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Data Package for the Low-Level Waste Disposal Development and Demonstration Program Environmental Impact Statement

Volume 2 of 2

Appendices E-O

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DATA PACKAGE FOR THE LOW-LEVEL WASTE DISPOSAL DEVELOPMENT AND DEMONSTRATION PROGRAM ENVIRONMENTAL IMPACT STATEMENT

Volume 2 of 2
Appendices E-O

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Prepared for the
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Prepared by the
OAK RIDGE NATIONAL LABORATORY
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DATA PACKAGE FOR THE LOW-LEVEL WASTE DISPOSAL DEVELOPMENT AND DEMONSTRATION PROGRAM ENVIRONMENTAL IMPACT STATEMENT

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APPENDIX E

HYDROLOGIC DATA SUMMARY FOR PROPOSED SOLID WASTE STORAGE AREA (SWSA) 7, JANUARY 1984–MARCH 1988

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HYDROLOGIC DATA SUMMARY FOR PROPOSED SOLID WASTE STORAGE AREA (SWSA) 7, JANUARY 1984-MARCH 1988

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The authors also thank James Lewis and Robert Livesay of the Knoxville Branch Office of the U.S. Geological Survey for their work in collecting stream discharge data And for making those data available for this report.

ABSTRACT

CLAPP, R. B., N. D. FARROW, L. A. MELROY, and K. T. STOCKING. 1988. Hydrologic data summary for proposed Solid Waste Storage Area (SWSA) 7, January 1984-March 1988. ORNL/TM-10943. Oak Ridge National Laboratory, Oak Ridge, Tennessee. ___ pp.

Proposed Solid Waste Storage Area 7 is located in the upper portion of Melton Branch Watershed near the Oak Ridge National Laboratory. It is currently being considered as a possible site for future low-level radioactive waste disposal. This report contains hydrologic data from the beginning of 1984 through March of 1988 that will be used in the overall site characterization. Precipitation and streamflow in Center Seven Creek (which drains the main watershed in the area) are reported for the entire record. Streamflow data for a gaging site on Upper Melton Branch and from two other tributaries (West Seven Creek and East Seven Creek) adjacent to Center Seven Creek are reported for shorter periods. Weekly water-level measurements in 22 monitoring wells are also presented, as are the results of a water-quality sampling campaign conducted in late April of 1985.

Comparison of runoff coefficients (runoff/precipitation) for the Center Seven Creek Watershed with those for the perimeter watersheds indicates that the main watershed is relatively watertight, although the vertical groundwater gradient indicates that there is some seepage loss. for the perimeter watersheds, there are probably groundwater losses. Flow beneath the stream gaging stations is the simplest explanation. An exponential decrease in hydraulic conductivity with depth suggests that groundwater flow tends to be shallow with the largest velocities located near the water table. Results from other studies on the watershed indicate that macropores provide rapid drainage of infiltrated water. This water moves in the downslope direction above the water table. Occasional and erratic increases in the water level in the monitoring wells are also attributed to macropores. The implications to site monitoring are discussed.

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1. INTRODUCTION

Proposed Solid Waste Storage Area (SWSA) 7 is located on the upper portion of the Melton Branch Watershed within the Oak Ridge Reservation (ORR). The site is currently being considered for development of a low-level radioactive waste (LLW) disposal facility. The Low Level Waste Disposal Development and Demonstration Project (LLWDDD) within Martin Marietta Energy Systems has the responsibility for site characterization at several candidate disposal sites and at proposed SWSA-7 in particular.

1.1 PURPOSE AND SCOPE OF REPORT

This document provides hydrologic data for SWSA-7 that will be part of the overall site characterization. Field studies at the site began in 1983; to date, an initial engineering feasibility study has been completed (MCI 1983), the soils have been characterized (Rothschild et al. 1984a), and an initial report of the site-specific geology and hydrology has been published (Rothschild et al. 1984b). Recently, the potential disposal capacity of proposed SWSA-7 was evaluated along with other candidate disposal sites (LGE 1988).

The present report is a continuation of the hydrologic data base contained in the report of Rothschild et al. (1984b). Precipitation and stream discharge for the period March 1983 through March 1988 are reported. In addition, discharge data published earlier (Rothschild et al. 1984b) are presented again, because the area for Center Seven Creek (C7C) Watershed has been revised, thereby affecting calculations of the streamflow per unit area and the rainfall-runoff ratios. Groundwater elevation data for January 1983 through March 1988 are summarized, and all groundwater elevations from late 1982 through March 1988 are listed in the appendices. Finally, water chemistry from samples retrieved in April 1985 from monitoring wells and three streams draining the site is also reported.

In the spring of 1987, an area to the southwest of SWSA-7 was identified as a site potentially suitable for above-grade disposal facilities. The new area is designated SWSA-7 Extended (SWSA-7X), and groundwater data collected there will be published elsewhere.

As shown in Fig. 1.1, SWSA-7 is drained mainly by C7C. The site is also drained by the perimeter tributaries East Seven Creek (E7C) and West Seven Creek (W7C). All three streams drain to the upper part of Melton Branch (Fig. 1.2). The area drained by C7C has been reevaluated since the publication of previous reports. Based on a newer map with 1.5-m (5-ft) contours, the area above the flume is 18.55 ha (45.8 acres or 0.0716 mile^2). This adjustment meant that values of streamflow reported on the basis of per unit watershed area had to be recalculated. The revised values are listed in Section 3.

1.2 UNITS OF MEASUREMENT

Data are reported in Systeme Internationale (S.I.) units to be consistent with early characterization reports. In most cases, data are also given in English units. The use of English units was requested by LLWDDD management because environmental characterization reports for other potential disposal sites use English units exclusively, and a uniform system for all measurements was needed.

1.3 RELEVANT STUDIES

Several research studies are being conducted in SWSA-7. They do not pose a problem to future use of the watershed, and they provide added information to the overall site characterization.

The Forest Clearing Experiment (FCE) is a project to predict and assess the effects on the water-table elevation caused by the removal of the forest cover prior to construction of a disposal facility. Results from the study are briefly reported in Section 4. The area cleared and planted to grass is shown in Fig. 1.1.

Research activities are also conducted at the Subsurface Transport Facility, located in the eastern end of C7C Watershed (Luxmoore and Abner 1987). It includes a subwatershed of 0.6 ha (1.5 acres) draining to a subsurface weir system where water flowing on the surface, upper subsurface (~0 to 1 m) and the lower subsurface (~1 to 2.5 m) will be measured and sampled. The computerized data

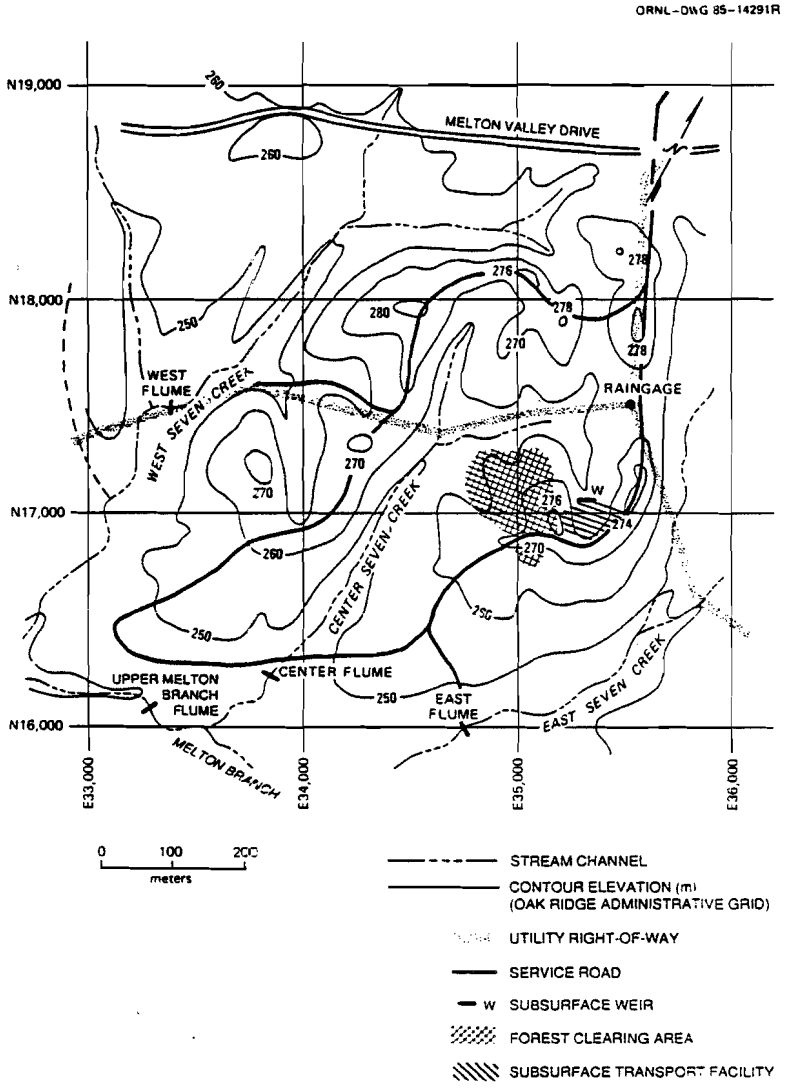

Fig. 1.1. Map of the SWSA-7 area.

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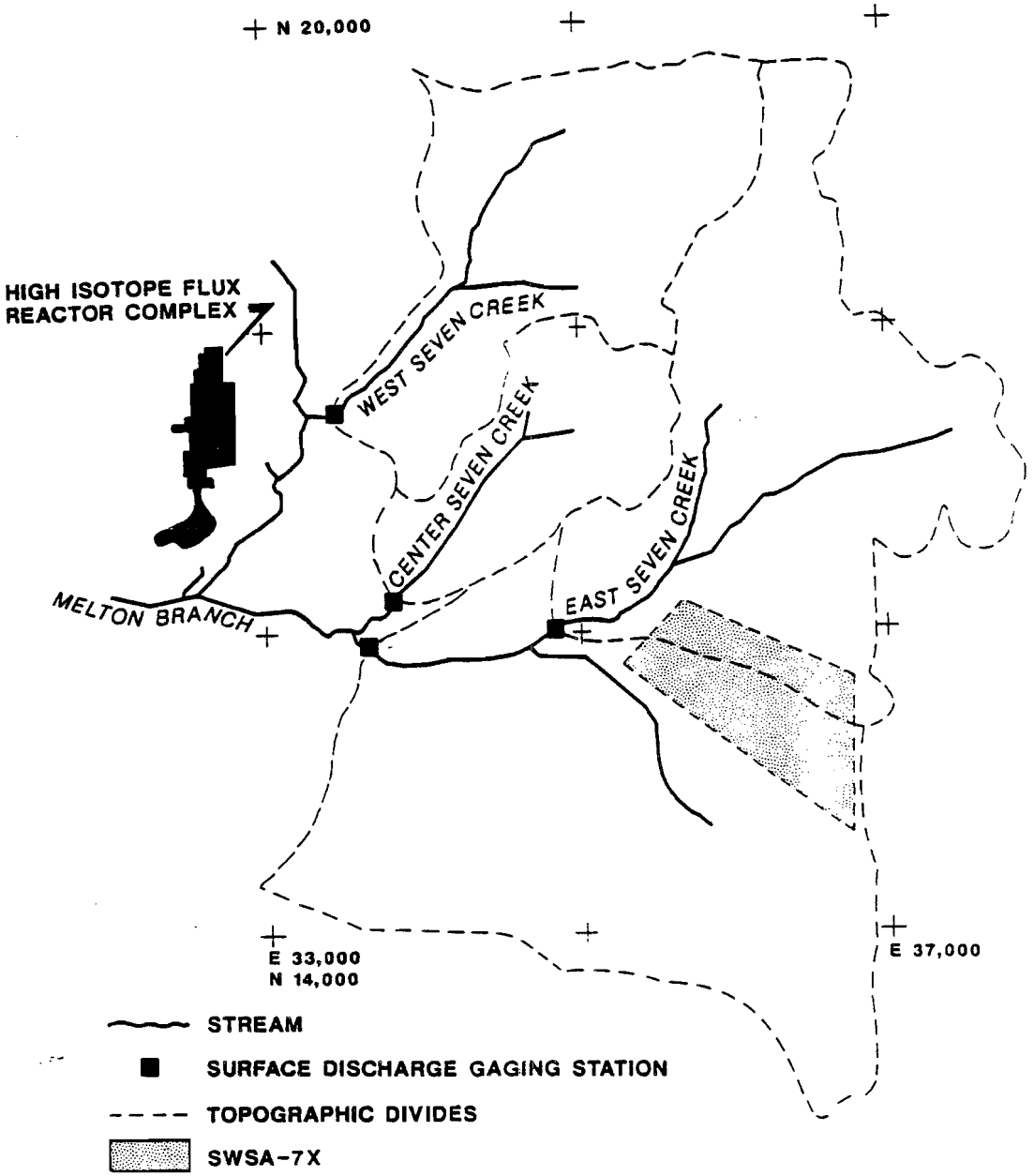

Fig. 1.2. Watersheds in the vicinity of SWSA-7.

logging system has not been implemented, and no flow data are available. At the facility, studies of surface and near-subsurface hydraulic conductivities under ranges of low matric tension have been performed, and the results are summarized in Section 4. The studies have demonstrated the importance of macropore flow in forest soils and the large degree of spatial variability in soil hydraulic properties.

2. PRECIPITATION

2.1 INSTALLATION OF A RECORDING RAIN GAGE

A recording rain gage (Belfort Instrument Co., weighing bucket type, Model 5780 with 7-d, spring-wound chart) was installed on the watershed at the intersection of the east end of the water-line right-of-way and the perimeter service road (Fig. 1.1). The approximate location on the Oak Ridge National Laboratory (ORNL) map grid is 17400°N, 33500°E. To provide sufficient clearing through the canopy, several trees were removed, and the collector was placed on a pedestal so that the rim is 2.13 m (7 ft) above ground level. The pedestal consists of a concrete pad 150-200 mm thick and stacked concrete block. An aluminum plate with leveling screws was fabricated to provide a level surface for the gage. A standard windscreen was also installed to prevent loss of precipitation due to wind divergence over the orifice. Data collection at the gage commenced in late May 1984.

2.2 PRECIPITATION MEASUREMENTS

Daily precipitation data for January 1984 through March 1988 are listed in Appendix A; and monthly precipitation values appear in Table 2.1. Precipitation measured at nearby Walker Branch Watershed (WBW) is used for periods when data at SWSA-7 are unavailable. The total rainfall for 1984 was 1312 mm (51.6 in.), which is close to the normal annual rainfall of 1336 mm as measured at the Oak Ridge Township Site (NOAA 1987). Since 1984, precipitation has been significantly below the normal: in 1985, the deficit was 223 mm (8.8 in.); in 1986, it was 352 mm (13.8 in.); and, in 1987, it was 448 mm (17.6 in.). For the first three months in 1988, the deficit was 108 mm (4.2 in.). The cumulative deficit for 3.25 years is 1131 mm (44.5 in.). This prolonged interval of below-normal rainfall is the most significant hydrologic event in this report.

Large storms occurred in early May 1984. During 2 d (May 2-3), there was 71.5 mm (2.8 in.) of rainfall, followed by 1 d with slight

Table 2.1. Monthly Precipitation

Year	Month	Precipitation (mm)	Precipitation (in.)
1983	Jan	37.92 *	1.49
	Feb	110.30 *	4.34
	Mar	53.71 *	2.11
	Apr	162.24 *	6.39
	May	163.48 *	6.44
	Jun	67.08 *	2.64
	Jul	41.78 *	1.64
	Aug	37.64 *	1.48
	Sep	48.01 *	1.89
	Oct	113.44 *	4.47
	Nov	135.17 *	5.32
	Dec	173.03 *	6.81
Total		1143.8 *	45.03
1984	Jan	62.37 *	2.46
	Feb	88.78 *	3.50
	Mar	110.44 *	4.35
	Apr	100.41 *	3.95
	May	278.77 *	10.98
	Jun	91.42	3.60
	Jul	155.98	6.14
	Aug	59.30	2.33
	Sep	34.78	1.37
	Oct	151.92	5.98
	Nov	127.39	5.02
	Dec	50.54	1.99
Total		1312.10	51.66
1985	Jan	67.55	2.66
	Feb	99.01	3.90
	Mar	58.68	2.31
	Apr	42.91	1.69
	May	73.79	2.91
	Jun	118.10	4.65
	Jul	139.18	5.48
	Aug	227.36	8.95
	Sep	40.40	1.59
	Oct	80.81	3.18
	Nov	111.20	4.38
	Dec	53.72	2.11
Total		1112.71	43.81

Table 2.1. (Continued)

Year	Month	Precipitation (mm)	Precipitation (in.)
1986	Jan	28.71	1.13
	Feb	121.20	4.77
	Mar	74.80	2.94
	Apr	39.85	1.57
	May	65.41	2.58
	Jun	43.19	1.70
	Jul	94.10	3.70
	Aug	97.81	3.85
	Sep	71.24	2.80
	Oct	120.63	4.75
	Nov	106.98	4.21
	Dec	120.34	4.74
Total		984.26	38.75
1987	Jan	122.26	4.81
	Feb	126.12	4.97
	Mar	62.47	2.46
	Apr	70.39	2.77
	May	80.54	3.17
	Jun	69.49	2.74
	Jul	63.53	2.50
	Aug	33.41	1.32
	Sep	103.64	4.08
	Oct	17.77	0.70
	Nov	51.92	2.04
	Dec	86.96	3.42
Total		888.5	34.98
1988	Jan	138.86	5.47
	Feb	71.49	2.81
	Mar	87.28	3.44
Total		297.63	11.72

*Average of measurements from two gages at Walker Branch Watershed.

rain (0.9 mm or 0.03 in.), then 1 d with no rain, followed by 3 d of rain. In the second storm (May 6-8), the rainfall totaled 141.2 mm (5.6 in.). The highest daily total was 74.2 mm (2.9 in.) on May 6, with the highest hourly amount being 24.1 mm (0.95 in.) on that day.

With respect to storm frequency, the first of the two storm events had a maximum 24-h depth of 66.2 mm (2.6 in.), with a recurrence interval of about 1.1 year, based on rainfall depth-probability relationships reported by Sheppard (1974). The second storm had a maximum 48-h depth of 136 mm (5.4 in.), corresponding to a recurrence interval of about 3.0 years. Considering extreme hydrologic events in general, these recurrence intervals are low (i.e., the probability of either rainfall event is comparatively large); however, the probability of having both storms within 2-3 d is low. It follows that conditions prior to the storm of May 6-8 were extremely wet; thus, the flood conditions observed in the region were uncharacteristically large. As discussed in Section 3, discharge measurements for this storm at C7C were not available due to water levels beyond the range of the stage-recorder.

2.3 CORRELATION WITH PRECIPITATION AT WALKER BRANCH

It is customary to use WBW precipitation data to estimate SWSA-7 precipitation for dates on which SWSA-7 data is not available. A statistical model was prepared to determine whether this is a valid approximation. The model was based on a comparison of WBW and SWSA-7 precipitation data for the period May 25, 1984, through May 31, 1985.

The WBW value which has previously been used to estimate SWSA-7 precipitation is an average of WBW rain gages 1 (WBW1) and 3 (WBW3), where

$$WBWAVG = (WBW1 + WBW3)/2 \quad . \tag{2.1}$$

Questionable data were deleted; in particular, data for two dates (July 6 and 7,1984), when there was heavy rainfall at approximately midnight, were not included due to the uncertainty related to the

synchronization of the clocks at the rain gages.

A linear regression was performed with the y-intercept value constrained 0.0. The resulting equation was

$$\text{SWSA-7} = 0.942\ (\text{WBWAVG}) \quad (n=124) \quad . \tag{2.2}$$

This relationship is plotted as the dashed line in Fig. 2.1. A t-test was again performed on the coefficient, which was not significantly different from 1.0 (95% confidence).

The daily WBW average precipitation is accepted as a valid estimator of SWSA-7 precipitation, and that the two may be related by a simple one-to-one correspondence.

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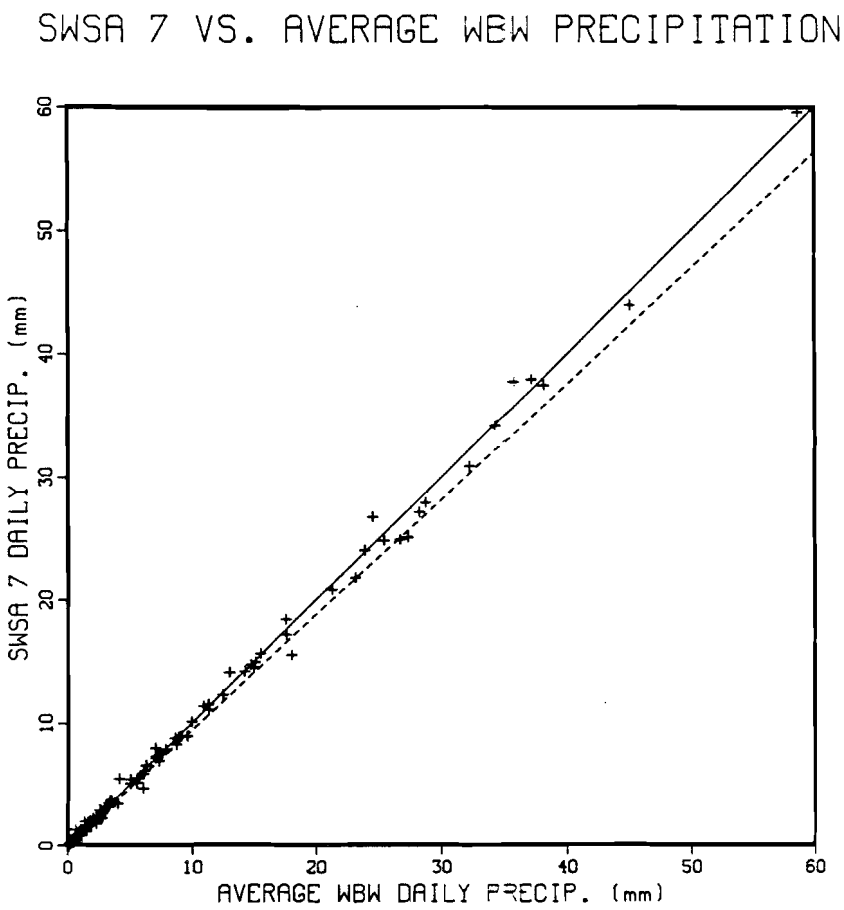

Fig. 2.1. Daily precipitation measured at SWSA-7 versus the average precipitation at Walker Branch Watershed.

3. SURFACE WATER

Surface streamflow is currently measured at four sites in the vicinity of SWSA-7, as shown in Fig. 1.2, although the length of record varies among the sites. On C7C, flows have been measured since the beginning of January 1983. Daily flows beginning with the start of record through March 1984 were reported by (Rothschild et al. 1984b). The monthly summaries listed below include data from that report because the watershed area was revised, requiring revision of the calculations of discharge per unit area.

In November 1984, a two-stage discharge monitoring system was installed at C7C to replace the temporary flume. The first stage is a sharp-crested weir with rectangular section and a small V-notch for measuring low flows, and the second stage is a 762-mm (2.5-ft) H-flume for measuring high flows. Details are provided in the next section.

In April 1985, the U.S. Geological Survey (USGS) began to collect flow measurements on Upper Melton Branch (UMB) site, which captures the runoff from E7C Watershed and from the SWSA-7X site. In the fall of 1985, discharge measurement devices were installed on the tributaries adjacent to C7C Watershed. On W7C a weir of the same dimensions as that used for low-flow measurement on C7C was installed. On E7C an H-flume, identical to the one used on C7C for high flows, was installed. During 1986, there was uncertainty within the LLWDDD program as to the need for SWSA-7 for future low-level waste disposal, and flow measurement on the perimeter creeks was not implemented.

In August 1987, the need for additional flow data at SWSA-7 was evident, and the USGS began collecting flow measurements at sites on W7C and E7C. At the same time, the USGS assumed responsibility for the H-flume at C7C. The H-flume is not accurate at flows less than 7 L/s (0.25 f^3/s). In fact, when the daily average flow was less than 7 L/s, as indicated from measurements at the V-notch weir, the USGS usually reported zero flow. To remove this bias, the average flows for C7C reported this section (as well as in in Tables C.5 and C.6 of Appendix C) are derived by merging the measurements made at both

low-flow and high-flow devices. (This practice of merging measurements was done routinely for the record prior to August 1987.)

Daily streamflow measurements with annual summaries for C7C are in Appendix C, and those for gages maintained by the USGS are in Appendix D. All the data tables extend to the end of March 1988. Data files are available from the Hydrologic Data Laboratory in the Environmental Sciences Division (ESD) at ORNL and from the Knoxville Branch, Tennessee District of the USGS. For C7C, measurements are stored in breakpoint format in units of liters per sedcond. From these files, hourly flows are generated, and, in turn, daily totals and monthly summaries are produced. Hourly discharge data and monthly summaries are available in ASCII format on 5 1/4-in. diskette by special request to ESD.

The USGS discharge data are recorded in cubic feet per second. The data provided by the USGS for this report are marked provisional, primarily because of the lack of direct measurements of stage and discharge at high flows. For the range of flows reported herein, the discharge data can be accepted with confidence. Table 3.1 contains the watershed areas and the USGS identification numbers for the gaging sites. The USGS collects 5-min stage data that are subsequently converted to discharge values. Requests for USGS data should be made to the District Office in Nashville, Tennessee.

3.1 REPLACEMENT OF THE TEMPORARY FLUME

In the fall of 1984, the temporary Parshall flume was replaced with the two-stage system shown in Fig. 3.1. The photograph taken from an upstream position shows the weir plate with V-notch (partially obscured by a leaf strainer), the instrument rack above the approach section of the flume, and H-flume itself (partially obscured by the catwalk). The installation of the system was a retrofit because the wing walls and the concrete pad were in place from the earlier, temporary flume. The new slume (Plastifab model with approach section and stilling well) was positioned over the old pad, and the interior

Table 3.1. Flow monitoring sites

	Center Seven Creek	West Seven Creek	East Seven Creek	Upper Melton Branch
Abbreviation area	C7C	W7C	E7C	UMB
m^2	1.85E + 05	3.74E + 05	5.62E + 05	1.35E + 06
$mile^2$	0.0716	0.144	0.217	0.520
USGS station number	03537200	03537300	03537050	03537100
Latitude	33°55'03"	35°55'11"	35°55'07"	35°54'59"
Longitude	84°17'55"	84°18'08'	84°17'43"	84°17'53"

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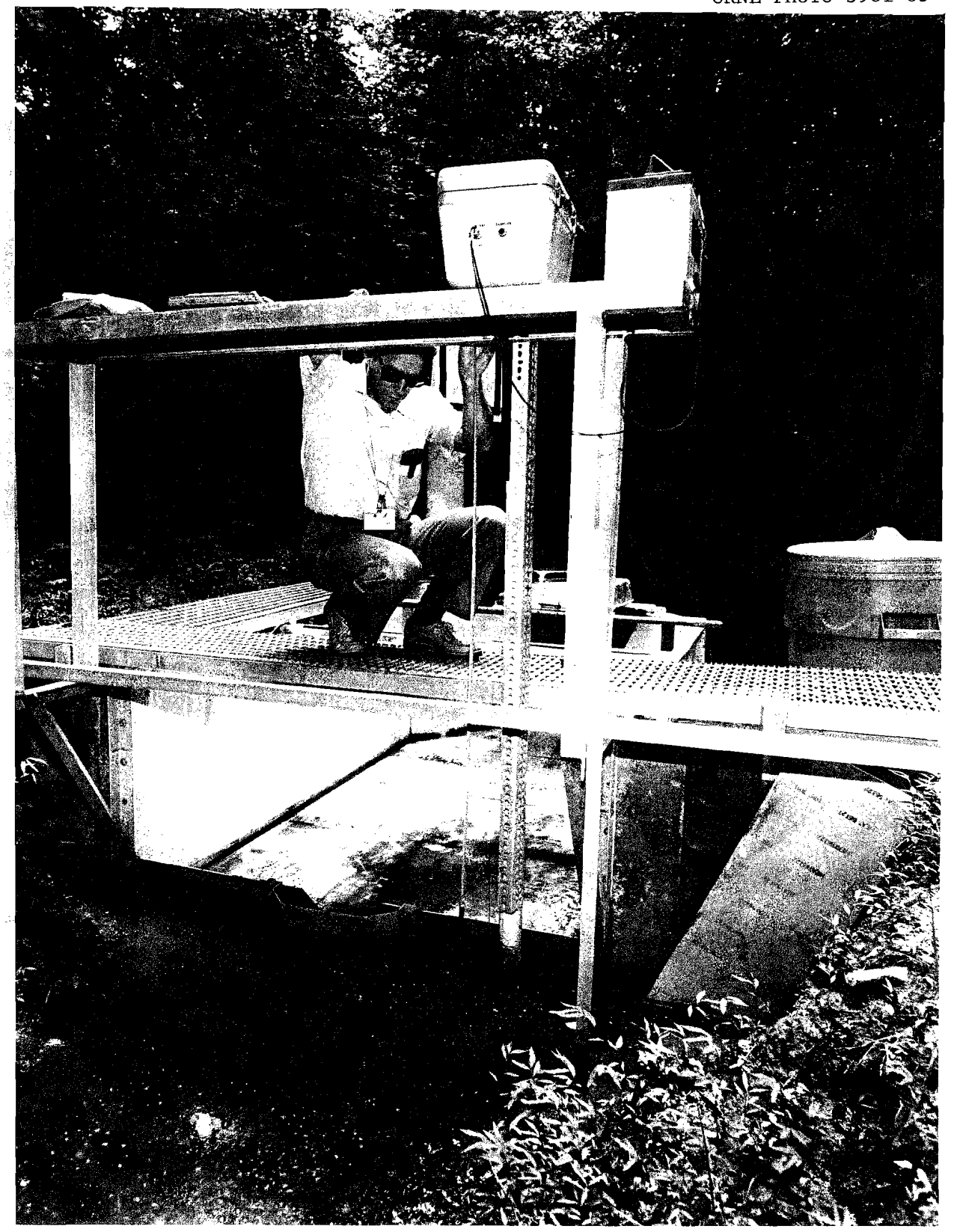

Fig. 3.1. Flow monitoring system at Center Seven Creek.

was temporarily reinforced to prevent distortion during the pouring of the concrete. The flume was leveled to within 1.2 mm by using a Pentax EDM Theodolite PX-10D, and metal bands were used to secure the flume to the pad in order to prevent "floating out" during the concrete work. Forms were positioned as to seal and support the flume opening. The concrete was filled to about one-half the height of the flume unit in a single pour. A catwalk was installed for access to the two instruments used to record stage heights.

The Stevens Digital Recorder Model 7001 was installed to measure water level in the H-flume, and the Plastifab enclosure was modified to permit direct access through two customized doors. A Manning Flow Totalizer (Dipper model) was used at the V-notch to measure stage height. During operation, both instruments were checked weekly and the circle chart from the Manning was retrieved. The punched paper tape was retrieved monthly (initially by Martin Marietta Energy Systems personnel and then by USGS personnel after August 1987). For data transcription, the circle charts were read directly, whereas the paper punch data were transferred electronically to computer files using a Stevens Data Translator Model STR 1000 connected to an IBM XT personal computer. Both recorders were operational in late November 1984.

3.2. CALIBRATION

In order to provide continuous stream flow records from C7C stage-discharge relationships were established for both the V-notch (low-flow) and the H-flume (high-flow) monitoring devices. To convert the stage data to flow on the weir shown in Figure 3.2, the theoretical rating was determined. For a 90° V-notch weir

$$Q_V = 0.01380\ (H)^{2.5} \quad \text{for } 0.0 \leq H \leq 12.2 \text{ cm } (0.4 \text{ ft}), \qquad (3.1)$$

where H is stage in centimeters, and Q_V is discharge from the V-notch in liters per second. The rating for the combined weir was derived by

ORNL-DWG 85-14174

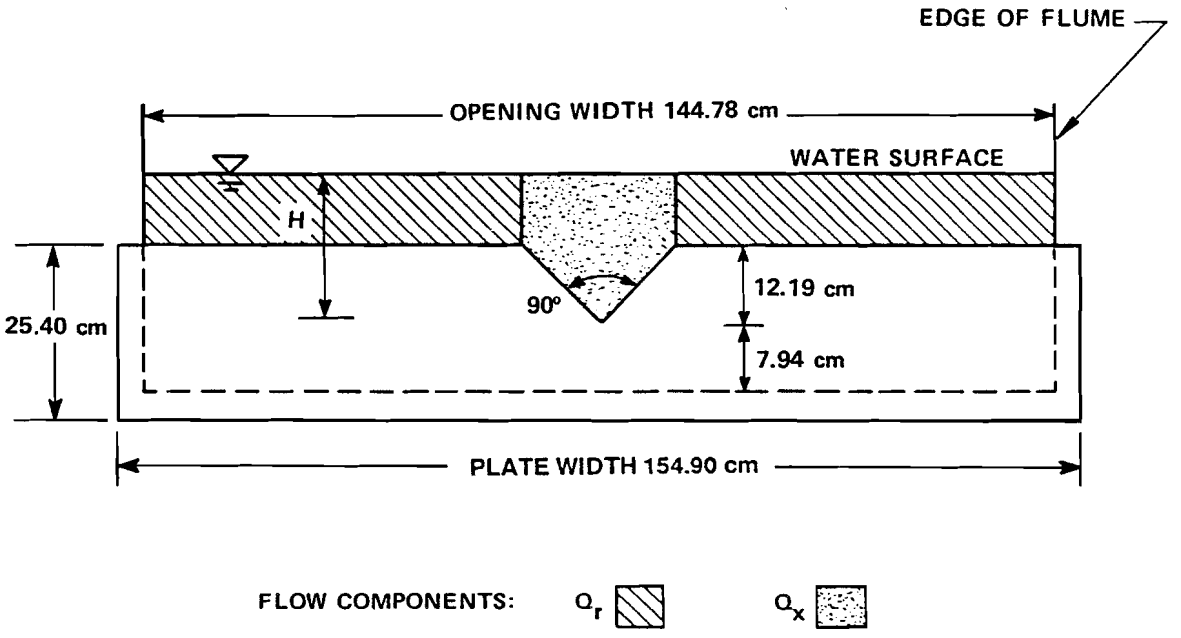

Fig. 3.2 V-notch weir dimensions.

the summation of the flows from the various weir sections. For the rectangular portion of the wier excluding the area over the V-notch (using end corrections):

$$Q_r = 0.01839[L - 0.2(H - 12.2)](H - 12.2)^{1.5}$$
$$Q_r = 0.01839[120.40 - 0.2(H - 12.2)](H - 12.2)^{1.5}$$
$$Q_r = 0.01839[120.40(H - 12.2)]^{1.5} - 0.01839(0.2)(H - 12.2)^{2.5}$$
$$Q_r = 2.2142(H - 12.2)^{1.5} - 0.00368(H - 12.2)^{2.5} \qquad (3.2a)$$

where Q_r is discharge for the rectangular weir (excluding the area over the V-notch) in liters per second. For the area over the V-notch:

$$Q_x = Q_v - 0.01380(H - 12.2)^{2.5}$$
$$Q_x = 0.01380(H)^{2.5} - 0.01380(H - 12.2)^{2.5} \qquad (3.2b)$$

where Q_x = discharge for the V-notch and the rectangular area above it in liters per second.

Also,

$$Q = Q_x + Q_r$$
$$Q = 2.2142(H - 12.2)^{1.5} - 0.01748(H - 12.2)^{2.5} + 0.01380(H)^{2.5}$$
$$\text{for } H \geq 12.2 \text{ cm}, \qquad (3.2c)$$

where Q is discharge for the combined weir in liters per second.

To verify the theoretical rating for the weir, volumetric flow measurements were taken concurrent with head determination on the weir. The field measurements are provided in Appendix B along with the computed flow for each stage. A plot showing the theoretical rating and the measured data is provided in Fig. 3.3. Because of good correlation between the theoretical rating and the data, the theoretical rating may be used with confidence to determine the flow from the V-notch weir.

To provide an accurate record over a wide range in flows whenever H exceeded 12.2 cm (0.40 ft) or Q exceeded 7.17 L/s (0.253 ft^3/s), flow data measured at the V-notch were replaced with those measured in the

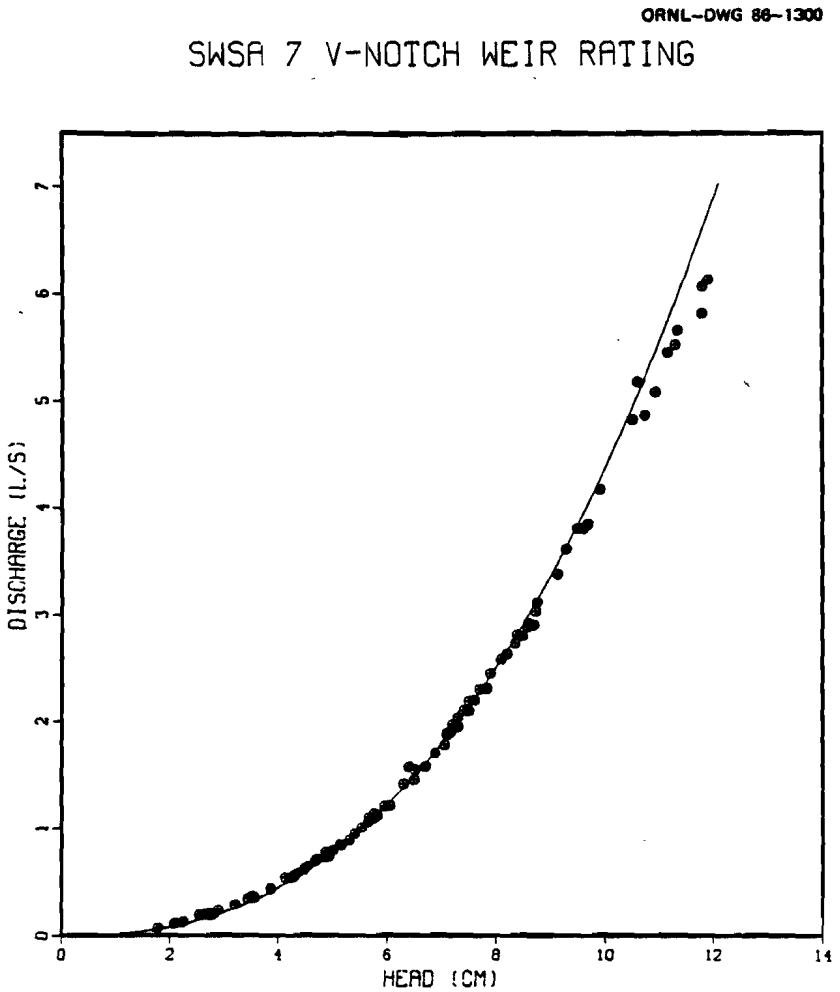

Fig. 3.3. SWSA-7 V-notch weir rating.

flume. A field rating of the H-flume was not developed because experience with the H-flumes at other sites has shown that the manufacturer's rating is accurate at high-flow conditions, but that some adjustment may be necessary for the low-flow ranges (Huff and Frederick 1984). Therefore, since the H-flume is to be used to record data during high-flow conditions, the manufacturers rating (translated to units of liters per second in Table 3.2) was used for flow computation.

3.3 STREAMFLOW

The monthly statistics for discharge measured at C7C are given in Table 3.3. Monthly peak discharges are not available for 1983. The peak flow for May 1984 is an estimate based on flows at other sites at ORNL, and the peak flows for August 1987 through March 1988 were measured at the V-notch weir. Hydrographs for 1984 through March 1988 appear in Figs. 3.4-3.8. The hydrographs were plotted from the mean daily flows.

3.3.1 Runoff Coefficients

The runoff coefficient, RC (expressed as a percent), is defined as the ratio of the runoff per unit watershed area to the precipitation. Annual values for C7C Watershed are given in Table 3.4; also given are values for the USGS-maintained gaging stations. Much of the data for these stations cover partial years.

The annual runoff for 1983 was 460 mm (RC = 40%), but the next year, the total runoff increased to 622 mm (RC = 48%). For 1984, the large storms of early May produced an unusually large amount of surface runoff that strongly affected the RC. If both the runoff and precipitation for 1984 are decreased by subtracting the respective amounts for the month of May, then the RC becomes 39%, similar to the value for 1983. These values are less than the long-term regional average coefficient for east Tennessee, which is 47% (TVA 1972).

Although both 1983 and 1984 had summer months with below normal rainfall, these years were relatively wet compared to later years.

Table 3.2. Theoretical flume rating (discharges in liters per second) for the 2.5-ft H-flume at SWSA-7

Stage (ft)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.00	0.00	0.03	0.06	0.11	0.18	0.25	0.35	0.46	0.57	0.71
0.10	0.84	1.00	1.15	1.32	1.50	1.68	1.89	2.10	2.33	2.56
0.20	2.80	3.07	3.34	3.62	3.91	4.21	4.53	4.86	5.20	5.56
0.30	5.92	6.28	6.65	7.05	7.49	7.93	8.38	8.83	9.31	9.80
0.40	10.30	10.82	11.34	11.86	12.38	12.90	13.50	14.10	14.72	15.36
0.50	16.00	16.64	17.28	17.96	18.68	19.40	20.12	20.84	21.60	22.40
0.60	23.20	24.00	24.80	25.62	26.46	27.30	28.18	29.06	30.00	31.00
0.70	32.00	32.92	33.84	34.80	35.80	36.80	37.88	38.96	40.04	41.12
0.80	42.20	43.32	44.44	45.62	46.86	48.10	49.30	50.50	51.76	53.08
0.90	54.40	55.68	56.96	58.32	59.76	61.20	62.60	64.00	65.42	66.86
1.00	68.30	69.74	71.18	72.70	74.30	75.90	77.50	79.10	80.74	82.42
1.10	84.10	85.82	87.54	89.24	90.92	92.60	94.40	96.20	98.08	100.04
1.20	102.00	104.00	106.00	107.80	109.40	111.00	113.00	115.00	117.00	119.00
1.30	121.00	123.40	125.80	128.00	130.00	132.00	134.40	136.80	139.00	141.00
1.40	143.00	145.40	147.80	150.20	152.60	155.00	157.40	159.80	162.20	164.60
1.50	167.00	169.40	171.80	174.40	177.20	180.00	182.80	185.60	188.40	191.20
1.60	194.00	196.80	199.60	202.40	205.20	208.00	210.80	213.60	216.60	219.80
1.70	223.00	225.80	228.60	231.60	234.80	238.00	241.20	244.40	247.60	250.80
1.80	254.00	257.60	261.20	264.60	267.80	271.00	274.60	278.20	281.80	285.40
1.90	289.00	292.20	295.40	298.80	302.40	306.00	310.00	314.00	318.00	322.00
2.00	326.00	330.00	334.00	338.00	342.00	346.00	349.60	353.20	357.00	361.00
2.10	365.00	369.00	373.00	377.00	381.00	385.00	389.40	393.80	398.20	402.60
2.20	407.00	411.40	415.80	420.20	424.60	429.00	433.40	437.80	442.40	447.20
2.30	452.00	456.80	461.60	466.20	470.60	475.00	479.80	484.60	489.40	494.20
2.40	499.00	504.20	509.40	514.40	519.20	524.00	529.20	534.40	539.40	544.20
2.50	549.00									

[a]For example, for a stage of 0.45 ft, the discharge is 12.90 L/s (the intersection of the 0.40 line and the 0.05 column).

Table 3.3. Monthly discharge from Center Seven Creek

Year	Month	Flow vol. (m^3*)	Flow depth (mm)	Mean flow rate (L/s)	Maximum flow rate (L/s)	Minimum flow rate (L/s)	Peak flow (L/s)
1983	Jan	6327	34.2	73.23	3.21	1.75	
	Feb	15780	85.3	182.64	46.82	1.68	
	Mar	4126	22.3	47.75	6.00	0.84	
	Apr	21870	118.2	253.12	113.41	1.52	
	May	13447	72.7	155.64	40.57	1.10	
	Jun	2317	12.5	26.82	3.82	0.40	
	Jul	667	3.6	7.72	0.52	0.00	
	Aug	397	2.1	4.59	0.28	0.00	
	Sep	237	1.3	2.74	0.33	0.00	
	Oct	1285	6.9	14.87	1.79	0.00	
	Nov	3475	18.8	40.22	15.77	0.03	
	Dec	15138	81.8	175.21	24.27	0.92	
	Total	85066	459.8				
1984	Jan	8838	47.8	102.29	13.06	0.95	18.6
	Feb	7894	42.7	91.37	14.95	0.90	59.7
	Mar	14487	78.3	167.67	37.30	1.50	98.5
	Apr	9528	51.5	110.28	19.55	1.12	40.9
	May	41141	222.4	476.17	116.25	1.08	248.3**
	Jun	1972	10.7	22.82	5.92	0.15	36.5
	Jul	9153	49.5	105.94	42.25	0.43	214.7
	Aug	2380	12.9	27.55	12.39	0.14	197.3
	Sep	687	3.7	7.95	0.68	0.10	4.7
	Oct	5229	28.3	60.52	19.82	0.22	233.7
	Nov	8518	46.0	98.59	27.68	0.13	98.1
	Dec	5736	31.0	66.39	5.30	0.61	6.4
	Total	115563	624.7				
1985	Jan	6110	33.0	70.72	7.24	0.87	24.8
	Feb	15027	81.2	173.93	44.54	1.83	145.4
	Mar	5713	30.9	66.12	4.31	1.05	6.5
	Apr	5705	30.8	66.03	11.11	0.46	32.9
	May	1771	9.6	20.50	3.66	0.13	13.5
	Jun	769	4.2	8.90	1.65	0.00	24
	Jul	1228	6.6	14.21	1.91	0.00	32.9
	Aug	9558	51.7	110.63	46.59	0.05	292.2
	Sep	913	4.9	10.56	2.52	0.10	58.3
	Oct	2086	11.3	24.14	4.04	0.20	25.6
	Nov	6231	33.7	72.12	13.64	0.41	89.2
	Dec	5916	32.0	68.47	8.28	0.42	18
	Total	61026.17	329.9				

Table 3.3. (Continued)

Year	Month	Flow vol. (m^3*)	Flow depth (mm)	Mean flow rate (L/s)	Maximum flow rate (L/s)	Minimum flow rate (L/s)	Peak flow (L/s)
1986	Jan	2976	16.1	34.44	3.73	0.31	14.7
	Feb	15595	84.3	180.50	42.22	0.96	205.2
	Mar	11906	64.4	137.80	32.01	1.30	334
	Apr	2367	12.8	27.40	2.79	0.46	9.8
	May	1157	6.3	13.40	2.15	0.10	7.3
	Jun	477	2.6	5.52	0.86	0.00	24.3
	Jul	2686	14.5	31.09	7.99	0.00	2
	Aug	71	0.4	0.82	0.31	0.00	6.5
	Sep	199	1.1	2.30	1.42	0.00	6.2
	Oct	1438	7.8	16.64	5.04	0.00	12
	Nov	2904	15.7	33.61	8.80	0.00	18
	Dec	17339	93.7	200.68	103.79	0.70	127.6
	Total	59115	319.5				
1987	Jan	16070	86.9	186.00	80.19	0.50	131.6
	Feb	9623	52.0	111.37	13.01	0.92	27.3
	Mar	7462	40.3	86.37	10.78	1.02	26.9
	Apr	9369	50.6	108.44	29.84	0.25	139.8
	May	1587	8.6	18.37	3.07	0.22	56.4
	Jun	1604	8.7	18.57	5.31	0.01	20.8
	Jul	475	2.6	5.50	2.18	0.00	9.8
	Aug	5	0.0	0.06	0.06	0.00	0.3**
	Sep	229	1.2	2.64	1.65	0.00	7.1**
	Oct	40	0.2	0.47	0.10	0.00	0.2**
	Nov	217	1.2	2.51	0.66	0.00	1.8**
	Dec	1577	8.5	18.25	2.94	0.02	6.9**
	Total	31745	171.5				
1988	Jan	14824	80.1	171.57	59.47	0.50	95.5**
	Feb	6224	33.6	72.04	26.05	0.57	4.5**
	Mar	10697	57.8	123.80	65.13	0.59	150 **
	Total	82545.53	446.2				

*Measured at V-notch weir.
**Estimate.

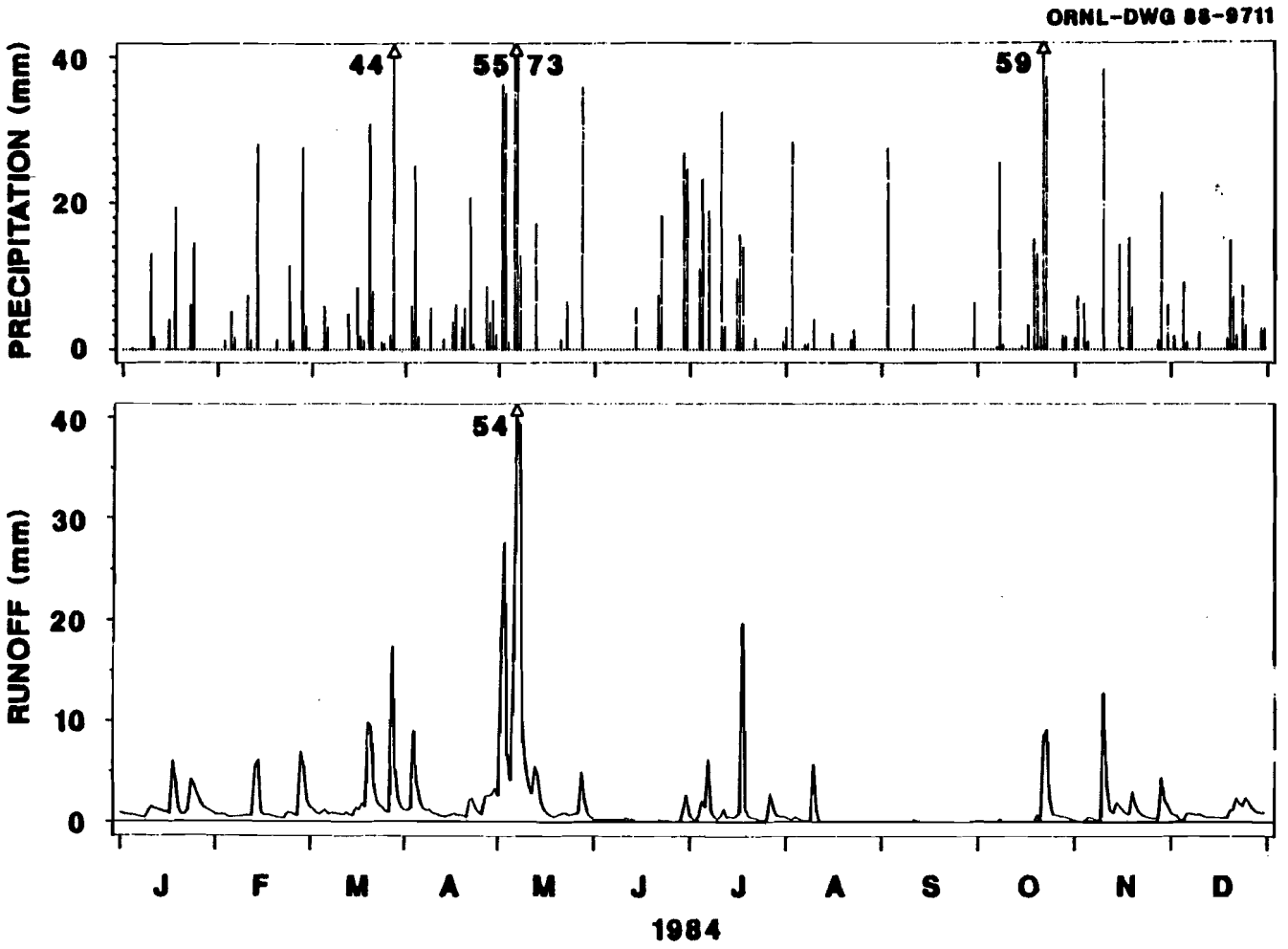

Fig. 3.4. Discharge hydrograph for Center Seven Creek, 1984.

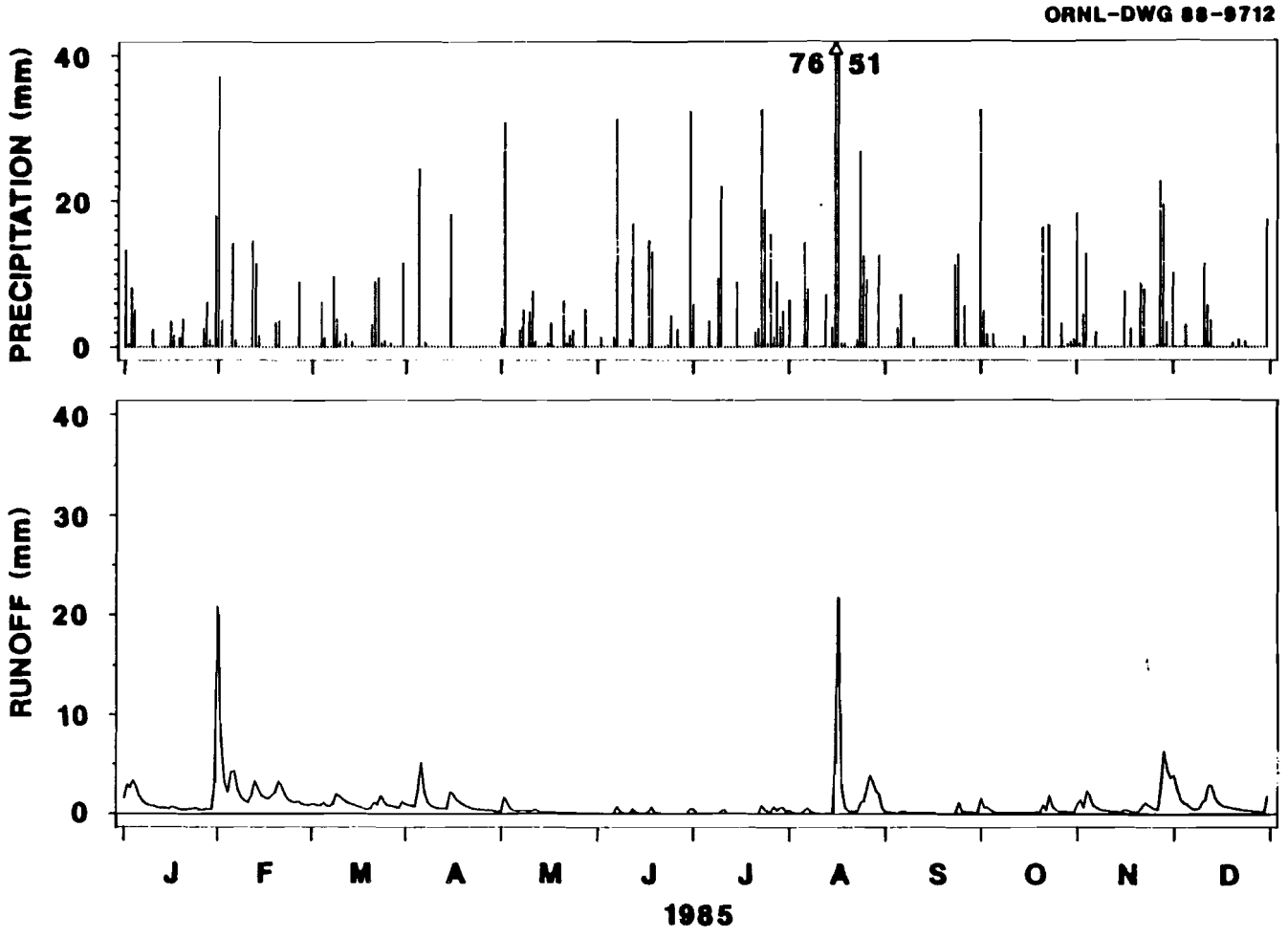

Fig. 3.5. Discharge hydrograph for Center Seven Creek, 1985.

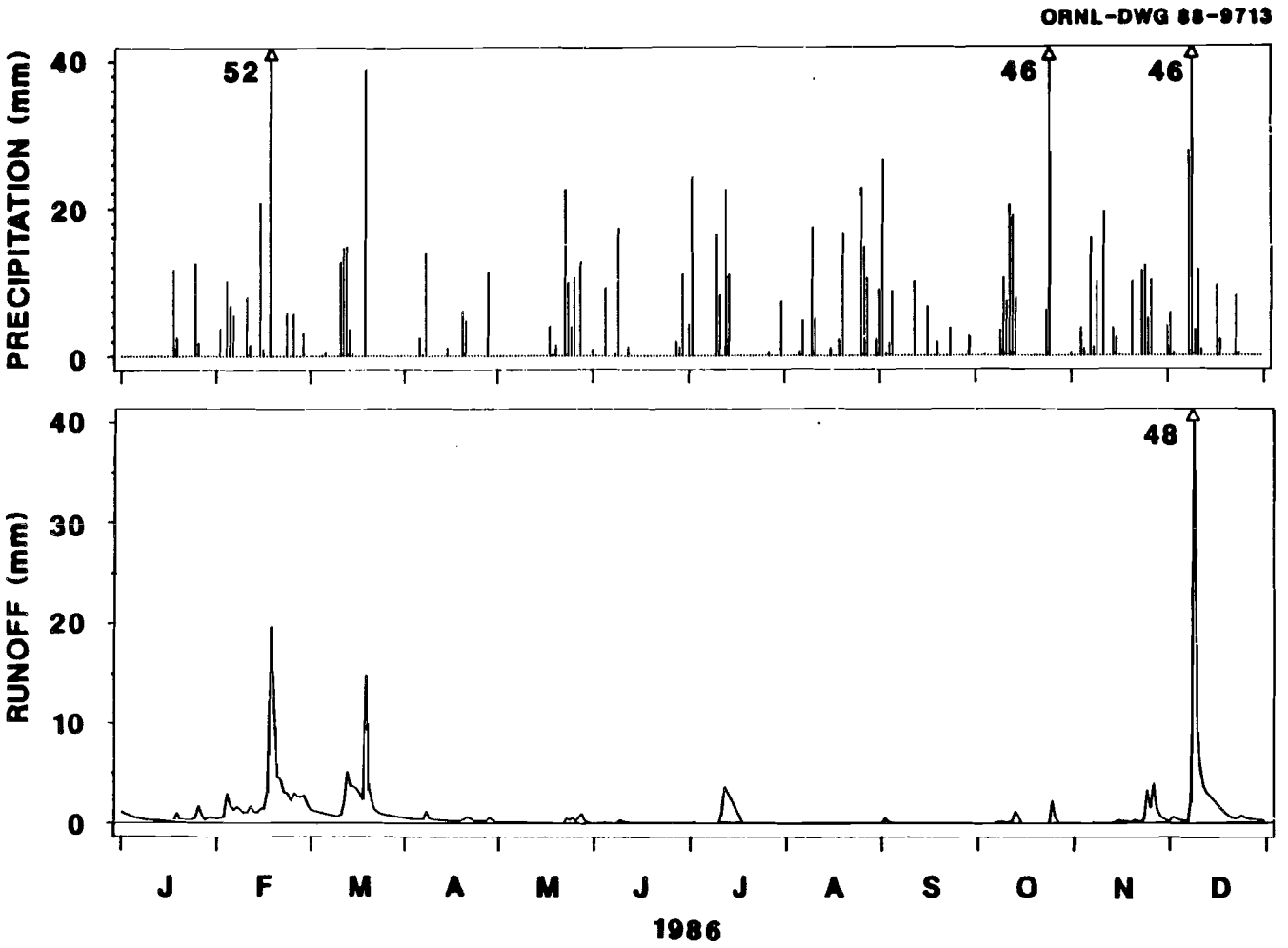

Fig. 3.6. Discharge hydrograph for Center Seven Creek, 1986.

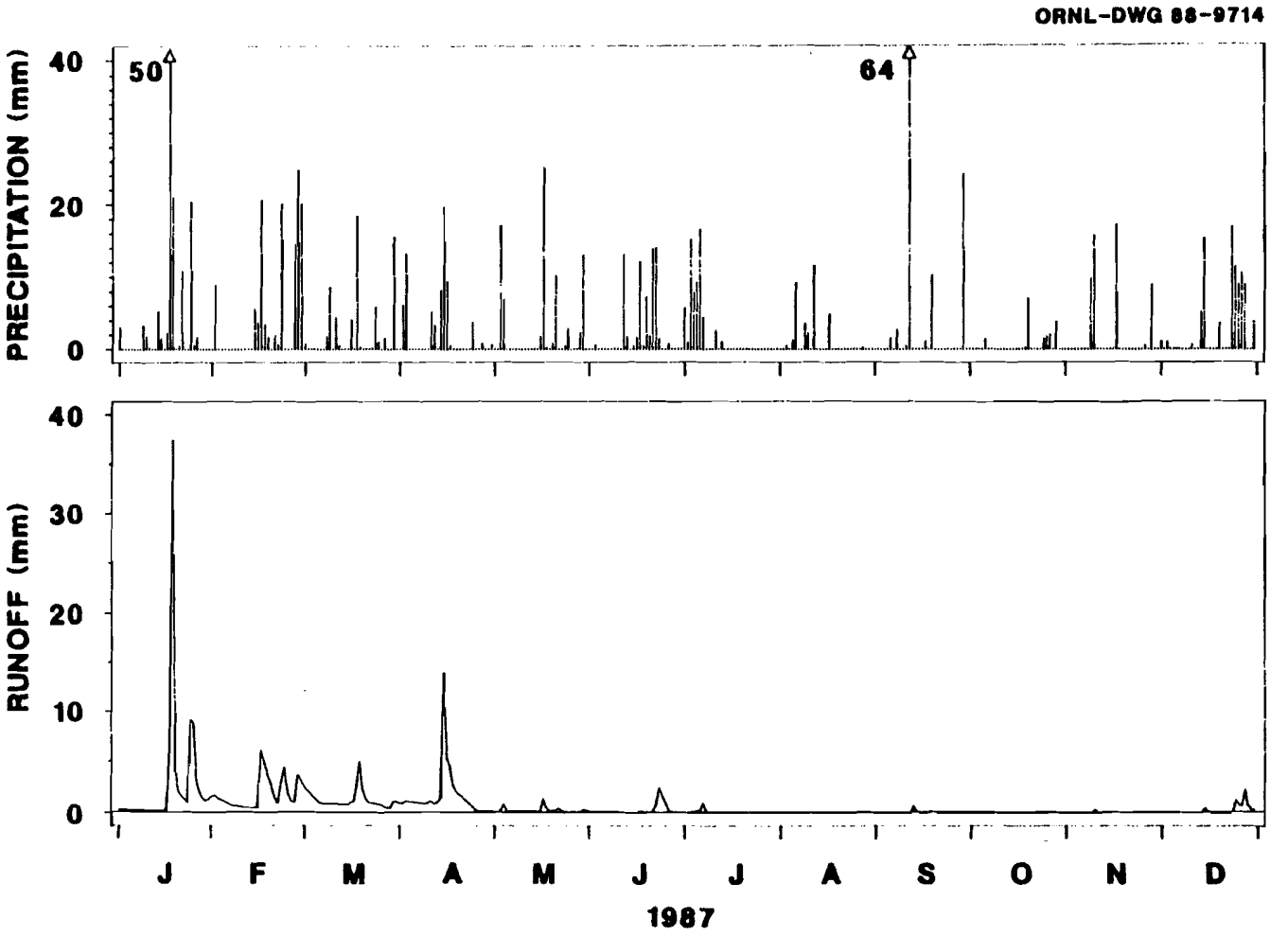

Fig. 3.7. Discharge hydrograph for Center Seven Creek, 1987.

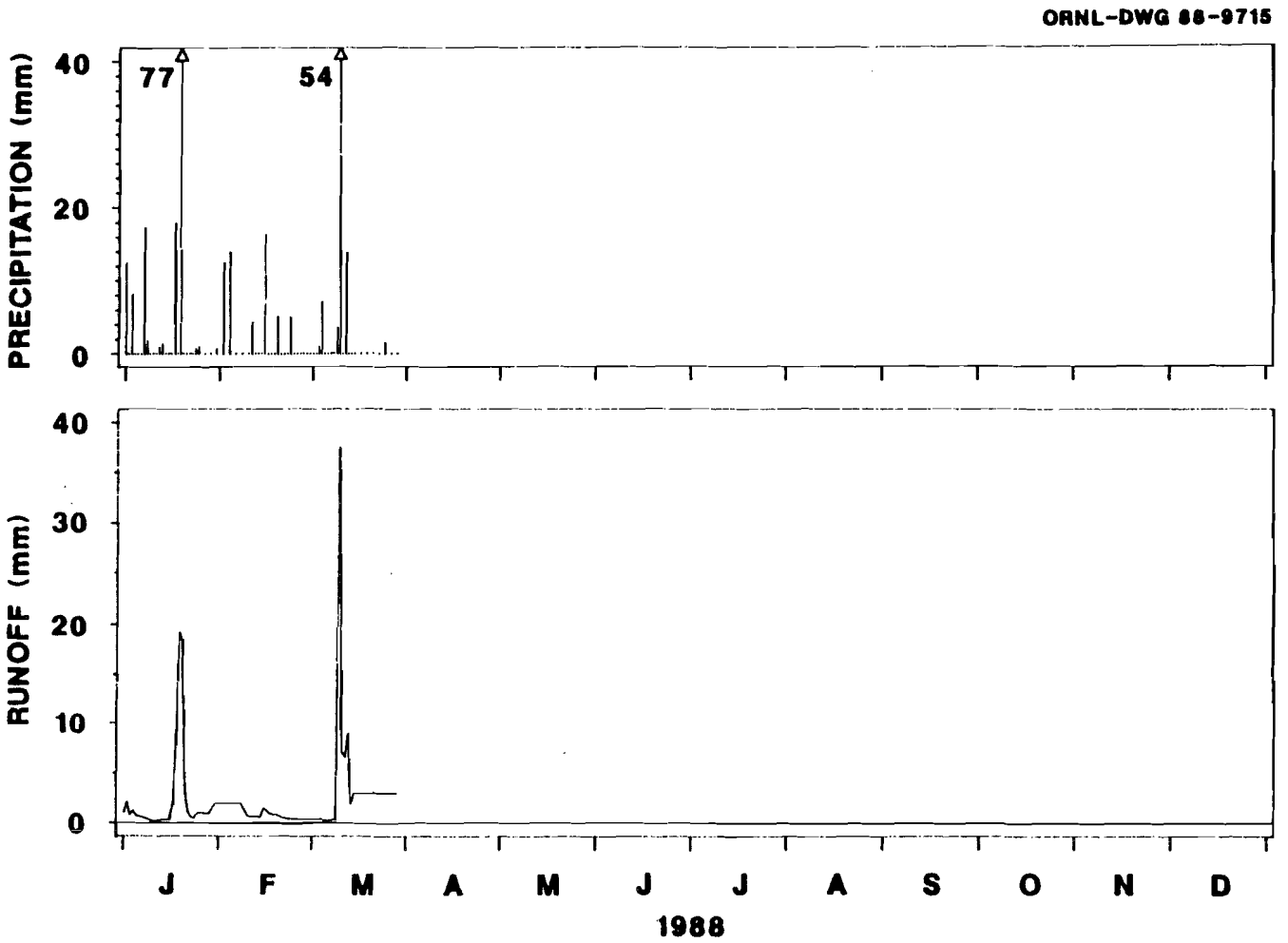

Fig. 3.8. Discharge hydrograph for Center Seven Creek, January-March, 1988

Table 3.4. Runoff coefficients (RC) for discharge monitoring sites (C7C is Center Seven Creek, UKB is Upper Melton Branch, and E7C is East Seven Creek)

Year	Total rainfall (mm)	Rainfall by site							
		C7C		UMB		W7C		E7C	
		runoff (mm)	RC (%)	Runoff (mm)	RC (%)	Runoff (mm)	RC (%)	Runoff (mm)	RC (%)
1983	1144	460	40.2						
1984	1312	625	47.6						
1985	1127	329.7	29.3						
1986	924	319.5	34.6	241	26.1				
1987	889	261	29.4	236	26.6				
Partial year									
1985*	887	184.8	20.8	142	16.0				
1988**	298	172	57.7	128	43.0	131	44.0	147	49.3

*April-December.
**January-March.

After 1984, rainfall deficits became large, and the annual RC for C7C showed a marked decline. For 1985, 1986, and 1987, conditions were relatively dry, and the average RC was 31%. The decrease in the RC from wet to dry years can be explained qualitatively in terms of potential evapotranspirational demand. When soil water is not limiting, evapotranspiration (ET) is determined largely by meteorological conditions (e.g., temperature, humidity, solar radiation). Consequently, these factors are fairly steady from year to year, and the annual ET tends to be constant also, accounting for a relatively large proportion of rainfall during dry years (equivalent to a low RC). Of course, annual ET is not constant because increased water stress during dry years leads to slightly lower ET losses.

When the RCs for the other gaging sites were compared for 1986 and 1987, the average RC for UMB was 26%, considerably less than the 32% average for C7C. Data for the partial years of record also show that there was more stream discharge from C7C than that observed at UMB (on a per-watershed-area basis).

For the perimeter creeks, W7C and E7C, no RC values for late 1987 were calculated because flows tended to be negligible. For the first three months in 1988, the coefficients for both of these creeks were less than that for C7C. For the same period, the RC for discharge at the UMB site was the lowest (43%). The low value of the RC at W7C could be explained by the fact that streamflow has been observed to bypass the weir during very wet conditions. The riparian area is relatively flat, and small ephemeral channels around the weir are evident. According to James Lewis of the USGS (personal communication, 1988), the duration of bypassing flow has been small, thus the mean daily flows are considered to be accurate. These channels will be filled in the fall of 1988.

3.3.2 Discussion of Runoff Coefficients

The precipitation loss (precipitation-runoff) or the relative precipitation loss (1-RC) provides insight into the possibility of a groundwater flow path that could transport dissolved contaminants out

of the watershed. Occurrence of such flowpaths can complicate subsurface monitoring for contamination for waste disposal sites. The significance of the precipitation loss can be evaluated by comparing the measured value for a watershed to the long-term, regional average or to values measured at nearby watersheds.

On an annual basis, ET accounts for most of the precipitation loss. Because climatic conditons and the vegetation cover are similar for all of the gaged watersheds, ET in any year is also expected to be similar. The long-term, regional average ET for large basins is about 740 mm or 53% of precipitation, although a variation within small watersheds and among different years can be expected.

The precipitation loss for C7C watershed in 1983 and 1984 when rainfall was near normal was about 60% (excluding the extreme rainfall in May 1984). Compared to the long-term average, this suggests about an 8% loss, which can be attributed to groundwater loss. Comparisons for later years when the loss rates were much higher are not justified because of the anomolous rainfall deficits.

Comparison of losses between C7C and the perimeter creeks (W7C, E7C and UMB) provide a relative picture of watershed losses and gains and suggest an opposite tendency. Because all the perimeter watersheds have higher precipitation losses than C7C Watershed, it is more probable that C7C Watershed is an importer of groundwater rather than an exporter.

For these perimeter watersheds the higher losses can be attributed to (1) groundwater divides that are different from surface divides or (2) a groundwater path under the gaging station. Flows from one watershed to another cannot be ruled out, especially for E7C where losses to the east (out of Melton Branch Watershed) are a possibility.

The simplest explanation for the losses is flow under the discharge stations because each of the perimeter gaging stations is located on a relatively flat riparian area underlain by alluvium. In contrast, the mouth of C7C has bedrock slopes enclosing a comparatively narrow riparian zone. Hydraulic conductivity in the alluvium is higher than that in the bedrock (1.5×10^{-4} cm/s) in Well 13 compared to the

geometric average of 1.3×10^{-5} for seven wells located along the ridgeline, as reported in Rothschild et al. (1984b).

In summary, comparisons of runoff coeifficients suggest that C7C Watershed is not losing large quantities of water, and, in fact, may be gaining water. Although the data records from E7C and W7C cover only a partial year and are therefore of questionable reliability, the 3 years of data at UMB support this conclusion. Although vertical hydraulic gradient measurements presented in Section 4 show that some groundwater flow is downward and out of C7C, that flow is probably small. Groundwater outflow could be balanced by groundwater inflow; however, it is unlikely that C7C watershed is a conduit that routes subsurface flows originating outside the watershed to the gaging site, while also losing water through a deep seepage route.

Consequently, for the purpose of environmental monitoring at the SWSA-7 site, the C7C Watershed can be considered essentially watertight. Because disposal facilities will be located on the ridges along the watershed divide, a component of groundwater at the facilities will flow toward E7C and W7C (both above and below the gaging station for W7C). Groundwater monitoring wells must be located on the side slopes below the facilities and in the alluvium where the creeks are located. In addition, groundwater monitoring wells should be located in the Melton Branch riparian area below the UMB gaging site. Environmental monitoring should include streamflow measurement and water quality sampling, too. As described in the next section, the streamflow is generated by both shallow and deep lateral subsurface flow (i.e., lateral flow both above and below the water table). Sampling streamflow at different stages of the hydrograph may provide a total picture of solute movement through various hydrologic pathways.

3.4 PEAK FLOW AND THE TIME OF CONCENTRATION

Peak flows can be evaluated with respect to the relationship derived by Sheppard (1974) for Oak Ridge catchments:

$$Q = 0.00244\ A^{0.8}\ P^{2} \quad , \qquad (3.3)$$

where

Q = peak flow rate (liters per second),

A = catchment area (hectares),

P = dormant season 48-h duration precipitation (millimeters).

The relationship is limited to $76.2 < P < 240$ mm (or $3 < P < 10$ in.); and as listed by Rothschild et al. (1984b), for recurrence intervals of 2, 5, 10, 50, and 100 years, the expected 48-h rainfalls are approximately 129, 160, 175, 213, and 231 mm (5.1, 6.3, 6.9, 8.4, and 9.1 in., respectively). Using the corrected area of 18.55 ha (0.0716 miles^2) for the SWSA-7 catchment, the respective flows are 420, 640, 770, 1100, and 1300 L/s (14.8, 22.6, 27.1, 40.2, and 47.2 ft^3/s, respectively).

For 1984 the maximum peak flow rate occurred on May 7, and its corresponding storm had a 48-h measured depth of 137 mm (5.4 in.). According to Sheppard (1974), this storm has a recurrence interval of approximately 3 years. The stage height exceeded the range of the stage-recorder from 1000 h April 6 until 1600 h April 7. Moreover, during this storm there were three distinct peaks in the hourly rainfall rate, making simple extrapolation impossible. Consequently, the estimated hydrograph used to generate the daily flows in Appendix B had to be derived from measurements made at gaging stations nearby. Although the estimated daily flows for May 6 and 7 at SWSA-7 are reasonable based on water budget estimations, the estimated breakpoint discharge data and peak flow of 248 L/s (8.8 ft^3/s) are less reliable. Given the intermittent pulses of rainfall during the storm, the flow was probably equal to or less than the calculated peak flow rate of 467 L/s (16.5 ft^3/s) using the relationship cited above.

The storm response of a watershed can be partly characterized by the time of concentration, t_c, which is the time of travel for surface runoff between the farthest point in the catchment and the stream gage. For small catchments such as SWSA-7, t_c can be estimated by the upland method, a technique within the hydrologic estimation methods used by the Soil Conservation Service (McCuen 1982). The most remote

point in the watershed was judged to be the rim of the gully in the southeast corner of the watershed (where the Subsurface Transport Facility is located). When the upland method is used, the distance for overland flow from this point to the upper end of C7C is about 94 m, and the time of travel is calculated as 3 min. For the length of the creek (~700 m), the time of travel is calculated as 17 min. Consequently, t_c is estimated to be 20 min. The approximation assumes steady flow, and for typical storms having a single pulse of intense rainfall the time between the peak rainfall rate and the peak runoff rate is expected to be slightly greater than t_c because of storage and momentum effects. Although 20 min is judged to be low for the watershed, inspection of the hourly rainfall-runoff record indicates that peak hourly flows usually occur during or 1 h after maximum hourly rainfall which conforms to these approximations. Direct measurement of flow velocities under high flow conditions would be useful in estimating the movement of surface-generated pollutants and in formulating water sampling strategies.

4. GROUNDWATER

4.1 GROUNDWATER DATA BASE

Water levels measured in wells were initially maintained in computer files by personnel in the Hydrologic Data Laboratory in ESD. The information was recorded and maintained in the 1022 data base system on the PDP-10. In August 1986, the data were transferred into a SAS data base system, and responsibility for maintaining the data base was transferred to the Remedial Action Program (RAP). For SWSA-7 the record for water levels is divided into yearly data files with one file containing all the pre-1986 data. These files were combined into a single file for the purpose of generating statistics and graphs. This special purpose file is available on the IBM 3033 from the data base group within RAP.

4.2 SOIL HYDRAULIC PROPERTIES

In a research project that is independent of the characterization work reported here, detailed measurements of hydraulic conductivity at the soil surface and near surface were made in the drainage area above the subsurface weir (see Figs. 1.2 and 4.1 for location). The purpose of the study was to characterize the flow in soil macropores, mesopores and micropores in a forested watershed. Macropores and mesopores associated with root channels, animal intrusion, soil structure, and other phenomena, transport water and solutes through the upper soil horizons at high flux rates relative to those typically measured in disturbed soil columns in the laboratory. In field work reported by Watson and Luxmore (1986) and analyzed by Wilson and Luxmoore (1987), double ring and tension infiltrometer measurements were made at 39 locations. The values of hydraulic conductivity, K, inferred from the steady-state infiltration rates were lognormally distributed at all levels of tension. For ponded, 20-, 50-, and 140-mm tension, the respective geometric means for K were 11.5, 1.73, 1.13, and 0.08×10^{-5} m/s. Despite the large flux rates attributed to macropores, the effective porosity of these pores is only 0.0032.

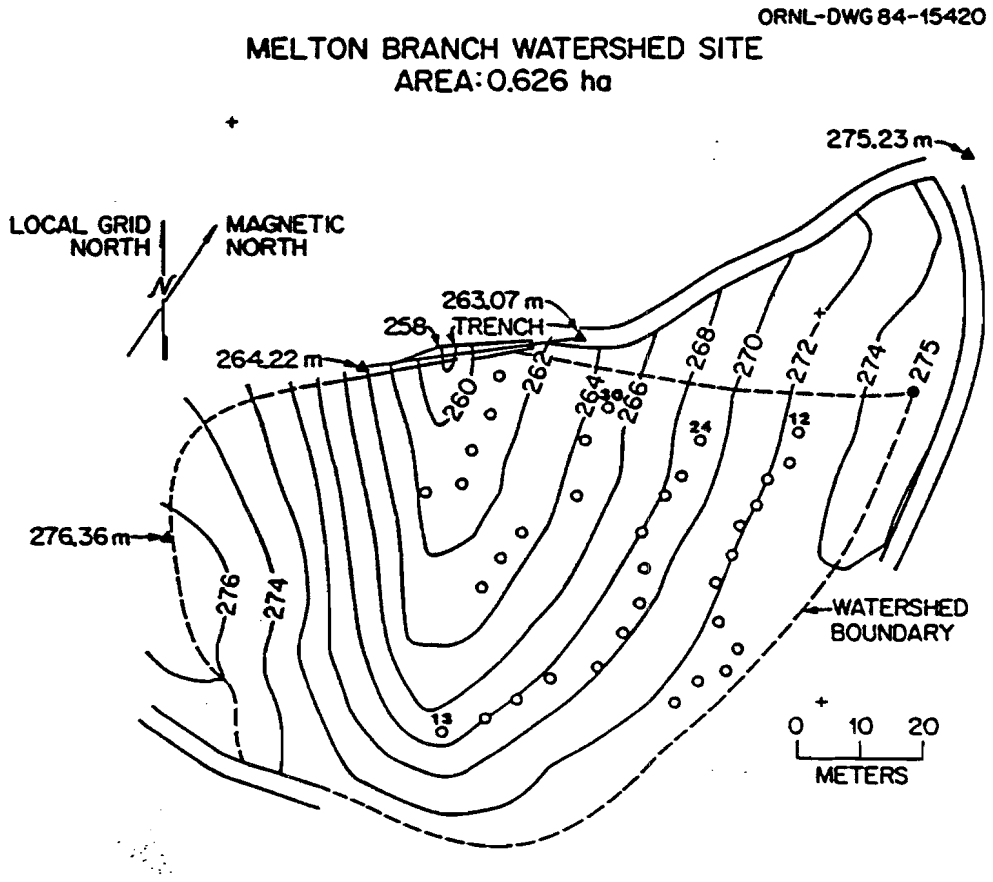

Fig. 4.1. Map of the Subsurface Transport Facility. In publications based on research at this facility, the drainage area is referred to as Melton Branch Watershed Site. (Open circles indicate locations of the infiltrometer tests.)

Wilson and Luxmoore (1988) defined mesopores as the largest pores filled with water at 20-mm tension, and they concluded that the mesopores provide sufficient infiltration capacity for total uptake of rainfall even at high intensities. Their results provide a quantitative explanation as to why overland flow is seldom observed in forested watersheds. In addition, they observed no spatial pattern among the 39 measurement locations; therefore, spatial correlation must be at scale lengths less than 4 m, the distance between adjacent measuring points in their study.

For the same subwatershed, Wilson et al. (ORNL, personal communication to author, 1988) report K values for subsurface soils measured by means of a Guelph permeameter. Determinations at 66 sites yielded an arithmetic average of 7.6×10^{-6} m/s and a geometric average of 1.96×10^{-6} m/s. The average depth of the measurements was 1.2 m.

4.3 VERTICAL DISTRIBUTION OF HYDRAULIC CONDUCTIVITY

To gain a qualitative picture of groundwater flow at the SWSA-7 site, it useful to examine the vertical distribution of hydraulic conductivity. Numerous inspections of hydraulic conductivity data measured on the ORR and specifically on the Conasauga formation suggest that hydraulic conductivity decreases with depth. The hydraulic conductivities measured on the C7C Watershed by different methods (Rothschild et al. 1984a, 1984b; Wilson and Luxmoore 1988; Wilson et al., ORNL, personal communication to author, 1988) were plotted against depth, as shown in Fig. 4.2. In preparing the plot, several assumptions were made. If K varies significantly with decreasing z, then slug tests made at wells with multiple screens will produce K values reflecting permeabilities of the upper screened interval. Thus, for five values of K for groundwater wells with multiple screens reported by Rothschild et al. (1984b), K was matched with the depth of the upper most well screen. In Fig. 4.2, the data points are labeled with the well number where K was determined. The geometric mean of the subsurface K measurements reported by Wilson

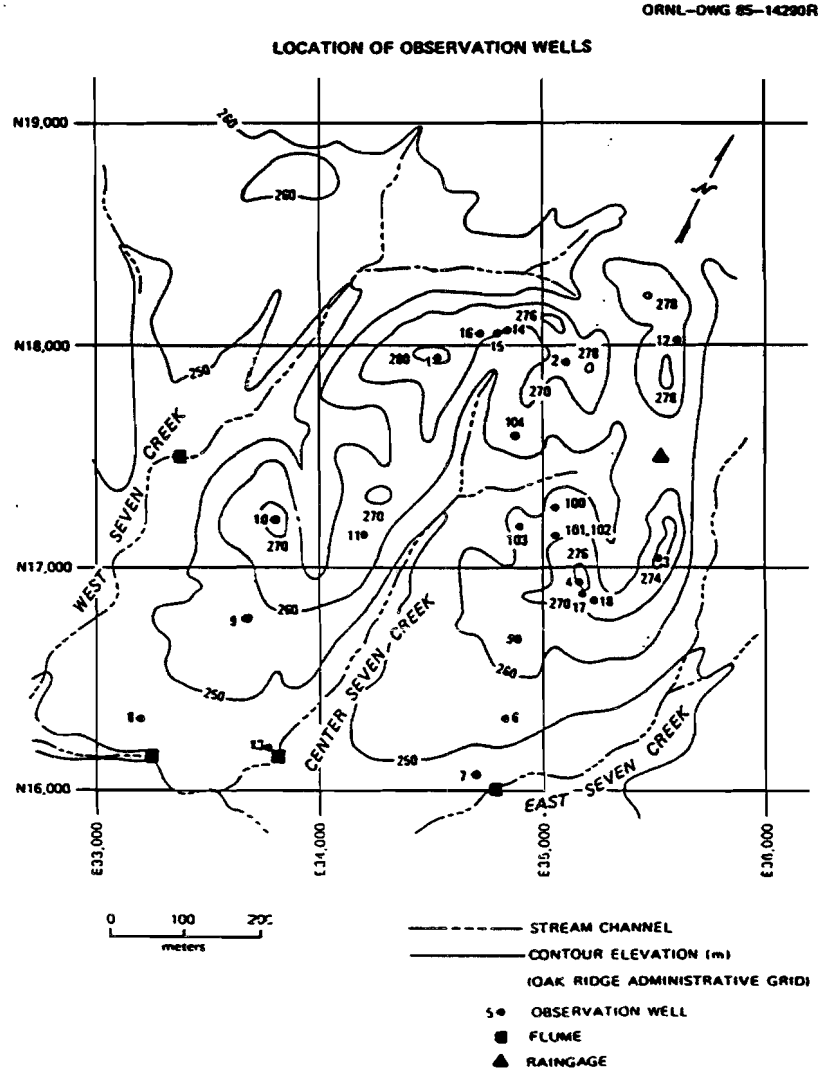

Fig. 4.2. Location of observation wells.

et al.(ORNL, personal communication to author, 1988) was plotted against the average depth of 1.2 m (identified as point SS). Likewise, the geometric mean of K determined from slug tests in shallow auger holes (as reported by Rothschild et al. 1984a) was plotted (point SC). One K value (at Well 3) was rejected because it is an outlier.

In calculating the variation of K with z, it is recognized that the original equations used to calculate K assumed certain flow paths around the well screen and uniformity in K. Thus, because K varies with depth, the values themselves are in error. Unfortunately, there is no method available for correcting them.

The regression shown by the solid line in Fig. 4.2 is given by the expression

$$\log K = 0.672 - 0.07920\ z, \quad r^2 = 0.73 \quad , \tag{4.1}$$

where units of z and K are meters and meters per day, respectively. The value for r^2 is misleadingly large because averaged data were used for data near the surface.

The effects of exponential decline in K with depth on groundwater movement has not been investigated in detail. Qualitatively, this distribution of K suggests that groundwater fluxes will be higher near the water table and lower at depth. Consequently, groundwater tends to move more laterally and less vertically, as compared to flows in a classical, homogeneous porous medium. In turn, this distribution of K may also help to explain the general observation that in the Conasauga shale formation, the water-table surface is a subdued replica of the ground surface, with highest groundwater elevations located beneath the ridges (Rothschild et al. 1984b). The effects of a exponential decline in K with depth on groundwater flow direction can be investigated by computer simulation, and such investigations could provide valuable information concerning potential contaminant migration.

4.4 INSTALLATION OF THE 100-SERIES WELLS

Four observation wells, numbered 100 through 103, were installed at SWSA-7 during the period of August through November 1982. The locations of the wells are shown in Fig. 4.3. In that figure, Wells 101 and 102 are designated by a single point because they are separated by only 0.50 m. These wells are located within the area that was cleared of vegetation and planted with grass in the late summer of 1985 as part of a special study designed to assess the effects of forest removal on groundwater elevation. The results of that study are discussed in a later section. The location and elevation data for the wells are given in Table 4.1, and the driller's notes are reproduced in Appendix E. No geophysical logs were made.

A fifth observation well (104) was installed in late September 1985 by placing a 50.8-mm (2-in.) screen and pipe in a shallow core hole that was used to measure the soil moisture. No drilling log was made, and the coordinates and elevation in Table 4.1 for Well 104 are approximate.

4.5 GROUNDWATER ELEVATIONS

General descriptions of the wells are given in Table 4.2. Water levels in wells tend to exhibit certain behaviors depending on location (ridge, hillside and valley). Measurements were made weekly at each well, starting shortly after completion in either 1982 or 1983, through September 1987; thereafter, levels were measured monthly. The water-level elevation data, reported in Appendix F, end in March 1988. Hydrographs of the water-level elevations are included for the wells discussed in this section. The remaining hydrographs are shown in Appendix G. For the period of December 2, 1984, through April 17, 1985, Well 13 had a packer placed between the upper and lower screens; thus Well 13LO and 13HI refer to water levels associated with the lower and upper well screens.

The univariate statistics for the depth from the surface to the water level for wells in SWSA-7 are listed in Table 4.3. Measurements prior to 1984 were not included because they contained erratic

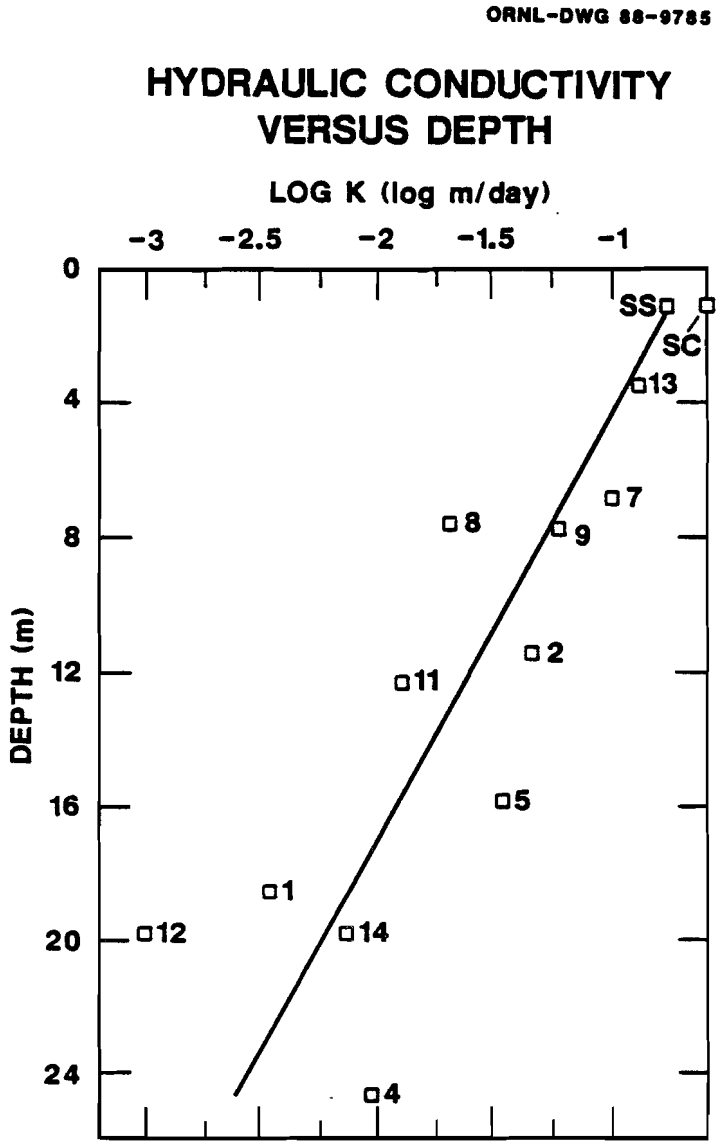

Fig. 4.3. Hydraulic conductivity versus depth.

Table 4.1. Location of the 100-series wells

Well #	ORNL Northing	ORNL Easting	Measuring point elevation (m)	Ground surface elevation (m)	Depth from surface to top of screen (m)	Depth from surface to well bottom (m)
100	17279.98	35064.71	263.530	263.348	6.93	9.98
101	17123.03	35105.25	270.089	269.890	17.73	20.78
102	17124.01	35106.58	270.646	269.885	10.16	13.21
103	7181.94	34896.51	264.588	264.027	8.09	11.14
104	17590.	34890.	268.04	267.31		

Table 4.2. General characteristics of Wells 1-18 and 100-103

Well No.	Surface elevation (m)	General well location	No. of screened intervals in well
1	287.67	Ridge	4
2	273.57	Ridge	3
3	274.97	Ridge	1
4	276.47	Ridge	1
5	263.62	Hillside	1
6	257.35	Hillside	1
7	246.37	Valley	1
8	242.94	Valley	1
9	257.07	Hillside	1
10	273.19	Ridge	4
11	268.80	Ridge	3
12	272.60	Ridge	1
13	243.11	Valley	2
13A	243.11	Valley	1
13B	243.11	Valley	1
14	273.25	Ridge	1
15	274.77	Ridge	1
16	277.22	Ridge	1
17	275.49	Ridge	1
18	273.84	Ridge	1
100	263.35	Hillside	1
101	269.89	Hillside	1
102	269.88	Hillside	1
103	264.03	Hillside	1

Table 4.3. Statistics of water elevations, January 1984-March 1988

Well	Number observations	Mean (ft)	Maximum (ft)	Minimum (ft)	Standard deviations (ft)	Skew (ft)
7-1	150	867.746	875.830	859.523	3.02531	0.3386
7-2	152	868.068	870.934	864.780	1.32353	-0.2806
7-3	154	847.644	859.732	842.835	2.36771	1.0563
7-4	153	861.794	872.835	854.580	4.43731	0.0983
7-5	154	833.713	837.582	829.412	1.15395	0.3367
7-6	153	821.662	841.896	816.190	5.33071	2.3381
7-7	153	804.917	806.508	785.214	1.74883	-9.5410
7-8	154	794.038	797.520	788.520	2.36250	-0.4654
7-9	153	818.038	825.300	815.240	2.01328	1.1126
7-10	154	826.685	834.569	821.610	2.80732	0.4789
7-11	151	829.172	851.030	823.590	3.42555	2.3038
7-12	154	869.366	875.181	864.450	1.91621	-0.4776
7-13	95	795.472	797.220	792.990	0.67008	-0.7822
7-13HI	54	795.791	797.425	794.571	0.59621	0.9340
7-13LO	50	796.074	797.425	794.636	0.79224	-0.4668
7-14	155	858.746	865.889	853.380	2.35225	0.0723
7-15	155	866.489	870.371	860.310	2.00104	-0.3587
7-16	156	869.872	879.701	864.690	2.28268	0.2304
7-17	152	863.132	882.168	856.260	3.28530	0.9417
7-18	154	857.862	867.231	848.365	3.75723	-0.1138
7-100	166	842.845	857.382	823.948	2.93902	-0.6094
7-101	167	846.188	855.518	841.607	2.53736	0.5838
7-102	166	848.949	863.375	844.641	2.02730	2.4233
7-103	166	839.385	845.880	835.360	2.51816	0.2523
7-104	75	848.142	856.105	839.780	3.01001	0.4836

water-level data associated with 1982 and 1983 hydrofracture disposal activities, which included high-pressure injection of radioactive wastes in a grout matrix. The facility was located 2.5 km to the west of SWSA-7 in Melton Valley. During and after these hydrofracture events, water levels in some of the deep wells at SWSA-7 dropped or rose abruptly, although the responses were neither uniform from well to well nor from one event to the next. Outlying observations attributed to hydrofracture waste-disposal activities are listed in Table 4.4. For many wells the outliers are the maximum or minimum water elevations on record. None of these outliers has been removed from the data base.

4.6 TRENDS IN WATER-TABLE ELEVATIONS

The statistics conform to the observations reported by Rothschild et al. (1984b). Assuming that water levels indicate water-table elevations, the data indicate that the depth to the water table is deeper at the higher elevations in the watershed and also more variable (higher standard deviations). The temporal variation in the water levels reflects the annual changes in the hydrologic cycle with the shallowest depths to water occurring in the late winter or early spring. The temporal variation also reflects the relative location of the wells. In the valleys in SWSA-7, the water-level fluctuations are related to individual storm events, and the response is dampened due to control by the nearly constant head at nearby drainage streams (e.g., Well 7 in Fig. 4.4). On hillsides, the variation due to individual storms is usually larger and the annual cycle is more apparent (e.g., Well 5 in Fig. 4.5). On the ridges, the response to individual storms is less apparent, and the annual cycle dominates (e.g., Well 4 in Fig. 4.6).

The water elevation for Well 1 (Fig. 4.7) also shows the underlying trend seen in most wells located on the ridges. The rainfall deficits observed in the summers of 1985, 1986, and 1987 are associated with a year-by-year decrease in the minimum annual water elevation. However, it is not possible to relate this trend in the low water level in Well 1 to persistence of drought conditions from one

Table 4.4. Outliers in water-level data following hydrofracture activities

Date of groundwater measurement	Wells with extreme change in water level	Hydrofracture event (dates and amount)	Comments
10/25/82	5, 14	10/26-29/82 2100 m^3 (557,000 gal)	The wells appear to be affected the day prior to injection in response to the preparatory pressurization of the aquifer at the injection site
7/11/83	15, 16, 17	7/12-14/82 1620 m^3 (428,000 gal)	Wells are affected the day prior to injection (see above)
7/18/83	15, 16, 17		Wells 15 and 16 had not returned to their pre-7/11/82 levels. Well 5 had also dropped significantly
7/26/83	5, 15, 16		Rebound of well levels was not complete
8/2/83	15, 16		Rebound of well levels not complete.
12/2/83	2, 3, 4, 12, 14, 15, 17	12/1-2/83 1620 m^3 (428,000 gal)	
12/9/83	12, 14, 17		Rebound of well levels not complete

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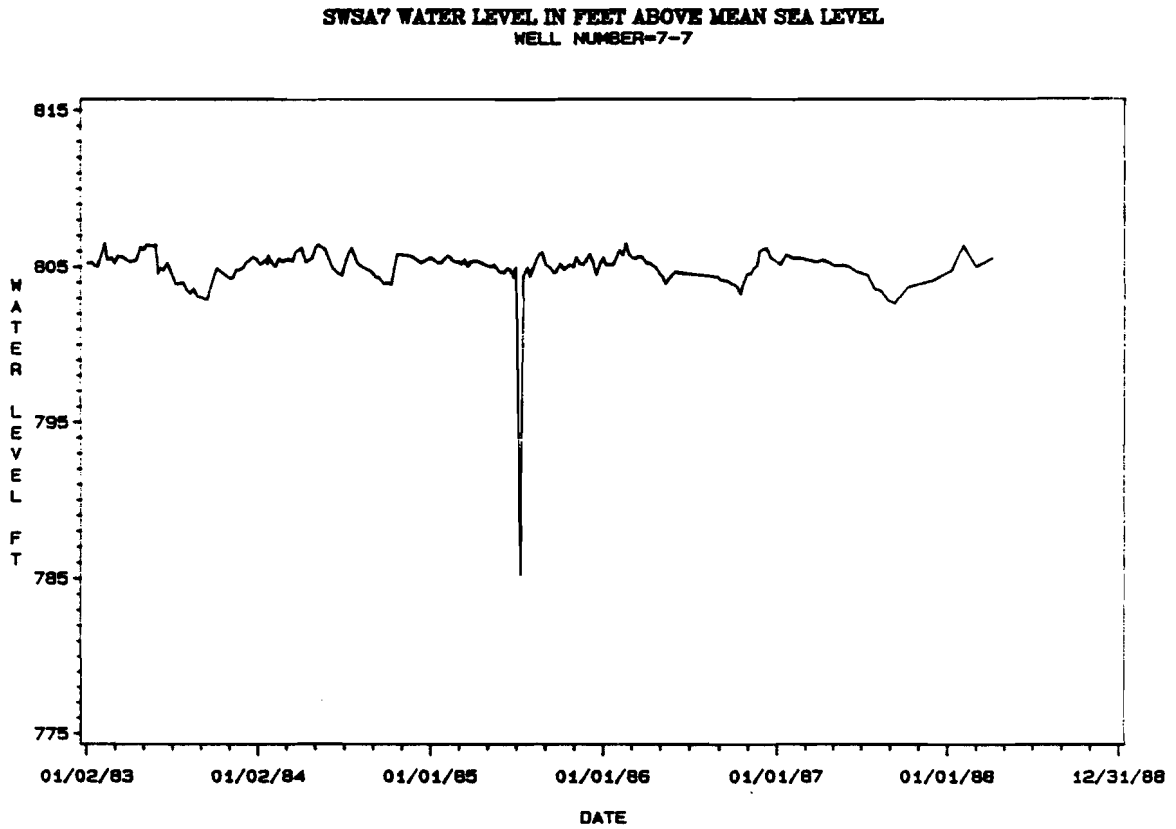

Fig. 4.4. Groundwater hydrograph, Well 7.

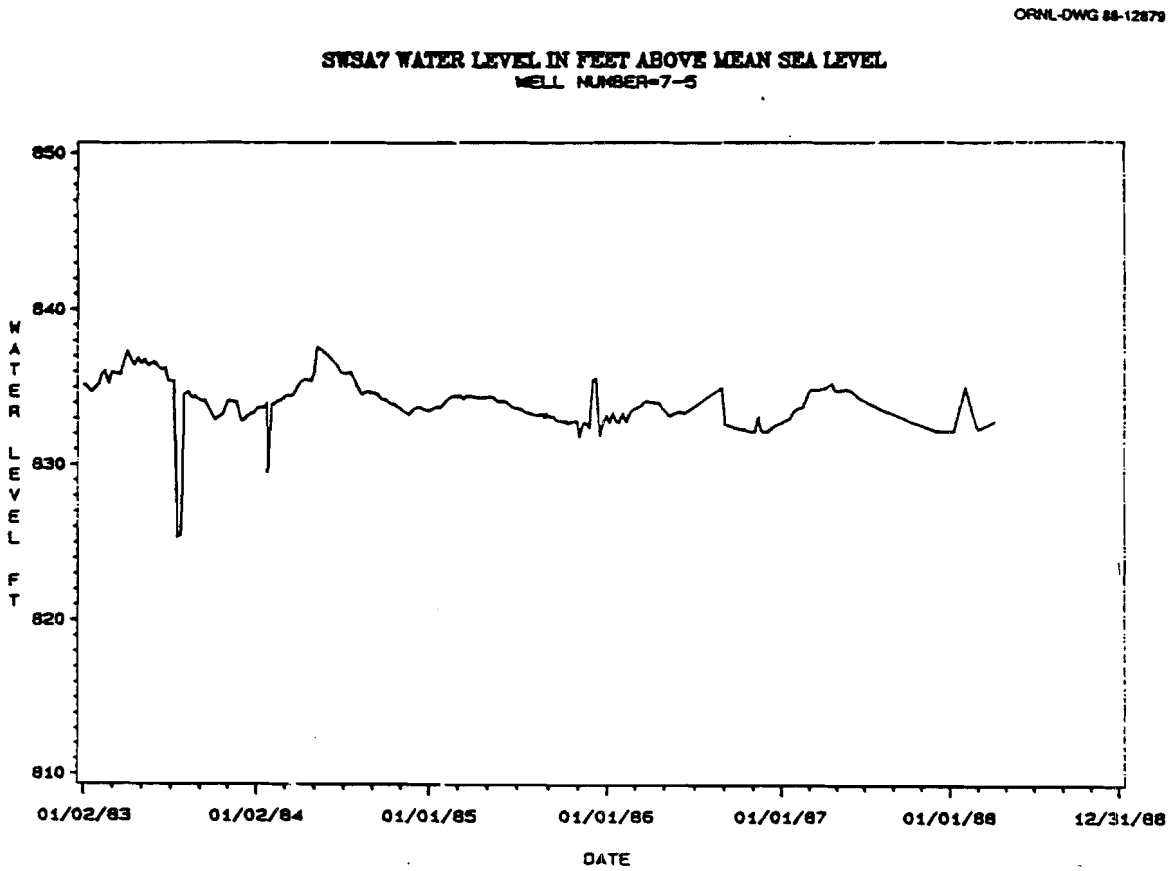

Fig. 4.5. Groundwater hydrograph, Well 5.

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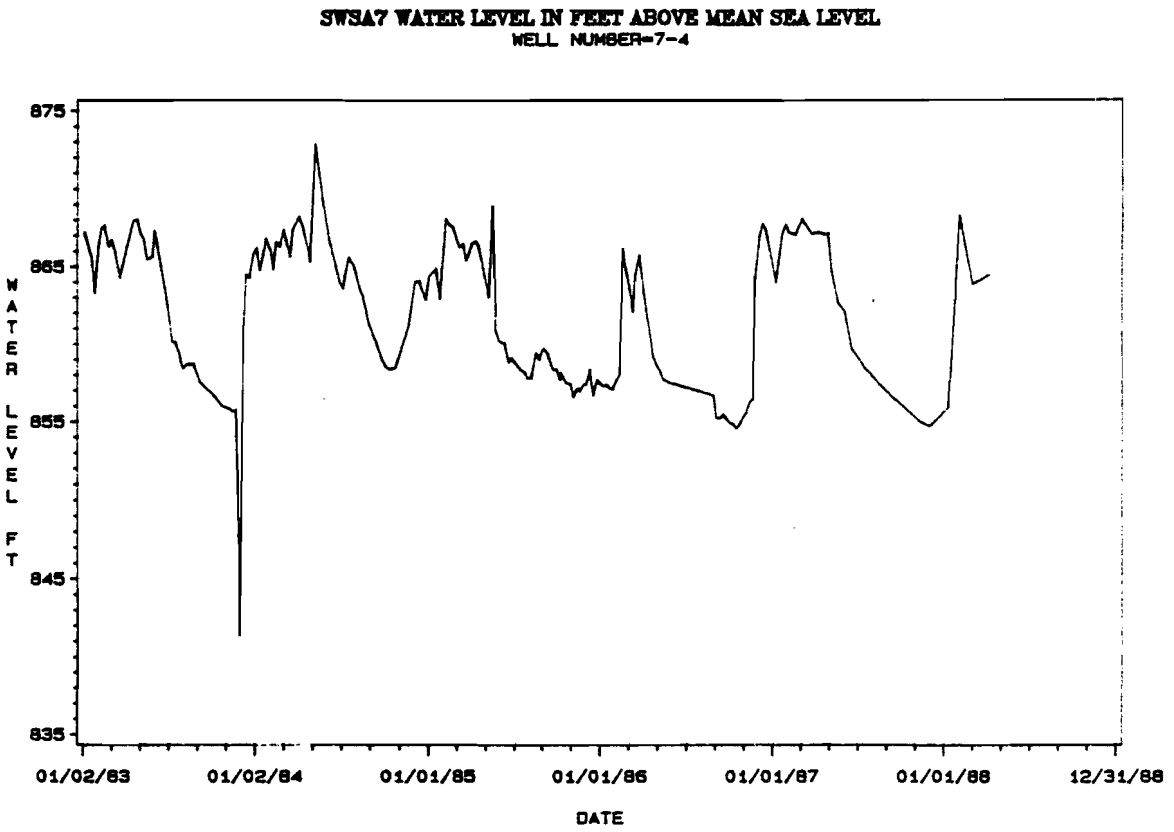

Fig. 4.6. Groundwater hydrograph, Well 4.

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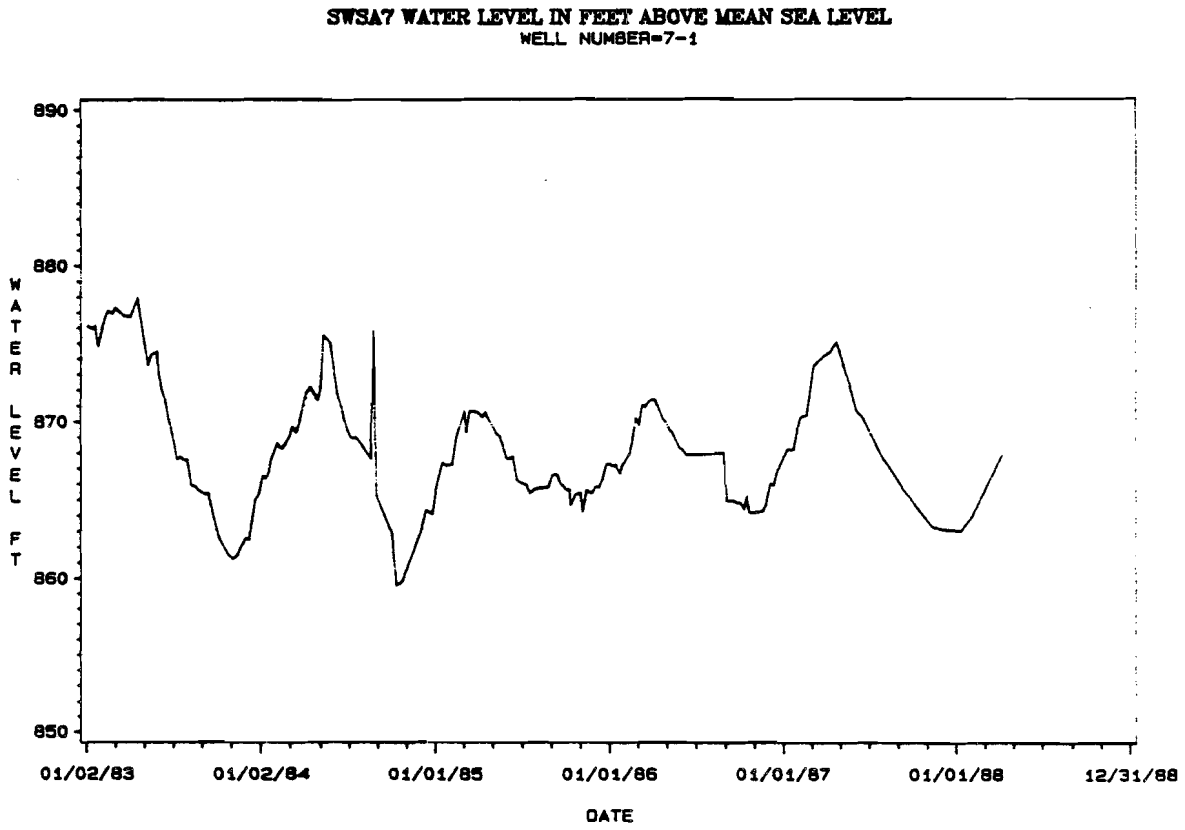

Fig. 4.7. Groundwater hydrograph, Well 1.

year to the next, because winter water levels often rose almost as high as they did in the relatively wet years 1983 and 1984. The records for Well 1 and other wells show that minimum annual water-level elevation often occurred in the summers of 1983 or 1984, though both had summer months with precipitation below normal. (The total precipitation for August and September 1983, and again for the same period in 1984, was about half the normal amount.)

It follows that water levels measured and reported by Rothschild et al. (1984b) are typical of SWSA-7 and that their maps (Rothschild's Figs. 30 and 31) of water elevation under wet and dry conditions remain valid for later years of the record.

4.6.1 Rapid Fluctuations in Water Levels

The extreme rainfall in early May 1984 caused water levels to rise to record elevations. For nine wells (3, 4, 6, 11, 14, 16, 17, 18, and 100), the water levels rose more than 1 m (3.3 ft) over the period of 1 to 2 weeks. Well 17 had the greatest increase, 4.9 m (16 ft), and Well 6 had an increase of 4.8 m (16 ft), followed by Wells 3 and 16, which rose about 2 m (6.6 ft) each. Eight other wells (2, 5, 9, 10, 12, 15, 102, and 103) had increases of less than 1 m (3.3 ft).

Records for many wells show rapid, large fluctuations that are attributable neither to hydrofracture nor to extreme rainfall. Well 11 had a rise of 7.9 m (26 ft) on November 26, 1986. In the 2-d period prior to the rise, there was 34 mm (1.3 in.) of rainfall, not an extreme amount. One week after the rise, the water level was still 5.4 m (17.6 ft) higher than the prestorm level, but after 2 weeks the level had receded to almost the pre-storm level. These outlying values are difficult to explain.

Well 6, located on a hillside on the south side of the study area, had large fluctuations throughout the record (Fig. 4.8). Rothschild et al. (1984b) attributed this response to a subsurface limestone stringer that provides a hydraulic connection with the surface.

The remainder of this section describes detailed work aimed at characterizing rapid fluctuations in water level observed in Well 101.

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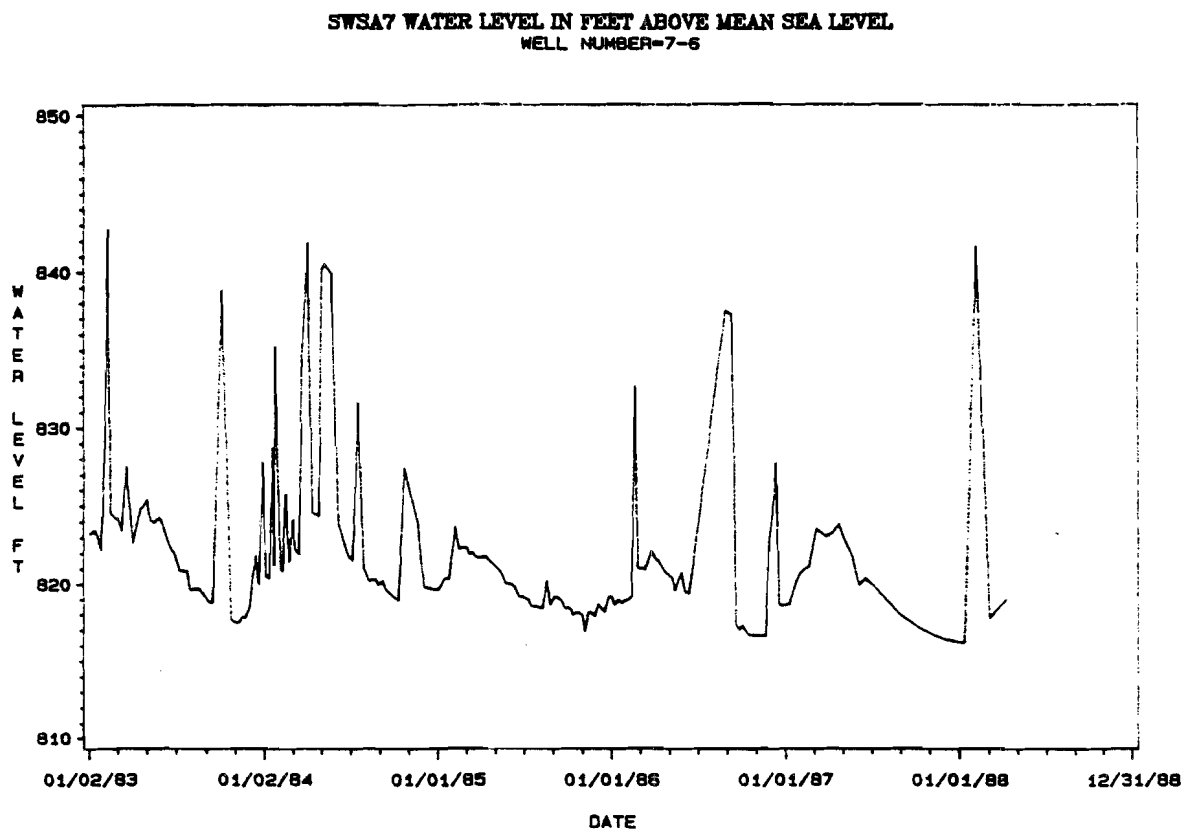

Fig. 4.8. Groundwater hydrograpy, Well 6.

Wells 101 and 102 are located close to each other, and the well screen in 101 is 10.8 m (35.4 ft) deeper than that in 102. The two wells were intended to provide data on the vertical hydraulic gradient; however, water level measurements taken at Well 101 indicate that it functions abnormally. From the record of water-level measurements, there are at least three anomalous increases in water level (Fig. 4.9). On December 29, 1983, the water level rose by 4.04 m (13.3 ft) from the previous weekly measurement and then fell to normal levels by the following week. Again, on October 23, 1984, the water level rose by 3.40 m (11.2 ft), and, on May 1, 1987, rose 1.81 m (5.9 ft), both times falling within the following week. Well 102, which is screened at a higher elevation, showed no simultaneous rises in elevation.

To investigate the behavior of Well 101, continuous measurement of the water-level elevation was made from October 30, 1984, to January 16, 1985. The measurements were made using a dipper-type Manning stage-recorder adapted for use in a 5.08 cm (2-in.) diam well (N. Farrow, personal communication, 1988). The system allows for a maximum range of 1.20 m (3.9 ft), which is sufficient for the special objective of measuring the time between rainfall and the rise in the well hydrograph.

During the period of measurement, one anomalous rise in water level was recorded. On November 10, a storm having a total depth of 43.7 mm (1.7 in.) and a maximum hourly intensity of 10.4 mm/h (0.41 in./h) at 1100 h was followed by a rise in water level starting 2 h later. Ten hours after the peak rainfall intensity, the well hydrograph rose abruptly 630 mm (24.8 in.) at which point the maximum range of the instrument was reached. Shortly thereafter, the hydrograph began to fall, and it recovered to the prestorm elevation about 24 h after the peak rainfall occurred.

No continuous measurements were made at Well 102; however, that well had only one anomalous water-level rise (August 9, 1985) and had none when extreme rises were measured in Well 101. Inspection of the well collars did not indicate any problems; thus, there is probably a connection between the nearby surface and the well screen of Well 101

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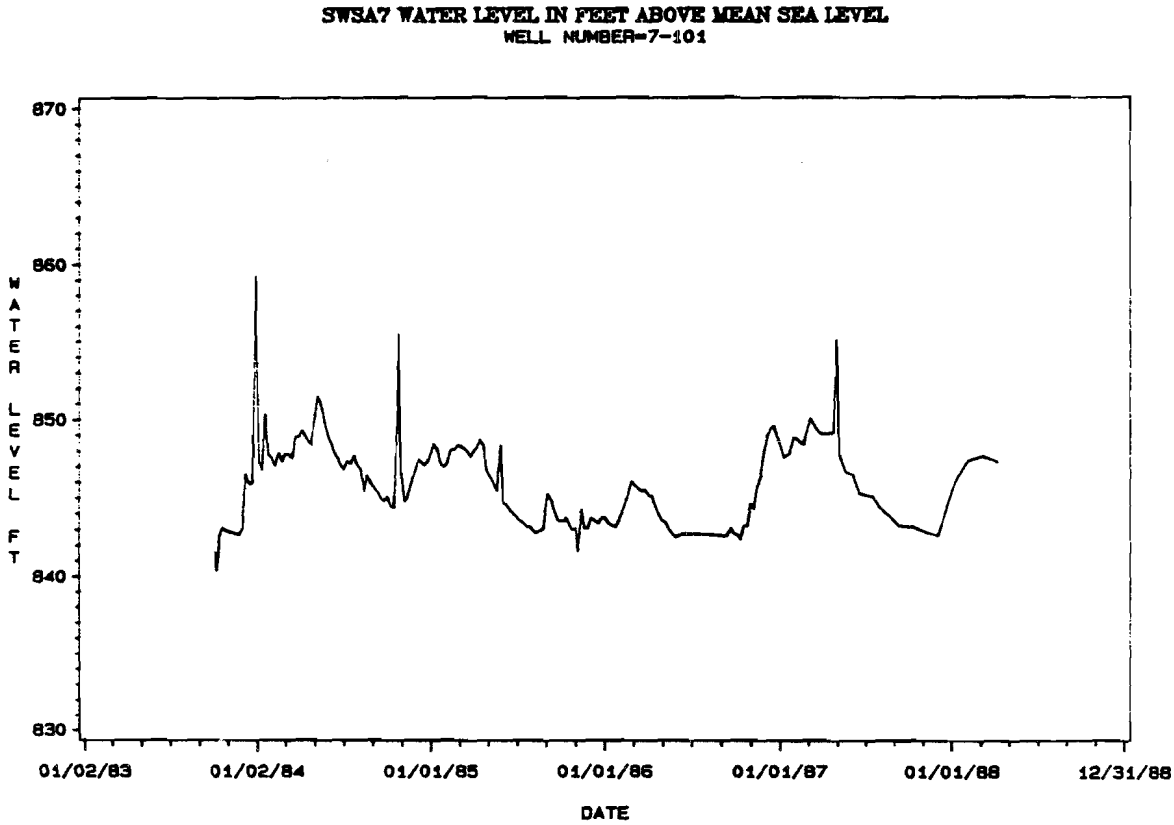

Fig. 4.9. Groundwater hydrograph, Well 101.

via soil macropores in the weathered C horizon that bypasses Well 102. Rapid fluctuations in Well 101 and other wells appear to be real, and this behavior is attributed to the complexity of the soil macropore system. It follows that individual measurements can, on rare occasion, be vastly misleading.

4.6.2 Vertical Gradient

To investigate vertical gradients in the groundwater system, Well 3, which is located on the alluvium near the confluence of C7C and UMB, was modified with a packer to measure hydraulic head at two depths. The well has two screened intervals centered at 3.5 m (11.5 ft) and 7.8 m (25.5 ft) from the surface. Pressure heads above these intervals were monitored for 16 months. The data are included in Appendix F (Table F.5), and the computed gradient is plotted in Fig. 4.10.

With depth, z, oriented positive upward, the gradient is computed as the difference in water-level elevation divided by the distance between the screen interval midpoints. A negative gradient implies upward flow. For a simple groundwater system with uniform hydraulic conductivity and an impermeable layer at depth, vertical groundwater flows near a surface stream will be upward, providing recharge to the stream. In contrast, a positive gradient indicates downward flow, and for Well 13 located in the riparian zone near the lowest point in the watershed, this condition implies loss to a deeper groundwater system.

In Fig. 4.10 the hydraulic gradient is negative during the winter of 1983-84. In the spring a positive gradient is established, indicating downward flow away from the streambed and riparian area. This condition persists for about 6 months, and in the fall there are occasional reversals following storms when rapid recharge to the water table occurred. The positive gradient is significant because it demonstrates that deep groundwater drainage occurs and that the streamflow is not the only method of discharge for the watershed. There is not sufficient information to calculate a reliable estimate of this deep groundwater component.

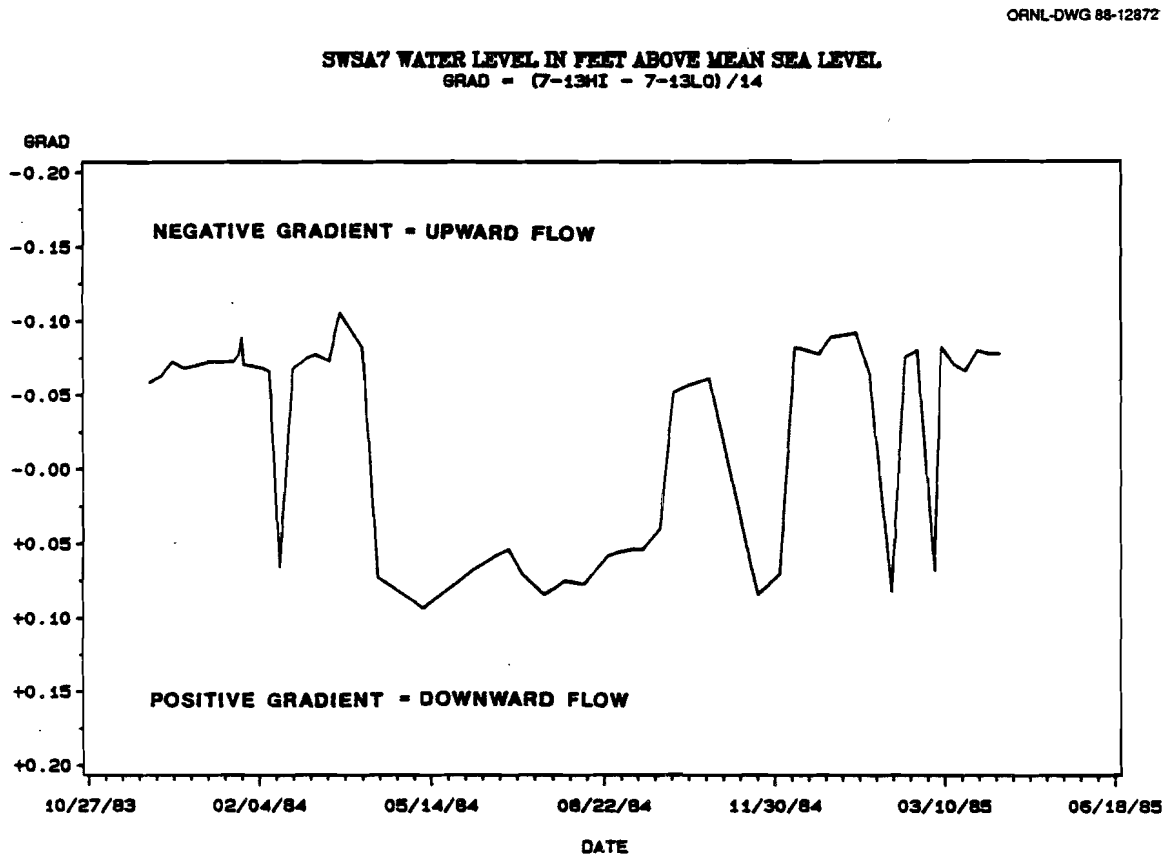

Fig. 4.10. Hydraulic gradient measured at Well 13.

In terms of monitoring groundwater flows, the likelihood of deep seepage loss near the mouth of C7C poses no particular problem. A pair of monitoring wells in the alluvium should suffice. It is recommended that the wells should be screened in approximately the upper 14 m (45 ft) and in the interval from about from 20 to 30 m (70 to 100 ft).

4.7 EFFECTS OF FOREST CLEARING

The FCE was begun in 1982 with two primary objectives: (1) to develop a methodology to predict changes to the water-table elevation caused by forest clearing that is typical of waste-disposal site development in humid climates, and (2) to evaluate that methodology by performing a field experiment. The basic hypothesis of the experiment is that changing the vegetation cover from forest to grass, as is done in disposal site development, will reduce ET losses and lead to a rise in the water table. The synopsis presented here covers only the changes in water-table elevation observed on an annual basis at the FCE site on SWSA-7.

The water-table elevation is important to the design and management of LLW disposal facilities because waste placed below the water table (in the zone of saturation) tends to leach contaminants faster (after the container fails). Consequently, if forest removal leads to a rise in the water table, a waste facility may not perform as designed based on data collected prior to forest clearing. Prediction capability to anticipate changes in water-table elevations is the desired product of this study.

Unpublished computer simulations using the water budget model linked to a groundwater-flow model showed that the average annual rate of recharge due to forest removal will be increased by 18%, from 1.13 mm/day to 1.33 mm/d; in turn, that change in recharge would result in a rise in the steady-state water-table elevation of approximately 1-1.2 m below the ridges and 0.2-0.6 m on the side slopes where Wells 100-103 are located.

The field experiment consisted of collecting groundwater elevation data at wells across SWSA-7 and then clearing the forest from

a designated area (Fig. 1.1) and monitoring the change in groundwater elevation. Measurements from early 1983 through mid-August 1985 were used to characterize the preclearing condition. At the end of this phase, a 151-ha site was cut using conventional techniques; the merchantable timber was harvested, remaining trees were cut for firewood, and stumps were removed by bulldozer and burned. The residue was pushed to west side of the site and to the lower side (across the service road). The remaining debris was removed by hand, and afterward the surface was smoothed with tractor and dragbar. Approximately 2700 Kg (3 tons) of 20-20-20 fertilizer was applied, and Fescue-31 grass seed was planted. Seeding occurred in the third week of September, and, because temperatures were decreasing, no mulch was applied. On October 2, an intense storm (depth = 52 mm) caused extensive gullying. Subsequently, the gullies were smoothed and reseeded, the entire area was mulched with straw, and straw bales were installed as sediment traps at the base of prominent gullies. A thick cover of grass was established in late October. Measurements of water-table elevation continued at the four wells located on the cleared site as well as at the other SWSA-7 wells.

From the beginning of the FCE, it was assumed that the changes to the water levels for the wells at the experimental site could not be detected from individual well hydrographs because the fluctuations due to storms and the seasonal cycle would mask differences due to changes in the surface vegetation. Consequently, other wells outside the site but within SWSA-7 were used to provide reference data. In essence, statistical models of the depth to water in Wells 100-103 were generated by multiple linear regression by using measurements at Wells 1-18. As an example, the predicted value for Well 103 (W103P) is given by

$$W103P = -0.0123 + 0.409\ W8 + 0.657\ W14 \quad , \quad r^2 = 0.88 \quad , \qquad (4.2)$$

where W8 and W14 designate the respective weekly measurements at those wells. All the variables are depth to water as determined from the

measuring point at each well. The wells selected as independent variables were carefully chosen to reduce covariance. Two statistical models were generated for each of the wells on the site. The resulting regression equations are not predictive in the sense of forecasting conditions in the future. Instead, for any ensemble of water-level measurements made at SWSA-7, they estimate the depth to water in the designated well under the condition of full forest cover, that is, without forest removal. Comparisons between the statistically generated water levels and observed water levels are used to verify (or refute) the simulation predictions.

Results for the first year following the forest clearing are shown in Fig. 4.11 in which the solid line is the measured water level at Well 103 prior to clearing and the dashed line indicates the water level after clearing. The R symbols are the regression estimates. Following an initial rise of the water table, as measured in Well 103, the water table falls below the estimated level. This trend is precisely opposite to that hypothesized in the formulation of the project.

Data collected since the fall of 1985 allow for a longer-term examination of the effect of forest clearing. In Table 4.5 average depth to water is used in the regression equations to yield a predicted average depth for the four wells on the cleared site. Because the predictive equations are linear, the use of averaged values for input is permissible; in fact, the error in the predicted mean value of the dependent variable will be lower than that associated with individual predictions. The difference in water depth in the last column is the key variable. A positive difference indicates that the water table has fallen whereas a negative difference indicates that the water table has risen.

In 1984, the differences in Table 4.5 are negligible (as expected because the forest area had not been cleared). In 1985, when the site was cleared for only 4 months, no clear trend in the differences is apparent; the same is true for 1986. However, in 1987 and for the first few months of 1988, the differences for all the wells are

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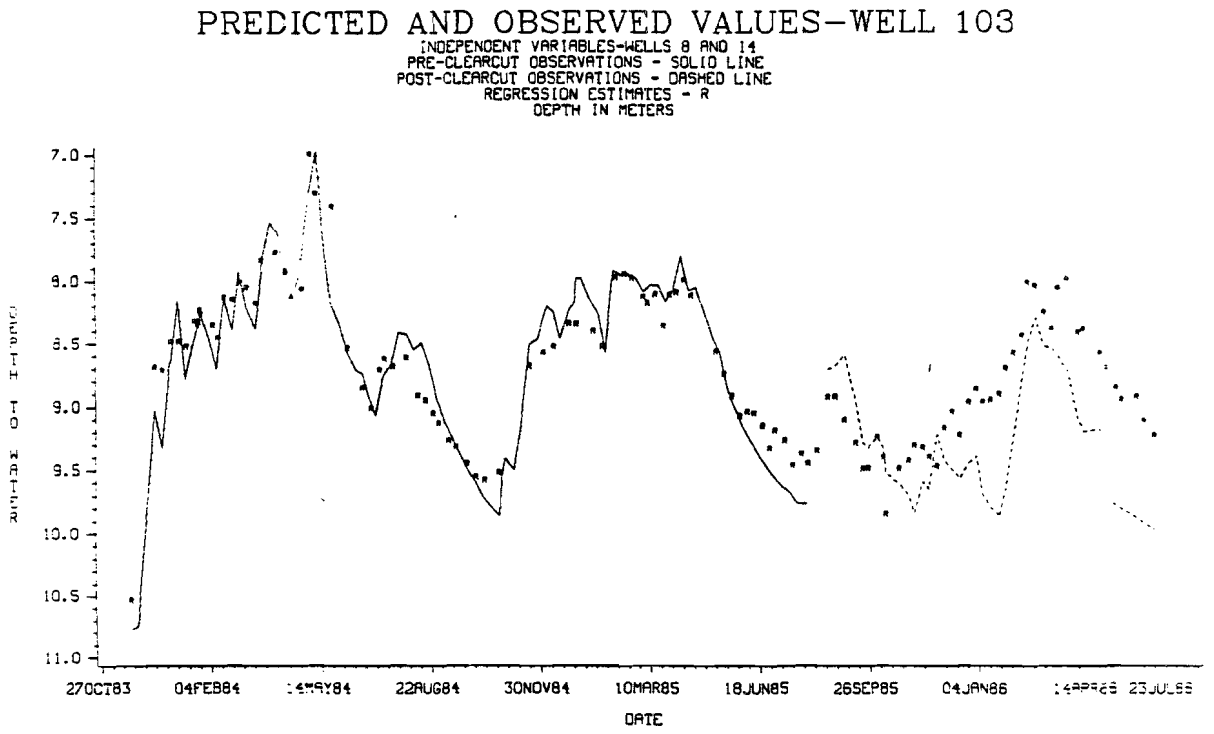

Fig. 4.11. Predicted and observed water levels, Well 103.

Table 4.5. Change in average depth to groundwater due to forest clearing

Year	Well No.	Predicted depth (m)	Observed average depth (m)	No. of observations (m)	Difference
1984	100	6.27	6.27	55	0.00
	101	11.63	11.50	57	-0.13
	102	10.97	11.04	55	0.07
	103	7.94	8.05	55	0.11
1985	100	6.65	6.60	49	-0.04
	101	11.93	12.19	48	0.26
	102	11.11	11.21	49	0.10
	103	8.35	8.29	49	-0.06
1986	100	6.94	6.60	36	-0.33
	101	12.06	12.46	36	0.40
	102	11.27	11.45	36	0.18
	103	8.53	8.43	36	-0.10
1987	100	6.72	6.38	22	-0.34
	101	11.94	11.77	22	-0.17
	102	11.02	10.75	22	-0.27
	103	8.39	7.98	22	-0.40
1988	100	7.26	5.93	4	-1.34
	101	12.36	11.65	4	-0.71
	102	11.51	10.65	4	-0.86
	103	8.90	7.49	4	-1.41

negative, as hypothesized at the beginning of the experiment. The 0.30 m (0.98 ft) rise in the water-level measurements for 1987 is within the range (0.2 -0.6 m) generated a priori by computer simulation. Significant also is the rise associated with the four measurements made early in 1988, because seasonal high water conditions exist at about this time of year, suggesting that the increase in water-table elevation may persist throughout the year, not just during the months of high ET. The analysis is complicated by drought effects. Depth to water increased for all wells during this period, but the relative changes support the hypothesis.

These results imply that engineers designing waste facilities for SWSA-7 should reduce estimates of the minimum depth to water by 1 m for disposal units placed along the ridge line. Other factors besides forest clearing affect saturation conditions in the vicinity of waste-disposal units. Past experience at SWSA-4 and SWSA-6 indicates that bathtubbing occurs where excavation and subsequent backfill produces zones of high porosity. These zones intersect macropores carrying water laterally above the water table, producing subsurface flooding following a storm.

One approach to solving the increased water-table elevation is to build drainage systems or to divert infiltration at the surface. These engineered features require periodic inspection and maintenance; thus they are suitable only for wastes that decay to safe levels while active maintenance can be provided.

5. WATER CHEMISTRY

To extend the water-chemistry data base, a set of water samples was collected from all wells and surrounding streams April 25-28, 1985. Samples for E7C and W7C were collected just upstream from the confluence with Melton Branch. The data augment information gathered during two past sampling events, one under high-flow conditions (February 1983) and the other under low-flow conditions (October 1983), as reported by Rothschild et al. (1984b). Because early April was relatively dry, the hydrologic conditions at the time of sampling are judged to be intermediate between those prevailing at the previous sampling events.

The results of the chemical analyses for major cations, major anions, selected radioisotopes, gross alpha activity, and total alkalinity appear in Appendix I. As expected, based on time of year and flow conditions, the concentrations in April 1985 generally lie between those of February and October 1983, with a slight bias toward the concentrations of February. The patterns reported by Rothschild et al. (1984b) were observed, that is, no contamination by radioisotopes, low but measurable amounts of ^{3}H in some wells, and relatively higher levels of SO_4 and total dissolved ion concentrations in the northernmost wells. Wells 100 and 101, which had not been previously sampled, had high levels of calcium and SO_4, a finding which was unexpected because these wells lie to the south.

6. SUMMARY AND CONCLUSIONS

In the time span covered by this report, the hydrologic instrumentation at the site was upgraded. The temporary flume on C7C was replaced with a dual measurement system to record low-flows and high-flows. Permanent flow monitoring systems were also installed on W7C, E7C, and UMB, and a recording rain gage was installed. New wells were drilled in the area designated for the FCE.

The most significant hydrologic event during the period was the extremely dry conditions in 1985 through the beginning of 1988. The second most significant event was the heavy rainfall of early May 1984. The RCs for C7C Watershed for 1983 and 1984 were 40% and 39%, respectively, if the data for May 1984 are not included. (With this data included, the coefficient is 48% for 1984.) For the following 3 dry years, the RCs decreased to an average of 31%. Compared to the streamflow at the UMB station, C7C produces about 5% more surface discharge per year per watershed area. Likewise, compared to the perimeter streams E7C and W7C, C7C also produces more surface discharge, although the record for E7C and W7C used for comparison is only 3 months long.

As for the groundwater monitoring, water levels were collected weekly from 1983 until September 1987 and monthly thereafter. Three hydrofracture waste-disposal events in late 1982 and 1983 caused both extreme increases and decreases in water levels for 1 to 2 weeks following injections, although the pattern was not consistent from well to well or from event to event. Hydrofracture activities were discontinued, and extreme elevations associated with hydrofracture are atypical.

Record groundwater elevations were observed in May 1984 following the extreme storms that occurred early that month. Occasional large increases in water levels in wells that were not associated with either extreme rainfall or hydrofracture were observed. These data are difficult to explain and are attributed to the macropore flow system in the weathered soil zone.

The vertical gradient in Well 13 located at the mouth of C7C was measured over a period of 15 months. Differential pressure heads imply that upward flow to the surface drainage system occurs during the winter. During the summer the gradient is reversed, and there is flow to a deeper groundwater system. Downward flow also occurs in the spring and fall following large storms. Although the data are insufficient to calculate amounts, some loss probably does occur via deep seepage in the riparian area of C7C.

The relatively low RCs for E7C, W7C, and UMB indicate that there is subsurface loss of water in those watersheds. Compared to the gaging station at C7C, the stations on the perimeter streams are located on wider riparian zones. These zones are underlain by porous alluvium; therefore, underflow at the gaging sites is a simple explanation for the water loss. Deviations in the subsurface divides relative to topographic divides are also possible. Seepage measurements along the upper portion of Melton Branch to determine inflow points are recommended.

Results from the FCE indicated that, 1 1/2 years after forest removal, water-table elevations have risen in the cleared area relative to water levels in the rest of the watershed. A rise of 1-1.2 m beneath the ridges and 0.4-0.6 m on hillslopes was predicted by using a combination of water-budget and groundwater models. The rise is attributed to the decrease in ET in the grass that replaces the forest cover. With respect to the design and management of waste-disposal facilities, the results of this experiment indicate that the depth to water will decrease during site development due to forest removal. Design specification based on water levels measured in a forested watershed should be adjusted for this decrease. Waste containers placed along the ridge should be reduced in depth by 1 m in order to avoid saturation. Of course, engineered systems to drain groundwater or to reduce infiltration will prevent this effect, if maintenance of such systems is compatible with the disposal strategy.

Analysis of water sampled in wells and streams during late April 1984 showed no indications of contamination by radioactivity. Cation and ion concentrations tended to be between those measured in the two water sampling campaigns reported by Rothschild et al. (1984b).

From the viewpoint of monitoring a possible waste disposal facility, C7C Watershed is judged to be relatively water tight although groundwater monitoring in the riparian area at the mouth of the watershed is recommended. For a disposal facility located along the ridge line, groundwater from the facility could move either to the C7C watershed or to the perimeter watersheds. The low RCs for the perimeter creeks imply that seepage losses probably occur. Location of monitoring points in these watersheds is more difficult.

The exponential decrease in hydraulic conductivity with depth observed at SWSA-7 has implications for groundwater flow and monitoring. Given this distribution of permeability, flow is expected to occur laterally, with largest velocities nearest to the water table. Consequently, leached contaminants will preferentially move laterally along shallow pathways. It follows that contamination measured in monitoring wells or in steams can provide early warning before significant contamination to deeper flow paths occurs. The advantage of fast, shallow pathways for monitoring possible contamination is offset to some unknown degree by the problem of macropore flow. Downhill groundwater flow can be confined to a narrow path that bypasses a monitoring well. The best monitoring system will consist of monitoring wells in the porous backfill surrounding waste containers, downslope monitoring wells, stream water sampling points, and wells in the stream riparian area.

More effort is needed to identify the exponential decrease in the hydraulic conductivity with respect to depth (or any other relationship that is observed) and to determine its effect on groundwater movement. Both field measurements and modeling are warranted. One goal should be to identify optimum sampling times (for both wells and streams) relative to storm events in order to

assure that the water is most likely to be representative of groundwater that was in contact with the waste containers.

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APPENDIX A
DAILY PRECIPITATION AT CENTER SEVEN CREEK WATERSHED

Table A.1. Precipitation at Center 7 Creek Watershed, 1984
Site ID = SW7
(units = mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.79	0.00	0.00	2.55	0.00
2	0.00	0.00	0.00	0.00	36.69	0.00	0.00	0.00	0.00	0.00	8.64	1.78
3	0.00	1.27	0.00	5.83	34.80	0.00	0.00	7.87	14.47	0.00	0.00	0.00
4	0.88	0.00	0.00	24.83	0.88	0.00	22.35	0.00	0.00	0.00	7.62	0.00
5	0.00	5.52	6.19	2.09	0.00	0.00	18.80	0.00	0.00	0.00	0.00	9.90
6	0.00	1.72	2.32	0.00	55.03	0.00	22.43	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	74.23	0.00	11.11	4.07	0.00	1.02	0.00	0.00
8	0.00	0.00	0.00	0.00	11.93	0.00	0.00	0.00	0.00	20.84	0.00	0.00
9	0.00	0.00	0.00	5.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	15.87	7.25	0.00	0.00	0.00	0.00	0.00	37.84	0.00	0.00	44.19	1.53
11	1.65	1.58	0.00	0.00	0.00	0.00	22.86	0.00	11.68	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	27.67	4.50	1.59	17.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	8.64	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	2.89	0.00	0.00	0.76	14.73	0.00
16	3.81	0.00	7.69	4.02	0.00	0.51	7.27	1.52	0.00	0.00	0.00	0.00
17	0.00	0.00	2.67	5.58	0.00	0.00	0.00	0.00	0.00	4.57	0.00	0.00
18	19.44	0.00	0.63	0.00	0.00	0.00	0.00	0.51	0.00	0.00	15.92	0.00
19	0.00	1.02	0.00	3.06	0.00	0.00	0.00	0.00	0.00	9.14	3.14	2.28
20	0.00	0.00	30.63	5.53	0.00	0.25	0.00	0.00	0.00	13.98	0.00	12.44
21	0.00	0.00	7.90	0.00	1.27	12.44	0.00	0.00	0.00	1.02	0.00	6.52
22	0.00	0.00	0.00	20.52	0.00	0.76	0.00	1.02	0.00	55.63	0.00	0.34
23	6.63	10.98	0.00	0.57	6.28	0.00	0.00	0.63	0.00	41.66	0.00	0.00
24	14.09	1.34	1.02	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00	9.32
25	0.00	0.00	0.89	0.00	0.00	0.00	2.29	0.00	0.00	0.00	0.00	2.37
26	0.00	0.00	0.00	0.00	1.02	0.00	13.85	0.00	0.00	0.00	0.00	0.00
27	0.00	27.39	1.98	8.70	0.00	0.00	24.77	3.05	0.00	0.00	2.69	0.00
28	0.00	2.97	44.02	3.68	39.62	0.00	0.00	0.00	0.00	3.30	21.70	0.00
29	0.00	0.07	0.00	6.67	0.00	35.81	0.50	0.00	0.00	0.00	0.00	0.00
30	0.00		0.00	2.28	0.00	32.25	4.33	0.00	8.63	0.00	6.21	2.28
31	0.00		0.00		0.00		2.53	0.00		0.00		1.78
Total	62.37	88.78	110.44	100.41	278.77	91.42	155.98	59.30	34.78	151.92	127.39	50.54
										Yearly total:		1312.1

Table A.2. Precipitation at Center 7 Creek Watershed, 1985
Site ID = SW7
(units = mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	13.21	37.02	0.00	0.00	3.04	0.00	5.83	6.35	0.00	32.40	18.17	10.17
2	0.51	3.61	0.00	0.00	30.70	1.27	0.00	0.00	0.00	4.94	0.51	0.00
3	8.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.77	4.56	0.00
4	4.94	0.00	6.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.73	0.00
5	0.00	14.14	0.98	24.26	0.00	0.00	0.00	0.00	2.54	1.78	0.00	3.04
6	0.00	1.04	0.00	0.00	0.00	1.27	3.55	14.22	7.12	0.00	0.00	0.00
7	0.00	0.00	0.00	0.63	2.29	31.11	0.00	7.87	0.00	0.00	2.03	0.00
8	0.00	0.00	9.40	0.00	5.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	4.07	0.00	0.00	0.00	9.40	0.00	0.00	0.00	0.00	0.00
10	2.54	0.00	0.77	0.00	4.83	0.00	21.84	0.00	1.27	0.00	0.00	0.00
11	0.00	14.43	0.00	0.00	7.61	1.01	0.00	0.00	0.00	0.00	0.00	11.42
12	0.00	11.48	1.78	0.00	0.77	16.77	0.00	0.00	0.00	0.00	0.00	5.73
13	0.00	1.54	0.00	0.00	0.00	0.00	0.00	7.11	0.00	0.00	0.00	3.69
14	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	18.02	0.00	0.00	8.89	2.68	0.00	1.52	0.00	0.00
16	3.63	0.00	0.00	0.00	0.51	0.00	0.00	75.85	0.00	0.00	7.63	0.00
17	1.45	0.00	0.00	0.00	3.29	14.48	0.00	50.54	0.00	0.00	0.00	0.00
18	0.00	3.37	0.00	0.00	0.00	12.95	0.00	0.51	0.00	0.00	2.54	0.00
19	1.26	3.49	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00
20	3.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63
21	0.00	0.00	3.14	0.00	6.35	0.00	2.03	0.00	0.00	16.26	8.66	0.00
22	0.00	0.00	8.78	0.00	0.51	0.00	2.57	0.00	0.00	0.00	7.85	1.01
23	0.00	0.00	9.40	0.00	1.53	0.25	32.48	1.02	11.20	16.64	0.00	0.00
24	0.00	0.00	0.51	0.00	2.29	4.32	18.80	26.68	12.68	0.00	0.00	0.76
25	0.00	8.89	0.76	0.00	0.00	0.00	0.51	12.44	0.00	0.00	0.71	0.00
26	0.00	0.00	0.00	0.00	0.00	2.41	15.35	9.14	5.59	0.00	0.34	0.00
27	2.55	0.00	0.51	0.00	0.00	0.00	1.42	0.00	0.00	3.30	22.61	0.00
28	6.08	0.00	0.00	0.00	4.98	0.00	8.89	0.00	0.00	0.00	19.43	0.00
29	0.00		0.00	0.00	0.00	0.00	2.80	0.00	0.00	0.38	3.43	0.00
30	1.26		0.00	0.00	0.00	32.26	4.82	12.44	0.00	0.76	0.00	0.00
31	18.05		11.44		0.00		0.00	0.00		1.06		17.27
Total	67.55	99.01	58.68	42.91	73.79	118.10	139.18	227.36	40.40	80.81	111.20	53.72
										Yearly total:		1112.71

Table A.3. Precipitation at Center 7 Creek Watershed, 1986
Site ID = SW7
(units = mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.00	0.00	0.00	0.00	0.00	0.90	4.32	0.00	8.90	0.00	0.51	4.06
2	0.00	3.81	0.00	0.00	0.00	0.00	24.13	0.00	26.43	0.00	0.00	5.82
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.51
4	0.00	10.02	0.00	0.00	0.00	0.00	0.00	0.00	1.78	0.25	3.81	0.00
5	0.00	5.23	0.00	0.00	0.00	9.14	0.00	0.00	8.62	0.00	1.00	0.00
6	0.00	5.46	0.64	2.54	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.25	0.00	0.00	0.00	4.83	0.00	0.00	15.76	0.00
8	0.00	0.00	0.00	13.84	0.00	0.51	0.00	0.00	0.00	0.00	1.27	27.65
9	0.00	0.00	0.00	0.00	0.00	17.15	0.00	0.00	0.00	3.57	9.91	46.01
10	0.00	7.92	0.00	0.00	0.00	0.00	16.25	17.28	0.00	10.50	0.00	3.59
11	0.00	1.63	12.81	0.00	0.00	0.00	8.13	5.08	0.00	7.29	19.42	11.63
12	0.00	0.00	12.70	0.00	0.00	1.27	0.00	0.00	9.91	20.34	0.00	1.02
13	0.00	0.00	14.74	0.00	0.00	0.00	22.35	0.00	0.00	18.83	0.00	0.00
14	0.00	20.69	3.67	0.00	0.00	0.00	10.92	0.00	0.00	7.81	3.81	0.00
15	0.00	1.02	0.38	1.14	0.00	0.00	0.00	0.00	0.00	0.00	2.52	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14	6.60	0.00	0.25	0.00
17	0.00	52.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.42
18	11.69	0.00	0.00	0.00	4.07	0.00	0.00	0.00	0.00	0.00	0.00	2.26
19	2.53	0.00	38.86	0.00	0.25	0.00	0.00	2.29	1.90	0.00	0.00	0.00
20	0.00	0.00	0.00	6.08	1.52	0.00	0.00	16.39	0.00	0.00	9.89	0.00
21	0.00	0.00	0.00	4.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	5.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	22.49	0.00	0.00	0.00	3.80	0.00	11.46	7.95
24	0.00	5.72	0.00	0.00	9.91	0.00	0.00	0.00	0.00	6.18	12.14	0.42
25	12.58	0.00	0.00	0.00	3.94	0.00	0.00	0.00	0.00	45.86	5.08	0.00
26	1.91	0.00	0.00	0.00	10.53	0.00	0.00	22.59	0.00	0.00	10.15	0.00
27	0.00	3.17	0.00	0.00	0.00	2.03	0.64	14.73	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	11.18	12.70	1.27	0.00	10.41	0.00	0.00	0.00	0.00
29	0.00	.	0.00	0.00	0.00	10.92	0.00	0.00	2.80	0.00	0.00	0.00
30	0.00	.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	.	0.00	.	0.00	.	7.36	2.31	.	0.00	.	0.00
Total	28.71	191.20	74.80	39.85	65.41	43.19	94.10	97.81	71.24	120.63	106.98	120.34

Table A.4. Precipitation at Center 7 Creek Watershed, 1987
Site ID = SW7
(units = mm)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3.05	0.00	0.76	0.00	0.00	0.00	5.72	0.00	0.00	0.00	0.00	1.02
2	0.00	8.89	0.00	6.12	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	13.20	17.00	0.64	15.24	0.51	0.00	0.00	0.00	1.02
4	0.00	0.00	0.00	0.00	6.88	0.00	7.88	0.00	0.00	0.00	0.00	0.10
5	0.00	0.00	0.00	0.00	0.00	0.00	9.27	1.27	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	16.51	9.14	1.53	1.40	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	4.32	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	1.78	0.00	0.00	0.00	0.00	0.00	2.67	0.00	0.00	0.00
9	3.30	0.00	8.64	0.00	0.00	0.00	0.00	3.56	0.00	0.00	9.73	0.00
10	1.78	0.00	0.00	0.00	0.00	0.00	0.00	2.29	0.00	0.00	15.65	0.00
11	0.25	0.00	4.31	5.08	0.00	0.00	2.54	0.00	0.51	0.00	0.00	0.64
12	0.00	0.00	0.50	3.30	0.00	13.08	0.00	11.56	63.51	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	1.78	1.03	0.00	0.00	0.00	0.00	0.00
14	5.08	5.60	0.00	8.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.09
15	1.51	3.64	0.00	19.57	0.00	0.51	0.00	0.00	0.00	0.00	0.00	15.23
16	0.00	20.61	4.06	9.40	1.78	1.65	0.00	0.00	0.00	0.00	0.00	0.00
17	2.29	3.44	0.00	0.51	25.15	12.08	0.00	4.83	1.14	0.00	17.15	0.00
18	50.10	1.77	18.28	0.00	0.25	0.50	0.00	0.00	0.00	0.00	0.00	0.00
19	20.98	0.00	0.25	0.00	0.00	7.24	0.00	0.00	10.16	0.25	0.00	0.00
20	0.00	1.91	0.00	0.00	0.76	1.91	0.00	0.00	0.00	6.97	0.00	3.56
21	0.52	0.76	0.00	0.00	10.15	13.84	0.00	0.00	0.00	0.00	0.00	0.00
22	10.78	20.06	0.00	0.00	0.00	13.97	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	5.84	3.68	0.51	0.00	0.00	0.00	0.00	0.00	0.00	16.81
25	20.34	0.00	1.02	0.00	2.82	0.00	0.00	0.00	0.00	1.52	0.00	11.38
26	0.63	14.57	0.00	0.00	0.00	0.77	0.00	0.00	0.00	1.79	0.51	8.89
27	1.65	24.80	1.52	0.76	0.00	0.00	0.00	0.00	0.00	2.03	0.00	10.52
28	0.00	20.07	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	8.88	8.89
29	0.00	.	0.00	0.00	2.29	0.00	0.00	0.00	24.12	3.81	0.00	0.00
30	0.00	.	15.51	0.63	12.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	.	0.00	.	0.00	.	0.00	0.00	.	0.00	.	3.81
Total	122.26	126.12	62.47	70.39	80.54	69.49	63.53	33.41	103.64	17.77	51.92	86.96
										Yearly total:		888.50

Table A.5. Precipitation at Center 7 Creek Watershed, 1988
January -- March
Site ID = SW7
(units = mm)

Day	Jan	Feb	Mar
1	12.45	0.00	0.00
2	0.00	12.58	0.00
3	8.13	14.23	1.02
4	0.00	13.96	7.11
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	17.28	0.00	0.00
8	1.78	0.00	0.00
9	0.00	0.00	3.56
10	0.00	0.00	53.86
11	0.00	4.32	0.00
12	0.89	0.00	13.84
13	1.27	0.00	0.00
14	0.00	0.00	0.00
15	0.00	16.37	0.00
16	0.00	0.00	0.00
17	17.82	0.00	0.00
18	0.00	0.00	2.80
19	76.97	5.07	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
23	0.00	4.96	0.00
24	0.73	0.00	0.00
25	0.91	0.00	1.52
26	0.00	0.00	2.54
27	0.00	0.00	0.00
28	0.00	0.00	0.00
29	0.00	0.00	0.00
30	0.00	.	0.51
31	0.63	.	0.52
Total	138.86	71.49	87.28

APPENDIX B
EVALUATION OF THE RATING CURVE FOR THE V-NOTCH WEIR

Table B.1. A comparison between the computed and measured flow at the SWSA-7 V-notch weir

Date	Measured stage (cm)	Measured flow (L/s)	Computed flow (L/s)	Relative error (%)
11/06/84	5.500	0.523	0.979	46.6
11/12/84	8.100	2.773	2.577	-7.6
11/20/84	9.500	3.901	3.839	-1.6
11/28/84	13.200	10.012	8.736	-14.6
12/06/84	8.000	2.379	2.498	4.8
12/12/84	6.000	1.153	1.217	5.2
12/18/84	5.700	0.779	1.070	27.2
12/26/84	9.900	3.685	4.256	13.4
12/31/84	7.700	1.898	2.270	16.4
01/07/85	8.300	2.514	2.739	8.2
01/14/85	6.100	1.043	1.268	17.8
02/04/85	9.600	3.809	3.941	3.3
02/19/85	11.800	6.068	6.601	8.1
02/19/85	11.900	6.132	6.741	9.0
02/19/85	11.800	5.819	6.601	11.8
02/20/85	11.300	5.525	5.923	6.7
02/20/85	10.600	5.178	5.048	-2.6
02/21/85	9.500	3.809	3.839	0.8
02/21/85	9.300	3.620	3.640	0.5
02/22/85	8.700	2.904	3.081	5.7
02/22/85	8.500	2.800	2.907	3.7
02/25/85	7.100	1.887	1.854	-1.8
02/25/85	7.100	1.871	1.854	-1.0
02/26/85	8.100	2.580	2.577	-0.1
02/26/85	7.900	2.446	2.421	-1.0
02/27/85	7.700	2.299	2.270	-1.3
02/27/85	7.500	2.188	2.126	-2.9
02/28/85	7.300	2.038	1.987	-2.6
02/28/85	7.400	2.107	2.056	-2.5
03/01/85	7.300	2.038	1.987	-2.6
03/04/85	6.400	1.570	1.430	-9.8
03/04/85	6.700	1.575	1.603	1.8
03/05/85	7.500	2.097	2.126	1.4
03/06/85	6.500	1.454	1.486	2.2
03/06/85	6.300	1.416	1.375	-3.0
03/11/85	8.600	2.923	2.993	2.3
03/12/85	8.200	2.631	2.657	1.0
03/13/85	7.300	1.949	1.987	1.9
03/13/85	7.200	1.971	1.920	-2.7
03/13/85	7.200	1.927	1.920	-0.4
03/14/85	7.060	1.779	1.828	2.7
03/15/85	6.510	1.541	1.492	-3.3

Table B.1. (continued)

Date	Measured stage (cm)	Measured flow (L/s)	Computed flow (L/s)	Relative error (%)
03/18/85	5.950	1.206	1.192	-1.2
03/19/85	5.810	1.117	1.123	0.5
03/19/85	5.760	1.138	1.099	-3.6
03/20/85	5.760	1.096	1.099	0.3
03/21/85	5.660	1.097	1.052	-4.3
03/22/85	10.510	4.824	4.942	2.4
03/25/85	9.140	3.382	3.485	3.0
04/01/85	7.610	2.199	2.205	0.3
04/04/85	6.880	1.700	1.713	0.8
04/08/85	8.760	3.112	3.134	0.7
04/10/85	7.160	1.892	1.893	0.1
04/15/85	13.430	10.056	9.122	-10.2
04/15/85	11.340	5.656	5.976	5.3
04/15/85	11.160	5.452	5.742	5.0
04/15/85	10.940	5.084	5.463	6.9
04/15/85	10.740	4.866	5.217	6.7
04/16/85	9.910	4.175	4.266	2.2
04/16/85	9.690	3.848	4.034	4.6
04/17/85	8.740	3.033	3.116	2.7
04/17/85	8.590	2.886	2.984	3.3
04/17/85	8.360	2.729	2.789	2.1
04/18/85	7.840	2.306	2.375	2.9
04/22/85	6.060	1.211	1.248	2.9
04/23/85	5.310	0.894	0.897	0.3
04/24/85	5.540	1.007	0.997	-1.0
04/25/85	5.410	0.951	0.939	-1.2
04/25/85	4.880	0.780	0.726	-7.5
04/26/85	5.160	0.848	0.835	-1.6
04/26/85	4.710	0.714	0.664	-7.4
04/29/85	4.880	0.744	0.726	-2.5
04/29/85	4.540	0.646	0.606	-6.7
04/30/85	4.480	0.630	0.586	-7.4
04/30/85	4.140	0.535	0.481	-11.2
05/01/85	4.360	0.583	0.548	-6.4
05/01/85	4.310	0.565	0.532	-6.2
05/03/85	8.380	2.814	2.805	-0.3
05/06/85	5.140	0.851	0.827	-2.9
05/06/85	4.690	0.699	0.657	-6.3
05/07/85	4.880	0.744	0.726	-2.4
05/07/85	5.660	1.065	1.052	-1.3
05/13/85	5.010	0.798	0.775	-2.9
05/14/85	4.480	0.613	0.586	-4.6
05/14/85	4.280	0.544	0.523	-3.9

Table B.1. (continued)

Date	Measured stage (cm)	Measured flow (L/s)	Computed flow (L/s)	Relative error (%)
05/15/85	4.280	0.542	0.523	-3.6
05/15/85	3.860	0.439	0.404	-8.8
05/15/85	3.560	0.353	0.330	-6.9
05/16/85	3.860	0.430	0.404	-6.5
05/16/85	3.440	0.346	0.303	-14.3
05/20/85	3.510	0.366	0.319	-14.9
05/21/85	4.940	0.744	0.749	0.6
05/28/85	4.880	0.734	0.726	-1.1
06/03/85	2.890	0.238	0.196	-21.6
06/04/85	2.090	0.108	0.087	-23.6
06/05/85	2.710	0.204	0.167	-22.5
06/05/85	2.810	0.204	0.183	-11.5
06/05/85	2.760	0.198	0.175	-13.5
06/05/85	2.780	0.197	0.178	-10.5
06/05/85	2.250	0.129	0.105	-22.6
06/05/85	1.780	0.070	0.058	-20.6
06/05/85	1.780	0.060	0.058	-2.1
06/06/85	2.760	0.178	0.175	-1.8
06/06/85	2.640	0.168	0.156	-7.7
06/06/85	2.640	0.191	0.156	-22.1
06/06/85	2.550	0.149	0.143	-4.3
06/06/85	2.550	0.066	0.143	54.3
06/06/85	2.080	0.104	0.086	-20.6
06/06/85	2.080	0.077	0.086	11.0
06/10/85	3.210	0.286	0.255	-12.1

APPENDIX C
MEAN DAILY DISCHARGE AT CENTER SEVEN CREEK

Table C.1. Daily average discharge at Center 7 Creek, 1983
(watershed area = 0.0716 $mile^2$)
(units = ft^3/s)

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.091	0.146	0.050	0.054	0.061	0.035	0.014	0.008	0.000	0.000	0.009	0.033
2	0.089	1.654	0.047	0.103	0.057	0.031	0.014	0.009	0.003	0.000	0.010	0.168
3	0.093	0.315	0.041	0.083	0.098	0.027	0.014	0.010	0.000	0.000	0.011	0.857
4	0.087	0.169	0.039	0.069	0.064	0.135	0.016	0.007	0.002	0.000	0.020	0.720
5	0.081	0.132	0.045	4.005	0.052	0.036	0.017	0.004	0.001	0.029	0.012	0.151
6	0.077	0.167	0.111	0.761	0.045	0.035	0.016	0.001	0.000	0.018	0.013	0.392
7	0.073	0.210	0.071	0.230	0.039	0.042	0.014	0.000	0.012	0.033	0.015	0.165
8	0.065	0.236	0.077	0.180	0.192	0.035	0.014	0.000	0.008	0.030	0.016	0.093
9	0.076	0.178	0.063	0.971	0.096	0.030	0.012	0.000	0.001	0.027	0.014	0.051
10	0.103	0.611	0.059	0.317	0.071	0.024	0.007	0.000	0.000	0.025	0.011	0.039
11	0.112	0.892	0.054	0.167	0.063	0.020	0.007	0.005	0.000	0.022	0.009	0.293
12	0.113	0.282	0.046	0.131	0.058	0.015	0.009	0.007	0.000	0.019	0.007	0.373
13	0.106	0.174	0.032	0.107	0.081	0.018	0.008	0.007	0.002	0.063	0.007	0.210
14	0.110	0.129	0.029	0.095	0.067	0.023	0.003	0.007	0.002	0.010	0.007	0.138
15	0.104	0.111	0.030	0.081	0.077	0.028	0.007	0.007	0.001	0.009	0.044	0.092
16	0.094	0.089	0.031	0.073	0.111	0.029	0.005	0.007	0.000	0.012	0.015	0.084
17	0.068	0.071	0.030	0.066	0.076	0.036	0.004	0.007	0.001	0.014	0.007	0.079
18	0.064	0.067	0.033	0.089	0.056	0.049	0.008	0.007	0.004	0.017	0.003	0.075
19	0.062	0.064	0.029	0.080	0.435	0.039	0.018	0.007	0.004	0.019	0.001	0.071
20	0.065	0.058	0.086	0.072	0.486	0.031	0.010	0.007	0.004	0.019	0.054	0.066
21	0.100	0.057	0.212	0.070	1.433	0.020	0.008	0.007	0.011	0.018	0.028	0.063
22	0.091	0.081	0.080	0.077	0.792	0.038	0.006	0.007	0.005	0.018	0.013	0.220
23	0.078	0.117	0.046	0.278	0.377	0.028	0.003	0.007	0.004	0.018	0.044	0.109
24	0.071	0.119	0.036	0.245	0.182	0.020	0.002	0.007	0.005	0.018	0.166	0.077
25	0.073	0.111	0.026	0.137	0.095	0.016	0.014	0.007	0.005	0.018	0.042	0.050
26	0.075	0.088	0.020	0.107	0.075	0.020	0.010	0.005	0.006	0.018	0.023	0.047
27	0.067	0.063	0.104	0.083	0.060	0.026	0.006	0.001	0.006	0.018	0.142	0.065
28	0.065	0.059	0.063	0.073	0.053	0.029	0.000	0.009	0.007	0.012	0.557	0.750
29	0.068		0.037	0.067	0.055	0.019	0.000	0.004	0.004	0.008	0.076	0.416
30	0.077		0.026	0.065	0.046	0.014	0.000	0.000	0.000	0.008	0.043	0.154
31	0.087		0.032		0.045		0.006	0.000		0.009		0.086
TOT.	2.585	6.450	1.685	8.936	5.498	0.948	0.272	0.161	0.098	0.529	1.419	6.187
MEAN	0.083	0.084	0.208	0.055	0.288	0.182	0.031	0.009	0.005	0.003	0.017	0.046
MAX	0.113	1.654	0.212	4.005	1.433	0.135	0.018	0.010	0.012	0.063	0.557	0.857
MIN	0.062	0.057	0.020	0.054	0.039	0.014	0.000	0.000	0.000	0.000	0.001	0.033
CFSM	1.16	1.17	2.91	0.77	4.03	2.54	0.43	0.12	0.07	0.04	0.24	0.64
IN.	1.15	2.86	0.75	3.96	2.44	0.42	0.12	0.07	0.04	0.23	0.63	2.74

Table C.2. Daily average discharge at Center 7 Creek, 1984
(watershed area = 0.0716 mi^2)
(units = ft^3/s)

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.068	0.061	0.113	0.092	0.203	0.027	0.058	0.042	0.004	0.010	0.018	0.074
2	0.061	0.054	0.101	0.090	1.340	0.022	0.027	0.027	0.004	0.008	0.010	0.061
3	0.058	0.060	0.073	0.107	2.082	0.022	0.018	0.025	0.015	0.008	0.004	0.053
4	0.055	0.054	0.064	0.690	0.529	0.023	0.060	0.041	0.014	0.009	0.011	0.022
5	0.052	0.041	0.080	0.314	0.316	0.023	0.164	0.030	0.014	0.009	0.041	0.022
6	0.047	0.037	0.096	0.165	1.250	0.024	0.116	0.021	0.013	0.010	0.036	0.068
7	0.042	0.040	0.066	0.107	4.105	0.025	0.473	0.017	0.013	0.010	0.030	0.069
8	0.037	0.043	0.072	0.090	2.957	0.025	0.089	0.014	0.012	0.030	0.024	0.064
9	0.034	0.044	0.069	0.096	0.678	0.025	0.041	0.011	0.012	0.012	0.019	0.057
10	0.082	0.051	0.065	0.076	0.435	0.027	0.024	0.438	0.011	0.011	0.978	0.065
11	0.117	0.049	0.061	0.065	0.294	0.031	0.048	0.106	0.024	0.011	0.289	0.054
12	0.102	0.049	0.057	0.056	0.215	0.028	0.102	0.008	0.017	0.011	0.094	0.043
13	0.094	0.425	0.075	0.048	0.421	0.024	0.037	0.009	0.012	0.011	0.071	0.039
14	0.086	0.465	0.057	0.039	0.360	0.017	0.042	0.009	0.010	0.011	0.155	0.039
15	0.079	0.078	0.053	0.050	0.169	0.011	0.036	0.007	0.008	0.011	0.125	0.039
16	0.076	0.053	0.113	0.060	0.101	0.008	0.046	0.007	0.009	0.011	0.095	0.037
17	0.064	0.057	0.097	0.069	0.070	0.008	0.075	0.007	0.006	0.011	0.068	0.036
18	0.461	0.049	0.145	0.056	0.055	0.009	1.492	0.009	0.005	0.011	0.067	0.037
19	0.311	0.042	0.120	0.055	0.042	0.010	0.102	0.011	0.006	0.011	0.236	0.038
20	0.111	0.035	0.748	0.049	0.050	0.010	0.045	0.014	0.007	0.066	0.130	0.095
21	0.055	0.032	0.723	0.040	0.061	0.015	0.035	0.014	0.008	0.011	0.083	0.099
22	0.066	0.032	0.279	0.168	0.071	0.015	0.032	0.014	0.009	0.651	0.060	0.188
23	0.102	0.074	0.163	0.182	0.071	0.011	0.025	0.014	0.010	0.700	0.048	0.145
24	0.329	0.072	0.125	0.123	0.057	0.012	0.015	0.014	0.007	0.186	0.040	0.126
25	0.278	0.061	0.110	0.082	0.063	0.009	0.016	0.014	0.004	0.061	0.034	0.187
26	0.212	0.050	0.081	0.060	0.069	0.005	0.035	0.014	0.004	0.056	0.032	0.157
27	0.158	0.528	0.075	0.196	0.075	0.007	0.222	0.011	0.004	0.050	0.032	0.115
28	0.115	0.415	1.317	0.201	0.382	0.009	0.121	0.007	0.004	0.045	0.341	0.092
29	0.100	0.173	0.413	0.208	0.182	0.115	0.055	0.006	0.004	0.040	0.170	0.077
30	0.087		0.189	0.258	0.071	0.209	0.048	0.005	0.015	0.034	0.132	0.073
31	0.074		0.122		0.038		0.043	0.005		0.026		0.074
TOT.	3.613	3.224	5.922	3.892	16.812	0.806	3.742	0.971	0.285	2.142	3.482	2.345
MEAN	0.117	0.104	0.191	0.126	0.542	0.026	0.121	0.031	0.009	0.069	0.112	0.076
MAX	0.461	0.528	1.317	0.690	4.105	0.209	1.492	0.438	0.024	0.700	0.978	0.188
MIN	0.034	0.032	0.053	0.039	0.038	0.005	0.015	0.005	0.004	0.008	0.004	0.022
CFSM	1.63	1.45	2.67	1.75	7.57	0.36	1.69	0.44	0.13	0.97	1.57	1.06
IN.	1.60	1.43	2.62	1.72	7.45	0.36	1.66	0.43	0.13	0.95	1.54	1.04

Table C.3. Daily average discharge at Center 7 Creek, 1985
(watershed area = 0.0716 mi^2)
(units = ft^3/s)

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.122	1.573	0.071	0.076	0.018	0.005	0.036	0.030	0.017	0.123	0.074	0.292
2	0.222	0.579	0.070	0.066	0.129	0.004	0.010	0.015	0.016	0.052	0.109	0.196
3	0.195	0.247	0.063	0.064	0.087	0.002	0.006	0.008	0.011	0.052	0.048	0.119
4	0.254	0.165	0.062	0.057	0.039	0.002	0.006	0.005	0.006	0.032	0.176	0.082
5	0.204	0.319	0.087	0.188	0.026	0.001	0.005	0.005	0.007	0.017	0.135	0.075
6	0.137	0.324	0.060	0.392	0.023	0.002	0.007	0.031	0.018	0.011	0.061	0.054
7	0.101	0.186	0.058	0.173	0.023	0.058	0.005	0.046	0.016	0.009	0.048	0.036
8	0.076	0.123	0.075	0.090	0.029	0.017	0.003	0.019	0.011	0.007	0.033	0.032
9	0.065	0.099	0.152	0.063	0.026	0.006	0.004	0.010	0.009	0.007	0.026	0.042
10	0.060	0.087	0.136	0.051	0.020	0.005	0.023	0.006	0.008	0.007	0.023	0.089
11	0.056	0.139	0.117	0.043	0.025	0.004	0.031	0.002	0.008	0.007	0.021	0.105
12	0.048	0.253	0.101	0.042	0.033	0.038	0.006	0.002	0.006	0.007	0.019	0.221
13	0.043	0.192	0.083	0.042	0.022	0.011	0.005	0.006	0.004	0.007	0.018	0.212
14	0.044	0.140	0.076	0.040	0.016	0.006	0.005	0.006	0.005	0.007	0.017	0.130
15	0.040	0.122	0.066	0.168	0.014	0.006	0.006	0.002	0.006	0.009	0.015	0.088
16	0.038	0.113	0.056	0.148	0.011	0.005	0.005	0.455	0.006	0.010	0.035	0.068
17	0.055	0.135	0.052	0.108	0.016	0.017	0.000	1.645	0.006	0.012	0.026	0.058
18	0.048	0.162	0.044	0.088	0.015	0.053	0.001	0.200	0.004	0.013	0.018	0.053
19	0.039	0.247	0.039	0.071	0.011	0.011	0.001	0.055	0.004	0.015	0.016	0.048
20	0.034	0.208	0.037	0.058	0.013	0.005	0.000	0.023	0.004	0.016	0.014	0.043
21	0.032	0.143	0.046	0.049	0.019	0.005	0.000	0.021	0.004	0.070	0.043	0.038
22	0.033	0.109	0.090	0.040	0.013	0.002	0.001	0.021	0.004	0.028	0.083	0.033
23	0.035	0.091	0.069	0.034	0.014	0.002	0.067	0.021	0.010	0.143	0.069	0.028
24	0.041	0.085	0.140	0.033	0.017	0.003	0.034	0.088	0.089	0.058	0.051	0.026
25	0.042	0.095	0.100	0.030	0.015	0.002	0.021	0.098	0.021	0.032	0.036	0.024
26	0.032	0.074	0.070	0.027	0.009	0.003	0.014	0.199	0.019	0.020	0.033	0.021
27	0.031	0.067	0.063	0.027	0.004	0.002	0.055	0.295	0.017	0.018	0.216	0.019
28	0.039	0.064	0.060	0.026	0.013	0.000	0.026	0.239	0.015	0.020	0.482	0.018
29	0.036		0.052	0.021	0.011	0.000	0.047	0.168	0.014	0.014	0.334	0.016
30	0.038		0.047	0.016	0.008	0.035	0.052	0.148	0.012	0.014	0.269	0.015
31	0.256		0.094		0.005		0.018	0.038		0.014		0.137
TOT.	2.496	6.141	2.336	2.331	0.724	0.312	0.500	3.907	0.377	0.851	2.548	2.418
MEAN	0.081	0.219	0.075	0.078	0.023	0.010	0.016	0.126	0.013	0.027	0.085	0.078
MAX	0.256	1.573	0.152	0.392	0.129	0.058	0.067	1.645	0.089	0.143	0.482	0.292
MIN	0.031	0.031	0.037	0.016	0.004	0.000	0.000	0.002	0.004	0.007	0.014	0.015
CFSM	1.12	3.06	1.05	1.09	0.33	0.15	0.23	1.76	0.18	0.38	1.19	1.09
IN.	1.11	2.72	1.03	1.03	0.32	0.14	0.22	1.73	0.17	0.38	1.13	1.07

Table C.4. Daily average discharge at Center 7 Creek, 1986
(watershed area = 0.0716 mi^2)
(units = ft^3/s)

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.087	0.034	0.101	0.042	0.014	0.007	0.006	0.000	0.000	0.000	0.000	0.028
2	0.071	0.042	0.094	0.039	0.013	0.007	0.013	0.000	0.050	0.000	0.000	0.056
3	0.063	0.048	0.087	0.035	0.013	0.010	0.006	0.000	0.017	0.001	0.000	0.041
4	0.053	0.225	0.081	0.035	0.013	0.012	0.002	0.000	0.010	0.004	0.000	0.033
5	0.043	0.131	0.075	0.034	0.012	0.012	0.001	0.000	0.003	0.008	0.000	0.029
6	0.039	0.099	0.069	0.033	0.012	0.011	0.000	0.000	0.001	0.011	0.000	0.026
7	0.034	0.127	0.063	0.032	0.011	0.004	0.000	0.000	0.000	0.015	0.013	0.025
8	0.029	0.098	0.059	0.098	0.011	0.004	0.000	0.000	0.000	0.019	0.000	0.205
9	0.025	0.079	0.055	0.039	0.009	0.030	0.000	0.000	0.000	0.023	0.000	3.665
10	0.024	0.081	0.052	0.032	0.007	0.019	0.002	0.000	0.000	0.009	0.000	0.684
11	0.023	0.132	0.068	0.029	0.006	0.013	0.081	0.000	0.000	0.018	0.000	0.418
12	0.022	0.083	0.175	0.027	0.005	0.010	0.282	0.000	0.000	0.026	0.000	0.287
13	0.021	0.079	0.398	0.026	0.004	0.007	0.235	0.000	0.000	0.096	0.009	0.235
14	0.018	0.110	0.280	0.025	0.004	0.007	0.187	0.000	0.000	0.060	0.021	0.208
15	0.016	0.110	0.279	0.024	0.004	0.006	0.140	0.000	0.000	0.009	0.028	0.182
16	0.013	0.257	0.264	0.023	0.004	0.006	0.092	0.000	0.000	0.004	0.023	0.155
17	0.011	1.491	0.227	0.022	0.004	0.005	0.045	0.000	0.000	0.003	0.020	0.128
18	0.012	0.866	0.179	0.022	0.005	0.004	0.006	0.000	0.000	0.003	0.017	0.102
19	0.080	0.346	1.130	0.024	0.004	0.004	0.000	0.000	0.000	0.002	0.015	0.077
20	0.028	0.325	0.280	0.031	0.004	0.002	0.000	0.002	0.000	0.002	0.031	0.061
21	0.026	0.231	0.180	0.050	0.004	0.000	0.000	0.000	0.000	0.001	0.022	0.047
22	0.026	0.226	0.108	0.043	0.004	0.000	0.000	0.000	0.000	0.000	0.018	0.041
23	0.027	0.170	0.088	0.027	0.042	0.000	0.000	0.000	0.000	0.004	0.039	0.047
24	0.029	0.230	0.075	0.022	0.027	0.000	0.000	0.000	0.000	0.002	0.261	0.063
25	0.044	0.202	0.069	0.021	0.045	0.000	0.000	0.000	0.000	0.178	0.121	0.050
26	0.132	0.198	0.064	0.021	0.020	0.000	0.000	0.003	0.000	0.044	0.311	0.039
27	0.069	0.212	0.060	0.020	0.054	0.000	0.000	0.010	0.000	0.014	0.113	0.036
28	0.028	0.141	0.057	0.045	0.076	0.000	0.000	0.011	0.000	0.011	0.059	0.034
29	0.042		0.053	0.031	0.023	0.008	0.000	0.002	0.000	0.008	0.038	0.031
30	0.045		0.049	0.016	0.014	0.009	0.000	0.000	0.000	0.006	0.028	0.028
31	0.038		0.046		0.008		0.000	0.000		0.010		0.026
TOT.	1.218	6.373	4.865	0.968	0.476	0.197	1.098	0.028	0.081	0.591	1.187	7.087
MEAN	0.039	0.206	0.157	0.031	0.015	0.006	0.035	0.001	0.003	0.019	0.038	0.229
MAX	0.132	1.491	1.130	0.098	0.076	0.030	0.282	0.011	0.050	0.178	0.311	3.665
MIN	0.011	0.034	0.046	0.016	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.025
CFSM	0.55	2.87	2.19	0.44	0.21	0.09	0.49	0.01	0.04	0.27	0.53	3.19
IN.	0.54	2.82	2.16	0.43	0.21	0.08	0.49	0.01	0.04	0.26	0.53	3.14

Table C.5. Daily average discharge at Center 7 Creek, 1987
(watershed area = 0.0716 mi^2)
(units = ft^3/s)

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1	0.024	0.123	0.191	0.075	0.008	0.014	0.004	0.000	0.000	0.000	0.003	0.004
2	0.023	0.130	0.167	0.070	0.010	0.012	0.006	0.000	0.000	0.000	0.002	0.004
3	0.023	0.107	0.142	0.088	0.016	0.009	0.010	0.000	0.000	0.000	0.002	0.004
4	0.022	0.095	0.118	0.085	0.069	0.007	0.014	0.000	0.000	0.000	0.001	0.004
5	0.021	0.083	0.093	0.081	0.019	0.007	0.019	0.000	0.000	0.000	0.000	0.004
6	0.020	0.071	0.073	0.078	0.016	0.006	0.020	0.002	0.000	0.000	0.000	0.004
7	0.019	0.059	0.070	0.074	0.016	0.006	0.077	0.000	0.000	0.000	0.001	0.004
8	0.018	0.051	0.069	0.071	0.020	0.005	0.009	0.000	0.000	0.000	0.002	0.004
9	0.018	0.047	0.068	0.067	0.020	0.005	0.007	0.000	0.000	0.000	0.003	0.004
10	0.018	0.043	0.067	0.074	0.018	0.004	0.007	0.000	0.000	0.000	0.023	0.004
11	0.019	0.039	0.066	0.092	0.017	0.004	0.006	0.000	0.000	0.000	0.006	0.004
12	0.019	0.035	0.065	0.072	0.016	0.005	0.005	0.000	0.058	0.000	0.004	0.004
13	0.020	0.033	0.064	0.077	0.015	0.010	0.004	0.000	0.011	0.000	0.003	0.004
14	0.020	0.039	0.063	0.120	0.013	0.006	0.003	0.000	0.000	0.000	0.002	0.004
15	0.021	0.037	0.061	1.054	0.012	0.005	0.002	0.000	0.000	0.000	0.002	0.036
16	0.021	0.459	0.078	0.405	0.011	0.004	0.001	0.000	0.000	0.000	0.001	0.010
17	0.023	0.371	0.087	0.337	0.108	0.016	0.000	0.000	0.000	0.000	0.013	0.004
18	0.541	0.285	0.208	0.198	0.039	0.009	0.000	0.000	0.000	0.000	0.004	0.001
19	2.832	0.219	0.381	0.157	0.017	0.010	0.000	0.000	0.013	0.000	0.003	0.002
20	0.323	0.122	0.173	0.136	0.014	0.007	0.000	0.000	0.011	0.002	0.001	0.003
21	0.160	0.072	0.110	0.116	0.022	0.014	0.000	0.000	0.000	0.004	0.000	0.002
22	0.126	0.227	0.077	0.095	0.035	0.067	0.000	0.000	0.000	0.002	0.000	0.001
23	0.100	0.339	0.075	0.075	0.017	0.187	0.000	0.000	0.000	0.000	0.000	0.001
24	0.081	0.151	0.070	0.053	0.009	0.130	0.000	0.000	0.000	0.000	0.000	0.011
25	0.696	0.089	0.064	0.023	0.008	0.072	0.000	0.000	0.000	0.000	0.000	0.104
26	0.664	0.078	0.058	0.013	0.008	0.018	0.000	0.000	0.000	0.000	0.000	0.064
27	0.241	0.288	0.045	0.012	0.009	0.007	0.000	0.000	0.000	0.002	0.000	0.059
28	0.153	0.240	0.036	0.011	0.010	0.006	0.000	0.000	0.000	0.000	0.004	0.180
29	0.107		0.037	0.010	0.010	0.002	0.000	0.000	0.000	0.000	0.006	0.058
30	0.089		0.084	0.009	0.023	0.000	0.000	0.000	0.000	0.003	0.004	0.030
31	0.103		0.088		0.023		0.000	0.000		0.003		0.028
TOT.	6.565	3.932	3.048	3.828	0.648	0.654	0.194	0.002	0.093	0.016	0.090	0.650
MEAN	0.212	0.140	0.098	0.128	0.021	0.022	0.006	0.000	0.003	0.001	0.003	0.021
MAX	2.832	0.459	0.381	1.054	0.108	0.187	0.077	0.002	0.058	0.004	0.023	0.180
MIN	0.018	0.033	0.036	0.009	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.001
CFSM	2.96	1.96	1.37	1.78	0.29	0.30	0.09	0.00	0.04	0.01	0.04	0.29
IN.	2.91	1.74	1.35	1.70	0.29	0.29	0.09	0.00	0.04	0.01	0.04	0.29

Table C.6. Daily average discharge at Center 7 Creek,
January - March 1988
(watershed area = 0.0716 mi^2)
(units = ft^3/s)

DATE	JAN	FEB	MAR
1	0.166	0.020	0.025
2	0.083	0.050	0.025
3	0.060	0.080	0.025
4	0.098	0.920	0.033
5	0.056	0.220	0.022
6	0.052	0.090	0.021
7	0.044	0.060	0.021
8	0.036	0.050	0.025
9	0.029	0.071	0.029
10	0.021	0.054	2.300
11	0.018	0.046	0.310
12	0.022	0.050	0.230
13	0.023	0.046	0.340
14	0.025	0.046	0.256
15	0.026	0.113	0.131
16	0.027	0.095	0.084
17	0.170	0.070	0.060
18	0.400	0.061	0.054
19	2.000	0.067	0.047
20	2.100	0.053	0.036
21	0.248	0.042	0.032
22	0.090	0.036	0.031
23	0.044	0.034	0.030
24	0.036	0.033	0.030
25	0.035	0.030	0.029
26	0.030	0.029	0.029
27	0.030	0.027	0.026
28	0.030	0.026	0.022
29	0.020	0.025	0.022
30	0.020		0.023
31	0.020		0.024
TOT.	6.059	2.544	4.372
MEAN	0.195	0.088	0.141
MAX	2.100	0.920	2.300
MIN	0.018	0.020	0.021
CFSM	2.73	1.23	1.97
IN.	2.68	1.13	1.94

APPENDIX D
MEAN DAILY DISCHARGE AT SITES MONITORED BY THE USGS

Table D.1. Discharge at Upper Melton Branch, April - December 1985

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - TENNESSEE DISTRICT 07/06/88
STATION NUMBER 03537100 MELTON BRANCH NR MELTON HILL NR OAK RIDGE, TN STREAM SOURCE AGENCY USGS
LATITUDE 355459 LONGITUDE 0841753 DRAINAGE AREA 0.52 DATUM 6640 STATE 47 COUNTY 145
DISCHARGE, IN CUBIC FEET PER SECOND, CALENDAR YEAR JANUARY TO DECEMBER 1985
MEAN VALUES

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	---	---	---	.50	.10	.01	.18	.12	.11	.39	.23	1.1
2	---	---	---	.45	.86	.01	.04	.06	.06	.27	.73	1.0
3	---	---	---	.38	.71	.01	.02	.03	.05	.27	.28	.57
4	---	---	---	.30	.24	.01	.01	.01	.04	.15	.79	.40
5	---	---	---	.60	.15	.0	.01	.01	.03	.08	.74	.38
6	---	---	---	1.2	.11	.0	.01	.06	.06	.05	.35	.30
7	---	---	---	.95	.11	.19	.01	.22	.05	.04	.25	.22
8	---	---	---	.80	.13	.07	.0	.09	.03	.04	.17	.18
9	---	---	---	.70	.12	.02	.0	.03	.02	.03	.13	.16
10	---	---	---	.60	.12	.01	.05	.02	.02	.03	.11	.13
11	---	---	---	.55	.22	.01	.15	.01	.02	.03	.10	.27
12	---	---	---	.45	.22	.08	.02	.01	.01	.03	.10	.58
13	---	---	---	.40	.11	.02	.01	.01	.01	.03	.10	1.2
14	---	---	---	.35	.08	.01	.01	.01	.01	.03	.09	.70
15	---	---	---	.82	.06	.01	.01	.01	.01	.03	.10	.45
16	---	---	---	.80	.04	.0	.01	6.5	.01	.03	.18	.34
17	---	---	---	.60	.06	.02	.0	15	.01	.02	.21	.28
18	---	---	---	.47	.05	.22	.00	1.9	.01	.02	.15	.22
19	---	---	---	.35	.03	.05	.0	.63	.01	.02	.13	.17
20	---	---	---	.31	.03	.02	.0	.28	.01	.02	.10	.17
21	---	---	---	.24	.05	.01	.0	.17	.0	.21	.22	.13
22	---	---	---	.20	.04	.01	.0	.09	.0	.09	.49	.14
23	---	---	---	.18	.03	.01	.16	.07	.01	.41	.32	.13
24	---	---	---	.17	.05	.01	.32	.68	.08	.39	.21	.12
25	---	---	---	.16	.04	.01	.14	.88	.02	.17	.16	.10
26	---	---	---	.16	.02	.01	.04	1.4	.04	.11	.13	.10
27	---	---	---	.12	.02	.01	.31	1.3	.03	.08	1.1	.10
28	---	---	---	.11	.03	.01	.14	.54	.02	.11	3.3	.10
29	---	---	---	.10	.03	.0	.12	.25	.02	.08	2.2	.10
30	---	---	---	.10	.02	.11	.15	.37	.01	.07	1.2	.10
31	---	---	---	---	.01	---	.08	.25	---	.07	---	.73
TOTAL	---	---	---	13.12	3.89	.96	2.00	31.01	.81	3.40	14.37	10.67
MEAN	---	---	---	.44	.13	.03	.06	1.00	.03	.11	.48	.34
MAX	---	---	---	1.2	.86	.22	.32	15	.11	.41	3.3	1.2
MIN	---	---	---	.10	.01	.00	.00	.01	.00	.02	.09	.10
CFSM	---	---	---	.84	.24	.06	.12	1.92	.05	.21	.92	.66
IN.	---	---	---	.94	.28	.07	.14	2.22	.06	.24	1.03	.76

Table D.2. Discharge at Upper Melton Branch, 1986

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - TENNESSEE DISTRICT 07/06/88
STATION NUMBER 03537100 MELTON BRANCH NR MELTON HILL NR OAK RIDGE, TN STREAM SOURCE AGENCY USGS
LATITUDE 355459 LONGITUDE 0841753 DRAINAGE AREA 0.52 DATUM 6640 STATE 47 COUNTY 145
PROVISIONAL DATA SUBJECT TO REVISION

DISCHARGE, IN CUBIC FEET PER SECOND, CALENDAR YEAR JANUARY TO DECEMBER 1986
MEAN VALUES

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	.68	.32	.39	.24	.05	.02	.01	.0	.0	.00	.02	.17
2	.39	.29	.36	.22	.04	.02	.07	.0	.01	.00	.01	.32
3	.31	.33	.33	.22	.03	.01	.03	.0	.01	.00	.01	.27
4	.23	.27	.32	.19	.03	.01	.02	.0	.0	.00	.01	.18
5	.19	1.6	.27	.17	.03	.03	.01	.0	.0	.00	.02	.14
6	.18	1.1	.28	.17	.03	.03	.01	.0	.01	.00	.01	.12
7	.17	.87	.24	.18	.03	.01	.01	.0	.0	.00	.08	.10
8	.17	.60	.22	.60	.02	.01	.01	.0	.0	.00	.17	1.4
9	.17	.48	.22	.27	.02	.09	.01	.0	.0	.00	.31	13
10	.19	.51	.22	.20	.02	.05	.01	.0	.0	.00	.16	3.8
11	.17	.93	.27	.17	.02	.03	.06	.0	.0	.00	.86	2.8
12	.16	.60	.83	.15	.02	.02	.04	.0	.0	.00	.46	1.6
13	.15	.46	2.5	.13	.02	.02	.10	.0	.0	.05	.19	.91
14	.14	.61	1.5	.13	.02	.01	.20	.0	.0	.06	.12	.57
15	.13	.59	1.1	.12	.02	.01	.02	.0	.0	.01	.19	.41
16	.13	.92	.80	.10	.01	.01	.01	.0	.0	.01	.15	.32
17	.13	14	.62	.10	.01	.01	.0	.0	.0	.00	.12	.28
18	.13	7.9	.52	.09	.01	.01	.0	.0	.0	.00	.09	.99
19	.65	2.1	13	.07	.02	.01	.0	.0	.0	.00	.07	.55
20	.31	1.3	1.9	.08	.02	.01	.0	.0	.0	.00	.27	.39
21	.30	1.0	1.2	.21	.02	.00	.0	.0	.0	.00	.25	.29
22	.25	.90	.88	.15	.02	.00	.0	.0	.0	.00	.16	.23
23	.20	.73	.69	.09	.11	.00	.0	.0	.0	.00	.23	.27
24	.20	.86	.56	.07	.06	.00	.0	.0	.0	.00	1.7	.42
25	.25	.70	.48	.07	.15	.00	.0	.0	.0	.95	.89	.29
26	.86	.63	.43	.06	.07	.00	.0	.0	.0	.25	1.8	.23
27	.75	.64	.37	.06	.24	.00	.0	.0	.0	.08	.80	.21
28	.65	.46	.32	.16	.38	.00	.0	.0	.0	.04	.40	.17
29	.50	---	.28	.09	.12	.00	.0	.0	.0	.03	.26	.17
30	.41	---	.27	.05	.05	.00	.0	.0	.0	.02	.19	.15
31	.37	---	.27	---	.03	---	.0	.0	---	.02	---	.13
TOTAL	9.52	41.70	31.64	4.61	1.72	.42	.62	.0	.03	1.52	10.0	30.88
MEAN	.31	1.49	1.02	.15	.06	.01	.02	.00	.00	.05	.33	.996
MAX	.86	14	13	.60	.38	.09	.20	.00	.01	.95	1.8	13
MIN	.13	.27	.22	.05	.01	.00	.00	.00	.00	.00	.01	.10
CFSM	.59	2.86	1.96	.30	.11	.0	.0	.00	.0	.09	.64	1.92
IN.	.68	2.98	2.26	.33	.12	.0	.0	.00	.0	.11	.72	2.21

CAL YR 1986 TOTAL 132.66 MEAN .36 MAX 14 MIN .00 CFSM .70 IN. 9.49

Table D.3. Discharge at Upper Melton Branch, 1987

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - TENNESSEE DISTRICT 07/06/88
STATION NUMBER 03537100 MELTON BRANCH NR MELTON HILL NR OAK RIDGE, TN STREAM SOURCE AGENCY USGS
LATITUDE 355459 LONGITUDE 0841753 DRAINAGE AREA 0.52 DATUM 6640 STATE 47 COUNTY 145
PROVISIONAL DATA SUBJECT TO REVISION

DISCHARGE, IN CUBIC FEET PER SECOND, CALENDAR YEAR JANUARY TO DECEMBER 1987
MEAN VALUES

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	.16	.38	3.5	.54	.12	.02	.00	.00	.00	.00	.00	.0
2	.13	.75	1.7	.51	.10	.02	.00	.00	.00	.00	.00	.00
3	.10	.66	1.2	.93	.12	.01	.01	.00	.00	.00	.00	.00
4	.10	.49	.84	1.3	.59	.01	.01	.00	.00	.00	.00	.00
5	.10	.41	.65	1.4	.14	.02	.01	.00	.00	.00	.00	.00
6	.10	.38	.53	1.3	.10	.01	.03	.00	.00	.00	.00	.00
7	.10	.33	.44	1.0	.09	.01	.23	.00	.00	.00	.00	.00
8	.07	.30	.44	.80	.07	.01	.03	.00	.00	.00	.00	.00
9	.08	.23	.81	.65	.06	.00	.01	.00	.00	.00	.00	.00
10	.12	.22	.51	.52	.05	.00	.01	.00	.00	.00	.00	.00
11	.10	.21	.41	.61	.04	.00	.01	.00	.00	.00	.00	.00
12	.09	.21	.51	.52	.04	.00	.01	.00	.00	.00	.00	.00
13	.07	.17	.39	.40	.03	.00	.00	.00	.00	.00	.00	.00
14	.08	.23	.38	.79	.03	.00	.00	.00	.00	.00	.00	.00
15	.17	.25	.33	4.0	.03	.00	.00	.00	.00	.00	.00	.02
16	.13	2.1	.41	2.0	.02	.00	.00	.00	.00	.00	.00	.01
17	.11	1.5	.33	1.7	.31	.01	.00	.00	.00	.00	.00	.01
18	2.1	1.2	.86	1.2	.15	.01	.00	.00	.00	.00	.0	.0
19	23	.91	1.9	.92	.06	.01	.00	.00	.00	.00	.0	.0
20	2.1	.71	1.1	.68	.05	.01	.00	.00	.00	.00	.00	.01
21	1.2	.67	.78	.54	.07	.02	.00	.00	.00	.00	.00	.01
22	1.0	2.0	.59	.42	.08	.16	.00	.00	.00	.00	.00	.0
23	.72	2.6	.49	.37	.04	.08	.00	.00	.00	.00	.00	.0
24	.54	1.3	.48	.34	.03	.03	.00	.00	.00	.00	.00	.01
25	3.0	.97	.57	.26	.02	.02	.00	.00	.00	.00	.00	.15
26	2.6	.79	.39	.22	.03	.01	.00	.00	.00	.00	.00	.14
27	1.2	9.1	.38	.20	.03	.01	.00	.00	.00	.00	.00	.16
28	.98	6.5	.33	.16	.03	.00	.00	.00	.00	.00	.00	.45
29	.73	---	.31	.14	.01	.00	.00	.00	.00	.00	.00	.14
30	.62	---	.77	.12	.03	.00	.00	.00	.00	.00	.0	.06
31	.46	---	.81	---	.04	---	.00	.00	---	.00	---	.05
TOTAL	42.06	35.57	23.14	24.54	2.61	.48	.36	.00	.00	.00	.00	1.22
MEAN	1.36	1.27	.75	.82	.08	.02	.01	.00	.00	.00	.00	.04
MAX	23	9.1	3.5	4.0	.59	.16	.23	.00	.00	.00	.00	.45
MIN	.07	.17	.31	.12	.01	.00	.00	.00	.00	.00	.00	.00
CFSM	2.61	2.44	1.44	1.57	.16	.0	.0	.00	.00	.00	.00	.08
IN.	3.01	2.54	1.66	1.76	.19	.0	.0	.00	.00	.00	.00	.09

CAL YR 1987 TOTAL 129.98 MEAN .36 MAX 23 MIN .00 CFSM .68 IN. 9.30

Table D.4. Discharge at Upper Melton Branch, January - March 1988

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - TENNESSEE DISTRICT 07/06/88
STATION NUMBER 03537100 MELTON BRANCH NR MELTON HILL NR OAK RIDGE, TN STREAM SOURCE AGENCY USGS
LATITUDE 355459 LONGITUDE 0841753 DRAINAGE AREA 0.52 DATUM 6640 STATE 47 COUNTY 145
PROVISIONAL DATA SUBJECT TO REVISION

DISCHARGE, IN CUBIC FEET PER SECOND
MEAN VALUES

DAY	JAN	FEB	MAR
1	.33	.07	.10
2	.22	.20	.10
3	.11	.48	.10
4	.22	4.8	.17
5	.11	1.4	.12
6	.07	.62	.10
7	.07	.41	.08
8	.06	.28	.07
9	.06	.21	.09
10	.05	.17	14
11	.05	.14	2.1
12	.05	.15	1.6
13	.05	.10	2.1
14	.05	.10	1.2
15	.05	.62	.70
16	.05	.52	.46
17	.08	.33	.35
18	1.3	.26	.32
19	12	.31	.29
20	14	.28	.23
21	1.3	.19	.19
22	.57	.17	.17
23	.32	.20	.13
24	.22	.18	.13
25	.18	.14	.13
26	.11	.13	.13
27	.10	.13	.11
28	.09	.11	.10
29	.07	.10	.10
30	.07	---	.10
31	.07	---	.09
TOTAL	32.08	12.80	25.66
MEAN	1.03	.44	.83
MAX	14	4.8	14
MIN	.05	.07	.07
CFSM	1.99	.85	1.59
IN.	2.29	.92	1.84

D.5. Discharge at East 7 Creek, October, 1987-March 1988

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - TENNESSEE DISTRICT
STATION NUMBER 03537050 MELTON BRANCH TRIB (EAST SEVEN) NR OAK RIDGE, TN STREAM SOURCE AGENCY USGS
LATITUDE 355507 LONGITUDE 0841743 DRAINAGE AREA DATUM STATE 47 COUNTY 145
PROVISIONAL DATA SUBJECT TO REVISION

DISCHARGE, IN CUBIC FEET PER SECOND
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR
1	.01	.00	.0	.19	.06	.05
2	.00	.00	.0	.13	.13	.05
3	.00	.00	.0	.06	.31	.05
4	.00	.00	.0	.15	3.0	.10
5	.00	.00	.0	.07	.67	.09
6	.00	.00	.0	.05	.33	.07
7	.00	.00	.0	.05	.26	.06
8	.00	.00	.0	.05	.15	.05
9	.00	.00	.0	.05	.12	.07
10	.00	.02	.0	.05	.09	6.8
11	.00	.0	.0	.05	.08	1.0
12	.00	.0	.0	.05	.09	.83
13	.00	.00	.0	.05	.07	1.2
14	.00	.00	.01	.05	.05	.54
15	.00	.00	.02	.05	.36	.32
16	.00	.00	.02	.05	.32	.23
17	.00	.01	.01	.05	.21	.17
18	.00	.0	.01	1.0	.17	.16
19	.00	.0	.01	4.4	.20	.16
20	.00	.0	.01	4.5	.19	.12
21	.00	.0	.01	.62	.13	.10
22	.00	.0	.0	.30	.10	.09
23	.00	.0	.0	.20	.13	.08
24	.00	.0	.01	.15	.13	.07
25	.00	.0	.13	.14	.10	.07
26	.00	.0	.09	.13	.09	.08
27	.00	.0	.00	.12	.00	.07
28	.00	.01	.15	.11	.07	.06
29	.00	.01	.07	.10	.07	.05
30	.0	.0	.03	.09	---	.04
31	.00	---	.02	.09	---	.04
TOTAL	.01	.05	.69	13.15	7.76	12.87
MEAN	.0	.0	.02	.42	.27	.42
MAX	.01	.02	.15	4.5	3.0	6.8
MIN	.00	.00	.00	.05	.05	.04
MED	.00	.00	.01	.09	.13	.08

Table D.6. Discharge at West 7 Creek, October, 1987-March, 1988

UNITED STATES DEPARTMENT OF THE INTERIOR - GEOLOGICAL SURVEY - TENNESSEE DISTRICT
STATION NUMBER 03537300 MELTON BRANCH TRIB (WEST SEVEN) NR OAK RIDGE, TN STREAM SOURCE AGENCY USGS
LATITUDE 355511 LONGITUDE 0841808 DRAINAGE AREA DATUM STATE 47 COUNTY 145
PROVISIONAL DATA SUBJECT TO REVISION

DISCHARGE, IN CUBIC FEET PER SECOND
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR
1	.00	.00	.00	.13	.02	.03
2	.00	.00	.00	.07	.10	.03
3	.00	.00	.00	.03	.19	.04
4	.00	.00	.00	.09	1.8	.06
5	.00	.00	.00	.03	.47	.04
6	.00	.00	.00	.01	.18	.03
7	.00	.00	.00	.01	.11	.03
8	.00	.00	.00	.01	.09	.02
9	.00	.00	.00	.01	.06	.04
10	.00	.00	.00	.01	.05	4.1
11	.00	.00	.00	.01	.05	.66
12	.00	.00	.00	.01	.05	.54
13	.00	.00	.00	.02	.03	.72
14	.00	.00	.00	.02	.03	.38
15	.00	.00	.03	.02	.23	.20
16	.00	.00	.0	.01	.19	.14
17	.00	.00	.00	.10	.14	.10
18	.00	.00	.00	.53	.11	.10
19	.00	.00	.00	2.6	.14	.09
20	.00	.00	.00	3.0	.11	.08
21	.00	.00	.00	.35	.07	.07
22	.00	.00	.00	.15	.07	.04
23	.00	.00	.00	.09	.08	.04
24	.00	.00	.01	.06	.07	.04
25	.00	.00	.15	.05	.05	.04
26	.00	.00	.10	.03	.05	.05
27	.00	.00	.07	.02	.05	.04
28	.00	.00	.19	.02	.04	.03
29	.00	.00	.05	.02	.04	.03
30	.00	.00	.01	.02	---	.03
31	.00	---	.01	.02	---	.03
TOTAL	.00	.00	.62	7.55	4.67	7.87
MEAN	.00	.00	.02	.24	.16	.25
MAX	.00	.00	.19	3.0	1.8	4.1
MIN	.00	.00	.00	.01	.02	.02
MED	.00	.00	.00	.02	.07	.04

APPENDIX E
DRILLER'S NOTES FOR 100-SERIES WELLS

Well 100

Drill dates: 1983 22Aug - 25Aug

Finished depth: 9.98 m

Depth (m)(approximate)	Notes & Comments
0-4	All overburden brown to tan; soft material
3.5	First indication of moisture
4.5	Weathered rock; firm material
7.5	Limey gray drill mud with rock fragments; Ten-centimeter (4-in.) augers were used to drill to the completed depth. Because of collapse near the surface, it was necessary to redrill the upper 4-5 m with a 15.2-cm (6 in.) auger.

The well was screened for 3.05 m (10 ft) with 5.1 cm (2 in.) pvc well screen with pvc cap on the bottom. Two-inch pvc material was used to case the remainder of the well.

Seven gallons of granite chips were worked in around the casing; then the casing was sealed with a 25/75 Bentonite/soil mixture (~5 gal). The well was backfilled up to within 1 m of the surface. The upper 1 m was sealed with bentonite/soil mixture. The casing was then set in in a concrete cap 38.1 cm (15 in.) diameter and 7.6-20.3 cm thick.

Well 101

Drill dates: 1983 30Aug-13Sept

Finished depth: 20.78 m

Depth (m)(approximate)	Notes & Comments
0-8.8	Overburden-brown to tan.
3.5	First indication of moisture.
11	Indication of limestone.
15	Hard limestone fragments; slow drilling.

This well was cased first with 7.6 cm (3 in.) thin wall pvc over the upper 12 m to check for groundwater accumulation. The 2-in. pvc casing with 2.7 m of well screen on the bottom was then put in place and gravel worked into the hole. The same procedure for finishing Well 100 was used here except that Well 101 and also 102 were set in concrete at the same time. The 7.6-cm casing was pulled during the backfilling of Well 101.

Well 102

Drill dates: 1983 30ct-1Nov

Finished depth: 13.21 m

Depth (m)(approximate)	Notes & Comments
0-10	Loose material; easy drilling with bulldog bit.
10-11	Slow drilling with BT rock bit. Note: This was moisture in this hole most of its total depth probably due to water used during developing Well 101, which is only 61 cm away.
11-13	Slow drilling--rocky.

This well was cased with 7.6-cm thin-wall pvc casing as was Well 101. With a pump and hose, the hole was washed through the 3-in. casing to remove as many cuttings as possible before casing with the 5.1-cm casing. The lower 3.05 m (10 ft) was screened.

Well 103

Drill dates: 1983 7Nov-21Nov.

Finished depth: 11.14 m

Depth (m)(approximate)	Notes & Comments
0-0.5	Color changed from dark to light tan.
1.5	First evidence of rock-limestone, i.e., when drilling without water, trimmings looked like dry cement.
7.6	First evidence of moisture.

After drilling and without casing, the hole was washed to remove trimmings. The 5.1-cm pvc casing with screen over the bottom 3.05 m was installed and finished as previously described.

APPENDIX F
GROUNDWATER ELEVATIONS AT PROPOSED SWSA-7

Table F.1. Groundwater elevations (in feet) for Wells 7-1 through 7-5

DATE	DATE	7-1	7-2	7-3	7-4	7-5
82161	06/10/82	.	.	851.63	.	.
82166	06/15/82	.	.	846.87	.	.
82168	06/17/82	.	.	851.46	.	.
82214	08/02/82	.	.	846.67	864.24	.
82225	08/13/82	.	.	846.25	859.38	833.94
82298	10/25/82	870.68	866.34	848.77	855.28	820.55
82337	12/03/82	873.07	868.93	853.50	865.49	834.86
83005	01/05/83	876.13	869.33	850.71	867.19	835.19
83014	01/14/83	875.93	869.26	849.99	866.24	834.89
83020	01/20/83	876.13	869.49	850.05	865.62	834.66
83027	01/27/83	874.81	869.13	848.84	863.29	834.96
83035	02/04/83	875.90	869.43	850.51	866.27	835.19
83041	02/10/83	876.68	869.72	851.89	867.49	835.81
83047	02/16/83	877.11	869.79	850.84	867.65	836.07
83056	02/25/83	876.91	868.44	850.05	866.27	835.19
83062	03/03/83	877.31	869.98	850.22	866.73	835.97
83070	03/11/83	.	869.75	849.69	865.88	835.88
83080	03/21/83	876.78	869.56	849.50	864.27	835.81
83094	04/04/83	876.72	869.52	850.35	866.14	837.39
83109	04/19/83	877.93	869.92	851.56	867.98	836.37
83117	04/27/83	.	870.34	851.43	868.08	836.93
83124	05/04/83	875.04	870.28	849.66	867.13	836.50
83131	05/11/83	873.60	870.61	849.82	866.73	836.79
83138	05/18/83	874.29	870.28	849.72	865.45	836.37
83150	05/30/83	874.52	870.28	850.32	865.68	836.63
83154	06/03/83	873.11	870.05	850.64	867.36	836.53
83159	06/08/83	872.25	869.23	849.46	866.63	836.30
83166	06/15/83	871.47	869.26	849.40	865.42	836.14
83174	06/23/83	870.12	869.29	849.07	863.98	836.24
83180	06/29/83	869.50	868.97	848.71	862.93	835.38
83192	07/11/83	867.59	868.08	847.82	860.14	835.38
83199	07/18/83	867.79	867.75	847.79	860.14	825.28
83207	07/26/83	867.56	867.82	847.43	859.35	825.48
83214	08/02/83	867.59	867.56	846.74	858.43	834.56
83222	08/10/83	865.92	866.93	847.26	858.73	834.69
83230	08/18/83	865.86	866.80	846.84	858.73	834.30
83237	08/25/83	865.63	866.51	846.94	858.76	834.40
83251	09/08/83	865.36	866.01	846.12	857.55	834.04
83258	09/15/83	865.43	865.78	845.95	857.35	834.14
83279	10/06/83	862.71	865.42	845.69	856.76	832.86
83297	10/24/83	861.62	865.23	844.97	856.04	833.28
83308	11/04/83	861.23	865.06	844.28	855.90	834.14
83315	11/11/83	861.39	864.80	844.41	855.81	834.04

Table F.1. (continued)

DATE	DATE	7-1	7-2	7-3	7-4	7-5
83320	11/16/83	861.59	862.31	844.44	855.68	834.04
83327	11/23/83	862.08	861.16	844.15	855.77	833.97
83336	12/02/83	862.57	851.22	831.25	841.34	832.76
83343	12/09/83	862.48	862.83	843.72	860.66	832.92
83349	12/15/83	863.59	867.00	849.00	864.53	833.09
83356	12/22/83	865.04	867.10	848.74	864.30	833.28
83364	12/30/83	865.40	.	849.33	865.81	833.35
84006	01/06/84	866.58	867.82	849.00	866.24	833.64
84013	01/13/84	866.38	867.33	848.45	864.76	833.64
84020	01/20/84	866.81	867.82	848.87	865.75	833.64
84023	01/23/84	867.33	868.05	849.27	866.21	833.74
84024	01/24/84	.	868.21	849.33	.	.
84025	01/25/84	867.66	868.24	849.23	866.63	833.91
84026	01/26/84	867.66	868.18	849.30	866.83	833.94
84027	01/27/84	.	867.75	.	.	829.41
84037	02/06/84	868.68	868.18	848.90	865.91	833.84
84041	02/10/84	868.41	867.95	848.61	864.80	833.84
84047	02/16/84	868.28	868.47	849.30	866.60	834.04
84055	02/24/84	868.64	868.47	849.07	866.31	834.10
84063	03/03/84	869.14	868.60	850.68	867.39	834.30
84068	03/08/84	869.73	868.70	849.33	866.76	834.47
84076	03/16/84	869.30	868.74	849.00	865.62	834.40
84082	03/22/84	869.96	869.26	850.64	867.36	834.53
84095	04/04/84	871.70	869.52	851.40	868.24	835.29
84104	04/13/84	872.29	.	850.45	867.49	835.51
84118	04/27/84	871.33	869.39	849.66	865.29	835.35
84125	05/04/84	872.12	870.31	854.88	869.82	835.97
84130	05/09/84	875.57	870.93	859.73	872.83	837.58
84145	05/24/84	875.01	870.61	855.04	869.36	837.22
84159	06/07/84	871.89	869.65	848.67	866.73	836.79
84172	06/20/84	870.45	870.57	847.92	865.12	836.34
84180	06/28/84	869.50	868.57	847.66	864.11	835.88
84188	07/06/84	868.97	866.21	847.40	863.55	835.81
84192	07/10/84	868.97	867.72	848.02	864.27	835.88
84200	07/18/84	868.97	868.83	847.40	865.62	835.94
84212	07/30/84	868.45	868.80	847.92	864.99	835.19
84223	08/10/84	867.92	.	846.97	863.58	834.47
84230	08/17/84	867.63	868.57	847.20	863.09	834.66
84237	08/24/84	875.83	868.38	847.26	862.14	834.69
84242	08/29/84	865.36	868.28	847.07	861.38	834.63
84251	09/07/84	864.58	867.78	846.74	860.63	834.56
84258	09/14/84	864.12	867.72	846.61	860.10	834.50
84268	09/24/84	863.39	867.33	846.08	859.19	834.14
84276	10/02/84	862.87	867.06	846.02	858.63	834.14
84284	10/10/84	859.52	866.83	845.75	858.37	833.91

Table F.1. (continued)

DATE	DATE	7-1	7-2	7-3	7-4	7-5
84297	10/23/84	859.79	866.80	845.69	858.50	833.78
84314	11/09/84	.	.	.	.	.
84325	11/20/84	862.08	867.49	847.30	861.25	833.15
84338	12/03/84	863.17	868.05	848.64	864.01	833.61
84347	12/12/84	864.38	868.18	848.61	864.07	833.68
84361	12/26/84	864.12	868.21	848.58	862.83	833.45
85002	01/02/85	865.59	868.41	848.97	864.37	833.42
85017	01/17/85	867.40	868.77	848.90	864.89	833.74
85025	01/25/85	867.20	868.57	848.38	862.89	833.64
85038	02/07/85	867.30	869.00	851.23	868.11	834.10
85046	02/15/85	868.97	869.10	850.18	867.72	834.30
85053	02/22/85	.	.	850.25	867.55	834.43
85063	03/04/85	870.68	869.03	849.27	866.57	834.33
85067	03/08/85	869.30	868.97	849.00	866.24	834.47
85074	03/15/85	870.68	869.16	849.10	866.47	834.20
85081	03/22/85	870.68	869.20	852.35	865.39	834.43
85088	03/29/85	870.61	869.36	849.04	865.94	834.40
85094	04/04/85	870.55	869.29	849.63	866.54	834.33
85101	04/11/85	870.28	869.26	849.72	866.67	834.33
85107	04/17/85	870.61	869.46	849.23	866.40	834.27
85129	05/09/85	869.27	868.87	848.22	862.99	834.37
85137	05/17/85	869.04	868.83	847.89	868.93	834.27
85144	05/24/85	868.38	868.57	847.40	860.96	834.01
85151	05/31/85	867.63	868.15	847.07	860.24	834.07
85158	06/07/85	867.69	868.08	846.90	860.07	834.04
85164	06/13/85	867.79	867.72	846.84	860.04	833.97
85172	06/21/85	866.28	867.36	846.41	858.79	833.71
85178	06/27/85	866.12	867.49	846.31	859.12	833.61
85183	07/02/85	866.05	867.33	846.41	858.92	833.58
85192	07/11/85	865.95	867.16	846.38	858.56	833.55
85199	07/18/85	865.43	867.03	842.83	858.33	833.35
85207	07/26/85	865.66	867.06	846.02	858.17	833.28
85213	08/01/85	865.76	867.16	846.21	857.77	833.25
85221	08/09/85	865.79	867.29	846.35	857.81	833.12
85231	08/19/85	865.82	868.28	846.97	859.45	833.28
85238	08/26/85	865.86	868.08	847.13	858.99	832.96
85240	08/28/85	.	.	.	.	833.30
85246	09/03/85	866.61	868.21	847.43	859.74	833.09
85256	09/13/85	866.64	868.11	847.10	859.42	833.05
85263	09/20/85	866.05	867.82	846.80	858.76	832.79
85268	09/25/85	865.92	867.69	846.35	858.33	832.79
85276	10/03/85	865.63	867.39	846.12	858.37	832.73
85282	10/09/85	865.69	867.36	846.08	857.68	832.79
85284	10/11/85	864.71	866.34	845.85	858.17	832.59
85296	10/23/85	865.40	867.42	845.75	857.48	832.76

Table F.1. (continued)

DATE	DATE	7-1	7-2	7-3	7-4	7-5
85305	11/01/85	865.49	867.33	845.82	857.41	832.76
85310	11/06/85	864.28	866.70	845.79	856.56	831.71
85318	11/14/85	865.69	867.49	846.25	857.15	832.73
85324	11/20/85	865.49	867.42	846.08	856.99	832.59
85331	11/27/85	865.53	866.60	846.05	857.41	832.33
85338	12/04/85	865.89	868.01	847.13	857.45	835.48
85345	12/11/85	865.86	868.51	847.33	858.40	835.58
85352	12/18/85	866.38	867.98	847.17	856.66	831.81
85360	12/26/85	867.33	868.70	847.72	857.74	832.73
86002	01/02/86	867.33	868.54	847.36	857.48	833.22
86008	01/08/86	867.17	868.34	847.30	857.32	832.66
86015	01/15/86	867.27	868.67	847.13	857.41	833.38
86023	01/23/86	866.64	868.15	847.03	857.12	832.73
86029	01/29/86	867.27	868.74	846.90	857.15	832.73
86036	02/05/86	867.59	868.67	847.43	857.68	833.32
86044	02/13/86	867.96	868.83	848.45	858.14	832.73
86050	02/19/86	868.94	870.08	851.00	866.21	833.19
86057	02/26/86	870.25	869.79	850.35	864.80	833.55
86064	03/05/86	869.79	869.59	849.13	863.75	833.61
86071	03/12/86	871.11	869.39	848.87	862.07	833.71
86077	03/18/86	870.94	869.62	849.59	864.50	833.84
86085	03/26/86	871.33	869.79	849.43	865.78	834.10
86094	04/04/86	871.47	869.10	849.00	863.45	834.01
86099	04/09/86	871.33	869.65	848.74	862.30	833.97
86114	04/24/86	870.19	869.13	847.72	859.25	833.94
86120	04/30/86	869.96	869.03	847.66	858.76	833.61
86129	05/09/86	869.43	868.64	847.03	858.27	833.32
86134	05/14/86	869.30	867.13	846.80	857.77	833.09
86148	05/28/86	868.38	866.73	846.61	857.55	833.35
86155	06/04/86	868.22	867.75	846.67	857.48	833.42
86164	06/13/86	867.89	867.46	846.55	857.42	833.25
86241	08/29/86	868.02	867.71	846.27	856.72	834.99
86247	09/04/86	864.95	865.95	844.77	855.27	832.54
86255	09/12/86	864.95	866.59	844.57	855.24	832.47
86262	09/19/86	864.95	865.29	844.48	855.51	832.43
86269	09/26/86	864.81	865.45	844.21	855.21	832.32
86276	10/03/86	864.83	865.51	844.17	854.94	832.32
86283	10/10/86	864.41	865.47	844.04	854.86	832.25
86290	10/17/86	865.26	865.62	843.99	854.58	832.25
86294	10/21/86	864.20	.	.	.	.
86297	10/24/86	.	865.36	843.81	854.88	832.11
86304	10/31/86	.	865.71	843.86	855.33	832.11
86311	11/07/86	.	865.71	843.78	855.64	832.11
86318	11/14/86	864.27	866.11	844.18	856.31	833.09
86325	11/21/86	864.37	866.43	844.42	856.51	832.08

Table F.1. (continued)

DATE	DATE	7-1	7-2	7-3	7-4	7-5
86330	11/26/86	864.72	867.41	844.54	864.19	832.13
86339	12/05/86	866.07	866.93	845.28	866.83	832.09
86346	12/12/86	865.94	868.77	847.47	867.79	832.34
86353	12/19/86	866.81	868.52	848.63	867.36	832.51
87009	01/09/87	868.22	868.48	847.36	863.96	832.80
87022	01/22/87	868.22	869.21	848.78	867.02	833.00
87030	01/30/87	869.42	869.29	850.31	867.73	833.43
87037	02/06/87	870.25	869.12	849.28	867.20	833.58
87051	02/20/87	870.42	869.17	849.30	867.03	833.72
87065	03/06/87	873.51	869.88	852.12	868.09	834.81
87086	03/27/87	874.14	870.23	849.63	867.08	834.81
87100	04/10/87	874.40	870.43	850.78	867.22	834.92
87114	04/24/87	875.09	870.74	850.98	867.04	835.25
87121	05/01/87	874.49	870.50	850.78	867.14	834.70
87128	05/08/87	873.64	870.17	849.08	864.69	834.70
87142	05/22/87	872.27	869.45	848.10	862.66	834.80
87156	06/05/87	870.71	870.06	847.76	862.06	834.71
87170	06/19/87	870.24	868.17	846.89	859.74	834.31
87198	07/17/87	868.49	867.27	846.28	858.47	833.87
87212	07/31/87	867.67	866.96	845.92	858.05	833.66
87226	08/14/87	867.09	866.58	845.45	857.52	833.45
87240	08/28/87	866.42	866.14	845.03	857.09	.
87254	09/11/87	865.74	865.77	844.58	856.70	833.14
87282	10/09/87	864.57	865.10	843.71	855.97	832.75
87316	11/12/87	863.27	864.78	843.10	855.02	832.38
87336	12/02/87	863.12	866.25	843.02	854.71	832.14
88011	01/11/88	863.02	865.03	843.62	855.95	832.10
88035	02/04/88	864.02	866.67	846.03	868.32	835.01
88062	03/02/88	865.76	866.92	847.14	863.85	832.18
88097	04/06/88	867.86	867.86	847.85	864.46	832.72

Table F.2. Groundwater elevations (in feet) at Wells 7-6 through 7-10

DATE	DATE	7-6	7-7	7-8	7-9	7-10
82004	01/04/82	824.57	806.18	797.52	815.83	.
82007	01/07/82	819.91	805.56	797.45	815.67	.
82013	01/13/82	820.24	804.67	796.18	815.83	.
82021	01/21/82	838.48	805.85	796.18	816.45	.
82028	01/28/82	821.91	805.03	795.85	816.22	.
82035	02/04/82	834.87	805.75	797.68	816.42	.
82042	02/11/82	826.90	805.56	797.52	817.04	.
82049	02/18/82	833.59	805.85	797.52	817.44	.
82056	02/25/82	823.98	804.80	797.36	817.87	.
82068	03/09/82	830.51	804.83	797.36	818.42	.
82074	03/15/82	839.63	805.66	797.09	819.11	.
82077	03/18/82	830.05	805.69	797.36	819.51	.
82085	03/26/82	816.86	805.43	797.03	820.33	.
82091	04/01/82	839.04	805.82	797.03	820.85	.
82104	04/14/82	824.83	804.90	795.68	821.93	.
82111	04/21/82	824.15	804.87	795.19	821.70	.
82119	04/29/82	823.98	805.16	797.03	822.20	.
82130	05/10/82	.	804.57	794.31	823.11	.
82141	05/21/82	822.77	804.51	792.70	823.21	.
82161	06/10/82	821.49	804.34	792.43	819.18	.
82166	06/15/82	820.21	804.47	793.03	819.83	.
82168	06/17/82	821.23	804.57	792.40	820.92	.
82214	08/02/82	819.62	804.90	793.58	819.28	.
82225	08/13/82	.	.	794.53	819.11	.
82298	10/25/82	818.44	804.51	792.89	817.60	825.45
82337	12/03/82	826.28	806.97	792.24	819.60	825.35
83005	01/05/83	823.26	805.26	797.03	820.10	826.92
83014	01/14/83	823.46	805.29	797.03	818.42	825.68
83020	01/20/83	823.06	805.06	797.03	820.06	828.60
83027	01/27/83	822.24	805.06	795.52	820.26	829.81
83035	02/04/83	828.15	805.88	779.54	820.39	828.47
83041	02/10/83	842.78	806.51	797.36	821.01	827.81
83047	02/16/83	824.60	805.46	796.50	821.38	831.85
83056	02/25/83	824.24	805.59	798.24	821.51	832.08
83062	03/03/83	824.24	805.23	795.72	.	833.75
83070	03/11/83	823.42	805.72	795.55	821.51	835.65
83080	03/21/83	827.56	805.62	795.68	821.67	832.90
83094	04/04/83	822.67	805.29	796.18	821.57	832.57
83109	04/19/83	824.77	805.46	795.75	822.46	834.14
83117	04/27/83	825.06	806.28	797.00	823.34	834.37
83124	05/04/83	825.42	806.08	796.18	823.08	.
83131	05/11/83	824.11	806.44	796.27	823.28	.
83138	05/18/83	823.95	806.34	796.21	823.15	.

Table F.2. (continued)

DATE	DATE	7-6	7-7	7-8	7-9	7-10
83150	05/30/83	824.28	806.38	796.24	823.31	.
83154	06/03/83	824.11	804.54	794.21	823.38	834.41
83159	06/08/83	823.55	804.93	794.27	823.11	833.55
83166	06/15/83	822.90	804.77	792.86	823.11	832.83
83174	06/23/83	822.28	805.26	792.66	822.33	832.93
83180	06/29/83	822.08	804.74	792.34	822.20	832.40
83192	07/11/83	820.86	803.85	791.06	821.11	831.06
83199	07/18/83	820.86	803.92	790.89	821.21	830.86
83207	07/26/83	820.86	803.98	794.24	821.34	830.80
83214	08/02/83	819.62	803.59	790.79	821.01	830.50
83222	08/10/83	819.72	803.26	790.20	819.77	827.61
83230	08/18/83	819.75	803.59	790.07	819.74	830.14
83237	08/25/83	819.45	803.10	789.81	819.77	827.02
83251	09/08/83	818.80	802.96	789.88	818.75	827.52
83258	09/15/83	818.80	802.87	789.94	818.03	827.55
83279	10/06/83	838.84	804.90	789.58	817.96	821.41
83297	10/24/83	817.71	804.44	791.71	817.44	824.14
83308	11/04/83	817.48	804.21	790.93	817.04	.
83315	11/11/83	817.58	804.34	791.65	817.67	823.12
83320	11/16/83	817.88	804.80	792.14	820.39	823.25
83327	11/23/83	817.85	804.77	792.53	822.29	823.32
83336	12/02/83	818.57	804.93	794.93	823.34	823.58
83343	12/09/83	820.54	805.29	796.01	817.14	823.97
83349	12/15/83	821.85	805.39	796.50	817.18	824.27
83356	12/22/83	820.01	805.62	796.14	817.27	824.33
83364	12/30/83	827.79	805.49	796.44	817.31	824.17
84006	01/06/84	820.50	805.13	796.01	817.47	824.27
84013	01/13/84	820.41	805.23	796.14	817.37	830.63
84020	01/20/84	828.77	805.49	796.57	817.41	824.30
84023	01/23/84	821.23	805.16	796.08	817.47	824.33
84024	01/24/84	.	.	796.21	.	824.53
84025	01/25/84	835.24	805.72	796.70	817.50	824.63
84026	01/26/84	832.84	805.59	796.57	817.54	824.63
84037	02/06/84	820.90	805.00	795.81	817.73	825.25
84041	02/10/84	820.90	805.03	795.52	817.77	825.42
84047	02/16/84	825.75	805.52	796.83	817.93	830.50
84055	02/24/84	821.49	805.29	796.57	818.13	827.55
84063	03/03/84	824.15	805.46	796.70	818.42	826.83
84068	03/08/84	822.24	805.46	796.50	818.62	828.07
84076	03/16/84	821.91	805.33	795.88	818.46	829.02
84082	03/22/84	834.25	805.92	797.19	819.01	830.07
84095	04/04/84	841.90	806.21	796.80	820.00	832.31
84104	04/13/84	824.64	805.26	795.85	820.65	832.63
84118	04/27/84	824.38	805.59	795.62	821.18	832.04

Table F.2. (continued)

DATE	DATE	7-6	7-7	7-8	7-9	7-10
84125	05/04/84	840.16	806.28	797.49	822.00	832.83
84130	05/09/84	840.55	806.41	797.52	823.64	834.57
84145	05/24/84	839.93	806.08	795.16	823.25	830.99
84159	06/07/84	823.85	804.97	793.29	823.84	831.12
84172	06/20/84	822.54	804.54	791.68	822.92	829.45
84180	06/28/84	821.78	804.44	791.32	822.43	829.71
84188	07/06/84	821.55	805.36	794.17	822.03	830.07
84192	07/10/84	823.98	805.75	794.83	821.80	829.65
84200	07/18/84	831.63	806.21	794.57	821.54	829.19
84212	07/30/84	821.03	805.26	795.16	821.15	828.63
84223	08/10/84	820.21	804.97	793.09	820.59	827.68
84230	08/17/84	820.31	804.87	793.03	820.39	827.48
84237	08/24/84	820.31	804.77	792.60	820.10	827.09
84242	08/29/84	819.98	804.70	792.14	819.77	826.83
84251	09/07/84	820.21	804.34	791.52	819.64	825.87
84258	09/14/84	819.65	804.31	791.32	819.24	825.84
84268	09/24/84	819.39	803.92	790.73	819.01	825.19
84276	10/02/84	819.13	803.98	790.37	818.82	824.89
84284	10/10/84	818.93	803.85	790.47	818.52	824.69
84297	10/23/84	827.43	805.82	792.70	818.13	824.79
84314	11/09/84	.	.	.	.	.
84325	11/20/84	823.88	805.69	797.23	817.77	824.50
84338	12/03/84	819.75	805.46	796.54	817.67	824.63
84347	12/12/84	819.72	805.23	796.08	817.73	824.82
84361	12/26/84	819.62	805.49	797.26	817.47	824.96
85002	01/02/85	819.65	805.62	797.23	817.08	824.82
85017	01/17/85	820.37	805.23	795.52	817.67	825.58
85025	01/25/85	820.34	805.23	795.13	817.64	825.81
85038	02/07/85	823.69	805.72	796.83	817.93	826.10
85046	02/15/85	822.24	805.52	796.63	818.36	826.83
85053	02/22/85	822.37	805.29	796.80	818.49	827.58
85063	03/04/85	822.31	805.29	795.95	819.11	829.25
85067	03/08/85	821.95	805.13	795.65	819.11	829.35
85074	03/15/85	822.05	805.46	795.95	819.14	829.62
85081	03/22/85	821.78	804.97	794.04	819.28	830.40
85088	03/29/85	821.72	805.33	795.81	819.28	830.34
85094	04/04/85	821.75	805.33	795.85	819.34	830.47
85101	04/11/85	821.82	805.36	796.01	819.57	830.73
85107	04/17/85	821.62	805.26	795.91	819.47	830.30
85129	05/09/85	820.96	804.97	794.27	819.67	830.27
85137	05/17/85	820.57	805.10	793.32	819.34	830.27
85144	05/24/85	820.04	804.80	792.34	819.11	829.81
85151	05/31/85	820.04	804.61	791.68	819.11	829.19
85158	06/07/85	819.95	804.61	792.01	819.11	829.06

Table F.2. (continued)

DATE	DATE	7-6	7-7	7-8	7-9	7-10
85164	06/13/85	819.78	804.90	792.27	818.85	828.89
85172	06/21/85	819.19	804.77	792.27	818.52	827.88
85178	06/27/85	819.19	804.28	791.16	818.09	827.91
85183	07/02/85	819.13	804.93	792.34	818.06	827.84
85192	07/11/85	818.99	785.21	792.14	818.00	827.45
85199	07/18/85	818.50	804.34	790.96	817.83	826.63
85207	07/26/85	818.53	804.97	791.91	817.77	826.43
85213	08/01/85	818.47	804.38	791.88	817.44	825.78
85221	08/09/85	818.40	805.03	792.73	817.34	825.65
85231	08/19/85	820.21	805.79	795.85	817.41	826.01
85238	08/26/85	818.67	805.92	795.55	817.18	825.42
85246	09/03/85	819.16	805.13	794.04	817.24	825.22
85256	09/13/85	819.13	804.90	792.73	817.11	825.09
85263	09/20/85	818.83	804.57	791.75	816.78	824.60
85268	09/25/85	818.40	804.67	792.04	816.72	824.37
85276	10/03/85	818.47	805.20	793.78	816.82	824.27
85282	10/09/85	818.31	804.93	792.34	816.55	824.17
85284	10/11/85	818.01	804.80	790.99	816.62	822.89
85296	10/23/85	818.17	805.13	792.27	816.65	824.23
85305	11/01/85	817.98	805.00	793.16	816.26	823.84
85310	11/06/85	816.93	805.62	795.75	815.40	822.89
85318	11/14/85	818.21	805.20	794.17	816.49	825.51
85324	11/20/85	818.14	805.13	793.88	816.16	823.68
85331	11/27/85	817.88	805.39	794.76	815.34	823.51
85338	12/04/85	818.70	805.82	796.31	815.44	823.35
85345	12/11/85	818.40	805.33	795.16	816.42	824.89
85352	12/18/85	818.17	804.47	794.40	815.44	823.74
85360	12/26/85	819.19	805.20	794.57	816.22	824.96
86002	01/02/86	819.16	805.62	795.55	816.39	825.38
86008	01/08/86	818.63	805.13	794.83	816.45	824.82
86015	01/15/86	818.93	805.13	794.40	816.19	824.73
86023	01/23/86	818.76	805.16	794.76	816.32	824.63
86029	01/29/86	818.93	805.52	795.65	816.16	824.86
86036	02/05/86	818.99	806.08	796.14	816.22	825.25
86044	02/13/86	819.22	805.75	796.44	816.45	825.35
86050	02/19/86	832.68	806.51	797.52	816.85	826.79
86057	02/26/86	821.03	805.82	796.77	816.39	827.19
86064	03/05/86	821.03	805.56	795.55	816.29	827.15
86071	03/12/86	820.93	805.52	794.73	817.31	827.91
86077	03/18/86	821.39	805.69	796.40	817.54	828.30
86085	03/26/86	822.14	805.62	796.60	816.49	829.02
86094	04/04/86	821.62	805.23	794.31	818.16	829.32
86099	04/09/86	821.55	805.26	794.37	818.03	829.32
86114	04/24/86	820.80	804.97	793.58	818.42	828.43

Table F.2. (continued)

DATE	DATE	7-6	7-7	7-8	7-9	7-10
86120	04/30/86	820.63	804.67	793.16	818.39	828.20
86129	05/09/86	820.41	804.31	792.53	818.39	827.94
86134	05/14/86	819.55	803.88	792.24	818.13	827.71
86148	05/28/86	820.77	804.44	793.12	818.29	827.19
86155	06/04/86	819.52	804.67	792.14	818.13	826.79
86164	06/13/86	819.36	804.57	791.81	817.54	826.47
86241	08/29/86	837.52	804.32	792.22	825.30	823.90
86247	09/04/86	837.39	804.13	791.80	824.17	823.73
86255	09/12/86	837.22	804.08	791.58	.	823.63
86261	09/18/86	.	.	.	822.18	.
86262	09/19/86	817.39	804.05	790.22	816.23	823.56
86269	09/26/86	817.04	803.92	789.65	816.13	823.36
86276	10/03/86	817.30	803.82	789.42	815.94	823.36
86283	10/10/86	816.95	803.69	789.13	815.94	823.13
86290	10/17/86	816.70	803.21	791.51	815.81	823.13
86297	10/24/86	816.70	804.00	790.18	815.74	822.78
86304	10/31/86	816.70	804.52	791.89	815.78	822.82
86311	11/07/86	816.65	804.52	791.13	815.66	822.71
86318	11/14/86	816.71	804.87	793.83	815.66	822.74
86325	11/21/86	816.71	805.06	793.80	815.56	823.03
86330	11/26/86	822.11	805.96	795.93	815.53	823.51
86339	12/05/86	824.70	806.13	795.61	816.65	824.03
86346	12/12/86	827.73	806.16	797.18	815.79	824.75
86353	12/19/86	818.60	805.60	796.71	815.82	824.95
87009	01/09/87	818.67	805.10	794.64	815.69	825.26
87022	01/22/87	820.10	805.77	796.93	815.86	825.83
87030	01/30/87	820.63	805.65	797.00	816.18	826.23
87037	02/06/87	820.87	805.54	796.40	816.36	826.48
87051	02/20/87	821.17	805.57	796.95	816.54	827.30
87065	03/06/87	823.54	805.44	796.80	817.48	830.27
87086	03/27/87	823.07	805.29	796.15	818.13	831.13
87100	04/10/87	823.29	805.44	796.45	818.71	831.56
87114	04/24/87	823.84	805.26	795.51	819.45	832.62
87121	05/01/87	823.18	805.13	794.17	819.69	832.48
87128	05/08/87	822.68	805.03	793.76	819.86	831.86
87142	05/22/87	821.75	805.10	792.90	820.04	830.81
87156	06/05/87	819.93	805.02	792.59	819.81	829.43
87170	06/19/87	820.39	804.71	791.48	819.51	829.22
87198	07/17/87	819.49	804.42	791.20	818.60	827.67
87212	07/31/87	819.02	803.58	790.14	818.30	826.84
87226	08/14/87	818.58	803.45	789.60	817.96	825.95
87240	08/28/87	818.08	802.84	789.03	817.61	825.19
87254	09/11/87	817.78	802.61	788.59	817.30	824.45
87282	10/09/87	817.15	803.67	788.52	816.71	823.10

Table F.2. (continued)

DATE	DATE	7-6	7-7	7-8	7-9	7-10
87316	11/12/87	816.63	803.95	788.63	816.16	821.95
87336	12/02/87	816.40	804.10	789.29	815.84	821.61
88011	01/11/88	816.19	804.73	792.53	815.36	821.84
88035	02/04/88	841.63	806.31	795.79	815.36	823.43
88062	03/02/88	817.76	804.94	795.36	815.24	824.15
88097	04/06/88	818.96	805.52	795.25	815.53	825.51

Table F.3. Groundwater elevations (in feet) at Wells 7-11 through 7-15

DATE	DATE	7-11	7-12	7-13	7-14	7-15
82298	10/25/82	826.11	866.68	796.01	849.42	.
82337	12/03/82	829.75	868.72	797.46	859.79	.
83005	01/05/83	831.75	.	796.18	861.03	.
83014	01/14/83	831.20	871.87	796.18	861.00	.
83020	01/20/83	831.26	872.29	795.72	860.64	.
83027	01/27/83	830.28	871.87	795.98	860.08	.
83035	02/04/83	831.10	871.64	796.41	861.72	.
83041	02/10/83	833.03	872.65	796.77	862.64	.
83047	02/16/83	832.90	872.85	796.54	862.44	.
83056	02/25/83	832.02	872.92	796.11	861.36	.
83062	03/03/83	832.21	875.15	796.01	861.98	.
83070	03/11/83	831.89	873.24	795.95	861.49	.
83080	03/21/83	831.43	873.47	796.28	861.53	.
83094	04/04/83	831.82	873.38	796.08	861.89	.
83109	04/19/83	833.76	874.10	796.08	862.08	.
83117	04/27/83	833.56	874.69	797.06	862.28	860.86
83124	05/04/83	832.84	873.77	796.57	862.21	868.07
83131	05/11/83	833.00	874.33	796.67	862.18	869.71
83138	05/18/83	832.71	873.64	796.51	862.15	869.39
83150	05/30/83	832.90	874.20	796.77	862.15	869.49
83154	06/03/83	833.43	874.16	795.85	862.12	870.44
83159	06/08/83	832.67	873.80	795.85	861.26	870.73
83166	06/15/83	832.05	873.15	795.39	860.38	868.60
83174	06/23/83	831.46	872.69	795.46	860.08	869.71
83180	06/29/83	831.39	872.16	795.33	860.02	869.55
83192	07/11/83	828.67	872.10	794.96	859.46	852.16
83199	07/18/83	827.78	.	794.73	859.46	861.35
83207	07/26/83	827.69	.	794.80	859.39	861.25
83214	08/02/83	827.78	869.80	794.67	859.49	861.41
83222	08/10/83	827.23	869.96	794.73	858.08	867.35
83230	08/18/83	827.29	869.11	794.67	857.85	866.50
83237	08/25/83	827.49	869.24	794.67	857.69	867.12
83251	09/08/83	826.54	868.65	794.83	857.62	867.09
83258	09/15/83	827.00	868.39	794.73	857.75	866.96
83279	10/06/83	825.68	867.70	793.95	856.28	865.52
83297	10/24/83	825.23	867.14	795.36	852.44	864.83
83308	11/04/83	825.03	866.85	794.96	855.23	864.24
83315	11/11/83	824.90	866.19	795.19	854.50	863.12
83320	11/16/83	824.70	866.65	795.19	853.98	861.22
83327	11/23/83	825.06	866.81	795.42	851.29	859.18
83336	12/02/83	826.44	863.40	.	840.07	849.64
83343	12/09/83	827.52	859.40	.	839.67	863.87

Table F.3. (continued)

DATE	DATE	7-11	7-12	7-13	7-14	7-15
83349	12/15/83	828.11	867.60	.	858.05	863.87
83356	12/22/83	828.80	867.93	.	858.15	864.17
83364	12/30/83	828.77	868.36	.	859.06	864.50
84006	01/06/84	829.69	868.72	.	859.36	868.40
84013	01/13/84	829.00	868.82	.	859.10	865.84
84020	01/20/84	829.29	869.05	.	859.82	865.42
84023	01/23/84	829.69	869.14	.	860.02	865.68
84024	01/24/84	.	869.31	.	860.05	865.78
84025	01/25/84	830.02	869.24	.	860.21	865.74
84026	01/26/84	829.95	869.34	.	860.15	865.81
84027	01/27/84	.	.	.	860.71	863.12
84037	02/06/84	.	869.64	.	860.15	866.43
84041	02/10/84	829.79	869.70	.	859.82	867.29
84047	02/16/84	830.08	869.90	.	860.64	866.83
84055	02/24/84	830.51	870.10	.	860.71	867.16
84063	03/03/84	830.90	870.32	.	861.30	867.52
84068	03/08/84	831.16	870.42	.	861.20	867.78
84076	03/16/84	831.00	870.55	.	860.97	867.81
84082	03/22/84	831.46	870.82	.	861.85	868.21
84095	04/04/84	833.49	871.18	.	862.41	868.83
84104	04/13/84	833.79	871.67	.	862.28	869.32
84118	04/27/84	832.74	871.44	.	861.69	869.45
84125	05/04/84	834.38	871.90	.	865.89	869.68
84130	05/09/84	838.68	872.42	.	864.31	870.24
84145	05/24/84	836.48	872.42	.	865.27	870.21
84159	06/07/84	831.98	872.56	.	860.80	870.37
84172	06/20/84	830.84	871.54	.	860.25	869.45
84180	06/28/84	830.11	871.28	.	859.66	869.35
84188	07/06/84	829.85	870.82	.	859.39	868.93
84192	07/10/84	829.75	870.78	.	859.43	869.09
84200	07/18/84	829.75	870.82	.	859.29	868.66
84212	07/30/84	829.59	870.82	.	859.26	868.24
84223	08/10/84	829.33	870.65	.	859.06	867.88
84230	08/17/84	829.23	870.36	.	858.90	867.71
84237	08/24/84	829.00	870.29	.	858.67	867.55
84242	08/29/84	828.67	870.19	.	858.57	867.55
84251	09/07/84	838.05	869.83	.	858.31	867.39
84258	09/14/84	827.98	869.54	.	858.18	867.06
84268	09/24/84	827.49	869.01	.	857.88	863.64
84276	10/02/84	827.10	868.72	.	857.59	866.70
84284	10/10/84	826.90	868.42	.	857.36	866.47
84297	10/23/84	826.83	865.11	.	856.31	866.20
84314	11/09/84	.	.	.	.	.
84325	11/20/84	827.98	868.06	.	857.69	864.83
84338	12/03/84	828.70	868.52	.	858.61	865.65

Table F.3. (continued)

DATE	DATE	7-11	7-12	7-13	7-14	7-15
84347	12/12/84	829.00	868.91	.	859.13	865.84
84361	12/26/84	828.87	869.11	.	859.33	866.07
85002	01/02/85	829.33	869.37	.	859.33	866.07
85017	01/17/85	830.31	870.32	.	860.11	866.83
85025	01/25/85	829.79	871.54	.	859.72	867.12
85038	02/07/85	830.67	870.65	.	861.43	867.48
85046	02/15/85	831.52	870.98	.	861.66	867.94
85053	02/22/85	825.78	871.01	.	861.39	868.11
85063	03/04/85	831.46	871.34	.	861.20	868.83
85067	03/08/85	831.10	871.21	.	861.13	868.50
85074	03/15/85	831.33	871.51	.	861.30	868.76
85081	03/22/85	831.43	875.18	.	861.23	868.83
85088	03/29/85	831.46	871.64	.	861.36	868.86
85094	04/04/85	831.85	871.74	.	861.43	868.96
85101	04/11/85	831.98	871.87	.	861.82	869.06
85107	04/17/85	832.12	871.83	796.70	861.26	869.09
85129	05/09/85	831.10	870.72	795.72	860.08	867.29
85137	05/17/85	830.67	871.08	795.39	859.79	868.11
85144	05/24/85	830.05	870.75	795.19	859.52	868.24
85151	05/31/85	829.13	867.24	795.06	859.16	868.04
85158	06/07/85	829.00	867.40	795.10	859.13	867.91
85164	06/13/85	828.67	870.06	795.16	858.90	867.84
85172	06/21/85	828.11	869.73	795.23	858.41	867.52
85178	06/27/85	827.92	869.54	794.80	858.21	867.16
85183	07/02/85	829.10	869.24	795.10	858.18	867.25
85192	07/11/85	827.55	869.08	795.06	857.92	866.99
85199	07/18/85	827.03	868.82	794.80	857.65	866.57
85207	07/26/85	827.06	868.68	795.19	857.52	866.60
85213	08/01/85	827.00	868.55	795.29	857.16	866.24
85221	08/09/85	.	868.72	795.36	857.13	866.17
85231	08/19/85	827.39	868.95	796.08	857.29	866.11
85238	08/26/85	827.52	868.98	796.05	857.49	865.88
85246	09/03/85	827.85	869.27	795.72	857.52	865.81
85256	09/13/85	827.72	869.70	795.42	857.46	865.78
85263	09/20/85	826.83	869.37	795.06	857.03	865.61
85268	09/25/85	827.03	869.14	795.19	856.87	865.48
85276	10/03/85	826.87	868.88	795.56	857.03	865.55
85282	10/09/85	826.93	868.95	795.39	857.10	865.52
85284	10/11/85	825.82	868.78	795.23	855.72	864.47
85296	10/23/85	826.83	868.68	795.49	856.70	865.42
85305	11/01/85	826.93	868.42	795.49	856.44	865.25
85310	11/06/85	826.08	868.36	795.69	855.46	864.33
85318	11/14/85	827.13	868.75	795.72	856.34	865.09
85324	11/20/85	826.93	869.14	795.49	856.14	864.86
85331	11/27/85	826.31	868.55	794.87	855.23	865.55

Table F.3. (continued)

DATE	DATE	7-11	7-12	7-13	7-14	7-15
85338	12/04/85	827.75	868.72	796.01	855.78	864.60
85345	12/11/85	832.77	869.27	795.69	857.13	864.96
85352	12/18/85	827.42	868.52	794.64	856.70	864.01
85360	12/26/85	828.38	869.60	795.69	857.88	865.19
86002	01/02/86	828.38	869.67	795.92	857.79	865.35
86008	01/08/86	828.05	869.57	795.85	857.72	865.32
86015	01/15/86	828.21	869.60	795.72	858.08	865.48
86023	01/23/86	827.82	869.27	795.69	858.08	865.38
86029	01/29/86	828.38	869.57	795.85	858.54	865.65
86036	02/05/86	828.51	869.57	796.18	858.84	865.74
86044	02/13/86	828.77	.	795.88	859.33	865.88
86045	02/14/86	.	869.90	.	.	.
86050	02/19/86	829.72	870.00	796.41	860.74	866.27
86057	02/26/86	830.54	870.75	796.08	861.07	866.79
86064	03/05/86	830.08	871.01	795.78	860.80	866.83
86071	03/12/86	830.64	870.72	795.95	860.67	867.12
86077	03/18/86	831.03	871.18	.	861.23	867.39
86085	03/26/86	831.75	871.24	796.24	861.46	867.81
86094	04/04/86	831.26	871.37	795.82	860.80	868.17
86099	04/09/86	831.20	871.37	795.85	860.87	868.37
86114	04/24/86	830.08	870.85	795.65	860.44	868.34
86120	04/30/86	829.59	870.69	.	860.11	868.17
86129	05/09/86	829.26	870.23	795.19	859.72	868.17
86134	05/14/86	829.16	869.90	795.16	859.43	868.01
86148	05/28/86	828.38	869.21	795.69	859.00	866.14
86155	06/04/86	828.18	869.14	795.16	858.67	867.52
86164	06/13/86	827.75	868.85	795.03	858.31	867.32
86236	08/24/86	826.06	.	.	.	.
86241	08/29/86	.	868.93	795.68	857.71	870.16
86247	09/04/86	825.31	866.71	795.07	856.09	865.07
86255	09/12/86	825.16	867.42	795.24	856.21	865.07
86262	09/19/86	825.00	866.30	795.07	855.67	865.58
86269	09/26/86	824.81	866.12	794.88	855.51	864.31
86276	10/03/86	824.83	866.04	794.70	855.57	864.23
86283	10/10/86	824.62	865.96	794.27	855.43	864.10
86290	10/17/86	824.62	866.00	795.13	855.13	863.91
86297	10/24/86	824.47	864.74	795.13	854.88	863.67
86304	10/31/86	824.54	865.80	.	854.81	863.63
86311	11/07/86	824.46	865.80	.	854.69	863.44
86318	11/14/86	824.69	865.96	795.58	854.61	863.33
86325	11/21/86	824.99	866.18	795.67	854.61	863.27
86330	11/26/86	851.03	866.34	797.22	854.67	863.21
86339	12/05/86	842.63	866.44	797.09	855.23	.
86340	12/06/86	.	.	.	.	863.21
86346	12/12/86	826.92	867.45	796.35	855.82	863.19

Table F.3. (continued)

DATE	DATE	7-11	7-12	7-13	7-14	7-15
86353	12/19/86	827.92	867.87	796.05	856.79	863.27
87009	01/09/87	828.26	868.91	795.67	857.28	864.07
87022	01/22/87	828.89	869.03	796.13	858.58	864.51
87030	01/30/87	830.09	869.39	796.08	859.69	864.89
87037	02/06/87	830.16	869.78	795.95	859.69	865.29
87051	02/20/87	830.29	870.24	796.16	860.45	866.02
87065	03/06/87	832.78	871.16	796.12	861.94	866.99
87086	03/27/87	832.61	871.52	796.02	861.82	868.27
87100	04/10/87	833.16	871.98	796.14	862.53	868.79
87114	04/24/87	834.02	872.45	796.01	862.56	869.23
87121	05/01/87	833.22	872.20	795.73	861.73	869.28
87128	05/08/87	832.20	871.94	795.55	861.11	869.28
87142	05/22/87	830.82	871.25	795.47	860.21	868.92
87156	06/05/87	830.68	870.42	795.47	860.84	868.71
87170	06/19/87	828.58	869.95	795.07	859.11	868.10
87198	07/17/87	827.40	868.77	794.95	858.06	867.11
87212	07/31/87	826.71	868.28	793.92	857.70	866.64
87226	08/14/87	826.15	867.88	794.12	857.17	866.17
87240	08/28/87	825.63	867.32	793.27	856.75	865.68
87254	09/11/87	825.16	866.94	792.99	856.27	865.16
87282	10/09/87	824.37	866.25	794.11	855.29	864.20
87316	11/12/87	823.76	865.44	795.03	854.38	863.21
87336	12/02/87	823.59	865.06	795.05	853.98	862.62
88011	01/11/88	824.17	864.47	795.30	853.38	861.81
88035	02/04/88	825.87	865.37	796.38	854.68	861.51
88062	03/02/88	827.16	.	795.40	856.65	862.22
88070	03/10/88	.	864.45	.	.	.
88097	04/06/88	828.34	866.86	795.87	856.72	860.31

Table F.4. Groundwater elevations (in feet) at Wells 7-16 through 7-18

DATE	DATE	7-16	7-17	7-18
83117	04/27/83	871.47	867.01	863.95
83124	05/04/83	872.88	866.29	862.28
83131	05/11/83	873.63	866.45	862.80
83138	05/18/83	873.53	865.47	863.49
83150	05/30/83	873.63	865.50	863.65
83154	06/03/83	874.06	866.55	862.47
83159	06/08/83	873.37	866.06	861.42
83166	06/15/83	873.40	865.47	860.41
83174	06/23/83	873.43	864.81	859.62
83180	06/29/83	872.81	864.68	859.06
83192	07/11/83	855.39	856.38	857.06
83199	07/18/83	855.39	863.24	856.99
83207	07/26/83	855.75	862.91	856.99
83214	08/02/83	855.39	862.78	.
83222	08/10/83	870.58	862.81	855.65
83230	08/18/83	870.55	862.32	855.81
83237	08/25/83	870.35	862.25	.
83251	09/08/83	869.76	861.53	.
83258	09/15/83	869.92	860.42	853.61
83279	10/06/83	868.91	860.55	853.42
83297	10/24/83	868.19	859.14	852.63
83308	11/04/83	867.59	858.38	852.63
83315	11/11/83	867.14	857.99	852.60
83320	11/16/83	867.66	858.12	852.79
83327	11/23/83	867.10	858.38	852.43
83336	12/02/83	866.94	844.50	853.32
83343	12/09/83	866.87	858.25	851.58
83349	12/15/83	866.97	864.65	859.98
83356	12/22/83	867.82	864.06	859.29
83364	12/30/83	868.35	865.96	861.19
84006	01/06/84	869.20	865.47	860.87
84013	01/13/84	869.46	865.04	860.41
84020	01/20/84	869.86	866.06	861.69
84023	01/23/84	870.02	865.76	861.82
84024	01/24/84	870.19	.	.
84025	01/25/84	870.29	865.80	861.72
84026	01/26/84	870.25	866.35	862.34
84027	01/27/84	867.33	.	860.21
84037	02/06/84	870.84	865.40	860.93
84041	02/10/84	870.81	865.04	860.24
84047	02/16/84	871.17	866.42	862.51
84055	02/24/84	871.47	865.76	861.42
84063	03/03/84	871.83	866.68	862.90
84068	03/08/84	871.86	866.12	861.92

Table F.4. (continued)

DATE	DATE	7-16	7-17	7-18
84076	03/16/84	871.93	865.47	861.06
84082	03/22/84	872.29	867.60	863.52
84095	04/04/84	873.01	867.34	863.52
84104	04/13/84	873.21	867.24	862.97
84118	04/27/84	879.70	866.16	862.57
84125	05/04/84	873.53	882.17	865.39
84130	05/09/84	874.39	871.67	867.23
84145	05/24/84	873.99	870.06	862.15
84159	06/07/84	873.57	865.93	861.06
84172	06/20/84	872.94	865.01	859.39
84180	06/28/84	872.68	864.71	858.96
84188	07/06/84	872.38	864.25	858.41
84192	07/10/84	872.16	864.29	858.57
84200	07/18/84	871.79	864.19	859.00
84212	07/30/84	871.56	864.22	859.36
84223	08/10/84	871.37	864.06	857.98
84230	08/17/84	871.27	863.86	857.85
84237	08/24/84	870.91	863.73	857.75
84242	08/29/84	870.78	863.40	857.42
84251	09/07/84	870.55	863.34	856.67
84258	09/14/84	870.35	863.27	856.44
84268	09/24/84	870.15	862.97	856.01
84276	10/02/84	869.60	862.81	855.55
84284	10/10/84	869.60	862.52	855.16
84297	10/23/84	869.33	862.32	854.86
84314	11/09/84	868.74	.	848.37
84325	11/20/84	868.51	863.01	858.80
84338	12/03/84	868.91	864.29	861.10
84347	12/12/84	869.30	864.52	860.80
84361	12/26/84	869.76	864.42	861.23
85002	01/02/85	870.06	864.45	861.16
85017	01/17/85	870.94	864.88	860.80
85025	01/25/85	871.01	864.42	859.49
85038	02/07/85	871.63	866.62	863.69
85046	02/15/85	871.63	866.45	863.16
85053	02/22/85	872.19	866.68	863.23
85063	03/04/85	872.29	865.96	862.11
85067	03/08/85	872.22	865.37	861.36
85074	03/15/85	872.45	865.17	862.05
85081	03/22/85	872.42	865.14	860.90
85088	03/29/85	872.52	865.30	862.21
85094	04/04/85	871.93	865.37	862.31
85101	04/11/85	869.30	865.50	862.60
85107	04/17/85	869.30	865.37	862.41
85129	05/09/85	871.79	864.25	859.46

Table F.4. (continued)

DATE	DATE	7-16	7-17	7-18
85137	05/17/85	871.89	864.02	855.39
85144	05/24/85	871.73	863.47	858.04
85151	05/31/85	871.47	863.30	857.19
85158	06/07/85	871.40	863.27	857.13
85164	06/13/85	870.94	863.17	856.86
85172	06/21/85	870.81	862.65	856.53
85178	06/27/85	870.61	862.65	856.04
85183	07/02/85	870.29	862.52	855.81
85192	07/11/85	870.19	862.29	855.52
85199	07/18/85	869.89	861.79	855.03
85207	07/26/85	869.79	862.22	854.93
85213	08/01/85	869.40	861.47	854.50
85221	08/09/85	869.27	861.43	854.60
85231	08/19/85	868.91	861.50	855.94
85238	08/26/85	868.81	861.60	855.85
85246	09/03/85	868.91	862.48	856.44
85256	09/13/85	868.87	862.29	855.88
85263	09/20/85	868.84	861.92	855.35
85268	09/25/85	868.61	861.50	854.83
85276	10/03/85	868.51	861.43	854.83
85282	10/09/85	868.51	861.20	854.70
85284	10/11/85	867.50	861.17	854.21
85296	10/23/85	868.38	861.04	853.55
85305	11/01/85	868.15	860.94	853.88
85310	11/06/85	867.20	859.73	852.93
85318	11/14/85	867.99	861.01	854.01
85324	11/20/85	867.79	860.55	853.84
85331	11/27/85	867.56	860.35	856.53
85338	12/04/85	866.48	860.38	857.55
85345	12/11/85	867.59	861.50	857.72
85352	12/18/85	866.71	860.87	857.19
85360	12/26/85	867.89	861.99	857.32
86002	01/02/86	868.19	861.86	857.39
86008	01/08/86	868.12	861.69	857.68
86015	01/15/86	868.48	861.86	857.16
86023	01/23/86	868.55	861.92	856.80
86029	01/29/86	868.58	861.60	858.18
86036	02/05/86	868.91	.	.
86044	02/13/86	864.71	862.52	858.54
86050	02/19/86	869.89	865.86	862.93
86057	02/26/86	870.58	865.07	861.82
86064	03/05/86	870.81	864.58	860.77
86071	03/12/86	871.14	864.19	859.65
86077	03/18/86	871.40	864.19	858.63
86085	03/26/86	872.09	865.24	861.72

Table F.4. (continued)

DATE	DATE	7-16	7-17	7-18
86094	04/04/86	872.19	864.62	860.21
86099	04/09/86	872.19	864.42	859.65
86114	04/24/86	871.83	863.47	858.04
86120	04/30/86	871.76	863.34	857.52
86129	05/09/86	871.47	863.20	857.13
86134	05/14/86	871.30	862.88	857.03
86148	05/28/86	871.04	862.29	856.53
86155	06/04/86	870.78	861.86	855.71
86164	06/13/86	870.25	861.73	855.26
86241	08/29/86	867.16	859.89	852.33
86247	09/04/86	868.10	858.31	852.35
86255	09/12/86	868.05	858.31	852.26
86262	09/19/86	867.79	857.89	852.06
86269	09/26/86	867.36	857.62	851.90
86276	10/03/86	867.66	857.52	851.94
86283	10/10/86	867.28	857.03	851.85
86290	10/17/86	867.09	857.03	851.55
86297	10/24/86	866.83	856.86	851.52
86304	10/31/86	866.74	856.89	851.83
86311	11/07/86	866.50	856.89	851.83
86318	11/14/86	866.43	856.89	851.76
86325	11/21/86	866.37	857.01	851.90
86330	11/26/86	866.15	857.12	851.96
86339	12/05/86	866.07	858.69	851.71
86346	12/12/86	865.79	859.20	856.98
86353	12/19/86	866.23	861.89	858.27
87009	01/09/87	867.40	861.77	857.53
87022	01/22/87	867.76	865.54	861.08
87030	01/30/87	868.73	865.73	862.41
87037	02/06/87	869.17	865.39	861.58
87051	02/20/87	870.09	865.72	862.15
87065	03/06/87	871.39	867.45	863.81
87086	03/27/87	872.24	866.06	862.33
87100	04/10/87	872.59	866.22	863.06
87114	04/24/87	873.08	866.09	862.65
87121	05/01/87	871.93	866.09	862.60
87128	05/08/87	872.78	865.09	860.17
87142	05/22/87	.	864.29	858.59
87143	05/23/87	872.26	.	.
87156	06/05/87	872.21	864.47	858.90
87170	06/19/87	871.40	863.23	856.84
87198	07/17/87	870.32	862.13	855.32
87212	07/31/87	869.86	861.67	854.80
87226	08/14/87	869.46	861.21	854.20
87240	08/28/87	868.83	860.59	853.71

Table F.4. (continued)

DATE	DATE	7-16	7-17	7-18
87254	09/11/87	868.46	859.99	853.15
87282	10/09/87	867.44	858.52	852.28
87316	11/12/87	866.51	857.02	851.48
87336	12/02/87	865.91	856.51	851.58
88011	01/11/88	864.84	856.26	851.49
88035	02/04/88	864.69	862.54	854.62
88062	03/02/88	865.80	862.04	857.67
88097	04/06/88	867.61	863.76	859.30

Table F.5. Groundwater elevations (in feet) at well screens 7-13L through 7-13H

DATE	DATE	7-13HI	7-13LO
83336	12/02/83	796.31	795.49
83343	12/09/83	796.51	795.62
83349	12/15/83	796.60	795.59
83356	12/22/83	796.77	795.82
83364	12/30/83	796.77	795.78
84006	01/06/84	796.47	795.46
84013	01/13/84	796.57	795.56
84020	01/20/84	796.80	795.78
84023	01/23/84	796.60	795.52
84025	01/25/84	797.03	795.78
84026	01/26/84	796.80	795.82
84037	02/06/84	796.38	795.42
84041	02/10/84	796.34	795.42
84047	02/16/84	794.83	795.75
84055	02/24/84	796.54	795.59
84063	03/03/84	796.77	795.72
84068	03/08/84	796.64	795.56
84076	03/16/84	796.60	795.59
84082	03/22/84	797.43	795.95
84095	04/04/84	797.43	796.28
84104	04/13/84	795.56	796.57
84118	04/27/84	.	795.82
84125	05/04/84	796.08	797.33
84130	05/09/84	796.11	797.43
84145	05/24/84	.	795.26
84159	06/07/84	795.10	796.05
84172	06/20/84	794.80	795.62
84180	06/28/84	794.64	795.39
84188	07/06/84	795.49	796.47
84192	07/10/84	.	795.59
84200	07/18/84	795.98	797.16
84212	07/30/84	795.42	796.47
84223	08/10/84	794.80	795.88
84230	08/17/84	.	794.57
84237	08/24/84	795.00	795.82
84242	08/29/84	794.87	795.65
84251	09/07/84	794.70	795.46
84258	09/14/84	794.70	795.46
84268	09/24/84	794.80	795.36
84276	10/02/84	795.46	794.73
84284	10/10/84	795.52	794.73
84297	10/23/84	796.87	796.01
84314	11/09/84	.	.
84325	11/20/84	795.56	796.74

Table F.5. (continued)

DATE	DATE	7-13HI	7-13LO
84338	12/03/84	795.75	796.74
84347	12/12/84	796.64	795.49
84361	12/26/84	796.77	795.69
85002	01/02/85	796.77	795.52
85017	01/17/85	796.74	795.46
85025	01/25/85	796.34	795.46
85038	02/07/85	795.78	796.93
85046	02/15/85	796.70	795.65
85053	02/22/85	796.80	795.69
85063	03/04/85	795.52	796.47
85067	03/08/85	796.34	795.19
85074	03/15/85	796.57	795.59
85081	03/22/85	796.51	795.59
85088	03/29/85	796.57	795.46
85094	04/04/85	796.57	795.49
85101	04/11/85	796.64	795.56

Table F.6. Groundwater elevations (in feet) for Wells 100 through 104

DATE	DATE	7-100	7-101	7-102	7-103	7-104
83249	09/06/83	837.86	.	.	.	.
83250	09/07/83	837.93	.	.	.	.
83277	10/04/83	.	841.51	853.37	.	.
83280	10/07/83	.	840.39	854.88	.	.
83284	10/11/83	.	.	853.79	.	.
83285	10/12/83	837.37	841.67	853.73	.	.
83286	10/13/83	837.37	842.59	.	.	.
83287	10/14/83	837.27	842.69	854.19	.	.
83293	10/20/83	837.40	843.12	853.27	.	.
83301	10/28/83	837.24	842.89	853.07	.	.
83307	11/03/83	837.20	.	.	.	.
83313	11/09/83	837.14	.	851.24	.	.
83315	11/11/83	.	.	847.69	.	.
83318	11/14/83	.	.	847.00	.	.
83320	11/16/83	837.14	842.72	846.51	.	.
83321	11/17/83	.	.	846.22	.	.
83322	11/18/83	.	.	846.02	.	.
83325	11/21/83	.	.	845.59	.	.
83326	11/22/83	.	.	845.43	.	.
83327	11/23/83	837.17	842.66	845.36	832.70	.
83332	11/28/83	.	.	846.97	832.80	.
83333	11/29/83	.	.	848.81	832.83	.
83334	11/30/83	838.02	843.08	848.68	833.03	.
83341	12/07/83	839.80	846.53	849.43	836.15	.
83349	12/15/83	841.44	845.87	848.12	838.44	.
83356	12/22/83	841.83	846.00	847.69	837.49	.
83363	12/29/83	843.11	859.26	849.14	839.69	.
84005	01/05/84	843.63	847.35	848.48	841.30	.
84012	01/12/84	843.27	846.76	847.82	839.26	.
84019	01/19/84	843.73	850.37	848.71	840.18	.
84026	01/26/84	844.36	847.74	848.48	840.94	.
84033	02/02/84	844.19	847.55	848.35	840.35	.
84040	02/09/84	843.63	847.02	848.12	839.53	.
84047	02/16/84	844.85	847.87	850.91	841.40	.
84055	02/24/84	844.42	847.32	849.04	840.54	.
84061	03/01/84	845.08	847.81	849.99	842.08	.
84068	03/08/84	844.85	847.78	849.10	841.13	.
84076	03/16/84	844.36	847.55	848.74	840.58	.
84083	03/23/84	846.00	848.92	851.07	842.35	.
84090	03/30/84	846.85	848.92	851.63	843.33	.
84097	04/06/84	847.08	849.32	851.92	843.07	.
84108	04/17/84	845.64	848.73	850.05	841.30	.
84116	04/25/84	845.34	848.37	849.56	842.05	.

Table F.6. (continued)

DATE	DATE	7-100	7-101	7-102	7-103	7-104
84124	05/03/84	851.67	850.17	852.09	844.12	.
84131	05/10/84	850.20	851.48	853.73	845.20	.
84137	05/16/84	848.26	850.99	852.71	842.97	.
84144	05/23/84	846.39	849.94	852.32	841.20	.
84151	05/30/84	845.21	849.05	851.73	840.71	.
84159	06/07/84	842.39	848.40	851.24	839.95	.
84166	06/14/84	843.77	847.78	850.74	839.49	.
84172	06/20/84	843.34	847.51	850.38	839.39	.
84177	06/25/84	843.01	847.12	850.09	838.84	.
84184	07/02/84	842.65	846.79	849.69	838.31	.
84191	07/09/84	843.14	847.35	849.69	839.36	.
84198	07/16/84	843.11	847.18	849.40	839.62	.
84205	07/23/84	843.40	847.71	849.50	840.48	.
84212	07/30/84	843.27	847.09	849.20	840.44	.
84219	08/06/84	842.95	846.82	849.10	840.02	.
84226	08/13/84	842.88	845.41	848.91	840.21	.
84233	08/20/84	842.58	846.46	848.84	839.66	.
84240	08/27/84	841.96	846.04	848.58	838.77	.
84248	09/04/84	841.44	845.64	848.41	838.18	.
84255	09/11/84	841.14	845.35	848.25	837.75	.
84261	09/17/84	840.81	844.99	847.95	837.36	.
84268	09/24/84	840.52	844.76	847.79	836.97	.
84275	10/01/84	840.16	845.05	847.53	836.64	.
84282	10/08/84	839.76	844.46	847.17	836.24	.
84289	10/15/84	839.60	844.36	847.20	836.01	.
84297	10/23/84	839.27	851.65	847.10	835.75	.
84298	10/24/84	840.25	855.52	847.92	835.78	.
84299	10/25/84	840.16	851.84	848.38	836.41	.
84300	10/26/84	840.22	850.30	848.32	836.77	.
84303	10/29/84	840.42	847.41	847.59	837.23	.
84304	10/30/84	.	846.73	.	.	.
84307	11/02/84	.	845.77	.	.	.
84311	11/06/84	840.25	844.72	847.04	836.93	.
84317	11/12/84	841.08	845.06	848.58	838.09	.
84325	11/20/84	842.79	846.06	848.45	840.18	.
84333	11/28/84	843.17	846.72	848.56	840.33	.
84341	12/06/84	843.83	847.45	848.68	841.18	.
84347	12/12/84	843.89	847.27	848.57	841.00	.
84353	12/18/84	843.40	847.08	848.38	840.32	.
84361	12/26/84	844.12	847.37	848.21	841.08	.
84366	12/31/84	844.26	847.81	848.51	841.28	.
85006	01/06/85	844.97	848.45	848.76	841.90	.
85014	01/14/85	844.51	848.12	848.71	841.33	.
85021	01/21/85	843.77	847.20	848.57	841.02	.

Table F.6. (continued)

DATE	DATE	7-100	7-101	7-102	7-103	7-104
85028	01/28/85	843.52	846.94	848.53	839.95	.
85035	02/04/85	845.65	847.22	851.26	842.09	.
85042	02/11/85	842.29	848.05	850.12	841.98	.
85050	02/19/85	845.53	848.09	849.45	841.98	.
85056	02/25/85	845.34	848.35	850.11	841.89	.
85063	03/04/85	845.09	848.29	849.67	841.52	.
85070	03/11/85	845.15	848.14	849.47	841.72	.
85077	03/18/85	844.66	847.95	849.43	841.71	.
85084	03/25/85	844.62	847.61	849.34	841.28	.
85091	04/01/85	844.82	847.90	849.46	841.59	.
85098	04/08/85	845.41	848.20	850.30	842.44	.
85105	04/15/85	845.14	848.71	850.16	841.58	.
85112	04/22/85	838.35	848.40	850.03	841.63	.
85113	04/23/85	.	.	850.10	841.48	.
85119	04/29/85	844.62	846.79	849.68	840.76	.
85126	05/06/85	844.22	846.37	849.56	840.36	.
85133	05/13/85	843.79	845.93	849.79	839.96	.
85140	05/20/85	843.59	845.43	849.21	839.02	.
85148	05/28/85	842.83	848.34	849.06	838.46	.
85154	06/03/85	842.49	844.71	848.83	838.01	.
85161	06/10/85	842.08	844.49	848.69	837.67	.
85168	06/17/85	841.77	844.21	848.50	837.31	.
85175	06/24/85	841.45	843.97	848.32	837.02	.
85182	07/01/85	841.15	843.74	848.11	836.74	.
85189	07/08/85	840.92	843.54	847.96	836.51	.
85196	07/15/85	840.70	843.39	847.86	836.35	.
85203	07/22/85	840.48	843.20	847.75	836.09	.
85211	07/30/85	840.48	843.16	847.53	836.10	.
85221	08/09/85	823.95	842.79	863.38	.	.
85231	08/19/85	842.88	.	.	839.53	.
85238	08/26/85	842.29	843.08	847.69	839.59	.
85246	09/03/85	842.95	845.25	847.89	839.89	.
85256	09/13/85	842.42	844.72	847.82	838.71	.
85263	09/20/85	841.24	843.97	847.33	837.62	.
85268	09/25/85	841.37	843.54	847.07	837.49	.
85276	10/03/85	841.24	843.54	847.20	837.79	.
85282	10/09/85	841.63	843.58	846.87	837.43	.
85284	10/11/85	841.37	843.74	846.71	836.80	845.57
85296	10/23/85	840.91	843.02	846.51	836.54	846.33
85305	11/01/85	840.91	843.08	846.94	836.21	846.16
85310	11/06/85	841.27	841.61	846.84	835.78	845.51
85318	11/14/85	841.63	844.26	844.64	836.61	846.52
85324	11/20/85	841.24	843.08	847.23	836.41	845.84
85331	11/27/85	842.03	843.08	847.40	837.82	846.66

Table F.6. (continued)

DATE	DATE	7-100	7-101	7-102	7-103	7-104
85338	12/04/85	841.96	843.74	846.45	837.13	848.62
85345	12/11/85	.	.	.	.	848.07
85352	12/18/85	841.73	843.38	846.38	836.67	847.38
85360	12/26/85	842.03	843.77	847.10	837.10	847.84
86002	01/02/86	841.67	843.74	847.04	837.26	848.13
86008	01/08/86	841.27	843.41	846.41	836.28	847.80
86015	01/15/86	841.40	843.28	846.81	835.95	847.38
86023	01/23/86	841.24	843.18	846.90	835.69	847.57
86029	01/29/86	841.53	843.51	847.30	836.44	849.02
86036	02/05/86	.	.	.	.	.
86045	02/14/86	.	.	.	.	850.36
86050	02/19/86	844.82	845.25	850.09	840.28	856.10
86057	02/26/86	857.38	846.07	848.61	840.84	853.25
86064	03/05/86	843.37	845.81	848.22	840.12	852.30
86071	03/12/86	843.24	845.58	847.86	840.05	852.43
86077	03/18/86	843.70	845.41	848.05	839.85	852.53
86085	03/26/86	843.57	845.48	847.95	839.43	852.66
86094	04/04/86	842.72	845.12	848.09	838.21	850.46
86099	04/09/86	842.65	845.12	847.99	837.92	850.66
86114	04/24/86	841.63	843.90	847.33	837.98	848.92
86120	04/30/86	841.11	843.61	847.23	837.36	848.26
86121	05/01/86	.	.	.	836.11	.
86129	05/09/86	840.81	843.38	847.00	.	848.00
86134	05/14/86	840.68	843.05	846.87	835.88	847.80
86148	05/28/86	840.55	842.53	846.28	835.65	847.57
86155	06/04/86	.	.	.	.	847.28
86164	06/13/86	840.19	842.76	846.51	835.36	847.08
86241	08/29/86	841.12	842.64	848.51	838.10	846.25
86247	09/04/86	839.23	842.60	848.51	836.38	845.64
86255	09/12/86	839.38	842.66	847.72	836.17	845.77
86262	09/19/86	839.70	843.10	846.64	836.28	845.47
86267	09/24/86	839.63	.	.	.	.
86269	09/26/86	.	842.78	846.35	836.02	845.30
86276	10/03/86	840.41	842.67	846.35	835.95	845.30
86283	10/10/86	838.90	842.34	846.19	835.65	845.20
86290	10/17/86	839.62	843.24	847.14	837.74	845.10
86297	10/24/86	839.60	843.24	846.76	836.94	844.97
86304	10/31/86	841.19	844.64	847.88	840.00	845.10
86311	11/07/86	841.19	844.29	847.25	838.69	845.10
86318	11/14/86	842.76	845.73	848.46	841.79	845.40
86325	11/21/86	843.31	846.31	848.27	841.98	845.40
86330	11/26/86	844.91	847.55	850.23	844.29	845.65
86339	12/05/86	846.29	848.90	851.29	845.88	849.10
86346	12/12/86	847.09	849.42	852.25	845.29	850.61
86353	12/19/86	846.13	849.58	852.17	844.53	849.90

Table F.6. (continued)

DATE	DATE	7-100	7-101	7-102	7-103	7-104
87009	01/09/87	844.40	847.53	850.70	841.31	848.08
87022	01/22/87	846.23	847.86	851.23	843.71	852.20
87030	01/30/87	846.09	848.83	851.56	843.75	852.87
87037	02/06/87	845.57	848.76	851.38	843.27	851.97
87051	02/20/87	845.40	848.36	851.75	843.13	852.32
87065	03/06/87	846.13	850.06	852.82	843.83	854.67
87086	03/27/87	845.20	849.09	852.06	842.42	852.28
87100	04/10/87	845.38	849.06	852.11	843.15	853.90
87114	04/24/87	845.14	849.16	851.93	842.49	853.52
87121	05/01/87	844.92	855.10	852.06	840.64	851.42
87128	05/08/87	844.06	847.65	851.13	840.54	850.25
87142	05/22/87	843.38	846.63	850.50	839.78	849.07
87156	06/05/87	842.40	846.46	850.03	839.49	847.37
87170	06/19/87	842.13	845.25	849.51	838.26	847.78
87198	07/17/87	841.75	845.06	849.12	838.26	847.05
87212	07/31/87	841.24	844.46	848.64	837.77	846.58
87226	08/14/87	840.82	844.02	848.53	837.35	846.23
87240	08/28/87	840.34	843.68	848.22	836.92	845.91
87254	09/11/87	839.70	843.25	847.92	836.55	845.60
87282	10/09/87	839.72	843.17	847.87	836.59	845.12
87316	11/12/87	838.65	842.76	848.00	835.86	839.78
87336	12/02/87	838.86	842.59	847.44	835.65	844.40
88011	01/11/88	842.05	846.23	849.10	840.97	844.75
88035	02/04/88	847.62	847.36	851.60	842.79	846.71
88062	03/02/88	844.44	847.66	850.62	842.17	847.17
88097	04/06/88	844.13	847.30	850.84	840.73	848.34

APPENDIX G
WELL HYDROGRAPHS

ORNL-DWG 88-12876

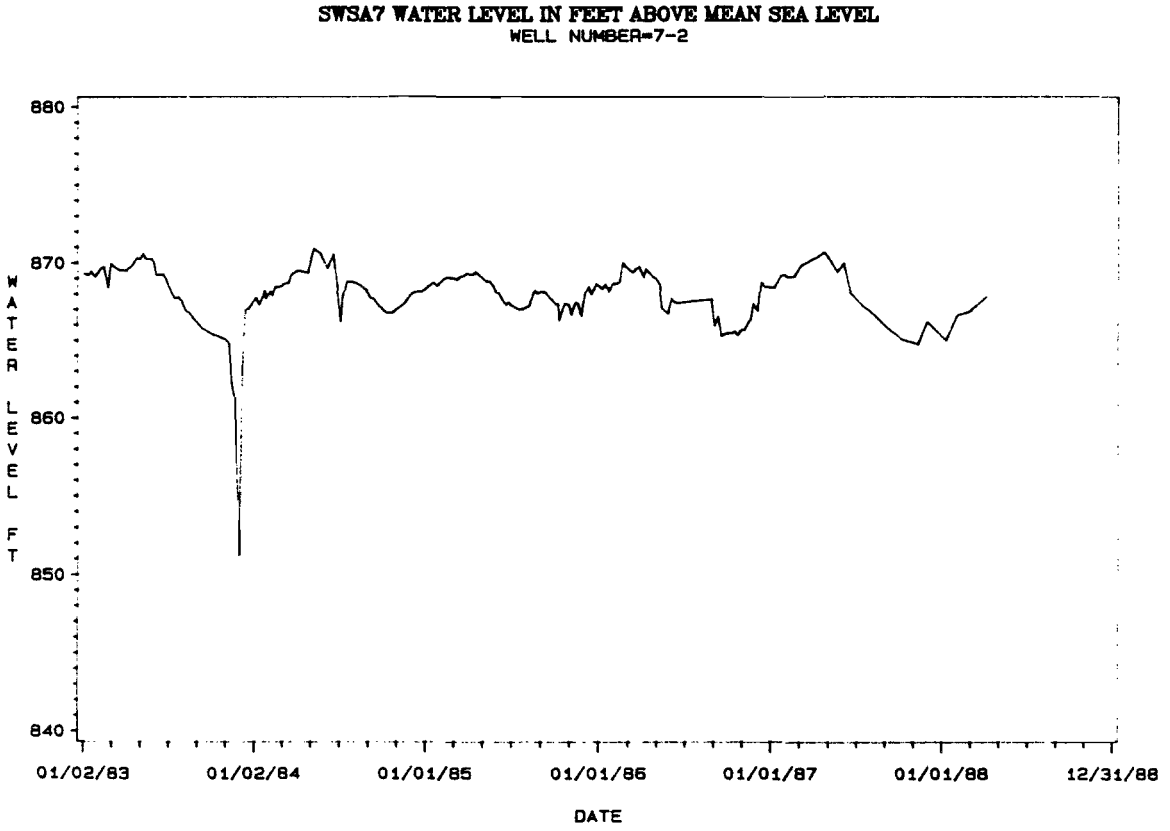

Fig. G.1. Hydrograph for Well 2.

ORNL-DWG 88-12877

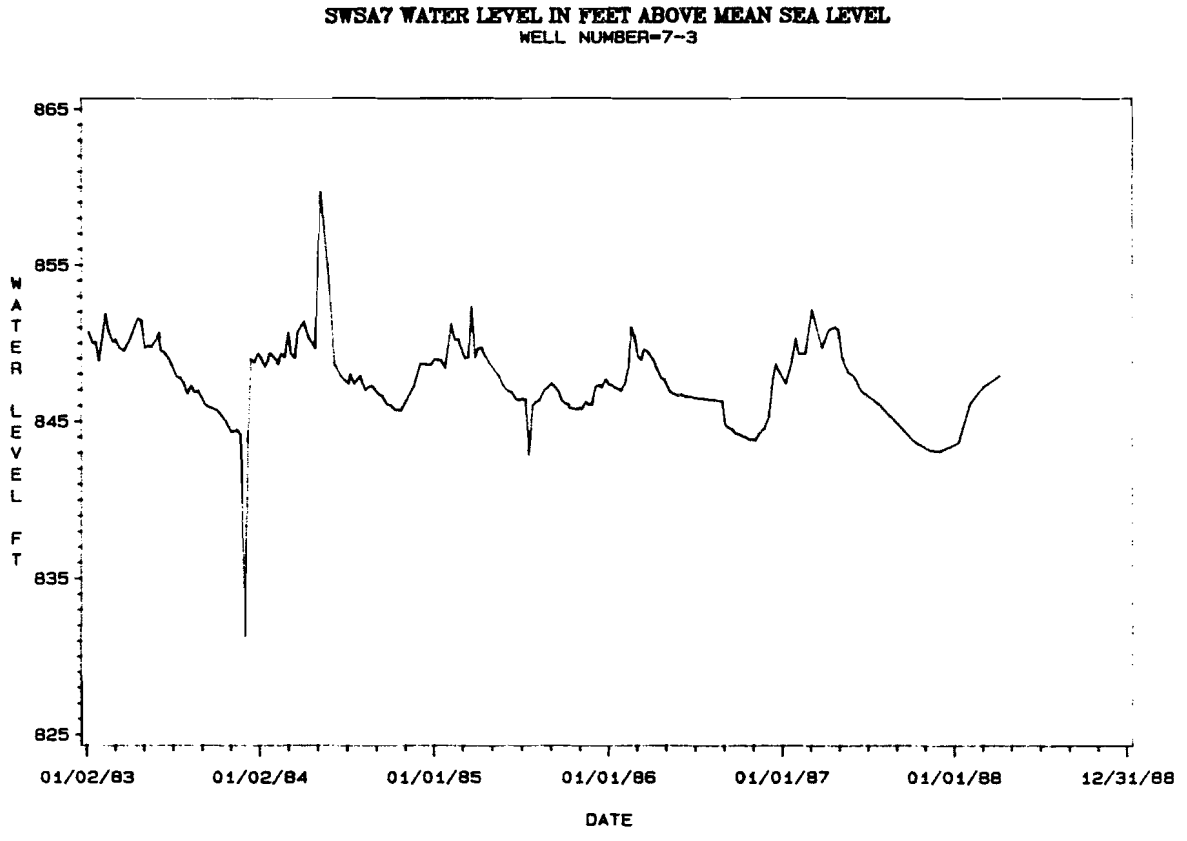

Fig. G.2. Hydrograph for Well 3.

ORNL-DWG 83-12883

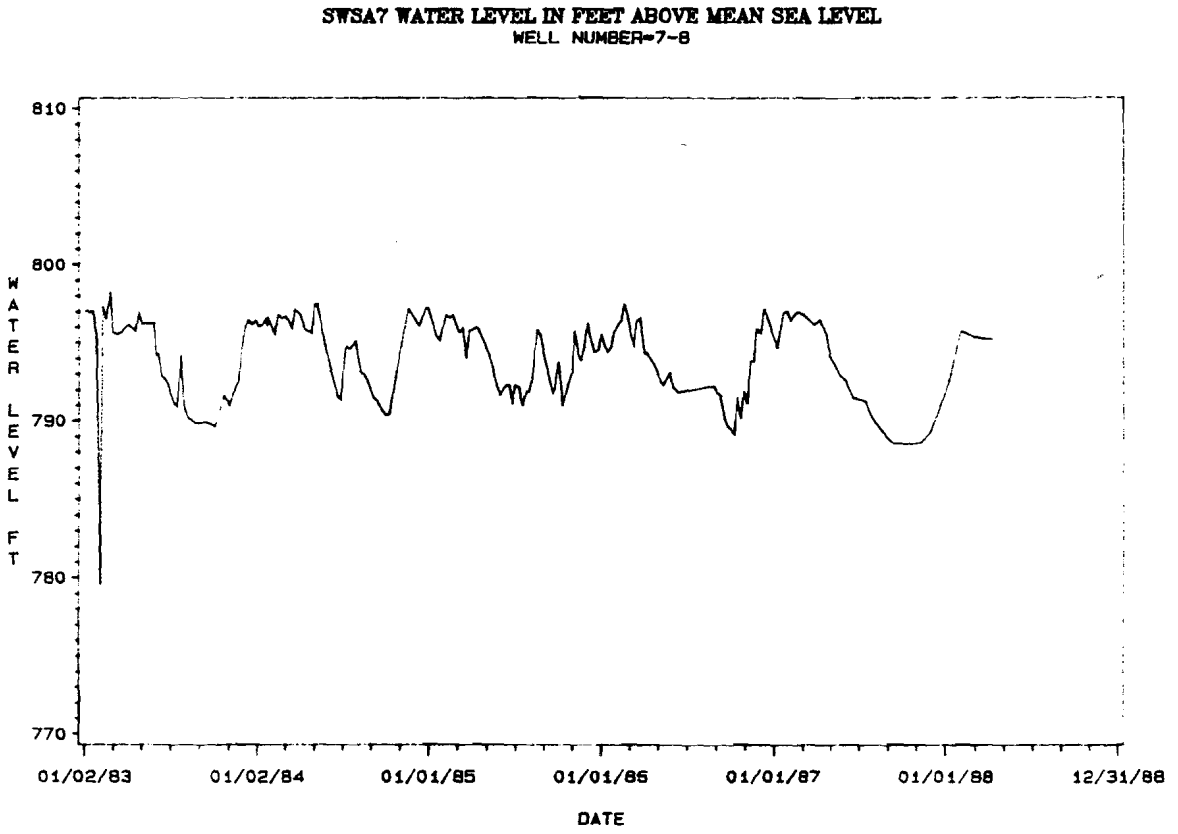

Fig. G.3. Hydrograph for Well 8.

CRNL-DWG 88-12884

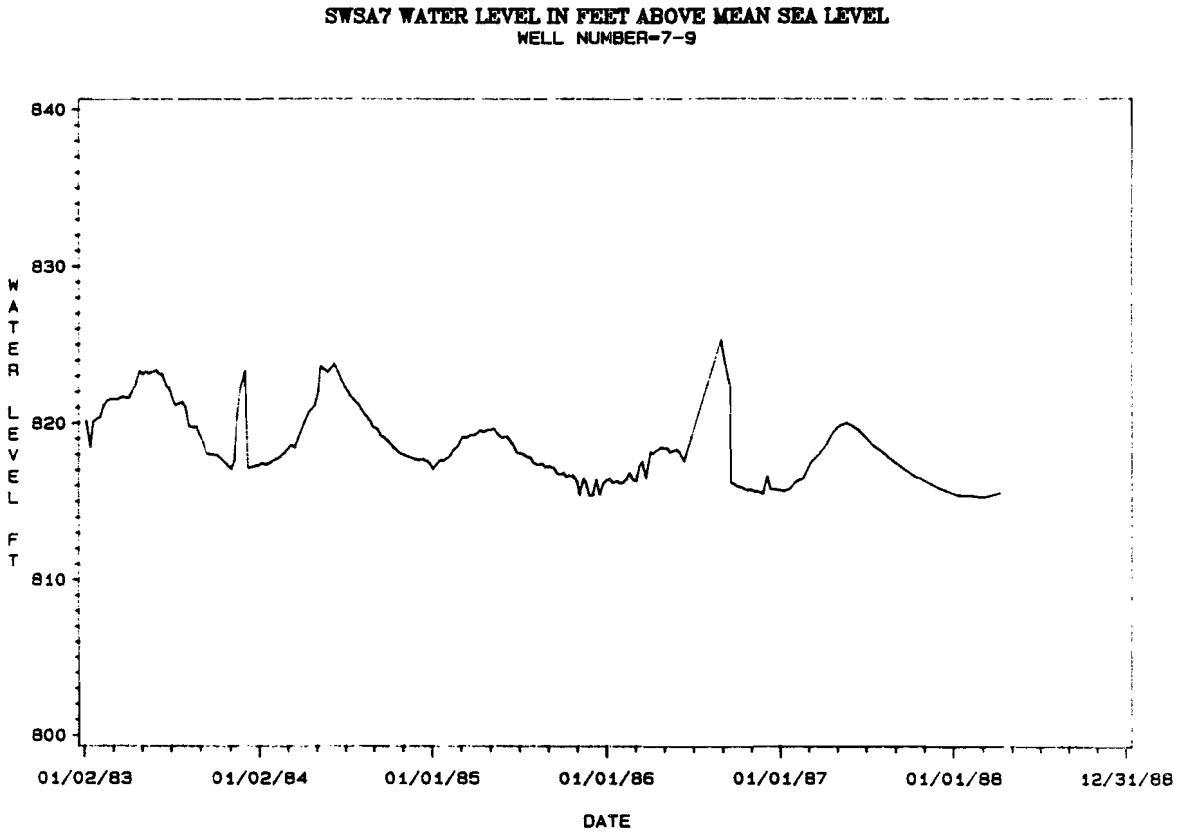

Fig. G.4. Hydrograph for Well 9.

ORNL-DWG 88-12881

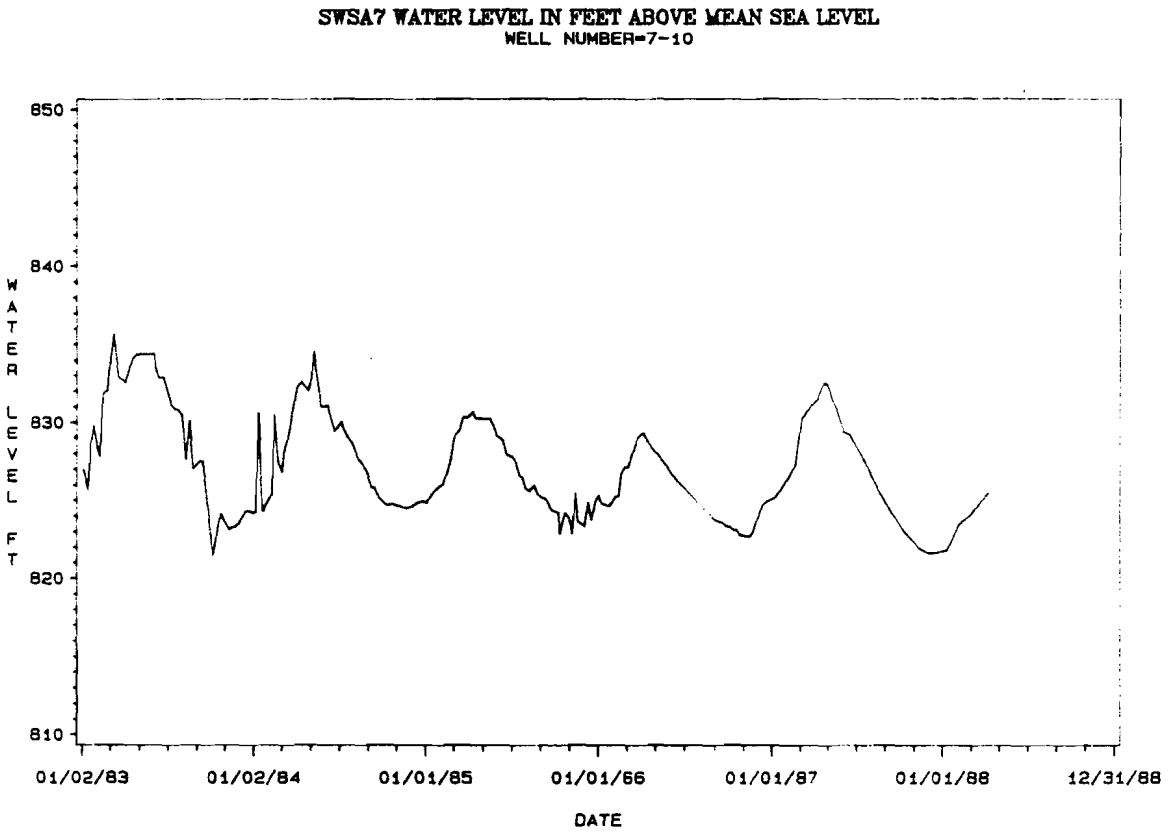

Fig. G.5. Hydrograph for Well 10.

ORNL-DWG 88-12885

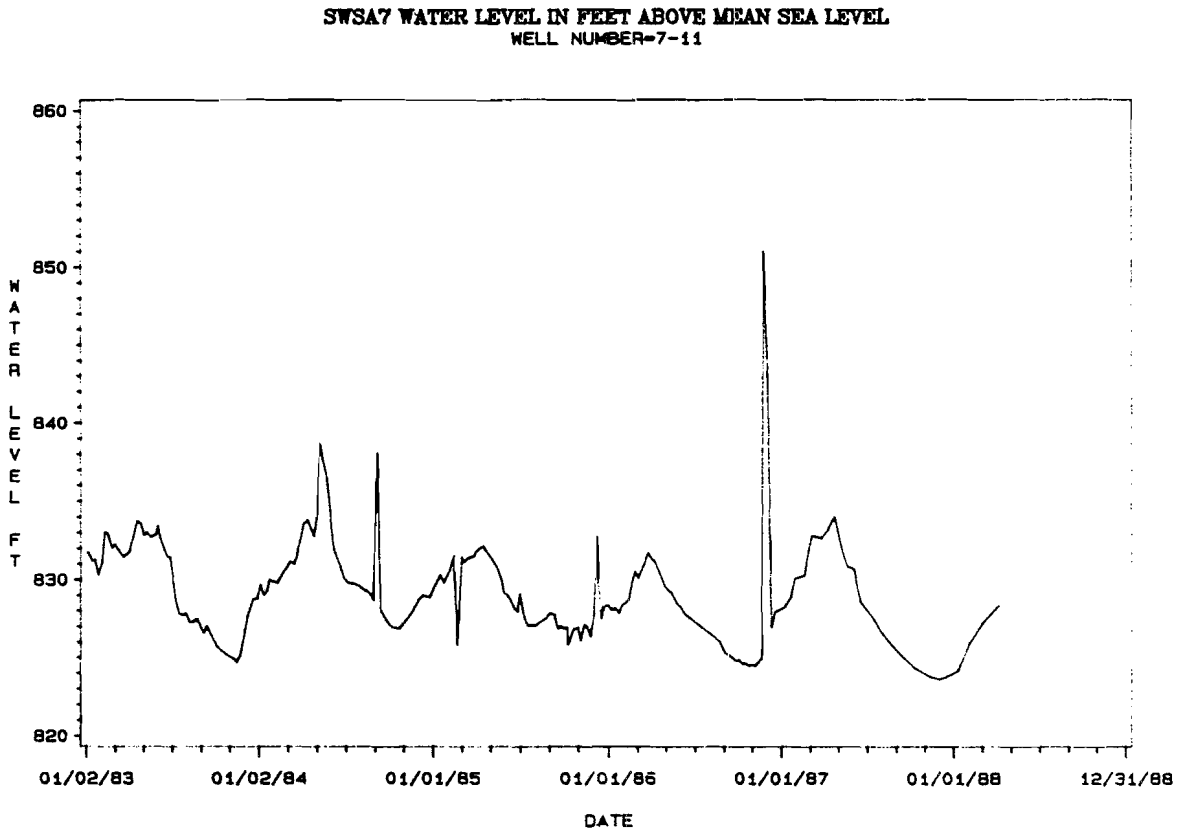

Fig. G.6. Hydrograph for Well 11.

ORNL-DWG 88-12886

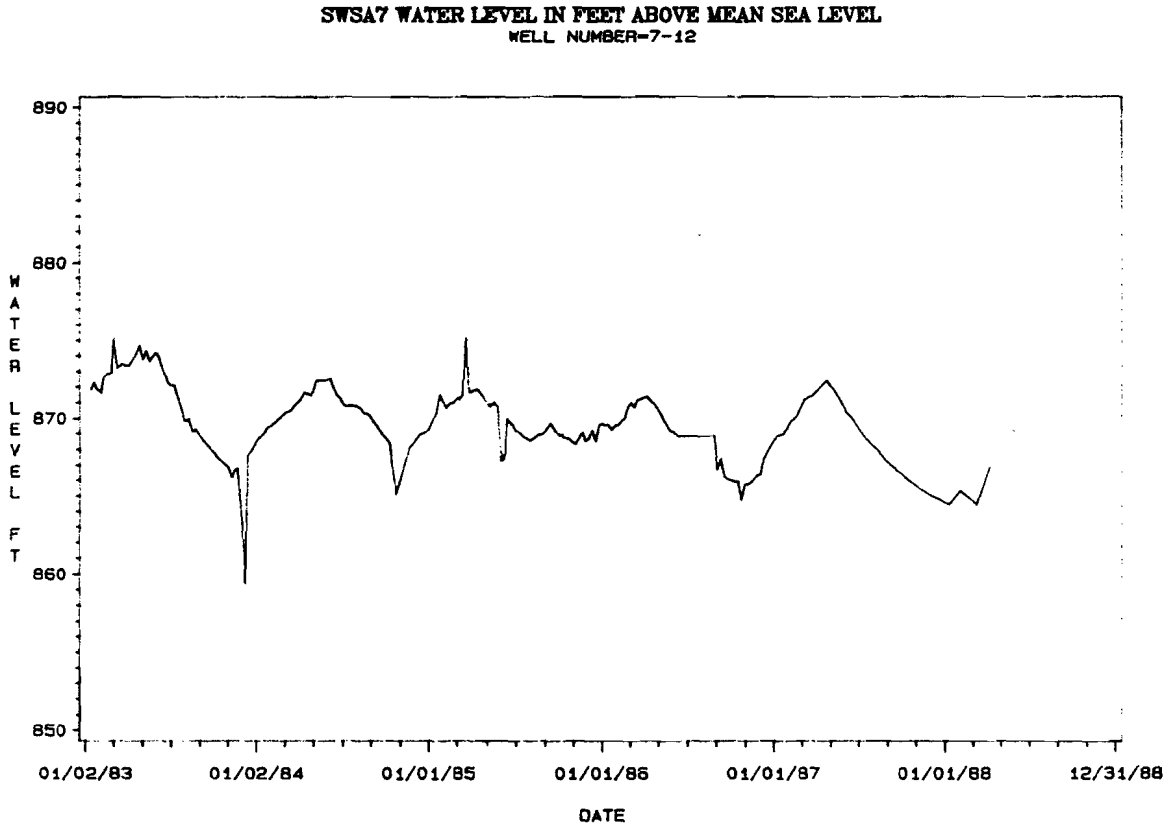

Fig. G.7. Hydrograph for Well 12.

ORNL-DWG 88-12873

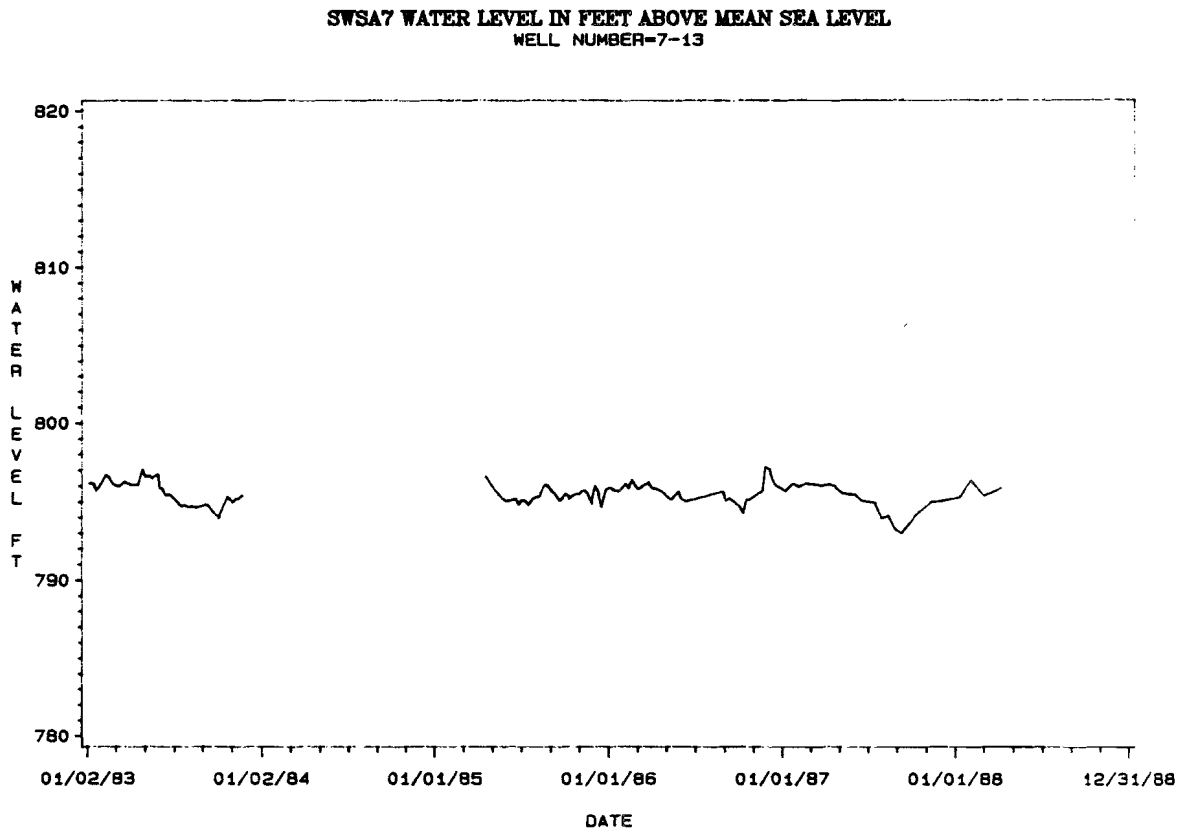

Fig. G.8. Hydrograph for Well 13.

ORNL-DWG 88-12897

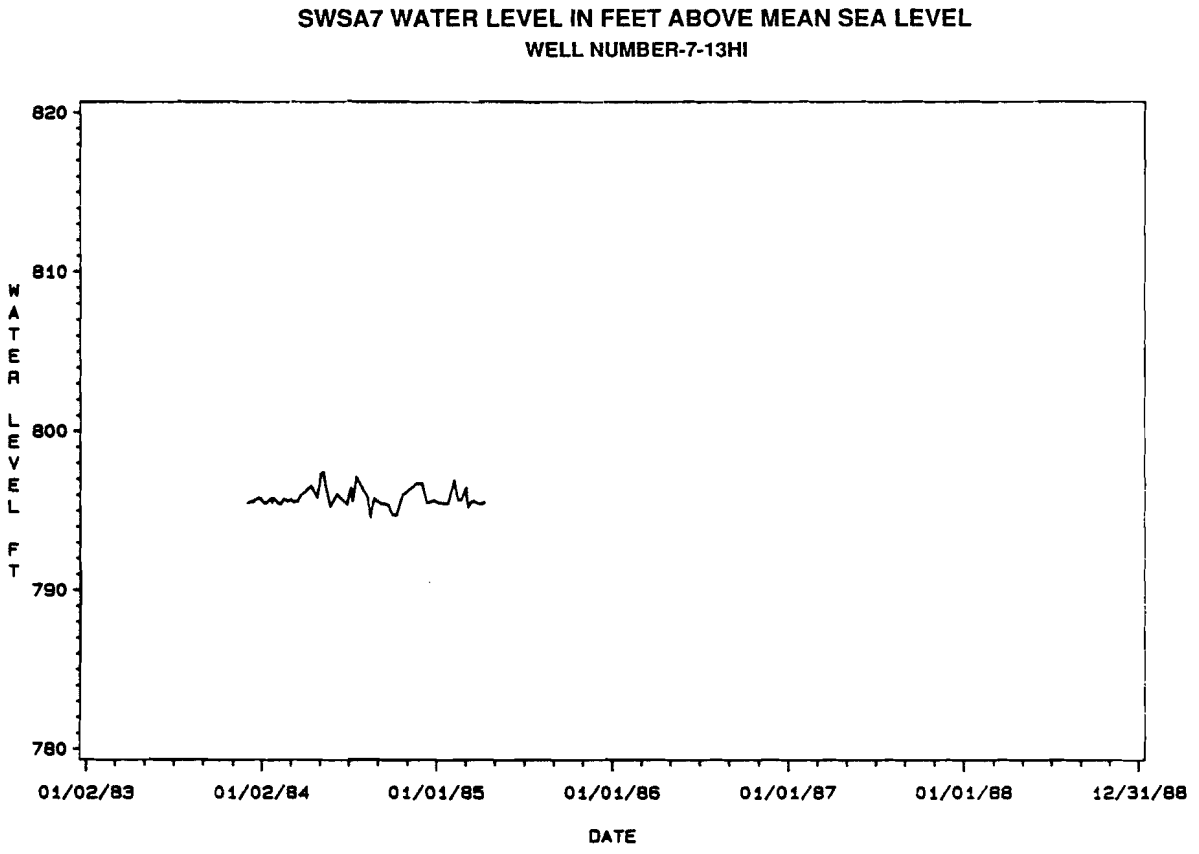

Fig. G.9. Hydrograph for Well 13HI.

ORNL-DWG 88-12874

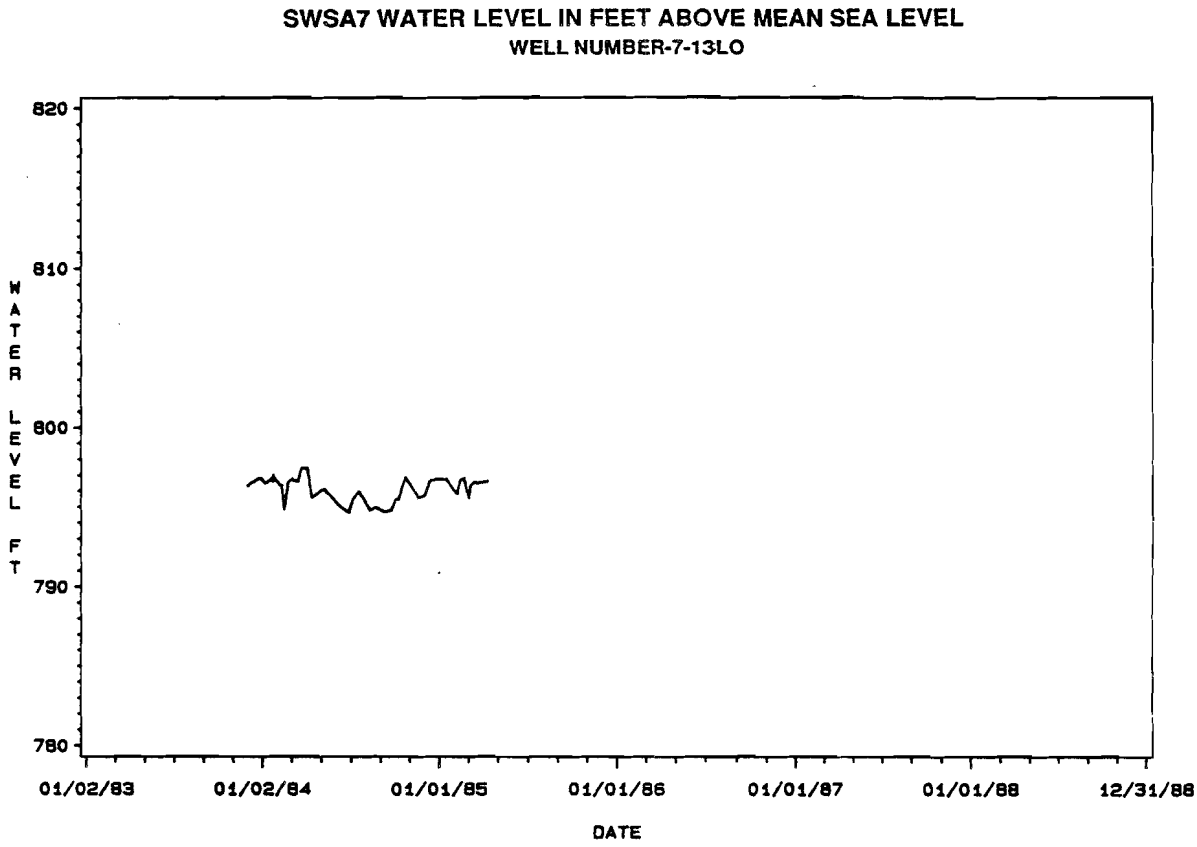

Fig. G.10. Hydrograph for Well 13LO.

ORNL-DWG 88-12887

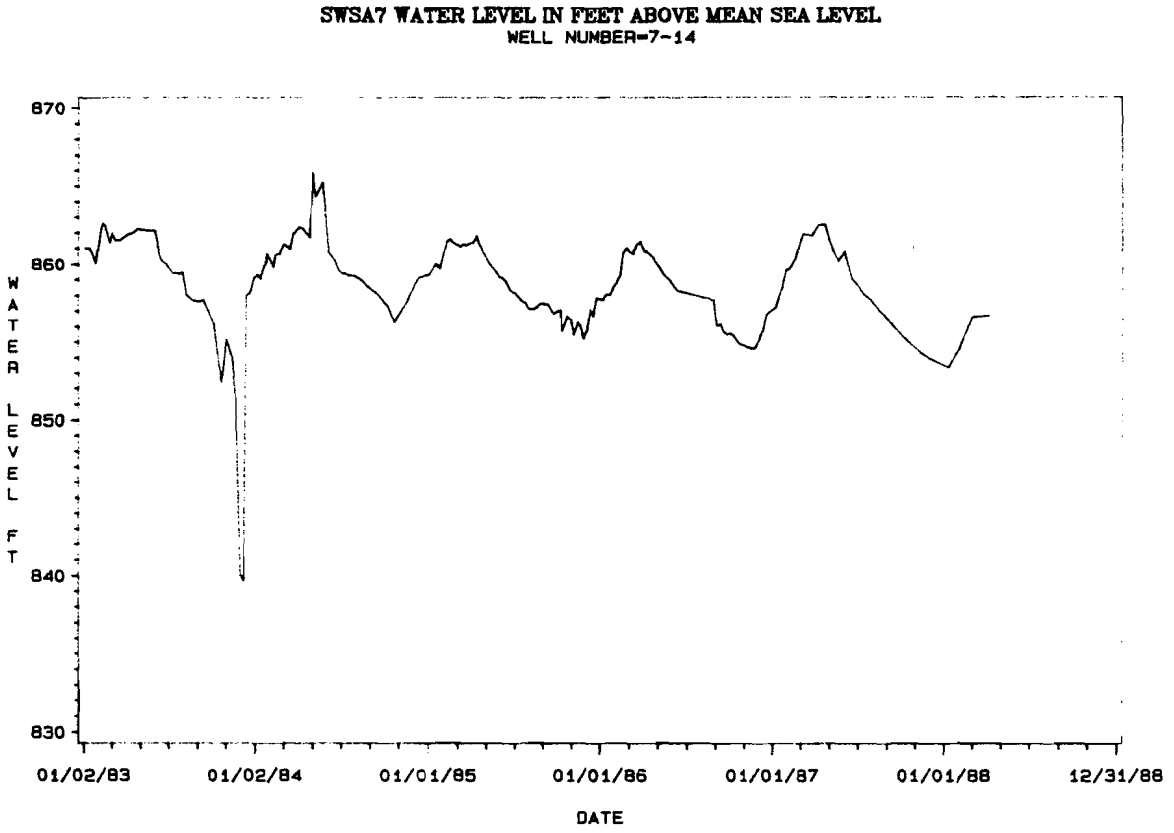

Fig. G.11. Hydrograph for Well 14.

ORNL-DWG 88-12888

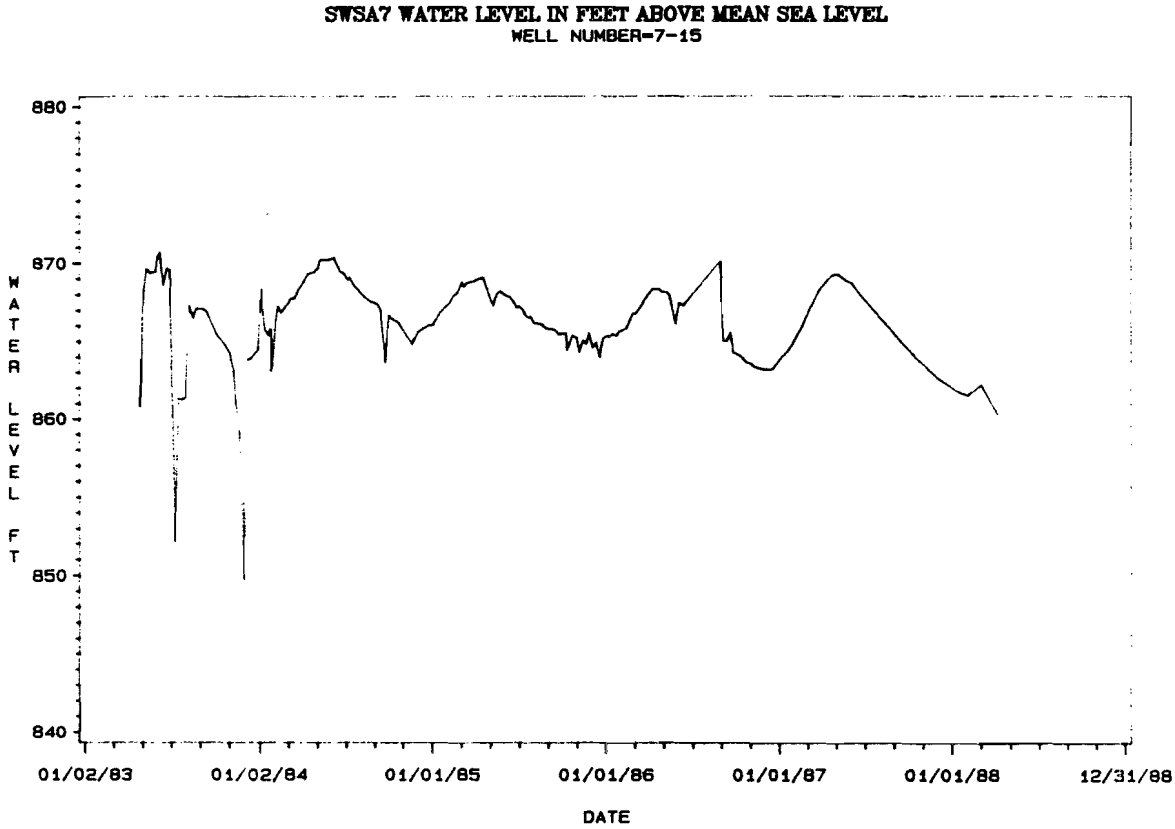

Fig. G.12. Hydrograph for Well 15.

ORNL-DWG 88-12889

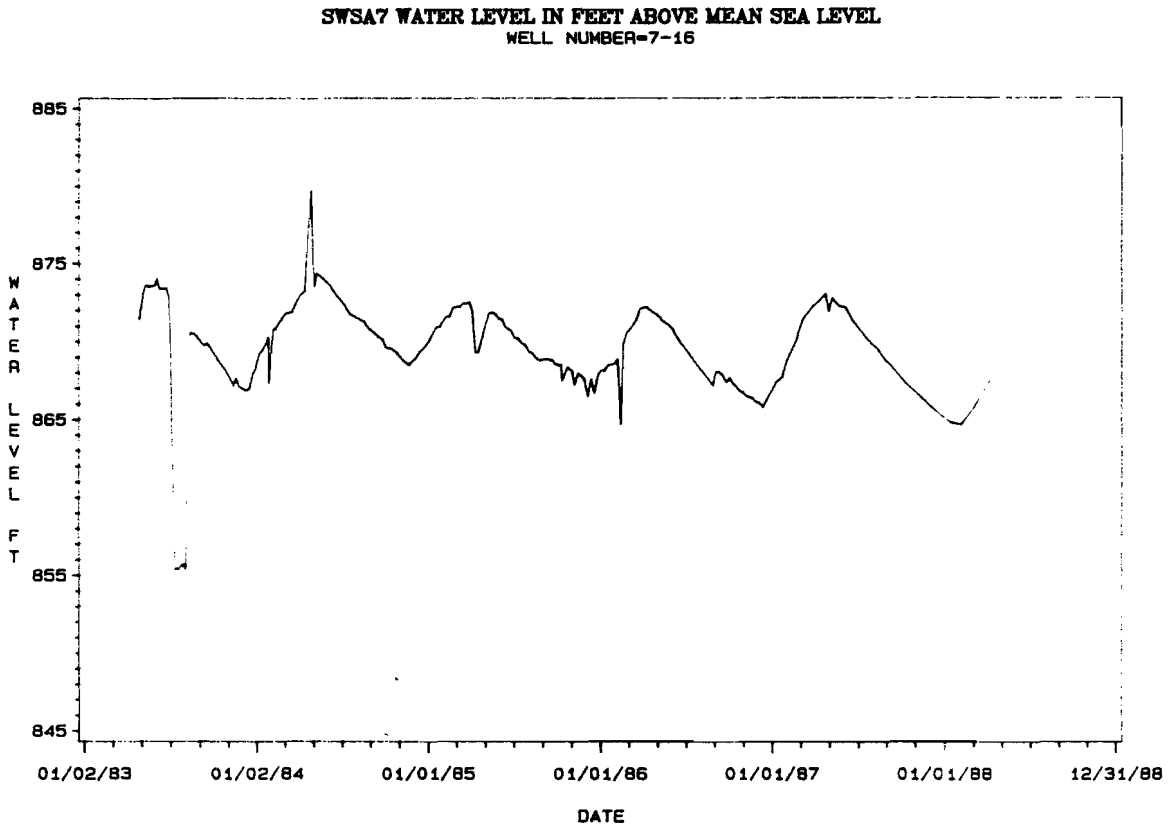

Fig. G.13. Hydrograph for Well 16.

ORNL-DWG 88-12890

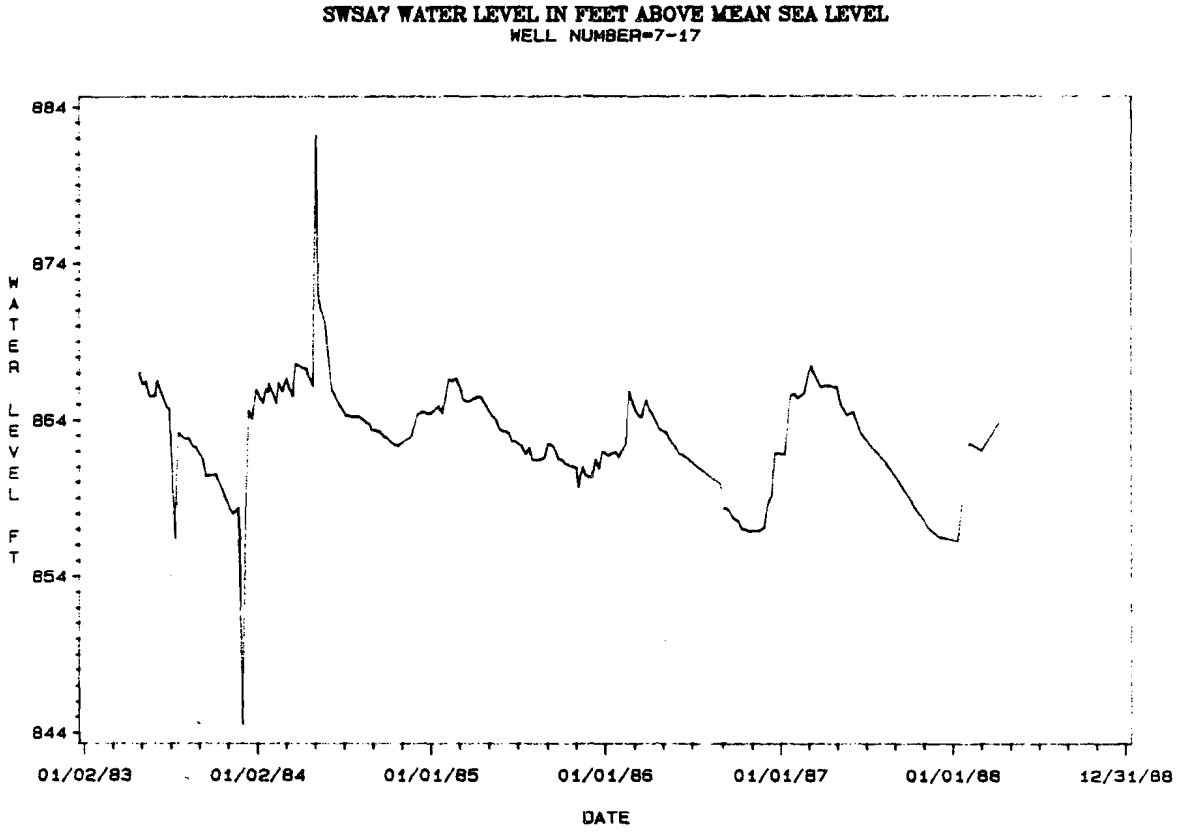

Fig. G.14. Hydrograph for Well 17.

ORNL-DWG 88-12892

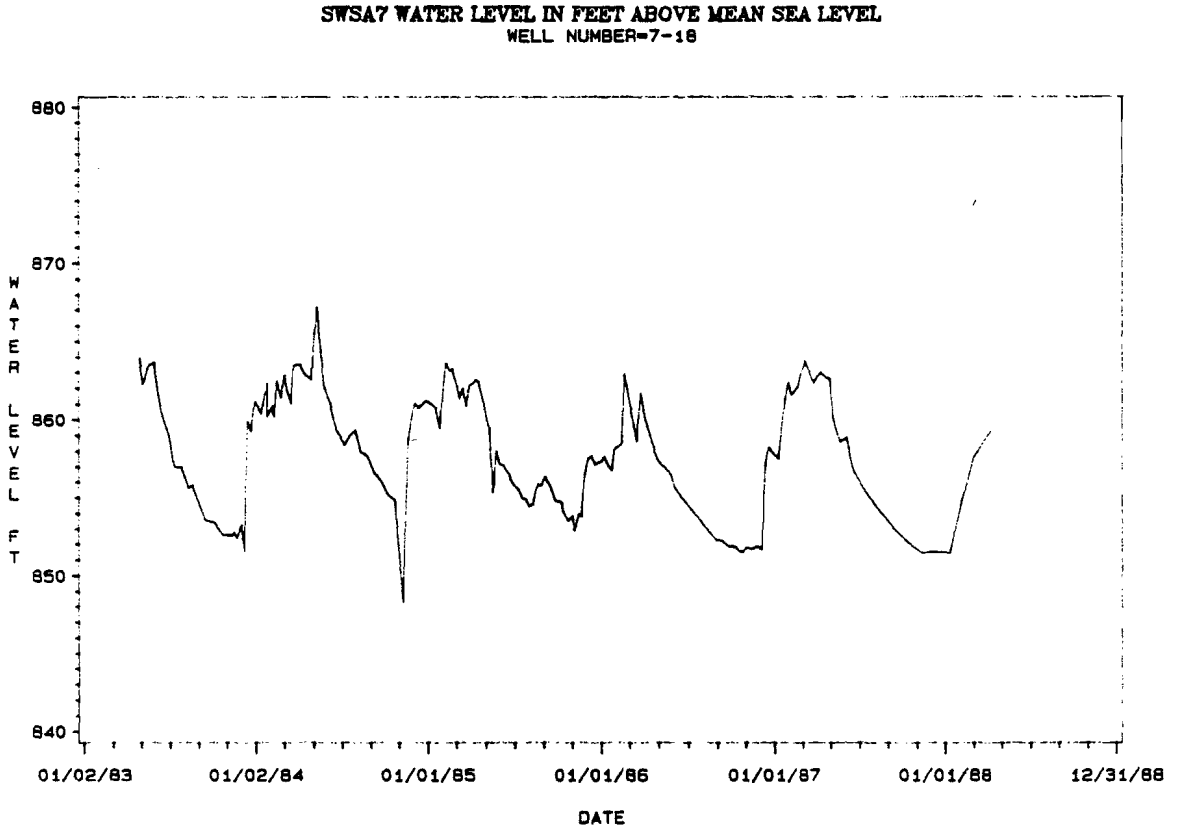

Fig. G.15. Hydrograph for Well 18.

ORNL-DWG 88-12893

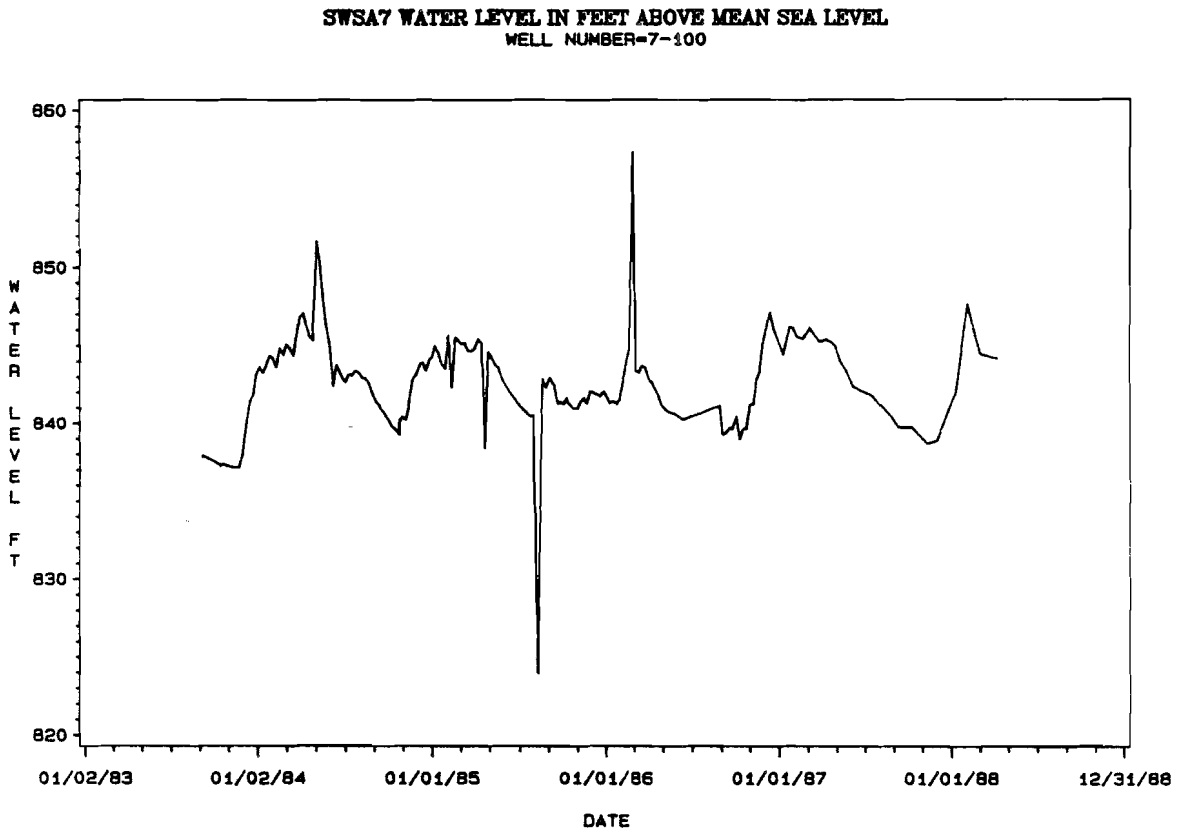

Fig. G.16. Hydrograph for Well 100.

ORNL DWG 88-12898

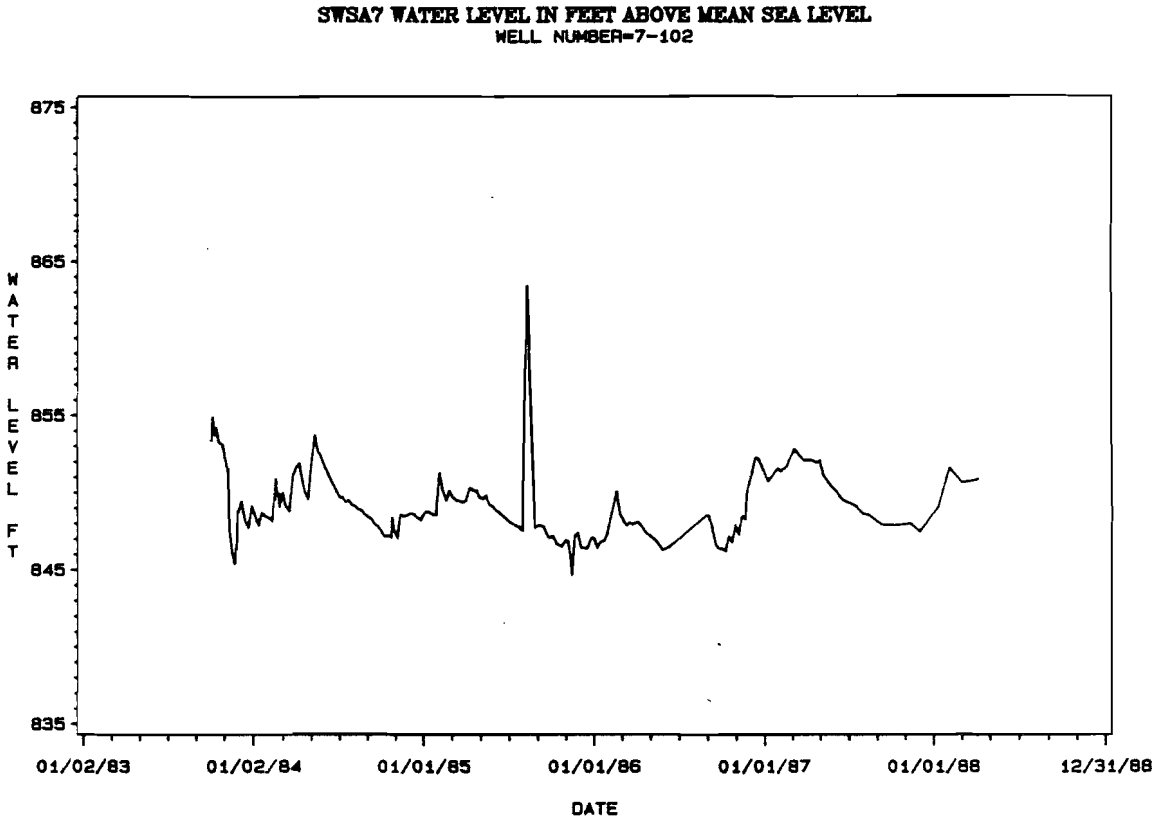

Fig. G.17. Hydrograph for Well 102.

ORNL-DWG 88-12895

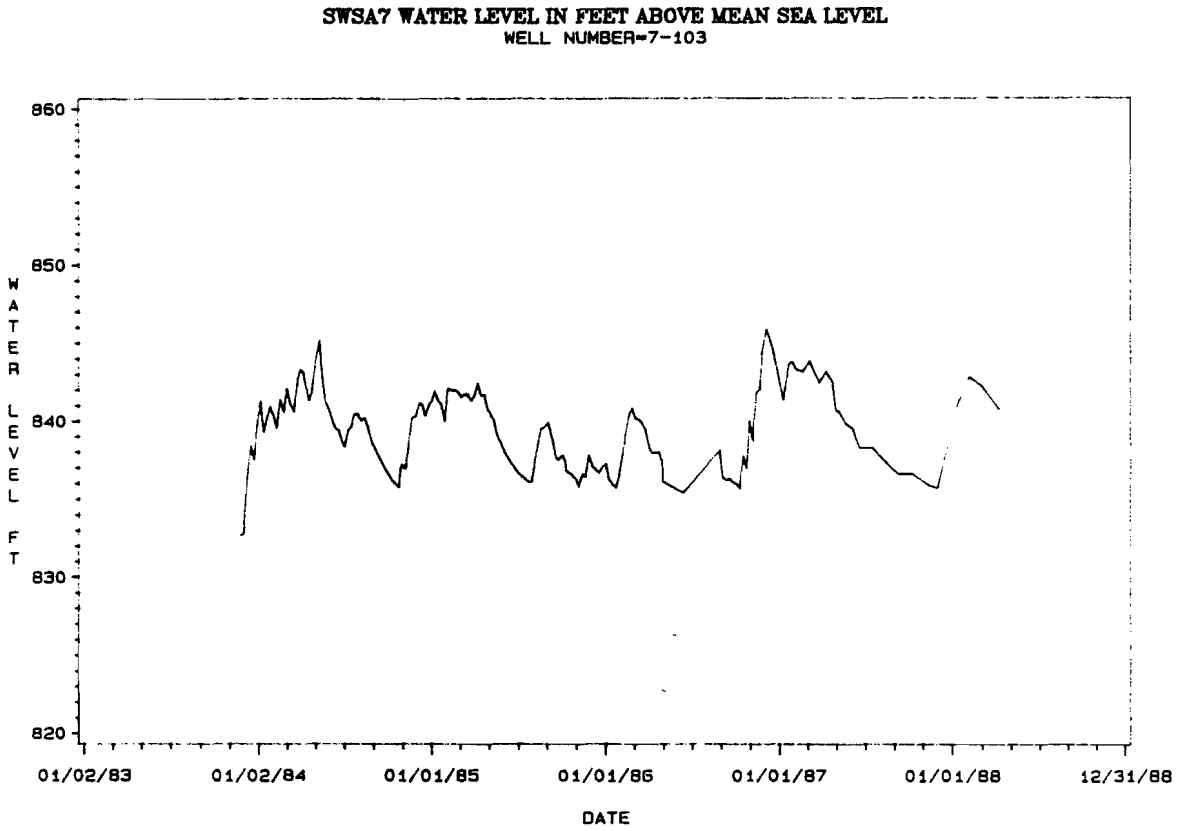

Fig. G.18. Hydrograph for Well 103.

ORNL-DWG 88-12896

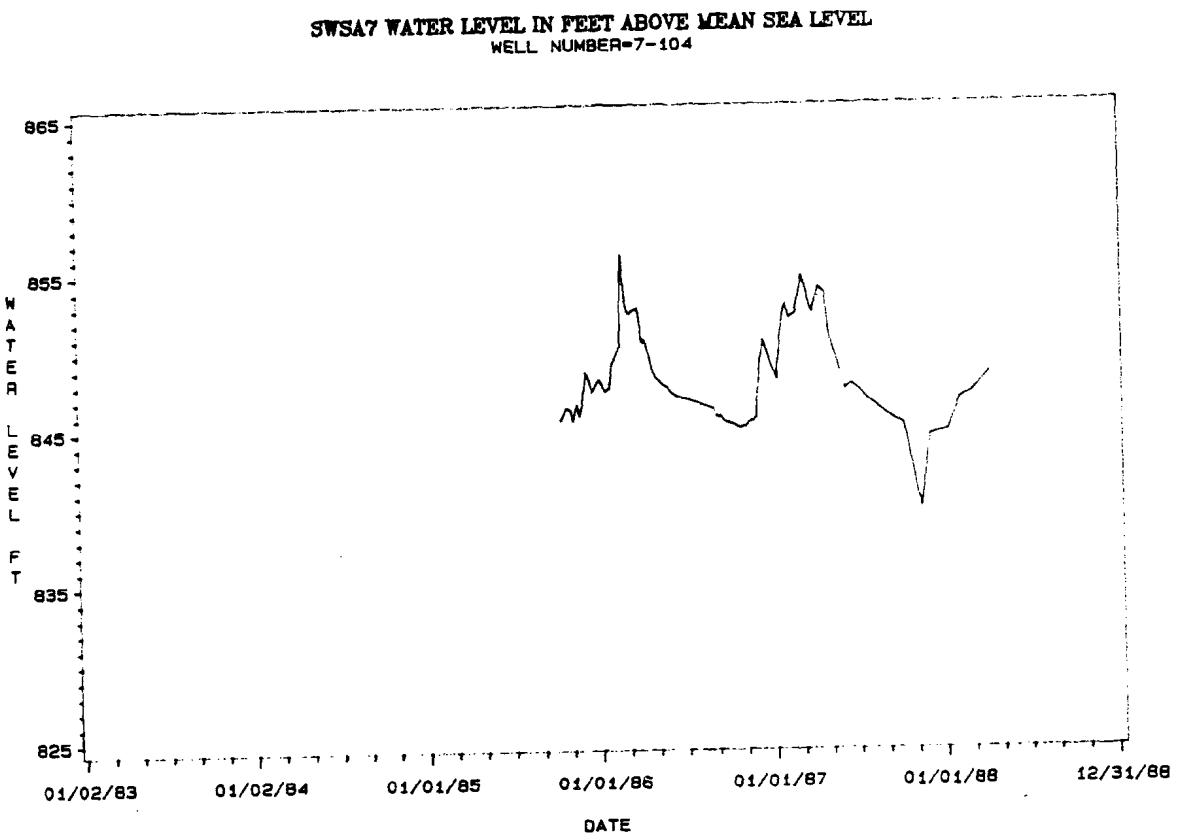

Fig. G.19. Hydrograph for Well 104.

APPENDIX H
STATISTICS FOR GROUNDWATER ELEVATIONS AT PROPOSED SWSA-7

Table H.1. Statistics for groundwater elevations (in feet) measured in 1982

Well	Number of observations	Mean	Max.	Min.	Std. dev.	Skew
7-1	2	871.876	873.074	870.679	1.69361	.
7-2	2	867.637	868.933	866.341	1.83281	.
7-3	7	849.308	853.498	846.247	2.89031	0.3332
7-4	4	861.097	865.485	855.281	4.68639	-0.5586
7-5	3	829.784	834.859	820.554	8.00707	-1.7066
7-6	24	825.981	839.632	816.862	6.77689	0.8617
7-7	25	805.218	806.967	804.343	0.65413	0.7521
7-8	26	795.582	797.684	792.238	1.98137	-0.5836
7-9	26	819.026	823.213	815.667	2.30619	0.2012
7-10	2	825.399	825.448	825.350	0.06960	.
7-11	2	827.932	829.753	826.111	2.57522	.
7-12	2	867.700	868.717	866.683	1.43841	.
7-13	2	796.736	797.458	796.014	1.02081	.
7-14	2	854.603	859.787	849.419	7.33125	.

Table H.2. Statistics for groundwater elevations (in feet) measured in 1983

Well	Number of observations	Mean	Max.	Min.	Std. dev.	Skew
7-1	41	869.772	877.930	861.229	5.77665	-0.0531
7-2	42	867.553	870.606	851.216	3.48080	-2.8505
7-3	43	848.030	851.890	831.253	3.45264	-2.8898
7-4	43	862.376	868.077	841.337	5.34028	-1.5894
7-5	43	834.586	837.385	825.278	2.40707	-2.6541
7-6	43	822.954	842.781	817.485	4.90400	2.3357
7-7	43	804.942	806.508	802.866	0.96482	-0.4746
7-8	43	793.740	798.242	779.541	3.44622	-1.7326
7-9	42	820.629	823.377	817.045	2.10512	-0.3693
7-10	38	828.929	835.652	821.413	4.04345	-0.1676
7-11	43	829.729	833.756	824.700	2.91037	-0.2978
7-12	40	870.682	875.148	859.399	3.48908	-1.0915
7-13	38	795.648	797.064	793.947	0.76823	-0.1181
7-13HI	5	795.660	795.818	795.489	0.13804	0.0655
7-13LO	5	796.592	796.769	796.310	0.19355	-0.6909
7-14	43	858.610	862.641	839.674	5.03376	-2.6104
7-15	30	864.730	870.732	849.635	4.98975	-1.3955
7-16	30	868.295	874.058	855.389	5.67378	-1.4432
7-17	30	862.096	867.010	844.502	4.56581	-2.0556
7-18	27	857.672	863.950	851.581	4.18107	0.0172
7-100	16	838.455	843.109	837.138	1.95975	1.5380
7-101	14	844.356	859.259	840.393	4.63765	2.8762
7-102	23	849.400	854.878	845.363	3.26923	0.4231
7-103	8	835.391	839.689	832.701	2.89950	0.3957

Table H.3. Statistics for groundwater elevations (in feet) measured in 1984

Well	Number of observations	Mean	Max.	Min.	Std. dev.	Skew
7-1	41	867.915	875.830	859.523	3.80459	-0.10061
7-2	41	868.380	870.934	866.210	1.03363	0.62385
7-3	42	848.896	859.732	845.689	2.60439	2.28930
7-4	41	864.691	872.835	858.365	3.17836	-0.17442
7-5	42	834.561	837.582	829.412	1.34521	-0.74169
7-6	41	824.804	841.896	818.929	6.69590	1.46745
7-7	41	805.246	806.410	803.850	0.63520	-0.39810
7-8	42	794.852	797.520	790.368	2.21382	-0.74509
7-9	41	819.563	823.837	817.373	1.98506	0.68919
7-10	42	827.678	834.569	824.267	2.94200	0.51724
7-11	40	830.477	838.677	826.833	2.72153	1.49631
7-12	42	870.034	872.556	865.108	1.39930	-0.75713
7-13HI	41	795.822	797.425	794.571	0.63261	0.75333
7-13LO	37	795.942	797.425	794.636	0.85761	-0.09543
7-14	43	860.036	865.889	856.309	1.94653	1.11025
7-15	43	867.376	870.371	863.120	1.72891	-0.25983
7-16	44	871.201	879.701	867.332	2.06154	1.58703
7-17	41	865.579	882.168	862.318	3.25534	3.59531
7-18	43	859.956	867.231	848.365	3.24662	-0.94533
7-100	55	843.418	851.673	839.271	2.52184	0.85069
7-101	57	847.650	855.518	844.363	2.09895	1.15115
7-102	55	849.246	853.729	847.036	1.54291	0.98469
7-103	55	839.811	845.201	835.752	2.17330	-0.03746

Table H.4. Statistics for groundwater elevations (in feet) measured in 1985

Well	Number of observations	Mean	Max.	Min.	Std. dev.	Skew
7-1	46	867.108	870.679	864.281	1.88311	0.8283
7-2	46	868.068	869.458	866.341	0.83536	-0.0484
7-3	47	847.477	852.350	842.835	1.72809	0.5076
7-4	47	861.034	868.930	856.561	3.90802	0.7139
7-5	48	833.551	835.581	831.709	0.83641	0.1000
7-6	47	819.710	823.686	816.927	1.58396	0.6368
7-7	47	804.677	805.918	785.214	2.92667	-6.6665
7-8	47	794.001	797.225	790.958	1.84693	0.0001
7-9	47	817.701	819.670	815.339	1.27642	-0.1424
7-10	47	826.657	830.731	822.889	2.45395	0.2582
7-11	46	828.761	832.772	825.783	2.02486	0.4060
7-12	47	869.784	875.181	867.241	1.45037	1.1971
7-13	34	795.401	796.703	794.636	0.42385	0.8207
7-13HI	13	795.696	796.933	795.194	0.47232	2.0305
7-13LO	13	796.451	796.802	795.522	0.38529	-1.6756
7-14	47	858.520	861.821	855.226	1.98033	0.2752
7-15	47	866.719	869.091	864.006	1.47529	0.0479
7-16	47	869.842	872.516	866.479	1.75686	-0.0562
7-17	47	862.949	866.682	859.726	1.93018	0.4164
7-18	47	857.597	863.688	852.926	3.18574	0.5621
7-100	49	842.336	845.649	823.948	3.19124	-4.0292
7-101	48	845.377	848.710	841.607	2.16920	0.2536
7-102	49	848.689	863.375	844.641	2.52752	4.1138
7-103	49	839.031	842.436	835.785	2.21224	0.1106
7-104	11	846.772	848.624	845.507	1.05660	0.5233

Table H.5. Statistics for groundwater elevations (in feet) measured in 1986

Well	Number of observations	Mean	Max.	Min.	Std. dev.	Skew
7-1	37	867.522	871.466	864.200	2.35849	0.16869
7-2	39	867.727	870.081	865.290	1.54848	-0.24371
7-3	39	846.647	851.004	843.780	2.06718	0.15345
7-4	39	859.200	867.790	854.580	4.14422	0.82877
7-5	39	832.996	834.990	832.080	0.72138	0.54298
7-6	39	821.286	837.520	816.650	5.65041	2.04424
7-7	39	804.953	806.508	803.210	0.81357	-0.11004
7-8	39	793.703	797.520	789.130	2.37128	-0.25051
7-9	39	817.242	825.300	815.530	2.18536	2.48992
7-10	39	825.433	829.320	822.710	2.13564	0.38581
7-11	39	828.687	851.030	824.460	4.95084	3.02075
7-12	39	868.557	871.375	864.740	2.04727	-0.24645
7-13	35	795.664	797.220	794.270	0.61403	0.32877
7-14	39	857.824	861.460	854.610	2.33504	0.03102
7-15	39	865.740	870.160	863.190	1.89581	0.25931
7-16	39	868.765	872.188	864.707	2.19430	0.15887
7-17	38	860.879	865.862	856.860	2.99758	-0.06738
7-18	38	855.851	862.933	851.520	3.57378	0.16108
7-100	36	842.333	857.382	838.900	3.31537	2.86869
7-101	36	844.496	849.580	842.340	1.97085	1.22594
7-102	36	847.903	852.250	846.190	1.55896	1.51854
7-103	36	838.565	845.880	835.360	2.96787	1.08610
7-104	38	848.180	856.105	844.970	2.86040	0.84181

Table H.6. Statistics for groundwater elevations (in feet) measured in 1987

Well	Number of observations	Mean	Max.	Min.	Std. dev.	Skew
7-1	22	869.609	875.09	863.12	3.69458	-0.1517
7-2	22	868.352	870.74	864.78	1.90750	-0.5242
7-3	22	847.647	852.12	843.02	2.71591	-0.2399
7-4	22	862.372	868.09	854.71	4.90127	-0.2727
7-5	21	833.854	835.25	832.14	0.93095	-0.2365
7-6	22	820.284	823.84	816.40	2.33873	-0.0238
7-7	22	804.667	805.77	802.61	0.94277	-0.8765
7-8	22	793.033	797.00	788.52	3.23223	-0.1423
7-9	22	817.809	820.04	815.69	1.49571	0.0815
7-10	22	827.602	832.62	821.61	3.36388	-0.0987
7-11	22	829.024	834.02	823.59	3.30312	-0.1882
7-12	22	869.371	872.45	865.06	2.21032	-0.4285
7-13	22	795.228	796.16	792.99	0.96776	-1.0683
7-14	22	858.961	862.56	853.98	2.61315	-0.3730
7-15	22	866.506	869.28	862.62	2.10572	-0.1627
7-16	22	869.992	873.08	865.91	2.18492	-0.2402
7-17	22	863.217	867.45	856.51	3.18415	-0.7690
7-18	22	858.192	863.81	851.48	4.23547	-0.2753
7-100	22	843.069	846.23	838.65	2.57602	-0.3709
7-101	22	846.763	855.10	842.59	3.05912	0.6949
7-102	22	850.205	852.82	847.44	1.72148	-0.2260
7-103	22	840.033	843.83	835.65	2.88507	-0.0691
7-104	22	849.017	854.67	839.78	3.80776	-0.4520

Table H.7. Statistics for groundwater elevations (in feet) measured in 1988 (January-March)

Well	Number of observations	Mean	Max.	Min.	Std. dev.	Skew
7-1	4	865.165	867.86	863.02	2.1236	0.5852
7-2	4	866.620	867.86	865.03	1.1773	-0.8531
7-3	4	846.160	847.85	843.62	1.8516	-1.1159
7-4	4	863.145	868.32	855.95	5.1889	-1.1036
7-5	4	833.002	835.01	832.10	1.3664	1.7700
7-6	4	823.635	841.63	816.19	12.0502	1.9467
7-7	4	805.375	806.31	804.73	0.7072	0.8844
7-8	4	794.732	795.79	792.53	1.4867	-1.8503
7-9	4	815.372	815.53	815.24	0.1193	0.6131
7-10	4	823.732	825.51	821.84	1.5283	-0.2094
7-11	4	826.385	828.34	824.17	1.7883	-0.3578
7-12	4	865.287	866.86	864.45	1.1327	1.2633
7-13	4	795.737	796.38	795.30	0.4952	0.7964
7-14	4	855.357	856.72	853.38	1.6224	-0.5242
7-15	4	861.462	862.22	860.31	0.8216	-1.2681
7-16	4	865.735	867.61	864.69	1.3432	1.3016
7-17	4	861.150	863.76	856.26	3.3391	-1.7152
7-18	4	855.770	859.30	851.49	3.4502	-0.4721
7-100	4	844.560	847.62	842.05	2.2995	0.6991
7-101	4	847.137	847.66	846.23	0.6252	-1.6087
7-102	4	850.540	851.60	849.10	1.0478	-1.0252
7-103	4	841.665	842.79	840.73	0.9794	0.2828
7-104	4	846.742	848.34	844.75	1.4951	-0.7500

APPENDIX I
WATER CHEMISTRY DATA

Table I.1. Water chemistry data (collected April 1985)

	pH	Al[a]	B[a]	Ca[a]	Fe[a]	Ka	Mg[a]	Mn[a]	Na[a]	Sr[a]	Cl[a]	F[1]
Well 1	6.4	<0.20	<0.10	250	0.700	4.90		0.4300	62.0	0.310	9.96	<0.5
Well 2	6.5	<0.20	<0.10	240	0.120	7.05		0.4000	55.0	0.410	19.30	<0.5
Well 3	6.7	<0.20	<0.10	130	0.100	2.21	32.00	0.0370	13.0	0.170	3.01	<0.5
Well 4	6.7	<0.20	<0.10	78	0.057	1.78	9.10	0.0220	3.4	0.072	1.56	<0.5
Well 5	6.5	<0.20	<0.10	63	0.110	1.14	8.20	0.0260	5.4	0.085	0.77	<0.5
Well 6	7.3	<0.20	<0.10	32	0.240	0.63	3.40	0.0360	1.5	0.027	0.76	<0.5
Well 7	8.0	<0.20	<0.10	11	0.150	2.89	10.00	0.0140		0.700	9.33	<0.5
Well 8	7.2	<0.20	<0.10	60	2.600	1.79	7.20	0.2700	3.4	0.100	1.59	<0.5
Well 9	6.6	<0.20	<0.10	23	0.120	0.76	3.60	0.1600	1.8	0.021	1.40	<0.5
Well 10	6.5	<0.20	<0.10	140	0.037	4.45		0.1300	37.0	0.390	1.87	<0.5
Well 11	6.6	<0.20	<0.10	130	<0.030	2.25	18.00	0.1000	19.0	0.180	3.13	<0.5
Well 12	7.0	<0.20	<0.10	350	0.120	13.20		0.2300		3.900	15.00	<0.5
Well 13	7.4	<0.20	<0.10	29	0.030	2.42	10.00	0.0910	16.0	0.540	0.80	<0.5
Well 14	6.9	<0.20	<0.10	130	0.086		5.80	0.2900	28.0	0.630	2.07	<0.5
Well 15	8.5	<0.20	<0.10	170	0.036	6.65		0.7100	33.0	0.910	2.96	<0.5
Well 16	6.9	<0.20	<0.10	110	0.040	4.80		0.5300	29.0	0.350	3.24	<0.5
Well 17	6.7	<0.20	<0.10	79	<0.030	8.50	13.00	<0.0030	3.8	0.87	3.29	<0.5
Well 18	6.8	<0.20	<0.10	91	0.170	2.02	20.00	0.2300	9.1	0.130	2.62	<0.5
Well 100	6.7	<0.20	<0.10	82	0.056	1.74	10.00	<0.0030	4.9	0.077	1.72	<0.5
Well 101	6.4	<0.20	<0.10	180	0.084	4.28	28.00	0.4300	20.00	0.210	3.83	<0.5
Well 102	6.8	<0.20	<0.10	190	0.220	4.52	42.00	0.9800	18.00	0.200	3.08	<0.5
Well 103	7.0	<0.20	<0.10	76	0.066	1.55	14.00	0.0099	4.0	0.085	1.94	<0.5
Center 7 Creek		<0.20	<0.10	44	0.730	1.30	5.80	0.0570	4.4	0.070	1.30	<0.5
East 7 Creek		<0.20	<0.10	39	0.110	1.82	7.90	0.0500	6.9	0.083	4.08	<0.5
West 7 Creek		<0.20	<0.10	21	0.240	2.11	6.90	0.0180	4.9	0.066	4.41	<0.5

	pH	PO4[a]	Si[b]	SO_4[a]	T. Alk.[c]	H-3[d]	Co-60[d]	Cs-137[d]	Sr-90[d]	Gross Alpha[d]
Well 1	6.4	<5.0	7.50	575.0	390	02±0.3	<.009	.220±.090	<.10	<5.0
Well 2	6.5	<5.0	4.90	1096.0	370	04±30	<.200	<.200	.11±.14	<5.0
Well 3	6.7	<0.5	4.50	127.0	330	08±30	<.100	.120±.100	.30±.11	<5.0
Well 4	6.7	<0.5	5.00	10.6	240	32±30	<.200	<.100	.16±.15	<4.0
Well 5	6.5	<0.5	7.80	11.8	400	16±30	<.200	<.200	.10±.14	<3.0
Well 6	7.3	<0.5	5.00	4.15	100	36±30	<.200	<.100	.06±.13	<4.0
Well 7	8.0	<1.0	6.70	12.1	230	03±30	<.200	<.100	.12±.14	<5.0
Well 8	7.2	<0.5	6.40	6.66	180	25±30	<.100	.260±.100	<.10	<4.0
Well 9	6.6	<0.5	6.30	3.34	80	44±30	.084±.07	<.050	.21±.17	<4.0
Well 10	6.5	<0.5	6.70	226.0	400	<30	<.070	<.060	.03±13	<4.0
Well 11	6.6	<0.5	5.90	121.0	300	16±30	<.100	<.100	<.10	<4.0
Well 12	7.0	<1.0	3.70	1500.0	320	<30	<.100	<.100	.01±.10	<4.0
Well 13	7.4	<0.5	7.70	11.6	150	<30	<.090	<.100	.05±.12	<4.0
Well 14	6.9	<0.1	9.10	335.0	340	06±30	<.070	<.060	.16±.15	<4.0
Well 15	8.5	<0.5	5.10	609.0	310	<30	<.070	<.060	.30±.10	<4.0
Well 16	6.9	<0.5	8.00	261.0	300	<30	<.100	<.200	<.10	<4.0
Well 17	6.7	<0.5	4.10	28.8	200	33±30	<.200	<.100	<.10	<4.0
Well 18	6.8	<0.5	5.60	35.3	300	37±28	<.200	<.100	<.10	1.0±2.3
Well 100	6.7	<0.5	4.50	21.0	220	67±29	<.20	<.200	<.10	0.5±2.0
Well 101	6.4	<0.5	5.60	290.0	230	12±27	<.090	<.060	<.10	0.3±2.4
Well 102	6.8	<0.5	3.80	438.0	240	39±28	<.070	.062±.057	.04±.14	0.1±1.9
Well 103	7.0	<0.5	3.50	43.6	220	66±29	<.100	<.100	.08±.14	0.5±2.1
Center 7 Creek		<0.5	4.90	12.7	120	71±29	<.100	<.100	.02±.10	<2.0
East 7 Creek		<0.5	3.40	29.3	110	64±29	<.100	<.070	.02±.10	0.6±2.0
West 7 Creek		<0.5	3.40	22.3	60	66±29	.110±.08	.980±.160	.11±.14	1.2±2.3

[a]Micrograms per milliliter.

[b]SiO_2 reported as Si (μg/mL).

[c]Micrograms per millileter of $CaCO_3$

Table I.2. Charge balance (milliequivalents)

Well	Ca	K	Mg	Na		Cl	SO_4	HCO_3	Anion	Cation	Diff.	% Error
1	12.48	0.13	4.61	2.70	I	0.28	11.96	3.90	19.9	16.1	3.8	21
2	11.98	0.18	10.70	2.39	I	0.54	22.80	3.70	25.2	27.0	-1.8	-7
3	6.49	0.06	2.63	0.57	I	0.08	2.64	3.30	9.7	6.0	3.7	47
4	3.89	0.05	0.75	0.15	I	0.04	0.22	2.40	4.8	2.7	2.2	58
5	3.14	0.03	0.67	0.23	I	0.02	0.25	4.00	4.1	4.3	-0.2	-4
6	1.60	0.02	0.28	0.07	I	0.02	0.09	1.00	2.0	1.1	0.9	55
7	0.55	0.07	0.82	3.57	I	0.26	0.25	2.30	5.0	2.8	2.2	56
8	2.99	0.05	0.59	0.15	I	0.04	0.14	1.80	3.8	2.0	1.8	62
9	1.15	0.02	0.30	0.08	I	0.04	0.07	0.80	1.5	0.9	0.6	52
10	6.99	0.11	4.03	1.61	I	0.05	4.70	4.00	12.7	8.8	4.0	37
11	6.49	0.06	1.48	0.83	I	0.09	2.52	3.00	8.9	5.6	3.3	45
12	17.47	0.34	10.70	2.31	I	0.42	31.20	3.20	30.8	34.8	-4.0	-12
13	1.45	0.06	0.82	0.70	I	0.02	0.24	1.50	3.0	1.8	1.3	53
14	6.49	0.15	4.86	1.22	I	0.06	6.97	3.40	12.7	10.4	2.3	20
15	8.48	0.17	6.09	1.44	I	0.08	12.67	3.10	16.2	15.9	0.3	2
16	5.49	0.12	3.70	1.26	I	0.09	5.43	3.00	10.6	8.5	2.1	22
17	3.94	0.22	1.07	0.17	I	0.09	0.60	2.00	5.4	2.7	2.7	67
18	4.54	0.05	1.65	0.40	I	0.07	0.73	3.00	6.6	3.8	2.8	54
100	4.09	0.04	0.82	0.21	I	0.05	0.44	2.20	5.2	2.7	2.5	63
101	8.98	0.11	2.30	0.87	I	0.11	6.03	2.30	12.3	8.4	3.8	37
102	9.48	0.12	3.46	0.78	I	0.09	9.11	2.40	13.8	11.6	2.2	18
103	3.79	0.04	1.15	0.17	I	0.05	0.91	2.20	5.2	3.2	2.0	48
C7 Creek	2.20	0.03	0.48	0.19	I	0.04	0.26	1.20	2.9	1.5	1.4	64
E7 Creek	1.95	0.05	0.65	0.30	I	0.12	0.61	1.10	2.9	1.8	1.1	47
W7 Creek	1.05	0.05	0.57	0.21	I	0.12	0.46	0.60	1.9	1.2	0.7	45

APPENDIX F

SOIL AND SAPROLITE CHARACTERIZATION OF THE LOW-LEVEL WASTE DISPOSAL DEVELOPMENT AND DEMONSTRATION SITE BEAR CREEK VALLEY

This appendix will also be published separately as ORNL/TM-10927

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**Environmental Sciences Division, ORNL

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ABSTRACT

The soil and saprolite characterization study was completed on the proposed Tumuli Low-Level Waste Disposal, Development, and Demonstration (LLWDDD) project site in Bear Creek Valley, Oak Ridge, Tennessee. The objectives of the study were to complete a detailed soil characterization of major soils on the site and evaluate the soil characteristics for the suitability of the site for both trench and tumuli burial of low-level nuclear waste. Detailed mapping and computer digitization was completed on the site. Nine profiles were excavated, described, and sampled on major soil mapping units of the upper Pumpkin Valley Shale, Rogersville Shale, Maryville Limestone, and Nolichucky Shale. Samples were prepared and analyzed for physical, chemical, and mineralogical characterization. Chemical analyses indicated that the soils were moderately acid, had cation exchange values ranging from 10 to 30 $cmol(+)\cdot kg^{-1}$, and had base saturation values <30%. Magnesium was the predominant exchangeable base found in residual soils. In highly developed soils, iron and manganese had translocated through the soil profile into the underlying saprolite. Most residual soils were shallow to saprolite as a result of geologic and anthropogenically accelerated erosion. This erosion resulted in soils with low to moderate available water holding capacity, low infiltration capacities, and high runoff rates. All soils contained clays that had low liquid and plastic limits and low activities (shrink-swell potential). Topographic reversal and alluvial accumulation revealed past climatic effects upon these soils. Radionuclide sorption ratios were high for soils containing high amounts of iron and manganese oxides and organic carbon. Evaluation of soil data suggested that soils formed on the upper Pumpkin Valley Shale and Maryville Limestone were the most developed soils on the site. High water tables restrict the use of conventional below ground waste trench burial in some soils formed on the upper Pumpkin Valley and all soils formed from Nolichucky Shales. Soil characteristics and underlying geologic conditions make placement of above-ground, low-level nuclear waste disposal facilities (Tumuli) possible in areas underlain by the Pumpkin Valley and Nolichucky Shales. Fill materials for these facilities could best be obtained from the areas of old alluvial soils and soils developed in colluvium from the Pumpkin Valley Shale and Rome Formation.

1. INTRODUCTION

The following study was completed on the proposed Tumulus Low-Level Waste Disposal Development and Demonstration (LLWDDD) project site in Bear Creek Valley, Oak Ridge Reservation, Tennessee. The objectives of the study were (1) to complete a detailed soil characterization of major soils on the site, and (2) evaluate the soil characteristics for the suitability of the site for both trench and tumuli burial of low-level nuclear waste. This information was necessary to gain a better understanding of the physiochemical, mineralogical, hydrological, and engineering properties related to land-use planning in the area. The study area was located in Bear Creek Valley, a northeast-southwest oriented linear valley underlain by carbonates and shales of the Conasauga Group. The LLWDDD site comprises about 300 acres. The site is bounded to the southwest by Tennessee Highway 95, to the southeast by Bear Creek, to the northeast by Gum Hollow Road, and to the northwest by Pine Ridge (Fig. 1).

The climate of the area is characterized by mild winters, long springs and falls, and warm, humid summers. Mean annual precipitation averages 136 $cm \cdot yr^{-1}$ (53.5 $in. \cdot yr^{-1}$). Rainfall amounts are greatest in spring and early summer, with less rainfall occuring in the fall. The mean annual air temperature is about 15°C. Mean annual soil temperature at a depth of 50 cm is around 16°C, with cooler and moister soils on northern aspects and warmer, drier soils on southern aspects (Lietzke et al. 1988).

The LLWDDD site soil characterization focused on investigating the soil profile from saprolite (weathered, soft rock) to the soil surface. Preliminary soil mapping and computer digitization of mapping data were completed before to site selection and sampling. Nine profiles were excavated, and samples were collected and prepared for physical, chemical, and mineralogical analysis at the Plant and Soil Science Department, the University of Tennessee, Knoxville (UTK). All analyses, except for X-ray diffraction and radioactive sorption analyses, were performed at UTK. The remaining procedures were completed at the Oak Ridge National Laboratory.

The soils and landforms of the LLWDDD site have undergone intense weathering and soil erosion cycles. Farming practices before the 1940s led to erosion of much of the topsoil, leaving areas of shallow soils and saprolite outcroppings. Other areas that were not cultivated in the past are very steep. These areas are located along the south slopes of Pine Ridge (Fig. 2). Considerable volumes of colluvium (soil moved and deposited by water and gravity) can be found at the foot of most ridges. Substantial areas of old and modern alluvium can be found in the Bear Creek floodplain and on old terraces and drainageways (Fig. 3) (Lietzke et al. 1988).

Soil parent materials consist of mixtures of limestones, dolomites, shales, and sandstones. Soil formation varies on each of these materials because of differences in permeability (rates), contents of primary minerals and carbonates, and degree of parent rock deformation by folding and faulting. The past folding and faulting of parent rock not only influenced soil formation, but also determined drainage patterns and the development of ridges.

Most of the area is covered with hardwoods. White oak and tulip poplar occupy areas with deeper soils containing moderate amounts of calcium. Eroded, nutrient-poor soils support chestnut oak stands and understories of greenbriar and blueberries. Pine plantations occupy the highly eroded soils.

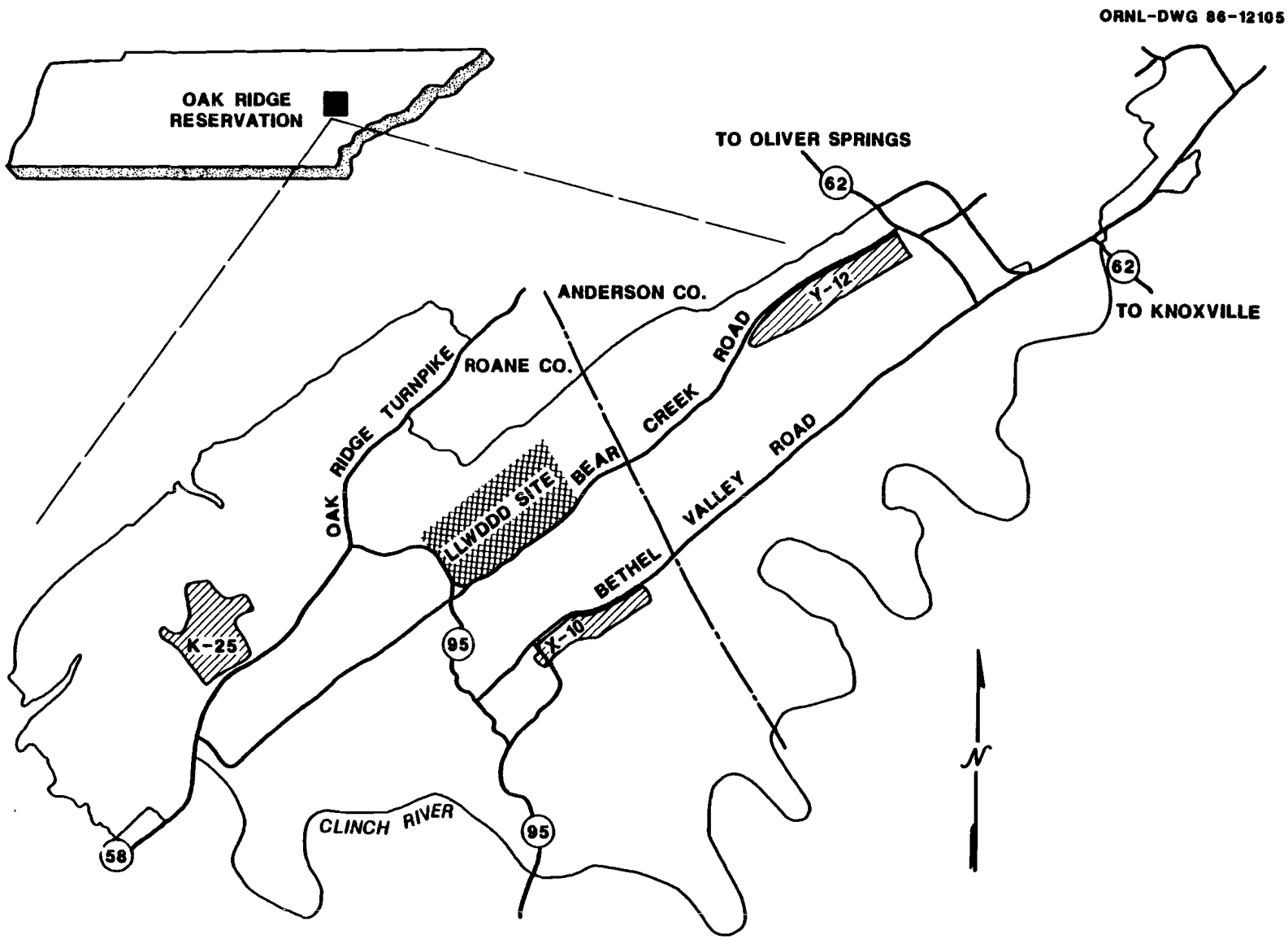

Fig. 1. Map of Oak Ridge Area.

ORNL-DWG 87-12159

SOIL SLOPE CLASS

Tumulus Disposal Demonstration Facility
Oak Ridge Reservation, Oak Ridge, TN
Low-Level Waste Design Development and Demonstration Program

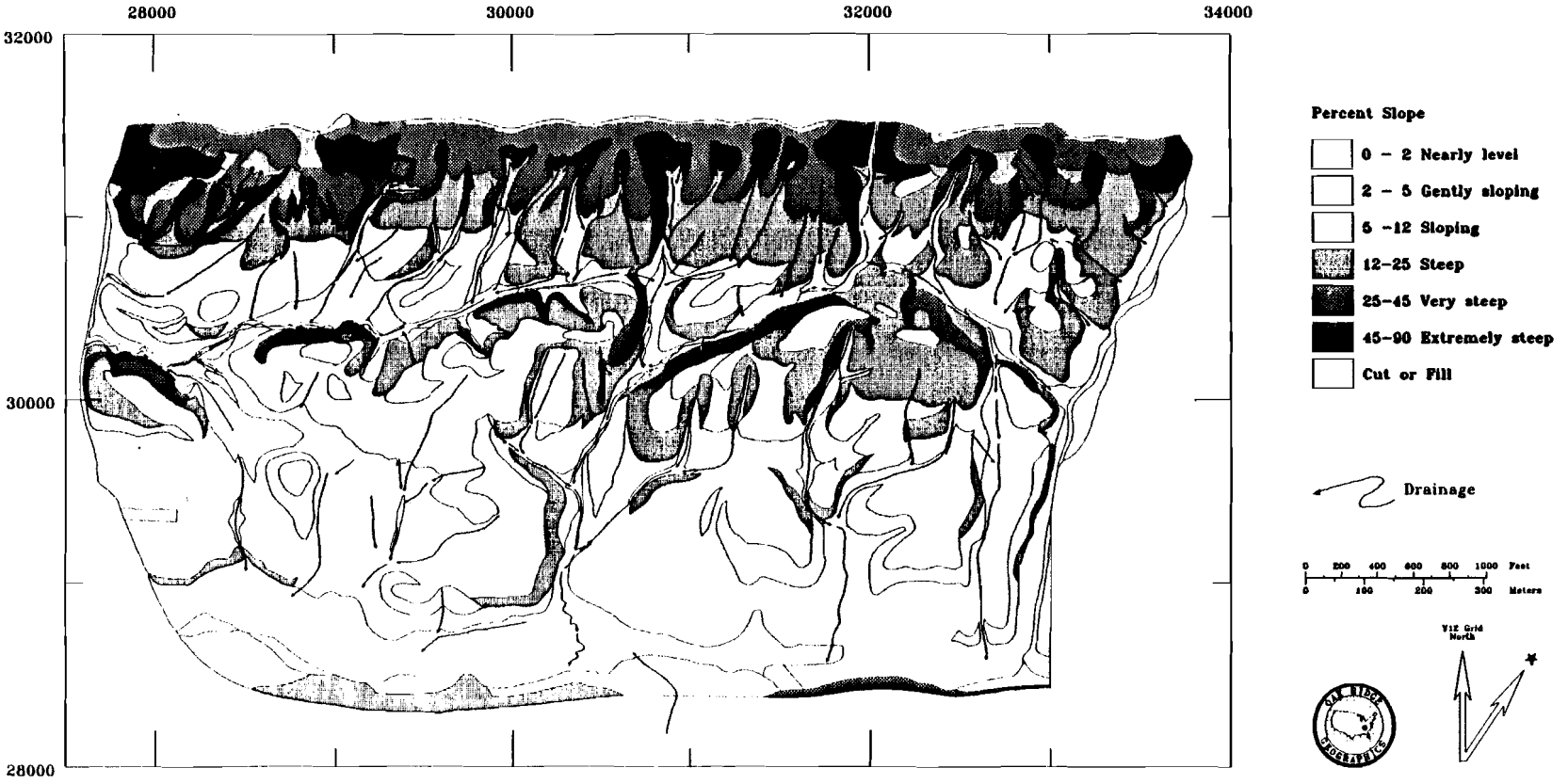

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Fig. 2. Soil slope class.

ORNL-DWG 87-12163

SURFICIAL GEOLOGY

Tumulus Disposal Demonstration Facility
Oak Ridge Reservation, Oak Ridge, TN
Low-Level Waste Design Development and Demonstration Program

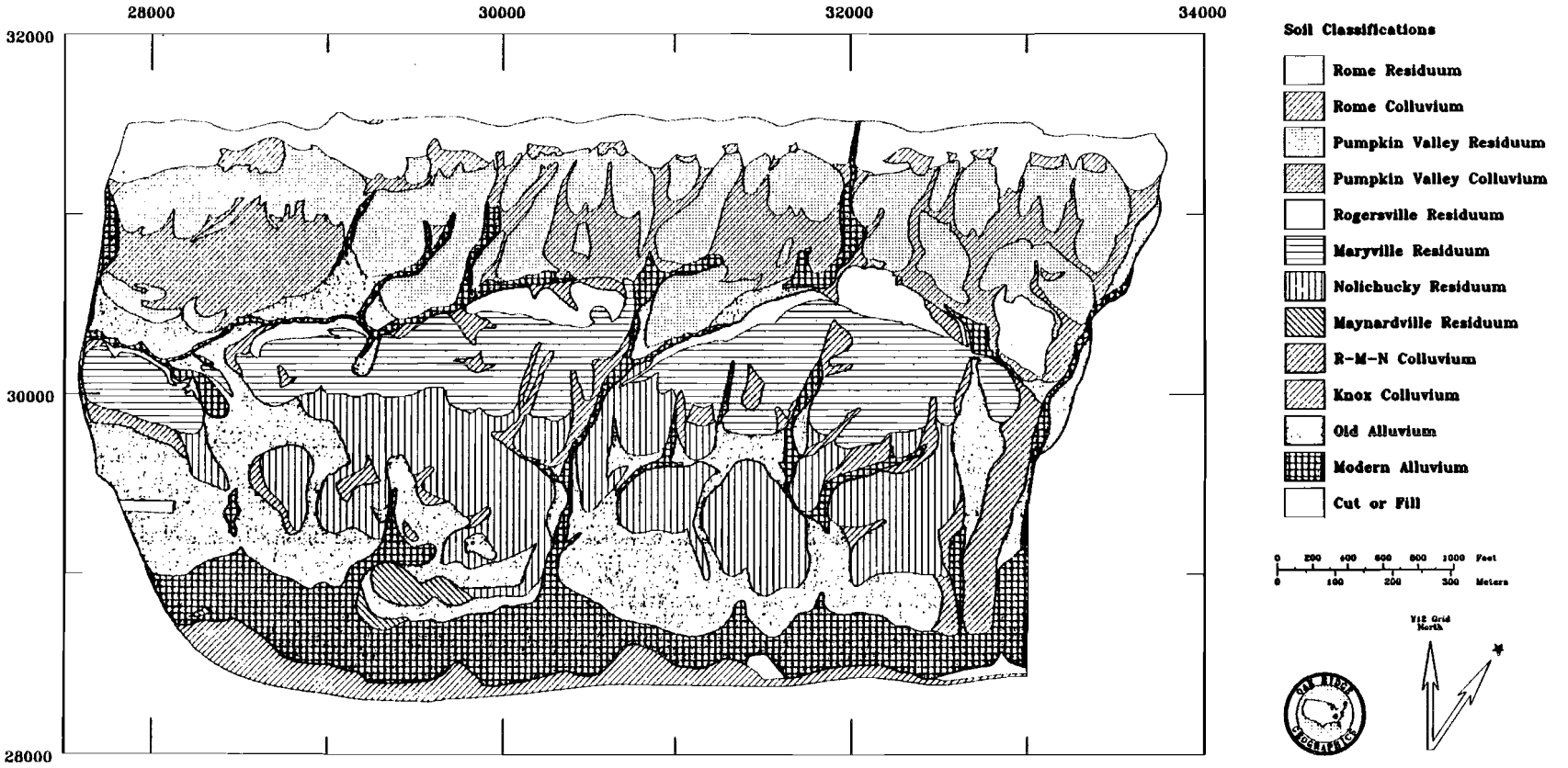

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Fig. 3. Surficial geology map.

Interpretation of soil data, radionuclide data, properties of underlying geologic parent materials, and hydrology will aid in long-range site planning for low-level radioactive waste disposal and determining the quantity and distribution of soils suitable as fill materials.

2. LITERATURE REVIEW

2.1 INTRODUCTION

In the United States, the major method of burial of industrial, municipal, and low-level nuclear wastes is shallow land burial (Wilson 1977, Davis 1983, Lee and Tank 1985). To minimize contamination of surrounding soils and groundwater supplies, proper steps must be taken to choose a suitable disposal site. Such properties as soil and saprolite characteristics (physical, chemical, and mineralogical), hydrology, erodibility, geology, and soil and clay stability are important criteria for site selection. East Tennessee and Oak Ridge area soils have not been thoroughly studied, but research projects are now under way to characterize the soils and their soil-forming processes.

2.2 CHARACTERISTICS OF SOILS AND SAPROLITES THAT AFFECT LOW-LEVEL NUCLEAR WASTE DISPOSAL

Low-level nuclear wastes result from articles coming into contact with radioactive matter. Such wastes may include paper, rags, gloves, tools, and experimental plants and animals (Lee and Tank 1985). Disposing of these waste has been a problem. Not disregarding federal regulations and socioeconomics, the simple matter of finding an ecologically safe and stable waste site has been a major problem. The first step in locating such a site lies with characterizing the soils and geology of the site under consideration.

Low-level waste disposal sites are usually located on stable landforms that have low groundwater tables and are well drained (Jacobs 1980, Lee and Tank 1985). Thus, such soil physical properties as plasticity, soil shear strength, bulk density, permeability, porosity, and particle size must be examined. These properties determine how useful a particular soil may be for sealing excavations containing wastes. Soils containing clays exhibiting good sealing qualities (low shrink-swell potential, low permeability, and high shear strength) perform best. Size and distribution of soil particles and clay mineralogy are important because they influence porosity and shear strength. In evaluating the many clay minerals found in soils, illite was found to perform best for sealing pit walls. Although smectite clays have lower permeabilities and are very plastic, they falter on shear strength and are too expansive. Illite is intermediate in desirable physical properties (Nowak 1980). Because clays in soils are usually "mixed" in mineralogy, fill materials and sealers have to be selected to contain a high amount of an acceptable clay mineral.

Saprolites are also very important in containing low-level nuclear wastes. "Saprolite" was first coined by G. F. Becker in 1894 as "a general name for thoroughly decomposed, earthy, but untransported rock" (Becker 1894, Calvert 1980). It is generally thought of as the intermediate between soil and unleached rock. Saprolites still hold rock structure, yet usually lack the color, hardness, and chemical composition of the parent rock. Saprolites are important in low-level waste disposal because they tend to restrict vertical water flow and have high sorptive abilities. The presence of amorphous iron and manganese coats on the surface of saprolite (Cr material)

increases the sorptive capacity of these materials for many radionuclides (Tamura 1965, Olsen et al. 1986). With respect to saprolites of certain geologic formations in East Tennessee, the Cambrian Conasauga Group saprolites have high sorptive capacities because of an abundance of amorphous iron and illitic clays (Cutshall et al. 1982). Most of the Conasauga group rocks and saprolites contain high amounts of quartz, illite, vermiculite, and kaolinite, cemented together in a calcite matrix. Weathering processes have removed most of the calcite cement, leaving thick saprolites that are sometimes clay plugged. This condition helps restrict water flow and heavy metal and radionuclide movement.

Of all particle size classes, the clays (size <0.002 mm) are the most active filterers of radionuclides. Clays are able to contain radionuclides by ion exchange, chemisorption, and precipitation (Lee and Tank 1985). Ion exchange occurs as cation exchange on clay edges where negative charges are present. Chemisorption occurs when an anion portion of a radionuclide bonds covalently to a cation within the clay structure (Schwertmann and Taylor 1977, Lee and Tank 1985). When a radionuclide enters the soil solution, it will often precipitate, forming secondary mineral coats on soil particles.

To assess the soil constituent stability of a waste site, one needs to understand the weathering processes and mineralogy of the site. Clay minerals present in rocks of the Conasauga Group commonly follow a muscovite to HIV (Al-hydroxyinterlayered vermiculite) weathering sequence. Beginning with a parent material containing muscovite, weathering reactions remove cations, resulting in an illitic clay mineral. Further weathering produces vermiculite and finally HIV. Biotite, also present in Conasauga rocks, weathers into kaolinite (Rice et al. 1985). The final weathering products of very old soils would be hydrous oxides like gibbsite and goethite or hematite. In the southeastern United States, the most common clay minerals found in soils are kaolinite and HIV. Looking at a typical soil profile from the surface downward, one would generally find the surface soils dominated by HIV. Kaolinite percentages increase with depth in the soil profile, and eventually surpass HIV. As soil parent materials are approached, kaolinite gives way to the parent minerals of biotite and muscovite (Karathanasis et al. 1983). The most stable clays over time appear to be those that are near the end of the weathering cycle. From a mineralogical point of view, minerals like kaolinite vermiculite and HIV could be good candidates for fill-in waste sites.

3. MATERIALS AND METHODS

3.1 FIELD

3.1.1 Geology

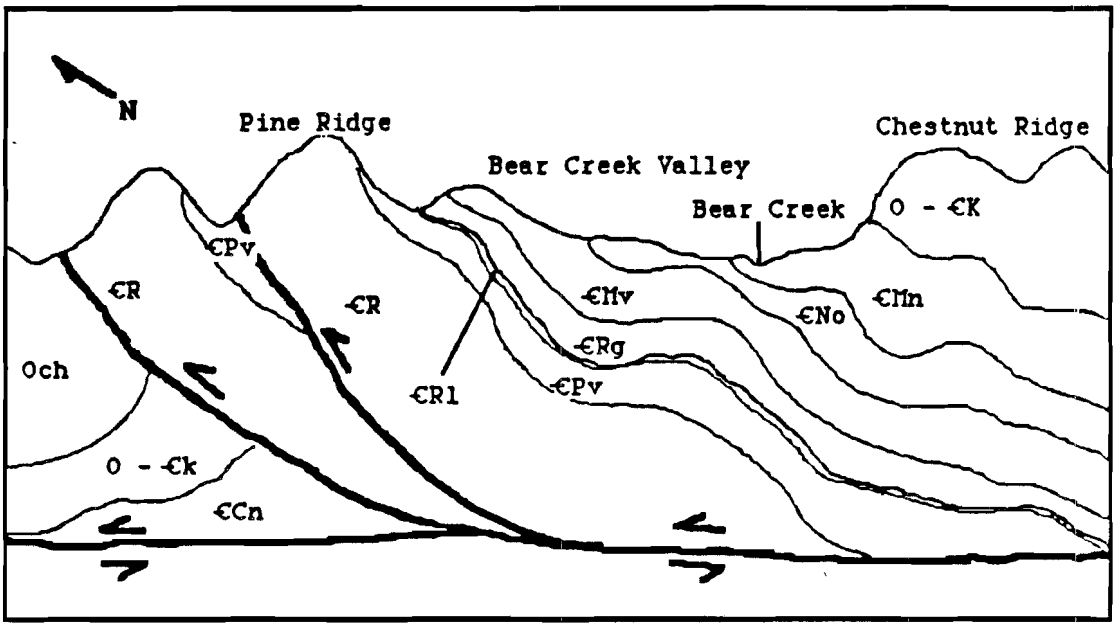
The LLWDDD Facility traversed the early to middle Cambrian carbonates and clastics of the Conasauga Group. Stratigraphic units of the uppermost Rome Formation, Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, Nolichucky Shale, and Maynardville Limestone were present in the study area. This stratigraphic section was a representation of a westward transgressing sea, resulting in a change from a section of terrigenous clastic sediments derived from western sources (Rome Formation) to the carbonate-rich Maynardville Limestones (Lee and Ketelle, 1988). These rock units have since been thrust faulted and dip southeastward between 30 and 70° (Fig. 4). The thrust fault at this locality was called the White Oak Mountain fault. The thrust fault ran along the north side of Pine Ridge in the Rome formation.

The Rome formation existed as a layer of very fine grained white arkosic sandstones along the summit and upper sideslopes of Pine Ridge. The Rome graded upward into a group of alternately layered glauconitic sandstone, siltstone, and shale bodies known as the Pumpkin Valley Shale. On the lower slopes of Pine Ridge, green glauconitic, fine textured sandstones, and buff colored siltstones persist (Lee and Ketelle 1988). Near the foot of many of the spur ridges of Pine Ridge, the upper Pumpkin Valley shale exists as a thinly laminated shale and thinly bedded, buff-colored siltstone.

Small exposures of Rutledge Limestone have been found on the LLWDDD Site, but most of the Rutledge limestone has been blanketed by alluvium and/or colluvium from the Rome and Pumpkin Valley Formations. The topographic position that this stratigraphic unit commonly occupied was low, often containing a stream or drainage divide. This unit rested between Pine Ridge and a smaller ridge whose north aspect contains Rogersville shale; a greenish-gray, fissile, laminated silty clay shale with few mudstone beds (Lee and Ketelle 1988). Near the summit of the smaller ridge running parallel to Pine Ridge, the Rogersville gave way to the Maryville Limestone.

The Maryville limestone unit on the LLWDDD site was highly weathered and leached, and the upper saprolite appeared as alternating bands of olive brown mudstones, siltstones, and thin lenses of sandstone. The Maryville unit was a ridge former, forming higher topography than any other formation within the Conasauga group. At this site, the Maryville Formation was in its shaly facies, in comparison with the true "limestone" facies that existed farther to the northeast (Lee and Ketelle 1988). This was caused by a locally deeper environment of deposition. Near the boundary with the Nolichucky shale, the Maryville contained thinly bedded limestones. The Nolichucky-Maryville boundary was transitional, and the presence of carbonates often produced a swale-like (saddle) topography.

Nearly level to sloping, subdued topography developed on the Nolichucky shale. The Nolichucky Shale was characterized as a dark brown, quartz silty, internally laminated shale with beds of silty, clayey lime mudstones (Lee and Ketelle 1988). The lower Nolichucky contained a few fine sandstone and



LEGEND

€Cn - Conasauga Group
- €R - Rome Formation
- €PV - Pumpkin Valley Shale (Lower, Upper)
- €R1 - Rutledge Limestone
- €Rg - Rogersville Shale
- €Mv - Maryville Limestone
- €No - Nolichucky Shale
- €Mn - Maynardville Limestone

O - €K - Knox Group (Dolomitic Limestones

OCh - Chickamauga Group (Shales and Limestones)

Fig. 4. Stratigraphy of Bear Creek Valley in the vicinity of the LLWDDD site.

limestone lenses. The limestone and lime mudstone lenses often weathered out near the surface, forming clay zones that alternate with shale. The upper member of the Nolichucky Shale increased in carbonate content and graded into the carbonate-rich Maynardville Limestone. On the LLWDDD site, alluvial terraces of Bear Creek covered most of this boundary (Lietzke et al. 1988).

On the LLWDDD site, the Maynardville Limestone was covered by Bear Creek alluvium, except for occasional limestone outcrops. This stratigraphic unit consisted of a mottled to ribboned to nodular finely grained limestone and stromatolitic finely grained limestone and dolostone (Lee and Ketelle 1988).

Between 250 and 260 m above mean sea level, a significant amount of old alluvium mantled the area. The alluvium was composed of very fine sands and coarse silts and contained very few, if any, rock fragments. The origin of this material appeared to be from the Rome Formation and Pumpkin Valley Shale (Lietzke et al. 1988). The alluvium had a distinctive brownish yellow subsoil color (10 YR 6/6).

3.1.2 Soil Profile Locations

For the soil and saprolite characterization of the LLWDDD site, profiles were located on the dominant soils of the upper Pumpkin Valley, Rogersville, Maryville, and Nolichucky Formations. Sites were selected by preliminary soil mapping, transect, and auger investigations. Eroded and uneroded sites were selected for both the upper Pumpkin Valley and Rogersville formations. Eroded sites were selected for the Maryville and Nolichucky formations. Two sites were also selected in the old alluvium above Bear Creek. Sites were selected based on representation of that site to the soil mapping unit most frequently found on a particular geologic formation (Fig. 5). At least one site was selected for each geologic formation present. Profiles were numbered using the mapping unit number and an erosion status symbol (E for eroded, N for noneroded). Pumpkin Valley Shale profiles were labeled 24-N and 24-E, Rogersville profiles were labeled 36-N and 36-E, and the single Nolichucky profile was labeled 51-E. A Maryville profile that contained both a colluvial and residual face was labeled 49 & 42-E (49 represented the Maryville colluvial face, and 42-E represented the Maryville residual face). The first old alluvial profile, containing Pumpkin Valley colluvium over old alluvium, was labeled 26/951. The other alluvial profile was labeled 951.

All sites, with the exception of profile 24-E, were located along one of two soils transects. The first transect (A-A′) followed a telephone line across a large expanse of old alluvium (See Fig. 7). Transect A-A′ started about 310 m east of the intersection of Tennessee Highway 95 and Bear Creek Valley Road and ended at Highway 95 near the watergap in Pine Ridge. The second transect (B-B′) ran perpendicular to geologic strike, and followed an old field road 350 m southwest of Gum Hollow Road (See Fig. 8). The transect extended from Bear Creek to the crest of Pine Ridge.

Profile 26/951 was located at the upper end of the alluvial transect on a footslope of Pine Ridge (latitude 35°56′30"N, longitude 84°20′30"N). Profile 951 was about 190 m down transect, on an old terrace (35°56′26"N, 84°20′28"W). About 165 m northeast of profile 951, profile 24-E rested in the middle of a pine plantation (35°56′35"N, 84°20′20"W). All other profile sites were located along the first transect. Profile 51-E was located in

SOIL SURVEY MAP

TUMULUS DISPOSAL DEMONSTRATION FACILITY
OAK RIDGE RESERVATION, OAK RIDGE, TN
LOW-LEVEL WASTE DESIGN DEVELOPMENT AND DEMONSTRATION PROGRAM

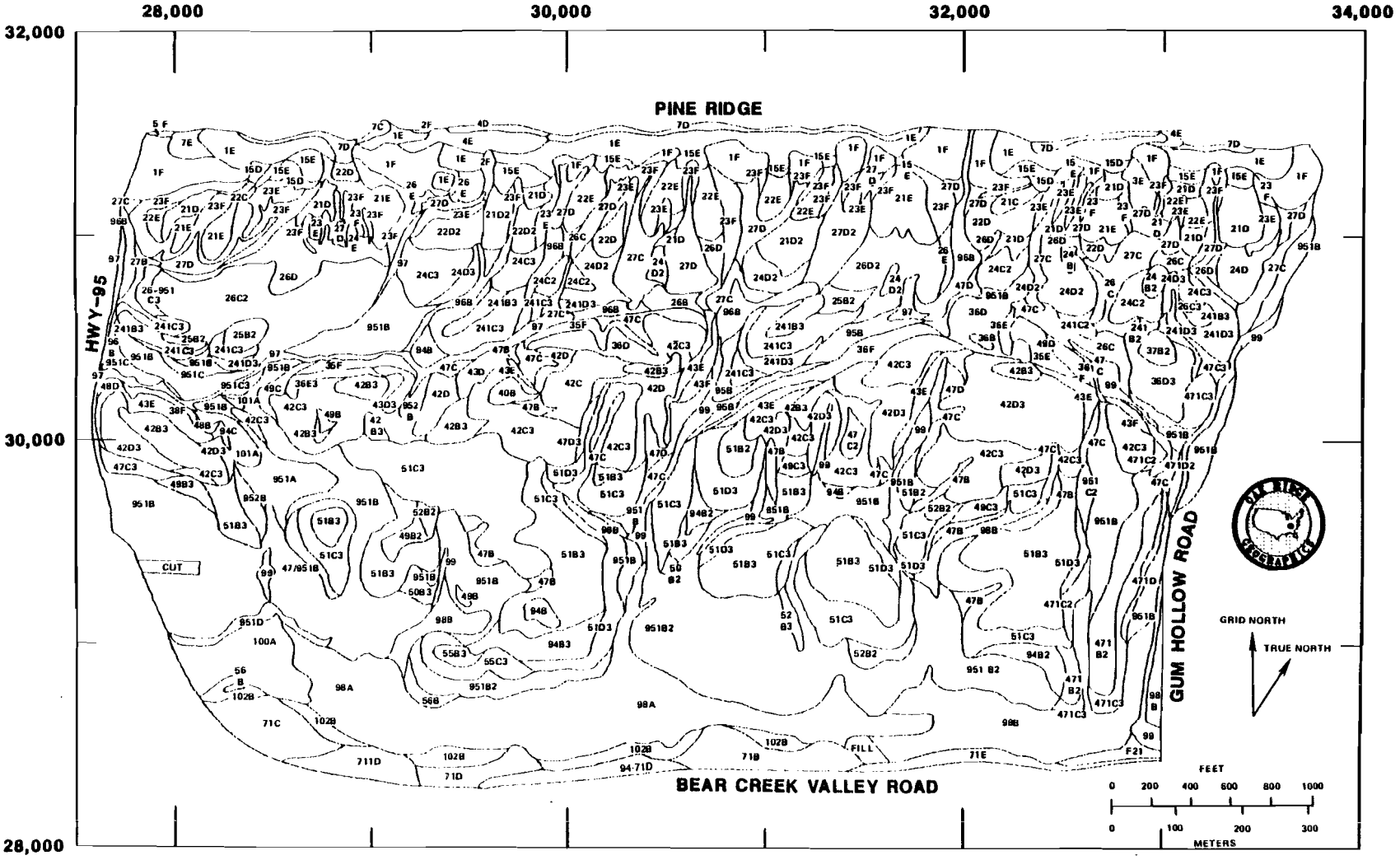


Fig. 5. Soil survey map of the LLWDDD site.

transplanted pines 125 m uptransect from Bear Creek (35°56′42"N, 84°19′38"W). Profiles 49 & 42-E were located in hardwoods on the south aspect of the small ridge formed in Maryville Limestone (35°56′ 46"N, 84°19′46"W). Profile 24-N was located on the lower slopes of the south aspect of Pine Ridge (35°56′56"N 84°19′47"W). Opposite the summit of this ridge, profiles 36-E (35°56′49"N, 84°19′50"W) and 36-N (35°56′50"N, 84°19′45"W) were located.

3.1.3 Sample Preparation

Thirty-six samples were collected from the nine profiles described. Profiles containing one or more Bt horizons or an A and E horizon were bulk sampled. Samples were placed in 3-L sample bags, labeled, and stored moist at room temperature. Samples then were air-dried, weighed, and passed through a 2-mm sieve to remove coarse fragments (SCS 1984). Coarse fragment contents were reported as volume percentages. Coarse fragments and fine earth materials were retained, bagged, and labeled for laboratory analysis.

3.2 LABORATORY

3.2.1 Chemical Analysis

Total carbon was determined by the dry combustion of 0.5 g of sample in a LECO CR12 carbon analyzer, model 781-700. Soil pH (1:1 soil water ratio) was measured using an Orion model 399A pH meter and combination electrode (McLean 1982). Exchangeable aluminum and hydrogen were determined by KCl extraction (Thomas 1982).

Cation exchange capacity was determined by ammonium saturation and sodium replacement (Chapman 1965). The procedure was modified by placing 2.5 g of air dry soil in a 50-mL centrifuge tube. Isopropyl alchol was replaced by ethanol. A Kjeltec 1004 distilling unit was employed to extract the ammonium. Base cations were measured with a Perkin Elmer 403 Spectrophotometer, and percent base saturation was determined by summation (Jackson 1958). Calcium carbonate equivalents were calculated using a neutralization potential procedure (Sobek et al. 1978). Free iron oxides were determined using the citrate-dithionite method (Olson and Ellis 1982). Manganese oxides were extracted and quantified by means of hydroxylamine hydrochloride (Chao 1972).

3.2.2 Physical Analysis

Texture determinations were made by pipete (EPA 1986). Fine silt plus clay and clay extractions were made using a 25-mL Lowry three-way pipete. Sand fractions were sieved into very fine, fine, medium, coarse, and very coarse sand. Percent coarse fragments were calculated (by volume) to determine the need for textural modifiers. Fifty milliliters of clay fraction was retained for X-ray diffraction analysis.

Atterberg limits were determined by methods described by the American Society for Testing and Materials (ASTM 1980). A Soiltest CL-205 liquid limit

device was used for the procedure. Shrinkage limit was determined by the equation SL = 20 + pi, where SL is shrinkage limit, and pi is the distance above or below the A-line that the plot of plasticity index and liquid limit rests on Casagrande's plasticity chart (Casagrande 1932).

Moisture retention at 33- and 1500-kPa pressures was measured on a Soilmoisture 5-bar and 15-bar Pressure Plate Extractor, model 1600 and 1500, respectively (SCS 1984). Available water was calculated as the difference between 33- and 1500-kPa water contents and corrected for >15% coarse fragments when necessary (SCS 1984). Total available water-holding capacity was calculated for all profiles from the surface to a depth of 150 cm or the upper boundary of hard Cr material, whichever is shallower.

Bulk densities were calculated by the core method (Blake and Hartge 1986a). Cores were collected in 7.6-cm-diam shelby tubes using a mobile drill. Cores were taken from one profile found on each of the major geologic formations and the 951 old alluvium and 26/951 colluvium and alluvium profiles. Cores were cut by pipe cutter, weighed, oven-dried at 105°C, and reweighed. Specific gravities (particle densities) were determined by the pychnometer method (Blake and Hartge 1986b). Random samples were pulled from the cores for specific gravity determination. Specific gravities were determined for an A, B, and Cr horizon for each profile sampled. Total porosity was determined from bulk density and specific gravity data.

3.2.3 Mineralogical Analysis

Both dithionite treated and untreated clay specimens were prepared for X-ray diffraction using the filter membrane peel technique (Drever 1973). Iron-stripped clay samples were prepared for X-ray diffraction using procedures of Jackson (1958). Magnesium saturated slides were scanned at room temperature and ambient humidity and following glycerol solvation. Diffraction scans of potassium saturated slides were made at room temperature and after 2-h heat treatments at 105, 300, and 550°C. Scans began and ended at 2 and 30°, 2 theta, respectively, using Cu K radiation at 35 kV and 20 mA. X-ray scans were made on a Norelco-Phillips X-ray diffractometer, model 3-202, computerized with a California Scientific computer system. Diffraction scans were plotted on a X-Y plotter, and data were stored on disk. Diffractograms were run at 1°/min and stepped at intervals of 0.04^{o}.

4. RESULTS AND DISCUSSION

4.1 SOIL MORPHOLOGY AND CLASSIFICATION

Field morphology of all soil profiles was recorded on form SCS-SO1-232. Soil profile classifications are listed in Table 1. Soil profile descriptions are presented in Appendix A. Profile 24-E [Fig. 6(a)] was characterized by having a 15-cm Ap horizon, abruptly overlying a dark reddish gray shale Cr horizon. The Cr material was coated with iron stains and patchy clay skins, indicating the presence of a clay-enriched subsoil horizon. Profile 24-N [Fig. 6(b)] had alternating Bt and Bw horizons interrupted by Cr materials. An abrupt, inclined, and highly irregular Cr boundary existed at 66 to 118 cm, and the Cr material was composed of alternating bands of dipping mudstones and glauconitic sandstones. Discontinuous red iron stains and continuous faint reddish brown clay skins coated Cr surfaces.

Profiles 36-E and 36-N [Figs. 6(c) and (d)] also contained alternating Bt and Bw horizons. In profile 36-E, the Cr material occurred between depths of 25 and 33 cm. The weathered shale saprolite of the Cr was coated with patchy clay films and iron coats. Thin clay zones were present along the left side of the profile and followed the bedding of the steeply dipping Cr material. Saprolite (Cr) horizons occurred between depths of 29 and 50 cm in profile 36-N. Patchy dark red iron stains and yellowish-red clay skins coated saprolite fragment surfaces. Below 130 cm, patchy black manganese coatings were present.

The west face of profiles 49 & 42-E [Fig. 6(e)] contained a yellowish-red colluvial Bt horizon underlain by saprolite at 100 cm (profile 49). The colluvium was part of an old gully fill. The Cr horizons were extremely firm and were coated by many dark red iron stains and few manganese coats. The right pit face (profile 42-E) had a residual Bw horizon with Cr material occurring at 16 cm.

Profile 51-E [Fig. 6(f)] contained a solum with an Ap horizon 18 cm thick and alternating Bw and Bt horizons. Weathered saprolite (Cr) material occurred between depths of 40 and 81 cm, alternating with 5- to 20-cm thick argillaceous limestone strata which had weathered to clayey B horizons possessing pedogenic structure. Both the Cr material and clay zones dipped southeastward at 25 to 30°. The saprolitic Cr material was a strong brown shale containing many continuous manganese and discountinuous, very dusky red iron stains on fragment surfaces. Profile 951 [Fig. 6(g)] contained two accumulations of brownish-yellow alluvium. The upper 76 cm contained silt loam and silty clay loam textured horizons. From 76 to 121 cm, the profile contained prismatic structured, loam-textured E and B horizons. Below 100 cm, the soil became gleyed with many light gray mottles. The Cr horizons below 121 cm contained olive brown Rogersville shales with many iron-manganese stains on saprolite fragment surfaces.

Profile 26/951 [Fig. 6(h)] was characterized by 122 cm of Pumpkin Valley colluvium over old alluvium (soil no. 951) and Pumpkin Valley Shale residuum. The colluvium contained alternating BC or CB horizons with high shale chip content and Bt horizons. The BC, CB, and Bt horizons were generally 15 to 20 cm thick. The Bt horizons were yellowish red to reddish brown and had clay loam textures. Between depths of 122 and 270 cm, a clay loam alluvium persisted. Structure was subangular blocky to weak prismatic, and thin dark

Table 1. USDA soil classification and parent materials for nine soil profiles on the LLWDDD site

Profile	USDA soil classification	Parent material(s)
42-E	Loamy-skeletal, mixed, thermic Ruptic-Ultic Dystrochrepts	Maryville limestone
24-N	Clayey, mixed, thermic Ruptic-Ultic Dystrochrepts	Pumpkin Valley Shale & Pumpkin Valley colluvium
36-E	Loamy-skeletal, mixed, thermic Ruptic-Ultic Dystrochrepts	Rogersville Shale
951	Fine-silty, mixed, thermic Typic Hapludults	Old Bear Creek alluvium over Pumpkin Valley Shale
24-E	Loamy-skeletal, shallow, mixed, thermic Typic Udorthents	Pumpkin Valley Shale
36-N	Loamy-skeletal, mixed, thermic Ruptic-Ultic Dystrochrepts	Rogersville Shale
51-E	Loamy-sheletal, mixed, thermic Ruptic-Ultic Dystrochrepts	Nolichucky Shale
26/951	Fine-loamy, mixed, thermic Typic Hapludults	Pumpkin Valley colluvium over old Bear Creek alluvium over Pumpkin Valley Shale
49	Clayey, mixed, thermic Typic Hapludults	Old Maryville colluvium

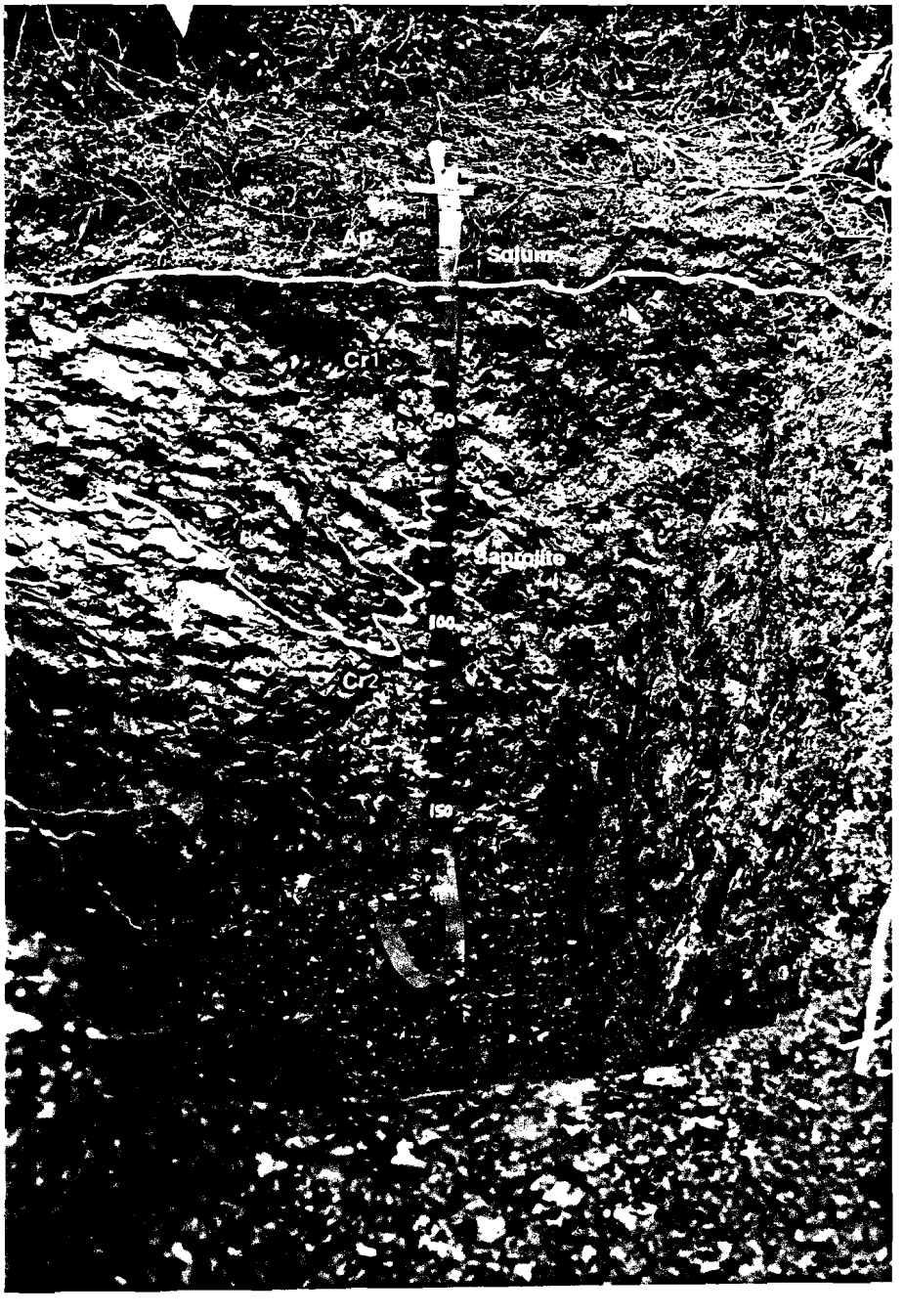


Fig. 6(a). Photograph of profile 24-E.

Fig. 6(b). Photograph of profile 24-N.

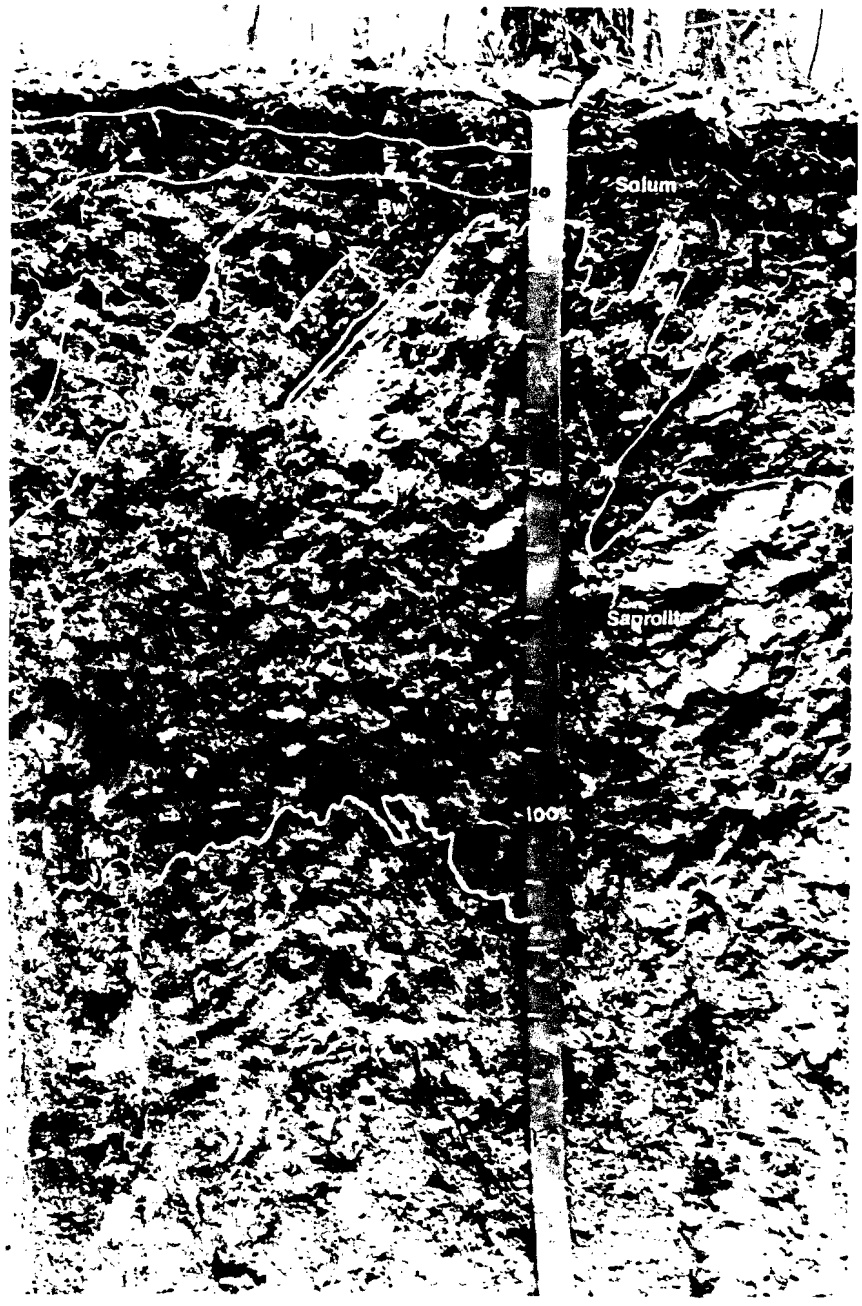


Fig. 6(c). Photograph of profile 36-E.

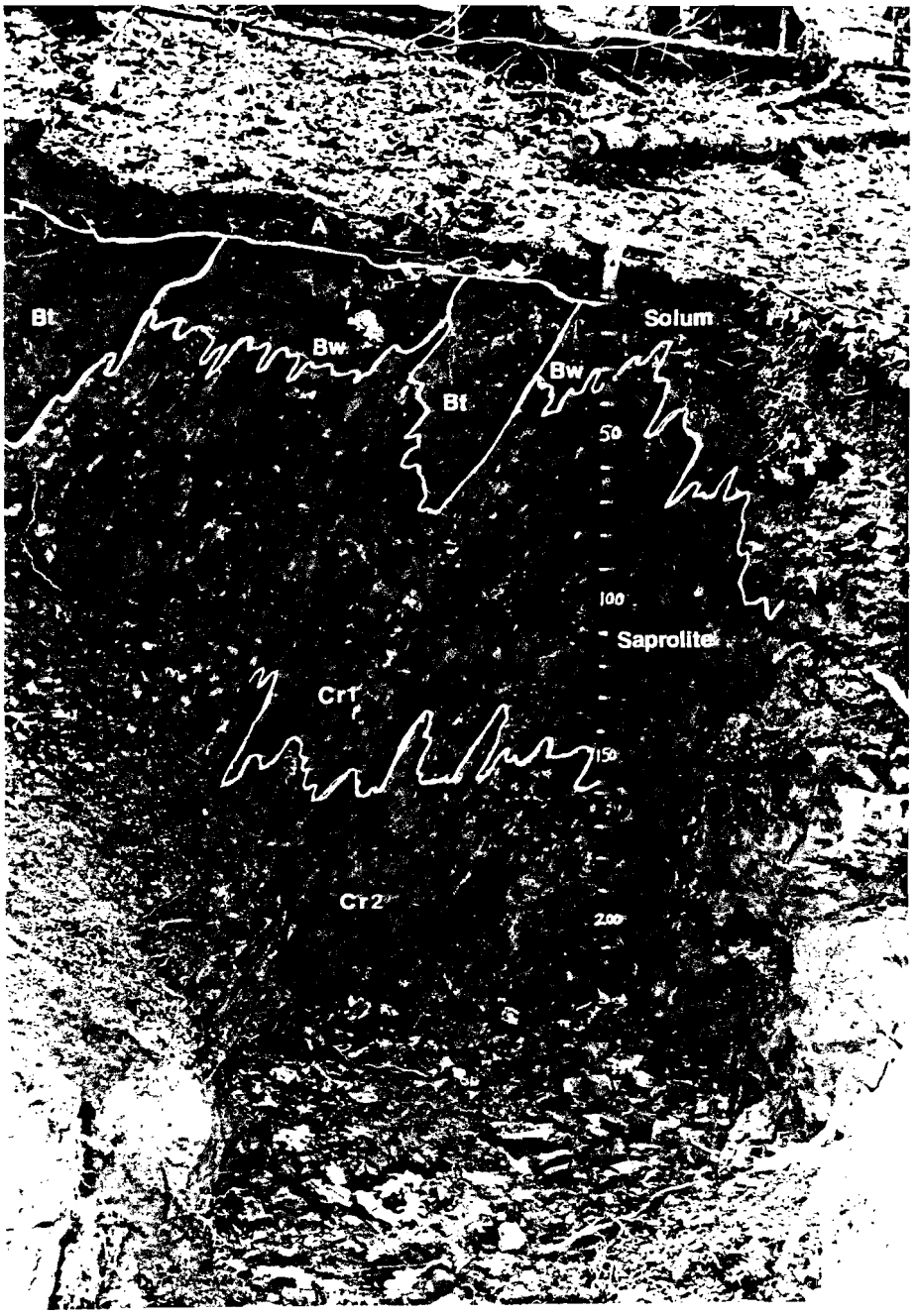


Fig. 6(d). Photograph of profile 36-N.

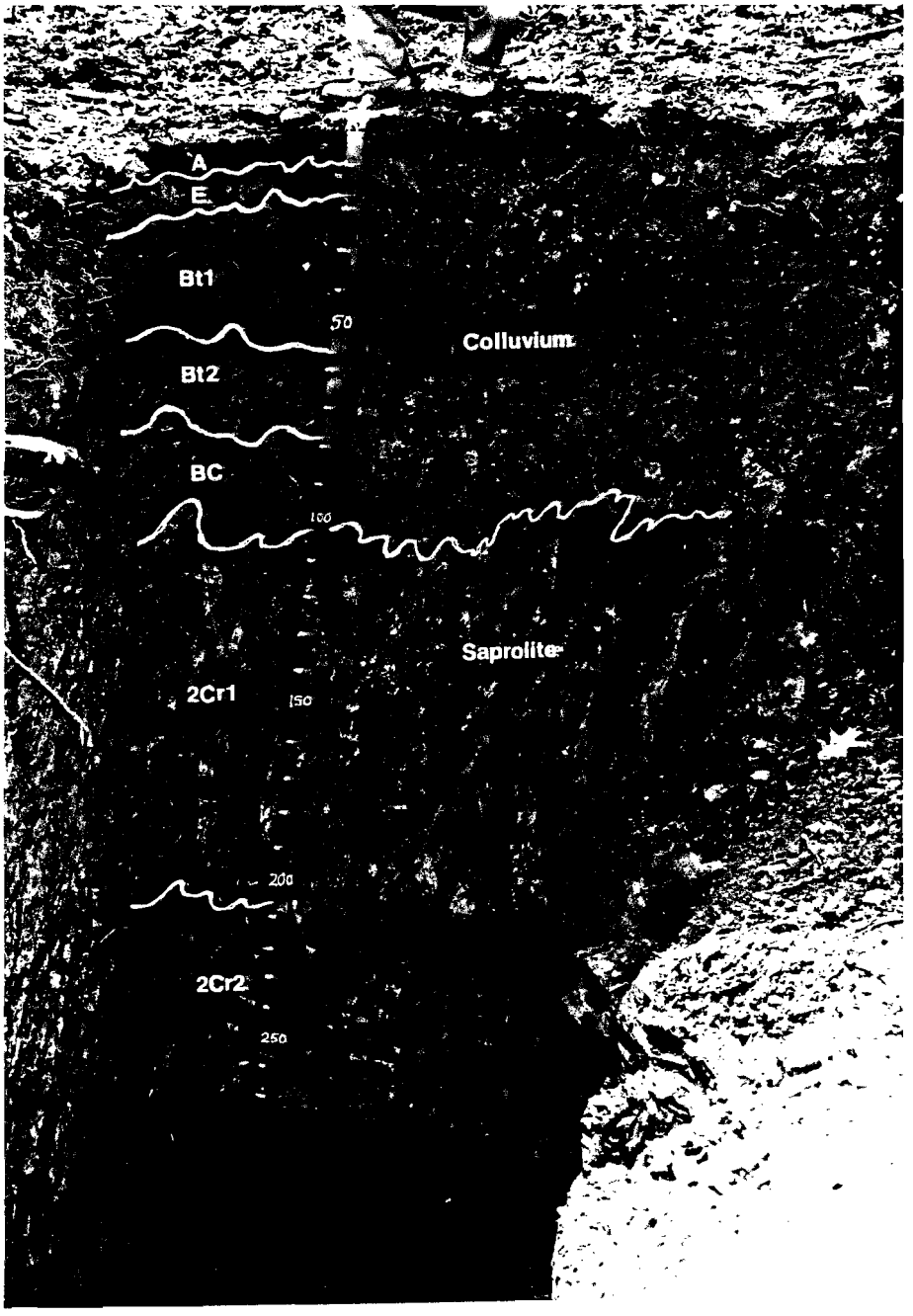


Fig. 6(e). Photograph of profile 49.

Fig. 6(f). Photograph of profile 51-E.

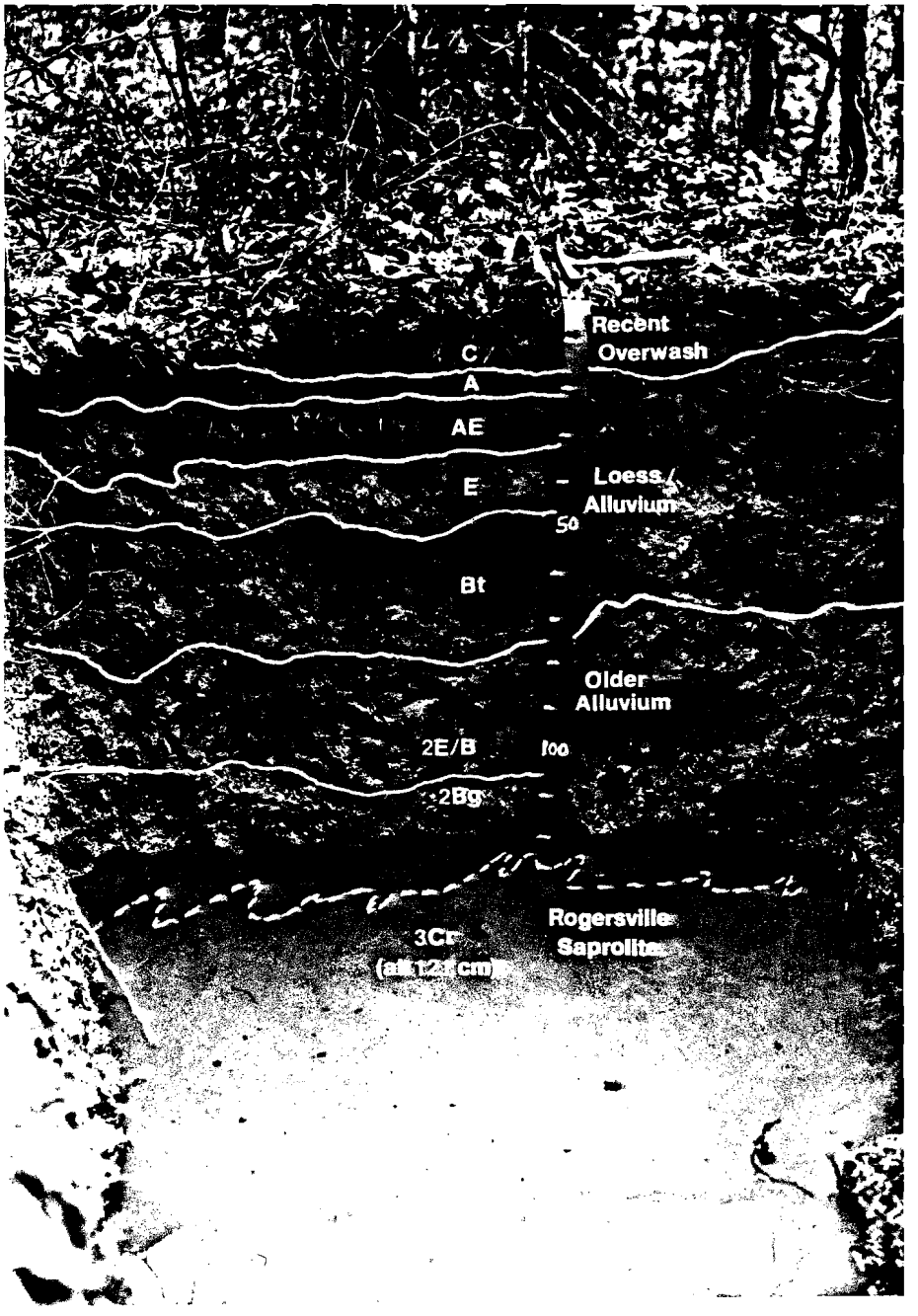


Fig. 6(g). Photograph of profile 951.

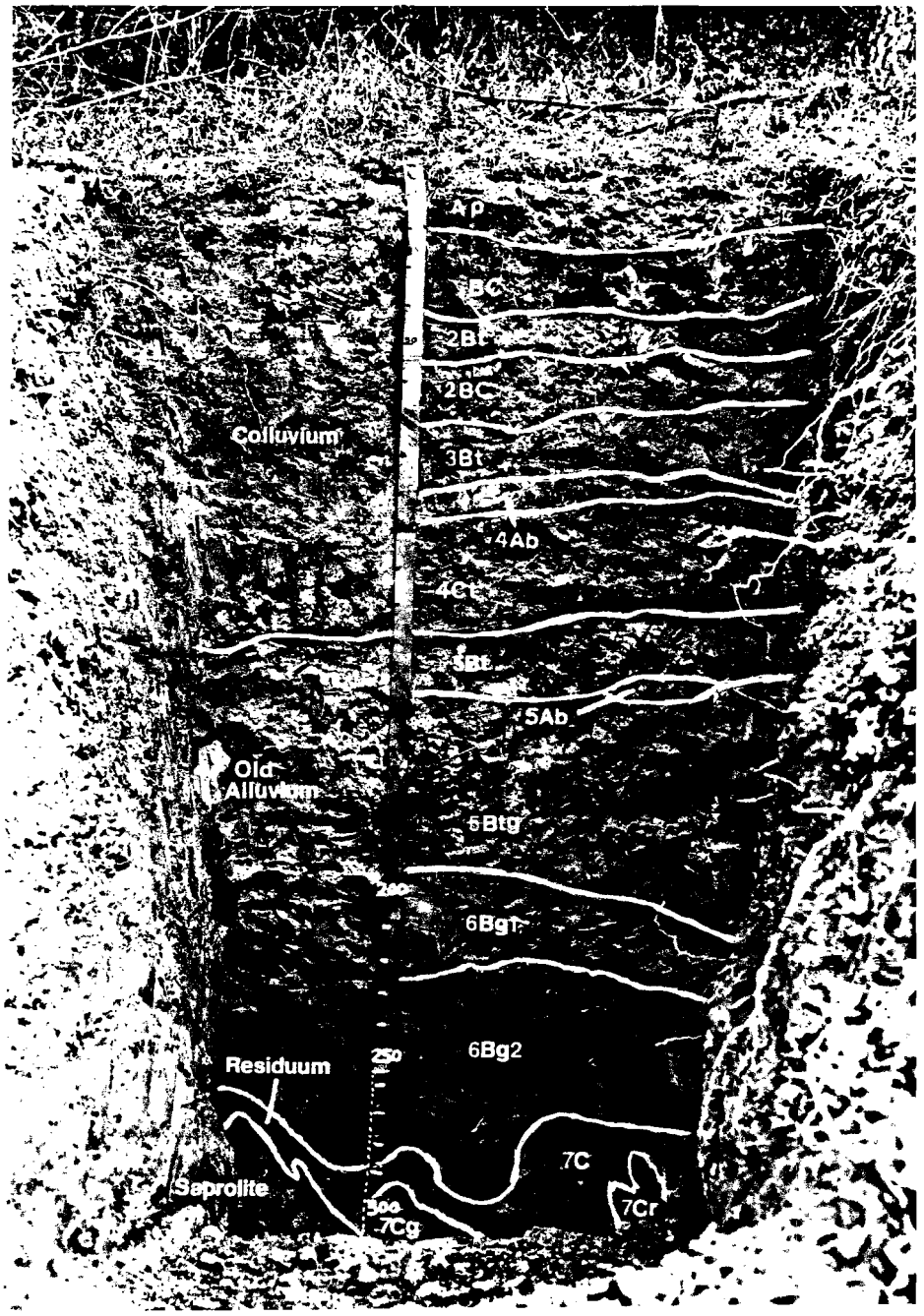


Fig. 6(h). Photograph of profile 26/951.

brown clay skins coated the ped surfaces. Soft Cr materials occurred below a depth of 325 cm and contained bluish-green glauconite with bluish clay coats.

4.2 PHYSICAL CHARACTERISTICS

4.2.1 Particle Size Distribution

Particle size data for all nine LLWDDD soil profiles are presented in Table 2. The surface horizons of most soils had silt loam or loam textures. In some instances, where erosion was severe, surface textures were clay loam. Soils commmonly increased in clay with depth and developed clay loam textures in Bt or Bw horizons. The exception was profile 24-N, which had a clay-textured Bt/Bw horizon. This soil profile developed on the highly weathered upper Pumpkin Valley Shale. Soil textures in Cr horizons were either loams or sandy loams. Although sand percentages commonly increased in the Cr horizons, some of the sand increase could be attributed to disintegration of rock fragments in the soil sieving process. Extreme evidence of this increase can be seen in Cr horizons of profile 24-N, where sand percentages increase 60% from overlying horizons. This sand increase can be explained by the nature of the saprolite that had been sieved. The Cr material was a highly weathered glauconitic sandstone that would slough under the sieving process. The majority of the sand particles were fine and very fine sands. In profile 26/951, very coarse sand, coarse sand, and medium sand percentages decreased greatly between the Bt and 5Btg horizons. The same three sand fraction percentages greatly increased between the 5Btg and 7Cr horizons. These differences in particle size gave evidence of discontinuities. The Bt horizon of profile 26/951 had a colluvial parentage and was full of small shale chips. The 5Btg horizon was composed of old alluvium, containing mostly fine sands and coarse silts. The 7Cr horizon was residuual, composed of glauconitic sandstone. Profile 951 contained discontinuities at 76 and 121 cm. The discontinuity at 76 cm formed the boundary between two separate alluviums. The discontinuity at 121 cm formed the boundary between the alluvium and the underlying Rogersville Shale saprolite.

4.2.2 Atterberg Limits

Liquid limit, plastic limit, plasticity index, shrinkage limit, and soil activity data are presented in Table 3. Liquid limit values for most profiles ranged from ~35 in A horizons to 50 to 60 in B horizons. Average plastic limit values were 25 for both A and B horizons. Plasticity index values ranged from 5 in A horizons to 20 to 25 in B horizons. Shrinkage limit values averaged 20 in A horizons, but decreased slightly in B horizons. Soil activities were <0.75 for most soil horizons. Atterberg data indicated that the soils on the tumuli site contained neutral activity clays with low shrink-swell potential. Higher amounts of organic matter were responsible for higher shrinkage limits and soil activities in A horizons. Organic matter absorbs water and thus increases the water content at which a soil ceases to shrink. Including the additions of organic carbon, the soil activities

Table 2. Pipete particle size distribution and textures for nine soil profiles on the LLWDDD site

				Class and particle diameter in (mm)											
				Sand (%)					Silt (%)		Total (%)				
Pit	Horizon	Depth (cm)	Coarse fragments >2 (%)	VCOS 2-1m	COS 1-0.5	MS 0.5-0.25	FS 0.25-0.1	VFS 0.1-0.05	COSI 0.05-0.02	FSI 0.02-.002	Sand 2-0.05	Silt 0.05-0.002	Clay <.002	Texture modifier	Texture
49 & 42-E	A-E[a]	0-14	23	5.0	3.9	1.6	4.5	18.2	28.3	26.8	33.2	55.1	11.7	Shaly	Silt loam
	A-Bw[b]	0-16	31	10.9	4.7	1.7	4.5	12.6	23.1	24.6	34.4	47.7	17.9	Shaly	Loam
	Bt1-Bt2	14-84	11	4.6	3.1	1.2	2.1	5.9	14.8	22.9	16.9	37.7	45.4		Clay
	2CB	84-102	54	5.1	2.5	0.9	2.1	4.1	15.7	24.5	14.7	40.2	45.1	Very sh.	Silty clay
	2Cr1	102-149	87	17.4	9.2	2.7	4.7	7.7	10.3	15.6	41.7	25.9	32.4	Ext. sh.	Clay loam
	2Cr2	149+	80	12.2	4.8	1.8	2.3	3.1	10.2	27.1	24.2	37.3	38.5	Ext. sh.	Clay loam
36-N	A	0-9	19	2.1	3.4	2.1	8.4	16.4	1.9	49.0	32.4	50.9	16.7	Shaly	Silt loam
	Bw	9-29	30	7.4	3.6	2.0	9.5	14.0	16.3	25.0	36.5	41.3	22.2	Shaly	Loam
	Cr1	29-130	71	26.9	7.6	3.2	8.1	9.4	9.0	11.5	55.2	20.5	24.3	Ext. sh.	Sandy clay loam
	Cr2	130+	74	19.5	10.3	2.8	5.1	5.9	15.0	18.8	43.6	33.8	22.6	Ext. sh.	Loam
24-E	Ap	0-15	25	2.3	5.0	2.9	8.1	13.9	16.2	29.0	32.2	45.2	22.6	Shaly	Loam
	Cr1	15-58	76	7.9	6.4	1.9	2.8	3.3	10.3	34.5	22.3	44.8	32.9	Ext. sh.	Clay loam
	Cr2	58+	98	18.8	10.1	3.2	5.4	6.1	3.7	29.0	43.6	32.7	23.7	Ext. sh.	Loam
951	Ap	20-28	4	1.7	1.7	0.7	6.3	22.3	33.8	27.5	32.7	61.3	6.0		Silt loam
	E1-E2	28-48	4	1.6	0.8	0.5	4.8	18.9	36.2	25.3	26.6	61.5	11.9		Silt loam
	Bt	48-76		1.2	0.5	0.3	5.7	17.6	26.1	20.9	25.3	47.0	27.7		Clay loam
	2E/B-2Btg	76-121	2	0.6	0.9	1.4	5.5	30.2	28.2	12.1	38.6	40.3	21.1		Loam
	3Cr	121+	97	20.4	8.2	2.2	5.6	10.0	14.5	19.5	46.4	34.0	19.6	Ext. sh.	Loam

Table 2. (continued)

Pit	Horizon	Depth (cm)	Coarse fragments >2 (%)	Class and particle diameter (mm)											
				Sand (%)					Silt (%)		Total (%)				
				VCOS 2-1	COS 1-0.05	MS 0.05-0.25	FS 0.25-0.1	VFS 0.1-0.05	COSI 0.05-0.02	FSI 0.02-0.002	Sand 2-0.05	Silt 0.05-0.002	Clay <0.002	Texture modifier	Texture
24-N	A-E	0-25	25	2.0	1.8	1.0	9.1	29.9	19.4	24.7	43.8	44.1	12.1	Shaly	Loam
	Bw-Bt	25-66	19	2.8	1.5	0.7	2.9	7.4	9.6	25.2	15.3	34.8	49.9	Shaly	Clay
	B/Cr	66-118	69	6.7	3.1	1.2	2.2	6.5	10.0	28.6	20.5	38.6	40.9	Ext. sh.	Clay
	Cr1 (G)	66-118	13	9.1	6.9	6.0	50.9	12.0	6.1	3.5	84.9	9.6	5.5		Loamy fine sand
	Cr2	118+	76	11.0	6.1	3.7	40.4	15.8	6.7	6.6	77.0	13.3	9.7	Ext. sh.	Fine sandy loam
36-E	A-Bw	0-25	19	5.0	4.0	2.2	4.9	9.1	14.0	28.2	25.2	42.2	32.6	Shaly	Clay loam
	Cr1	25-200	65	14.8	10.2	3.3	6.0	4.0	7.0	18.0	38.3	25.0	36.7	Ext. sh.	Clay loam
	Cr1 (G)	100	90	8.9	6.4	4.3	18.4	10.7	13.6	10.0	48.7	23.7	27.7	Ext. sh.	Sandy clay loam
	Cr2	200+	82	30.1	13.0	3.7	7.1	6.2	7.3	14.3	60.1	21.6	18.3	Ext. sh.	Crse. sandy loam
51-E	Ap	0-18	9	4.1	2.7	1.3	3.0	6.2	29.2	28.8	17.3	58.0	24.7		Silt loam
	Cr	18-175	88	20.1	10.3	2.9	3.0	2.1	9.5	19.3	38.4	28.8	32.8	Ext. sh.	Clay loam
	2Cr	150-250	79	13.0	4.0	1.6	2.0	7.1	21.8	25.8	27.7	47.6	24.7	Ext. sh.	Loam
	3Cr (R)	250+	94	9.3	11.6	2.2	2.7	2.3	26.8	18.4	28.1	45.2	26.7	Ext. sh.	Loam
	3Cr (Y)	250+	89	14.3	5.0	1.4	2.6	8.8	20.5	22.0	32.1	42.5	25.4	Ext. sh.	Loam
26/95l	Ap	0-21	24	1.8	2.3	1.9	12.0	30.4	11.7	19.8	48.4	31.5	20.1	Gravelly	Loam
	Bt1-4Bt	21-122	9	5.8	2.2	0.9	8.5	17.5	18.3	18.6	34.9	36.9	28.2		Clay loam
	5Bt1-6Bw2	122-270		0.3	0.1	0.4	8.3	22.8	19.4	16.2	31.9	35.6	32.5		Clay loam
	7C-7Cr	270+	86	9.6	4.9	2.5	17.4	10.8	11.1	22.2	45.2	33.3	21.5	Ext. gr.	Loam

[a]Colluvial face (profile 49) [b]Residual face (profile 42-E)
(G) = Glauconitic
(R) = Reddish coats (iron)
(Y) = Yellowish (iron and/or clay) coats
ext. = extremely sh. = shaly gr. = gravelly

Table 3. Atterberg limits of nine soil profiles on the LLWDDD site

Pit	Horizon	Depth (cm)	Atterberg limits					
			Liquid limit (%)	Plastic limit (%)	Plasticity index (%)	Flow index	Shrinkage limit (%)	Activity ratio
49 and 42-E	A-E[a]	0-14	33.1	29.1	4.0	7.9	25.6	0.34
	A-E[b]	0-16	27.9	26.7	1.2	31.7	24.6	0.06
	Bt1-Bt2	14-84	58.3	30.8	27.5	12.1	20.5	0.61
36-N	A	0-9	42.6	35.2	7.4	6.0	29.1	0.44
	Bw	9-29	32.4	21.9	10.5	7.4	18.6	0.47
24-E	Ap	0-15	35.0	25.1	9.9	13.7	21.1	0.44
951	Ap	20-28	27.3	22.0	5.3	5.3	20.0	0.88
	E1-E2	28-48	21.9	18.5	3.4	2.0	18.0	0.28
	Bt	48-76	40.6	20.1	18.5	15.2	16.5	0.67
	2E/B-2Btg	76-121	30.1	18.1	12.0	4.7	15.4	0.59

Table 3. (continued)

Pit	Horizon	Depth (cm)	Atterberg limits: Liquid limit (%)	Plastic limit (%)	Plasticity index (%)	Flow index	Shrinkage limit (%)	Activity ratio
24-N	A-E	0-25	28.3	24.3	4.0	4.6	22.1	0.33
	Bw-Bt	25-66	60.9	33.0	27.9	30.1	22.0	0.56
36-E	A-Bw	0-25	46.0	31.5	14.5	24.2	24.5	0.44
51-E	Ap	0-18	35.9	24.9	11.0	2.2	20.6	0.44
26/951	Ap	0-21	32.1	22.9	9.2	7.5	19.6	0.46
	Bt1-4Bt	21-122	40.8	23.6	19.2	11.5	18.0	0.68
	5Bt1-6Bw2	122-270	45.3	20.9	24.4	14.6	14.1	0.75

[a]Colluvial face (profile 49) [b]Residual face (profile 42-E)
(G) = Glauconitic
(R) = Reddish coats (iron)
(Y) = Yellowish (iron and/or clay) coats

suggest that 1:1 kaolinitic or 2:1 nonswelling (vermiculitic) clay minerals were present in all soil profiles on the LLWDDD site.

4.2.3 Bulk Density and Total Porosity

Bulk density, specific gravity, and total porosity values are given in Table 4. Soil cores were taken from soil profiles when soil moisture levels were low, but most of the moisture was retained until the time of analysis (as indicated by reported field moisture contents). Bulk density values averaged from 1.2 $Mg \cdot m^{-3}$ in A horizon, to 1.5 $Mg \cdot m^{-3}$ in B horizons and 1.6 $Mg \cdot m^{-3}$ in Cr horizons. Values found in the solum of most LLWDDD site soils were within the optimum range for adequate water and air movement and vegetative establishment. Only severely eroded profiles (profile 24-E) and profiles exhibiting limited soil development (profiles 36-N, 36-E) had high bulk density values within 50 cm of the soil surface. Specific gravity (particle density) values averaged 2.60 $Mg \cdot m^{-3}$ in A horizons, 2.66 $Mg \cdot m^{-3}$ in B horizons, and 2.73 $Mg \cdot m^{-3}$ in Cr horizons. Cr horizons were dense with respect to the overlying solum. Highly weathered saprolites were not as dense as harder, less weathered saprolites but were still dense enough to lower total porosity. In one case (3Cr horizon of profile 951), bulk density approached 1.9 $Mg \cdot m^{-3}$ and total porosity was 31.2%. Such values may extremely limit permeability. Gleying of soil horizons above the saprolite in profile 951 was evidence of slow permeability and subsequent perching of water. Gleying of soil horizons above Cr materials in other profiles (51-E and 26/951) were also related to lowered permeability rates.

4.2.4 Moisture Retention

Table 5 contains 33- and 1500-kPa moisture retention data. Available water-holding capacity values were highest in A horizons, decreased greatly in B horizons, and increased slightly in Cr horizons. When adjusted for coarse fragment content, available water-holding capacity values were highest for A horizons but gradually decreased with depth. Adjusted Cr horizon values were extremely low. The highest available moisture values were found in the alluvial and colluvial profiles (profiles 951, 26/951, and 49). Adjusted for bulk density, available water-holding capacities averaged 0.20 $cm \cdot cm^{-1}$ for alluvial materials and 0.10 $cm \cdot cm^{-1}$ for colluvium. Examining the total available moisture values for the LLWDDD profiles, profiles 951, 26/951, 49, 42-E, and 24-N had low available water-holding capacities (<7.5 to 15 cm water per profile). All other profiles had very low available water holding capacities (<7.5 cm water per profile).

4.3 CHEMICAL CHARACTERISTICS

4.3.1 Cation Exchange Capacity and Exchangeable Acidity

Soil pH, total carbon, exchangeable acidity, exchangeable aluminum, and exchangeable hydrogen values are presented in Table 6. Cation exchange capacity, exchangeable bases, base saturation, and calcium carbonate equivalent values are presented in Table 7. Total carbon values for most

Table 4. Bulk density, specific gravity, and total porosity for nine soil profiles on the LLWDDD site

Pit	Horizon	Depth (cm)	Field[a] moisture (%)	Bulk density (Mg m^{-3})	Specific gravity (Mg m^{-3})	Total porosity (%)
49 and 42-E	A-E[b]	0-14	16.59	0.94	2.59	63.67
	A-Bw[c]	0-16	16.59	0.94	2.59	63.67
	Bt1-Bt2	14-84	16.45	1.24	2.67	53.58
	2CB	84-102	18.30	1.38	2.67	48.31
	2Cr1	102-149	18.42	1.59	2.67	42.04
	2Cr2	149+	16.57	1.55	2.67	42.01
36-N	A	0-9	1.00	1.57	2.64	45.54
	Bw	9-29	8.40	1.38	2.56	46.08
	Cr1	29-130	0.87	1.63	2.66	38.82
	Cr2	130+	0.87	1.63	2.66	38.82
24-E	Ap	0-15	11.10	1.22	2.60	53.14
	Cr1	15-58	12.23	1.57	2.74	42.85
	Cr2	58+	12.23	1.57	2.74	42.85
951	Ap	20-28	14.35	1.34	2.63	49.14
	E1-E2	28-48	13.14	1.32	2.66	50.38
	Bt	48-76	14.24	1.32	2.66	50.38
	2E/B-2Btg	76-121	10.42	1.62	2.66	39.11
	3Cr	121+	7.42	1.88	2.73	31.20

Table 4. (continued)

Pit	Horizon	Depth (cm)	Fielda moisture (%)	Bulk density (Mg m^{-3})	Specific gravity (Mg m^{-3})	Total porosity (%)
24-N	A-E	0-25	11.10	1.22	2.60	53.14
	Bw-Bt	25-66	14.67	1.47	2.69	45.41
	B/Cr1	66-118	12.23	1.57	2.69	41.64
	Cr1	66-118	12.23	1.57	2.74	42.85
	Cr2	118+	12.23	1.57	2.74	42.85
36-E	A-Bw	0-25	1.00	1.57	2.64	45.54
	Cr1	25-200	0.87	1.63	2.66	38.82
	Cr1 (G)	100	0.87	1.63	2.66	38.82
	Cr2	200+	0.87	1.63	2.66	38.82
51-E	Ap	0-18	15.65	1.44	2.60	44.70
	Cr	18-150	19.53	1.34	2.72	50.74
	2Cr	150-250	17.63	1.55	2.72	43.16
	3Cr (R)	250+	14.35	1.26	2.72	53.68
	3Cr (Y)	250+	14.35	1.26	2.72	53.68
26/951	Ap	0-21	6.41	1.14	2.63	56.66
	Bt1-4Bt	21-122	10.83	1.55	2.66	41.73
	5Bt1-6Bw2	122-270	15.09	1.46	2.66	45.11
	7C-7Cr	270+	14.36	1.59	2.73	41.76

[a]Moisture contents (% by weight) present in core samples at time of analysis.

[b]Colluvial face (profile 49) [c]Residual face (profile 42-E)
(G) = Glauconitic
(R) = Reddish coats (iron)
(Y) = Yellowish (iron and/or clay) coats

Table 5. 33 and 1500 kPa moisture retention and available water-holding capacity for eight soil pits on the LLWDDD site

Pit	Horizon	Depth (cm)	Coarse fragments (%)	Moisture retention: 33 kPa (%)	1500 kPa (%)	AWC[a] (%)	AWC[b] adjusted (%)	Bulk density (Mg m^{-3})	AWC (% by volume)	AWC (cm cm^{-1})	TAWC[c] (cm $profile^{-1}$)
49 and 42-E	A-E[d]	0-14	22.4	30.28	14.69	15.59	12.10	0.94	11.37	0.11	
	A-Bw[e]	0-16	32.4	30.98	17.55	13.43	9.08	0.94	8.54	0.08	
	Bt1-Bt2	16-84	11.0	36.40	27.09	9.31	9.31	1.24	11.54	0.12	
	2CB	84-102	65.3	34.15	26.08	8.07	2.80	1.38	3.86	0.04	
	2Cr1	102-149	94.4	28.75	20.54	8.21	0.46	1.59	0.73	0.01	
	2Cr2	149+	89.6	31.32	22.25	9.07	0.94	1.55	1.46	0.01	11.5
36-N	A	0-9	28.9	30.21	20.07	10.14	7.21	1.57	11.32	0.11	
	Bw	9-29	41.2	24.83	18.64	6.19	3.64	1.38	5.02	0.05	
	Cr1	29-130	85.1	26.53	17.95	8.58	1.28	1.63	2.09	0.02	
	Cr2	130+	88.2	23.73	15.99	7.74	0.91	1.63	1.48	0.01	4.0
24-E	Ap	0-15	33.2	25.06	18.56	6.50	4.34	1.22	5.29	0.05	
	Cr1	15-58	87.4	25.74	19.74	6.00	0.76	1.57	1.19	0.01	
	Cr2	58+	98.4	22.17	15.21	6.96	0.11	1.57	0.17	0.00	1.2
951	Ap	20-28	4.5	28.32	8.94	19.38	19.38	1.34	25.97	0.26	
	E1-E2	28-48	3.8	22.25	10.91	11.34	11.34	1.32	14.97	0.15	
	Bt	48-76	0.2	26.18	18.83	7.35	7.35	1.32	9.70	0.09	
	2E/B-2Btg	76-121	1.6	21.81	13.48	8.33	8.33	1.62	13.49	0.13	
	3Cr	121+	96.6	24.98	15.14	9.84	0.33	1.88	0.62	0.01	13.5

Table 5. (continued)

Pit	Horizon	Depth (cm)	Coarse fragments (%)	Moisture retention: 33 kPa (%)	1500 kPa (%)	AWC[a] (%)	AWC[b] adjusted (%)	Bulk density (Mg m^{-3})	AWC (% by volume)	AWC (cm cm^{-1})	TAWC[c] (cm $profile^{-1}$)
24-N	A-E	0-25	31.7	26.46	11.67	14.79	10.10	1.22	12.32	0.12	
	Bw-Bt	25-66	27.7	36.23	27.96	8.27	5.98	1.47	8.79	0.08	
	B/Cr	66-118	80.9	30.12	22.67	7.45	1.42	1.57	2.23	0.02	
	Cr1 (G)	66-118	18.1	15.50	10.42	5.08	4.16	1.57	6.53	0.07	
	Cr2	118+	87.7	17.62	11.16	6.46	0.79	1.57	1.24	0.01	7.6
36-E	A-Bw	0-25	29.0	31.92	23.20	8.72	6.19	1.57	9.72	0.09	
	Cr1	25-200	77.1	28.56	20.78	7.78	1.78	1.63	2.90	0.03	
	Cr1 (G)	100	94.1	28.17	21.25	6.92	0.41	1.63	0.67	0.01	
	Cr2	200+	91.3	21.76	15.05	6.71	0.58	1.63	0.95	0.01	6.0
51-E	Ap	0-18	13.1	27.50	19.19	8.31	8.31	1.44	11.97	0.12	
	Cr	18-150	95.0	29.03	22.73	6.30	0.32	1.34	0.43	0.00	
	2Cr	150-250	88.8	32.91	20.37	12.54	1.40	1.55	2.17	0.02	
	3Cr (R)	250+	96.2	21.01	17.52	3.49	0.13	1.26	0.16	0.00	
	3Cr (Y)	250+	94.7	38.21	21.02	17.19	0.91	1.26	1.15	0.01	2.2
26/951	Ap	0-21	28.0	21.15	16.16	4.99	3.59	1.14	4.09	0.04	
	Bt1-4Bt	21-122	13.4	26.52	20.01	6.51	6.51	1.55	10.09	0.10	
	5Bt1-6Bw2	122-270	0.1	27.37	19.70	7.67	7.67	1.46	11.20	0.11	
	7C-7Cr	270+	93.2	25.20	17.37	7.83	0.53	1.59	0.84	0.01	14.0

[a]Available water-holding capacity
[b]Available water-holding capacity adjusted for coarse fragments (>15% fragments)
[c]Total available water-holding capacity for the top 150 cm of the soil profile (or to the upper boundary of hard saprolite)
[d]Colluvial face (profile 49) [e]Residual face (profile 42-E)
(G) = Glauconitic
(R) = Reddish coats (iron)
(Y) = Yellowish (iron and/or clay) coats

Table 6. pH, KCl exchangeable acidity, aluminum and hydrogen, and total carbon for nine soil profiles on the LLWDDD site

Pit	Horizon	Depth (cm)	pH	Total carbon (%)	KCl exchangeable acidity [cmol(+) kg^{-1}] Total	Al^{3+}	H^{+}
49 and 42-E	A-E[a]	0-14	4.65	2.76	3.2	2.6	0.6
	A-Bw[b]	0-16	4.71	2.13	3.7	3.3	0.4
	Bt1-Bt2	14-84	4.65	0.35	10.0	9.0	1.0
	2CB	84-102	4.81	0.16	10.6	9.8	0.8
	2Cr1	102-149	4.85	0.13	10.1	8.9	1.2
	2Cr2	149+	5.22	0.18	7.7	6.8	0.9
36-N	A	0-9	4.40	3.47	6.9	6.1	0.8
	Bw	9-29	4.62	0.56	8.8	8.0	0.8
	Cr1	29-130	4.72	0.15	16.6	15.5	1.1
	Cr2	130+	5.00	0.05	13.8	12.2	1.6
24-E	Ap	0-15	4.92	1.14	2.5	2.3	0.2
	Cr1	15-58	5.10	0.23	5.9	5.2	0.7
	Cr2	58+	4.90	0.11	6.0	5.4	0.6
951	Ap	20-28	4.35	1.81	2.9	2.1	0.8
	E1-E2	28-48	4.05	0.32	3.1	2.7	0.4
	Bt	48-76	4.42	0.22	8.5	7.6	0.9
	2E/B-2Btg	76-121	4.81	0.10	6.5	5.3	0.8
	3Cr	121+	6.29	0.24	0.3	0.3	0.0

Table 6. (continued)

Pit	Horizon	Depth (cm)	pH	Total carbon (%)	KCl exchangeable acidity [cmol(+) kg^{-1}] Total	Al^{3+}	H^{+}
24-N	A-E	0-25	4.49	2.03	3.0	2.6	0.4
	Bw-Bt	25-66	4.58	0.31	10.9	9.7	1.2
	B/Cr	66-118	4.75	0.16	12.8	11.6	1.2
	Cr1 (G)	66-118	4.76	0.06	13.7	12.7	1.0
	Cr2	118+	4.84		13.7	12.6	1.1
36-E	A-Bw	0-25	4.46	2.64	8.5	7.8	0.7
	Cr1	25-200	4.76	0.18	14.4	13.4	1.0
	Cr1 (G)	100	4.35	0.23	20.3	18.6	1.7
	Cr2	200+	5.00		13.3	12.4	0.9
51-E	Ap	0-18	4.70	1.30	5.9	5.2	0.7
	Cr	18-150	4.81	0.08	12.7	12.0	0.7
	2Cr	150-250	4.95	0.10	13.0	12.4	0.6
	3Cr (R)	250+	4.82	0.25	10.9	10.2	0.7
	3Cr (Y)	250+	4.82	0.11	10.3	9.4	0.9
26/951	Ap	0-21	4.70	1.71	3.5	3.2	0.3
	Bt1-4Bt	21-122	4.91	0.12	7.0	6.9	0.1
	5Bt1-6Bw2	122-270	4.96	0.09	6.4	6.3	0.1
	7C-7Cr	270+	5.10	8.8	8.5	0.3	

[a]Colluvial face (profile 49) [b]Residual face (profile 42-E)
(G) = Glauconitic
(R) = Reddish coats (iron)
(Y) = Yellowish (iron and/or clay) coats

Table 7. Cation exchange capacity, exchangeable bases, percent base saturation, and calcium carbonate equivalents for nine soil profiles on the LLWDDD site

Pit	Horizon	Depth (cm)	pH	Cation exchange capacity [cmol(+) kg^{-1}]							Calcium carbonate equivalent (%)
				Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	Total bases	CEC	Base saturation (%)	
49 and 42-E	A-E[a]	0-14	4.65	2.52	0.59	0.24	0.03	3.38	13.50	25.0	
	A-Bw[b]	0-16	4.71	2.82	1.12	0.31	0.03	4.28	13.46	31.8	
	Bt1-Bt2	14-84	4.65	2.84	1.83	0.37	0.02	5.06	23.87	21.2	
	2CB	84-102	4.81	0.10	0.82	0.28	0.02	1.22	23.87	5.1	
	2Cr	102-149	4.85	0.08	2.22	0.29	0.08	2.67	23.26	11.5	
	2Cr2	149+	5.22	1.58	3.71	0.33	0.19	5.81	22.64	25.7	0.49
36-N	A	0-9	4.40	1.98	0.58	0.28	0.03	2.87	18.97	15.1	
	Bw	9-29	4.62	0.52	1.24	4.00	0.01	5.77	23.26	24.8	
	Cr1	29-130	4.72	0.04	1.13	0.95	0.06	2.18	28.15	7.7	
	Cr2	130+	5.00	0.52	2.16	0.26	0.16	3.10	26.32	11.8	
24-E	Ap	0-15	4.92	5.01	1.48	0.31	0.01	6.81	18.36	37.1	
	Cr1	15-58	5.10	3.68	2.02	0.31	0.03	6.04	23.26	26.0	
	Cr2	58+	4.90	2.38	3.36	0.43	0.03	6.20	23.26	26.7	2.50
951	Ap	20-28	4.35	0.42	0.12	0.05	0.02	0.61	8.57	7.1	
	E1-E2	28-48	4.05	0.16	0.03	0.05	0.00	0.24	6.12	3.9	
	Bt	48-76	4.42	0.68	0.43	0.12	0.00	1.23	15.97	7.7	
	2E/B-2Btg	76-121	4.81	2.86	0.82	0.11	0.03	3.64	17.14	21.2	
	3Cr	121+	6.29	17.02	2.72	0.18	0.01	19.93	22.03	90.5	10.23

Table 7. (continued)

Pit	Horizon	Depth (cm)	pH	Cation exchange capacity [cmol(+) kg^{-1}] Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	Total bases	CEC	Base saturation (%)	Calcium carbonate equivalent (%)
24-N	A-E	0-25	4.49	0.32	0.07	0.12	0.00	0.51	9.18	5.6	
	Bw-Bt	25-66	4.58	0.38	1.20	0.33	0.00	1.91	25.70	7.4	
	B/Cr	66-118	4.75	0.16	0.65	0.23	0.02	1.06	16.52	6.4	
	Cr1 (G)	66-118	4.76	0.20	1.15	0.27	0.00	1.62	21.42	7.6	
	Cr2	118+	4.84	0.03	1.14	0.18	0.01	1.36	21.42	6.4	
36-E	A-Bw	0-25	4.46	2.44	3.69	0.29	0.03	6.45	22.03	29.3	
	Cr1	25-200	4.76	0.06	0.52	0.52	0.03	1.13	22.03	5.1	
	Cr1 (G)	100	4.35	0.08	0.53	0.46	0.02	1.09	30.60	3.6	
	Cr2	200+	5.00	0.02	1.23	1.38	0.09	2.72	23.76	11.7	
51-E	Ap	0-18	4.70	1.12	0.44	0.27	0.02	1.85	15.30	12.1	
	Cr	18-150	4.81	0.16	0.84	0.36	0.05	1.41	22.40	6.3	
	2Cr	150-250	4.95	0.05	0.56	0.23	0.09	0.93	34.15	2.7	
	3Cr (R)	250+	4.82	0.28	1.15	0.36	0.17	1.96	21.05	9.3	
	3Cr (Y)	250+	4.82	0.14	0.91	0.23	0.06	1.34	20.56	6.5	
26/951	Ap	0-21	4.70	2.10	0.66	0.28	0.03	3.07	13.22	23.2	
	Bt1-4Bt	21-122	4.91	1.29	0.55	0.10	0.09	2.03	15.05	13.5	
	5Bt1-6Bw2	122-270	4.96	0.31	0.45	0.17	0.03	0.96	16.77	5.7	
	7C-7Cr	270+	5.10	0.26	0.93	0.24	0.04	1.47	17.75	8.3	

[a]Colluvial face (profile 49) [b]Residual face (profile 42-E)
(G) = Glauconitic
(R) = Reddish coats (iron)
(Y) = Yellowish (iron and/or clay) coats

profiles ranged from an average of 2.1% in A horizons to 0.2% in B and Cr horizons. Total carbon values in saprolites approached zero at 200 cm depth in most soil profiles. Soil pH values ranged from ~4.5 at the surface to slightly >5.0 at a depth of 2 m. An exception was found in profile 951, for which a pH value >6.0 existed in the 3Cr horizon. Exchangeable aluminum values were lowest in A horizons, increased and reached a maximum in B horizons, and decreased in the Cr horizons. The amount of exchangeable acidity present was related to the amount of clay and iron oxides present. Exchangeable acidity in most LLWDDD site soils was dominated by aluminum.

Cation exchange values commonly ranged from 10 $cmol(+)\cdot kg^{-1}$ in A horizons to around 25 $cmol(+)\cdot kg^{-1}$ in B and Cr horizons. Values were slightly lower in alluvial and colluvial soils because of a lower clay content, less mineral weathering and clay formation, and differing mineralogies. These cation-exchange capacity values were higher than those commonly associated with soils dominated by kaolinitic minerals; thus, some form of weathered vermiculite or illite most likely dominated clay mineralogy.

Average base saturation values for all profiles studied were <35%. The 3Cr horizon of profile 951 had artificially high base saturation because of the presence of free carbonates in the slightly weathered Rogersville Shale saprolite. This material had a calcium carbonate equivalent of 10.23%, and calcium carbonates were readily soluble in the neutral normal ammonium acetate solution used to extract the exchangeable bases. The 2Cr2 horizon of profile 49 and the Cr2 horizon of profile 24-E were the only other horizons containing positive calcium carbonate equivalents; however, magnesium was still the dominant exchangeable cation.

For residual soils, exchangeable bases were dominated by magnesium. Exceptions were found in A horizons, where biotic activity concentrates and recycles calcium. The LLWDDD site soils, for the most part, were weathered to such a degree that calcium had leached from the upper 2 to 3 m of the solum and saprolite. Exchangeable calcium did increase with depth but seldom exceeded values of exchangeable magnesium. Exceptions can be found in profiles 24E and 36-E, for which high exchangeable calcium values in the surface horizon may be the result of past liming practices.

Exchangeable calcium values were found to be higher in colluvial horizons of the soil profiles studied. In colluvial horizons of profiles 49 and 26/951, exchangeable calcium dominated the exchange complex. Exchangeable calcium values may be higher in colluvial materials because processes have not been sufficient to leach out all carbonates, or there has been a recharge of carbonates from higher areas where limestone strata are present.

In all profiles studied, exchangeable potassium and sodium values were low. Weathering has been sufficient to remove most mineral forms of potassium and sodium. An exception could be found in profile 951, in which the saprolite is naturally lower in potassium and sodium-bearing minerals. Exchangeable potassium values were, on average, equally distributed throughout all soil horizons. Exchangeable sodium generally increased with depth, reaching a maximum in the lower Cr horizons. Exchangeable sodium values were highest in Cr horizons of profiles 49 and 42E. This finding was expected because the Maryville limestone is known to contain appreciable amounts of halite.

4.3.2 Iron and Manganese

Iron and manganese data are presented in Table 8. Citrate-dithionite reducible free iron oxide values ranged from 0.53 to 4.83% for the eight soil profiles studied. Iron contents were highest in B and upper Cr horizons. Soils formed in the upper Pumpkin Valley Shales (profiles 24-N and 24-E), on average, contained the highest iron oxide content. This result was expected because Pumpkin Valley parent materials contained large amounts of chlorite and glauconite, iron-rich clay minerals. Weathering of chlorite and glauconite proceeded fairly rapidly because the upper Pumpkin Valley saprolite has relatively higher permeability rates. Iron contents in the upper Pumpkin Valley profiles were high well into the saprolite. This indicates that weathering processes had penetrated the Pumpkin Valley Shale relatively deeply. Profiles 49 and 42- E also contained high amounts of iron oxides, indicating that weathering and iron movement had penetrated relatively deeply into the Maryville saprolite.

Profiles 951 and 26/951 contained the least amount of free iron oxides. The colluvial Ap and Bt horizons of profile 26/951 contained appreciable amounts of iron, but deeper alluvial horizons had less iron. Free iron oxides increased in the 7Cr horizon because of weathering of chloritic and glauconitic materials present in the Pumpkin Valley residuum. Profile 951 also contained low amounts of iron oxides within the alluvial horizons. The extremely low amounts of iron present in the 2Btg horizon suggested that reducing conditions persisted for an appreciable amount of time and that iron migration from the horizon had occurred. Iron oxides increased in the 3Cr horizon, where hard saprolite was encountered and into which iron had been translocated.

Dithionite extractable manganese values ranged from 0 to 0.3% in the nine profiles studied. Manganese oxides reached maximum concentrations deep within the Cr horizons. Within the LLWDDD site soil profiles, manganese had migrated much more deeply into the saprolites than had iron. Soil profile 51-E (developed on the Nolichucky Shale) contained the highest amounts of manganese oxides, and their distribution was nearly equal throughout the soil and saprolite profile. Alluvial profiles 951 and 26/951 were almost devoid of manganese oxides, with the exception of the 3Cr horizon of profile 951. The hard saprolite present in the 3Cr horizon restricted vertical flow of water, and manganese had accumulated both on weathered rock surfaces and along fracture planes. Similar restrictions to water flow in profiles such as 51-E had produced numerous iron and manganese coatings on saprolite fragment surfaces.

Hydroxylamine HCl reducible manganese values were commonly low ($<300\ mg \cdot kg^{-1}$) in A and B horizons and high ($>1200\ mg \cdot kg^{-1}$) in lower Cr horizons. Values were commonly lowest in B horizons. Hydroxylamine reducible manganese values were a good indicator of degree of mineral weathering and translocation of manganese in the soil system. With the highest values being found in lower Cr horizons of most profiles studied, weathering had progressed several meters into the saprolites. Exceptions were found in two soil profiles (36-E and 26/951) in which only trace amounts of hydroxylamine reducible manganese occurred in deeper saprolites. These profiles were less weathered compared with the other soil profiles.

Table 8. Sodium citrate - dithionite extractable iron and manganese and hydroxylamine HCl reducible manganese for nine soil profiles on the LLWDDD site

			CBD extractable		Hydroxylamine HCl reducible
Pit	Horizon	Depth (cm)	Free iron oxides (%)	Free manganese oxides (%)	Manganese (mg kg^{-1})
49 & 42-E	A-E[a]	0-14	1.92	0.04	86
	A-Bw[b]	0-16	2.13	0.03	255
	Bt1-Bt2	14-84	3.67	0.00	12
	2CB	84-102	3.99	0.01	26
	2Cr1	102-149	3.16	0.05	80
	2Cr2	149+	2.14	0.12	1200
36-N	A	0-9	1.24	0.09	795
	Bw	9-29	1.62	0.02	1
	Cr1	29-130	2.36	0.06	91
	Cr2	130+	2.27	0.32	3095
24-E	Ap	0-15	2.92	0.04	91
	Cr1	15-58	3.65	0.02	102
	Cr2	58+	3.28	0.34	2660
951	Ap	20-28	0.53	0.00	41
	E1-E2	28-48	1.11	0.04	238
	Bt	48-76	1.39	0.01	98
	2E/B-2Btg	76-121	0.52	0.00	14
	3Cr	121+	2.29	0.28	2700

Table 8. (continued)

Pit	Horizon	Depth (cm)	CBD extractable: Free iron oxides (%)	CBD extractable: Free manganese oxides (%)	Hydroxylamine HCl reducible: Manganese (mg kg^{-1})
24-N	A-E	0-25	1.49	0.02	187
	Bw-Bt	25-66	4.35	0.00	8
	B/Cr	66-118	3.87	0.19	1460
	Cr1 (G)	66-118	4.17	0.00	13
	Cr2	118+	2.30	0.12	1190
36-E	A-Bw	0-25	2.63	0.04	295
	Cr1	25-200	4.83	0.00	10
	Cr1 (G)	100	3.93	0.00	17
	Cr2	200+	2.47	0.00	10
51-E	Ap	0-18	2.36	0.10	855
	Cr	18-150	2.62	0.18	1630
	2Cr	150-250	2.26	0.08	131
	3Cr (R)	250+	2.35	0.11	1225
	3Cr (Y)	250+	2.94	0.19	1595
26/951	Ap	0-21	2.14	0.03	246
	Bt1-4Bt	21-122	2.77	0.02	48
	5Bt1-6Bw2	122-270	1.92	0.01	53
	7C-7Cr	270+	4.09	0.02	135

[a]Colluvial face (profile 49) [b]Residual face (profile 42-E)
(G) = Glauconitic
(R) = Reddish coats (iron)
(Y) = Yellowish (iron and/or clay) coats

4.4 MINERALOGICAL CHARACTERISTICS

4.4.1 X-ray Diffraction

X-ray diffraction data are presented in Table 9. The X-ray diffraction patterns are presented in Appendix B. The geologic formations of the LLWDDD site were high in illite. Of the geologic formations studied, the Cambrian aged Pumpkin Valley Shale contained the highest amount of illite (Lee et al. 1987). Both the unweathered Nolichucky and Pumpkin Valley Shales contained moderate to high amounts (10 to 20%) of chlorite and kaolinite. The chlorite weathered to vermiculite as the shales became leached and oxidized. The clay fraction of the uneroded soil formed on the upper Pumpkin Valley Shale (Profile 24-N) contained traces of vermiculite and illite, high amounts (>30%) of Al-hydroxyinterlayered vermiculites (HIV) and kaolinite, and moderate amounts (20 to 30%) of quartz in the A and E horizons. With depth in profile 24-N, vermiculite increased to moderate amounts (20 to 30%), HIV decreased to trace amounts, kaolinite and quartz decreased to low (10 to 20%) amounts, and illite increased to moderate amounts (20 to 30%). Trace amounts of illite were found in the glauconitic saprolite. Most of the kaolinite found in the soil and saprolite of profile 24-N was inherited from the unleached, unoxidized upper Pumpkin Valley Shale.

In comparing the non-eroded (profile 24-N) and eroded (profile 24-E) soil formed on the upper Pumpkin Valley Shale, HIV amounts differed greatly. Because of severe erosion, most of the soil and some of the highly weathered saprolite of profile 24-E had been eroded. Thus, HIV was present in only trace amounts in profile 24-E.

Both non-eroded (profile 36-N) and eroded (profile 36- E) soils formed on the Rogersville Shale had similar clay mineralogies. Hydroxyinterlayered vermiculites were present in trace amounts or were not detectable in both soils. Also, kaolinite was present in lesser amounts compared with the soils formed in the upper Pumpkin Valley Shale. The mineralogy data presented indicate that the soils formed on the Rogersville Shale were less weathered than the upper Pumpkin Valley soils.

The colluvial soil found on the Maryville Limestone (profile 49) contained traces of kaolinite but moderate amounts (20 to 30%) of HIV. The colluvium was highly weathered, as indicated by the presence of trace amounts of kaolinite and moderate amounts of HIV. The aluminum needed for HIV formation most likely came from the dissolution of kaolinite.

The soil formed on the Nolichucky Shale (profile 51-E) generally contained only trace amounts of kaolinite and HIV in the clay fraction. Profile 51-E contained a high amount of illite. This profile had not experienced a high degree of weathering. A high degree of erosion has removed most of the upper soil horizons, resulting in lower amounts of kaolinite and HIV. The clay-coated saprolites (Horizon 3Cr (Y)) did contain higher amounts of HIV than iron-coated saprolites. Such clay zones indicate water flow zones within the Nolichucky saprolite. These zones had experienced more intense weathering and clay translocation.

The old alluvial soil (profile 951) had experienced a great deal of weathering. High amounts (>30%) of kaolinite were present in the Bt horizon, and medium amounts (20 to 30%) of HIV could be found in the Ap horizon. The 3Cr horizon of Profile 951 was in the Rogersville Shale saprolite. The

Table 9. Summary of clay mineralogy for nine soil profiles on the LLWDDD site

Pit	Horizon	Depth (cm)	Minerals Present in Clay Fraction[a] (<0.002 mm)				
			Vermiculite	HIV[b]	Illite	Kaolinite	Quartz
24-N	A-E	0-25	T	H	T	H	M
	Bw-Bt	25-66	L	M	L	H	L
	B/Cr	66-118	M	L	M	H	L
	Cr1 (G)	66-118	M	T	T	L	L
24-E	Ap	0-15	M	T	L	H	M
	Cr1	15-58	M	T	M	H	M
36-N	A	0-9	L	T	M	M	M
	Bw	9-29	M	T	M	L	M
	Cr1	29-130	H	ND	H	L	L
36-E	A-Bw	0-25	L	T	M	H	M
	Cr1	25-200	L	T	H	M	T
49 and 42-E	A-E[c]	0-14	T	M	L	T	M
	Bt1-Bt2[c]	14-84	H	M	M	T	L
	2Cr2	149+	M	L	M	T	L
51-E	Ap	0-18	T	L	M	T	M
	Cr	18-150	L	T	H	T	T
	3Cr (R)	250+	L	T	H	T	T
	3Cr (Y)	250+	L	L	M	T	T
951	Ap	20-28	T	M	ND	L	L
	Bt	48-76	M	T	H	H	L
	3Cr	121+	M	T	M	L	T
26/951	Ap	0-21	L	M	L	H	M
	Bt1-4Bt	21-122	M	L	L	M	L
	5Bt1-6Bw2	122-270	M	M	L	H	L
	7C-7Cr	270+	H	T	M	L	M

[a]Mineral amounts present in the following relative terms:
ND = not detected, T = trace (<10%), L = low (10 + 20%),
M = medium (20 + 30%), H = high (>30%)

[b]HIV = Al-hydroxyinterlayered vermiculites

[c]Colluvial Face (profile 49)
(G) = Glauconitic (R) = Reddish coats (Iron)
(Y) = Yellowish (iron and/or clay) coats

saprolite was not very weathered, as indicated by the moderate amounts (20 to 30%) of illite and vermiculite and low to trace amounts of kaolinite and HIV. Kaolinite and HIV present in the saprolite were found in clay zones between shale faces.

Profile 26/951 contained several discontinuities and weathering sequences. The first 122 cm of the soil profile contained old colluvium derived from the Pumpkin Valley Shale. The colluvium had been deposited long enough to experience a moderate to high degree of weathering. Kaolinite was present in high (>30%) to moderate (20 to 30%) amounts. Hydroxyinterlayered vermiculites were present in moderate (20 to 30%) to low (10 to 20%) amounts. Vermiculite, illite, and quartz were also present in moderate to low amounts.

From 122 to 270 cm in profile 26/951, the soil was derived from alluvial parent materials. The alluvial sequence also experienced a high degree of weathering before being buried by colluvium. Amounts of clay fraction kaolinite, HIV, illite, vermiculite, and quartz were similar to those found in the colluvium. Visual observations of clay skins on alluvial ped faces suggested that some of the clays found in the alluvial sequence had been translocated from the overlying colluvial materials.

The final sequence present in the 26/951 profile was derived from the Pumpkin Valley Shale residuum. The residual soil and saprolite contained only trace amounts of HIV and low amounts (10 to 20%) of kaolinite. Quartz, vermiculite, and illite were present in moderate amounts (20 to 30%). These materials were moderately weathered but still exhibited the influence of the parent material mineralogy (vermiculite, illite, and quartz).

4.5 LANDFORM DEVELOPMENT

Soil and landform development is a function of the five factors of soil formation: climate, relief, biota, time, and parent materials. Although climate was the most important factor in driving the forces of geologic weathering and soil development, differences in soil development caused by climate on each of the four major geologic rock units present on the LLWDDD site were minor. In soils developed on the Rogersville Shales, however, parent material and aspect influences were probably as important as climate in controlling soil development. The Rogersville Shale landform was the only one on the LLWDDD site that rests on steep, obsequent slopes. Geologic parent materials dipped perpendicular to the soil surface, and past geologic weathering was concentrated on ends of the shale bodies rather than along bedding planes. The Rogersville Shale saprolite, however, was highly impermeable to water movement. This impermeability resulted in slower weathering rates and less soil development, despite the Rogersville saprolite bedding planes being nearly vertical and being more susceptible to water infiltration. Most importantly, the steep slopes on which the soils of the Rogersville Shale formed increased erosion and decreased water infiltration. The effect of slope and geologic parent materials are shown in Figs. 7 and 8, which are transect investigations of major feologic formations found on the LLWDDD site. Geologic and accelerated erosion outpaced soil development on much of the Rogersville landscape, leading to shallow soils. Clay, iron, and manganese formation and movement had been restricted to zones within the saprolite where shattering of shale bodies had occured because of faulting.

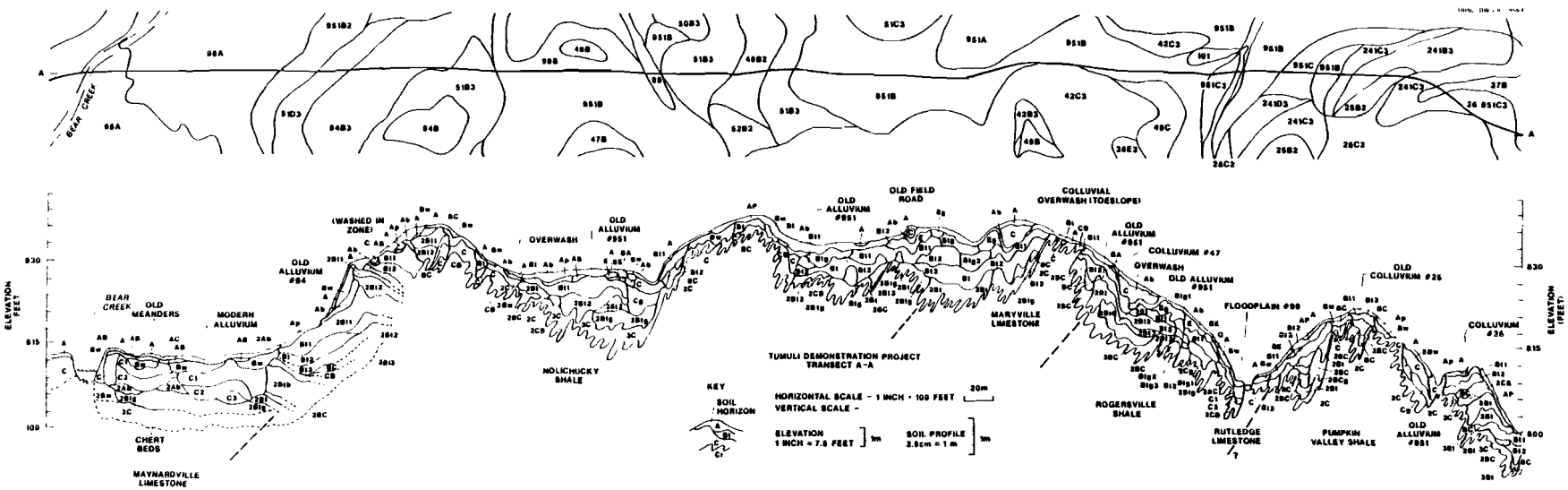


Fig. 7. Transect A-A'.

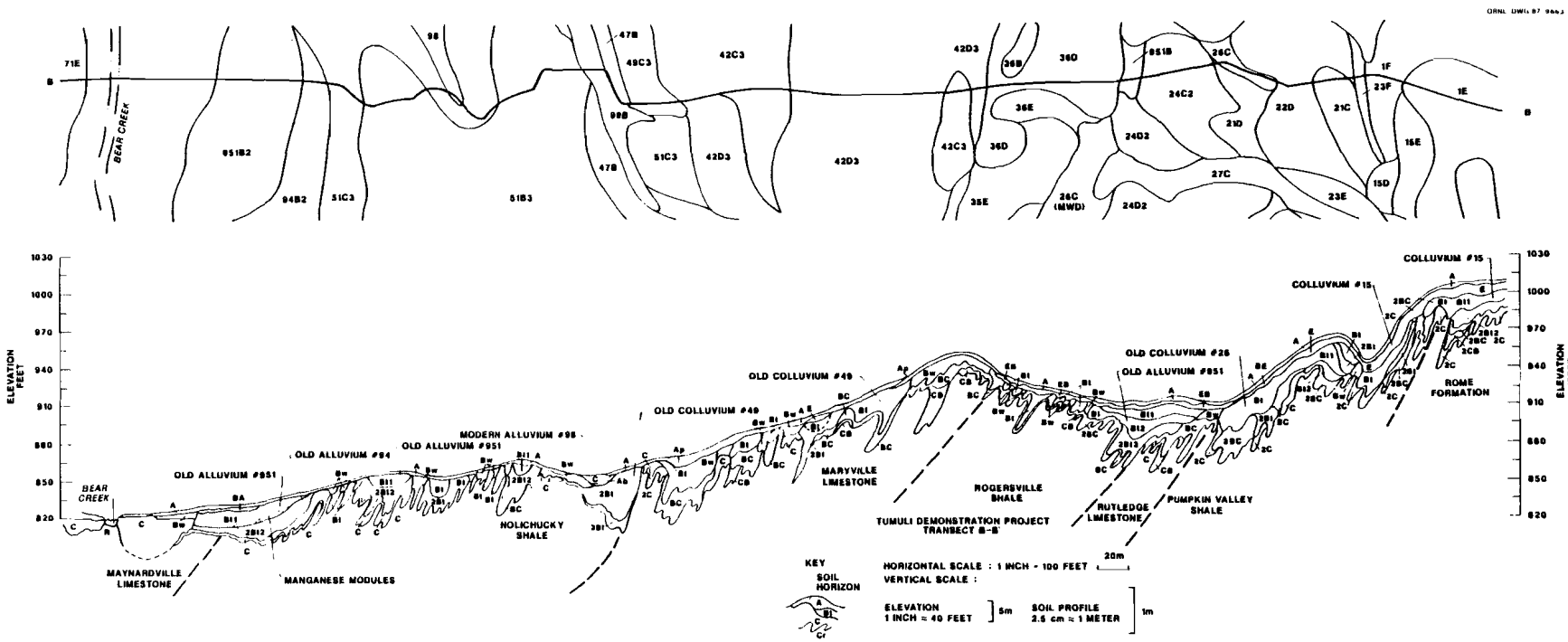


Fig. 8. Transect B-B′.

These were the zones where water was able to penetrate the raw, partially weathered saprolites. Higher concentrations of manganese oxides (Table 7) denoted areas where vertical water movement was slowed or stopped.

Soils formed on the upper Pumpkin Valley Shale (profiles 24-N and 24-E) exist on south aspect slopes of Pine Ridge and are underlain by permeable glauconitic and illitic sandstones and shales. They have been highly weathered and have received more direct sunlight than those formed on the Rogersville Shale. As a result, the soils of the upper Pumpkin Valley Shale have undergone more wet-dry cycles, which promote more clay translocation into the B horizons (Table 2). Also, lower slope gradients decreased erosion susceptibility. On uneroded sites, clay percentages exceeded 45% in Bt horizons, and these clays (as well as the whole soil) contained a high percentage of iron oxide coatings (Table 8). High iron contents extended well into the saprolites. The iron most likely originated from the chloritic and glauconitic (ferrous illite) materials inherent in the saprolites and hard rock. Soil hues on uneroded sites often were 5YR to 2.5YR. Because of the apparent permeability of saprolites, weathering had proceeded quite deeply. The saprolites were quite soft, allowing auger penetration for some depth. These properties were passed on to the overlying soils. The loamy textures of A horizons permitted excellent infiltration, and the B horizons allowed considerable vertical water flow. Based on the data of profile 24-N, residual soils formed on the upper Pumpkin Valley Shale had the highest avaliable water-holding capacity of all residual soils. This property enhanced the ability of these soils to resist erosive forces and to provide adequate moisture for vegetation. Evidence of thicker soils on the upper Pumpkin Valley Shale is shown in Fig. 8. Also, the transect results showed extreme variability of soil development caused by parent materials. More permeable beds of parent materials produced deeper soils. As is true for upper Pumpkin Valley Shale parent materials, the permeable parent materials were cyclically alternating with more resistant, less permeable parent materials.

Other indicators for the intense weathering of upper Pumpkin Valley soils can be shown with the chemical data in Tables 6 and 7. The uneroded profile (24-N) had the lowest base saturation and calcium carbonate equivalent values of any soil profile studied. The unweathered upper Pumpkin Valley shale probably had the lowest carbonate content of any geologic formation within the LLWDDD site. Exchangeable acidity values were also the highest in any profile. Although exchangeable aluminum dominated the exchangeable acidity, exchangeable hydrogen values were somewhat higher than those found in other profiles. Although carbonates were present in low quantities throughout the Pumpkin Valley Shales, weathering processes had removed them from the uppermost weathered zones. Evidence of small quantities of carbonates were found in the saprolite of the very highly eroded soil profile 24-E (Table 7), where a measurable calcium carbonate equivalent was found in the lower saprolite. Past farming and foresting activities have stripped the soil and some of the uppermost saprolite from this site, bringing relatively fresh, less weathered materials closer to the surface.

The Pumpkin Valley Shales have undergone significant episodes of colluviation. During the Pleistocene, climatic conditions were such that soils on the Pumpkin Valley Shale were unstable. Intense freeze-thaw cycles and runoff probably caused large amounts of soil and saprolite material to flow through drainage ways, choking them with coarse sediments. The streams

diverted to the sides of choked streambeds and cut into the residuum and saprolites. By the time the climate became less severe, new stream channels had developed in positions once occupied by spur ridges, and old stream channels were now in the higher positions of the landscape. This form of topographic reversal is diagrammed in Fig. 9.

Overall, three major episodes of colluviation have been identified on the south aspect of Pine Ridge. The oldest colluviation probably occurred at the beginning of Pleistocene climatic instability. The second most likely occurred in late Pleistocene or during the Wisconsinan. The latest was Holocene in origin, and the soils show minimal soil horizonation. The second colluvial episode is represented in profile 26/951. Alternating bands of weathered shale chips and clay-rich argillic horizons in the upper 146 cm of profile 26/951 denote moderately old colluviation of Pumpkin Valley materials. This material had a clay loam texture (Table 7) and was moderately weathered [as shown by iron oxide content (Table 8)]. This material covered considerable areas of the lowermost slopes of the south aspect of Pine Ridge but was <2 m thick.

Soils formed on the Maryville Limestone (profiles 49 and 42-E) were found on the south aspect of a smaller lateral ridge southeast of Pine Ridge. These soils formed under climatic and topographic conditions similar to those that favored the weathering of Pumpkin Valley Shale. Parent materials, however, differed. The Maryville parent materials were initially higher in carbonates, thus delaying saprolite weathering and clay formation. Evidence of residual carbonates could be found in the lower saprolites (Table 7) because of the presence of measurable calcium carbonate equivalents and higher amounts of exchangeable calcium. Residual B horizons were quite high in clay when soils were on low sloping landforms. But on steep slopes (>25%), shallow residual soils (Ruptic-Ultic and Typic Dystrocrepts) with Bw and intermittently shallow Bt horizons were common, as shown in Fig. 8. These soils, like those found on the Pumpkin Valley Shale, showed extreme soil variability with respect to depth and development.

Profile 49 and 42-E contained both a residual (profile 42-E) and colluvial (profile 49) face. The residual face contained a shallow A and Bw horizon (0 - 16 cm) over saprolite in various stages of weathering. The solum (A and Bw horizons) contained very little clay (Table 2) with low amounts of free iron oxides. Available water-holding capacities (cm/cm soil) were somewhat lower than those found in the Pumpkin Valley soils (Table 5). The saprolite was highly weathered to about 150 cm, where the weathered rock became massive and water movement was restricted [as indicated by accumulations of manganese oxides (Table 8)].

The colluvial face of the soil formed on the Maryville Limestone (profile 49) was a cut along the long axis of an old gully fill. Gully fills, such as this one, were common on Maryville and Pumpkin Valley landscapes (Fig. 8). The profile 49 gully fill was 84 cm thick. This colluvium had been in place for some time and was highly weathered. The Bt horizon contained a high percentage of clay (Table 2) and free iron (Table 8). The colluvium was younger than the underlying residuum, as indicated by the dominance of exchangeable calcium on soil exchange sites (Table 7). The colluvial materials contained calcium-bearing coarse fragments, which have not completely weathered. The colluvium did have a moderate to high available water-holding capacity (Table 5) and appeared to be more permeable than the

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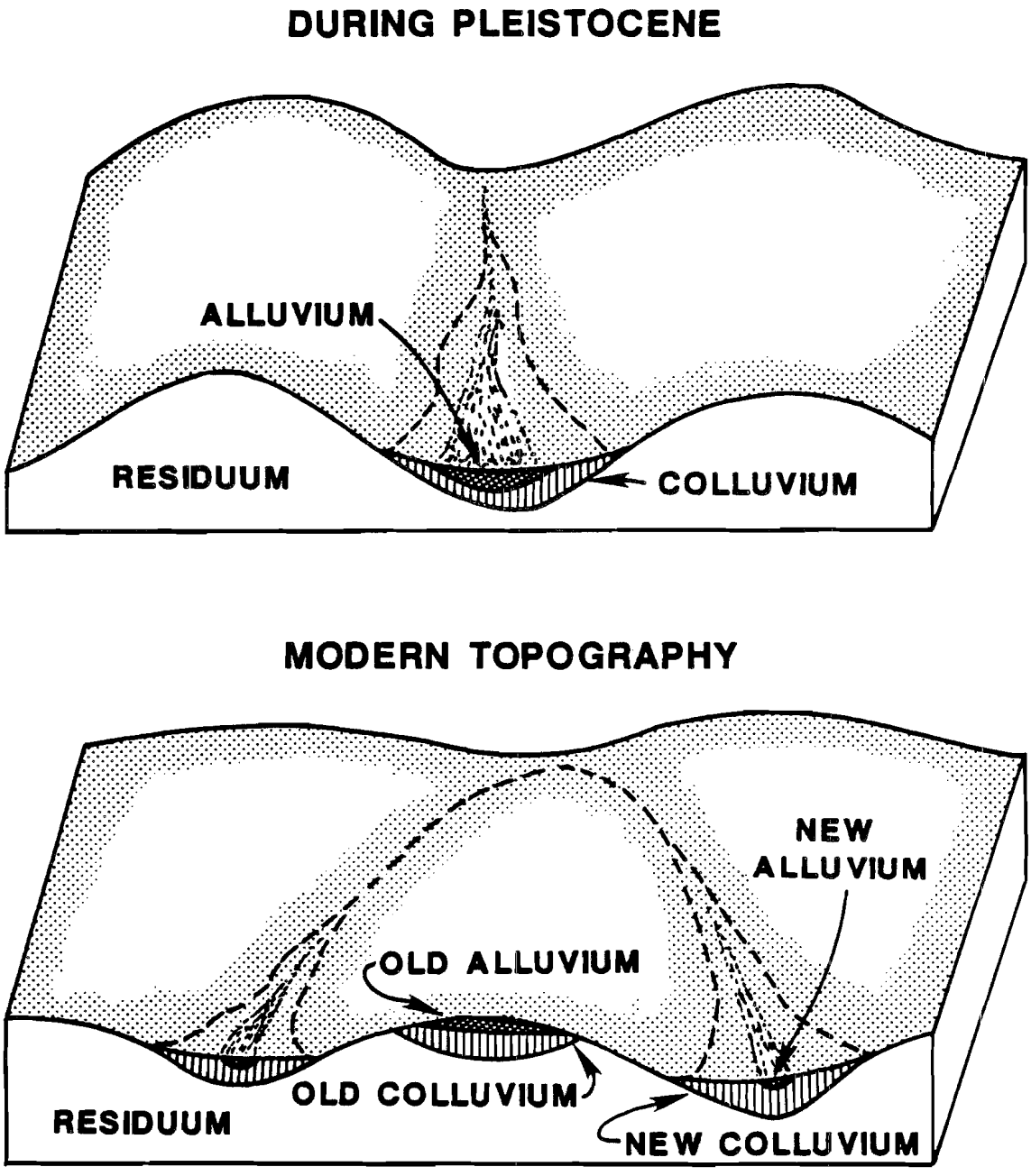

Fig. 9. Diagram of topographic reversal.

associated residual soil. These characteristics appeared to be common to all soils developed on the Maryville Limestone that were investigated.

The Nolichucky Shale underlies low, gently to moderately sloping landforms between the Maryville ridge and Bear Creek. Profile 51-E represented the typical soils found on the Nolichucky Shale. These soils formed on massive, interbedded shale and argillaceous limestone parent materials. Because of the initially lower calcium carbonate content, Nolichucky parent materials were more highly weathered than Maryville parent materials. Free iron and manganese contents (Table 8) were high throughout the soil and saprolite profile. Both iron and manganese had migrated through macropores and cracks deeply into the saprolite. Exchangeable acidity values (Table 6) were high, and base saturation values (Table 7) were low. These chemical indicators show that the soils formed on the Nolichucky Shale were highly weathered.

Because of the relative impermeability of the Nolichucky Shale saprolite, even on gently sloping landscapes, overland runoff and surface erosion have been quite severe. As a result, saprolites occurred close to the surface. These soils were in agriculture before the 1940s, and much of the soil has been eroded away as a result. The remnants of the soil solum existed as tonguings of Bt and Bw material that penetrated into the more permeable saprolite zones. These tonguings were often the residual remains of thin strata of weathered limestones that alternated with the harder shale saprolites.

The LLWDDD site contained a large expanse of old alluvium (profiles 951 and 26/951), which rests on terraces above Bear Creek (Fig. 7). These soils contained higher amounts of sand and silt, most of which occurred in the coarse silt and very fine sand fractions (Table 2). This material was most likely deposited in a slow water (backwater or lake) environment. Based on the relatively uniform particle size of the old alluvial sediments, water velocities at the time of deposition were estimated to be $<0.3\ cm \cdot sec^{-1}$ (Hjulstrom 1939). The old alluvium was most likely deposited by either the damming of Bear Creek or by backwater flooding from the Clinch River. The alluvial soils, because of their high silt and very fine sand contents, had the highest available water-holding capacities of any soils on the tumuli site (Table 5). Free iron and manganese oxide contents (Table 8) were not very high because of the reduction and removal of the oxides from the soil profile. The soils have been weathered to some extent, as indicated by low base saturation and exchangeable calcium values (Table 7) and high exchangeable acidity values (Table 6). Because the alluvial materials were subjected to a reducing environment, lateral or downward translocations of iron probably occurred.

Based on the data presented for the nine profiles studied, the Pumpkin Valley soils were most highly weathered. The order of weathering and soil formation for soils found on the four geologic formations of the LLWDDD site were as follows:

Upper Pumpkin Valley > Nolichucky > Maryville > Rogersville.

The upper Pumpkin Valley Shale was more permeable and contained an initially low calcium carbonate content. The Nolichucky Shale also contained low carbonates, but the saprolite was less permeable. The high calcium carbonate

content of the Maryville Limestone greatly limited soil development. Finally, the least weathered soils were found on the Rogersville Shale because of steep slopes and low permeability of the shales.

4.6 EVALUATION OF RADIONUCLIDE SORPTION DATA AND TUMULI SITE SELECTION

The radiunuclide sorption data are presented in Table 10. Radioactive cobalt (Co), strontium (Sr), cesium (Cs), technecium (Tc), and uranium (U) were placed in groundwater samples at $1.0 \cdot 10^{-8}$ M concentrations. Soils were saturated with the solution, and the amount of radionuclides sorbed to the soils was measured. For the nine profiles studied, cobalt values were highest in the A horizons. Complexing of cobalt with organic matter was mostly responsible for the high values. Cobalt values were lowest in B horizons and generally increased slightly in the saprolite. The increase of cobalt sorption was most likely related to sorption with manganese oxides.

Technecium existed in the groundwater as an oxyanion (TcO_4^-). Technecium was not sorbed in any great amounts to the tumuli soils. Minor sorption occurred in A horizons because the A horizons had higher amounts of organic matter that had variable charge properties. Technecium sorption values were negative in B and Cr horizons, suggesting anion repulsion. In natural soil systems, technecium would be expected to leach from the soil in a manner similar to sulfate and nitrate.

Sorption of the other three radionuclides--uranium, strontium, and cesium--was most directly influenced by soil pH, clay mineralogy, and cation exchange properties (Baes and Sharp 1983). Strontium has sorptive characteristics similar to calcium, whereas cesium has characteristics similar to potassium. Because of narrow ranges in these properties within the LLWDDD soils, few statistical correlations could be made with respect to these properties. Uranium and cesium were strongly sorbed to nearly all soils. Strontium had a wide range of values, with the highest values found in the saprolite. A small correlation (r value) was found between strontium sorption and concentration of manganese oxides. Strontium, cesium, and uranium sorption in these soils was most likely influenced by many soil properties. For example, strontium sorption was most likely influenced by the presence of exchange sites on clays, iron and manganese oxides, and soil pH. Sorption values for strontium were low in alluvial soils as a result of low clay content and resulting lower cation exchange capacity.

After evaluating the soil properties in the nine LLWDDD site soils studied, some suggestions could be made about the placement of conventional and tumuli low-level radioactive waste trenches and the location and use of soil fill materials. A tumuli trench is an aboveground method of low-level radioactive waste burial. The tumuli trench concept uses areas where high water tables are present and contains a concrete containment structure that prohibits water movement from the trench (Fig. 10).

At first glance, the soils formed on the upper Pumpkin Valley Shales would make excellent sites for both tumuli and conventional low-level nuclear waste burial. These soils were highly weathered, stable, far from major streams, and had excellent soil properties. Also, there was a substantial amount of alluvium present in drainage ways at the base of Pine Ridge, which could act as a buffer for accidential waste seepage. Artesian head was

Table 10. Radionuclide sorption data for nine LLWDDD soil profiles

Pit	Horizon	Depth (cm)	Radionuclide sorption ratios (L Kg^{-1}) Co	Sr	Cs	Tc	U
24-N	A-E	0-25	391	49	1819	0.23	746
	Bw-Bt	25-66	151	157	>10000	0.27	>10000
	B/Cr	66-118	717	832	>10000	0.02	>10000
	Cr1	66-118	938	1046	>10000		3923
24-E	Ap	0-15	5687	865	>10000	0.01	>10000
	Cr1	15-58	879	958	>10000		>10000
36-E	A-Bw	0-25	2107	270	>10000	0.84	3239
	Cr1	25-200	938	1008	>10000		>10000
36-N	A	0-9	1267	218	7241	0.45	1263
	Bw	9-29	162	165	>10000	0.03	3810
	Cr1	29-130	532	596	>10000	0.13	5881
49 &	A-E[a]	0-14	7296	185	2538	0.44	1843
42-E	A-Bw[b]	0-16	217	234	>10000	0.04	>10000
	2Cr2	149+	1960	2231	>10000		>10000
51-E	Ap	0-18	7575	167	>10000	0.15	3604
	Cr	18-150	1848	1995	>10000		3659
	3Cr (R)	250+	3104	3736	>10000		3580
	3Cr (Y)	250+	1476	1667	>10000		4228
951	Ap	20-28	188	79	1745	0.28	510
	Bt	48-76	66	76	>10000	0.14	6441
	3Cr	121+	>10000	592	>10000	0.12	>10000
26/951	Ap	0-21	4688	201	8651	0.24	2216
	Bt1-4Bt	21-122	320	346	>10000	0.27	3715
	5Bt1-6Bw2	122-270	314	337	>10000	0.14	5679
	7C-7Cr	270+	1498	1717	>10000		3355

[a]Colluvial face (profile 49) [b]Residual face (profile 42-E)
(G) = Glauconitic
(Y) = Reddish coats (iron) (Y) = Yellowish (iron and/or clay) coats

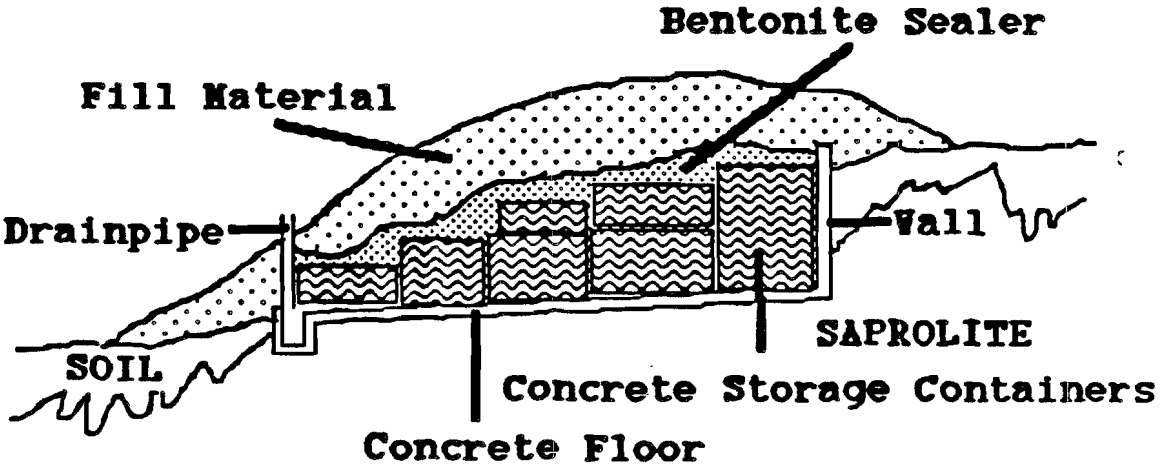

Fig. 10. Diagram of tumulus low-level waste trench.

present at the base of Pumpkin Valley Shale. This fact, however, should not pose problems for the conventional burial of wastes. Thus, both conventional and tumuli waste burial would be options for Pumpkin Valley soils. Soils formed on the Nolichucky Shale, however, have a problem with respect to groundwater. Because of a high water table in the Nolichucky, placement of tumuli trenches would be a more favorable option.

The soils formed on the Maryville Limestone, despite being shallow and having less weathered saprolites at depth, would make excellent sites for conventional trench burial. Low water tables and the presence of carbonates at depth would permit safe containment of most radionuclides.

For the selection of soil fill materials, three criteria were used. First, the material must be available in large amounts. Second, it must be inexpensive to obtain. And third, the material must posess soil properties suitable for radionuclide containment and establishment of vegetation. The old alluvial soils present on terraces of Bear Creek best meet the criteria. These soils had high available water capacities suitable for establishing surface cover, excellent permeability, and moderate to high sorption capacities for most radionuclides. More importantly, these soils were present in large quantities on the LLWDDD site and could be mined and transported at minimal cost. The alluvial soils, however, do have a few drawbacks. First, they contain a high proportion of coarse silt and very fine sand, which is highly erodible. Second, these soils are saturated during wet weather, which may cause problems with obtaining fill. Third, these soils are hard to compact. The problem of erodibility could be prevented by applying a surface layer of Pumpkin Valley or Maryville colluvium. These materials are permeable and exhibit high available water-holding capacities. They also contain higher amounts of clay and coarse fragments, thus decreasing the susceptibility of the alluvium to erosion. The colluvium could also be used as primary trench fill materials. The 26/951 soils, plus other Pumpkin Valley colluvial soils, would be the best potential sources of fill and cover materials on the LLWDDD site.

5. SUMMARY AND CONCLUSIONS

The soil and saprolite characterization study took place on the LLWDDD site in an attempt to establish land use planning for the site. Nine soil and saprolite profiles were characterized using standard soil survey techniques. Soils formed on the Pumpkin Valley Shale had been weathered the most, as indicated by high clay contents, low exchangeable calcium and base saturation values, and high exchangeable aluminum and iron oxide contents. Soils formed on the Rogersville Shale were least weathered as a result of occupying north aspect obsequent slopes, where impermeability of parent materials (to weathering) and steep slopes affected soil formation. Soils formed on the Maryville Limestones and Nolichucky Shales were highly weathered, but steep slopes and/or lower permeability rates had allowed geologic and accelerated erosion to remove most of the soil profile. Most of the soils studied greatly sorbed Co, Sr, Cs, and U. Technecium was not sorbed to any extent because of anion repulsion. Soils formed on the Nolichucky Shale should be restricted to tumuli waste burial because of high water tables. Soils formed on the Maryville Limestones were suitable for trench or tumuli burial. Old colluvial materials would make excellent trench fill materials. The alluvial materials (951 soils) were saturated during wet periods, were extremely erodible, and could not be compacted. Erosion of this material could be minimized by applying colluvial materials with low erodibility over the alluvium.

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Appendix A

SOIL PROFILE DESCRIPTIONS

Soil No: 51-E (Soil Derived from Cambrian aged Nolichucky shale)

Location: LLWDDD Site. E30230, N29250 Y-12 grid.

Classification: Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.

Pedon Classification:Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.

Geomorphic Position: Upper slightly convex sideslope of low hillsides.

Slope: 4% with southeast aspect.

Parent material: Nolichucky saprolite (Saprolite from claystone, siltstone and argillaceous limestone along with thin strata of very fine sandy loam).

Described by: Lambert, Lietzke, and Jenkins. March 13, 1987

Notes: Because of the ruptic nature of the soil, it was necessary to describe three profiles in order to encompass the "cyclic" variability of one pedon.

Part 1 - ULTIC PORTION

Oi 2 to 0 cm; leaf litter

Ap 0 to 18 cm; Dark yellowish brown (10YR 4/4) silt loam; moderate fine granular structure; very friable; many fine and medium roots between peds; many fine pores; pH 4.7; abrupt wavy boundary.

Bt 18 to 33 cm; Mottled yellowish red (5YR 5/8), yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6) silty clay; moderate medium subangular blocky structure; firm; common fine prominent brownish gray (10YR 6/2) mottles in ped interiors; many continuous and distinct brown (7.5YR 5/4) clay films on ped faces; few fine and medium roots between peds; common fine pores; pH 4.8; clear irregular boundary. (Argillic Horizon part of pedon)

BC 33 to 64 cm; Strong brown (7.5YR 5/6) shaly silty clay loam; weak medium subangular blocky structure; firm; common medium prominent light brownish gray (2.5Y 6/2) mottles in ped interiors; many continuous distinct brown (7.5YR 5/4) clay films on ped faces and coating rock fragments; common discontinuous prominent red (2.5YR 4/6) iron stains on some ped faces; common fine and medium roots; few to common pores; pH 4.8; abrupt inclined boundary. (Thin sandstone strata are 10YR 6/8)

C 64 to 71 cm; Strong brown (7.5YR 5/6) very shaly clay loam; massive rock controlled structure; firm; common discontinuous faint brown (7.5YR 5/4) clay films on rock fragments; few fine roots in cracks; common fine pores; about 50% shale and siltstone fragments; pH 4.8; abrupt inclined boundary.

2CB 71 to 81 cm; Yellowish red (5YR 5/6) clay; massive; firm; many discontinuous distinct brown (7.5YR 5.4) clay films on fracture and joint faces; few fine roots; few fine pores; pH 4.8; abrupt irregular inclined boundary. (Argillaceous limestone saprolite stratum sandwiched between shale and siltstone saprolite

3Cr 81 to 92 cm; Oxidized and leached saprolite from siltstone and shale; fragment interiors are brown (7.5YR 5/6); common discontinuous prominent red (2.5YR 4.6) iron-clay films on fragment faces; water flow zones are light brownish gray (2.5Y 6/2).

4Cr2 92 to 100 cm; Oxidized and leached saprolite from siltstone and claystone ; fragment interiors are 10YR 5/6 and 7.5YR 5/6; very firm; many discontinuous prominent red (10R 4/8) stains on fragment faces; few discontinuous distinct strong brown (7.5YR 4/6) clay coatings on fragment faces in flow zones; few fine roots in flow zones; pH 4.8.

Part 2 - Located about 3 feet away from Part 1.

RUPTIC PORTION

Oi 2 to 0 cm; leaf litter; abrupt smooth boundary

Ap 0 to 20 cm; Dark yellowish brown (10YR 4/4) silt loam; moderate fine granular structure; very friable; many fine roots throughout; many fine and medium tubular pores; pH 4.7; abrupt wavy boundary.

Bw 20 to 40 cm; Brown (7.5YR 5/4) extremely shaly silty clay loam; weak medium subangular blocky structure; firm; many continuous faint brown (7.5YR 5/4) clay films on some ped faces and on most shale fragments; few fine roots; many pores; pH 4.8; clear irregular inclined boundary. (Cambic part of soil profile).

Cr 40 to 70 cm; Oxidized and leached saprolite from claystone and siltstone; fragment interiors have (10R 4/8) iron coatings on some fragment faces; common discontinuous prominent black manganese coatings on other fragment faces; many discontinuous brown (7.5YR 5/4) clay films on other rock fragments in more permeable zones; water flow zones have gray (10YR 5/1) streaks; root mats continue down through gray areas; pH 4.8.

Part 3 - Located about 3 feet away from Part 2

RUPTIC PORTION

Ap 0 to 18 cm; Dark yellowish brown (10YR 4/4) silt loam; weak fine granular structure; very friable; many fine and medium roots between peds; many fine pores; pH 4.7; abrupt wavy boundary

Cr 18 to 30 cm; Oxidized and leached saprolite from siltstone and claystone; fragment interiors are (10YR 5/6 or 7.5YR 5/6) rock controlled structure; very firm; fragments are coated with either brown (7.5YR 5/4) clay or black manganese coatings; few fine roots in cracks; pH 4.8; abrupt inclined boundary.

2Bt 30 to 66 cm; Yellowish brown (10YR 5/6) clay loam; moderate coarse subangular blocky structure; firm; common fine prominent gray (10YR 6/1) mottles in ped interiors; ped exteriors are coated with continuous brown (7.5YR 5/4) clay; common fine and medium roots between peds; common fine and medium pores; pH 4.8; abrupt inclined boundary. (This horizon formed in saprolite from argillaceous limestone. This section was described just above the massive C horizon zone which perched water into this Bt zone). 3Cr66 to 117 cm; oxidized and leached saprolite from siltstone and claystone; rock controlled structure; very firm; many discontinuous prominent red (2.5YR 4/6) iron stains on some fragment faces; other fragments are partially coated by black manganese oxides; no clay films were noted on fragments. Water seems to flow in the unsaturated mode in this material. pH 4.9.

Soil No: 49 (Colluvial face of soil derived from Cambrian aged Maryville Limestone)

Location: LLWDDD Site. E32060. N30200Y-12 grid

Classification: Typic Hapludults; clayey mixed, thermic.

Geomorphic Position:Narrow old gully fill on upper slightly convex sideslope of hillside

Slope: 18% with southeast aspect.

Parent material: Old colluvium derived from Maryville and Rogersville residuum

Described by: Lambert and P. D. Alley. June 11, 1987.

Oi 2 to 0 cm; leaf litter and pine needles; abrupt wavy boundary.

A 0 to 5 cm; Very dark grayish brown (10YR 3/2) silt loam; moderate fine medium granular structure; friable; many fine roots throughout; many fine pores; pH 4.6; clear smooth boundary. E5 to 14 cm; Dark yellowish brown (10YR 4/4) loam; weak fine subangular blocky structure; friable; common fine roots throughout; common fine pores; pH 4.7; clear smooth boundary.

Bt 114 to 50 cm; Mottled yellowish red (5YR 4/6 and 5/8) clay; strong medium subangular blocky structure; firm; many continuous faint

yellowish red (5YR 4/6) clay films on faces of peds; few fine roots between peds; few to common pores; pH 4.6; gradual wavy boundary.

Bt2 50 to 84 cm; Mottled yellowish brown (10YR 5/4), strong brown (7.5YR 5/6) and red (2.5YR 4/6) clay; moderate medium subangular blocky structure; firm; common discontinuous distinct yellowish brown (10YR 5/4) clay films on faces of some peds; few fine roots between peds; pH 4.8; clear wavy boundary.

2CB 84 to 102 cm; Highly mottled red (2.5YR 4/6) black (5Y 2/1) and olive (5Y 5/6) extremely shaly silty clay; massive; rock controlled structure; very firm; many continuous distinct red (2.5YR 4/6) clay films on rock fragments; common patchy black manganese coatings on some fragment faces; few fine roots on fragment faces; pH 4.8; clear steeply inclined boundary.

2Cr1 102 to 149 cm; Oxidized and leached saprolite from claystone and siltstone that has olive brown (2.5YR 4/4) fragment interiors; rock controlled structure; very firm; many continuous prominent dark red (10R 3/6) iron oxide coatings and black manganese coatings on fragment faces; few fine root mats in upper part where roots extend downward on dip planes; pH 4.8; steeply inclined gradual boundary(60 degree dip).

2Cr2 148 to 300 cm; Oxidized and leached saprolite from claystone and siltstone; fragment interiors are olive (5Y 4/4) to olive gray (5Y 5/2); rock controlled structure; very firm; most fragments are coated with weak red (10R 4/4) iron oxides or black manganese oxides; some fragments in water flow zones are coated with olive gray (5Y 5/2 clay; pH 5.2.

Soil No: 42-E (Residual Face of soil derived from Cambrian aged Maryville Limestone)

Location: LLWDDD Site. E32060, N30200 Y-12 grid

Classification: Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.

Geomorphic Position: Upper third of convex sideslope.

Slope: 18% with southeast aspect.

Parent material: Saprolite from claystone, siltstone along with thin strata of very fine sandstone.

Described by: Lambert and P. D. Alley. June 11, 1987

(This profile was described in the same pit as the No.49 colluvial profile but on the wall to the left of the colluvial wall)

RUPTIC PORTION

A 0 to 5 cm; Dark brown (10YR 3/3) shaly silt loam; moderate fine and medium granular structure; friable; many fine roots and pores throughout; pH 4.7; clear smooth boundary.

Bw 5 to 16 cm; Dark yellowish brown (10YR 4/4) shaly loam; weak fine and medium subangular blocky structure; firm; common fine and medium roots and pores throughout; pH 4.7; gradual inclined boundary

The intermittent Bt horizon (ULTIC PORTION) occurs at about the same depth and extends deeper down dip into the Cr horizon beneath. It has a 5YR to 2.5YR hue and clayey texture.

Soil No: 36-N (Slightly eroded soil formed on the Cambrian aged Rogersville Shale)

Location: LLWDDD Site. E32325, N30480Y-12 grid

Classification: Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.

Geomorphic Position: Upper third of summit with northwest aspect.

Parent material: Saprolite from claystone and siltstone along with strata of glauconitic very fine grained sandstone.

Described by: Lambert June 25, 1987

RUPTIC PORTION

Oi 3 to 0 cm; leaf litter and thin sapric material with many fine roots; abrupt smooth boundary.

A 0 to 9 cm; Dark grayish brown (10YR 4/2) shaly silt loam; moderate fine granular structure; very friable; many fine roots and pores throughout; pH 4.4; clear wavy boundary.

Bw 9 to 29 cm; Yellowish brown (10YR 5/6) very shaly loam; weak fine and medium subangular blocky structure; firm; few patchy brown (10YR 5/3) silt coatings on ped faces; few fine roots and common to many pores; pH 4.6; gradual wavy boundary.

Cr1 29 to 130 cm; Variegated pale olive (5Y 6/4), yellowish red (5YR 5/6) and light gray (5BG 7/1) oxidized and leached saprolite from claystone and siltstone; extremely firm; many nearly continuous distinct yellowish red(5YR 5/6) clay films on fragment faces; common patchy prominent red (10R 4/8) iron stains on some fragments; fine root mats in upper part; pH 4.7; gradual inclined boundary. (This zone contains thin glauconitic sandstone strata)

Cr2 130 to 200 cm; Light gray (5BG 7/1) yellowish red (5YR 5/6) oxidized and leached saprolite from claystone and siltstone; extremely firm; few patchy prominent black manganese oxide coatings on some fragment faces and dark red (10R 3/6) iron coatings on other fragments; few patchy distinct yellowish red (5YR 5/6) clay films coating fragment faces in water flow zones; pH 5.0.(Note: BG hues are of less oxidized fragment interiors).

ULTIC PORTION

A 0 to 9 cm; Dark grayish brown (10YR 4/2) shaly silt loam; moderate fine granular structure; very friable; many fine roots and pores throughout; pH 4.4; clear wavy boundary.

E 9 to 30 cm; Brown (10YR 5/3) shaly silt loam; weak fine subangular blocky structure; friable; few fine roots throughout; many fine pores; pH 4.4; clear wavy boundary.

Bt 30 to 50 cm; Yellowish red (5YR 5/6) shaly clay; moderate medium subangular blocky structure; firm; many continuous yellowish red (5YR 4/6) clay films on ped faces; few fine roots between peds; common pores; pH 4.6; clear highly irregular boundary.

Cr1 50 to 95 cm; Dark yellowish brown (10YR 4/6), yellowish red (5YR 4/6), light olive brown (2.5Y 5/6) oxidized and leached saprolite from claystone and siltstone; very firm; many nearly continuous distinct yellowish red (5YR 4/6) clay films on fragment faces; few patchy prominent red (10R 4/6) iron stains on some fragments; few fine root mats in upper part; pH 4.7.

Soil No: 36-E (Severely eroded soil formed on the Cambrian aged Rogersville Shale)

Location: LLWDDD Site. E32025N30540 Y-12 grid

Classification: Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.

Geomorphic Position: Upper convex sideslope and summits of low hills.

Slope: 10% with west aspect.

Parent material: Saprolite from claystone, siltstone and thin to thick strata of glauconitic very fine grained sandstone

Described by: Lambert March 14, 1987

RUPTIC PORTION

Oi 2 to 0 cm; leaf litter.

A 0 to 4 cm; Very dark grayish brown (10YR 3/2) shaly clay loam; moderate medium granular structure; friable; many fine roots and pores throughout; pH 4.5; abrupt wavy boundary.

Bw 4 to 25 cm; Yellowish brown (10YR 5/4) shaly loam; moderate fine and medium subangular blocky structure; friable; common patchy yellowish brown (10YR 5/6) clay films on ped faces and coating most fragments in the lower part; common medium and fine roots and pores throughout; pH 4.5; gradual inclined boundary.

Cr1 25 to 200 cm; Variegated light gray (5BG 7/1), yellowish red (5YR 5/6), and yellowish brown (10YR 5/6) oxidized and leached saprolite from claystone and siltstone; extremely firm; common discontinuous yellowish red (5YR 5/6) iron-clay films on fragment faces; and discontinuous yellowish brown (10YR 5/6) clay films on fragment faces; few root mats in upper part; pH 4.7; clear inclined boundary.

Cr2 200 to 300 cm; Variegated light gray (5BG 7/1), reddish yellow (7.5YR 6/6), and red (2.5YR 4/6) oxidized and leached saprolite from claystone and siltstone; extremely firm; common distinct reddish yellow (7.5YR 5/6) and red (2.5YR 4/6) iron-clay coatings on fragment faces; pH 5.0.

ULTIC PORTION

Oi 2 to 0 cm; leaf litter.

A 0 to 4 cm; Very dark grayish brown (10YR 3/2) shaly clay loam; moderate medium granular structure; friable; many fine roots and pores throughout; pH 4.5; abrupt wavy boundary.

E 4 to 12 cm; Yellowish brown (10YR 5/4) shaly clay loam; moderate fine and medium subangular blocky structure; friable; common fine and medium roots and pores throughout; pH 4.5; clear wavy boundary.

Bt1 12 to 25 cm; Yellowish brown (10YR 5/6) shaly clay loam; moderate medium subangular blocky structure; firm; discontinuous brown (10YR 5/3) skeletons on some ped faces; common fine and medium roots between peds; common pores; pH 4.6; clear wavy boundary.

Bt2 25 to 33 cm; Yellowish brown (10YR 5/6) very shaly clay loam; moderate medium subangular blocky structure; firm; discontinuous yellowish brown (10YR 5/4) clay films on ped faces and coating most fragments; common fine pores; pH 4.7; clear irregular boundary.

Cr1 33 to 200 cm; Variegated light gray (5BG 7/1), yellowish red (5YR 5/6), and yellowish brown (10YR 5/6) oxidized and leached saprolite from claystone and siltstone; extremely firm; common discontinuous yellowish red (5YR 5/6) iron-clay films on fragment faces; and discontinuous yellowish brown (10YR 5/6) clay films on fragment

faces; few root mats in upper part; pH 4.7; clear inclined boundary.

Cr2 200 to 300 cm; Variegated light gray (5BG 7/1), reddish yellow (7.5YR 6/6), and red (2.5YR 4/6) oxidized and leached saprolite from claystone and siltstone; extremely firm; common distinct reddish yellow (7.5YR 6/6) and red (2.5YR 4/6) iron-clay coatings on fragment faces; pH 5.0. (A glauconitic zone had a 1:1 water pH of 4.3)

Soil No: 24-E (Very severely eroded soil formed on the Cambrian aged Pumpkin Valley Shale)

Location: LLWDDD Site. E29250N30815Y-12 grid

Series Classification: Ruptic Ultic Dystrochrepts; loamy-skeletal, mixed, thermic.

Pedon Classification: Typic Udorthents; loamy-skeletal, shallow, mixed, thermic.

Geomorphic Position: Convex sideslope and summits of low hills.

Slope: 13% with southeast aspect.

Parent material: Saprolite from claystone, siltstone and thin to thick strata of glauconitic very fine grained sandstone of middle member.

Described by: Lambert May 21, 1987

Ap 0 to 15 cm; Dark brown (10YR 4/3) shaly loam; moderate fine and medium granular structure; friable; common fine and medium roots and pores throughout; pH 4.9; clear smooth boundary.

Cr1 15 to 58 cm; Variegated strata of dark reddish brown (5YR 4/2), yellowish brown (10YR 6/8) and red (2.5YR 4/6) oxidized and leached saprolite from siltstone, claystone and glauconitic very fine grained sandstone; extremely firm; common discontinuous dark brown (10YR 4/3) iron oxyhydroxide stains on fragments; few red (2.5YR 4/6) iron coatings on other fragments; few root mats in upper part that extend downward along dip planes; pH 5.1; gradual inclined boundary.

Cr2 58 to 200 cm; Variegated strata of dark reddish gray (5YR 4/2), light gray (5BG 7/1) and brown (10YR 5/3) oxidized and leached saprolite from siltstone, claystone and glauconitic very fine grained sandstone; extremely firm; common discontinuous dusky red (10R 3/4) iron stains on fragment faces, and black manganese oxide coatings on other fragment faces; pH 4.9.

Soil No: 24-N (Slightly eroded soil formed on the Cambrian aged Pumpkin Valley Shale)

Location: LLWDDD Site. E32275N30840Y-12 grid

Series Classification: Ruptic Ultic Dystrochrepts; clayey, mixed, thermic.

Geomorphic Position: Convex sideslopes and summits of low hills.

Slope: 10% with southeast aspect.

Parent material: Saprolite from claystone, siltstone and thin to thick strata of glauconitic very fine grained sandstone of middle member.

Described by: Lietzke and Lambert April3, 1987

Oi 2 to 0 cm; leaf litter

A 0 to 8 cm; Dark grayish brown (10YR 4/2) shaly loam; moderate fine granular structure; friable; common to many fine and medium roots and pores throughout; pH 4.5; clear smooth boundary.

E 8 to 25 cm; Light yellowish brown (10YR 6/4) shaly loam; weak fine and medium subangular blocky structure; friable; common fine roots throughout; many pores; pH 4.5; gradual wavy boundary (gradual boundary includes a thin strong brown (7.5YR 4/4) Bt1 horizon).

Bw 25 to 55 cm; Yellowish red (5YR 4/6) very shaly clay loam; weak fine and medium subangular blocky structure; firm; nearly continuous red (2.5YR 4/8) clay films on fragment faces and on some ped faces; Few patchy red (10R 4/8) iron oxide-clay coatings on some fragment faces; few to common fine roots; common to many pores; pH 4.7; clear inclined boundary.

[RUPTIC PORTION OF PEDON]

Bt 25 to 66 cm; Yellowish red (5YR 4/6) shaly clay; moderate medium subangular blocky structure; firm; continuous reddish brown (5YR 4/4) clay films on ped faces; few to common fine roots between peds; many pores; pH 4.5; clear inclined boundary.

[ULTIC PORTION OF PEDON]

B/Cr1 66 to 118 cm; Weak red (2.5YR 4/2) extremely shaly clay; weak medium subangular blocky structure (B part) and massive (Cr part); very firm; nearly continuous reddish brown (5YR 4/4) clay films on fragment faces; few fine roots; many pores; Ph 4.7; abrupt irregular inclined boundary.

Cr2 118 to 200 cm; Highly variegated weak red (2.5YR 4/2) red (2.5YR 5/6) oxidized and leached saprolite from siltstone, claystone and glauconitic very fine grained sandstone; extremely firm; nearly continuous reddish brown (5YR 4/4) clay coatings on fragment faces; patchy red (10R 4/8) iron oxide coatings on some fragment faces; very few fine roots in cracks; pH 4.8.

Soil No: 951 (Old Alluvial soil over hard Rogersville saprolite)

Location: LLWDDD Site. E28360N30175Y-12 grid

Series Classification: Typic Hapludults; fine-silty, siliceous, thermic.

Geomorphic Position: slightly dissected terraces with some convexity

Slope: 5% with west aspect.

Parent material: Pleistocene alluvium derived from mostly local sources.

Described by: Lambert June 15, 1987

Oi 2 to 0 cm; Leaf litter

C 0 to 20 cm; Dark brown (10YR 4/3) silt loam; massive; very friable; many fine roots and pores; clear broken boundary (This soil material, from clearing and bulldozing was pushed off of the telephone cable right of way where this pit was located)

A 20 to 28 cm; Very dark grayish brown (10YR 3/2) silt loam; weak fine granular blocky structure; very friable; common fine roots throughout; many pores; pH 4.3; clear smooth boundary.

E1 28 to 37 cm; Brown (10YR 5/3) silt loam; weak fine subangular blocky structure; very friable; few fine roots throughout; many pores; pH 4.0; clear smooth boundary.

E2 37 to 48 cm; Light yellowish brown (10YR 6/4) silt loam; weak fine subangular blocky structure; very friable; very few fine roots throughout; many pores; pH 4.1; gradual wavy boundary.

Bt 48 to 76 cm; Brownish yellow (10YR 6/6) and light yellowish brown (10YR 6/4) clay loam; strong medium subangular blocky structure; friable; thin discontinuous light yellowish brown (10YR 6/4) clay films on ped faces; few patchy black manganese oxide stains on some ped faces; common to many 1-2 mm iron-manganese nodules; few to common roots between peds; common to many pores; pH 4.4; clear wavy boundary.

2E/B 76 to 101 cm; Light yellowish brown (2.5Y 6/4) silt loam (E part) and mottled yellowish red (5YR 5/6) and brownish yellow (10YR 6/8)

loam; moderate medium and coarse subangular blocky structure; very friable; thin patchy yellowish brown (10YR 5/6) clay films on some peds (B part) and brownish yellow (10YR 6/8) skeletons on some peds (E part); few fine roots between peds; many pores; pH 4.4; clear wavy boundary.

2Btg 101 to 121 cm; highly mottled light gray (5Y 7/2), yellowish brown (10YR 5/6) and light red (2.5YR 6/6) loam; weak to moderate medium prismatic structure parting to moderate medium and coarse subangular blocky structure; friable; continuous yellowish brown (10YR 5/6) clay films on prism faces; few patchy manganese oxide coatings on some peds in prism interiors; light greenish gray (5G 6/1) reduced zones in root channels; few fine roots between prisms; pH 4.8; abrupt wavy boundary.

3Cr 121 to 200 cm; Olive brown (2.5Y 4/4), strong brown (7.5YR 5/6) extremely shaly loam Rogersville saprolite; many discontinuous manganese oxide stains on fragment faces; some strong brown (7.5YR 5/6) iron oxyhydroxides on other fragment faces and few dusky red (2.5YR 3/2) iron oxide stains on other fragment faces; light greenish gray (5G 6/1) reduced zones around fine root mats along joint planes; pH 6.3.

Soil No: 26/951 (Pumpkin Valley colluvium over old alluvium over Pumpkin Valley residual soil and saprolite)

Location: LLWDDD Site. E27875N30780Y-12 grid

Series Classification: Typic Hapludults; fine-loamy, mixed, hermic.

Geomorphic Position: low terrace covered toeslope with some convexity

Slope: 10% with west aspect.

Parent material: Pumpkin Valley colluvium over Pleistocene Alluvium derived from mostly local sources over Pumpkin valley residuum.

Described by: Lambert and Lietzke June 9, 1987

Ap 0 to 21 cm; Dark brown (10YR 4/3) gravelly loam; moderate medium and coarse granular structure; friable; common fine and very fine roots throughout; many pores throughout; pH 4.7; abrupt smooth boundary.

Bt1 21 to 43 cm; Yellowish red (5YR 4/6) and brownish yellow (10YR 6/8) gravelly clay loam; weak fine and medium subangular blocky structure; firm; thin continuous reddish brown (5YR 4/6) clay films on ped faces; few fine roots between peds; many pores; pH 4.9; clear wavy boundary.

[BASE OF YOUNGEST COLLUVIUM]

2Bt2 43 to 55 cm; Yellowish red (5YR 4/6) and reddish brown (5YR 4/4) clay loam; moderate medium subangular blocky structure; firm; thin continuous reddish brown (5YR 4/4) clay films on ped faces; few fine roots between peds; many pores; pH 4.9; clear wavy boundary.

2BC 55 to 74 cm; Yellowish red (5YR 4/6 and yellow (5Y 7/6) gravelly clay loam; weak medium subangular blocky structure; firm; thin discontinuous yellowish red (5YR 4/6) clay films on ped faces; few patchy manganese oxide coatings on some ped faces; few fine roots; many fine pores; pH 4.9; clear wavy boundary.

3Bt 74 to 87 cm; Reddish brown (5YR 4/4) and yellowish red (5YR 4/6) clay loam; moderate medium subangular blocky structure; firm; thin continuous yellowish red (5YR 4/6) clay films on ped faces; few fine roots between peds; many fine pores; pH 4.9; clear wavy boundary.

[BASE OF INTERMEDIATE COLLUVIUM]

4Ab 87 to 95 cm; Mottled light brownish gray (2.5Y 6/2) and yellowish red (5YR 4/6) loam; weak fine and medium subangular blocky structure; firm; thin patchy yellowish red (5YR 4/6) clay films on ped faces, and patchy strong brown (7.5YR 4/4) iron oxyhydroxide stains throughout; few to common fine roots between peds; many fine pores; pH 4.9; clear irregular boundary.

4Bt 95 to 122 cm; brownish yellow (10YR 6/8), yellow (2.5Y 8/8) and light greenish gray (5BG 6/2) gravelly clay loam; weak fine and medium subangular blocky structure; very firm; thin discontinuous dark yellowish brown (10YR 4/4) clay films on ped faces; common patchy strong brown (7.5YR 5/6) iron oxyhydroxide coatings on some ped faces; very few fine roots between peds; many fine pores; pH 4.9; clear wavy boundary.

[BASE OF OLDEST COLLUVIUM]

5Bt1 122 to 146 cm; Dark brown (7.5YR 4/4), yellowish brown (10YR 5/4), and brownish yellow (10YR 6/8) loam; moderate medium subangular blocky structure; very firm; thin discontinuous dark brown (7.5YR 4/4) clay films on ped faces; patchy manganese oxide stains on some ped faces; very few fine roots between peds; common fine pores; pH 4.9; clear wavy boundary.

5Bt2 146 to 202 cm; Dark brown (7.5YR 4/4) and yellowish brown (10YR 5/4) clay loam; weak coarse subangular blocky structure; very firm; thin continuous dark brown (7.5YR 4/4) clay films on ped faces; patchy manganese oxide stains on ped faces; very few fine roots between peds; many fine pores; pH 4.9; clear wavy boundary.

[BASE OF UPPER ALLUVIUM]

6Bw1 202 to 234 cm; light olive brown (2.5Y 5/4) loam; weak medium subangular blocky structure; firm; patchy manganese oxide coatings on some ped faces, and patchy brownish yellow (10YR 6/8) iron oxyhydroxide stains on other ped faces; very few fine roots between peds; pH 4.9; clear wavy boundary.

6Bw2 234 to 270 cm; mottled dark yellowish brown (10YR 4/8), and light olive brown (2.5Y 5/4) loam; weak medium subangular blocky structure; firm; thin discontinuous reddish brown (5YR 4/4) clay films on faces of primary peds; patchy manganese coatings on secondary ped faces; very few fine roots between peds; few to common fine pores; pH 4.9; clear wavy boundary.

[BASE OF OLDER ALLUVIUM]

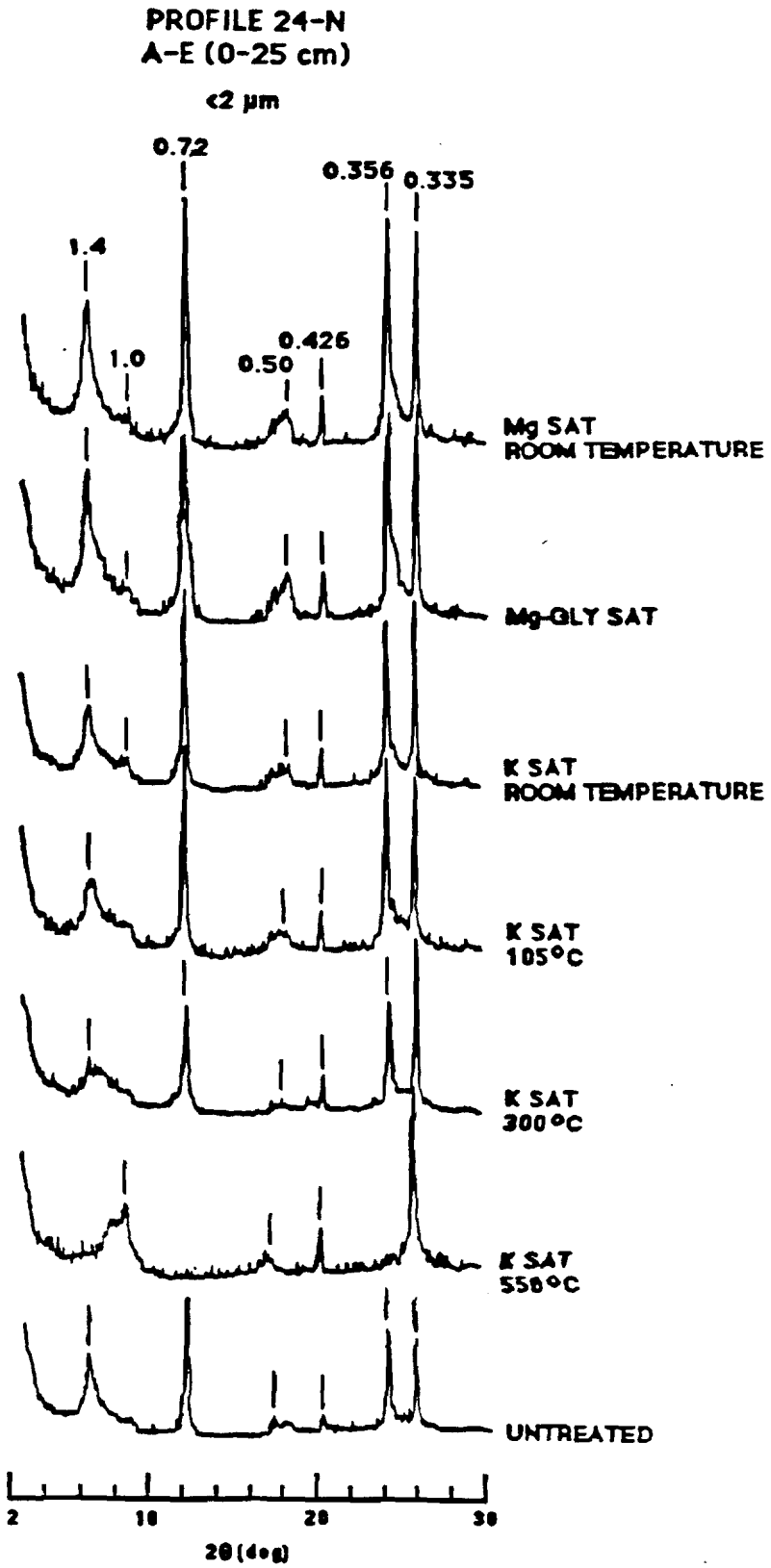
7C 270 to 325 cm; Mottled brownish yellow (10YR 6/8), yellow (2.5Y 7/8) and olive yellow (5Y 6/6) oxidized and leached saprolite from middle member of Pumpkin Valley Formation; contains greenish glauconitic strata; firm; common patchy dark red (10R 3/6) iron stains on joint and fracture faces; few very fine roots along dip planes; pH 5.0; clear inclined boundary.

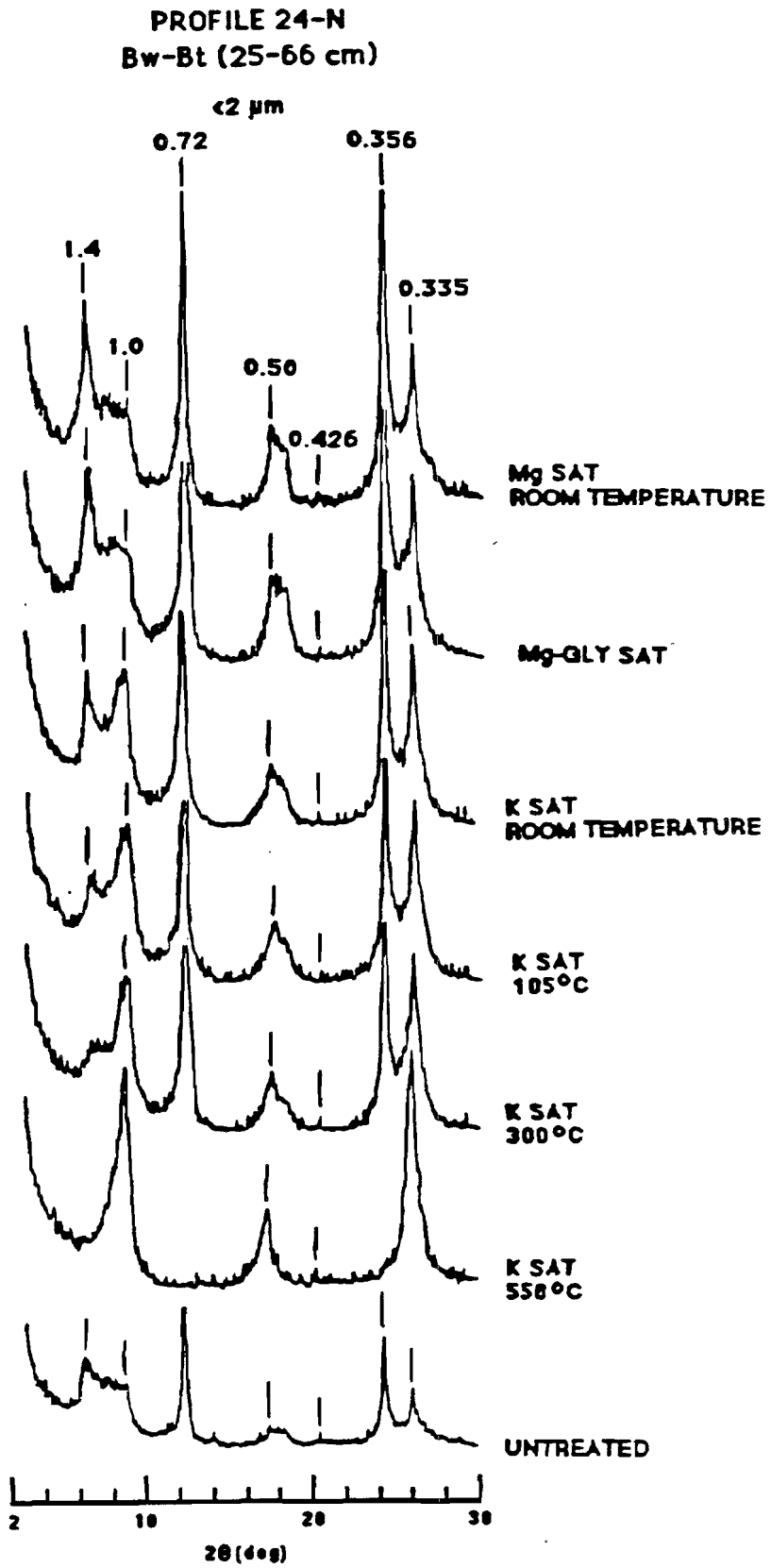
[PUMPKIN VALLEY RESIDUUM]

7Cr 325 to 350 cm; Highly variegated and mottled oxidized and leached saprolite from middle member of Pumpkin Valley; very firm; few root mats in upper part along dip planes; pH 5.1.

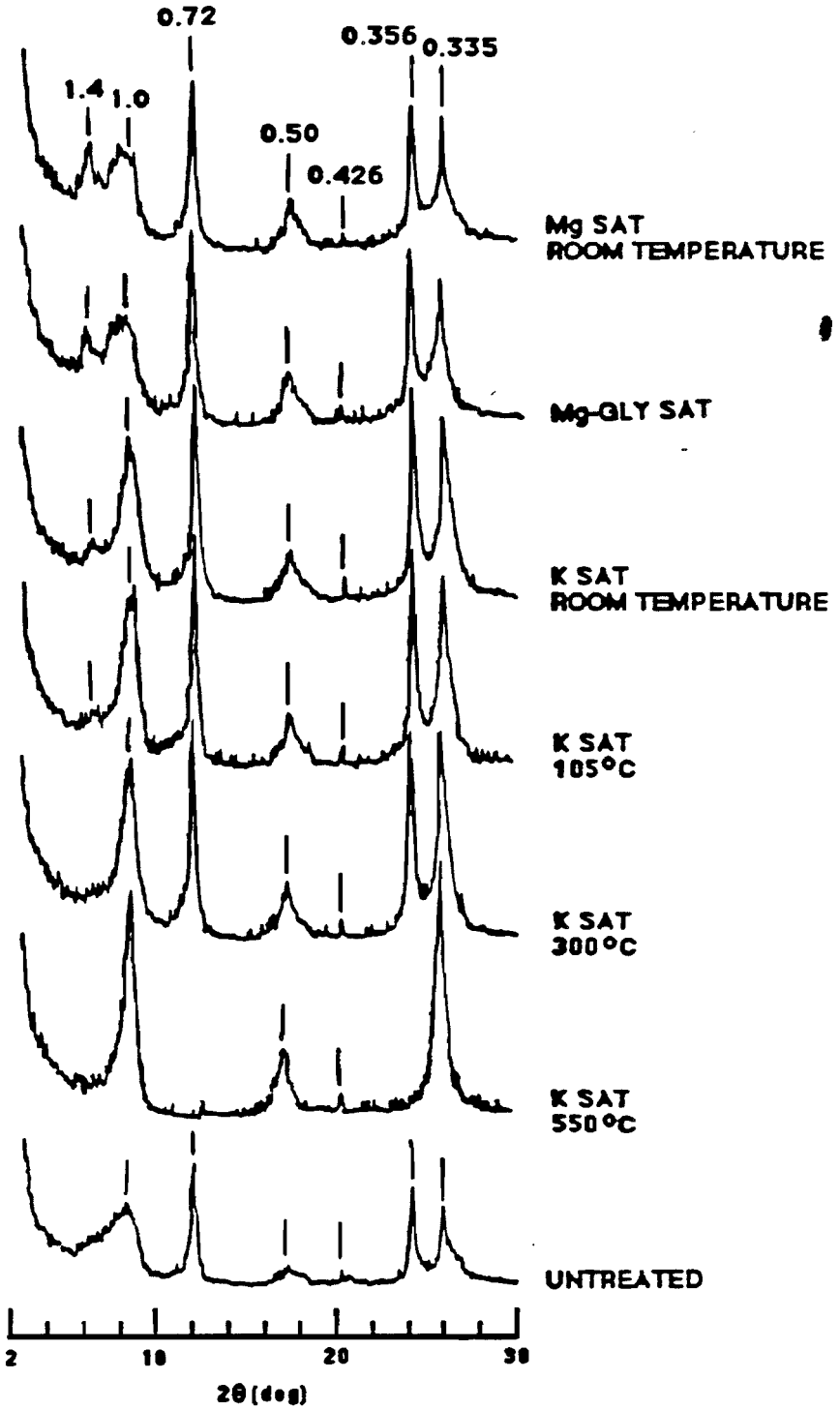
Appendix B

X-RAY DIFFRACTOGRAMS OF CLAY FRACTIONS FROM SELECTED SOIL PROFILES

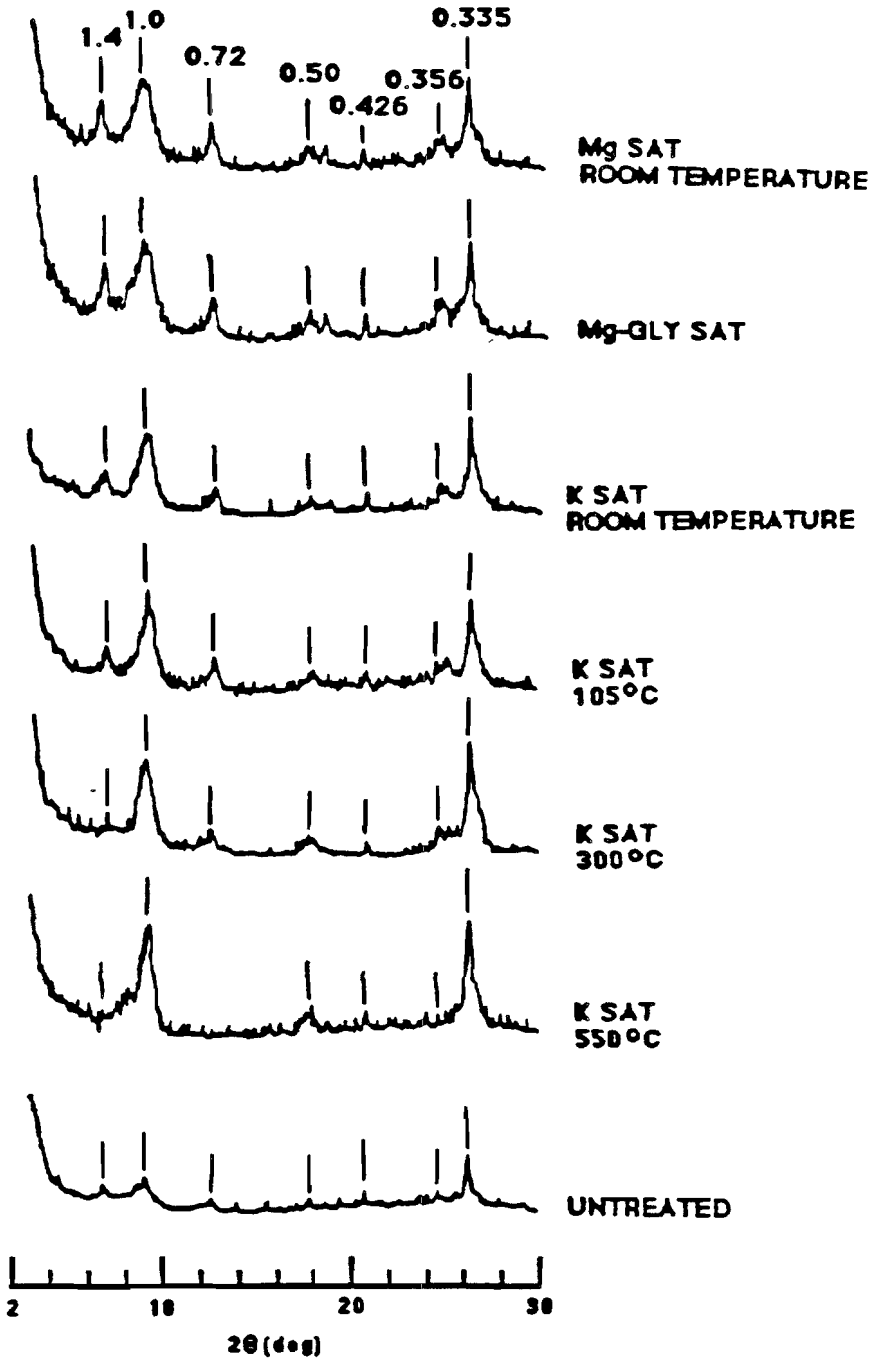

PROFILE 24-N
A-E (0-25 cm)
<2 µm
0.72
0.356
0.335
1.4
1.0
0.50
0.426
Mg SAT
ROOM TEMPERATURE
Mg-GLY SAT
K SAT
ROOM TEMPERATURE
K SAT
105°C
K SAT
300°C
K SAT
550°C
UNTREATED
2
10
20
30
2θ (deg)


PROFILE 24-N
Bw-Bt (25-66 cm)
<2 µm
0.72
0.356
1.4
0.335
1.0
0.50
0.426
Mg SAT
ROOM TEMPERATURE
Mg-GLY SAT
K SAT
ROOM TEMPERATURE
K SAT
105°C
K SAT
300°C
K SAT
550°C
UNTREATED
2
10
20
30
2θ (deg)

PROFILE 24-N
B/Cr (66-118 cm)
<2 µm

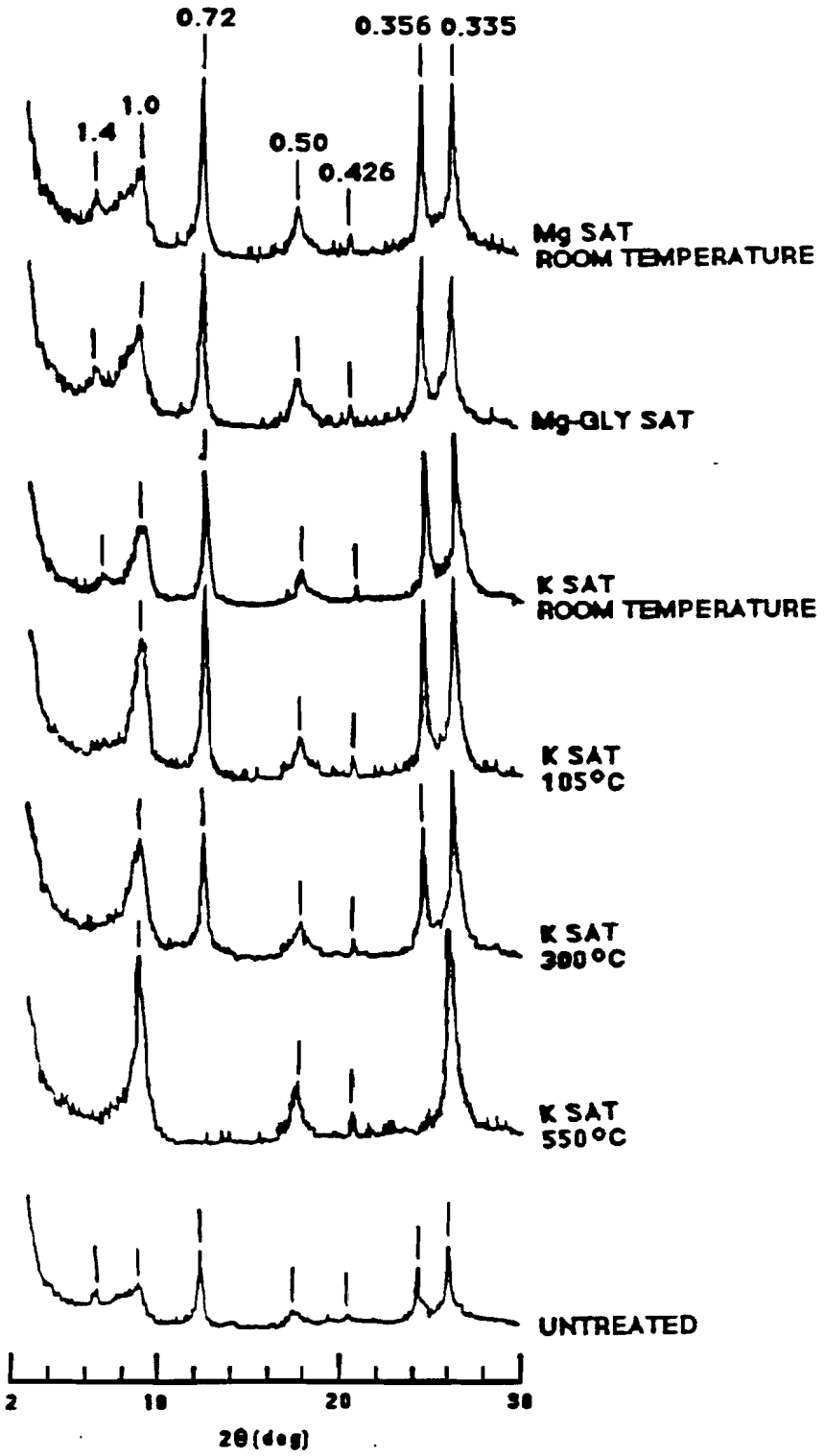


PROFILE 24-N
Cr1 (G) (66-118 cm)
<2 µm



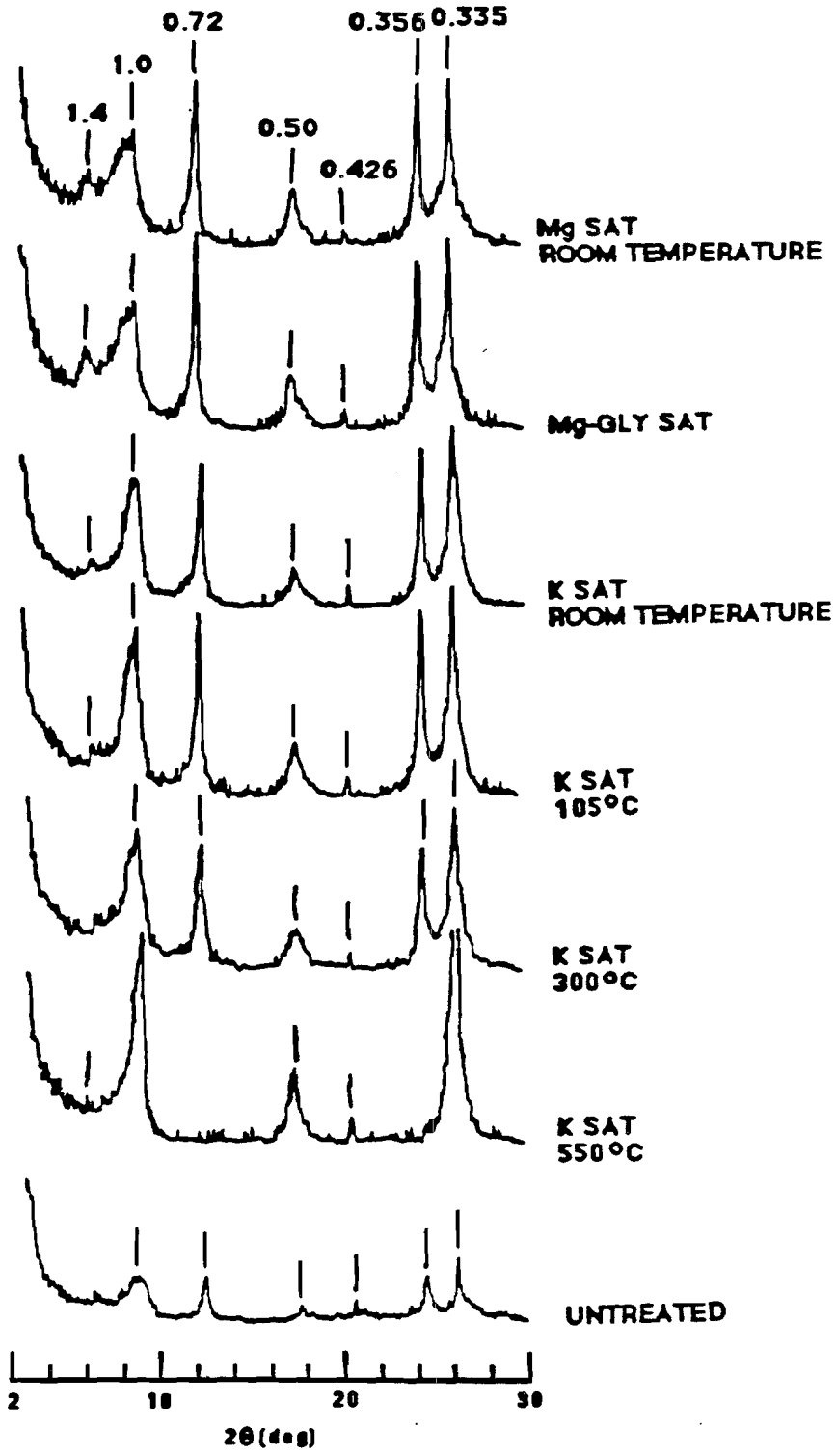
PROFILE 24-E
Ap (0-15 cm)

<2 µm

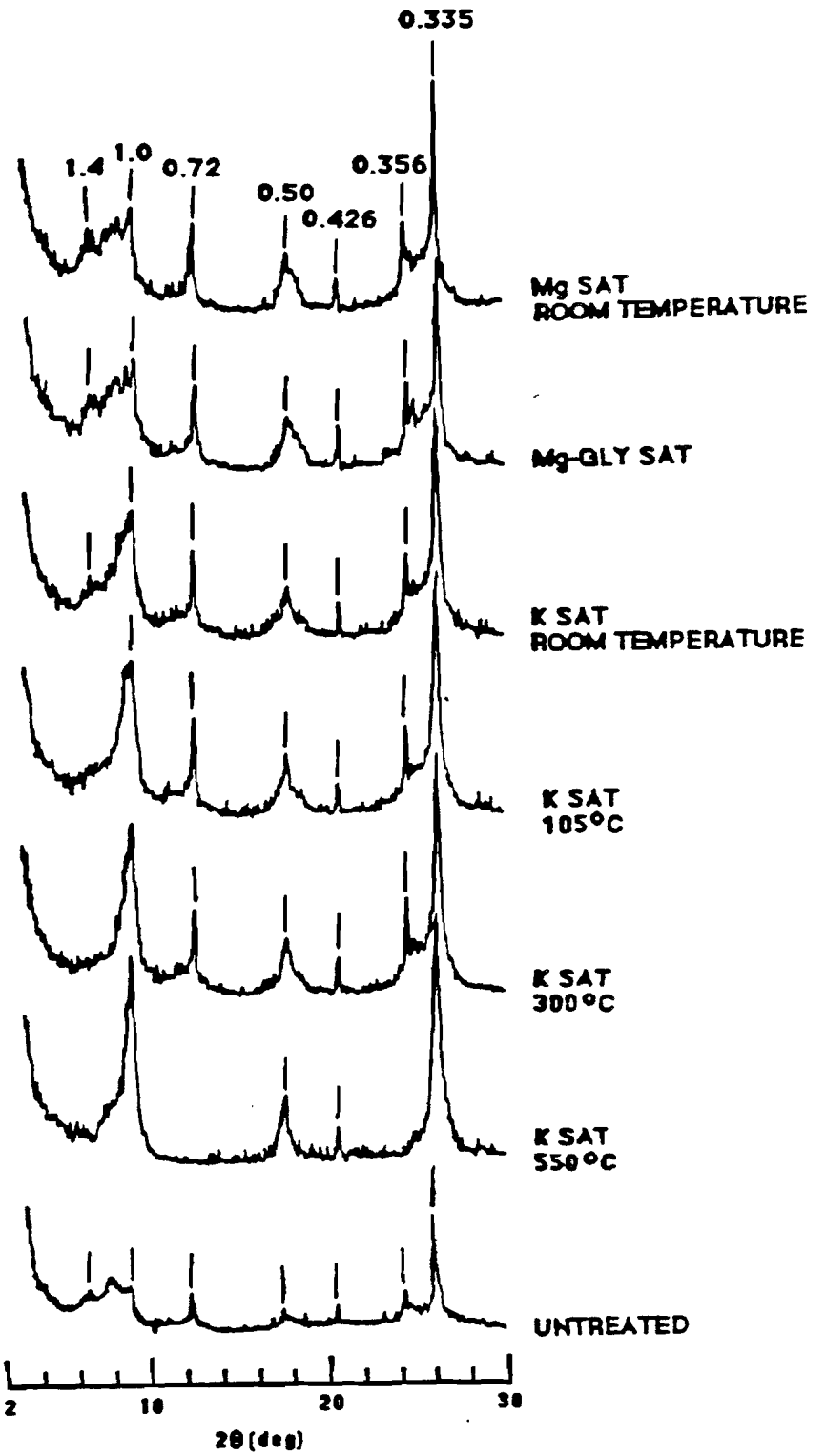


PROFILE 24-E
Cr1 (15-58 cm)

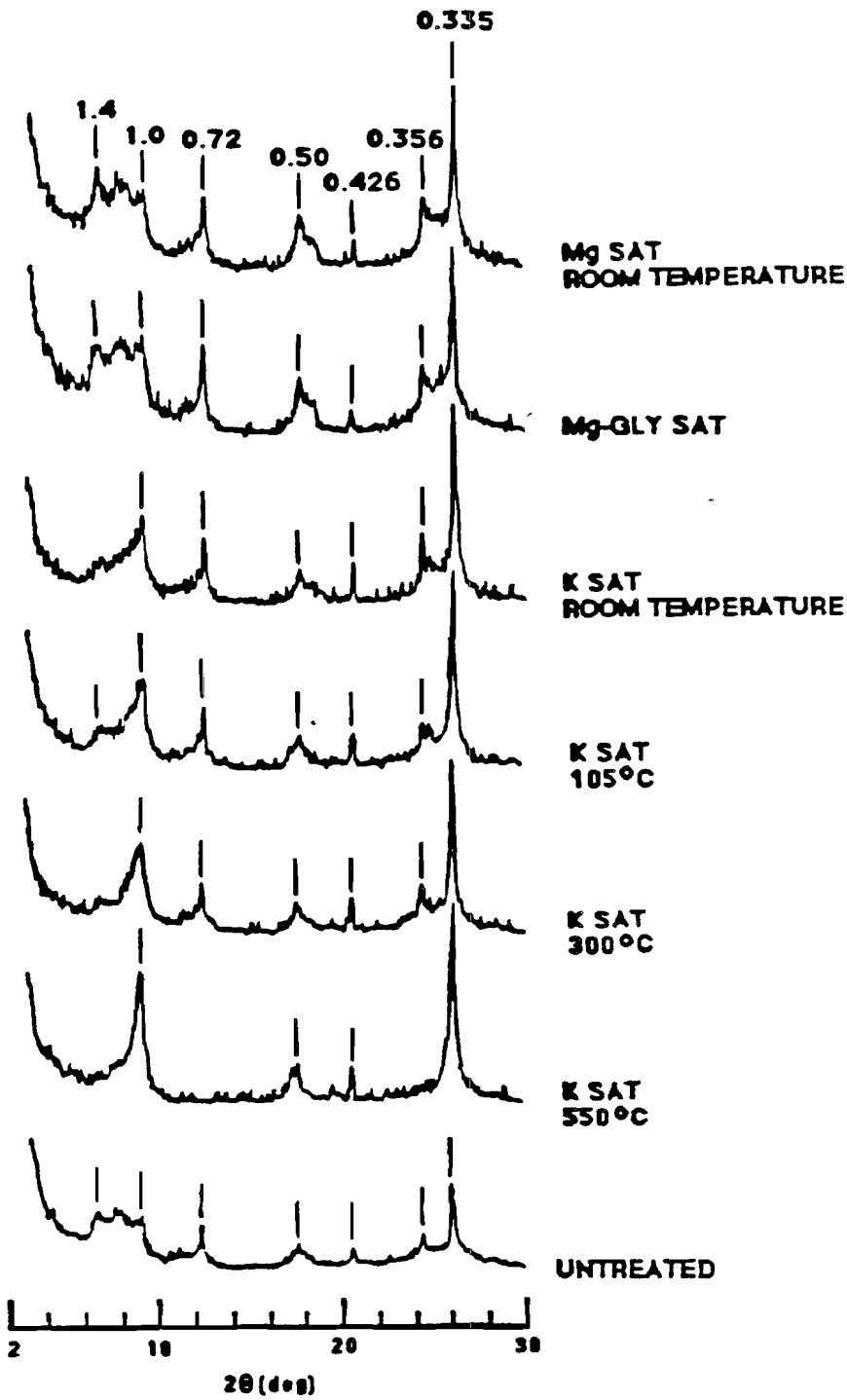
<2 µm



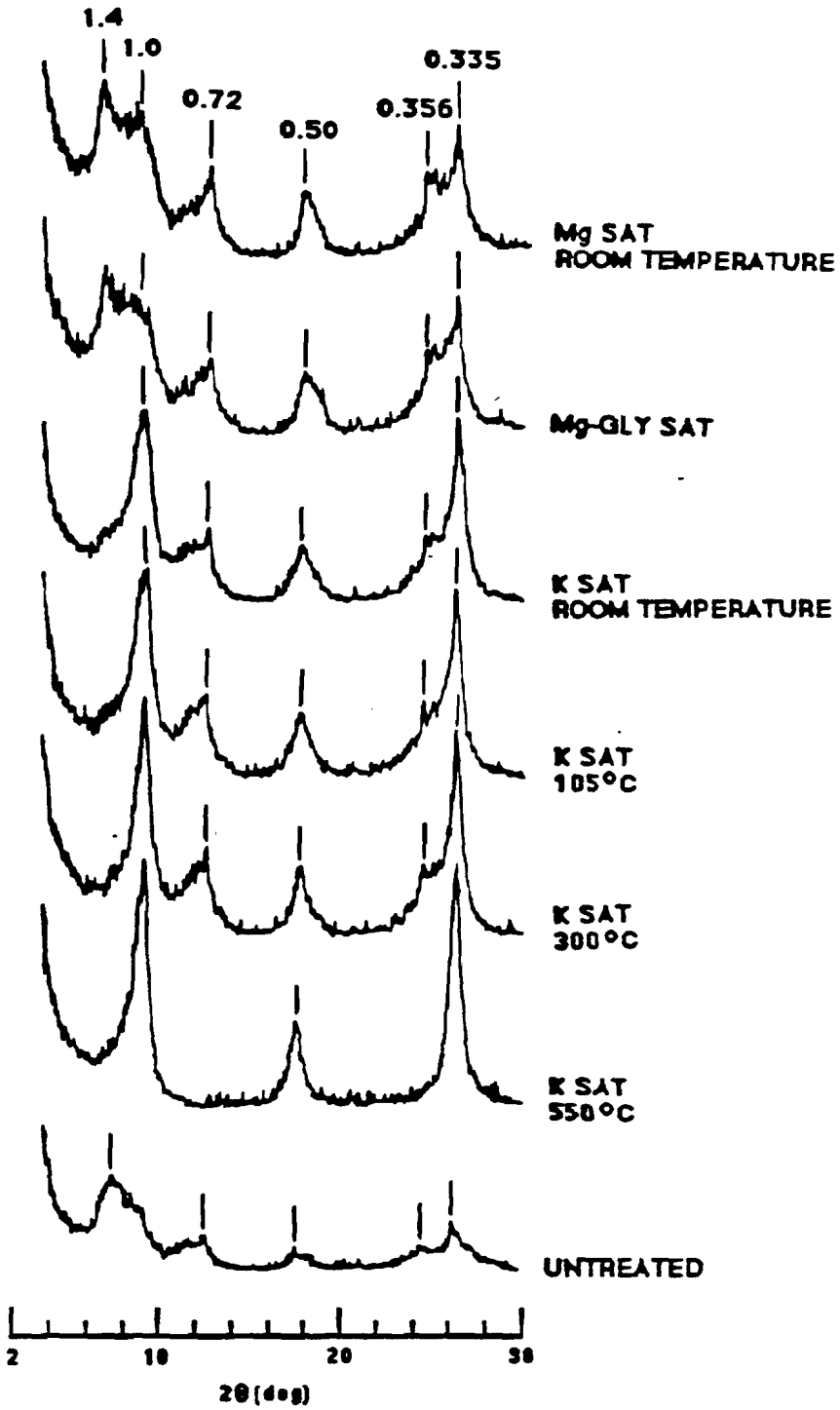
PROFILE 36-N
A (0-9 cm)
<2 µm

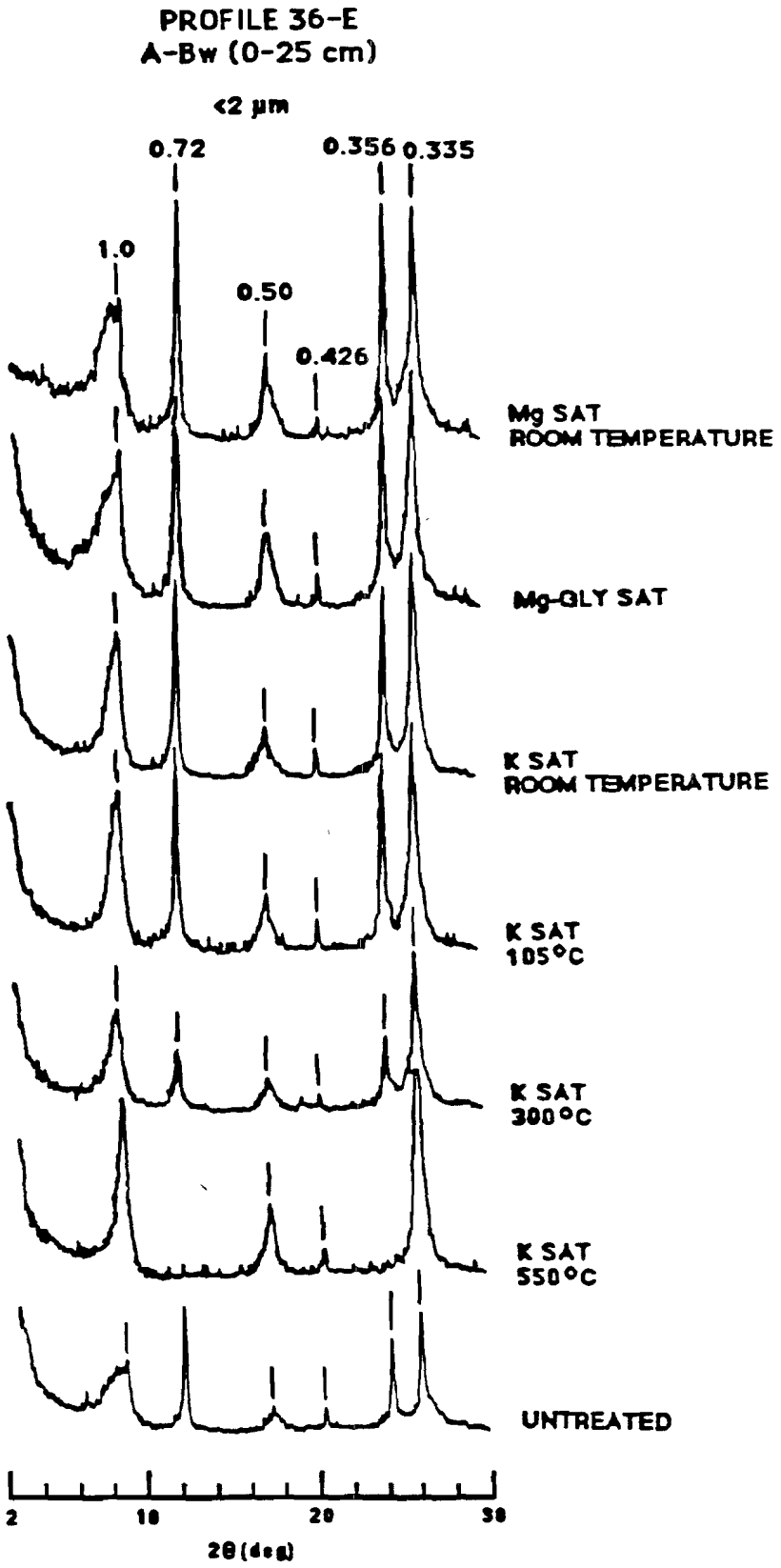


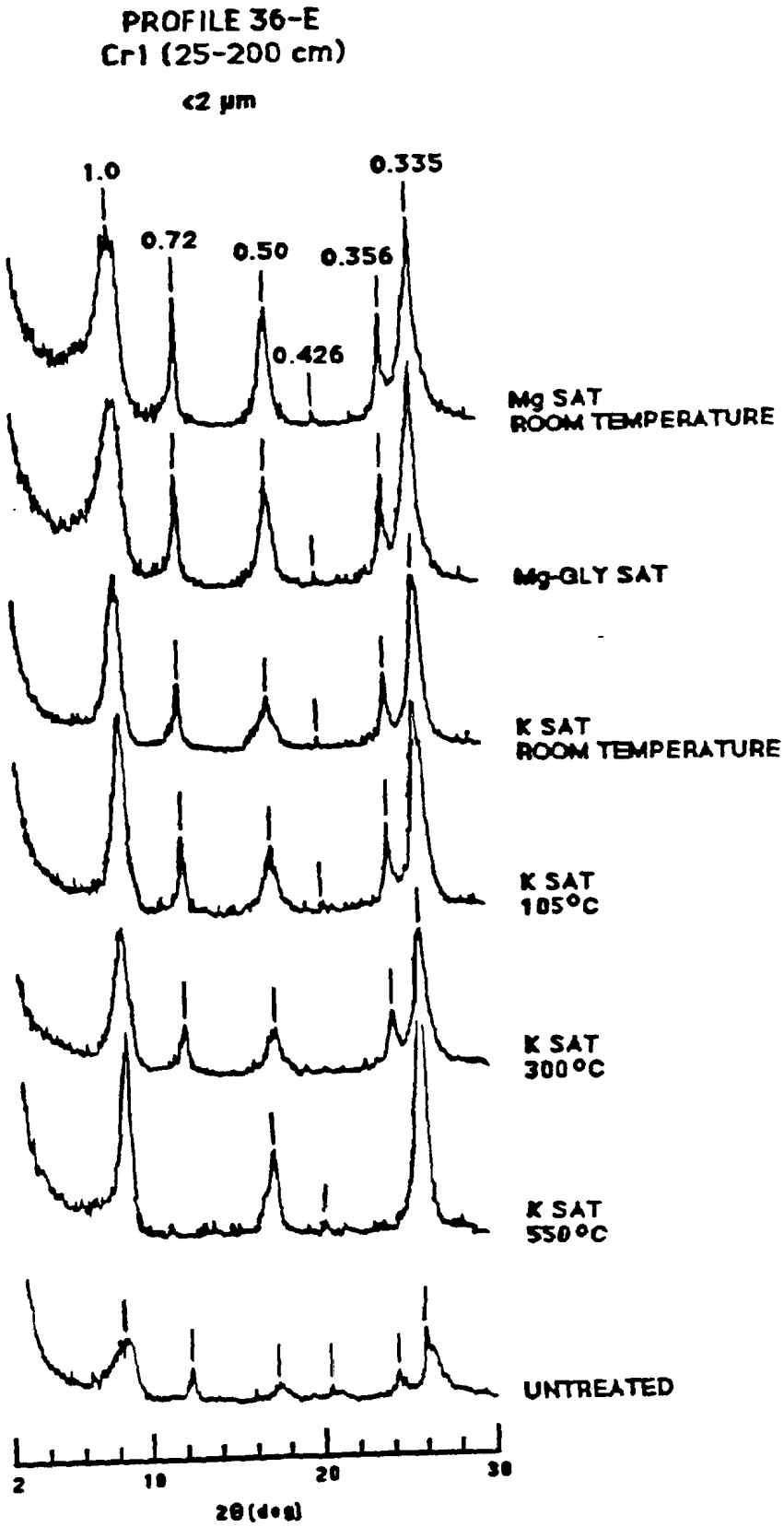
PROFILE 36-N
Bw (9-29 cm)
<2 µm



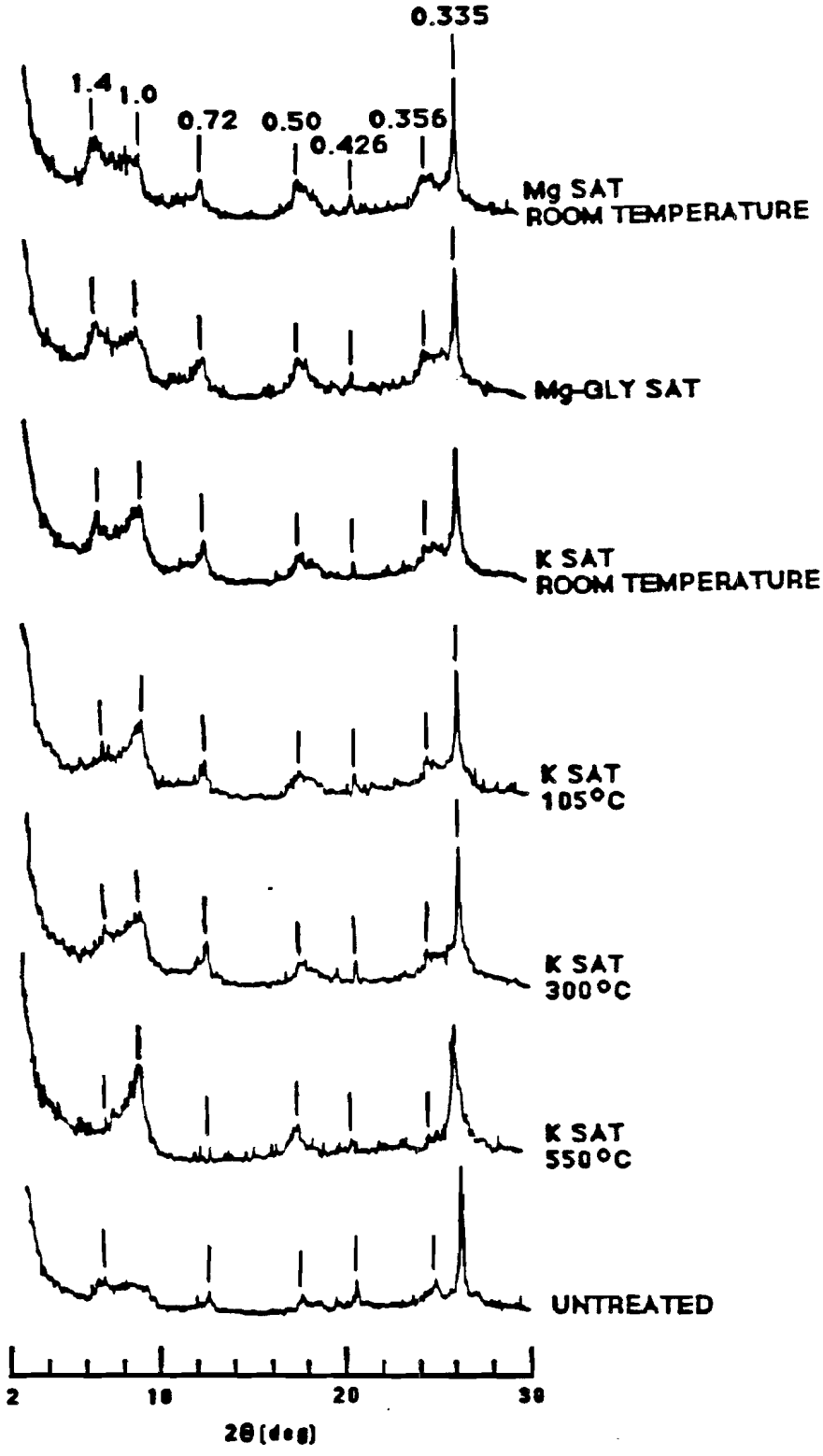
PROFILE 36-N
Cr1 (29-130 cm)
<2 µm

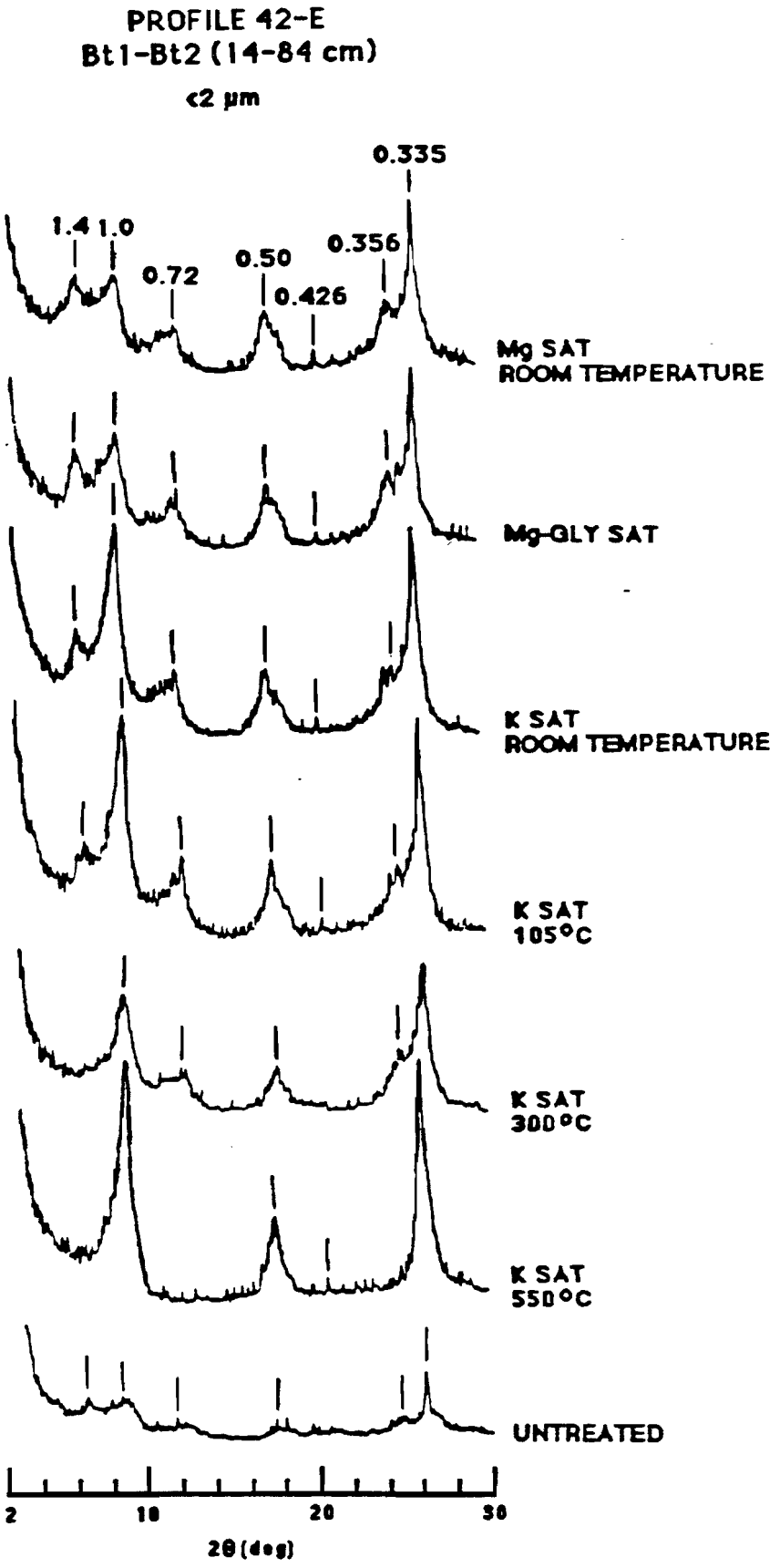



PROFILE 36-E
A-Bw (0-25 cm)
<2 µm
0.72
0.356
0.335
1.0
0.50
0.426
Mg SAT
ROOM TEMPERATURE
Mg-GLY SAT
K SAT
ROOM TEMPERATURE
K SAT
105°C
K SAT
300°C
K SAT
550°C
UNTREATED
2
10
20
30
2θ (deg)

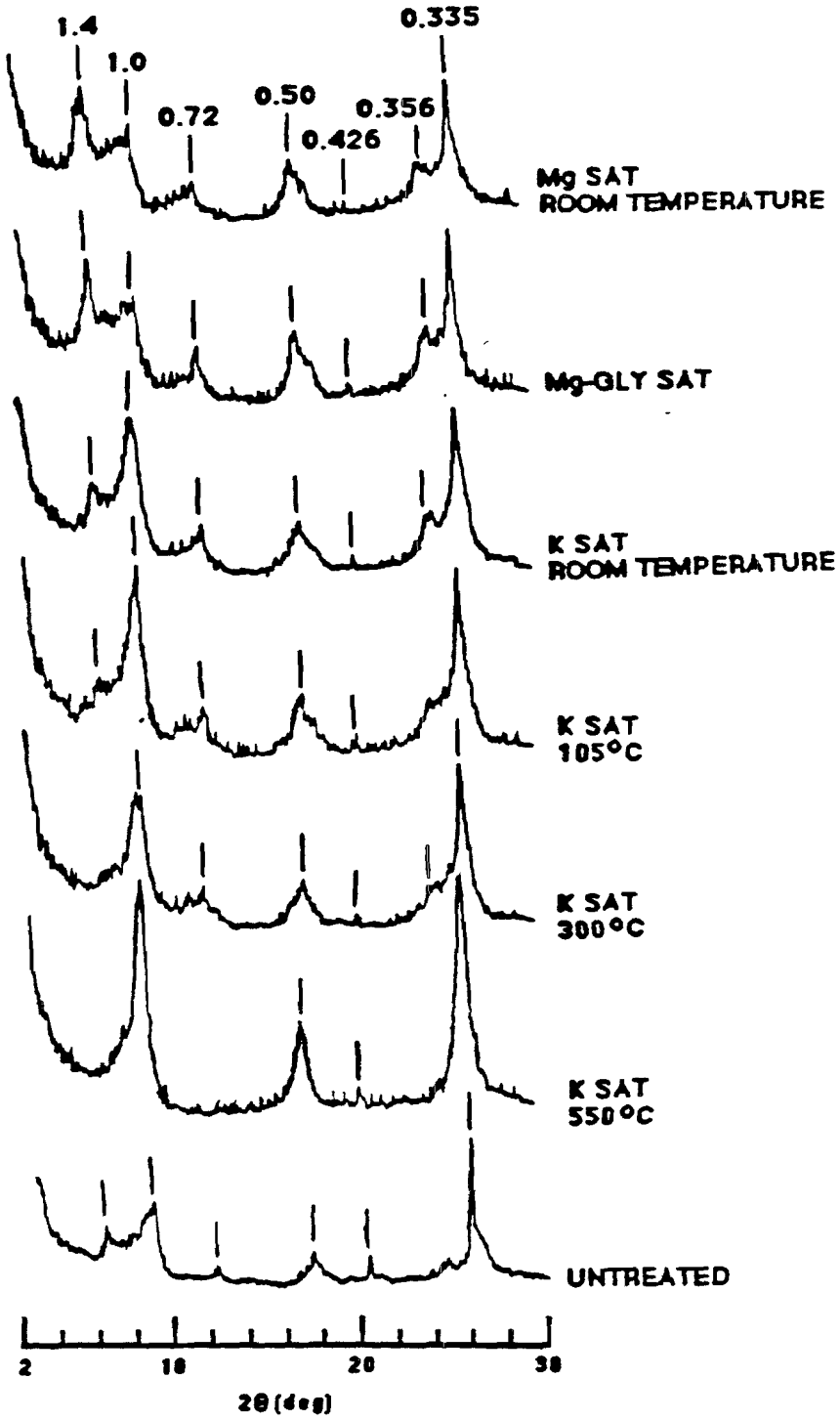

PROFILE 36-E
Cr1 (25-200 cm)
<2 µm
1.0
0.72
0.50
0.426
0.356
0.335
Mg SAT
ROOM TEMPERATURE
Mg-GLY SAT
K SAT
ROOM TEMPERATURE
K SAT
105°C
K SAT
300°C
K SAT
550°C
UNTREATED
2
10
20
30
2θ (deg)

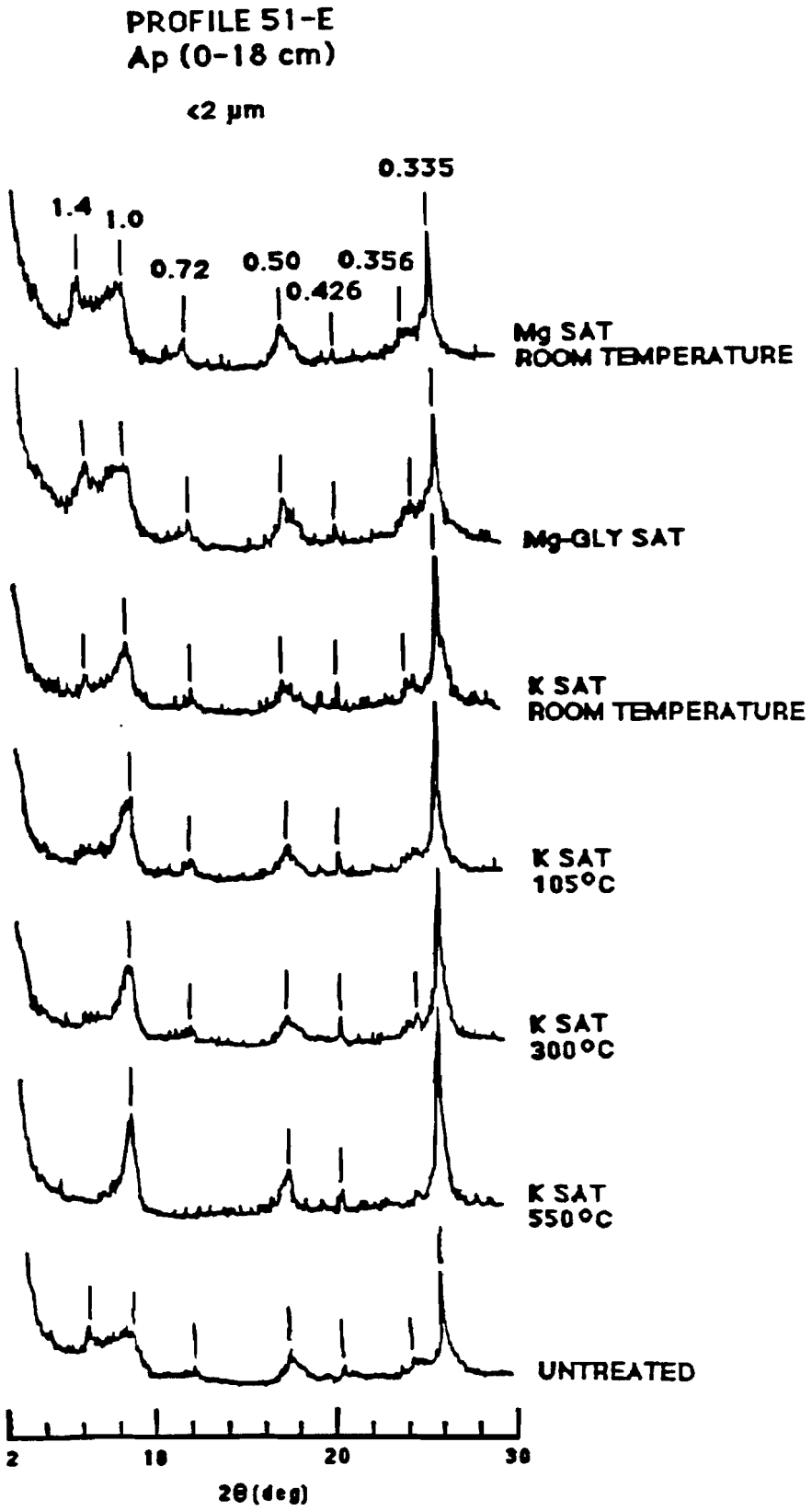
PROFILE 42-E
A-E (0-14 cm)
<2 µm



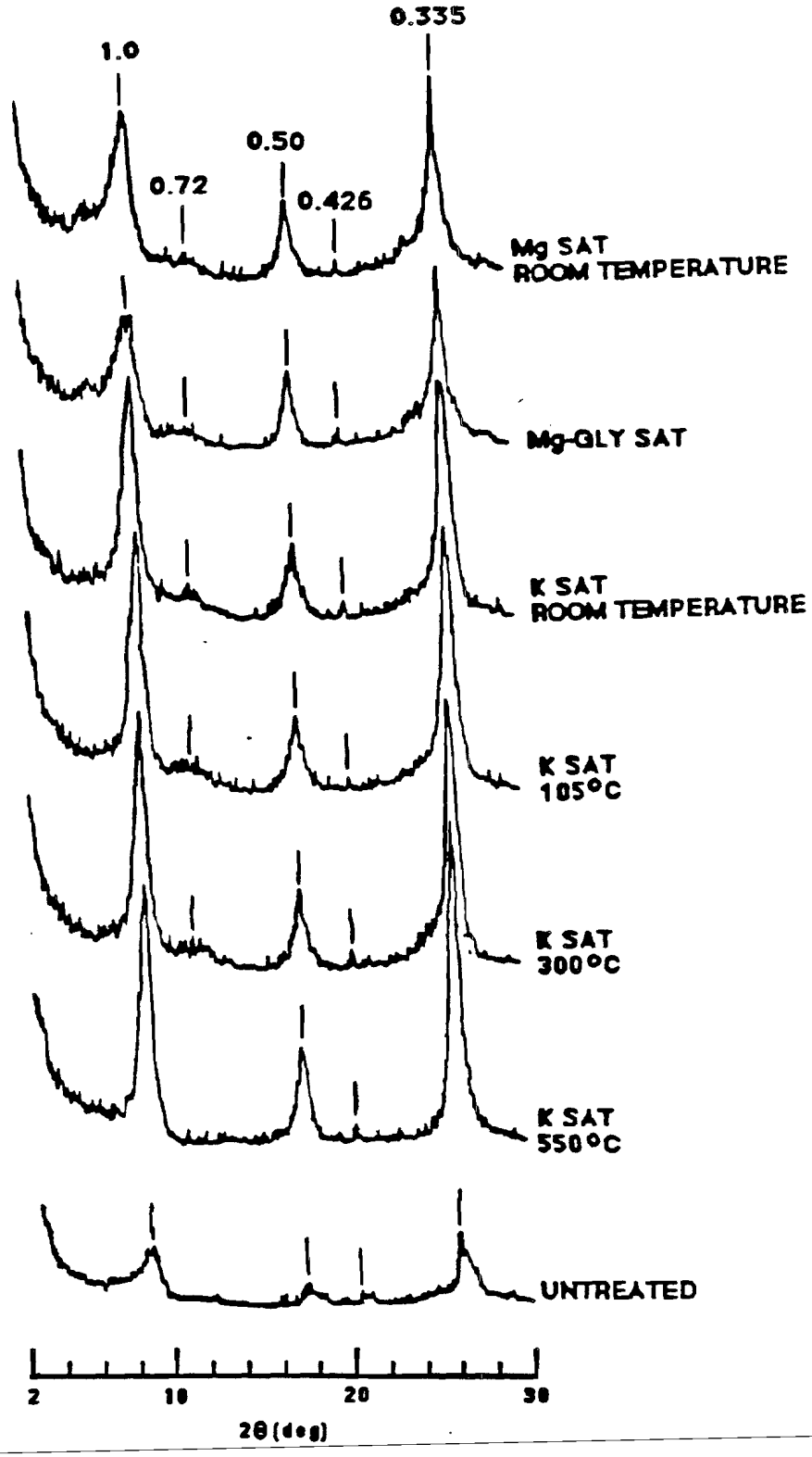

PROFILE 42-E
Bt1-Bt2 (14-84 cm)
<2 µm
0.335
1.4
1.0
0.72
0.50
0.426
0.356
Mg SAT
ROOM TEMPERATURE
Mg-GLY SAT
K SAT
ROOM TEMPERATURE
K SAT
105°C
K SAT
300°C
K SAT
550°C
UNTREATED
2
10
20
30
2θ (deg)

PROFILE 42-E
2Cr2 (149+ cm)
< 2 µm



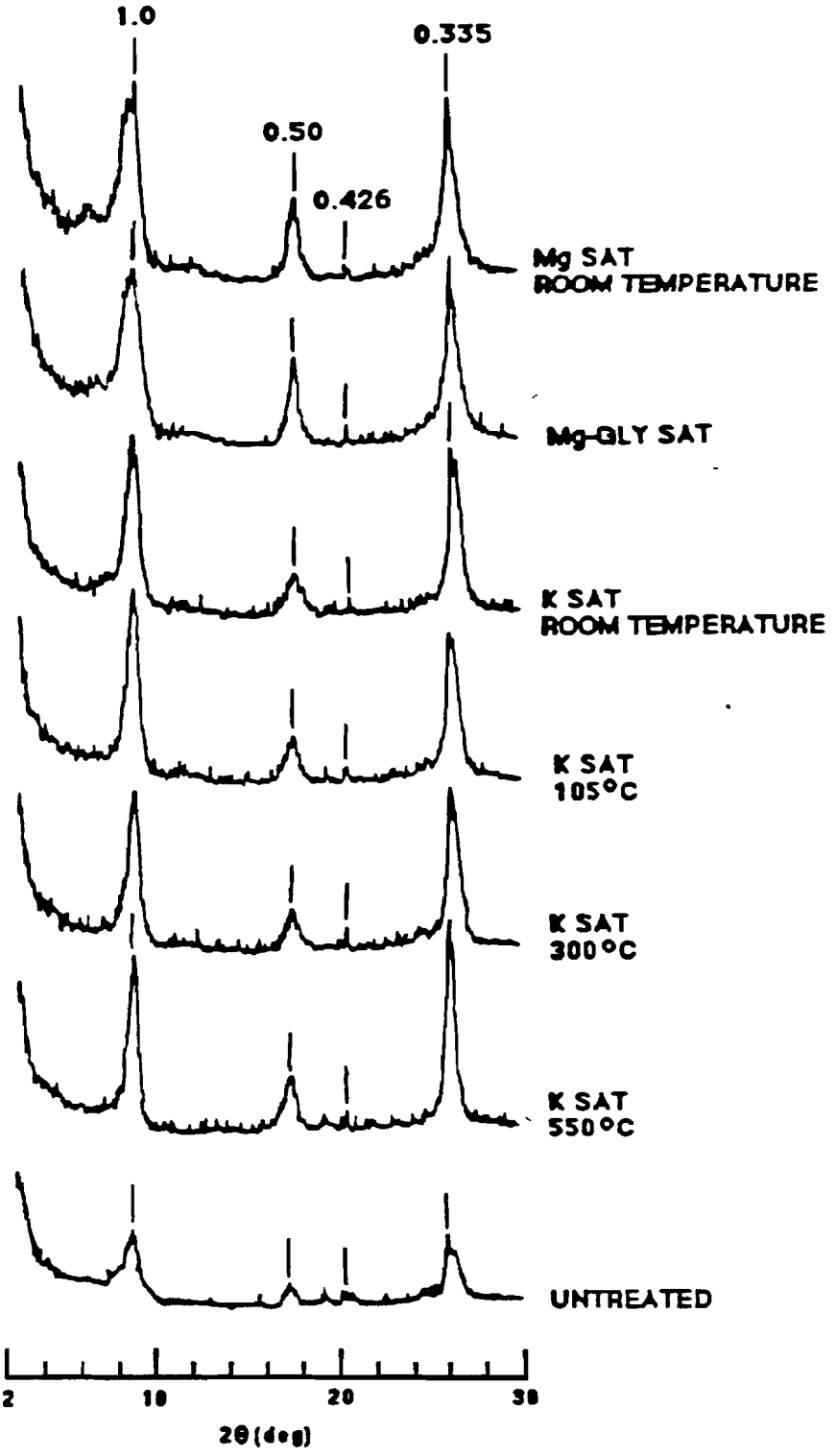

PROFILE 51-E
Ap (0-18 cm)
<2 µm
0.335
1.4
1.0
0.72
0.50
0.356
0.426
Mg SAT
ROOM TEMPERATURE
Mg-GLY SAT
K SAT
ROOM TEMPERATURE
K SAT
105°C
K SAT
300°C
K SAT
550°C
UNTREATED
2
18
20
30
2θ (deg)

PROFILE 51-E
Cr (18-150 cm)
<2 µm



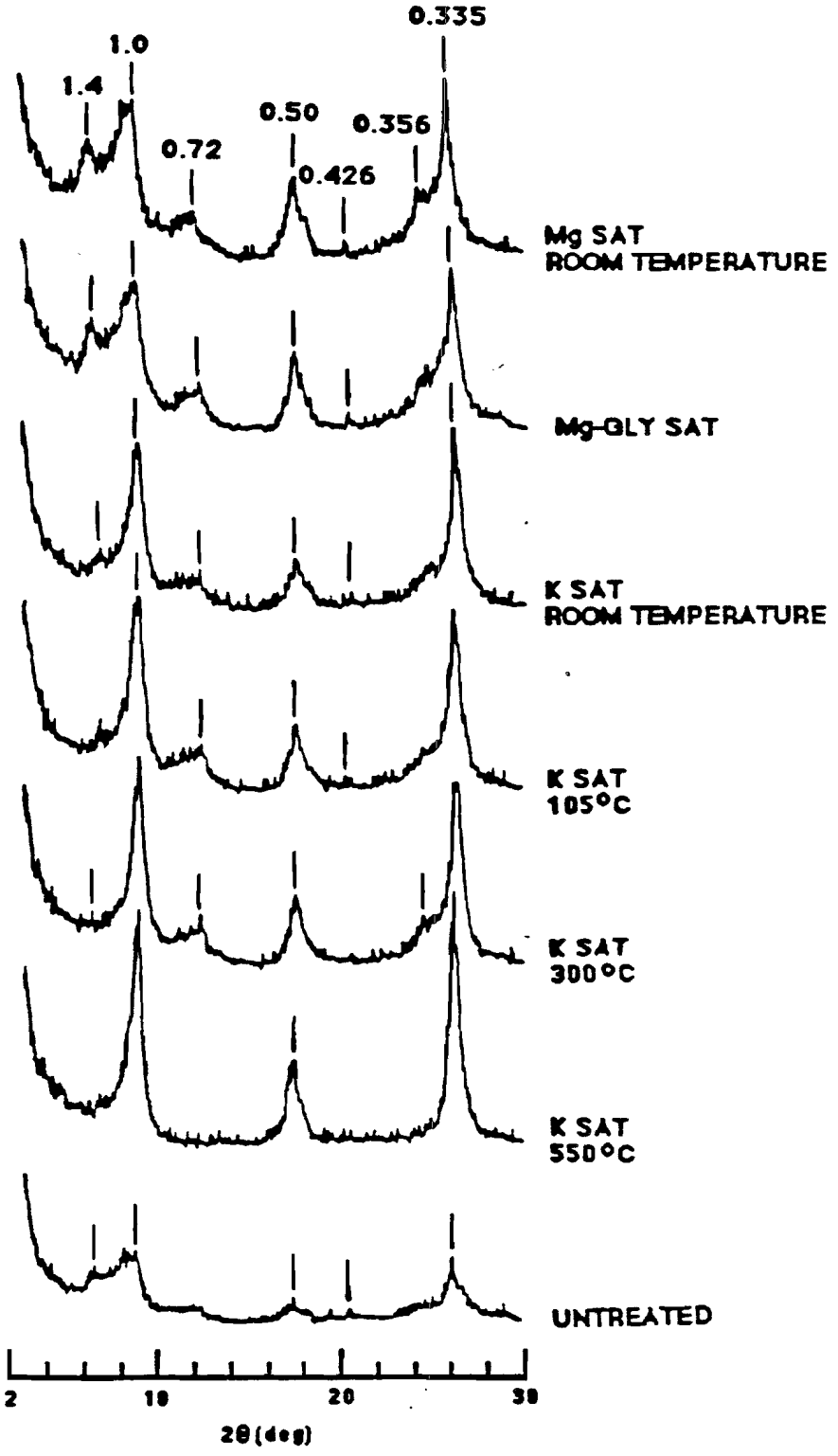
PROFILE 51-E
3Cr (R) (250+ cm)

<2 µm

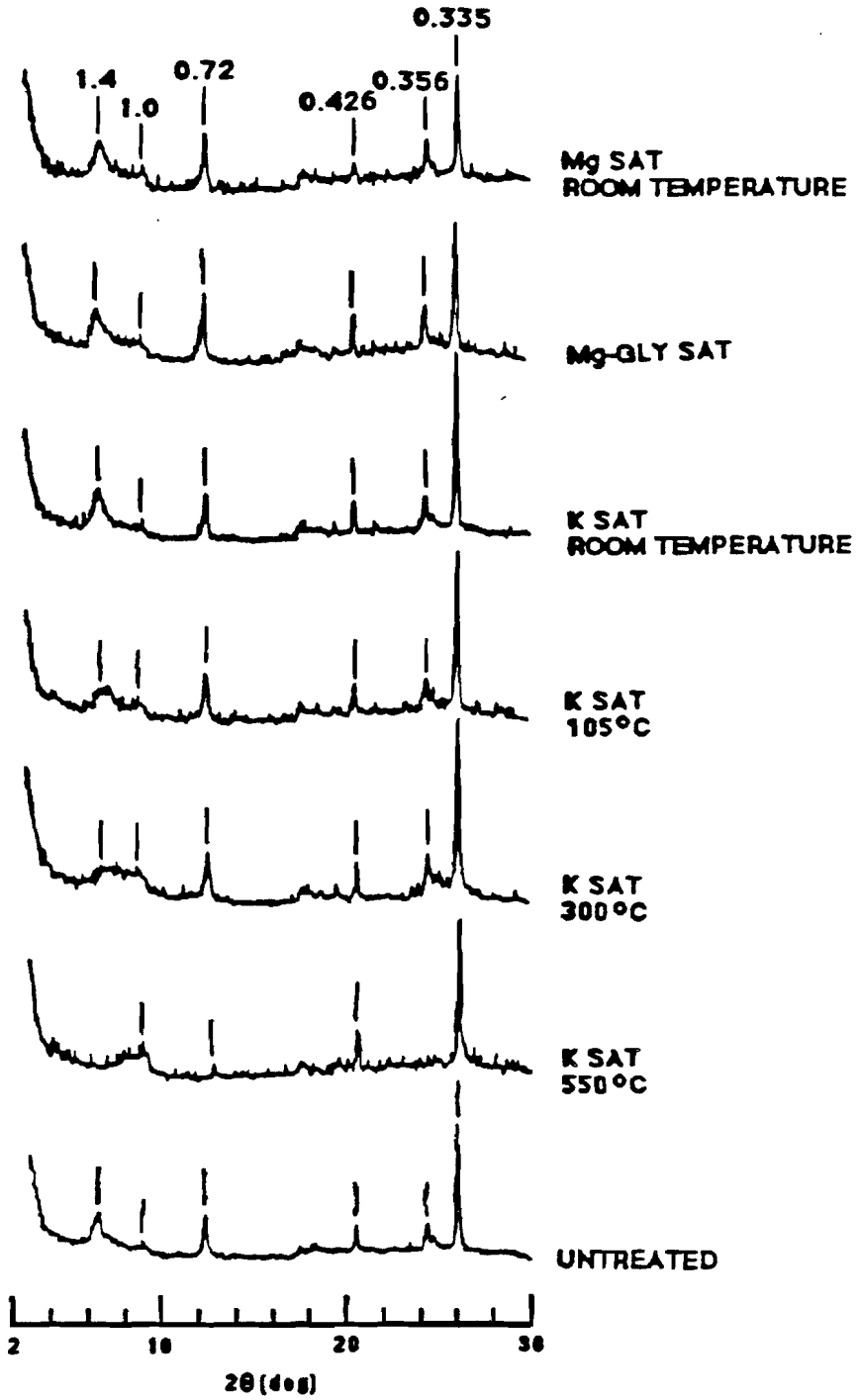


PROFILE 51-E
3Cr (Y) (250+ cm)

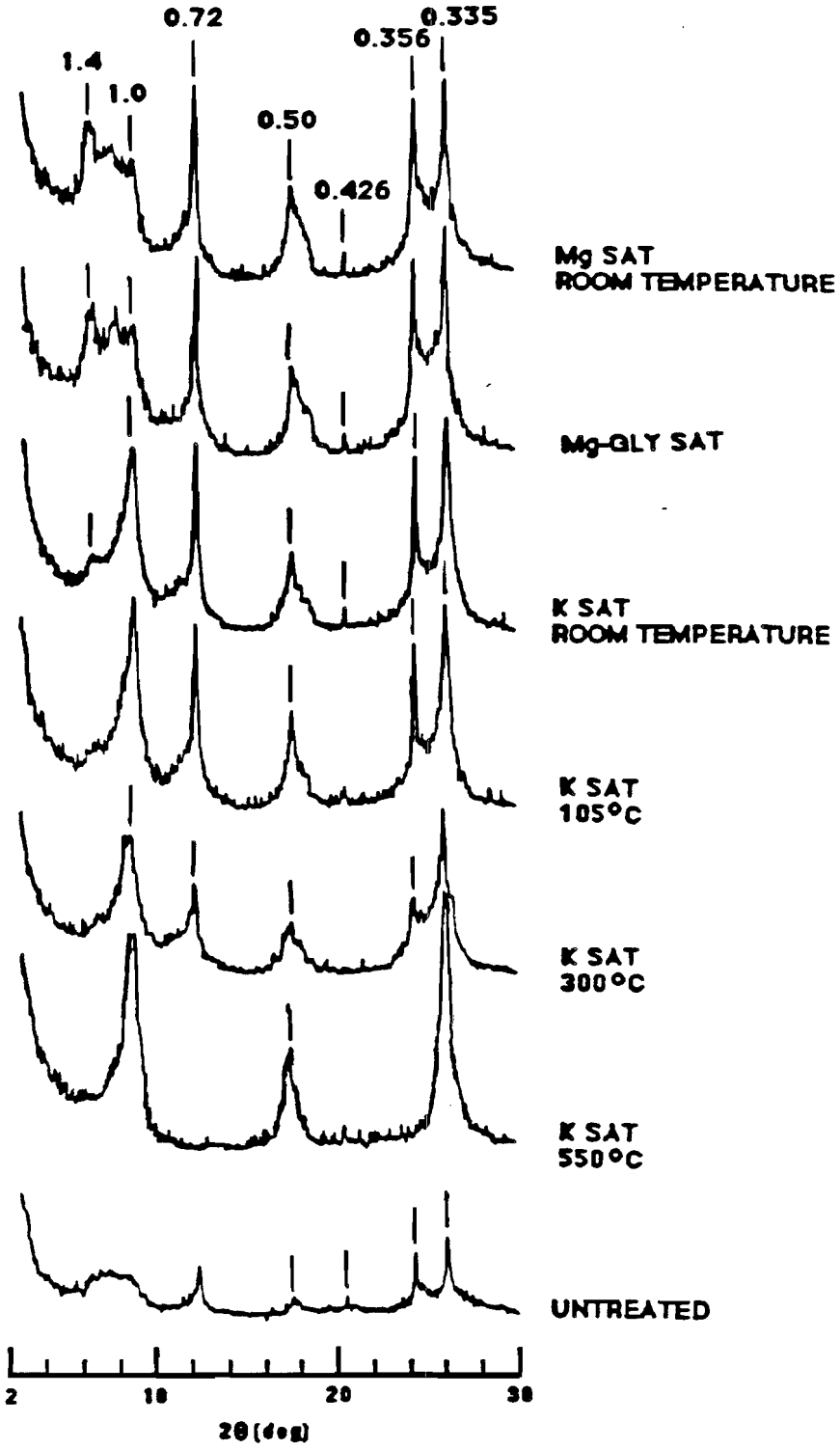
<2 µm



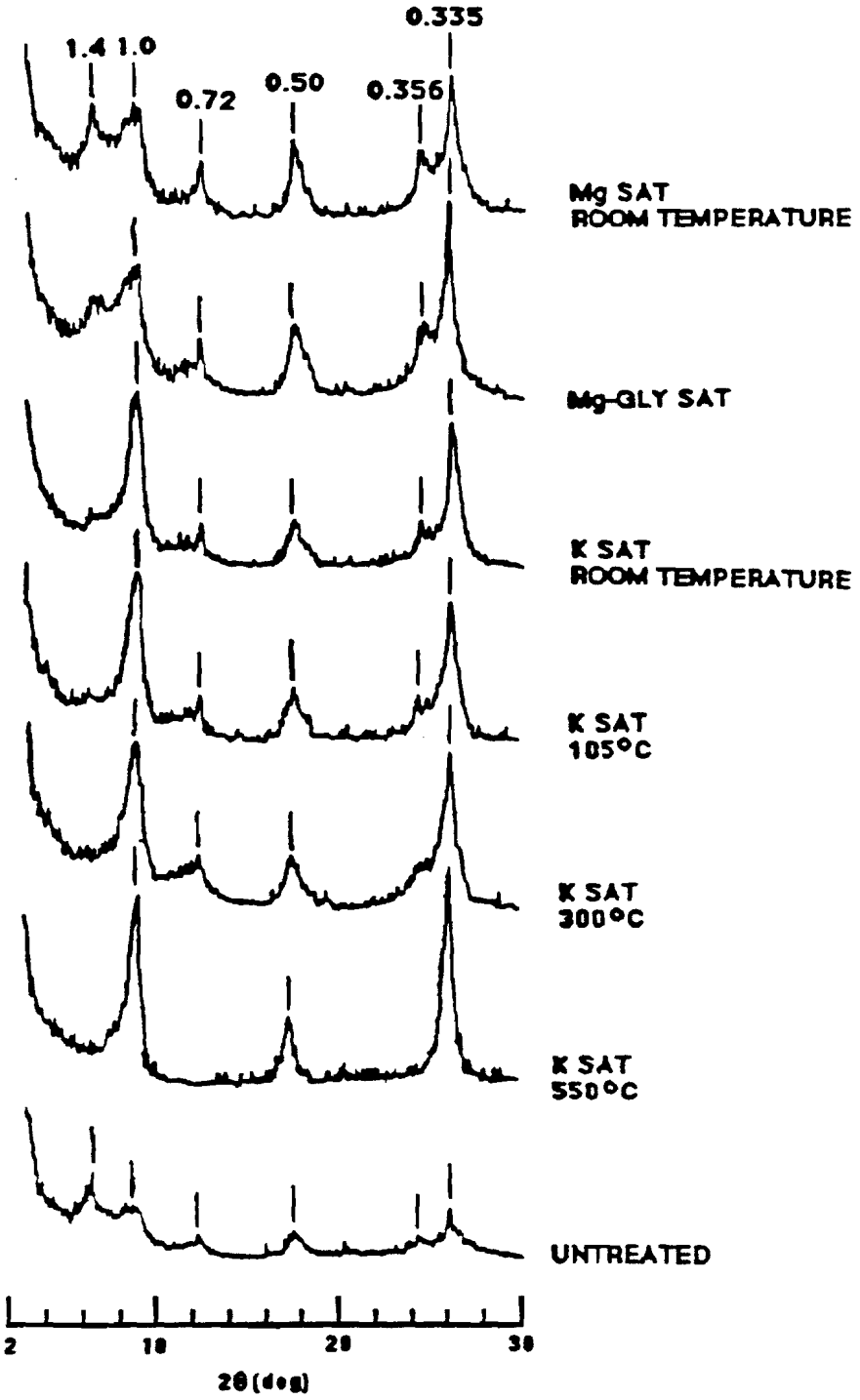
PROFILE 951
Ap (20-28 cm)
<2 µm



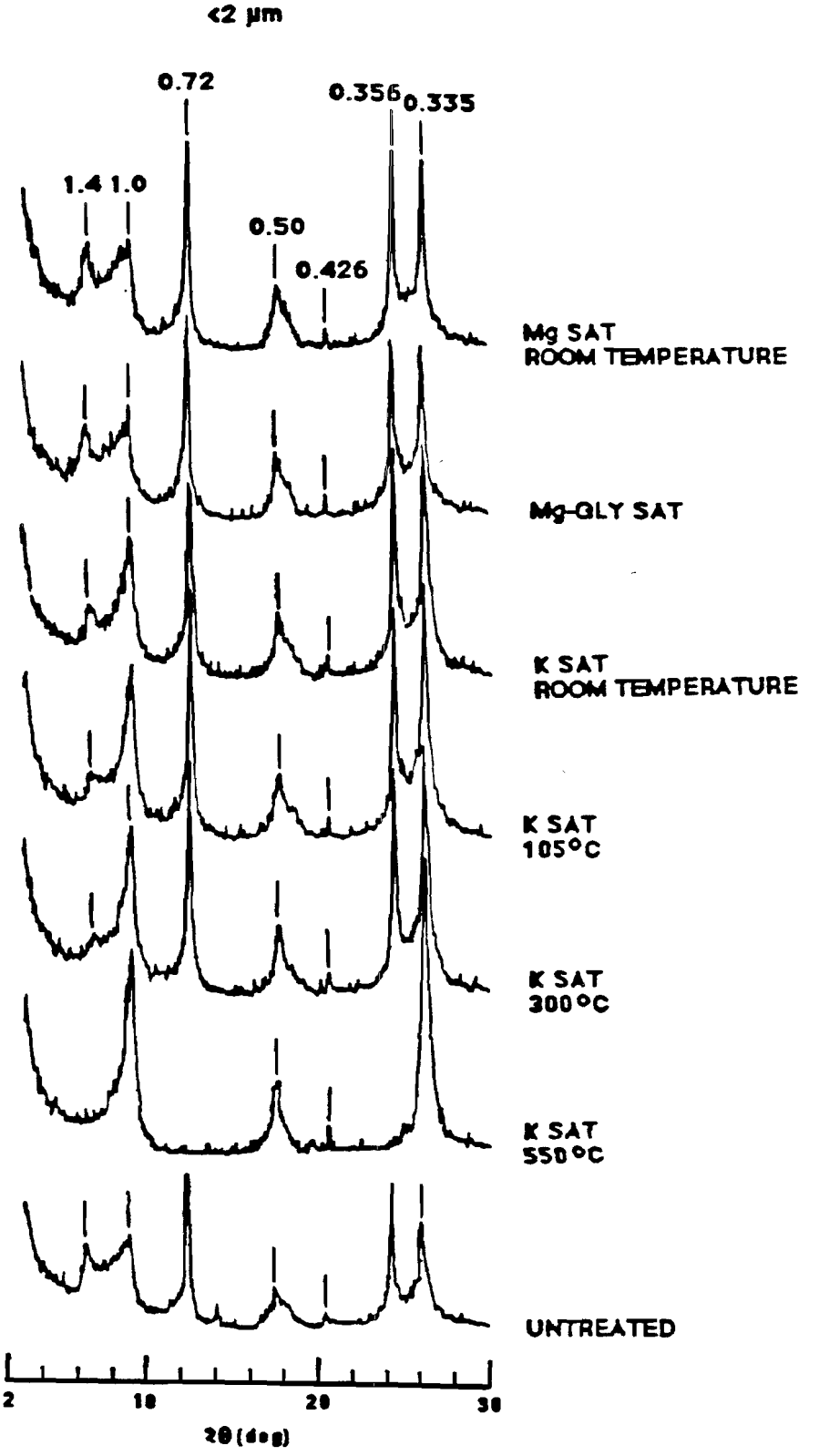
PROFILE 951
Bt (48-76 cm)
<2 µm



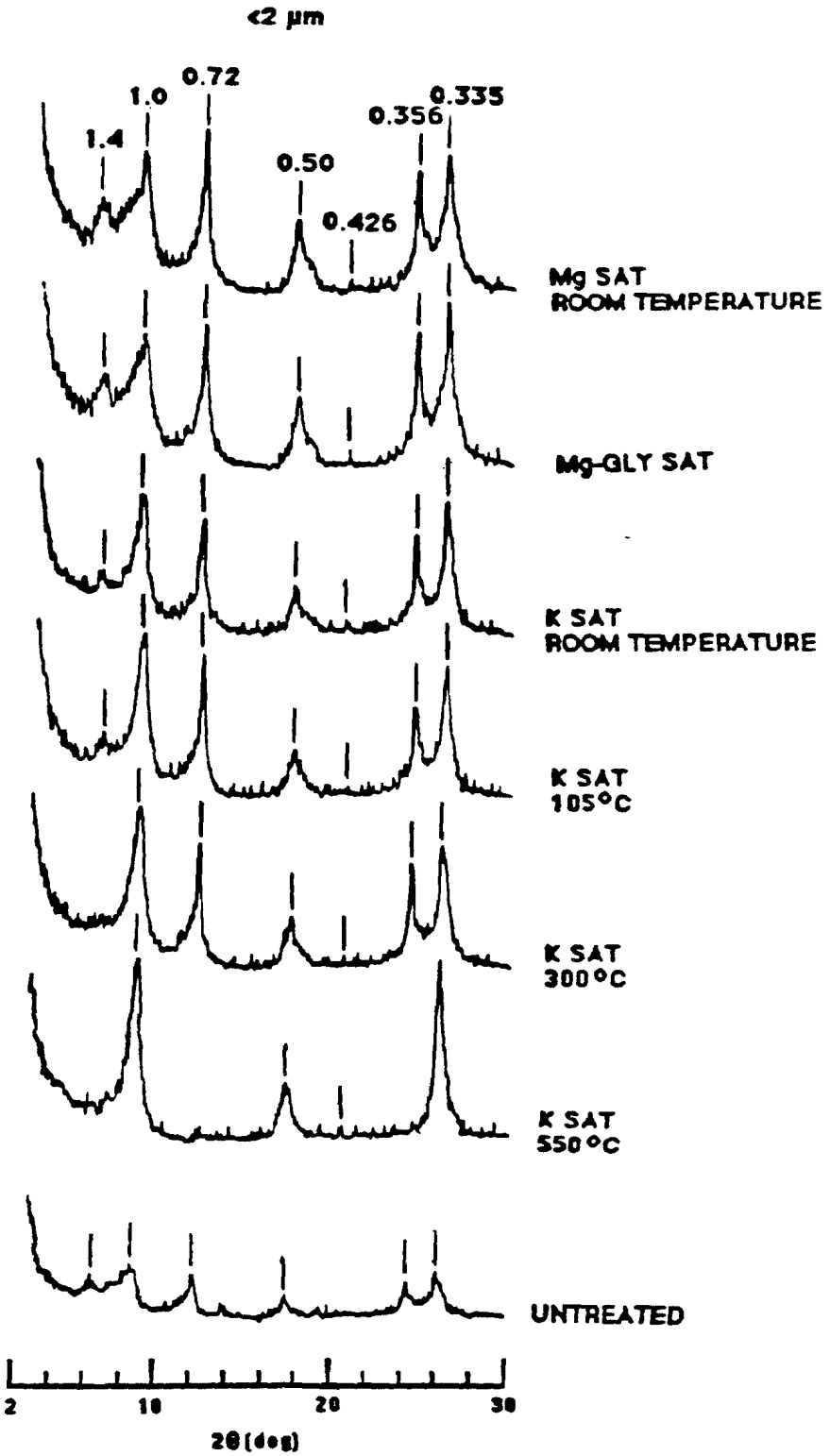
PROFILE 951
3Cr (121+ cm)
<2 µm



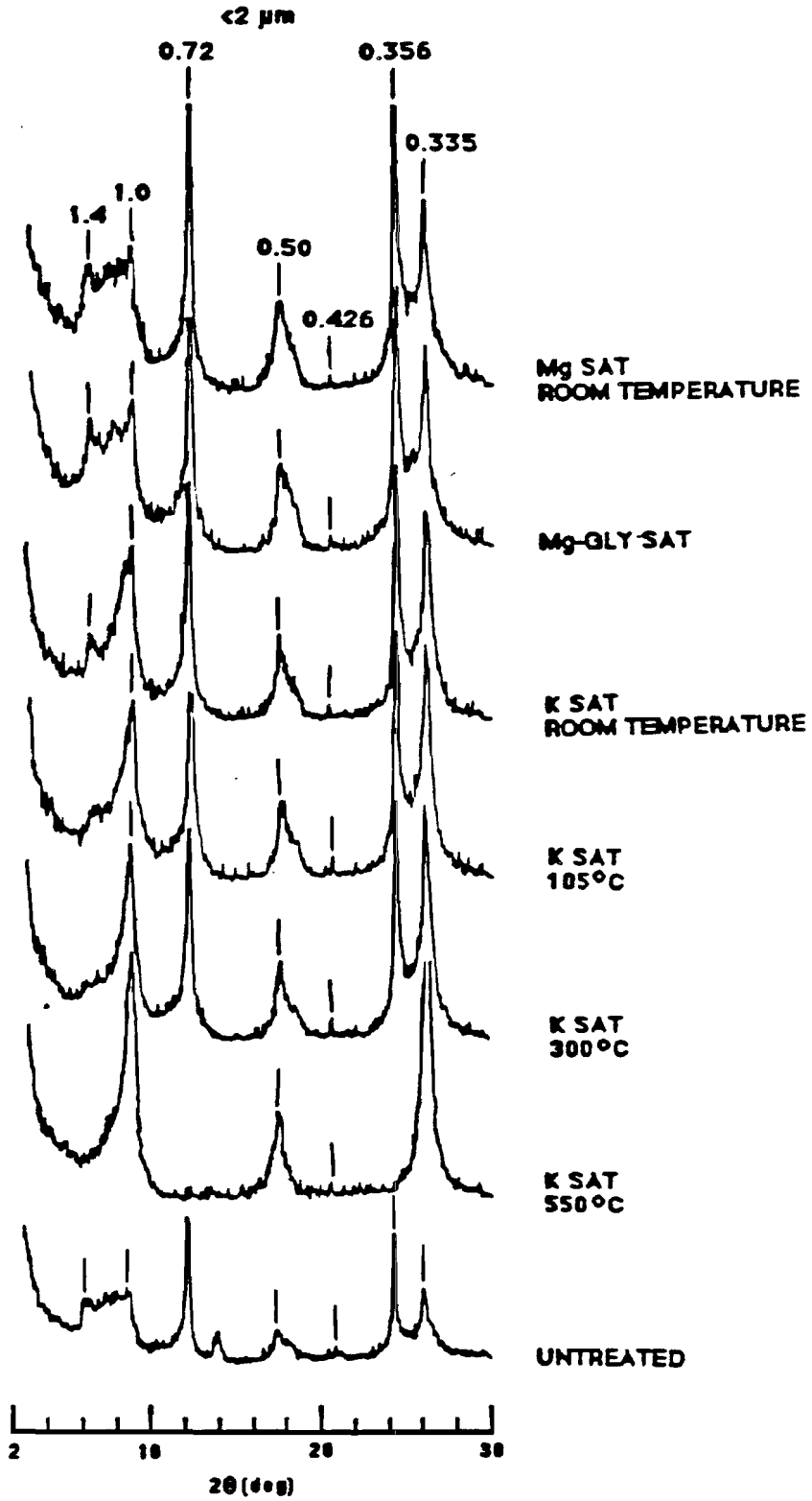
PROFILE 26/951
Ap (0-21 cm)



PROFILE 26/951
Bt1-4Bt (21-122 cm)

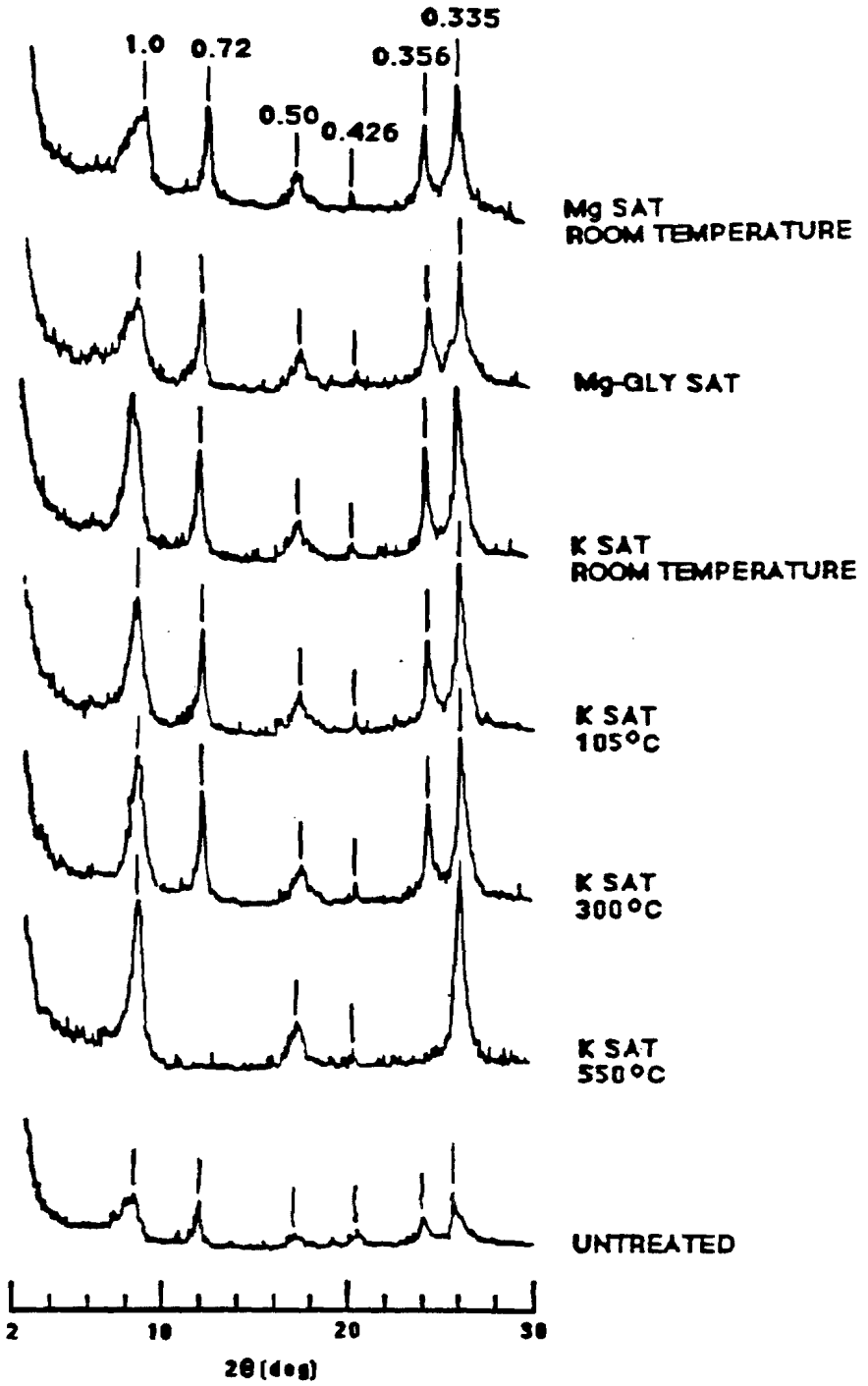


PROFILE 26/951
5Bt1-6Bw2 (122-270 cm)



PROFILE 26/951
7C-7Cr (270+ cm)

<2 µm



APPENDIX G

PART I. DRILLING AND WELL CONSTRUCTION LOGS FOR BEAR CREEK VALLEY SITE PIEZOMETERS

PART II. BEAR CREEK VALLEY WELL HYDROGRAPHS

R. H. Ketelle

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PART I

DRILLING AND WELL CONSTRUCTION LOGS FOR BEAR CREEK VALLEY SITE PIEZOMETERS

WELL LOG

WELL NUMBER GW-405

DATE 3/18/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

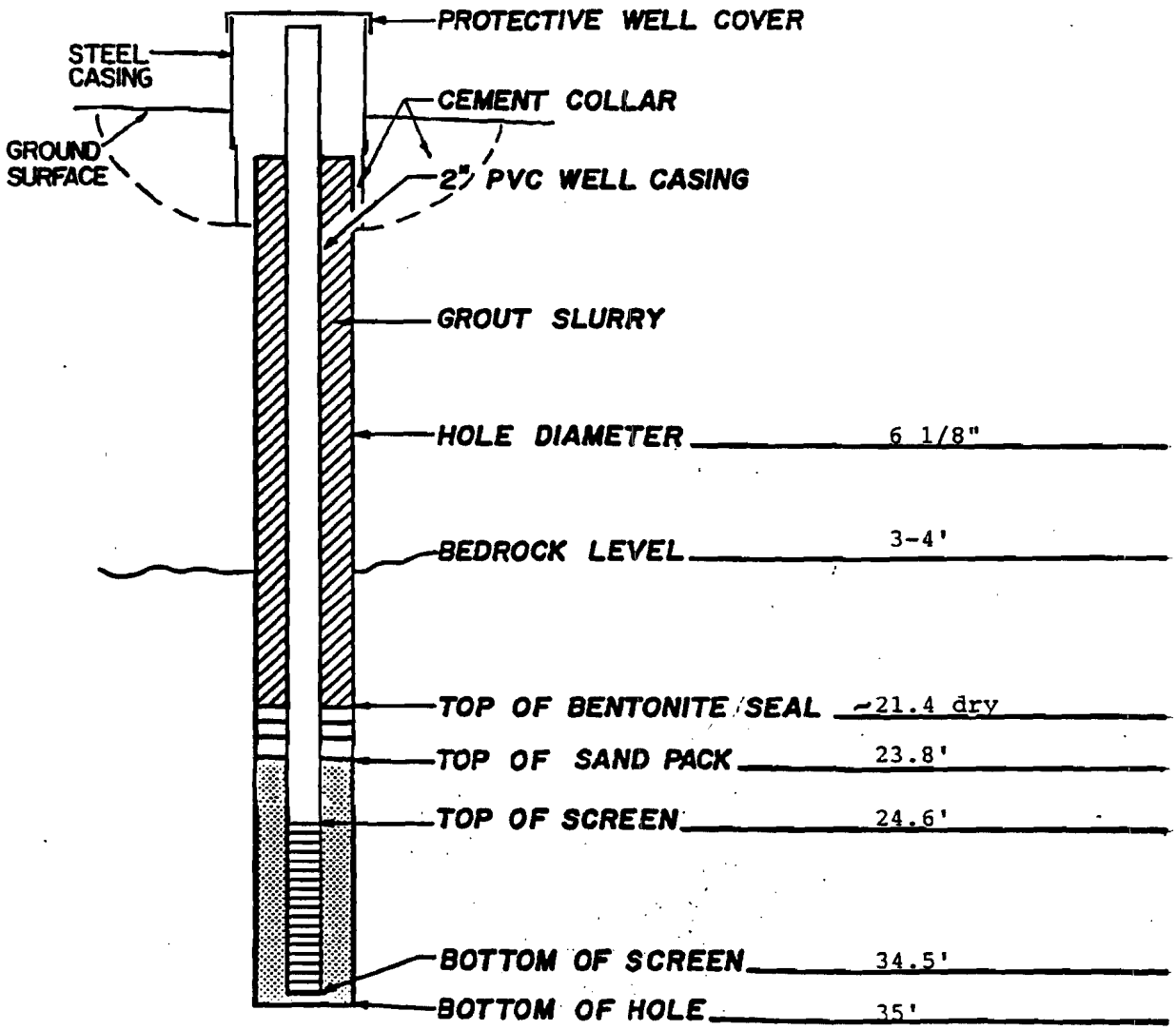
DEPTH	(FT)	DESCRIPTION
5	10	MED. GRAY SHALE
10	15	SAME AS ABOVE WITH PINK BROWN SILTY LIME
15	20	MED. GREENISH GRAY SHALE
		WITH 40% BROWN & PINK SILTSTONE
20	25	50 % GREEN SHALE 50%
		LT. TO MED. GRAY LIMESTONE,
		CALCITE VEINS
25	30	SAME AS ABOVE EXCEPT
		LIMESTONE TO DK. GRAY
30	35	MED. GREENISH GRAY SHALE
		WITH 10% LT. GRAY LIMESTONE, PINK
		CALCITE VEINS

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-405 **DATE INSTALLED:** 3-18-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

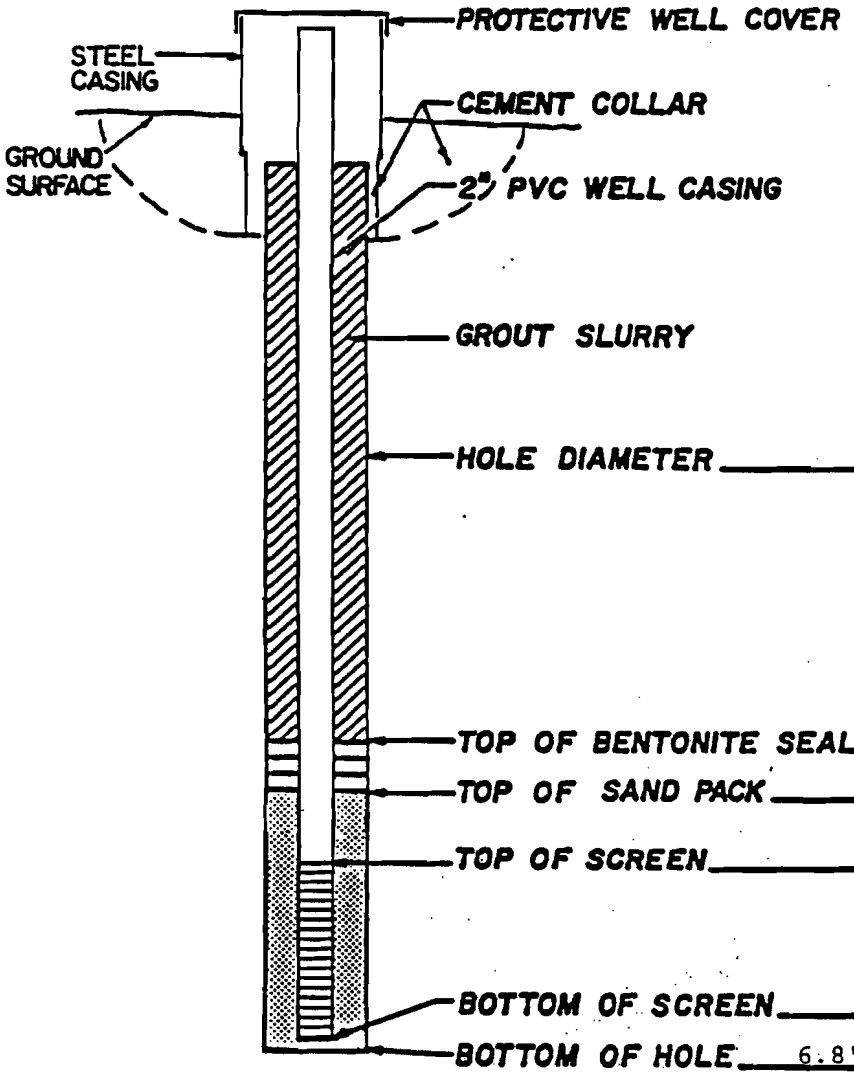
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-406 **DATE INSTALLED:** 3-30-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



HOLE DIAMETER 6 5/8"

TOP OF BENTONITE SEAL ~1.5'

TOP OF SAND PACK ~2.7'

TOP OF SCREEN 2.9'

BOTTOM OF SCREEN 6.6'

BOTTOM OF HOLE 6.8', 6.6' after caving

BEDROCK LEVEL 3'-4' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-407

DATE 3/17/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

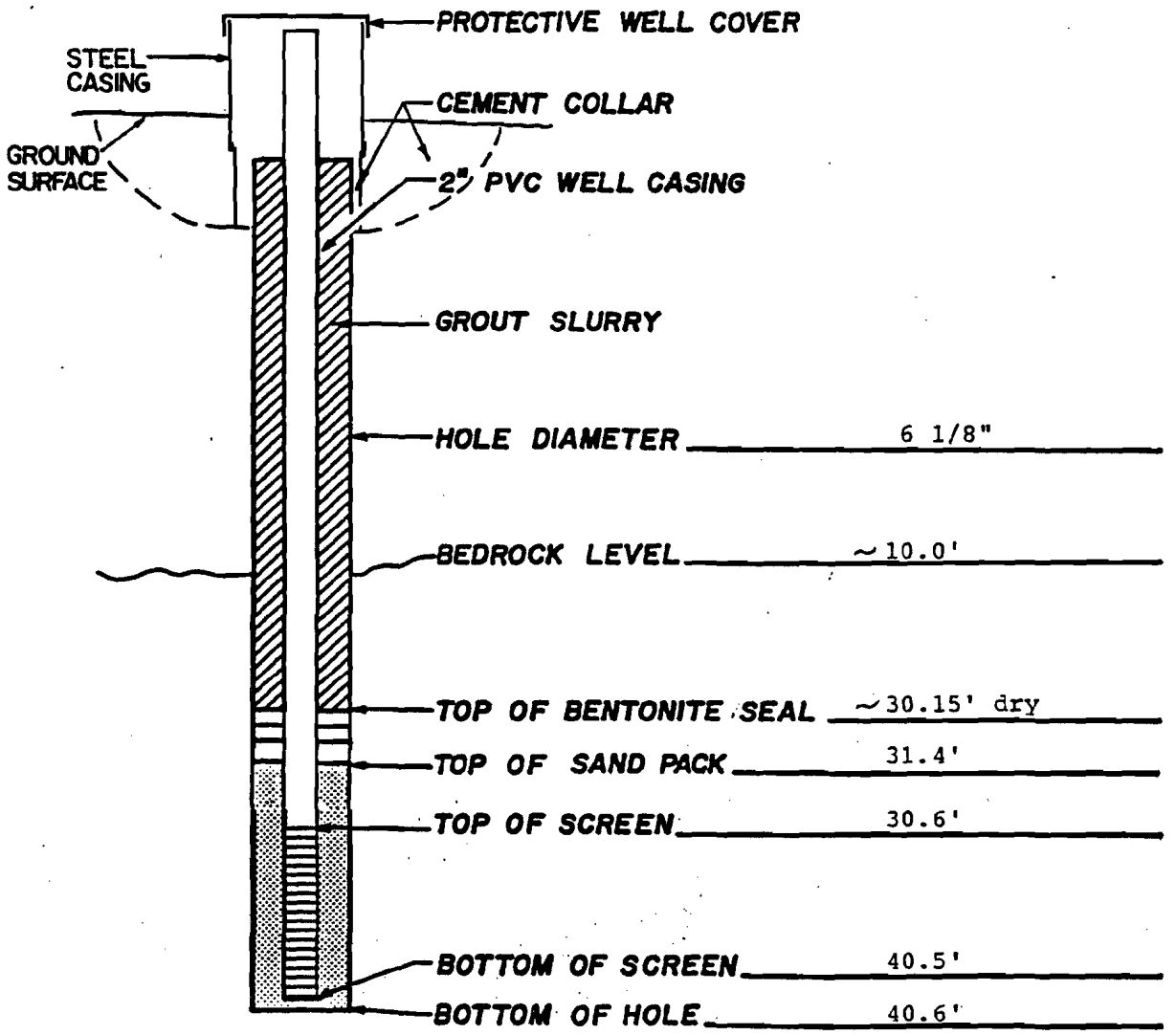
LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

DEPTH	(FT)	DESCRIPTION
5	10	WEATHERED SHALE SPAROLITE
10	15	GREENISH GRAY SHALE
15	20	SAME AS ABOVE
20	25	SAME AS ABOVE WITH MINOR PINK CALCITE VEINS
25	30	GREENISH GRAY SHALE
30	35	SAME AS ABOVE
35	40.6	SAME AS ABOVE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-407 **DATE INSTALLED:** 3-17-87
MAP NO. Bear Creek
LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

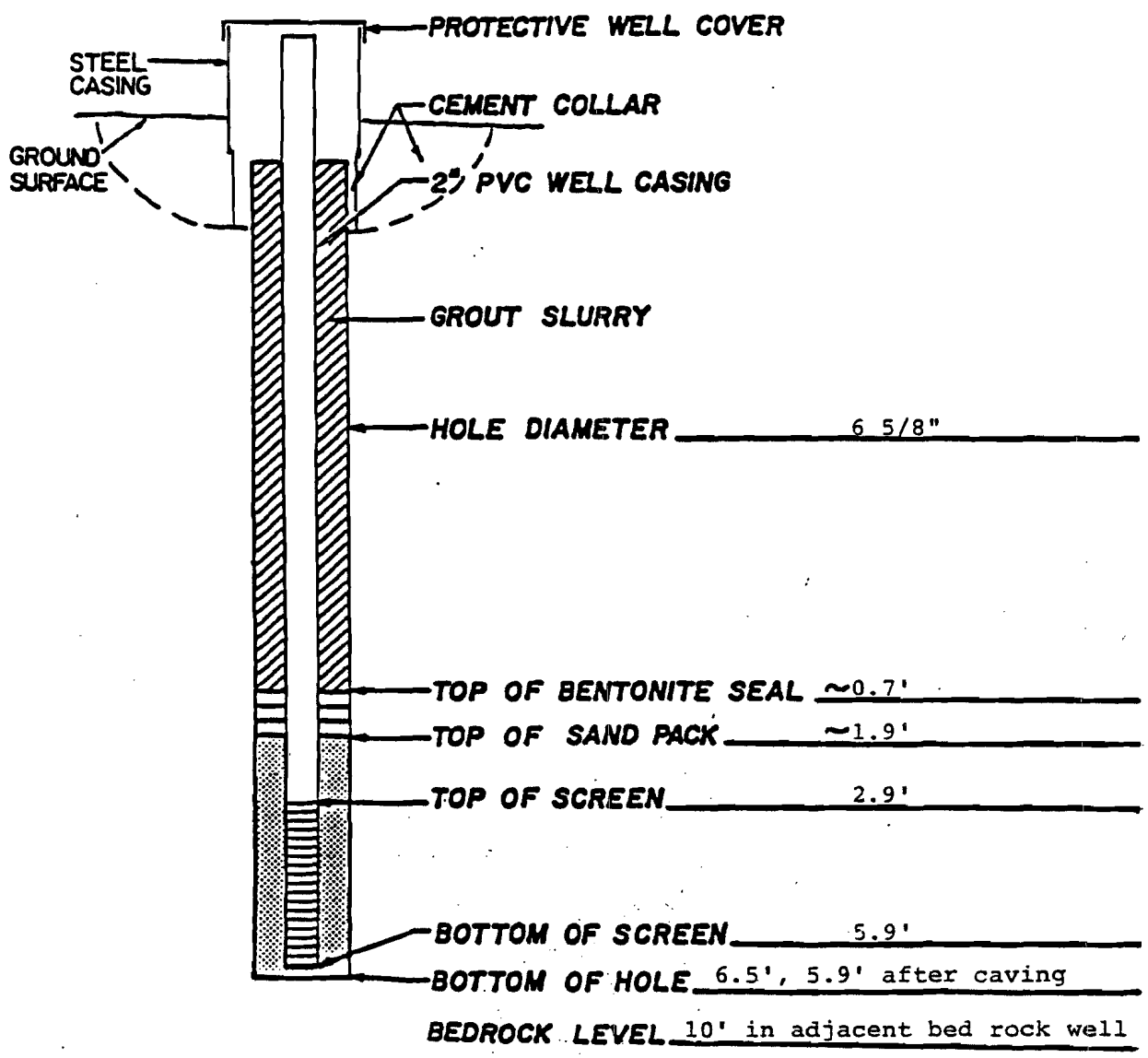
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-408 DATE INSTALLED: 3-26-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER ~~GW-408-A~~ 409

DATE 3/17/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

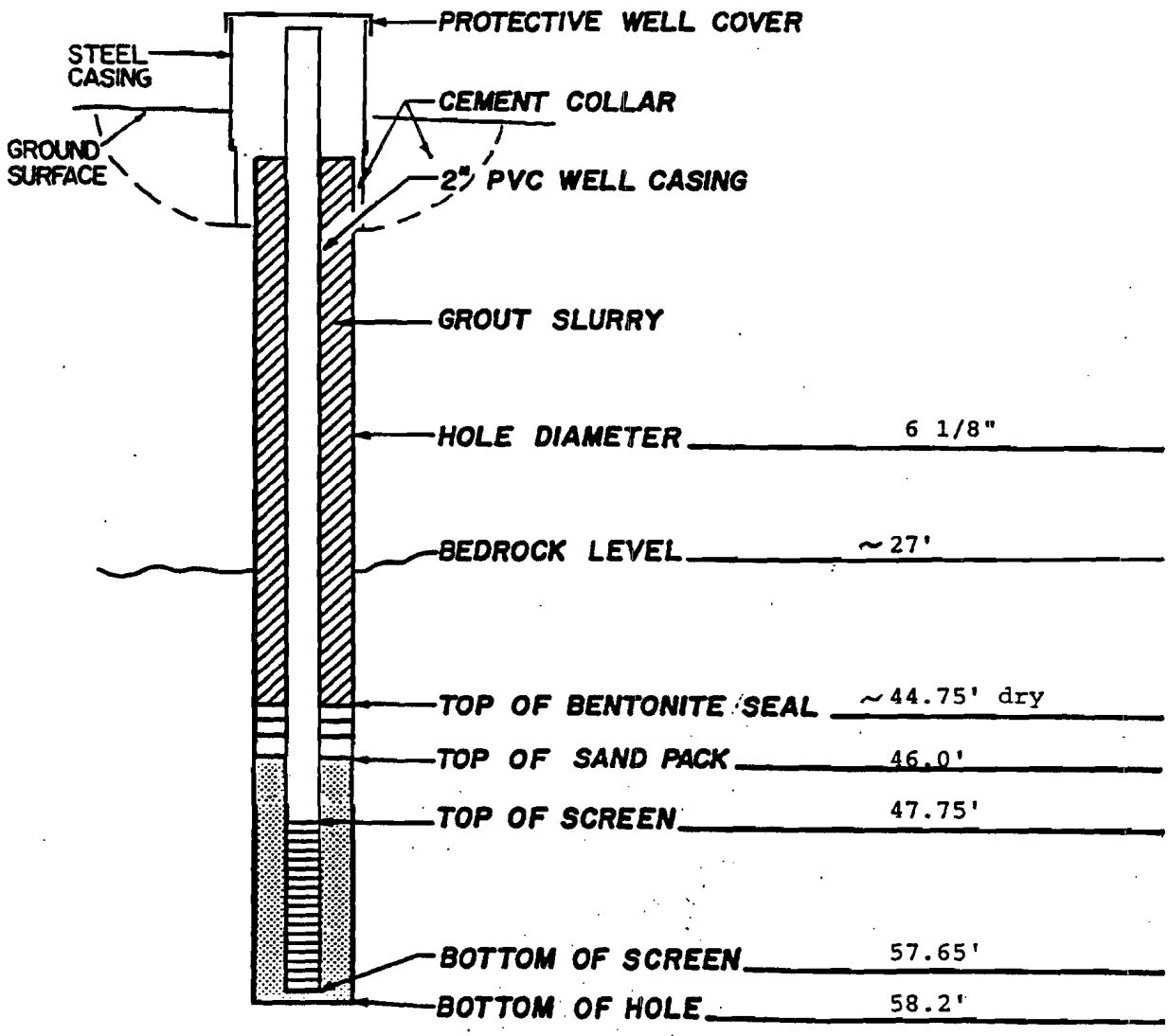
DEPTH	(FT)	DESCRIPTION
0	5	RED BROWN CLAY
5	10	SAME AS ABOVE WITH OLIVE SHALE SAPROLITE
15	20	SAME AS ABOVE
20	25	SAME AS ABOVE WITH SILTSTONE, OLIVE GREEN
25	27	SAME AS ABOVE
27	30	BED ROCK AT 27 FT. GREENISH GRAY SHALE
30	35	MED. GRAY SHALE & SANDSTONE TO BLACK MOSTLY SHALE
35	40	SAME AS ABOVE EXCEPT SANDSTONE CALCAREOUS
40	45	MEDIUM GRAY SHALE WITH MINOR LT. GRAY MUDSTONE & CALCITE VEINS
45	50	GREEN SILTSTONE, GREEN GRAY TO MED. GRAY SHALE, MINOR LT. GRAY MUDSTONE
50	58.2	RED GREENISH GRAY SHALE WITH MINOR GREEN SILTSTONE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-~~408A~~ 409 **DATE INSTALLED:** 3-17-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

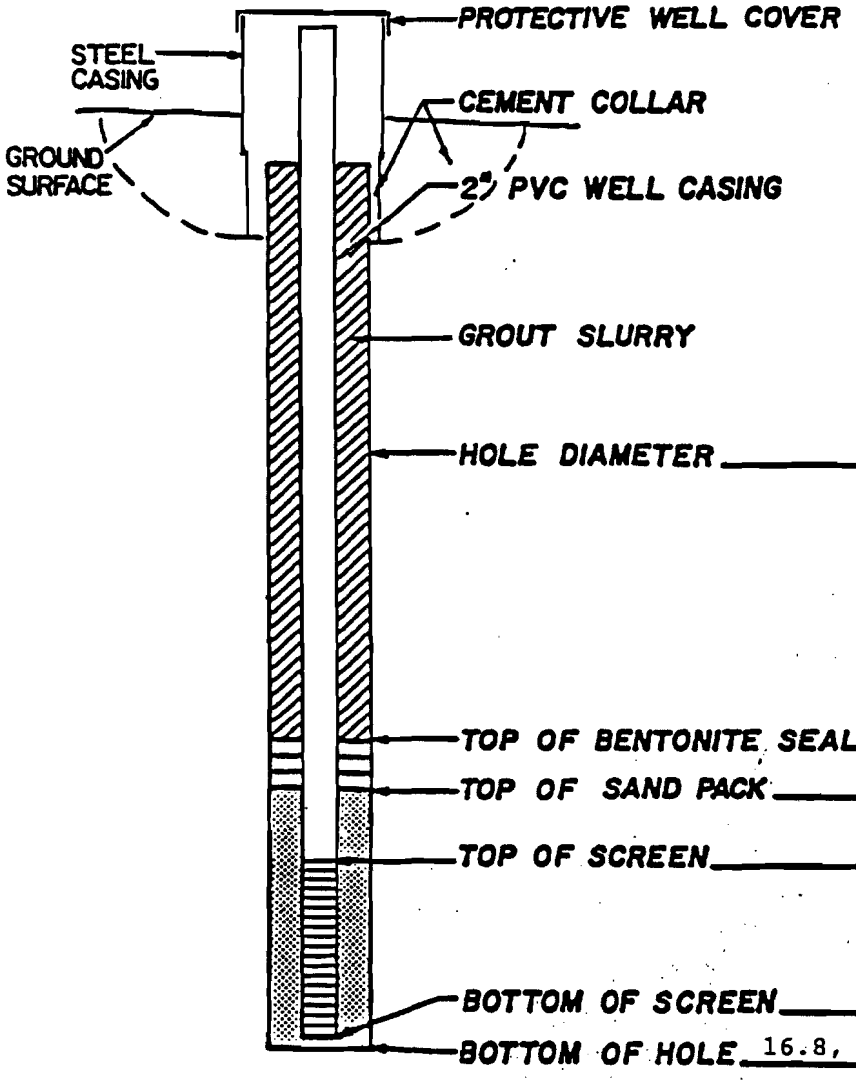
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-410 **DATE INSTALLED:** 3-30-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



HOLE DIAMETER 6 5/8"

TOP OF BENTONITE SEAL ~1.55'

TOP OF SAND PACK ~2.75'

TOP OF SCREEN 3.85'

BOTTOM OF SCREEN 13.75'

BOTTOM OF HOLE 16.8, 13.75 after caving

BEDROCK LEVEL 27' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

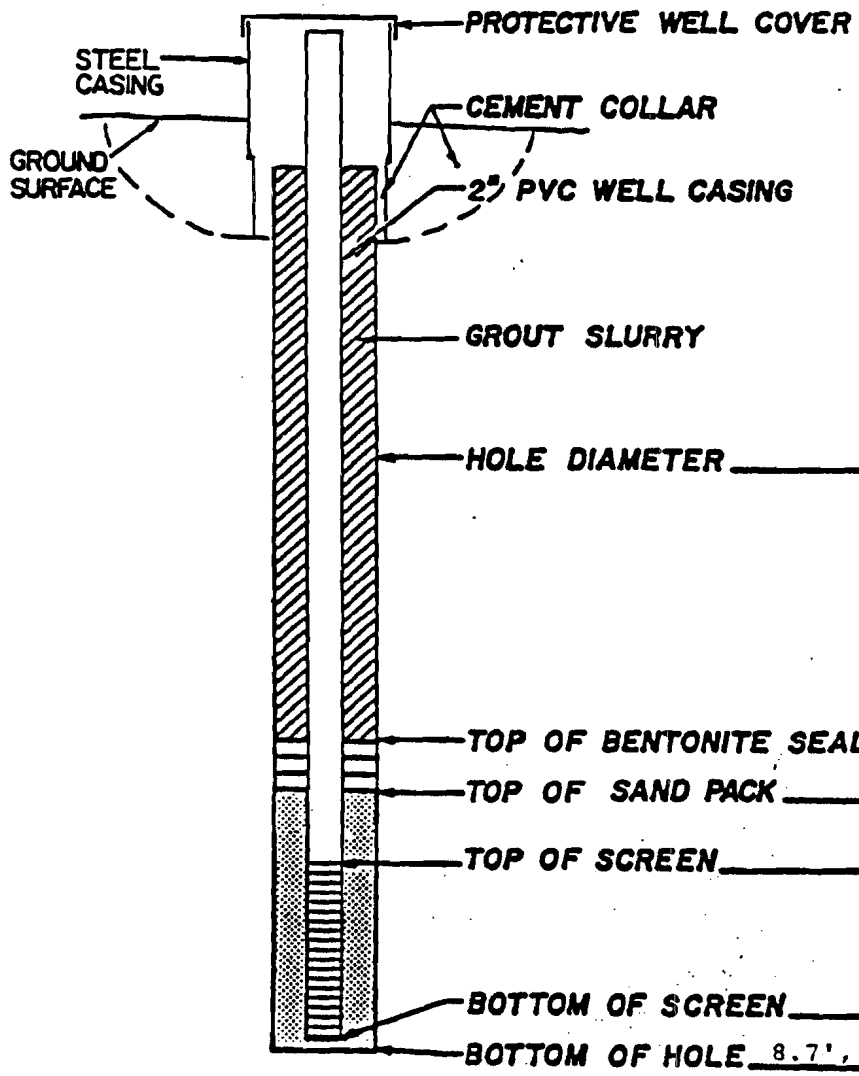
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-411 **DATE INSTALLED:** 3-31-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



HOLE DIAMETER 6 5/8"

TOP OF BENTONITE SEAL ~1.65'

TOP OF SAND PACK ~2.85'

TOP OF SCREEN 3.35'

BOTTOM OF SCREEN 8.35'

BOTTOM OF HOLE 8.7', 8.35' after caving

BEDROCK LEVEL 8'-10' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-~~421~~ 412

DATE 3/27/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

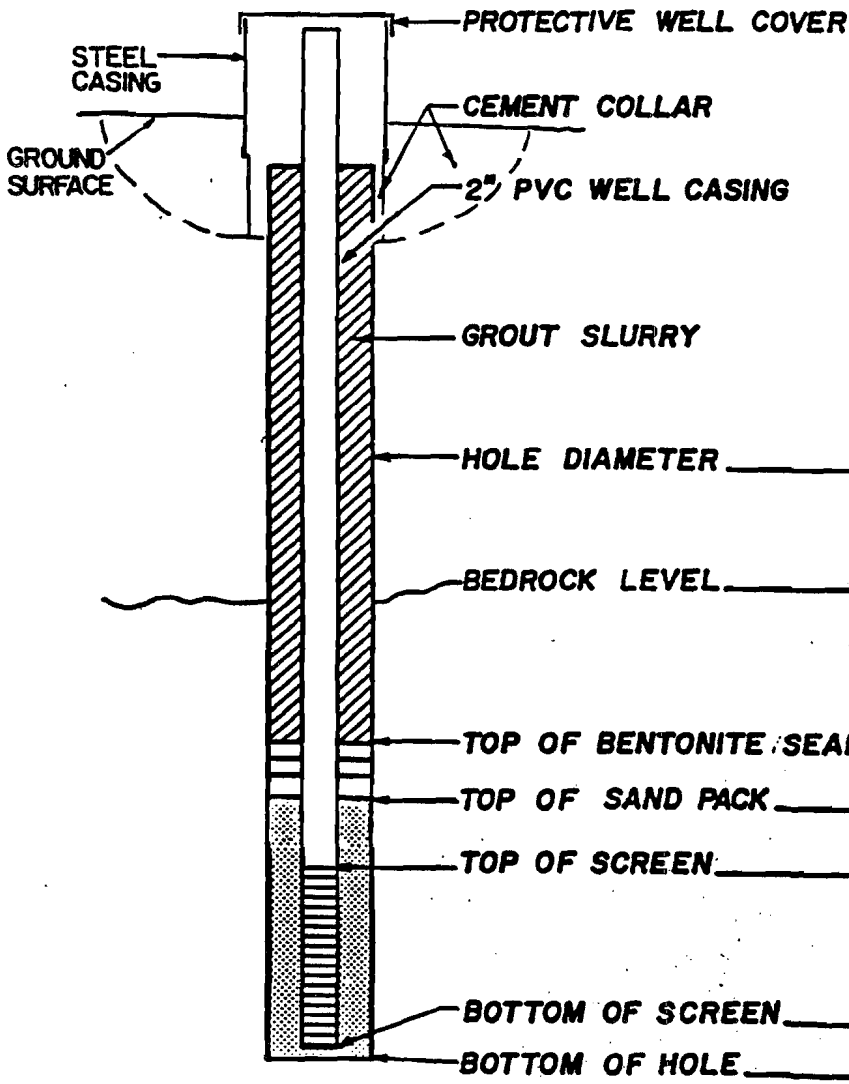
DEPTH	(FT)	DESCRIPTION
8	10	LT. GRAY TO LT. BROWNISH GRAY SHALE
10	15	GREENISH GRAY TO MAROON GRAY SHALE, MINOR CALCITE VEINS
15	20	GREEN GRAY SILTSTONE AND MAROON GRAY SHALE, MINOR CALCITE VEINS
20	25	SAME AS ABOVE WITH CALCITE VEINS
25	30	SAME AS ABOVE WITH MORE CALICITE, GREEN SILTSTONE DOMINANT
30	40.1	SAME AS ABOVE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-~~411~~ 412 **DATE INSTALLED:** 3-27-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

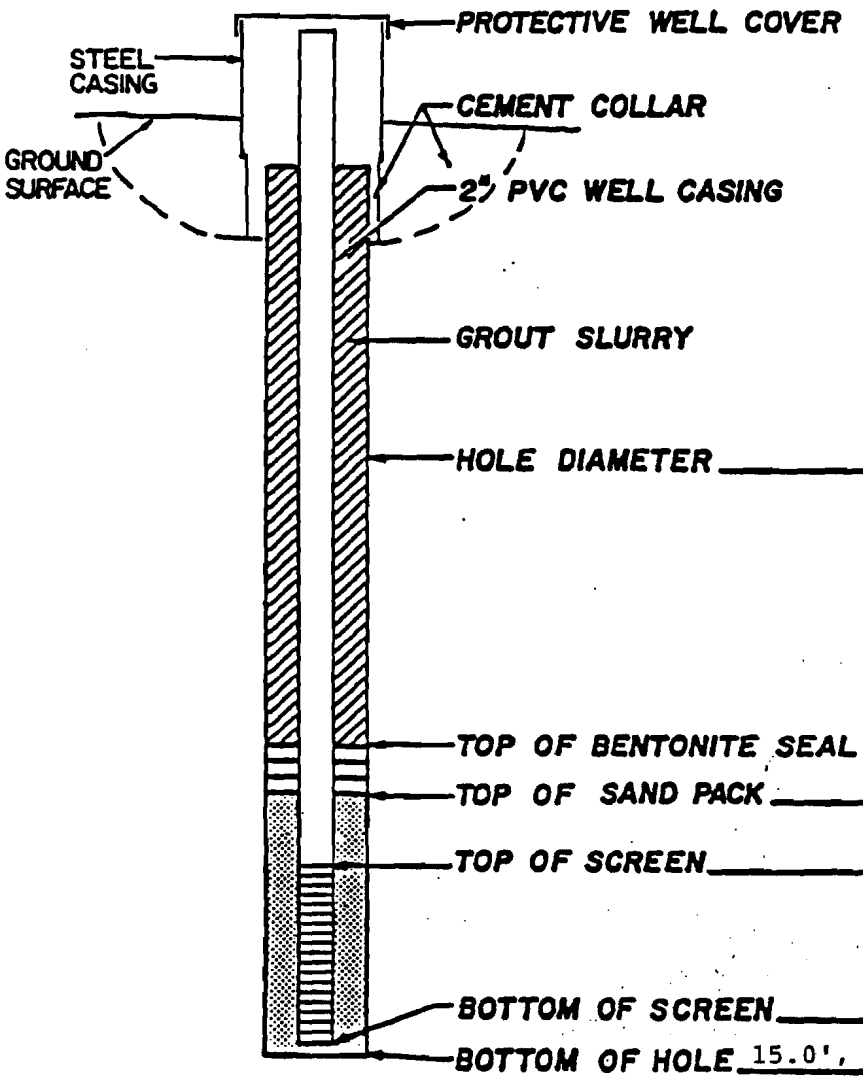
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-413 **DATE INSTALLED:** 3-24-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



HOLE DIAMETER 6 5/8"

TOP OF BENTONITE SEAL ~1.35'

TOP OF SAND PACK ~ 2.55'

TOP OF SCREEN 3.65'

BOTTOM OF SCREEN 13.55'

BOTTOM OF HOLE 15.0', 13.55' after caving

BEDROCK LEVEL 20'-25' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-414

DATE 3/23/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

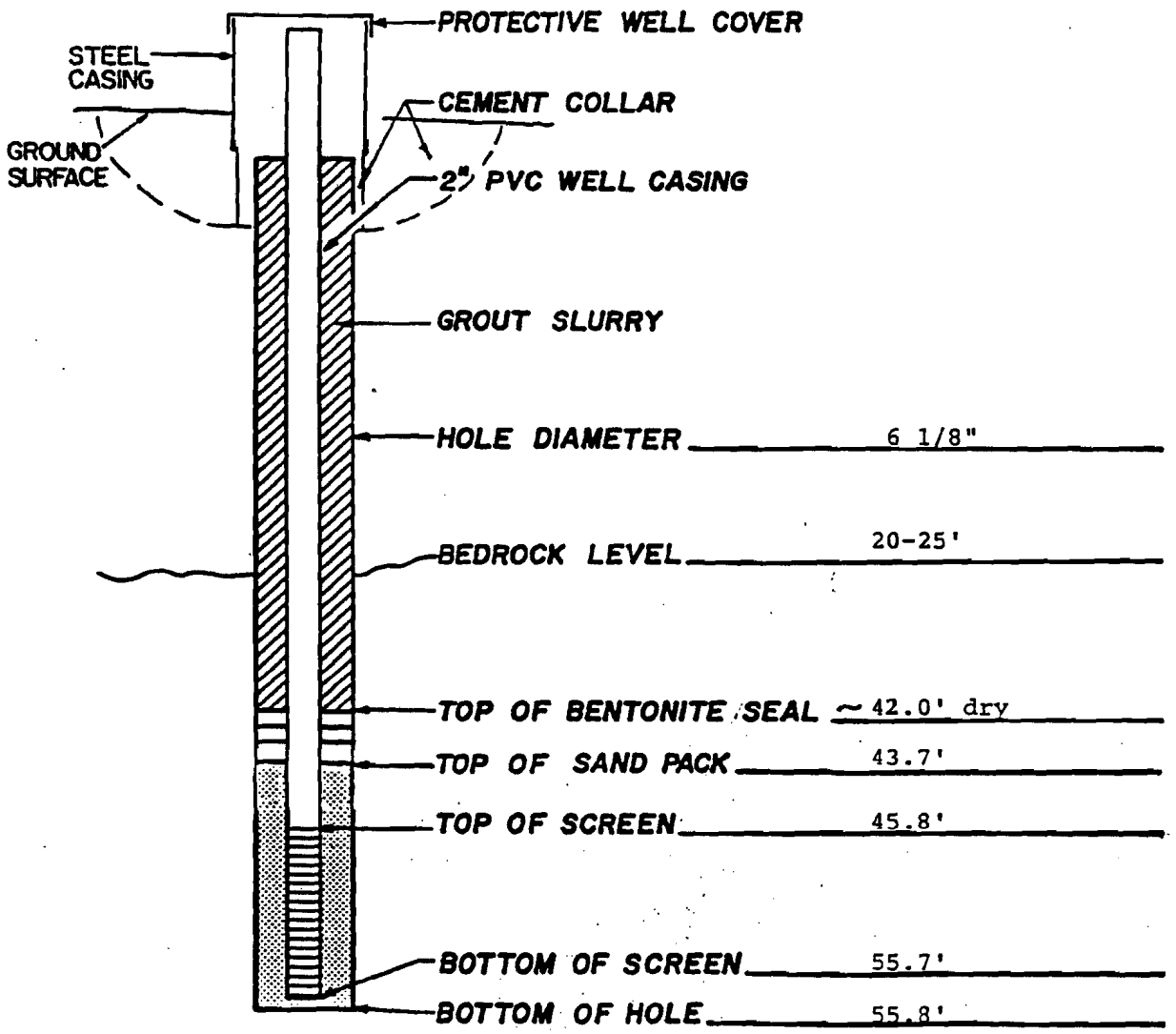
DEPTH	(FT)	DESCRIPTION
15	20	OLIVE GREEN SHALE SAPROLITE
20	25	LT. TO MED. GRAY SHALE, SOME WEATHERED
		BED ROCK 20-25,' WASN'T THERE
		AT CHANGE
25	30	GREENISH GRAY SHALE AND
		SILTSTONE
30	40	SAME AS ABOVE
40	45	SAME AS ABOVE WITH CALCITE
		VEINS
45	50	SAME AS ABOVE 30-40
50	55.8	SAME AS ABOVE 40-45

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-414 **DATE INSTALLED:** 3-28-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

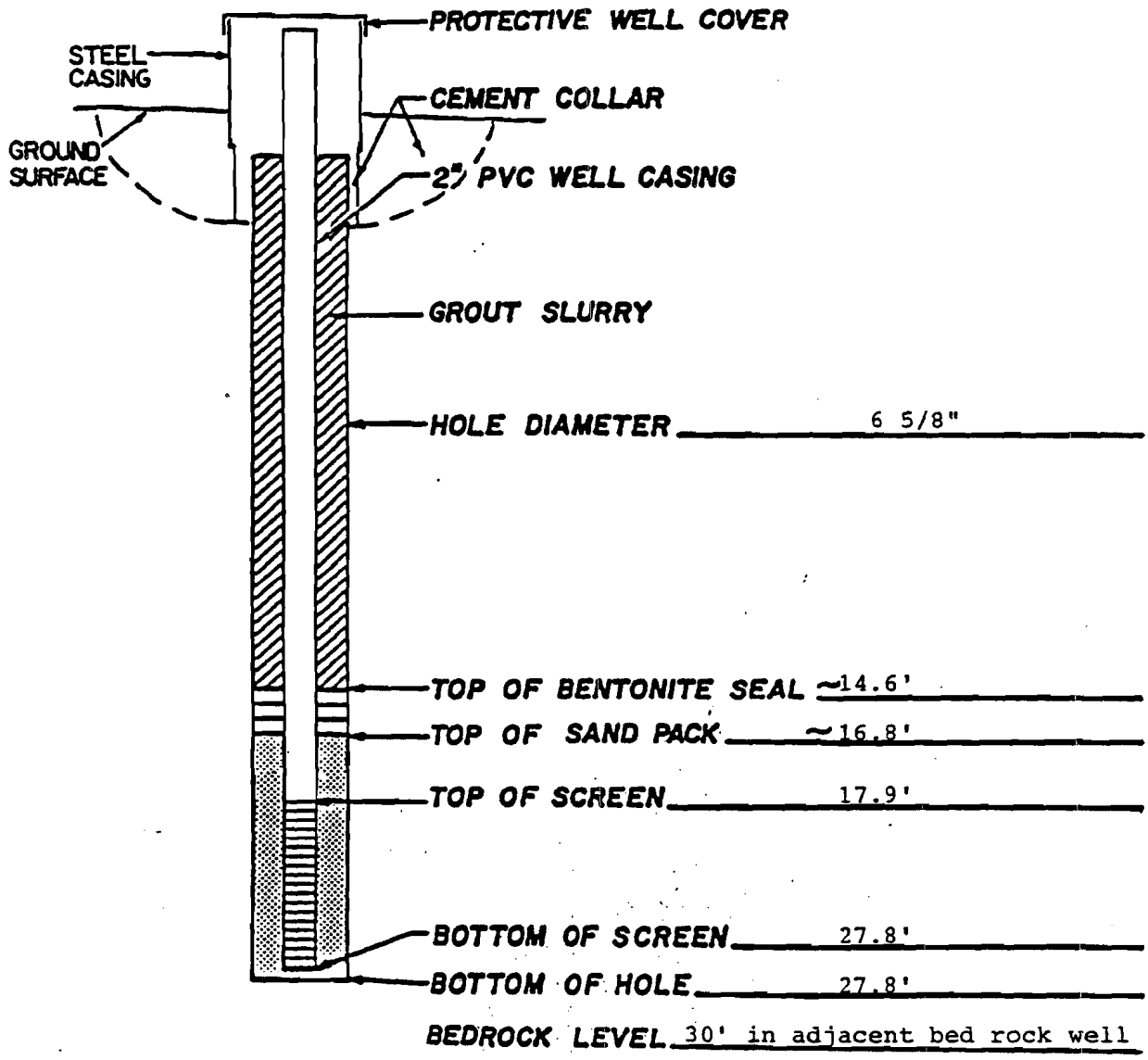
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-415 **DATE INSTALLED:** 3-24-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-~~425~~ 416

DATE 3/23/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

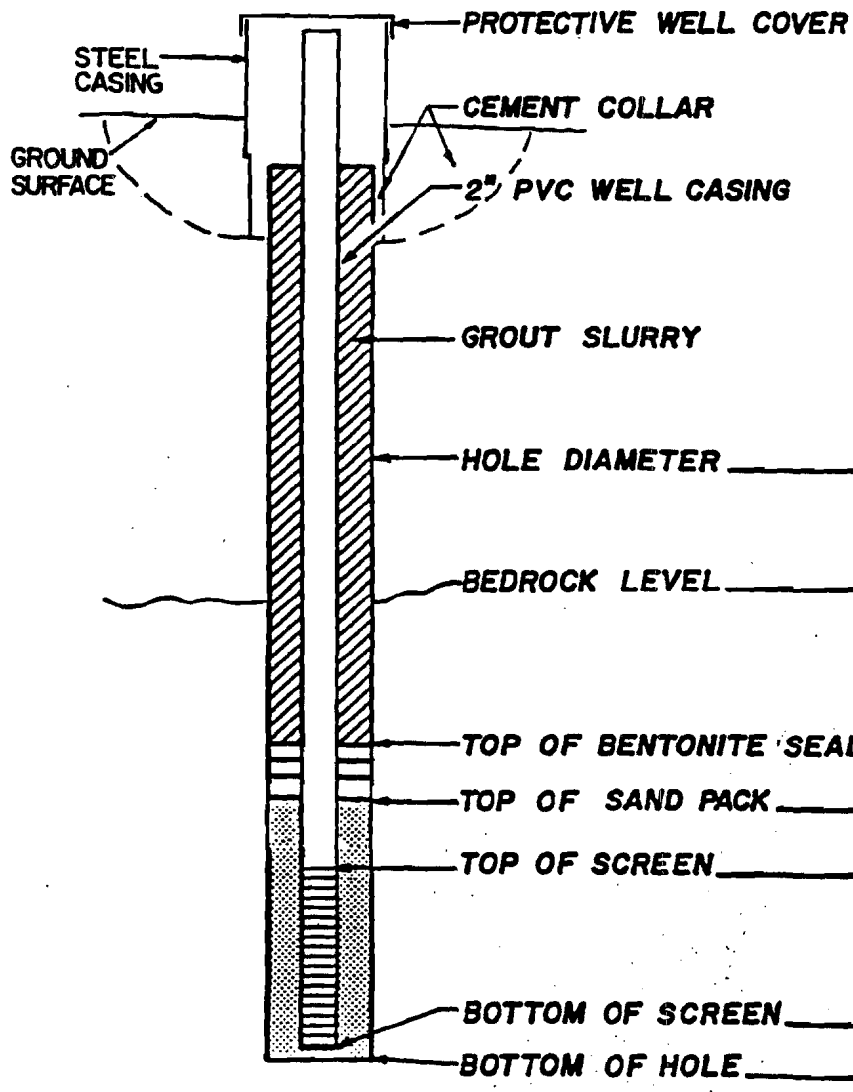
DEPTH	(FT)	DESCRIPTION
30	35	LT. TO MED. GRAY SHALE,
		SHALE, LIMESTONE
		HARD, RED BROWN SILTSTONE
35	40	SAME AS ABOVE
40	45	SAME AS ABOVE
45	50	LT. GRAY SHALE, SLIGHTLY GREEN,
		WITH MINOR CALCITE VEINS
50	55	MED. GREENISH GRAY SILTSTONE,
		CALCAREOUS, MINOR LT. GRAY
		SHALE & LT. GRAY LIMESTONE,
		CALCITE VEINS
55	61.2	SAME AS ABOVE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-~~415~~ 416 **DATE INSTALLED:** 3-23-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER - GW-417

DATE 3/11/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

RECOVERED 20-25 GAL. IN 20 MIN.

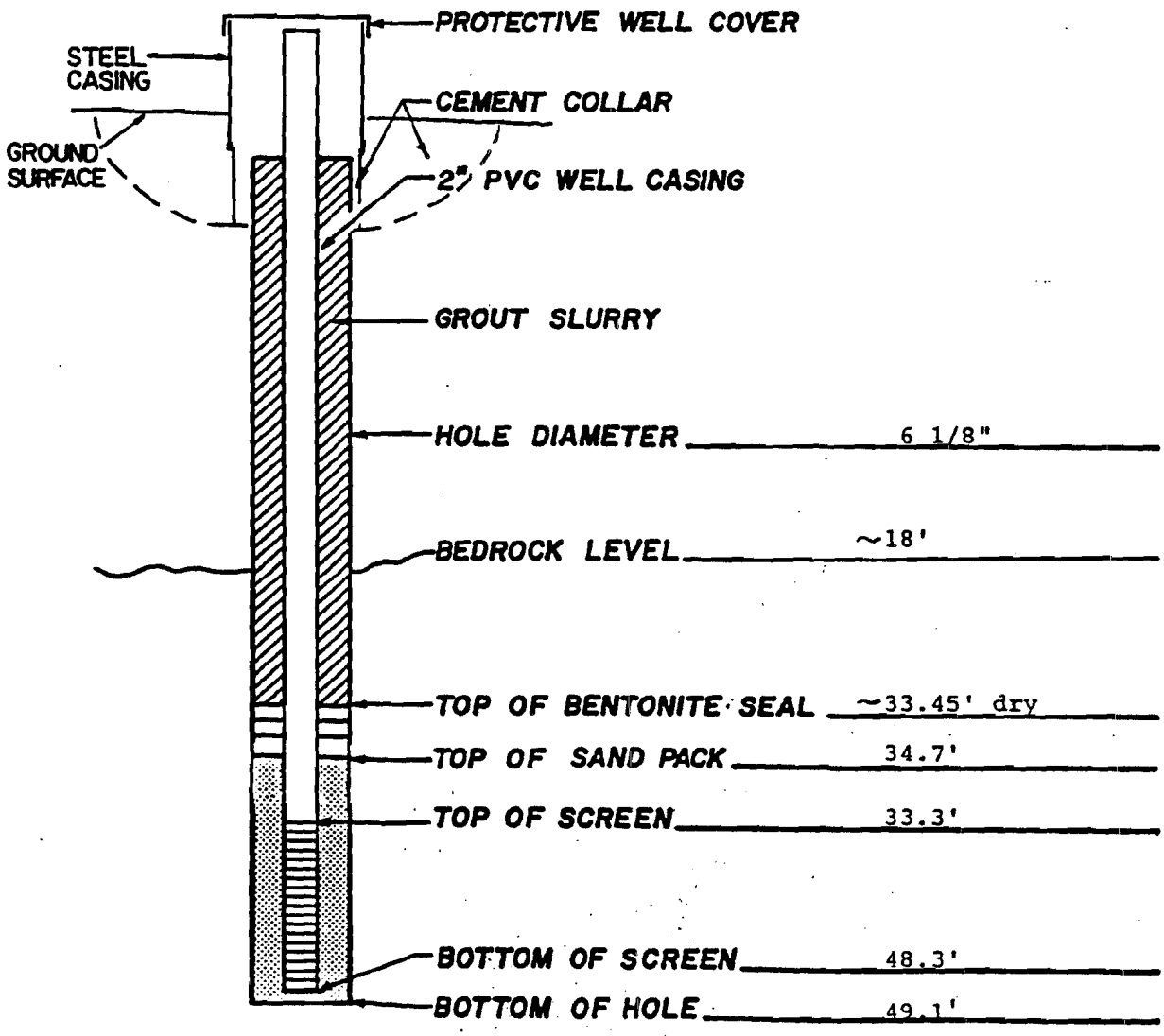
DEPTH	(FT)	DESCRIPTION
0	4	LT. BROWN TO RED SILTY LOAM WITH MINOR CLAY
4	5	LT. BROWN TO LT. GRAY TO OLIVE SHALE SAPROLITE
5	10	SAME AS ABOVE
10	15	SAME AS ABOVE WITH DARK BROWN SANDSTONE @ 11-12; 14-15
15	18	SAME AS 5-10
18	25	FRESH BED ROCK AT 18 FT. MED. DARK GRAY SHALE
25	30	SAME AS ABOVE PINK CALCITE VEINS
30	35 -	MEDIUM BLUISH GRAY SHALE; LT. GRAY MUDSTONE IN MINOR AMOUNTS
35	40	SOFT SHALE, MED. GRAY POWDER, SLIGHT DAMPNESS, CLUMPS
40	45	MED. GREENISH GRAY SILTSTONE WITH CALCITE VEINS
45	49.1	SAME AS ABOVE EXCEPT THINNER BEDDED AND MED. GRAY SHALE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-417 **DATE INSTALLED:** 3-11-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

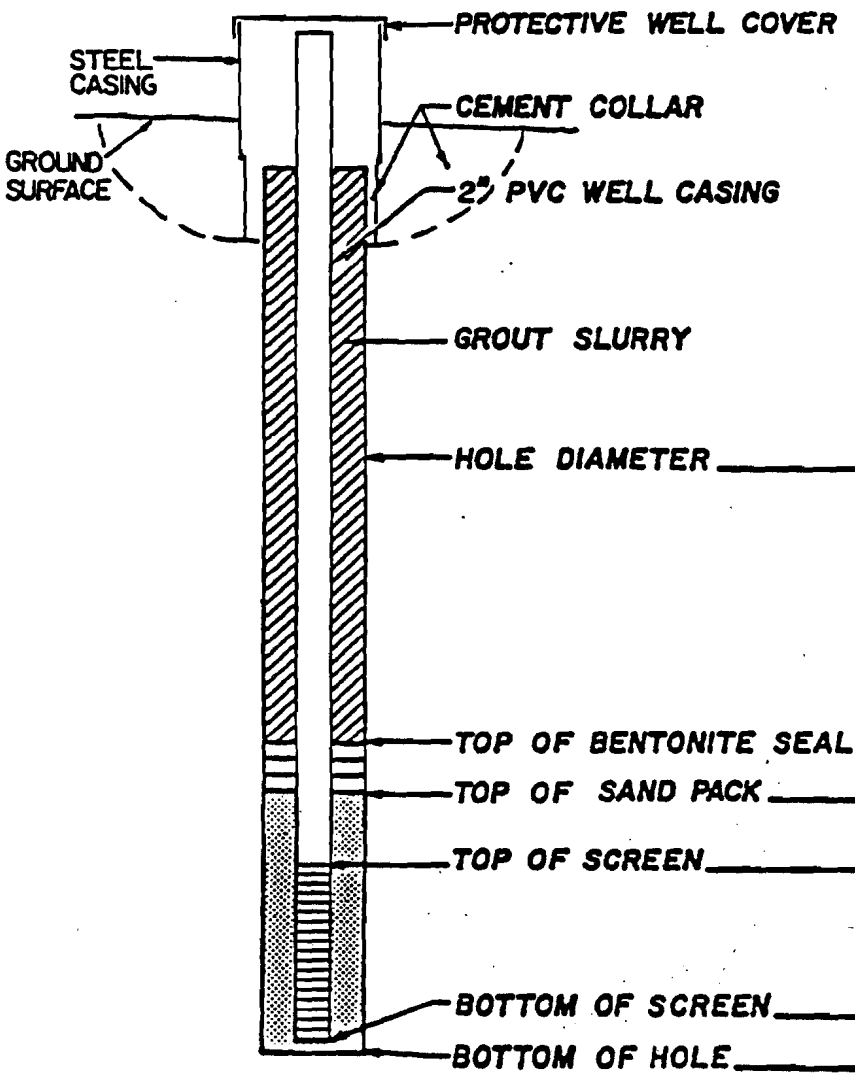
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-418 DATE INSTALLED: 3-23-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



HOLE DIAMETER 6 5/8"

TOP OF BENTONITE SEAL ~8.9'

TOP OF SAND PACK ~10.1'

TOP OF SCREEN 11.2'

BOTTOM OF SCREEN 21.1'

BOTTOM OF HOLE 21.2'

BEDROCK LEVEL 18' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

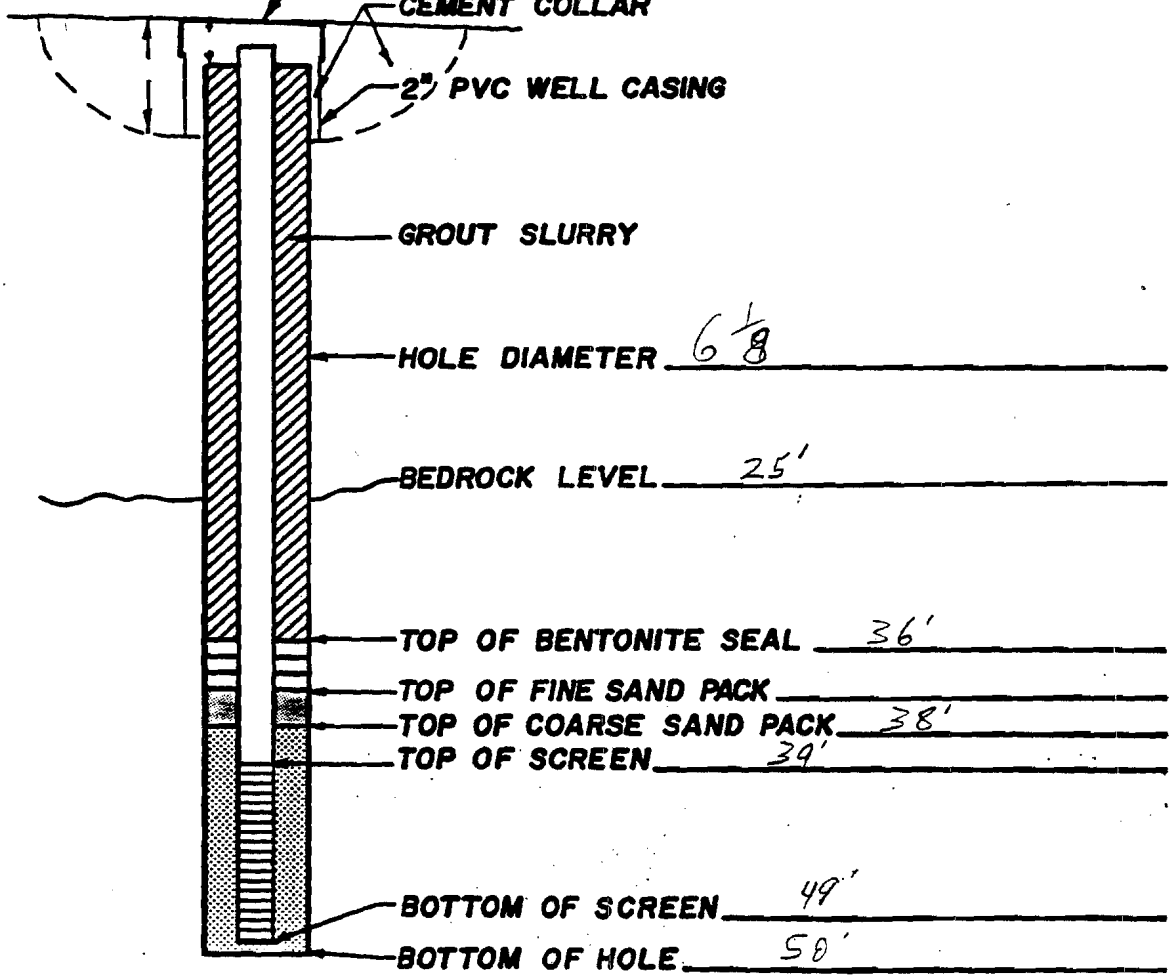
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW 419 DATE INSTALLED: 3/10/87

MAP NO. _____

LOCATION NORTH: _____ EAST: _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

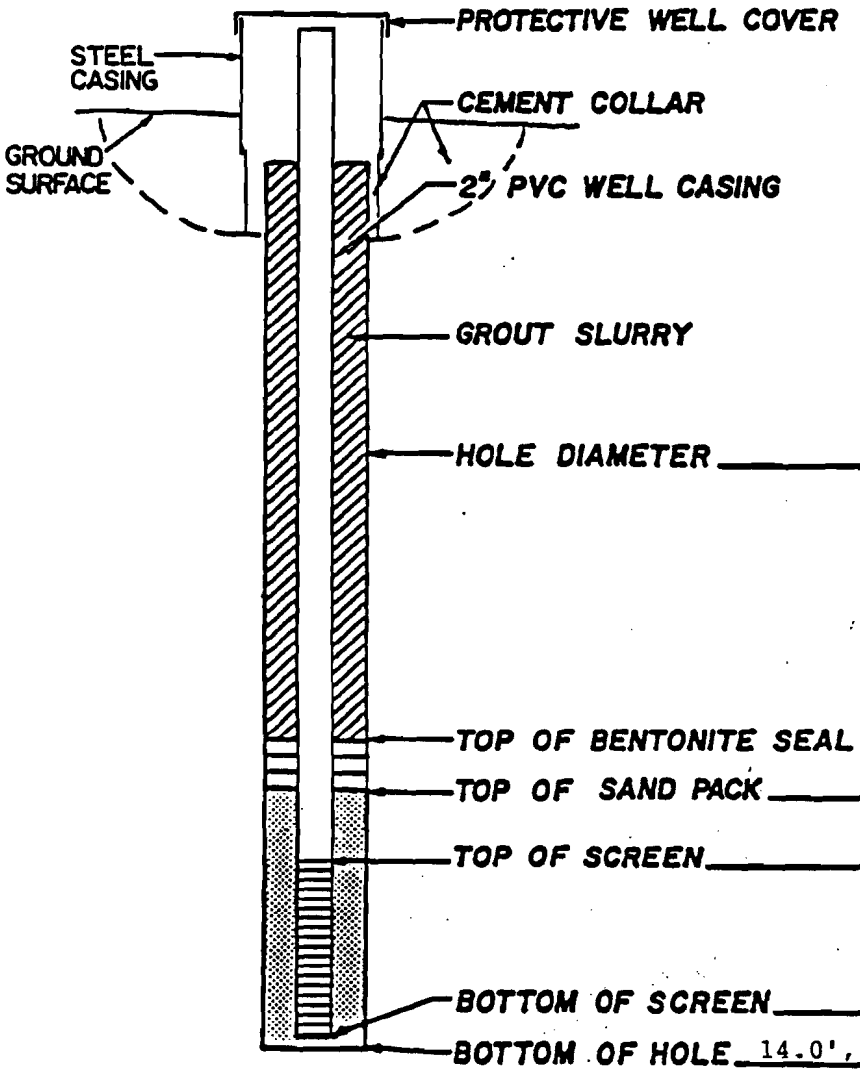
MCI/CONSULTING ENGINEERS, INC.
NASHVILLE KNOXVILLE HUNTSVILLE LOUISVILLE

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-420 **DATE INSTALLED:** 3-23-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



HOLE DIAMETER: 6 5/8"

TOP OF BENTONITE SEAL: ~1.55'

TOP OF SAND PACK: ~2.75'

TOP OF SCREEN: 3.85'

BOTTOM OF SCREEN: 13.75'

BOTTOM OF HOLE: 14.0', 13.75' after caving

BEDROCK LEVEL: _____

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-421

DATE 5-1-87

DRILLER - Highland

MAP NUMBER N/A

HELPER

RIG Ing. Rand RD-10

H. P.

STATIC WATER LEVEL Not measured

LOGGED BY T. Sturdivant

LOCATION Bear Creek Valley

PLANT COORDINATES N E

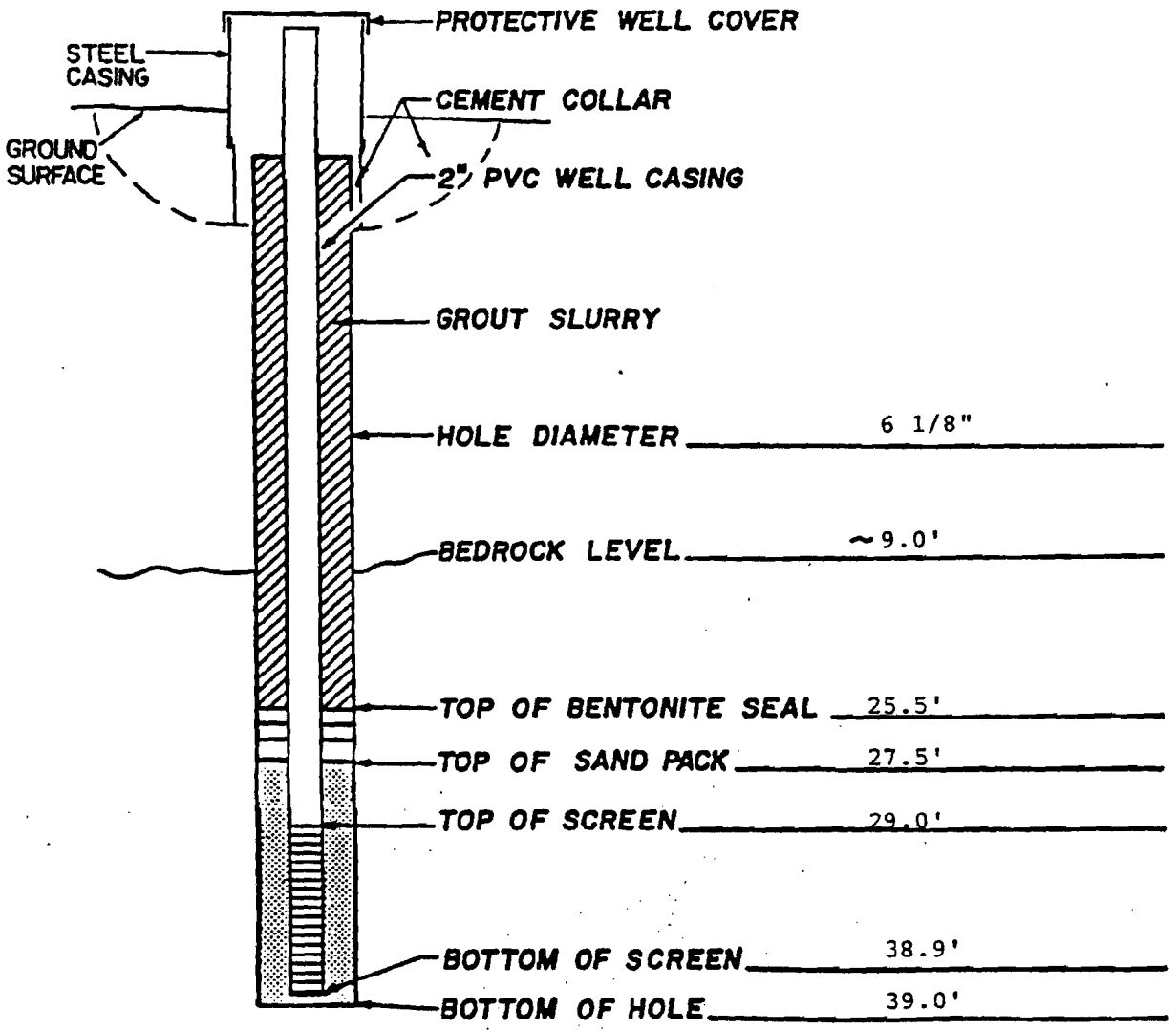
DEPTH	(FT)	DESCRIPTION	
8	10	Oolitic and non-oolitic chart	lt. to med. brown
10	15	med. dk. to lt gray limestone, micrite to minor chert, orange brown	fine grained intra-clastic
15	20	Same as above	
20	23.5	Same as above	
23.5	26	cavity	
26	30	Same as above	
30	35	Same as above	
35	39	Same as above with minor coarse grained limestone cavity at ~ 38'	

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-421 DATE INSTALLED: 5-1-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

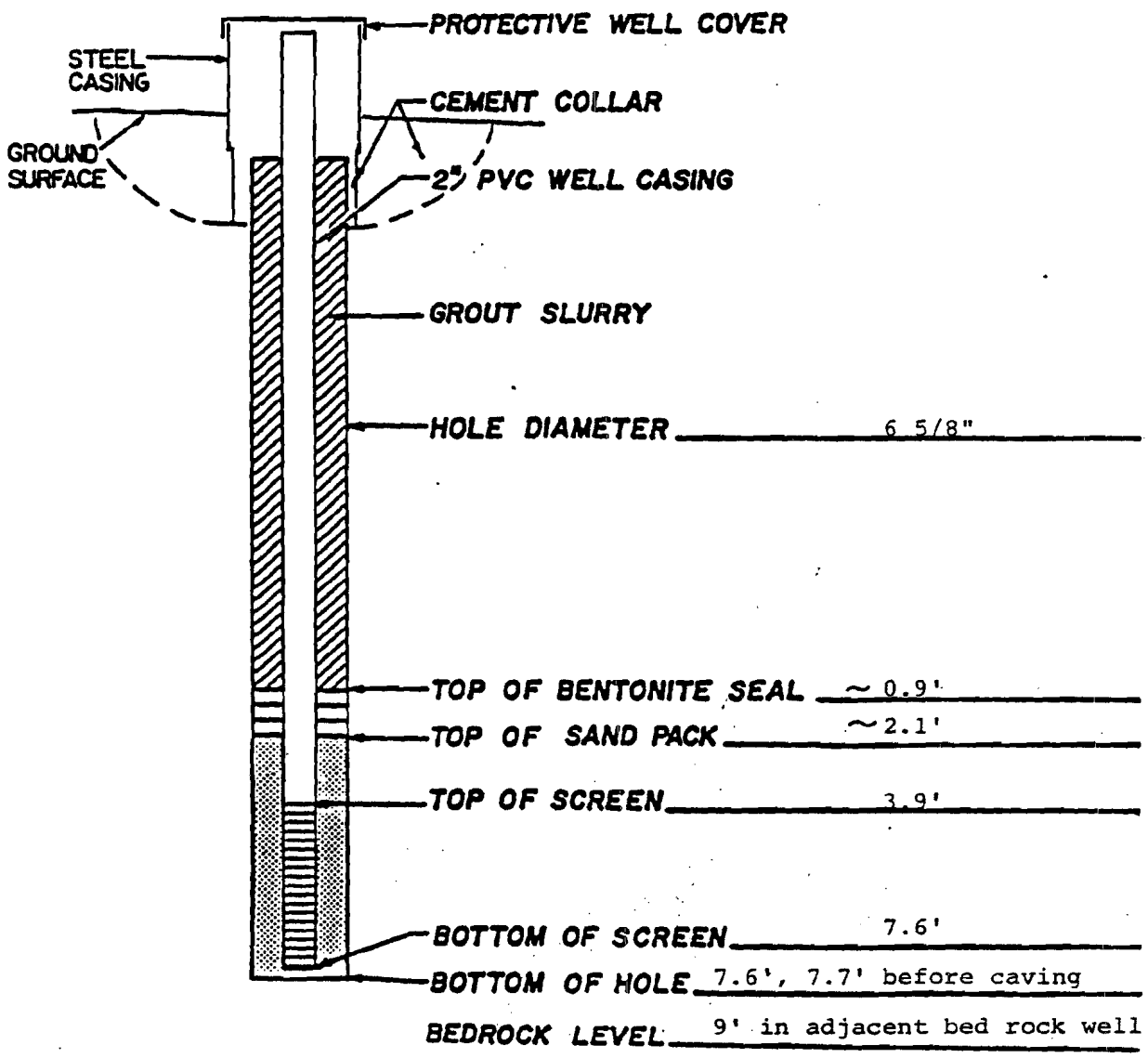
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-422 DATE INSTALLED: 5-20-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-423

DATE 5-6-87

DRILLER Highland

MAP NUMBER N/A

HELPER

RIG Ing. Rand RD-10

H. P.

STATIC WATER LEVEL Not measured

LOGGED BY T. Sturdivant

LOCATION Bear Creek Valley

PLANT COORDINATES N E

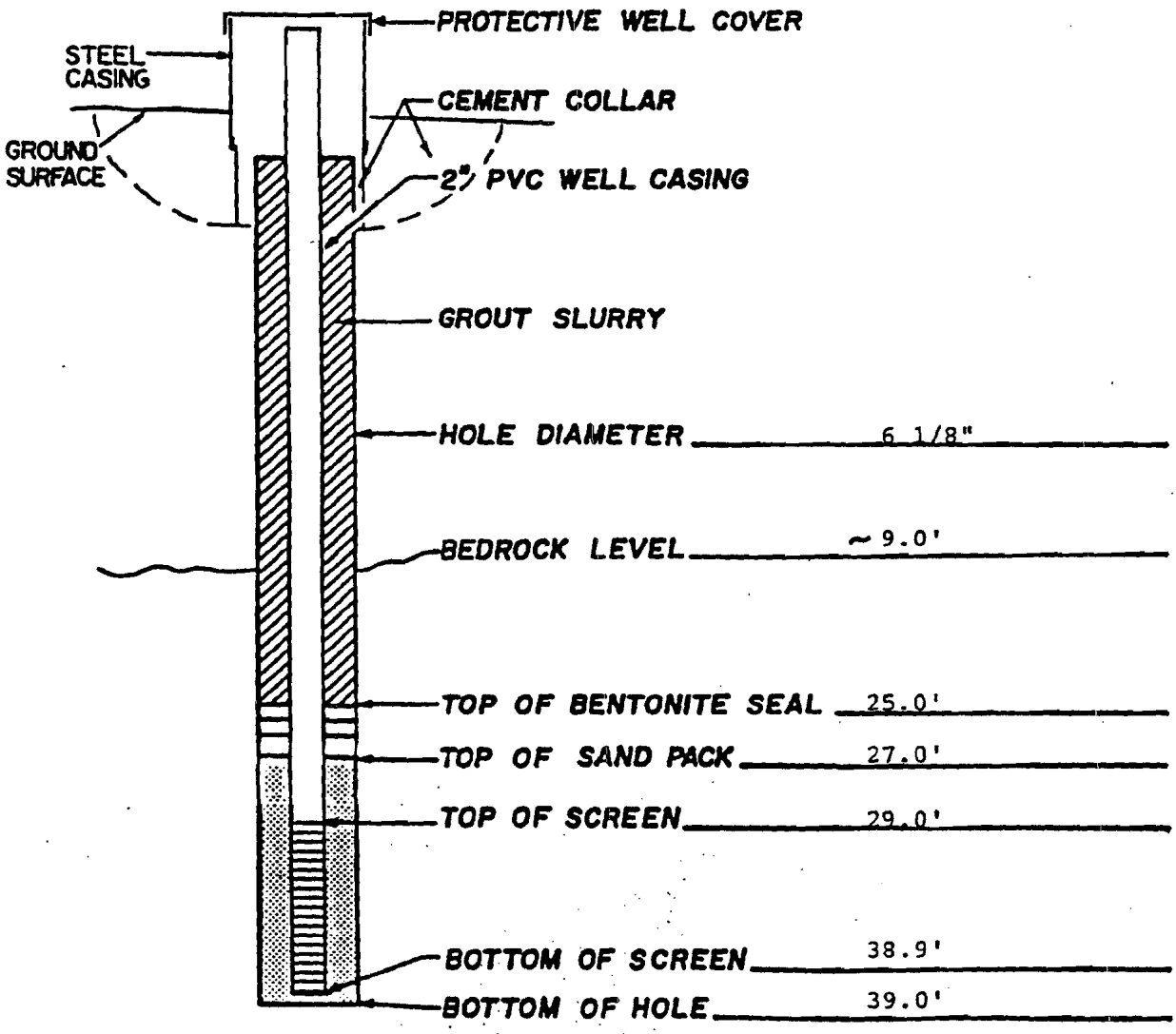
DEPTH	(FT)	DESCRIPTION
9	14	Med. gray limestone with minor calcite
14	19	Same as above with some weathering
19	24	Same as above
24	29	Med. to dk. gray limestone with minor calcite
29	34	Same as above with micrite
34	39	Same as above

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-423 DATE INSTALLED: 5-6-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:

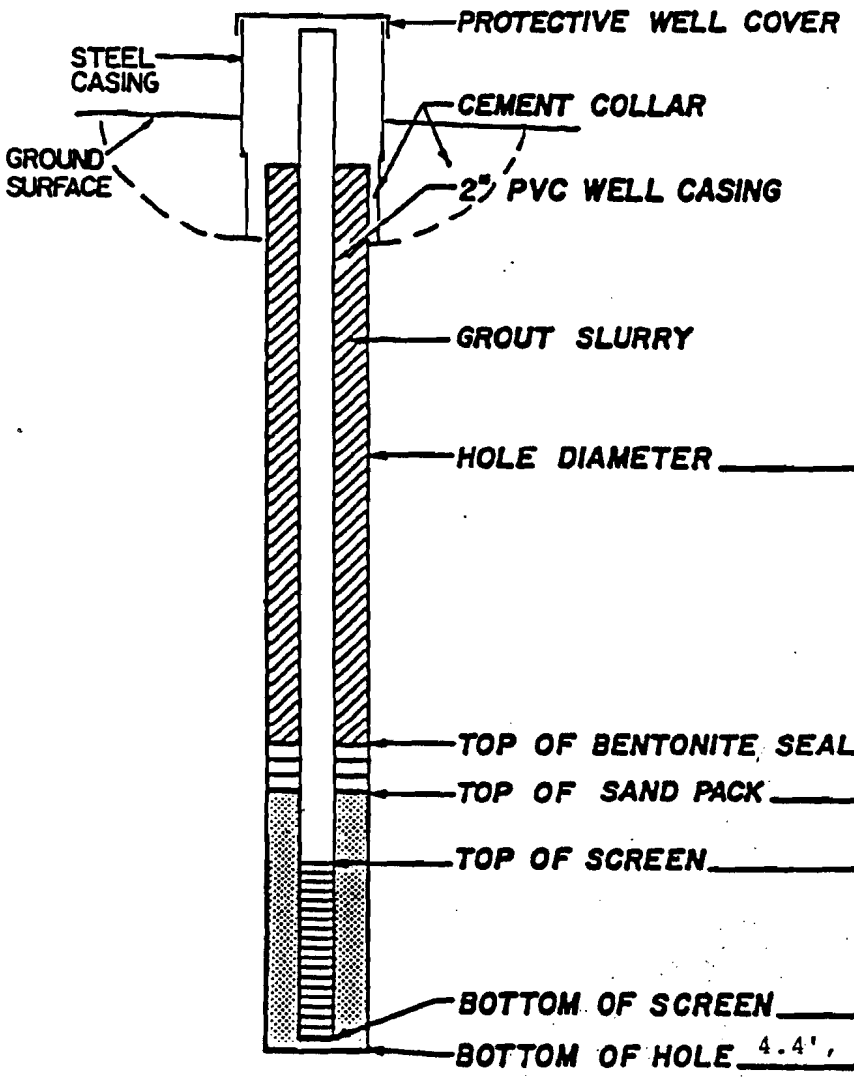


NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-424 **DATE INSTALLED:** 5-21-87
MAP NO. Bear Creek
LOCATION NORTH: _____ **EAST:** _____



HOLE DIAMETER 6 5/8"

TOP OF BENTONITE SEAL ~1.8'

TOP OF SAND PACK ~3.0'

TOP OF SCREEN 3.4'

BOTTOM OF SCREEN 4.4'

BOTTOM OF HOLE 4.4', 4.5' before caving

BEDROCK LEVEL 9' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-~~434~~ 425

DATE 3/11/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

MADE ~ 25-30 GALLON IN 30 MINUTES.

DEPTH	(FT)	DESCRIPTION
0	2.5	REDDISH BROWN SILTY LOAM
2.5	5	TAN-LAVENDER-OLIVE SHALE SAPROLITE
5	10	SAME AS ABOVE
10	15	LT.BROWN CLAY WITH MINOR SHALE SAPROLITE
15	20	LT. ORANGE BROWN CLAY WITH MINOR CHIPS OF SHALE SAPROLITE
20	23.5	SAME AS ABOVE
23.5	30	LT. OLIVE BROWN SHALE SAPROLITE AND MINOR AMOUNTS OF LT. GRAY TO OLIVE MICRITE LIMESTONE AND CRYSTALLINE DK. GRAY LIMESTONE SOME OLIVE SHALE SAPROLITE
30	35	LT. BROWN TO GRAY MICRITE
35	40	WEATHERED BROWN TO GRAY LIMESTONE
40	45	SAME AS ABOVE
45	50	LT. GRAY TO LT. BROWN MICRITE LIMESTONE - AND MINOR OLIVE SHALE SAPROLITE
50	55	SAME AS ABOVE WITH DARK GRAY SHALE AND MED. GRAY CRYSTALLINE LIMESTONE
55	60	LT. GRAY MICRITE TO FINE GRAINED LIMESTONE WITH MEDIUM GRAY CRYSTALLINE LIMESTONE WITH Fe STAINS, VERY LITTLE GREEN SHALE SAPROLITE

WELL NUMBER: GW-~~424~~ 425
PAGE 2
3-11-87

ATTACHMENT

3/11/87 LOST CIRCULATION
AT 50 FEET FOLLOWING ROD CHANGE
DRILLING WITH AIR ONLY, GROUND
HEAVED AND CRACKED WITH MUD
SPEWING OUT. PULLED OFF
HOLE FOR THE DAY.

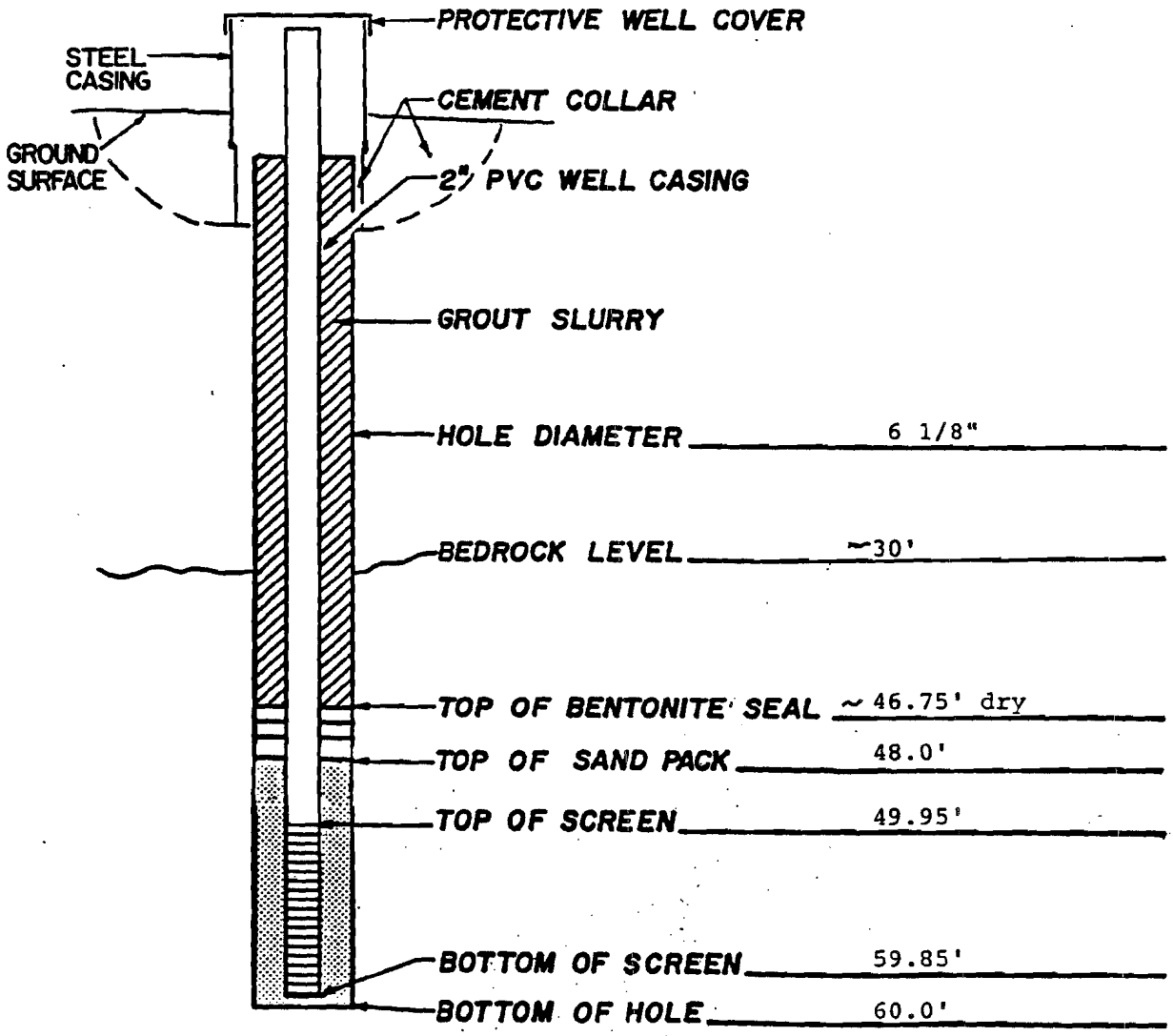
3/12/87 OBTAINED WATER TRUCK AND
DRILLED 10 MORE FEET WITH CIRCULATION
- WATER WAS VERY MUDDY BUT CLEARED
SOME. COMPLETED HOLE WITH NO PROBLEM.

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-~~[illegible]~~ 425 **DATE INSTALLED:** 3-12-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

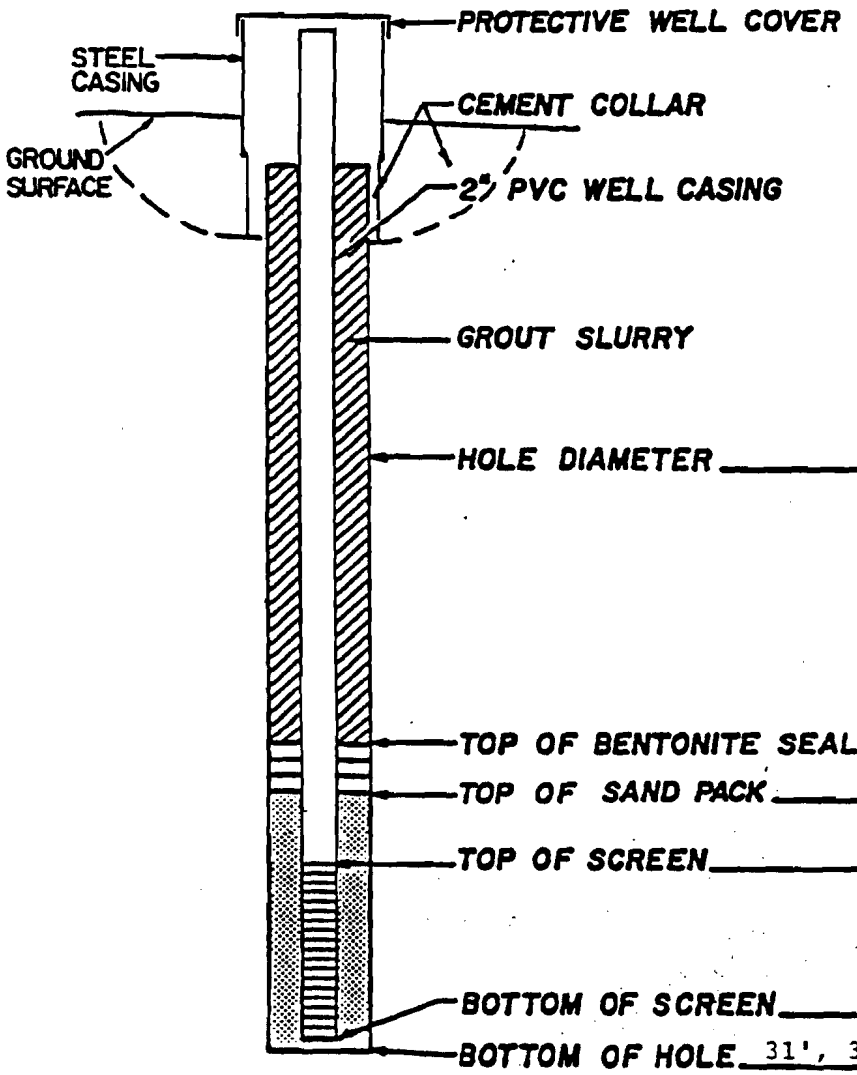
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-426 DATE INSTALLED: 3-23-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



HOLE DIAMETER 6 5/8"

TOP OF BENTONITE SEAL ~18.8'

TOP OF SAND PACK ~20.0'

TOP OF SCREEN 21.1'

BOTTOM OF SCREEN 31.0'

BOTTOM OF HOLE 31', 31.3' before caving

BEDROCK LEVEL 30' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-427

DATE 5-11-87

DRILLER Highland

MAP NUMBER N/A

HELPER

RIG Ing. Rand RD-10

H. P.

STATIC WATER LEVEL Not measured

LOGGED BY T. Sturdivant

LOCATION Bear Creek Valley

PLANT COORDINATES N E

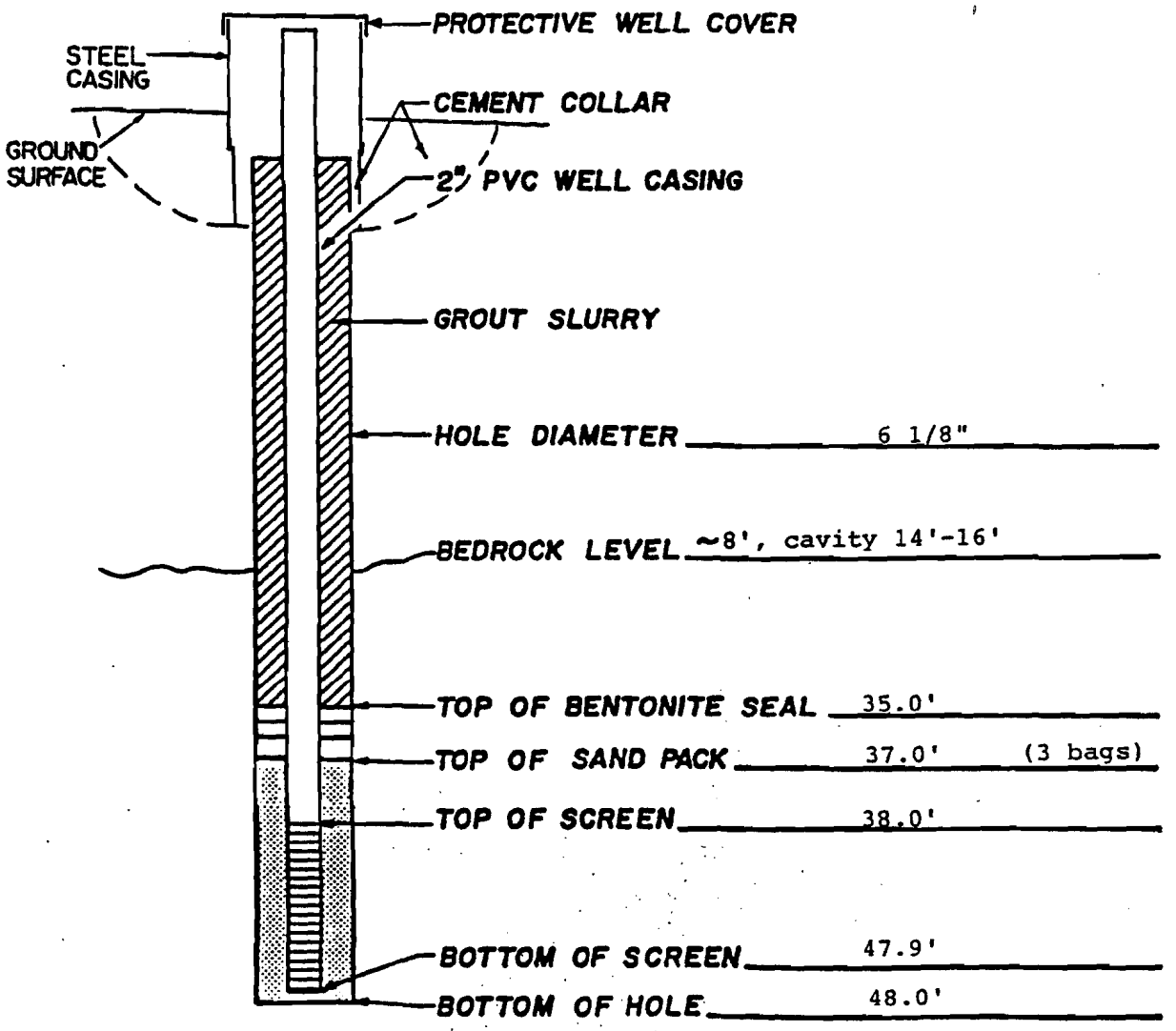
DEPTH	(FT)	DESCRIPTION
5		lt. brown to reddish brown chert
	10	and med. brown sandstone
10	14	lt. brownish gray limestone with minor chert
14	16	cavity
16	20	very lt. gray crystalline limestone
20		dark gray crystalline limestone with
	25	light mottling
25	30	Same as above
30	35	very lt. gray limestone and very dark gray limestone
30	35	very lt. gray to med. gray limestone
35	40	Same as above, mostly med. gray
40	45	med. gray limestone with minor lt. gray limestone
45	48	A mixture of all of the above-cavity encountered

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-427 **DATE INSTALLED:** 5-11-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND. Cavity at bottom lots H_2O

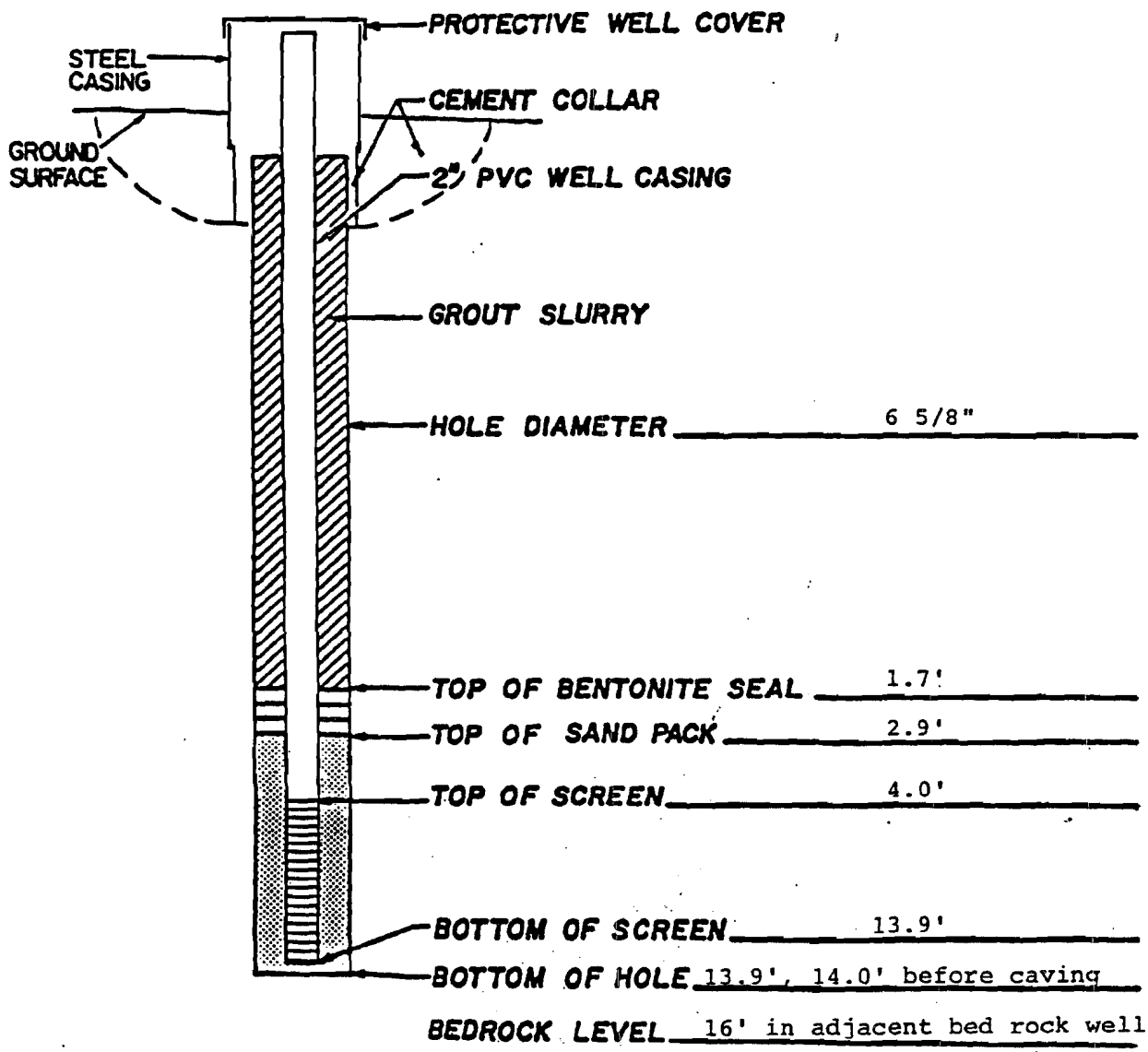
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-428 **DATE INSTALLED:** 5-20-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

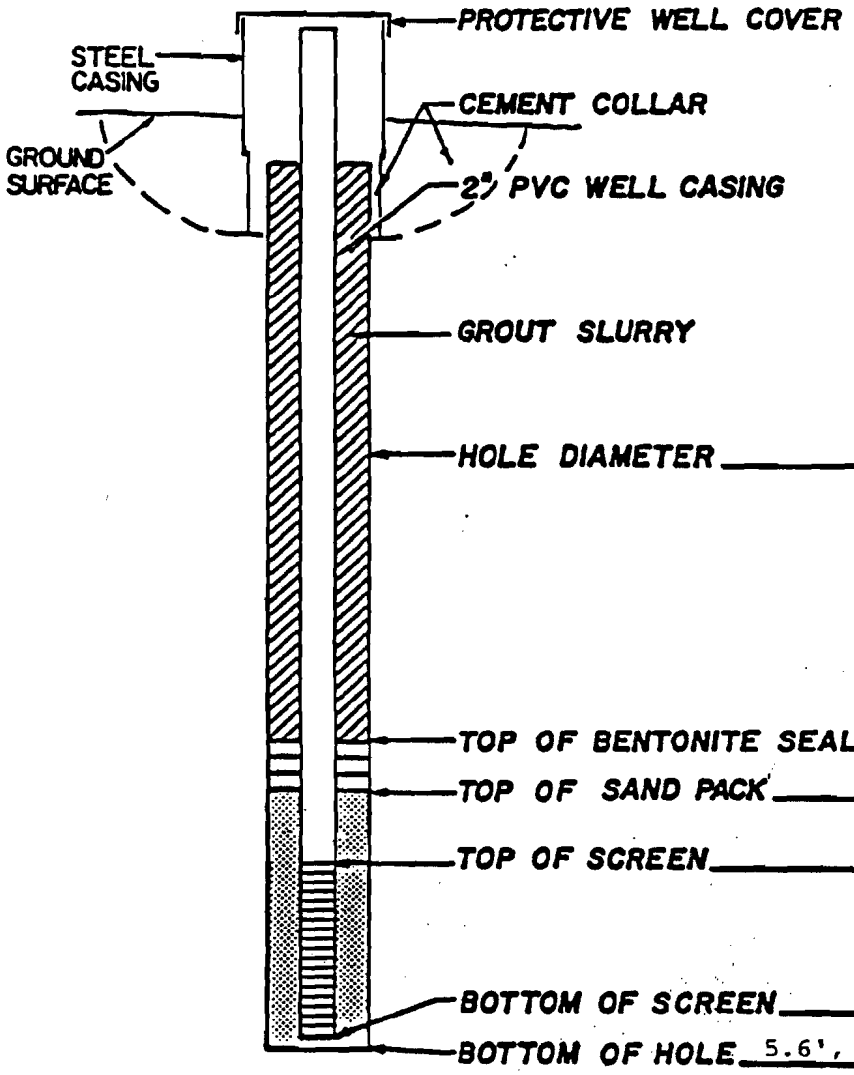
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-429 DATE INSTALLED: 3-23-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



TOP OF BENTONITE SEAL ~0.3'

TOP OF SAND PACK ~ 1.5'

TOP OF SCREEN 1.6'

BOTTOM OF SCREEN 5.6'

BOTTOM OF HOLE 5.6', 5.9' before caving

BEDROCK LEVEL 8' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-~~439~~ 430

DATE 3/13/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

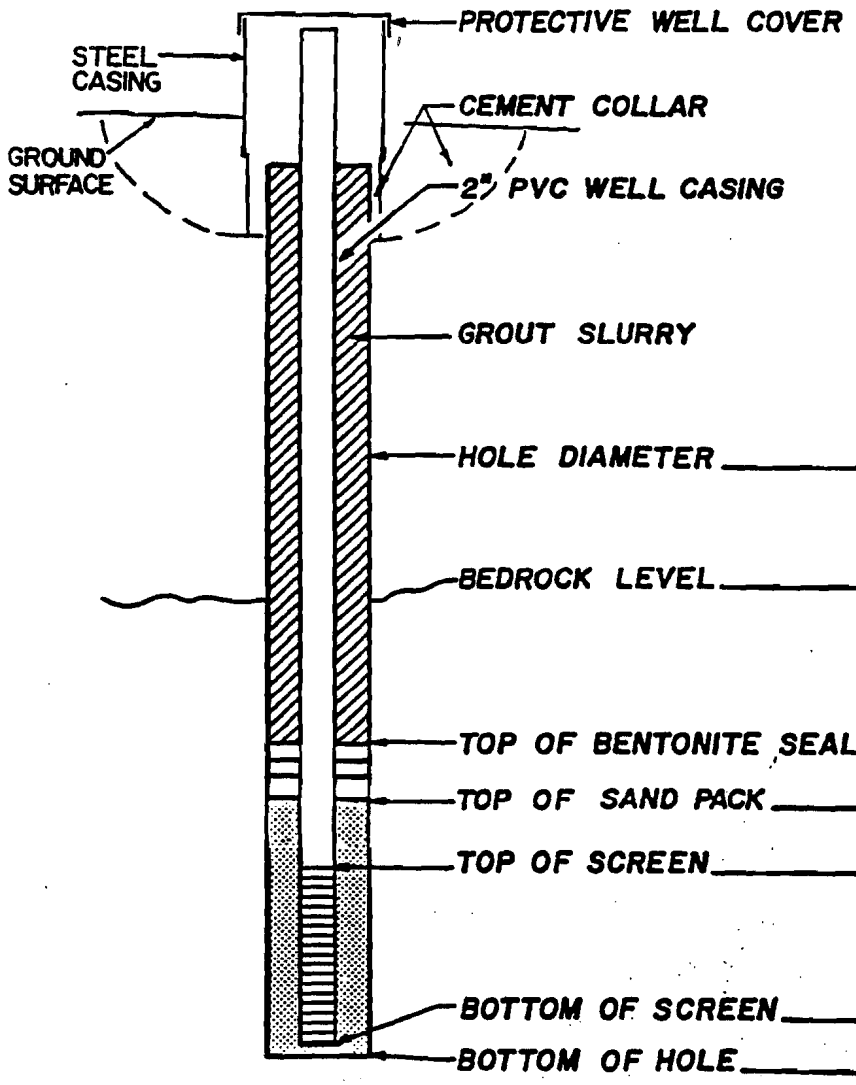
DEPTH	(FT)	DESCRIPTION
0	2	MED. BROWN SILT LOAM
2	5	MED. DARK GRAY TO OLIVE GRAY SHALE SAPROLITE WITH LT. BROWN, HARD SILTSTONE FRAGMENTS
5	10	MED. GRAY SHALE SLIGHT GREEN CAST
10	15	SAME AS ABOVE WITH CALCITE VEINS
15	17	SAME AS ABOVE
17	20	SAME WITH 50% DARK GRAY CRYSTALLINE LIMESTONE AND GRAY BLUE SHALE, Fe STAINS
20	22	SAME AS ABOVE
22	23	GREENISH GRAY SHALE WITH 50% Fe STAINED
23	26	50% GREEN SHALE WITH Fe STAINS, 50% MED. TO DARK GRAY CRYSTALLINE LIMESTONE
26	30	MED. GREENISH GRAY SHALE
30	31	SAME AS ABOVE WITH 5% OOLITIC LIMESTONE WITH CALCITE VEINS
32	35	50% GREENISH GRAY SHALE, 50% MAROON GRAY SHALE SOME CALCITE VEINS
35	36	60% OOLITIC MED. GRAY LIMESTONE 50% GREEN GRAY SHALE, 10% RED SHALE
36	37	50% GREEN GRAY SHALE 50%, MAROON GRAY SHALE MINOR CALCITE VEINS
37	38.2	SAME AS ABOVE WITH 10% LT. TO MED. GRAY OOLITIC CRYSTALLINE LIMESTONE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-~~429~~ 430 **DATE INSTALLED:** 3-13-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

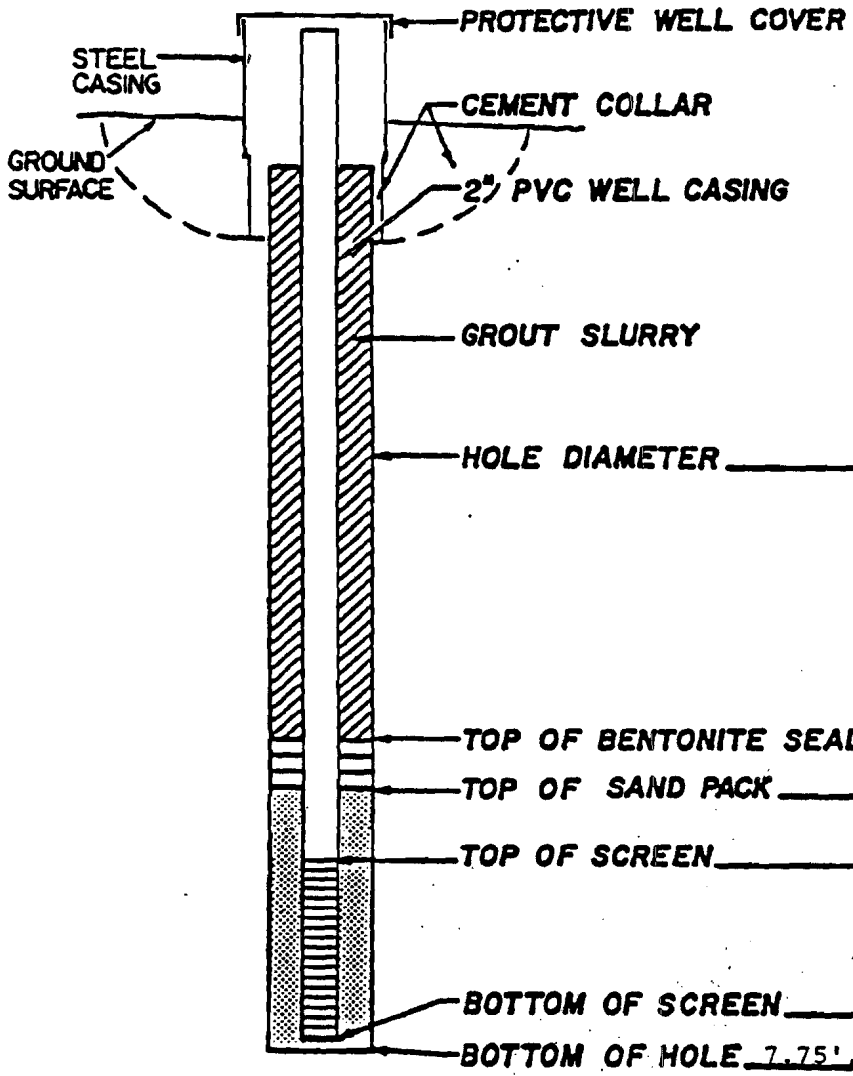
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-431 DATE INSTALLED: 3-38-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



HOLE DIAMETER 6 5/8"

TOP OF BENTONITE SEAL ~ 0

TOP OF SAND PACK ~ .75'

TOP OF SCREEN .75'

BOTTOM OF SCREEN 7.75'

BOTTOM OF HOLE 7.75', 9.0' before caving

BEDROCK LEVEL 10' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-~~[illegible]~~ 432

DATE 3/26/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

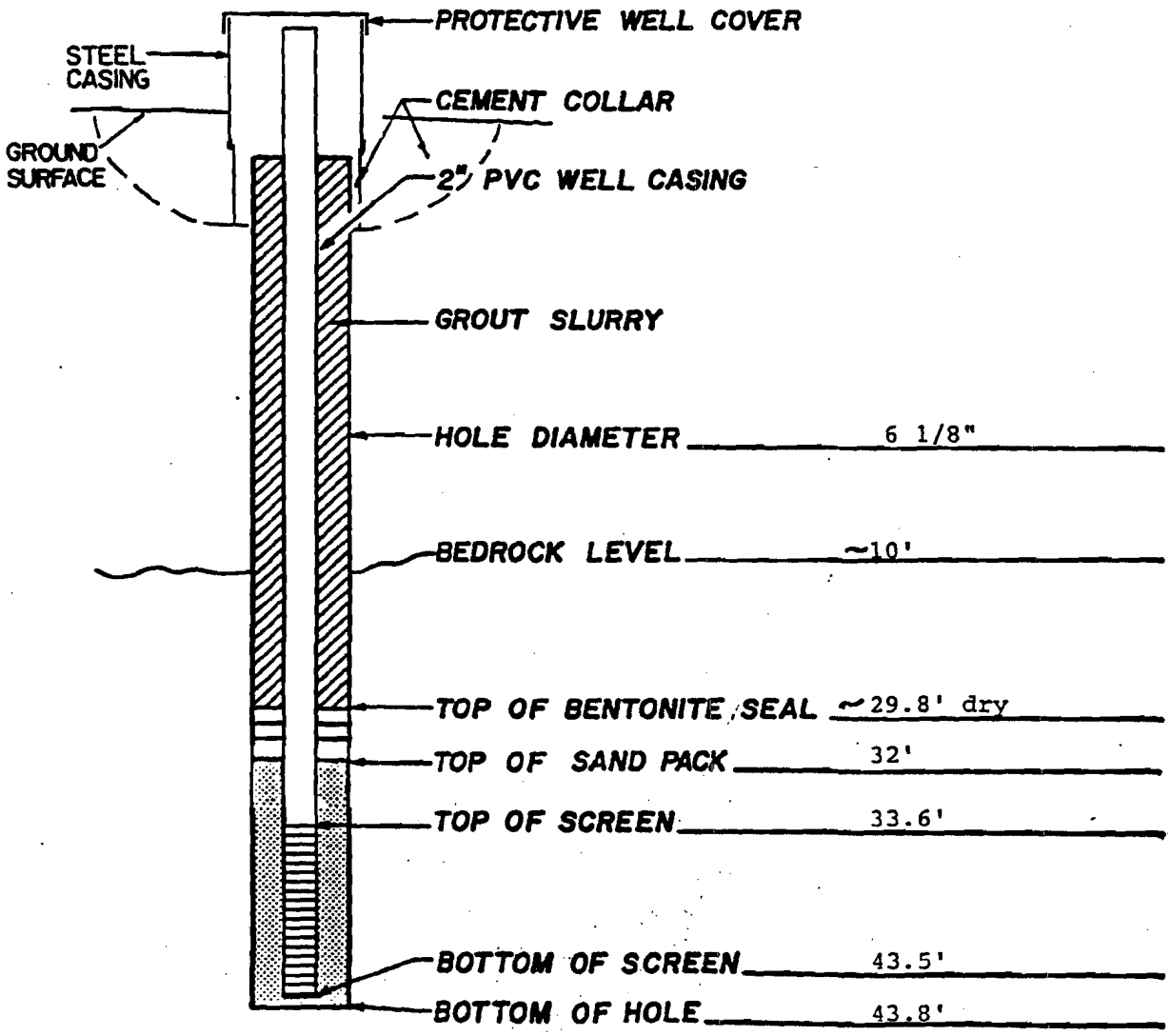
DEPTH	(FT)	DESCRIPTION
10	15	GREENISH GRAY SILTSTONE,
		SOME WITH LT. GRAY LIMESTONE
		LAMINAE
	15	MINOR AMOUNTS OF LT. GRAY SHALE
		MINOR CALCITE VEINS
15	20	LT. GRAY SHALE
20	30	50% LT. GRAY SHALE, 50% GREEN GRAY
		SILTSTONE - CALCITE VEINS
30	43.8	SAME AS ABOVE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-432 DATE INSTALLED: 3-26-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-~~433~~ 434

DATE 3/27/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

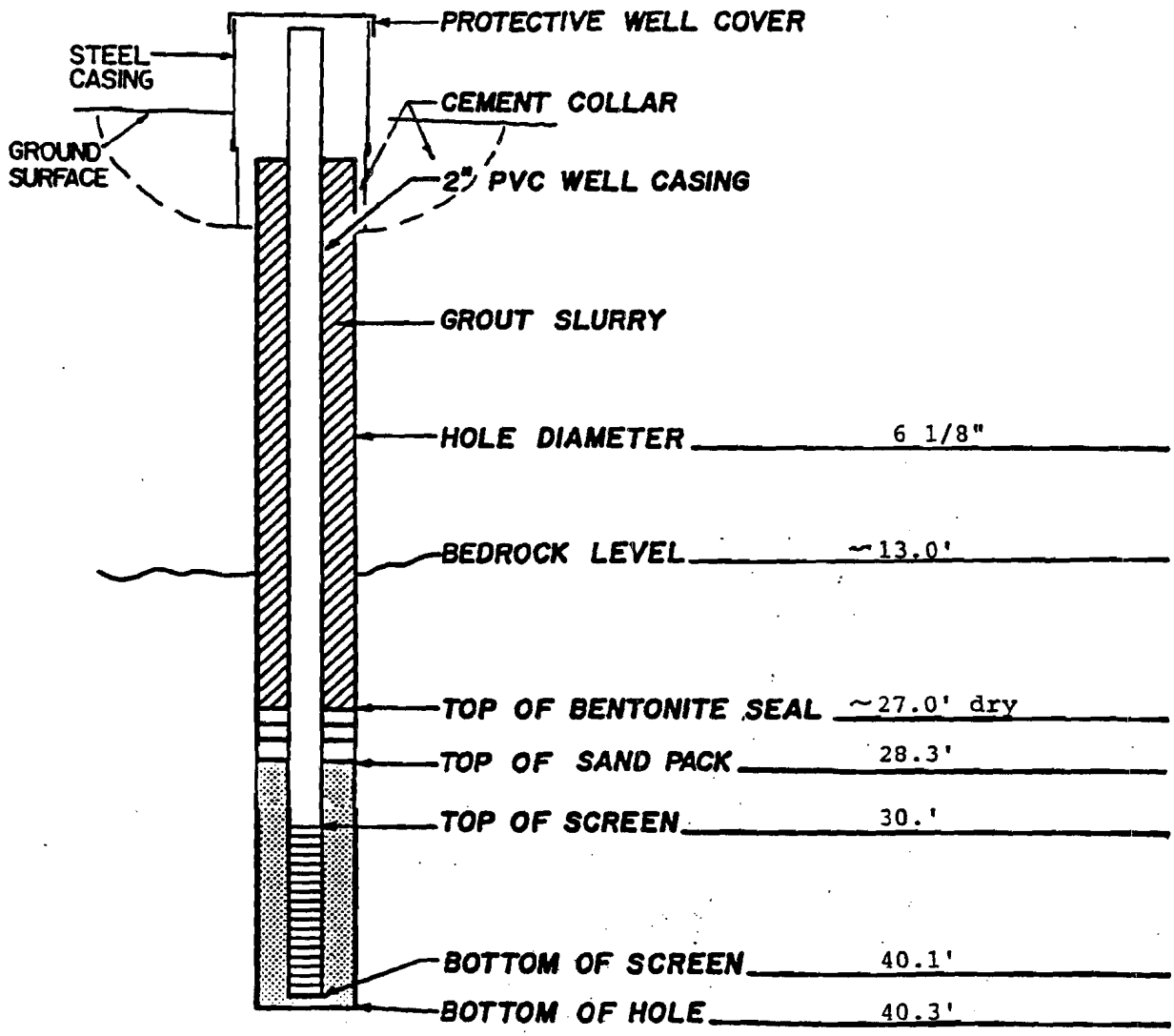
DEPTH	(FT)	DESCRIPTION
10	15	MAROON BROWN SHALE
15	20	GREEN GRAY SILTSTONE AND SHALE, MAROON BROWN SHALE
20	25	GREENISH GRAY SHALE WITH MINOR SILTSTONE LAMINAE
25	30	GREENISH GRAY SILTSTONE AND SHALE, MAROON GRAY SHALE
30	40.3	SAME AS ABOVE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-~~433~~ 434 DATE INSTALLED: 3-27-87

MAP NO. Bear Creek

LOCATION NORTH: _____ EAST: _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

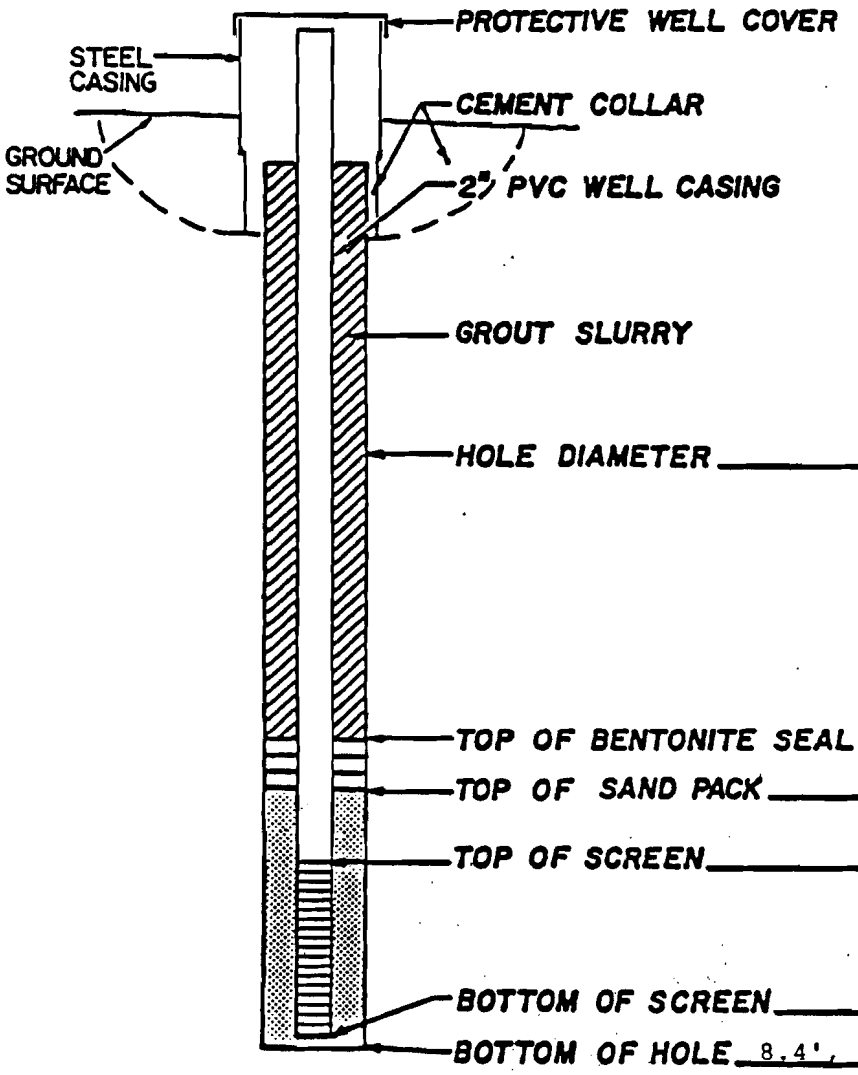
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-435 **DATE INSTALLED:** 3-25-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



HOLE DIAMETER 6 5/8"

TOP OF BENTONITE SEAL ~0.35'

TOP OF SAND PACK ~1.55'

TOP OF SCREEN 3.4'

BOTTOM OF SCREEN 8.4'

BOTTOM OF HOLE 8.4', 9.0' before caving

BEDROCK LEVEL 13' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-~~435~~ 436

DATE 3/20/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

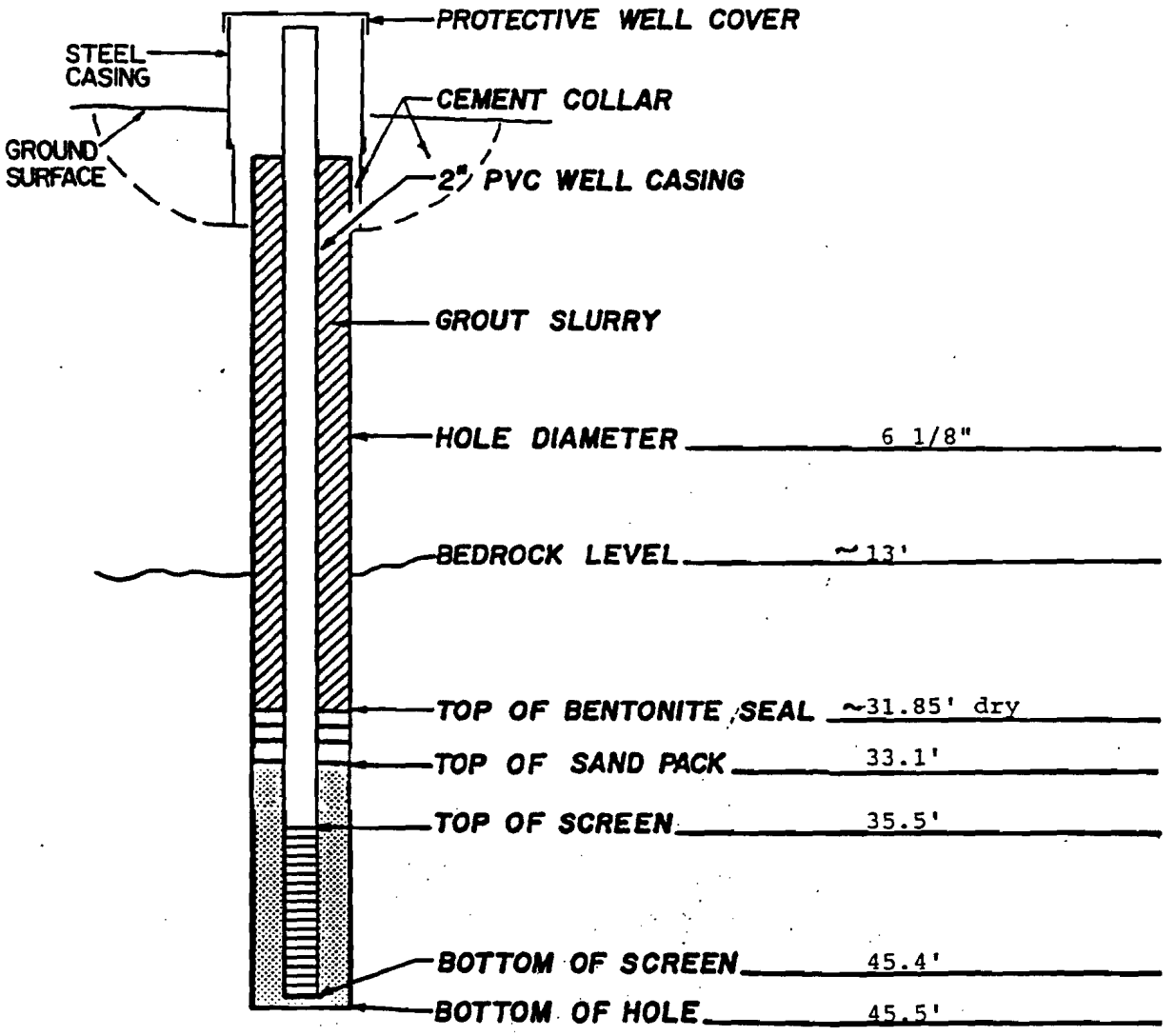
DEPTH	(FT)	DESCRIPTION
		BED ROCK AT 13'
13	20	MED. GREENISH GRAY SHALE, 10% LT. BROWN GRAY LIMESTONE
20	25	BLUISH GREENISH GRAY SHALE AND MED. GRAY SHALE, MINOR CALCITE VEINS
25	30	SAME AS ABOVE
30	35	SAME AS ABOVE
35	40	MED. SLIGHT GREEN GRAY SHALE WITH MINOR LT. TO MED. GRAY MICRITE
40	45.5	SAME AS ABOVE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-436 **DATE INSTALLED:** 3-20-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

437

WELL LOG

WELL NUMBER GW-[redacted]

DATE 3/17/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

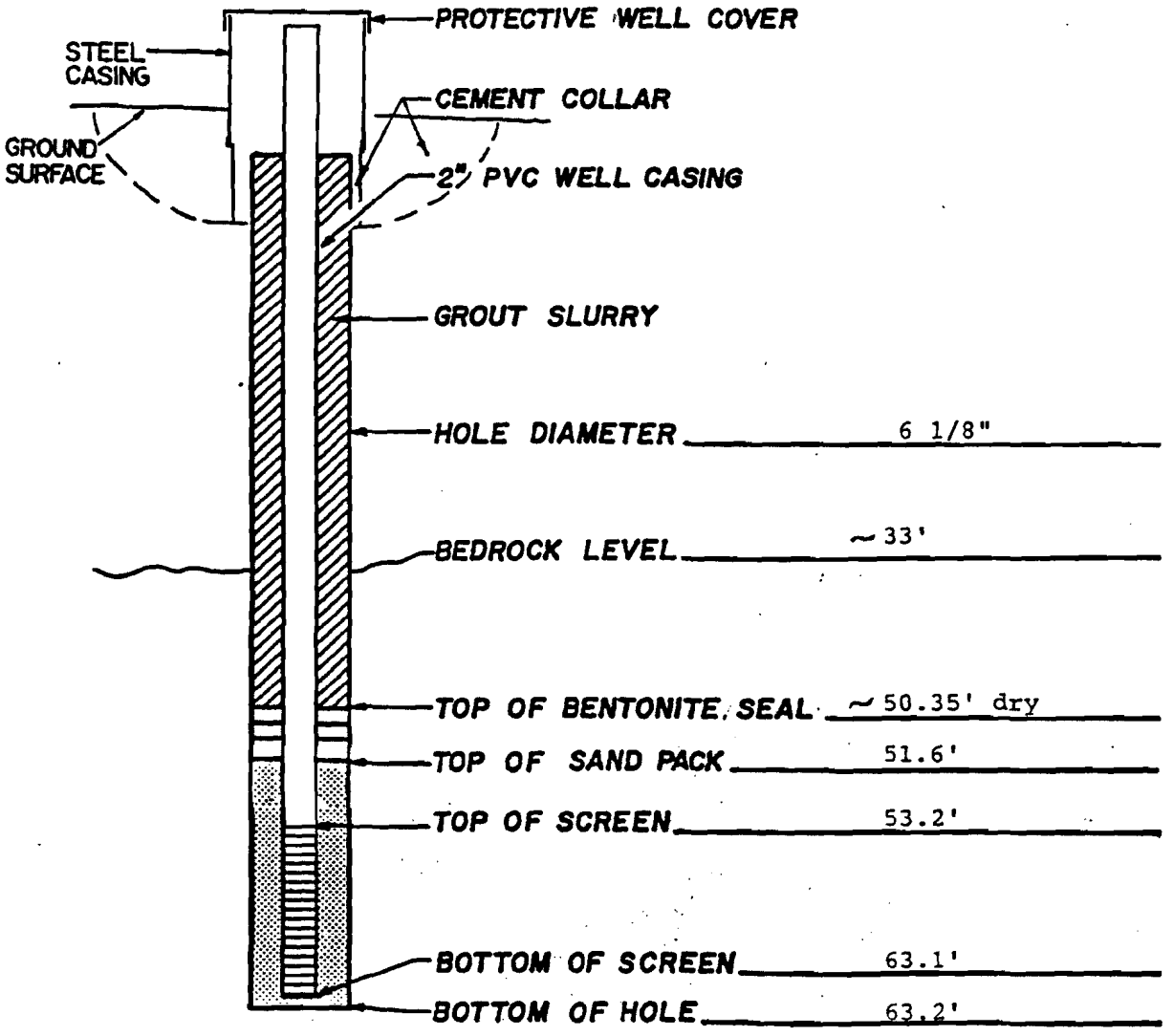
DEPTH	(FT)	DESCRIPTION
0	20	BROWN SOIL TO DARK RED BROWN SOIL WITH GREEN SHALE SAPROLITE
20	25	LT. BROWN TO OLIVE GRAY SHALE AND SILTSTONE WITH MUCH Fe STAIN
25	33	SAME AS ABOVE
33	35	MED. GREENISH GRAY SHALE, 30% LT. TO MED. GRAY MICRITE TO FINE GRAINED LIMESTONE
35	40	SAME AS ABOVE EXCEPT 20% LIMESTONE WITH CALCITE VEINS
40	45	MED. GRAY SHALE, 20% LT. TO MED. GRAY CRYSTALLINE LIMESTONE
45	50	SAME AS ABOVE EXCEPT <10% LIMESTONE
50	55	SAME AS ABOVE WITH CALCITE VEINS
55	60	SAME AS ABOVE
60	63.2	SAME AS ABOVE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-~~436~~ 437 DATE INSTALLED: 3-17-87

MAP NO. Bear Creek

LOCATION NORTH: _____ EAST: _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

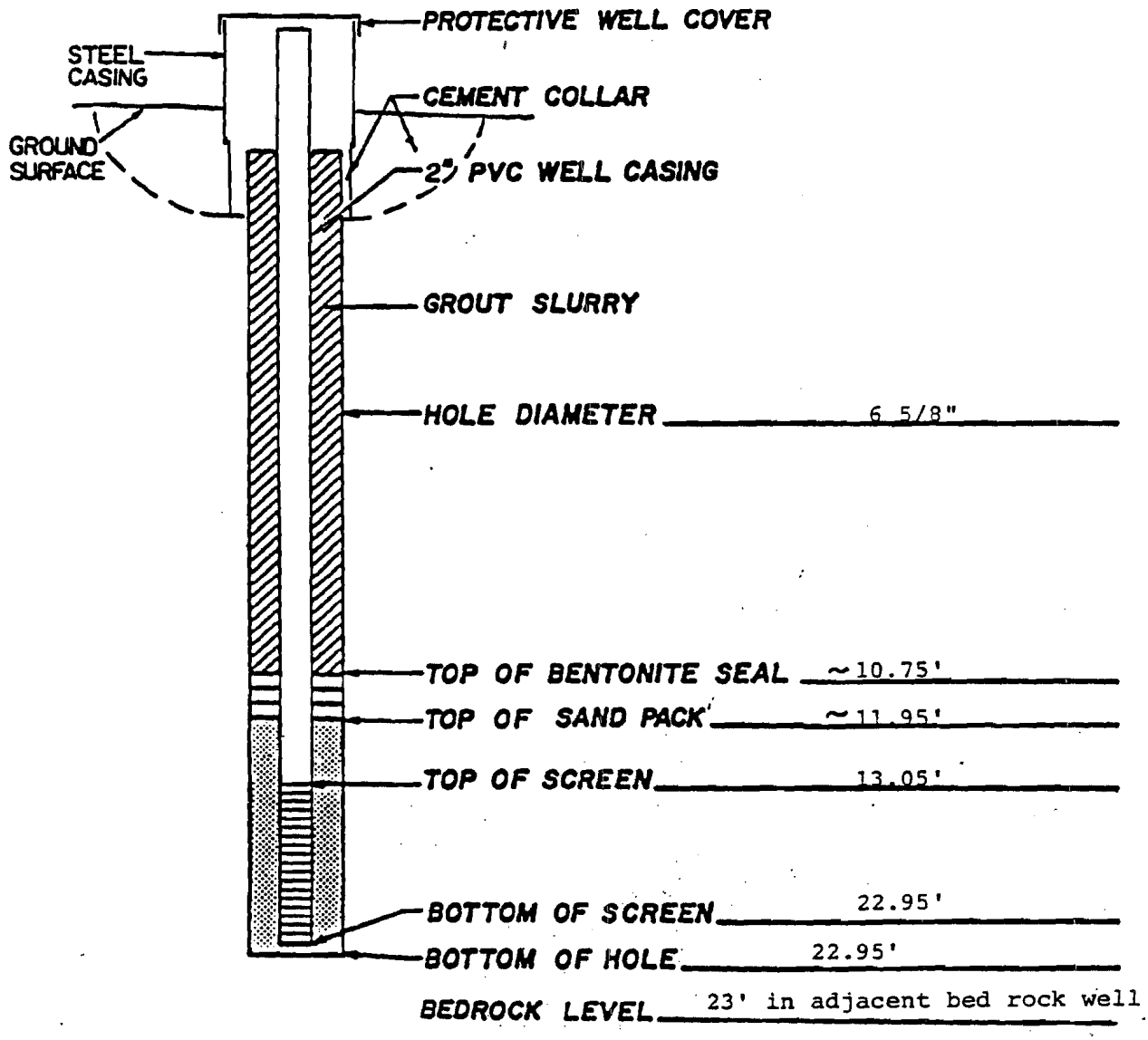
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-438 DATE INSTALLED: 3-23-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-~~438~~ 439

DATE 3/16/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

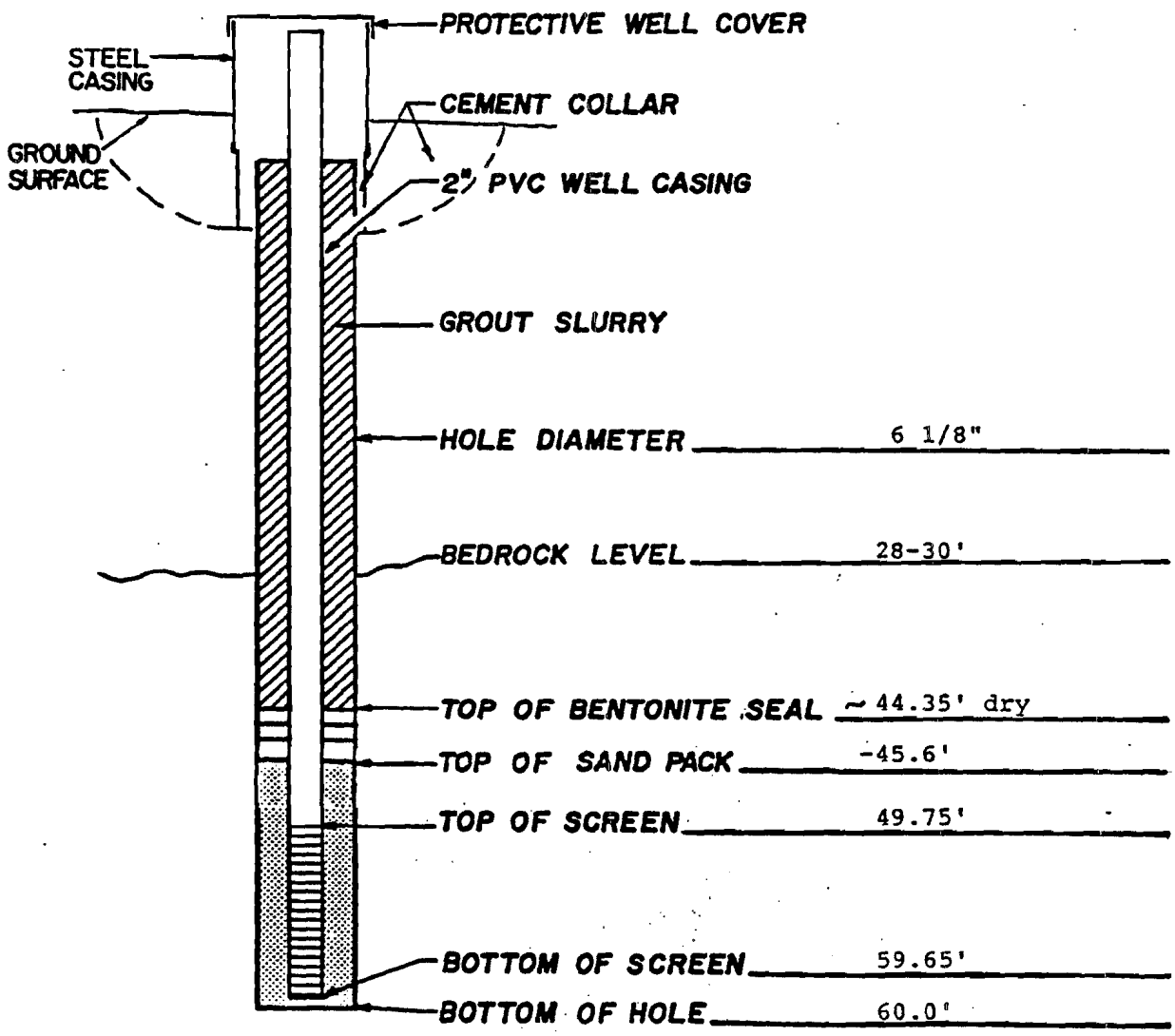
DEPTH	(FT)	DESCRIPTION
5	10	LT. OLIVE GREEN SHALE SAPROLITE AND REDDISH ORANGE CLAY WITH MINOR GREEN MUDSTONE
10	15	SAME AS ABOVE
15	17	LAVENDER SHALE SAPROLITE
17	20	SAME AS 5-10
20	25	LT. OLIVE GRAY SHALE SAPROLITE
25	30	50% MED. GRAY SHALE, 50% GREEN SHALE SAPROLITE FRESH BED ROCK AT 28'
30	35	70% MED. GRAY SHALE, 30% GREEN SHALE MINOR AMOUNTS MED GRAY FINE-GRAINED LIMESTONE WITH CALCITE VEINS
35	39	50% MED. GRAY SHALE, 50% GREEN SHALE MINOR CALCITE VEINS
39	40	LAVENDER GRAY SHALE
40	45	80% LAVENDER GRAY SHALE, 20% GREEN SHALE
45	50	50% GRAY SHALE, 50% GREEN SHALE MINOR MUDSTONE AND FINE-GRAINED LIMESTONE
50	55	SAME AS ABOVE WITH MINOR MED. GRAY SILTY LIMESTONE, MORE CALCITE
55	57	50% MED. GREEN GRAY SILTY LIMESTONE, 50% GRAY TO GREEN SHALE WITH Fe STAINS
57	58	30% LIMESTONE SAME AS ABOVE, 70% GREEN AND GRAY SHALE MINOR Fe STAINS
58	59	50% LAVENDER GRAY SHALE 50% GREEN GRAY SILTY LIMESTONE
59	60	MED. GRAY SHALE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-~~[illegible]~~ 439 **DATE INSTALLED:** 3-16-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

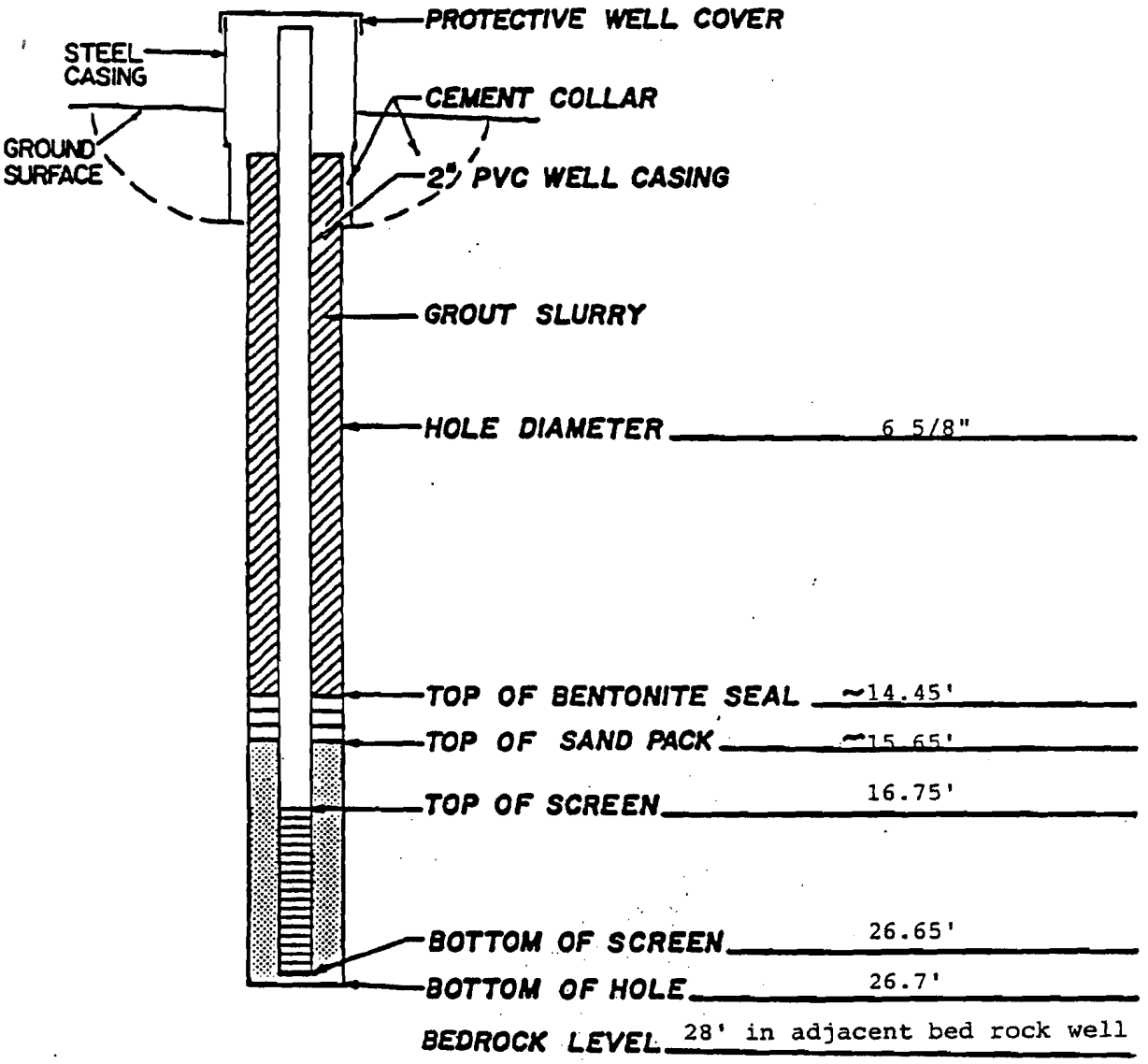
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-440 DATE INSTALLED: 3-23-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-~~[illegible]~~ 441

DATE 3/23/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

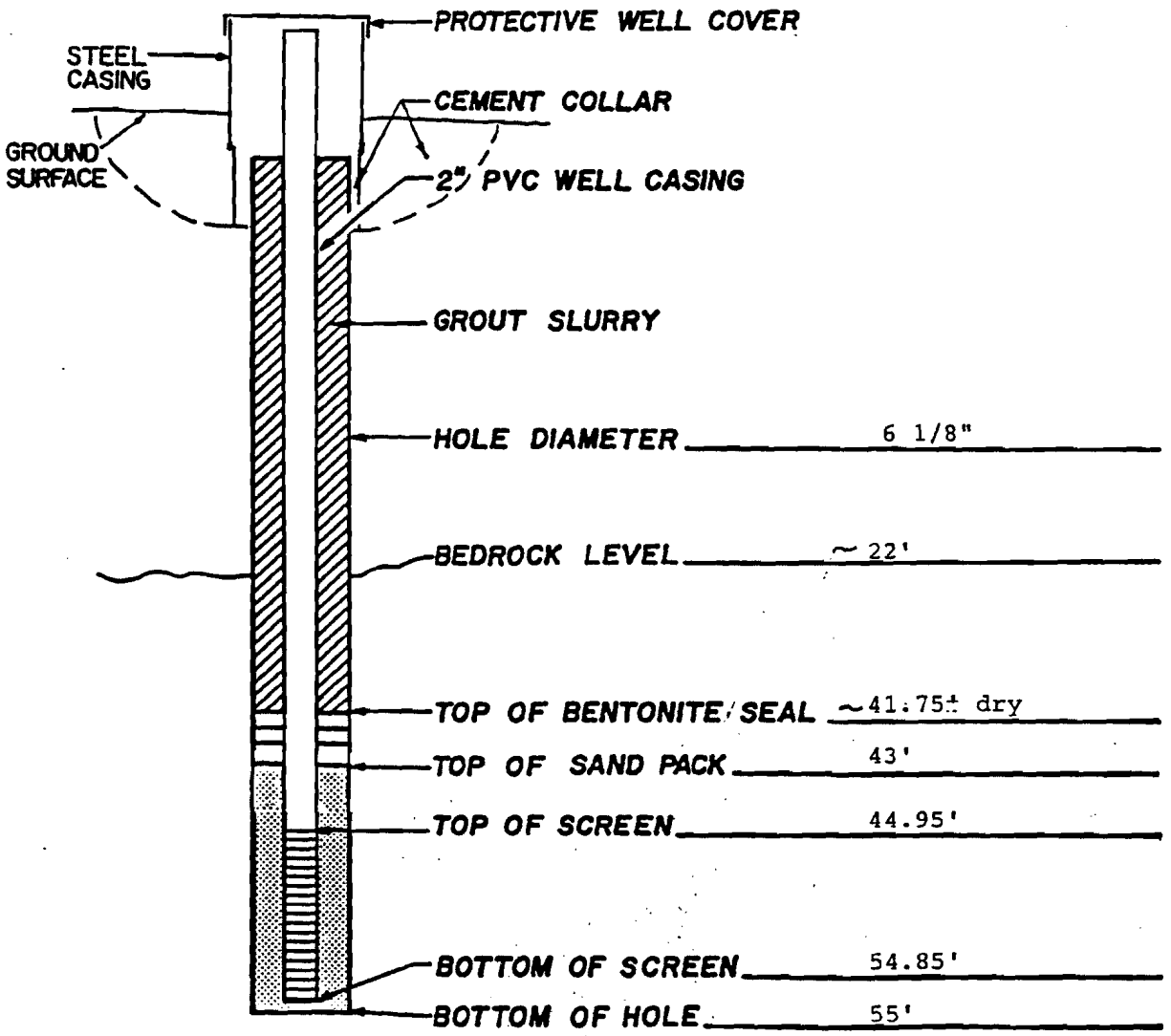
DEPTH	(FT)	DESCRIPTION
22	25	LT. TO MED. GRAY MICRITE LIMESTONE TO FINE-GRAINED CRYSTALLINE LIMESTONE AND PINK CALCITE
25	30	LT. TO MED. GRAY OOLITIC LIMESTONE - WITH CALCITE VEINS, MINOR AMOUNT OF LT. GRAY OOLITIC TO FINE GRAINED LIMESTONE
30	35	LT. GRAY SHALE WITH MINOR AMOUNT OF VERY LT. BROWN GRAY MICRITE LIMESTONE
35	40	SAME AS ABOVE
40	45	SAME AS ABOVE
45	50	SAME AS ABOVE WITH MINOR PINK CALCITE
50	55	SAME AS ABOVE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-441 DATE INSTALLED: 3-23-87

MAP NO. Bear Creek

LOCATION NORTH: _____ EAST: _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

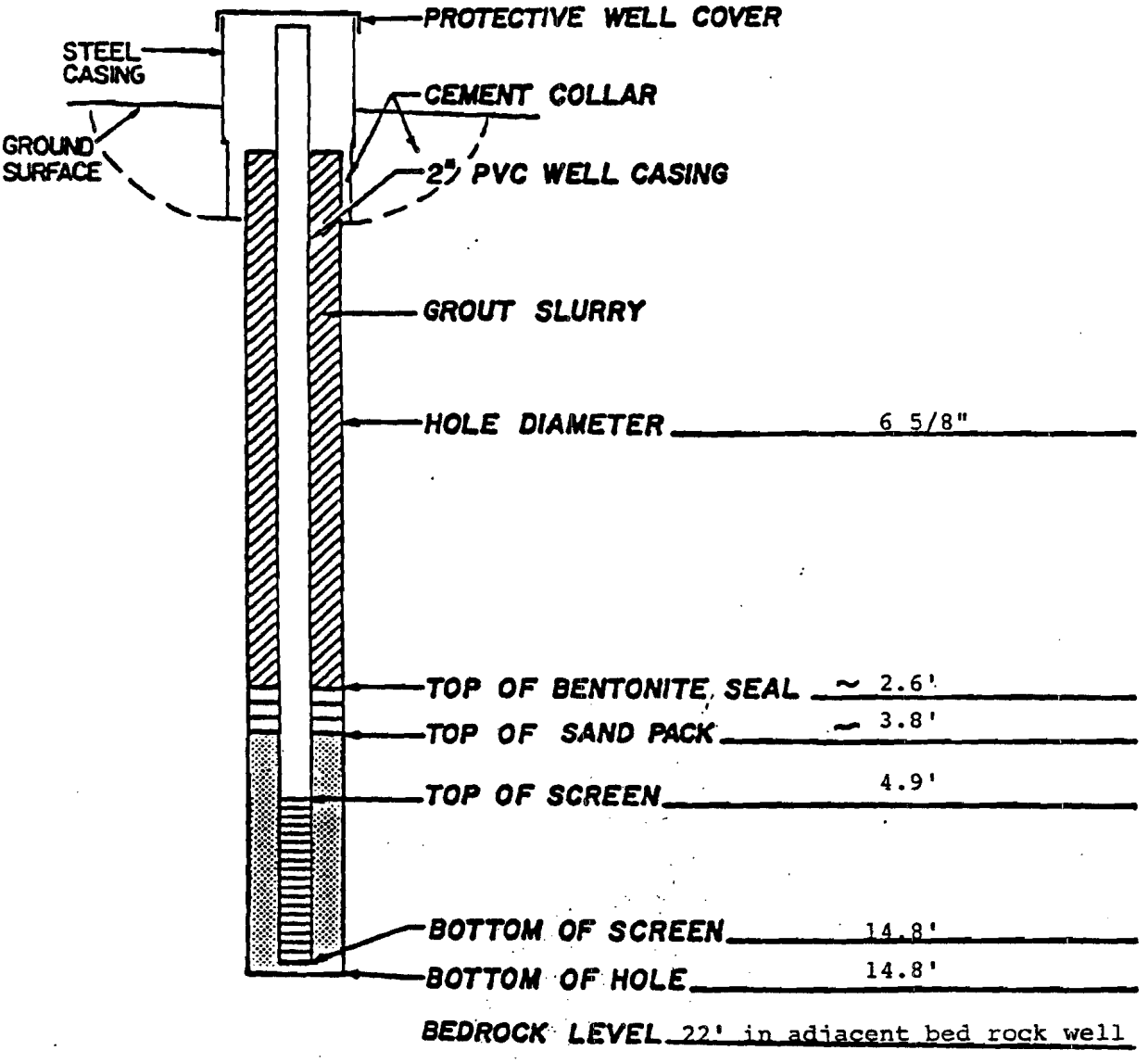
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-442 DATE INSTALLED: 3-24-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

GERAGHTY & MILLER, INC.
Ground-Water Consultants

LITHOLOGIC LOG

BORING NO.	GW-443
PROJECT	Site Characterization

LOCATION	Y-12 PLANT COORDINATES	SURFACE ELEVATION	TOTAL DEPTH
Y-12 Plant, Gum Hollow	NORTH 28, 713.58 EAST 31,880.90	827.75 ft msl	50.0 ft
GEOLOGIST	**SAMPLE INTERVAL**	**SAMPLE TYPE**	**PURPOSE OF BORING**
D. Caldwell	5 ft	Cuttings	Monitor Well
DRILLER	**DRILLING CONTRACTOR**	**DRILLING METHOD**	**RIG TYPE**
G. Ragsdale	Highland Drilling	Air Rotary	Ingersoll-Rand T-4
GEOPHYSICAL CONTRACTOR	**GEOPHYSICAL LOGS**		
None	None		

DEPTH IN FEET	GRAPHIC LOG	DESCRIPTION	COMMENTS
0		CLAY (100%), brown, plastic.	
10		LIMESTONE (100%), micritic to sparry, light to medium gray, oolitic in places, some occasional calcite veins.	
20		15.0' - 42.0' Micritic, light to medium gray, with a trace of calcite veins.	
30			
40		42.0' - 43.0' Clay-filled cavity. 43.0' - 50.0' Micritic to oolitic, occasionally sparry, gray to light gray.	Borehole produced water (~15 gpm) at 42 ft
50			
60			
70			
80			
90			

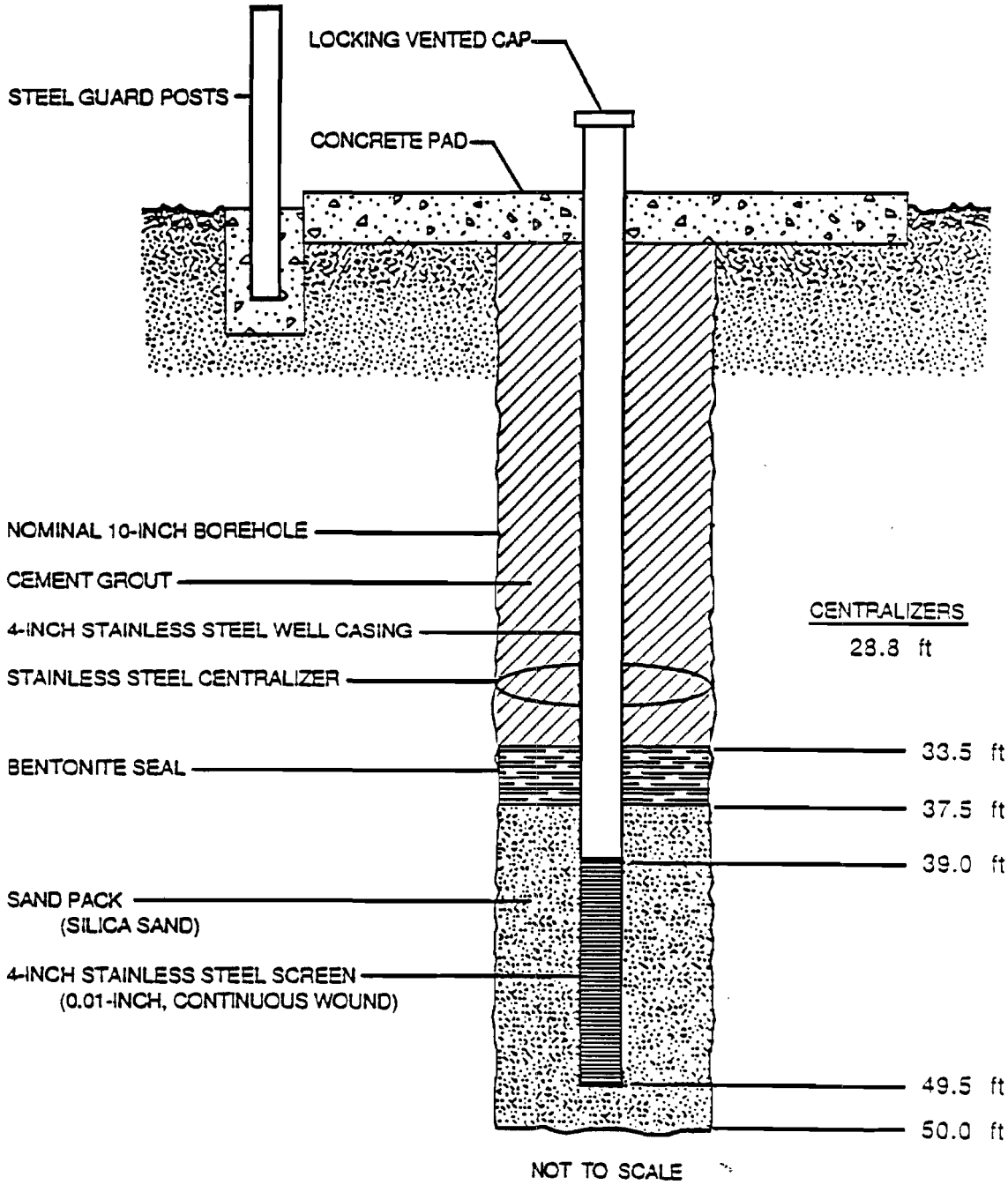
GERAGHTY & MILLER, INC.
Ground-Water Consultants

WELL CONSTRUCTION DIAGRAM

BORING NO. GW-443

PROJECT Site Characterization

LOCATION	Y-12 PLANT COORDINATES	SURFACE ELEVATION	TOP OF CASING ELEVATION
Y-12 Plant, Gum Hollow	NORTH 28, 713.58 EAST 31,880.90	827.75 ft msl	829.37 ft msl
GEOLOGIST	**DRILLING CONTRACTOR**	**DRILLING METHOD**	**RIG TYPE**
D. Caldwell	Highland Drilling	Air Rotary	Ingersoll-Rand T-4
DEVELOPMENT METHOD	**VOLUME EVACUATED**	**DATE WELL COMPLETED**	**FORMATION MONITORED**
Swab/Submersible Pump	26,314 gallons	05-22-87	Maynardville Limestone



NOTE: ALL DEPTH MEASUREMENTS IN FEET BELOW GROUND SURFACE

GERAGHTY & MILLER, INC.
Ground-Water Consultants

LITHOLOGIC LOG

BORING NO. GW-445

PROJECT Site Characterization

LOCATION	Y-12 PLANT COORDINATES	SURFACE ELEVATION	TOTAL DEPTH
Y-12 Plant, Gum Hollow	NORTH 29,250.20 EAST 31,805.46	842.15 ft msl	47.0 ft
GEOLOGIST	**SAMPLE INTERVAL**	**SAMPLE TYPE**	**PURPOSE OF BORING**
G. Weiss/I. Gurney	5 ft	Cuttings	Monitor Well
DRILLER	**DRILLING CONTRACTOR**	**DRILLING METHOD**	**RIG TYPE**
R. Phillips	Highland Drilling	Air Rotary	Ingersoll-Rand T-4
GEOPHYSICAL CONTRACTOR	**GEOPHYSICAL LOGS**		
None	None		

DEPTH IN FEET	GRAPHIC LOG	DESCRIPTION	COMMENTS
0		CLAY (100%), brown, plastic.	
10		LIMESTONE (50%), oolitic, gray, weathered in places, some secondary calcite; shale (50%), maroon and green-gray, silty 7.0' - 16.0' Limestone and shale, weathered.	
20			Borehole produced water (~2-3 gpm) at 22 ft
30		30.0' - 40.0' Shale (70%); limestone (30%).	
40		40.0' - 47.0' Limestone (70%), micritic, argillaceous, olive-gray, some secondary calcite; shale (30%), maroon and green-gray, silty.	Borehole produced water (~5-10 gpm) at 43 ft
50			
60			
70			
80			
90			

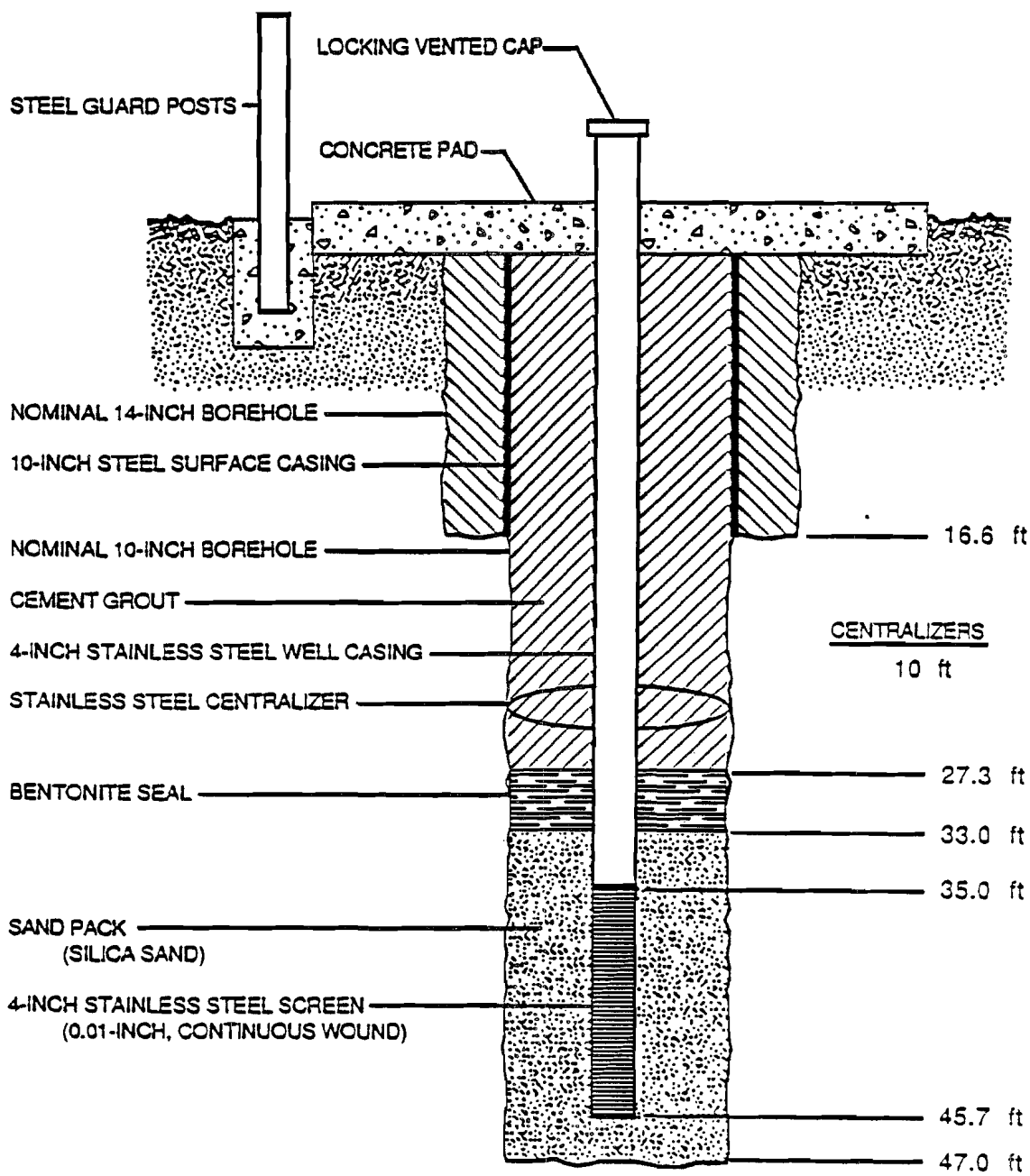
GERAGHTY & MILLER, INC.
Ground-Water Consultants

WELL CONSTRUCTION DIAGRAM

BORING NO. GW-445

PROJECT Site Characterization

LOCATION	Y-12 PLANT COORDINATES	SURFACE ELEVATION	TOP OF CASING ELEVATION
Y-12 Plant, Gum Hollow	NORTH 29,250.20 EAST 31,805.46	842.15 ft msl	846.53 ft msl
GEOLOGIST	**DRILLING CONTRACTOR**	**DRILLING METHOD**	**RIG TYPE**
G. Weiss/I. Gurney	Highland Drilling	Air Rotary	Ingersoll-Rand T-4
DEVELOPMENT METHOD	**VOLUME EVACUATED**	**DATE WELL COMPLETED**	**FORMATION MONITORED**
Swab	1,160 gallons	04-07-87	Nolichucky Shale



NOT TO SCALE

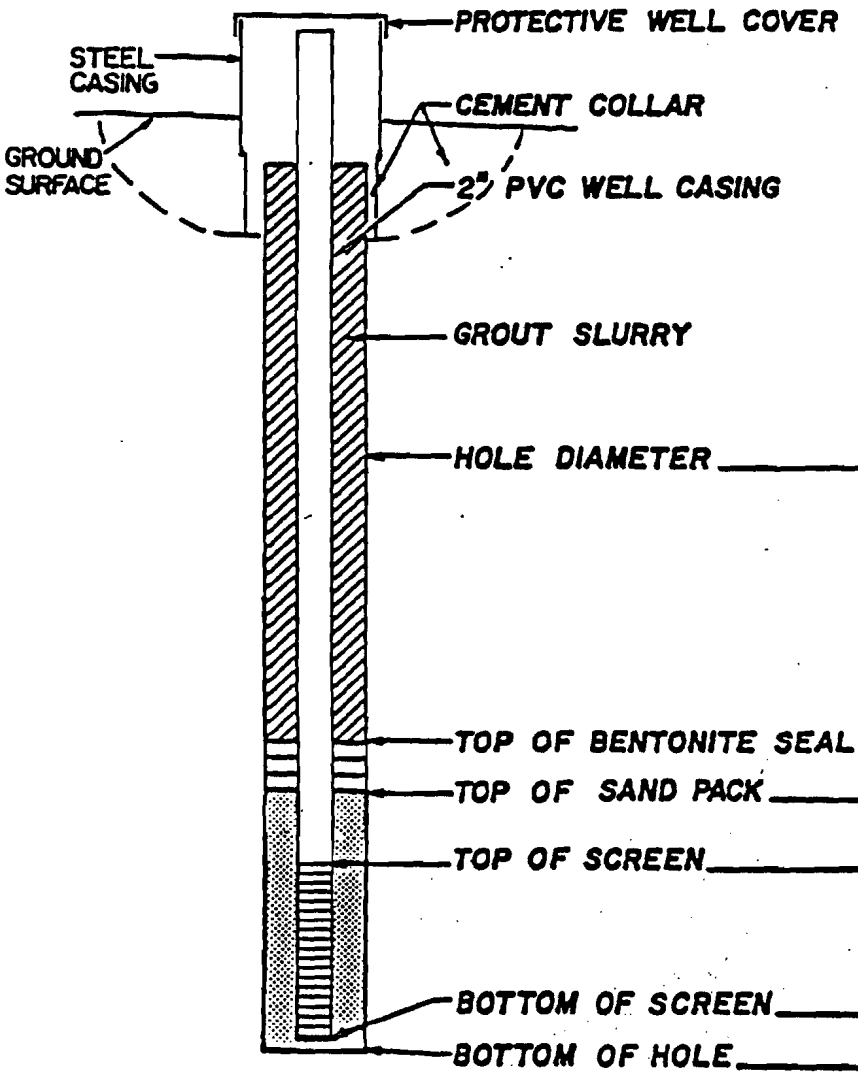
NOTE: ALL DEPTH MEASUREMENTS IN FEET BELOW GROUND SURFACE

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-447 **DATE INSTALLED:** 3-25-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



BEDROCK LEVEL 12'-15' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-448

DATE 3/19/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

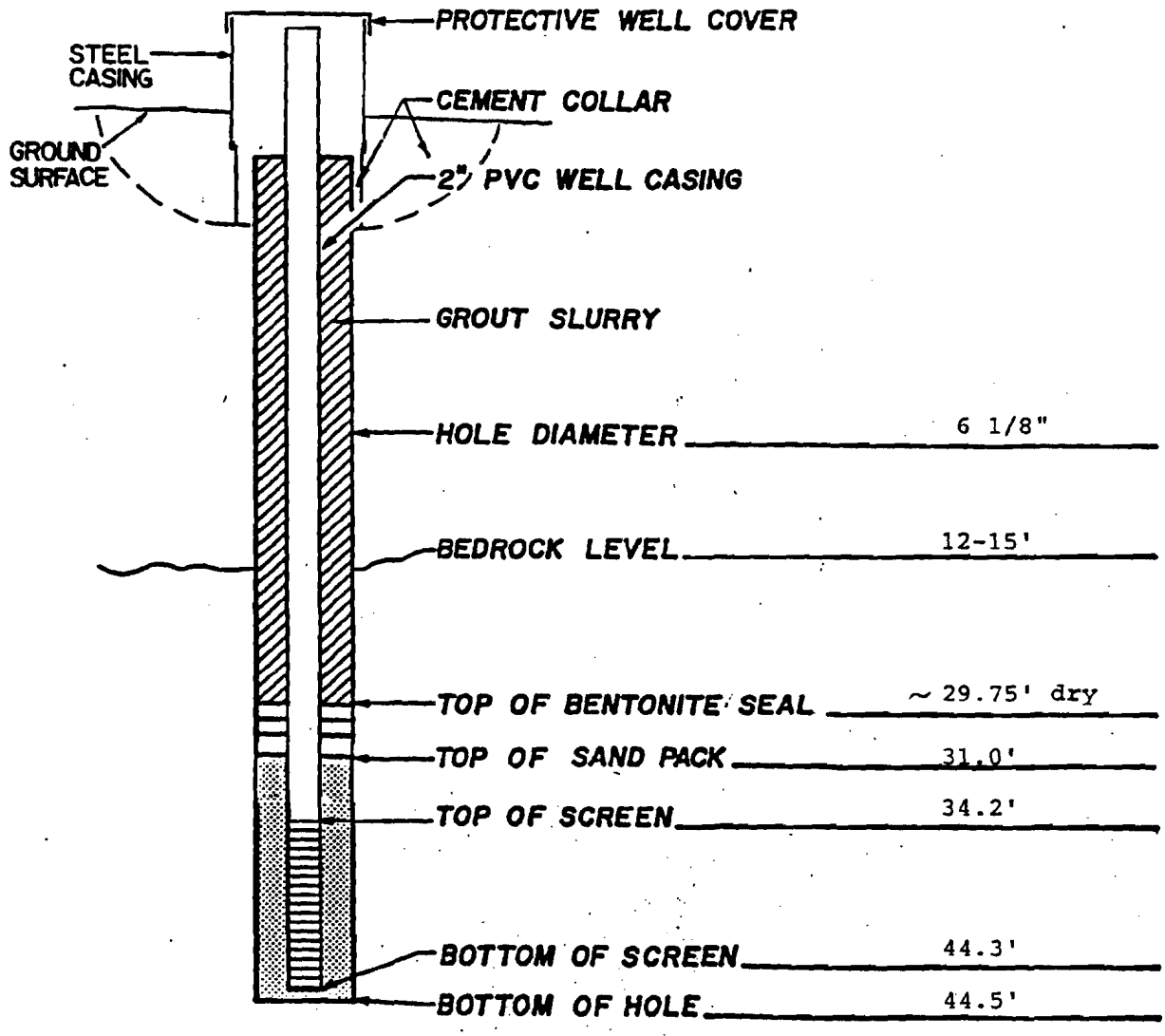
DEPTH	(FT)	DESCRIPTION
10	15	GREEN SHALE SAPROLITE - 1ST BED ROCK AT 12' HARD AT 15'
15	20	70% MED. GRAY SHALE, 30% LT. TO MED. GRAY TO BROWN FINE-GRAINED CRYSTALLINE LIMESTONE
20	25	SAME AS ABOVE EXCEPT 50/50
25	30	GREENISH GRAY SHALE WITH 10% LT. GRAY CALCAREOUS MUDSTONE TO FINE-GRAINED CRYSTALLINE LIMESTONE
30	35	SAME AS ABOVE EXCEPT LIMESTONE <5%
35	40	SAME AS 25 - 30
40	44.5	MED GREENISH GRAY SHALE, 30% LIMESTONE LT. BROWNISH GRAY TO MED. GRAY

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-~~446~~ 448 **DATE INSTALLED:** 3-19-87

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

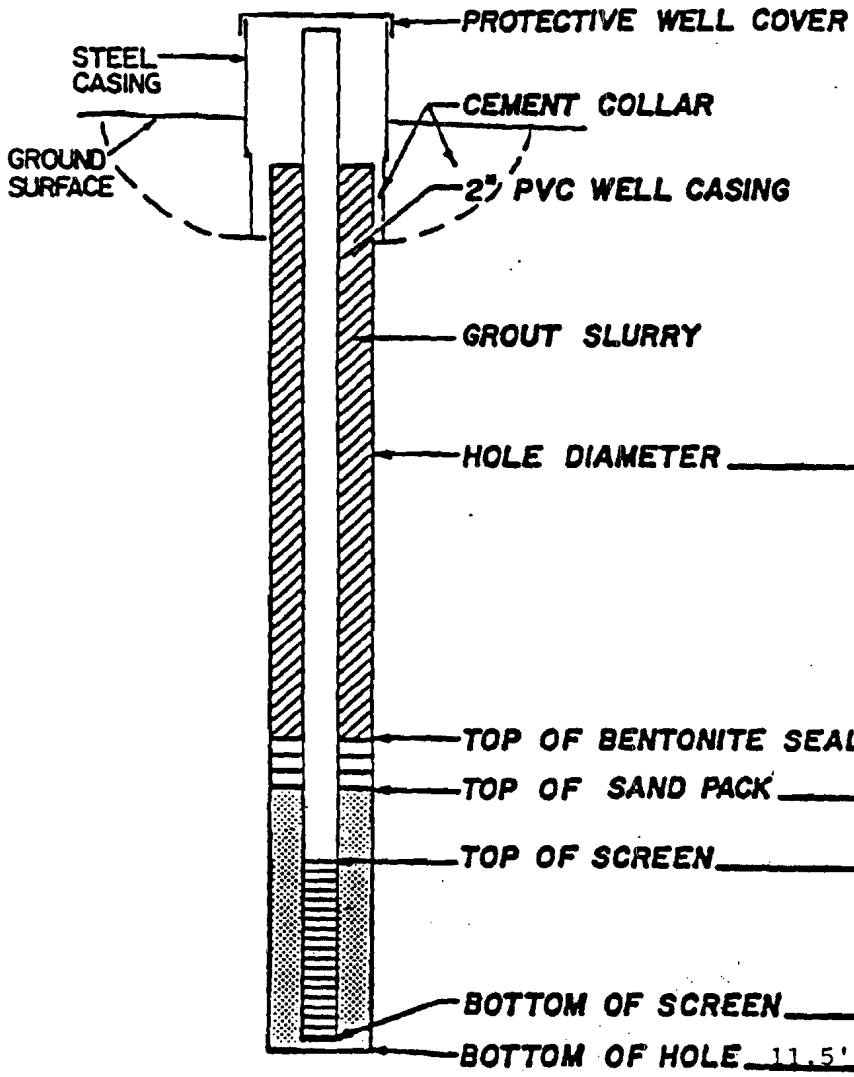
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-449 DATE INSTALLED: _____

MAP NO. Bear Creek

LOCATION NORTH: _____ EAST: _____



HOLE DIAMETER 6 5/8"

TOP OF BENTONITE SEAL ~4.8'

TOP OF SAND PACK ~ 6.0'

TOP OF SCREEN 6.5'

BOTTOM OF SCREEN 11.5'

BOTTOM OF HOLE 11.5', 12.2' before caving

BEDROCK LEVEL 25' in adjacent bed rock well

NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-~~418~~ 450

DATE 3/20/87

DRILLER HIGHLAND, RANDY PHILLIPS

MAP NUMBER N/A

HELPER RANDY RUSSEL

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

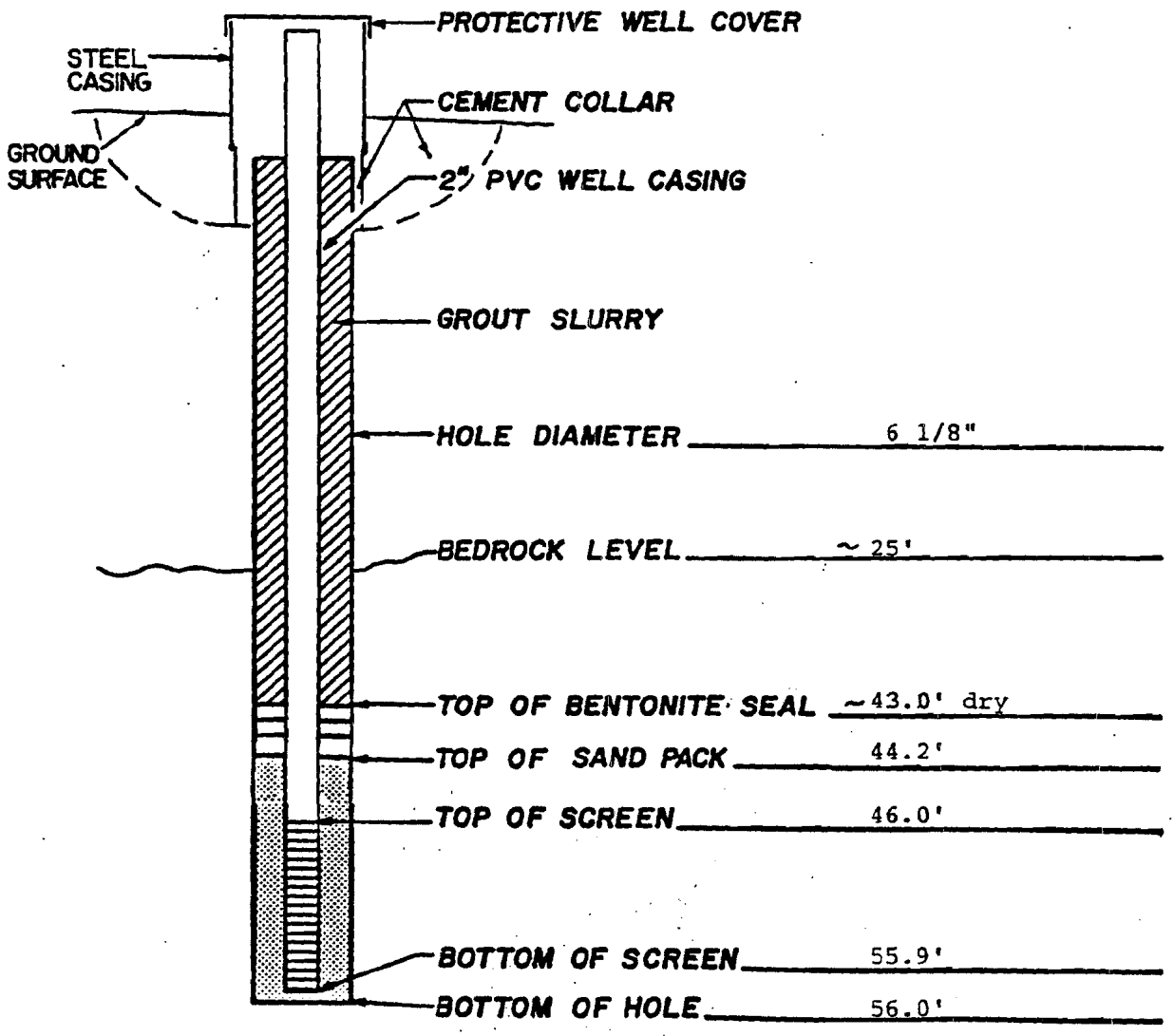
DEPTH	(FT)	DESCRIPTION
25	30	MED. TO MAROON GRAY SHALE
30	35	SAME AS ABOVE WITH MINOR AMOUNTS OLIVE TO BROWN GRAY SILTY LIMESTONE
35	40	50% MAROON BROWN SHALE, 50% MED. GRAY SHALE WITH MINOR AMOUNTS BLUE GRAY SILTSTONE
40	45	SAME AS ABOVE
45	50	SAME AS ABOVE
50	56	MED. GRAY SHALE, 20 % MAROON BROWN SHALE

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. GW-~~448~~ 450 DATE INSTALLED: 3-19-87

MAP NO. Bear Creek

LOCATION NORTH: _____ EAST: _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

WELL LOG

WELL NUMBER GW-451

DATE 7/23/87

DRILLER HIGHLAND

MAP NUMBER N/A

HELPER

RIG ING. RAND, RD-10

H. P.

STATIC WATER LEVEL NOT MEASURED

LOGGED BY T. STURDIVANT

LOCATION BEAR CREEK VALLEY

PLANT COORDINATES N: E:

DEPTH	(FT)	DESCRIPTION
5	10	Maroonish brown silty clay
10	15	Same as above with maroon brown shale saprolite shale frags are maroon brown with minor amount being green siltstone
15	20	Same as above, mostly recemented shale muck
20	25	Same as above
25	30	Same as above, probably -sample was grout
30	35	Maroon brown and gray green shale with green siltstone
35	40	Same as above
40	45	Same as above
45	50	Same as above
slight change →		
50	55	Med. gray shale/mudstone and glauconitic siltstone
55	60	Same as above with minor lime/ siltstone laminae
60	65	Greenish gray shale with minor maroon brown shale

DEPTH	(FT)	DESCRIPTION
65	70	Greenish gray shale and maroon brown shale
70	75	Maroon brown shale and glauconitic siltstone/calcarenite
75	80	Same as above
80	85	Maroon brown shale, green gray shale and minor green siltstone
85	90	Same as above
90	95	Dark steel gray shale and green-gray calcarenitic siltstone, glauconitic
95	100	Same as above
100	105	Same as above with some highly calcarenitic siltstone
105	110	Same as above
110	115	Same as above
115	120	Same as above
120	125	Same as above
125	130	Same as above
130	135	Steel gray shale and green-gray glauconitic siltstone
135	140	Same as above mostly siltstone
140	145	Same as above
145	150	Same as above
150	155	Same as above
155	160	Same as above shale getting more maroon
160	165	Dark steel gray shale and calcarenitic, glauconitic siltstone
165	170	Same as above
170	175	Same as above
175	180	Same as above
180	185	Same as above, shale has a maroon gray cast

change in lithology

	DEPTH (FT)		DESCRIPTION
	185	190	Same as above
	190	195	Very maroonish brown shale and greenish gray glauconitic siltstone
	195	200	Maroonish gray shale and greenish-gray glauconitic siltstone
	200	205	Same as above except shale is more maroon brown
	205	210	Same as above
	210	215	Maroon brown shale and greenish-gray glauconitic siltstone
	215	220	Same as above
	220	225	Same as above
	225	230	Greenish gray siltstone with very minor maroon shale + calcarenite
	230	235	Same as above
	235	240	Same as above
	240	245	Greenish gray, highly +glauconitic calcarenitic siltstone with minor maroon shale
€ pv	245	250	Same as above
€ rm	250	255	Tan orthoquartizite sandstone and maroon-brown arkosic sandstone, rest of internal is as 245-250
	255	260	H. gray orthoquartzite to medium gray arlcosic sandstone
	260	265	Same as above with medium gray shale
	265	270	Same as above, dominated by shale and medium gray arkosic sandstone
	270	275	Medium gray shale and medium gray arkosic sandstone
	275	280	Same as above glauconitic - may be calcarenitic (don't have acid)
	280	285	Same as above

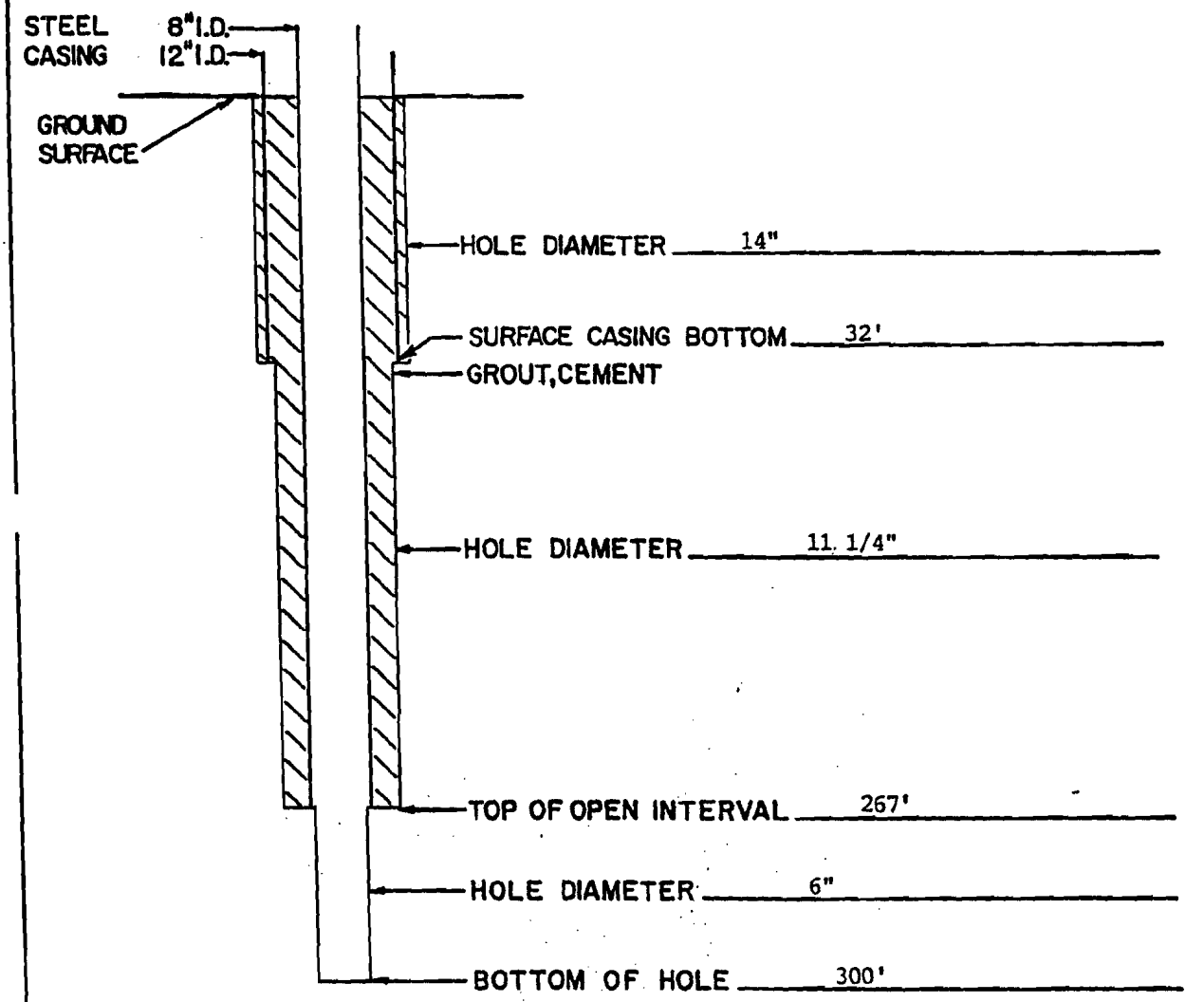
DEPTH (FT)		DESCRIPTION
285	290	Same as above
290	295	Lt. gray orthoquartzite to medium green-gray arkosic sandstone with minor medium gray shale
295	300	Same as above, mostly lt. gray orthoquartzite

OPEN HOLE MONITOR WELL – IN BED ROCK

WELL NO. GW 451 DATE INSTALLED: _____

MAP NO. Bear Creek

LOCATION NORTH: _____ EAST: _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

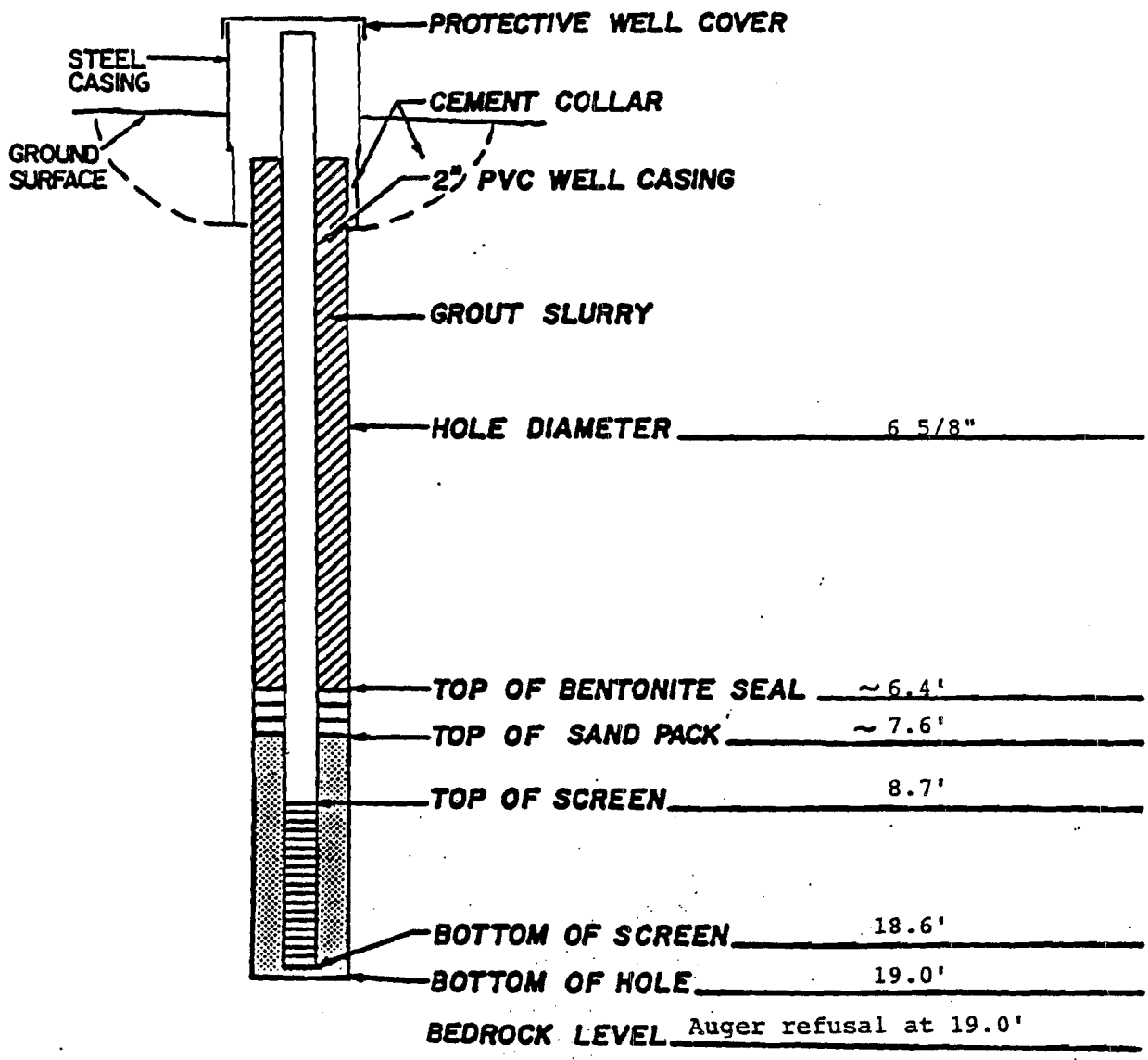
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION ABOVE BED ROCK

WELL NO. GW-452 DATE INSTALLED: 3-31-87

MAP NO. Bear Creek

LOCATION NORTH: EAST:



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

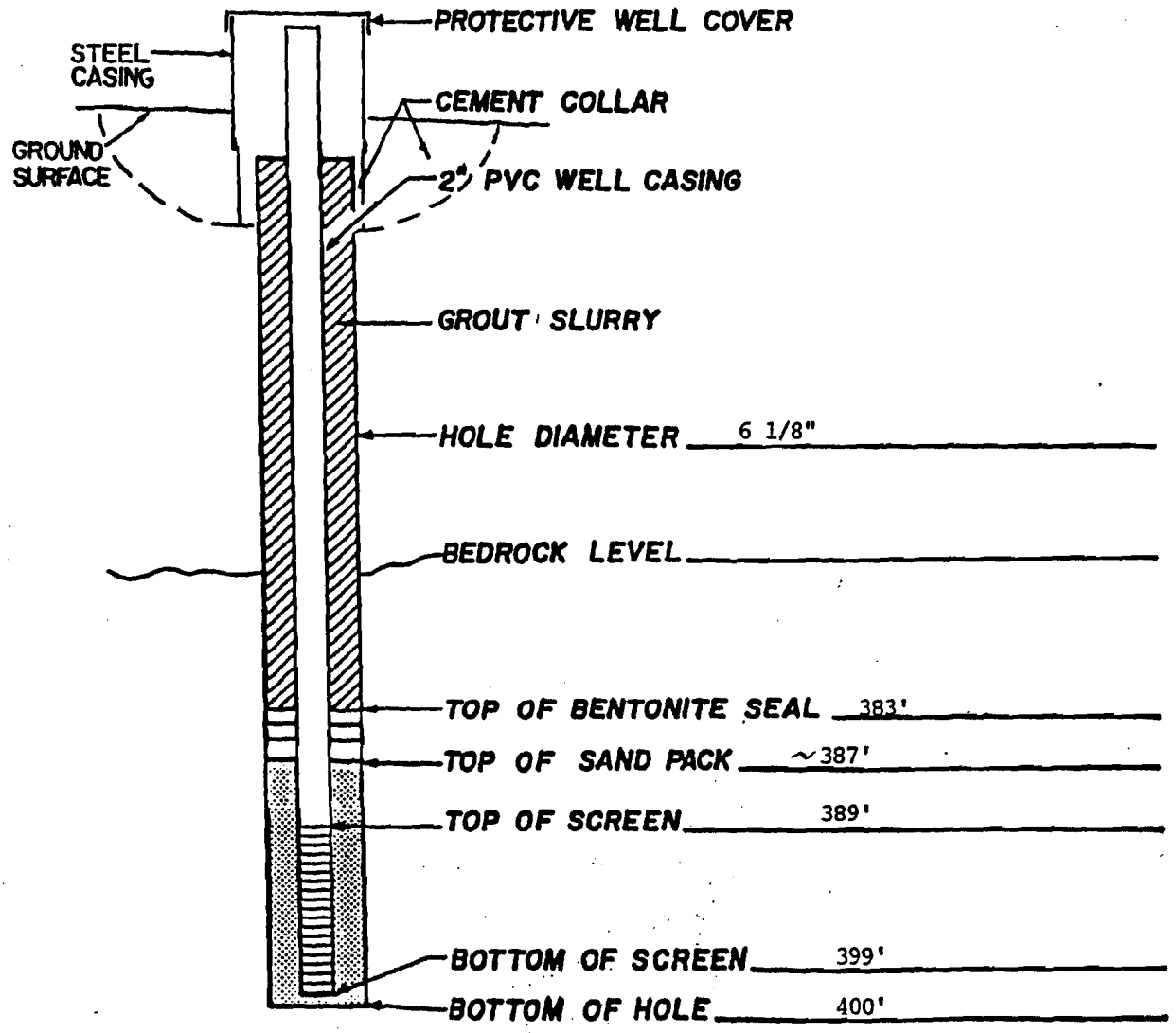
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. LL HAZ 13 **DATE INSTALLED:** _____

MAP NO. Bear Creek

LOCATION NORTH: _____ **EAST:** _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

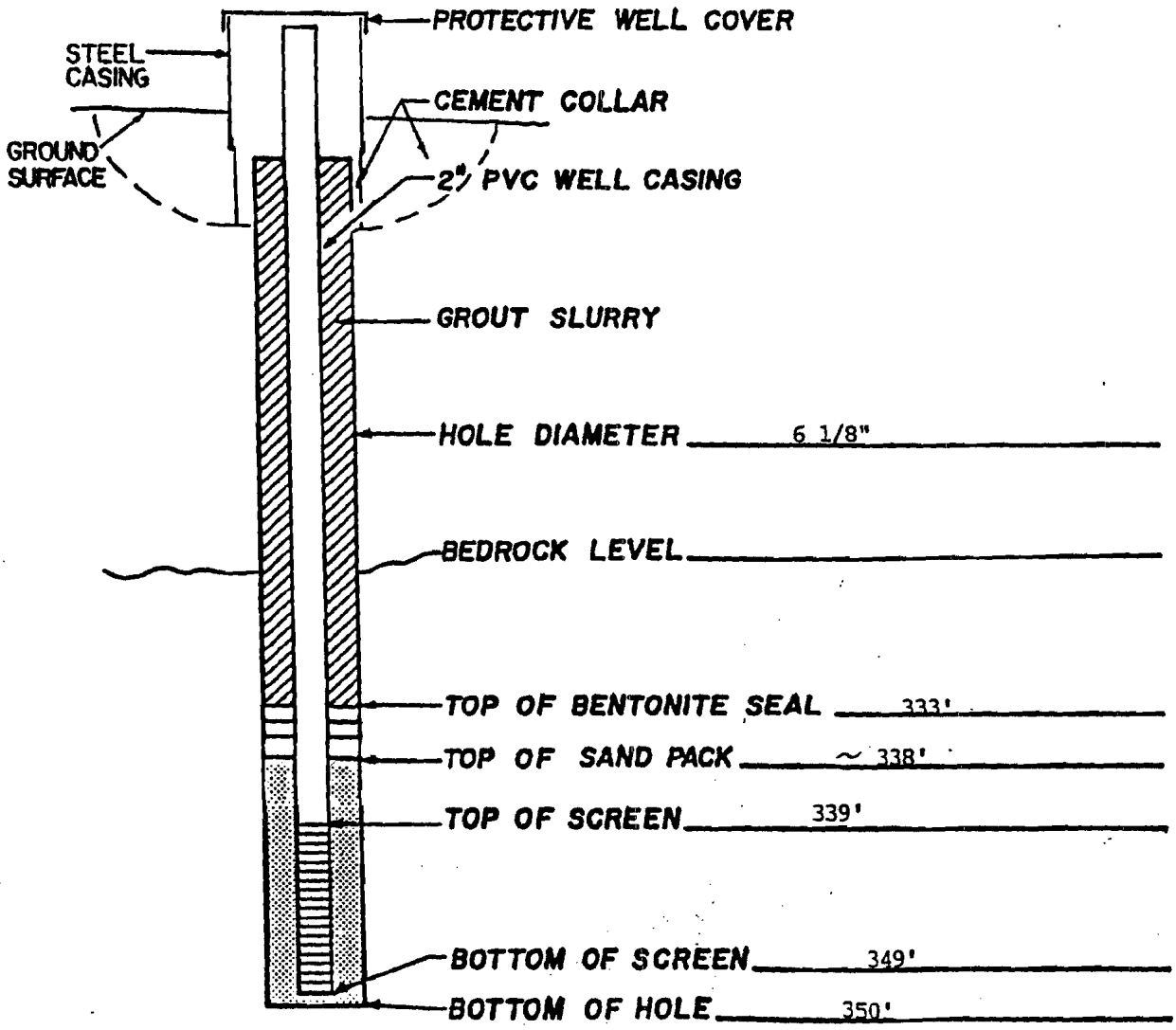
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. LL HAZ 14 DATE INSTALLED: _____

MAP NO. Bear Creek

LOCATION NORTH: _____ EAST: _____



NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

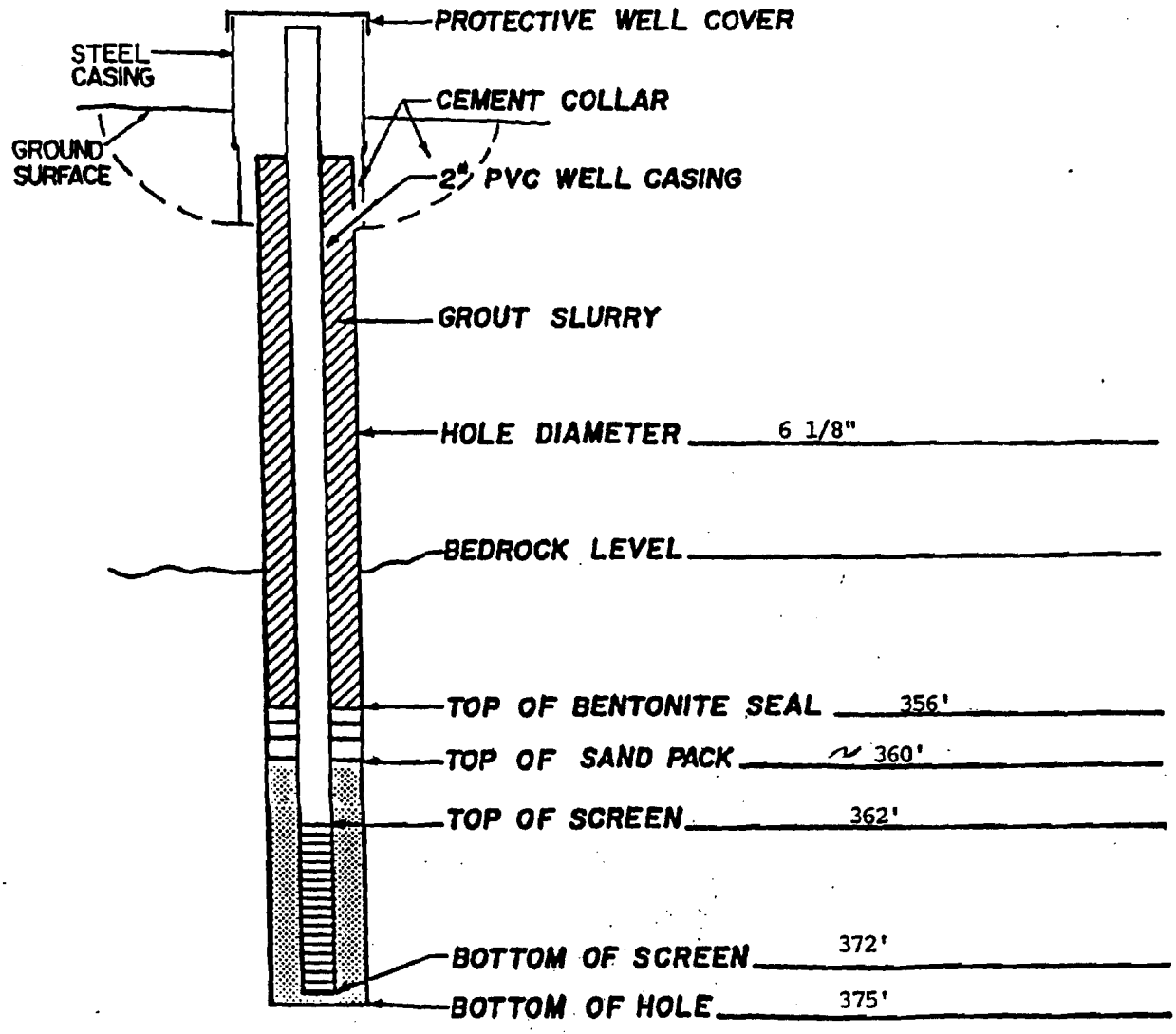
DRAWING NOT TO SCALE.

PIEZOMETER CONSTRUCTION IN ROCK

WELL NO. LL HAZ 15 DATE INSTALLED: _____

MAP NO. Bear Creek

LOCATION NORTH: _____ EAST: _____

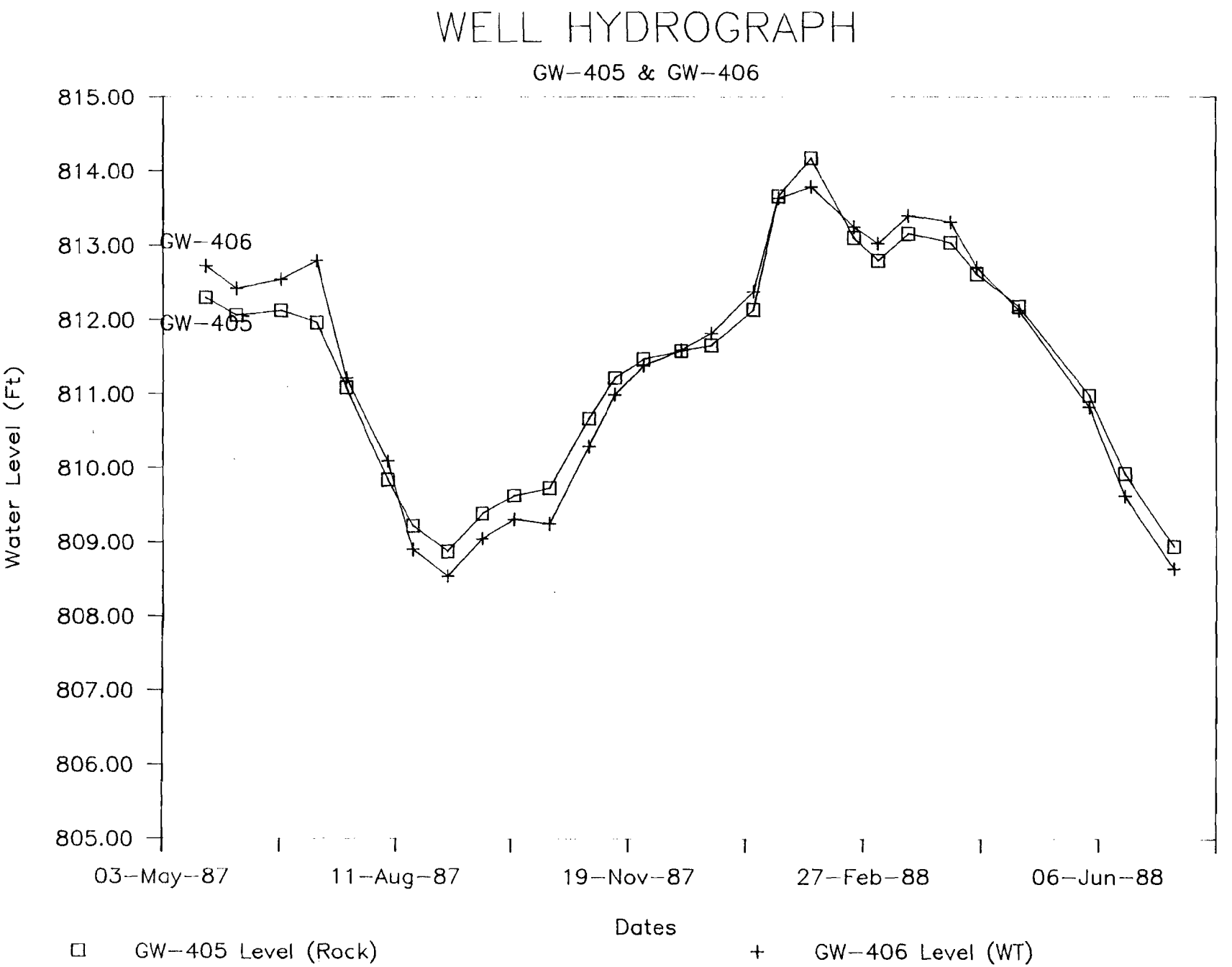


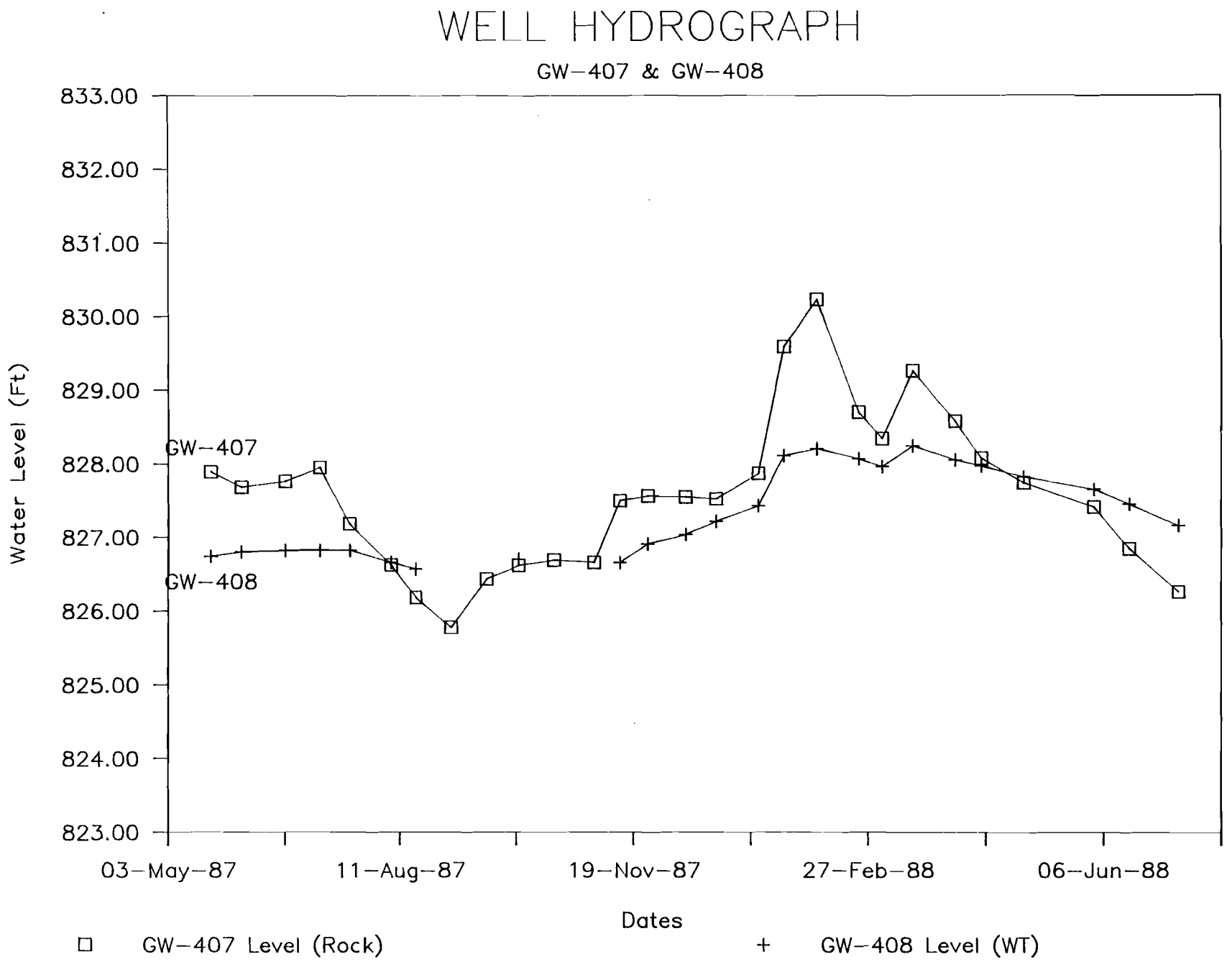
NOTE: ALL DEPTHS ARE RELATIVE TO TOP OF GROUND.

DRAWING NOT TO SCALE.

PART II

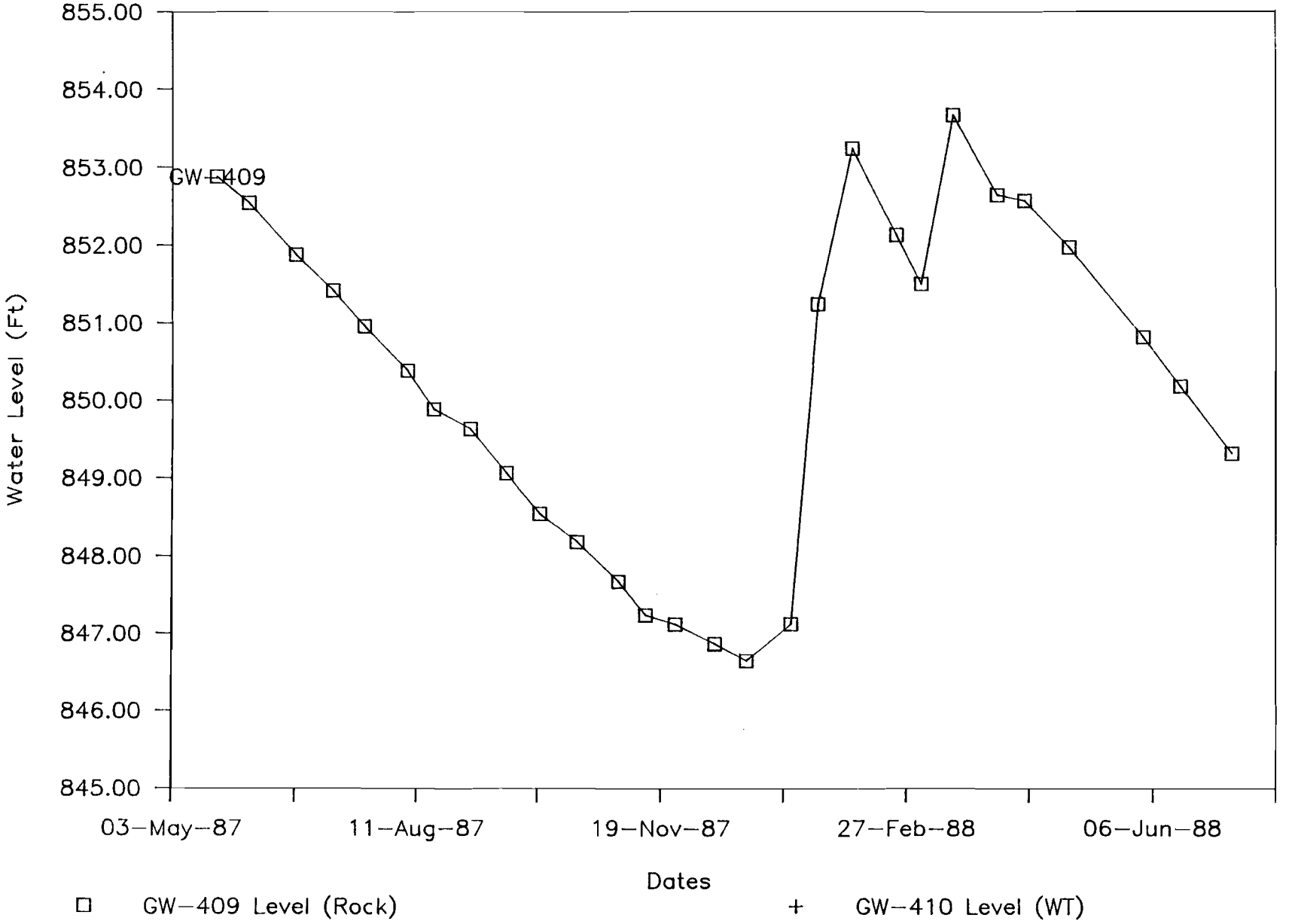
BEAR CREEK VALLEY WELL HYDROGRAPHS

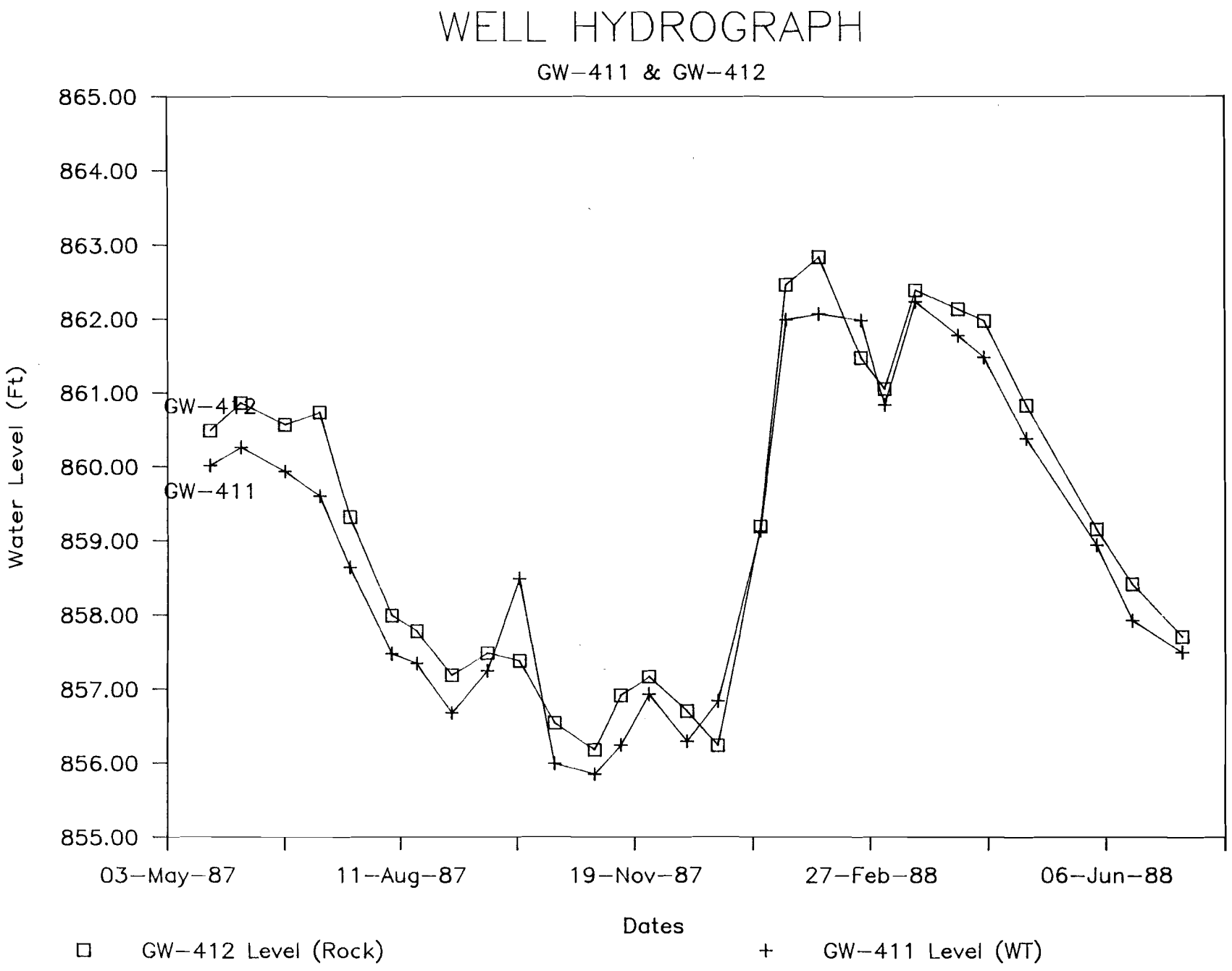

WELL HYDROGRAPH
GW-405 & GW-406
815.00
814.00
813.00
812.00
811.00
810.00
809.00
808.00
807.00
806.00
805.00
Water Level (Ft)
GW-406
GW-405
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-405 Level (Rock)
GW-406 Level (WT)


WELL HYDROGRAPH
GW-407 & GW-408
833.00
832.00
831.00
830.00
829.00
828.00
827.00
826.00
825.00
824.00
823.00
Water Level (Ft)
GW-407
GW-408
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-407 Level (Rock)
GW-408 Level (WT)

WELL HYDROGRAPH

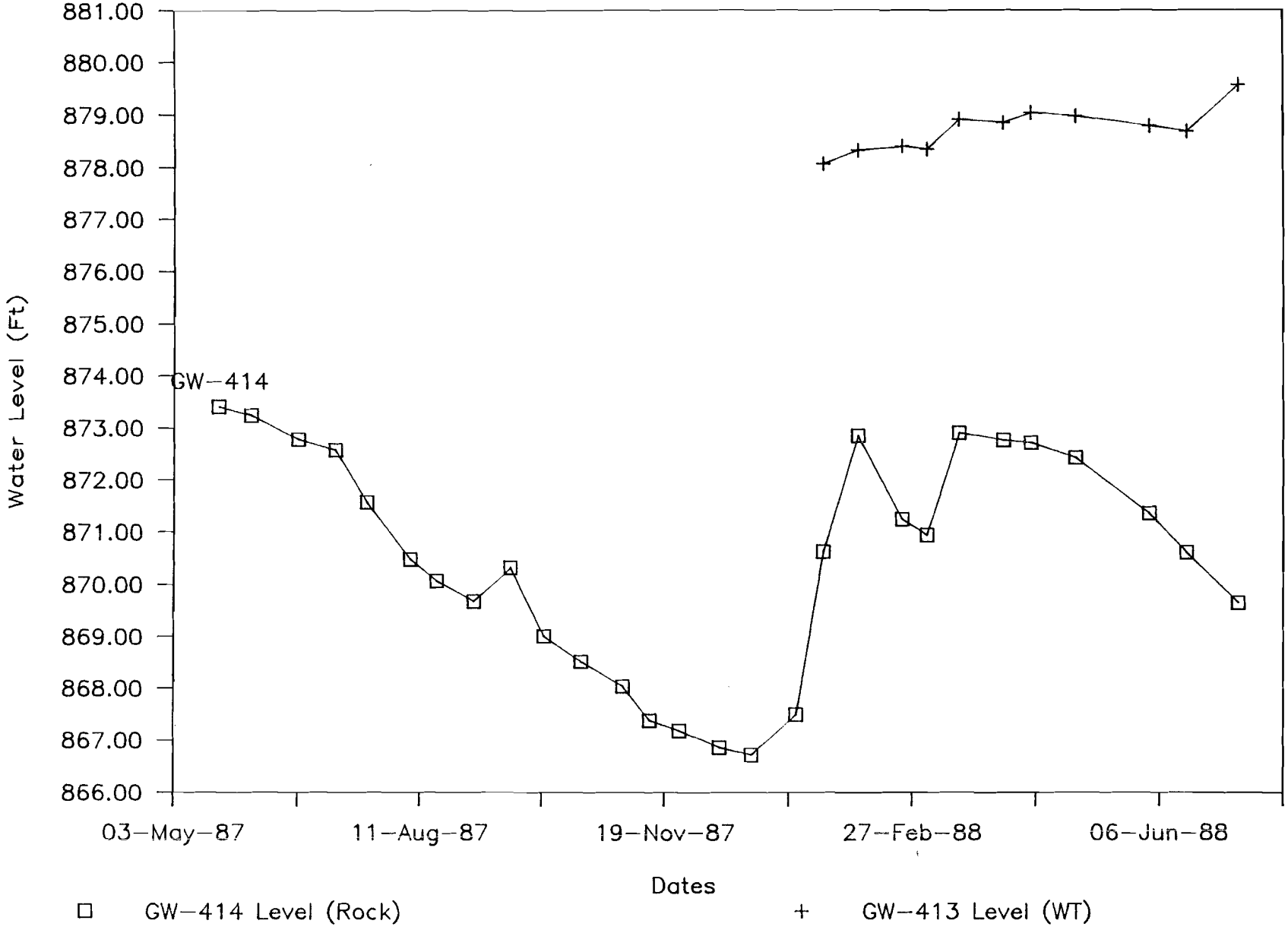
GW-409 & GW-410




WELL HYDROGRAPH
GW-411 & GW-412
865.00
864.00
863.00
862.00
861.00
860.00
859.00
858.00
857.00
856.00
855.00
Water Level (Ft)
GW-412
GW-411
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-412 Level (Rock)
GW-411 Level (WT)

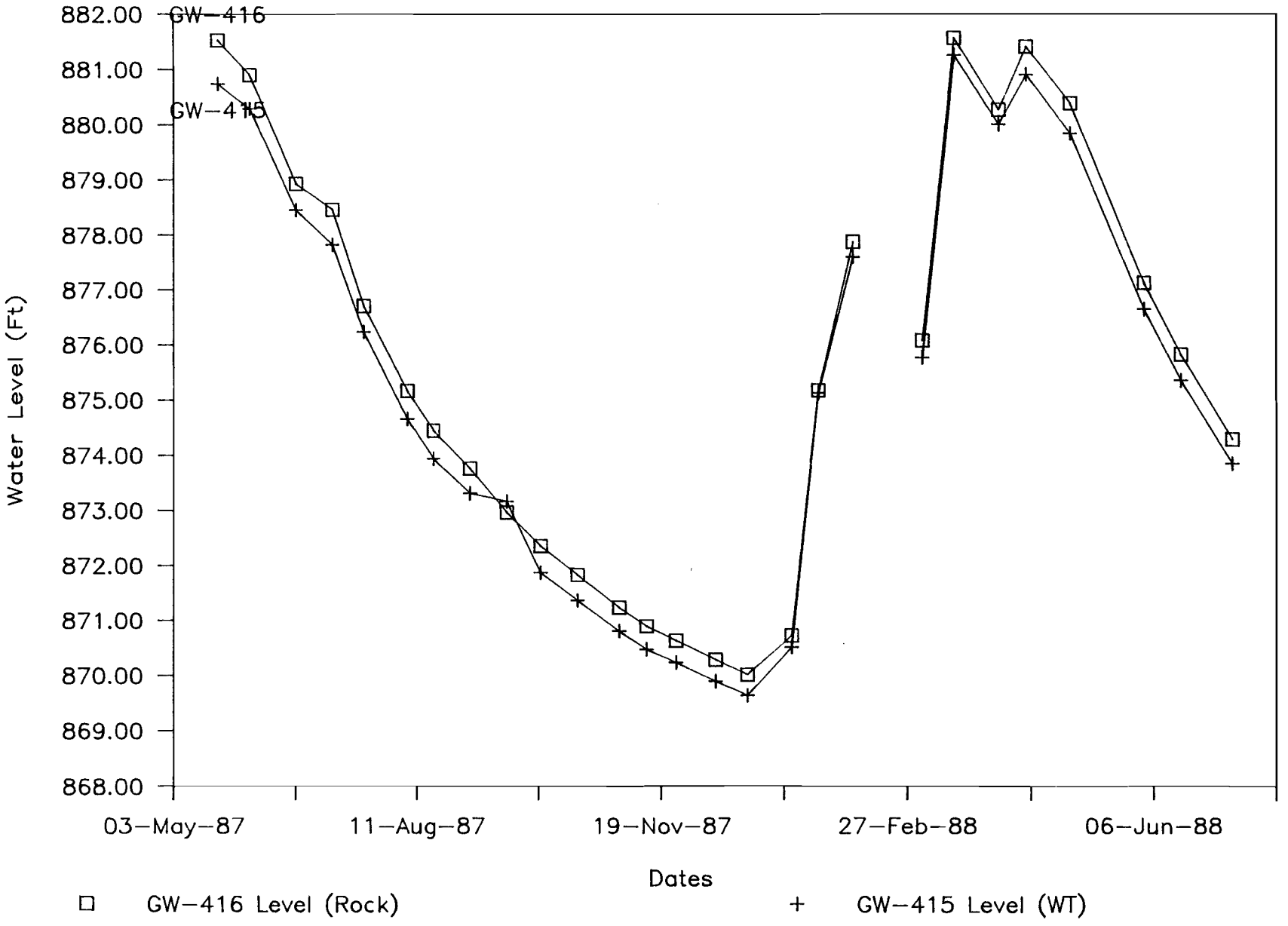
WELL HYDROGRAPH

GW-413 & GW-414



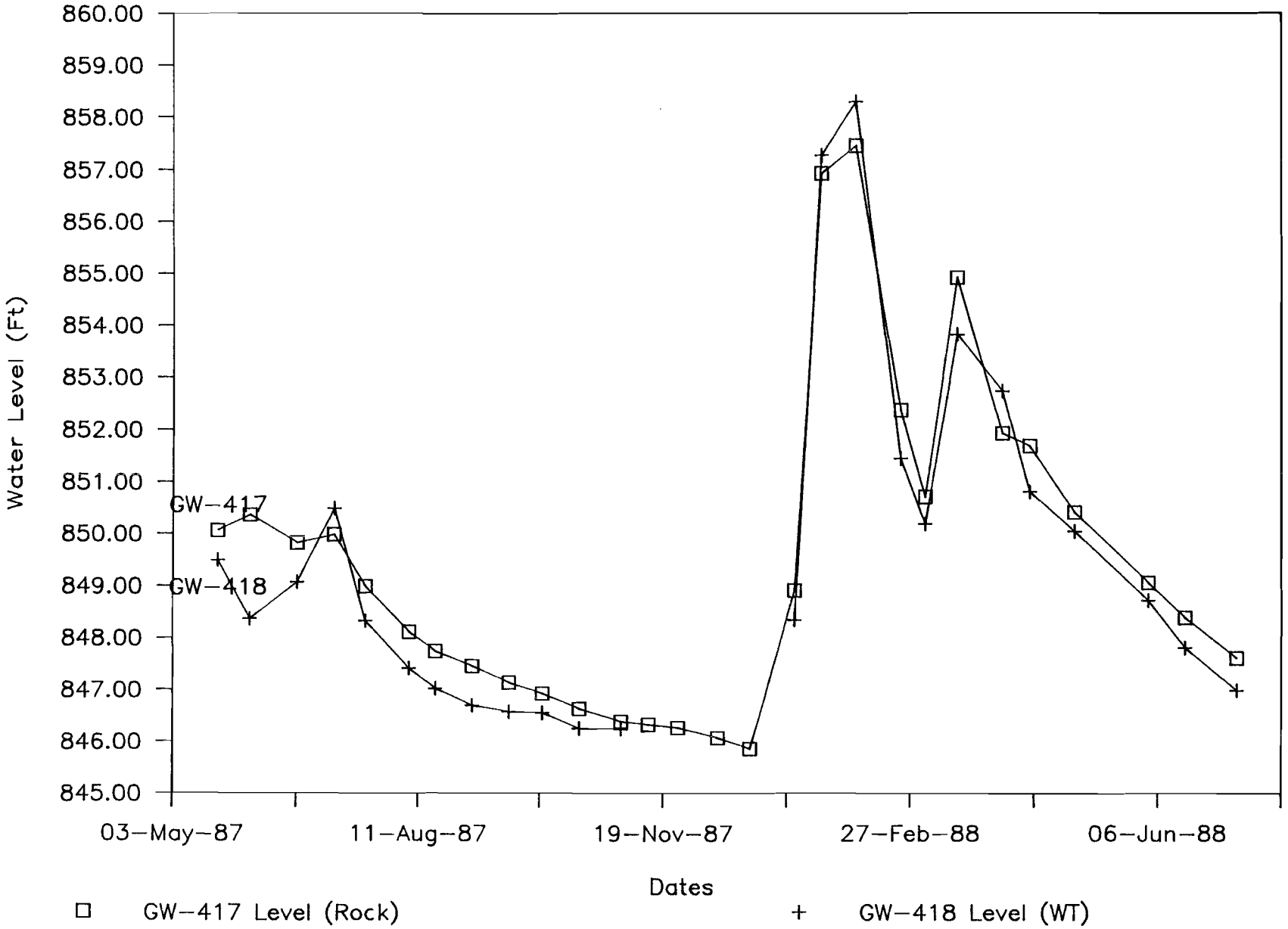
WELL HYDROGRAPH

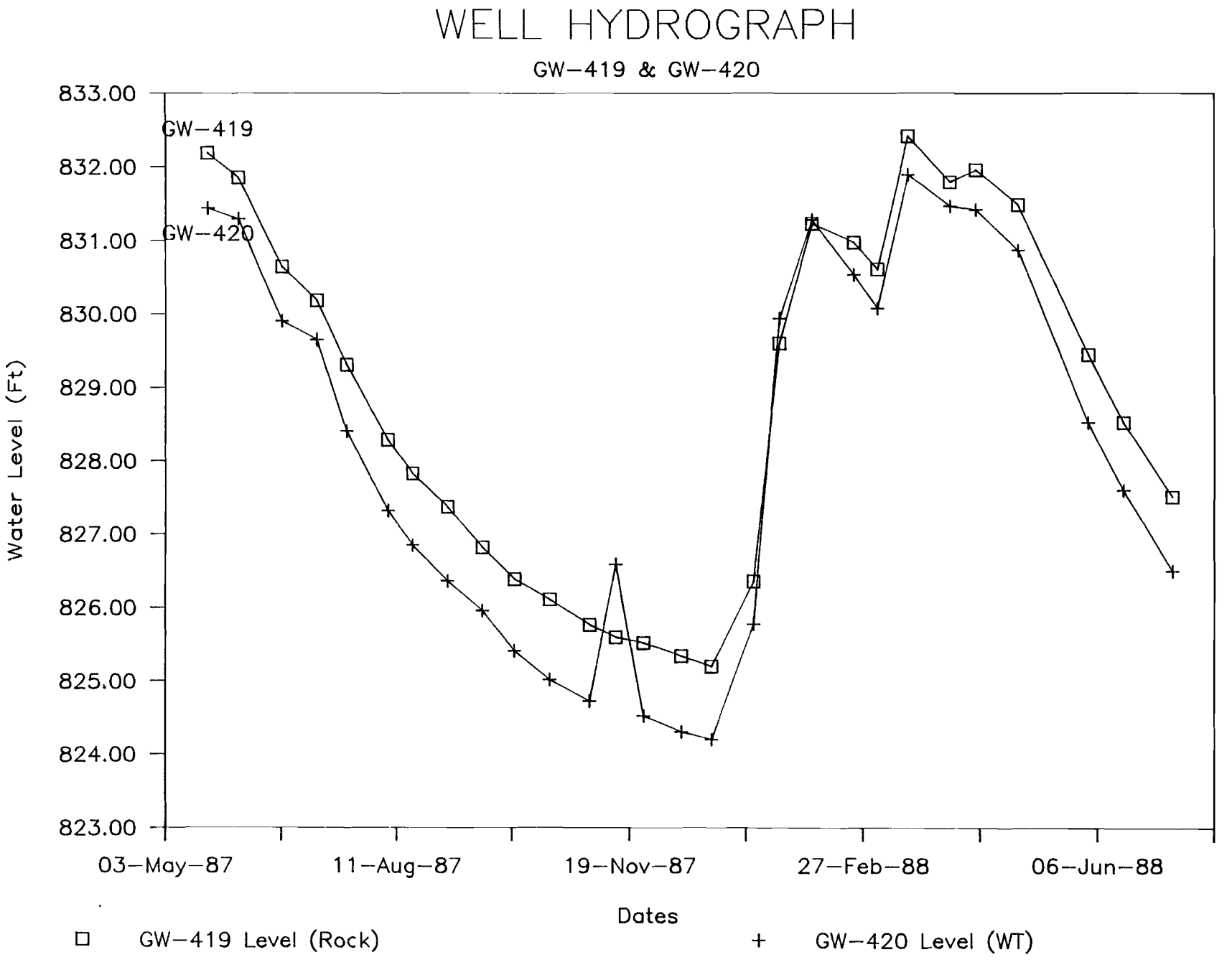
GW-415 & GW-416



WELL HYDROGRAPH

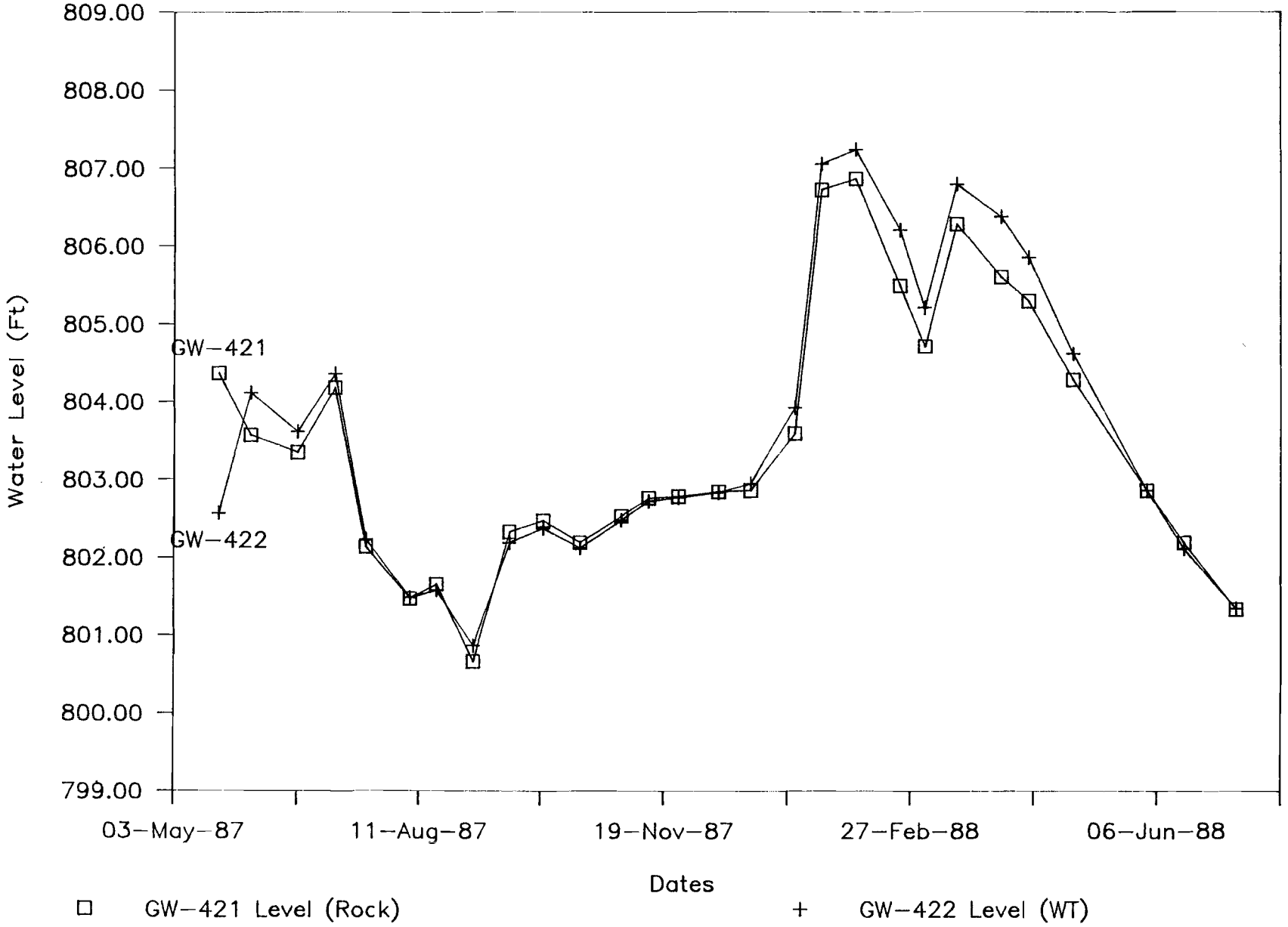
GW-417 & GW-418




WELL HYDROGRAPH
GW-419 & GW-420
GW-419
GW-420
833.00
832.00
831.00
830.00
829.00
828.00
827.00
826.00
825.00
824.00
823.00
Water Level (Ft)
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-419 Level (Rock)
GW-420 Level (WT)

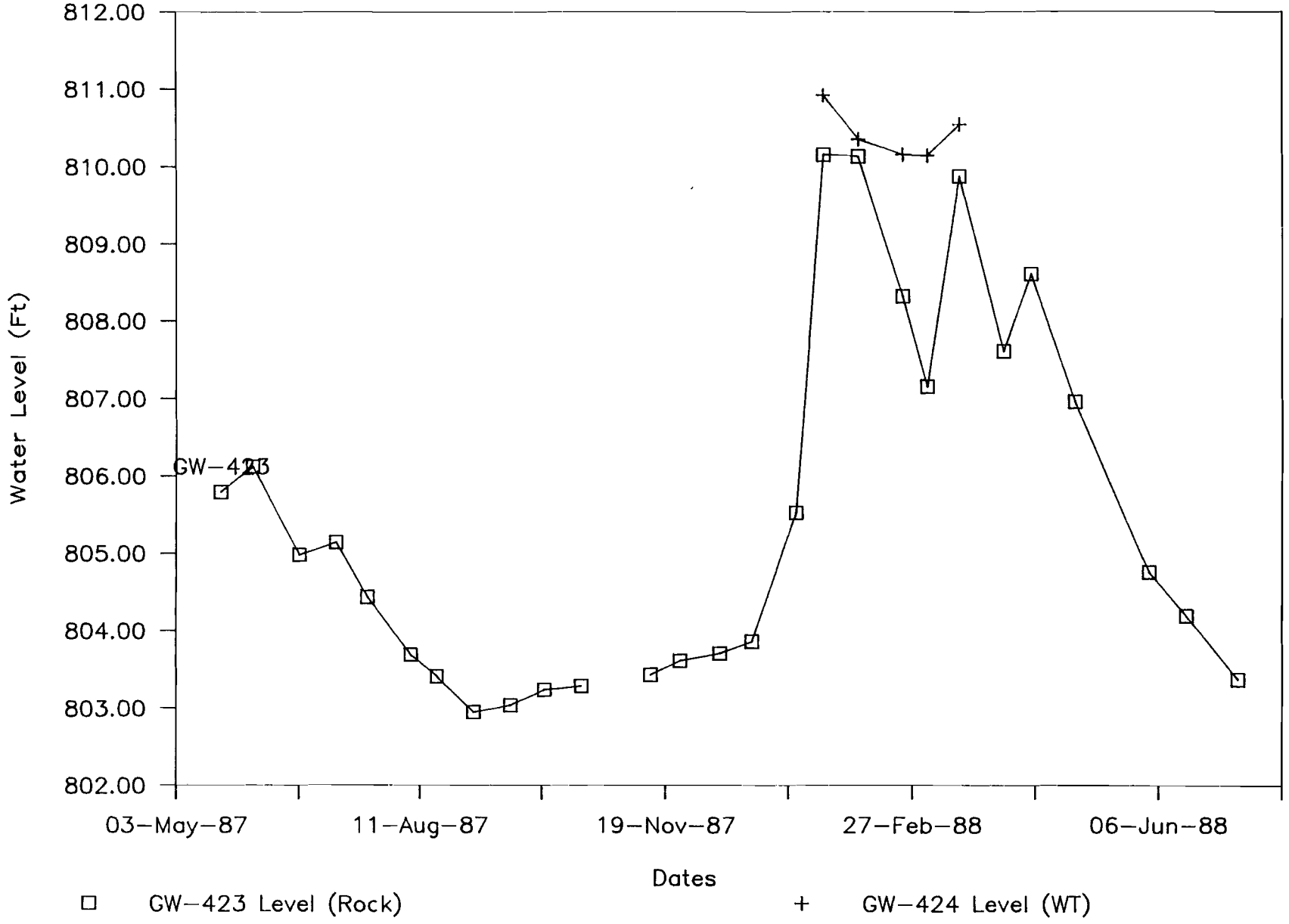
WELL HYDROGRAPH

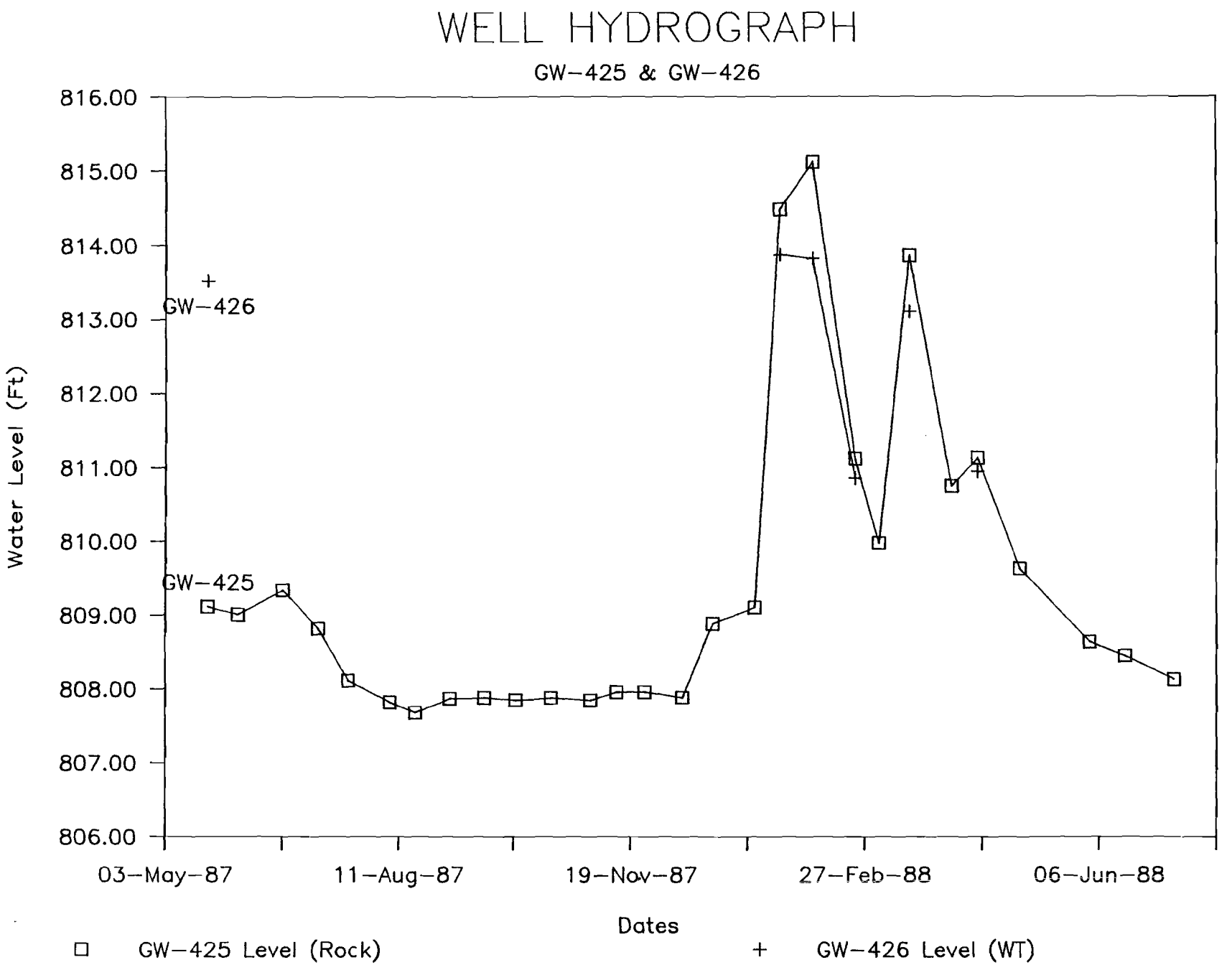
GW-421 & GW-422

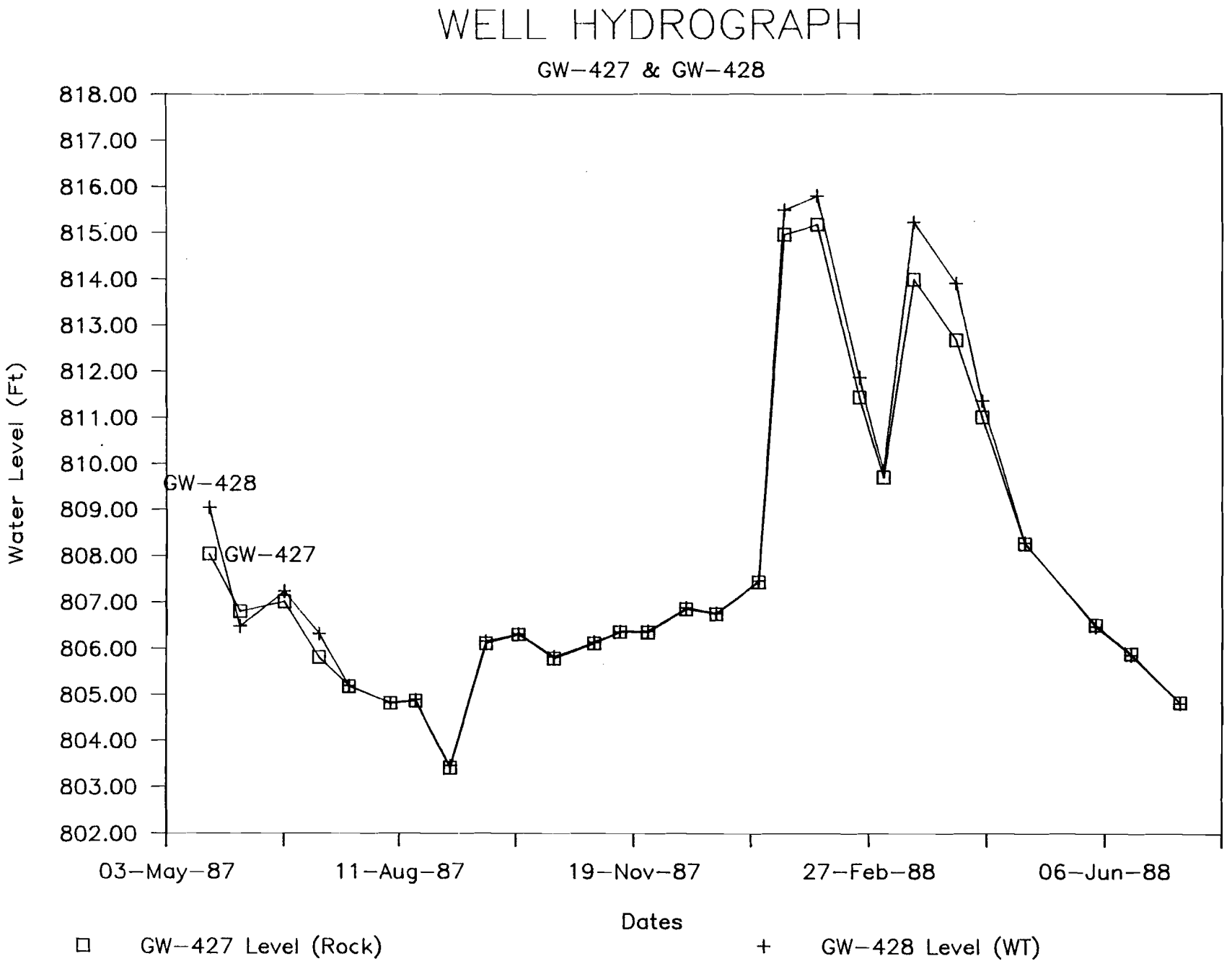


WELL HYDROGRAPH

GW-423 & GW-424

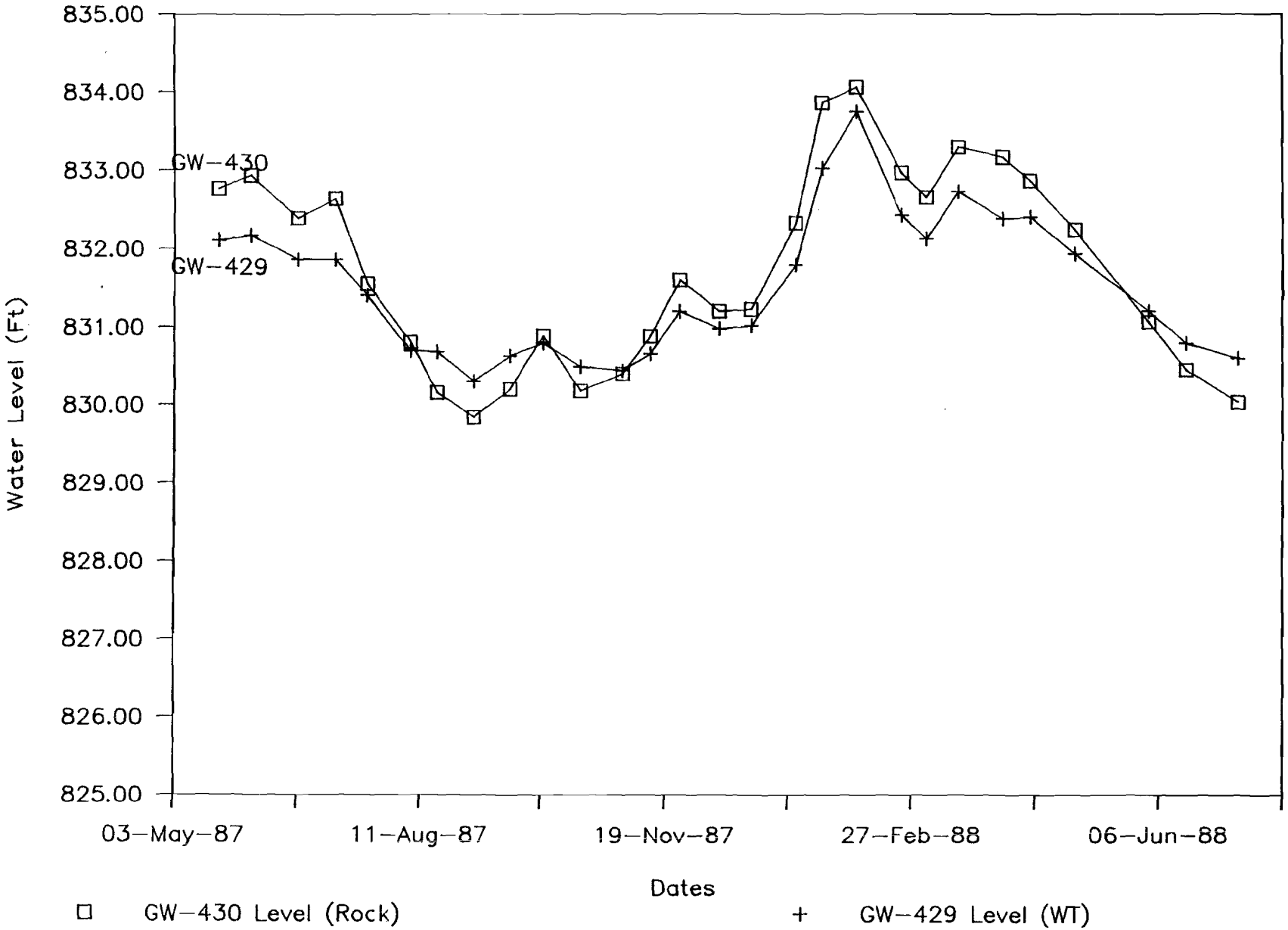



WELL HYDROGRAPH
GW-425 & GW-426
816.00
815.00
814.00
813.00
812.00
811.00
810.00
809.00
808.00
807.00
806.00
Water Level (Ft)
GW-426
GW-425
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-425 Level (Rock)
GW-426 Level (WT)


WELL HYDROGRAPH
GW-427 & GW-428
818.00
817.00
816.00
815.00
814.00
813.00
812.00
811.00
810.00
809.00
808.00
807.00
806.00
805.00
804.00
803.00
802.00
Water Level (Ft)
GW-428
GW-427
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-427 Level (Rock)
GW-428 Level (WT)

WELL HYDROGRAPH

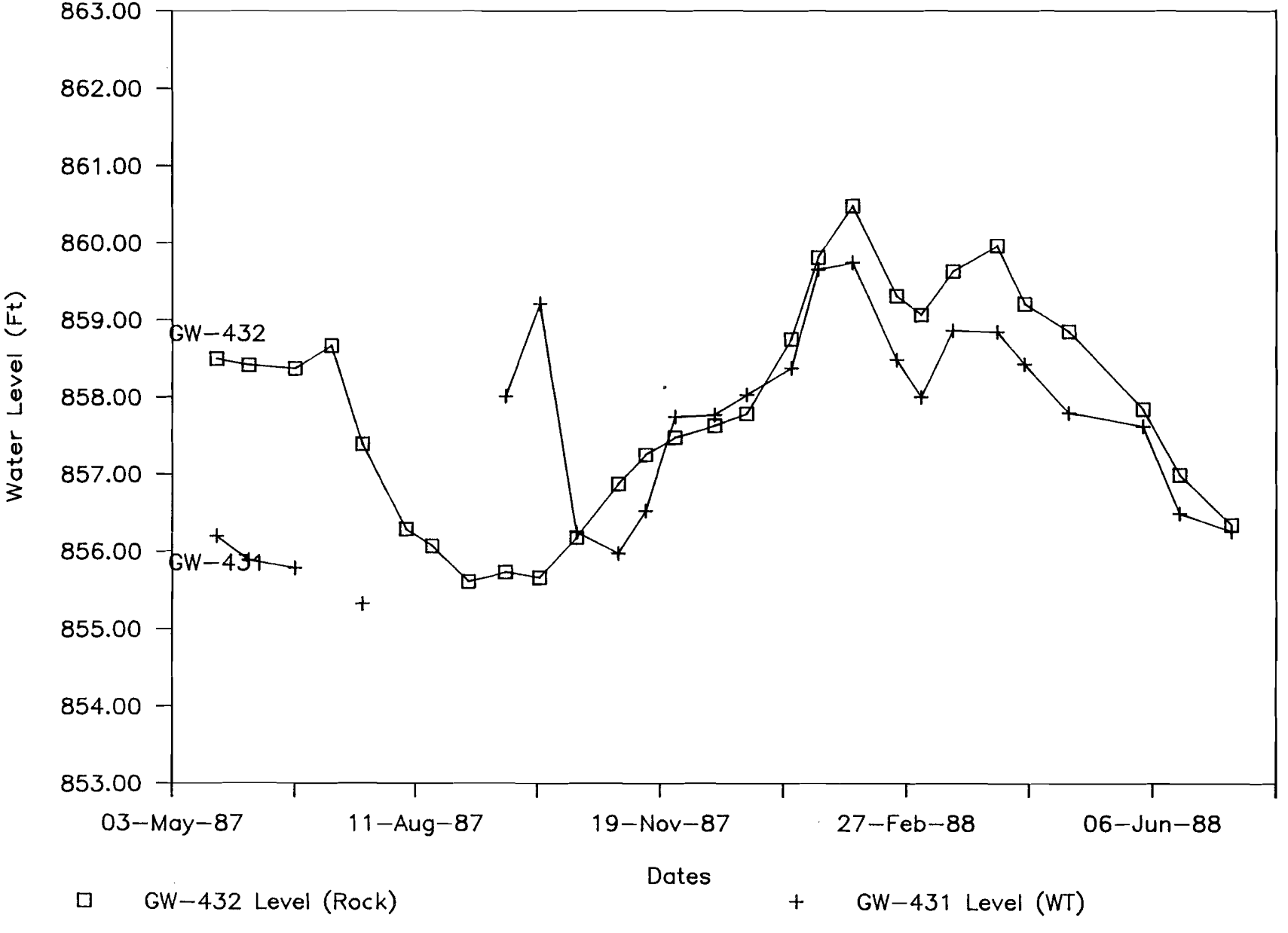
GW-429 & GW-430



□ GW-430 Level (Rock) + GW-429 Level (WT)

WELL HYDROGRAPH

GW-431 & GW-432



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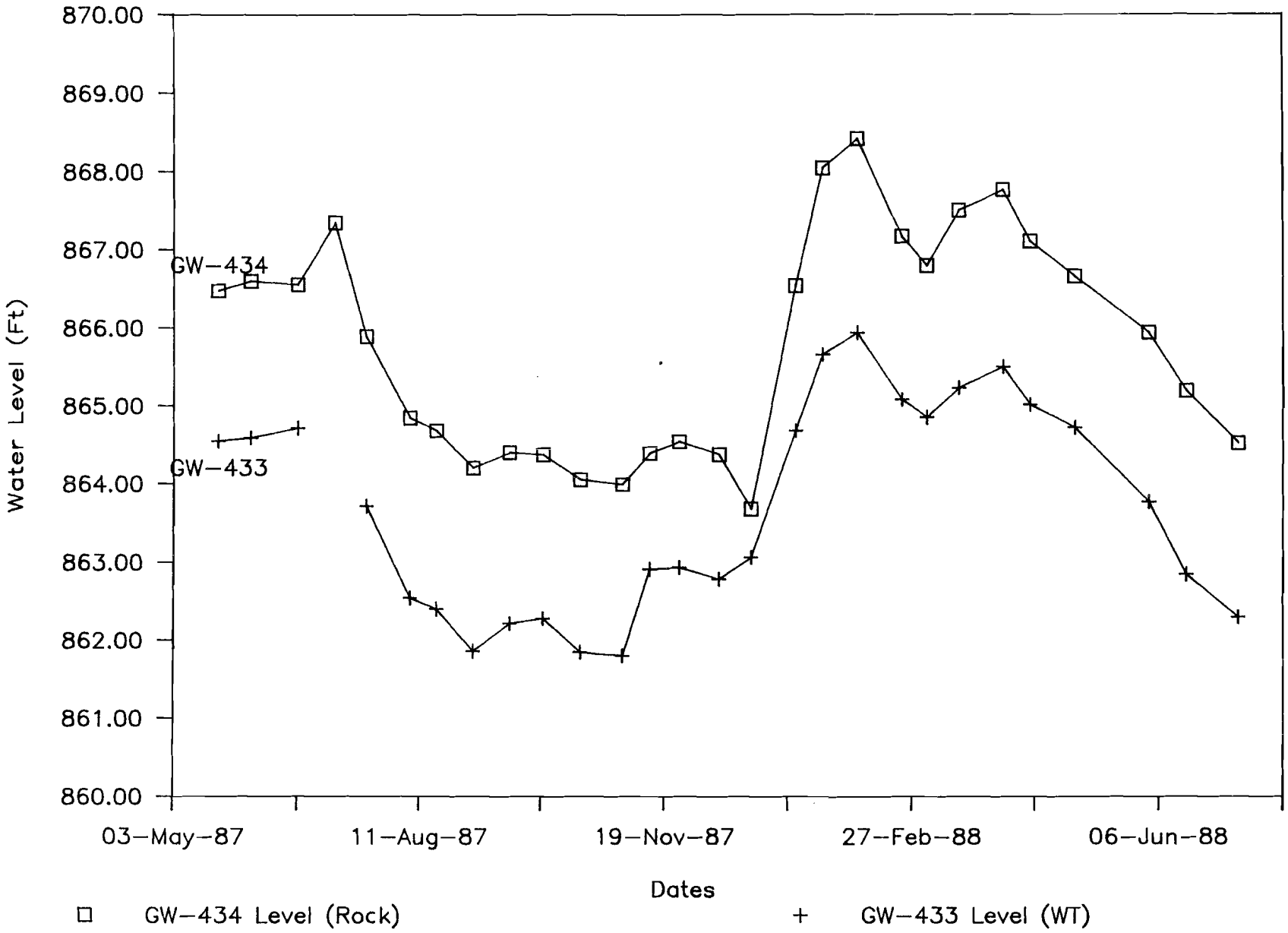
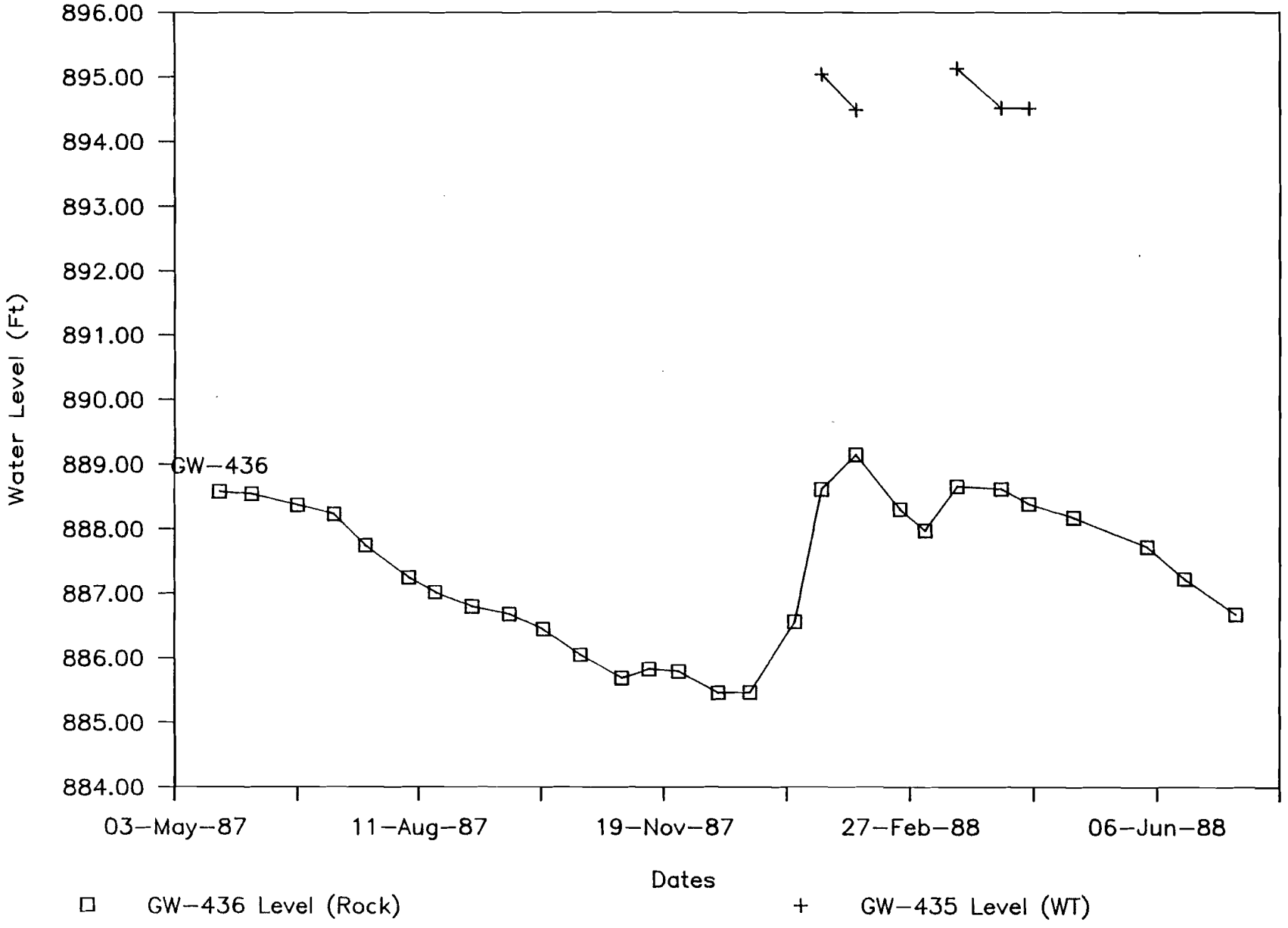
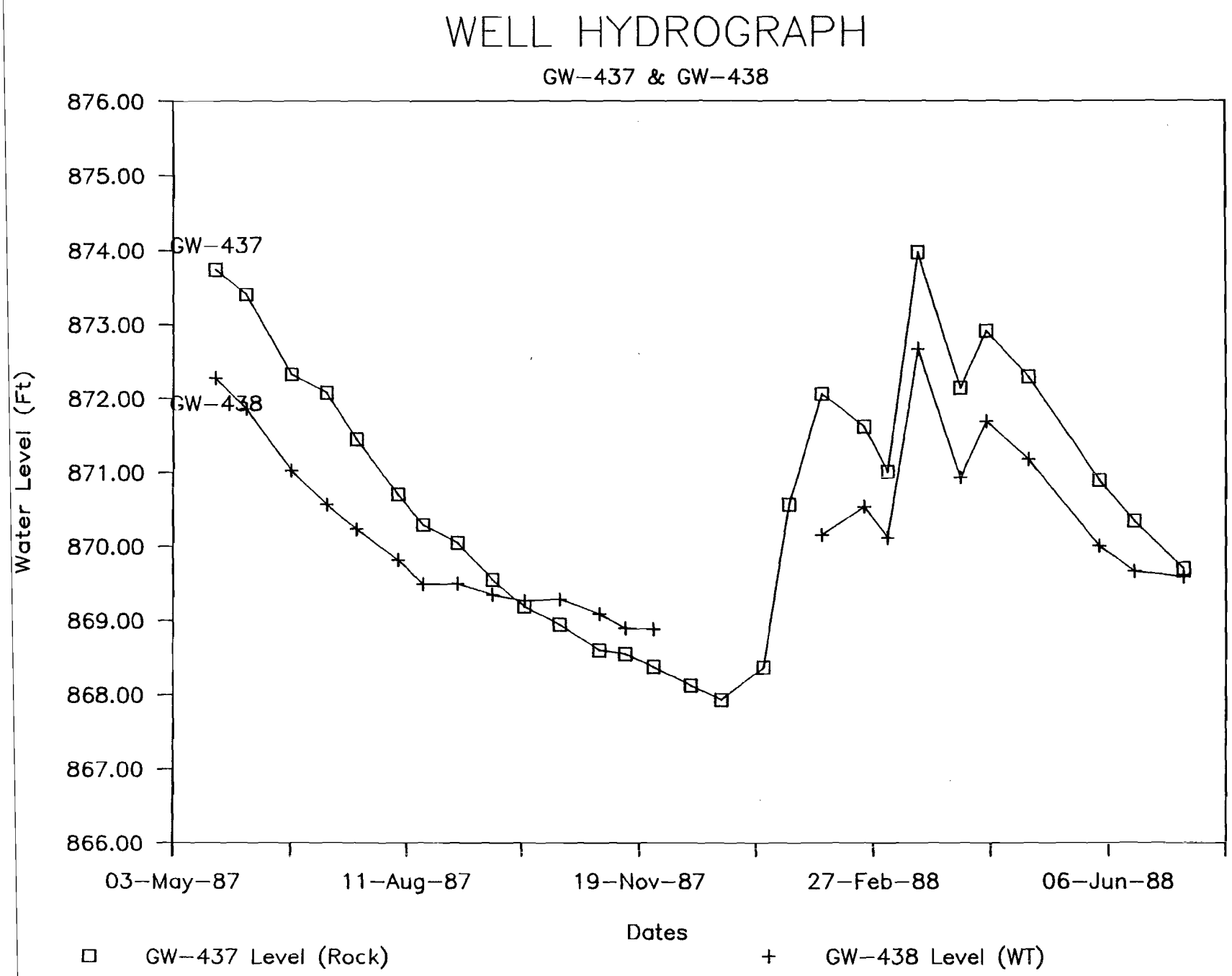
GW-433 & GW-434

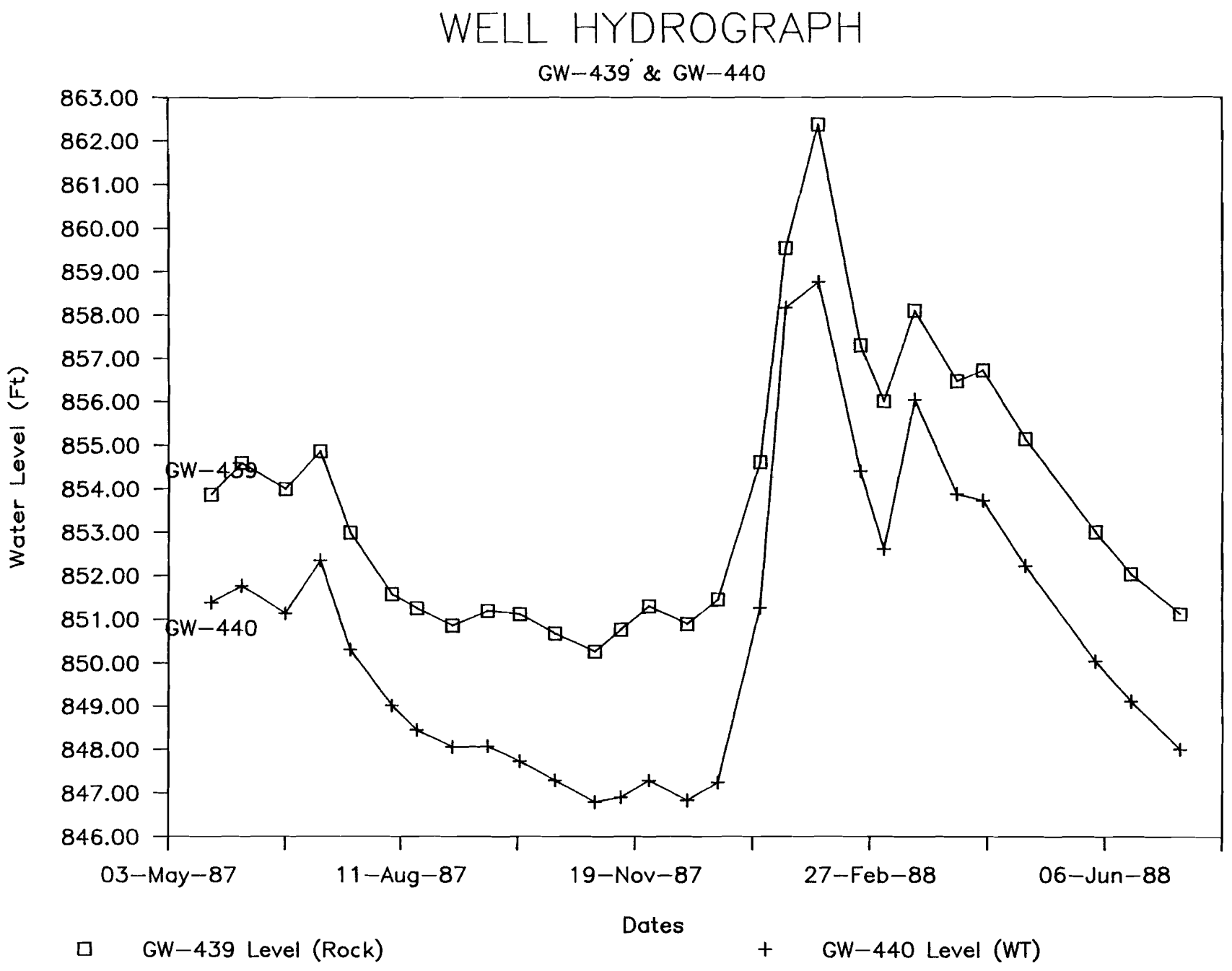


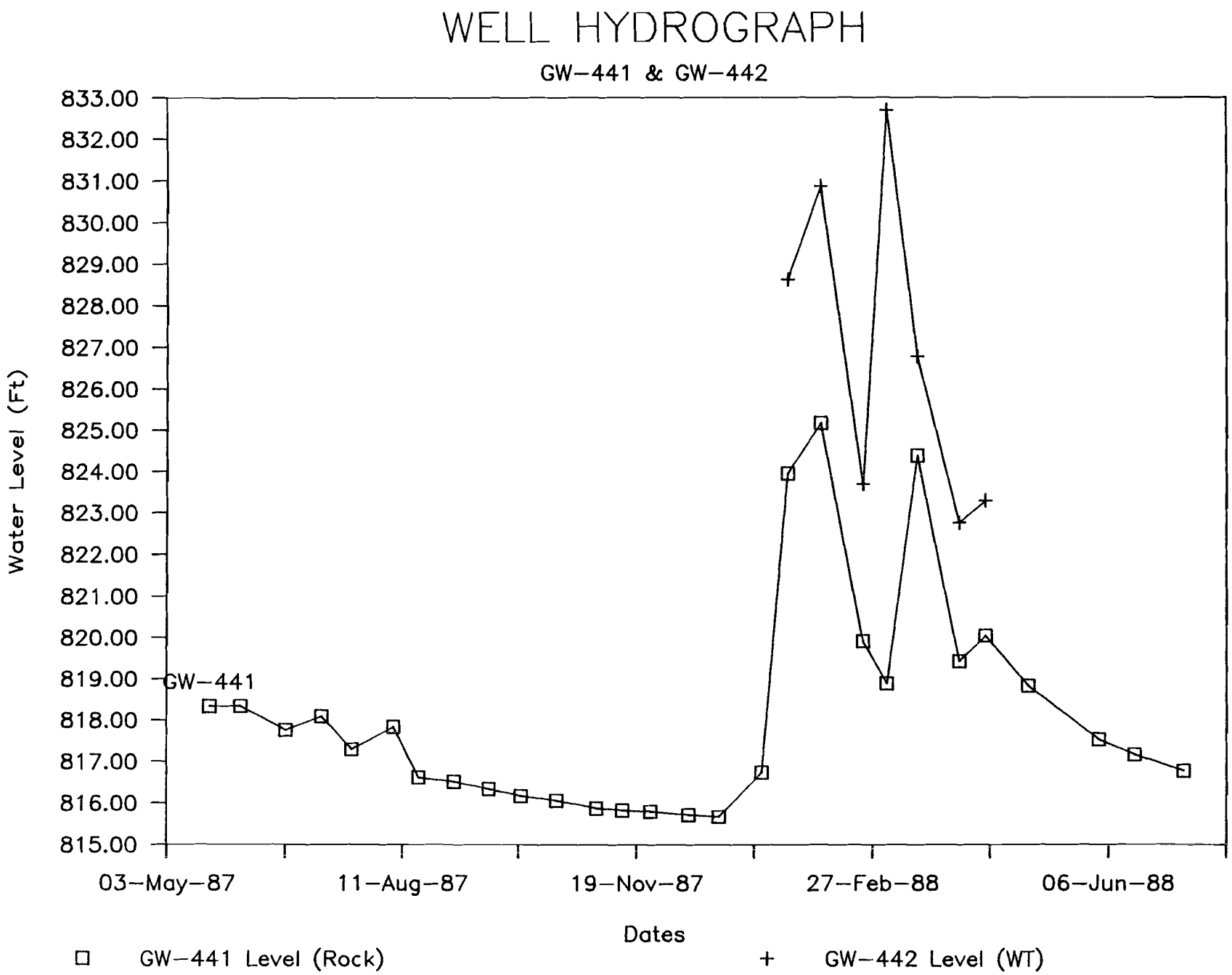
WELL HYDROGRAPH

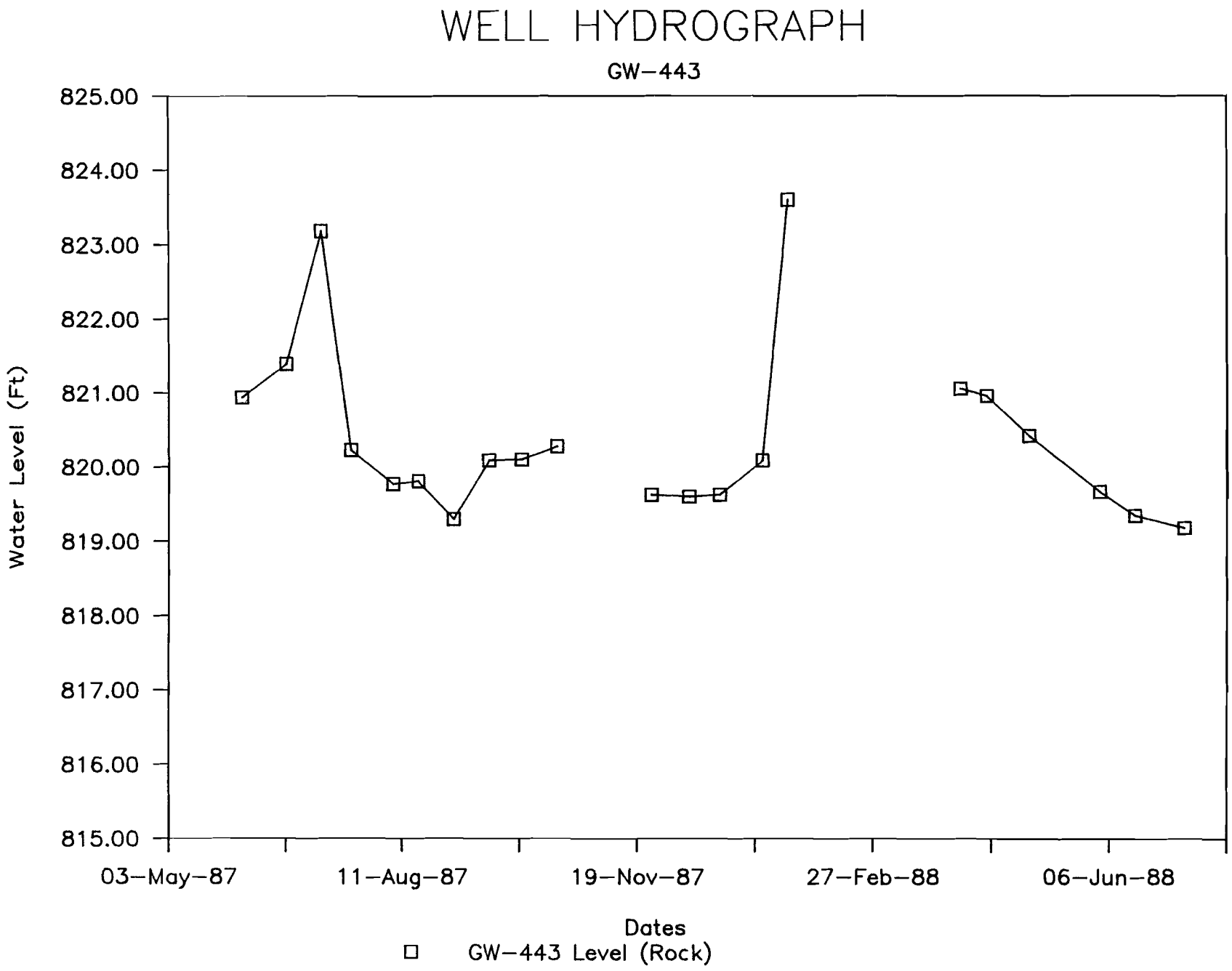
GW-435 & GW-436

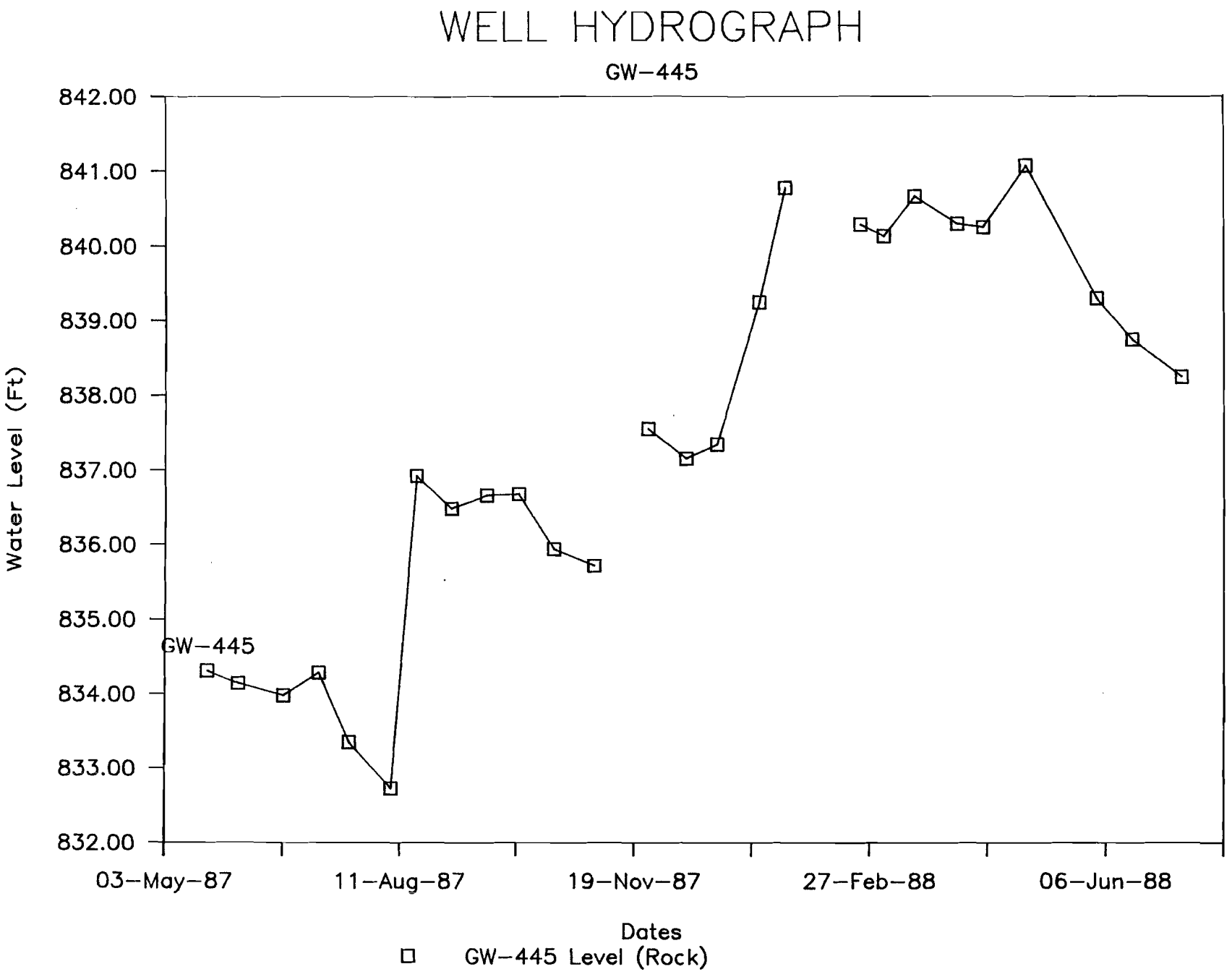



WELL HYDROGRAPH
GW-437 & GW-438
876.00
875.00
874.00
873.00
872.00
871.00
870.00
869.00
868.00
867.00
866.00
Water Level (Ft)
GW-437
GW-438
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-437 Level (Rock)
GW-438 Level (WT)


WELL HYDROGRAPH
GW-439 & GW-440
Water Level (Ft)
863.00
862.00
861.00
860.00
859.00
858.00
857.00
856.00
855.00
854.00
853.00
852.00
851.00
850.00
849.00
848.00
847.00
846.00
GW-439
GW-440
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-439 Level (Rock)
GW-440 Level (WT)

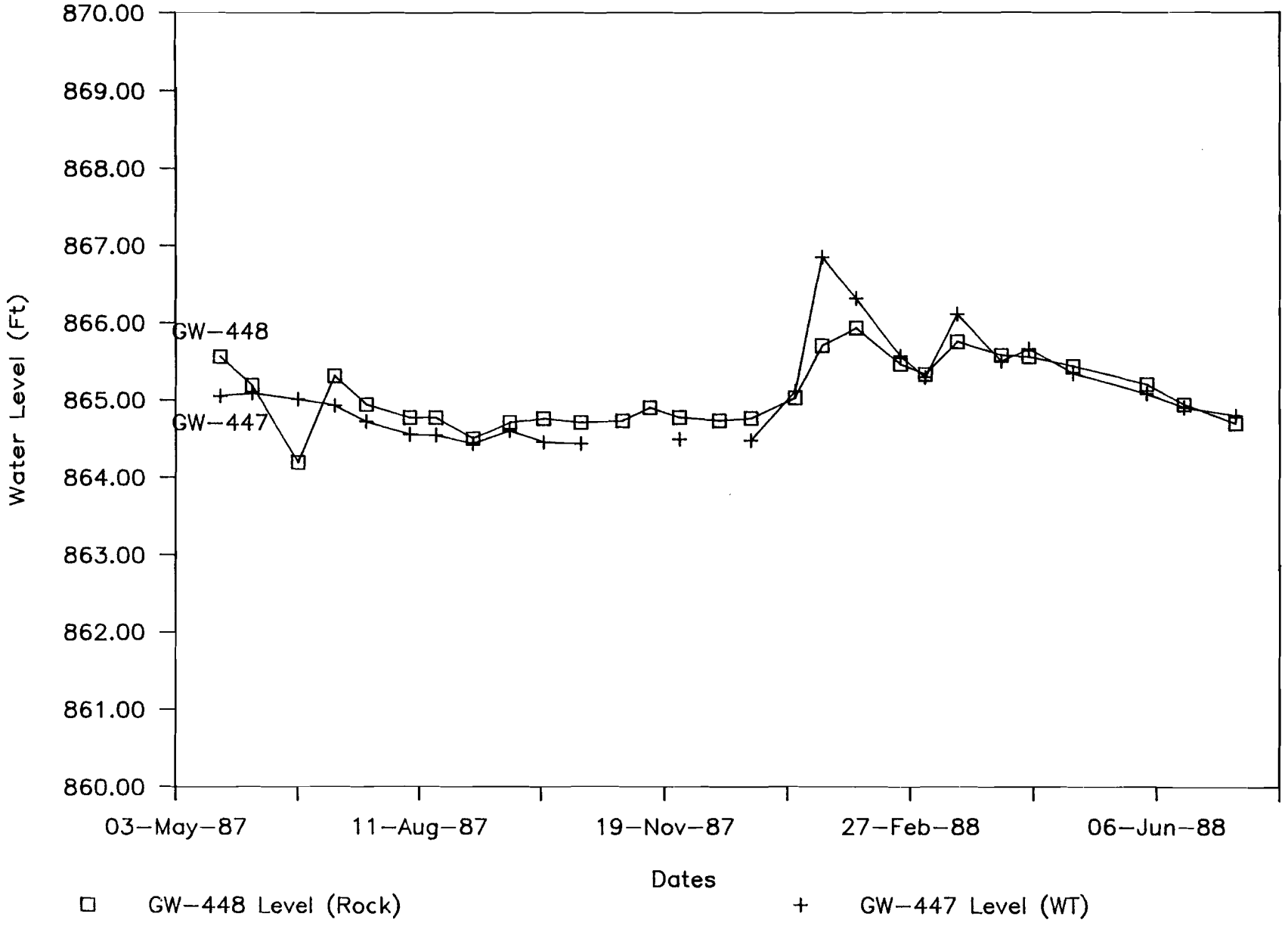

WELL HYDROGRAPH
GW-441 & GW-442
Water Level (Ft)
833.00
832.00
831.00
830.00
829.00
828.00
827.00
826.00
825.00
824.00
823.00
822.00
821.00
820.00
819.00
818.00
817.00
816.00
815.00
GW-441
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-441 Level (Rock)
GW-442 Level (WT)

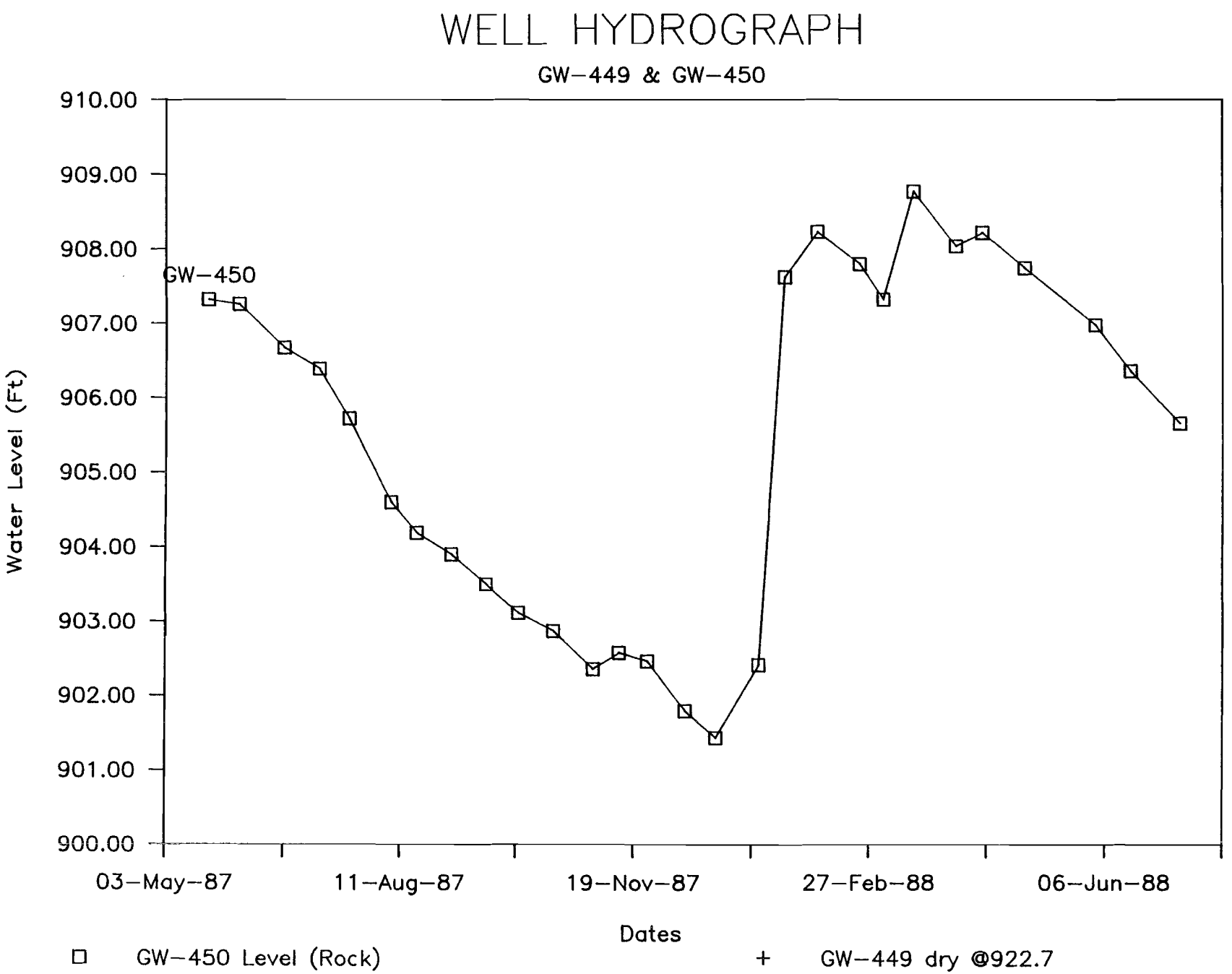

WELL HYDROGRAPH
GW-443
825.00
824.00
823.00
822.00
821.00
820.00
819.00
818.00
817.00
816.00
815.00
Water Level (Ft)
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-443 Level (Rock)

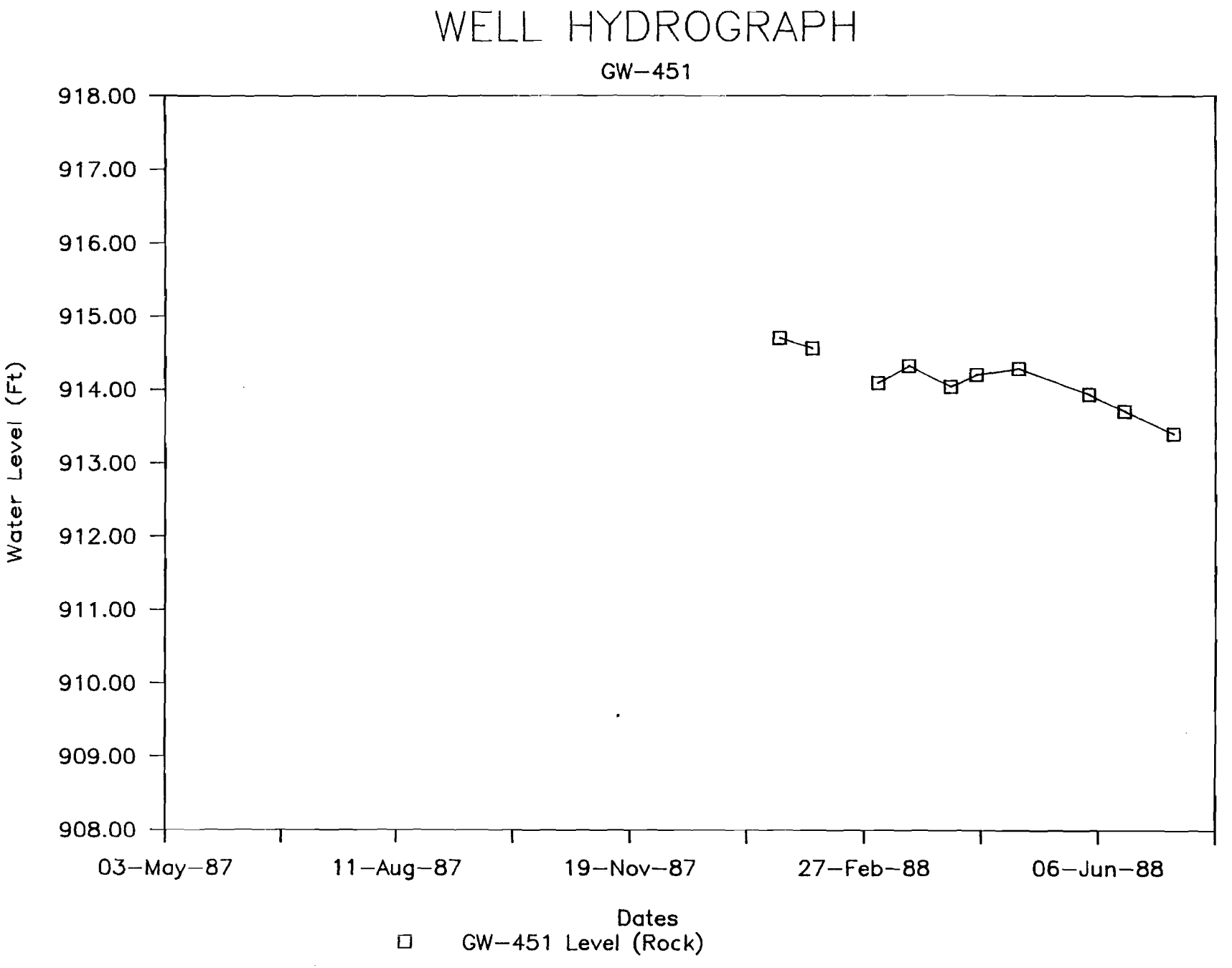

WELL HYDROGRAPH
GW-445
842.00
841.00
840.00
839.00
838.00
837.00
836.00
835.00
834.00
833.00
832.00
Water Level (Ft)
GW-445
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-445 Level (Rock)

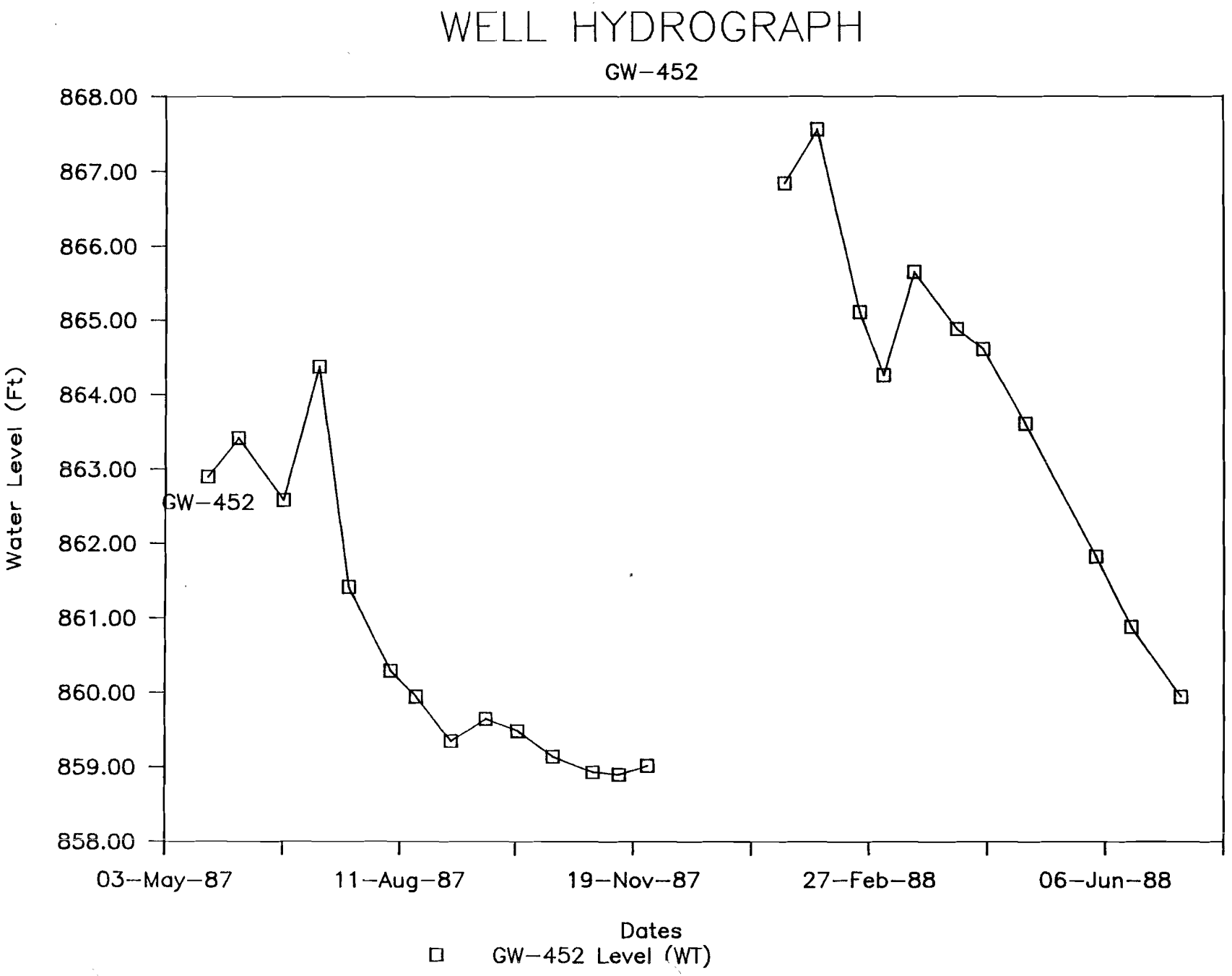
WELL HYDROGRAPH

GW-447 & GW-448




WELL HYDROGRAPH
GW-449 & GW-450
910.00
909.00
908.00
907.00
906.00
905.00
904.00
903.00
902.00
901.00
900.00
Water Level (Ft)
GW-450
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-450 Level (Rock)
GW-449 dry @922.7


WELL HYDROGRAPH
GW-451
918.00
917.00
916.00
915.00
914.00
913.00
912.00
911.00
910.00
909.00
908.00
Water Level (Ft)
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-451 Level (Rock)


WELL HYDROGRAPH
GW-452
868.00
867.00
866.00
865.00
864.00
863.00
862.00
861.00
860.00
859.00
858.00
Water Level (Ft)
GW-452
03-May-87
11-Aug-87
19-Nov-87
27-Feb-88
06-Jun-88
Dates
GW-452 Level (WT)

APPENDIX H

BEAR CREEK VALLEY SURFACE WATER DISCHARGE DATA

R. H. Ketelle

LIST OF TABLES

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Surface discharge summary, January - December 1985, Bear Creek at State Hwy 95 near Oak Ridge, TN: Alias=GS7, USGS site ID = 03538270 . . . . . H-5

Surface discharge summary, January - December 1986, Bear Creek at State Hwy 95 near Oak Ridge, TN: Alias=GS7, USGS site ID = 03538270 . . . . . H-6

Surface discharge summary, January - December 1987, Bear Creek at State Hwy 95 near Oak Ridge, TN: Alias=GS7, USGS site ID = 03538270 . . . . . H-7

Surface discharge summary, January - December 1988, Bear Creek at State Hwy 95 near Oak Ridge, TN: Alias=GS7, USGS site ID = 03538270 . . . . . H-8

Surface discharge summary, January - December 1986, Bear Creek at Pine Ridge near Wheat, TN: Alias=GS8, USGS site ID = 03538273 . . . . . H-9

Surface discharge summary, January - December 1987, Bear Creek at Pine Ridge near Wheat, TN: Alias=GS8, USGS site ID = 03538273 . . . . . H-10

Surface discharge summary, January - December 1988, Bear Creek at Pine Ridge near Wheat, TN: Alias=GS8, USGS site ID = 03538273 . . . . . H-11

Surface discharge summary, January - December 1986, Bear Creek near Wheat, TN: Alias=GS9, USGS site ID = 035382673 . . . . . H-12

Surface discharge summary, January - December 1987, Bear Creek near Wheat, TN: Alias=GS9, USGS site ID = 035382673 . . . . . H-13

Surface discharge summary, January - December 1988, Bear Creek near Wheat, TN: Alias=GS9, USGS site ID = 035382673 . . . . . H-14

Surface discharge summary, January - December 1986, Bear Creek trib above Bear Creek Road near Wheat, TN: Alias=GS10, USGS site ID = 035382672 . . . . . H-15

Surface discharge summary, January - December 1987, Bear Creek trib above Bear Creek Road near Wheat, TN: Alias=GS10, USGS site ID = 035382672 . . . . . H-16

LIST OF TABLES (Cont'd)

Table | Page

Surface discharge summary, January - December 1988, Bear Creek trib above Bear Creek Road near Wheat, TN: Alias=GS10, USGS site ID = 035382672 . . . . . H-17

Surface discharge summary, January - December 1986, Bear Creek trib near Wheat, TN: Alias=GS11, USGS site ID = 035382677 . . . . H-18

Surface discharge summary, January - December 1987, Bear Creek trib near Wheat, TN: Alias=GS11, USGS site ID = 035382677 . . . . H-19

Surface discharge summary, January - December 1988, Bear Creek trib near Wheat, TN: Alias=GS11, USGS site ID = 035382677 . . . . H-20

Surface discharge summary, January - December 1986, Bear Creek trib at Hwy 95 near Wheat, TN: Alias=GS12, USGS site ID = 03538272 . . . . . H-21

Surface discharge summary, January - December 1987, Bear Creek trib at Hwy 95 near Wheat, TN: Alias=GS12, USGS site ID = 03538272 . . . . . H-22

Surface discharge summary, January - December 1988, Bear Creek trib at Hwy 95 near Wheat, TN: Alias=GS12, USGS site ID = 03538272 . . . . . H-23

Precipitation summary, January - December 1986, Bear Creek burial ground: site ID =BUR H-24

Precipitation summary, January - December 1987, Bear Creek burial ground: site ID =BUR H-25

Precipitation summary, January - December 1988, Bear Creek burial ground: site ID =BUR H-26

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1985
BEAR CREEK AT STATE HWY 95 NR OAK RIDGE, TN: ALIAS=GS7
USGS SITE ID = 03538270
Flow in cfs

DAY	JAN85	FEB85	MAR85	APR85	MAY85	JUN85	JUL85	AUG85	SEP85	OCT85	NOV85	DEC85
1	-	-	5.60	5.80	1.90	1.10	2.10	4.40	4.80	4.00	1.30	10.00
2	-	-	5.60	5.30	12.00	0.92	1.10	2.50	3.30	3.80	3.90	9.50
3	-	-	5.10	5.10	10.00	0.88	0.86	1.60	2.80	2.50	2.50	7.20
4	-	-	4.50	4.60	6.00	0.79	0.73	1.20	2.80	1.90	3.60	5.90
5	-	-	5.10	7.30	4.10	0.74	0.68	1.10	2.10	1.50	4.30	5.40
6	-	-	3.90	18.00	3.30	0.79	0.68	1.30	3.80	1.30	3.10	4.60
7	-	-	3.50	13.00	2.90	2.80	0.66	1.80	3.00	1.20	2.60	3.70
8	-	-	3.60	10.00	2.70	2.10	0.58	1.40	2.10	1.10	2.30	3.30
9	-	-	8.70	8.80	2.60	1.30	0.62	1.10	1.80	1.00	1.90	3.00
10	-	-	8.10	7.80	2.40	1.00	0.91	0.88	1.60	0.96	1.70	2.70
11	-	-	7.80	6.70	2.30	0.99	4.50	0.78	1.50	0.90	1.60	2.70
12	-	-	7.60	5.80	2.20	2.50	1.10	0.67	1.30	0.87	1.50	3.80
13	-	-	6.60	5.60	2.00	1.40	0.87	0.62	1.20	0.84	1.40	6.60
14	-	-	5.90	5.20	1.80	1.10	0.77	0.59	1.10	0.85	1.30	5.80
15	-	-	5.40	9.50	1.60	0.94	0.79	0.57	1.10	1.30	1.30	5.20
16	-	-	4.50	9.30	1.50	0.88	1.00	7.70	1.00	1.10	1.30	4.80
17	-	-	4.20	8.00	1.60	1.90	0.75	79.00	1.00	0.91	2.30	4.20
18	-	-	3.80	7.00	1.70	4.10	0.58	19.00	0.98	0.84	1.60	3.60
19	-	-	3.50	5.90	1.50	1.60	0.50	9.60	0.87	0.79	1.50	3.00
20	-	-	3.30	5.70	1.50	1.20	0.47	6.20	0.78	0.79	1.30	2.90
21	-	-	3.30	5.00	1.50	0.97	0.48	4.00	0.74	1.10	1.80	2.70
22	-	-	5.10	4.00	1.50	0.87	0.43	2.70	0.74	1.30	4.90	2.40
23	-	-	4.80	3.50	1.70	0.78	1.50	2.20	0.82	1.70	3.50	2.60
24	-	-	8.60	3.30	1.50	0.73	13.00	14.00	1.20	3.30	2.90	2.50
25	-	-	7.80	3.00	1.40	0.78	5.10	17.00	0.93	1.80	2.50	2.20
26	-	-	6.90	2.70	1.20	0.76	1.90	30.00	1.30	1.40	2.30	1.90
27	-	-	6.30	2.60	1.10	0.71	7.40	13.00	1.50	1.20	8.00	1.90
28	-	-	5.90	2.50	1.10	0.63	2.70	8.70	0.98	1.20	18.00	1.90
29	-	-	5.50	2.30	1.20	0.59	2.80	6.10	0.86	1.20	20.00	1.80
30	-	-	4.90	2.10	1.00	0.64	3.40	6.90	0.80	1.20	12.00	1.70
31	-	-	5.70	.	1.10	.	2.60	7.10	.	1.20	.	4.20
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	-	-	3.30	2.10	1.00	0.59	0.43	0.57	0.74	0.79	1.30	1.70
MAX	-	-	8.70	18.00	12.00	4.10	13.00	79.00	4.80	4.00	20.00	10.00
MEAN	-	-	5.52	6.18	2.58	1.22	1.99	8.18	1.63	1.45	3.94	3.99

gs7y85.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1986
BEAR CREEK AT STATE HWY 95 NR OAK RIDGE, TN: ALIAS=GS7
USGS SITE ID = 03538270
Flow in cfs

DAY	JAN86	FEB86	MAR86	APR86	MAY86	JUN86	JUL86	AUG86	SEP86	OCT86	NOV86	DEC86
1	4.50	3.00	5.80	3.50	1.50	1.30	0.42	0.34	0.58	0.30	0.83	2.80
2	3.60	2.90	5.60	3.40	1.40	1.20	1.60	0.31	4.90	0.63	0.78	3.90
3	3.50	3.20	5.50	3.20	1.30	1.00	0.96	0.29	2.40	0.41	0.71	4.30
4	3.20	3.10	5.00	3.00	1.20	1.00	0.60	0.29	1.10	0.34	0.69	3.40
5	2.90	12.00	4.30	2.80	1.20	1.30	0.51	0.26	1.20	0.38	0.73	2.90
6	2.50	11.00	4.10	2.70	1.20	2.60	0.47	0.23	1.30	0.40	0.75	2.60
7	2.40	11.00	3.80	2.70	1.20	1.20	0.43	0.26	0.66	0.33	1.00	2.30
8	2.20	8.50	3.40	4.20	1.10	1.10	0.43	0.26	0.54	0.30	3.40	7.80
9	1.90	7.30	3.30	3.30	1.10	1.50	0.42	0.26	0.46	0.28	4.30	86.00
10	2.00	6.60	3.20	2.90	1.00	1.80	0.79	0.24	0.43	0.33	2.60	47.00
11	2.00	6.80	3.50	2.70	0.98	1.20	1.50	0.52	0.44	0.90	5.50	30.00
12	1.90	5.60	5.80	2.50	0.98	1.00	0.59	0.43	0.60	0.64	4.70	20.00
13	1.90	5.10	13.00	2.40	1.00	0.84	2.50	0.33	0.44	7.50	2.70	13.00
14	1.80	5.20	12.00	2.30	0.98	0.78	5.70	0.28	0.38	4.20	2.00	9.20
15	1.70	5.60	11.00	2.20	0.92	0.73	3.10	0.26	0.37	1.50	2.10	7.20
16	1.70	7.40	9.10	2.10	0.84	0.68	1.10	0.26	0.54	0.99	1.90	5.70
17	1.60	64.00	7.90	2.10	0.83	0.63	0.82	0.26	0.48	0.81	1.70	4.90
18	1.60	75.00	6.90	2.00	0.88	0.59	0.65	0.26	0.43	0.66	1.50	9.40
19	4.50	30.00	32.00	1.90	1.00	0.59	0.57	0.26	0.43	0.58	1.30	6.50
20	3.40	19.00	17.00	1.90	0.89	0.55	0.50	0.31	0.43	0.53	2.70	5.70
21	3.00	14.00	12.00	2.50	0.83	0.55	0.46	0.30	0.43	0.50	2.80	5.00
22	2.70	12.00	9.50	2.10	0.79	0.51	0.42	0.30	0.38	0.47	2.10	4.00
23	2.40	9.90	8.30	1.80	3.00	0.51	0.38	0.30	0.37	0.47	2.30	3.80
24	2.30	9.90	7.20	1.70	1.90	0.45	0.38	0.35	0.34	0.48	11.00	5.10
25	2.50	8.80	6.20	1.70	3.40	0.43	0.36	0.28	0.36	13.00	6.90	4.00
26	4.20	8.30	5.70	1.70	1.90	0.43	0.33	0.76	0.34	5.30	13.00	3.50
27	5.10	8.10	5.60	1.60	3.90	0.43	0.33	2.40	0.33	2.20	7.80	3.20
28	4.50	6.70	5.10	1.80	3.80	0.42	0.30	1.80	0.30	1.60	5.50	3.00
29	4.00	.	4.50	2.00	2.60	0.38	0.30	0.72	0.30	1.30	4.10	2.80
30	3.60	.	4.10	1.60	1.90	0.42	0.30	0.47	0.31	1.10	3.30	2.70
31	3.20	.	3.80	.	1.50	.	0.32	0.38	.	0.92	.	2.50
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	1.60	2.90	3.20	1.60	0.79	0.38	0.30	0.23	0.30	0.28	0.69	2.30
MAX	5.10	75.00	32.00	4.20	3.90	2.60	5.70	2.40	4.90	13.00	13.00	86.00
MEAN	2.85	13.21	7.55	2.41	1.52	0.87	0.89	0.45	0.72	1.59	3.36	10.14

gs7y86.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1987
BEAR CREEK AT STATE HIGHWAY 95: ALIAS=GS7
SITE ID = 03538270
Flow in cubic feet/second

DAY	JAN87	FEB87	MAR87	APR87	MAY87	JUN87	JUL87	AUG87	SEP87	OCT87	NOV87	DEC87
1	2.40	6.10	42.00	5.50	3.00	1.60	0.76	0.32	0.23	0.62	0.50	0.59
2	2.40	6.90	23.00	5.50	2.80	1.40	0.73	0.30	0.21	0.45	0.51	0.53
3	2.10	6.70	16.00	6.60	2.80	1.30	0.71	0.30	0.20	0.37	0.51	0.51
4	2.00	5.80	12.00	8.40	8.10	1.20	1.30	0.30	0.19	0.34	0.51	0.47
5	1.90	5.40	9.90	9.10	4.50	1.10	1.60	0.30	0.20	0.34	0.51	0.47
6	1.80	5.20	8.40	9.80	3.50	0.98	3.60	0.41	0.22	0.34	0.50	0.44
7	1.80	5.00	7.40	10.00	3.00	0.89	13.00	0.37	0.26	0.34	0.51	0.46
8	1.60	4.50	6.70	9.10	2.60	0.83	2.40	0.35	0.28	0.34	0.51	0.47
9	1.60	3.80	7.20	8.10	2.40	0.78	1.50	0.42	0.38	0.34	0.46	0.45
10	1.70	3.40	6.30	7.20	2.10	0.74	1.20	0.45	0.35	0.34	1.10	0.44
11	1.70	3.20	5.60	6.70	2.00	0.74	2.50	0.42	0.24	0.34	1.00	0.43
12	1.50	3.10	5.50	6.00	1.90	0.74	1.90	0.45	4.90	0.34	0.65	0.42
13	1.50	3.00	5.30	5.60	1.80	0.88	1.10	0.44	0.94	0.34	0.55	0.42
14	1.50	2.90	5.10	6.30	1.70	0.83	0.95	0.30	0.51	0.31	0.50	0.43
15	1.90	3.10	5.10	22.00	1.70	0.78	0.75	0.33	0.40	0.33	0.46	2.10
16	1.80	13.00	5.40	17.00	1.60	2.00	0.62	0.32	0.34	0.34	0.41	1.60
17	1.70	13.00	5.10	16.00	1.60	3.90	0.60	0.33	0.34	0.34	1.60	1.10
18	6.60	11.00	6.40	13.00	2.00	1.60	0.64	0.35	0.34	0.34	1.40	0.89
19	105.00	9.10	15.00	10.00	1.60	1.20	0.67	0.28	0.41	0.34	0.80	0.80
20	29.00	8.20	11.00	8.80	2.00	1.20	0.77	0.26	0.35	0.42	0.62	0.86
21	18.00	7.80	9.40	7.40	2.10	1.30	0.64	0.26	0.34	0.49	0.54	0.83
22	14.00	13.00	8.20	6.50	2.80	2.90	0.77	0.25	0.34	0.51	0.51	0.79
23	11.00	23.00	7.20	5.80	2.30	2.30	0.58	0.22	0.33	0.51	0.48	0.75
24	8.30	15.00	6.50	6.50	2.00	1.60	0.53	0.22	0.30	0.54	0.47	0.84
25	19.00	12.00	6.20	5.50	3.20	1.30	0.49	0.21	0.30	0.59	0.47	8.70
26	28.00	9.60	5.70	4.90	5.00	1.00	0.47	0.24	0.31	0.56	0.47	6.30
27	17.00	54.00	5.40	4.10	2.50	0.90	0.53	0.26	0.30	0.67	0.47	.
28	13.00	54.00	5.10	3.80	1.70	0.78	0.52	0.25	0.26	0.62	0.48	.
29	10.00	.	4.30	3.50	1.40	0.69	0.47	0.27	0.28	0.63	0.61	.
30	8.90	.	5.40	3.30	3.10	0.71	0.36	0.30	2.50	0.60	0.65	.
31	7.40	.	6.40	.	2.60	.	0.34	0.30	.	0.54	.	.
	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
MIN	1.50	2.90	4.30	3.30	1.40	0.69	0.34	0.21	0.19	0.31	0.41	0.00
MAX	105.00	54.00	42.00	22.00	8.10	3.90	13.00	0.45	4.90	0.67	1.60	8.70
MEAN	10.52	11.10	8.97	8.07	2.63	1.27	1.39	0.32	0.55	0.44	0.63	1.15

sw87_gs7.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1988
BEAR CREEK AT ST HWY 95 NR OAK RIDGE, TN: ALIAS=GS7
USGS SITE ID = 03538270
Flow in cfs

DAY	JAN88	FEB88	MAR88	APR88	MAY88	JUN88	JUL88	AUG88	SEP88	OCT88	NOV88	DEC88
1	2.90	1.60	.	2.10	-	-	-	-	-	-	-	-
2	2.80	2.20	.	3.10	-	-	-	-	-	-	-	-
3	2.00	4.70	.	2.90	-	-	-	-	-	-	-	-
4	3.20	30.00	.	3.40	-	-	-	-	-	-	-	-
5	2.10	.	.	3.20	-	-	-	-	-	-	-	-
6	1.60	.	.	.	-	-	-	-	-	-	-	-
7	1.30	.	.	.	-	-	-	-	-	-	-	-
8	1.40	.	.	.	-	-	-	-	-	-	-	-
9	1.30	.	.	.	-	-	-	-	-	-	-	-
10	1.00	.	.	.	-	-	-	-	-	-	-	-
11	0.99	.	.	.	-	-	-	-	-	-	-	-
12	0.92	.	.	.	-	-	-	-	-	-	-	-
13	1.00	.	.	.	-	-	-	-	-	-	-	-
14	1.30	.	.	.	-	-	-	-	-	-	-	-
15	1.20	.	9.60	.	-	-	-	-	-	-	-	-
16	1.10	.	7.80	.	-	-	-	-	-	-	-	-
17	1.90	.	6.20	.	-	-	-	-	-	-	-	-
18	6.10	.	5.60	.	-	-	-	-	-	-	-	-
19	24.00	.	5.20	.	-	-	-	-	-	-	-	-
20	93.00	.	4.00	.	-	-	-	-	-	-	-	-
21	16.00	.	3.50	.	-	-	-	-	-	-	-	-
22	9.10	.	3.10	.	-	-	-	-	-	-	-	-
23	6.20	.	2.80	.	-	-	-	-	-	-	-	-
24	4.80	.	2.60	.	-	-	-	-	-	-	-	-
25	3.60	.	2.50	.	-	-	-	-	-	-	-	-
26	2.90	.	2.50	.	-	-	-	-	-	-	-	-
27	2.40	.	2.60	.	-	-	-	-	-	-	-	-
28	2.10	.	2.30	.	-	-	-	-	-	-	-	-
29	1.90	.	2.00	.	-	-	-	-	-	-	-	-
30	1.70	.	1.90	.	-	-	-	-	-	-	-	-
31	1.60	.	1.90	.	-	-	-	-	-	-	-	-
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	0.92	1.60	1.90	2.10	-	-	-	-	-	-	-	-
MAX	93.00	30.00	9.60	3.40	-	-	-	-	-	-	-	-
MEAN	6.56	9.63	3.89	2.88	-	-	-	-	-	-	-	-

gs7y88.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1986
BEAR CREEK AT PINE RIDGE NEAR WHEAT, TN: ALIAS=GS8
USGS SITE ID = 03538273
Flow in cfs

DAY	JAN86	FEB86	MAR86	APR86	MAY86	JUN86	JUL86	AUG86	SEP86	OCT86	NOV86	DEC86
1	-	-	-	-	-	-	-	-	-	0.34	0.98	2.90
2	-	-	-	-	-	-	-	-	-	0.65	0.91	4.30
3	-	-	-	-	-	-	-	-	-	0.39	0.83	4.80
4	-	-	-	-	-	-	-	-	-	0.35	0.78	3.70
5	-	-	-	-	-	-	-	-	-	0.33	0.88	3.10
6	-	-	-	-	-	-	-	-	-	0.32	0.88	2.70
7	-	-	-	-	-	-	-	-	-	0.32	1.20	2.40
8	-	-	-	-	-	-	-	-	-	0.32	3.50	9.10
9	-	-	-	-	-	-	-	-	-	0.33	4.30	117.00
10	-	-	-	-	-	-	-	-	-	0.35	2.90	45.00
11	-	-	-	-	-	-	-	-	-	0.93	5.80	27.00
12	-	-	-	-	-	-	-	-	-	0.64	4.80	18.00
13	-	-	-	-	-	-	-	-	-	6.30	2.90	12.00
14	-	-	-	-	-	-	-	-	-	3.80	2.20	8.30
15	-	-	-	-	-	-	-	-	-	1.40	2.30	6.60
16	-	-	-	-	-	-	-	-	-	1.00	2.10	5.40
17	-	-	-	-	-	-	-	-	-	0.82	1.80	4.80
18	-	-	-	-	-	-	-	-	-	0.60	1.60	9.40
19	-	-	-	-	-	-	-	-	-	0.50	1.50	6.40
20	-	-	-	-	-	-	-	-	-	0.46	2.90	5.60
21	-	-	-	-	-	-	-	-	-	0.42	3.00	4.80
22	-	-	-	-	-	-	-	-	-	0.39	2.30	4.10
23	-	-	-	-	-	-	-	-	-	0.38	2.50	4.00
24	-	-	-	-	-	-	-	-	-	0.37	12.00	5.20
25	-	-	-	-	-	-	-	-	0.33	13.00	7.60	4.20
26	-	-	-	-	-	-	-	-	0.31	4.40	16.00	3.60
27	-	-	-	-	-	-	-	-	0.31	2.30	8.40	3.30
28	-	-	-	-	-	-	-	-	0.31	1.70	5.60	3.10
29	-	-	-	-	-	-	-	-	0.31	1.30	4.30	2.90
30	-	-	-	-	-	-	-	-	0.32	1.20	3.40	2.80
31	-	-	-	-	-	-	-	-	.	1.10	.	2.50
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	-	-	-	-	-	-	-	-	0.31	0.32	0.78	2.40
MAX	-	-	-	-	-	-	-	-	0.33	13.00	16.00	117.00
MEAN	-	-	-	-	-	-	-	-	0.32	1.51	3.67	10.94

gs8y86.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1987
BEAR CREEK AT PINE RIDGE, NEAR WHEAT, TN: ALIAS=GS8
USGS SITE ID = 03538273
Flow in cfs

DAY	JAN87	FEB87	MAR87	APR87	MAY87	JUN87	JUL87	AUG87	SEP87	OCT87	NOV87	DEC87
1	2.60	6.30	46.00	5.70	2.80	1.30	0.49	0.27	0.24	0.45	0.56	0.44
2	2.40	7.50	23.00	5.60	2.60	1.20	0.53	0.27	0.24	0.35	0.53	0.41
3	2.20	6.80	16.00	7.70	2.70	1.10	0.55	0.27	0.24	0.31	0.50	0.39
4	2.10	5.90	13.00	9.30	8.20	1.00	1.00	0.26	0.24	0.31	0.51	0.38
5	2.00	5.30	10.00	10.00	4.40	0.88	1.50	0.27	0.24	0.31	0.51	0.37
6	1.90	5.00	8.60	13.00	3.60	0.76	3.50	0.26	0.25	0.31	0.52	0.37
7	1.80	4.90	7.50	12.00	3.00	0.67	12.00	0.27	0.25	0.31	0.52	0.35
8	1.80	4.70	7.00	10.00	2.50	0.61	2.20	0.26	0.25	0.31	0.52	0.35
9	1.70	4.20	7.80	8.70	2.10	0.56	1.20	0.26	0.26	0.31	0.56	0.35
10	2.00	3.60	6.40	7.50	1.90	0.54	0.95	0.27	0.26	0.31	1.30	0.35
11	1.80	3.50	5.50	7.10	1.80	0.52	2.20	0.26	0.26	0.29	1.10	0.35
12	1.60	3.40	5.70	6.40	1.60	0.53	1.60	0.27	4.60	0.29	0.76	0.35
13	1.60	3.10	5.10	5.60	1.50	0.66	0.86	0.27	0.89	0.31	0.53	0.34
14	1.60	3.20	5.00	7.00	1.40	0.56	0.67	0.27	0.50	0.32	0.39	0.34
15	2.20	3.40	4.90	22.00	1.30	0.53	0.53	0.27	0.42	0.32	0.37	1.40
16	2.00	13.00	5.50	18.00	1.30	2.20	0.46	0.27	0.40	0.32	0.37	0.93
17	1.90	14.00	4.90	16.00	1.40	3.90	0.43	0.28	0.39	0.33	1.30	0.56
18	7.50	12.00	6.40	14.00	1.70	1.40	0.39	0.28	0.31	0.33	1.10	0.45
19	197.00	10.00	16.00	11.00	1.30	1.00	0.38	0.27	0.33	0.34	0.58	0.42
20	27.00	8.70	12.00	8.80	2.00	1.10	0.36	0.26	0.32	0.35	0.47	0.45
21	16.00	8.50	9.70	7.60	2.10	1.20	0.34	0.26	0.32	0.38	0.42	0.42
22	14.00	14.00	8.30	6.70	2.40	3.80	0.33	0.25	0.32	0.40	0.41	0.40
23	11.00	24.00	7.30	5.90	1.60	2.80	0.33	0.25	0.30	0.41	0.39	0.38
24	8.10	16.00	6.60	6.70	1.30	1.50	0.32	0.24	0.30	0.41	0.38	0.44
25	19.00	13.00	6.50	5.40	2.30	1.10	0.30	0.24	0.29	0.42	0.38	6.60
26	26.00	11.00	5.50	4.70	2.70	0.89	0.29	0.24	0.29	0.43	0.37	3.80
27	16.00	71.00	5.00	4.30	1.70	0.66	0.28	0.24	0.28	0.46	0.38	2.90
28	13.00	66.00	4.80	3.90	1.40	0.55	0.28	0.24	0.28	0.50	0.38	4.80
29	10.00	.	4.40	3.40	1.10	0.50	0.28	0.24	0.32	0.54	0.48	2.70
30	8.70	.	5.70	3.10	2.80	0.45	0.27	0.24	2.20	0.55	0.49	1.60
31	7.20	.	6.80	.	2.50	.	0.27	0.24	.	0.56	.	1.20
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	1.60	3.10	4.40	3.10	1.10	0.45	0.27	0.24	0.24	0.29	0.37	0.34
MAX	197.00	71.00	46.00	22.00	8.20	3.90	12.00	0.28	4.60	0.56	1.30	6.60
MEAN	13.35	12.57	9.25	8.57	2.29	1.15	1.13	0.26	0.53	0.37	0.57	1.12

gs8y87.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1988
BEAR CREEK AT PINE RIDGE, NEAR WHEAT, TN: ALIAS=GS8
USGS SITE ID = 03538273
Flow in cfs

DAY	JAN88	FEB88	MAR88	APR88	MAY88	JUN88	JUL88	AUG88	SEP88	OCT88	NOV88	DEC88
1	2.90	1.20	1.80	2.00	-	-	-	-	-	-	-	-
2	2.60	2.10	1.60	3.00	-	-	-	-	-	-	-	-
3	1.80	4.30	1.60	2.60	-	-	-	-	-	-	-	-
4	3.10	33.00	1.90	3.60	-	-	-	-	-	-	-	-
5	1.90	15.00	1.80	3.20	-	-	-	-	-	-	-	-
6	1.30	9.10	1.50	.	-	-	-	-	-	-	-	-
7	1.20	6.60	1.40	.	-	-	-	-	-	-	-	-
8	1.20	5.30	1.30	.	-	-	-	-	-	-	-	-
9	1.00	4.40	1.40	.	-	-	-	-	-	-	-	-
10	0.87	3.50	93.00	.	-	-	-	-	-	-	-	-
11	0.78	2.90	24.00	.	-	-	-	-	-	-	-	-
12	0.76	2.90	16.00	.	-	-	-	-	-	-	-	-
13	0.92	2.40	18.00	.	-	-	-	-	-	-	-	-
14	1.20	2.10	13.00	.	-	-	-	-	-	-	-	-
15	1.00	4.90	9.30	.	-	-	-	-	-	-	-	-
16	0.98	5.20	7.20	.	-	-	-	-	-	-	-	-
17	1.90	4.50	5.80	.	-	-	-	-	-	-	-	-
18	7.40	4.00	5.10	.	-	-	-	-	-	-	-	-
19	48.00	4.30	4.70	.	-	-	-	-	-	-	-	-
20	150.00	4.30	3.80	.	-	-	-	-	-	-	-	-
21	40.00	3.50	3.30	.	-	-	-	-	-	-	-	-
22	9.00	3.00	2.80	.	-	-	-	-	-	-	-	-
23	4.50	3.00	2.40	.	-	-	-	-	-	-	-	-
24	3.00	3.00	2.20	.	-	-	-	-	-	-	-	-
25	2.50	2.60	2.20	.	-	-	-	-	-	-	-	-
26	2.00	2.40	2.20	.	-	-	-	-	-	-	-	-
27	1.70	2.40	2.10	.	-	-	-	-	-	-	-	-
28	1.50	2.20	1.90	.	-	-	-	-	-	-	-	-
29	1.40	.	1.80	.	-	-	-	-	-	-	-	-
30	1.30	.	1.60	.	-	-	-	-	-	-	-	-
31	1.20	.	1.60	.	-	-	-	-	-	-	-	-
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	0.76	1.20	1.30	2.00	-	-	-	-	-	-	-	-
MAX	150.00	33.00	93.00	3.60	-	-	-	-	-	-	-	-
MEAN	9.64	5.15	7.69	2.88	-	-	-	-	-	-	-	-

gs8y88.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1986
BEAR CREEK NEAR WHEAT,TN: ALIAS=GS9
USGS SITE ID = 035382673
Flow in cfs

DAY	JAN86	FEB86	MAR86	APR86	MAY86	JUN86	JUL86	AUG86	SEP86	OCT86	NOV86	DEC86
1	-	-	-	-	-	-	-	-	.	0.22	0.53	1.50
2	-	-	-	-	-	-	-	-	.	0.54	0.48	2.40
3	-	-	-	-	-	-	-	-	.	0.29	0.47	2.60
4	-	-	-	-	-	-	-	-	.	0.23	0.44	1.80
5	-	-	-	-	-	-	-	-	.	0.21	0.48	1.50
6	-	-	-	-	-	-	-	-	.	0.19	0.48	1.30
7	-	-	-	-	-	-	-	-	.	0.19	0.97	1.20
8	-	-	-	-	-	-	-	-	.	0.19	1.80	7.00
9	-	-	-	-	-	-	-	-	.	0.21	2.70	74.00
10	-	-	-	-	-	-	-	-	.	0.28	1.50	27.00
11	-	-	-	-	-	-	-	-	.	0.56	4.20	17.00
12	-	-	-	-	-	-	-	-	.	0.59	2.80	10.00
13	-	-	-	-	-	-	-	-	.	4.80	1.60	6.10
14	-	-	-	-	-	-	-	-	.	2.80	1.20	4.40
15	-	-	-	-	-	-	-	-	.	0.83	1.30	3.50
16	-	-	-	-	-	-	-	-	.	0.58	1.20	2.90
17	-	-	-	-	-	-	-	-	.	0.48	0.98	2.50
18	-	-	-	-	-	-	-	-	.	0.40	0.89	6.30
19	-	-	-	-	-	-	-	-	.	0.35	0.78	3.80
20	-	-	-	-	-	-	-	-	.	0.32	2.00	3.20
21	-	-	-	-	-	-	-	-	.	0.29	1.60	2.60
22	-	-	-	-	-	-	-	-	.	0.29	1.20	2.10
23	-	-	-	-	-	-	-	-	.	0.29	1.80	2.10
24	-	-	-	-	-	-	-	-	.	0.28	8.00	2.90
25	-	-	-	-	-	-	-	-	0.23	10.00	4.60	2.20
26	-	-	-	-	-	-	-	-	0.23	2.70	9.50	1.80
27	-	-	-	-	-	-	-	-	0.23	1.30	4.70	1.70
28	-	-	-	-	-	-	-	-	0.22	0.89	3.00	1.50
29	-	-	-	-	-	-	-	-	0.22	0.72	2.20	1.50
30	-	-	-	-	-	-	-	-	0.21	0.64	1.70	1.40
31	-	-	-	-	-	-	-	-	.	0.55	.	1.20
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	-	-	-	-	-	-	-	-	0.21	0.19	0.44	1.20
MAX	-	-	-	-	-	-	-	-	0.23	10.00	9.50	74.00
MEAN	-	-	-	-	-	-	-	-	0.22	1.04	2.17	6.48

gs9y86.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1987
BEAR CREEK NEAR WHEAT: ALIAS=GS9
SITE ID = 035382673
Flow in cubic feet/second

DAY	JAN87	FEB87	MAR87	APR87	MAY87	JUN87	JUL87	AUG87	SEP87	OCT87	NOV87	DEC87
1	1.30	3.10	26.00	2.80	1.30	0.62	0.20	0.07	0.03	0.30	0.44	0.22
2	1.20	3.90	12.00	2.80	1.20	0.55	0.21	0.06	0.02	0.19	0.40	0.19
3	1.00	3.40	8.30	4.10	1.30	0.49	0.24	0.06	0.01	0.14	0.39	0.18
4	0.99	3.00	6.10	4.90	5.00	0.46	0.54	0.06	0.01	0.14	0.39	0.19
5	0.96	2.60	5.00	5.30	2.00	0.39	0.83	0.07	0.01	0.14	0.38	0.16
6	0.91	2.40	4.20	6.20	1.60	0.33	1.90	0.07	0.03	0.14	0.40	0.16
7	0.91	2.40	3.60	5.70	1.30	0.30	11.00	0.08	0.06	0.14	0.40	0.16
8	0.86	2.20	3.40	4.90	1.10	0.28	1.20	0.07	0.09	0.14	0.40	0.16
9	0.85	1.80	4.00	4.10	0.96	0.25	0.71	0.06	0.13	0.14	0.41	0.16
10	0.95	1.60	3.10	3.50	0.88	0.24	0.54	0.08	0.11	0.14	0.75	0.16
11	0.87	1.60	2.60	3.40	0.81	0.23	1.90	0.05	0.11	0.14	0.41	0.16
12	0.80	1.50	2.90	3.10	0.77	0.24	0.89	0.08	4.10	0.14	0.26	0.16
13	0.76	1.40	2.50	2.60	0.74	0.32	0.54	0.09	0.43	0.16	0.20	0.15
14	0.79	1.50	2.40	3.50	0.72	0.26	0.40	0.10	0.25	0.19	0.18	0.17
15	1.20	1.50	2.40	16.00	0.69	0.23	0.31	0.07	0.16	0.19	0.16	1.10
16	0.98	8.30	3.00	10.00	0.65	1.50	0.27	0.05	0.13	0.19	0.15	0.52
17	0.90	7.10	2.40	8.90	0.68	1.90	0.23	0.06	0.12	0.20	0.99	0.33
18	5.70	6.30	4.50	6.70	0.85	0.62	0.20	0.07	0.12	0.23	0.53	0.27
19	105.00	5.10	9.60	5.30	0.68	0.46	0.18	0.05	0.16	0.28	0.32	0.24
20	15.00	4.40	6.30	4.30	0.87	0.52	0.16	0.02	0.19	0.34	0.25	0.28
21	8.60	4.30	5.10	3.70	0.85	0.81	0.16	0.02	0.15	0.37	0.20	0.24
22	7.00	9.30	4.20	3.20	0.99	1.30	0.15	0.02	0.12	0.36	0.19	0.22
23	5.10	15.00	3.60	2.80	0.68	0.68	0.14	0.02	0.12	0.37	0.19	0.20
24	4.00	8.40	3.30	3.40	0.62	0.48	0.13	0.01	0.11	0.40	0.16	0.27
25	13.00	6.20	3.20	2.50	1.10	0.39	0.12	0.01	0.10	0.42	0.16	5.00
26	16.00	5.20	2.60	2.10	0.91	0.33	0.11	0.01	0.10	0.41	0.16	2.50
27	8.60	42.00	2.40	1.90	0.63	0.27	0.10	0.02	0.10	0.44	0.16	1.80
28	6.50	38.00	2.20	1.70	0.53	0.21	0.10	0.02	0.10	0.42	0.18	3.10
29	5.00	.	2.00	1.50	0.97	0.19	0.09	0.02	0.17	0.45	0.29	1.40
30	4.40	.	3.10	1.50	1.40	0.17	0.08	0.02	1.90	0.51	0.26	0.85
31	3.50	.	3.50	.	1.20	.	0.08	0.03	.	0.46	.	0.69
	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
MIN	0.76	1.40	2.00	1.50	0.53	0.17	0.08	0.01	0.01	0.14	0.15	0.15
MAX	105.00	42.00	26.00	16.00	5.00	1.90	11.00	0.10	4.10	0.51	0.99	5.00
MEAN	7.21	6.91	4.82	4.41	1.10	0.50	0.76	0.05	0.31	0.27	0.33	0.69

sw87_gs9.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1988
BEAR CREEK NEAR WHEAT, TN: ALIAS=GS9
USGS SITE ID = 035382673
Flow in cfs

DAY	JAN88	FEB88	MAR88	APR88	MAY88	JUN88	JUL88	AUG88	SEP88	OCT88	NOV88	DEC88
1	2.10	0.75	0.87	1.10	-	-	-	-	-	-	-	-
2	1.40	1.40	0.84	1.50	-	-	-	-	-	-	-	-
3	0.97	3.50	0.84	1.30	-	-	-	-	-	-	-	-
4	1.90	23.00	0.99	1.70	-	-	-	-	-	-	-	-
5	1.00	8.20	0.86	1.40	-	-	-	-	-	-	-	-
6	0.75	4.60	0.79	.	-	-	-	-	-	-	-	-
7	0.68	3.20	0.75	.	-	-	-	-	-	-	-	-
8	0.69	2.60	0.71	.	-	-	-	-	-	-	-	-
9	0.60	2.00	0.76	.	-	-	-	-	-	-	-	-
10	0.51	1.60	53.00	.	-	-	-	-	-	-	-	-
11	0.46	1.40	13.00	.	-	-	-	-	-	-	-	-
12	0.44	1.40	8.30	.	-	-	-	-	-	-	-	-
13	0.58	1.10	9.50	.	-	-	-	-	-	-	-	-
14	0.69	1.00	6.10	.	-	-	-	-	-	-	-	-
15	0.58	3.20	4.50	.	-	-	-	-	-	-	-	-
16	0.56	2.90	3.50	.	-	-	-	-	-	-	-	-
17	1.50	2.30	2.80	.	-	-	-	-	-	-	-	-
18	4.00	2.00	2.50	.	-	-	-	-	-	-	-	-
19	31.00	2.30	2.30	.	-	-	-	-	-	-	-	-
20	110.00	2.10	1.80	.	-	-	-	-	-	-	-	-
21	8.10	1.70	1.60	.	-	-	-	-	-	-	-	-
22	4.30	1.50	1.30	.	-	-	-	-	-	-	-	-
23	2.90	1.60	1.20	.	-	-	-	-	-	-	-	-
24	2.10	1.50	1.10	.	-	-	-	-	-	-	-	-
25	1.70	1.20	1.10	.	-	-	-	-	-	-	-	-
26	1.30	1.20	1.10	.	-	-	-	-	-	-	-	-
27	1.00	1.10	1.10	.	-	-	-	-	-	-	-	-
28	0.94	1.00	0.92	.	-	-	-	-	-	-	-	-
29	0.87	.	0.86	.	-	-	-	-	-	-	-	-
30	0.81	.	0.85	.	-	-	-	-	-	-	-	-
31	0.77	.	0.85	.	-	-	-	-	-	-	-	-
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	0.44	0.75	0.71	1.10	-	-	-	-	-	-	-	-
MAX	110.00	23.00	53.00	1.70	-	-	-	-	-	-	-	-
MEAN	5.97	2.91	4.09	1.40	-	-	-	-	-	-	-	-

gs9y88.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1986
BEAR CREEK TRIB ABOVE BEAR CREEK ROAD NR WHEAT,TN: ALIAS=GS10
USGS SITE ID = 035382672
Flow in cfs

DAY	JAN86	FEB86	MAR86	APR86	MAY86	JUN86	JUL86	AUG86	SEP86	OCT86	NOV86	DEC86
1	-	-	-	-	-	-	-	-	-	0.01	0.03	0.12
2	-	-	-	-	-	-	-	-	-	0.01	0.03	0.16
3	-	-	-	-	-	-	-	-	-	0.01	0.02	0.18
4	-	-	-	-	-	-	-	-	-	0.01	0.02	0.15
5	-	-	-	-	-	-	-	-	-	0.01	0.04	0.13
6	-	-	-	-	-	-	-	-	-	0.00	0.03	0.12
7	-	-	-	-	-	-	-	-	-	0.00	0.06	0.10
8	-	-	-	-	-	-	-	-	-	0.00	0.07	0.49
9	-	-	-	-	-	-	-	-	-	0.00	0.10	7.80
10	-	-	-	-	-	-	-	-	-	0.02	0.09	2.90
11	-	-	-	-	-	-	-	-	-	0.03	0.18	1.60
12	-	-	-	-	-	-	-	-	-	0.03	0.16	1.10
13	-	-	-	-	-	-	-	-	-	0.09	0.10	0.54
14	-	-	-	-	-	-	-	-	-	0.06	0.07	0.36
15	-	-	-	-	-	-	-	-	-	0.03	0.08	0.26
16	-	-	-	-	-	-	-	-	-	0.02	0.07	0.20
17	-	-	-	-	-	-	-	-	-	0.02	0.06	0.18
18	-	-	-	-	-	-	-	-	-	0.02	0.05	0.35
19	-	-	-	-	-	-	-	-	-	0.02	0.04	0.29
20	-	-	-	-	-	-	-	-	-	0.02	0.09	0.25
21	-	-	-	-	-	-	-	-	-	0.01	0.10	0.20
22	-	-	-	-	-	-	-	-	-	0.01	0.08	0.16
23	-	-	-	-	-	-	-	-	-	0.01	0.10	0.16
24	-	-	-	-	-	-	-	-	-	0.01	0.44	0.19
25	-	-	-	-	-	-	-	-	0.01	0.38	0.37	0.16
26	-	-	-	-	-	-	-	-	0.01	0.14	1.00	0.14
27	-	-	-	-	-	-	-	-	0.01	0.07	0.50	0.13
28	-	-	-	-	-	-	-	-	0.01	0.05	0.28	0.13
29	-	-	-	-	-	-	-	-	0.01	0.03	0.19	0.12
30	-	-	-	-	-	-	-	-	0.01	0.03	0.14	0.12
31	-	-	-	-	-	-	-	-	.	0.03	.	0.11
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	-	-	-	-	-	-	-	-	0.01	0.00	0.02	0.10
MAX	-	-	-	-	-	-	-	-	0.01	0.00	0.02	0.10
MEAN	-	-	-	-	-	-	-	-	0.01	0.04	0.15	0.61

gs10y86.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1987
BEAR CREEK TRIB ABOVE BEAR CREEK ROAD NR WHEAT,TN: ALIAS=GS10
USGS SITE ID = 035382672
Flow in cfs

DAY	JAN87	FEB87	MAR87	APR87	MAY87	JUN87	JUL87	AUG87	SEP87	OCT87	NOV87	DEC87
1	0.11	0.22	2.40	0.22	0.11	0.06	0.03	0.01	0.00	0.00	0.00	0.00
2	0.10	0.27	1.00	0.23	0.09	0.05	0.03	0.01	0.00	0.00	0.00	0.00
3	0.09	0.26	0.59	0.28	0.10	0.04	0.04	0.01	0.00	0.00	0.00	0.00
4	0.08	0.23	0.41	0.35	0.53	0.05	0.05	0.02	0.00	0.00	0.00	0.00
5	0.08	0.20	0.33	0.48	0.23	0.04	0.07	0.02	0.00	0.00	0.00	0.00
6	0.07	0.18	0.27	0.69	0.16	0.03	0.08	0.03	0.00	0.00	0.00	0.00
7	0.07	0.18	0.23	0.62	0.14	0.03	0.12	0.02	0.00	0.00	0.00	0.00
8	0.07	0.16	0.22	0.47	0.12	0.03	0.07	0.02	0.00	0.00	0.00	0.00
9	0.07	0.13	0.23	0.35	0.11	0.02	0.05	0.01	0.00	0.00	0.00	0.00
10	0.07	0.13	0.18	0.28	0.09	0.02	0.04	0.04	0.00	0.00	0.05	0.00
11	0.07	0.12	0.17	0.25	0.08	0.02	0.04	0.01	0.00	0.00	0.01	0.00
12	0.07	0.12	0.18	0.22	0.07	0.02	0.03	0.02	0.09	0.00	0.00	0.00
13	0.07	0.11	0.17	0.18	0.06	0.03	0.03	0.01	0.01	0.00	0.00	0.00
14	0.07	0.12	0.17	0.28	0.06	0.03	0.03	0.00	0.00	0.00	0.00	0.00
15	0.09	0.11	0.17	1.60	0.03	0.03	0.02	0.00	0.00	0.00	0.00	0.04
16	0.08	0.52	0.19	1.20	0.03	0.07	0.02	0.00	0.00	0.00	0.00	0.01
17	0.07	0.70	0.17	1.00	0.05	0.08	0.02	0.01	0.00	0.00	0.04	0.01
18	0.37	0.62	0.26	0.67	0.05	0.05	0.02	0.01	0.00	0.00	0.01	0.00
19	11.00	0.48	0.66	0.46	0.04	0.04	0.02	0.00	0.02	0.00	0.00	0.00
20	1.50	0.38	0.58	0.35	0.09	0.06	0.02	0.00	0.00	0.00	0.00	0.01
21	0.69	0.34	0.43	0.28	0.09	0.06	0.02	0.00	0.00	0.00	0.00	0.00
22	0.50	0.65	0.33	0.22	0.09	0.09	0.01	0.00	0.00	0.00	0.00	0.00
23	0.35	1.50	0.27	0.18	0.06	0.09	0.02	0.00	0.00	0.00	0.00	0.00
24	0.27	0.87	0.24	0.27	0.06	0.06	0.02	0.00	0.00	0.00	0.00	0.02
25	0.84	0.53	0.23	0.19	0.20	0.05	0.02	0.00	0.00	0.00	0.00	0.12
26	1.60	0.42	0.18	0.17	0.15	0.04	0.02	0.00	0.00	0.00	0.00	0.08
27	0.83	4.10	0.17	0.15	0.09	0.03	0.01	0.00	0.00	0.01	0.00	.
28	0.52	3.60	0.15	0.14	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.11
29	0.38	.	0.14	0.13	0.05	0.02	0.01	0.00	0.02	0.00	0.00	0.06
30	0.32	.	0.20	0.12	0.07	0.02	0.01	0.00	0.02	0.01	0.00	0.03
31	0.25	.	0.24	.	0.09	.	0.01	0.00	.	0.00	.	0.02
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	0.07	0.11	0.14	0.12	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00
MAX	11.00	4.10	2.40	1.60	0.53	0.09	0.12	0.04	0.09	0.01	0.05	0.12
MEAN	0.67	0.62	0.36	0.40	0.11	0.04	0.03	0.01	0.01	0.00	0.00	0.02

gs10y87.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1988
BEAR CREEK TRIB ABOVE BEAR CREEK ROAD NR WHEAT,TN: ALIAS=GS10
USGS SITE ID = 035382672
Flow in cfs

DAY	JAN88	FEB88	MAR88	APR88	MAY88	JUN88	JUL88	AUG88	SEP88	OCT88	NOV88	DEC88
1	0.08	0.04	0.07	0.10	-	-	-	-	-	-	-	-
2	0.07	0.08	0.07	0.13	-	-	-	-	-	-	-	-
3	0.05	0.17	0.07	0.14	-	-	-	-	-	-	-	-
4	0.08	2.00	0.08	0.17	-	-	-	-	-	-	-	-
5	0.06	0.86	0.07	0.17	-	-	-	-	-	-	-	-
6	0.05	0.40	0.06	-	-	-	-	-	-	-	-	-
7	0.05	0.28	0.05	-	-	-	-	-	-	-	-	-
8	0.05	0.19	0.05	-	-	-	-	-	-	-	-	-
9	0.05	0.15	0.06	-	-	-	-	-	-	-	-	-
10	0.05	0.13	5.70	-	-	-	-	-	-	-	-	-
11	0.05	0.12	1.40	-	-	-	-	-	-	-	-	-
12	0.05	0.11	0.77	-	-	-	-	-	-	-	-	-
13	0.04	0.09	0.80	-	-	-	-	-	-	-	-	-
14	0.04	0.09	0.55	-	-	-	-	-	-	-	-	-
15	0.04	0.18	0.37	-	-	-	-	-	-	-	-	-
16	0.04	0.20	0.27	-	-	-	-	-	-	-	-	-
17	0.04	0.17	0.21	-	-	-	-	-	-	-	-	-
18	0.20	0.15	0.18	-	-	-	-	-	-	-	-	-
19	4.10	0.16	0.15	-	-	-	-	-	-	-	-	-
20	7.40	0.15	0.13	-	-	-	-	-	-	-	-	-
21	0.69	0.13	0.12	-	-	-	-	-	-	-	-	-
22	0.31	0.12	0.11	-	-	-	-	-	-	-	-	-
23	0.19	0.13	0.10	-	-	-	-	-	-	-	-	-
24	0.14	0.12	0.09	-	-	-	-	-	-	-	-	-
25	0.12	0.11	0.09	-	-	-	-	-	-	-	-	-
26	0.09	0.10	0.09	-	-	-	-	-	-	-	-	-
27	0.08	0.10	0.08	-	-	-	-	-	-	-	-	-
28	0.07	0.09	0.08	-	-	-	-	-	-	-	-	-
29	0.05	.	0.07	-	-	-	-	-	-	-	-	-
30	0.05	.	0.07	-	-	-	-	-	-	-	-	-
31	0.04	.	0.07	-	-	-	-	-	-	-	-	-
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	0.04	0.04	0.05	-	-	-	-	-	-	-	-	-
MAX	7.40	2.00	5.70	-	-	-	-	-	-	-	-	-
MEAN	0.47	0.24	0.39	-	-	-	-	-	-	-	-	-

gs10y88.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1986
BEAR CREEK TRIB NEAR WHEAT,TN: ALIAS=GS11
USGS SITE ID = 035382677
Flow in cfs

DAY	JAN86	FEB86	MAR86	APR86	MAY86	JUN86	JUL86	AUG86	SEP86	OCT86	NOV86	DEC86
1	-	-	-	-	-	-	-	-	-	0.00	0.01	0.06
2	-	-	-	-	-	-	-	-	-	0.00	0.01	0.11
3	-	-	-	-	-	-	-	-	-	0.00	0.01	0.12
4	-	-	-	-	-	-	-	-	-	0.00	0.01	0.09
5	-	-	-	-	-	-	-	-	-	0.00	0.02	0.07
6	-	-	-	-	-	-	-	-	-	0.00	0.02	0.06
7	-	-	-	-	-	-	-	-	-	0.00	0.04	0.05
8	-	-	-	-	-	-	-	-	-	0.00	0.03	0.34
9	-	-	-	-	-	-	-	-	-	0.00	0.06	3.60
10	-	-	-	-	-	-	-	-	-	0.00	0.04	1.40
11	-	-	-	-	-	-	-	-	-	0.00	0.16	0.85
12	-	-	-	-	-	-	-	-	-	0.01	0.11	0.57
13	-	-	-	-	-	-	-	-	-	0.03	0.05	0.30
14	-	-	-	-	-	-	-	-	-	0.02	0.03	0.19
15	-	-	-	-	-	-	-	-	-	0.01	0.04	0.14
16	-	-	-	-	-	-	-	-	-	0.00	0.03	0.10
17	-	-	-	-	-	-	-	-	-	0.00	0.03	0.10
18	-	-	-	-	-	-	-	-	-	0.00	0.03	0.21
19	-	-	-	-	-	-	-	-	-	0.00	0.02	0.15
20	-	-	-	-	-	-	-	-	-	0.00	0.07	0.12
21	-	-	-	-	-	-	-	-	-	0.00	0.07	0.09
22	-	-	-	-	-	-	-	-	-	0.00	0.05	0.08
23	-	-	-	-	-	-	-	-	-	0.01	0.07	0.08
24	-	-	-	-	-	-	-	-	-	0.01	0.37	0.10
25	-	-	-	-	-	-	-	-	0.00	0.18	0.25	0.08
26	-	-	-	-	-	-	-	-	0.00	0.05	0.58	0.07
27	-	-	-	-	-	-	-	-	0.00	0.02	0.25	0.07
28	-	-	-	-	-	-	-	-	0.00	0.01	0.13	0.06
29	-	-	-	-	-	-	-	-	0.00	0.01	0.09	0.06
30	-	-	-	-	-	-	-	-	0.00	0.01	0.07	0.05
31	-	-	-	-	-	-	-	-	.	0.01	.	0.04
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	-	-	-	-	-	-	-	-	0.00	0.00	0.01	0.04
MAX	-	-	-	-	-	-	-	-	0.00	0.18	0.58	3.60
MEAN	-	-	-	-	-	-	-	-	0.00	0.01	0.09	0.30

gs11y86.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1987
BEAR CREEK TRIB NEAR WHEAT,TN: ALIAS=GS11
USGS SITE ID = 035382677
Flow in cfs

DAY	JAN87	FEB87	MAR87	APR87	MAY87	JUN87	JUL87	AUG87	SEP87	OCT87	NOV87	DEC87
1	0.05	0.13	1.10	0.10	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00
2	0.04	0.18	0.46	0.10	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00
3	0.03	0.17	0.26	0.16	0.03	0.01	0.03	0.00	0.00	0.00	0.00	0.00
4	0.03	0.15	0.16	0.23	0.32	0.02	0.02	0.00	0.00	0.00	0.00	0.00
5	0.03	0.12	0.13	0.37	0.10	0.02	0.10	0.00	0.00	0.00	0.00	0.00
6	0.03	0.11	0.10	0.44	0.06	0.02	0.10	0.00	0.00	0.00	0.00	0.00
7	0.03	0.10	0.08	0.36	0.05	0.01	0.09	0.00	0.00	0.00	0.00	0.00
8	0.03	0.10	0.09	0.25	0.04	0.01	0.03	0.00	0.00	0.00	0.00	0.00
9	0.03	0.09	0.10	0.17	0.03	0.01	0.03	0.00	0.00	0.00	0.00	0.00
10	0.03	0.08	0.08	0.14	0.03	0.01	0.02	0.00	0.00	0.00	0.09	0.00
11	0.03	0.08	0.08	0.13	0.02	0.01	0.02	0.00	0.00	0.00	0.00	0.00
12	0.03	0.07	0.09	0.11	0.02	0.01	0.01	0.00	0.02	0.00	0.00	0.00
13	0.03	0.04	0.08	0.09	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00
14	0.03	0.05	0.08	0.17	0.02	0.01	0.02	0.00	0.00	0.00	0.00	0.00
15	0.04	0.05	0.08	0.74	0.03	0.01	0.02	0.00	0.00	0.00	0.00	0.02
16	0.03	0.45	0.08	0.55	0.02	0.11	0.02	0.00	0.00	0.00	0.00	0.00
17	0.03	0.47	0.07	0.48	0.04	0.07	0.01	0.00	0.00	0.00	0.06	0.00
18	0.32	0.36	0.15	0.29	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00
19	5.00	0.26	0.46	0.17	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00
20	0.74	0.19	0.36	0.12	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00
21	0.39	0.16	0.23	0.10	0.06	0.03	0.01	0.00	0.00	0.00	0.00	0.00
22	0.28	0.38	0.15	0.08	0.06	0.07	0.01	0.00	0.00	0.00	0.00	0.00
23	0.19	0.79	0.12	0.06	0.03	0.06	0.01	0.00	0.00	0.00	0.00	0.00
24	0.16	0.42	0.11	0.14	0.02	0.03	0.01	0.00	0.00	0.00	0.00	0.01
25	0.56	0.24	0.10	0.08	0.15	0.03	0.00	0.00	0.00	0.00	0.00	0.07
26	0.83	0.18	0.08	0.06	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.04
27	0.45	2.10	0.07	0.05	0.04	0.01	0.00	0.00	0.00	0.01	0.00	0.03
28	0.29	1.70	0.06	0.04	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.07
29	0.20	.	0.05	0.03	0.02	0.01	0.00	0.00	0.02	0.00	0.00	0.02
30	0.16	.	0.10	0.03	0.05	0.01	0.00	0.00	0.01	0.01	0.00	0.01
31	0.15	.	0.12	.	0.04	.	0.00	0.00	.	0.00	.	0.01
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	0.03	0.04	0.05	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
MAX	5.00	2.10	1.10	0.74	0.32	0.11	0.10	0.00	0.02	0.01	0.09	0.07
MEAN	0.33	0.33	0.17	0.19	0.05	0.03	0.02	0.00	0.00	0.00	0.01	0.01

gs11y87.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1988
BEAR CREEK TRIB NEAR WHEAT,TN: ALIAS=GS11
USGS SITE ID = 035382677
Flow in cfs

DAY	JAN88	FEB88	MAR88	APR88	MAY88	JUN88	JUL88	AUG88	SEP88	OCT88	NOV88	DEC88
1	0.05	0.01	0.01	0.04	-	-	-	-	-	-	-	-
2	0.03	0.05	0.01	0.07	-	-	-	-	-	-	-	-
3	0.03	0.11	0.01	0.07	-	-	-	-	-	-	-	-
4	0.04	1.00	0.02	0.08	-	-	-	-	-	-	-	-
5	0.02	0.43	0.01	0.06	-	-	-	-	-	-	-	-
6	0.03	0.18	0.00	.	-	-	-	-	-	-	-	-
7	0.03	0.12	0.00	.	-	-	-	-	-	-	-	-
8	0.02	0.09	0.00	.	-	-	-	-	-	-	-	-
9	0.01	0.06	0.00	.	-	-	-	-	-	-	-	-
10	0.01	0.04	2.80	.	-	-	-	-	-	-	-	-
11	0.01	0.03	0.68	.	-	-	-	-	-	-	-	-
12	0.02	0.03	0.40	.	-	-	-	-	-	-	-	-
13	0.01	0.02	0.44	.	-	-	-	-	-	-	-	-
14	0.03	0.02	0.25	.	-	-	-	-	-	-	-	-
15	0.03	0.11	0.14	.	-	-	-	-	-	-	-	-
16	0.02	0.10	0.10	.	-	-	-	-	-	-	-	-
17	0.05	0.08	0.09	.	-	-	-	-	-	-	-	-
18	0.20	0.06	0.07	.	-	-	-	-	-	-	-	-
19	2.30	0.08	0.05	.	-	-	-	-	-	-	-	-
20	3.40	0.07	0.03	.	-	-	-	-	-	-	-	-
21	0.41	0.05	0.03	.	-	-	-	-	-	-	-	-
22	0.18	0.04	0.02	.	-	-	-	-	-	-	-	-
23	0.12	0.05	0.01	.	-	-	-	-	-	-	-	-
24	0.07	0.03	0.01	.	-	-	-	-	-	-	-	-
25	0.05	0.03	0.01	.	-	-	-	-	-	-	-	-
26	0.03	0.02	0.01	.	-	-	-	-	-	-	-	-
27	0.02	0.02	0.00	.	-	-	-	-	-	-	-	-
28	0.02	0.02	0.00	.	-	-	-	-	-	-	-	-
29	0.01	.	0.00	.	-	-	-	-	-	-	-	-
30	0.01	.	0.00	.	-	-	-	-	-	-	-	-
31	0.01	.	0.00	.	-	-	-	-	-	-	-	-
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	0.01	0.01	0.00	-	-	-	-	-	-	-	-	-
MAX	3.40	1.00	2.80	-	-	-	-	-	-	-	-	-
MEAN	0.23	0.11	0.17	-	-	-	-	-	-	-	-	-

gs11y88.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1986
BEAR CREEK TRIB AT HWY 95 NEAR WHEAT,TN: ALIAS=GS12
USGS SITE ID = 03538272
Flow in cfs

DAY	JAN86	FEB86	MAR86	APR86	MAY86	JUN86	JUL86	AUG86	SEP86	OCT86	NOV86	DEC86
1	-	-	-	-	-	-	-	-	-	0.00	0.01	0.04
2	-	-	-	-	-	-	-	-	-	0.00	0.01	0.10
3	-	-	-	-	-	-	-	-	-	0.00	0.01	0.11
4	-	-	-	-	-	-	-	-	-	0.00	0.01	0.09
5	-	-	-	-	-	-	-	-	-	0.00	0.01	0.07
6	-	-	-	-	-	-	-	-	-	0.00	0.01	0.06
7	-	-	-	-	-	-	-	-	-	0.00	0.04	0.06
8	-	-	-	-	-	-	-	-	-	0.00	0.04	0.23
9	-	-	-	-	-	-	-	-	-	0.00	0.07	2.40
10	-	-	-	-	-	-	-	-	-	0.00	0.03	1.00
11	-	-	-	-	-	-	-	-	-	0.00	0.07	0.61
12	-	-	-	-	-	-	-	-	-	0.01	0.04	0.41
13	-	-	-	-	-	-	-	-	-	0.04	0.02	0.23
14	-	-	-	-	-	-	-	-	-	0.02	0.02	0.17
15	-	-	-	-	-	-	-	-	-	0.00	0.03	0.12
16	-	-	-	-	-	-	-	-	-	0.00	0.03	0.10
17	-	-	-	-	-	-	-	-	-	0.00	0.03	0.10
18	-	-	-	-	-	-	-	-	-	0.00	0.02	0.18
19	-	-	-	-	-	-	-	-	-	0.00	0.02	0.14
20	-	-	-	-	-	-	-	-	-	0.00	0.05	0.11
21	-	-	-	-	-	-	-	-	-	0.00	0.04	0.09
22	-	-	-	-	-	-	-	-	-	0.00	0.03	0.08
23	-	-	-	-	-	-	-	-	-	0.00	0.04	0.09
24	-	-	-	-	-	-	-	-	-	0.00	0.15	0.10
25	-	-	-	-	-	-	-	-	0.00	0.13	0.12	0.08
26	-	-	-	-	-	-	-	-	0.00	0.03	0.32	0.08
27	-	-	-	-	-	-	-	-	0.00	0.02	0.15	0.07
28	-	-	-	-	-	-	-	-	0.00	0.01	0.09	0.06
29	-	-	-	-	-	-	-	-	0.00	0.01	0.07	0.06
30	-	-	-	-	-	-	-	-	0.00	0.00	0.05	0.05
31	-	-	-	-	-	-	-	-	.	0.00	.	0.04
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	-	-	-	-	-	-	-	-	0.00	0.00	0.01	0.04
MAX	-	-	-	-	-	-	-	-	0.00	0.13	0.32	2.40
MEAN	-	-	-	-	-	-	-	-	0.00	0.01	0.05	0.23

gs12y86.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1987
BEAR CREEK TRIB AT HWY 95 NEAR WHEAT, TN: ALIAS=GS12
USGS SITE ID = 03538272
Flow in cfs

DAY	JAN87	FEB87	MAR87	APR87	MAY87	JUN87	JUL87	AUG87	SEP87	OCT87	NOV87	DEC87
1	0.05	0.11	0.96	0.10	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.01
2	0.04	0.14	0.43	0.10	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.01
3	0.03	0.13	0.28	0.15	0.04	0.01	0.02	0.00	0.00	0.00	0.00	0.01
4	0.03	0.12	0.19	0.18	0.21	0.02	0.02	0.00	0.00	0.00	0.00	0.01
5	0.03	0.10	0.15	0.23	0.10	0.01	0.04	0.00	0.00	0.00	0.00	0.01
6	0.03	0.09	0.13	0.31	0.07	0.01	0.04	0.00	0.00	0.00	0.00	0.01
7	0.03	0.08	0.11	0.24	0.05	0.01	0.06	0.00	0.00	0.00	0.00	0.01
8	0.03	0.07	0.10	0.18	0.04	0.00	0.02	0.00	0.00	0.00	0.00	0.01
9	0.03	0.09	0.12	0.14	0.03	0.00	0.02	0.00	0.00	0.00	0.00	0.01
10	0.03	0.08	0.08	0.12	0.03	0.00	0.01	0.00	0.00	0.00	0.03	0.01
11	0.03	0.06	0.06	0.11	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.01
12	0.03	0.06	0.08	0.10	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.01
13	0.02	0.05	0.06	0.09	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.01
14	0.02	0.05	0.07	0.14	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.01
15	0.04	0.05	0.07	0.45	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.05
16	0.03	0.31	0.09	0.41	0.02	0.11	0.00	0.00	0.00	0.00	0.00	0.01
17	0.03	0.33	0.07	0.37	0.04	0.06	0.00	0.00	0.00	0.00	0.05	0.00
18	0.22	0.29	0.12	0.26	0.02	0.03	0.00	0.00	0.00	0.00	0.02	0.00
19	3.60	0.22	0.30	0.18	0.02	0.02	0.00	0.00	0.00	0.00	0.01	0.00
20	0.62	0.18	0.31	0.14	0.07	0.02	0.00	0.00	0.00	0.00	0.01	0.01
21	0.34	0.16	0.21	0.11	0.06	0.02	0.00	0.00	0.00	0.00	0.01	0.01
22	0.25	0.30	0.16	0.10	0.06	0.06	0.00	0.00	0.00	0.00	0.01	0.00
23	0.18	0.60	0.13	0.09	0.03	0.06	0.00	0.00	0.00	0.00	0.01	0.00
24	0.15	0.36	0.12	0.13	0.02	0.02	0.00	0.00	0.00	0.00	0.01	0.02
25	0.41	0.24	0.12	0.09	0.08	0.02	0.00	0.00	0.00	0.00	0.01	0.10
26	0.63	0.19	0.09	0.08	0.06	0.01	0.00	0.00	0.00	0.00	0.01	0.06
27	0.37	1.70	0.09	0.07	0.04	0.01	0.00	0.00	0.00	0.00	0.01	0.04
28	0.25	1.50	0.08	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.07
29	0.19	.	0.07	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.03	0.03
30	0.16	.	0.11	0.04	0.05	0.00	0.00	0.00	0.01	0.00	0.02	0.02
31	0.13	.	0.11	.	0.04	.	0.00	0.00	.	0.00	.	0.01
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	0.02	0.05	0.06	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MAX	3.60	1.70	0.96	0.45	0.21	0.11	0.06	0.00	0.01	0.00	0.05	0.10
MEAN	0.26	0.27	0.16	0.16	0.05	0.02	0.01	0.00	0.00	0.00	0.01	0.02

gs12y87.wk1

SURFACE DISCHARGE SUMMARY, JANUARY -- DECEMBER 1988
BEAR CREEK TRIB AT HWY 95 NEAR WHEAT,TN: ALIAS=GS12
USGS SITE ID = 03538272
Flow in cfs

DAY	JAN88	FEB88	MAR88	APR88	MAY88	JUN88	JUL88	AUG88	SEP88	OCT88	NOV88	DEC88
1	0.05	0.04	0.05	0.07	-	-	-	-	-	-	-	-
2	0.04	0.06	0.05	0.10	-	-	-	-	-	-	-	-
3	0.03	0.09	0.05	0.10	-	-	-	-	-	-	-	-
4	0.04	0.75	0.07	0.12	-	-	-	-	-	-	-	-
5	0.02	0.40	0.07	0.10	-	-	-	-	-	-	-	-
6	0.02	0.21	0.07	.	-	-	-	-	-	-	-	-
7	0.02	0.16	0.07	.	-	-	-	-	-	-	-	-
8	0.02	0.13	0.06	.	-	-	-	-	-	-	-	-
9	0.02	0.10	0.06	.	-	-	-	-	-	-	-	-
10	0.02	0.09	2.20	.	-	-	-	-	-	-	-	-
11	0.02	0.07	0.67	.	-	-	-	-	-	-	-	-
12	0.02	0.07	0.41	.	-	-	-	-	-	-	-	-
13	0.03	0.06	0.44	.	-	-	-	-	-	-	-	-
14	0.03	0.06	0.31	.	-	-	-	-	-	-	-	-
15	0.02	0.13	0.22	.	-	-	-	-	-	-	-	-
16	0.02	0.12	0.16	.	-	-	-	-	-	-	-	-
17	0.03	0.11	0.13	.	-	-	-	-	-	-	-	-
18	0.14	0.09	0.12	.	-	-	-	-	-	-	-	-
19	1.20	0.10	0.11	.	-	-	-	-	-	-	-	-
20	2.30	0.10	0.09	.	-	-	-	-	-	-	-	-
21	0.34	0.09	0.07	.	-	-	-	-	-	-	-	-
22	0.16	0.08	0.07	.	-	-	-	-	-	-	-	-
23	0.11	0.08	0.06	.	-	-	-	-	-	-	-	-
24	0.09	0.07	0.05	.	-	-	-	-	-	-	-	-
25	0.07	0.07	0.05	.	-	-	-	-	-	-	-	-
26	0.06	0.07	0.06	.	-	-	-	-	-	-	-	-
27	0.05	0.07	0.05	.	-	-	-	-	-	-	-	-
28	0.04	0.06	0.04	.	-	-	-	-	-	-	-	-
29	0.03	.	0.03	.	-	-	-	-	-	-	-	-
30	0.04	.	0.03	.	-	-	-	-	-	-	-	-
31	0.04	.	0.04	.	-	-	-	-	-	-	-	-
	======	======	======	======	======	======	======	======	======	======	======	======
MIN	0.02	0.04	0.03	0.07	-	-	-	-	-	-	-	-
MAX	2.30	0.75	2.20	0.12	-	-	-	-	-	-	-	-
MEAN	0.17	0.13	0.19	0.10	-	-	-	-	-	-	-	-

gs12y88.wk1

PRECIPITATION SUMMARY, JANUARY -- DECEMBER 1986
BEAR CREEK BURIAL GROUND: SITE ID = BUR
Precipitation in mm.

DAY	JAN86	FEB86	MAR86	APR86	MAY86	JUN86	JUL86	AUG86	SEP86	OCT86	NOV86	DEC86
1	0.00	0.00	0.00	0.00	0.00	1.78	3.56	0.00	10.41	6.35	0.63	4.05
2	0.00	3.82	0.00	0.00	0.00	0.00	30.23	0.00	27.94	0.00	0.00	7.88
3	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00
4	0.00	10.69	0.00	0.00	0.00	0.00	0.00	0.00	2.03	0.00	2.81	0.00
5	0.00	8.12	0.76	0.00	0.00	18.03	0.00	0.00	6.86	0.00	2.26	0.00
6	0.00	10.41	0.00	0.76	0.00	0.00	0.00	3.18	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	1.52	0.00	0.00	0.00	3.17	0.00	0.00	14.48	0.00
8	0.00	0.00	0.00	15.37	0.00	3.43	0.00	0.00	0.00	0.00	0.38	31.78
9	0.00	0.00	0.00	0.00	0.00	9.02	0.00	0.51	0.00	3.29	10.16	45.16
10	0.00	5.85	0.00	0.00	0.00	0.00	21.08	17.79	0.00	8.43	0.00	5.10
11	0.00	1.26	4.06	0.00	0.00	0.00	0.00	3.80	0.00	6.55	16.01	9.11
12	0.00	0.00	12.96	0.00	0.00	0.00	0.00	0.00	8.13	19.43	0.00	0.51
13	0.00	0.00	12.82	0.00	0.00	0.00	26.92	0.00	0.00	17.53	0.00	0.00
14	0.00	18.02	3.55	0.25	0.00	0.00	31.76	0.00	0.00	7.11	3.44	0.00
15	0.00	1.02	0.00	0.25	0.00	0.00	0.51	0.00	0.00	0.00	3.04	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02	9.39	0.00	0.00	0.00
17	0.00	47.27	0.00	0.00	0.00	0.00	0.00	0.00	1.27	0.00	0.00	13.24
18	12.19	1.00	0.03	0.00	7.11	0.00	0.00	0.00	0.00	0.00	0.00	1.50
19	3.04	0.00	26.25	0.00	0.00	0.00	0.00	0.00	2.03	0.00	0.00	0.00
20	0.00	0.00	0.00	7.87	0.00	0.00	0.00	4.32	1.14	0.00	11.68	0.00
21	0.00	0.00	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	6.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	28.71	0.00	0.00	9.40	1.52	0.00	11.74	6.75
24	0.00	5.33	0.00	0.00	7.62	0.00	0.00	0.00	5.08	7.47	10.14	0.87
25	10.67	0.00	0.00	0.00	2.28	0.00	0.00	0.00	0.25	42.83	6.60	0.00
26	3.56	0.00	0.00	0.00	11.40	0.00	0.00	37.46	0.00	0.00	10.41	0.00
27	0.00	2.04	0.00	0.00	0.76	0.00	0.00	8.77	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	11.17	9.26	0.00	0.00	8.14	0.00	0.00	0.00	0.00
29	0.00	.	0.00	0.00	0.51	0.00	0.00	0.00	3.30	0.00	0.00	0.00
30	0.00	.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	.	0.00	.	0.00	.	11.30	1.01	.	0.00	.	0.00
	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
TOTAL (mm)	29.46	121.68	60.43	38.97	67.65	32.26	125.36	98.57	79.60	118.99	103.78	125.95
TOTAL (in)	1.16	4.79	2.38	1.53	2.66	1.27	4.94	3.88	3.13	4.68	4.09	4.96

1986 TOTAL (mm): 1002.70
1986 TOTAL (in): 39.48

BUR_86.wk1

PRECIPITATION SUMMARY, JANUARY -- DECEMBER 1987

BEAR CREEK BURIAL GROUND: SITE ID = BUR

Precipitation in mm.

DAY	JAN87	FEB87	MAR87	APR87	MAY87	JUN87	JUL87	AUG87	SEP87	OCT87	NOV87	DEC87
1	2.54	0.00	0.76	0.00	0.00	0.00	6.10	0.00	0.00	0.00	0.00	0.00
2	0.00	7.87	0.00	6.12	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	13.20	20.46	4.45	13.85	1.65	0.00	0.00	0.00	1.27
4	0.00	0.00	0.00	0.00	4.69	0.00	4.83	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	15.11	1.27	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	32.01	4.06	1.53	2.03	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	5.84	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	2.15	0.00	0.00	0.00	0.00	0.00	4.83	0.00	0.00	0.00
9	2.55	0.00	6.99	0.00	0.00	0.00	0.00	5.08	0.25	0.00	7.43	0.00
10	0.76	0.00	0.00	0.00	0.00	0.25	0.00	2.29	0.00	0.00	15.31	0.00
11	0.63	0.00	3.56	4.07	0.00	0.00	9.91	0.00	0.38	0.00	0.00	0.50
12	0.00	0.00	0.76	2.54	0.00	6.48	0.00	13.46	50.31	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	1.65	1.02	0.00	0.00	0.00	0.00	0.00	0.00
14	4.83	4.82	0.00	8.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.07
15	2.79	2.03	0.00	18.55	0.00	0.25	0.00	0.00	0.00	0.00	0.00	14.10
16	0.00	22.86	7.36	7.12	0.63	32.90	0.00	0.00	0.00	0.00	0.00	0.00
17	1.94	2.79	0.00	0.00	7.62	6.36	0.00	3.43	4.32	0.00	17.53	0.00
18	33.22	2.55	17.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	30.24	0.00	1.14	0.00	1.90	4.07	0.00	0.00	10.40	0.25	0.00	0.00
20	0.00	2.28	0.00	0.00	1.65	5.34	0.00	0.00	0.00	6.72	0.00	4.19
21	0.00	1.01	0.00	0.00	8.89	12.06	0.00	0.00	0.00	0.00	0.00	0.00
22	9.52	19.82	0.00	0.00	0.00	1.27	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	1.77	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.00	5.08	11.43	2.29	0.00	0.00	0.00	0.00	0.00	0.00	17.27
25	21.45	0.00	1.02	0.00	6.86	0.25	0.00	0.00	0.00	4.83	0.00	13.97
26	0.00	12.31	0.00	0.00	0.76	0.25	0.00	0.00	0.00	1.41	0.76	8.88
27	1.78	23.87	1.15	0.00	0.00	0.00	0.00	0.00	0.00	2.15	0.00	6.48
28	0.00	19.57	0.00	0.00	0.89	0.00	0.00	0.25	0.00	0.00	8.89	8.38
29	0.00	.	0.00	0.00	11.81	0.00	0.00	0.00	25.66	1.78	0.00	0.00
30	0.00	.	13.84	0.00	8.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	.	0.00	.	0.00	.	0.00	0.00	.	0.00	.	3.56
	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
TOTAL (mm)	112.25	121.78	61.21	71.66	78.48	76.72	87.91	31.49	97.68	19.17	49.92	82.67
TOTAL (in)	4.42	4.79	2.41	2.82	3.09	3.02	3.46	1.24	3.85	0.75	1.97	3.25

1987 TOTAL (mm): 890.94

1987 TOTAL (in): 35.08

PRECIPITATION SUMMARY JANUARY -- DECEMBER 1988
BEAR CREEK BURIAL GROUND: SITE ID = BUR
Precipitation in mm.

DAY	JAN88	FEB88	MAR88	APR88	MAY88	JUN88	JUL88	AUG88	SEP88	OCT88	NOV88	DEC88
1	9.39	0.00	0.00	10.41	0.00	0.00	0.00	.	.	.	.	.
2	0.00	12.44	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
3	7.74	17.40	1.27	5.83	5.84	0.00	7.32	.	.	.	.	.
4	0.00	13.84	5.84	0.00	11.17	0.00	0.00	.	.	.	.	.
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
6	0.00	0.00	0.00	21.84	0.00	0.00	0.00	.	.	.	.	.
7	11.54	0.00	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
9	0.00	0.00	2.67	0.00	10.54	3.06	0.00	.	.	.	.	.
10	0.00	0.00	50.04	0.00	14.61	0.00	0.00	.	.	.	.	.
11	0.00	4.31	0.00	0.76	0.00	0.00	4.61	.	.	.	.	.
12	0.51	0.00	12.71	6.86	0.00	0.00	53.54	.	.	.	.	.
13	1.28	0.00	0.00	0.00	0.00	0.00	43.46	.	.	.	.	.
14	0.00	0.00	0.00	0.00	1.14	0.00	0.00	.	.	.	.	.
15	0.00	14.97	0.00	5.09	0.00	0.00	0.00	.	.	.	.	.
16	0.00	0.00	0.00	0.00	0.00	6.98	8.26	.	.	.	.	.
17	12.71	0.00	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
18	0.00	0.00	3.82	19.56	0.00	0.00	0.00	.	.	.	.	.
19	76.19	5.59	0.00	4.83	0.00	0.00	0.00	.	.	.	.	.
20	1.02	0.00	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
21	0.00	0.00	0.00	0.00	0.00	0.00	31.99	.	.	.	.	.
22	0.00	0.00	0.00	0.00	0.50	0.00	0.00	.	.	.	.	.
23	0.00	5.07	0.00	7.49	0.51	0.00	3.82	.	.	.	.	.
24	1.27	0.00	1.01	0.25	18.02	0.00	0.00	.	.	.	.	.
25	0.00	0.00	2.17	0.00	1.27	11.05	0.00	.	.	.	.	.
26	0.00	0.00	3.30	0.00	0.00	0.00	11.54	.	.	.	.	.
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.	.	.	.	.
30	0.00	.	0.26	0.00	0.00	1.32	0.00	.	.	.	.	.
31	0.50	.	1.27	.	0.00	.	0.00	.	.	.	.	.
	======	======	======	======	======	======	======	======	======	======	======	======
TOTAL (mm)	122.15	73.62	84.36	82.92	63.60	22.41	164.54	.	.	.	.	.
TOTAL (in)	4.81	2.90	3.32	3.26	2.50	0.88	6.48	.	.	.	.	.

1988 TOTAL (mm): 613.60
1988 TOTAL (in): 24.16

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APPENDIX I

ADDENDUM TO SOIL SURVEY OF WEST CHESTNUT RIDGE

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APPENDIX I

ADDENDUM TO THE SOIL SURVEY OF WEST CHESTNUT RIDGE

1. INTRODUCTION

The soils of West Chestnut Ridge were mapped in 1984. Since then, advances in soil-geology and soil-geomorphology relationships have necessitated that the soil mapping be reevaluated and brought up to date.

The mapping unit descriptions presented in this document replace those presented in Lee et al. (1984).

The soils map that accompanies this supplement (Fig. 1) has an identification legend (Table 1) which identifies (1) the landform and parent materials, (2) the slope class, and (3) the erosion class of site soils.

Table 2 contains a conversion legend that relates the soils information contained in Lee et al. (1984) to the present soil map, mapping unit descriptions, and interpretations of this supplement.

2. WEST CHESTNUT RIDGE SURFICIAL GEOLOGY AND GEOMORPHOLOGY

2.1 SURFICIAL GEOLOGY

The Knox Group consists of five recognizable Formations which are commonly identified by their location with respect to formations above and below, and by the type of chert they contain. The youngest formation in the Knox is the Mascot. This formation contains subrounded jasperoid and chalcedonous chert which is a visual clue used to separate it from the Unit A of the Chickamauga with its tabular chert. The next formation in the Knox is the Kingsport. This formation contains variable chert, much of which is oolitic. In soil mapping, it was not possible to distinguish saprolites nor soil morphology between the Mascot and the Kingsport. They are grouped together into the Newala Formation, which can be distinguished from the Chickamauga above and the Longview and Chelpultepec Formations below. Areas of ledges and pinnacles commonly occur in the uppermost part of the Newala Formation, especially on steep drainageway sideslopes. Shallow depressions are also common in the upper Newala near the Chickamauga contact.

The Longview Formation typically contains abundant dolomoldic chert which clearly distinguishes the formation. Because of its high chert content, the Longview Formation tends to be a ridge former. The Chelpultepec Formation occurs below the Longview. It has variable chert content and contains some very fine grained sandstone strata and lenses which contribute to a loam rather than silt loam surface and a slightly lower subsoil clay content. However, sometimes the presence of loess masks the presence of higher sand content in the surface. Soils that formed in Chelpultepec

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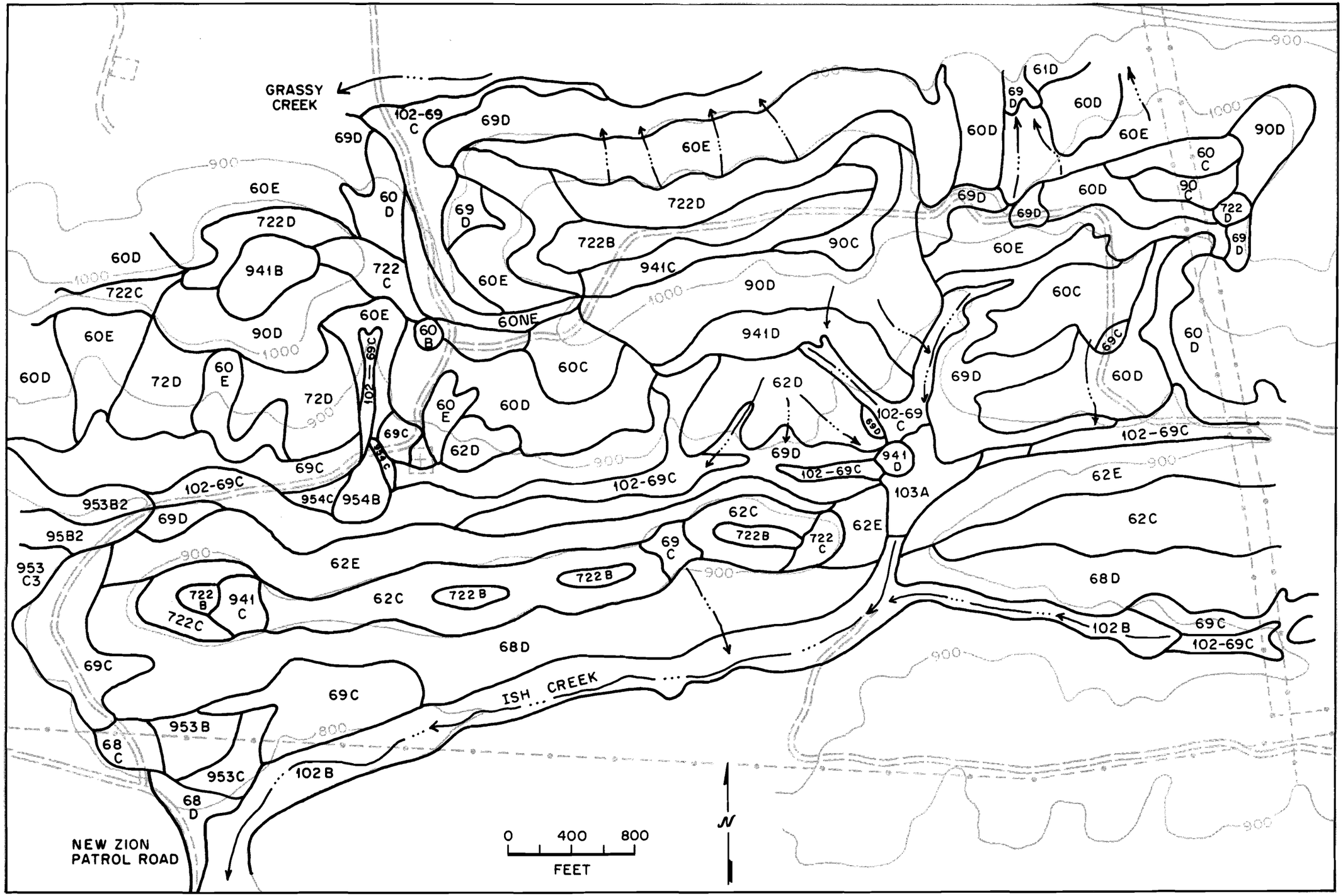

Fig. 1. Soils Map of the West Chestnut Ridge Site.

Table 1. Central waste facility soil legend

Iden.	Classification
60	Typic Paleudults; clayey, kaolinitic, thermic. **Parent Materials:** Copper Ridge residuum, warm aspects.
60N	Typic Paleudults; clayey, kaolinitic, thermic. **Parent Materials:** Copper Ridge residuum, cool aspects.
61	Typic Hapludalfs; fine, mixed, thermic. **Parent Materials:** Lower Copper Ridge-Maynardville Transition
62	Typic Paleudults; clayey, kaolinitic, thermic. **Parent Materials:** Chelpultepec residuum.
68	Typic Paleudults; clayey, kaolinitic, thermic. **Parent Materials:** Newela residuum
69	Fragic Paleudults; loamy-skeletal, siliceous, thermic **Parent Materials:** Pleistocene Knox Colluvium.
90	Rhodic Paleudults; clayey, oxidic, thermic. **Parent Materials:** Tertiary Alluvium.
102	Typic or Aquic Udifluvents; loamy-skeletal, siliceous, thermic. **Parent Materials:** Modern Alluvium.
102-69	Udifluvents-Paleudults; loamy-skeletal, siliceous, thermic. **Parent Materials:** Holocene and Modern Toeslope alluvium and colluvium.
103	Typic or Aeric Fluvaquents; fine-silty or loamy-skeletal, siliceous, thermic. **Parent Materials:** Modern over Holocene Alluvium.
722	Typic Paleudults; fine-loamy, siliceous, thermic. **Parent Materials:** Tertiary Ridgetop Colluvium.
941	Typic Paleudults; fine-loamy. siliceous, thermic. **Parent Materials:** Tertiary Ridgetop colluvium-alluvium.
953	Typic Paleudults; fine-loamy, siliceous, thermic. **Parent Materials:** Early to Mid-Pleistocene Alluvium on recognizable terrace landforms.
954	Typic Paleudults; fine-loamy, siliceous, thermic. **Parent Materials:** Mid to Late Pleistocene Alluvium.

Table 1 (continued)

Slope Classes		Erosion Classes	
A	0 to 2% slopes	0, 1, 2	(Not shown on soil map range from slightly overwashed to moderately eroded.
B	2 to 5% slopes		
C	5 to 12% slopes		
D	12 to 25% slopes		
E	25 to 45% slopes	3	severely eroded (shown on soil map).
F	> 45% slopes	4	very severely eroded with gullies

Table 2. Conversion legend

TM-9361	Current Legend
1	69
2	63 (included with No. 62 at 1:12000 scale)
3	90, 941, 722
4	62
5	60, 61
5a	60N
6	102, 102-69, 103
7	68
8	953
9	954

saprolite have 5YR hues in the upper, mottle-free subsoil, while the Longview and Newala Formations above and the Copper Ridge Formation below typically have 2.5YR hues in the upper, mottle-free subsoil. The Copper Ridge Formation is the lowest and oldest of the Knox Group. This formation also has variable chert content, but most of the chert is massive. The Copper Ridge saprolite is characterized by a mostly reddish clay-plugged upper saprolite that grades irregularly downward into a yellowish high-silt material with red clay that fills voids in old fractures and voids. A thick lag gravel layer, thick E horizons, gradational E/B and B/E horizons and red (2.5YR) upper subsoil horizons with much lower but highly variable chert content are common features of Copper Ridge soils. The lower Copper Ridge including the transition to the underlying Maynardville Limestone of the Conasauga is massive dolomite that contains very little chert and/or other impurities. The residue collapses so the saprolite does not form. Instead, red clay is nearly in contact with hard rock with only a weathering zone 1 to 5 cm thick between. The soils in this section are mostly Alfisols and are located only on the steep sideslope of Chestnut Ridge above Bear Creek Road. Common rock outcrops, mostly ledges, are a surface feature of this part of the lower Copper Ridge Formation. A topographic bench part way up the slope marks the break between this lower chert-free part of the Copper Ridge and the upper cherty part of the Copper Ridge that forms saprolite or saprolitic materials. Most residual soils on the Knox are Paleudults with some Hapludults on very steep slopes.

2.2 GEOMORPHIC FEATURES

Important geomorphic features on Chestnut Ridge include depressions that are located mostly on broad stable upland ridges, the presence of ancient, presumed pre-Pleistocene, alluvium (Soil No. 90), the associated mixed toeslope colluvium and alluvium, footslope colluvium, and a thin mantle of loess that has been preserved in at least some surface depressions. The presence of ancient colluvium (Soil No. 722) and toeslope colluvium (Soil No. 941) that mantles part of the site indicates that topographic inversion has taken place and that the very cherty colluvium has armoured and protected ridge tops, which explains why, in part, why the ancient colluvium (Soil No. 722) is always on the broadest and highest elevations. Figure 2 indicates a probable tertiary landform that could explain the presence of colluvium in a drainageway, the presence of associated ancient alluvium and the mixed colluvium-alluvium. It is presumed that the Conasauga formations to the north were higher during the late Tertiary. Wetter and more freeze-thaw conditions during the early Pleistocene would affect the Conasauga high silt soils, which are more geomorphically sensitive, more than the Knox soils. To the south, the Chickamauga Group would probably also have been higher, and it was denuded by slope processes in a similar manner during early Pleistocene glacial periods. The reasoning for this is that the colluvium was deposited in a lowland drainageway, and second, chert from the Knox is not strewn over the Conasauga to the north nor the Chickamauga to the south. The only chert that was observed north of Bear Creek is located on the Nolichucky slightly above the present elevation of Bear Creek, and could have been deposited there when Bear Creek aggraded its channel during the late Pleistocene. Considerable chert occurs as bedload in Bear Creek and Grassy Creek, but not

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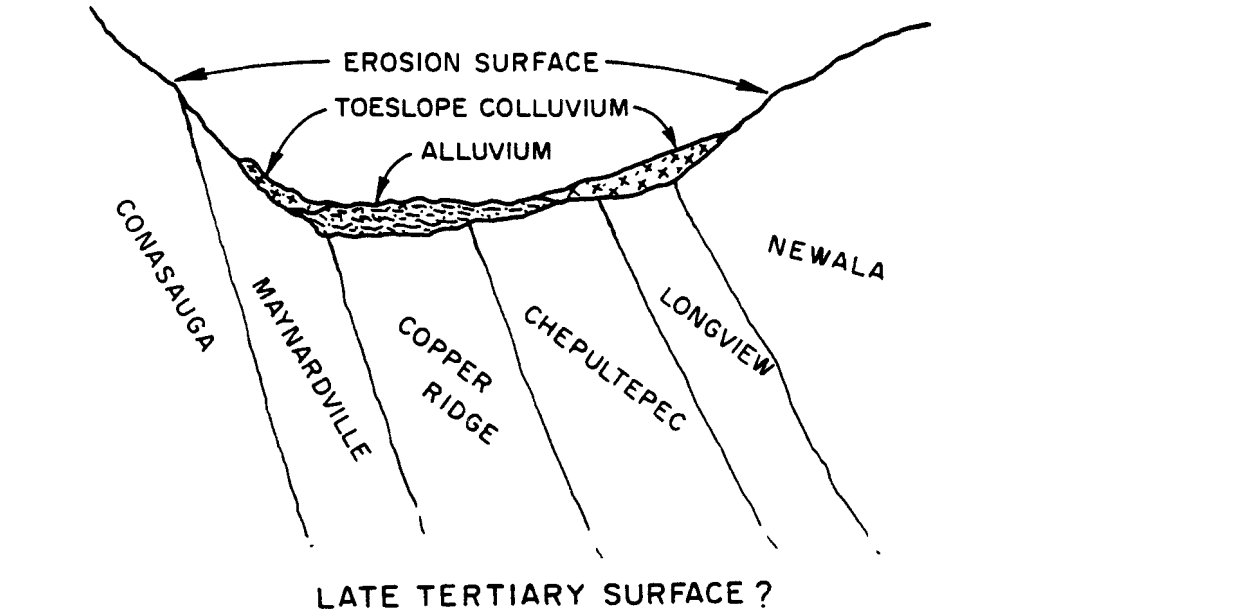


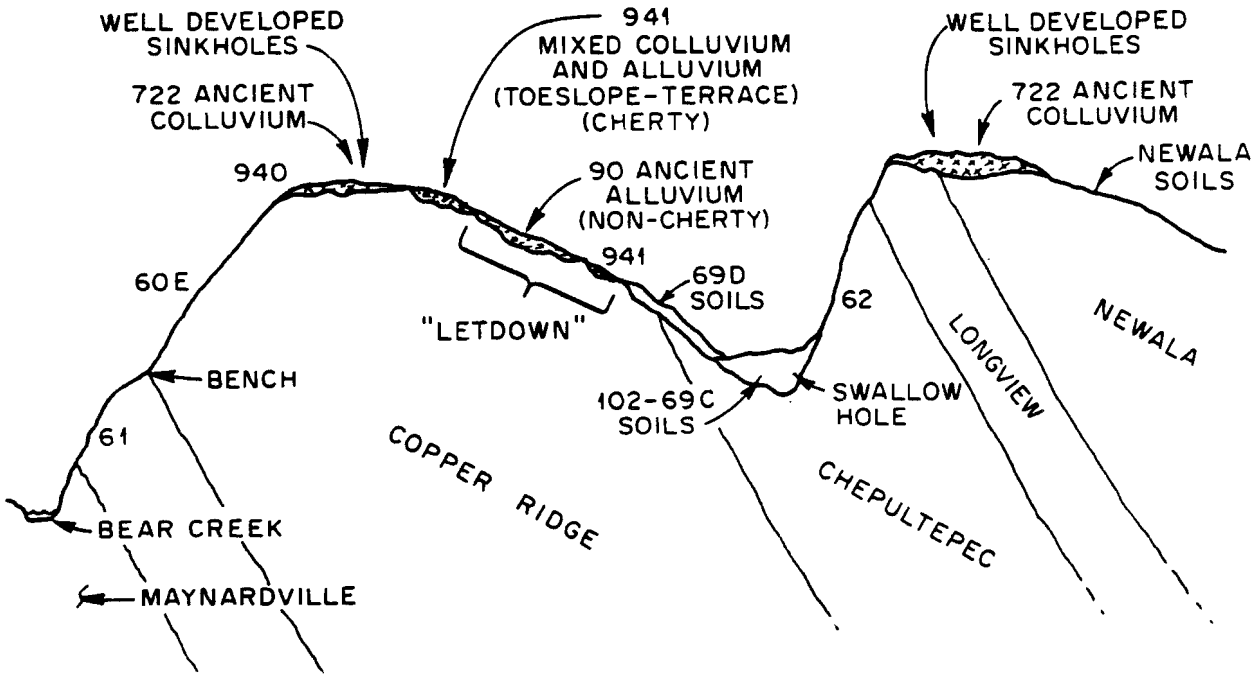


Fig. 2. Present West Chestnut Ridge Cross-section.

to the extent as the chert in Ish Creek. The source ofthe chert in Bear and Grassy Creeks was from colluvial fans of draninageways cutting back into Chestnut Ridge during the middle and late Pleistocene.

The presence of well developed depressions only on stable uplands of Chestnut Ridge also suggests that they are of considerable antiquity, and probably formed when the landform they are now on was a footslope-toeslope that received considerably more run-on water that allowed for deep percolation, that did not become saturated with respect to calcium carbonate which allowed for rapid development of channels and caves. Present swallow holes and cave openings on Chestnut Ridge are located either in drainageways or in toeslope landforms. The presence of loess in two depressions that have been investigated indicates that the depressions have been stable for at least 25,000? years to more than 100,000? years in another depression where there are two layers of loess.

The dark red ancient alluvium on Chestnut Ridge seems to be meander loops of an ancient river. The active borrow pit on Chestnut Ridge that is located just west of the Y-12 Plant has exposed a considerable thickness on this dark red clayer alluvium. Of interest, is the fact that this ancient alluvium contains very little chert.

3. SOIL MAPPING UNIT DESCRIPTIONS

<u>60C, 60D, 60E Soils</u>. Typic Paleudults; clayey, kaolinitic, thermic. These soils formed in residuum of the Copper Ridge Formation. The residuum has high silt plus clay content and highly variable chert content. Soils of this unit are on doubly convex landforms. The A and E horizons are very cherty due to lag chert left behind as fines are washed downslope by overland flow. The Bt horizons beneath vary in chert content from about 5 to 30%. Some included soils have more than 35% chert in the subsoil and others are almost chert-free. The chert is commonly oolittic, but both massive and chalky types are present. The upper part of the subsoil is free of yellow mottles. In some areas the lower subsoil becomes increasingly mottled in shades of yellow due to decreased permeability. Decreased permeability in the lower subsoil can result in the temporary perching of water which is accompanied by gray colors in reduced water flow zones. Even in well drained permeable soils, the lower subsoil and the underlying saprolitic materials will have increasing amounts of yellow. The yellow color represents the oxidized and highly leached saprolite. Saprolite color is dominated by yellow and red. Yellowish red to red clay coats voids and fracture faces in the upper saprolite. Depth to rock is generally deep, probably more than 50 feet. Some drill holes have penetrated more than 100 feet of saprolite before encountering rock. However, due Karst geomorphic processes in an acidic humid environment, and to the way carbonate rock weathers, pinnacles and ledges, either attached or detached are common feature of the underlying rock topography. Surface depressions are a common expression of collapse of caverns and solution channels, and are a common surface feature of these soils. Some areas have higher concentration of depressions than other areas. Because of the large numbers and variable sizes of depressions, they were not

shown on the soil map. Most depressions occur on crestal landforms, evidence of their relative geomorphic age. Most depressions in the higher elevation uplands appear to be stable and do not exhibit evidence of activity. Most depressions with active shallow holes and cave entrances seem to be situated on lower sideslopes.

Because of the high chert content in the upper 40 to 80 cm of the soil, most areas of these soils were not cleared and cultivated. They were apparently periodically logged, along with some woodland pasturing. Present forest vegetation ranges from stands dominated by chestnut oak to stands dominated by white and red oak. Based on observations along Chestnut Ridge, better forest stands of white oak, red oak and tulip poplar are probably underlain by either pinnacles, ledges or bedrock that are closer to the surface where long-lived tree roots can encounter them and cycle calcium to the surface, while the chestnut oak forest is over areas much deeper to rock or areas where there are few if any pinnacles and tree roots do not encounter rock. Today, white oak tends to be a climax species on Chestnut Ridge because of long term cycling and conservation of calcium in the O and A horizons of these forest soils. Forest stands on Chestnut Ridge are still in the process of adjusting from the demise of chestnut trees, which dominated the canopy at one time. Past landuse practices of partial clearing, pasturing and burning increased overland flow and the removal of nutrient-rich O, and A horizons. Regrowth of trees on these eroded areas follows different successional pathways than on other areas which were not as disturbed.

Delineations of No. 60C soils are located on broad ridgetop summits. They commonly have small areas that are nearly level (A slopes) and gently sloping (B slopes) that are included at the 1:10000 mapping scale, but which could be resolved at 1:100 or 1:200 scale mapping should use intensity require knowledge of the location and extent of these areas. Many delineations of No. 60D soils occur on ridgetops where there are numerous depressions. Most delineations of No. 60E soils are on southerly to northwesterly aspects. Most areas of No. 60E soils are also on obsequent slopes that have more outcrops of rock. In general, rock outcrops are very rare in delineations of No. 60C and No. 60D soils.

These soils have fair to good potential for many landuses and are presently underutilized on the Reservation. There is always a hazard of cavern collapse or the enlargement and deepening of existing depressions. (Map Units No. 5 and 5a in TM-9361.)

These soils have been extensively utilized for sanitary waste disposal in many areas of East Tennessee and Virginia. Because of the possibility of a cavern opening beneath a trench, and because of the lower cation exchange capacity, trenches should be designed so that the lower end comes to the surface. Any leachate will then flow down the trench, come to the surface, and be collected and treated. There is a high probability of ground water contamination with improperly designed sanitary landfills in karst areas.

<u>60N, 60E Soils</u>. Typic Paleudults; clayey, kaolinitic, thermic. These soils formed in residuum of the Copper Ridge Formation. They occur in

protected shaded and cool northeast and east aspects on the north side of Chestnut Ridge. They have a thicker and darker A horizon and a darker and less distinct E horizon beneath than the adjacent No. 60 soils which occur on southerly,and westerly aspects. Most areas of these soils occur on obsequent slopes where the rock dips into the slope. Rock outcrops generally occur with a higher frequency in areas of these soils. The higher nutrient content of the No. 60N soils compared to the No. 60 soils is also reflected in the forest vegetation composition including canopy trees as well as the forest floor vegetation. Especially noticeable is the presence of sugar maple saplings that are growing thickly in areas that were partially logged about 10 to 15 years ago.

Because of the steep slopes and high erosion hazard, these soils are best managed for long-term hardwood forest rotation, with timber stand improvement to remove poor stock. (Map Units No. 5 and 5a in TM-9361.)

<u>61D, 61E Soils</u>. Typic or Ultic Hapludalfs; fine, mixed or kaolinitic, thermic. These soils formed in residuum weathered from the lowermost Copper Ridge Formation and the boundary zone between the Copper Ridge Formation and the Maynardville Formation. Because of the high carbonate content and lack of skeletal structure, saprolite does not form. Where saprolite does not form, the red clayey residual material lies in nearly direct contact with rock with only a thin weathering zone 2 to 10 cm thick separating the soil from the rock. These soils occur on the lower third of the slope that forms the west edge of Chestnut Ridge. Rock outcrops are common. The presence of long-lived red cedar also is a good indicator that carbonate rock is fairly close to the surface. Depth to rock is generally between 1 and 1.5 meters. These soils have a red (2.5YR) clayey subsoil that contains very little chert. The chert content in A and E horizons is variable, but is usually more than 15%. The chert in A and E horizons is from chert in the upper Copper Ridge that has been transported downslope most likely by creep processes and that now mantles these soils. These soils occur below a topographic bench that separates them from the Copper Ridge No. 60 and No. 60N soils. There is also a large increase in chert both on the surface and in the soil above the bench which indicates a change in soils.

Because of the generally shallow and variable depth to rock, and steep slopes, these soils are best suited for long term hardwood forest, managing for tree species that require higher soil pH.

<u>62C, 62D, 62E Soils</u>. Typic Paleudults; clayey; kaolinitic, thermic. Soils of these map units formed in thick saprolite weathered from dolomite of the Chelpultepec Formation. These soils are on upland summits and convex sideslopes. The A and E horizons of these soils have higher chert content than subsoil horizons due to the lag gravel effect. The uppermost Bt horizon in uneroded soils has a 10YR or 7.5YR hue and a clay loam texture, but the lower clayey horizons become redder in 5YR and 2.5YR hues and the amount of yellow colors from saprolite increases with depth. Subsoil chert content is highly variable ranging from less than 5% to more than 35% and is not predictable. Included in mapping at a scale of 1:10000 to 1:12000 are the Longview soils (No. 63). The location and extent of the Longview soils can generally be mapped at a scale of 1:100 to 1:200. The No. 63 Longview soils

occupy the highest middle ridge of Chestnut Ridge. The Longview soils usually have cobble and boulder-sized blocks of chert on the surface. The Longview subsoil usually has a high chert content averaging more than 35%. The Longview soils are also commonly covered by ancient colluvium that has a high chert content. (For more details about the No. 63 soils, see the No. 63 map unit description). (Map Unit No. 4 in TM-9361.)

Chelpultepec soils have about the same potentials and problems of the No. 60 soils.

63C, 63D, 63E Soils. Typic Paleudults; clayey-skeletal, kaolinitic, thermic. These soils formed in very cherty saprolite that weathered from the Longview Formation. Soils in this unit occur only on narrow ridgetops and summit shoulders. The Longview Formation is less than 15 to about 20 meters thick and could not be mapped at a scale of 1:10000. Large blocks of dolomoldic chert on the surface serve to identify the presence of the Longview Formation. However, other chert from the Newela Formation has also been let-down onto the Longview and does not have dolomolds. Dolomoldic chert form the Longview has also been let-down onto Chelpultec soils downslope. However, dolomolds in substratum chert fragments usually confirms that the soil formed in Longview residuum. Most areas of these soils were never cleared and farmed due to the high chert content on the surface and within the soil. These soils have a very thick, very cherty to extremely cherty E horizon that extends to a depth of 60 to 80 cm. Depth to the red (2.5YR hue) clayey Bt horizon is commonly 75 to 90 cm. Many areas of these soils were commonly mapped as "Bodine" in the past. Most areas identified as "Bodine" in the Anderson County soil survey report that are on the Knox Group are formed from either the Longview or extremely cherty soils with thick E horizons in the adjacent Copper Ridge, Chelpultepec and Newala Formations, or from ancient cherty ridgetop colluvium. The colluvium that is derived from the Longview soils has a very high chert content throughout and the footslope soils are loamy-skeletal.

These soils have limited extent but their location and extent can be important for some land uses where high surface and subsoil chert content is a limiting consideration. Because of the high chert content, they have low water storage capacity. Trees tend to be subjected to several drought-stress cycles during the summer. Consequently, only trees which can tolerate drought stress, will grow well on these soils. (Map Unit No. 2 in TM-9361.)

68B, 68C, 68D, 68E Soils. Typic Paleudults; clayey, kaolinitic, thermic. These soils formed in saprolite weathered from the Newala Formation. They have a variable chert content. Subsoil chert is quite soft and chalky, appearing to be highly weathered and being transformed to kaolinite and serves as an indicator for these soils. The Bt horizon is red (2.5YR hue) in the upper part, and does not exhibit much evidence of degradation. The lower subsoil stays redder with depth than most other Knox Group soils. Most areas of these soils are on the south side of Chestnut Ridge and occupy about one-third of the surface area.

In mapping soils and saprolites of the Newala, it was not possible to identify either the Mascot or Kingsport Formations by chert characteristics,

or by saprolite and soil morphology. Most soils underlain by the Kingsport are deep to rock and have few if any outcrops. Ledges and pinnacles along with a concentration of depressions are characteristics of the Mascot Formation. Areas with ledges and rock outcrops were mapped as Soil No. 65. No areas of the No. 65 soils were identifed on this waste disposal site. (Map Unit No. 7 in TM-9361.)

Newala soils have about the same potentials and problems for waste disposal as the No. 60 soils.

69C, 69D Soils. Fragic Paleudults; loamy-skeletal or fine-loamy, siliceous, thermic. These soils formed in a minimum of 0.5 m to several meters of colluvium derived from residual soils of the Knox Group. They have more than 15% chert throughout and can range to more than 50% in some areas. These soils occur in saddles and below saddles to the heads of drains. These soils also occur on lower sideslopes and commonly have a doubly concave slope configuration. Most areas of these soils have a restrictive layer that perches water during wet periods. The restrictive layer, identified by the presence of 10YR 6/3 mottles, locates a discontinuity and the presence of an older, often truncated paleosol, that formed in either an older colluvium or residuum beneath. Some areas of these soils have a fragipan, but the fragipan is intermittant. Most of the surficial colluvium is of late Pleistocene age, with the latest period of upland denudation and downslope mas movement occuring during the Wisconsinan stage of glaciation. Buried beneath this younger colluvium are one or more older colluvial diamictons of probable mid and early Pleistocene. The No. 69 colluvial soils have not experienced topographic inversion. Where topographic inversion has ocurred, the ancient late Tertiary? or early Pleistocene colluvial soils are identified as No. 721 or No. 722 soils on the soil map.

The dominant subsurface waterflow in these soils is lateral downslope. Water perches and flows above the fragic layer. During wet periods of late winter the soil above the fragic layer is often saturated. Shallow pits and drill holes fill rapidly under these wet conditions. However, during the summer, these soils dry out and become droughty as plant extract the soil water from above the pan. The high chert content of these soils also reduces water storage capacity. Some roots do penetrate the pan and can extract water from deeper parts of the soil. Because of the extensive lateral waterflow, these soils are highly leached and extremely acidic. Forest vegetation is not productive on these soils in contrast to the Knox No. 71 and No. 72 colluvial soils.

These soils have good engineering properties of compaction in contrast to the adjacent high silt plus clay content residual soils. Thickness of colluvium varies from about 50 cm on upper concave sideslopes to 30 or more meters on some low footslopes. (Map Unit No. 1 in TM-9361.)

These soils can be utilized for waste disposal provided that overland and subsurface lateral flow can be controlled and diverted from trenches. These soils have a higher potential for disposal of wastes by the construction of tumuli. The colluvial material has good compaction properties because of its lower clay content when compared to residual soils.

However, in its natural state, colluvium is generally more permeable than adjacent residual soil materials.

90B, 90C, 90D Soils. Rhodic Paleudults; clayey, oxidic, thermic. The soils in these map units formed in alluvium of probable late Tertiary or early Pleistocene age. Today, these soils occupy some of the higher elevations on Chestnut Ridge. Most areas of these soils were preserved on southeast and south slopes, which tend to be more geomorphically stable, and are mostly underlain by residuum of the Copper Ridge Formation. No areas the No. 90 soils have been mapped over the Newala or Chickamauga Group A Formations on Chestnut Ridge.

The No. 90 soils have a thick dark surface layer and dark red clayey subsoil horizons. Most areas of these soils have very few coarse fragments. Only fragments resistant to weathering remain. These are chert of local origin and meta-quartzites from the Unakas that have been impregnated with maghemite and magnatite iron oxides. Another key indicator of these soils is the presence of numerous small hard manganese-iron nodules throughout the soil, that do not occur in adjacent residual or colluvial soils.

Because of their favorable physical properties nearly all areas of these soils were in agriculture when the area was taken over by the AEC. Because the soils are permeable they were not severely eroded, although there are some severely eroded areas. The soils are sticky when wet because of the high iron oxide content, but they dry rapidly and become very friable with strong granular or blocky soil structure.

These soils are the alluvial remnants preserved from an earlier erosion cycle. Several questions remain as to how these soils became dark red including: what is the source of all the iron oxide? Was the iron oxide translocated from higher landforms when these soils were in floodplain and terrace landforms? Today, except for the occasional rounded river slick, it is difficult to imagine that these soils were once in low-lying but well-drained floodplain landscapes with hills rising from their edge. The present distribution of iron oxides and their color suggests that these soils were not subjected to a long period of fluctuating water tables. If they had, then the iron would have been organized into hard nodules, with a pale soil matrix between nodules. Typically, these soils are identified by the numerous iron shot that are about 1 to 2 mm in diameter. This soil feature would suggest that these soils were once in a fluctuating water table zone a condition required for the migration of these oxides into hard nodules. However, as rivers shifted course and continued to downcut, the soil would have become better drained. It would seem that further additions of iron would be necessary to form the dark red colors observed today. There are at least two sources of additional iron that are now disseminated throughout these dark red soils. One source is deposition from the air, the other iron source is from weatherable biotite and chlorite minerals carried from the Unakas by an ancestral Tennessee River. (Map Unit No. 3 in TM-9361.)

102B Soils. Typic and Aquic Udifluvents; fine-loamy or loamy-skeletal, siliceous, thermic. These well and moderately well drained soils formed in alluvium washed from upland and colluvial soils of the Knox Group. The upper

part of these soils is derived from Modern age sediments washed down into drainageways by land clearing and subsequent agricultural activities of european settlers. The thickness of this Modern age sediment ranges from about 50 to more than 100 cm. The Modern sediments commonly contain one or more buried surface layers, the results of catastrophic local intense storms. Buried soils beneath this Modern age alluvium have a variety of morphologic expression ranging from weak cambic horizons to clay enriched argillic horizons. The largest area of these soils occurs along Ish Creek. However, most areas of these soils occur in narrow drainageways and are mapped as a complex with low toeslope colluvial soils, and are identified by the No. 102-69 symbol. (Map Unit No. 6 in TM-9361.)

These soils are not suited for the disposal of wastes. They are important for their ability to filter and purify overland runoff and shallow groundwater that discharges to the surface through them.

<u>102/69C,102/69D Soils</u>. Udifluvents and Paleudults; loamy-skeletal, siliceous, thermic. The landforms and soils in these units occur as a complex that comprise the coves and narrow drainageways of Chestnut Ridge. The No. 102 soils occur in floodplains and narrow bottoms. They are stratified and show minimal evidence of soil genesis. Textures are cherty to extremely cherty silt loams and loams. The No. 69 colluvial soils occur in narrow strips on toeslopes that are too small to delineate, but are important in hydrology and landuse. Also included in the No. 69 parts are small alluvial fans from recently cut gullies, the results of past land mismanagement from both farming and forestry. Old farm or logging access roads are a common feature in areas of these soils, especially in wider drainageways. Most of the soils in these mapping units are well-drained but some areas, where small seeps and springs occur, are wet. Knick points, entrenched channels and overwashed zones occur throughout the No. 102 soil areas, giving rise to a complicated sequence and pattern of soils. Fragipans occur in the No. 69 soil areas, as well as areas without fragipans or areas that have fragic subsoil properties. Some toeslope areas have been covered by modern slope wash from agricultural fields on the slopes above. Most vegetation on these soils is forest regrowth ranging from tulip poplar to red maple, Paw Paws are common in some moist drainageways. Some areas of these soils have abundant cobble-sized and boulder-sized chert on the surface and in the soil. Most rainfall and run-on water from higher slopes infiltrates and flows downward and laterally in these soils. Consequently, these soils have a tendency to become filled with water during wet periods. Water also perches at discontinuities. (Map Unit No. 6 in TM-9361.)

These soils are not suited for the disposal of wastes. They are valuable for their ability to filter and purify runon water from higher areas. They should not be disturbed, but should remain vegetated during any nearby waste disposal operations.

<u>103A Soils</u>. Fluvaquents and Ochraqualfs; loamy-skeletal, siliceous, thermic. The soils in this map unit are undifferentiated with respect to their morphology and classification. They are somewhat poorly drained to very poorly drained. Most of the delineations in this unit generally contain springs and seeps that keep the soils wet and saturated most of the time.

In other areas that are wet, stream channels tend to be poorly defined or else they are very shallow. Only vegetation tolerant of wet conditions grows well on these soils. Small areas of these soils occur as inclusions in larger areas of No. 102-69 soils. (Map Unit No. 6 in TM-9361.)

These soils are unsuited for waste disposal and should be kept in a natural condition, not filled by debris from slope clearing activities. They are important in maintaining stream water quality regardless of landuse in the upper portions of the watershed they are in.

722B, 722C, 722D Soils. Typic Paleudults; fine-loamy, siliceous, thermic. The soils in these map units formed in ancient toeslope colluvium, that through topographic inversion, now occupy upland summit landscapes. Soils in these map units occur on broad stable high elevation upland summits on Chestnut Ridge and are generally underlain by the Longview Formation and parts of the Chepultepec and Newala formations on either side. They have a thicker and more strongly expressed E horizon than the younger No. 72 soils which occur on recognizable colluvial landforms. A paleosol that formed in very cherty residuum commonly occurs beneath the colluvium. The chert fragments in this old paleosol are highly weathered, most are soft and easily broken by the auger which indicates a long ahe of weathering. Chert fragments in the colluvium are also highly weathered and commonly impregnated with iron oxides. Downslope from delineations of these No. 722 soils, it is common to find adjacent areas of the No. 941 soils that formed in ancient toeslope-fan terrace colluvium-alluvium. Both these No. 722 soils and the related No. 941 and No. 90 soils have a probable late Tertiary age considering the time required for topographic inversion and rubrification of the the No. 90 alluvium.

Most areas of these soils were cultivated in the past and were moderately eroded. Some of these once open field areas are currently maintained in pine plantations. (Included in Map Unit No. 3.)

These soils have good potential for waste disposal in trenches. Depth to the underlying Knox residuum is variable. Design of trenches and pretreatment of soils will be the same as for those areas where Knox residual soils are exposed at the surface.

941B, 941C, 941D Soils. Typic Paleudults; fine-loamy, siliceous, thermic. These soils are on broad upland summit landscapes. They formed in a mixture of local cherty colluvium and alluvium and the underlying Knox clayey residuum, and were mapped whenever the surficial materials were more than 50 cm thick. These soils originally occupied low toeslope-terrace landforms where alluvium and colluvium accumulated. Subsequent topographic inversion has transformed these once low landforms to where they are today (Fig. 2). The soils in these map units have subsoils that contain less clay than nearby residual soils. Subsoil colors also tend to be redder than the adjacent residual soils, but less red and with lower clay content than the adjacent No. 90 ancient alluvial soils. A more important indicator of these soils is the highly weathered and iron-impregnated nature of the chert fragments. Many chert fragments are quite soft and have partially converted to kaolinite. Other chert fragments have a red rind. These soils occupy a

transition zone between the No. 722 soils, which were stripped free of iron and manganese oxides, and the No. 90 soils. Where these soil occur near the No. 722 soils, they have a higher chert content and less red colors, while areas near No. 90 soils have dark red colors and less chert. As mapped on Chestnut Ridge, the No. 941 soils represent at least two erosion cycles. Ridgetop areas of No. 941 soils represent the remnants of the oldest cycle. Other areas of No. 941 soils are mapped at lower elevation on Chestnut Ridge on old fan-terace landscapes, but still high above present areas toeslope and fan-terrace colluvium-alluvium deposition. The extent of the No. 941 soils is not large, but the age and geomorphic history of these soils and the associated No. 722 and No. 90 soils is important in the determination of the ages of landform surfaces and the development of karst topographic features. (Included in Map Unit No. 3.) These soils are suited for waste disposal.

95B2 Soils. Typic Hapludults; fine-loamy, mixed, thermic. (Sequatchie). These soils generally occur on wider low terraces along the Clinch River, but were mapped in alluvial floodplain sediments of an abandoned meander loop of the Clinch River. They are considered to have a late Pleistocene or early Holocene age. They have a high content of very fine sand throughout the profile, and a yellowish brown Bt horizon with a loam or light clay loam texture. There are generally very few or no coarse fragments. They have segregated iron-manganese zones in the subsoil, but no hard nodules, an indication that the meander was abandoned in the late Pleistocene to Early Holocene or ~ 30,000 to 18,000 years ago.

These soils are best suited as a source of cover material because of their favorable physical, chemical and mineralogical properties.

953B, 953B2, 953C, 953C3 Soils. Typic Paleudults; clayey or fine-loamy, siliceous, thermic. (Waynesboro). These soils were mapped on partially dissected terrace landforms that are not attached to the present-day terrace-floodplain landforms of the Clinch River. The largest extent of these soils occurs in an abandoned meander of the Clinch River at an elevation of 830 to 850 feet. These soils have a yellowish-red clay loam subsoil that contains local chert plus other rounded quartzites and sandstones of more distant origin. Most areas of these soils, because of favorable physical properties and gantle slopes, were used for intensive agricultural production. As a consequence, erosion was severe before abandonment. Most areas of these soils today are in managed forest for short-rotation biomass research.

These soils are best utilized for continued biomass research. They are a good source of cover materials.

954B, 954C Soils. Typic Paleudults; fine-loamy, siliceous, thermic. (Etowah) These soils are on high river terrace landscapes. They formed in a mixture of Clinch River alluvium from local and distant origins. Continued downcutting by the Clinch River after deposition has resulted in the present high elevation of these soils above the river in an abandoned meander. They occupy higher terraces adjacent to the No. 95 soils. Because of favorable physical and chemical properties, these soils were sought for agricultural activities and intensively used for crops. Most of these soils are presently

used for biomass production research or for other research activities. However, some small areas have been planted to pines, or have reverted to woodland. (Map Units No. 8 and 9.)

These soils are best utilized for continued biomass research activities.

APPENDIX J

WELL CONSTRUCTION LOGS AND SOIL TEST DATA FOR THE WEST CHESTNUT RIDGE SITE

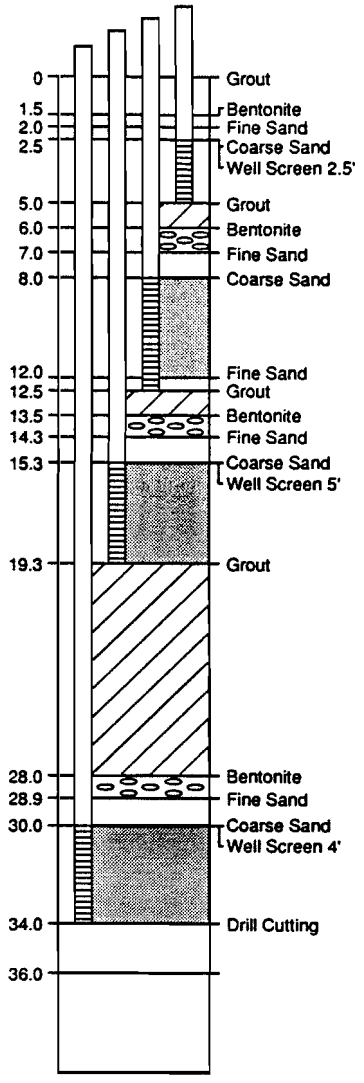
R. H. Ketelle

PART 1

WELL CONSTRUCTION LOGS OF SHALLOW CLUSTER WELLS

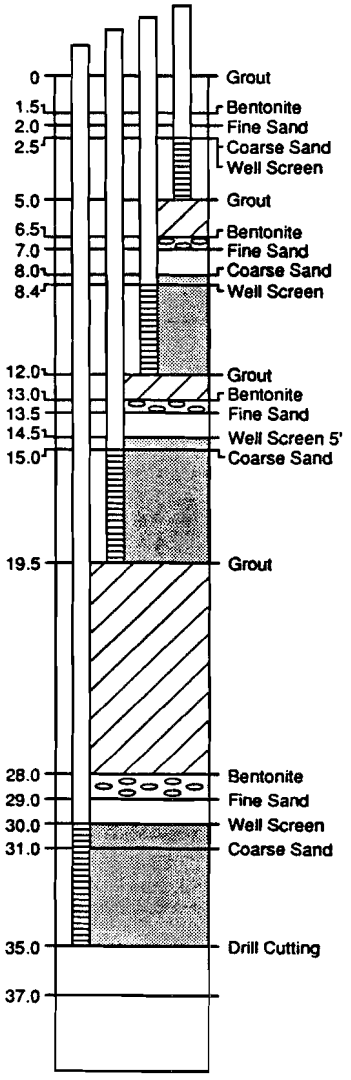
ORNL-DWG 88M-13402

CLUSTER WELL CONSTRUCTION LOG
CLUSTER 1



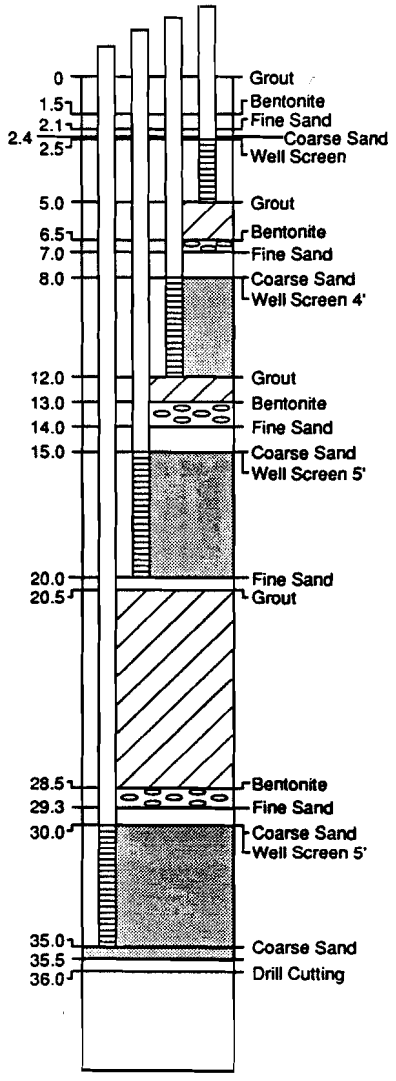
ORNL-DWG 88M-13403

CLUSTER WELL CONSTRUCTION LOG
CLUSTER 2



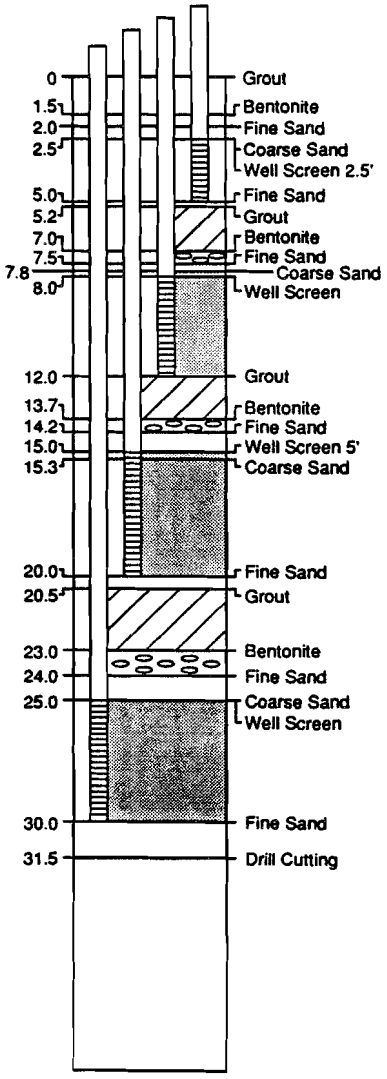
ORNL-DWG 88M-13404

CLUSTER WELL CONSTRUCTION LOG
CLUSTER 3



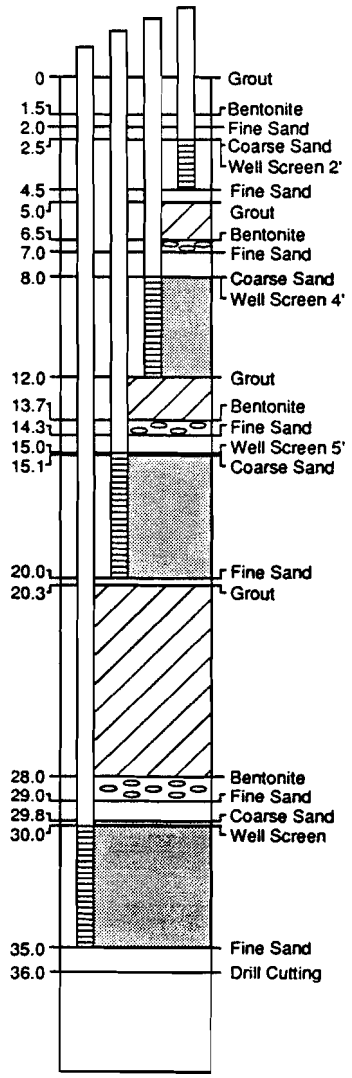
ORNL-DWG 88M-13405

CLUSTER WELL CONSTRUCTION LOG
CLUSTER 4



ORNL-DWG 88M-13406

CLUSTER WELL CONSTRUCTION LOG
CLUSTER 5



PART 2

WELL CONSTRUCTION LOGS AND SOIL TEST DATA FROM A SERIES OF WELLS DRILLED IN 1980

The following information is excerpted directly from the Geotek Engineering Company report on Subsurface Investigations for M-47846 Landfill (February 5, 1981). Locations of the subject borings are shown in Plate 4 of the main body of this report.

SOIL TEST BORINGS

SAN1-SAN10 were made in the proposed sanitary landfill site in residual soils and dolomitic rock strata of the Knox Formation.

All borings were advanced into the soil by means of a truck-mounted drilling rig using 8 1/2-in. hollow stem augers. The drilling rig was equipped for soil sampling and penetration testing in accordance with ASTM Specification D-1568-67 and for NXM diamond core drilling. Relatively undisturbed samples were obtained from depths as shown on the log of borings attached. The undisturbed soil samples were secured by 3-in. thin wall Shelby tube samplers. The tubes were then identified, sealed, and transmitted to the laboratory for general soil testing. Boring logs are included on pages J-42 through J-70.

All borings were converted to observation wells by inserting 2 in. or 6 in. PVC casing with bottom perforated sections. The annular space was filled with sand or pea gravel.

The observation well data are summarized in Table 1.

LABORATORY TESTING

To determine the degree of plasticity of the soil, Atterberg limit tests were performed on the samples of soil obtained from the borings. The soil used in these tests is only that passing U.S. Sieve No. 40. Results of the tests are shown in Table 2 along with natural moisture contents. Soil gradations with hydrometer analyses were performed on several samples from the sanitary landfill site as shown in Figs. 1-9.

In order to determine the shear strength of the soil, unconfined compression tests were performed on the undisturbed soil samples obtained from the borings. The samples tested had a ratio of height to diameter of approximately 2:1. Results of the tests are shown in Table 3 and also plotted as curves relating stresses and strains, Figs. 10-12.

In order to evaluate soil compressibility, consolidation tests were performed on undisturbed samples obtained by Shelby tubes from the borings. The tests were performed in accordance to ASTM Specification D-2435. Results of these tests are given in Figs. 13-23 as e-log p curves and C_v-log p plots. Values of permeability in the vertical direction, k, were then computed using values of e and C_v from these plots at the existing overburden pressure in the field. The permeability values are summarized in Table 4.

For comparison, permeabilities were determined for the samples in falling head permeameters for samples trimmed from Shelby tubes in accordance with U.S. Corps of Engineers Specification EM-1110-2-1906. These values are also given in Table 4.

Table 1. Observation well data

Boring Number	Rock Depth, ft	Water Table Depth, ft	Perforated Casing Depth, ft
SAN1	98	NR	78 - 98
SAN2	40	NR	38 - 43
SAN3	18	NR	37 - 57
SAN4	35	NR	31 - 35
SAN5	34	NR	30 - 34
SAN6	42	NR	38 - 42
SAN7	59.5	40	55.5 - 59.5
SAN8	39	NR	35 - 39
SAN9	38.5	NR	34.5 - 38.5
SAN10	53	NR	49 - 53

NOTE: NR - Not recorded

Table 2. Atterberg limit test results and natural moisture content of soil samples

Boring Number	Depth, ft	Soil Description	Natural Water Content, %	Liquid Limit, %	Plasticity Index
SAN1	5.0 - 7.0	Red cherty clay	20.9	60	28
SAN1	15.0 - 17.0	Red cherty clay	28.9	68	27
SAN2	5.0 - 7.0	Red cherty clay	24.6	71	32
SAN2	10.0 - 11.5	Red cherty clay	30.3	68	30
SAN2	20.0 - 21.5	Red-brown clay	31.2	50	18
SAN2	25.0 - 26.5	Red-brown clay	32.7	52	20
SAN2	30.0 - 31.5	Red-brown clay	33.5	58	27
SAN2	35.0 - 36.5	Red-brown clay	33.2	63	30
SAN3	5.0 - 6.5	Red cherty clay	37.5	94	50
SAN4	0 - 1.5	Red cherty clay	27.8	49	25
SAN4	5.0 - 6.5	Red cherty clay	24.5	56	29
SAN4	10.0 - 11.5	Red cherty clay	27.3	58	28
SAN4	15.0 - 17.0	Red cherty clay	29.4	64	32
SAN4	20.0 - 21.5	Red cherty clay	28.6	67	34
SAN4	25.0 - 26.0	Red sandy clay	19.8	42	21
SAN4	30.0 - 31.5	Brown-red clay	24.0	43	23
SAN5	0 - 1.5	Red silty clay	26.9	45	24
SAN5	5.0 - 6.5	Red clay	35.8	69	30
SAN5	10.0 - 12.0	Red clay	36.7	74	31
SAN5	15.0 - 16.5	Red silty clay	40.9	70	30
SAN5	20.0 - 21.5	Brown red clay	39.1	73	32
SAN5	25.0 - 26.5	Brown red clay	52.6	78	34
SAN5	30.0 - 31.5	Brown red clay	53.0	76	35
SAN6	0 - 1.5	Red silty clay	18.2	47	23
SAN6	5.0 - 6.5	Red silty clay	20.6	50	25
SAN6	10.0 - 11.5	Red silty clay	23.4	52	26
SAN6	15.0 - 16.5	Red silty clay	30.2	72	33
SAN6	20.0 - 21.5	Red silty clay	37.4	68	30
SAN6	25.0 - 26.5	Red silty clay	43.2	70	31
SAN6	30.0 - 31.5	Red silty clay	45.3	74	33
SAN6	35.0 - 36.5	Yellow sandy clay	49.0	71	34
SAN6	40.0 - 41.5	Red sandy clay	48.7	74	35
SAN7	0 - 1.5	Yellow silty clay	20.8	35	14
SAN7	5.0 - 7.0	Red cherty clay	21.9	33	12
SAN7	10.0 - 11.5	Red cherty clay	18.0	42	18
SAN7	15.0 - 16.5	Red cherty clay	18.6	47	25
SAN7	20.0 - 21.5	Red cherty clay	17.5	44	24
SAN7	25.0 - 26.5	Red cherty clay	22.9	47	26
SAN7	30.0 - 31.5	Red cherty clay	23.2	54	25
SAN7	35.0 - 36.5	Red cherty clay	30.1	56	27
SAN7	40.0 - 41.5	Brown-yellow-red sandy clay	29.0	47	24

Table 2. (continued)

Boring Number	Depth, ft	Soil Description	Natural Water Content, %	Liquid Limit, %	Plasticity Index
SAN7	45.0 - 46.5	Brown-red cherty clay	26.1	56	28
SAN7	50.0 - 51.5	Brown-red clay	31.7	54	28
SAN7	55.0 - 56.5	Brown-red clay	33.4	55	26
SAN8	0 - 1.5	Red cherty clay	19.7	41	22
SAN8	5.0 - 6.5	Red cherty clay	20.3	49	23
SAN8	10.5 - 12.0	Red cherty clay	20.7	55	29
SAN8	15.0 - 16.5	Red cherty clay	30.4	53	28
SAN8	25.0 - 26.5	Red clay	38.6	59	32
SAN8	30.0 - 31.5	Red clay	37.1	58	30
SAN8	35.0 - 36.5	Red clay	34.1	56	29
SAN9	0 - 1.5	Red cherty clay	24.3	38	13
SAN9	5.0 - 6.5	Red cherty clay	21.5	47	22
SAN9	10.0 - 11.5	Red brown clay	20.7	40	17
SAN9	15.0 - 16.5	Red cherty clay	26.0	45	18
SAN9	20.0 - 22.0	Red cherty clay	38.0	46	14
SAN9	25.0 - 26.5	Red cherty clay	32.9	42	19
SAN9	30.0 - 31.5	Red cherty clay	33.5	50	22
SAN9	35.0 - 36.5	Red cherty clay	36.5	52	20
SAN10	0 - 1.5	Red cherty clay	22.6	43	15
SAN10	5.0 - 6.5	Red cherty clay	25.1	40	16
SAN10	10.0 - 12.0	Red cherty clay	43.7	79	39
SAN10	15.0 - 16.5	Red cherty clay	40.5	67	32
SAN10	20.0 - 21.5	Red cherty clay	42.6	73	33
SAN10	25.0 - 26.5	Red cherty clay	41.2	70	32
SAN10	30.0 - 31.5	Red cherty clay	40.1	72	33
SAN10	35.0 - 36.5	Red cherty clay	47.9	75	30
SAN10	40.0 - 41.5	Red-brown clay	45.8	60	27
SAN10	45.0 - 46.5	Red-brown clay	49.0	62	26
SAN10	51.0 - 52.0	Red sandy gravely clay	56.2	67	31

Table 3. Results of unconfined compression tests

Boring Number	Depth, ft	Natural Water Content, %	Wet Unit Weight, pcf	Unconfined Compressive Strength, psf	Strain at Failure, %
SAN1	5.0 - 7.0	20.9	112.9	3,640	3.9
SAN1	15.0 - 17.0	28.9	120.2	4,470	4.2
SAN2	5.0 - 7.0	24.6	112.8	4,210	4.7
SAN3	5.0 - 6.5	37.5	110.1	2,300	2.7
SAN4	15.0 - 17.0	29.4	114.5	3,550	4.5
SAN5	10.0 - 12.0	36.7	112.0	4,280	5.9
SAN6	15.0 - 16.5	30.2	110.5	6,090	7.1
SAN7	5.0 - 7.0	21.9	123.8	3,800	6.5
SAN8	30.0 - 31.5	37.1	115.3	2,190	3.5
SAN9	20.0 - 22.0	38.0	110.7	3,330	5.3
SAN10	10.0 - 12.0	43.7	113.8	7,304	2.8

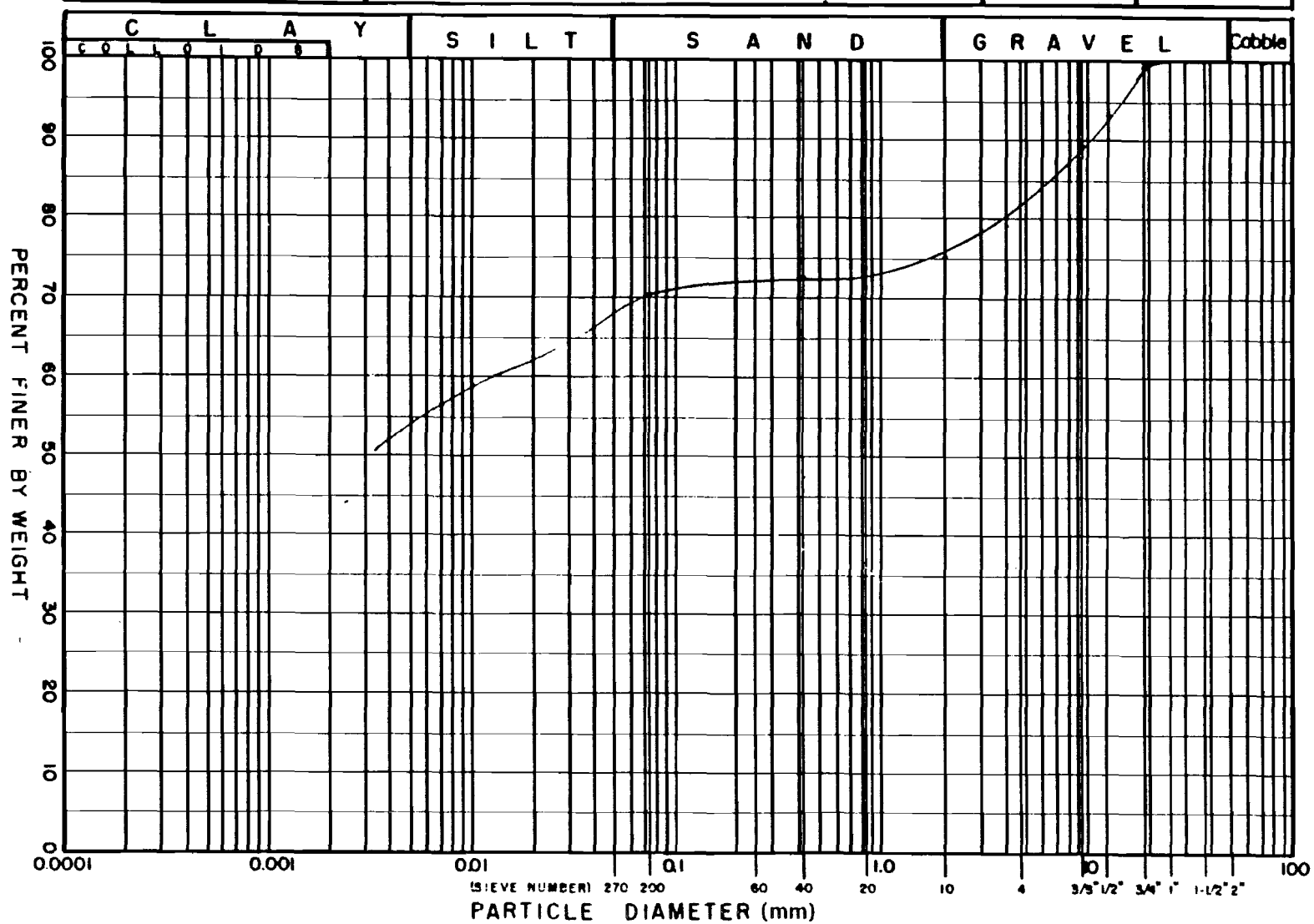
Table 4. Soil sample permeability values

Boring Number	Depth, ft	K from Consolidation Tests, 10^{-6} cm/sec	K from permeameter Tests, 10^{-6} cm/sec
SAN1	5.0 - 7.0	.32	.49
SAN1	15.0 - 17.0	.55	.15
SAN2	5.0 - 7.0	15	.12
SAN3	5.0 - 6.5	.21	.37
SAN4	15.0 - 17.0	1.1	.16
SAN5	10.0 - 12.0	.59	.096
SAN6	15.0 - 16.5	.46	.18
SAN7	5.0 - 7.0	28	63
SAN8	30.0 - 31.5	2.4	1.4
SAN9	20.0 - 22.0	3.7	4.8
SAN10	10.0 - 12.0	.13	.084

FIG. 1 **GRAIN SIZE DISTRIBUTION**

Geotek Project No. _____
Project Union Carbide K-21
SAN-1 15'-17'

Sample No.	Line Symbol	Textural Classification	Tested By	Date
Depth 15'-17'	———	red cherty clay		
	— — —			
	—·—			
	—··—			



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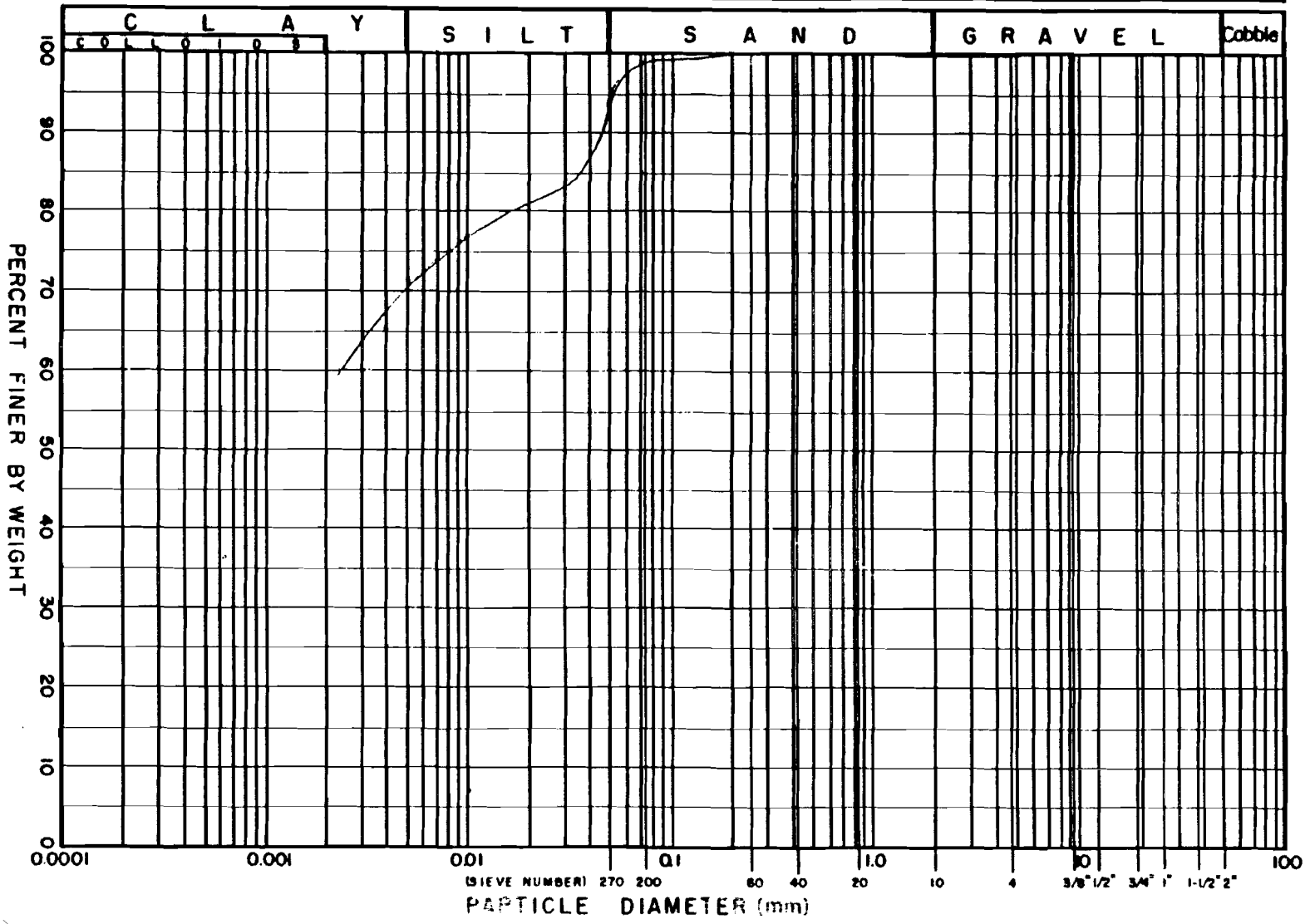
J-19

FIG. 2 **GRAIN SIZE DISTRIBUTION**

Geotek Project No. _____
Project Union Carbide K-21
Sam #2 5'-7'

Sample No.	Line Symbol	Textural Classification	Tested By	Date
5'-7'	———	red cherty clay		
	— —			
	—·—			
	—··—			



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J-20

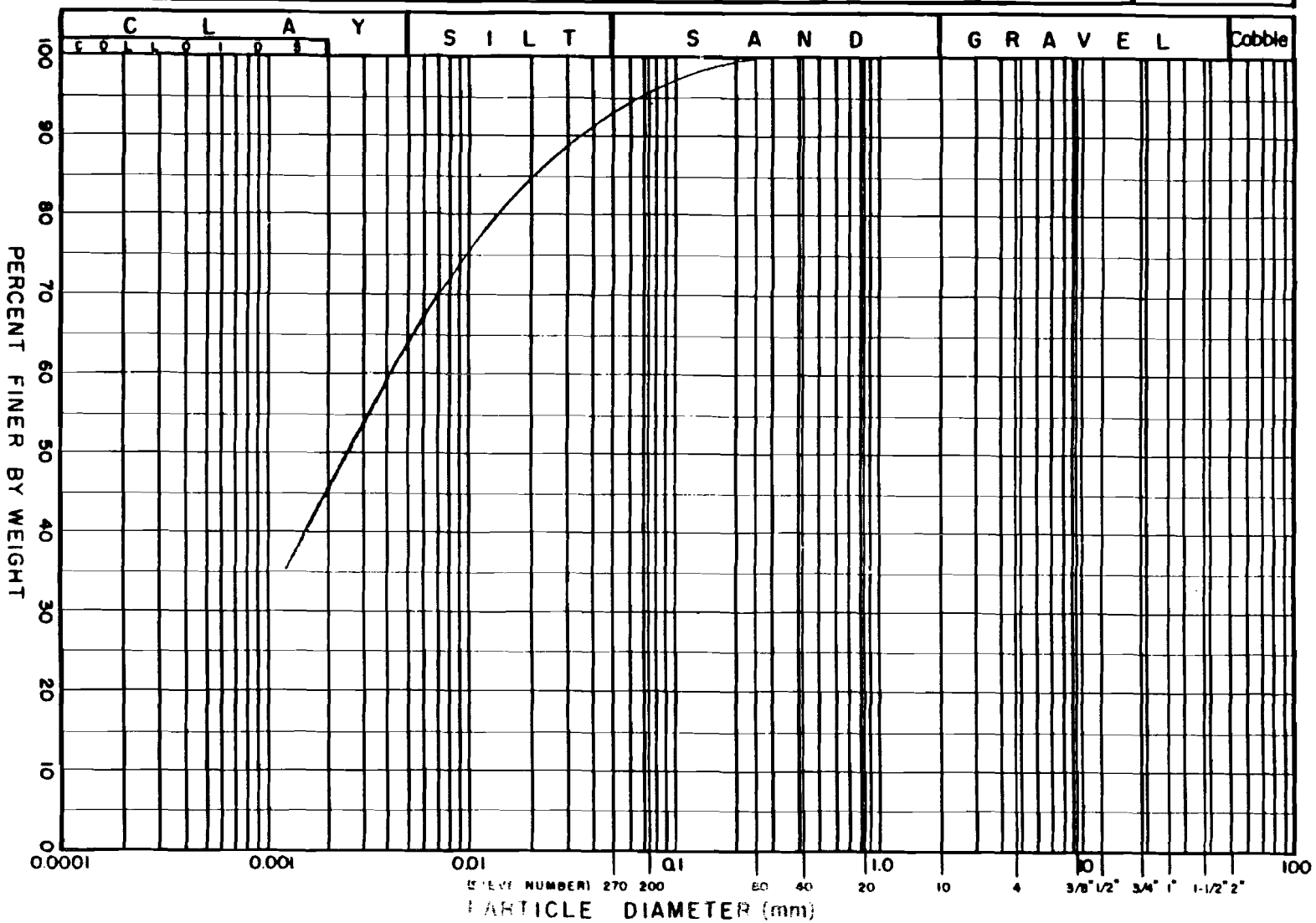
FIG. 3 **GRAIN SIZE DISTRIBUTION**

Geotek Project No. _____

Project Union Carbide K-21

SAN 3 5-6.5

Sample No.	Line Symbol	Textural Classification	Tested By	Date
5-6.5'	———	red cherty clay		
	— · —			
	— · · —			



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J-21

FIG. 4 **GRAIN SIZE DISTRIBUTION**

Geotek Project No. _____

Project Union Carbide K-21
San-5 10'-12'

Sample No.	Line Symbol	Textural Classification	Tested By	Date
10-12'	———	red clay		
	— —			
	—·—			
	—··—			

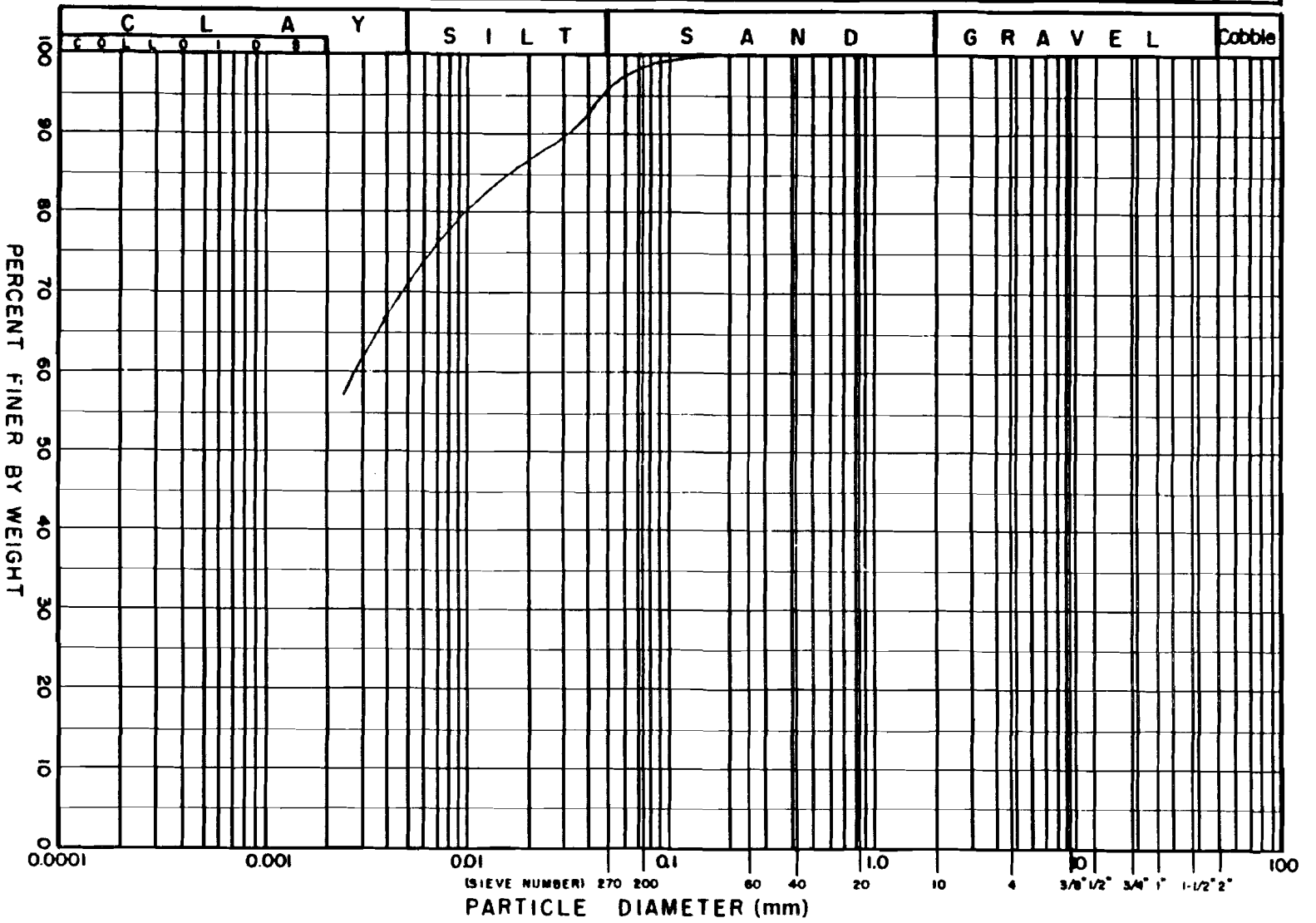

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FIG. 5 **GRAIN SIZE DISTRIBUTION**

Geotek Project No. _____
Project Union Carbide K-21
San 6 Depth 15'-16'

Sample No.	Line Symbol	Textural Classification	Tested By	Date
15'-16'	———	red silty clay		
	— —			
	—·—			
	—··—			

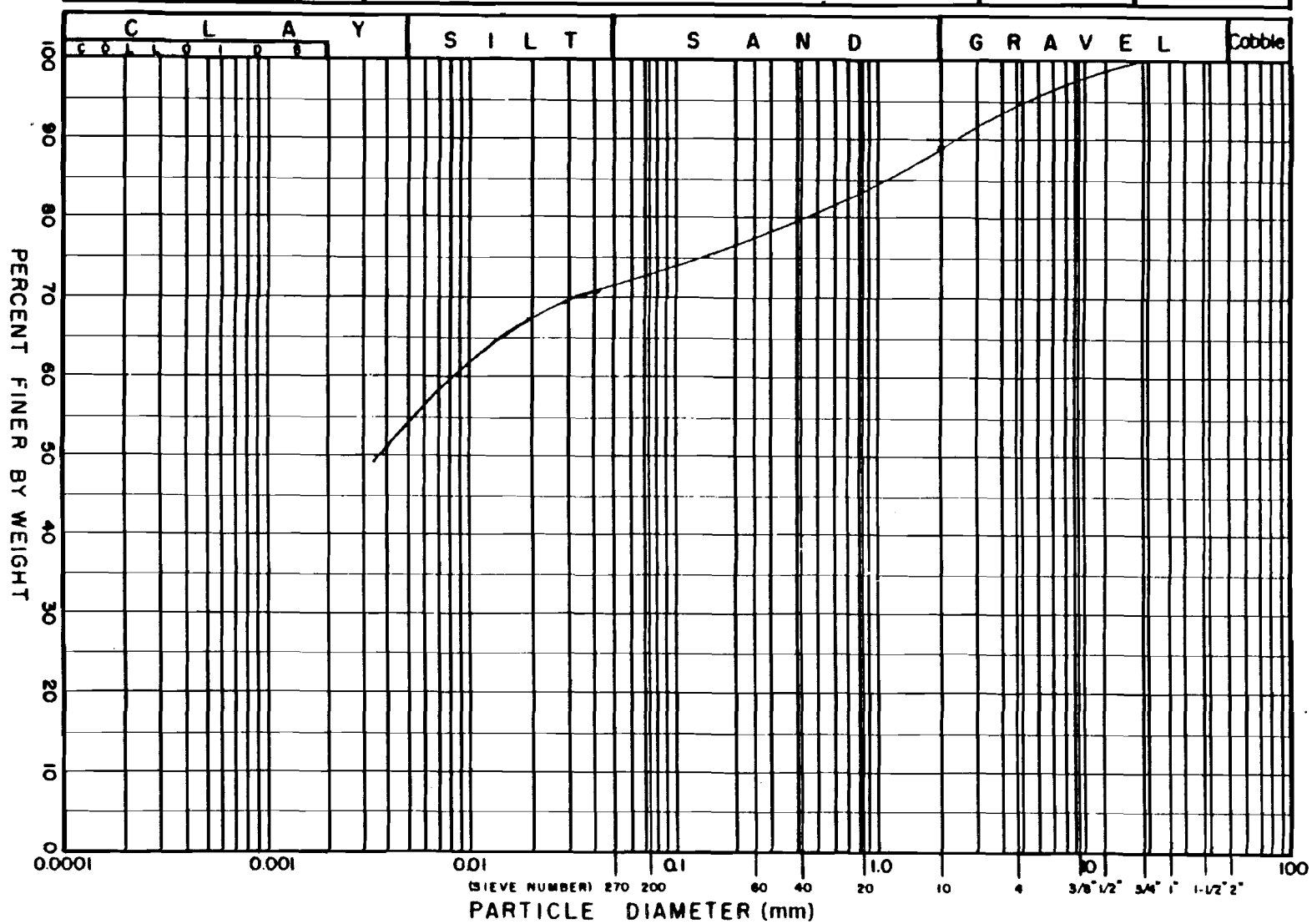

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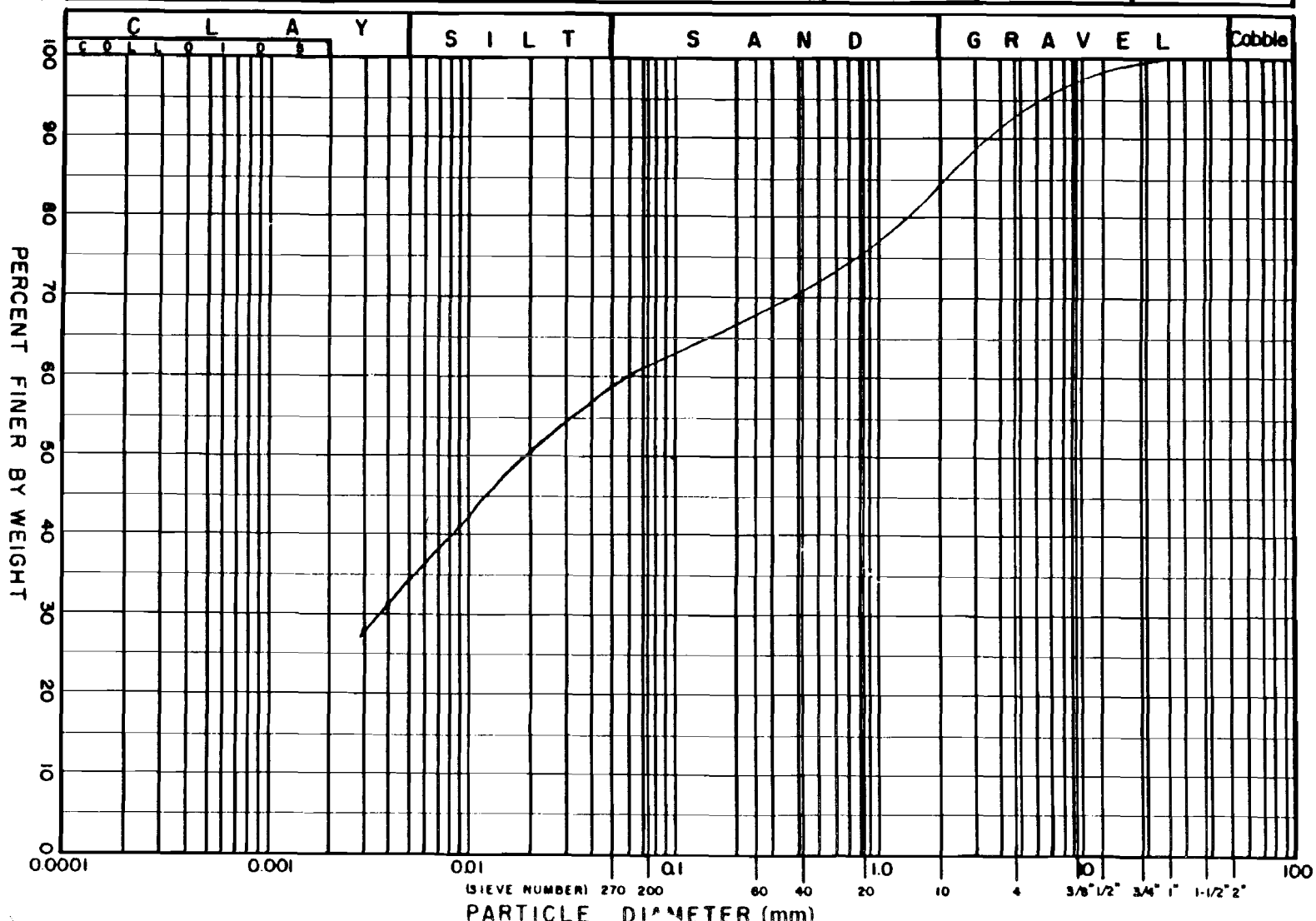
FIG. 6 **GRAIN SIZE DISTRIBUTION**

Geotek Project No. _____

Project Union Carbide K-21

SAN 7 5'-7'

Sample No.	Line Symbol	Textural Classification	Tested By	Date
5'-7'	———	red cherty clay		
	— —			
	— · —			
	— ·· —			



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J-24

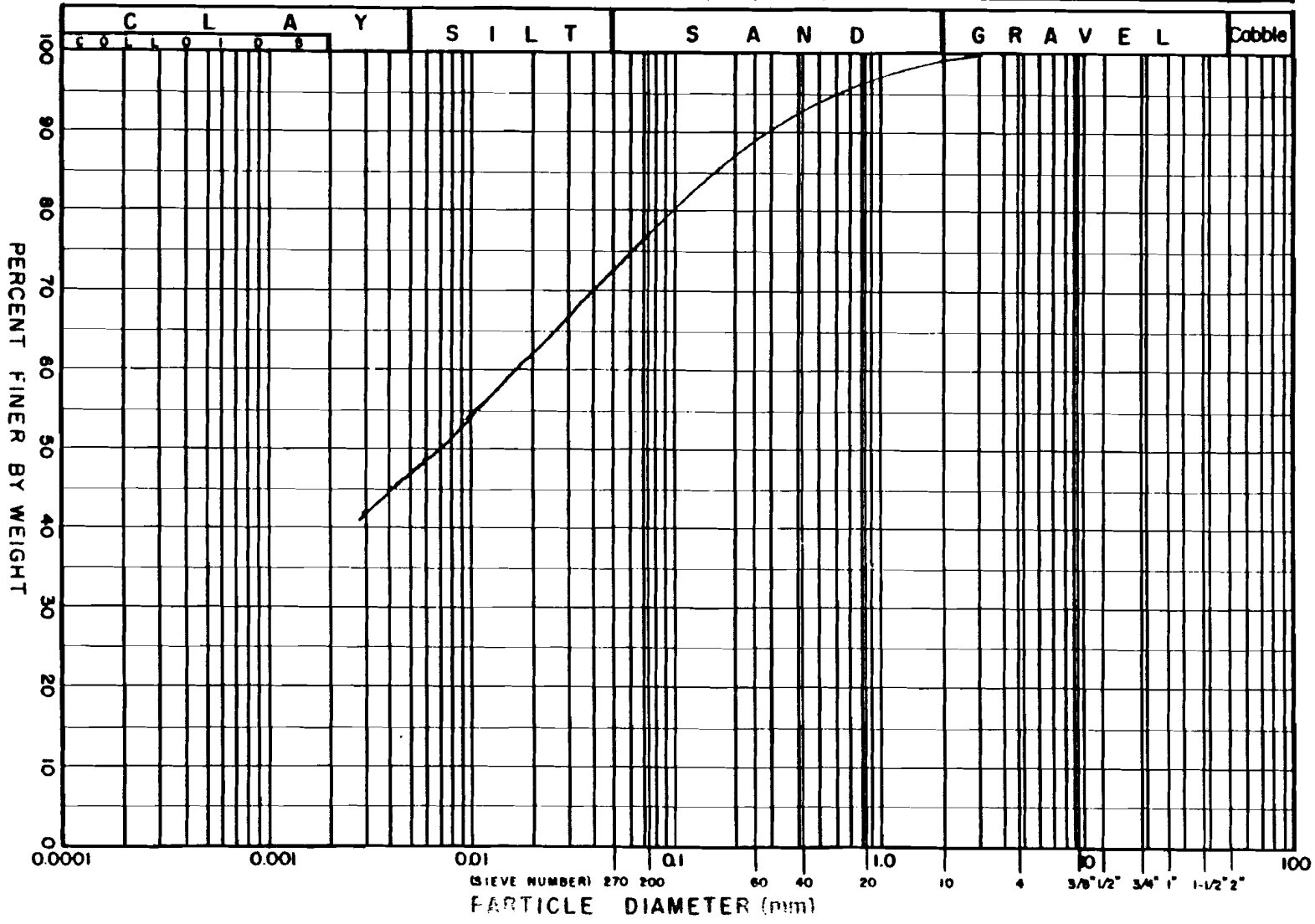
FIG. 7 **GRAIN SIZE DISTRIBUTION**

Geotek Project No. _____

Project Union Carbide K-21

SAN 8 30'-31.5'

Sample No.	Line Symbol	Textural Classification	Tested By	Date
30'-31.5'	———	red clay		
	— — —			
	—·—			
	—··—			



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J-25

FIG 8 **GRAIN SIZE DISTRIBUTION**

Geotek Project No. _____

Project Union Carbide K-21
SAN 9 20'-22'

Sample No.	Line Symbol	Textural Classification	Tested By	Date
20'-22'	———	red cherty clay		
	— —			
	—·—			
	—··—			

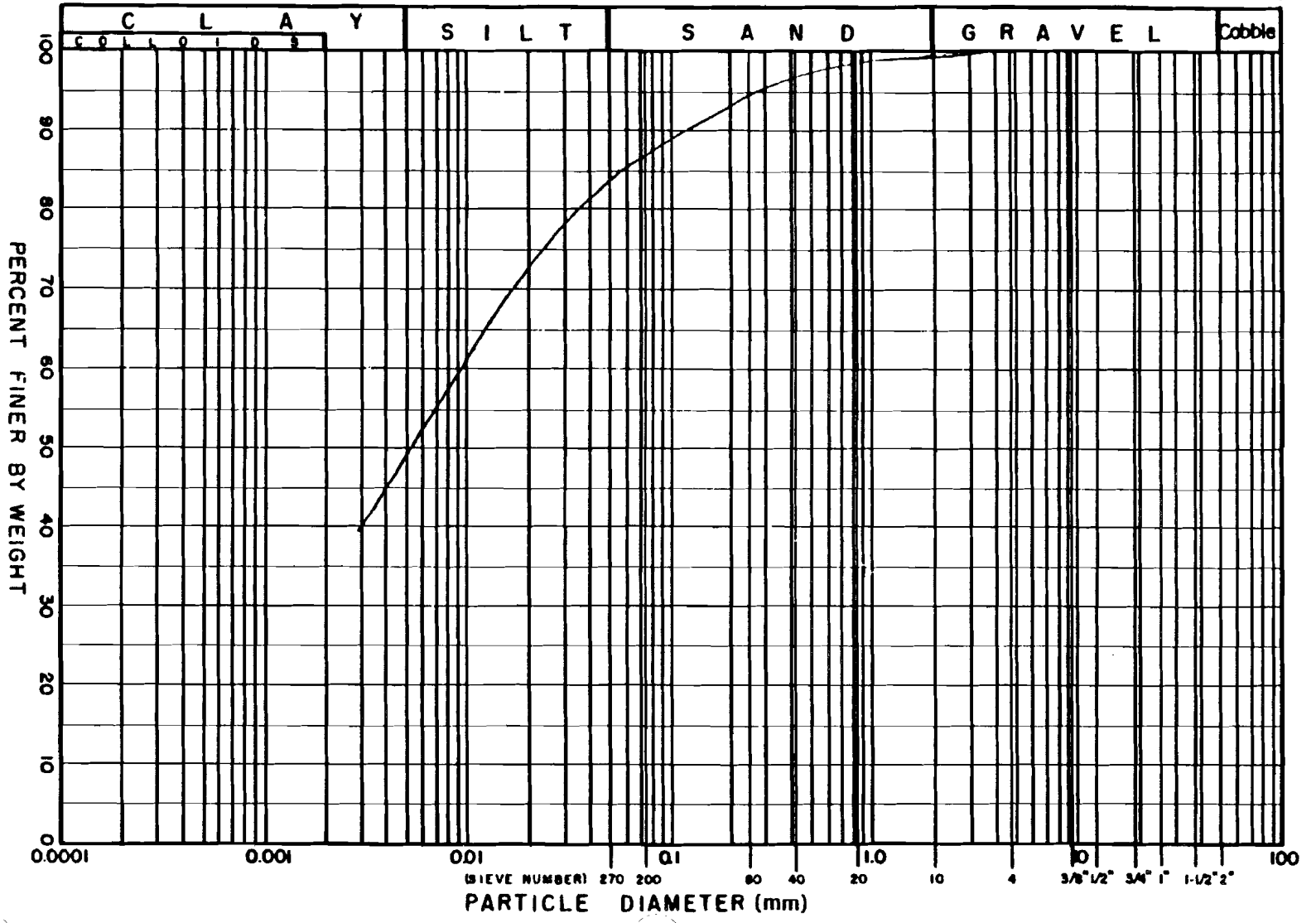

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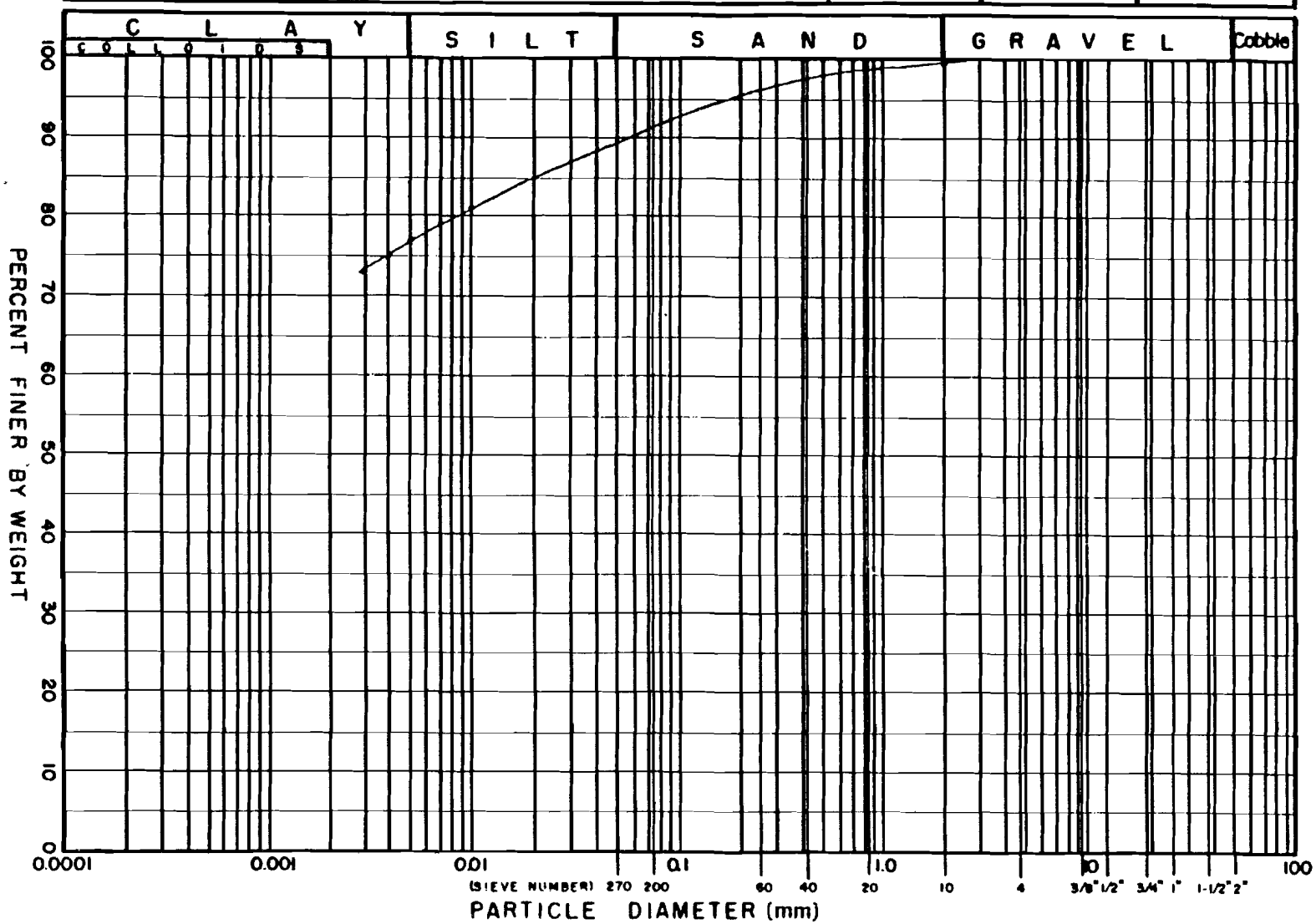
FIG. 9

GRAIN SIZE DISTRIBUTION

Geotek Project No. _____

Project Union Carbide K-21
SAN 10 10'-12'

Sample No.	Line Symbol	Textural Classification	Tested By	Date
10'-12'	———	red cherty clay		
	— —			
	—·—			
	—··—			



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J-27

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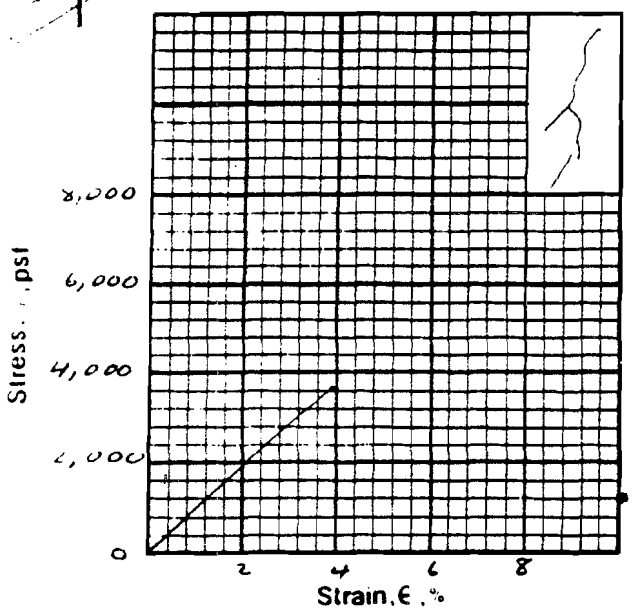
615-256-6891

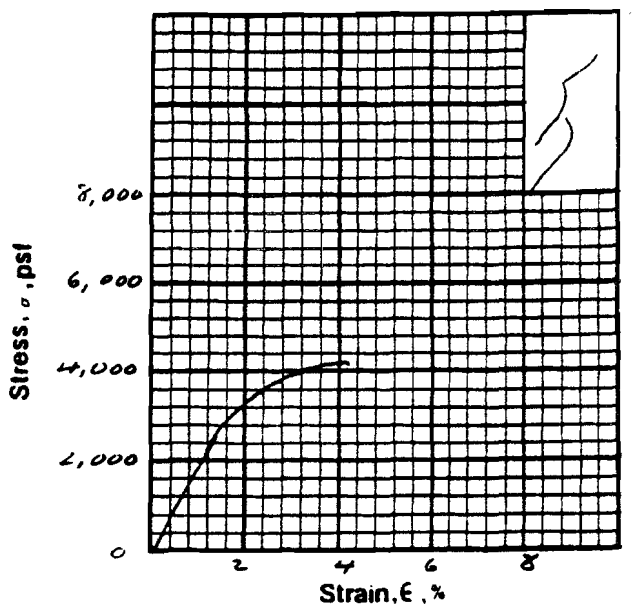
UNCONFINED COMPRESSION TESTS



Bor. SAN 1, Depth 5-7 ft, w 20.9%

σ_{max} 3,640 psf, ϵ_f 3.9%, γ_m 112.9 pcf

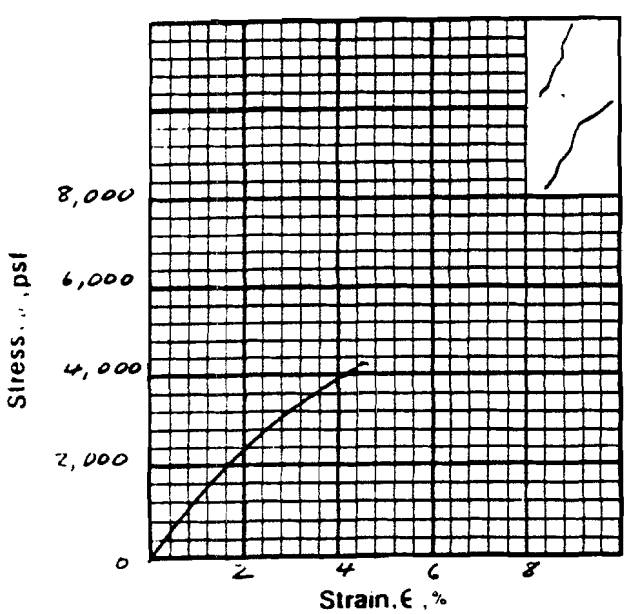
Description red cherty clay



Bor. SAN 1, Depth 15-17 ft, w 28.9%

σ_{max} 4,470 psf, ϵ_f 4.2%, γ_m 120.2 pcf

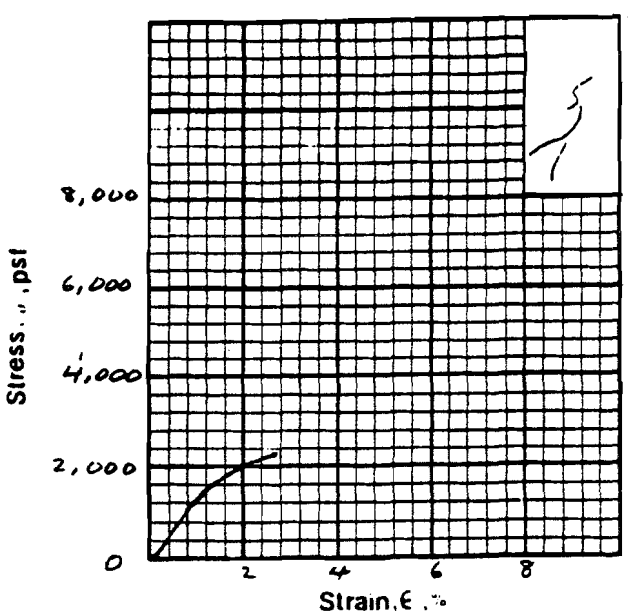
Description red cherty clay



Bor. SAN 2, Depth 5-7 ft, w 24.6%

σ_{max} 4,210 psf, ϵ_f 4.7%, γ_m 112.8 pcf

Description red cherty clay



Bor. SAN 3, Depth 5-6.5 ft, w 37.5%

σ_{max} 2,300 psf, ϵ_f 2.7%, γ_m 110.1 pcf

Description red cherty clay

w — water content
σ_{max} — ultimate compressive strength
ϵ_f — strain at failure
γ_m — moisture unit weight

Project: K-21

Date: _____ Fig: 10

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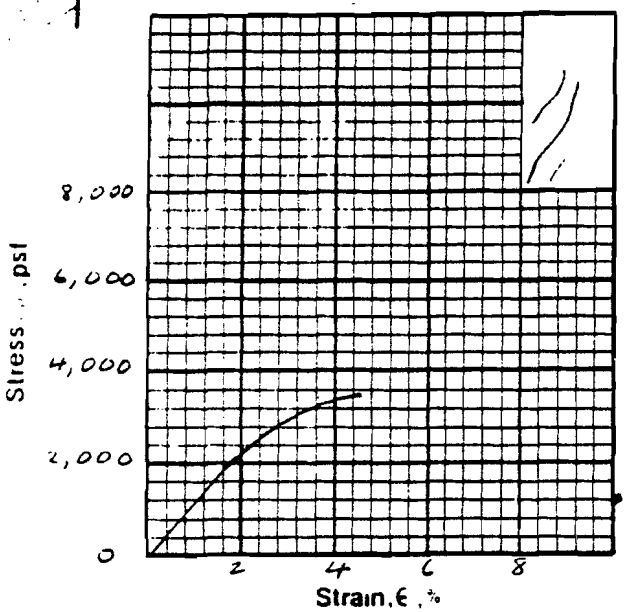
J-29

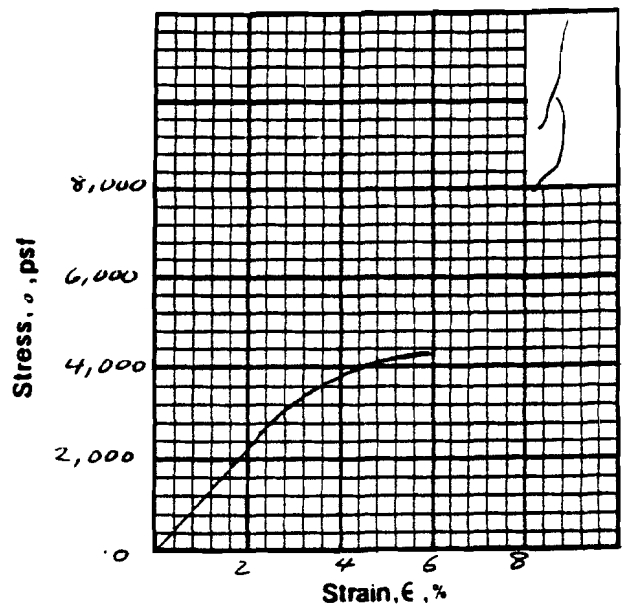
UNCONFINED COMPRESSION TESTS



Bor. SAN 4, Depth 15-17 ft, w 29.4 %

σ_{max} 3,550 psf, ϵ_f 4.5 %, γ_m 114.5 pcf

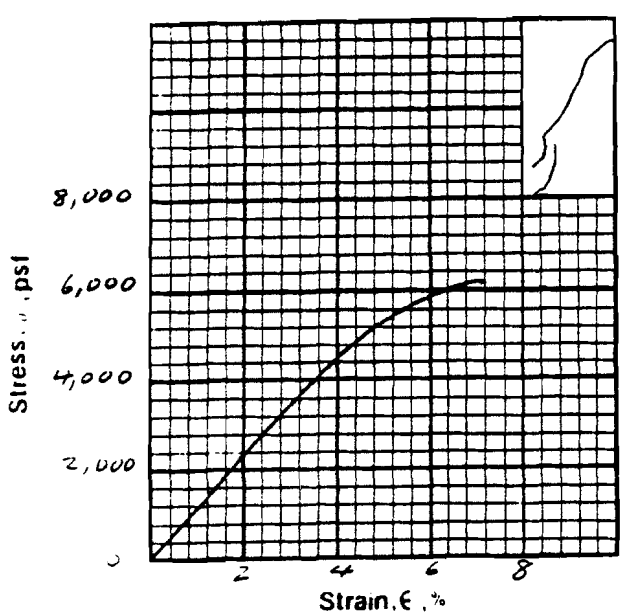
Description red cherty clay



Bor. SAN 5, Depth 10-12 ft, w 36.7 %

σ_{max} 4,280 psf, ϵ_f 5.9 %, γ_m 112.0 pcf

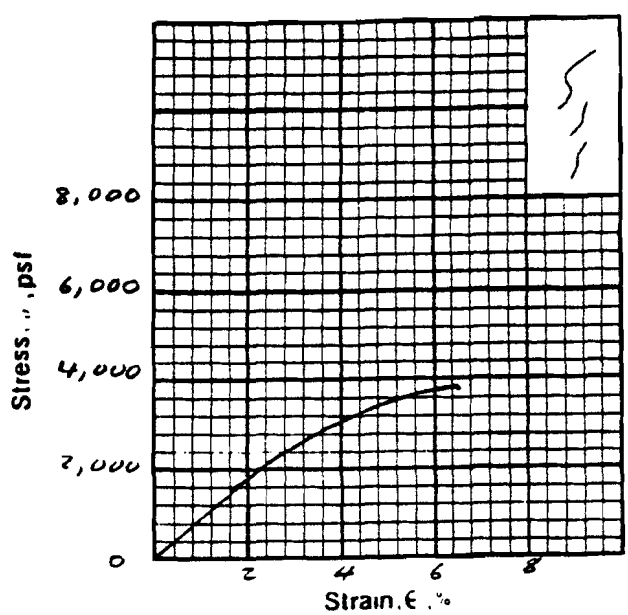
Description red clay



Bor. SAN 6, Depth 15-16.5 ft, w 30.2 %

σ_{max} 6,090 psf, ϵ_f 7.1 %, γ_m 110.5 pcf

Description red silty clay



Bor. SAN 7, Depth 5-7 ft, w 21.9 %

σ_{max} 3,800 psf, ϵ_f 6.5 %, γ_m 123.8 pcf

Description red cherty clay

w — water content
σ_{max} — ultimate compressive strength
ϵ_f — strain at failure
γ_m — moisture unit weight

Project: K-21

Date: _____ Fig: 11

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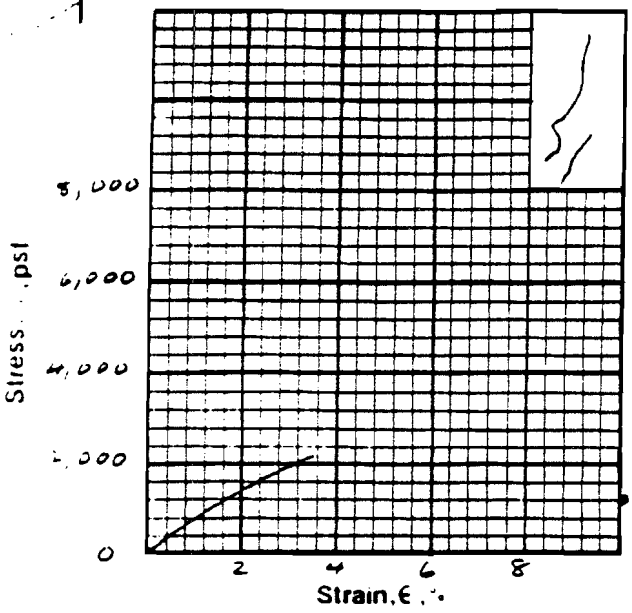
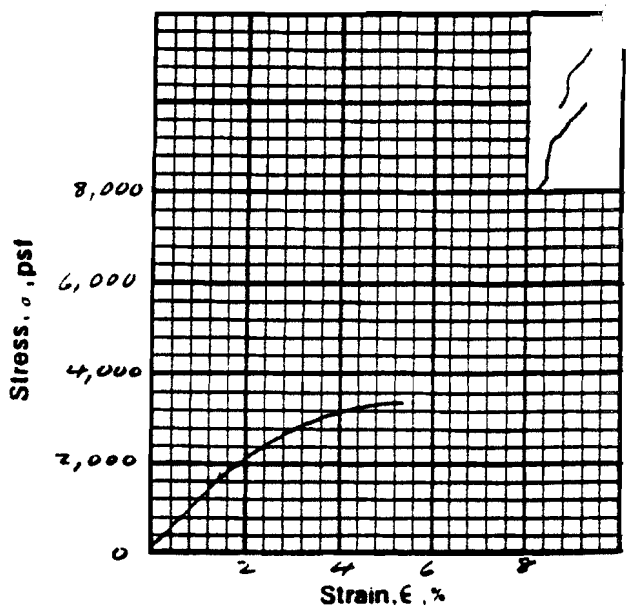
UNCONFINED COMPRESSION TESTS



Bor. SAN 8, Depth 30 - 31.5 ft, w 37.1 %

σ_{max} 2,190 psf, ϵ_f 2.5 %, γ_m 115.3 pcf

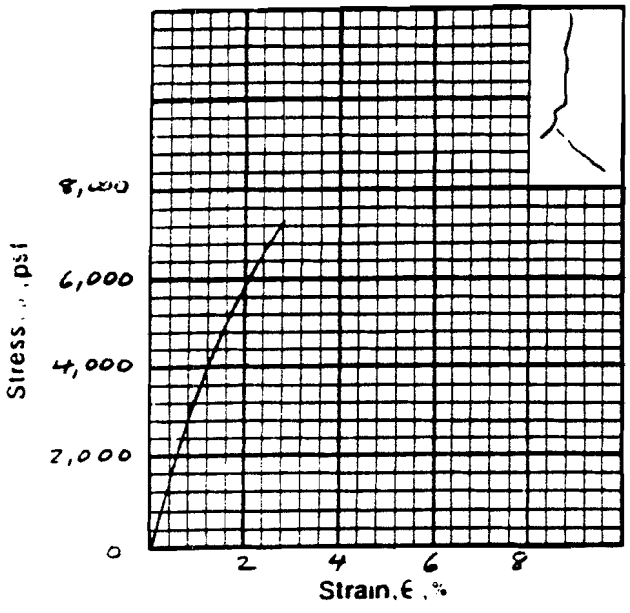
Description red clay



Bor. SAN 9, Depth 20 - 22 ft, w 38.0 %

σ_{max} 3,330 psf, ϵ_f 5.3 %, γ_m 110.7 pcf

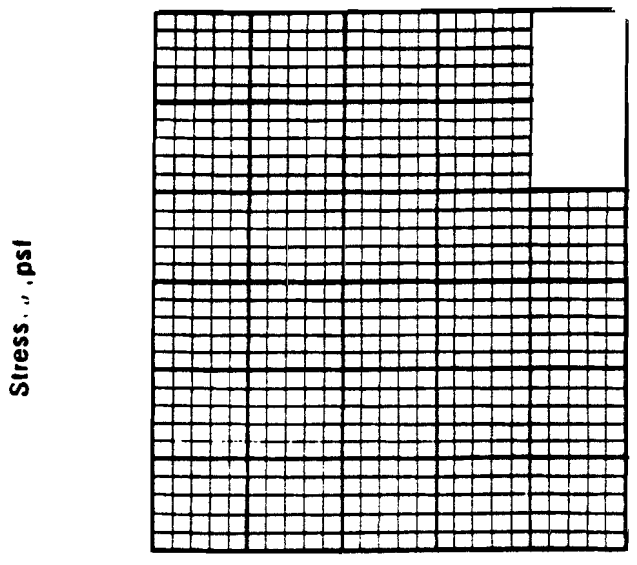
Description red cherty clay



Bor. SAN 10, Depth 10 - 12 ft, w 43.7 %

σ_{max} 7,300 psf, ϵ_f 2.8 %, γ_m 113.8 pcf

Description red cherty clay



Bor. ____, Depth ____ ft, w ____ %

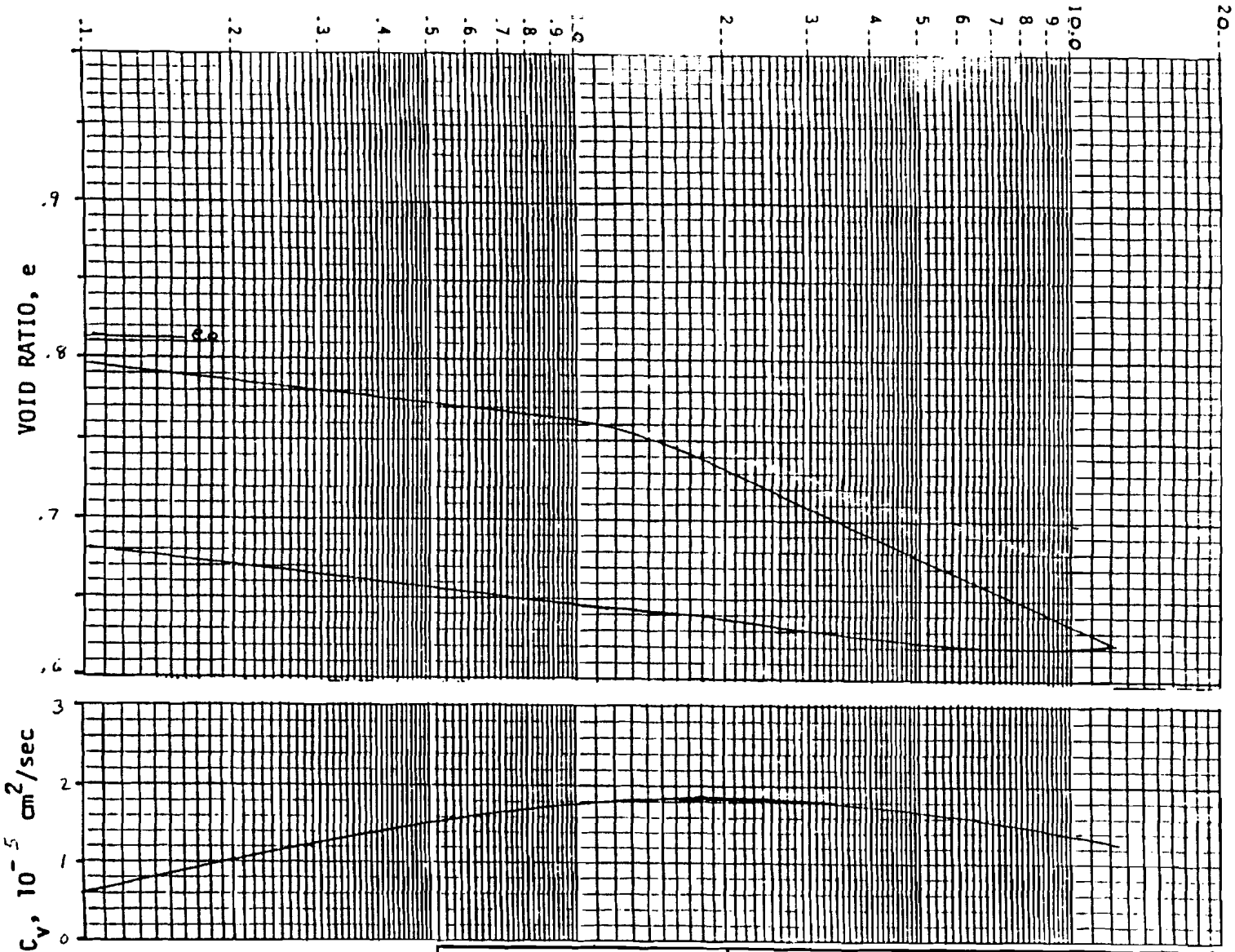
σ_{max} ____ psf, ϵ_f ____ %, γ_m ____ pcf

Description ____

W — water content
σ_{max} — ultimate compressive strength
ϵ_f — strain at failure
γ_m — moisture unit weight

Project: K-21

Date: ____ Fig: 12



BORING SAN1

DEPTH 5'-7'

LL 60 %

PI 28

W 20.9 %

e_o .812

γ_m 112.9 pcf

SOIL DESCRIPTION

red cherty clay

p_c = .339 tsf

k = 3.2×10^{-7} cm/sec

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GEOTEK ENGINEERING COMPANY

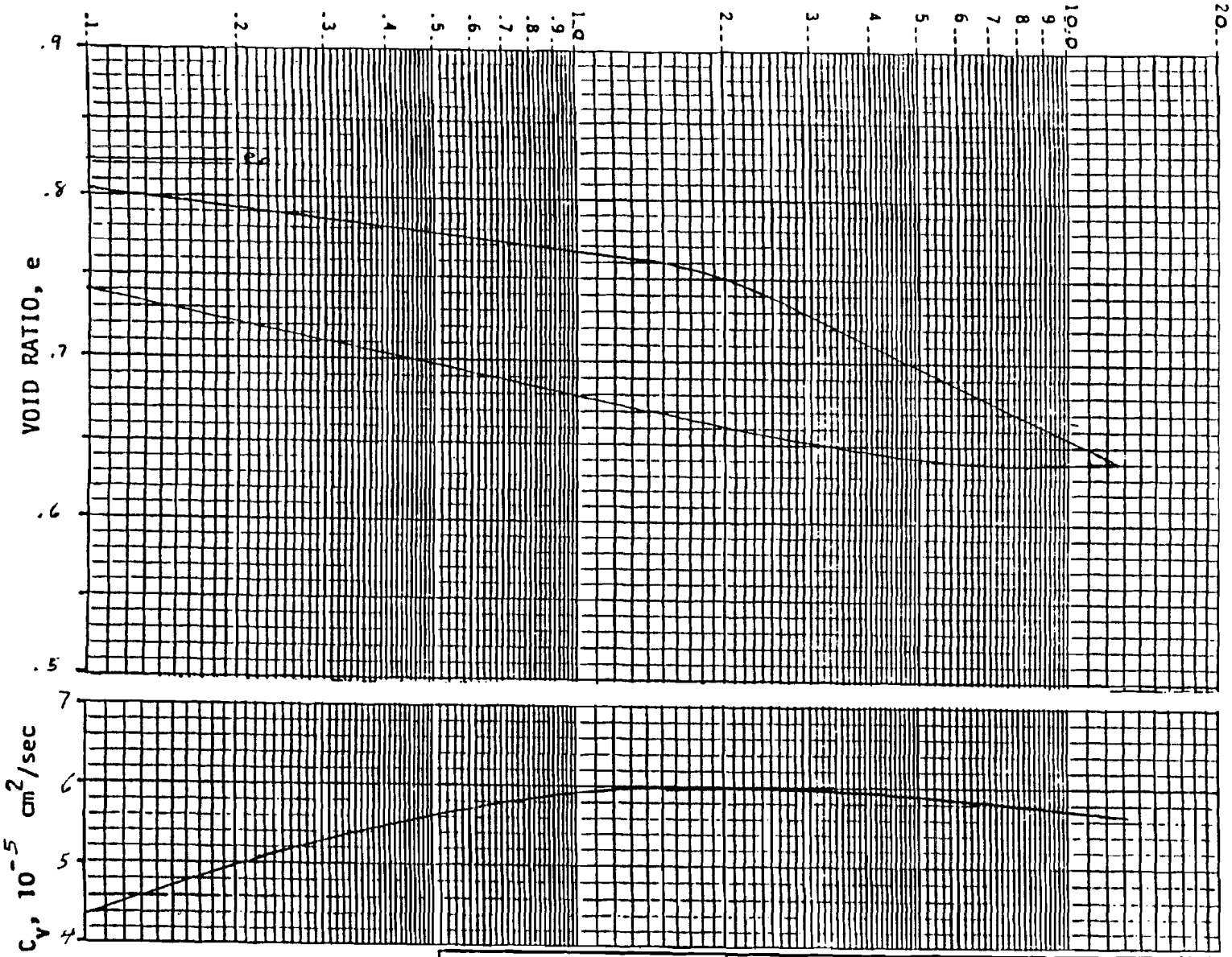
Date:

Project: K-21

Fig. 13

CONSOLIDATION TEST RESULTS

Drawing No. 33



BORING SAN 1

DEPTH 15'-17'

LL 68%

PI 27

W 28.9%

e_o .821

γ_m 120.2 pcf

SOIL DESCRIPTION

red cherty clay

P_o = .032 tsf

k = 5.5×10^{-7}

GEOTEK ENGINEERING COMPANY

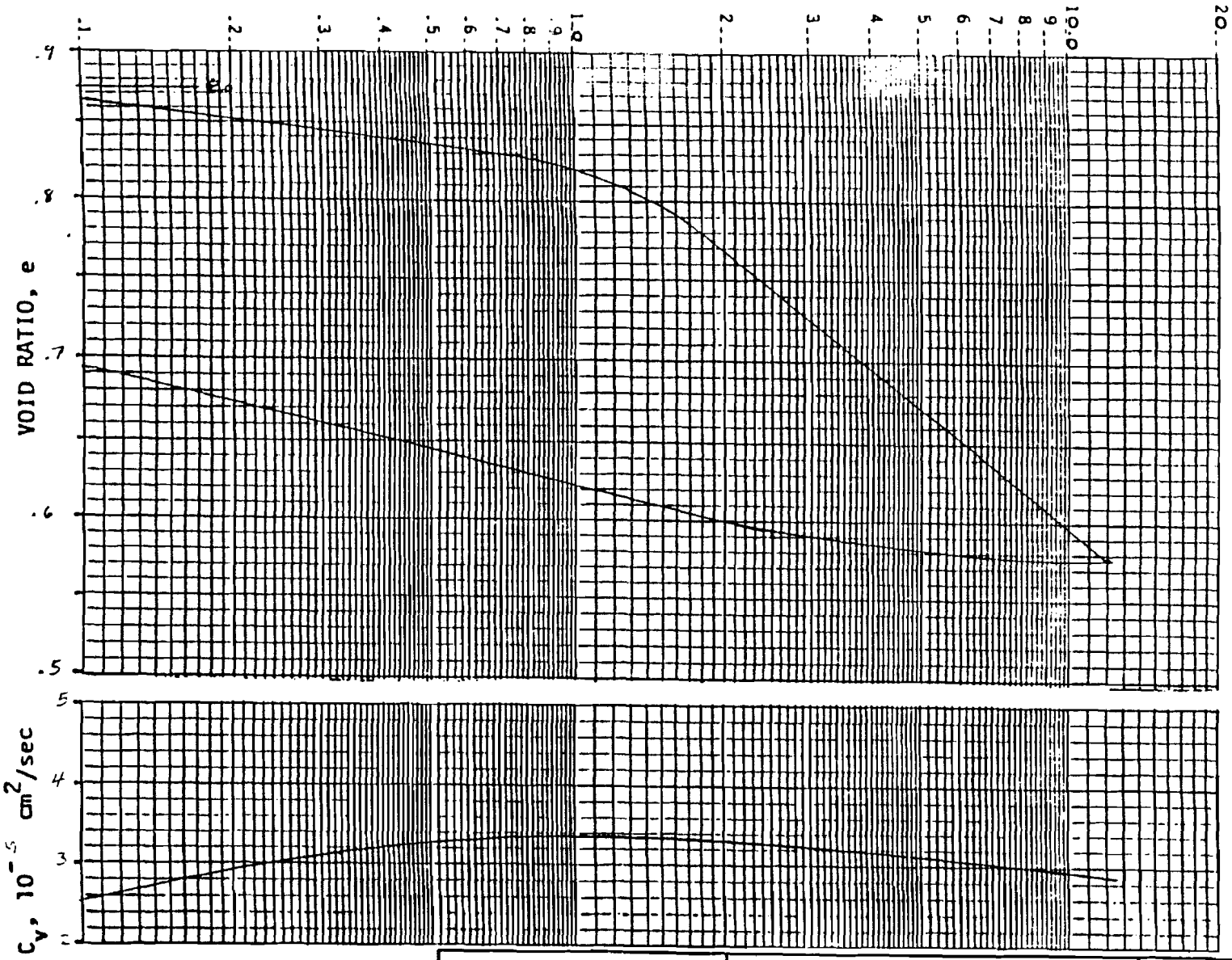
Date:

Project: K-21

Fig. 14

CONSOLIDATION TEST RESULTS

Drawing No. 34



BORING SAN 2

DEPTH 5'-7'

LL 71 %

PI 32

W 24.6 %

e_o .876

γ_m 112.8 pcf

SOIL DESCRIPTION

red cherty clay

P_o = .338

k = 1.5×10^{-5}

GEOTEK ENGINEERING COMPANY

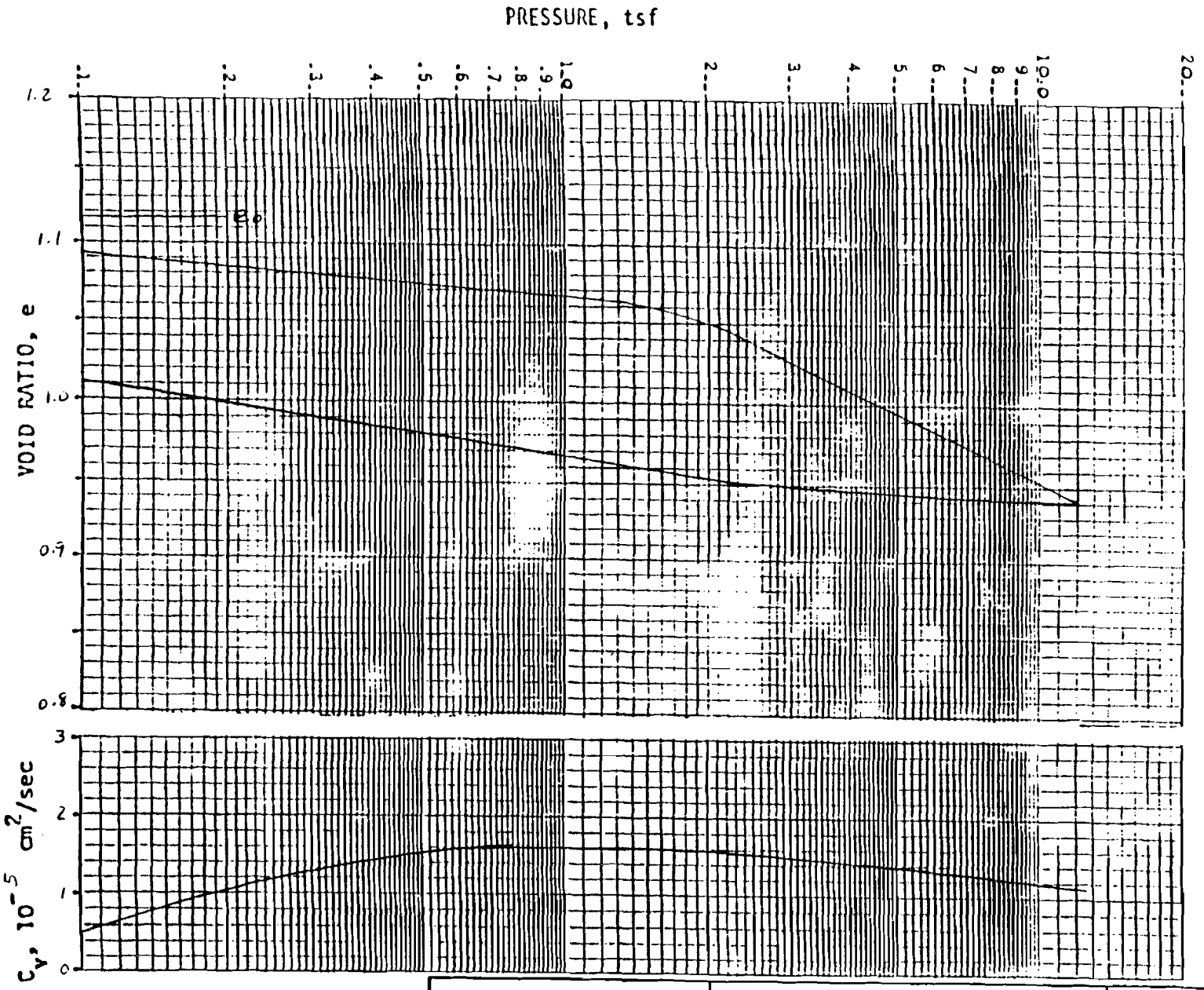
Date:

Project: K-21

Fig. 15

CONSOLIDATION TEST RESULTS

Drawing No. 35



BORING SAN 3

DEPTH 5'-6.5'

LL 94 %

PI 50

W 37.5 %

e_o 1.119

γ_m 110.1 pcf

SOIL DESCRIPTION

red cherty clay

P_o = .317 tsf

k = 2.1×10^{-7} cm/sec

GEOTEK ENGINEERING COMPANY

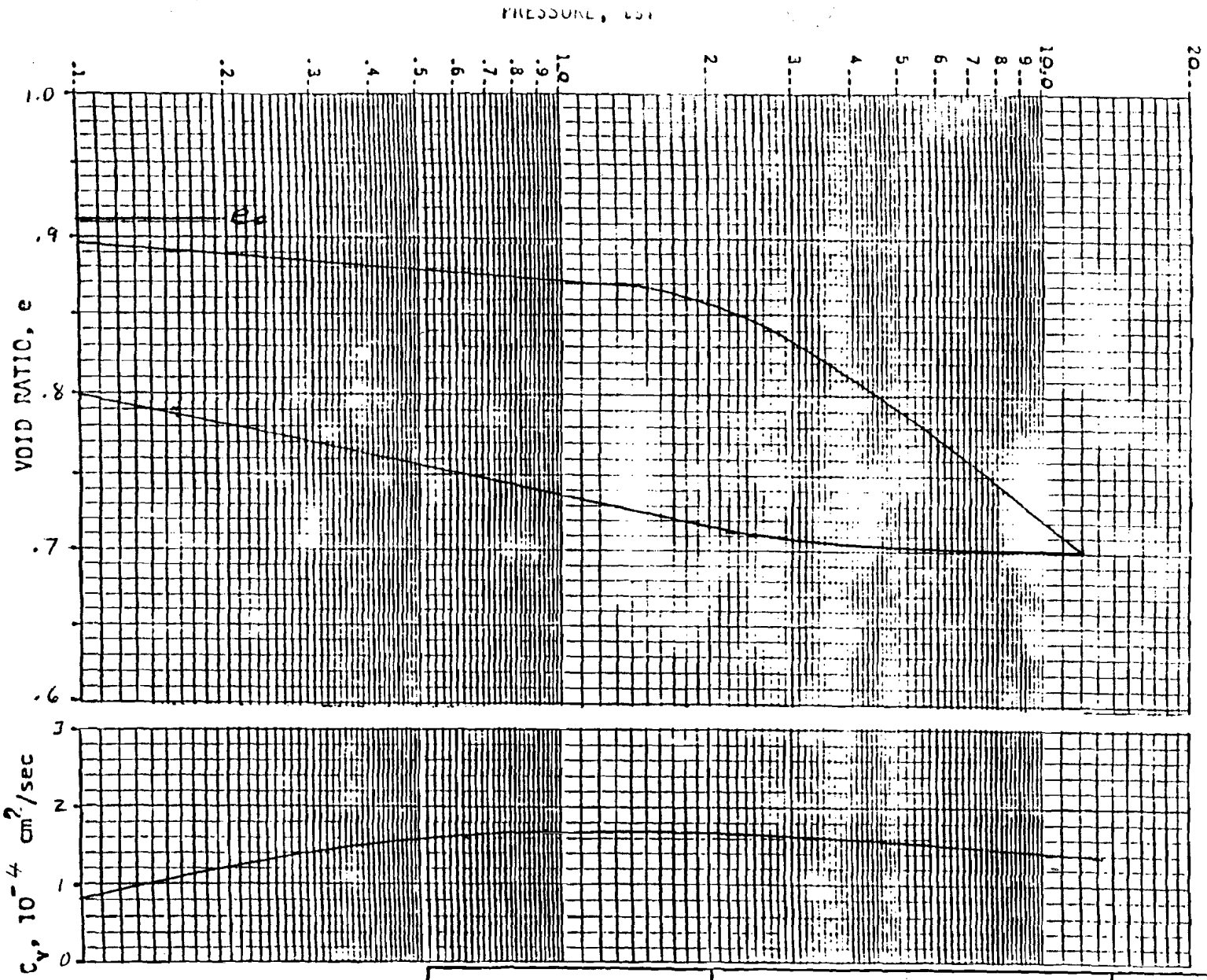
Date:

Project: K-21

Fig. 16

CONSOLIDATION TEST RESULTS

Drawing No. 36



BORING SAN 4

DEPTH 15'-17'

LL 64 %

PI 32

W 29.4 %

e_o .912

γ_m 114.5 pcf

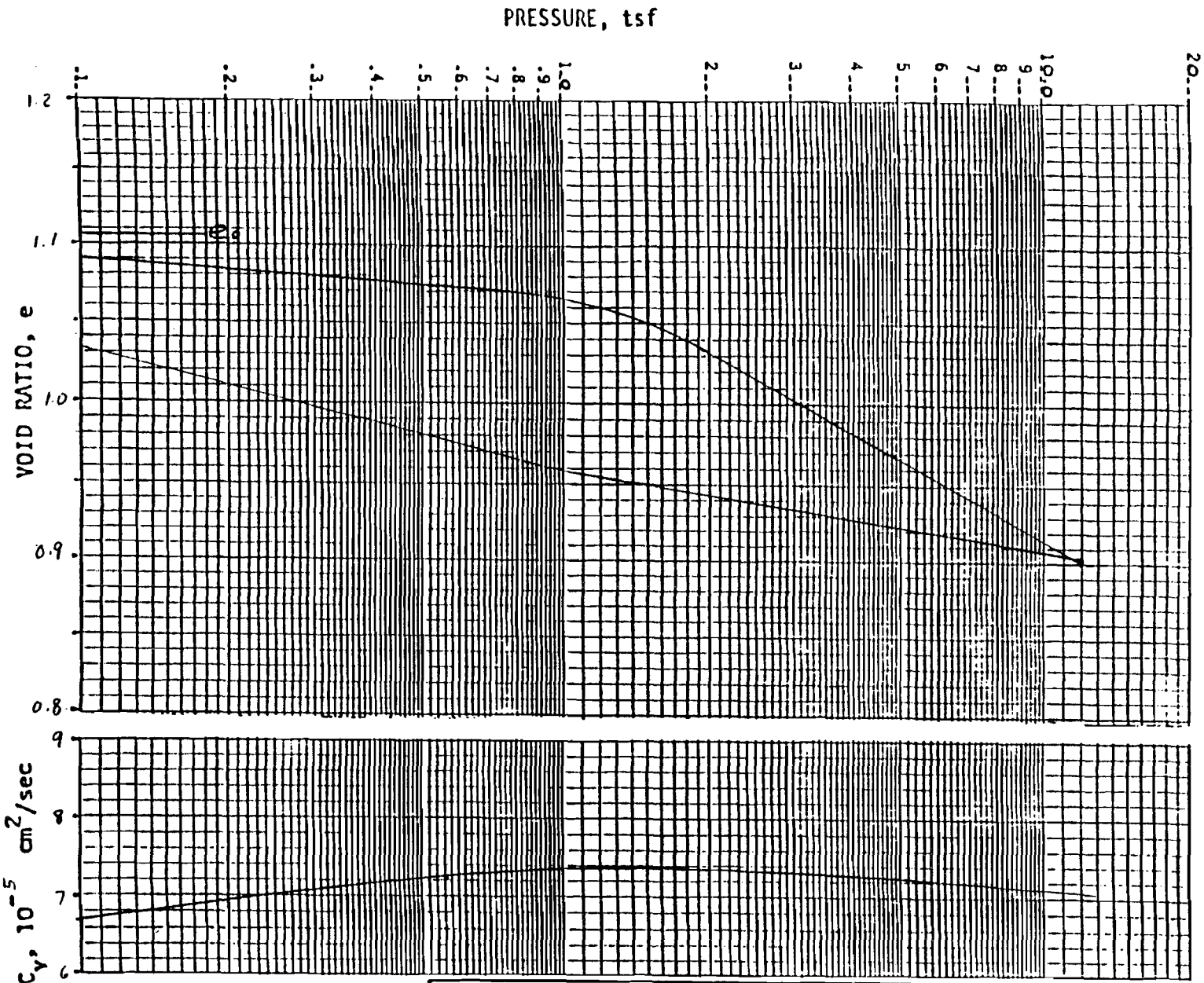
SOIL DESCRIPTION

red cherty clay

P_c = .916 tsf

k = 1.1×10^{-6} cm/sec

GEOTEK ENGINEERING COMPANY	Date:	CONSOLIDATION TEST RESULTS
	Project: K-21	
	Fig. 17	Drawing No. 37



BORING SAN 5

DEPTH 10'-12'

LL 74 %

PI 31

W 36.7 %

e_o 1.070

γ_m 112.0 pcf

SOIL DESCRIPTION

red clay

P_c = .616 tsf

k = 5.9 × 10^{-7} cm/sec

GEOTEK ENGINEERING COMPANY

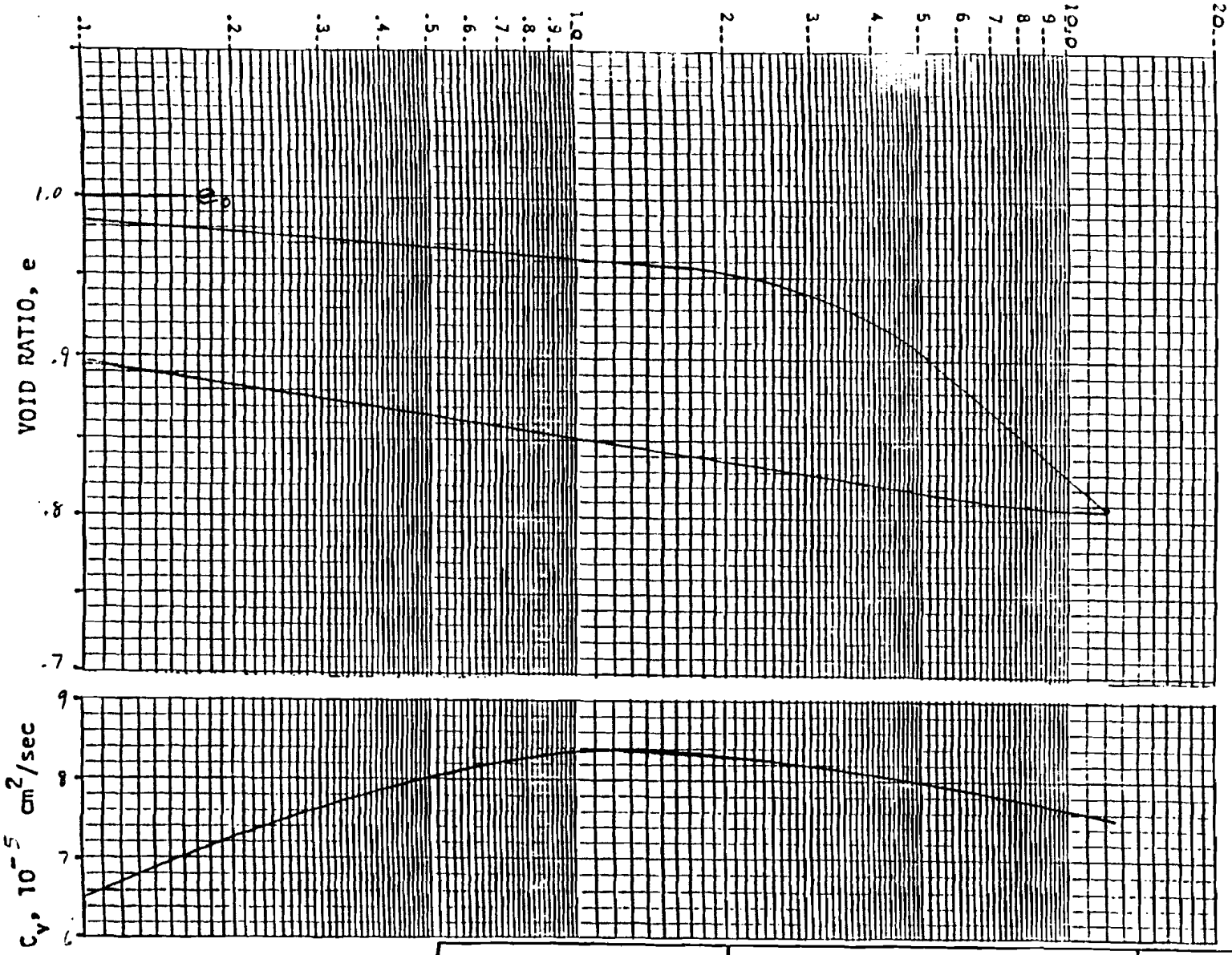
Date:

Project: K-21

Fig. 18

CONSOLIDATION TEST RESULTS

Drawing No. 38



BORING SAN 6

DEPTH 15'-16.5'

LL 72 %

PI 33

W 30.2 %

e_o 1.000

γ_m 110.5 pcf

SOIL DESCRIPTION

red silty clay

P_o = .871 tsf

$k = 4.6 \times 10^{-7}$ cm/sec

GEOTEK ENGINEERING COMPANY

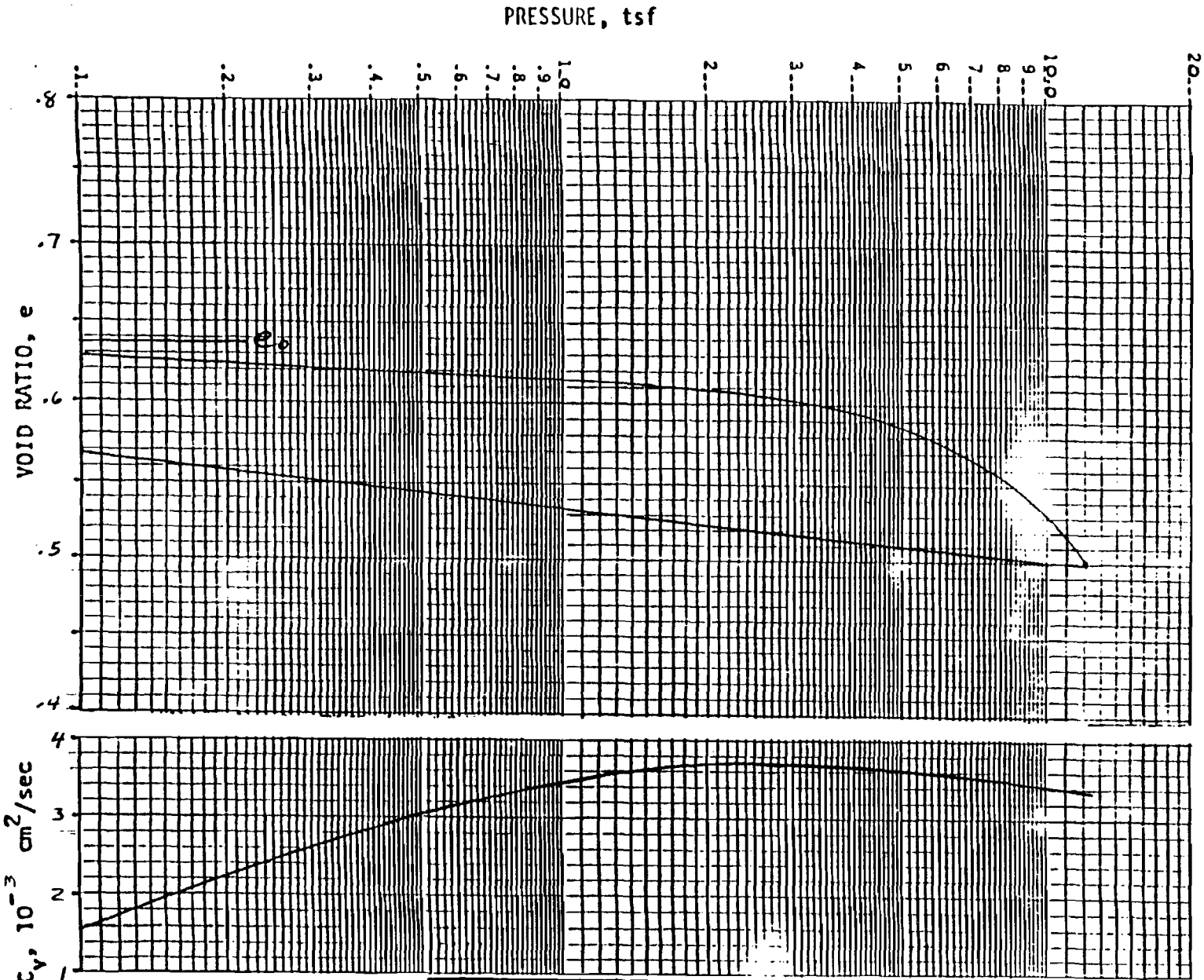
Date:

Project: K-21

Fig. 19

CONSOLIDATION TEST RESULTS

Drawing No. 39



BORING SAN 7

DEPTH 5'-7'

LL 33 %

PI 12

W 21.9 %

e_o .639

γ_m 123.8 pcf

SOIL DESCRIPTION

red cherty clay

P_o = .371 tsf

k = 2.8×10^{-5} cm/sec

GEOTEK ENGINEERING COMPANY

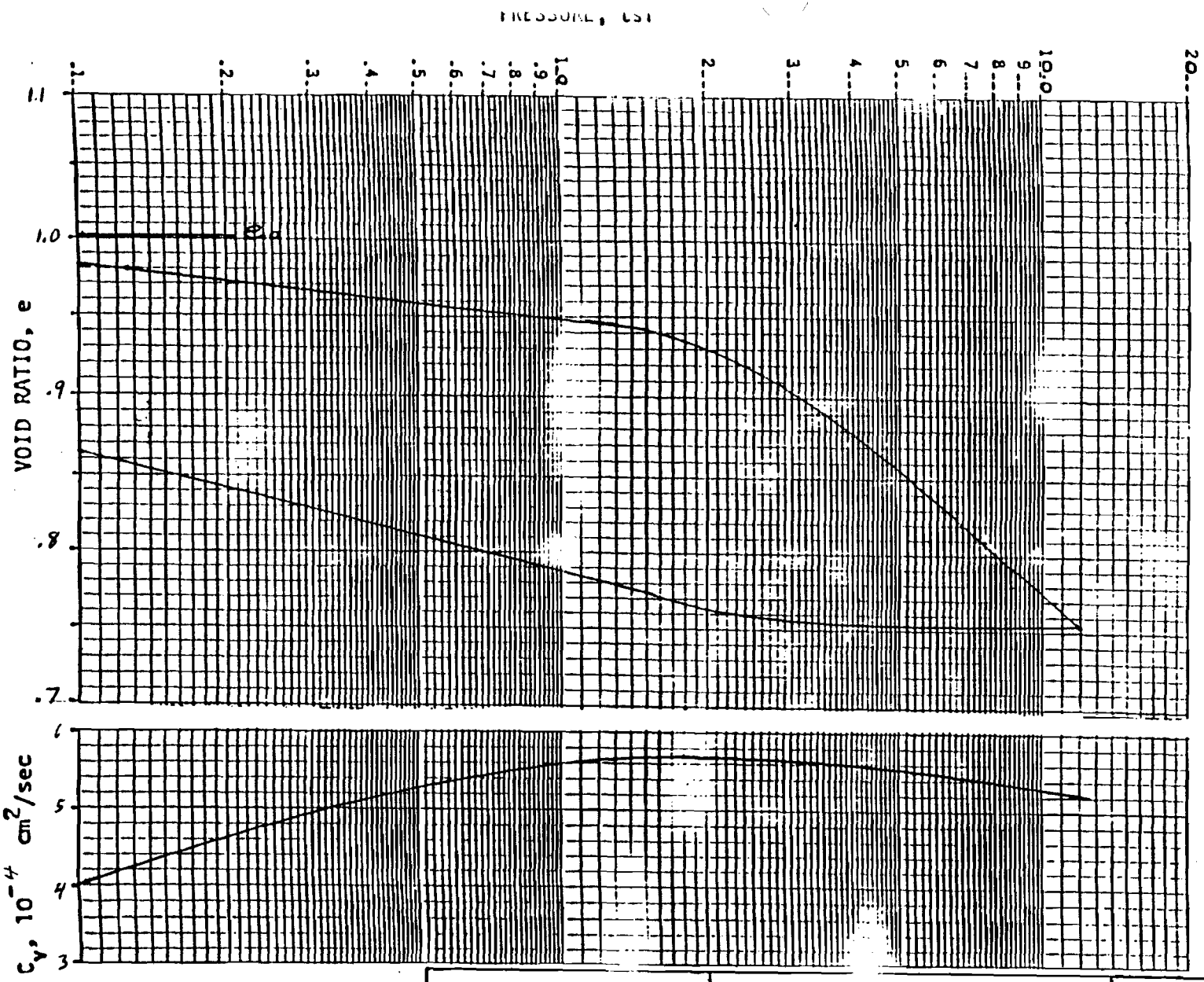
Date:

Project: K-21

Fig. 20

CONSOLIDATION TEST RESULTS

Drawing No. 40



BORING SAN 8

DEPTH 30'-31.5'

LL 58 %

PI 30

W 37.1 %

e_o 1.004

γ_m 115.3 pcf

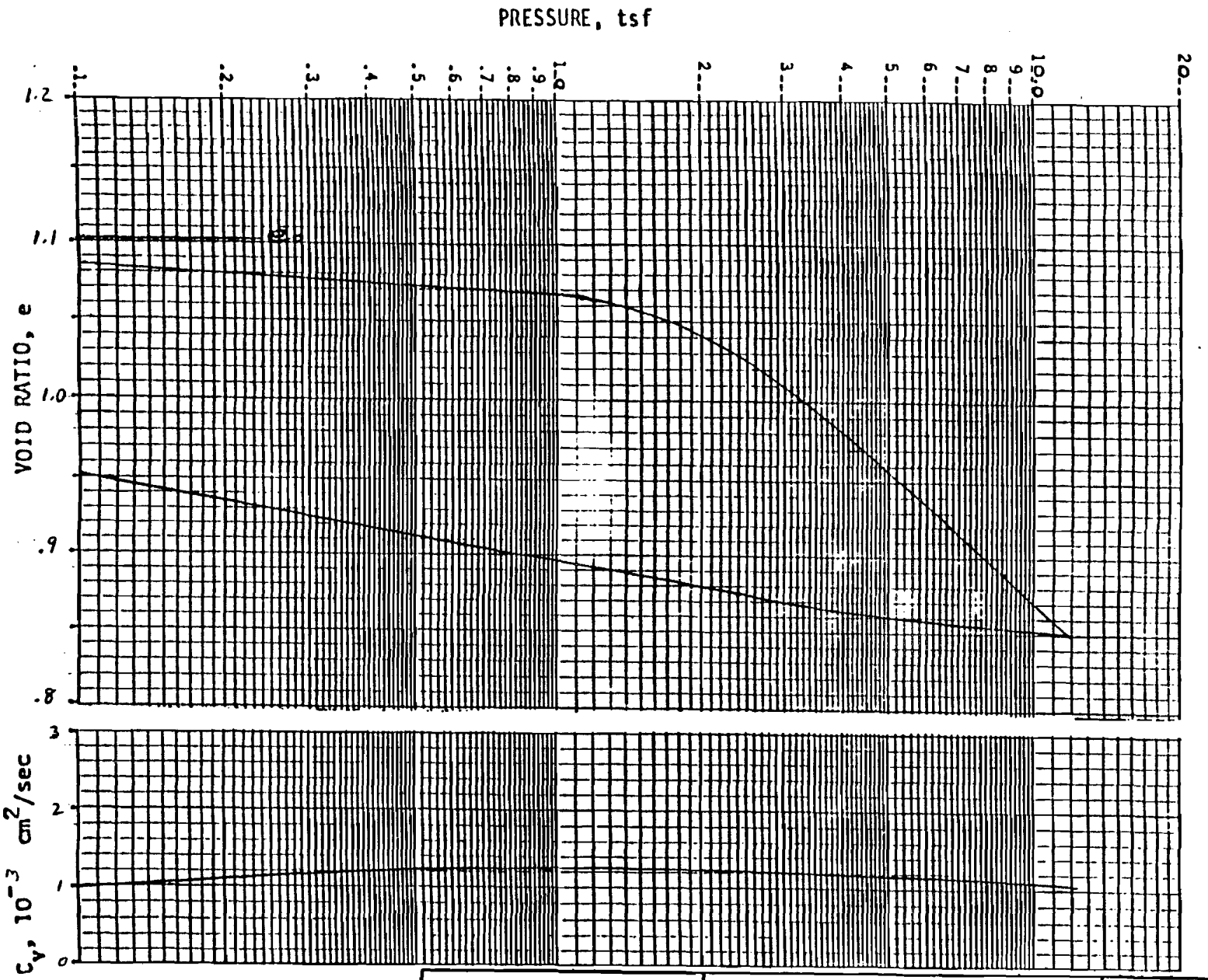
SOIL DESCRIPTION

red clay

P_o = 1.77 tsf

k = 2.4×10^{-6} cm/sec

GEOTEK ENGINEERING COMPANY	Date:	CONSOLIDATION TEST RESULTS
	Project: K-21	
	Fig. 21	Drawing No. 41



BORING SAN 9

DEPTH 20'-22'

LL 46 %

PI 14

W 38.0 %

e_0 1.101

γ_m 110.7 pcF

SOIL DESCRIPTION

red cherty clay

P_o = 1.16 tsf

k = 3.7×10^{-6} cm/sec

GEOTEK ENGINEERING COMPANY

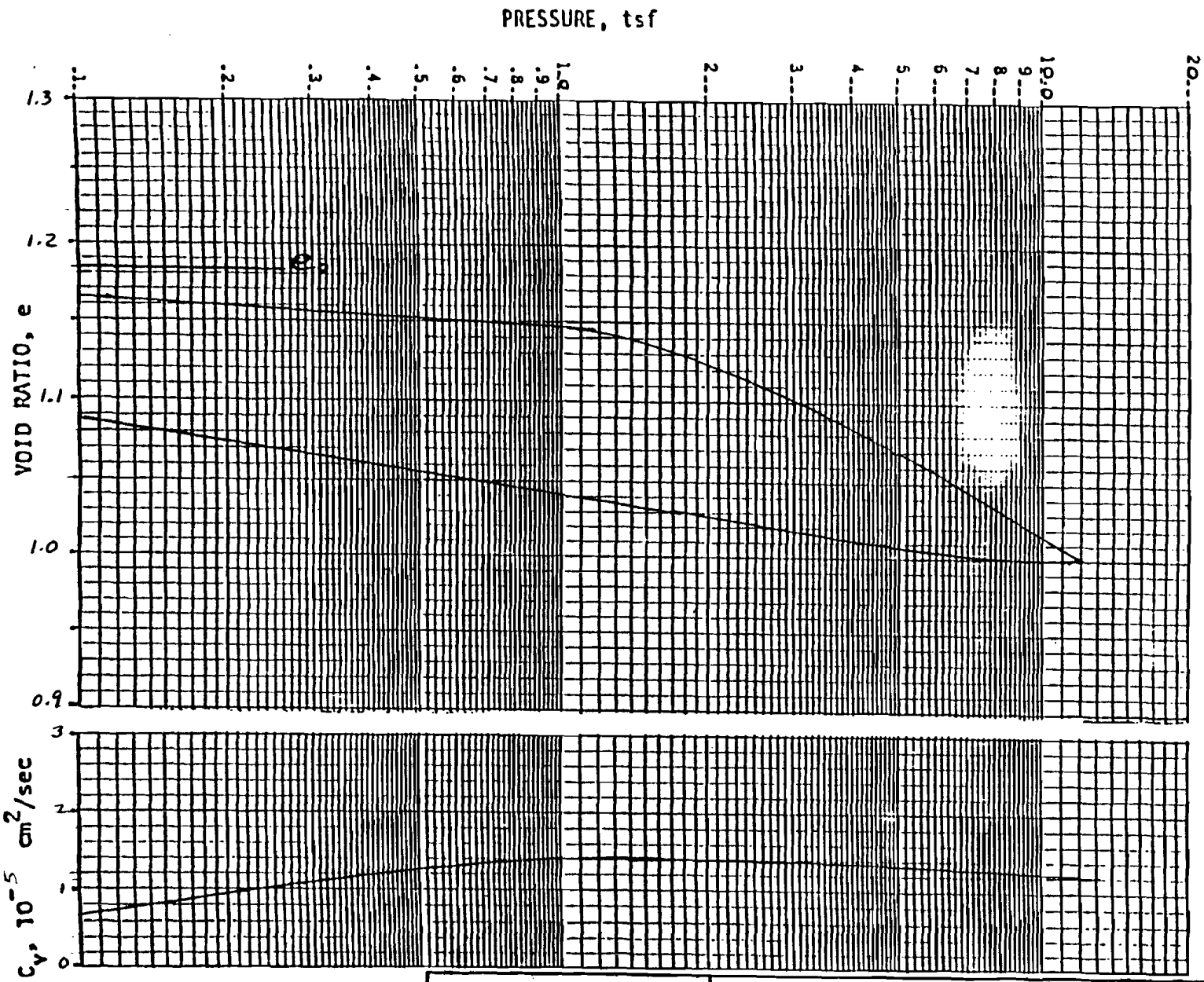
Date:

Project: K-21

Fig. 22

CONSOLIDATION TEST RESULTS

Drawing No. 42



BORING SAN 10

DEPTH 10'-12'

LL 79 %

PI 39

W 43.7 %

e_o 1.183

γ_m 111.8 pcf

SOIL DESCRIPTION

red cherty clay

P_o = .615 tsf

k = 1.3×10^{-7} cm/sec

GEOTEK ENGINEERING COMPANY

Date:

Project: K-21

Fig. 23

CONSOLIDATION TEST RESULTS

Drawing No. 43

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-1 Date 11/21/80 Sheet 1 of 5
Type of Boring 8"auger Rig Mobile B50
Casing used _____ Size ____ Drilling mud used _____
Boring begun 11/21 Boring completed 12/1/80
Ground Elevation _____ referred to _____ Datum
Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										0		
										1		
										2		
										3		
										4		
						S	SAN 105			5–7		
												Red cherty clay
										8		
										9		
										10		
										11		
										12		
										13		
										14		
						S	SAN 115			15–17		
										18		
										19		
										20		

* N = Standard Penetration, S = Shelby Tube

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ENGINEERING COMPANY

Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.

Project LL HAZ Site II

Location of Boring:

Water Level	
Time	
Date	

Boring No. SAN-1 Date 11/21/80 Sheet 1 of 5

Type of Boring 8" auger Rig Mobile B50

Casing used _____ Size _____ Drilling mud used _____

Boring begun 11/21 Boring completed 12/1/80

Ground Elevation _____ referred to _____ Datum

Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										0		
										1		
										2		
										3		
										4		
						S	SAN 105			5–7		
												Red cherty clay
										8		
										9		
										10		
										11		
										12		
										13		
										14		
						S	SAN 115			15–17		
										18		
										19		
										20		

* N = Standard Penetration, S = Shelby Tube

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-1 Date _____ Sheet 2 of 5
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____
_____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										20		
										21		Red clay, moist
										22		
										23		
										24		Clayey chert gravel
										25		
										26		
										27		
										28		
										29		
										30		
										31		Moist brownish red clay
										32		
										33		
										34		
										35		
										36		
										37		
										38		
										39		
										40		

* N = Standard Penetration, S = Shelby Tube

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GEOTEK
ENGINEERING COMPANY

Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-1 Date _____ Sheet 3 of 5
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____
_____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										40		
										41		
										42		
										43		
										44		
										45		
										46		
										47		
										48		
										49		
										50		Brownish red clay
										51		
										52		
										53		
										54		
										55		
										56		
										57		
										58		
										59		
										60		

* N = Standard Penetration, S = Shelby Tube

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GEOTEK
ENGINEERING COMPANY

Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-1 Date _____ Sheet 4 of 5
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____
_____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										60		
										61		
										62		Cherty red clay
										63		
										64		
										65		
										66		
										67		
										68		Moist brownish red clay
										69		
										70		
										71		
										72		
										73		
										74		
										75		
										76		
										77		
										78		
										79		
										80		

* N = Standard Penetration, S = Shelby Tube

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-1 Date _____ Sheet 5 of 5
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min	% Drill Water Return	R Q D %	Sample Type*	Sample No	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										60		
										61		Chert and red clay
										62		
										63		
										64		
										65		
										66		
										67		
										68		
										69		
										70		
										71		
										72		Hard and broken chert
										73		Soft yellow-brown clay
										74		
										75		
										76		Chert gravel
										77		Weathered limestone
										78		End of boring at 98'0"
										79		Set 100' of 2" PVC to 98' depth, 20' perforated, 98'gravel filled, 2' stick-up
										100		

* N = Standard Penetration, S = Shelby Tube

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ENGINEERING COMPANY

Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-2 Date 12/1/80 Sheet 1 of 3
Type of Boring Auger Rig Mobile B50
Casing used ____ Size ____ Drilling mud used ____
Boring begun 12/1 Boring completed 12/4/80
Ground Elevation ____ referred to ____
____ Datum
Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft	Recovery Ft	% Recovery	Drilling Time, min	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										0		
						N	S201.5	2				
								7		1		Red cherty clay
								9	16	2		
										3		
										4		Hard chert gravel
										5		
						S	S205.0			6		Red cherty clay
										7		
										8		
										9		
										10		
						N	S210.0	10				
								8		11		
								14	22			
										12		
										13		
										14		
										15		
						N	S215.0	6				
								9		16		
								12				
								16	28	17		
										18		
										19		Moist brownish red clay
										20		

* N = Standard Penetration, S = Shelby Tube

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-2 Date _____ Sheet 2 of 3
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft	Recovery Ft	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S220.0	9		20		
								9				
								12	21	21		Brownish red clay
										22		
										23		
										24		
										25		
						N	S225.0	9				
								9		26		
								12	21			
										27		
										28		
										29		
										30		
						N	S230.0	4				
								11		31		
								9	20			
										32		
										33		Chert gravel
										34		
										35		
						N	S235.0	12				
								9		36		
								13	22			
										37		Brown-red clay
										38		
										39		
										40		Hard chert

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-2 Date _____ Sheet 3 of 3
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____
_____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
								100+	100+	40		Refusal on spoon at 40'0"
										41		Roller bit to 43'0" in limestone
										42		
										43		End of boring at 43'0"
										44		
										45		Set observation well - 44' of 6" PVC, 5' perforated, 43' sand filled, 1' stick-up
										46		
										47		
										48		
										49		
										50		
										51		
										52		
										53		
										54		
										55		
										56		
										57		
										58		
										59		
										60		

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-3 Date 11/14/80 Sheet 1 of 3
Type of Boring Rollerbit Rig Joy 6727
Casing used ____ Size ____ Drilling mud used ____
Boring begun ____ Boring completed ____
Ground Elevation ____ referred to ____
____ Datum
Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										0		
										1		
										2		
										3		
										4		
						S	S305.0			5		Red cherty clay
										6		
										7		
										8		
										9		
										10		
										11		
										12		
										13		Pinkish red clay
										14		
										15		
										16		
										17		
										18		Chert gravel bed, top of weathered rock
										19		Chert very hard below 18'0"
										20		

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-3 Date _____ Sheet 2 of 3
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										20		
										21		Gravel bed
										22		
										23		
										24		
										25		Red cherty clay
										26		
										27		
										28		
										29		
										30		
										31		
										32		
										33		
										34		
										35		
										36		Solid chert
										37		
										38		
										39		
										40		

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Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-3 Date _____ Sheet 3 of 3
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____
_____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
										40		
										41		
										42		Solid chert
										43		
										44		
										45		
										46		
										47		
										48		Medium hard red clay & chert
										49		
										50		
										51		
										52		Soft red clay
										53		
										54		
										55		Limestone or dolomite
										56		
										57		End of boring at 57'0"
										58		Set 57½' of 6" PVC to 57' depth, 20' perforated, 57' sand filled, 1/2' stick-up
										59		
										60		

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-4 Date 12/4/80 Sheet 1 of 2
Type of Boring 8"auger Rig Mobile B50
Casing used ____ Size ____ Drilling mud used ____
Boring begun 12/4 Boring completed 12/5/80
Ground Elevation ____ referred to ____ Datum
Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S400.0	4		0		
								7		1		
								6	13			
										2		
										3		
										4		
										5		
						N	S405.0	8				
								14		6		
								18	32			
										7		Red cherty clay
										8		
										9		
										10		
						N	S410.0	4				
								10		11		
								14	24			
										12		
										13		
										14		
										15		
						S	S415.0			16		
										17		
										18		
										19		
										20		

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Log Of Boring

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Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-4 Date _____ Sheet 2 of 2
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft	Recovery Ft	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S420.0	1		20		
								11		21		
								16	27			Red cherty clay
										22		
										23		
										24		
										25		Red moist clay
						N	S425.0	10				
								17	27	26		
								50+				
										27		Water in sandy clay with hard chert
										28		
										29		
										30		
						N	S430.0	4				
								9		31		
								8	17			Brownish moist red clay
										32		
										33		
										34		
										35		Auger refusal and end of boring at 35'0"
										36		
										37		Set observation well - 38.2' of 6" PVC set to 35' depth, 4' perforated 35' sand filled, 1.2' stick-up
										38		
										39		
										40		

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-5 Date 12/5/80 Sheet 1 of 2
Type of Boring Auger Rig Mobile B50
Casing used ____ Size ____ Drilling mud used ____
Boring begun 12/5 Boring completed 12/5/80
Ground Elevation ____ referred to ____ Datum
Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S500.0	5		0		
								6		1		
								7	13			
										2		
										3		
										4		
										5		
						N	S505.0	5				
								5		6		
								9	14			
										7		Red silty clay
										8		
										9		
										10		
						S	S510.0			11		
										12		
										13		
										14		
										15		
						N	S515.0					
										16		
										17		
										18		
										19		
										20		

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Job No. 79-687-X

Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-5 Date _____ Sheet 2 of 2
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S520.0	3		20		
								7		21		
								10	17			
										22		Moist brownish red clay
										23		
										24		
										25		
						N	S525.0	3				
								4		26		
								5	9			
										27		
										28		
										29		
												Chert gravel
										30		
						N	S530.0	3				
								3				
								7	10	31		Soft red clay
										32		
										33		Top of limestone at 34'0"
												End of boring at 34'0"
										34		
												Set observation well - 36' of 6"
										35		PVC, 4' perforated, 34' sand filled
										36		2' stick-up
										37		
										38		
										39		
										40		

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-6 Date 12/8/80 Sheet 1 of 3
Type of Boring Auger Rig Mobile B50
Casing used ____ Size ____ Drilling mud used ____
Boring begun 12/8 Boring completed 12/10/80
Ground Elevation ____ referred to ____ Datum
Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S600.0	6		0		
								5		1		
								5	10			
										2		Hard below 2'0"
										3		
										4		
										5		
						N	S605.0	7				
								12		6		
								19	31			Red silty clay
										7		
										8		
										9		
										10		
						N	S610.0	4				
								7		11		
								12	19			
										12		
										13		
										14		
										15		
						S	S615.0					Red cherty clay
										16		
										17		
										18		
										19		
										20		

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-6 Date _____ Sheet 2 of 3
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S620.0	3		20		
								5		21		
								7	12			
										22		
										23		
										24		
										25		
						N	S625.0	4				
								4		26		
								6	10			Moist red silty clay
										27		
										28		
										29		
										30		
						N	S630.0	3				
								4		31		
								5	9			
										32		
										33		
										34		
										35		
						N	S635.0	3				
								3		36		Yellow sand & clay water zone
								5	8			
										37		Red clay
										38		
										39		
										40		

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Boring No. SAN-6 Date _____ Sheet 3 of 3
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____
_____ Datum
Field Party: _____

Location of Boring:	
Water Level	
Time	
Date	

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S640.0	2		40		
								3				
								10	13	41		Sandy red clay
										42		Auger refusal and End of boring at 42'0"
										43		
										44		Set observation well - set 45.5' of 6" PVC, 4' perforated, 42' sand filled, 2.5' stick-up
										45		
										46		
										47		
										48		
										49		
										50		
										51		
										52		
										53		
										54		
										55		
										56		
										57		
										58		
										59		
										60		

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Log Of Boring

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Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	40
Time	4 pm
Date	12/15/80

Boring No. SAN-7 Date 12/10/80 Sheet 1 of 3
Type of Boring Auger Rig Mobile B50
Casing used ____ Size ____ Drilling mud used ____
Boring begun 12/10 Boring completed 12/15/80
Ground Elevation ____ referred to ____
____ Datum
Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S700.0	4		0		
								3		1		Yellow silty clay
								4	7			
										2		
										3		
										4		
										5		Red cherty clay
						S	S705.0			6		
										7		
										8		
										9		
										10		
						N	S710.0	7				
								12		11		
								24	36			
										12		
										13		
										14		
										15		
						N	S715.0	6				
								10		16		
								13	23			
										17		
										18		
										19		
										20		

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Log Of Boring

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Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-7 Date _____ Sheet 2 of 3
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____
_____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S720.0	3		20		
								8				
								15	23	21		
										22		
										23		
										24		
										25		
						N	S725.0	3				
								4		26		
								8	12			
										27		
										28		Moist red cherty clay
										29		
										30		
						N	S730.0	5				
								7		31		
								11	18			
										32		
										33		
										34		
										35		
						N	S735.0	4				
								6		36		
								7	13			
										37		
										38		
										39		
										40		

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Client Union Carbide Corporation
Project LL HAZ Site II

Boring No. SAN-7 Date _____ Sheet 3 of 3
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____
_____ Datum
Field Party: _____

Location of Boring:	
Water Level	
Time	
Date	

Rock Data: Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Soil Data: Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S740.0	4		40		
								7		41		
								8	15			Brown, yellow to red sandy clay
										42		water zone
										43		
										44		
										45		
						N	S745.0	4				
								14		46		
								19	33			
										47		
										48		Brownish red cherty clay
										49		
										50		
						N	S750.0	3				
								3		51		
								5	8			Soft brownish red clay
										52		
										53		
										54		
										55		
						N	S755.0	2				
								3		56		
								5	8			
										57		
										58		
										59		Auger refusal and end of boring at 59'6" - Set observation well, set
										60		63' of 6" PVC to 59.5' depth, 4' perforated, 59.5 sand filled, 3.5' stick-up

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-8 Date 12/15/80 Sheet 1 of 2
Type of Boring 8"auger Rig Mobile B50
Casing used _____ Size _____ Drilling mud used _____
Boring begun 12/15 Boring completed 12/16/80
Ground Elevation _____ referred to _____ Datum
Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S800.0	3		0		
								3				
								3	6	1		Red cherty clay
										2		
										3		
										4		
										5		
						N	S805.0	5				
								14		6		
								23	37			
										7		
										8		
										9		
										10		
						S	S810.0					Shelby refused at 6" - no recovery
						N	S810.5	11		11		
								18				
								22	40	12		
										13		
										14		
										15		
						N	S815.0	3				
								24		16		
								28	52			
										17		
										18		
										19		Hard clayey chert
										20		

* N = Standard Penetration, S = Shelby Tube

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GEOTEK
ENGINEERING COMPANY

Log Of Boring

Job No. 79-687-X

Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-8 Date _____ Sheet 2 of 2
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
								100+	100+	20		Hard clayey chert
										21		
										22		Sampler refused at 20'0"
										23		
										24		Moist red clay
										25		
						N	S825.0	4				
								6		26		
								8	14			
										27		
										28		
										29		
										30		
						S	S830.0			31		
										32		
										33		
										34		
										35		
						N	S835.0	4				
								5		36		
								5	10			
										37		
										38		Auger refusal and rock at 39'0" -
										39		End of boring at 39'0"
												Set 42' of 6" PVC to 39' depth, 4'
										40		perforated, 39' sand filled, 3'
												stick-up

* N = Standard Penetration, S = Shelby Tube

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-9 Date 12/16/80 Sheet 1 of 2
Type of Boring Auger Rig Mobile B50
Casing used ____ Size ____ Drilling mud used ____
Boring begun 12/16 Boring completed 12/16/80
Ground Elevation ____ referred to ____ Datum
Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S900.0	2		0		
								6				
								8	14	1		
										2		
										3		Red cherty clay
										4		
										5		
						N	S905.0	6				
								11		6		
								15	26			
										7		
										8		
										9		
										10		
						N	S910.0	6				
								8		11		
								11	19			Reddish brown clay
										12		
										13		
										14		
										15		
						N	S915.0	6				
								8		16		
								10	18			Red cherty clay
										17		
										18		
										19		
										20		

* N = Standard Penetration, S = Shelby Tube

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-9 Date 12/16/80 Sheet 2 of 2
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____
_____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						S	S920.0			20		
										21		
										22		Red cherty clay
										23		
										24		
										25		
						N	S925.0	2				
								5		26		
								6	11			
										27		
										28		
										29		
										30		
						N	S930.0	2				
								5		31		
								7	12			Red clay with traces of chert
										32		
										33		
										34		
										35		
						N	S935.0	3				
								5		36		
								7	12			
										37		Auger refusal and
										38		End of boring at 38'6"
										39		Observation well - set 41.5' of 6" PVC to 38.5' depth, 4' perforated, 38.5' sand filled, 3' stick-up
										40		

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-10 Date 12/17/80 Sheet 1 of 3
Type of Boring 8"auger Rig Mobile B50
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____ Datum
Field Party: RM & Randy Collins

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S1000.0	2		0		Topsoil
								3				
								5	8	1		
										2		
										3		Red clay with traces of chert
										4		
										5		
						N	S1005.0	3				
								15		6		
								17	32			
										7		
										8		
										9		
										10		
						S	S1010.0			11		
										12		
										13		
										14		
										15		
						N	S1015.0	3				
								5		16		
								8	13			
										17		
										18		
										19		
										20		

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corp.
Project LL HAZ Site II

Boring No. SAN-10 Date _____ Sheet 2 of 3
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____ Datum
Field Party: _____

Location of Boring:	
Water Level	
Time	
Date	

Rock Data: Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	RQD %	Soil Data: Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S1020.0	3		20		
								5				
								7	12	21		
										22		
										23		Red clay with traces of chert
										24		
										25		
						N	S1025.0	3				
								6		26		
								9	15			
										27		
										28		
										29		
										30		
						N	S1030.0	6				
								8		31		
								11	19			
										32		
										33		
										34		
										35		
						N	S1035.0	3				
								5		36		
								9	14			
										37		
										38		
										39		Clayey chert
										40		

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Log Of Boring

Job No. 79-687-X

Client Union Carbide Corporation
Project LL HAZ Site II

Location of Boring:	
Water Level	
Time	
Date	

Boring No. SAN-10 Date _____ Sheet 3 of 3
Type of Boring _____ Rig _____
Casing used _____ Size _____ Drilling mud used _____
Boring begun _____ Boring completed _____
Ground Elevation _____ referred to _____ Datum
Field Party: _____

Rock Data						Soil Data						
Length cored Ft.	Recovery Ft.	% Recovery	Drilling Time, min.	% Drill Water Return	R Q D %	Sample Type*	Sample No.	Blows per 6" Drive	N-Value	DEPTH IN FEET	GRAPH	Description of soil or rock & notes on drilling operation
						N	S1040.0	2		40		
								2				
								4	6	41		Reddish brown clay
										42		
										43		
										44		
										45		
						N	S1045.0	2				Soft
								2		46		
								3	5			
										47		
										48		
										49		
										50		
										51		Red clay with traces of sand and gravel
						N	S1051.0	3				
								2		52		
								0	2			
										53		Cavity 52'3" to 53'0"
												End of boring and refusal at 53'0"
										54		
										55		
										56		
										57		Set observation well, 55' of 6" pvc
										58		set to 53'depth, 4' perforated, 53' sand filled, 2' stick up
										59		
										60		

* N = Standard Penetration, S = Shelby Tube

APPENDIX K

WEST CHESTNUT RIDGE WELL HYDROGRAPHS

R. H. Ketelle

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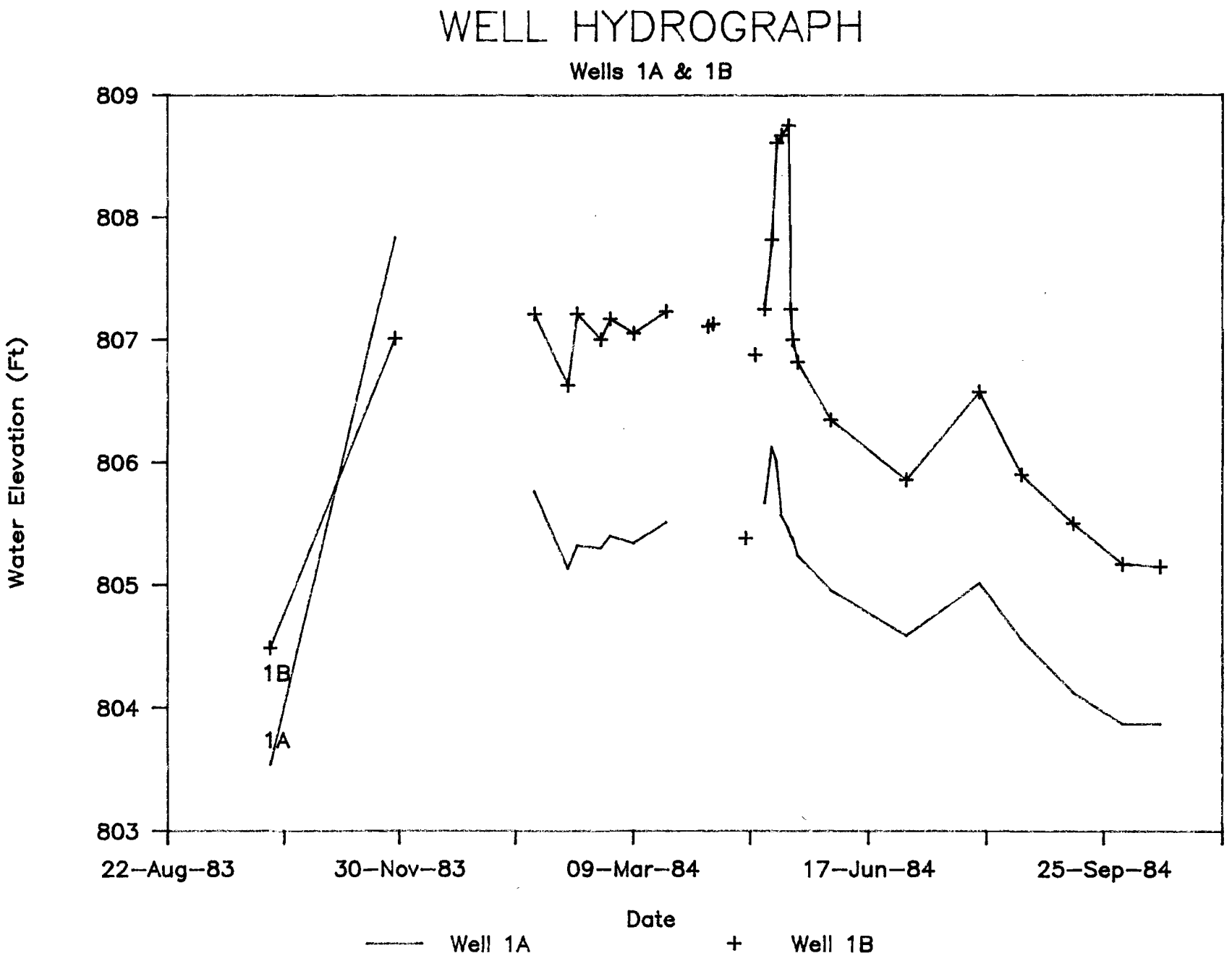
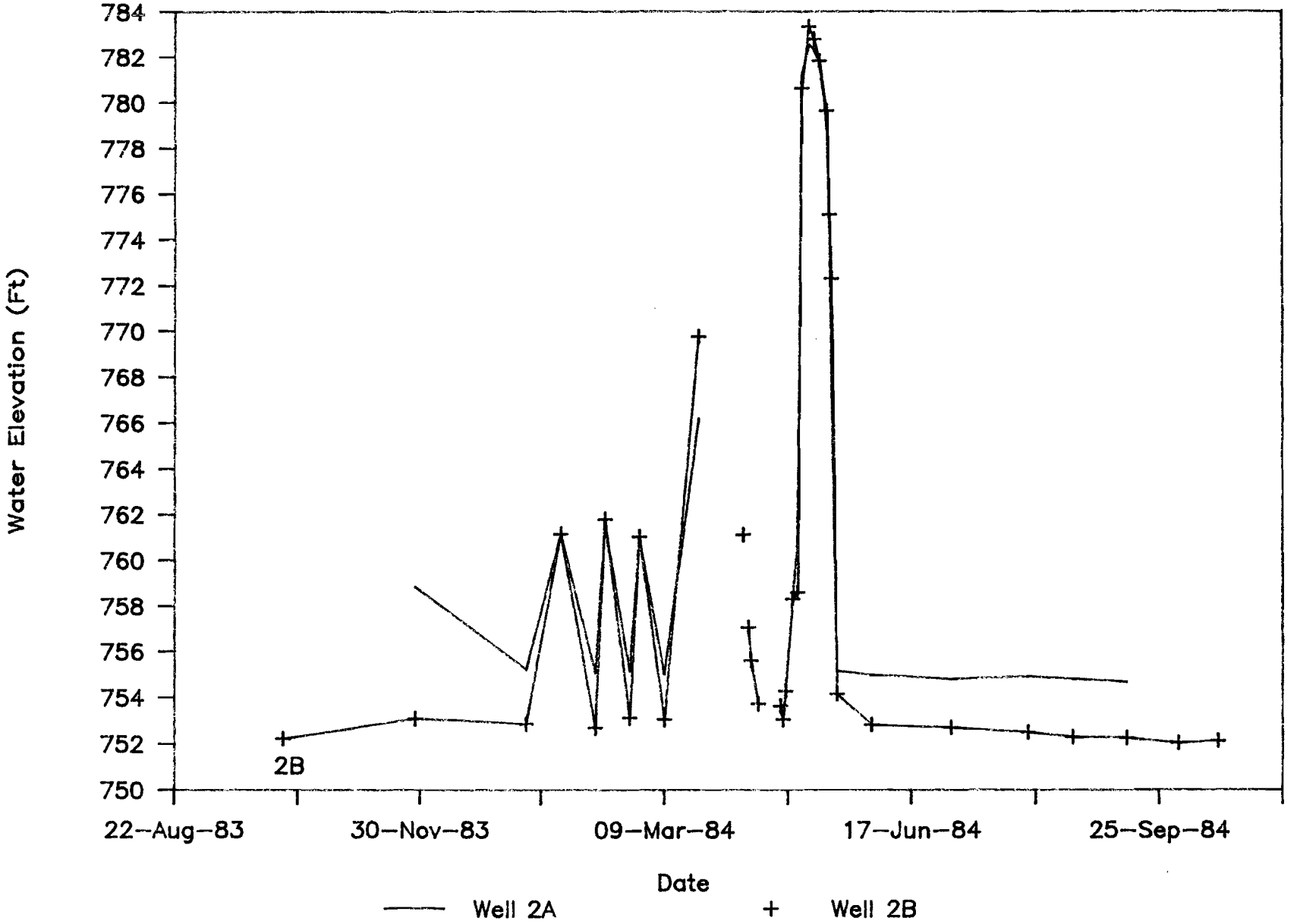
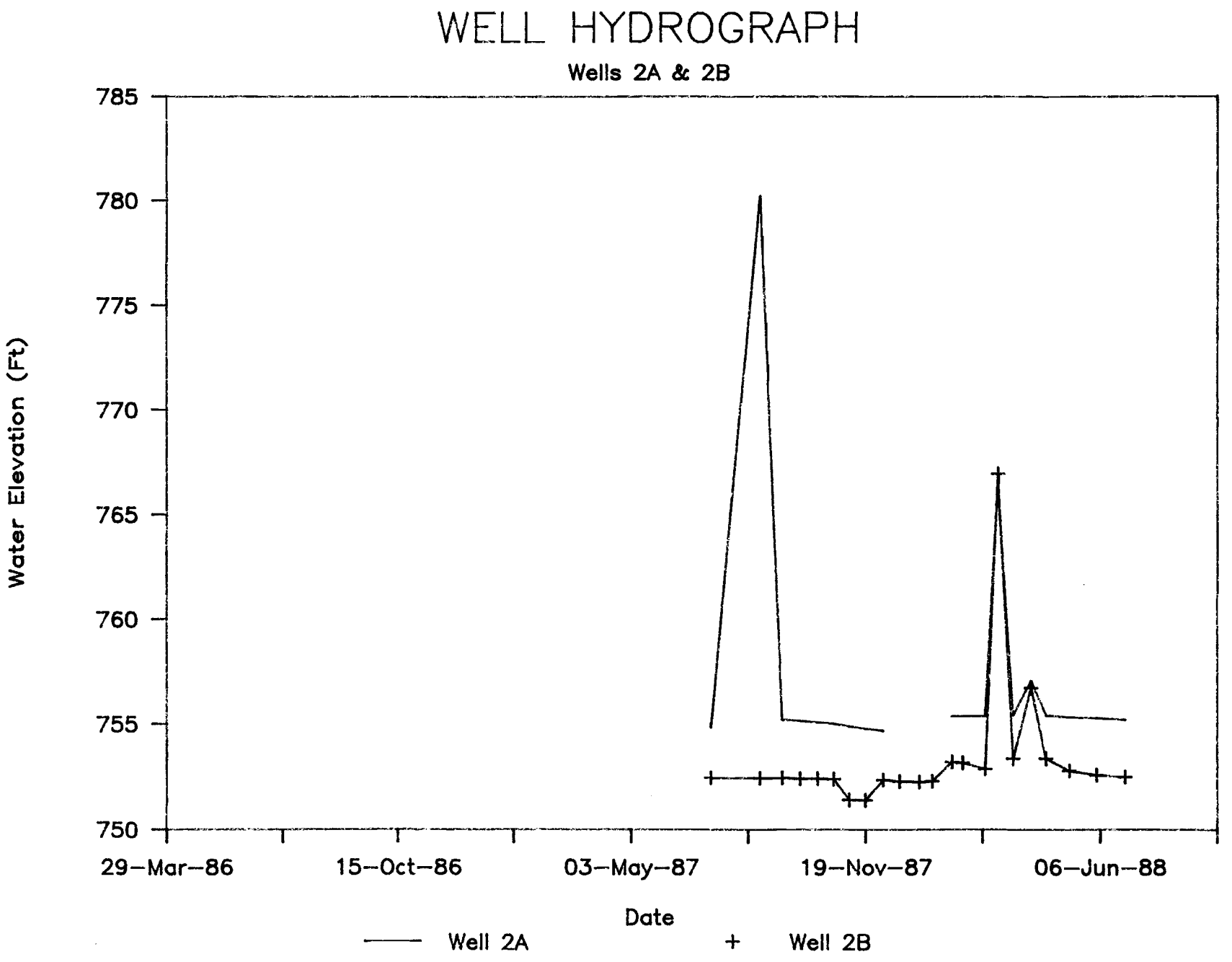
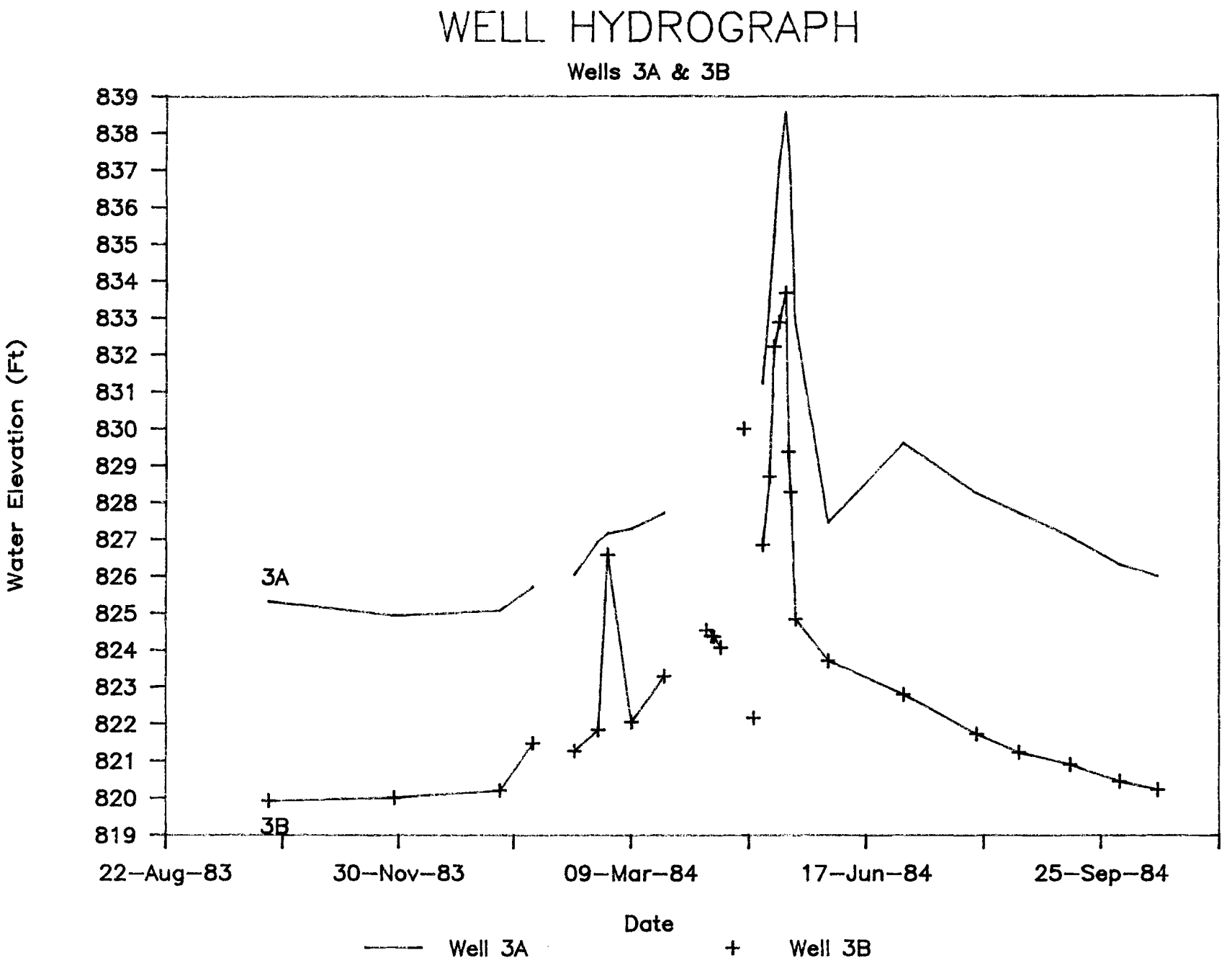

WELL HYDROGRAPH
Wells 1A & 1B
809
808
807
806
805
804
803
Water Elevation (Ft)
1B
1A
22-Aug-83
30-Nov-83
09-Mar-84
17-Jun-84
25-Sep-84
Date
Well 1A
Well 1B

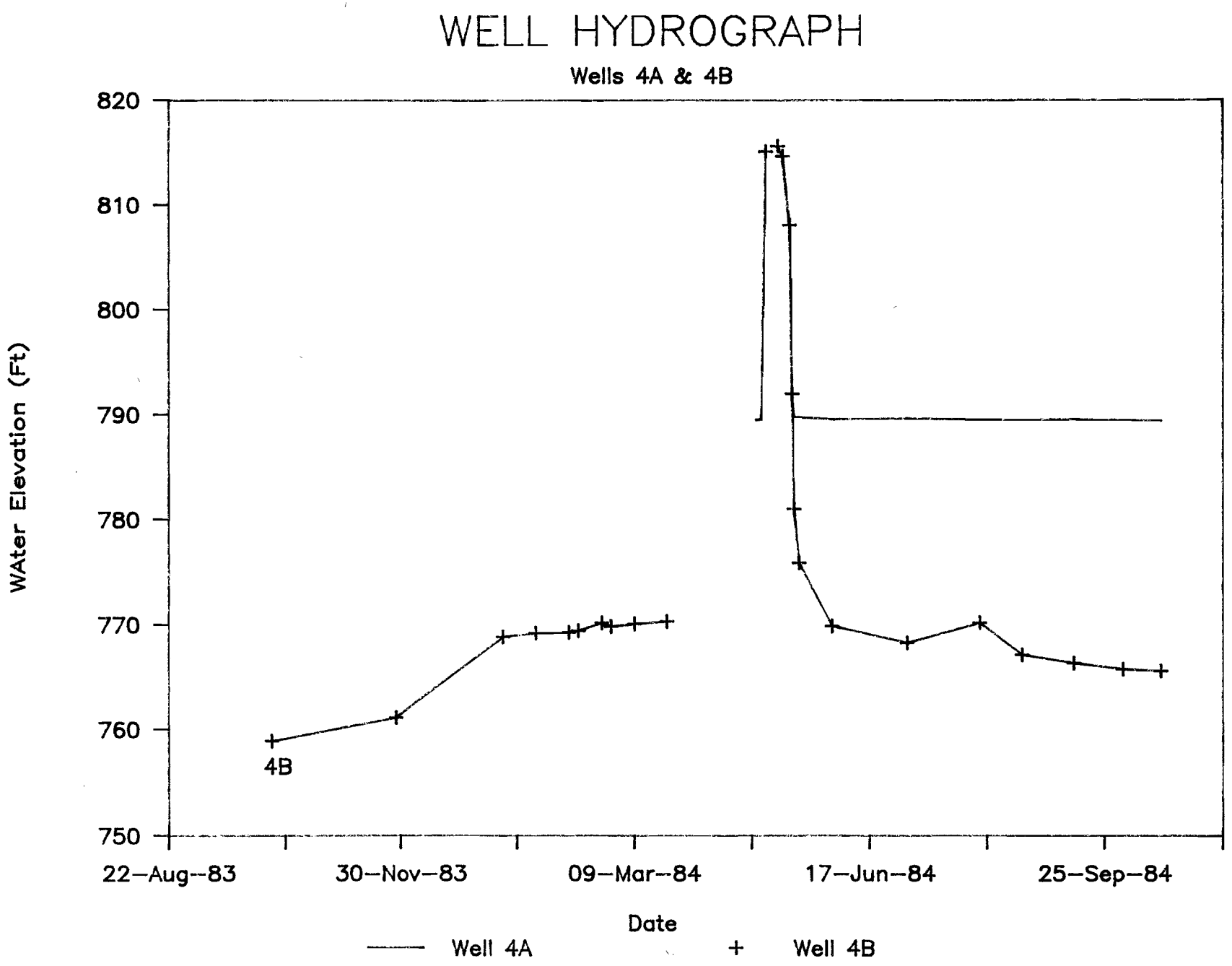
WELL HYDROGRAPH

Wells 2A & 2B



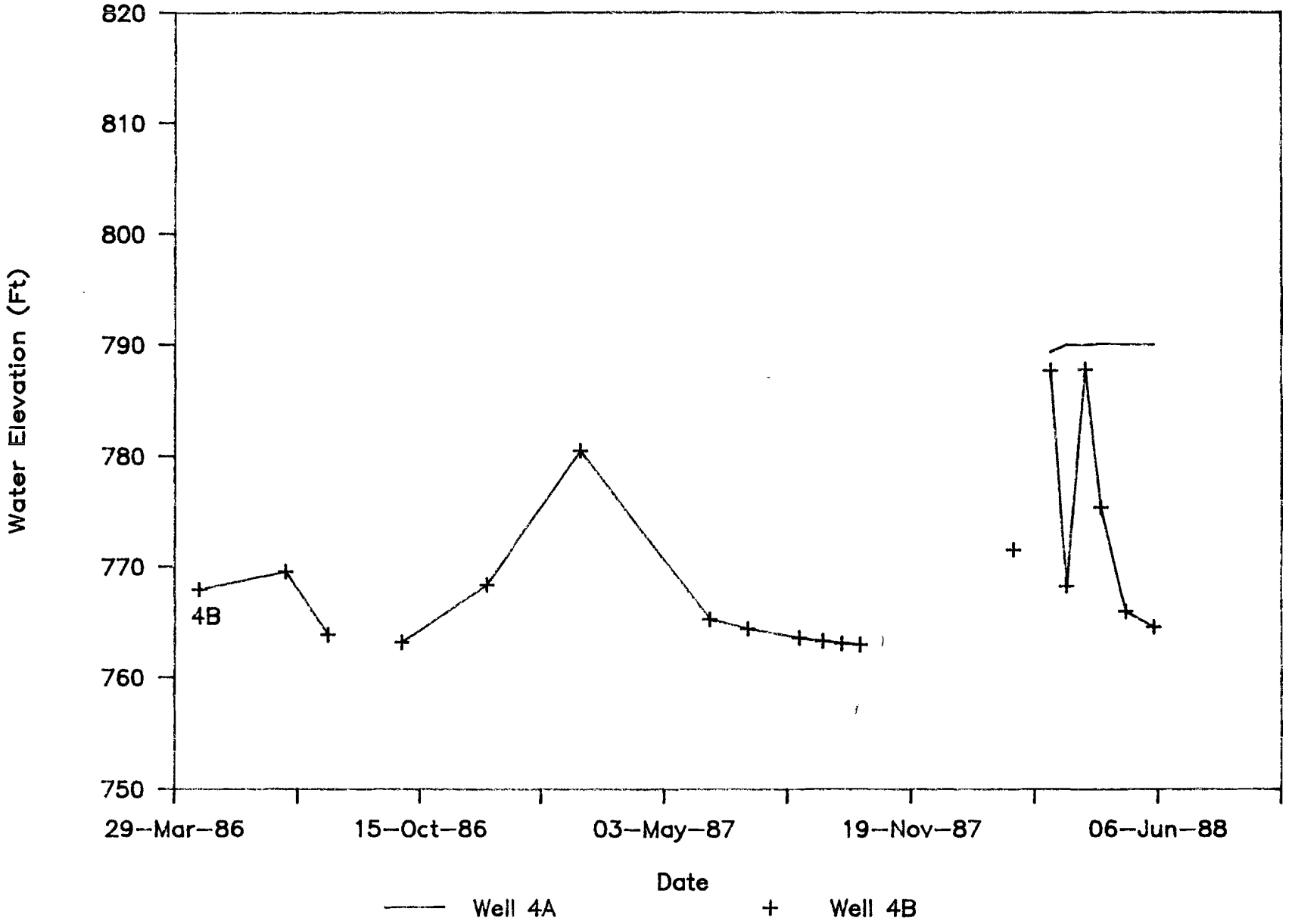

WELL HYDROGRAPH
Wells 2A & 2B
785
780
775
770
765
760
755
750
Water Elevation (Ft)
29-Mar-86
15-Oct-86
03-May-87
19-Nov-87
06-Jun-88
Date
Well 2A
Well 2B


WELL HYDROGRAPH
Wells 3A & 3B
Water Elevation (Ft)
839
838
837
836
835
834
833
832
831
830
829
828
827
826
825
824
823
822
821
820
819
3A
3B
22-Aug-83
30-Nov-83
09-Mar-84
17-Jun-84
25-Sep-84
Date
Well 3A
Well 3B


WELL HYDROGRAPH
Wells 4A & 4B
820
810
800
790
780
770
760
750
WAter Elevation (Ft)
4B
22–Aug–83
30–Nov–83
09–Mar–84
17–Jun–84
25–Sep–84
Date
Well 4A
Well 4B

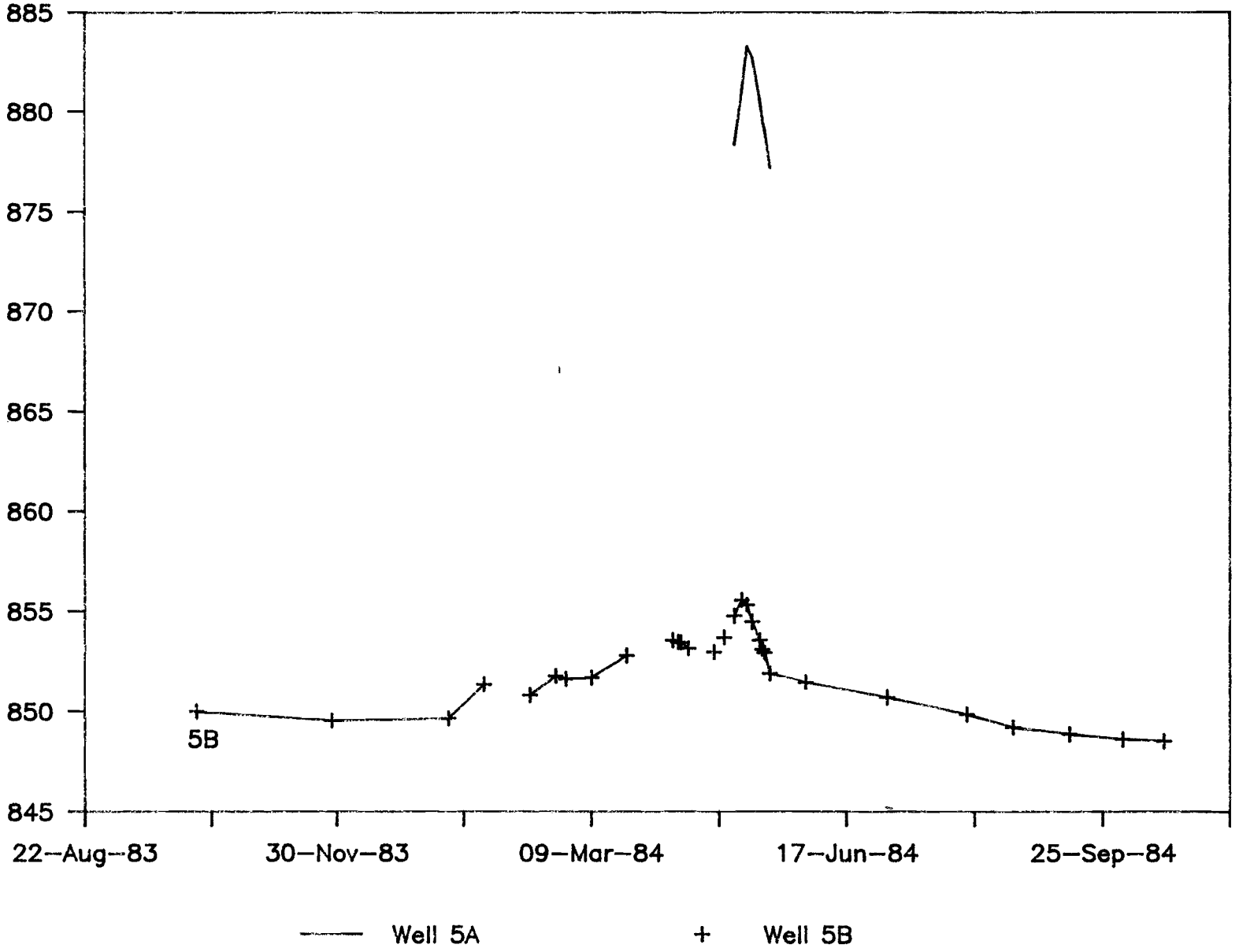
WELL HYDROGRAPH

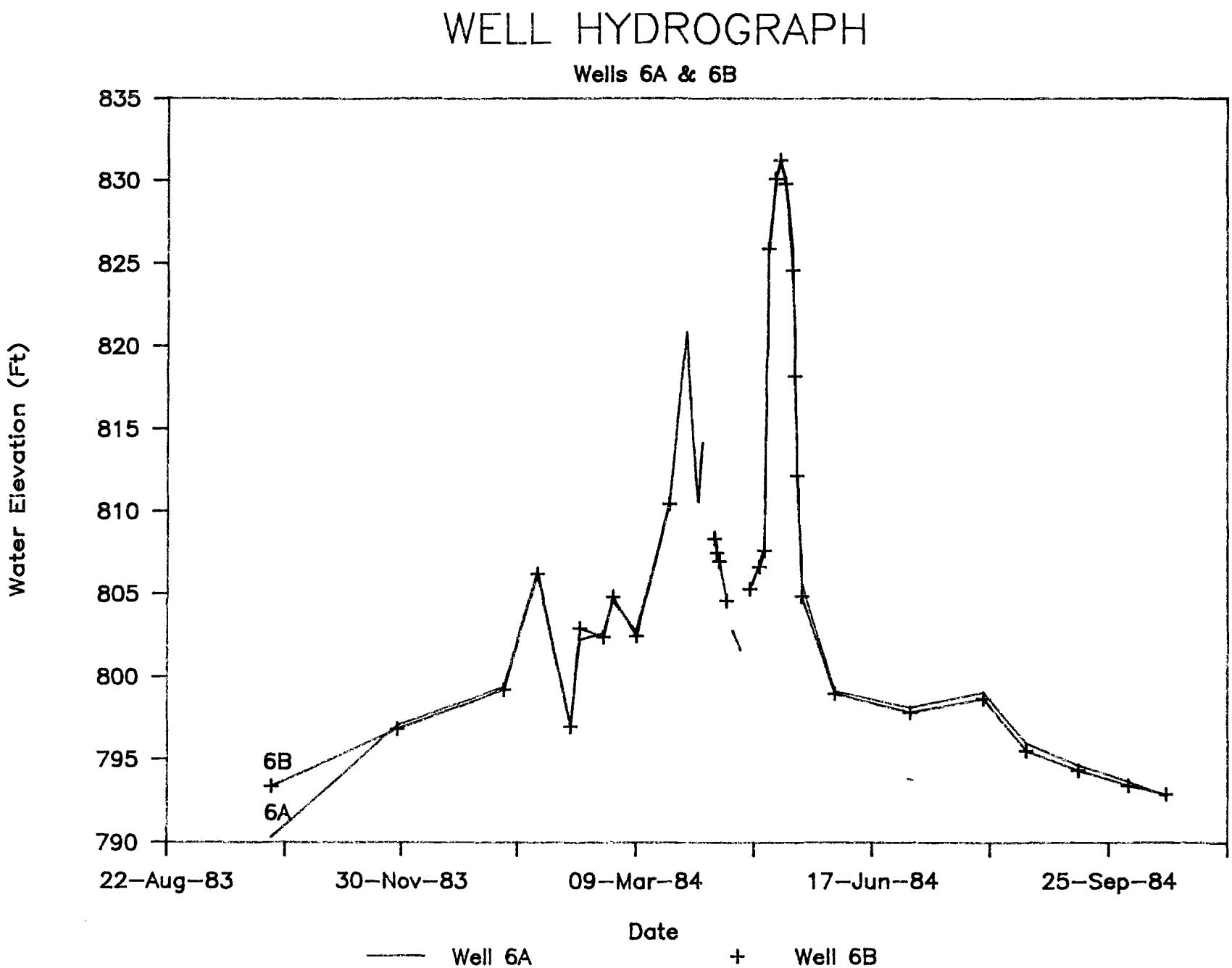
Wells 4A & 4B

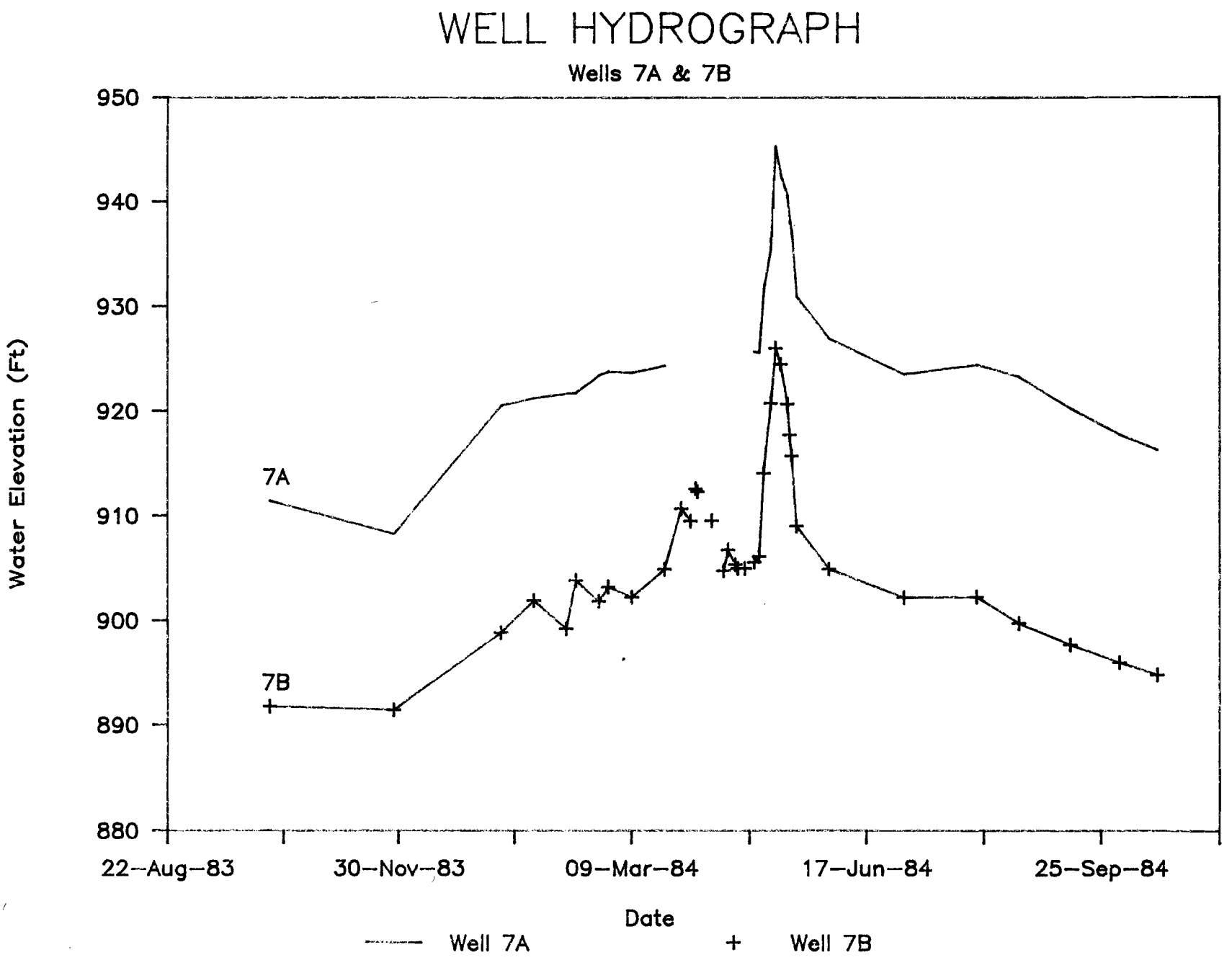


WELL HYDROGRAPH

Wells 5A & 5B

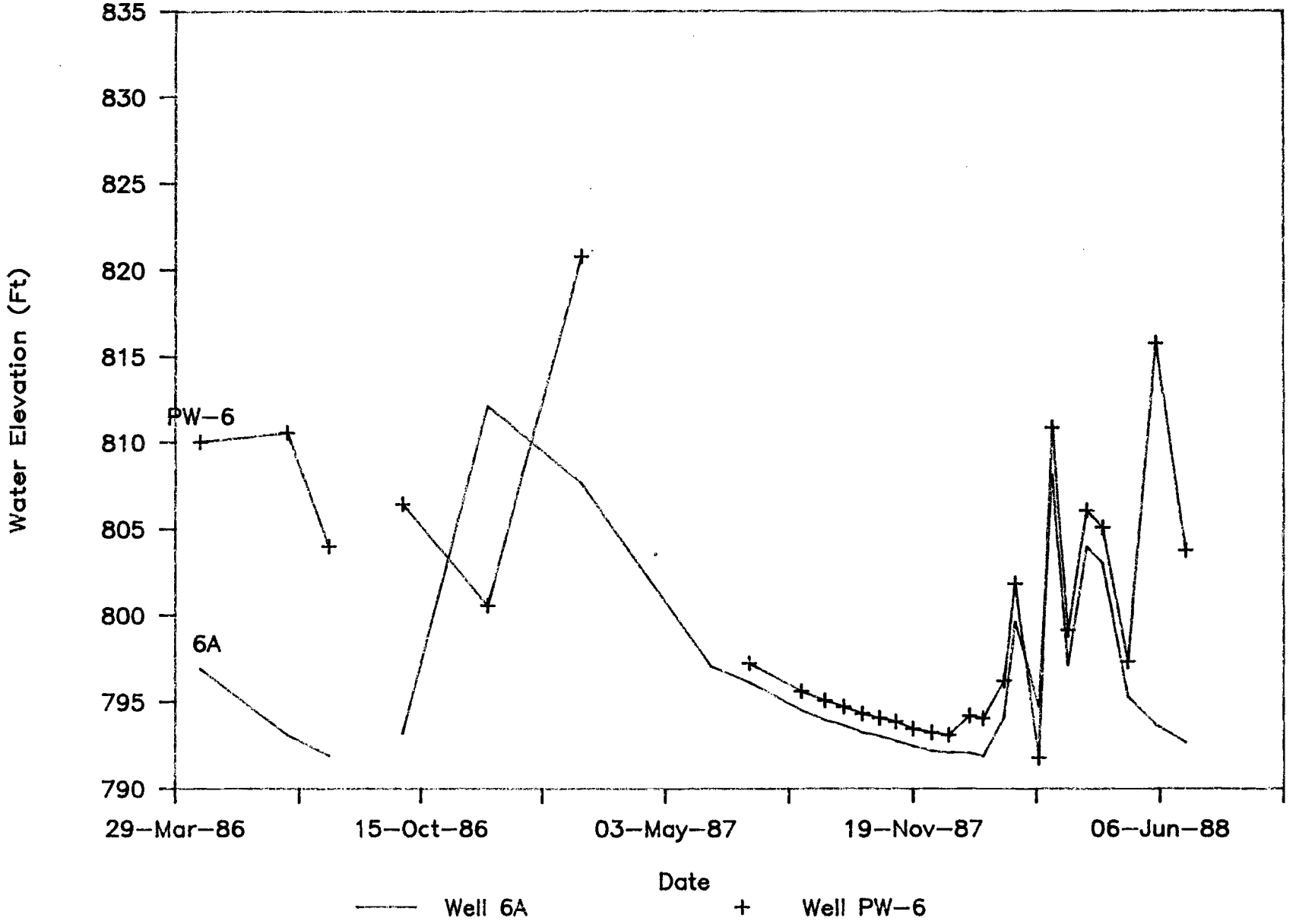


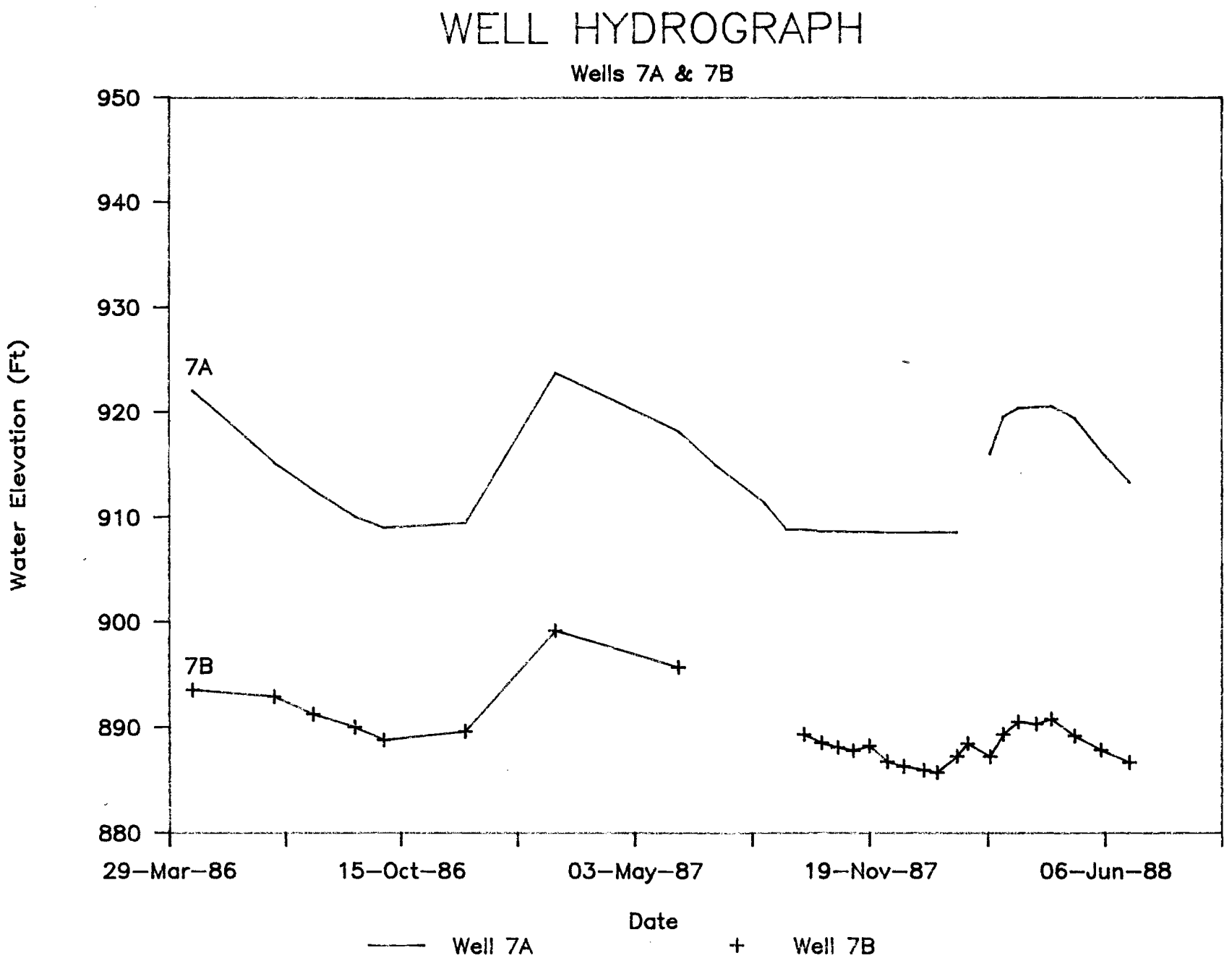

WELL HYDROGRAPH
Wells 6A & 6B
Water Elevation (Ft)
835
830
825
820
815
810
805
800
795
790
6B
6A
22-Aug-83
30-Nov-83
09-Mar-84
17-Jun-84
25-Sep-84
Date
Well 6A
Well 6B

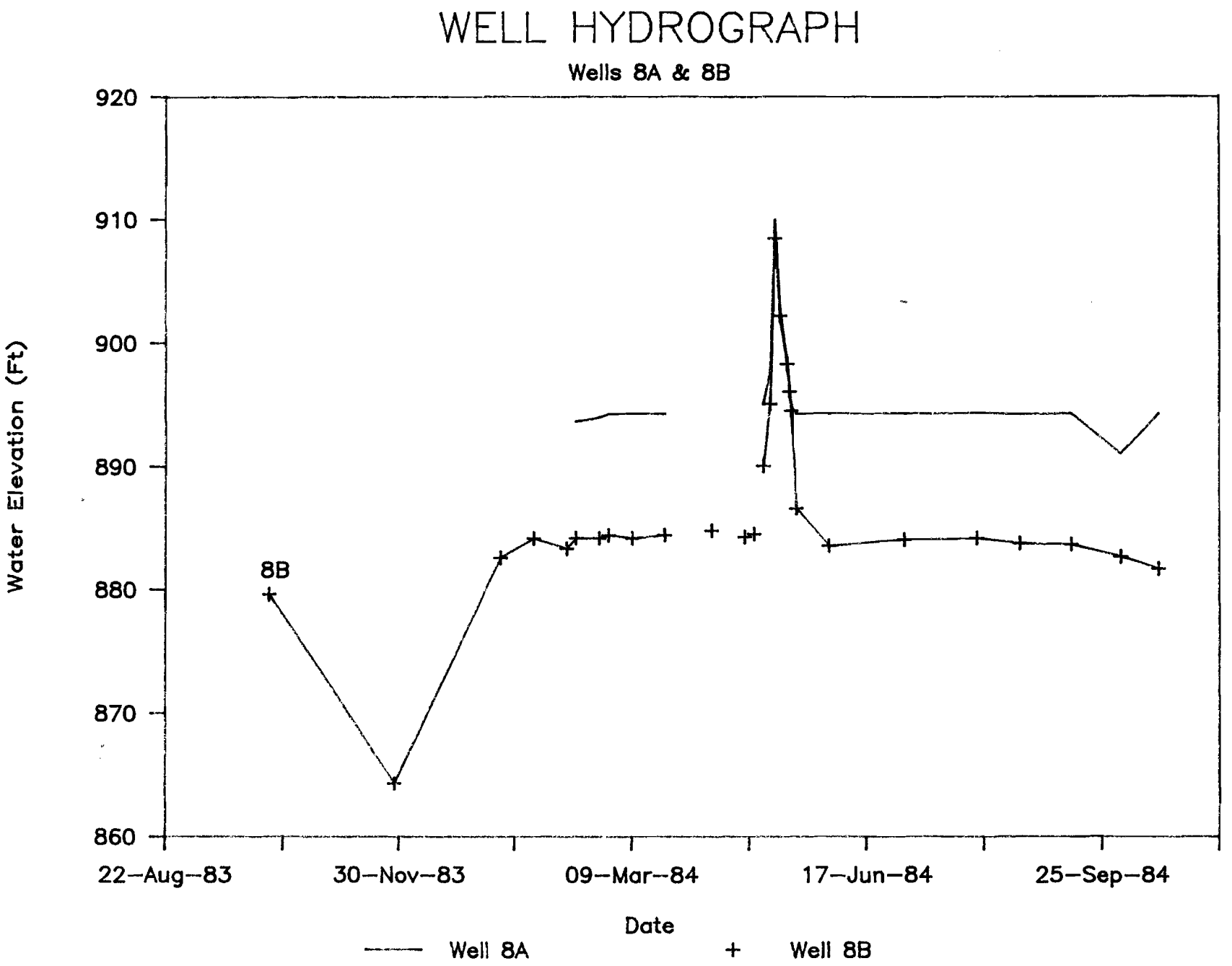

WELL HYDROGRAPH
Wells 7A & 7B
950
940
930
920
910
900
890
880
Water Elevation (Ft)
7A
7B
22-Aug-83
30-Nov-83
09-Mar-84
17-Jun-84
25-Sep-84
Date
Well 7A
Well 7B

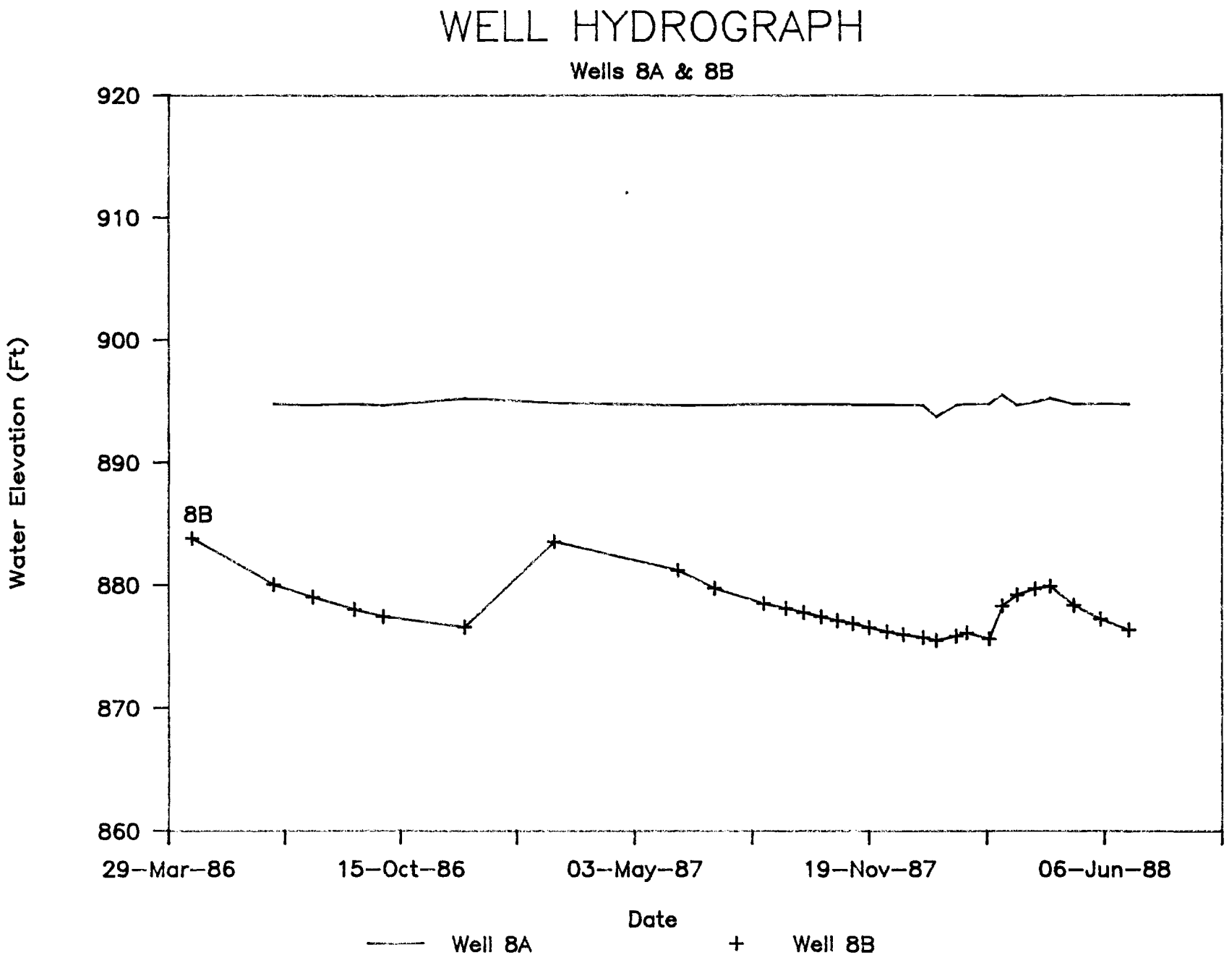
WELL HYDROGRAPH

Wells 6A & PW-6



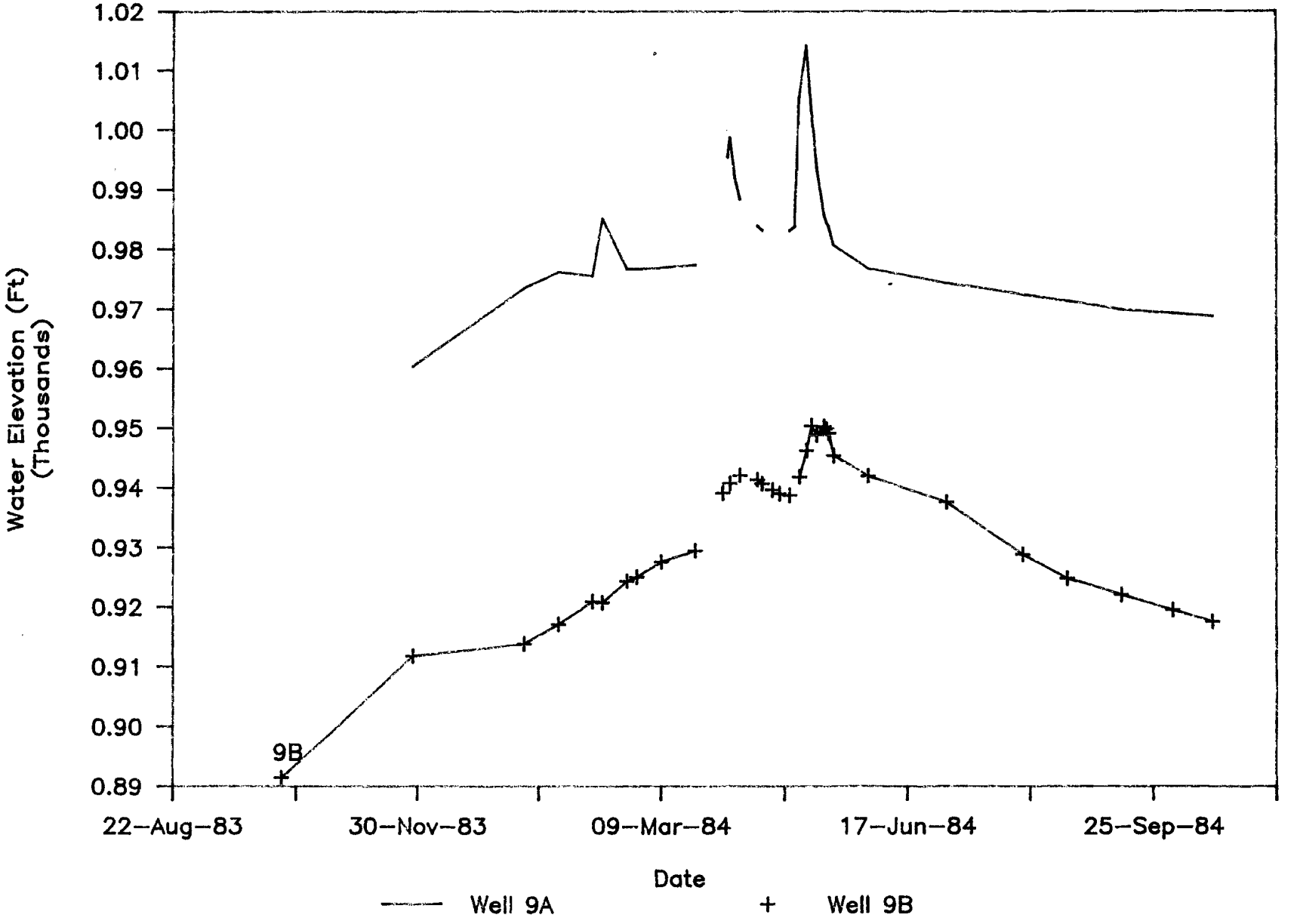

WELL HYDROGRAPH
Wells 7A & 7B
950
940
930
920
910
900
890
880
Water Elevation (Ft)
7A
7B
29-Mar-86
15-Oct-86
03-May-87
19-Nov-87
06-Jun-88
Date
Well 7A
Well 7B

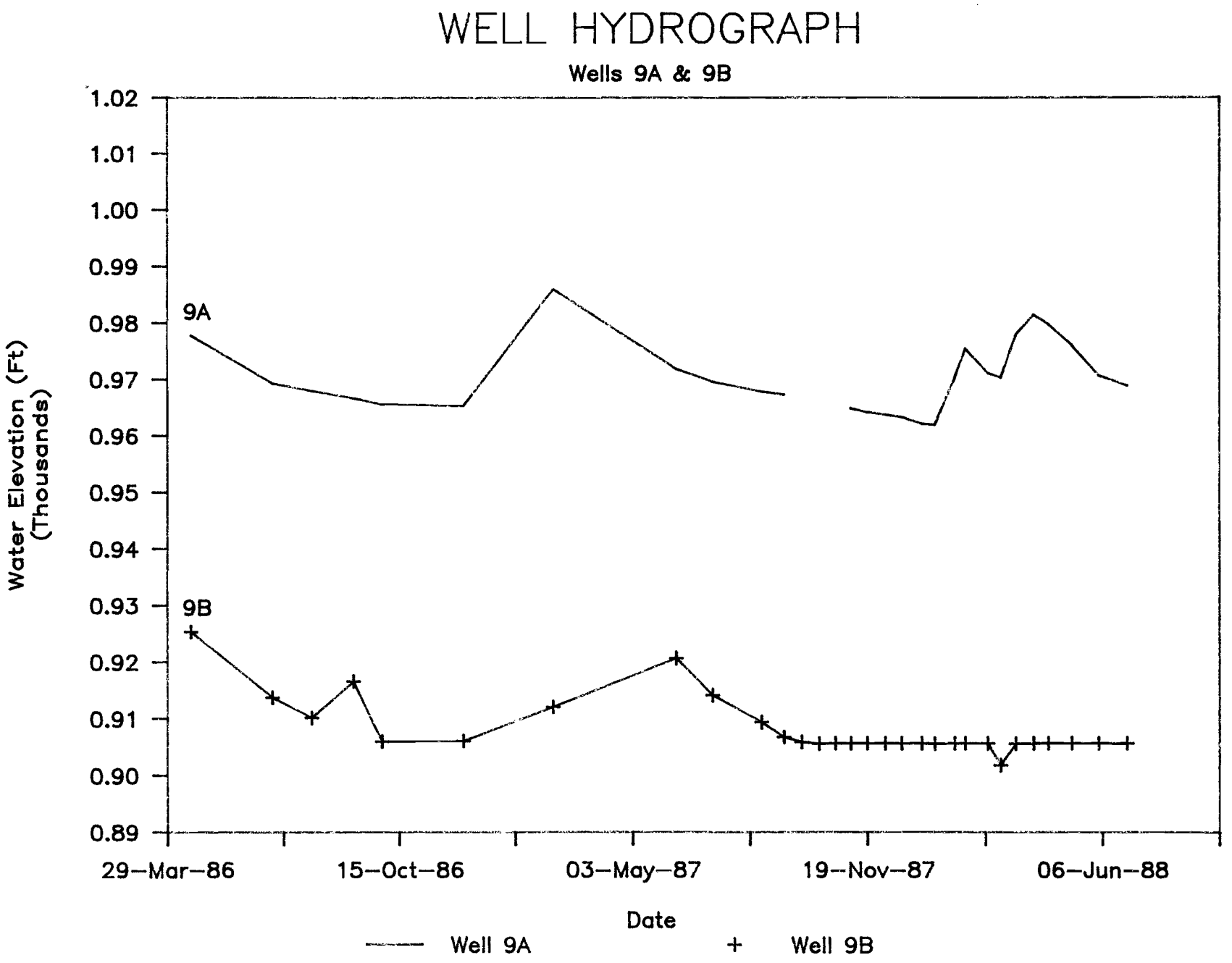

WELL HYDROGRAPH
Wells 8A & 8B
920
910
900
890
880
870
860
Water Elevation (Ft)
8B
22-Aug-83
30-Nov-83
09-Mar-84
17-Jun-84
25-Sep-84
Date
Well 8A
Well 8B


WELL HYDROGRAPH
Wells 8A & 8B
920
910
900
890
880
870
860
Water Elevation (Ft)
8B
29-Mar-86
15-Oct-86
03-May-87
19-Nov-87
06-Jun-88
Date
Well 8A
Well 8B

WELL HYDROGRAPH

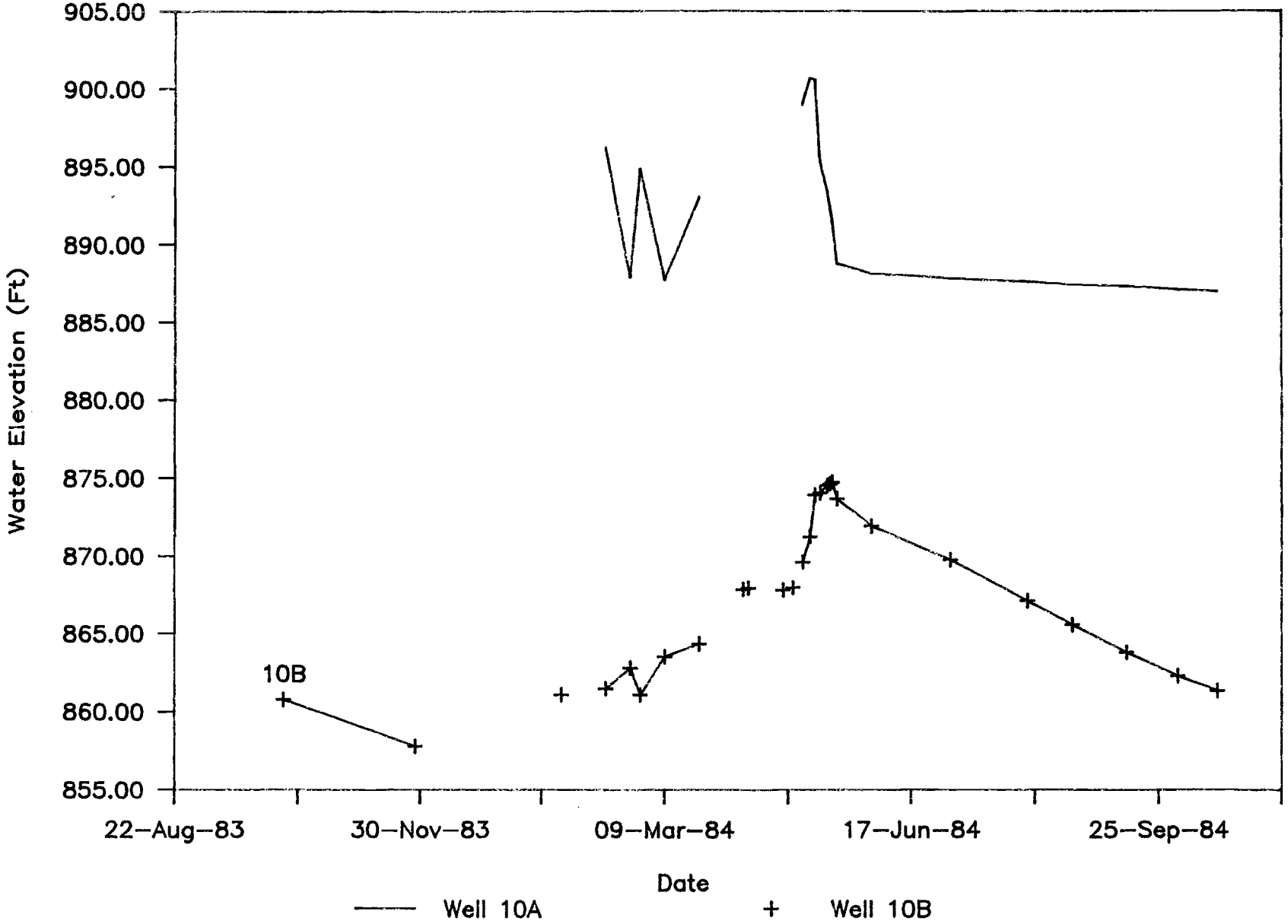
Wells 9A & 9B

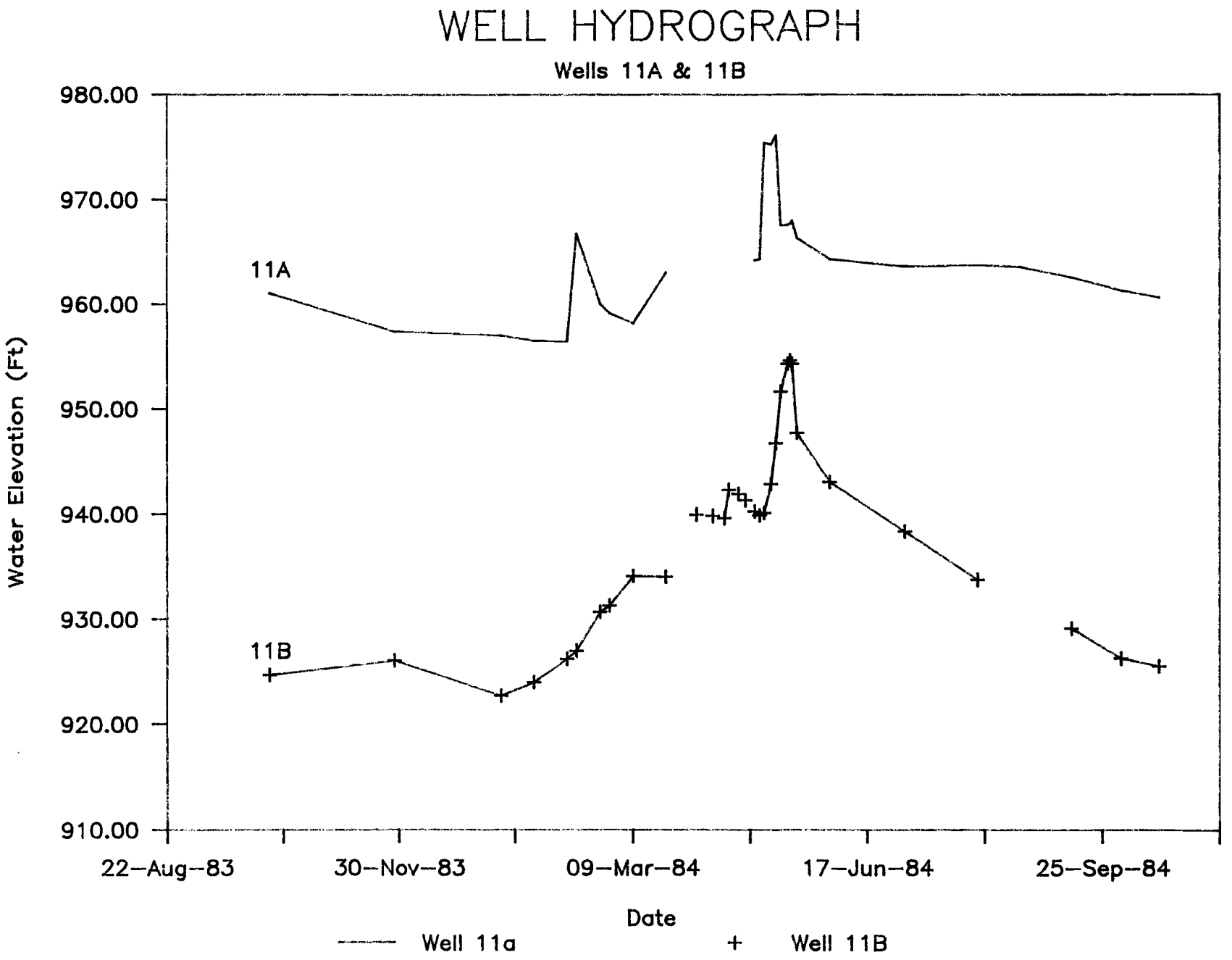



WELL HYDROGRAPH
Wells 9A & 9B
Water Elevation (Ft)
(Thousands)
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.90
0.89
9A
9B
29-Mar-86
15-Oct-86
03-May-87
19-Nov-87
06-Jun-88
Date
Well 9A
Well 9B

WELL HYDROGRAPH

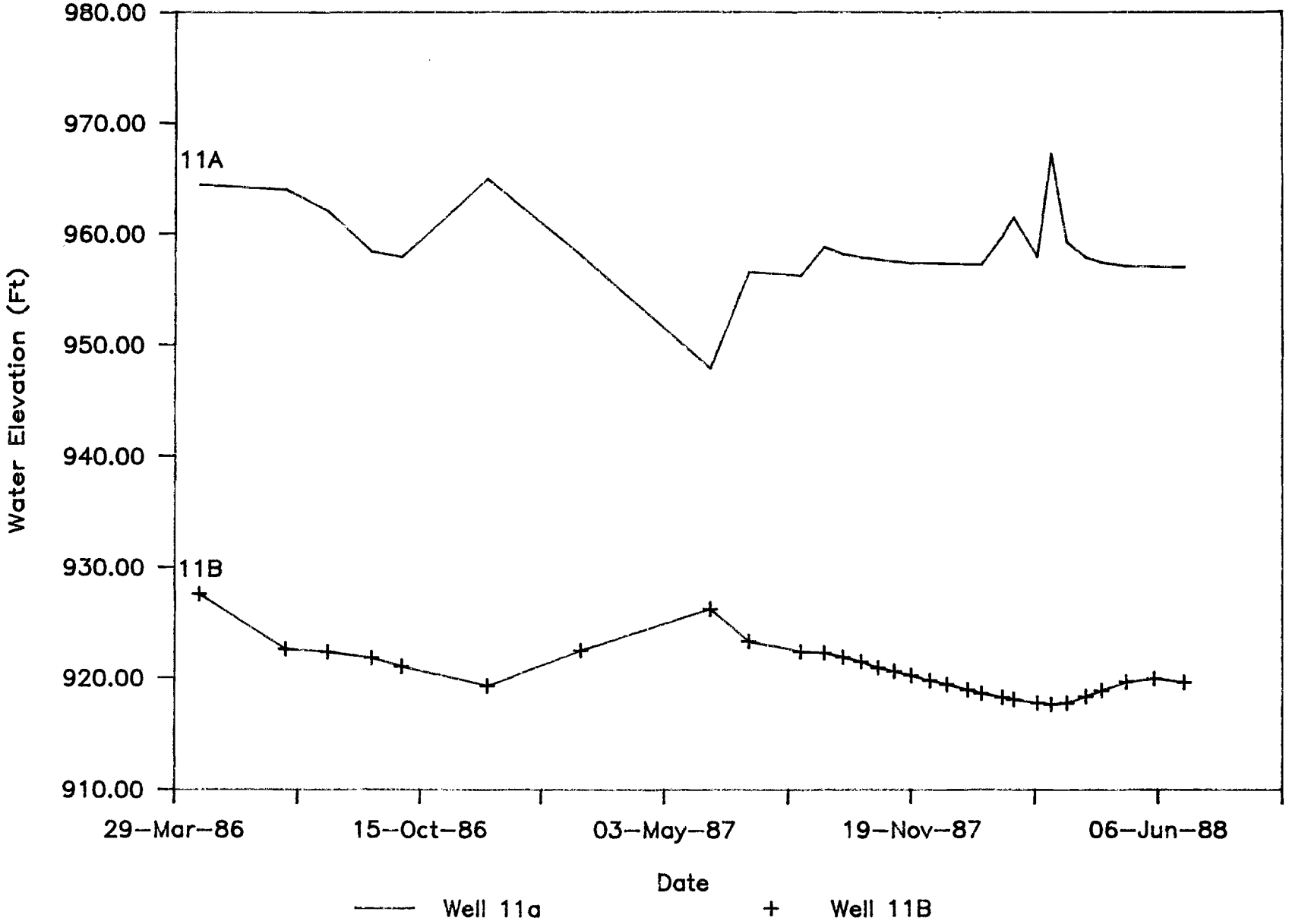
Wells 10A & 10B

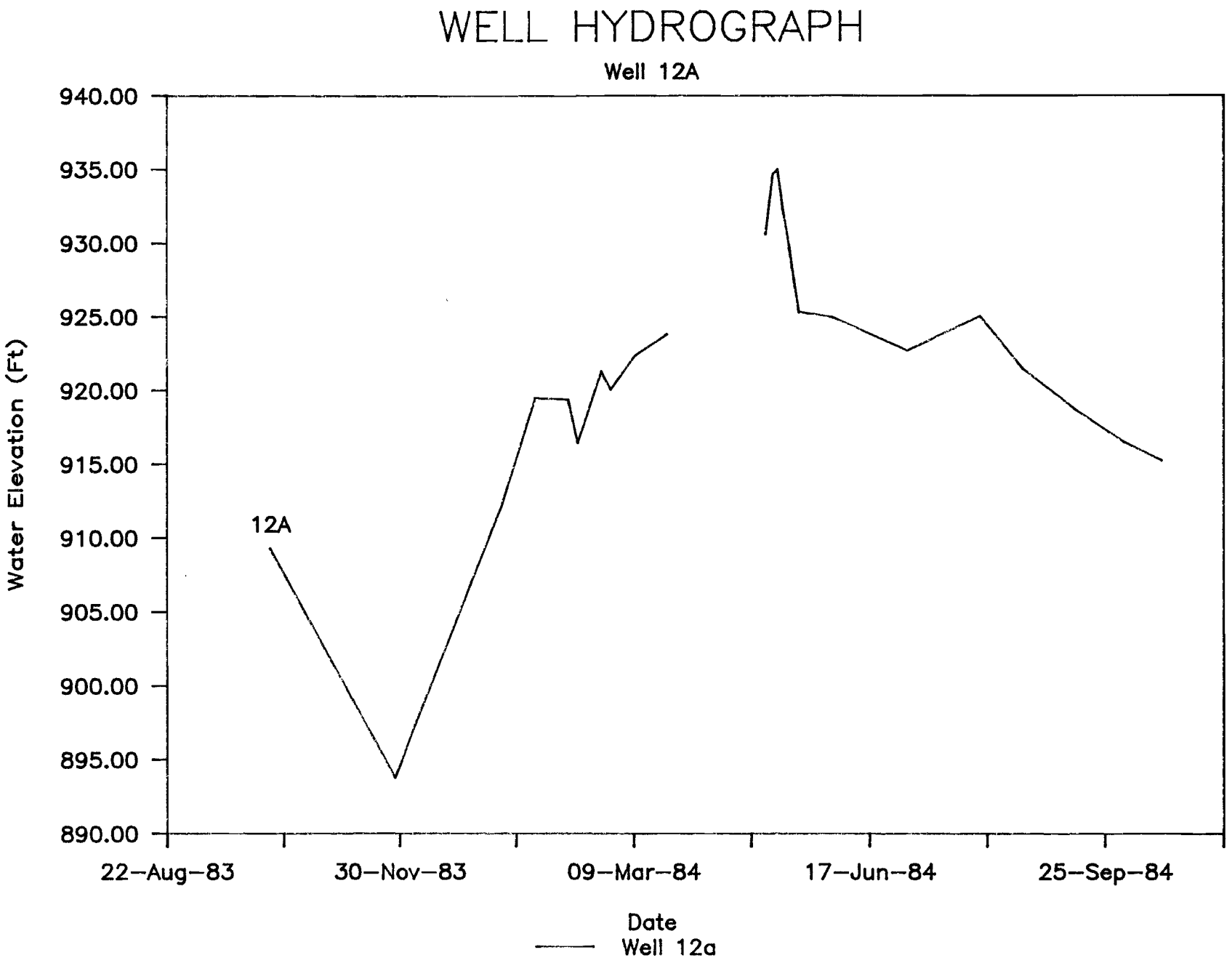



WELL HYDROGRAPH
Wells 11A & 11B
980.00
970.00
960.00
950.00
940.00
930.00
920.00
910.00
Water Elevation (Ft)
11A
11B
22-Aug-83
30-Nov-83
09-Mar-84
17-Jun-84
25-Sep-84
Date
Well 11a
Well 11B

WELL HYDROGRAPH

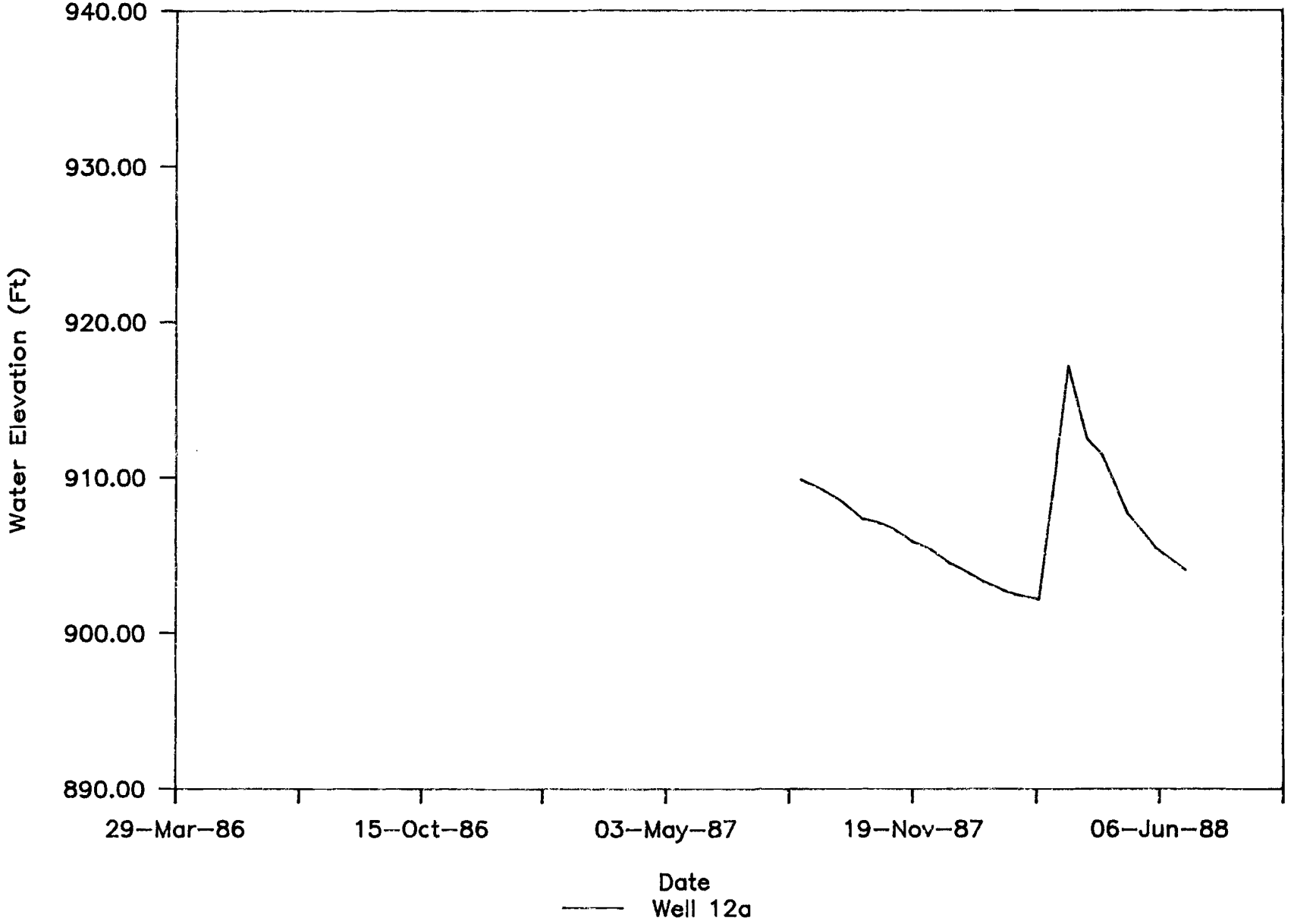
Wells 11A & 11B




WELL HYDROGRAPH
Well 12A
940.00
935.00
930.00
925.00
920.00
915.00
910.00
905.00
900.00
895.00
890.00
Water Elevation (Ft)
12A
22-Aug-83
30-Nov-83
09-Mar-84
17-Jun-84
25-Sep-84
Date
Well 12a

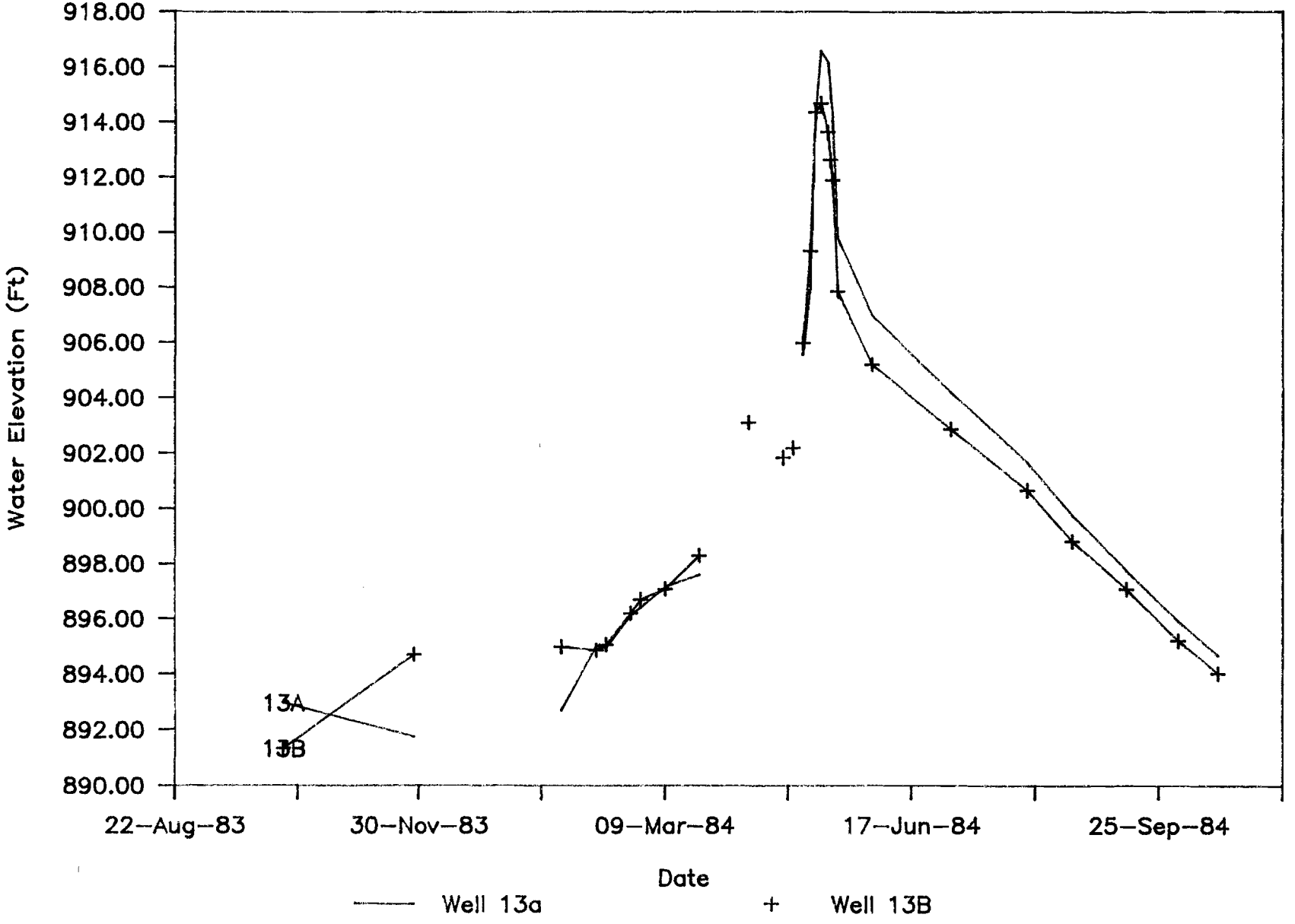
WELL HYDROGRAPH

Well 12A



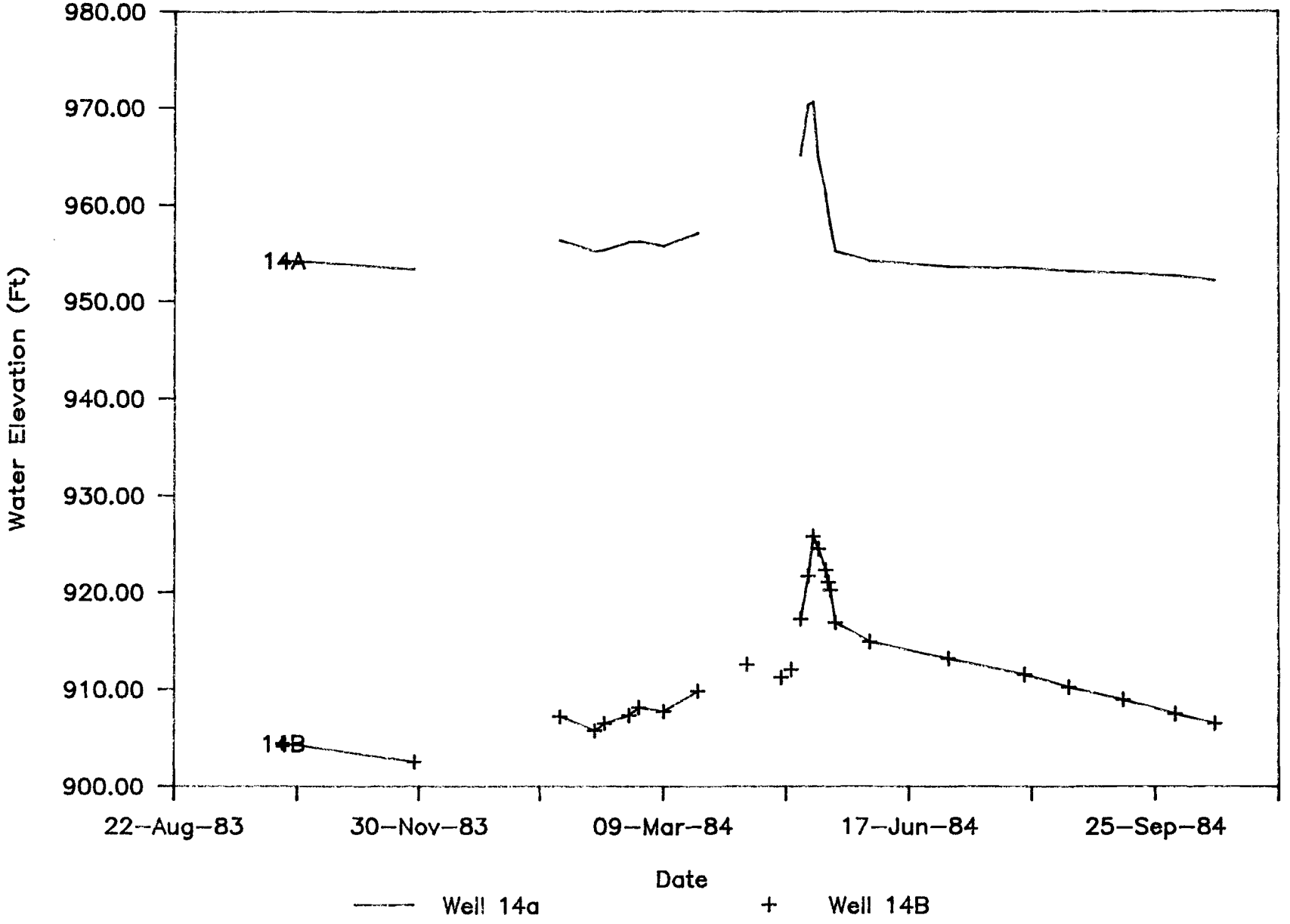
WELL HYDROGRAPH

Wells 13A & 13B



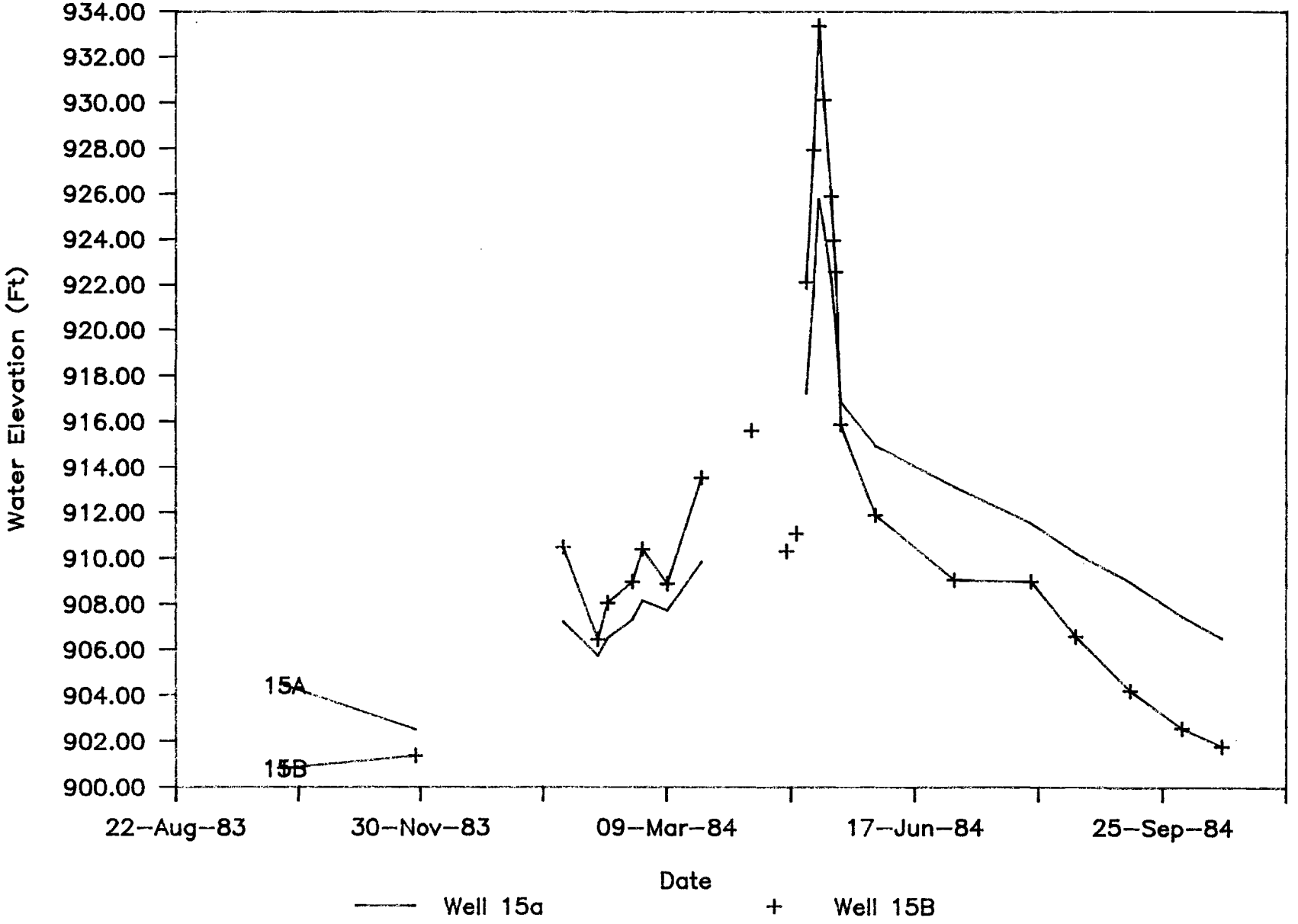
WELL HYDROGRAPH

Wells 14A & 14B



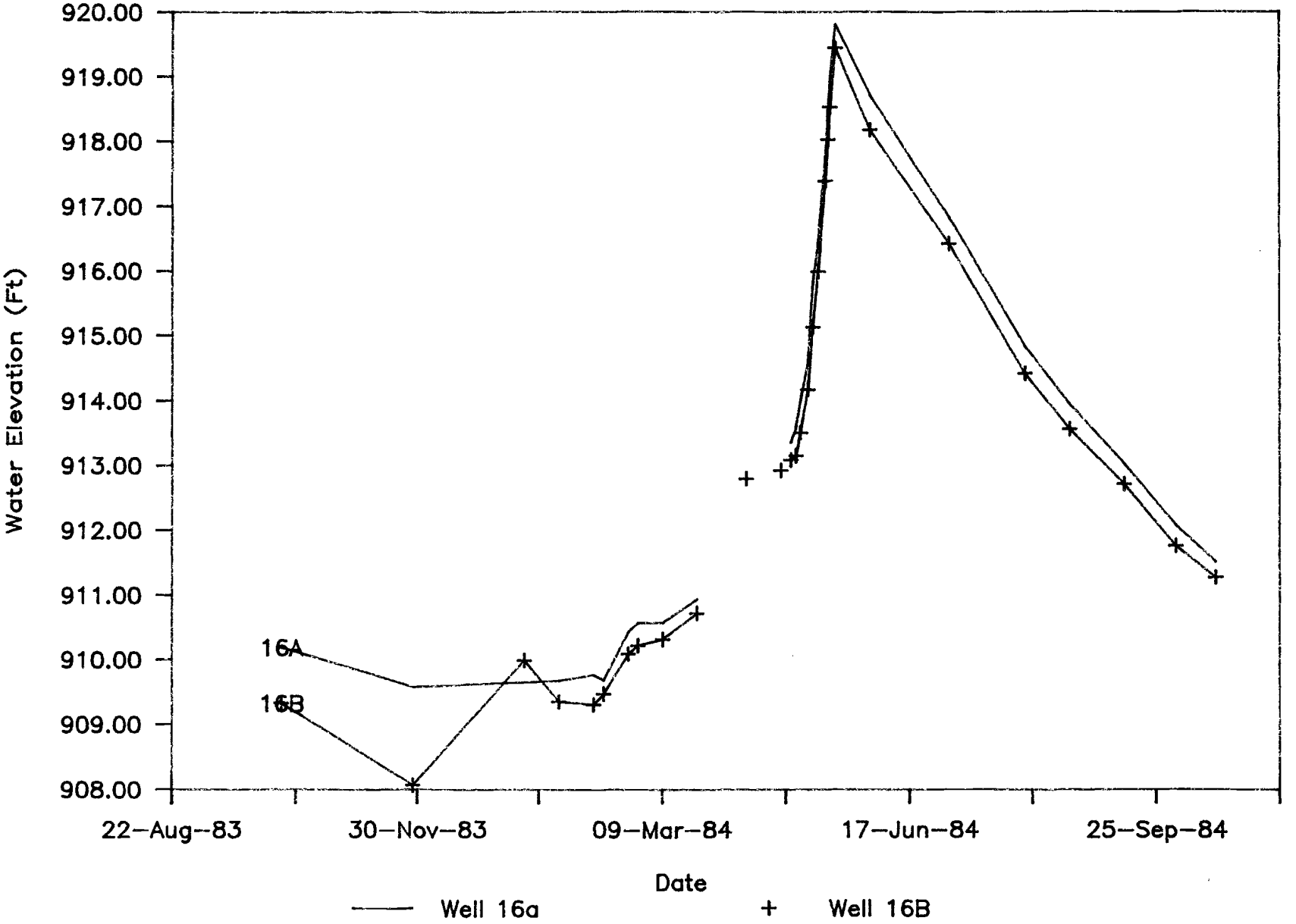
WELL HYDROGRAPH

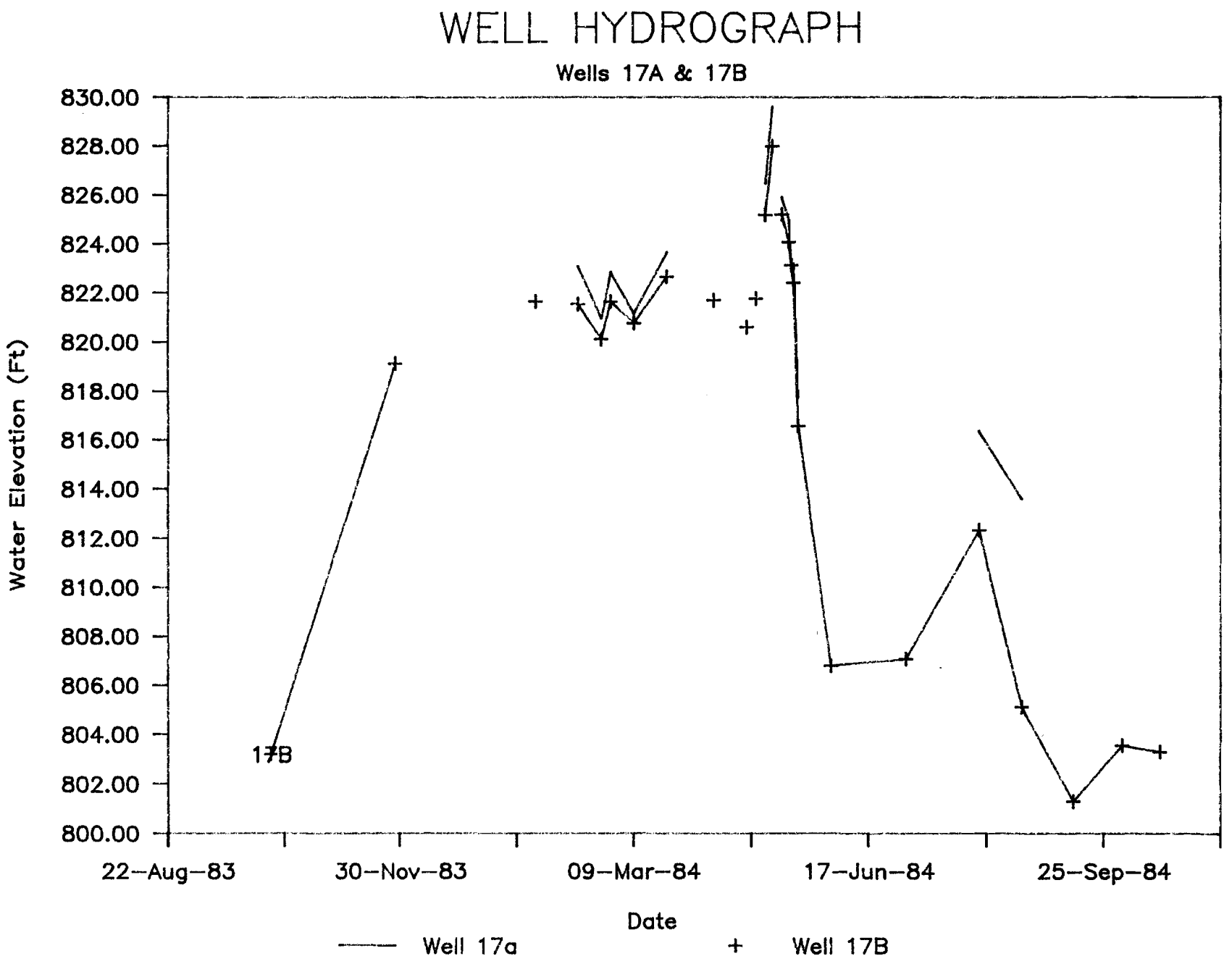
Wells 15A & 15B



WELL HYDROGRAPH

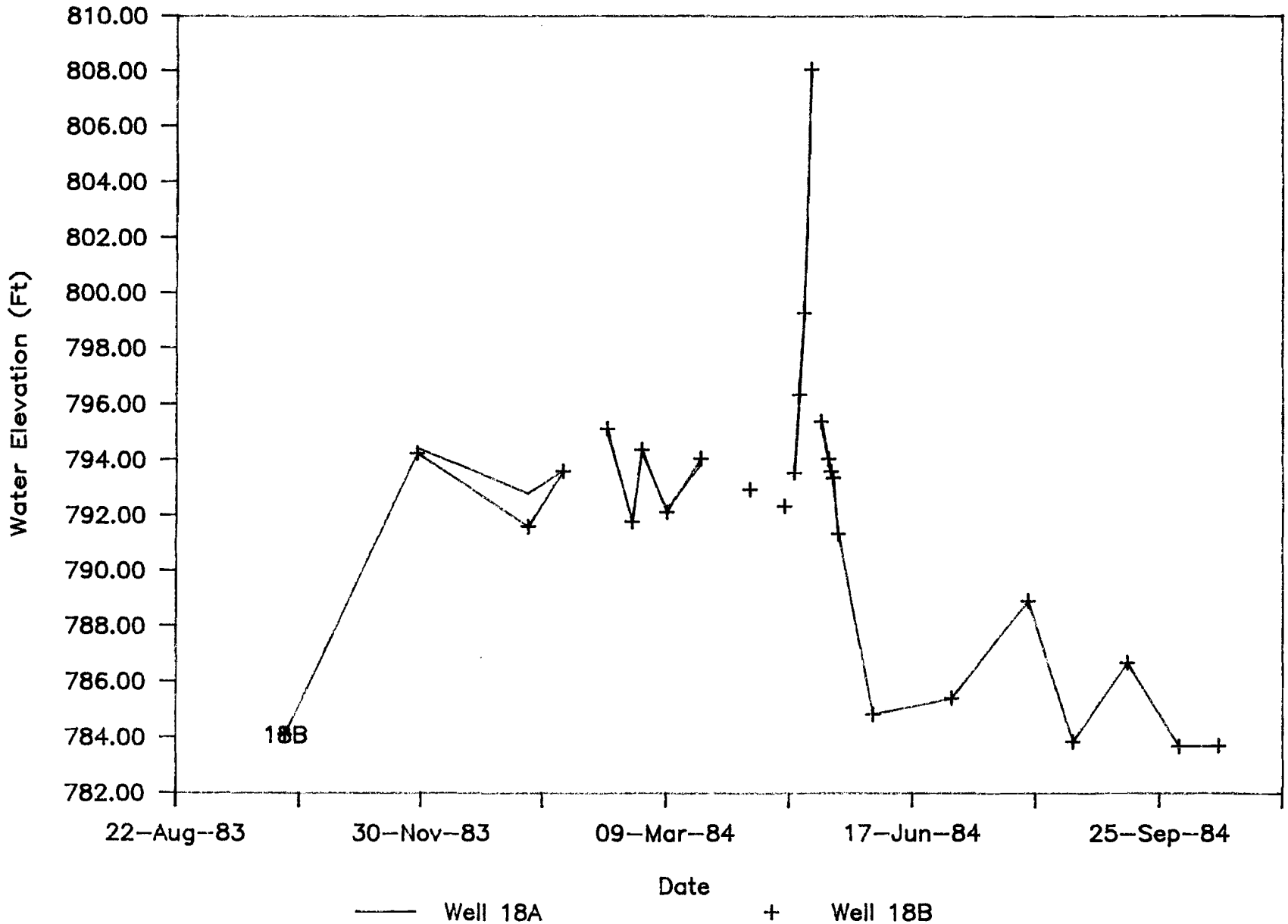
Wells 16A & 16B

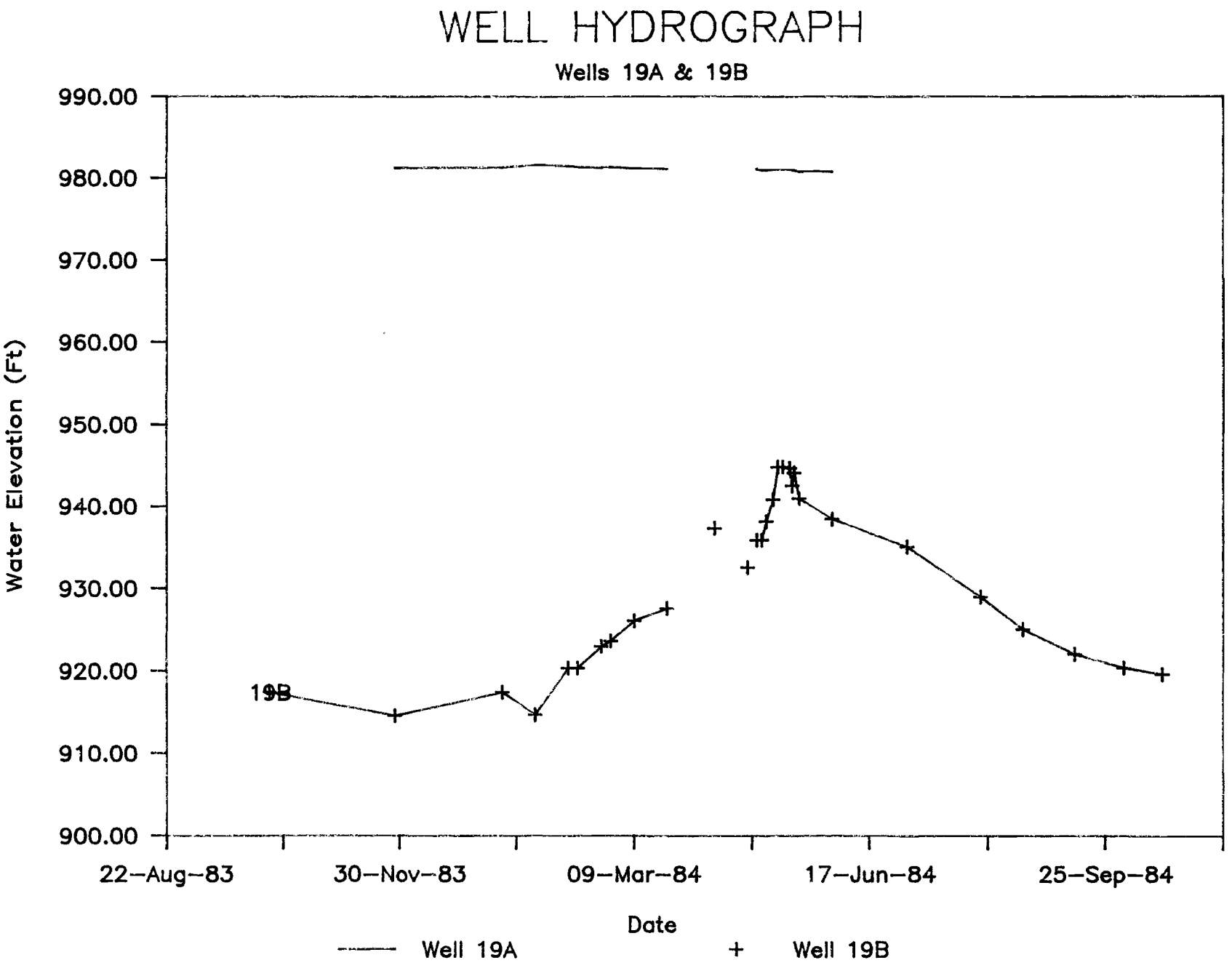


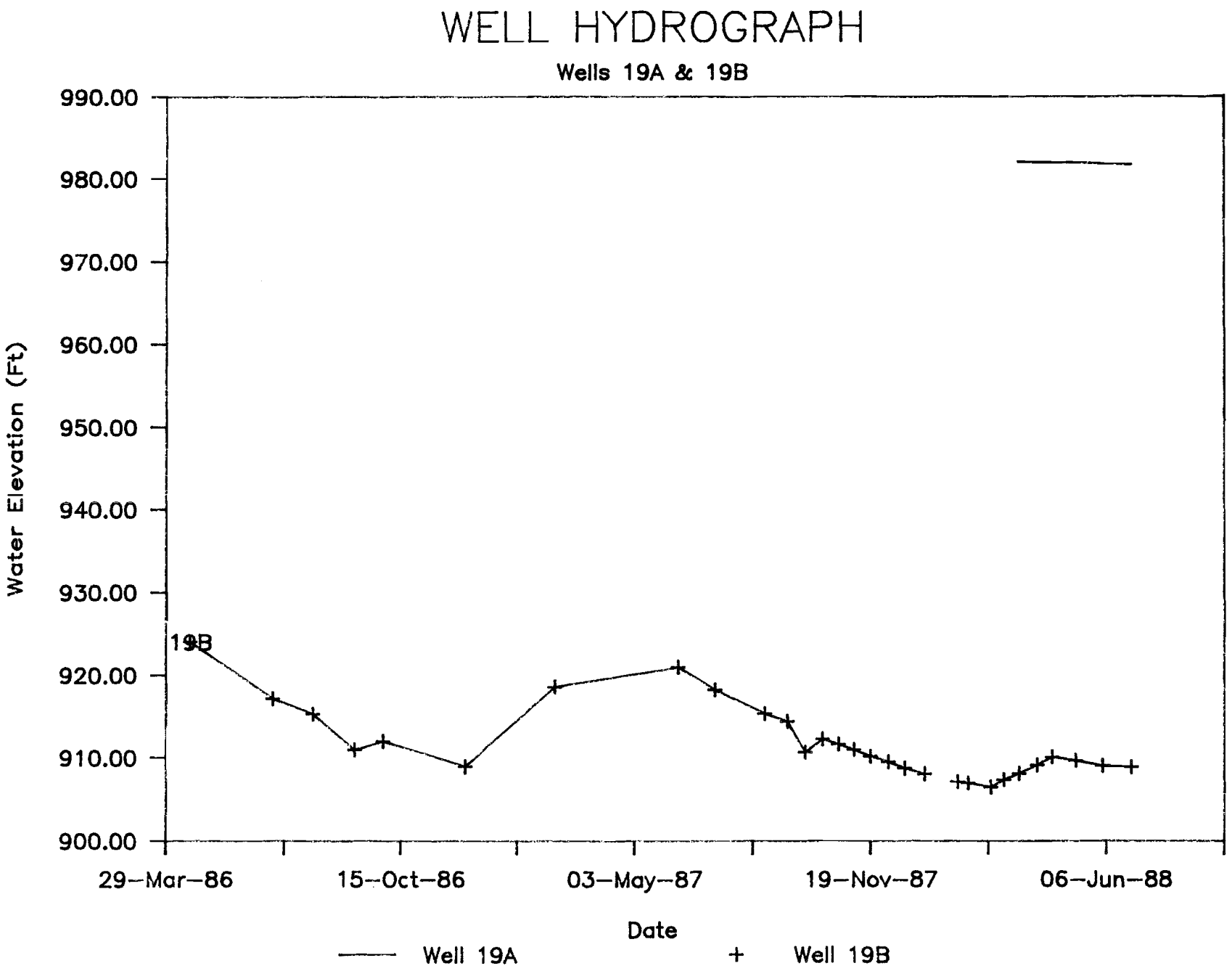

WELL HYDROGRAPH
Wells 17A & 17B
Water Elevation (Ft)
830.00
828.00
826.00
824.00
822.00
820.00
818.00
816.00
814.00
812.00
810.00
808.00
806.00
804.00
802.00
800.00
17B
22-Aug-83
30-Nov-83
09-Mar-84
17-Jun-84
25-Sep-84
Date
Well 17a
Well 17B

WELL HYDROGRAPH

Wells 18A & 18B

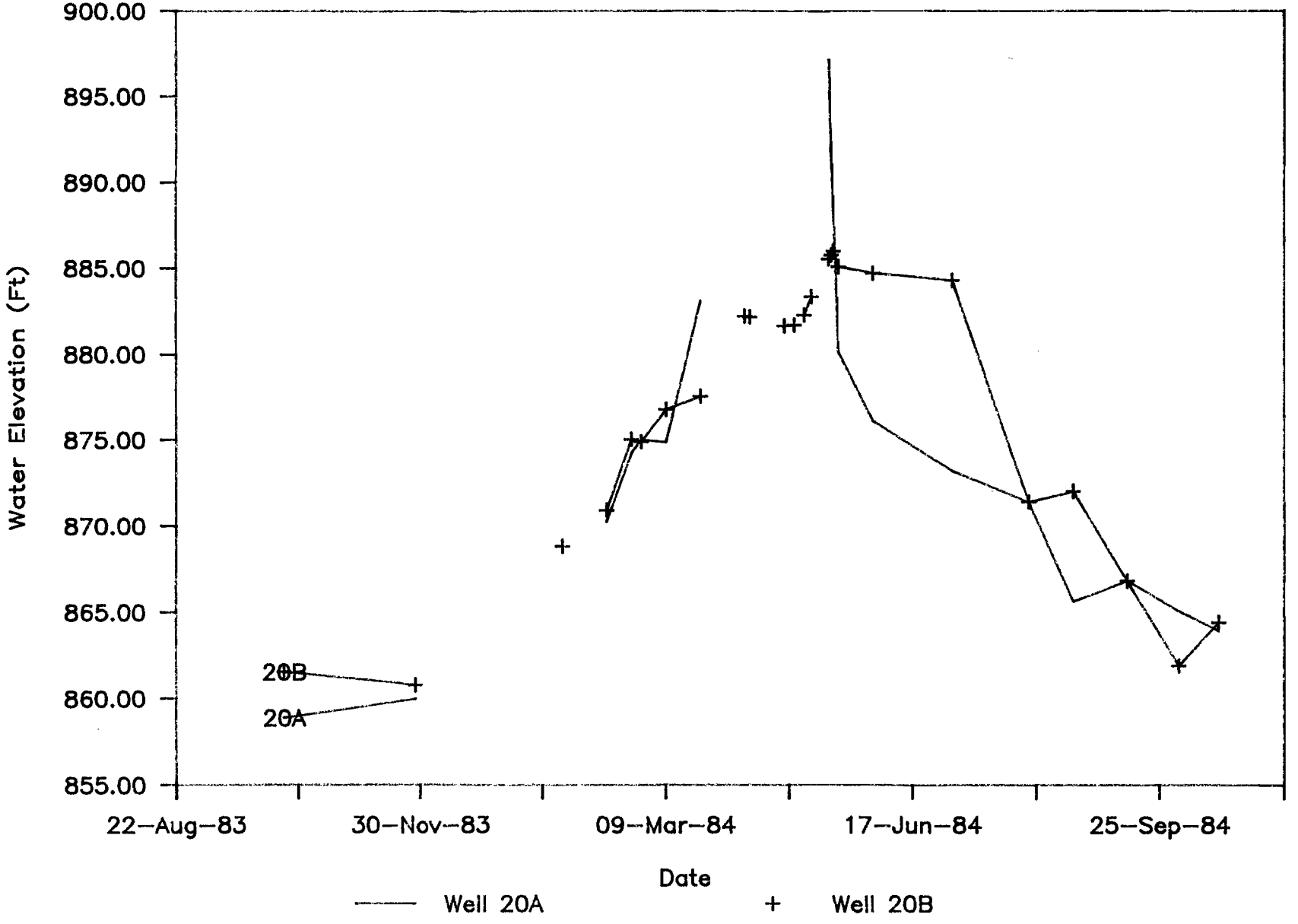



WELL HYDROGRAPH
Wells 19A & 19B
990.00
980.00
970.00
960.00
950.00
940.00
930.00
920.00
910.00
900.00
Water Elevation (Ft)
19B
22-Aug-83
30-Nov-83
09-Mar-84
17-Jun-84
25-Sep-84
Date
Well 19A
Well 19B


WELL HYDROGRAPH
Wells 19A & 19B
990.00
980.00
970.00
960.00
950.00
940.00
930.00
920.00
910.00
900.00
Water Elevation (Ft)
19B
29-Mar-86
15-Oct-86
03-May-87
19-Nov-87
06-Jun-88
Date
Well 19A
Well 19B

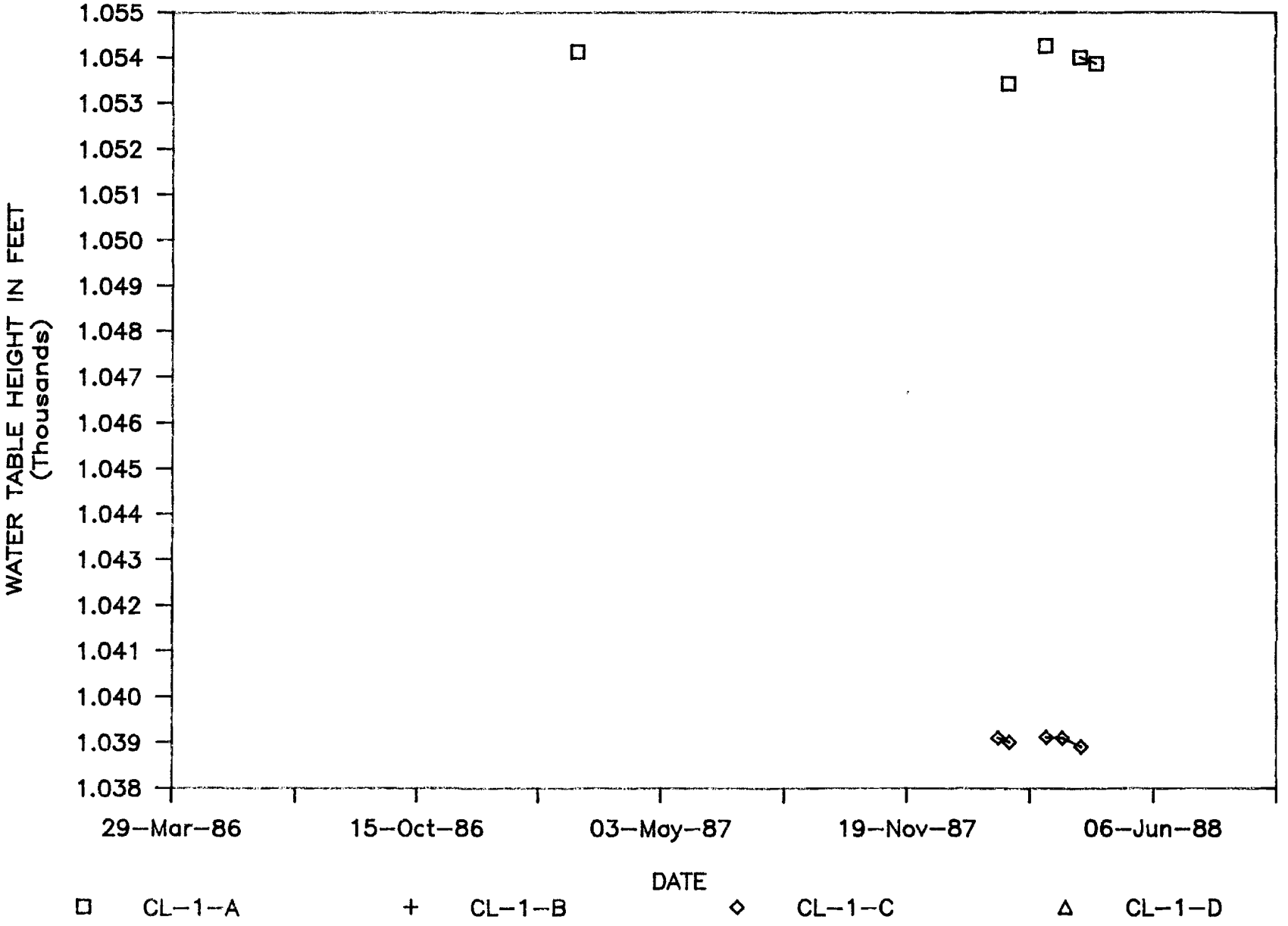
WELL HYDROGRAPH

Wells 20A & 20B



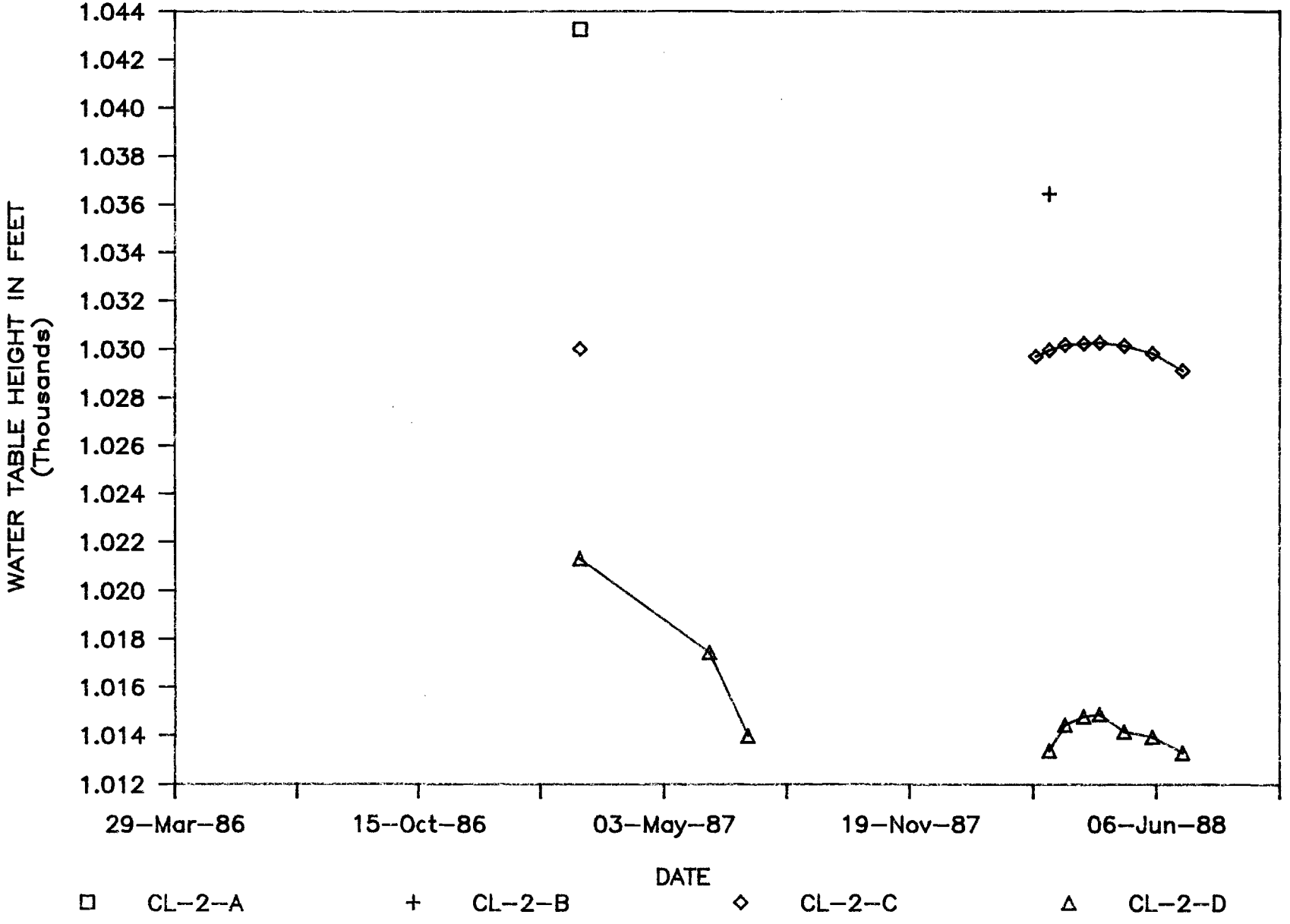
CLUSTER WELL HYDROGRAPH

Cluster 1



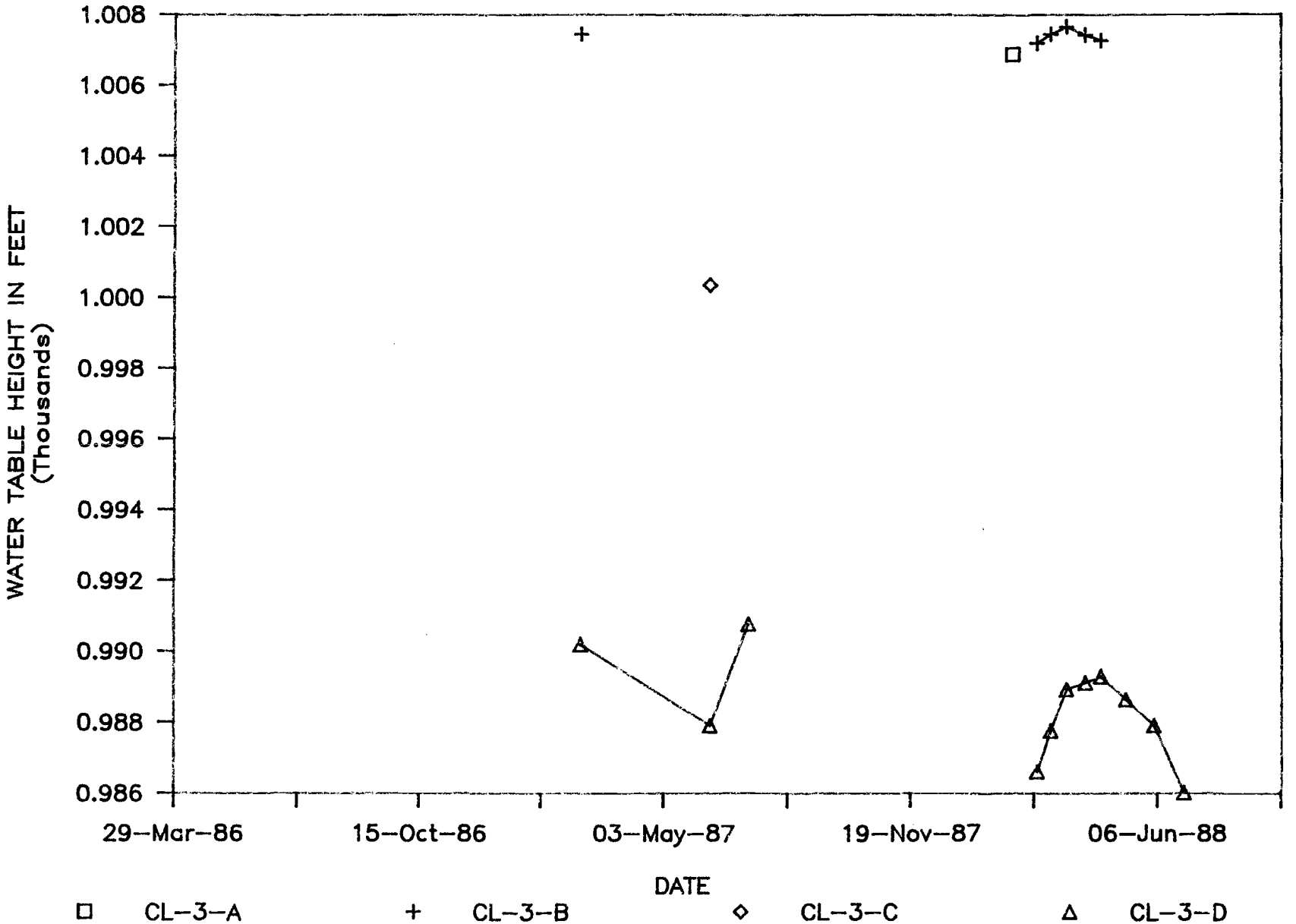
CLUSTER WELL HYDROGRAPH

Cluster 2



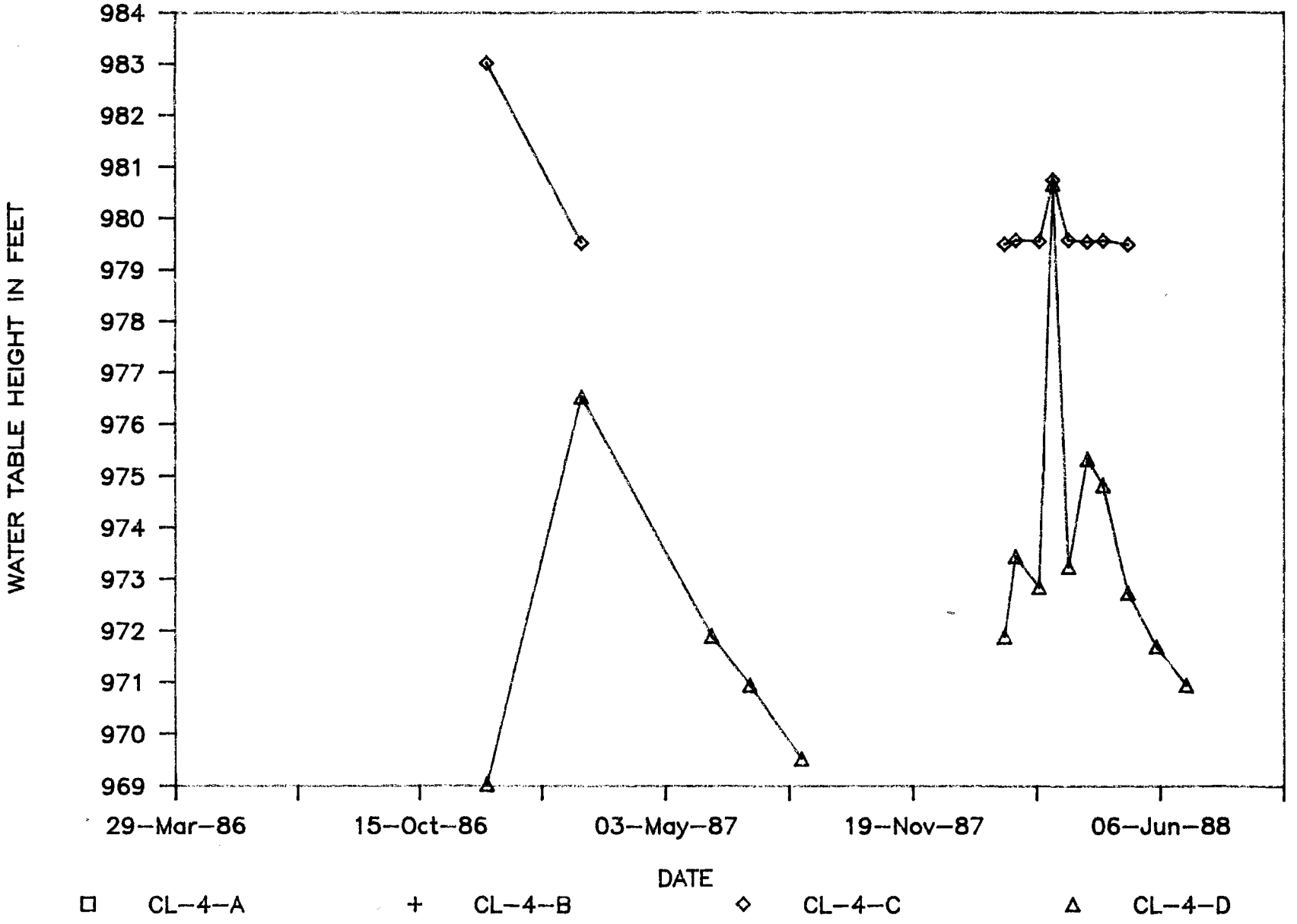
CLUSTER WELL HYDROGRAPH

Cluster 3



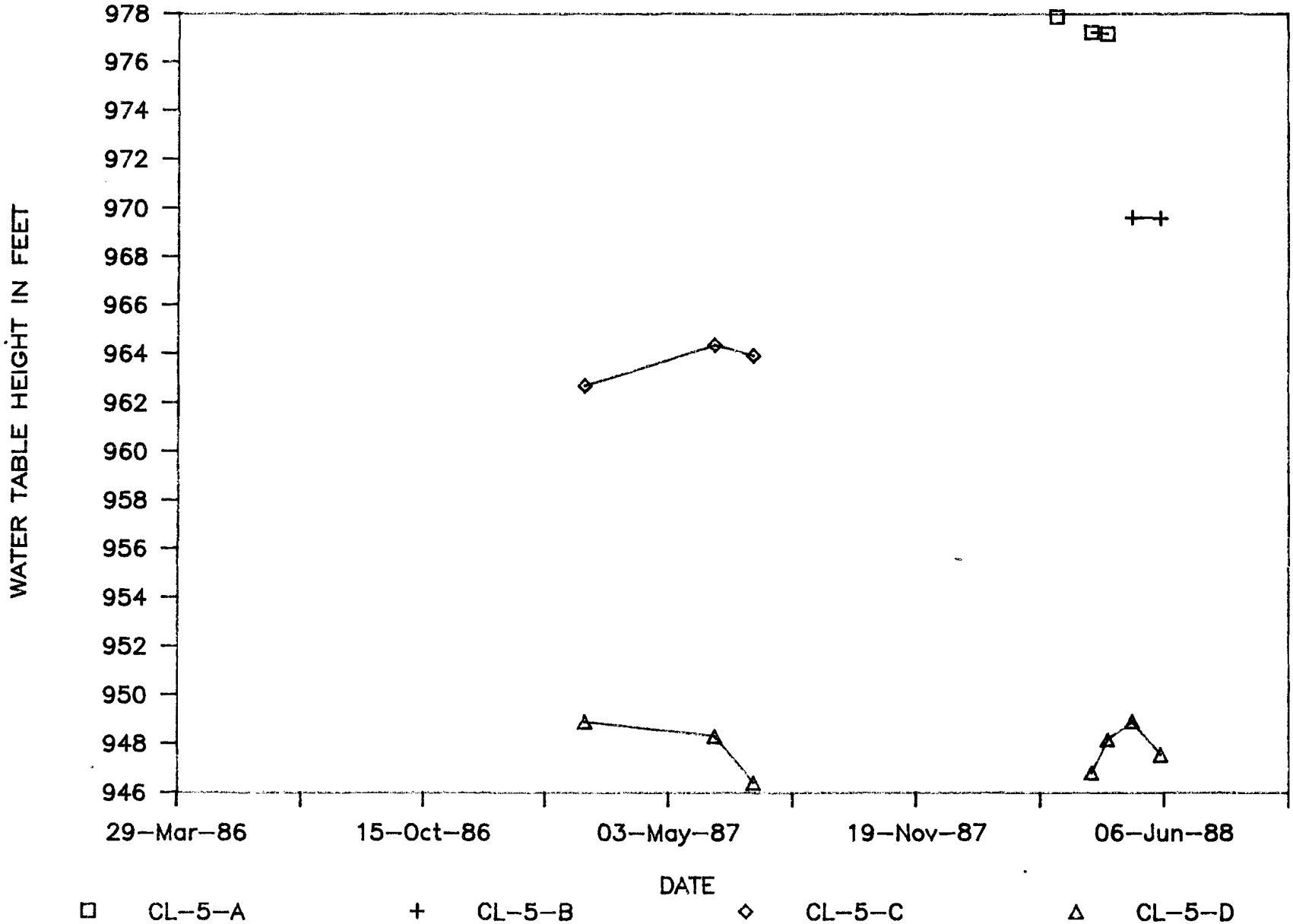
CLUSTER WELL HYDROGRAPH

Cluster 4



CLUSTER WELL HYDROGRAPH

Cluster 5



APPENDIX L

WATER QUALITY DATA FROM WEST CHESTNUT RIDGE ON TWO SAMPLING DATES IN 1984

R. H. Ketelle

West Chestnut Ridge Surface Water Quality Data[1]

Parameter	CWDF-1		CWDF-7	
	6/18/84	11/1/84	6/18/84	11/1/84
		Cations		
Ag	<0.03	<0.04	<0.03	<0.04
Al	<0.018	<0.3	0.0404	<0.03
As	<0.01	<0.19	<0.01	<0.19
B	<0.018	<0.03	<0.018	<0.03
Ba	0.0367	0.0632	<0.02	<0.015
Be	0.00197	<0.0007	0.0198	<0.0007
Ca	28.8	25.1	28.0	28.8
Cd	<0.013	<0.03	<0.013	<0.03
Co	<0.01	<0.015	<0.01	<0.015
Cr	<0.015	<0.008	<0.015	0.113
Cu	<0.018	<0.0175	<0.018	<0.0175
Fe	<0.01	0.0534	0.0141	0.364
Ga	0.0694	<0.21	0.0796	<0.21
Hf	<0.016	<0.042	0.0188	<0.042
Hg	<0.01	<0.05	<0.01	<0.05
K	17.1	<16.0	16.6	<16.0
Li	0.0375	<0.11	0.0351	<0.11
Mg	11.7	11.9	16.4	17.5
Mn	<0.023	0.0202	<0.023	0.0386
Mo	<0.01	<0.016	<0.01	<0.016
Na	1.0	1.13	0.647	0.943
Mi	0.00502	<0.055	0.00643	0.078
P		<0.1	<0.26	<0.1
Pb	<0.0092	<0.15	<0.0092	<0.15
Sb	0.268	<0.33	0.268	<0.33
Se		<0.3		
Si	3.04	4.01	3.32	4.24
Sr	0.0427	0.0435	0.0136	0.0172
Ti	0.011	<0.015	0.0113	<0.015
V	0.0194	<0.022	0.0252	<0.022
Zn	<0.01	<0.017	<0.01	<0.017
Zr	<0.01	<0.057	<0.01	<0.057
		Anions		
Br	<2	<5	<2	<5
Cl	1	2	1	1
F	<1	<1	<1	<1
NO_3	<5	<5	<5	<5
PO_4	<5	<5	<5	<5
SO_4	<5	<5	<5	<5
CO_3	0		0	
HCO_3	122		139	

West Chestnut Ridge Surface Water Quality Data[1]

Parameter	CWDF-1		CWDF-7	
	6/18/84	11/1/84	6/18/84	11/1/84
		Radionuclides[2]		
Sr-90	0.05+-0.05	0.01+-.13	0.04+-.06	0.02+-.11
Pu-239	<0.001		<0.001	
Th-232	<0.001		<0.01	
Ra-226	<0.002		<0.01	
U-238	0.073+-.007		0.074+-.007	
Tc-99	0.026+-0.054		0.01+-.05	
H-3	20+-33		32+-32	
C-14	19+-29		19+-29	
Cm-244	<0.001		<0.001	
Cs-137	<0.06	0.03+-.06	<0.04	<0.01
Co-60	<0.07	0.10+-.05	<0.06	
Mn-54	<0.06		<0.04	
Pb-210	<0.05		0.037+-.051	<0.1
Ru-106	<0.4		<0.4	
G-alpha		2.6+-2.8		0.5+-1.7
G-beta		1.6+-2.0		0.6+-1.8
		Total Organic Carbon		
	0.6	1.5	0.03	0.5

[1]Concentrations for cations, anions, TOC are μg/ml except Hg which is ng/ml.

[2]Radionuclide data are reported as bequerel/liter with analytical uncertainty due to decay event counting statistics at the 95% confidence level.

West Chestnut Ridge Groundwater Analyses

	Well 3A		Well 3B		Well 6A		Well PW-6		Well 9A		Well 9B		Well 18B	
	6/15/84	11/1/84	6/15/84	11/1/84	6/15/84	11/1/84	6/15/84	11/1/84	6/15/84	11/1/84	6/15/84	11/1/84	6/15/84	11/1/84
Radionuclides														
Sr-90	<0.06	0.01+-.11	0.04+-.08	0.03+-.13	0.03+-.06	0.02+-.14	0.03+-.06	0.07+-.16	0.04+-.07		0.06+-.07		<0.08	0.01+-.10
Pu-239	<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	
Th-232	0.0042+-.0015		0.0016+-.0011		<0.001		<0.001		<0.001		<0.001		0.010+-.002	
Ra-226	<0.01		<0.01		<0.01		<0.01		<0.01		<0.01		<0.01	
U-238	0.073+-.006		0.072+-.006		0.072+-.006		0.072+-.006		0.067+-.006		0.075+-.006		0.074+-.010	
Tc-99	0.032+-.063		<0.06		0.045+-.069		0.027+-.069		0.045+-.058		<0.04		0.016+-.046	
H-3	20+-33		32+-32		32+-32		31+-31		20+-33		33+-33		33+-33	
C-14	19+-29		19+-29		19+-29		19+-29		19+-29		19+-29		38+-30	
Cm-244	<0.001		<0.001		<0.001		0.0015+-.0006		<0.001		<0.001		<0.001	
Cs-137	<0.05	0.04+-.04	<0.05	<0.01	<0.02	0.03+-.06	<0.06	<0.01	<0.06		<0.08		<0.06	0.03+-.02
Co-60	<0.07	0.09+-.05	<0.06	0.06+-.06	<0.1	0.10+-.05	<0.08	<0.2	<0.08		<0.08		<0.07	0.2+-.1
Mn-54	<0.05		<0.05		<0.07		<0.05		<0.05		<0.06		<0.05	
Pb-210	0.008+-.043		0.029+-.049		<0.05		0.050+-.056		0.009+-.049		0.018+-.047		<0.04	
Ru-106	<0.4		<0.4		<0.6		<0.5		<0.5		<0.6		<0.5	
G-alpha		1.1+-2.1		0.3+-1.0		0.9+-2.1		1.5+-2.3						0.3+-1.7
G-beta		<2		1.0+-2.0		2.4+-2.2		<2						<2
Total Organic Carbon														
TOC	3.5	2.3	3.8	2.8	2.4	1.2	0.2	1.1	2.3		2.9		1.7	4.8

WEST CHESTNUT RIDGE SITE GROUND WATER QUALITY DATA

Parameter	Well 3A 6/18/84	Well 3A 10/31/84	Well 3B 6/18/84	Well 3B 10/31/84	Well 6A 6/18/84	Well 6A 10/31/84	Well PW6 6/18/84	Well PW6 10/31/84	Well 9A 6/18/84	Well 9B 6/18/84	Well 18B 6/18/84	Well 18B 10/31/84
						Cations						
Ag	<0.03	<0.04	<0.03	<0.04	<0.03	<0.04	0.03	<0.04	<0.03	<0.03	<0.03	<0.04
Al	2.28	0.582	0.043	<0.03	<0.018	0.977	<0.018	<0.3	<0.018	<0.018	<0.018	<0.03
As	<0.01	<0.19	<0.01	<0.19	<0.01	<0.19	<0.01	<0.19	<0.01	<0.01	<0.01	<0.19
B	<0.018	<0.03	<0.018	<0.03	<0.018	<0.03	<0.018	<0.03	<0.018	<0.018	<0.018	<0.03
Ba	<0.02	0.043	<0.02	0.018	<0.02	0.621	0.032	0.054	<0.02	<0.02	<0.02	<0.015
Be	0.0021	0.0015	0.0019	<0.0007	0.0019	0.02	0.002	<0.0007	0.002	0.002	0.002	<0.0007
Ca	25.7	29.1	24.4	35.1	29.2	61.0	32.6	31.8	24.2	27.5	46.7	44.7
Cd	<0.013	<0.03	<0.013	<0.03	<0.013	0.05	<0.013	<0.03	<0.013	<0.013	<0.013	<0.03
Co	<0.01	0.027	<0.01	<0.015	<0.01	0.049	<0.01	<0.015	<0.01	<0.01	<0.01	<0.015
Cr	<0.015	<0.008	<0.015	0.089	<0.015	0.011	<0.015	0.019	<0.015	<0.015	<0.015	<0.008
Cu	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018
Fe	1.23	1.66	0.033	1.35	<0.01	0.172	<0.01	0.149	<0.01	<0.01	<0.01	0.171
Ga	0.076	<0.21	0.067	<0.21	0.061	<0.21	0.075	<0.21	0.065	0.069	0.058	<0.21
Hf	0.083	0.048	<0.016	<0.042	<0.016	0.114	0.018	<0.042	<0.016	<0.016	<0.016	<0.042
K	15.6	<16	18.1	<16	16.2	<16	16.4	<16	17.1	17.1	16.3	<16
Li	0.031	<0.11	0.036	<0.11	0.036	<0.11	0.035	<0.11	0.035	0.036	0.038	<0.11
Mg	12.3	14.4	18.5	20.5	16.5	32.4	18.2	18.0	10.4	16.4	9.21	8.91
Mn	4.3	5.2	<0.023	0.144	<0.023	6.92	<0.023	0.052	<0.023	<0.023	<0.023	0.053
Mo	0.011	<0.016	<0.01	<0.016	<0.01	<0.016	<0.01	<0.016	<0.01	<0.01	<0.01	<0.016
Na	1.95	1.56	2.61	0.98	0.96	1.11	0.67	0.82	0.93	0.83	1.83	1.91
Ni	0.007	<0.055	<0.005	0.056	<0.005	0.092	0.005	<0.055	0.005	<0.005	0.006	<0.055
Pb	<0.009	<0.15	<0.009	<0.15	<0.009	<0.15	<0.009	<0.15	<0.009	<0.009	<0.009	<0.15
Sb	0.265	0.33	0.243	<0.33	0.26	<0.33	0.267	<0.33	0.255	0.276	0.285	<0.33
Si	8.63	4.14	2.15	3.37	2.21	6.91	3.05	4.02	2.8	3.22	2.61	3.54
Sr	0.033	0.037	0.028	0.028	0.025	0.063	0.02	0.025	0.02	0.013	0.079	0.086
Ti	0.101	<0.015	0.012	<0.015	0.01	0.023	0.011	<0.015	0.01	0.01	0.01	<0.015
V	0.024	<0.022	0.027	<0.022	0.024	0.038	0.028	<0.022	0.017	0.025	0.015	<0.022
Zn	<0.01	0.0604	<0.01	<0.017	<0.01	0.392	<0.01	<0.017	<0.01	<0.01	<0.01	<0.017
Zr	<0.01	<0.057	<0.01	<0.057	<0.01	<0.057	<0.01	<0.057	<0.01	<0.01	<0.01	<0.057
						Anions						
Br	<2	<5	<2	<5	<2	<5	<2	<5	<2	<2	<2	<5
Cl	1	1	3	1	<1	1	<1	1	1	1	2	2
F	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
NO_3	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
P	<0.26	<0.1	<0.26	<0.1	<0.26	<1	<0.26	<0.1	<0.26	<0.26	<0.26	<0.1
PO_4	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
SO_4	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	6	8
CO_3	0		0		0		0		0	0	0	
HCO_3	123		140		146		160		101	135	148	

Wells 3A&B are screened in Upper Chepultepec dolomite residuum and bedrock respectively.
Wells 6A&PW6 are screened in Middle Chepultepec dolomite residuum and bedrock respectively.
Wells 9A&9B are screened in Copper Ridge dolomite residuum and bedrock respectively.
Well 18B is screened in Mayndardville limestone.

Cations and Anions are reported as $\mu g/ml$.

Field Physiochemical Data
10/31/84

Parameter	Well 3A	Well 3B	Well 6A	Well P-6	Well 18B
Temp (°C)	14.7	14.7	15.0	15.7	14.2
pH (units)	7.00	7.70	7.08	7.12	7.43
Eh (mv)	-2.6	-42	-1.8	-5.7	-25
Spec. Cond. mho/cm	186	246	154	200	227

APPENDIX M

PRECIPITATION AND STREAMFLOW IN THE VICINITY OF WEST CHESTNUT RIDGE NEAR OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENNESSEE

(October 1985–March 1988)

R. B. Clapp and B. J. Frederick

DRAFT

ORNL/TM-10936

ENVIRONMENTAL SCIENCES DIVISION

PRECIPITATION AND STREAMFLOW IN THE VICINITY OF WEST CHESTNUT RIDGE NEAR OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENNESSEE (OCTOBER 1985-MARCH 1988)

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Environmental Sciences Division
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ABSTRACT

Clapp, R. B., and B. J. Frederick. 1988. Precipitation and Streamflow in the Vicinity of West Chestnut Ridge Near Oak Ridge National Laboratory, Oak Ridge, Tennessee (October 1985-March 1988). ORNL/TM-10936. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 80 pp.

The West Chestnut Ridge area is under consideration for development of a new waste disposal facility for either solid waste or low-level radioactive waste. As part of the site characterization, this report contains hydrologic data collected over a 2 1/2-year period (October 1985 through March 1988). The most significant event in the hydrologic record was the continuation of the drought conditions that began after the heavy rains of May 1984. Relative to normal annual rainfall, the precipitation deficit for water year 1986 was 18.08 in. (461.77 mm), and the deficit for 1987 was 7.92 in. (201.10 mm). For the first six months of water year 1988 the deficit was 11.72 in. (297.77 in.). For the period of record, daily average streamflow is reported for five gaging stations. Eighty-four percent of the daily values are considered good, which means within 10% of the true value. Only 0.3% (or 15 station days) are not within 15%, and these data were associated with incidences in which flume capacity was exceeded or with erratic flow behavior. The ratio of runoff per unit watershed area to precipitation is reported for the basins above each gaging station.

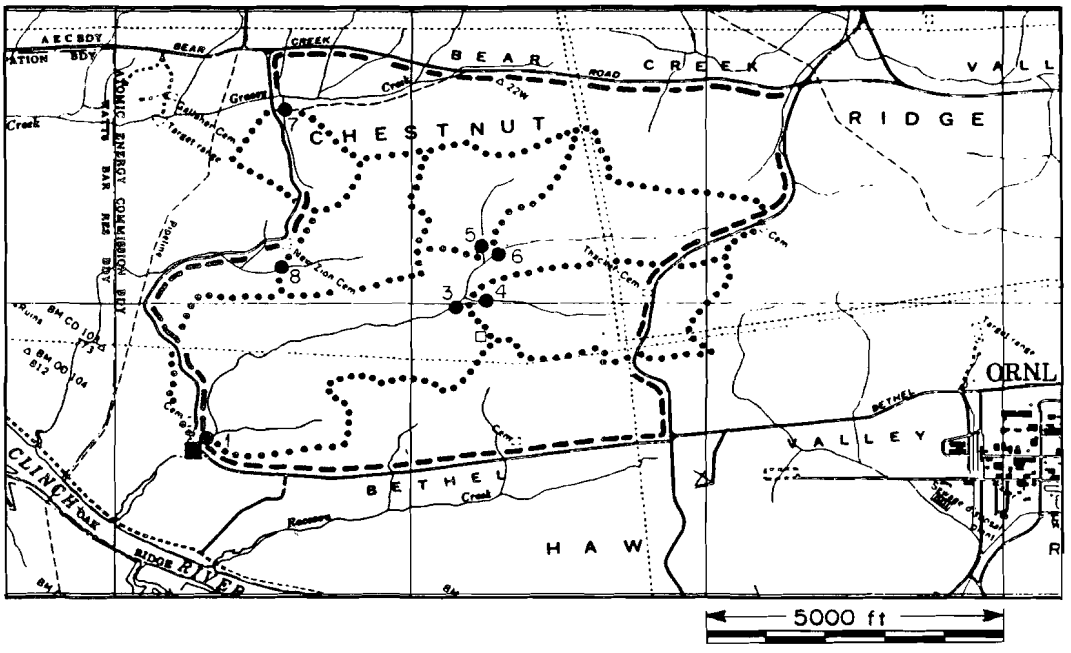
1. INTRODUCTION

The objective of this report is to present streamflow and precipitation data for the period October 1985 through March 1988, at sites located on West Chestnut Ridge (Fig. 1), near Oak Ridge National Laboratory. These data were collected as part of site characterization activities managed by the Low-level Waste Disposal Development and Demonstration (LLWDDD) program. Site characterization is required because West Chestnut Ridge is under consideration for development of a waste disposal facility for either solid waste or low level radioactive waste. In the early 1980's this area was under consideration as a site for a disposal facility for low level radioactive wastes generated at all three plants on the Oak Ridge reservation. Although that plan was never implemented the names of the hydrologic gaging stations are still know as the Central Waste Disposal Facility (CWDF) station 1, 2, etc.

Reports by Huff et al. (1984) and Elmore et al. (1985) present data collected in this vicinity prior to October 1983. Reports by Huff and Frederick (1984 and 1987) present streamflow and precipitation data for the period October 1983 through September 1985 and include detailed descriptions of equipment installed at each site and discussion of the methods used in converting field data to streamflow. Because these streamflow records were collected on watersheds relatively unaffected by works of man, they are especially important in determining the natural precipitation-runoff relationship for the area. Consequently, they provide valuable baseline data for comparison regulated basins. Work presented here documents data collection activities for the period October 1, 1985, through March 31, 1988. Summaries presented are primarily daily averages, with records collected at 15-min intervals. Arrangements may be made to obtain unit record data by contacting the Environmental Sciences Division, Hydrologic Data Center. Data are stored on floppy disks. Data for site CWDF 1 are IBM PC compatible for the entire period, but data for other sites are formatted for processing by Apple IIe computer up to

ORNL DWG 83-941R

CWDF SITE: SURFACE WATER HYDROLOGIC CHARACTERIZATION PLAN



■ PERMANENT FLUME LOCATION
● FLUME
□ RAINGAUGE
WEST CHESTNUT RIDGE SITE
CWDF CATCHMENT, SUBCATCHMENTS
SURFACE STREAMS

Fig. 1. Location of Streamflow gaging stations on West Chestnut Ridge.

March 4, 1988. Beginning March 4, 1988, data for all sites are IBM PC-compatible. Processing programs are modifications of ones obtained from Manning Technologies, Inc., for the Apple computer, and from Leopold Stevens, Inc., for the IBM PC-compatible data.

The precipitation data were collected at the Ish Creek gaging station (Fig. 1). Hourly or daily values of precipitation are available also by contacting the Hydrologic Data Center.

Mean daily flow rates for all five sites and daily precipitation are tabulated by month (Appendix A), and all data are given in SI units. In addition, the same data are organized by water year and given in American customary units (Appendix B). The use of American customary units was requested by LLWDDD personnel in order to be consistent with other site characterization reports in which these units are used exclusively.

2. GENERAL SUMMARY OF HYDROLOGIC CONDITIONS

2.1 WATER YEAR 1986

The drought conditions that began after the heavy rains in May 1984 continued. Normal rainfall was determined by using the 30-year period 1951 through 1980. Only one month during the water year had rainfall significantly above normal, August, when precipitation was 1.18 in. (29.97 mm) greater than the 3.69-in. (93.73-mm) normal for August. Three other months recorded slightly above normal: October, with 0.08 in. (2.03 mm) above the 3.06-in. (77.72-mm) normal; November, with 0.03 in. (0.76 mm) above the 4.69-in. (119.13-mm) normal; and February, with 0.08 in. (2.03 mm) above the 4.74-in. (120.40-mm) normal. The deficit for the year was 18.08 in. (461.77 mm). Cumulative deficit from May 1984 through September 1986, was 28.07 inches (712.98 mm).

The maximum day was February 17, with 1.76 in. (44.61 mm); the maximum week was May 22-29, with 3.18 in. (80.77 mm); and the maximum month was August, with 4.87 in. (123.79 mm).

2.2 WATER YEAR 1987

This year, five months recorded above-normal precipitation, but the deficit in the remaining seven months was so much greater than the excess that the drought continued. Above-normal months were October (+2.04 in., or 51.74 mm); November (+0.18 in., or 4.69 mm); February (+0.81 in., or 20.57 mm); May (+0.03 in., or 0.85 mm); and September, (+0.30 in., 7.60 mm). Deficit for the year was 7.92 in. (201.10 mm), and cumulative deficit since May 1984 was 35.98 in. (913.98 mm).

The maximum day was January 18, with 2.14 in. (54.35 mm); the maximum week was December 7-13, with 3.67 in. (93.20 mm); and the maximum month was December, with 5.26 in. (133.62 mm).

2.3 OCTOBER 1987 THROUGH MARCH 1988

Only one month, January, recorded above-normal precipitation, but the excess was insignificant [0.06 in. (1.55 mm)]. Consequently, the drought becomes increasingly severe. Deficit for the period was 11.72 in. (297.77 mm), and cumulative deficit since May of 1984 was 47.71 in. (1211.75 mm).

The maximum day was January 19, with 2.95 in. (74.97 mm); the maximum week was January 16-23, with 3.64 in. (92.46 mm); and the maximum month was January, with 5.33 in. (135.41 mm).

3. RECORD EVALUATION

The stage record for each site was examined for errors resulting from equipment malfunction or temporary changes in hydraulic conditions, such as debris buildup in the control structure. This examination relies upon comparison with flow at nearby sites, weather conditions, and the professional judgement of the hydrologist in charge, who made on-site inspections at each site once a week during the entire period. These weekly visits were invaluable, especially during low-flow periods at CWDF 1 and during the leaf buildup periods at CWDF 3 and CWDF 4.

Because the stage-discharge relationship, or rating curve, at all sites is considered reliable, discharge figures for all periods of valid stage record are considered "good," meaning that 95% of the daily discharge figures are within 10% of the true value. In all cases where the stage record appeared to be invalid, estimates of daily discharge have been reported and noted. In some instances, the estimated value is considered to be of comparable quality to the "valid" record, but for the most part, the estimated days are probably no better than "fair," meaning that 95% of the daily discharge figures are within 15% of the true value. Because of the weekly inspections, the only records considered "poor" (i.e., less than "fair" accuracy) are the relatively few instances when the flow exceeded the flume capacity at CWDF 4, or the extremely erratic stage record at CWDF 3. Of the 4565 station days of record covered by this report, 84% are considered good and 16% are considered fair. Only 15 days, or about 0.3%, are considered poor. Individual site records are discussed in the following paragraphs.

CWDF 1

Eighty-nine percent of the daily discharge values are good, and 11% are fair. Nearly all of the fair record was the result of faulty intake operation during periods when the stage was less than 0.26 ft (discharge less than 1.06 L/s, or 0.037 cfs). For some as yet unknown reason, the water level in the stilling-well does not drop below 0.26 ft, even though the bottom of the intake is at about 0.00 ft, which is also the minimum elevation of the flume throat, and the bottom of the stilling-well is at gage height (0.70 ft). Plans are under way to dig out the intake to identify and correct the problem. During the period covered by this report, major periods of low water were July and August of 1986 and August and September of 1987.

CWDF 3

Eighty-four percent of the daily discharge values are good, 15% are fair, and 1% are poor. The fair record was the result of erratic behavior of the electronic instrumentation which occurred at

unpredictable intervals throughout the period of record, or a combination of instrument problems and leaf buildup in the flume during the fall months. In February and March of 1988, modifications were made to the flume to allow installation of a stilling-well and a float-operated stage recorder, which has proven to be a more reliable instrument for field installation. Major periods of fair record are October 1986 and July, August, and September of 1987. The poor record occurred during a wet period in February 1986 and was the result of extremely erratic behavior of the instrumentation.

CWDF 4

Seventy-four percent of the daily discharge values are good, 25% are fair, and 1% poor. The fair record was the result of erratic behavior of the electronic instrumentation and of two 1-week periods when the instrument was completely out of service for repair. As was the case at CWDF 3, the erratic behavior occurred at unpredictable intervals. Also, as at CWDF 3, the instrumentation was replaced with a stilling-well and a float-operated recorder. Major periods of fair record were August and September of 1986 and July, August, September, November, and December of 1987. Poor record was obtained February 17-19, 1986; December 9-11, 1986; January 19-21, 1987; and February 28 to March 1, 1987, when flow exceeded the flume capacity.

CWDF 7

Eighty-one percent of the daily discharge values are good, and 19% are fair. The fair record was the result of instrumentation problems, as explained in remarks for sites CWDF 3 and CWDF 4. At this site, however, the problem was with the ultrasonic transducer used to measure water level rather than with the recording instrument. Replacement of the transducer relieved some of the problems, but the recording instrument was still unpredictable enough to make replacement with a float-operated instrument necessary. Major periods of fair record were October 1985; October and November of 1986; and August, September, and November of 1987.

CWDF 8

Ninety-two percent of the daily discharge values are good, and 8% are fair, considering the entire period of the report. However, the good record includes 382 days when the stream was dry. The dry periods were June 16, 1986, to October 25, 1986; October 29, 1986, to November 4, 1986; and June 10, 1987, to January 16, 1988. If these periods are excluded from the evaluation, 85% of the record is good and 15% fair. Fair record was October 1985 and November 1986, the result of erratic behavior of the instruments and/or leaves blocking the flume throat. Despite the fact that the instrumentation at this site performed appreciably better than sites 3, 4, and 7, these instruments were also replaced with float-operated instruments in March 1988, to be consistent with the other sites on the project and thus facilitate records processing.

4. RUNOFF VERSUS PRECIPITATION

Tables 1 through 3 present precipitation and runoff data by month and water year. Runoff data have been converted to millimeters from the basin area so that a direct ratio to precipitation in millimeters on the basin can be made.

These data provide some evidence of possible groundwater loss from the basins. Groundwater loss is important if West Chestnut Ridge is selected as a site for waste disposal. Groundwater loss is associated with subsurface flow paths that could transport contaminants away from the watershed. The basins are ranked in Table 4 according to precipitation loss (precipitation - runoff) with the basin above gaging station 8 having the greatest loss and that above station 7 having the least. Evapotranspiration (ET) is the largest component of the precipitation loss, and ET at the watershed scale in humid climates is mostly a function of climatic variables (solar radiation, temperature, humidity and windspeed); consequently, annual ET is usually considered to be uniform for a region. If ET is assumed to be uniform and if the annual change in storage is assumed to be negligible, then the basin in

Table 1. Comparison of precipitation and runoff for October 1985 to September 1986

Station	1985 Oct.	1985 Nov.	1985 Dec.	1986 Jan.	1986 Feb.	1986 Mar.	1986 Apr.	1986 May	1986 June	1986 July	1986 Aug.	1986 Sept.	1986 Water year
						Precipitation (mm)							
ISH	79.77	119.89	56.76	35.05	122.46	74.68	47.37	88.51	33.50	78.37	123.79	69.34	929.49
						Runoff (mm)							
CWDF 1	6.79	24.69	23.18	14.90	73.72	45.11	11.11	6.77	3.68	1.24	1.69	2.34	215.22
3	4.28	24.64	20.63	12.51	70.26	40.79	9.00	3.84	1.68	0.50	0.56	0.91	189.60
4	3.12	18.48	17.72	11.04	67.12	38.20	7.21	2.14	0.89	0.08	0.35	0.56	166.91
7	11.06	28.49	24.35	15.60	77.79	48.65	27.57	19.34	13.62	11.76	9.34	5.10	292.67
8	1.78	13.70	13.87	7.39	61.64	38.19	7.36	1.45	0.30	0.00	0.00	0.00	145.68
						Runoff/rainfall ratio							
CWDF 1	.09	0.21	0.41	0.43	0.60	0.60	0.23	0.08	0.11	0.02	0.01	0.03	0.23
3	.05	0.21	0.36	0.36	0.57	0.55	0.19	0.04	0.05	0.01	<.01	0.01	0.20
4	.04	0.15	0.31	0.31	0.55	0.51	0.15	0.02	0.03	<.01	<.01	0.01	0.18
7	.14	0.24	0.43	0.45	0.63	0.65	0.58	0.22	0.41	0.15	0.08	0.07	0.31
8	.02	0.11	0.24	0.21	0.50	0.51	0.16	0.02	0.01	0.00	0.00	0.00	0.16

Table 2. Comparison of precipitation and runoff for October 1986 to September 1987

Station	1986 Oct.	1986 Nov.	1986 Dec.	1987 Jan.	1987 Feb.	1987 Mar.	1987 Apr.	1987 May	1987 June	1987 July	1987 Aug.	1987 Sept.	1987 Water year
						Precipitation (mm)							
ISH	129.46	123.82	133.62	130.02	140.97	69.32	82.21	112.86	64.27	62.59	39.59	98.79	1187.52
						Runoff (mm)							
CWDF 1	6.03	17.87	48.68	67.50	61.96	49.57	42.84	8.29	3.85	2.67	0.47	1.43	311.16
3	2.52	13.54	51.98	62.66	59.53	46.26	39.88	5.30	2.37	1.60	0.35	0.64	286.63
4	1.44	11.92	48.07	56.41	57.23	47.10	34.39	4.04	1.09	0.41	0.08	0.23	262.41
7	9.84	15.95	38.40	58.76	63.71	63.12	49.98	20.45	10.07	9.33	8.42	8.92	356.95
8	0.05	3.49	23.65	34.77	36.14	39.47	31.21	2.61	0.09	0.00	0.00	0.00	171.48
						Runoff/rainfall ratio							
CWDF 1	0.05	0.14	0.36	0.52	0.44	0.72	0.52	0.07	0.06	0.04	0.01	0.01	0.26
3	0.02	0.11	0.39	0.48	0.42	0.66	0.49	0.05	0.04	0.03	0.01	0.01	0.24
4	0.01	0.10	0.36	0.43	0.41	0.68	0.44	0.04	0.02	0.01	<0.01	<.01	0.22
7	0.08	0.13	0.29	0.45	0.45	0.91	0.61	0.18	0.16	0.15	0.21	0.09	0.30
8	<0.01	0.03	0.18	0.27	0.26	0.57	0.38	0.02	<.01	0.00	0.00	0.00	0.14

Table 3. Comparison of precipitation and runoff for October 1987 to March 1988

Station	1987 Oct.	1987 Nov.	1987 Dec.	1988 Jan.	1988 Feb.	1988 Mar.	Oct. 1987-Mar. 1988
				Precipitation (mm)			
ISH	16.76	55.98	85.22	135.46	68.68	83.18	445.28
				Runoff (mm)			
CWDF 1	1.66	3.03	7.34	34.76	22.45	39.04	108.28
3	1.45	0.80	2.13	23.95	19.41	39.23	86.97
4	0.45	0.21	0.50	20.00	19.10	29.03	69.29
7	7.08	6.24	10.28	28.26	19.96	37.42	109.24
8	0.00	0.00	0.00	12.32	10.68	13.45	36.45
				Runoff/rainfall ratio			
CWDF 1	0.10	0.05	0.09	0.26	0.33	0.47	0.24
3	0.09	0.01	0.02	0.18	0.28	0.47	0.20
4	0.03	<.01	0.01	0.15	0.28	0.35	0.16
7	0.42	0.11	0.12	0.21	0.29	0.45	0.25
8	0.00	0.00	0.00	0.09	0.16	0.16	0.08

Table 4. Annual precipitation loss for West Chestnut Ridge basins

Water year	Station	Precipitation loss (mm)	Fraction of precipitation
1986	8	783.8	0.84
	4	762.6	0.82
	3	739.9	0.80
	1	714.3	0.77
	7	636.8	0.68
1987	8	1016.0	0.86
	4	952.1	0.80
	3	900.9	0.76
	1	876.4	0.74
	7	830.6	0.70

throughout the year from a groundwater spring. The net groundwater component for this basin may be positive. An independent estimate of ET is needed to calculate the actual net groundwater loss.

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APPENDIX A

MONTHLY FLOW SUMMARIES
(SI Units)

Table A.1. CWDF Hydrologic Summary for October 1985

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
10/01/85	33.02	17.80 *	5.90	1.80 *	0.88	0.08
10/02/85	2.54	12.09	5.06	1.60 *	0.97	0.26
10/03/85	0.25	8.21	3.69	1.10 *	0.84	0.29
10/04/85	1.02	6.83	2.89	0.90	0.66	0.22 *
10/05/85	0.00	5.64	1.95	0.61	0.54 *	0.22 *
10/06/85	0.00	5.08	1.39	0.42	0.49 *	0.21 *
10/07/85	0.00	4.70	1.28	0.39	0.45 *	0.21 *
10/08/85	0.00	4.64	1.22	0.37	0.44 *	0.21 *
10/09/85	0.00	4.51	1.22 *	0.38	0.43 *	0.20 *
10/10/85	0.00	4.43	1.22 *	0.43	0.42 *	0.20 *
10/11/85	0.00	4.26	1.22 *	0.43	0.40 *	0.20 *
10/12/85	0.00	4.19	1.21 *	0.42	0.39 *	0.19 *
10/13/85	0.00	4.19	1.20 *	0.42 *	0.39 *	0.19 *
10/14/85	0.00	4.45	1.20 *	0.41 *	0.41 *	0.21 *
10/15/85	2.80	4.66	1.58	0.59	0.70 *	0.23 *
10/16/85	0.00	4.59	1.94	0.50	0.59 *	0.21 *
10/17/85	0.00	4.25	1.13	0.40 *	0.42 *	0.20 *
10/18/85	0.00	4.13	1.13 *	0.36 *	0.38 *	0.19 *
10/19/85	0.00	3.98	1.12	0.34	0.38 *	0.18 *
10/20/85	0.00	3.94	1.13	0.34	0.54	0.17 *
10/21/85	14.48	6.35	2.93	0.52	0.77	0.25 *
10/22/85	0.00	5.73	2.35	0.57	0.68	0.23 *
10/23/85	18.79	10.38	5.38	0.81	0.99	0.32 *
10/24/85	0.77	11.87	5.33	1.22	0.96	0.22 *
10/25/85	0.00	7.79	3.36	0.83	0.59	0.21 *
10/26/85	0.00	6.58	2.53	0.62	0.47	0.20 *
10/27/85	1.88	5.98	2.32	0.59	0.52	0.20 *
10/28/85	1.42	6.17	2.58	0.63	0.58	0.21 *
10/29/85	1.02	5.59	2.05	0.52	0.50	0.20 *
10/30/85	1.78	5.60	2.10	0.54	0.56	0.20 *
10/31/85	0.00	5.45	2.20	0.59	0.58	0.19
VOLUME (M**3)		16766.8	6204.4	1697.8	1548.3	561.6
AVE FLOW (L/S)		6.26	2.32	0.63	0.58	0.21
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		2.53	1.60	1.17	4.13	0.67
PEAK FLOW (L/S)		28.60	18.01	2.09	2.31	0.61
MAX DAY (L/S)		17.80	5.90	1.80	0.99	0.32
MIN DAY (L/S)		3.94	1.12	0.34	0.38	0.08
TOTAL (MM)	79.77	6.79	4.28	3.12	11.06	1.78

NOTE: AN ASTERISK (*) AFTER THE DATA INDICATES AN ADJUSTED VALUE, WHERE THE ORIGINAL STAGE RECORD WAS INCOMPLETE, FAULTY OR AFFECTED BY BACKWATER. -99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.2. CWDF Hydrologic Summary for November 1985

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
11/01/85	22.62	10.13	4.85	1.01	0.96	0.30
11/02/85	0.00	22.75	9.26	2.83	1.26	0.73
11/03/85	7.62	16.70	8.14	2.53	1.03	0.64
11/04/85	9.65	21.99	11.05	3.55	1.60 *	1.14
11/05/85	0.00	22.34	11.37	3.85	1.80 *	1.52
11/06/85	0.00	16.56	8.46	2.82	1.40 *	1.28
11/07/85	1.52	13.66	6.47	2.00	1.00 *	0.93
11/08/85	0.00	10.74	4.46	1.27	0.68 *	0.58
11/09/85	0.00	8.75	3.73	1.10	0.62	0.48
11/10/85	0.00	7.87	3.56	1.13	0.72	0.43
11/11/85	0.00	7.31	3.35	1.09	0.76	0.37
11/12/85	0.00	6.81	3.13	1.01	0.76	0.34
11/13/85	0.00	6.44	2.94	0.98	0.81	0.25
11/14/85	0.00	6.40	2.83	0.96	0.83	0.26
11/15/85	0.00	5.99	2.70	0.92	0.84	0.21
11/16/85	7.61	6.75	3.74	1.03	1.05	0.55
11/17/85	0.00	7.43	3.53	1.05	0.90	0.59
11/18/85	0.00	6.32	2.80	0.96	0.80	0.18
11/19/85	0.00	5.89	2.65	0.92	0.82	0.18
11/20/85	0.00	5.49	2.47	0.83	0.85	0.13
11/21/85	14.47	7.77	4.13	0.94	0.97	0.15
11/22/85	4.57	16.21	7.62	2.48	1.15	0.51
11/23/85	0.00	14.05	6.62	2.24	0.99	0.40
11/24/85	0.00	12.03	6.79	2.01	1.19	0.48
11/25/85	0.00	11.45	7.43	1.80	1.10	0.58
11/26/85	0.00	10.66	6.93	1.81	1.26	0.69
11/27/85	26.17	59.02	37.69	11.13	2.13	3.51
11/28/85	23.12	137.40	86.10	22.30	5.01	9.85
11/29/85	2.54	141.19	97.64	24.89	7.96	13.29
11/30/85	0.00	79.64	50.53	14.90	4.92	9.39
VOLUME (M**3)		60975.9	35680.6	10051.8	3989.1	4314.8
AVE FLOW (L/S)		23.52	13.77	3.88	1.54	1.66
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		9.52	9.51	7.13	10.99	5.28
PEAK FLOW (L/S)		344.00	191.78	72.00 *	11.39	23.82
MAX DAY (L/S)		141.19	97.64	24.89	7.96	13.29
MIN DAY (L/S)		5.49	2.47	0.83	0.62	0.13
TOTAL (MM)	119.89	24.69	24.64	18.48	28.49	13.70

NOTE: AN ASTERISK (*) AFTER THE DATA INDICATES AN ADJUSTED VALUE, WHERE THE ORIGINAL STAGE RECORD WAS INCOMPLETE, FAULTY OR AFFECTED BY BACKWATER. -99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.3. CWDF Hydrologic Summary for December 1985

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
12/01/85	10.16	71.22	43.21	13.67	3.79	7.49
12/02/85	0.00	63.88	34.38	10.09	2.50	5.03
12/03/85	0.00	49.89	25.68	6.83	2.20	4.89
12/04/85	0.00	35.18	19.92	5.76	2.02	3.66
12/05/85	2.57	28.85	17.18	5.80	1.81	2.94
12/06/85	0.23	22.55	12.59	4.25	1.41	1.96
12/07/85	0.00	17.05	8.93	3.18	1.13	1.34
12/08/85	0.00	15.55	8.06	3.01	1.17	1.13
12/09/85	0.00	14.03	6.83	2.57	0.87	0.91
12/10/85	0.00	12.24	5.77	2.12	0.67	0.77
12/11/85	11.18	14.20	8.20	2.85	1.14	1.13
12/12/85	6.10	20.16	10.57	3.88	1.41	1.24
12/13/85	3.56	36.00	16.58	5.96	1.66	1.63
12/14/85	0.00	29.46	14.52	4.88	1.37	1.55
12/15/85	0.00	25.49	14.26	4.83	1.45	1.78
12/16/85	0.00	23.34	13.19	4.50	1.45	1.87
12/17/85	0.00	20.56	11.64	3.94	1.36	1.71
12/18/85	0.00	17.09	8.70	2.85	1.10	1.18
12/19/85	0.00	14.09	6.56	2.23	0.88	0.95
12/20/85	1.89	14.12	6.96	2.48	1.12	1.01
12/21/85	0.00	12.43	5.46	1.80	0.76	0.73
12/22/85	0.00	11.69	5.56	1.91	0.90	0.78
12/23/85	0.00	12.40	6.40	2.13	1.08	0.81
12/24/85	0.51	11.48	5.65	1.76	1.06	0.77
12/25/85	0.00	9.55	3.60	1.05	0.67	0.43
12/26/85	0.00	8.02	3.13	0.89	0.71	0.44
12/27/85	0.00	8.17	3.41	0.97	0.71	0.47
12/28/85	0.00	7.78	3.13	0.85	0.65	0.36
12/29/85	0.00	7.49	2.97	0.82	0.64	0.32
12/30/85	0.00	7.02	2.65	0.73	0.62	0.29
12/31/85	20.56	21.63	10.01	3.01	1.15	1.00
VOLUME (M**3)		57249.5	29868.5	9642.2	3409.3	4369.2
AVE FLOW (L/S)		21.37	11.15	3.60	1.27	1.63
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		8.65	7.70	6.62	9.09	5.18
PEAK FLOW (L/S)		88.00	57.66	19.74	4.67	11.75
MAX DAY (L/S)		71.22	43.21	13.67	3.79	7.49
MIN DAY (L/S)		7.02	2.65	0.73	0.62	0.29
TOTAL (MM)	56.76	23.18	20.63	17.72	24.35	13.87

NOTE: AN ASTERISK (*) AFTER THE DATA INDICATES AN ADJUSTED VALUE, WHERE THE ORIGINAL STAGE RECORD WAS INCOMPLETE, FAULTY OR AFFECTED BY BACKWATER.
-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.4. CWDF Hydrologic Summary for January 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
01/01/86	0.00	18.89	7.79	2.90	0.94	0.64
01/02/86	0.00	14.56	6.72	2.56	0.89	0.63
01/03/86	0.00	14.24	7.16	2.71	0.83	0.70
01/04/86	0.00	13.10	6.88	2.69	0.82	0.74
01/05/86	0.00	12.46	5.89	2.17	0.66	0.62
01/06/86	0.00	10.92	5.17	1.90	0.64	0.62
01/07/86	0.00	10.24	4.96	1.75	0.58	0.61
01/08/86	0.00	8.61	3.67	1.22	0.51	0.52
01/09/86	0.00	8.05	3.66	1.26	0.52	0.56
01/10/86	0.00	9.05	4.68	1.68	0.60	0.54
01/11/86	0.00	8.89	4.25	1.48	0.58	0.35
01/12/86	0.00	8.30	4.17	1.42	0.67	0.39
01/13/86	0.00	8.12	3.89	1.27	0.58	0.34
01/14/86	0.00	7.58	3.62	1.14	0.58	0.36
01/15/86	0.00	7.18	3.09	0.97	0.49	0.28
01/16/86	0.00	6.56	2.87	0.89	0.48	0.26
01/17/86	0.00	6.43	3.12	0.97	0.59	0.28
01/18/86	11.41	6.88	3.86	1.19	0.74	0.40
01/19/86	7.12	27.10	13.12	3.79	1.36	1.43
01/20/86	0.00	16.02	7.64	2.34	1.05	0.76
01/21/86	0.00	13.74	6.52	1.85	0.86	0.89
01/22/86	0.00	12.91	6.67	1.89	0.98	1.04
01/23/86	0.00	11.39	5.37	1.47	0.74	0.79
01/24/86	0.00	10.90	5.30	1.52	0.75	0.82
01/25/86	14.76	13.06	7.16	2.18	1.00	1.11
01/26/86	1.76	29.45	13.75	4.86	1.26	1.87
01/27/86	0.00	28.57	13.93	4.82	1.15	1.84
01/28/86	0.00	23.86	12.85	4.26	1.19	2.06
01/29/86	0.00	24.10	14.09	4.54	1.46	2.47
01/30/86	0.00	18.73	9.62	3.03	0.92	1.70
01/31/86	0.00	15.97	8.21	2.80	0.85	1.33
VOLUME (M**3)		36794.3	18116.4	6006.5	2183.3	2328.5
AVE FLOW (L/S)		13.74	6.76	2.24	0.82	0.87
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		5.56	4.67	4.12	5.82	2.76
PEAK FLOW (L/S)		42.50	27.38	6.31	3.19	4.71
MAX DAY (L/S)		29.45	14.09	4.86	1.46	2.47
MIN DAY (L/S)		6.43	2.87	0.89	0.48	0.26
TOTAL (MM)	35.05	14.90	12.51	11.04	15.60	7.39

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Table A.5. CWDF Hydrologic Summary for February 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
02/01/86	0.00	14.97	7.83	2.65	0.90	1.12
02/02/86	3.82	14.77	8.56	2.86	1.07	1.34
02/03/86	0.00	16.00	9.42	3.14	1.07	1.53
02/04/86	11.32	14.72	9.09	3.13	1.16	1.56
02/05/86	5.57	61.63	32.09	9.98	1.86	4.06
02/06/86	6.10	60.84	38.22	10.92	3.02	5.69
02/07/86	0.00	59.63	36.00 *	11.00 *	3.07	5.78
02/08/86	0.00	50.98	32.00 *	10.00 *	2.67	5.35
02/09/86	0.00	41.47	25.00 *	9.20 *	2.62	4.75
02/10/86	7.12	36.21	22.00 *	8.50 *	2.43	4.40
02/11/86	1.27	41.82	24.00 *	9.00 *	2.05	3.88
02/12/86	0.00	27.20	17.00 *	6.00 *	1.58	2.79
02/13/86	0.00	23.93	15.00 *	5.60 *	1.36	2.48
02/14/86	22.24	30.60	20.00 *	6.80 *	2.00	3.71
02/15/86	0.63	30.47	20.00 *	6.90 *	1.78	3.30
02/16/86	0.00	41.53	24.00 *	9.00 *	1.79	3.57
02/17/86	44.61	372.84	200.00 *	75.00 *	17.62	24.75
02/18/86	3.01	443.88	250.00 *	95.00 *	28.57	49.07 *
02/19/86	0.00	197.19	100.00 *	35.00 *	13.74	28.32
02/20/86	0.00	115.23	70.10	25.16	7.86	16.46
02/21/86	0.00	80.61	47.51	18.57	7.03 *	11.42
02/22/86	7.11	66.16	36.44	13.06	4.28	8.56
02/23/86	0.00	54.30	26.11	9.34	2.90	5.98
02/24/86	6.10	52.63	26.65	9.02	3.15	6.41
02/25/86	0.00	44.32	20.91	7.07	2.48	5.19
02/26/86	0.51	43.54	23.33	7.75	2.92	5.12
02/27/86	3.05	41.47	22.15	7.41	3.13	4.97
02/28/86	0.00	28.51	14.15	5.54	1.94	3.18
VOLUME (M**3)		182083.7	101741.2	36512.6	10890.7	19417.5
AVE FLOW (L/S)		75.27	42.06	15.09	4.50	8.03
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		30.47	29.04	27.74	32.16	25.48
PEAK FLOW (L/S)		736.00	300.00 *	120.00 *	42.04	80.00 *
MAX DAY (L/S)		443.88	250.00	95.00	28.57	49.07
MIN DAY (L/S)		14.72	7.83	2.65	0.90	1.12
TOTAL (MM)	122.46	73.72	70.26	67.12	77.79	61.64

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.6. CWDF Hydrologic Summary for March 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
03/01/86	0.00	23.75	11.36	4.78	1.58	2.52
03/02/86	0.00	22.13	11.29	4.87	1.74	2.43
03/03/86	0.00	21.84	10.98	4.59	1.82	2.34
03/04/86	0.00	19.29	9.22	3.98	1.64	2.12
03/05/86	0.00	17.46	8.03	3.57	1.45	1.82
03/06/86	0.64	17.42	8.44	3.69	1.51	1.92
03/07/86	0.00	15.30	6.70	2.95	1.32	1.55
03/08/86	0.00	13.33	5.43	2.51	1.16	1.33
03/09/86	0.00	12.68	5.67	2.69	1.21	1.28
03/10/86	0.00	13.06	6.63	3.20	1.60	1.47
03/11/86	4.83	15.34	7.57	3.24	1.41	1.71
03/12/86	17.40	40.87	17.65	7.47	1.89	3.15
03/13/86	13.97	78.95	39.13	14.91	2.92	5.99
03/14/86	4.06	77.16	41.82	14.31	4.03	7.72
03/15/86	0.51	66.28	36.77	12.29	3.40	6.79
03/16/86	0.00	56.54	29.14	9.34	2.68	5.78
03/17/86	0.00	46.60	22.51	8.35	2.34	5.05
03/18/86	0.03	38.94	20.42	8.09	2.42	4.57
03/19/86	33.24	211.32	122.34	31.76	9.87	14.57
03/20/86	0.00	115.14	71.95	22.83	7.80	11.98
03/21/86	0.00	75.75	42.37	13.92	4.62	10.98
03/22/86	0.00	59.50	29.62	10.26	3.39	8.82
03/23/86	0.00	48.71	24.04	7.92	2.92	7.27
03/24/86	0.00	37.01	18.75	6.97	2.15	5.63
03/25/86	0.00	28.82	15.15	5.99	2.01	4.33
03/26/86	0.00	25.18	13.62	5.61	2.16	3.36
03/27/86	0.00	22.49	12.01	5.10	1.89 *	2.89
03/28/86	0.00	19.38	9.75	4.28	1.52	2.76
03/29/86	0.00	17.42	8.89	3.93	1.50	2.50 *
03/30/86	0.00	16.47	8.52	3.68	1.49	2.40 *
03/31/86	0.00	15.35	7.92	3.41	1.39	2.20 *
VOLUME (M**3)		111411.1	59070.8	20778.3	6810.9	12029.5
AVE FLOW (L/S)		41.60	22.05	7.76	2.54	4.49
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		16.84	15.23	14.26	18.16	14.26
PEAK FLOW (L/S)		718.00	291.53	100.00 *	17.68	37.40
MAX DAY (L/S)		211.32	122.34	31.76	9.87	14.57
MIN DAY (L/S)		12.68	5.43	2.51	1.16	1.28
TOTAL (MM)	74.68	45.11	40.79	38.20	48.65	38.19

NOTE: AN ASTERISK (*) AFTER THE DATA INDICATES AN ADJUSTED VALUE, WHERE THE ORIGINAL STAGE RECORD WAS INCOMPLETE, FAULTY OR AFFECTED BY BACKWATER. -99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.7. CWDF Hydrologic Summary for April 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
04/01/86	0.00	14.27	7.55	3.14	1.47	2.00 *
04/02/86	0.00	13.66	7.45	3.04	1.52	1.90 *
04/03/86	0.00	12.86	6.98	2.82	1.48	1.80 *
04/04/86	0.00	11.33	6.14	2.17	1.58	1.40 *
04/05/86	0.00	10.26	5.57	1.70	1.76	1.04
04/06/86	5.08	11.08	5.88	1.68	1.90	1.18
04/07/86	0.00	11.35	5.91	1.65	1.82	1.15
04/08/86	19.57	29.44	14.03	4.06	2.39	2.50
04/09/86	0.00	17.21	7.60	2.26	1.86	1.22
04/10/86	0.00	14.00	5.77	1.68	1.56	0.95
04/11/86	0.00	12.87	5.50	1.62	1.63	0.93
04/12/86	0.00	12.02	5.08	1.47	1.46	0.88
04/13/86	0.00	11.29	4.99	1.44	1.56	0.90
04/14/86	1.02	10.66	4.90	1.43	1.66	0.88
04/15/86	0.50	9.76	4.52	1.34	1.63	0.78
04/16/86	0.00	9.11	4.15	1.08	1.53	0.58
04/17/86	0.00	8.74	4.05	1.06	1.56	0.57
04/18/86	0.00	8.31	3.59	0.98	1.20	0.52
04/19/86	0.00	7.75	3.48	1.00	1.28	0.52
04/20/86	7.49	8.27	4.68	1.27	1.71	0.73
04/21/86	3.30	11.00	5.73	1.35	1.63	0.79
04/22/86	0.00	8.72	3.95	0.90	1.17	0.46
04/23/86	0.00	7.50	2.83	0.68	1.02	0.32
04/24/86	0.00	6.96	2.75	0.72	1.07	0.35
04/25/86	0.00	6.69	2.80	0.80	1.12	0.41
04/26/86	0.00	6.33	2.78	0.83	1.16	0.42
04/27/86	0.00	5.92	2.58	0.79	1.18	0.39
04/28/86	10.41	7.64	4.04	0.94	1.53	0.54
04/29/86	0.00	6.92	3.10	0.80	1.15	0.42
04/30/86	0.00	5.65	2.42	0.68	1.09	0.32
VOLUME (M**3)		27438.0	13029.1	3920.8	3860.4	2319.8
AVE FLOW (L/S)		10.59	5.03	1.51	1.49	0.89
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		4.29	3.47	2.78	10.64	2.84
PEAK FLOW (L/S)		53.80	29.51	6.84	4.51	6.54
MAX DAY (L/S)		29.44	14.03	4.06	2.39	2.50
MIN DAY (L/S)		5.65	2.42	0.68	1.02	0.32
TOTAL (MM)	47.37	11.11	9.00	7.21	27.57	7.36

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.8. CWDF Hydrologic Summary for May 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
05/01/86	0.00	5.38	2.50	0.72	1.39	0.31
05/02/86	0.00	5.06	1.75	0.51	0.91	0.17
05/03/86	0.00	4.68	1.36	0.37	0.76	0.08
05/04/86	0.00	4.58	1.23	0.32	0.74	0.08
05/05/86	0.00	4.51	1.29	0.37	0.85	0.10
05/06/86	0.00	4.54	1.41	0.41	0.99	0.13
05/07/86	0.00	4.41	1.42	0.41	0.95	0.12
05/08/86	0.00	4.26	1.33	0.37	0.96	0.11
05/09/86	0.00	4.05	1.01	0.27	0.75	0.08
05/10/86	0.00	3.92	0.96	0.27	0.84	0.08
05/11/86	0.00	3.81	1.08	0.26	0.99	0.08
05/12/86	0.00	3.69	1.20	0.27	1.04	0.08
05/13/86	0.25	3.78	1.24	0.28	1.01	0.08
05/14/86	0.00	3.66	1.03	0.24	0.90	0.07
05/15/86	0.00	3.47	0.87	0.20	0.95	0.07
05/16/86	0.00	3.28	0.78	0.16	0.86	0.05
05/17/86	0.00	3.11	0.65	0.13	0.76	0.02
05/18/86	7.49	3.47	1.13	0.17	1.13	0.03
05/19/86	0.00	3.65	1.23	0.22	1.02	0.02
05/20/86	0.00	3.43	0.85	0.15	0.77	0.01
05/21/86	0.00	3.26	0.56	0.08	0.69	0.01
05/22/86	0.00	3.12	0.40	0.05	0.63	0.01
05/23/86	20.57	6.51	2.65	0.23	1.13	0.02
05/24/86	33.02	12.23	6.07	0.61	1.39	0.66
05/25/86	3.30	21.19	6.73	1.25	1.47	0.62
05/26/86	9.69	8.81	3.69	0.67	1.32	0.29
05/27/86	3.40	17.15	6.22	1.20	1.60	0.67
05/28/86	10.79	17.06	6.04	1.28	1.48	0.56
05/29/86	0.00	10.66	3.59	0.90	1.21	0.35
05/30/86	0.00	7.23	2.32	0.63	0.98	0.19
05/31/86	0.00	5.69	1.70	0.47	0.86	0.13
VOLUME (M**3)		16731.4	5554.7	1163.8	2706.9	456.2
AVE FLOW (L/S)		6.25	2.07	0.43	1.01	0.17
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		2.53	1.43	0.80	7.22	0.54
PEAK FLOW (L/S)		152.00	99.45	7.53	15.96	16.90
MAX DAY (L/S)		21.19	6.73	1.28	1.60	0.67
MIN DAY (L/S)		3.11	0.40	0.05	0.63	0.01
TOTAL (MM)	88.51	6.77	3.84	2.14	19.34	1.45

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Table A.9. CWDF Hydrologic Summary for June 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
06/01/86	3.79	4.85	1.44	0.41	0.93	0.11
06/02/86	0.00	4.77	1.38	0.40	1.03	0.09
06/03/86	0.00	4.03	1.06	0.34	1.00	0.07
06/04/86	0.00	4.06	1.12	0.28	1.18	0.06
06/05/86	24.89	13.14	4.21	0.64	0.98	0.10
06/06/86	0.00	13.00	3.74	0.95	0.80	0.11
06/07/86	0.00	6.93	1.88	0.51	0.73	0.11
06/08/86	2.03	5.69	1.53	0.39	0.75	0.09
06/09/86	2.79	5.10	1.61	0.31	0.86	0.08
06/10/86	0.00	5.60	1.82	0.33	0.84	0.08
06/11/86	0.00	4.67	1.43	0.28	0.79	0.09
06/12/86	0.00	3.88	1.01	0.21	0.74	0.05
06/13/86	0.00	3.38	0.69	0.12	0.65	0.02
06/14/86	0.00	2.92	0.55	0.08	0.60	0.01
06/15/86	0.00	2.52	0.48	0.07	0.64	0.01
06/16/86	0.00	2.25	0.40	0.05	0.58	0.00
06/17/86	0.00	2.03	0.39	0.04	0.63	0.00
06/18/86	0.00	1.87	0.37 *	0.02	0.57	0.00
06/19/86	0.00	1.85	0.35 *	0.02	0.59	0.00
06/20/86	0.00	1.85	0.34 *	0.02	0.59	0.00
06/21/86	0.00	1.50	0.32 *	0.02	0.60	0.00
06/22/86	0.00	1.41	0.30 *	0.02	0.55	0.00
06/23/86	0.00	1.30 *	0.28 *	0.02	0.55	0.00
06/24/86	0.00	1.20 *	0.26 *	0.02	0.64	0.00
06/25/86	0.00	1.10 *	0.25 *	0.01	0.55	0.00
06/26/86	0.00	1.00 *	0.23 *	0.01	0.64	0.00
06/27/86	0.00	0.90 *	0.21 *	0.01	0.77	0.00
06/28/86	0.00	0.80 *	0.19 *	0.01	0.73	0.00
06/29/86	0.00	0.70 *	0.17 *	0.01	0.81	0.00
06/30/86	0.00	0.80 *	0.16 *	0.02	0.75	0.00
VOLUME (M**3)		9080.6	2433.9	485.6	1906.8	93.3
AVE FLOW (L/S)		3.50	0.94	0.19	0.74	0.04
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		1.42	0.65	0.34	5.25	0.11
PEAK FLOW (L/S)		73.00	29.72	4.26	11.39	0.49
MAX DAY (L/S)		13.14	4.21	0.95	1.18	0.11
MIN DAY (L/S)		0.70	0.16	0.01	0.55	0.00
TOTAL (MM)	33.50	3.68	1.68	0.89	13.62	0.30

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.10. CWDF Hydrologic Summary for July 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
07/01/86	6.86	1.51	0.24	0.02	0.90	0.00
07/02/86	29.08	5.46	1.23	0.10	1.14	0.00
07/03/86	0.00	2.59	0.50 *	0.02	0.62	0.00
07/04/86	0.00	1.94	0.20	0.01	0.51	0.00
07/05/86	0.00	1.61	0.17	0.01	0.56	0.00
07/06/86	0.00	1.32	0.16	0.01	0.53	0.00
07/07/86	0.00	0.90 *	0.14	0.01	0.52	0.00
07/08/86	0.00	0.70 *	0.11	0.01	0.63	0.00
07/09/86	0.00	0.50 *	0.12	0.01	0.67	0.00
07/10/86	11.43	1.42	0.50	0.01	0.81	0.00
07/11/86	1.02	1.59 *	0.34	0.01	0.76	0.00
07/12/86	0.00	0.96	0.25	0.01	0.64	0.00
07/13/86	12.70	1.31	0.53	0.02	0.74	0.00
07/14/86	9.91	2.24	0.94	0.04	0.79	0.00
07/15/86	0.00	2.81	0.65	0.03	0.70	0.00
07/16/86	0.00	1.73	0.38	0.02	0.66	0.00
07/17/86	0.00	1.47	0.27	0.01	0.52	0.00
07/18/86	0.00	0.90 *	0.19	0.01	0.47	0.00
07/19/86	0.00	0.60 *	0.16	0.01	0.48	0.00
07/20/86	0.00	0.50 *	0.14	0.01	0.45	0.00
07/21/86	0.00	0.45 *	0.14 *	0.01	0.49	0.00
07/22/86	0.00	0.40 *	0.13 *	0.01	0.48	0.00
07/23/86	0.00	0.34 *	0.12	0.01	0.53	0.00
07/24/86	0.00	0.30 *	0.11 *	0.01 *	0.55	0.00
07/25/86	0.00	0.28 *	0.10	0.01 *	0.54	0.00
07/26/86	0.00	0.26 *	0.09	0.01 *	0.58	0.00
07/27/86	1.78	0.26 *	0.09	0.01 *	0.59	0.00
07/28/86	0.00	0.26 *	0.09	0.01 *	0.64	0.00
07/29/86	0.00	0.24 *	0.08	0.01 *	0.53	0.00
07/30/86	0.00	0.24 *	0.08 *	0.01 *	0.39	0.00
07/31/86	5.59	0.30 *	0.11	0.01	0.64	0.00
VOLUME (M**3)		3057.7	722.3	42.3	1646.8	0.0
AVE FLOW (L/S)		1.14	0.27	0.02	0.61	0.00
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		0.46	0.19	0.03	4.39	0.00
PEAK FLOW (L/S)		15.70	5.29	0.49	3.82	0.00
MAX DAY (L/S)		5.46	1.23	0.10	1.14	0.00
MIN DAY (L/S)		0.24	0.08	0.01	0.39	0.00
TOTAL (MM)	78.37	1.24	0.50	0.08	11.76	0.00

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.11. CWDF Hydrologic Summary for August 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
08/01/86	0.00	0.60 *	0.20	0.01 *	0.40	0.00
08/02/86	0.00	0.40 *	0.13	0.01 *	0.45	0.00
08/03/86	0.00	0.28 *	0.08	0.01 *	0.35	0.00
08/04/86	0.00	0.26 *	0.07	0.01 *	0.39	0.00
08/05/86	0.00	0.22 *	0.06	0.01 *	0.38	0.00
08/06/86	2.04	0.26 *	0.07	0.01 *	0.61	0.00
08/07/86	4.06	0.34 *	0.13	0.03 *	0.61	0.00
08/08/86	0.00	0.32 *	0.19	0.03 *	0.53	0.00
08/09/86	0.00	0.30 *	0.12	0.03 *	0.60	0.00
08/10/86	16.10	0.80 *	0.17	0.03 *	0.52	0.00
08/11/86	9.80	3.02	0.66	0.10 *	0.75	0.00
08/12/86	0.00	1.44	0.27	0.06 *	0.46	0.00
08/13/86	0.00	1.17	0.21	0.04 *	0.25	0.00
08/14/86	0.00	0.90 *	0.19	0.02 *	0.39	0.00
08/15/86	0.00	0.85 *	0.17	0.01 *	0.41	0.00
08/16/86	2.79	0.80 *	0.16	0.01 *	0.49	0.00
08/17/86	0.00	0.90 *	0.25	0.02 *	0.56	0.00
08/18/86	0.00	0.75 *	0.18	0.01 *	0.48	0.00
08/19/86	0.00	0.60 *	0.13	0.01 *	0.42	0.00
08/20/86	20.58	3.22	0.54	0.10 *	0.67	0.00
08/21/86	0.00	1.22	0.25	0.06 *	0.57	0.00
08/22/86	0.00	1.00 *	0.20	0.04 *	0.51	0.00
08/23/86	0.00	0.85 *	0.17	0.02 *	0.50	0.00
08/24/86	0.00	0.70 *	0.14	0.02 *	0.49	0.00
08/25/86	0.00	0.55 *	0.08	0.01 *	0.36	0.00
08/26/86	30.86	2.99	0.49	0.04 *	0.73	0.00
08/27/86	25.27	9.14	1.86	0.70 *	1.05	0.00
08/28/86	10.93	7.44	1.27	0.50 *	0.46	0.00
08/29/86	0.00	3.12	0.35	0.10 *	0.20	0.00
08/30/86	0.00	2.03	0.29	0.08 *	0.22	0.00
08/31/86	1.36	1.87	0.35	0.10 *	0.32	0.00
VOLUME (M**3)		4176.6	814.8	192.7	1307.2	0.0
AVE FLOW (L/S)		1.56	0.30	0.07	0.49	0.00
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		0.63	0.21	0.13	3.49	0.00
PEAK FLOW (L/S)		64.00	23.67	8.00 *	7.83	0.00
MAX DAY (L/S)		9.14	1.86	0.70	1.05	0.00
MIN DAY (L/S)		0.22	0.06	0.01	0.20	0.00
TOTAL (MM)	123.79	1.69	0.56	0.35	9.34	0.00

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Table A.12. CWDF Hydrologic Summary for September 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
09/01/86	10.92	3.18	0.74	0.30 *	0.40	0.00
09/02/86	21.34	11.54	2.57	1.00 *	0.77	0.00
09/03/86	0.00	7.13	1.15	0.40 *	0.48	0.00
09/04/86	3.30	4.51	0.83	0.10 *	0.46	0.00
09/05/86	2.29	3.60	0.66	0.04	0.34	0.00
09/06/86	0.00	2.40	0.35	0.02	0.17	0.00
09/07/86	0.00	1.78	0.31	0.02	0.16	0.00
09/08/86	0.00	1.56	0.30 *	0.02	0.18	0.00
09/09/86	0.00	1.45	0.28 *	0.03	0.17	0.00
09/10/86	0.00	1.25	0.26 *	0.05	0.23	0.00
09/11/86	0.00	1.20	0.24 *	0.03	0.25	0.00
09/12/86	10.66	2.26	0.56	0.13	0.27	0.00
09/13/86	0.00	1.36	0.26	0.06	0.16	0.00
09/14/86	0.00	1.22	0.24	0.05	0.18	0.00
09/15/86	0.00	1.18	0.22	0.05	0.21	0.00
09/16/86	8.51	2.10	0.49	0.12	0.29	0.00
09/17/86	0.76	1.45	0.37	0.11	0.26	0.00
09/18/86	0.00	1.38	0.40	0.05	0.31	0.00
09/19/86	3.81	1.58	0.44	0.04	0.34	0.00
09/20/86	0.64	1.78	0.47	0.08	0.31	0.00
09/21/86	0.00	1.61	0.42	0.07	0.27	0.00
09/22/86	0.00	1.42	0.42	0.05	0.24	0.00
09/23/86	6.35	1.79	0.61	0.12	0.28	0.00
09/24/86	0.00	1.47	0.44	0.12	0.25	0.00
09/25/86	0.00	1.33	0.37	0.07	0.22	0.00
09/26/86	0.00	1.18	0.32 *	0.06	0.22	0.00
09/27/86	0.00	1.09	0.28 *	0.07	0.19	0.00
09/28/86	0.00	1.06	0.22 *	0.08	0.20	0.00
09/29/86	0.76	1.06	0.30 *	0.09	0.22	0.00
09/30/86	0.00	1.09	0.74	0.12	0.24	0.00
VOLUME (M**3)		5789.7	1318.5	306.7	714.5	0.0
AVE FLOW (L/S)		2.23	0.51	0.12	0.28	0.00
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		0.90	0.35	0.22	1.97	0.00
PEAK FLOW (L/S)		30.30	11.96	3.00 *	2.76	0.00
MAX DAY (L/S)		11.54	2.57	1.00	0.77	0.00
MIN DAY (L/S)		1.06	0.22	0.02	0.16	0.00
TOTAL (MM)	69.34	2.34	0.91	0.56	5.10	0.00

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Table A.13. CWDF Hydrologic Summary for October 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
10/01/86	0.00	1.05 *	0.69	0.12 *	0.24 *	0.00
10/02/86	0.00	1.00 *	0.86	0.12 *	0.24 *	0.00
10/03/86	0.00	0.96 *	0.71	0.11 *	0.23 *	0.00
10/04/86	0.00	0.94 *	0.54	0.11 *	0.23 *	0.00
10/05/86	0.00	0.92 *	0.48	0.10 *	0.22 *	0.00
10/06/86	0.00	0.90 *	0.41	0.09 *	0.21 *	0.00
10/07/86	0.00	0.88 *	0.39 *	0.08 *	0.20 *	0.00
10/08/86	0.00	0.86 *	0.37 *	0.07 *	0.20 *	0.00
10/09/86	3.93	0.95 *	0.58	0.14 *	0.32 *	0.00
10/10/86	15.12	2.12	0.82	0.20 *	0.45 *	0.00
10/11/86	7.37	4.20	1.19	0.30 *	0.65 *	0.00
10/12/86	20.70	4.16	1.29	0.32 *	0.70 *	0.00
10/13/86	19.38	15.09	3.54	0.88 *	0.96 *	0.00
10/14/86	5.52	11.13	1.77	0.44 *	0.50 *	0.00
10/15/86	0.00	5.13	0.81 *	0.20 *	0.47 *	0.00
10/16/86	0.00	3.66	0.58 *	0.14 *	0.43 *	0.00
10/17/86	0.00	3.03	0.48 *	0.12 *	0.42 *	0.00
10/18/86	0.00	2.69	0.43 *	0.11 *	0.41 *	0.00
10/19/86	0.00	2.48	0.40 *	0.10 *	0.40 *	0.00
10/20/86	0.00	2.45	0.39 *	0.10 *	0.39 *	0.00
10/21/86	0.00	2.34	0.37 *	0.09 *	0.38 *	0.00
10/22/86	0.00	2.31	0.36 *	0.08 *	0.37 *	0.00
10/23/86	0.00	2.31	0.36 *	0.07 *	0.36 *	0.00
10/24/86	5.14	2.44	0.38 *	0.08 *	0.38 *	0.00
10/25/86	51.79	49.34	9.79	2.06 *	2.60 *	0.00
10/26/86	0.51	19.01	5.51	1.16 *	1.50 *	0.15
10/27/86	0.00	8.84	2.78	0.58 *	0.75 *	0.02
10/28/86	0.00	6.37	1.79	0.37 *	0.48 *	0.00
10/29/86	0.00	5.49	1.54 *	0.29 *	0.45 *	0.00
10/30/86	0.00	4.87	1.36 *	0.24 *	0.43 *	0.00
10/31/86	0.00	4.34	1.21 *	0.21 *	0.38 *	0.00
VOLUME (M**3)		14883.3	3644.4	784.5	1378.1	14.7
AVE FLOW (L/S)		5.56	1.36	0.29	0.51	0.01
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		2.25	0.94	0.54	3.68	0.02
PEAK FLOW (L/S)		76.00	17.81	-99.00	-99.00	0.98 *
MAX DAY (L/S)		49.34	9.79	2.06	2.60	0.15
MIN DAY (L/S)		0.86	0.36	0.07	0.20	0.00
TOTAL (MM)	129.46	6.03	2.52	1.44	9.84	0.05

NOTE: AN ASTERISK (*) AFTER THE DATA INDICATES AN ADJUSTED VALUE, WHERE THE ORIGINAL STAGE RECORD WAS INCOMPLETE, FAULTY OR AFFECTED BY BACKWATER. -99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.14. CWDF Hydrologic Summary for November 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
11/01/86	0.76	4.08	1.14 *	0.20 *	0.37 *	0.00
11/02/86	0.00	3.91	1.09 *	0.19 *	0.36 *	0.00
11/03/86	0.00	3.73	1.04 *	0.18 *	0.35 *	0.00
11/04/86	2.79	3.66	1.02 *	0.17 *	0.34 *	0.00
11/05/86	2.03	4.06	1.13 *	0.19 *	0.32	0.03 *
11/06/86	0.00	3.93	1.09 *	0.18 *	0.30	0.09 *
11/07/86	17.26	5.90	2.44	0.77	0.29	0.15 *
11/08/86	0.51	8.95	2.97	0.89	0.36	0.30 *
11/09/86	9.91	11.34	4.23	1.16	0.37	0.28 *
11/10/86	0.00	9.51	3.23	1.52	0.29	0.26 *
11/11/86	20.56	32.56	12.49	5.07	1.03	0.60 *
11/12/86	0.00	22.03	8.73	4.00	1.20 *	0.50 *
11/13/86	0.00	12.06	4.61	2.08	0.60 *	0.40 *
11/14/86	4.32	8.29	2.97	1.21	0.50 *	0.30 *
11/15/86	3.31	9.01	4.14	1.58	0.48 *	0.26 *
11/16/86	0.75	8.10	3.73	1.47	0.46 *	0.22 *
11/17/86	0.76	7.22	3.40	1.35	0.44 *	0.18 *
11/18/86	0.00	6.50	2.90	1.24	0.44 *	0.16 *
11/19/86	0.00	5.62	2.23	0.89	0.44 *	0.14 *
11/20/86	12.19	10.21	4.61	1.46	0.64 *	0.20 *
11/21/86	0.00	10.95	3.77	1.59	0.60 *	0.18 *
11/22/86	0.00	8.22	3.03	1.28	0.58 *	0.16 *
11/23/86	12.07	10.30	5.25	1.99	0.56 *	0.15 *
11/24/86	14.36	59.46	23.09	7.94	2.10 *	1.20 *
11/25/86	9.41	44.50	21.05	7.04	2.00 *	1.30 *
11/26/86	11.94	85.66	42.73	10.22	2.52 *	1.40 *
11/27/86	0.00	50.72	25.11	7.42	2.30 *	1.28 *
11/28/86	0.00	27.49	15.29	5.07	2.10 *	1.13 *
11/29/86	0.00	18.48	10.31	3.77	1.86 *	1.00 *
11/30/86	0.89	14.50	8.06	2.95	1.65 *	0.86 *
VOLUME (M**3)		44146.1	19602.4	6486.0	2233.4	1099.9
AVE FLOW (L/S)		17.03	7.56	2.50	0.86	0.42
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		6.90	5.22	4.60	6.15	1.35
PEAK FLOW (L/S)		109.00	57.01	15.31	-99.00	3.71 *
MAX DAY (L/S)		85.66	42.73	10.22	2.52	1.40
MIN DAY (L/S)		3.66	1.02	0.17	0.29	0.00
TOTAL (MM)	123.82	17.87	13.54	11.92	15.95	3.49

NOTE: AN ASTERISK (*) AFTER THE DATA INDICATES AN ADJUSTED VALUE, WHERE THE ORIGINAL STAGE RECORD WAS INCOMPLETE, FAULTY OR AFFECTED BY BACKWATER. -99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.15. CWDF Hydrologic Summary for December 1986

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
12/01/86	7.24	11.51	6.59	2.38	1.42 *	0.73 *
12/02/86	8.89	20.56	11.44	4.08	1.20 *	0.60 *
12/03/86	0.00	18.62	9.13	3.49	0.98 *	0.46 *
12/04/86	0.00	14.62	6.62	2.87	0.77 *	0.33 *
12/05/86	0.00	12.17	5.23	2.42	0.42	0.24
12/06/86	0.00	10.36	4.30	2.02	0.37	0.24
12/07/86	0.00	9.12	3.92	1.83	0.41	0.25
12/08/86	30.30	45.60	22.09	7.04	1.44	1.43
12/09/86	45.36	359.89	222.98	70.00 *	11.80	14.30
12/10/86	3.68	233.61	146.94	48.00 *	10.14	15.32
12/11/86	13.35	168.26	108.50	35.00 *	6.89	12.45
12/12/86	0.51	84.13	71.00	22.37	5.63	8.99
12/13/86	0.00	54.14	38.74	12.07	3.18	5.60
12/14/86	0.00	25.75	27.40	8.96	1.95	3.89
12/15/86	0.00	20.75	20.25	7.78	1.29	3.07
12/16/86	0.00	42.56	14.32	6.61	0.97	2.01
12/17/86	10.46	29.18	12.99	5.66	1.10	1.64
12/18/86	3.15	25.57	19.99	7.73	1.35	1.91
12/19/86	0.00	20.14	15.18	6.32	1.14	1.34
12/20/86	0.00	17.04	14.18	5.92	1.07	1.42
12/21/86	0.00	17.64	10.77	4.58	0.82	1.19
12/22/86	0.00	26.15	8.73	3.87	0.69	0.95
12/23/86	9.92	19.12	10.65	4.45	0.96	1.21
12/24/86	0.76	15.70	13.42	5.76	1.30	1.56
12/25/86	0.00	14.75	8.76	3.94	0.93	1.04
12/26/86	0.00	13.88	7.12	3.32	0.75	0.82
12/27/86	0.00	13.02	6.94	3.27	0.69	0.74
12/28/86	0.00	13.16	6.36	3.06	0.65	0.67
12/29/86	0.00	11.55	5.87	2.78	0.63	0.61
12/30/86	0.00	11.68	5.86	2.81	0.72	0.64
12/31/86	0.00	11.44	4.85	2.26	0.57	0.58
VOLUME (M**3)		120240.3	75264.8	26149.0	5376.7	7450.3
AVE FLOW (L/S)		44.89	28.10	9.76	2.01	2.78
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		18.18	19.41	17.95	14.34	8.83
PEAK FLOW (L/S)		478.00	308.69	110.00 *	18.85	21.70
MAX DAY (L/S)		359.89	222.98	70.00	11.80	15.32
MIN DAY (L/S)		9.12	3.92	1.83	0.37	0.24
TOTAL (MM)	133.62	48.68	51.98	48.07	38.40	23.65

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.16. CWDF Hydrologic Summary for January 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
01/01/87	2.53	12.40 *	5.24	2.47	0.62	0.66
01/02/87	0.51	11.00 *	4.16	2.06	0.66	0.56
01/03/87	0.00	9.27	3.15	1.50	0.50	0.45
01/04/87	0.00	8.42	2.90	1.44	0.57	0.40
01/05/87	0.00	7.99	2.61	1.30	0.48	0.34
01/06/87	0.00	7.55	2.75	1.26	0.49	0.33
01/07/87	0.00	7.34	2.77	1.39	0.62	0.34
01/08/87	0.00	7.09	2.29	1.19	0.47	0.29
01/09/87	3.05	6.80	3.00	1.16	0.53	0.31
01/10/87	2.30	7.81	2.79	1.43	0.62	0.35
01/11/87	0.51	7.32	2.38	1.26	0.53	0.27
01/12/87	0.00	6.55	2.14	1.04	0.42	0.22
01/13/87	0.00	6.06	2.02	1.00	0.43	0.21
01/14/87	4.61	5.91	2.43	1.08	0.57	0.23
01/15/87	2.27	7.97	3.70	1.41	0.71	0.39
01/16/87	0.00	7.42	3.19	1.46	0.65	0.32
01/17/87	2.57	6.81	2.83	1.35	0.57	0.26
01/18/87	54.35	52.44	19.98	6.79	1.63	1.79
01/19/87	18.73	632.83	337.93	130.00 *	27.81	25.58
01/20/87	0.00	208.26	127.60	45.00 *	11.52	16.63
01/21/87	0.00	118.70	72.56	25.00 *	6.72	11.72
01/22/87	12.20	89.44	53.18	17.62	4.80	9.47
01/23/87	0.00	64.97	33.56	10.36	3.02	5.92
01/24/87	0.00	50.75	25.81	7.69	1.99	4.57
01/25/87	23.63	104.00	54.54	15.58	3.02	6.80
01/26/87	0.98	151.24	93.81	22.37	6.42	9.26
01/27/87	1.78	99.92	60.89	15.57	6.08	8.22
01/28/87	0.00	74.47	42.73	11.71	4.50	6.94
01/29/87	0.00	60.16	31.89	9.24	3.46	5.67
01/30/87	0.00	52.05	26.90	7.98	2.97	4.85
01/31/87	0.00	36.85	18.36	6.44	1.83	3.41
VOLUME (M**3)		166733.9	90727.8	30685.0	8226.1	10952.1
AVE FLOW (L/S)		62.25	33.87	11.46	3.07	4.09
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		25.20	23.39	21.06	21.94	12.98
PEAK FLOW (L/S)		1160.00	526.91	200.00 *	57.26	38.33
MAX DAY (L/S)		632.83	337.93	130.00	27.81	25.58
MIN DAY (L/S)		5.91	2.02	1.00	0.42	0.21
TOTAL (MM)	130.02	67.50	62.66	56.41	58.76	34.77

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.17. CWDF Hydrologic Summary for February 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
02/01/87	0.00	30.11	16.44	6.13	1.73	2.59
02/02/87	10.29	42.28	21.86	7.60	2.24	3.04
02/03/87	0.00	35.33	16.26	6.27	1.76	2.23
02/04/87	0.00	26.89	13.23	6.01	1.56	1.90
02/05/87	0.00	23.96	12.44	6.55	1.39	1.85
02/06/87	0.00	23.56	12.74	6.53	1.54	1.92
02/07/87	0.00	23.77	12.68	6.39	1.48	2.10
02/08/87	0.00	21.73	11.66	5.84	1.65	2.00
02/09/87	0.00	17.06	7.82	4.18	1.04	1.40
02/10/87	0.00	14.81	6.60	3.79	0.91	1.13
02/11/87	0.00	14.18	6.96	3.97	1.20	1.15
02/12/87	0.00	14.42	7.51	4.10	1.26	1.31
02/13/87	0.00	12.89	6.09	3.09	1.01	1.12
02/14/87	6.09	14.10	7.74	3.65	1.32	1.35
02/15/87	2.29	14.46	7.43	3.58	1.35	1.37
02/16/87	25.39	81.36	35.70	13.43	2.70	4.09
02/17/87	2.67	81.03	44.61	13.50	4.38	6.19
02/18/87	2.53	71.66	39.88	12.79	4.52	6.21
02/19/87	0.00	59.75	31.14	10.07	3.67	5.11
02/20/87	2.80	51.87	26.58	9.37	3.10	4.80
02/21/87	1.01	48.51	25.06	9.38	2.91	4.59
02/22/87	21.72	73.50	38.24	14.08	3.46	5.88
02/23/87	0.00	123.54	74.92	25.34	5.34	8.21
02/24/87	0.00	88.67	55.02	17.44	6.41	7.83
02/25/87	0.00	68.19	38.12	12.60	4.71	6.66
02/26/87	15.27	57.33	30.99	10.67	3.96	6.28
02/27/87	28.93	311.23	184.76	64.00 *	15.99	16.94
02/28/87	21.98	325.23	205.14	70.00 *	20.65	22.52
VOLUME (M**3)		153050.7	86194.4	31134.2	8919.9	11384.9
AVE FLOW (L/S)		63.26	35.63	12.87	3.69	4.71
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		25.61	24.61	23.66	26.34	14.94
PEAK FLOW (L/S)		478.00	301.78	110.00 *	28.84	21.73
MAX DAY (L/S)		325.23	205.14	70.00	20.65	22.52
MIN DAY (L/S)		12.89	6.09	3.09	0.91	1.12
TOTAL (MM)	140.97	61.96	59.53	57.23	63.71	36.14

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.18. CWDF Hydrologic Summary for March 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
03/01/87	0.00	243.90	155.80	50.00 *	18.22	20.76
03/02/87	0.00	133.28	80.18	28.35	9.23	14.98
03/03/87	0.00	88.59	51.98	20.17	6.44	11.20
03/04/87	0.00	67.06	35.53	15.37	4.79	8.24
03/05/87	0.00	55.97	27.72	11.12	3.88	6.38
03/06/87	0.00	44.82	21.46	9.11	2.96	4.97
03/07/87	0.00	35.08	17.89	8.20	2.52	4.37
03/08/87	2.42	33.34	18.30	8.59	2.85	4.04
03/09/87	10.40	40.14	20.65	9.30	3.02	4.36
03/10/87	0.00	27.47	12.59	6.30	2.24	2.65
03/11/87	4.83	21.77	10.62	5.08	1.83	2.05
03/12/87	0.50	23.92	11.02	4.96	1.58	1.92
03/13/87	0.00	21.64	10.27	4.69	1.39	1.75
03/14/87	0.00	22.11	11.45	5.00	1.58	2.06
03/15/87	0.00	22.20	11.96	5.06	1.83	2.31
03/16/87	3.81	23.05	12.48	5.21	1.89	2.51
03/17/87	0.00	19.13	10.07	4.37	1.67	1.94
03/18/87	18.28	30.29	16.22	6.47	1.67	2.83
03/19/87	2.03	68.55	32.45	10.78	2.82	4.33
03/20/87	0.00	59.30	30.47	9.74	3.43	5.04
03/21/87	0.00	53.14	27.08	8.97	3.76	4.84
03/22/87	0.00	43.29	22.56	7.92	3.36	4.27
03/23/87	0.00	34.66	18.62	7.10	2.96	3.99
03/24/87	5.85	30.92	18.04	6.92	2.70	3.86
03/25/87	1.65	29.01	17.01	6.43	2.58	3.39
03/26/87	0.00	22.66	11.90	5.02	1.83	2.54
03/27/87	1.27	20.88	11.73	5.12	1.89	2.48
03/28/87	0.00	18.97	9.90	4.35	1.72	2.17
03/29/87	0.00	16.93	9.34	4.26	1.64	2.09
03/30/87	18.28	31.05	15.84	6.49	1.94	3.12
03/31/87	0.00	33.87	14.08	6.13	2.05	2.46
VOLUME (M**3)		122427.9	66978.1	25624.5	8836.1	12433.0
AVE FLOW (L/S)		45.71	25.01	9.57	3.30	4.64
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		18.51	17.27	17.59	23.56	14.74
PEAK FLOW (L/S)		344.00	223.84	80.00 *	27.12	26.43
MAX DAY (L/S)		243.90	155.80	50.00	18.22	20.76
MIN DAY (L/S)		16.93	9.34	4.26	1.39	1.75
TOTAL (MM)	69.32	49.57	46.26	47.10	63.12	39.47

NOTE: AN ASTERISK (*) AFTER THE DATA INDICATES AN ADJUSTED VALUE, WHERE THE ORIGINAL STAGE RECORD WAS INCOMPLETE, FAULTY OR AFFECTED BY BACKWATER.
-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.19. CWDF Hydrologic Summary for April 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
04/01/87	0.00	24.74	12.08	5.12	1.83	2.15
04/02/87	7.88	26.44	19.23	4.96	2.05	2.44
04/03/87	18.30	38.10	17.06	5.42	2.10	3.13
04/04/87	0.00	47.91	18.71	5.59	2.24	3.13
04/05/87	0.00	55.63	24.83	8.68	2.67	4.01
04/06/87	0.00	63.61	33.73	9.90	3.50	4.95
04/07/87	0.00	62.59	35.30	9.86	4.74	5.59
04/08/87	0.00	54.95	29.37	9.27	4.00	4.91
04/09/87	0.00	45.10	28.12	7.35	3.26	4.34
04/10/87	0.00	34.71	18.27	6.06	2.76	4.03
04/11/87	5.844	33.38	17.95	6.14	2.33	3.95
04/12/87	4.19	28.92	15.35	5.63	2.39	3.32
04/13/87	0.00	22.95	11.81	4.55	1.86	2.47
04/14/87	9.66	32.64	17.34	6.83	2.42	3.21
04/15/87	15.62	87.96	54.04	14.90	3.16	5.24
04/16/87	13.22	90.29	58.74	13.96	4.82	7.71
04/17/87	0.38	92.75	60.61	17.12	6.15	8.14
04/18/87	0.00	72.97	43.10	13.68	5.20	7.15
04/19/87	0.00	59.08	30.76	10.36	4.25	5.88
04/20/87	0.00	47.11	23.58	8.79	3.16	5.20
04/21/87	0.00	35.89	18.51	7.64	2.39	4.76
04/22/87	0.00	29.48	15.43	6.90	1.62	3.95
04/23/87	0.00	25.06	13.16	6.35	1.94	3.08
04/24/87	6.10	24.02	12.34	5.12	2.05	2.73
04/25/87	0.00	18.57	8.81	3.52	1.53	1.91
04/26/87	0.00	15.94	7.07	3.01	1.37	1.52
04/27/87	0.00	14.76	6.62	2.85	1.44	1.41
04/28/87	0.00	14.20	6.07	2.52	1.25	1.23
04/29/87	0.00	12.82	5.21	2.17	1.25	1.12
04/30/87	1.02	12.09	5.18	2.27	1.25	1.14
VOLUME (M**3)		105810.6	57748.0	18707.3	6996.7	9832.3
AVE FLOW (L/S)		40.82	22.28	7.22	2.70	3.79
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		16.53	15.39	13.27	19.28	12.04
PEAK FLOW (L/S)		123.00	73.31	32.79	6.92	10.19
MAX DAY (L/S)		92.75	60.61	17.12	6.15	8.14
MIN DAY (L/S)		12.09	5.18	2.17	1.25	1.12
TOTAL (MM)	82.21	42.84	39.88	34.39	49.98	31.21

NOTE: AN ASTERISK (*) AFTER THE DATA INDICATES AN ADJUSTED VALUE, WHERE THE ORIGINAL STAGE RECORD WAS INCOMPLETE, FAULTY OR AFFECTED BY BACKWATER. -99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.20. CWDF Hydrologic Summary for May 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
05/01/87	0.00	11.45	4.37	1.71	1.27	0.84
05/02/87	0.00	10.05	3.68	1.27	1.18	0.50
05/03/87	15.60	10.95	4.40	1.33	1.36	0.64
05/04/87	8.00	19.90	10.07	2.72	1.62	1.24
05/05/87	0.00	11.19	4.05	1.30	1.07	0.47
05/06/87	0.00	10.08	3.38	1.12	1.09	0.40
05/07/87	0.00	9.07	2.84	0.98	0.89	0.30
05/08/87	0.00	7.08	2.38	0.81	0.88	0.21
05/09/87	0.00	6.06	2.12	0.69	0.80	0.16
05/10/87	0.00	5.59	1.94	0.65	0.86	0.16
05/11/87	0.00	5.20	1.80	0.64	0.97	0.13
05/12/87	0.00	4.94	1.80	0.64	0.97	0.12
05/13/87	0.51	4.68	1.64	0.57	0.92	0.11
05/14/87	0.00	4.30	1.58	0.50	1.00	0.10
05/15/87	0.00	4.05	1.53	0.46	1.03	0.09
05/16/87	0.76	3.89	1.40	0.41	0.93	0.08
05/17/87	17.27	5.44	2.58	0.50	1.14	0.26
05/18/87	0.37	6.29	2.69	0.64	1.07	0.25
05/19/87	0.00	4.67	1.83	0.50	1.07	0.14
05/20/87	27.56	14.42	5.79	0.99	1.58	0.73
05/21/87	10.41	11.20	4.89	1.03	1.60	0.52
05/22/87	0.00	10.68	4.09	1.04	1.31	0.39
05/23/87	0.00	6.74	2.55	0.73	1.12	0.21
05/24/87	0.64	5.50	1.96	0.54	0.94	0.15
05/25/87	13.46	6.94	2.52	0.52	1.01	0.34
05/26/87	0.00	7.38	2.56	0.75	0.88	0.27
05/27/87	1.14	5.17	1.83	0.56	0.90	0.12
05/28/87	0.00	4.48	1.56	0.44	0.91	0.09
05/29/87	3.30	4.47	1.32	0.36	0.76	0.05
05/30/87	13.84	6.08	1.28	0.40	1.03	0.20
05/31/87	0.00	9.13	2.32	0.62	0.98	0.26
VOLUME (M**3)		20482.8	7668.0	2196.3	2863.3	823.4
AVE FLOW (L/S)		7.65	2.86	0.82	1.07	0.31
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		3.10	1.98	1.51	7.64	0.98
PEAK FLOW (L/S)		76.00	35.98	6.66	7.60	7.73
MAX DAY (L/S)		19.90	10.07	2.72	1.62	1.24
MIN DAY (L/S)		3.89	1.28	0.36	0.76	0.05
TOTAL (MM)	112.86	8.29	5.30	4.04	20.45	2.61

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.21. CWDF Hydrologic Summary for June 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
06/01/87	0.00	5.79	1.83	0.50	0.96	0.12
06/02/87	0.00	5.00	1.58	0.42	0.84	0.07
06/03/87	1.55	4.16	1.29	0.35	0.84	0.05
06/04/87	0.00	3.78	1.47 *	0.29	0.83	0.03
06/05/87	0.00	3.22	1.22 *	0.15	0.50	0.01
06/06/87	0.00	2.92	1.08 *	0.09	0.44	0.01
06/07/87	0.00	2.71	0.98 *	0.07	0.43	0.01
06/08/87	0.00	2.49	0.87 *	0.06	0.48	0.01
06/09/87	0.00	2.32	0.79 *	0.05	0.49	0.01
06/10/87	0.00	2.25	0.74 *	0.06	0.56	0.00
06/11/87	0.00	2.08	0.67 *	0.05	0.57	0.00
06/12/87	6.35	2.15	0.67 *	0.06	0.64	0.00
06/13/87	1.02	2.66	0.79	0.06	0.67	0.00
06/14/87	0.00	2.41	0.62	0.06	0.55	0.00
06/15/87	0.76	2.22	0.60	0.06	0.53	0.00
06/16/87	0.63	2.27	0.64	0.07	0.64	0.00
06/17/87	1.65	2.55	0.72	0.07	0.57	0.00
06/18/87	2.03	2.23	0.60	0.06	0.51	0.00
06/19/87	2.41	2.36	0.67	0.07	0.49	0.00
06/20/87	3.30	2.53	0.80	0.08	0.52	0.00
06/21/87	9.40	2.79	0.79	0.09	0.49	0.00
06/22/87	30.73	15.42	8.99	1.54	0.84	0.00
06/23/87	0.25	11.67	4.50	0.96	0.65	0.00
06/24/87	0.00	5.12	1.92	0.60	0.44	0.00
06/25/87	0.00	3.96	1.32	0.38	0.41	0.00
06/26/87	3.81	3.58	1.30	0.29	0.40	0.00
06/27/87	0.38	2.79	0.72	0.14	0.25	0.00
06/28/87	0.00	2.38	0.53	0.07	0.23	0.00
06/29/87	0.00	2.18	0.55	0.06	0.26	0.00
06/30/87	0.00	2.06	0.39	0.06	0.28	0.00
VOLUME (M**3)		9508.3	3424.9	593.6	1409.2	27.6
AVE FLOW (L/S)		3.67	1.32	0.23	0.54	0.01
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		1.49	0.91	0.42	3.88	0.03
PEAK FLOW (L/S)		123.00	67.12	25.22	6.55	0.19
MAX DAY (L/S)		15.42	8.99	1.54	0.96	0.12
MIN DAY (L/S)		2.06	0.39	0.05	0.23	0.00
TOTAL (MM)	64.27	3.85	2.37	1.09	10.07	0.09

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.22. CWDF Hydrologic Summary for July 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
07/01/87	5.21	2.48	0.91	0.07	0.51	0.00
07/02/87	2.54	2.82	0.85	0.06	0.52	0.00
07/03/87	14.34	3.44	1.07	0.07	0.54	0.00
07/04/87	7.23	5.00	1.46	0.11	0.60	0.00
07/05/87	11.68	5.71	2.10	0.23	0.74	0.00
07/06/87	1.82	6.56	2.45	0.29	0.74	0.00
07/07/87	7.08	7.07	2.42	0.33	0.58	0.00
07/08/87	0.00	4.32	1.38	0.23	0.48	0.00
07/09/87	0.00	3.45	1.09	0.13	0.48	0.00
07/10/87	0.00	3.07	0.93	0.09	0.57	0.00
07/11/87	9.14	3.83	1.41	0.10	0.71	0.00
07/12/87	0.00	3.67	1.28	0.09	0.67	0.00
07/13/87	3.55	3.18	1.11	0.10	0.64	0.00
07/14/87	0.00	2.79	0.86	0.09 *	0.51	0.00
07/15/87	0.00	2.31	0.79 *	0.08 *	0.40	0.00
07/16/87	0.00	2.11	0.72 *	0.07 *	0.39	0.00
07/17/87	0.00	1.96	0.65 *	0.06 *	0.40	0.00
07/18/87	0.00	1.78	0.62 *	0.05 *	0.45	0.00
07/19/87	0.00	1.67	0.58 *	0.04 *	0.41	0.00
07/20/87	0.00	1.56	0.55 *	0.03 *	0.44	0.00
07/21/87	0.00	1.47	0.52 *	0.03 *	0.43	0.00
07/22/87	0.00	1.40 *	0.49 *	0.03 *	0.43	0.00
07/23/87	0.00	1.10 *	0.45 *	0.03 *	0.44	0.00
07/24/87	0.00	0.80 *	0.41 *	0.03 *	0.40	0.00
07/25/87	0.00	0.65 *	0.37 *	0.02 *	0.39 *	0.00
07/26/87	0.00	0.50 *	0.33 *	0.02 *	0.39 *	0.00
07/27/87	0.00	0.42 *	0.29 *	0.02 *	0.38 *	0.00
07/28/87	0.00	0.36 *	0.25 *	0.02 *	0.38 *	0.00
07/29/87	0.00	0.31 *	0.21 *	0.02 *	0.37 *	0.00
07/30/87	0.00	0.27 *	0.18 *	0.02 *	0.37 *	0.00
07/31/87	0.00	0.24 *	0.15 *	0.02 *	0.36 *	0.00
VOLUME (M**3)		6592.3	2322.4	222.9	1306.4	0.0
AVE FLOW (L/S)		2.46	0.87	0.08	0.49	0.00
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		1.00	0.60	0.15	3.48	0.00
PEAK FLOW (L/S)		12.50	4.24	0.58	1.89	0.00
MAX DAY (L/S)		7.07	2.45	0.33	0.74	0.00
MIN DAY (L/S)		0.24	0.15	0.02	0.36	0.00
TOTAL (MM)	62.59	2.67	1.60	0.41	9.33	0.00

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.23. CWDF Hydrologic Summary for August 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
08/01/87	0.00	0.22 *	0.12 *	0.02 *	0.36 *	0.00
08/02/87	0.00	0.20 *	0.10 *	0.02 *	0.35 *	0.00
08/03/87	0.00	0.18 *	0.08 *	0.02 *	0.35 *	0.00
08/04/87	0.00	0.16 *	0.07 *	0.02 *	0.35 *	0.00
08/05/87	1.26	0.14 *	0.07 *	0.01 *	0.37 *	0.00
08/06/87	0.63	0.40 *	0.20 *	0.01 *	0.42 *	0.00
08/07/87	0.00	0.39 *	0.19 *	0.01 *	0.38 *	0.00
08/08/87	0.00	0.38 *	0.18 *	0.01 *	0.37 *	0.00
08/09/87	0.76	0.38 *	0.18 *	0.01 *	0.36 *	0.00
08/10/87	5.58	0.40 *	0.20 *	0.01 *	0.60 *	0.00
08/11/87	0.00	0.38 *	0.19 *	0.01 *	0.50 *	0.00
08/12/87	21.71	0.70 *	0.40 *	0.05 *	0.80 *	0.00
08/13/87	0.00	0.65 *	0.38 *	0.04 *	0.90 *	0.00
08/14/87	0.00	0.60 *	0.34 *	0.03 *	0.48 *	0.00
08/15/87	0.00	0.58 *	0.32 *	0.03 *	0.44 *	0.00
08/16/87	0.00	0.56 *	0.30 *	0.02 *	0.40 *	0.00
08/17/87	9.40	0.60 *	0.28 *	0.02 *	0.54 *	0.00
08/18/87	0.00	0.58 *	0.26 *	0.02 *	0.52 *	0.00
08/19/87	0.00	0.56 *	0.24 *	0.02 *	0.50 *	0.00
08/20/87	0.00	0.52 *	0.22 *	0.02 *	0.49 *	0.00
08/21/87	0.00	0.50 *	0.20 *	0.01 *	0.48 *	0.00
08/22/87	0.00	0.48 *	0.18 *	0.01 *	0.45 *	0.00
08/23/87	0.00	0.46 *	0.17 *	0.01 *	0.43 *	0.00
08/24/87	0.00	0.45 *	0.16 *	0.01 *	0.41 *	0.00
08/25/87	0.00	0.44 *	0.15 *	0.01 *	0.39 *	0.00
08/26/87	0.00	0.43 *	0.14 *	0.01 *	0.37 *	0.00
08/27/87	0.00	0.42 *	0.13 *	0.01 *	0.35 *	0.00
08/28/87	0.25	0.41 *	0.12 *	0.01 *	0.33 *	0.00
08/29/87	0.00	0.40 *	0.11 *	0.01 *	0.33 *	0.00
08/30/87	0.00	0.39 *	0.10 *	0.01 *	0.32 *	0.00
08/31/87	0.00	0.38 *	0.09 *	0.01 *	0.31 *	0.00
VOLUME (M**3)		1152.6	507.2	44.1	1179.4	0.0
AVE FLOW (L/S)		0.43	0.19	0.02	0.44	0.00
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		0.17	0.13	0.03	3.15	0.00
PEAK FLOW (L/S)		11.30	-99.00	-99.00	-99.00	0.00
MAX DAY (L/S)		0.70	0.40	0.05	0.90	0.00
MIN DAY (L/S)		0.14	0.07	0.01	0.31	0.00
TOTAL (MM)	39.59	0.47	0.35	0.08	8.42	0.00

NOTE: AN ASTERISK (*) AFTER THE DATA INDICATES AN ADJUSTED VALUE, WHERE THE ORIGINAL STAGE RECORD WAS INCOMPLETE, FAULTY OR AFFECTED BY BACKWATER. -99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.24. CWDF Hydrologic Summary for September 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
09/01/87	0.00	0.37 *	0.08 *	0.01 *	0.30 *	0.00
09/02/87	0.00	0.36 *	0.08 *	0.01 *	0.29 *	0.00
09/03/87	0.00	0.35 *	0.07 *	0.01 *	0.28 *	0.00
09/04/87	0.00	0.34 *	0.07 *	0.01 *	0.28 *	0.00
09/05/87	0.00	0.33 *	0.06 *	0.01 *	0.28 *	0.00
09/06/87	3.18	0.32 *	0.06 *	0.01	0.29 *	0.00
09/07/87	0.00	0.31 *	0.05 *	0.02	0.29 *	0.00
09/08/87	10.66	0.60 *	0.36	0.04	0.50 *	0.00
09/09/87	0.00	0.58 *	0.30 *	0.05	0.45 *	0.00
09/10/87	0.00	0.56 *	0.26 *	0.05	0.40 *	0.00
09/11/87	0.89	0.53 *	0.22 *	0.04	0.38 *	0.00
09/12/87	50.93	10.11	2.30	0.11	1.00 *	0.00
09/13/87	0.00	2.69	0.55	0.08 *	0.80 *	0.00
09/14/87	0.00	1.83	0.35 *	0.06 *	0.70 *	0.00
09/15/87	0.00	1.37	0.34 *	0.06 *	0.50 *	0.00
09/16/87	0.00	1.28	0.33 *	0.05 *	0.47 *	0.00
09/17/87	0.00	1.27	0.32 *	0.05 *	0.45 *	0.00
09/18/87	0.00	1.26	0.31 *	0.04 *	0.44 *	0.00
09/19/87	7.99	1.72	0.53	0.07 *	0.60 *	0.00
09/20/87	0.00	1.74	0.28	0.06 *	0.58 *	0.00
09/21/87	0.00	1.37	0.26 *	0.06 *	0.55 *	0.00
09/22/87	0.00	1.23 *	0.24 *	0.05 *	0.51 *	0.00
09/23/87	0.00	1.09 *	0.22 *	0.05 *	0.48 *	0.00
09/24/87	0.00	0.95 *	0.21 *	0.04 *	0.45	0.00
09/25/87	0.00	0.90 *	0.20 *	0.04 *	0.45	0.00
09/26/87	0.00	0.85 *	0.19 *	0.03 *	0.45	0.00
09/27/87	0.00	0.80 *	0.18 *	0.03 *	0.45	0.00
09/28/87	0.00	0.75 *	0.16 *	0.03 *	0.46	0.00
09/29/87	25.14	1.47	1.14	0.18	0.81	0.00
09/30/87	0.00	3.54	1.04	0.07	0.56	0.00
VOLUME (M**3)		3531.2	929.7	122.7	1248.5	0.0
AVE FLOW (L/S)		1.36	0.36	0.05	0.48	0.00
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		0.55	0.25	0.09	3.44	0.00
PEAK FLOW (L/S)		70.00	19.40	1.59	8.03	0.00
MAX DAY (L/S)		10.11	2.30	0.18	1.00	0.00
MIN DAY (L/S)		0.31	0.05	0.01	0.28	0.00
TOTAL (MM)	98.79	1.43	0.64	0.23	8.92	0.00

NOTE: AN ASTERISK (*) AFTER THE DATA INDICATES AN ADJUSTED VALUE, WHERE THE ORIGINAL STAGE RECORD WAS INCOMPLETE, FAULTY OR AFFECTED BY BACKWATER.
-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.25. CWDF Hydrologic Summary for October 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
10/01/87	0.00	1.73	0.37	0.06 *	0.42	0.00
10/02/87	0.00	1.39	0.31	0.06	0.48	0.00
10/03/87	0.00	1.30	0.34	0.06	0.31	0.00
10/04/87	0.00	1.33	0.37	0.06	0.31	0.00
10/05/87	0.63	1.39	0.48	0.08	0.31	0.00
10/06/87	0.00	1.39	0.59	0.11	0.45	0.00
10/07/87	0.00	1.42	0.82	0.06	0.40	0.00
10/08/87	0.00	1.30	0.54	0.03	0.31	0.00
10/09/87	0.00	1.27	0.48 *	0.03	0.37	0.00
10/10/87	0.00	1.39	0.45	0.03	0.31	0.00
10/11/87	0.00	1.42	0.42 *	0.03	0.45	0.00
10/12/87	0.00	1.42	0.37	0.03	0.45	0.00
10/13/87	0.00	1.42	0.34 *	0.03	0.42	0.00
10/14/87	0.00	1.39	0.31	0.03 *	0.40	0.00
10/15/87	0.00	1.39	0.31 *	0.03 *	0.28	0.00
10/16/87	0.00	1.42	0.31 *	0.03	0.28	0.00
10/17/87	0.00	1.42	0.31	0.03	0.31	0.00
10/18/87	0.00	1.42	0.31 *	0.03	0.31	0.00
10/19/87	0.25	1.42	0.42	0.06	0.40	0.00
10/20/87	7.62	1.42	10.76	0.34	0.59	0.00
10/21/87	0.00	1.70	0.96 *	0.20	0.34	0.00
10/22/87	0.00	1.78	0.85 *	0.17 *	0.31	0.00
10/23/87	0.00	1.67	0.45 *	0.11 *	0.28	0.00
10/24/87	0.00	1.67	0.40	0.06	0.37	0.00
10/25/87	1.27	1.70	0.40	0.11	0.40	0.00
10/26/87	0.79	1.70	0.37	0.17	0.37	0.00
10/27/87	2.77	1.93	0.40	0.31	0.40	0.00
10/28/87	0.00	1.81	0.40	0.25	0.28	0.00
10/29/87	3.43	1.81	0.45 *	0.17 *	0.40	0.00
10/30/87	0.00	1.81	0.51	0.03	0.40	0.00
10/31/87	0.00	1.84	0.42	0.03	0.34	0.00
VOLUME (M**3)		4098.5	2094.5	242.2	991.0	0.0
AVE FLOW (L/S)		1.53	0.78	0.09	0.37	0.00
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		0.62	0.54	0.17	2.64	0.00
PEAK FLOW (L/S)		2.15	1.98	0.79	1.08	0.00
MAX DAY (L/S)		1.93	10.76	0.34	0.59	0.00
MIN DAY (L/S)		1.27	0.31	0.03	0.28	0.00
TOTAL (MM)	16.76	1.66	1.45	0.45	7.08	0.00

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.26. CWDF Hydrologic Summary for November 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
11/01/87	0.00	1.81	0.40	0.03 *	0.34	0.00
11/02/87	0.00	1.81	0.37	0.03 *	0.34	0.00
11/03/87	0.00	1.73	0.28	0.03 *	0.31	0.00
11/04/87	0.00	1.78	0.34	0.03 *	0.34	0.00
11/05/87	0.00	1.90	0.28	0.03 *	0.31	0.00
11/06/87	0.00	1.98	0.25	0.03	0.31 *	0.00
11/07/87	0.00	2.01	0.25	0.03	0.31 *	0.00
11/08/87	0.00	2.15	0.42	0.03	0.28 *	0.00
11/09/87	9.50	2.27	1.42	0.06	0.31	0.00
11/10/87	19.05	6.94	0.91	0.08	0.42	0.00
11/11/87	0.00	4.16	0.25	0.06 *	0.37 *	0.00
11/12/87	0.00	4.02	0.20	0.03 *	0.31 *	0.00
11/13/87	0.00	2.69	0.23	0.03 *	0.31 *	0.00
11/14/87	0.00	2.49	0.23	0.03 *	0.28 *	0.00
11/15/87	0.00	2.44	0.31	0.03 *	0.28 *	0.00
11/16/87	0.00	2.32	1.10	0.06	0.28 *	0.00
11/17/87	20.57	6.63	1.36	0.25	0.51	0.00
11/18/87	0.00	4.79	0.57	0.08	0.45 *	0.00
11/19/87	0.00	3.46	0.40	0.03	0.40 *	0.00
11/20/87	0.00	2.97	0.34	0.03 *	0.40 *	0.00
11/21/87	0.00	2.69	0.25	0.03 *	0.37 *	0.00
11/22/87	0.00	2.63	0.23	0.03	0.37 *	0.00
11/23/87	0.00	2.49	0.34	0.03 *	0.37 *	0.00
11/24/87	0.00	2.49	0.34	0.03 *	0.34 *	0.00
11/25/87	0.00	2.49	0.40	0.03 *	0.34 *	0.00
11/26/87	0.00	2.49	0.40	0.03 *	0.28	0.00
11/27/87	0.00	2.49	0.37	0.06	0.28	0.00
11/28/87	6.86	2.52	0.57	0.06	0.37	0.00
11/29/87	0.00	3.09	0.37	0.03	0.28	0.00
11/30/87	0.00	2.75	0.31	0.03 *	0.23	0.00
VOLUME (M**3)		7472.7	1164.7	115.0	873.5	0.0
AVE FLOW (L/S)		2.88	0.45	0.04	0.34	0.00
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		1.17	0.31	0.08	2.41	0.00
PEAK FLOW (L/S)		9.66	4.13	0.68	0.76	0.00
MAX DAY (L/S)		6.94	1.42	0.25	0.51	0.00
MIN DAY (L/S)		1.73	0.20	0.03	0.23	0.00
TOTAL (MM)	55.98	3.03	0.80	0.21	6.24	0.00

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.27. CWDF Hydrologic Summary for December 1987

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
12/01/87	0.63	2.63	0.23	0.03 *	0.20	0.00
12/02/87	0.00	2.44	0.20	0.03 *	0.11	0.00
12/03/87	1.02	2.32	0.45	0.03 *	0.34	0.00
12/04/87	0.00	2.41	0.42	0.06 *	0.42	0.00
12/05/87	0.00	2.32	0.40 *	0.06 *	0.42 *	0.00
12/06/87	0.00	2.32	0.37	0.06 *	0.42	0.00
12/07/87	0.00	2.32	0.37	0.06 *	0.42 *	0.00
12/08/87	0.00	2.32	0.45	0.06 *	0.40 *	0.00
12/09/87	0.00	2.35	0.51	0.06 *	0.40 *	0.00
12/10/87	0.00	2.41	0.40	0.08 *	0.40 *	0.00
12/11/87	0.51	2.32	0.42	0.08 *	0.34 *	0.00
12/12/87	0.00	3.40	0.40 *	0.06 *	0.34	0.00
12/13/87	0.00	6.12	0.37	0.06 *	0.34 *	0.00
12/14/87	4.83	6.26	0.59	0.06 *	0.59	0.00
12/15/87	15.49	10.54	2.35	0.14 *	0.74	0.00
12/16/87	0.00	8.35	1.27	0.06 *	0.42	0.00
12/17/87	0.00	7.39	0.85	0.06 *	0.31	0.00
12/18/87	0.00	6.85	0.62	0.06 *	0.31	0.00
12/19/87	0.00	6.74	0.71	0.06 *	0.51	0.00
12/20/87	4.06	7.02	0.93	0.06 *	0.57	0.00
12/21/87	0.00	6.83	0.68	0.03 *	0.54	0.00
12/22/87	0.00	6.68	0.68	0.03 *	0.51	0.00
12/23/87	0.00	6.43	0.51	0.03 *	0.37	0.00
12/24/87	16.89	7.73	1.19	0.11 *	0.65	0.00
12/25/87	12.57	20.31	4.79	0.37 *	1.36	0.00
12/26/87	9.40	14.41	3.26	0.23 *	1.05	0.00
12/27/87	8.89	12.89	2.95	0.23 *	0.99	0.00
12/28/87	7.87	19.20	4.28	0.34 *	1.33	0.00
12/29/87	0.00	11.50	2.18	0.28 *	0.68	0.00
12/30/87	0.00	8.44	1.47	0.17 *	0.48	0.00
12/31/87	3.05	6.51	1.39	0.14 *	0.68	0.00
VOLUME (M**3)		18123.8	3083.0	271.6	1438.7	0.0
AVE FLOW (L/S)		6.77	1.15	0.10	0.54	0.00
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		2.74	0.79	0.19	3.84	0.00
PEAK FLOW (L/S)		33.13	11.89	0.85 *	2.52	0.00
MAX DAY (L/S)		20.31	4.79	0.37	1.36	0.00
MIN DAY (L/S)		2.32	0.20	0.03	0.11	0.00
TOTAL (MM)	85.22	7.34	2.13	0.50	10.28	0.00

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.28. CWDF Hydrologic Summary for January 1988

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
01/01/88	11.94	11.78	2.83	0.25 *	0.96	0.00
01/02/88	0.00	9.91	1.95	0.17 *	0.76	0.00
01/03/88	8.13	7.70	1.84	0.20 *	0.74	0.00
01/04/88	0.00	10.48	2.32	0.25 *	0.76	0.00
01/05/88	0.00	7.82	1.56	0.23 *	0.76 *	0.00
01/06/88	0.00	6.34	1.33	0.23 *	0.79	0.00
01/07/88	17.93	5.78	1.42 *	0.25 *	0.79 *	0.00
01/08/88	0.63	6.03	1.70 *	0.34 *	1.05	0.00
01/09/88	0.00	5.30	1.42 *	0.31	0.85 *	0.00
01/10/88	0.00	4.90	1.13 *	0.23	0.79 *	0.00
01/11/88	0.00	4.64	0.85 *	0.23	0.74 *	0.00
01/12/88	0.51	4.56	0.85 *	0.25	0.68 *	0.00
01/13/88	1.27	5.41	1.05	0.25	0.62	0.00
01/14/88	0.00	5.44	0.85	0.25	0.62 *	0.00
01/15/88	0.00	5.15	0.76	0.25	0.57 *	0.00
01/16/88	0.00	5.01	0.79	0.28	0.62 *	0.00
01/17/88	14.35	8.64	1.87	0.51	1.70	0.08
01/18/88	0.00	36.39	8.10	4.08	1.08	0.14
01/19/88	74.98	185.64	80.34	17.11	6.15	6.71
01/20/88	3.15	398.35	171.34	52.59	14.33	18.24
01/21/88	0.00	86.72	46.33	18.52	4.02	7.62
01/22/88	0.00	51.71	25.23	8.27	2.01	4.73
01/23/88	0.00	31.27	15.01	6.00	0.99	3.06
01/24/88	0.76	19.74	9.46	4.30	0.71	1.70
01/25/88	1.04	15.01	6.23	3.09	0.57	0.99
01/26/88	0.00	11.81	3.68	1.73	0.34	0.45
01/27/88	0.00	10.48	2.61	1.27	0.31	0.31
01/28/88	0.00	9.77	2.18	1.13	0.28	0.25
01/29/88	0.00	8.30	1.98	1.08	0.31	0.23
01/30/88	0.00	6.94	2.07	1.08	0.40	0.20
01/31/88	0.76	6.71	2.27	1.16	0.48	0.20
VOLUME (M**3)		85857.5	34676.7	10878.7	3956.6	3880.7
AVE FLOW (L/S)		32.06	12.95	4.06	1.48	1.45
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		12.98	8.94	7.47	10.55	4.60
PEAK FLOW (L/S)		1665.22	512.08	169.92 *	53.24	53.55
MAX DAY (L/S)		398.35	171.34	52.59	14.33	18.24
MIN DAY (L/S)		4.56	0.76	0.17	0.28	0.00
TOTAL (MM)	135.46	34.76	23.95	20.00	28.26	12.32

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.29. CWDF Hydrologic Summary for February 1988

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
02/01/88	0.00	6.49	2.15	1.13	0.51	0.14
02/02/88	13.21	10.45	4.42	1.70	0.79	0.37
02/03/88	10.46	15.92	6.32	2.78	0.96	0.65
02/04/88	16.97	118.92	63.47	18.41	3.85	4.56
02/05/88	0.00	77.26	49.64	13.62	4.02	6.09
02/06/88	0.00	52.39	28.32	8.33	2.41	4.45
02/07/88	0.00	34.86	19.77	6.60	1.53	3.82
02/08/88	0.00	24.84	14.05	5.44	0.99	2.69
02/09/88	0.00	18.72	9.88	4.19	0.91 *	1.78
02/10/88	0.00	14.92	7.25	3.23	0.85 *	1.22
02/11/88	4.32	13.20	6.17	3.03	0.79 *	1.02
02/12/88	0.00	13.11	5.15	2.44	0.74 *	0.74
02/13/88	0.00	10.62	3.62	1.81	0.74	0.57
02/14/88	0.00	9.37	3.31	1.76	0.71	0.57
02/15/88	14.60	23.22	10.42	4.70	0.99	1.27
02/16/88	0.00	20.99	8.50	4.05	1.05	0.76
02/17/88	0.00	17.13	7.93	3.74	0.91	0.74
02/18/88	0.00	16.40	8.44	4.02	0.79	0.93
02/19/88	4.83	19.20	11.04	5.01	1.02	1.05 *
02/20/88	0.00	17.95	8.75	3.94	1.05	0.93 *
02/21/88	0.00	14.19	5.95	2.58	0.88	0.85 *
02/22/88	0.00	12.63	5.83	2.83	0.76	0.76 *
02/23/88	4.29	14.05	7.31	3.26	0.82	0.65 *
02/24/88	0.00	12.63	5.47	2.18	0.76	0.57 *
02/25/88	0.00	11.16	4.70	1.95	0.68	0.45 *
02/26/88	0.00	10.59	4.28	1.90	0.76	0.37 *
02/27/88	0.00	10.85	5.04	2.32	0.79	0.34 *
02/28/88	0.00	10.28	4.30	1.76	0.71	0.31 *
02/29/88	0.00	9.46	3.79	1.59	0.57	0.28 *
VOLUME (M**3)		55450.5	28104.5	10391.8	2794.3	3364.4
AVE FLOW (L/S)		22.13	11.22	4.15	1.12	1.34
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		8.96	7.75	7.62	7.97	4.26
PEAK FLOW (L/S)		218.91	100.03	28.32 *	6.06	7.14
MAX DAY (L/S)		118.92	63.47	18.41	4.02	6.09
MIN DAY (L/S)		6.49	2.15	1.13	0.51	0.14
TOTAL (MM)	68.68	22.45	19.41	19.10	19.96	10.68

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-99 IN PEAK FLOW INDICATES INVALID OR MISSING DATA.

Table A.30. CWDF Hydrologic Summary for March 1988

DATE	PREC (MM)	CWDF 1 (L/S)	CWDF 3 (L/S)	CWDF 4 (L/S)	CWDF 7 (L/S)	CWDF 8 (L/S)
03/01/88	0.00	8.67	3.14	1.30	0.54	0.28 *
03/02/88	0.00	8.24	3.09	1.27	0.54	0.28 *
03/03/88	0.25	8.24	3.40	1.50	0.54	0.28 *
03/04/88	5.08	5.78	4.28	1.56	0.59	0.34 *
03/05/88	0.00	8.58	3.48	1.30	0.54	0.31
03/06/88	0.00	7.90	2.89	1.08	0.51	0.28
03/07/88	0.00	7.56	2.66	1.05	0.48	0.23
03/08/88	0.00	7.33	2.44	0.96	0.48	0.20
03/09/88	2.79	7.84	2.78	0.96	0.51	0.17
03/10/88	51.82	300.02	164.51	13.79	12.69	0.88
03/11/88	0.00	148.48	104.61	29.99	8.10	5.24
03/12/88	13.21	103.08	71.48	22.32	5.35	9.23
03/13/88	0.00	104.53	68.99	22.71	4.84	7.62
03/14/88	0.00	75.81	50.10	15.69	4.50	5.75
03/15/88	0.00	58.08	34.49	11.64	3.79	4.02
03/16/88	0.00	41.97	24.13	8.58	2.32	2.95
03/17/88	0.00	29.51	17.11	6.80	1.70	2.27
03/18/88	2.67	25.69	15.49	6.20	1.47	1.64
03/19/88	0.25	22.09	12.86	5.38	1.39	1.22
03/20/88	0.00	17.39	9.57	4.13	1.16	0.91
03/21/88	0.00	14.92	7.87	3.43	1.02	0.48
03/22/88	0.00	13.03	6.32	2.80	0.88	0.31
03/23/88	0.00	11.61	5.52	2.49	0.79	0.23
03/24/88	0.00	11.07	5.04	2.35	0.79	0.20
03/25/88	1.52	11.47	5.30	2.35	0.82	0.40
03/26/88	2.54	11.58	5.72	2.41	0.82	0.65
03/27/88	0.00	10.54	4.93	2.07	0.76	0.68
03/28/88	0.00	9.23	4.02	1.78	0.68	0.62
03/29/88	0.00	8.64	3.74	1.70	0.68	0.51
03/30/88	0.25	8.55	3.65	1.61	0.68	0.45
03/31/88	2.79	8.75	3.85	1.56	0.65	0.42
VOLUME (M**3)		96440.1	56803.6	15792.0	5238.7	4237.9
AVE FLOW (L/S)		36.01	21.21	5.90	1.96	1.58
AREA (KM**2)		2.470	1.448	0.544	0.140	0.315
UNIT AREA FLOW (L/S/KM**2)		14.58	14.65	10.84	13.97	5.02
PEAK FLOW (L/S)		591.89	274.70	51.54	23.17	13.31
MAX DAY (L/S)		300.02	164.51	29.99	12.69	9.23
MIN DAY (L/S)		5.78	2.44	0.96	0.48	0.17
TOTAL (MM)	83.18	39.04	39.23	29.03	37.42	13.45

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APPENDIX B

YEARLY FLOW SUMMARIES
(American Customary Units)

Table B.1. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 1
Water Year 1986
AREA = 0.954 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.629	0.358	2.515	0.667	0.529	0.839	0.504	0.190	0.171	0.053	0.021	0.112
2	0.427	0.803	2.256	0.514	0.522	0.781	0.482	0.179	0.168	0.193	0.014	0.407
3	0.290	0.590	1.762	0.503	0.565	0.771	0.454	0.165	0.142	0.091	0.010	0.252
4	0.241	0.776	1.242	0.463	0.520	0.681	0.400	0.162	0.143	0.069	0.009	0.159
5	0.199	0.789	1.019	0.440	2.176	0.617	0.362	0.159	0.464	0.057	0.008	0.127
6	0.179	0.585	0.796	0.386	2.148	0.615	0.391	0.160	0.459	0.047	0.009	0.085
7	0.166	0.482	0.602	0.362	2.106	0.540	0.401	0.156	0.245	0.032	0.012	0.063
8	0.164	0.379	0.549	0.304	1.800	0.471	1.040	0.150	0.201	0.025	0.011	0.055
9	0.159	0.309	0.495	0.284	1.464	0.448	0.608	0.143	0.180	0.018	0.011	0.051
10	0.156	0.278	0.432	0.320	1.279	0.461	0.494	0.138	0.198	0.050	0.028	0.044
11	0.150	0.258	0.501	0.314	1.477	0.542	0.454	0.135	0.165	0.056	0.107	0.042
12	0.148	0.240	0.712	0.293	0.960	1.443	0.424	0.130	0.137	0.034	0.051	0.080
13	0.148	0.227	1.271	0.287	0.845	2.788	0.399	0.133	0.119	0.046	0.041	0.048
14	0.157	0.226	1.040	0.268	1.080	2.725	0.376	0.129	0.103	0.079	0.032	0.043
15	0.165	0.212	0.900	0.254	1.076	2.340	0.345	0.123	0.089	0.099	0.030	0.042
16	0.162	0.238	0.824	0.232	1.466	1.996	0.322	0.116	0.079	0.061	0.028	0.074
17	0.150	0.262	0.726	0.227	13.165	1.645	0.309	0.110	0.072	0.052	0.032	0.051
18	0.146	0.223	0.603	0.243	15.673	1.375	0.293	0.123	0.066	0.032	0.026	0.049
19	0.141	0.208	0.498	0.957	6.963	7.462	0.274	0.129	0.065	0.021	0.021	0.056
20	0.139	0.194	0.499	0.566	4.069	4.066	0.292	0.121	0.065	0.018	0.114	0.063
21	0.224	0.274	0.439	0.485	2.846	2.675	0.388	0.115	0.053	0.016	0.043	0.057
22	0.202	0.572	0.413	0.456	2.336	2.101	0.308	0.110	0.050	0.014	0.035	0.050
23	0.367	0.496	0.438	0.402	1.917	1.720	0.265	0.230	0.046	0.012	0.030	0.063
24	0.419	0.425	0.405	0.385	1.858	1.307	0.246	0.432	0.042	0.011	0.025	0.052
25	0.275	0.404	0.337	0.461	1.565	1.018	0.236	0.748	0.039	0.010	0.019	0.047
26	0.232	0.376	0.283	1.040	1.537	0.889	0.224	0.311	0.035	0.009	0.106	0.042
27	0.211	2.084	0.288	1.009	1.464	0.794	0.209	0.606	0.032	0.009	0.323	0.038
28	0.218	4.852	0.275	0.842	1.007	0.684	0.270	0.602	0.028	0.009	0.263	0.037
29	0.197	4.985	0.264	0.851		0.615	0.244	0.376	0.025	0.008	0.110	0.037
30	0.198	2.812	0.248	0.661		0.582	0.200	0.255	0.028	0.008	0.072	0.038
31	0.192		0.764	0.564		0.542		0.201		0.011	0.066	
TOT.	6.852	24.920	23.397	15.037	74.414	45.532	11.213	6.838	3.711	1.250	1.707	2.366
MEAN	0.221	0.831	0.755	0.485	2.658	1.469	0.374	0.221	0.124	0.040	0.055	0.079
PEAK	1.010	12.147	3.108	1.501	25.989	25.354	1.900	5.367	2.578	0.554	2.260	1.070
MAX day	0.629	4.985	2.515	1.040	15.673	7.462	1.040	0.748	0.464	0.193	0.323	0.407
MIN day	0.139	0.194	0.248	0.227	0.520	0.448	0.200	0.110	0.025	0.008	0.008	0.037
CFSM	0.232	0.871	0.791	0.509	2.786	1.540	0.392	0.231	0.130	0.042	0.058	0.083
IN.	0.267	0.972	0.912	0.586	2.901	1.775	0.437	0.267	0.145	0.049	0.067	0.092

Table B.2. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 3
Water Year 1986
AREA = 0.559 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.208	0.171	1.526	0.275	0.276	0.401	0.267	0.088	0.051	0.008	0.007	0.026
2	0.179	0.327	1.214	0.237	0.302	0.399	0.263	0.062	0.049	0.043	0.005	0.091
3	0.130	0.287	0.907	0.253	0.333	0.388	0.246	0.048	0.037	0.018	0.003	0.041
4	0.102	0.390	0.703	0.243	0.321	0.326	0.217	0.043	0.040	0.007	0.002	0.029
5	0.069	0.401	0.607	0.208	1.133	0.284	0.197	0.046	0.149	0.006	0.002	0.023
6	0.049	0.299	0.445	0.183	1.350	0.298	0.208	0.050	0.132	0.006	0.002	0.012
7	0.045	0.228	0.315	0.175	1.271	0.237	0.209	0.050	0.066	0.005	0.005	0.011
8	0.043	0.157	0.285	0.130	1.130	0.192	0.495	0.047	0.054	0.004	0.007	0.011
9	0.043	0.132	0.241	0.129	0.883	0.200	0.268	0.036	0.057	0.004	0.004	0.010
10	0.043	0.126	0.204	0.165	0.777	0.234	0.204	0.034	0.064	0.018	0.006	0.009
11	0.043	0.118	0.290	0.150	0.847	0.267	0.194	0.038	0.050	0.012	0.023	0.008
12	0.043	0.111	0.373	0.147	0.600	0.623	0.179	0.042	0.036	0.009	0.010	0.020
13	0.042	0.104	0.585	0.137	0.530	1.382	0.176	0.044	0.024	0.019	0.007	0.009
14	0.042	0.100	0.513	0.128	0.706	1.477	0.173	0.036	0.019	0.033	0.007	0.008
15	0.056	0.095	0.504	0.109	0.706	1.298	0.160	0.031	0.017	0.023	0.006	0.008
16	0.069	0.132	0.466	0.101	0.847	1.029	0.147	0.028	0.014	0.013	0.006	0.017
17	0.040	0.125	0.411	0.110	7.062	0.795	0.143	0.023	0.014	0.010	0.009	0.013
18	0.040	0.099	0.307	0.136	8.828	0.721	0.127	0.040	0.013	0.007	0.006	0.014
19	0.040	0.094	0.232	0.463	3.531	4.320	0.123	0.043	0.012	0.006	0.005	0.016
20	0.040	0.087	0.246	0.270	2.475	2.541	0.165	0.030	0.012	0.005	0.019	0.017
21	0.103	0.146	0.193	0.230	1.678	1.496	0.202	0.020	0.011	0.005	0.009	0.015
22	0.083	0.269	0.196	0.236	1.287	1.046	0.139	0.014	0.011	0.005	0.007	0.015
23	0.190	0.234	0.226	0.190	0.922	0.849	0.100	0.094	0.010	0.004	0.006	0.022
24	0.188	0.240	0.200	0.187	0.941	0.662	0.097	0.214	0.009	0.004	0.005	0.016
25	0.119	0.262	0.127	0.253	0.738	0.535	0.099	0.238	0.009	0.004	0.003	0.013
26	0.089	0.245	0.111	0.486	0.824	0.481	0.098	0.130	0.008	0.003	0.017	0.011
27	0.082	1.331	0.120	0.492	0.782	0.424	0.091	0.220	0.007	0.003	0.066	0.010
28	0.091	3.040	0.111	0.454	0.500	0.344	0.143	0.213	0.007	0.003	0.045	0.008
29	0.072	3.448	0.105	0.498		0.314	0.109	0.127	0.006	0.003	0.012	0.011
30	0.074	1.784	0.094	0.340		0.301	0.085	0.082	0.006	0.003	0.010	0.026
31	0.078		0.353	0.290		0.280		0.060		0.004	0.012	
TOT.	2.536	14.582	12.207	7.404	41.580	24.141	5.325	2.270	0.995	0.295	0.333	0.539
MEAN	0.082	0.486	0.394	0.239	1.485	0.779	0.177	0.073	0.033	0.010	0.011	0.018
PEAK	0.636	6.772	2.036	0.967	10.593	10.295	1.092	3.511	0.099	0.187	0.836	0.422
MAX day	0.208	3.448	1.526	0.498	8.828	4.320	0.495	0.238	0.149	0.043	0.066	0.091
MIN day	0.040	0.087	0.094	0.101	0.276	0.192	0.085	0.014	0.006	0.003	0.002	0.008
CFSM	0.146	0.869	0.704	0.427	2.656	1.393	0.317	0.131	0.059	0.017	0.019	0.032
IN.	0.169	0.970	0.812	0.492	2.765	1.606	0.354	0.151	0.066	0.020	0.022	0.036

Table B.3. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 4
Water Year 1986
AREA = 0.210 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.064	0.036	0.483	0.102	0.094	0.169	0.111	0.025	0.014	0.001	0.000	0.011
2	0.056	0.100	0.356	0.090	0.101	0.172	0.107	0.018	0.014	0.004	0.000	0.035
3	0.039	0.089	0.241	0.096	0.111	0.162	0.100	0.013	0.012	0.001	0.000	0.014
4	0.032	0.125	0.203	0.095	0.111	0.141	0.077	0.011	0.010	0.000	0.000	0.004
5	0.022	0.136	0.205	0.077	0.352	0.126	0.060	0.013	0.023	0.000	0.000	0.001
6	0.015	0.100	0.150	0.067	0.386	0.130	0.059	0.014	0.034	0.000	0.000	0.001
7	0.014	0.071	0.112	0.062	0.388	0.104	0.058	0.014	0.018	0.000	0.001	0.001
8	0.013	0.045	0.106	0.043	0.353	0.089	0.143	0.013	0.014	0.000	0.001	0.001
9	0.013	0.039	0.091	0.044	0.325	0.095	0.080	0.010	0.011	0.000	0.001	0.001
10	0.015	0.040	0.075	0.059	0.300	0.113	0.059	0.010	0.012	0.000	0.001	0.002
11	0.015	0.038	0.101	0.052	0.318	0.114	0.057	0.009	0.010	0.000	0.004	0.001
12	0.015	0.036	0.137	0.050	0.212	0.264	0.052	0.010	0.007	0.000	0.002	0.005
13	0.015	0.035	0.210	0.045	0.198	0.526	0.051	0.010	0.004	0.001	0.001	0.002
14	0.014	0.034	0.172	0.040	0.240	0.505	0.050	0.008	0.003	0.001	0.001	0.002
15	0.021	0.032	0.171	0.034	0.244	0.434	0.047	0.007	0.002	0.001	0.000	0.002
16	0.018	0.036	0.159	0.031	0.318	0.330	0.038	0.006	0.002	0.001	0.000	0.004
17	0.014	0.037	0.139	0.034	2.648	0.295	0.037	0.005	0.001	0.000	0.001	0.004
18	0.013	0.034	0.101	0.042	3.354	0.286	0.035	0.006	0.001	0.000	0.000	0.002
19	0.012	0.032	0.079	0.134	1.236	1.121	0.035	0.008	0.001	0.000	0.000	0.001
20	0.012	0.029	0.088	0.083	0.888	0.806	0.045	0.005	0.001	0.000	0.004	0.003
21	0.018	0.033	0.064	0.065	0.656	0.492	0.048	0.003	0.001	0.000	0.002	0.002
22	0.020	0.088	0.067	0.067	0.461	0.362	0.032	0.002	0.001	0.000	0.001	0.002
23	0.029	0.079	0.075	0.052	0.330	0.280	0.024	0.008	0.001	0.000	0.001	0.004
24	0.043	0.071	0.062	0.054	0.318	0.246	0.025	0.022	0.001	0.000	0.001	0.004
25	0.029	0.064	0.037	0.077	0.250	0.212	0.028	0.044	0.000	0.000	0.000	0.002
26	0.022	0.064	0.031	0.172	0.274	0.198	0.029	0.024	0.000	0.000	0.001	0.002
27	0.021	0.393	0.034	0.170	0.262	0.180	0.028	0.042	0.000	0.000	0.025	0.002
28	0.022	0.787	0.030	0.150	0.196	0.151	0.033	0.045	0.000	0.000	0.018	0.003
29	0.018	0.879	0.029	0.160		0.139	0.028	0.032	0.000	0.000	0.004	0.003
30	0.019	0.526	0.026	0.107		0.130	0.024	0.022	0.001	0.000	0.003	0.004
31	0.021		0.106	0.099		0.120		0.017		0.000	0.004	
TOT.	0.694	4.108	3.941	2.455	14.922	8.492	1.602	0.476	0.198	0.017	0.079	0.125
MEAN	0.022	0.137	0.127	0.079	0.533	0.274	0.053	0.015	0.007	0.001	0.003	0.004
PEAK	0.074	2.543	0.697	0.222	4.237	3.531	0.241	0.295	0.151	0.017	0.283	0.106
MAX day	0.064	0.879	0.483	0.172	3.354	1.121	0.143	0.045	0.034	0.004	0.025	0.035
MIN day	0.012	0.029	0.026	0.031	0.094	0.089	0.024	0.002	0.000	0.000	0.000	0.001
CFSM	0.107	0.652	0.605	0.377	2.537	1.304	0.254	0.073	0.031	0.003	0.012	0.020
IN.	0.123	0.727	0.698	0.435	2.642	1.503	0.284	0.084	0.035	0.003	0.014	0.022

Table B.4. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 7
Water Year 1986
AREA = 0.054 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.031	0.034	0.134	0.033	0.032	0.056	0.052	0.049	0.033	0.032	0.014	0.014
2	0.034	0.044	0.088	0.031	0.038	0.061	0.054	0.032	0.036	0.040	0.016	0.027
3	0.030	0.036	0.078	0.029	0.038	0.064	0.052	0.027	0.035	0.022	0.012	0.017
4	0.023	0.056	0.071	0.029	0.041	0.058	0.056	0.026	0.042	0.018	0.014	0.016
5	0.019	0.064	0.064	0.023	0.066	0.051	0.062	0.030	0.035	0.020	0.013	0.012
6	0.017	0.049	0.050	0.023	0.107	0.053	0.067	0.035	0.028	0.019	0.022	0.006
7	0.016	0.035	0.040	0.020	0.108	0.047	0.064	0.034	0.026	0.018	0.022	0.006
8	0.016	0.024	0.041	0.018	0.094	0.041	0.084	0.034	0.026	0.022	0.019	0.006
9	0.015	0.022	0.031	0.018	0.093	0.043	0.066	0.026	0.030	0.024	0.021	0.006
10	0.015	0.025	0.024	0.021	0.086	0.056	0.055	0.030	0.030	0.029	0.018	0.008
11	0.014	0.027	0.040	0.020	0.072	0.050	0.058	0.035	0.028	0.027	0.026	0.009
12	0.014	0.027	0.050	0.024	0.056	0.067	0.052	0.037	0.026	0.023	0.016	0.010
13	0.014	0.029	0.059	0.020	0.048	0.103	0.055	0.036	0.023	0.026	0.009	0.006
14	0.014	0.029	0.048	0.020	0.071	0.142	0.059	0.032	0.021	0.028	0.014	0.006
15	0.025	0.030	0.051	0.017	0.063	0.120	0.058	0.034	0.023	0.025	0.014	0.007
16	0.021	0.037	0.051	0.017	0.063	0.095	0.054	0.030	0.020	0.023	0.017	0.010
17	0.015	0.032	0.048	0.021	0.622	0.083	0.055	0.027	0.022	0.018	0.020	0.009
18	0.013	0.028	0.039	0.026	1.009	0.085	0.042	0.040	0.020	0.017	0.017	0.011
19	0.013	0.029	0.031	0.048	0.485	0.349	0.045	0.036	0.021	0.017	0.015	0.012
20	0.019	0.030	0.040	0.037	0.278	0.275	0.060	0.027	0.021	0.016	0.024	0.011
21	0.027	0.034	0.027	0.030	0.248	0.163	0.058	0.024	0.021	0.017	0.020	0.010
22	0.024	0.041	0.032	0.035	0.151	0.120	0.041	0.022	0.019	0.017	0.018	0.008
23	0.035	0.035	0.038	0.026	0.102	0.103	0.036	0.040	0.019	0.019	0.018	0.010
24	0.034	0.042	0.037	0.026	0.111	0.076	0.038	0.049	0.023	0.019	0.017	0.009
25	0.021	0.039	0.024	0.035	0.088	0.071	0.040	0.052	0.019	0.019	0.013	0.008
26	0.017	0.044	0.025	0.044	0.103	0.076	0.041	0.047	0.023	0.020	0.026	0.008
27	0.018	0.075	0.025	0.041	0.111	0.067	0.042	0.056	0.027	0.021	0.037	0.007
28	0.020	0.177	0.023	0.042	0.069	0.054	0.054	0.052	0.026	0.023	0.016	0.007
29	0.018	0.281	0.023	0.052		0.053	0.041	0.043	0.029	0.019	0.007	0.008
30	0.020	0.174	0.022	0.032		0.053	0.038	0.035	0.026	0.014	0.008	0.008
31	0.020		0.041	0.030		0.049		0.030		0.023	0.011	
TOT.	0.633	1.630	1.393	0.892	4.451	2.783	1.578	1.106	0.779	0.673	0.534	0.292
MEAN	0.020	0.054	0.045	0.029	0.159	0.090	0.053	0.036	0.026	0.022	0.017	0.010
PEAK	0.082	0.402	0.165	0.113	1.484	0.624	0.160	0.563	0.402	0.135	0.276	0.098
MAX day	0.035	0.281	0.134	0.052	1.009	0.349	0.084	0.056	0.042	0.040	0.037	0.027
MIN day	0.013	0.022	0.022	0.017	0.032	0.041	0.036	0.022	0.019	0.014	0.007	0.006
CFSM	0.378	1.005	0.831	0.532	2.940	1.661	0.973	0.660	0.481	0.402	0.319	0.180
IN.	0.435	1.121	0.958	0.614	3.062	1.915	1.085	0.761	0.536	0.463	0.368	0.201

Table B.5. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 8
Water Year 1986
AREA = 0.122 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.003	0.011	0.264	0.023	0.040	0.089	0.071	0.011	0.004	0.000	0.000	0.000
2	0.009	0.026	0.178	0.022	0.047	0.086	0.067	0.006	0.003	0.000	0.000	0.000
3	0.010	0.023	0.173	0.025	0.054	0.083	0.064	0.003	0.002	0.000	0.000	0.000
4	0.008	0.040	0.129	0.026	0.055	0.075	0.049	0.003	0.002	0.000	0.000	0.000
5	0.008	0.054	0.104	0.022	0.143	0.064	0.037	0.004	0.004	0.000	0.000	0.000
6	0.007	0.045	0.069	0.022	0.201	0.068	0.042	0.005	0.004	0.000	0.000	0.000
7	0.007	0.033	0.047	0.022	0.204	0.055	0.041	0.004	0.004	0.000	0.000	0.000
8	0.007	0.020	0.040	0.018	0.189	0.047	0.088	0.004	0.003	0.000	0.000	0.000
9	0.007	0.017	0.032	0.020	0.168	0.045	0.043	0.003	0.003	0.000	0.000	0.000
10	0.007	0.015	0.027	0.019	0.155	0.052	0.034	0.003	0.003	0.000	0.000	0.000
11	0.007	0.013	0.040	0.012	0.137	0.060	0.033	0.003	0.003	0.000	0.000	0.000
12	0.007	0.012	0.044	0.014	0.099	0.111	0.031	0.003	0.002	0.000	0.000	0.000
13	0.007	0.009	0.058	0.012	0.088	0.212	0.032	0.003	0.001	0.000	0.000	0.000
14	0.007	0.009	0.055	0.013	0.131	0.273	0.031	0.002	0.000	0.000	0.000	0.000
15	0.008	0.007	0.063	0.010	0.117	0.240	0.028	0.002	0.000	0.000	0.000	0.000
16	0.007	0.019	0.066	0.009	0.126	0.204	0.020	0.002	0.000	0.000	0.000	0.000
17	0.007	0.021	0.060	0.010	0.874	0.178	0.020	0.001	0.000	0.000	0.000	0.000
18	0.007	0.006	0.042	0.014	1.733	0.161	0.018	0.001	0.000	0.000	0.000	0.000
19	0.006	0.006	0.034	0.050	1.000	0.514	0.018	0.001	0.000	0.000	0.000	0.000
20	0.006	0.005	0.036	0.027	0.581	0.423	0.026	0.000	0.000	0.000	0.000	0.000
21	0.009	0.005	0.026	0.031	0.403	0.388	0.028	0.000	0.000	0.000	0.000	0.000
22	0.008	0.018	0.028	0.037	0.302	0.311	0.016	0.000	0.000	0.000	0.000	0.000
23	0.011	0.014	0.029	0.028	0.211	0.257	0.011	0.001	0.000	0.000	0.000	0.000
24	0.008	0.017	0.027	0.029	0.226	0.199	0.012	0.023	0.000	0.000	0.000	0.000
25	0.007	0.020	0.015	0.039	0.183	0.153	0.014	0.022	0.000	0.000	0.000	0.000
26	0.007	0.024	0.016	0.066	0.181	0.119	0.015	0.010	0.000	0.000	0.000	0.000
27	0.007	0.124	0.017	0.065	0.175	0.102	0.014	0.024	0.000	0.000	0.000	0.000
28	0.007	0.348	0.013	0.073	0.112	0.097	0.019	0.020	0.000	0.000	0.000	0.000
29	0.007	0.469	0.011	0.087		0.088	0.015	0.012	0.000	0.000	0.000	0.000
30	0.007	0.332	0.010	0.060		0.085	0.011	0.007	0.000	0.000	0.000	0.000
31	0.007		0.035	0.047		0.078		0.005		0.000	0.000	
TOT.	0.230	1.763	1.786	0.952	7.936	4.916	0.948	0.186	0.038	0.000	0.000	0.000
MEAN	0.007	0.059	0.058	0.031	0.283	0.159	0.032	0.006	0.001	0.000	0.000	0.000
PEAK	0.022	0.841	0.415	0.166	2.825	1.320	0.231	0.596	0.017	0.000	0.000	0.000
MAX day	0.011	0.469	0.264	0.087	1.733	0.514	0.088	0.024	0.004	0.000	0.000	0.000
MIN day	0.003	0.005	0.010	0.009	0.040	0.045	0.011	0.000	0.000	0.000	0.000	0.000
CFSM	0.061	0.483	0.474	0.252	2.330	1.304	0.260	0.049	0.010	0.000	0.000	0.000
IN.	0.070	0.539	0.546	0.291	2.426	1.503	0.290	0.057	0.012	0.000	0.000	0.000

Table B.6. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 1
Water Year 1987
AREA = 0.954 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.037	0.144	0.406	0.438	1.063	8.612	0.874	0.404	0.204	0.088	0.008	0.013
2	0.035	0.138	0.726	0.388	1.493	4.706	0.934	0.355	0.177	0.100	0.007	0.013
3	0.034	0.132	0.657	0.327	1.248	3.128	1.345	0.387	0.147	0.121	0.006	0.012
4	0.033	0.129	0.516	0.297	0.949	2.368	1.692	0.703	0.133	0.177	0.006	0.012
5	0.032	0.143	0.430	0.282	0.846	1.976	1.964	0.395	0.114	0.202	0.005	0.012
6	0.032	0.139	0.366	0.267	0.832	1.583	2.246	0.356	0.103	0.232	0.014	0.011
7	0.031	0.208	0.322	0.259	0.839	1.239	2.210	0.320	0.096	0.250	0.014	0.011
8	0.030	0.316	1.610	0.250	0.767	1.177	1.940	0.250	0.088	0.153	0.013	0.021
9	0.034	0.400	12.708	0.240	0.602	1.417	1.592	0.214	0.082	0.122	0.013	0.020
10	0.075	0.336	8.249	0.276	0.523	0.970	1.226	0.197	0.079	0.108	0.014	0.020
11	0.148	1.150	5.941	0.258	0.501	0.769	1.179	0.184	0.073	0.135	0.013	0.019
12	0.147	0.778	2.971	0.231	0.509	0.845	1.021	0.174	0.076	0.130	0.025	0.357
13	0.533	0.426	1.912	0.214	0.455	0.764	0.810	0.165	0.094	0.112	0.023	0.095
14	0.393	0.293	0.909	0.209	0.498	0.781	1.153	0.152	0.085	0.099	0.021	0.065
15	0.181	0.318	0.733	0.281	0.511	0.784	3.106	0.143	0.078	0.082	0.020	0.048
16	0.129	0.286	1.503	0.262	2.873	0.814	3.188	0.137	0.080	0.075	0.020	0.045
17	0.107	0.255	1.030	0.240	2.861	0.675	3.275	0.192	0.090	0.069	0.021	0.045
18	0.095	0.230	0.903	1.852	2.530	1.070	2.577	0.222	0.079	0.063	0.020	0.044
19	0.088	0.198	0.711	22.345	2.110	2.421	2.086	0.165	0.083	0.059	0.020	0.061
20	0.087	0.361	0.602	7.354	1.832	2.094	1.663	0.509	0.089	0.055	0.018	0.061
21	0.083	0.387	0.623	4.191	1.713	1.876	1.267	0.395	0.099	0.052	0.018	0.048
22	0.082	0.290	0.923	3.158	2.595	1.529	1.041	0.377	0.544	0.049	0.017	0.043
23	0.082	0.364	0.675	2.294	4.362	1.224	0.885	0.238	0.412	0.039	0.016	0.038
24	0.086	2.100	0.554	1.792	3.131	1.092	0.848	0.194	0.181	0.028	0.016	0.034
25	1.742	1.571	0.521	3.672	2.408	1.024	0.656	0.245	0.140	0.023	0.016	0.032
26	0.671	3.025	0.490	5.340	2.024	0.800	0.563	0.261	0.126	0.018	0.015	0.030
27	0.312	1.791	0.460	3.528	10.990	0.737	0.521	0.183	0.099	0.015	0.015	0.028
28	0.225	0.971	0.465	2.630	11.484	0.670	0.501	0.158	0.084	0.013	0.014	0.026
29	0.194	0.653	0.408	2.124		0.598	0.453	0.158	0.077	0.011	0.014	0.052
30	0.172	0.512	0.412	1.838		1.096	0.427	0.215	0.073	0.010	0.014	0.125
31	0.153		0.404	1.301		1.196		0.322		0.008	0.013	
TOT.	6.083	18.042	49.140	68.141	62.549	50.034	43.243	8.371	3.886	2.694	0.471	1.443
MEAN	0.196	0.601	1.585	2.198	2.234	1.614	1.441	0.270	0.130	0.087	0.015	0.048
PEAK	2.992	4.291	18.819	45.669	18.819	13.543	4.843	2.992	4.843	0.492	0.445	2.756
MAX day	1.742	3.025	12.708	22.345	11.484	8.612	3.275	0.703	0.544	0.250	0.025	0.357
MIN day	0.030	0.129	0.322	0.209	0.455	0.598	0.427	0.137	0.073	0.008	0.005	0.011
CFSM	0.206	0.631	1.662	2.305	2.342	1.692	1.511	0.283	0.136	0.091	0.016	0.050
IN.	0.237	0.703	1.916	2.657	2.439	1.951	1.686	0.326	0.152	0.105	0.018	0.056

Table B.7. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 3
Water Year 1987
AREA = 0.559 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.024	0.040	0.233	0.185	0.580	5.501	0.427	0.154	0.065	0.032	0.004	0.003
2	0.030	0.038	0.404	0.147	0.772	2.831	0.679	0.130	0.056	0.030	0.004	0.003
3	0.025	0.037	0.322	0.111	0.574	1.835	0.602	0.155	0.046	0.038	0.003	0.002
4	0.019	0.036	0.234	0.102	0.467	1.255	0.661	0.356	0.052	0.052	0.002	0.002
5	0.017	0.040	0.185	0.092	0.439	0.979	0.877	0.143	0.043	0.074	0.002	0.002
6	0.014	0.038	0.152	0.097	0.450	0.758	1.191	0.119	0.038	0.087	0.007	0.002
7	0.014	0.086	0.138	0.098	0.448	0.632	1.246	0.100	0.035	0.085	0.007	0.002
8	0.013	0.105	0.780	0.081	0.412	0.646	1.037	0.084	0.031	0.049	0.006	0.013
9	0.020	0.149	7.873	0.106	0.276	0.729	0.993	0.075	0.028	0.038	0.006	0.011
10	0.029	0.114	5.188	0.099	0.233	0.445	0.645	0.069	0.026	0.033	0.007	0.009
11	0.042	0.441	3.831	0.084	0.246	0.375	0.634	0.064	0.024	0.050	0.007	0.008
12	0.046	0.308	2.507	0.076	0.265	0.389	0.542	0.064	0.024	0.045	0.014	0.081
13	0.125	0.163	1.368	0.071	0.215	0.363	0.417	0.058	0.028	0.039	0.013	0.019
14	0.062	0.105	0.967	0.086	0.273	0.404	0.612	0.056	0.022	0.030	0.012	0.012
15	0.029	0.146	0.715	0.131	0.262	0.422	1.908	0.054	0.021	0.028	0.011	0.012
16	0.020	0.132	0.506	0.113	1.261	0.441	2.074	0.049	0.023	0.025	0.011	0.012
17	0.017	0.120	0.459	0.100	1.575	0.356	2.140	0.091	0.025	0.023	0.010	0.011
18	0.015	0.102	0.706	0.705	1.408	0.573	1.522	0.095	0.021	0.022	0.009	0.011
19	0.014	0.079	0.536	11.932	1.100	1.146	1.086	0.065	0.024	0.020	0.008	0.019
20	0.014	0.163	0.501	4.506	0.939	1.076	0.833	0.204	0.028	0.019	0.008	0.010
21	0.013	0.133	0.380	2.562	0.885	0.956	0.654	0.173	0.028	0.018	0.007	0.009
22	0.013	0.107	0.308	1.878	1.350	0.797	0.545	0.144	0.317	0.017	0.006	0.008
23	0.013	0.185	0.376	1.185	2.645	0.657	0.465	0.090	0.159	0.016	0.006	0.008
24	0.013	0.815	0.474	0.911	1.943	0.637	0.436	0.069	0.068	0.014	0.006	0.007
25	0.346	0.743	0.309	1.926	1.346	0.601	0.311	0.089	0.047	0.013	0.005	0.007
26	0.195	1.509	0.251	3.312	1.094	0.420	0.250	0.090	0.046	0.012	0.005	0.007
27	0.098	0.887	0.245	2.150	6.524	0.414	0.234	0.065	0.025	0.010	0.005	0.006
28	0.063	0.540	0.225	1.509	7.243	0.350	0.214	0.055	0.019	0.009	0.004	0.006
29	0.054	0.364	0.207	1.126		0.330	0.184	0.047	0.019	0.007	0.004	0.040
30	0.048	0.285	0.207	0.950		0.559	0.183	0.045	0.014	0.006	0.004	0.037
31	0.043		0.171	0.648		0.497		0.082		0.005	0.003	
TOT.	1.489	8.011	30.759	37.079	35.226	27.373	23.600	3.134	1.400	0.949	0.207	0.380
MEAN	0.048	0.267	0.992	1.196	1.258	0.883	0.787	0.101	0.047	0.031	0.007	0.013
PEAK	0.629	2.013	10.900	18.60	10.656	7.904	2.588	1.271	2.371	0.150	-99.000	0.685
MAX day	0.346	1.509	7.873	11.932	7.243	5.501	2.140	0.356	0.317	0.087	0.014	0.081
MIN day	0.013	0.036	0.138	0.071	0.215	0.330	0.183	0.045	0.014	0.005	0.002	0.002
CFSM	0.086	0.478	1.775	2.139	2.250	1.579	1.407	0.181	0.083	0.055	0.012	0.023
IN.	0.099	0.533	2.046	2.466	2.343	1.821	1.570	0.208	0.093	0.063	0.014	0.025

Table B.8. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 4
Water Year 1987
AREA = 0.210 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.004	0.007	0.084	0.087	0.216	1.766	0.181	0.060	0.018	0.002	0.001	0.000
2	0.004	0.007	0.144	0.073	0.268	1.001	0.175	0.045	0.015	0.002	0.001	0.000
3	0.004	0.006	0.123	0.053	0.221	0.712	0.191	0.047	0.012	0.002	0.001	0.000
4	0.004	0.006	0.101	0.051	0.212	0.543	0.197	0.096	0.010	0.004	0.001	0.000
5	0.004	0.007	0.085	0.046	0.231	0.393	0.306	0.046	0.005	0.008	0.000	0.000
6	0.003	0.006	0.071	0.044	0.231	0.322	0.350	0.040	0.003	0.010	0.000	0.000
7	0.003	0.027	0.065	0.049	0.226	0.290	0.348	0.035	0.002	0.012	0.000	0.001
8	0.002	0.031	0.249	0.042	0.206	0.303	0.327	0.029	0.002	0.008	0.000	0.001
9	0.005	0.041	2.472	0.041	0.148	0.328	0.260	0.024	0.002	0.005	0.000	0.002
10	0.007	0.054	1.695	0.050	0.134	0.222	0.214	0.023	0.002	0.003	0.000	0.002
11	0.011	0.179	1.236	0.044	0.140	0.179	0.217	0.023	0.002	0.004	0.000	0.001
12	0.011	0.141	0.790	0.037	0.145	0.175	0.199	0.023	0.002	0.003	0.002	0.004
13	0.031	0.073	0.426	0.035	0.109	0.166	0.161	0.020	0.002	0.004	0.001	0.003
14	0.016	0.043	0.316	0.038	0.129	0.177	0.241	0.018	0.002	0.003	0.001	0.002
15	0.007	0.056	0.275	0.050	0.126	0.179	0.526	0.016	0.002	0.003	0.001	0.002
16	0.005	0.052	0.233	0.052	0.474	0.184	0.493	0.014	0.002	0.002	0.001	0.002
17	0.004	0.048	0.200	0.048	0.477	0.154	0.605	0.018	0.002	0.002	0.001	0.002
18	0.004	0.044	0.273	0.240	0.452	0.228	0.483	0.023	0.002	0.002	0.001	0.001
19	0.004	0.031	0.223	4.590	0.356	0.381	0.366	0.018	0.002	0.001	0.001	0.002
20	0.004	0.052	0.209	1.589	0.331	0.344	0.310	0.035	0.003	0.001	0.001	0.002
21	0.003	0.056	0.162	0.883	0.331	0.317	0.270	0.036	0.003	0.001	0.000	0.002
22	0.003	0.045	0.137	0.622	0.497	0.280	0.244	0.037	0.054	0.001	0.000	0.002
23	0.002	0.070	0.157	0.366	0.895	0.251	0.224	0.026	0.034	0.001	0.000	0.002
24	0.003	0.280	0.203	0.272	0.616	0.244	0.181	0.019	0.021	0.001	0.000	0.001
25	0.073	0.249	0.139	0.550	0.445	0.227	0.124	0.018	0.013	0.001	0.000	0.001
26	0.041	0.361	0.117	0.790	0.377	0.177	0.106	0.026	0.010	0.001	0.000	0.001
27	0.020	0.262	0.115	0.550	2.260	0.181	0.101	0.020	0.005	0.001	0.000	0.001
28	0.013	0.179	0.108	0.413	2.472	0.154	0.089	0.016	0.002	0.001	0.000	0.001
29	0.010	0.133	0.098	0.326		0.150	0.077	0.013	0.002	0.001	0.000	0.006
30	0.008	0.104	0.099	0.282		0.229	0.080	0.014	0.002	0.001	0.000	0.002
31	0.007		0.080	0.227		0.216		0.022		0.001	0.000	
TOT.	0.321	2.651	10.687	12.540	12.724	10.472	7.645	0.898	0.243	0.091	0.018	0.050
MEAN	0.010	0.088	0.345	0.405	0.454	0.338	0.255	0.029	0.008	0.003	0.001	0.002
PEAK	-99.000	0.541	3.884	7.062 *	3.884 *	2.825	1.158	0.235	0.891	0.021	-99.000	0.057
MAX day	0.073	0.361	2.472	4.590	2.472	1.766	0.605	0.096	0.054	0.012	0.002	0.006
MIN day	0.002	0.006	0.065	0.035	0.109	0.150	0.077	0.013	0.002	0.001	0.000	0.000
CFSM	0.049	0.421	1.641	1.926	2.163	1.608	1.213	0.138	0.038	0.014	0.003	0.008
IN.	0.057	0.469	1.892	2.220	2.253	1.854	1.353	0.159	0.043	0.016	0.003	0.009

Table B.9. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 7
Water Year 1987
AREA = 0.054 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.008	0.013	0.050	0.022	0.061	0.643	0.065	0.045	0.034	0.018	0.013	0.011
2	0.008	0.013	0.042	0.023	0.079	0.326	0.072	0.042	0.030	0.018	0.012	0.010
3	0.008	0.012	0.035	0.018	0.062	0.227	0.074	0.048	0.030	0.019	0.012	0.010
4	0.008	0.012	0.027	0.020	0.055	0.169	0.079	0.057	0.029	0.021	0.012	0.010
5	0.008	0.011	0.015	0.017	0.049	0.137	0.094	0.038	0.018	0.026	0.013	0.010
6	0.007	0.011	0.013	0.017	0.054	0.105	0.124	0.038	0.016	0.026	0.015	0.010
7	0.007	0.010	0.014	0.022	0.052	0.089	0.167	0.031	0.015	0.020	0.013	0.010
8	0.007	0.013	0.051	0.017	0.058	0.101	0.141	0.031	0.017	0.017	0.013	0.018
9	0.011	0.013	0.417	0.019	0.037	0.107	0.115	0.028	0.017	0.017	0.013	0.016
10	0.016	0.010	0.358	0.022	0.032	0.079	0.097	0.030	0.020	0.020	0.021	0.014
11	0.023	0.036	0.243	0.019	0.042	0.065	0.082	0.034	0.020	0.025	0.018	0.013
12	0.025	0.042	0.199	0.015	0.044	0.056	0.084	0.034	0.023	0.024	0.028	0.035
13	0.034	0.021	0.112	0.015	0.036	0.049	0.066	0.032	0.024	0.023	0.032	0.028
14	0.018	0.018	0.069	0.020	0.047	0.056	0.085	0.035	0.019	0.018	0.017	0.025
15	0.017	0.017	0.046	0.025	0.048	0.065	0.112	0.036	0.019	0.014	0.016	0.018
16	0.015	0.016	0.034	0.023	0.095	0.067	0.170	0.033	0.023	0.014	0.014	0.017
17	0.015	0.016	0.039	0.020	0.155	0.059	0.217	0.040	0.020	0.014	0.019	0.016
18	0.014	0.016	0.048	0.058	0.160	0.059	0.184	0.038	0.018	0.016	0.018	0.016
19	0.014	0.016	0.040	0.982	0.130	0.100	0.150	0.038	0.017	0.014	0.018	0.021
20	0.014	0.023	0.038	0.407	0.109	0.121	0.112	0.056	0.018	0.016	0.017	0.020
21	0.013	0.021	0.029	0.237	0.103	0.133	0.084	0.056	0.017	0.015	0.017	0.019
22	0.013	0.020	0.024	0.169	0.122	0.119	0.057	0.046	0.030	0.015	0.016	0.018
23	0.013	0.020	0.034	0.107	0.189	0.105	0.069	0.040	0.023	0.016	0.015	0.017
24	0.013	0.074	0.046	0.070	0.226	0.095	0.072	0.033	0.016	0.014	0.014	0.016
25	0.092	0.071	0.033	0.107	0.166	0.091	0.054	0.036	0.014	0.014	0.014	0.016
26	0.053	0.089	0.026	0.227	0.140	0.065	0.048	0.031	0.014	0.014	0.013	0.016
27	0.026	0.081	0.024	0.215	0.565	0.067	0.051	0.032	0.009	0.013	0.012	0.016
28	0.017	0.074	0.023	0.159	0.729	0.061	0.044	0.032	0.008	0.013	0.012	0.016
29	0.016	0.066	0.022	0.122		0.058	0.044	0.027	0.009	0.013	0.012	0.029
30	0.015	0.058	0.025	0.105		0.069	0.044	0.036	0.010	0.013	0.011	0.020
31	0.013		0.020	0.065		0.072		0.035		0.013	0.011	
TOT.	0.563	0.913	2.197	3.362	3.645	3.611	2.859	1.170	0.576	0.534	0.482	0.510
MEAN	0.018	0.030	0.071	0.108	0.130	0.116	0.095	0.038	0.019	0.017	0.016	0.017
PEAK	-99.000	-99.000	0.665	2.022	1.018	0.958	0.244	0.268	0.231	0.066	-99.000	0.783
MAX day	0.092	0.089	0.417	0.982	0.729	0.643	0.217	0.057	0.034	0.026	0.032	0.035
MIN day	0.007	0.010	0.013	0.015	0.032	0.049	0.044	0.027	0.008	0.013	0.011	0.010
CFSM	0.336	0.563	1.311	2.006	2.408	2.155	1.763	0.698	0.355	0.319	0.288	0.315
IN.	0.387	0.628	1.512	2.313	2.508	2.484	1.967	0.805	0.396	0.367	0.332	0.351

Table B.10. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 8
Water Year 1987
AREA = 0.122 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0.000	0.000	0.026	0.023	0.091	0.733	0.076	0.030	0.004	0.000	0.000	0.000
2	0.000	0.000	0.021	0.020	0.107	0.529	0.086	0.018	0.002	0.000	0.000	0.000
3	0.000	0.000	0.016	0.016	0.079	0.395	0.111	0.023	0.002	0.000	0.000	0.000
4	0.000	0.000	0.012	0.014	0.067	0.291	0.111	0.044	0.001	0.000	0.000	0.000
5	0.000	0.001	0.008	0.012	0.065	0.225	0.142	0.017	0.000	0.000	0.000	0.000
6	0.000	0.003	0.008	0.012	0.068	0.175	0.175	0.014	0.000	0.000	0.000	0.000
7	0.000	0.005	0.009	0.012	0.074	0.154	0.197	0.011	0.000	0.000	0.000	0.000
8	0.000	0.011	0.050	0.010	0.071	0.143	0.173	0.007	0.000	0.000	0.000	0.000
9	0.000	0.010	0.505	0.011	0.049	0.154	0.153	0.006	0.000	0.000	0.000	0.000
10	0.000	0.009	0.541	0.012	0.040	0.094	0.142	0.006	0.000	0.000	0.000	0.000
11	0.000	0.021	0.440	0.010	0.041	0.072	0.139	0.005	0.000	0.000	0.000	0.000
12	0.000	0.018	0.317	0.008	0.046	0.068	0.117	0.004	0.000	0.000	0.000	0.000
13	0.000	0.014	0.198	0.007	0.040	0.062	0.087	0.004	0.000	0.000	0.000	0.000
14	0.000	0.011	0.137	0.008	0.048	0.073	0.113	0.004	0.000	0.000	0.000	0.000
15	0.000	0.009	0.108	0.014	0.048	0.082	0.185	0.003	0.000	0.000	0.000	0.000
16	0.000	0.008	0.071	0.011	0.144	0.089	0.272	0.003	0.000	0.000	0.000	0.000
17	0.000	0.006	0.058	0.009	0.219	0.069	0.287	0.009	0.000	0.000	0.000	0.000
18	0.000	0.006	0.067	0.063	0.219	0.100	0.252	0.009	0.000	0.000	0.000	0.000
19	0.000	0.005	0.047	0.903	0.180	0.153	0.208	0.005	0.000	0.000	0.000	0.000
20	0.000	0.007	0.050	0.587	0.169	0.178	0.184	0.026	0.000	0.000	0.000	0.000
21	0.000	0.006	0.042	0.414	0.162	0.171	0.168	0.018	0.000	0.000	0.000	0.000
22	0.000	0.006	0.034	0.334	0.208	0.151	0.139	0.014	0.000	0.000	0.000	0.000
23	0.000	0.005	0.043	0.209	0.290	0.141	0.109	0.007	0.000	0.000	0.000	0.000
24	0.000	0.042	0.055	0.161	0.276	0.136	0.096	0.005	0.000	0.000	0.000	0.000
25	0.000	0.046	0.037	0.240	0.235	0.120	0.067	0.012	0.000	0.000	0.000	0.000
26	0.005	0.049	0.029	0.327	0.222	0.090	0.054	0.010	0.000	0.000	0.000	0.000
27	0.001	0.045	0.026	0.290	0.598	0.088	0.050	0.004	0.000	0.000	0.000	0.000
28	0.000	0.040	0.024	0.245	0.795	0.077	0.043	0.003	0.000	0.000	0.000	0.000
29	0.000	0.035	0.022	0.200		0.074	0.040	0.002	0.000	0.000	0.000	0.000
30	0.000	0.030	0.023	0.171		0.110	0.040	0.007	0.000	0.000	0.000	0.000
31	0.000		0.020	0.120		0.087		0.009		0.000	0.000	
TOT.	0.006	0.449	3.045	4.476	4.653	5.081	4.018	0.337	0.011	0.000	0.000	0.000
MEAN	0.000	0.015	0.098	0.144	0.166	0.164	0.134	0.011	0.000	0.000	0.000	0.000
PEAK	0.035	0.131	0.766	1.353	0.768	0.934	0.360	0.273	0.006	0.000	0.000	0.000
MAX day	0.005	0.049	0.541	0.903	0.795	0.733	0.287	0.044	0.004	0.000	0.000	0.000
MIN day	0.000	0.000	0.008	0.007	0.040	0.062	0.040	0.002	0.000	0.000	0.000	0.000
CFSM	0.002	0.123	0.807	1.187	1.366	1.348	1.101	0.089	0.003	0.000	0.000	0.000
IN.	0.002	0.137	0.931	1.368	1.423	1.553	1.229	0.103	0.003	0.000	0.000	0.000

Table B.11. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 1
Water Year 1988
AREA = 0.954 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR
1	0.061	0.064	0.093	0.416	0.229	0.306
2	0.049	0.064	0.086	0.350	0.369	0.291
3	0.046	0.061	0.082	0.272	0.562	0.291
4	0.047	0.063	0.085	0.370	4.199	0.204
5	0.049	0.067	0.082	0.276	2.728	0.303
6	0.049	0.070	0.082	0.224	1.850	0.279
7	0.050	0.071	0.082	0.204	1.231	0.267
8	0.046	0.076	0.082	0.213	0.877	0.259
9	0.045	0.080	0.083	0.187	0.661	0.277
10	0.049	0.245	0.085	0.173	0.527	10.594
11	0.050	0.147	0.082	0.164	0.466	5.243
12	0.050	0.142	0.120	0.161	0.463	3.640
13	0.050	0.095	0.216	0.191	0.375	3.691
14	0.049	0.088	0.221	0.192	0.331	2.677
15	0.049	0.086	0.372	0.182	0.820	2.051
16	0.050	0.082	0.295	0.177	0.741	1.482
17	0.050	0.234	0.261	0.305	0.605	1.042
18	0.050	0.169	0.242	1.285	0.579	0.907
19	0.050	0.122	0.238	6.555	0.678	0.780
20	0.050	0.105	0.248	14.066	0.634	0.614
21	0.060	0.095	0.241	3.062	0.501	0.527
22	0.063	0.093	0.236	1.826	0.446	0.460
23	0.059	0.088	0.227	1.104	0.496	0.410
24	0.059	0.088	0.273	0.697	0.446	0.391
25	0.060	0.088	0.717	0.530	0.394	0.405
26	0.060	0.088	0.509	0.417	0.374	0.409
27	0.068	0.088	0.455	0.370	0.383	0.372
28	0.064	0.089	0.678	0.345	0.363	0.326
29	0.064	0.109	0.406	0.293	0.334	0.305
30	0.064	0.097	0.298	0.245		0.302
31	0.065		0.230	0.237		0.309
TOT.	1.675	3.054	7.407	35.088	22.662	39.413
MEAN	0.054	0.102	0.239	1.132	0.781	1.271
PEAK	0.076	0.341	1.170	58.801	7.730	20.900
MAX day	0.068	0.245	0.717	14.066	4.199	10.594
MIN day	0.045	0.061	0.082	0.161	0.229	0.204
CFSM	0.057	0.107	0.251	1.187	0.819	1.333
IN.	0.065	0.119	0.289	1.368	0.884	1.537

Table B.12. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 3
Water Year 1988
AREA = 0.559 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR
1	0.013	0.014	0.008	0.100	0.076	0.111
2	0.011	0.013	0.007	0.069	0.156	0.109
3	0.012	0.010	0.016	0.065	0.223	0.120
4	0.013	0.012	0.015	0.082	2.241	0.151
5	0.017	0.010	0.014	0.055	1.753	0.123
6	0.021	0.009	0.013	0.047	1.000	0.102
7	0.029	0.009	0.013	0.050	0.698	0.094
8	0.019	0.015	0.016	0.060	0.496	0.086
9	0.017	0.050	0.018	0.050	0.349	0.098
10	0.016	0.032	0.014	0.040	0.256	5.809
11	0.015	0.009	0.015	0.030	0.218	3.694
12	0.013	0.007	0.014	0.030	0.182	2.524
13	0.012	0.008	0.013	0.037	0.128	2.436
14	0.011	0.008	0.021	0.030	0.117	1.769
15	0.011	0.011	0.083	0.027	0.368	1.218
16	0.011	0.039	0.045	0.028	0.300	0.852
17	0.011	0.048	0.030	0.066	0.280	0.604
18	0.011	0.020	0.022	0.286	0.298	0.547
19	0.015	0.014	0.025	2.837	0.390	0.454
20	0.380	0.012	0.033	6.050	0.309	0.338
21	0.034	0.009	0.024	1.636	0.210	0.278
22	0.030	0.008	0.024	0.891	0.206	0.223
23	0.016	0.012	0.018	0.530	0.258	0.195
24	0.014	0.012	0.042	0.334	0.193	0.178
25	0.014	0.014	0.169	0.220	0.166	0.187
26	0.013	0.014	0.115	0.130	0.151	0.202
27	0.014	0.013	0.104	0.092	0.178	0.174
28	0.014	0.020	0.151	0.077	0.152	0.142
29	0.016	0.013	0.077	0.070	0.134	0.132
30	0.018	0.011	0.052	0.073		0.129
31	0.015		0.049	0.080		0.136
TOT.	0.856	0.476	1.260	14.172	11.486	23.215
MEAN	0.028	0.016	0.041	0.457	0.396	0.749
PEAK	0.070	0.146	0.420	18.082	3.532	9.700
MAX day	0.380	0.050	0.169	6.050	2.241	5.809
MIN day	0.011	0.007	0.007	0.027	0.076	0.086
CFSM	0.049	0.028	0.073	0.818	0.708	1.339
IN.	0.057	0.032	0.084	0.943	0.764	1.544

Table B.13. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 4
Water Year 1988
AREA = 0.210 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR
1	0.002	0.001	0.001	0.009	0.040	0.046
2	0.002	0.001	0.001	0.006	0.060	0.045
3	0.002	0.001	0.001	0.007	0.098	0.053
4	0.002	0.001	0.002	0.009	0.650	0.055
5	0.003	0.001	0.002	0.008	0.481	0.046
6	0.004	0.001	0.002	0.008	0.294	0.038
7	0.002	0.001	0.002	0.009	0.233	0.037
8	0.001	0.001	0.002	0.012	0.192	0.034
9	0.001	0.002	0.002	0.011	0.148	0.034
10	0.001	0.003	0.003	0.008	0.114	0.487
11	0.001	0.002	0.003	0.008	0.107	1.059
12	0.001	0.001	0.002	0.009	0.086	0.788
13	0.001	0.001	0.002	0.009	0.064	0.802
14	0.001	0.001	0.002	0.009	0.062	0.554
15	0.001	0.001	0.005	0.009	0.166	0.411
16	0.001	0.002	0.002	0.010	0.143	0.303
17	0.001	0.009	0.002	0.018	0.132	0.240
18	0.001	0.003	0.002	0.144	0.142	0.219
19	0.002	0.001	0.002	0.604	0.177	0.190
20	0.012	0.001	0.002	1.857	0.139	0.146
21	0.007	0.001	0.001	0.654	0.091	0.121
22	0.006	0.001	0.001	0.292	0.100	0.099
23	0.004	0.001	0.001	0.212	0.115	0.088
24	0.002	0.001	0.004	0.152	0.077	0.083
25	0.004	0.001	0.013	0.109	0.069	0.083
26	0.006	0.001	0.008	0.061	0.067	0.085
27	0.011	0.002	0.008	0.045	0.082	0.073
28	0.009	0.002	0.012	0.040	0.062	0.063
29	0.006	0.001	0.010	0.038	0.056	0.060
30	0.001	0.001	0.006	0.038		0.057
31	0.001		0.005	0.041		0.055
TOT.	0.099	0.047	0.111	4.446	4.247	6.454
MEAN	0.003	0.002	0.004	0.143	0.146	0.208
PEAK	0.028	0.024	0.030	6.000	1.000	1.820
MAX day	0.012	0.009	0.013	1.857	0.650	1.059
MIN day	0.001	0.001	0.001	0.006	0.040	0.034
CFSM	0.015	0.007	0.017	0.683	0.697	0.991
IN.	0.018	0.008	0.020	0.787	0.752	1.143

Table B.14. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 7
Water Year 1988
AREA = 0.054 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR
1	0.015	0.012	0.007	0.034	0.018	0.019
2	0.017	0.012	0.004	0.027	0.028	0.019
3	0.011	0.011	0.012	0.026	0.034	0.019
4	0.011	0.012	0.015	0.027	0.136	0.021
5	0.011	0.011	0.015	0.027	0.142	0.019
6	0.016	0.011	0.015	0.028	0.085	0.018
7	0.014	0.011	0.015	0.028	0.054	0.017
8	0.011	0.010	0.014	0.037	0.035	0.017
9	0.013	0.011	0.014	0.030	0.032	0.018
10	0.011	0.015	0.014	0.028	0.030	0.448
11	0.016	0.013	0.012	0.026	0.028	0.286
12	0.016	0.011	0.012	0.024	0.026	0.189
13	0.015	0.011	0.012	0.022	0.026	0.171
14	0.014	0.010	0.021	0.022	0.025	0.159
15	0.010	0.010	0.026	0.020	0.035	0.134
16	0.010	0.010	0.015	0.022	0.037	0.082
17	0.011	0.018	0.011	0.060	0.032	0.060
18	0.011	0.016	0.011	0.038	0.028	0.052
19	0.014	0.014	0.018	0.217	0.036	0.049
20	0.021	0.014	0.020	0.506	0.037	0.041
21	0.012	0.013	0.019	0.142	0.031	0.036
22	0.011	0.013	0.018	0.071	0.027	0.031
23	0.010	0.013	0.013	0.035	0.029	0.028
24	0.013	0.012	0.023	0.025	0.027	0.028
25	0.014	0.012	0.048	0.020	0.024	0.029
26	0.013	0.010	0.037	0.012	0.027	0.029
27	0.014	0.010	0.035	0.011	0.028	0.027
28	0.010	0.013	0.047	0.010	0.025	0.024
29	0.014	0.010	0.024	0.011	0.020	0.024
30	0.014	0.008	0.017	0.014		0.024
31	0.012		0.024	0.017		0.023
TOT.	0.405	0.357	0.588	1.617	1.142	2.141
MEAN	0.013	0.012	0.019	0.052	0.039	0.069
PEAK	0.038	0.027	0.089	1.880	0.214	0.818
MAX day	0.021	0.018	0.048	0.506	0.142	0.448
MIN day	0.010	0.008	0.004	0.010	0.018	0.017
CFSM	0.242	0.220	0.351	0.965	0.728	1.278
IN.	0.279	0.246	0.404	1.112	0.786	1.473

Table B.15. DAILY AVERAGE DISCHARGE
CENTRAL WASTE DISPOSAL FACILITY: CWDF 8
Water Year 1988
AREA = 0.122 SQUARE MILES
(UNITS = CFS)

DAY	OCT	NOV	DEC	JAN	FEB	MAR
1	0.000	0.000	0.000	0.000	0.005	0.010
2	0.000	0.000	0.000	0.000	0.013	0.010
3	0.000	0.000	0.000	0.000	0.023	0.010
4	0.000	0.000	0.000	0.000	0.161	0.012
5	0.000	0.000	0.000	0.000	0.215	0.011
6	0.000	0.000	0.000	0.000	0.157	0.010
7	0.000	0.000	0.000	0.000	0.135	0.008
8	0.000	0.000	0.000	0.000	0.095	0.007
9	0.000	0.000	0.000	0.000	0.063	0.006
10	0.000	0.000	0.000	0.000	0.043	0.031
11	0.000	0.000	0.000	0.000	0.036	0.185
12	0.000	0.000	0.000	0.000	0.026	0.326
13	0.000	0.000	0.000	0.000	0.020	0.269
14	0.000	0.000	0.000	0.000	0.020	0.203
15	0.000	0.000	0.000	0.000	0.045	0.142
16	0.000	0.000	0.000	0.000	0.027	0.104
17	0.000	0.000	0.000	0.003	0.026	0.080
18	0.000	0.000	0.000	0.005	0.033	0.058
19	0.000	0.000	0.000	0.237	0.037	0.043
20	0.000	0.000	0.000	0.644	0.033	0.032
21	0.000	0.000	0.000	0.269	0.030	0.017
22	0.000	0.000	0.000	0.167	0.027	0.011
23	0.000	0.000	0.000	0.108	0.023	0.008
24	0.000	0.000	0.000	0.060	0.020	0.007
25	0.000	0.000	0.000	0.035	0.016	0.014
26	0.000	0.000	0.000	0.016	0.013	0.023
27	0.000	0.000	0.000	0.011	0.012	0.024
28	0.000	0.000	0.000	0.009	0.011	0.022
29	0.000	0.000	0.000	0.008	0.010	0.018
30	0.000	0.000	0.000	0.007		0.016
31	0.000		0.000	0.007		0.015
TOT.	0.000	0.000	0.000	1.586	1.375	1.732
MEAN	0.000	0.000	0.000	0.051	0.047	0.056
PEAK	0.000	0.000	0.000	1.891	0.252	0.470
MAX day	0.000	0.000	0.000	0.644	0.215	0.326
MIN day	0.000	0.000	0.000	0.000	0.005	0.006
CFSM	0.000	0.000	0.000	0.421	0.390	0.459
IN.	0.000	0.000	0.000	0.485	0.420	0.530

APPENDIX N

SMALL MAMMAL SAMPLING AT FOUR PROPOSED LOW-LEVEL WASTE DISPOSAL SITES ON THE OAK RIDGE RESERVATION

SPRING 1988

Katie Greenberg

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N.1. INTRODUCTION

Small mammal populations were sampled at four sites proposed for low-level radioactive waste dumping on the Oak Ridge Reservation (ORR). The sites sampled were:

Area 1. New Zion Patrol Road (Sect. N.2.1),
Area 2. Gum Branch/Bear Creek (Sect. N.3.1),
Area 3. Melton Valley Drive (Sect. N.4.1),
Area 4. East Chestnut Ridge site (Sect. N.5.1).

An attempt was made to sample representative as well as unusual habitat types if present. All areas were surveyed using straight Sherman live traps placed approximately 10 m apart in straight-line transects. The number of traps and total trap-nights varies with the transect, as described below.

N.2 AREA 1, NEW ZION PATROL ROAD

Four habitat types were sampled in Area 1. Transect locations and dominant forest type for each transect are designated in Fig. N.2.1. The habitat description and trapping results are given below.

N.2.1 Transect A

Mixed pine and hardwood: Virginia pine, slash pine, loblolly pine, yellow poplar, and red oak.

Number of traps along transect: 15
Number of nights trapped: 5
Total number of trap-nights: 75
Number of individuals of each species:

4 *Peromyscus leucopus*

N.2.2 Transect B

Oldfield (overgrown powerline right-of-way): Broomsedge, grasses, sumac, blackberry, and tree seedlings.

Number of traps along transect: 20
Number of nights trapped: 5
Total number of trap-nights: 100
Number of individuals of each species:

4 *Peromyscus leucopus*
1 *Mus musculus*
3 *Reithrodontomys humulis*

NOTE: Animal tracks noted along or near Connelly powerline include coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), and turkey (*Meleagris gallopavo*).

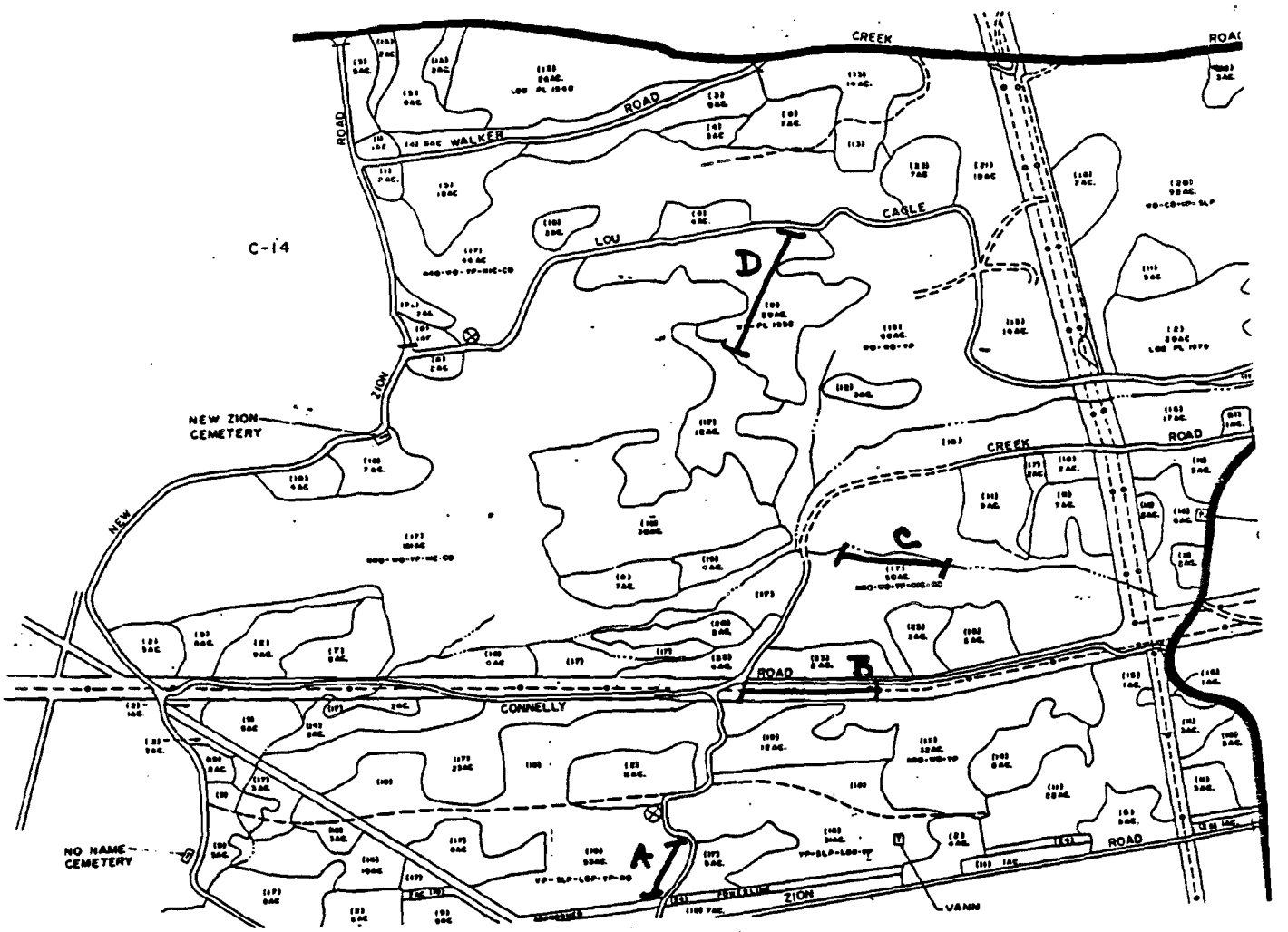

Fig. N.2.1 Location of Area 1, New Zion Patrol Road. Transects A-D are denoted by A-D.

N.2.3 Transect C

Mixed hardwood along Grassy Creek streambank: northern red oak, white oak, yellow poplar, hickory, and chestnut oak.

Number of traps along transect: 20
Number of nights trapped: 5
Total number of trap-nights: 100
Number of individuals of each species:

5 *Peromyscus leucopus*

NOTE: Captured 1 crayfish.

N.2.4 Transect D

White pine plantation (planted in 1952).

Number of traps along transect: 20
Number of nights trapped: 5
Total number of trap-nights: 100
Number of individuals of each species:

5 *Peromyscus leucopus*

Total number of trap-nights in Area 1: 375.

N.3 AREA 2, GUM BRANCH ROAD/BEAR CREEK ROAD

Four habitat types were sampled in Area 2. Transect locations and dominant forest type for each transect are designated in Fig. N.3.1. The habitat description and trapping results are given below.

N.3.1 Transect A

Loblolly pine plantation (planted in 1976).

Number of traps along transect: 20
Number of nights trapped: 6
Total number of trap-nights: 120
Number of individuals of each species: 0 captures.

N.3.2 Transect B

Loblolly pine plantation (planted in 1948).

Number of traps along transect: 20
Number of nights trapped: 6
Total number of trap-nights: 120
Number of individuals of each species:

7 *Peromyscus leucopus*
1 *Ochrotomys nuttalli*

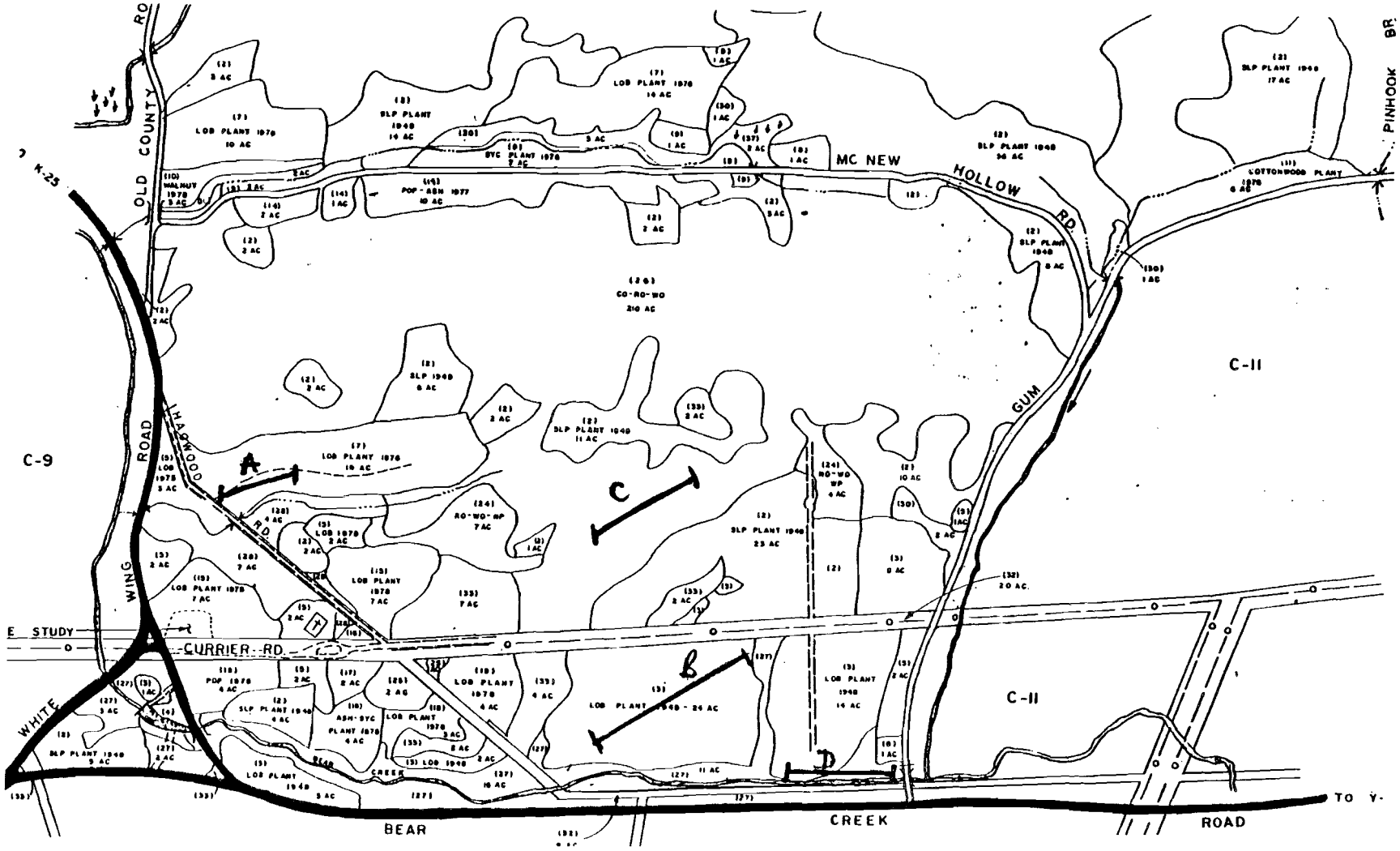

Fig. N.3.1 Location of Area 2, Gum Branch Road/Bear Creek Road. Transects A-C are denoted by A-C.

N.3.3 Transect C

Chestnut oak, red oak, and white oak along a ridgetop.

Number of traps along transect: 20
Number of nights trapped: 6
Total number of trap-nights: 120
Number of individuals of each species:

4 *Peromyscus leucopus*

N.3.4 Transect D

Disturbed area along Bear Creek (vegetation type 27).

Number of traps along transect: 9
Number of nights trapped: 6
Total number of trap-nights: 54
Number of individuals of each species:

6 *Peromyscus leucopus*
Total number of trap-nights in Area 2: 413

N.4 AREA 3, MELTON VALLEY DRIVE

Four habitat types were sampled in Area 3. Transect locations and dominant forest type for each transect are designated in Fig. N.4.1. The habitat description and trapping results are given below.

N.4.1 Transect A

Natural Pine habitat.

Number of traps along transect: 20
Number of nights trapped: 6
Total number of trap-nights: 120
Number of individuals of each species:

6 *Peromyscus leucopus*
1 *Ochrotomys nuttalli*
1 *Mus musculus*

N.4.2 Transect B

Low/wetland area (grasses, cattails, wetland species).

Number of traps along transect: 4
Number of nights trapped: 6
Total number of trap-nights: 24
Number of individuals of each species:

2 *Peromyscus leucopus*

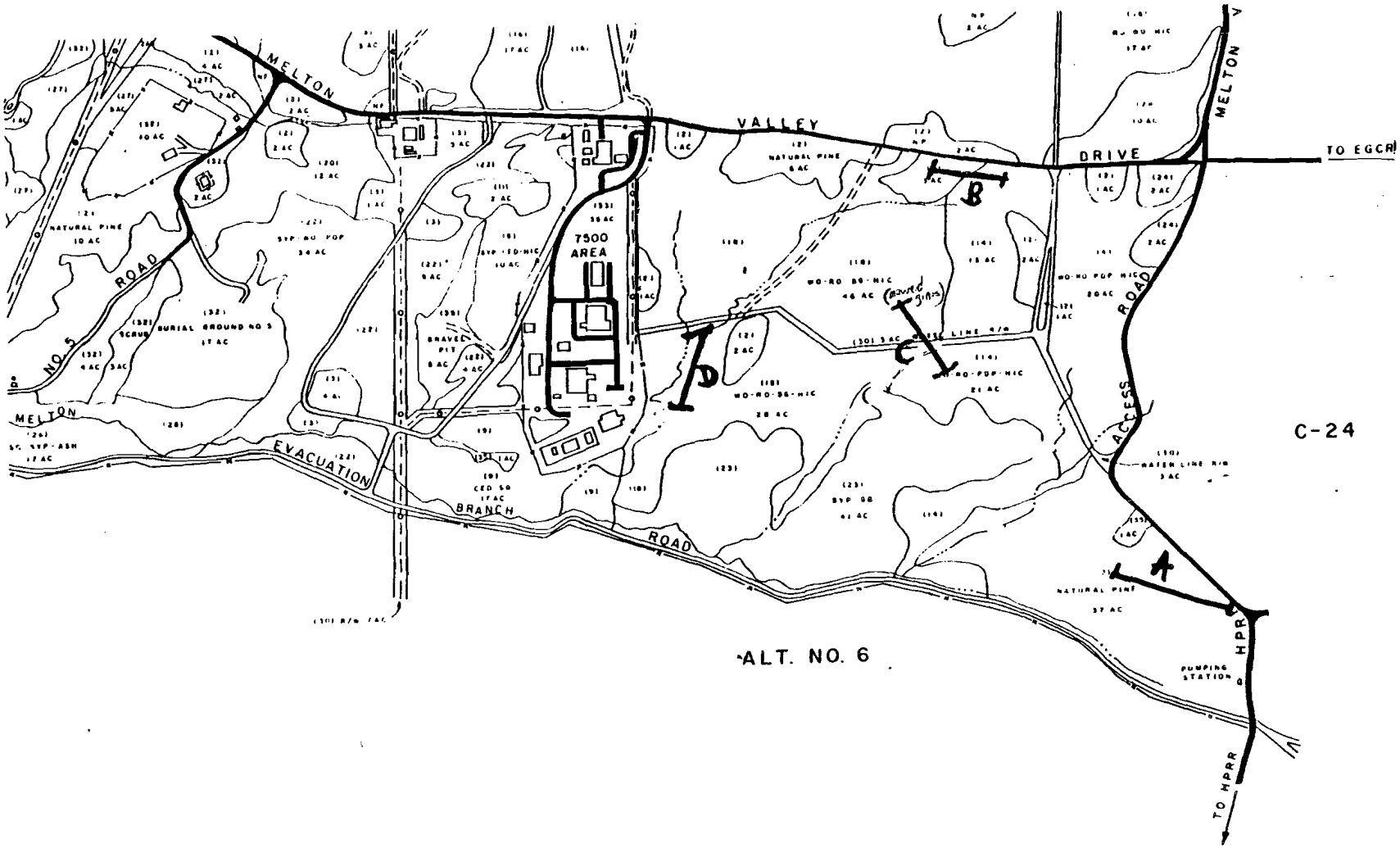

Fig. N.4.1 Location of Area 3, Melton Valley Drive. Transects A-D are denoted by A-D.

N.4.3 Transect C

Open, mowed meadow (lawn) on ridgetop.

Number of traps along transect: 10
Number of nights trapped: 5
Total number of trap-nights: 50
Number of individuals of each species: 0 capture.

N.4.4 Transect D

Mixed hardwood (white oak, red oak, yellow poplar, and hickory) along streambank.

Number of traps along transect: 20
Number of nights trapped: 5
Total number of trap-nights: 100
Number of individuals of each species:

2 *Peromyscus leucopus*
1 *Mus musculus*

Total number of trapnights in Area 3: 294.

N.5 AREA 4, EAST CHESTNUT RIDGE

Three habitat types were sampled in Area 4. Transect locations and dominant forest type for each transect are designated in Fig. N.5.1. The habitat description and trapping results are given below.

N.5.1 Transect A

Pasture along drainage gully.

Number of traps along transect: 20
Number of nights trapped: 5
Total number of trap-nights: 100
Number of individuals of each species:

2 *Peromyscus leucopus*
1 *Reithrodontomys humulis*

N.5.2 Transect B

Willows/lowland/tailings pond.

Number of traps along transect: 20
Number of nights trapped: 5
Total number of trap-nights: 100
Number of individuals of each species:

7 *Peromyscus leucopus*

NOTE: Coyote tracks were noted in tailings pond.

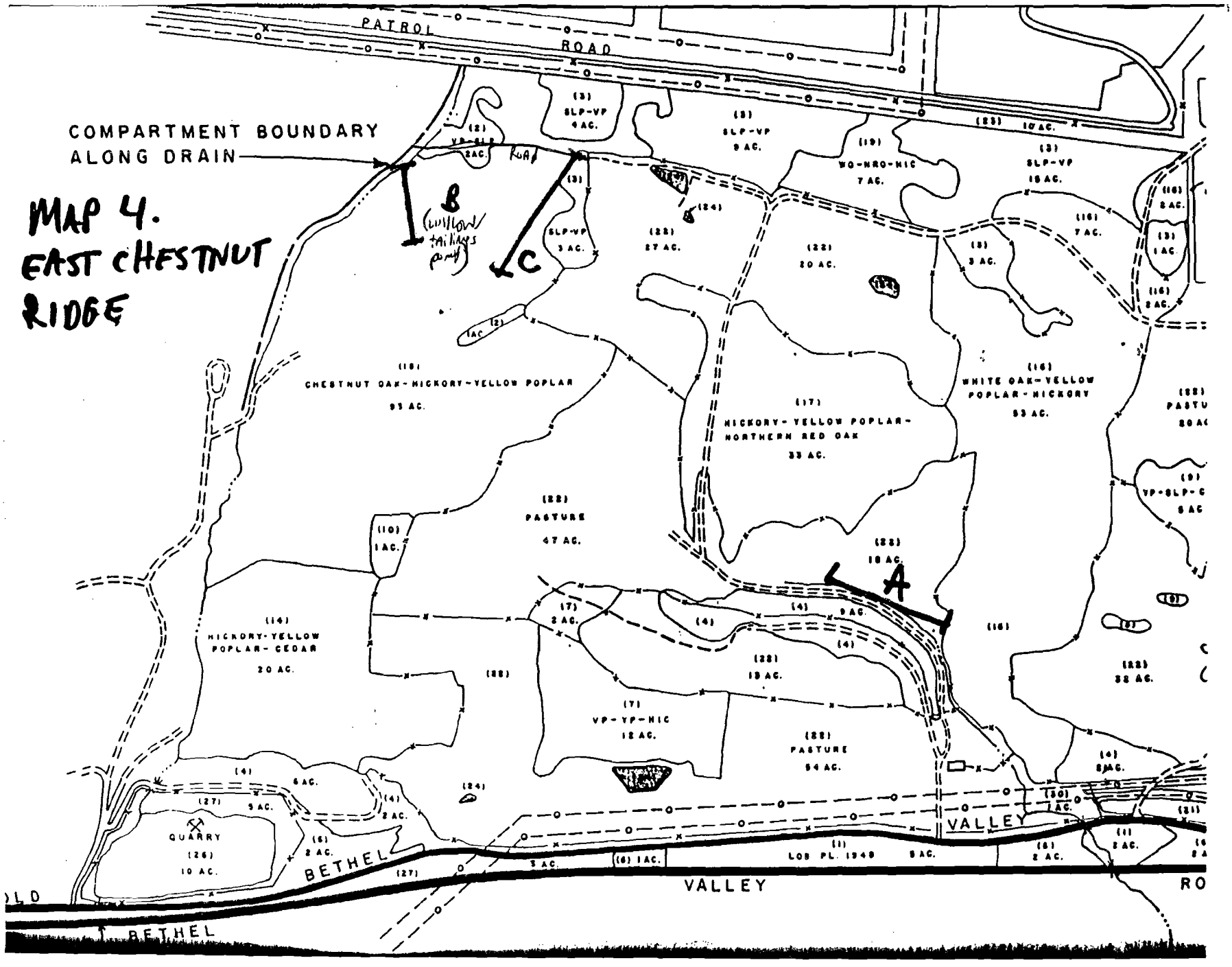

Fig. N.5.1 Location of Area 4, East Chestnut Ridge. Transects A-C are denoted by A-C.

N.5.3 Transect C

Mixed hardwoods, chestnut oak, hickory, and yellow poplar.

Number of traps along transect: 20
Number of nights trapped: 5
Total number of trap-nights: 100
Number of individuals of each species:

1 *Peromyscus leucopus*

NOTE: Trapped 1 five-lined skink 1 (*Eumeces fasciatus*).

Total number of trap-nights in Area 4: 280.

Rodent species common to the Oak Ridge Reservation that were conspicuously absent include cotton rat (*Sigmodon hispidus*) and pine vole (*Microtus pinetorum*). Other mammalian species known to occur on the ORR are listed in Attachment I.

ATTACHMENT I

MAMMALS ON THE OAK RIDGE RESERVATION

Table 1. Checklist of mammals on the Oak Ridge Reservation

Order Family Common name	Genus, Species	Habitat
Marsupiala		
Didelphidae		
Opossum	*Didelphis virginiana*	Forest edges; woodland streams, ponds
Insectivora		
Soricidae		
Southeastern shrew	*Sorex longirostris*	Various
Short-tailed shrew	*Blarina brevicauda*	Moist forests, brush, abandoned fields, dense pasture
Least shrew	*Cryptotis parva*	Fields, grassy areas
Talpidae		
Eastern mole	*Scalopus aquaticus*	Loose, well-drained soils of floodplains, stream-banks, fields, woods
Chiroptera		
Fespertilionidae		
Little brown bat	*Myotis lucifugus*	Caves, buildings, hollow trees
Keen's bat	*Myotis keenii*	Caves, buildings, hollow trees, forests
Silver-haired bat	*Lasionycteris noctivagans*	Forests, buildings, caves
Eastern pipistrelle	*Pipistrellus subflavus*	Caves, rock crevices, buildings, forests, near water
Big brown bat	*Eptesicus fuscus*	Caves, crevices, hollow trees, buildings, forests
Red bat	*Lasiurus borealis*	Wooded areas, caves

Table 1. (continued)

Order Family Common name	Genus, Species	Habitat
Hoary bat	*Lasiurus cinereus*	Wooded areas
Evening bat	*Nycticeius humeralis*	Buildings, hollow trees
Lagomorpha		
Leporidae		
Eastern cottontail rabbit	*Sylvilagus floridanus*	Brush, forest with nearby openings, swamp edges, weed patches
Rodentia		
Sciuridae		
Eastern chipmunk	*Tamias striatus*	Deciduous forests, brushy areas
Groundhog	*Marmota monax*	Fields, forest edges, fencerows, pastures, roadsides
Eastern gray squirrel	*Sciurus carolinensis*	Hardwood or mixed conifer/deciduous forests
Southern flying squirrel	*Glaucomys volans*	Deciduous or mixed conifer/deciduous woods
Castoridae		
Beaver	*Castor canadensis*	Streams and lakes with trees on banks
Cricetidae		
Rice rat	*Oryzomys palustris*	Wet areas, grasses, sedges
Eastern harvest mouse	*Reithrodontomys humulis*	Abandoned fields, moist grass/forb areas
White-footed mouse	*Peromyscus leucopus*	Wooded or brushy areas

Table 1. (continued)

Order Family Common name	Genus, Species	Habitat
Golden mouse	*Ochrotomys nuttalli*	Forests, thicket edges with ascending vines, cane thickets
Cotton rat	*Sigmodon hispidus*	Tall grassy and weedy areas
Pine vole	*Microtus pinetorum*	Abandoned fields, forest edges
Muskrat	*Ondatra zibethica*	Edges of ponds, lakes, and streams; wet areas
Norway rat	*Rattus norvegicus*	Buildings, rubbish areas
House mouse	*Mus musculus*	Buildings, adjacent fields
Carnivora		
Canidae		
Coyote	*Canis latrans*	Open woodlands, brushy areas, prairies
Red fox	*Vulpes vulpes*	Mixture of forest and open country
Gray fox	*Urocyon cinereoargenteus*	Open forests and nearby abandoned fields
Procyonidae		
Racoon	*Procyon lotor*	Streams and lake borders, forests, fields
Mustelidae		
Long-tailed weasel	*Mustela frenata*	Near water
Mink	*Mustela vison*	Along streams, lakes, in nearby forests, fields
Striped skunk	*Mephitis mephitis*	Semiopen mixed woods, brush, or prairie

Table 1. (continued)

Order Family Common name	Genus, Species	Habitat
Eastern spotted skunk	*Spilogale putorius*	Brushy or sparsely wooded areas, along streams; prairies
Felidae		
Bobcat	*Lynx rufus*	Forests, brushy areas, abandoned fields
Cougar	*Felis concolor*	Forests, brushy areas
Artiodactyla		
Cervidae		
White-tailed deer	*Odocoileus virginianus*	Forests, abandoned fields, brushy areas, pastures

APPENDIX O

ECOLOGY OF THE OAK RIDGE RESERVATION

G. F. Cada, R. L. Kroodsma, and P. D. Parr

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APPENDIX O

ECOLOGY OF THE OAK RIDGE RESERVATION

1. TERRESTRIAL FLORA

Management of radioactive low-level waste (LLW) is essential to continued operation of current facilities on the Oak Ridge Reservation (ORR). New sites for waste storage on the ORR have been proposed (Lockwood Greene 1987). This section provides information on the vegetation, including rare plant species, of four areas proposed for LLW disposal (Fig. 1.1).

The ORR is a 15,000-ha tract in the Ridge and Valley Physiographic Province of east Tennessee. The land was acquired by the federal government in 1942 for the wartime Manhattan Project and was primarily in agricultural use at the time of purchase. Aerial photographs taken in the late 1930s show that much of the area was in forest. Clearings for orchards and pastures were on some of the upper slopes, rocky areas, and some ridgetops; tillage crops are evident on the lower slopes and bottomland. Severe erosion is evident in some areas. Except on very steep slopes, most of the forests had been cut for timber, though not necessarily cleared. Public access to the land was restricted in 1942, except for developments at the Y-12 Plant, Oak Ridge Gaseous Diffusion Plant (ORGDP), and Oak Ridge National Laboratory (ORNL). Natural plant communities have since reestablished themselves on most of the ORR. Many areas on the ORR are maintained as pine plantation or nonforested areas for various purposes.

The general vegetation of the ORR is described by Kitchings and Mann (1976):

"The dominant oak-hickory association in the Ridge and Valley Province contains elements of the mixed mesophytic association commonly found in the adjacent Cumberland Mountains. Plant communities of the ORR are characteristic of those found in the intermountain regions of Appalachia from the Allegheny Mountains in southern Pennsylvania to the southern extension of the Cumberland Mountains in northern Alabama (as described by Braun 1950). On the ORR, the oak-hickory association is typified by extensive stands of mixed yellow pine and hardwoods as well as oak and hickory. Yellow poplar often forms nearly pure stands on well-drained bottomlands and lower slopes while willow, sycamore and boxelder border streams and are dominant on poorly drained floodplains. Species more commonly found in the mixed mesophytic association, such as beech, sugar maple, magnolias, buckeye, and basswood, often occur in coves and sheltered slopes. In addition, approximately 2000 ha of the ORR were planted in loblolly pine between 1947 and 1956, while smaller acreages have since been planted in loblolly pine, black walnut, riverbirch, sycamore, and poplar."

The major plant communities of the ORR were grouped into seven categories by Dahlman, Kitchings, and Elrod (1977). More recent field work has shown that there are some inaccuracies in the descriptions of the communities and their locations on the ORR (Linda K. Mann, ORNL, personal communication, July 1988). A condensed version of the major communities described by the authors, with inaccuracies omitted and modifications

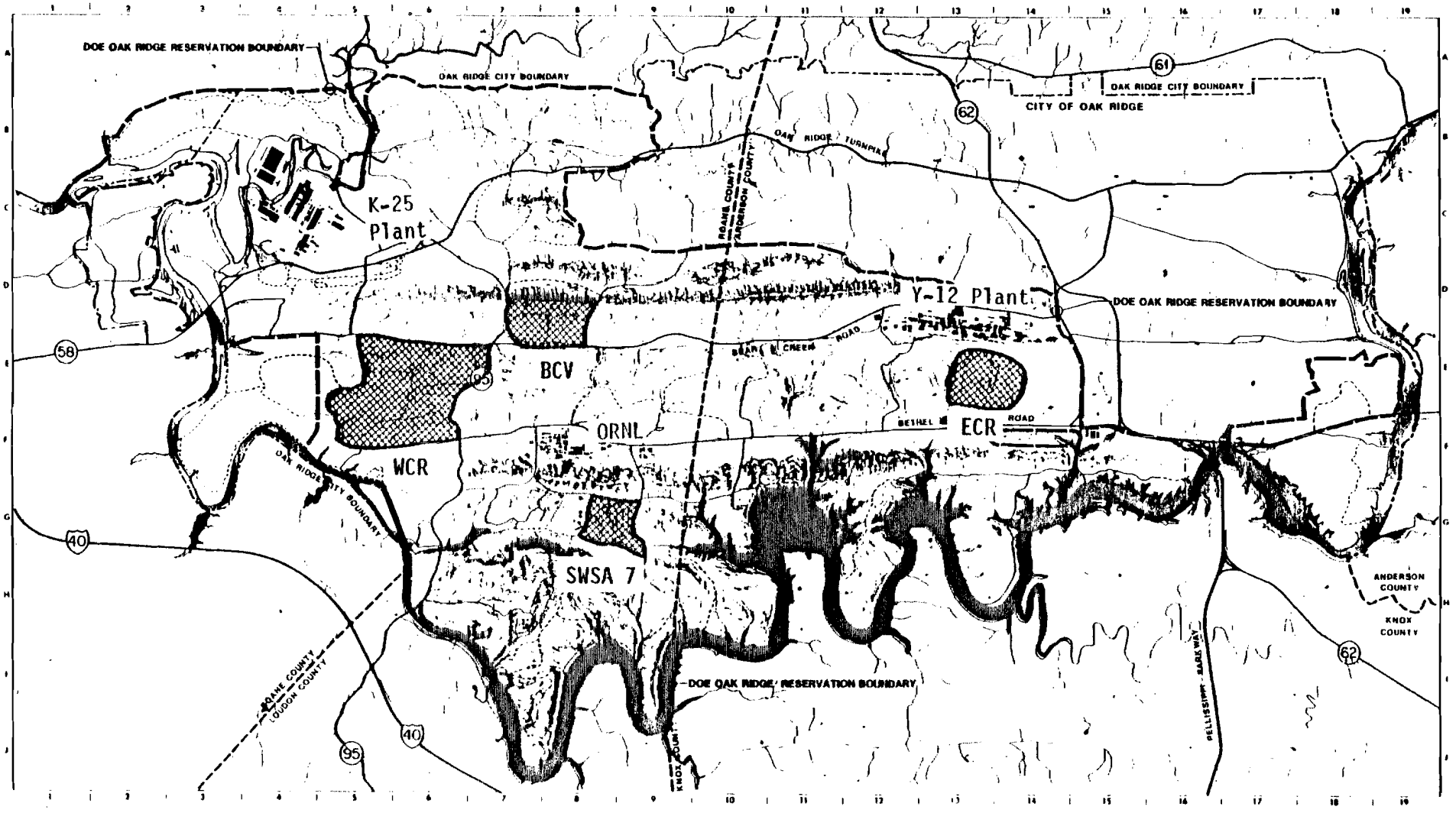

Fig. 1.1 Four areas on the ORR proposed for Low-Level Waste disposal. 1. West Chestnut Ridge (WCR), 2. Bear Creek Valley (BCV), 3. East Chestnut Ridge (ECR), and 4. Proposed Solid Waste Storage Area 7 (SWSA 7).

added, is presented in the following paragraphs. A general vegetative cover map, updated by Dennis M. Bradburn (ORNL, personal communication, July 1988) using the most recent forest management compartment surveys (1978-1987), is shown in Fig. 1.2. Table 1.1 provides estimates of abundance (percentages) of various community types on the ORR and at the four LLWDDD sites.

Pine and pine-hardwood. Natural pine forests are dominated by shortleaf pine (*Pinus echinata*) and Virginia pine (*Pinus virginiana*); associated hardwood species include oaks (*Quercus* spp.), hickories (*Carya* spp.), and tulip poplar (*Liriodendron tulipifera*). Large tracts of planted loblolly pine (*Pinus taeda*), a valuable timber species, and shortleaf pine occur as plantation monocultures. About one-third of the ORR land area is of this type.

Hemlock, white pine, and hardwood. This type, representing a Southern Appalachian extension of a northern (and higher elevation) forest, is extremely rare on the reservation. Small areas on steep slopes above Poplar Creek on Black Oak Ridge and McKinney Ridge are virtually all that remain. Dominant species are hemlock (*Tsuga canadensis*) and white pine (*Pinus strobus*).

Cedar, cedar-pine, and cedar-hardwood. This type is extensive on the reservation, predominating in Bethel Valley and in the southern areas adjacent or close to the Clinch River and Melton Hill Reservoir. The type is best developed on shallow soil over limestone (or dolomite). The dominant species is eastern red cedar (*Juniperus virginiana*), associated with shortleaf and Virginia pine, tulip poplar, oaks, hickories, redbud (*Cercis canadensis*), sassafras (*Sassafras albidum*), and other hardwoods.

Bottomland hardwood. This type, restricted to small floodplains along creek bottoms, comprises a small portion of forest communities of the ORR. Small areas occur along Gum Hollow Creek, Bear Creek, and Grassy Creek, with larger areas along White Oak Creek and in the reservation portion of the East Fork Poplar Creek drainage. Dominant are cottonwood (*Populus deltoides*), sycamore (*Platanus occidentalis*), elm (*Ulmus americana*), ash (*Fraxinus* spp.), willow (*Salix* spp.), silver maple (*Acer saccharinum*), and river birch (*Betula nigra*).

Upland hardwood. This type is important on the reservation, occupying roughly 20% of the total land area. Largest concentrations occur on Black Oak, East Fork, Pine, Chestnut, and Copper ridges. Scattered patches occur almost throughout the reservation area. This forest is essentially an oak-hickory complex, representative of the climax community in this region of the eastern United States. Important species include chestnut oak (*Quercus prinus*), white oak (*Q. alba*), black oak (*Q. velutina*), northern red oak (*Q. rubra*), scarlet oak (*Q. coccinea*), post oak (*Q. stellata*), various hickories (*Carya* spp.), and ash (*Fraxinus* spp.), tulip poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), dogwood (*Cornus florida*), beech (*Fagus grandiflora*), and others.

Northern hardwood. Northern hardwood forest is rare on the ORR, occurring in small areas on Black Oak Ridge, Copper Ridge and Bull

Fig. 1.2 Distribution of plant communities on the Oak Ridge Reservation. Small areas of hemlock, white pine and hardwood community type are not shown. From: Oak Ridge Reservation Site Development and Facilities Utilization Plan (Draft) 1988.

ORNL DWG 87 11108

GENERAL VEGETATION COVER

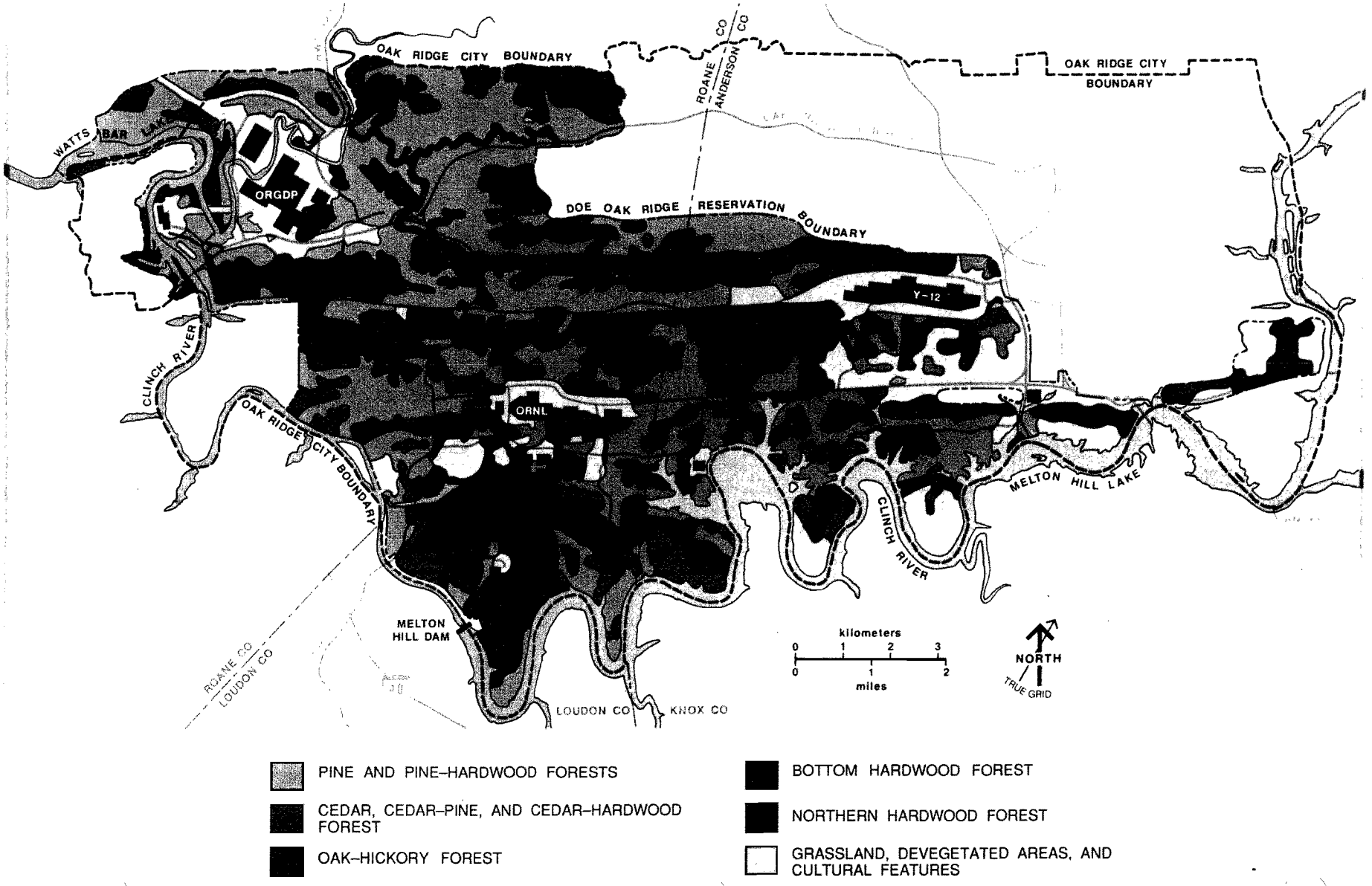

Table 1.1. Estimates of the abundance (percent) of various communities on the Oak Ridge Reservation and on four sites proposed for low level waste disposal, including for candidate disposal areas within the proposed sites

Habitat	Oak Ridge Reservation[a]	West Chestnut Ridge (WCR)	WCR Candidate areas "A"	WCR Candidate areas "B"	WCR Candidate areas "C"	Bear Creek Valley (BCR)	BCR Candidate areas	East Chestnut Ridge (ECR)	ECR Candidate areas	SWSA 7	SWSA-7 Candidate areas
Pine	29.8	39	27	55	55	45	79	12	12	41	52
Plantations	14.8	21	24	54	49	45	79	0	0	0	0
Natural stands	15.0	18	3	<1	6	0	0	12	12	41	52
Hemlock, white pine, and hardwoods	0.3	0	0	0	0	0	0	0	0	0	0
Cedar and open scrub	3.7	<1	0	0	0	0	0	0	0	0	0
Hardwoods	51.0	53	71	45	33	47	21	54	46	58	48
Upland hardwoods[b]	48.1	50[c]	69	45	33	31	12	54	46	58	48
Bottomland hardwoods	2.5	0	2	0	0	11[d]	0	0	0	0	0
Scrub hardwoods	0.4	3[e]	0	0	0	5	9	0	0	0	0
Swamp or marsh	0.1	0	0	0	0	0	0	0	0	0	0
Nonforest	15.5	9	1	0	12	8	0	34	42	1	<1
Fields, old field, pasture, lawns	7.6	<1	0		0	0		33	42	0	0
Roads[f]	2.6	3	NE[g]		NE	0		NE	NE	NE	NE
Rights-of-way	5.3	5	1		12	8		1	0	1	<1

[a] Facility areas within fences are not included.
[b] Includes a few small stands of northern hardwood forest (a rare type on the ORR) on Copper Ridge and Black Oak Ridge.
[c] Includes hardwood plantation.
[d] Includes bottomland hardwood.
[e] Clearcuts and abandoned rights-of-way.
[f] This category is much underestimated; many new roads to monitoring well have been constructed in the last few years and are not on maps at present.
[g] NE = No estimate.

SOURCE: Estimates of community types on the ORR were provided by L. K. Mann, unpublished data, 1978. Habitats on the proposed LLW sites were estimated using ORR Forest Compartment maps (D. M. Bradburn 1977).

Bluff. Elements of this type also occur in small stream drainages and on north facing slopes along the Clinch River. Composition is similar to the upland hardwood forest, with mixtures of sugar maple (Acer saccharum), hemlock (Tsuga canadensis), basswood (Tilia heterophylla), and buckeye (Aesculus octandra).

Nonforest. This is a variable category that includes primarily grasslands, devegetated areas, and cultural features. The grasslands are of several types. Native or semi-native successional areas are either maintained (e.g., under power-transmission lines) or are reverting to forest. Dominants include species of bluestem (Andropogon spp.), fescue (Festuca spp.), and bluegrass (Poa spp.). Small but significant areas of nonsuccessional grassland occur as forest openings or intermixed with successional grasslands (Mann and Kitchings 1982). These areas are termed "barrens" and are found in calcareous rock outcrop and shallow soil areas. The dominant species are drought-tolerant grasses and forbs, many of which are uncommon or rare in Tennessee. Barrens occur on the ORR in Bethel Valley and East Fork Valley. Cultivated grasslands are lawns or pastures. These predominate in and around the three plant areas (ORNL, Y-12, and ORGDP). Grasses include fescue species, bluegrass, and orchard grass (Dactylis glomerata) with other species.

The vascular flora of the ORR has been inventoried and updated (Olson, Cristofolini, and Cristofolini 1966; Mann and Bierner 1975; Mann, Patrick, and DeSelm 1985; Larry Pounds, University of Tennessee, personal communication, 1988). The most recent checklist for the site contains 885 taxa. Previous reports (Kroodsma 1985; Dahlman, Kitchings, and Elrod 1977) list the number of species on the ORR as 1370; earlier checklists included taxa likely to occur on the site based on composite county records.

About 5000 ha of the ORR has been designated by DOE as a National Environmental Research Park (NERP). Responsibilities of the NERP program include the description, monitoring, and protection of rare plant resources on the ORR. Eleven plant species found on the ORR are listed by the state or federal government as endangered, threatened, or of special concern. Table 1.2 lists the species, their status on the rare plant lists, and their habitats. Tables 1.3 and 1.4 define the various state and federal status categories.

Although the entire reservation has not been surveyed for rare species, 23 different areas harboring rare plant species (state or federally listed) have been designated as NERP Natural Areas (Parr and Pounds 1987; Parr 1984) and are shown in Fig. 1.3. These areas include river and creek bluffs, calcareous barrens, mesic forests, floodplains, and wetlands.

Environmental research and characterization sites are scattered across the entire ORR. Locations of field research and/or characterization sites that fall within or adjacent to the boundaries of the proposed LLW storage areas are shown in Fig. 1.4. Descriptive information on each of the research areas shown on the map in Fig. 1.4 is contained in Table 1.5.

Table 1.2 Rare plant species on the ORR, their status on the state and federal rare plant lists, and their habitats

Species	Status		Habitat
	Tenn.	Federal category	
1. *Aureolaria patula*	T[a]	1	River bluffs near waterline
2. *Cimicifuga rubifolia*	T	2	River bluffs near waterline
3. *Delphinium exaltatum*	E		Open rocky woods and barrens (limestone)
4. *Diervilla lonicera*	T		River cliffs
5. *Fothergilla major*	T		Acid forest
6. *Hydrastis canadensis*	T		Limestone, moist woods
7. *Lilium canadense*	T		Moist woods and edges
8. *Panax quinquefolius*	T		Rich woods
9. *Platanthera flava*	S		Shaded wetland
10. *Saxifraga careyana*	S	2	On limestone near the lake
11. *Spiranthes ovalis*	S		Woods over limestone

[a]T = threatened, E = endangered, S = special concern.

Table 1.3. Definitions of status for listing for federal threatened and endangered plant species[a]

Definitions of status are taken from the U.S. Fish and Wildlife Service's Notice of Plant Taxa for listing as endangered or threatened. The plants listed in categories 1 and 2 may be considered candidates for addition to the list of endangered and threatened plants; as a result, consideration should be given to them in environmental planning.

Category 1: Taxa for which the Forest Service has sufficient information on hand to support the biological appropriateness of their being listed as endangered or threatened species.

Category 2: Taxa for which information now in the possession of the Service indicates the probable appropriateness of listing as endangered or threatened but for which sufficient information is not available to biologically support a proposed rule.

Category 3: Taxa no longer being considered for listing as endangered or threatened.

3A. Taxa for which the Service has persuasive evidence of extinction.

3B. Names that (on the basis of current taxonomic understanding) do not represent taxa meeting the Act's definition of "species."

3C. Taxa that have proven to be more abundant or widespread than was previously believed and/or those that are not subject to any identifiable threat.

[a]Federal Register 45 (242):82480-82568 (December 15, 1980).

Table 1.4. Definitions of status for official list of Tennessee's rare plants[a]

E - Endangered species are now in danger of becoming extinct in Tennessee because of their rarity throughout their range, or their rarity in Tennessee as a result of sensitive habitat or restricted area of distribution.

T - Threatened species are likely to become endangered in the immediately foreseeable future as a result of rapid habitat destruction or commercial exploitation.

S - Special concern species are those requiring particular attention because they are rare or distinctive in Tennessee because the state represents the limit or near-limit of their geographic range, or their status is undetermined because of insufficient information.

P - Possibly extirpated species have not been seen in Tennessee within the last 20 years.

[a]Adapted from Committee for Tennessee Rare Plants. 1978. "The Rare Vascular Plants of Tennessee," J. Tenn. Acad. Sci. 53(4):128-133.

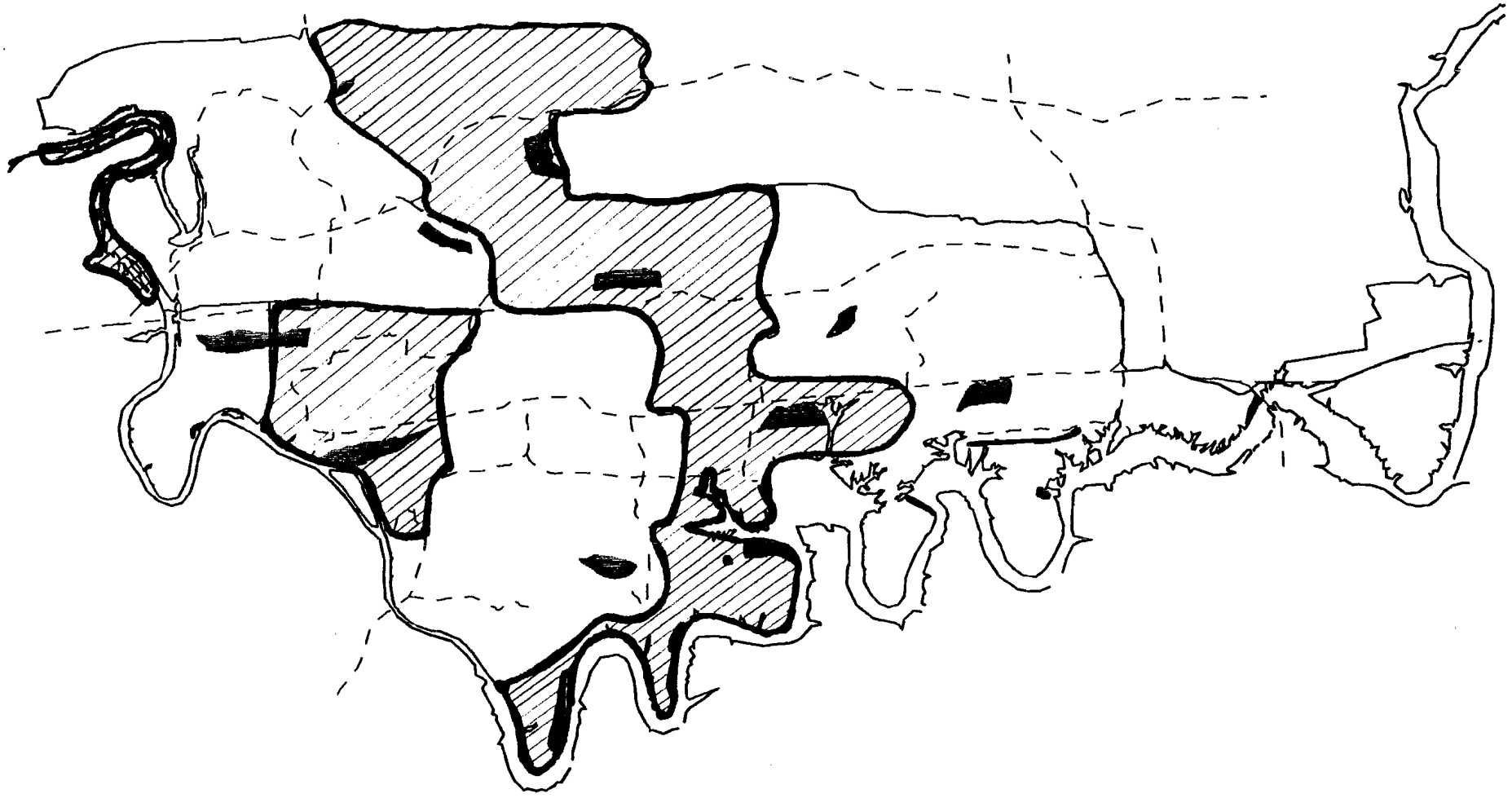

Fig. 1.3 National Environmental Research Park boundaries (hatched areas) and Natural Areas containing state or federally listed rare plant species (solid areas).

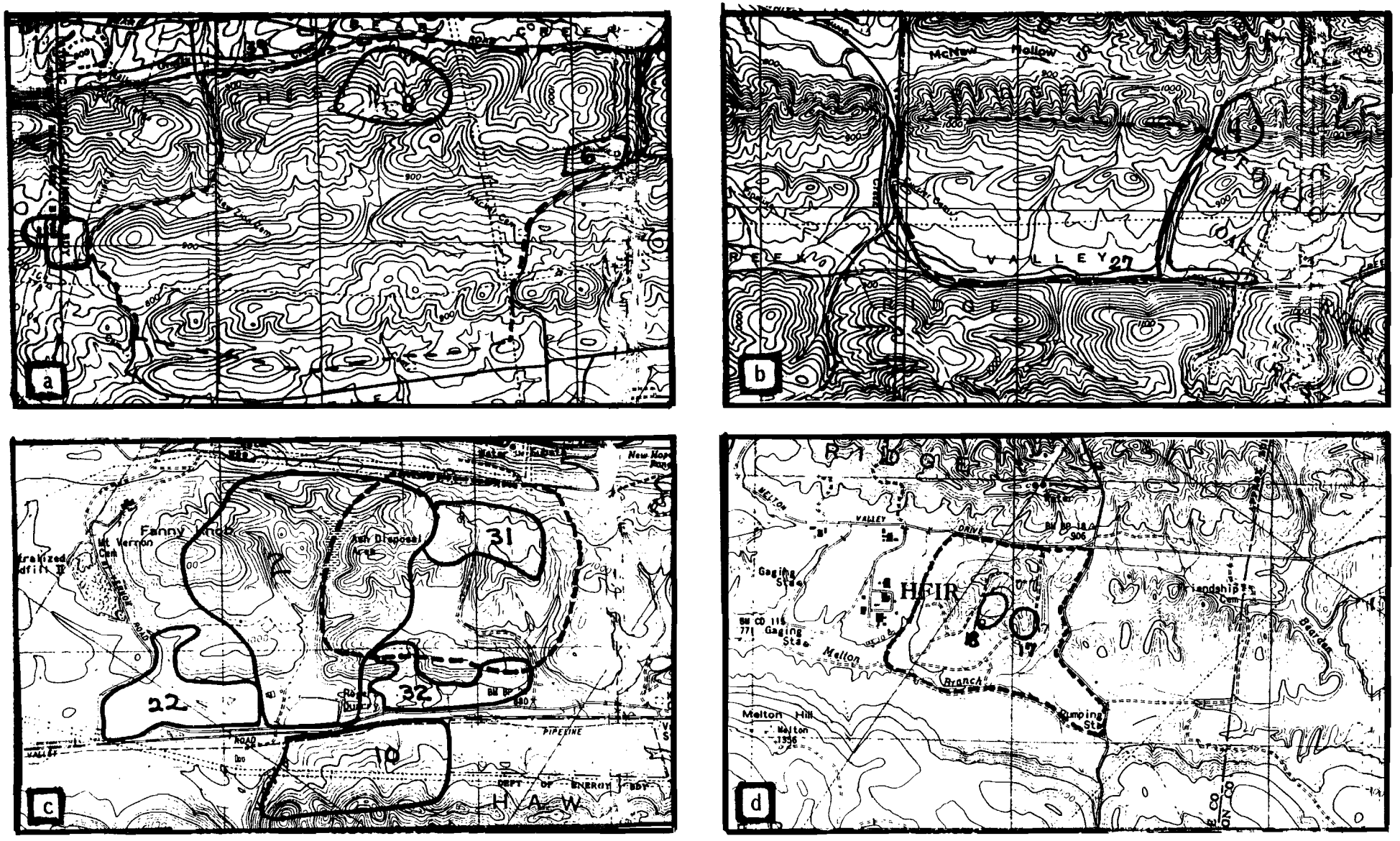

Fig. 1.4 Locations of environmental research and/or characterization sites within proposed waste areas. (a) West Chestnut Ridge, (b) Bear Creek Valley, (c) East Chestnut Ridge, and (d) proposed Solid Waste Storage Area 7.

Table 1.5. Research sites within or adjacent to boundaries of proposed low-level waste disposal areas (Names of current principal investigators are also given)

West Chestnut Ridge Area

Research Area No. 6. Pine Harvesting Plots. D. W. Johnson, Environmental Sciences Division (ESD). Funded by the Environmental Protection Agency (EPA). Long-term. This study is an investigation of the combined effects of harvesting and acid deposition on nutrient loss from the forest.

Research Area No. 8. Whole-tree harvesting: nutrient export and availability. L. K. Mann, D. W. Johnson, and D. C. West (ESD). Funded by DOE. Long-term. These studies are evaluating long-term consequences of increased biomass utilization, including monitoring the effects of whole-tree harvest vs conventional harvest on forest regeneration.

Research Area No. 44. Biomass fertilizer study. D. W. Johnson, P. Layton, R. Norby, E. G. O'Neill, and J. W. Ranney (ESD). Funded by DOE's Biomass Energy Technology Division. Long-term, began 1986. This study is evaluating two types of fertilizer application and consequent effects on a monoculture system.

Research involving entire site. Wild turkey studies. W. Minser (University of Tennessee), J. Evans, Tennessee Wildlife Resources Agency (TWRA), and P. D. Parr (ESD). Funded by National Environmental Research Park, TWRA, and the National Wild Turkey Federation. Long-term, began 1986. This study involves radio tracking and habitat studies of wild turkeys recently re-introduced to the Oak Ridge Reservation. West Chestnut Ridge includes home range (and nesting areas) for many turkey.

West Bear Creek Valley Area

Research Area No. 4. Plant population monitoring. L. K. Mann (ESD). Funded by National Environmental Research Park. Long-term, began in 1981. Permanent plots are used to monitor long-term changes in population densities of herbaceous species in disturbed and undisturbed communities.

Research Area No. 27. Bear Creek hydrological characterization. D. D. Huff (ESD). Funded by DOE and the Y-12 Plant. Long-term, began 1983. This study is a characterization of surface water and groundwater flow systems in the Bear Creek watershed related to the waste management program.

Research Area No. 27. Bear Creek characterization. R. R. Turner (ESD). Funded by the Y-12 Plant. Long-term. This research is a characterization study of Bear Creek to evaluate water, sediment, and floodplain contaminants.

Table 1.5 (continued)

Research Area No. 27. Bear Creek biological and chemical characterization. H. Boston, J. M. Loar, and A. J. Stewart (ESD). Funded by the Y-12 Plant. Long-term, began in 1986. This research will assess existing contamination in Bear Creek Valley and implement a remedial action plan to mitigate impacts of the contamination and to monitor the effectiveness of the remedial action.

Research Area No. 27. East Fork Poplar Creek survey. S. M. Adams (ESD). Funded by DOE. Long-term, began 1986. This research is designed to assess biological indicators of contaminant-related stress.

East Chestnut Ridge Area

Research Area No. 2. Y-12 coal ash study. R. R. Turner and M. A. Bogle (ESD). Funded by the Y-12 Plant. Began 1985. This study is designed to determine the effects of coal ash disposal on water quality in McCoy Branch watershed.

Research Area No. 2. Rogers Quarry research. B. L. Kimmel and R. R. Turner (ESD). Funded by Y-12 Plant. Long-term. Limnological monitoring is related to high pH episodes in outflow.

Research Area No. 10. Rare plant population monitoring. P. D. Parr and L. K. Mann (ESD). Funded by National Environmental Research Park. Long-term, began 1981. This study is designed to monitor the world's largest known population of Tall Larkspur, *Delphinium exaltatum*, and to collect information on the species autecology to evaluate habitat requirements necessary to prescribe habitat maintenance.

Research Areas No. 22, 31, and 32. Terrestrial applications of sewage sludge on the Oak Ridge Reservation. H. L. Boston, D. W. Johnson, J. W. Ranney, J. W. Johnston, H. van Miegrot (ESD) and D. M. Bradburn (P&E). Funded by DOE-ORO. Long-term, began 1986. An investigation of strategies to maximize plant growth and minimize water pollution.

Proposed Solid Waste Storage Area 7

Research Area No. 17. Hydrologic transport of buried trace elements in contrasting watersheds. R. W. Arnseth, R. J. Luxmoore, G. R. Southworth (ESD), P. Jardine, and G. Wilson (UT). Funded by DOE. Long-term. This research will define and compare the pathways and rates of trace element movement in two small watersheds with contrasting soil profile development and determine the significance of soil variability, macropores, and variables contributing to chemical transport.

Research Area No. 18. Clear-cut studies. R. B. Clapp (ESD). Funded by DOE. Long-term, began 1982. This study is monitoring the response of the water table before and after clear-cutting to evaluate modeling predictions.

2. TERRESTRIAL FAUNA

This section provides a general description of the terrestrial fauna found on the ORR and on LLWDDD sites within the reservation. The status of threatened and endangered animal species on the reservation has been described in detail in a previous report (Kroodsma 1987) that also provides a list of literature on the ORR fauna. The reader is referred to a previous unpublished report (Kroodsma 1985) that provides an overview of the habitats and biota of the ORR.

The abundance and habitat preference of terrestrial fauna on the ORR are presented in Tables 2.1 through 2.3. The breeding birds of the specific sites (Figs. 2.1 through 2.5) were surveyed during May and June of various years from 1975 to 1988, as shown in Table 2.4. Mammals of these sites were surveyed by Greenberg (1988), whose report is attached as Appendix N.

The plant communities on the reservation provide habitat for a large number of animal species. About 60 species of reptiles and amphibians, more than 120 species of terrestrial birds (excluding 32 species of waterfowl, wading birds, and shorebirds), and about 40 species of mammals have been recorded.

Habitats supporting the greatest number of species are those dominated by hardwood tree species, followed by wetlands, then old fields, fields (e.g., pastures, cultivated fields), and pine plantations. Hardwoods are required by most species occurring in hardwood-dominated or pine-dominated forests. Of all the reptile, bird, and mammal species that breed on the reservation, only the pine warbler requires pine. Bird species characteristic of old fields require the presence of brushy vegetation such as shrubs, saplings, and blackberry (Rubus).

Most of the species such as wild turkey, red-tailed hawk, red fox, bobcat, white-tailed deer that use more than one habitat type (e.g., forest and fields) depend more on the presence of trees, forest, or brush than on the presence of fields. However, limited amounts of cultivated or old fields are beneficial to several of these species. Populations of such species are often densest in predominately forested areas with small fields interspersed among the forest.

In contrast to the reservation, the surrounding countryside consists of a much greater proportion of cultivated fields, pastures, and residential areas. In this area, the forests are much more fragmented than on the reservation, and the rate of species turnover (loss) may be high because of the small size of the forested tracts. Because of the greater continuity of forests on the reservation and because of a lack of human disturbance over much of the area, many forest wildlife species that are disproportionately affected by forest fragmentation may find an abundance of suitable habitat on the reservation. Thus, the reservation may serve as a refuge for wildlife and as a source of colonizing immigrants into surrounding areas. In others words, the reservation may serve outlying areas by providing a continual source of forest wildlife.

Table 2.1. Amphibians, reptiles, birds, and mammals characteristic of or dependent on various habitats of the Oak Ridge Reservation

	Field	Old field[a]	Pine plantations	Hardwood and hardwood-pine forest	Water and Wetlands	Combination of two or more habitats
Number of bird species	10	13	3	53	39	
Number of mammal species	2	3	0	7	4	
Number of reptile and ammphibian species	0	0	0	7	21	
Representative species	Grasshopper sparrow Eastern meadowlark Least shrew Eastern mole	Prairie warbler Yellowthroat Blue grosbeak Yellow-breasted chat Indigo bunting Field sparrow Towhee Eastern harvest mouse Hispid cotton rat Eastern cottontail	Pine warbler Pine siskin Red crossbill	Cooper's hawk Yellow-billed cuckoo Red-bellied woodpecker Downy woodpecker Wood peewee Acadian flycatcher Worm-eating warbler Black and white warbler Kentucky warbler Tufted titmouse Scarlet tanager Ovenbird White-breasted nuthatch Indiana bat Red bat Hoary bat Eastern chipmunk Gray squirrel Flying squirrel White-footed mouse	Wood duck Scaup Ring-necked duck Green heron Great blue heron Belted kingfisher Mink Beaver Rice rat Muskrat Snapping turtle Map turtle Eastern painted turtle Northern water snake Queen snake Red-spotted newt Bullfrog	Bobwhite Red-tailed hawk Turkey vulture Common crow Barn swallow Cardinal Oppossum Southeastern shrew Short-tailed shrew Big brown bat Little brown bat Silver-haired bat Eastern pipistrel Evening bat Raccoon Long-tailed weasel Striped skunk Red fox Gray fox Bobcat

Table 2.1 (continued)

	Field	Old field[a]	Pine plantations	Hardwood and hardwood-pine forest	Water and Wetlands	Combination of two or more habitats
Representative species (cont.)				Woodchuck Box turtle Broad-headed skink Northern ringneck snake		Golden mouse Pine vole White-tailed deer Green anole Northern brown snake Northern black racer Slimy salamander Cave salamander Upland chorus frog Pickerel frog

[a]The "old field" category includes young pine plantations prior to canopy closure as well as broad-leaved vegetation types.

Table 2.2. Amphibian and reptilian species and their habitat preferences on the Oak Ridge Reservation

Species[a]	Number collected[a]	Habitat
Spotted salamander	1[b]	Pond, pool, spring branch, marsh
Red-spotted newt (eft), pond (adult and larvae)	1[c]	Upland and floodplain forest 25[d]
Dusky salamander	34[b] 14[d]	Spring, spring branch, spring seep, stream, marsh
Slimy salamander	4[b]	Upland and floodplain forest, cave
Northern red salamander	2[b] 1[d]	Spring, spring seep, marsh, pool
Two-lined salamander	4[e] 12[d]	Spring, spring seep and branch, pool, marsh
Cave salamander	6[b]	Caves
Eastern spadefoot toad	15	Pools in ruderous areas and old fields
American toad	9	Upland and floodplain forest, old field, ruderous area
Fowler's toad	10	Upland and floodplain forest, old field, ruderous area
Northern cricket frog	16	Pond, marsh, stream, embayment
Spring peeper	heard	Pool, pond, marsh
Gray treefrog	23	Pool, pond, marsh, forest
Chorus frog	heard	Pool, pond, spring seep, marsh
Eastern narrow-mouthed toad	58	Pond, pool, old field, ruderous area
Bullfrog	3	Pond, stream
Green frog	8	Pond, stream
Leopard frog	22	Pond, pool, marsh, spring seep, floodplain forest

Table 2.2. (continued)

Species[a]	Number collected[a]	Habitat
Pickerel frog	4	Pond, pool, stream, spring branch, floodplain forest
Box turtle	6	Floodplain and upland forest, old field, ruderous area
Northern fence lizard	6	Upland forest, old field, ruderous area
Six-lined racerunner	5	Ruderous area, old field-transition, old field
Ground skink	3	Upland and floodplain forest, old field-transition
Five-lined skink	6	Floodplain and upland forest, old field-transition, mixed hardwood and pine
Broad-headed skink	1	Floodplain and upland forest
Queen snake	6	Stream, fluvial
Water snake	7	Stream, fluvial, spring branch, pond, marsh
Brown snake	1	Old field, upland forest, mixed hardwood and pine
Red-bellied snake	1	Upland forest, old field
Eastern garter snake	9	Old field, floodplain forest, pond
Eastern earth snake	1	Old field, upland forest, mixed hardwood and pine
Northern ringneck snake	6	Upland and floodplain forest, spring seep
Worm snake	14	Upland and floodplain forest, old field
Black racer	7	Old field, upland and floodplain forest, mixed hardwood and pine, ruderous area

Table 2.2. (continued)

Species[a]	Number collected[a]	Habitat
Rough green snake	2	Old field
Corn snake	4	Old field, upland and floodplain forest
Rat snake	5	Old field, upland and floodplain forest
Mole snake	1	Old field, mixed hardwood and pine
Black kingsnake	3	Old field, mixed hardwood and pine, upland forest
Eastern kingsnake	3	Upland forest, mixed hardwood and pine
Scarlet snake	1	Upland forest, mixed hardwood and pine
Northern copperhead	5	Upland and floodplain forest, mixed hardwood and pine, old field

[a]Species and number of specimens collected at the Oak Ridge Reservation by Johnson (1964); species that were not collected but which Johnson expected to occur in the area are red-backed salamander, spring salamander, long-tailed salamander, green anole, slender glass lizard, hognose snake, and crowned snake.

[b]Adult(s)

[c]Eft

[d]Larvae

[e]Subadults

Table 2.3. Mammal species and their habitat preferences on the Oak Ridge Reservation[a]

Species	Abundance[b]	Wetlands	Old fields	Hardwood forest[c]	Pine forest
Oppossum	C		X	X	X
Short-tailed shrew	C			X	
Least shrew	R		X		
Eastern mole	R		X		
Southeastern shrew	R			X	
Big brown bat	N	X	X	X	
Silver-haired bat	C	X	X	X	
Red bat	C	X	X	X	
Hoary bat	U	X	X	X	
Keen's myotis	R	X	X	X	
Little brown bat	C	X	X	X	
Indiana myotis	E	X	X	X	
Evening bat	C	X	X	X	
Eastern pipistrelle	C	X	X	X	
Eastern cottontail	C		X	X	X
Beaver	E	X			
Southern flying squirrel	C			X	
Woodchuck	C		X	X	X
Pine vole	C		X		
House mouse	U		X		
Golden mouse	C			X	X
Muskrat	C	X			
Marsh rice rat	U	X	X		
White-footed mouse	C			X	
Norway rat	U		X		
Eastern harvest mouse	U		X		
Gray squirrel	C			X	
Hispid cotton rat	C	X	X		
Eastern chipmunk	C			X	

Table 2.3. (continued)

Species	Abundance[b]	Wetlands	Old fields	Hardwood forest[c]	Pine forest
Bobcat	U	X	X	X	X
Striped skunk	C	X	X	X	
Long-tailed weasel	U	X	X	X	
Mink	U	X			
Raccoon	U	X	X	X	
Gray fox	C	X	X	X	X
Red fox	C	X	X	X	X
White-tailed deer	C	X	X	X	X

[a]Source: Modified from Dahlman, Kitchings, and Elrod (1977)
[b]A = abundant
C = common
U = uncommon
R = rare
N = no information but probably uncommon or rare
E = probably absent at the site
[c]Also includes pine-hardwood forest

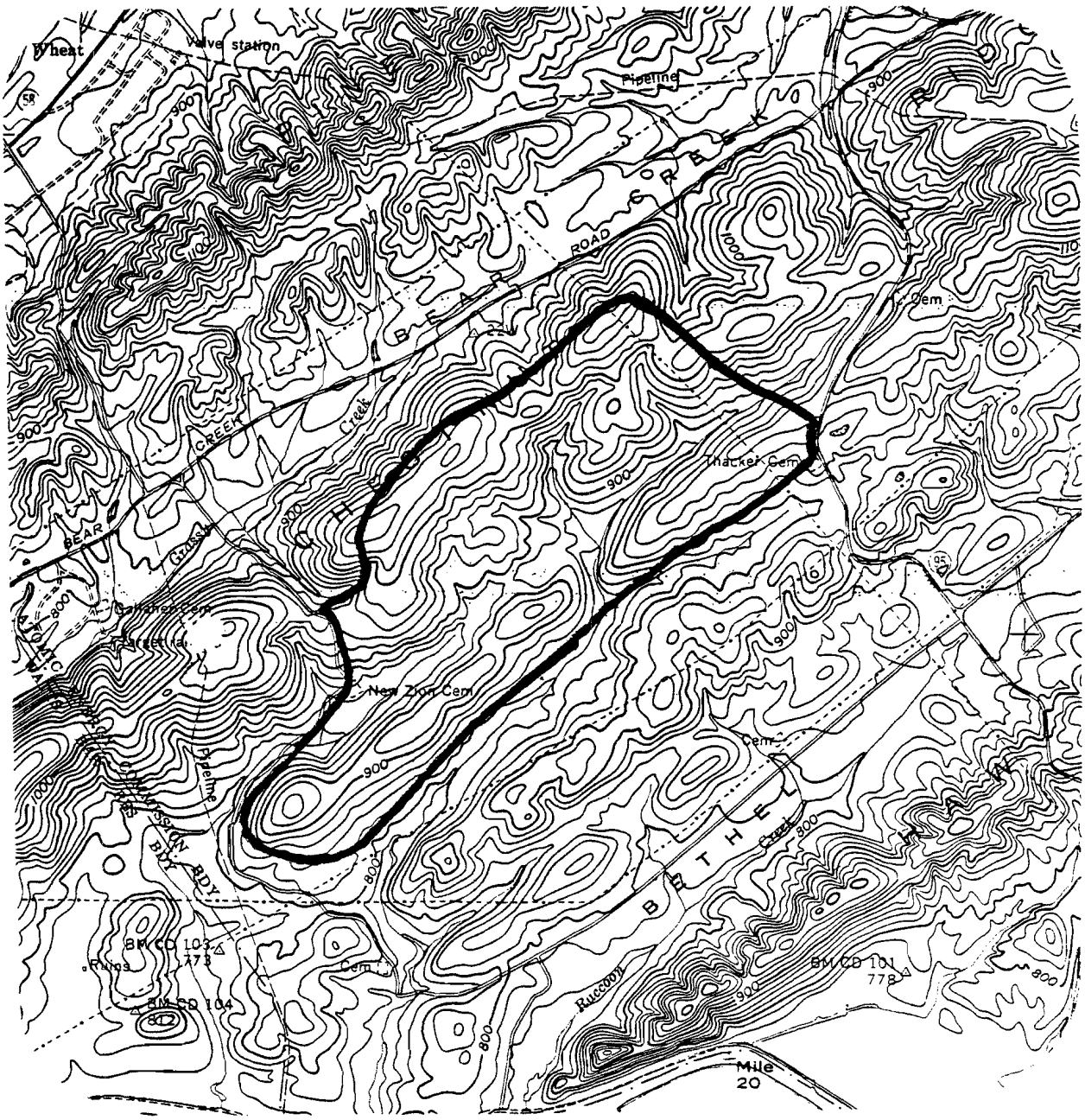

Fig. 2.1 Avifauna survey area at West Chestnut Ridge, 1988.

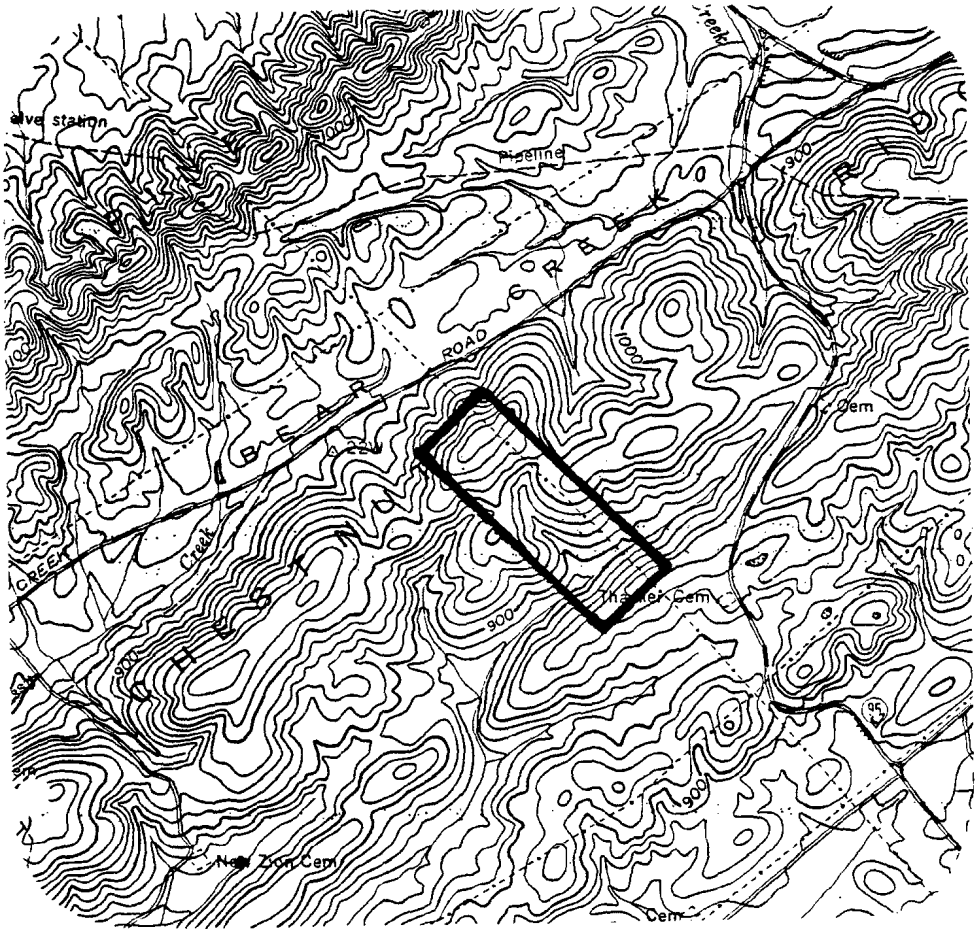

Fig. 2.2 Avifauna survey area in forest (1977, 1979) and power-line corridor (1975, 1977, 1979, 1980) at West Chestnut Ridge.

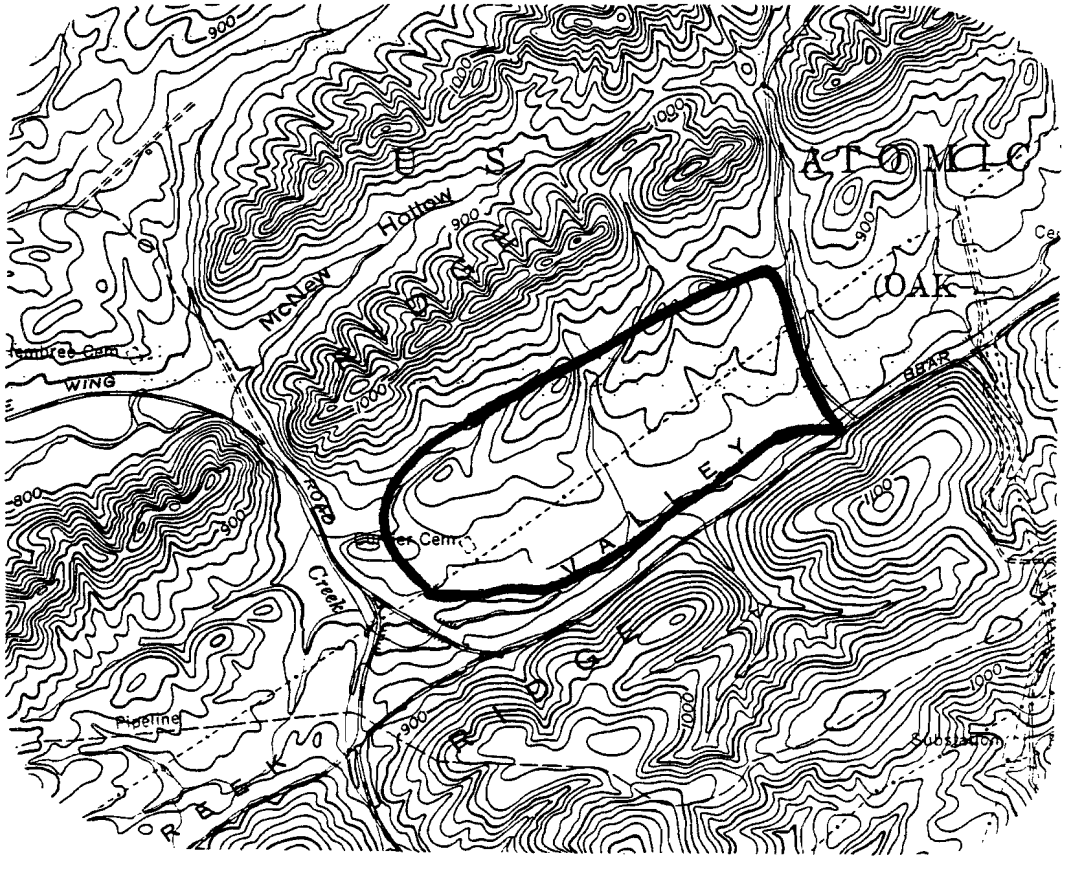

Fig. 2.3 Avifauna survey area at Bear Creek.

Fig. 2.4 Avifauna survey area at Solid Waste Storage Area 7, 1985 and 1988.

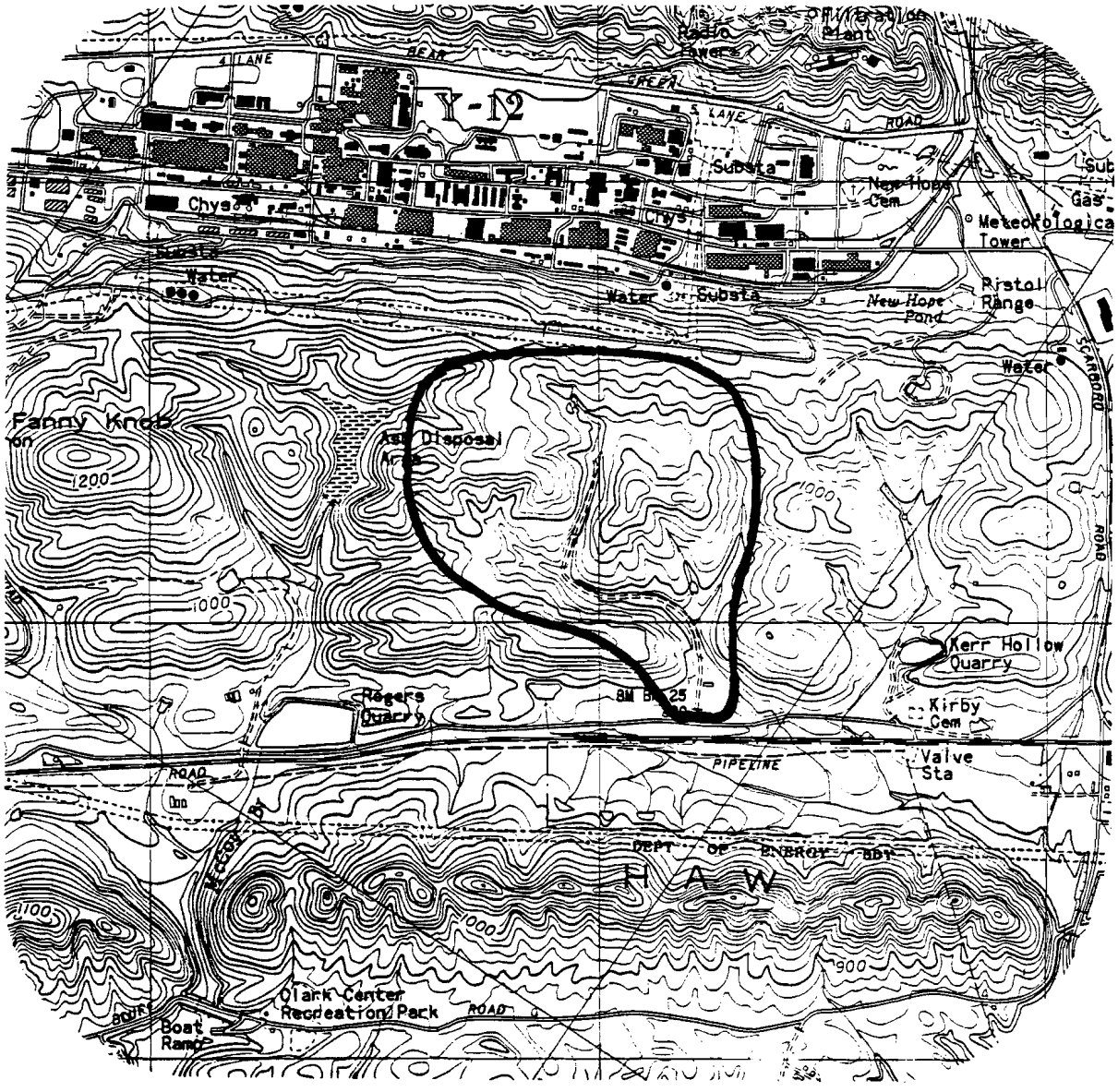

Fig. 2.5 Avifauna survey area at East Chestnut Ridge, 1988.

Table 2.4. Bird species observed on the U.S. Department of Energy Oak Ridge Reservation[a]

Species	Status in Oak Ridge area	Abundance on Oak Ridge Reserv.	West Chestnut Ridge, 1988	West Chestnut Ridge forest, 1977 & 1979	WCR power-line corridor, 1975,77 79,80	Bear Creek, 1988	SWSA 7, 1988	SWSA 7, 1985	East Chestnut Ridge, 1988
Canada goose	PR	C				V			
Wood duck	PR	U							
Black vulture	PR	C							
Turkey vulture	PR	C							
Northern harrier	WV	R							
Sharp-shinned hawk	PR	E							
Cooper's hawk	PR	R		P					
Northern goshawk	WV	R							
Red-shouldered hawk	PR	U	P						
Broad-winged hawk	SR	U				P	P		
Red-tailed hawk	PR	C	P	P	P		P		P
American kestrel	PR	R							P
Ruffed grouse	PR	U	P						
Wild turkey	PR	U	U						
Killdeer	PR	U							
American woodcock	PR	U		P					
Northern bobwhite	PR	C	U	U	U	C			U
Mourning dove	PR	C				U	U		C
Black-billed cuckoo	M	N							
Yellow-billed cuckoo	SR	C	C	C	U	U	C	C	C
Common barn owl	PR	N							

Table 2.4. (continued)

Species	Status in Oak Ridge area	Abundance on Oak Ridge Reserv.	West Chestnut Ridge, 1988	West Chestnut Ridge forest, 1977 & 1979	WCR power-line corridor, 1975,77 79,80	Bear Creek, 1988	SWSA 7, 1988	SWSA 7, 1985	East Chestnut Ridge, 1988
Eastern screech owl	PR	C							
Great horned owl	PR	C							
Barred owl	PR	C	P				P	P	
Long-eared owl	WV	R							
Short-eared owl	WV	R							
Northern saw-whet owl	WV	R							
Common nighthawk	SR	R[b]							
Chuck-will's-widow	SR	U[b]						U	
Whippoorwill	SR	C	U	C		C			
Chimney swift	SR	C				V			
Ruby-throated hummingbird	SR	C		U		U		U	
Belted kingfisher	PR	U				V	V		
Red-headed woodpecker	PR	R							
Red-bellied woodpecker	PR	C	C	C		U	C	C	C
Yellow-bellied sapsucker	WV	U							
Downy woodpecker	PR	C	U	U		C	C	U	C
Hairy woodpecker	PR	C	U	C		U	C	C	U
Northern flicker	PR	C		U		U		U	C
Pileated woodpecker	PR	C	P	P		P	P	P	
Olive-sided flycatcher	M	R							
Eastern wood pewee	SR	U	U	U					

Table 2.4. (continued)

Species	Status in Oak Ridge area	Abundance on Oak Ridge Reserv.	West Chestnut Ridge, 1988	West Chestnut Ridge forest, 1977 & 1979	WCR power-line corridor, 1975,77 79,80	Bear Creek, 1988	SWSA 7, 1988	SWSA 7, 1985	East Chestnut Ridge, 1988
Yellow-bellied flycatcher	M	N							
Acadian flycatcher	SR	C	C	C				C	
Alder flycatcher	M	N							
Willow flycatcher	SR	R							
Least flycatcher	M	N							
Eastern phoebe	PR	C		U		U			U
Great-crested flycatcher	SR	C	U	U		U		U	U
Eastern kingbird	SR	U							
Northern rough-winged swallow	SR	U							
Barn swallow	SR	C							V
Blue jay	PR	C	C	C		C	C	C	C
American crow	PR	C	P	P		P	P	P	P
Carolina chickadee	PR	A	C	C		C	C	C	C
Tufted titmouse	PR	A	C	C		C	C	C	C
Red-breasted nuthatch	WV	U							
White-breasted nuthatch	PR	C	C	C		U	C	C	C
Brown creeper	MV	U							
Carolina wren	PR	C	U	U	V	C	C	C	U
Bewick's wren	PR	E							
House wren	SR	R[a]							
Winter wren	WV	U							

Table 2.4. (continued)

Species	Status in Oak Ridge area	Abundance on Oak Ridge Reserv.	West Chestnut Ridge, 1988	West Chestnut Ridge forest, 1977 & 1979	WCR power-line corridor, 1975,77 79,80	Bear Creek, 1988	SWSA 7, 1988	SWSA 7, 1985	East Chestnut Ridge, 1988
Sedge wren	M	R							
Golden-crowned kinglet	WV	C							
Ruby-crowned kinglet	WV	C							
Blue-gray gnatcatcher	SR	C	C	U	C	C	C	C	C
Eastern bluebird	PR	C			V			V	
Veery	M	N							
Gray-cheeked thrush	M	C							
Swainson's thrush	M	A							
Hermit thrush	WV	C							
Wood thrush	SR	C	C	A		U		U	C
American robin	PR	U[b]					U	U	U
Gray catbird	SR	U[b]		V	V				
Northern mockingbird	PR	U[b]							
Brown thrasher	PR	U				U			U
Cedar waxwing	PR	U	V						
Loggerhead shrike	PR	E							
European starling	PR	C[c]							
Red-eyed vireo	SR	A	A	A		C	C	C	C
White-eyed vireo	SR	C			U	C			
Solitary vireo	M	U							
Yellow-throated vireo	SR	U	U	U			U	U	

Table 2.4. (continued)

Species	Status in Oak Ridge area	Abundance on Oak Ridge Reserv.	West Chestnut Ridge, 1988	West Chestnut Ridge forest, 1977 & 1979	WCR power-line corridor, 1975,77 79,80	Bear Creek, 1988	SWSA 7, 1988	SWSA 7, 1985	East Chestnut Ridge, 1988
Warbling vireo	M	N							
Philadelphia vireo	M	N							
Blue-winged warbler	M	N							
Golden-winged warbler	SR	E[d]							
Tennessee warbler	M	C							
Orange-crowned warbler	M	N							
Nashville warbler	M	N							
Northern parula	SR	U	U				C	C	
Yellow warbler	SR	U							
Chestnut-sided warbler	M	N							
Magnolia warbler	M	N							
Cape May warbler	M	C							
Black-throated blue warbler	M	N							
Yellow-rumped warbler	WV	C							
Black-throated green warbler	M	C							
Blackburnian warbler	M	N							
Yellow-throated warbler	SR	U[b]	U					C	
Pine warbler	SR	C	C	U		A	C	U	
Prairie warbler	SR	C	C		A	C			
Palm warbler	M	N							
Bay-breasted warbler	M	C							

Table 2.4. (continued)

Species	Status in Oak Ridge area	Abundance on Oak Ridge Reserv.	West Chestnut Ridge, 1988	West Chestnut Ridge forest, 1977 & 1979	WCR power-line corridor, 1975,77 79,80	Bear Creek, 1988	SWSA 7, 1988	SWSA 7, 1985	East Chestnut Ridge, 1988
Cerulean warbler	SR	R							
Black-and-white warbler	SR	R		V					
American redstart	M	N							
Prothonotary warbler	SR	U							
Worm-eating warbler	SR	U	R						
Swainson's warbler	SR	E							
Ovenbird	SR	C	C	C		C	C	C	
Northern waterthrush	M	N							
Louisiana waterthrush	SR	U					R	R	
Kentucky warbler	SR	C	U	U		C		U	U
Connecticut warbler	M	N							
Mourning warbler	M	N							
Common yellowthroat	SR	C	U		A	C			U
Hooded warbler	SR	C	U	C	V	A			
Wilson's warbler	M	N							
Canada warbler	M	N							
Yellow-breasted chat	SR	C	C		A	C			C
Summer tanager	SR	C	U	U	U		U	U	U
Scarlet tanager	SR	C	C	C		C	C	U	C
Northern cardinal	PR	C	C	U	C	A	C	C	C
Rose-breasted grosbeak	M	C							

Table 2.4. (continued)

Species	Status in Oak Ridge area	Abundance on Oak Ridge Reserv.	West Chestnut Ridge, 1988	West Chestnut Ridge forest, 1977 & 1979	WCR power-line corridor, 1975,77 79,80	Bear Creek, 1988	SWSA 7, 1988	SWSA 7, 1985	East Chestnut Ridge, 1988
Blue grosbeak	SR	U							
Indigo bunting	SR	A	C		A	C	C	C	A
Dickcissel	M	N							
Rufous-sided towhee	PR	C	C		C	C			U
Bachman's sparrow	SR	E							
Chipping sparrow	SR	U							
Field sparrow	PR	C	C		A	C			C
Vesper sparrow	WV	N							
Lark sparrow	M	R							
Savannah sparrow	WV	U							
Grasshopper sparrow	SR	E[d]							
Henslow's sparrow	M	R							
Le Conte's sparrow	M	N							
Sharp-tailed sparrow	M	N							
Fox sparrow	WV	R							
Song sparrow	PR	U[a]			V				
Lincoln's sparrow	M	N							
Swamp sparrow	WV	U							
White-throated sparrow	WV	C							
White-crowned sparrow	MV	U							
Dark-eyed junco	WV	C							
Red-winged blackbird	PR	U[b]							C

Table 2.4. (continued)

Species	Status in Oak Ridge area	Abundance on Oak Ridge Reserv.	West Chestnut Ridge, 1988	West Chestnut Ridge forest, 1977 & 1979	WCR power-line corridor, 1975,77 79,80	Bear Creek, 1988	SWSA 7, 1988	SWSA 7, 1985	East Chestnut Ridge, 1988
Eastern meadowlark	PR	C							
Rusty blackbird	WV	R							
Brewer's blackbird	MV	R							
Common grackle	PR	C	U				U	U	U
Brown-headed cowbird	PR	C	C	C		C	C	C	U
Orchard oriole	SR	U							
Northern oriole	SR	R							
Purple finch	WV	C							
House finch	PR	U[b]							
Red crossbill	WV	R							
Pine siskin	WV	U							
American goldfinch	PR	C			C	U			
Evening grosbeak	WV	U							
House sparrow	PR	U[b]							

[a]Only those species for which suitable habitat may be present on the various sites are included. PR = permanent resident, SR = summer resident, WV winter visitor, M = occurs exclusively or almost exclusively during migration, A = abundant, C = common, U = uncommon, R = rare, P = present, V = visitor, N = no information but probably uncommon or rare, E = probably absent as a breeder at the site. Common names of species are according to the 34th Supplement to the American Ornithologist's Union Checklist of North American Birds, Supplement to The Auk, Vol. 99, No. 3, July 1982.
[b]Locally common in region.
[c]Locally abundant in region.
[d]Locally uncommon in region.

Threatened and Endangered Species

No species listed by the federal government as threatened or endangered is present on the ORR (Kroodsma 1987).

The only state listed species known to occur on the ORR is the Cooper's hawk (listed as threatened), which has been observed during the nesting season on one of the LLWDDD sites (West Chestnut Ridge) and in several other areas on the ORR. It probably occurs in low densities (e.g., one pair per 6 to 8 miles) in forested areas throughout the ORR.

Two other state listed species observed on the ORR during the last 10 years or so are the grasshopper sparrow (listed as threatened) and Bachman's sparrow (listed as endangered). Surveys for these species were conducted on the LLWDDD sites and other areas during the nesting seasons of 1986 and 1987, but none were found. They probably no longer occur on the ORR.

The state of Tennessee also lists a large number of species as "in need of management" (Kroodsma 1987). Two such species on and in the vicinity of the LLWDDD sites are the black vulture and red-shouldered hawk.

3. AQUATIC BIOTA

Most of the streams on the ORR are small, having drainage basins of <20 km^2 and mean flow rates of <0.3 m^3/s (Dahlman, Kitchings, and Elrod 1977). Many streams are in forested watersheds and consequently are heterotrophically based (i.e., unlike larger, more open streams, they receive much of their energy and nutrient input from leaf litter and relatively less from autochthonous production by algae and periphyton).

Benthic invertebrate communities are typically dominated by aquatic insects; other important components include molluscs (clams and snails), oligochaetes (worms), and crustaceans (amphipods, isopods, and crayfish). The most common insects in terms of number of taxa and density are the Chironomidae (midges), which are normally abundant in silty, low-gradient, warmwater streams and are relatively more tolerant of pollutants (heavy metals, organic enrichment, low dissolved oxygen) than other organisms. Unimpacted streams on the reservation tend to have highest densities and biomass of benthic invertebrates, greatest numbers of taxa (richness), and greatest numbers of "clean-water" taxa (e.g., mayflies and stoneflies).

Fish communities in ORR streams are typical of those in small, warmwater systems. Sixty-four species, representing 17 families of fish, have been collected on or adjacent to the reservation (M. G. Ryon, ORNL, personal communication). The minnow family has the largest number of species (14) and is numerically dominant in most streams. Other diverse and abundant fish families are the suckers (10 species) and the sunfish and bass family (11 species). In general, number of species at a site increases as a function of stream size, but this trend is complicated by the presence of pollutants and barriers to movement (Loar 1988). Not only are densities and biomass highly variable among sites and seasons but also the comparisons are complicated by effects of pollution (including fishkills) and drought conditions. Most streams on the ORR have simple fish communities, dominated by tolerant species.

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ANNOTATED BIBLIOGRAPHY OF LLWDDD CHARACTERIZATION STUDIES

R. S. Weaver

III. ANNOTATED BIBLIOGRAPHY OF LLWDDD CHARACTERIZATION STUDIES

III.1 LISTING OF LLWDDD PUBLICATIONS

LLWDDD-1

Appendices: Remedial Alternatives for Bear Creek Valley Waste Disposal Area. L. L. McCauley, ORNL, Health, Safety, Environment, and Accountability Division, June 21, 1985. Y/TS-109.

Included in this document is information relevant to an assessment of the environmental impacts and initial design of remedial components of the Bear Creek Valley waste disposal area. Ecological characterizations and treatability studies are described in Appendices A and C. Appendix B discusses the clean closure plan prepared by H&R Technical Associates. The information discussed in these appendices has been incorporated in a document titled **Remedial Alternatives for Bear Creek Valley Waste Disposal Area** (Y/SUB/85-00206C/3).

LLWDDD-2

Environmental Data for the White Oak Creek/White Oak Lake Watershed. C. B. Sherwood and J. M. Loar, ORNL, Environmental Sciences Division, January 1987, Environmental Sciences Division Publication No. 2779, ORNL/TM-10062.

Oak Ridge National Laboratory is located in the White Oak Creek (WOC)/White Oak Lake (WOL) watershed, which drains approximately 16.8 km_2 (6.5 $mile^2$). WOC has been utilized for the discharge of treated and untreated wastes from routine operations since the Laboratory's inception. This report, prepared to compile existing information on the content and quantity of hazardous substances in the WOC/WOL watershed, provides background information on the geology, hydrology, and ecology of the site for use in planning future remedial programs.

LLWDDD-3

Draft Environmental Impact Statement: Central Waste Disposal Facility for Low-Level Radioactive Waste. Oak Ridge Reservation, Oak Ridge, TN. U.S. Department of Energy, Washington, D.C., September 1984, DOE/EIS-0110-D.

An assessment of potential environmental impacts associated with the proposed construction of a new Central Waste Disposal Facility for low-level radioactive waste at the Oak Ridge Reservation is presented. Alternatives and predicted environmental impacts, detailed information on analyses of the environmental consequences and alternatives, environmental permits, regulations and approval, and purpose and need for a decision is discussed. Impacts will be considered by the U.S. Department of Energy in its decision on whether, where, and how to construct and operate such a facility.

LLWDDD-4

Environmental Analysis of the Operation of Oak Ridge National Laboratory (X-10 Site). J. W. Boyle et al., ORNL, Energy Division, November 1982, ORNL-5870.

An environmental analysis of the operation of Oak Ridge National Laboratory facilities in Bethel Valley and Melton Valley was conducted to resent information on potential effects on the environment. This analysis addresses current operations at ORNL (X-10 site) and ORNL personnel located at Y-12, where liquid and gaseous waste streams feed into common collection (and treatment) systems. Description of the site, characteristics of existing environment, environmental impacts, and economic effects are discussed.

LLWDDD-5

Technical Background Information for the ORNL Environmental and Safety Report. Volume II: A Description of the Aquatic Ecology of White Oak Creek Watershed and the Clinch River Below Melton Hill Dam. J. M. Loar, J. A. Solomon, and G. F. Cada, Environmental Sciences Division Publication No. 1852, October 1981, ORNL/TM-7509/V2.

A biological sampling program was iniated in March 1979 to characterize the aquatic communities in the vicinity of Oak Ridge National Laboratory. Data on taxonomic composition abundances and temporal distribution of each community are presented for the three study areas: Upper White Oak Creek watershed, White Oak Lake, and the Clinch River (including White Oak Creek embayment). Data on periphyton and ichthyoplankton communities, results, summaries, and conclusions are discussed.

Information obtained in this study will be the basis for evaluating the effects of plant operation on aquatic biota in the annual environmental and safety report for ORNL.

LLWDDD-6

Environmental Sciences Division Second Annual Draft Report on the ORNL Biological Monitoring and Abatement Program. J. M. Loar (ed)., Environmental Sciences Division Publication, April 29, 1988, ORNL-TM.

Structured around the seven major tasks that comprise the Biological Monitoring and Abatement Program, this report presents results of studies conducted in 1987. Report includes (1) toxicity monitoring, (2) bioaccumulation monitoring, (3) biological indicator studies, (4) instream ecological monitoring, (5) assessment of contaminants and radiological studies, and (6) contaminant transport, distribution, and fate in the WOC. **Report updates LLWDDD-7.**

LLWDDD-7

First Annual Draft Report on the ORNL Biological Monitoring and Abatement Program. J. M. Loar (ed)., Environmental Sciences Division Publication 2915, April 24, 1987, ORNL/TM-10399.

The first in a series of annual reports presenting the results of the Biological Monitoring and Abatement Program for White Oak Creek watershed and the Clinch River. Report describes studies that were conducted from March through December 1986. In addition to results of investigations, significant modifications in the scope of work presented in the program are addressed.

LLWDDD-8

Characterization of Fish and Benthic Invertebrates of Melton Branch, Oak Ridge Reservation. G. F. Cada, ORNL, Environmental Sciences Division, Draft Report, July 1986.

Previous studies of the aquatic biota of nearby streams (i.e., Melton Branch and White Oak) are summarized. This draft report describes the results of a baseline survey of Melton Branch between May 1985 and April 1986. Survey includes fish and benthic invertebrates in the vicinity of the proposed Melton Branch.

LLWDDD-9

Preliminary Draft Environmental Analysis: Oak Ridge Operations. Volume VI, Section 2.5.5.

An environmental analysis to assess the impact of the Oak Ridge Reservation is discussed. Observations and radioanalysis of the white tail deer population, identification and characterization of existing biological and ecological communities and endangered species, and life histories of fish species of the Clinch River are discussed. Baseline information on social, economic and political impacts, characterization of land use, and geography is reviewed.

LLWDDD-10

Precipitation and Streamflow in the Vicinity of West Chestnut Ridge Near Oak Ridge National Laboratory, Oak Ridge, Tennessee. (Water Years 1984-1985). D. D. Huff and B. F. Frederick, Environmental Sciences Division Publication 2937, September 1987, ORNL/TM-10500.

Hydrologic data collection at sites on West Chestnut Ridge near Oak Ridge National Laboratory, begun in 1982, are described. General summary of hydrology conditions, data collection, processing procedures, and evaluation of records for 1983-1985 is included. Daily values of precipitation data for 1984-1985 are discussed.

LLWDDD-11

Hydrologic Investigations in the Vicinity of the Proposed Central Waste Disposal Facility, Oak Ridge National Laboratory, Tennessee. D. D. Huff and B. J. Frederick, Environmental Sciences Division Publication No. 2393, December 1984, ORNL/TM-9354.

Data collection for hydrologic evaluation of the proposed Central Waste Disposal Facility began in July 1982 with biweekly measurements of stream flows at seven locations. Documentation of data collected and characterization of surface water hydrology at the proposed site are the objectives of this report. Summaries of precipitation and streamflow data programs are also discussed.

LLWDDD-12

West Chestnut Ridge Hydrologic Studies. J. L. Elmore, D. D. Huff, and J. R. Jones, Environmental Sciences Division Publication No. 2476, August 1985, ORNL/TM-9392.

A hydrology study has been continuing since July 1982. Preliminary site characterization collected for the proposed West Chestnut Ridge Central Waste Disposal Facility includes collection and analysis of data on stream flows, watershed areas, precipitation values, water level measurements at piezometer sites, and physiochemical properties of surface water.

LLWDDD-13

A Checklist of the Vascular Plants on the Department of Energy Oak Ridge Reservation. L. K. Mann, T. S. Patrick, and H. R. DeSelm, Oak Ridge National Laboratory. Journal of the Tennessee Academy of Science, 60(1), January 1985.

Plants have been collected on the Department of Energy Oak Ridge Reservation for 30 years in conjunction with environmental research at Oak Ridge National Laboratory. Authors present a vascular plant checklist of the site, including 114 families, 458 genera, and 842 species, subspecies, and varieties. Description of the study area, methods, and results are presented in this five-page study.

LLWDDD-14

Ecological Characterization of Terrestrial Biota of the Proposed Solid Waste Storage Area (SWSA) 7. R. L. Kroodsma, Environmental Sciences Division, September 1985.

Over time, the storage space in locations at ORNL designated for low-level radioactive wastes has been filled to capacity, and new storage areas must now be used, according to researchers. A new Solid Waste Storage Area (SWSA-7) has been proposed to receive low-level wastes after SWSA-6 (currently used location) is depleted. Information on soils, the

distribution and species composition of plant communities, abundance of fauna, and the occurrence of rare and endangered species and terrestrial biotic communities of the Oak Ridge Reservation and the proposed SWSA-7 site are described.

LLWDDD-15

Botanical Survey of Freels Bend and Surrounding Areas. L. Pounds, Botanical Conservation Consultant to the National Environmental Research Park, October 1987.

Freels Bend and the area surrounding it consists of approximately 4000 acres that the City of Oak Ridge has expressed an interest in acquiring from the Department of Energy. Report presents results of survey of rare plant populations or significant habitat from August 20 to September 18, 1987. A habitat description is provided, with a general estimate of the size of the rare plant population in ten areas.

LLWDDD-16

Report on Preliminary Site Characterization of the West Chestnut Ridge Site. R. H. Ketelle, Energy Division, Environmental Impact Section. Prepared for L. H. Stinton, Union Carbide Corporation-Nuclear Division Engineering, ORNL/NFW-82-21, 47 pp., October 26, 1982.

Preliminary results of a site characterization study on West Chestnut Ridge are presented. The site characterization provides documentation that can be used to plan future investigations of the risk posed by the karst features identified on the site and the mechanisms of moisture transport through the residual soils. Investigations completed include site topography, geology, hydrogeology, field mapping of the site geology, and feasibility of low-level radioactive waste disposal on the West Chestnut Ridge Site.

LLWDDD-17

Stratigraphic Influence on Deep Groundwater Flow in the Knox Group Copper Ridge Dolomite on the West Chestnut Ridge Site. R. R. Lee and R. H. Ketelle, ORNL, Energy Division, ORNL/TM-10479, October 1987.

The Department of Energy is considering locations on the Oak Ridge Reservation for the development and demonstration of new technologies. To assist DOE in its decision-making process, a study of rock coring and geophysical logging was undertaken on West Chestnut Ridge to develop an increased understanding of saturated groundwater flow through weathered and un-weathered bedrock beneath the proposed site. The controlling influence of stratigraphy on deep groundwater flow in the Copper Ridge area will be described in this report, as well as detailed rock characteristics used to define three facies types with geophysical and geochemical data. The relationship between stratabound flow pathways and both aquifer recharge and infiltration is also reviewed.

LLWDDD-18

Hydrologic Study And Evaluation of Ish Creek Watershed (West Chestnut Ridge Proposed Disposal Site). D. D. Huff, J. L Elmore, and D. C. Farmer, Environmental Sciences Division Publication No. 2267, ORNL/TM-8960, March 1984.

Hydrologic information and a sampling network was used as a basis for selection of sites for more permanent hydrologic monitoring and characterization of the Ish Creek catchment. As part of the site characterization work for the proposed West Chestnut Ridge Waste Disposal Facility, this report contains hydrologic information assembled from literature sources and direct field measurements. Based on the findings of this study, a practical design capacity for a flume to measure site runoff would range between 1 and 3000 L/s, although flows up to 4500 L/s (10-year recurrence interval) may be encountered according to authors.

LLWDDD-19

Geochemical and Mineralogical Properties of Copper Ridge and Chepultepec Regolith at the Oak Ridge National Laboratory Reservation-West Chestnut Ridge Site. H. C. Monger, a thesis presented for the Master of Science degree, University of Tennessee, Knoxville, June 1986, 120 pp.

The nature and properties of regolith overlying the Copper Ridge and Chepultepec formations of the Knox Group at the Oak Ridge National Laboratory Reservation-West Chestnut Ridge Site were investigated to determine (a) their natural ability to absorb dissolved waste, (b) the weathering products of siliceous carbonates, and (c) processes leading to pedogenic horizonation. Results of this study are presented.

LLWDDD-20

Geochemical and Mineralogical Characterization of Surficial Residuum Formed from Lower Knox Group Dolostone, West Chestnut Ridge, Oak Ridge, Tennessee. A. S. Crafts. A thesis presented for the Master of Science degree, University of Tennessee, Knoxville, March 1987, 121 pp.

Physical, mineralogical, and geochemical characteristics of bulk residuum samples were analyzed to characterize the weathering behavior of siliceous and argillaceous dolostones of the residuum overlying the Lower Knox Group dolostones at West Chestnut Ridge on the Oak Ridge Reservation. In addition, the study explains the weathering behavior of siliceus dolostones in a warm, humid environment. Background and previous studies, results, summary, and suggestions for further research are discussed.

LLWDDD-21

Task 2. Well Logging and Geohydrologic Testing: Site Characterization and Groundwater Flow Computer Model Application, Volume II of VI. W. G. Gierke,

W. B. Lozier, and R. Pearson, Golder Associates, Inc., Atlanta, GA. Prepared for ORNL, Energy Division, Contract No. 30X-SA706C, May 1988, Final Report.

Data management procedures used to establish uniform sampling, description, and recording of geologic information from retained rock core samples and rotary samples are presented. Rock core, field boring, and well installation logs and slug test data and results are also attached.

LLWDDD-22

Task 2, Well Logging and Geohydrologic Testing: Site Characterization and Groundwater Flow Computer Model Application, Volume I of VI.
W. G. Gierke, W. B. Lozier, and R. Pearson, Golder Associates, Inc., Atlanta, GA. Prepared for ORNL, Energy Division, ORNL/Sub/30A-SA706C, May 1988, Final Report.

This report describes the results of field work and analysis performed for well logging and geohydrologic testing at Bear Creek Valley. Objectives and scope of work, general site geology and hydrogeology, and the field activities, field procedures, data base, data analyses, interpretations, and QA/QC procedure applied at the site are outlined. The report concludes with a reassessment of the conceptual site hydrogeologic model, including the preliminary use of a groundwater flow model. Researchers obtain sufficient data to describe and document the nature of the groundwater flow system at the Bear Creek Valley site.

LLWDDD-23

Task 2, Well Logging and Geohydrologic Testing: Site Characterization and Groundwater Flow Computer Model Application, Volume III of VI. W. G. Gierke, W. B. Lozier, and R. Pearson, Golder Associates, Inc., Atlanta, GA. Prepared for ORNL, Energy Division, ORNL/Sub/30A-SA706C, May 1988, Final Report.

Arithmetic transducer plots and Gringartin log-log plots for all packer tests are outlined in Volume 3. The objective of the packer testing program was to determine major hydraulic properties of the aquifer, such as hydraulic conductivity and hydraulic head, in three dimensions. Charts, graphs, and tables are used to identify and analyze data.

LLWDDD-24

Task 2, Well Logging and Geohydrologic Testing: Site Characterization and Groundwater Flow Computer Model Application, Volume VI. of VI. W. G. Gierke, W. B. Lozier, and R. Pearson, Golder Associates, Inc., Atlanta, GA. Prepared by ORNL, Energy Division, ORNL Sub/30A-SA706C, May 1988, Final Report.

Results and major conclusions of the test data analysis and pump test description, test field data for Nolichucky pump test, and Maynardville field data and drawdown test are outlined. Pump tests were performed as part of Task 2 in the Nolichucky Shale and the Maynardville limestones to evaluate

the hydraulic characteristics of the aquifiers and to determine the principle values (maximum and mimimum).

LLWDDD-25

Soils, Surficial Geology, and Geomorphology of the Bear Creek Valley Low-Level Waste Disposal Development and Demonstration Program Site.
D. A. Lietzke, S. Y. Lee, and R. E. Lambert, Oak Ridge National Laboratory, Environmental Sciences Division Publication 3017. Prepared for the Office of Defense Waste and Transportation Management, ORNL/TM-10573, April 1988.

An extensive soil survey was conducted on the proposed LLWDDD site in Bear Creek Valley. Soils on the site were related to the underlying residuum and to the surficial colluvium and alluvium. Results of the survey investigation indicated that the deeply weathered Pumpkin Valley residuum has good potential for the construction of tumuli or other types of below-ground or above-ground burial of repackaged compacted waste. Methods for mapping soils, mapping unit descriptions, and references are also included.

LLWDDD-26

Characterization of Soil at Proposed Solid Waste Storage Area (SWSA) 7.
E. R. Rothschild, et al., Oak Ridge National Laboratory, Environmental Sciences Division Publication 2384. Prepared for the Office of Defense Waste and Byproduct Management, ORNL/TM-9326, December 1984.

To supplement other waste disposal operations on the DOE Oak Ridge Reservation, the soils at a potential site for shallow land burial of low-level radioactive waste have been characterized. Proposed Solid Waste Storage Area (SWSA) 7 is located in Melton Valley, east of the current burial facilities in the valley. This report focuses on a detailed soil survey; hydraulics, radionuclide, adsorption, and chemical properties; mineralogy; and potential for erosion and engineering characteristics.

LLWDDD-27

Geohydrologic Characterization of Proposed Solid Waste Storage Area (SWSA) 7.
E. R. Rothschild, et al., Environmental Sciences Division Publication No. 2380. Prepared by the Office of Defense Waste and Byproduct Management, ORNL/TM-9314, December 1984.

To supplement other waste disposal operations on the DOE Oak Ridge Reservation, the geohydrology at the proposed site for shallow-land burial of low-level radioactive waste (Solid Waste Storage Area 7) has been characterized. Climate, site-specific information on stream flow collected through the installation of a flume and temporary gaging station, a calculated water budget, data on groundwater level fluctuations and aquifer properties collected through extensive monitoring well network, and background stream and groundwater chemistry determined for the site, have been characterized.

LLWDDD-28

Infiltration, Macroporosity, and Mesoporosity Distributions on Two Forested Watersheds. G. V. Wilson and R. J. Luxmoore, Soil Sci. Soc. Am. J., 52:329-335, 1988.

Macro- and meso processes substantially control the subsurface flow in forested watersheds according to authors. Spatial variability in porosity of actively conducting soil macro- and mesopores was estimated on a field scale at two contrasting forested watersheds from ponded and tension infiltration measurements.

LLWDDD-29

Soil and Surficial Geology Guidebook to the Oak Ridge Reservation, Oak Ridge Tennessee. S. Y. Lee, D. A. Lietzke, R. H. Ketelle, and J. T. Ammons. Environmental Sciences Division Publication No. 3112, ORNL/TM-10803, June 1988, 89 pp.

This soil and surficial geology guidebook is organized in four parts: (1) introduction to the Oak Ridge area, (2) geologic and hydrologic setting, (3) soil surficial geology and geomorphic relations, and (4) sitelogs, including soil description and characterization data. Soil survey and characterization studies were begun five years ago to support the Nuclear and Chemical Waste programs at ORNL and at the Oak Ridge Y-12 Plant. Part of the studies were conducted by the Department of Plant and Soil Science, University of Tennessee, Knoxville.

LLWDDD-30

Mineralogical Characterization of West Chestnut Ridge Soils. S. Y. Lee, O. C. Kopp, and D. A. Lietzke. Environmental Sciences Division Publication No. 2418, ORNL/TM-9361. Prepared for the Office of Defense Waste and Byproducts Management, December 1984, 85 pp.

A section of West Chestnut Ridge in Roane County has been selected as a candidate site for a new low-level radioactive waste disposal facility (designated the Central Waste Disposal Facility) for the DOE Oak Ridge plants. Bedrock geology, surface and subsurface hydrology, physiochemical properties of the soil, geographic setting, long-term structural stability, and management of the site after waste disposal and closure are assessed and documented in this report.

LLWDDD-31

Task 2, Well Logging And Geohydrologic Testing: Site Characterization And Groundwater Flow Computer Model Application, Volume IV. of VI. Final Report. W. G. Gierke, W. B. Lozier, and R. Pearson, Golder Associates, Atlanta, GA., ORNL/Sub/30X-SA706C, May 1988.

Results of standard packer testing is presented in Horner semi-log plots and Bredehoeft and Papadopulos pressure slug decay plots and data. The Horner method is a semi-log method in which the head (or pressure) is plotted against the log of the ratio of the duration of the flow period (T), plus elapsed shut-in time (t'), to elapsed shut-in time. The Bredehoeft and Papdopoulos method is a type curve procedure in which the head ratio (head above static at any instance in time after pressure pulse shut-in divided by the initial pressure pulse head above static) is plotted against the log of time since pressure slug shut in. Both methods are found in this report, Appendices D3 and D4.

LLWDDD-32

Task 2, Well Logging and Geohydrologic Testing: Site Characterization and Groundwater Flow Computer Model Application, Volume V. of VI. Final Report. W. G. Gierke, W. B. Lozier, and R. Pearson, Golder Associates, Atlanta, GA., ORNL/Sub/30X-SA706C, May 1988.

Reduced field data or data reduction for each packer test is presented in Volume V, Appendix D5. The first step in the data reduction process are: (1) to reduce the transducer readings to total hydraulic head and (2) to calculate the flow rate and the elapsed shut-in time data. The shut-in data and flow rates determined, are designated in Appendix D5 under the column "tst status."

LLWDDD-33

Radionuclide Migration Pathways Analysis for the Oak Ridge Central Waste Disposal Facility on the West Chestnut Ridge Site. F. G. Pin, et al., ORNL, Energy Division, ORNL/TM-9231, October 1984.

A dose-to-man pathways analysis is performed for disposal of low-level radioactive waste at the Central Waste Disposal Facility on the West Chestnut Ridge Site. Both shallow land burial (trench) and above-ground (tumulus) disposal methods are considered. The waste volumes, characteristics, and radionuclides concentrations are those of waste streams anticipated from the Oak Ridge National Laboratory, the Y-12 Plant, and the Oak Ridge Gaseous Diffusion Plant. Exposure pathways examined include (1) migration and transport of leachate from the waste disposal units to the Clinch River and (2) those potentially associated with inadvertent intrusion following a 100-year period of institutional control.

LLWDDD-34

Site Characterization of the West Chestnut Ridge Site. R. H. Ketelle and D. D. Huff, ORNL/TM-9229, September 1984.

Results of the investigations performed during September 1984 on the West Chestnut Ridge site, including geomorphic observations, area geologic mapping, surficial soil mapping, subsurface investigations, soil geochemical and minerological analyses, geohydrologic testing, groundwater fluctuation

monitoring, surface water discharge, and precipitation monitoring. Summaries are also included for each investigation. The most significant aspects of ongoing site investigations are highlighted throughout the document to provide an understanding of the overall site geologic and geohydrologic system.

LLWDDD-35

Geochemical Information for the West Chestnut Ridge Central Waste Disposal Facility For Low-Level Radioactive Waste. F. D. Seeley and A. D. Kelmers, Chemical Technology Division, ORNL-6061, June 1984, 227 pp.

The objective of this geochemical support effort was to supply the needed radionuclide behavior information and to characterize the site soil and groundwater geochemically. Sorption and solubility measurements of both soil and groundwater systems are assessed.

LLWDDD-36

Subsurface Characterization and Geohydrologic Site Evaluation: West Chestnut Ridge Site. Prepared by Woodward-Clyde Consultants, Wayne, NJ, Volume I(II), ORNL/Sub/83-64764/1&VI, January 25, 1984.

The West Chestnut Ridge Site at the Oak Ridge National Laboratory is being considered for use as a repository for low-level radioactive waste. A geohydrological characterization of site for use in pathways analysis and preliminary geotechnical recommendations to be used for development of a site utilization plan are outlined. Subsurface conditions were investigated at 20 locations and observation wells installed. Field testing included standard penetration test, permeability tests in soil and rock, and well pumping test. Laboratory testing included permeability, strength and compaction, and index and physical property tests.

LLWDDD-37

Appendices: Subsurface Characterization and Geohydrologic Site Evaluation, West Chestnut Ridge Site. Prepared by Woodward-Clyde Consultants, Wayne, NJ, Volume II(II), ORNL/Sub/83-64764/1&V2, January 25, 1984.

The objectives of this study were to characterize the site, provide enough soil, geologic, and geohydrologic data to enable prediction of site performance, and design information for site development. Soil sampling and testing, bedrock and geohydrologic testing investigations are presented. Results of this characterization study will provide input data for (1) transport models to be used in pathways analysis of the site and (2) development of a site utilization plan.

LLWDDD-38

Spatial Variability of Subsoil Hydraulic Properties of Two Forested Watersheds. G. V. Wilson, James M. Alfonsi, and P. M. Jardine. Research sponsored by the Ecological Research Division, Office of Health and Environmental Research, U.S. Department of Energy, undated.

The Guelph Parameter was used by authors to determine the spatial variability in steady-state percolation rates of two forested watersheds, Walker Branch and Melton Branch, in eastern Tennessee. This study (1) determines the variability and spatial dependency of the subsoil hydraulic properties of two forested watersheds, and (2) assesses the applicability of this method to heterogenous conditions from assumptions of an analysis.

LLWDDD-39

Conceptual Layout of Proposed Low Level Radioactive Waste Burial Ground SWSA-7 Site. Prepared by MCI/Consulting Engineers, Inc., Knoxville, TN, MCI-83-575, Final Report, September 30, 1983.

Future operation of the Oak Ridge National Laboratory will require additional areas suitable for the disposal of radioactive wastes according to researchers. MCI/Consulting Engineers, Inc., was contracted by ORNL to address siting requirements and investigate optimum land usage methods for a new burial area, designated as Solid Waste Storage Area 7. This report conceptualizes preliminary site layouts and general operating procedures for the proposed burial site. Siting requirements for all levels of development for SWSA 7 are detailed.

LLWDDD-40

Low Level Waste Disposal Facility Development Study, Phase I-Final Report. Prepared by Lockwood Greene Engineers, Oak Ridge, TN, U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, Tennessee, Contract No. DE-AC05-81OR206/76, June 3, 1988.

The purpose of this study is to support the LLWDDD program in the analysis of low-level waste disposal concepts for use on the Oak Ridge Reservation. Concepts are described in the strategic planning document for the LLWDDD program, but this evaluation serves to identify options, provide cost data for each option, and give drawings to illustrate the concept in relation to specific sites on the Oak Ridge Reservation.

LLWDDD-41

Resource Management Plan for the Oak Ridge Reservation. Volume 24: Threatened and Endangered Animal Species. R. L. Kroodsma. ORNL/ESH-1/V24, January 1987.

United States and Tennessee laws provide protection for wildlife species that the U.S. Fish and Wildlife Service and the Tennessee Wildlife Resources Agency have determined to be endandangered or threatened. These laws and their implications for management of the Oak Ridge Reservation are reviewed. The historical occurrence, current status, and recommended surveys and management plans for all threatened and endangered wildlife species on the Oak Ridge Reservation are discussed.

LLWDDD-42

Identification of Sites for the Low-Level Waste Disposal Development and Demonstration Program. R. H. Ketelle and D. W. Lee, Oak Ridge National Laboratory, Energy Division, ORNL/TM-10221, April 1988.

Results of site selection studies for potential low-level radioactive waste disposal sites on the Oak Ridge Reservation are presented. Summaries of the site selection procedures used and results of previous site selection studies are included. Recommendations of sites for demonstration of shallow land burial engineered trench designs and of above-grade disposal using design concepts similar to those used in the tumulus disposal are outlined. This study updates Use of DOE Site Selection Criteria for Screening Low-Level Waste Disposal Sites on the Oak Ridge Reservation, ORNL/TM-9717.

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