SUMMARY OF PHASE I INVESTIGATIONS AT PUBLIC SERVICE COMPANY OF NEW MEXICO - PERSON GENERATING STATION, ALBUQUERQUE, NM

prepared for:

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December 29, 1983

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1.0 EXECUTIVE SUMMARY

The first phase of the soil contamination investigation at the Person Generating Station has allowed a preliminary determination of:

- --The lithology at the site (uniform sand)
- --The hydrologic properties of the unsaturated zone
- --The approximate vertical and lateral extent of PCE in the soil
- --The concentrations of PCE in the soil
- --The mechanisms for the approximate rate of movement of PCE in the unsaturated zone
- --The approximate depth to groundwater (115')

The soil sampling was done in accordance with established drilling and coring procedures to assure no cross-contamination of samples and no movement of fluids down the sealed boreholes. These procedures are described in Section 2.0. Analytical procedures used to establish PCE concentrations in the soil are described in Section 3.0.

In order to evaluate the potential for the PCE described in Section 4.2 to migrate in the unsaturated zone, unsaturated hydraulic conductivities (Ku) were determined through laboratory tests. The relationship of these conductivities to measured moisture contents is described in Section 4.4. In general, it was found that unsaturated hydraulic conductivities for most of the affected zone approach zero and where they are measurable, they range from 10^{-6} to 10^{-7} cm/sec. As a result, it appears that the PCE in the unsaturated zone will remain at approximately the same vertical location with the exception of molecular/vapor phase transport.

The porosity of the sands at the site range from 22-27% which are typical values for medium-coarse grained sands. Saturated hydraulic conductivities (Ksat) determined for three samples from PS-4 averaged about .008 cm/sec.

The question of how to locate a possible background borehole and groundwater monitoring well are discussed in Sections 5.0 and 6.0. It will be necessary to complete the second phase of the investigation before these holes can be located confidently, should they be needed.

2.0 SAMPLING PROGRAM METHODOLOGY

During the period of October 24-October 27, 1983 an initial drilling and soil sampling program was carried out by PNM and Geoscience Consultants at Person Generating Station. This program consisted of drilling five hollow stem auger holes (PS-1,PS-2,PS-3,PS-4,PS-5) in the vicinity of the waste tank to depths of 50,50,60,90,90 feet respectively (Figure 2-1). These holes were sampled at 2.5' intervals with a split spoon sampler. After sample removal, the split spoon samplers were entirely disassembled and steam (250°F) cleaned and allowed to dry prior to taking another sample. The upper and lower 6 cm of a 46 cm long split spoon sample were discarded to avoid sample contamination from material that may have been present in or on the sides of the auger (Plate 1).

Immediately after splitting the core barrel, samples were taken throughout the length of the core to minimize the effect of any small difference in grain size. Samples were collected in 40 ml VOA vials for chemical analysis (Plate 2). The remainder of the samples were frozen for any future analysis that may be required. Samples were handled with disposable rubber gloves discarded after each use to prevent cross contamination.

Every 5 feet a representative sample was taken immediately after opening the core barrel for soil

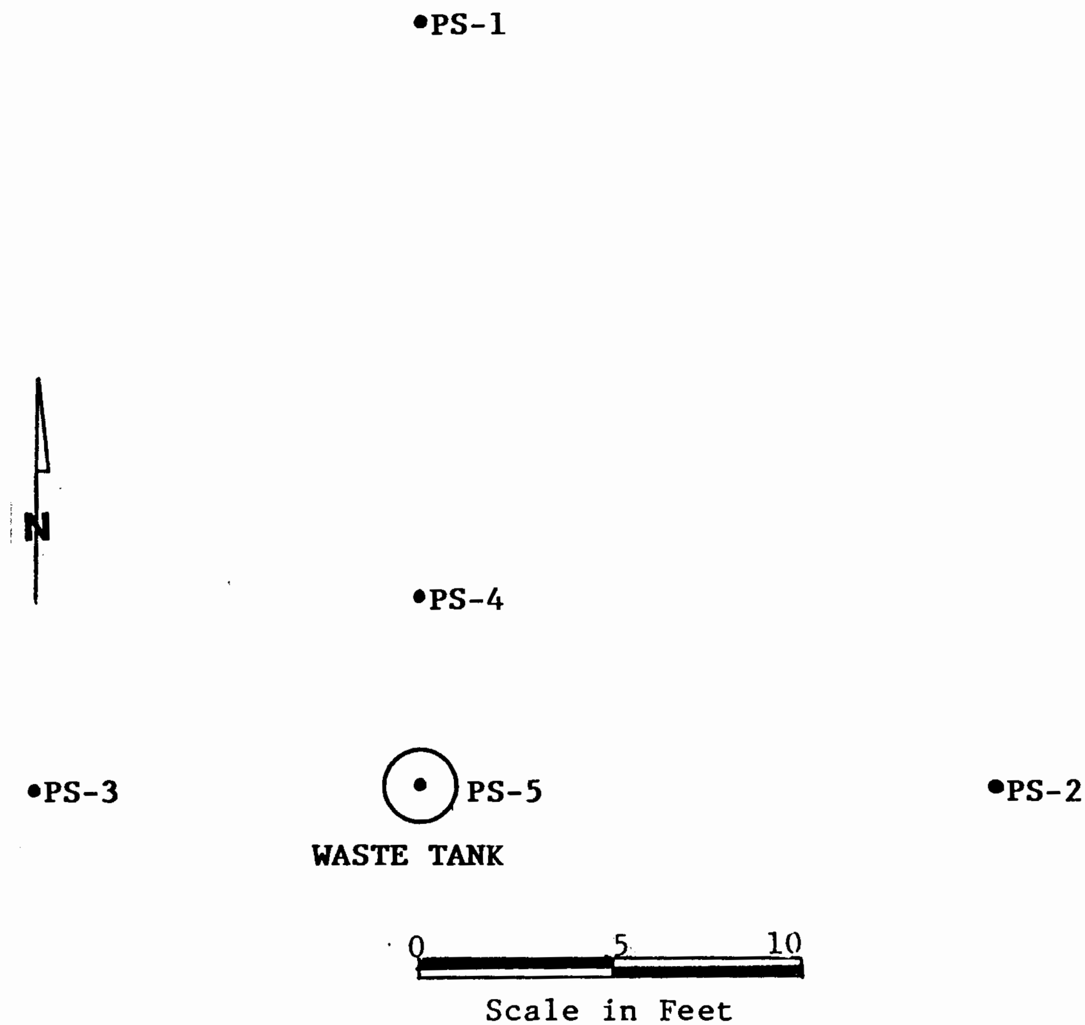

Figure 2-1 Map showing layout of Phase 1 core holes in relation to location of waste tank

Plate 1 - Typical split spoon sample prior to removal of ends to assure no sample cross-contamination. Note uniformity of grains.

Plate 2 - Samples in 40 ml vials from entire length of core to eliminate size effect.

moisture analysis. These samples were immediately sealed in two plastic bags and mason jars to prevent moisture loss. The auger holes were backfilled with bentonite pellets and granular bentonite to seal the hole and to insure that fluids could not move down the bore hole. Samples were kept in coolers with ice and transported to the laboratory daily for analysis. Samples from depths of 25',40', and 70' in hole PS-4 were sent to Dr. Daniel B. Stephens at NMIMT for development of soil moisture characteristic curves in order to determine unsaturated hydraulic conductivity (Ku) as a function of volumetric soil moisture (θ) for the material at the site.

3.0 ANALYTICAL PROGRAM

Soil samples were analyzed for concentrations of tetrachlorethylene (PCE) and for weight percent moisture. In addition, three samples from different depths (25',40', and 70'of PS-4) were sent to Dr. Daniel B. Stephens (NMIMT) for development of soil moisture characteristic curve, Ku and Ksat determinations.

3.1 CHEMICAL ANALYSIS OF SOIL SAMPLES

Soil samples analyzed for tetrachloroethylene (PCE) were stored frozen in VOA vials until analyses were performed. In the laboratory, samples were thawed and a representative portion of the soil in the vial was extracted using methanol. The extract was analyzed using gas chromatography with electron capture detection. The procedure that was utilized is included in "Test Methods for Evaluating Solid Waste", 2nd edition, USEPA, SWER, SW846, 1982 and "Organic Analysis using Gas Chromatography/Mass Spectrometry", 1979, Budde & Eichelberger, Ann Arbor Science Press.

Replicate samples from some vials were analyzed to evaluate PCE concentration variability due to grain size variation in the vial and differences introduced by subsampling soil from the VOA vial. Since tetrachloroethylene (PCE) is the least volatile of the wastes stored in the tank, it will have a longer residence time in the soil and thus it was chosen as the most conservative organic tracer for studying the soil contamination. Soil moisture tests were done by drying the material at 75°C for 36 hours. This method assured the release of all the moisture in the sample with the exception of molecular (bound water) which does not affect unsaturated hydraulic conductivities (Ku).

3.2 UNSATURATED HYDRAULIC CONDUCTIVITY (Ku) LABORATORY DETERMINATION

Three soil samples sent to Dr. Daniel B. Stephens of NMIMT were analyzed in the laboratory to determine Ku values at depths of 25', 40', and 70'. Since the material was quite uniform throughout, the soil moisture characteristic curves did not vary greatly with depth.

All moisture content data are reported on a volumetric rather than on a mass basis. During analysis for volumetric water content and pressure head the soil remains in stainless steel rings. Two methods of analysis were employed: the hanging water column and the volumetric pressure plate extractor. Procedures for both methods follow those prescribed in Methods of Soil Analysis, American Society of Agronomy, C.A. Black, et al.(eds.), 1965. The results of the analysis are represented graphically in Section 4.3.

During the final step of determining moisture content versus pressure head the soil samples are oven dried for 24 hours at 105°C. The oven drying is necessary to calculate water contents and porosity. To determine saturated hydraulic conductivity all samples were placed in a constant head permeameter specifically designed to accommodate 100cc stainless steel rings. The samples were soaked in the permeameter for about 24 hours. Socorro city tap water was used in the permeameter. There was no evidence of piping through any of the samples. Measurements of hydraulic gradient and flow rate in the permeameter were taken within the subsequent 24 hour period.

A methodology by Mualem (WRR,12(3),1976) to determine hydraulic conductivity versus pressure head was used in conjunction with a computer program by R. van Genuchten (Princeton University, Civil Engineering Department, Research Report 78-WR-08,1978.) Data requirements for the computer model include the volumetric water content versus pressure head and saturated hydraulic conductivity. Recently reported studies and previous experience indicate that this approach provides a accurate representation of the unsaturated hydraulic conductivities (Van Genuchten, 1980, Soil Science Soc. Amer. Proc. 44(5).

4.0 ANALYSIS OF AVAILABLE DATA AND RESULTS

An analysis of the results of the Phase 1 coring, sampling, analyses, and laboratory measurements is presented in this section.

4.1 LITHOLOGIC DESCRIPTION OF SITE

The coring and logging of the five holes drilled in Phase 1 of the study indicate that the material consists of a fairly uniform, medium-coarse grained, fluvially deposited sand with some minor amounts of clay and gravel to a depth of at least 90' (depth of deepest core hole). No continuous gravel or clay lenses could be correlated between any of the holes. Within an individual core, when gravel or clay was present, the thickness never exceeded 20 cm. The grain size of sand was uniform throughout the profile. In summary, the lithology of the site is characterized by large scale homogeneity and very small scale heterogeneity consisting of clay and non-continuous gravels. No cracks or other potential fluid channels were visible in any of the cores.

4.2 RESULTS OF CHEMICAL ANALYSIS

Results of the soil samples analyzed for PCE are included in Table 4-1 and Figure 4-1. The detection limit for PCE is .001 mg/l (1ppb). Core holes PS-1 and PS-2, at

PERSON GENERATING STATION
RESULTS OF PHASE 1 ANALYSES
TETRACHLOROETHYLENE(ppm)

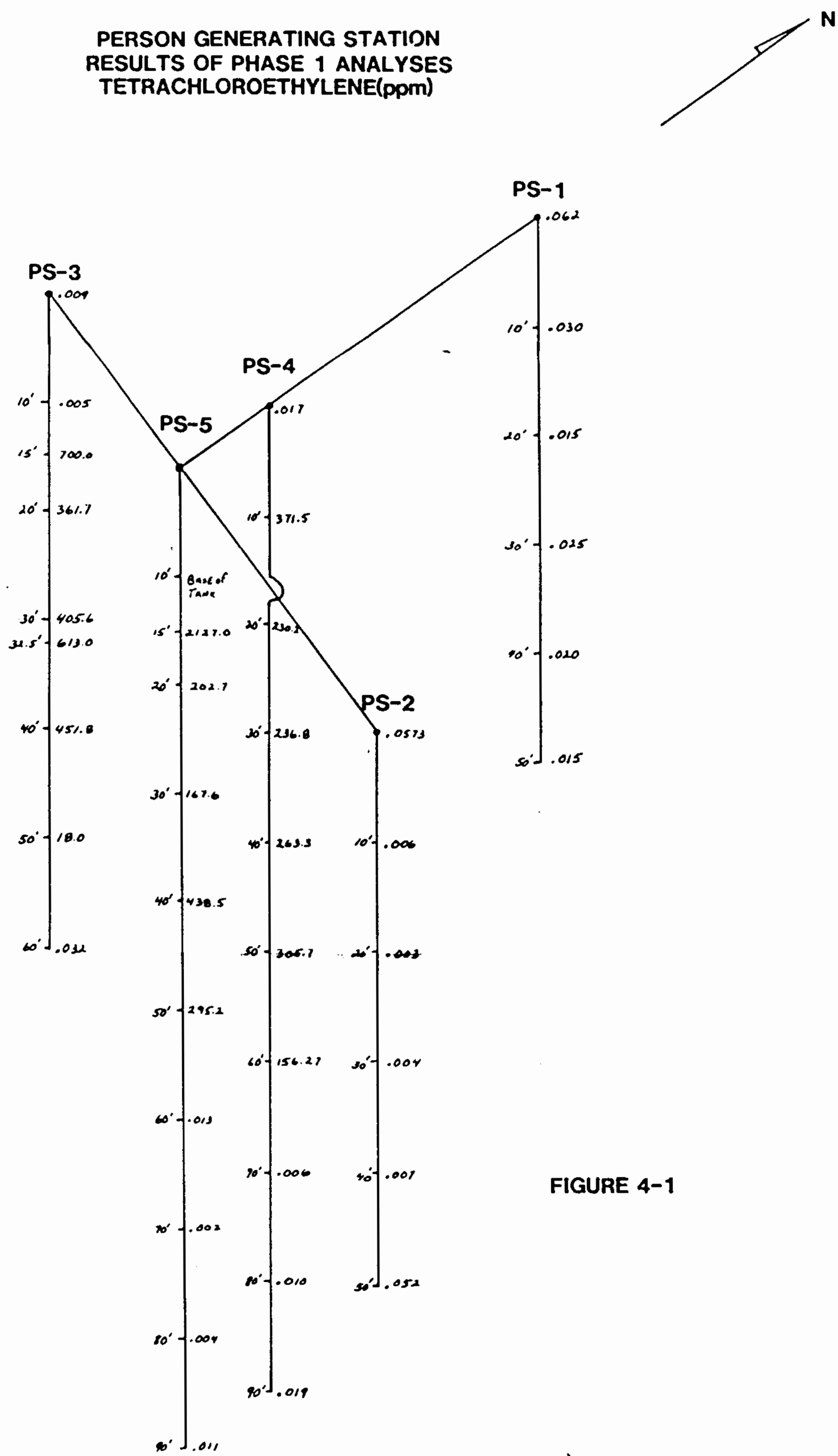

FIGURE 4-1

(505) 345-8964
7300 Jefferson St. NE
Albuquerque, NM 87109

Analytical and Environmental Services

AnaCor Laboratories

To: PNM
Alvarado Square
Albuquerque,NM 87158

Date: 8 November 1983
JV-1192 (Revised)

Attention: Jody Plum

Analyte: Tetrachloroethylene

Sample ID	Analytical Results	Sample ID	Analytical Results
1 - Surface	0.062 ppm	3 - 60'	0.032 ppm
1 - 10'	0.030 ppm	4 - Surface	0.017 ppm
1 - 20'	0.015 ppm	4 - 10'	371.5 ppm
1 - 30'	0.025 ppm	4 - 20'	230.2 ppm
1 - 40'	0.020 ppm	4 - 30'	236.8 ppm
1 - 50'	0.015 ppm	4 - 40'	263.3± 70.4 ppm
2 - Surface	0.0573 ± 0.0319 ppm	4 - 50'	305.7± 113.2 ppm
2 - 10'	0.006 ppm	4 - 60'	156.27 ppm
2 - 20'	0.003 ppm	4 - 70'	0.006± 0.002 ppm
2 - 30'	0.004 ppm	4 - 80'	0.010± 0.003 ppm
2 - 40'	0.007 ppm	4 - 90'	0.019± 0.016 ppm
2 - 50'	0.052 ppm	5 - 15'	2127.0 ppm
3 - Surface	0.009 ppm	5 - 20'	202.7 ppm
3 - 10'	0.005 ppm	5 - 30'	167.6 ppm
3 - 15'	700.0 ppm	5 - 40'	438.5± 211.0 ppm
3 - 20'	361.7 ppm	5 - 50'	295.2 ±40.0 ppm
3 - 32.5	613.0 ppm	5 - 60'	0.013 ppm
3 - 30'	405.6 ppm	5 - 70'	0.002 ppm
3 - 40'	451.8 ppm	5 - 80'	0.004± .0006 ppm
3 - 50'	18.0 ppm	5 - 90'	0.011± 0.006 ppm

Normal Detection Limit: .001 mg/l

Reference: "Test Methods for Evaluating Solid Waste", 2nd Edition, USEPA, SWER, SW846, 1982.

Table 4-1 PCE Analysis at Person Generating Station

20 feet north and 15 feet east respectively, show very low levels of PCE. These levels are indicative of vapor phase transport and/or molecular diffusion and not liquid movement. These holes are outside the boundary of the soil contaminated by liquid PCE. The other three core holes (PS-3,PS-4,PS-5) show a sharp vertical concentration gradient at the 40-60 foot level which indicates that the mechanism for PCE movement below this level has been largely due to molecular diffusion and/or vapor phase transport. This is further substantiated by an examination of the low Ku values that correspond to the volumetric moisture contents (θ) encountered at these depths in all the core holes. The additional 8 core holes being drilled under Phase 2 of the investigation will provide much better definition of the soil volume contaminated by PCE.

4.3 RESULTS OF MOISTURE CONTENT TESTS

The results of the moisture content analyses performed on the samples is given in Table 4-2. This table converts the weight % moisture reported by the laboratory to the volumetric moisture content necessary to determine Ku values from soil moisture characteristic curves by using bulk density values for differing grain sizes. The results from the moisture content analyses show a uniform gradient with an average value of less than

TABLE 4-2
MOISTURE CONTENT OF UNSATURATED ZONE
PERSON STATION

	depth	wt % fluid	*	θ
PS-1	30	3.67	1.6	5.8
	40	4.27	1.6	6.83
	50	2.28	1.65	3.76
				av. θ = 5.4
PS-2	22.5	7.85	1.5	11.8
	32.5	4.95	1.6	7.9
	42.5	3.64	1.65	6.0
	50.00	6.56	1.5	9.8
				av. θ = 8.9
PS-3	30	3.14	1.65	5.2
	40	3.81	1.65	6.3
	50	2.87	1.65	4.7
	60	5.74	1.5	8.61
				av. θ = 6.2
PS-4	5	3.15	1.65	5.2
	10	3.98	1.65	6.6
	15	5.6	1.65	9.2
	20	6.67	1.5	10.00
	25	5.08	1.65	8.4
	30	5.78	1.5	8.7
	35	9.24	1.4	12.9
	40	4.32	1.6	6.48
	50	4.93	1.65	8.1
	60	5.11	1.65	8.4
	70	5.19	1.6	8.3
	80	7.06	1.5	10.6
	90	5.69	1.65	9.4
				av. θ = 9.0
PS-5	15	4.45	1.7	7.6
	20	5.18	1.5	7.7
	25	5.89	1.5	8.8
	30	7.13	1.5	10.7
	35	7.05	1.5	10.6
	40	4.43	1.65	7.3
	45	5.28	1.5	7.9
	50	6.68	1.5	10.2
	60	3.42	1.6	5.6
	70	3.10	1.7	5.3
	80	2.39	1.6	3.8
	90	2.76	1.7	4.7
				av. θ = 7.5

* determined from field observations of grain size verified by lab tests

TABLE 4-2
MOISTURE CONTENT OF UNSATUARATED ZONE
PERSON STATION

	depth	wt % fluid	ρ_B*	θ**
PS-1	30	3.67	1.6	5.8
	40	4.27	1.6	6.83
	50	2.28	1.65	3.76
				av. θ = 5.4
PS-2	22.5	7.85	1.5	11.8
	32.5	4.95	1.6	7.9
	42.5	3.64	1.65	6.0
	50.00	6.56	1.5	9.8
				av. θ = 8.9
PS-3	30	3.14	1.65	5.2
	40	3.81	1.65	6.3
	50	2.87	1.65	4.7
	60	5.74	1.5	8.61
				av. θ = 6.2
PS-4	5	3.15	1.65	5.2
	10	3.98	1.65	6.6
	15	5.6	1.65	9.2
	20	6.67	1.5	10.00
	25	5.08	1.65	8.4
	30	5.78	1.5	8.7
	35	9.24	1.4	12.9
	40	4.32	1.6	6.48
	50	4.93	1.65	8.1
	60	5.11	1.65	8.4
	70	5.19	1.6	8.3
	80	7.06	1.5	10.6
	90	5.69	1.65	9.4
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PS-5	15	4.45	1.7	7.6
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	70	3.10	1.7	5.3
	80	2.39	1.6	3.8
	90	2.76	1.7	4.7
				av. θ = 7.5

*ρ_B = Bulk Density (g/cc) (determined from field observations of grain size verified by lab tests)
**θ = Volumetric Moisture Content (%)

9 %. These volumetric moisture contents yield very low Ku values when using data developed from the three samples taken at various depths (25',40', and 70') in PS-4.

4.4 RELATIONSHIP OF MOISTURE CONTENT (θ) TO UNSATURATED HYDRAULIC CONDUCTIVITY (Ku)

The relationship of volumetric moisture content (θ) to unsaturated hydraulic conductivity (Ku) was determined for the soil at the Person Generating Station site through the laboratory analysis described in Section 3.2. The soil moisture characteristic curves shown in Figures 4-2, 4-3, and 4-4 were used to determine Ku values for each interval where moisture content analyses were performed. Ku values determined through this method generally approach zero and in the few instances where Ku values are greater than zero, only two or three values exceed 10^{-7} cm/sec (Figures 4-2, 4-3, 4-4). These values are about 6 x 10^{-6} cm/sec. All of the lab determined Ku values tend to be higher than actual field conditions since the technique in Section 3.2 yields maximum values.

4.5 POROSITY AND SATURATED HYDRAULIC CONDUCTIVITY (Ksat)

The porosity of the sands at the site range from 22-27% which are typical values for medium-coarse grained sands. Saturated hydraulic conductivities were calculated

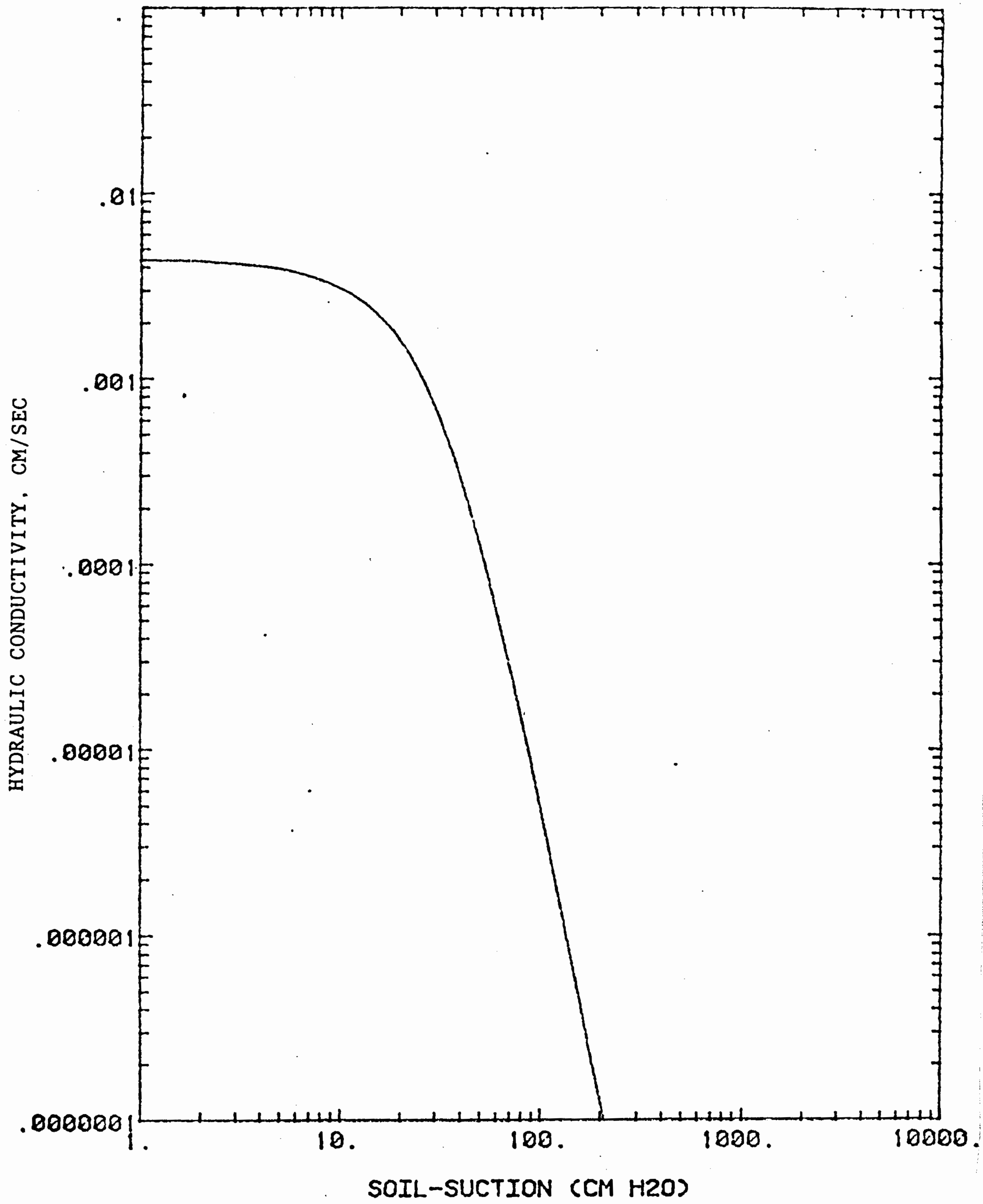


Figure 4-2A PS-4 25'

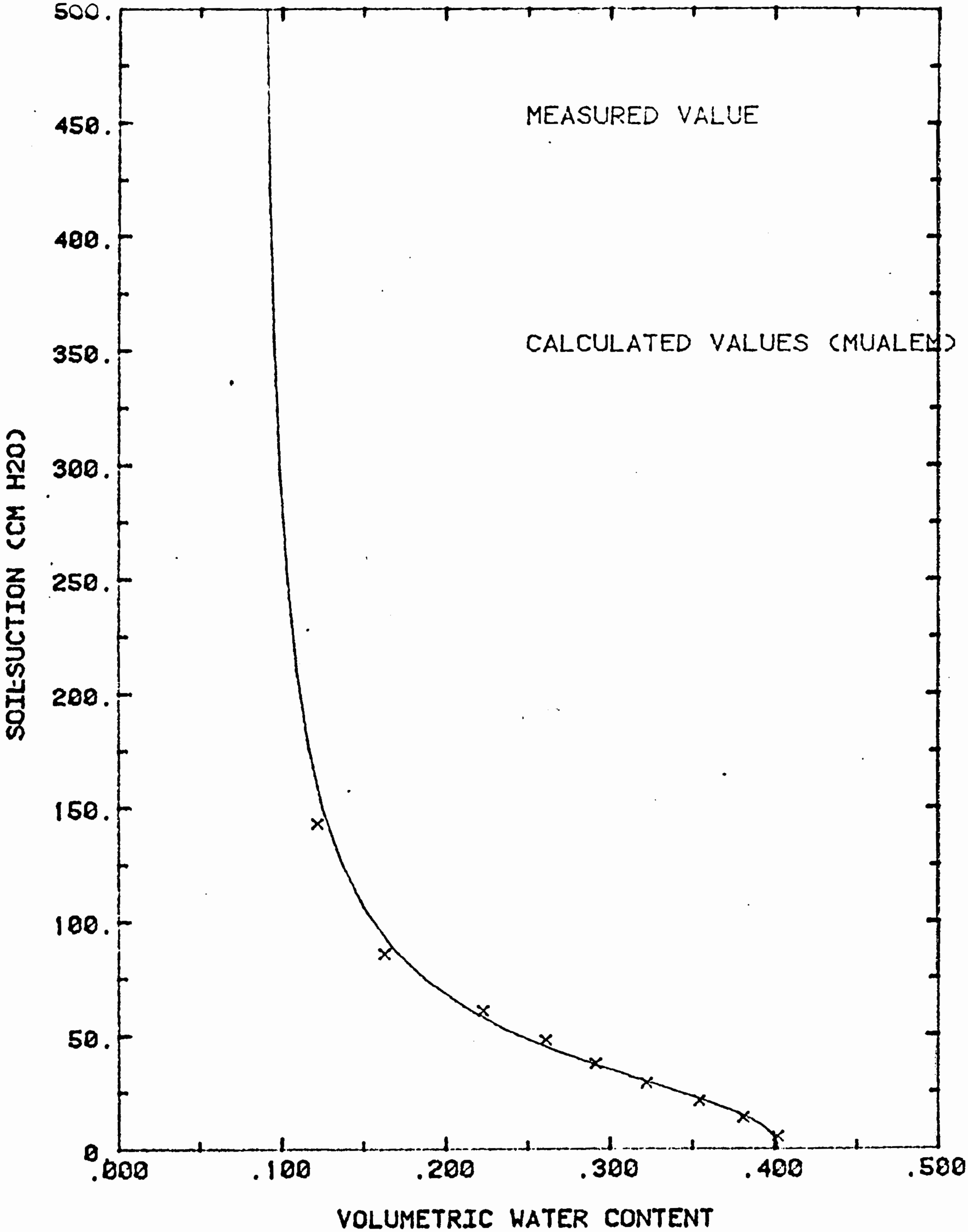


Figure 4-2B PS-4 25'

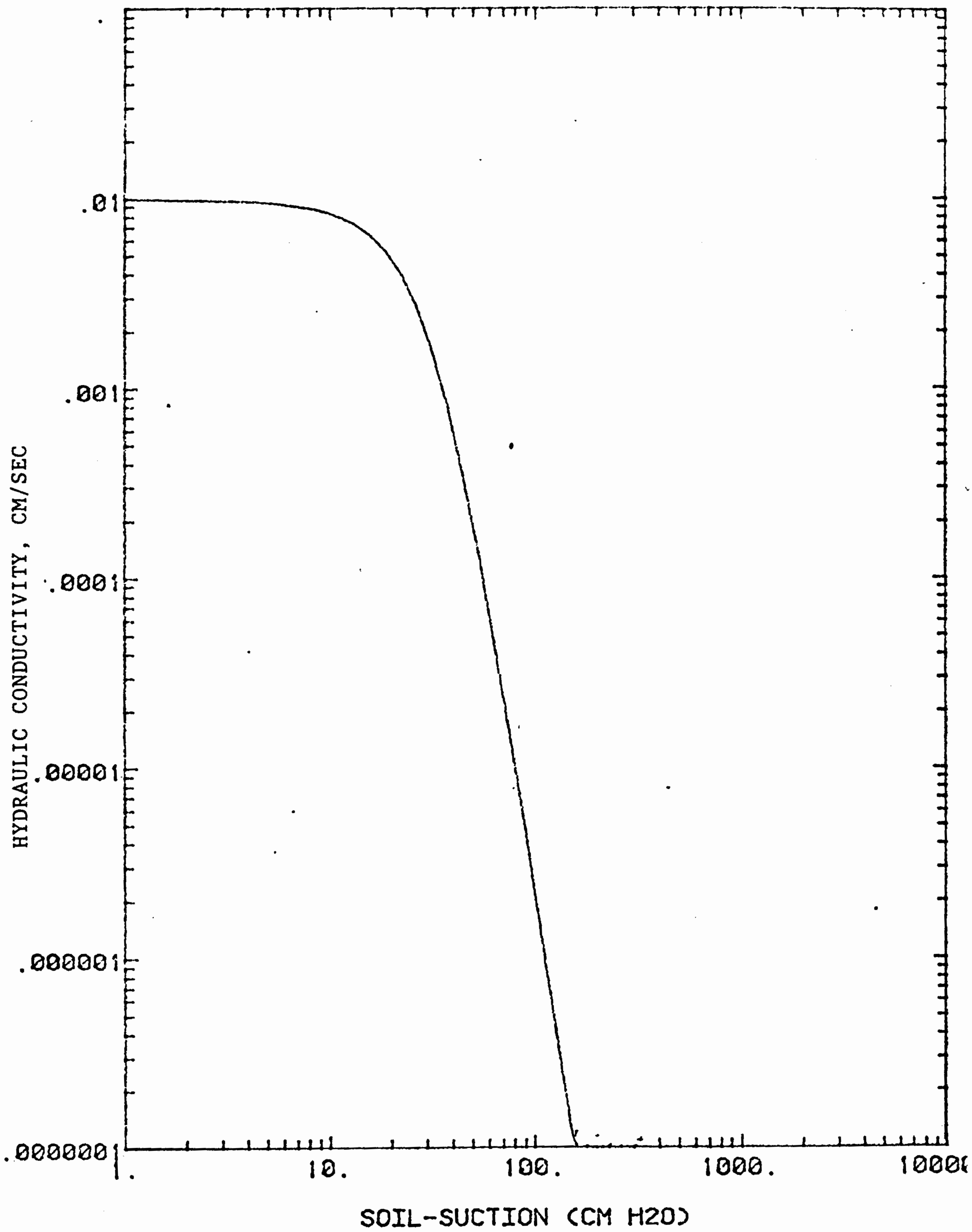


Figure 4-3A PS-4 40'

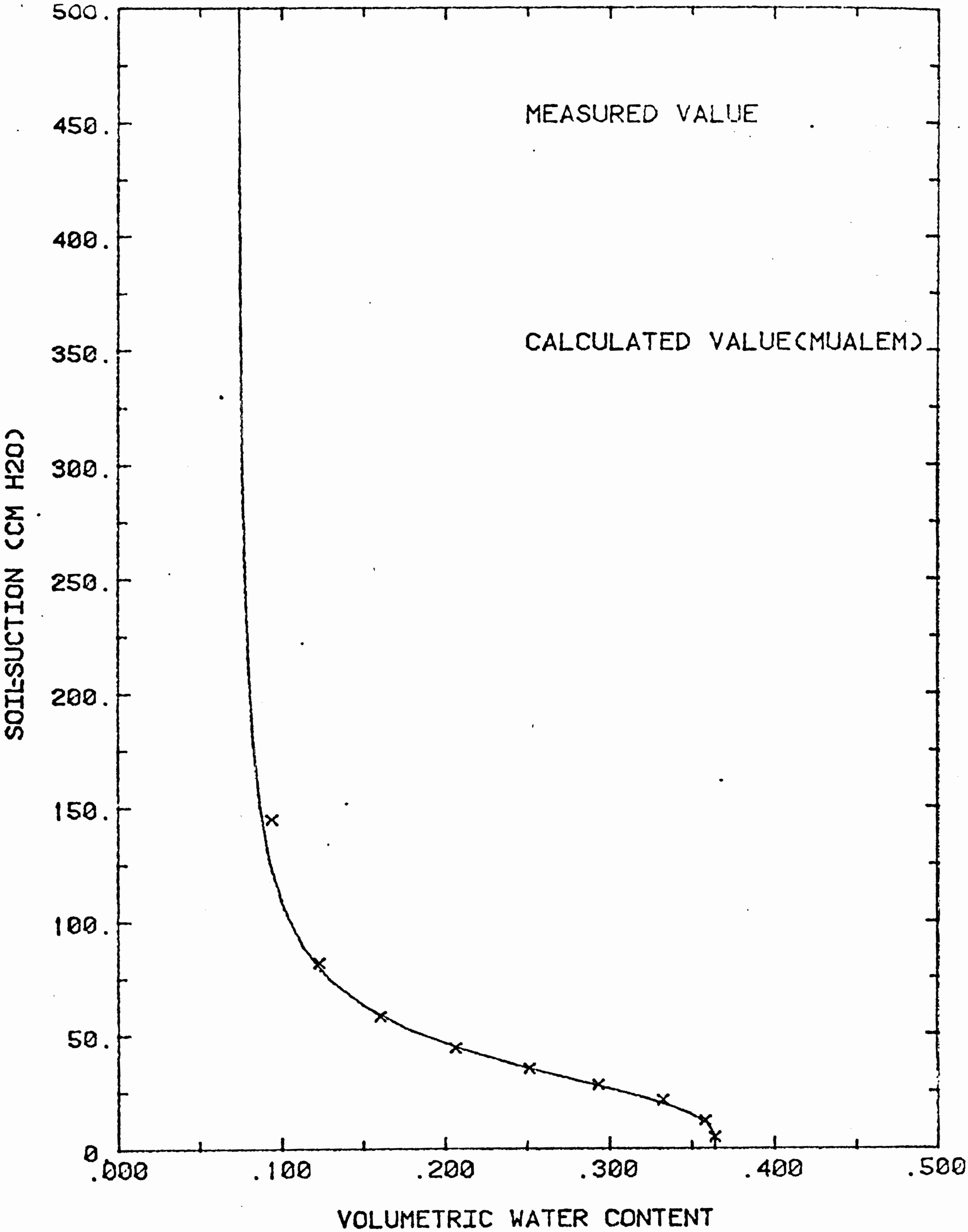


Figure 4-3B PS-4 40'

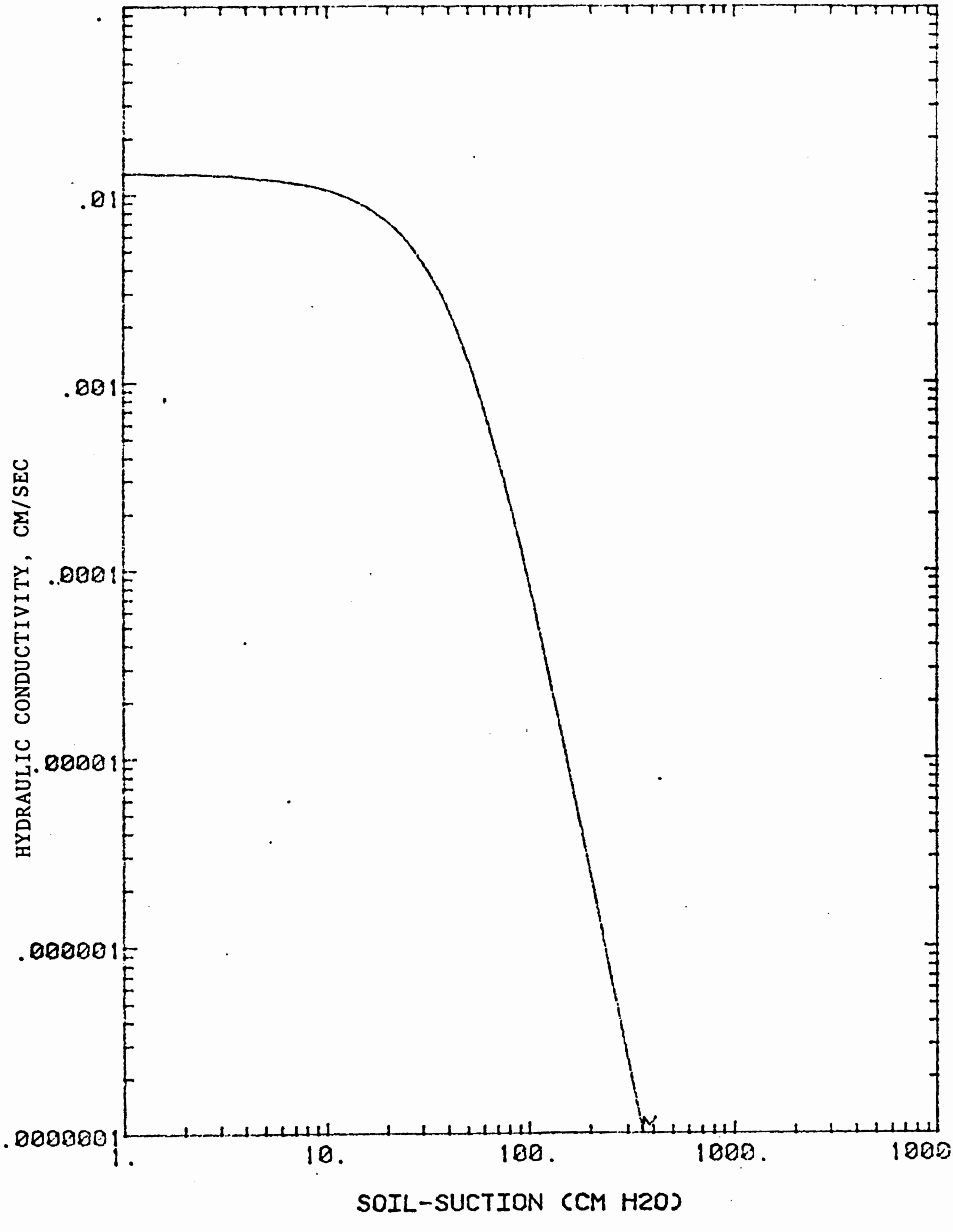


Figure 4-4A PS-4 70'

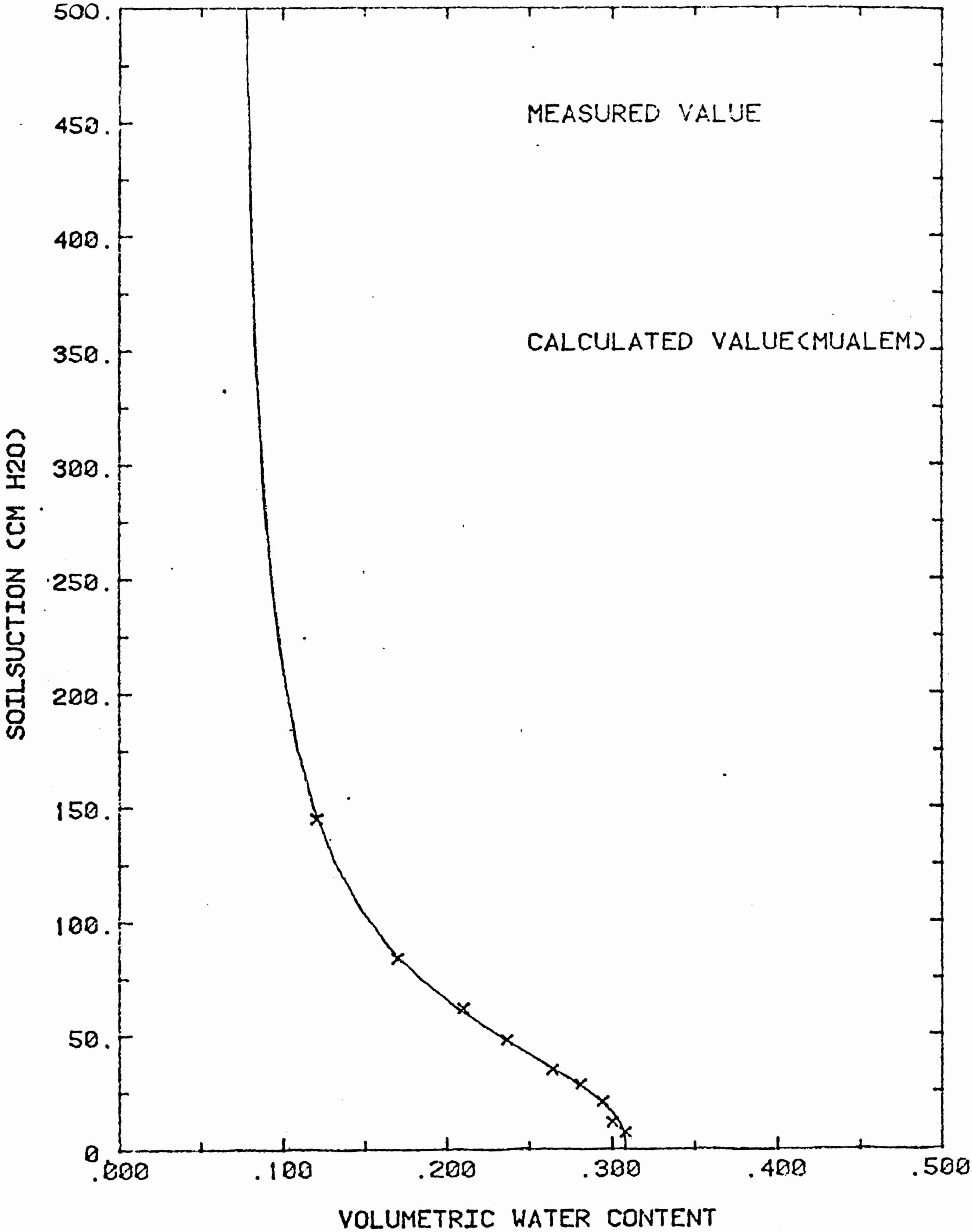


Figure 4-4B PS-4 70'

by wetting samples slowly with a constant head apparatus manufactured by Eikelkamp Equipment for Soil Research. Samples were wetted slowly from below to reduce entrapped air content. Saturated hydraulic conductivities (Ksat) determined with the above described method for three samples from PS-4 averaged .008 cm/sec.

4.6 MOVEMENT OF CONTAMINANT (PCE)

Movement of PCE in the unsaturated zone can take place through two principal mechanisms:

--Unsaturated Fluid Flow
--Molecular Diffusion/Vapor Phase Transport

4.6.1 Unsaturated Fluid Flow

The low Ku values obtained through the lab analysis of samples indicate that most of the contamination present in the soil beneath the waste tank at Person Generating Station can not presently be moving at any measurable rate through the unsaturated zone. Some redistribution of moisture in the profile may occur as zones that have greater than an average volumetric moisture content (8.33) drain at rates that may approach 10^{-7} cm/sec.

4.6.2 Molecular Diffusion/Vapor Transport

The low concentration observed indicate that the movement of PCE in the soil also occurs by a combination of vapor phase movement and molecular diffusion. This mechanism is much slower than unsaturated fluid flow and is not capable of creating very elevated concentrations. This is evidenced by the low concentrations in PS-1 and PS-2 and below the 60' interval in the other core holes.

5.0 SELECTION OF A BACKGROUND BOREHOLE

The results of the Phase 2 drilling currently underway will enable the selection of a suitable background site that will be sufficiently close to the tank so as to be representative and yet outside influence of the PCE in the vapor phase. It is impossible to locate such a background hole at present due to the non-symmetry of PCE distribution observed in the Phase 1 sampling. The increased accuracy in determining the shape and extent of PCE in the soil will allow the selection of a background bore hole site.

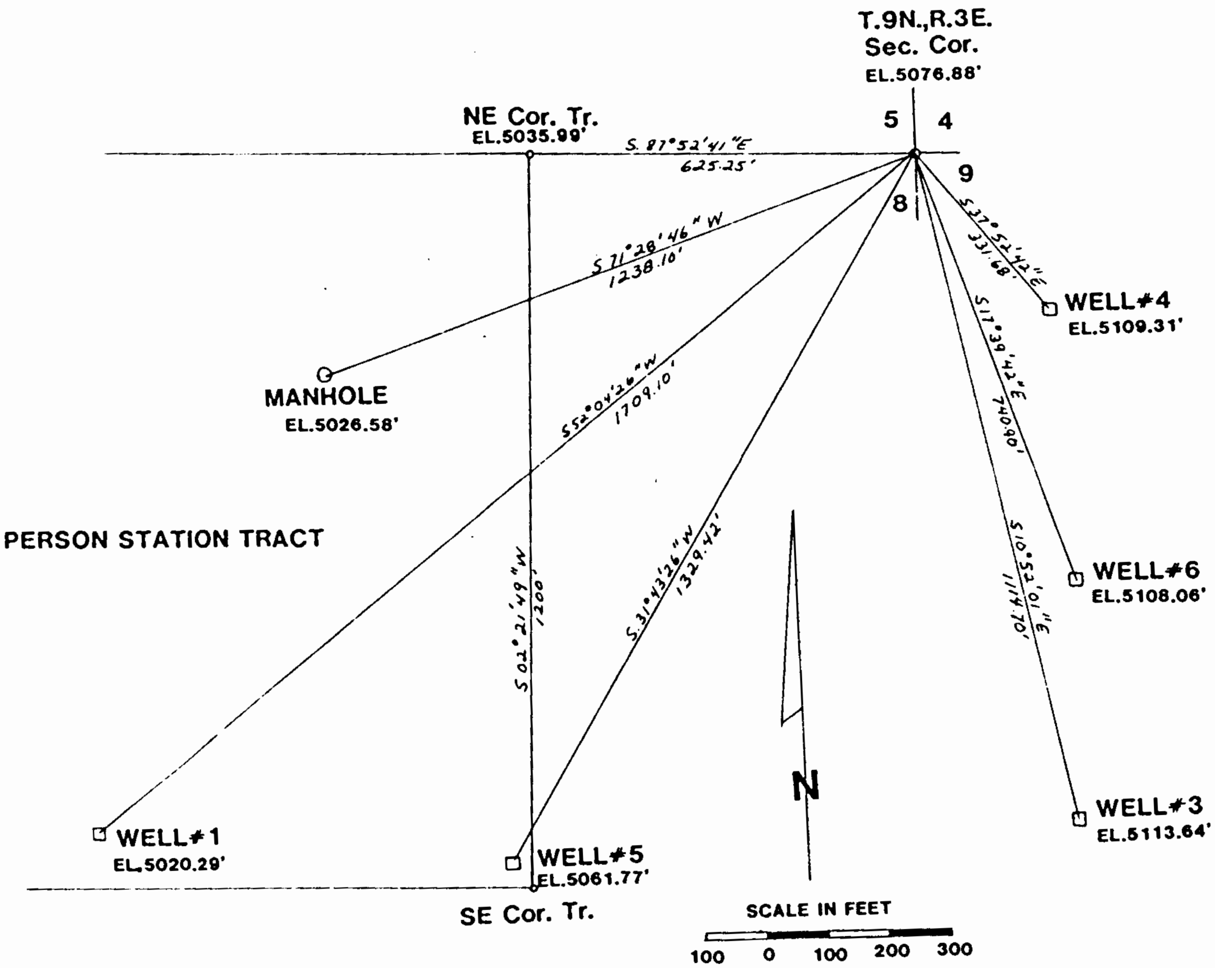
6.0 GROUNDWATER SAMPLING AND LOCATION OF A GROUNDWATER MONITORING WELL

The standard techniques used thus far for soil sampling and described in Section 2.0 are not suitable for obtaining a representative grab sample of groundwater due to the high probability of contamination of the sample from contact with the inside and outside of the hollow stem auger. The proper procedure for sampling the groundwater in this situation (where maximum possible concentrations expected are near the detection limit) would be to establish the local groundwater gradient in the area and to properly install and develop a groundwater monitoring well downgradient from the plume.

In an attempt to establish the hydraulic gradient at the site, water levels were taken from some deep wells (Figure 6-1) that exist at Person Generating Station. Water level measurements from these wells indicate that the gradients, although small, are not as expected in the area. This is due to the fact that these wells have been used as production wells and some still continue to be pumped on a daily basis. Therefore, static water levels are difficult to establish. The appropriate method for establishing the gradient in the vicinity of the tank would be to drill exploratory wells outside the plume and perform a 3 point problem. In order to accomplish this, the results from the Phase 2 drilling must be analyzed to

PERSON STATION SURVEY

NOVEMBER 15, 1983



STATIC WATER LEVELS

ELEVATION

		WELL#1	WELL#5	WELL#6
DATE	11/9/83	4908.37'	4911.37'	4904.9'
	12/6/83	4906.29'	4910.57'	4905.76'

FIGURE 6-1

determine the limits of the contaminated soil. Once the gradient is determined, a representative downgradient monitoring well location could be selected.