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STABILIZATION PLAN

mc 1925

AMAX Inc. Property
Wood County, West Virginia

AMAX Inc.
Environmental Services Inc.
September 1980

Assisted by
Roy E. Williams and Associates
Hydrogeology

Chem-Nuclear Systems Inc.
Health Physics

Bell Consultants
Mapping, Surveying and Engineering

Woodward-Clyde Consultants
Geotechnical Engineering

Carl Morris Consultant
Construction Engineering

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Date 10/25/82

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AMAX property, Wood County, West Virginia

TABLE OF CONTENTS

INTRODUCTION

An onsite stabilization plan is presented in this report for the AMAX Inc. property in Wood County, West Virginia (Figure 1). Once farm land, the area along the river is now largely industrial. The property is located eight miles southwest of Parkersburg, West Virginia, on the west bank of the Ohio River in an area known as Washington Bottom (Figure 1). One-third of the property, encompassing 126 acres, has been developed for use.

The primary access road, intersecting DuPont Road, marks the northern boundary line (Figure 2). Farm land is directly south and north of the property line. The facilities on the property consist of an office building, new plant buildings, roadways, old building foundations (slabs and floors), storage areas, water and gas mains, an elevated water storage tank and well field, storm drainage systems, and a railroad spur from the Baltimore and Ohio Railroad line leading to the plant (Figure 3).

Topographically the area is characterized by a series of river bank terraces, rising in elevation to the east (Figure 4). The plant facilities are located on the highest bench of these terraces, between the elevation 625 and 635 feet above mean sea level (MSL). Generally, the drainage pattern is west toward the river, with some drainage to ditches along the roadway to the east. An incised gully drains a portion of the surface runoff to the southwest (Figure 4).

Soils in the area are classified as the Huntington-Ashton-Whellington Association. They are well drained and brown in color. These soils develop mainly in silty materials and overlie sand and gravel submaterial.

The hydrogeology of the Washington Bottom site is entirely within the unglaciated portion of the Allegheny Plateau Physiographic Province. Clay, sandy clay, and silt are found within a few feet, to as much as ten feet, from the surface. The underlying sand and gravel vary in thickness above the bedrock. The thicker sand and gravel deposits underlie the higher terraces. The thickness of the alluvium decreases in depth from east to west where it meets the river.

The plant's water tower is located on the east edge of the highest of the land terraces (Figure 3) and it is within several hundred feet of the east bedrock wall of the river valley. In this area, the thickness of the alluvium is about 100 feet (Figure 5). The water table in the area is about 50 feet below the surface, depending upon the topographic relief. The general movement of the groundwater system is toward the river to the west. There are no low permeability layers beneath the site that would cause perch water saturation zones to form during groundwater recharge events. Geotechnical investigations characterizing this condition are discussed in detail in the technical studies section of this report. Wells in the area have operated at the rate of 100 gallons per minute or greater.

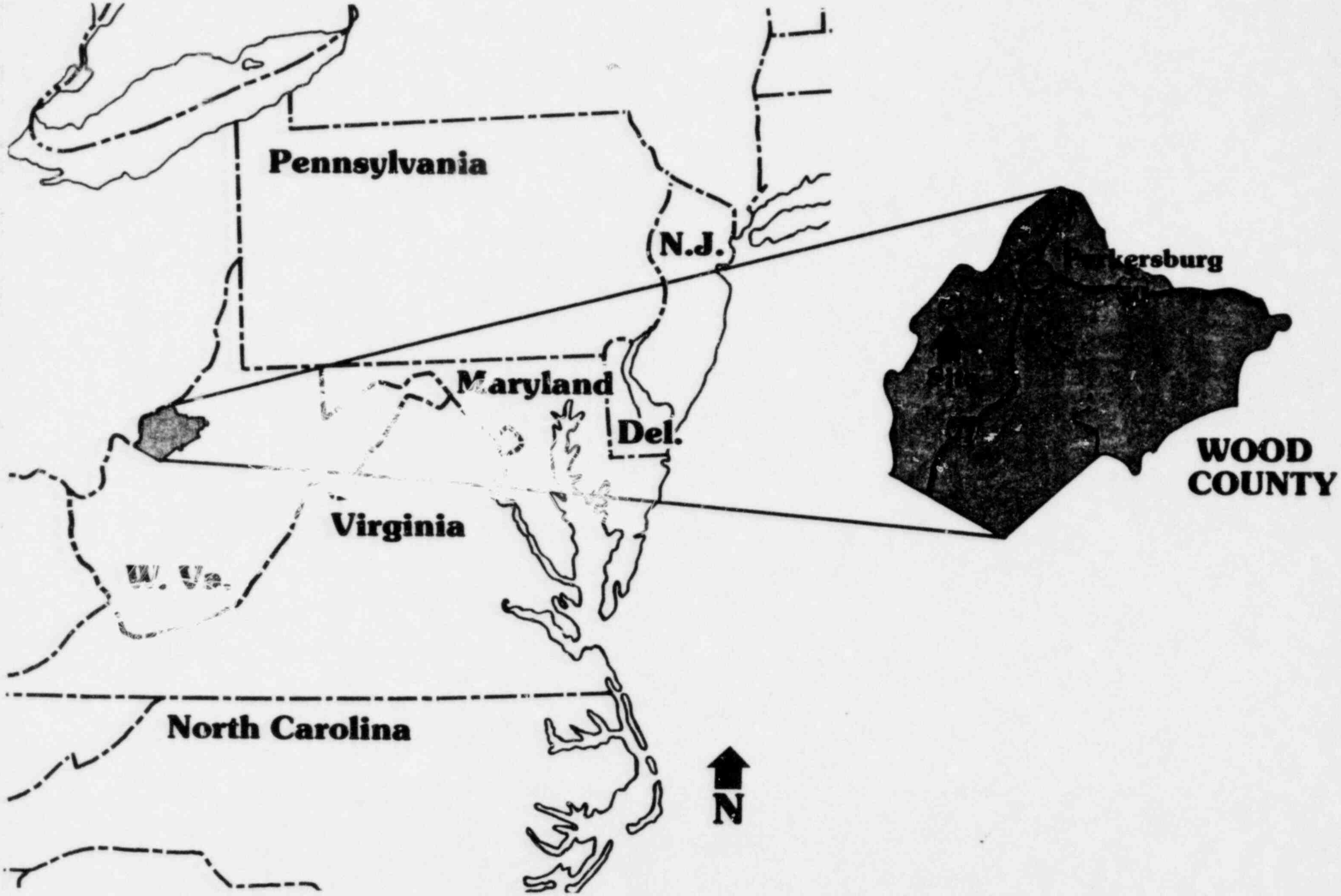


Figure 1. Location of Project Site

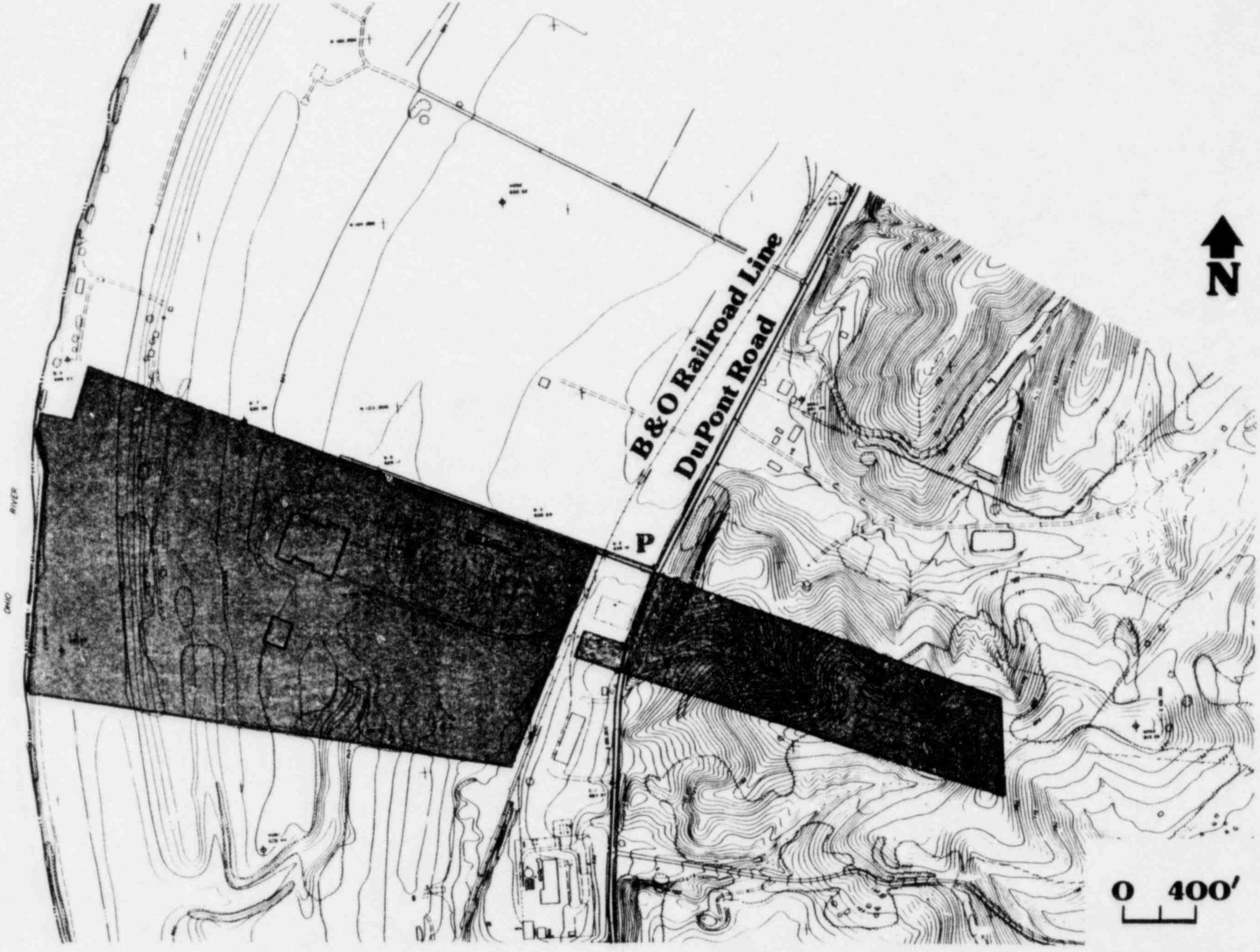


Figure 2. Location of Property

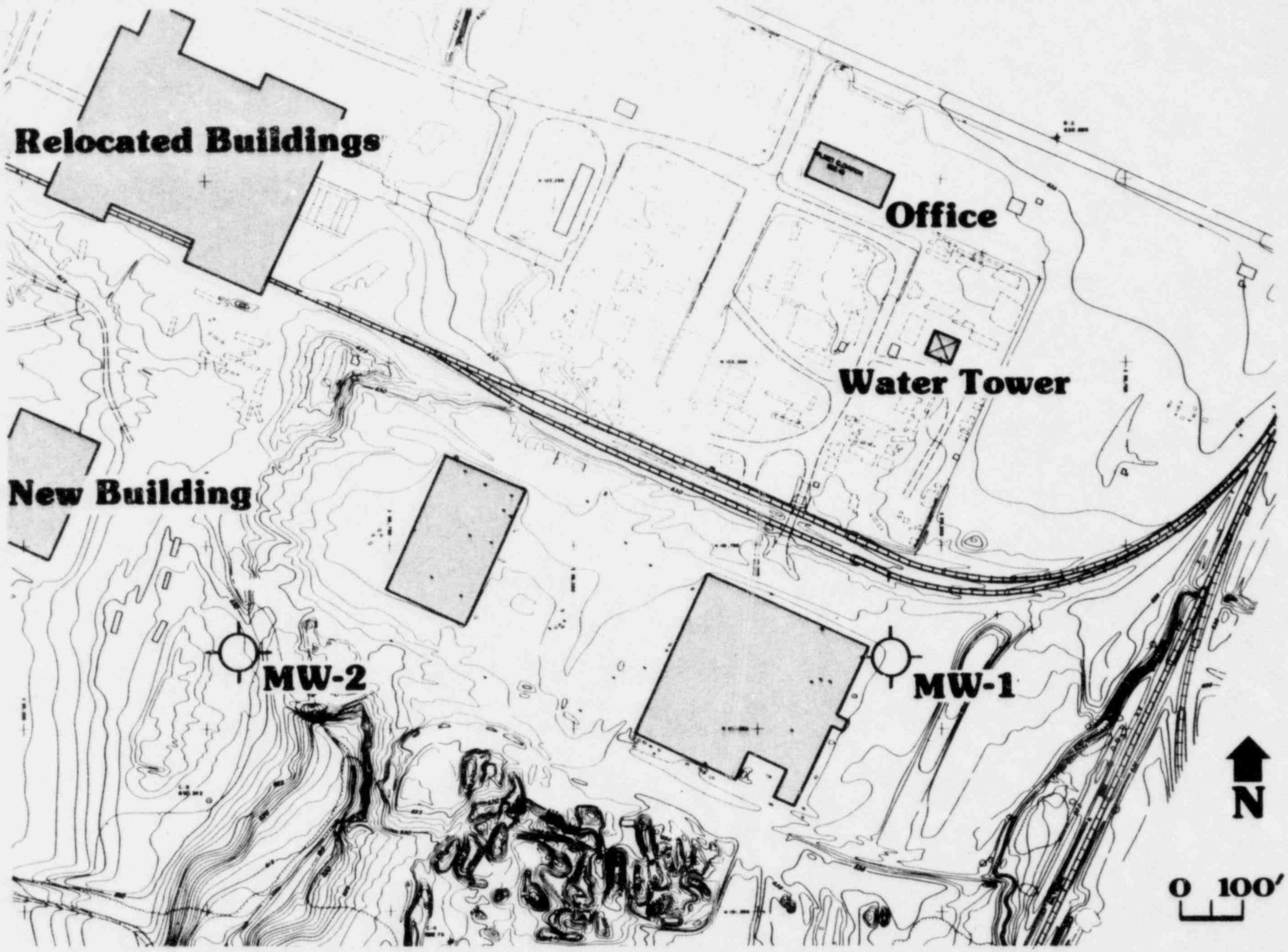


Figure 3. Facilities on Site

Figure 4. Surface Drainage

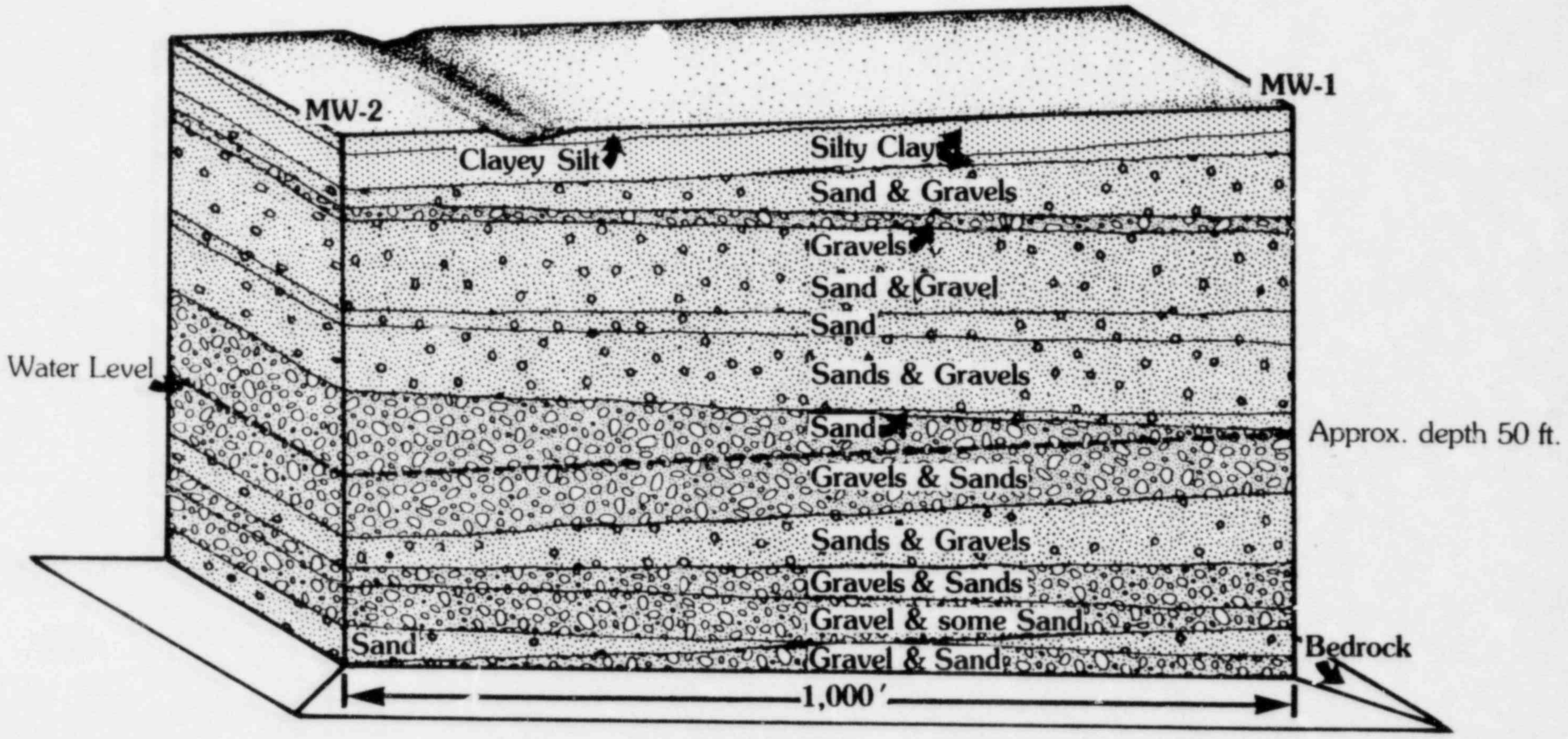


Figure 5. Hydrogeologic Profile

HISTORY OF THE PROPERTY

The Wood County plant site was developed by the Carborundum Company in 1957 for the production of high-grade zirconium metal for use in the construction of nuclear reactors for the U.S. Navy under an Atomic Energy Commission contract. The Atomic Energy Commission and U.S. Bureau of Mines process was used. This process started with the conversion of zircon ore to zirconium carbide, followed by the chlorination of the carbide to zirconium tetrachloride (98 percent zirconium and 2 percent hafnium metal). The metal complex was then separated into the zirconium and hafnium fractions and the metal was recovered by the Kroll Process. Magnesium metal was reacted with the zirconium tetrachloride under pressure in the Kroll process. A process waste, commonly called "sidewall material," resulting from this reaction can become pyrophoric under certain conditions.

During 1961 and 1962, the Carborundum Company processed Nigerian zirconium ore under an Atomic Energy Commission license. In addition to zirconium, this ore contained 6 percent hafnium, and up to 6 percent thorium (ThO_2). The processing of the radioactive Nigerian concentrate was under the surveillance of the Atomic Energy Commission, and both the ore and all residuals were stored in drums on the site. The use of Nigerian ore ended in 1962 when zircon was again processed by the original system. Zircon processing continued until 1970.

AMAX and Carborundum operated the facility as a joint venture, Carborundum Metals Climax, from 1965 to 1967. AMAX then became the owner of the business. The Nigerian ore and radioactive residual were stored on the site until September 1968. During the seven years of storage, some drums had deteriorated and spilled on the soils in the storage area. To reduce the residual radiation to approved levels, it was necessary to dispose of soil located beneath the stored drums. Nearly 3,000 drums of ore, residual material, and soil were transported from the property to an approved AEC burial site at Morehead, Kentucky in 1968.

The processing of zirconium ore was discontinued in late 1969, when purchased zirconium tetrachloride was substituted. AMAX produced zirconium and hafnium metal sponge until November 1974, at which time all production at the site was terminated.

In November 1974, AMAX received a license from the Nuclear Regulatory Commission (NRC) to conduct laboratory-scale experiments on Baddeleyite ore (ZrO_2) which contained less than 0.5 percent total thorium and uranium. The test material and all of the process residuals were contained within one building on the site. After the laboratory tests were concluded in late 1975, all remaining Baddeleyite ore was sold and its process residuals were transported to an approved NRC disposal site. Based on a site inspection in 1977 concerning the closeout of AMAX's Baddeleyite license, NRC identified soil associated with the Nigerian ore a above acceptable radiation limits. Seventy (70) drums of soil were transported in late 1977 to an approved NRC disposal site.

In March 1977, the Wood County property and buildings were sold to L. B. Foster Company (Foster) for use as a pipe manufacturing facility. Building construction, which started in 1977, ceased in March 1978 when pyrophoric material was uncovered.

As a result of problems encountered in the construction of new buildings with regard to pyrophoric material found on the property in 1978, AMAX repurchased the site from Foster. Further investigations indicated that some radioactive residues remained at the site, and AMAX undertook a program to clear the area. As a first step, Chem-Nuclear Systems, Inc. completed a radiological assessment of the site in December 1978.

During 1979, Foster leased from AMAX a portion of the property west of the former zirconium plant which was found to be free of radioactivity, and their pipe manufacturing buildings were relocated as shown in Figure 3. The manufacture of pipe was begun again in late 1979 by Foster.

In addition to further studies completed by Chem-Nuclear Systems, Inc. in 1979, AMAX initiated a comprehensive series of technical studies toward the development of the stabilization plan.

STABILIZATION PLAN

The proposed onsite stabilization plan selected by AMAX Environmental Services, Inc. (ESI) is based on technical studies and a review of alternative methods. The fundamental steps in the design and construction of the plan are described in this section and the more detailed technical information is provided in the next section of the report.

As the first step, radiological health-physicists conducted a survey of the property to ensure the level of radiation was safe for workers. The alpha radiation survey, which primarily detects the presence of radioactive gas, was conducted within the building located on the property in 1978. The levels measured met the federal guidelines and standards and the buildings were designated for unrestricted use.

A gamma radiation survey covered the entire property. The background radiation for the Washington Bottoms area was found to be about 12.2 μR/hr. as compared to 14 μR/hr., the average natural background to which most people of the world are exposed, and 19 μR/hr., the average dose background exposure of an individual living in Denver, Colorado. A grid consisting of 1,400 cells, 25 feet by 25 feet, was used in the survey to locate soils of higher-than-background levels of radiation. Highly sensitive meters were used to measure gamma radiation at the surface and within water-jetted boreholes to determine the depth of elevated radiation. The cells with radiation measurements

Above twice background are illustrated in Figure 6. The highest direct gamma measurement was determined to be 900 μR/hr., yet, the dose rate for the great majority of the cells found to have radiation higher-than-background were in the order of 20 μR/hr., or about two-times background. The highest radiation measurements were along the fence, east of the water tower, where the drums of Nigerian ore and process waste had been stored. The depth of radioactively-enriched soil was between 4 and 24 inches from the surface at the former manufacturing site in Parcel B. Radiation levels greater than two-times background were found at depths as great as 15 feet near the south side of the large concrete slabs located south of the rail spur in Parcel C.

The soils identified as radioactively-enriched will be collected from the former zirconium manufacturing area identified as Parcel B, and designated drainage paths, and moved to a control area. The control area is located in Parcel C as outlined in Figure 6 and covers a portion of the radioactively-enriched soil and all potential pyrophoric material located below ground surface. Radiological decontamination specialists and their contractors will clear all subject areas outside of the control area, and qualified inspectors will determine when an area has been cleared to meet government criteria. After the radioactively-enriched soils have been placed in the control area the stabilization mound will be constructed.

The steps for constructing the earthen cover are illustrated in Figure 7. The existing surface conditions within the control area and below an elevation of 634 feet (MSL) are not disturbed (Step A). Thus, the concrete foundations and slabs will remain intact, but the earth mounds to the south are excavated to average ground level. The selected radioactively-enriched soil from Parcel B and other drainage areas is collected and placed within the control area. Approximately 10,000 cubic yards of selected soil is to be compacted over the existing ground cover (Step B). Next, a 6-inch layer of clayey material is compacted over the selected soil (Step C) to form a base upon which to build a clay cover. The 12-inch clay layer is constructed in two or more lifts to form a highly impervious earthen layer with an infiltration permeability of less than 1×10^{-7} cm/sec (Step D). Then a 30-inch layer of soil is placed over the clay cap to protect it from natural weathering and to provide a suitable topsoil for growing grass (Step E). The profile scale used to illustrate the construction of the mound is greatly exaggerated in Figure 7, A through E. To provide a true perspective of the completed mound, the design dimension of the profile view is illustrated in Figure 7 (Step F). The plan view for the completed mound and the surface grading in the stabilization area are shown in Figure 8.

The site-specific nature of the stabilization area permits the control of both surface and subsurface water movement. Drainage from the control area can be directed away by grading the surface to meet design requirements. As located, the control area is protected against flooding from high water in either the local streams or the Ohio River.

The groundwater movement beneath the control area can be directly controlled by forming an engineered surface structure. Sophisticated geophysical borehole

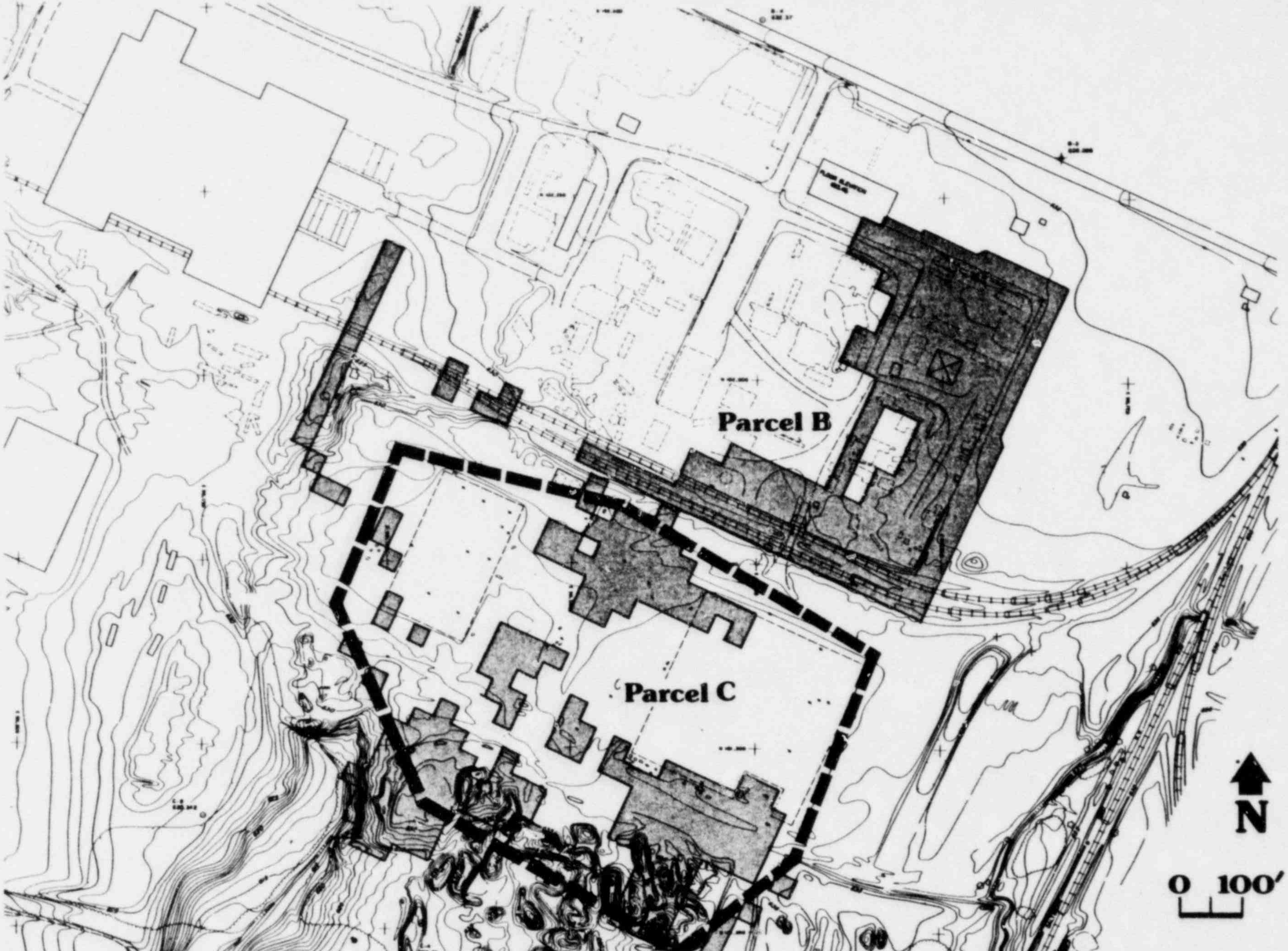
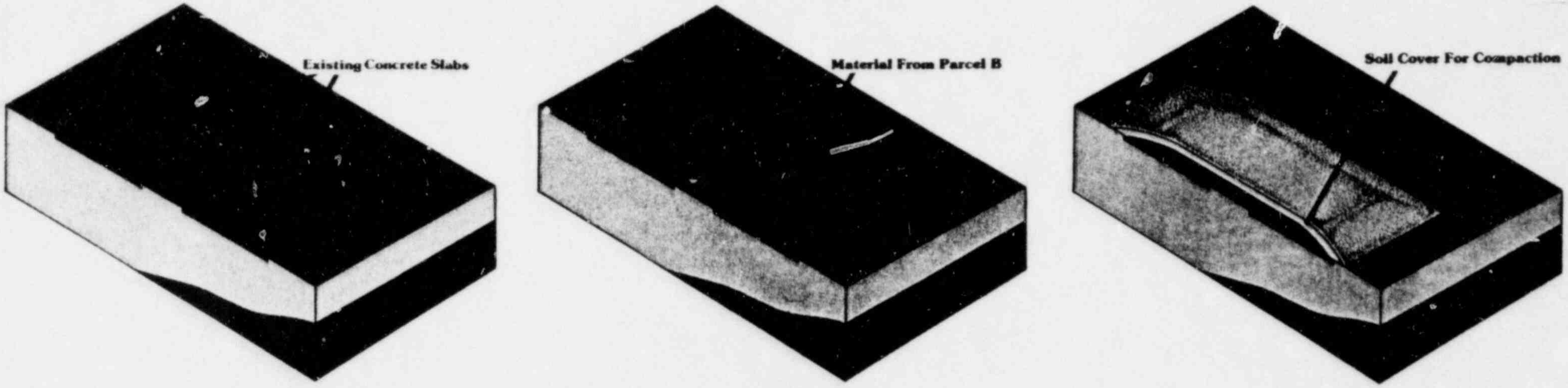


Figure 6. Location of Radioactively Enriched Soil, Greater than Background, and Outline of Control Area

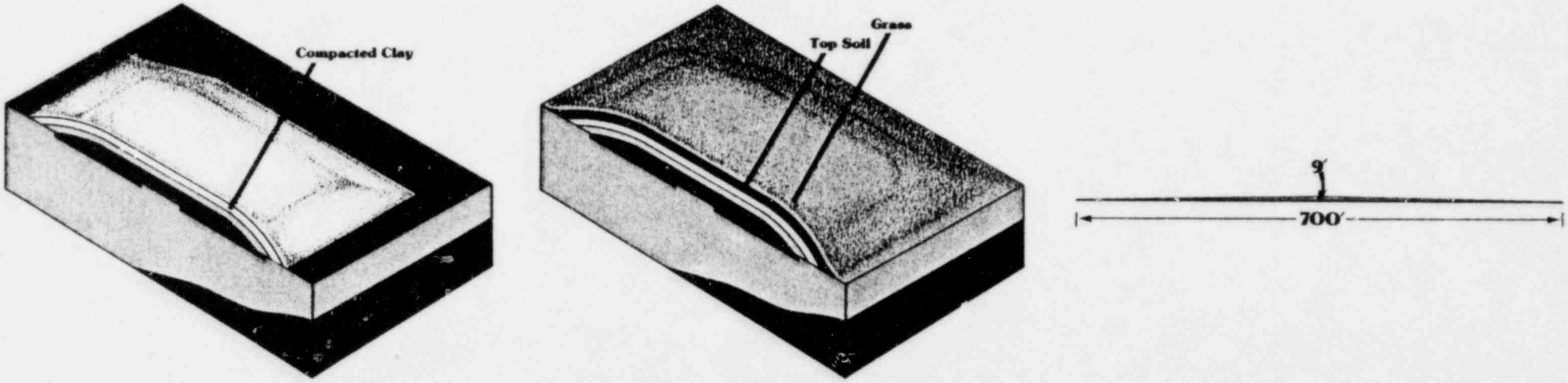
STABILIZATION PLAN (*A-E not drawn to scale)



A. Existing Ground Surface*

B. Placement of Selected Soils*

C. Compacted Soil*



D. Impervious Clay Crown*

E. Final Top Soil*

F. Perspective of Mound

Figure 7. Stabilization Plan

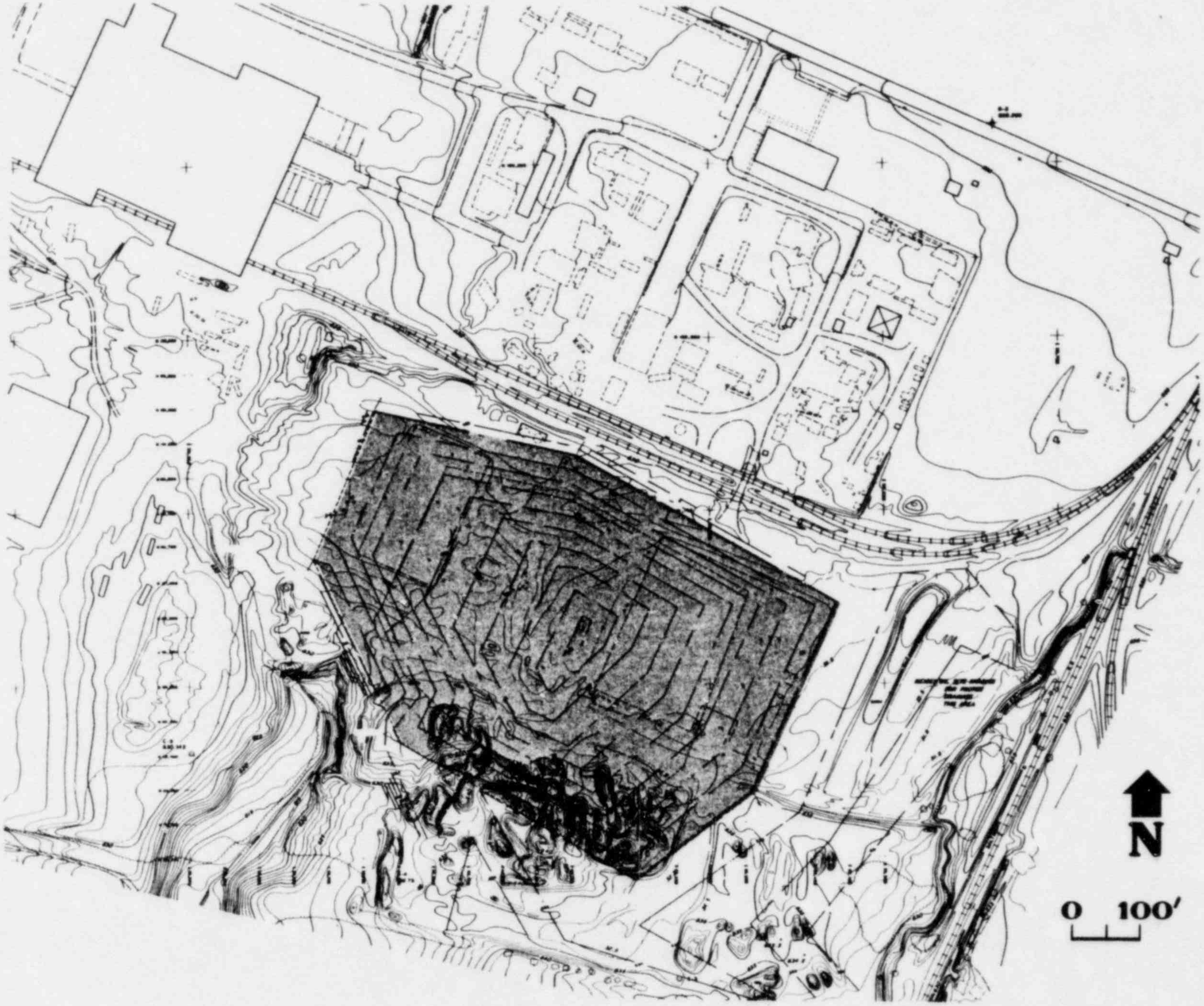


Figure 8. Plan View of Stabization Area

logging was used to characterize the aquifer located below the control area (Figure 5). Except for the clayey soils found at the surface to a depth of 10 feet, the logging detected no clayey material within the sand-gravel aquifer down to bedrock, about 100 feet below the surface. Without clay lens strata present, neither perched water nor horizontal groundwater movement could occur in the unsaturated portion of the aquifer. The unsaturated zone is that section of the aquifer between the surface and the groundwater table. Based on a hydrogeological assessment, when the surface cover is constructed, groundwater can only move horizontally beneath the control area in the sand and gravel aquifer section below the water table, 50 feet below the surface. Therefore, the construction of an engineered clay cap over the control area would restrict the only water that could come into contact with the material contained below the cap. Thus, the controlled material beneath the clay cap will be isolated from contact with moving water, and will restrict the migration of any radioactive material to the regional groundwater system. Any potentially pyrophoric material located within the covered area will oxidize with time to become a stable metal oxide equivalent to iron rust.

The stabilization plan was selected after reviewing the physical characteristics of the site, defining the location and low intensity of the radioactively-enriched soil and evaluating other control alternatives. This plan was selected based on the following factors:

1. The plan avoids the disturbance of potential pyrophoric material and avoids endangering the health and safety of workers during the construction of the plan.

2. The 1.5 million cubic feet of soil subject to control is of such low-level radiation that none of the existing NRC licensed disposal sites, i.e., Barnwell, South Carolina or Beatty, Nevada, can accept the soil under their current allocation programs.

3. This plan controls the radioactively-enriched soil within the boundaries of the property and avoids any accidents that could be caused by transporting over 3,000 truckloads of material off-site.

4. The plan provides the highest degree of overall safety and is cost-effective.

STABILIZATION PLAN

TECHNICAL

BACKGROUND-TECHNICAL STUDIES

The technical studies used for collecting detailed information on the property are organized under the following topics:

- TOPOGRAPHIC MAPPING AND SURFACE DRAINAGE
- SUBSURFACE GEOLOGY AND GROUNDWATER MOVEMENT
- SOIL INVESTIGATION AND CLASSIFICATION OF CONSTRUCTION MATERIALS
- RADIOLOGICAL SURVEY AND THE HEALTH-PHYSICS ASSESSMENT OF THE SITE

AMAX retained experts for each of the above subjects to collect the necessary information that would describe the present status of the property. The coordination of the baseline studies and the final design of the stabilization plan was the responsibility of AMAX Environmental Services, Inc. (ESI). Information was transfered to computer storage to provide for rapid data access and graphical display of the collected information.

TOPOGRAPHIC MAPPING AND SURFACE DRAINAGE

Topographic Mapping

Bell Mapping Company, (Bell) was responsible for obtaining high-quality aerial photographs of the area, with adequate ground survey control to produce topographic maps using photogrammetric methods. Three base maps were developed. The Area Map is drawn with an elevation contour interval of 5 feet (Figure 9). This map covers the entire property, including the parcel east of DuPont Road. The scale for the Site Map is magnified and the elevation contour interval is 1 foot (Figure 10). A higher degree of detail on the variations in elevation was considered necessary for accurately determining the surface water drainage patterns. The greatest detail is provided on the Detailed Site Map. Intermediate spot elevations are added in addition to the 1-foot elevation contours (Figure 11). Bell also was responsible for surveying the location and elevations for the geophysical and soil surveys.

The aerial photographs taken on February 13, 1980 are part of the project record file.

Surface Drainage

The elevation contours provided on the topographic maps are used to determine the direction of surface flow patterns at any point in the surveyed area. The major drainages are apparent (Figure 4). The drainage from the steep, sloped hills to the east are intercepted

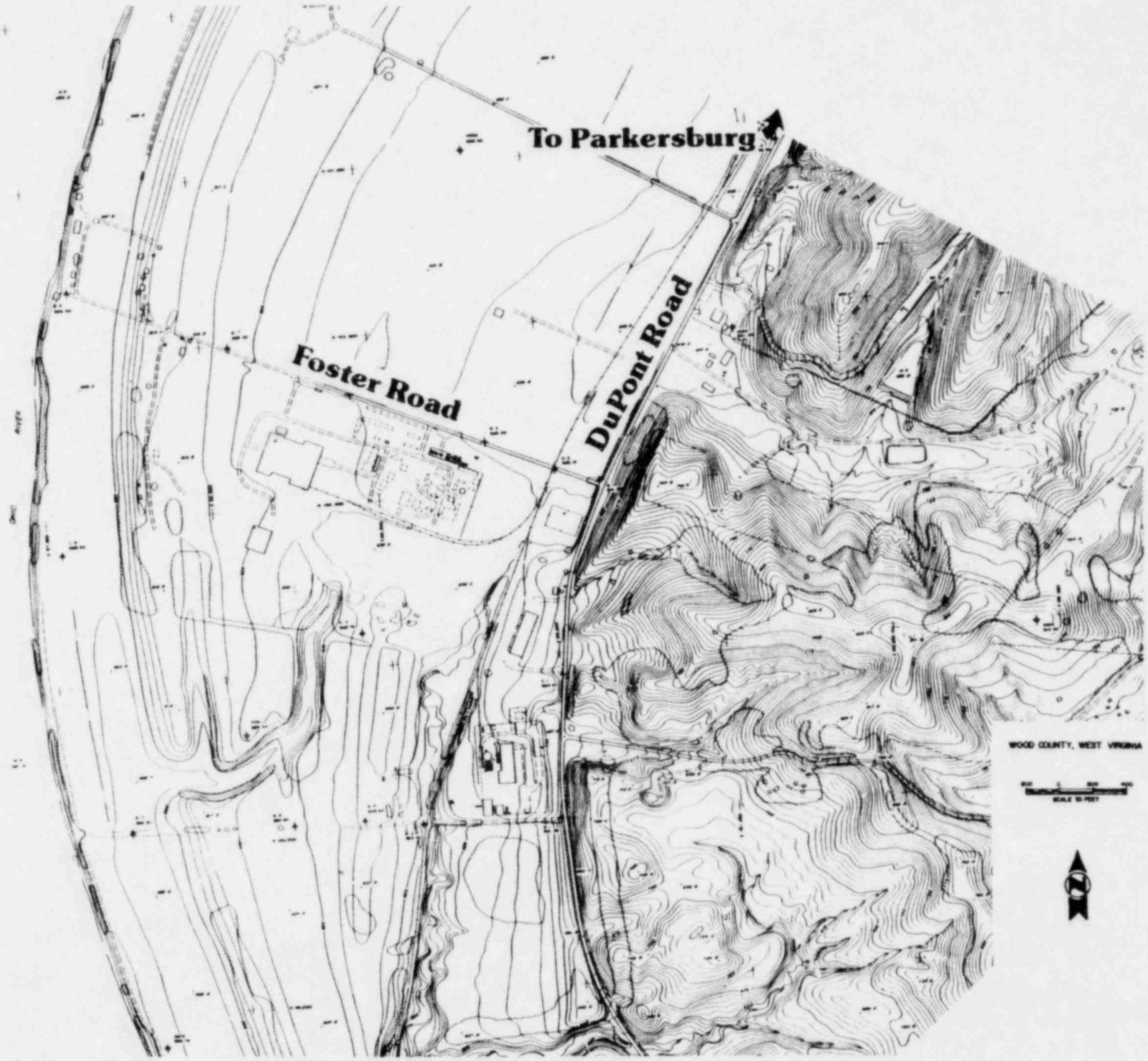


Figure 9. Area Map

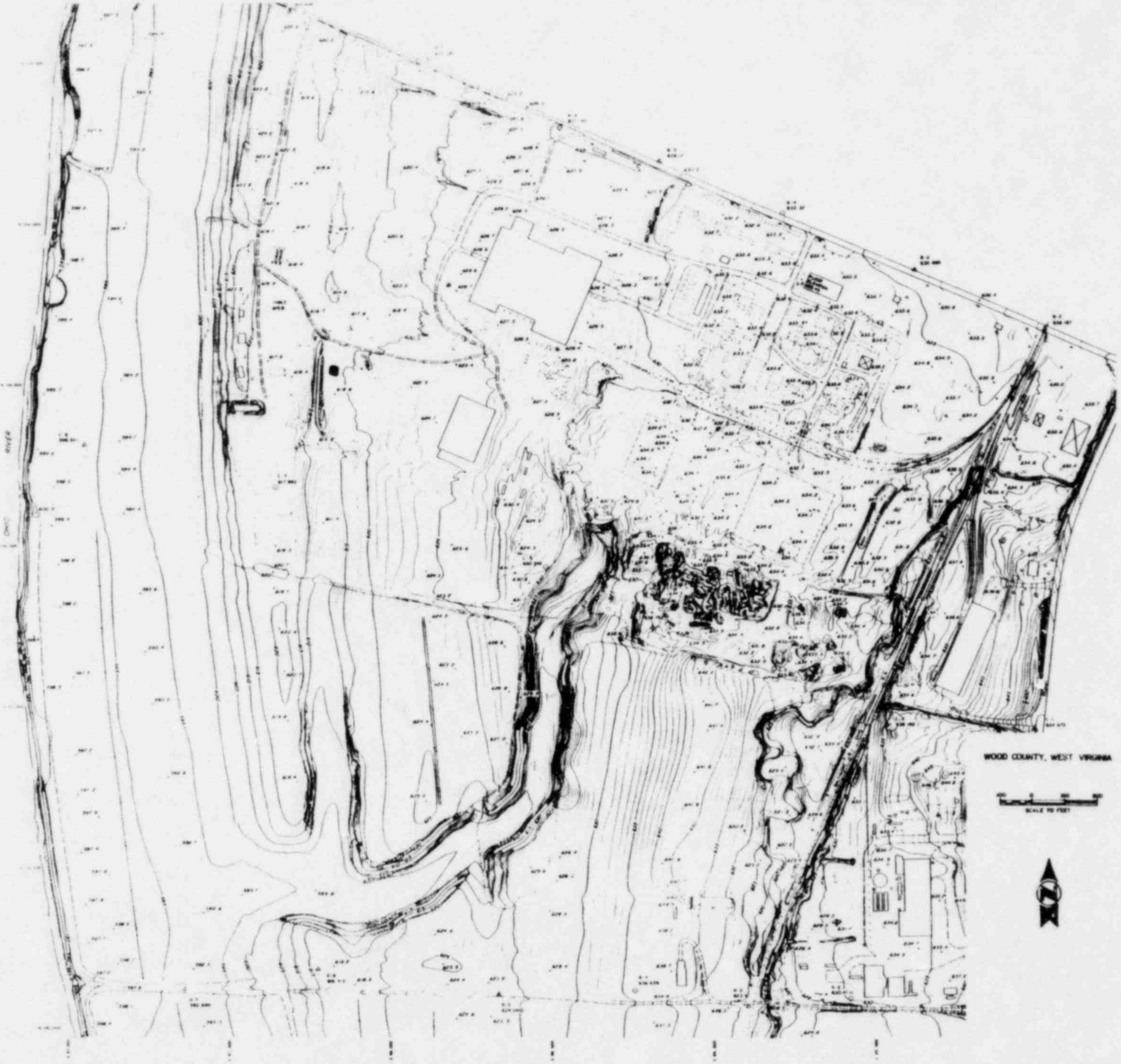


Figure 10. Site Map

Figure 11. Detailed Site Map

by the highway and railroad drainage systems and are diverted into a small creek that flows south along the west side of the Baltimore & Ohio Railroad (B & O) track line. This creek flows southwest for one mile before discharging to the Ohio River. The drainage from the property located west of the B & O track flows west toward the Ohio River except for the surface water that is intercepted by the incised gully, which drains to the southwest. A storm sewer drainage system was constructed in the area of the former plant, and provides for piping and discharging the collected waters to the lower terrace downstream and west of the buildings. Direct surface drainage to the Ohio River is restricted by a ridge running along the east bank of the Ohio River. Infiltration and direct drainage through farm land drains to the river and prevents the accumulation of water on the lower terrace.

SUBSURFACE GEOLOGY AND GROUNDWATER MOVEMENT

Subsurface Geology

Roy E. Williams and Associates (Williams and Associates) were assigned the responsibility for defining the hydrogeological characteristics of the site. To define the hydrostratigraphy, the latest drilling methods, sampling procedures, and borehole geophysical logging techniques were applied. Soil pit information was used to define the near-surface conditions. By evaluating the soils information collected from the area, it was determined that a layer of clayey silt, ranging in thickness from 1 to 10 feet, covers the upper river terrace. An analysis of the geophysical logging data and samples taken from the two boreholes drilled and logged at the site in June 1980 indicate that the clayey, silty surface layer is underlain to bedrock by a section of fine sand to coarse gravel. Bedrock is about 100 feet below the ground surface. The groundwater table in the area ranges between 50 and 55 feet below the ground surface. No perched saturation zone exists above the water table, and there are no fine-grained (clay or silt) hydrostratigraphic units which could act as perched horizons.

Surface Soil Conditions

Soil pits were dug by backhoe near each of the two monitoring wells, MW-1 and MW-2 (Figure 3), to provide information on the near-ground subsurface conditions for use in supplementing the information collected by the borehole logging system. Geotechnical engineers provided the soil information.

The soil pit near MW-1 exposed manmade fill (0.0'-0.5'), clay, very silty, and sand (0.5'-3.0'), and gravel, very sandy, slightly silty (3.0'-11.0'). The soil pit near MW-2 exposed manmade fill (0.0'-2.0'), topsoil horizon (2.0'-3.0'), clayey silt (3.0'-8.0'), fine-grained sand (8.0'-9.5') and clean fine- to medium--grained sand (9.5'-12.0'). These data were correlated with the borehole logging information for developing subsurface sections.

Test Hole Drilling

Two multi-purpose boreholes were drilled on the site, MW-1 and MW-2 (Figure 3), during the week of June 23-27, 1980 by Layne-New York Company, Inc. (Layne) under the supervision of Williams and Associates. The purpose of the wells was to gather information on the hydrostratigraphy beneath and adjacent to the proposed stabilization area, and to serve in the future as monitoring wells. The initial objective of the drilling program was to determine whether any fine-grained strata (clay) occur within the coarser-grained sand and gravel stream terrace deposits known to exist at the site.

It was recognized before the drilling program that collecting sand and gravel samples from the borehole would be difficult. Coarse gravels tend to plug the opening in split spoon samplers and, if present, restrict the collection of any fine-grained material. To overcome this limitation, the drilling program was designed to accommodate the use of special geophysical logging probes. Maximum logging results were obtained by constructing open (uncased) holes. This condition was achieved by drilling MW-1 and MW-2 by a rotary mud technique. An 8-inch rotary bit was used for drilling and a bentonite slurry (mud) was pumped through the inside of the drill stem and discharged at the bit. The mud then flushes up the outside of the drill stem carrying the drill cuttings from the hole. An earthen pit was constructed to permit the cuttings to settle and decanted mud to be recycled to the drilling circuit. After completing the drilling and allowing the recycled mud time to remove the remaining cuttings, the hole remained full of bentonite slurry. The specific gravity of the slurry was sufficiently high to prevent the walls from collapsing. The stability of the holes constructed by this drilling method allowed for the geophysical probes to be lowered and raised in the well without introducing errors normally caused by cased holes.

Geophysical Logging

Snyder Drilling Service supplied the geophysical equipment and services for logging the holes. Four physical logs were taken at each of the two holes; ely, the natural gamma log, the neutron epithermal tron log, the gamma gamma log, and the caliper log. These logs, when analyzed together for each hole, provided a useful and reliable technique for identifying hydrostratigraphic variations down to a lens one-foot thick. With this detailed geophysical logging information, along with supplemental information developed from the analysis of material collected with split spoon samplers and grab samples of cuttings collected during the drilling operation, an interpretation of the hydrostratigraphy for the site was developed by Williams and Associates.

Geophysical Log Correlation for MW-1

MW-1 was drilled to bedrock, a depth of 99.5 feet (100 feet). The four geophysical logs were run to a maximum depth of 96.5 feet on June 26, 1980. Grab samples of cuttings were collected during drilling operations.

The natural gamma tool recorded very low count rates within the subsurface materials with a small increase within the top seven feet of material. This increase indicates a finer-grained matrix (Figure 12). Below seven feet this tool indicates clean sands and gravels throughout the borehole.

The neutron epithermal neutron tool and gamma gamma tool were used to assess variations in subsurface porosity and density. Because both tools are affected by changes in the borehole diameter and rugosity (nonuniformity), a caliper log was required for indexing the former logs. The caliper log (Figure 13) indicates caving occurred within the top 30 feet of the borehole. The borehole diameter differences were taken into consideration in the assessment of the neutron epithermal neutron and gamma gamma log responses.

Below the 30-foot zone, the neutron epithermal neutron log indicates a small variation in porosity, which corresponds to the varying percentages of coarse sands and gravels in the section (Figure 12). The neutron epithermal neutron log is displayed on an expanded scale to emphasize the porosity range between 20 and 30 percent, the common porosity range for sands and gravels. If clay or silt lenses had occurred within the lower 70 feet of the borehole, the neutron log would have extended to the left, indicating substantial increases in porosity associated with finer-grain hydrostratigraphic units. The gamma gamma log is a density indicator which is calibrated in grams per cubic centimeter. The density log below a depth of 30 feet is highly consistent at approximately two grams per cubic centimeter, which is common for coarse-grain sediment (Figure 14).

Geophysical Log Correlation for MW-2

MW-2 was drilled to bedrock, a depth of 96.5 feet. The four geophysical logs for the borehole were run on June 27, 1980. Both grab samples of the cuttings and materials collected by split spoon samplers were taken during drilling operations for the evaluation along with the logging data.

In general, the information collected during the drilling, logging, and sampling indicates that the section is composed of sands and gravels to bedrock with the exception of the upper 12 feet of fine-grained silty material at the surface (Figures 15, 16, and 17). A detailed interpretation of the subsurface hydrostratigraphy followed the procedures described for MW-1.

Geophysical Logging Summary

Logging results for both MW-1 and MW-2 indicate that the hydrostratigraphic section beneath the AMAX Wood County site is composed entirely of sands and gravels to bedrock. Some fine-grained silty-clay material is present at the surface, as evidenced by the higher natural gamma counts (Figures 12 and 15), but does not extend below a depth of 12 feet. Some variation in grain size occurs within the sand and gravel section as shown by the geophysical logs. This variation ranges between coarse gravel to medium sand typical to the natural depositional characteristics of a former river system.

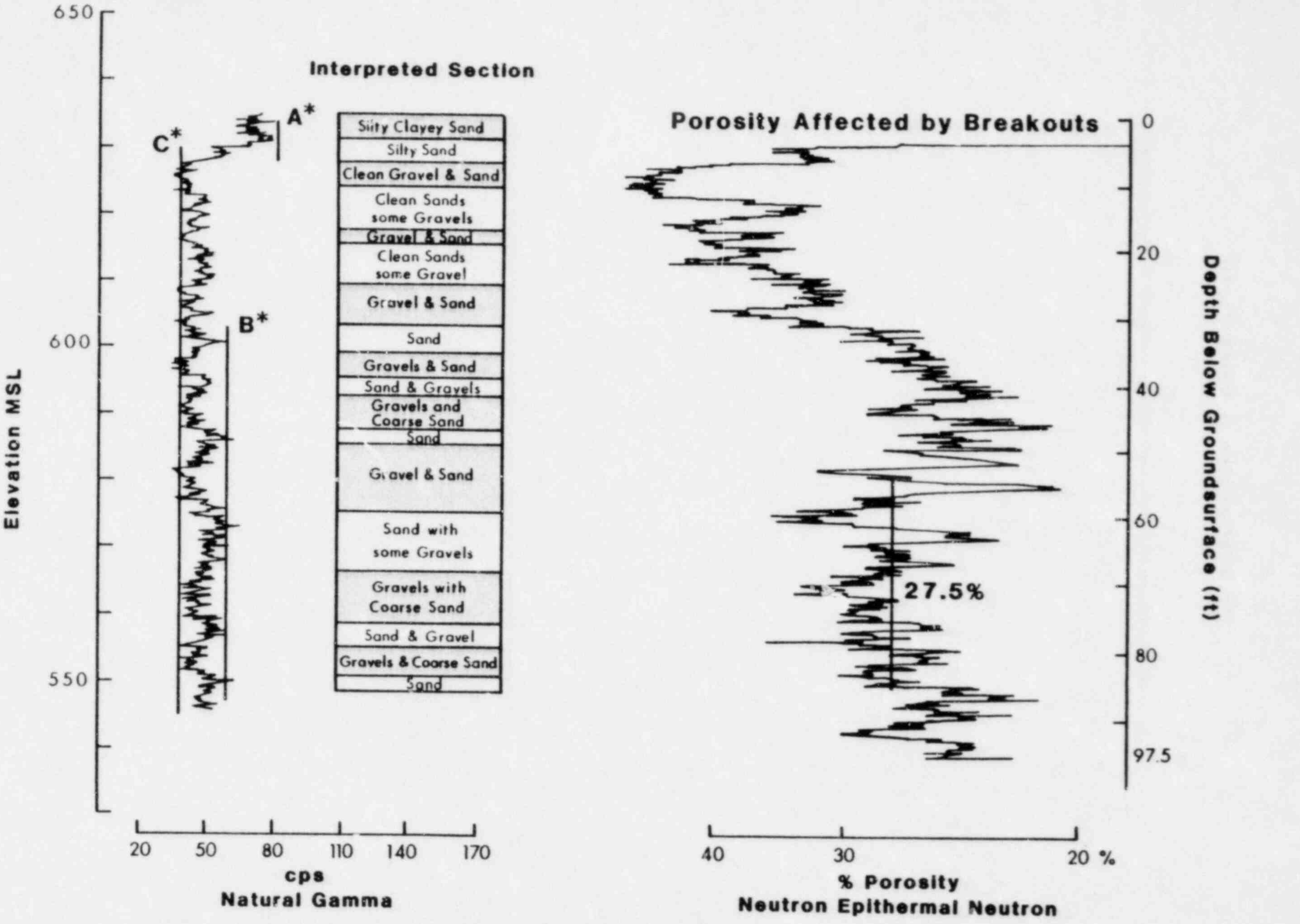


Figure 12. Natural Gamma & Epithermal Neutron Logs for MW-1

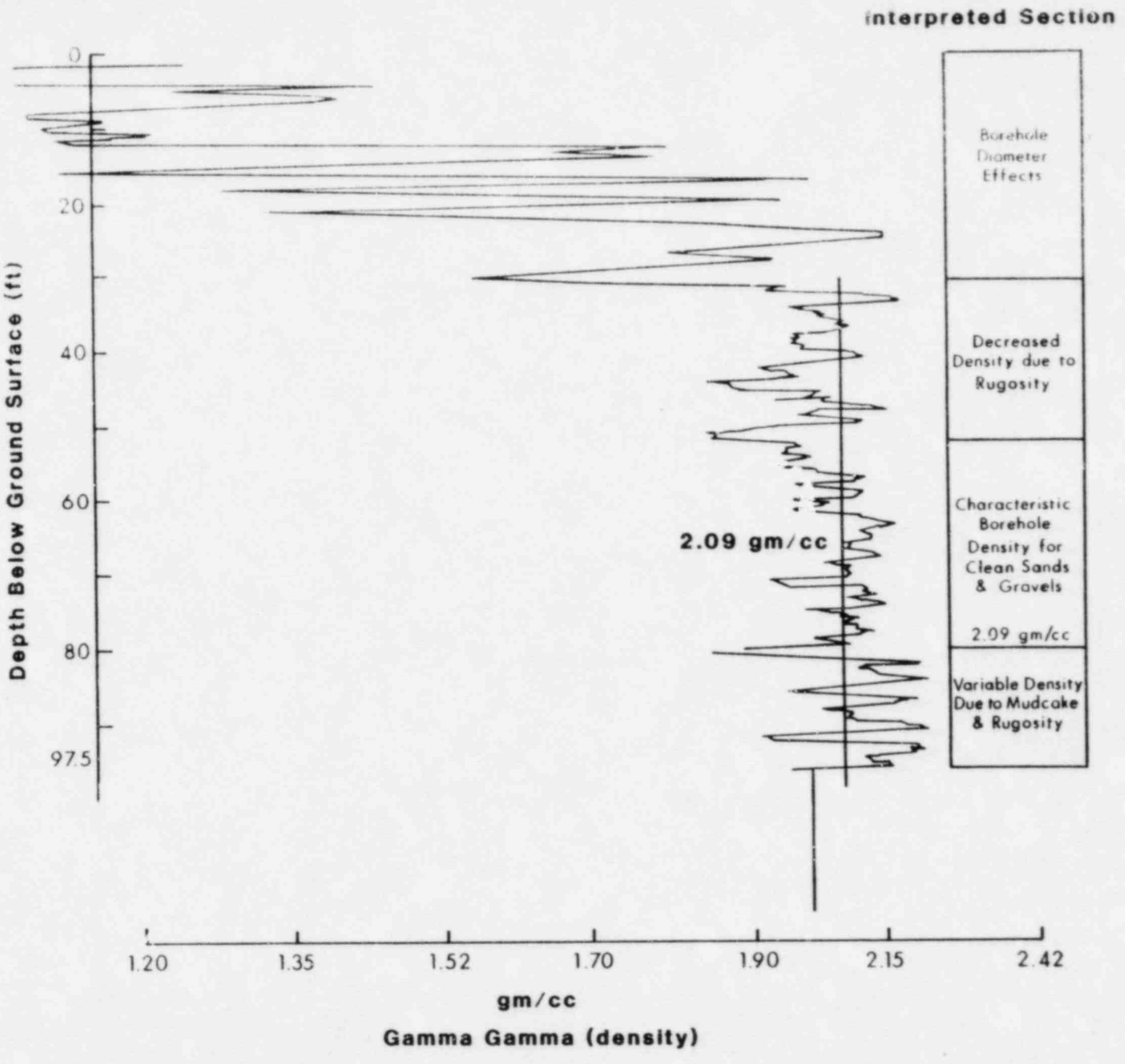


Figure 13. Gamma Gamma (density) Log for MW-1

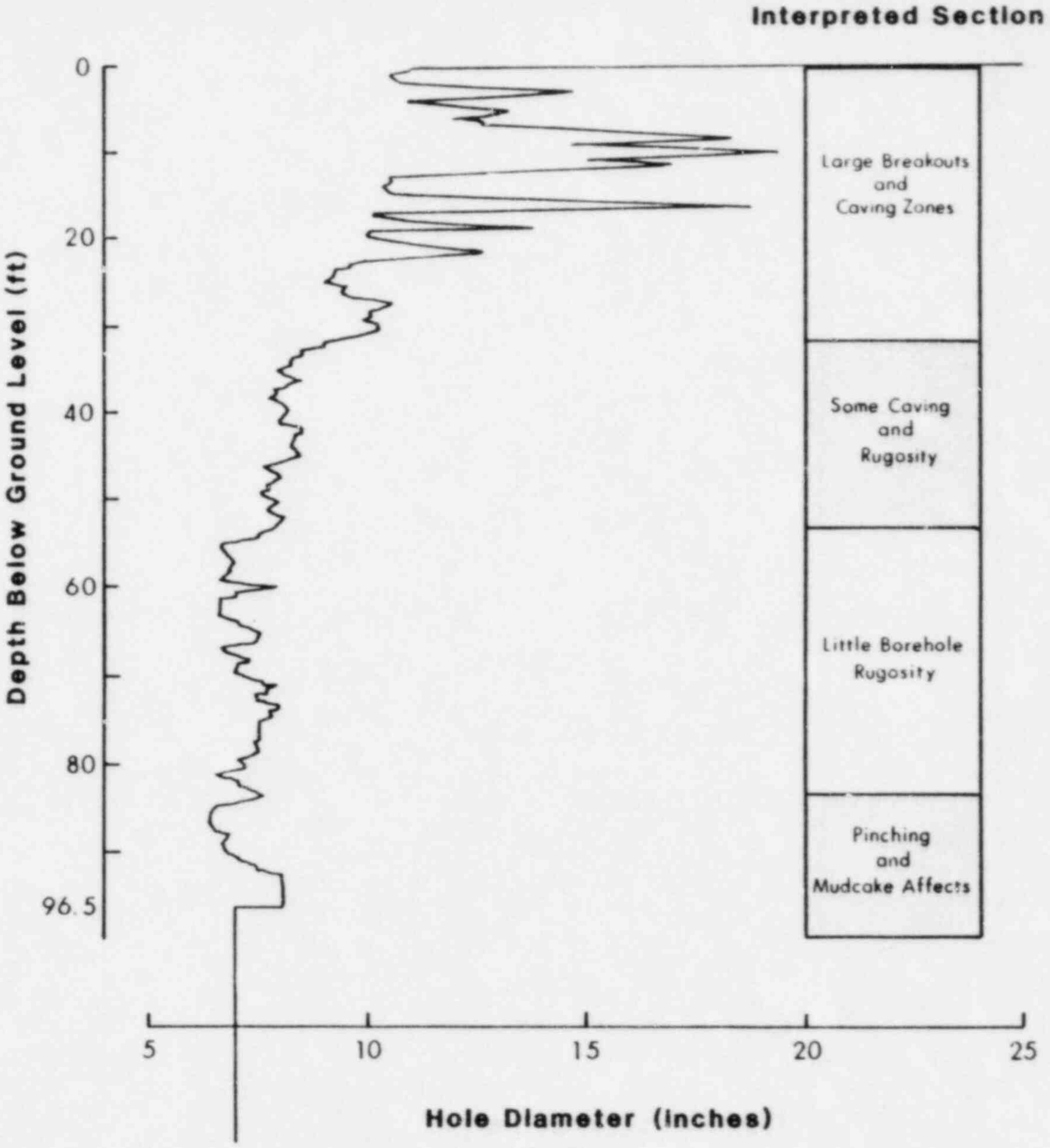


Figure 14. Caliper Log for MW-1

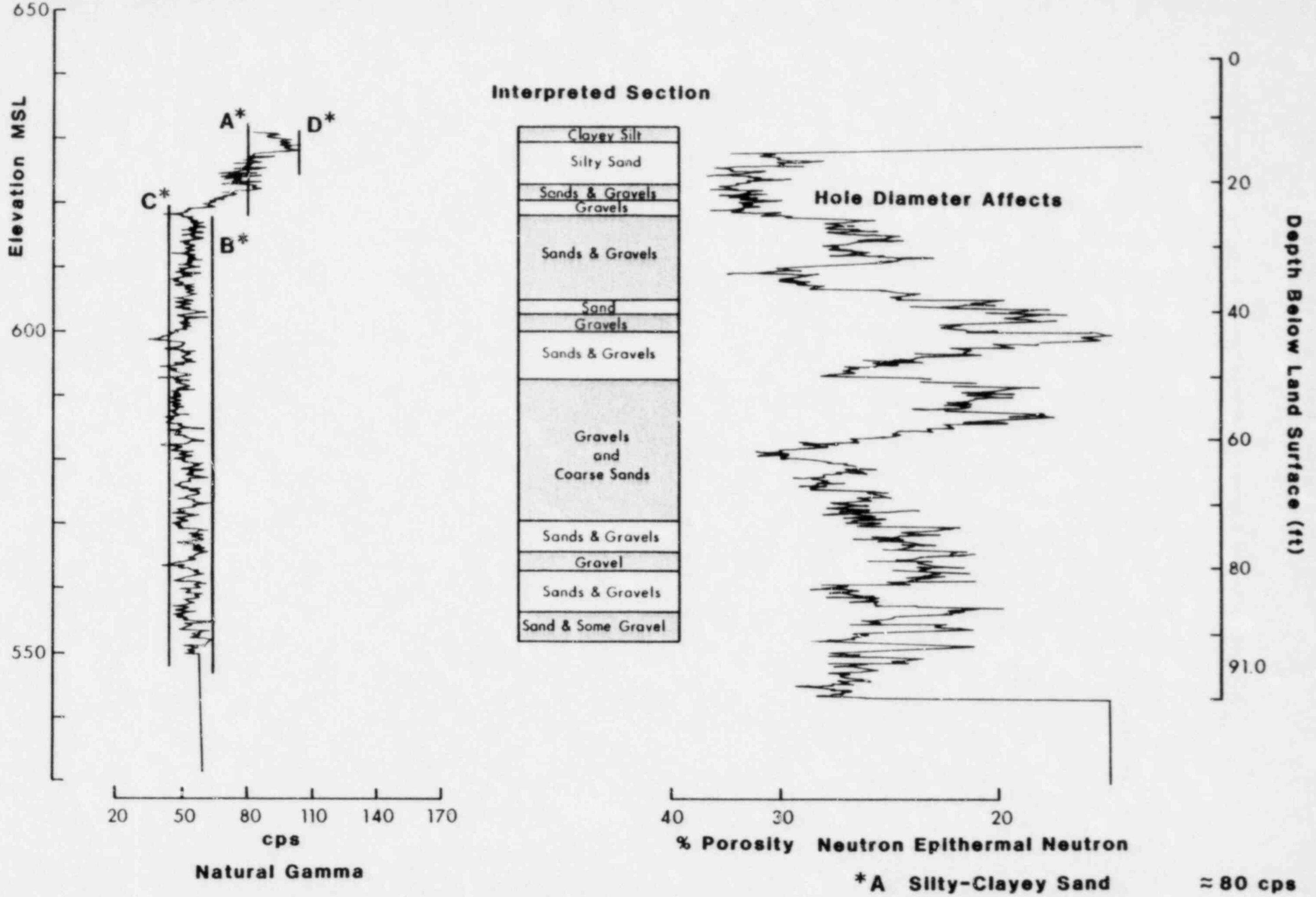


Figure 15. Natural Gamma and Neutron Epithermal Neutron Logs for MW-2

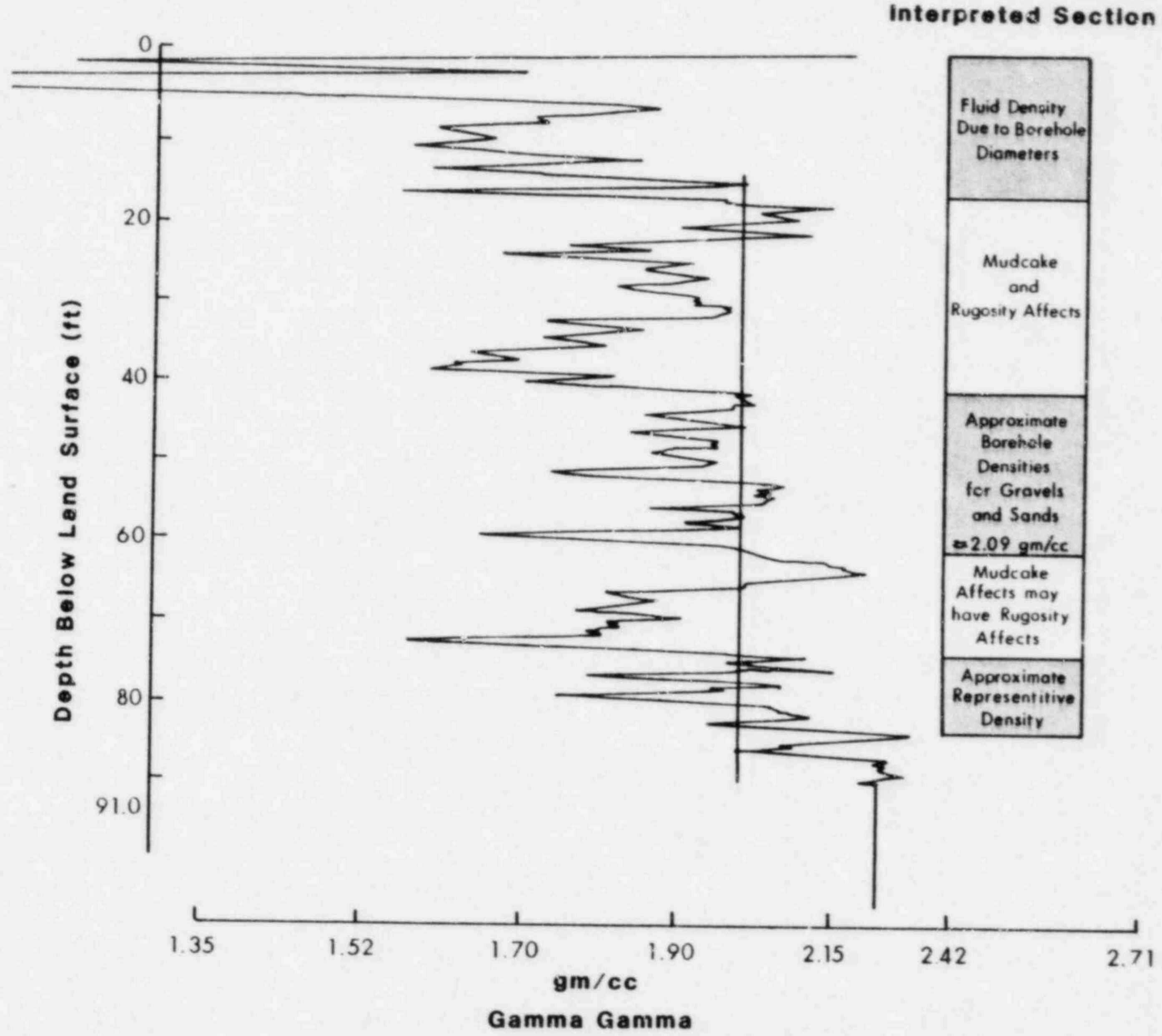


Figure 16. Gamma Gamma (density) Log of MW-2

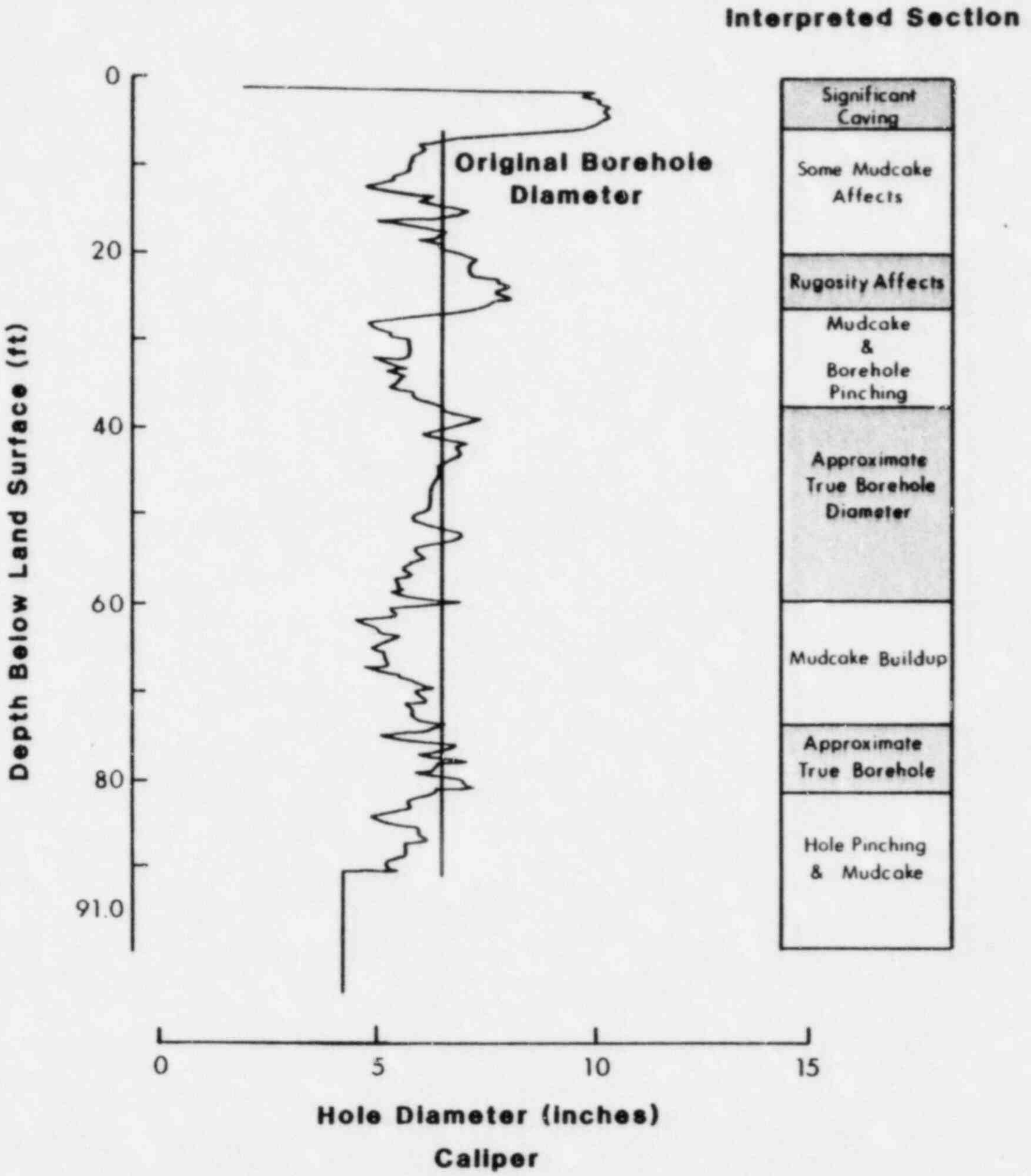


Figure 17. Caliper Log for MW-2

Figure 18 depicts a hydrostratigraphic correlation between MW-1 and MW-2, located approximately 1,000 feet apart, utilizing the natural gamma logs from each hole. This cross-section runs approximately east to west on the upper terrace and indicates the consistency of the section underlying the area. Figure 5 is a simplified illustration of the information contained in Figure 18.

SOIL INVESTIGATION AND CLASSIFICATION OF CONSTRUCTION MATERIALS

Woodward-Clyde Consultants were responsible for conducting soil investigations to identify the local availability of clayey material and other soils required for designing an earthen structure. A general survey was made in Wood County to identify potential sources of clay in the vicinity of the site. Thirty-six (36) test pits were dug on the site to collect soil samples for laboratory testing.

Based on these soil investigations, clayey material, suitable for constructing water-tight barriers, was found to be available in the vicinity of the property. An existing clay borrow pit operated by DeBarr and located east of Parkersburg next to Highway 47, was found to meet the soil requirements specified. Also, surficial clayey material was located on the property.

On-Site Borrow Sources

Four potential borrow sources were investigated on-site, and are numbered as Areas, 1, 2, 3, and 4, as shown on Figure 19. Areas 1, 2, and 3 are located on the terraces. Area 4 is in a moderately hilly area abutting the terraces. Area 1 and the northern half of Area 2 appear to be relatively undisturbed ground, except for surficial agricultural activities. The southern portion of Area 2 was once used for recreational activities and has recently been used for pipe storage. Area 3 appears to have undergone some excavation and contains localized areas of manmade fill. Areas 1 and 3 are generally vegetated with weeds and grasses. Areas 2 and 4 also are covered with weeds and grasses, and sections of the southern portion of Area 4 are forested.

Test pits in Area 1 showed about 0.5 to 1 foot of clays and silts with roots overlying about 4 feet to more than 12 feet of silty to very silty, sandy clays and very clayey, sandy silts. Some layers of silty and clayey sands were found below a depth of five feet in Test Pits TP-16, TP-18, and TP-19. Generally, siltier soils were found in the northeastern portion of Area 1. Test pits in Area 2 showed about 0.5 feet of clays, silts and sands, with roots overlying about 3 to 10 feet of man-made fill or 0.5 to 1.5 feet of clays, silts, and sands with roots overlying about 1 to 9.5 feet of silty to very silty, sandy clays and very clayey, sandy silts, or clean to silty and clayey sands overlying clean, sandy gravels. Test pits in Area 4 showed about 0.5 to 3 feet of clays and silts with roots overlying about 1 to 8.5 feet of silty to very silty, sandy clays

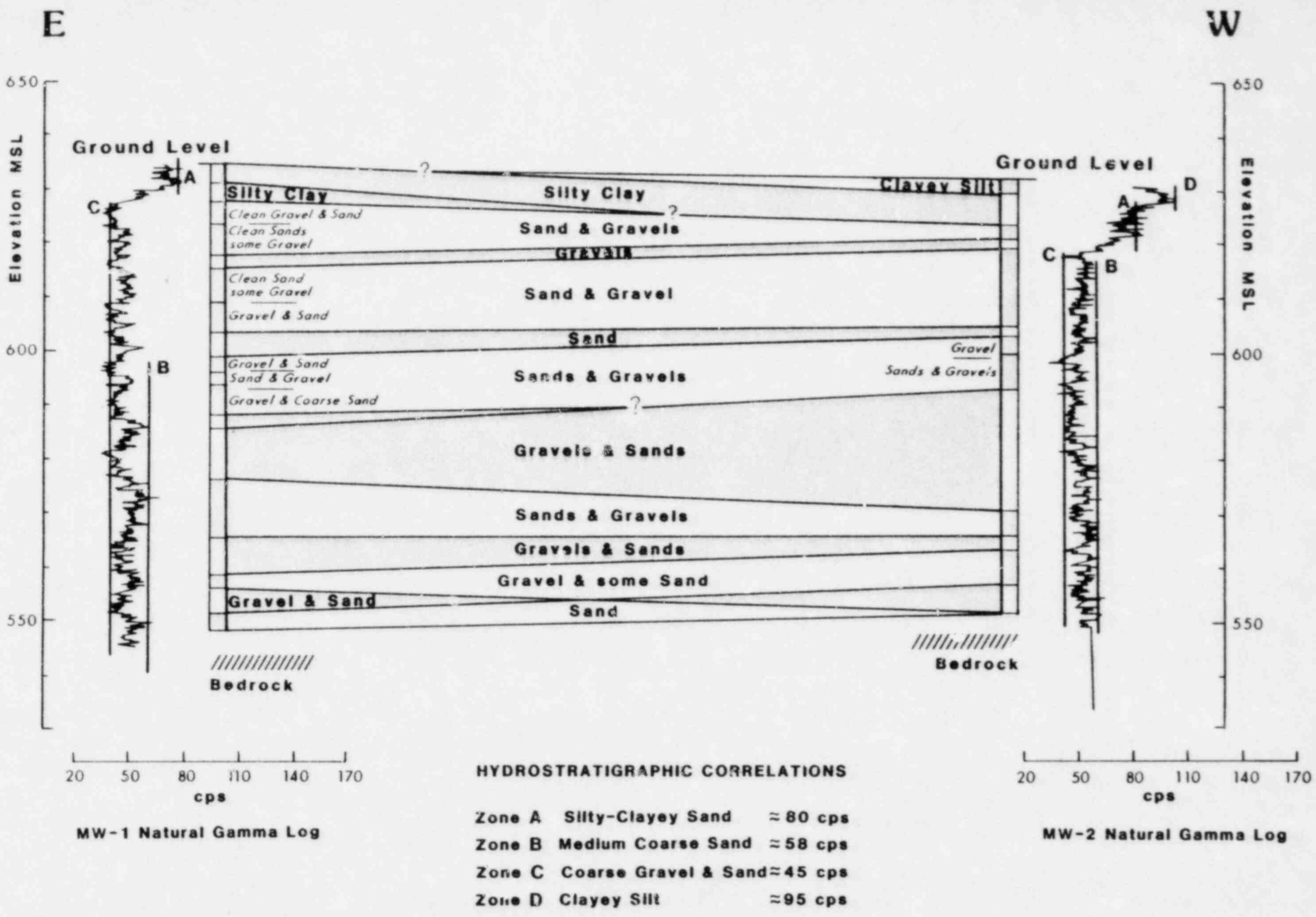


Figure 18. East-West Correlation Between MW-1 and MW-2; Normal Gamma and Lithology Logs

overlying claystone bedrock. Clayey, sandy silts are found to a depth of 3 to 4 feet in Test Pits TP-29, TP-30, and TP-31. Generally, clayey soils overlie claystone bedrock in the southwest portion of Area 4.

The test pits in Areas 1 through 4 were dry at the time of excavation. The locations and summary logs of the test pits are shown on Figures 19 and 20, respectively.

On the basis of field observations and laboratory testing, the soils exposed in the southern portion of Area 1 and the southwestern portion of Area 4 were found to be suitable for constructing a clayey soil cap. Classification test results indicate that the clay materials are generally sandy, silty clays according to the Unified Soil Classification System. Laboratory permeability test results on samples of these soils compacted to 98 percent of the design optimum density (ASTM D 698) indicate permeabilities ranging from 0.05 to 0.29 x 10^{-7} centimeters per second. These materials would be suitable for use in the construction of a clay layer to form a water barrier.

RADIOLOGICAL CHARACTERISTICS OF THE SITE

Chem-Nuclear Systems, Inc. was responsible for conducting comprehensive radiological surveys on the property to assess the relative radiological hazards to individuals present on the site. An in-depth survey was carried out during the months of July through October 1978. The survey yielded the following information: 1) it identified the location of radioactively-enriched soil on the site, 2) it quantified the radiation levels present, 3) it identified the level of radioactivity present as a function of soil depth, and 4) it identified the radionuclides present in representative samples of soil and water collected either on or near the site.

Radiation Instrumentation and Assessments

Low level gamma radiation measurements (0-500 µR/hr.) were performed using a Reuter Stokes Environmental Radiation Monitor, Model RSS-111. This instrument is a pressurized ion chamber capable of making accurate measurements of gamma radiation encountered in the natural environment.

Gamma radiation measurements taken in drill holes (soil radiation profiles), or in the range above useful scale of the RSS-111, were made using a sodium iodide (NaI) scintillation detector. This instrument was a Ludlum Model 3 equipped with a 44-2 probe (1 inch by 1 inch NaI).

Alpha radiation measurements were made using an Eberline Portable Scaler Model PS-2 equipped with a Model RD-13A detector (scintillation detector) and an Eberline LIN-LOG alpha survey meter model PAC-45 with the AC-3-7 probe (scintillation detector).

General field survey instruments used for betagamma radiation measurements were the Eberline E-120 meter equipped with either the HP-177 or HP-210 probes.

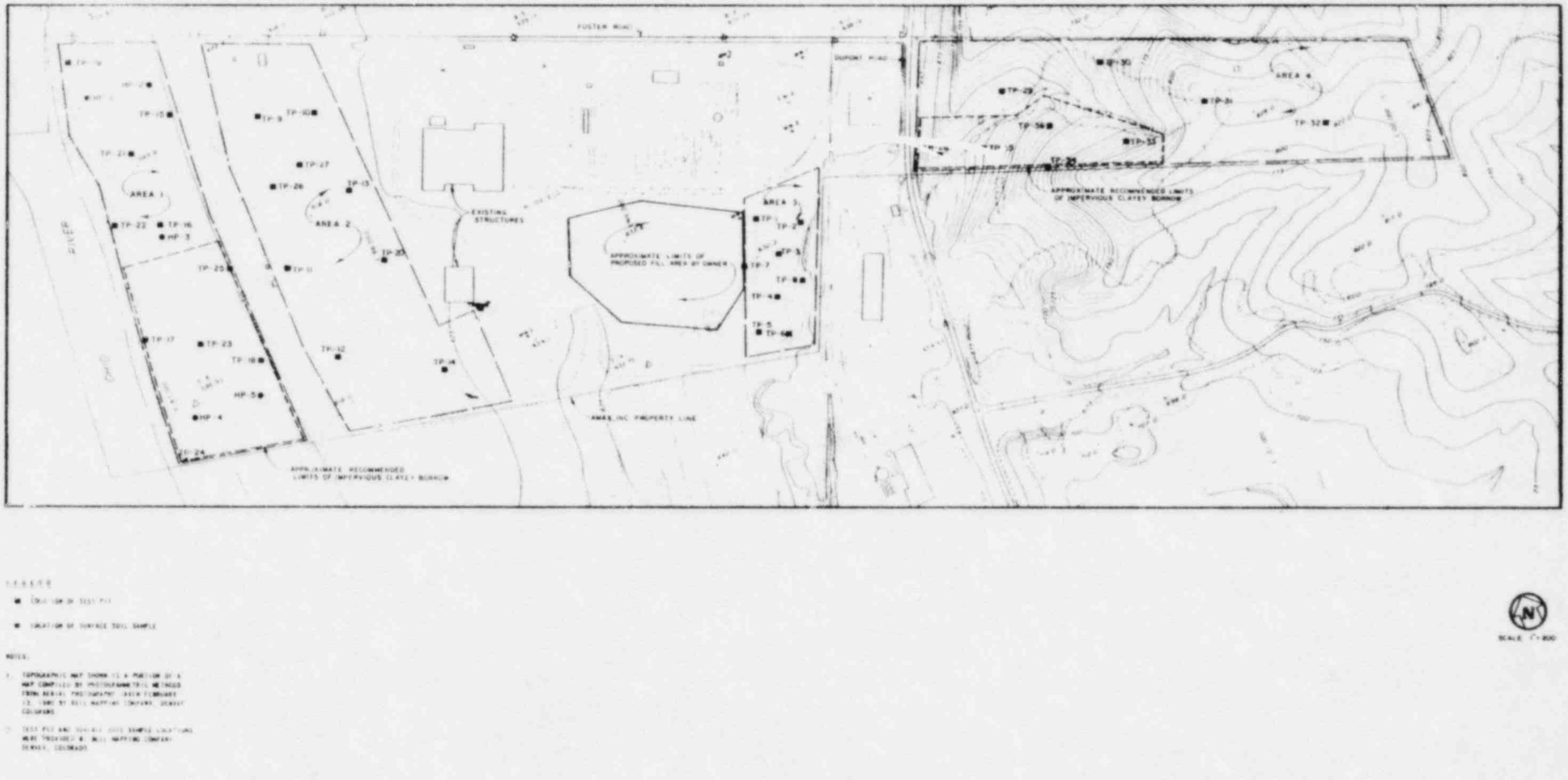
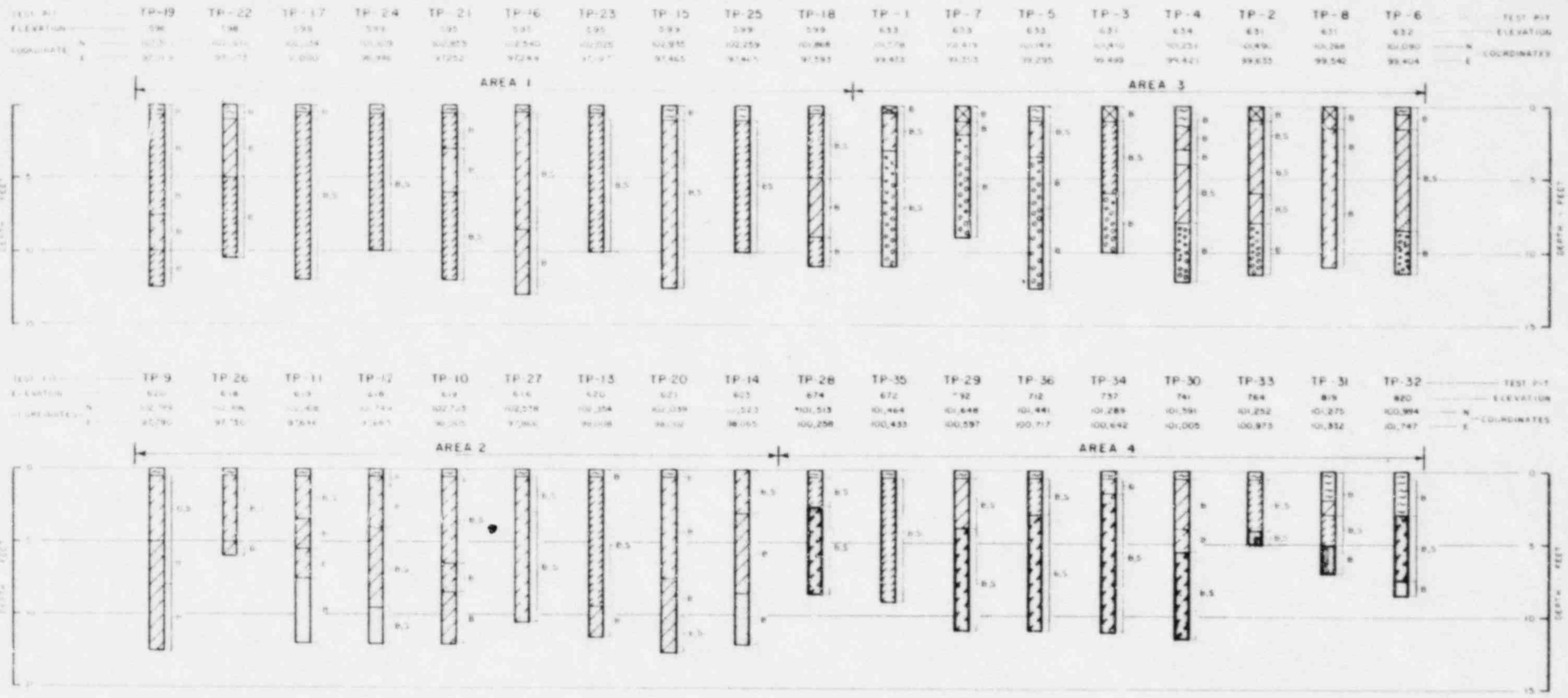


Figure 19. Location of Test Pits



LEGEND

☒ MAN-MADE FILL, SAND, SILT, CLAY, GRAVELLY, ROOTS, SOME ORGANICS, ASH CINDERS, DRY TO MOIST, BROWN, GRAY (SM, ML, CL).

▤ SAND, SILT, CLAY, NUMEROUS ROOTS, SOME ORGANICS, MOIST TO VERY MOIST, BROWN (SM, SC, CL, ML).

▨ CLAY, MEDIUM STIFF TO VERY STIFF, SILTY TO VERY SILTY, SANDY TO VERY SANDY, LOW PLASTICITY, MOIST TO VERY MOIST, BROWN, GRAY (CL, CL-ML).

▨ CLAY, STIFF TO VERY STIFF, SLIGHTLY SANDY TO VERY SANDY, SILTY, MODERATE TO HIGH PLASTICITY, MOIST TO VERY MOIST, BROWN, RED, TAN (CL).

▨ SILT, MEDIUM DENSE, CLAYEY TO VERY CLAYEY, SLIGHTLY SANDY TO VERY SANDY, MOIST TO VERY MOIST, BROWN (ML).

▨ SAND, MEDIUM DENSE, CLAYEY TO VERY CLAYEY, SILTY, MOIST TO VERY MOIST, BROWN (SC).

▨ SAND, MEDIUM DENSE, SILTY TO VERY SILTY, CLAYEY SAND LAYERS, MOIST TO VERY MOIST, BROWN (SM).

☐ SAND, MEDIUM DENSE, CLEAN TO SLIGHTLY SILTY, MOIST, BROWN (SP, SP-SM).

▩ GRAVEL, MEDIUM DENSE TO DENSE, SANDY TO VERY SANDY, CLEAN TO SLIGHTLY SILTY, MOIST, BROWN (GP, GP-GM).

▩ CLAYSTONE, MEDIUM HARD TO VERY HARD, THIN SILTSTONE LAYERS, MODERATE TO DIFFICULT TO EXCAVATE WITH BACKHOE, BREAKS DOWN TO SAND, SILT AND CLAY SIZED PIECES DURING EXCAVATION WITH BACKHOE, MODERATE TO HIGH PLASTICITY, MOIST TO VERY MOIST, RED, TAN (BEDROCK).

☐ CLAYSTONE, HARD TO VERY HARD, VERY SILTY TO SILTY, SANDY, DIFFICULT TO EXCAVATE WITH BACKHOE, BREAKS DOWN TO COBBLE, GRAVEL AND SAND SIZED PIECES DURING EXCAVATION WITH BACKHOE, MODERATE PLASTICITY, MOIST, TAN, BROWN (BEDROCK).

| |}B INDICATES SMALL BAG SAMPLE TAKEN FROM DEPTH INTERVAL SHOWN.

| |}S INDICATES LARGE SACK SAMPLE TAKEN FROM DEPTH INTERVAL SHOWN.

NOTES:

1. TEST PITS WERE EXCAVATED BETWEEN JUNE 24 AND JULY 3, 1980 WITH A MODEL 3500A INTERNATIONAL HARVESTER BACKHOE EQUIPPED WITH A 30-INCH WIDE BUCKET.
2. SURVEYED TEST PIT LOCATIONS AND ELEVATIONS WERE PROVIDED BY BELL MAPPING COMPANY, DENVER, COLORADO.
3. TEST PITS WERE DRY AT THE TIME OF EXCAVATION.
4. TEST PIT LOGS IN THIS REPORT ARE SUBJECT TO LIMITATIONS, EXPLANATIONS AND CONCLUSIONS OF THIS REPORT.
5. THESE TEST PIT LOGS SUMMARIZE FINDINGS RELIED ON IF FORMULATING THE DESIGN CRITERIA PRESENTED IN THIS REPORT. THE EXPLORATIONS WERE NOT MADE TO DEFINE CONDITIONS FOR CONSTRUCTION NOR IS THE INFORMATION PRESENTED HEREIN FOR THAT PURPOSE.

Figure 20. Summary of Logs

Instrument Calibration and Source Checks

All project instruments were calibrated by Eberline Instrument Corporation or Rutgers University prior to the start of the assessment survey with the exception of the RSS-111. The RSS-111 instrument was factory calibrated in July of 1978 (prior to survey). All instruments were source checked daily using the appropriate radioactive check sources for the particular instrument.

Background Radiation Measurement and Verification

To assure accurate gamma radiation measurements and to establish general area natural radiation levels, background gamma radiation measurements were made daily at a selected background position at the site periphery. These measurements included two readings with the NaI scintillation crystal, one at six inches above soil surface and one at a soil depth of two feet. In addition, a reading was made with the RSS-111 pressurized ion chamber approximately one meter above soil surface. All measurements made with the NaI scintillation crystal were made above ground and in a drill hole bored similar to the techniques used for the site survey.

Natural radiation background as measured with the pressurized ion chamber ranged from 12.0 μR/hr. to 12.4 μR/hr. (measured at the selected background position at the site periphery).

Soil Analysis

Twenty-three (23) soil samples were taken and forwarded to Teledyne Isotopes for analysis (Table 1).

TABLE 1

SUMMARY OF TELEDYNE SOIL SAMPLES

(NOVEMBER 15, 1979)

Location of Samples	1-Nuclides, pCi/g dry AC-228*	 U-238
Point P	1.35 ± 0.18	0.5 ± 0.1
Grid #2: Surface	13.60 ± 0.18	0.9 ± 0.2
Grid #2: 2 Ft. Depth	408.00 ± 41.00	40.0 ± 4.0
Grid #8: Surface	13.20 ± 1.30	1.2 ± 0.2
Grid #8: 2 Ft. Depth	8.36 ± 0.84	0.9 ± 0.2
Grid #12: 2 Surface	1270.00 ± 130.00	42.0 ± 6.0
Grid #12: 2 Ft. Depth	5.66 ± 0.57	0.8 ± 0.2
Grid #11: Surface	337.00 ± 34.00	
Grid #20: Surface	712.00 ± 71.00	
DRN SMPL NR PMP Surface	378.00 ± 38.00	
Grid #1063: Surface	1810.00 ± 180.00	
Grid #1030: Surface	339.00 ± 34.00	
Grid #65: Surface	-- --	
Grid #13: Surface	192.00 ± 19.00	
Grid #38: Surface	39.40 ± 3.90	
Grid #113: Surface	332.00 ± 33.00	
Grid #681: Surface	372.00 ± 37.00	
Grid #892: Surface	229.00 ± 23.00	
25 Ft. EXT DRN MN GHLA	45.60 ± 4.60	
Grid #80RR: Surface	306.00 ± 31.00	
Grid #80: 2 Ft. Depth	1.14 ± 0.18	
Grid #224RR: Surface	256.00 ± 26.00	
Grid #224RR: 2 Ft. Depth	30.30 ± 3.00	

* The activity of ^{228}Ac is equivalent to the activity of ^{232}Th.

These samples were used to establish relative quantities of contaminants present, and to establish data correlations between gamma exposure rates made in the field and the soil thorium and uranium content. The majority of the isotopes were identified utilizing Ge(Li) gamma spectrometry. The uranium and thorium analysis was determined by chemical digestion, chemical separation, electrodeposition, and finally alpha spectral analysis.

A comparison of these data show reasonable correlation between field measurements and soil analysis. The following observations were noted:

1) Soil analyses at the selected background position at the site periphery indicate background quantities of thorium, uranium, and the associated decay progeny. The NaI scintillation detector displayed a relatively low count rate in comparison to on-site readings. The pressurized ion chamber indicated background exposure rates (12 μR/hr. or 105 mR/yr.) found at point F as shown in Figure 2, near the north boundary of the property.

2) Soil analyses at the survey grid positions with high gamma exposure rates indicate elevated levels of thorium, uranium, and the associated decay progeny. There were no significant levels of fission products from fallout associated with nuclear weapons testing found in any of the soil samples. One of the fission products, cesium, was present in a few samples, but the levels were such that no interference on the gamma readings was assumed.

Based on these factors, the field sampling techniques used were considered sensitive to radiological components associated with the former operation. The field measurements do not appear to be biased by other naturally occurring radionuclides or fission products from weapons testing or other sources. The significance of the levels of uranium and thorium in the soil samples will be discussed later.

Surface Radiation Measurement

In general, surface radiation measurement for field mapping of radioactivity was performed with the pressurized ion chamber and NaI detector. Measurements were made as follows:

1) The former zirconium plant site and storage areas were grided into 1,422 cell areas, with each cell measuring approximately 25 feet by 25 feet (Figure 21).

2) Corners of each grid were marked with wooden stakes.

3) A gamma scan of each cell area was made with the NaI scintillation detector.

4) At the highest gamma flux detected with the NaI scintillation detector, the exposure rate was measured with the pressurized ion chamber.

5) At the few positions where exposure rates exceeded the capabilities of the ion chamber (500 μR/hr.), readings were taken with the NaI

Figure 21. Radiological Survey Grid

Guideline - A recommended approach, procedure, or technique which may be utilized and has been found to be acceptable by the issuing authority.

Regulation - Requirements issued by a responsible authority or government body carrying the force of law.

External Gamma Radiation

The recommendations of the International Commission on Radiological Protection (ICRP) have constituted the internationally accepted standards for radiation protection since 1928. The fundamental philosphy of ICRP is that any unnecessary exposure should be avoided and radiation exposure should be kept as low as reasonably achievable. Due to the natural radiation levels found in the earth's environment, exposure to radiation is unavoidable. Annual limits for whole-body exposure have been recommended by this recognized authority as 0.17 rem for the general population, 0.50 rem for an adult exposed in the course of his work. All exposure limits are defined as radiation exposure above that due to background radiation.

Federal regulations found in the Code of Federal Regulations, Title 10, Part 20 (10 CFR 20) limit radiation exposure to the whole body in unrestricted areas (general population) to 0.50 rem/yr., 0.002 rem in one hour, or 0.10 rem in seven consecutive days. In restricted areas the exposure limit to certain critical organs of a worker is limited by these regulations to 1.25 rem in any calendar quarter. Appendix B of 10 CFR 20 has limiting concentrations in air and water for

detector. The detector was field calibrated by taking measurements in an adjoining grid, determining the ratio between the measurements, and applying the ratio to the NaI count rate.

Figure 22 depicts the areas greater than two times, five times, and ten times above the background radiation level measured at Point P.

Subsurface Radiation Measurements

In order to determine the depth of radioactive material, holes twelve feet deep were water-jetted into the ground. Water jetting was utilized due to the possible pyrophoric nature of the material. The holes were located, in areas indicating radioactivity, in rows separated by eight feet and at about nine-foot intervals along the row. A gamma scan was performed with the NaI detector at two-foot intervals in each hole. The depths with greater-than-twice-background levels of radiation were measured and mapped.

Health Physics Assessment

The definitions for the radiological standards, guidelines and regulations used in evaluating the potential hazards associated with the radioactive material detected on the site are the following:

Standard - A method, technique or numerical value established by a recognized authority based on the best scientific opinion or data available.

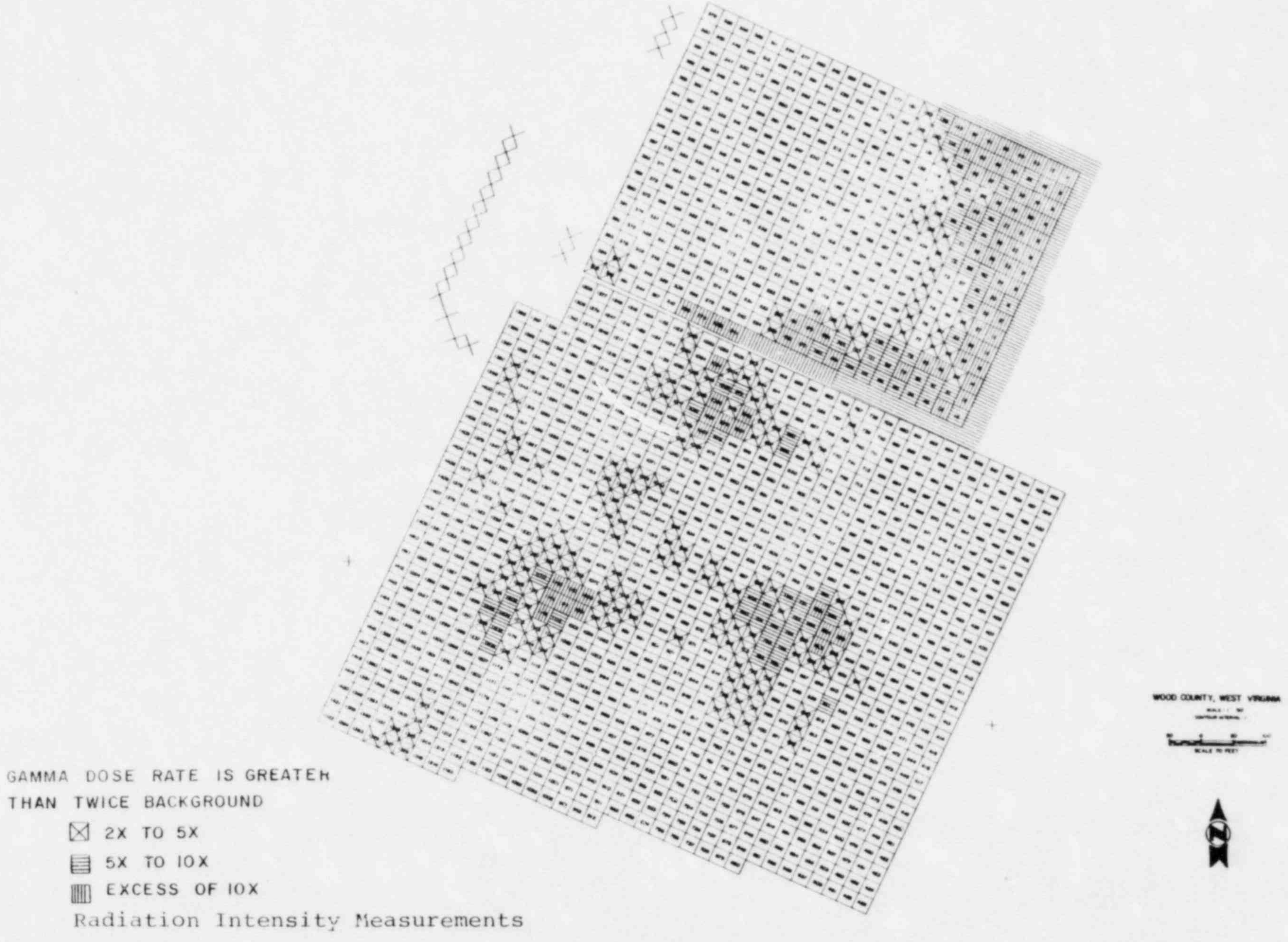


Figure 22. Radiation Levels

radioactive isotopes. These concentrations are calculated to result in radiation exposure to the whole body or certain critical organs of the body that are equivalent to the previously stated limits. The above doses are the upper limits for radiation exposure. In all cases, exposure to radiation must be as low as reasonably achievable. The term "as low as reasonably achievable," as defined in 10 CFR 20.1, means "as low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety."

Surface Contamination

The Nuclear Regulatory Commission's Division of Fuel Cycle and Material Safety has issued "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material" (November 1976). This document specifies the limits for surface radioactivity and radiation exposure rates associated with the surface contamination which should be met prior to release of equipment or facilities for unrestricted use. These guidelines are in general agreement with standards issued by the American National Standards Institute in the draft document "Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use" (N13.12). The surface contamination limits for removable natural thorium and uranium is 1,000 dpm/100 cm^2.

Soil Contamination

Uranium and thorium are naturally occurring radionuclides found in varying degrees in most soils. Thorium-232 can naturally range from about 0.2 pCi/g in sandstone up to 2.2 pCi/g in igneous rock. Uranium-238 can range from about 0.2 pCi/g in basalt up to 1.6 pCi/g in salic (NCRP 45, p. 59). There are localized areas where uranium and thorium can be found at significantly higher concentrations, up to several hundred picocuries per gram. With such a wide spectrum of concentrations, a cut-off point is needed to separate material containing innocuous levels of uranium and thorium from material with significant levels. This delineation is made by designating material or soil as source material. Source material is defined in 10 CFR 20.3 as "(i) uranium or thorium, or any combination thereof, in any physical or chemical form or (ii) ores which contain by weight one-twentieth of one percent (0.05%) or more of a) uranium, b) thorium or, c) any combination thereof."

Direction Gamma Exposure Rates

At three locations on the survey grid, No. 11, 12, (near the fence east of the water tower) and No. 175, (on the former plant site), the gamma exposure rates exceed 595 µR/hr. A continuous exposure of 595 µR/hr for seven consecutive days will result in a dose of 100 mrem. Access to this area by the general public is currently restricted and controlled by a fence. The area has been cleared of stored pipe materials, and administrative controls are exercised over the area by Foster to prevent unnecessary access by employees.

While the highest gamma exposure rate found was 900 μR/hr., the majority of the readings were in the order of 20 μR/hr or about two-times natural background. The gamma exposure rates measured will not expose workers to an excessive amount of radiation during the cleanup operation. Precautions were made to minimize the exposure. Chem-Nuclear employees received approximately 0.44 rem for 2,000 hours of exposure. An average exposure of 0.22 mrem/hr is consistent with the observed radiation measured at the site.

Alpha Smears

Smears were taken in all of the buildings as they existed at the time of the survey on July 1978 to determine the level of removable (smearable) radioactive material. The smears were counted for alpha radiation due to the preponderence of alpha decay in the potential contaminants. As referenced earlier, the limit for removable uranium or thorium is 1,000 dpm/100 cm^2 for alpha contamination. The buildings surveyed met the guidelines and standards, and were released for unrestricted use.

Soil Contamination

The background soil sample indicates that the Th-232 concentration is about 1.4 pCi/g and that the U-238 concentration is about 0.5 pCi/g. This is consistent with the background values reported in NCRP 45. To classify the material as source material, a calculation was made to express 0.05% by weight as pCi/g. The results of the calculation show 55 pCi/g of Th-232 or 170 pCi/g of U-238 correspond to the 0.05% by weight. Twelve of the 23 soil samples listed in Table 1 exceed these levels and indicate the presence of souce material. The highest soil sample is from grid 4, near the fence east of the water tower, with a concentration of 1.8 μCi/g. This would calculate for thorium to a value of 1.6% by weight as opposed to the 6% thorium content of the Nigerian ore.

CONSTRUCTION OF THE STABILIZATION PLAN

Collection of Selected Materials

Decontamination specialists will be used to excavate and collect all radioactively-enriched soil present in the area and transport it to the control site. No excavation will be required in the control area. The Chem-Nuclear survey indicates that nearly 85 percent of the radioactive soil is in the stabilization area of Parcel C, and a major portion is contained within the limits of the control area. With an overall estimate of 1.5 million cubic yards of selected soil on the property, only 225,000 cubic feet (8,333 cubic yards) of this material needs to be transported from Parcel C.

Following the removal of the radioactively-enriched soil from the areas to be cleared in order to meet the radioactive criteria specified by NRC, an inspector from Chem-Nuclear will clear the area. Federal inspectors will be encouraged to participate in these inspections. After the area has been cleared, the area will be graded to the surrounding contours. Roadways, rail track, and drainages will be returned to their previous use.

All soil materials are to be maintained in a moist condition to retard dust. Water sprinklers (Rainbirds) or water truck sprays will be used. The moisture content in the transported material will aid in the compaction of the selected soils in the control area.

Construction of the Cover

Grading around the control area will be done to the lines, grades, and dimensions shown on Figure 23. During the progress of the work, the owner's representatives may vary the slopes, grades, or dimensions of the excavation to ensure that the overall objectives of the plan are met. No excavation shall be made in frozen material without adopting special construction techniques.

Selected Material Layer

The layer of selected material to be stabilized will be placed in 4-inch maximum loose lifts and compacted by a minimum of four passes of a Caterpillar Model D-8 dozer, or equivalent. Care will be taken to confine these materials within the limits of the compacted fill area. The earth mound has been designed to contain up to 30,000 cubic yards of selected material, should that be necessary. Field surveys have identified about 10,000 cubic yards to be contained from Parcel B and associated drainage areas.

The construction of the stabilization mound will consist of the placement and compaction of the selected material, the soil cover, the clay cap, and the topsoil; as illustrated in Figure 7. Fill operations to form the individual layers will be continuous and expeditious while maintaining proper placement and compaction.

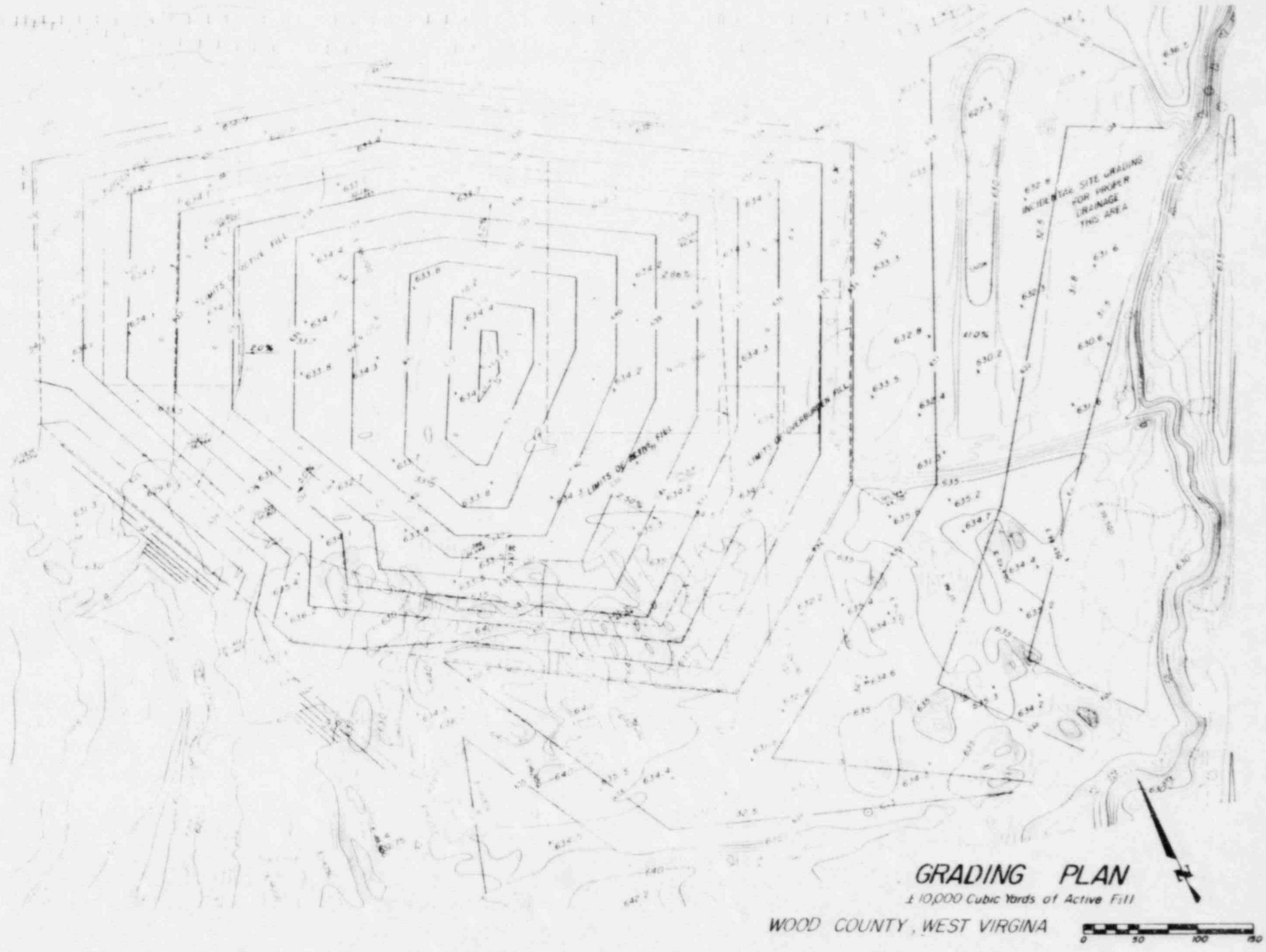


Figure 23. Detailed Plan View of Stabilization Area

The contractor will be required to submit a plan for the placement and compaction of the fill material for approval. A geotechnical specialist will be responsible for sampling the compacted fill and perform field and laboratory tests to verify that the compacted fill meets the design requirements.

Soil Layer

The soil cover will consist of inorganic clayey soil, smaller than 4 inches in size, taken from the borrow area designated. The soil shall be placed and dozed over the layer of selected material in a manner that will minimize mixing of material with the selected material. The fill material will be placed in 12-inch maximum loose lifts at, or above, optimum moisture content and compacted to a dense layer, using rubber-tired rollers, if needed. Each compaction lift shall be scarified, if necessary, prior to the placement of the next lift to provide a uniform blend and bonding between successive lifts. To effect bonding between successive lifts, water may be used. The earthwork shall be maintained to provide drianage during the construction of the layer. When complete, the compacted layer will be 6 inches thick.

Low Permeability Clay Layer

The clay layer will consist of inorganic clay; classified as CL by the Unified Soil Classification System, smaller than 4 inches in size; taken from the borrow area designated by the owner for covering the soil layer. The clay layer will be a minimum of 1-foot thick, and shall have a coefficient of permeability of less than, or equal to, 1×10^{-7} centimeters per second. The clay material will be placed in 8-inch maximum loose lifts at optimum, or above, moisture content and compacted by a smooth wheel or a rubber-tired compactor to at least 98 percent density (ASTM D 698). The moisture content will be uniform throughout each lift.

If the moisture content is less than specified for compaction, water will be spread on the material during excavation, or during placement and compaction. If water is added, the soil will be sufficiently mixed to develop a uniform moisture content.

The soil will be blended as necessary to achieve the specific compaction. Each compacted lift will be wetted, if necessary, and scarified prior to the placement of the next lift to provide a uniform blend and bonding between each successive lift.

The clay cover will be constructed to provide drainage at all times, and constructed to a final minimum grade of 1 percent.

Topsoil Layer

The topsoil layer will be constructed to the lines and grades shown on Figure 23, or as directed by the owner's representative. The material will be excavated from designated borrow areas, or taken from any topsoil stockpiled during construction, and used to cover the clay layer and provide a suitable material for supporting grass cover. The topsoil will be placed in 12-inch loose lifts, and at a moisture content optimum for compaction. A Caterpillar Model D-8 dozer, or equivalent, will be used to compact the topsoil by making two passes. No compaction of the top 6 inches will be required, and the total thickness of the topsoil will be a minimum of 30 inches.

The topsoil layer will be constructed to provide drainage at all times. The limits of the final grade will be a minimum grade of 1 percent to a maximum grade of 5 percent.

Seeding

Limestone and fertilizer will be applied to the surface of the completed topsoil layer. Common agricultural limestone will be spread and mixed with the topsoil to a depth of 6 inches at the rate of 2.5 tons per acre. Fertilizer of mixture 10-10-10, or similar grade, will be spread and mixed at the rate of 1,000 pounds per acre. These application rates are based on chemical analysis of representative soil samples and knowledge of the agronomy of the area, and were recommended by the county extension agent from the West Virginia Cooperative Extension Services. A disc, or other suitable farm implement, will be used to mix the limestone and fertilizer with the topsoil.

The area covered by topsoil shall be seeded to a hardy, short-rooted grass, such as Kentucky 31 Fescue, at the rate of 50 pounds of seed per acre. The seed will be of high quality, containing no noxious weeds, less than 1 percent weed seed, and will have no less than an 80 percent germination rate. The seeds will be broadcast in a uniform manner, and lightly covered with a minimum of 1/4 inch to a maximum of 1/2 inch of topsoil; then rolled with a cultipacker to lightly pack the seedbed surface.

The seeding may be performed between April 15 and Spetember 15. Two tons of well-spread straw per acre will be required to be added over the packed seedbed surface for planting seed between May 15 and August 15. A field review of the area will be made after six months to determine whether any area will require reseeding, and to determine whether additional surface drainage will be required. If required by the government agencies responsible, a security fence will be constructed.

STABILIZATION PLAN

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INDEX OF FIGURES

Page numbers refer to pages in text. Figures follow in sequence after first reference in text.

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