infinite Lateral Extent

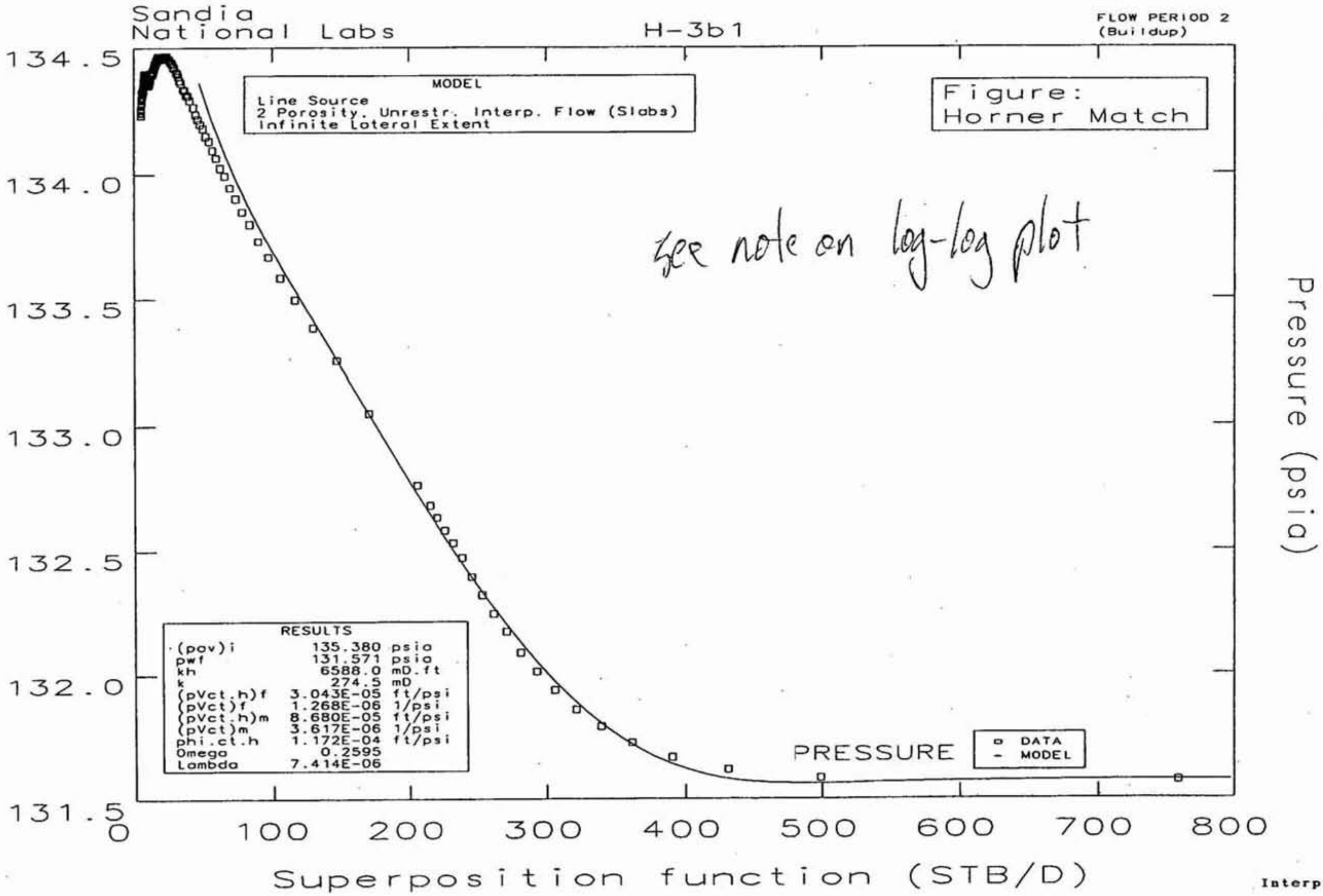
RESULTS

(pav)i	135.380	psia
pwf	131.571	psia
kh	6588.0	mD.ft
k	274.5	mD
(pVct.h)f	3.043E-05	ft/psi
(pVct)f	1.268E-06	1/psi
(pVct.h)m	8.680E-05	ft/psi
(pVct)m	3.617E-06	1/psi
phi.ct.h	1.172E-04	ft/psi
Omega	0.2595	
Lambda	7.414E-06	

Interpret/2

00 not independently fit: kh taken from match to FP24, and other parameters then fit to early-time data only

Information Only



see note on log-log plot

RESULTS

(pav)i	135.380	psia
pwf	131.571	psia
kh	6588.0	mD.ft
k	274.5	mD
(pVct.h)f	3.043E-05	ft/psi
(pVct)f	1.268E-06	1/psi
(pVct.h)m	8.680E-05	ft/psi
(pVct)m	3.617E-06	1/psi
phi.ct.h	1.172E-04	ft/psi
Omega	0.2595	
Lambda	7.414E-06	

Interpret/2

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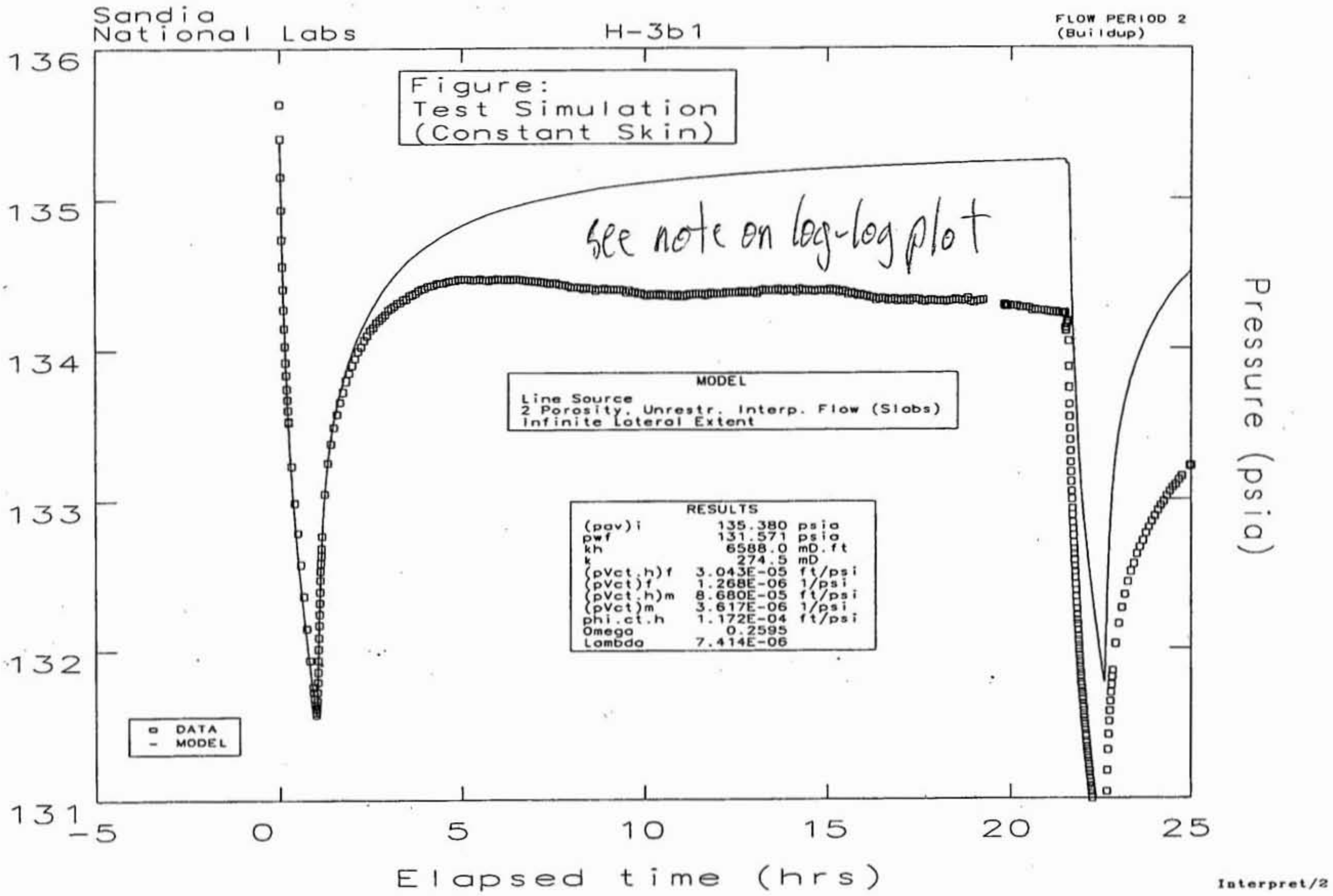
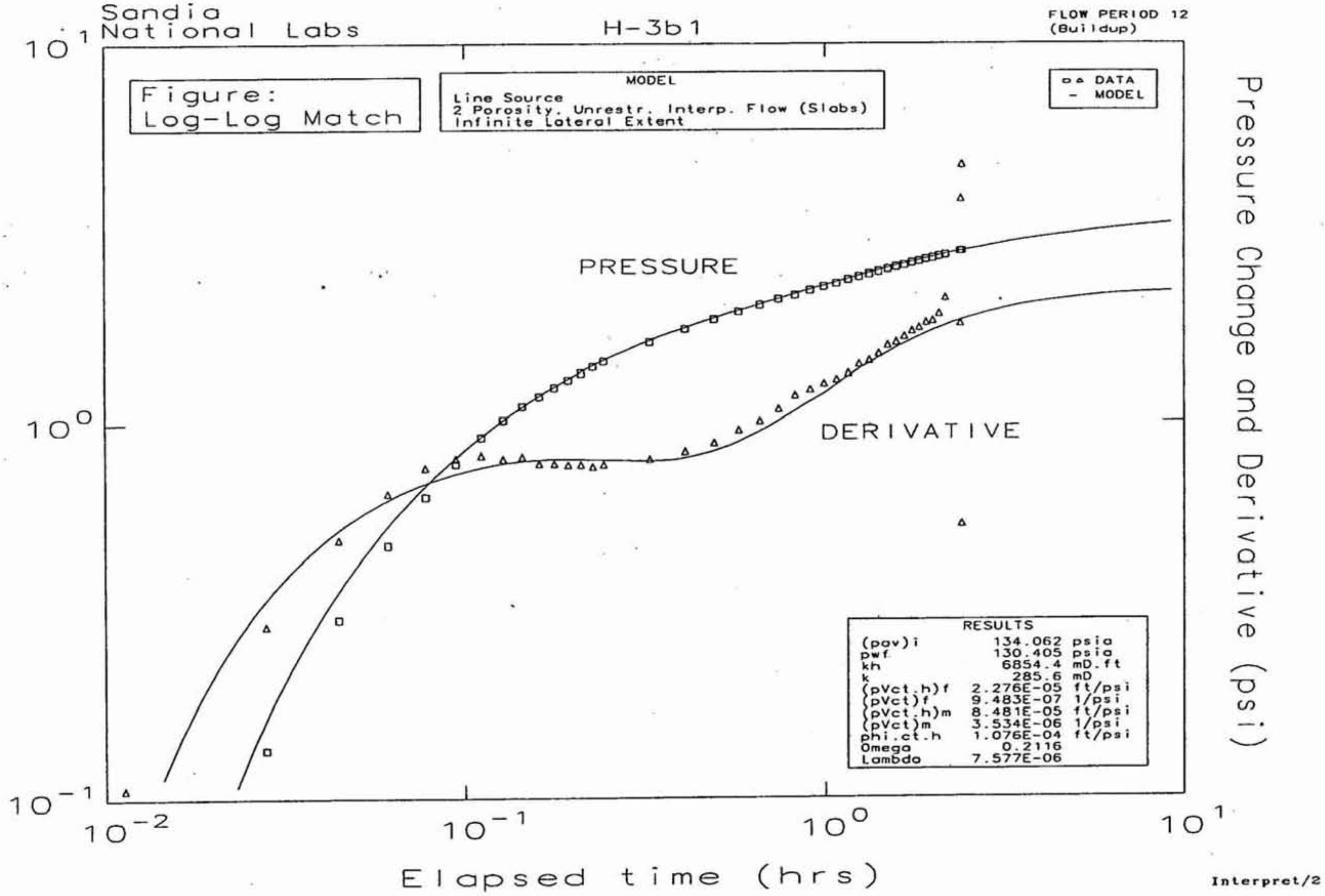
Information Only



see note on log-log plot

10

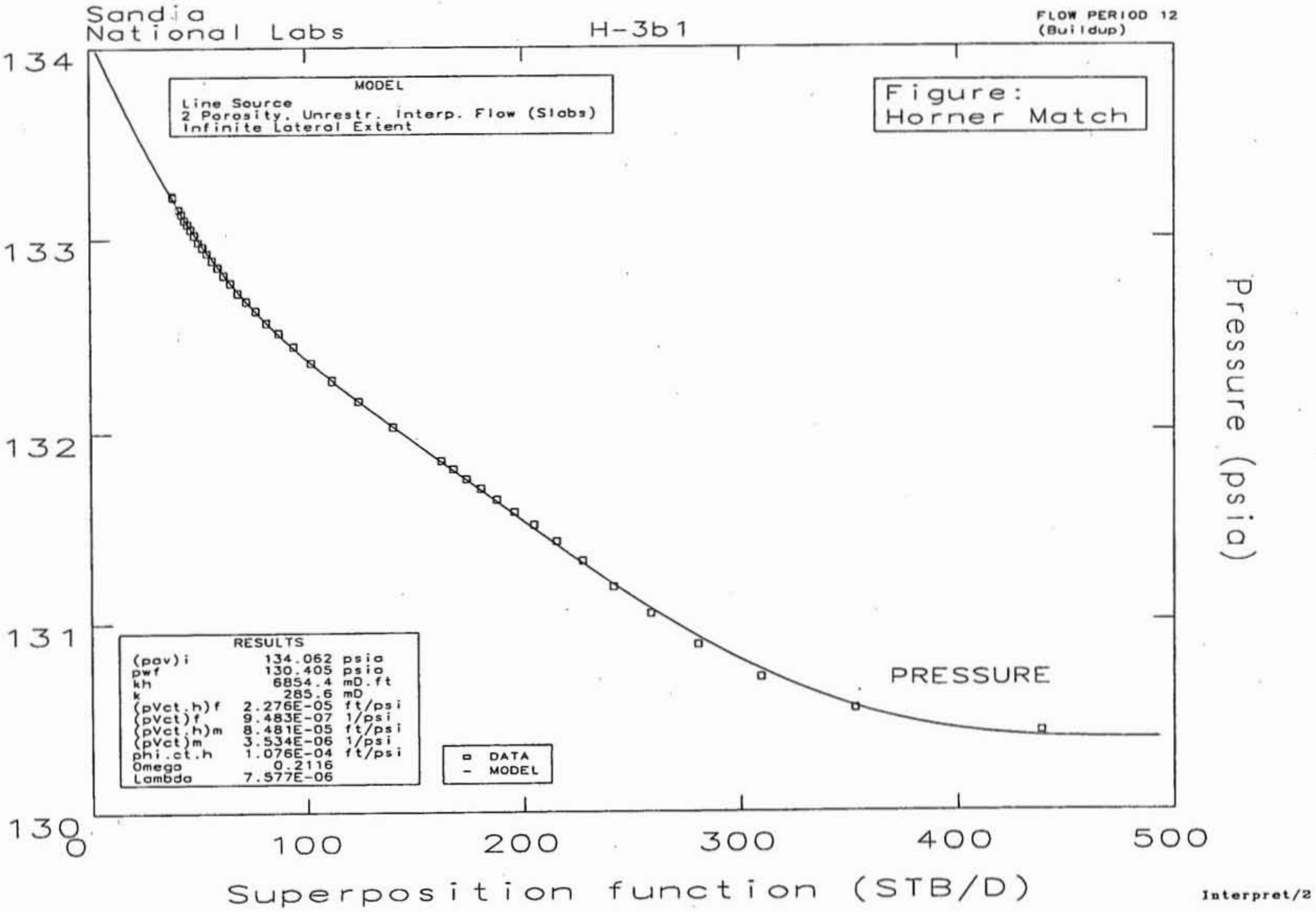
Information Only



RESULTS

(pav)i	134.062	psia
pwf	130.405	psia
kh	6854.4	mD.ft
k	285.6	mD
(pVct.h)f	2.276E-05	ft/psi
(pVct)f	9.483E-07	1/psi
(pVct.h)m	8.481E-05	ft/psi
(pVct)m	3.534E-06	1/psi
phi.ct.h	1.076E-04	ft/psi
Omega	0.2116	
Lambda	7.577E-06	

Information Only

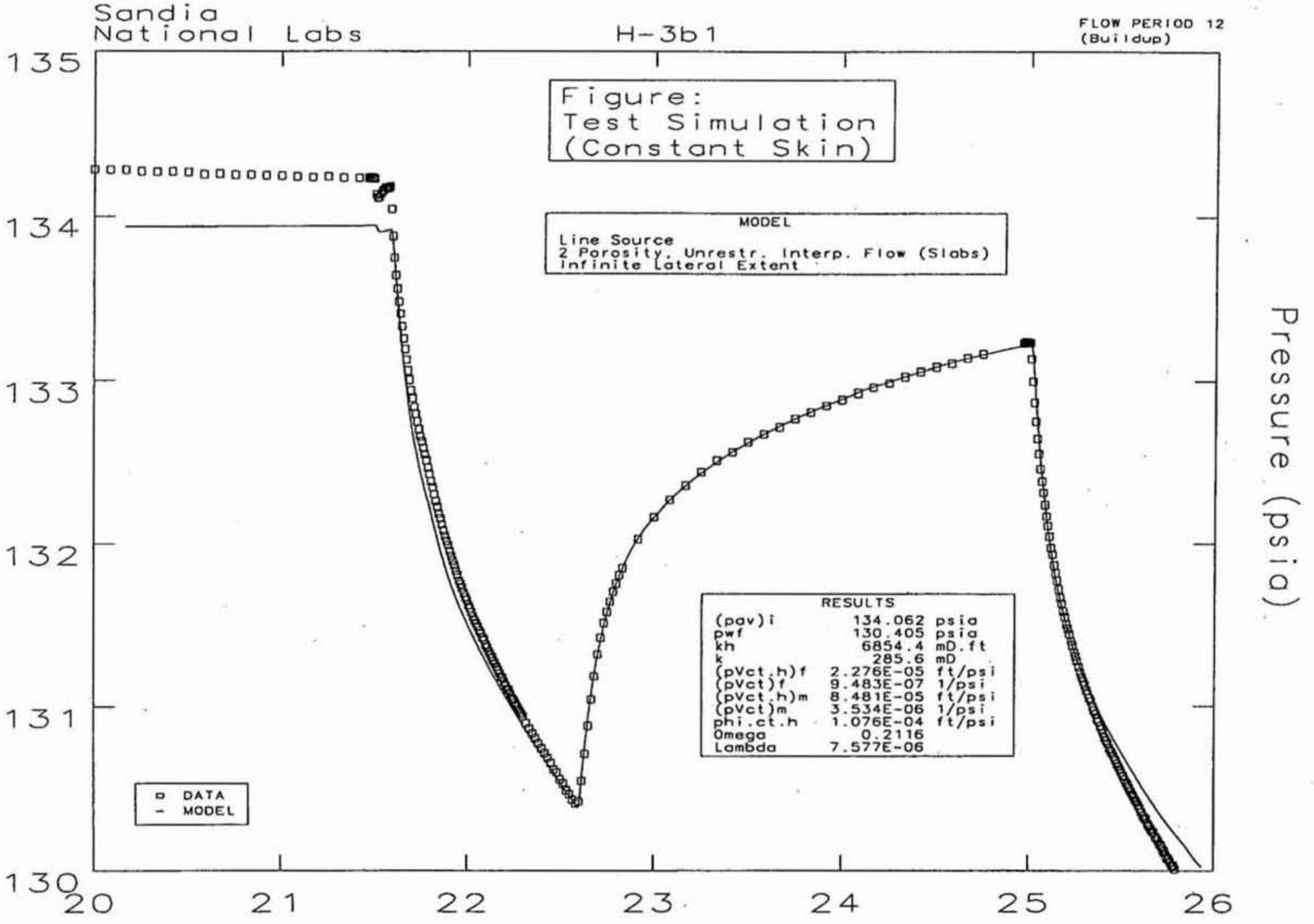


RESULTS

(pav)i	134.062	psia
pwf	130.405	psia
kh	6854.4	mD.ft
k	285.6	mD
(pVct.h)f	2.276E-05	ft/psi
(pVct)f	9.483E-07	1/psi
(pVct.h)m	8.481E-05	ft/psi
(pVct)m	3.534E-06	1/psi
phi.ct.h	1.076E-04	ft/psi
Omega	0.2116	
Lambda	7.577E-06	

12

Information Only



Interpret/2

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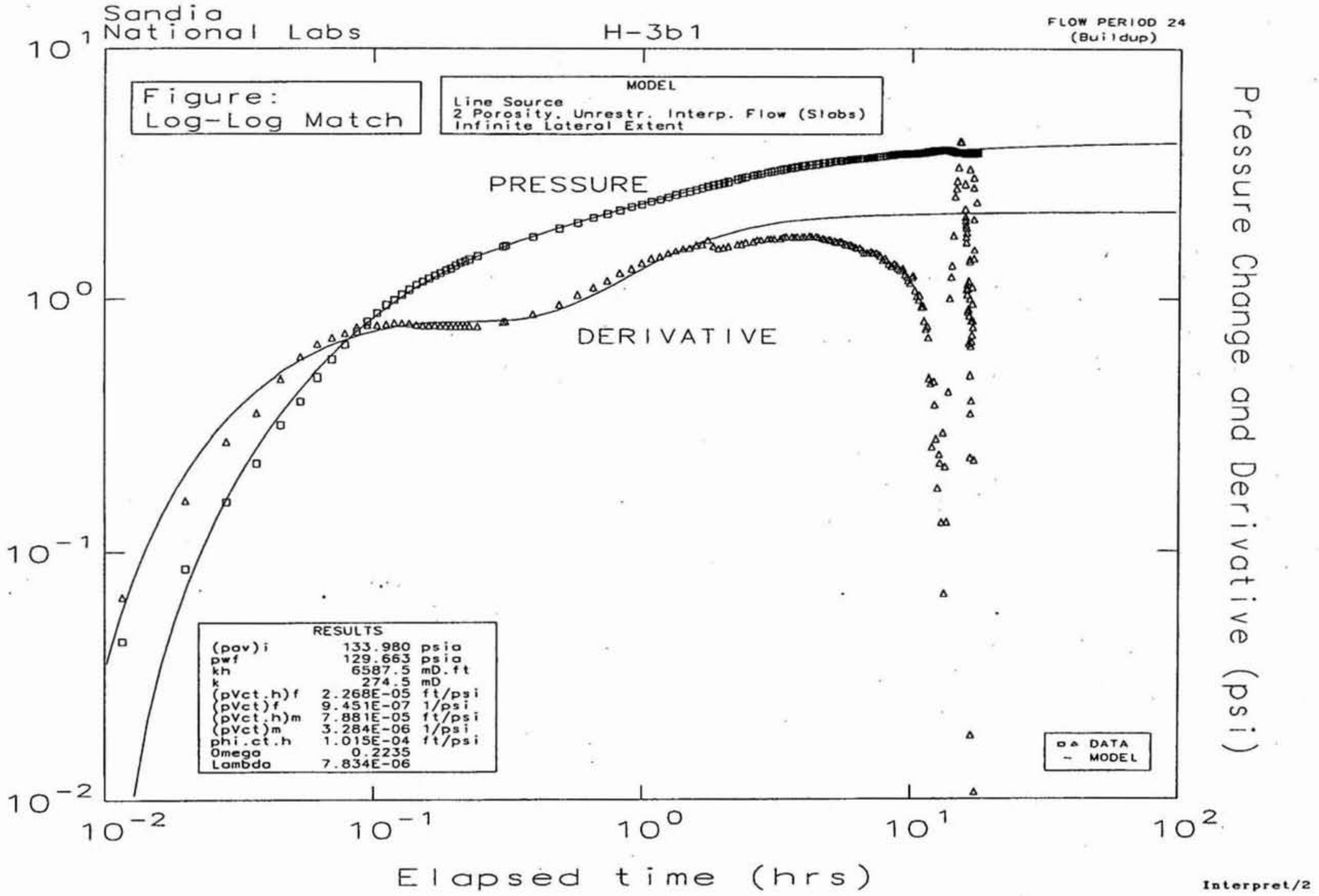
Information Only



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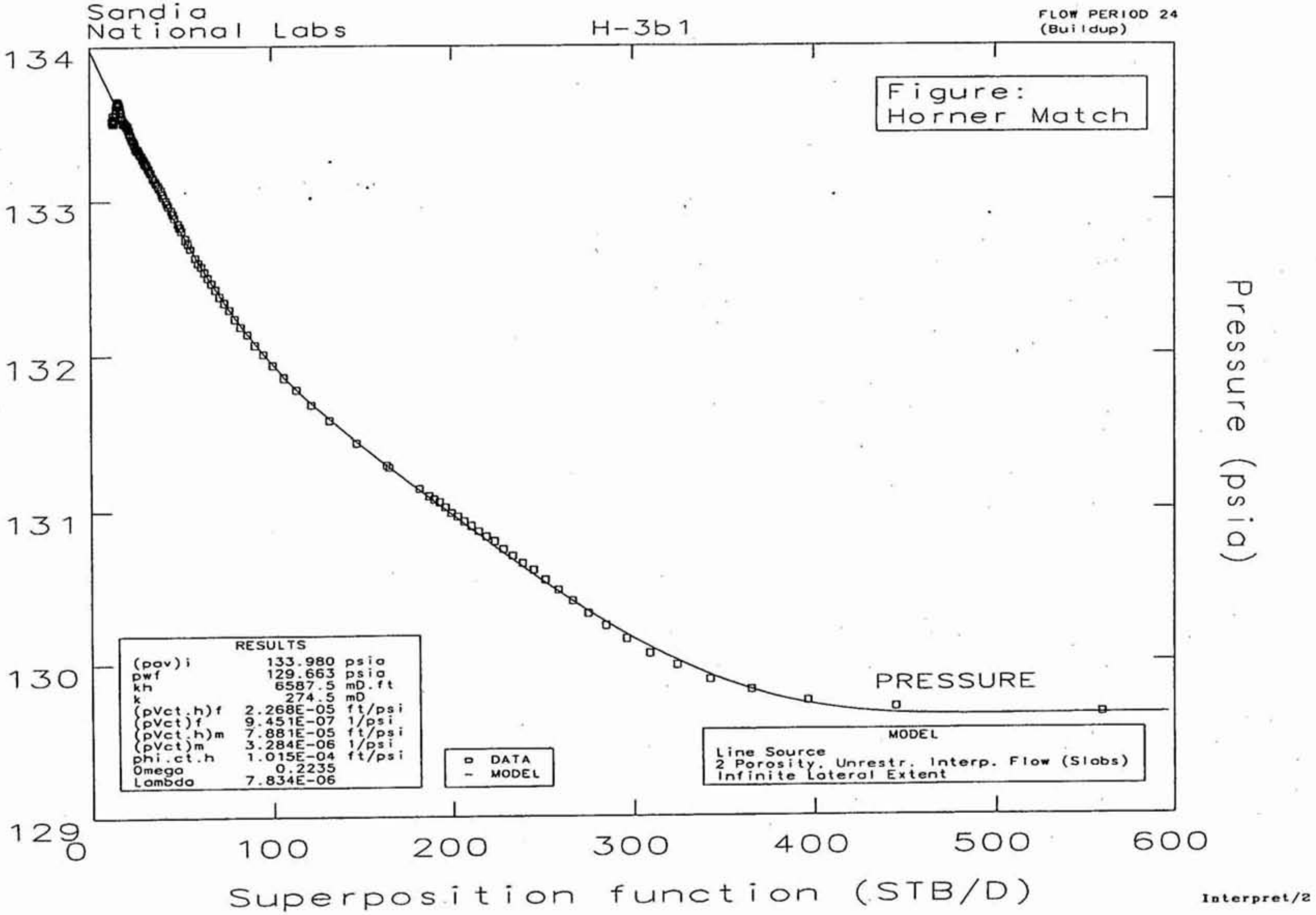
Information Only



RESULTS

(pav)i	133.980	psia
pwf	129.663	psia
kh	6587.5	mD.ft
k	274.5	mD
(pVct.h)f	2.268E-05	ft/psi
(pVct)f	9.451E-07	1/psi
(pVct.h)m	7.881E-05	ft/psi
(pVct)m	3.284E-06	1/psi
phi.ct.h	1.015E-04	ft/psi
Omega	0.2235	
Lambda	7.834E-06	

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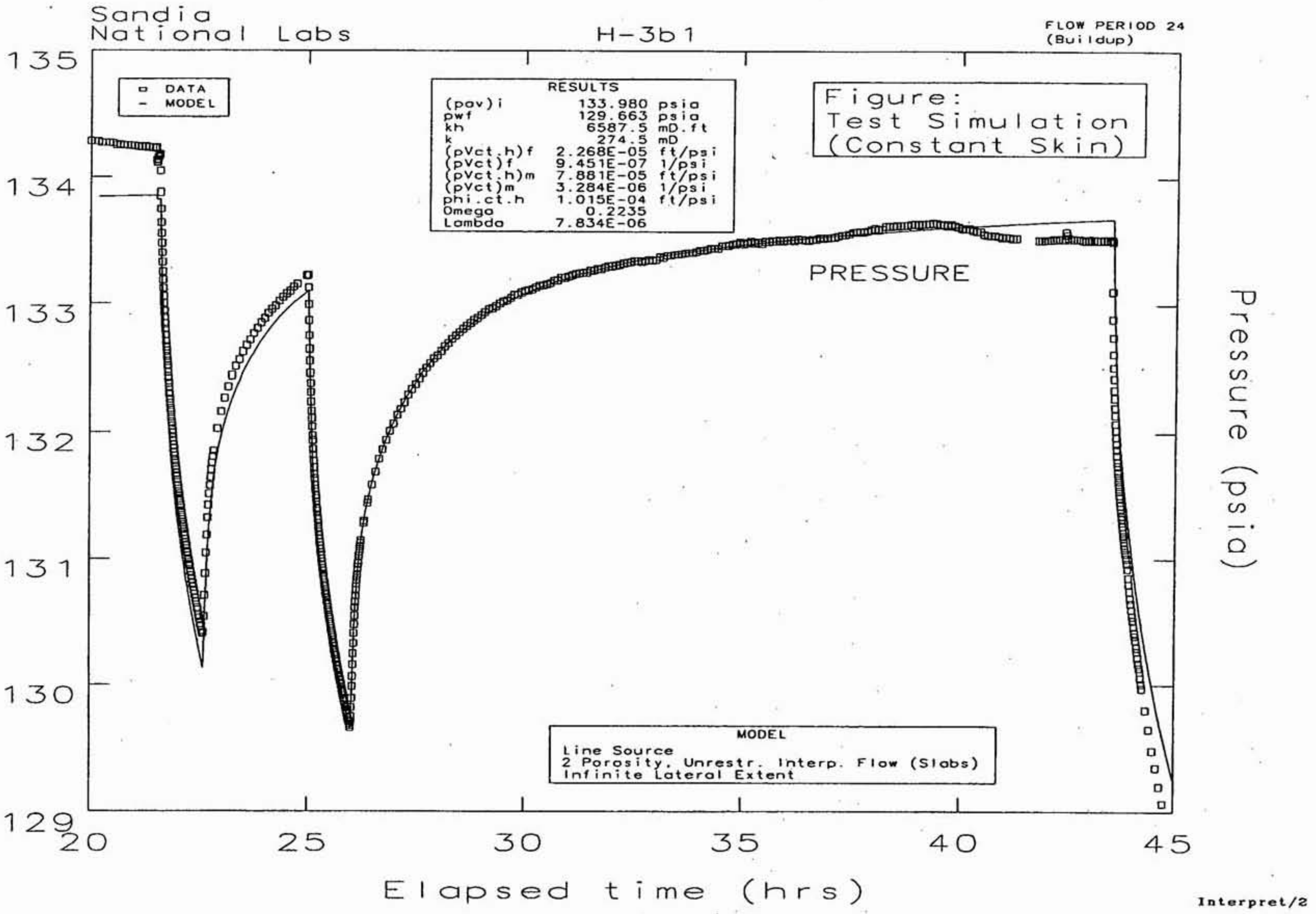
Information Only



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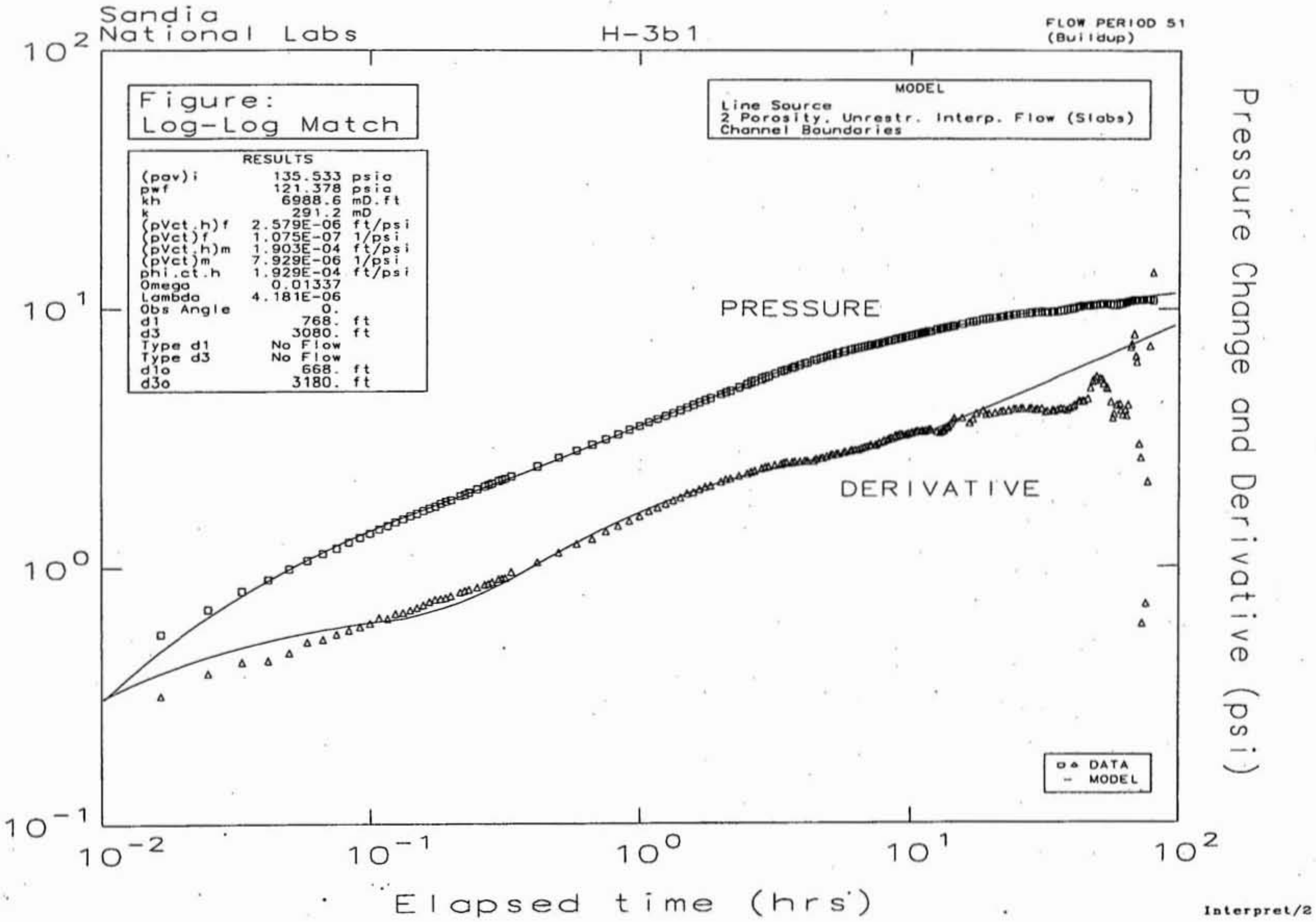
Information Only



RESULTS

(pav)i	135.533	psia
pwf	121.378	psia
kh	6988.6	mD.ft
k	291.2	mD
(pVct.h)f	2.579E-06	ft/psi
(pVct)f	1.075E-07	1/psi
(pVct.h)m	1.903E-04	ft/psi
(pVct)m	7.929E-06	1/psi
phi.ct.h	1.929E-04	ft/psi
Omega	0.01337	
Lambda	4.181E-06	
Obs Angle	0.	
d1	768.	ft
d3	3080.	ft
Type d1	No Flow	
Type d3	No Flow	
d1o	668.	ft
d3o	3180.	ft

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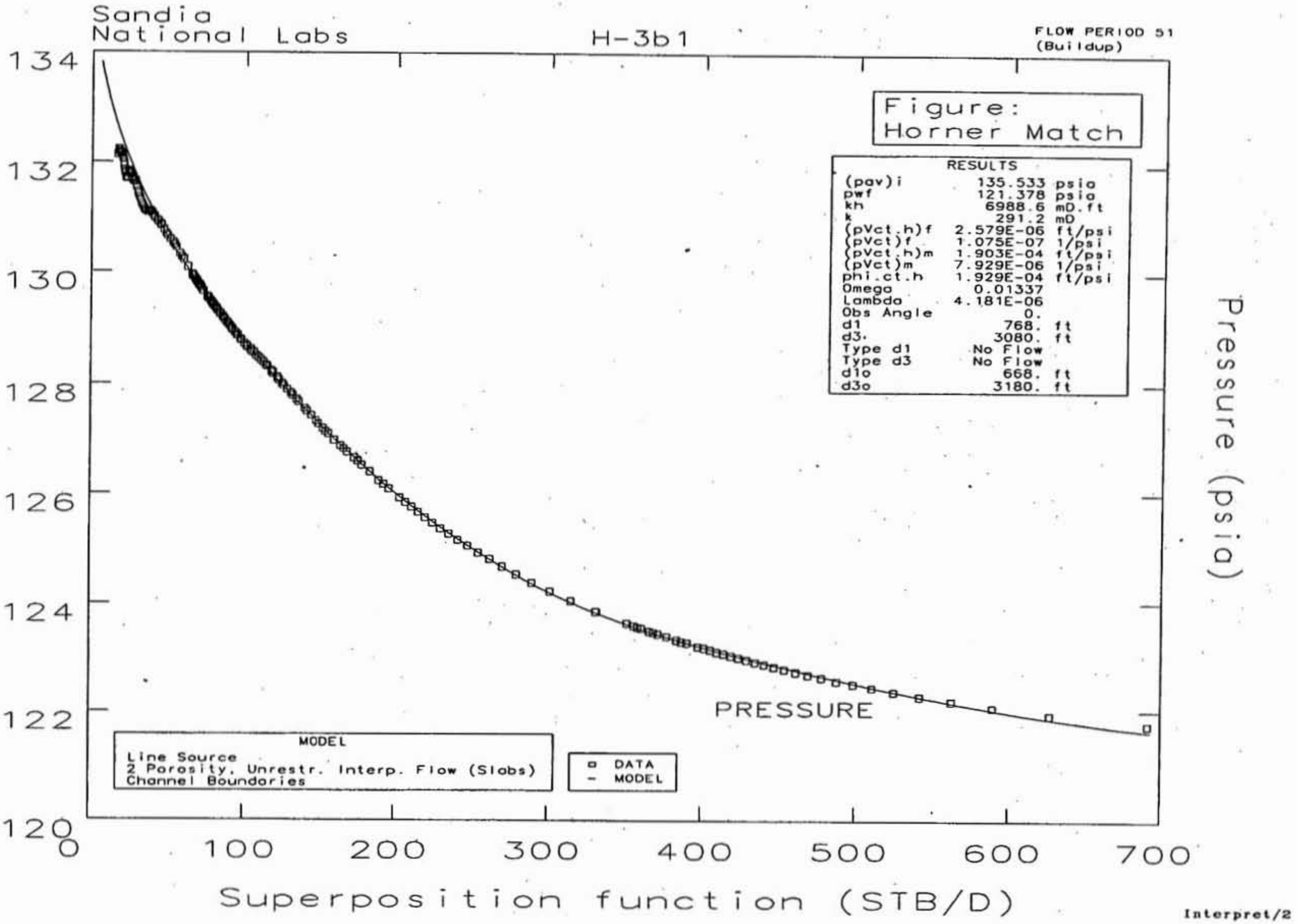
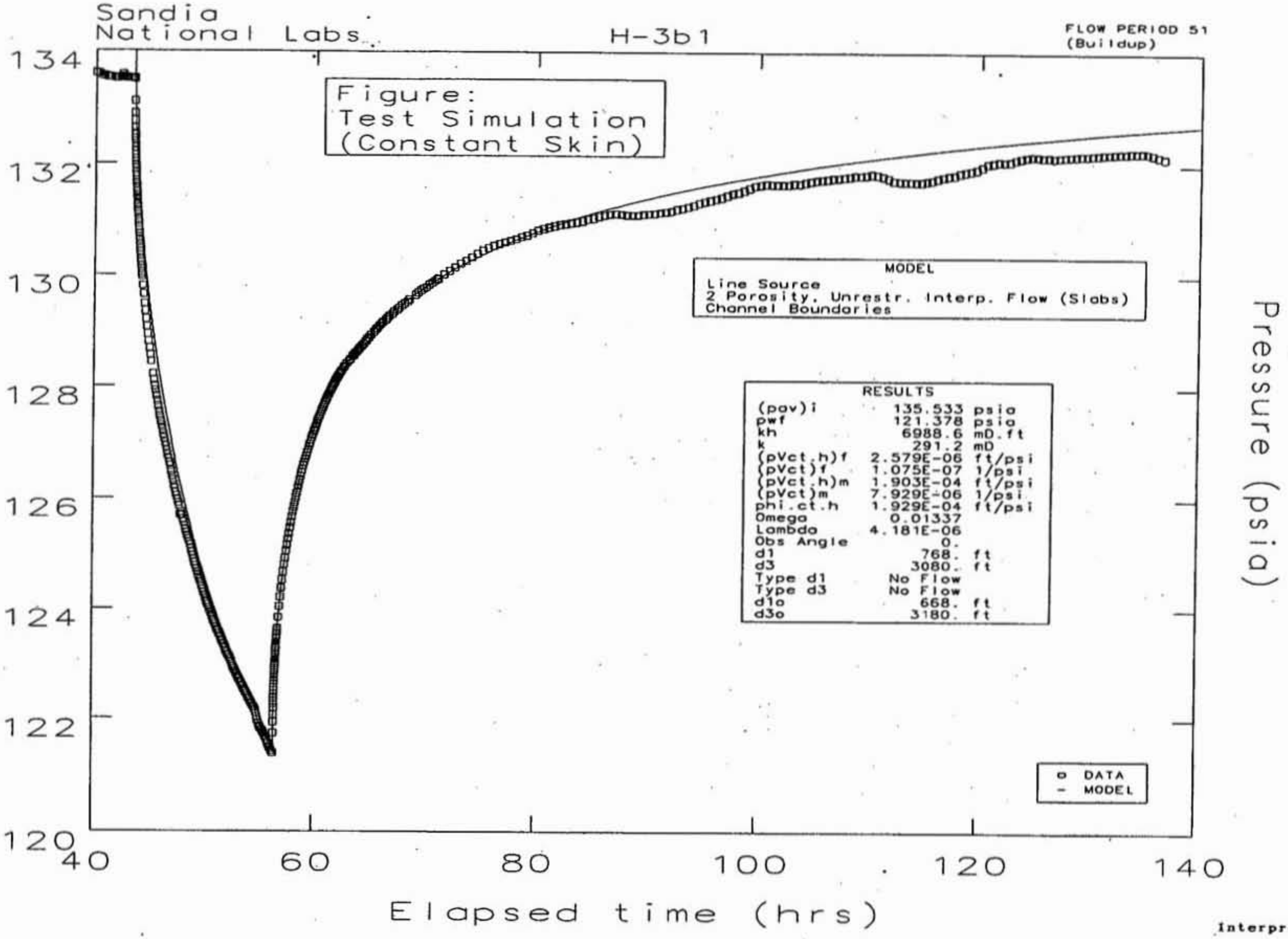
Information Only



18

Information Only



RESULTS

(pav)i	135.533	psia
pwf	121.378	psia
kh	6988.6	mD.ft
k	291.2	mD
(pVct.h)f	2.579E-06	ft/psi
(pVct)f	1.075E-07	1/psi
(pVct.h)m	1.903E-04	ft/psi
(pVct)m	7.929E-06	1/psi
phi.ct.h	1.929E-04	ft/psi
Omega	0.01337	
Lambda	4.181E-06	
Obs Angle	0.	
d1	768.	ft
d3	3080.	ft
Type d1	No Flow	
Type d3	No Flow	
d1o	668.	ft
d3o	3180.	ft

Interpret/2

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Information Only

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```
+-----------------------------------------------------------------------------+
| Baker Atlas GEOScience                                            WorkBench |
+-----------------------------------------------------------------------------+
|                                                                             |
|                        WELL TEST ANALYSIS REPORT                            |
|                                                                             |
+-----------------------------------------------------------------------------+

  Company:     Sandia National Labs
  Field:       WIPP                            Date:        04-Mar-02
  Formation:   Rustler                         Test No:     1-4
  Zone:        Culebra                         Test Date:   April 17-23, 1984
  Well:        H-3b2                           Gauge:       Gauge 1


                             ANALYSIS SUMMARY

     First three tests conducted with no packer in pumping well (H-3b3).
     Last test conducted with packer inflated in pumping well.
     FP2 = buildup from test 1; FP12 = buildup from test 2;
     FP24 = buildup from test 3; FP51 = buildup from test 4.


+-----------------------------------------------------------------------------+
| Baker Atlas GEOScience                                            WorkBench |
+-----------------------------------------------------------------------------+
|                                                                             |
|                             Results Summary                                |
|                                                                             |
+-----------------------------------------------------------------------------+


     Near wellbore effects:   Line Source
     Reservoir behaviour:     2 Porosity, Unrestr. Interp. Flow (Slabs)
     Boundary effects:        Infinite Lateral Extent


   Flow Period:           2            12            24        Units

   (pav)i             133.834       133.676       133.484      psia
   pwf                129.756       129.712       129.010      psia
   kh                  6761.2        6044.2        6789.6      mD.ft
   k                    281.7         251.8         282.9      mD
   (pVct.h)f        4.738E-05     3.129E-05     4.054E-05      ft/psi
   (pVct)f          1.974E-06     1.304E-06     1.689E-06      1/psi
   (pVct.h)m        8.278E-05     1.037E-04     7.632E-05      ft/psi
   (pVct)m          3.449E-06     4.319E-06     3.180E-06      1/psi
   phi.ct.h         1.302E-04     1.350E-04     1.169E-04      ft/psi
   Omega               0.3640        0.2319        0.3469
   Lambda           5.154E-06     6.807E-06     4.871E-06
```

Information Only

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+-----------------------------------------------------------------------------+
| Baker Atlas GEOScience                                            WorkBench |
+-----------------------------------------------------------------------------+
|                                                                             |
|                              Results Summary                                |
|                                                                             |
+-----------------------------------------------------------------------------+


   Near wellbore effects:    Line Source
   Reservoir behaviour:      2 Porosity, Unrestr. Interp. Flow (Slabs)
   Boundary effects:         Channel Boundaries


  Flow Period:       51      Units

 (pav)i           134.950    psia
 pwf              120.908    psia
 kh                6861.6    mD.ft
 k                  285.9    mD
 (pVct.h)f      1.872E-05    ft/psi
 (pVct)f        7.800E-07    1/psi
 (pVct.h)m      8.682E-05    ft/psi
 (pVct)m        3.617E-06    1/psi
 phi.ct.h       1.055E-04    ft/psi
 Omega             0.1774
 Lambda         6.309E-06
 Obs Angle             0.
 d1                 1115.    ft
 d3                  416.    ft
 Type d1          No Flow
 Type d3          No Flow
 d1o                1028.    ft
 d3o                 503.    ft
```

Information Only

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+------------------------------------------------------------------------------+
|  Baker Atlas GEOScience                                            WorkBench |
+------------------------------------------------------------------------------+
|                                                                              |
|                           Well & Reservoir Parameters                        |
|                                                                              |
+------------------------------------------------------------------------------+


                         WELL AND RESERVOIR DATA  (Water)

   Multiphase flow at wellbore:   NO
   Multiphase in reservoir    :   NO

   Matrix Porosity                                      0.160       fraction
   Reservoir Thickness                                  24.00       ft
   Wellbore Radius                                      0.198       ft
   Distance To Producing Well (*)                       87.93       ft

   Water Formation Volume Factor                        1.000       RB/STB
   Water Viscosity                                    1.00          cp
   Total Compressibility                            1.000E-05       1/psi

   (*) = For Interference Tests Only
```

Information Only

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+-----------------------------------------------------------------------------+
| Baker Atlas GEOScience                                           WorkBench |
+-----------------------------------------------------------------------------+
|                                                                             |
|                    Analysis Parameters and Results                          |
|                                                                             |
+-----------------------------------------------------------------------------+


                  ANALYSIS MODEL, FLOW PERIOD:    2

   Near wellbore effects:   Line Source
   Reservoir behaviour:     2 Porosity, Unrestr. Interp. Flow (Slabs)
   Boundary effects:        Infinite Lateral Extent


                ANALYSIS PARAMETERS, FLOW PERIOD:    2

   Pressure match, PM                                        0.196    1/psi
   Time match, TM                                             4.87    1/hr
   Storativity ratio, Omega                                  0.364
   Transition curve match, B.rD2                             0.932


                 ANALYSIS RESULTS, FLOW PERIOD:    2

   Initial average reservoir pressure, (pav)i              133.834    psia
   Flowing pressure, pwf                                   129.756    psia
   Permeability Thickness, kh                            6.761E+03    mD.ft
   Permeability, k                                            282.    mD
   High K medium storativity, (pVct.h)f                  4.738E-05    ft/psi
   High K medium specific storativity, (pVct)f           1.974E-06    1/psi
   Low K medium storativity, (pVct.h)m                   8.278E-05    ft/psi
   Low K medium specific storativity, (pVct)m            3.449E-06    1/psi
   Total storativity, phi.ct.h                           1.302E-04    ft/psi
   Storativity ratio, Omega                                  0.364
   Interporosity flow coefficient, Lambda                5.154E-06
```

Information Only

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```
+------------------------------------------------------------------------------+
| Baker Atlas GEOScience                                             WorkBench |
+------------------------------------------------------------------------------+
|                                                                              |
|                      Analysis Parameters and Results                         |
|                                                                              |
+------------------------------------------------------------------------------+


                   ANALYSIS MODEL, FLOW PERIOD:   12

   Near wellbore effects:   Line Source
   Reservoir behaviour:     2 Porosity, Unrestr. Interp. Flow (Slabs)
   Boundary effects:        Infinite Lateral Extent


                 ANALYSIS PARAMETERS, FLOW PERIOD:   12

   Pressure match, PM                                        0.194   1/psi
   Time match, TM                                             6.59   1/hr
   Storativity ratio, Omega                                  0.232
   Transition curve match, B.rD2                              1.93


                  ANALYSIS RESULTS, FLOW PERIOD:   12

   Initial average reservoir pressure, (pav)i              133.676   psia
   Flowing pressure, pwf                                   129.712   psia
   Permeability Thickness, kh                            6.044E+03   mD.ft
   Permeability, k                                            252.   mD
   High K medium storativity, (pVct.h)f                  3.129E-05   ft/psi
   High K medium specific storativity, (pVct)f           1.304E-06   1/psi
   Low K medium storativity, (pVct.h)m                   1.037E-04   ft/psi
   Low K medium specific storativity, (pVct)m            4.319E-06   1/psi
   Total storativity, phi.ct.h                           1.350E-04   ft/psi
   Storativity ratio, Omega                                  0.232
   Interporosity flow coefficient, Lambda                6.807E-06
```

Information Only

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+------------------------------------------------------------------------------+
| Baker Atlas GEOScience                                             WorkBench |
+------------------------------------------------------------------------------+
|                                                                              |
|                      Analysis Parameters and Results                         |
|                                                                              |
+------------------------------------------------------------------------------+


                  ANALYSIS MODEL, FLOW PERIOD:   24

    Near wellbore effects:   Line Source
    Reservoir behaviour:     2 Porosity, Unrestr. Interp. Flow (Slabs)
    Boundary effects:        Infinite Lateral Extent


                ANALYSIS PARAMETERS, FLOW PERIOD:   24

    Pressure match, PM                                        0.228   1/psi
    Time match, TM                                             5.71   1/hr
    Storativity ratio, Omega                                  0.347
    Transition curve match, B.rD2                             0.924


                 ANALYSIS RESULTS, FLOW PERIOD:   24

    Initial average reservoir pressure, (pav)i              133.484   psia
    Flowing pressure, pwf                                   129.010   psia
    Permeability Thickness, kh                            6.790E+03   mD.ft
    Permeability, k                                            283.   mD
    High K medium storativity, (pVct.h)f                  4.054E-05   ft/psi
    High K medium specific storativity, (pVct)f           1.689E-06   1/psi
    Low K medium storativity, (pVct.h)m                   7.632E-05   ft/psi
    Low K medium specific storativity, (pVct)m            3.180E-06   1/psi
    Total storativity, phi.ct.h                           1.169E-04   ft/psi
    Storativity ratio, Omega                                  0.347
    Interporosity flow coefficient, Lambda                4.871E-06
```

Information Only

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+------------------------------------------------------------------------------+
| Baker Atlas GEOScience                                              WorkBench |
+------------------------------------------------------------------------------+
|                                                                              |
|                        Analysis Parameters and Results                       |
|                                                                              |
+------------------------------------------------------------------------------+


                    ANALYSIS MODEL, FLOW PERIOD:   51

    Near wellbore effects:   Line Source
    Reservoir behaviour:     2 Porosity, Unrestr. Interp. Flow (Slabs)
    Boundary effects:        Channel Boundaries


                  ANALYSIS PARAMETERS, FLOW PERIOD:   51

    Pressure match, PM                                         0.228   1/psi
    Time match, TM                                              12.5   1/hr
    Storativity ratio, Omega                                   0.177
    Transition curve match, B.rD2                               2.34
    Obs Angle                                                     0.
    Dimensionless distance: first boundary, (d1)D               644.
    Dimensionless distance: third boundary, (d3)D                89.


                    ANALYSIS RESULTS, FLOW PERIOD:   51

    Initial average reservoir pressure, (pav)i               134.950   psia
    Flowing pressure, pwf                                    120.908   psia
    Permeability Thickness, kh                             6.862E+03   mD.ft
    Permeability, k                                             286.   mD
    High K medium storativity, (pVct.h)f                   1.872E-05   ft/psi
    High K medium specific storativity, (pVct)f            7.800E-07   1/psi
    Low K medium storativity, (pVct.h)m                    8.682E-05   ft/psi
    Low K medium specific storativity, (pVct)m             3.617E-06   1/psi
    Total storativity, phi.ct.h                            1.055E-04   ft/psi
    Storativity ratio, Omega                                   0.177
    Interporosity flow coefficient, Lambda                 6.309E-06
    Obs Angle                                                     0.
    Distance to first boundary, d1                             1115.   ft
    Distance to third boundary, d3                              416.   ft
    Type of first boundary, Type d1                      No Flow
    Type of third boundary, Type d3                      No Flow
    Distance of obs. well to first boundary, d1o               1028.   ft
    Distance of obs. well to third boundary, d3o                503.   ft
```
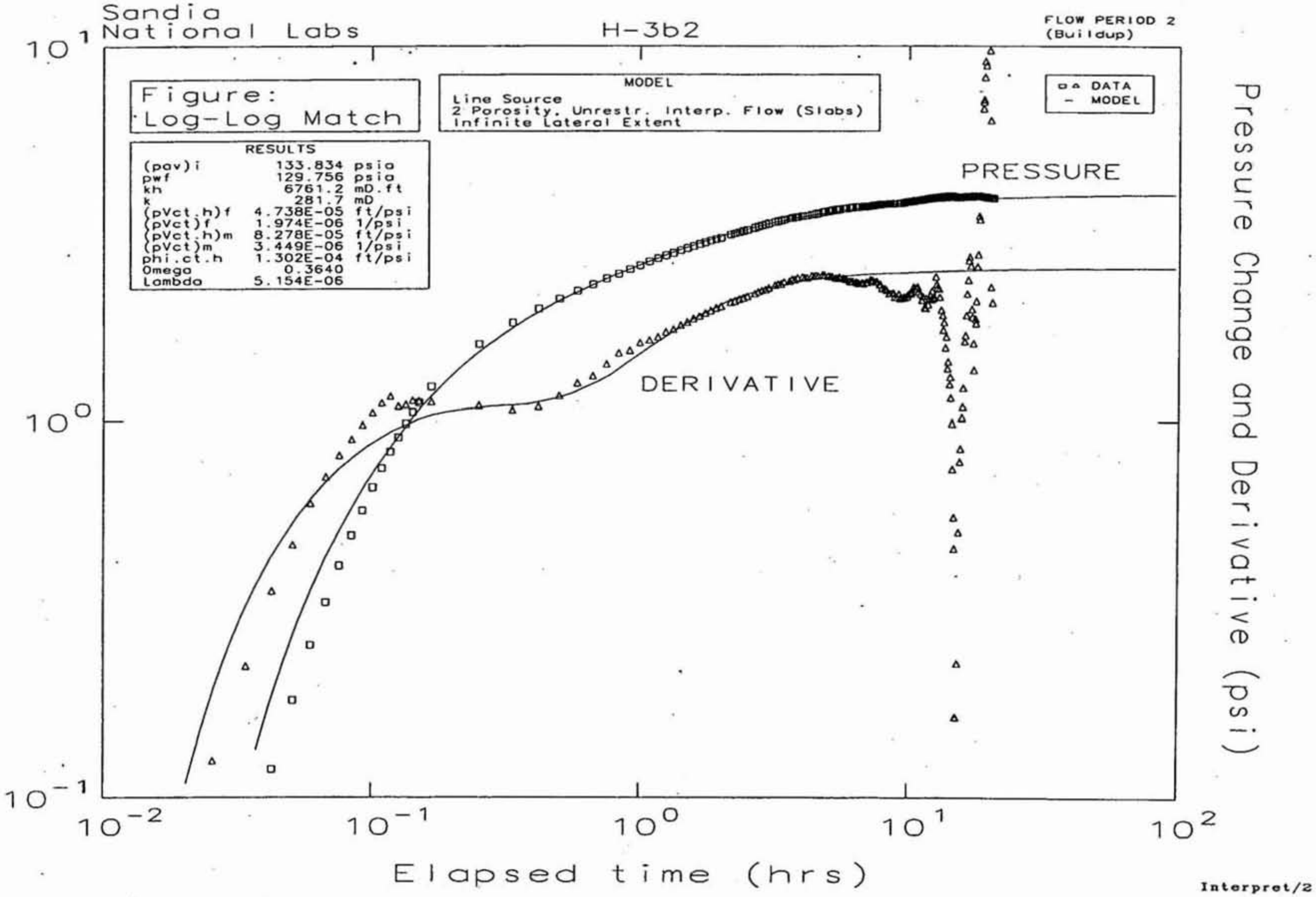

Information Only

7



Information Only

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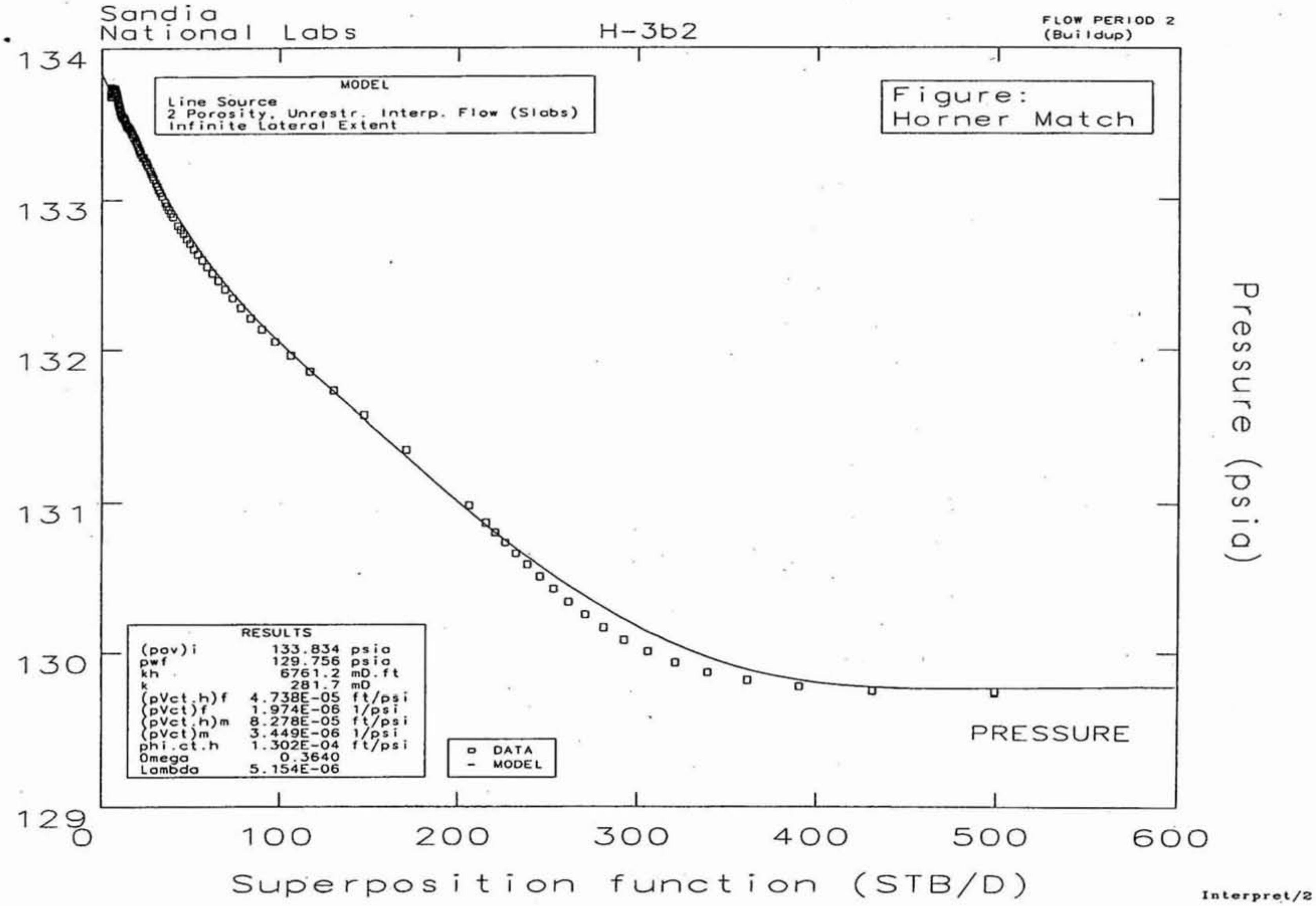
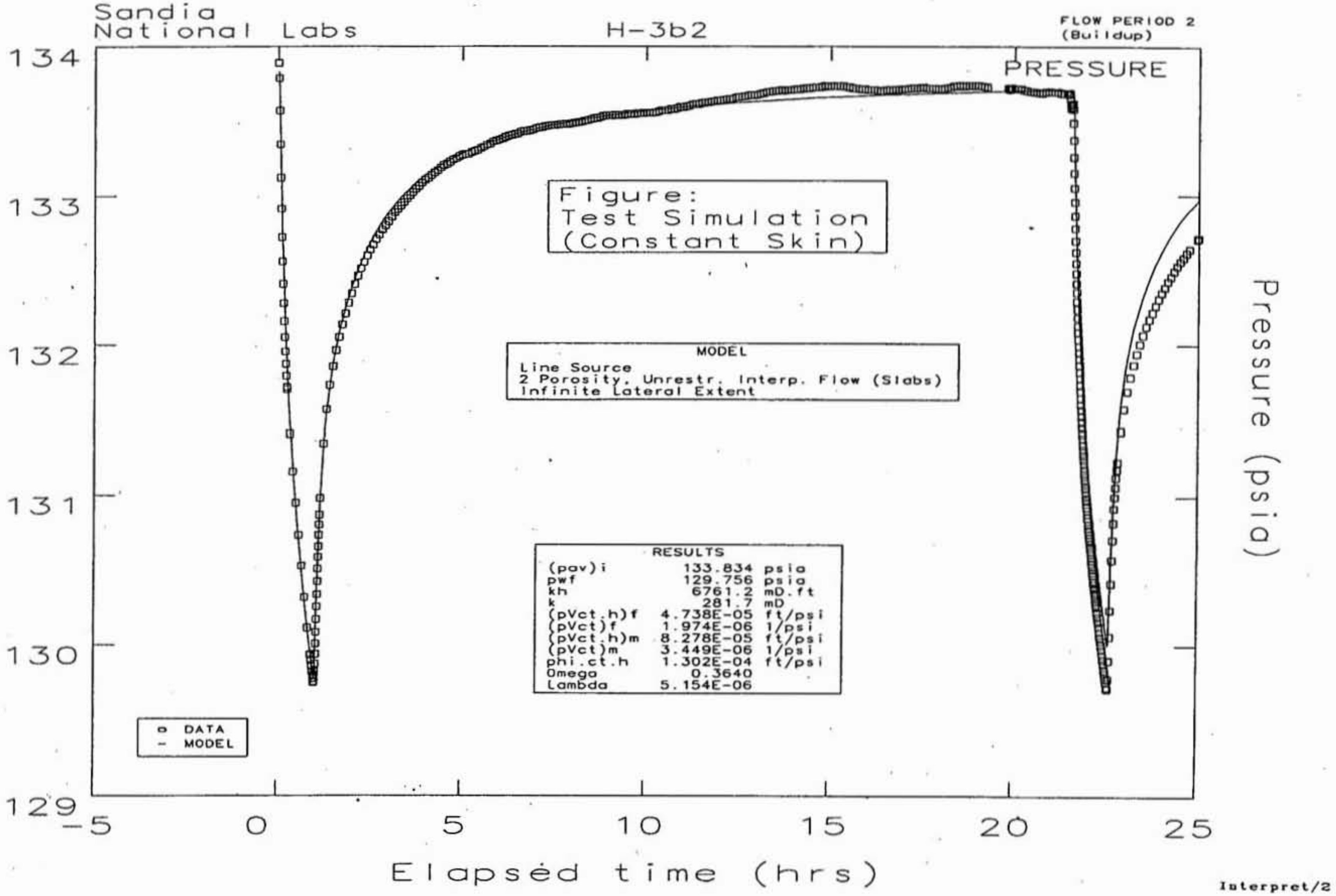


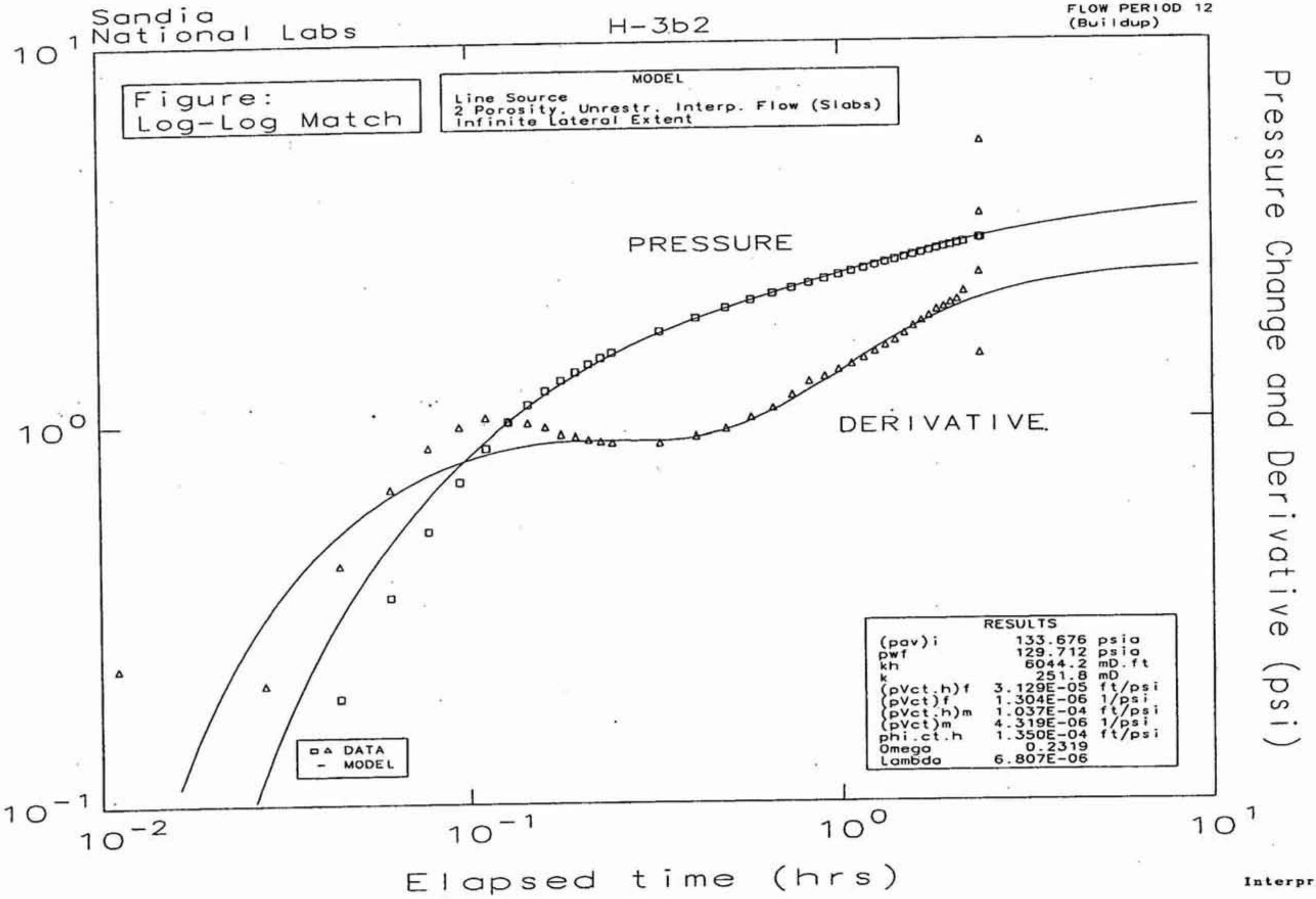
Information Only

9



10

Information Only

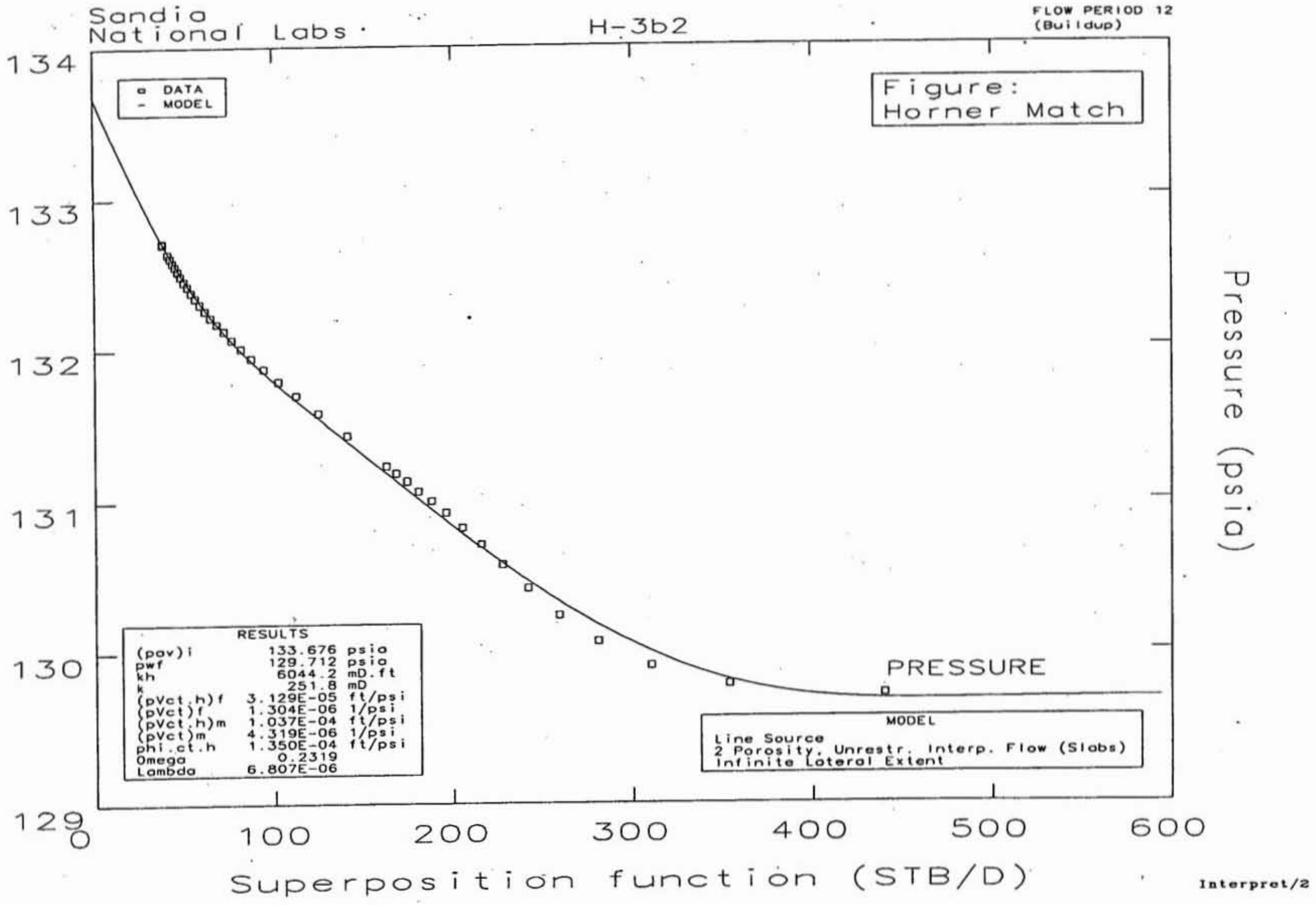


(pav)i	133.676	psia
pwf	129.712	psia
kh	6044.2	mD.ft
k	251.8	mD
(pVct.h)f	3.129E-05	ft/psi
(pVct)f	1.304E-06	1/psi
(pVct.h)m	1.037E-04	ft/psi
(pVct)m	4.319E-06	1/psi
phi.ct.h	1.350E-04	ft/psi
Omega	0.2319	
Lambda	6.807E-06	

Interpret/2

11

Information Only



RESULTS

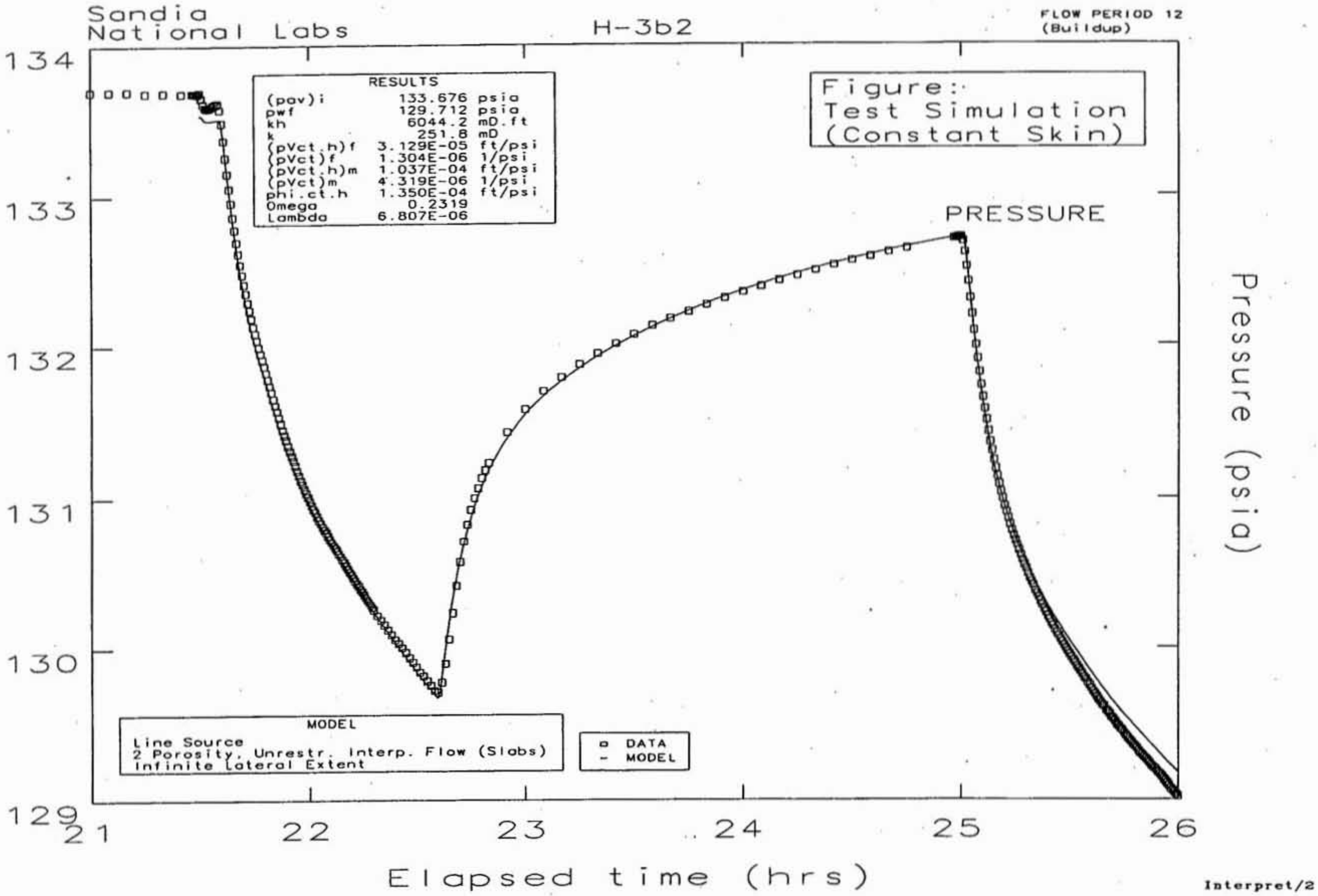
(pav)i	133.676	psia
pwf	129.712	psia
kh	6044.2	mD.ft
k	251.8	mD
(pVct.h)f	3.129E-05	ft/psi
(pVct)f	1.304E-06	1/psi
(pVct.h)m	1.037E-04	ft/psi
(pVct)m	4.319E-06	1/psi
phi.ct.h	1.350E-04	ft/psi
Omega	0.2319	
Lambda	6.807E-06	

MODEL

Line Source
2 Porosity, Unrestr. Interp. Flow (Slabs)
Infinite Lateral Extent

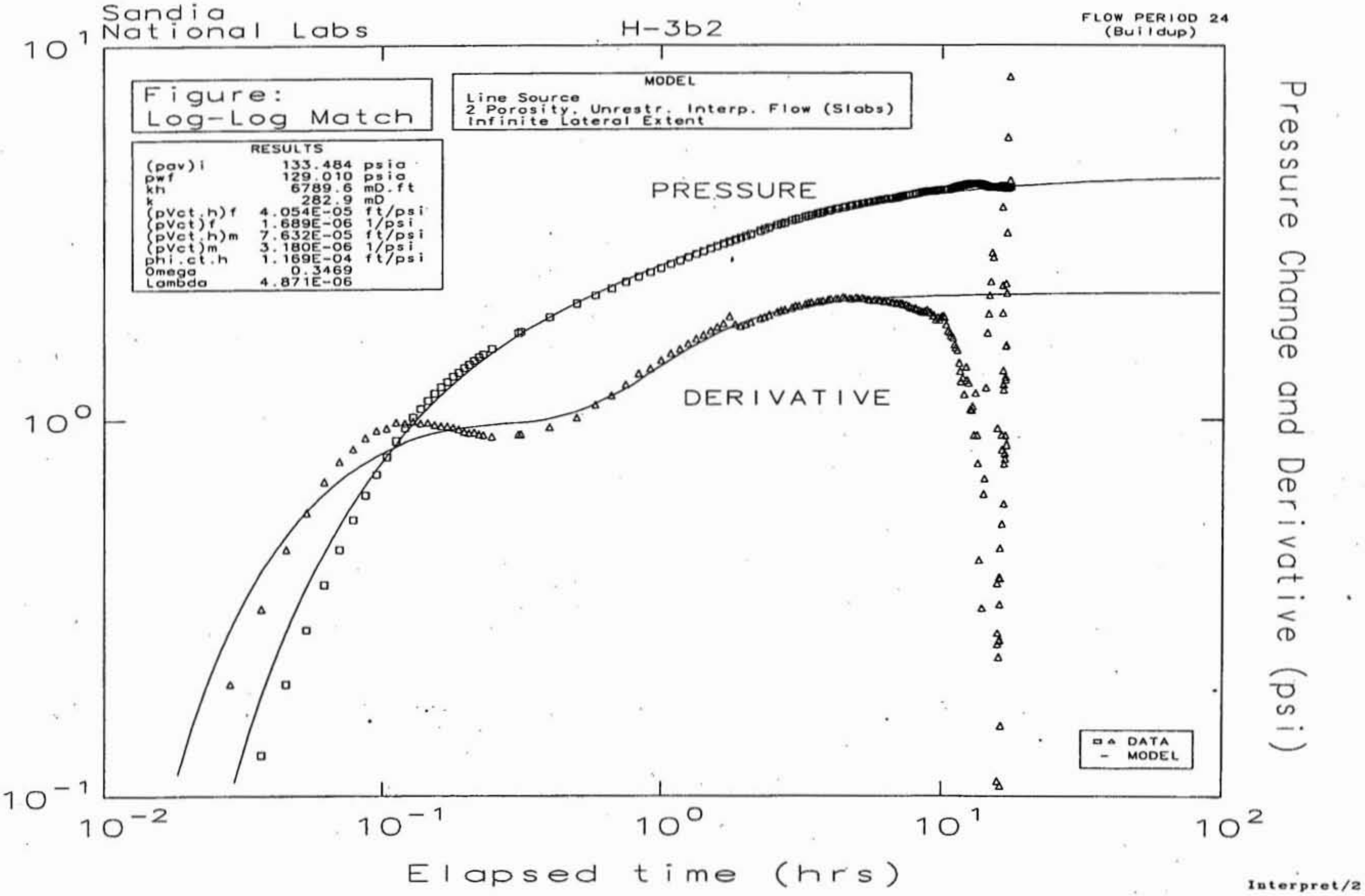
Information Only

12



Information Only

13



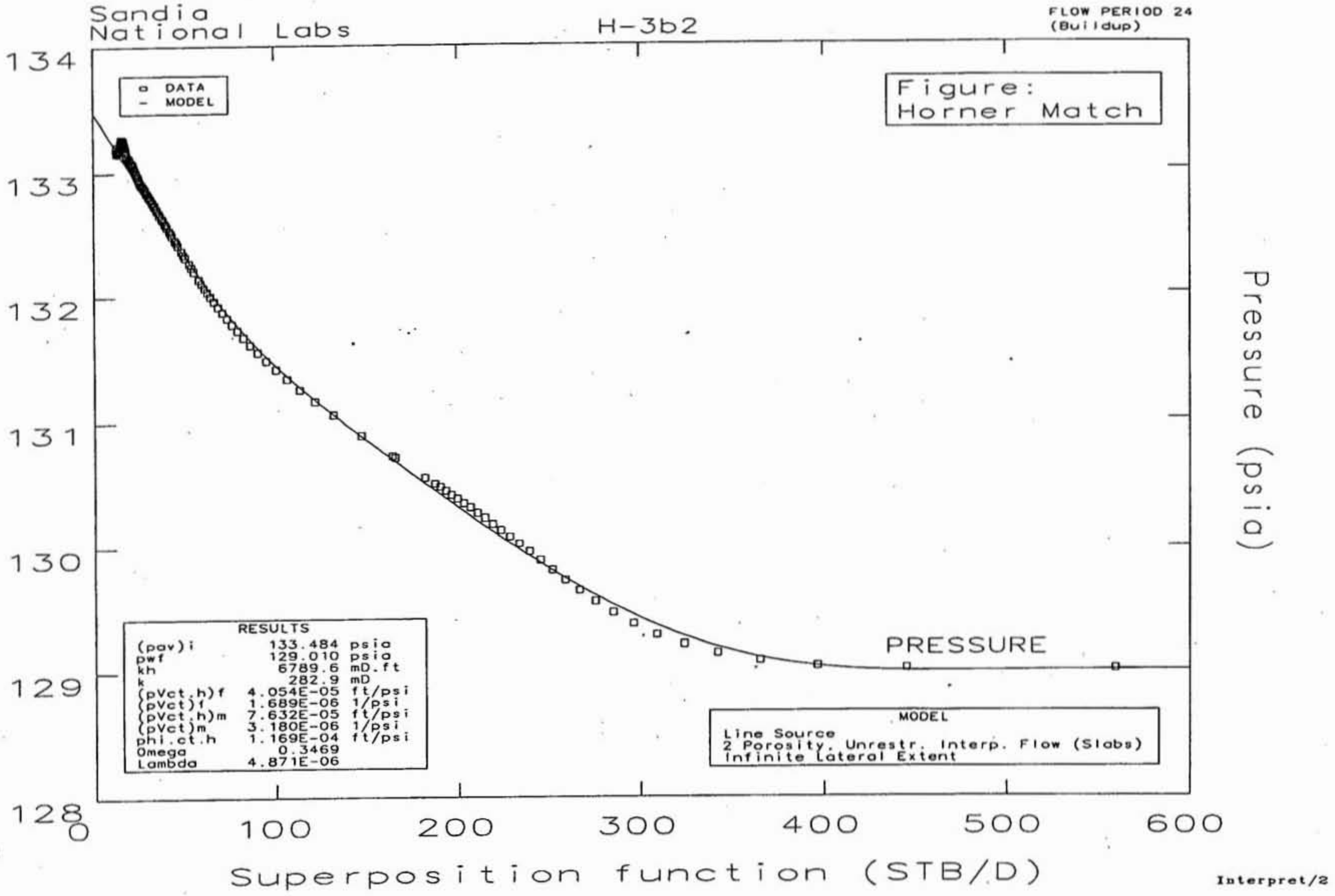
MODEL

Line Source
2 Porosity, Unrestr. Interp. Flow (Slabs)
Infinite Lateral Extent

RESULTS

(pav)i	133.484	psia
pwf	129.010	psia
kh	6789.6	mD.ft
k	282.9	mD
(pVct.h)f	4.054E-05	ft/psi
(pVct)f	1.689E-06	1/psi
(pVct.h)m	7.632E-05	ft/psi
(pVct)m	3.180E-06	1/psi
phi.ct.h	1.169E-04	ft/psi
Omega	0.3469	
Lambda	4.871E-06	

Information Only



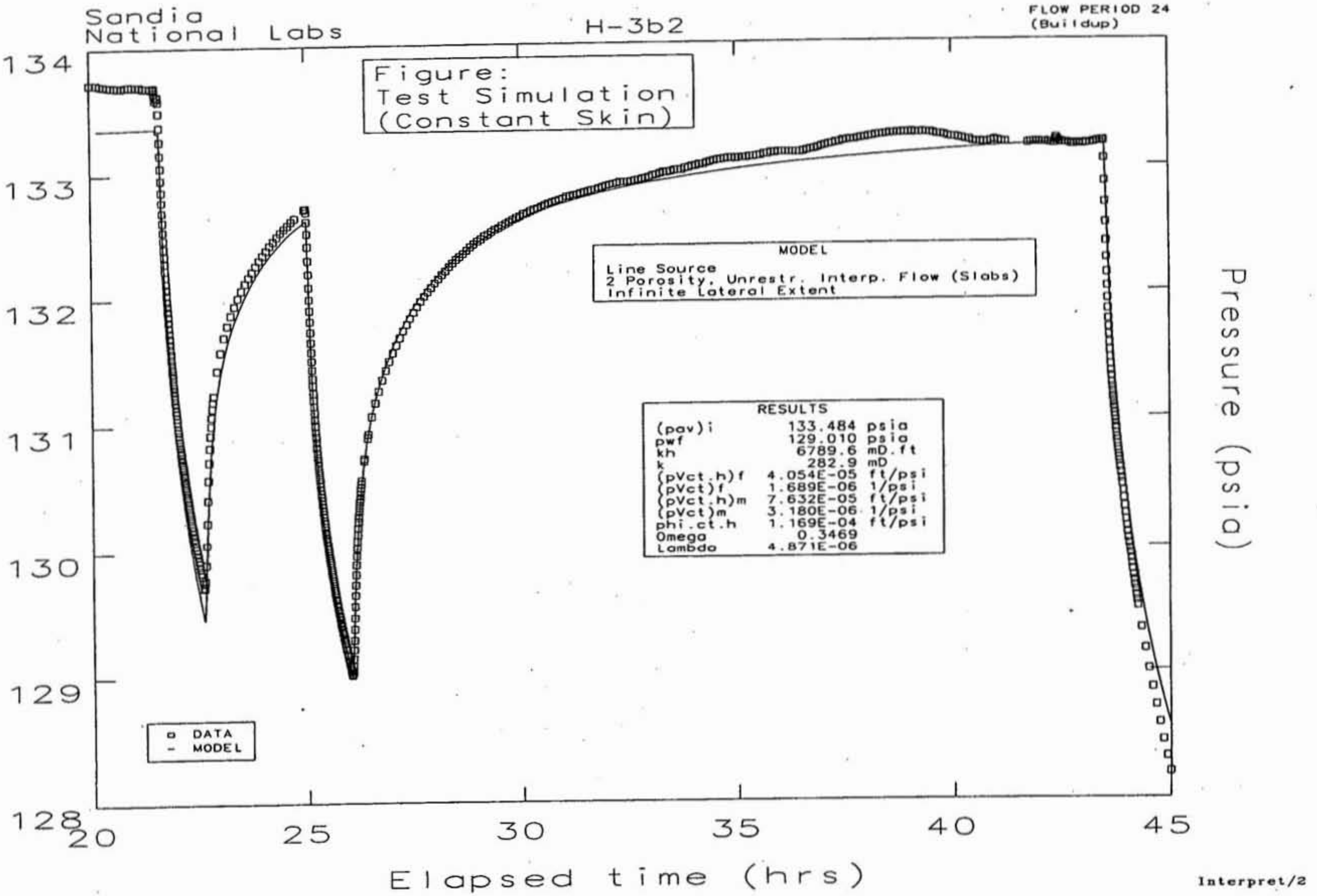
RESULTS

(pav)i	133.484	psia
pwf	129.010	psia
kh	6789.6	mD.ft
k	282.9	mD
(pVct.h)f	4.054E-05	ft/psi
(pVct)f	1.689E-06	1/psi
(pVct.h)m	7.632E-05	ft/psi
(pVct)m	3.180E-06	1/psi
phi.ct.h	1.169E-04	ft/psi
Omega	0.3469	
Lambda	4.871E-06	

MODEL

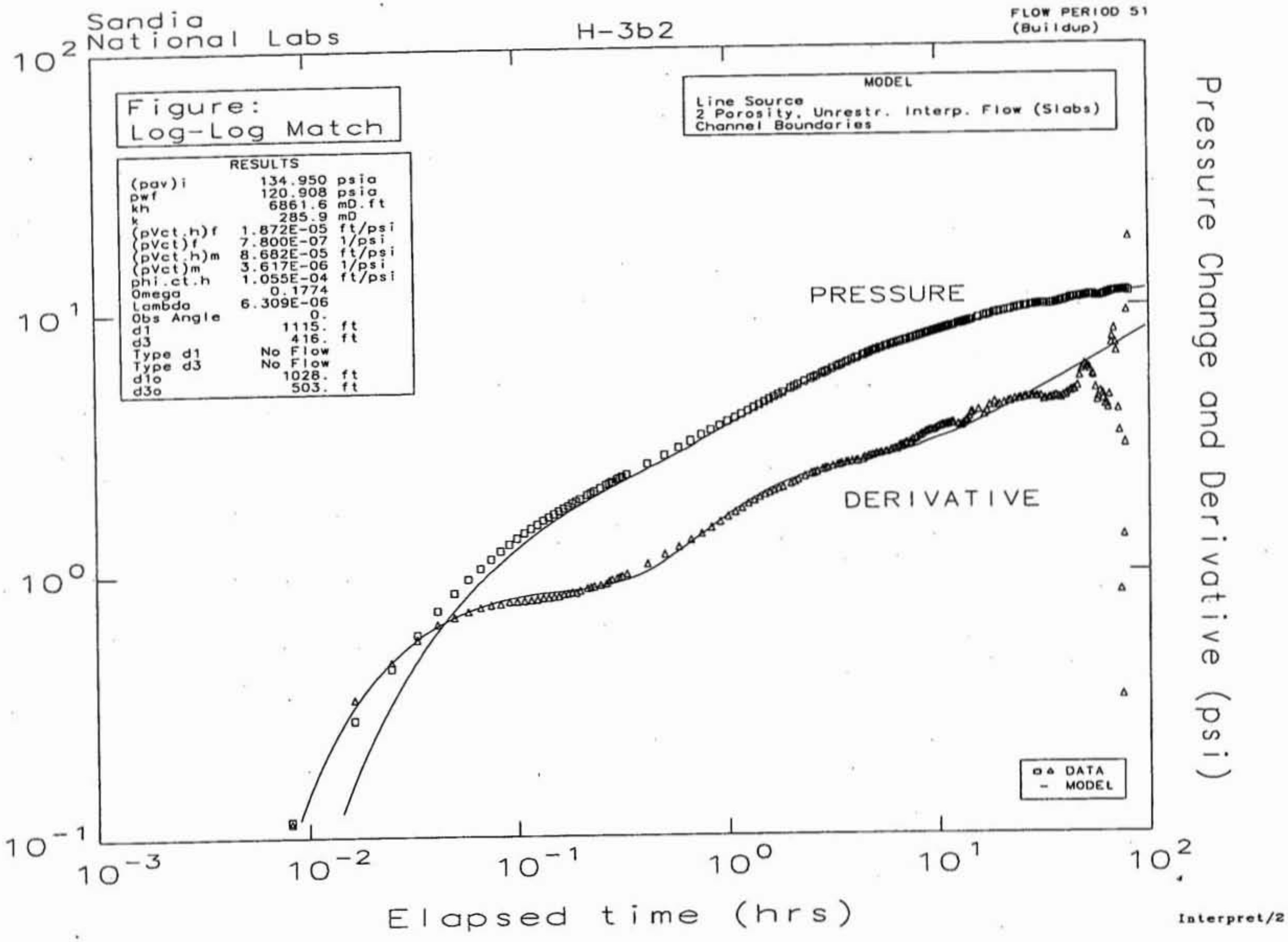
Line Source
2 Porosity, Unrestr. Interp. Flow (Slabs)
Infinite Lateral Extent

Information Only



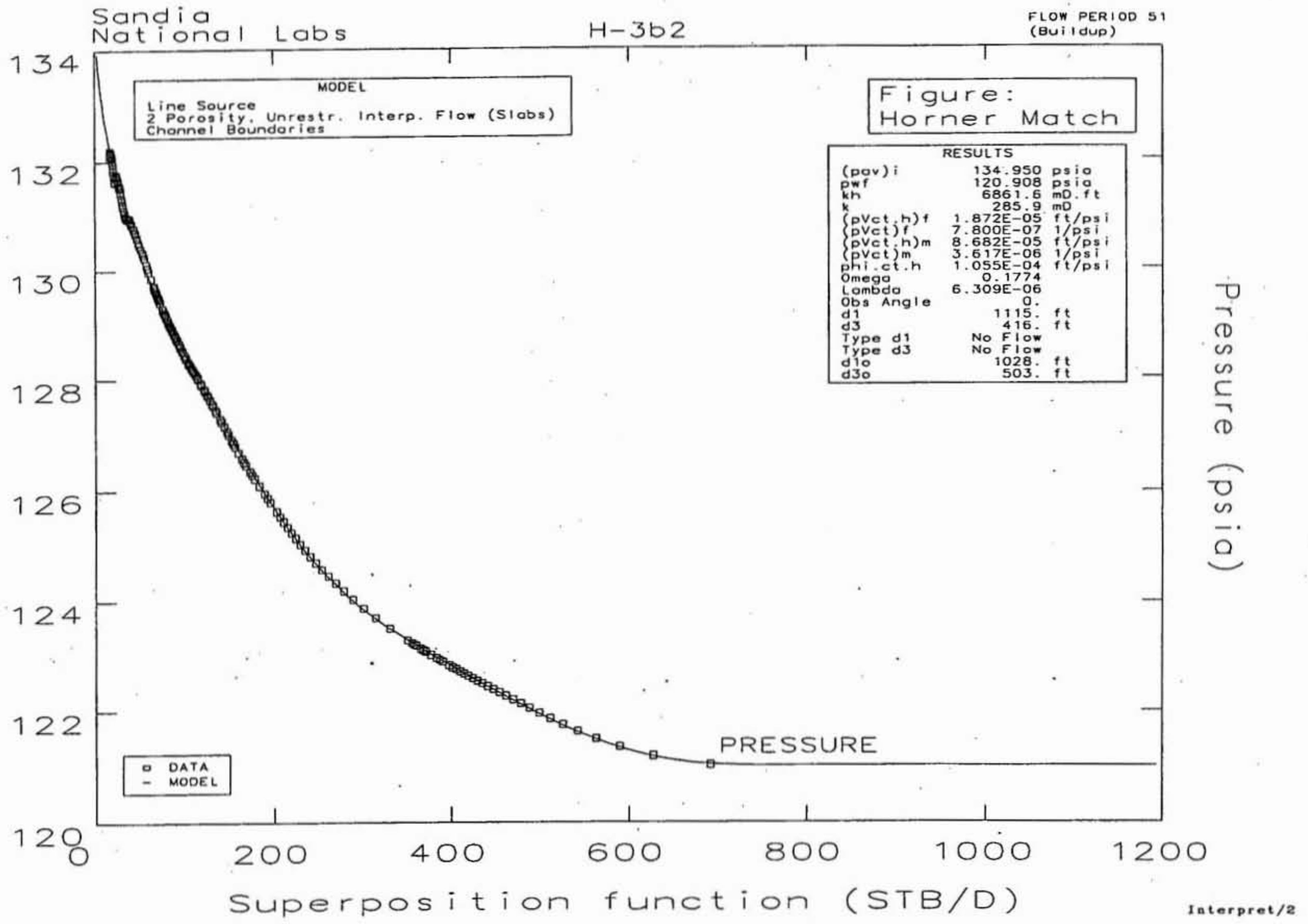
Information Only

16



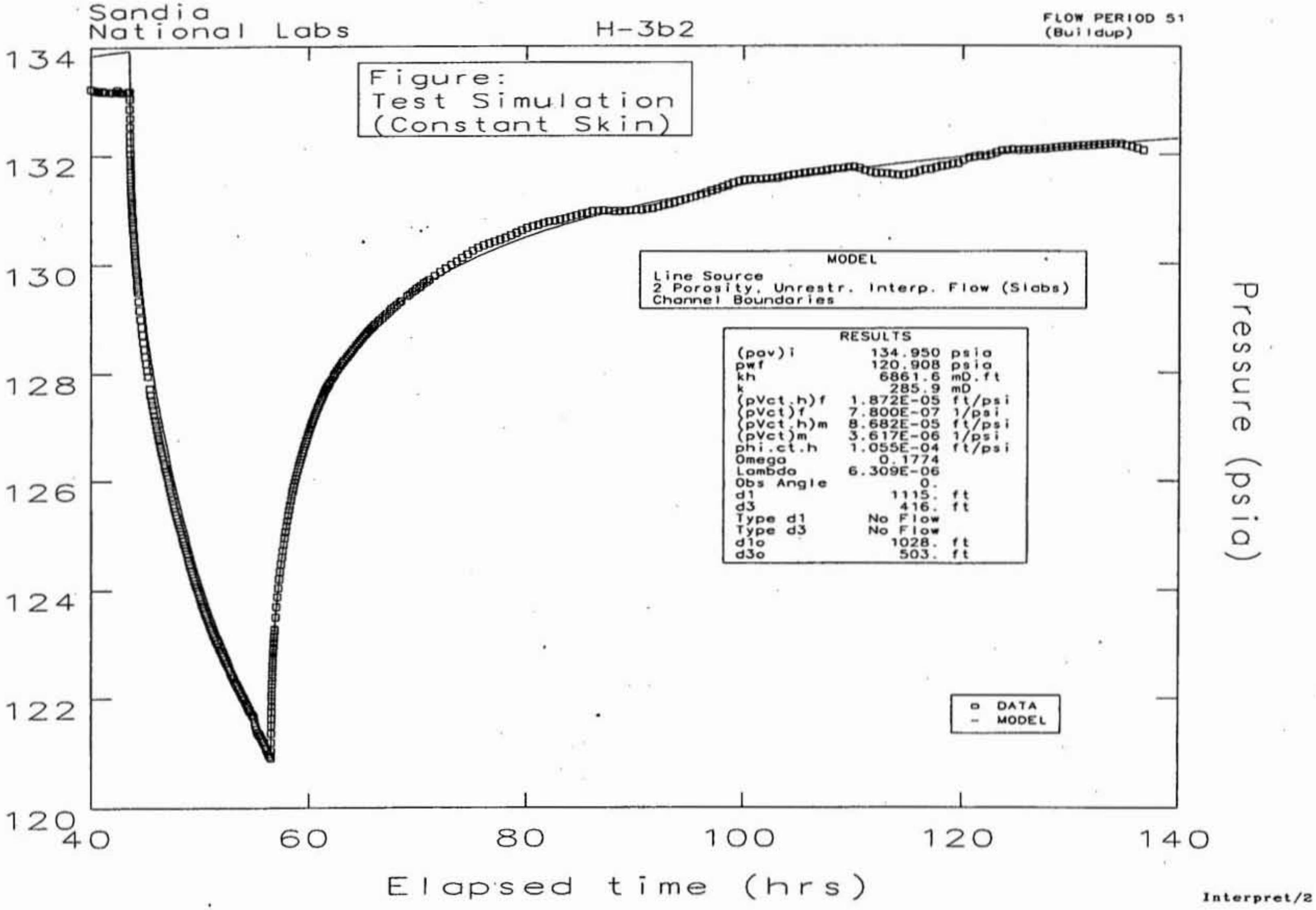
RESULTS		
(pav)i	134.950	psia
pwf	120.908	psia
kh	6861.6	mD.ft
k	285.9	mD
(pVct.h)f	1.872E-05	ft/psi
(pVct)f	7.800E-07	1/psi
(pVct.h)m	8.682E-05	ft/psi
(pVct)m	3.617E-06	1/psi
phi.ct.h	1.055E-04	ft/psi
Omega	0.1774	
Lambda	6.309E-06	
Obs Angle	0.	
d1	1115.	ft
d3	416.	ft
Type d1	No Flow	
Type d3	No Flow	
d1o	1028.	ft
d3o	503.	ft

Information Only



Information Only

18



MODEL

Line Source
2 Porosity, Unrestr. Interp. Flow (Slabs)
Channel Boundaries

RESULTS

(pav)i	134.950	psia
pwf	120.908	psia
kh	6861.6	mD.ft
k	285.9	mD
(pVct.h)f	1.872E-05	ft/psi
(pVct)f	7.800E-07	1/psi
(pVct.h)m	8.682E-05	ft/psi
(pVct)m	3.617E-06	1/psi
phi.ct.h	1.055E-04	ft/psi
Omega	0.1774	
Lambda	6.309E-06	
Obs Angle	0.	
d1	1115.	ft
d3	416.	ft
Type d1	No Flow	
Type d3	No Flow	
d1o	1028.	ft
d3o	503.	ft

Information Only

(9)

H3B3 16 April 84 MONDAY

tubing tally

	Length	total Length	
#1	24.7	24.70	to pump intake
#2	21.1	45.80	

1600 Real time Sent Fire Ball Home
Will Run tubing and Pump down Hole
Tommorrow.

Generator check list

Amps = 50
Hz = 60
Voltage = 210
Fuel P = 29
Oil P. = 38
temp = 175

Fuel = ½
Oil = 11

17 April 84 TUESday

Wayne
Fireball

0900 Run tubing Down H3B3

24 Joints at 21.1 feet = 506.40 feet
45.80

Depth to intake (pump intake) 552.20

Setup computer and transducers. Data to
be stored on HY313: F8,1

1530 Turn pump on Pump at ~ 8 gpm

Information Only

H-3 Log Book Volume IV

17 April 84 ~~Wednesday~~ Day 108 Wayne
Tuesday continued Bruns

1530 ~~Arrive~~ at H-3

Generator CheckList
Amps = 25
Hertz = 60
Voltage = 210
Fuel Pressure = 29
oil Pressure = 37
Temperature = 165 °F

Fuel Level = Full
oil Level = 11 gal

Hole #	Serial #	Sup ExcT	Gage ExcT	Sensitivity	Water Level	Scanner ~~Signal~~ ch#	Matrix ch#
H3B3	94911	10.3	10.0	1.00879	417.54	21,22	2,3
H3B1	95078	10.3	10.0	2.51793	416.26	23,24	4,5
H3B2	94910	10.3	10.0	1.00746	417.32	25,26	6,7
Barometer		280				31	1

Data Stored on HY318: F8,1

computer time 16:30 pump turned off. Totall gallons pumped = 427 gallons = ~7.12 gpm

1700 Left Site Scan interval = 5minutes

Information Only

H-3 log Book

18 April 84 Day 109 Wednesday Wayne Brais

0900 Arrive at H-3

Setup Discharge Line with Regulating Valve and Zurn Flow meter. We anticipate an average Flow rate of about 6 gpm for the duration of the Pump test. The pump test will Last for about 60 minutes. Recovery will last about 2 hours assuming a little longer period of time to Recharge System and to improve modify our field technique.

1040 Water level Measurements

H3B1 (Iron Horse) = ~~418.1~~ 127.01 meters ±.06
416.69 feet

H3B2 (Iron Horse) = 127.52 meters ±.06
418.38 feet

H3B3 (Trans Ducer) = 418.1 Feet

Measurement are Relative to The top of The tubing in H3B1 and to the top of The casing in H3B2, MB.

Hole #	Serial #	Sup Exct	Gauge Exct	Sensitivity	Water Level	Scanner Ch #.	Matrix Ch #
H3B3	94911	10.3	10.0	1.00879	418.1	21,22	2,3
H3B1	95078	10.3	10.0	2.51793	416.69	23,24	4,5
H3B2	94910	10.3	10.0	1.00746	418.38	25,26	6,7

Information Only

H-3 Log Book

18 April 84 Wednesday Wayne

Ervin

Data to be Stored on HY319: F8,0

11:19 Program H7319: F80 Started

Scan inteval Set to 60 seconds

11:25 Scan interval Set to 5 minutes

427 meter Reading Initial

1300 START Pump test - False Start
turn Pump off

1305 START Pump

1310 7 gallons / 63.25 seconds = 6.6 gpm meter

1312 7 gallons / 65.30 Seconds = 6.43 gpm (meter)

1315 meter reading 495 gallons

1317 7 gallons / 68.05 Seconds (meter) (6.17 gpm)
gas flow

Information Only

1322 7 gallons / 62.46 seconds 6.7 gpm meter

H-3

H-3 pump test continued

1322 25 liters / 60 seconds = 6.61 gpm

1326 7 gallons / 103.56 seconds = 6.60 gpm meter
63.56s

Time	Flow Rate	Flow Rate	Meter Reading
13:32	[illegible]/ 55.11	6.45 gpm	
13:34	7gal/ 64.93	6.46 gpm	
13:36	24.5 l / 60 seconds	Bucket 6.48 gpm	625.0 m
1340	7 gal / 65.25	Meter 6.4~~3~~4 gpm	
1342	24.5 l / 60 Sec	6.48 gpm	
1344	7 gal / 64.09	6.5~~3~~5 gpm	
1346	24.0 / 60 Sec	6.35 gpm	
13 48	7 gal / 65.13	6.4~~4~~5 gpm	
1354	24.5 l/ 60 Sec	6.48 gpm	
1355	7 gal / 105.97 65.97s	6.3~~6~~7 gpm	
1403	7 gal / 105.25 65.25s	6.4~~3~~4 gpm	
	24 l / 60 seconds	6.34 gpm	

Average Flow Rate for test
6.48 gpm

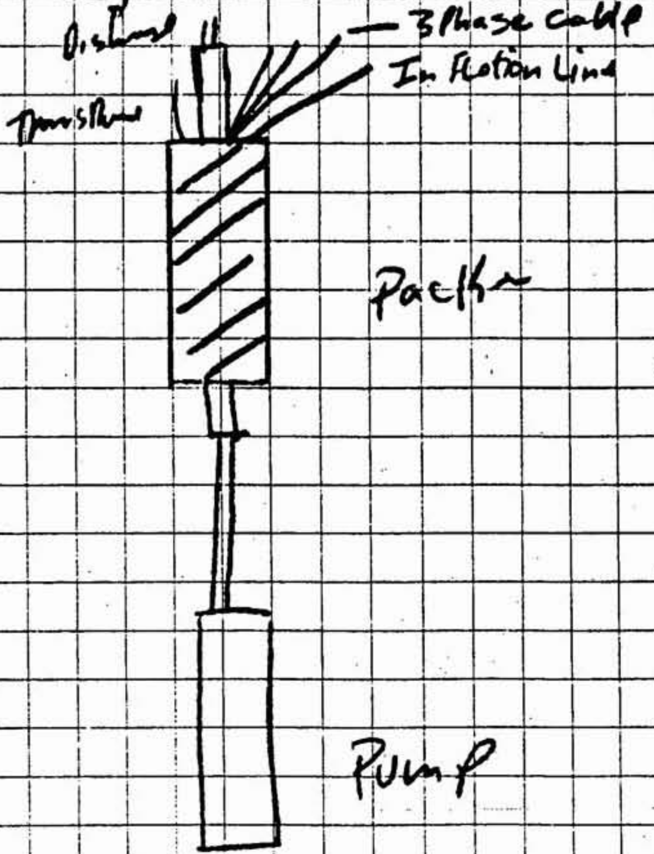
1405:20 Stop End Pumping

Final Meter 816.5 gallons

Information Only

14:12 you will notice on observing the pumping well and observation well data that the pumping well responds or recovers more quickly than the observation well This might indicate several factors

1) Skin effect or lack of well efficiency
2) a fractured system
3) Density Variations in the observation Well water within the wells themselves.



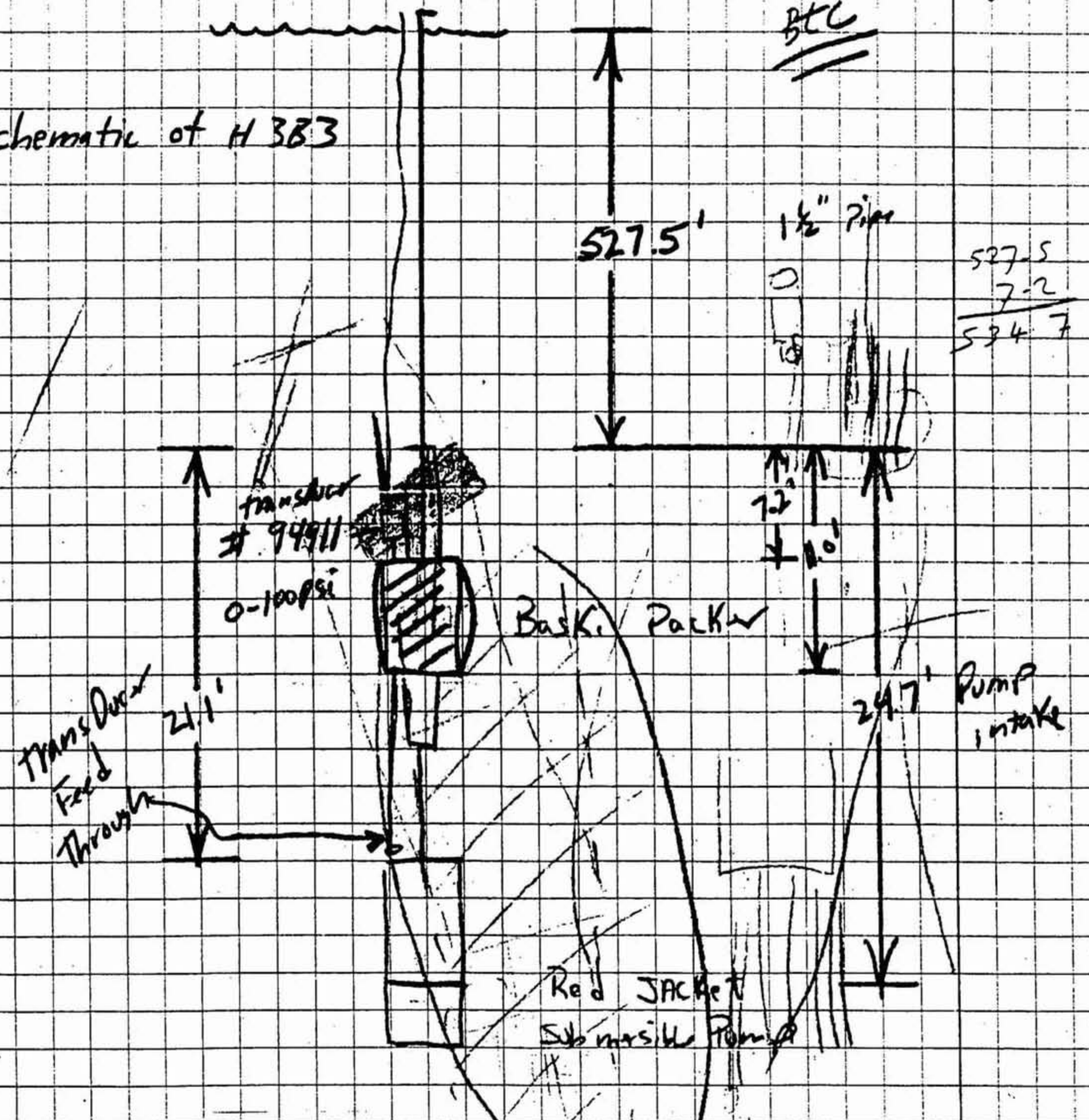
Information Only

H 3 Log Book

18 April 84 Wednesday Wayne

BTC

Schematic of H3B3



Trans Ducer set at 548.6 BTC
(Feed Through)

Depth to Water 418.1 BTC

~ 130.5 Feet of Head X Density factor

Information Only

H-3 Log Book

18 April 84 Wednesday Wayne

1405 — Monitor Recovery

1630 — Started Second 60 minute
pump test

16 32 — 7 gal / 55.81s = 7.53 gpm

16.37 — 7 gal / 61.79 6.80 gpm

time Flow Rate ~~meter Reading~~

1640 — 7gal / 63.53 6.61 gal/min

1641 — 25 / 60 sec 6.61 gpm

16 44 — 7gal / 64 6.56 gpm

1645 — 928.8 gallon meter reading
24.5 l / 60 Seconds 6.48 gpm

1648 — 7gal / 65.14 seconds 6.44 gpm

1652 — 7 gal / 65.17 seconds 6.44 gpm
25 l / 60 Sec 6.61 gpm ??

1654 — 24l / 60 Seconds 6.34 gpm

1657 — 7gal / 6660 seconds 6.31 gpm

1700 meter Reading 1[illegible] meter Reading
7gal / 66.52 seconds 6.31 gpm

1700 24l / 60 Seconds 6.34 gpm

1705 7gal / 66.35 [illegible] 6.33
24l / 60 Sec 6.34 gpm

Information Only

1

H-3 Log Book

18 April 84 Wednesday

Abeyta
Bruin
Boussalort

Time	Flow Rate		Meter Reading
17:09	7 gal / 106.32 = 66.32 sec 24 l / 60 Sec		6.33 gpm 6.34 gpm
1713	7 gal / 107.30 = 67.3 sec ~ 24 l / 60 Sec		6.24 gpm
1728	7 gal / 108.36 = 68.36 s ~ 24 l / 7 Seconds		6.14 gpm

1730:20 Turned Pump off

1749 Change Scan Rate

840419 DAY 110 BRUIS

WATER LEVELS (IRON HORSE)

0827 H3B1 127.4M x 3.2808 = 417.97FT +or-.04M
0835 H3B2 127.87M x 3.2808 = 419.51'Ft +or-.06M

Stopped the program and got plots of yesterdays 60-minute tests

A New Diskett HY320, FG1 was set up to START The Anisotrophy test for H 3B3. The designed Flow rate will be ~ 6.5 gpm

Information Only

H-3 Log Book

19 April 84 Day 110 Thursday

Wayne
Evans
Manual

Hydrologic characterization of test site

Project : Wipp
Location : Carlsbad, N.M
Test Pad H-3
Type of Test Anisotrophy

Designed Flow Rate : 6.5 gpm
Average Flow Rate :

Well Stats :

		SWL (ft)	Depth of Hole (ft)	Cas. ID
Observation Well ~~Test Well (Pumping Well)~~ :	H3B1	417.97	894.0	5.3
Observation Well	H3B 2	419.51	731.2	5.3
Pumping Well	H3B 3	419.20	729.0	5.3

Formation Interval — Culebra 670-694 ft BTC

Test Stats

Time Test Started

Time Test Ended

Duration of test

Water Chemistry

Special Comments

Information Only

H-3 Log Book

19 April 84 Day 110 Thursday

Wayne
Bruis
Manuel

0902 Reset timers

0955 Began to Inflate Packer will inflate packer to 200 psi above ambient. Ambient equals ~ 58 psi. 200 + 58 = 258 psi packer Inflation Pressure.

1000 Packer Inflated to 300 psi

Instrumentation Specs: transducer

Well #	transducer Serial #	Power Exct volt	Gauge Exct volt	Gauge Sensitivity	Depth to water	Scanner Signal ch #	Matrix Signal ch #
H3B3	94911	10.3	10.0	1.00879	419.2	21,22	2,3
H3B1	95078	10.3	10.0	2.51783	417.97	23,24	4,5
H3B2	94910	10.3	10.0	1.00746	419.57	25,26	6,7
Barometer						31	1

Information Only

H-3

19 April 84 Day 110 Thursday

Wayne
Brian
Armand

Instrumentation Data Continued

	Property #	Calibration Expiration date
DVM	B-965664	8-6-84
Voltage Std	B-766217	4-14-84
Heise Gause	SN - 53734	2-28-85

Acqusition, Data Reduction, ______

Initial Meter Reading 1203 gallons

Generator CheckList

Amps 40
Hertz 60
Voltage 210
Fuel Pressure 30
oil Pressure 37
Temp 175

Fuel Level 3/4 Full
oil Level 9 Gallons

~~0827 H3B1 127.4m x 3.2808~~

WATER LEVELS

0855 DOE-1 152.19 m x 3.2808 = 499.3 ft (IRON HORSE +0R- .04m
0917 H1 450-5.28 = 444.72ft (STEEL TAPE)
0929 H1 MAG. 279-9.7 = 269.3ft " "
0937 H2A 322-5.53 = 316.47ft " "
0942 H2B 395-5.99 = 389.01ft " "
0950 H2C 419-5.26 = 413.74ft " "
0955 H2B2 123.24m x 3.2808 = 404.33ft (IRON HORSE)
+0R- .01M

Information Only

H-3 ~~Log~~ Book

19 April 84 Day 110 Wayne

10 55 changed Scan rate to 30 seconds Bruss

Time	Flow Rate	Comments	Manual Meter Rea.
11:00	START Pump test - on H3B3		
1103	FLOW RATE 7 GAL / 61.4	6.84 gpm	
1104	60 sec / 25 LITERS	6.61 gpm	
1107	7 GAL / 62.87	6.68 gpm	
1109	60 sec / >24.5 l	6.48 gpm	
1110	7 GAL / 63.53	6.61 gpm	
11 12	60 Sec / >24 l	6.34 gpm	
11 13	7 gal / 65.71	6.39 gpm	
11 15	24 l / 60 Seconds	6.34 gpm	
11 16	7 gal / 66.46 seconds	6.39 gpm	
1118	24 L / 60 SEC	6.34	4378
1120	7 GAL / 66.57 SEC	6.30	
1122	LESS THAN 24 / 60 SEC		
1122	7 GAL / 68.4 SEC ADJUSTING FLOW		
1125	7 GAL / 64.76 SEC		
1127	7 GAL / 64.27 SEC		
1128	7 GAL / 64.31 SEC		
1131	7 GAL / 64.23		

Information Only

H3 LOG WAYNE

840419 DAY 110 BRUIS

MANUEL

1133 7GAL / 64.51 SEC 6.51 GPM
1135 7GAL / 64.87 SEC

1138 Sample taken conductance = 6.1 x 10⁴ µ
temp = 24°C
Specific Gravity = 1.042 %.

1139 7GAL / 64 seconds

1141 7 GAL / 64.02 SEC 6.56 GPM

1142 7 GAL / 63.64 SEC 6.59 GPM

1145 24 L / 60 SEC
1145 SCAN RATE CHANGED TO 5 MIN INTERVAL

1147 7 GAL / 64.07 SEC 6.55 GPM

1148 7 GAL / 63.98 SEC. 6.56 GPM

1150 7 GAL / 64.24 SEC 6.53 GPM

1151 7 GAL / 64.01 SEC 6.56 GPM

1153 7 GAL / 64.28 SEC 6.53 GPM

1154 7 GAL / 64.33 6.52 GPM

1156 7 GAL / 64.71 6.49 GPM

1157 7 GAL / 64.27

1159 / 60 SEC

Information Only

1200 METER READING 1594 | 6.51 GPM

H3 LOG

840419 DAY 110

1201	7 GAL / 64.45	6.52 GPM
1203	7 GAL / 64.51	6.51 GPM
1204	7 GAL / 64.90	6.47 GPM
1206	7 GAL / 64.83	6.~~51~~ 48 GPM
1207	7 GAL / 65.0	6.46 GPM
1209	7 GAL / 64.68	6.49 GPM
1210	7 GAL / 64.39	6.52 GPM
1211	7 GAL / 64.73	6.~~48~~ 49 GPM
1215	L / 60 SEC	
1217	7 GAL / 64.82	6.~~47~~ 48 GPM
12.19	~~7/~~ 7 GAL / 65.06	6.~~45~~ 46 GPM
1220	7 GAL / 65.09	6.45 GPM
1221	PACKER INFLATION IS 330 PSI	
1222	7 GAL / 65.23	6.4~~3~~ 4 GPM
1223	7/GAL / 64.92	6.4~~6~~ 7 GPM
1224	7 GAL / 65.45	6.4~~1~~ 2 GPM
1226	7 GAL / 65.15	6.4~~4~~ 5 GPM
1227	7 GAL / 65.1	6.42 GPM
1229	7 GAL / 64.93	6.47

Information Only

LOG

840419 DAY 110 A/RU15

1231 24 L / 60 SEC

1236 7 GAL / 65.31 6.43 GPM

1235 TOOK SAMPLE
CONDUCTANCE = 7.0[illegible] x 10^4 MHOS Per/cm
TEMP = 24° C
SPECIFIC GRAVITY = 1.04 gm/cm³

1241 7 GAL / 65.60 6.40 GPM

7

1245 7 GAL / 65.96 6.36 GPM

1247 24 L / 60 SEC

9

1250 7 GAL / 65.74 6.38 GPM

1256 7 GAL / 66.09 6.35 GPM

30

1257 7 GAL / 66.71 6.29 GPM

1300 METER READING 1980 6.47 GPM

3

1305 7 gal / 66.37 seconds 6.32 GPM

1322 7 gal / 66.22 Seconds 6.34 GPM

1350 7 GAL / 67.06 SEC 6.26 GPM

1350 METER READING 2300

WATER LEVELS (IRON HORSE)
1317 H3B1 131.22 m x 3.2808 = 430.5 ft + or - .06 M
1340 H3B2 132.1 m x 3.2808 = 433.39 ft + or - .04 M

1406 7 gal / 66.96 Seconds 6.27

Information Only

H3 LOG   WAYNE

840419   DAY 110   BRULS & MANUK

WATER LEVEL (IRON HORSE)

1405 152.12m x 3.2808 = 499.07 ft +or- .08 m

1430   7 GAL / 67.87 SEC   6.1~~8~~9 GPM

ADJUSTED FLOW RATE

1433   7 GAL / 66.32 SEC   6.33 GPM

1435   7 GAL / 65.96 Sec   6.3~~6~~7 GPM

1436   TEMPERATURE 23° C

CONDUCTANCE 7.0×10^4 MHOS / CM

DENSITY 1.038

1445   7 GAL / 65.47 SEC   6.4~~1~~2 GPM

1450   7 GAL / 64.69 SEC   6.49 GPM

1500   7 GAL / 65.35 SEC   6.4~~2~~3 GPM

1512   7 GAL / 66.05 SEC   6.3~~5~~6 GPM

1544   7 GAL / 66.33 Sec   6.33 GPM

adj Flow   Wayne

1545   Metr Reading   3024 gallons

1550   7 GAL / 65.19 Sec   6.44 GPM

1553   7 GAL / 65.48 Sec   6.41 GPM

15:58   7 GAL / 66.05 Sec   6.36 GPM

1600   7 GAL / 65.78 Sec   6.38 gpm

1600   Meter Reading 3120 gallons

Information Only

H-3 Log Book

19 APRIL 84 Thursday Day 110 Wayne

Bruis

16:26 24L / 60Sec 6.34 gpm manual

WATER LEVELS

1 1512 132.16M x 3.2808 = 433.59 ft + or - .03 m (IRON HORSE)
2 1325 133.28M x 3.2808 = 437.26 ft + or - .04 m " "
1 1544 152.16M x 3.2808 = 499.20 ft + or - .04 M " "
1600 450-5.28 = 444.72 ft (STEEL TAPE)

1619 7 GAL / 66.62 6.30 GPM
ADJUSTED FLOW RATE

1622 7 GAL / 65.27 6.43

1623 7 GAL / 64.84 6.48

1625 7 GaL / 65.13 6.45

1627 7 GaL / 64.77 6.48

1629 7 GaL / 64.12 6.55

1645 7 GAL / 64.73 6.49

1700 7 GAL / 65.39 6.42

1715 7 GaL / 66.04 6.36

1731 7 GaL / 65.95 6.37

1745 7 GaL / 66.42 6.32
60 sec / 24 L

1800 7 GaL / 6637 6.33

Information Only

H-3 LOG BOOK

840419 THURSDAY Day 110 MANUEL

1815	7 GAL / 65.89	6.37
1830	7 GaL / 65.98	6.37
1846	7 GaL / 66.49	6.32
1900	7 GaL / 67.10	6.26
1903	60 sec / 23.5 L	
1915	7 GaL / 66.97	6.27
1930	7 GaL / 68.28	6.15
1945	7 GaL / 67.59	6.21
2000	7 GaL / 68.20	6.16
2001	60 sec / 23.5 L	
2015	7 GaL / 66.76	6.29
2030	7 GaL / 66.83	6.28
2045	7 GaL / 67.64	6.21
2100	7 GaL / 68.72	6.11
2102	60 sec / 23.5 L	
2116	7 GaL / 68.19	6.16
2130	7 GAL / 68.88	6.10
2145	7 GaL / 69.20	6.07
2200	7 GAL / 69.13	6.08
2202	60 sec / 23 L	

2213 Packer Inflation Pressure = 320 psi N.C.

Information Only

19 April 84 Day NO Wayne

2210 Wayne Arrives back at Site
The Average Flow Rate is down to about 6.08 gpm. will adjust Flow. I instructed [illegible] not to adjust Flow while I was away. I did not want him playing with the regulating valve since it is so sensitive to adjustments and he had no experience with the valve.
Wayne Stewart

2223 adjusted flow Rate Wayne

2236 7 gallons / 65 seconds 6.46 gpm

2240 7 gallons / 65.33 seconds 6.43 gpm

2246 7 gallons / 65.79 Seconds 6.38 gpm

2252 7 gallons / 66.33 Seconds 6.33 gpm

2300 5759 Gallons Meter Reading (6.28 gpm)

2308 7 gallons / 67.62 Seconds 6.21 gpm

The meter valve is open all the way I cannot get any higher flow Rate

2330 Doe-1 152.1 meters
498.9

Information Only

19 April 84 Thursday Wayne

2400 – Stop test Monitor Recovery. Since we don't have any Flow Regulating Capability I have decided to Stop The test and to Restart test Saturday Morning at 0900 Q = 5 gpm instead of 6.5 gpm

20 Apr 84 Final Meter Reading 6124 gallons

0000 – Scan Interval 30 Seconds

0020 – Scan interval 5 minutes

The HP Computer is not programmed properly for Leap Year so Day 110 is actually Day 111

Information Only

Software Used

Program	Version	Purpose	QA status
Excel	2000	data entry and calculations	off the shelf
Grapher	2.01	data plotting	off the shelf
Interpret 2000	2.01.240	test interpretation	off the shelf

All software was run under Windows 2000 Professional on a Dell Precision 330 computer with a 1.8-GHz Pentium 4 processor and 512 Mbytes of RAM.

Information Only

Computer Files for 1984 H-3 Pumping Tests

DAS files transferred from HP-9845 to PC disks:
- HY318.dat
- HY319.dat
- HY320.dat

DAS files with conversions to pressure:
- HY318.xls
- HY319.xls
- HY320.xls

Hand-entered flow-rate data file:
- H-3-Q.xls

Miscellaneous Grapher files for plots of data:
- H-3b184.grf—plots of H-3b1 pressure data
- H-3b284.grf—plots of H-3b2 pressure data
- H-3b384.grf—plots of H-3b3 pressure data
- H-384Q.grf—plots of flow-rate data

Input files for Interpret 2000:
- H3PINT2.xls—pressure input
- H3QINT2.xls—flow rate input

Interpret 2000 analysis files:
- H-3b1-84.rec
- H-3b2-84.rec
- H-3b3-84.rec

Interpret 2000 graph files:
- H-3b1-84-FP2-LL.cgm—Log-log plot for FP2
- H-3b1-84-FP2-H.cgm—Horner plot for FP2
- H-3b1-84-FP2-S.cgm—Linear-linear simulation plot for FP2
- H-3b1-84-FP12-LL.cgm
- H-3b1-84-FP12-H.cgm
- H-3b1-84-FP12-S.cgm
- H-3b1-84-FP24-LL.cgm
- H-3b1-84-FP24-H.cgm
- H-3b1-84-FP24-S.cgm
- H-3b1-84-FP51-LL.cgm
- H-3b1-84-FP51-H.cgm
- H-3b1-84-FP51-S.cgm
- H-3b2-84-FP2-LL.cgm
- H-3b2-84-FP2-H.cgm
- H-3b2-84-FP2-S.cgm

Information Only

1/2

H-3b2-84-FP12-LL.cgm
H-3b2-84-FP12-H.cgm
H-3b2-84-FP12-S.cgm
H-3b2-84-FP24-LL.cgm
H-3b2-84-FP24-H.cgm
H-3b2-84-FP24-S.cgm
H-3b2-84-FP51-LL.cgm
H-3b2-84-FP51-H.cgm
H-3b2-84-FP51-S.cgm
H-3b3-84-FP2-LL.cgm
H-3b3-84-FP2-H.cgm
H-3b3-84-FP2-S.cgm
H-3b3-84-FP12-LL.cgm
H-3b3-84-FP12-H.cgm
H-3b3-84-FP12-S.cgm
H-3b3-84-FP24-LL.cgm
H-3b3-84-FP24-H.cgm
H-3b3-84-FP24-S.cgm
H-3b3-84-FP51-LL.cgm
H-3b3-84-FP51-H.cgm
H-3b3-84-FP51-S.cgm
H-3b1-84figs.doc—compilation of above-listed H-3b1 .cgm files into Word document
H-3b2-84figs.doc—compilation of above-listed H-3b2 .cgm files into Word document
H-3b3-84figs.doc—compilation of above-listed H-3b3 .cgm files into Word document
H-3b3-84-FP51-LL-VF.cgm—Log-log plot using vertical-fracture model
H-3b3-84-FP51-H-VF.cgm—Horner plot using vertical-fracture model
H-3b3-84-FP51-S-VF.cgm—Linear-linear simulation using vertical-fracture model
H-3b3-84-VFfigs.doc—compilation of above-listed H-3b3 .cgm files using vertical-fracture model into Word document

Interpret 2000 report files:
H-3b1-84.doc
H-3b2-84.doc
H-3b3-84.doc

Information Only

References

Baker Service Tools. 1985. *Tech Facts*. Houston, TX: Baker Service Tools.

Beauheim, R.L. 1987. *Analysis of Pumping Tests of the Culebra Dolomite Conducted at the H-3 Hydropad at the Waste Isolation Pilot Plant (WIPP) Site*. SAND86-2311. Albuquerque, NM: Sandia National Laboratories.

Beauheim, R.L. 1989. *Interpretation of H-11b4 Hydraulic Tests and the H-11 Multipad Pumping Test of the Culebra Dolomite at the Waste Isolation Pilot Plant (WIPP) Site*. SAND89-0536. Albuquerque, NM: Sandia National Laboratories.

Beauheim, R.L. 2000. *Analysis Plan for Non-Salado Hydraulic-Test Interpretations*. AP-070. Albuquerque, NM: Sandia National Laboratories.

Beauheim, R.L., G.J. Saulnier, Jr., and J.D. Avis. 1991. *Interpretation of Brine-Permeability Tests of the Salado Formation at the Waste Isolation Pilot Plant: First Interim Report*. SAND90-0083. Albuquerque, NM: Sandia National Laboratories.

Bourdet, D., J.A. Ayoub, and Y.M. Pirard. 1989. "Use of Pressure Derivative in Well-Test Interpretation," *SPE Formation Evaluation*. Vol. 4, no. 2, 293-302.

Earlougher, R.C., Jr. 1977. *Advances in Well Test Analysis*. Monograph Volume 5. Dallas, TX: Society of Petroleum Engineers of AIME, 264 p.

Gonzales, M.M. 1989. *Compilation and Comparison of Test-Hole Location Surveys in the Vicinity of the Waste Isolation Pilot Plant Site*. SAND88-1065. Albuquerque, NM: Sandia National Laboratories.

Gringarten, A.C. 1984. "Interpretation of Tests in Fissured and Multilayered Reservoirs with Double-Porosity Behavior: Theory and Practice," *JPT, Journal of Petroleum Technology*. Vol. 36, no. 4, 549-564.

Horner, D.R. 1951. "Pressure Build-up in Wells," *Proceedings of the Third World Petroleum Conference, The Hague, Netherlands, May 29, 1951*. Leiden, The Netherlands: E.J. Brill. Sec. II, 503-523. Reprinted 1967. *Pressure Analysis Methods*. SPE Reprint Series Vol. 9. New York, NY: American Institute of Mining, Metallurgical and Petroleum Engineers, Inc. 25-43.

Jones, T.L., V.A. Kelley, J.F. Pickens, D.T. Upton, R.L. Beauheim, and P.B. Davies. 1992. *Integration of Interpretation Results of Tracer Tests Performed in the Culebra Dolomite at the Waste Isolation Pilot Plant Site*. SAND92-1579. Albuquerque, NM: Sandia National Laboratories.

Information Only

Mercer, J.W., and B.R. Orr. 1979. *Interim Data Report on the Geohydrology of the Proposed Waste Isolation Pilot Plant Site, Southeast New Mexico.* Water-Resources Investigations Report 79-98. Albuquerque, NM: USGS.

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