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MARTIN MARIETTA

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ENVIRONMENTAL SCIENCES DIVISION
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BY.
MARIETTA ENERGY SYSTEMS, INC.
UNITED STATES
ENT OF ENERGY

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EXECUTIVE SUMMARY

An investigation of the extent and fate of spills and leaks of elemental mercury at the Oak Ridge Y-12 Plant has been carried out. Most of the mercury was released during the period 1953 to 1963, with much smaller releases continuing over the past 20 years. It is estimated that 428,000 lb were lost to earth materials in the area (UCC-ND 1983). In order to evaluate the fate of the metal in the subsurface, a multiphased well installation and soil boring program was carried out. A phased approach was utilized to minimize the total number of borings and to concentrate on potential problem areas while still assessing the problem as a whole.

Phase I of the program involved the installation of monitoring wells, soil borings, and the drilling of rock cores. All sampling operations were performed in the same boreholes to minimize drilling and to maximize the data for a single location. The rock cores were logged and used to evaluate the hydrogeology of the plant site. The soil borings were taken with a sampling device that allowed essentially undisturbed samples to be collected, described, and then analyzed for total mercury content. After earth materials were sampled, monitoring wells of polyvinyl chloride (PVC) and stainless steel construction were installed in the boreholes. Wells were emplaced in nests so that the three-dimensional aspects of groundwater flow could be analyzed and samples from discrete horizons could be collected. The well locations were chosen such that probable migration paths of both mercury and groundwater were likely to be intersected. To do this, an evaluation of the preconstruction hydrology of the site was carried out, and the hydraulic properties of the aquifer were assessed. This predrilling assessment minimized the total number of borings and allowed their placement to be optimized.

Phase II of the program involved the drilling of a series of soil borings at four locations in the plant. The drilling locations were based on the data collected during Phase I of the study and known spill locations. The final part of the program, Phase III, involved the

installation of several additional monitoring wells at key locations downflow of potentially contaminated areas. The overall program resulted in the installation of a 43-well monitoring network, the analysis of 430 soil/mud samples and 113 groundwater samples for mercury content. In addition, 59 analyses for uranium in groundwater were made, and 132 anion and cation analyses were run.

The results of the investigation cover three important areas: (1) the hydrogeology of the Y-12 Plant, which is underlain by the Conasauga Group; (2) the fate of mercury losses at the plant; and (3) an evaluation of the general groundwater chemistry and contamination. The hydrogeology of the plant is dominated by the original East Fork Poplar Creek drainage channel and the extensive solution cavity system that surrounds the creek within the Maynardville Limestone. Although the original hydrologic system at the plant has been altered due to construction and recontouring of the topography, the original drainage still plays an important role in the subsurface movement of water. The three-dimensional flow system within the plant has been assessed, and a permanent network has been installed for continued monitoring of water levels and for the collection of water samples. In general, groundwater flow is from northwest to southeast, with Upper East Fork Poplar Creek (UEFPC) being the local discharge area. Adjacent to UEFPC, groundwater flow appears to be predominantly southwest to northeast (along strike).

Mercury analyses of soils and fill indicate that high concentrations (up to 1% by weight) of mercury occur in the shallow soil and fill at several sites within the plant, but the estimated total quantity located (~7000lbs) represents only about 2% of the amount estimated to have been lost to the ground. Additional quantities of mercury may exist in the extensive cavity system underlying much of the plant. Detection of metallic mercury in these solution zones was believed at the outset of the study to be unlikely, and none was encountered in this study. Results of mercury analyses of groundwater indicate that mercury does not appear to be moving in significant quantities in an aqueous phase: the highest soluble concentrations found (~1 µg/L) were limited to three wells. The occurrence of elevated mercury levels mainly in shallow (≤10ft) soils and fill, and of mainly background levels in groundwater, indicate that the metal has been generally immobilized/retained in upper earth materials. At two sites (buildings 9201-2 and 81-10), high mercury levels and their proximity to surface water (UEFPC) justify further studies to characterize the environmental impacts. Because large-scale removal and disposal of soil is quite expensive, it is of great value to identify those areas where such action is not required.

The analyses of the groundwater samples for basic chemical constituents and contaminants yielded several important and interesting findings. Several contaminant plumes occur in the plant: sulfates from the Y-12 coal pile, nitrates from the S-3 ponds or one of the process buildings (9201-5), chlorides from several sources, and general increases of electrical conductance and alkalinity. The configuration of the various plumes support the flow system analysis based on potentiometric head measurements. Several of the chemical constituents in groundwater, in particular the Mg:Ca ratio and the silica content, were found to vary with the geologic formation in which the wells were situated. These chemical differences indicate that the water chemistry along a flow path in the subsurface is altered by the various formations of the Conasauga Group, and that the source of groundwater in an area may be qualitatively determined.

ABSTRACT

E. R. ROTHSCHILD, R. R. TURNER, S. H. STOW, M. A. BOGLE, L. K. HYDER, O. M. SEALAND, and H. J. WYRICK. 1984. Investigation of subsurface mercury at the Oak Ridge Y-12 Plant. ORNL/TM-9092. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 270 pp.

An investigation of the fate of spills and leaks of elemental mercury at the Oak Ridge Y-12 Plant has been carried out through a multiphased well installation and soil boring program. The overall program resulted in the installation of a 43-well monitoring network and the analysis of 430 soil/mud samples and 113 groundwater samples for mercury content. In addition, 59 analyses for uranium in groundwater were made, and 132 anion and cation analyses were run. The hydrogeology of the plant is dominated by the original Upper East Fork Poplar Creek drainage channel and the extensive solution cavity system that underlies the creek the Maynardville Limestone. Although the original hydrologic system at the plant has been altered due to construction and recontouring of the topography, the original drainage still plays an important role in the subsurface movement of water. Results of mercury analyses of soils and fill indicate that high concentrations (up to 1% by weight) of mercury occur in the shallow earth materials at several sites within the plant, but the estimated total quantity located (~7000 lb) represents only about 2% of the amount estimated to have been lost to the ground. Results of mercury analyses of groundwater indicate that mercury does not appear to be moving in significant quantities in an aqueous phase: the highest soluble concentrations found (~1 µg/L) were limited to three wells. The analyses of the groundwater samples for other chemical constituents revealed the presence of several contaminant plumes within the plant, including sulfates from a large coal pile, nitrates from liquid waste disposal operations, and chlorides from several sources, as well as general increases of electrical conductance and alkalinity.

1. INTRODUCTION

Following declassification on March 19, 1983, the U.S. Department of Energy released a report, prepared in 1977, containing preliminary information on mercury losses and unaccounted-for mercury at the Oak Ridge Y-12 Plant. A subsequent report (UCC-ND 1983) identified a number of locations where mercury was used and was spilled and/or lost in the 1950s and 1960s, and concluded that about 428,000 lb of the lost mercury is now contained in the earth below the spill locations. However, there were no studies to confirm this conclusion. Similarly, there are no data to permit assessment of either the possible presence of mercury in the groundwater or the hydrologic characteristics at the spill locations; nor are there detailed geologic data of the Y-12 site, specifically of the rock units underlying the spill areas. This study was undertaken to address the above issues. The initial phases of the study began in August 1983, and field investigations ended in May 1984.

2. OBJECTIVE AND APPROACH

The objective of this study was the verification and characterization of mercury contamination in the earth materials and the groundwater in the vicinity of known spill locations at the Y-12 Plant. If contamination was found the extent of the contaminated zone was to be determined as well as possible.

In order to achieve the objective of this study, the geologic, hydrologic, and topographic characteristics of the spill locations were determined. This was accomplished by field mapping, core drilling, geophysical logging, construction of monitoring wells, and use of topographic maps. To determine the presence and extent of mercury contamination, samples of groundwater and earth materials were collected and analyzed chemically.

This report documents the technical data collected to date on the extent and fate of mercury contamination at the Y-12 Plant and presents observations, conclusions, and recommendations.

3. INVESTIGATION RATIONALE AND PROGRESS TO DATE

3.1 MERCURY ACCUMULATIONS

Mercury in the metallic form has been released during the period 1953 to 1963 in and around several buildings at the Y-12 Plant, including 9204-4, 9202, 9201-5, 9201-4, 9201-2, 81-10, the old deflasking area near 9103, and the old mercury storage area near Guard Portal 33.

The most probable locations of mercury accumulation, if they exist, are in permeable zones in the fill and bedrock and along contacts between rock and fill. Permeable zones include open fractures and solution features in the bedrock and open voids in fill material. Contacts between more permeable zones and less permeable zones are possible areas of mercury "pooling." These include the contacts between fill and native material, between weathered and unweathered rock, and possibly along the contact between the Nolichucky and Maynardville Formations. Mercury may also tend to pool in preconstruction topographic lows.

The drilling program has focused around likely accumulation areas, attempting to intersect as many features as possible. Undisturbed soil and rock samples were obtained to determine mercury content.

3.2 GROUNDWATER MONITORING

Just as mercury may accumulate in permeable zones and along contacts between various materials, these are also areas where groundwater movement is greatest. Groundwater flow is generally from higher elevations to lower (toward East Fork Poplar Creek), but flow also occurs along strike due to solution features and fracturing.

Groundwater around the spill/leakage locations has been monitored for chemical constituents and water levels. Monitoring wells are located downslope and along strike from mercury-use areas. Wells are also located in preconstruction topographic lows. Monitoring wells are clustered in groups or "nests." Each nest consists of several wells with different completion depths at one location. This vertical resolution allows an estimate of the vertical extent of mercury contamination and aids in the interpretation of the three-dimensional groundwater flow regime.

3.3 DRILLING PATTERN AND TECHNIQUES

The drilling program, which was designed in three phases, enabled data to be collected with increasing detail and a narrowing of scope with each subsequent phase.

Throughout this document, wells and borings are identified by a sequence of paired numbers (e.g., 60-1). The first number of the pair (60) refers to the general location of the site. This number is based on the Oak Ridge Reservation (ORR) grid system used in the plant. For example, the wells near building 9201-2 having easting coordinates of between E60,000 and E61,000 (longitudinal grid lines) were therefore designated 60-1 wells. The "1" simple refers to the first site in the "60" area. Within the plant, locations range from 53 to 60. The letter designations for wells refer to their relative depths, "A" being the shallowest and "C" the deepest.

3.3.1 Phase I

The first phase of drilling was the completion of monitoring well nests close to mercury use or spill areas (Fig. 1). Drilling has permitted the acquisition of three types of information: (1) an estimate of the extent of the contamination problem, (2) data on the site geology, (3) and data on the groundwater flow system. This phase included 11 well nests, each nest containing two or three drill holes. The shallowest hole was screened near the water table. The second well was finished at the bedrock-fill interface, if extant. If the water table

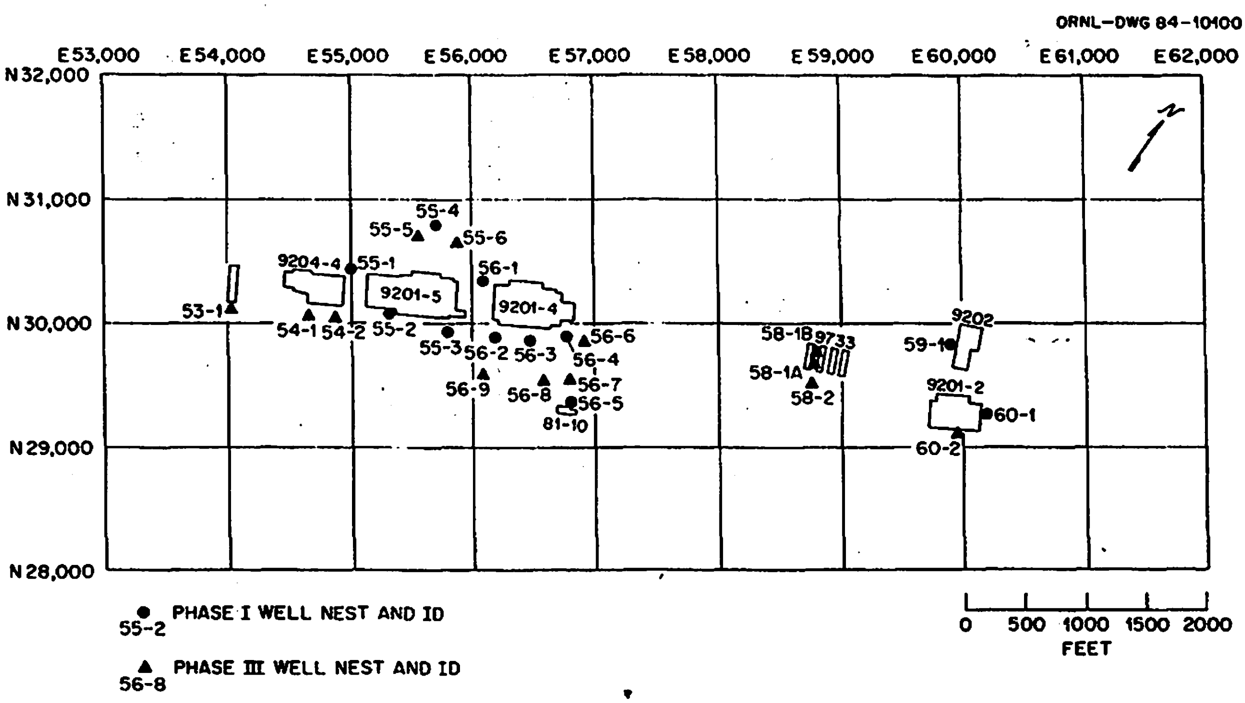

Fig. 1. Location of monitoring wells installed and sampled during the investigation of subsurface mercury at the Y-12 Plant.

at a particular location was at this interface, the second hole was extended deeper (10 to 20 ft). The deepest hole was drilled to a depth of approximately 75 ft.

During drilling, holes were continuously sampled, using either a modified Denison sampler (Acker 1974) or Shelby tubes until these methods could progress no further. In the deepest hole of eight of the nests, NX-size core was taken, using a diamond bit, when solid rock was encountered. The drilling fluid used during rock coring was clean water (from fire hydrants in the plant). In the two shallow holes after coring, a 6-in. air hammer was used to deepen and/or to ream the holes prior to well installation. These drilling procedures allowed samples to be retrieved and tested with minimum disturbance. A portable mercury vapor analyzer was used in a limited manner during Phase I drilling to determine at the site whether mercury-bearing earth materials had been encountered (see Sect. 6.5)

This first phase of drilling was very important in setting the scope of work to follow. The rock cores and samples, in conjunction with the logs, have helped in evaluation of the geology of the site, and in correlation of the strata with other areas that have been more fully studied. The purpose of the geophysical logs is twofold. First, because of the electrical properties of mercury, it was hoped that electrical logs would be useful in identifying mercury-filled fractures, cavities, and zones. Second, the logs have allowed correlation between various holes and characterization of the geologic media.

3.3.2 Phase II

The second phase of drilling involved 55 soil borings. These holes were drilled immediately adjacent to, or in, spill areas; some holes were drilled farther away from spill sites, downflow and along strike, to determine the lateral extent of mercury movement. Drilling was concentrated around buildings 9201-2, 81-10, 9733-1, and the old mercury storage area. These sites are representative of various spill/use locations and also appear to be the most contaminated areas based on preliminary data. In the fill and weathered bedrock, a modified Denison sampler or Shelby tubes were used to retrieve undisturbed samples for mercury analysis. These holes were backfilled with a mixture of cuttings and bentonite to deter the vertical migration of possible contaminants.

3.3.3 Phase III

Phase III involved the drilling of wells situated in strategic locations along projected flow paths from the spill/use areas. Locations were selected on the basis of data from Phases I and II, but in general they were located outside immediate zones of contamination. These wells were drilled and sampled by the same methods used in Phases I and II.

4. SITE GEOLOGY

4.1 PROGRAM DESCRIPTION

The goals of the geologic investigation are to describe the local lithology and structural geology of the site, to describe the weathering characteristics of the rock underlying the Y-12 Plant, and to evaluate the local geology with regard to the regional and reservation geology.

Geologic data were obtained from three sources. Prior to any field work in the Y-12 Plant area, previous studies and reports were evaluated, the majority of which were engineering and foundation studies. Most of the data in these reports concerned very shallow depths. In order to evaluate the site geology in conjunction with hydrologic studies, eight 75-ft-long core holes were drilled. To supplement subsurface data, measurements and descriptions from surface outcrops were made. Outcrops within the Y-12 Plant are very rare; therefore, rock exposures in construction pits and trenches were studied. Following are detailed discussions of the geologic data acquired from these sources.

4.2 SITE DESCRIPTION AND PREVIOUS WORK

The Y-12 Plant lies within the Valley and Ridge physiographic province, which is characterized by a succession of southwest-trending ridges and valleys. The topography of the site is a function of the underlying geologic structure and the differential erosion of underlying rock formations.

The Y-12 Plant is located within Bear Creek Valley, which is bounded by Pine Ridge to the north and Chestnut Ridge to the south. The valley is underlain by rocks of the Cambrian-aged Conasauga Group (Maynardville, Nolichucky, Maryville, Rogersville, Rutledge, and Pumpkin Valley Formations, listed in descending order). Pine Ridge is held up by the sandy shales and sandstones of the Rome Formation, and Chestnut Ridge is underlain by dolomite of the Knox Group. The valley lies within the White Oak Mountain thrust block, and the geologic strike of strata in the area is approximately N 55° E with a dip of approximately 45° SE.

The general geology of Bear Creek Valley has been described in various documents and will not be covered in this report. West of the Y-12 Plant, a major geologic investigation was undertaken in conjunction with the development of the Exxon Nuclear Fuel Recovery and Recycling Center (NFRRC) (Law Engineering 1976). Core holes were drilled across the valley, and geologic sections were described; these holes will be referred to later in this report. Other studies in the area of the Y-12 Plant have been much smaller in scale.

Most of the drilling and geologic work performed around the Y-12 Plant has been in conjunction with engineering and foundation studies. These reports, which date from the mid-1940s to the present, vary greatly in quality and scope. Approximately 75 reports were available for evaluation. In total, about 500 holes have been drilled in and around the Y-12 Plant. In general, the holes are shallow "soil borings" of 10- to 20-ft depth. Many data are given on engineering characteristics (Atterberg limits, shear strength, etc.), but there are very few data on hydraulic properties, and useful geologic descriptions are not included in any of the reports.

Several generalizations about the site can be gleaned from the engineering reports. First, the site topography has been greatly altered; hills were flattened and valleys filled. As an example of this, Fig. 2 shows buildings 9201-4 and 9201-5 and the original site topography. Second, the fill material in original topographic lows is highly variable. Soil, rock, concrete, wood, and steel have all been found in borings of fill material. In addition, the compactness of the fill varies greatly; the fill may be tightly compacted or have a large number of voids. Third, the depth to rock is very shallow in most areas. Finally, the depth to groundwater is shallow in most areas, and

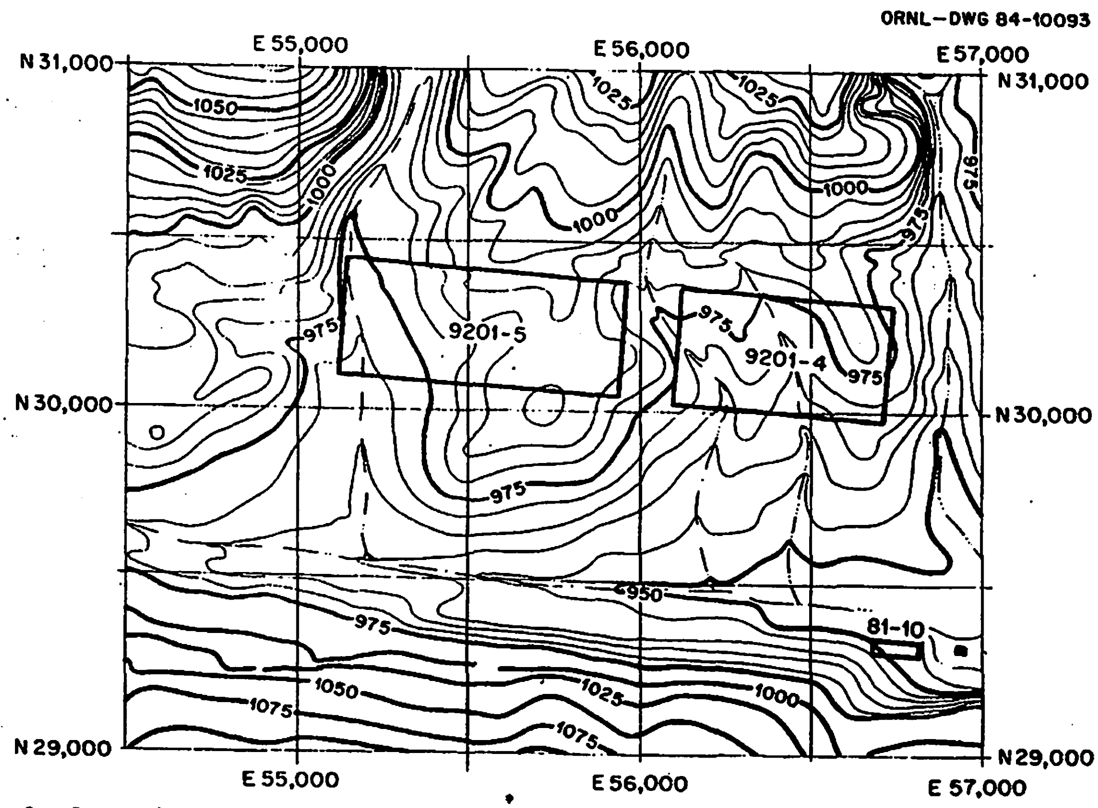

Fig. 2. Preconstruction topography of Y-12 Plant area with current locations of buildings 9201-5, 9201-4, and 81-10.

in many places the fill material is saturated. Of all the reports, three (U.S. Army Corps of Engineers 1954a,b; Geotek 1979) were particularly valuable, and these will be discussed later in this report where germane.

4.3 SUBSURFACE DRILLING AND GEOPHYSICAL LOGGING

After selection of 11 sites for well nests, two types of drilling/sampling were initiated. The first method allowed for retrieval of undisturbed samples of the unconsolidated materials and weathered shale. This was done by Shelby tube sampling, which was selected over split spoon sampling, which generally causes disturbance of the sample, resulting in agitation and a possible loss of entrapped mercury. The Shelby tube sampling was done in two ways. The first 2 ft of material were sampled by driving the 2.5-in. Shelby tube into the ground and retrieving the filled tube. The remainder of the sampling was carried out by a continuous Shelby tube technique (modified Denison sampler); the tubes were driven by advancing a 6-in hollow-stem auger fitted with a special bit that allowed the tube to remain about 3-in. in front of the bit. As the auger rotated, the tube remained stationary because of a bearing system within the first auger flight. After a 2-ft advancement, the tube was retrieved by a wireline and a new tube was inserted. This method was continued until "refusal" by the auger or crushing of the tube. This continuous Shelby tube technique provides undisturbed samples because the tube is advanced in front of the auger. The method is also very good for sampling in harder material, such as weathered shale, because minimal external tube surface is exposed; thus, there is minimal friction with the side wall. The tubes were later cut lengthwise with a circular saw for study and sampling. It was clear after inspection that the samples were essentially undisturbed and that in areas or zones where visible mercury was present, the mercury was retained.

After the relatively soft upper materials were sampled, the second drilling method, rock coring, was used. Eight sites were chosen for taking continuous rock core to a depth of 75 ft (Fig. 3). The sites were chosen to yield core from all representative geologic formations. Prior to coring, a 4.5-in. surface casing was set in competent rock. Coring then proceeded using an NX-size diamond bit (approximately 2 in.). The only drilling fluid utilized was water from fire hydrants on site. The water was recirculated after passing through a settling basin to remove cuttings. Water samples were periodically collected and analyzed for mercury content (Appendix C). The cores were logged in the field, then placed in core boxes, which are stored in a refrigerated environment. The lithologic logs are included in Appendix A.

Geophysical logs were run on seven holes (Appendix A). Because of problems with side wall collapse, not all core holes were logged, and some uncored holes were logged. Equipment problems dictated which logs were run on a each hole, but, in general, the logs run were caliper, natural gamma, density (gamma-gamma), resistivity, neutron, and sonic. In some cases, a microresistivity log was also run.

4.4 INVESTIGATION OF SURFACE OUTCROPS

During the investigation, several construction projects were under way south of building 9201-4. The pipeline and foundation excavations exposed fill, soil, and weathered rock, allowing geologic data to be collected. The data collected are incorporated in a geologic map (Fig. 4) and will be discussed in the following section.

4.5 DISCUSSION OF RESULTS

Two maps were produced from data collected during this study. The first is a very general map for the Y-12 Plant (Fig. 3) which shows the approximate location of formational contacts. For more accurate formational contacts, longer cores need to be taken from the site. The second map (Fig. 4) shows more detailed data from the area behind building 9201-4.

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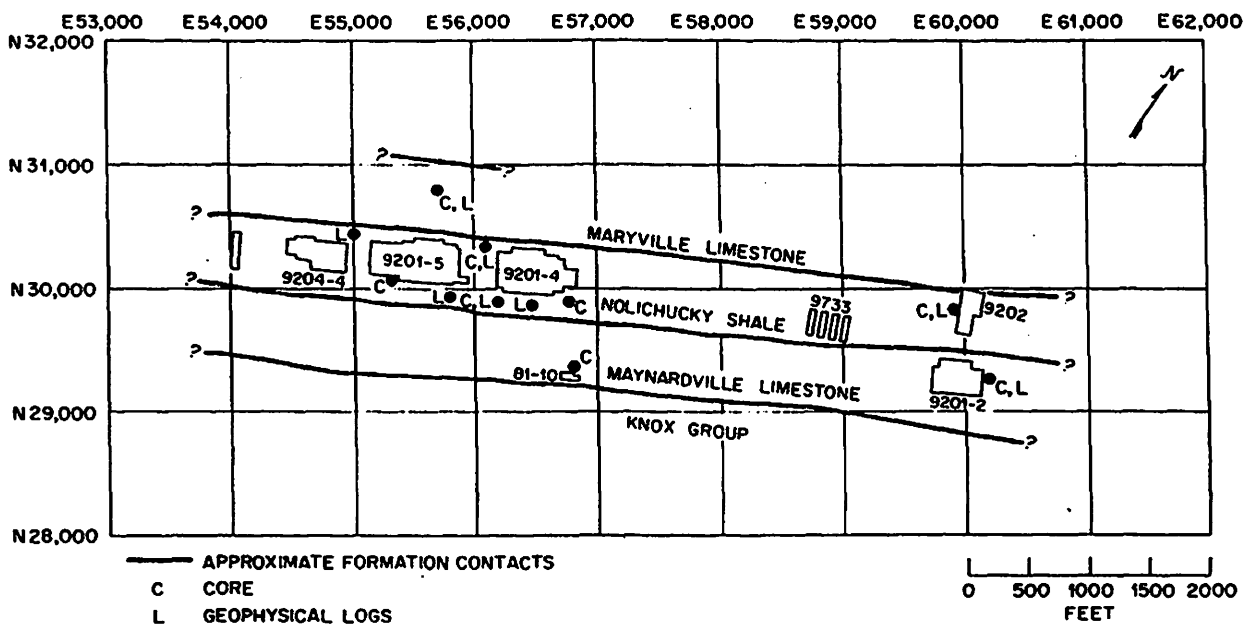

Fig. 3. Generalized geologic map of the Y-12 Plant.

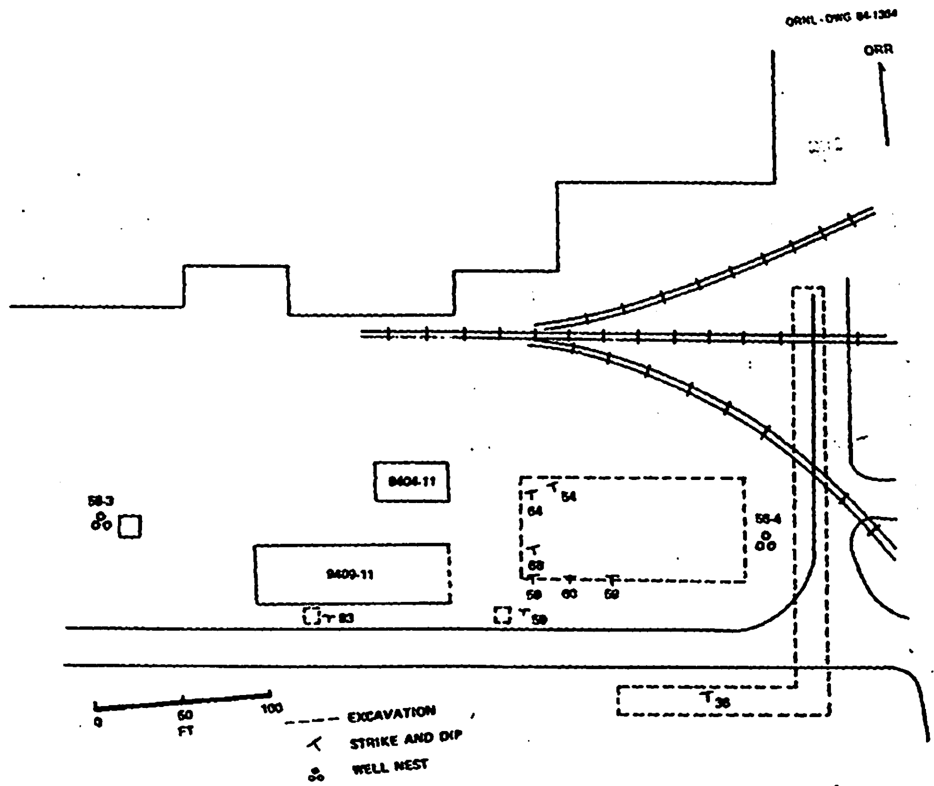

Fig. 4. Structural geology of area south of building 9201-4. Measurements made in construction excavations.

The areas studied within the Y-12 Plant appear to be underlain by three formations (Fig. 3). The southeastern part of the plant is underlain by the Maynardville Limestone. Buildings 81-10 (site 56-5) and 9201-2 (site 60-1) are built on the Maynardville Limestone.

Stratigraphically beneath the Maynardville Limestone is the Nolichucky Shale. The drill sites surrounding buildings 9204-4, 9201-4, 9201-5, and 9733-1, as well as the site at building 9202, penetrate the Nolichucky Shale. The drilling at building 9103 (site 55-4) penetrated the Maryville Limestone, which lies stratigraphically below the Nolichucky Shale. During the drilling program, none of the lower three formations of the Conasauga Group was encountered (they crop out to the northwest of building 9103) nor were rocks of the Knox Group (outcrops of Knox Group are seen southeast of Third Street) encountered.

In the following sections, the results of the geologic investigation are discussed.

4.5.1 Unconsolidated Materials

Fill, soil, and weathered shale (saprolite) samples were obtained by Shelby tube sampling (see earlier section discussing sampling techniques), augering, and hand sampling of outcrops. The greatest amount of descriptive information was obtained from the Shelby tube samples, and the following represents the study of these samples.

Thirty-four sites where Shelby tubes were collected have been examined, described (Appendix B), and sampled. Total depth ranges from 3.5 to 34 ft (Table 1). The general stratigraphic sequence observed in the cores is fill material at the top underlain by bedded shale. The shale is highly weathered at the top; in most cases, a relict soil horizon can be noted at the top of the shale, below the fill. A thin soil zone also occurs on top of the fill occasionally. Following are general descriptions of the fill material, and relict soil and shale horizons. Detailed descriptions of cores are included in Appendix B.

Table 1. Summary of boring data on total depth and approximate depth to native materials (alluvium, soil, or weathered shale) (details are given in logs for individual borings)

Borehole	Total depth (ft)	Depth to native earth materials (ft)
53-1/B1	6.0	>6.0
53-1/B5	6.0	3.0
53-1/B18	6.0	4.0
55-1B	11.0	1.5
55-2A	15.0	9.5
55-2C	14.5	12.0
55-3C	10.0	7.0
55-4A	20.5	7.0
56-1	0.0	~1.0
56-2C	10.0	6.0
56-3C	8.5	4.5
56-4C	14.5	5.5
56-5C	17.0	>17.0
56-5/B2	32.0	23.0
56-5/B3	34.0	32.0
56-5/B4	19.5	>19.5
56-5/B5	31.0	26.0
56-5/B6	30.25	25.0
56-5/B7	26.0	19.0
56-5/B8	13.0	>13.0
56-5/B9	17.0	>17.0
58-1/M	14.0	8.0
58-1/N	20.7	3.5
58-1/O	5.6	4.5
58-1/Q	9.8	8.2
59-1/C	22.0	3.5
60-1A	18.0	8.0
60-1/B1	15.0	14.0
60-1/B2	16.0	9.0
60-1/B3	20.0	17.5
60-1/B4	13.0	11.0
60-1/B5	13.0	7.5
60-1/B6	17.0	>17.0
60-1/B7	14.0	8.0
60-1/B8	9.0	6.0

The thickness of fill material ranges up to at least 34 ft (location 56-5/B3, where Shelby tube refusal was encountered at the 34 ft depth). The fill material is highly variable in composition and texture. Color ranges from gray to red brown to yellow brown and dark brown. Generally, it contains angular gravel-sized clasts of dolomite and weathered shale up to 2 in. across mixed with clay. In some cores, pieces of asphalt, wood, roots, and wire are found in the fill. The percentage of dolomite and shale clasts varies greatly and ranges up to approximately 90% in thin (less than 4 in.) zones. The shale clasts are often stained by manganese oxide and exhibit bedding structure. In some cores, the upper part of the fill is composed dominantly of dolomite clasts, and is highly porous and very unconsolidated. Compactness and consolidation of the fill increase with depth. At locations not overlain by asphalt, the upper part of the fill is characterized by a thin zone (less than 4 in.) of organic-rich soil and grass. A previous description of fill material at the Y-12 Plant (U.S. Army Corps of Engineers 1954b) indicated that the fill contains considerable voids and that drilling fluids are lost in the voids. Laboratory tests showed the fill to have a high water content and relatively low density.

Below the fill material, shale, relic soil, or alluvium occur. For purposes of discussion, the in-place soil or alluvium are considered to be the materials lying between the fill material and shale in which bedding can be recognized. The soil zone varies in color from browns to grays, but most generally is yellowish brown; occasionally mottled greenish zones are seen. The soil zone is typically a homogeneous, structureless, well-compacted clay; rarely sandy horizons occur. The bottom of the soil is marked by a fairly sharp transition (a few inches) to strata in which bedding can be recognized.

The shale underlying the soil is highly chemically weathered at the top, where it is easily disaggregated. This very weathered rock, which is often called saprolite, retains the structural features of the unweathered bedrock. Colors are highly variable and reflect types and degrees of weathering; various hues of yellowish brown are most common, but grayish orange, brownish black, and blue gray also occur locally. With depth the shale becomes harder, friable, less porous, and the most common color is pale brown. Throughout the shale, bedding planes dip at 45 to 80°. In most cores there are joints perpendicular to bedding. The joints are at least 2 in. in length and may be longer, but their termination on the sides of the core precludes determination of their actual extent. The bedding and joint surfaces are commonly marked by a dark reddish-brown and yellow-brown oxide coloration, indicative of a high degree of weathering from movement of groundwater. This is most common in the upper parts of the shale where weathering has been most effective.

Additional samples of unconsolidated material (fill, soil, weathered shale) were taken from excavation trenches. One large trench, southeast of building 9201-4, was sampled at 24 locations to assess the possibility of mercury contamination at this site; these data are discussed later in this report. During the sampling of this trench, a clear distinction could be made between the fill and the underlying soil/shale, and the location of a prefill stream channel was noted.

4.5.2 Maynardville Limestone

The Maynardville Limestone is the uppermost formation of the Conasauga Group. It occurs throughout East Tennessee and is divisible into two regionally consistent members: an uppermost Chances Branch Member and an underlying Low Hollow Member (Hasson and Haase 1984).

Based on data from the Exxon NFRRC site west of the Y-12 Plant (Law Engineering 1975), the thickness of the Maynardville Limestone in Bear Creek Valley (White Oak Mountain thrust block) is estimated to be 360 ± 40 ft. Based on data from the Copper Creek thrust block (Haase et al. 1984), the Chances Branch Member is estimated to be approximately 160 ft thick and the Low Hollow Member to be 200 ft thick near the Y-12 Plant. Coring data from Copper Ridge (Haase et al, 1984) show that the Chances Branch Member consists of medium- to thin-bedded buff and light-gray dolostones, ribbon-bedded dolostones/limestones, and thin-bedded medium-gray limestones. The Low Hollow Member is principally wavy to even thin-bedded (oö)microsparite, with alternating horizons of dolomite-bearing, ribbon-bedded microsparite and calcarenite. The Low Hollow Member and the lower portion of the Chances Branch Member are oölitic.

The lower contact of the Maynardville Limestone with the Nolichucky Shale is gradational over approximately a 15-ft interval. The Maynardville Limestone is overlain by the Copper Ridge Dolomite (Knox Group), and the contact is marked principally by a sharp decrease in dolomite content and a change in stratification patterns (Haase et al. 1984).

As can be seen in Fig. 3, cores taken from sites 56-5 (81-10) and 60-1 (9201-2) penetrate the Maynardville Limestone. The lithologic logs from both sites indicate a significant amount of solution activity, with 2- to 3-ft-thick cavities present. From the drilling and logging, it is difficult to say if the cavities are water- or clay-filled. Based on water loss during drilling, it appears that at least some of the cavities are water-filled.

After coring, the borehole at site 56-5 collapsed; therefore, no geophysical logs are available for this site. The geophysical logs from site 60-1 show well the cavities present at that site (Appendix A). The cavities appear as peaks at depths of 25, 32, 43, and 45 ft. The increases shown by the natural gamma log may indicate that the cavities are partially filled with clay or with very fluid mud. The logs from site 60-1 show how valuable logging may be in locating permeable zones.

The dip of strata in both boreholes ranges from 40 to 50°. This is an apparent dip (relative to the side of the core), not a true dip. Based on a dip of 45°, approximately 53 ft of section is actually seen in each core hole.

At both sites, cores of the entire section showed signs of groundwater movement. This is inferred primarily from the presence of iron oxide within fractures or voids.

Two reports by the Army Corps of Engineers (1954 a,b) discuss extensive drilling performed as part of a foundation analysis for the Y-12 Steam Plant (building 9401-3). A geologic cross section contained in both reports is reproduced in Fig. 5. We interpret the section to be in the lower Maynardville Limestone; the bedding dip is approximately 45° SE with a perpendicular joint set. During drilling, significant losses of drill mud occurred due to poorly or uncompacted fill. Solution cavities are numerous. Most are less than 1 ft thick, but cavities up to 8 ft in thickness were encountered. The cavities appear to follow the strike and dip of bedding (i.e., along bedding planes) and were filled with a soft, yellow, plastic clay that provided no resistance to drilling. Sound rock occurs at about 25 ft (based on limited solution activity and with regard to rock strength for a foundation).

Drilling west of the Y-12 Plant indicated significant solution activity within the Maynardville Limestone (Bechtel 1984a); and in drilling beneath the Y-12 coal pile, an 11-ft-thick solution cavity was encountered (Rothschild et al., in prep.).

4.5.3 Nolichucky Shale

The Nolichucky Shale lies stratigraphically beneath the Maynardville Limestone. Throughout East Tennessee, the Nolichucky Shale can be divided into three members: the Upper Shale, the Bradley Creek, and the Lower Shale Members (Hasson and Haase 1984). Based on data from the Exxon NFRRC site (Law Engineering 1975), the Nolichucky Shale in Bear Creek Valley is approximately 375 ± 40 ft thick.

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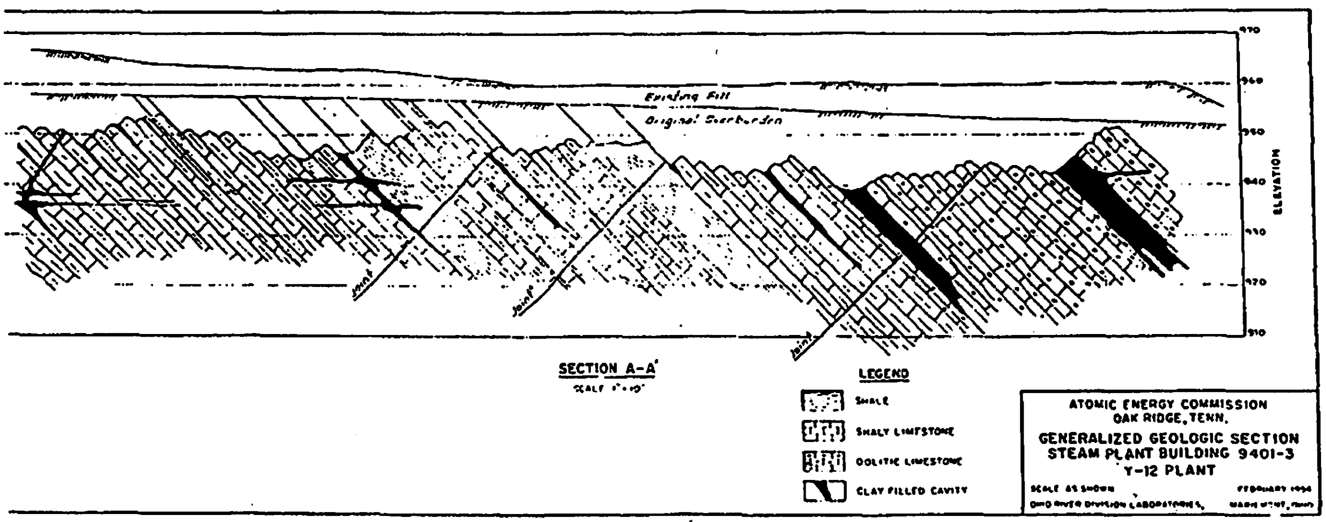

Fig. 5. Geologic cross section through part of the Maynardville Formation. Source: U.S. Army Corps of Engineers (1954b).

The Upper Shale Member consists of complexly interbedded calcareous shale/mudstone and limestone lithologies. The Bradley Creek Member consists predominantly of lenticularly to irregularly stratified bio(oö)micrite and biosparite. The Lower Shale Member consists of repeated cycles of shale and limestone. Most carbonates in the lower member are oölitic, and many beds contain intraclasts. The lower contact of the Nolichucky Shale with the underlying Maryville Limestone is gradational over about 50 ft, with an increase in carbonate content with depth. Descriptions are based on Haase et al. (1984).

The majority of core holes drilled on site penetrated the Nolichucky Shale. This formation underlies most of the areas of known mercury usage (buildings 9204-4, 9201-5, 9201-4, 9733-1, and 9202). The cores taken at sites 55-2, 56-1, 56-2, 56-4, and 59-1 represent the Nolichucky Shale.

Except for the core hole from site 55-2, none of the holes indicated the presence of significant solution activity. In drilling at site 55-2, several large cavities and a thick zone of highly weathered rock, loose fill, or alluvium (see original topography in Fig. 2) were encountered. All of the cores showed signs of water movement (iron precipitate, open fractures, or solution cavities) to a depth of 50 ft or greater, with the exception of site 56-1 where fresh bedrock was encountered at a depth of approximately 8 ft.

In addition to geophysical logs on some of the core holes, logs were also run on holes at sites 55-1, 55-3, and 56-3. The logs show very clearly the alternating shale and limestone beds. The logs from 55-1, 55-3, 56-2, and 59-1 show a number of spikes, which may be fracture zones. The log taken from borehole 56-3 is short in length because of the side wall collapse. The zone causing the wall failure can be seen on the log at a depth of approximately 38 ft.

The apparent dip of bedding in the cores of the Nolichucky Shale averages approximately 55° and ranges from 45 to 60°. Using an average dip of 55°, about 43 ft of section occur in each core, and a surface outcrop width of about 460 ft can be calculated using a formation thickness of 375 ft.

4.5.4 Maryville Limestone

Underlying the Nolichucky Shale is the Maryville Limestone. The core from Copper Ridge shows that the upper part of the Maryville Limestone is characterized by the abundant occurrence of 1- to 5-ft intervals of distinctive flat pebble conglomerate. The lower part of the Maryville Limestone is composed of 0.5- to 1-ft beds of calcareous mudstone, interstratified with biosparites, intraoöbiosparites, calcarenites, and calcareous siltstones. The lowermost 50 ft of the Maryville Limestone is characterized by an increase in calcareous mudstone content prior to grading into the massive mudstones of the underlying Rogersville Shale.

The data from west of the Y-12 Plant (Law Engineering 1975) indicate a thickness of 375 ± 40 ft for the Maryville Formation. The only site of interest to the mercury investigation that is underlain by this formation is site 55-4, near the old deflasking site (where mercury was unloaded from trucks prior to distribution within the plant).

Based on the logs and on projected surface outcrops, it is difficult to tell if the core from site 55-4 is actually in the lower Maryville Limestone, the upper Rogersville Shale, or both. In any case, the rock is quite solid with no major fracture zones or solution activity. Weathered rock appears to be limited to about the upper 30 ft at the site. The average bedding dip seen in the core is about 50° and ranges from 45 to 75°.

4.5.5 Structural Geology of the Site

Structurally, the Conasauga Group can be quite complex. As described earlier, the average strike and dip of bedding in the Y-12 Plant area is approximately N 55° E, 45° SE. The data shown in Fig. 4 indicate that in a small area, the strike ranges from N 35° E to N 65° E, and the dip varies from 54 to 83° SE. Small scale-folding greatly influences bedding and joints in the area.

The U.S. Army Corps of Engineers (1954a) report that in the Y-12 Plant area at least two joint sets have been identified; one set has a strike of N 55° E and a dip of 45° NW, and a second set has a strike of N 35° W and dip of 35° NE. The spacing of joints varies from a few inches to as much as 20 ft. In addition to these two major sets of joints, the report cites evidence of the presence of sheet-jointing parallel to the surface of the valley. Additional work near the Y-12 Plant and in Melton Valley on joint orientations and spacing is described in Sledz and Huff (1981). Work conducted in Melton Valley (Sledz and Huff 1981; Davis et al. 1983; Rothschild et al. 1984) indicates that joint orientation is extremely variable and is especially dependent upon small scale geologic structures. Spacing between joints is quite variable, from fractions of inches to several feet and is partially controlled by lithology and thickness. Because of the regional thrusting, small-scale folds with axes parallel to geologic strike are also common. Movement has occurred along bedding planes in the Conasauga Group, as indicated by polishing and striations.

The outcrops exposed by construction behind building 9201-4 allowed observations to be made of the structural geology. A structural geologic map of this site is shown in Fig. 4. In the foundation excavation (large pit), two major joint sets were observed. The first has a strike of approximately N 33° W with a dip of 89° SW. The second set strikes approximately N 46° W and dips 57° NE. The spacing of joints is on the order of 0.5 to 3 in. A minor, high-angle joint set was also observed; it has a strike and dip of approximately N 10° W, 84° SW, respectively. In the pipeline trench south of Second Street, two joint sets were also noted. The dominant joint set has a strike of N 50° W with a dip of 72° SW. The second joint set has a strike of approximately N 74° W and a dip of 46° NE.

The orientation and number of joints is extremely important because they in part control the movement of groundwater. Although data on joint sets are important, data are limited to the few available outcrops.

5. HYDROLOGY

5.1 SURFACE WATER FLOW AND THE IMPACT OF PLANT CONSTRUCTION

The preconstruction surface water drainage for the Y-12 Plant area is shown in Fig. 6. In general, streams drained from a series of hills in the northern part of the Y-12 Plant area to Upper East Fork Poplar Creek. The surface water divide between UEFPC and Bear Creek lies along the western edge of the Y-12 Plant. Based on experience in other areas underlain by the Conasauga Group, depth to groundwater in the Y-12 Plant area probably ranged from about 30 ft beneath the hills to essentially zero near streams. In general, the water table was probably a subdued image of the surface topography.

After construction of the Y-12 facilities, all north-south surface drainages were eliminated. In part, these have been replaced by subsurface drains in the Y-12 Plant area. UEFPC was also altered; the headwaters are now an underground drainageway (storm sewer system), and the channel has been significantly straightened in the Y-12 Plant area.

Altering the natural hydrologic system by changing the topography and rerouting the stream has very likely caused significant changes in the groundwater flow system. The water table in the Y-12 Plant area probably still mimics the present topography so that in many areas the lower portion of the fill material is now saturated. The existence of buried stream channels also alters groundwater flow; they are likely to act as conduits for groundwater movement. For example, the channel that existed west of building 9201-5 is probably still active (Figs. 2 and 6). The current elevation around 9201-4 is between 960 and 965 ft above MSL. Around building 9201-5 elevation ranges between 975 and 980 ft above MSL. It is apparent from Fig. 2 that hills were leveled around building 9201-4, and stream channels were filled near building 9201-5. Further evidence of the importance of old drainageways to water movement is presented in Section 7, "Groundwater Chemistry."

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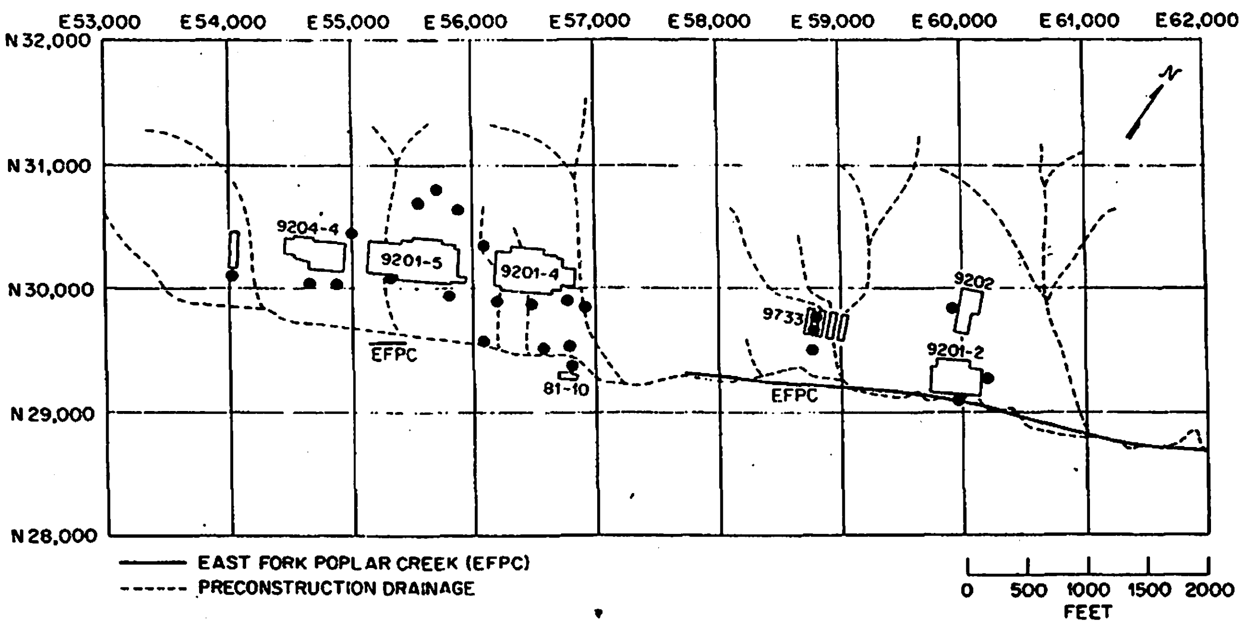

Fig. 6. Surface water drainage before and after construction of the Y-12 Plant.

Preliminary data for Bear Creek near the Bear Creek Valley Burial Grounds indicate that there is an intimate connection between the creek and the extensive solution cavity system surrounding the creek. The solution cavity system is pervasive in the Maynardville Limestone all along UEFPC and, in conjunction with UEFPC, acts as a drain for surface and groundwater to leave the valley. This conduit still appears to be active in the Y-12 Plant area even though the old creekbed has been significantly altered and storm sewers replace stream channels.

5.2 GROUNDWATER HYDROLOGY

5.2.1 Completion of Monitoring Wells

In total, 43 wells were completed in 24 locations (Fig. 1). After drilling was complete, with either an auger or air-hammer, the hole was cleaned to remove cuttings by further augering or compressed air. Most boreholes were stable and remained open without collapsing. In several areas, a temporary surface casing was required to keep the hole open. Table 2 lists the wells, their depths, ground elevation, measuring point elevation, and notes on well completion.

All wells were completed with a 5-ft section of 4-in. 0.01-in. slot stainless steel spiral-wound well screen with end cap (with the exception of three wells as noted in Table 2). A 10-ft section of 4-in. polyvinyl chloride (PVC) casing was threaded into the screen. Above the threaded casing, 20-ft sections of PVC casing with bell couplings were utilized. The bottom 6 ft of the annulus was backfilled with clean pea gravel/sand. Two feet of clean sand was placed above the pea gravel to prevent fines from washing into the gravel pack. A 3-ft bentonite seal was placed above the gravel and sand to isolate the screened portion of the well. Clean cuttings were used to backfill the holes to within several feet of the ground surface, and then a cement seal was poured. In areas of known soil contamination, the backfill used was a mixture of one-third bentonite and two-thirds fine sand. A diagram of a typical well is shown in Fig. 7.

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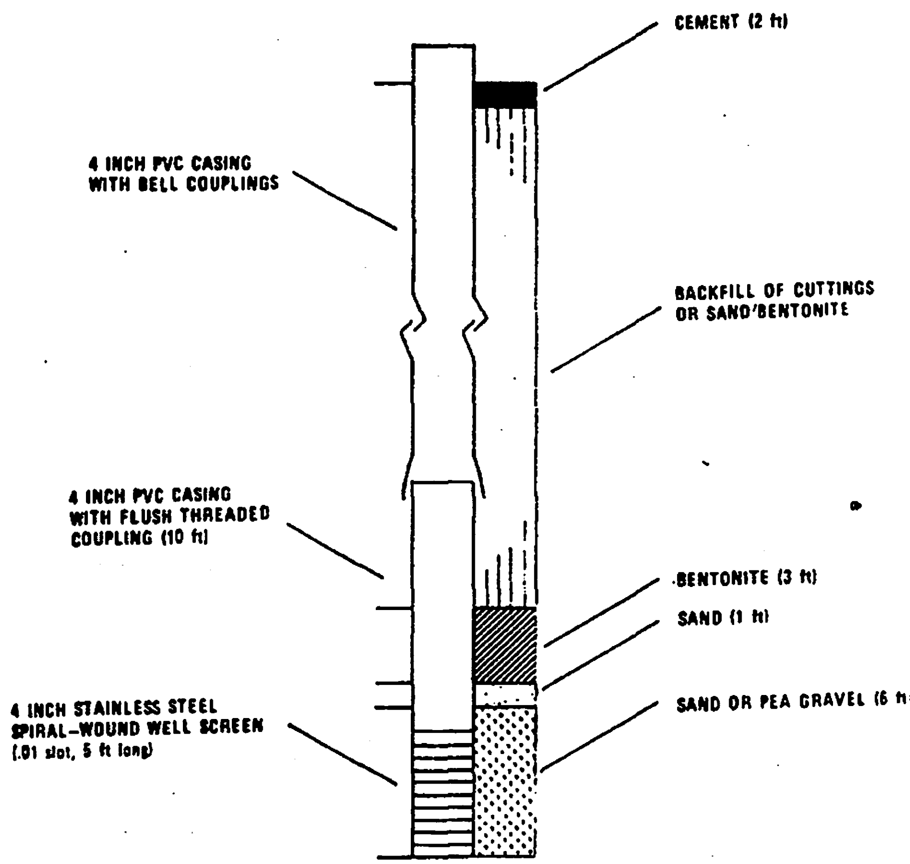

Fig. 7. Typical monitoring well completion.

Table 2. Y-12 monitoring well completion data

Well nest	Well ID	North coordinate	East coordinate	Total casing length (ft)	Elevation of measuring point (ft-MSL)	Elevation of ground surface (ft-MSL)	Note on zone of completion
53-1	A	30,176.21	53,814.62	22.05	993.65	990.67	
54 1	A	30,010.02	54,702.89	23.03	983.87	981.71	
54-2	A	30,009.19	54,855.11	26.31	983.77	981.07	
55-1	A	30,469.88	55,014.07	19.29	986.67	986.20	
55-1	B	30,469.23	55,009.99	38.78	986.26	986.05	
55-1	C	30,466.74	55,013.13	75.72	986.73	985.85	
55-2	A	30,085.32	55,194.96	14.11	976.74	976.17	Highly weathered rock
55-2	B	30,084.88	55,199.17	27.59	977.25	976.17	Highly weathered rock
55-2	C	30,085.70	55 202.96	75.89	976.85	976.07	
55-3	A	29,959.34	55,695.12	14.34	972.46	971.59	
55-3	B	29,958.73	55,698.77	38.09	973.32	971.57	
55-3	C	29,958.59	55,702.65	71.53	974.34	971.76	
55-4	B	30,762.67	55,694.55	25.49	1004.68	1003.92	
55-4	C	30,762.77	55,698.10	72.64	1004.86	1003.95	
55-5	A	30,697.60	55,556.53	10.86	988.58	986.67	
55-6	A	30,667.34	55,906.66	12.89	989.04	986.82	
56-1	A	30,350.69	56,079.34	19.03	969.25	968.72	
56-1	C	30,355.03	56,077.03	75.30	969.49	968.89	
56-2	A	29,880.85	56,228.12	15.12	963.30	962.52	
56-2	B	29,883.61	56,225.60	38.81	962.28	962.21	
56-2	C	29,884.63	56,230.51	71.30	964.94	962.44	
56-3	A	29,866.66	56,452.76	17.78	963.03	962.35	Possible solution cavity
56-3	B	29,867.20	56,447.67	33.43	963.40	962.36	Possible solution cavity
56-3	C	29,859.16	56,449.10	55.48	962.86	962.36	
56-4	A	29,819.59	56,802.01	12.14	962.07	960.10	Weathered rock
56-4	B	29,815.13	56,799.28	32.58	961.38	960.56	

Table 2. (continued)

Well nest	Well ID	North coordinate	East coordinate	Total casing length (ft)	Elevation of measuring point (ft-MSL)	Elevation of ground surface (ft-MSL)	Note on zone of completion
56-4	C	29,815.06	56,804.51	76.28	962.62	959.05	
56-5	A	29,380.21	56,823.85	12.60	966.69	965.90	Fill
56-5	B	29,382.47	56,827.82	35.10	966.72	965.87	Solution cavity
56-5	C	29,375.47	56,818.57	71.59	967.30	966.34	
56-6	A	29,783.24	56,915.30	21.03	960.28	958.12	
56-7	A	29,449.16	56,814.30	21.10	958.45	956.62	
56-8	A	29,465.51	56,545.71	25.56	962.46	959.15	
56-9	A	29,532.83	56,043.39	17.29	965.86	963.81	
58-1	A	29,647.52	58,777.80	11.15	947.84	947.20	Installed in 58-1/BN
58-1	B			22.64			Installed in 58-1/BO
58-2	A	29,500.33	58,772.32	9.94	938.16	936.23	
59-1	A	29,830.55	59,884.79	13.22	945.75	945.26	
59-1	B	29,835.10	59,885.47	36.94	945.69	945.07	
59-1	C	29,834.00	59,881.56	73.92	945.87	945.12	
60-1	A	29,225.67	60,199.87	23.20	929.66	929.29	Wells are shallow due to problems with well collapse
60-1	B	29,225.44	60,203.55	29.23	929.80	929.16	
60-2	A	29,097.06	60,118.58	13.52	929.69	927.77	

[a]All wells are completed with 5 ft stainless steel screen with the following exceptions: well 53-1A is an all stainless steel, 2-in. diam well, with a 5 ft screen; and wells 56-7 and 56-8 have 5-ft, 0.01 in. slot PVC screens.

To help ensure the low permeability of the backfilled cuttings, laboratory permeability tests were run on two samples of the uncompacted cuttings. Permeability values were found to be 1.02×10^{-4} and 3.43×10^{-5} cm/s. Thus, the permeability of the compacted backfill is expected to be as low as or lower than that of the surrounding aquifer materials (Table 3).

The completion method used allows a 5-ft zone to be isolated for hydraulic measurements or water quality samples. The wells are suitable for sampling of either organic or inorganic contaminants. No glue was used in the bottom 15 ft of the well, but samples were be taken directly from the screened portion. Sampling from the screened portion helps to ensure that fresh formation water has been sampled and that the water has come in contact only with stainless steel.

After completion, all wells were surveyed in. The appropriate elevations and locations are given in Table 2.

5.2.2 Groundwater Flow System

In the Conasauga Group, groundwater flow is largely controlled by fractures, folds, solution features, and the orientation of bedding. Groundwater flow, as well as surface water flow, is predominantly south, to UEFPC or its old channel. Although the hydraulic gradient is toward UEFPC, significant water flow is likely to occur along strike (east-west on the ORR grid) due to anisotropic permeability and the pervasive along-strike solution cavity system.

Water levels and water samples were gathered from 43 wells (Appendix C), comprising 11 well nests and 13 single well sites. The location and identification of well locations can be seen in Fig. 1. Based on data from shallow (water table) wells, a map of the potentiometric surface was drawn (Fig. 8). The map is based on data from April 4, 1983, and approximates the highest water levels recorded during this study. The data indicate that flow is to the southeast from the high areas of the

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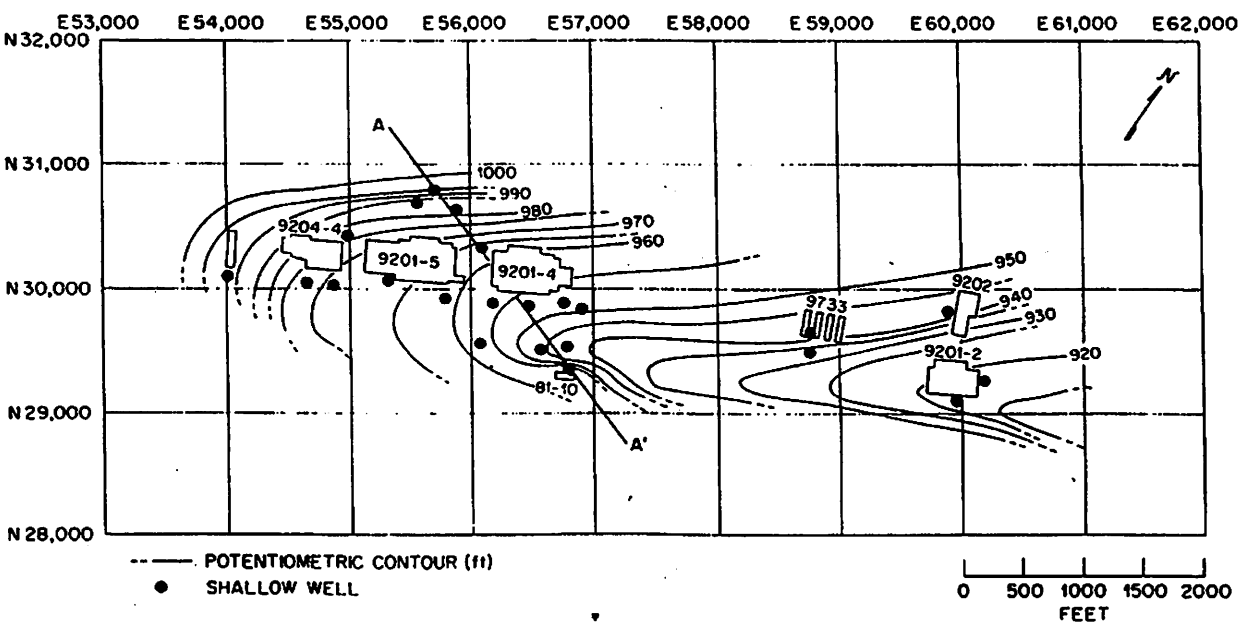

Fig. 8. Potentiometric surface at Y-12 Plant for April 4, 1984. Contours based on measurements in shallow wells only. This date approximates high-water-level conditions.

Table 3. Field-determined hydraulic conductivity (K) values for the Conasauga Group

Source	Site[a]	Average K Value[b] (cm/s)	Number of tests
Geotek 1979	West of Y-12 Plant	8.91×10^{-5}	9
Law Engineering 1983	West of Y-12 Plant	2.95×10^{-4}	7
Davis et al. 1983	ORNL-SWSA 6	6.31×10^{-5}	36
Rothschild et al. 1984	ORNL-SWSA 7	2.57×10^{-5}	12
Bechtel National, Inc. 1984a	BCVBG (weathered rock)	8.2×10^{-5}	26
Bechtel National, Inc. 1984a	BCVBG	1.3×10^{-6}	35
Bechtel National, Inc. 1984b	BCV oil landfarm	1.2×10^{-4}	12
This study	Y-12 Plant	3.54×10^{-4}	18

[a]BCVBG = Bear Creek Valley burial ground. BCV = Bear Creek Valley.

[b]Geometric mean.

Y-12 Plant, then has a considerable eastern component in the low areas (e.g., flow is off the hills and appears to discharge into UEFPC or its old channel). A very steep gradient near building 81-10 causes the "kink" in the potentiometric contours near that site. This "kink" is probably related to a bend in the original channel of UEFPC; that is, the old channel is controlling groundwater flow as much as or more than the underground storm sewer system. An alternative explanation for this phenomena is that the shallow well at 81-10 (56-4A) is completed in a perched water table, but during drilling at the site, this did not appear to be the case.

A two-dimensional cross section constructed along A-A' (Fig. 9) shows slight upward gradients in the wells north of First Street (56-1, 55-6, 55-4), indicating recharge from farther uphill discharging into the valley. The other wells in the cross section show downward gradients, indicative of groundwater discharging into the old UEFPC channel. Steep downward gradients occur near building 81-10 (56-5) due to the steep topography and the proximity to the old UEFPC channel.

It must be kept in mind that although potentiometric contours can be drawn, flow is not likely to be directly down gradient due to the apparent anisotropy of the formations. The anisotropy will very likely cause water to move preferentially along geologic strike and dip. The results of a pump test performed in the Bear Creek Valley burial grounds (Law Engineering 1983) indicated a horizontal to vertical anisotropy ratio of about 3:1. Water flow will also be controlled locally by the existence of folds, faults, fracture zones, and solution cavities.

The groundwater divide between the UEFPC and Bear Creek drainage basins probably occurs in the same area as the surface water divide, west of mercury spill/use areas. The UEFPC and its old channel are major groundwater discharge zones for the Y-12 Plant, and little flow beneath the creek is likely (i.e., underflow to the Knox Group). The magnitude of groundwater flow along strike to and from the Bear Creek watershed is unknown.

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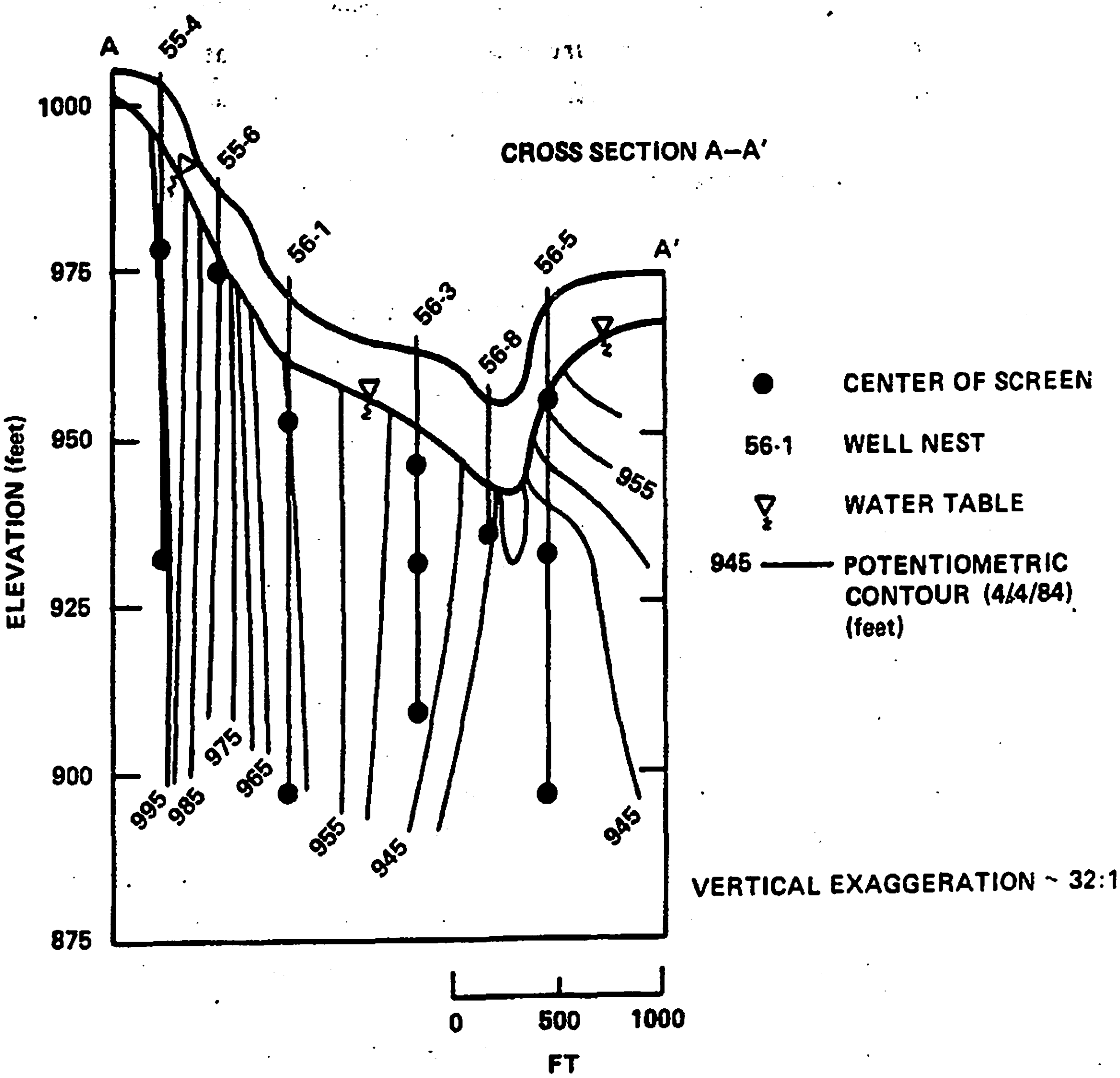

Fig. 9. Hydrologic cross section along A-A'(see Fig. 8).

Water level fluctuations have been monitored on a weekly basis from the well network. The data cover a period from November 1983 to April 1984 and are plotted as hydrographs in Appendix C. In general, fluctuations on the order of 2 to 3 ft have been observed in the wells over the observation period, primarily in response to precipitation. The shallow wells and wells completed in solution cavities show the greatest fluctuations.

The head relationship between wells in a nest is generally constant, except temporarily after storms when shallow wells or wells completed in solution cavities may respond more quickly than other wells in a nest (such as well 56-3B). Three nests clearly show downward gradients between the wells (55-1, 56-3, and 56-5), and four well nests consistently show upward gradients (55-3, 55-4, and 59-1). In well nest 60-1 very little head difference is seen between the wells, which is probably due to their proximity to the actual discharge area for the valley (they are in the cavity system adjacent to the old UEFPC channel) and to the small vertical distance between the two screened intervals. Three nests (55-2, 56-2, and 56-4) have head relationships that are not as clear. The local flow system around nest 56-4 was highly disturbed during the water level observation period. Adjacent to the nest, the drilling and pumping of an elevator shaft and excavation work took place for several months. The pumping not only complicated the head distribution, but also dried up the shallow well. The head relationships apparent in nest 55-2, 56-2, and 56-4 may be due to their proximity to old stream channels (Fig. 6). Locally, the base of these channels (fill/rock contact) may act as discharge zones due to their increased permeability.

Knowledge about the depth to water in an area is often important for evaluating contamination problems and designing remedial actions. Figure 10 displays the relationship between the water level elevation and the ground surface elevation at a given site within the Y-12 Plant area. The line of regression ($r^2 = 0.98$) is water level elevation (ft) = -7.95 + 1.00 [ground elevation (ft)].

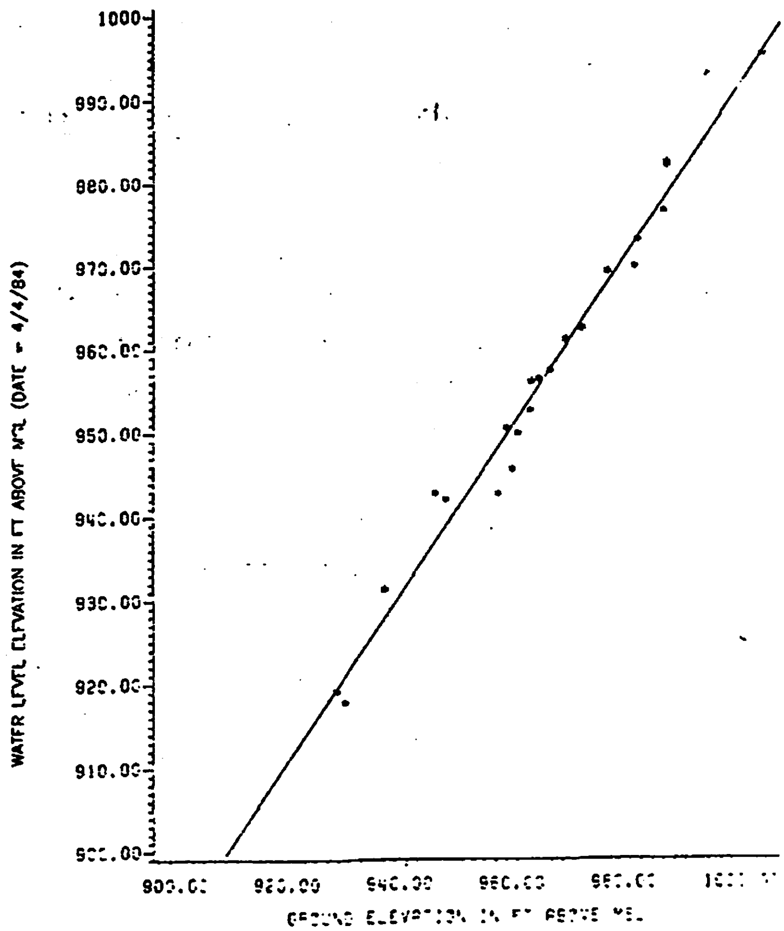

Fig. 10. Water level elevation vs ground surface elevation for April 4, 1984 (high-water-level conditions). Measurements are from shallow wells only.

Very simply, the relationship states that throughout the plant, the depth to water is about 8 ft. The slope of the line is 1.00, which is not what is expected. Generally, the depth to water is greater beneath hills and closer to the surface in valley bottoms (e.g., for one site underlain by the Conasauga Group in Melton Valley, a slope of 0.64 was determined for this relationship (Rothschild et al. 1984). This constant relationship is probably the result of two factors: first, topographic relief has been dampened by construction; and, second, the discharge area is not at the surface in the valley, but at a depth of several tens of feet (the storm sewer-UEFPC-solution cavity system). This site-specific relationship can be used to predict water levels in areas within the plant where monitoring wells are lacking.

The three-dimensional resolution of the head distribution in the valley and temporal variations is essential for estimating water and/or contaminant movement and is critical for the calibration of numerical flow models if they are to be produced.

5.2.3 Aquifer Properties

A rather extensive data base exists on the hydraulic properties of the Conasauga Group. Hydrogeologic characterizations have been performed or are ongoing in both Melton Valley and Bear Creek Valley, both of which are underlain by the Conasauga Group. To assess how the strata within the plant compare to other tested areas, 18 hydraulic conductivity (K) determinations were made (Table 4). The determinations were made by "slug" tests (Hvorslev 1951), which measure the K of materials immediately surrounding the sand packed interval of a well. The geometric mean for K in the plant is 3.54×10^{-4} cm/s. Two values of K are very high (55-3B and 56-4C) and probably overestimate K. Excessive drawdown at well 56-4C, due to adjacent pumping, might have caused an overestimate there. Also, during the installation of well 55-3B, problems were encountered with collapse and loss of water circulation; thus, this test zone may be highly disturbed. The value for well 56-5C is also very high, but this well may, at least in part, be completed in a zone with solution cavities.

Table 4. Hydraulic conductivity (K) values from slug tests in the Y-12 Plant

Well	K (cm/s)
55-1A	4.23×10^{-4}
55-1B	4.04×10^{-4}
55-1C	1.20×10^{-4}
55-2C	5.10×10^{-4}
55-3A	5.84×10^{-4}
55-3B	1.63×10^{-3}
55-3C	6.65×10^{-5}
55-4B	4.45×10^{-4}
55-4C	1.72×10^{-4}
56-1A	5.11×10^{-5}
56-1C	6.61×10^{-4}
56-2A	8.05×10^{-4}
56-2B	2.97×10^{-4}
56-2C	1.59×10^{-4}
56-3A	2.82×10^{-4}
56-3C	5.64×10^{-4}
56-4C	1.28×10^{-3} [a]
56-5C	2.48×10^{-2}
	Geometric mean = 3.54×10^{-4} cm/s

[a]Pumping going on nearby during test; therefore, reported value of K is likely to be high.

The hydraulic conductivity determinations made in the plant compare very well with those for other areas on the ORR (Table 3). With the exception of tests in the unweathered rock at the Bear Creek Valley burial grounds, all the K values are within one order of magnitude--surprisingly consistent. Local variations in K are likely to occur due to lithologic and structural heterogeneities of the aquifer, but, in general, hydraulic conductivity and other aquifer properties (e.g., porosity, transmissivity, and anisotropy) are likely to be similar. That is, based on variations in K for the Conasauga Group, it appears that other data should be transferable from one site to another, especially within valleys. Data on hydraulic properties not collected during this investigation can be gleaned from the reports referenced in Table 3. Large-scale heterogeneities between areas underlain by the Conasauga Group are important; these include large structural features (faults/fracture zones), differing hydrologic units (alluvium, fill, and weathered vs unweathered rock), and varying stratigraphy (the extensive solution cavity system apparent in the Maynardville Limestone). These large-scale variation/conditions must be assessed for each area of concern.

6. SURFACE AND SUBSURFACE SAMPLING AND ANALYSIS FOR MERCURY CONTAMINATION

6.1 WELL SAMPLING AND ANALYSIS

Prior to any well sampling, all wells were developed by removing 5 to 10 pore volumes of water from each well. One pore volume is the amount of water in the casing and sand pack under equilibrium conditions. An acid-washed (5% nitric acid), distilled water-rinsed, positive displacement pump was used for development. Well development is intended to remove any nonnative water introduced during drilling and to help produce a filter pack around the well screen (to reduce infiltration of fine sediment). Most wells yielded clear water after development.

Immediately prior to taking a water sample, 5 pore volumes of water were removed from the well. This evacuation of water helped ensure that freshwater from the aquifer was sampled. In most cases, water levels in the well dropped quickly or the well dried out, and a recovery period was required to remove more water. An acid-washed, distilled water-rinsed, stainless steel bladder pump was used for well evacuation. Compressed N_2 gas was the displacement medium.

After evacuating the well, a water sample was taken, using a point source (a ball valve on each end) Teflon bailer that had been washed with acid and rinsed with distilled water. Attached to the bottom end of the bailer was a stainless steel "probe" to keep the bailer off the bottom of the well (and off any possible sediment) and within the screened portion of the well. Thus, samples were taken from about 2 ft from the bottom, where freshwater in contact only with stainless steel could be removed. When the sample was retrieved, the water was removed by use of a Teflon emptying device and placed, without filtration, into bottles containing nitric acid and potassium dichromate as a preservative (Feldman 1974a). Samples were not filtered prior to preservation for two reasons: (1) even under ideal conditions, filtration can result in either sample contamination or loss of soluble mercury by sorption to filter and glassware; (2) total analysis is a better index of groundwater contamination by mercury because mercury is expected to be largely (>90%) associated with suspended matter (Cranston and Buckley 1972).

Prior to evacuation of any well, water levels were noted in all wells within a nest. After sampling, measurements of electrical conductance, pH, and temperature were made either in situ (by lowering a probe into the well) or on the surface by retrieving a bailed sample (see later discussion of general groundwater chemistry).

Mercury in well-water samples was determined by the method of Feldman (1974b). Previous comparison of this method with the U.S. Environmental Protection Agency (USEPA) method (USEPA 1979; method 245.1) has demonstrated that results are equivalent. However, the method of Feldman, as applied in the ORNL Environmental Analysis Laboratory, affords higher sensitivity (0.01 µg/L vs. 0.1 µg/L). Mercury in well sediment was determined by the USEPA method (USEPA 1979) for sediment. Methyl mercury was not analyzed for in any well-water samples because it was expected to be absent or to be present at extremely low concentrations (below analytical detection limits).

6.2 RESULTS OF WELL-WATER ANALYSES

All wells have been sampled and the water analyzed for mercury at least once, most having been sampled two to five times. Table 5 summarizes analytical data for mercury for the period November 10, 1983, through March 27, 1984.

In the assessment of possible groundwater contamination by mercury, it is important to obtain samples having only natural suspended sediment (i.e., without sampling-induced turbidity) because mercury is readily sorbed onto sediment. The nitric acid and potassium dichromate used to preserve the samples will release sorbed mercury from sediment, making it detectable during analysis. High amounts of suspended sediment can therefore result in an anomalously high concentration of mercury, which

Table 5. Mercury in Y-12 groundwater

Nest	Well	Date	Quality[a]	Mercury (µg/L)
53-1		15MAY84	TM	0.10
54-1	A	03MAR84	TM	0.04
54-1	A	12MAR84	TM	0.03
54-2	A	03MAR84	TM	0.04
54-2	A	12MAR84	TM	0.09
55-1	A	10NOV83	TM	1.10
55-1	A	16DEC83	C	0.06
55-1	A	25JAN84	TM	0.06
55-1	A	12MAR84	TM	0.04
55-1	B	10NOV83	C	0.10
55-1	B	25JAN84	TM	0.09
55-1	C	14NOV83	C	0.60
55-1	C	25JAN84	C	0.13
55-2	A	17NOV83	TM	3.50
55-2	A	15DEC83	C	1.70
55-2	A	16DEC83	C	1.10
55-2	A	26JAN84	TM	0.73
55-2	A	20MAR84	TM	0.06
55-2	B	17NOV83	C	0.04
55-2	B	26JAN84	C	0.03
55-2	B	22MAR84	C	<0.01
55-2	C	05DEC83	C	0.08
55-2	C	26JAN84	C	<0.01
55-2	C	22MAR84	C	<0.01
55-3	A	16NOV83	C	1.10
55-3	A	15DEC83	C	0.15
55-3	A	27JAN84	TM	0.04
55-3	A	20MAR84	M	20.00
55-3	B	16NOV83	C	0.03
55-3	B	27JAN84	C	0.33
55-3	B	26MAR84	TM	0.20
55-3	C	16NOV83	C	0.07
55-3	C	27JAN84	C	<0.01
55-3	C	26MAR84	C	0.01
55-4	B	08DEC83	C	0.16
55-4	B	10FEB84	TM	0.05
55-4	B	12MAR84	C	0.07
55-4	C	08DEC83	M	4.00
55-4	C	10FEB84	M	0.20
55-5	A	05MAR84	VM	93.00
55-5	A	12MAR84	VM	11.00
55-6	A	05MAR84	VM	1.10
55-6	A	12MAR84	M	4.90

Table 5. (continued)

Nest	Well	Date	Quality[a]	Mercury (µg/L)
56-1	A	14NOV83	TM	0.50
56-1	A	14NOV83	TM	0.90
56-1	A	16DEC83	C	0.19
56-1	A	02FEB84	TM	0.13
56-1	A	12MAR84	TM	0.16
56-1	C	14NOV83	C	0.30
56-1	C	14NOV83	C	0.40
56-1	C	02FEB84	C	0.05
56-2	A	05DEC83	VM	5.20
56-2	A	05DEC83	VM	145.00
56-2	A	06DEC83	U	5.20
56-2	A	15DEC83	C	0.62
56-2	A	30JAN84	TM	0.86
56-2	A	20MAR84	TM	0.73
56-2	B	06DEC83	C	0.15
56-2	B	30JAN84	TM	0.35
56-2	B	27MAR84	M	0.10
56-2	C	06DEC83	C	1.30
56-2	C	06DEC83	C	0.95
56-2	C	31JAN84	TM	0.13
56-2	C	27MAR84	TM	0.43
56-3	A	07DEC83	C	0.91
56-3	A	01FEB84	TM	0.29
56-3	A	20MAR84	TM	0.18
56-3	B	07DEC83	C	0.08
56-3	B	01FEB84	C	0.02
56-3	C	07DEC83	C	<0.01
56-3	C	01FEB84	C	<0.01
56-4	B	09DEC83	C	0.05
56-4	B	03FEB84	C	0.02
56-4	B	06FEB84	•	•
56-4	B	19MAR84	M	0.10
56-4	C	09DEC83	C	0.03
56-4	C	02FEB84	C	0.03
56-5	A	13MAR84	TM	4.30
56-5	B	15DEC83	C	1.30
56-5	B	16JAN84	C	0.94
56-5	C	14DEC83	C	0.17
56-5	C	16JAN84	C	0.88
56-6	A	03MAR84	M	0.21
56-6	A	05MAR84	M	0.50

Table 5. (continued)

Nest	Well	Date	Quality[a]	Mercury (µg/L)
56-6	A	19MAR84	TM	0.17
56-7	A	02MAR84	TM	1.90
56-7	A	13MAR84	TM	7.60
56-8	A	02MAR84	C	<0.01
56-8	A	13MAR84	TM	1.00
56-9	A	02MAR84	TM	0.02
56-9	A	14MAR84	TM	0.05
58-1	A	10JAN84	U	14.00
58-1	A	18JAN84	TM	16.00
58-1	A	15MAR84	TM	30.00
58-1	B	10JAN84	U	2.00
58-1	B	18JAN84	TM	7.60
58-1	B	15MAR84	TM	0.71
58-1	C	10JAN84	U	40.00
58-2	A	02MAR84	M	0.21
58-2	A	19MAR84	TM	0.06
59-1	A	11DEC83	C	0.02
59-1	A	23JAN84	TM	0.40
59-1	A	19MAR84	TM	0.40
59-1	B	13DEC83	C	<0.01
59-1	B	23JAN84	TM	0.05
59-1	C	11DEC83	TM	<0.01
59-1	C	24JAN84	C	0.01
60-1	A	13DEC83	M	8.10
60-1	A	17JAN84	M	1.10
60-1	A	14MAR84	VM	28.00
60-1	B	13DEC83	M	1.30
60-1	B	18JAN84	VM	0.69
60-2	A	02MAR84	TM	0.10
60-2	A	14MAR84	C	<0.01

[a] C = clear; TM = trace mud; M = muddy; VM = very muddy; U = unpurged.

is not necessarily representative of the mercury concentration of the water. Thus, it is necessary to obtain samples for analysis that are free of sediment or to note the presence of sediment in samples that contain detectable amounts. In Table 5, the designations C, TM, M, and VM are approximately equivalent to total suspended matter (sediment) concentrations of <10 mg/L, 10 to 100 mg/L, 100 to 10,000 mg/L and >10,000 mg/L, respectively. To get sediment-free samples, the water can be filtered (the reasons for not filtering were stated earlier) or the well can be pumped and evacuated until clear formation water is obtained.

In spite of prolonged pumping during well development, several wells continued to yield turbid water samples. Samples with sediment are not considered to be representative of formation water because the sediment is presumed to be entrained only as a consequence of well drawdown. This is not to imply that sediment is never transported by groundwater. Ordinarily, however, groundwater moves through formations without resuspending previously deposited sediments. The local temporary velocity increase associated with pumping sometimes results in sediment resuspension, particularly during the early stages of well use. In most cases, turbid samples were associated with the shallowest wells (A and B), which are screened in fill, soil, and weathered rock.

Before examining these data, it is important to define a minimum concentration of mercury in groundwater that will be considered as evidence of contamination. For water samples with little suspended matter (e.g., <10 mg/L), the value often used as a natural background value for stream water, 0.05 µg/L, is also appropriate for groundwater. Allowing for somewhat higher concentrations of suspended matter concentrations (e.g., 50 mg/L) would yield an upper limit of perhaps 0.5 µg/L mercury. Thus, groundwater samples with values in excess of 0.5 µg/L will be interpreted as having mercury concentrations "above background." Kaiser and Tolg (1980) show a range of mercury concentrations for unpolluted groundwater of 0.01 to 0.46 µg/L.

Groundwater, which may serve as an untreated potable water supply, may contain up to 2 µg/L before exceeding the state and federal drinking water standard for mercury.

The data in Table 5 support the following immediate conclusions:

1. No wells yielded "clear" groundwater samples with mercury concentrations which exceeded the national primary drinking water standard (NPDWS) of 2 µg/L. Three wells (55-2A, 56-2C, and 56-2B) yielded "clear" samples with mercury concentrations close to 50% of the NPDWS.

2. Nine wells yielded "clear" groundwater samples with mercury concentrations which are suggestive of low-level contamination (0.1 to 1 µg/L).

3. Fifteen additional wells yielded "clear" groundwater samples with essentially background concentrations (<0.1 µg/L).

Further interpretation of the data in Table 5 requires examination of the mercury content of suspended matter from 28 of the wells (Table 6). Three of these wells (56-5A, 58-1A, and 60-1A) show a high mercury content (>10 µg/g) in suspended matter. These wells are located, respectively, near 81-10, in the 9733-1 alcove, and near 9201-2, all areas of known high contamination of upper soil and fill. Suspended matter from 15 additional wells showed slight (0.5 to 1 µg/g) to moderately elevated (1 to 10 µg/g) mercury concentrations, while suspended matter from the remaining 10 wells showed no evidence (mercury $\leq$0.5 µg/g) of contamination. Table 7 gives the ranking of mercury concentrations for all wells. All but four wells (55-1A, 55-1B, 56-4C, and 59-1A) have some evidence (water and/or suspended matter analyses) of contamination by mercury. Thus, of the known mercury use or spill areas, only the 9202 area (wells 59-1A, 59-1B, 59-1C) appears not to be contaminated.

Table 6. Comparison of mercury concentrations in water and in suspended solids

Nest	Well	Date	Mercury in water (µg/L)	Quality[a]	Mercury in solids (µg/g)
54-1	A	12MAR84	0.03	TM	0.06
54-2	A	12MAR84	0.09	TM	0.15
55-1	A	25JAN84	0.06	TM	0.25
55-1	A	12MAR84	0.04	TM	0.13
55-1	B	25JAN84	0.09	TM	0.13
55-2	A	26JAN84	0.73	TM	1.60
55-2	A	20MAR84	0.06	TM	2.50
55-3	A	27JAN84	0.04	TM	0.40
55-3	A	20MAR84	20.00	M	2.30
55-3	B	27JAN84	0.33	C	0.05
55-3	B	26MAR84	0.20	TM	0.26
55-4	C	08DEC83	4.00	M	0.26
55-4	C	10FEB84	0.20	M	0.45
55-5	A	05MAR84	93.00	VM	3.70
55-5	A	12MAR84	11.00	VM	5.70
55-6	A	05MAR84	1.10	VM	2.10
55-6	A	12MAR84	4.90	M	2.00
56-1	A	12MAR84	0.16	TM	0.61
56-2	A	05DEC83	5.20	VM	3.10
56-2	A	05DEC83	145.00	VM	3.10
56-2	A	30JAN84	0.86	TM	2.80
56-2	A	20MAR84	0.73	TM	3.10
56-2	B	06DEC83	0.15	C	0.61
56-2	B	30JAN84	0.35	TM	0.55
56-2	B	27MAR84	0.10	M	0.94
56-2	C	06DEC83	1.30	C	1.60
56-2	C	06DEC83	0.95	C	1.60
56-2	C	27MAR84	0.43	TM	2.20
56-3	A	01FEB84	0.29	TM	8.60
56-4	B	19MAR84	0.10	M	3.00
56-5	A	13MAR84	4.30	TM	17.00
56-6	A	19MAR84	0.17	TM	0.13
56-7	A	13MAR84	7.60	TM	10.00
56-8	A	13MAR84	1.00	TM	1.20
56-9	A	14MAR84	0.05	TM	0.10
58-1	A	15MAR84	30.00	TM	168.00
58-1	B	18JAN84	7.60	TM	6.80
58-1	B	15MAR84	0.71	TM	2.10
58-2	A	19MAR84	0.06	TM	0.29
59-1	A	23JAN84	0.40	TM	0.35
59-1	A	19MAR84	0.40	TM	0.40
60-1	A	13DEC83	8.10	M	6.20
60-1	A	14MAR84	28.00	VM	13.00
60-1	A	14MAR84	28.00	VM	12.00
60-1	B	13DEC83	1.30	M	7.20
60-1	B	18JAN84	0.69	VM	2.60
60-2	A	14MAR84	-0.01	C	1.10

[a]C = clear; TM = trace mud; M = muddy; VM = very muddy.

Table 7. Rankings of mercury concentrations in wells from analyses of (1) suspended sediment, (2) all water samples, and (3) only "clear" water samples

Ranking	Wells
	Suspended sediment samples (µg/g)
≤0.5	54-1A, 54-2A, 55-1A, 55-1B, 55-3B, 55-4C, 56-6A, 56-9A, 58-2A, 59-1A
0.5-1	56-1A, 56-2B
1-10	55-2A, 55-3A, 55-5A, 55-6A, 56-2A, 56-2C, 56-3A, 56-4B, 56-7A 56-8A, 58-1B, 60-1B, 60-2A
>10	56-5A, 58-1A, 60-1A
	All water samples (µg/L)
≤0.1	53-1A, 54-1A, 54-2A, 55-1A,[a] 55-1B, 55-2B, 55-2C, 55-3C, 55-4B,[a] 56-3B, 56-3C, 56-4B, 56-4C, 56-9A, 59-1B, 59-1C, 60-2A
0.1-1.0	55-1C, 55-3B, 56-1A, 56-1C, 56-2A,[a] 56-2B, 56-2C,[a] 56-3A, 56-5C, 56-6A, 56-8A, 58-2A, 59-1A
1-10	55-2A, 55-4C, 55-6A, 56-5A, 56-5B, 56-7A, 58-1B, 60-1B
>10	55-3A, 55-5A, 58-1A, 58-1C, 60-1A
	Only "clear" water samples (µg/L)
≤0.1	55-1A, 55-1B, 55-2B, 55-2C, 55-3C, 55-4B, 56-3B, 56-3C, 56-4B 56-4C, 56-8A, 59-1A, 59-1B, 59-1C, 60-2A
0.1-1.0	55-1C, 55-3A,[a] 55-3B, 56-1A, 56-1C, 56-2A, 56-2B, 56-3A, 56-5C,
1-10	55-2A, 56-2C, 56-5B
(>10)	--

[a]Exclusive of first observation.

It is important to consider whether some wells may have been contaminated as a result of well drilling, i.e., by downward transport of contaminants in the upper soil and fill to well screen depths by auger reentries and other well installation activities. Availability of analyses of soil cores (discussed in detail later) provides some means of determining whether near-surface contamination has been dragged downward. Corresponding soil data for each well screen depth is available for only some of the wells (Table 8). As suggested by the data summarized in Table 8, five wells (55-3A, 56-3A, 56-3B, 58-1B, and 60-1A) may contain mercury-contaminated sediment due to well installation (i.e., mercury concentration in sediment much greater than that in boring samples).

One of the groundwater samples was filtered (0.4-μm pore size) before mercury analysis. For this one sample (56-2A, 12/5/83), the soluble concentration was 0.04 μg/L, whereas the total mercury concentration in a replicate sample was 145 μg/L. The sample that was filtered contained about 50 g/L of sediment with a mercury concentration of 3.1 μg/g. This case illustrates very well the impact of sediment on total mercury concentration in a sample. Several other samples were turbid and contained over 10 g/L of sediment; thus, a mercury concentration in the range of 1 to 2 μg/L would be expected for these samples even in the absence of groundwater contamination. For example, a water sample containing 1 g/L of suspended sediment with a mercury content of 0.5 μg/g in the sediment will be analyzed as having a total mercury concentration of 0.5 μg/L.

6.2.1 Results of Drilling Water Analyses

Included in Appendix D are analyses of drilling water samples collected at intervals during the drilling of the core holes. These samples were collected with the hope of being able to identify mercury-rich zones at depth, if they exist, and to monitor water quality.

Table 8. Comparison of Hg concentration in soil/fill boring samples from approximate well screen depths to suspended matter Hg concentrations. Letters in () indicate boring ID if other than well ID.

Well ID	Boring samples[a] (µg/g)	Suspended matter (µg/g)
55-1A	<0.1 (B, C)	0.13-0.25
55-2A	1.3	1.6-2.5
55-3A	<0.1	0.4-2.3[b]
56-3A	<0.1 (C)	8.6[b]
56-4B	<0.1 (C)	3.0[b]
56-5A	48 (B)	17
58-1A	17	168
58-1B	0.3	2.1-6.8[b]
59-1A	0.4	0.35-0.40
60-1A	<0.1	6.5-13[b]
60-1B	2.3	2.6-7.2

[a]Letters in parentheses indicate boring identification if other than well identification.

[b]Possible contamination of screen level from well installation.

Analyses were made of the water, including suspended sediment, and of the supernatant after the sediment had been separated by centrifugation. In all cases (Appendix D) the supernatants have very low mercury concentrations (<1.0 µg/L). Most of the unseparated samples also have low concentrations (10.0 µg/L or less) of mercury, but in two cases (sites 56-5 and 60-1) elevated concentrations (4800 and 170 µg/L) occur. Only limited sampling was done at site 56-5 because there was a total loss of drilling water starting at a depth of about 30 ft.

6.3 SAMPLING AND ANALYSIS OF UNCONSOLIDATED MATERIALS

Soil samples were taken, using the Shelby tube method described earlier. After "refusal" by that technique, straight augering continued. After a short distance (usually 2 ft) the auger was removed and a "bag" sample was retrieved off the drill bit. Sampling continued until auger "refusal." In some sites, near-surface samples were retrieved, using a hand auger or probe. Samples were also retrieved by hand sampling in pits and trenches.

After sampling, all bags or tubes were labeled and sealed to minimize vapor loss. All samples were transferred to a refrigerated (4°C) environment to limit mercury loss prior to analysis and for storage.

The Shelby tubes were split open using a circular saw, and the tube was logged and then channel-sampled over its entire length (about 2 ft). Where distinct horizons were apparent, subsamples of that horizon were removed. Bag samples were homogenized and subsampled prior to testing.

The mercury concentration in soil samples was determined by the USEPA method (USEPA 1979; method 245.5). Prior to submission for mercury analysis, soil and mud samples were dried in a forced-air oven at 55°C for 16 h. A few samples collected early in the study were analyzed without drying, but this procedure was abandoned as discussed later. The USEPA methods manual (USEPA 1979) states that drying at 60°C does not result in the loss of mercury from sediment. Experience at ORNL has confirmed this, but not for soils where mercury may occur in the elemental state as visible beads. Because some of the soil samples obtained for this study contained small visible beads of mercury, it was deemed important to test for mercury losses by volatilization from small mercury beads. As demonstrated in Fig. 11, mercury is lost slowly from small beads (approximately 100 mg, 1 to 2 mm in diameter) held in a 55°C drying oven for extended periods of time. The losses were insignificant (less than 1% of initial weight) over the 16-h period used for soils from this study. For much smaller beads (e.g., microscopic) with higher surface areas, the losses could be higher; thus, drying times were kept as short as possible (16 h or less). We do not think that oven drying of soil samples in this study resulted in significant losses of mercury, but it would be prudent to consider all reported soil values as minimum values.

6.4 RESULTS OF SOIL SAMPLING

Soil sampling was carried out in two phases. Phase I sampling took place during initial installation of monitoring wells and allowed determination of which sites warranted further investigation. Phase II sampling involved detailed soil borings at three locations where the mercury concentrations were highest (58-1, 56-5, and 60-1) and one additional area (53-1). In total, 382 soil samples were analyzed for total mercury content; complete analytical results and graphic plots of the data are included in Appendix E.

6.4.1 Phase I of Soil Sampling

Prior to examination of the soil data, the significance of reported mercury levels should be kept in mind. Background levels of mercury in soil or sediment are generally 0.05 to 0.2 µg/g (Fleischer 1970; Pierce et al. 1970); thus, levels above 0.2 µg/g might indicate contamination.

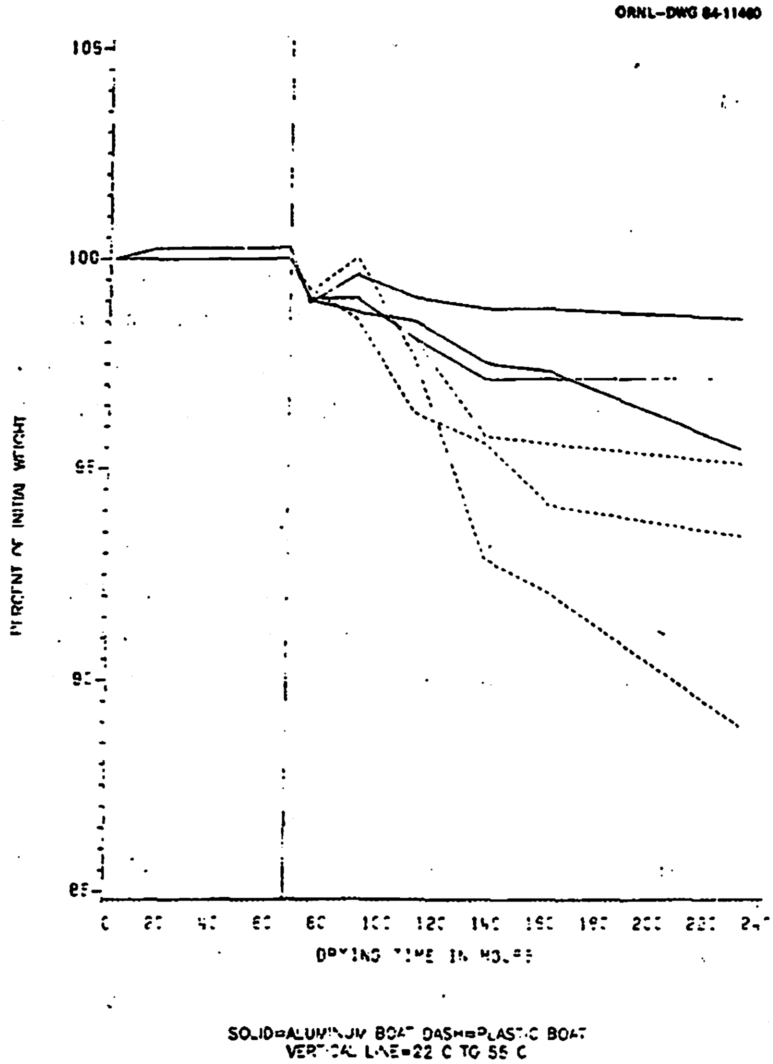

Fig. 11. Loss of mercury from small beads (weighing 76 to 135 mg each) at 55°C. Values plotted are percentages of initial weight as a function of time. Solid lines are for beads in aluminum weighing dishes; dashed lines are for beads in plastic dishes. Dishes were transferred to 55°C oven at 65 h (vertical line).

Some of the early analyses were performed on a wet-weight basis. This method was discontinued for two reasons: first, the samples were more difficult to homogenize than dry samples; second, a time-consuming correction was required to convert the data to a dry-weight basis. All concentrations from wet samples were less than 0.2 µg/g, with most being less than 0.05 µg/g.

Soil samples were collected from all well sites (except location 56-1, where rock was at the surface) and analyzed. Data from sites 55-1, 55-3, 56-3, and 56-4 indicate that these areas are uncontaminated. One sample of fill from each site showed slight contamination. The possibility exists that the fill material may have been contaminated prior to its placement (alluvium from UEFPC has been used for fill at various localities).

Somewhat higher concentrations are found at sites 55-2, 55-4, 56-2, and 59-1, but the values are all less than 5 µg/g. The largest concentrations occur in the upper 5 ft of fill, but concentrations greater than 0.2 µg/g are found through the entire thickness of the fill at these sites.

The two sites where mercury levels are highest are 56-5 (building 81-10) and 60-1 (building 9201-2). The most extreme contamination is at site 56-5 where mercury was detected on the order of hundreds of micrograms per gram as deep as 17 ft. Small beads of visible mercury were noted in the Shelby tube samples at 6 ft depth for this location. Based on Phase I studies, the contamination at site 60-1 is much less than that at 56-5 and occurs only in the upper 5 ft of the fill. These areas are discussed in greater detail in following sections.

Extensive sampling of fill and weathered shale was also performed behind building 9201-4 in a pipeline excavation trench. Data for this site, and two other pits in that area, are also included in Appendix E. The sampling locations in the trench are shown in Fig. 12. The samples are limited in vertical extent but cover a wide area. The area shows

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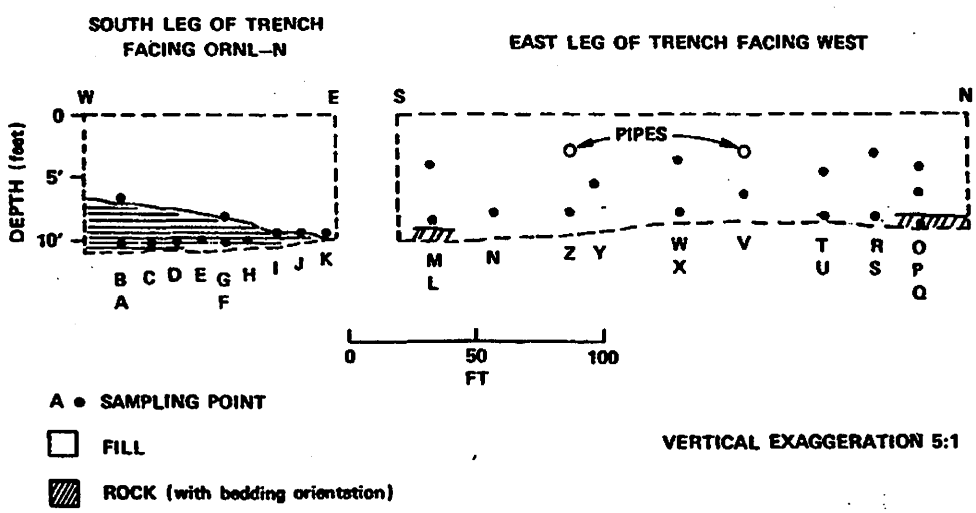

Fig. 12. Sampling locations within trench south of building 9201-4 (long trench in Fig. 4).

signs of low-level mercury contamination throughout (>0.2 µg/g), although no levels of mercury greater than 1.67 µg/g were encountered. Samples from the two nearby pits (Fig. 12) have concentrations less than 0.05 µg/g.

In general, the results of Phase I soil sampling did not indicate widespread areas of high mercury concentrations; the two areas of greatest concern are near buildings 81-10 and 9201-2.

6.4.2 Phase II of Soil Sampling

Investigations at Building 9733 Alcoves

In the process of digging French drains near building 9733-1, construction workers discovered visible mercury in the fill and weathered shale. Although this area had not previously been noted as a mercury spill area, it was the site of a pilot-scale operation where mercury was used in the early 1950s. The profiles exposed by hand digging the holes for French drains were especially interesting to this project because they revealed that mercury, occurring as fairly large beads (up to 0.25 in.) in a porous medium (coarse-loamy sand to fine-loamy gravel), had apparently not migrated significantly for 30 years. Although it could not be determined how this area was initially contaminated, the site provided an opportunity to document the areal and vertical distribution of mercury in an area with minimal postcontamination disturbance by construction (the alcove is grassed and open only to foot traffic).

A series of bucket auger samples was obtained in October 1983 at nine locations (A through I in Fig. 13) in the south alcove between buildings 9733-1 and 9733-2. At each location, auger samples representing up to 12 in. of material were taken sequentially until the auger could not be advanced deeper. In addition, exposed material in the two French drain holes (TP1 and TP2) were sampled at 6-in. intervals. Nearly all of these samples have been analyzed for total

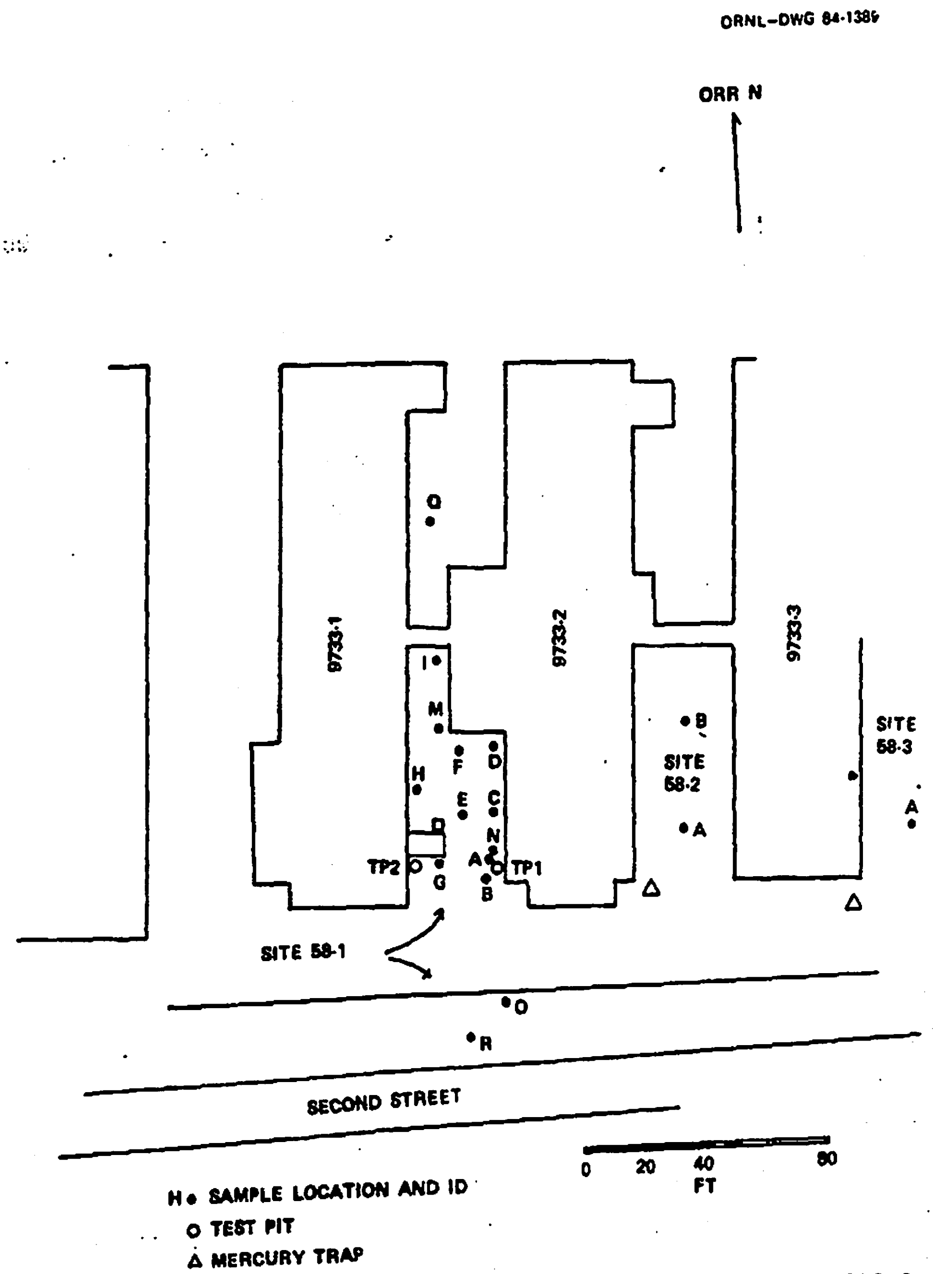

Fig. 13. Phase II sampling locations near building 9733-1.

mercury; the data are included in Appendix E. Mercury concentrations range from 4.8 to 10,600 µg/g; sites B and E have the highest concentrations. Except at location C, where the boring extends to a depth of only 18 in., all of the profiles show a decrease in mercury concentrations with depth. Although the bulk of the contamination appears to be confined to the upper 2 ft, even the deepest samples obtained have greatly elevated concentrations (by a factor of 100) over natural background (>0.2 µg/g).

The bucket augering method used allowed for the possibility that contaminated material near the surface could be carried downward, thereby contaminating lower samples. To avert this situation, soil sampling with the power hollow-stem auger and Shelby tubes was undertaken to better define the vertical limits of contamination and to allow for well installation. In December 1983, a drill rig was hoisted by crane into the enclosed south alcove, and two holes (58-1M, 58-1N) were augered to refusal (Fig. 13). Shelby tube cores were obtained in the upper soil horizons, but only auger-tip samples could be obtained in the deeper shale saprolite. An additional hole (58-1Q) was augered and sampled in the north alcove between buildings 9733-1 and 9733-2 (Fig. 12). PVC casings (2-in. inside diameter), slotted in the lower 3 ft, were installed in holes 58-1N and 58-1Q to provide for groundwater sampling. Minimal investment was made in these wells because it was anticipated that they would be removed during excavation of the contaminated soil in the very near future.

Results of mercury analysis of soil samples from 58-1M, 58-1N, and 58-1Q are displayed in Fig. 14 and tabulated in Appendix E. Except for the surface sample (0 to 5 in.) from hole 58-1N, which has a mercury concentration of 561 µg/g, the samples from power augering were generally lower in mercury content than were those from the earlier hand augering. These results confirm that elevated levels of mercury (10 times background or more) do occur down to auger refusal in the south alcove. A crude estimate of the quantity of mercury in the south alcove would be on the order of 1300 lb or less. Most of this would be

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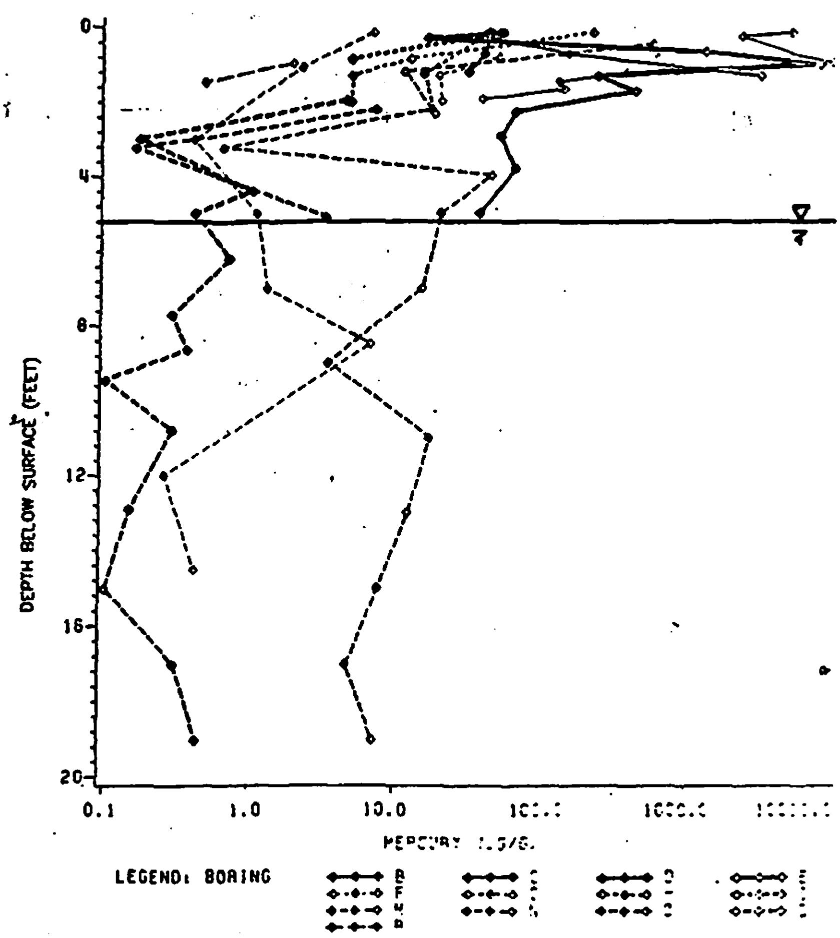

HORIZONTAL LINE IS TOP OF WATER TABLE

Fig. 14. Mercury concentrations in soil cores taken near building 9733-1.

recoverable by removing the top 2 to 6 ft of earth material. The vertical distribution of mercury in the soils is shown in Fig. 14, as is the approximate depth to groundwater.

Analyses of samples from the boring in the north alcove (58-1Q) reveal elevated mercury levels (4.5 µg/g) in the upper 2 ft and at about 5 ft (1.0 µg/g). The remainder of the hole, which penetrated to 23 ft, has only background levels of mercury (<0.2 µg/g).

Additional shallower borings were made across the road from the south alcove between buildings 9733-1 and 9733-2 and in the alcoves to the east (Fig. 13). One sample of a black sludge from one of the concrete traps on the south side of 9733-1 contains a mercury concentration of 6430 µg/g. Based on old engineering drawings, it appears that this trap, and others like it in the area, was apparently used to trap mercury spilled within the nearby building.

Investigations at Building 81-10

Building 81-10, the old mercury furnace, is the only site investigated south of UEFPC. Initial drilling there indicated that a significant amount of fill underlies the site (34 ft of fill at site 56-5/B3). Beneath the fill lies bedrock of the Maynardville Formation. The formation is riddled with solution cavities, and drilling at the site was particularly difficult (lost water circulation and side wall collapse). Phase I soil sampling indicated a high mercury concentration to a depth of about 6 ft, and anomalously high values were encountered at even greater depths. Because of the geology, the results of Phase I drilling, and its proximity to the UEFPC (Fig. 6), it was decided to further characterize this potential mercury source.

In December 1983, eight soil borings were completed near building 81-10 (borings 56-5/B2 to B9). The location of the borings and the general site layout can be seen in Fig. 15. Drilling was concentrated north of 81-10, between the old furnace and UEFPC. Two borings were drilled

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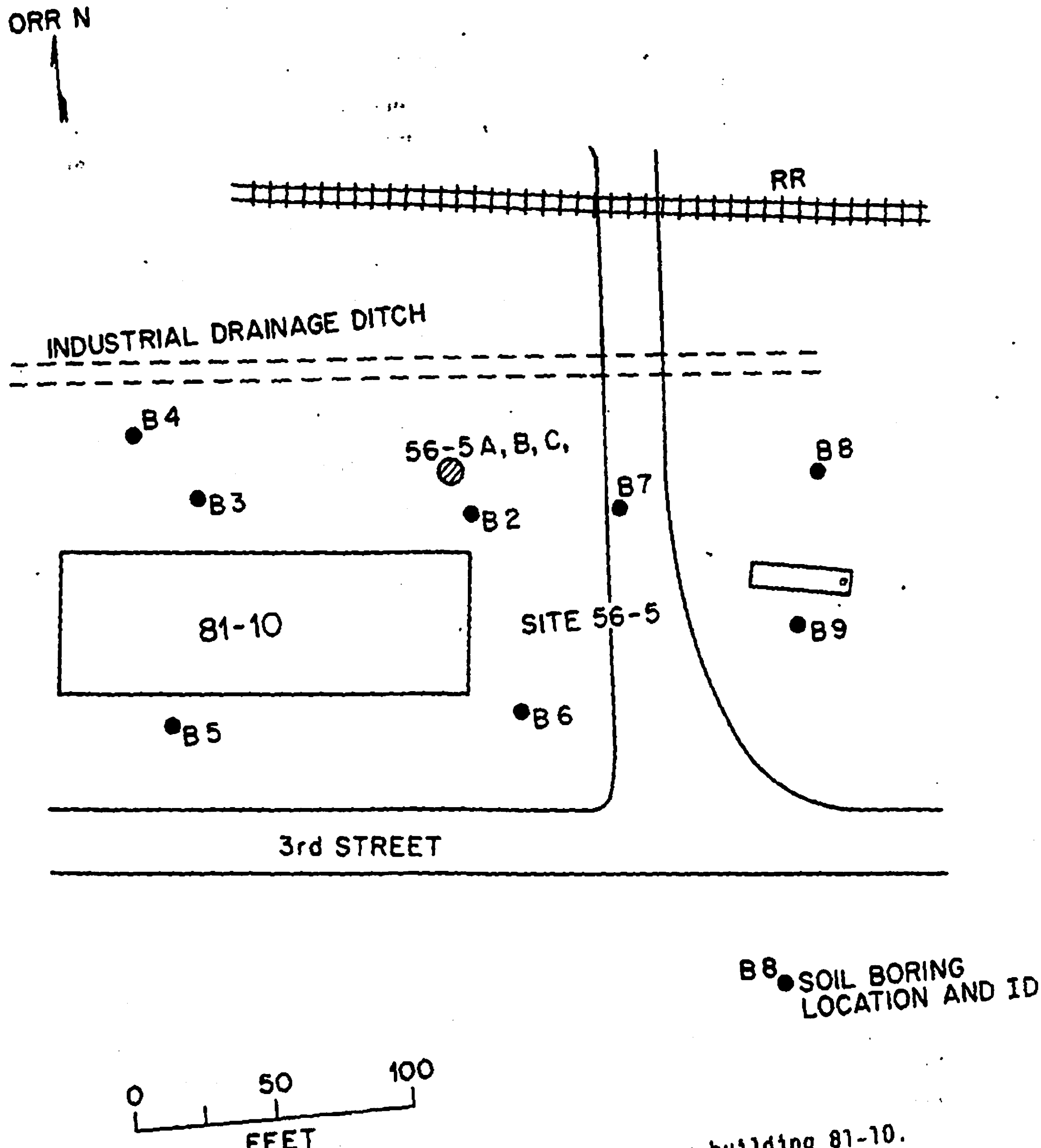

Fig. 15. Phase II sampling locations near building 81-10.

east of 81-10 near a site where facilities associated with the mercury furnace were located. The Shelby tube samples were collected as described earlier, and logs of all sections are included in Appendix B.

All of the samples collected have been analyzed for total mercury content; the results are included in Appendix E. The data are plotted, along with the approximate depth to water, in Fig. 16. The mercury concentrations in the near-surface samples collected from all the sites were above background (>0.2 µg/g), and most near-surface soils have a concentration above 12 µg/g. Sites 56-5/B3 and B4 appear to be the most highly contaminated areas; concentrations of greater than 1000 µg/g were encountered in both borings. The Phase I boring (56-5C) was also highly contaminated. Mercury concentration tends to decrease with depth in most borings, but distinct high-concentration zones at depth were noted (Fig. 16). The area of greatest mercury contamination appears to be north of building 81-10, with high mercury concentrations evident to depths as great as 15 ft. The surrounding area shows elevated concentrations of mercury, but the contamination is generally limited to the upper 4 to 6 ft of fill. It is interesting to note that at most of the sites a mercury peak is present at a depth of 4 to 6 ft; perhaps the depth of this peak is indicative of the rate of mercury movement in the subsurface. It is estimated that about 2800 lb of mercury is contained in the unconsolidated earth materials near building 81-10.

Investigations at Building 9201-2

Building 9201-2 was the site of an early pilot plant that used mercury in its process stream. As well as possible leakage from the system, large losses (~95,000 lb) of mercury were reported to have occurred within the bay on the east side of the building from 1951 to 1955 (UCC-ND Task Force 1983). The site is underlain by new fill (after spills), old fill, alluvium, and bedrock of the Maynardville Formation.

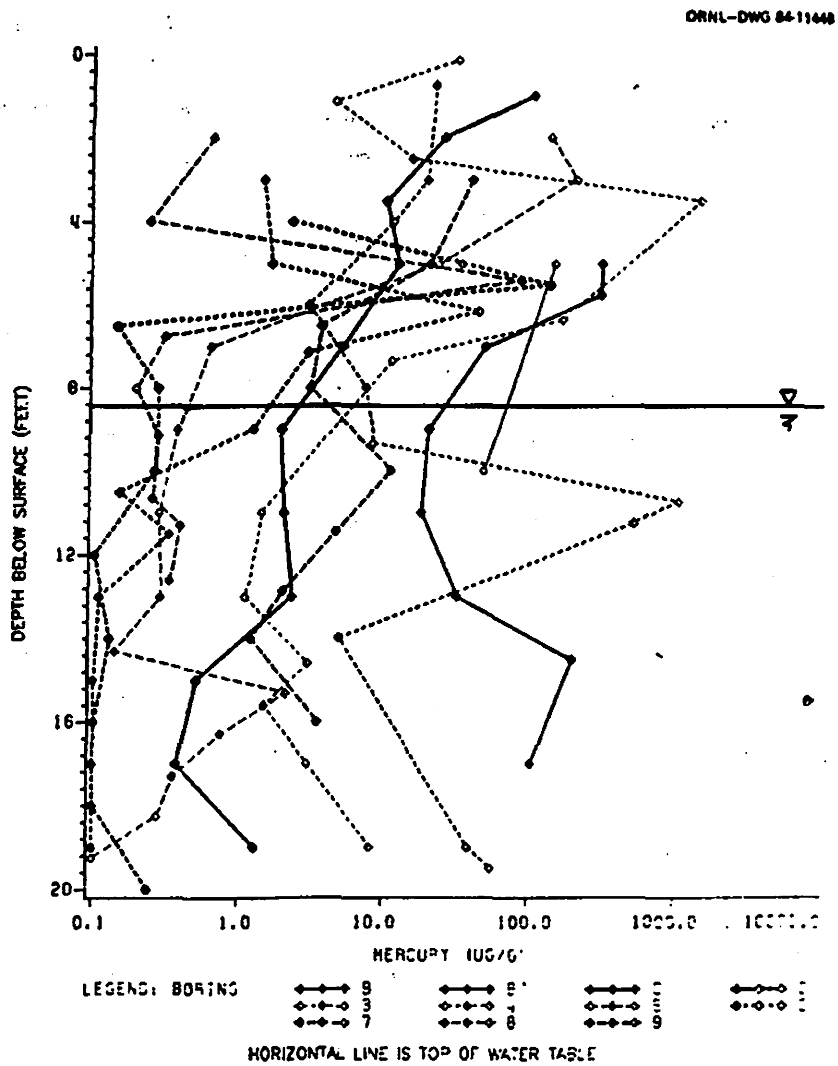

Fig. 16. Mercury concentrations in soil cores taken near building 81-10.

The geology and stratigraphy of the site is complex and has been modified greatly since construction of the building. The original construction plans (unpublished drawings by Stone & Webster, 1943) for the site indicate that a meander of UEFPC has since been straightened, and that a rather large spring (22 ft deep, 30 ft in diameter, with a flow of about 500 gpm) was sealed to accommodate the construction of building 9201-2. These original features are indicated in Fig. 17. Phase I drilling at the site indicated that significant solution cavities underlie the site, as is typical for the formation.

Initial borings at the site indicated mercury contamination, and because of the potential for accumulation (mercury not recovered after being spilled), a second phase of eight borings were completed at the site (Fig. 17). The borings were located downflow (toward UEFPC) of the spill site and within the old meander loop south of 9201-2. Samples were collected as previously described. High concentrations of mercury, with values as high as 5000 µg/g, and significant contamination as deep as 13 ft (500 µg/g) were encountered in boring 60-1/B4. It appears that most of the mercury was retained in sediments immediately surrounding the spill site (borings 60-1/B3-6) and that migration within the unconsolidated materials has not been extensive. Some elevated mercury values are apparent in boring 60-1/B1; these are very likely caused by a general loss of mercury from the building, not from the large spill. Although the highest mercury concentrations were found surrounding the spill area, almost all samples collected had above-background concentrations (>0.2 µg/g). Figure 18 shows the distribution of mercury in the borings from the site; based on the boring data, it is estimated that about 2700 lb of mercury is contained in the unconsolidated earth materials at the site.

<u>Investigations at the Old Mercury Storage Area</u>

After completion of the Phase I studies, it was reported that visible mercury had been found in soils near guard portal 33. The area has been described as an old storage site for mercury flasks (G. Kamp,

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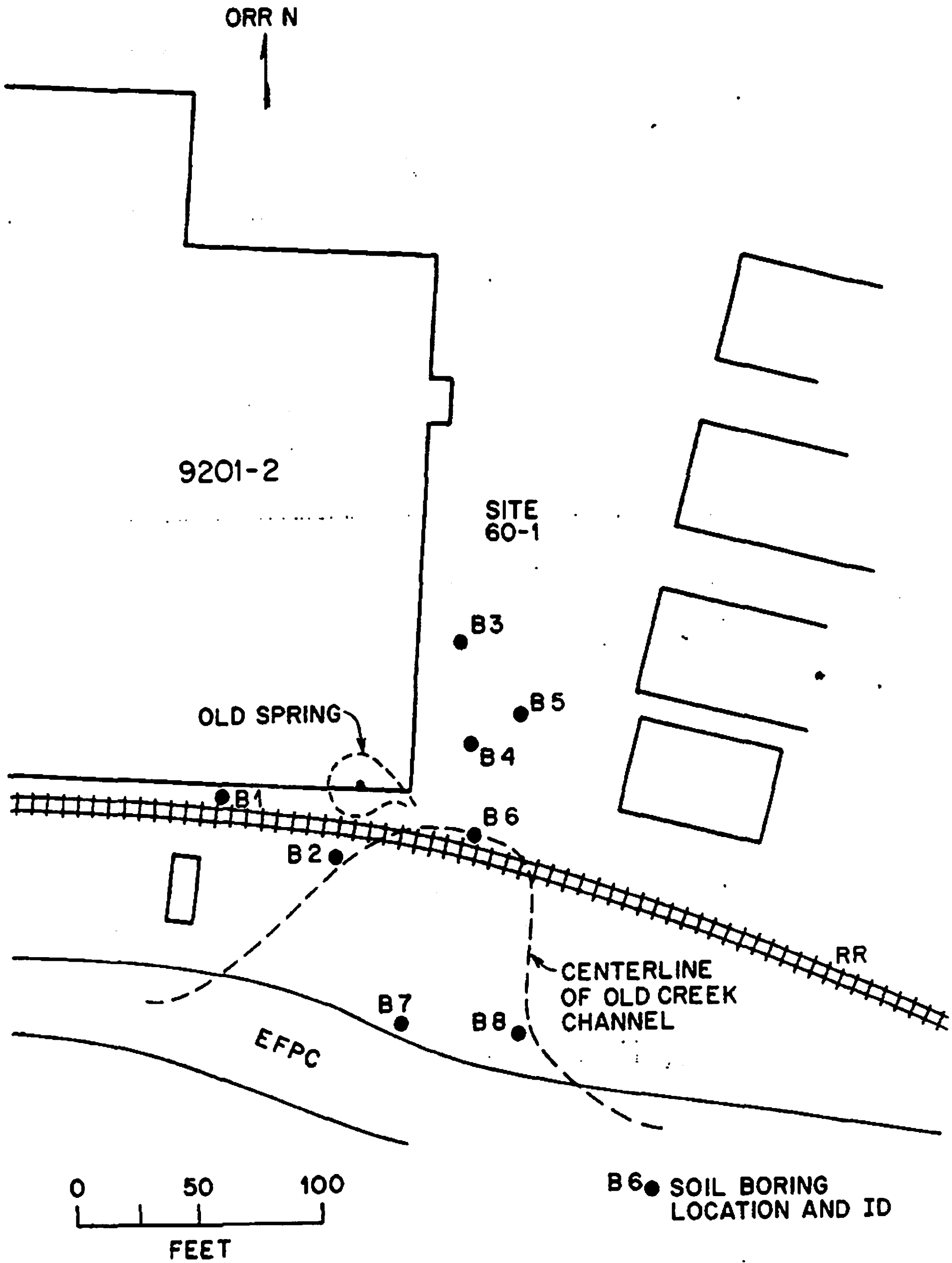

Fig. 17. Phase II sampling locations near building 9201-2. Preconstruction hydrologic features are indicated with dashed lines.

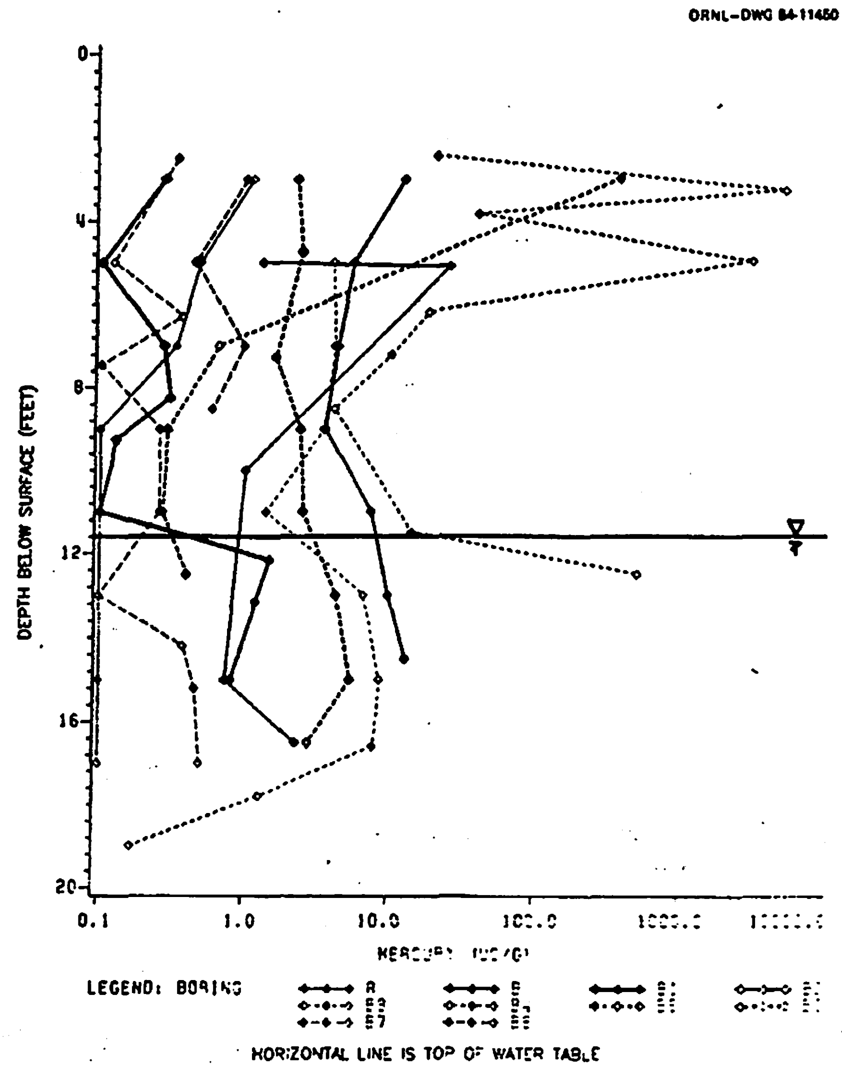

Fig. 18. Mercury concentrations in soil cores taken near building 9201-2.

personal communication). The site is generally underlain by 2 to 6 ft of fill material, beneath which is weathered shale of the Nolichucky Formation.

A total of 21 shallow borings (Fig. 19) were completed at the site during February 1984. At the same time, a shallow well was completed south of the site (well 53-1A). Of the 21 borings, 3 have been described (Appendix B) and sampled. All the samples analyzed have above-background mercury concentrations (>0.2 µg/g), but none of the samples had greater than 12 µg/g of mercury. Contamination appears to be restricted to the very shallow earth materials, and the highest concentration encountered was 7.80 µg/g (Fig. 20). It is estimated that about 15 lb of mercury are contained in the earth materials at this site.

6.5 RESULTS OF EXPERIMENTS WITH MERCURY VAPOR ANALYZERS

For extensive or long-range studies to be carried out, a rapid method of screening soils and subsurface materials for mercury contamination is needed. Cleanup operations especially would benefit from an in-field screening method, which would allow operations to be directed for maximum recovery while they are under way. Detailed mapping of zones of contamination without the need to refer to hundreds of laboratory analyses would also be helpful. Therefore, attempts were made, using different monitors in the laboratory and in the field, to measure mercury vapor concentrations as an indicator of soil concentrations.

Use of a simple vapor monitor (Bacharach Model MV2) held over soil or rock cores can, at best, provide only qualitative data. Initially, we improved slightly on this procedure by placing the unopened Shelby tubes into a length of 4-in.-diam PVC pipe with endcaps drilled to accept tubing connectors. One end of this pipe isolation chamber was connected to an MSA MercSorb respirator cartridge to remove mercury and other air contaminants in the inflowing air. The other end was

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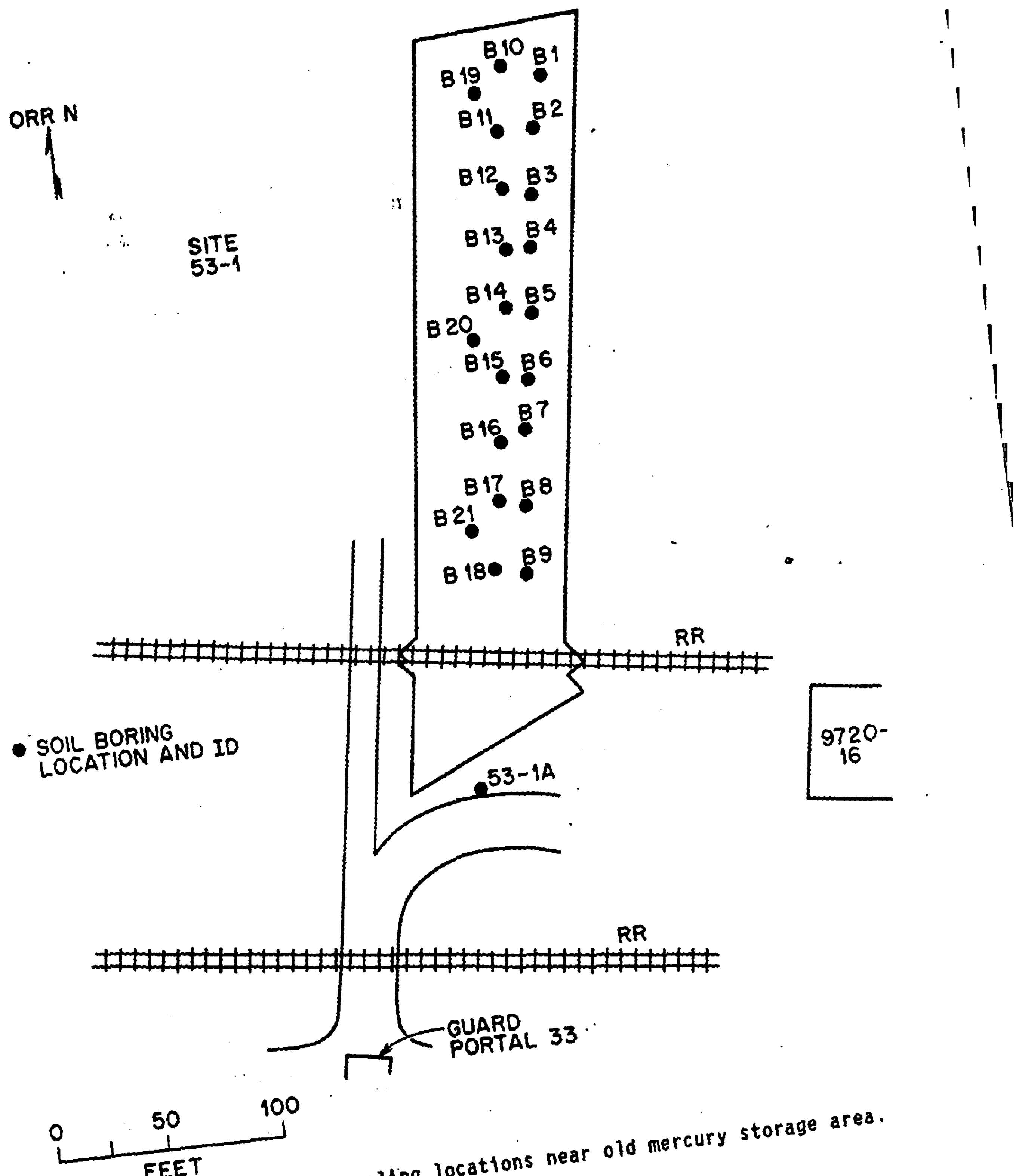

Fig. 19. Phase II sampling locations near old mercury storage area.

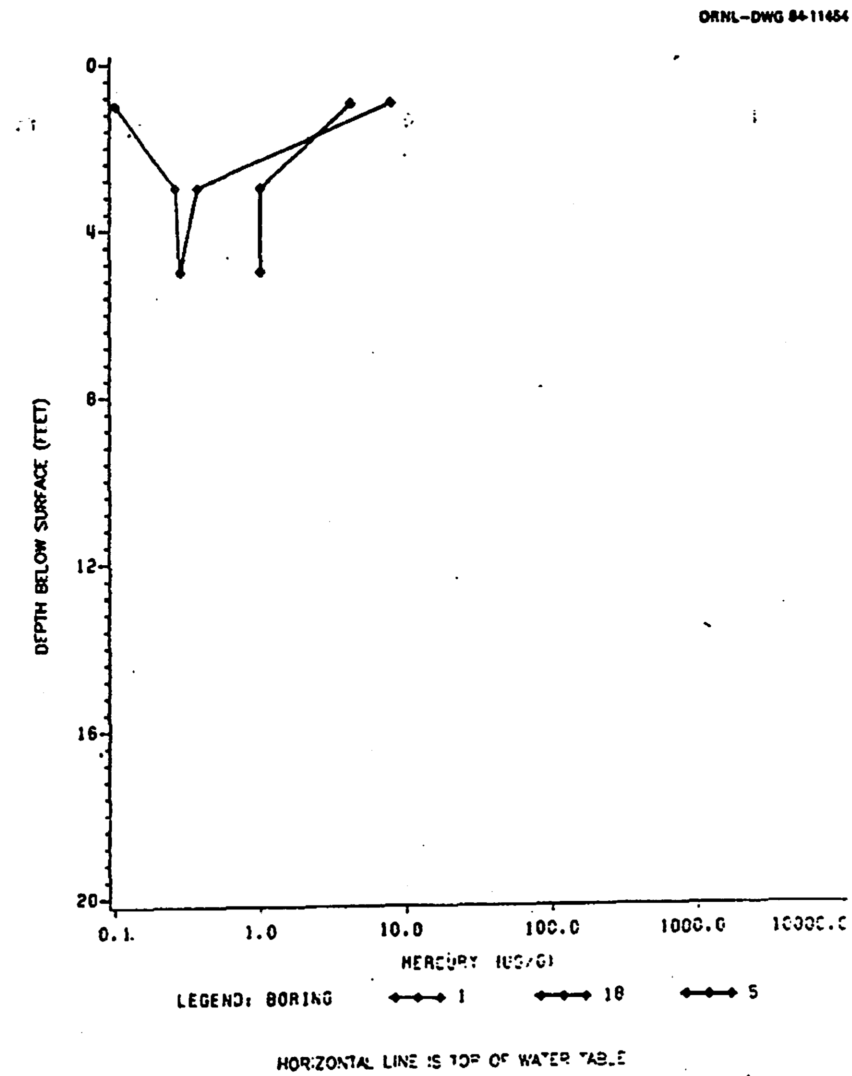

Fig. 20. Mercury concentrations in soil cores taken near old mercury storage area.

connected to a Bacharach Model MV2 portable mercury monitor. Operating the monitor in this configuration for 10 to 15 min usually gave stable readings. High mercury vapor readings were obtained for some, but not all, of the Shelby tubes, which were subsequently found to contain elevated mercury levels by wet chemical analysis.

Based on our limited success with the Bacharach monitor and crude isolation chamber, a decision was made to evaluate a more sensitive mercury monitor, the Jerome Model 411 gold film mercury vapor analyzer attached to a smaller, more sophisticated isolation chamber. The Jerome monitor was made available to us for only a few days by the Y-12 Industrial Hygiene group, so we could not fully explore its potential. Nonetheless, enough data were obtained to demonstrate merit in further studies.

Figure 21 depicts the experimental apparatus employing the Jerome monitor. The sample chamber has a volume of 650 mL and, thus, at the air intake flow rate (12.5 mL/s) of the Jerome, about 1 min is required to replace the air in the empty chamber. Air is pulled though the chamber, using the external air pump, at a flow rate equal to that of the Jerome. After several minutes, the valve (stopcock) is switched to the Jerome for a 10-s sampling period. Mercury readings are taken until a steady-state value is obtained by alternating the airflow between the Jerome and the external pump. Preliminary work without continuous flushing of air through the chamber resulted in rapid saturation of the gold film for even small (100 mg) samples containing 126 µg Hg/g. Continuous chamber flushing at the same flow rate used by the internal Jerome air pump results in a steady-state vapor concentration that may be related to the total mercury content of the sample in the chamber.

Interestingly, one sample containing 52 µg Hg/g yielded essentially no mercury vapor, whereas another sample containing 126 µg Hg/g yielded vapor in nearly direct proportion to the weight of the sample in the chamber (Table 9). This suggests that some samples contain

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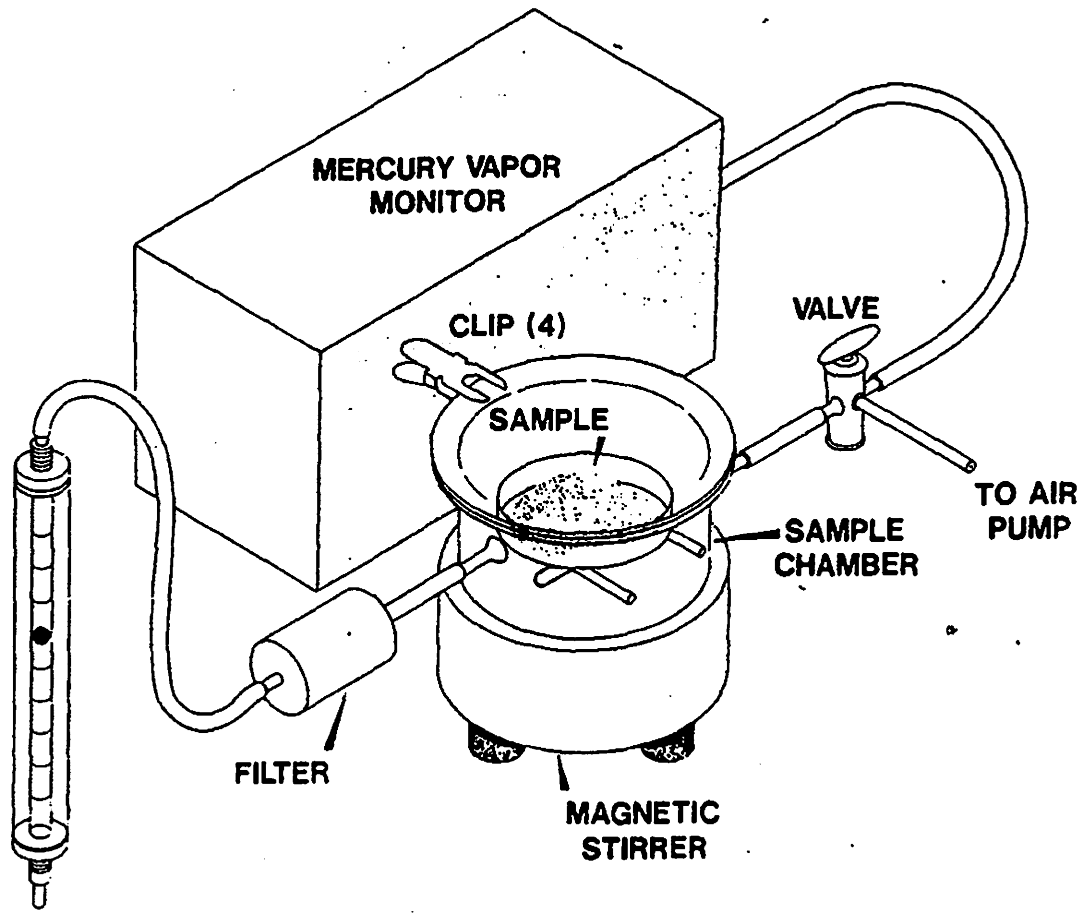

Fig. 21. Laboratory setup for testing mercury vapor analyzer for us in screening soil samples.

Table 9. Results of mercury vapor concentration in air over different amounts of sample 4B-7 held in 655-mL chamber with air flow of 750 mL/min (total mercury in sample 126 µg/g)

	Weight of sample (g) 1.000	2.000
Concentration of mercury vapor[a] (mg/m^3)	0.050	0.126
	0.060	0.159
	0.055	0.160
	0.057	0.141
	0.060	0.139
	0.050	0.147
	0.063	0.140
	0.060	0.143
	0.062	0.148
	0.057	0.144
	0.072	0.124
	0.068	0.124
	--	0.121
		0.123
	--	0.121

[a]Successive 10-s sampling periods.

volatile mercury while others do not. The absence of vapor over a sample containing 52 µg Hg/g illustrates one flaw in this approach, i.e., the assumption that any mercury in the sample is in a form permitting a significant vapor phase.

Although most of the difficulties with the apparatus and the Jerome monitor have been worked out, further testing is required. If further exploration for mercury becomes necessary, apparatus similar to that described here could be very useful for quickly determining whether elevated mercury levels are present in samples from a given area. Although this approach might incorrectly classify some samples or areas as uncontaminated, it has a high probability of detecting mercury in samples containing microscopic beads of mercury such as have been observed in soils from known spill areas (buildings 9733-1, 81-10, 9201-2). The main improvement in the apparatus would be to modify the Jerome to operate on 110 V ac. With samples having a high mercury content, even small sample weights rapidly saturate the gold film. Without ac operation, gold film purging quickly depletes the batteries, which require 14 h to recharge.

7. GROUNDWATER CHEMISTRY

7.1 SAMPLING AND ANALYSIS PROCEDURES

After all wells were developed, samples were collected for analysis of major anions and cations, trace elements, alkalinity, and uranium (in addition to mercury analysis and field measurements). The same sampling procedures described previously were used. Most wells were sampled at least twice during the study with the exception of a few deep wells, which were sampled only once. The major cations and trace metals were analyzed using inductively coupled plasma emission spectroscopy (Method 200.7, USEPA Report 600/4-79-020; USEPA 1979). Analysis of anions was by ion chromotography (Method 300.0, USEPA 600/4-84-017; 1984 addendum to USEPA 1979). Analyses for uranium were run using a fluorometric technique for uranium in water (Method EC-191, UCC-ND Environmental and Effluent Analysis Manual).

7.2 RESULTS OF WATER ANALYSES

The results of the analytical program and graphical displays of sample charge balances are included in Appendix F. The groundwater at the study site is generally of the Ca-Mg/HCO_3 type. The relative importance of other ions varies, depending on the well; it should be noted that in many cases, anthropogenic inputs account for a major portion of the total charge balance (Cl, SO_4, and NO_3). For example, in well 55-2B, NO_3 accounts for almost 15% of the total ionic equivalency and in well 53-1A NO_3 accounts for nearly 100% of the total ionic equivalency. (Appendix F). Calcium was the dominant cation in the latter well.

As an aid in assessing geochemical conditions within the various geologic formations underlying the Y-12 Plant, water samples from the different formations were compared. Figures 22 to 24 show the ion balances for water samples taken from the three formations: Maryville Limestone (wells 55-4, 55-5, and 55-6), Nolichucky Shale (wells 54-1, 54-2, 55-1, 55-2, 55-3, 56-1, 56-2, 56-3, 56-4, 56-6, 58-1, and 59-1), and Maynardville Limestone (56-5, 56-7, 56-8, 56-9, 58-2, 60-1,

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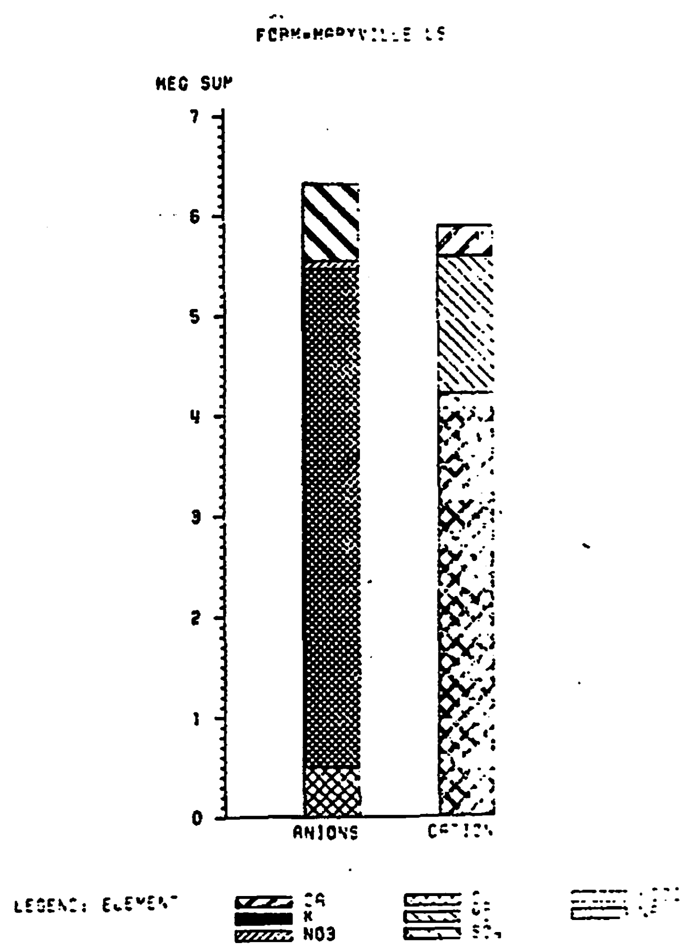

Fig. 22. Ion balance for groundwater samples from wells completed in the Maryville Limestone. Represents average of all samples.

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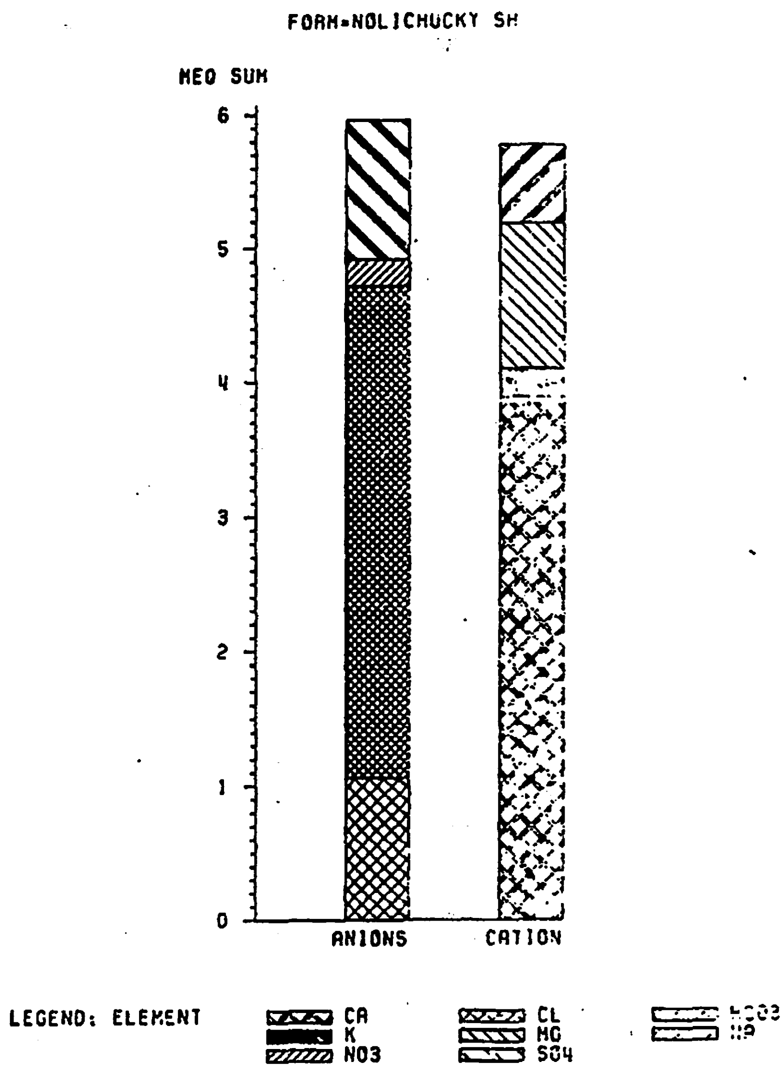

Fig. 23. Ion balance for groundwater samples from wells completed in the Nolichucky Shale. Represents average of all samples.

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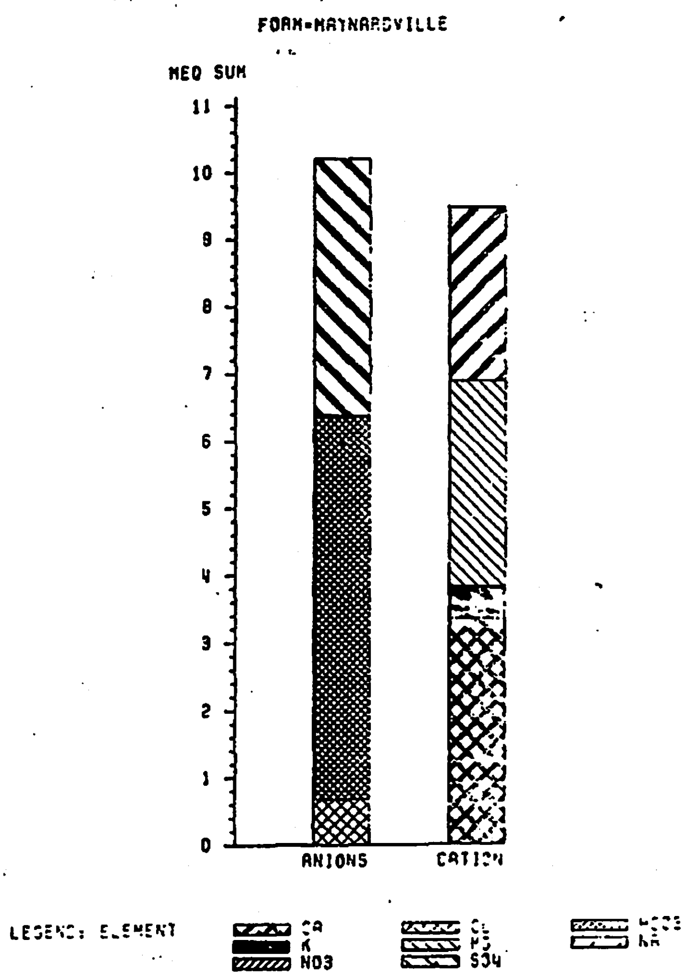

Fig. 24. Ion balance for groundwater samples from wells completed in the Maynardville Limestone. Represents average of all samples.

and 60-2). To analyze differences between the groups of wells, a Waller-Duncan K-ratio t-test (SAS Institute 1982) was used (Table 10). The analysis yields six statistically significant differences between the groups of samples:

1. Water from the Maynardville Limestone contains a high concentration of SO_4 which is most likely a result of the location of the coal pile.
2. The formation waters contain lower amounts of silica down-section; silica concentrations are highest in the water from the Maryville Limestone and lowest in water from the Maynardville Limestone. This pattern is concordant with the relative amounts of siliceous rock in the formations of the Conasauga Group.
3. Alkalinity is lowest in water of the Nolichucky Shale, which is indicative of the relatively low carbonate content in this formation.
4. Differences in potassium concentration are observed, but they may be due to large variations in detection limits. Note that, for statistical analysis, "less than" values were treated as equivalent to the detection limit.
5. The Ca:Mg ratio is lower in the Maynardville Limestone than in the other formations; this is probably a result of a relatively high magnesium concentration in groundwater discharge from the Knox Dolomite underlying Chestnut Ridge.
6. Sodium, manganese, and magnesium concentrations are all highest in water from the Maynardville Limestone.

Comparisons of water constituents with depth were also made, but the overall results do not appear to be significant. By comparing wells at a given location (Appendix F), trends and variations can be seen. For example, alkalinity, SO_4, and uranium were generally highest in the shallowest well of a nest and decreased with increasing depth. In contrast, NO_3 was generally highest in the deepest well of a nest and exhibited increasing concentrations with depth.

Several chemical species are useful as indicators of groundwater contamination: SO_4, NO_3, and chloride. Electrical conductance and alkalinity can also be indicators of groundwater contamination. These five indicators were mapped (Figs. 25-29) using mean values of

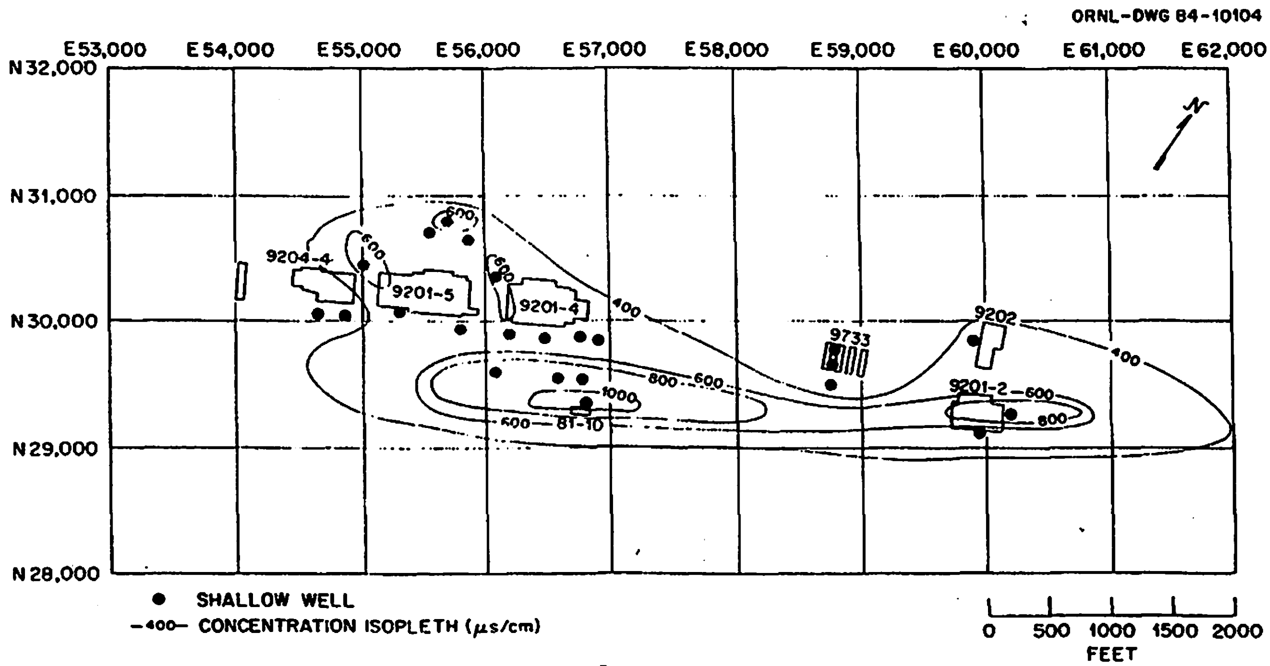

Fig. 25. Electrical conductance in shallow groundwater at the Y-12 Plant.

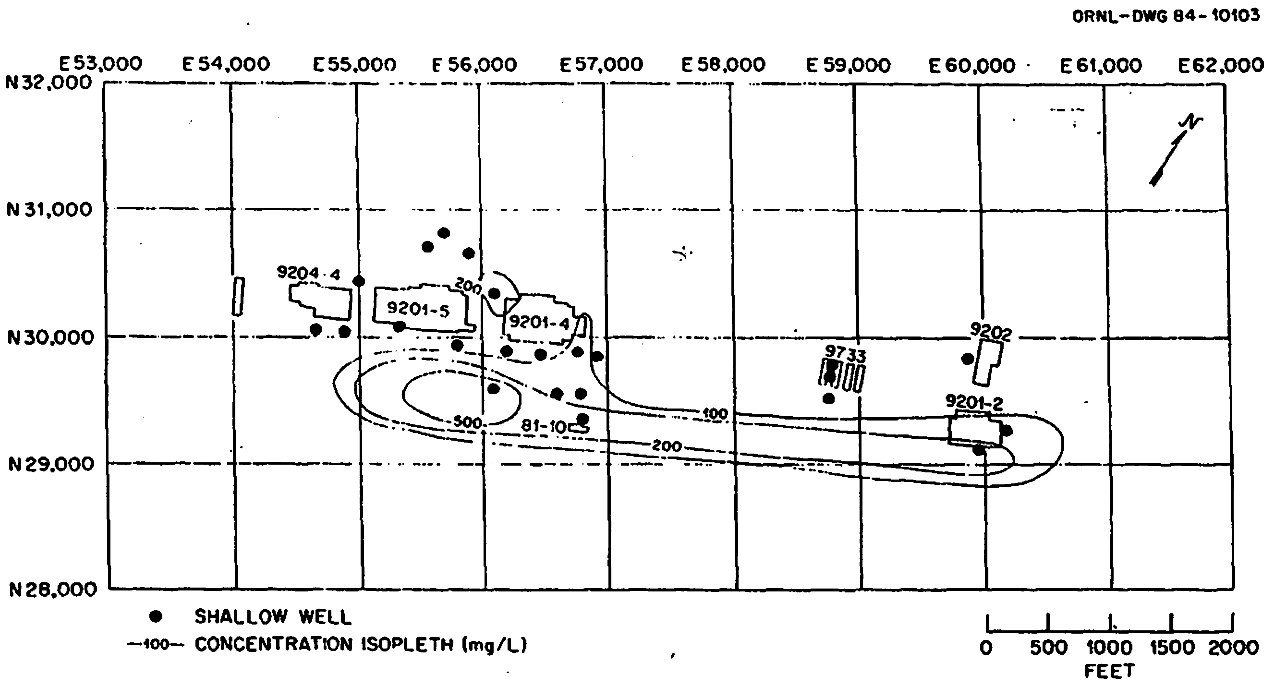

Fig. 26. Concentration of SO_4 in shallow groundwater at the Y-12 Plant.

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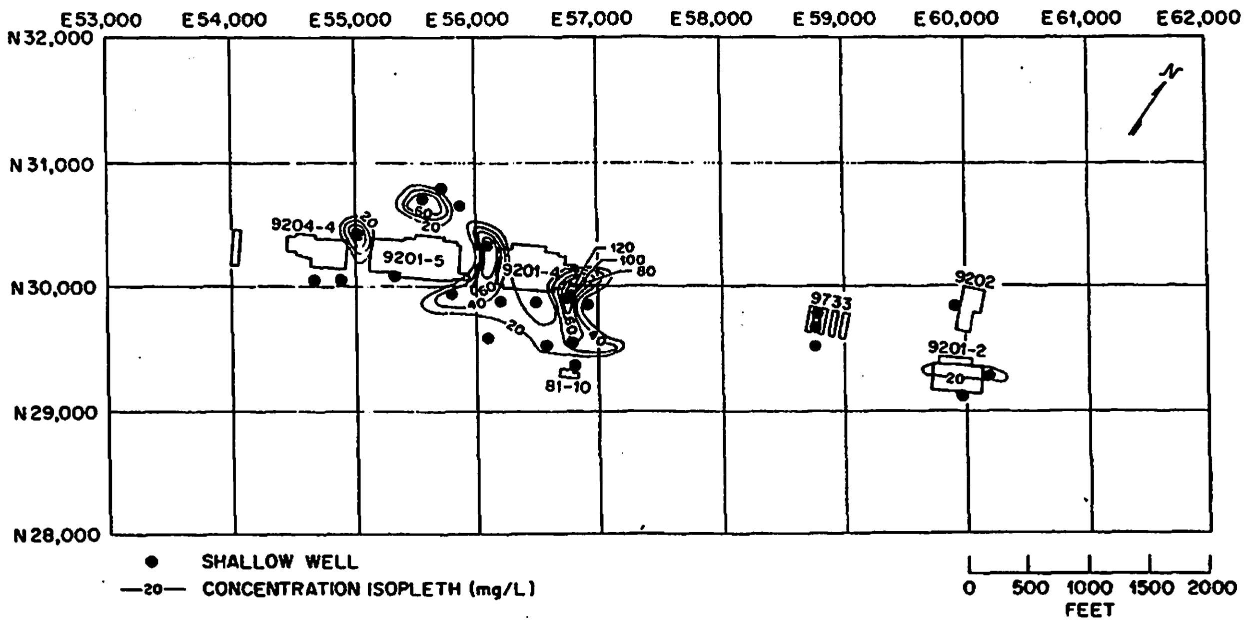

Fig. 27. Concentration of chlorine in shallow groundwater at the Y-12 Plant.

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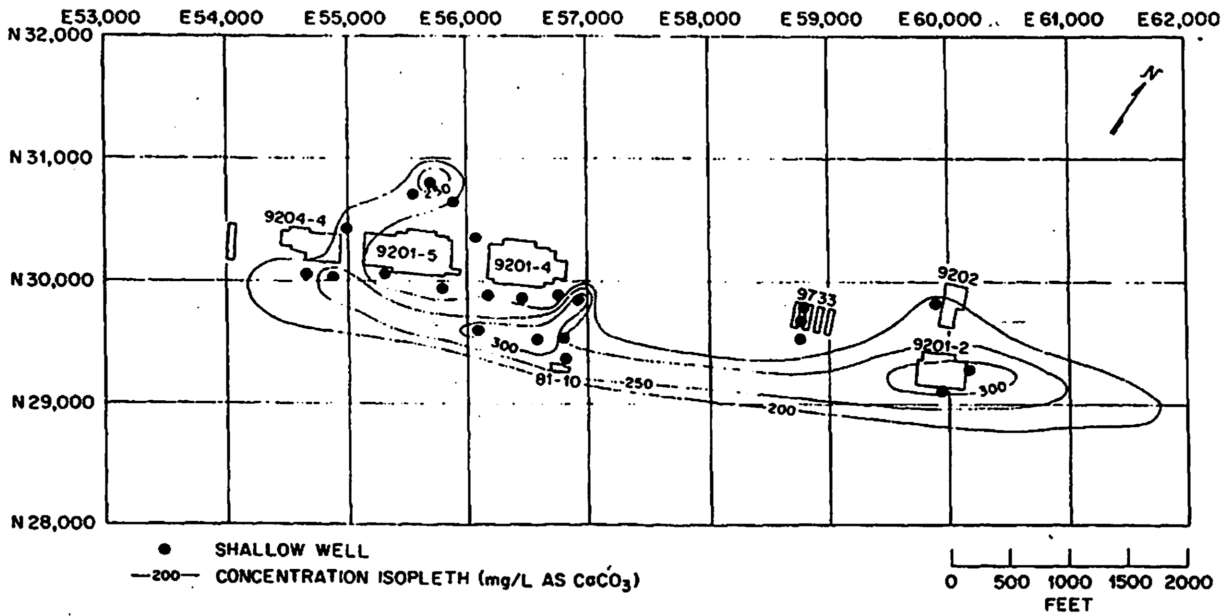

Fig. 28. Alkalinity of shallow groundwater at the Y-12 Plant.

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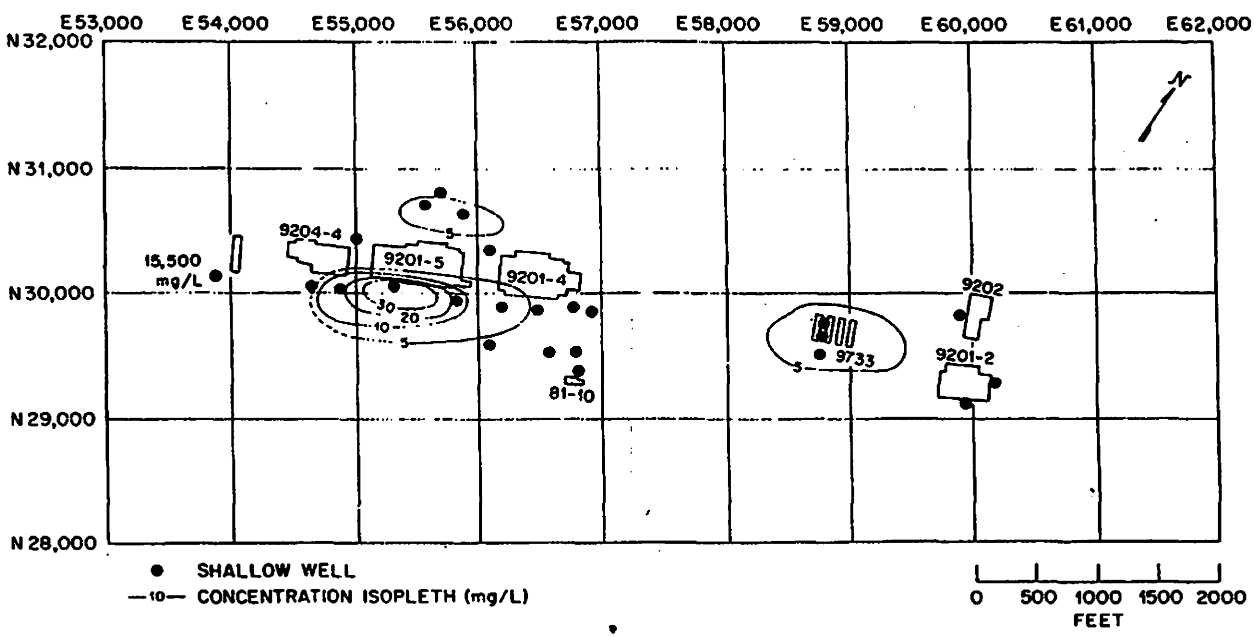

Fig. 29. Concentration of NO_3 in shallow groundwater at the Y-12 Plant.

Table 10. Means* for selected Y-12 groundwater constituents as a function of geologic formation

	Detection limit	Maryville	Maynardville	Nolichucky**
pH		6.8[b]	7.4[a]	7.2[a,b]
EC		609.0[a]	723.0[a]	545.0[a]
Alk		248.0[a]	284.0[a]	183.0[b]
NO_3	(0.04 to 0.5)	5.15[a]	1.85[a]	9.05[a]
SO_4		37.0[b]	184.0[a]	50.0[b]
Cl		17.8[a]	23.8[a]	36.4[a]
Ca		81.0[a]	67.0[a]	72.0[a]
Mg		16.7[b]	37.4[a]	13.2[b]
Na		7.0[b]	59.4[a]	13.5[b]
K	(4 to 54)	6.1[b]	18.2[a]	8.3[b]
Si		8.67[a]	3.53[c]	5.17[b]
Mn	(0.02)	0.40[b]	1.40[a]	0.33[b]

*For a given row, means followed by the same letter (a, b, c) are not significantly different at the 5% level (Waller-Duncan K-ratio t-test).

**Exclusive of Well 53-1A.

concentrations for shallow wells in the Y-12 Plant. The most striking feature of the plumes is the apparent high concentrations within the old UEFPC channel and the solution system surrounding the old creek. That is, subsurface flow is controlled by the creek-fill-solution cavity system, and the system probably acts as a "collector" or drain for the plant site. It is also apparent that concentrations of indicator species are high in groundwater and that the groundwater is not necessarily discharging into UEFPC adjacent to the apparent sources. It should be noted that although high concentrations of various constituents are found in the old UEFPC channel and its tributaries, sampling bias may exist; i.e, most wells were placed in these channels to intercept potentially contaminated groundwater.

The concentration isopleths on the maps (Figs. 25-29) are very similar to each other, but there are important differences. The isopleths for electrical conductance indicate areas significantly above background (100 to 200 µs/cm) in the old UEFPC valley (Fig. 25). There does not appear to be a single source for the high conductance, although it is highest just east of the Y-12 coal pile. Because no wells have been installed west of the coal pile, it is not known if the high conductivity plume extends to or originates west of the coal pile (such as at the S-3 ponds). The isopleths for SO_4 in groundwater indicate a plume that probably originates at the Y-12 coal pile and extends down valley (east) to at least building 9201-2 (Fig. 26). There also appears to be a source of SO_4 north of buildings 9201-5 and 9201-4. Groundwater near the coal pile and north of buildings 9201-5 and 9201-4 approaches or exceeds the drinking water standard (250 mg/L) for SO_4. Concentrations of chloride are quite high in isolated localities north of UEFPC, indicating sources in or near buildings 9201-5, 9201-4, and 9103 (Fig. 27). These small plumes appear to be related to old tributaries to UEFPC (see Fig. 6). The map giving the alkalinity of groundwater (Fig. 28) indicates that various sources exist, with concentrations being highest near buildings 9201-4, 9201-2, and 9103.

The concentration of NO_3 in groundwater is quite high at the plant (Fig. 29). Nitrate is generally a good indicator species for contamination and is a contaminant itself; NO_3 is also attenuated to a very low degree by movement through geologic media, i.e., it is generally considered to be "conservative" in nature. Taken together the data for the wells south of 9204-4, 9201-5, and 9201-4 suggest the presence of a plume (Fig. 29) of high NO_3 groundwater centered beneath or immediately south of 9201-5. Well 53-1A, located west of this area and about one-half the distance to the S-3 ponds, exhibited extremely high NO_3 levels (15,500 mg/L). It is highly likely that the high NO_3 (up to 83 mg/L) groundwater south of 9201-5 is related to the extremely high NO_3 groundwater at Well 53-1A but the well density between the two areas is too sparse to define the boundaries of the plume. The S-3 ponds are almost certainly implicated in the high NO_3 levels at Well 53-1A and probably implicated in the high NO_3 levels in deeper groundwater south of 9201-5. The national primary drinking water standard (NPDWS) for NO_3 is 45 mg/L (USEPA 1976) and thus groundwater from Well 53-1A greatly exceeds the NPDWS. Deeper groundwater (Wells 55-2B and 55-2C) south of 9201-5 exceeds the NPDWS by about a factor of 2.

Analyses for uranium were also run on the water samples because of the large number of possible source terms in the Y-12 Plant. Most of the uranium values were quite low (<0.01 mg/L); only three wells had greater than 0.01 mg/L (55-2A, 55-5A, and 56-5A). The highest concentration encountered was in well 56-5A (0.17 mg/L); the source may be materials that were stored at building 81-10 until the initiation of drilling for this project. Typical uranium concentrations in fresh groundwater from nonmineralized areas range from <0.001mg/L to 0.01mg/L (Rogers and Adams 1970). Concentrations in mineralized areas (near ore bodies) range up to 0.46mg/L.

8. CONCLUSIONS AND RECOMMENDATIONS

The results of this study provide data in two areas: first, the basic hydrogeology of the Y-12 Plant, including the geology, the groundwater flow system, and basic groundwater chemistry; and second, the extent and nature of subsurface mercury contamination in the plant, both in earth materials and groundwater. Table 11 summarizes the number and types of samples collected during this 9-month study (August 1983 to April 1984).

The geology of the site was characterized by means of field mapping, core drilling and logging, and analysis of previously collected data. The area of study is underlain by four formations of the Conasauga Group, from youngest to oldest: the Maynardville Limestone, the Nolichucky Shale, the Maryville Limestone, and the Rogersville Shale. Structural deformations are important to water movement within the Conasauga Group (strike and dip of bedding, faults, fractures, and folding), and the extensive solution cavity system in the Maynardville Limestone is likely to dominate subsurface movement of water in the valley. In order to gather further information on the orientation and number of fractures in the Conasauga Group, it is recommended that several observation pits be excavated. The hilly topography of the site prior to construction of the plant has been greatly altered, and fill material plays an important role as the uppermost hydrostratigraphic unit.

The hydrology of the site was investigated through the installation of 43 monitoring wells from which data on groundwater chemistry, water level fluctuations, and aquifer properties were collected. The hydrology of the site has been greatly impacted by plant construction and topographic alterations. Groundwater flow is generally north to south toward UEFPC. The original UEFPC channel appears to dominate the flow system, this is probably due to the original solution cavity system that is associated with it and to the more permeable (than surrounding rock) fill material used to recontour the surface water

Table 11. Inventory of samples and sampling points

Monitoring wells installed	43
Analyses of mercury in soils and well sediment	430
Analyses of mercury in groundwater	113
Analyses of mercury in drilling waters	31
Analyses of uranium in groundwater	59
Analyses for major cations and trace elements (ICP-OES)[a]	67
Analyses for major anions (IC)[b]	65

[a]Inductively Coupled Plasma-Optical Emission Spectroscopy.

[b]Ion Chromotography.

channels. After reaching the local discharge area (UEFPC), water then moves southeast. The permeability of the strata ranges from about 3.54×10^{-4} cm/s in the fractured and bedded rocks to essentially infinity where solution cavities are present. The location and temporal variability of the groundwater divide between the Bear Creek and UEFPC watersheds is uncertain and needs to be evaluated further.

To assess subsurface contamination by mercury in the plant, a total of 113 water samples and 430 soil/mud samples were analyzed. Samples were collected from many sites within the plant where contamination was suspected; after initial assessment of the data, four sites were studied in greater detail. In general, it does not appear that mercury is mobile in an aqueous phase. Many water samples had above-background mercury concentrations, but it was concluded that the mercury content of most of these sample was due to excessive amounts of sediment in the samples. No wells yielded clear groundwater samples with mercury concentration in excess of the NPDWS (2 µg/L), although three wells (two south of buildings 9201-5 and 9201-4 and one north of building 81-10) yielded clear samples that approached 50% of the NPDWS. Nine wells yielded clear groundwater samples suggestive of a low level of mercury contamination (0.1 to 1.0 µg/L), while 15 wells were essentially free of aqueous mercury contamination. Of the sites investigated, the soil column of building 81-10 was the only one that contained a very high concentration of mercury below the saturated zone (water table); this is likely to be the cause of the contaminated groundwater in this area.

Based on the cores from the four sites that were studied in detail, it is estimated that a total of approximately 7000 lb of mercury is contained in the soils and weathered rock of these areas (Table 12). Of the 7000 lb estimate, 50 lb (?) of mercury might be accounted for on the basis of the shallow contamination (but possibly large areal extent) of other areas in the plants. Because of the extensive cavity system underlying a large portion of the plant, and two of the more contaminated areas in particular (buildings 81-10, 9201-2), an

Table 12. Estimate of mercury content in soil, fill, and weathered rock

Site	Mercury content (lb)
Old mercury storage area (well 53-1)	15
81-10 area (well 56-5)	2800
9733 alcoves (well 58-1)	1300
9201-2 area (well 60-1)	2700
Other areas	50 (?)
Total	6865

additional quantity of mercury may be held in solution cavities. Detection, investigation, and retrieval of mercury in solution zones is very hit-or-miss in nature, and none was encountered in this study. It appears that even if mercury is present in these zones, it is relatively immobile in the aqueous phase. Mercury held in solution cavities may be less mobile than mercury held in soil because of a decrease in its surface area (i.e., seams vs small beads) and because the mercury in soils tends to be exposed to varying geochemical conditions resulting from seasonal variations in water levels.

The results of this study indicate that the sites where the potential movement of mercury, and thus its exposure to the biosphere, is greatest is at the old mercury furnace at building 81-10 and at building 9201-2. At both sites the mercury levels in deeper fill are quite high and below the zone of saturation. The sites are in close proximity to UEFPC and the solution cavity system surrounding it; thus, flow paths to surface water bodies and the biosphere are short.

The results of the other groundwater chemistry analyses indicate that the groundwater within the plant is being impacted by a variety of sources. Plumes of NO_3, SO_4, and electrical conductance have all been identified. The contamination of groundwater by NO_3 is potentially the most important water quality problem in the plant (with regard to the analytical work performed in this study). Very high levels of NO_3 are present in groundwater from some areas, and contamination is present to relatively great depths (at least 75 ft). The origin of the NO_3 plume is uncertain; but the S-3 ponds are strongly implicated. The extent of groundwater degradation in the plants warrants further investigation and possible remedial action. Organic contaminants were not analyzed for in this investigation but should be included in future studies.

If field investigations of mercury contamination are to continue, it is recommended that the use of the mercury vapor analyzer be perfected as a field/screening tool. This effort will greatly streamline characterization and remedial studies, and will also save considerable analytical costs.

This study has covered a relatively short time span with regard to hydrologic variability, but the initial monitoring network has been installed and measurements have been made. It is recommended that both water level monitoring and water quality sampling be continued. These measurements will supplement the analysis of mercury contamination and of general groundwater quality in the plant.

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ENGLISH-TO-SI CONVERSION FACTORS

To convert from	to	multiply by
foot (ft)	meter (m)	0.30
inch (in)	centimeter (cm)	2.54
pound (lb)	kilogram (kg)	0.45

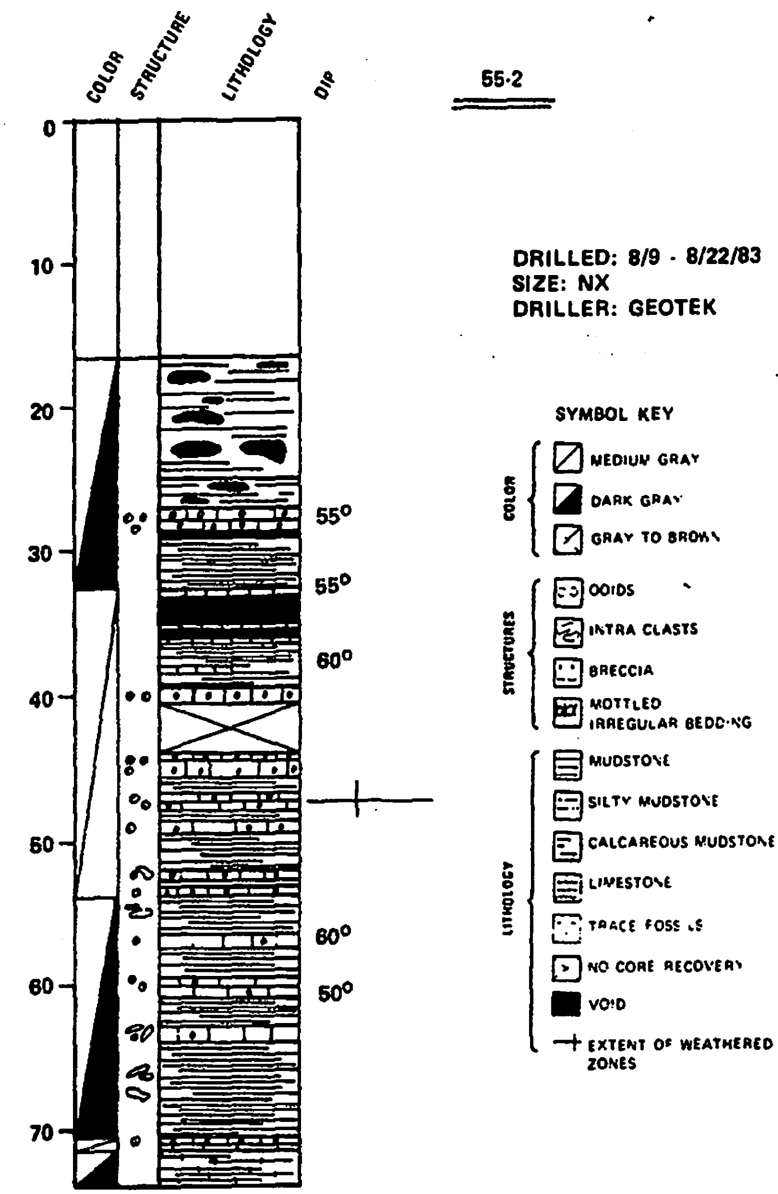
Appendix A

GEOPHYSICAL AND LITHOLOGIC LOGS

Appendix A

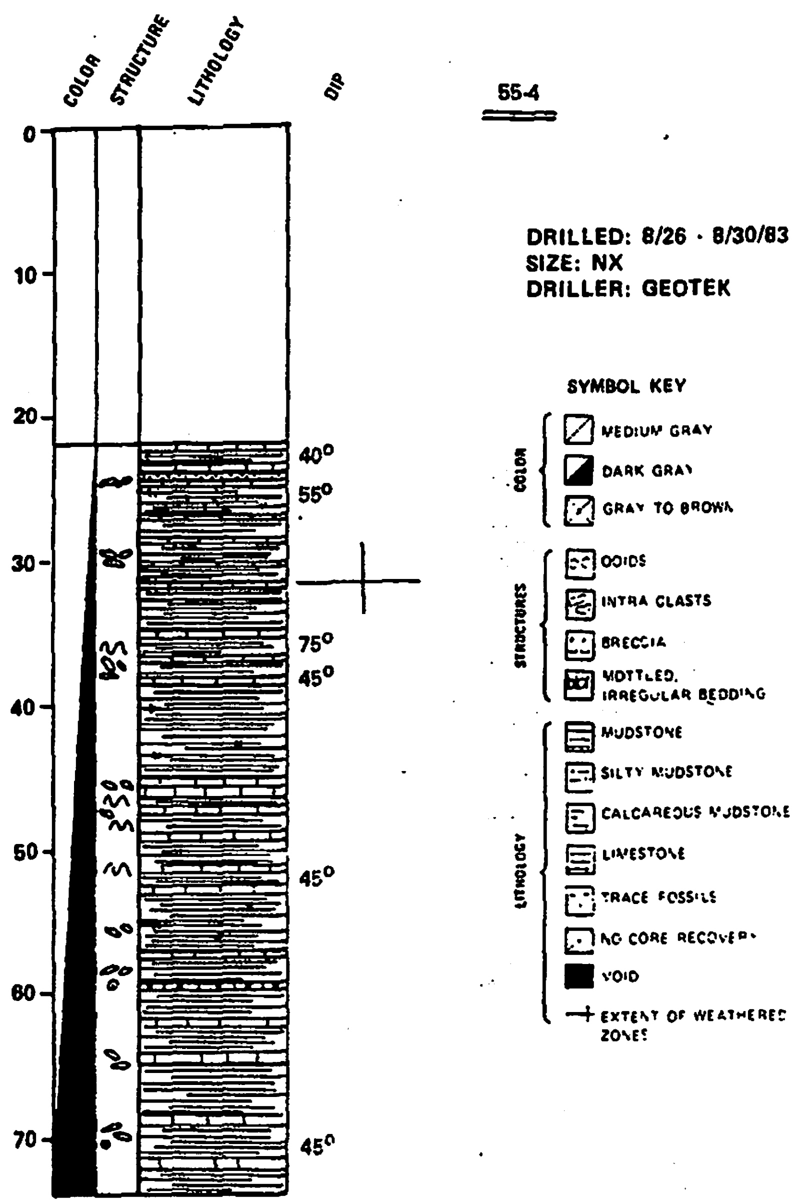
GEOPHYSICAL AND LITHOLOGIC LOGS

ORNL–DWG 84-1365



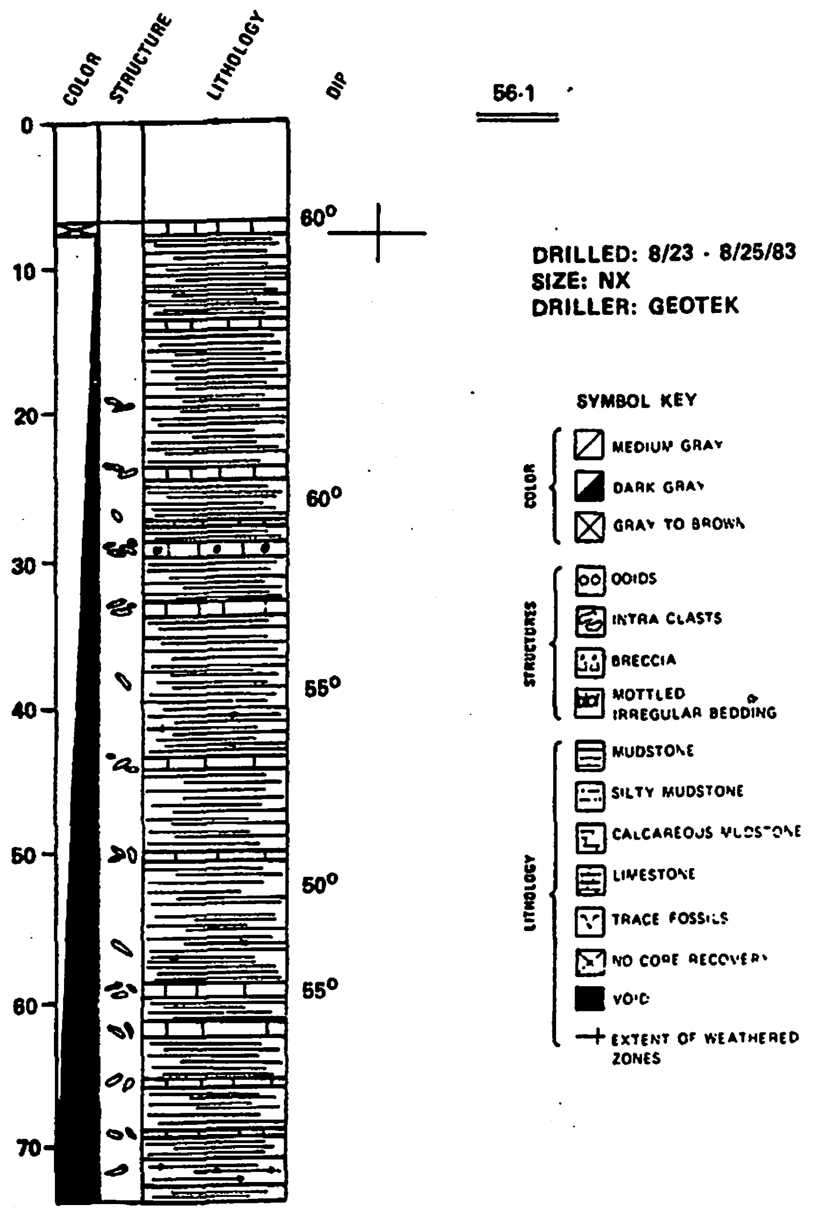
Appendix A (continued).

ORNL–DWG 84-1369



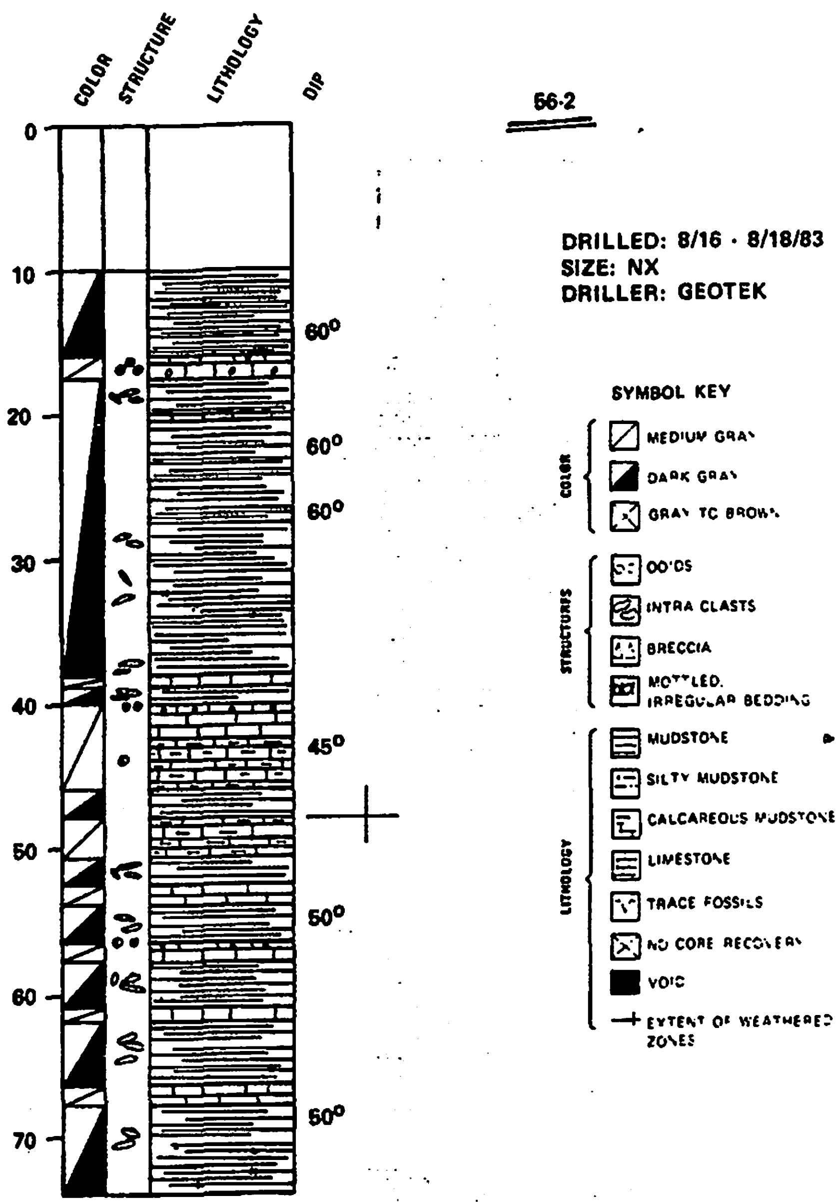
Appendix A (continued).

ORNL-DWG 84-1367



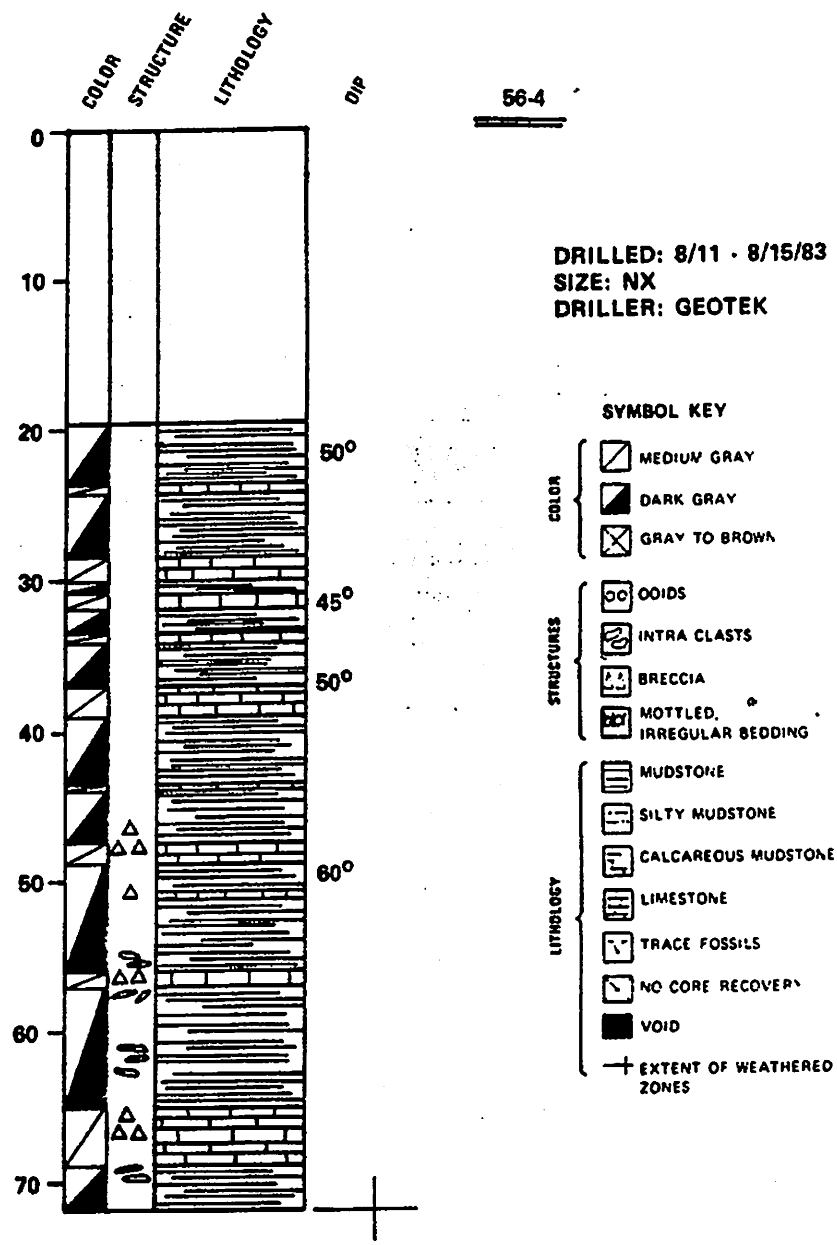
Appendix A (continued).

ORNL-DWG 84-1371

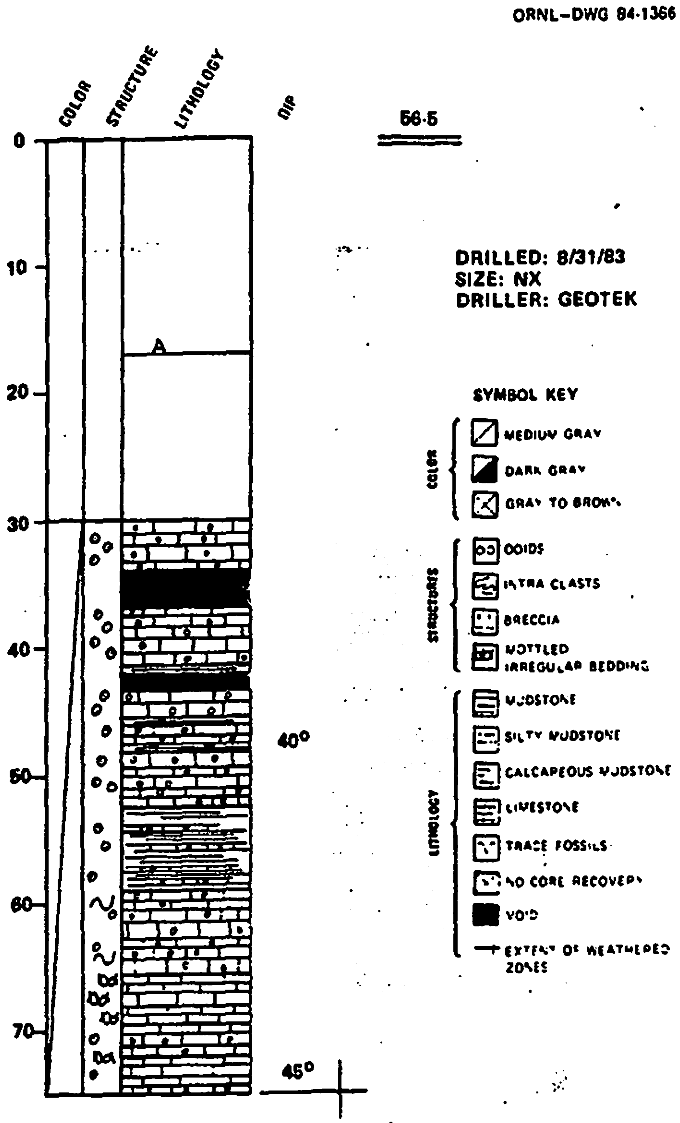


Appendix A (continued).

ORNL-DWG 84-1368



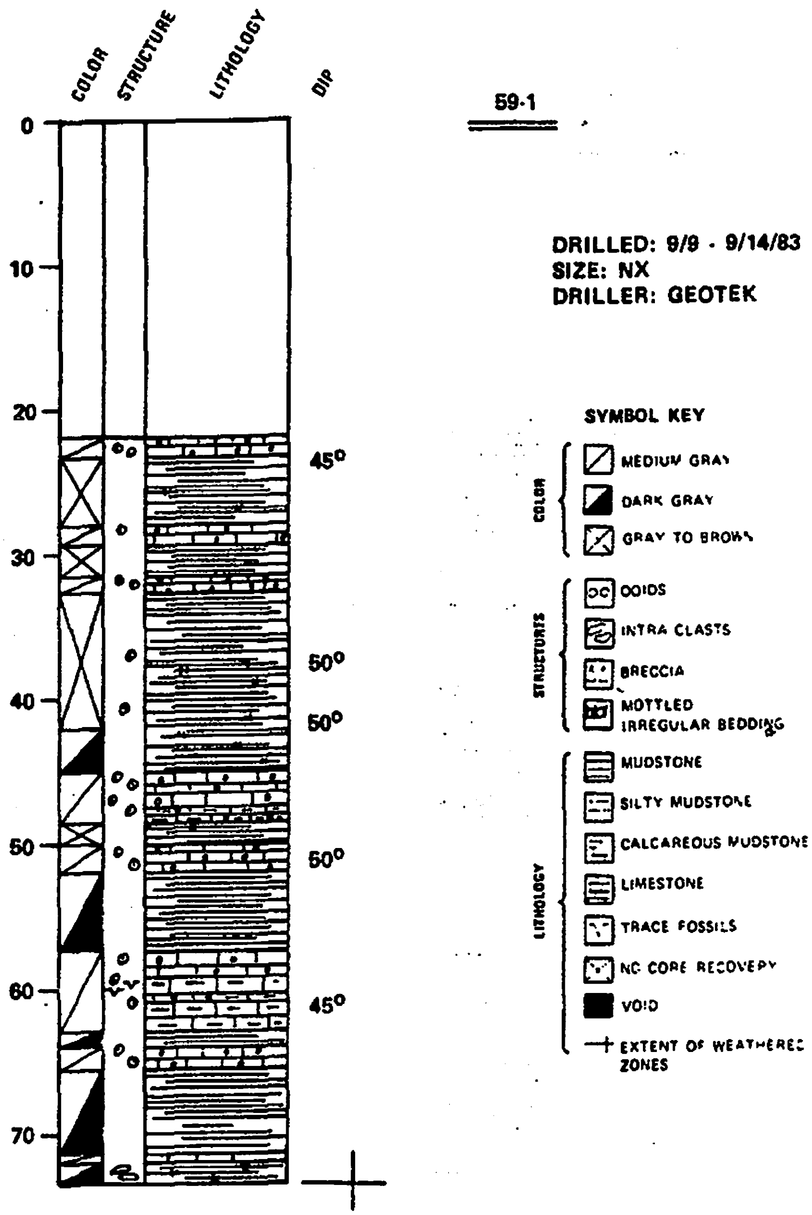
Appendix A (continued).



A– SOIL SAMPLES TAKEN TO 17'. WHEN CORING BEGAN, CASING WAS SET AT 17'. DRILL BIT THEN DROPPED TO 30'. FROM 17–30' IS PROBABLY VERY SOFT (SATURATED) FILL. (30' OF FILL HAS BEEN FOUND IN BORINGS NEARBY.)

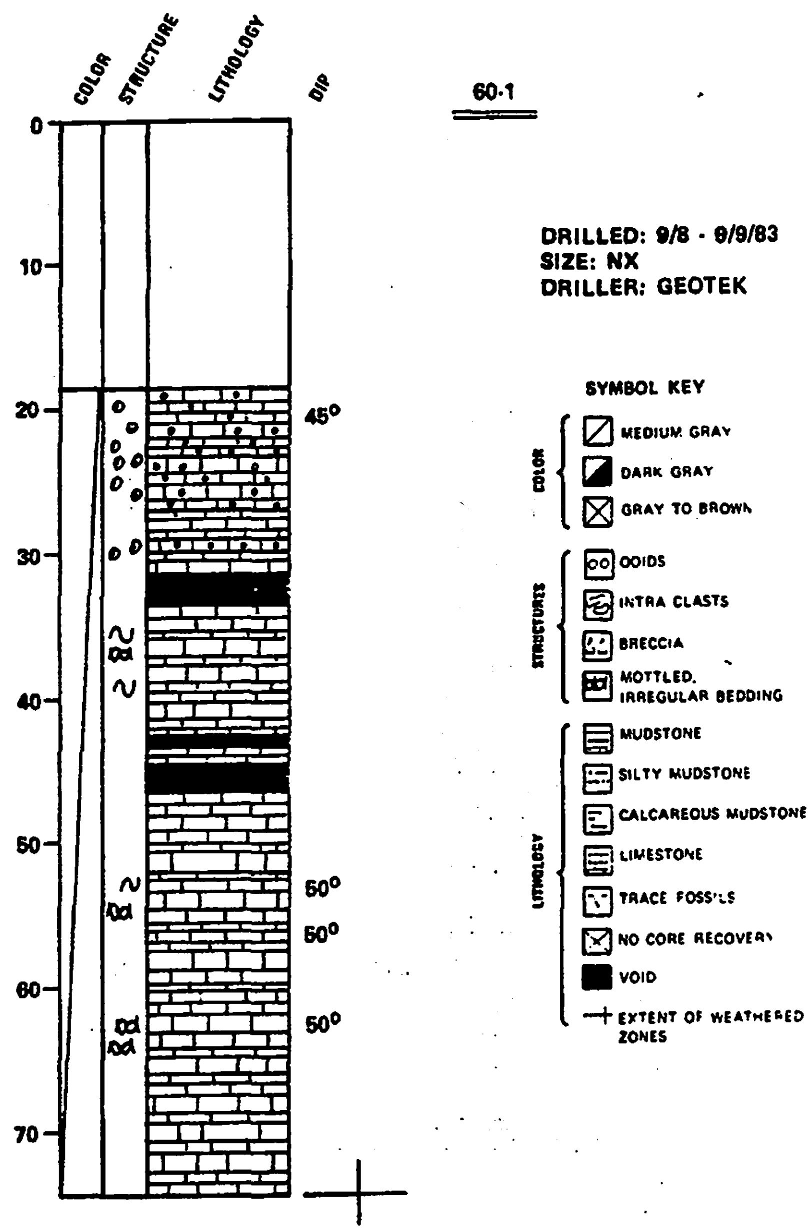
Appendix A (continued).

ORNL-DWG 84-1372

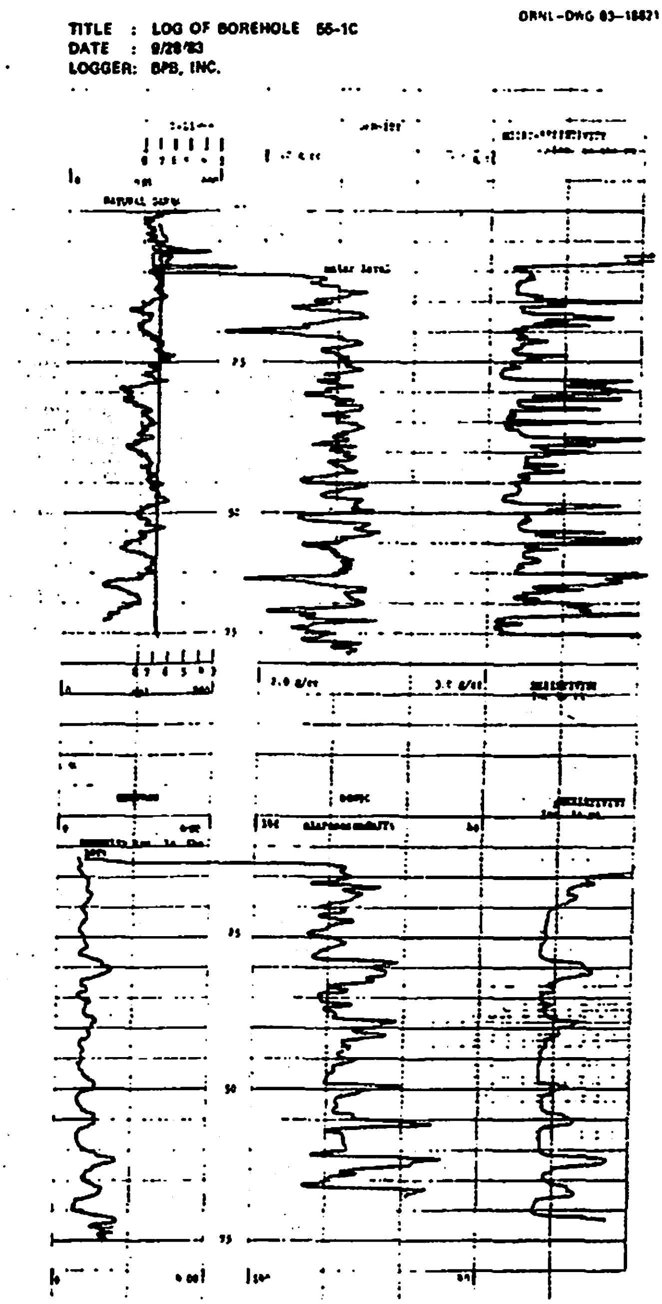


Appendix A (continued).

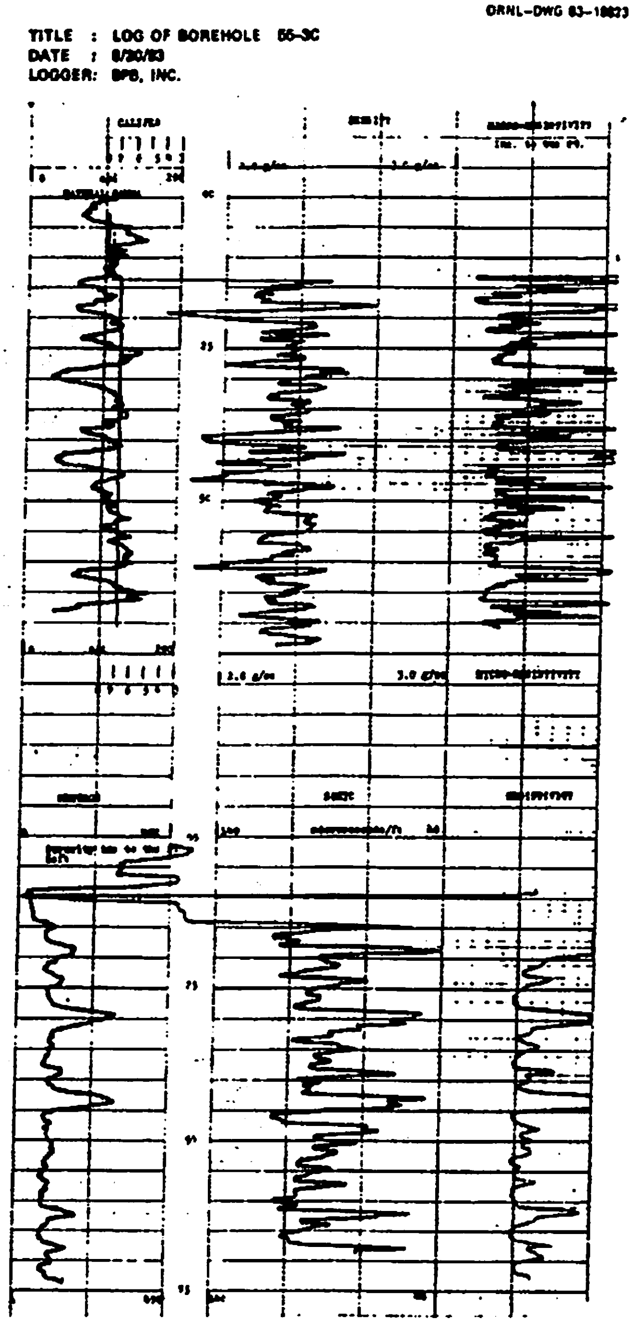
ORNL-DWG 84-1370



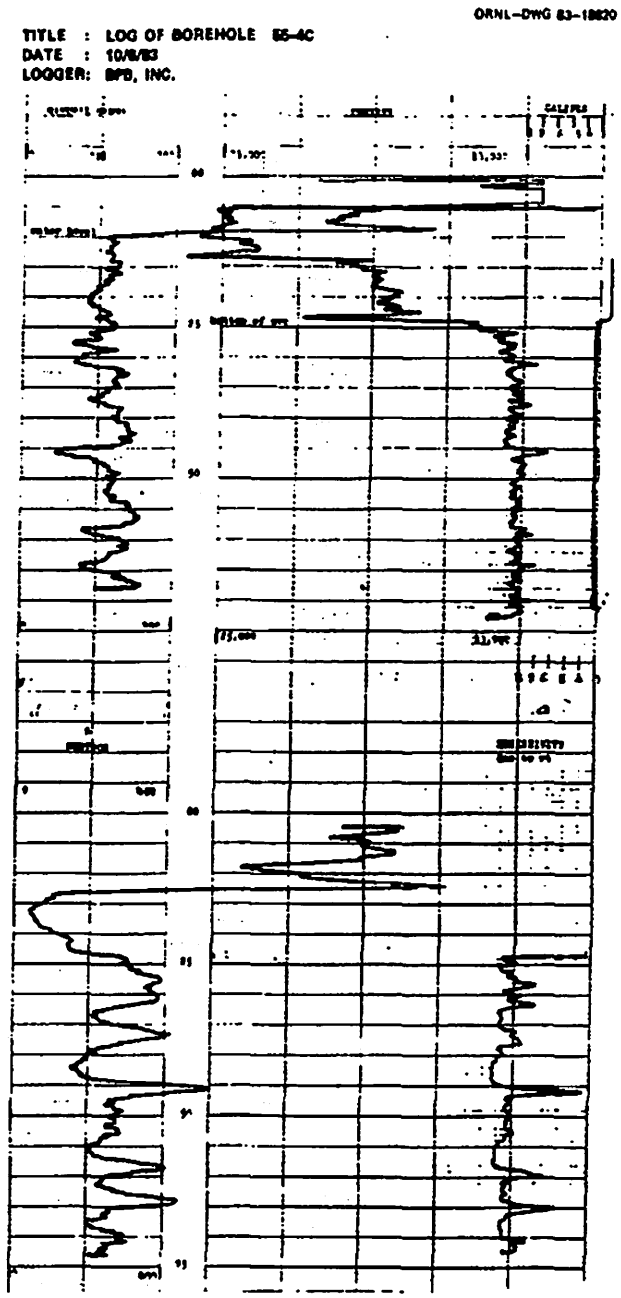
Appendix A (continued).



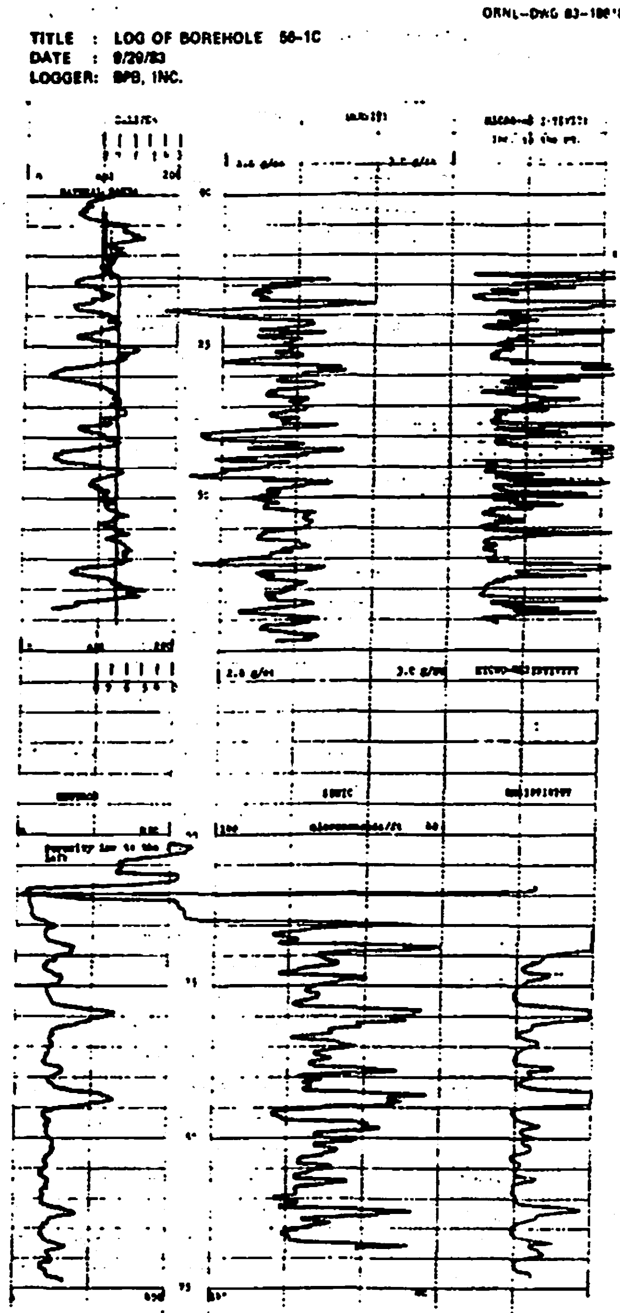
Appendix A (continued).



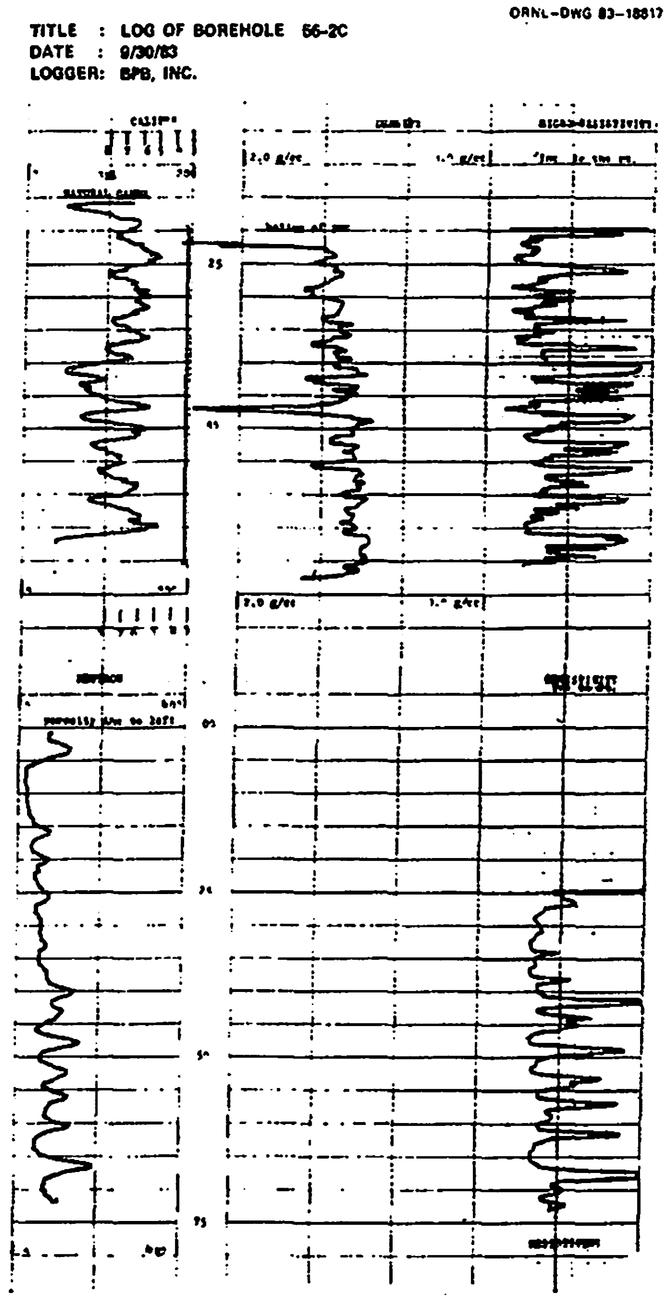
Appendix A (continued).



Appendix A (continued).



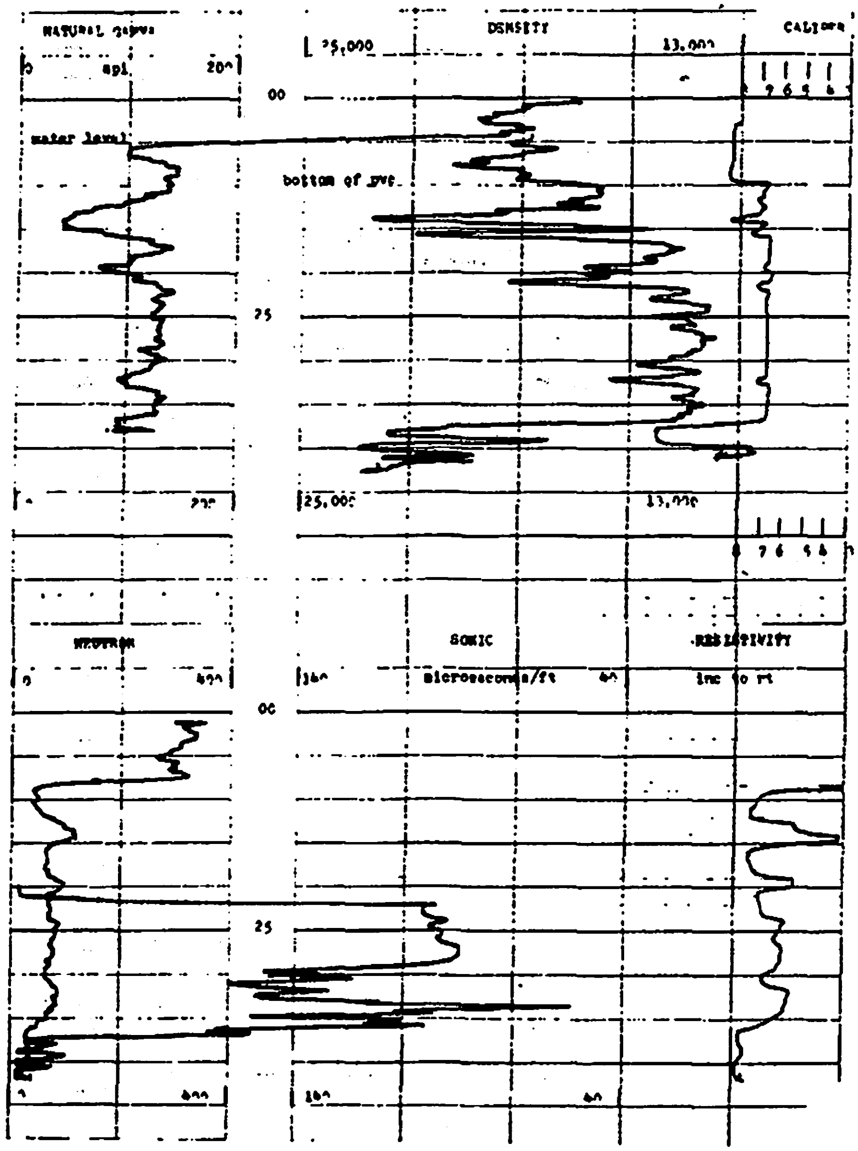
Appendix A (continued).



Appendix A (continued).

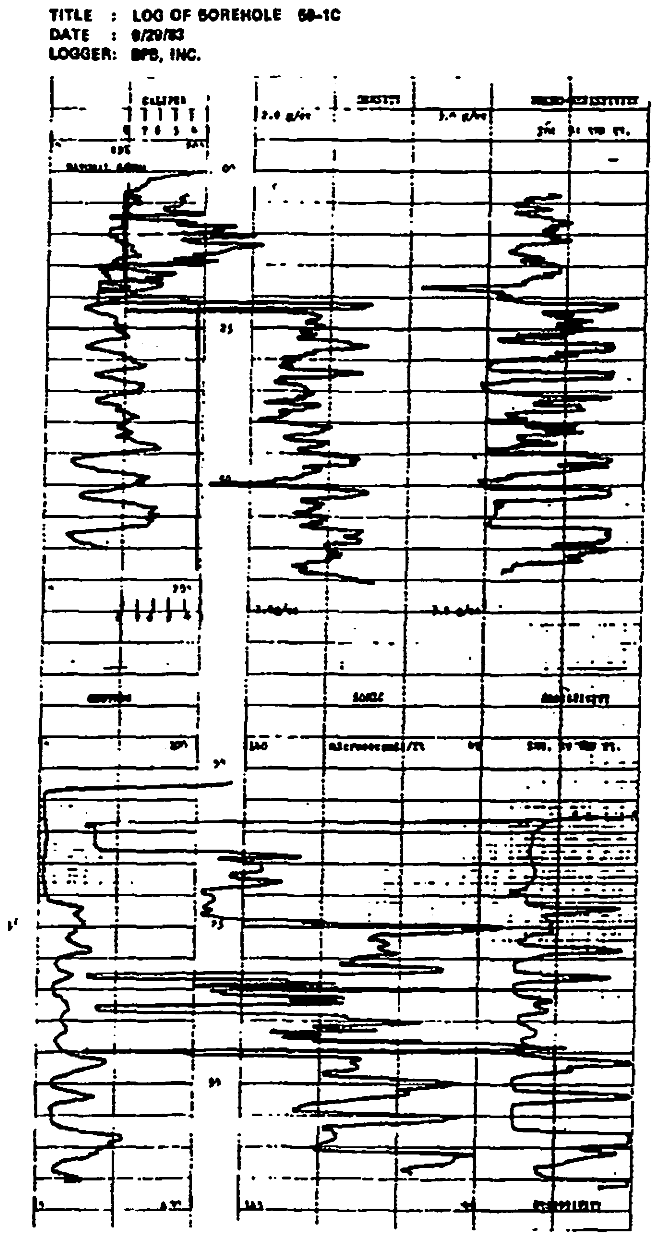
ORNL-DWG 83-18819

TITLE : LOG OF BOREHOLE 56-3C
DATE : 10/6/83
LOGGER: BPB, INC.



Appendix A (continued).

ORNL-DWG 83-18824

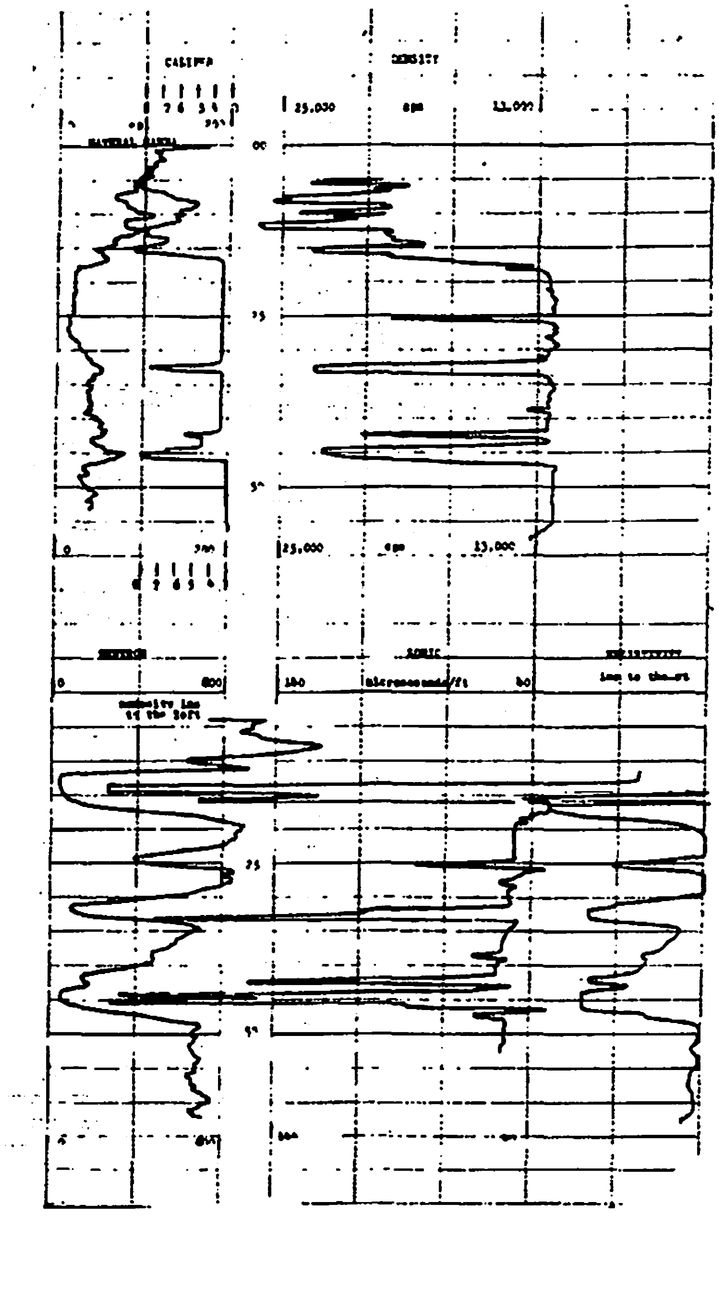


 6/12/2023 5:28:50 PM

Appendix A (continued).

ORNL-DWG 83-18822

TITLE : LOG OF BOREHOLE 60-1C
DATE : 9/30/83
LOGGER: BPB, INC.



Appendix B

LOGS OF SOIL BORINGS

Appendix B

LOGS OF SOIL BORINGS

LOG OF BORING

Boring No. 53-1/B1
Date 2-28-84
Location [illegible] Area

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		96		Loose soil and grass, underlain by 60/40 mix of clay and small clasts. Clasts are various hues of brown and gray
4	PS		67		~85% clay (10 Y 5/4, 5 Y 6/6, 5 YR 5/6), small (< 1/2" dia) shale clasts.
6	PS		100		Brown (10 YR 5/4, 5 YR 4/4) silty clay with streaks and specks of black, and few chert clasts (< 1/8" dia).
8					
0					
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 53-1;B5
Date 2-28-8-
Location Hy Stewart Area

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
	PS	\	79		TOP FEW INCHES SOIL AND ROAD GRAVEL. REMAINDER 50/50 MIX OF CLAY (5Y5/1 TO 5YR 5/6) AND SHALE CLASTS
2					
	PS	\	100		TOP 1 FT IS FILL, AS ABOVE. BELOW APPEARS TO BE [illegible], SHALE AND CLAY (5GY 5/1). DIP ~0-30° AT INTERFACE IS HORIZON OF BLACK MATERIAL (CARBON?) AND ROOTS.
4					
	PS	\	88		OLIVE GRAY (5Y5/2) SILTY CLAY, WITH MINOR AMOUNTS OF FRAGMENTS OF CHERT AND SILTSTONE.
6					
8					
0					
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 53-1/B18
Date 2-29-84
Location Hg Storage Area

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0	PS		83		TOP 8" IS SOIL (10YR 4/2) AND ROAD GRAVEL. REMAINDER IS 60/40 MIX OF CLAY (10YR 5/4) AND SILTSTONE, SHALE AND CHERT FRAGMENTS (<¾").
2	PS		54		50/50 MIX OF SHALE, CHERT AND SILTSTONE CLASTS AND CLAY (10YR 5/4 IN UPPER HALF, 5Y 5/2 IN LOWER HALF).
4	PS		100		UPPER 17" IS GRAY (5Y 4/1) WEATHERED SHALE AND CLAY BEDS. REMAINDER IS GRAY (5Y 6/1) CLAY WITH SPECKS OF BLACK.
6					
8					
0					
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 55-1B
Date 8/4/83
Location 9201-5

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		67		WEATHERED SHALE, HIGHLY FRACTURED, DIP 70-80°. SHALE IS 5 B 7/1, FRACTURE AND BEDDING SURFACES STAINED (10 R 3/4).
	CS		100		TOP IS GRAY (5 YR [illegible]) PARTLY CLAY. REMAINDER AS ABOVE.
4					
6	AB				
8					
10	AB				
2					AUGER REFUSAL AT 11'
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 55-2A
Date 8-8-83
Location 920--5

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		100		TOP 6" ROAD GRAVEL. REMAINDER IS CLAY FILL WITH SMALL CLASTS OF SHALE.
4	CS				AS ABOVE. BROWN IN COLOR, SOME DARK ZONES WITH Mn STAINING ON CLASTS.
6	CS				AS ABOVE. BOTTOM 1 FT. IS RED-BROWN IN COLOR.
8	CS				AS ABOVE.
10	CS				0-2" AS ABOVE; OVERLYING ~4" OF CLAY (5YR5/2) OVERLIES 7" OF [illegible] CLAY (10 YR 5/1). REMAINDER. MED DK GRAY CLAY, BROWN AT BOTTOM
2	CS				TOP 16" AS ABOVE (10 YR 5/4) GRADING INTO 4" OF GRAY CLAY. REMAINDER. HIGHLY WEATHERED SHALE, DIPPING ~55° (10 YR 5/4 TO 5 YR 2/1)
4	CS		100		TOP 4" LOOSE WET CLAY (5 Y 5/2). REMAINDER IS WEATHERED SHALE.
					REFUSAL AT 15.0'
6					
8					
20					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 55.2C
Date 8/8/83
Location 920,-5

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	CS		75		TOP HALF FILL OF UNCONSOLIDATED CLAY, ASPHALT REMAINDER: COMPACTED CLAY WITH CLASTS OF LIMESTONE
4	CS				
6	CS				
8	CS				
10	CS				
2	CS				
4	CS				REFUSAL AT 14'6"
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 55-3 C
Date 8/5/83
Location 4201-5

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS				FILL OF CLAY AND CLASTS OF SHALE AND LIMESTONE
4					
6	CS		100		UPPER 10"± FILL CONTAINING CLASTS OF LIMESTONE. REMAINDER IS WEATHERED SHALE DIPPING ~30° (5YR 5/2 GRADING TO 10YR 6/4 TO 10Y 6/2).
8	CS		100		AS ABOVE
10					REFUSAL AT 10'.
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 55-4 A
Date 8/15/83
Location 9103

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		83		GRAY FILL, SILT AND SHALE CLASTS.
4					
6	CS				
	CS				UPPER HALF IS AT BROWN SOIL, OVERLIES SHALE (5YR 6/4) THAT DIPS ~35°, AS LAMINATED
8					
10	AB				
2					
4	AB				
6					
8	AB				
20					AUGER REFUSAL AT 20'6"
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-5/82
Date 12/8/83
Location B1-10

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0	AB				
2	PS		54		UPPER 3" IS ABOVE SILTY CLAY (10 YR 4/2) WITH ROAD GRAVEL AND SHALE CLASTS. REMAINDER IS COMPACTED CLAY (10 YR 5/2) WITH FEW (<20%) CLASTS OF SHALE (<1" DIA).
4	PS		.75		50/50 MIX OF CLAY (10 YR 5/4 TO 10 YR 6/2) AND SHALE CLASTS (5 Y 5/2). CLASTS 1/2 - 3" DIA.
6	CS		54		AS ABOVE. BOTTOM 2" IS FRIABLE RED (5R 4/2) SHALE.
8	CS		92		UPPER 7" IS CONTINUATION OF RED SHALE (~20° DIP). REMAINDER IS INTERBEDDED CLAY AND SHALE.
10	CS		54		60-70% COMPACTED CLAY (10 YR 5/4) WITH STREAKS OF 5YR 5/6 AND 10YR 7/1 AND SHALE INTERBEDS.
2	CS		67		AS ABOVE DIPS APPEAR TO BE 10-20°
4	CS		83		50/50 CLAY (5YR 5/6) AND SHALE (5R 4/2) INTERBEDS. (DIP ~20°). IN BOTTOM 3" SHALES AND CLAYS ARE GRAY GREEN (5GY 3/2, 10GY 5/2).
6	CS		50		50/50 MIX OF CLAY (10GY 5/2) AND SHALE (5R [illegible]). LENSES OF BROWN (10 YR 5/4) SILTY CLAY AND SHALE CLASTS. PLANT ROOTS IN MIDDLE OF INTERVAL.
8	CS		67		AS ABOVE.
20	CS		100		UPPER 6" IS PLASTIC CLAY (10GY 6/1, 5GY 6/1) WITH THIN SHALE INTERBEDS. GRADES TO 50/50 MIX OF SHALE (5Y 5/2) AND CLAY (5Y 5/2) WITH MOTTLES (10 YR 5/4, 5 YR 4/2), SOME ROOTS; SILT CONTENT INC. W/DEPTH.
2	CS		67		TOP 1" IS SHALE (5R 4/2) DIPPING ~45°. BENEATH IS 6" OF CLAY (10 YR 5/4) WITH THIN [illegible] SHALE INTERBEDS (5 YR 5/2). REMAINDER IS REPEAT OF THESE TWO UNITS
4	CS		83		6" OF CLAY (10 YR 6/2, 5Y 6/1) WITH SHALE INTERBEDS 8 1/2" OF THIN BEDDED SHALE (5GY 6/1) AND SILTY CLAY; THIN CHARCOAL (?) LAYER. REMAINDER IS SILTY CLAY (5Y [illegible], 5GY 4/1) WITH PLANT ROOTS
6	CS		100		GRAY (5Y 5/2) SILTY CLAY. UPPER 9" WITH PLANT ROOTS BITS OF CHARCOAL (?) THROUGHOUT. SOME RIVER GRAVEL (?).
8	CS		75		COMPACTED SILTY CLAY (5Y 5/2) WITH MOTTLES (10 YR 4/2). BITS OF CHARCOAL (?) NEAR TOP.
30	CS		92'		DARK YEL-BR SILTY CLAY WITH FEW SILTSTONE PEBBLES (<1" DIA) THAT HAVE OX STAINING.

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-2 C
Date 8/4/83
Location 9201-4

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	CS		92		FILL, MOSTLY DOLOMITIC ROAD GRAVEL.
4	CS		25		AS ABOVE
6	CS		50		0-8" [illegible] GRAVEL, 8-10", [illegible] BROWN SAND. REMAINDER IS HARD CLAY.
8	CS		92		TO 5". HARD CLAY SOIL. REMAINDER IS WEATHERED SHALE DIPPING ~45°.
10	CS		100		TOP 5" WEATHERED SHALE, [illegible] 2" OF CLAY. REMAINDER IS [illegible] SHALE.
					REFUSAL AT 10'
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-3 C
Date 8-2-83
Location 920-4

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		83		0-16". Compacted clay fill with dolomite and gravel, sharp color transition to clay fill with shale clasts.
4	PS		100		Top 21" clay fill with shale clasts, mottled with gray. Remainder is [illegible] colored silt (?).
6	PS		75		0-14" as above, grades into dk brown, then lt brown cohesive clay without clasts.
8	CS		100		Yellow cohesive clay [illegible] clay w/ gravel bottom several inches is w shale
	CS		100		Weathered shale. Dip ~ 45°
					Refusal at 8'6".
10					
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-4 C
Date 7/29/83
Location 920.-4

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		75		TOP 13" COMPACTED CLAY (10 YR 7/3) FILL WITH SHALE CLASTS, SOME SAND LENSES. REMAINDER: AS ABOVE, COLOR IS 10 YR 5/6.
4	CS		100		TOP 6": AS ABOVE. SHARP CONTACT WITH UNDERLYING LT. YELLOW CLAY WITH LARGE (UP TO 1½") SHALE FRAGMENTS.
6	CS		71		TOP 4": LOOSE, CLAST RICH FILL. GRADES INTO DENSE SILTY CLAY (LT. GRAY) WHICH APPEARS TO BE 'B' HORIZON SOIL.
8	CS		100		0-3" AS ABOVE. REMAINDER IS CLAY RICH, WEATHERED SHALE.
10	CS		83		WEATHERED SHALE, ~ VERTICAL BEDDING.
2	CS		79		0-8" SOFT GRAY CLAY WITH SOME SHALE BEDS, GRADES INTO BROWN CLAYEY WEATHERED ROCK, AND THEN TO STRONGLY FRIABLE W SHALE.
	CS		100		SLIGHTLY WEATHERED TO UNWEATHERED SHALE
4	CS		100		UNWEATHERED SHALE REFUSAL AT 14'3".
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit   PS = Push Shelby   CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-5/B2 cont'd
Date 12/8/83
Location B1-10

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
30	CS		75		COMPACTED CLAY (10YR 4/2) WITH FEW ROUNDED SILTSTONE PEBBLES ([illegible] ½" DIA) STAINED BLK. MOTTLES OF BLACK AND BROWN (10 R 4/6) IN CLAY.
2					AUGER REFUSAL AT 32'.
4					
6					
8					
0					
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-5/83
Date 12/6/83
Location B1-10

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0	PS		67		UPPER 4": UNCOMPACTED CLAY AND SHALE CLASTS (5YR 4/1 - 10YR 4/2). LOWER 12": SHALE AND CLAY, COMPACTED, SHALE THICK IN PLACES (5Y 5/2) AND STAINED WITH DARK REDDISH BROWN AND DARK BROWN.
2	PS		79		UPPER 12": DK GRAY CLAY (N3) AND SHALE FRAGMENTS, SOME ANHYDRITE GRAVEL. SHARP CONTACT W/ BROWN; DK YEL-BR (10YR 4/2) COMPACTED CLAY AND SHALE CLASTS (10YR 4/2, 5Y 5/2)
4	AB				
6	CS		67		UPPER HALF IS 50/50 MIX OF LOOSE SILTY CLAY (10YR 4/2, 5Y 3/2) AND ANHYDRITE/SHALE CLASTS. LOWER HALF IS MOSTLY SHALE CLASTS (10YR 5/4) UP TO 2½" DIA, W/ SOME CLAY MATRIX. SOME STAINED (5YR 3/1)
8					
10	CS		79		COMPACTED SILTY CLAY AND SHALE CLASTS (2" MAX DIA); MOSTLY DK YEL-BR (10YR 4/2). IRON STAINING, AND SOME BANDS OF GRAY (5Y 7/2) IN UPPER PART.
12	CS		83		SHALE FRAGMENTS [illegible] W/ SOME CLAY; BROWN IN COLOR (10YR 4/2, 5YR 3/2) WITH VARIABLE [illegible] CLASTS.
14	CS		100		UPPER HALF IS 50/50 MIX OF LOOSELY COMPACTED SILTY CLAY AND SHALE CLASTS (10YR 4/2) W/ SOME STAINING (5YR 2/1). LOWER HALF ~80% CLAY (5Y 5/2 AND 10YR 6/2) AND SHALE CLASTS.
16	CS		100		COMPACTED CLAY W/ SHALE CLASTS. MOST [illegible] SHALE IS IN UPPER HALF. [illegible] AT BASE IS 5½" GRAY (5Y [illegible]) CLAY ZONE, W/ BROWN (10YR [illegible]) CLAY ON [illegible] SIDE.
18	CS		85		TOP 8": [illegible] CLAY (10YR 6/2), OVERLYING 6" OF GREEN TO GRAY (N4 TO 5GY 4/1) SILTY CLAY ([illegible], ~30° DIP); [illegible] 2-3" OF SHALE. REMAINDER IS SHALE, SILTSTONE AND CLAY.
20	CS		100		CLAY W/ MINOR AMOUNT OF SHALE (½-1") [illegible] CLASTS. [illegible] (10YR 5/4) [illegible] (10YR 4/2). CLASTS ARE STAINED (5YR 2/1)
22	CS		100		COMPACTED CLAY (10YR [illegible]) W/ SHALE CLASTS (½-1"). [illegible] CLAY (10YR 2/2), W/ FEW CLASTS, [illegible] [illegible] BANDS OF VARIOUS COLORED CLAYS
24	CS		88		COMPACTED SILTY CLAY, OLIVE (5Y 4/2), WITH [illegible] (5YR 4/1). SOME [illegible], AND [illegible]
26	CS		88		UPPER 8": AS ABOVE [illegible] 2" CLAY [illegible] [illegible] REMAINDER [illegible] [illegible] CLASTS [illegible] 10YR 4/2.
28	CS		100		LOOSELY COMPACTED SILTY CLAY (10YR 4/2) W/ SHALE CLASTS (5YR 5/1).
30					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-5/83 cont'd
Date 12/6/83
Location B1-10

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0	CS		79		70/30 MIX OF CLAY (10YR 4/2 TO 10YR 5/4) AND WEATHERED CHERT/DOLOMITE (N5, 10YR 7/4). CLAY IS SILTY TOWARDS TOP OF INTERVAL.
2	CS		83		COMPACTED MOD YEL-BR (10YR 5/4) CLAY WITH STREAKS OF 5YR 3/4 AND 5YR 3/2. SMALL CHERT FRAGMENTS IN UPPER 5".
4					AUGER REFUSAL AT 34'.
6					
8					
0					
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-5/84
Date 12/5/83
Location 61-10

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0	PS		67		50/50 mix of clay (10YR 4/2) and road gravel/chert fragments.
2	AB				
4	PS		46		50/50 mix of olive (5Y 4/3) clay and shale fragments (various colors).
6	CS		96		Mix of lg. shale fragments, clasts of siltstone, pieces of brick, and clay (10YR 4/2).
8	CS		75		50/50 mix of shale/sandstone/road gravel and clay (10YR 4/2).
10	CS		58		50/50 mix of clay (10YR 4/2, 10Y 4/2) and shale fragments/road gravel/coal.
	CS		100		[illegible] of silty clay (5G 4/1) and shale clasts.
2					Hit tile and brick - no sample.
4	CS		92		[illegible] clay (5Y 6/1), some road gravel and coal within interval. Lower 5" is clay and shale, either in place or a large clast.
6	AB				
8					
	AB				
20					Auger refusal at 19'6".
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-5/85
Date 2-8-84
Location 81-10

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		81		70/30 mix of shale clasts and clay (10YR 5/4); most of clay is in lower half of interval.
4	PS		100		As above. Shale clasts are up to 2" dia, lower half of interval is ~65% clay with small (<1" dia) clasts of shale.
6	CS		67		75/25 mix of shale/siltstone clasts and clay. Upper part of interval contains loose clayey soil (10YR 4/2) and asphalt.
8	CS		75		As above. Clasts up to 2½".
10	CS		65		Olive gray (5Y 5/2) clay w/mottles (10YR 5/6) with some clasts of shale and chert. Color of clay varies with depth (10YR 6/6, 5Y 4/1).
2	CS		88		~90% clay and silty clay in subhorizontal bands (2-6" thick). Colors from top to bot.: 10YR 5/4, 10YR 4/1 to 5Y 5/2, 10YR 6/6, 5Y 3/2, 10YR 5/4. Some chert clasts and rootlets.
4	CS		90		70/30 mix of shale fragments and clay (10YR 4/2)
6	CS		67		50/50 mix of clay and shale clasts.
8	CS		88		70/30 mix of clay (10YR 5/4) with fragments of shale and siltstone.
20	CS		96		80/20 mix of shale/siltstone clasts and clay (10YR 5/4, 10YR 4/4, 10YR 6/2).
2	CS		85		50/50 clay (5YR 5/6) and shale clasts
4	CS		100		~85% clay (10YR 6/6, 10YR 5/1) with some some shale and chert clasts.
6	CS		85		~95% clay, upper 1' is brown (10YR 4/2) with small (<½") chert fragments. Remainder is clay (5YR 4/4) with fragments of chert and limestone.
8	CS		90		80/20 mix of clay (5YR 4/4) with fragments of chert, limestone and dolomite.
30	CS		100		~90% clay and silty clay (10YR 4/2, 5YR 4/4, 5Y 6/1) with clasts of chert and siltstone.

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-5/86
Date 2/9/84
Location B'-10

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0	AB				
2					
4	PS		79		50/50 MIX OF CLAY (YEL TO BROWN GRAY) AND SHALE FRAGMENTS CLAST GENERALLY < 2".
6	CS		100		TOP HALF: 50/50 MIX OF CLAY (10YR 4/2, 4/6) AND LIMESTONE/DOLOMITE GRAVEL AND ASPHALT. BOTTOM HALF 70/30 MIX OF SHALE CLASTS AND CLAY (10YR 5/1, 10YR 7/4)
8	CS		100		50/50 MIX OF CLAY (10YR 5/4, 10YR 7/4) AND SHALE FRAGMENTS (<2" DIA).
10	CS		71		AS ABOVE EXCEPT ~70% CLAY/30% CLASTS.
2	CS		75		LT OLIVE GRAY (5Y 6/2) CLAY W/ MOTTLES OF BROWN (10YR 5/4) FEW CLASTS OF SHALE
4	CS		21		25/75 MIX OF CLAY AND CLASTS OF SHALE, SILTSTONE AND SANDSTONE
6	CS		96		50/50 MIX OF CLAY (BROWN, GRAY AND ORANGE) AND SHALE FRAGMENTS
8	CS		100		AS ABOVE. CLASTS UP TO 3" DIA
20	CS		92		50/50 MIX OF CLAY (10YR 4/2 NEAR TOP TO 10YR 5/4 TOWARDS BOTTOM OF INTERVAL) AND SHALE CLASTS. BOTTOM 6": LESS THAN 20% CLASTS.
2	CS		100		UPPER 4": 50/50 MIX OF CLAY (10YR 4/2) AND SMALL (<1/2") SHALE CLASTS. BELOW IS A ZONE OF GRAY SILTY CLAY (5Y 4/1) WITH SM CLASTS OF CHERT AND SHALE. BOTTOM: 60/40 MIX OF CLAY (5Y 6/1, 10YR 4/2) AND SHALE (<1").
4	CS		100		50/50 MIX OF BROWN (10YR 5/4, 5YR 4/3) CLAY AND SMALL (<1/2") SHALE AND SILTSTONE FRAGMENTS.
6	CS		71		OLIVE GRAY (5Y 5/2) SILTY CLAY, WITH ROOTLETS, CARBON AND CHERT FRAGMENTS
8	CS		100		CLAY AND SILTY CLAY (5Y 5/2) WITH ZONES OF SMALL SHALE AND SILTSTONE CLASTS. SOME ROOTLETS IN SECTION
30	CS		100		50/50 MIX OF BROWN (10YR 4/2) CLAY AND HIGHLY WEATHERED CHERT CLASTS.
					AUGER REFUSAL AT 30'2"

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued)

LOG OF BORING

Boring No. SG-5/87
Date 12-13-83
Location 81-10

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0–2	AB				
2–4	PS		75		70/30 mix of clay (10YR 7/2) and sand clasts [illegible] clasts of [illegible] (<2½" dia).
4–6	CS		64		As above. Clay (10YR 7/2) with mottles (10R 4/6) and bands (10YR 6/6, 10YR 7/6, 5YR 5/6).
6–8	CS		62		50/50 mix of mudstone/shale (mostly 5YR 8/1) clasts (≤3" dia) and clay (as in previous interval).
8–10	CS		75		50/50 mix of clay (10YR 8/1 with mottles of 10R 4/6) and shale/mudstone clasts. Brown-black staining on clasts.
10–12	CS		42		60/40 mix of clay (10YR 8/1, becoming 10YR 7/2 in lower 3") with mottles (5YR 6/6) and streaks (10R 4/6) and sand clasts (5YR [illegible] predominates) ≤1" dia. Dk staining of clasts
12–14	CS		79		As above, some clasts up to 3" dia. Mottles more prominent (10YR 6/6, 10YR 7/8, 5YR 5/6)
14–16	CS		75		Upper 7½". Clay (10YR 6/6) with streaks of [illegible] (10R 4/6). Remainder is 50/50 mix of shale/mudstone clasts and clay (clay as above, with bands of [illegible], 10YR 5/6 and 5YR 4/6). Dark staining on clasts
16–18	CS		48		Upper 5½" is brown (10YR 5/6) clay with mottles and streaks ([illegible]). Some small (<½") clasts of [illegible] and fine sandstone. Remainder is 50/50 mix of clay (10YR 5/6) and shale clasts (<3" dia)
18–20	CS		81		Upper 6" as [illegible] above, with bands of clay (5GY 8/1, 5Y 4/1) [illegible] (charcoal(?) bits) with [illegible], [illegible] is clay (10Y 4/1) with [illegible] and [illegible].
20–22	CS		60		Clay (5Y 6/1) with streaks (5GY 6/1, 10YR 5/6) and a few pebbles (<1" dia). Lower 4" has clayey [illegible] (10YR 5/6) with [illegible] (10YR 4/6, 10R 4/6).
22–24	CS		64		Gray (5Y 5/1) clay with scattered (<10%) pebbles of fine sandstone (½–2½" dia) and chert (<¼"). Bottom 1½" contains abundant rounded clasts (¼–½" dia.)
24–26	CS		96		Clay (10YR 6/1) with streaks (5YR 4/6, 5Y 6/1) and specks of charcoal. Upper half: <50% sandstone and chert fragments (1–3" dia). Lower half few (<10%) small (¼–½") clasts. [illegible] ?
26–30					Auger refusal at 26'

*AB = Auger Bit   PS = Push Shelby   CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-5/80
Date 12-13-83
Location [illegible]

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		75		[illegible] mix of [illegible] and clay (10 YR 4/3)
4	PS		67		[illegible] (10 YR 5/8) [illegible] (5 Y 6/1) [illegible].
6	CS		67		Upper 10" is [illegible] (10 YR 5/6) with [illegible]
8	CS		83		[illegible] clay (5 Y 6/2) and shale, [illegible]
10	CS		50		[illegible] (5 Y 6/1 to 10 YR 5/8 at bottom) and shale fragments
2	CS		71		Upper 7" is [illegible] clay (5 Y 6/1) and shale fragments. Lower 10" is silty clay (5 Y 4/2, 10 YR 4/1) with [illegible] of shale and chert.
4					Auger refusal at 13'.
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-5189
Date 12-13-83
Location 81-10

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		100		Solid mix of clay ([illegible]) and sand clasts.
4	PS		100		As above
6	CS		75		As above, with some road gravel.
8	CS		79		Several distinct zones of contrasting [illegible] clay colors [illegible]: 5Y 5/1, 10YR 5/4 and 5Y 6/1. Some chert fragments in center of interval.
10	CS		100		Solid mix of sand and clay. Can be divided into 4 zones of various clay colors and silt content.
2	CS		60		Clay ranging from 10YR 5/4 near top to 10YR 5/1 to 5Y 5/1 at base. Some fragments near top, chert and coal in lower portion.
4	CS		88		Gray (5Y 5/1) silty clay in upper 3', grading to gray/green (5Y 5/1, 10YR 5/4) clay mix chert and coal (<25% of total) throughout.
6	CS		42		Solid mix of silty clay (10YR 5/4) and weathered chert, dolomite and sandstone (1/2 - 3" chunks).
8					Auger refusal at 17'.
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 56-5 C
Date 8-10-83
Location 61-10

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS				
4	CS		100		TOP 8". COMPACTED CLAY FILL WITH CLUMPS. 8-12" ASPHALT 12-14" [illegible] OF ASPH. REMAINDER IS CLAY WITH SEAMS OF [illegible].
6	CS		92		CLAY FILL WITH CLUMPS OF DOLOMITE ROAD GRAVEL.
8	CS		83		AS ABOVE, WITH SOME DISTINCT [illegible] ZONES.
10	CS		96		AS ABOVE TOP 1 FT IS VERY WET.
2	CS		92		ROCKY FILL WITH PIECES OF WOOD AND ASPHALT
4	CS		100		FILL WITH ASPHALT, BRICK AND COPPER WIRE
6	AB				
8					REFUSAL AT 17' - HIT COPPER WIRE.
20					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 58-1/M
Date 11/29/83
Location 9733-,

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0	PS		75		GRASS, SOIL (10YR 4/2) AND FILL OF CLAY (5YR 4/4) AND WEATHERED SHALE.
2	PS		62		AS ABOVE.
4	CS		100		UPPER 15" AS ABOVE; OVERLIES 6" OF SANDY FILL WITH SHALE CLASTS. REMAINDER IS FILL AS PREVIOUSLY DESCRIBED.
6	CS		96		FILL, AS ABOVE.
8	CS		83		WEATHERED SHALE.
10	AB				REFUSAL OF SAMPLER AT 9'
2	AB				
4					AUGER REFUSAL AT 14' 6"
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 58-1/N
Date 11/29/83
Location 9733-1

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0	PS		96		GRASS AND SOIL OVERLYING 18" OF BEDDED SHALE AND SOIL (DIP ~60°). VISIBLE MERCURY IN UPPER 5"
2	PS		88		UPPER 6" STRUCTURELESS SOIL (10 YR 3/4); OVERLYING WEATHERED SHALE.
4	AB				REFUSAL OF SAMPLER AT 4'.
6	AB				
8	AB				
10	AB				
2	AB				
4	AB				
6	AB				
8	AB				
20	AB				
					AUGER REFUSAL AT 20'8"
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. SA-110
Date 12/1/83
Location 9733-1

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		100		TOP 6": UNCONSOLIDATED FILL (10YR 4/3); REMAINDER IS FILL (10 YR 6/3) WITH MOTTLES, ROOTS AND SOME SMALL SHALE CLASTS.
4	PS		100		AS ABOVE.
	PS		100		FILL (?) (10 YR 4/2) WITH ROOTS.
6					AUGER REFUSAL AT 5'7".
8					
10					
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 5B-1/Q
Date 12/2/83
Location 9733-1

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		83		GRASS, SOIL AND FILL WITH LARGE SHALE CLASTS (UP TO 2" DIA). COLOR 9YR 5/2 WITH ZONES OF 10 YR 6/6
4	PS		100		UPPER 4" AS ABOVE - REMAINDER IS WEATHERED SHALE (10YR 7/4 - 10YR 4/2). DIP ~50-60°, STAINING ON FRACTURES AND BEDDING PLANES.
	CS		100		BROWN WEATHERED SHALE (10YR 6/6 - 10YR 4/2) WITH STAINING
6	AB				
8	CS		100		FILL WITH CLASTS OF SHALE, SOME ROOTS (10YR 3/2), UNDERLAIN BY 15" OF WEATHERED SHALE (~75° DIP)
10	CS		100		WEATHERED SHALE (5YR 5/2).
					REFUSAL OF SAMPLER AT 9'9".
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

 6/12/2023 5:28:55 PM

Appendix B (continued).

LOG OF BORING

Boring No. 59-1 C
Date 81.183
Location 9202

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0–2	AB				
2–4	PS		50		UPPER 4": BROWN (10YR 4/3) SOIL; OVERLYING LT GRAY (N8) HARD CLAY WITH BROWN MOTTLES. LT. BROWN (10YR 7/4) CLAY AT BOTTOM.
4–4.5	CS		100		FRACTURED, WEATHERED SHALE (5YR 4/1), DK STAINING ON BEDDING PLANES. REFUSAL OF SAMPLER AT 4'6".
6–8	AB				
10–14	AB				
16–20	AB				
20–22					
22					AUGER REFUSAL AT 22
24					
26					
28					
30					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 60-1 A
Date 8/11/83
Location 9201-2

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		100		CLAY FILL, GRAY AT TOP, MOST IS BROWN IN COLOR, WITH CLASTS OF SHALE.
4	CS		75		AS ABOVE.
6	CS		50		AS ABOVE.
8	CS		100		CLAYEY SOIL (10YR 5/4). MOTTLED WITH GREEN.
10	CS		100		TOP 5" AS ABOVE. GRADES INTO DARKER ZONE (5YR 4/4) WITH CLASTS OF CHERT AND BLACK STAINING.
2	CS		100		TOP 10" AS ABOVE. REMAINDER IS SANDY SOIL (10YR 5/4)
4	CS		100		CLAYEY SOIL (10YR 5/4) WITH GREEN MOTTLES.
6	CS		100		AS ABOVE. SLIGHTLY DARKER, VERY CLAY RICH.
8					AUGER REFUSAL AT 18'.
20					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 60-1/83
Date 12-15-83
Location 9201-2

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		54		TOP 4" IS SOME GRAVEL; UNDERLAIN BY 1" OF SILTY SOIL/GRAVEL MIX [illegible]. REMAINDER IS MIX OF 70% CLAY [illegible] AND 30% SHALE CLASTS OF VARIOUS SIZES
4	CS		79		MIX OF ~60% CLAY [illegible] AND ~40% SMALL (<1" DIA) CLASTS OF SHALE [illegible]. BOTTOM 3": MOSTLY SHALE FRAGMENTS.
6	CS		48		MIX OF ~60% CLAY [illegible] AND SMALL (<½") SHALE AND SILTSTONE CLASTS.
8	CS		83		UPPER 3": 50/50 MIX OF CLAY [illegible] WITH MOTTLES [illegible] AND SILTSTONE CLASTS. REMAINDER: 50/50 MIX OF CLAY [illegible] WITH MOTTLES [illegible] AND SM (<½") CLASTS OF SHALE, SILTSTONE AND [illegible].
10	CS		83		50/50 MIX OF CLAY (5Y 5/6) AND CHERT FRAGMENTS.
2	CS		42		CLAY [illegible] WITH <10% FRAGMENTS OF CHERT [illegible] AND SILTSTONE [illegible] FRAGMENTS ALL < 1" DIA.
4	CS		100		[illegible] SILTY CLAY [illegible] WITH [illegible] CLASTS OF CHERT & SILTSTONE [illegible].
6					AUGER REFUSAL AT 15'.
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 60-1/82
Date 12-14-83
Location 9201-2

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		75		60/40 MIX OF CLAY (10YR 4/2) AND ROAD GRAVEL (<1" [illegible]). GRADES INTO MOTTLED CLAY (10YR 5/4, 10YR 4/2) WITH SHALE CLASTS.
4	CS		81		60/40 MIX OF CLAY (10YR 5/4) AND SHALE CLASTS. ~80% CLAY AT BOTTOM.
6	CS		50		80/20 MIX OF CLAY (10YR 5/4) AND SHALE/DOLOMITE CLASTS
8	CS		75		UPPER 6½": YEL-GREEN (10YR 5/4) CLAY WITH MOTTLES (5YR 6/6) AND FEW SHALE FRAGMENTS. SHARP CONTACT WITH LOWER UNIT OF GRAY (5Y 4/1) CLAY WITH SOME PLANT REMAINS.
10	CS		67		GRAY (5Y 5/2) CLAY, LIGHTER COLOR TOWARDS BOTTOM OF INTERVAL, WITH MOTTLES (10YR 4/1, [illegible]).
2	CS		83		UPPER 4". AS ABOVE, OVERLYING THINLY BEDDED SILT AND SILTY CLAY (10YR 5/3, 5Y 6/2) SOME CHERT AT CONTACT. BEDS DIP 0-30°.
4	CS		79		GRAY (5Y 5/2) CLAY WITH MOTTLES (10YR 5/4) UPPER 3". 10% FINE (1/16-1/4") ROUNDED PEBBLES (LIMESTONE) OVERLIES 3" CLAY LAYER, WHICH OVERLIES 4" PEBBLE/CLAY AGG. REMAINDER IS SILT, SAND AND CLAY MIX
6					AUGER REFUSAL AT 16'
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 60-1/83
Date 12-20-83
Location 9201-2

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0	AB				
2					
4	CS		83		50/50 MIX OF CLAY (10YR 5/4) AND SHALE CLASTS OF VARIOUS SIZES
6	CS		88		AS ABOVE
8	CS		100		AS ABOVE, MORE CLAY (60/40 MIX)
10	CS		63		70/30 MIX OF CLAY (10YR 5/4) AND SMALL (<1" DIA) SHALE CLASTS WITH SOME DOLOMITE GRAVEL.
2	CS		69		60/40 MIX OF CLAY (5Y 5/2) AND SHALE CLASTS
4	CS		60		AS ABOVE, SOME LARGE SHALE CLASTS (UP TO 2" DIA)
6	CS		79		UPPER 14" YEL-BR (10YR 5/6) CLAY WITH <20% SMALL FRAGMENTS OF CHERT (10YR 7/4). LOWER PART IS GRAY SILTY CLAY (5Y 5/2) WITH STREAKS OF 5Y 7/2
8	CS		83		INTERLAYERED CLAY, ~80% YEL-BR (10YR 5/6) AND ~20% GRAY (10YR 7/4, DO) MUDSTONE. SUB-HORIZONTAL BEDS <1/2" THICK.
20					AUGER REFUSAL AT 20'.
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 6Q-1/B4
Date 12-19-93
Location 9201-2

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		94		50/50 MIX OF CLAY (10YR 5/4 TO 5Y5/2 AT DEPTH) AND SHALE FRAGMENTS. LAYER OF ROUNDED GRAVEL HALF WAY DOWN INTERVAL. VISIBLE MERCURY BELOW GRAVEL BED, IN CLAY.
4	CS		63		70/30 MIX OF CLAY (10YR 5/4, 5Y 5/1) AND SHALE CLASTS/GRAVEL. VISIBLE MERCURY THROUGHOUT, (MOSTLY) NEAR GRAVEL RICH ZONES.
6	CS		77		UPPER 6". GRAY (5Y5/2, 10YR4/2) CLAY WITH ROAD GRAVEL, LOWER PART IS YEL (10YR 6/6) CLAY WITH CHERT FRAGMENTS.
8	CS		75		YEL-BR (10YR 5/4) CLAY WITH SCATTERED GRAVEL OF [illegible] SANDSTONE (10YR 8/2) NO [illegible]
10					
	CS		75		GRAY (5Y4/1) CLAY WITH SCATTERED PLANT REMAINS.
2	AB				
4					AUGER REFUSAL AT 13'.
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 60-1/85
Date 12-20-83
Location 4201-2

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		88		[illegible] mix of shale clasts (various colors) and clay (10YR 4/2, 10YR 8/4) - bottom 2" is silty clay (10YR 4/3) with few clasts.
4	AB				
6	CS		100		Dk yel-br (10YR 6/6) clay with shale clasts. Bottom 6" contains thin (1/16") beds of shale and siltstone (5YR 3/2) that dip ~30°. Beds and clasts coated with oxides
8	CS		96		[illegible] clay (10YR 6/6) with scattered fragments of highly weathered shale
10	CS		75		Yel-br (10YR 5/4) clay with mottles (10YR 6/2, 10YR 6/6) and lenses of darker material (5YR 3/2 [illegible]) no rock fragments. Bedding (?) @ ~45°
2	CS		100		Mostly clay (10YR 6/6) with bands of darker material.
					Auger refusal at 13'.
4					
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 60-1/86
Date 12-19-83
Location 9201-2

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		92		50/50 mix of clay (10YR 6/4) and road gravel/shale chips.
4	CS		100		50/50 mix of clay (10YR 5/4 with [illegible]) and road gravel/shale chips.
6					
	CS		83		50/50 mix of clay (10YR 4/3) and debris of road gravel, some chert fragments.
8	CS		88		Top 3": GR (10YR 6/8) clay over 6" gray (5Y 5/1) clay over darker gray (5Y 4/1) clay. Some gravel and chert fragments.
10	CS		69		Gray (5Y 4/1) clay with some chert fragments (10YR 7/4, 5Y 7/2).
2	CS		56		Gray (5Y 6/1) clay grading to brown (10YR 5/4, 10YR 4/3) in bottom 3". Chert fragments throughout.
4	CS		63		>90% clay (10YR 5/4) with mottles (10YR 5/2, 5Y 4/1) some chert and shale fragments
6	CS		100		As above.
8					Auger refusal at 17'.
20					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 60-1/87
Date 12-15-83
Location 920-2

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		46		MIX OF CLAY (10YR 5/4) AND ROAD GRAVEL/ WEATHERED CHERT.
4	CS		58		AS ABOVE.
6	CS		83		TOP FOOT LT BR (5YR 5/6) CLAY WITH MOTTLES (10YR 7/8, 10YR 6/?, 5Y 5/2) SOME CHERT FRAGMENTS. LOWER HALF IS GRAY (5Y 4/1, 5Y 5/2) CLAY WITH MOTTLES (10YR 5/?, 10Y 6/3) AND CHERT FRAGMENTS.
8	CS		98		GRAY (5Y 5/2, 5Y 4/1) SILTY CLAY WITH PLANT REMAINS
10	CS		88		GRAY (5Y 5/2, 5Y 3/2) SILTY CLAY NEAR TOP AND BOTTOM OF INTERVAL. BROWN (10YR 4/3, 10YR 5/4) MOTTLES IN TOP 4" WITH SOME CHERT FRAGMENTS. PLANT REMAINS AND SOME CHERT IN LOWER PART OF INTERVAL.
2	CS		85		GRAY (5Y 6/2) SILTY CLAY BECOMING SILT FREE TOWARDS BOTTOM. CONTAINS MOTTLES (5Y 3/2) AND PLANT REMAINS.
4					AUGER REFUSAL AT 18'
6					
8					
0					
2					
4					
6					
8					
0					

*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix B (continued).

LOG OF BORING

Boring No. 60-1/88
Date 12-16-83
Location 9201-2

Depth (ft)	Sample Type*	Sample Interval	Recovery/ Compacted Length (%)	Lithologic Log	Description & Notes
0					
2	PS		33		MIXTURE OF HOST SOIL, SHALE CLASTS AND ROAD GRAVEL.
4	CS		46		MIXED MIX OF CLAY (10 YR 5/4 TO 5 YR 5/6 AT BASE) AND SHALE CLASTS. SOME GRAVEL IN UPPER FEW INCHES
6	CS.		94		7905 SILTY GRAY (5Y6/1) CLAY WITH MOTTLES (10YR 5/4). SOME PLANT REMAINS AND CHERT FRAGMENTS
8	CS		58		AS ABOVE.
10					AUGER REFUSAL AT 9'
2					
4					
6					
8					
0					
2					
4					
6					
8					
0					

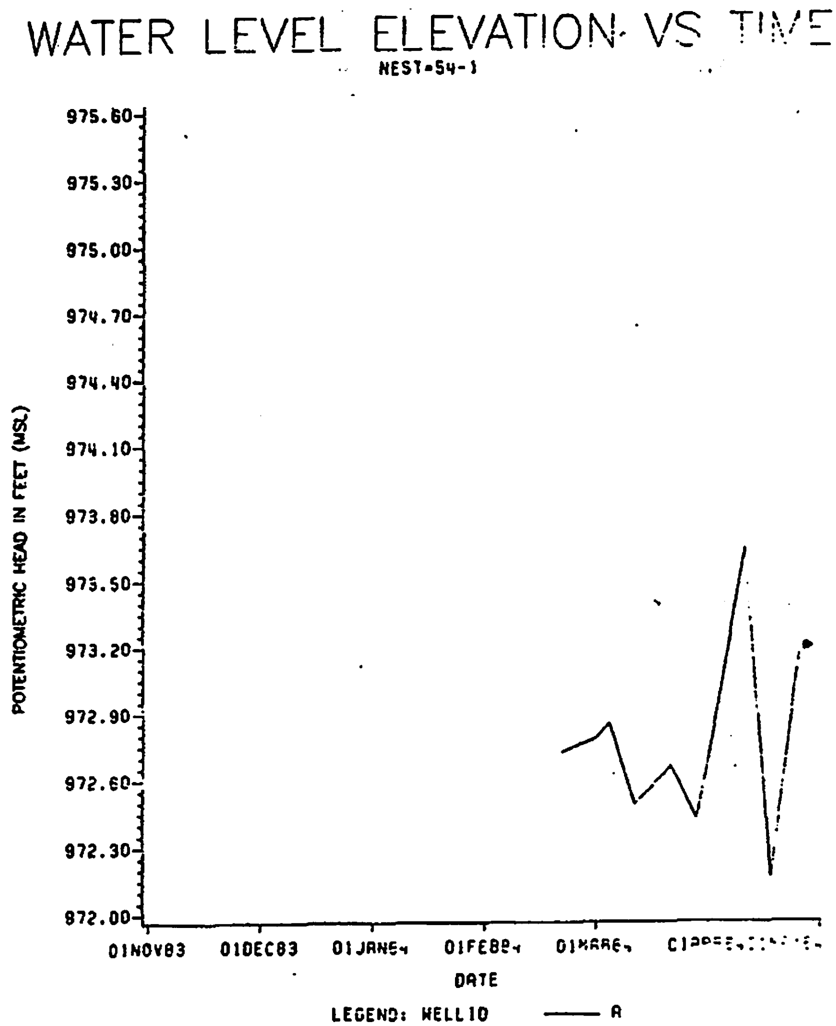
*AB = Auger Bit PS = Push Shelby CS = Continuous Shelby

Appendix C

GROUNDWATER HYDROGRAPHS

Appendix C

GROUNDWATER HYDROGRAPHS



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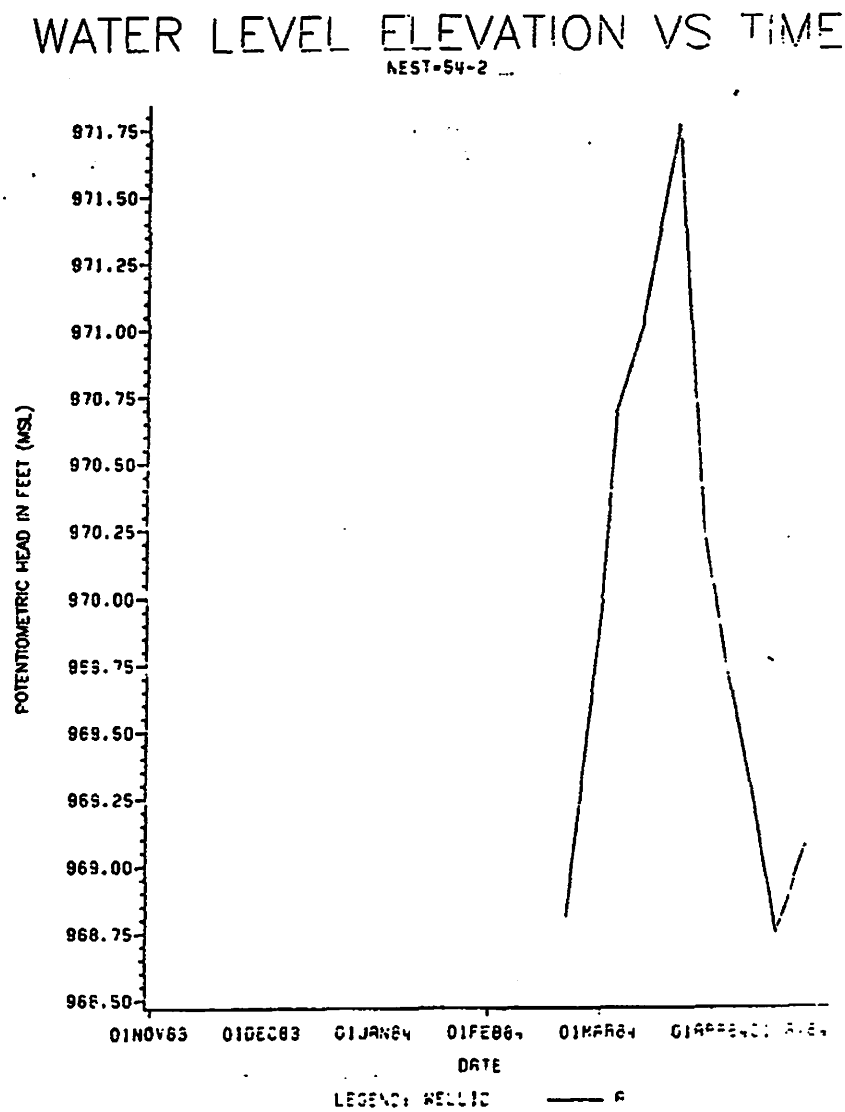

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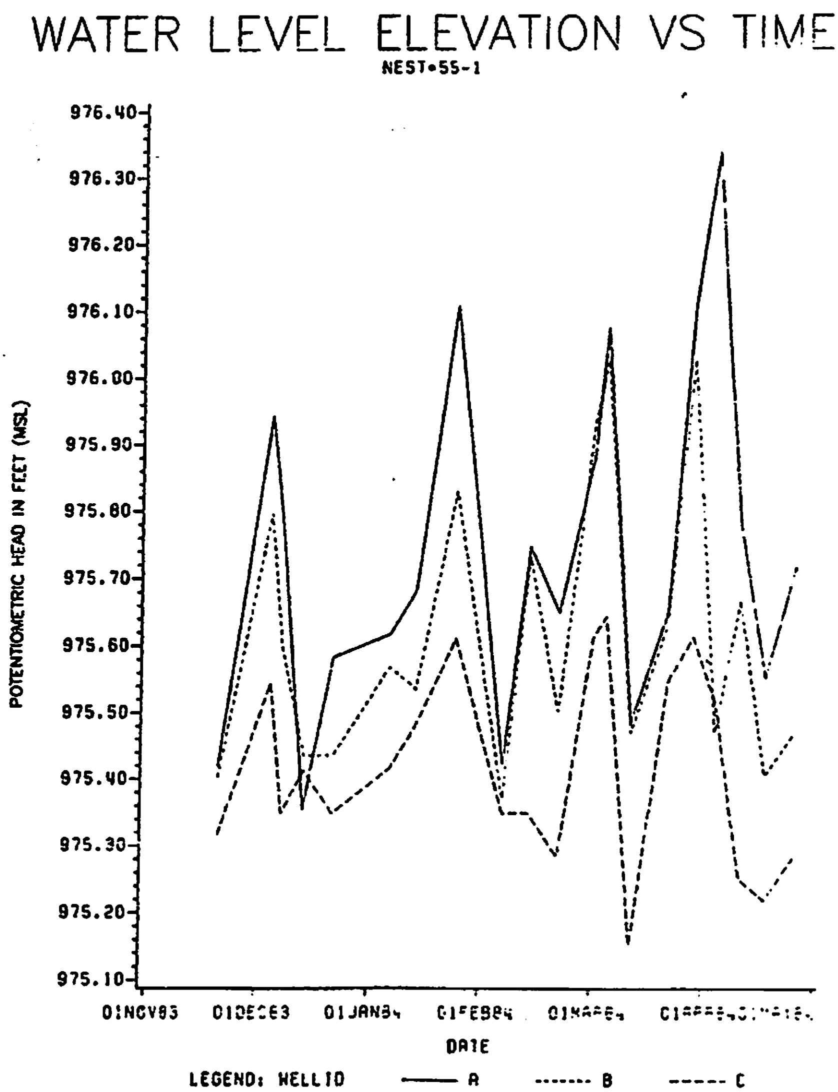

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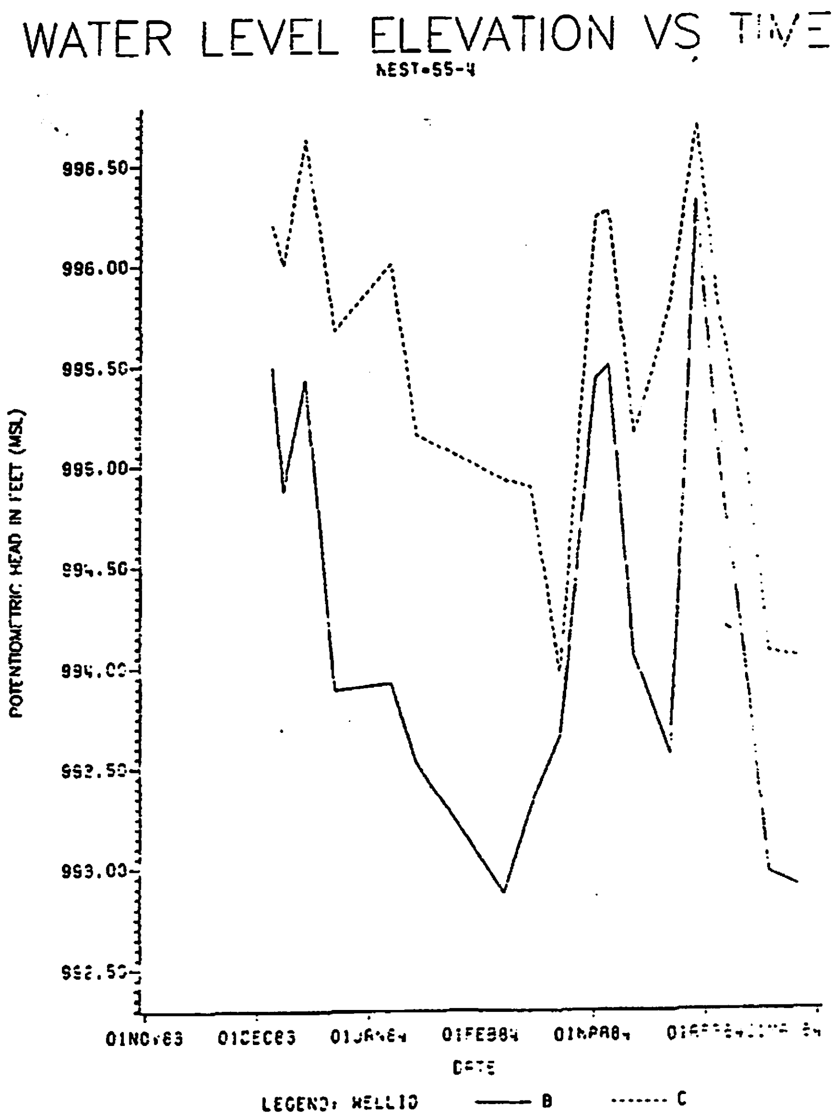

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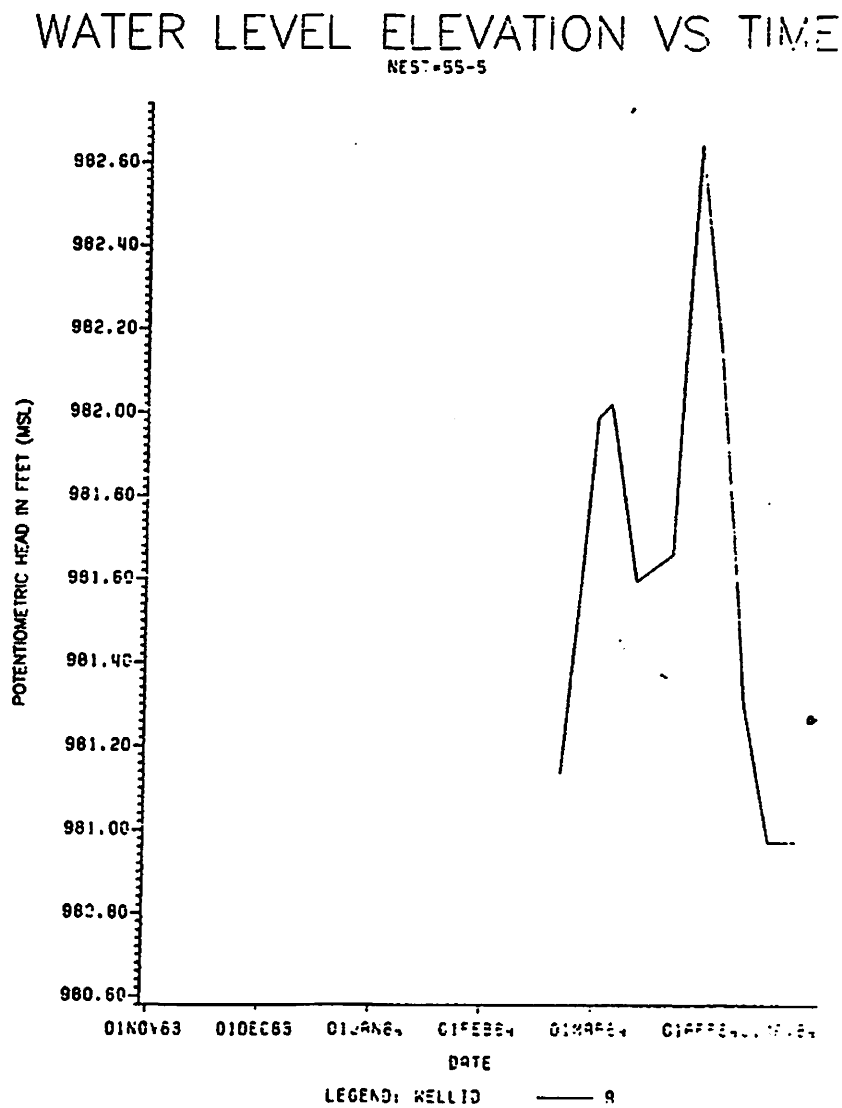

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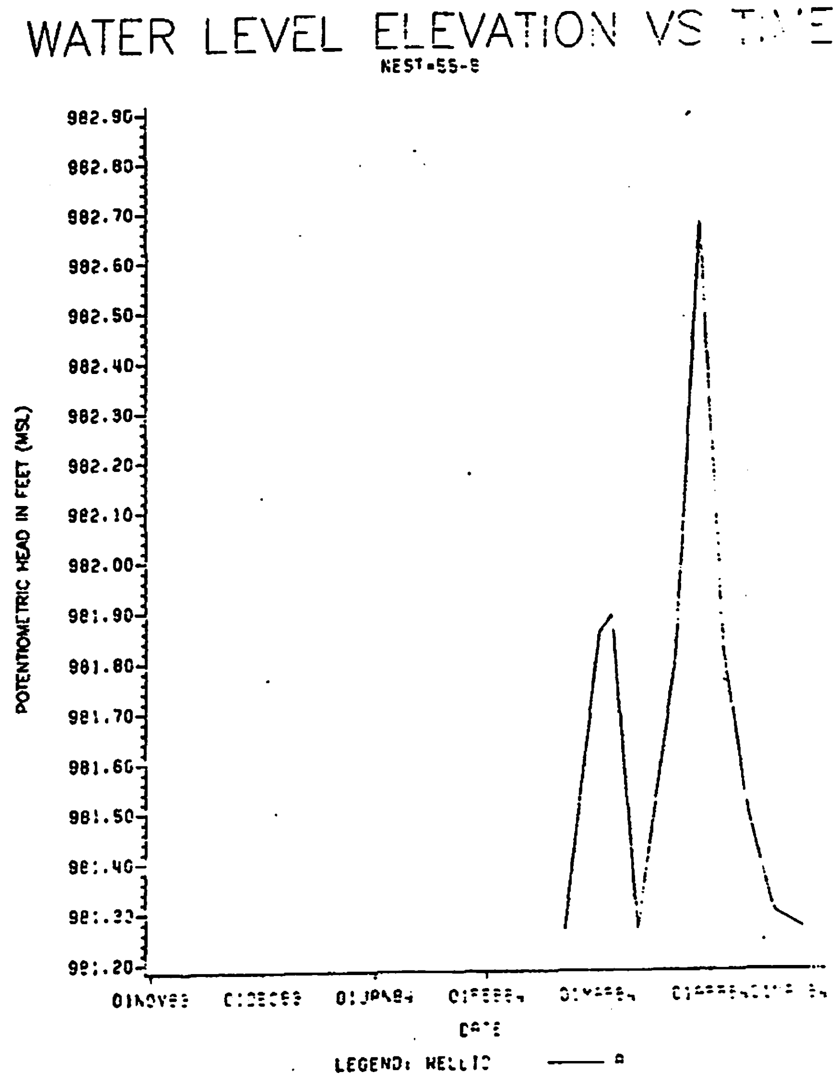

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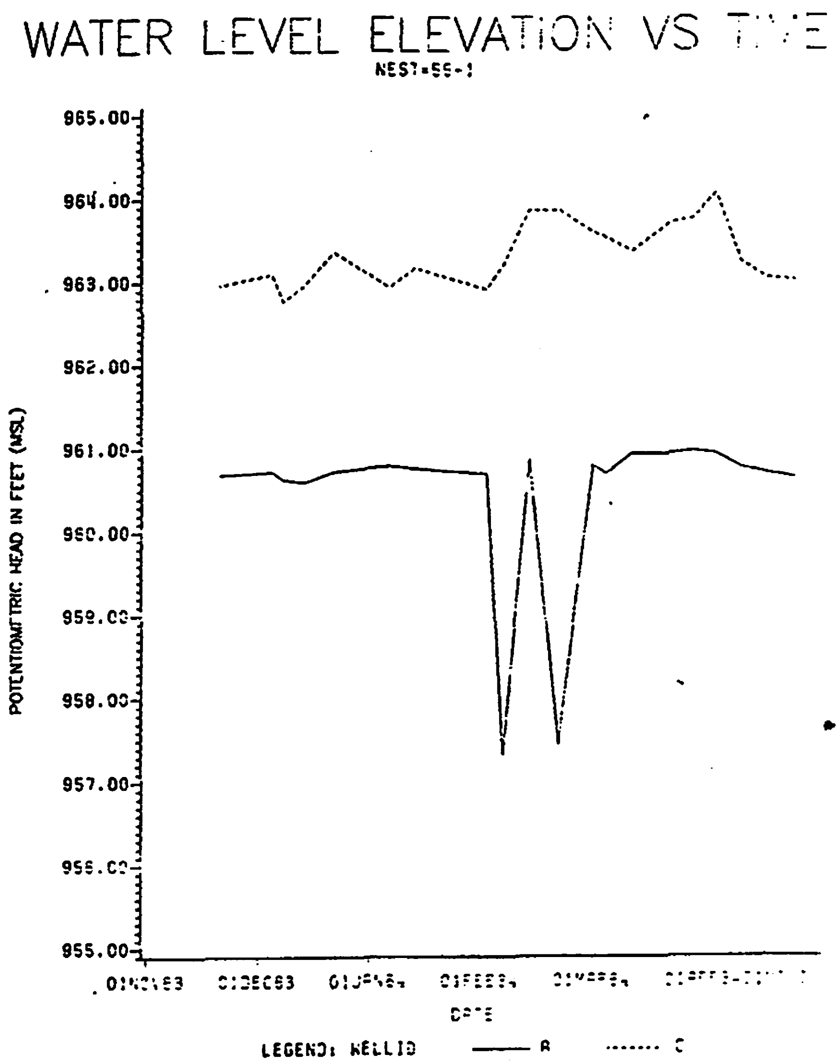

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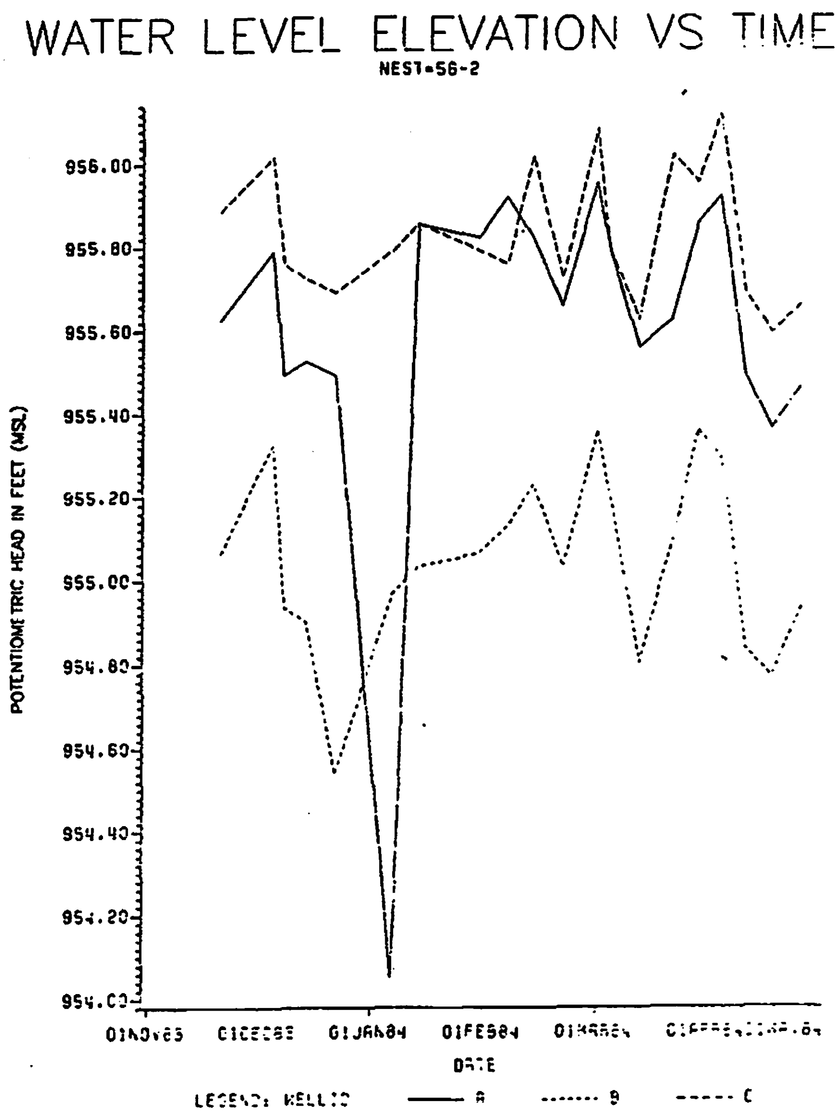

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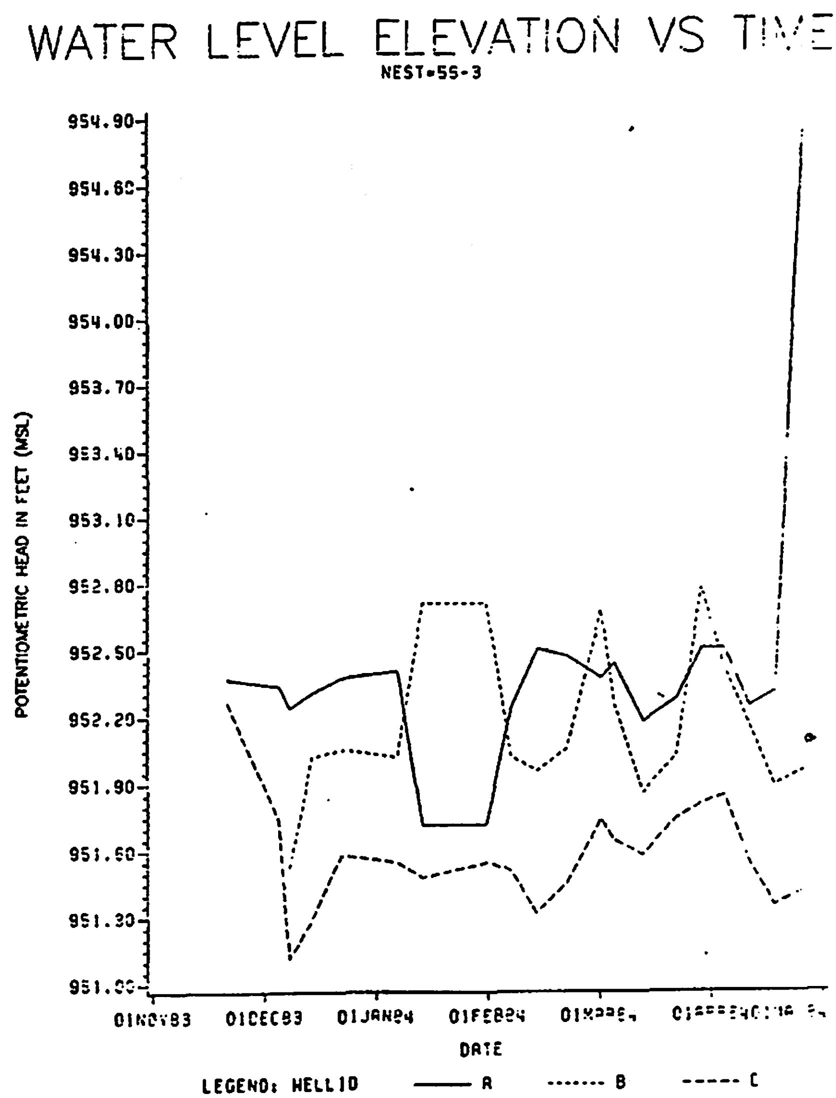

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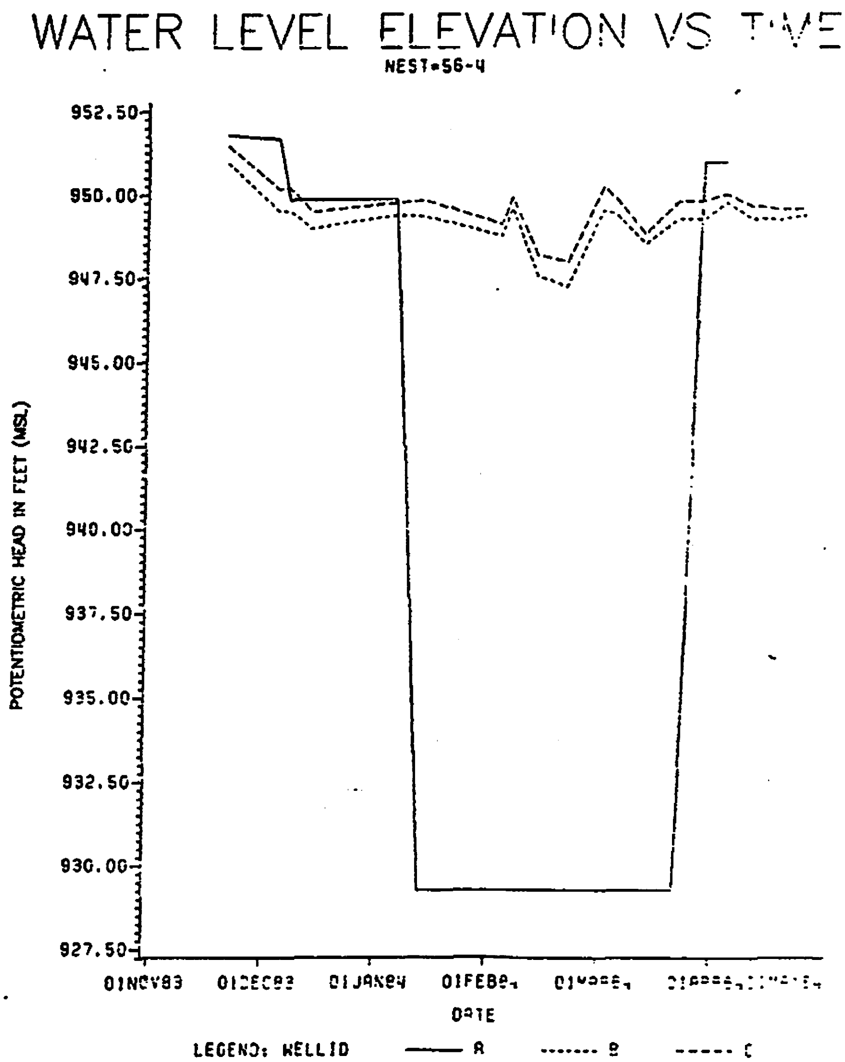

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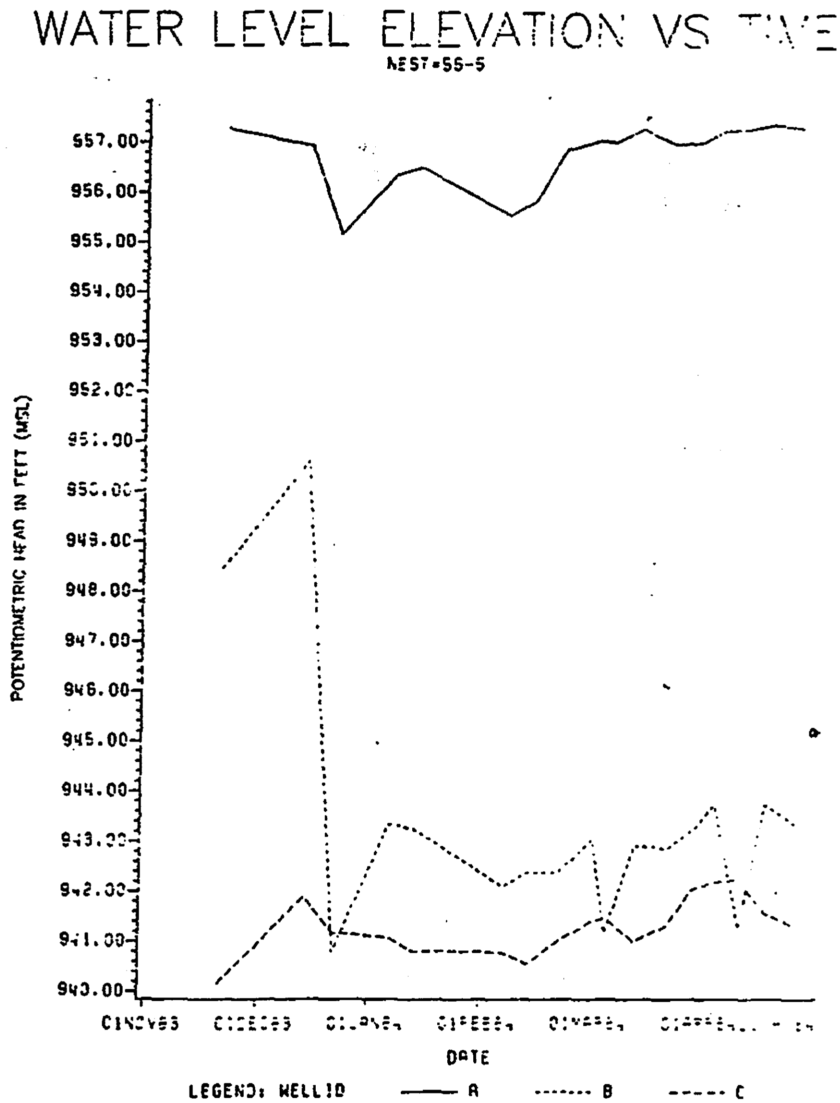

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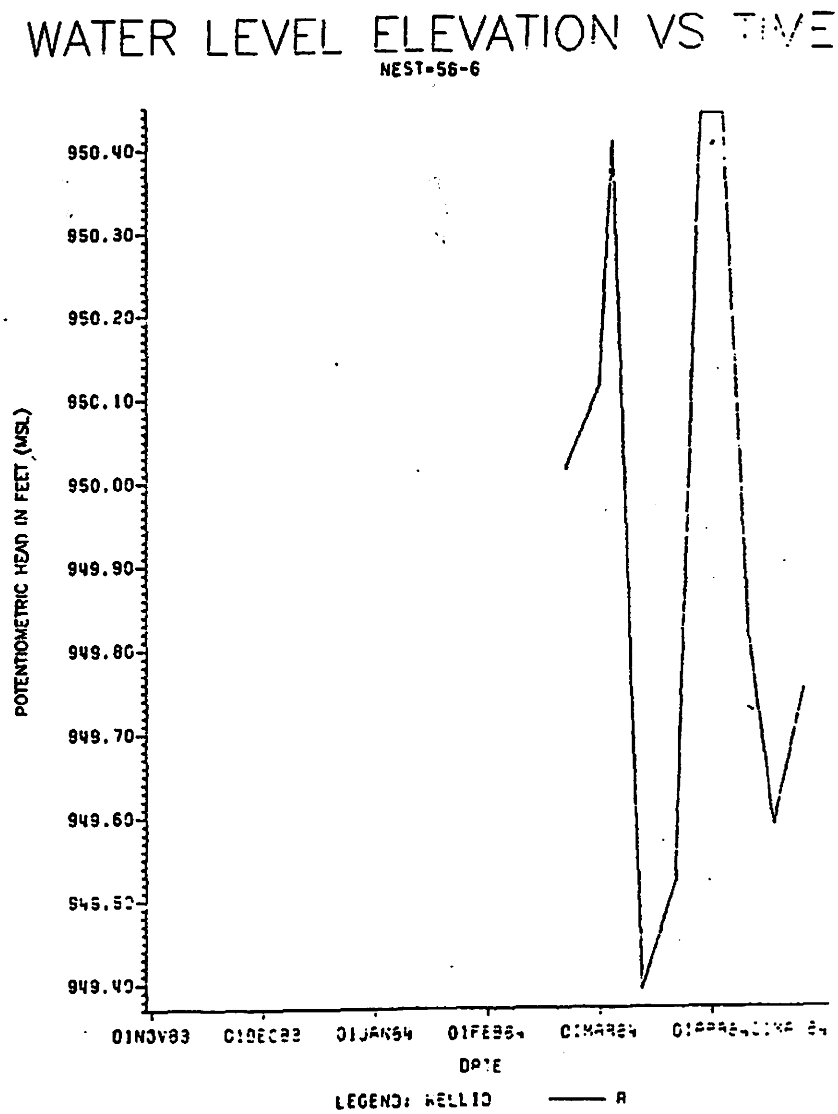

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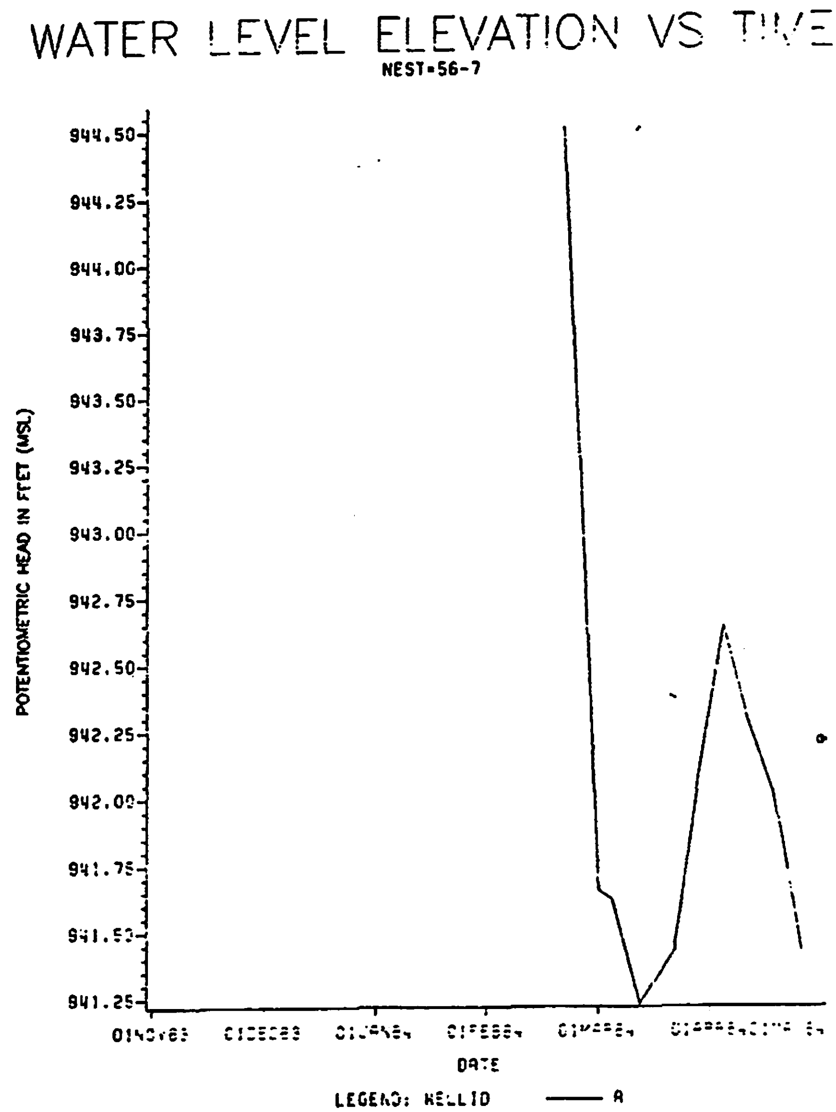

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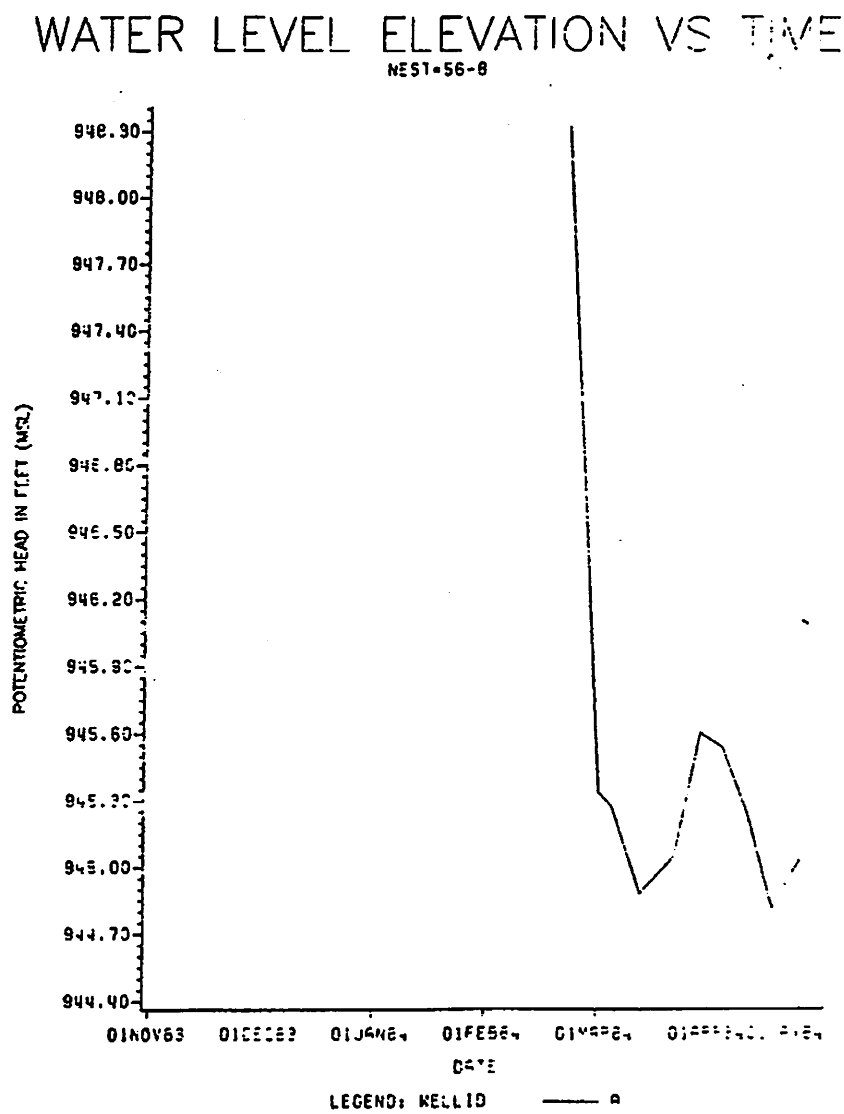

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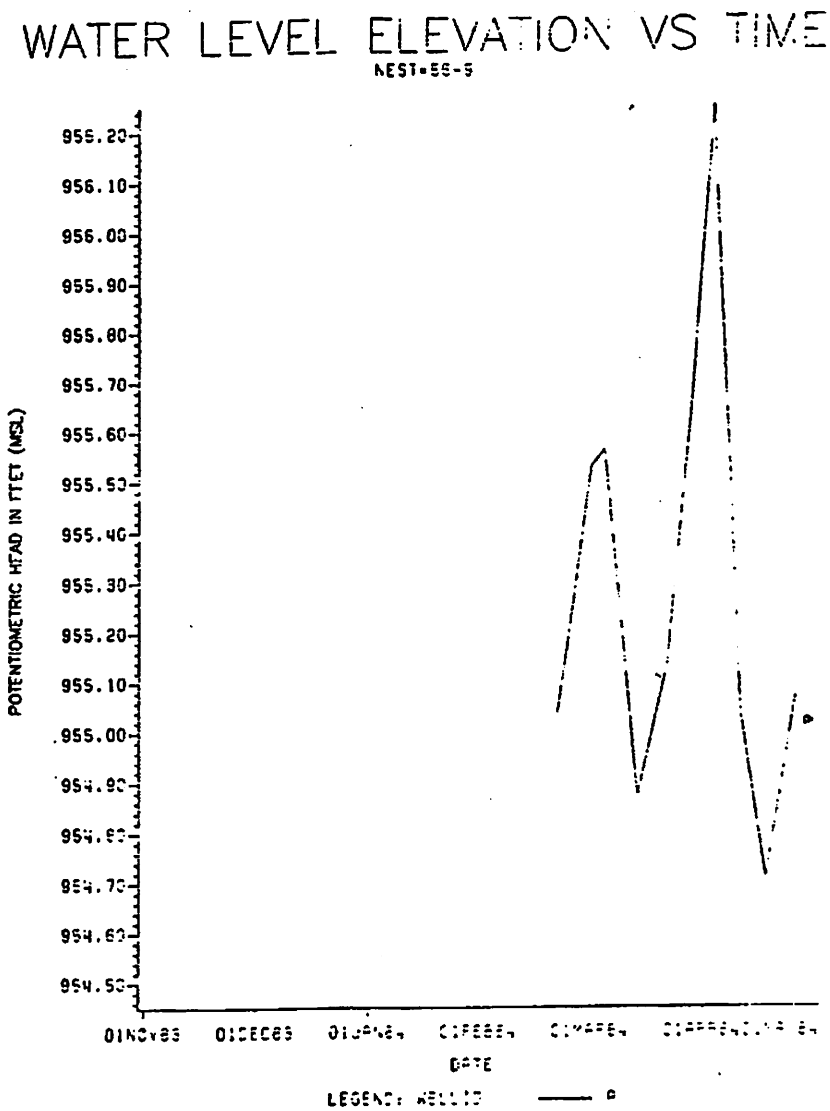

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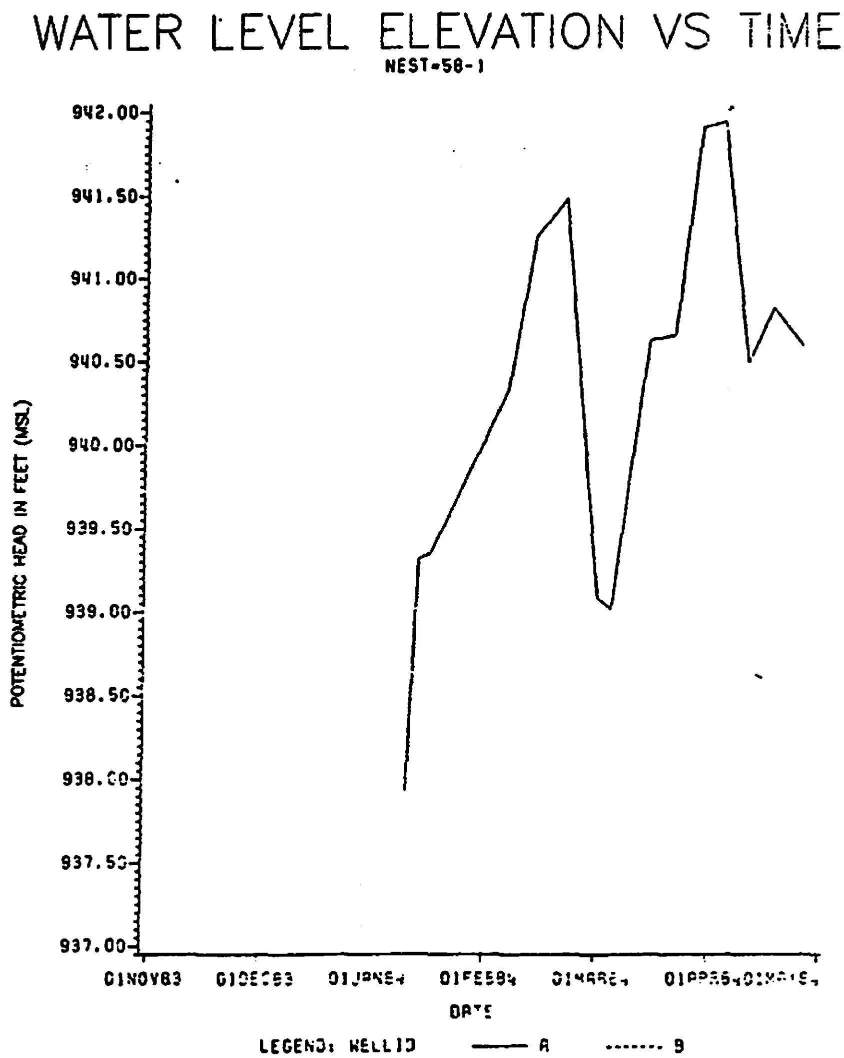

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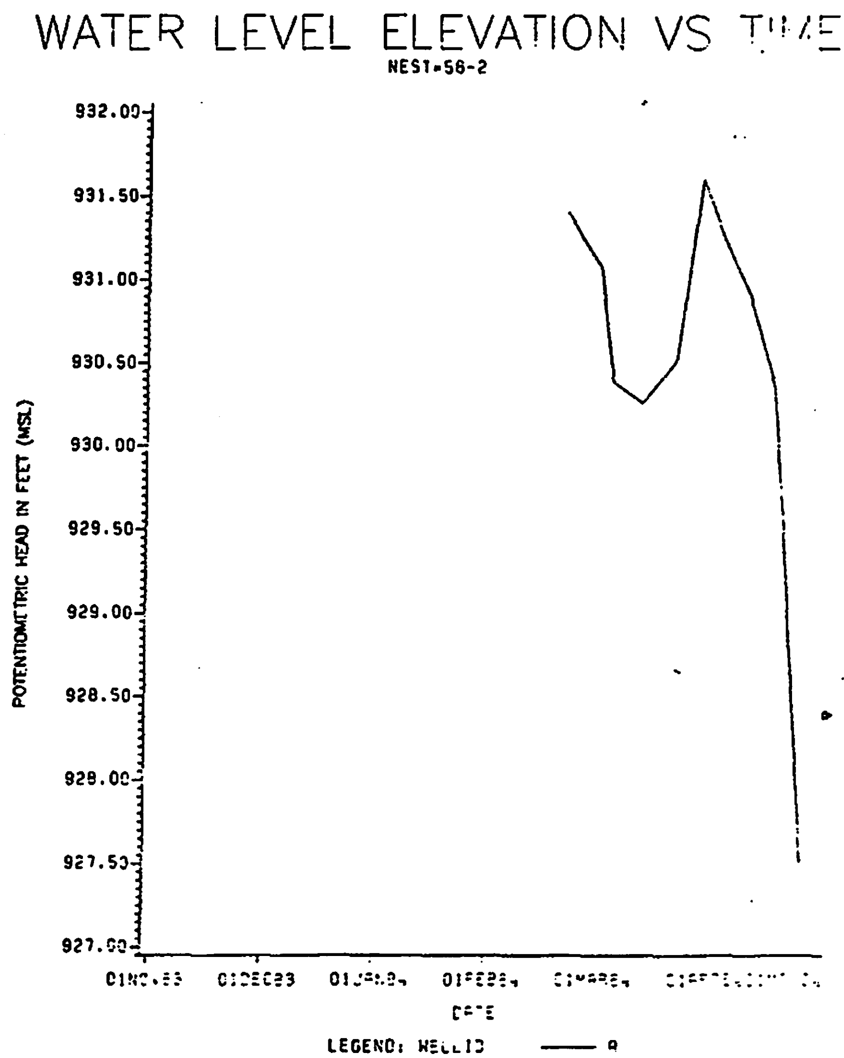

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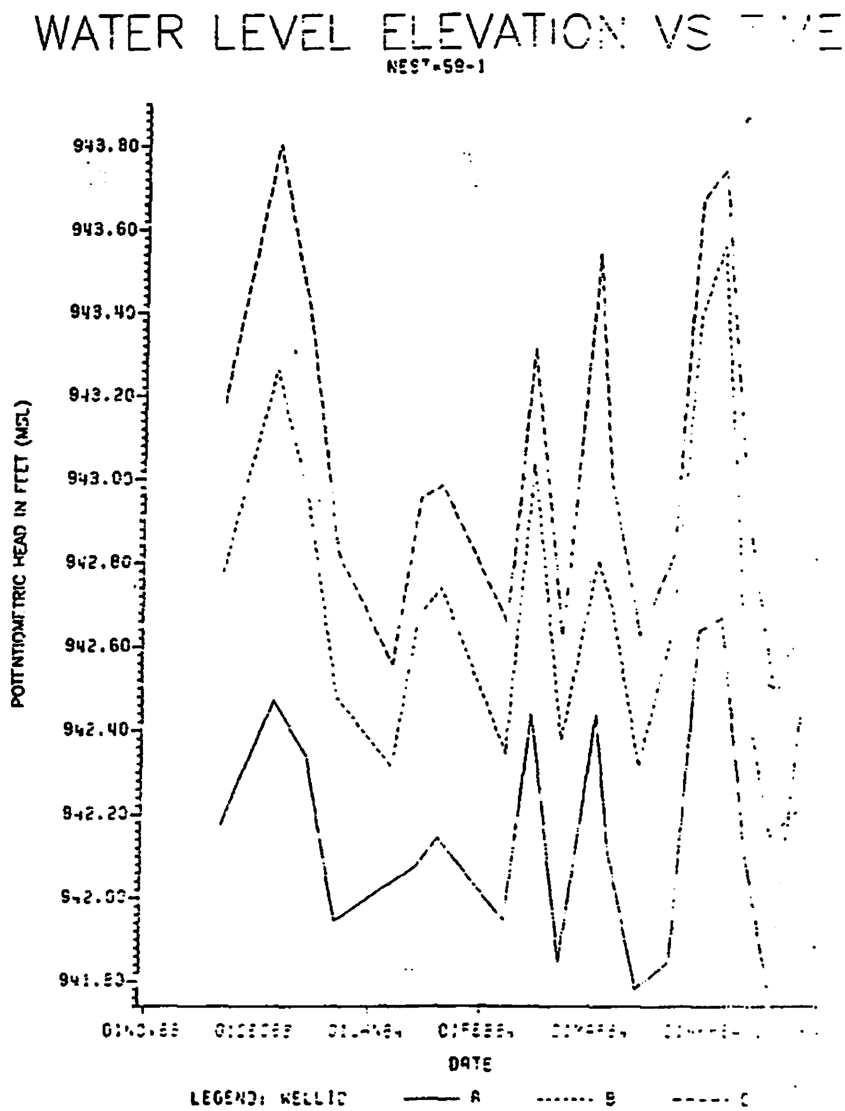

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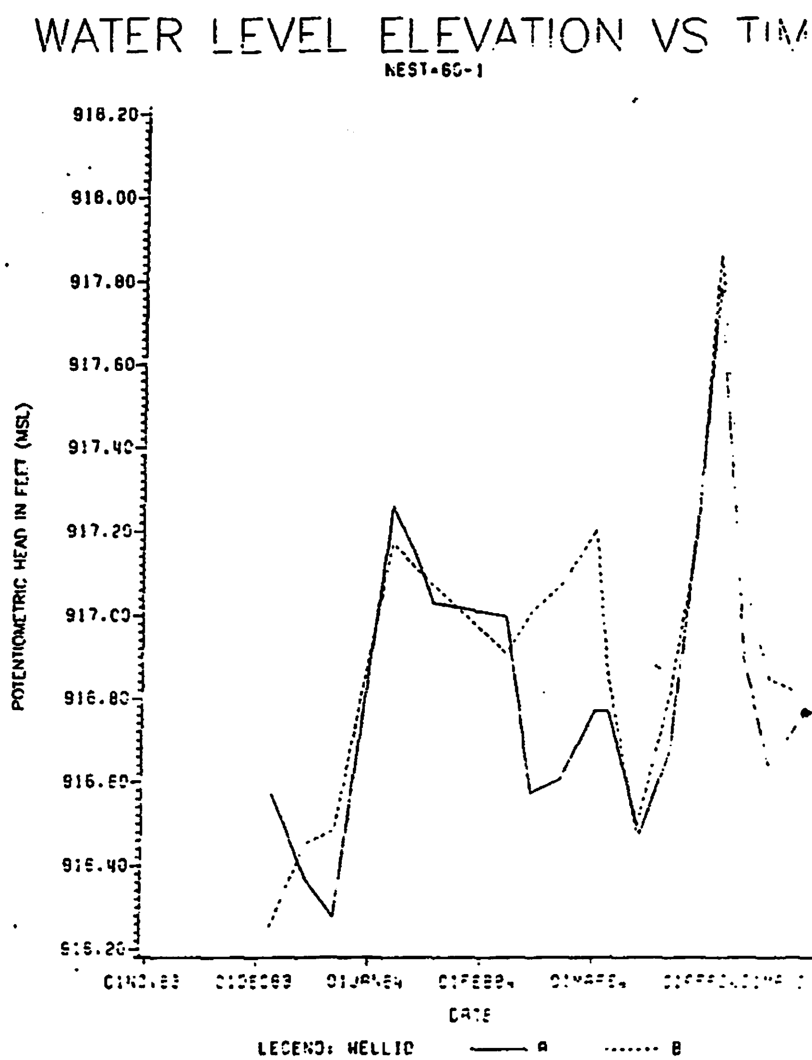

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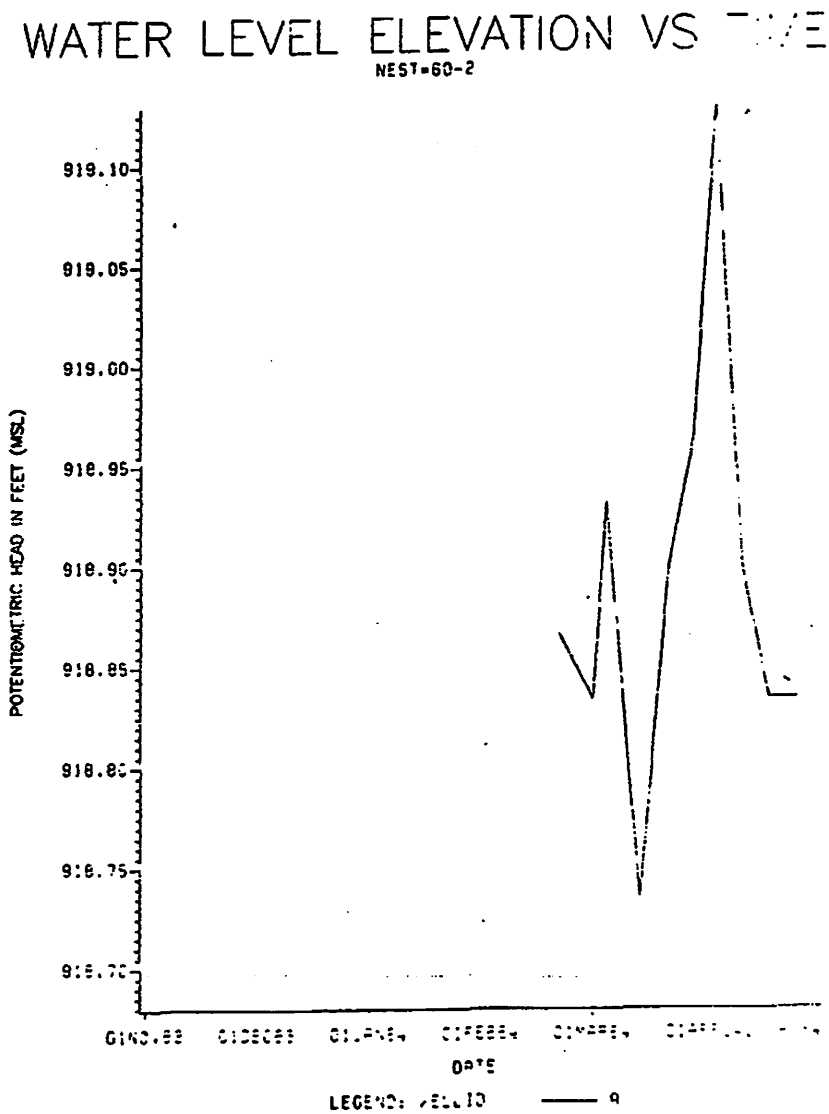

Appendix D

DRILL WATER ANALYSES

Appendix D

DRILL WATER ANALYSES

Table D-1. Hg Analyses of Drill Waters (For Cores)[a]

Hole ID	Date	Time	Lab #	Hg (µg/mL) Suspension	Hg (µg/mL) Supernatent
56-4 C	8/11/83	1300	3859	0.009	<0.001
56-4 C	8/1/83	1530	3919	0.002	<0.001
56-4 C	8/12/83	1100	3921	0.002	<0.001
56-4 C	8/12/83	1425	3920	0.002	<0.001
56-4 C	8/15/83	1155	3966	<0.001	<0.001
56-2 C	8/16/83		3697	0.003	<0.001
56-2 C	8/16/83		3968	<0.001	<0.001
56-2 C	8/17/83		3969	<0.001	<0.001
56-2 C	8/17/83		3970	<0.001	<0.001
56-2 C	8/18/83		3973	<0.001	<0.001
55-2 C	8/18/83	1450	4382	0.001	<0.001
55-2 C	8/22/83	1500	4383	<0.001	<0.001
55-2 C	8/19/83	1010	4186	<0.001	<0.001
55-2 C	8/19/83	1430	4187	<0.001	<0.001
55-1 C	8/23/83	1400	4384	<0.001	<0.001
55-1 C	8/24/83	0900	4385	0.004	<0.001
55-1 C	8/24/83	1300	4386	0.014	<0.001
55-1 C	8/24/83	1630	4387	0.012	<0.001
55-1 C	8/25/83	1405	4388	<0.001	<0.001
55-4	8/26/83	1130	4435	<0.001	<0.001
55-4	8/26/83	1430	4436	<0.001	<0.001
56-5	8/31/83	1050	4437	4.8	<0.001
60-1 C	9/8/83	1129	4654	0.014	<0.001
60-1 C	9/8/83	1600	4655	0.001	<0.001
60-1 C	9/8/83	1730	4656	0.004	<0.001
60-1 C	9/9/83	0955	4657	0.017	<0.001
59-1	9/13/83	0930	4685	0.001	<0.001
59-1	9/13/83	1145	4686	0.002	<0.001
59-1	9/13/83	1500	4687	0.001	<0.001
59-1	9/14/83	1020	5471	<0.001	<0.001
59-1	9/14/83	1520	5472	<0.001	<0.001

[a]Drill water was recirculated throughout drilling of entire hole with the exception of hole 56-4 C for which water was circulated once through. The source of all water was local fire hydrants.

Appendix E

ANALYSES AND PLOTS OF MERCURY IN SOILS, FILL, AND WEATHERED ROCK

Appendix E

ANALYSES AND PLOTS OF MERCURY IN SOILS, FILL, AND WEATHERED ROCK

Table E-1. Mercury in fill, soil, and weathered rock samples collected during drilling

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

MISCELLANEOUS SITES

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
PIT1WP12		T	09MAY83	•	•	-0.05	•	W SHALE
PIT2WOFI		T	09MAY83	•	•	-0.05	•	W SHALE
TRENCH	A	T	09MAY83	•	•	•	0.33	W SHALE
9733-2	A	SC	21JAN83	•	1.0	•	4.00	
9733-3	A	SC	21JAN83	•	1.0	•	0.72	
9733-2	A	SC	21JAN83	1	1.3	•	34.00	
TRENCH	B	T	09MAY83	•	•	•	0.74	W SHALE
9733-2	B	SC	21JAN83	•	1.0	•	1.00	
TRENCH	C	T	09MAY83	•	•	•	0.15	W SHALE
TRENCH	D	T	09MAY83	•	•	•	0.40	W SHALE
TRENCH	E	T	09MAY83	•	•	•	0.32	W SHALE
TRENCH	F	T	09MAY83	•	•	•	0.20	W SHALE
TRENCH	G	T	09MAY83	•	•	•	0.66	W SHALE
TRENCH	H	T	09MAY83	•	•	•	0.55	W SHALE
9733-2	HGTRP	T	01DEC83	•	•	•	6430.00	FILL
TRENCH	I	T	09MAY83	•	•	•	0.57	FILL
TRENCH	J	T	09MAY83	•	•	•	0.72	FILL
TRENCH	K	T	09MAY83	•	•	•	0.83	FILL
TRENCH	L	T	09MAY83	•	•	•	0.61	FILL
TRENCH	M	T	09MAY83	•	•	•	0.26	FILL
TRENCH	N	T	09MAY83	•	•	•	0.53	FILL
TRENCH	O	T	16AUG83	•	•	•	0.38	FILL
TRENCH	P	T	16AUG83	•	•	•	0.33	FILL
TRENCH	Q	T	16AUG83	•	•	•	0.38	FILL
TRENCH	R	T	16AUG83	•	•	•	0.42	FILL
TRENCH	S	T	16AUG83	•	•	•	0.42	FILL
TRENCH	T	T	16AUG83	•	•	•	1.00	FILL
TRENCH	U	T	16AUG83	•	•	•	1.67	FILL
TRENCH	V	T	16AUG83	•	•	•	0.85	FILL
TRENCH	W	T	16AUG83	•	•	•	0.85	FILL
TRENCH	X	T	16AUG83	•	•	•	0.31	FILL
TRENCH	Y	T	16AUG83	•	•	•	0.34	FILL
TRENCH	Z	T	16AUG83	•	•	•	0.47	FILL

Table E-2. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 53-1)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 53-1

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
N POST33	1	PS	•	0	2	•	0.08	
N POST33	1	CS	•	2	4	•	0.26	
N POST33	1	CS	•	4	6	•	0.28	
N POS133	18	PS	•	0	2	•	7.80	
N POST33	18	CS	•	2	4	•	0.37	
N POS133	18	CS	•	4	6	•	0.28	
N POS133	5	PS	•	0	2	•	4.20	
N POS133	5	CS	•	2	4	•	1.00	
N POS133	5	CS	•	4	6	•	1.00	

Table E 3. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 55-1)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 55-1

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
NW9201-5	B	AB	04AUG83	•	8	-0.05	•	W SHALE
NW9201-5	B	AB	04AUG83	•	11	-0.05	•	CALC SHALE
NW9201-5	C	AB	04AUG83	•	5	-0.05	•	W SHALE

Table E-4. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 55-2)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 55-2

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
S 9201-4	A	AB	08AUG83	•	15.0	1.40	•	FILL
S 9201-4	B	AB	08AUG83	•	5.0	1.30	•	FILL
S 9201-4	B	AB	08AUG83	•	5.1	1.90	•	FILL
S 9201-4	B	AB	08AUG83	•	10.0	0.85	•	FILL
S 9201-4	B	AB	08AUG83	•	10.5	0.64	•	W SHALE
S 9201-4	B	AB	08AUG83	•	15.0	0.61	•	W SHALE
S 9201-4	B	BB	08AUG83	•	15.5	0.63	•	W SHALE

Table E-5. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 55-3)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 55-3

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
S 9201-5	A'	AB	05AUG83	•	16	-0.05	•	W SHALE
S 9201-5	B'	AB	05AUG83	•	10	-0.05	•	W SHALE
S 9201-5	B'	AB	05AUG83	•	15	-0.05	•	W SHALE
S 9201-5	B'	AB	05AUG83	•	18	-0.05	•	W SHALE
S 9201-5	C'	PS	05AUG83	2	4	0.03	•	FILL
S 9201-5	C'	CS	05AUG83	6	7	0.10	•	FILL
S 9201-5	C'	CS	05AUG83	7,	8	0.26	•	W SHALE
S 9201-5	C'	CS	05AUG83	8	10	0.04	•	W SHALE

Table E-6. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 55-4)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 55-4

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
S 9103	A	PS	15AUG83	2	3.0	•	4.90	FILL
S 9103	A	CS	15AUG83	6	7.0	•	0.04	W SHALE
S 9103	A	AB	15AUG83	•	12.0	•	0.96	W SHALE
S 9103	A	AB	15AUG83	•	17.0	•	0.70	W SHALE
S 9103	A	AB	15AUG83	•	20.5	•	0.40	W SHALE
S 9103	B		16AUG83	•	5.0	•	0.53	W SHALE
S 9103	B	AB	16AUG83	•	10.0	•	0.17	W SHALE
S 9103	B	AB	16AUG83	•	15.0	•	0.27	W SHALE
S 9103	B	AB	16AUG83	•	20.0	•	0.35	W SHALE
S 9103	B	AB	16AUG83	•	22.0	•	0.65	W SHALE

Table E-7. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 56-2)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 56-2

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
S 9201-4	C	CS	09AUG83	1	3	•	5.00	FILL
S 9201-4	C	CS	09AUG83	3	5	•	2.20	FILL
S 9201-4	C	CS	09AUG83	5	7	•	1.20	FILL
S 9201-4	C	CS	09AUG83	7	9	•	0.67	FILL
S 9201-4	C	CS	09AUG83	9	10	•	0.61	W SHALE

Table E-8. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 56-3)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 56-3

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
S 9201-4	C	PS	02AUG83	1	3.0	-0.05	•	FILL
S 9201-4	C	PS	02AUG83	3	5.0	-0.05	•	FILL
S 9201-4	C	PS	02AUG83	5	7.0	-0.05	•	W SHALE
S 9201-4	C	CS	02AUG83	7	8.0	-0.05	•	W SHALE
S 9201-4	C	CS	02AUG83	8	8.5	-0.05	•	W SHALE

Table E-9. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 56-4)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 56-4

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
S 9201-4	C	CS	29JUL83	12.0	•	-0.05	•	W SHALE
S 9201-4	C	PS	29JUL83	1.0	1.5	-0.05	•	FILL
S 9201-4	C	PS	29JUL83	1.5	3.0	0.13	•	W SHALE
S 9201-4	C	CS	29JUL83	3.0	5.0	-0.05	•	W SHALE
S 9201-4	C	CS	29JUL83	5.0	5.3	-0.05	•	W SHALE
S 9201-4	C	CS	29JUL83	5.3	7.2	-0.05	•	W SHALE
S 9201-4	C	CS	29JUL83	7.2	9.0	-0.05	•	W SHALE
S 9201-4	C	CS	29JUL83	9.0	11.0	-0.05	•	W SHALE
S 9201-4	C	CS	29JUL83	11.0	12.0	-0.05	•	W SHALE
S 9201-4	C	CS	29JUL83	•	14.2	-0.05	•	W SHALE

Appendix E (continued).

Table E-10. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 56-5)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 56-5

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
N 81-10	B	AB	10AUG83	•	5.0	•	144.00	FILL
N 81-10	B	AB	10AUG83	•	10.0	•	48.00	FILL
N 81-10	B'	AB	10AUG83	•	5.0	•	33.00	FILL
N 81-10	C	CS	10AUG83	4.0	6.0	•	303.00	FILL
N 81-10	C	CS	10AUG83	5.5	6.0	•	303.00	FILL
N 81-10	C	CS	10AUG83	6.0	8.0		49.00	FILL
N 81-10	C	CS	10AUG83	8.0	10.0	•	20.00	FILL
N 81-10	C	CS	10AUG83	10.0	12.0	•	18.00	FILL
N 81-10	C	CS	10AUG83	12.0	14.0	•	32.00	FILL
N 81-10	C	CS	10AUG83	14.0	15.0	•	198.00	FILL
N 81-10	C	AB	10AUG83	•	17.0	•	105.00	FILL
N 81-10	2	AB	•	•	1.0	•	100.00	FILL
N 81-10	2	CS	•	1.0	3.0	•	25.00	FILL
	2	CS	•	3.0	4.0	•	9.80	FILL
	2	CS	•	4.0	6.0	•	12.00	FILL
	2	CS	•	6.0	8.0	•	5.00	FILL
	2	CS	•	8.0	10.0	•	1.90	FILL
	2	CS	•	10.0	12.0	•	2.00	FILL
	2	CS	•	12.0	14.0	•	2.30	FILL
	2	CS	•	14.0	16.0	•	0.51	FILL
	2	CS	•	16.0	18.0	•	0.38	FILL
	2	CS	•	18.0	20.0	•	1.30	FILL
	2	CS	•	20.0	22.0	•	4.20	FILL
	2	CS	•	22.0	23.2	•	1.30	FILL
	2	CS	•	23.2	24.0	•	0.88	FILL
N 81-10	2	CS	•	24.0	26.0	•	0.79	
N 81-10	2	CS	•	26.0	28.0	•	0.45	
N 81-10	2	CS	•	28.0	30.0	•	0.97	W SHALE
N 81-10	2	CS	•	30.0	32.0	•	0.89	W SHALE
N 81-10	3	PS	•	0.0	0.3	•	30.00	FILL
N 81-10	3	PS	•	0.3	2.0	•	4.30	FILL
N 81-10	3	CS	•	2.0	3.0	•	15.00	FILL
N 81-10	3	CS	•	3.0	4.0	•	1436.00	FILL
N 81-10	3	CS	•	6.0	6.7	•	164.00	FILL
N 81-10	3	CS	•	6.7	8.0	•	11.00	FILL
N 81-10	3	CS	•	10.0	12.0	•	1.40	FILL
N 81-10	3	CS	•	12.0	14.0	•	1.10	FILL
N 81-10	3	CS	•	14.0	15.2	•	3.00	FILL

Appendix E (continued).

Table E.10. (continued)

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
N 81-10	3	CS	•	15.2	16.0	•	1.50	FILL
N 81-10	3	CS	•	16.0	18.0	•	3.00	FILL
N 81-10	3	CS	•	18.0	20.0	•	8.20	FILL
N 81-10	3	CS	•	20.0	22.0	•	2.00	FILL
N 81-10	3	CS	•	22.0	24.0	•	4.10	FILL
N 81-10	3	CS	•	24.0	26.0	•	0.60	
N 81-10	3	CS	•	26.0	28.0	•	2.60	
N 81-10	3	CS	•	28.0	30.0	•	1.90	W SHALE
N 81-10	3	CS	•	30.0	32.0	•	1.30	W SHALE
N 81-10	4	CS	•	32.0	34.0	•	0.56	W SHALE
N 81-10	4	PS	•	0.0	1.5	•	21.00	FILL
N 81-10	4	AB	•	•	3.0	•	19.00	FILL
N 81-10	4	CS	•	3.0	5.0	•	11.00	FILL
N 81-10	4	PS	•	5.0	7.0	•	2.90	FILL
N 81-10	4	PS	•	7.0	9.0	•	7.20	FILL
N 81-10	4	PS	•	9.0	9.7	•	8.20	FILL
N 81-10	4	CS	•	10.5	11.0	•	1040.00	FILL
N 81-10	4	CS	•	11.0	11.5	•	515.00	
N 81-10	4	PS	•	13.0	15.0	•	4.90	W SHALE
N 81-10	4	AB	•	•	19.0	•	39.00	
N 81-10	4	A5	•	•	19.5	•	56.00	
N 81-10	5	CS	•	2.0	4.0	•	1.40	
N 81-10	5	CS	•	4.0	6.0	•	1.60	
N 81-10	5	CS	•	6.0	6.3	•	44.00	
N 81-10	5	CS	•	6.3	8.0	•	2.90	
N 81-10	5	CS	•	8.0	10.0	•	1.20	
N 81-10	5	CS	•	10.0	11.0	•	0.15	
N 81-10	5	CS	•	11.0	12.0	•	0.33	
N 81-10	5	CS	•	12.0	14.0	•	0.11	
N 81-10	5	CS	•	14.0	16.0	•	0.06	
N 81-10	5	CS	•	16.0	18.0	•	0.03	
N 81-10	5	CS	•	18.0	20.0	•	0.05	
N 81-10	5	CS	•	20.0	22.0	•	0.06	
N 81-10	5	CS	•	22.0	24.0	•	0.10	
N 81-10	5	CS	•	24.0	26.0	•	0.12	
N 81-10	5	CS	•	26.0	28.0	•	0.09	
N 81-10	5	CS	•	28.0	30.0	•	0.25	
N 81-10	5	CS	•	30.0	31.0	•	0.44	
N 81-10	6	CS	•	3.0	5.0	•	2.20	
N 81-10	6	CS	•	5.0	6.0	•	135.00	
N 81-10	6	CS	•	6.0	7.0	•	0.14	
N 81-10	6	CS	•	7.0	9.0	•	0.27	
N 81-10	6	CS	•	9.0	11.0	•	0.26	
N 81-10	6	CS	•	18.0	20.0	•	8.20	
N 81-10	6	CS	•	11.0	13.0	•	0.10	

Appendix E (continued).

Table E-10. (continued)

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
N 81-10	6	CS	•	13.0	15.0	•	0.13	
N 81-10	6	CS	•	15.0	17.0	•	0.09	
N 81-10	6	CS	•	17.0	19.0	•	0.09	
N 81-10	6	CS	•	19.0	21.0	•	0.24	
N 81-10	6	CS	•	21.0	23.0	•	0.09	
N 81-10	6	CS	•	23.0	25.0	•	0.12	
N 81-10	6	CS	•	25.0	27.0	•	0.06	
N 81-10	6	CS	•	27.0	29.0	•	0.07	
N 81-10	6	CS	•	29.0	30.2	•	0.14	
N 81-10	7	AB	•	•	2.0	•	134.00	FILL
N 81-10	7	CS	•	2.0	4.0	•	199.00	FILL
N 81-10	7	CS	•	4.0	6.0	•	23.00	FILL
N 81-10	7	CS	•	6.0	8.0	•	0.62	FILL
N 81-10	7	CS	•	8.0	10.0	•	0.37	FILL
N 81-10	7	CS	•	10.0	12.0	•	0.28	FILL
N 81-10	7	CS	•	12.0	14.0	•	0.29	FILL
N 81-10	7	CS	•	14.0	14.6	•	0.14	FILL
N 81-10	7	CS	•	14.6	16.0	•	2.10	FILL
N 81-10	7	CS	•	16.0	16.6	•	0.75	FILL
N 81-10	7	CS	•	16.6	18.0	•	0.36	FILL
N 81-10	7	CS	•	18.5	20.0	•	0.10	
N 81-10	7	CS	•	18.0	18.5	•	0.28	
N 81-10	7	CS	•	20.0	22.0	•	0.35	
N 81-10	7	CS	•	22.0	24.0	•	0.26	
N 81-10	7	CS	•	24.0	26.0	•	0.36	
N 81-10	7	CS	•	1.0	3.0	•	0.63	FILL
N 81-10	8	CS	•	3.0	5.0	•	0.23	FILL
N 81-10	8	CS	•	5.0	5.8	•	84.00	FILL
N 81-10	8	CS	•	6.5	7.0	•	0.30	FILL
N 81-10	8	CS	•	7.0	9.0	•	0.19	FILL
N 81-10	8	CS	•	9.0	9.3	•	0.27	FILL
N 81-10	8	CS	•	10.3	11.0	•	0.25	FILL
N 81-10	8	CS	•	11.0	11.6	•	0.39	FILL
N 81-10	8	CS	•	12.2	13.0	•	0.33	
N 81-10	8	CS	•	2.0	4.0	•	39.00	
N 81-10	9	CS	•	4.0	6.0	•	20.00	
N 81-10	9	CS	•	6.0	7.0	•	3.60	
N 81-10	9	CS	•	7.0	9.0	•	3.00	
N 81-10	9	CS	•	9.0	11.0	•	11.00	
N 81-10	9	CS	•	11.0	11.9	•	4.60	
N 81-10	9	CS	•	12.7	13.0	•	2.00	
N 81-10	9	CS	•	13.0	15.0	•	1.20	
N 81-10	9	CS	•	15.0	17.0	•	3.50	

Appendix E (continued).

Table E-11. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 58-1)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 58-1

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
9733-1	B	BA	26AUG83	•	0.2	•	5000.0	
9733-1	B	BA	26AUG83	0.2	0.4	•	2300.0	
9733-1	B	BA	26AUG83	0.4	0.7	•	10600.0	
9733-1	B	BA	26AUG83	0.7	0.9	•	5600.0	
9733-1	B	BA	26AUG83	0.9	1.1	•	9700.0	
9733-1	B	BA	26AUG83	1.1	1.4	•	370.0	
9733-1	B	BA	26AUG83	1.4	1.6	•	126.0	
9733-1	B	BA	26AUG83	1.6	1.8	•	138.0	
9733-1	B	BA	26AUG83	1.8	2.1	•	38.0	
9733-1	C	BA	26AUG83	•	0.3	•	39.0	
9733-1	C	BA	26AUG83	0.6	0.9	•	145.0	
9733-1	C	BA	26AUG83	1.2	1:5	•	3100.0	
9733-1	D	BA	02SEP83	•	0.2	•	43.0	
9733-1	D	BA	02SEP83	0.6	0.9	•	39.0	
9733-1	D	BA	02SEP83	1.2	1.3	•	30.0	
9733-1	E	BA	02SEP83	•	0.2	•	51.0	
9733-1	E	BA	02SEP83	0.2	0.5	•	16.0	
9733-1	E	BA	02SEP83	0.5	0.9	•	1300.0	
9733-1	E	BA	02SEP83	0.9	1.2	•	7900.0	
9733-1	E	BA	02SEP83	1.2	1.5	•	233.0	
9733-1	E	BA	02SEP83	1.5	2.0	•	425.0	
9733-1	E	BA	02SEP83	2.0	2.6	•	64.0	
9733-1	E	BA	02SEP83	2.6	3.3	•	50.0	
9733-1	E	BA	02SEP83	3.3	4.3	•	64.0	
9733-1	E	BA	02SEP83	4.3	5.7	•	37.0	
9733-1	F	BA	02SEP83	•	0.2	•	49.0	
9733-1	F	BA	02SEP83	0.7	1.0	•	49.0	
9733-1	F	BA	02SEP83	1.2	1.5	•	19.0	
9733-1	F	BA	02SEP83	1.8	2.2	•	20.0	
9733-1	G	BA	02SEP83	•	0.2	•	214.0	
9733-1	G	BA	02SEP83	0.8	1.0	•	12.0	
9733-1	G	BA	02SEP83	1.2	1.5	•	4.8	
9733-1	G	BA	02SEP83	1.9	2.2	•	4.8	
9733-1	H	BA	02SEP83	•	0.2	•	41.0	
9733-1	H	BA	02SEP83	0.8	1.8	•	15.0	
9733-1	H	BA	02SEP83	2.2	2.5	•	18.0	
9733-1	I	BA	02SEP83	•	0.2	•	52.0	
9733-1	I	BA	02SEP83	0.8	1.0	•	4.8	

Appendix E (continued).

Table E-11. (continued)

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
9733-1	M	PS	29NOV83	•	0.2	•	6.8	
9733-1	M	PS	29NOV83	0.2	2.0	•	2.2	
9733-1	M	PS	29NOV83	2.0	4.0	•	0.4	
9733-1	M	CS	29NOV83	4.0	6.0	•	1.1	
9733-1	M	CS	29NOV83	6.0	8.0	•	1.3	
9733-1	M	CS	29NOV83	8.0	9.0	•	6.7	
9733-1	M	AB	29NOV83	•	12.0	•	0.3	
9733-1	M	AB	29NOV83	•	14.5	•	0.42	
9733-1	N	PS	29NOV83	•	0.5	•	561.00	
9733-1	N	PS	29NOV83	0.5	2.0	•	11.00	
9733-1	N	AB	29NOV83	2.0	2.5	•	17.00	
9733-1	N	AB	29NOV83	2.5	4.0	•	0.64	
9733-1	N	AB	29NOV83	•	4.0	•	44.00	
9733-1	N	AB	29NOV83	•	5.0	•	20.00	
9733-1	N	AB	29NOV83	•	7.0	•	15.00	
9733-1	N	AB	29NOV83	•	9.0	•	3.40	
9733-1	N	AB	29NOV83	•	11.0	•	17.00	
9733-1	N	AB	29NOV83	•	13.0	•	12.00	
9733-1	N	AB	29NOV83	•	15.0	•	7.60	
9733-1	N	AB	29NOV83	•	17.0	•	4.70	
9733-1	N	AB	29NOV83	•	19.0	•	7.20	
9733-1	N	AB	29NOV83	•	20.7	•	4.80	
9733-1	O	PS	01DEC83	2.0	2.5	•	7.10	FILL
9733-1	O	PS	01DEC83	2.5	4.0	•	0.16	FILL
9733-1	O	CS	01DEC83	4.6	5.6	•	3.30	W SHALE
9733-1	Q	PS	02DEC83	•	2.0	•	4.50	FILL
9733-1	Q	PS	02DEC83	2.0	4.0	•	0.17	W SHALE
9733-1	Q	CS	02DEC83	4.0	4.8	•	1.00	W SHALE
9733-1	Q	AB	02DEC83	4.8	5.2	•	0.41	W SHALE
9733-1	Q	CS	02DEC83	5.2	7.2	•	0.71	W SHALE
9733-1	Q	CS	02DEC83	7.2	8.2	•	0.29	W SHALE
9733-1	Q	AB	02DEC83	8.2	9.1	•	0.37	W SHALE
9733-1	Q	AB	02DEC83	9.1	9.8	•	0.07	W SHALE
9733-1	Q	AB	02DEC83	9.8	11.8	•	0.29	W SHALE
9733-1	Q	AB	02DEC83	11.8	14.0	•	0.15	W SHALE
9733-1	Q	AB	02DEC83	14.0	16.0	•	0.08	W SHALE
9733-1	Q	AB	02DEC83	16.0	18.0	•	0.31	W SHALE
9733-1	Q	AB	02DEC83	18.0	20.0	•	0.44	W SHALE
9733-1	Q	AB	02DEC83	•	22.0	•	0.33	W SHALE
9733-1	Q	AB	02DEC83	•	23.0	•	0.11	W SHALE
9733-1	R	SC	21JAN83	•	1.0	•	1.90	
9733-1	R	SC	21JAN83	1.0	2.0	•	0.47	
9733-1	TP2	T	02SEP83	•	0.5	•	296.00	
9733-1	TP2	T	02SEP83	1.0	1.5	•	80.00	
9733-1	TP2	T	02SEP83	2.0	2.5	•	74.00	

Table E-12. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 59-1)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 59-1

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
W 9202	A	AB	11AUG83	•	10.0	•	0.36	W SHALE
W 9202	A	AB	11AUG83	•	15.0	•	0.43	W SHALE
W 9202	B	AB	11AUG83	•	5.0	•	0.79	W SHALE
W 9202	B	AB	11AUG83	•	10.0	•	0.97	W SHALE
W 9202	B	AB	11AUG83	•	15.0	•	0.74	W SHALE
W 9202	B	AB	11AUG83	•	20.0	•	0.20	W SHALE
W 9202	C	PS	11AUG83	2	4.0	•	0.51	W SHALE
W 9202	C	CS	11AUG83	4	4.5	•	0.08	W SHALE
W 9202	C	AB	11AUG83	•	9.5	•	0.69	W SHALE
W 9202	C	AB	11AUG83	•	15.5	•	0.22	W SHALE
W 9202	C	AB	11AUG83	•	20.0	•	0.09	W SHALE

Appendix E (continued).

Table E-13. Mercury in fill, soil, and weathered rock samples collected during drilling. (Site 60-1)

TYPE: AB = auger bit, PS = push Shelby, CS = continuous Shelby, BA = bucket auger, SC = soil corer, T = trowel. UP, DOWN, and DEPTH in feet below surface; HG = Hg in µg/g dry weight; WHG = Hg in µg/g, wet weight basis. Negative prefix denotes "less than."

SITE 60-1

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
E 9201-2	A	PS	12AUG83	2.0	4.0	•	1.10	FILL
E 9201-2	A	CS	12AUG83	4.0	6.0	•	0.48	FILL
E 9201-2	A	CS	12AUG83	6.0	8.0	•	0.33	FILL
E 9201-2	A	CS	12AUG83	8.0	10.0	•	0.09	FILL
E 9201-2	A	CS	12AUG83	10.0	12.0	•	0.09	FILL
E 9201-2	A	CS	12AUG83	12.0	14.0	•	0.10	FILL
E 9201-2	A	CS	12AUG83	14.0	16.0	•	0.05	FILL
E 9201-2	A	CS	12AUG83	16.0	18.0	•	0.06	FILL
E 9201-2	B	AB	12AUG83	•	5.0	•	1.30	FILL
E 9201-2	B	AB	12AUG83	•	5.1	•	25.00	FILL
E 9201-2	B	AB	12AUG83	•	10.0	•	1.00	FILL
E 9201-2	B	AB	12AUG83	•	15.0	•	0.74	FILL
E 9201-2	B	AB	12AUG83	•	16.5	•	2.30	
E 9201-2	B1	CS	•	2.0	4.0	•	12.00	
E 9201-2	B1	CS	•	4.0	6.0	•	5.50	
E 9201-2	B1	CS	•	6.0	8.0	•	4.30	
E 9201-2	B1	CS	•	8.0	10.0	•	3.60	
E 9201-2	B1	CS	•	10.0	12.0	•	7.40	
E 9201-2	B1	CS	•	12.0	14.0	•	9.80	
E 9201-2	B1	CS	•	14.0	15.0	•	13.00	
E 9201-2	B2	CS	•	2.0	4.0	•	0.27	
E 9201-2	B2	CS	•	4.0	6.0	•	0.04	
E 9201-2	B2	CS	•	6.0	8.0	•	0.27	
E 9201-2	B2	CS	•	8.0	8.5	•	0.30	
E 9201-2	B2	CS	•	8.5	10.0	•	0.13	
E 9201-2	B2	CS	•	10.0	12.0	•	0.06	
E 9201-2	B2	CS	•	12.0	12.3	•	1.50	
E 9201-2	B2	CS	•	12.3	14.0	•	1.20	
E 9201-2	B2	CS	•	14.0	16.0	•	0.81	
E 9201-2	B3	CS	•	4.0	6.0	•	4.00	
E 9201-2	B3	CS	•	6.0	8.0	•	4.10	
E 9201-2	B3	CS	•	8.0	10.0	•	3.50	
E 9201-2	B3	CS	•	10.0	12.0	•	1.40	
E 9201-2	B3	CS	•	12.0	14.0	•	6.70	
E 9201-2	B3	CS	•	14.0	16.0	•	8.60	
E 9201-2	B3	CS	•	16.0	17.2	•	7.90	
E 9201-2	B3	CS	•	17.6	18.0	•	1.30	

Appendix E (continued).

Table E-13. (continued)

SITE	BORING	TYPE	DATE	UP	DOWN	WHG	HG	DESCRI
E 9201-2	B3	CS	•	18.0	20.0	•	0.17	
E 9201-2	B4	CS	•	2.0	2.9	•	20.00	
E 9201-2	B4	CS	•	2.9	3.7	•	5000.00	
E 9201-2	B4	CS	•	3.7	4.0	•	39.00	
E 9201-2	B4	CS	•	4.0	6.0	•	3000.00	
E 9201-2	B4	CS	•	6.0	6.4	•	18.00	
E 9201-2	B4	CS	•	6.4	8.0	•	10.00	
E 9201-2	B4	CS	•	8.0	9.0	•	4.10	
E 9201-2	B4	CS	•	11.0	12.0	•	14.00	
E 9201-2	B4	CS	•	12.0	13.0	•	500.00	
E 9201-2	B5	CS	•	2.0	4.0	•	362.00	
E 9201-2	B5	CS	•	6.0	8.0	•	0.65	
E 9201-2	B5	CS	•	8.0	10.0	•	0.29	
E 9201-2	B5	CS	•	10.0	12.0	•	0.27	
E 9201-2	B5	CS	•	12.0	13.0	•	0.40	
E 9201-2	B6	CS	•	2.0	4.0	•	2.20	
E 9201-2	B6	CS	•	4.0	5.5	•	2.40	
E 9201-2	B6	CS	•	6.5	8.0	•	1.60	
E 9201-2	B6	CS	•	8.0	10.0	•	2.40	
E 9201-2	B6	CS	•	10.0	12.0	•	2.50	
E 9201-2	B6	CS	•	12.0	14.0	•	4.30	
E 9201-2	B6	CS	•	14.0	16.0	•	5.40	
E 9201-2	B6	CS	•	16.0	17.0	•	2.80	
E 9201-2	B7	CS	•	1.5	3.5	•	0.33	
E 9201-2	B7	CS	•	4.0	6.0	•	0.12	
E 9201-2	B7	CS	•	6.0	6.6	•	0.36	
E 9201-2	B7	CS	•	6.9	8.0	•	0.09	
E 9201-2	B7	CS	•	8.0	10.0	•	0.26	
E 9201-2	B7	CS	•	10.0	12.0	•	0.26	
E 9201-2	B7	CS	•	12.0	14.0	•	0.06	
E 9201-2	B7	CS	•	14.0	14.4	•	0.38	
E 9201-2	B7	CS	•	14.4	16.0	•	0.46	
E 9201-2	B7	CS	•	16.0	18.0	•	0.50	
E 9201-2	B8	CS	•	2.0	4.0	•	0.98	
E 9201-2	B8	CS	•	4.0	6.0	•	0.44	
E 9201-2	B8	CS	•	6.0	8.0	•	0.97	
E 9201-2	B8	CS	•	8.0	9.0	•	0.59	
E 9201-2	C	AB	12AUG83	•	18.5	•	0.62	FILL

Appendix F

GROUNDWATER CHEMISTRY DATA

Appendix F

GROUNDWATER CHEMISTRY DATA

Table F-1. Water quality data for Y-12 wells

NEST	WELL	DATE	LEVEL	QUALITY	FPH	EC	HG	U	TEMP
53-1	A	15MAY84	•	TM	•	6920	0.10	•	26.6
54-1	A	03MAR84	3.36	TM	•	172	0.04	0.001	24.0
54-1	A	12MAR84	3.47	TM	7.00	520	0.03	0.001	15.3
54-2	A	03MAR84	3.39	TM	•	176	0.04	0.001	23.8
54-2	A	12MAR84	3.89	TM	6.80	554	0.09	0.001	15.7
55-1	A	10NOV83	•	TM	8.18	702	1.10	•	•
55-1	A	16DEC83	•	C	•	•	0.06	•	•
55-1	A	25JAN84	3.22	TM	7.00	594	0.06	0.002	15.1
55-1	A	12MAR84	3.41	TM	7.00	783	0.04	0.002	15.4
55-1	B	10NOV83	•	C	8.05	740	0.10	•	•
55-1	B	25JAN84	3.18	TM	6.90	793	0.09	0.001	17.1
55-1	C	14NOV83	3.67	C	7.91	560	0.60	•	•
55-1	C	25JAN84	3.39	C	6.90	781	0.13	0.001	16.9
55-2	A	17NOV83	2.70	TM	•	•	3.50	•	•
55-2	A	15DEC83	•	C	•	•	1.70	•	•
55-2	A	16DEC83	•	C	7.00	359	1.10	•	•
55-2	A	26JAN84	2.48	TM	6.90	469	0.73	0.009	16.5
55-2	A	20MAR84	2.53	TM	6.80	467	0.06	0.012	14.9
55-2	B	17NOV83	2.60	C	•	•	0.04	•	•
55-2	B	26JAN84	2.49	C	6.70	521	0.03	0.001	18.2
55-2	B	22MAR84	2.49	C	6.50	535	-0.01	0.002	15.9
55-2	C	05DEC83	•	C	7.30	547	0.08	•	•
55-2	C	26JAN84	2.57	C	7.20	609	-0.01	0.001	15.5
55-2	C	22MAR84	2.58	C	6.90	613	-0.01	0.002	16.5
55-3	A	16NOV83	3.09	C	•	•	1.10	•	•
55-3	A	15DEC83	•	C	7.30	478	0.15	•	•
55-3	A	27JAN84	3.45	TM	7.00	583	0.04	0.002	19.6
55-3	A	20MAR84	3.26	M	6.80	526	20.00	0.003	17.4
55-3	B	16NOV83	3.90	C	•	•	0.03	•	•
55-3	B	27JAN84	3.98	C	7.20	467	0.33	0.002	18.7
55-3	B	26MAR84	3.47	TM	7.60	498	0.20	-0.001	18.7
55-3	C	16NOV83	3.67	C	•	•	0.07	•	•
55-3	C	27JAN84	3.69	C	7.40	411	-0.01	0.001	18.6
55-3	C	26MAR84	3.49	C	7.80	420	0.01	-0.001	18.4
55-4	B	08DEC83	1.84	C	•	•	0.16	•	•
55-4	B	10FEB84	3.37	TM	6.50	709	0.05	0.002	18.6
55-4	B	12MAR84	3.24	C	6.60	677	0.07	0.001	18.9

Appendix F (continued).

Table F-1. Water quality data for Y-12 wells (continued)

NEST	WELL	DATE	LEVEL	QUALITY	FPH	EC	HG	U	TEMP
55-4	C	08DEC83	2.14	M	•	•	4.00	•	•
55-4	C	10FEB84	2.87	M	6.90	615	0.20	0.001	15.1
55-5	A	05MAR84	2.09	VM	•	553	93.00	0.028	24.0
55-5	A	12MAR84	2.13	VM	6.90	612	11.00	0.011	12.0
55-6	A	05MAR84	3.05	VM	•	•	1.10	0.002	•
55-6	A	12MAR84	2.37	M	6.60	487	4.90	0.001	12.1
56-1	A	14NOV83	2.60	TM	8.33	628	0.50	•	•
56-1	A	14NOV83	2.60	TM	8.33	628	0.90	•	•
56-1	A	16DEC83	•	C	7.20	534	0.19	•	•
56-1	A	02FEB84	2.61	TM	7.30	627	0.13	0.005	17.0
56-1	A	12MAR84	2.54	TM	7.30	847	0.16	0.003	14.0
56-1	C	14NOV83	1.89	C	8.42	465	0.30	•	•
56-1	C	14NOV83	1.89	C	8.42	465	0.40	•	•
56-1	C	02FEB84	2.01	C	7.20	895	0.05	0.002	15.6
56-2	A	05DEC83	2.29	VM	7.18	555	5.20	•	•
56-2	A	05DEC83	2.29	VM	7.18	555	145.00	•	•
56-2	A	06DEC83	•	U	7.40	449	5.20	•	•
56-2	A	15DEC83	•	C	7.20	474	0.62	•	•
56-2	A	30JAN84	2.28	TM	7.30	767	0.86	0.006	14.0
56-2	A	20MAR84	2.30	TM	7.00	695	0.73	0.006	14.8
56-2	B	06DEC83	•	C	7.40	449	0.15	•	•
56-2	B	30JAN84	2.20	TM	7.60	483	0.35	0.002	13.3
56-2	B	27MAR84	2.22	M	7.30	497	0.10	-0.001	17.8
56-2	C	06DEC83	•	C	8.26	462	1.30	•	•
56-2	C	06DEC83	•	C	8.26	462	0.95	•	•
56-2	C	31JAN84	2.79	TM	8.20	477	0.13	0.001	14.3
56-2	C	27MAR84	2.73	TM	8.20	476	0.43	-0.001	17.7
56-3	A	07DEC83	3.28	C	•	•	0.91	•	•
56-3	A	01FEB84	3.45	TM	7.40	384	0.29	0.004	17.7
56-3	A	20MAR84	3.25	TM	7.10	399	0.18	0.003	16.5
56-3	B	07DEC83	3.25	C	7.00	855	0.08	•	•
56-3	B	01FEB84	3.26	C	7.00	780	0.02	0.002	18.3
56-3	C	07DEC83	3.74	C	•	•	-0.01	•	•
56-3	C	01FEB84	3.45	C	7.00	891	-0.01	0.002	17.6
56-4	B	09DEC83	•	C	6.30	920	0.05	•	•
56-4	B	03FEB84	4.12	C	6.90	1225	0.02	•	15.5
56-4	B	06FEB84	•		7.00	247	•	0.001	•
56-4	B	19MAR84	3.44	M	6.70	1300	0.10	0.003	20.4
56-4	C	09DEC83	•	C	7.30	790	0.03	•	•
56-4	C	02FEB84	3.85	C	7.00	1055	0.03	0.001	15.4
56-5	A	13MAR84	2.87	TM	7.10	1086	4.30	0.170	11.9
56-5	B	15DEC83	•	C	7.40	803	1.30	•	•
56-5	B	16JAN84	7.14	C	7.60	282	0.94	•	11.2
56-5	C	14DEC83	•	C	6.30	636	0.17	•	•

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Appendix F (continued).

Table F-1. Water quality data for Y-12 wells (continued)

NEST	WELL	DATE	LEVEL	QUALITY	FPH	EC	HG	U	TEMP
56-5	C	16JAN84	8.05	C	6.60	769	0.88	•	14.3
56-6	A	03MAR84	3.00	M	•	146	0.21	0.001	24.2
56-6	A	05MAR84	•	M	•	•	0.50	•	•
56-6	A	19MAR84	3.22	TM	7.10	905	0.17	0.002	21.3
56-7	A	02MAR84	5.12	TM	•	682	1.90	0.002	25.4
56-7	A	13MAR84	5.25	TM	6.80	970	7.60	0.002	15.8
56-8	A	02MAR84	3.21	C	•	921	-0.01	0.002	24.9
56-8	A	13MAR84	5.36	TM	7.10	925	1.00	0.002	16.3
56-9	A	02MAR84	3.20	TM	•	392	0.02	0.003	24.8
56-9	A	14MAR84	3.33	TM	7.70	1468	0.05	0.003	13.8
58-1	A	10JAN84	3.02	U	•	105	14.00	•	23.6
58-1	A	18JAN84	3.88	TM	•	102	16.00	0.008	•
58-1	A	15MAR84	2.20	TM	6.30	96	30.00	•	18.6
58-1	B	10JAN84	3.69	U	•	155	2.00	•	•
58-1	B	18JAN84	2.59	TM	7.90	134	7.60	0.002	23.8
58-1	B	15MAR84	3.00	TM	7.10	166	0.71	•	19.5
58-1	C	10JAN84	1.25	U	•	•	40.00	•	•
58-2	A	02MAR84	2.36	M	•	97	0.21	0.001	23.7
58-2	A	19MAR84	3.56	TM	7.80	474	0.06	0.002	16.9
59-1	A	11DEC83	1.02	C	6.70	469	0.02	•	•
59-1	A	23JAN84	1.10	TM	6.20	456	0.40	•	12.5
59-1	A	19MAR84	1.23	TM	6.50	462	0.40	0.003	21.8
59-1	B	13DEC83	0.77	C	7.10	337	-0.01	•	•
59-1	B	23JAN84	0.90	TM	7.00	434	0.05	•	12.9
59-1	C	11DEC83	0.80	TM	7.10	358	-0.01	•	•
59-1	C	24JAN84	0.88	C	7.20	383	0.01	0.001	16.3
60-1	A	13DEC83	4.02	M	7.60	703	8.10	•	•
60-1	A	17JAN84	3.85	M	7.60	1048	1.10	0.003	12.1
60-1	A	14MAR84	4.02	VM	7.30	998	28.00	0.005	12.6
60-1	B	13DEC83	4.39	M	7.75	583	1.30	•	•
60-1	B	18JAN84	2.78	VM	•	483	0.69	0.003	•
60-2	A	02MAR84	3.33	TM	•	426	0.10	0.002	23.9
60-2	A	14MAR84	3.34	C	7.10	716	-0.01	0.001	16.8

Appendix F (continued).

Table F-1. Water quality data for Y-12 wells (continued)

NEST	WELL	DATE	ALK	F	CL	SO_4	NO_3	CA	MG	NA	K	SI
53-1	A	15MAY84	223	-2.0	14.7	14.7	15500.	4430.	512.	671.	-180.	35.1
54-1	A	03MAR84	207	-0.05	9.1	42	2.90	31.0	24.0	29.0	-4.0	5.50
54-1	A	12MAR84	210	-0.50	9.7	44	4.50	29.0	24.0	28.0	-9.0	6.70
54-2	A	03MAR84	280	0.20	9.3	14	18.00	66.0	27.0	3.9	-4.0	5.90
54-2	A	12MAR84	250	-0.50	8.3	14	21.00	83.0	11.0	2.7	-9.0	4.10
55-1	A	25JAN84	•	•	•	•	•	120.0	15.0	12.0	-4.0	6.20
55-1	A	25JAN84	230	-0.50	81.0	20	4.90	•	•	•	•	•
55-1	A	12MAR84	230	-0.50	96.0	21	1.40	99.0	16.0	9.3	-9.0	5.40
55-1	B	25JAN84	•	•	•	•	•	120.0	16.0	9.4	-4.0	10.30
55-1	B	25JAN84	160	-0.50	120.0	13	0.42	•	•	•	•	•
55-1	C	25JAN84	•	•	•	•	•	87.0	11.0	8.0	-4.0	9.70
55-1	C	25JAN84	200	-0.50	26.0	32	-0.00	•	•	•	•	•
55-2	A	26JAN84	•	•	•	•	•	75.0	4.4	4.1	-4.0	4.04
55-2	A	26JAN84	160	-0.50	10.5	23	30.00	•	•	•	•	•
55-2	A	20MAR84	170	-0.50	10.3	19	40.80	60.0	4.5	3.6	-9.0	3.30
55-2	B	26JAN84	•	•	•	•	•	86.0	5.3	4.7	-4.0	8.60
55-2	B	26JAN84	160	-0.50	11.0	13	91.00	•	•	•	•	•
55-2	B	22MAR84	162	-0.50	11.0	12	76.00	65.0	4.9	4.6	-9.0	6.20
55-2	C	20JAN84	170	-0.50	11.0	11	78.00	•	•	•	•	•
55-2	C	26JAN84	•	•	•	•	•	75.0	10.7	24.0	8.8	8.80
55-2	C	22MAR84	217	-0.50	11.0	11	69.00	52.0	13.0	25.0	17.0	6.50
55-3	A	27JAN84	•	-0.50	72.0	44	•	88.0	11.0	7.4	-4.0	5.80
55-3	A	20MAR84	180	-0.50	18.0	60	10.10	65.0	9.9	5.7	-9.0	4.01
55-3	B	27JAN84	150	-0.50	43.0	25	2.40	67.0	12.0	3.5	-4.0	7.10
55-3	B	26MAR84	140	-0.50	30.0	38	5.00	62.0	13.0	4.3	9.5	6.00
55-3	C	27JAN84	140	-0.50	22.0	21	0.44	46.0	13.0	9.8	9.5	8.40
55-3	C	27MAR84	150	-0.50	28.0	22	1.20	39.0	13.0	7.9	17.0	6.40
55-4	B	10FEB84	305	-0.50	8.6	10	-0.04	80.0	14.0	5.7	-4.0	11.00
55-4	B	12MAR84	280	-0.50	25.0	24	7.04	97.0	11.0	6.8	-9.0	11.00
55-4	C	10FEB84	260	-0.50	7.8	10	0.18	93.0	18.0	5.9	-4.0	9.60
55-5	A	03MAR84	250	0.43	22.0	59	8.00	95.0	13.0	14.0	-4.0	3.80
55-5	A	12MAR84	240	-0.50	26.0	60	6.30	93.0	12.0	5.8	-9.0	6.20
55-6	A	03MAR84	210	0.10	20.0	51	8.50	58.0	26.0	6.1	-4.0	9.30
55-6	A	12MAR84	190	-0.50	15.0	45	6.03	51.0	23.0	4.5	-9.0	9.80
56-1	A	02FEB84	160	-0.50	133.0	120	4.20	96.0	18.0	38.0	7.4	4.02
56-1	A	12MAR84	170	-0.50	91.0	120	1.30	95.0	19.0	22.0	-9.0	6.10
56-[illegible]	C	02FEB84	16[illegible]	-0.50	52.0	75	-0.04	74.0	16.0	22.0	8.9	5.20
56-[illegible]	A	30JAN84	200	-0.50	33.0	102	6.10	110.0	10.7	19.0	-4.0	3.00
56-2	A	20MAR84	202	0.84	23.0	91	5.00	89.0	10.3	13.0	-9.0	3.01
56-2	B	30JAN84	18[illegible]	-0.05	10.0	54	2.70	•	•	•	•	•

Appendix F (continued).

Table F-1. Water quality data for Y-12 wells (continued)

NEST	WELL	DATE	ALK	F	CL	SO_4	NO_3	CA	MG	NA	K	SI
56-2	B	27MAR84	180	-0.50	9.4	57	2.50	61.0	10.9	10.3	13.0	4.60
56-2	C	31JAN84	210	-0.05	11.0	21	0.12	5.3	1.4	87.0	9.5	4.70
56-2	C	27MAR84	189	-0.50	10.4	20	1.10	4.6	1.2	51.0	14.0	5.20
56-3	A	01FEB84	120	-0.50	11.0	49	8.08	60.0	4.1	4.7	-4.0	2.20
56-3	A	20MAR84	130	-0.50	16.0	49	1.40	54.0	4.8	4.1	-9.0	2.20
56-3	B	01FEB84	160	-0.50	87.0	81	4.40	130.0	6.1	4.5	-4.0	3.20
56-3	C	01FEB84	170	-0.50	99.0	120	3.30	140.0	8.9	10.1	-4.0	3.80
56-4	B	03FEB84	•	•	•	•	•	180.0	17.0	18.0	6.3	2.90
56-4	B	06FEB84	140	-0.50	107.0	130	1.20	120.0	24.0	25.0	45.0	4.60
56-4	B	19MAR84	170	-0.50	170.00	240	3.10	170.0	18.0	13.0	-9.0	3.04
56-4	C	03FEB84	160	-0.50	120.00	160	1.60	140.0	27.0	24.0	9.5	4.50
56-5	A	13MAR84	280	0.58	15.00	220	0.85	150.0	26.0	19.0	-9.0	2.09
56-6	A	03MAR84	390	0.20	7.90	22	-0.10	83.0	45.0	3.8	-8.0	7.30
56-6	A	19MAR84	320	-0.50	7.40	22	-0.50	78.0	25.0	3.8	-9.0	7.90
56-7	A	02MAR84	230	0.20	49.00	86	1.30	68.0	27.0	23.0	-4.0	2.00
56-7	A	13MAR84	270	-0.50	70.00	130	1.40	73.0	54.0	34.0	-54.0	4.30
56-8	A	02MAR84	320	0.40	28.00	140	0.10	71.0	24.0	58.0	-4.0	3.90
56-8	A	13MAR84	340	-0.50	33.00	140	-0.50	58.0	51.0	47.0	-54.0	5.03
56-9	A	02MAR84	309	0.70	5.04	480	4.80	130.0	81.0	4.0	19.0	1.40
56-9	A	14MAR84	340	-0.50	5.40	520	-0.50	130.0	130.0	4.9	-54.0	3.20
58-1	A	18JAN84	120	-0.50	4.30	33	5.06	42.0	12.0	4.7	-4.0	3.00
58-1	A	15MAR84	54	0.50	10.90	50	6.80	29.0	7.7	3.7	-9.0	2.40
58-1	B	18JAN84	180	-0.50	2.70	27	9.90	72.0	9.8	3.8	-4.0	3.90
58-1	B	15MAR84	169	-0.50	2.60	23	4.60	62.0	6.5	3.7	-9.0	2.90
58-2	A	02MAR84	110	0.10	5.20	26	7.08	16.0	24.0	4.5	4.6	3.60
58-2	A	19MAR84	180	-0.50	11.00	45	5.90	36.0	27.0	5.2	-9.0	4.05
59-1	A	23JAN84	•	•	•	•	•	76.0	3.0	4.0	-4.0	7.70
59-1	A	19MAR84	204	-0.50	14.00	15	0.99	49.0	12.0	6.1	-9.0	2.20
59-1	B	23JAN84	•	•	•	•	•	77.0	18.0	11.0	-4.0	1.90
59-1	C	24JAN84	150	-0.50	13.00	19	1.80	58.0	10.7	4.5	-4.0	7.50
60-1	A	18JAN84	300	-0.50	20.90	110	1.90	37.0	20.0	110.0	13.0	5.30
60-1	A	14MAR84	440	0.88	26.00	220	-0.50	18.0	3.3	230.0	-9.0	4.70
60-1	B	18JAN84	230	-0.50	32.00	51	0.51	66.0	7.8	54.0	7.6	3.70
60-2	A	02MAR84	330	0.60	22.00	340	-0.10	39.0	23.0	190.0	-4.0	2.90
60-2	A	14MAR84	290	-0.50	11.00	66	-0.50	47.0	26.0	49.0	-9.0	3.20

Appendix F (continued).

Table F-1. Water quality data for Y-12 wells (continued)

NEST	WELL	DATE	FE	MN	AL	TI	BA	B	BE	CD	CO	CR
53-1	A	15MAY84	-0.2	2.36	-0.36	0.30	28.4	-0.36	-0.02	-0.26	-0.2	-0.3
54-1	A	03MAR84	0.20	2.100	-0.06	0.06	0.09	0.74	-0.001	-0.009	0.13	-0.02
54-1	A	12MAR84	0.25	2.600	-0.06	0.06	0.08	0.85	-0.001	-0.009	0.15	-0.02
54-2	A	03MAR84	-0.02	0.720	-0.06	0.06	0.12	-0.08	-0.001	-0.009	-0.01	-0.02
54-2	A	12MAR84	-0.02	0.016	-0.06	0.05	0.12	0.08	-0.001	-0.009	-0.01	-0.02
55-1	A	25JAN84	-0.02	0.102	0.10	0.05	0.48	-0.08	-0.001	-0.009	-0.01	-0.02
55-1	A	12MAR84	-0.02	0.089	-0.06	0.05	0.42	-0.08	-0.001	-0.009	-0.01	-0.02
55-1	B	25JAN84	-0.02	0.470	0.07	0.05	0.63	-0.08	-0.001	-0.009	-0.01	-0.02
55-1	C	25JAN84	-0.02	0.091	0.08	0.05	0.35	-0.08	-0.001	-0.009	-0.01	-0.02
55-2	A	26JAN84	-0.02	1.200	0.07	0.05	0.07	-0.08	-0.001	-0.009	-0.01	-0.02
55-2	A	20MAR84	-0.02	-0.001	-0.06	0.06	0.08	-0.08	-0.001	-0.009	-0.01	-0.02
55-2	B	26JAN84	-0.02	1.100	0.09	0.05	0.30	-0.08	-0.001	-0.009	-0.01	-0.02
55-2	B	22MAR84	-0.02	0.970	-0.06	0.06	0.26	-0.08	-0.001	-0.009	-0.01	-0.02
55-2	C	26JAN84	0.02	0.210	0.07	0.05	0.57	0.08	-0.001	-0.009	-0.01	-0.02
55-2	C	22MAR84	-0.02	0.130	-0.06	0.06	0.72	-0.08	-0.001	-0.009	-0.01	-0.02
55-3	A	27JAN84	0.21	0.260	0.40	0.05	0.20	0.10	-0.001	-0.009	-0.01	-0.02
55-3	A	20MAR84	-0.02	-0.001	-0.06	0.06	0.09	0.08	-0.001	-0.009	-0.01	-0.02
55-3	B	27JAN84	-0.02	0.370	0.07	0.05	0.32	0.10	-0.001	-0.009	-0.01	-0.02
55-3	B	26MAR84	-0.02	0.082	-0.06	0.05	0.29	0.09	-0.001	-0.009	-0.01	-0.02
55-3	C	27JAN84	0.02	0.075	-0.06	0.05	0.46	0.16	-0.001	-0.009	-0.01	-0.02
55-3	C	27MAR84	-0.02	0.084	-0.06	0.06	0.41	0.12	-0.001	-0.009	-0.01	-0.02
55-4	B	10FEB84	-0.02	0.150	-0.06	0.06	0.29	-0.08	-0.001	-0.009	-0.01	-0.02
55-4	B	12MAR84	-0.02	0.180	-0.06	0.05	0.26	-0.08	-0.001	-0.009	-0.01	-0.02
55-4	C	10FEB84	-0.02	1.300	-0.06	0.06	0.31	-0.08	-0.001	-0.009	-0.01	-0.02
55-5	A	03MAR84	-0.02	0.280	-0.06	0.06	0.14	-0.08	-0.001	-0.009	-0.01	-0.02
55-5	A	12MAR84	0.02	0.860	-0.06	0.05	0.16	-0.08	-0.001	-0.009	-0.01	-0.02
55-6	A	03MAR84	-0.02	-0.001	-0.06	0.06	0.07	-0.08	-0.001	-0.009	-0.01	-0.02
55-6	A	12MAR84	0.02	0.034	-0.06	0.06	0.07	-0.08	-0.001	-0.009	-0.01	-0.02
56-1	A	02FEB84	-0.02	0.067	0.16	0.06	0.06	-0.08	-0.001	-0.009	-0.01	-0.02
56-1	A	12MAR84	-0.02	0.046	-0.06	0.06	0.06	-0.08	-0.001	-0.009	-0.01	-0.02
56-1	C	02FEB84	-0.02	0.170	0.17	0.06	0.21	-0.08	-0.001	-0.009	-0.01	-0.02
56-2	A	30JAN84	0.02	-0.001	0.06	0.06	0.07	0.21	-0.001	-0.009	-0.01	-0.02
56-2	A	20MAR84	-0.02	-0.001	-0.06	0.06	0.06	0.18	-0.001	-0.009	-0.01	-0.02
56-2	B	27MAR84	0.02	-0.001	-0.06	0.06	0.17	0.13	-0.001	-0.009	-0.01	-0.02
56-2	C	31JAN84	-0.02	0.004	-0.06	0.06	0.10	0.72	-0.001	-0.009	-0.01	-0.02
56-2	C	27MAR84	-0.02	0.005	-0.06	0.05	0.09	0.70	-0.001	-0.009	-0.01	-0.02
56-3	A	01FEB84	-0.02	-0.001	0.08	0.06	0.05	0.32	-0.001	-0.009	-0.01	-0.02
56-3	A	20MAR84	-0.02	-0.001	-0.06	0.06	0.06	0.43	-0.001	-0.009	-0.01	-0.02
56-3	B	01FEB84	-0.02	-0.001	0.07	0.06	0.12	-0.08	-0.001	-0.009	-0.01	-0.02
56-3	C	01FEB84	-0.02	-0.001	0.07	0.06	0.08	-0.08	-0.001	-0.009	-0.01	-0.02
56-4	B	03FEB84	-0.02	0.015	0.21	0.06	0.01	-0.08	0.001	-0.009	-0.01	-0.02
56-4	B	06FEB84	-0.02	0.006	0.17	0.06	0.15	-0.08	-0.001	-0.009	-0.01	-0.02

Appendix F (continued).

Table F-1. Water quality data for Y-12 wells (continued)

NEST	WELL	DATE	FE	MN	AL	TI	BA	B	BE	CD	CO	CR
56-4	B	19MAR84	-0.02	0.001	-0.06	0.06	-0.00	-0.08	-0.001	-0.009	-0.01	-0.02
56-4	C	03FEB84	-0.02	0.003	0.20	0.06	0.11	-0.08	0.001	-0.009	-0.01	-0.02
56-5	A	13MAR84	-0.02	0.430	-0.06	0.06	0.08	0.20	-0.001	-0.009	-0.01	-0.02
56-6	A	03MAR84	-0.04	0.420	-0.12	0.12	0.24	-0.15	-0.003	-0.018	-0.03	-0.05
56-6	A	19MAR84	-0.02	0.380	-0.06	0.06	0.21	0.08	-0.001	-0.009	-0.01	0.03
56-7	A	02MAR84	-0.02	1.500	-0.06	0.06	0.06	0.23	-0.001	-0.009	-0.01	-0.02
56-7	A	13MAR84	-0.12	1.800	-0.35	0.32	0.08	-0.46	-0.008	-0.055	-0.08	-0.14
56-8	A	02MAR84	-0.02	5.900	-0.06	0.06	0.09	0.39	-0.001	-0.009	-0.01	-0.02
56-8	A	13MAR84	-0.12	4.700	-0.35	0.32	0.10	-0.46	-0.008	-0.055	-0.08	-0.14
56-9	A	02MAR84	-0.06	1.100	-0.17	0.19	0.13	-0.23	-0.004	-0.028	-0.04	-0.07
56-9	A	14MAR84	-0.12	0.702	-0.35	0.33	0.11	-0.46	-0.008	-0.055	-0.08	-0.14
58-1	A	18JAN84	-0.02	0.190	0.08	0.05	0.09	-0.08	-0.001	-0.009	-0.01	-0.02
58-1	A	15MAR84	-0.02	0.046	-0.06	0.06	0.05	-0.08	-0.001	-0.009	-0.01	-0.02
58-1	B	18JAN84	-0.02	0.310	0.09	0.05	0.08	-0.08	-0.001	-0.009	-0.01	-0.02
58-1	B	15MAR84	-0.02	1.600	-0.06	0.06	0.05	-0.08	-0.001	-0.009	-0.01	-0.02
58-2	A	02MAR84	-0.02	-0.001	-0.06	0.06	0.02	-0.08	-0.001	-0.009	-0.01	-0.02
58-2	A	19MAR84	-0.02	-0.001	-0.06	0.06	0.02	0.14	-0.001	-0.009	-0.01	0.03
59-1	A	23JAN84	-0.02	0.010	0.08	0.06	0.08	-0.08	-0.001	-0.009	-0.01	-0.02
59-1	A	19MAR84	-0.02	-0.001	-0.06	0.06	0.08	-0.08	-0.001	-0.009	-0.01	-0.02
59-1	B	23JAN84	-0.02	0.094	0.08	0.05	0.13	-0.08	-0.001	-0.009	-0.01	-0.02
59-1	C	24JAN84	-0.02	-0.001	0.07	0.05	0.26	-0.08	-0.001	-0.009	-0.01	-0.02
60-1	A	18JAN84	-0.02	0.200	0.08	0.05	0.09	-0.08	-0.001	-0.009	-0.01	-0.02
60-1	A	14MAR84	-0.02	0.407	-0.06	0.05	0.08	0.14	-0.001	-0.009	-0.01	-0.02
60-1	B	18JAN84	-0.02	1.900	0.09	0.05	0.11	-0.08	-0.001	-0.009	-0.01	-0.02
60-2	A	02MAR84	-0.02	0.460	-0.06	0.06	0.18	0.09	-0.001	-0.009	-0.01	-0.02
60-2	A	14MAR84	-0.02	0.500	-0.06	0.06	0.22	-0.08	-0.001	-0.009	-0.01	-0.02

Appendix F (continued).

Table F-1. Water quality data for Y-12 wells (continued)

NEST	WELL	DATE	CU	GA	HF	MO	NI	PB	SB	SE	SR	V
53-1	A	15MAY84	-0.36	-0.64	-0.32	-0.20	0.163	-0.18	3.06	•	12.00	0.70
54-1	A	03MAR84	-0.03	-0.07	0.08	-0.03	-0.110	-0.26	-0.20	-0.43	0.10	-0.01
54-1	A	12MAR84	-0.03	-0.07	-0.05	-0.03	0.120	-0.26	-0.20	-0.43	0.10	-0.01
54-2	A	03MAR84	-0.03	-0.07	0.08	-0.03	-0.110	-0.26	-0.20	-0.43	0.15	0.02
54-2	A	12MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.18	-0.01
55-1	A	25JAN84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.24	-0.01
55-1	A	12MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.24	-0.01
55-1	B	25JAN84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.53	-0.01
55-1	C	25JAN84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.46	-0.01
55-2	A	26JAN84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.17	-0.01
55-2	A	20MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.15	-0.01
55-2	B	26JAN84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.24	-0.01
55-2	B	22MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.18	-0.01
55-2	C	26JAN84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	1.06	-0.01
55-2	C	22MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	1.40	-0.01
55-3	A	27JAN84	0.05	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.38	-0.01
55-3	A	20MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.25	-0.01
55-3	B	27JAN84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.63	-0.01
55-3	B	26MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.55	-0.01
55-3	C	27JAN84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	1.20	-0.01
55-3	C	27MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	1.20	-0.01
55-4	B	10FEB84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.31	-0.01
55-4	B	12MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.19	-0.01
55-4	C	10FEB84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.37	-0.01
55-5	A	03MAR84	-0.03	-0.07	-0.05	-0.03	-0.110	-0.26	-0.20	-0.43	0.16	-0.01
55-5	A	12MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.17	-0.01
55-6	A	03MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.12	-0.01
55-6	A	12MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.86	0.10	0.02
56-1	A	02FEB84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.62	-0.01
56-1	A	12MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.71	-0.01
56-1	C	02FEB84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.87	-0.01
56-2	A	30JAN84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.14	-0.43	0.22	-0.01
56-2	A	20MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.19	-0.01
56-2	B	27MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.25	-0.01
56-2	C	31JAN84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.14	-0.43	0.27	-0.01
56-2	C	27MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.21	-0.01
56-3	A	01FEB84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.10	-0.01
56-3	A	20MAR84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.10	-0.01
56-3	B	01FEB84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.19	-0.01
56-3	C	01FEB84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.24	-0.01
56-4	B	03FEB84	-0.03	-0.07	-0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.34	-0.01
56-4	B	06FEB84	-0.03	-0.07	0.05	-0.03	-0.110	-0.26	-0.20	-0.43	0.53	-0.01

Appendix F (continued).

Table F-1. Water quality data for Y-12 wells (continued)

NEST	WELL	DATE	CU	GA	HF	MO	NI	PB	SB	SE	SR	V
56-4	B	19MAR84	-0.03	-0.07	0.04	-0.03	-0.110	-0.26	-0.20	-0.43	0.34	-0.01
56-4	C	03FEB84	-0.03	-0.07	0.05	-0.03	-0.110	-0.26	-0.20	-0.43	0.59	-0.01
56-5	A	18MAR84	-0.03	-0.07	0.05	-0.03	-0.110	-0.26	-0.20	-0.43	0.69	0.02
56-6	A	08MAR84	-0.06	-0.14	0.12	-0.05	-0.110	-0.52	-0.40	-0.86	0.33	-0.03
56-6	A	19MAR84	-0.03	-0.07	0.09	-0.03	-0.110	-0.26	-0.20	-0.43	0.36	0.03
56-7	A	02MAR84	-0.03	-0.07	0.08	-0.03	-0.11	-0.26	-0.2	-0.43	0.13	0.02
56-7	A	13MAR84	-0.19	-0.42	-0.24	-0.16	-0.11	-1.60	-1.2	-2.60	0.15	-0.09
56-8	A	02MAR84	-0.03	-0.42	0.12	-0.03	-0.11	-0.26	-0.2	-0.43	0.14	-0.02
56-8	A	13MAR84	-0.19	-0.21	-0.24	-0.16	-0.11	-1.60	-1.2	-2.60	0.14	-0.09
56-9	A	02MAR84	-0.10	-0.42	0.27	-0.08	-0.11	-0.78	-0.6	-1.30	1.60	0.07
56-9	A	14MAR84	-0.19	-0.07	-0.24	-0.16	-0.11	-1.60	-1.2	-2.60	1.90	-0.09
58-1	A	18JAN84	-0.03	-0.07	-0.04	-0.03	-0.11	-0.26	-0.2	-0.43	0.08	-0.01
58-1	A	15MAR84	-0.03	-0.07	-0.04	-0.03	-0.11	-0.26	-0.2	-0.43	0.06	-0.01
58-1	B	18JAN84	-0.03	-0.07	-0.04	-0.03	-0.11	-0.26	-0.2	-0.43	0.16	-0.01
58-1	B	15MAR84	-0.03	-0.07	-0.04	-0.03	-0.11	-0.26	-0.2	-0.43	0.12	-0.01
58-2	A	02MAR84	-0.03	-0.07	0.07	-0.03	-0.11	-0.26	-0.2	-0.43	0.04	-0.01
58-2	A	19MAR84	-0.03	-0.07	0.07	-0.03	-0.11	-0.26	-0.2	-0.43	0.09	0.02
59-1	A	23JAN84	-0.03	-0.07	-0.04	-0.03	-0.11	-0.26	-0.2	-0.43	0.16	-0.01
59-1	A	19MAR84	-0.03	-0.07	-0.04	-0.03	-0.11	-0.26	-0.2	-0.43	0.19	-0.01
59-1	B	23JAN84	-0.03	-0.07	-0.04	-0.03	-0.11	-0.26	-0.2	-0.43	0.28	-0.01
59-1	C	24JAN84	-0.03	-0.07	0.04	-0.03	-0.11	-0.26	-0.2	-0.43	0.31	-0.01
60-1	A	18JAN84	-0.03	-0.07	0.04	-0.03	-0.11	-0.26	-0.2	-0.43	0.18	-0.01
60-1	A	14MAR84	-0.03	-0.07	0.04	0.08	-0.11	-0.26	-0.2	-0.43	0.11	-0.01
60-1	B	18JAN84	-0.03	-0.07	0.05	-0.03	-0.11	-0.26	-0.2	-0.43	0.39	-0.01
60-2	A	02MAR84	-0.03	-0.07	0.06	0.04	-0.11	-0.26	-0.2	-0.43	0.10	-0.01
60-2	A	14MAR84	-0.03	-0.07	0.05	-0.03	-0.11	-0.26	-0.2	-0.43	0.10	-0.02

Appendix F (continued).

Table F-1. Water quality data for Y-12 wells (continued)

NEST	WELL	DATE	ZN	ZR	P	AS	LI
53-1	A	15MAY84	-0.20	1.220	-5.20	-0.20	0.472
54-1	A	03MAR84	0.07	-0.018	-0.33	-0.64	-0.100
54-1	A	12MAR84	0.09	-0.018	-0.33	-0.64	-0.100
54-2	A	03MAR84	0.07	-0.018	-0.33	-0.64	-0.100
54-2	A	12MAR84	0.10	-0.018	-0.33	-0.64	-0.100
55-1	A	25JAN84	0.05	-0.018	-0.33	-0.64	-0.100
55-1	A	12MAR84	0.06	-0.018	-0.33	-0.64	-0.100
55-1	B	25JAN84	-0.02	-0.018	-0.33	-0.64	-0.100
55-1	C	25JAN84	0.03	-0.018	-0.33	-0.64	-0.100
55-2	A	26JAN84	-0.02	-0.018	-0.33	-0.64	-0.100
55-2	A	20MAR84	0.05	-0.018	-0.33	-0.64	-0.100
55-2	B	26JAN84	-0.02	-0.018	-0.33	-0.64	-0.100
55-2	B	22MAR84	0.04	-0.018	-0.33	-0.64	0.130
55-2	C	26JAN84	-0.02	-0.018	-0.33	-0.64	-0.100
55-2	C	22MAR84	0.05	-0.018	-0.33	-0.64	0.160
55-3	A	27JAN84	0.09	-0.018	-0.33	-0.64	-0.100
55-3	A	20MAR84	0.05	-0.018	-0.33	-0.64	-0.100
55-3	B	27JAN84	-0.02	-0.018	-0.33	-0.64	-0.100
55-3	B	26MAR84	0.15	-0.018	-0.33	-0.64	0.180
55-3	C	27JAN84	-0.02	-0.018	-0.33	-0.64	-0.100
55-3	C	27MAR84	0.26	-0.018	-0.33	-0.64	0.190
55-4	B	10FEB84	0.03	-0.018	-0.33	-0.64	-0.100
55-4	B	12MAR84	0.07	-0.018	-0.33	0.64	-0.100
55-4	C	10FEB84	-0.02	-0.018	-0.33	-0.64	-0.100
55-5	A	03MAR84	0.07	-0.018	-0.33	0.64	-0.100
55-5	A	12MAR84	0.08	-0.018	-0.33	-0.64	-0.100
55-6	A	03MAR84	0.07	-0.018	-0.33	-0.64	-0.100
55-6	A	12MAR84	0.09	-0.018	-0.33	-0.64	-0.100
56-1	A	02FEB84	0.02	-0.018	-0.33	-0.64	-0.150
56-1	A	12MAR84	0.07	-0.018	-0.33	-0.64	-0.100
56-1	C	02FEB84	0.02	-0.018	-0.33	-0.64	0.180
56-2	A	30JAN84	-0.02	-0.018	-0.33	-0.64	-0.100
56-2	A	20MAR84	0.05	-0.018	-0.33	-0.64	-0.100
56-2	B	27MAR84	0.06	-0.018	-0.33	-0.64	0.190
56-2	C	31JAN84	-0.02	-0.018	-0.33	-0.64	0.120
56-2	C	27MAR84	0.07	-0.018	-0.33	-0.64	0.240
56-3	A	01FEB84	-0.02	-0.018	-0.33	-0.64	-0.100
56-3	A	20MAR84	0.05	-0.018	-0.33	-0.64	-0.100
56-3	B	01FEB84	0.05	-0.018	-0.33	-0.64	-0.100
56-3	C	01FEB84	0.05	-0.018	-0.33	-0.64	-0.100
56-4	B	03FEB84	0.03	-0.018	-0.33	-0.64	0.150
56-4	B	06FEB84	0.02	-0.018	-0.33	-0.64	0.150

Appendix F (continued).

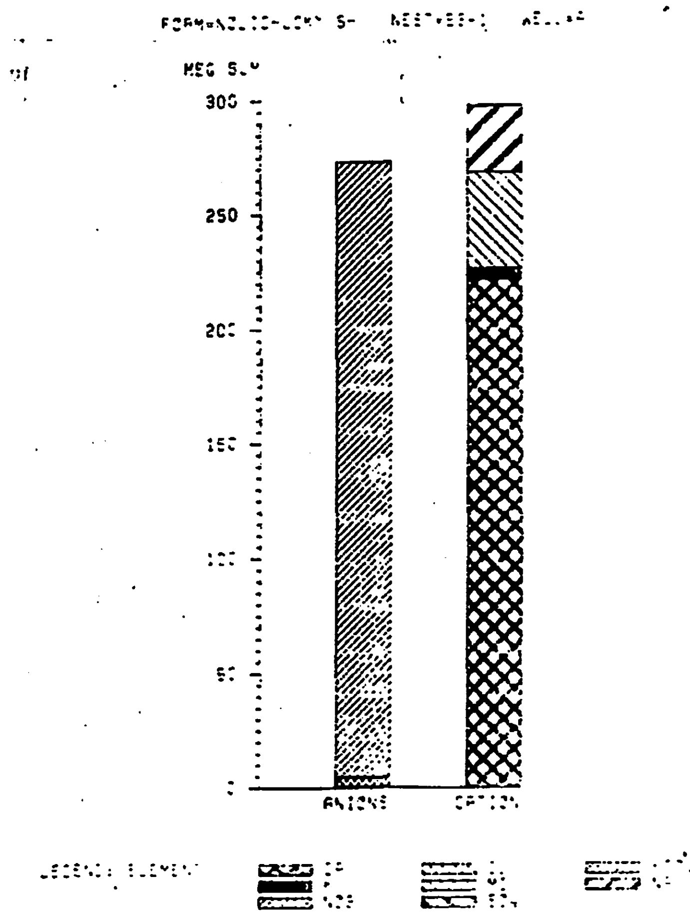
Table F-1. Water quality data for Y-12 wells (continued)

NEST	WELL	DATE	ZN	ZR	P	AS	LI
56-4	B	19MAR84	0.06	-0.018	-0.33	-0.64	-0.100
56-4	C	03FEB84	-0.02	-0.018	-0.33	-0.64	0.140
56-5	A	13MAR84	0.04	-0.018	-0.33	1.10	-0.100
56-6	A	03MAR84	0.07	-0.036	-0.66	-1.30	-0.200
56-6	A	19MAR84	0.04	-0.018	-0.33	-0.64	-0.100
56-7	A	02MAR84	0.06	-0.018	-0.33	-0.64	-0.10
56-7	A	13MAR84	-0.11	-0.108	-2.00	-3.80	-0.60
56-8	A	02MAR84	0.10	-0.018	-0.33	-0.64	-0.10
56-8	A	13MAR84	.	-0.108	-2.00	-3.80	-0.60
56-9	A	02MAR84	0.09	-0.054	-0.99	2.01	0.30
56-9	A	14MAR84	0.21	-0.108	-2.00	-3.80	-0.60
58-1	A	18JAN84	-0.02	-0.018	-0.33	-0.64	0.12
58-1	A	15MAR84	0.10	-0.018	-0.33	-0.64	0.10
58-1	B	18JAN84	0.04	-0.018	-0.33	-0.64	0.13
58-1	B	15MAR84	0.18	-0.018	-0.33	-0.64	-0.10
58-2	A	02MAR84	0.06	-0.018	-0.33	-0.64	-0.10
58-2	A	19MAR84	0.07	-0.018	-0.33	-0.64	-0.10
59-1	A	23JAN84	0.04	-0.018	-0.33	-0.64	-0.10
59-1	A	19MAR84	0.07	-0.018	-0.33	-0.64	-0.10
59-1	B	23JAN84	0.09	-0.018	-0.33	-0.64	-0.10
59-1	C	24JAN84	-0.02	-0.016	-0.33	-0.64	0.83
60-1	A	18JAN84	-0.02	-0.018	-0.33	-0.64	0.57
60-1	A	14MAR84	0.04	-0.018	-0.33	-0.64	0.28
60-1	B	18JAN84	-0.02	-0.018	-0.33	-0.64	-0.18
60-2	A	02MAR84	0.09	-0.018	-0.33	-0.64	-0.10
60-2	A	14MAR84	0.15	-0.018	-0.33	-0.64	-0.10

Concentrations in mg/L except as noted LEVEL is water level in meters below measuring point QUALITY is U = Unpurged, C = Clear, TM = Trace mud, M = Muddy, VM = Very muddy HG is in µg/L, FPH = Field pH, EC = Conductance in µS/cm Negative prefix denotes value reported as less than TEMP = Water temperature in centigrade, ALK=Total alkalinity in mg/l $CaCO_3$

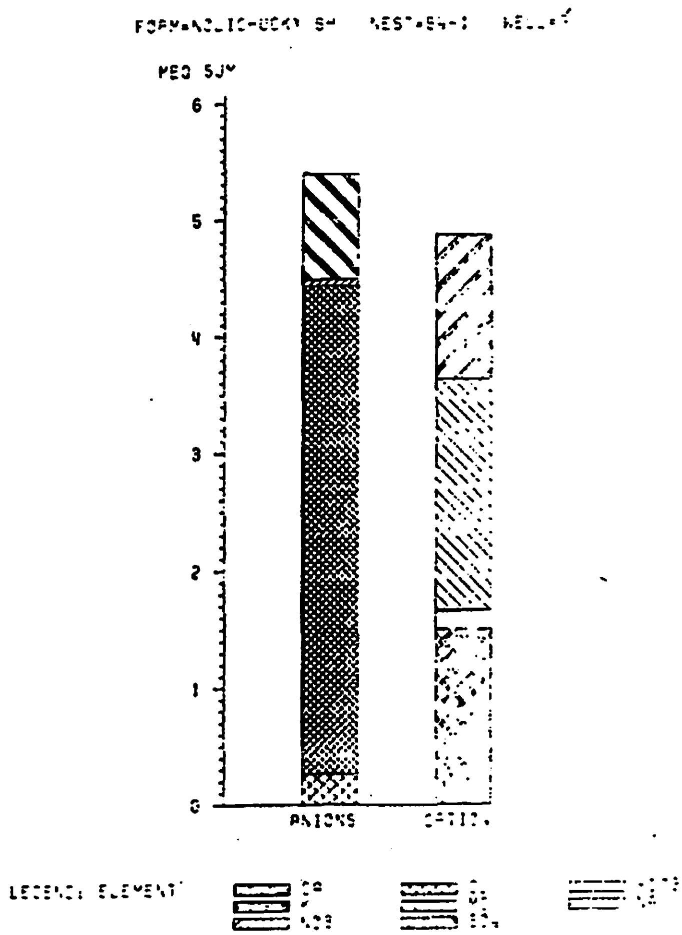
Appendix F (continued).

Ion Balances in Y-12 Groundwater

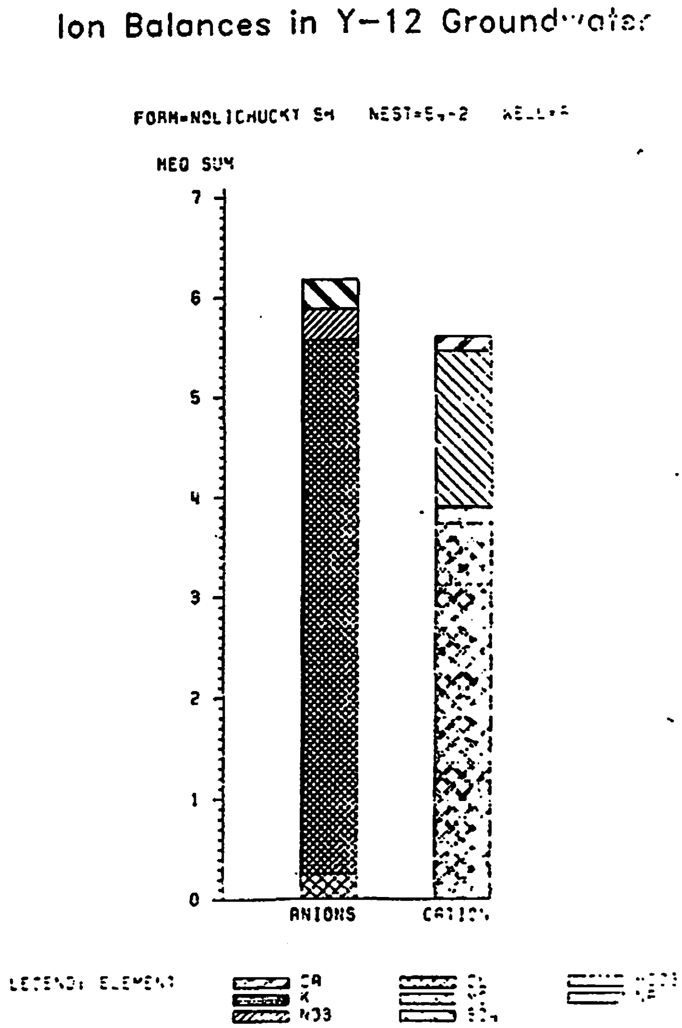


Appendix F (continued).

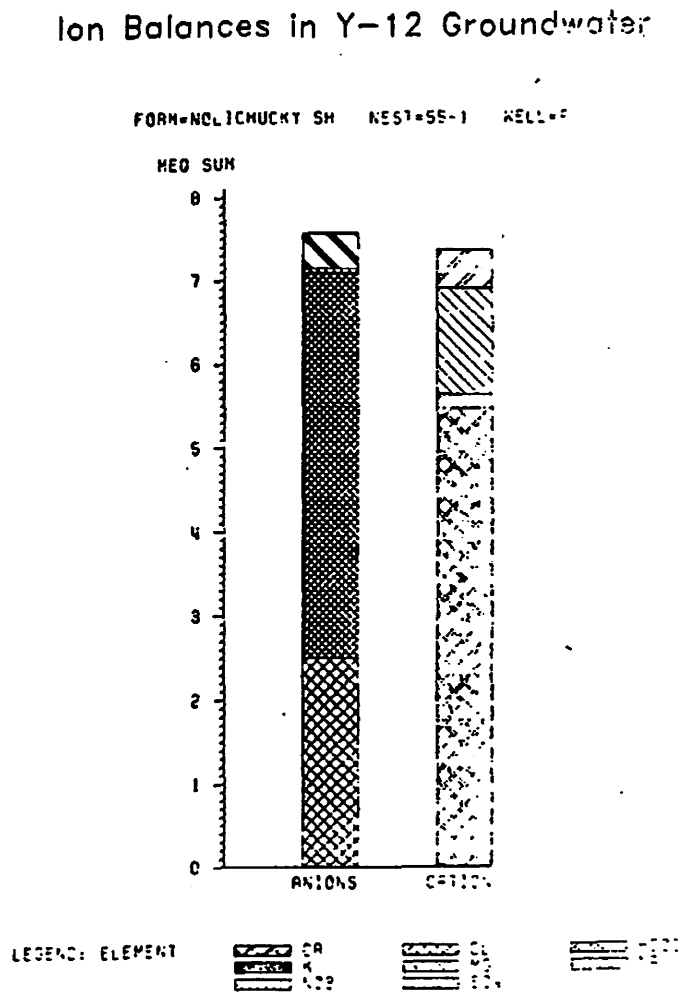
Ion Balances in Y-12 Groundwater



Appendix F (continued).

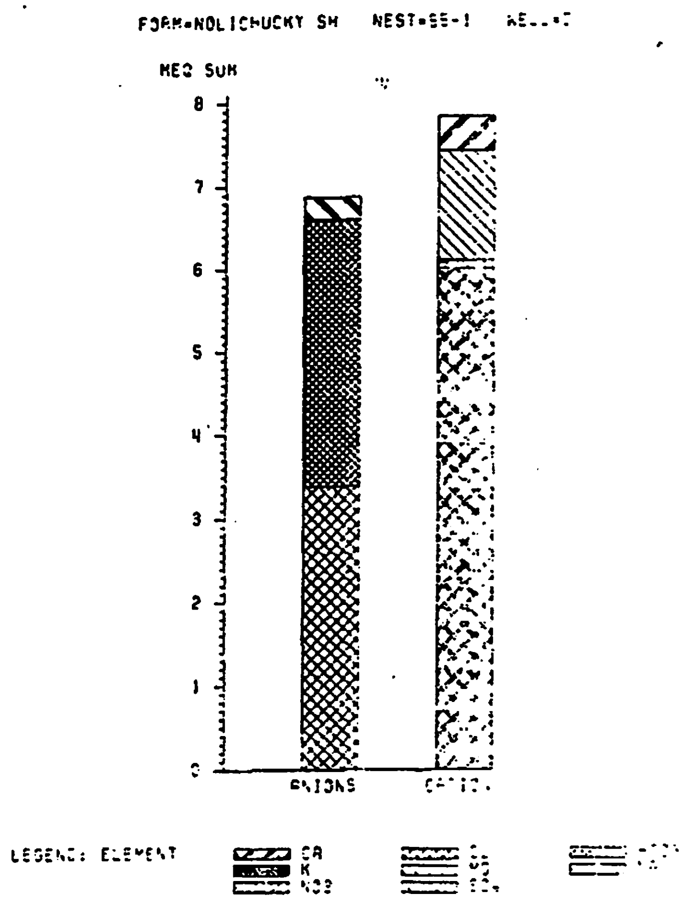


Appendix F (continued).



Appendix F (continued).

Ion Balances in Y-12 Groundwater



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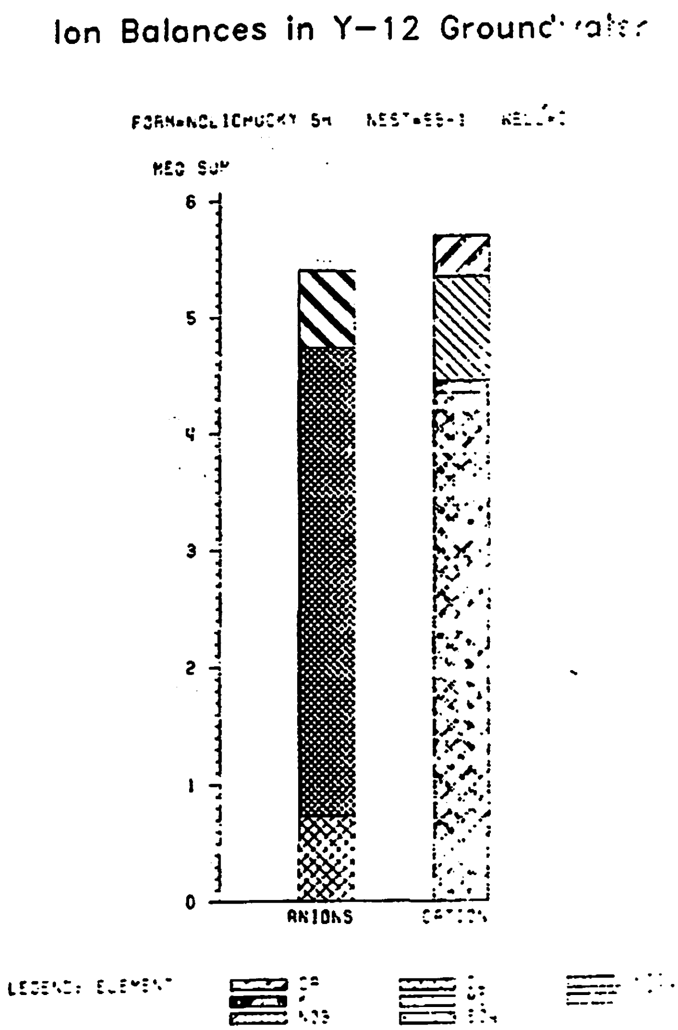

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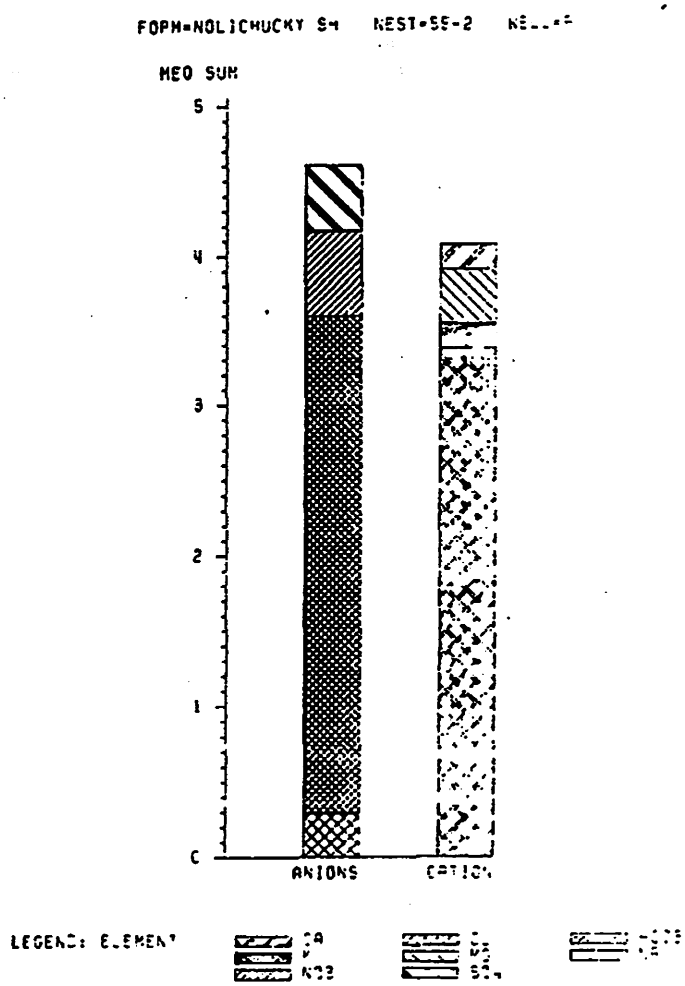
Ion Balances in Y–12 Groundwater



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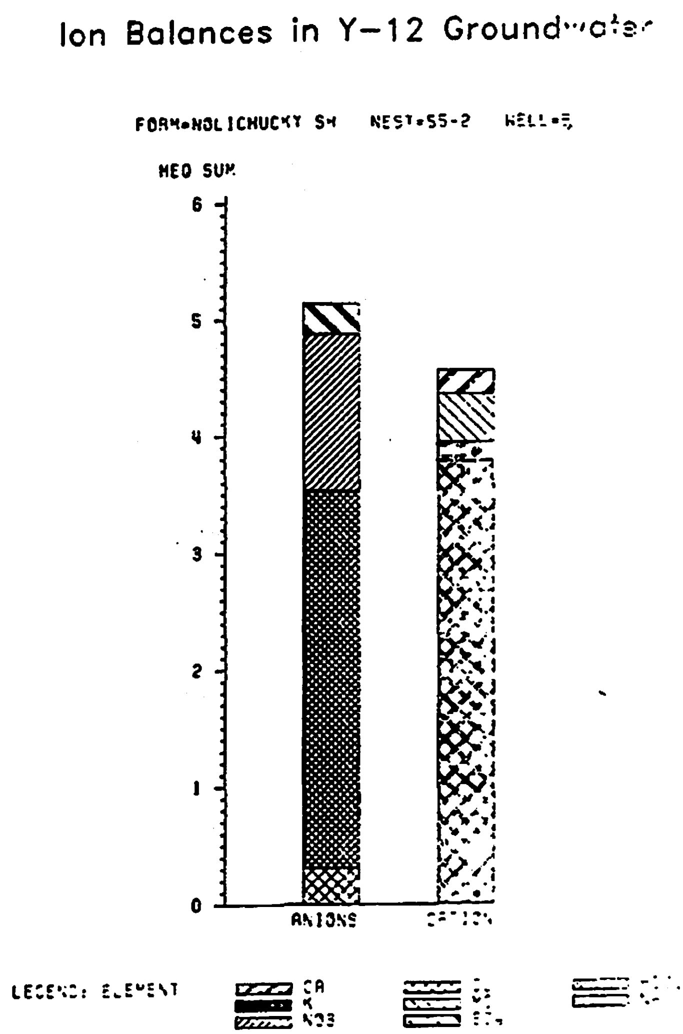

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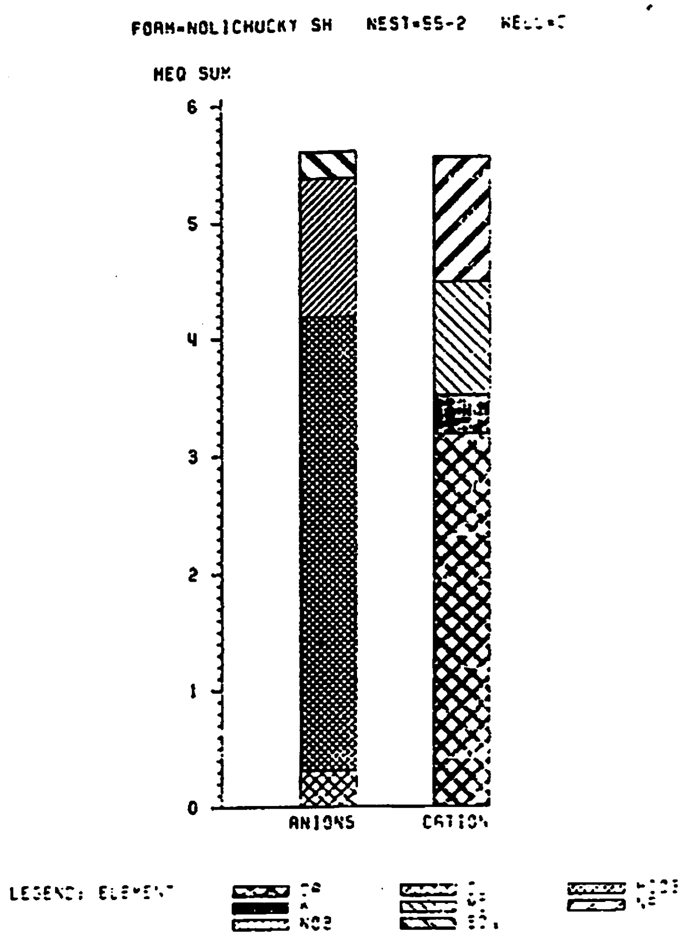
Ion Balances in Y-12 Groundwater



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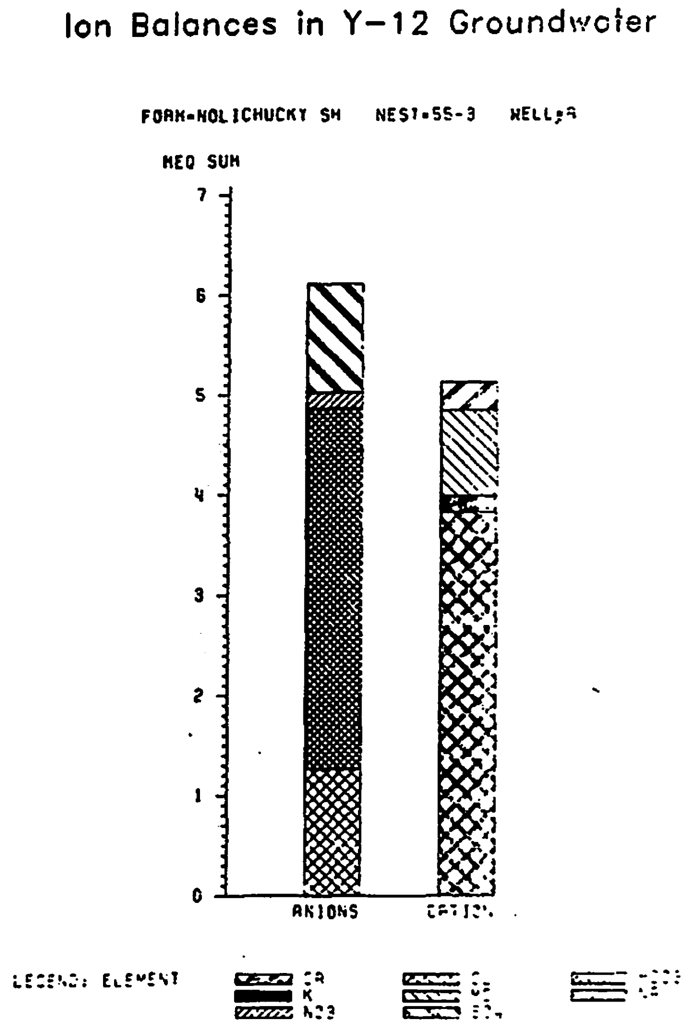

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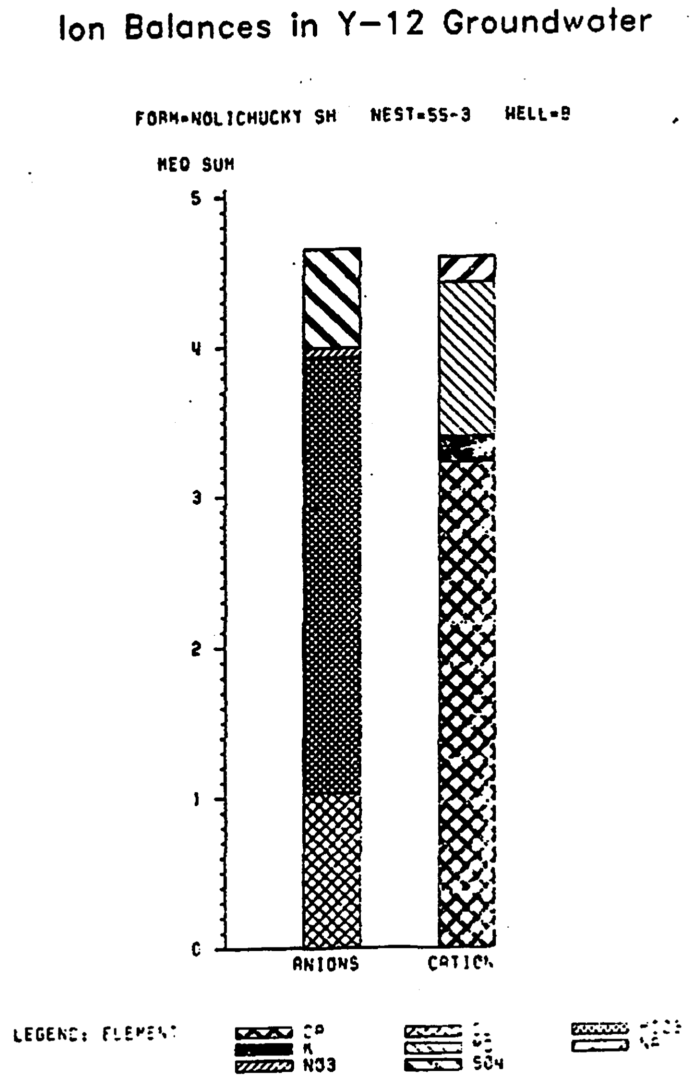

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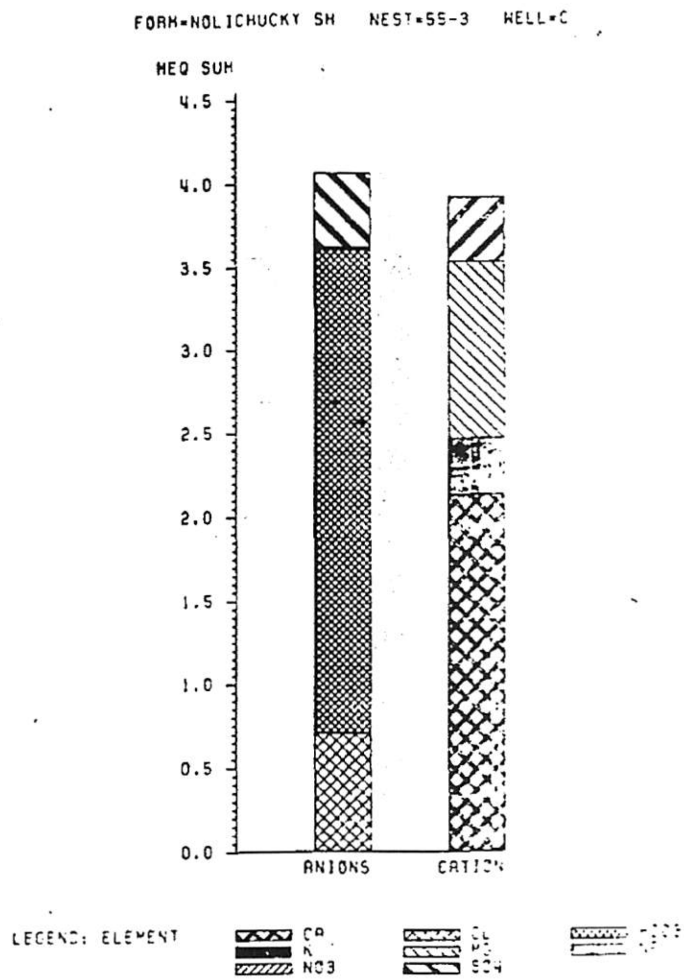
Ion Balances in Y-12 Groundwater



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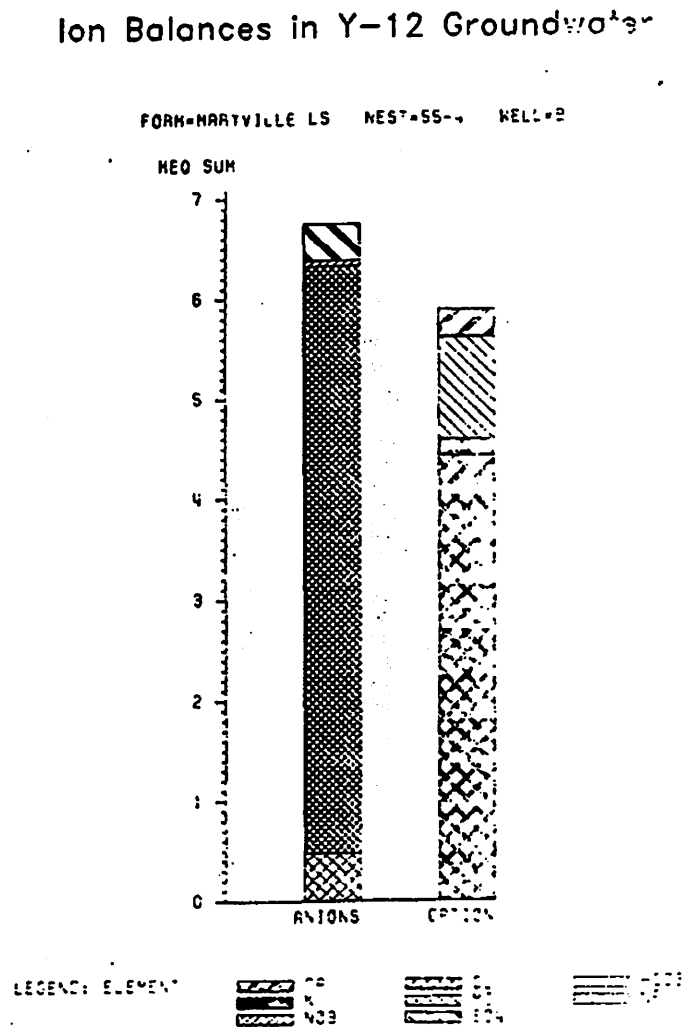

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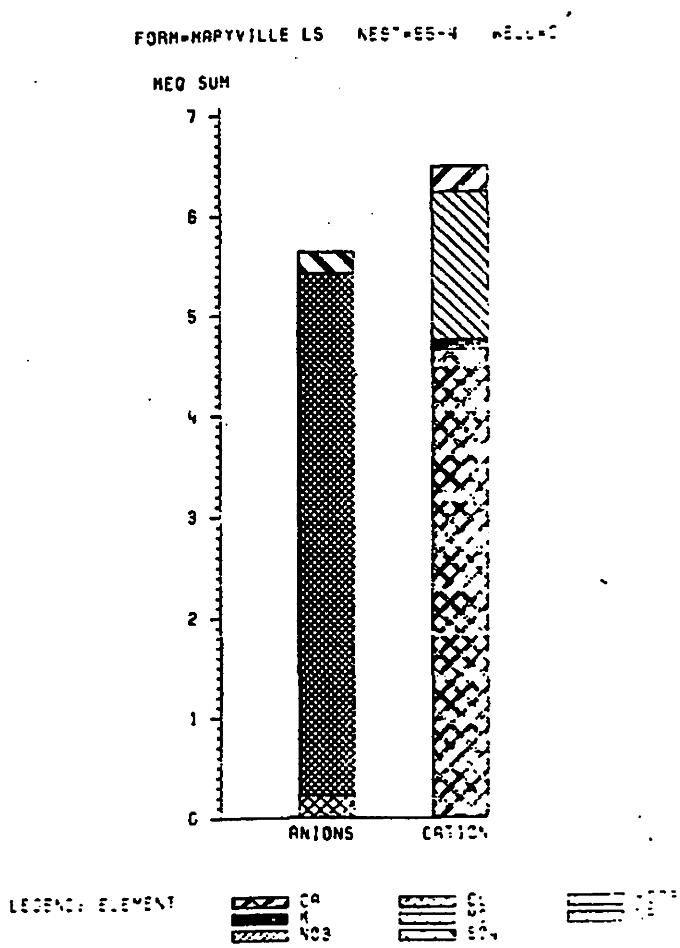
Ion Balances in Y-12 Groundwater



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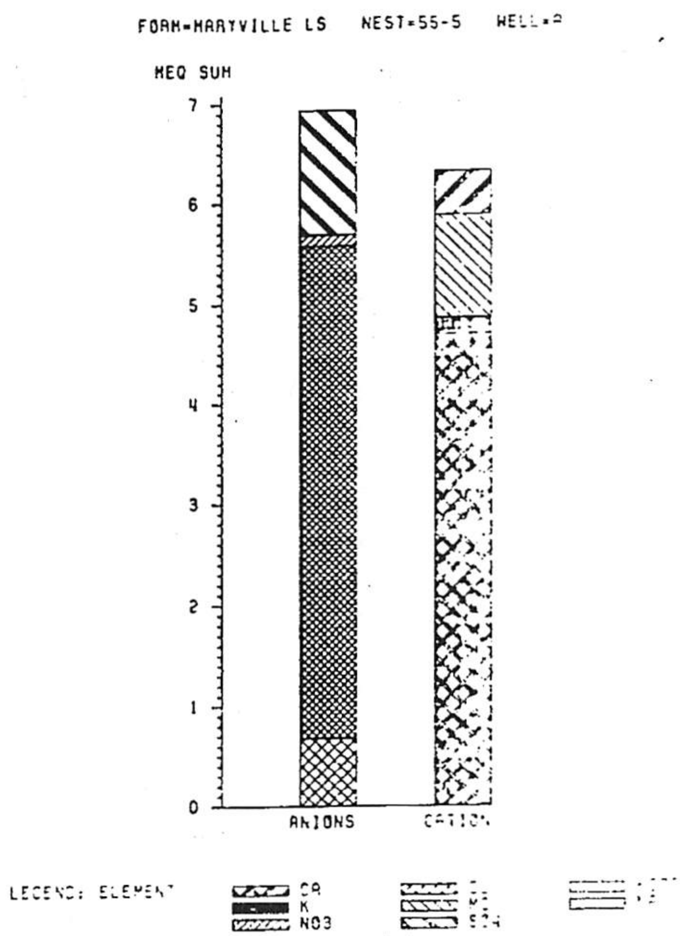
Ion Balances in Y-12 Groundwater



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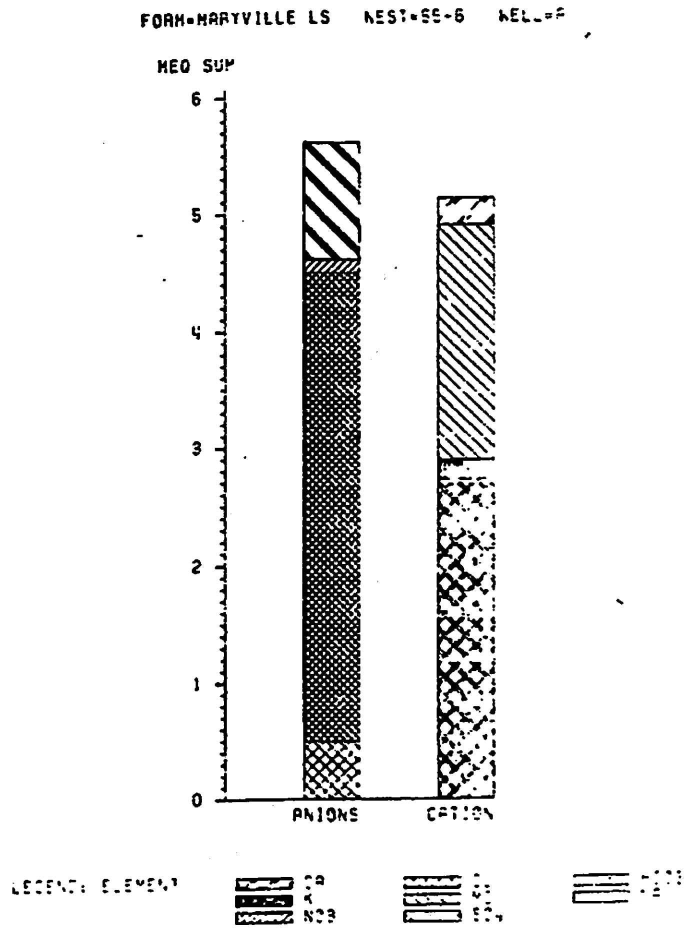
Ion Balances in Y-12 Groundwater



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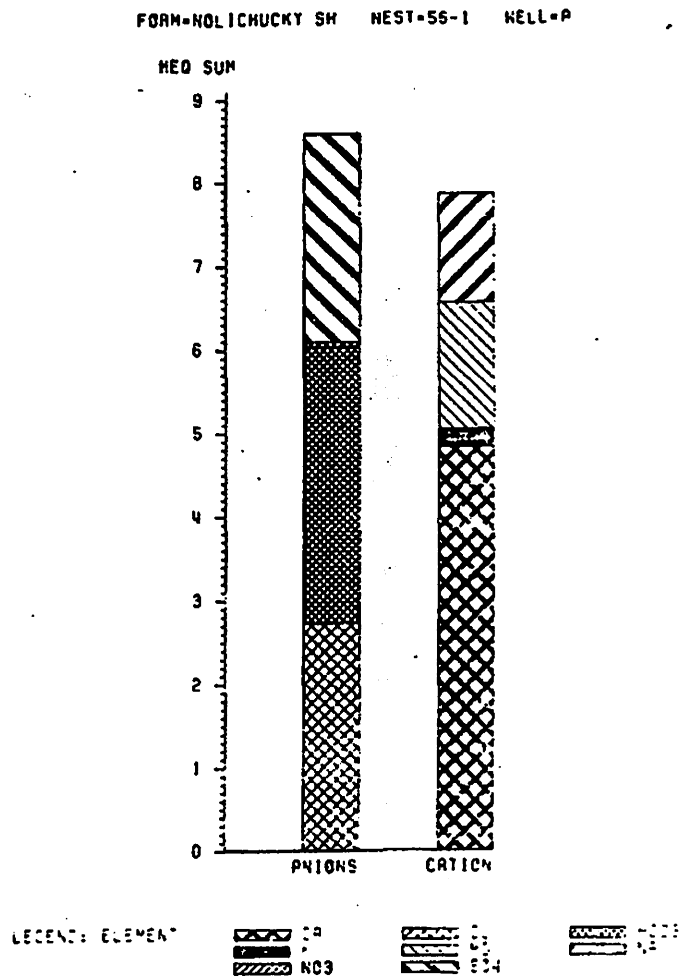
Ion Balances in Y-12 Groundwater



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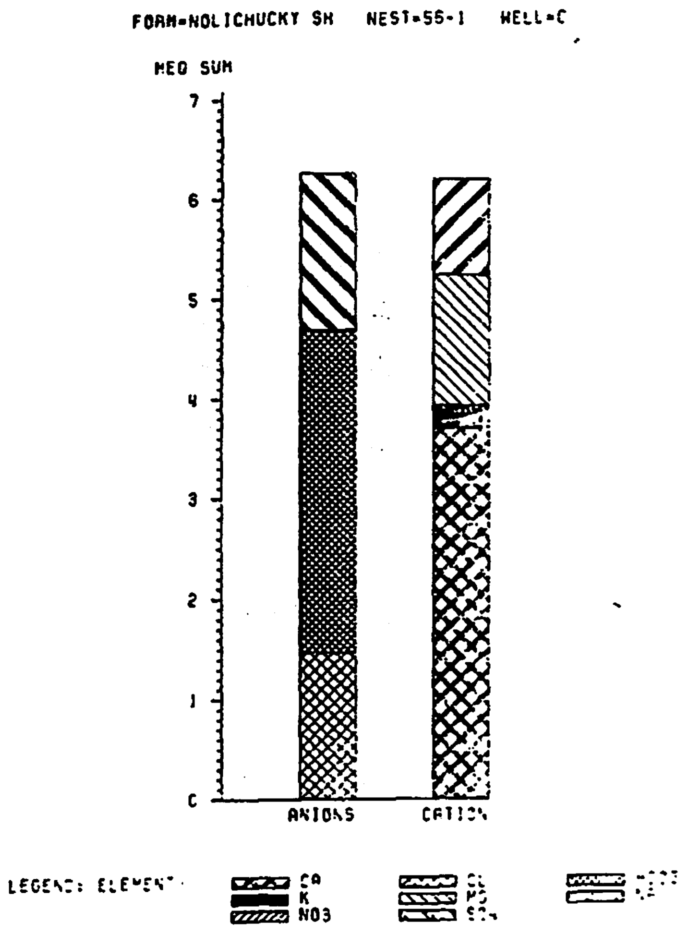
Ion Balances in Y-12 Groundwater



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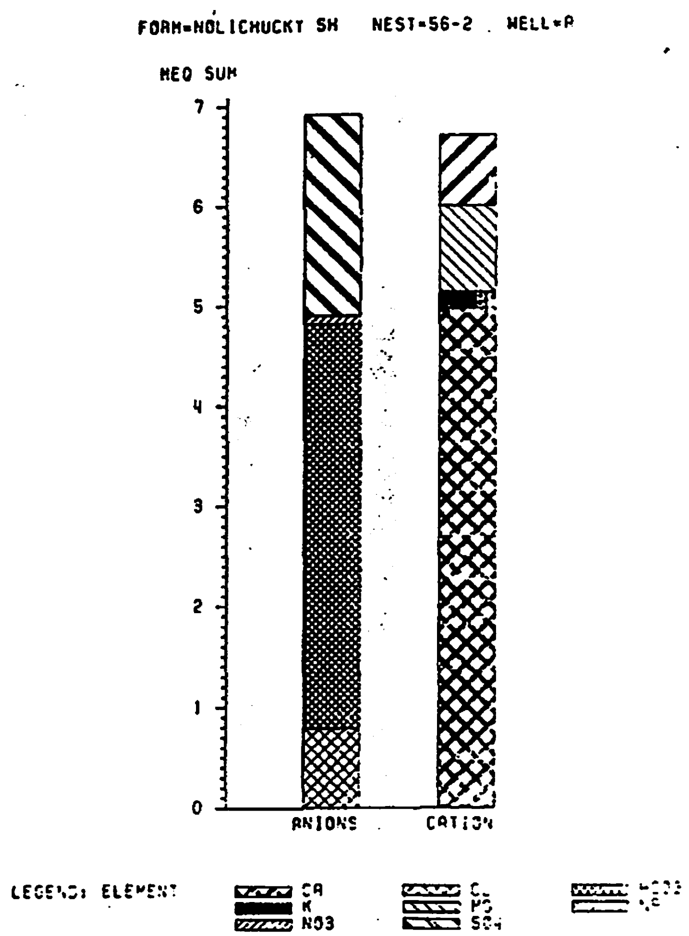
Ion Balances in Y-12 Groundwater



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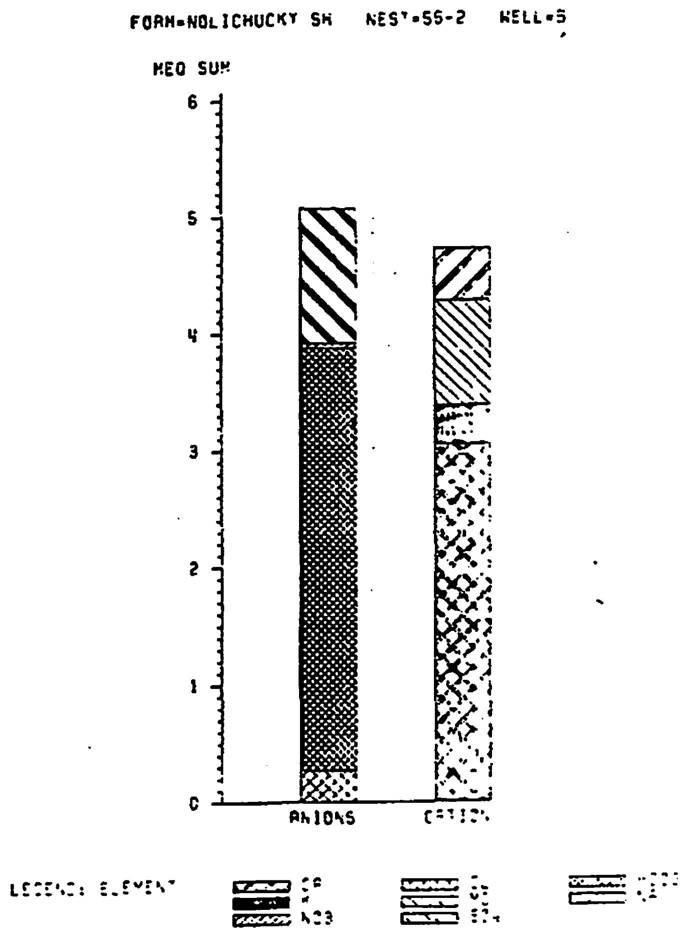
Ion Balances in Y-12 Groundwater



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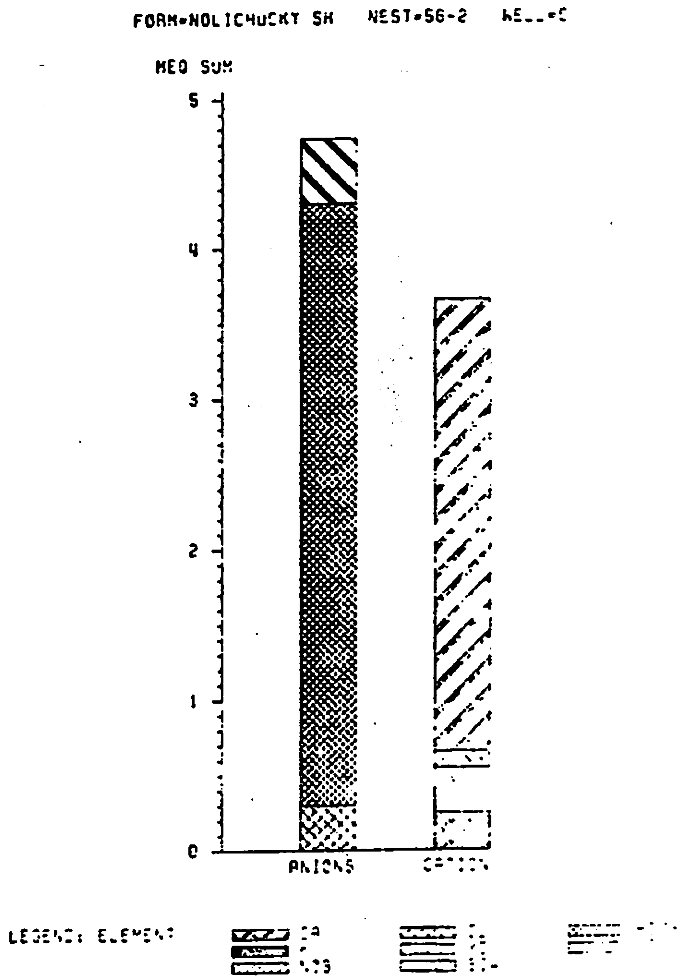
Ion Balances in Y-12 Groundwater



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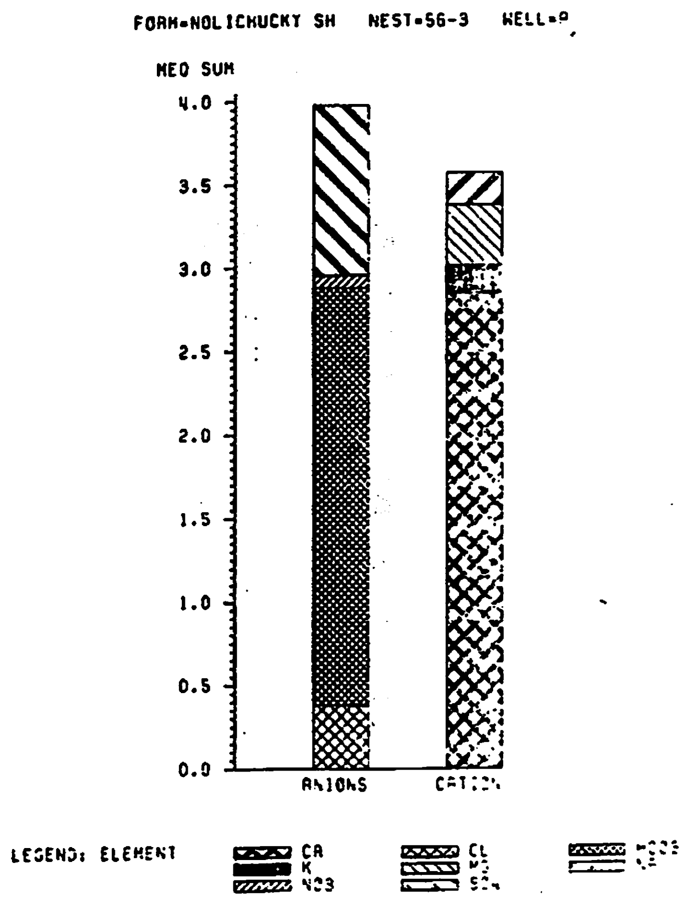
Ion Balances in Y-12 Groundwater



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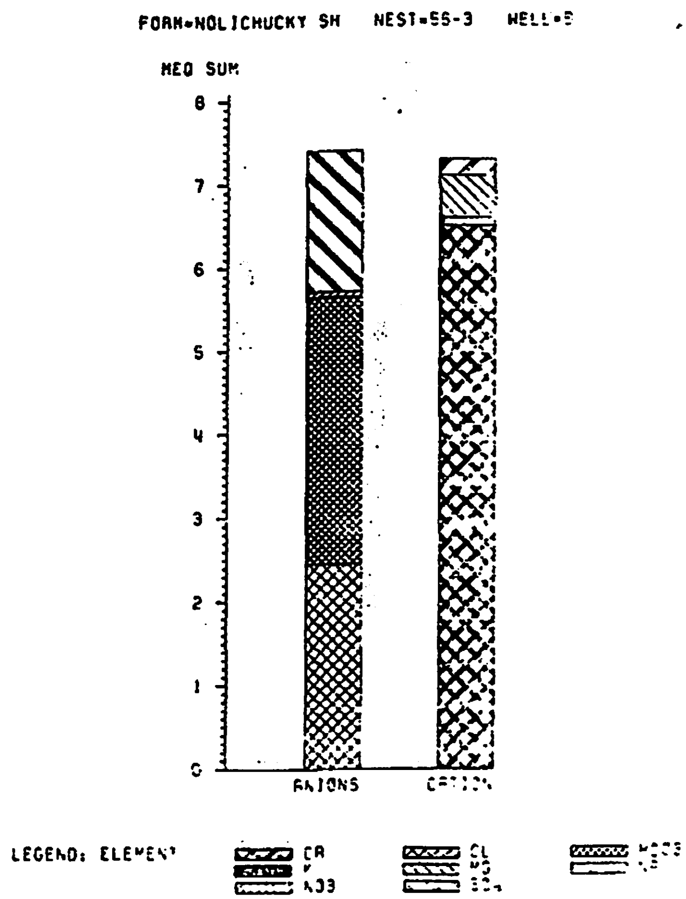

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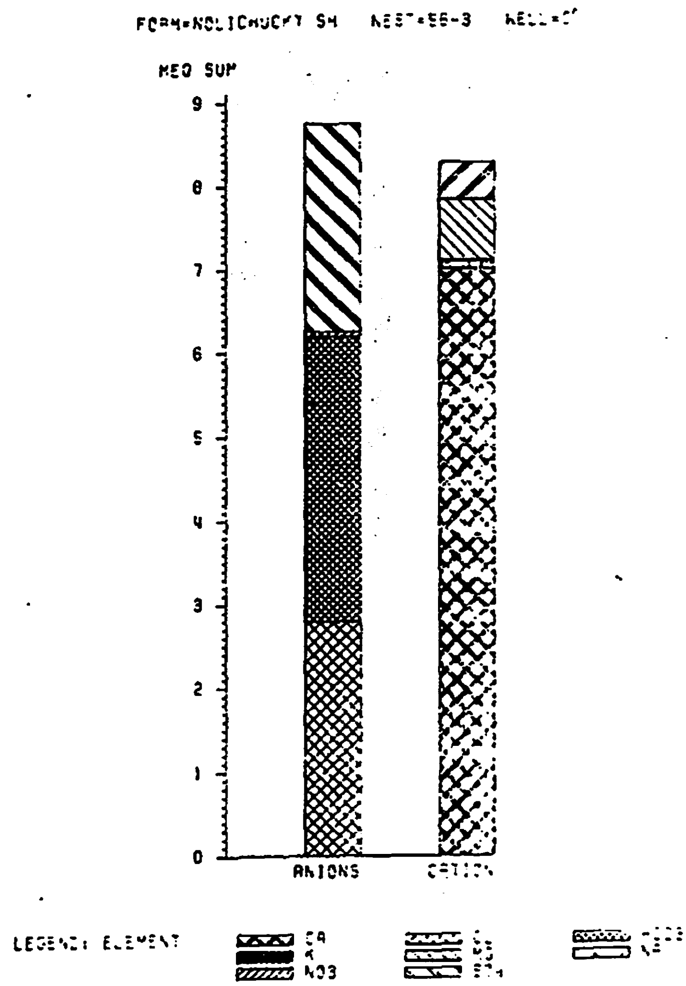
Ion Balances in Y-12 Groundwater



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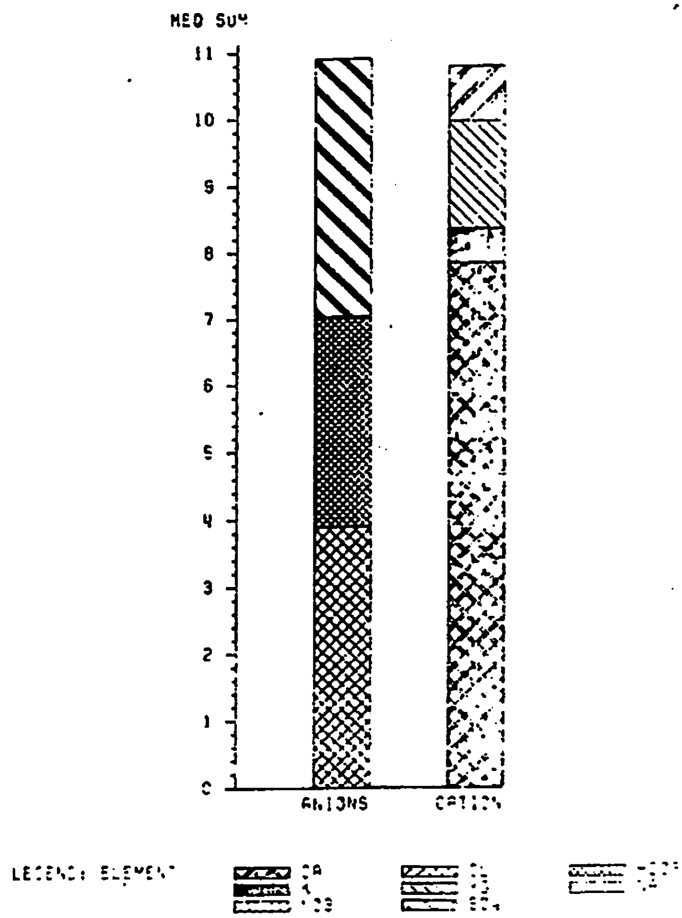
Ion Balances in Y-12 Groundwater

FORM=NOLICHUCKY SH



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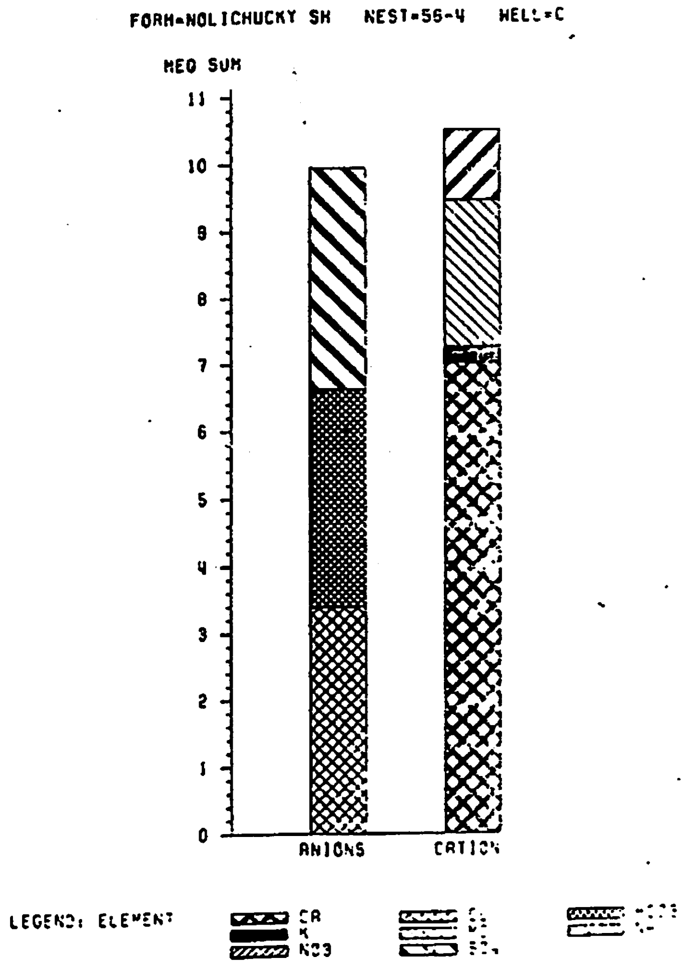
Ion Balances in Y-12 Groundwater



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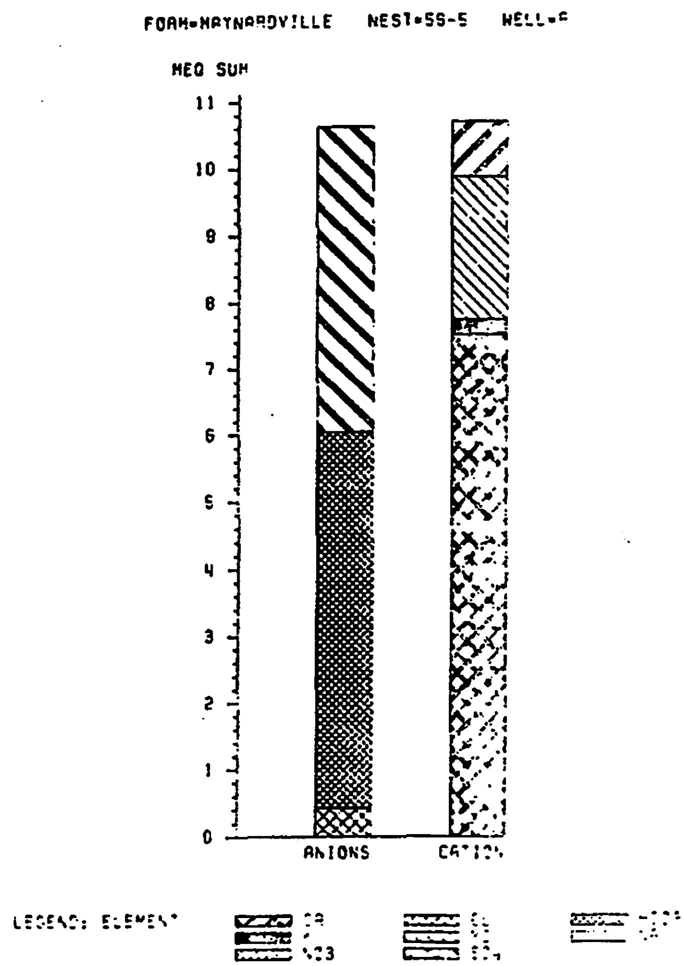
Ion Balances in Y-12 Groundwater



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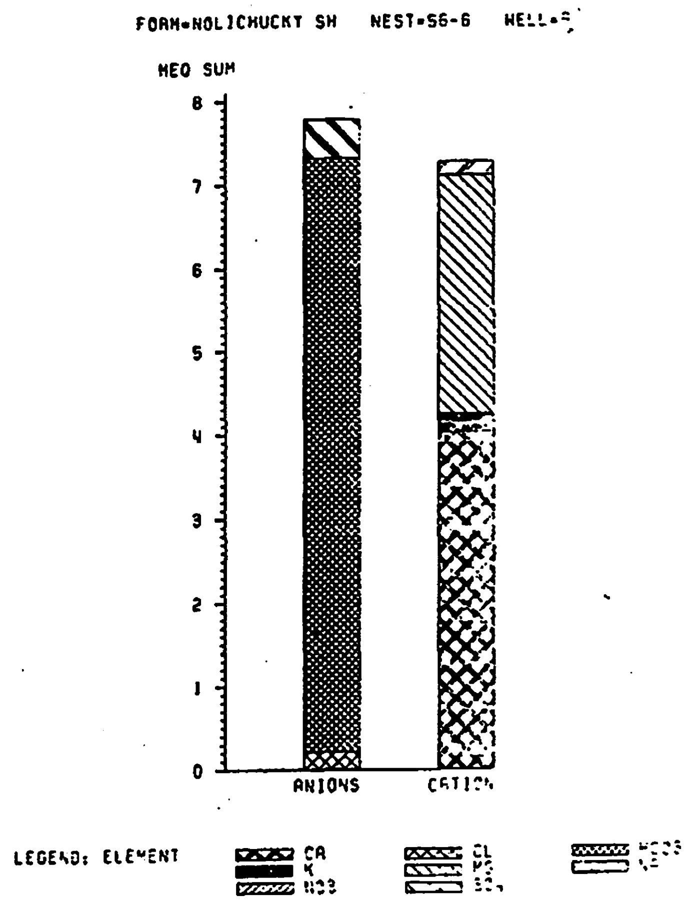
Ion Balances in Y-12 Groundwater



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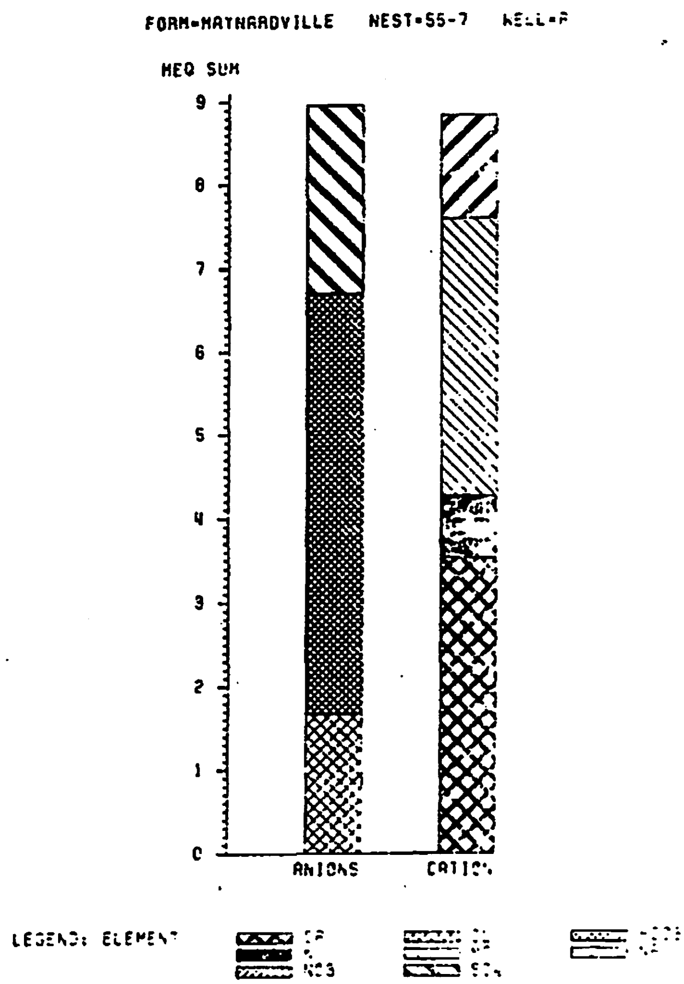
Ion Balances in Y-12 Groundwater



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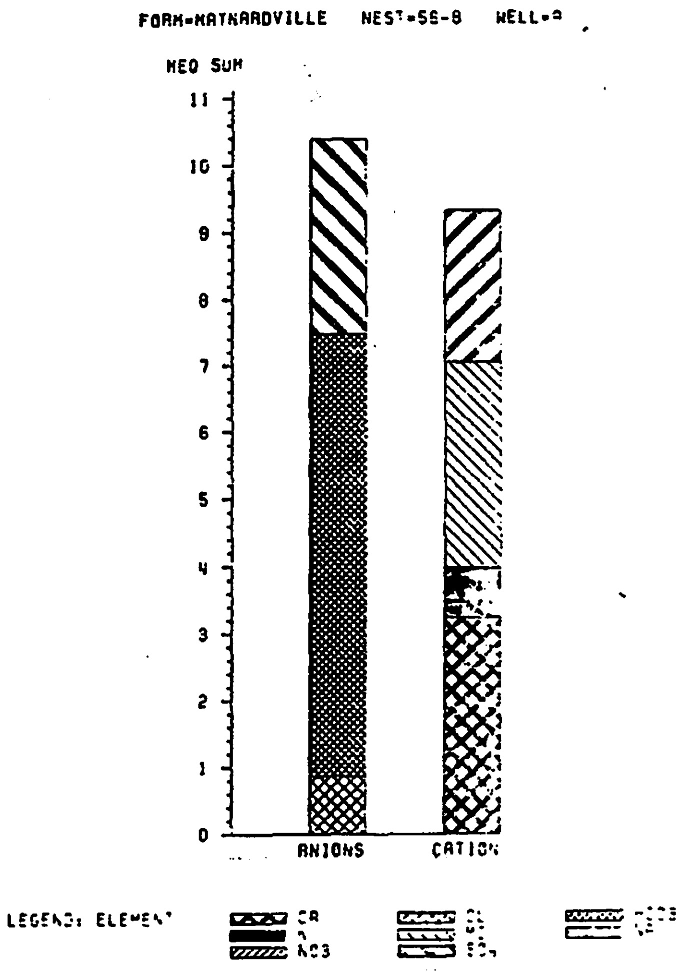
Ion Balances in Y-12 Groundwater



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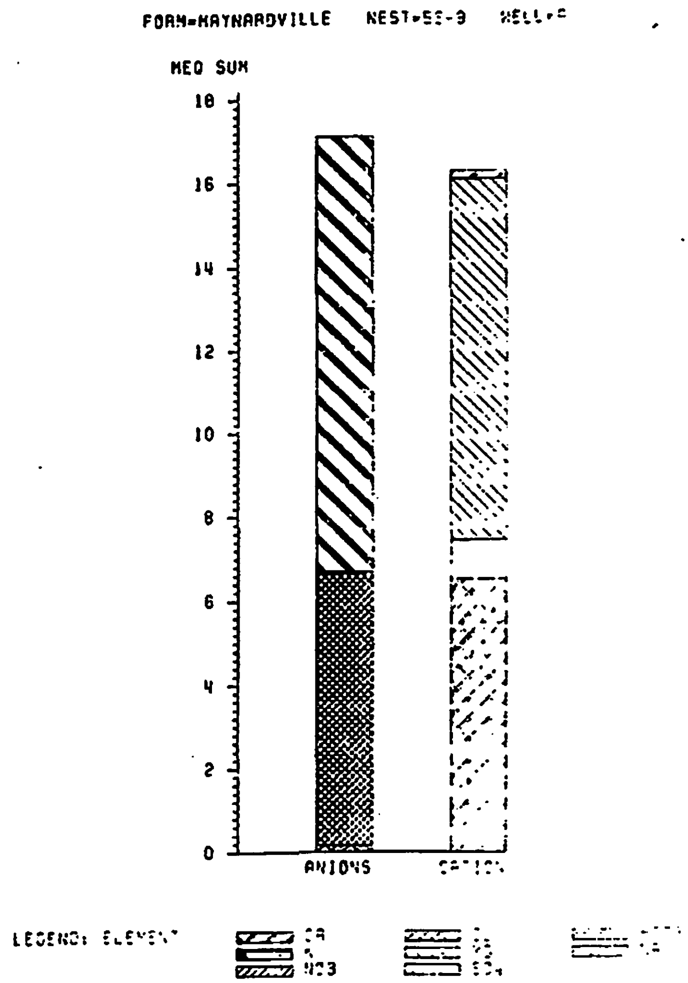
Ion Balances in Y-12 Groundwater



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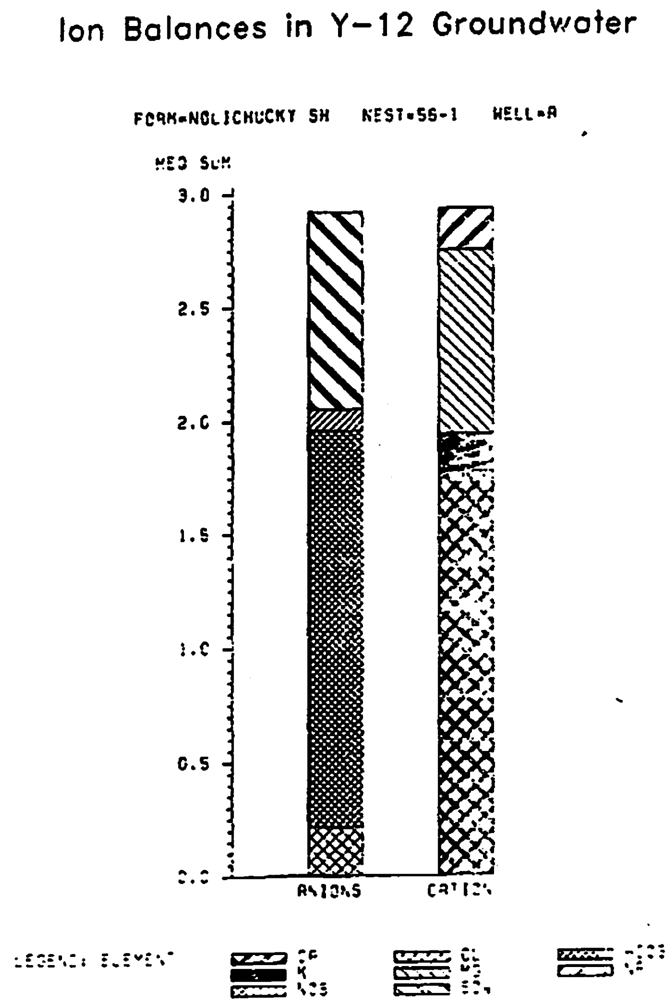

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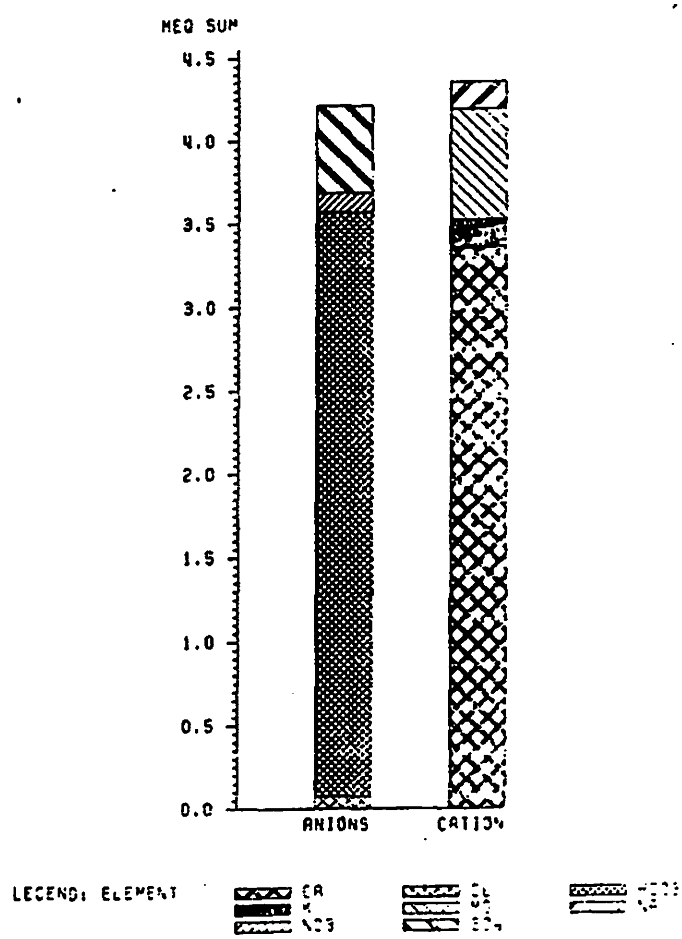
Ion Balances in Y-12 Groundwater

FORM=NOLICHUCKY SH   NEST=58-1   WELL=3



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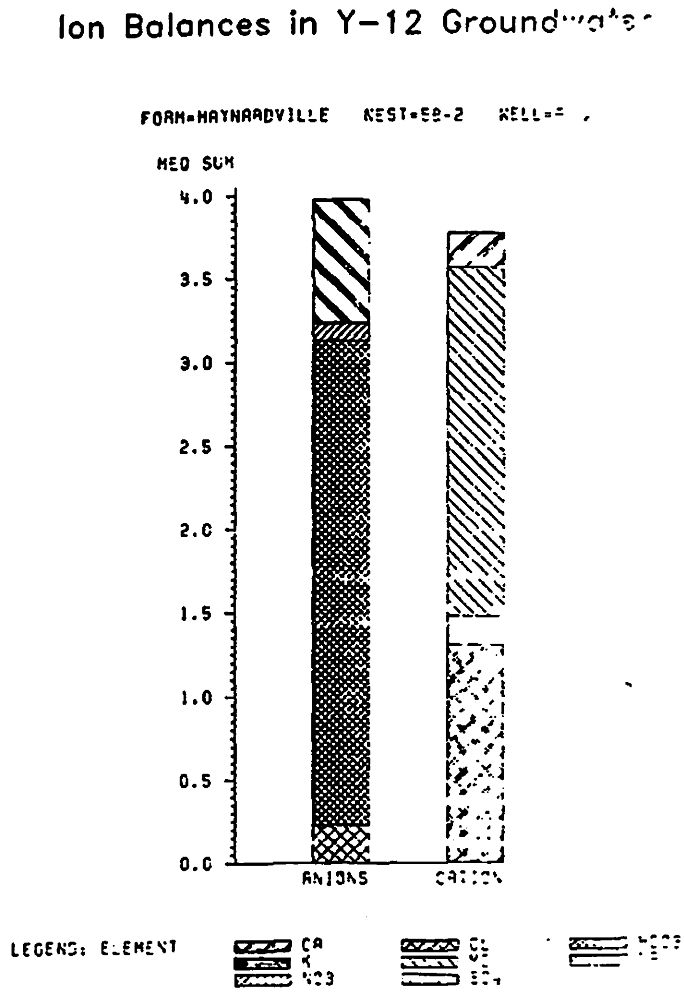

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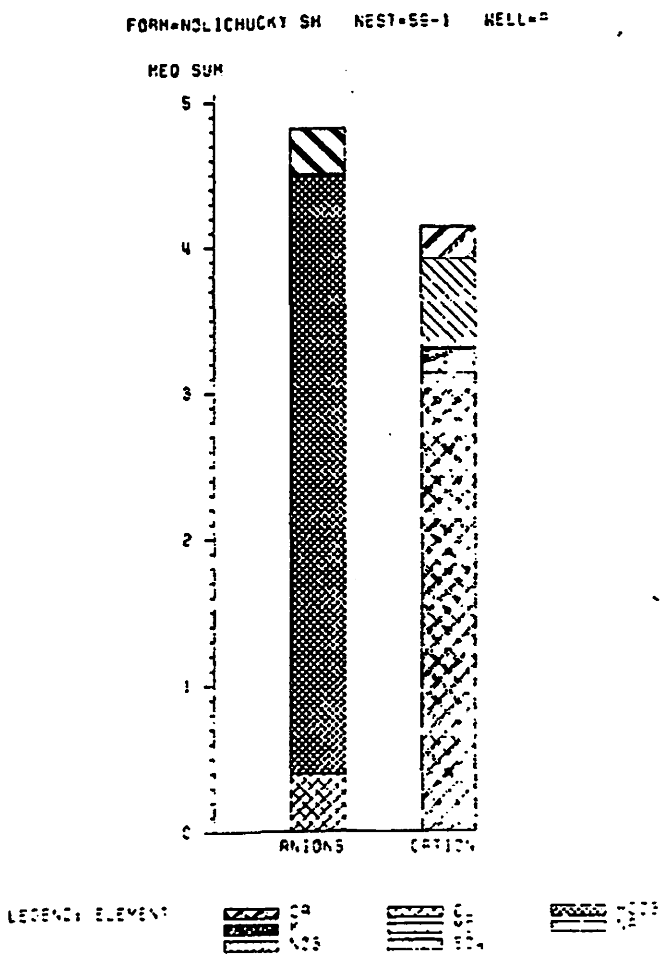
Ion Balances in Y-12 Groundwater



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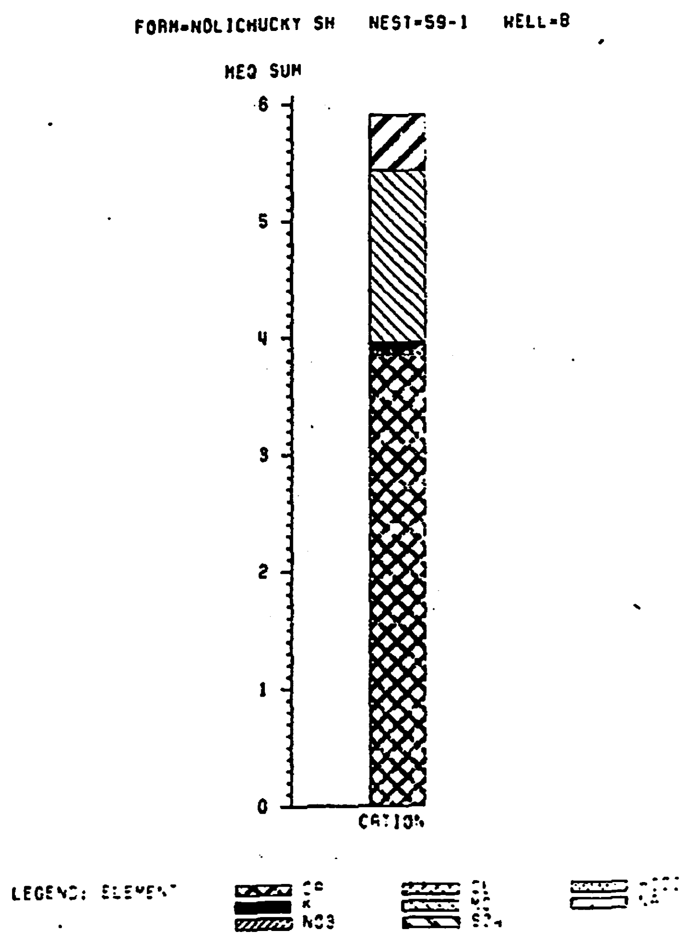
Ion Balances in Y-12 Groundwater



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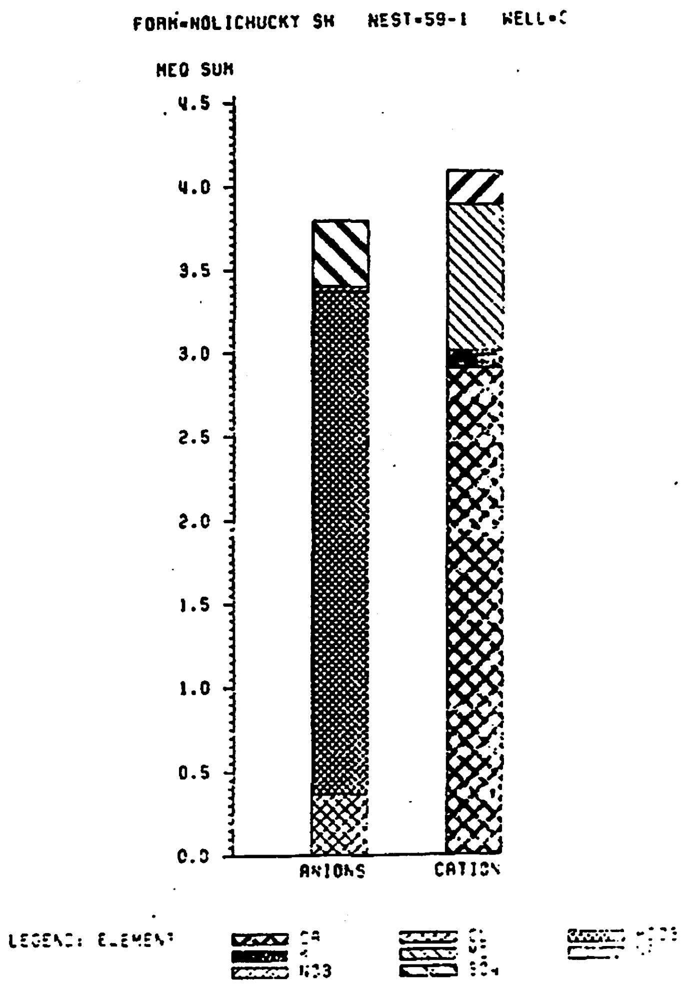
Ion Balances in Y-12 Groundwater



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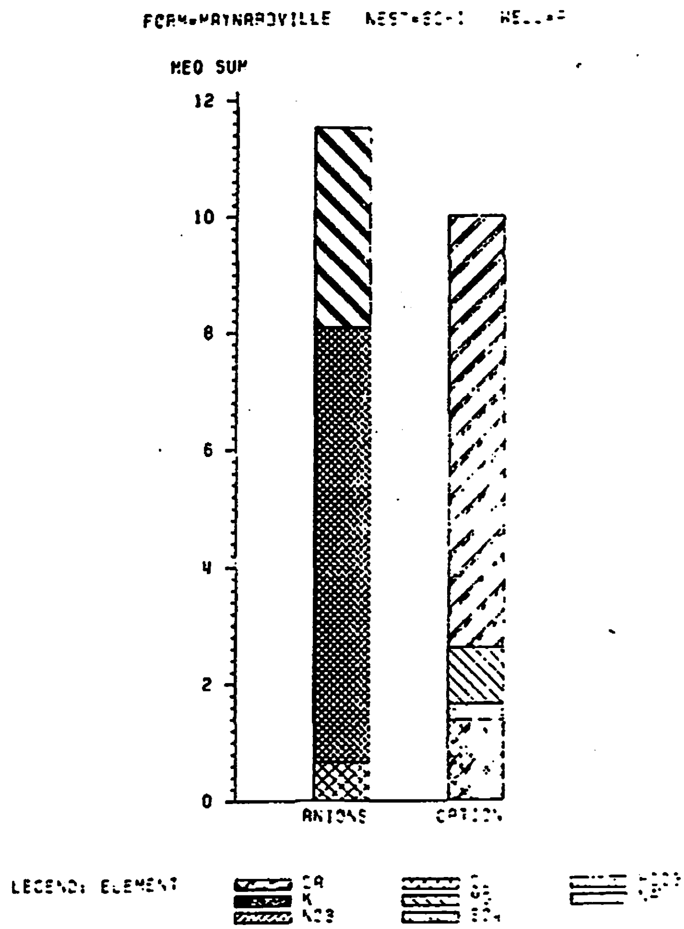
Ion Balances in Y-12 Groundwater



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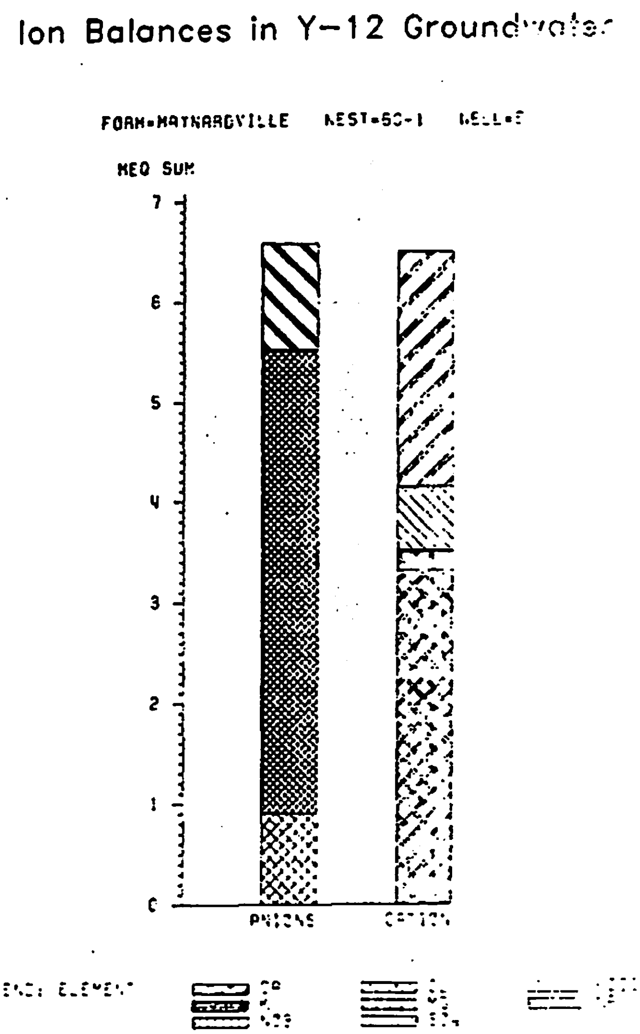

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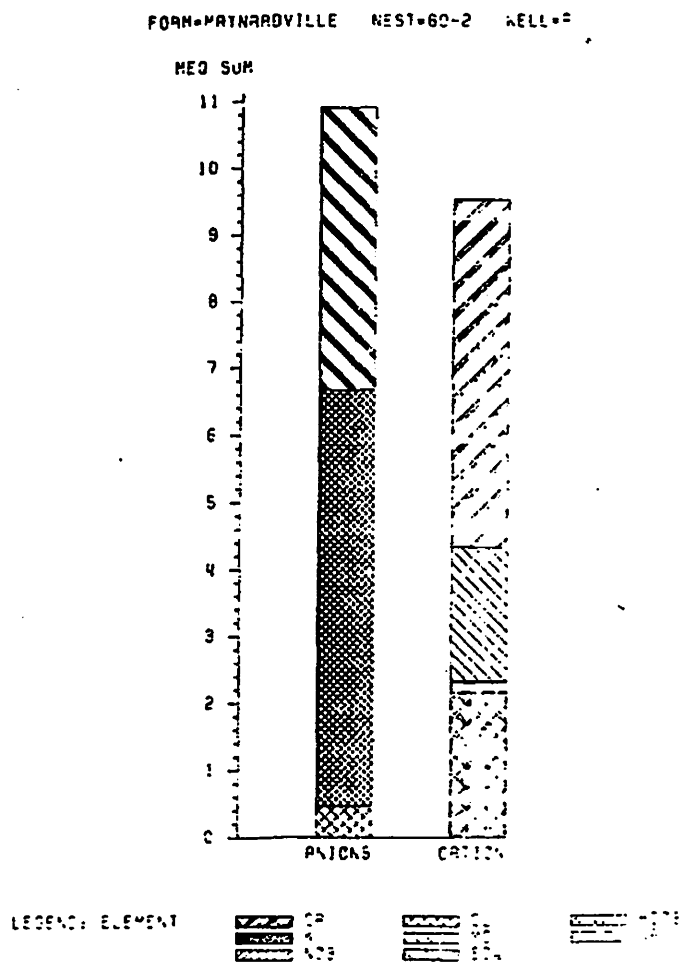
Ion Balances in Y-12 Groundwater



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