APPENDIX 3.10

GEOTECHNICAL LABORATORY TEST RESULTS

CORE ANALYSIS REPORT

FOR

U.S. POLLUTION CONTROL INC.,C/O MDK CONSULTANTS

MULTI-WELL
LONE MOUNTAIN PROJECT
MAJOR, OKLAHOMA

Litton
Core Lab

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August 21, 1987

United States Pollution Control, Inc.
2000 Classen Center
Suite 400 South
Oklahoma City, Oklahoma 73106

Attention: Mr. Roy Murphy

Subject: Lone Mountain Facility
Multiple Well Core Analysis
Major County, Oklahoma

Gentlemen:

Core taken from the subject wells were received in the Tulsa laboratory for analytical testing described in the following report.

Shallow earth core samples were delivered to the facilities by Douglas Kent, PhD. of MDK Consultants, Stillwater, Oklahoma. The samples were wrapped in Saran and foil for preservation purposes.

Cylindrical samples were shaped for Horizontal permeability and porosity measurements, along with Vertical samples for permeability measurements only.

Four samples were removed by Dr. Kent for X-ray diffraction analysis. These samples were shipped to our Petrology Laboratory in Dallas, Texas. The samples are as follows:

1) TB-1 Well - 314.7 ft.
2) TB-3 Well - 73.3 ft.
3) TB-4 Well - 71.0 ft.
4) TB-6 Well - 24.5 ft.

After the samples were shaped they were allowed to dry in a humidity oven for 72 hours to ensure drying weight stability. Humidity drying was utilized because of the high clay nature of the earth samples.

After the samples dried they were allowed to cool at room temperature in an air tight system. This prevented introduction of atmospheric humidity (moisture) to the samples.

The shaped cylindrical plug samples were no longer than 4.5 cm and diameter no larger than 2.53 cm. This allows the samples to be within size range of the property measuring equipment.

After samples have cooled at room temperature they were weighed for Grain Volume measurements. This is the first step in porosity determination.

General

Porosity is a very important rock property; it is defined as the ratio of the void or pore volume to the bulk volume of a material and is usually expressed as a percentage. The amount of pore space which can be occupied by hydrocarbons or water in a reservoir must be known for any intelligent evaluation or engineering function to be performed on the reservoir.

Core Laboratories utilizes its SVP porosimeter (Small Volume Porosimeter^{TM}). The "porosimeter" is a volume measuring instrument; it can be used to determine the volume of grains or the volume of the pores of a sample. It utilizes the principle of gas expansion, as described by Boyle's Law; a known (reference cell) volume of helium gas, at a measured-preset pressure is isothermally expanded into an unknown void volume. After expansion, the resultant equilibrium pressure is measured; the equilibrium pressure is dependent upon the magnitude of the unknown volume. The magnitude of the unknown volume may be calculated using Boyle's Law. The small volume porosimeter measures grain volume (Vg). "Boyle's Law" can be expressed by the equation:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

In our application the temperature remains constant and the equation becomes:

$$P_1V_1 = P_2V_2$$

Helium gas at pressure P_1 measured by a transducer is expanded into a sample chamber (volume V_c) and P_2 is again measured. If the volume of the reference cell (V_r) is known, the volume of the sample chamber V_c can be calculated:

$$P_1V_r = P_2(V_r+V_c)$$

If a sample is added into the sample chamber, the gas expands into the chamber and into the pore space of the core and the equation becomes:

$$P_1V_r = P_2(V_r+V_c-V_g)$$

where V_g is the grain volume of the core sample. V_r and V_c remain constant in our apparatus and V_r is unknown. If two trial runs are made with different, but know, V_g's in the machine, two equations can be written and solved simultaneously to calculate V_r. Algebraically rearrange the basic equation to get our two trial run data in a more useable form.

$$P_1V_r = P_2(V_r+V_c-V_g)$$

$$\frac{P_1V_r}{P_2} = (V_r+V_c-V_g)$$

Equation 1: $$\frac{P_1}{P_2}V_r = V_r+V_c-V_g$$

Example:	P_1	P_2	V_g
Trial Run 1	12142	4738	12.87
Trial Run 2	12141	8485	17.699

The values of V_g are determined by the disk volumes placed in the sample chamber. Substituting the values of P_1, P_2, and V_g for each trial run into equation 1:

Run 1 $$\frac{12142}{4738}V_r = V_r+V_c-12.87$$

Run 2 $$\frac{12141}{8485}V_r = V_r+V_c-17.699$$

Simplify P_1/P_2

$$2.565V_r = V_r+V_c-12.87$$
$$1.431V_r = V_r+V_c-17.699$$

To solve simultaneously, subtract Run 1 from Run 2 or:

$$\begin{array}{rcl} 2.563V_r & = & (V_r+V_c)-12.87 \\ -1.431V_r & = & -(V_r+V_c)+17.699 \\ \hline 1.132V_r & = & 0+4.829 \\ V_r & = & 4.266 \end{array}$$

To get a value for V_c substitute V_r in one of the above equations and solve for V_c:

$$2.563(4.266) = 4.266+V_c-12.87$$
$$V_c = 10.934+12.87-4.266$$
$$V_c = 19.538$$

$$\text{Grain Density} = \frac{\text{Sample weight (dry)}}{\text{Grain Volume}}$$

Helium is used as the test gas because (1) the small helium molecule will penetrate the very small capillaries sometimes associated with reservoir rock, (2) the low mass of the helium atom allows it to have a higher diffusivity, which helps it to permeate porous media, and (3) the absorption of helium on the surfaces of the rock is minimal. For these reasons the use of helium results in more accurate volume determinations.

Core Laboratories' Small Volume Helium Porosimeter measures grain volumes @ 200 psi of helium. This allows for faster and more thorough penetration in small pore volume samples.

The next step after grain volume measurements are bulk volume measurements, this allows us to calculate porosity by means of:

$$\text{Porosity} = \frac{\text{Bulk Volume-Grain Volume}}{\text{Bulk Volume}} \text{ X } 100$$

The standard Core Laboratory mercury pump is used in routine core analysis to measure three values; the bulk volume and gas bulk of a Σ of Fluids sample, and the Bulk Volume of a Boyle's Law porosity plug sample. Special Core Analysis uses the mercury pump for Capillary Pressure and Pore Size Distribution tests, which will not be discussed here.

The mercury pump is a high pressure volumetric displacement pump to which a sample chamber is attached. The displacement is accomplished by a screw-actuated plunger which operates through a packing gland into a reservoir cylinder. The two micrometer scales attached to the plunger allow the displacement to be read in increments of 0.01 cubic centimeters. The sample chamber is sealed by closing the needle valve in the cap, and a 1000 psi pressure gauge is attached to the cylinder to indicate the pressure of the system.

Mercury is used as the liquid medium because of its high surface tension, low compressibility, and non-wetting properties.

To determine the Bulk Volume of a sample, first zero the pump. Turn the handle clockwise, dropping the mercury level far enough to load the sample. Remove the cap and place the sample in the sample chamber. Replace and lock the cap making sure the needle valve is open. Slowly turn the handle counter-clockwise until a bubble of mercury appears in the cap's recess and touches the needle valve. Record the linear scale and inside micrometer scale reading as one reading. This value is a corrected bulk volume which is a multiple entered into an adjoining digital device.

After Bulk Volumes are measured, porosity is calculated. The samples are now ready for permeability measurements.

As related to earth formations, permeability is a property of the formation and is a measure of the formation's capacity to induct fluids (oil, gas and water). The Core Laboratories' Micro Permeameter is an instrument designed to determine this property of fluid transmissibility. Permeability values, as determined by the correct operation of this instrument, should be within 5% of the actual permeability.

The dimension of permeability is defined as the "Darcy". A sample is described as having a Darcy permeability when an incompressible liquid of one centipoise viscosity will flow at a rate of 1 cm/sec., through a cross-sectional area of one sq.cm., along a one cm. length with a flowing pressure differential of one atmosphere. Laminar (viscous, nonturbulent) flow conditions are assumed.

The Darcy equation relating to compressible fluids (gas) is as follows:

$$Kg = \frac{2\,\mu(qg)(L)(Pa)}{A(P_1+P_2)(P_1-P_2)}$$

Kg = Permeability (darcies)

μ = Gas viscosity (cp) at mean pressure and temperature of the sample (Nitrogen)

qg = Gas volume rate at atmospheric pressure and temperature (cm^3/sec)

P_1 = In flow or upstream pressure

P_2 = Out flow or downstream pressure

P_a = Atmospheric pressure

Permeability Calculations

$$Kg = \frac{CqaL}{A}$$

Kg = Gas permeability (millidarcies)
qa = Volume flow rate of air (cm^3/sec)
L = Sample length (cm)
A = Sample area (cm)

$$qa = \frac{(\text{Orifice Q})(h_w)}{200}$$

Orifice Q = Orifice constant; volume flow rate of air (nitrogen) through the orifice when flowing pressure drop of 200 mm. of water is imposed across the orifice (cm^3/sec)

hw = Orifice water manometer reading

Therefore: Kg in millidarcies = $C(\text{orifice Q})\ \frac{hw}{200}\quad\frac{L}{A}$

After the cylindrical samples were measured for permeability (millidarcies) they were corrected for temperature 16°C and converted to centimeters per/sec.
1 md = 9.66×10^{-7} centimeters per/sec.

Because of the permeability differences of the samples, different upstream pressures and orifice values (Q) were used to measure flow. These pressure and orifice values are listed in tabular form on the cm.per/sec. conversion table in this report.

Tabular, statistical and conversion information is included in this report. Thank you very much for letting Core Lab be of service.

Sincerely,

Michael C. Hudson

Michael C. Hudson
Lab Supervisor

MCH:reh

cc: MDK Consultants
Rt. 3, Box 83
Stillwater, Oklahoma 74074
Attn: Dr. D. Kent

Core Lab

File 43404-87082 [illegible] 1 of 3
Well As Specified Below
U.S. Pollution Control, Inc.

CALCULATED EQUIVALENT FLOW RATES TO FRESH WATER @16oC cm/sec

Sample Number	Depth, feet	Intrinsic Permeability to Nitrogen, Horizontal Kh, millidarcys	Hydraulic Conductivity to Water @16^{o}C Permeability to Nitrogen, Equivalent Flow Rate Qwh, cm/sec	Intrinsic Permeability to Nitrogen, Vertical Kv, millidarcys	Hydraulic Conductivity to Water @16^{o}C Permeability to Nitrogen, Equivalent Flow Rate Qwv, cm/sec	Upstream Pressure psi Kh	Upstream Pressure psi Kv	Orifice Value (Q) Kh	Orifice Value (Q) Kv
TB-1 Well									
*1	203.4	14	1.25 E-5			2		1.726	
*2	254.3	3.4	3.03 E-6			7.05		.636	
*3	314.5	7.6	6.77 E-6			2		.636	
TB-2 Well									
*1	137.0	24	2.14 E-5			2		.636	
*2	164.0	25	2.23 E-5			2		.636	
*3	273.4	129	1.15 E-4			2		3.015	
TB-3 Well									
*1	49.5	28	2.50 E-5			2		1.870	
*2	73.0	5.7	5.08 E-6			2		.166	
TB-4 Well									
*1	43.5	47	4.19 E-5	0.07	6.24 E-8	2	16.8	3.015	.0513
*2	67.5	73	6.02 E-5			2		3.015	

*Mounted in Lead sleeves because of poor sample integrity.
(Samples may not represent true reservoir values.)

(1 md = 9.66×10^{-7} centimeters per/sec.)

File 43404-87082 Pa 2 of 3
Well As Specified Below
U.S. Pollution Control, Inc.

CALCULATED EQUIVALENT FLOW RATES TO FRESH WATER
@16oC cm/sec

Sample Number	Depth, feet	Intrinsic Permeability to Nitrogen, Horizontal Kh, millidarcys	Hydraulic Conductivity to Water @16^{o}C Permeability to Nitrogen, Equivalent Flow Rate Qwh, cm/sec	Intrinsic Permeability to Nitrogen, Vertical Kv, millidarcys	Hydraulic Conductivity to Water @16^{o}C Permeability to Nitrogen, Equivalent Flow Rate Qwv, cm/sec	Upstream Pressure psi Kh	Upstream Pressure psi Kv	Orifice Value (Q) Kh	Orifice Value (Q) Kv
TB-5 Well									
*1	97.8	7419	6.61 E-3			2		6.506	
TB-6 Well									
*1	31.3	4.2	3.74 E-6	0.07	6.24 E-8	2	16.8	.166	.0513
2	41.8	1.4	1.25 E-6	0.04	3.56 E-8	12.3	16.8	.166	.0513
3	77.0	0.29	2.58 E-7			21.6		.166	
4	97.7	0.05	4.46 E-8			21.6		.0134	
5	114.5	0.20	1.78 E-7	0.03	2.67 E-8	2	27.3	.0134	.0134
TB-11 Well									
1	36.0	0.013	1.16 E-8	0.03	2.67 E-8	31.7	16.8	.0513	.0134
TB-13 Well									
1	43.5	0.04	3.56 E-8	0.04	3.56 E-8	31.7	16.8	.0134	.0134
2	67.0	0.03	2.67 E-8	0.04	3.56 E-8	31.7	27.3	.0134	.0134

*Mounted in Lead sleeves because of poor sample integrity.
(Samples may not represent true reservoir values.)

(1 md = 9.66 x 10^{-7} centimeters per/sec.)

Well As Specified Below

U.S. Pollution Control, Inc.

CALCULATED EQUIVALENT FLOW RATES TO FRESH WATER
@16oC cm/sec

Sample Number	Depth, feet	Intrinsic Permeability to Nitrogen, Horizontal Kh, millidarcys	Hydraulic Conductivity to Water @16^{o}C Permeability to Nitrogen, Equivalent Flow Rate Qwh, cm/sec	Intrinsic Permeability to Nitrogen, Vertical Kv, millidarcys	Hydraulic Conductivity to Water @16^{o}C Permeability to Nitrogen, Equivalent Flow Rate Qwv, cm/sec	Upstream Pressure psi Kh	Upstream Pressure psi Kv	Orifice Value (Q) Kh	Orifice Value (Q) Kv
TB-14 Well									
1	72.5	0.27	2.41 E-7	0.05	4.46 E-8	7.05	21.6	.0134	.0134
2	91.0	0.13	1.16 E-7	0.03	2.67 E-8	9.8	21.6	.0134	.0134
3	109.0	0.21	1.87 E-7			7.05		.0134	
4	167.0	122	1.09 E-4	54	4.81 E-5	2	2	3.015	3.015
5	225.0	0.69	6.15 E-7	0.23	2.05 E-7	2	7.05	.0134	.0134
6	330.0	5.0	4.46 E-6	0.06	5.35 E-8	7.05	12.3	.636	.0134
7	364.5	1.4	1.25 E-6			2		.0513	
8	392.8	Sample failed							
TB-15 Well									
1	15.5	4.7	4.19 E-6	0.08	7.13 E-8	2	12.3	.166	.0134
2	31.0	Sample failed							
3	57.0	0.03	2.67 E-8			31.7		.0513	
4	63.5	0.38	3.39 E-7	0.06	5.35 E-8	7.05	2	.0513	.0134
5	77.0	7.2	6.42 E-6	0.01	8.91 E-9	2	2	.583	.0134
6	86.5	.57	5.08 E-7			7.05		.0513	

(1 md = 9.66 x 10^{-7} centimeters per/sec.)

C O R E   L A B O R A T O R I E S,   I N C.

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-1

MAJOR, OKLAHOMA

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT
Coring Fluid :
Elevation :

File : 43404-87082
Date : 20-AUG-1987
API No. :
Analysts: MCH

CORE ANALYSIS RESULTS

SAMPLE NUMBER	DEPTH ft	PERMEABILITY (HORIZONTAL) Kair md	POROSITY (HELIUM) %	GRAIN DENSITY gm/cc	DESCRIPTION
1	203.4	14.0	26.7	2.44	Clst rdsh gyp uncons
2	254.3	3.40	25.3	2.52	Clst rdsh gyp uncons
3	314.5	7.60	20.9	2.38	Clst rdsh gyp uncons

CORE LABORATORIES, INC.

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-1

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT

File : 43404-87082
Date : 20-AUG-1987

TABLE I

SUMMARY OF CORE DATA

ZONE AND CUTOFF DATA

ZONE:

Identification	FLOWER POT
Top Depth	203.4 ft
Bottom Depth	314.5 ft
Number of Samples	3

DATA TYPE:

Porosity	HELIUM
Permeability	HORIZONTAL

CUTOFFS:

Porosity (Minimum)	0.0 %
Permeability (Minimum)	0.0000 md
Water Saturation (Maximum)	
Oil Saturation (Minimum)	
Grain Density (Minimum)	2.00 gm/cc
Grain Density (Maximum)	3.00 gm/cc
Lithology Excluded	NONE

CHARACTERISTICS REMAINING AFTER CUTOFFS

ZONE:

Number of Samples	3
Thickness Represented	3.0 ft

POROSITY:

Storage Capacity	72.9 Ø-ft
Arithmetic Average	24.3 %
Minimum	20.9 %
Maximum	26.7 %
Median	25.3 %
Standard Deviation	±3.0 %

GRAIN DENSITY:

Arithmetic Average	2.45 gm/cc
Minimum	2.38 gm/cc
Maximum	2.52 gm/cc
Median	2.44 gm/cc
Standard Deviation	±0.07 gm/cc

PERMEABILITY:

Flow Capacity	25.0 md-ft
Arithmetic Average	8.33 md
Geometric Average	7.13 md
Harmonic Average	6.03 md
Minimum	3.40 md
Maximum	14.0 md
Median	7.60 md
Standard Deviation	$10^{\pm0.727}$ md

HETEROGENEITY (Permeability):

Variation	0.609
Lorenz Coefficient	0.295

AVERAGE SATURATIONS (Pore Volume):

Oil	
Water	

CORE LABORATORIES, INC.

U.S. POLLUTION CONTROL, INC. C\0 MDK CONSULTANTS		Field	: LONE MOUNTAIN FACILITY		File	: 43404-87082
TB-2		Formation	: FLOWER POT		Date	: 20-AUG-1987
		Coring Fluid	:		API No.	:
MAJOR, OKLAHOMA		Elevation	:		Analysts:	MCH

CORE ANALYSIS RESULTS

SAMPLE NUMBER	DEPTH ft	PERMEABILITY (HORIZONTAL) Kair md	POROSITY (HELIUM) %	GRAIN DENSITY gm/cc	DESCRIPTION
1	137.0	24.0	27.3	2.61	Clst rdsh gyp uncons
2	164.0	25.0	29.0	2.62	Clst rdsh gyp uncons
3	273.4	129.	23.3	2.68	Clst rdsh gyp uncons

CORE LABORATORIES, INC.

U.S. POLLUTION CONTROL, INC. C\0 MDK CONSULTANTS	Field	: LONE MOUNTAIN FACILITY	File	: 43404-87082
TB-2	Formation	: FLOWER POT	Date	: 20-AUG-1987

TABLE I

SUMMARY OF CORE DATA

ZONE AND CUTOFF DATA

ZONE:

Identification	FLOWER POT
Top Depth	137.0 ft
Bottom Depth	273.4 ft
Number of Samples	3

DATA TYPE:

Porosity	HELIUM
Permeability	HORIZONTAL

CUTOFFS:

Porosity (Minimum)	0.0 %
Permeability (Minimum)	0.0000 md
Water Saturation (Maximum)	
Oil Saturation (Minimum)	
Grain Density (Minimum)	2.00 gm/cc
Grain Density (Maximum)	3.00 gm/cc
Lithology Excluded	NONE

CHARACTERISTICS REMAINING AFTER CUTOFFS

ZONE:

Number of Samples	3
Thickness Represented	3.0 ft

POROSITY:

Storage Capacity	79.6 ø-ft
Arithmetic Average	26.5 %
Minimum	23.3 %
Maximum	29.0 %
Median	27.3 %
Standard Deviation	±2.9 %

GRAIN DENSITY:

Arithmetic Average	2.64 gm/cc
Minimum	2.61 gm/cc
Maximum	2.68 gm/cc
Median	2.62 gm/cc
Standard Deviation	±0.04 gm/cc

PERMEABILITY:

Flow Capacity	178.0 md-ft
Arithmetic Average	59.3 md
Geometric Average	42.6 md
Harmonic Average	33.6 md
Minimum	24.0 md
Maximum	129. md
Median	25.0 md
Standard Deviation	$10^{\pm1.781}$ md

HETEROGENEITY (Permeability):

Variation	0.047
Lorenz Coefficient	0.458

AVERAGE SATURATIONS (Pore Volume):

Oil	
Water	

CORE LABORATORIES, INC.

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-3

MAJOR, OKLAHOMA

Field : LONE MOUNTAIN
Formation : FLOWER POT
Coring Fluid :
Elevation :

File : 43404-87082
Date : 20-AUG-1987
API No. :
Analysts: MCH

CORE ANALYSIS RESULTS

SAMPLE NUMBER	DEPTH ft	PERMEABILITY (HORIZONTAL) Kair md	POROSITY (HELIUM) %	GRAIN DENSITY gm/cc	DESCRIPTION
1	49.5	28.0	29.4	2.62	Clst rdsh gyp uncons
2	73.0	5.70	26.3	2.58	Clst rdsh gyp uncons

C O R E   L A B O R A T O R I E S ,   I N C .

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-3

Field : LONE MOUNTAIN
Formation : FLOWER POT

File : 43404-87082
Date : 20-AUG-1987

TABLE I

SUMMARY OF CORE DATA

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   ZONE AND CUTOFF DATA                      CHARACTERISTICS REMAINING AFTER CUTOFFS
_______________________________________  _____________________________________________________________________

ZONE:                                    ZONE:                                      PERMEABILITY:
 Identification ----------- FLOWER POT    Number of Samples -----        2
 Top Depth ----------------     49.5 ft   Thickness Represented -        2.0 ft      Flow Capacity ---------       33.7 md-ft
 Bottom Depth -------------     73.0 ft                                              Arithmetic Average ----     16.9  md
 Number of Samples --------     2        POROSITY: .                                 Geometric Average -----     12.6  md
                                                                                     Harmonic Average ------      9.47 md
DATA TYPE:                                Storage Capacity ------     55.7 Ø-ft      Minimum ---------------      5.70 md
                                          Arithmetic Average ----     27.9 %         Maximum ---------------     28.0  md
 Porosity ------                HELIUM    Minimum ---------------     26.3 %         Median ----------------     16.9  md
 Permeability --            HORIZONTAL    Maximum ---------------     29.4 %                                        ±1.198
                                          Median ----------------     27.9 %         Standard Deviation ----    10      md
CUTOFFS:                                  Standard Deviation ----     ±2.2 %
                                                                                    HETEROGENEITY (Permeability):
 Porosity (Minimum) -------      0.0 %   GRAIN DENSITY:
 Permeability (Minimum) ---   0.0000 md                                              Variation ------------      0.000
 Water Saturation (Maximum)               Arithmetic Average ----     2.60 gm/cc     Lorenz Coefficient ----      0.363
 Oil Saturation (Minimum) -               Minimum ---------------     2.58 gm/cc
 Grain Density (Minimum) --     2.00 gm/cc Maximum ---------------    2.62 gm/cc    AVERAGE SATURATIONS (Pore Volume):
 Grain Density (Maximum) --     3.00 gm/cc Median ----------------    2.60 gm/cc
 Lithology Excluded -------     NONE      Standard Deviation ----    ±0.03 gm/cc     Oil -----------------
                                                                                     Water ---------------
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CORE LABORATORIES, INC.

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-4

USA, OKLAHOMA

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT
Coring Fluid :
Elevation :

File : 43404-87082
Date : 21-AUG-1987
API No. :
Analysts: MCH

CORE ANALYSIS RESULTS

SAMPLE NUMBER	DEPTH	PERMEABILITY		POROSITY (HELIUM)	GRAIN DENSITY	DESCRIPTION
	ft	(HORIZONTAL) Kair md	(VERTICAL) Kair md	%	gm/cc	
1	43.5	47.0	0.070	23.2	2.66	Clst rdsh gyp uncons
2	67.5	73.0		23.2	2.66	Clst rdsh gyp uncons

CORE LABORATORIES, INC.

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-4

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT

File : 43404-87082
Date : 21-AUG-1987

TABLE I

SUMMARY OF CORE DATA

ZONE AND CUTOFF DATA

ZONE:	
Identification	FLOWER POT
Top Depth	43.5 ft
Bottom Depth	67.5 ft
Number of Samples	2
DATA TYPE:	
Porosity	HELIUM
Permeability	HORIZONTAL
CUTOFFS:	
Porosity (Minimum)	0.0 %
Permeability (Minimum)	0.0000 md
Water Saturation (Maximum)	
Oil Saturation (Minimum)	
Grain Density (Minimum)	2.00 gm/cc
Grain Density (Maximum)	3.00 gm/cc
Lithology Excluded	NONE

CHARACTERISTICS REMAINING AFTER CUTOFFS

ZONE:	
Number of Samples	2
Thickness Represented	2.0 ft
POROSITY:	
Storage Capacity	46.4 Ø-ft
Arithmetic Average	23.2 %
Minimum	23.2 %
Maximum	23.2 %
Median	23.2 %
Standard Deviation	0.0 %
GRAIN DENSITY:	
Arithmetic Average	2.66 gm/cc
Minimum	2.66 gm/cc
Maximum	2.66 gm/cc
Median	2.66 gm/cc
Standard Deviation	0.00 gm/cc

PERMEABILITY:	
Flow Capacity	120.0 md-ft
Arithmetic Average	60.0 md
Geometric Average	58.6 md
Harmonic Average	57.2 md
Minimum	47.0 md
Maximum	73.0 md
Median	60.0 md
Standard Deviation	$10^{\pm 1.264}$ md
HETEROGENEITY (Permeability):	
Variation	0.000
Lorenz Coefficient	0.126
AVERAGE SATURATIONS (Pore Volume):	
Oil	
Water	

C O R E   L A B O R A T O R I E S,   I N C.

U.S.POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-5

USA, OKLAHOMA

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT
Coring Fluid :
Elevation :

File : 43404-87082
Date : 20-AUG-1987
API No. :
Analysts: MCH

C O R E   A N A L Y S I S   R E S U L T S

SAMPLE NUMBER	DEPTH ft	PERMEABILITY (HORIZONTAL) Kair md	POROSITY (HELIUM) %	GRAIN DENSITY gm/cc	DESCRIPTION
1	97.8	7419.	21.8	2.52	Clst rdsh gyp uncons

CORE LABORATORIES, INC.

U.S. POLLUTION CONTROL, INC.C\O MDK CONSULTANTS
TB-6

MAJOR, OKLAHOMA

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT
Coring Fluid :
Elevation :

File : 43404-87082
Date : 20-AUG-1987
API No. :
Analysts: MCH

CORE ANALYSIS RESULTS

SAMPLE NUMBER	DEPTH	PERMEABILITY		POROSITY (HELIUM)	GRAIN DENSITY	DESCRIPTION
		(HORIZONTAL) Kair	(VERTICAL) Kair			
	ft	md	md	%	gm/cc	
1	31.3	4.20	0.070	27.1	2.58	Clst rdsh gyp uncons
2	41.8	1.40	0.040	25.9	2.54	Clst rdsh gyp uncons
3	77.0	0.290		30.7	2.58	Clst rdsh gyp
4	97.7	0.050		29.1	2.61	Clst rdsh gyp
5	114.5	0.200	0.030	26.3	2.56	Clst rdsh gyp

C O R E   L A B O R A T O R I E S,   I N C.

U.S. POLLUTION CONTROL, INC.C\O MDK CONSULTANTS
TB-6

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT

File : 43404-87082
Date : 20-AUG-1987

TABLE I

SUMMARY OF CORE DATA

ZONE AND CUTOFF DATA		CHARACTERISTICS REMAINING AFTER CUTOFFS			
ZONE:		ZONE:		PERMEABILITY:	
Identification	FLOWER POT	Number of Samples	5		
Top Depth	31.3 ft	Thickness Represented	5.0 ft	Flow Capacity	6.1 md·ft
Bottom Depth	114.5 ft			Arithmetic Average	1.23 md
Number of Samples	5	POROSITY:		Geometric Average	0.443 md
				Harmonic Average	0.170 md
DATA TYPE:		Storage Capacity	139.1 Ø·ft	Minimum	0.050 md
		Arithmetic Average	27.8 %	Maximum	4.20 md
Porosity	HELIUM	Minimum	25.9 %	Median	0.290 md
Permeability	HORIZONTAL	Maximum	30.7 %	Standard Deviation	$10^{\pm0.242}$ md
		Median	27.1 %		
CUTOFFS:		Standard Deviation	±2.0 %	HETEROGENEITY (Permeability):	
Porosity (Minimum)	0.0 %	GRAIN DENSITY:		Variation	0.848
Permeability (Minimum)	0.0000 md			Lorenz Coefficient	0.659
Water Saturation (Maximum)		Arithmetic Average	2.57 gm/cc		
Oil Saturation (Minimum)		Minimum	2.54 gm/cc	AVERAGE SATURATIONS (Pore Volume):	
Grain Density (Minimum)	2.00 gm/cc	Maximum	2.61 gm/cc		
Grain Density (Maximum)	3.00 gm/cc	Median	2.58 gm/cc	Oil	
Lithology Excluded	NONE	Standard Deviation	±0.03 gm/cc	Water	

CORE LABORATORIES, INC.

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-11

MAJOR, OKLAHOMA

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT
Coring Fluid :
Elevation :

File : 43404-87082
Date : 20-AUG-1987
API No. :
Analysts: MCH

CORE ANALYSIS RESULTS

SAMPLE NUMBER	DEPTH ft	PERMEABILITY (HORIZONTAL) Kair md	PERMEABILITY (VERTICAL) Kair md	POROSITY (HELIUM) %	GRAIN DENSITY gm/cc	DESCRIPTION
1	36.0	0.013	0.030	29.2	2.66	Clst rdsh gyp

CORE LABORATORIES, INC.

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-13

MAJOR, OKLAHOMA

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT
Coring Fluid :
Elevation :

File : 43404-87082
Date : 20-AUG-1987
API No. :
Analysts: MCH

CORE ANALYSIS RESULTS

SAMPLE NUMBER	DEPTH	PERMEABILITY		POROSITY (HELIUM)	GRAIN DENSITY	DESCRIPTION
		(HORIZONTAL) Kair	(VERTICAL) Kair			
	ft	md	md	%	gm/cc	
1	43.5	0.040	0.040	26.7	2.65	Clst rdsh gyp
2	67.0	0.030	0.040	26.2	2.58	Clst rdsh gyp

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-13

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT

File : 43404-87082
Date : 20-AUG-1987

TABLE I

SUMMARY OF CORE DATA

ZONE AND CUTOFF DATA

ZONE:

Identification	FLOWER POT
Top Depth	43.5 ft
Bottom Depth	67.0 ft
Number of Samples	2

DATA TYPE:

Porosity	HELIUM
Permeability --	HORIZONTAL

CUTOFFS:

Porosity (Minimum)	0.0 %
Permeability (Minimum) ...	0.0000 md
Water Saturation (Maximum)	
Oil Saturation (Minimum) .	
Grain Density (Minimum) ..	2.00 gm/cc
Grain Density (Maximum) ..	3.00 gm/cc
Lithology Excluded	NONE

CHARACTERISTICS REMAINING AFTER CUTOFFS

ZONE:

Number of Samples	2
Thickness Represented -	2.0 ft

POROSITY:

Storage Capacity	52.9 Ø-ft
Arithmetic Average	26.5 %
Minimum	26.2 %
Maximum	26.7 %
Median	26.5 %
Standard Deviation	0.4 %

GRAIN DENSITY:

Arithmetic Average	2.62 gm/cc
Minimum	2.58 gm/cc
Maximum	2.65 gm/cc
Median	2.62 gm/cc
Standard Deviation	0.05 gm/cc

PERMEABILITY:

Flow Capacity	0.1 md·ft
Arithmetic Average	0.035 md
Geometric Average	0.035 md
Harmonic Average	0.034 md
Minimum	0.030 md
Maximum	0.040 md
Median	0.035 md
Standard Deviation	0.0 md

HETEROGENEITY (Permeability):

Variation	0.000
Lorenz Coefficient	0.077

AVERAGE SATURATIONS (Pore Volume):

Oil	
Water	

C O R E   L A B O R A T O R I E S,   I N C.

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-14

MAJOR, OKLAHOMA

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT
Coring Fluid :
Elevation :

File : 43404-87082
Date : 20-AUG-1987
API No. :
Analysts: MCH

CORE ANALYSIS RESULTS

SAMPLE NUMBER	DEPTH	PERMEABILITY		POROSITY (HELIUM)	GRAIN DENSITY	DESCRIPTION
		(HORIZONTAL) Kair	(VERTICAL) Kair			
	ft	md	md	%	gm/cc	
1	72.5	0.270	0.050	22.7	2.54	Clst gry gyp
2	91.0	0.130	0.030	26.2	2.57	Clst rdsh gyp
3	109.0	0.210		23.0	2.58	Clst rdsh gyp
4	167.0	122.	54.0	21.1	2.48	Clst rdsh gyp uncons
5	225.0	0.690	0.230	21.9	2.59	Clst rdsh gyp
6	330.0	5.00	0.060	20.1	2.56	Clst rdsh gyp
7	364.5	1.40		10.2	2.51	Clst rdsh gyp
	392.8					SAMPLE FAILED

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS	Field : LONE MOUNTAIN FACILITY	File : 43404-87082
TB-14	Formation : FLOWER POT	Date : 20-AUG-1987

TABLE I

SUMMARY OF CORE DATA

ZONE AND CUTOFF DATA

ZONE:

Identification ···········	FLOWER POT
Top Depth ···············	72.5 ft
Bottom Depth ·············	364.5 ft
Number of Samples ········	7

DATA TYPE:

Porosity ······	HELIUM
Permeability ··	HORIZONTAL

CUTOFFS:

Porosity (Minimum) ·······	0.0 %
Permeability (Minimum) ···	0.0000 md
Water Saturation (Maximum)	
Oil Saturation (Minimum) ·	
Grain Density (Minimum) ··	2.00 gm/cc
Grain Density (Maximum) ··	3.00 gm/cc
Lithology Excluded ·······	NONE

CHARACTERISTICS REMAINING AFTER CUTOFFS

ZONE:

Number of Samples ·····	7
Thickness Represented ·	7.0 ft

POROSITY:

Storage Capacity ······	145.2 ø-ft
Arithmetic Average ····	20.7 %
Minimum ···············	10.2 %
Maximum ···············	26.2 %
Median ················	21.9 %
Standard Deviation ····	±5.0 %

GRAIN DENSITY:

Arithmetic Average ····	2.55 gm/cc
Minimum ···············	2.48 gm/cc
Maximum ···············	2.59 gm/cc
Median ················	2.56 gm/cc
Standard Deviation ····	±0.04 gm/cc

PERMEABILITY:

Flow Capacity ·········	129.7 md-ft
Arithmetic Average ····	18.5 md
Geometric Average ·····	1.23 md
Harmonic Average ······	0.378 md
Minimum ···············	0.130 md
Maximum ···············	122. md
Median ················	0.690 md
Standard Deviation ····	$10^{\pm 1.660}$ md

HETEROGENEITY (Permeability):

Variation ·············	0.769
Lorenz Coefficient ····	0.850

AVERAGE SATURATIONS (Pore Volume):

Oil ···················	
Water ·················	

C O R E   L A B O R A T O R I E S ,   I N C .

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS
TB-15

MAJOR, OKLAHOMA

Field : LONE MOUNTAIN FACILITY
Formation : FLOWER POT
Coring Fluid :
Elevation :

File : 43404-87082
Date : 20-AUG-1987
API No. :
Analysts: MCH

C O R E   A N A L Y S I S   R E S U L T S

SAMPLE NUMBER	DEPTH	PERMEABILITY		POROSITY (HELIUM)	GRAIN DENSITY	DESCRIPTION
		(HORIZONTAL) Kair	(VERTICAL) Kair			
	ft	md	md	%	gm/cc	
1	15.5	4.70	0.080	31.0	2.63	Clst gry v·crack
	31.0					SAMPLE FAILED
3	57.0	0.030		28.1	2.63	Clst rdsh gyp
4	63.5	0.380	0.060	28.9	2.62	Clst rdsh gyp
5	77.0	7.20	0.010	19.5	2.55	Clst rdsh gyp
6	86.5	0.570		21.0	2.50	Clst rdsh gyp

C O R E   L A B O R A T O R I E S ,   I N C .

U.S. POLLUTION CONTROL, INC. C\O MDK CONSULTANTS	Field : LONE MOUNTAIN FACILITY	File : 43404-87082
TB-15	Formation : FLOWER POT	Date : 20-AUG-1987

TABLE I

SUMMARY OF CORE DATA

ZONE AND CUTOFF DATA

ZONE:

Identification	FLOWER POT
Top Depth	15.5 ft
Bottom Depth	86.5 ft
Number of Samples	5

DATA TYPE:

Porosity	HELIUM
Permeability	HORIZONTAL

CUTOFFS:

Porosity (Minimum)	0.0 %
Permeability (Minimum)	0.0000 md
Water Saturation (Maximum)	
Oil Saturation (Minimum)	
Grain Density (Minimum)	2.00 gm/cc
Grain Density (Maximum)	3.00 gm/cc
Lithology Excluded	NONE

CHARACTERISTICS REMAINING AFTER CUTOFFS

ZONE:

Number of Samples	5
Thickness Represented	5.0 ft

POROSITY:

Storage Capacity	128.5 Ø-ft
Arithmetic Average	25.7 %
Minimum	19.5 %
Maximum	31.0 %
Median	28.1 %
Standard Deviation	±5.1 %

GRAIN DENSITY:

Arithmetic Average	2.59 gm/cc
Minimum	2.50 gm/cc
Maximum	2.63 gm/cc
Median	2.62 gm/cc
Standard Deviation	±0.06 gm/cc

PERMEABILITY:

Flow Capacity	12.9 md-ft
Arithmetic Average	2.58 md
Geometric Average	0.739 md
Harmonic Average	0.131 md
Minimum	0.030 md
Maximum	7.20 md
Median	0.570 md
Standard Deviation	$10^{\pm 0.507}$ md

HETEROGENEITY (Permeability):

Variation	0.941
Lorenz Coefficient	0.660

AVERAGE SATURATIONS (Pore Volume):

Oil	
Water	

HYDRAULIC CONDUCTIVITY
CORE TEST DATA
(Lone Mountain - U.S.P.C.I Project)

TABLE E-6.7

BORING	DEPTH	ORIENTATION- HORIZONTAL/ VERTICAL	UNCONFINED AQUIFER	UNCONFINED AQUITARD	AQUICLUDE	UPPER CONFINED AQUIFER	CONFINED AQUITARD	LOWER CONFINED AQUIFER
TB-1								
(0-256)	203.4	# HORIZONTAL	1.25E-05	*	*	*	*	*
(256-311)	254.3	# HORIZONTAL	3.03E-06	*	*	*	*	*
(311-328)	314.5	# HORIZONTAL	*	*	6.77E-06	*	*	*
TB-2								
(0-264)	137.0	# HORIZONTAL	2.14E-05	*	*	*	*	*
(264-317)	164.0	# HORIZONTAL	2.23E-05	*	*	*	*	*
(317-332)	273.4	# HORIZONTAL	*	1.15E-04	*	*	*	*
TB-3								
(0-105)	49.5	# HORIZONTAL	2.50E-05	*	*	*	*	*
(105-174)	73.0	# HORIZONTAL	5.08E-06	*	*	*	*	*
(174-179)			*	*	*	*	*	*
TB-4								
(0-99)	43.5	# HORIZONTAL	4.19E-05	*	*	*	*	*
(99-172)		# VERTICAL	6.24E-08	*	*	*	*	*
(172-187)	67.5	# HORIZONTAL	6.02E-05	*	*	*	*	*
TB-5								
(0-71)	97.8	# HORIZONTAL	*	6.61E-03	*	*	*	*
(71-133)			*	*	*	*	*	*
(133-147)			*	*	*	*	*	*
TB-6								
(0-69)	31.3	# HORIZONTAL	3.74E-06	*	*	*	*	*
(69-117)		# VERTICAL	6.24E-08	*	*	*	*	*
(117-132)	41.8	HORIZONTAL	1.25E-06	*	*	*	*	*
		VERTICAL	3.56E-08	*	*	*	*	*
	77.0	HORIZONTAL	*	2.58E-07	*	*	*	*
	97.7	HORIZONTAL	*	4.46E-08	*	*	*	*
	114.5	HORIZONTAL	*	1.78E-07	*	*	*	*
		VERTICAL	*	2.67E-08	*	*	*	*
TB-11								
(0-36)	36.0	HORIZONTAL	1.16E-08	*	*	*	*	*
(36-82)		VERTICAL	2.67E-08	*	*	*	*	*
(82-98)			*	*	*	*	*	*
TB-13								
(0-32)	43.5	HORIZONTAL	*	3.56E-08	*	*	*	*
(32-86)		VERTICAL	*	3.56E-08	*	*	*	*
(86-103)	67.0	HORIZONTAL	*	2.67E-08	*	*	*	*
		VERTICAL	*	3.56E-08	*	*	*	*

HYDRAULIC CONDUCTIVITY
CORE TEST DATA
(Lone Mountain - U.S.P.C.I Project)

TABLE E-6.7

BORING	DEPTH	ORIENTATION- HORIZONTAL/ VERTICAL	UNCONFINED AQUIFER	UNCONFINED AQUITARD	AQUICLUDE	UPPER CONFINED AQUIFER	CONFINED AQUITARD	LOWER CONFINED AQUIFER
TB-14								
(0-62)	72.5	HORIZONTAL	#	2.41E-07	#	#	#	#
(62-92)		VERTICAL	#	4.46E-08	#	#	#	#
(92-107)	91.0	HORIZONTAL	#	1.16E-07	#	#	#	#
(107-181)		VERTICAL	#	2.67E-08	#	#	#	#
(181-342)	109.0	HORIZONTAL	#	#	#	1.87E-07	#	#
(342- +)	167.0	HORIZONTAL	#	#	#	1.09E-04	#	#
		VERTICAL	#	#	#	4.81E-05	#	#
	225.0	HORIZONTAL	#	#	#	#	6.15E-07	#
		VERTICAL	#	#	#	#	2.05E-07	#
	330.0	HORIZONTAL	#	#	#	#	4.46E-06	#
		VERTICAL	#	#	#	#	5.35E-08	#
	364.5	HORIZONTAL	#	#	#	#	#	1.25E-06
TB-15								
(0-37)	15.5	HORIZONTAL	4.19E-06	#	#	#	#	#
(37-63)		VERTICAL	7.13E-08	#	#	#	#	#
(63-79)	57.0	HORIZONTAL	#	2.67E-08	#	#	#	#
(79-153)	63.5	HORIZONTAL	#	#	3.39E-07	#	#	#
(153-313)		VERTICAL	#	#	5.35E-08	#	#	#
(313- +)	77.0	HORIZONTAL	#	#	6.42E-06	#	#	#
		VERTICAL	#	#	8.91E-09	#	#	#
	86.5	HORIZONTAL	#	#	#	5.08E-07	#	#
HORIZONTAL TEST AVERAGE		(TB-6 - TB-15, EXCEPT #)	1.81E-06	1.16E-07	3.38E-06	3.66E-05	2.54E-06	1.25E-06
VERTICAL TEST AVERAGE		(TB-6 - TB-15, EXCEPT #)	4.45E-08	3.38E-08	3.12E-08	4.81E-05	1.29E-07	#

#: -MOUNTED IN LEAD SLEEVES BECAUSE OF POOR SAMPLE INTEGRITY.
(Samples may not represent true reservoir values.)
-NOT USED IN TEST AVERAGE

NOT RECOMMENDED, BUT AVERAGE OF ALL TEST BORINGS AS FOLLOWS:

HORIZONTAL TEST AVERAGE	(INCLUDES ALL TEST BORINGS)	1.67E-05	6.73E-04	4.44E-06	3.66E-05	2.54E-06	1.25E-06
VERTICAL TEST AVERAGE	(INCLUDES ALL TEST BORINGS)	5.17E-08	3.38E-08	3.12E-08	1.29E-07	2.32E-07	#

HYDRAULIC CONDUCTIVITY
(cm/sec)

APPENDIX 3.11

PUMP TEST RESULTS

Pump Test (1988)

atomic adsorption technique. Samples are being analyzed biweekly by the laboratory at the Lone Mountain Facility. The samples are analyzed for the tracers and compared against preliminary background data. Concentrations (C) are compared to the initial concentrations (Co) in source wells by computing a ratio, C/Co, and plotted as a function of time. The arrival of a tracer to a receptor well will appear as a steep rise in the C/Co values with respect to time. The arrival of a tracer has not been noted in the receptor wells for the TNA and TNB wells which correspond to the shallow unconfined aquifer and the intermediate unconfined aquitard. Excursions of 0.4 to 0.5 in C/Co ratios have been noted in tracer nests TNC and TND. However, it is too early to determine if these are true tracer arrivals or if it is due to contamination by the bailer or due to fractures induced by hydrofracturing. Smaller variations in tracer concentration can be noted in all tracer nests and are attributed to variations in mixing of the water column and to residual quantities of tracer which were introduced when the test was initiated. Both printed data and graphs concerning this effort are found in Appendix E-6.5.

Pumping Tests

Pumping tests were conducted on two wells of the Cedar Hills nest; CHD and CHF. The data are included in Appendix E-6.6. The test data were analyzed using three computational methods to determine the in-situ hydraulic conductivity of the confined aquifers: (1) Jacob Method, (2) Theis Method, and (3) Hantush-Jacob Method. These methods are described in a USGS publication entitled Ground-Water Hydraulics, (Lohman, 1979). The analysis for each test are also included in Appendix E-6.6. These methods are based on transient drawdown data. Table E-6.5 compares the hydraulic conductivity and storage coefficiencies by the three methods.

TABLE E-6.5

COMBINED ANALYSES OF ALL PUMPING TEST DATA

Including: Theis, Jacob, & Hantush

(Lone Mountain - U.S.P.C.I. Project)

PUMP TEST INFO.	THEIS	JACOB	HANTUSH
CH D Pumping CH C Observation 02-18-88	K = 6.2 E-6 S = 2.16 E-2	K = 9.19 E-6 S = 9.53 E-3	K = 3.7 E-6 S = 8.12 E-3
CH F Pumping CH E Observation 02-22-88	K = 1.87 E-5 S = 6.89 E-4	K = 2.2 E-5 S = 5.14 E-4	K = 1.61 E-5 S = 8.6 E-5
CH F Pumping CH E Observation 03-01-88	K = 2.56 E-5 S = 8.25 E-4	K = 2.97 E-5 S = 7.45 E-3	K = 2.05 E-5 S = 8.84 E-5

K = Hydraulic conductivity; cm/sec.

S = Storage coefficient

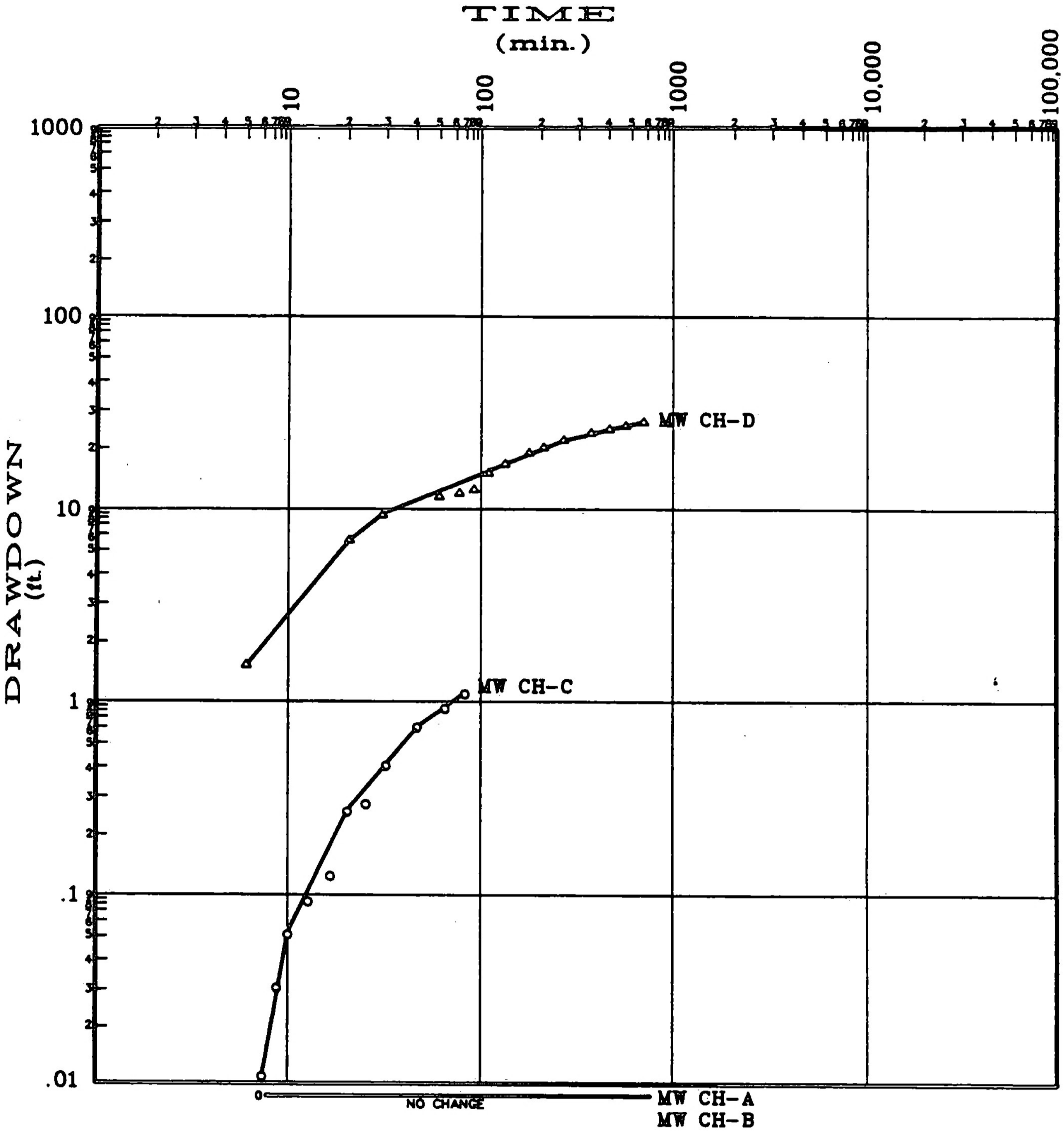
Two tests were conducted on MW-CHF on February 18, 1988, and March 1, 1988. The pumping well was CHF, and CHE was used as an observation well. Both wells were screened over the same interval of the Cedar Hills Sandstone or Lower Confined Aquifer. A one and one-half (1 1/2) horsepower submersible pump was used set at a depth of 330 feet. The discharge rates were 2.6 gpm and 1.25 gpm. The pumping test duration was twenty-nine (29) hours and forty-three (43) hours, respectively.

A third test was conducted at CHD on February 18, 1988. The pumping well was CHD, and CHC was used as an observation well. Both wells were screened in the upper confined aquifer but at different intervals. The pumping rate was 0.1 gpm using the Well Wizard^R sampling pump which was installed in the well. The duration of the test was twelve (12) hours.

A deeper Cedar Hill Sandstone observation well, OW-7, and two shallower wells, MW-CHA and MW-CHB, were also monitored during the tests. Drawdown responses in all wells are shown in Figs. E-6.5, E-6.6, and E-6.7. The OW-7 well responded slowly. MW-CHA and MW-CHB did not respond to pumping from any of the tests for either upper or lower confined aquifers. The lack of response in MW-CHA and CHB over a forty-three hour period is indicative of no vertical leakage from the shallow unconfined aquifer or aquitard. It was concluded that an aquiclude exists between the unconfined and confined interval.

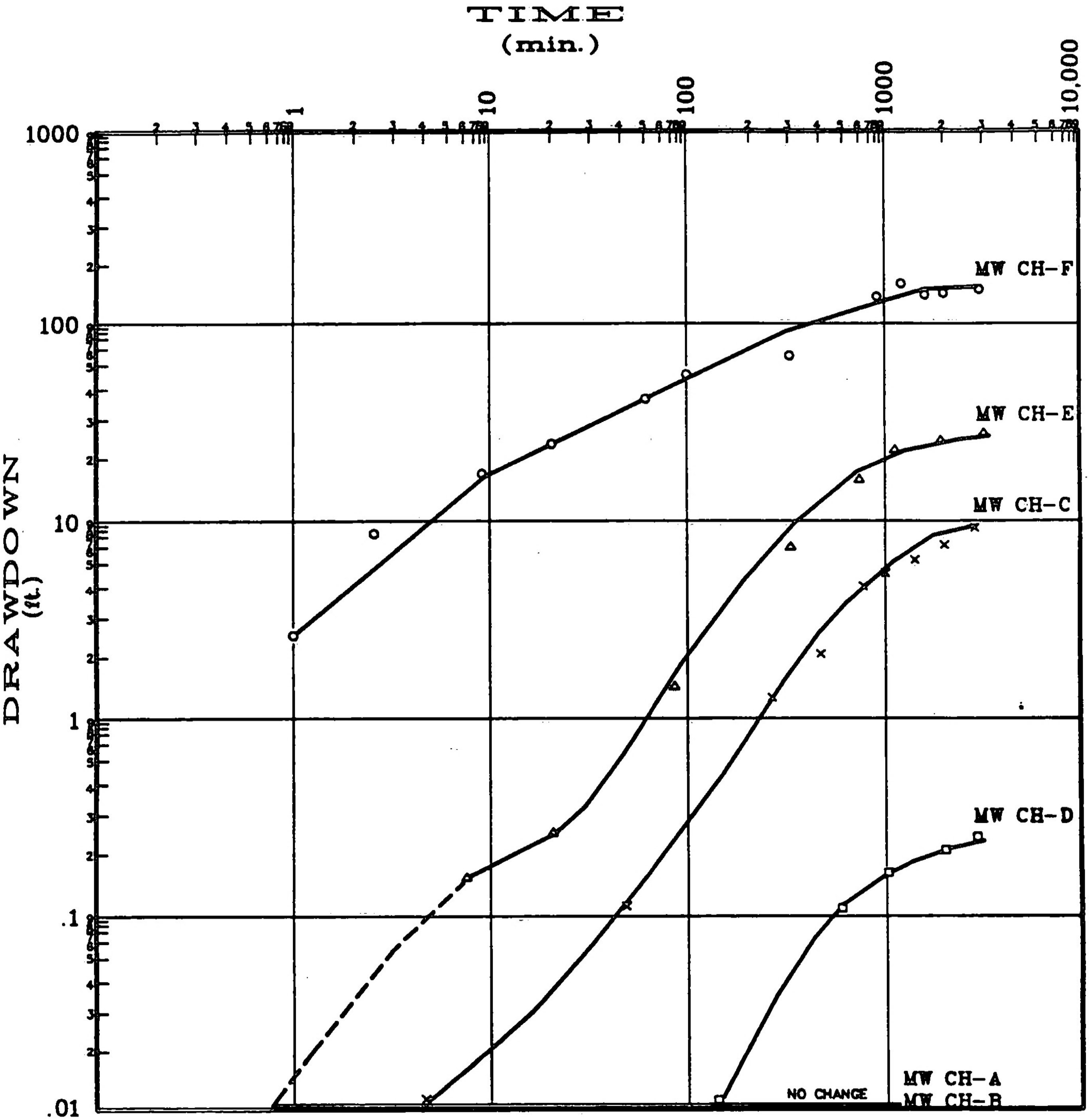
Summary of Hydraulic Data

Hydraulic conductivity data from laboratory cores, slug tests, and packer tests were compared with depth elevations in the scatter diagrams which were included as Figures 10, 11, and 12 of the Site Characterization Study. Data appeared to be distributed randomly over four orders of magnitude (1×10^{-8} to 1×10^{-4} cm/sec). Vertical and horizontal



WELL RESPONSE GRAPH
PUMPING WELL MW CH–D
2–17–88

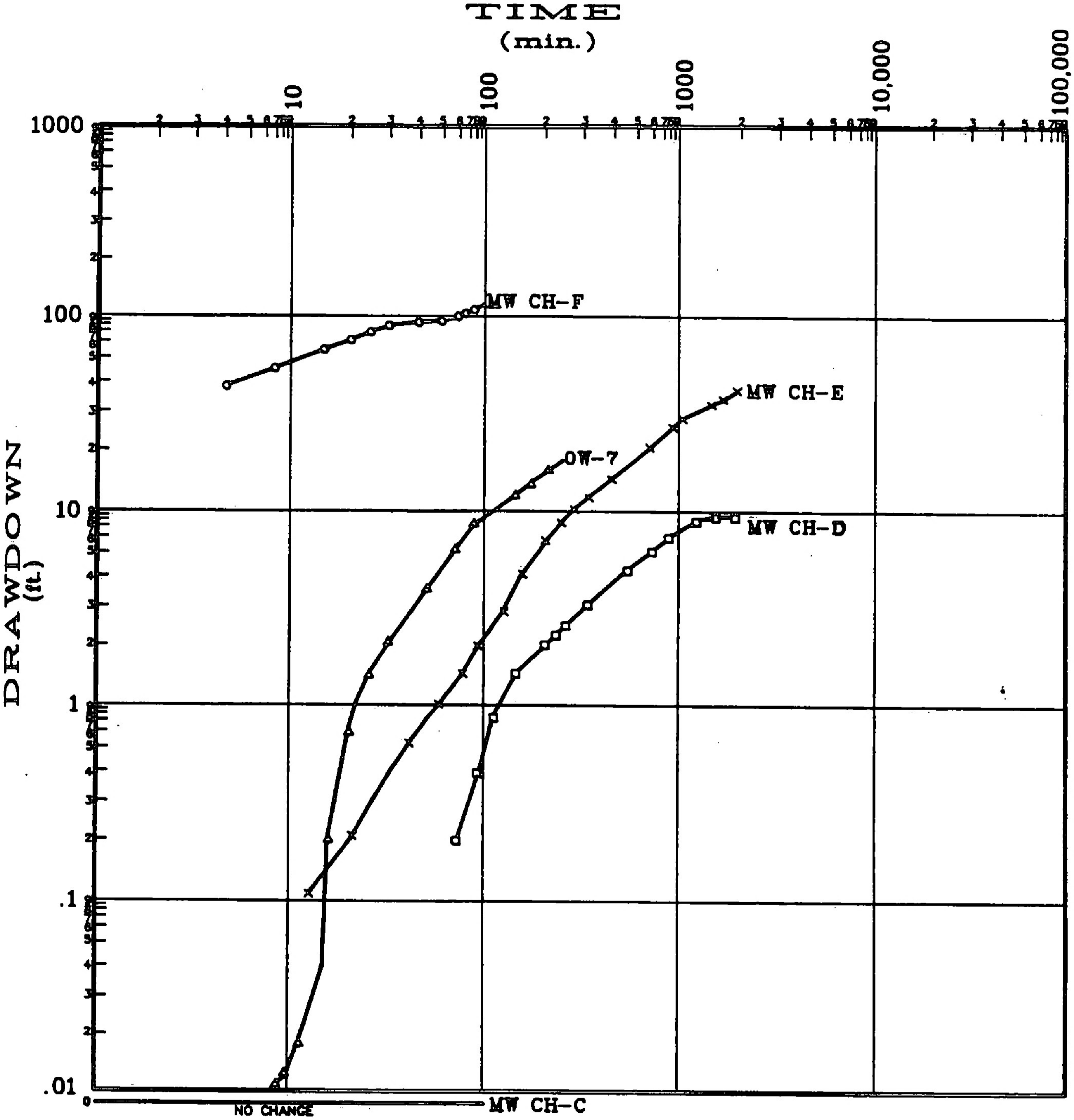
FIG. E-6.5



WELL RESPONSE GRAPH
PUMPING WELL MW CH-F

2-22-88

FIG. E-6.6



WELL RESPONSE GRAPH
PUMPING WELL MW CH–F

3–1–88

FIG. E-6.7

PUMPING TEST CH F 1
OBSERVATION WELLS CH C, CH D, AND CH E
02-22-88 thru 02-24-88
(Lone Mountain - U.S.P.C.I. Project)

ELL CH F **PUMPING**

Static water level @ 12:45 p.m., 02-22-88 = 12.3

Pumping began @ 1:00 p.m., 02-22 and ended @ 8:59 a.m., 02-23.

DATE	MINUTES	DEPTH	CHANGE
02-22-88	0	13.00	0.70
	1	14.80	2.50
	2	17.47	5.17
	3	21.26	8.96
	6	24.82	12.52
	9	27.12	14.82
	13	30.48	18.18
	19	35.48	23.18
	27	41.14	28.84
	39	47.69	35.39
	53	53.69	41.39
	64	57.57	45.27
	78	61.61	49.31
	101	66.34	54.04
	141	71.70	59.40
	161	74.07	61.77
	241	76.16	63.86
	304	85.22	72.92
	387	97.27	84.97
	519	104.72	92.42
02-23-88	716	104.42	92.12
	850	130.50	118.20
	970	138.05	125.75
	1,154	146.80	134.50
	1,499	120.23	107.93
	1,516	119.17	106.87
	1,576	115.50	103.20
	1,624	114.85	102.55
	1,725	114.15	101.85
	* 1,780	111.70	99.40
	1,790	113.30	101.10
	1,936	122.45	110.15
	2,073	127.80	115.50
02-24-88	2,161	132.20	119.90
	2,299	138.69	126.39
	2,640	138.70	126.40

Pumping ceased.

* Pump stopped for 30 seconds.

PUMPING TEST CH F 1
OBSERVATION WELLS CH C, CH D, AND CH E
02-22-88 thru 02-24-88
(Lone Mountain - U.S.P.C.I. Project)

WELL CH C OBSERVATION

Static water level @ 1:00 p.m., 02-22-88 = 6.39

Well observed 1:00 p.m., 02-22-88 thru 8:58 a.m., 02-24-88.

DATE	MINUTES	DEPTH	CHANGE
02-22-88	15	6.39	0.00
	23	6.40	0.01
	56	6.38	0.00
	67	6.38	0.00
	82	6.38	0.00
	107	6.38	0.00
	145	6.38	0.00
	175	6.42	0.03
	244	6.45	0.06
	309	6.48	0.09
	392	6.52	0.13
	523	6.60	0.21
	723	6.70	0.30
	972	6.85	0.46
	1,161	6.96	0.57
	1,327	7.05	0.66
02-23-88	1,491	7.13	0.74
	1,579	7.16	0.77
	1,627	7.19	0.80
	1,726	7.22	0.83
	1,783	7.42	1.03
	1,940	7.30	0.90
	2,077	7.37	0.98
02-24-88	2,164	7.37	0.98
	2,296	7.42	1.03
	2,504	7.50	1.11
	2,638	7.52	1.13

PUMPING TEST CH F 1
OBSERVATION WELLS CH C, CH D, AND CH E
02-22-88 thru 02-24-88
(Lone Mountain - U.S.P.C.I. Project)

WELL CH D OBSERVATION

Static water level @ 12:49 p.m., 02-22-88 = 5.97

Well observed 12:49 p.m., 02-22-88 thru 8:57 a.m., 02-24-88.

DATE	MINUTES	DEPTH	CHANGE
02-22-88	4	5.97	0.00
	17	6.00	0.03
	24	6.02	0.05
	28	6.05	0.08
	45	6.08	0.11
	58	6.15	0.18
	69	6.19	0.22
	84	6.28	0.31
	109	6.44	0.47
	147	6.65	1.13
	177	6.82	0.85
	246	7.32	1.35
	310	7.69	1.72
	394	8.07	2.10
	525	8.52	2.55
02-23-88	724	9.20	3.23
	857	9.73	3.76
	974	10.29	4.32
	1,163	11.05	5.08
	1,331	11.52	5.55
	1,493	11.90	5.93
	1,583	12.10	6.13
	1,631	12.19	6.22
	1,728	12.38	6.41
	1,785	12.52	6.55
	1,942	12.90	6.93
	2,079	13.13	7.16
02-24-88	2,166	13.30	7.33
	2,298	13.62	7.65
	2,506	14.15	8.18
	2,640	14.43	8.46

PUMPING TEST CH F 1
OBSERVATION WELLS CH C, CH D, AND CH E
02-22-88 thru 02-24-88
(Lone Mountain - U.S.P.C.I. Project)

WELL CH E OBSERVATION

Static water level @ 12:48 p.m., 02-22-88 = 1.00

Well observed 1:00 p.m., 02-22-88 thru 8:54 a.m., 02-24-88.

DATE	MINUTES	DEPTH	CHANGE
02-22-88	7	1.15	0.15
	13	1.16	0.16
	20	1.26	0.26
	29	1.32	0.32
	41	1.46	0.46
	54	1.64	0.64
	65	1.82	0.82
	80	2.05	1.05
	105	2.45	1.45
	143	3.30	2.30
	173	3.88	2.88
	243	5.32	4.32
	306	6.59	5.59
	390	8.33	7.33
	520	10.73	9.73
02-23-88	699	13.57	12.57
	832	15.16	14.16
	956	17.04	16.04
	1,140	19.30	18.30
	1,304	22.00	21.00
	1,469	20.56	19.56
	1,493	20.63	19.63
	1,560	20.70	19.70
	1,604	20.75	19.75
	1,704	20.84	19.84
	1,761	20.87	19.87
	1,917	21.16	20.16
	2,055	21.64	20.64
02-24-88	2,142	21.98	20.98
	2,273	22.72	21.72
	2,482	23.72	22.72
	2,624	24.50	23.50

PUMPING TEST CH F 2
OBSERVATION WELL CHE
03-01-88 thru 03-02-88
(Lone Mountain - U.S.P.C.I. Project)

WELL CH F PUMPING

Static water level @ 10:55 a.m., 03-01-88 = 7.81

Pumping began @ 11:36 a.m., 03-01 and ended @

DATE	MINUTES	DEPTH	CHANGE
03-01-88	0	7.81	0.00
	4	45.95	38.14
	6	50.19	42.38
	7	53.11	45.30
	9	55.80	47.99
	11	59.00	51.19
	13	61.90	54.09
	15	65.10	57.29
	17	69.28	61.47
	19	71.40	63.59
	21	73.55	65.74
	23	76.00	68.19
	25	78.56	70.75
	27	80.90	73.09
	29	83.20	75.39
	31	85.40	77.59
	33	87.51	79.70
	35	89.53	81.72
	37	91.32	83.51
	39	93.22	85.41
	41	95.10	87.29
	44	97.73	89.92
	47	100.00	92.19
	50	102.42	94.61
	53	104.50	96.69
	56	106.20	98.39
	59	106.50	98.69
	63	107.76	99.95
	67	108.57	100.76
	76	117.80	109.99

PUMPING TEST CH F 2
OBSERVATION WELL CHE
03-01-88 thru 03-02-88
(Lone Mountain - U.S.P.C.I. Project)

WELL CH E OBSERVATION

Static water level @ 10:50 a.m., 03-01-88 = 0.00

Well observed 11:36 a.m., 03-01-88 thru 4:50 p.m., 03-02-88.

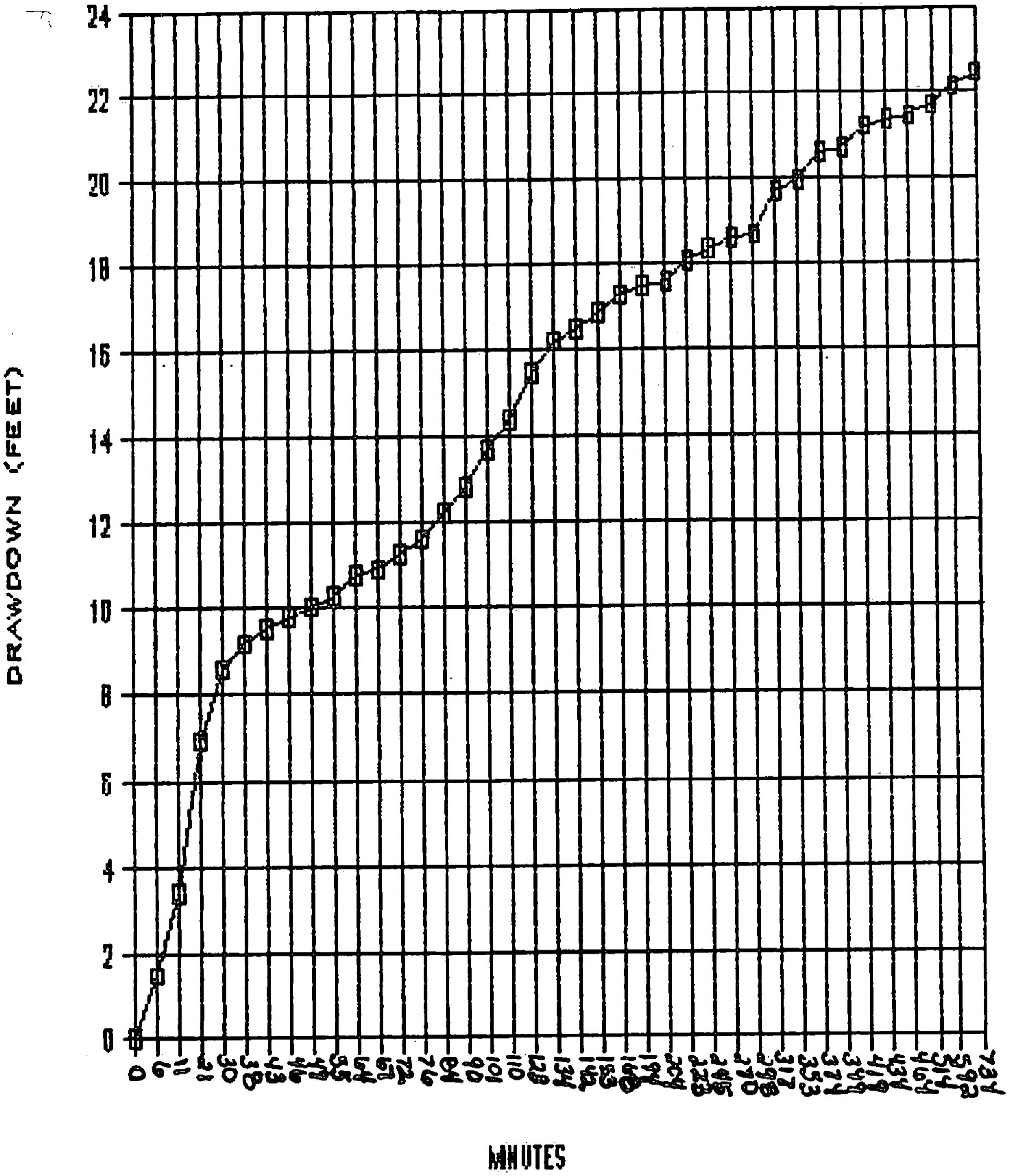
DATE	MINUTES	DEPTH	CHANGE
03-01-88	0	0.00	0.00
	4	0.00	0.00
	6	0.00	0.00
	7	0.00	0.00
	9	0.00	0.00
	11	0.00	0.00
	13	0.10	0.10
	15	0.14	0.14
	17	0.19	0.19
	19	0.20	0.20
	21	0.23	0.23
	23	0.26	0.26
	25	0.29	0.29
	27	0.33	0.33
	29	0.38	0.38
	31	0.40	0.40
	33	0.44	0.44
	35	0.49	0.49
	37	0.53	0.53
	39	0.58	0.58
	41	0.62	0.62
	44	0.68	0.68
	47	0.77	0.77
	50	0.85	0.85
	53	0.90	0.90
	56	1.00	1.00
	59	1.10	1.10
	63	1.23	1.23
	67	1.32	1.32
	71	1.47	1.47
	76	1.64	1.64
	81	1.84	1.84
	86	2.00	2.00
	91	2.35	2.35
	98	2.48	2.48

PUMPING TEST CH F 2
OBSERVATION WELL CHE
03-01-88 thru 03-02-88
(Lone Mountain - U.S.P.C.I. Project)

DATE	MINUTES	DEPTH	CHANGE
03-01-88	103	2.60	2.60
	107	2.77	2.77
	112	2.91	2.91
	128	3.53	3.53
	136	3.88	3.88
	144	4.25	4.25
	161	4.98	4.98
	171	5.33	5.33
	181	5.84	5.84
	196	6.72	6.72
	219	7.69	7.69
	234	8.26	8.26
	249	8.90	8.90
	264	9.50	9.50
	292	10.62	10.62
	324	11.87	11.87
	354	12.91	12.91
	384	13.96	13.96
	444	15.88	15.88
	504	17.32	17.32
	564	18.82	18.82
	624	20.17	20.17
	714	21.88	21.88
03-02-88	804	23.55	23.55
	894	24.74	24.74
	1044	26.85	26.85
	1224	28.69	28.69
	1434	30.81	30.81
	1554	31.70	31.70
	1644	31.73	31.73
	1674	31.77	31.77
	1704	31.78	31.78
	1734	31.78	31.78
	1754	31.78	31.78

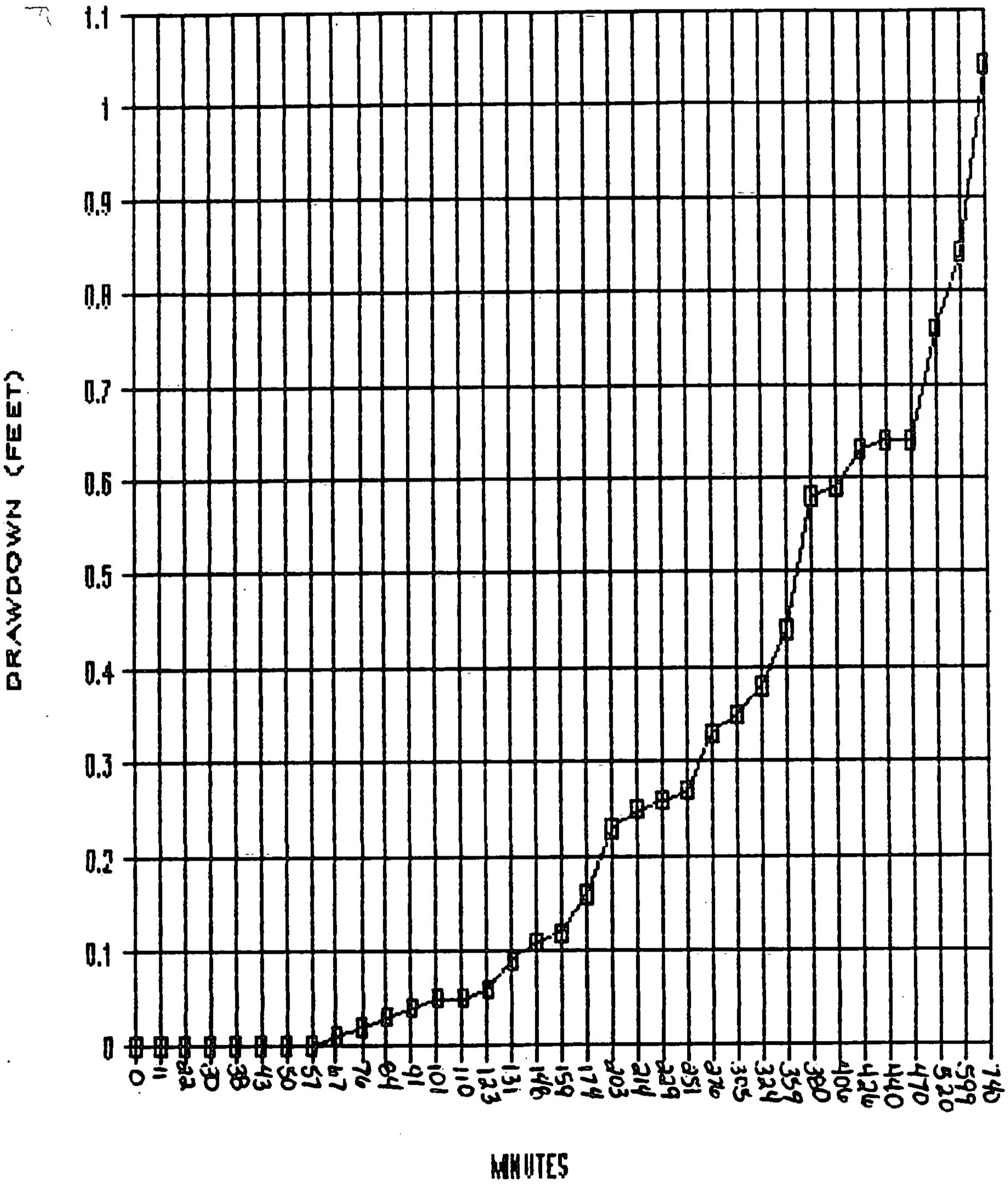
PUMP TEST CH D 1

WELL CH D PUMPING



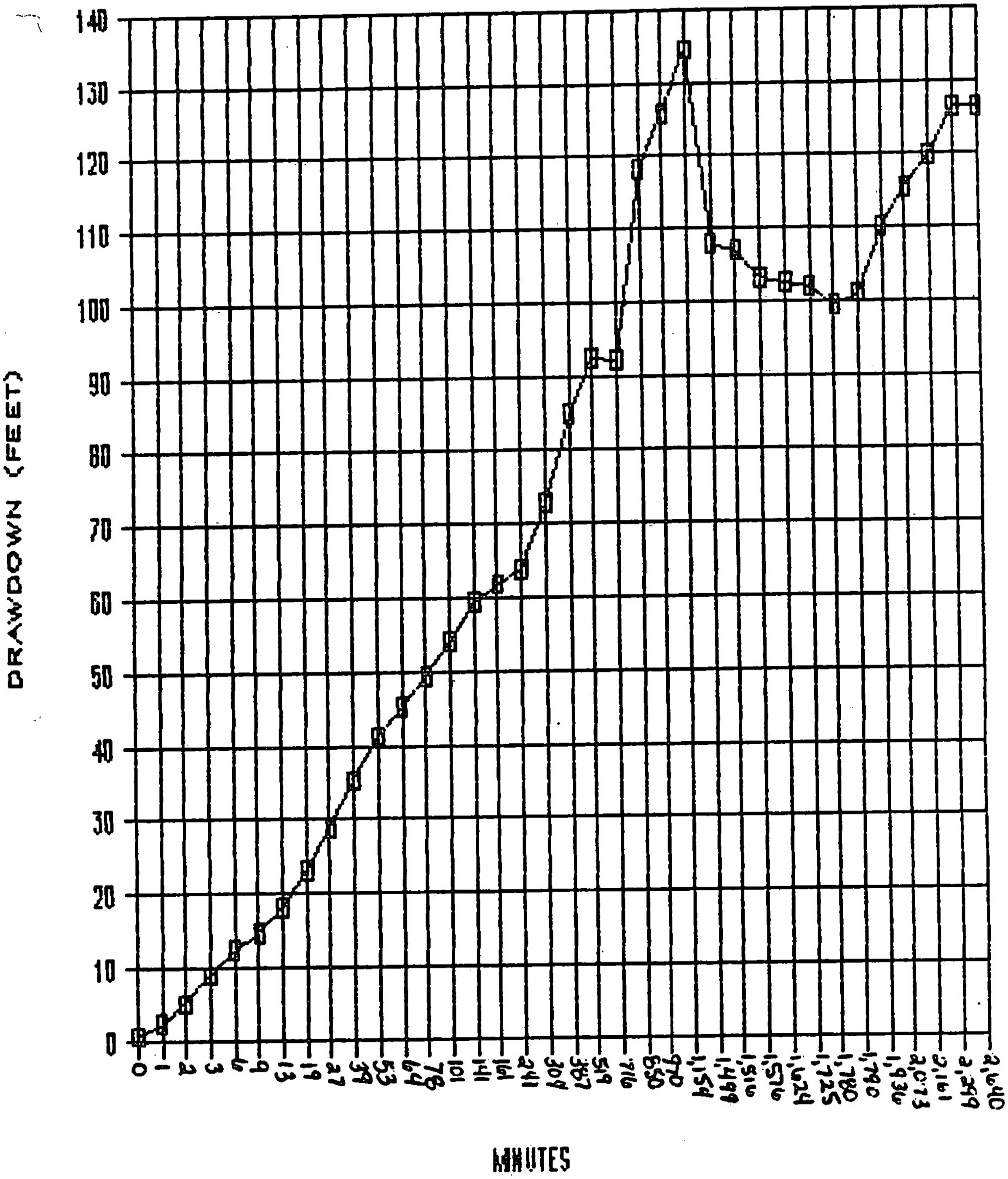
PUMP TEST CH D 1

WELL CH C OBSERVATION



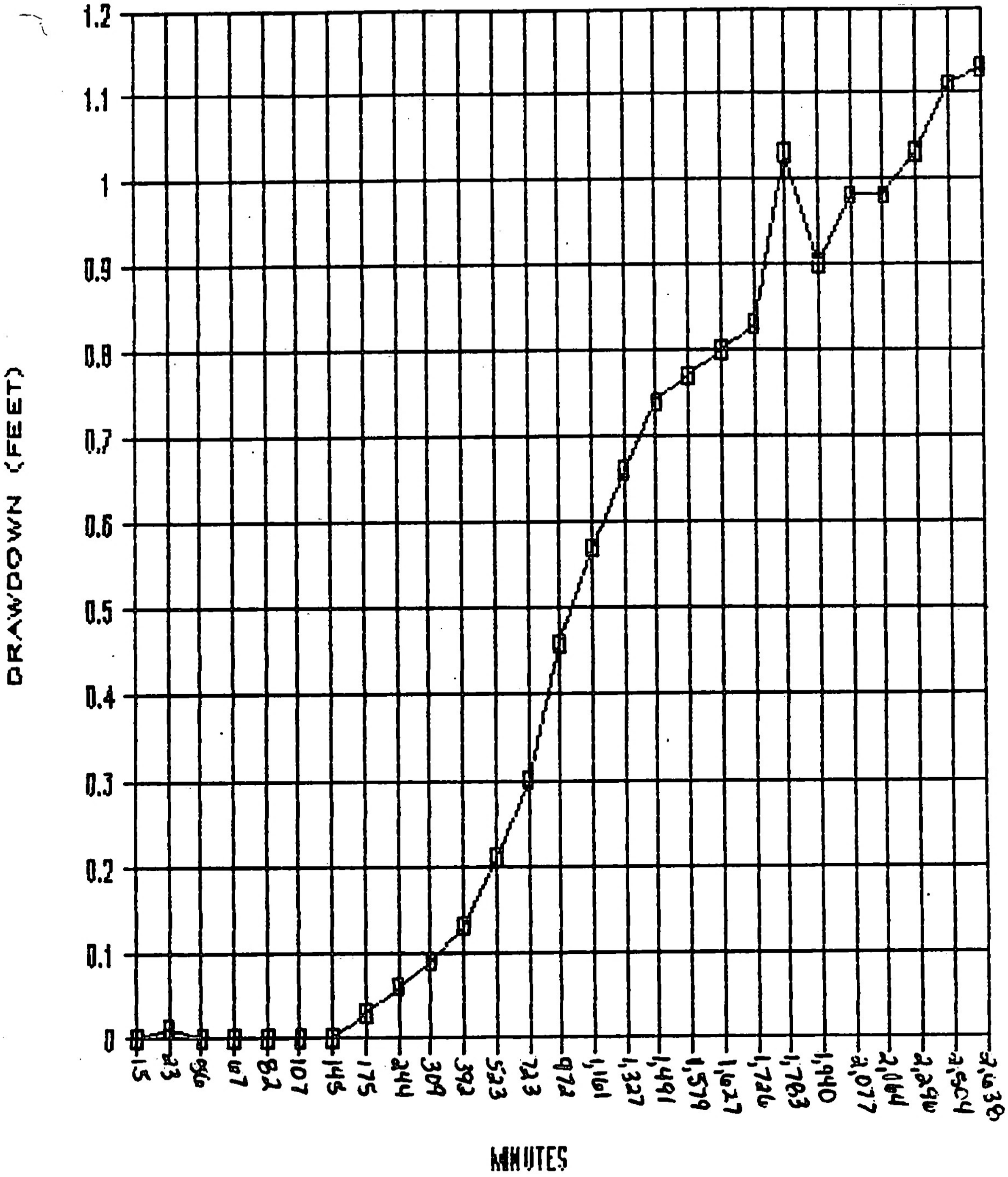
PUMP TEST CH F 1

WELL CH F PUMPING



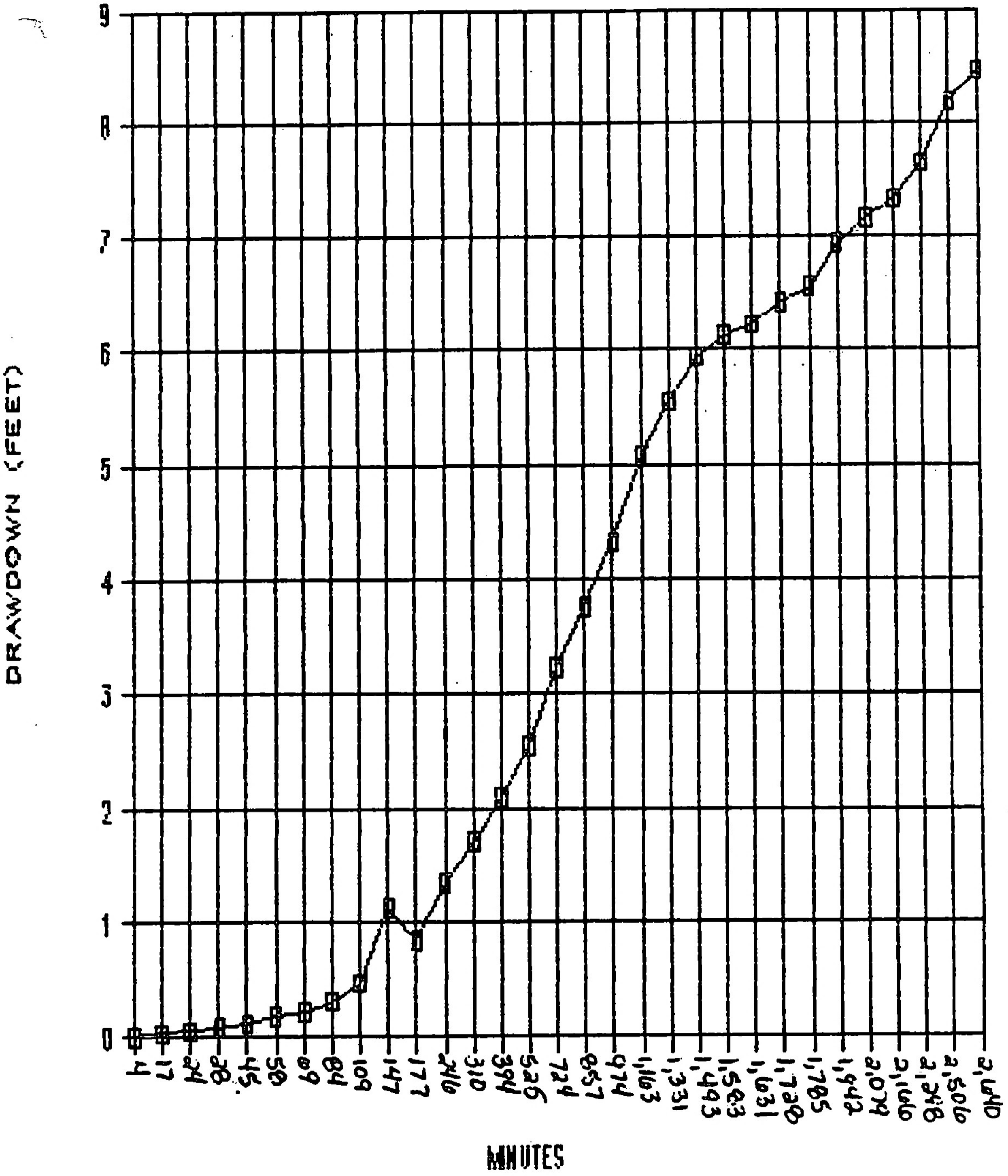
PUMP TEST CH F 1

WELL CH C OBSERVATION



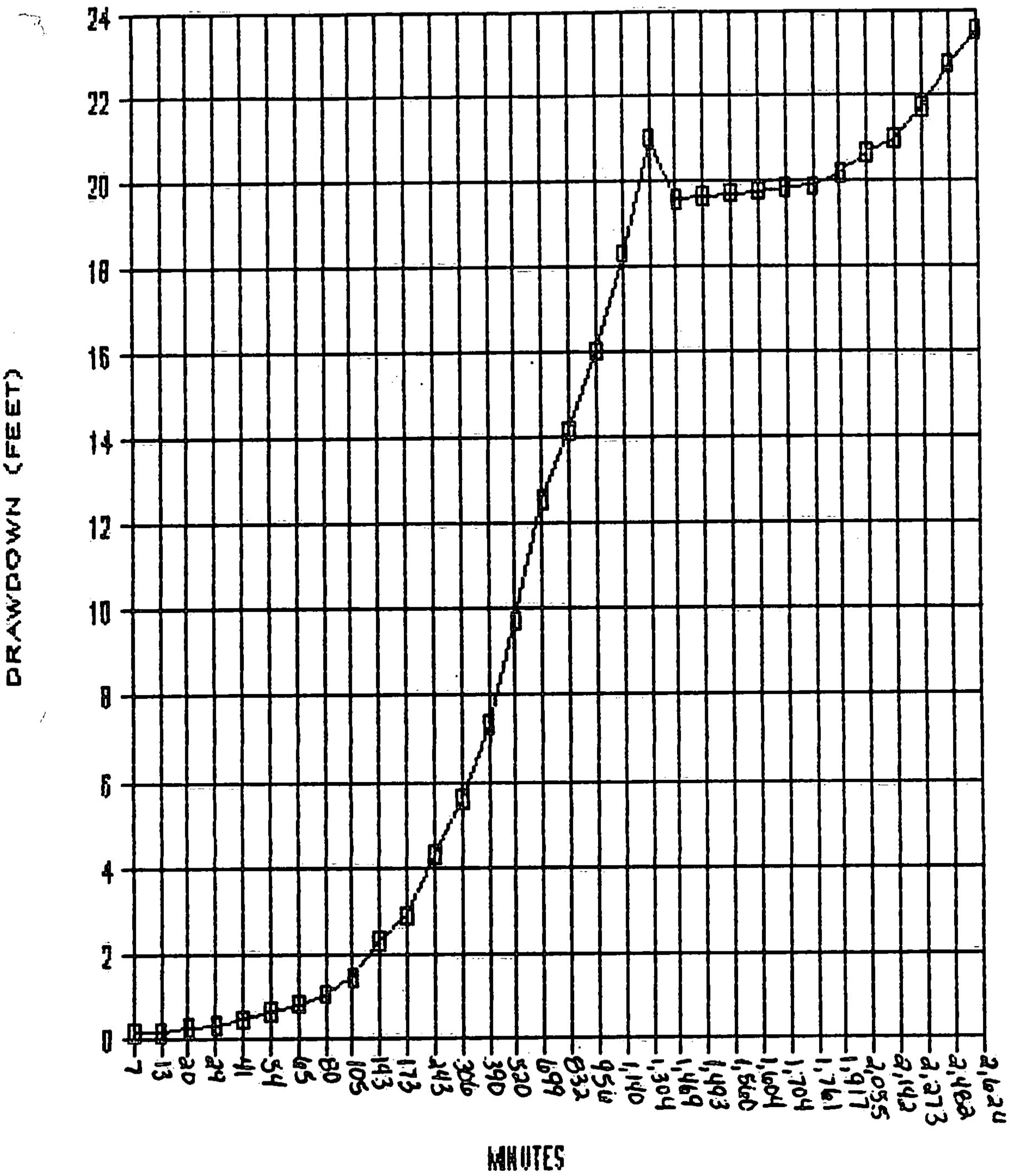
PUMP TEST CH F 1

WELL CH D OBSERVATION



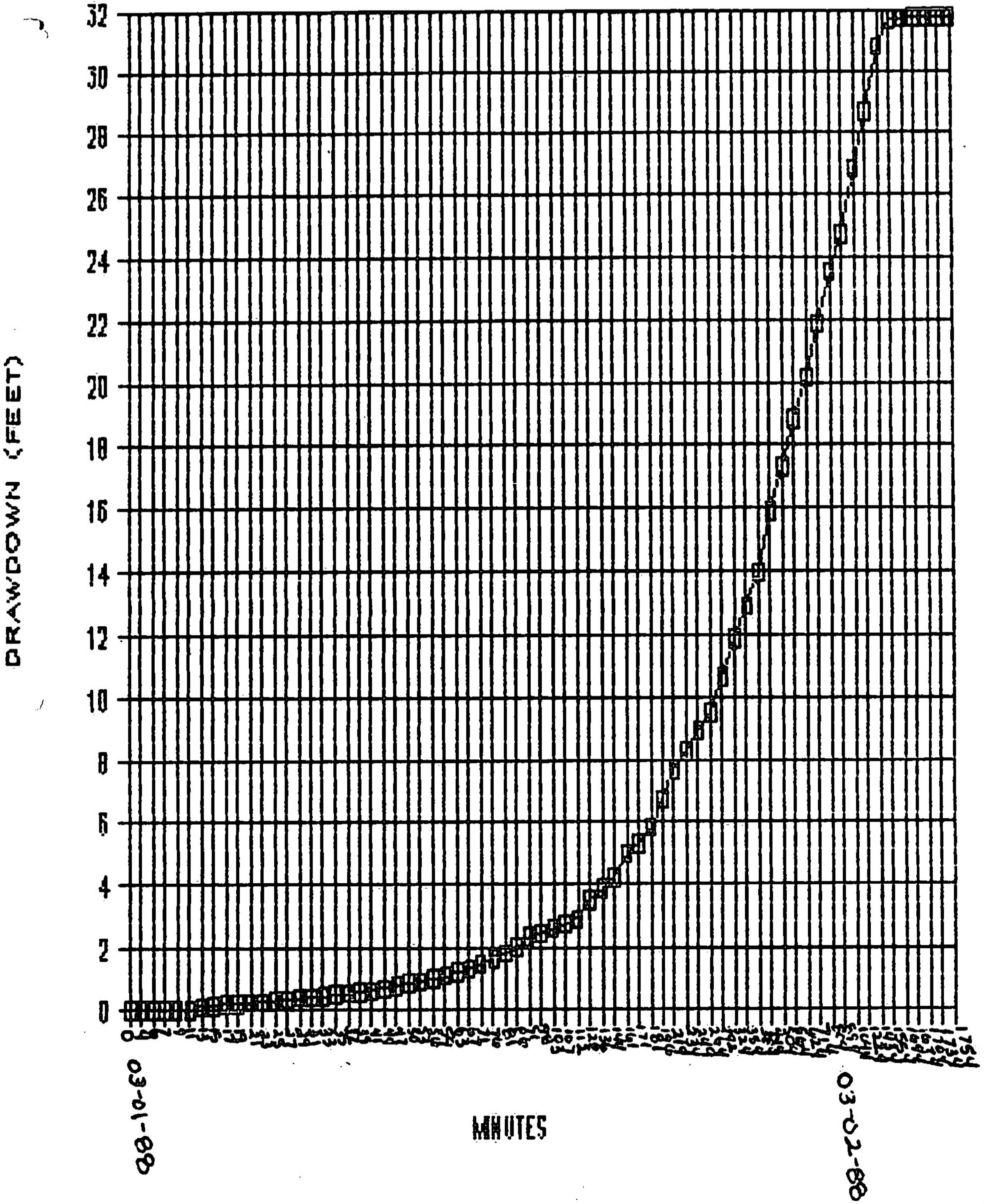
PUMP TEST CH F 1

WELL CH E OBSERVATION



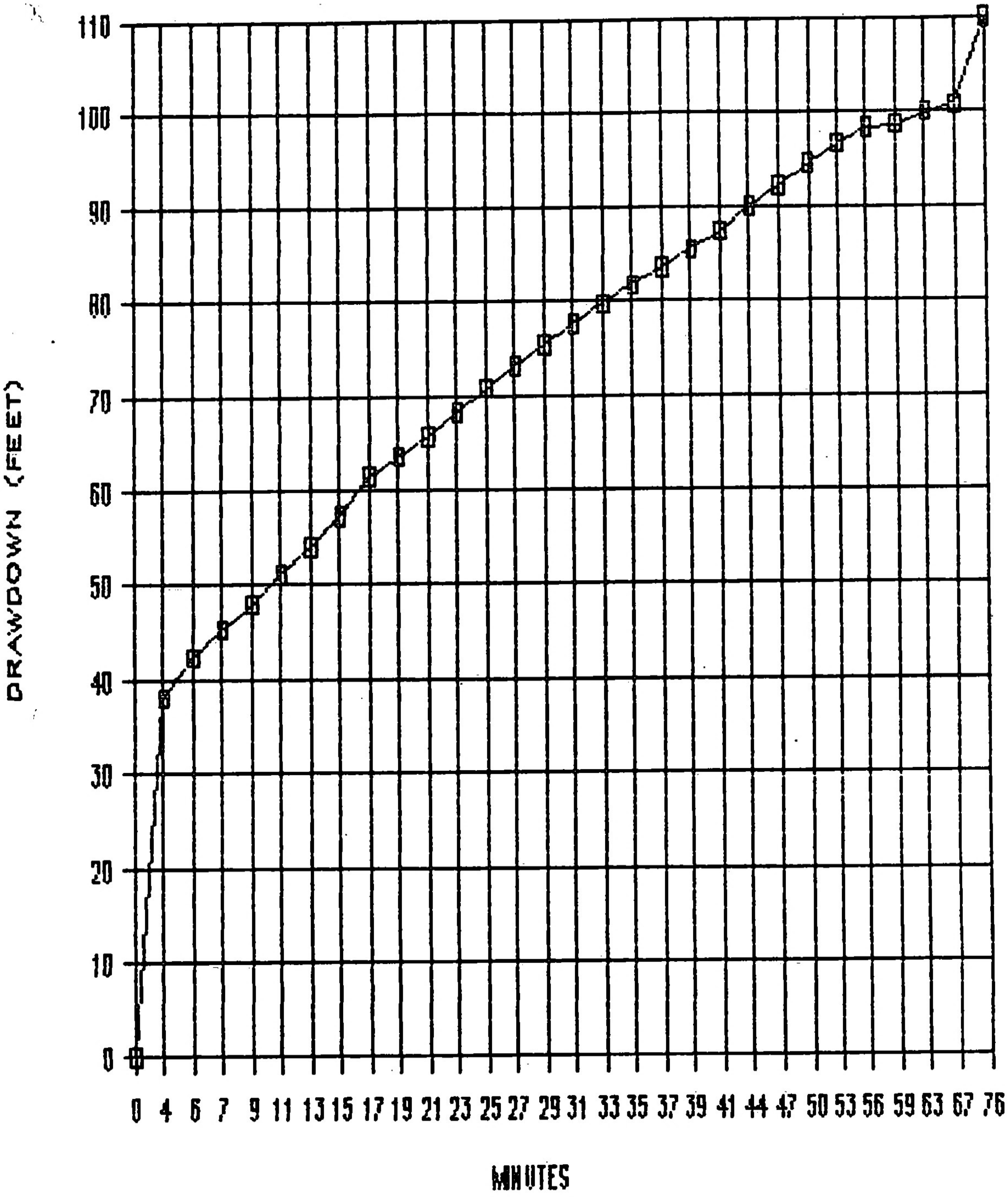
PUMP TEST CHF 2

WELL CH E OBSERVATION



PUMP TEST CH F 2

WELL CH F PUMPING



ANALYSIS OF PUMP TESTS

CH D 1, CH F 1, CH F 2

USING METHODS I & II

(Lone Mountain - U.S.P.C.I. Project)

METHOD I: COOPER-JACOB SOLUTION

EXPLANATION

T = (35)(Q)/(Change)(S)

where:

Q = discharge in gal/min.

(Change)(S) = drawdown change over 1 log cycle of the straight-line portion of the graph.

T = transmissivity; ft^2/day

K = T/b

where:

T = transmisivity; ft^2/sec.

b = screen length + sand pack above screen

K = hydraulic conductivity; cm/sec.

$S = (2.25)(T)(t_0)/r^2$

where:

T = transmissivity; m^2/day

t_0 = number of days

r = distance between the pumping well and the observation well; meters

S = storage coefficient

ANALYSIS OF PUMP TESTS; METHOD I: COOPER-JACOB; (CONT.)

PUMP TEST CH D 1: WELL CH C OBSERVATION (02-18-88)

T = (35)(Q)/(Change)(S)

where:

Q = 0.10 gal/min.

(Change)(S) = 1.84 ft.

$$T = \frac{35(0.10)}{1.84} = 1.90\ \text{ft}^2/\text{day}$$

$$= 2.20 \times 10^{-5}\ \text{ft}^2/\text{sec.}$$

K = T/b where: b = 73

$$K = \frac{2.20 \times 10^{-5}}{73} = 3.01 \times 10^{-7}\ \text{ft/sec.}$$

$$= 9.19 \times 10^{-6}\ \text{cm/sec.}$$

$S = (2.25)(T)(t_0)/r^2$ where:

$T = 0.17\ m^2/\text{day}$

t_0 = .0896 days

r = 1.89 m

$$S = \frac{(2.25)(0.17)(.0896)}{(1.89m)^2} = 9.53 \times 10^{-3}$$

PUMP TEST CH F 1: WELL CH E OBSERVATION (02-22-88)

$T = (35)(Q)/(\text{Change})(S)$

where:

$Q = 1.25$ gal/min.

$(\text{Change})(S) = 18.3$ ft.

$$T = \frac{35(1.25)}{18.3} = 2.39 \text{ ft}^2/\text{day}$$
$$= 2.7 \times 10^{-5} \text{ ft}^2/\text{sec.}$$

$K = T/b$ where: $b = 38$

$$K = \frac{2.7 \times 10^{-5}}{38} = 7.2 \times 10^{-7} \text{ ft/sec.}$$
$$= 2.2 \times 10^{-5} \text{ cm/sec.}$$

$S = (2.25)(T)(t_0)/r^2$ where:

$T = 0.222 \text{ m}^2/\text{day}$

$t_0 = .097$ days

$r = 9.71$ m

$$S = \frac{(2.25)(.222)(.097)}{(9.71)^2} = 5.14 \times 10^{-4}$$

ANALYSIS OF PUMP TESTS; METHOD I: COOPER-JACOB; (CONT.)

PUMP TEST CH F 2: WELL CH E OBSERVATION (03-01-88)

$T = (35)(Q)/(\text{Change})(S)$

where:

$Q = 2.6$ gal/min.

$(\text{Change})(S) = 28.5$ ft.

$$T = \frac{35(2.6)}{28.5} = 3.21 \text{ ft}^2/\text{day}$$
$$= 3.71 \times 10^{-5} \text{ ft}^2/\text{sec.}$$

$K = T/b$ where: $b = 38$

$$K = \frac{3.71 \times 10^{-5}}{38} = 9.76 \times 10^{-7} \text{ ft/sec.}$$
$$= 2.97 \times 10^{-5} \text{ cm/sec.}$$

$S = (2.25)(T)(t_0)/r^2$ where:

$T = 0.30 \text{ m}^2/\text{day}$

$t_0 = 1.041$ days

$r = 9.71$ m

$$S = \frac{(2.25)(.30)(1.041)}{(9.71\text{m})^2} = 7.45 \times 10^{-3}$$

METHOD II: HANTUSH-JACOB METHOD

EXPLANATION

$$T = \frac{Q}{(4)(3.14)(s)} [L(u,v)]$$

where:

Q = discharge; gal/min.*

s = drawdown; ft.

L(u,v) = leakance function

T = transmissivity; ft^2/day

* NOTE: Conversion from gal/min. to ft^3/day = $\frac{1{,}440 \text{ min/day}}{7.48 \text{ gal/ft}^3}$

$$K = T/b$$

where:

T = transmissivity; ft^2/day

b = thickness (screen + sandpack)

K = hydraulic conductivity; cm/sec.

$$S = [4(T)] \frac{t/r^2}{1/u}$$

where:

T = transmissivity; ft^2/day

t = time; days

r = distance between pumping well and observation well; ft.

1/u = well function

S = storage coefficient

$$K'/b' = [4(T)] \frac{v^2}{r^2}$$

where:

T = transmissivity; ft^2/day

v = type curve parameter

r = distance between pumping well and observation well; ft.

K' = vertical hydraulic conductivity of confining unit; ft^2/day

b' = thickness of the confining unit; ft.

ANALYSIS OF PUMP TESTS; METHOD II: HANTUSH-JACOB; (CONT.)

PUMP TEST CH D 1: **WELL CH C** **OBSERVATION** **(02-18-88)**

$$T = \frac{Q}{(4)(3.14)(s)} [L(u,v)]$$

where:

$Q = 0.1$ gal/min.

$s = 2$ ft.

$L(u,v) = 1.0$

$$T = \frac{(0.1)(1,440 \text{ min/day})}{(4)(3.14)(2)(7.48 \text{ gal/ft}^3)} (1.0)$$

$$= 0.766 \text{ ft}^2\text{/day}$$

$$= 8.866 \times 10^{-6} \text{ ft}^2\text{/sec.}$$

$K = T/b$ where: $b = 73$

$$K = \frac{8.866 \times 10^{-6}}{73} = 1.21 \times 10^{-7} \text{ ft/sec.}$$

$$= 3.70 \times 10^{-6} \text{ cm/sec.}$$

$$S = [4(T)] \frac{t/r^2}{1/u}$$

where: $T = 0.766$ $1/u = 10$

$t/r^2 = 2.65 \times 10^{-2}$ days/ft^2

$$S = [4(0.766)] \frac{2.65 \times 10^{-2}}{10} = 8.12 \times 10^{-3}$$

$$K'/b' = [4(T)] \frac{v^2}{r^2}$$

where: $b' = 45$ ft. $T = 0.766$

$v^2 = 0.8$ $r^2 = 38.44$

$$K'/b' = \frac{K'}{45} = [4(0.766)] \frac{0.8}{38.44}$$

$$= 2.87 \text{ ft/day}$$

$$= 1.01 \times 10^{-3} \text{ cm/sec.}$$

ANALYSIS OF PUMP TESTS; METHOD II: HANTUSH-JACOB; (CONT.)

PUMP TEST CH F 1: WELL CH E OBSERVATION (02-22-88)

$$T = \frac{Q}{(4)(3.14)(s)} [L(u,v)]$$

where:

$Q = 1.25$ gal/min.

$s = 11$ ft.

$L(u,v) = 1.0$

$$T = \frac{(1.25)(1{,}440 \text{ min/day})}{(4)(3.14)(11)(7.48 \text{ gal/ft}^3)} (1.0)$$

$$= 1.7406 \text{ ft}^2\text{/day}$$

$$= 2.01 \times 10^{-5} \text{ ft}^2\text{/sec.}$$

$K = T/b$ where: $b = 38$

$$K = \frac{2.01 \times 10^{-5}}{38} = 5.28 \times 10^{-7} \text{ft/sec.}$$

$$= 1.61 \times 10^{-5} \text{ cm/sec.}$$

$$S = [4(T)] \frac{t/r^2}{1/u}$$

where: $T = 1.74$ $1/u = 10$

$t/r^2 = 1.24 \times 10^{-4}$ days/ft^2

$$S = [4(1.74)] \frac{1.24 \times 10^{-4}}{10} = 8.6 \times 10^{-5}$$

$$K'/b' = [4(T)] \frac{v^2}{r^2}$$

where: $b' = 162$ ft. $T = 1.7406$

$v^2 = 0.8$ $r^2 = 1015.06$

$$K'/b' = \frac{K'}{162} = [4(1.7406)] \frac{0.8}{1015.06}$$

$$= 8.9 \times 10^{-1} \text{ ft/day}$$

$$= 3.13 \times 10^{-4} \text{ cm/sec.}$$

ANALYSIS OF PUMP TESTS; METHOD II: HANTUSH-JACOB; (CONT.)

PUMP TEST CH F 1: WELL CH E OBSERVATION (03-01-88)

$$T = \frac{Q}{(4)(3.14)(s)} [L(u,v)]$$

where:

$Q = 2.6$ gal/min.

$s = 18$ ft.

$L(u,v) = 1.0$

$$T = \frac{(2.6)(1,440 \text{ min/day})}{(4)(3.14)(18)(7.48 \text{ gal/ft}^3)} (1.0)$$

$= 2.21 \text{ ft}^2\text{/day}$

$= 2.56 \times 10^{-5} \text{ ft}^2\text{/sec.}$

$K = T/b$ where: $b = 38$

$$K = \frac{2.56 \times 10^{-5}}{38} = 6.73 \times 10^{-7} \text{ft/sec.}$$

$= 2.05 \times 10^{-5}$ cm/sec.

$$S = [4(T)] \frac{t/r^2}{1/u}$$

where: $T = 2.21$ $1/u = 10$

$t/r^2 = 1.0 \times 10^{-4} \text{ days/ft}^2$

$$S = [4(2.21)] \frac{1.0 \times 10^{-4}}{10} = 8.84 \times 10^{-5}$$

$$K'/b' = [4(T)] \frac{v^2}{r^2}$$

where: $b' = 162$ ft. $T = 2.21$

$v^2 = 0.8$ $r^2 = 1015.06$

$$K'/b' = \frac{K'}{162} = [4(2.21)] \frac{0.8}{1015.06}$$

$= 1.129$ ft/day

$= 3.98 \times 10^{-4}$ cm/sec.

```
***************************** 'THEISFIT' *****************************

CALCULATION OF 'BEST FIT' TRANSMISSIVITY AND STORAGE COEFFICIENT BY
AUTOMATICALLY FITTING EXPERIMENTAL PUMPTEST DATA TO THE THEIS EQUATION
IN A LEAST SQUARES SENSE.
------------------------------------------------------------------------
'ISPCI PUMP TEST  CHC OBSERVATION WELL   2-18-88
------------------------------------------------------------------------




****************************** INPUT DATA ******************************

ENGLISH UNITS

INITIAL ESTIMATE FOR STORAGE COEFFICIENT:  .0005
INITIAL ESTIMATE FOR TRANSMISSIVITY:  .4  [GAL/MIN/FT]

PUMPAGE RATE:  .1  [GAL/MIN]
OBSERVATION DISTANCE FROM PUMPING WELL:  6.2  [FT]

NUMBER OF ENTERED TIME-DRAWDOWN DATA PAIRS:  14

------------------------------------------------------------------------
                   EXPERIMENTAL TIME-DRAWDOWN DATA
------------------------------------------------------------------------

                    TIME [MIN]       DRAWDOWN  [FT]
------------------------------------------------------------------------
                       57              0
                       67              .01
                       91              .04
                       110             .05
                       131             9.000001E-02
                       159             .12
                       203             .23
                       229             .26
                       276             .33
                       359             .44
                       406             .59
                       440             .64
                       520             .76
                       740             1.04
```

```
*************************** RESULTS **********************************

                    KB= TRANSMISSIVITY         SC= STORAGE COEFFICIENT

                                                           SC = .0015
ITERATION 1    BEST FIT: KB = .02  [GAL/MIN/FT]            SC = .0045
ITERATION 2    BEST FIT: KB = 2.275363E-02  [GAL/MIN/FT]  SC = 1.330748E-02
ITERATION 3    BEST FIT: KB = 1.312593E-02  [GAL/MIN/FT]  SC = 2.127703E-02
ITERATION 4    BEST FIT: KB = 8.627776E-03  [GAL/MIN/FT]  SC = 2.196227E-02
ITERATION 5    BEST FIT: KB = 6.550239E-03  [GAL/MIN/FT]  SC = 2.157274E-02
ITERATION 6    BEST FIT: KB = 6.650208E-03  [GAL/MIN/FT]  SC = 2.18 E-2
ITERATION 7    BEST FIT: KB = 6.651805E-03  [GAL/MIN/FT]
```

WELL CH C OBSERVATION 02-18-88

CONVERSIONS

$$T = (6.65 \times 10^{-3} \text{ gal/min/ft.}) \times 1,440 = 9.58 \text{ gal/day/ft.}$$

$$= 9.58 \times (1.438 \times 10^{-7}) = 1.38 \times 10^{-6} \text{ m}^2\text{/sec.}$$

$K = T/b$ where: $b = 73$ ft.
$= 22.25$ m

$$K = \frac{1.38 \times 10^{-6}}{22.25} = 6.2 \times 10^{-8} \text{ m/sec.}$$

$$= 6.2 \times 10^{-6} \text{ cm/sec.}$$

Cell 5 Pump Test (1996)

APPENDIX C

AQUIFER STRESS TEST
LONE MOUNTAIN FACILITY
CELL 5 CMS

CONTENTS

ATTACHMENTS

APPENDIX C

LONE MOUNTAIN FACILITY
CELL 5 CMS
HYDROGEOLOGIC INVESTIGATION AND STRESS TEST UP-GRADIENT OF CLOSED CELLS

INTRODUCTION

A hydrogeologic investigation consisting of drilling, well construction, and an aquifer stress test was completed on the southwest side of the Lone Mountain Facility up-gradient of closed Cells 1 through 8, and the Drum Cell. The purpose of the stress test was to determine draw down characteristics of the area, and to provide data with which to calibrate a hydrologic computer model. Information provided by the stress test data will be used to determine the effectiveness of a larger scale dewatering program.

Past investigations by Laidlaw suggest that pumping groundwater up-gradient of the cells may lower the potentiometric surface within the cells, cutting off the production of leachate, and thereby providing control for the plume down-gradient of Cell 5. Up-gradient dewatering is therefore addressed as a proposed remedial option in this Cell 5 Corrective Measures Study (CMS).

In accordance with the work plan, the stress test program was divided into the following segments

- Review of hydrogeology and previous work
- Drilling and well construction
- Operation of the stress test
- Analysis of results

REVIEW OF HYDROGEOLOGY AND PREVIOUS WORK

Groundwater modelling and evaluation of a dewatering system at the Lone Mountain Facility was completed by Laidlaw in 1994, and submitted as an internal draft entitled "Lone Mountain Facility Dewatering Feasibility Evaluation" in January, 1995. The purpose of the study was to evaluate the effects of groundwater extraction up-gradient (west) of Cells 1 through 8 and the Drum Cell, using a computer model to simulate various pumping scenarios to predict the effects on the potentiometric surface. Conclusions of the study were stated as follows:

- A linear system of 34 extraction wells with approximately 60 feet of draw down would be required;
- Combined production from the wells of approximately 2 gpm would dewater the leachate detection systems of each of the nine closed cells;
- The RCRA monitoring well network would not be adversely affected (dewatered); and
- Groundwater extracted from the wells would not be contaminated.

The model assumed that the formation matrix was uniform, and did not consider the possible presence of secondary permeability. On the basis of experience gained from drilling for the Cell 5 RFI and other drilling performed at the site, zones of increased secondary permeability are sometimes present in the Lone Mountain area that are capable of providing water in greater quantities than the normally occurring claystone matrix. A primary objective of the up-gradient dewatering test drilling program was to determine if zones of increased permeability exist in the area up-gradient of the cells.

Aerial photography was examined and possible fracture zones were mapped from joint sets visible in the gypsum caprock on the top of a mesa which adjoins the Lone Mountain Facility to the west. Field work was conducted on the outcrops as a follow up to air photo analysis, and projections of possibly disturbed zones were made. Several bore hole locations, including ST-3 and ST-4 in the pump test area, were selected based on projections of the linear features.

An evaluation of available hydrogeologic data was conducted for existing wells in the stress test area. Recovery rates observed during purging and sampling for the semi-annual events were reviewed. However the information did not predict local trends of high water productivity.

DRILLING AND WELL CONSTRUCTION

Preparations for the program included contracting of a rotary drilling rig, procurement of equipment and supplies, and planning of drill site locations. Drill sites were selected at locations where existing utilities, structures, and facility operations were not adversely impacted. The sites are shown on Plate 1 on the western edge of the container storage area. Drilling depths were determined by correlating the area to drilling performed in the Cell 5 area; holes were generally bottomed at the top of the unit referred to in the Cell 5 area as the First Green Claystone ("Cell 5 Interim Measure Report", 1995).

Soil Borings

The first phase of drilling consisted of a sequence of 19 borings which investigated the subsurface to a maximum depth of 88 feet below the ground surface. The purpose of the borings was to provide lithologic control and to determine the abundance and occurrence of groundwater in the area. The borings were drilled 50 to 100 feet apart along a northwesterly line (ST-1 through ST-19, Plate C-1).

A second phase of drilling was conducted in areas where favorable hydrologic conditions were encountered, and in areas where isolation of zones was necessary to determine differences in groundwater quality (specific conductance, Ph) at various depths. The borings were drilled as offsets to pre-existing borings, and are numbered ST-20 through ST-28. Borings ST-3, ST-23, ST-26, and ST-27 were later converted to cased wells for use in the stress test.

An air-rotary drill was used to drill the borings. Lithologies of the drill holes were logged and are included in this appendix. Indications of groundwater encountered during drilling were noted on the logs. Drill cuttings from most of the borings were dry, indicating poor conditions for groundwater production.

Construction of the Stress Test Pumping Well

Soil boring ST-23 was selected as the pump well based on the occurrence of wet cuttings noted during drilling, and the occurrence of wet cuttings in nearby boring ST-3. The initial 5-inch diameter borehole was drilled to a depth of 75 feet below ground surface. Total depth was determined by drilling to the top of the First Green Claystone (Figure C-1).

Following collection of a field parameters sample and measurement of the groundwater level, the boring was temporarily plugged with bentonite to protect the bore hole walls from fracturing and caving. After approximately one week the boring was reamed to 12 inches in diameter to a depth of 75 feet; the well was constructed of 8-inch inside diameter schedule 40 PVC casing and well screen (see well log and Table 1 for details).

The well was developed to remove silt. Electricity and a control box were installed at the well site. A Grundfos reddi-flow pump was installed at the bottom of the well, and well controls were installed to allow the pump to cycle on and off as necessary. Water discharged from the well was piped directly to the container parking drainage sumps. Water from the sumps is used at the stabilization facility.

Construction of the Observation Wells and Open Boring Observation Points

Construction details for the cased observation wells ST-3, ST-26, and ST-27 are found in Table 1 and the well logs. Observation well ST-3 was screened from 14 to 74 feet below ground surface, in the same stratigraphic horizon as ST-23.

Observation wells ST-26 and ST-27 are close offsets to ST-23, and have screened intervals in the upper and lower portions of the hydrogeologic interval above the First Green Claystone (see Figure C-1). The design allows drawdown characteristics from both the deep and shallow portions of the interval to be observed. Well ST-26 is screened from 1404 feet to 1384 feet, and ST-27 is screened from 1379 feet to 1359 feet below ground surface.

A series of ten borings were left open for monitoring during the test. Surface casings 2 to 6 feet long were installed at the top of each boring to prevent caving of fill material and provide a measuring point. The longer 5-6 foot casings were employed if water was noted in the fill material in the upper five feet of the borings, preventing infiltration of surface water.

Well construction data and monitoring schedules for all wells are shown on the following table:

TABLE C-1
WELL CONSTRUCTION DETAILS AND STRESS TEST MONITORING SCHEDULE

Well I.D. & Purpose	Hole Size, Casing Type & Size	Casing Depth & Elevation of the Screened Interval	Gauging Frequency
ST-23 Pump Well	12" Hole, 8" PVC	0-15' Blank 15-75' Screen (1419.24-1359.24)	Gauge prior to start of test
ST-3 Observation Well	12" Hole, 6" PVC	0-14' Blank 14-74' Screen (1420-1360') 74-79' Blank	1st 4 hrs: each 30 minutes 2nd 4 hrs: each hour 2nd day-2 weeks: daily
ST-26 Shallow Up-gradient Obs. Well	8.5" Hole, 2" PVC	0-30' Blank 30-50' Screen (1404-1384')	Same as above
ST-27 Deep Down-gradient Obs. Well	8.5" Hole, 2" PVC	0-55' Blank 55-75' Screen (1379-1359')	Same as above
ST-28 Observation Boring	5" Hole, 6" PVC	0-2' Surface Csg 78.5' Total Depth (TD)	Same as above
ST-4 Observation Boring	5" Hole, 6" PVC	0-2' Surface Csg 77' TD	Same as above
ST-5 Observation Boring	5" Hole, 6" PVC	0-2' Surface Csg 75' TD	Same as above
ST-22 Observation Boring	5" Hole, 6" PVC	0-2' Surface Csg 75' TD	1st day: hourly 2nd day-2 weeks: daily
ST-6 Observation Boring	5" Hole, 6" PVC	0-2' Surface Csg 75' TD	Same as above
ST-21 Observation Boring	5" Hole, 6" PVC	0-2' Surface Csg 74' TD	Same as above
ST-7 Observation Boring	5" Hole, 6" PVC	0-5.5' Surface Casing 74' TD	Same as above
ST-8 Observation Boring	5" Hole, 6" PVC	0-5.5' Surface Casing 73' TD	Same as above
ST-9 Observation Boring	5" Hole, 6" PVC	0-6' Surface Csg 72' TD	Same as above
ST-20 Observation Boring	5" Hole, 6" PVC	0-2' Surface Csg 72' TD	Same as above

TABLE C-1
CONTINUED
OUTLYING OBSERVATION WELLS

Well I.D.	Depth & Elevation of Screened Interval	Scheduled Gauging Frequency
OW-4	Unknown - Bottom of well elevation is 1365' at 95' TD	Daily
MW-4A2	16.6-31.6' (1404.35-1389.35)	Daily
MW-8A1	14.8-29.8' (1380.24-1365.24)	Weekly

Management of Soil Cuttings and Water Produced During Drilling

Drill cuttings and groundwater produced during drilling were uncontaminated, therefore decontamination of the drill rig and drilling tools was not required between holes. Water and cuttings produced during the program were properly disposed by Lone Mountain Facility staff.

Soil Boring Abandonment

Plugging and abandonment of borings was performed in accordance with applicable facility permit requirements. A tremie pipe was run to the bottom of the hole, and a mixture of portland cement, water, and bentonite (2-5%) was pumped to the bottom of the hole to displace groundwater, and provide an effective seal from total depth to surface. After the boring was filled to within one foot of the surface, a poured in place concrete cap was emplaced at the ground surface.

Surveying

Coordinates and ground surface elevations were established for all wells and borings. Top of casing (measuring point) elevations were established for the pumping well and observation wells.

HYDROGEOLOGY AND GROUNDWATER QUALITY ENCOUNTERED IN SOIL BORINGS

Lithologies encountered during the drilling program were similar to lithologies in the Cell 5 area. Red claystone intervals up to 20 feet in thickness are interbedded with greenish gray claystones up to 6 feet thick. The borings were bottomed in the green claystone that correlates with the primary aquitard (First Green Claystone) in the Cell 5 area.

Following completion of drilling, the borings were allowed to stand open overnight to allow groundwater infiltration. Water levels were measured in the open holes on the following day. Samples were collected for testing of pH and specific conductance parameters.

Water levels were noted within 6 feet of the surface in soil boring ST-3. In outlying zones to the north and south, holes remained dry, or nearly dry after standing open for several days. Table C-2 shows the initial water level measurement data for each boring, and the specific conductance measurement of the groundwater.

Specific conductance measurements vary in apparent response to the source of groundwater sampled from the borings. High conductance levels greater than 100,000 μ mohs were collected from borings in which the deeper portion of the hole was isolated for sampling (ST-24 for example), or that were poor water producers, allowing water to be collected from within a few feet of the total depth. Water infiltration in the poor producers was apparently sourced from deeper intervals with high levels of natural salts.

Waters sampled from borings in which water levels rose much closer to the surface appear to be associated with surface water infiltration, and exhibit lower specific conductance (values less than 20,000 units). Specific conductance measurements in the 20,000 to 100,000 range may indicate that water was being contributed from several horizons and mixed to produce the more average values. The values from all borings ranged from 6440 units in water from ST-3 to 146,900 units in the water sample from ST-18.

TABLE C-2
INITIAL WATER LEVEL MEASUREMENTS AND GROUNDWATER SAMPLING RESULTS - SOIL BORINGS

Boring Number	Date	Sample Interval - Open Hole	Depth to Water	Specific Conductance (μ mohs)
ST-1	6/04/96 6/05/96	0-80' 0-80'	Dry 78.14'	NA 140,100
ST-2	6/04/96 6/05/96	0-80'	71.40' 62.76'	107,600 103,200
ST-3	6/04/96 6/05/96 6/06/96 6/06/96	0-79' Shallow Deep	18.50' 5.79' 6.40' 6.40'	19,950 7,140 *6,440 **25,800
ST-4	6/04/96 6/05/96	0-77'	58.00' 34.00'	6,440 9,120
ST-5	6/05/96	0-75'	63.14'	39,200
ST-6	6/05/96	0-75'	70.11'	83,400
ST-7	6/05/96	0-74'	59.20'	47,000
ST-8	6/05/96	0-73'	17.00'	18,550
ST-9	6/05/96	0-72'	62.75'	50,400
ST-10	6/05/96	0-72'	21.15'	20,600
ST-11	6/05/96	0-72'	56.20'	35,200
ST-12	6/05/96	0-75'	60.10'	32,100
ST-13	6/06/96	0-74'	70.50'	81,100
ST-14	6/06/96	0-75'	39.43'	21,400
ST-15	6/06/96	0-74'	23.08'	25,800
ST-16	6/06/96	0-74'	35.18'	16,820
ST-17	6/06/96	0-74'	55.80'	43,200
ST-18	6/06/96 6/07/96	0-88'	Dry 86.90'	NA 146,900
ST-19	6/06/96	0-88'	83.30'	89,000
ST-20	6/06/96	0-72'	11.65'	17,430
ST-21	6/06/96 6/07/96	0-74'	73.55' 71.80'	NA 112,500

TABLE C-2
INITIAL WATER LEVEL MEASUREMENTS AND GROUNDWATER SAMPLING RESULTS - SOIL BORINGS

Boring Number	Date	Sample Interval - Open Hole	Depth to Water	Specific Conductance (μ mohs)
ST-22	6/06/96	0-75'	73.00'	103,000
ST-23	6/06/96 6/06/96	0-75'	22.12' 22.12'	*18,730 **28,600
ST-24	6/10/96	66-77'	75.63'	101,200
ST-25	6/10/96	50-66'	Dry	NA
ST-26	6/10/96	23.6-50'	40.60'	41,500
ST-27	6/10/96	49.6-61'	59.97'	73,600
ST-28	6/12/96	0-78.5'	71.35'	59,500

* Sample bailer filled near upper part of water column
** Sample bailer dropped to bottom of water column

A cross section (Figure 1) of the pump test area shows the occurrences of the red and green claystones in relationship to the pump test wells. As indicated on the section, the screened intervals in ST-23 (pumping well) and ST-3 (cased observation well) are in place from near surface to total depth at approximately 75 feet.

Observation wells ST-26 and ST-27 are screened in the upper and lower portions of the stress test hydrogeologic unit. Differences in specific conductance between the upper and lower zones are 41,500 units in the shallower well ST-26 and 73,600 units in ST-27.

OPERATION OF THE STRESS TEST

The stress test started on July 23, 1996 using a Grundfos Reddi-flow pump placed near the bottom of well ST-23. The pumping rate averaged 70 gallons per day (.049 gpm) for the duration of the test, which is ongoing at the writing of this report. Total gallons pumped to date (through September 17, 1996) is approximately 3,800 gallons. The test continues to be run, and will continue for an extended period of time to determine if other wells will be affected during a longer test period.

The pump is controlled by on and off switches to handle the low flow into the well. The pump cycles approximately each hour, pumping for approximately 1.13 minutes, followed by 54.54 minutes off. The on and off trigger points are controlled by probes set near the bottom of the well, to maximize drawdown. The pump is set to start when the water level is at 74.32 feet below the top of the casing, and switches off when the water level drops to 75.46 feet.

Measurements of water levels were conducted as scheduled on Table C-1 and as recorded on Table C-3. Note that rainfall events occurred during the period between July 23 and September 4, 1996 totalling 7.91 inches of rain, causing water levels to rise in most wells.

STRESS TEST DATA ANALYSIS

Objective

Analysis of water level data from stress test observation wells was conducted to obtain an estimate of aquifer properties using AQTESOLV[1]. The aquifer properties estimated were transmissivity (T) and storage coefficient (S).

AQTESOLV Data Input

The data input into AQTESOLV included:

- Pumping rate (Q) of ST-23 = 70 gals/day = 0.006499 ft^3/min
- Pumping and observation well locations
- Radius of the casing (r_c) in ST-23 = 4 inches = 0.3333 feet
- Radius of the borehole (r_w) in ST-23 = 6 inches = 0.5 feet

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[1] AQTESOLV, Glenn M. Duffield, Aquifer Test Solver, Version 2.01, Geraghty & Miller, Inc. February 1995.

- Aquifer Saturated thickness (b) = 59 feet
- Observation well measurements (time and displacement)
- Partial penetrations depths of observation wells (ST-26 = 15 to 35 feet and ST-27 = 40 to 59). For Neuman solution only.

These input parameters were obtained from well logs, survey data, and water level observations.

AQTESOLV Solution Methodology

Two observation wells were selected (ST-26 and ST-27) for curve matching solution in AQTESOLV. These two wells were selected because of their proximity to ST-23 (less then 10 feet) and the observed drawdown caused by pumping from ST-23 (Figure C-1).

The groundwater levels in the remaining stress test wells (ST-3, ST-4, ST-5, and ST-28) did not show any effect from pumping in ST-23. The groundwater level in these wells actually increased during the stress test period (Figure C-2).

AQTESOLV allows the user to choose from 3 different solution methods. They are Theis, Cooper-Jacob, and Neuman. The user must then select which curve matches the observed drawdown. Each of the three curve matching methods was performed on ST-26 and ST-27.

AQTESOLV Results

The results of the curve matching analysis of ST-26 and ST-27 are presented in Figures C-3 and C-4. The curve which fits ST-26 best is Theis, with a transmissivity of 4.56 x 10^{-5} ft^2/min. The curve which fits ST-27 best is Neuman with a transmissivity of 7.43 x 10^{-5} ft^2/min. These transmissivity values were used as input for the general site groundwater model.

The site groundwater model (Appendix A) was used to simulate dewatering of Cell 5 by upgradient groundwater extraction. Only pumping well scenarios were considered as other methods of extraction were determined to be economically infeasible. The number and location of extraction points were varied as well as production rates to determine the optimum dewatering network. Results of the simulation indicated that 35 extraction wells spaced at a maximum of 50 feet intervals and pumping approximately 17 gallons per day would be required to effectively dewater the cell areas.

TABLE C−3

Lone Mountain
Upgradient Stress Test

ST−3 Elev. 1437.22			ST−26 Elev. 1437.22			ST−27 Elev. 1437.07			ST−28 Elev. 1437.58			ST−4 Elev. 1434.69			ST−5 Elev. 1434.46			ST−23 Elev. 1437.18				
e	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	pH	Sp. Cond.	F
43	10.36		10:49	22.81		10:45	12.04		11:01	7.55		11:04	6.38		11:05	10.77		10:47	11.30			
55	10.32	0.04	11:56	22.81	0	11:56	13.81	−1.77	12:02	7.54	0.01	11:59	6.36	0.02	12:00	10.76	0.01	11:54	44.70			
25	10.30	0.06	12:29	22.80	0.01	12:27	15.94	−3.90	12:32	7.54	0.01	12:34	6.39	−0.01	12:35	10.76	0.01					
55	10.28	0.08	12:54	22.81	0	12:53	17.55	−5.51	12:57	7.53	0.02	12:58	6.37	0.01	13:00	10.76	0.01					
58	10.21	0.15	13:57	22.74	0.07	13:55	21.05	−9.01	14:00	7.53	0.02	14:02	6.35	0.03	14:03	10.76	0.01					
33	10.24	0.12	14:30	22.81	0	14:29	22.67	−10.63	14:34	7.55	0.00	14:35	6.39	−0.01	14:36	10.76	0.01					
06	10.23	0.13	15:02	22.81	0	15:00	23.94	−11.90	15:07	7.53	0.02	15:09	6.37	0.01	15:10	10.76	0.01					
						15:29	25.20	−13.16														
						16:00	26.10	−14.06														
5	10.71	−0.35	10:49	22.82	−0.01	10:47	35.13	−23.09	10:53	7.31	0.24	10:55	6.77	−0.39	11:49	10.80	−0.03					
8	11.08	−0.72	11:18	22.87	−0.06	11:14	37.23	−25.19	11:20	7.20	0.35	11:22	6.90	−0.52	11:23	10.77	0					
2	11.19	−0.83	12:57	22.94	−0.13	12:55	38.38	−26.34	13:00	2.36	5.19	13:04	3.62	2.76	13:06	10.78	−0.01					
3	10.98	−0.62	15:07	23.02	−0.21	15:06	39.39	−27.35	15:10	6.60	0.95	15:14	3.21	3.17	15:16	10.60	0.17					
6	10.78	−0.42	15:10	23.10	−0.29	15:08	40.63	−28.59	15:13	6.82	0.73	15:15	3.37	3.01	15:16	10.44	0.33					
5	10.83	−0.47	13:40	23.19	−0.38	13:38	41.51	−29.47	13:44	6.66	0.89	13:46	3.39	2.99	13:48	10.41	0.36					
0	10.52	−0.16	15:52	23.28	−0.47	15:51	42.08	−30.04	15:58	6.69	0.86	15:54	3.45	2.93	15:56	10.26	0.51					
1	10.54	−0.18	11:23	23.37	−0.56	11:22	42.31	−30.27	11:33	6.85	0.70	11:24	3.74	2.64	11:25	10.31	0.46					
4	10.35	0.01	15:56	24.05	−1.24	15:55	42.54	−30.50	16:07	6.28	1.27	16:00	2.90	3.48	16:01	10.26	0.51					
3	10.22	0.14	13:30	25.46	−2.65	13:29	42.72	−30.68	13:38	6.56	0.99	13:32	2.98	3.40	13:34	10.10	0.67					
9	10.02	0.34	16:01	27.67	−4.86	16:00	43.16	−31.12	16:16	5.39	2.16	16:10	2.50	3.88	16:12	9.73	1.04					
5	9.83	0.53	16:07	29.30	−6.49	16:06	43.50	−31.46	16:16	6.34	1.21	16:11	2.95	3.43	16:12	9.45	1.32					
3	9.90	0.46	15:31	31.15	−8.34	15:30	43.76	−31.72	15:38	6.58	0.97	15:32	3.10	3.28	15:34	9.44	1.33					
5	10.01	0.35	14:59	33.17	−10.36	14:57	43.89	−31.85	15:15	6.72	0.83	15:02	3.33	3.05	15:03	9.53	1.24					
3	9.60	0.76	15:01	36.78	−13.97	15:00	44.21	−32.17	15:03	6.48	1.07	15:05	3.20	3.18	15:06	8.89	1.88			7.60	19460	
5	10.00	0.36	14:06	37.06	−14.25	13:58	44.18	−32.14	14:29	6.78	0.77	14:21	4.89	1.49								N
															15:07	9.18	1.59					N
	9.61	0.75	11:30	39.00	−16.19	11:29	44.06	−32.02	11:38	4.90	2.65	11:31	2.18	4.20	11:31	8.85	1.92					
	9.47	0.89	14:05	38.47	−15.66	14:03	43.89	−31.85	14:07	6.05	1.50	14:09	3.20	3.18	14:10	8.51	2.26					

TABLE C-3 CONTINUED

Lone Mountain
Upgradient Stress Test

ST-22		ST-6			ST-21			ST-7			ST-8			ST-9			ST-20			MW-8A1			MW-4A2			OW-4	
lev. 1433.77		Elev. 1434.21			Elev. 1433.88			Elev. 1433.84			Elev. 1434.13			Elev. 1433.22			Elev. 1433.59			Elev. 1397.36			Elev. 1423.88			Elev. 1461.	
epth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)	Net. Chg.	Time	Depth to (ft.)
10.52		11:07	9.42		11:08	7.83		11:09	5.42		11:10	4.05		11:10	4.13		11:11	3.49		10:28	5.56		10:34	17.25		10:40	19.79
10.52	0	12:37	9.40	0.02	12:37	7.82	0.01	12:38	5.40	0.02	12:39	4.03	0.02	12:39	4.11	0.02	12:40	3.47	0.02								
10.50	0.02	14:05	9.38	0.04	14:06	7.80	0.03	14:06	5.38	0.04	14:07	4.02	0.03	14:08	4.10	0.03	14:09	3.45	0.04								
10.49	0.03	15:11	9.38	0.04	15:12	7.80	0.03	15:12	5.37	0.05	15:13	4.01	0.04	15:14	4.10	0.03	15:15	3.44	0.05								
10.48	0.04	11:03	9.38	0.04																							
10.48	0.04																										
10.48	0.04																										
10.38	0.14																										
10.38	0.14																										
10.27	0.25	13:51	9.12	0.30																							
10.21	0.31	11:27	9.02	0.40	11:27	7.18	0.65	11:28	4.66	0.76	11:29	3.34	0.71	11:30	3.54	0.59	11:31	2.90	0.59	13:31	5.28	0.28	14:10	16.11	1.14	11:19	19.84
10.05	0.47	13:37	8.84	0.58																							
9.95	0.57	16:15	8.72	0.70																							
9.84	0.68	16:14	8.61	0.81																							
9.75	0.77	15:36	8.54	0.88																							
9.66	0.86	15:05	8.47	0.95	15:07	6.38	1.45	15:08	4.50	0.92	15:09	3.20	0.85	15:11	3.44	0.69	15:12	2.80	0.69	14:49	4.94	0.62	15:20	15.36	1.89	15:17	19.85
8.27	2.25	15:08	5.43	3.99	15:09	4.44	3.39	15:10	4.27	1.15	15:11	2.99	1.06	15:12	3.29	0.84	15:13	2.60	0.89								
																				15:38	4.37	1.19				15:48	19.86
8.74	1.78	15:08	7.32	2.10	15:09	5.17	2.66	15:10	4.45	0.97	15:11	3.15	0.90	15:12	3.36	0.77	15:13	2.72	0.77	15:25	4.13	1.43	15:20	14.84	2.41	15:17	19.85
8.80	1.72	11:33	7.36	2.06	11:33	5.02	2.81	11:34	4.35	1.07	11:35	3.00	1.05	11:35	3.25	0.88	11:36	2.53	0.96	11:04	3.95	1.61	11:48	14.57	2.68	11:42	19.83
8.53	1.99	14:12	7.03	2.39	14:13	4.98	2.85	14:13	4.44	0.98	14:14	2.97	1.08	14:15	3.26	0.87	14:16	2.57	0.92	14:51	3.93	1.63	14:47	14.55	2.70	14:23	19.84

Figure 9:
LOWER RED CLAYSTONE STRESS TEST OBSERVED DRAWDOWNS

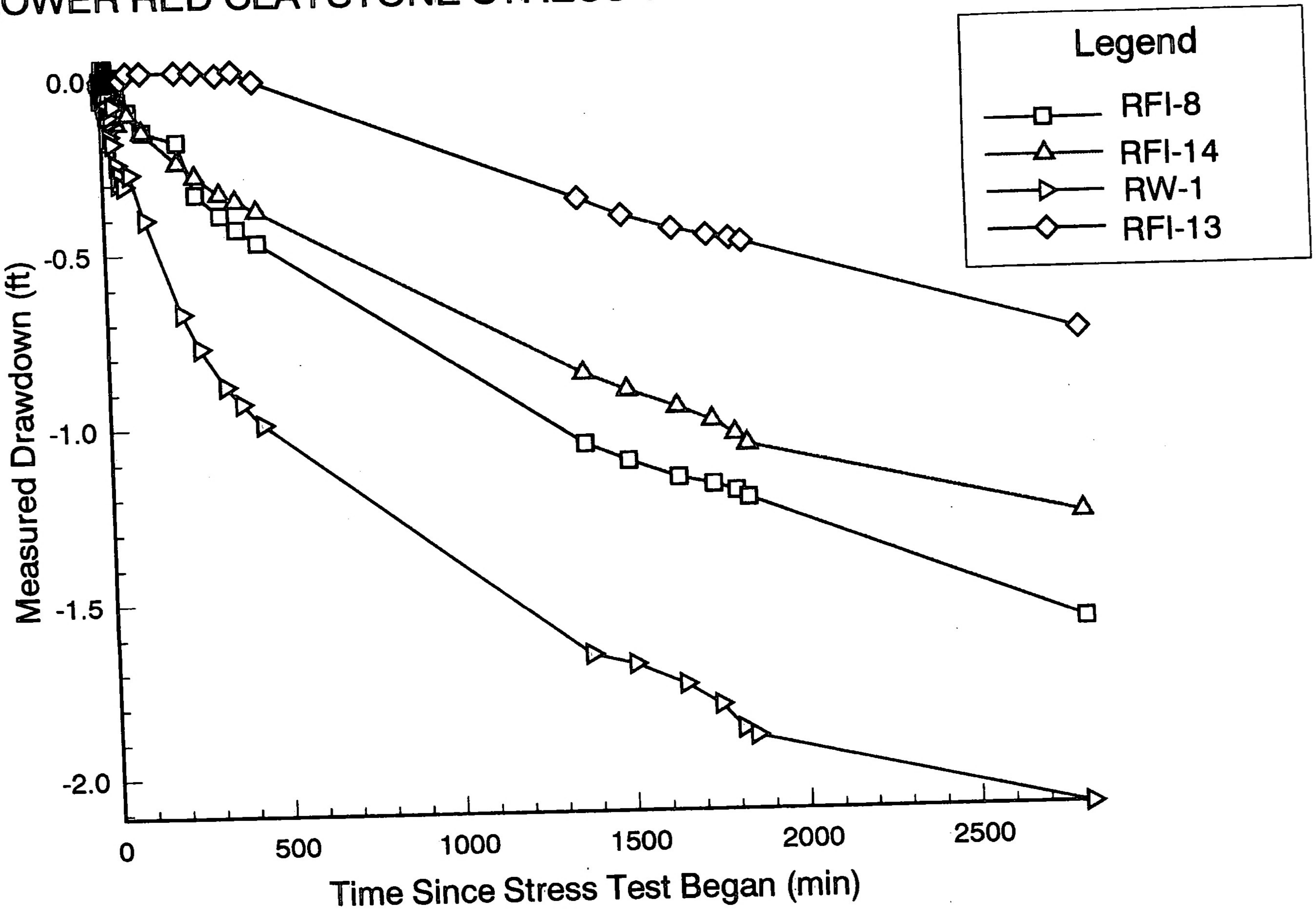
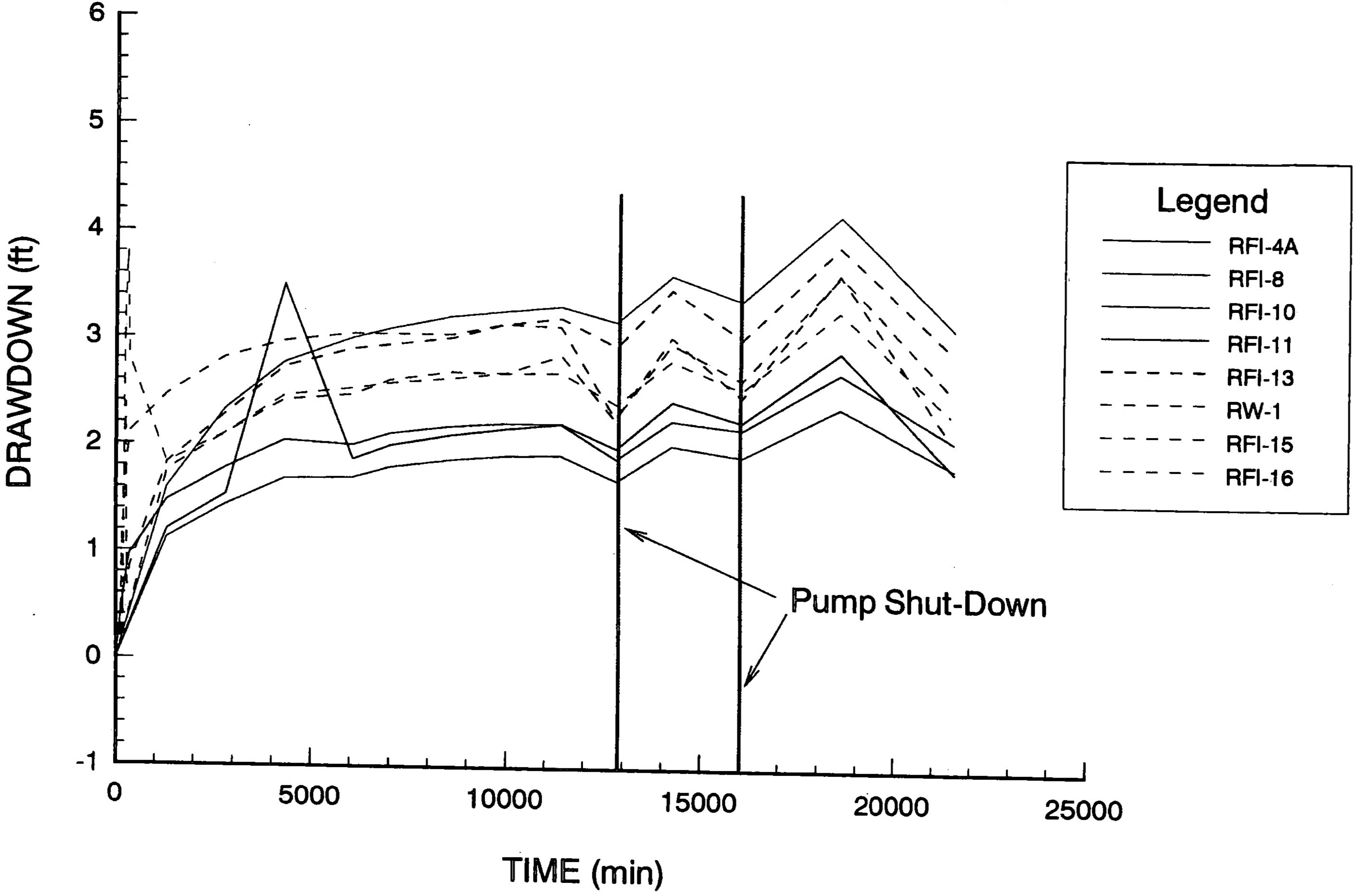
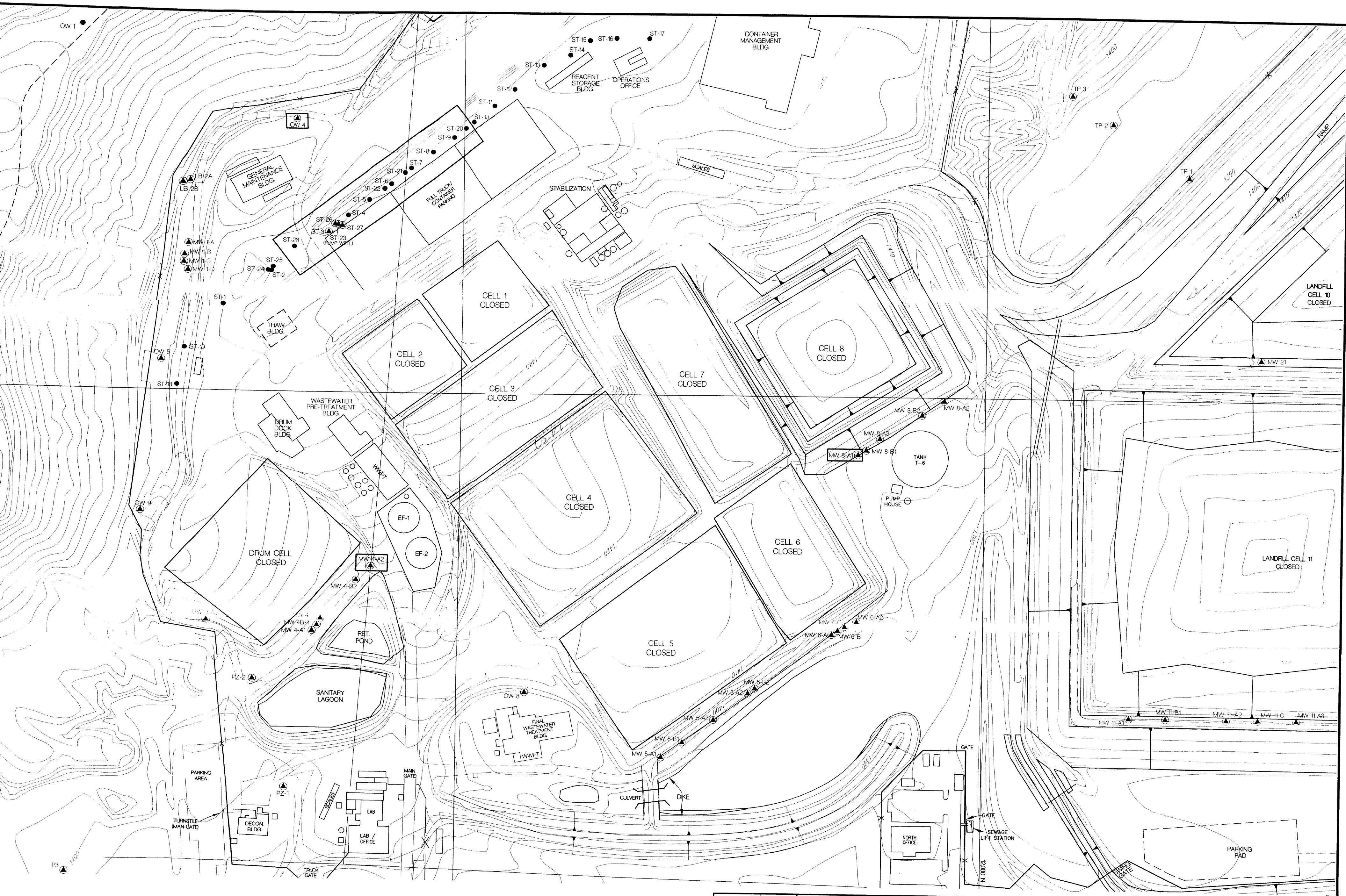


FIGURE 10
LONE MOUNTAIN CELL 5 PUMP TEST RESULTS





LEGEND

MW 4-C ▲ GROUNDWATER MONITORING WELL

MW 4-A2 ▲ MONITORED DURING STRESS TEST

ST-1 ● EXPLORATORY BOREHOLE OR PIEZOMETER

— NORTH

0 80 160
FEET

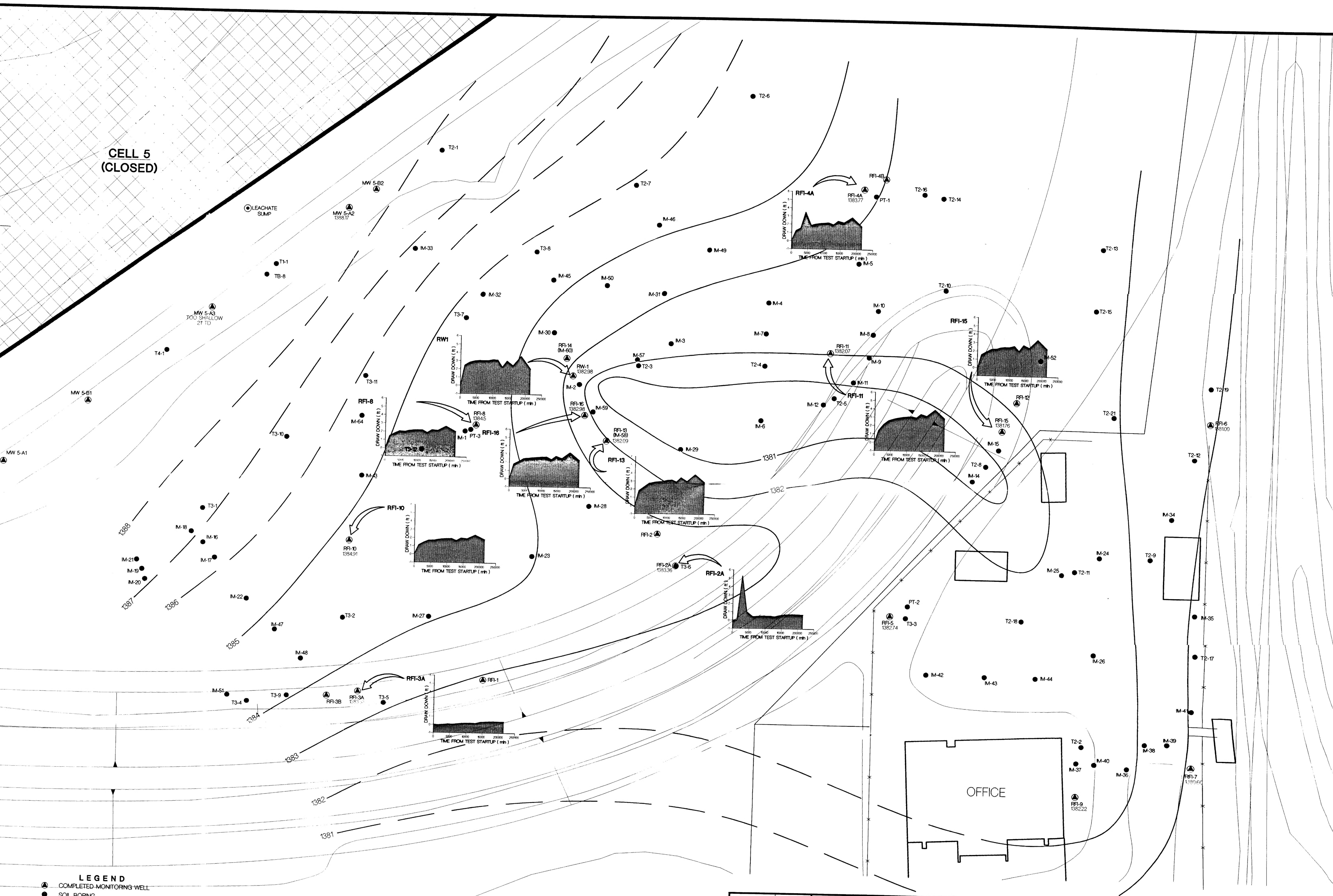
	BY	DATE
DRAWN	CJJ	9/18/96
CHECKED		
APPROVED		
APPROVED		
APPROVED		

USPCI
A LAIDLAW COMPANY

LONE MOUNTAIN FACILITY

PLATE C-1
UP-GRADIENT STRESS TEST - MONITOR WELLS AND SOIL BORINGS

SCALE: 1" = 80'
DWG. NO: 96328-25



LEGEND

- ▲ COMPLETED MONITORING WELL
- ● SOIL BORING
- — GROUNDWATER ELEVATION CONTOUR IN UPPER RED CLAYSTONE UNIT (ftmsl)

—North

0 20 40
FEET

	BY	DATE
DRAWN	WRB	10/17/95
CHECKED		
APPROVED		
APPROVED		
APPROVED		

USPCI
A LAIDLAW COMPANY

LONE MOUNTAIN FACILITY

PLATE 1
GROUNDWATER DRAWDOWN OVER TIME AND MAXIMUM CAPTURE ZONE

SCALE: 1" = 20'

DWG. NO: 96328-05

APPENDIX 3.12

GEOPHYSICAL LOGS AND LOG ANALYSIS REPORT

Lone Mountain Site Characterization Study
Geophysical Logging Conditions and Specifications

Logging Tool Specifications

9030A

Measures Natural Gamma Ray in API units, Density in g/cc, Guard Resistivity in Ohm-meters, and Caliper in inches.
Dimensions: 121" x 2.2"
Source-detector spacing: 7.5"
Source type: 125mCi. Cs137
Caliper arm lengths: 8" or 14"
Recommended logging speed: 30'/min.

9071

Measures Natural Gamma, Self Potential (SP) in millivolts, 16" and 64" Normal Resistivity in Ohm-meters, Temperature in Deg. F, and Compensated (dual spaced) Neutron in percent porosity or API-N.
Dimensions: 101" x 2.9"
Source-detector spacings: Near 10.8" Far: 24.5"
Source type: 5 Ci. AmBe
Recommended logging speed: 30'/min.

9067

Slimhole gamma-neutron probe for logging inside drill rods or small boreholes. Measures Natural Gamma in API or CPS and Neutron in API units.
Dimensions: 98" x 1.25"
Source-detector spacing: 14"
Source type: 1 Ci. AmBe
Recommended logging speed: 30'/min.

9080

Spectral Gamma (KUT): Measures Potassium concentration in percent, uranium in ppm, and thorium in ppm.
Dimensions: 80.5" x 2.5"
Recommended logging speed: 10'/min.

9500

Induction resistivity. Measures deep and medium inductively focused resistivity in Ohm-meters, guard (LL7) resistivity in Ohm-meters, and S.P. in mV.
Dimensions: 173" x 3.25"
Receiver coil spacings: Med. 27" Deep: 40"
Recommended logging speed: 60'/min.

Calibrations

The parameters which require additional field calibration in the Compulog II system are the 9030 density and caliper, the 9071 near and far neutron, the 9067 neutron, and the 9500 deep and medium induction resistivity. The system software allows for a two-point calibration (i.e., the response of a sensor to known values may be established at two points along the response curve). For example the gamma-gamma density detector is calibrated by noting the CPS reading in water, with an apparent (electron) density of 1.106 g/cc, and then the CPS reading is determined for an aluminum block with a density of 2.612. This establishes the slope of the calibration curve and allows an accurate response between the two points. Similarly, the induction resistivities are set up using copper loops with known conductivities (one high and one low) to establish the two calibration points. The tool actually measures formation conductivities which are then inverted by the logging program to produce the resistivty values.
The neutron tools are calibrated using a standard (API) number established at the API test pit in Houston in conjuction with the measured response in the water tank to convert the raw cps to normalized (API) CPS units. Other parameters may (optionally) be calibrated or left with the system defaults in which case the tool responds exactly as it was set up when assembled in the lab. These parameters are the guard resistiviy, the SP, and natural gamma. If calibration of the electic logs is desired it is a matter of connecting the tool to the "cal box" with various known SP or resistivity settings and selecting a high and a low meter setting to establish the calibration curve. Calibration of the KUT tool is done by adjusting it to established tolerances in the laboratory prior to assembly, then the tool is run in the DOE test facilities at Grand Junction, Colorado, to establish the calibration numbers, known as the stripping matrix, used by the computer to convert the raw data to processed information.

Hole Conditions

The test borings were all 4 inches in diameter with the exception of TB-1, TB-2, and TB-14, which were 8 inches in diameter when logged.

The electric logs of the large holes were effectively shorted out due to the extreme masking effect of the large amount of fluid present between the tool and the formation, and the high conductivity of the borehole fluid. Even under ideal borehole conditions, the electric logs would have shown very low resistivities, owing to the lithological conditions, i.e., clay shales saturated with conductive connate water. The large holes also produced very poor density curves due to the extreme borehole rugosity in the friable, unconsolidated sandy zones and in the fractured, more soluble gypsum layers. In some zones the diameter exceeded 13", the maximum limit of the caliper. It was in these extremely washed out zones that even the induction tool was unable to provide good data, in that the mathematics for converting the conductivity to resitivity would break down at such high conductivities, far outside the calibrated range of the tool. This situation resulted in a spike in the middle of the resistivity low on the plot, an artifact produced by the plotting algorithm in the software.

Scale Selection

The scales selected represent the best compromise in that for some holes they seem too insensitive to display enough detail, but in other holes they are the most sensitive scales useable without excessive off scale deflections. The scales used were fairly sensitive, due to the lack of variation in the sediments at the site, i.e., essentially all shale with thin gypsum layers too thin to cause any appreciable deflection of the curves. The intent was to avoid changing scales once a particular set was agreed upon and found to work in most of the holes. When off scale deflections did occur, it was often possible to simply bias (shift) the plot and avoid a scale change.

Additional plots

Composite logs for each hole were produced by merging the data from the various tools into a single large file for that hole using a software merge utility. The plots produced from this data displayed the natural gamma curve from the 9030 tool as it has the largest detector of the tools run and thus the best averaging, the S.P. from the 9071 tool, the induction curves from the 9500 tool, the density and caliper from the 9030 and the neutron log from the 9067. Some of these logs exhibit a diffent beginning depth for some of the parameters due to the fact that it was not possible to get all the smaller, ligther tools down as far as the larger, heavier ones. This effect is only noticeable in the extreme cases, as a certain amount is normal due to sensor offsets, e.g., in the 9030 the natural gamma detector is near the top of the tool, and the density detector is at the bottom.

CENTURY COMPU-LOG

DIGITAL COMPUTER LOG

MW 8-A

COMPANY : U.S.P.C.I.
WELL : MWH-30
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLAHOMA
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/27/87
DEPTH-DRILLER : 30
DEPTH-LOGGER : 29
LOG BOTTOM : 29
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

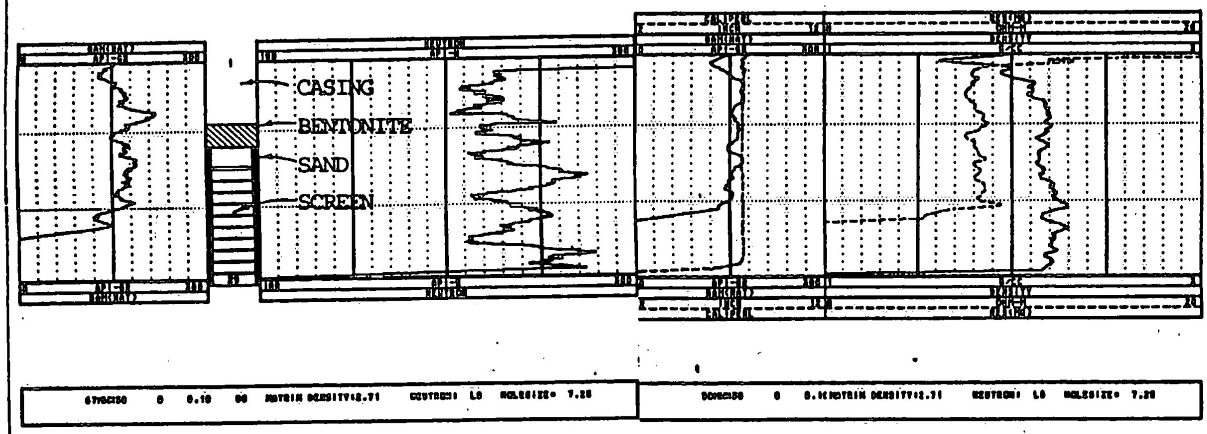
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



CENTURY COMPU-LOG

DIGITAL COMPUTER LOG

MW 8-B

COMPANY : U.S.P.C.I.
WELL : MWH-71
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLAHOMA
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/26/87
DEPTH-DRILLER : 71
DEPTH-LOGGER : 71
LOG BOTTOM : 71
LOG TOP : 0
TOOL TYPE : 9030A1

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

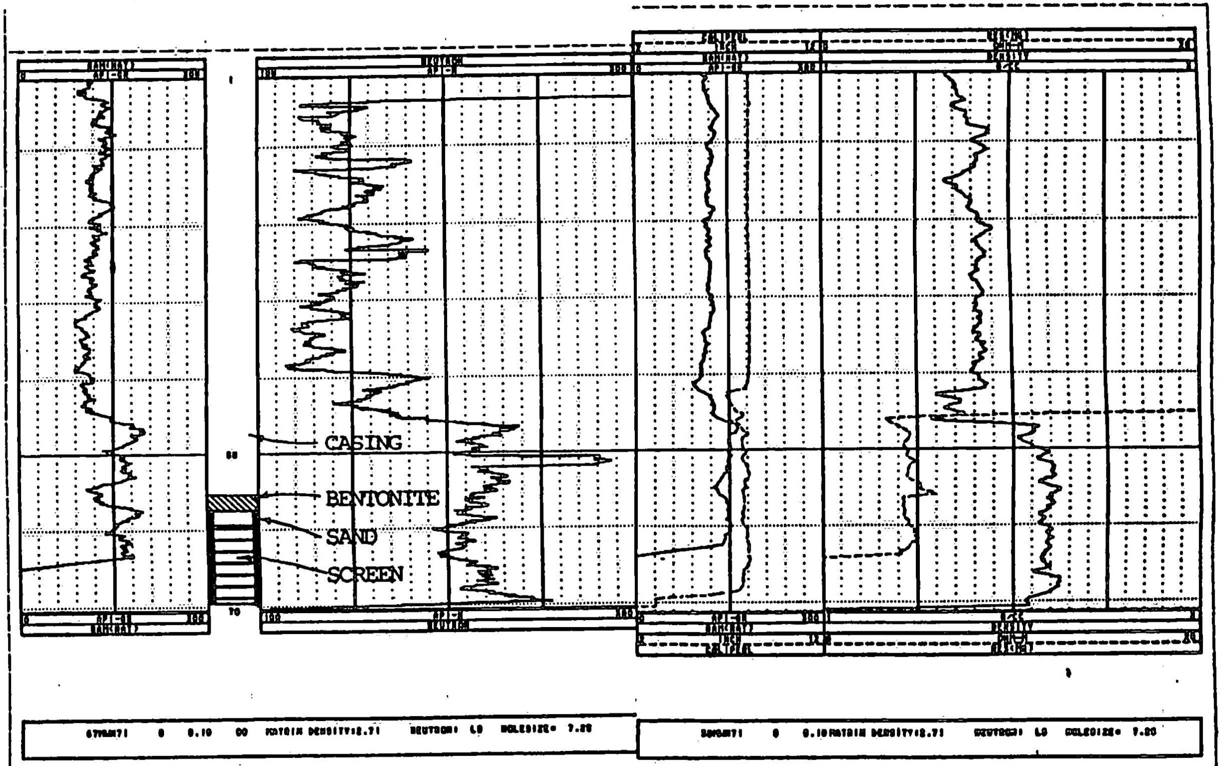
CASING-DRILLER : 46
CASING-LOGGER : 46
CASING TYPE : P.V.C.
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



CENTURY COMPU-LOG

DIGITAL COMPUTER LOG

MW 10-A

COMPANY : U.S.P.C.I.
WELL : MWJ-17
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION :
TOWNSHIP :
RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/26/87
DEPTH-DRILLER : 17
DEPTH-LOGGER : 15
LOG BOTTOM : 15
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

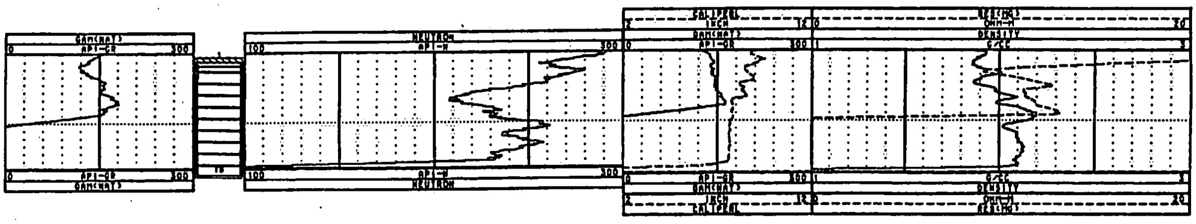
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



67MWD17 0 0.10 00 MATRIX DENSITY:2.71 NEUTRON: LO HOLESIZE= 7.25

30MWD17 0 0.10MATRIX DENSITY:2.71 NEUTRON: LO HOLESIZE= 7.25

CENTURY COMPU-LOG

DIGITAL COMPUTER LOG

MW 10-B

COMPANY : U.S.P.C.I.
WELL : MWJ-59
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/22/87
DEPTH-DRILLER : 59
DEPTH-LOGGER : 58
LOG BOTTOM : 58
LOG TOP : 0
TOOL TYPE : 9030A1

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

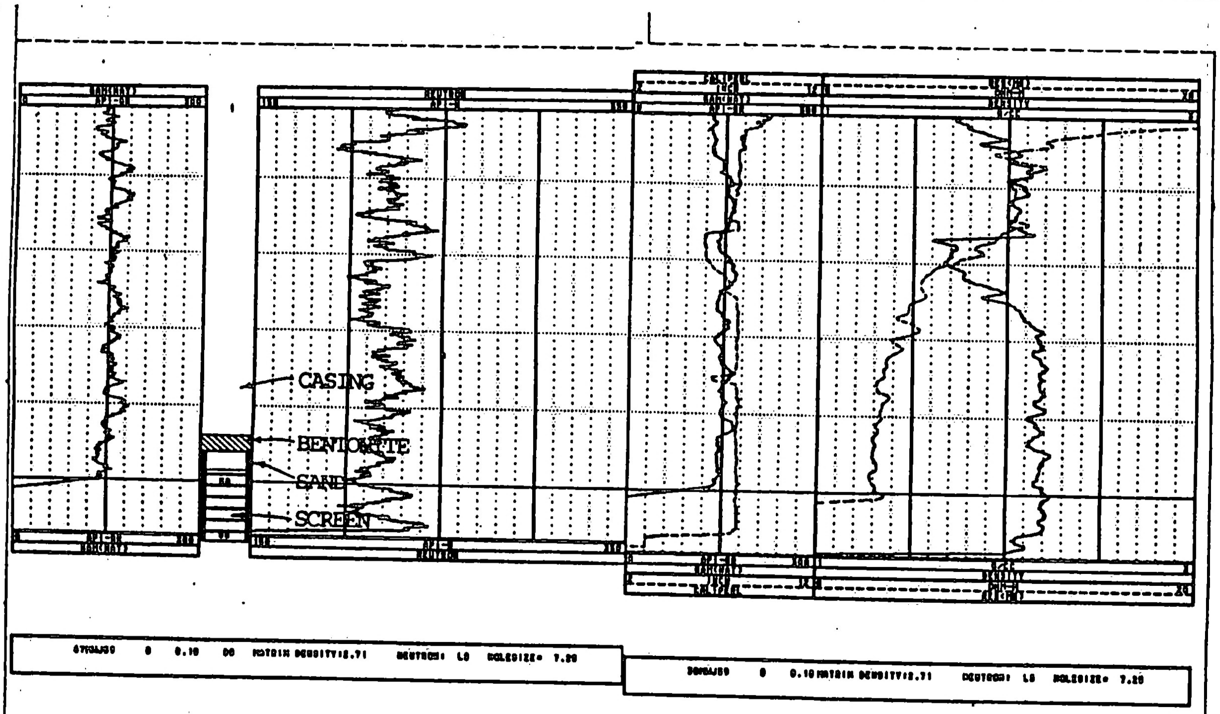
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



CENTURY COMPU-LOG

DIGITAL COMPUTER LOG

MW 6-A

COMPANY : U.S.P.C.I.
WELL : MWG-23
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/21/87
DEPTH-DRILLER : 23
DEPTH-LOGGER : 23
LOG BOTTOM : 23
LOG TOP : 0
TOOL TYPE : 9067

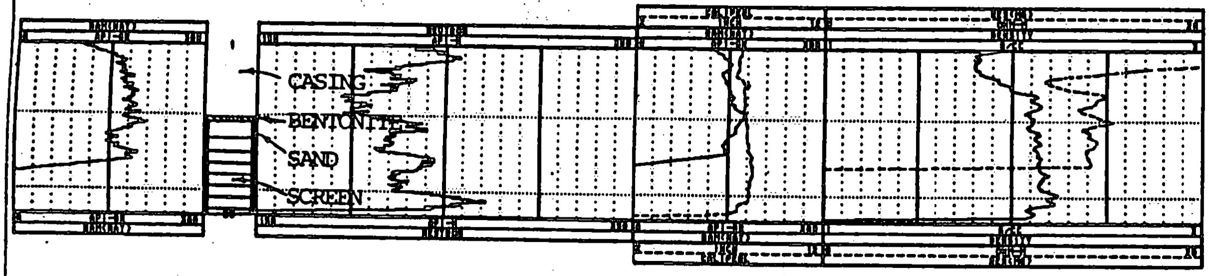
BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :



[illegible] 0 0.10 90 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 7.25

[illegible] 0 0.10 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 7.25

COMPU-LOG

DIGITAL COMPUTER LOG

MW 6-B

OTHER SERVICES

COMPANY : U.S.P.C.I.
WELL : MWG-41
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/26/87
DEPTH-DRILLER : 41
DEPTH-LOGGER : 39
LOG BOTTOM : 39
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H20
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

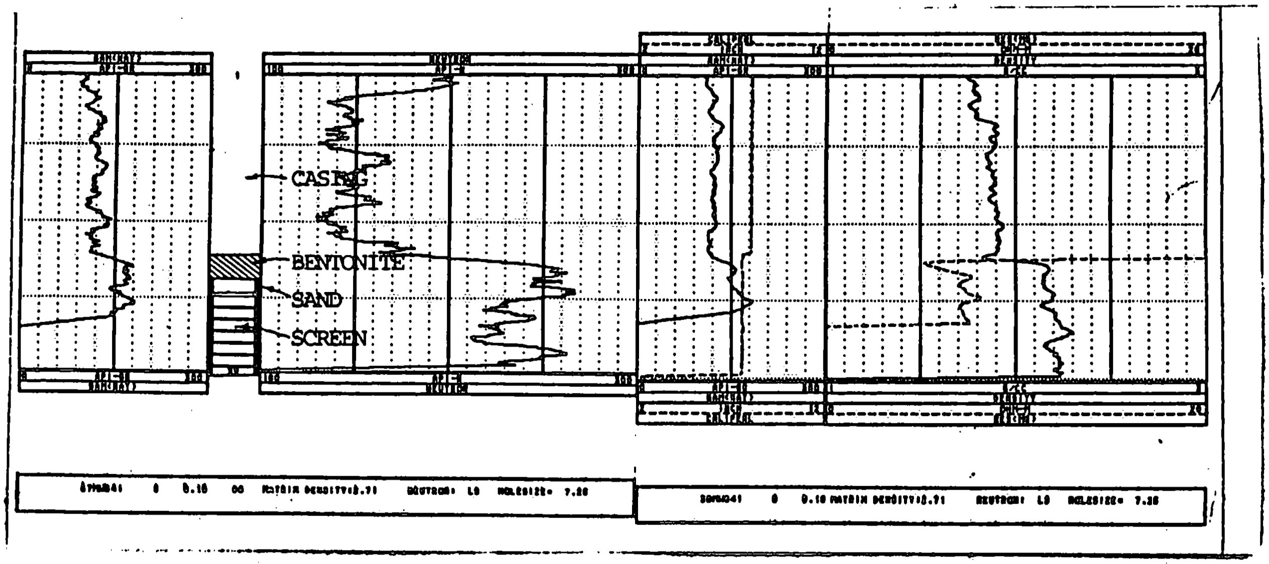
CASING-DRILLER : 25
CASING-LOGGER : 25
CASING TYPE : P.V.C.
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



COMPU-LOG

DIGITAL COMPUTER LOG

MW 6-C

COMPANY : U.S.P.C.I.
WELL : MWG-71
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLAHOMA
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/26/87
DEPTH-DRILLER : 71
DEPTH-LOGGER : 70
LOG BOTTOM : 70
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H20
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

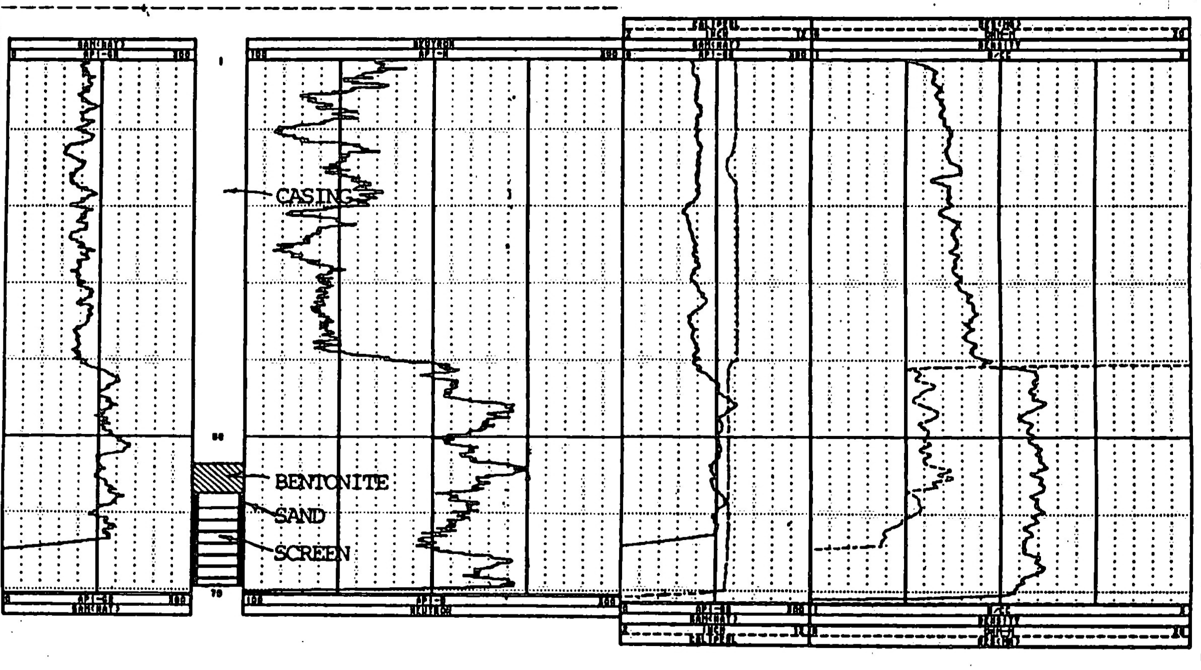
CASING-DRILLER : 41
CASING-LOGGER : 41
CASING TYPE : P.V.C.
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



CENTURY COMPU-LOG

DIGITAL COMPUTER LOG

MW 5-A

COMPANY : U.S.P.C.I.
WELL : MWF-30
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/19/87
DEPTH-DRILLER : 30.4
DEPTH-LOGGER : 29.97
LOG BOTTOM : 29
LOG TOP : 0
TOOL TYPE : 9030A1

BOREHOLE FLUID : H20
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

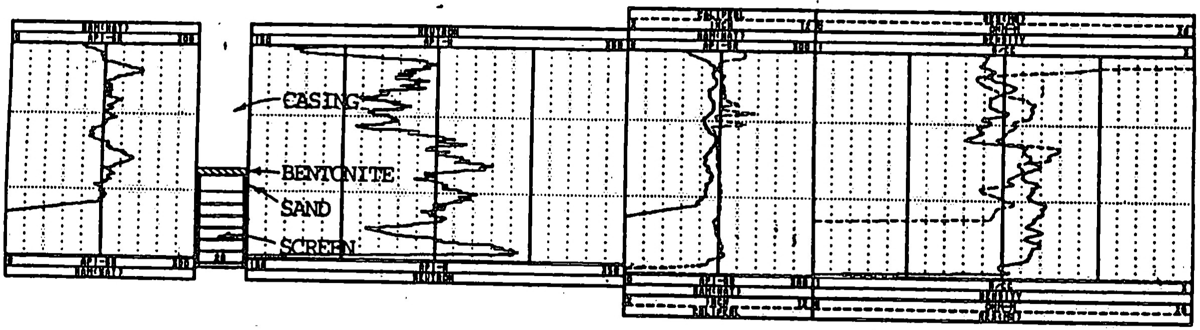
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



[illegible] 0 0.10 90 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 7.25

[illegible] 0 0.10 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 7.25

CENTURY COMPU-LOG

DIGITAL COMPUTER LOG

MW 5-B

COMPANY : U.S.P.C.I.
WELL : MWF-71
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/25/87
DEPTH-DRILLER : 71
DEPTH-LOGGER : 68
LOG BOTTOM : 68
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H20
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

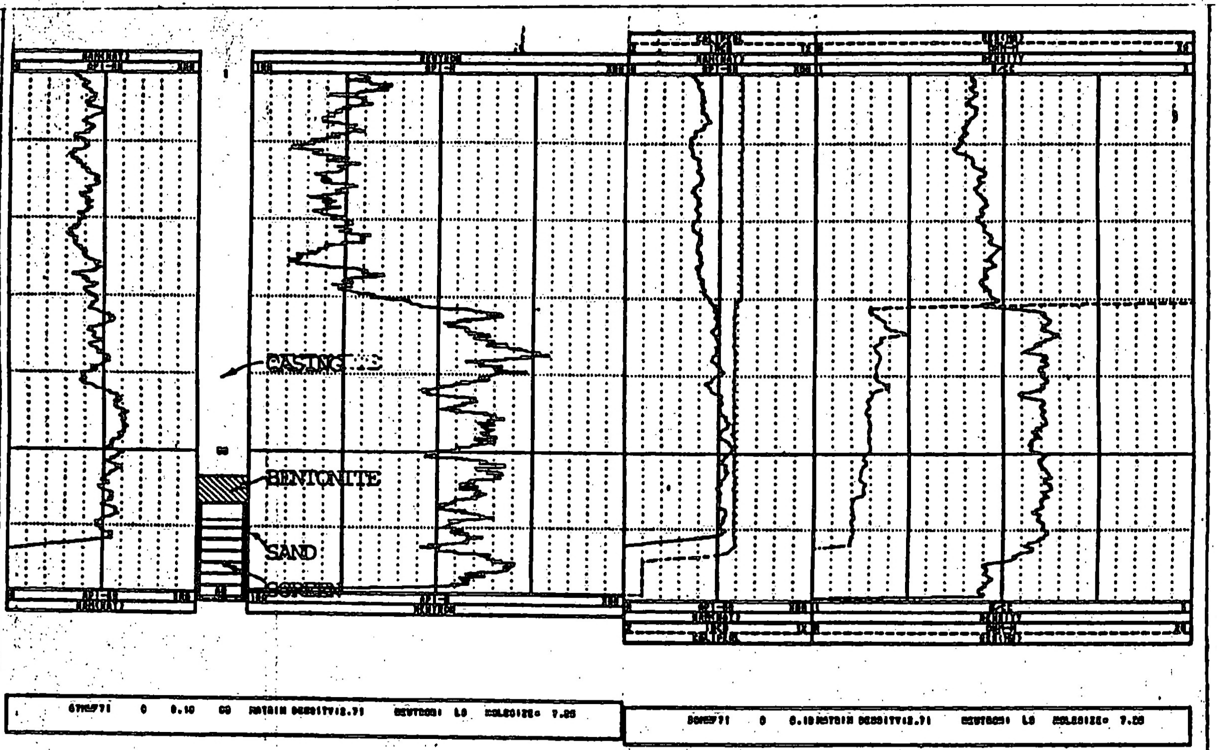
CASING-DRILLER : 30
CASING-LOGGER : 31
CASING TYPE : P.V.C.
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



DIGITAL COMPUTER LOG

COMPANY : U.S.P.C.I.
WELL : MWK-164
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION :
TOWNSHIP :
RANGE :

MW CH-D

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/25/87
DEPTH-DRILLER : 164
DEPTH-LOGGER : 163
LOG BOTTOM : 163
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H20
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

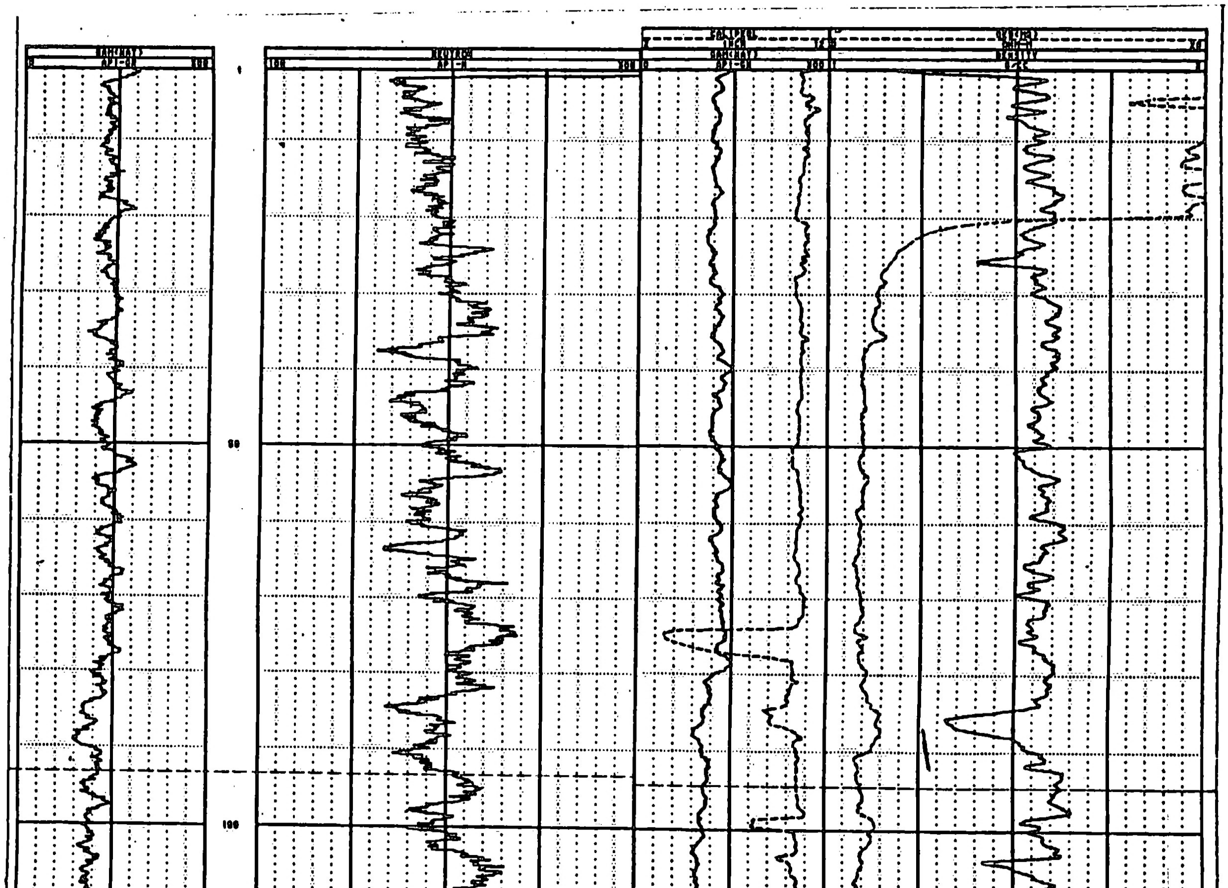
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE :
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 10
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



CENTURY COMPU-LOG

DIGITAL COMPUTER LOG

MW 4-A

COMPANY : U.S.P.C.I.
WELL : MWE-29
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/28/87
DEPTH-DRILLER : 29
DEPTH-LOGGER : 27
LOG BOTTOM : 27
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H20
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

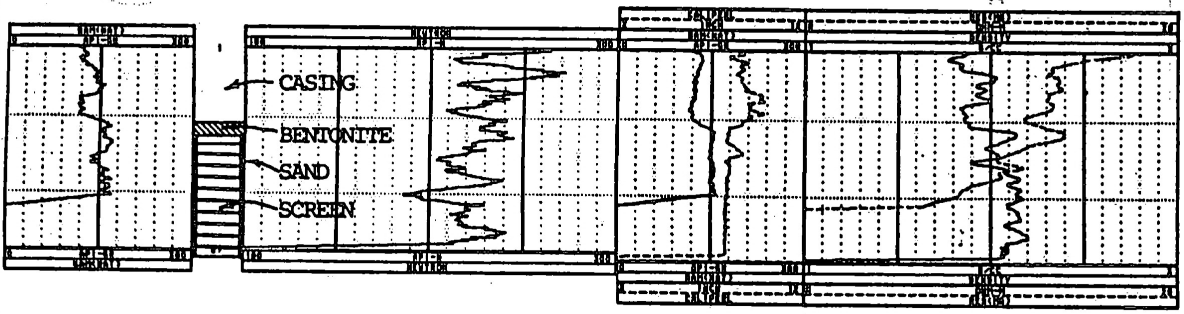
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



[illegible] 0 0.10 00 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 7.25

[illegible] 0 0.10 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 7.25

CENTURY COMPU-LOG

DIGITAL COMPUTER LOG

MW 4-B

COMPANY : U.S.P.C.I.
WELL : MWE-74
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLAHOMA
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/27/87
DEPTH-DRILLER : 74
DEPTH-LOGGER : 72
LOG BOTTOM : 72
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

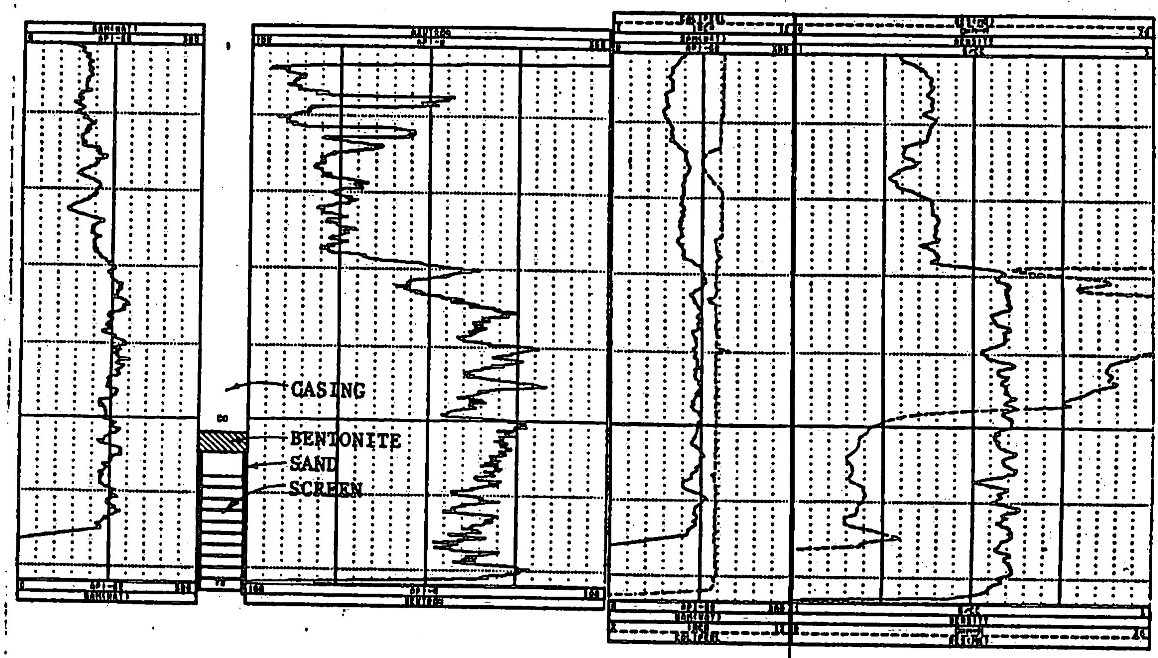
CASING-DRILLER : 29
CASING-LOGGER : 29
CASING TYPE : P.V.C.
CASING WEIGHT :

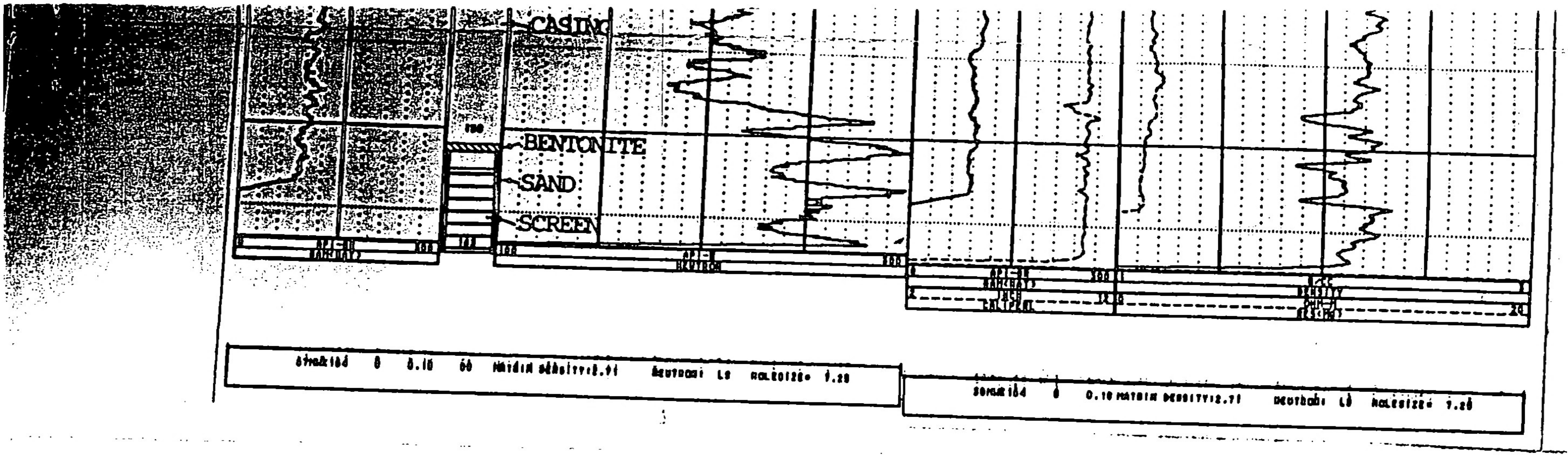
LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS




CASING
BENTONITE
SAND
SCREEN
API-GR
GAM(NAT)
100
API-U
NEUTRON
0
API-GR
GAM(NAT)
INCH
CALIPER
DENSITY
RES(FR)
20
SONIC 104 0 0.10 60 MATRIX DENSITY 2.71 NEUTRON LS HOLESIZE= 7.20
SONIC 104 0 0.10 MATRIX DENSITY 2.71 NEUTRON LS HOLESIZE= 7.20

COMPU-LOG

DIGITAL COMPUTER LOG.

MW 4-C

COMPANY : U.S.P.C.I.
WELL : MWE-92
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/29/87
DEPTH-DRILLER : 92
DEPTH-LOGGER : 91
LOG BOTTOM : 91
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H20
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

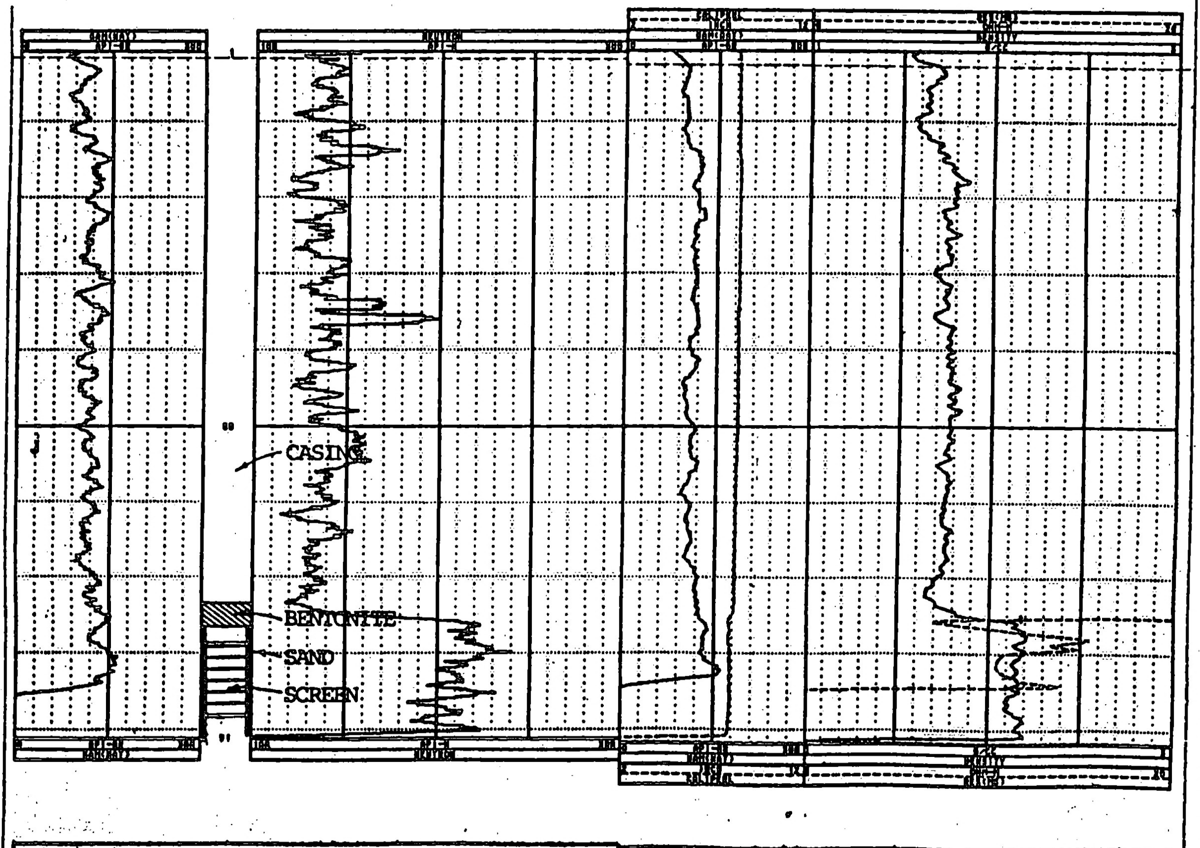
CASING-DRILLER :
CASING-LOGGER : 76
CASING TYPE : P.V.C.
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



CENTURY
COMPU-LOG

DIGITAL COMPUTER LOG

MW 1-C

COMPANY : U.S.P.C.I.
WELL : MWA-47
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLAHOMA
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/26/87
DEPTH-DRILLER : 47
DEPTH-LOGGER : 43
LOG BOTTOM : 43
LOG TOP : 0
TOOL TYPE : 9067

CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

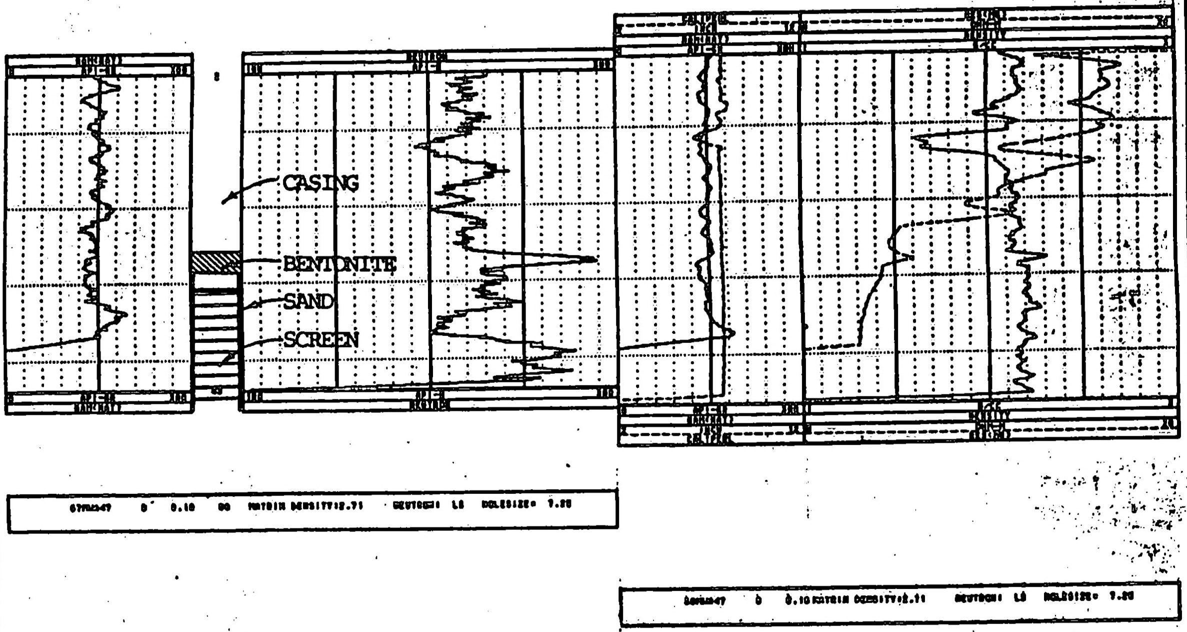
BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



CENTURY
COMPU-LOG

DIGITAL COMPUTER LOG

MW 1-C

COMPANY : U.S.P.C.I.
WELL : MWA-47
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLAHOMA
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/26/87
DEPTH-DRILLER : 47
DEPTH-LOGGER : 43
LOG BOTTOM : 43
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

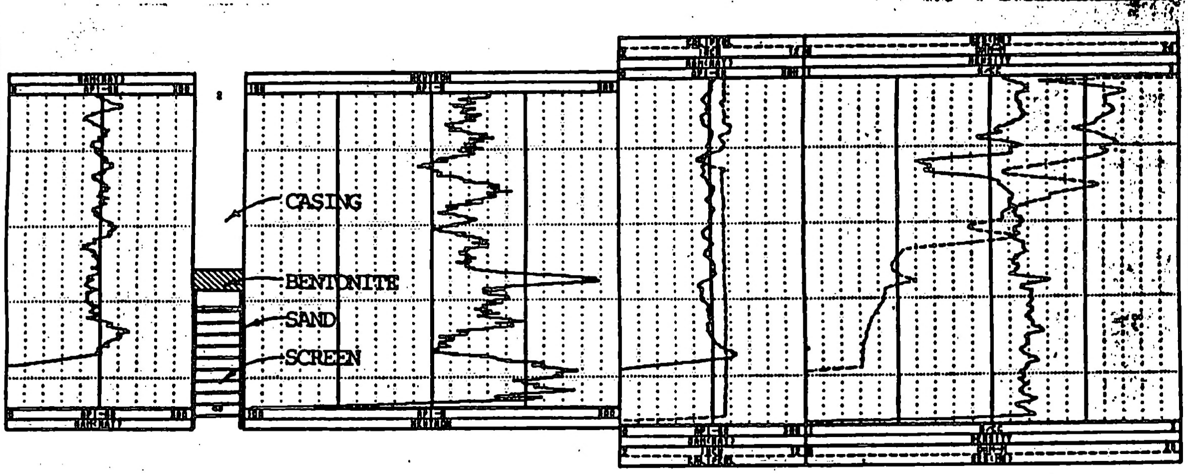
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



[illegible] 0 0.10 CG MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 7.25

[illegible] 0 0.10 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 7.25

MW 2-C

COMPANY : U.S.P.C.I.
WELL : MWB-144
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/21/87
DEPTH-DRILLER : 144
DEPTH-LOGGER : 125
LOG BOTTOM : 125
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

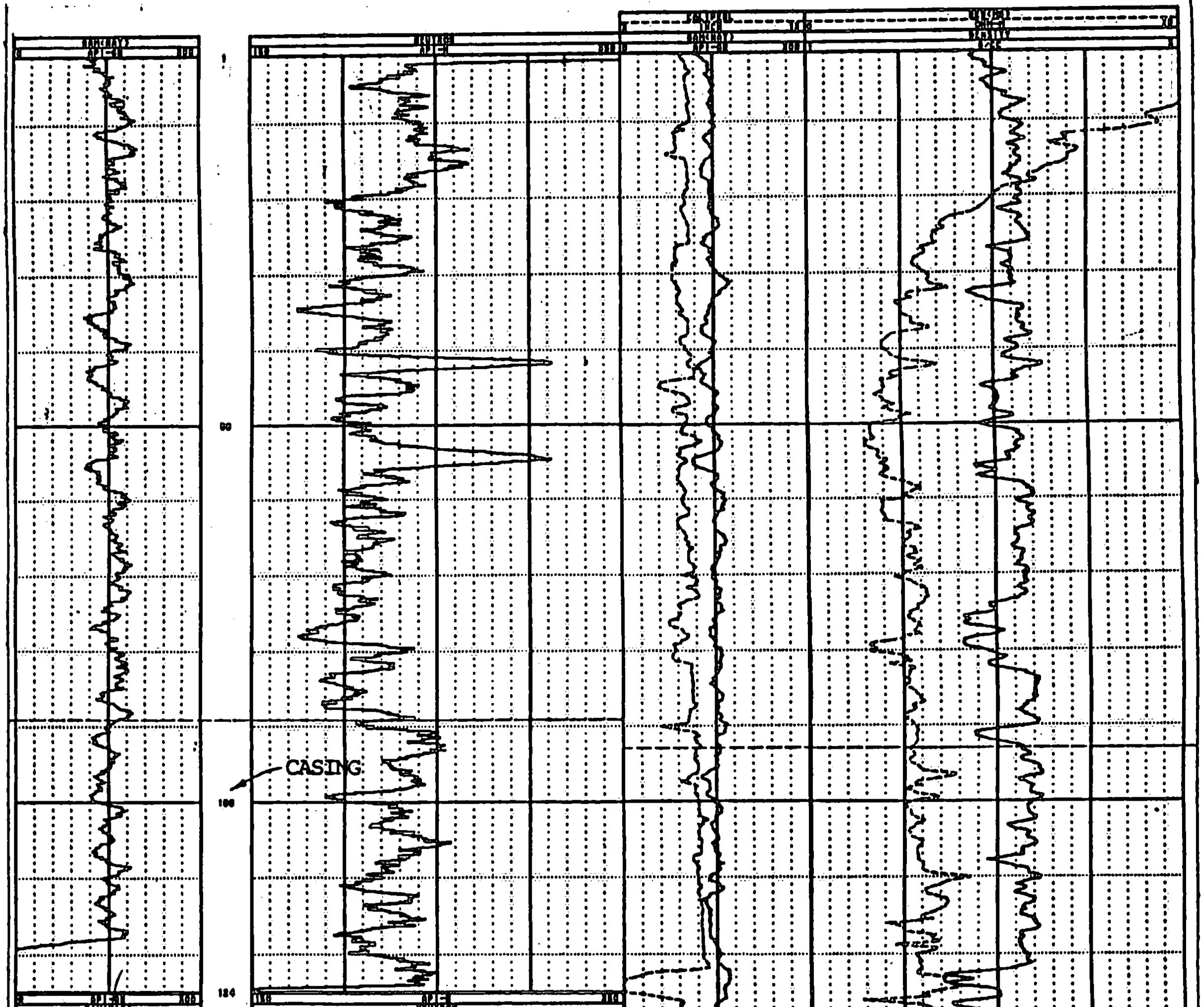
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS : UNABLE TO REACH T.D.

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



MW 1-D

COMPANY : U.S.P.C.I.
WELL : MWA-132
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/23/87
DEPTH-DRILLER : 132
DEPTH-LOGGER : 132
LOG BOTTOM : 132
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H20
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

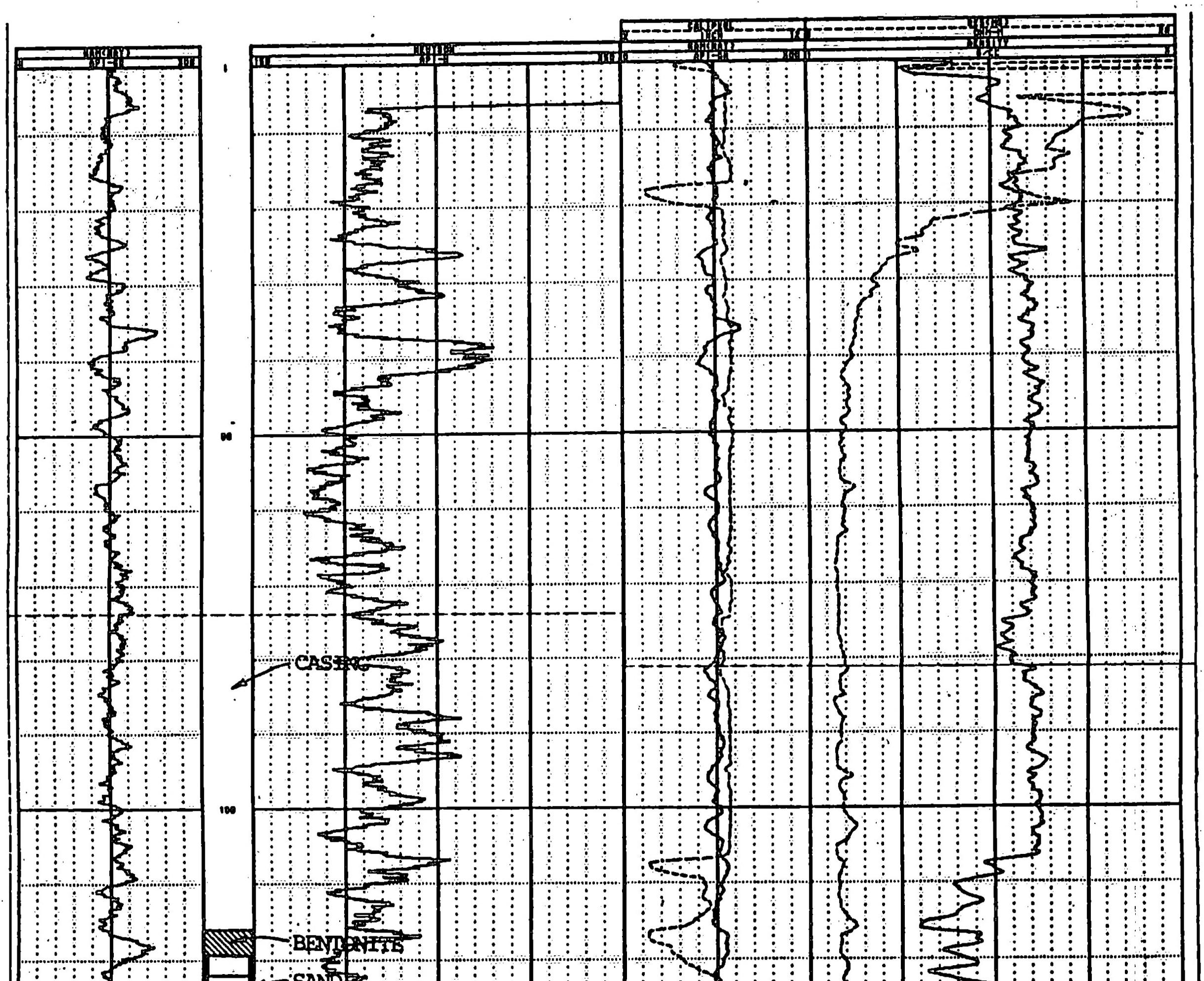
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



DIGITAL COMPUTER LOG

MW 3-A

COMPANY : U.S.P.C.I.
WELL : MWD-23
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/22/87
DEPTH-DRILLER : 23
DEPTH-LOGGER : 21.8
LOG BOTTOM : 21.8
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE : -
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

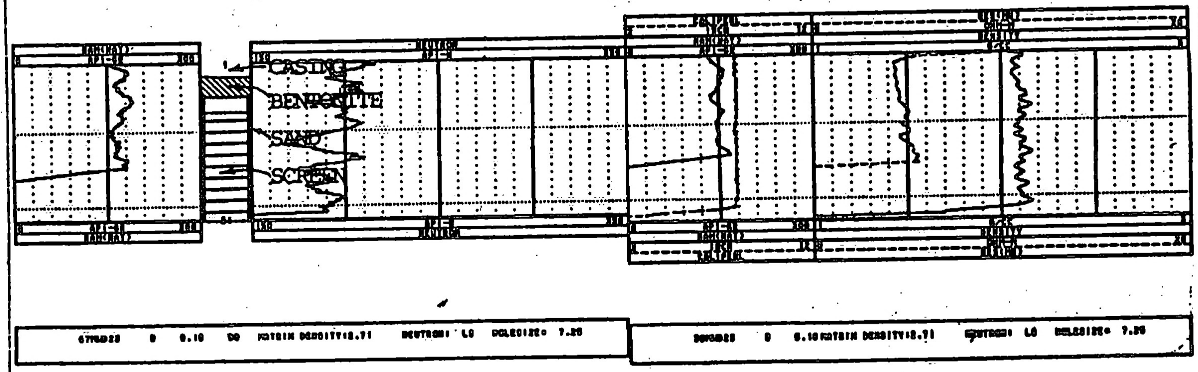
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



COMPU-LOG

DIGITAL COMPUTER LOG

COMPANY : U.S.P.C.I.
WELL : MWD-89
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

MW 3-B

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/28/87
DEPTH-DRILLER : 89
DEPTH-LOGGER : 87
LOG BOTTOM : 87
LOG TOP : 0
TOOL TYPE : 9067

CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

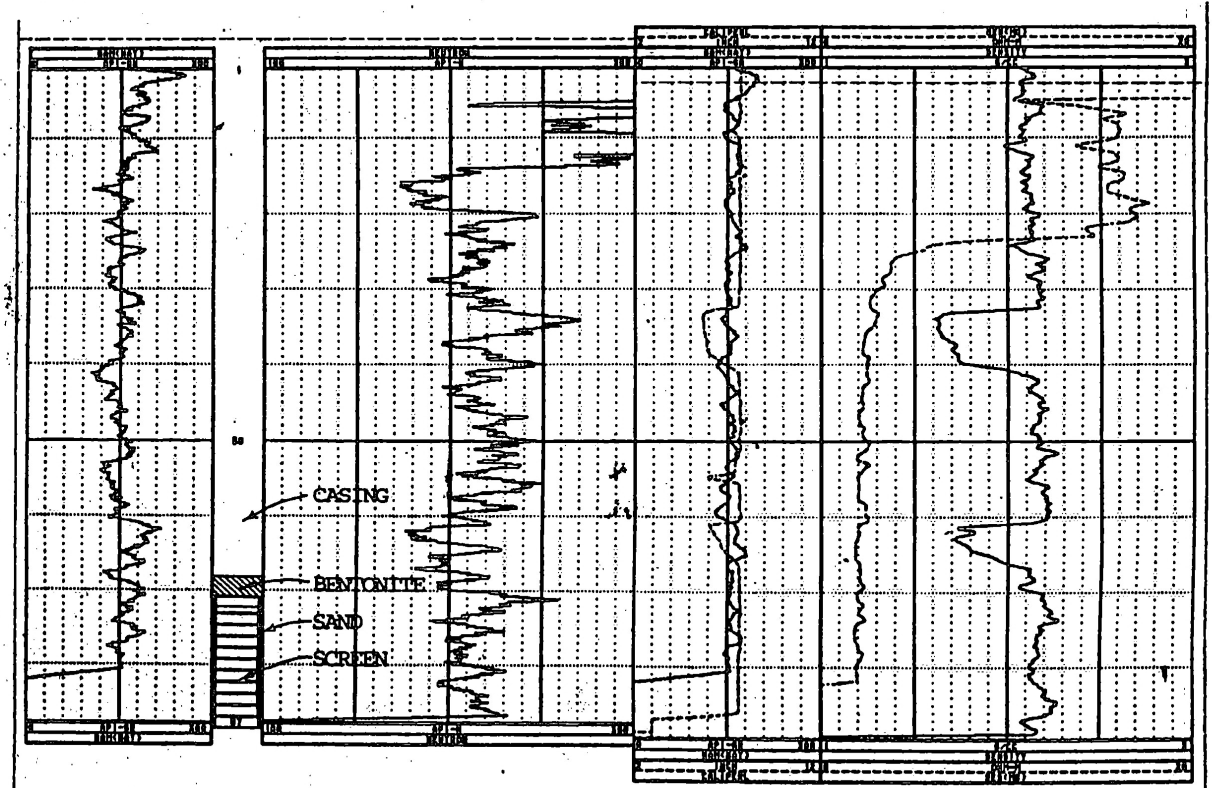
BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS



DIGITAL COMPUTER LOG

MW 3-C

COMPANY : U.S.P.C.I.
WELL : MWD-116
FIELD : LONE MOUNTAIN
COUNTY : MAJOR
STATE : OKLA.
NATION : USA
LOCATION : WAYNOKA
SECTION : TOWNSHIP : RANGE :

OTHER SERVICES

PERMANENT DATUM : GL
ELEV. PERM. DATUM :
LOG MEASURED FROM : GL
DRLG. MEASURED FROM : GL

ELEVATIONS
KB :
DF :
GL :

DATE : 08/29/87
DEPTH-DRILLER : 116
DEPTH-LOGGER : 115
LOG BOTTOM : 115
LOG TOP : 0
TOOL TYPE : 9067

BOREHOLE FLUID : H2O
FLUID WT/VIS :
SAMPLE SOURCE :
RM : @ F
RMF : @ F
RMC : @ F
RM @ BHT : @ F
CIRC STOPPED :

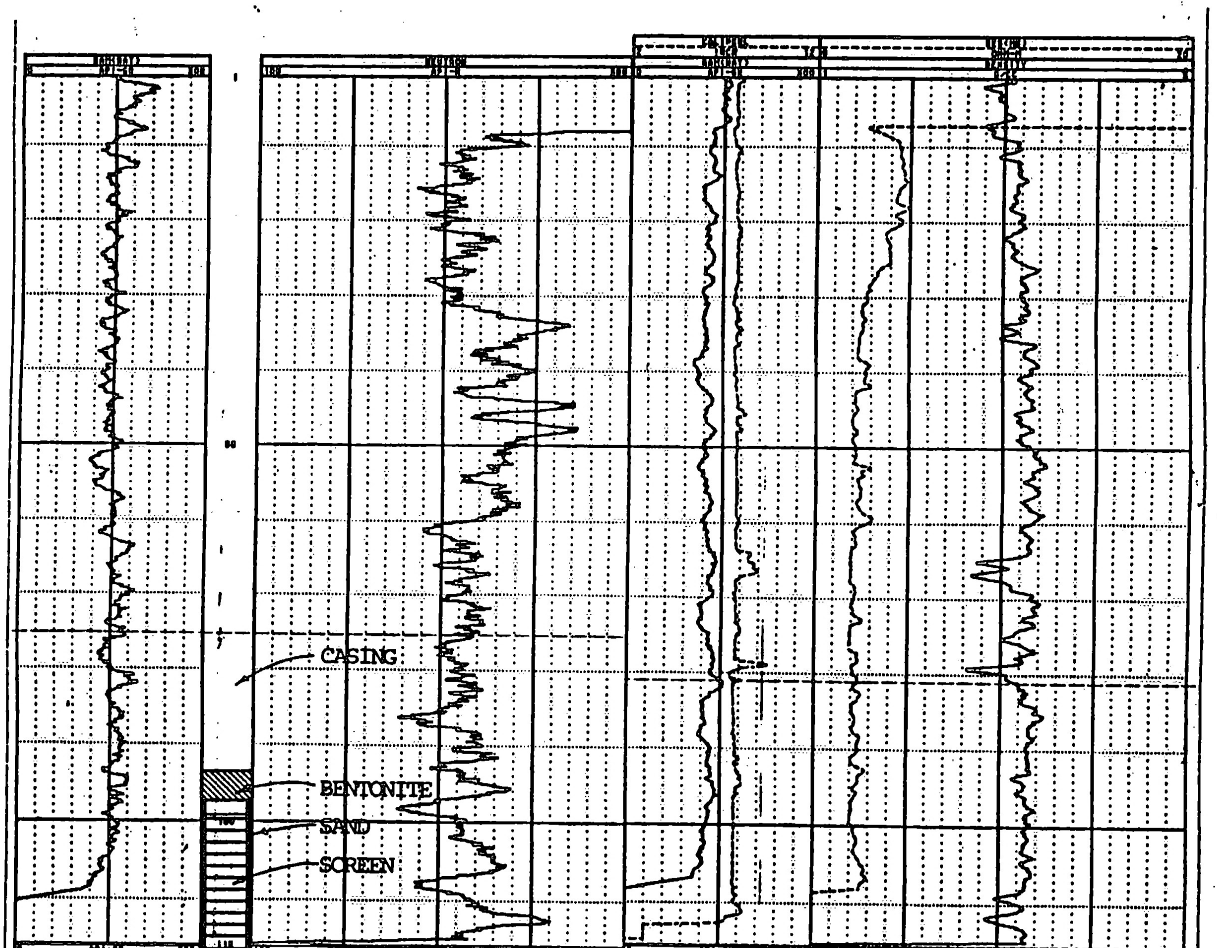
CASING-DRILLER :
CASING-LOGGER :
CASING TYPE : NONE
CASING WEIGHT :

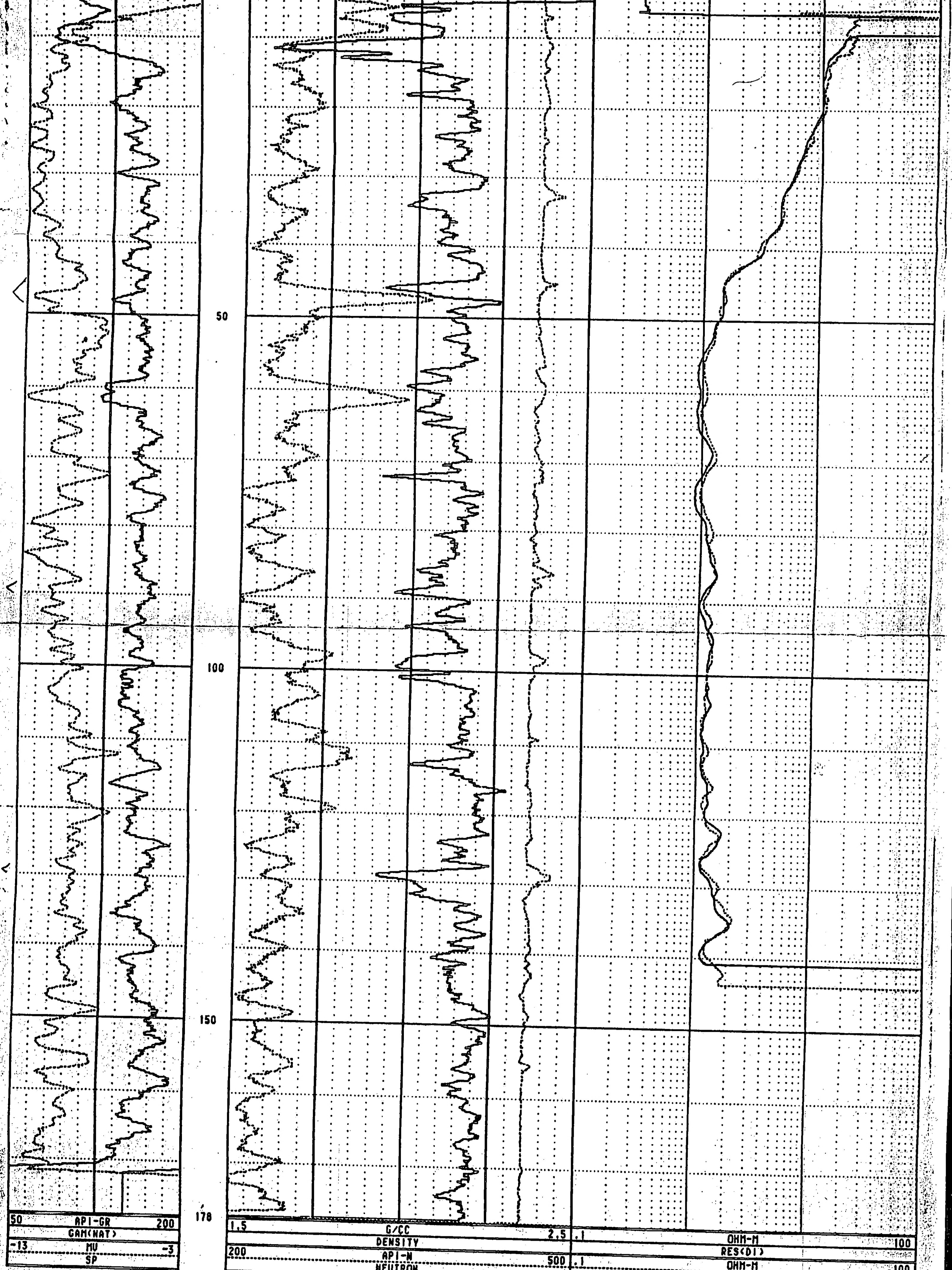
LOGGING UNIT : 7909
FIELD OFFICE : TULSA
RECORDED BY : R. MILLER
WITNESSED BY :

BIT SIZE : 7.25
DEPTH : T.D.

REMARKS :

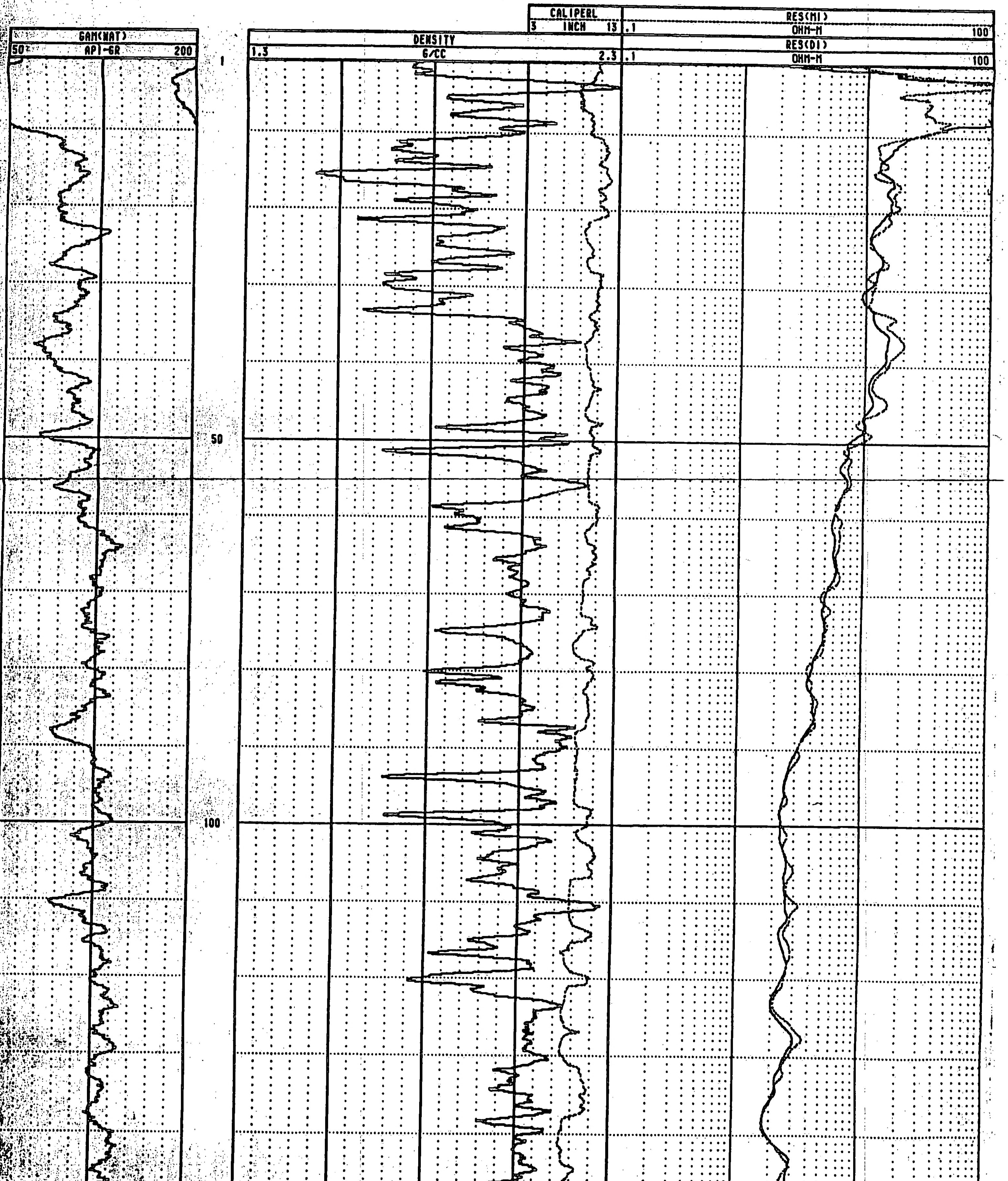
ALL SERVICES PROVIDED SUBJECT TO CGC STANDARD TERMS AND CONDITIONS

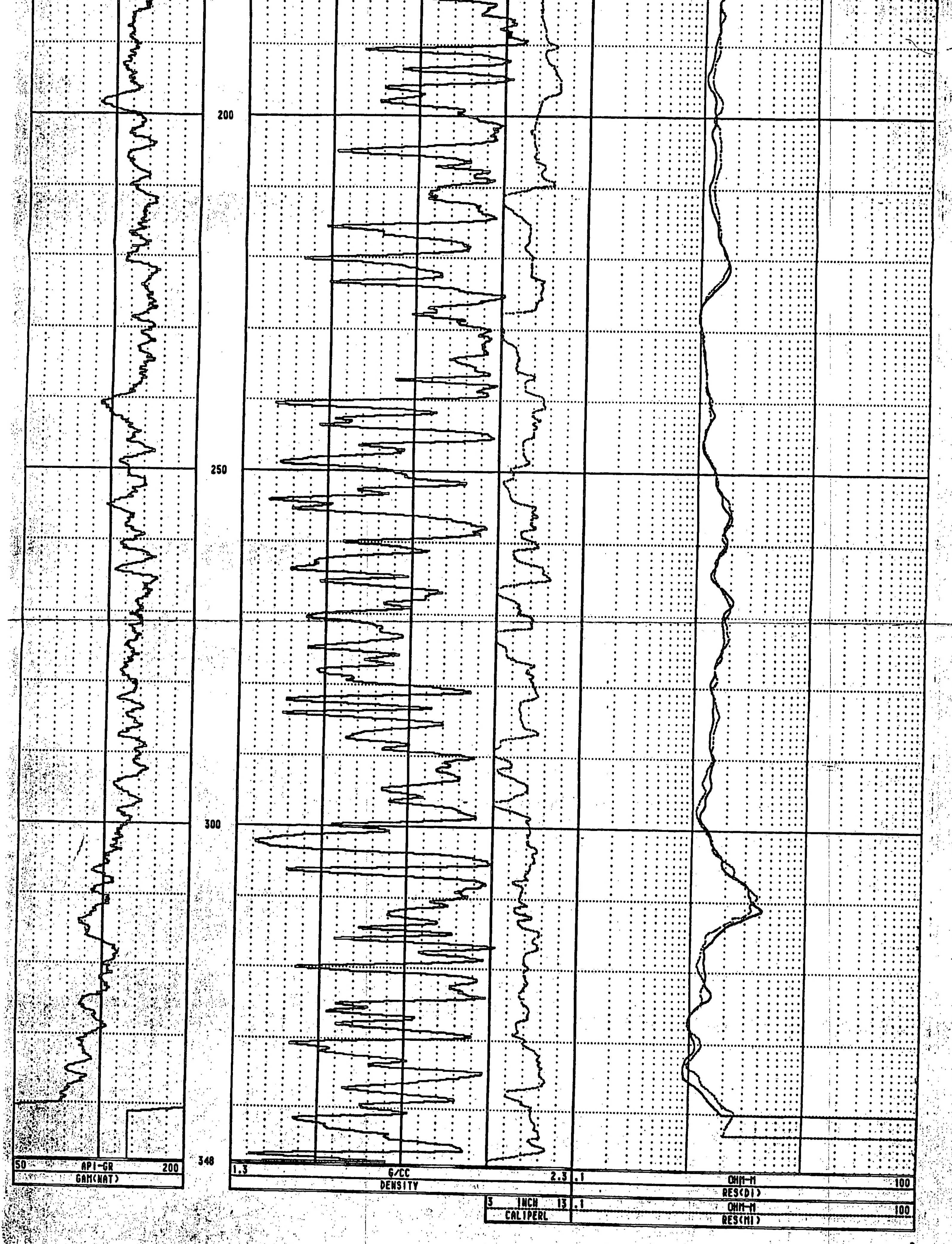


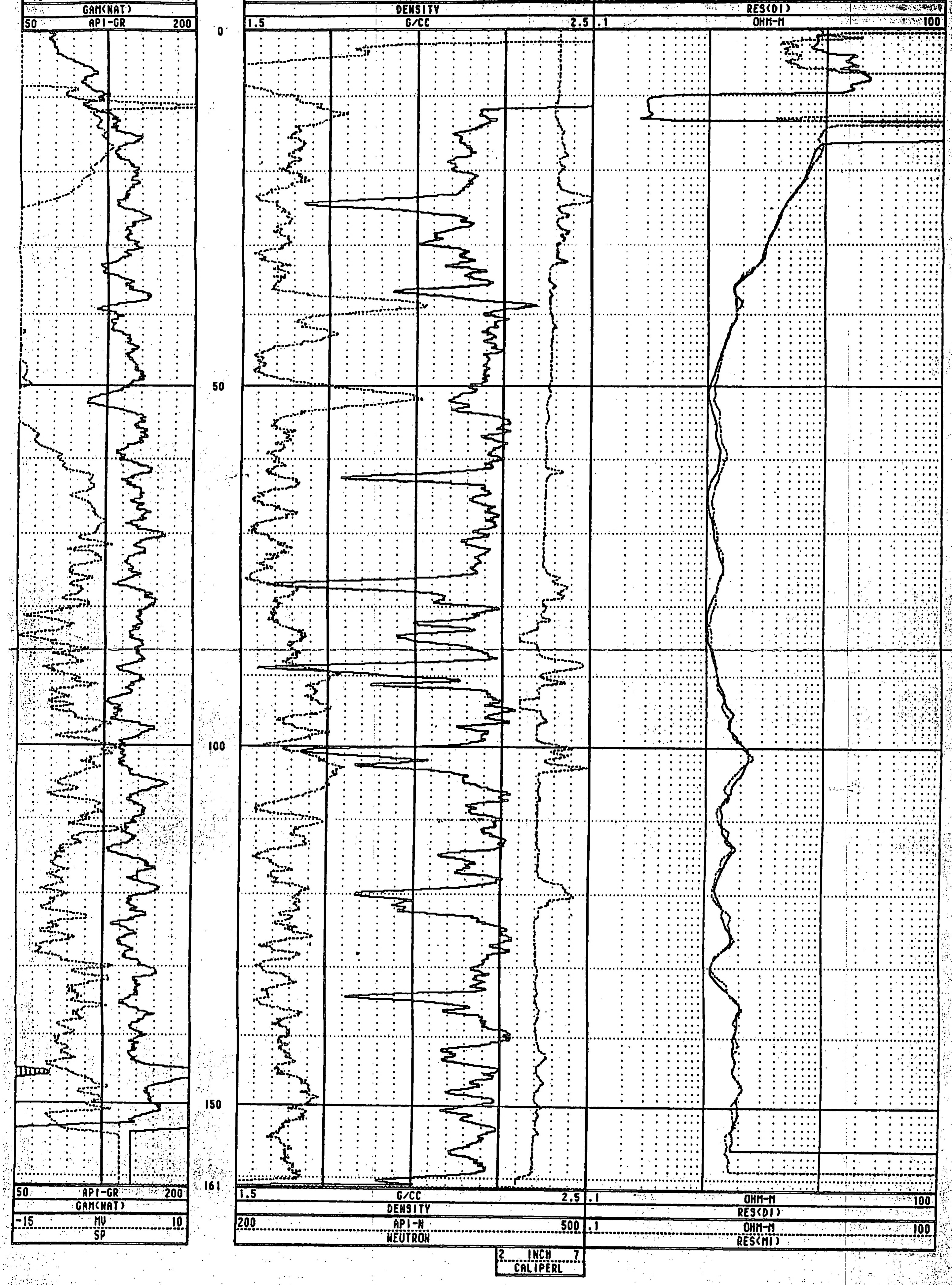

50
100
150
178
50
API-GR
200
GAM(NAT)
-13
MV
-3
SP
1.5
G/CC
2.5
DENSITY
200
API-N
500
NEUTRON
.1
OHM-M
100
RES(DI)
.1
OHM-M
100

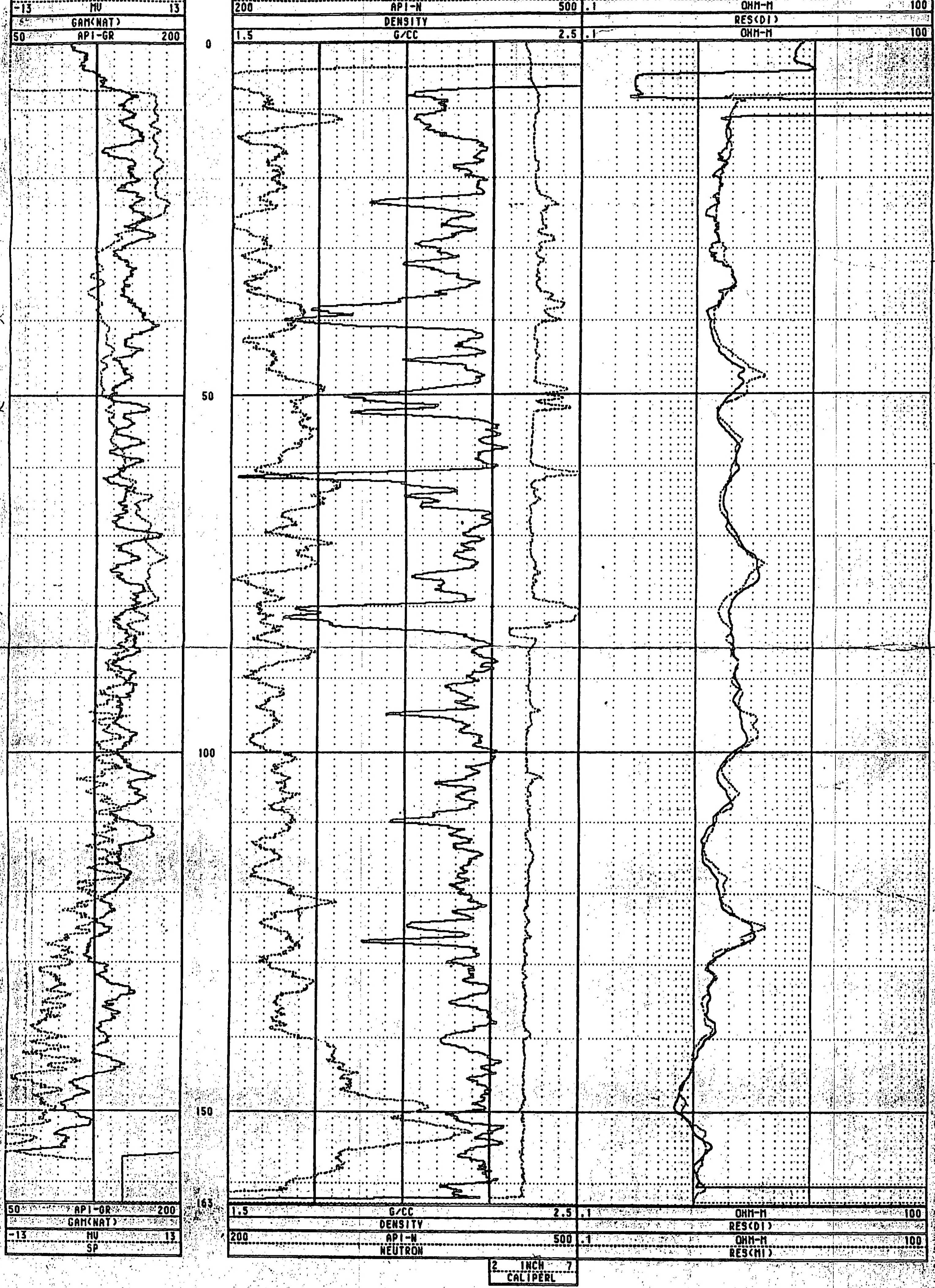
USPCI INC. GEOPHYSICAL LOG

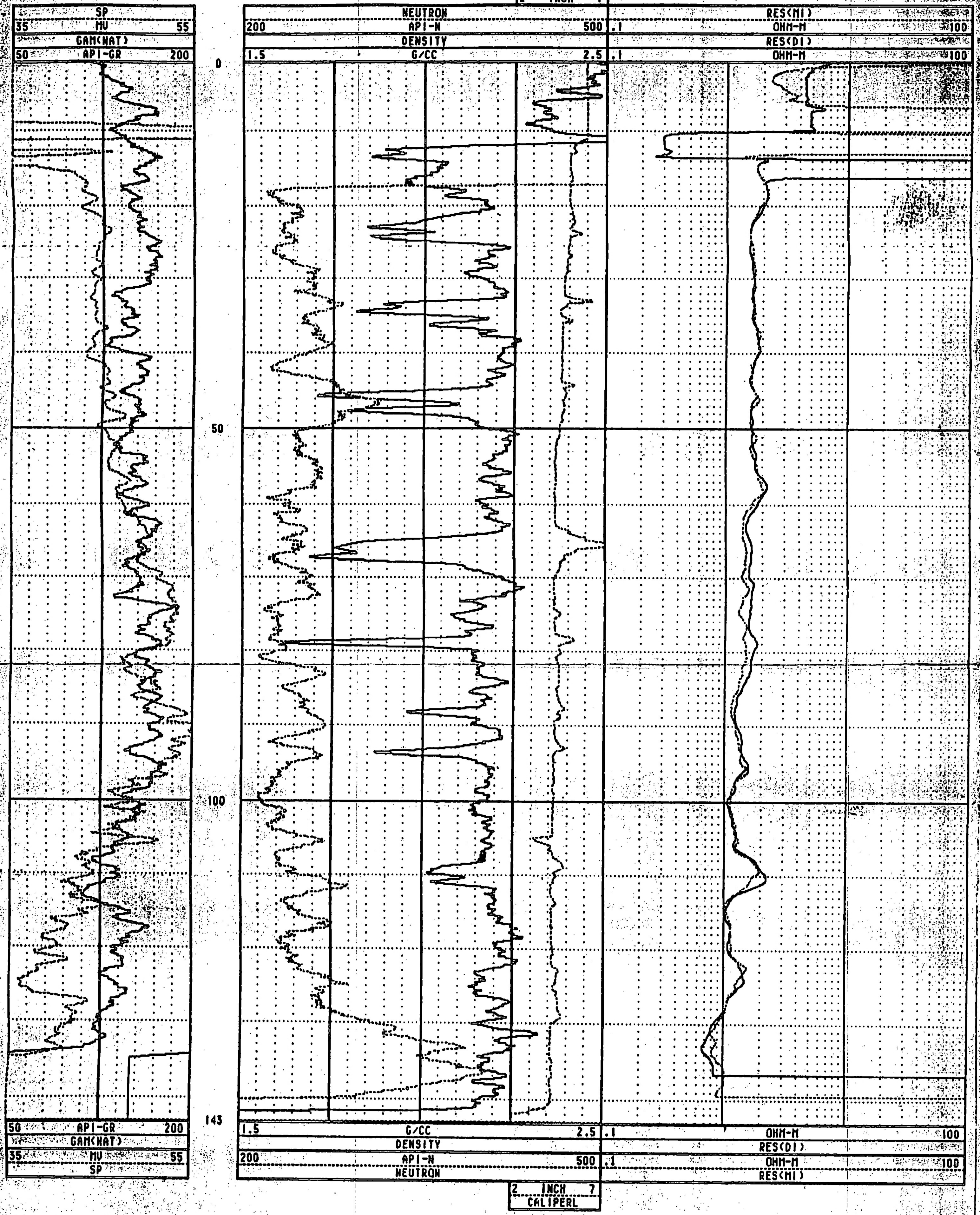
PROJECT NO.: 3187108
BORING NO.: TB-2-8
BORING LOCATION: 7776.5E - 11200.0N
SURFACE ELEV.: 1607.1
CONTRACTOR: CENTURY GEOPHYSICAL CORP.
DRILLER'S DEPTH: 357.6'
DATE LOGGED: 6/23/87
LOGGER: R. MILLER
LOGGER'S DEPTH: 348'




200
250
300
348
50 API-GR 200
GAM(NAT)
1.3 G/CC 2.3
DENSITY
3 INCH 13
CALIPERL
.1 OHM-M 100
RES(DI)
.1 OHM-M 100
RES(MI)


GAM(NAT)
50 API-GR 200
DENSITY
1.5 G/CC 2.5
RES(DI)
.1 OHM-M 100
0
50
100
150
161
50 API-GR 200
GAM(NAT)
-15 MV 10
SP
1.5 G/CC 2.5
DENSITY
200 API-N 500
NEUTRON
2 INCH 7
CALIPERL
.1 OHM-M 100
RES(DI)
.1 OHM-M 100
RES(MI)


-13 MV 13
GAM(NAT)
50 API-GR 200
200 API-N 500
DENSITY
1.5 G/CC 2.5
.1 OHM-M 100
RES(DI)
.1 OHM-M 100
0
50
100
150
163
50 API-GR 200
GAM(NAT)
-13 MV 13
SP
1.5 G/CC 2.5
DENSITY
200 API-N 500
NEUTRON
.1 OHM-M 100
RES(DI)
.1 OHM-M 100
RES(MI)
2 INCH 7
CALIPERL

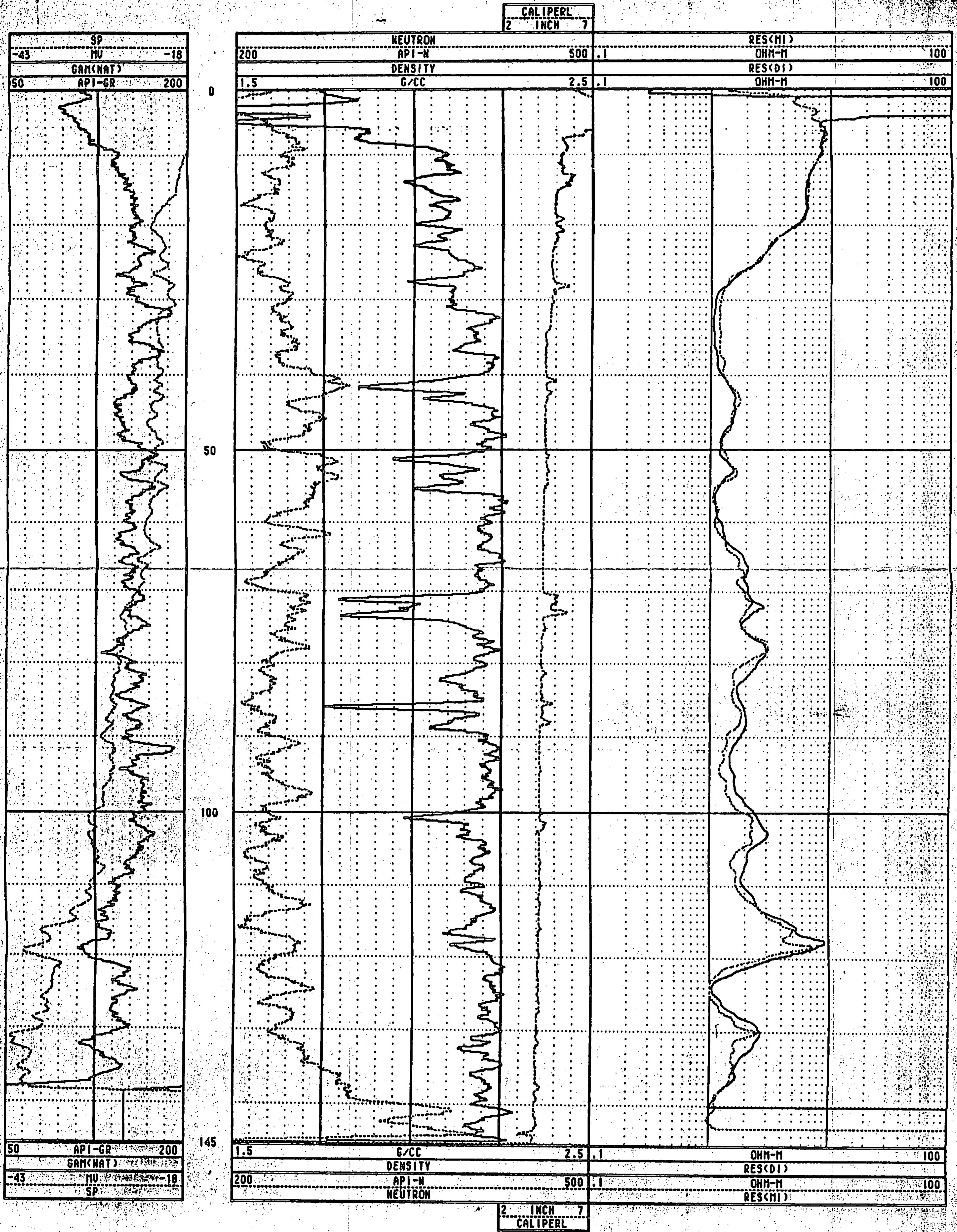


TB6M 0 0.10 00 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 4.00

TB-6

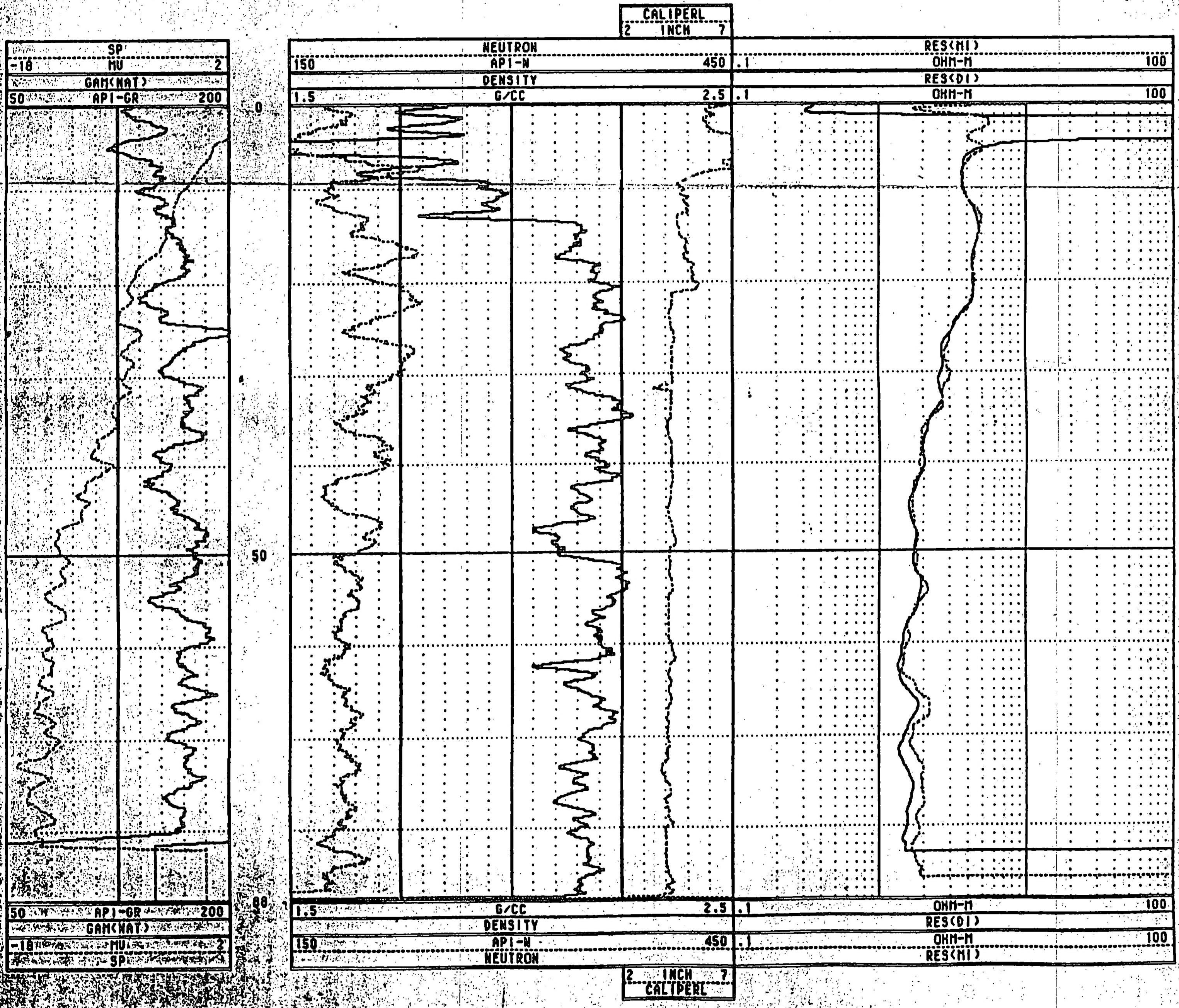
PROJECT NO.: 3187108
BORING NO.: TB-7
BORING LOCATION: 9429.2E - 10753.9N
SURFACE ELEV.: 1413.9 DRILLER'S DEPTH: 148.5'

DATE LOGGED: 6/17/87
CONTRACTOR: CENTURY GEOPHYSICAL CORP.
LOGGER: R. MILLER
LOGGER'S DEPTH: 145'



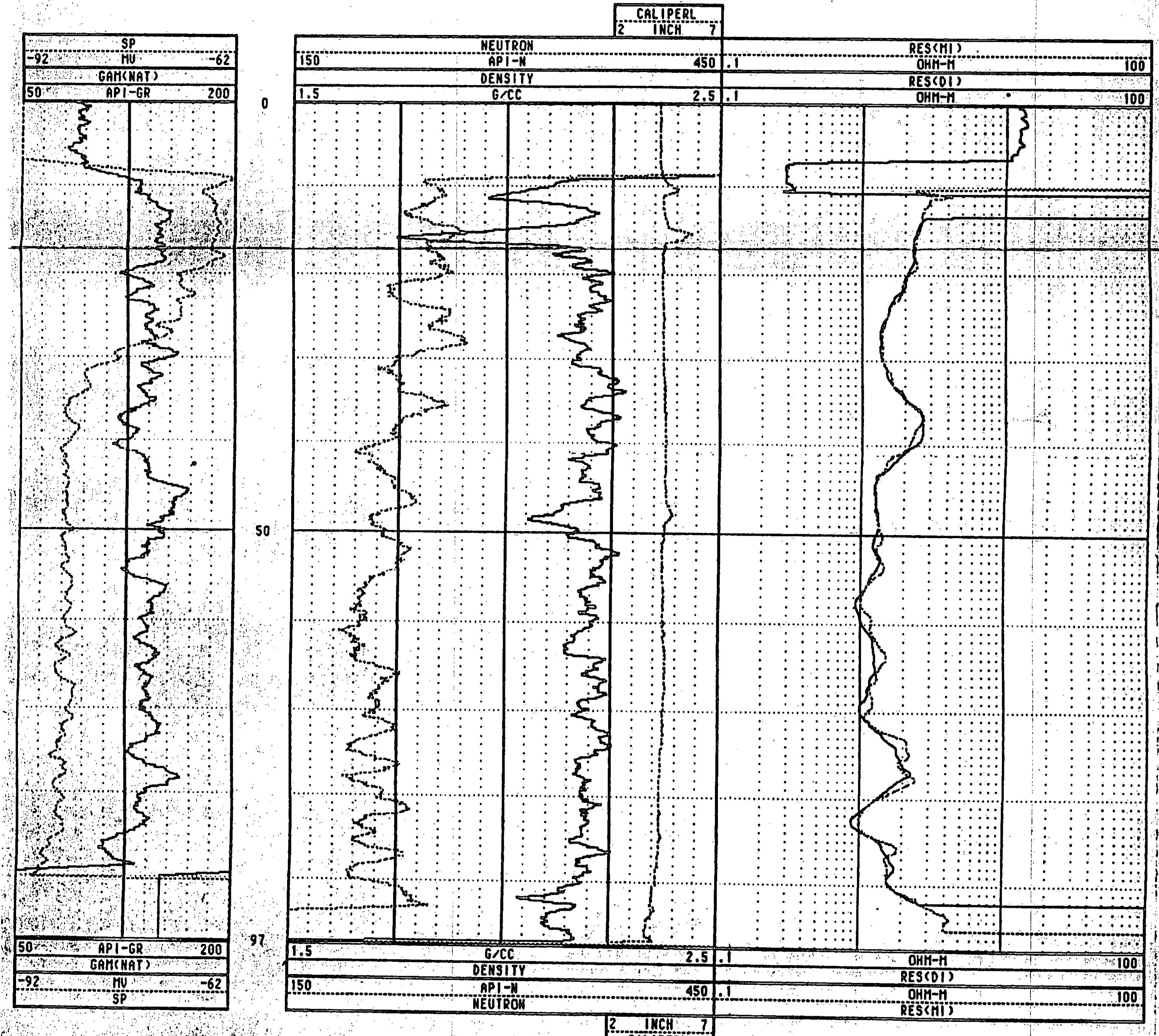
USPCI INC. GEOPHYSICAL LOG

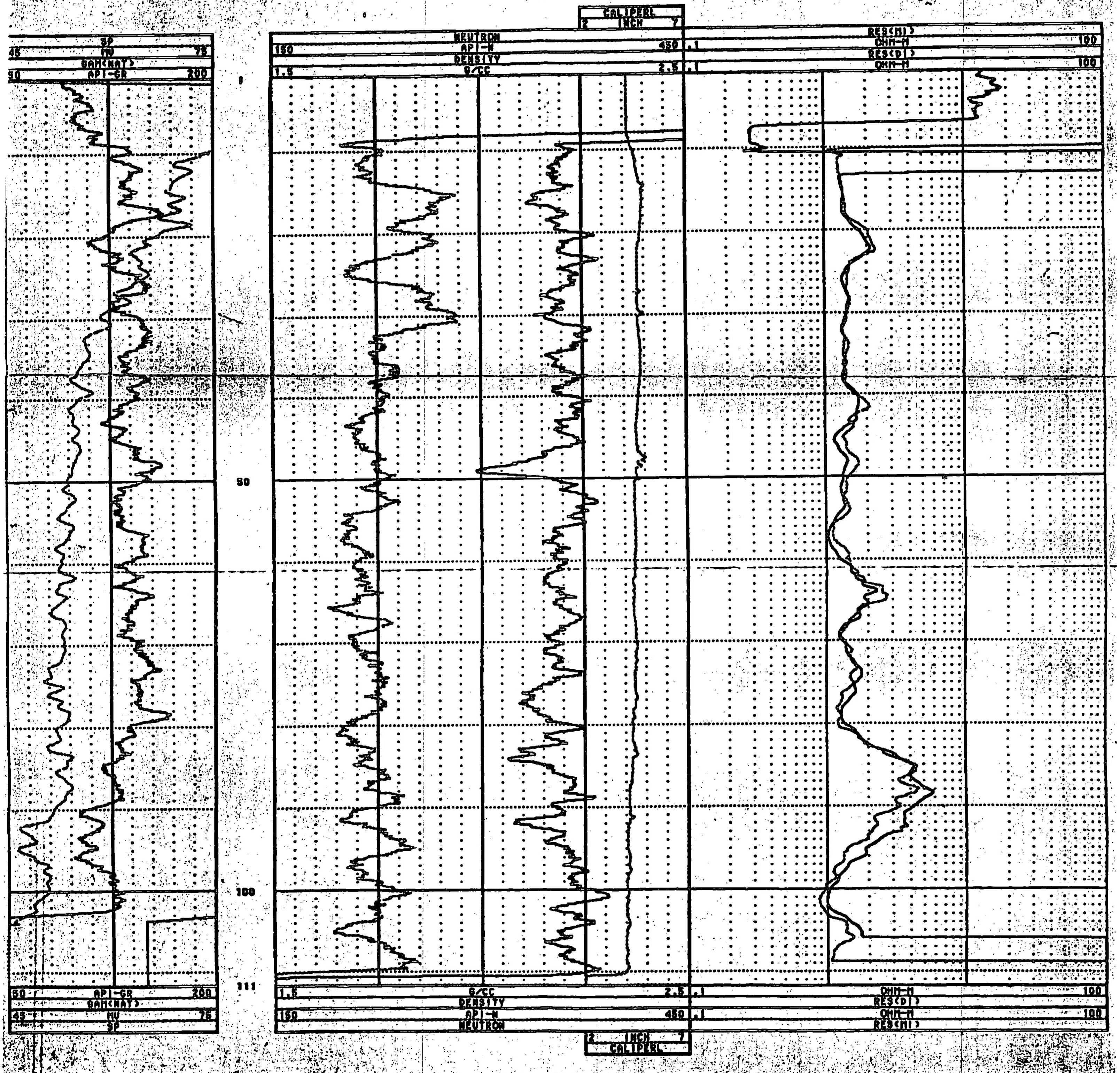
PROJECT NO.: 3187108
BORING NO.: TB-8
BORING LOCATION: 9602E - 11516N
SURFACE ELEV.: 1394.3
DRILLER'S DEPTH: 98.1'
CONTRACTOR: CENTURY GEOPHYSICAL CORP.
DATE LOGGED: 7/16/87
LOGGER: R MILLER
LOGGER'S DEPTH: 88'



USPCI INC. GEOPHYSICAL LOG

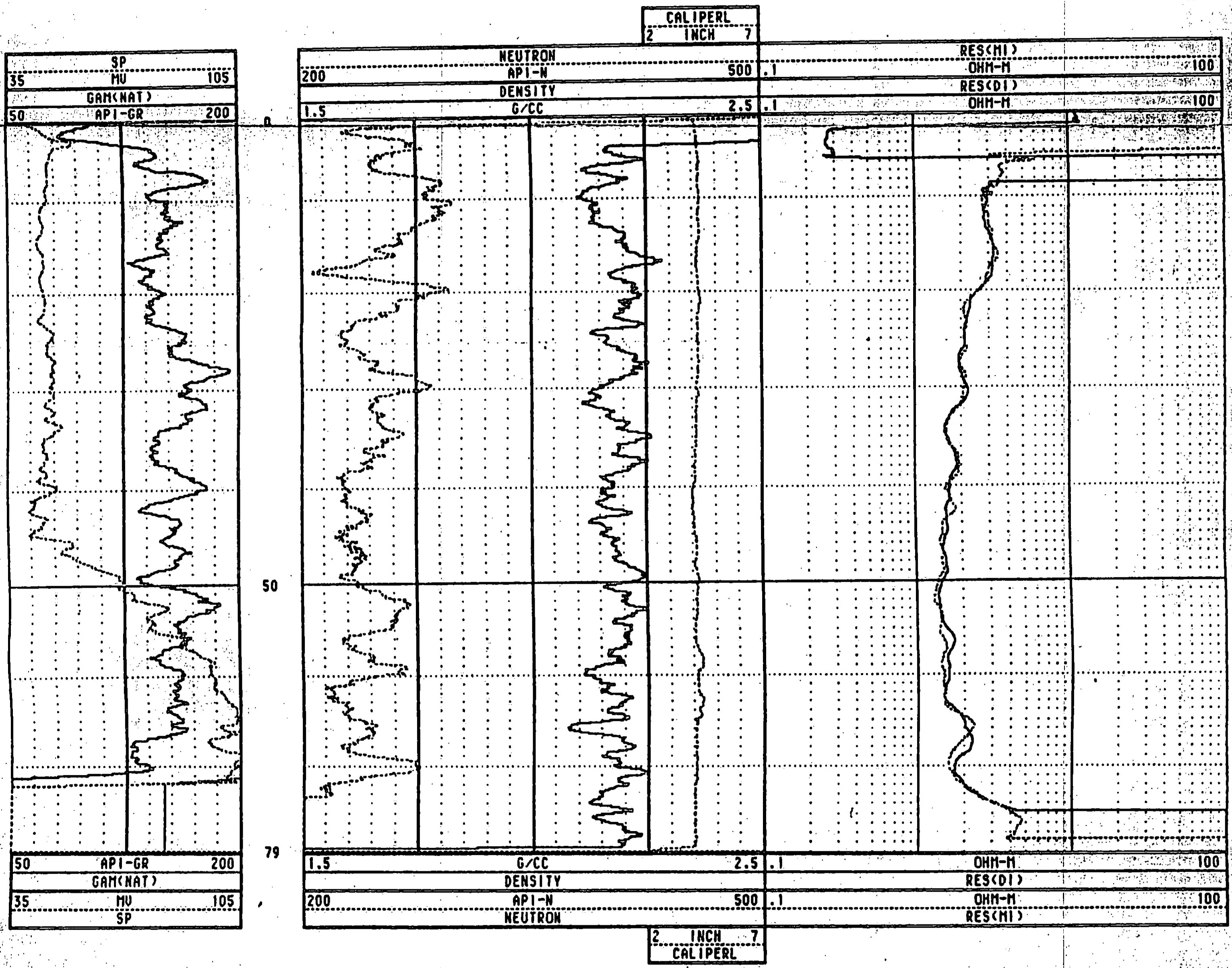
PROJECT NO.: 3187108
BORING NO.: TB-9
BORING LOCATION: 9417E - 11773N
SURFACE ELEV.: 1393.8
DRILLER'S DEPTH: 98.9'
CONTRACTOR: CENTURY GEOPHYSICAL CORP.
DATE LOGGED: 7/22/87
LOGGER: R. MILLER
LOGGER'S DEPTH: 97'




CALIPERL
2 INCH 7
SP
45 MV 75
GAM(NAT)
50 API-GR 200
NEUTRON
150 API-N 450
DENSITY
1.5 G/CC 2.5
RES(MI)
.1 OHM-M 100
RES(DI)
.1 OHM-M 100
1
50
100
111
50 API-GR 200
GAM(NAT)
45 MV 75
SP
1.5 G/CC 2.5
DENSITY
150 API-N 450
NEUTRON
.1 OHM-M 100
RES(DI)
.1 OHM-M 100
RES(MI)
2 INCH 7
CALIPERL

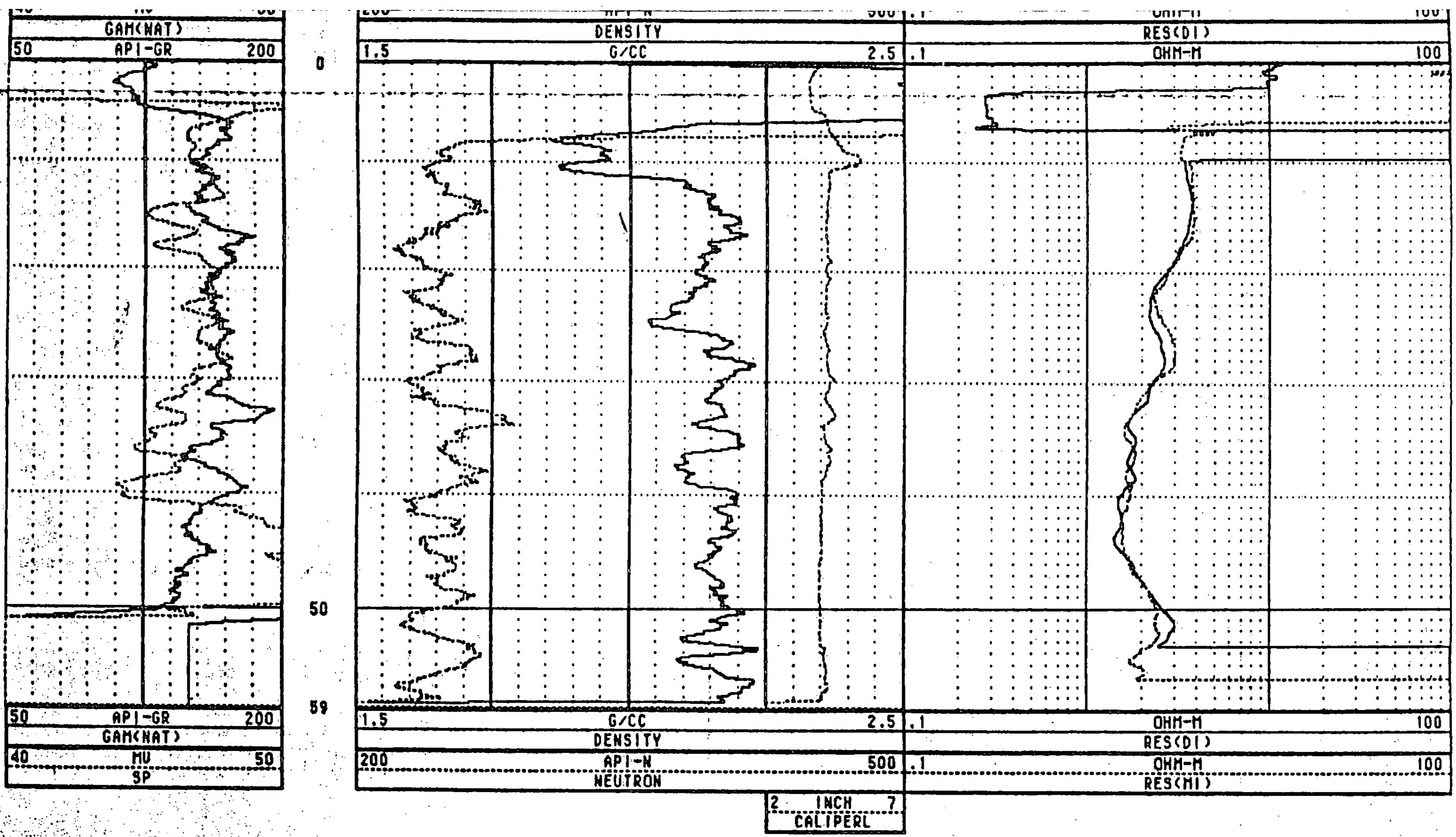
USPCI INC. GEOPHYSICAL LOG

PROJECT NO.: 3187108
BORING NO.: TB-11
BORING LOCATION: 9617.4E - 12600N
SURFACE ELEV.: 1378.8
DRILLER'S DEPTH: - 84.5'
DATE LOGGED: 4/23/87
CONTRACTOR: CENTURY GEOPHYSICAL CORP.
LOGGER: R. MILLER
LOGGER'S DEPTH: 79'



USPCI INC. GEOPHYSICAL LOG

PROJECT NO.: 3187108
BORING NO.: TB-12
BORING LOCATION: 9790.2E - 14620N
SURFACE ELEV.: 1365
DATE LOGGED: 4/27/87
CONTRACTOR: CENTURY GEOPHYSICAL CORP.
LOGGER: R. MILLER
DRILLER'S DEPTH: 67.8'
LOGGER'S DEPTH: 59'

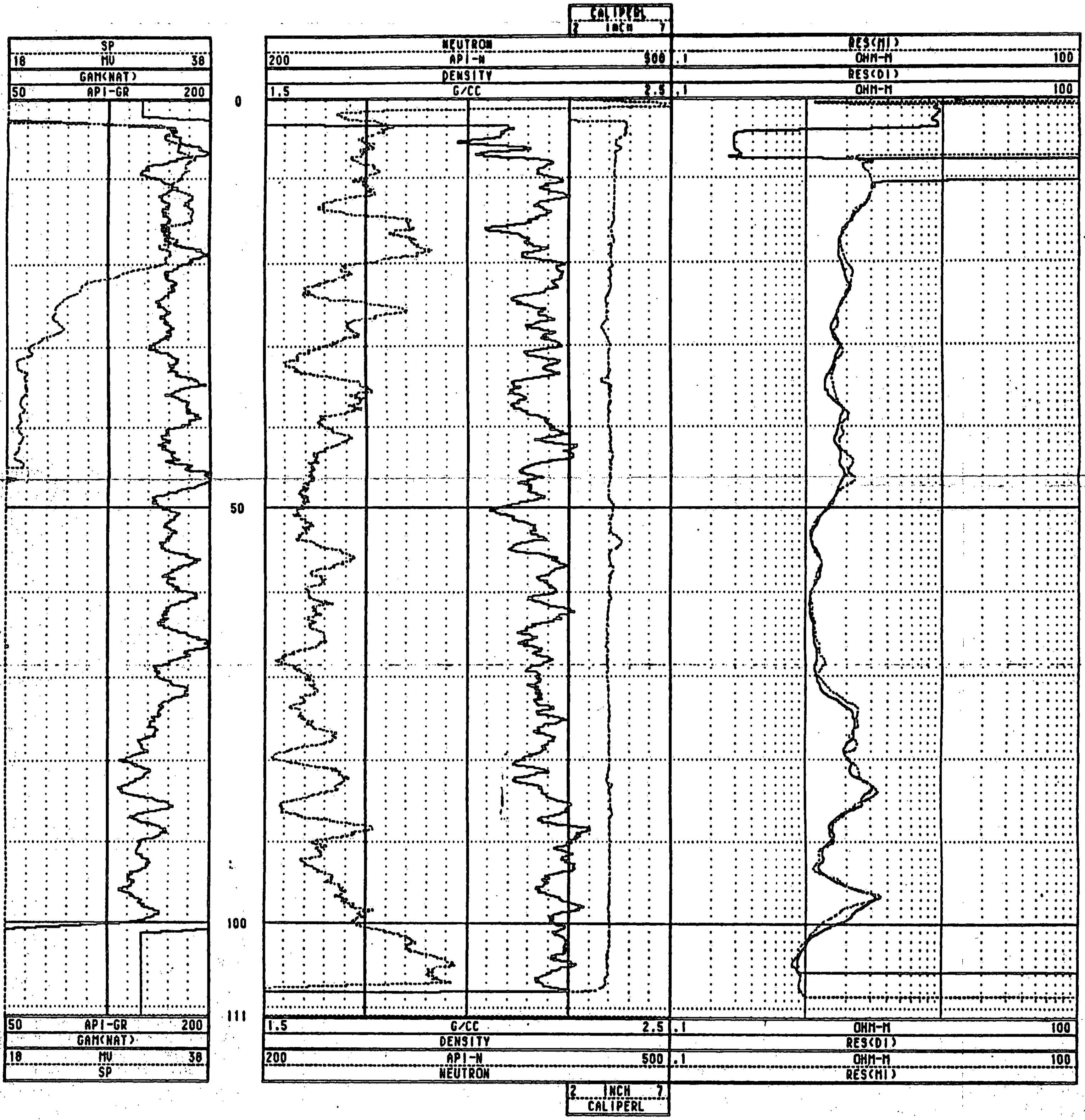


12 0 0.10 00 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 4.00

TB-12

USPCI INC. GEOPHYSICAL LOG

PROJECT NO.: 3187108
BORING NO.: TB-13
BORING LOCATION: 9448.6E - 12044.8N
SURFACE ELEV.: 1384
DATE LOGGED: 4/30/87
CONTRACTOR: CENTURY GEOPHYSICAL CORP.
LOGGER: R. MILLER
DRILLER'S DEPTH: 111.5'
LOGGER'S DEPTH: 111'

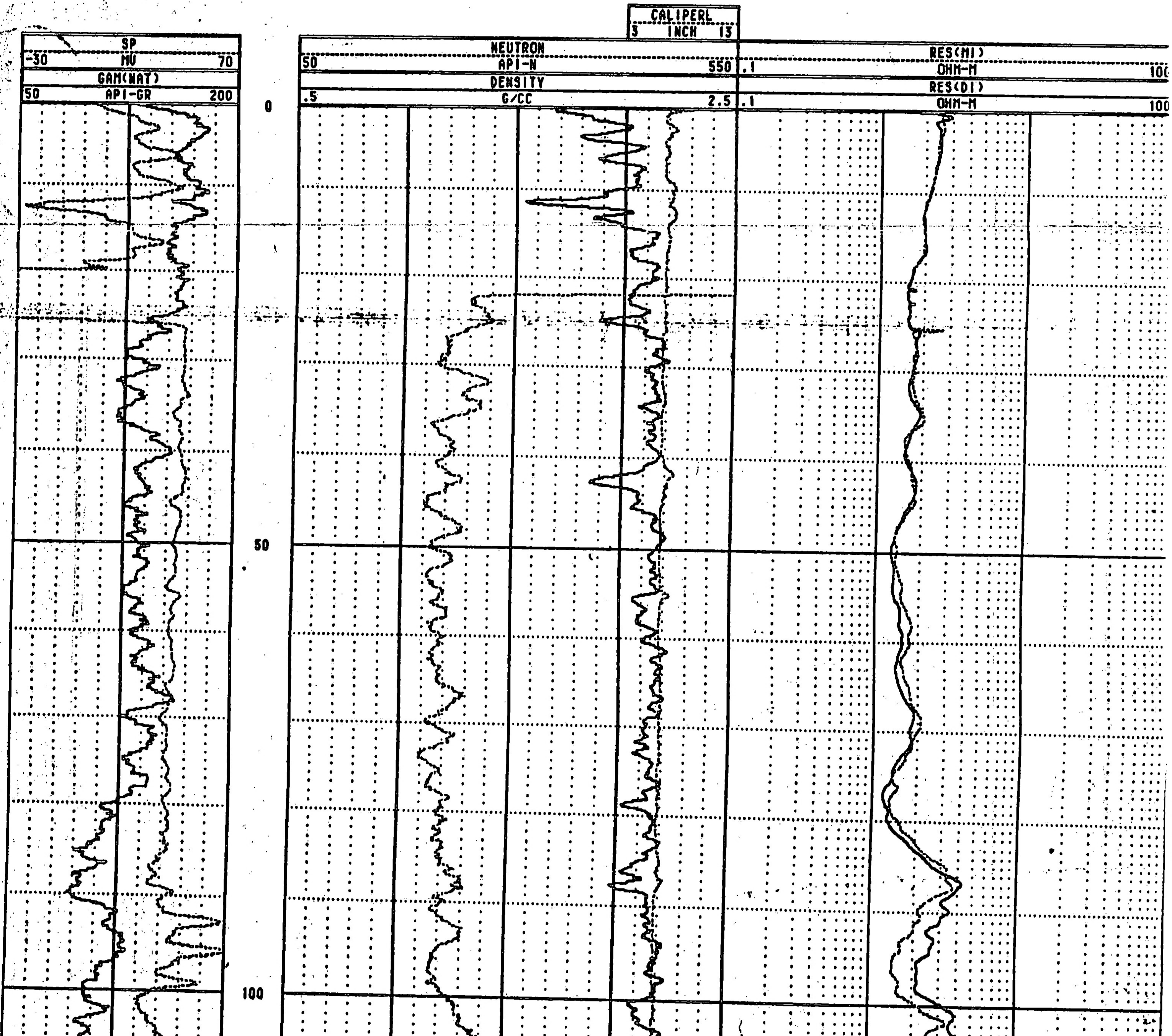


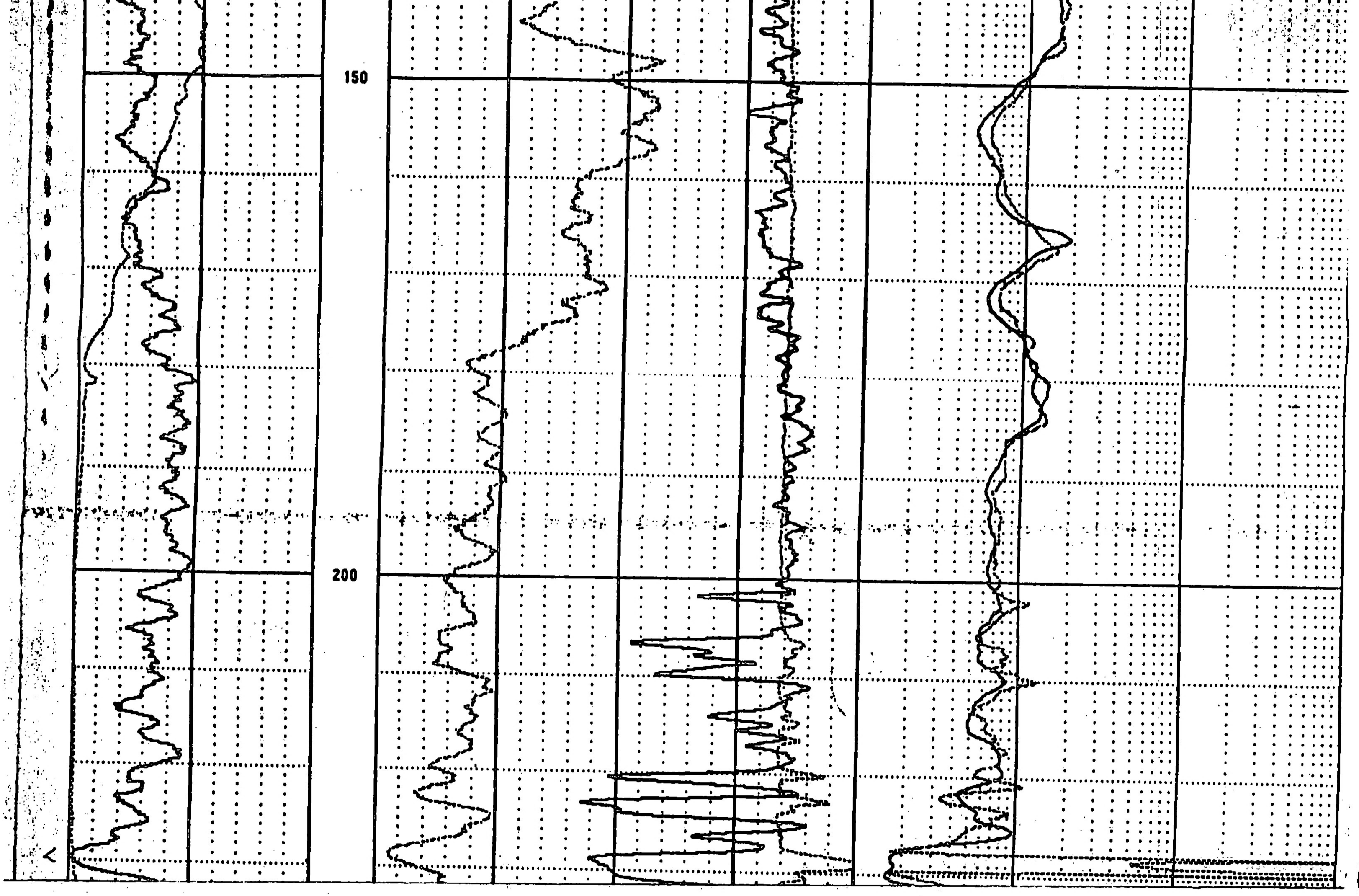
13 0 0.10 00 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 4.00

TB-13

USPCI INC. GEOPHYSICAL LOG

PROJECT NO.: 3187108
DATE LOGGED: 5/17/87
BORING NO.: TB-14
CONTRACTOR: CENTURY GEOPHYSICAL CORP.
BORING LOCATION: 7345.8E - 13922.4N
LOGGER: R. MILLER
SURFACE ELEV.: 1393.8
DRILLER'S DEPTH: 418.1'
LOGGER'S DEPTH: 403'

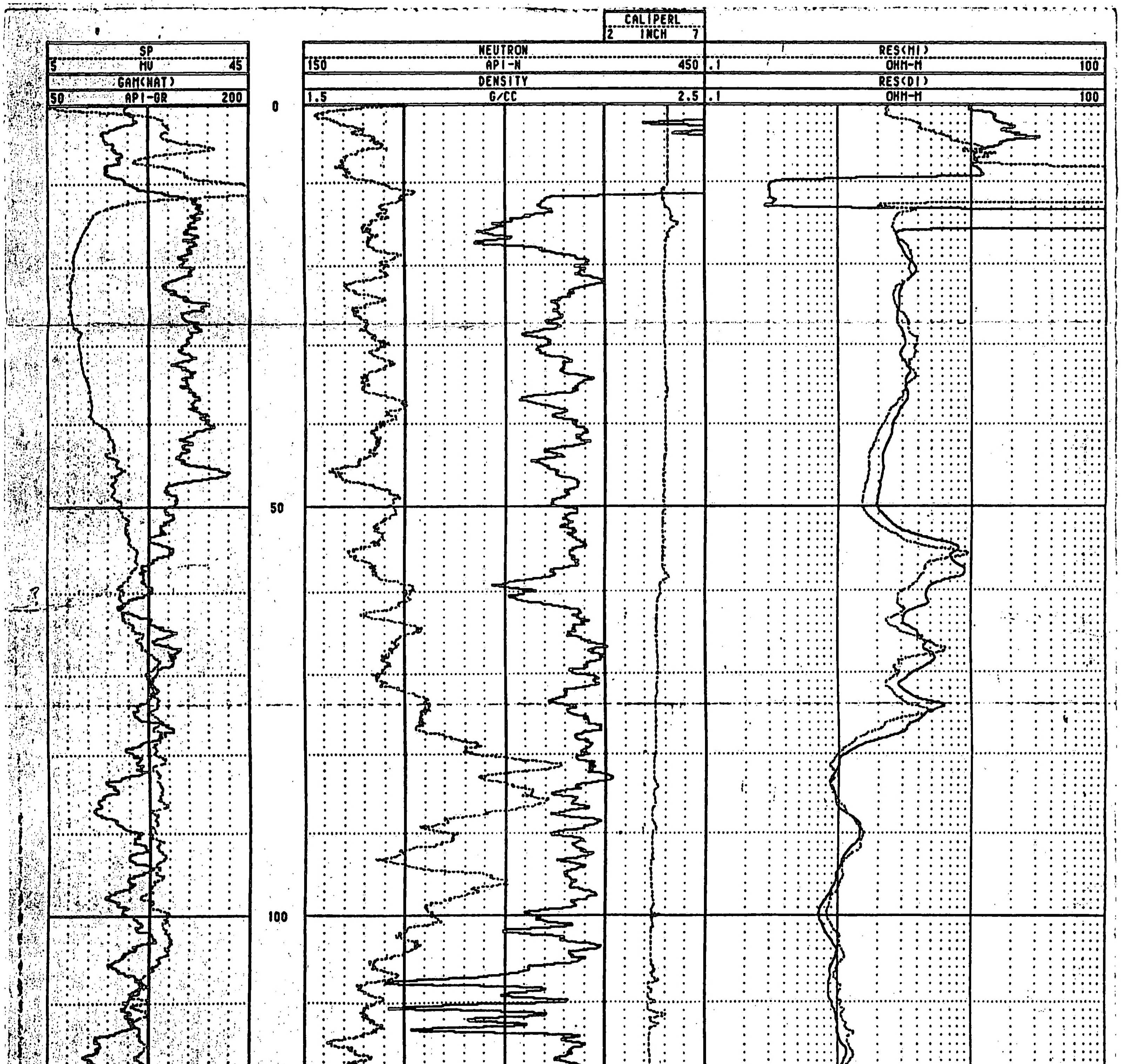


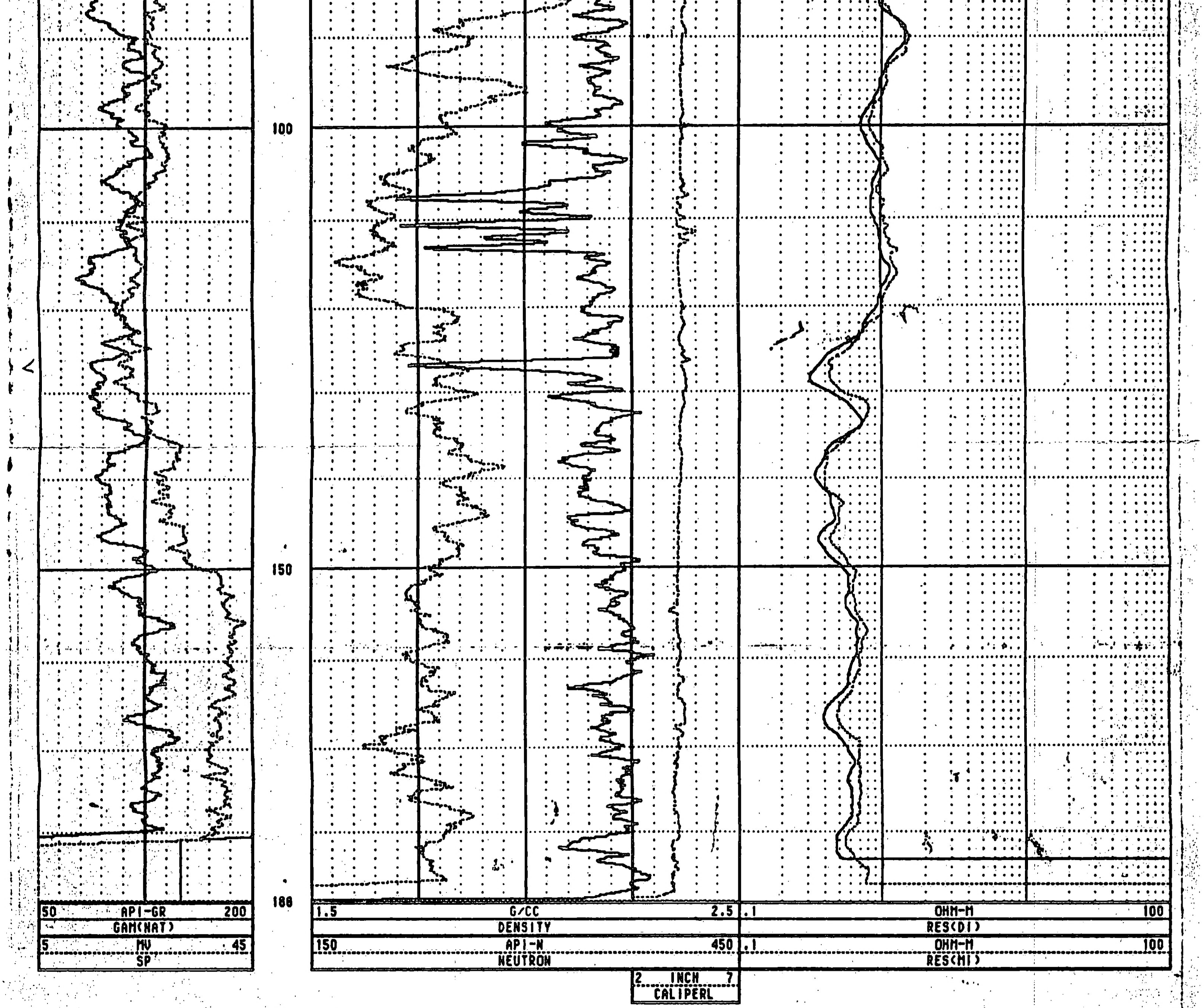

150
200

USPCI INC. GEOPHYSICAL LOG

PROJECT NO.: 3187108
BORING NO.: TB-15
BORING LOCATION: 9314.2E - 14020.5N
SURFACE ELEV.: 1371.8
DRILLER'S DEPTH: 175'
CONTRACTOR: CENTURY GEOPHYSICAL CORP.
DATE LOGGED: 5/17/87
LOGGER: R. MILLER
LOGGER'S DEPTH: 188'

NOTE: DRILLER'S DEPTH EQUATES TO CORE DEPTH. DRILLING WENT ON APPROXIMATELY 15 FEET BEYOND THIS POINT WITH NO DESCRIPTION.



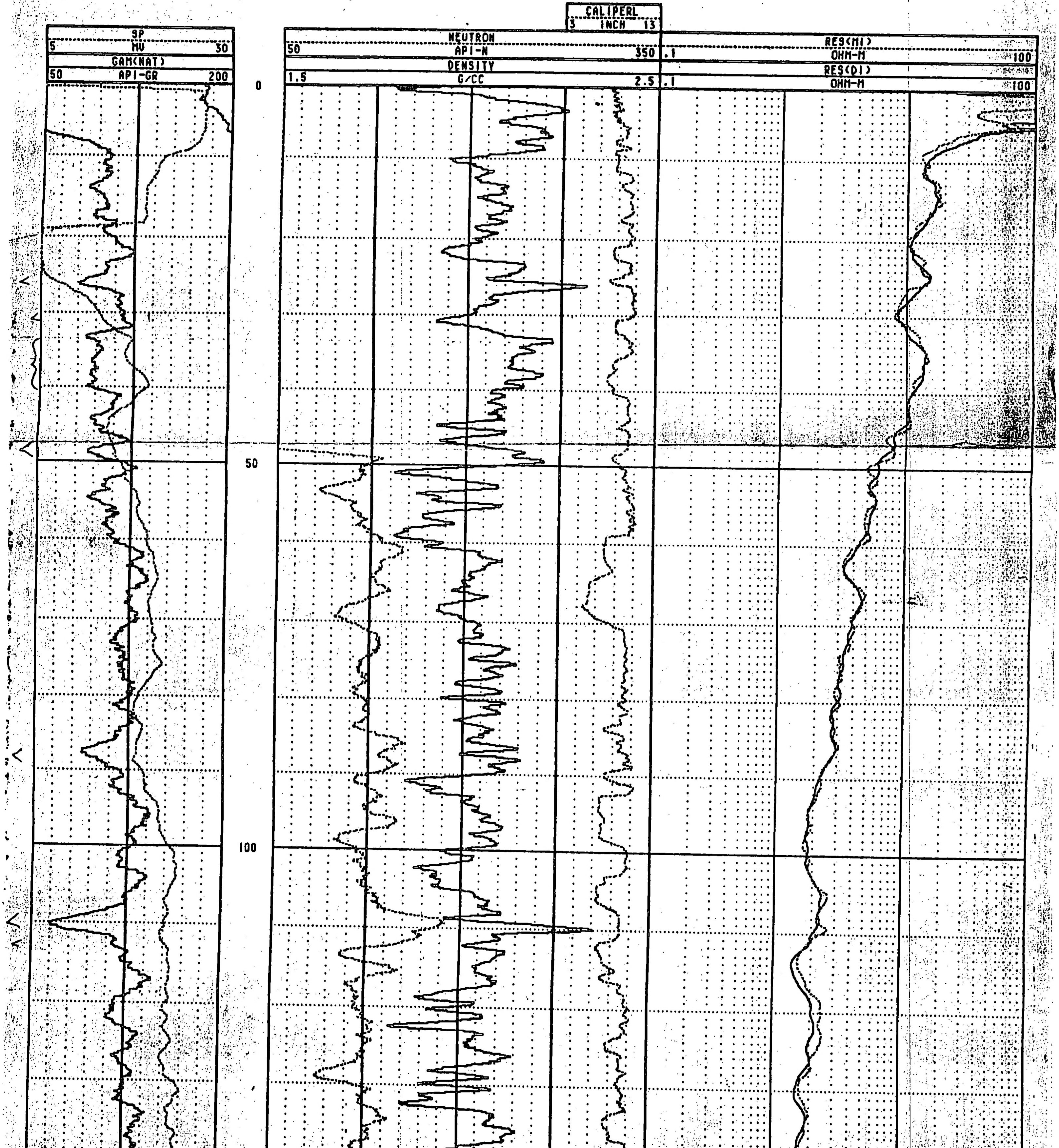


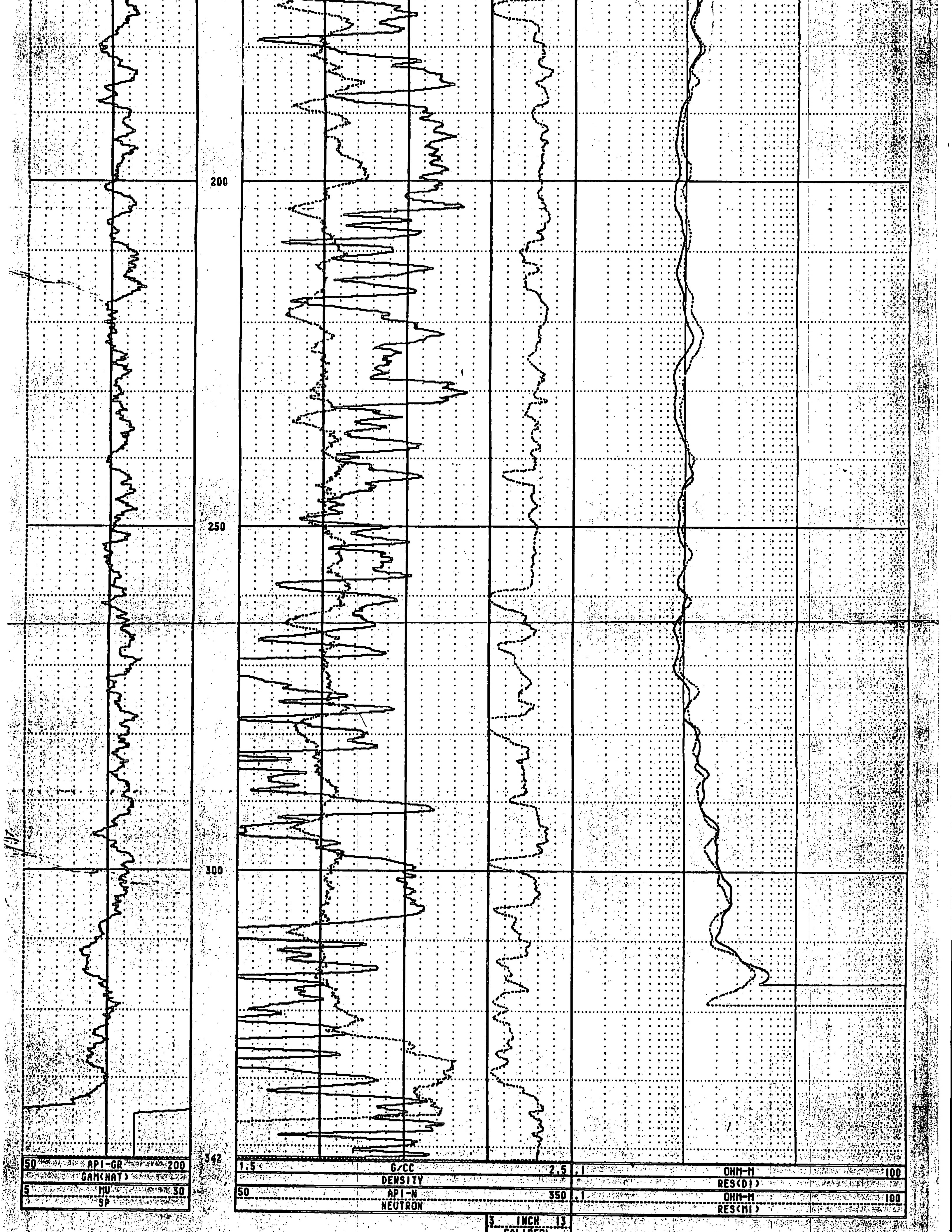
TB15 0 0.10 00 MATRIX DENSITY:2.71 NEUTRON: LS HOLESIZE= 4.00

TB-15

USPCI INC. GEOPHYSICAL LOG

PROJECT NO.: 3187108
BORING NO.: TB-1
BORING LOCATION: 8306.0E - 10292.1N
SURFACE ELEV.: 1606.9
DATE LOGGED: 6/12/87
CONTRACTOR: CENTURY GEOPHYSICAL CORP.
LOGGER: R. MILLER
DRILLER'S DEPTH: 331.3'
LOGGER'S DEPTH: 342'




200
250
300
342
50 API-GR 200
GAM(NAT)
5 MV 30
SP
1.5 G/CC 2.5
DENSITY
50 API-N 350
NEUTRON
3 INCH 13
CALIPER
.1 OHM-M 100
RES(DI)
.1 OHM-M 100
RES(MI)