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STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS, INC.

Final Report

UNDERGROUND POLLUTION INVESTIGATION AT IOWA ARMY AMMUNITION PLANT, BURLINGTON, IOWA

Contract No. DACA87-80-C-0333

Volume I

Submitted to:

U.S. Army Corps of Engineers
Omaha District Office
6014 U.S. Post Office and Courthouse
Omaha, Nebraska 68102

Submitted by:

SCS Engineers
4014 Long Beach Boulevard
Long Beach, California 90807

February 22, 1982

SCS ENGINEERS
STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS, INC.

4014 LONG BEACH BOULEVARD
LONG BEACH, CALIFORNIA 90807
(213) 426-9544

ROBERT P. STEARNS, PE
E.T. CONRAD, PE
CURTIS J. SCHMIDT, PE

MARK L. BRECHER, PE
GARY L. MITCHELL, PE
DAVID E. ROSS, PE
DONALD E. SHILESKY, ScD
JOHN P. WOODYARD, PE
RODERICK A. CARR
MILES J. HAVEN
JAMES J. WALSH, PE
WILLIAM DEGRANDE

February 24, 1982
File No. 18029

Mr. Glen Mitchell
Department of the Army
Omaha District Corps of Engineers
6014 U.S. Post Office and Courthouse
Omaha, Nebraska 68102

Subject: Submittal of Final Report

Dear Mr. Mitchell:

Enclosed are four (4) copies of Volume I of the final engineering report. Volume II (Appendices) is essentially the same as the draft submitted to you earlier, except for the following:

- Change of Appendix B to Appendix A, C to B, D to C, E to D, A to E, and F to G.
- Addition of Appendix F to Volume II (attached).

Copies of Volume I are distributed to the addresses listed in the Scope of Work.

We have also assembled data from the engineering report, and have prepared a separate report for each of Sites Z_1 and Z_2. These two site reports can be used in permit application. As such, they do not contain (1) areas of regulatory violation, and (2) cost estimates for site closure. We feel that this information should be reserved for in-house use, and have included it only in the engineering report.

Regarding permit application for Sites Z_1 and Z_2, we have talked at length with the Iowa Department of Environmental Quality (DEQ) and EPA Region VII in Kansas City. The IAAP has filed Part A for the whole plant. Currently, there is no standard form for hazardous waste facility permit application (Part B). It is evident that Site Z_1 has been inactive, and will require a cleanup plan with closure and post-closure care. Since Site Z_2 is considered active, the IAAP will need to file Part B for it. Due to the limited scope of work, the data contained in the engineering report are not sufficient for use in filing Part B. Please refer to 40 CFR Parts 122 and 124 for additional information.

The project has suffered to a certain extent due to the discontinuity of communication resulting from changes in Project Officer (Messrs. Thompson, Young, and Mitchell). The project was completed 2 months behind schedule because of delay (1) in the delivery of TNT and RDX standard solutions, and (2) in the draft final review. Thanks to support and understanding from you and Mr. Carlock, the final report has been revised to reflect the review comments and suggestions of the Army. Responses to these review comments are summarized in Exhibit A.

We have enjoyed working with you and your district in this project. Please call me if you have any questions regarding our final submittal or responses to the review comments.

Very truly yours,

Tan Phung

Hang-Tan Phung, Ph.D.
Project Manager
SCS ENGINEERS

HTP/jml
Enclosure

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SECTION 1

SUMMARY

An investigation was undertaken at the Iowa Army Ammunition Plant (IAAP) to provide permit application and construction planning in an effort to bring three selected facilities into compliance with regulations of (1) the Resource Conservation and Recovery Act (RCRA) and (2) the Iowa Department of Environmental Quality.

The three facilities selected are:

- Site Z_1 - abandoned pinkwater lagoon.
- Site Z_2 - Detonator Line 6 effluent treatment/disposal facilities.
- Site Z_3 - new Line 4A evaporation spray lagoon.

Results of geotechnical and laboratory investigations at Sites Z_1 and Z_2 reveal that operation of these disposal sites has not resulted in significant subsurface water contamination. Further, the geologic conditions at both sites are such that contamination of the water supply aquifers is unlikely to occur. In both cases, however, the potential for additional surface water contamination exists.

At Site Z_1, a volume of explosive-contaminated sediments exists. Additional studies will be necessary to determine the areal extent of these sediments and the amount of explosives that they contain. If, as currently appears to be the case, these materials are hazardous, their excavation, desensitization, and removal to a secure landfill are recommended. Brush Creek, impounded to form the abandoned pinkwater lagoon, has eroded the contaminated sediments and has transported them downstream. The creek valley should be investigated to determine whether or not deposits of explosive-contaminated sediments have formed due to redeposition of the eroded pinkwater lagoon sediments. If such deposits have formed, they should also be desensitized and removed to a secure landfill.

The Detonator Line 6 treatment/disposal facilities at Site Z_2 are likewise situated in an environment where significant ground water contamination is unlikely. The facility was designed and operated in a manner similar to a subsurface septic disposal system. Desensitized effluent was discharged into a

series of shallow leach beds which presumably allowed the wastewater to percolate into the subsurface. However, due to the small size of the beds and the low permeability of the soils at the site, it is likely that most of the discharge overflowed to the land surface. Additional studies are required to determine whether or not a zone of soil contaminated with heavy metals surrounds the leach beds. Further, surficial soil sampling is recommended to determine the severity of surface contamination in the drainage ways downgradient from Site Z_2.

Two alternatives for site closure exist:

- Removal of contaminated soil and leach bed materials.
- Covering and regrading the areas around each of the leach beds.

The extent and severity of the expected heavy metal contamination (if such exists) will determine the appropriateness of either option. The use of land downslope from Site Z_2 for food chain crop production is a real concern. Thus, the recommended studies should be completed as soon as possible.

If the removal option is implemented at both Sites Z_1 and Z_2 to effect site closure, ground water monitoring will not be required. If Site Z_2 is covered and regraded, additional ground water monitoring wells should be installed immediately downgradient from the contaminated soil zone around the leach bed. Such wells should become a portion of the permanent ground water monitoring system.

Using the two site closure/remedial scenarios (in-situ closure and removal/closure), preliminary cost estimates for construction were made for Sites Z_1 and Z_2. These estimates were based on various assumptions, since the the limits of contaminated area are not known.

An operations/contingency plan which was substantially provided by the Corps is presented herein. This plan is suitable to meet RCRA requirements for all three sites.

The U.S. Environmental Protection Agency (EPA) currently regulates hazardous waste treatment, storage, and disposal facilities. This authority will be granted to the states as they develop the means for its implementation. At the time of this submission, such authority has not been granted to Iowa. Further, the EPA has not promulgated any formal mechanism for permitting abandoned or discontinued disposal sites under the current interim status of RCRA. Thus, no permit application forms exist for Sites Z_1 and Z_2. Permit application and documentation for Site Z_3 is not included in the scope of this investigation.

SECTION 2

INTRODUCTION

The U.S. Army plans to bring all hazardous waste treatment/storage/disposal (TSD) facilities at Army installations into compliance with federal, state, and local guidelines and regulations pertaining to hazardous waste TSD sites. The installation selected for investigation in this project is the Iowa Army Ammunition Plant (IAAP) located in Burlington, Iowa.

The investigation was limited to three sites: an abandoned pinkwater lagoon (Site Z_1), leach beds of a detonator line (Site Z_2), and a new evaporation lagoon (Site Z_3). The goal of this study was to provide permit application and construction planning to bring Sites Z_1 and Z_2 into compliance with standards set forth by regulations issued under the Resource Conservation and Recovery Act (RCRA) and all other federal, state, and local regulations.

The project team consisted of SGS Engineers, Terracon Consultants, and Bio-Chem Analysts. Project duration was 12 months starting October 1, 1980. Project completion was delayed due to the acquisition of standard solutions of explosives, and the extended time required by the Corps of Engineers to review the draft report.

SECTION 3

DESCRIPTION OF THE IOWA ARMY AMMUNITION PLANT

REGIONAL CONSIDERATIONS

The IAAP is located in Des Moines County, Southeastern Iowa. It consists of approximately 19,000 ac situated 8 mi west of the city of Burlington, Iowa, and the Mississippi River; 1 mi northeast of the town of Augusta on the Skunk River; and immediately south of U.S. Highway 34 (Figure 3-1).

Topography

The topography of the study area and its environs consists of a gently undulating upland plateau having a slight inclination to the southeast with steep hilly areas near the margins of stream valleys. The amount of level bottom land along the streams is small compared to the extensive areas of upland. Total relief within the IAAP boundary is approximately 200 ft with a regional slope toward the south-southeast. Elevations range from approximately 730 ft in the northern part of the plant to 530 ft in the southern part (MSL datum).

Drainage

The IAAP is drained by three creeks, Spring Creek, Long Creek, and Brush Creek. They divide the facility into three distinct drainage systems.

Spring Creek drains the eastern portion of the facility. It originates just north of the Burlington Northern Railroad easement, and flows south-southeast into the Mississippi River. It has eroded a gully from 50 to 80 ft deep, increasing in depth from north to south. The creek flows continuously within the confines of the IAAP. Its drainage area within the confines of the facility is approximately 3,000 ac.

Long Creek drains the western portion of the IAAP. It originates about 2 mi north of the installation's northwest corner, and flows in a southeasterly direction immediately adjacent to the southwest boundary of the plant and into the Skunk River. The approximate drainage area is 11,500 ac within the IAAP. It has eroded completely through the quaternary deposits and into the sedimentary bedrock units of the upland plateau, forming a gully which ranges in depth from 50 ft to over 200 ft within the facility. Numerous bedrock outcroppings occur in the valley

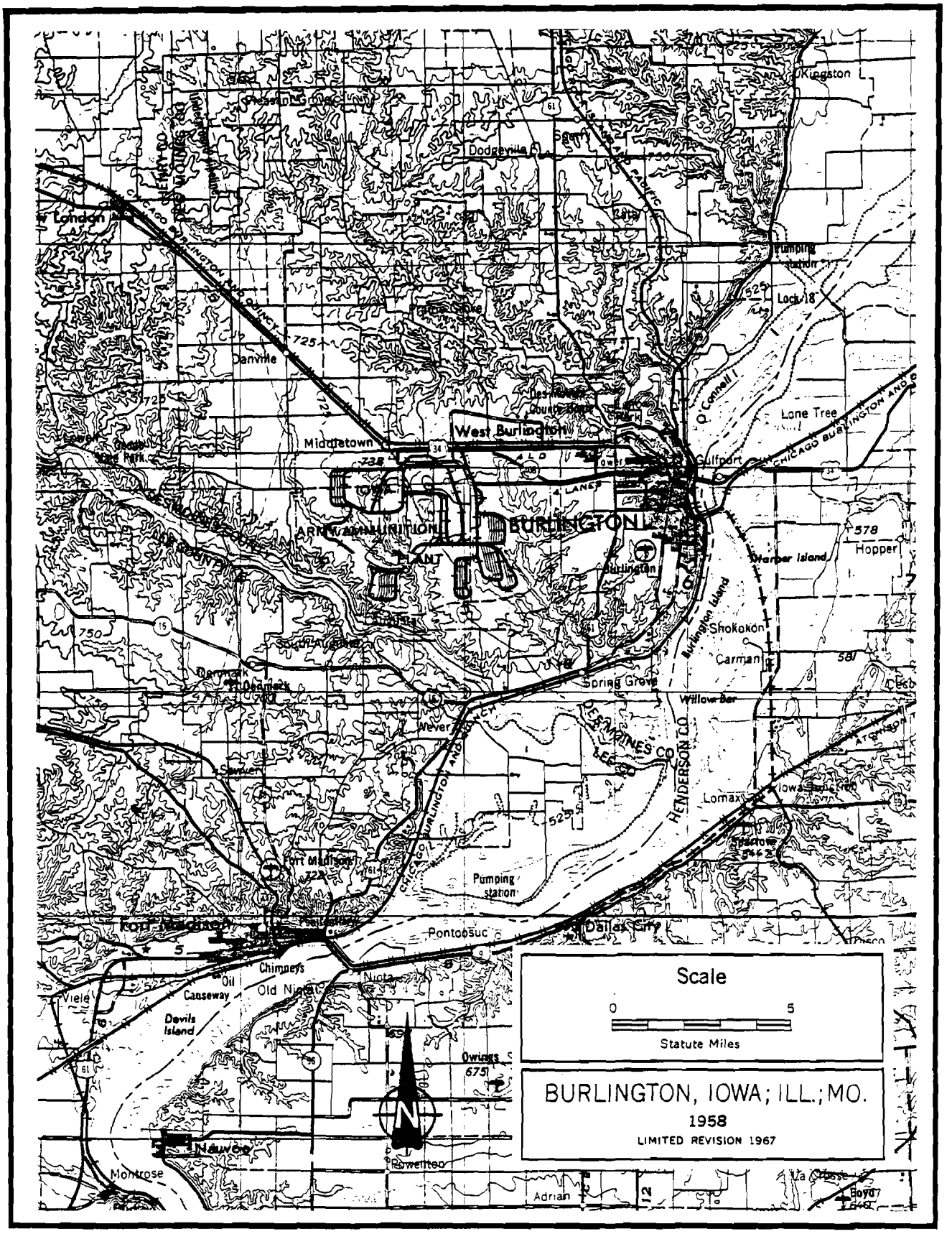

Figure 3-1. Location Map, Iowa Army Ammunition Plant.

walls in the southern third of the plant. Long Creek has been dammed, creating an 83-ac lake within the IAAP.

Brush Creek drains the central portion of the facility. It originates within the facility and flows in a southeasterly direction into the confluence of the Skunk and Mississippi Rivers. Brush Creek cuts into the plateau to an average depth of 10 ft in the vicinity of its origin, and over 60 ft at the southern IAAP boundary. It has a drainage area of approximately 4,500 ac within the IAAP confines.

Climate, Vegetation, and Land Use

The climate of southeastern Iowa is characterized by marked seasonal variations. During 6 months of the year, unstable humid air masses flowing north from the Gulf of Mexico produce a summer rainfall maximum. It is not uncommon to receive up to 1 in of rain in less than an hour during severe summer thunderstorms.

In the winter, a prevailing northwesterly flow of dry Canadian air produces cold, relatively dry weather. Snow occurs during at least 3 months of the winter season. Periodically throughout the year, air masses flowing from the Pacific Ocean move across the western states and reach Iowa. The dominance of these air masses produces comparatively mild and dry weather. Hot, desiccating winds, originating in the deserts of the southwestern states, occasionally sweep through southeastern Iowa. Selected climatological records depicting normal and extreme values of precipitation, temperature, humidity, and wind are presented in Table 3-1.

During 1980, precipitation in the Burlington area was 14 in above normal. Higher than normal precipitation occurred during the summer between July and September. From October through December, precipitation was slightly below the norm, with a total of 5.63 in occurring during this period (see Table 3-2).

The natural vegetation surrounding the IAAP is primarily second-growth forested land on the steep and rough terrain adjoining the stream valleys. This forest cover consists of a mixture of deciduous and coniferous trees. Sections of the open level upland consist of native grasses and tillable prairie soils used for corn and soybean production.

Geologic Conditions

The IAAP is underlain by the southern Iowa Drift Plain which resulted from four glacial periods of the Pleistocene Age. Beginning with the oldest, the four glacial periods are as follows (Flint, 1967):

- The Nebraskan Drift consists of a massive clay-rich till with lenses of statified drift.

TABLE 3-1. CLIMATIC VARIABLES, NORMALS, MEANS, AND EXTREMES FOR BURLINGTON, IOWA

Month	Temperature							Precipitation												Relative Humidity				Wind				
	Normal			Extremes											Snow, Sleet											Fastest Mile		
	Daily Maximum	Daily Minimum	Monthly	Record Highest	Year	Record Lowest	Year	Normal Total	Maximum Monthly	Year	Minimum Monthly	Year	Maximum in 24 hrs.	Year	Mean Total	Maximum Monthly	Year	Maximum in 24 hrs.	Year	Midnight CST	6:00 A.M. CST	Noon CST	6:00 P.M. CST	Mean Hourly Speed	Prevailing Direction	Speed	Direction	Year
J	32.7	16.1	24.4	68	1950	-24	1957	1.64	5.30	1907	0.17	1956	2.05	1904	7.1	21.0	1936	11.5	1898	78	80	69	74	11.2	NW	49	W	1952
F	36.5	19.1	27.8	76	1930	-27	1905	1.39	4.27	1900	0.17	1947+	1.60	1953+	5.8	20.0	1900	8.7	1961	78	81	68	72	11.6	NW	46	NW	1947
M	46.9	27.6	37.3	88	1910+	-13	1960	2.71	6.62	1921	0.30	1918	3.19	1944	4.9	28.2	1912	13.0	1912	78	82	64	66	12.4	NW	56	SW	1950
A	61.4	40.2	50.8	93	1930	13	1920	3.44	7.45	1965	1.09	1962	4.36	1950	1.1	10.5	1910	7.0	1912	74	79	55	57	12.3	NW	73	W	1947
M	72.5	51.5	61.8	103	1934	26	1907	4.03	11.34	1908	0.96	1949	3.54	1904	T	1.0	1944	1.0	1944	77	81	56	57	10.6	SSW	68	SW	1950
J	82.7	61.5	72.1	105	1934	39	1913	5.01	13.91	1924	0.69	1922	6.28	1933	0.0	0.0		0.0		80	83	58	60	9.2	S	72	NW	1964
J	87.6	65.6	76.6	111	1936	47	1947	3.40	10.81	1915	0.18	1913	2.69	1924	0.0	0.0		0.0		82	85	57	59	8.0	S	65	NW	1964
A	85.2	63.9	74.6	110	1934	41	1950	3.61	10.62	1902	0.36	1901	4.65	1952	0.0	0.0		0.0		83	88	58	62	8.0	S	73	N	1947
S	77.3	54.6	66.0	103	1913	23	1899	3.19	14.30	1926	0.15	1940	5.96	1961	T	1.2	1942	1.2	1942	80	88	55	63	9.0	S	56	W	1962
O	66.6	44.1	55.4	95	1899	10	1925	2.70	15.10	1941	0.06	1964	4.20	1927	0.3	4.5	1916	4.0	1929	75	83	52	62	9.5	S	63	W	1953
N	48.8	29.9	39.4	86	1899	-2	1898	1.88	6.43	1934	0.08	1917	2.61	1928	1.2	5.2	1937	4.0	1925	77	81	61	69	11.4	NW	56	NW	1964
D	36.5	20.3	28.4	67	1951	-19	1924	1.60	4.39	1909	0.20	1919	2.11	1942	5.5	24.0	1909	11.0	1909	79	82	69	75	11.0	WNW	72	SW	1948
YR	61.2	41.2	51.2	111	Jul. 1936	-27	Feb. 1905	34.60	15.10	Oct. 1941	0.06	Oct. 1964	6.28	Jun. 1933	25.9	28.2	Mar. 1912	13.0	Mar. 1912	79	83	60	65	10.4	S	73	N	Aug. 1947+

Data are from Municipal Airport, Burlington, Iowa

* Daily temperature extremes and precipitation measurements are from the Cooperative location beginning 1-1-65; data are from Airport Station locations and the Cooperative locations occupied prior to 9-30-40.

TABLE 3-2. MONTHLY WEATHER D/ . FOR BURLINGTON, IOWA, IN 1980

Monthly Records

	Mean Temperature		Precipitation (In.)		
Month	°F	°F 30 Yr. Avg.	30 Yr. Avg.	Normal	Depart From 30 Yr. Avg.
January	25.1	22.9	1.58	1.07	-0.51
February	21.3	27.3	1.25	1.49*	+0.24
March	35.9	36.9	2.65	2.43	-0.22
April	50.2	51.3	3.79	1.60	-2.19
May	63.7	61.8	3.58	3.87	+0.29
June	70.7	71.4	4.71	8.60	+3.89
July	78.8	75.4	3.76	5.45	+1.69
August	76.6	73.9	3.36	11.40	+8.04
September	62.2*	65.4	3.74	7.22	+3.48
October	50.8	55.3	3.02	1.89	-1.13
November	41.6	39.8	1.60	0.81	-0.79
December	28.8	27.6	1.59	2.93	+1.34
Total			34.63	48.76	+14.13
Average		50.8			

* Estimated data

- The Kansan Drift consists of a clay-rich till similar to the Nebraskan till, except that it contains little stratified drift.

- The Illinoian Drift consists of a clay-rich till with stonier stratified drift.

- The Wisconsin Drift consists of a till richer in lithic fragments with cobbles and boulders. It is the source of surficial loess deposition at the IAAP.

Throughout most of the region surrounding the study area, the drift consists of glacial till belonging to the Nebraskan and Kansan stages of glaciation. However, a small area of eastern Iowa which includes the IAAP was covered by the Kelleville Till, a member of the Glasford Formation deposited during the Illinoian glacial period. The area has since been exposed to erosion, weathering processes, and loess deposition. The loess consists of clayey silt with sand overlying the glacial tills. This surficial aeolian unit is pervasive except where removed by erosion. (This report does not differentiate between the various tills of the Drift Plain due to their homogeneity with regard to pertinent engineering properties.) Overlying the glacial till and/or loess in the stream valleys are alluvial sediments comprised of medium- to fine-grained sandy silt with varying proportions of gravel. These sediments are derived from the erosion of loess and till soils.

Bedrock Stratigraphy

The Drift Plain is deposited unconformably on thick sequences of near horizontal sedimentary rocks of the Paleozoic Age. The unconformity represents approximately 270 million years of nondeposition and/or erosion of preexisting rock. The horizontal sedimentary rocks are predominantly limestones intercalated with varying thicknesses of shales and sandstones, representing a transgression/regression depositional environment.

The sedimentary units underlying the glacial drift range from Cambrian-Ordovician to Mississippian in age. A generalized stratigraphic column is presented in Figure 3-2. This interpretative column is based on published information and logs of IAAP water supply wells (Keyes, 1894).

The topography of the bedrock surface beneath the IAAP appears to be relatively flat. A bedrock ridge or high, trending east-west, appears to bisect the plant. All three study sites are located to the north of this divide. The estimated elevation of the bedrock beneath Sites Z_1, Z_2, and Z_3 are 630, 650, and 575 ft, respectively (MSL datum). To the north of the bedrock ridge, the rock surface slopes to the north-northwest; to the south, it slopes in a southerly direction.

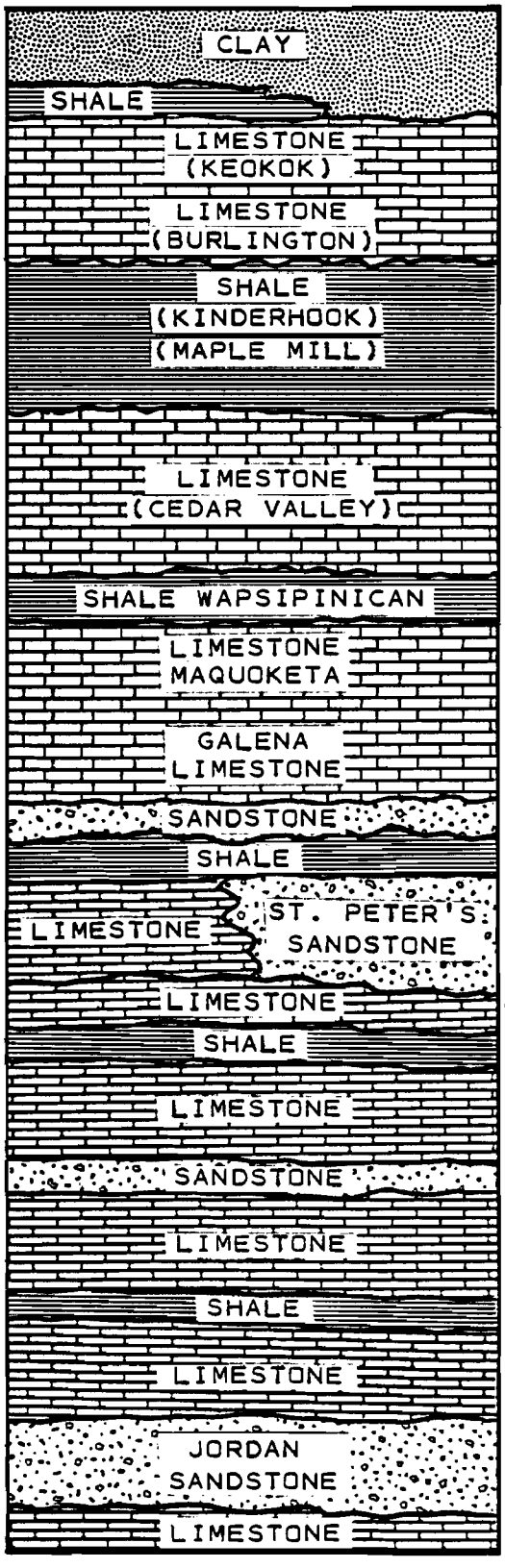

Figure 3-2. Generalized Bedrock Stratigraphy at IAAP (Based on IAAP Well Logs).

Hydrogeologic Conditions

Four significant aquifers are known to exist in the southeast region of Iowa. The uppermost, a discontinuous surficial aquifer, is comprised of unconsolidated material deposited by glaciers and streams. The plant site is bordered on the south by an alluvial aquifer of the Skunk River, and on the north by a buried channel aquifer which originates coincident with the Flint River north of West Burlington. Little information is available regarding these water bearing surficial units. The three bedrock aquifers are known as the Mississippian aquifer, the Devonian aquifer, and the Cambrian-Ordovician aquifer. The hydrogeologic units of southeast Iowa are summarized in Table 3-3 (Iowa Geologic Survey, 1971).

The shallowest bedrock aquifer, the Mississippian, is generally seperated from the surficial deposits by an aquiclude of Pennsylvanian shales. This aquifer is mainly comprised of carbonate rocks, limestone and dolomite. The Warsaw Formation, included in the Mississippian aquifer, contains shale which often acts as an aquiclude within the aquifer, and locally affects its yield.

The Devonian aquifer is found below the Mississippian aquifer, and is separated from it by a thick unit comprised predominantly of shale. The rocks of the Devonian aquifer are mostly carbonates.

The Cambrian-Ordovician aquifer is separated from the overlying Devonian aquifer by a thick shale and dolomite interval. It is predominantly dolomite; however, two sandstone units occur within the sequence, the St. Peter's and the Jordan sandstones. The lower unit, the Jordan sandstone, is the principal water-bearing zone, and accounts for the high yields obtainable from this aquifer.

The surficial soils overlying nearly the entire IAAP, and including the three study sites, are classified as a drift aquifer with a possible individual well yield of less than 20 gpm (Iowa Geologic Survey, 1971). The upper part of the Mississippian aquifer is not present; the lower part, which is present, is likely to produce individual well yields of less than 20 gpm. The lower part of the Mississippian aquifer is approximately 200 ft thick, and is found at or near an elevation of 600 ft (MSL datum).

The logs of four deep water wells installed at the IAAP indicate that the top of the Devonian aquifer (approximately 160 ft thick) is found at 130 ft above sea level. Individual well yields from this aquifer in the vicinity of the study area range from 20 to 50 gpm.

The elevation of the top of the Cambrian-Ordovician aquifer is approximately 400 ft below sea level in the vicinity of the

TABLE 3-3. HYDROGEOLOGIC UNITS IN SOUTHEAST IOWA

Hydrogeologic Unit	Name of Rock Unit	Type of Rock
Surficial aquifers alluvial buried-channel drift	Undifferentiated	 Sand, gravel, silt, and clay Sand, gravel, silt, and clay Till (sandy, pebbly clay), sand, and silt
Aquiclude	Undifferentiated	Shale, sandstone, limestone, and coal
Mississippian aquifer upper	St. Louis Spergen	Limestone and sandstone Limestone
lower	Warsaw Keokuk Burlington Hampton Starrs Cave	Shale and dolomite Dolomite, limestone, and shale Dolomite and limestone Limestone and dolomite Limestone
Aquiclude	Prospect Hill McCraney	Siltstone Limestone
	Yellow Spring Lime Creek	Shale, dolomite and siltstone Dolomite and shale
Devonian aquifer	Cedar Valley Wapsipinicon	Limestone and dolomite Dolomite, limestone, shale, and gypsum
	Undifferentiated	Dolomite
Aquiclude	Maquoketa Galena Decorah Platteville	Dolomite and shale Dolomite and chert Limestone and shale Limestone, shale, and sandstone
Cambrian- Ordovician aquifer	St. Peter Prairie du Chien	Sandstone Dolomite and sandstone
	Jordan St. Lawrence	Sandstone Dolomite
Not considered an aquifer in southeast Iowa	Franconia Galesville Eau Claire Mt. Simon	Shale, siltstone, and sandstone Sandstone Sandstone, shale, and dolomite Sandstone
		Sandstone, igneous rocks, and metamorphic rocks

IAAP. The aquifer is approximately 750 ft thick excluding the St. Lawrence dolomite (its basal unit). The principal water-bearing unit within this aquifer is the Jordan sandstone. The top of the Jordan sandstone occurs at about 1,100 ft below sea level; in the vicinity of the study area, it is approximately 60 ft thick. The possible yield of individual wells penetrating this aquifer within the study area is more than 1,000 gpm.

STUDY SITES

The three sites studied are situated in the north central portion of the plant (Figure 3-3). They are designated as Sites Z_1, Z_2, and Z_3.

Site Z_1

Site Z_1 consists of an abandoned 4-ac pinkwater lagoon located entirely within the moderately to steeply sloped valley walls of Brush Creek, a continuous stream flowing generally from northwest to southeast across the eastern third of the plant facility. It is bounded on the south and west by Plant Road D, and on the east by the perimeter fence of Line 1. The northern edge of the study site is about 2,800 ft upstream of the intersection of Brush Creek with Plant Road D.

Site Z_2

Site Z_2 encompasses nine waste processing sumps located in Detonator Line 6. The site is situated in the relatively flat upland portion of the plant facility. It is generally bounded on the north and west by the Line 6 perimeter fence, on the south by Percussion Line 9, and on the east by Plant Road F.

Size Z_3

Site Z_3 encompasses a new waste treatment system spray lagoon. This facility was under construction during the field investigation of this study. The lagoon is part of a new addition to Detonator Assembly Line 4A. This site may ultimately replace the nine Line 6 treatment and disposal sumps at Site Z_2.

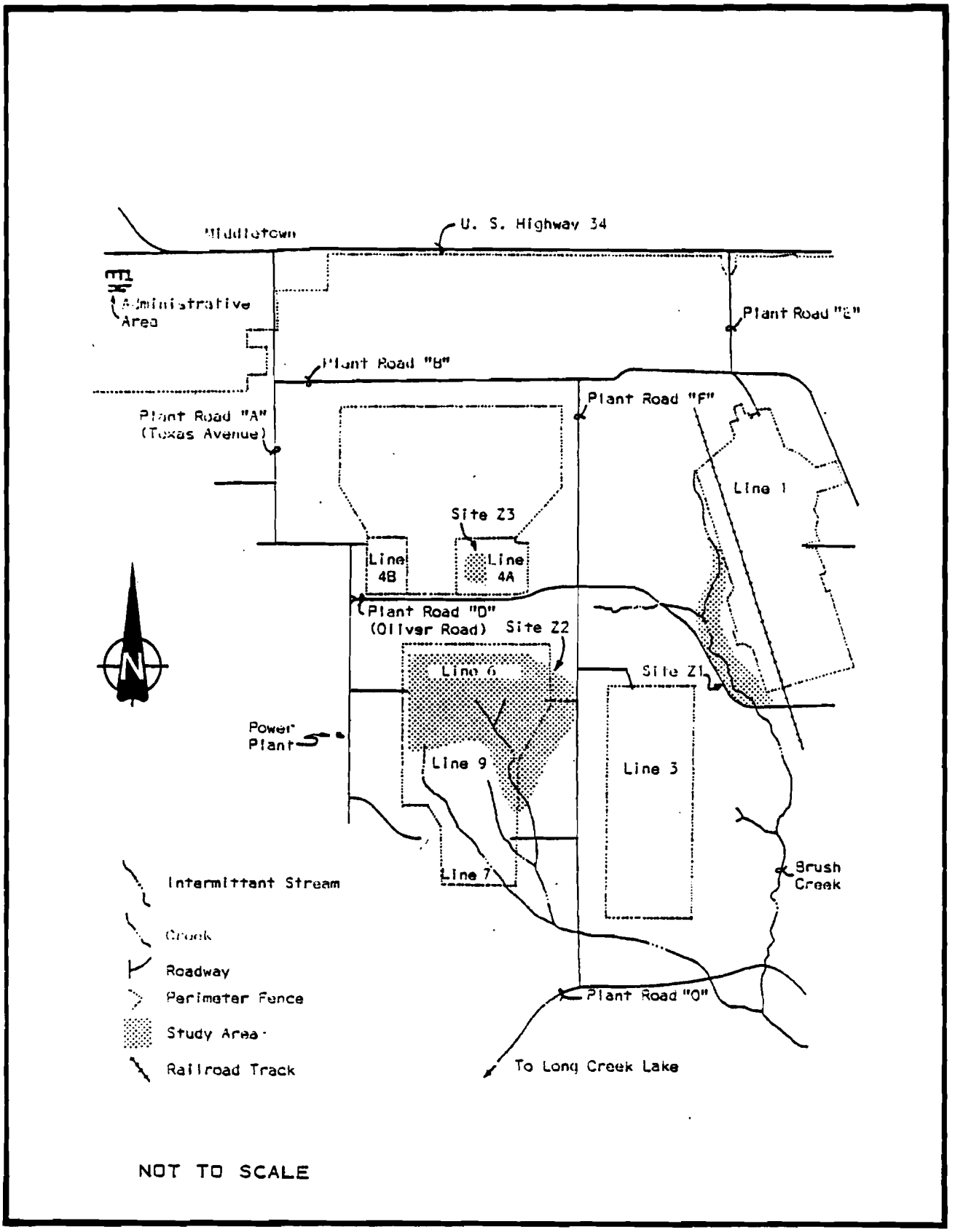

Figure 3-3. Project Site Location Diagram.

SECTION 4

SITE INVESTIGATION

REVIEW OF EXISTING INFORMATION

At the outset of this investigation, a literature search was conducted to gather information regarding area geology, development, and history of the IAAP (particularly Sites Z_1, Z_2, and Z_3), and associated environmental impact assessment. Specific data collected for this investigation included:

- A geologic map with descriptions of the formations in the vicinity.
- Logs of four deep water supply wells and a map showing their location at the IAAP.
- Topographic maps of the IAAP.
- Maps showing the general layout and drainage of the IAAP.
- Soil Conservation Service maps for the area surrounding the IAAP.
- Climatological data.
- U.S. Army Environmental Hygiene Agency (AEHA) report on the IAAP (U.S. AEHA, 1980).

As part of the data gathering interviews with IAAP personnel were conducted to clarify site use history, disposal practices, and future plans for the three sites.

Interviews with Iowa's Department of Environmental Quality and EPA Region VII officials were also held to acquire knowledge of pertinent regulations and permit applications for hazardous waste TSD facilities.

EXPLORATION AND FIELD TESTING

Drilling and Monitoring Well Installation Plan

During site reconnaissance, locations of the borings and monitoring wells at the three study sites were identified. They were staked using a measuring tape and visual orientation with identifiable structures and prominent land forms. A drilling/

monitoring well plan was then prepared and approved by the Corps of Engineers prior to initiation of the fieldwork. However, during drilling, it was necessary to relocate several borings as a result of (1) the development of pertinent site-specific hydrogeological data, and (2) the ongoing construction at Site Z_3 which required the relocation of two borings and associated monitoring wells. All changes in the drilling/monitoring well plan were made with the approval of the Corps of Engineers.

The actual horizontal and vertical locations of the borings and monitoring wells were determined by using a surveyor's transit and chain. The horizontal positions were referenced to a local coordinate system established by the Corps of Engineers for the construction of the new detonator assembly facility at Line 4A. The three benchmarks used had the following coordinates: North 9882.60 ft, East 8,953.17 ft; North 9,134.85 ft, East 10,014.07 ft; North 10,006.00 ft, East 10,004.00 ft. An approximate conversion of this local coordinate system to the State Plane Coordinate System, Iowa South Zone, established in 1955, may be obtained by adding the local north and east coordinates to 294,126 North and 2,615,430 East, respectively. All horizontal positions discussed in this report refer to the Corps of Engineers Line 4A local coordinate system.

Ground surface elevations and top-of-pipe elevations for the boring and monitoring well locations were determined by using a surveyor's transit. These elevations were referenced to nearby floor slabs or benchmarks having known elevations.

Drilling and Sampling Methods

The soil borings were made using both truck- and track-mounted, rotary-type drilling rigs which were equipped with a hydraulic head employed in the drilling and sampling operations. The boreholes were advanced using either continuous flight augers or hollow stem augers. Representative undisturbed samples were obtained by means of the Shelby tube sampling procedure in accordance with ASTM Specification D-1587. In the Shelby tube sampling procedure, a thin-wall, steel, seamless tube with a sharp cutting edge is pushed into the ground with hydraulic pressure so that a relatively undisturbed sample is obtained in cohesive soil.

In general, 24-in-long Shelby tube samples were taken at 5-ft intervals throughout the entire depth of the borings. These samples were visually classified in the field, sealed, and returned to the laboratory for further classification and testing.

Monitoring Well Installation

Initially, it was specified that Sites Z_1 and Z_2 would require four 50-ft-deep monitoring wells per site. Each well would be constructed to draw water from the uppermost aquifer

where ground water contamination (if it occurred) was most likely to be found.

During drilling, it was determined that information concerning the vertical hydraulic gradient at Sites Z_1 and Z_2 would be needed to better understand the probable path of contaminant flow. Without exceeding the total allowable monitoring well installation/development budget, a combination of shallow and deep wells was substituted for one downgradient well at each of the sites.

At Site Z_1, four monitoring wells were installed downgradient of the abandoned pinkwater lagoon. Well Nos. 1 and 3 were located approximately 100 ft east and west, respectively, of Brush Creek. Well Nos. 2 and 2A (30 ft and 10 ft deep, respectively) were located adjacent to Brush Creek. Background Well No. 6 (50 ft deep) was located approximately 200 ft upstream of the northern limit of the possible high stream flow impoundment area. It is approximately 2,600 ft upstream from the now demolished dam. Six additional borings ranging in depth from 10 to 20 ft were located within and around the impoundment area to more precisely define the nature and extent of waste sedimentation. The locations of the exploratory and monitoring wells at Site Z_1 are shown in Figure 4-1.

At Site Z_2, the proposed plan originally called for a total of 19 explorations including the installation of an upgradient and three downgradient monitoring wells in selected boreholes. Monitoring Well No. 18 was installed as a shallow well/deep well combination to permit preliminary assessment of vertical gradients at Site Z_2. Locations of the borings and monitoring wells are shown in Figure 4-2.

Five monitoring wells were installed in test borings at Site Z_3. The locations and depths of these wells were specified by the Corps of Engineers. The purpose of the wells is to provide a ground water monitoring system for the lagoon facility. Due to the ongoing construction at the lagoon site, it was impossible to install Well No. 5 at the originally specified location. With approval of the Corps, Well No. 5 was relocated and completed to a depth of 18.5 ft. Well No. 4 was completed to a depth of 26.5 ft. The monitoring well locations are shown in Figure 4-3.

In general, the monitoring wells were installed in borings completed by the hollow stem auger methods. However, at several locations, the monitoring wells were installed in boreholes previously completed with 4-in-diameter continuous flight augers. In these cases, the hollow stem auger was used to enlarge the borehole's diameter to approximately 8.5 in. The borings and monitoring wells were logged in the field, and the field logs were modified on the basis of laboratory examination and testing of the soil samples recovered from each boring. General notes pertaining to the boring logs and the terms and symbols used are

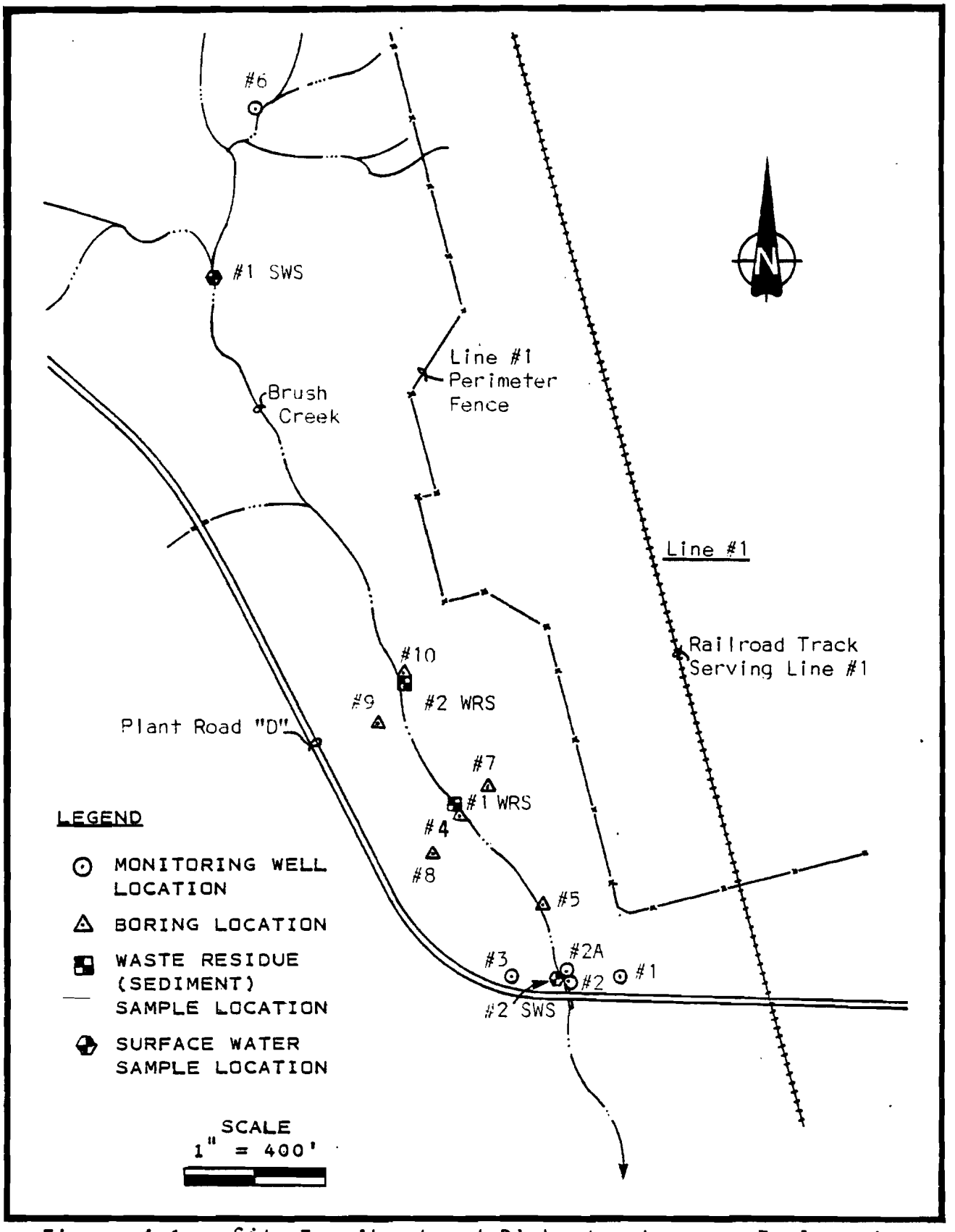

Figure 4-1. Site Z, Abandoned Pinkwater Lagoon, Exploration Location Plan.

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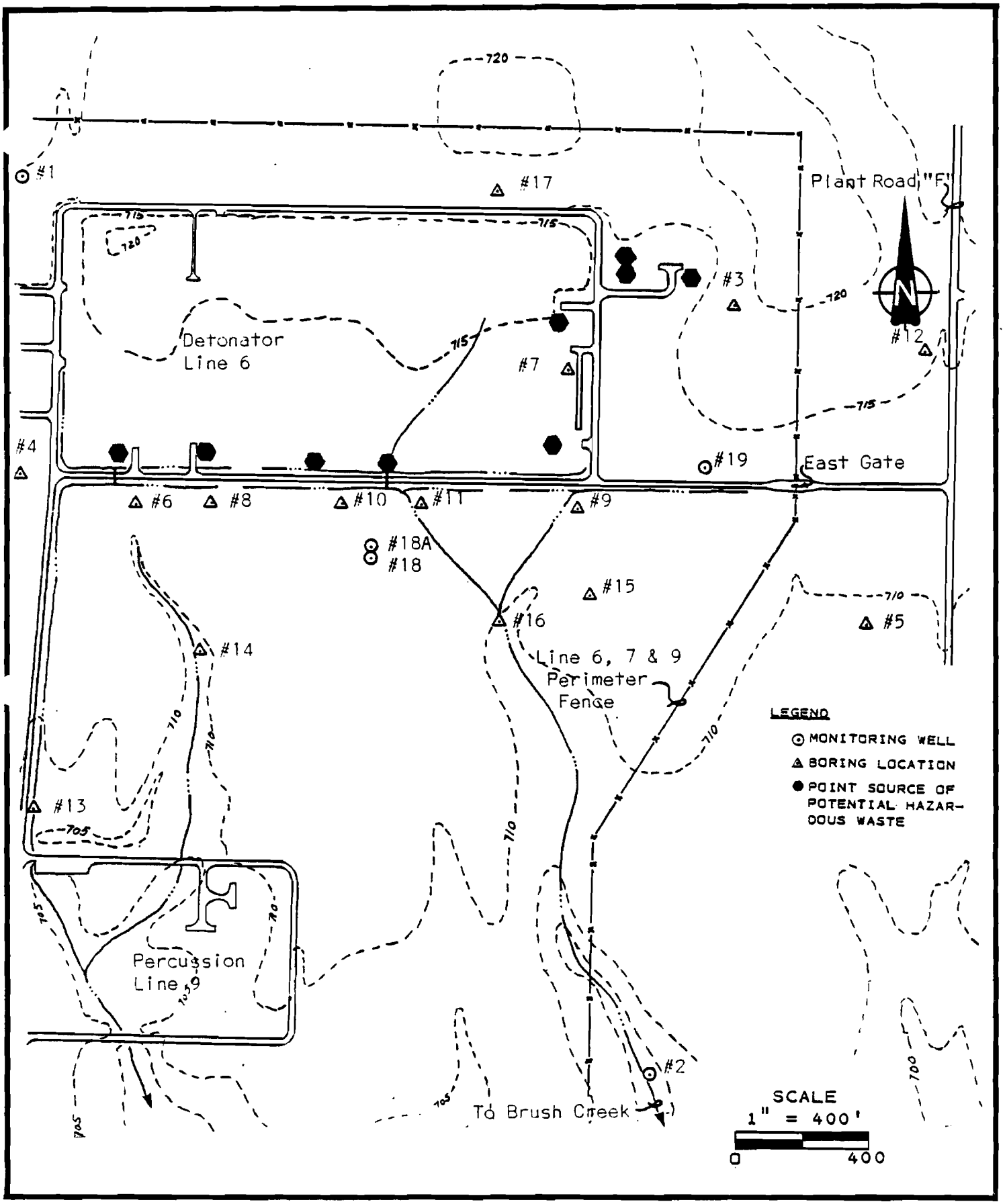


Figure 4-2. Site Z_2, Detonator Line 6, Exploration Location Plan.

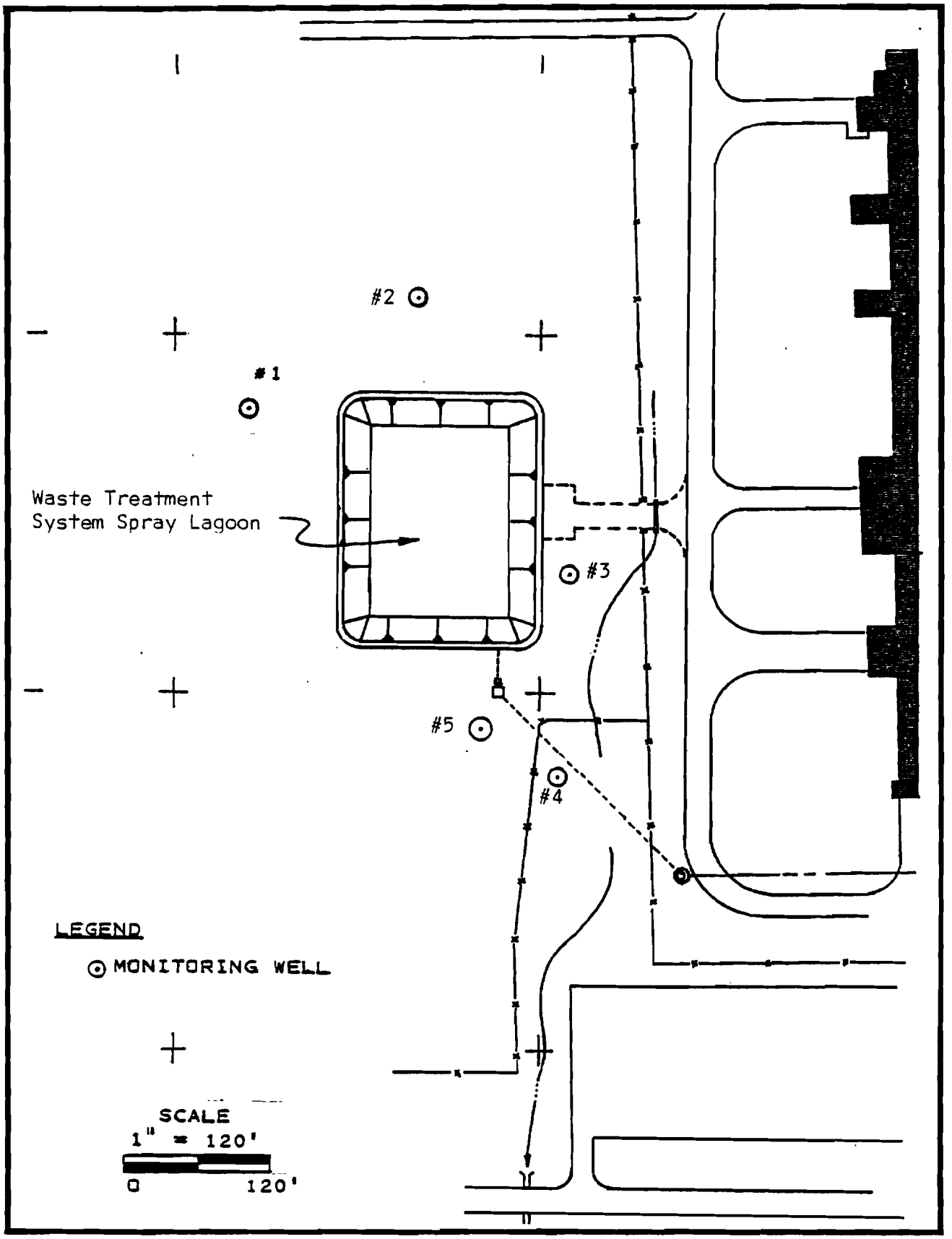


Figure 4-3. Site Z_3, Spray Lagoon, Exploration Location Plan.

presented in Appendix A. The final logs for Sites Z_1, Z_2, and Z_3 are presented in Appendices B, C, and D, respectively.

After completion of the well bore to the desired depth, a well screen was joined to an appropriate length of 4-in-ID PVC plastic casing pipe (Schedule 40) and lowered into the hole. All casing sections had nonthreaded joints, and were joined by means of solvent welding to form watertight joints. A sand pack consisting of clean-washed, medium-to-coarse concrete sand was installed for at least the full length of the well screen. Longer sections of sand pack were installed as site conditions dictated. Approximately 3 ft of bentonite pellets were installed at the top of the sand pack to form a seal to prevent surface water from entering the well. The annulus between the well casing and surrounding soil was grouted with a mixture of 90 percent portland cement and 10 percent bentonite. The well screens employed consist of 4-in-ID, continuously slotted PVC material (0.02-in openings) manufactured by Johnson UOP.

A threaded or flanged cap was installed upon completion of the well to prevent material from entering the casing. The top of the casing was cut approximately 24 to 36 in above the natural ground surface. Several well casing tops were cut 40 to 50 in above the natural ground level so that (1) they would be visible from a distance, (2) ground water would not flow out of the casing, and (3) surface water would not flow into the casing. A concrete pad, 3 ft square by 4 in thick, was placed around the well. Three 2-in steel posts filled with concrete were equally spaced around the well casing and embedded in the concrete pad. The posts were painted yellow, and extended approximately 5 ft above the top of the pad.

Monitoring well installation details are shown on the boring logs. A typical monitoring well installation is detailed in Figure 4-4.

Well Development

Subsequent to their installation, the monitoring wells were developed by pumping. A submersible pump was temporarily installed in each well, and the well was pumped and allowed to partially recover repeatedly. The well development process removed fine soil particles from the backfill and natural soil material surrounding the well screen. At completion, water entering each of the well screens was substantially free of sand and suspended silt particles.

Laboratory Analysis

The Shelby tube soil samples were transported to the soils testing laboratory for analysis on a regular basis. The samples were first visually examined and classified using the Unified Soil Classification System (USCS). Selected soil samples were then analyzed for pertinent chemical and physical characteristics

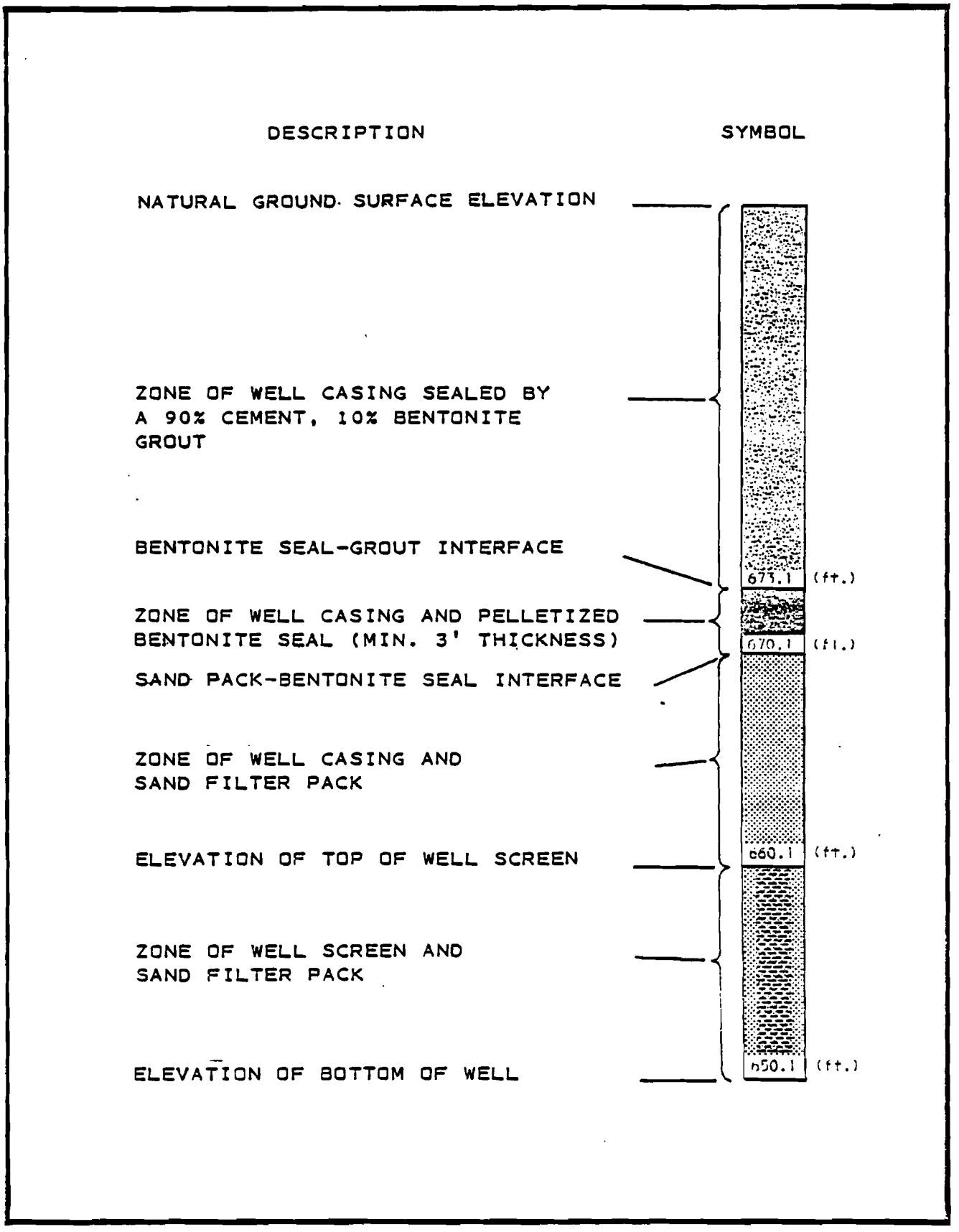


Figure 4-4. Monitoring Well Detail and Legend.

using the procedures given in Table 4-1. The results of all soil laboratory analyses are presented in Appendices B, C, and D.

FIELD SAMPLING

The number of samples for each sample type, sampling time, and sample preservation method were, to a large extent, specified in the contract requirements. Little flexibility was allowed.

Waste Sampling

On January 7, 1981, two grab sediment samples were collected from representative contaminated areas in the abandoned lagoon at Site Z_1. The sample stations are shown on Figure 4-5. On March 13, 1981, two grab effluent samples were taken from the lead azide treatment sumps at Site Z_2 by site contractor personnel, following desensitization of the explosives.

Surface Water Sampling

Surface water samples were obtained from Brush Creek in the vicinity of the abandoned pinkwater lagoon (Site Z_1). Two sampling stations were selected for this site, one upstream and one downstream of the probable location of the sediment impoundment (Figure 4-6). The downgradient station (No. 2) is located adjacent to monitoring Well Nos. 2 and 2A, downstream from the razed dam. The upgradient station (No. 1) is located immediately downstream from the IAAP NPDES monitoring station No. 1.

Surface water samples were collected at the midpoint and mid-depth of the Brush Creek stream channel. The samples were collected on December 18, 1980, and January 16 and 28, 1981. Flow rates, which were similar at the three sampling times, were estimated at 250 to 400 gpm.

Ground Water Sampling

Ground water samples were collected after the water depth in the monitoring wells had been measured and recorded. The wells were then pumped in an attempt to remove three times the casing volume. Since most of the wells recharged at a rate insufficient to permit the removal of three well casing volumes of water in a single continuous period of pumping, each well was pumped or bailed dry prior to taking the sample. When the well had recharged to a sufficient level, the samples were obtained by bailing. A PVC plastic pipe bailer with a brass-foot valve was used to complete this operation. With the exception of Well No. 2A (Site Z_1) and Well No. 2 (Site Z_3), each well produced a sufficient volume of samples at each incidence of sampling during the 3-consecutive-day sampling period. Notes and observations made during sampling operations are summarized in Appendices B, C, and D for Sites Z_1, Z_2, and Z_3, respectively.

TABLE 4-1. ANALYTICAL PROCEDURES FOR PHYSICAL AND CHEMICAL CHARACTERIZATION OF SELECTED SOIL SAMPLES

Characteristic	ASTM Procedure
Atterberg Limits	D-423-66/D-424-59
Grain Size Analysis (sieving and hydrometer)	D-422-63
Constant Head Permeability	D-2434-68
Moisture Content	D-2216-71
Dry Density	D-2937-71
Cation Exchange Capacity (CEC)	1:1 ratio in water*

* Black, et al., 1965. p. 922.

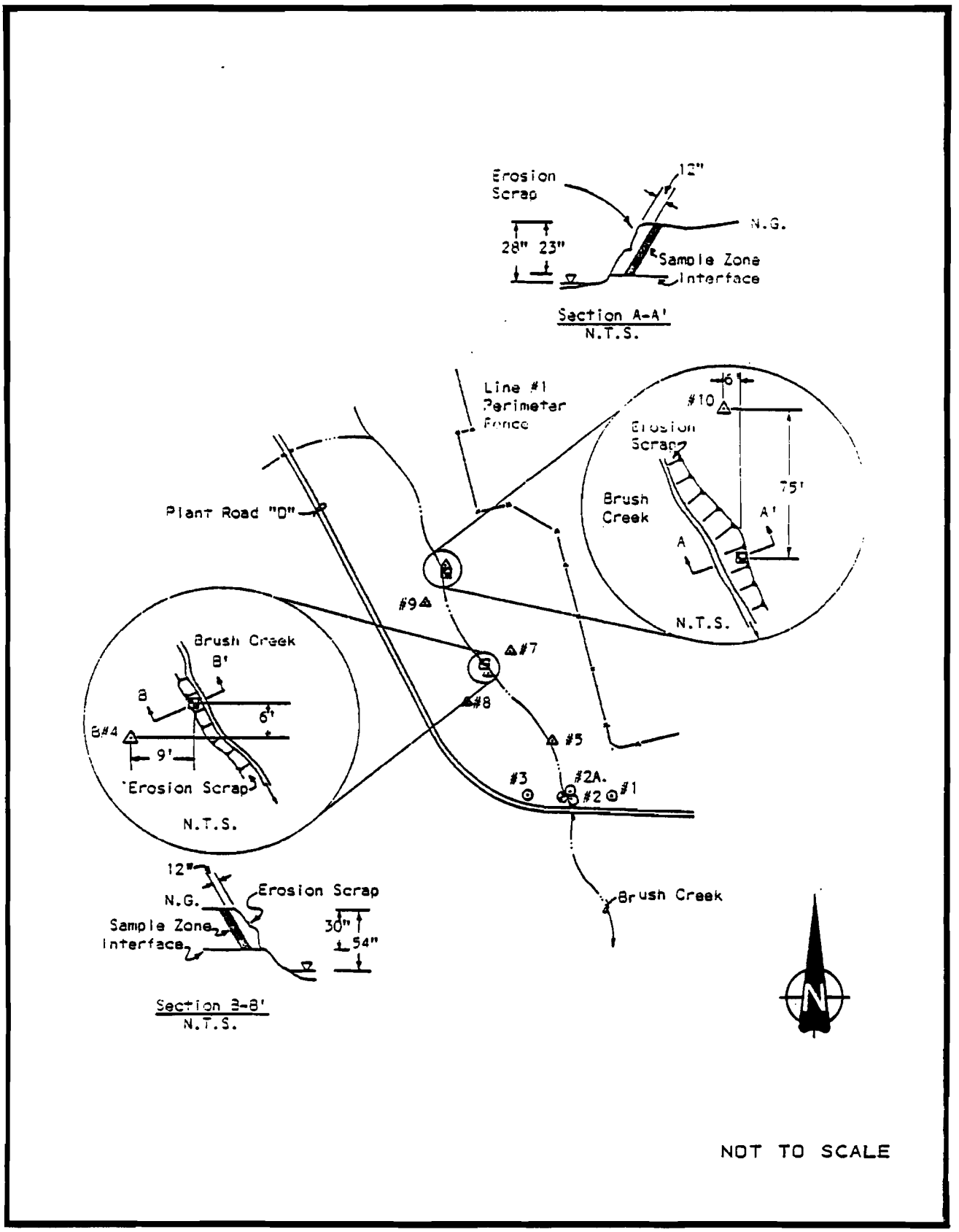


Figure 4-5. Waste Residue (Sediment) Sample Locations, Site Z_1.

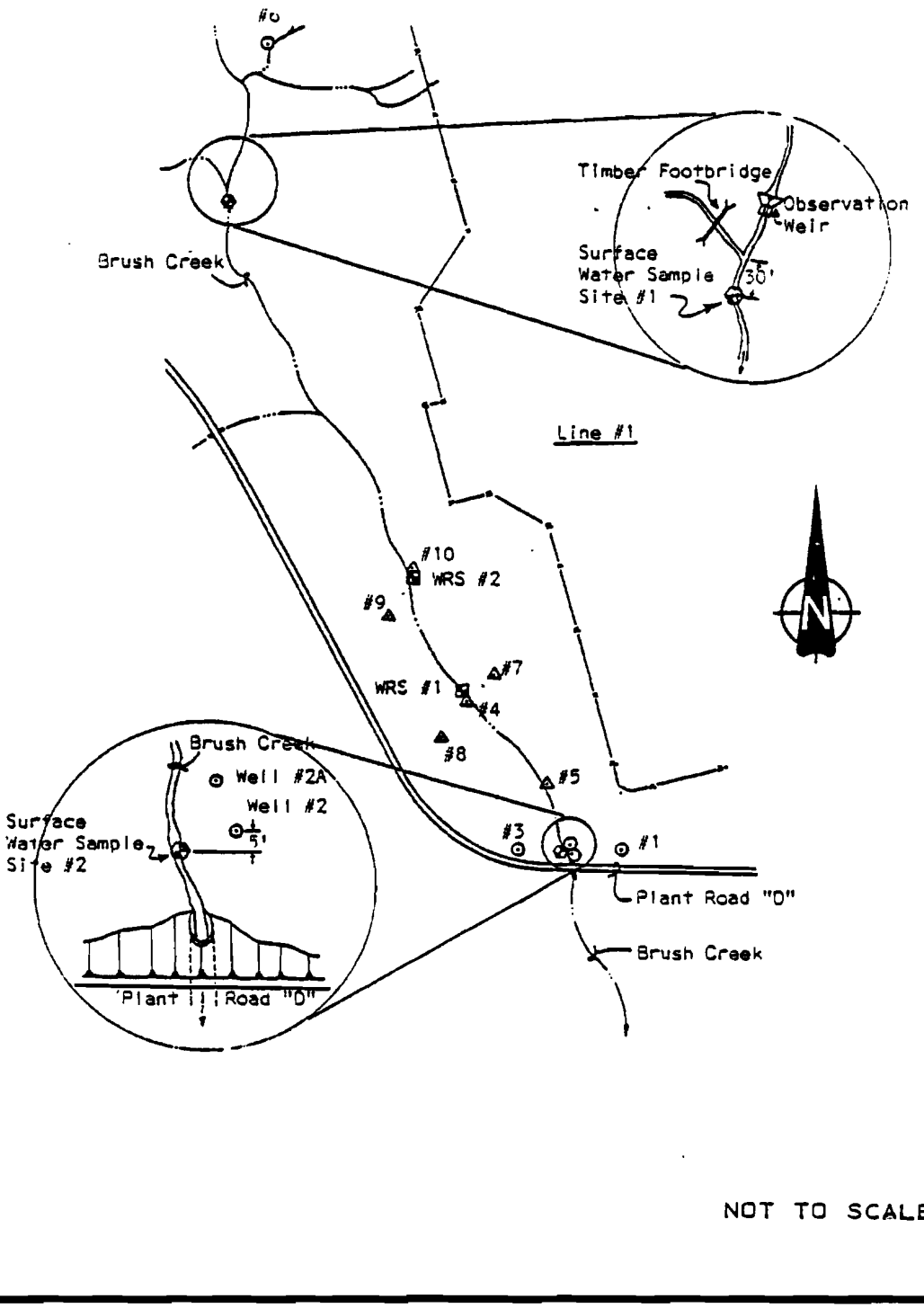


Figure 4-6. Surface Water Sampling Stations, Site Z_1.

Each individual container of the ground water sample set received from the chemical analysis laboratory had undergone solvent prerinsing, and contained preservatives which precluded container rinsing on site with sample waters. The bailing equipment and funnels used during collection were rinsed thoroughly with distilled water prior to sampling.

Sample Preservation and Shipment

To preserve water samples for chemical analysis of a wide spectrum of parameters, six different types of bottles were used for each water sample (Table 4-2). The sample bottles and caps were cleaned by first washing with detergent and rinsing with distilled water, 5 percent ultrex nitric acid, deionized water, and mili-q (organics- and inorganic-free) water; appropriate preservatives were then added to the bottles in the laboratory before shipping to the site.

The water sample bottles were properly packed and chilled with blue ice, and the containers sealed prior to shipping to the laboratory in Huntsville, Alabama, by express air freight. The samples were delivered to the laboratory on the following morning.

CHEMICAL ANALYSES

The analytical parameters selected for waste and water samples were specified in the contract requirements. These parameters should serve the screening purposes for which the study was intended.

Chemical Characterization of Wastes

Waste samples collected from Sites Z_1 and Z_2 were chemically characterized for their ignitability, corrosivity, reactivity, and EP toxicity, using EPA-approved methods (EPA, 1980).

Chemical Analysis of Surface and Ground Waters

Water pH and temperature were measured at the time that samples were collected. Other parameters were determined in the laboratory within the maximum allowable holding time.

Upon arrival, an aliquot of the supernatant was taken from bottle No. 1 and digested with concentrated, redistilled HNO_3 (EPA, 1974). After digestion, the sample was ready for trace metal analysis.

Except for TNT and RDX, the parameters chosen were interim primary and secondary drinking water standards and/or those for which maximum contaminant levels in ground water have been established (EPA, 1979). Analytical procedures for the selected parameters are presented in Table 4-3.

TABLE 4-2. BOTTLE TYPES AND PRESERVATIVES ADDED

Bottle Number	Type	Preservation	Parameters
1	0.5 gal, plastic	Cool*	Electrical conductivity, metals, sulfate, chloride, fluoride, turbidity, TNT, and RDX
2	0.5 gal, plastic	Cool	Radium, gross alpha, gross beta
3	0.5 gal, glass	Cool	Pesticides/herbicides
4	200 ml, plastic	H_2SO_4 to pH $\leq$ 2	Chemical oxygen demand, total organic carbon, and nitrate
5	500 ml, amber glass	1 g $CuSO_4$/l	Phenols
6	100 ml, plastic	$NaHSO_4$	Total coliform

* At 4°C.

TABLE 4-3. ANALYTICAL PROCEDURES FOR WATER SAMPLES

Parameter	Method	Reference*
pH	Glass electrode	424
Conductivity	Conductivity meter	205
Turbidity	Nephelometer	214 A
Chemical Oxygen Demand	Dichromate reflux	508
Total Organic Carbon	Combustion - Infrared (carbon analyzer)	505
Sodium	Flame photometry	320 A
Iron	Atomic absorption (AA) spectrophotometry	320 A
Manganese	AA	301 A, II
Barium	AA	301 A, II
Cadmium	AA	301A, II
Total Chromium	AA	301 A, II
Lead	AA	301 A, II
Mercury	Flameless AA	301 A, VI
Selenium	Conversion to hydride, followed by AA	301 A, VII
Arsenic	Same as selenium	
Chloride	Argentometry	408 A
Nitrate	Brucine	419 D
Sulfate	Gravimetry	427 A
Fluoride	Electrode	414 B
Phenols	Aminoantipurine (colorimetry)	510 D
Endrine	Gas chromatography, using EC detector (GC/EC)	509 A
Lindane	GC/EC	509 A
Methoxychlor	GC/EC	509 A
Toxaphane	GC/EC	509 A
2,4-D	GC/EC	509 A
2,4,5-TP (silver)	GC/EC	509 A
Total Coliform Bacteria	Membrane filter	909 C

TABLE 4-3 (continued)

Parameter	Method	Reference*
TNT and RDX	GC/EC	AEHA APG, MD, 2 1010
Radium	Proportional counter	703
Gross Alpha	Same as radium	703
Gross Beta	Same as radium	703

* Standard Methods, 1975, unless otherwise indicated.

Quality Control Program

In addition to sample identification, preservation, and shipment, stringent laboratory quality control was followed. All samples were analyzed before their holding times or maximum shelf life expired (see Table 4-4).

Immediately after the samples arrived, they were recorded on the document log. The project number and sample numbers were also recorded on an internal custody sheet mounted on the refrigerator door. The analyst checked samples in and out by writing the date, time, and initials on the internal custody sheet. Sample extracts were catalogued by project number, and returned to the sample custodian for storage. All raw data, lab notebooks, and extraction methods were coded by appropriate case number and sample identification. All reports, raw data, and calculations were filed in the project file. As the sample analyses were completed, all containers with remaining samples were stored in a special room designated "custody of sample room." A list of the samples and their identifications was kept in this room. Samples are normally kept for 2 months after the final report has been submitted.

As part of the routine quality control program, 10 percent of the samples were split and separately analyzed on the same day. The duplicate samples were treated the same way, and analyzed by the same procedure.

For metal determination, three different standard concentrations were entered on the atomic absorption (AA) unit. These standards were within the linear curve of specific metal concentration linearity. Ten percent of the samples selected were also treated to see the effect of addition for different metals. All metal analyses were run with a blank in which milli-q water and the same concentration of acid used for sample digestion were adopted.

For wet chemical analyses, the normality of the standard was checked before testing and sample itself.

Different concentrations of pesticide/herbicide standards were spiked with milli-q water to plot the standard curve. This standard curve was used to determine the pesticide/herbicide concentrations in the unknown samples. As a quality control program, approximately 10 percent of the samples were used to check the accuracy of the determination.

Under this quality control program, the results of the split samples were used as a means to check the validity of the reported results (see Appendix E).

TABLE 4-4. PRESERVATION METHODS FOR DIFFERENT PARAMETERS IN WATER SAMPLES

Parameter	Method	Maximum Holding Time
pH	Cool	6 hr (on-site)
Conductivity	Cool	24 hr
Turbidity	Cool	24 hr
Chemical Oxygen Demand	H_2SO_4 to pH $\leq$ 2	7 days
Total Organic Carbon	Cool, HCl to pH $\leq$ 2	24 hr
Metals	HNO_3 to pH $\leq$ 2	6 mo
Chloride	Cool	7 days
Nitrate	Cool H_2SO_4 to pH $\leq$ 2	24 hr
Sulfate	Cool	7 days
Fluoride	Cool	7 days
Phenols	$CuSO_4$	24 hr
Pesticides/Herbicides	Cool	-
Radioactivity	Cool	-
Total Coliform	$NaHSO_4$	24 hr

* At 4°C.

SECTION 5

EVALUATION OF STUDY SITES

SITE Z_1 - ABANDONED PINKWATER LAGOON

Site Z_1 encompasses the location of sediment deposition which occurred on Brush Creek as a result of its impoundment by a concrete and earthen dam. This facility was in use from the late 1940's to the mid-1950's. The dam was constructed across the creek approximately 200 ft north of the intersection of Brush Creek and Plant Road D (Oliver Road). The purpose of the dam was to impound effluent generated by Line 1 munition operations. Based on elevations of apparent sediment resulting from this operation and the elevation of remnant portions of the demolished dam, it is believed that waste sedimentation occurred in an impoundment area approximately 3.6 ac in size which apparently extended over 1,300 ft upstream from the dam. Backwater impoundment during periods of high stream flow could have extended over the area of potential contamination to an impoundment area of approximately 7.5 ac, reaching approximately 2,400 ft upstream from the impoundment structure.

Topography

Site Z_1 is comprised of the valley containing Brush Creek, an intermittent stream which flows in a generally south-southeasterly direction (Figure 5-1). The high point of the study area, elevation 683.5 ft, is located at Well No. 6. The lowest point, 670 ft above sea level, is located near Well No. 2 at the south end of the study area.

The sides of the valley along Brush Creek adjacent to Site Z_1 are less than 50 percent wooded. They are covered with a mixture of deciduous and coniferous trees and short shrubby undergrowth. The remaining side slopes and narrow valley floor areas are covered with native grassy vegetation. Little or no vegetation was found in the area immediately upstream from the demolished dam. Waste sediment in this area was apparently deposited in the greatest thickness, and considerable stream scour has occurred.

Use History

Site Z_1, the abandoned pinkwater lagoon, was operated during the period from 1948 to 1957. Line 1 began operating in 1941, and has continued to operate more or less continuously up to the

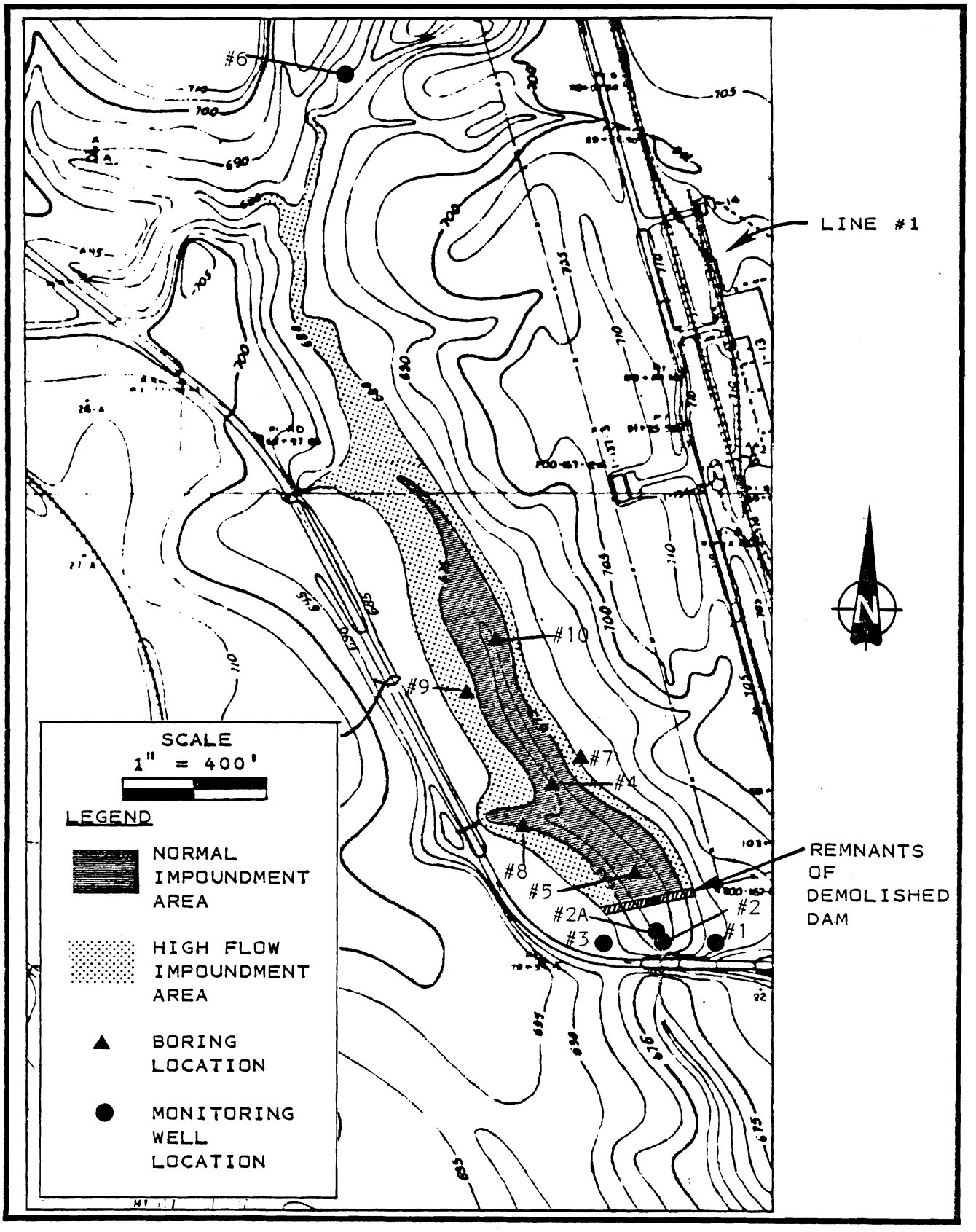


Figure 5-1. Site Z_1, Abandoned Pinkwater Lagoon.

present time. Periods of high production coincided with military operations during World War II, the Korean conflict, and the Vietnam conflict.

Direct discharge from Line 1 apparently resulted in contamination of several private wells downstream from the IAAP after World War II. These domestic supplies were provided with individual treatment systems until the contamination problem was mitigated (oral communication with IAAP staff). In the middle to late 1940's, attempts were made to treat the effluent by means of lime stabilization. A hopper was installed in the vicinity of the D Road bridge, and fly ash was added to the stream. Results of this attempt to improve Brush Creek water quality are unknown.

In 1948, the dam was erected. The lagoon received discharges from the total Line 1 facility, materials eroded from a coal pile, and condensate from a coal-fired power plant. Originally, the Line 1 effluent was discharged to the stream and lagoon by overland flow and through a number of small ditches. Later, several small settling basins were installed upgradient of the pinkwater lagoon. A portion, if not all, of the Line 1 discharge passed through these basins prior to entering the pinkwater lagoon.

In 1957, the dam was razed, and the creek was allowed to return to a natural flow condition. At the time the dam was razed, an attempt was made to remove the accumulated sediments and burn them. These efforts were met with only partial success, as evidenced by explosive-containing sediments found in the old lagoon area.

The actual quantity of sediments originally deposited in the abandoned pinkwater lagoon is unknown. Removal of the dam has caused the stream to erode a channel 3.5 to 4 ft deep through portions of the lagoon area. The top 1 to 1.5 ft of material exposed in the eroded bank is distinctly darker than the underlying soil. It also contains numerous coal fragments locally. This material appears to be the remnants of the sediment deposited in the abandoned pinkwater lagoon during its period of operation. Vegetation (grasses, shrubs, and small trees) has become established in portions of the abandoned lagoon bottom not subject to stream scour.

The AEHA investigated this site in March 1980 (U.S. AEHA, 1980). During September 1979, the U.S. EPA's surveillance and analysis emergency response group (Region VII) sampled sediment from the abandoned pinkwater lagoon. However, no analyses were conducted on these samples.

Waste Characterization

Historically, the abandoned pinkwater lagoon received all wastewater discharges from Line 1 including process water, washdown water, and other water that contacted explosives. The types

of material processed at Line 1 (hence, potentially included in the discharge) included:

- Composition "B."
- PBX.
- RDX.
- TNT.
- Baratol.
- Boracitol.

The actual quantity of discharge is not known, nor could it be accurately estimated by the IAAP staff. The quantity was reportedly substantial; the effluent was so heavily laden with TNT that at times Brush Creek ran red. Peak usage of Line 1 and the corresponding peak discharge occurred during the late 1940's.

In this study, two sediment samples from the pinkwater lagoon were characterized according to ignitability, corrosivity, reactivity, and EP toxicity to provide a basis for hazardous waste classification. The data show that the waste-contaminated sediments are neither corrosive nor reactive (Table 5-1). Sample No. 1 had a flash point of 43°C, which is slightly lower than the 60°C limit specified under RCRA, indicating that the material is ignitable. Sample No. 2, however, had a higher flash point than the RCRA criterion. There is no apparent correlation between flash points and concentrations of explosive residue found in the sediment samples.

Except for barium, all parameters analyzed were nondetectable in the EP toxicity tests (Table 5-2). All concentrations are below the maximum contaminant levels under RCRA criteria.

The hazardous nature of the waste residue in the sediment at Site Z_1 is probably due to the presence of high concentrations of TNT and RDX. The AEHA survey reports TNT and RDX concentrations to be 30,454 and 53,671 mg/kg, respectively (U.S. AEHA, 1980). The grab samples collected in this study, however, showed considerably lower concentrations, i.e., 0.82 and 0.03 mg/kg TNT, and <0.011 and 27.2 mg/kg RDX. This would suggest soil variability and the uneven distribution of explosives in the lagoon.

Wastewater Treatment and Disposal Practices

During the period that the lagoon was in use, no treatment of pinkwater was known to have been implemented. Presently, Line 1 discharges are treated by means of activated carbon filtration.

Subsurface Conditions

The extent of the abandoned pinkwater lagoon was controlled by the local topography and the crest elevation of the dam. Sediments that developed while the lagoon was in operation form a distinct surficial mantle where they have not been removed by erosion. This mantle, where exposed in the stream channel or

TABLE 5-1. RESULTS OF IGNITABILITY, CORROSIVITY, AND REACTIVITY TESTS FOR SEDIMENT SAMPLES FROM SITE Z_1

Test	No. 1	No. 2	Selected RCRA Criterion*
Ignitability (Flash Point, °C)	43	>82	<60
Corrosivity (pH)	7.88	7.92	≤2 to ≥12.5
Reactivity	N/D†	N/D	Reacts violently with water

* Federal Register, May 19, 1980. pp. 33121-33122.

† Not detected.

TABLE 5-2. ANALYSIS OF EP TOXICITY FOR TWO SEDIMENT SAMPLES FROM SITE Z_1*

Parameter	No. 1	No. 2	Maximum Contaminant Level†
	- - - - - - - -	- (mg/l) - - - - - - - - - -	
Arsenic	<0.005	<0.005	5.0
Barium	0.560	0.570	100.0
Cadmium	<0.001	<0.001	1.0
Chromium	<0.022	0.020	5.0
Lead	<0.005	<0.005	5.0
Mercury	0.0017	0.0017	0.2
Selenium	<0.005	<0.005	1.0
Silver	<0.001	<0.001	5.0
Endrin	<0.0002	0.0002	0.02
Lindane	<0.001	<0.001	0.4
Methoxychlor	<0.01	<0.01	10.0
Toxaphene	<0.001	<0.001	0.5
2,4-D	<0.01	<0.01	10.0
2,4,5-TP Silvex	<0.005	<0.005	1.0

* Samples taken on January 7, 1981.

† Federal Register, May 19, 1980. p. 33122.

revealed by the explorations, is a dark brown to black sandy silt and/or sandy clayey silt containing coal fragments. This zone ranges up to at least 2.5 ft thick (at Borings 4 and 10). Its estimated extent is shown in Figure 5-1. Although the possibility of contaminated sediments existing in the high flow impoundment area and the channel of Brush Creek along Line 1 cannot be discounted, substantial accumulations are not anticipated.

The waste-containing sediment is underlain by natural soils. Based on their depositional and engineering characteristics, these soils form three distinct groups:

- Glacial Till - brown to grey, medium to hard (generally stiff to very stiff), sandy silty clay with a trace of gravel, with occasional sand seams interspersed (CL-CH).

- Loess - brown becoming grey, medium to stiff, silty clay with tract of sand grading upward to a dark brown clayey silty loam at the surface (CL-CH).

- Alluvium - localized deposits of stratified silty sand, sandy silty clay, and sandy silt with some gravel (derived from the underlying loess and glacial till deposits).

Contact between the loess and till deposits is generally marked by a distinct color change indicative of chemical weathering.

The alluvial soils are restricted to the bottom of the valley containing Brush Creek. The loess soils generally blanket the glacial tills to depths of 6 to 12 ft, except where removed by erosion (e.g., stream valleys). The actual thickness of the till soils, though unknown, is expected to be substantial (i.e., on the order of 100 ft). The index properties of the loess and till soils are summarized in Figures 5-2 through 5-4. Grain size distribution analyses for selected samples are presented in Appendix B. Field observations and testing results suggest that both the loess and till soils are relatively uniform and very slowly permeable, exhibiting only minor fluctuations in moisture content and dry density with depth. The locations of the interpretative subsurface profiles are shown on Figure 5-5. The vertical distribution of the subsurface units are shown in Figures 5-6 and 5-7.

Hydrogeologic Conditions

Ground water levels were monitored in all explorations at Site Z_1. The monitoring wells provide long-term ground water level and quality monitoring capability. The water levels in the exploratory holes were allowed to stabilize prior to backfilling with grout to permit the measurement of a true static condition. An interpretative hydrogeologic map depicting the elevation of the potentiometric surface at Site Z_1, measured on January 7, 1981, is presented in Figure 5-8. The ground water flow pattern

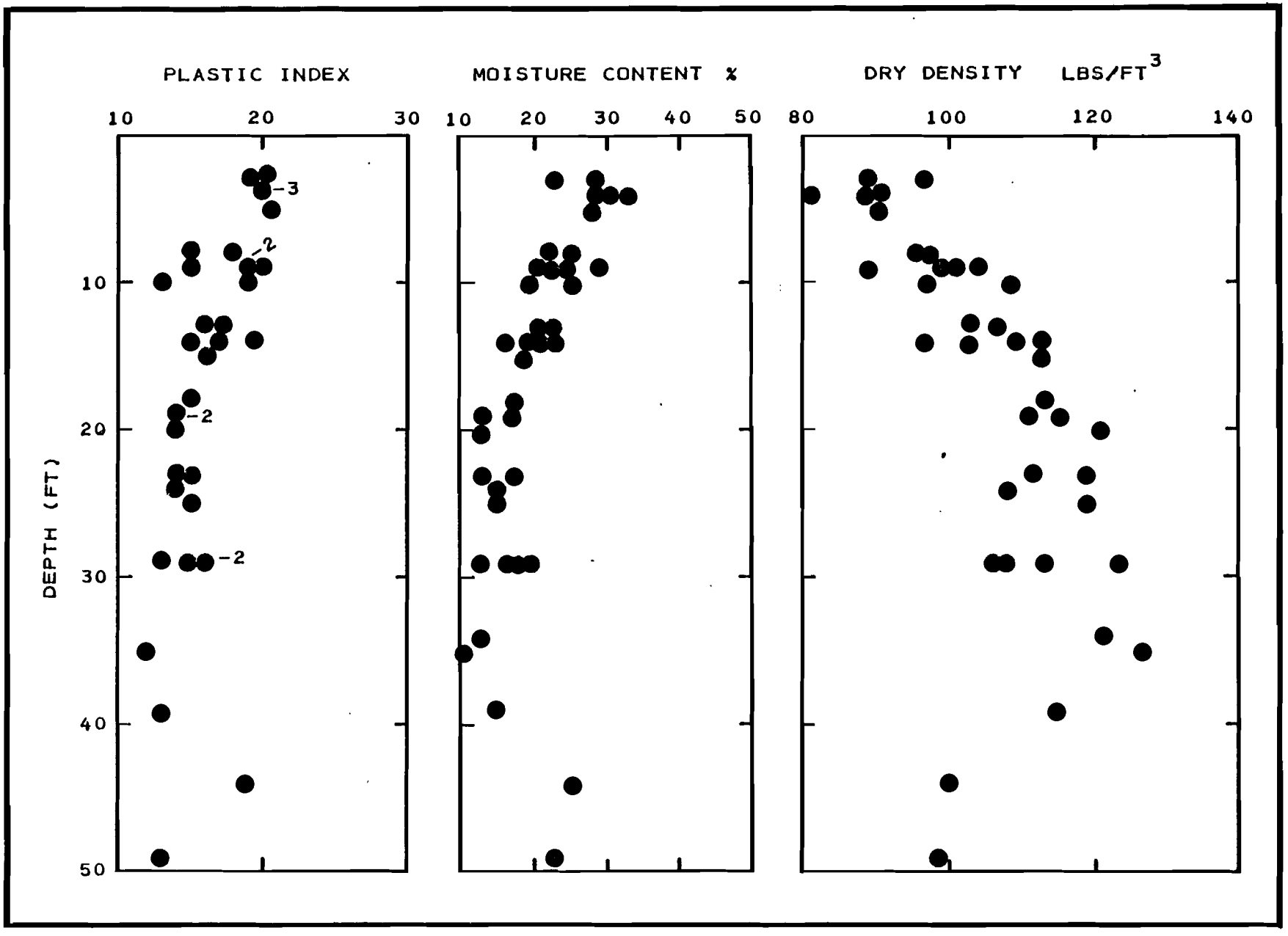


Figure 5-2. Characteristics of Selected Soil Samples, Site Z_1.

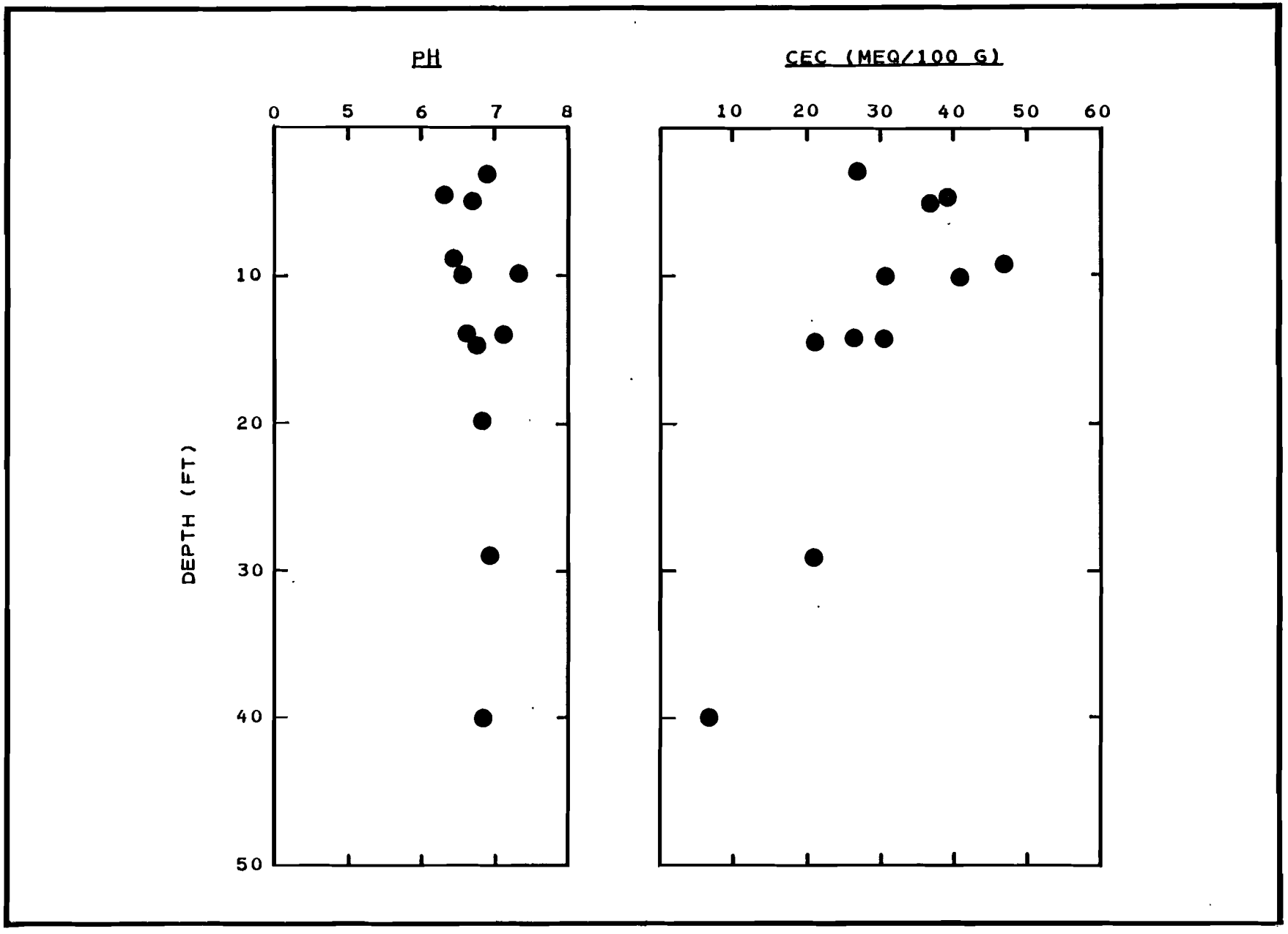


Figure 5-3. Soil pH and Cation Exchange Capacity as a Function of Depth, Site Z_1.

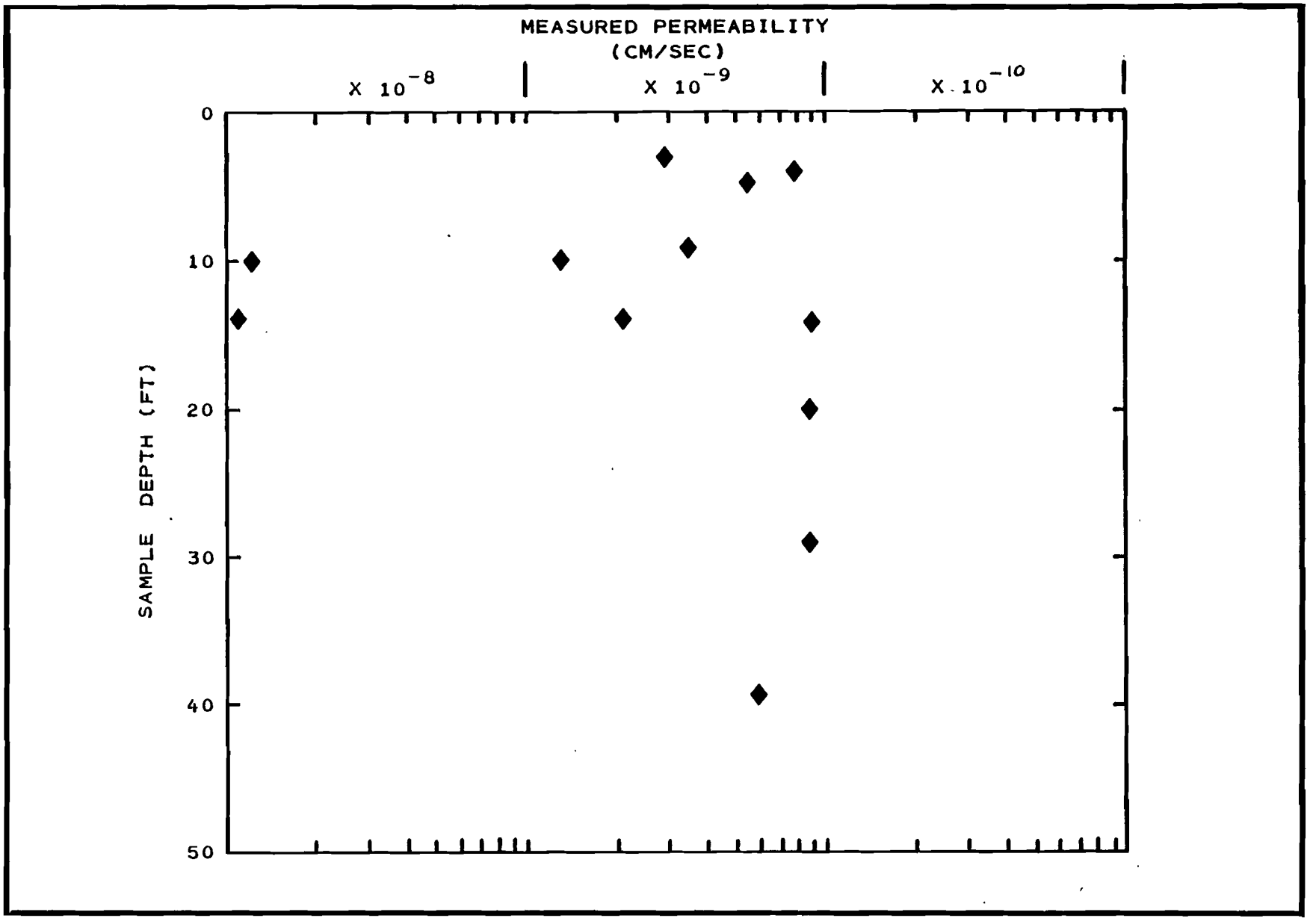


Figure 5-4. Permeability of Selected Soil Samples, Site Z_1.

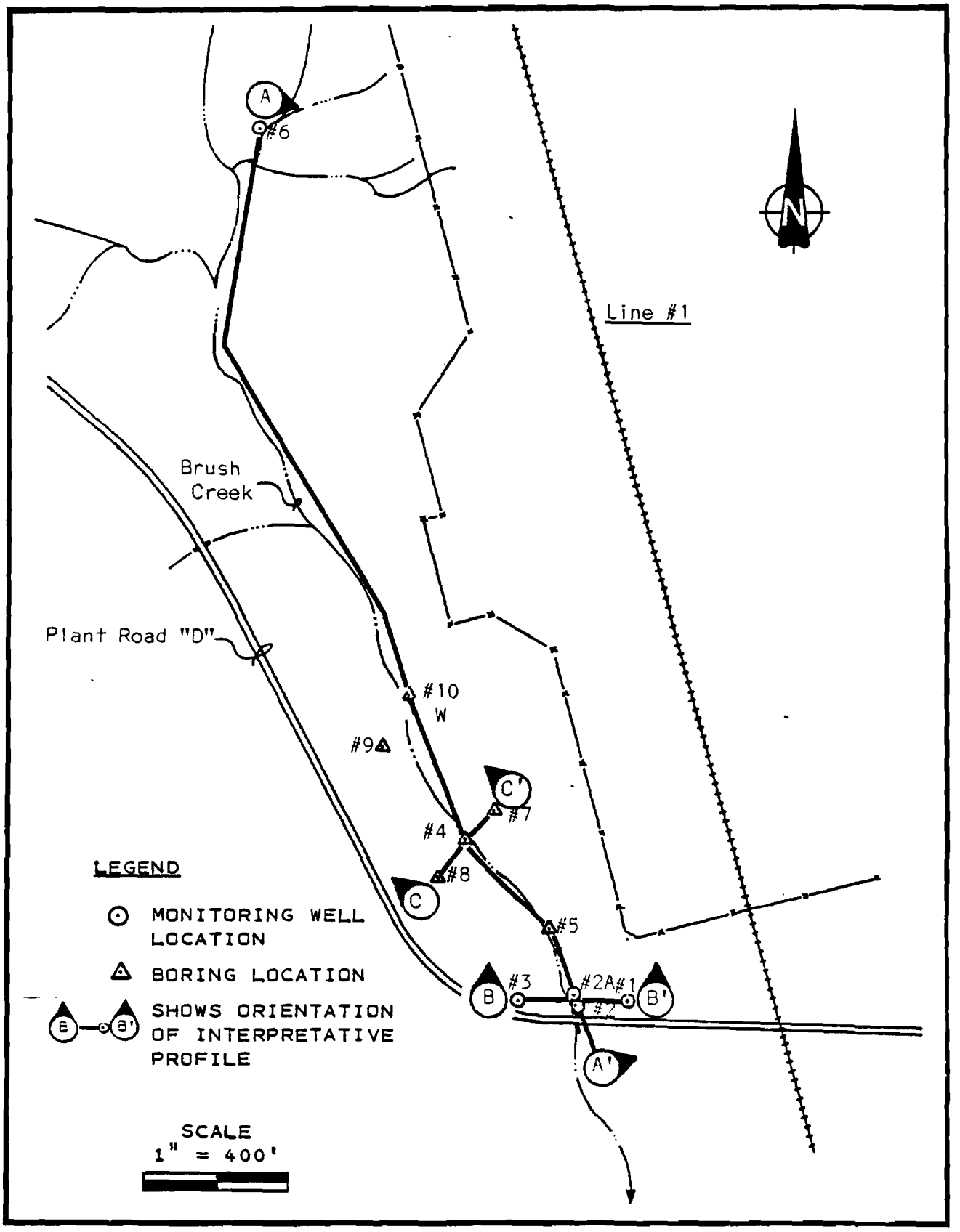


Figure 5-5. Interpretative Subsurface Profile Location Map, Site Z_1.

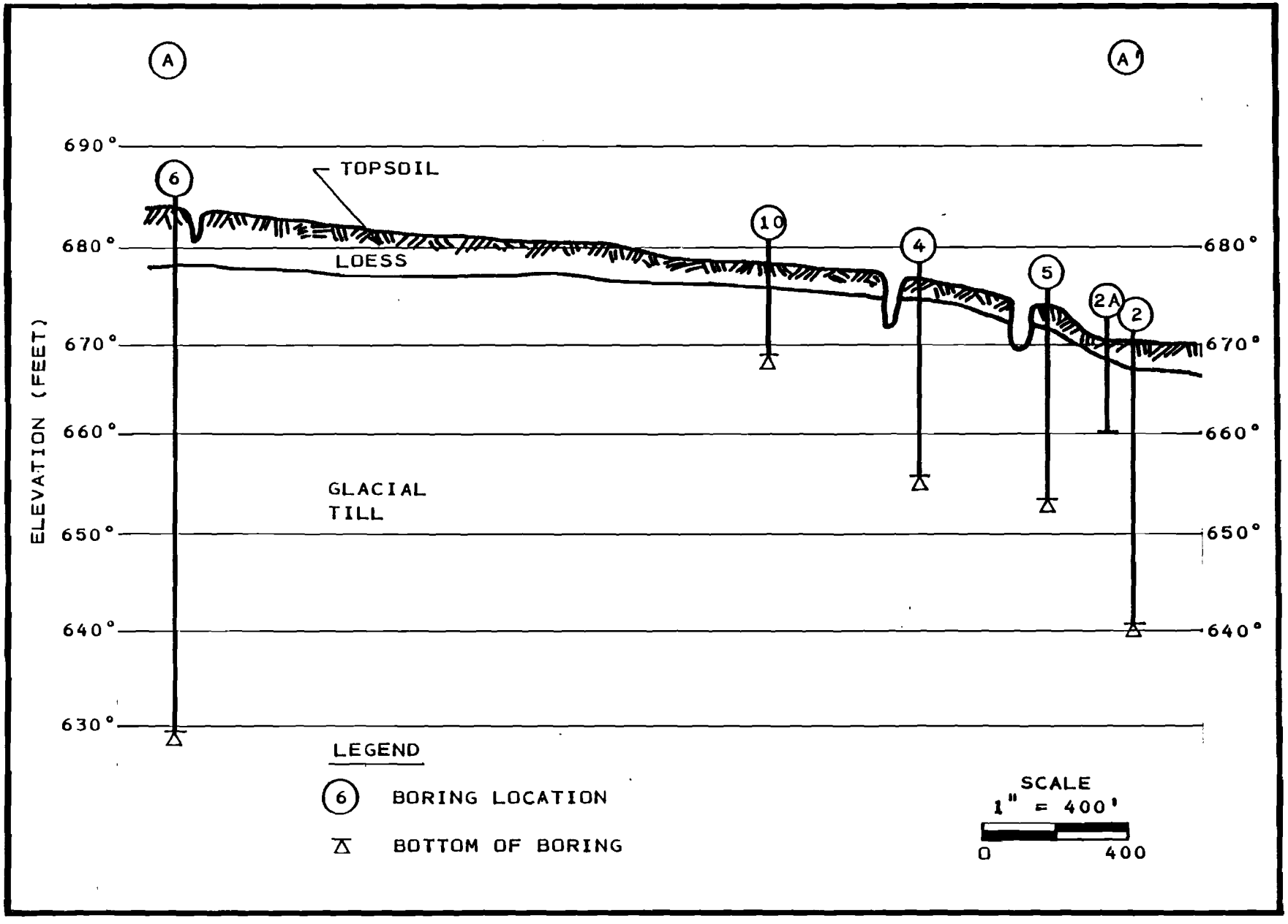


Figure 5-6. Interpretative Subsurface Profile, Site Z_1.

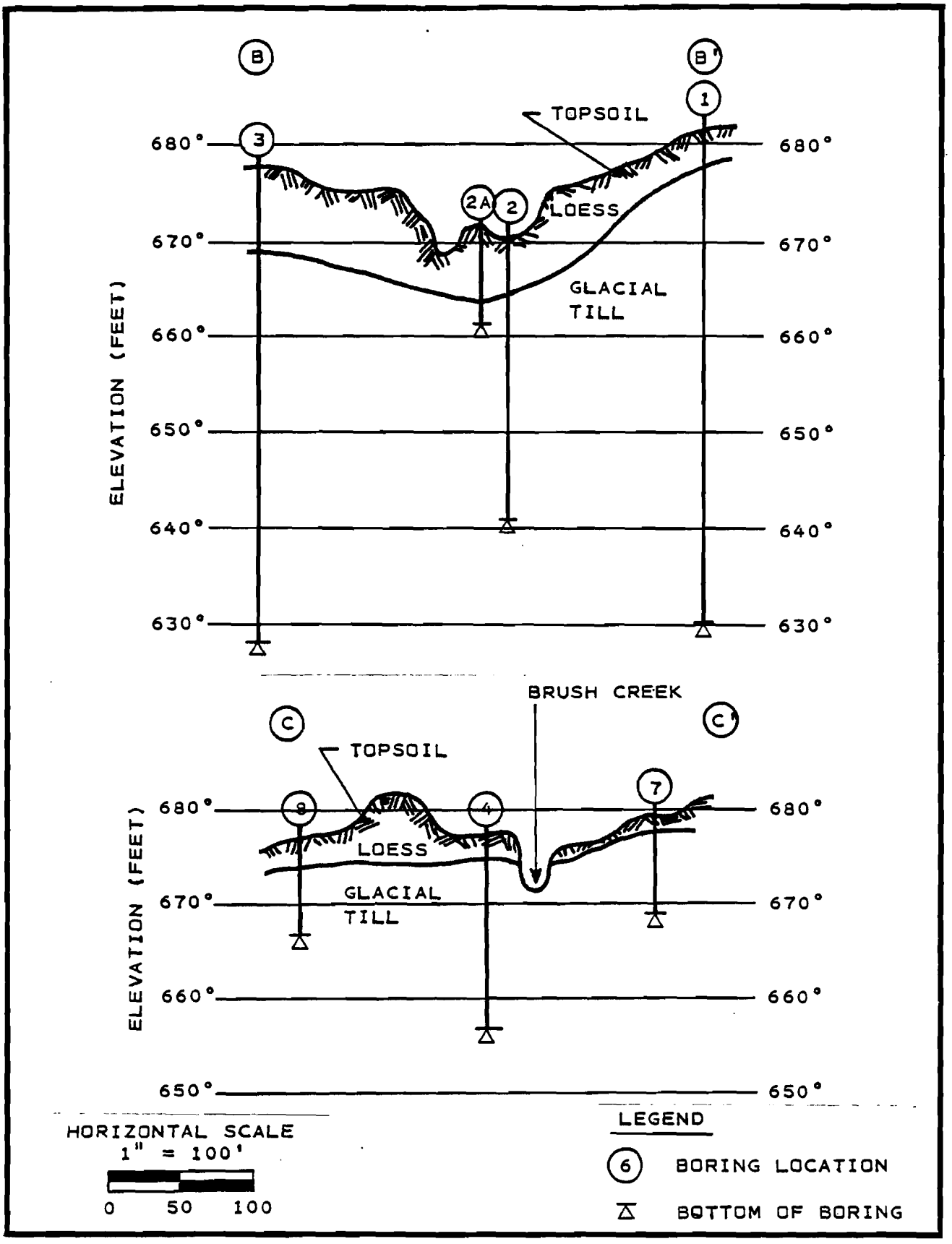


Figure 5-7. Interpretative Subsurface Profiles, Site Z_1.

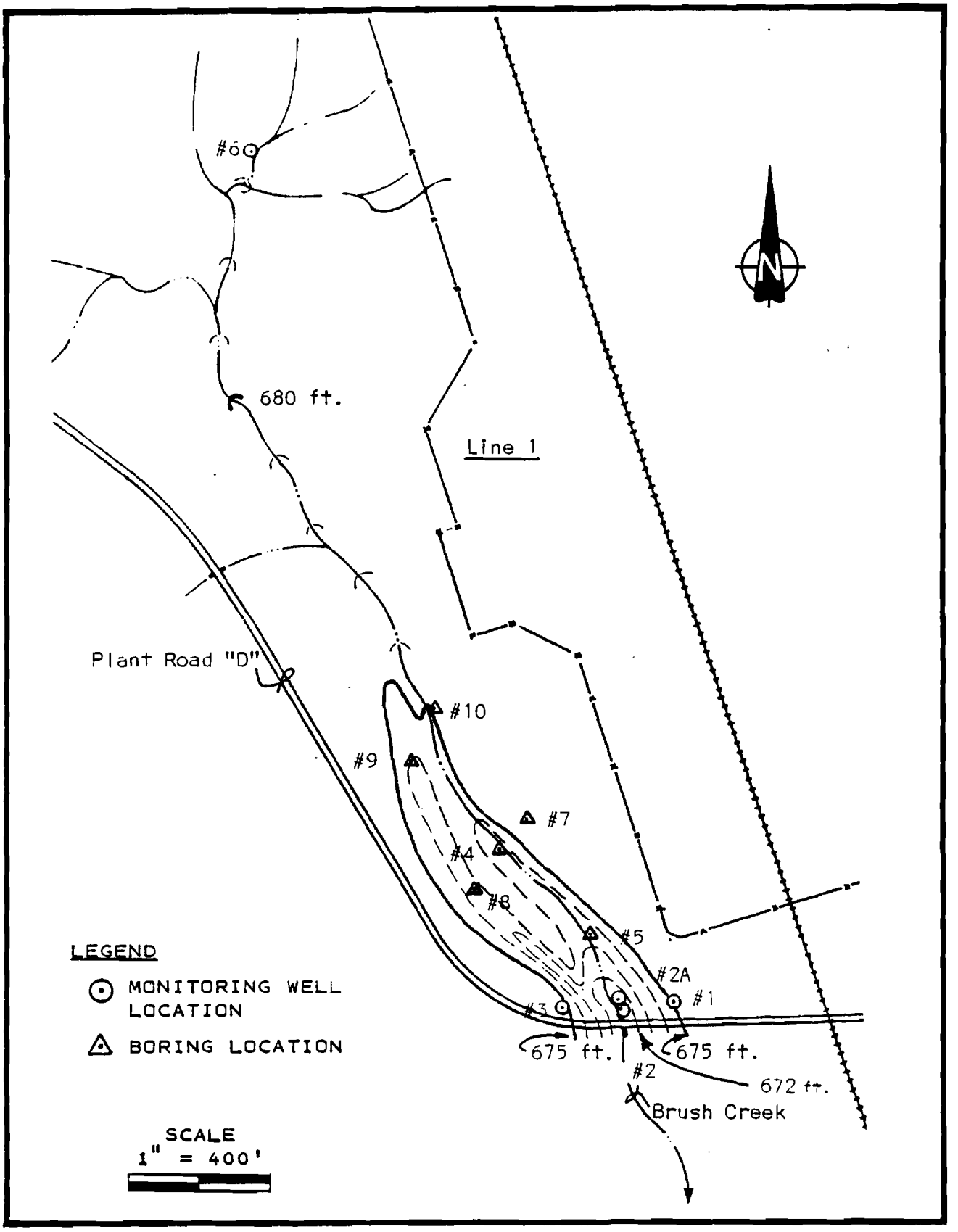


Figure 5-8. Ground Water Table Contour Map, Site Z_1.

is controlled by the site topography, and is convergent upon becoming parallel to Brush Creek. The ground water flow system is effluent in the vicinity of Site Z_1, as evidenced by the relatively steep upward vertical gradient at monitoring Well Nos. 2 and 2A, and the convergence of the water table equipotentials to the alignment of Brush Creek.

The average coefficient of permeability of the till soils at Site Z_1 is 6.3×10^{-9} cm/sec. The loess soils exhibit a similar average coefficient of 7.9×10^{-9} cm/sec. Thus, although the surficial aquifer discharges into Brush Creek under relatively steep gradients, the actual quantity and rate of discharge is relatively small due to the very low permeability of the soil materials.

The ground water flow patterns at Site Z_1 were determined subsequent to a period of anomalously high rainfall. However, since the ground slope around Site Z_1 is conducive to rapid runoff and the recharge effect of precipitation is reduced during the winter months due to frost, it appears likely that Brush Creek normally exists in an effluent condition. If the effluent or discharge condition is generally dominant, then it is unlikely that contaminants would migrate from the abandoned lagoon into the subsurface environment to any significant extent.

During operation of the lagoon, the apparently normal ground water discharge condition observed may have been reversed. If such a reversal occurred, its effects would be minimal with regard to contaminant migration. The postulated gradient reversal would cause the ponded pinkwater to enter the ground water system and flow away from the lagoon laterally and/or downward from the lagoon bottom, then parallel the creek. However, the reversal would be a local and short-term phenomenon. Ultimately, the normal discharge condition would either reestablish itself around and beneath the lagoon or the subsurface discharge from the lagoon would flow beyond the hydrologic influence of the lagoon and then discharge to Brush Creek, under the influence of the normal regime.

If the discharge condition is not generally dominant, then a subsurface contaminant plume not restricted to the immediate vicinity of the lagoon could have developed. Migration of any such plume would very likely parallel the valley containing Brush Creek and, to a large extent, be restricted to the alluvium. Assuming that hydrogeologic conditions permitted its development, the plume could have been either continuous or discontinuous depending on seasonal fluctuations of the ground water table level, pond level, and hydrogeologic regime. Further, as the presumed plume migrated downgradient, it would likely discharge to the stream channel.

Quality of Surface and Ground Waters

Concentrations of various constituents in the two surface water samples varied with sampling time and location (Tables 5-3 and 5-4). The water was strongly alkaline, and showed relatively high manganese concentrations that may be background levels. The high alkalinity may be due to discharges from upstream activities and/or localized limestone deposits. Concentrations of sodium, sulfate, and chloride increased with corresonding increases in conductivities in subsequent samplings. Major contaminants analyzed such as trace metals, organic chemicals, coliform bacteria, radioactivity, TNT, and RDX were generally not detectable.

Analytical data of ground water samples taken from the four monitoring wells in 3 consecutive days are shown with EPA ground water quality criteria in Tables 5-5 through 5-8. Overall, there is no evidence of ground water contamination from any of the samples analyzed. Concentrations of most of the constituents varied slightly with well locations and sampling time. However, chemical oxygen demand and total organic carbon levels fluctuated greatly over the three sampling dates.

Manganese concentrations in all water samples exceeded the maximum level of ground water quality criteria. This is indicative of high background levels of this metal.

RDX was detected in two samples from Well No. 2A, a downgradient well from the pinkwater lagoon. However, TNT was not detected. Further sampling is necessary to verify the presence of RDX in the ground water in this area. This well is relatively shallow, and provides samples of ground water from the uppermost portion of the water table including the alluvium.

Remedial Action and Site Closure Considerations

Investigation of the impacts of the abandoned pinkwater lagoon at Site Z_1 revealed the following:

- No significant ground water contamination was detected.
- No surface water contamination was detected.
- The site's hydrogeologic conditions are such that development of the subsurface contaminant plumes is unlikely. If plumes were to develop, they would be restricted to a shallow area in the valley containing Brush Creek.
- Significant quantities of explosives apparently remain in the sediments deposited during operation of the lagoon (U.S. AEHA, 1980).
- The contaminated sediments are subject to erosion and scour during periods of high stream flow.

TABLE 5-3. CHEMICAL ANALYSES OF SURFACE WATER SAMPLES TAKEN AT VARIOUS TIMES FROM STATION 1 OF SITE Z_1

Parameter	Sampling Date 12-18-80	1-15-81	1-29-81	Mean
Temperature, °C	-	4	5	4.5
pH	8.41	9.27	9.08	8.92
Conductivity, umhos/cm	575	875	1220	890
Turbidity, TU	0.4	1.9	0.3	0.9
	- - - - - - - - - - (mg/l) - - - - - - - - - -			
Cadmium	<0.001	<0.001	<0.001	<0.001
Chromium, Total	0.031	0.048	0.068	0.049
Iron	0.0470	0.219	0.115	0.127
Manganese	0.149	0.121	0.044	0.105
Lead	<0.005	<0.005	<0.005	<0.005
Silver	0.002	<0.001	<0.001	-
Barium	0.119	0.090	0.040	0.083
Chloride	48.0	106.0	300.0	151.3
Fluoride	0.360	1.38	1.72	1.15
Sulfate	99.0	219.0	188.0	168.7
Sodium	63.2	285.0	348.0	232.1
Arsenic	<0.005	<0.005	<0.005	<0.005
Selenium	<0.005	<0.005	<0.005	<0.005
Mercury	0.008	<0.0003	<0.0003	-
Nitrate-N	0.01	4.73	3.01	2.58
Chemical Oxygen Demand	48.0	71.6	12.0	43.9
Total Organic Carbon	<1.0	29.0	<1.0	-
Phenols	<0.01	<0.01	<0.01	<0.001
Endrin	<0.0002	<0.0002	<0.0002	<0.0002
Lindane	<0.001	<0.001	<0.001	<0.001
Methoxychlor	<0.01	<0.01	<0.01	<0.01
Toxaphene	<0.001	<0.001	<0.001	<0.001
2,4-D	<0.01	<0.01	<0.01	<0.01
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005
TNT	<0.005	<0.005	<0.005	<0.005
RDX	<0.011	<0.011	<0.011	<0.011
Coliform Bacteria, c/100 ml	N/D*	N/D	N/D	N/D
Radium, pCi/l	0.7±0.1	0.02±0.01	<0.06±0.01	-
Gross Alpha, pCi/l	1.9±1.8	0.8±1.7	0.6±0.5	-
Gross Beta, pCi/l	2.4±3.9	2.4±6.3	0.4±8.9	-

* Not detected.

TABLE 5-4. CHEMICAL ANALYSES OF SURFACE WATER SAMPLES TAKEN AT VARIOUS TIMES FROM STATION 2 OF SITE Z_1

Parameter	Sampling Date 12-18-80	1-15-81	1-29-81	Mean
Temperature, °C	-	4	4	4
pH	8.31	9.22	8.95	8.83
Conductivity, umhos/cm	625	875	3,750	1,750
Turbidity, TU	0.6	2.5	0.5	1.2
	- - - - - - - - - - - (mg/l) - - - - - - - - - - -			
Cadmium	<0.001	<0.001	<0.001	<0.001
Chromium, Total	0.037	0.056	0.057	0.050
Iron	0.277	0.269	<0.01	-
Manganese	0.168	0.122	0.109	0.133
Lead	<0.005	<0.005	<0.005	<0.005
Silver	<0.001	<0.001	<0.001	<0.001
Barium	0.121	0.090	<0.001	-
Chloride	65.5	102.5	700.0	289.3
Fluoride	0.21	1.89	1.66	1.25
Sulfate	128.0	203.0	204.0	178.3
Sodium	73.8	267.0	539.0	293.3
Arsenic	<0.005	<0.005	<0.005	<0.005
Selenium	<0.005	<0.005	<0.005	<0.005
Mercury	0.0008	<0.0003	<0.0003	-
Nitrate-N	6.24	4.87	2.94	4.68
Chemical Oxygen Demand	60.0	7.6	36.0	34.5
Total Organic Carbon	<1.0	12.0	12.0	-
Phenols	<0.01	<0.01	<0.01	<0.01
Endrin	<0.0002	<0.0002	<0.0002	<0.0002
Lindane	<0.001	<0.001	<0.001	<0.001
Methoxychlor	<0.01	<0.01	<0.01	<0.01
Toxaphene	<0.001	<0.001	<0.001	<0.001
2,4-D	<0.01	<0.01	<0.01	<0.01
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005
TNT	<0.005	<0.005	<0.005	<0.005
RDX	<0.011	<0.011	<0.011	<0.011
Coliform Bacteria, c/100 ml	56	N/D*	N/D	-
Radium, pCi/l	0.1±0.1	1.5±0.2	0.6±0.1	
Gross Alpha, pCi/l	0.3±0.9	1.4±2.0	1.1±3.1	
Gross Beta, pCi/l	5.6±5.3	6.5±6.5	<0.8±15.6	

* Not detected.

TABLE 5-5. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 1 OF SITE Z_1

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	9	9	7	8	
pH	7.55	7.48	7.28	7.43	6.5-8.5
Conductivity, umhos/cm	640	610	600	617	
Turbidity, TU	24	5.4	1.1	10.2	1
	- - - - - - - - - - - (mg/l) - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	0.007	0.038	0.040	0.028	0.05
Iron	3.042	3.042	0.088	1.157	0.3
Manganese	1.173	0.827	0.772	0.924	0.05
Lead	0.061	<0.005	<0.005	-	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.400	0.480	0.290	0.390	1
Chloride	5.0	4.0	3.5	4.2	250
Fluoride	0.62	0.59	0.60	0.60	1.4-2.4
Sulfate	91.0	34.0	54.0	59.7	250
Sodium	52.5	57.7	55.6	55.3	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.0005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.011	0.06	<0.01	-	10
Chemical Oxygen Demand	84.0	6.0	12.0	34.0	
Total Organic Carbon	28.0	<1.0	188.0	-	
Phenols	0.019	0.019	<0.01	-	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.001	0.004
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.001	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	N/D†	N/D	N/D	N/D	4
Radium, pCi/l	<0.02±0.01	1.1±0.2	<0.02±0.01	-	5
Gross Alpha, pCi/l	2.2±1.9	13.9±5.7	1.5±1.7	-	15
Gross Beta, pCi/l	3.4±3.7	8.0±5.3	2.0±3.8		

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not Detected.

TABLE 5-6. CHEMICAL ANALYSIS OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 2A OF SITE Z_1

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81*	Mean	Maximum Level†
Temperature, °C	9	3	8.5	6.8	
pH	7.25	7.54	7.27	7.35	6.5-8.5
Conductivity, umhos/cm	590	840	590	673	
Turbidity, TU	0.5	0.7	1.2	0.8	1
	- - - - - - - - - - - - (mg/l) - - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	0.013	<0.005	0.023	-	0.05
Iron	0.543	0.375	0.351	0.423	0.3
Manganese	1.075	0.510	0.737	0.774	0.05
Lead	0.140	0.011	<0.005	-	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.330	0.340	0.330	0.330	1
Chloride	4.0	34.0	5.5	14.5	250
Fluoride	0.57	0.22	0.58	0.46	1.4-2.4
Sulfate	24.0	178.0	22.0	74.7	250
Sodium	59.4	46.4	58.0	54.6	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	0.0017	<0.0003	-	0.002
Nitrate-N	0.21	0.28	0.79	0.43	10
Chemical Oxygen Demand	369.2	372.0	52.0	264.4	
Total Organic Carbon	60.0	8.0	202.0	90.0	
Phenols	<0.01	<0.01	<0.01	<0.01	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.001	0.001
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	0.445	0.030	<0.011	-	
Coliform Bacteria, c/100 ml	N/D#	N/D	N/D	N/D	4
Radium, pCi/l	0.5±0.1	-**	0.1±0.1	-	5
Gross Alpha, pCi/l	1.5±1.7	-	2.1±2.1	-	15
Gross Beta, pCi/l	6.1±4.6	-	0.6±4.0	-	

* The January 29, 1981, sample was taken from Well No. 2 because Well No. 2A did not recharge.
† EPA Ground Water Quality Criteria (EPA, 1979).
\# Not detected.
** Insufficient sample.

TABLE 5-7. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 3 OF SITE Z_1

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	8	8	7	7.6	
pH	7.24	7.26	7.28	7.2	6.5-8.5
Conductivity, umhos/cm	750	740	730	740	
Turbidity, TU	0.7	0.7	1.8	1.1	1
	- - - - - - - - - - - -		-(mg/l)-	- - - - - - - - - - - -	
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	0.014	0.035	0.038	0.029	0.05
Iron	2.276	0.179	0.175	0.877	0.3
Manganese	0.308	0.209	0.108	0.208	0.05
Lead	0.053	<0.005	<0.005	-	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.320	0.320	0.300	0.310	1
Chloride	4.0	5.0	4.5	4.5	250
Fluoride	0.44	0.43	0.45	0.44	1.4-2.4
Sulfate	9.0	8.0	5.0	7.3	250
Sodium	61.4	61.2	60.5	61.0	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.03	0.11	0.14	0.09	10
Chemical Oxygen Demand	76.0	4.0	4.0	28.0	
Total Organic Carbon	37.0	2.0	591.0	210.0	
Phenols	<0.01	<0.01	<0.01	<0.01	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.01	0.004
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	N/D†	2	N/D	-	4
Radium, pCi/l	0.5±0.1	0.5±0.1	<0.02±0.01	-	5
Gross Alpha, pCi/l	0.2±0.5	1.3±1.8	0.2±0.6	-	15
Gross Beta, pCi/l	5.1±4.9	<0.2±4.7	0.9±3.1	-	

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not detected.

TABLE 5-8. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 6 OF SITE Z_1

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	7	6.5	6.5	6.7	
pH	7.23	7.21	7.22	7.22	6.5-8.5
Conductivity, umhos/cm	800	810	820	810	
Turbidity, TU	7.8	2.3	1.1	3.7	
	- - - - - - - - - - - - (mg/l) - - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	0.012	<0.005	0.034	-	0.05
Iron	0.100	1.023	0.133	0.419	0.3
Manganese	1.211	1.046	0.992	1.083	0.05
Lead	<0.005	0.110	<0.005	-	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	1.300	0.150	0.230	0.560	1
Chloride	5.0	7.0	5.5	5.8	250
Fluoride	0.52	0.47	0.51	0.50	1.4-2.4
Sulfate	19.0	12.0	12.0	14.3	250
Sodium	68.6	72.7	68.2	69.8	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.03	0.14	0.07	0.08	10
Chemical Oxygen Demand	32.0	4.0	8.0	14.7	
Total Organic Carbon	42.0	<1.0	115.0	-	
Phenols	<0.01	<0.01	<0.01	<0.01	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.001	0.004
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	4	N/D*	N/D	-	4
Radium, pCi/l	1.1±0.2	0.8±0.1	0.8±0.1	-	5
Gross Alpha, pCi/l	0.4±1.0	0.6±1.2	0.9±1.6	-	15
Gross Beta, pCi/l	0.2±4.4	16.1±6.3	3.0±6.2	-	

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not detected.

As such, remedial action to mitigate existing ground water contamination does not appear to be a consideration at Site Z_1. However, it will be necessary to close the site in an environmentally sound manner. The following factors will need to be addressed in closing the site:

- The presence of sediments contaminated with explosives.
- The sediments are subject to erosion and transport by Brush Creek.
- The fate of the contaminated sediments already transported downstream by Brush Creek.

It is also pertinent to note that:

- The abandoned lagoon is bisected by Brush Creek.
- The ground water table is at a very shallow depth.
- Prior to installation of the lagoon, high-volume discharges from Line 1 to Brush Creek caused ground water contamination to the south of the IAAP. Several private water supply wells were affected. This occurrence is evidence that Brush Creek provides recharge to a potentially usable aquifer at some location downstream from Site Z_1.

In view of the foregoing considerations, it appears that the present and future environmental impact of the abandoned pink-water lagoon is limited to:

- Erosion and siltation problems during periods of high runoff.
- The existence of explosive-contaminated sediments at the site.
- Transport of explosive-contaminated sediments downstream to a location where the potential for their entrance to the ground water table is considerably more likely than at Site Z_1.

As the site presently exists, it is likely that erosion and transport of explosive-contaminated sediments will continue unless action is taken to prevent erosion. Amelioration of this condition is one of the primary objectives of the site closure plan.

Two possible closure scenarios exist:

- In-situ closure option - The site could be stabilized to prevent future erosion of contaminated sediments, provided with final cover and runoff control features,

revegetated, and maintained as a closed land disposal site.

- Removal option - The explosive contaminated sediments could be desensitized, removed from the site, and placed in an approved land disposal area. The site could be regraded and revegetated. Maintenance would be required until the vegetation is established, and long-term monitoring would not be required.

The specific features and required work elements for each of these scenarios are presented in Tables 5-9 and 5-10. Preliminary cost estimates for closure construction are given in DD Form 1391 (Appendix F). It is recommended that the removal option be implemented since it affords a greater degree of environmental protection, and is considerably more acceptable from a regulatory standpoint.

It is not possible to detail the final topographic configuration of Site Z_1 (i.e., subsequent to removal of the contaminated sediments and regrading) until additional subsurface investigations are completed. The purpose of these investigations is to clearly define the depth and areal extent of the explosive-contaminated sediments and thus delineate the limits of excavation required for their removal. This investigation can be accomplished most expeditiously by means of shallow test pits and/or hand auger borings. The area suspected to contain the contaminated sediments should be gridded, and the extent of the sediments should be determined at a number of sections perpendicular to the long axis of the site. The estimated limits of the abandoned pinkwater lagoon, as shown in Figure 5-1, provide a basis for initiation of the investigation. The area of the high flow impoundment and the channel of Brush Creek should be included in this investigation. The borings and/or test pits should be logged in the field, and selected samples analyzed for TNT and RDX. It is anticipated that the contaminated sediments will be readily discernable on the basis of visual examination. They are considerably darker in color than the natural soils due to the presence of coal fragments. They also exhibit small-scale bedding features not typical of the loess and till deposits. These features, however, are present in the alluvium; thus, the color variations are an important criterion.

Since the actual concentration of explosives contained in the sediments varies in an unpredictable manner and since the overall explosive concentration will determine the need for their desensitization the recommended investigation should include the following specific components:

- The samples obtained for TNT and RDX analyses should be distributed to be representative of the entire deposit of

TABLE 5-9. FEATURES OF IN-SITU CLOSURE OPTION, SITE Z_1

Feature	Work Element
Desensitization of Explosives	• Flash on-site if considered safe when site is dry.
Surface Water Control	
Permanent	• Channelize Brush Creek. • Install perimeter diversionary ditches.
Temporary	• Install and maintain sedimentation basin to control siltation during construction.
Cover Disposal Site	• Grub site. • Grade site. • Borrow and transport cover material to site. • Place, grade, and compact cover material. • Borrow, transport, place, and grade topsoil. • Revegetate site.
Maintain Site	• Regrade slopes/cover. • Revegetate slopes/cover.
Monitoring Requirements	• Ground water monitoring. • Surface water monitoring.
Engineering Studies	• Define actual limits of the contaminated sediments. • Conduct detailed topographic survey. • Identify and test borrow source for cover and loam. • Prepare construction plans and specifications.

TABLE 5-10. FEATURES OF REMOVAL OPTION, SITE Z_1

Feature	Work Element
Densensitization of Explosives	• Flash on-site or on a burning ground, depending on content of explosives in sediment.
Removal of Desensitized Sediments	• Remove and haul burned residue to approved disposal site. • Dispose of burned residue.
Surface Water Control	• Construct and maintain sedimentation basin during construction period.
Site Grading	• Regrade disturbed areas. • Borrow, transport, and place loam in disturbed areas. • Revegetate site.
Maintain Site	• Regrade and seed as required.
Monitoring Requirements	• None long-term.
Engineering Studies	• Define actual limits of the contaminated sediments. • Identify borrow source for loam. • Prepare plans and specifications. • Identify disposal site.

pinkwater lagoon sediments. Thus, an appropriate sampling procedure should be utilized. One such procedure would consist of:

- Excavation of a test pit at each sampling location to reveal the depth of pinkwater lagoon sediments
- Excavation of a small vertical trench of regular dimensions in the test pit sidewall, and placement of this material on a quartering canvas
- Thorough mechanical mixing of the bulk sample
- Reduction of the sample size by quartering.

- Additional samples from below the sediment zone should be obtained to permit assessment of small-scale leaching of contaminants into the underlying natural soils. Several sample locations should be selected during completion of the investigation, and a series of samples obtained from below the pinkwater lagoon sediments. Sample depths of 0.5, 1, 1.5, and 2 ft are recommended. If deeper samples are required, the thin wall samples obtained during completion of this current investigation should suffice.
- If hand auger explorations are used in lieu of test pits, analogous sampling procedures should be utilized.

The site's hydrogeologic conditions are such that substantial downward movement of contaminants is not anticipated.

The recommended investigation will define the area to be excavated and the depth of overexcavation required. The explosive contaminated material should be desensitized and disposed of in a secure landfill.

From a regulatory standpoint, the removal option is more favorable than the in-situ closure option. It is apparent that the site does not meet the Iowa siting requirements for solid waste disposal sites. (Iowa hazardous waste disposal site requirements have not been finalized as of August 1981; however, they are expected to be more restrictive than the solid waste disposal site requirements presented.)

It is further recommended that a study be implemented to determine whether or not the erosion and transport of explosive contaminated sediments in the past has resulted in the deposition of explosive-contaminated alluvium along Brush Creek downstream from Site Z_1. It is possible that this material has been widely dispersed. However, it is also possible that deposits containing significant concentrations of these explosives exist. Thus, a reconnaissance level study of Brush Creek, including sampling and analysis of sediment, between Site Z_1 and its confluence with the Skunk/Mississippi River system is warranted. The findings of

this preliminary study will determine the need for additional investigatory and/or remedial work.

SITE Z_2 - DETONATOR LINE 6

Site Z_2 encompasses the possible area of contamination that may have occurred during the operation of the wet sump/filter bed waste processing/disposal facilities used to treat and dispose of effluent from Detonator Line 6.

Topography

The site slopes in a generally south-southeasterly direction. The elevation ranges from approximately 723 ft at the north end of the site to about 698 ft at the south end (Figure 4-2). Portions of the study area are leased for use as crop land, but most of the area within the Line 6 perimeter fence is covered with native grassy vegetation.

Man-made drainage ways to collect runoff from the northern portion of the study area connect to several natural intermittent grassed waterways at the south end of the site. In areas of particularly low gradient, water rush and cattail-type stands are found with occasional scrublike deciduous trees. During completion of this study, standing water was normally observed in a number of the drainage ditches at the north end and central portions of the site (north of Borings 5, 14, and 16).

Use History

Detonators are manufactured at Line 6. Effluent containing excess and scrap explosives and other waste material which has contacted explosives is placed in one of several sumps for periodic desensitization prior to disposal. This effluent is hand-carried to the sumps by Line 6 personnel. Secondary wash water is also routed to the sumps by means of troughs or metal gutters. The desensitization sumps are subterranean metal containers (generally stainless steel) used for both storage and chemical treatment of the explosive waste material. Treated wastes are pumped into leach beds (shallow dry wells) for discharge to the subsurface. The locations of the sumps and leach beds are shown in Figure 5-9; their pertinent construction features are shown in Figure 5-10.

Operation of Line 6 began in 1941. Production rates have varied considerably, with the highest production in recent years coinciding with the Vietnam conflict. It is assumed that high production rates were also associated with the Korean conflict and World War II. No records of waste generation and discharge quantities are available.

Currently, there are a total of 11 sumps that discharge into seven leach beds. The characteristics of the sumps and their reported usage are summarized in Table 5-11. The future use of

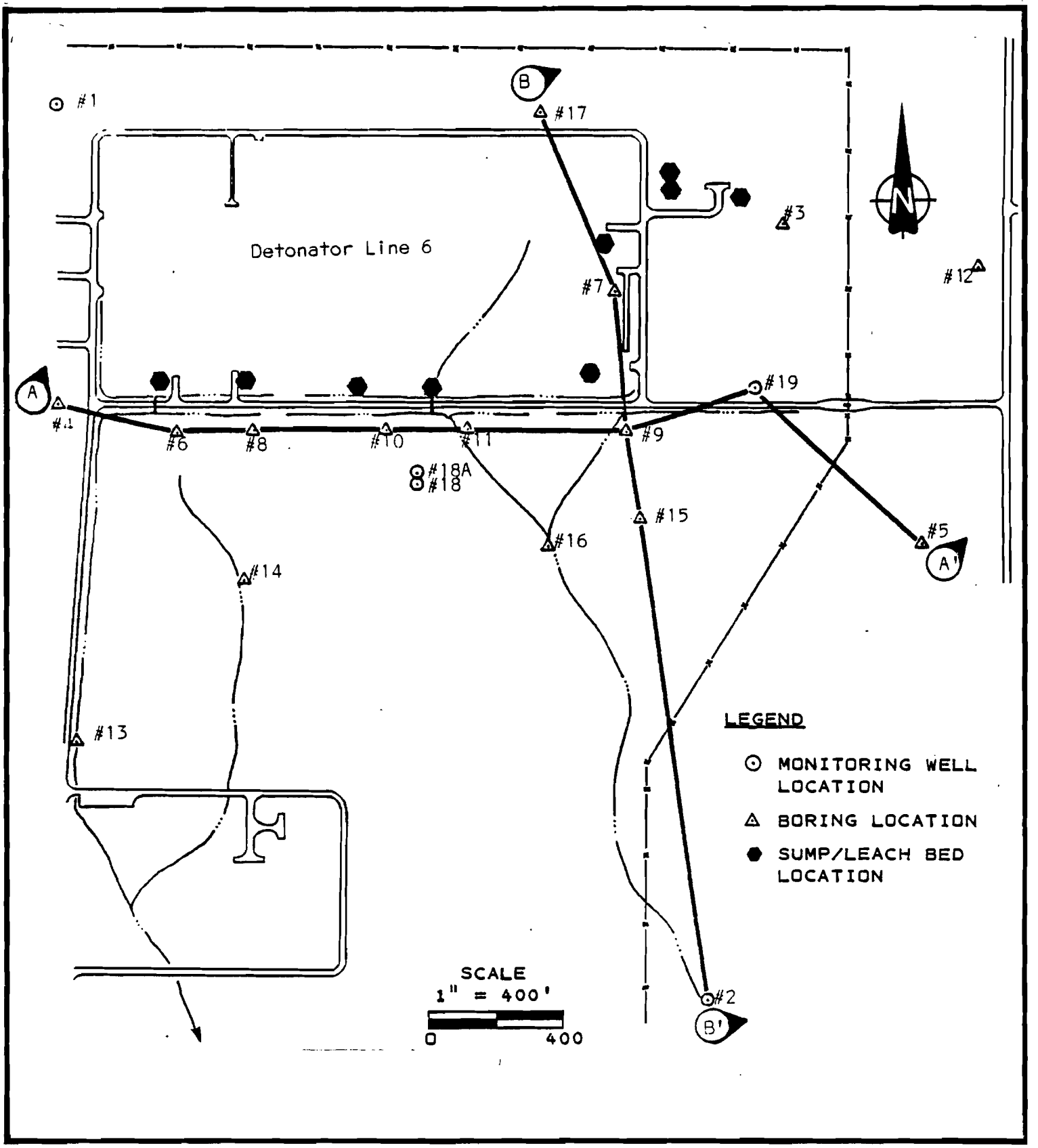


Figure 5-9. Site Z_2, Exploration Location Plan.

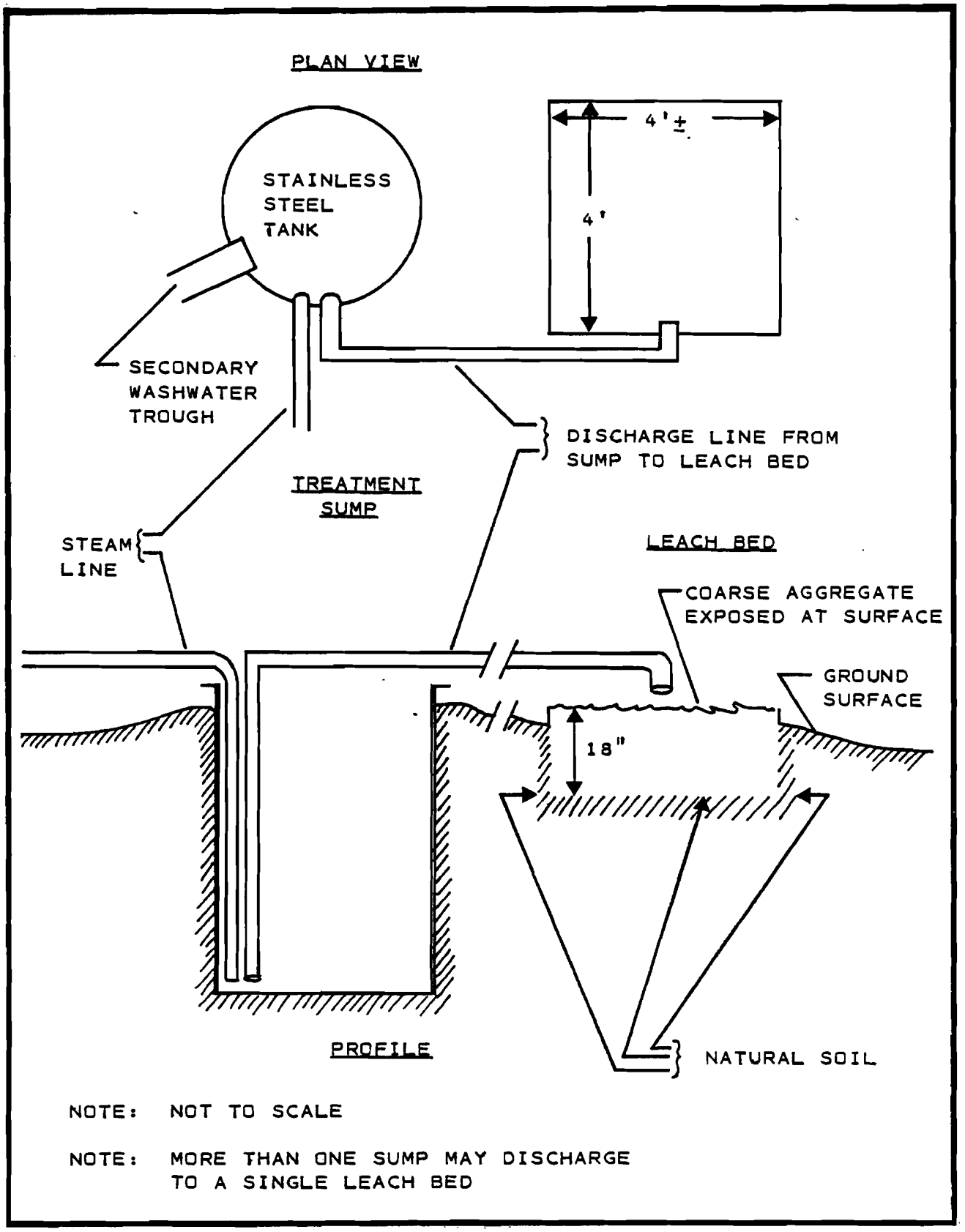


Figure 5-10. Schematic Portrayal of Treatment Sump Leach Bed.

TABLE 5-11. LINE 6 WASTE TREATMENT/DISPOSAL FACILITY, SITE Z_2

Site†	Number of Sumps	Volume (gal/sump)	Use* Peak# (gal/yr)	Use* Current** (gal/yr)	Comments
6-18	1	-	-	-	Old facility, date of last use not known, but before 1963
6-25	3	300	0	0	Built for laboratory use, apparently never used
6-35	1		-	-	See note for 6-18 above
6-68	2	900	46,800	10,800	None
6-88	2	900	93,600	0	Not used since 1975
6-89	2	900	164,250	4,500	None

* Table based on interviews with IAAP production staff and their estimates.

† IAAP designation.

During Vietnam conflict, earlier information not available.

** 1975 and subsequent years.

Line 6 is uncertain. The waste treatment and disposal activities presently carried out at Line 6 will likely be replaced by the Detonator Assembly Line 4A facilities currently under construction at Site Z_3.

Waste Characterization

The primary waste stream is related to the manufacture of detonators and potentially includes:

- Lead azide.
- Lead styphnate.
- RDX.
- Fulminate of mercury.
- Tetrazine.
- Barium nitrate.
- Antimony sulphate.

The proportions of these materials have been variable throughout the history of the facility, depending on the product being manufactured. For the past few years, the primary waste has been lead azide. Materials introduced into the waste stream during the treatment process include:

- Acetic acid.
- Sodium nitrite.
- Sodium sulfate.

The characteristics of the wastewater discharge probably varies significantly from sump to sump according to Line 6 production rates and products. The composition of the present day discharge is based primarily on relatively small quantities of lead azide which have been highly diluted with desensitization chemicals. However, in the past, a variety of explosives in substantially greater volumes contributed to the composition of the wastewater.

Two desensitized waste effluent samples were obtained from desensitized sumps for hazardous waste characterization. The effluent is not ignitable, corrosive, or reactive (Table 5-12), or hazardous based on EP toxicity testing (Table 5-13). Note that the effluent collected from Line 6 may not be representative of that generated in past years due to low effluent volumes resulting from reduced operations. The AEHA data suggest that the waste residue in the leach beds may contain high concentrations of several metals, including lead and barium (U.S. AEHA, 1980).

TABLE 5-12. RESULTS OF IGNITABILITY, CORROSIVITY, AND REACTIVITY TESTS FOR TWO EFFLUENT SAMPLES FROM SITE Z_2

Test	"E" Sump	"W" Sump	Selected RCRA* Criterion
Ignitability (Flash Point, °C)	>82	>82	<60
Corrosivity (pH)	8.84	8.21	≤ 2 to ≥ 12.5
Reactivity	N/D†	N/D	Reacts violently with water

* Federal Register, May 19, 1980. pp. 33121-33122 (EPA, 1980).

† Not detected.

TABLE 5-13. RESULTS OF EP TOXICITY TESTS FOR TWO EFFLUENT SAMPLES TAKEN FROM SITE Z_2

Parameter	"E" Sump	"W" Sump	Maximum Contaminant Level*
	(mg/l)		
Arsenic	<0.005	<0.005	5.0
Barium	0.194	0.009	100.0
Cadmium	<0.001	<0.001	1.0
Chromium	<0.01	0.013	5.0
Lead	0.070	0.050	5.0
Mercury	<0.0003	<0.0003	0.2
Selenium	<0.005	<0.005	1.0
Silver	<0.001	<0.001	5.0
Endrin	<0.0002	<0.0002	0.02
Lindane	<0.001	<0.001	0.4
Methoxychlor	<0.01	<0.01	10.0
Toxaphene	<0.001	<0.001	0.5
2,4-D	<0.01	<0.01	10.0
2,4,5-TP Silvex	<0.005	<0.005	1.0

* Federal Register, May 19, 1980. p. 33122 (EPA, 1980).

Treatment and Disposal Practices

The wastewater is stored at the sumps until it is desensitized. The process involves the following elements:

- Five gallons of acetic acid are added to the sump.
- Eight 1-quart scoops of sodium nitrite and 6 quart scoops of sodium sulfate are then added.
- The mixture is charged with steam, and boiled for at least 3 hours.
- The residue is tested to determine if it is completely desensitized (nonexplosive). If not, it is subjected to additional boiling and then retested. If the solution is desensitized, it is discharged into the leach bed.

The waste solution is pumped from the sump into a small, shallow leach bed nearby. As sludge builds up in the sump, it is removed and disposed of at the IAAP landfill. The leach beds are approximately 4 ft square at the surface, and comprised of coarse aggregate approximately 18 in deep (exposed at the surface). Examination of these structures revealed that they probably overflow when sumps are emptied into them. They were observed to overflow as a result of precipitation entering them. Earlier, the AEHA conducted an investigation at the Line 6 facility (U.S. AEHA, 1980).

Subsurface Conditions

Results of the explorations revealed that the site is underlain by loess and till soils. The loess forms a surficial layer blanketing the till to depths ranging from 8 to 17 ft. The physical properties of these units are summarized in Figures 5-11 through 5-13. Grain size distribution analyses were completed on selected samples; the results are presented graphically in Appendix C.

The glacial till consists of a brown to grey, medium to hard (generally stiff to very stiff) sandy silty clay with occasional sand seams interspersed.

The loess soil consists of a brown becoming grey, medium to stiff silty clay with a trace of sand grading upward to a dark brown clayey silty loam at the surface.

These units are generally separated by a distinct color change like that usually associated with chemical weathering. The actual thickness of the till unit is unknown. It is expected to be relatively thick (estimated to be in excess of 50 ft) in the vicinity of Site Z_2. Detailed logs of all explorations are presented in Appendix C. The vertical distribution of the loess and till units is shown on the interpretative subsurface profiles

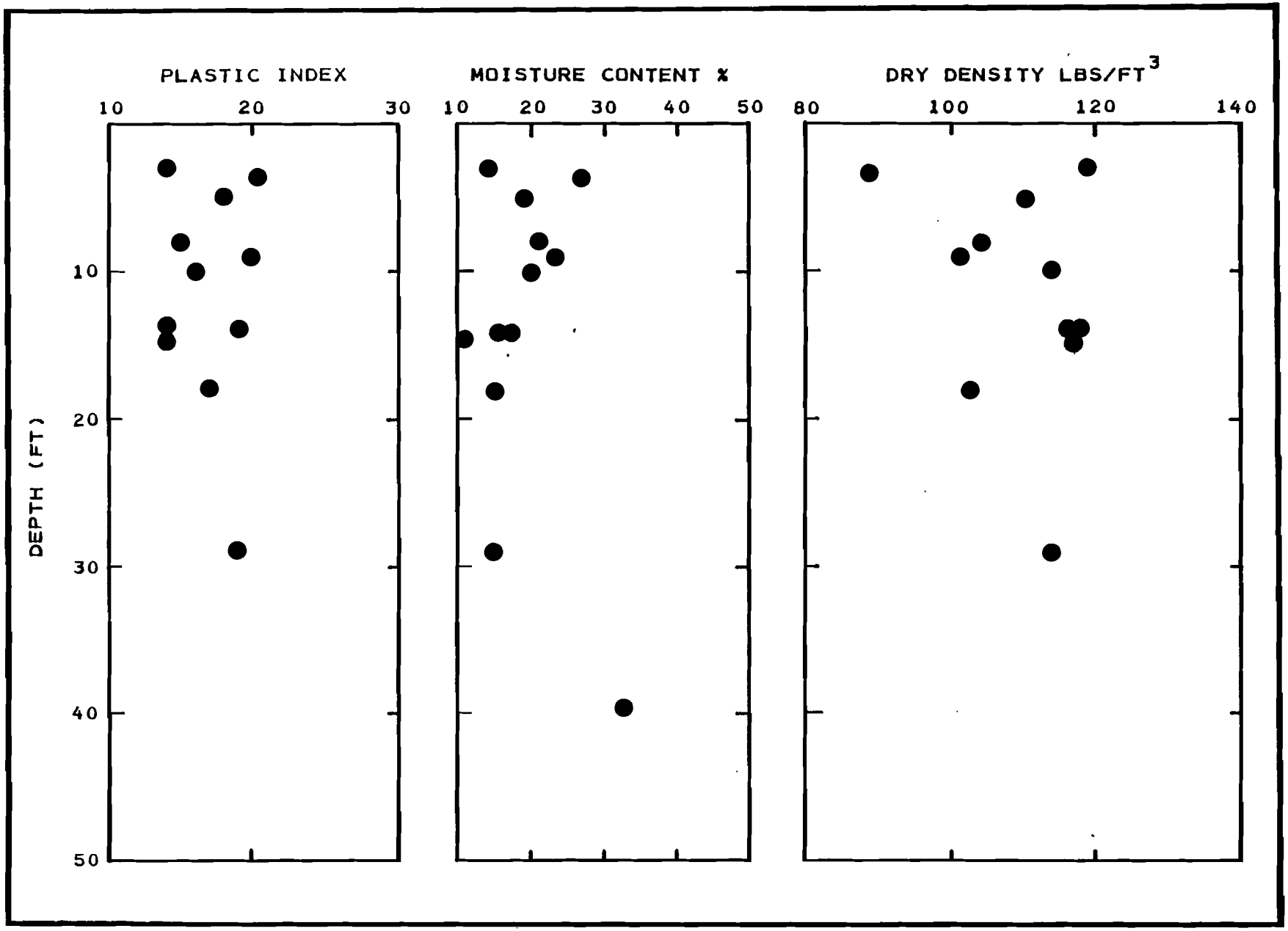


Figure 5-11. Characteristics of Selected Soil Samples, Site Z_2.

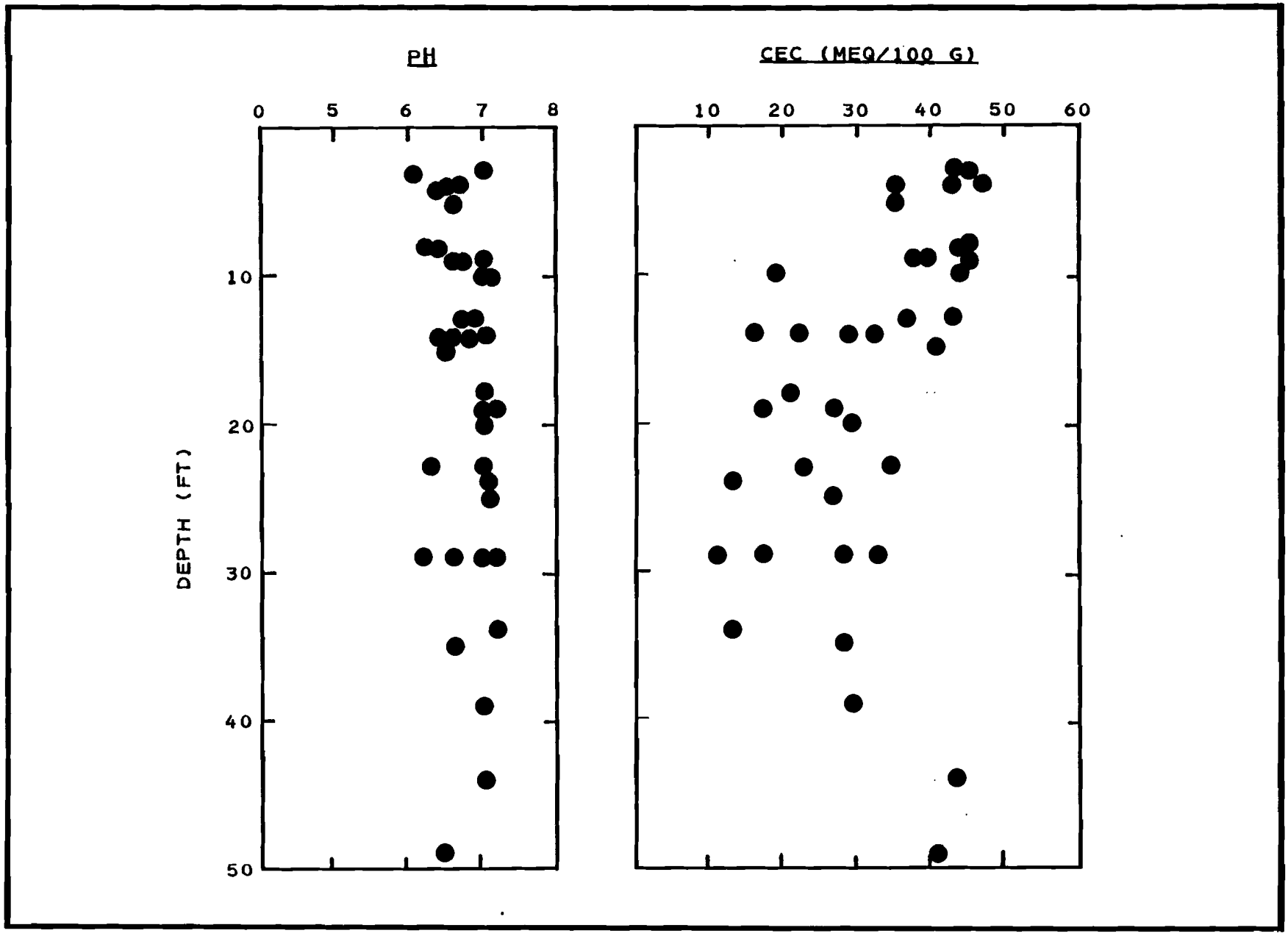


Figure 5-12. Soil pH and Cation Exchange Capacity as a Function of Depth, Site Z_2.

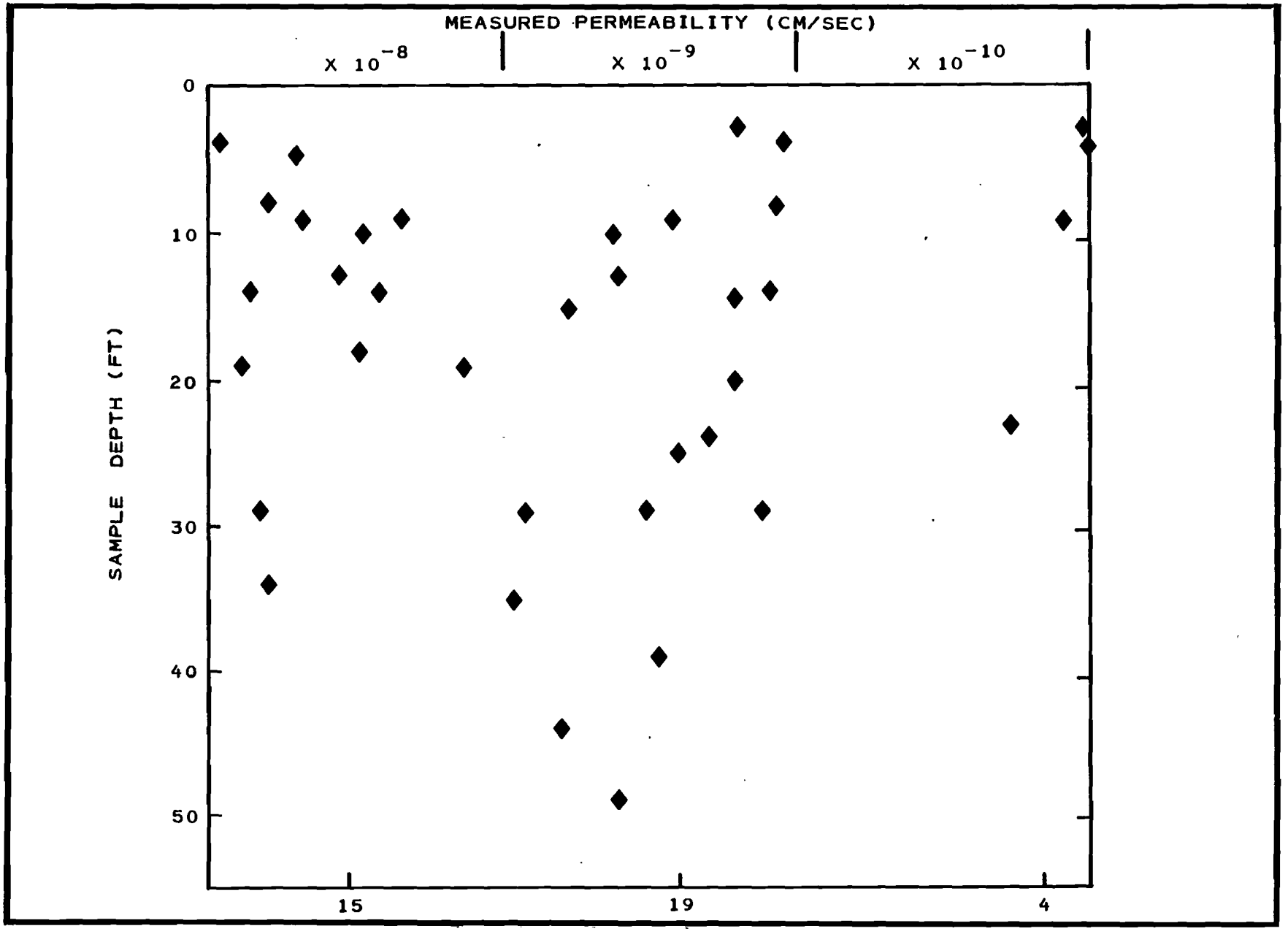


Figure 5-13. Permeability of Selected Soil Samples, Site Z_2.

(Figures 5-14 and 5-15). The locations of these profiles is shown on Figure 5-9.

Hydrogeologic Conditions

Ground water levels were measured in the exploratory borings and monitoring wells. The water levels in the borings were allowed to stabilize prior to grout sealing of the boreholes. The monitoring wells provide for long-term ground water level monitoring. Stabilized ground water levels were measured three times during this investigation, on November 26 and December 3, 1980, and on January 6, 1981.

Interpretative potentiometric surface contour maps were prepared, based on these three sets of data, and are presented as Figures 5-16 through 5-18. In all three cases, the ground water flow pattern paralleled the land surface topography by exhibiting a general gradient towards the south. Although the hydraulic gradient varied with time and location, it averaged approximately 1 ft per 100 ft at Site Z_2.

The variations in water table elevations in the central portions of the site (i.e., in the vicinity of Borings B-10 and B-11) are anomalous. The three hydrogeologic maps depict the development of a distinct water table mound in this area. The mound appears to be related to preferential ground water recharge, which is likely the result of surface water ponding. The surficial drainage pattern is poorly developed in this area, and considerable ponding was observed during this study. The possibility that this mound formed as a result of leakage from a water or steam line was considered. However, no such subterranean structure is known to exist in this area. Overall, the three hydrogeologic maps depict a slight decline in water table elevation between November and December, and a moderate but general rise in water table in December and January attributable to recharge in response to unseasonably warm weather, high precipitation, and poor surficial runoff. The general vicinity of Site Z_2 must be considered as a ground water recharge area, but vertical gradients in the upper 30 ft of the soil profile are not pronounced. Only minor differences in ground water level were observed between monitoring Well Nos. 18 and 18A (the shallow well/deep well combination). The measured downward vertical gradient at this location ranged from slight to negligible.

The permeability of both the loess and till soils are very low averaging 8.4×10^{-9} cm/sec and 1.4×10^{-8} cm/sec, respectively. The desensitized Line 6 effluent is discharged into leach beds adjacent to the sumps. These leachate beds are

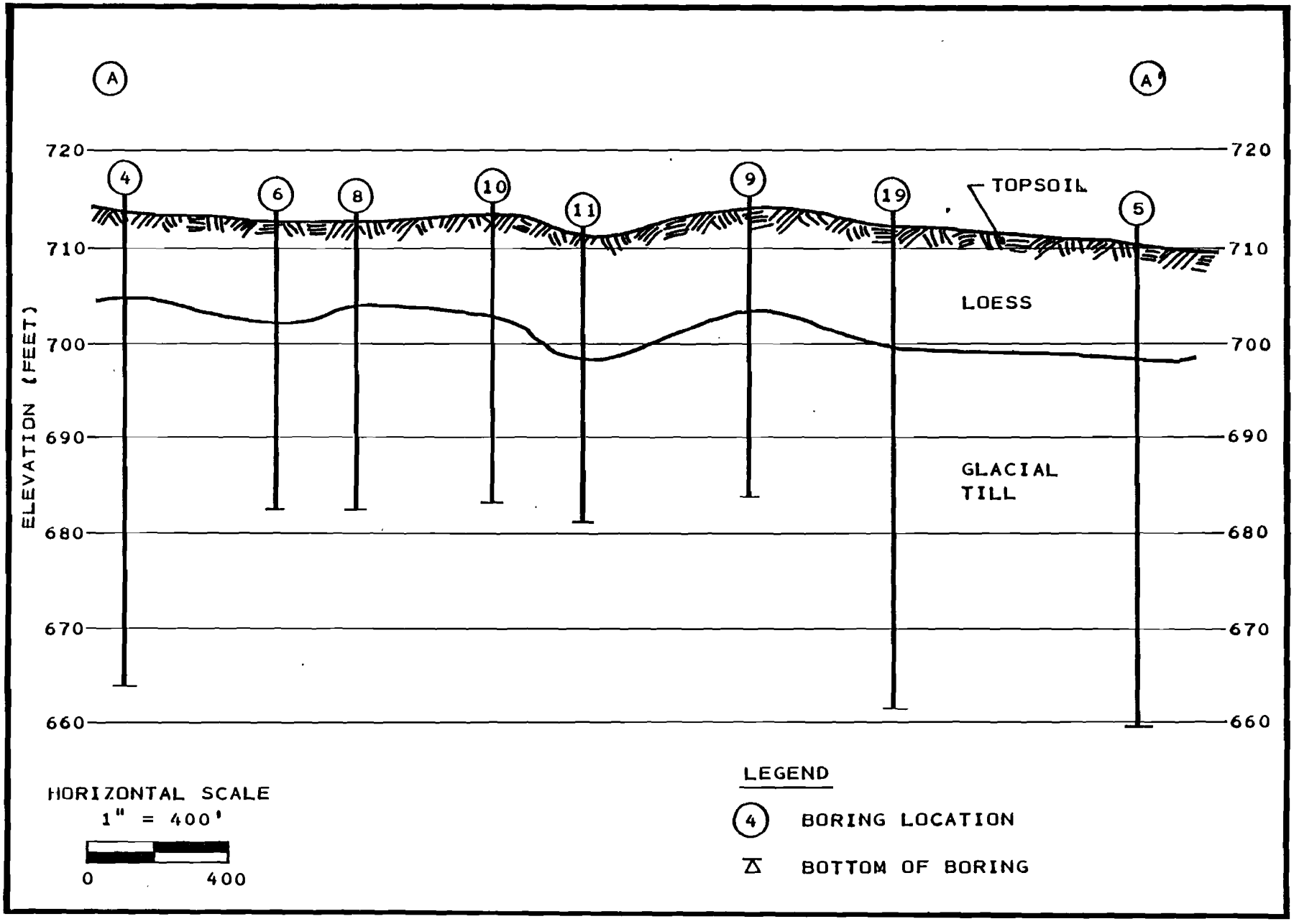


Figure 5-14. Interpretative Subsurface Profile, Site Z_2.

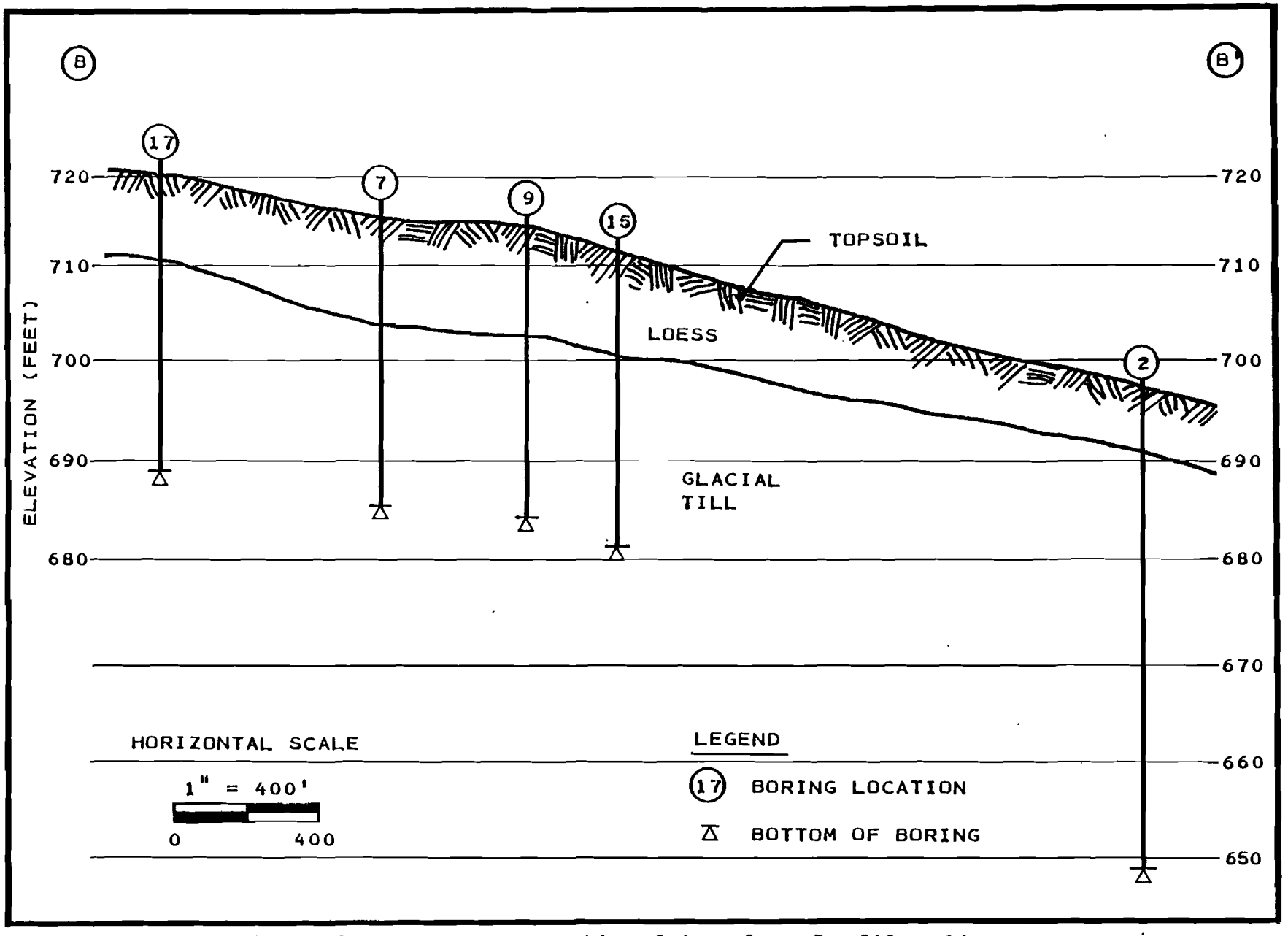


Figure 5-15. Interpretative Subsurface Profile, Site Z_2.

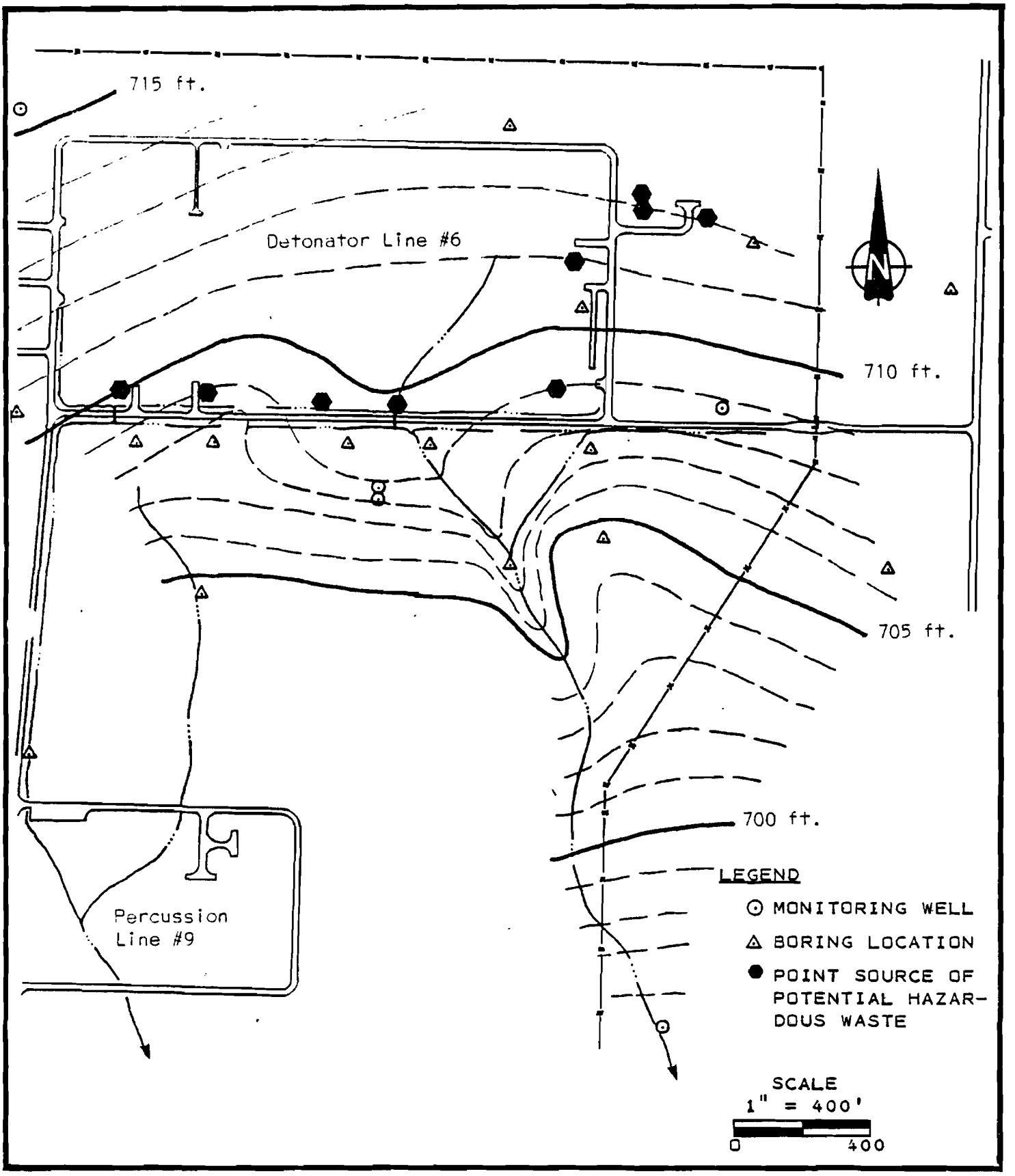


Figure 5-16. Ground Water Table Elevation Contour Map, Site Z_2, November 26, 1980.

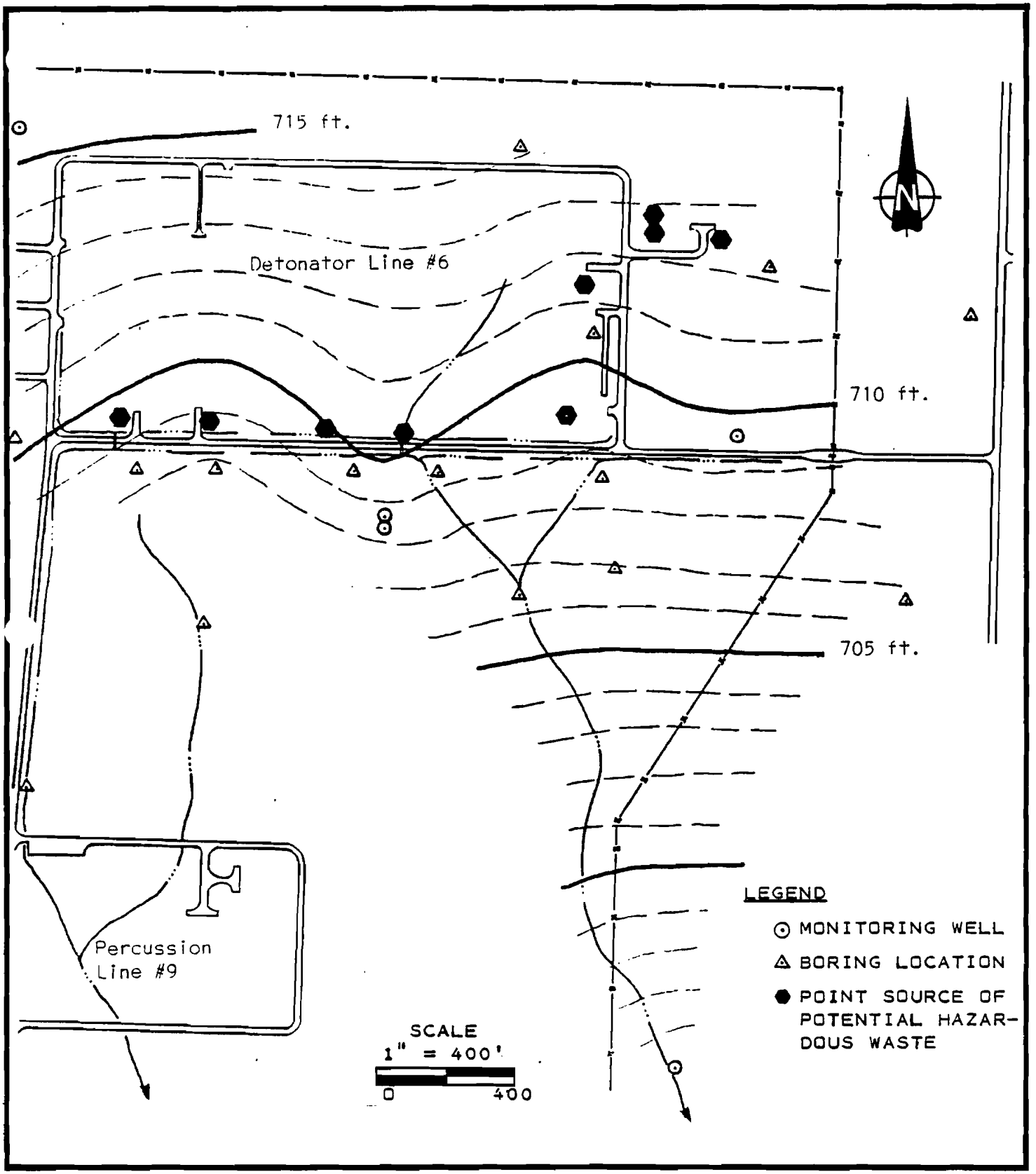


Figure 5-17. Ground Water Table Elevation Contour Map, Site Z_2, December 3, 1980.

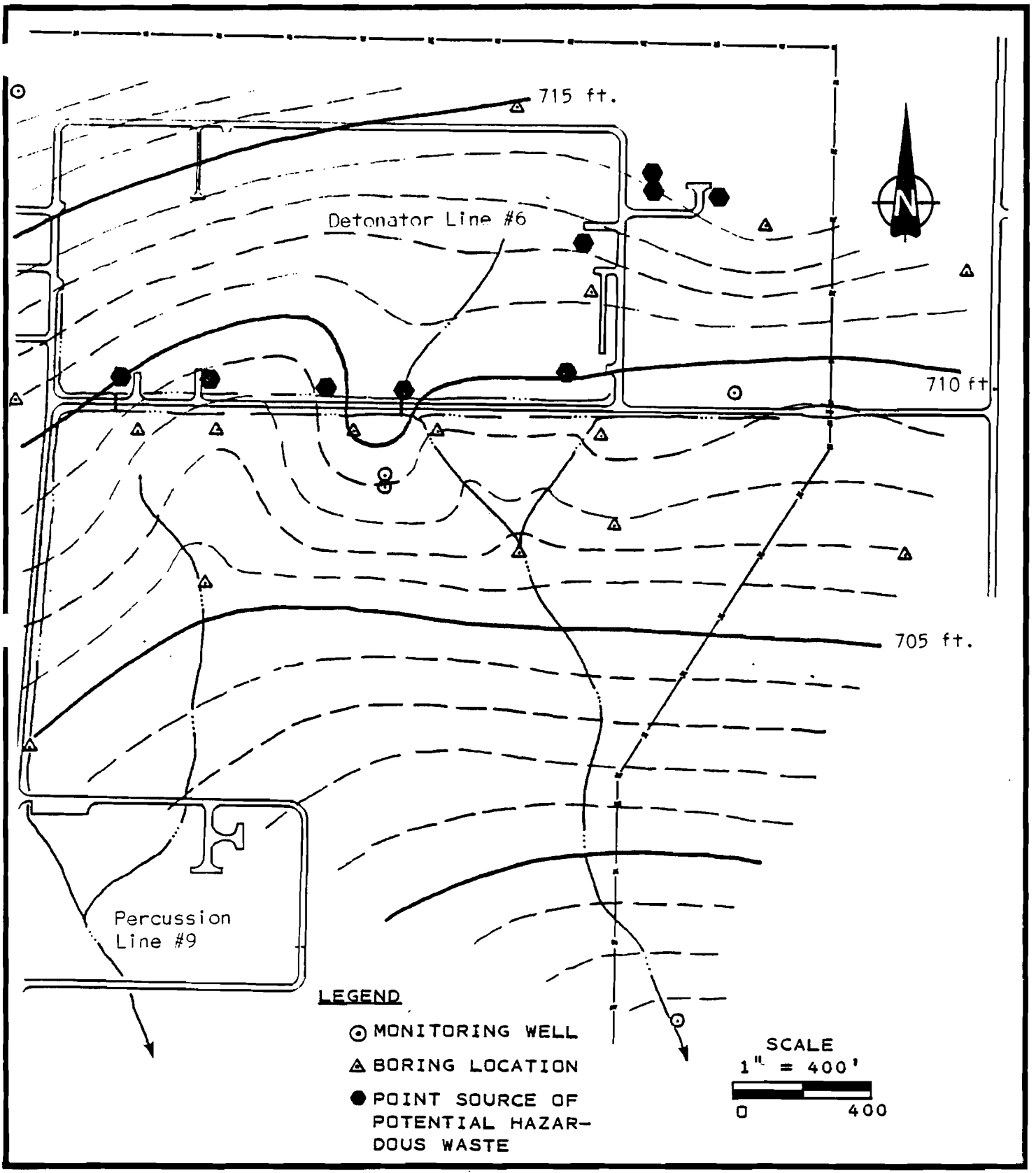


Figure 5-18. Ground Water Table Elevation Contour Map, Site Z_2, January 6, 1981.

located in the loess soils. The effectiveness of these leach beds must be questioned since:

- The coarse aggregate comprising the beds is exposed.
- The natural soil surrounding the beds has a very low permeability.
- The beds are very small relative to the effluent quantities that they received during periods of high production at Line 6.
- Despite limited recent usage, the beds were observed to be full of water and overflowing during the rainy periods of November and December 1980, thus demonstrating that they were overloaded during periods of low production.
- The bottoms of the beds are normally close to ground water table elevation.

Thus, it appears likely that over the long term, a considerable portion of the effluent discharged into the leach beds has overflowed to the ground surface and entered the surficial drainage ways. The actual effectiveness of each of the beds likely varied due to usage, location, and topography. The effluent that did penetrate into the subsurface soils would have moved very slowly under relatively low hydraulic gradients away from the beds and southward. The remainder of the effluent would have entered the surface drainage system, been diluted with surface water, and dispersed downslope (i.e., to the south).

Ground Water Quality

Concentrations of various constituents analyzed in ground water samples from downgradient Well Nos. 2, 18A, and 19 were similar to those from the background upgradient Well No. 1 (Tables 5-14 through 5-17). For comparison purposes, maximum contaminant levels for ground water quality (EPA, 1979) are also included in the tables. The results indicate that the ground water in the vicinity of the leach beds was not adversely affected by the waste treatment and discharge practices at Site Z_2.

Of the constituents analyzed, concentrations of total organic carbon, chemical oxygen demand, iron, and manganese fluctuated greatly with sampling time. Water pH's were near neutral and, except for manganese, other inorganic and organic chemicals (including TNT and RDX), coliform, and radioactivity were all below detection limits. Since relatively high concentrations of manganese were consistently detected in all samples, this metal is believed to be indigenous, rather than derived from the waste source.

TABLE 5-14. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 1 OF SITE Z_2

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	9	8.5	8	8.5	
pH	7.06	7.14	7.17	7.12	6.5-8.5
Conductivity, umhos/cm	640	610	600	38.7	
Turbidity, TU	1.1	0.1	0.2	0.5	1
	- - - - - - - - - - - - (mg/l) - - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	<0.005	0.015	<0.005	-	0.05
Iron	0.053	0.217	0.029	0.100	0.3
Manganese	0.005	1.455	0.561	0.674	0.05
Lead	<0.005	<0.005	<0.005	<0.005	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.090	0.070	0.040	0.070	1
Chloride	4.5	6.0	5.5	5.3	250
Fluoride	0.52	0.54	0.55	0.54	1.4-2.4
Sulfate	37.0	33.0	29.0	33.0	250
Sodium	31.4	30.6	29.0	30.3	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.03	1.60	1.86	1.16	10
Chemical Oxygen Demand	104.0	8.0	4.0	38.7	
Total Organic Carbon	43.0	<1.0	33.0	-	
Phenols	0.01	<0.01	<0.01	-	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.001	0.001
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	N/D†	N/D	N/D	N/D	4
Radium, pCi/l	0.6±0.1	<0.05± <0.01	<0.02± 0.01	-	5
Gross Alpha, pCi/l	2.8±2.5	0.3±2.5	1.8±2.0	-	15
Gross Beta, pCi/l	4.7±3.7	3.2±4.5	7.5±7.6	-	

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not detected.

TABLE 5-15. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 2 OF SITE Z_2

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	7	8	7	7.3	
pH	7.08	7.10	7.07	7.08	6.5-8.5
Conductivity, umhos/cm	640	625	600	622	
Turbidity, TU	3.6	0.2	0.5	1.4	1
	- - - - - - - - - - - (mg/l) - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	0.010	0.025	<0.005	-	0.05
Iron	0.117	0.075	0.036	0.076	0.3
Manganese	<0.005	1.426	1.031	-	0.05
Lead	<0.005	<0.005	<0.005	<0.005	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.280	0.240	0.200	0.240	1
Chloride	4.0	4.5	4.0	4.2	250
Fluoride	0.38	0.33	0.40	0.37	1.4-2.4
Sulfate	10.0	122.0	154.0	58.7	250
Sodium	36.0	41.1	41.1	39.4	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.04	0.43	0.14	0.20	10
Chemical Oxygen Demand	208.0	224.0	8.0	146.7	
Total Organic Carbon	110.0	23.0	109.0	80.7	
Phenols	<0.01	0.019	<0.01	-	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.001	0.004
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	N/D†	2	N/D	-	4
Radium, pCi/l	1/1±0.2	1.49±0.2	<0.06±0.01	-	5
Gross Alpha, pCi/l	2.3±2.0	0.6±1.1	5.1±3.2	-	15
Gross Beta, pCi/l	3.0±3.7	5.9±4.4	2.6±3.6	-	

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not detected.

TABLE 5-16. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 18A OF SITE Z_2

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	7	6	5	6	
pH	6.86	6.90	6.90	6.89	6.5-8.5
Conductivity, umhos/cm	400	390	400	397	
Turbidity, TU	2.1	6.2	0.4	2.9	
	- - - - - - - - - - - - - (mg/l) - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	<0.005	0.014	0.032	-	0.05
Iron	0.043	0.259	0.072	0.125	0.3
Manganese	0.321	0.420	0.307	0.349	0.05
Lead	<0.005	<0.005	<0.005	<0.005	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.110	0.120	0.060	0.097	1
Chloride	4.5	4.0	4.5	4.3	250
Fluoride	0.35	0.34	0.37	0.35	1.4-2.4
Sulfate	134.0	128.0	116.0	126.0	250
Sodium	31.0	33.9	34.3	33.07	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.28	0.04	0.14	0.15	10
Chemical Oxygen Demand	64.0	6.0	20.0	30.0	
Total Organic Carbon	56.0	<1.0	4.0		
Phenols	<0.01	<0.01	<0.01	<0.01	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.001	0.004
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	≤0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	N/D†	N/D	N/D	N/D	4
Radium, pCi/l	1.1±0.2	1.0±0.2	19.1±2.9	-	5
Gross Alpha, pCi/l	72.1±9.8	0.7±1.0	0.2±0.5	-	15
Gross Beta, pCi/l	108.9±11.0	0.1±2.5	0.1±2.5	-	

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not detected.

TABLE 5-17. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 19 OF SITE Z_2

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	8.5	9	7.5	8.3	
pH	7.88	7.61	7.44	7.64	6.5-8.5
Conductivity, umhos/cm	575	650	700	642	
Turbidity, TU	0.80	0.30	0.40	0.50	
	- - - - - - - - - - - - (mg/l) - - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	0.012	0.011	0.012	0.012	0.05
Iron	<0.01	0.027	0.137	-	0.3
Manganese	0.806	1.161	0.380	0.782	0.05
Lead	<0.005	<0.005	<0.005	<0.005	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.110	0.110	0.120	0.113	1
Chloride	19.0	18.5	15.0	17.5	250
Fluoride	0.43	0.38	0.36	0.39	1.4-2.4
Sulfate	166.0	125.0	14.0	101.7	250
Sodium	54.0	60.3	64.1	59.5	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.24	0.14	0.14	0.17	10
Chemical Oxygen Demand	144.0	108.0	16.0	89.3	
Total Organic Carbon	76.0	11.0	<1.0	-	
Phenols	<0.01	<0.01	<0.01	<0.01	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	0.001	<0.001	0.004
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	8	2	N/D†	-	4
Radium, pCi/l	0.4±0.1	<0.04±0.01	0.2±0.1	-	5
Gross Alpha, pCi/l	1.4±1.6	2.8±2.4	4.5±4.7		15
Gross Beta, pCi/l	14.7±5.1	2.7±4.5	4.1±5.6	-	

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not detected.

Remedial Action and Site Closure Considerations

Site Z_2 investigations revealed the following:

- No evidence of ground water contamination was detected.
- The leach beds do not and probably never have performed as intended. Since most of the effluent placed in them has either overflowed to the land surface or evapotranspired, limited volumes have probably migrated into the highly impervious surrounding soils.
- The present-day effluent likely differs markedly from effluent generated during periods of high Line 6 production.

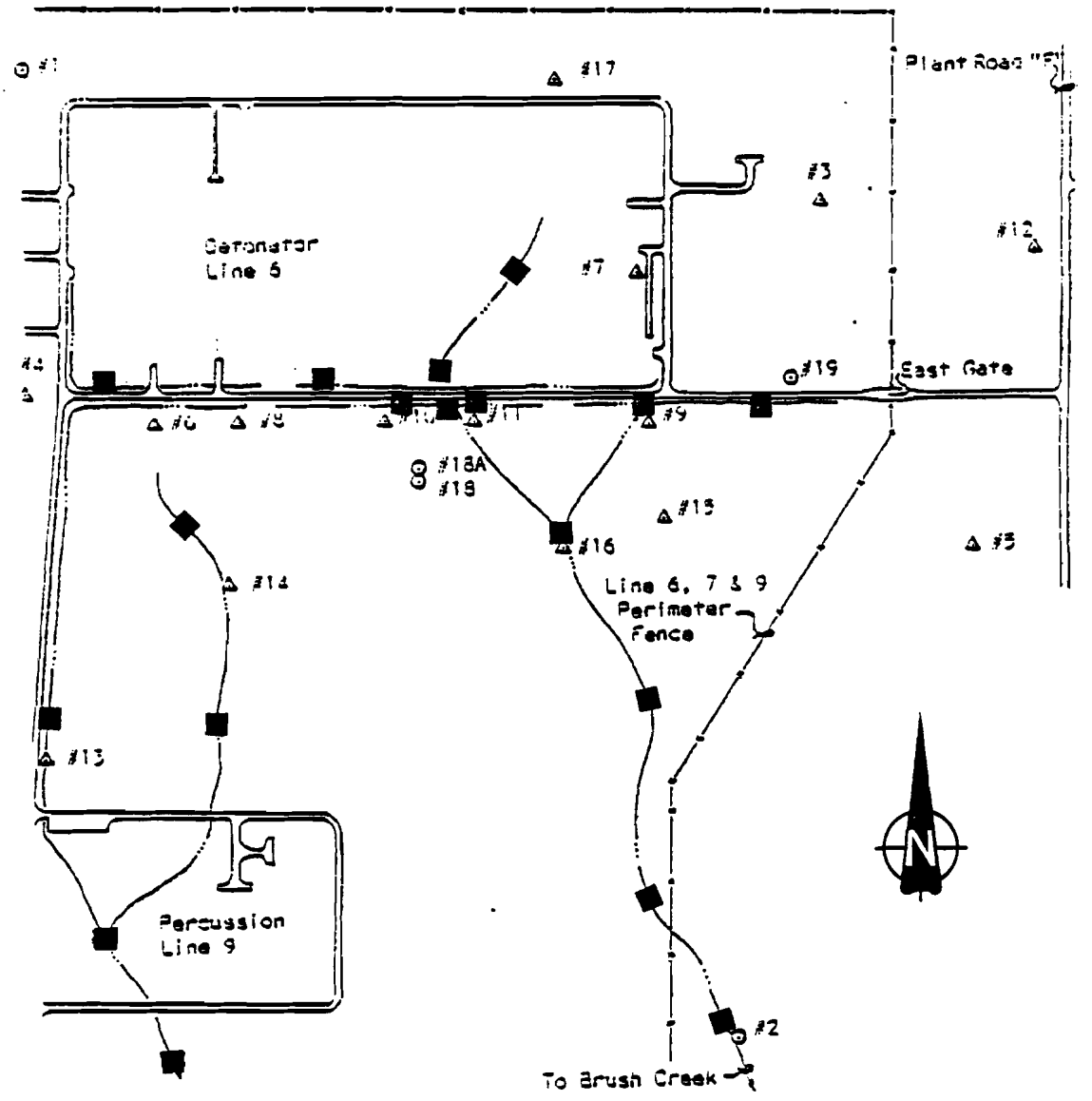
The treatment and disposal operation of Line 6 may have resulted in the discharge of contaminants to the surface and their accumulation in the leach beds and adjacent natural soils. Further investigations will be required to determine the extent and severity of this probable contamination. The investigation should address:

- The potential surficial contaminant migration pathways.
- The accumulation and characteristics of effluent sludge in the leach beds.
- The contamination of natural soils surrounding and underlying the leach beds.

To fully address these factors, the investigation should include a surface and subsurface soil sampling effort and a detailed geologic study of the leach beds and immediately surrounding areas. A recommended surficial sampling and analysis plan is presented in Figure 5-19. This plan will determine whether or not overflow of the leach beds has resulted in widespread surficial contamination. Additional efforts may be required to accurately define the impacted areas if significant levels of contamination are detected. A sample of residue from each of the beds should be obtained for analysis.

Two of the more intensively utilized beds should be explored in considerable detail to define the expected zone of contamination both horizontally and vertically. The contaminated zone (if it exists) probably extends only a few feet or tens of feet from the leach beds.

We recommend the following subsurface exploration, sampling, and analysis plan. Sampling locations around the two sumps should include both surface and subsurface locations, and should be predicated upon the local topographic conditions and the ground water table gradients at each. The subsurface samples should be obtained from depths of 2, 4, 6, and 10 ft below the



LEGEND

- ⊙ MONITORING WELL LOCATION
- △ BORING LOCATION
- ■ PROPOSED SURFACE SOIL SAMPLE LOCATION

NOTES:

1. NOT TO SCALE
2. SAMPLES TO BE TAKEN FROM UPPER 6 IN. OF SOIL PROFILE AT LOWEST POINT OF DRAINAGE WAY CHANNEL
3. SAMPLES TO BE ANALYZED FOR LEAD AND BARIUM

Figure 5-19. Proposed Surficial Sampling Plan, Site Z_2.

leach beds as well as at comparable depths 20 ft downgradient and 20 ft upgradient. These samples can be taken from hollow stem auger borings. The surface samples should be obtained at those locations most likely to have been contaminated by overflow of the leach beds. At least four samples should be taken from the immediate vicinity of each of the beds.

It is probable that the leach beds and a restricted volume of soil surrounding each bed will be contaminated with heavy metals including lead and barium. If this is the case and contaminant levels are found to exceed the limits established by the EP toxicity test (EPA, 1980), remedial action and site closure options for Site Z_2 will include (1) removal and disposal of contaminated soil in an approved chemical landfill, or (2) site closure.

Future land use and economic factors will determine the most feasible course of action (i.e., closure or removal). The long-term advantages of the removal option include elimination of monitoring requirements, and considerably greater freedom for future site use.

Details of the removal option would be predicated on the findings of the recommended investigation. The details and work elements of the in-situ closure option are relatively straightforward, and include the following:

- Improvement of the surface drainage pattern in the general area of Site Z_2 to:

  - Eliminate ponding
  - Reduce infiltration and hence ground water recharge
  - Expedite runoff away from the leach beds.

- Removing the treatment sumps and backfilling the resultant holes with clayey borrow compacted to achieve low permeabilities in the order of the permeability of the surrounding soil.

- Installation of a final cover of low-permeability native clay over the leach bed and backfilled sump location that extends a minimum of 10 ft beyond the contaminated soil zone.

- Installation of a perimeter ditch around the covered site.

- Placement of a loamy soil over all disturbed areas, and revegetation.

Preliminary cost estimates for closure construction are given in DD Form 1391 (Appendix F).

A conceptual portrayal of a closed leach bed area is presented in Figure 5-20. The actual dimensions and material quantities that would be involved in closing each of the leach bed sites will be determined during the recommended investigation. Additional investigations of sump site G-35 should not be necessary (see Appendix E). This facility was constructed for use by the Line 6 laboratory, but was reportedly never used. Due to a lack of records, a soil sample should be taken from the bottom of the leach bed and analyzed to confirm this report. Any corrective action required to ameliorate surficial contamination as a result of leach bed overflow will be identified during completion of the recommended investigation.

SITE Z_3 - DETONATOR ASSEMBLY LINE 4A

Site Z_3 is located in the north central portion of the IAAP on the relatively flat upland surface. The site consists of a new spray lagoon and associated structures, and is located approximately 300 ft west of the new detonator assembly building of Line 4A, and 550 ft north of Plant Road D. The lagoon was under construction at the time that the field investigation portion of this study was completed.

Topography

The site is nearly level with a very gradual slope in all directions away from the center of the spray lagoon site. A man-made drainage way runs from north to south along the eastern portion of the study area. The highest point of the study area, excluding the proposed lagoon dike, is at an elevation of about 724 ft (MSL datum), and located approximately midway between Well Nos. 1 and 2. The lowest point on the site occurs in the southeastern corner of the study area in the drainage ditch, about 30 ft east of Well No. 4. The elevation at this location is about 714 ft (MSL datum).

At the time of this report, the spray lagoon and appurtenances were under construction, and the entire site had been rough-graded, and materials stockpiled at various locations.

Subsurface Condition

Site Z_3 is underlain by loess and till soils. The surficial loess unit is approximately 15 ft thick. The thickness of the underlying till unit is unknown, but it is expected to be substantial. The engineering characteristics of these units are shown in Figures 5-21 through 5-23. The natural soils are very similar to those found at Sites Z_1 and Z_2. The vertical distribution of the loess and till soils is shown in Figure 5-24. Detailed logs of all explorations are presented in Appendix D.

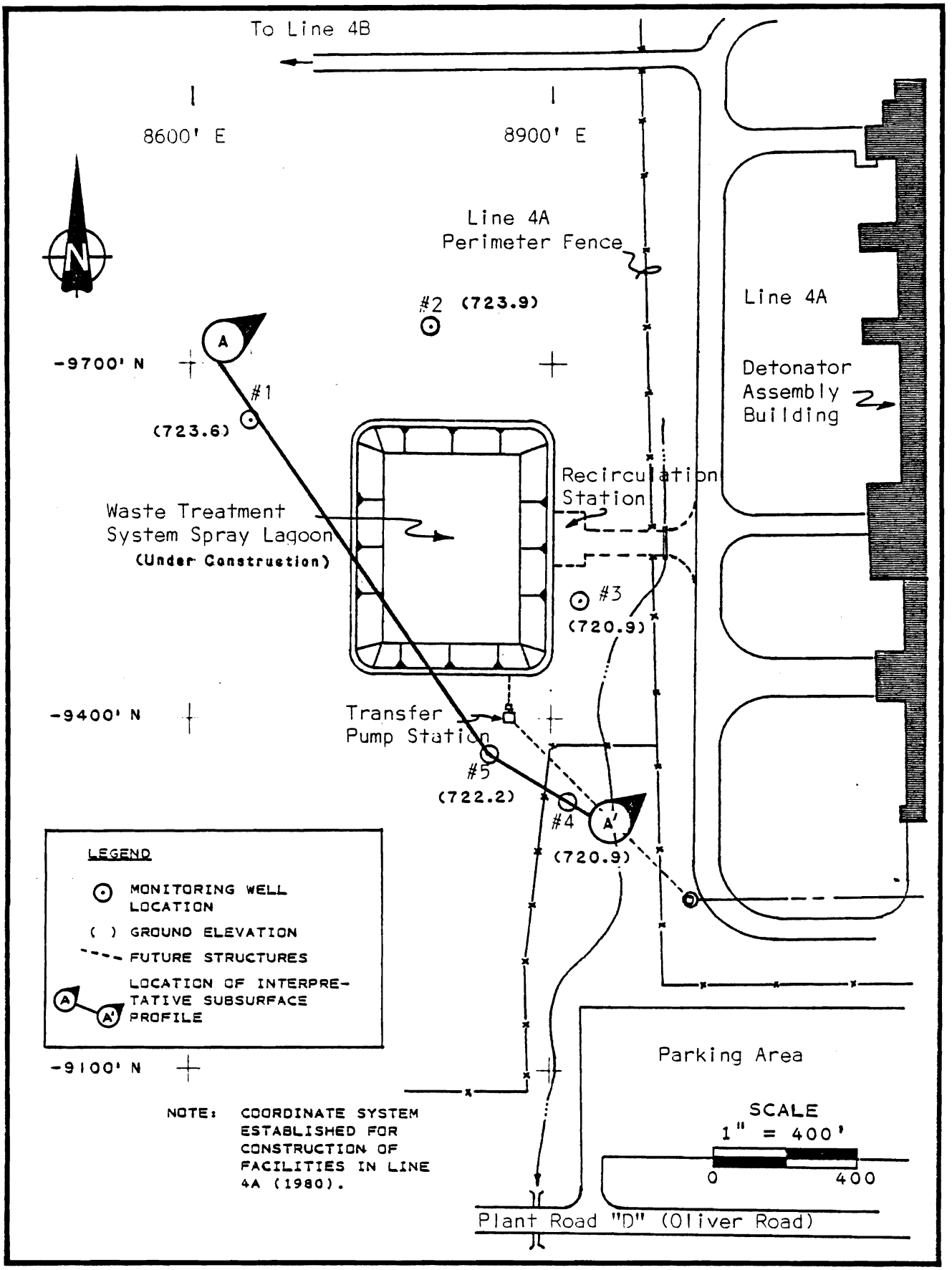


Figure 5-20. Map of Site Z_3.

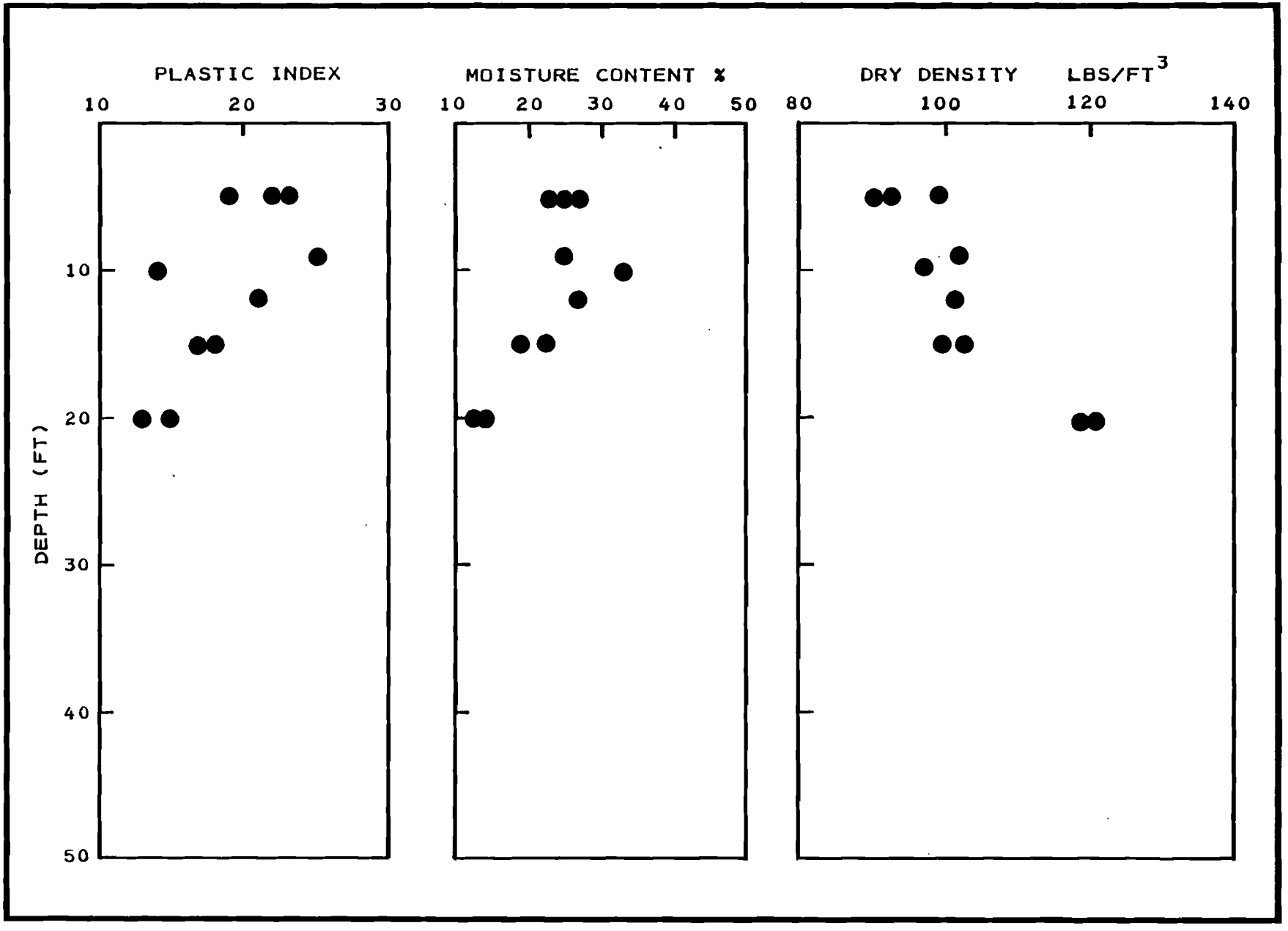


Figure 5-21. Characteristics of Selected Soil Samples, Site Z_3.

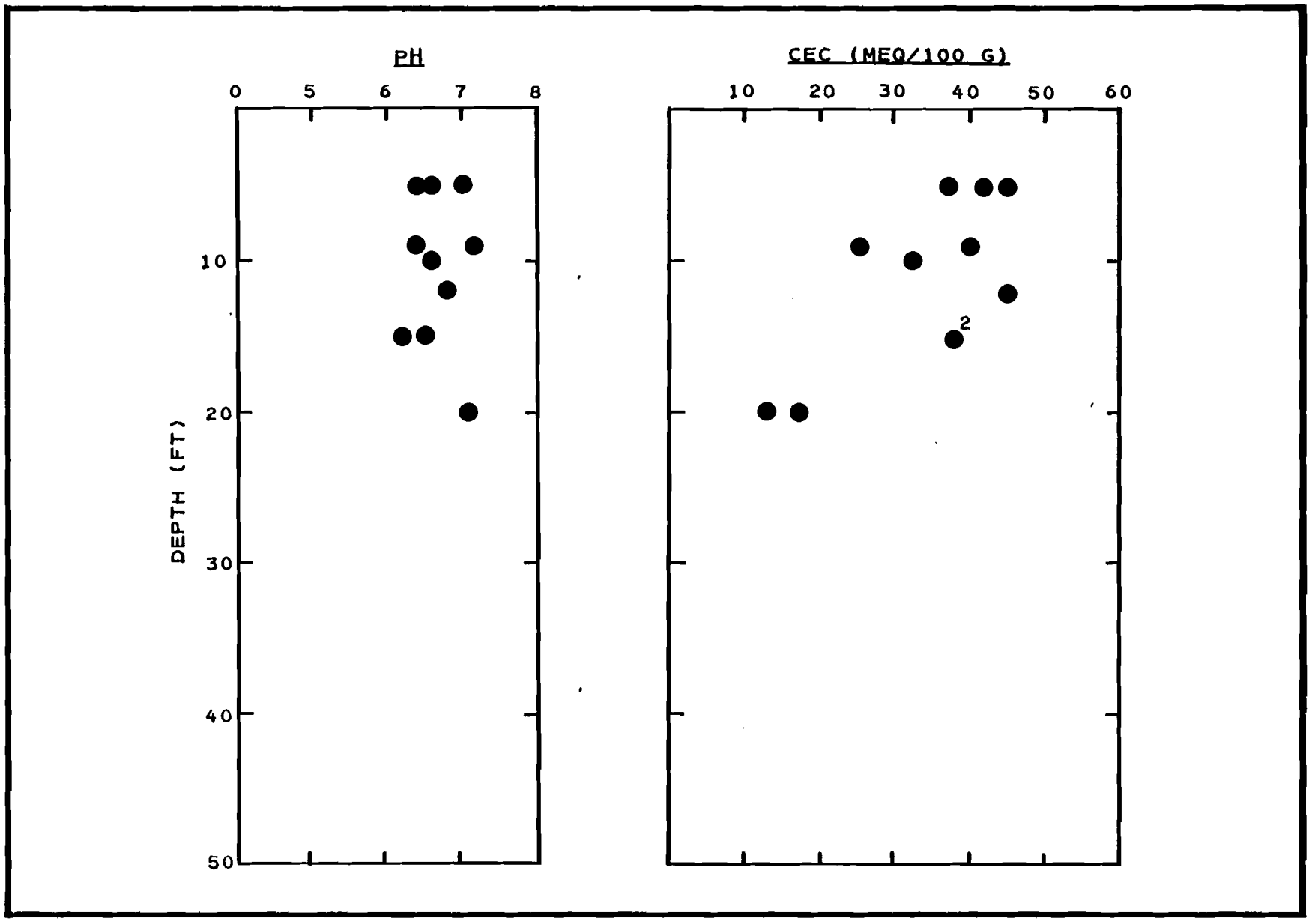


Figure 5-22. Soil pH and Cation Exchange Capacity as a Function of Depth, Site Z_3.

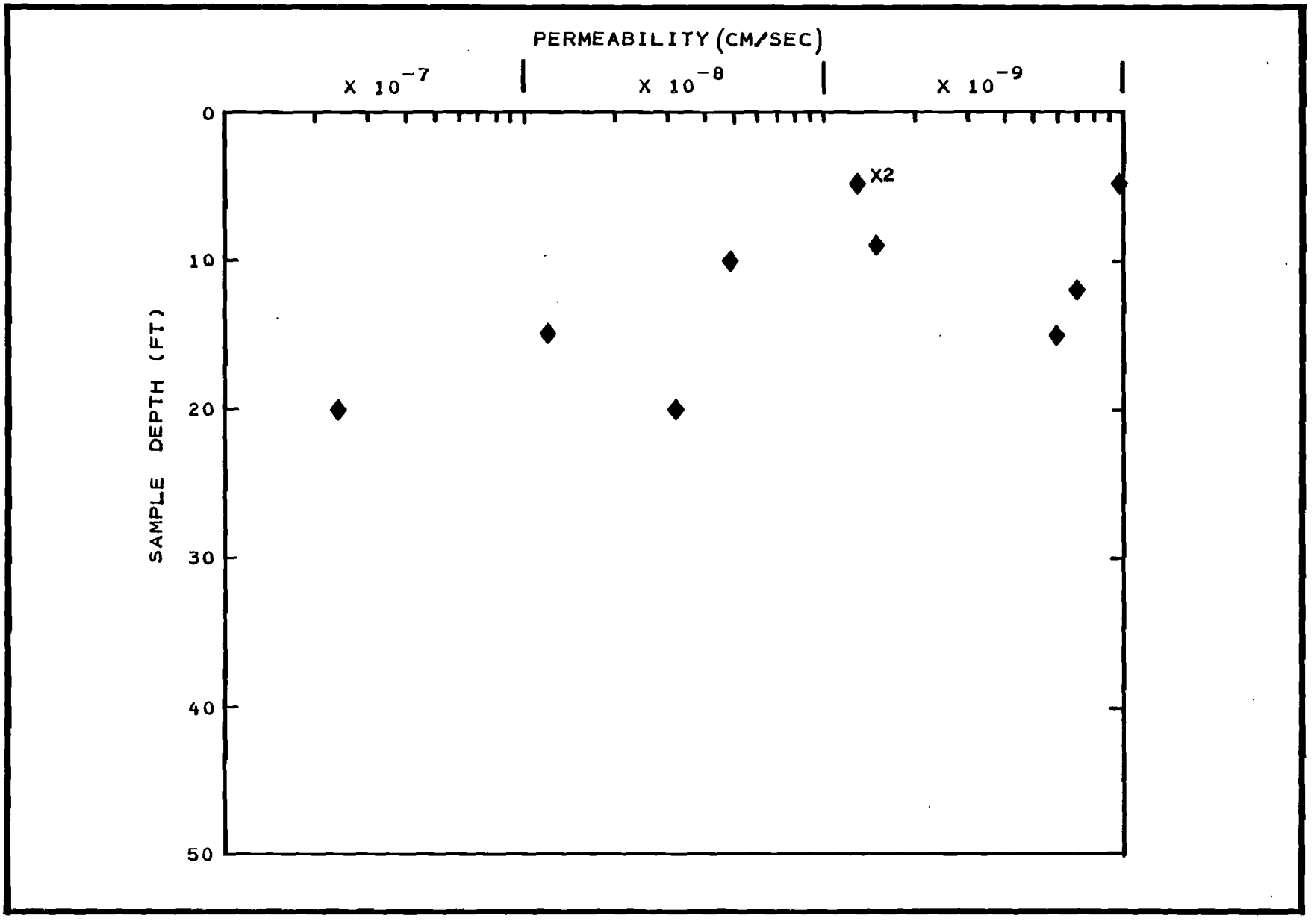


Figure 5-23. Permeability of Selected Soil Samples, Site Z_3.

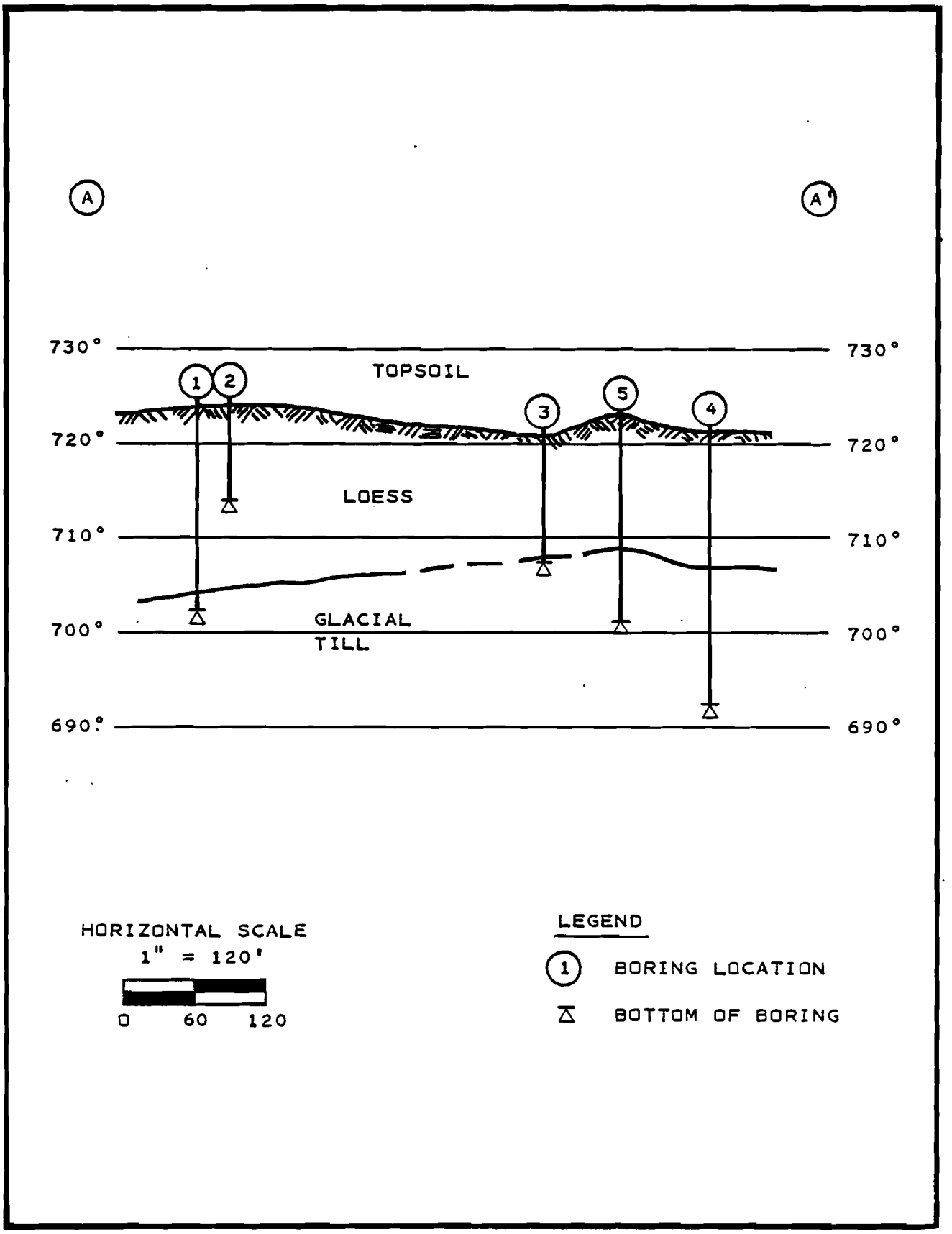


Figure 5-24. Interpretative Subsurface Profile, Site Z_3.

Hydrogeologic Conditions

The ground water table was encountered in all monitoring wells. A contour map of the ground water table elevations measured on January 8, 1981, is presented in Figure 5-25. The ground water table gradient is approximately 2 ft per 100 ft toward the southeast, generally paralleling the slope of the land.

The five monitoring wells provide two upgradient (Nos. 1 and 2) and three downgradient (Nos. 3, 4, and 5) ground water monitoring locations. This monitoring system, based on the observed ground water flow pattern, appears suitable to permit long-term evaluation of the lagoon's performance.

Ground Water Quality

No appreciable differences in constituent concentrations were found among the water samples from the four monitoring wells (Tables 5-18 through 5-21). Contaminants of concern, such as heavy metals, chlorinated hydrocarbons, coliform bacteria, radioactivity, and explosive residue, were either nondetectable or below the levels of EPA ground water quality criteria. Two abnormalities were found: ground water from Well Nos. 3 and 5 showed high pH's and extremely high levels of manganese. They are believed to be indigenous, resulting from localized limestone fragments in the till and/or a highly reduced zone near the well.

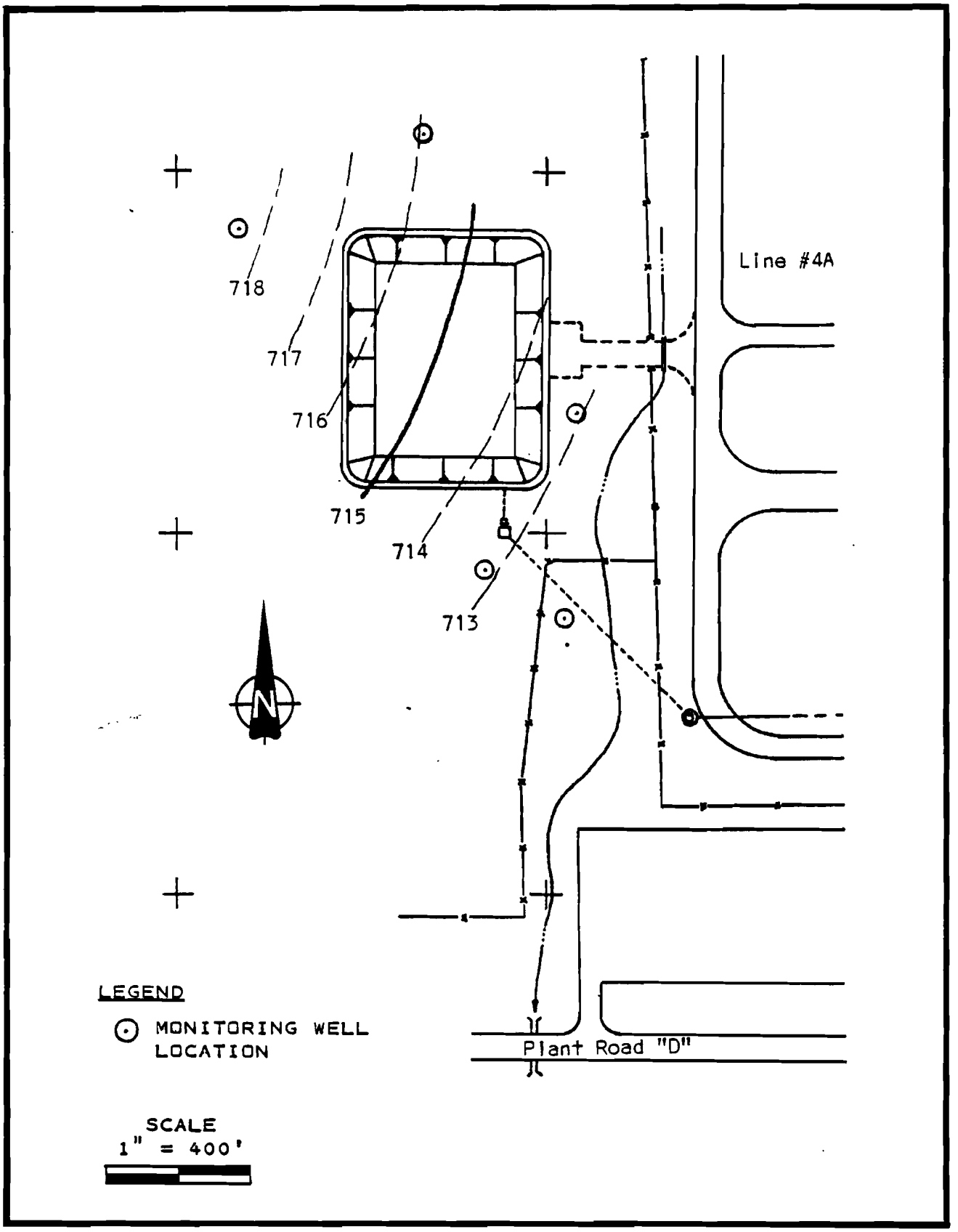


Figure 5-25. Ground Water Table Elevation Contour Map, Site Z_3.

TABLE 5-18. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 1 OF SITE Z_3

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	8	8	7	7.7	
pH	7.24	7.51	7.31	7.35	6.5-8.5
Conductivity, umhos/cm	400	400	390	397	
Turbidity, TU	3.7	1.6	1.7	2.3	1
	- - - - - - - - - - - - - (mg/l) - - - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	<0.005	<0.005	<0.005	<0.005	0.05
Iron	<0.01	0.032	0.024	-	0.3
Manganese	0.692	0.509	0.272	0.491	0.05
Lead	<0.005	<0.005	<0.005	<0.005	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.110	0.100	0.090	0.100	1
Chloride	5.0	5.5	5.5	5.3	250
Fluoride	0.35	0.40	0.37	0.37	1.4-2.4
Sulfate	57.0	41.0	43.0	47.0	250
Sodium	26.3	30.5	31.0	29.3	
Arsenic	0.02	<0.005	<0.005	-	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.06	<0.01	0.07	-	10
Chemical Oxygen Demand	88.0	56.0	4.0	49.3	
Total Organic Carbon	40.0	2.0	<1.0	-	
Phenols	<0.01	<0.01	<0.01	<0.01	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.001	0.004
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	N/D†	N/D	N/D	N/D	4
Radium, pCi/l	<0.04±0.01	<0.05±0.01	0.6±0.1	-	5
Gross Alpha, pCi/l	1.7±1.8	0.2±0.5	1.9±1.8	-	15
Gross Beta, pCi/l	1.8±2.9	1.6±2.8	1.5±3.1	-	

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not detected.

TABLE 5-19. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 3 OF SITE Z_3

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	8	7	8	7.7	
pH	7.24	7.11	6.99	7.11	7.6-8.5
Conductivity, umhos/cm	425	375	375	392	
Turbidity, TU	2.2	3.0	0.4	1.9	1
	- - - - - - - - - - - - (mg/l) - - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	<0.005	<0.005	<0.005	<0.005	0.05
Iron	0.040	0.109	<0.001	-	0.3
Manganese	3.940	2.836	1.909	2.895	0.05
Lead	<0.005	<0.005	<0.005	<0.005	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.150	0.110	0.070	0.110	1
Chloride	9.0	6.0	16.0	10.3	250
Fluoride	0.24	0.21	0.21	0.22	1.4-2.4
Sulfate	117.0	99.0	114.0	110.0	250
Sodium	29.4	35.8	34.8	33.4	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.06	0.04	0.11	0.07	10
Chemical Oxygen Demand	100.0	4.0	48.0	50.7	
Total Organic Carbon	176.0	93.0	4.0	91.0	
Phenols	<0.01	<0.01	<0.01	<0.01	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.001	0.004
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	N/D†	N/D	N/D	N/D	4
Radium, pCi/l	0.09±0.1	<0.05±0.01	0.7±0.1	-	5
Gross Alpha, pCi/l	2.7±2.1	1.5±1.5	0.2±0.5	-	15
Gross Beta, pCi/l	4.2±3.5	3.9±4.2	<0.1±0.2	-	

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not detected.

TABLE 5-20. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 4 OF SITE Z_3

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	9	9.5	9	9.2	
pH	7.71	7.54	7.62	7.62	6.5-8.5
Conductivity, umhos/cm	490	475	475	480	
Turbidity, TU	2.2	3.9	1.1	2.4	1
	- - - - - - - - - - - - (mg/l) - - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	0.013	<0.005	<0.005	-	0.05
Iron	0.185	0.136	0.248	0.190	0.3
Manganese	0.032	0.675	0.532	0.413	0.05
Lead	<0.005	<0.005	<0.005	<0.005	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.160	0.100	0.080	0.113	1
Chloride	6.0	5.5	4.5	5.3	250
Fluoride	0.36	0.35	0.32	0.34	1.4-2.4
Sulfate	75.0	70.0	79.0	74.7	250
Sodium	34.5	39.0	38.7	37.4	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.60	0.72	0.78	0.70	10
Chemical Oxygen Demand	4.0	8.0	8.0	6.6	
Total Organic Carbon	141.0	307.0	13.0	153.7	
Phenols	<0.01	<0.01	<0.01	<0.01	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.001	0.004
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	2	N/D†	N/D	-	4
Radium, pCi/l	0.4±0.1	<0.04±0.01	0.2±0.1	-	5
Gross Alpha, pCi/l	3.3±2.9	0.3±0.7	0.8±1.0	-	15
Gross Beta, pCi/l	<0.2±5.0	0.1±2.8	10.2±4.2	-	

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not detected.

TABLE 5-21. CHEMICAL ANALYSES OF GROUND WATER SAMPLES TAKEN FOR 3 CONSECUTIVE DAYS FROM WELL NO. 5 OF SITE Z_3

Parameter	Sampling Date 1-27-81	1-28-81	1-29-81	Mean	Maximum Level*
Temperature, °C	9	9	8	8.7	
pH	9.15	8.71	8.39	8.75	6.5-8.5
Conductivity, umhos/cm	300	325	350	325	
Turbidity, TU	1.0	0.8	0.3	0.7	1
	- - - - - - - - - - - - - (mg/l) - - - - - - - - - - - - -				
Cadmium	<0.001	<0.001	<0.001	<0.001	0.010
Chromium, Total	0.015	<0.032	<0.005	-	0.05
Iron	0.369	0.127	<0.01	-	0.3
Manganese	0.043	0.083	<0.005	-	0.05
Lead	<0.005	<0.005	<0.005	<0.005	0.05
Silver	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.050	0.050	0.030	0.043	1
Chloride	5.5	7.5	10.5	7.8	250
Fluoride	0.38	0.34	0.29	0.34	1.4-2.4
Sulfate	114.0	98.0	84.0	98.7	250
Sodium	26.8	30.4	29.7	28.9	
Arsenic	<0.005	<0.005	<0.005	<0.005	0.05
Selenium	<0.005	<0.005	<0.005	<0.005	0.01
Mercury	<0.0003	<0.0003	<0.0003	<0.0003	0.002
Nitrate-N	0.26	0.28	0.43	0.32	10
Chemical Oxygen Demand	100.0	4.0	36.0	46.7	
Total Organic Carbon	64.0	214.0	11.0	96.3	
Phenols	<0.01	<0.01	<0.01	<0.01	
Endrin	<0.0002	<0.0002	<0.0002	<0.0002	0.0002
Lindane	<0.001	<0.001	<0.001	<0.001	0.004
Methoxychlor	<0.01	<0.01	<0.01	<0.01	0.1
Toxaphene	<0.001	<0.001	<0.001	<0.001	0.005
2,4-D	<0.01	<0.01	<0.01	<0.01	0.1
2,4,5-TP Silvex	<0.005	<0.005	<0.005	<0.005	0.01
TNT	<0.005	<0.005	<0.005	<0.005	
RDX	<0.011	<0.011	<0.011	<0.011	
Coliform Bacteria, c/100 ml	N/D†	N/D	N/D	-	4
Radium, pCi/l	0.2±0.1	0.5±0.1	0.1±0.1	-	5
Gross Alpha, pCi/l	0.6±0.9	0.2±0.5	0.7±0.9	-	15
Gross Beta, pCi/l	0.6±1.5	0.6±1.5	<0.1±0.2	-	

* EPA Ground Water Quality Criteria (EPA, 1979).

† Not detected.

SECTION 6

FACILITY OPERATIONS AND CONTINGENCY PLAN

A number of regulatory violations were identified during the course of this study. The areas that do not conform to the interim and final standards under RCRA Subtitle C are shown in Tables 6-1 and 6-2 for Sites Z_1 and Z_2.

A facility operations and contingency plan was prepared to meet the requirements of 40 CFR 265.50, Hazardous Waste Management System, Federal Register, May 19, 1980. Each of the facilities addressed in this plan has been investigated as a portion of this study, and described in detail in earlier sections of this report. Since many of the specific items required in an operations and contingency plan have been presented in or appended to this report, they are referenced rather than reproduced in this section. These items are summarized in Table 6-3.

Recommendations for remedial measures and additional studies at Sites Z_1 and Z_2 have been made at the conclusion of each site evaluation (see Section 5). The findings and conclusions of these recommended studies will be relevant to this plan, and should become a portion of this document. Upon completion of these studies, this plan should be reviewed relative to the findings and amended, if warranted.

Emergency coordinator information is summarized in Table 6-4. Fire and emergency equipment is maintained on site, and cooperative agreements exist between the IAAP and local fire departments. Available emergency equipment and its location are summarized in Table 6-5.

Additional information on the operations and contingency plan for Sites Z_1 and Z_2 is presented in Appendix G.

TABLE 6-1. AREAS OF REGULATORY VIOLATION AT SITE Z_1

Area	RCRA Regulation*
Waste analysis	Subpart B, Section 265.13#
Warning sign	Subpart B, Section 265.14#
General inspection	Subpart B, Section 265.15#
Personnel training	Subpart B, Section 265.16#
Contingency plan	Subpart D, Section 265.52#
Operating record	Subpart E, Section 265.73#
Ground water monitoring	Subpart F, Sections 265.90 through 265.94†
Closure and post-closure plan	Subpart G, Sections 265.110 through 265.120**
Waste containment	Subpart K, Section 265.223#

* Promulgated by EPA under RCRA Subtitle C, Section 3004. All regulations are specified in Part 265, and published in Federal Register dated 5-19-80.

\# Final standard.

† Interim final standard.

** Sections 265.110, 114, 115 are final standards; Sections 265.111, 117, 118 are interim final standards; Sections 265.112 and 113 are interim final standards, which were amended on 10-30-80; Sections 265.119 and 120 are final standards but amendment has been proposed.

TABLE 6-2. AREAS OF REGULATORY VIOLATION AT SITE Z_2

Area	RCRA Regulation*
Waste analysis	Subpart B, Section 265.13#
Warning sign	Subpart B, Section 265.14#
General inspection	Subpart B, Section 265.15#
Personnel training	Subpart B, Section 265.16#
Contingency plan	Subpart D, Section 265.52#
Operating record	Subpart E, Section 265.73#
Ground water monitoring	Subpart F, Sections 265.90 through 265.94†
Closure and post-closure plan	Subpart G, Sections 265.110 through 265.120**
Waste containment	Subpart K, Sections 265.222 and 265.223#

* Promulgated by EPA under RCRA Subtitle C, Section 3004. All regulations are specified in Part 265, and published in Federal Register dated 5-19-80.

\# Final standard.

† Interim final standard.

** Sections 265.110, 114, 115 are final standards; Sections 265.111, 117, 118 are interim final standards; Sections 265.112 and 113 are interim final standards, which were amended on 10-30-80; Sections 265.119 and 120 are final standards but amendment has been proposed.

TABLE 6-3. FACILITY OPERATIONS AND CONTINGENCY PLAN INFORMATION LOCATED IN OTHER SECTIONS OF THIS REPORT

Required Information	Reference* Site Z_1	Site Z_2
Description of the sites	5-1	5-28
Existing topographic plot plan	5-2	5-28
Proposed topographic plot plan	NA	NA
Operational plot plan	NA	Appendix G
Geologic cross sections	5-7	5-35
Description of waste characteristics and quantities	5-3	5-32
Expected life of site	NA	NA
Site closure plans	5-16	5-50
Operating procedures	NA	5-28
Safety/service provisions	NA	Appendix G
Surface water monitoring	5-16	NA
Ground water monitoring	5-16	5-45

* Page numbers in text, unless otherwise indicated.

TABLE 6-4. LIST OF EMERGENCY COORDINATORS

On-Scene Coordinators*	Alternatives
D. D. Mellinger Mechanical Supervisor Bus. Phone: (319) 753-7315 Home Phone: (319) 753-1914	F. C. Laue Environmental Coordinator Bus. Phone: (319) 753-7538 Home Phone: (319) 752-5648
J. E. Shannan Safety Manager Bus. Phone: (319)753-7319 Home Phone: (319) 754-8954	G. Miller Security Police Chief Bus. Phone: (319) 753-7103 Home Phone: (319) 752-6272
R. H. Tiemeier Plant & Utilities Manager Bus. Phone: (319) 753-7103 Home Phone: (319) 952-2332	

Department of the Army Liaison Personnel

Department of the Army: G. H. Mathes
Chief Engineer
Bus. Phone: (319) 753-7101
Home Phone: (319) 753-1027

* These contractor personnel have been assigned the responsibility of supervising all cleanup and decontamination activities resulting from an accidental discharge of oil or hazardous materials within the installation's boundaries. Following an accidental spill, the on-scene coordinator will notify the personnel listed as soon as possible.

TABLE 6-5. EMERGENCY EQUIPMENT AVAILABLE TO IAAP

On-Site Equipment	Location
Pump truck, 750 gpm	Bldg. 200-131-3
Two Ambulances	Bldg. 200-131-3
Tank truck, 1,500 gal	Bldg. 400-138
Tractors	Bldg. 400-138
Bulldozers	Bldg. 400-138
Gradealls	Bldg. 400-138
Dump trucks	Bldg. 400-138
Graders	Bldg. 400-138
End loaders	Bldg. 400-138
Pumps	Bldg. 400-138
Oil skimmers	Bldg. 400-138
Available Off Site Equipment	**Source**
Additional large earth-moving equipment	Iowa National Guard U.S. Army Reserve Engineer Battalion
Fire trucks with 4-man crews (to provide standby protection for nonexplosive areas of the installation; total of 2 trucks)	Burlington Iowa, Fire Department Ft. Madison, Iowa Fire Department

SECTION 7

REFERENCES

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2. Flint, R. F. Glacial and Pleistocene Geology. New York, New York, 1967.

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5. Standard Methods for the Examination of Water and Wastewater. 14th Edition. American Public Health Association, Washington, D.C., 1975.

6. U.S. Army Environmental Hygiene Agency. Hazardous Waste Special Study at Iowa Army Ammunition Plant, March 3-12, 1980, Aberdeen Proving Ground, Maryland. U.S. AEHA Control No. 81-26-8211-81, 1980.

7. U.S. Environmental Protection Agency. Criteria for Classification of Solid Waste Disposal Facilities and Practices. Federal Register, Vol. 44, No. 179, September 13, 1979.

8. U.S. Environmental Protection Agency. Hazardous Waste and Consolidated Permit Regulations. Federal Register, Vol. 45, No. 981, Book 2, May 19, 1980.

9. U.S. Environmental Protection Agency. Manual of Methods for Chemical Analysis of Water and Wastes. EPA-625/6-74-003, 1974.

Volume 2

SCS ENGINEERS

STEARNS, CONRAD AND SCHMIDT
CONSULTING ENGINEERS, INC.

LOG OF BORING NO. Z3 #1

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE LINE 4A
NEW WASTEWATER LAGOON

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No.	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs./ft²	Water Content-%	Dry Density lbs./ft³	Unified Class Symbol	Depth	Elevation	Description (Well Installed 12-5-80; Surface Elevation - 723.6)	Monitoring Well Details
	HS									721.6	CLAYEY SILT Dark Brown (2.0)	719.6
1	ST	24	1			23.7	100	CL-CH	5		SILTY CLAY TRACE SAND Gray Brown Stiff	716.6
	HS											714.6
2	ST	24	11					CL	10			
	HS											
3	ST	24	12					CL	15			
	HS											704.6
4	ST	24	14			13.6	120	CL-ML	20	704.1	(19.5) SANDY CLAYEY SILT TRACE GRAVEL (21.0) (GLACIAL TILL) Brown, Hard	
										702.6	Bottom of Boring	
									25			

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	9.5'	W.S. OR W.D.	17.2' A.B.
W.L.		B.C.R.	A.C.R.
W.L.	10' 1 hr A.B./5.2' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-5-80
BORING COMPLETED	12-5-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

Draft Final Report

UNDERGROUND POLLUTION INVESTIGATION AT IOWA ARMY AMMUNITION PLANT, BURLINGTON, IOWA

Contract No. DACA87-80-C-0333

Volume II

Submitted to:

U.S. Army Corps of Engineers
Omaha District Office
6014 U.S. Post Office and Courthouse
Omaha, Nebraska 68102

Submitted by:

SCS Engineers
4014 Long Beach Boulevard
Long Beach, California 90807

September 22, 1981

APPENDIX A

RESULTS OF SPLIT SAMPLES AS A PART OF QUALITY CONTROL PROGRAM

• VIJAY THAKORE: PRESIDENT, TECHNICAL DIRECTOR

RESULTS OF SPLIT SAMPLES AS A PART OF QUALITY CONTROL PROGRAM FOR CONTRACT NUMBER DACA87-C-0333, BURLINGTON IAAP

Sample I.D.:	Surface Water Sta. 1-S-#2 01/15/81 9:30 AM Temp. 4°C pH 9.27 S/U
BCA Lab Number:	81-284- 81-289

PARAMETER:	REPORTED RESULTS: mg/l	SPLIT SAMPLE RESULTS: mg/l
Cadmium	<0.001	<0.001
Chromium, Total	0.048	0.0486
Iron	0.219	0.218
Manganese	0.121	0.122
Lead	<0.005	<0.005
Silver	<0.001	<0.005
Barium	0.09	0.092
Specific Conductivity (micromhos/Cm)	875.0	875.0
Chloride	106.0	110.0
Fluoride	1.38	1.385
Sulfate	219.0	225.0
Sodium	285.0	289.0
Arsenic	<0.005	<0.005
Selenium	<0.005	<0.005
Mercury	<0.0003	<0.0003
Turbidity	1.9 (NTU)	1.85 (NTU)
Endrin	<0.0002	<0.0002
Lindane	<0.001	<0.001

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RESULTS OF SPLIT SAMPLES AS A PART OF QUALITY CONTROL PROGRAM

BCA Lab Number:	81-284- 81-289 (cont'd)	
PARAMETER:	REPORTED RESULTS: mg/l	SPLIT SAMPLE RESULTS: mg/l
Methoxychlor	<0.01	<0.01
Toxaphene	<0.001	<0.001
C.O.D.	71.6	72.0
Total Organic Carbon	29.0	30.0
Nitrate (as N)	4.73	4.81
Phenol	<0.01	<0.01
Total Coliform	N/D	N/D

RESULTS OF SPLIT SAMPLES AS A PART OF QUALITY CONTROL PROGRAM

Sample I.D.: Z2 #18A-S-1
01/27/81
Temp. 7°C
pH 6.86 S/U

BCA Lab Number: 81-606-
81-611

PARAMETER:	REPORTED RESULTS: mg/l	SPLIT SAMPLE RESULTS: mg/l
Cadmium	<0.001	<0.001
Chromium, Total	<0.005	<0.005
Iron	0.043	0.048
Manganese	0.321	0.315
Lead	<0.005	<0.005
Silver	<0.001	<0.001
Barium	0.110	0.098
Specific Conductivity (Micromhos/Cm)	400.0	400.0
Chloride	4.5	4.0
Fluoride	0.35	0.36
Sulfate	134.0	140.0
Sodium	31.0	30.5
Arsenic	<0.005	<0.005
Selenium	<0.005	<0.005
Mercury	<0.0003	<0.0003
Turbidity	2.1 (NTU)	2.0 (NTU)
Endrin	<0.0002	<0.0002
Lindane	<0.001	<0.001
Methoxychlor	<0.01	<0.01
Toxaphene	<0.001	<0.001

RESULTS OF SPLIT SAMPLES AS A PART OF QUALITY CONTROL PROGRAM

BCA Lab Number: 81-606-
81-611

PARAMETER:	REPORTED RESULTS: mg/l	SPLIT SAMPLE RESULTS: mg/l
C.O.D.	64.0	68.0
Total Organic Carbon	65.0	54.0
Nitrate	0.28	0.30
Phenol	<0.01	0.01
Total Coliform	N/D	N/D

RESULTS OF SPLIT SAMPLES AS A PART OF QUALITY CONTROL PROGRAM

ample I.D.:	Z3 #1-S-2 01/28/81 Temp. 8°C pH 7.51 S/U
BCA Lab Number;	81-716- 81-721

PARAMETER:	REPORTED RESULTS: mg/l	SPLIT SAMPLE RESULTS: mg/l
Cadmium	<0.001	<0.001
Chromium, Total	<0.005	<0.005
Iron	0.032	0.031
Manganese	0.509	0.52
Lead	<0.005	<0.005
Silver	<0.001	<0.001
Barium	0.100	0.095
Specific Conductivity (Micromhos/Cm)	400.0	410.0
Chloride	5.5	5.0
Fluoride	0.40	0.395
Sulfate	41.0	39.0
Sodium	30.5	30.0
Arsenic	<0.005	<0.005
Selenium	<0.005	<0.005
Mercury	<0.0003	<0.0003
Turbidity	1.60 (NTU)	1.7 (NTU)
Endrin	<0.0002	<0.0002
Lindane	<0.001	<0.001
Methoxychlor	<0.01	<0.01
Toxaphene	<0.001	<0.001
C.O.D.	56.0	60.0

RESULTS OF SPLIT SAMPLES AS A PART OF QUALITY CONTROL PROGRAM

BCA Lab Number: 81-716-
81-721

PARAMETER:	REPORTED RESULTS: mg/l	SPLIT SAMPLE RESULTS: mg/l
Total Organic Carbon	2.0	1.95
Nitrate (as N)	<0.01	<0.01
Phenol	<0.01	<0.01
Total Coliform	N/D	N/D

ample I.D.:	Z3 #4-S-3 01/29/81 Temp. 9°C pH 7.62 S/U
BCA Lab Number:	81-832- 81-837

PARAMETER:	REPORTED RESULTS:	SPLIT SAMPLE RESULTS:
Cadmium	<0.001	<0.001
Chromium, Total	<0.005	<0.005
Iron	0.248	0.25
Manganese	0.532	0.528
Lead	<0.005	<0.005
Silver	<0.001	<0.001
Barium	0.08	0.075
ɔpecific Conductivity (Micromhos/Cm)	475.0	475.0
Chloride	4.5	4.5
Fluoride	0.32	0.315
Sulfate	79.0	82.0
Sodium	38.7	38.0
Arsenic	<0.005	<0.005
Selenium	<0.005	<0.005
Mercury	<0.0003	<0.0003
Turbidity	1.10 (NTU)	1.0 (NTU)
Endrin	<0.0002	<0.0002
Lindane	<0.001	<0.001
Methoxychlor	<0.01	<0.01
.oxaphene	<0.001	<0.001

RESULTS OF SPLIT SAMPLES AS A PART OF QUALITY CONTROL PROGRAM

CA Lab Number: 81-732-
81-837

PARAMETER:	REPORTED RESULTS:	SPLIT SAMPLE RESULTS:
Total Organic Carbon	13.0	12.5
Nitrate (as N)	0.78	0.76
Phenol	<0.01	<0.01
Total Coliform	N/D	N/D

• VIJAY THAKORE: PRESIDENT, TECHNICAL DIRECTOR

TNT & RDX

QUALITY CONTROL DATA

Samples run in duplicate for TNT & RDX:

Sample #:	TNT PPM	TNT PPM
284	<0.005	<0.005
618	<0.005	<0.005
704	<0.005	<0.005
796	<0.005	<0.005

Sample #:	RDX PPM	RDX PPM
284	<0.011	<0.011
618	<0.011	<0.011
704	<0.011	<0.011
796	<0.011	<0.011

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• VIJAY THAKORE: PRESIDENT, TECHNICAL DIRECTOR

GROSS ALPHA, GROSS BETA, TOTAL RADIUM

QUALITY CONTROL DATA

Duplicate sample with ccunting error:

Sample #:	Gross Alpha Pci/L:	Gross Alpha Pci/L:
577	3.2 ± 2.3	3.2 ± 2.3
619	1.2 ± 0.5	1.2 ± 0.5
693	2.2 ± 2.2	2.2 ± 2.2
815	4.8 ± 5.0	4.8 ± 5.0

Sample #:	Gross Beta Pci/L:	Gross Beta Pci/L:
577	5.6 ± 3.8	5.6 ± 3.8
619	1.1 ± 2.5	1.1 ± 2.5
693	3.1 ± 5.6	3.1 ± 5.6
815	7.5 ± 7.6	7.5 ± 7.6

Sample #:	Total Radium Pci/L:	Total Radium Pci/L:
577	0.8 ± 0.1	0.8 ± 0.1
619	0.4 ± 0.1	0.4 ± 0.1
693	0.1 ± 0.1	0.1 ± 0.1
815	0.1 ± 0.1	0.1 ± 0.1

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APPENDIX B

GENERAL NOTES, UNIFIED SOIL CLASSIFICATION SYSTEM, AND MONITORING WELL DATA

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS	.	Split Spoon—1⅜" I.D., 2" O.D., unless otherwise noted	PS	Piston Sample
ST		Shelby Tube—2" O.D., unless otherwise noted	WS	: Wash Sample
PA		Power Auger	FT	: Fish Tail
HA		Hand Auger	RB	: Rock Bit
DB		Diamond Bit—4 in, N, B	BS	: Bulk Sample
AS		Auger Sample	PM	Pressuremeter
HS		Hollow Stem Auger	DC	. Dutch Cone
VS		Vane Shear		

Standard "N" Penetration. Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon, except where noted.

WATER LEVEL MEASUREMENT SYMBOLS:

WL	.	Water Level	WS	. While Sampling
WCI	:	Wet Cave In	WD	. While Drilling
DCI	:	Dry Cave In	BCR	: Before Casing Removal
AB	.	After Boring	ACR	: After Casing Removal

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious soils, the indicated elevations are considered reliable ground water levels. In low permeability soils, the accurate determination of ground water elevations is not possible in even several days observation, and additional evidence of ground water elevations must be sought.

DESCRIPTIVE SOIL CLASSIFICATION:

Coarse Grained or Granular Soils have more than 50% of their dry weight retained on a #200 sieve; they are described as: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50 % of their dry weight retained on a #200 sieve; they are described as: clays, or clayey silts if they are cohesive, and silts if they are slightly cohesive or non-cohesive. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, granular soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their consistency and plasticity. Example: Clayey silt, trace sand moderately plastic, stiff; silty fine sand, trace gravel, medium dense.

GRAIN SIZE TERMINOLOGY

Major Component Of Sample	Size Range
Boulders	Over 8 in. (200mm)
Cobbles	8 in. to 3 in. (200mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 2mm)
Sand	#4 to #200 sieve (2mm to .074mm)
Silt or Clay	Passing #200 sieve (0.074mm)

RELATIVE PROPORTIONS

Descriptive Term(s) (Of Components Also Present in Sample)	Percent of Dry Weight
Trace	1-10
Little	10-20
Some	20-35
And	35-50

RELATIVE DENSITY OF GRANULAR SOILS:

N-Blows/ft.	Relative Density
0-3	Very Loose
4-9	Loose
10-29	Medium Dense
30-49	Dense
50-80	Very Dense
80 +	Extremely Dense

CONSISTENCY OF COHESIVE SOILS:

Unconfined Compressive Strength, Qu, psf	Consistency
◄ 500	Very Soft
500- 1,000	Soft
1,000- 2,000	Medium
2,000- 4,000	Stiff
4,000- 8,000	Very Stiff
8,000-16,000	Hard
► 16,000	Very Hard

PLASTICITY OF FINE GRAINED SOILS:

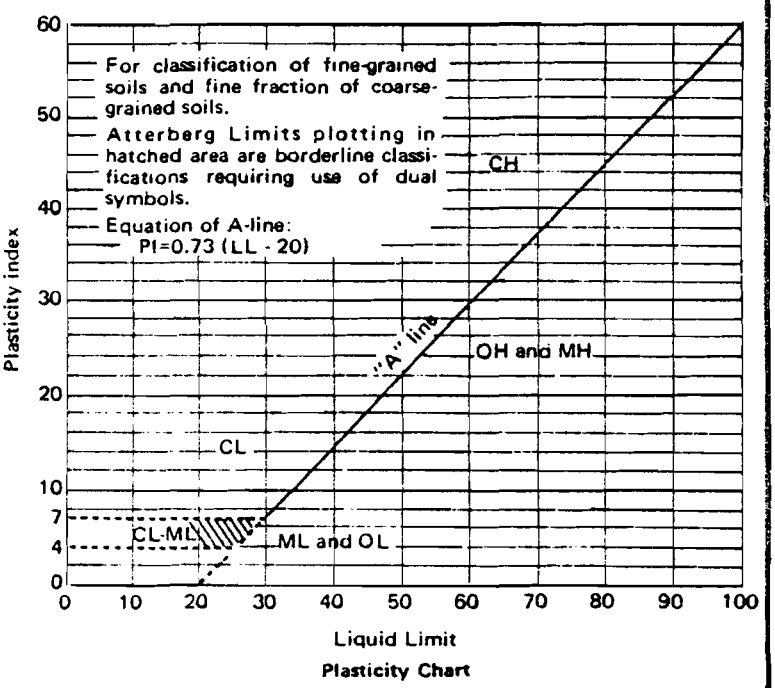
Term	Plasticity Index
None to slight	0- 3
Slight	4- 7
Moderate	8-25
High	► 25

UNIFIED SOIL CLASSIFICATION SYSTEM

Major divisions			Group symbols	Typical names	Laboratory classification criteria	
Coarse-grained soils (More than half of material is *larger* than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines	$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils (More than half of material is *smaller* than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL	Organic silts and organic silty clays of low plasticity		
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity, organic silts		
	Highly organic soils		Pt	Peat and other highly organic soils		

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

- Less than 5 per cent . . . . . GW, GP, SW, SP
- More than 12 per cent . . . . . GM, GC, SM, SC
- 5 to 12 per cent . . . . . *Borderline* cases requiring dual symbols



Plasticity Chart

TERRACON CONSULTANTS, INC.

TABLE

SUPPLEMENTAL MONITORING WELL LOG DETAILS
IOWA ARMY AMMUNITION PLANT, BURLINGTON, IOWA
JOB NO. 680574

Well	x[a] North (ft.)	y[a] South (ft.)	Natural Grade Elevation	Top of Pipe Elevation (ft.)	Installation Date	Nominal Hole Diameter (in.)	Well Depth (ft.)	Casing[b] Depth (ft.)	Screen[c] Length (ft.)	Cement Used (bags)
Z1#1	7192	14117	682.1	685.8	12-3-80	8.5	50	40	10	4½
Z1#2	7181	13955	670.7	673.8	12-22-80	8.5	30	20	10	3
Z1#2A	7195	13948	671.0	673.9	12-22-80	8.5	10	5	5	½
Z1#3	7169	13794	677.6	680.6	12-4-80	8.5	46	36	10	½
Z1#6	9566	13239	683.5	687.3	12-2-80	8.5	49	39	10	½
Z2#1	8016	8182	722.7	725.4	11-25-80	8.5	54	44	10	½
Z2#2	5376	10010	698.4	692.6	12-11-80	8.5	30	20	10	½
Z2#18	6895	9173	712.4	716.0	12-10-80	8.5	50	40	10	5
Z2#18A	6924	9173	712.5	716.9	12-10-80	8.5	10	5	5	½
Z2#19	7192	10148	712.6	715.9	12-10-80 and 12-11-80	8.5	50	40	10	½
Z3#1	9650	8650	723.6	726.4	12-5-80	8.5	19	9	10	½
Z3#2	9730	8800	723.9	727.1	12-5-80	8.5	8	3	5	¼
Z3#3	9500	8925	720.9	722.1	12-9-80	8.5	11.5	6.5	5	½
Z3#4	9330	8915	720.9	725.4	12-12-80	8.5	28	18	10	1
Z3#5	9370	8850	722.2	725.8	12-9-80	8.5	18.5	8.5	10	½

(a) Set according to local coordinate system established by C.O.E. for construction on Line 4A, for approximate conversion to State Plane Coordinate System, Iowa South Zone, Est. 1955 use the following formula S.P.C. = L.C. + (294,126 North) (2,615,430 East)

(b) Nominal 4" inside casing diameter, schedule 40 PVC plastic pipe in accordance with ASTM D 1785-74.

(c) Johnson well screen, V shaped size 20 slot (0.020"), nominal 4" inside diameter PVC.

MONITORING WELL WATER LEVEL RECORD

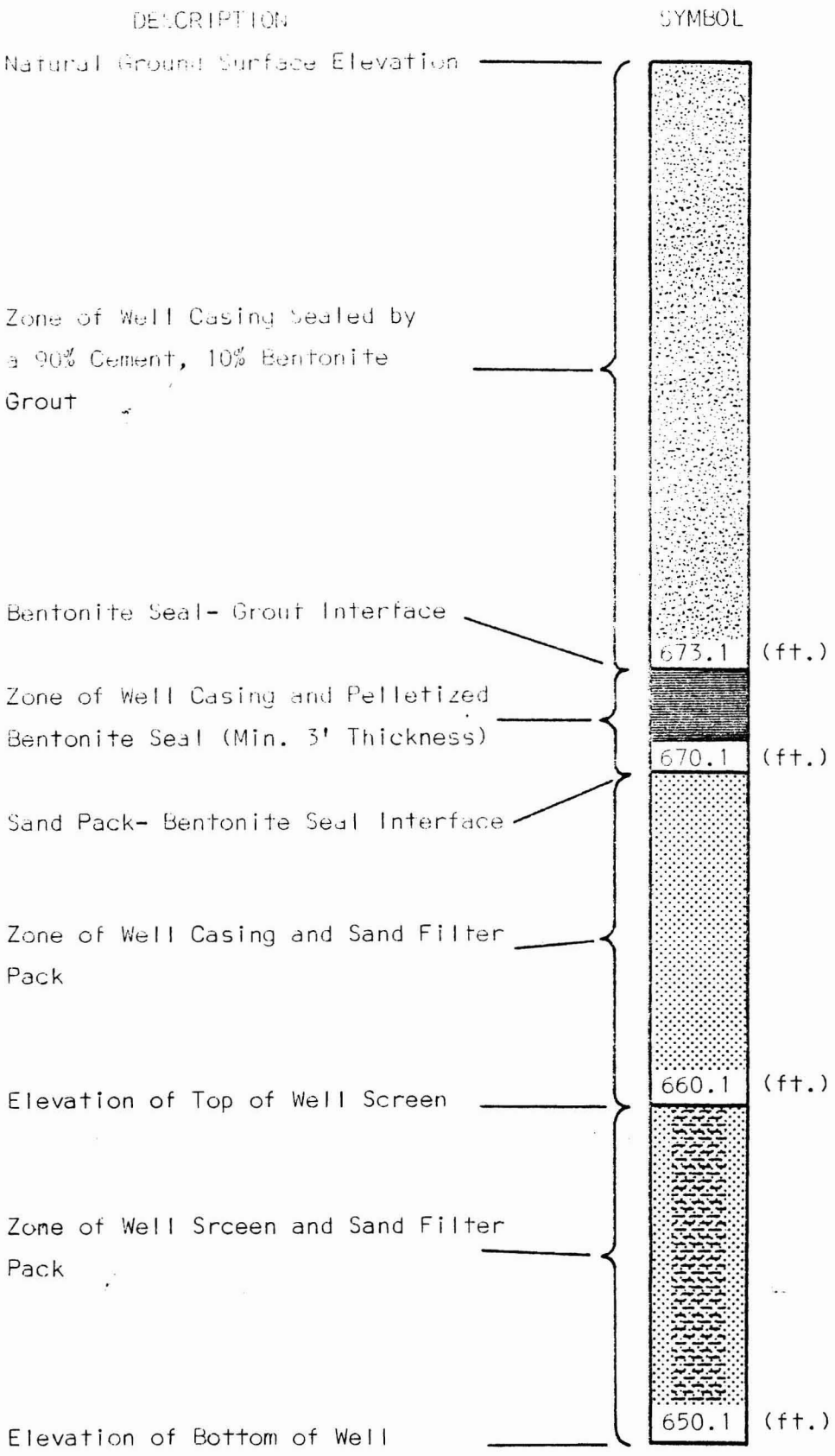
IOWA APMY AMMUNITION PLANT

BURLINGTON, IOWA

TCI JOB NO. 680574 / 3-3-81

SITE NO.	WELL NUMBER	READING DATE / ELEVATION TOP OF PIPE (FEET)								
			WATER DEPTH	WATER LEVEL ELEV.	WATER DEPTH	WATER LEVEL ELEV.	WATER DEPTH	WATER LEVEL ELEV.	WATER DEPTH	WATER LEVEL ELEV.
Z1	1	685.8								
	2	673.8								
	2A	673.9								
	3	680.6								
	6	687.3								
Z2	1	725.4								
	2	692.6								
	18	716.0								
	18A	716.9								
	19	715.9								
Z3	1	726.4								
	2	727.1								
	3	722.1								
	4	725.4								
	5	725.8								

MONITORING WELL DETAIL LEGEND



APPENDIX C

SITE Z_1 DATA

LOG OF BORING NO. Z1 #1

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Well Installed 12-3-80 **Description** Surface Elevation = 682.1	Monitoring Well Details
	HS									681.1	(1.0) SILT TRACE SAND, Dark Brown	
											CLAYEY SILT Brown	
										678.1	(4.0)	
1	ST	24	5			19.2	110	CH	5		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Very Stiff to Stiff	
	HS											
2	ST	24	8					CL	10			
	HS											
3	ST	24	14					CL	15			
	HS											
4	ST	24	17			15.9	115	CH	20		To Gray Brown at 19'.	
	HS											659.1
5	ST	24	18					CH	25			656.1
	HS										Thin Sand Seams at 29'.	
6	ST	24	8					CL SM	30	651.6	(30.5)	
										650.6	(31.5) COARSE SAND, Brown	
											Continued on Sheet #2	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	43'	W.S. OR W.D.	47' A.B.
W.L.		B.C.R.	A.C.R.
W.L.	18' 1 hr. A.B./7' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED 12-3-80
BORING COMPLETED 12-3-80
RIG CME 75 **FOREMAN** JM
APPROVED JFH **JOB #** 680574

LOG OF BORING NO. Z1 #1 (Continued)

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE BRUSH CREEK
ABANDONED RINKWATER LAGOON

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
									30		Continued from Sheet #1	
										650.6	(31.5)	
	HS										SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL)	
7	CT	24	17					CL	35		Gray Brown to Gray Very Stiff to Hard	
	HS											
8	ST	24	12					CL	40			642.1
	HS											
9	ST	24	6					CL-ML	45			
	HS											
10	ST	24	13					CL	50			632.1
										631.1	(51.0)	
									55		Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	43'	W.S. OR W.D.	47' A.B.
W.L.		B.C.R.	A.C.R.
W.L.	18' 1 hr. A.B./7' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-3-80
BORING COMPLETED	12-3-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z1 #2

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description (Well Installed 12-22-80)	Monitoring Well Details
	PA										SANDY SILT Dark Brown	
										665.7	(4.0)	
1	ST	24	8					CL	5		SILTY CLAY TRACE SAND Gray Very Stiff	
	PA									663.7	(7.0)	
2	ST	24	12			20.1	104	CL-CH	10		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown Very Stiff to Hard	
	PA											
3	ST	24	20					CL	15			653.7
	PA											
4	ST	24	18					CL	20			650.7
	PA										To Gray at 22'.	
5	ST	24	16					CL	25			
	PA											
6	ST	24	10			13.7	114	CL-SC			Fine to Medium Sand Seam at 29'.	
									30	640.7	(30.0)	640.7
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	W.S. OR W.D.	4'	A.B.
W.L.	B.C.R.		A.C.R.
W.L.	+0.4 on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED 12-22-80
BORING COMPLETED 12-22-80
RIG Bomb **FOREMAN** REF
APPROVED JFH **JOB #** 680574

LOG OF BORING NO. Z1 #2A

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Uncontined Compressive Strength-lbs/ft²	Water Content-%	Dry Density-lbs./ft³	Unified Class Symbol	Depth	Elevation	Well Installed 12-22-80 Description Surface Elevation = 671.0	Monitoring Well Details
	HS										SANDY SILT Dark Brown Medium	669.0
										668.0	(3.0)	
1	ST	24	4					CL	5		SILTY CLAY TRACE SAND Gray Brown Very Stiff	666.0
										664.0	(7.0)	
	ST	24	16					CL-CH	10	661.0	SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL Gray to Gray Brown (10.0) Very Stiff	661.0
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS			
W.L.	W.S. OR W.D.	None	A.B.
W.L.	B.C.R.		A.C.R.
W.L.	4.8' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-22-80
BORING COMPLETED	12-22-80
RIG Bomb	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z1 #3

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Well Installed 12-4-80	
											Surface Elevation = 677.6	
	HS										CLAYEY SILT Dark Brown	
										675.6	(2.0)	
1	ST	24	2					CL	5		CLAYEY SILT Dark Brown Stiff	
	HS											
										668.6	(9.0)	
2	ST	24	6			21.3	105	CL	10		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown to Greenish Brown Stiff to Very Stiff	
	HS											
3	ST	24	9					CL	15			
	HS											
4	ST	24	12					CL	20		Greenish Gray with Sand Seams at 20'.	
	HS											
5	ST	24	13					CL	25			
	HS											
										648.6	(29.0)	
									30		Continued on Sheet #2	

672.6

669.6

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	12.5' W.S. OR W.D.	A.B.
W.L.	B.C.R.	A.C.R.
W.L.	2.0' on 1-8-81	

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-4-80
BORING COMPLETED	12-4-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z1 #3 (Continued)

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
										648.6	(27.0) Continued from Sheet #1	
6	ST	18	13					CL	30		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL)	
	HS										Brown Gray to Gray Hard	
7	ST	18	16					CL	35		With Coarse Sand and Gravel Seams at 30'.	641.6
	HS											
8	ST	6	4			[illegible]	[illegible]	SC			Very Sandy at 39.5'.	
	HS								40			
9	ST	6	8					ML-CL			Very Silty at 44.5'.	
	HS								45			631.6
10	ST	12	7					CL	50	627.6	(50.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	12.5' W.S. OR W.D.	A.B.
W.L.	B.C.R.	A.C.R.
W.L.	2.0' on 1-8-81	

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-4-80
BORING COMPLETED	12-4-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z1 #4

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs /ft²	Water Content-%	Dry Density lbs /ft³	United Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Surface Elevation = 676.6	
	PA										SANDY SILT TRACE CLAY WITH COAL CHIPS	
1	ST	24	13			14.0	119	CL		674.1	(2.5) Dark Brown to Black	
	PA								5		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Stiff	
2	ST	24	12					CL		667.6	(9.0)	
	PA								10		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown Stiff to Very Stiff	
3	ST	24	12			16.5	116	CL				
	PA								15			
4	ST	24	16					CL				
									20	656.6	(20.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU, THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	W.S. OR W.D.	None	A.B.
W.L.	B.C.R.		A.C.R.
W.L.	2.8' on 1-7-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-23-80
BORING COMPLETED	12-23-80
RIG Bomb/CME 45	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z1 #5

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE
BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Surface Elevation = 674.2	
1	ST	24	8					ML		627.7	(1.5) SEE NOTE #1 BELOW	
								CL			SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL)	
	PA								5		Brown to Gray Brown Stiff to Very Stiff	
2	ST	24	17			23.5	101	CL				
	PA								10	663.2	(11.0)	
											SANDY SILTY CLAY TRACE GRAVEL WITH SAND SEAMS (GLACIAL TILL)	
3	ST	24	16			14.1	118	CL			Brown Very Stiff to Hard	
	PA								15			
4	ST	24	18					CL				
									20	654.2	(20.0)	
											Bottom of Boring	
											NOTE #1: CLAYEY SILT TRACE SAND WITH COAL CHIPS Dark Brown to Black	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	W.S. OR W.D.	None	A.B.
W.L.	B.C.R.		A.C.R.
W.L.	0.8' on 1-7-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-22-80
BORING COMPLETED	12-22-80
RIG Bomb/CME 45	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. ZI #6

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Well Installed 12-2-80	
											Surface Elevation = 683.5	
	HS									682.5	(1.0) CLAYEY SILT, Dark Brown	
1	ST	24	3			27.8	90	CL	5		SILTY CLAY SOME SAND Dark Brown Very Stiff	679.5
	HS									677.5	(6.0)	676.5
2	ST	24	14					CL	10		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Very Stiff to Hard	
	HS											
3	ST	24	21			11.5	117	CL	15			
	HS											
4	ST	24	13					CL	20			
	HS											
5	ST	24	19					CL	25		To Gray at 24.8 Feet.	
	HS									655.0	(28.5)	
									30		Continued on Sheet #2	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	7.5' W.S. OR W.D.	44.5'	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	0.0' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED 11-26-80
BORING COMPLETED 11-26-80
RIG CME 75 **FOREMAN** JM
APPROVED JEH **JOB #** 680574

LOG OF BORING NO. ZI #6 (continued)

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. CORPS OF ENGINEERS

SITE
BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs /ft²	Water Content-%	Dry Density-lbs /ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
										655.0	(28.5) Continued from Sheet #1	
6	ST	24	11					CL	30		SANDY SILTY CLAY TRACE GRAVEL WITH SAND LAYERS Gray Green	
	HS									651.5	(32.0) Very Stiff	
7	ST	24	14					CL	35		SANDY SILTY CLAY TRACE GRAVEL Gray Hard	
	HS											
8	ST	6	4					CL		645.0	(38.5)	644.5
	HS								40		SANDY SILTY CLAY TRACE GRAVEL WITH COARSE SAND AND GRAVEL SEAMS Gray Hard	
9	ST	18						CL	45			
	HS											
10	ST	12	8					CL				634.5
	HS								50			
										630.0	(53.5)	
									55		Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES. IN-SITU, THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	7.5' W.S. OR W.D.	44.5' A.B.
W.L.	B.C.R.	A.C.R.
W.L.	0.0' on 1-8-81	

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines IA
Kansas City Wichita KS

BORING STARTED	11-26-80
BORING COMPLETED	11-26-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. ZI #7

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE
BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Surface Elevation = 679.2	
1	ST	24	4					CL		677.7	(1.5) SANDY SILTY CLAY Brown	
	PA								5		SANDY SILTY CLAY TRACE GRAVEL Gray Brown Very Stiff to Hard	
2	ST	24	15					CL	10	669.2	(10.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES. IN-SITU, THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS			
W.L.	W.S. OR W.D.	None	A.B.
W.L.	B.C.R.		A.C.R.
W.L.	1.3' on 1-7-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-22-80
BORING COMPLETED	12-22-80
RIG Bomb/CME 45	**FOREMAN** TT
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z1 #8

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description (Surface Elevation = 676.2)	Monitoring Well Details
	PA										SILTY CLAY TRACE SAND Dark Brown	
1	ST	24	9					CL	5	672.2	(3.0) SANDY [illegible] TRACE GRAVEL [illegible] Brown [illegible] Very Stiff	
	PA											
2	ST	24	9					CL	10	666.2	(10.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	W.S. OR W.D.	None	A.B.
W.L.	B.C.R.		A.C.R.
W.L.	2.5' on 1-7-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-23-80
BORING COMPLETED	12-23-80
RIG Bomb/CME 45	**FOREMAN** TBT
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. ZI #9

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE ERUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density-lbs./ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Surface Elevation = 677.4	
	PA										CLAYEY SILT WITH SAND SEAMS Dark Brown Stiff (4.0)	
1	ST	24	10					CL CL	5	673.4	SILTY CLAY LITTLE SAND WITH NUMEROUS SAND SEAMS Brown Gray Stiff to Very Stiff	
	PA											
2	ST	24	10					SC-CL	10	667.4	(10.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	7'	W.S. OR W.D.	None A.B.
W.L.		B.C.R.	A.C.R.
W.L.	3.4' on 1-7-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED 12-23-80
BORING COMPLETED 12-23-80
RIG Bomb/CME 45 **FOREMAN** REF
APPROVED JFH **JOB #** 680574

LOG OF BORING NO. ZI #10

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE BRUSH CREEK
ABANDONED PINKWATER LAGOON

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Surface Elevation = 678.3	
	PA										SANDY SILT WITH COAL CHIPS Dark Brown to Black	
										675.8	(2.5)	
1	ST	24	12					CL			SANDY SILTY CLAY TRACE GRAVEL Brown Very Stiff	
	PA								5			
2	ST	24	16					CL				
									10	668.3	(10.0)	
											Bottom of Boring	

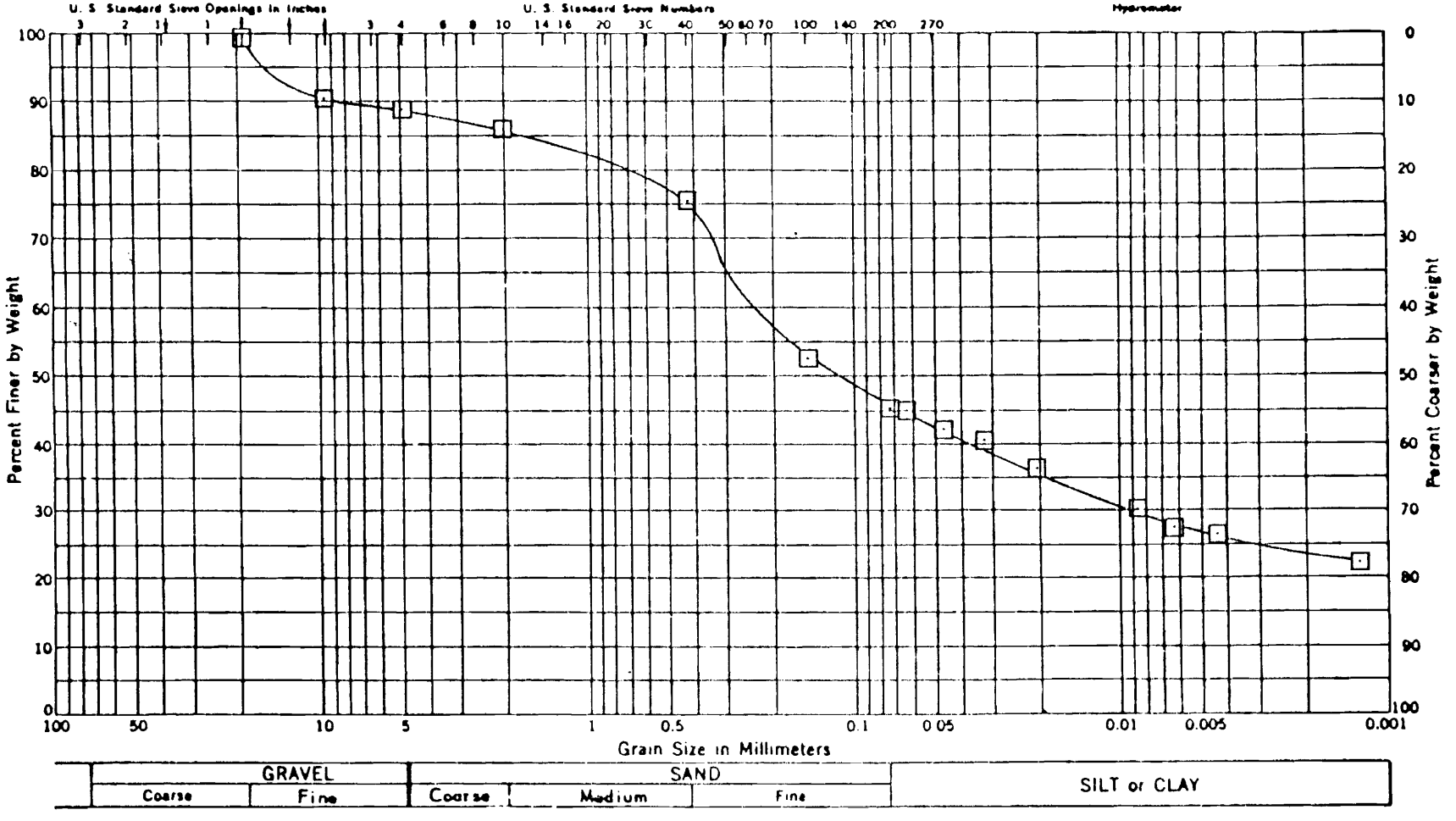
THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	W.S. OR W.D.	None	A.B.
W.L.	B.C.R.		A.C.R.
W.L.	5.3' on 1-7-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-23-80
BORING COMPLETED	12-23-80
RIG Bomb/CME 45	**FOREMAN** TBT
APPROVED JFH	**JOB #** 680574



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		54	18	36	
					UNIFIED CLASSIFICATION (CH)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

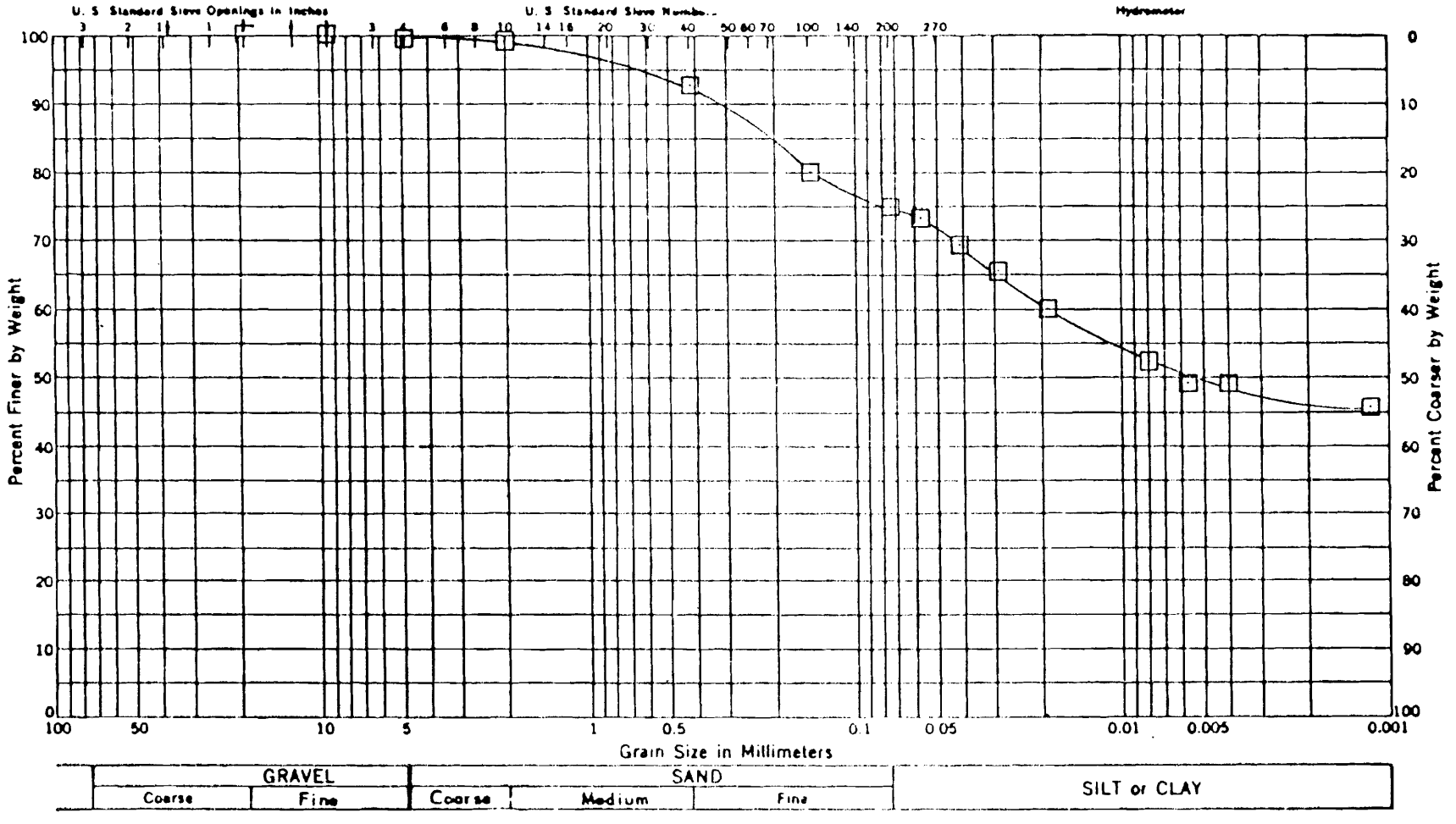
BORING 1 SAMPLE 1

DEPTH 4.0 - 6.0 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/15/81	680574

147



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
4		58	17	41	
					UNIFIED CLASSIFICATION (CH)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

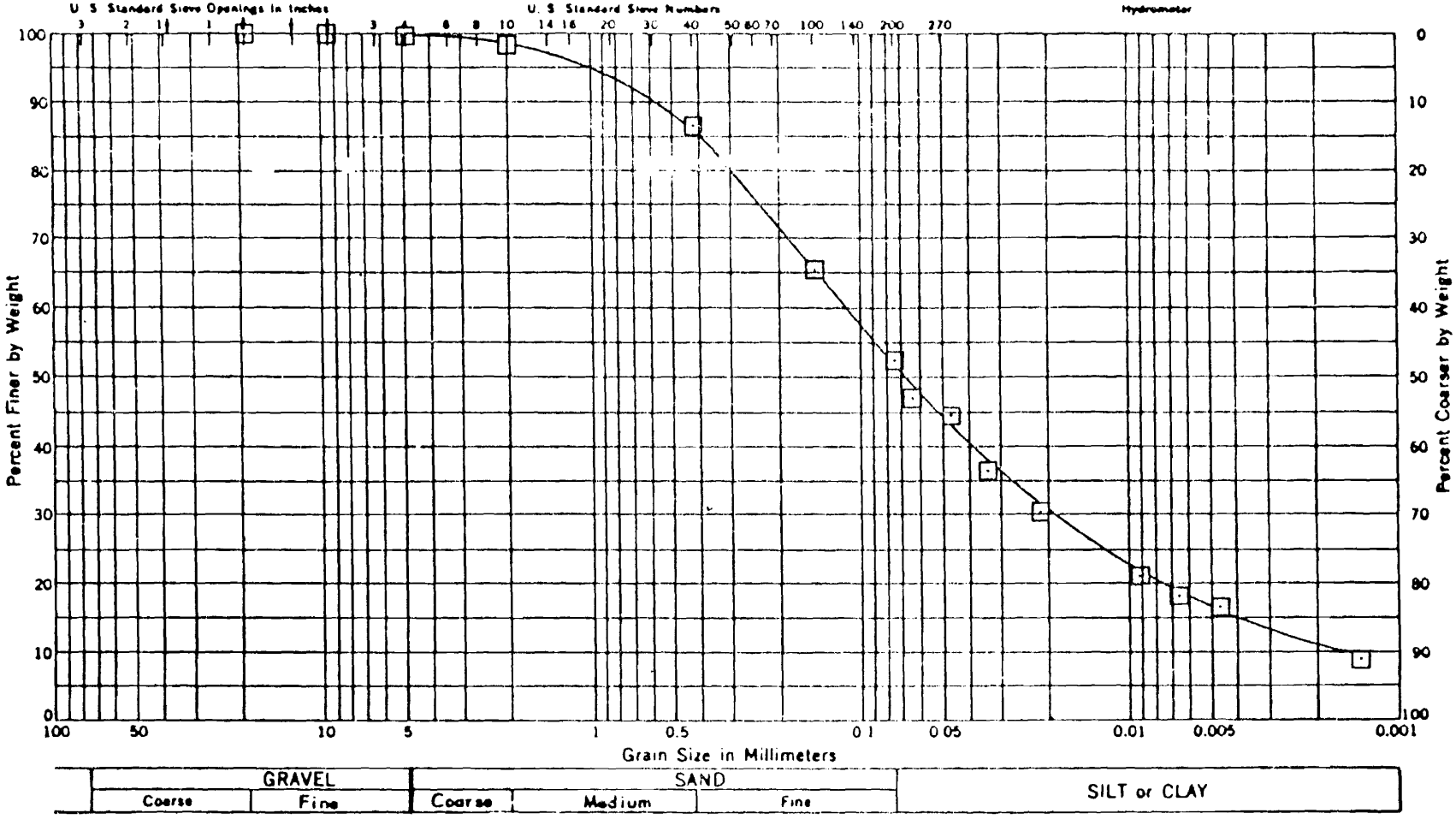
BORING 1 SAMPLE 4

DEPTH 19.0-21.0 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/15/81	680574

150



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
9		19	14	5	
					UNIFIED CLASSIFICATION (CL-ML)

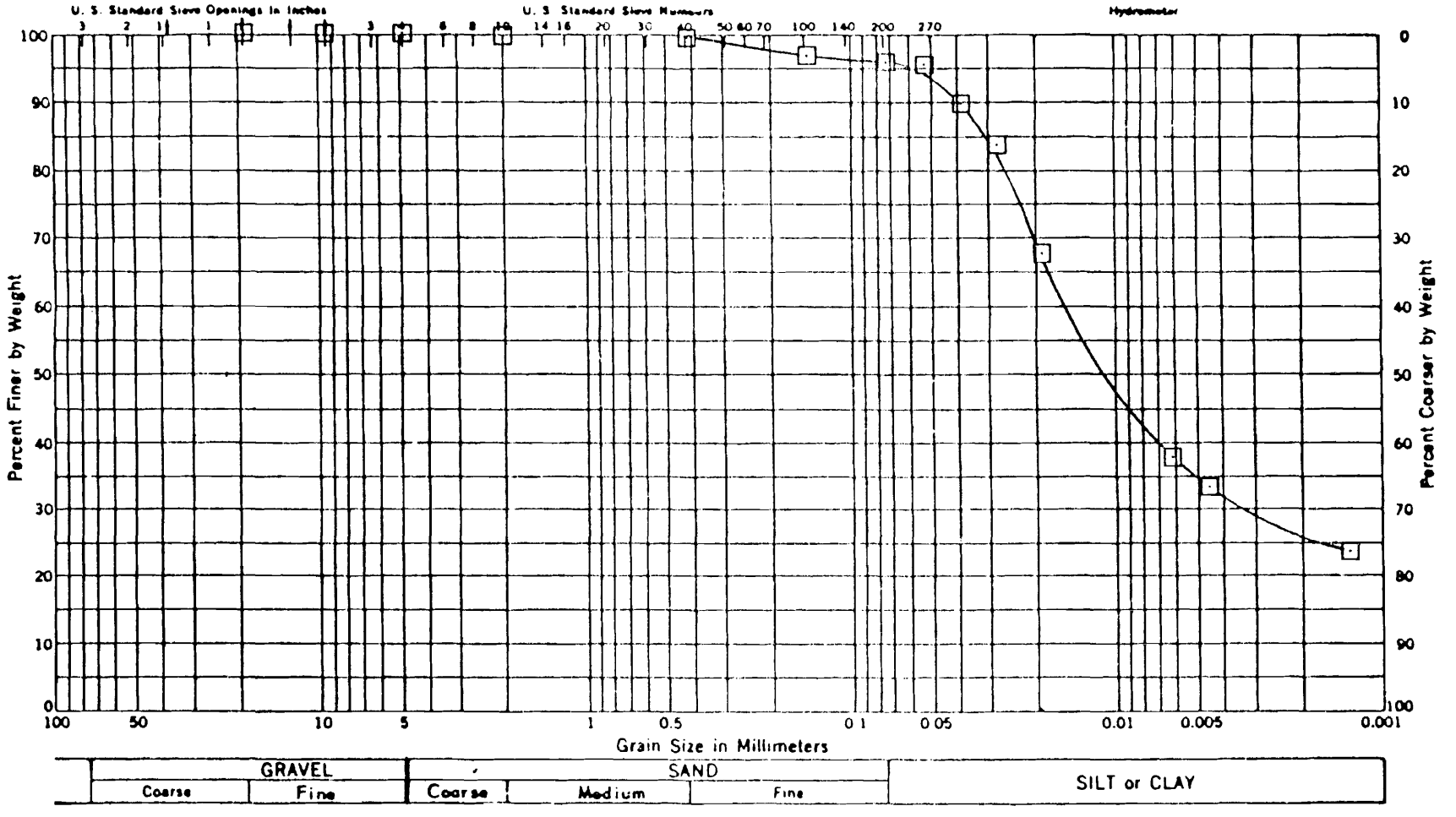
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

BORING 1 SAMPLE 9
DEPTH 44 - 45 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H	01/15/81	680574

151



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		45	24	21	
					UNIFIED CLASSIFICATION (CL)

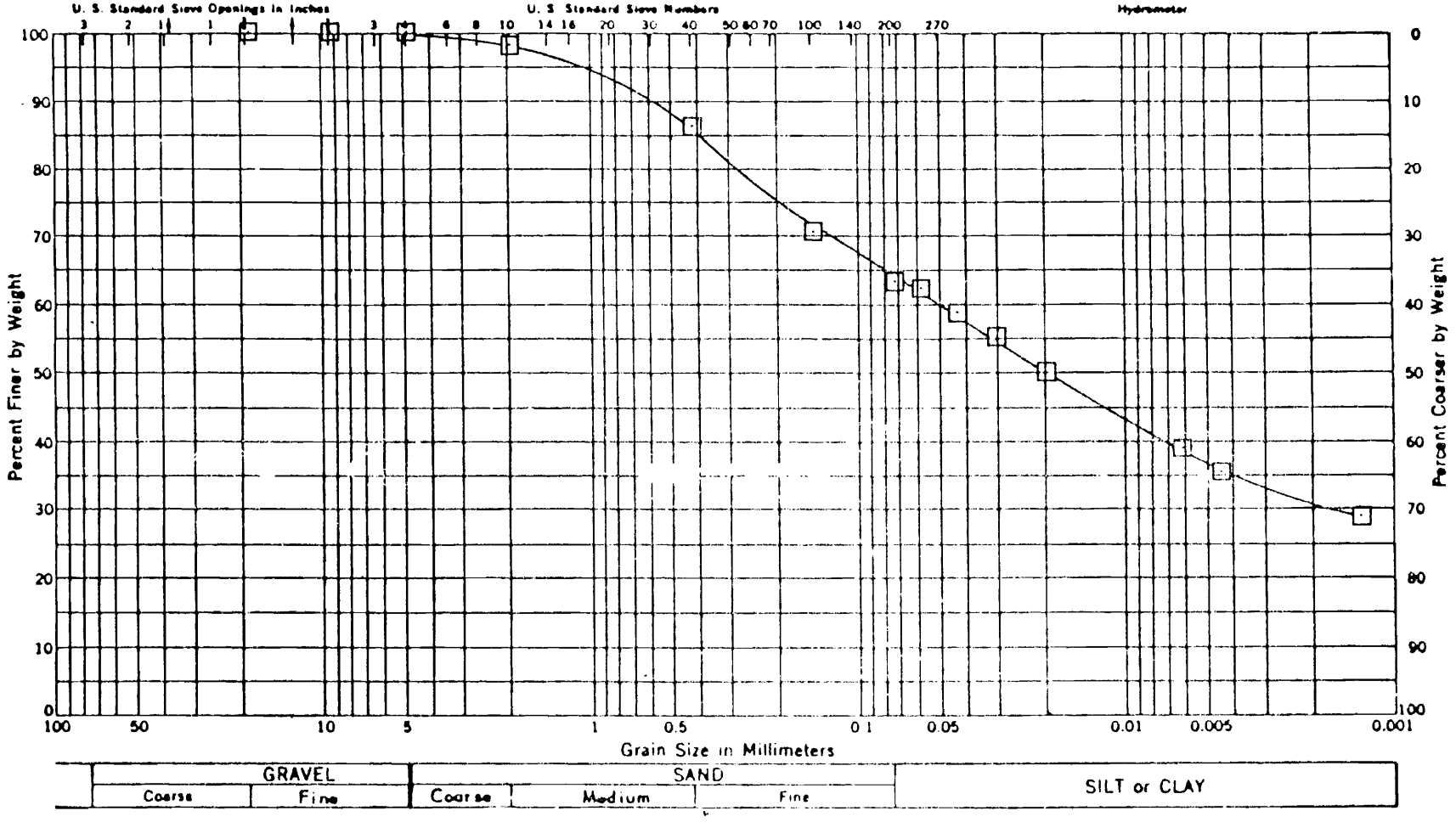
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

BORING 2 SAMPLE 1

DEPTH 4 - 6 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/15/81	680574



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		48	16	32	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

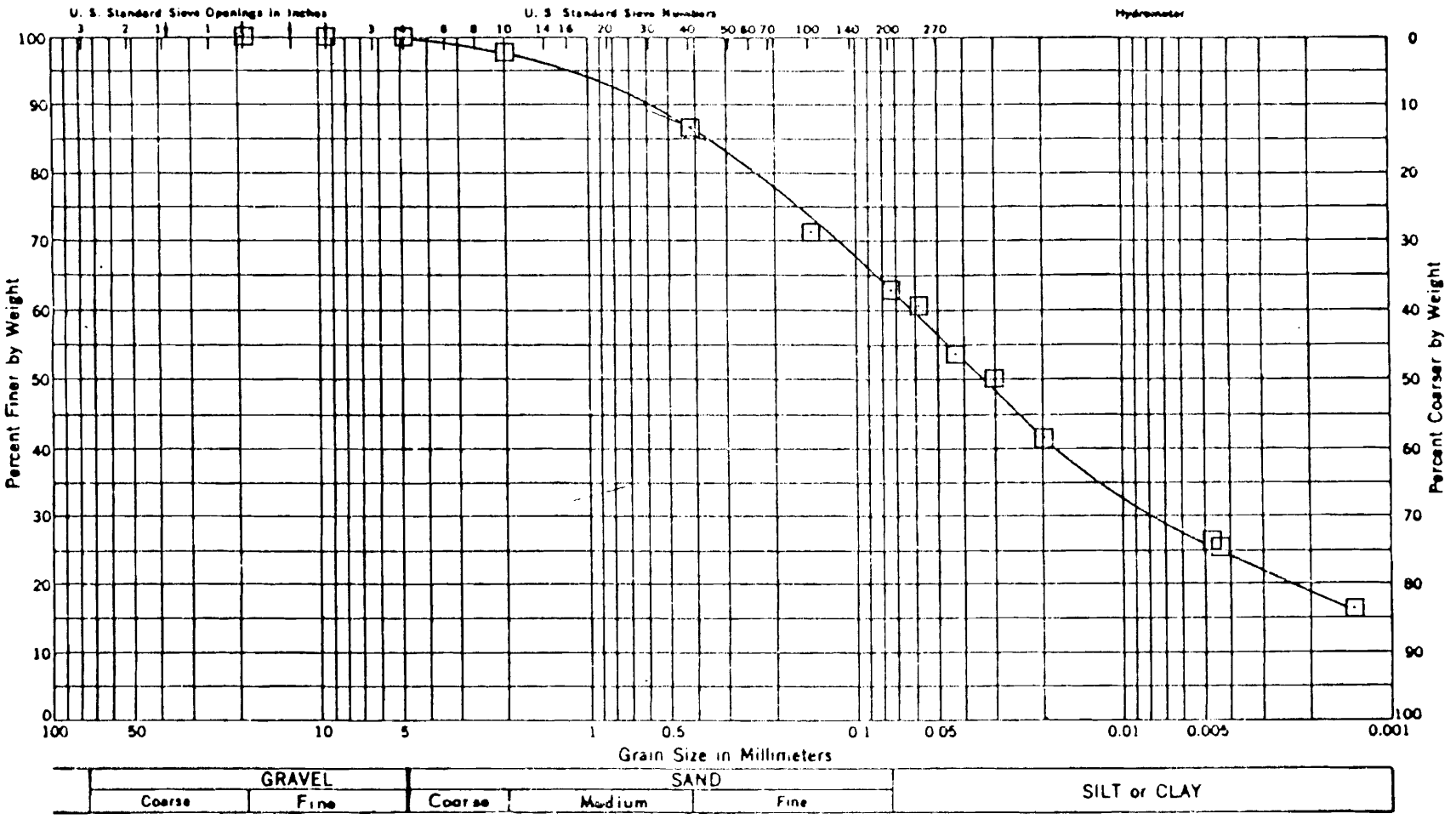
BORING 2 SAMPLE 2

DEPTH 9 - 11 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/15/81	680574

153



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
6		32	16	16	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

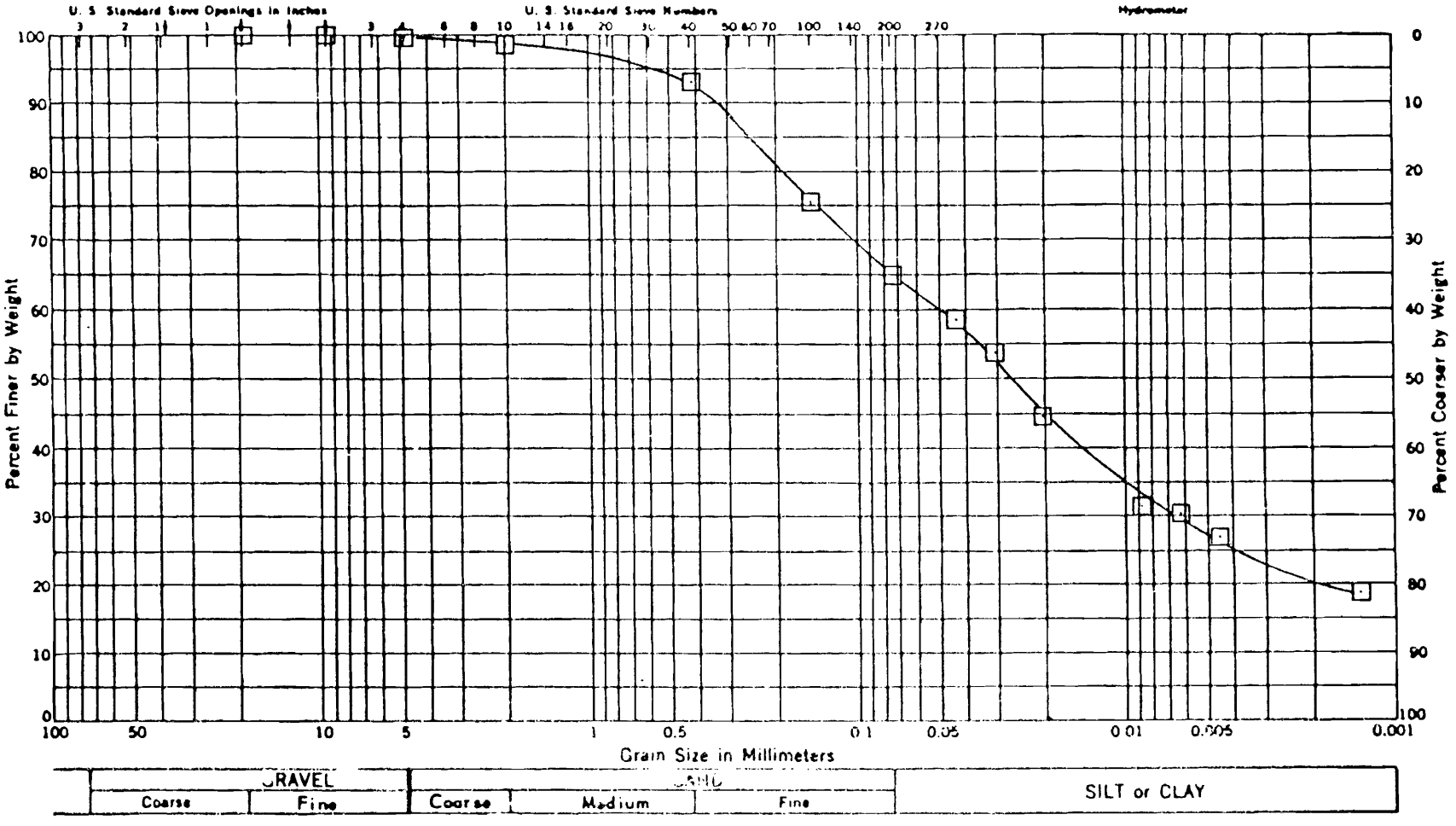
BORING 2 SAMPLE 6

DEPTH 28 - 30 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/16/81	680574

154



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		28	15	13	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

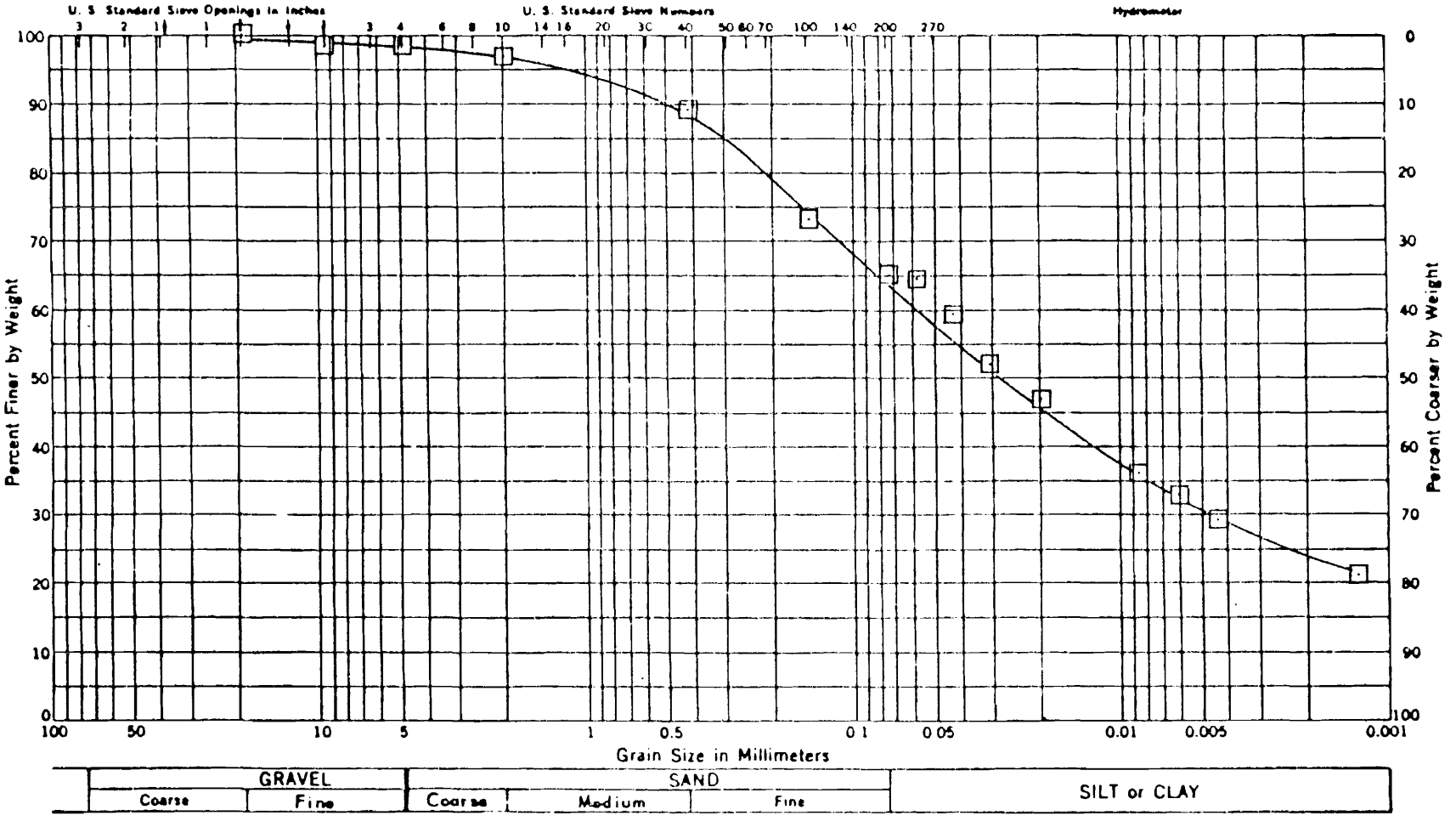
BORING 3 SAMPLE 2

DEPTH 9-11 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/16/81	680574

155



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
5		29	13	16	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

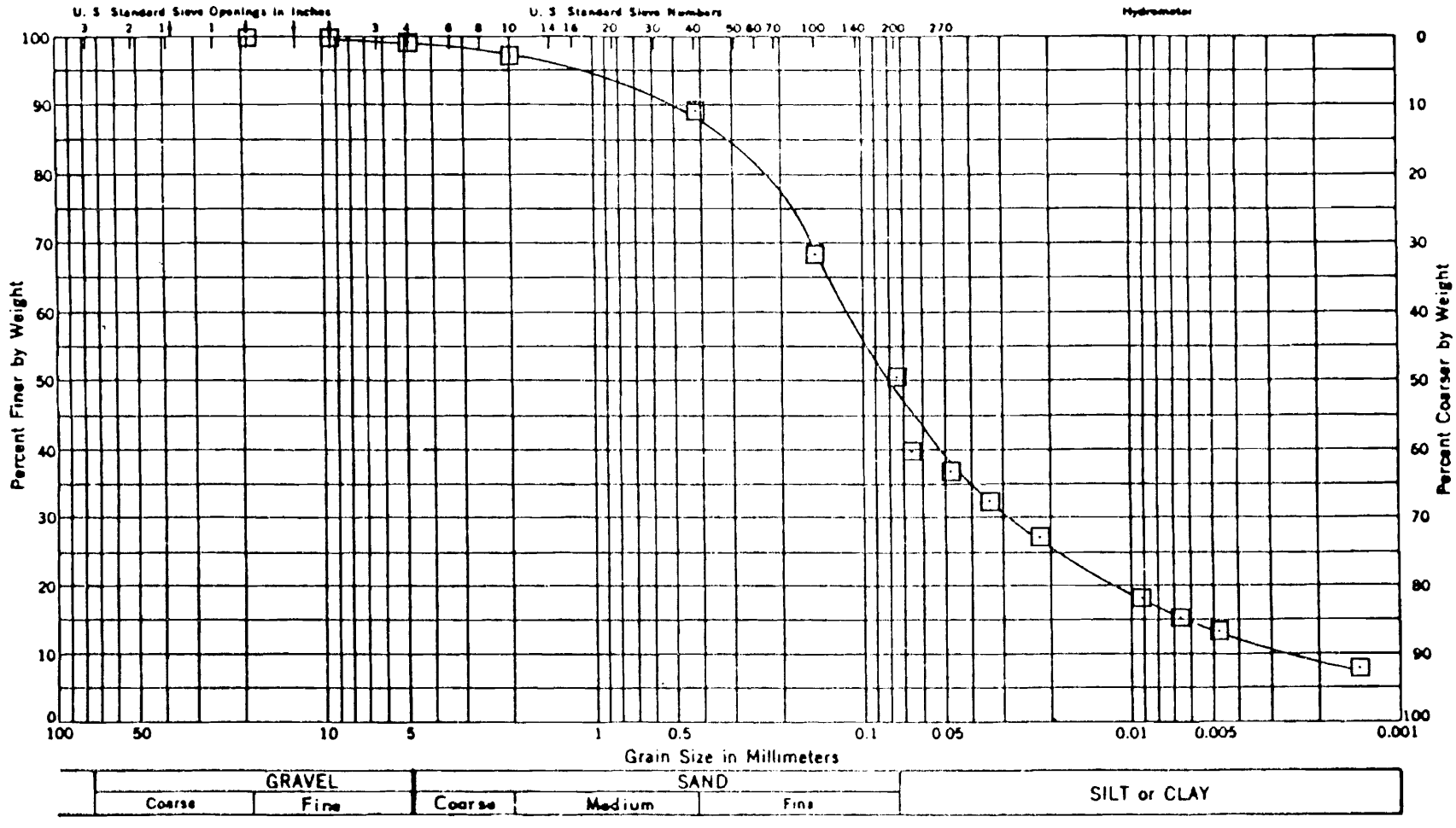
BORING 3 SAMPLE 5

DEPTH 24-26 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/16/81	680574

951



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
8					
					UNIFIED CLASSIFICATION (SC)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

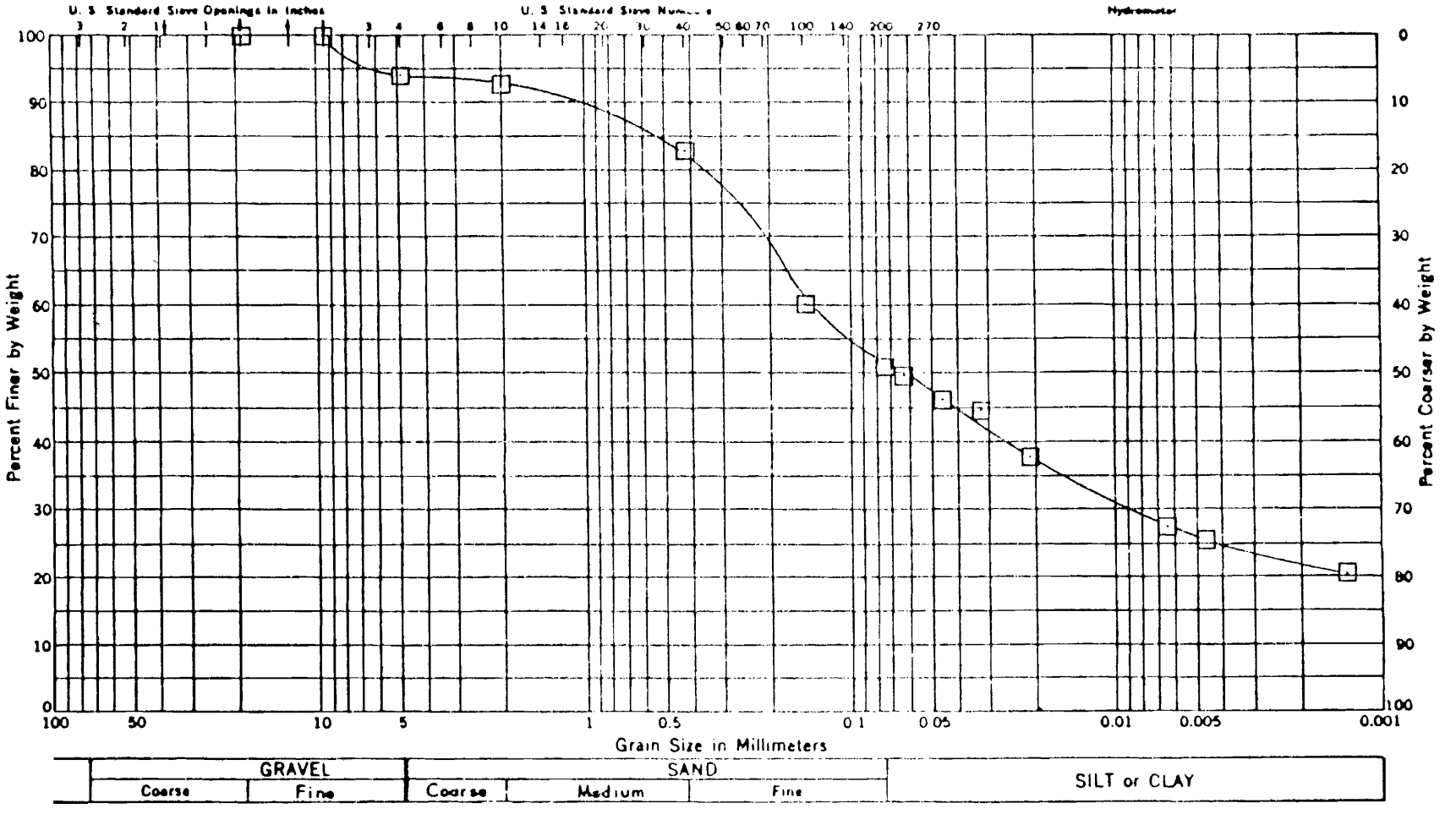
BORING 3 SAMPLE 8

DEPTH 39-39.5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/16/81	680574

157



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		28	14	14	
					UNIFIED CLASSIFICATION (CL)

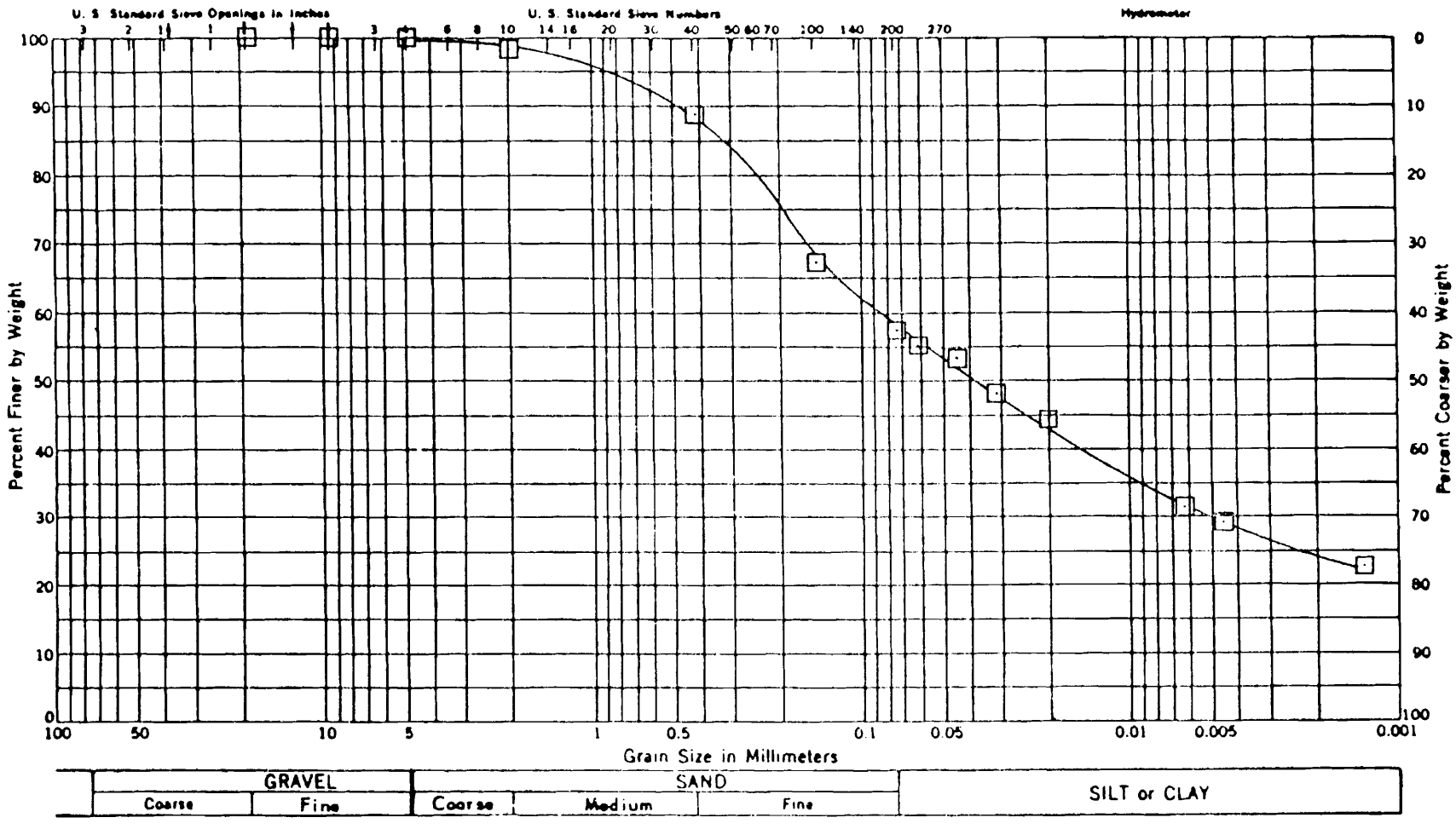
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

BORING 4 SAMPLE 1
DEPTH 2-4 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/16/81	680574

851



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		29	13	16	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

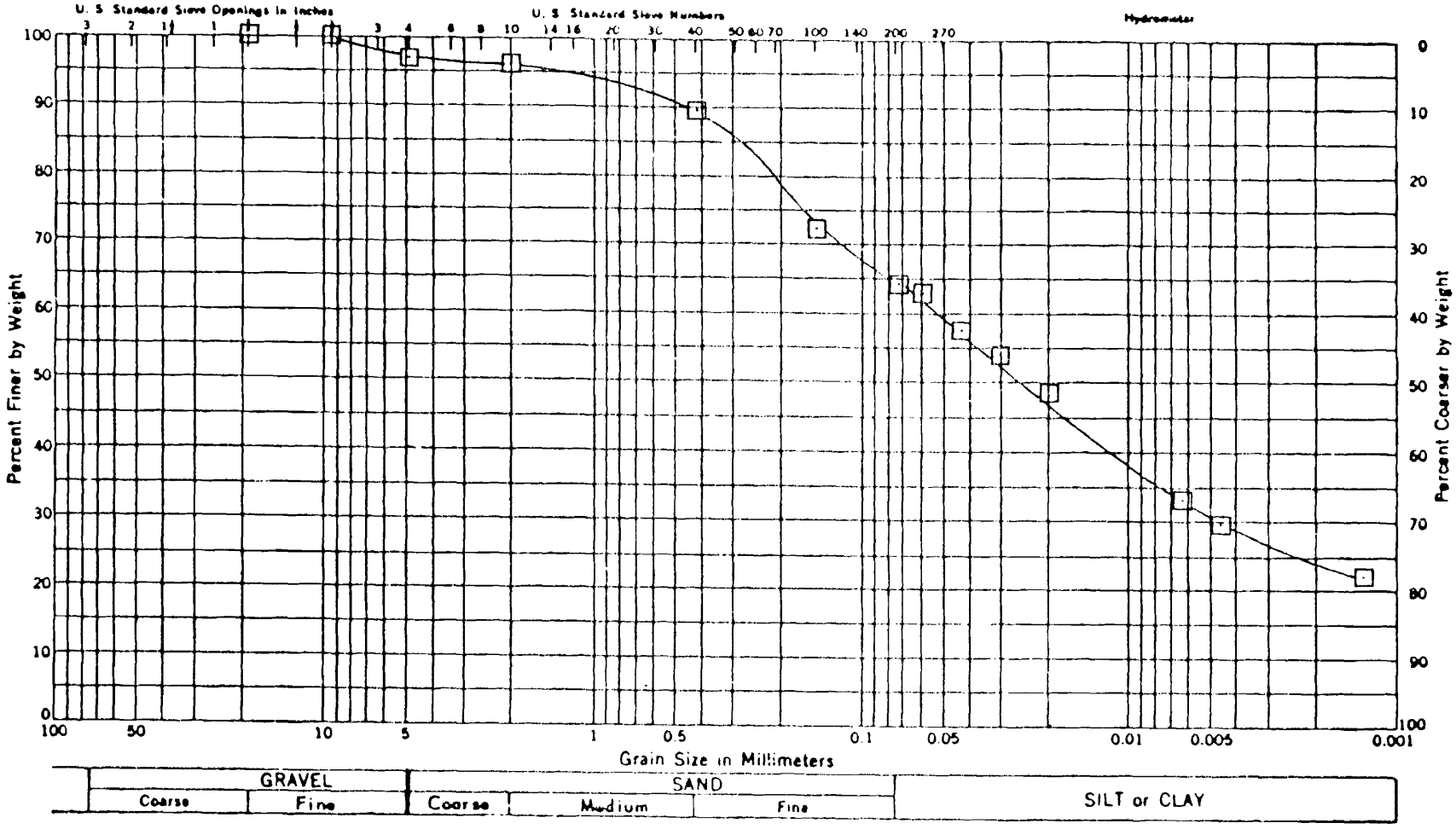
BORING 4 SAMPLE 2

DEPTH 8-10 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/16/81	680574

151



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		37	14	23	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

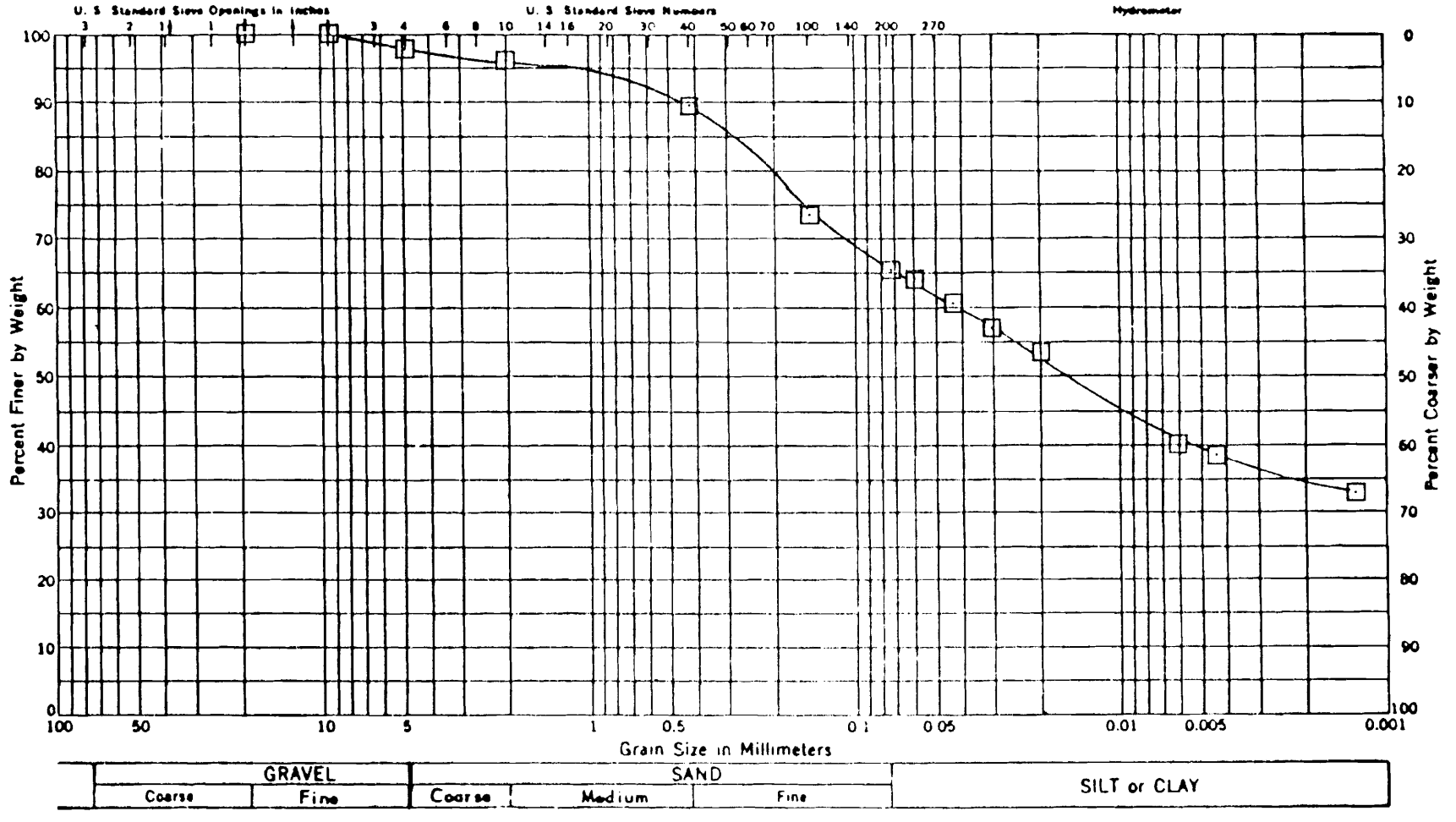
BORING 4 SAMPLE 3

DEPTH 13-15 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H	01/16/81	680574

091



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		45	20	25	
					UNIFIED CLASSIFICATION (CL)

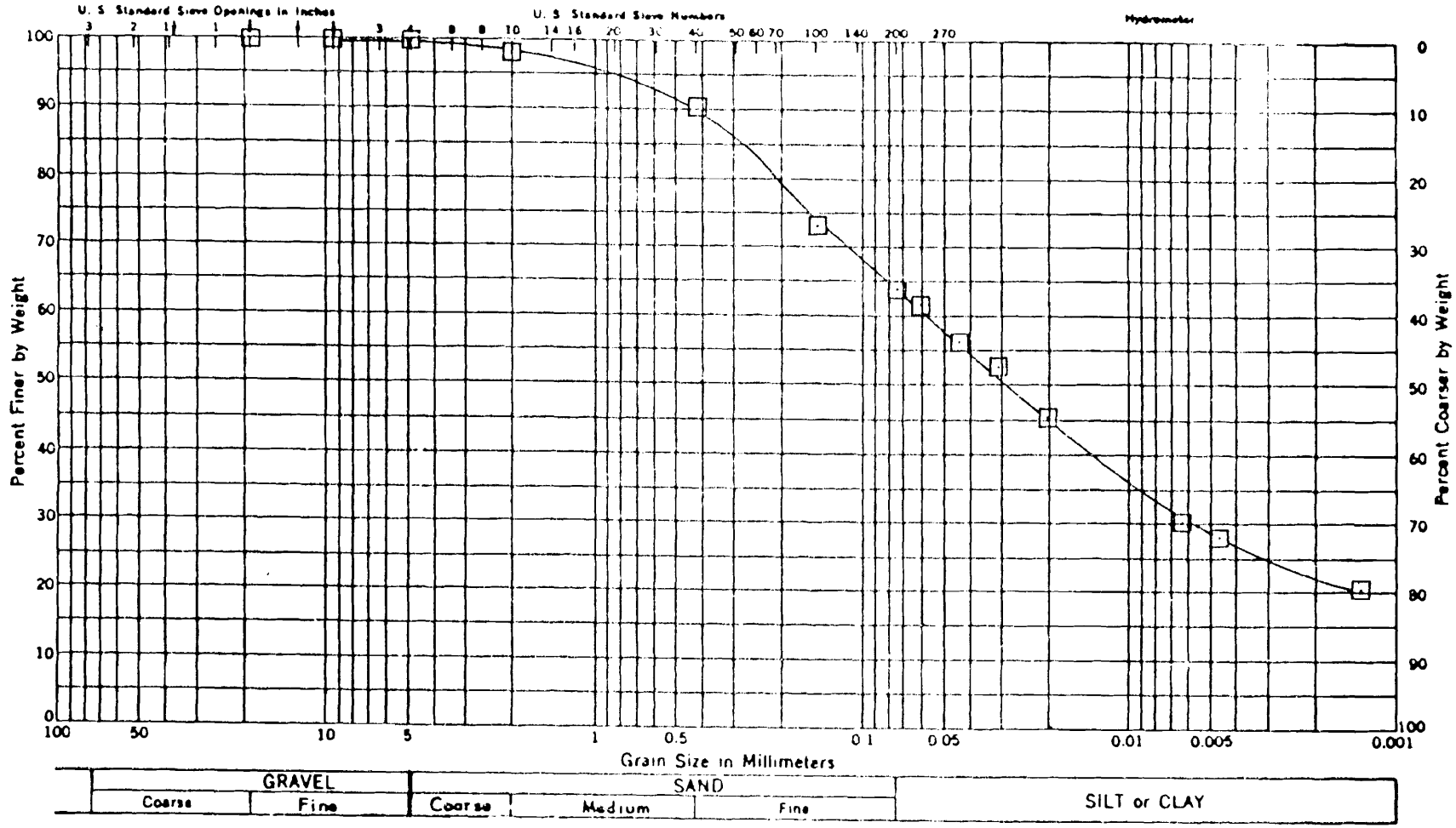
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

BORING 5 SAMPLE 2
DEPTH 8 - 10 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H	01/16/81	680574

191



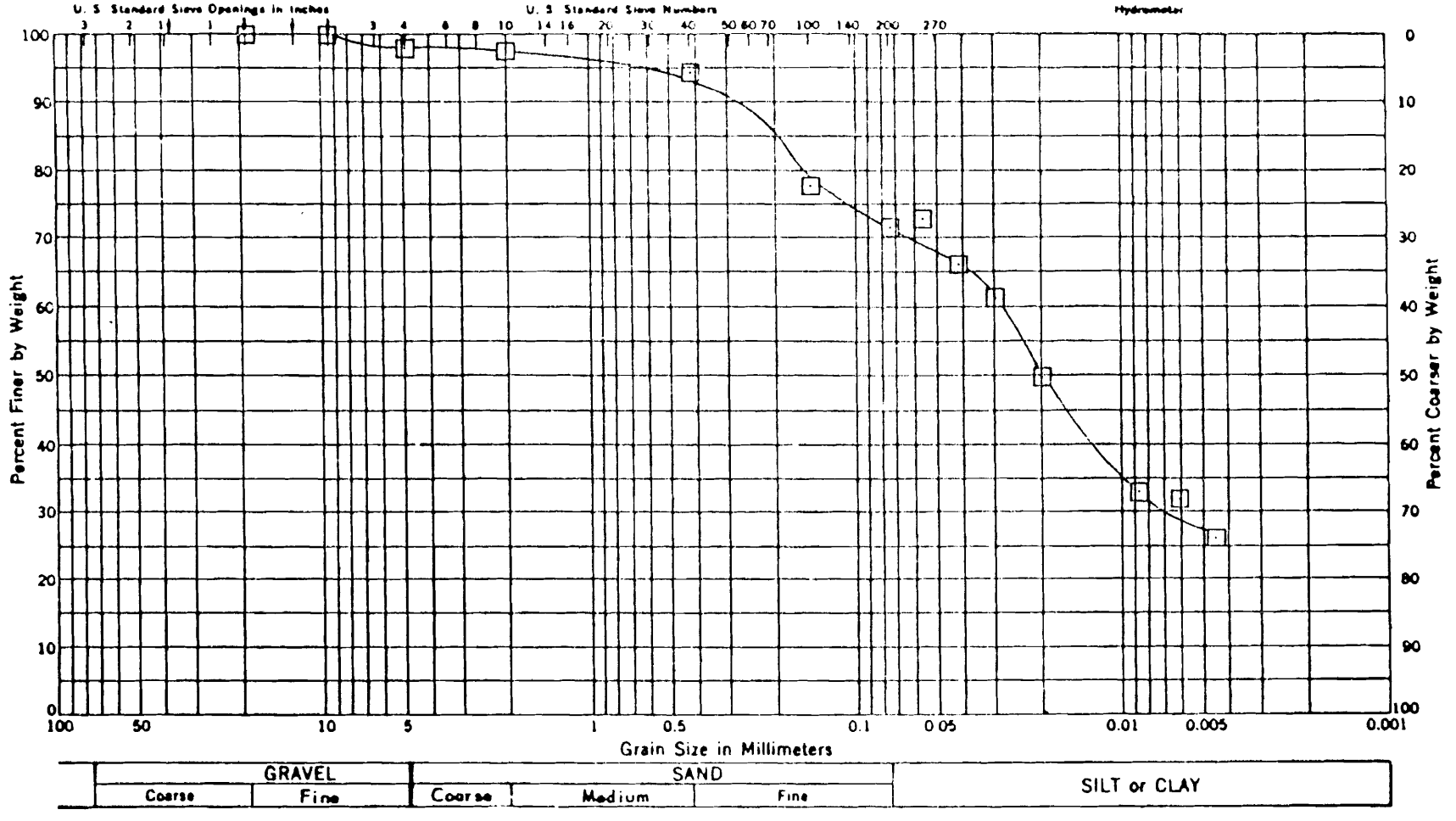
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		31	18	13	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

BORING 5 SAMPLE 3
DEPTH 13.0-15.0 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/16/81	680574



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		35	21	14	
					UNIFIED CLASSIFICATION (CL)

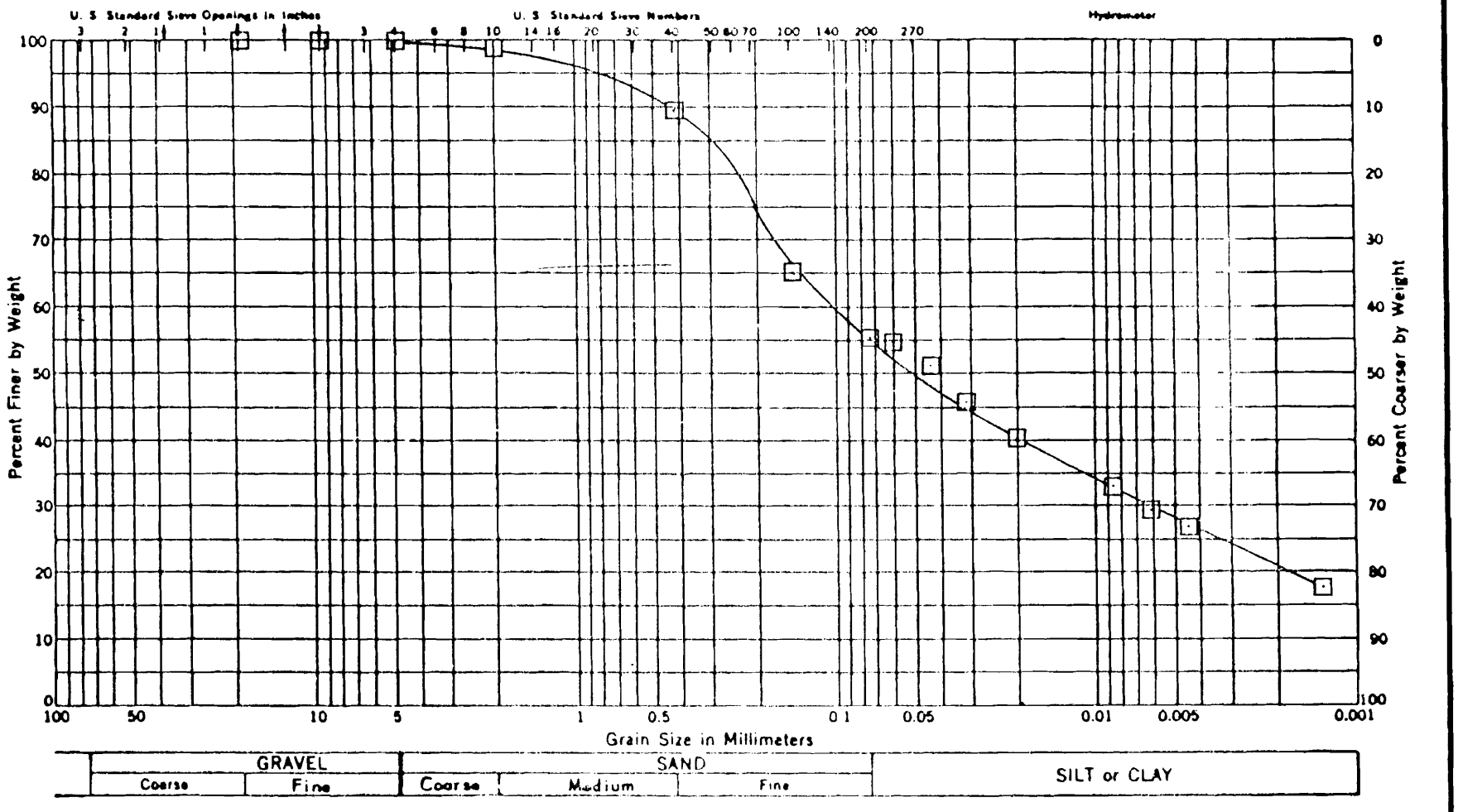
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

BORING 6 SAMPLE 1

DEPTH 3.5-5.5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/16/81	680574



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		29	14	15	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

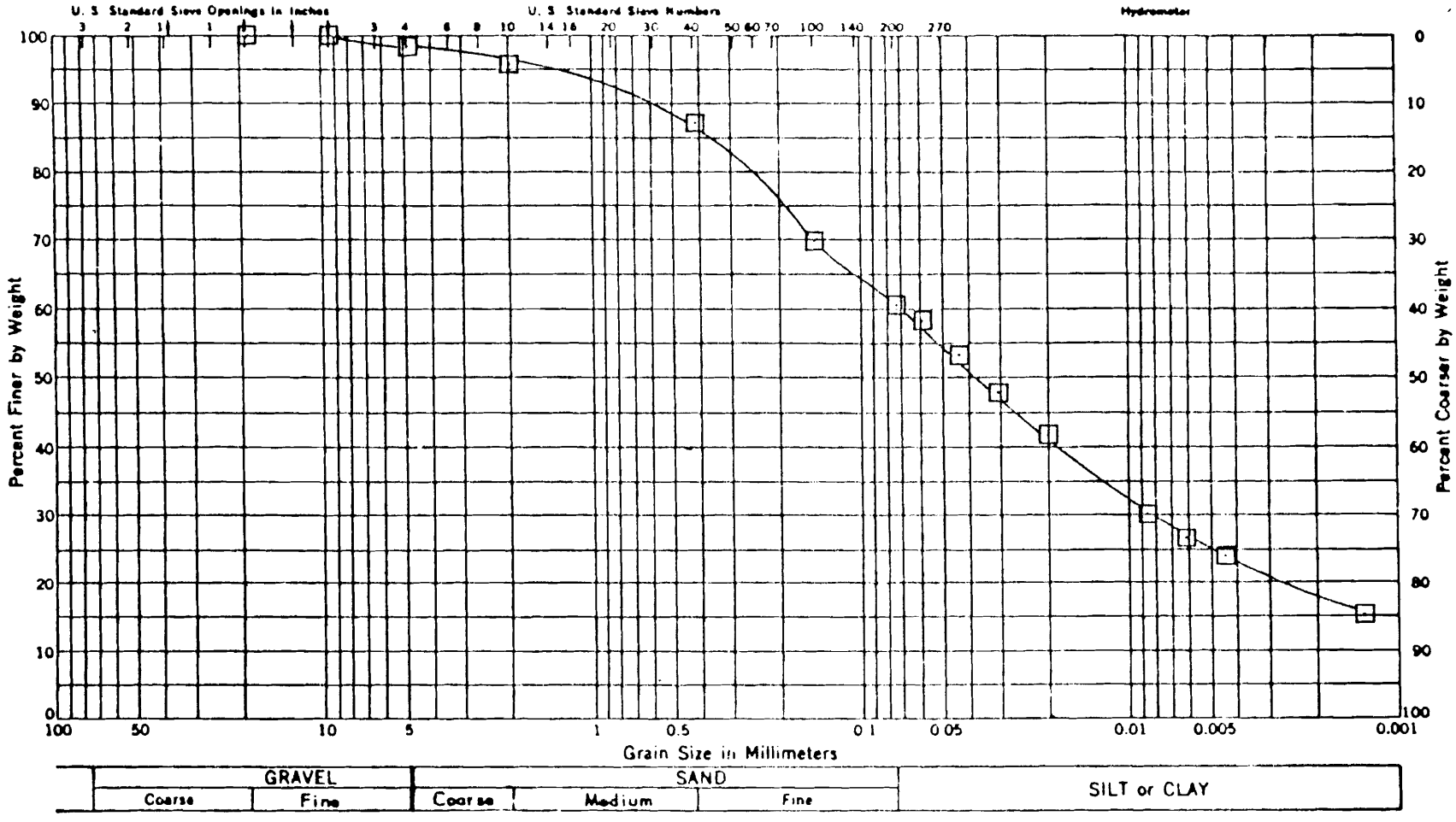
BORING 6 SAMPLE 3

DEPTH 13.5-15.5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/16/81	680574

491



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
7		28	17	11	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

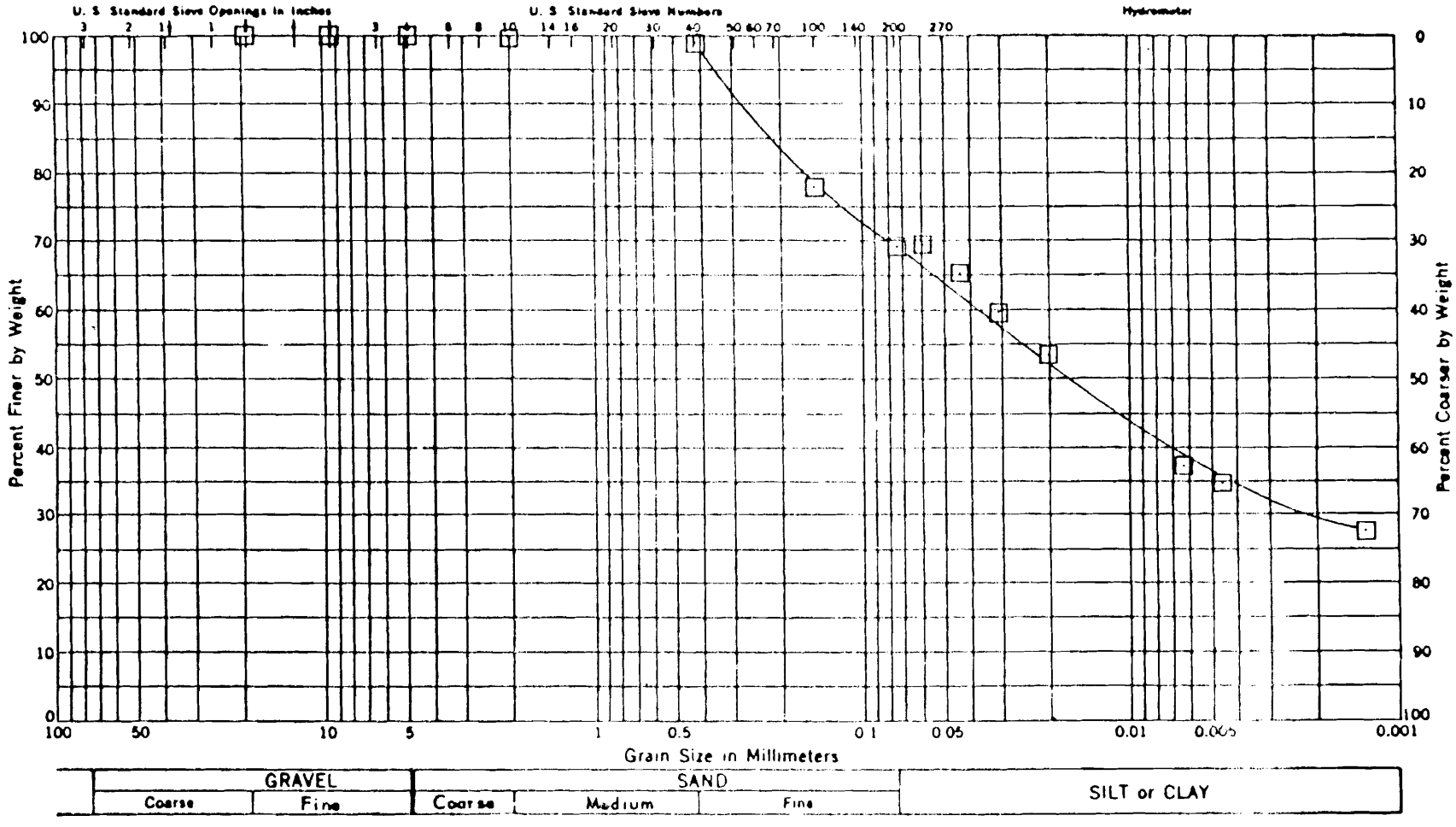
BORING 6 SAMPLE 7

DEPTH 33.5-35.5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/16/81	680574

591



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		34	15	19	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

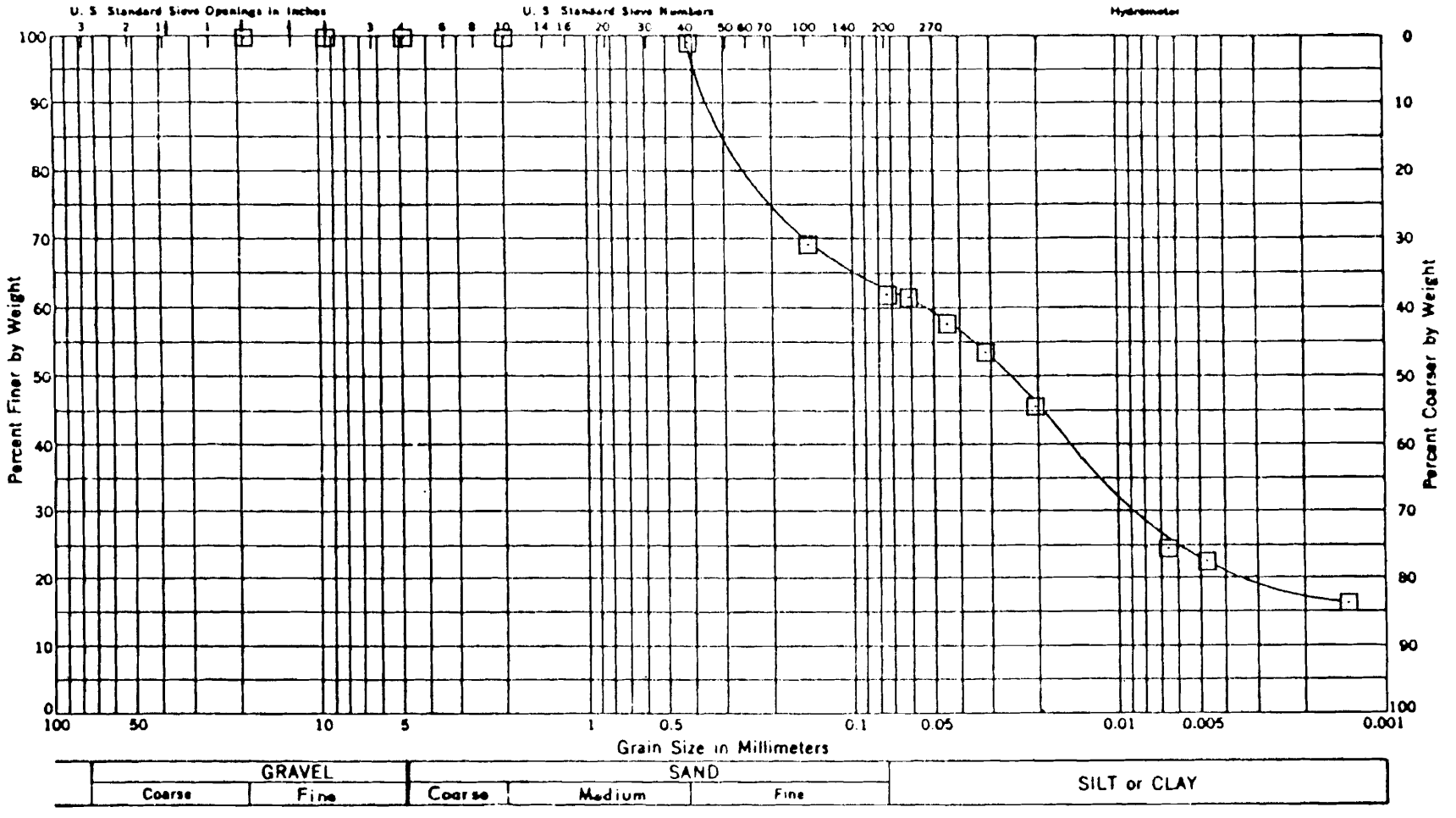
BORING 7 SAMPLE 1

DEPTH 0 - 2 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/16/81	680574

991



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		29	18	11	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

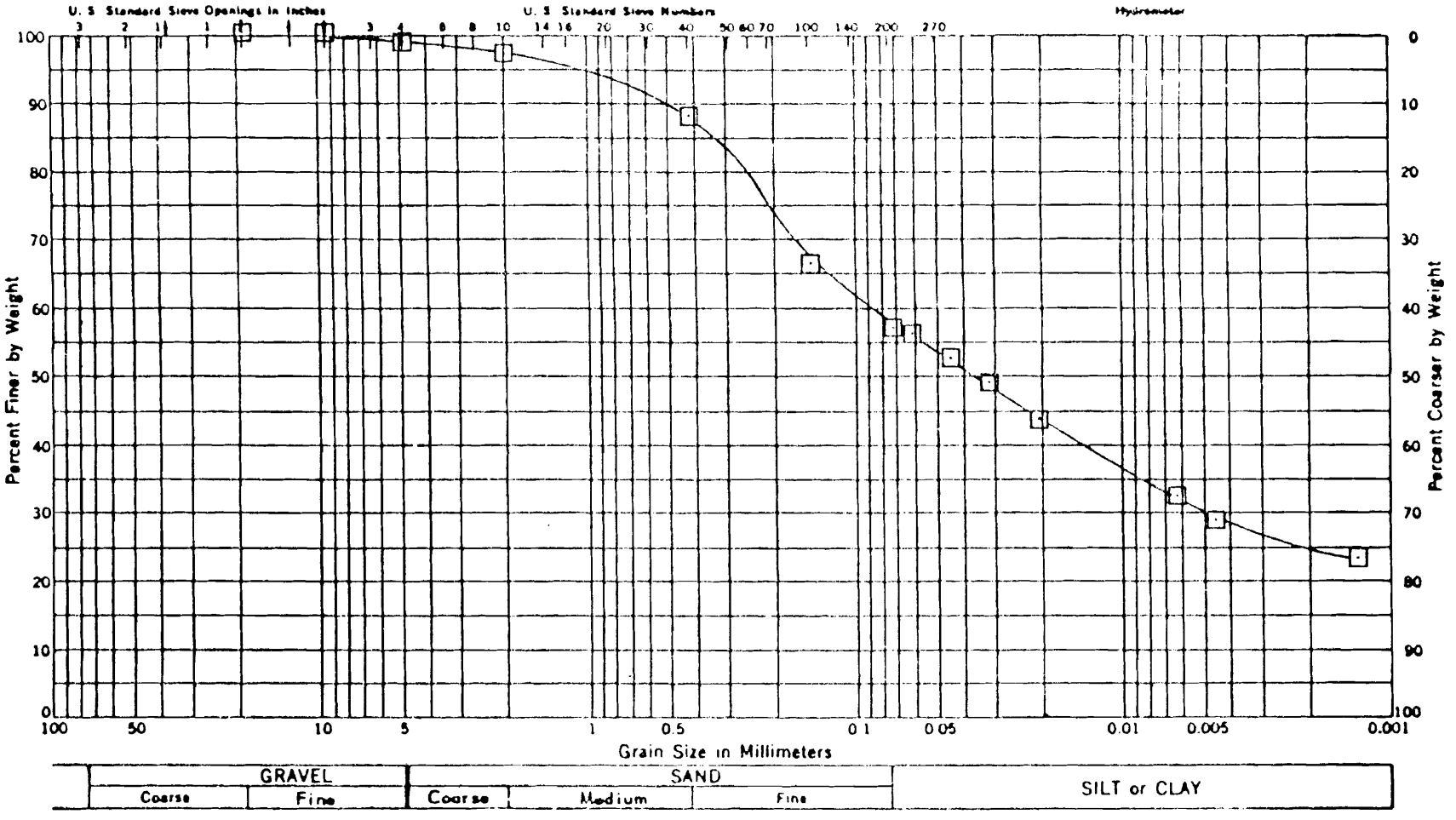
BORING 9 SAMPLE 1

DEPTH 3 - 5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/16/81	680574

191



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		29	13	16	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-1

BORING 10 SAMPLE 1

DEPTH 2.5 - 4.5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/16/81	680574

891

IOWA ARMY AMMUNITION PLANT

BURLINGTON, IOWA

JOB NO. 680574

CONSTANT HEAD PERMEABILITY TEST RESULTS

SITE Z-1

Boring	Sample	Depth (ft)	Moisture Content %	Dry Density pcf	Coefficient of Permeability cm/sec
1	1	4.0- 6.0	19.2	110.3	5.3×10^{-9}
1	4	19.0-21.0	15.9	115.3	8.9×10^{-9}
2	2	9.0-11.0	20.1	103.8	1.3×10^{-9}
2	6	28.0-30.0	13.7	114.4	8.7×10^{-9}
3	2	9.0-11.0	21.3	104.8	1.2×10^{-8}
3	8	39.0-39.5	32.5	80.5	5.9×10^{-9}
4	1	2.0- 4.0	14.0	118.9	2.9×10^{-9}
4	3	13.0-15.0	16.5	116.2	2.1×10^{-9}
5	2	8.0-10.0	23.5	101.1	3.5×10^{-9}
5	3	13.0-15.0	14.1	118.1	1.0×10^{-8}
6	1	3.5- 5.5	27.8	89.5	7.9×10^{-9}
6	3	13.5-15.5	11.5	117.4	9.1×10^{-9}

Table

BORING AND WELL SURVEY DATA
SITE Z1 - ABANDONED PINKWATER LAGOON
IOWA ARMY AMMUNITION PLANT - BURLINGTON, IOWA
JOB NO. 680574 MARCH 31, 1981

Site	C.O.E. Local Coordinate N (ft)	C.O.E. Local Coordinate E (ft)	Elevation Natural Ground (ft)	Elevation Top of Pipe (ft)
Z1#1	7192	14117	682.1	685.8
Z1#2	7181	13955	670.7	673.8
Z1#2A	7195	13948	671.0	673.9
Z1#3	7169	13794	677.6	680.6
Z1#4	7610	13677	676.6	-
Z1#5	7366	13868	674.2	-
Z1#6	9566	13239	683.5	687.3
Z1#7	7679	13760	679.2	-
Z1#8	7488	13584	676.2	-
Z1#9	7862	13390	677.4	-
Z1#10	7990	13405	678.3	-

Table

WATER LEVEL OBSERVATIONS
SITE Z1 - ABANDONED PINKWATER LAGOON
IOWA ARMY AMMUNITION PLANT - BURLINGTON, IOWA
JOB NO. 680574 MARCH 3, 1981

	Water Encountered			Water Level Records					
Site	Date	D.B. (ft)	A.B. (ft)	Date	WLE Elev(ft)	Date	WLE Elev(ft)	Date	WLE Elev(ft)
Z1#1	12-3-80	43	47	1-8-81	675.1	1-8-81	672.1	1-9-81	676.3
Z1#2	12-22-80	-	4	1-8-81	671.1	1-8-81	655.3	1-9-81	659.5
Z1#2A	12-22-80	-	-	1-8-81	666.2	1-8-81	665.2	1-9-81	-
Z1#3	12-4-80	12.5	-	1-8-81	675.6	1-8-81	675.8	1-9-81	675.9
Z1#6	11-26-80	7.5	44.5	1-8-81	683.5	1-8-81	681.2	1-9-81	682.5
Z1#4	12-23-80	-	-	1-7-81	673.7				
Z1#5	12-22-80	-	-	1-7-81	673.3				
Z1#7	12-22-80	-	-	1-7-81	677.9				
Z1#8	12-23-80	-	-	1-7-81	673.7				
Z1#9	12-23-80	-	-	1-7-81	674.0				
Z1#10	12-22-80	-	-	1-7-81	675.0				

Table

WATER SAMPLING OBSERVATIONS
SITE Z1 - ABANDONED PINKWATER LAGOON
IOWA ARMY AMMUNITION PLANT - BURLINGTON, IOWA
JOB NO. 680574 MARCH 3, 1981

Water Sampling Records

Site	Date	WLE Elev(ft)	Temp °C	pH	Date	WLE Elev(ft)	Temp °C	pH	Date	WLE Elev(ft)	Temp °C	pH
Z1#1	1-27-81	676.4	9	7.55	1-28-81	676.4	9	7.48	1-29-81	676.5	7	7.47
Z1#2	-	-	-	-	-	-	-	-	1-29-81	671.0	8.5	7.27
Z1#2A	1-27-81	667.7	6.5	7.25	1-28-81	663.0	3	7.54	-	-	-	-
Z1#3	1-27-81	675.8	8	7.24	1-28-81	675.8	8	7.26	1-29-81	675.7	7	7.28
Z1#6	1-27-81	682.3	7	7.23	1-28-81	682.1	6.5	7.21	1-29-81	682.5	6 6.5	7.22 7.22

Table

SURFACE WATER SAMPLE RECORD
SITE Z1 - ABANDONED PINKWATER LAGOON
IOWA ARMY AMMUNITION PLANT - BURLINGTON, IOWA
JOB NO. 680574 MARCH 3, 1981

Site	Sample	Date	Time	Temp. °C	pH	By	Remarks
SWSZ1#1	1	12-18-80		-	-	EGH	By SCS, Engineers*
SWSZ1#1	2	1-15-81	9:30 A.M.	4	9.3	JFH	Clear With Soot
SWSZ1#1	3	1-28-81	16:35	5	9.1	JFH	Clear With Soot
SWSZ1#2	1	12-18-80	-	-	-	EGH	By SCS, Engineers*
SWSZ1#2	2	1-15-81	9:50 A.M.	4	9.2	JFH	Clear With Soot
SWSZ1#2	3	1-28-81	16:45	4	9.0	JFH	Clear With Soot

* Data Not Available to Terracon

(Note) Stream Flow was visually estimated as 1 CFS on January 15 and January 28, 1981.

APPENDIX D

SITE Z_2 DATA

LOG OF BORING NO. Z2 #1

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Well Installed 11-25-80 Description Surface Elevation = 722.7	Monitoring Well Details
	PA									720.7	CLAYEY SILT TRACE SAND Dark Brown (2.0)	719.7
1	ST	24	13			30.2	91	CL	5		SILTY CLAY TRACE SAND Gray Brown Medium	
	PA									714.7	(8.0)	716.7
2	ST	24	13					CL	10		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Medium to Stiff	
	PA											
3	ST	24	8			19.3	109	CL	15			
	PA											
4	ST	24	20					CL	20			
	PA										To Gray Brown at 23'.	
5	ST	24	16					CL	25			
	PA									699.7	(26.0)	
6	ST	24	10					CL	30	692.7	SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray (30.0) Very Stiff	
											Continued on Sheet #2	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU, THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	8'	W.S. OR W.D.	11.3' A.B.
W.L.		B.C.R.	A.C.R.
W.L.	18.2' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita KS

BORING STARTED	11-20-80
BORING COMPLETED	11-20-80
RIG CME 55 #4	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #2

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density-lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Well Installed 12-11-80	
	PA										Surface Elevation = 698.4	
											SILTY CLAY TRACE SAND	695.4
1	ST	24	8			28.6	89	CL	5		Dark Brown Stiff	
	PA									691.9	(6.5)	692.4
2	ST	24						CL	10		SANDY SILTY CLAY TRACE GRAVEL WITH SAND SEAMS (GLACIAL TILL) Brown Very Stiff to Hard	
	PA											
3	ST	24	19					CL	15		With Occasional Sand Seams at 16'.	
	PA											
4	ST	24	19					CL	20			678.4
	PA											
5	ST	24	11			17.9	112	CL	25			
	PA											
6	ST	24	13					CL	30	668.4	(30.0)	668.4
											Continued on Sheet #2	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	7.5' W.S. OR W.D.	10.3' A.B.
W.L.	B.C.R.	A.C.R.
W.L.	2.0' on 1-8-81	

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-20-80
BORING COMPLETED	11-20-80
RIG CME 55 #4	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #2 (Continued)

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbo	Depth	Elevation	Description	Monitoring Well Details
											Continued from Sheet #1	
									30		(30.0)	
	PA									668.4	SANDY SILTY CLAY TRACE GRAVEL WITH SAND SEAMS (GLACIAL TILL)	
7	ST	24	8					CL	35		Brown Very Stiff to Hard	
	PA											
8	ST	24	12					CL	40			
	PA											
9	ST	24	13					CL	45		With Numerous Sand Seams at 43.5'.	
	PA											
10	ST	24	12					CL	50		(50.0)	
										648.4	Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	7.5' W.S. OR W.D.	10.3' A.B.
W.L.	B.C.R.	A.C.R.
W.L.	2.0' on 1-8-81	

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita KS

BORING STARTED	11-20-80
BORING COMPLETED	11-20-80
RIG CME 55 #4	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #3

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Surface Elevation = 716.9	
	PA										CLAYEY SILT Dark Brown	
										714.9	(2.0)	
1	ST	24	7					CH	5		SILTY CLAY TRACE SAND Brown Medium	
	PA										Gray at 4'.	
2	ST	24	20					CL-CH	10		Brown at 9'.	
	PA											
										703.9	(13.0)	
3	ST	24	7			16.4	113	CL	15		SANDY SILTY CLAY TRACE GRAVEL WITH SAND SEAMS (GLACIAL TILL) Brown Stiff to Very Stiff	
	PA											
4	ST	24	15					CL	20		With Numerous Sand Seams at 19'.	
	PA											
5	ST	24	11			15.7	108	CL	25		Gray at 24'.	
	PA											
6	ST	24	10					CL	30			
										686.9	(30.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU, THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	9.0' W.S. OR W.D.	8.1' A.B.	
W.L.	B.C.R.	A.C.R.	
W.L.	4.7' on 11-25-80		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-21-80
BORING COMPLETED	11-21-80
RIG CME 55 #4	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #4

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbo	Depth	Elevation	Description (Surface Elevation = 713.8)	Monitoring Well Details
	PA									712.3	(1.5) CLAYEY SILT, Dark Brown	
1	ST	24	8					CL-CH	5		SILTY CLAY Brown to Gray Brown Medium to Stiff	
	PA											
2	ST	24	11					CL		704.5	(9.5)	
	PA							CL	10		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown Stiff to Very Stiff Brown at 13'.	
3	ST	24	15					CL				
	PA								15			
4	ST	24	17					CL				
	PA								20			
5	ST	24	16					CL				
	PA								25			
6	ST	24	18					CL			With Occasional Sand Seams	
									30	683.8	(30.0) at 29'.	
											Continued on Sheet #2	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS		
W.L.	3.5' W.S. OR W.D.	3.75' A.B.
W.L.	B.C.R.	A.C.R.
W.L.	3.3' on 11-25-80	

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-21-80
BORING COMPLETED	11-22-80
RIG CME 55 #4	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #4 (Continued)

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density-lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Continued from Sheet #1	
									30	683.8 (30.0)		
	PA										SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Stiff to Very Stiff	
7	ST	24	15			12.1	122	CL				
	PA								35			
8	ST	24	15					CL				
	PA								40			
										671.3 (42.5)		
9	ST	24	17			25.3	101	CH			SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Very Stiff	
	PA								45		Brown at 48.5'.	
10	ST	24	18					CH				
									50	663.8 (50.0)		
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	3.5'	W.S. OR W.D.	3.75' A.B.
W.L.		B.C.R.	A.C.R.
W.L.	3.3' on 11-25-80		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines IA
Kansas City Wichita, KS

BORING STARTED	11-21-80
BORING COMPLETED	11-22-80
RIG CME 55 #4	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #5

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE
LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description (Surface Elevation = 710.6)	Monitoring Well Details
	PA									708.6	SILTY CLAY TRACE SAND Dark Brown (2.0)	
1	ST	24	6					CL-CH	5		SILTY CLAY TRACE SAND Gray Brown Stiff	
	PA									702.6	(8.0)	
2	ST	24	16			22.1	104	CL	10		SILTY CLAY LITTLE SAND Gray Medium	
	PA									699.6	(11.0)	
3	ST	24	13					CL	15		SANDY CLAYEY SILT TRACE GRAVEL (GLACIAL TILL) Brown Stiff	
	PA										Gray Brown at 18'.	
4	ST	24	19					CL	20			
	PA									688.6	(22.0)	
5	ST	24	15					CL-CH	25		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Very Stiff to Hard With Sand Seams at 24'.	
	PA											
6	ST	24	18					CL	30	680.6	(30.0)	
											Continued on Sheet #2	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	7.0' W.S. OR W.D. WCI	11.5' A.B.	
W.L.	B.C.R.	A.C.R.	
W.L.	3.7' on 11-26-80		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-21-80
BORING COMPLETED	11-21-80
RIG CME 55 #4	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #5 (continued)

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Continued from Sheet #1	
											(30.0)	
									30	680.6		
	PA										SANDY SILTY CLAY TRACE GRAVEL WITH SAND SEAMS (GLACIAL TILL)	
7	ST	24	17					CL			Brown	
									35		Very Stiff to Hard	
	PA											
8	ST	24	15			15.4	115	CL				
									40			
	PA											
9	ST	24	16					CL				
									45			
	PA											
											(47.5)	
										663.1	SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL)	
10	ST	24	16					CL			(50.0) Greenish Gray, Very Stiff	
									50	660.6		
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	7.0'	W.S. OR W.D. WCI	11.5' A.B.
W.L.		B.C.R.	A.C.R.
W.L.	3.7' on 11-26-80		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines IA
Kansas City Wichita, KS

BORING STARTED	11-21-80
BORING COMPLETED	11-21-80
RIG CME 55 #4	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #6

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE
LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description Surface Elevation = 712.8	Monitoring Well Details
	PA									710.8	CLAYEY SILT Dark Brown (2.0)	
1	ST	24	6			28.6	91	CH	5		SILTY CLAY TRACE SAND Gray Stiff to Medium	
	PA											
2	ST	24	20			29.0	90	CH-CL	10	701.8	(11.0)	
	PA										SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Stiff	
3	ST	24	14					CH-CL	15			
	PA											
4	ST	24	15					CL	20		Brown at 19.0'.	
	PA									689.8	(23.0)	
5	ST	24	14					CH-CL	25		SANDY SILTY CLAY TRACE GRAVEL WITH SAND SEAMS (GLACIAL TILL) Gray Brown to Gray Very Stiff to Hard	
	PA											
6	ST	24	16					CL	30	682.8	(30.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	6.0'	W.S. OR W.D.	4.75' A.B.
W.L.		B.C.R.	A.C.R.
W.L.	4.3' on 11-25-80		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-22-80
BORING COMPLETED	11-22-80
RIG CME 55 #4	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #7

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE
LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Surface Elevation = 715.8	
	PA										CLAYEY SILT	
										713.8	(2.0) Dark Brown	
1	ST	24	6			28.6	89	CH-CL			SILTY CLAY TRACE SAND	
	PA								5		Dark Brown	
											Very Stiff to Stiff	
											To Gray Brown at 5.0'.	
2	ST	24	13					CH-CL				
	PA								10			
										703.8	(12.0)	
3	ST	24	14					CH			SANDY SILTY CLAY TRACE GRAVEL	
	PA								15		(GLACIAL TILL)	
											Brown Gray to Brown	
											Stiff to Very Stiff	
4	ST	24	24					CL				
	PA								20			
5	ST	24	18			17.9	112	CL				
	PA								25			
6	ST	24	15					CL				
									30	685.8	(30.0)	
											Bottom of Boring .	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	8.7'	W.S. OR W.D.	20'	A.B.	
W.L.		B.C.R.		A.C.R.	
W.L.	5.5' on 11-26-80				

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-24-80
BORING COMPLETED	11-24-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #8

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description (Surface Elevation = 712.7)	Monitoring Well Details
	PA									710.7	CLAYEY SILT Dark Brown (2.0)	
1	ST	24	14					CH	5		SILTY CLAY TRACE SAND Gray Brown Medium	
	PA											
2	ST	24	10			24.5	100	CL		704.0	(8.7)	
	PA							CL	10		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown Stiff	
3	ST	24	10			21.8	104	CL				
	PA								15			
4	ST	24	15					CL		694.7	(18.0)	
	PA								20		SANDY SILTY CLAY TRACE GRAVEL WITH SAND SEAMS (GLACIAL TILL) Brown Very Stiff	
5	ST	24	15					CL				
	PA								25			
6	ST	24	17					CL				
									30	682.7	(30.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	7.0' W.S. OR W.D.	17.2'	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	5.3' on 11-25-80		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-22-80
BORING COMPLETED	11-22-80
RIG CME 55	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #9

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE
LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density-lbs/ft³	Unified Class Symbol	Depth	Elevation	Description (Surface Elevation = 714.3)	Monitoring Well Details
	PA										CLAYEY SILT Dark Brown	
1	ST	24	4					CH		712.3 (2.0)	SILTY CLAY TRACE SAND Gray Brown Hard	
	PA								5			
2	ST	24	19					CH-CL CL-CH		706.3 (8.0)	SANDY SILTY CLAY Brown Gray Stiff	
	PA								10	703.3 (11.0)	SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Stiff	
3	ST	24	13			21.1	107	CL				
	PA								15			
4	ST	24	22					CL				
	PA								20			
5	ST	24	18					CL				
	PA								25			
6	ST	24	15			19.7	108	CL		686.3 (28.0)	SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray, Very Stiff	
									30	684.3 (30.0)	Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	6.5' W.S. OR W.D.	10.7'	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	5.7' at 24 hr./4.9' on 1-6-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-24-80
BORING COMPLETED	11-24-80
RIG CME 75	**FOREMAN** JM
APPROVED JEH	**JOB #** 680574

LOG OF BORING NO. Z2 #10

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density-lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Surface Elevation - 713.5	
	PA									712.0	CLAYEY SILT (1.5) Dark Brown	
1	ST	24	6			32.6	82	CH	5		SILTY CLAY TRACE SAND Gray Brown Medium	
	PA									705.5	(8.0)	
2	ST	24	14					CL	10		SILTY CLAY LITTLE SAND WITH SAND SEAMS Dark Gray	
	PA									702.5	(11.0) Soft	
3	ST	24	12					CL	15		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Medium to Stiff	
	PA											
4	ST	24	16			17.5	116	CL	20			
	PA											
5	ST	24	13					CH CL	25	689.5	(24.0) SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Stiff	
	PA									685.5	(28.0)	
6	ST	24	16					CL-CH	30		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL)	
										683.5	(30.0) Light Gray, Very Stiff	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	4.0' W.S. OR W.D.	6.0'	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	3.9' on 11-25-80		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-22-80
BORING COMPLETED	11-22-80
RIG CME 55	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #11

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description (Surface Elevation = 711.2)	Monitoring Well Details
	PA										CLAYEY SILT Dark Brown	
										708.7	(2.5)	
1	ST	24	9					CL	5		SILTY CLAY TRACE SAND Gray Medium	
	PA									703.2	(7.5)	
2	ST	24	--					CL	10		SANDY SILTY CLAY WITH SAND SEAMS Gray Brown Stiff	
	PA									698.2	(13.0)	
3	ST	24	20			23.2	97	CL	15		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown Stiff to Very Stiff Gray at 18'.	
	PA											
4	ST	24	12					CL	20			
	PA											
5	ST	24	14					CL	25			
	PA											
6	ST	24	16					CL		682.4	(28.8)	
						16.9	114	CL	30	681.2	(30.0) SEE NOTE #1 BELOW Bottom of Boring	
											NOTE #1: SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL), Brown, Hard	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	5.0' W.S. OR W.D.	9.75'	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	2.2' on 11-25-80		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita KS

BORING STARTED	11-22-80
BORING COMPLETED	11-22-80
RIG CME 55	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #12

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description (Surface Elevation - 713.7)	Monitoring Well Details
	PA									711.7	CLAYEY SILT Dark Brown (2.0)	
1	ST	24	10					CL	5		SILTY CLAY LITTLE SAND Brown Stiff	
	PA									705.7	(8.5)	
2	ST	24	8					CL	10		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Very Stiff	
	PA										(14.5)	
3	ST	24	12			13.2	120	CL ML	15	699.2	FINE TO MEDIUM SANDY SILT TRACE CLAY Brown Medium to Stiff	
	PA									694.7	(19.0)	
4	ST	24	8					CL	20		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown Stiff	
	PA											
5	ST	24	8			15.1	119	CL	25			
	PA											
6	ST	24	13					CL				
									30	683.7	(30.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS

W.L.	7.0' W.S. OR W.D.	8.5'	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	2.1' on 1-7-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-4-80
BORING COMPLETED	12-4-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #13

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description (Surface Elevation = 704.9)	Monitoring Well Details
	PA									702.9	CLAYEY SILT Dark Brown (2.0)	
1	ST	24	10					CL-CH	5		SILTY CLAY TRACE SAND Gray Brown Stiff	
	PA									696.9	(8.0)	
2	ST	24	13			19.5	108	CL	10		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Medium	
	PA									692.9	(12.0)	
3	ST	24	10			19.0	113	CH	15		SILTY CLAY LITTLE SAND TRACE GRAVEL (GLACIAL TILL) Gray Very Stiff	
	PA									686.4	(18.5)	
4	ST	24	15					CL	20		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown Hard To Brown at 22'.	
	PA											
5	ST	24	12					CL-CH	25			
	PA											
6	ST	24	17					CL-CH				
									30	674.9	(30.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	2.0' W.S. OR W.D.	8.5'	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	0.0' on 1-6-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-5-80
BORING COMPLETED	12-5-80
RIG CME 45 (Bomb)	**FOREMAN** REF
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #14

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft.²	Water Content-%	Dry Density-lbs/ft.³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Surface Elevation - 709.5	
	PA										CLAYEY SILT	
										707.5	(2.0) Dark Brown	
1	ST	24	4			22.7	97	CH			SILTY CLAY TRACE SAND	
	PA								5		Dark Gray	
											Stiff	
											Gray at 6'.	
2	ST	24	14			25.8	97	CH-CL				
	PA								10			
3	ST	24	15					CL				
										695.5	(14.0)	
	PA								15		SANDY SILTY CLAY TRACE GRAVEL WITH SAND SEAMS (GLACIAL TILL)	
4	ST	24	19					CH-CL			Gray	
											Very Stiff	
	PA								20		Brown at 17'.	
											Light Gray at 20'.	
5	ST	24	15					CH-CL				
	PA								25			
6	ST	24	13					CH-CL			Brown at 29'.	
									30	679.5	(30.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU, THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	17.5' W.S. OR W.D.	21.0' A.B.	
W.L.	B.C.R.	A.C.R.	
W.L.	5.2' on 12-3-80		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-25-80
BORING COMPLETED	11-25-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO

OWNER

ARCHITECT-ENGINEER

CORPS OF ENGINEERS

SITE

PROJECT NAME

CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sample Penetration	Recovery	Blows/ft	Unconfined Compressive Strength tons/ft²	Water Content	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
	PA										Surface Elevation = 711.7	
											CLAYEY SILT	
											(2.0) Dark Gray	
1	ST	24	9					CL-CH		709.7		
											SILTY CLAY TRACE SAND	
	PA								5		Brown Gray	
											Stiff	
2	ST	24	6					CL				
											(10.0)	
	PA								10	701.7		
											SANDY SILTY CLAY TRACE	
											GRAVEL (GLACIAL TILL)	
3	ST	24	17					CL			Gray Brown	
											Stiff	
	PA								15			
											To Brown at 15'.	
4	ST	24	16			17.4	114	CL				
	PA								20			
								CL				
5	ST	24	15					CH		688.7	(23.0)	
											SANDY SILTY CLAY TRACE	
	PA								25		GRAVEL (GLACIAL TILL)	
											Gray to Gray Brown	
											Very Stiff to Hard	
6	ST	24	16			18.9	108	CL				
									30	681.7	(30.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS

W.L.	5.2' W.S. OR W.D.	5.5' A.B.	
W.L.	B.C.R.	A.C.R.	
W.L.	4.8' at 6hrs/3.9' on 1-6-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-25-80
BORING COMPLETED	11-25-80
RIG CME 75	FOREMAN JM
APPROVED JFH	JOB # 680574

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LOG OF BORING NO. Z2 #16

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description (Surface Elevation - 709.7)	Monitoring Well Details
	PA										CLAYEY SILT	
										707.7	(2.0) Dark Brown	
1	ST	24	4					CH			SILTY CLAY TRACE SAND Dark Gray Medium to Stiff	
	PA								5			
2	ST	24	9			22.4	97	CH-CL			Gray at 9.0'.	
	PA								10	699.2	(10.5)	
3	ST	24	15					CL			SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown Medium to Stiff	
	PA								15		Gray at 17'.	
4	ST	24	20					CL				
	PA								20	688.2	(21.5)	
5	ST	24	19			13.8	119	CL-CH			SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown to Brown Very Stiff	
	PA								25			
6	ST	24	13					CL				
									30	679.7	(30.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES. IN SITU, THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS

W.L.	6.0'	W.S. OR W.D.	26.0' A.B.
W.L.		B.C.R.	A.C.R.
W.L.	3.3; at 4hrs/1.9' on 12-3-80		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-25-80
BORING COMPLETED	11-25-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #17

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE
LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description (Surface Elevation = 710.0)	Monitoring Well Details
	PA										CLAYEY SILT Dark Brown	
										717.0	(2.0)	
1	ST	24	4					CL			SILTY CLAY SOME SAND Gray Brown to Brown Very Stiff	
	PA								5			
2	ST	24	13					CL				
								CL		711.0	(8.0)	
	PA								10		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Stiff to Very Stiff	
3	ST	24	15			22.2	104	CL				
	PA								15			
4	ST	24	18					CL				
	PA								20			
5	ST	24	13					CL				
	PA								25			
6	ST	24	10			13.1	123	CL				
									30	689.0	(30.0)	
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN-SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	7.7'	W.S. OR W.D.	10.0'	A.B.
W.L.		B.C.R.		A.C.R.
W.L.	4.9' on 11-26-80			

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	11-24-80
BORING COMPLETED	11-24-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #18

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE
LINE c
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Well Installed 12-10-80	
											Surface Elevation = 712.4	
	HS									710.4	CLAYEY SILT Dark Brown (2.0)	
1	ST	24	6			28.2	91	CL	5		SILTY CLAY TRACE SAND Brown Gray Stiff	
	HS										Gray at 8.0'.	
2	ST	24	7					CL	10			
	HS											
3	ST	24	13					CL	15			
	HS									695.9	(16.5)	695.4
											SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL)	692.4
4	ST	24	18					CL	20		Gray to Brown Gray Stiff to Very Stiff	
	HS											
5	ST	24	10					CL	25			
	HS									684.4	(28.0)	
6	ST	24	9					CL	30		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown to Brown	
										681.4	(31.0) Very Stiff to Hard	
											Continued on Sheet #2	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	4.0' W.S. OR W.D.	32.0'	A.B.
W.L.		B.C.R.	A C.R.
W.L.	4.3' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-10-80
BORING COMPLETED	12-10-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #18 (Continued)

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
									50		Continued from Sheet #1	
										681.4 (31.0)		
	HS										SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL)	
7	ST	24	12			10.4	126	CL	55		Gray Brown to Brown Very Stiff to Hard	
	HS											
8	ST	24	16					CL	40			672.4
	HS											
9	ST	24	17					CL	45			
	HS											
10	ST	24	14					CL				
									50	662.4 (50.0)		662.4
											Bottom of Boring	

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	4.0' W.S. OR W.D.	32.0'	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	4.3' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-9-80
BORING COMPLETED	12-10-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #18A

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE
LINE c
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Well Installed 12-10-80 Description Surface Elevation = 712.5	Monitoring Well Details
										710.5	CLAYEY SILT Dark Brown	709.5
	PA								5	(2.0)	SILTY CLAY TRACE SAND Brown Gray Stiff Gray at 8.0'.	707.5
									10	702.5	(10.0) Bottom of Boring	702.5

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	4.0' W.S. OR W.D.	- -	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	3.2' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-10-80
BORING COMPLETED	12-10-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. 22 #19

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Well Installed 12-10-80 and 12-11-80

Sample No	Type Sample	Sample Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content %	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
											Surface Elevation = 712.6	
										711.1	CLAYEY SILT (1.5) Dark Brown	
	HS											709.6
1	ST	24	7								SILTY CLAY TRACE SAND Gray Brown Stiff	
	HS											706.6
2	ST	24	9			25.4	98	CH	10			
	HS									699.6	(13.0)	
3	ST	24	12					CL	15		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Stiff to Very Stiff	
	HS											
4	ST	24	21					CL	20		Sand Seams at 20.5'.	
	HS											
5	ST	24	11					CL	25			
	HS											
6	ST	24	10					CL	30			
										679.6	(33.0)	

Contined on Sheet #2

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU THE TRANSITION MAY BE GRADUAL

WATER LEVEL OBSERVATIONS

W.L.	18.0' W.S. OR W.D.	42.0'	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	3.3' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-10-80
BORING COMPLETED	12-10-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574

LOG OF BORING NO. Z2 #19 (Continued)

OWNER IOWA ARMY AMMUNITION PLANT
BURLINGTON, IOWA

ARCHITECT-ENGINEER
U. S. ARMY CORPS OF ENGINEERS

SITE LINE 6
DETONATOR LINE

PROJECT NAME
SUBSURFACE CONTAMINATION INVESTIGATION

Sample No	Type Sample	Sampling Distance	Recovery	Blows/ft	Unconfined Compressive Strength-lbs/ft²	Water Content-%	Dry Density lbs/ft³	Unified Class Symbol	Depth	Elevation	Description	Monitoring Well Details
									30			
										679.6	(33.0)	
7	ST	24	15					CL	35		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Brown Hard	
	HS									675.6	(37.0)	
8	ST	24	12					CL	40		SANDY SILTY CLAY TRACE GRAVEL (GLACIAL TILL) Gray Brown Stiff to Very Stiff	672.6
	HS											
9	ST	24	12					CL	45			
	HS											
10	ST	24	16			23.2	99	CL	50	662.6	(50.0)	662.6

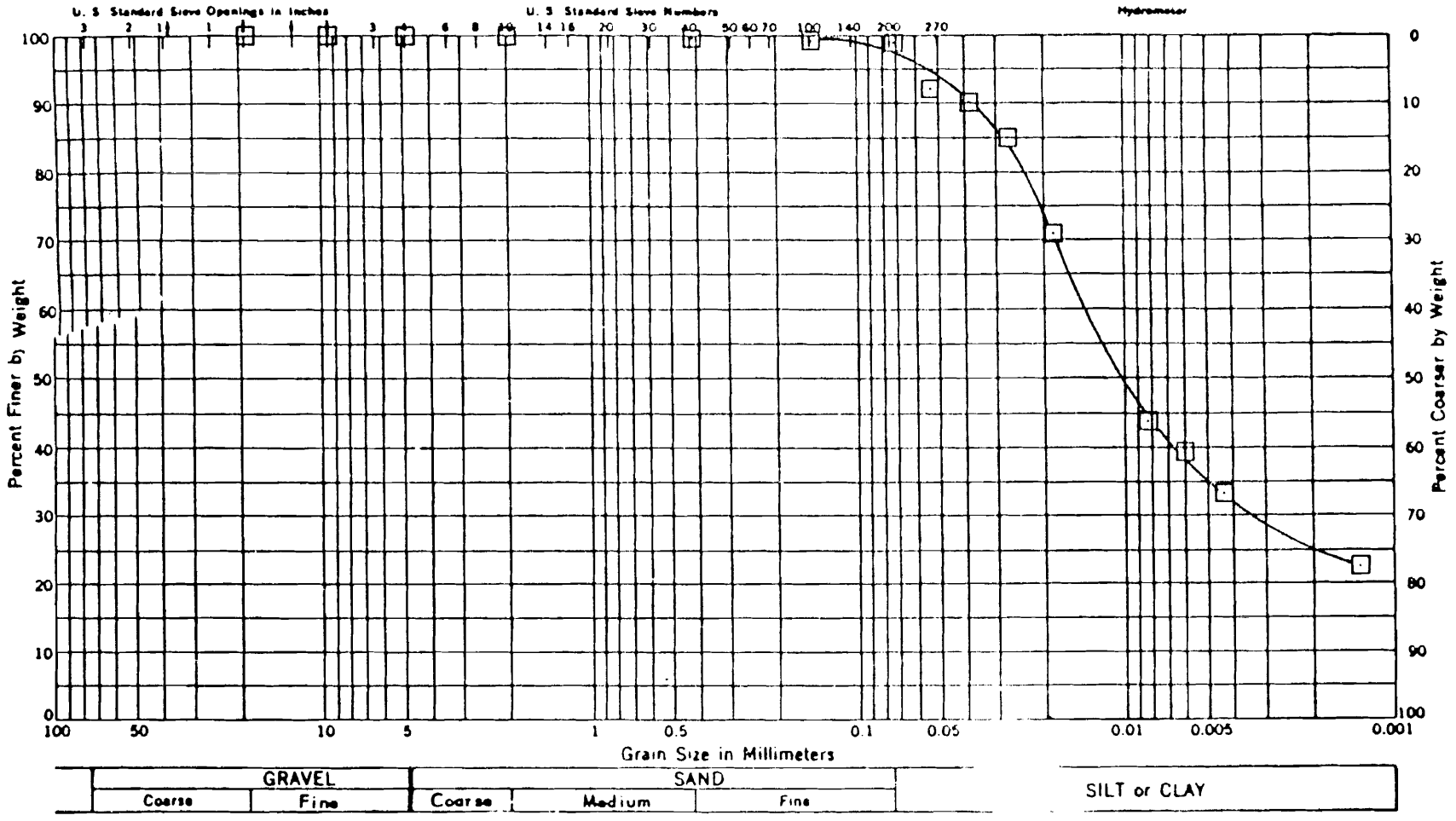
THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES IN SITU. THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS

W.L.	18.0' W.S. OR W.D.	42.0'	A.B.
W.L.		B.C.R.	A.C.R.
W.L.	3.3' on 1-8-81		

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

BORING STARTED	12-10-80
BORING COMPLETED	12-10-80
RIG CME 75	**FOREMAN** JM
APPROVED JFH	**JOB #** 680574



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		46	20	26	
					UNIFIED CLASSIFICATION (CL)

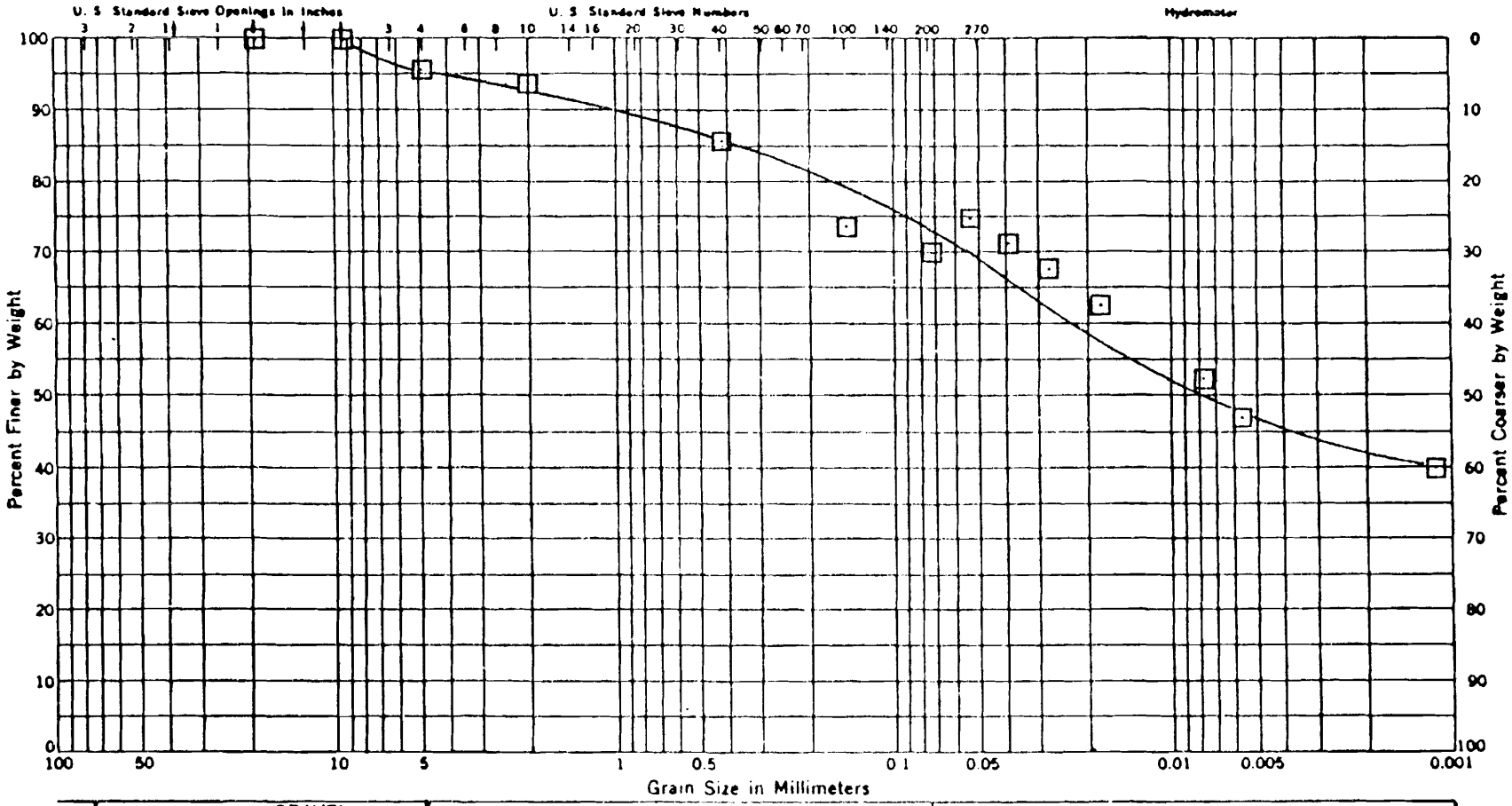
... ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 1 SAMPLE 1
DEPTH 3 - 5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/16/81	680874

206



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		41	15	26	
					UNIFIED CLASSIFICATION (CL)

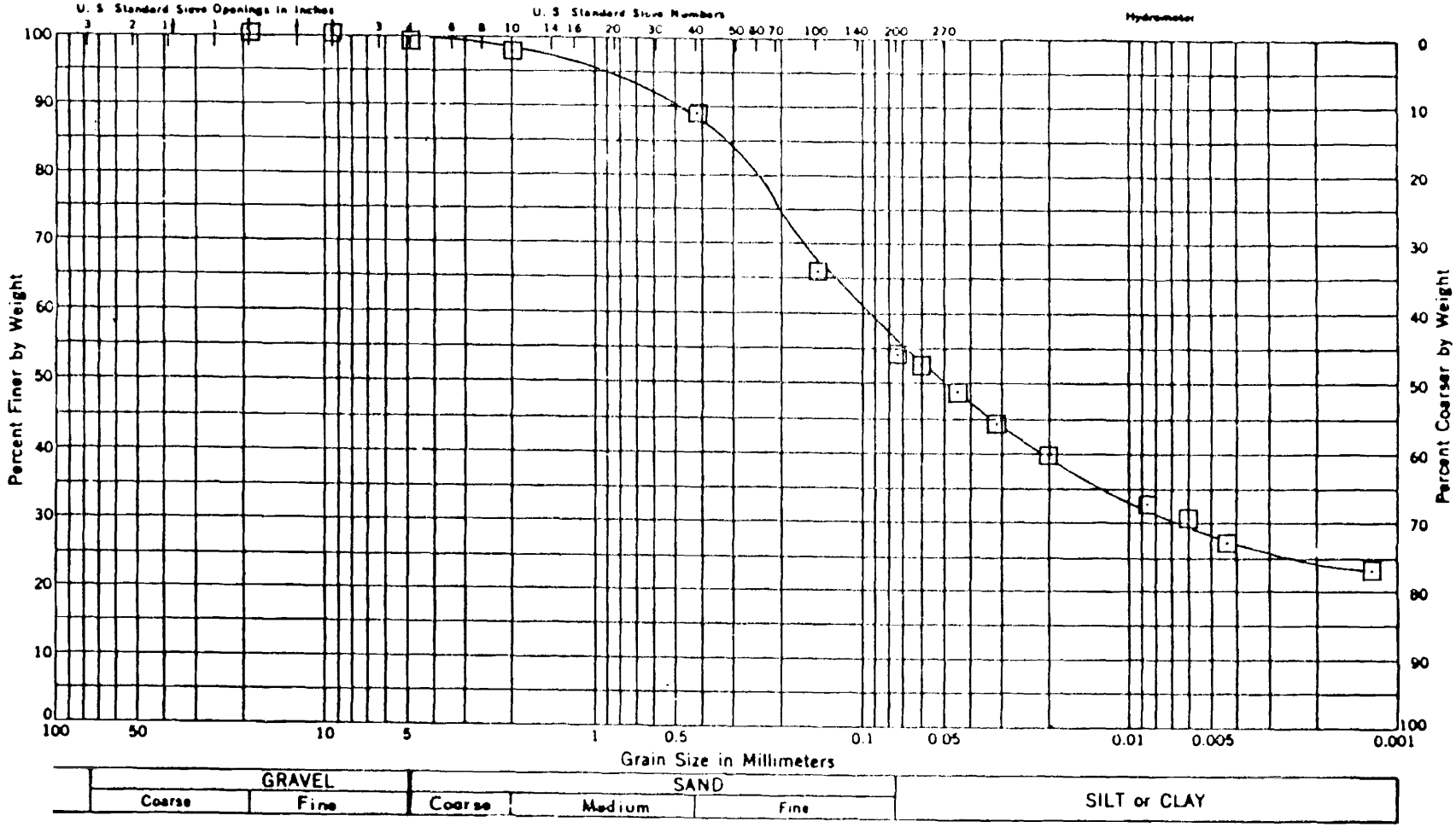
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 1 SAMPLE 3
DEPTH 13 - 15 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/20/81	680874

201



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
8		29	14	15	
					UNIFIED CLASSIFICATION (CL)

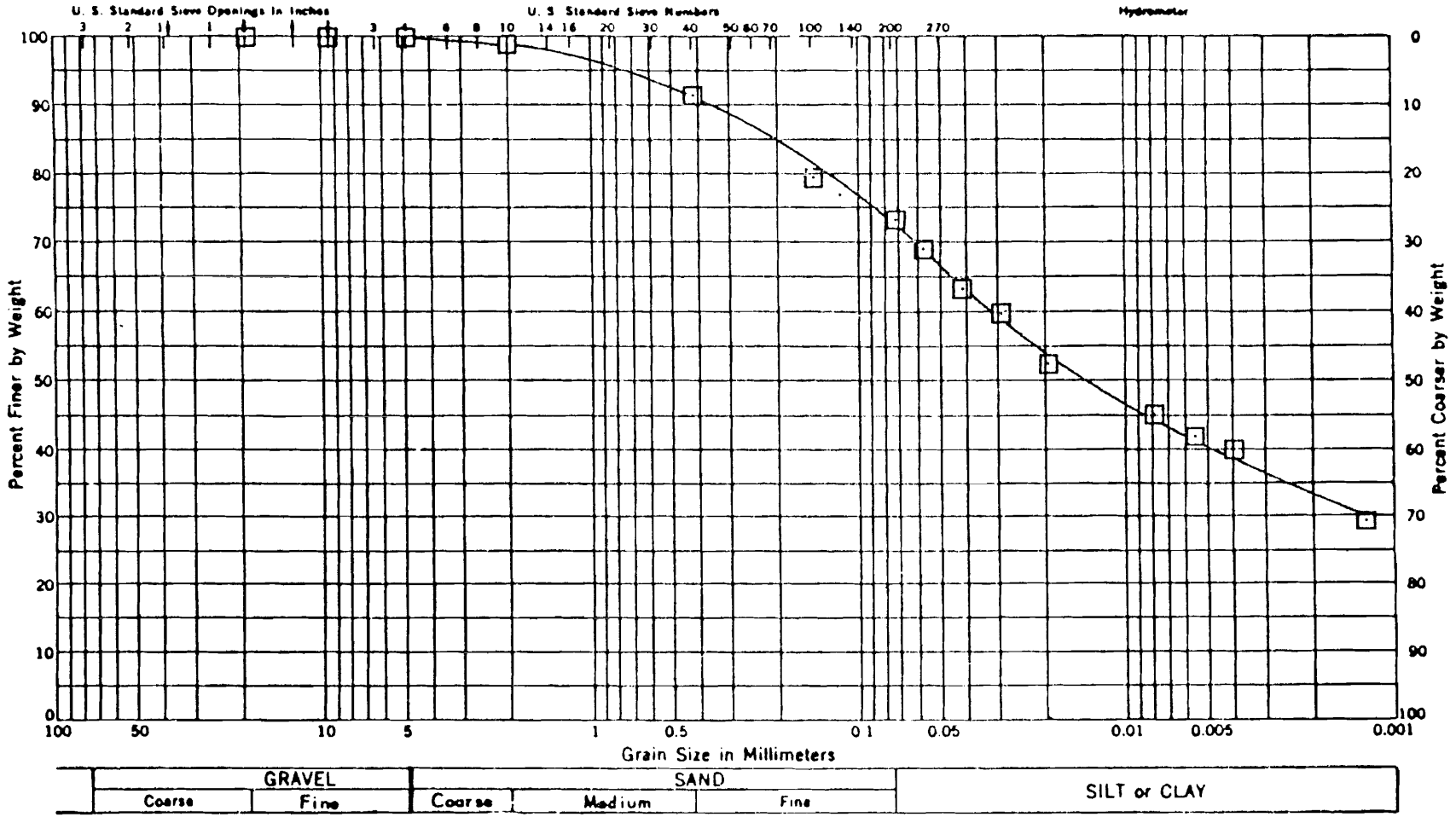
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 1 SAMPLE 8
DEPTH 38 - 40 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

APPROVED	DATE	JOB No.
JFH	01/16/81	680874

202



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		42	14	28	
					UNIFIED CLASSIFICATION (CL)

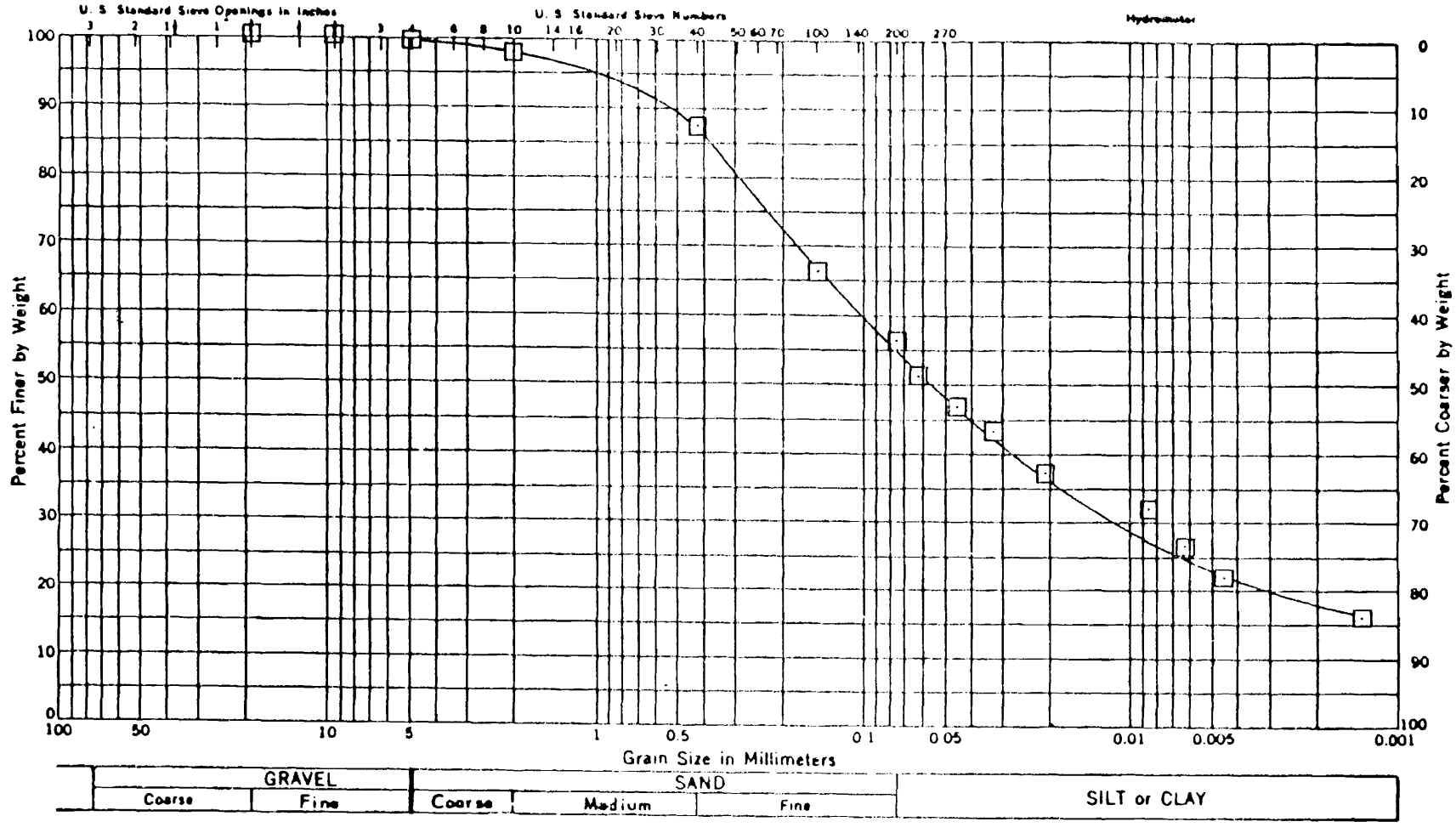
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 2 SAMPLE 2

DEPTH 8 - 10 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/20/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
4		26	14	12	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

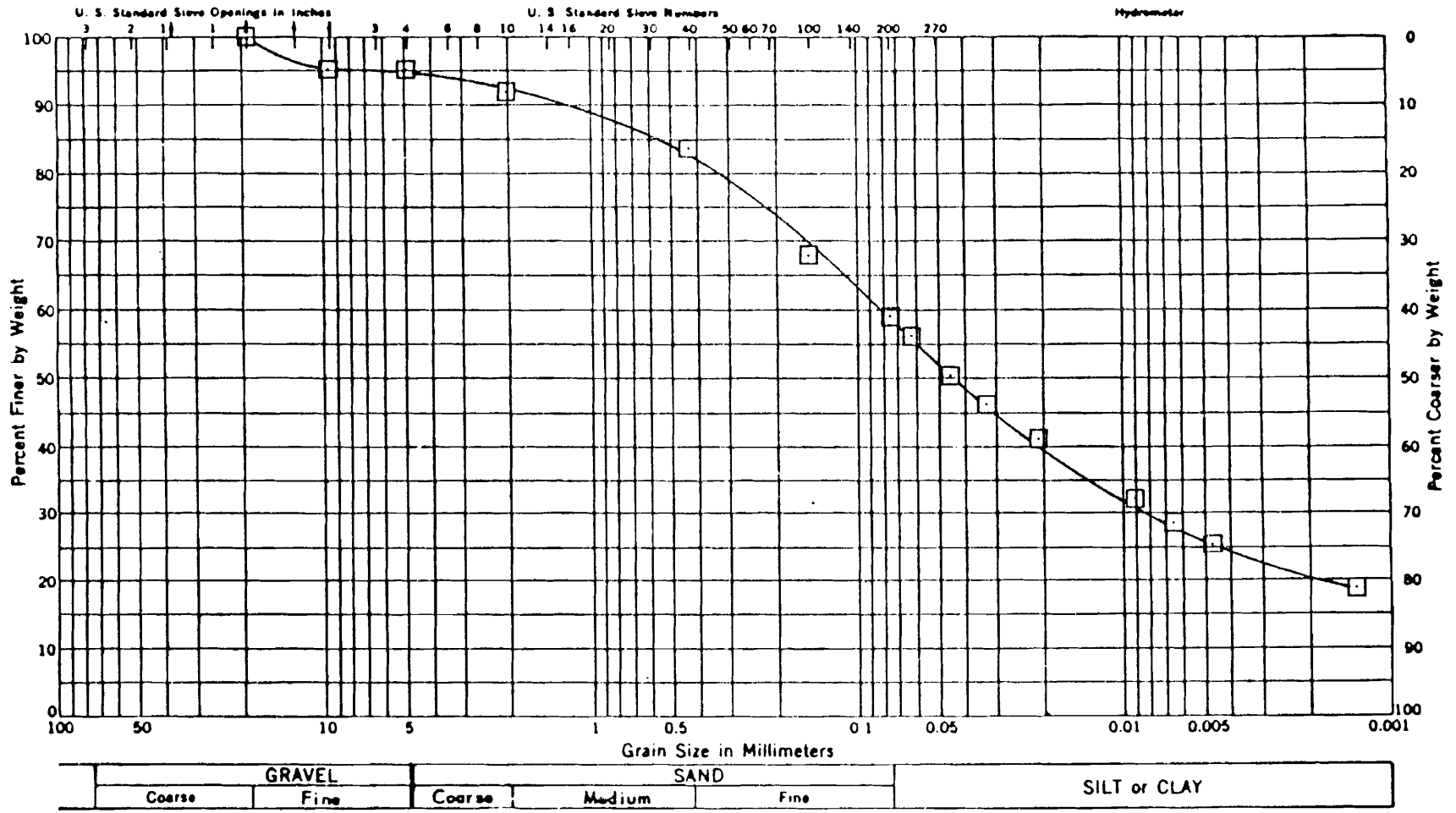
BORING 2 SAMPLE 4

DEPTH 18 - 20 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/16/81	680874

204



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
10		30	16	14	
					UNIFIED CLASSIFICATION (CL)

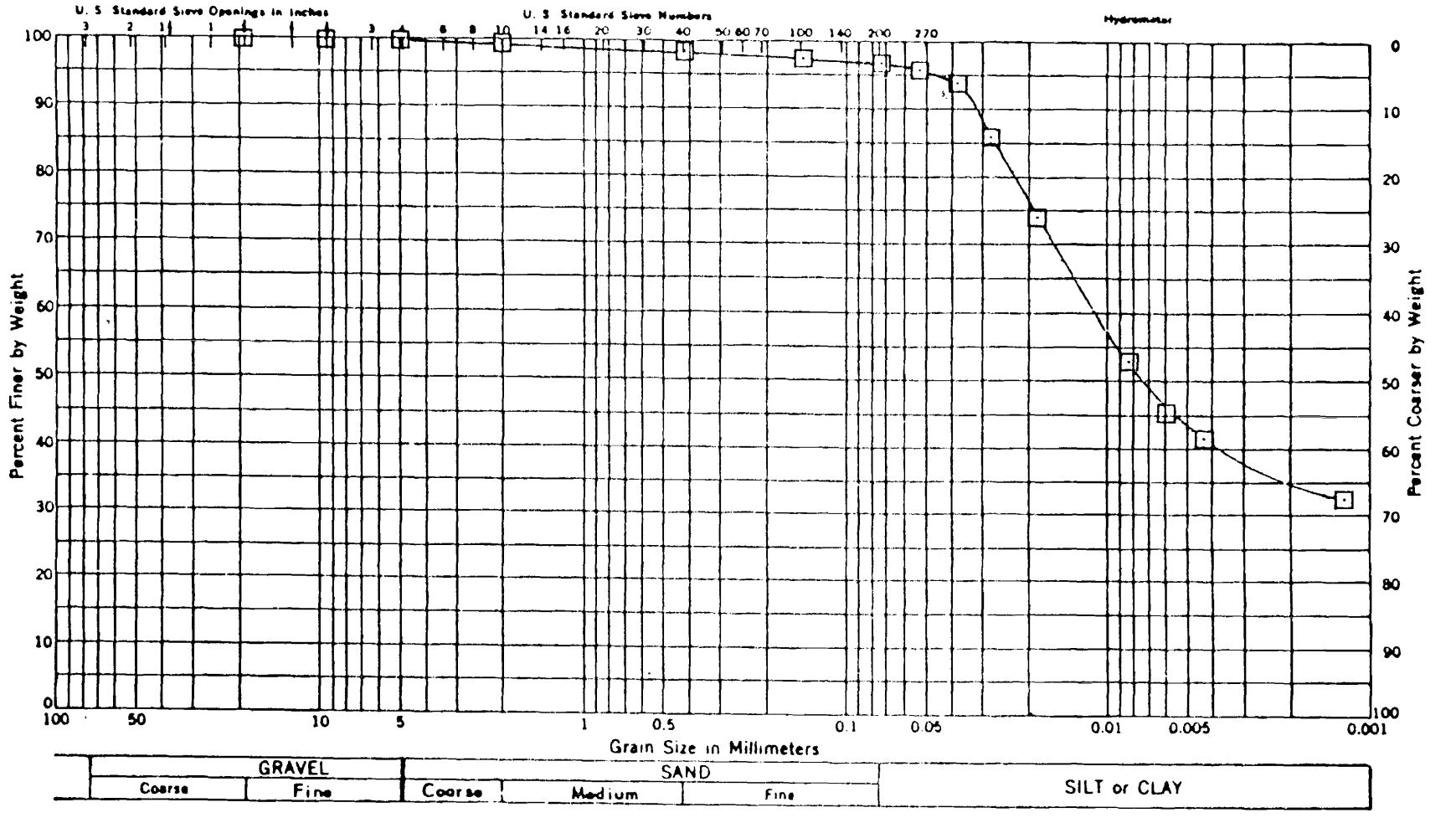
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 2 SAMPLE 10

DEPTH 48 - 50 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/16/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		54	22	32	
					UNIFIED CLASSIFICATION (CH)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

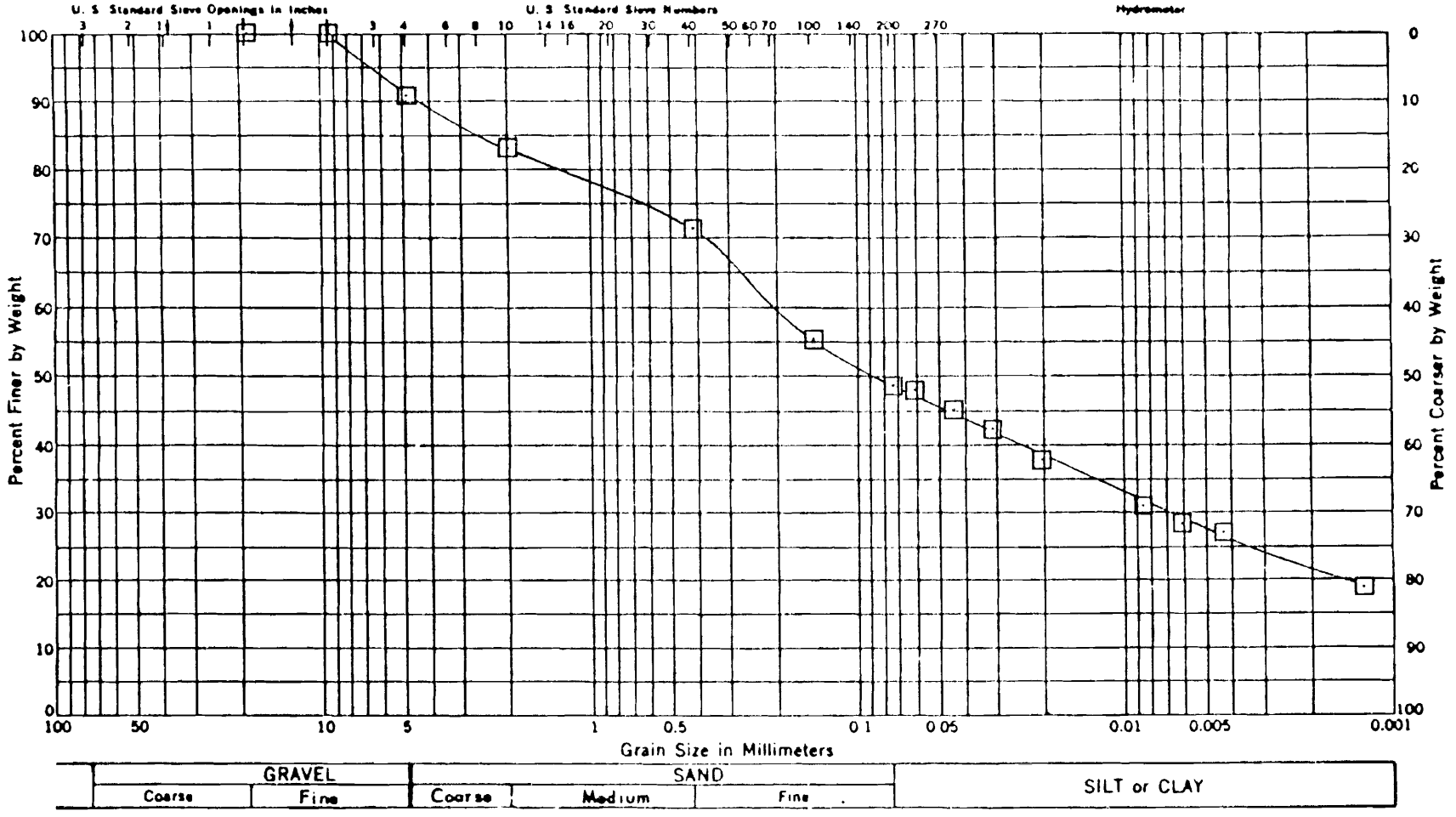
BORING 3 SAMPLE 1

DEPTH 3 - 5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/21/81	680874

206



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		45	19	26	
					UNIFIED CLASSIFICATION (CL)

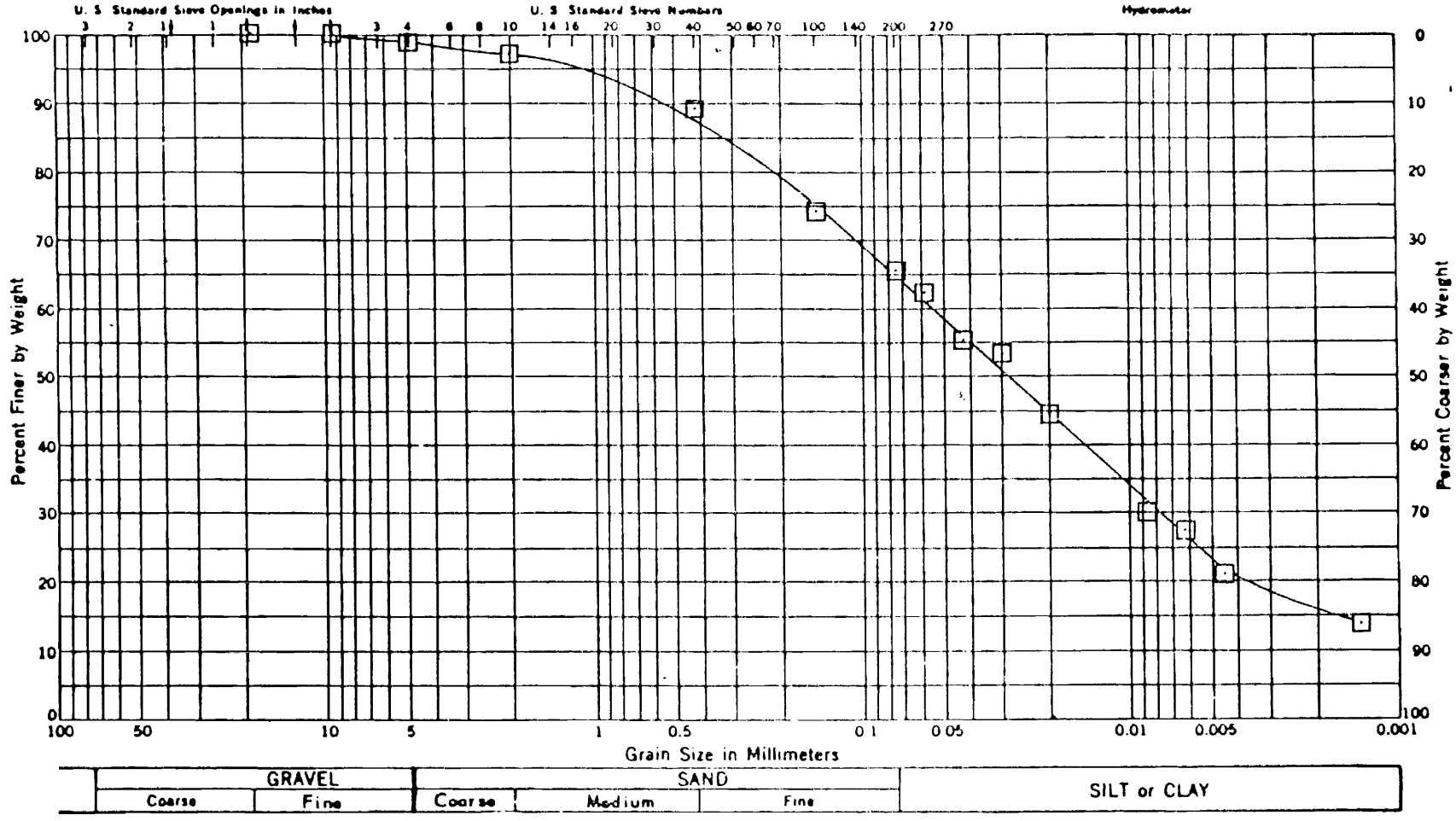
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 3 SAMPLE 3
DEPTH 13 - 15 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/16/81	680874

207



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
5		26	14	12	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

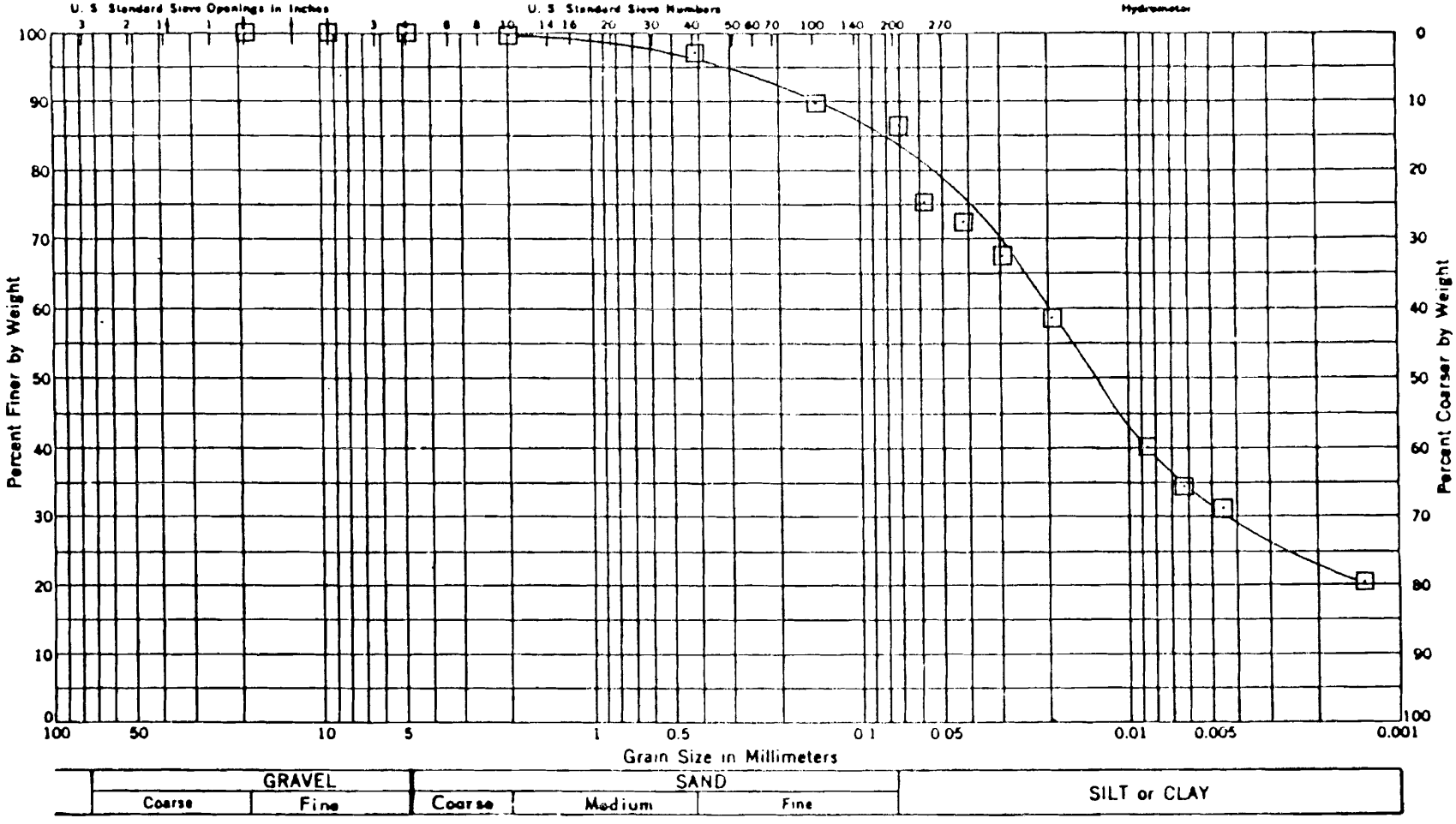
BORING 3 SAMPLE 5

DEPTH 23 - 25 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/16/81	680874

208



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		43	19	24	
					UNIFIED CLASSIFICATION (CL)

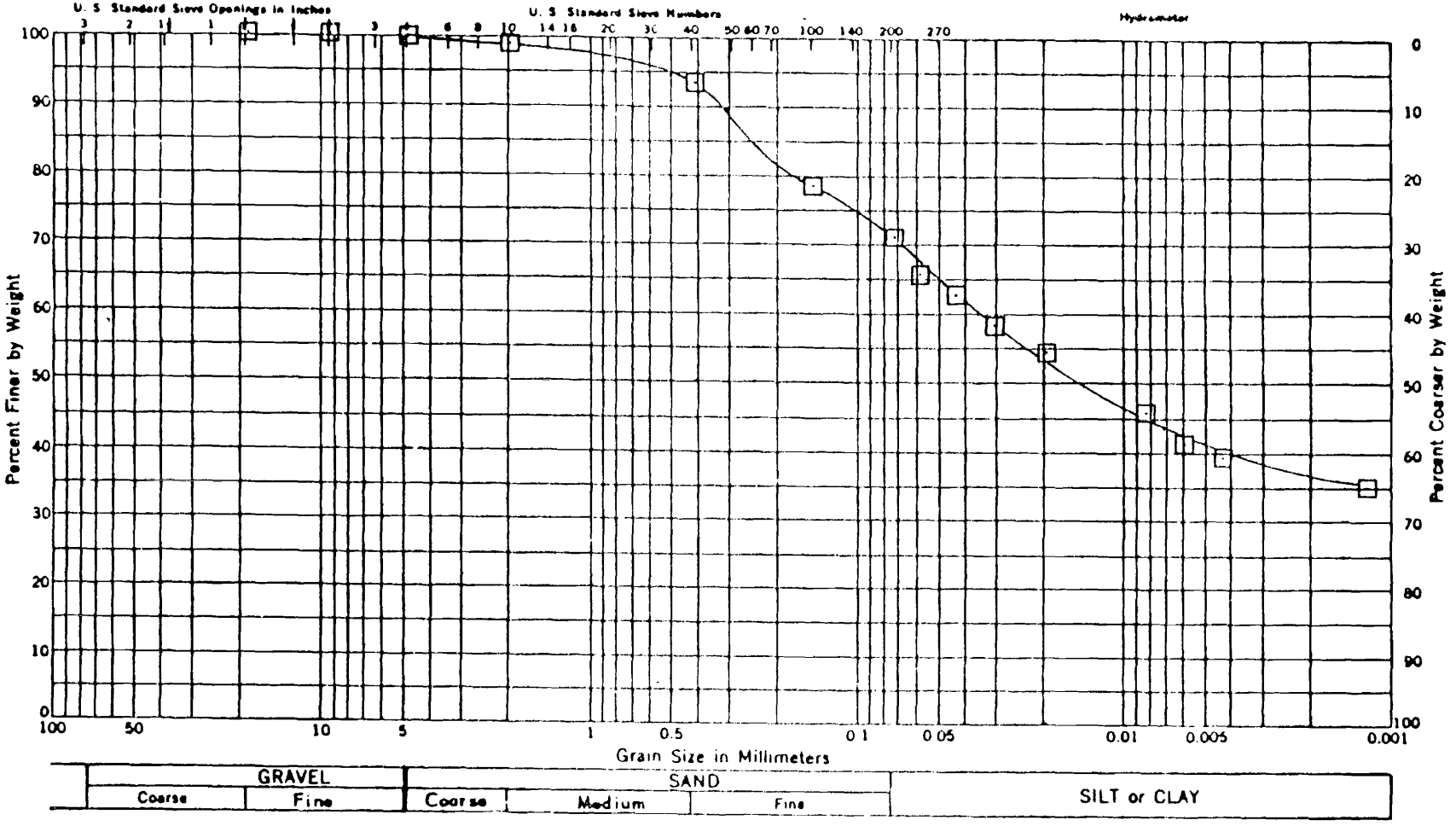
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 4 SAMPLE 2
DEPTH 8 - 10 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/16/81	680874

209



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
9		51	18	33	
					UNIFIED CLASSIFICATION (CH)

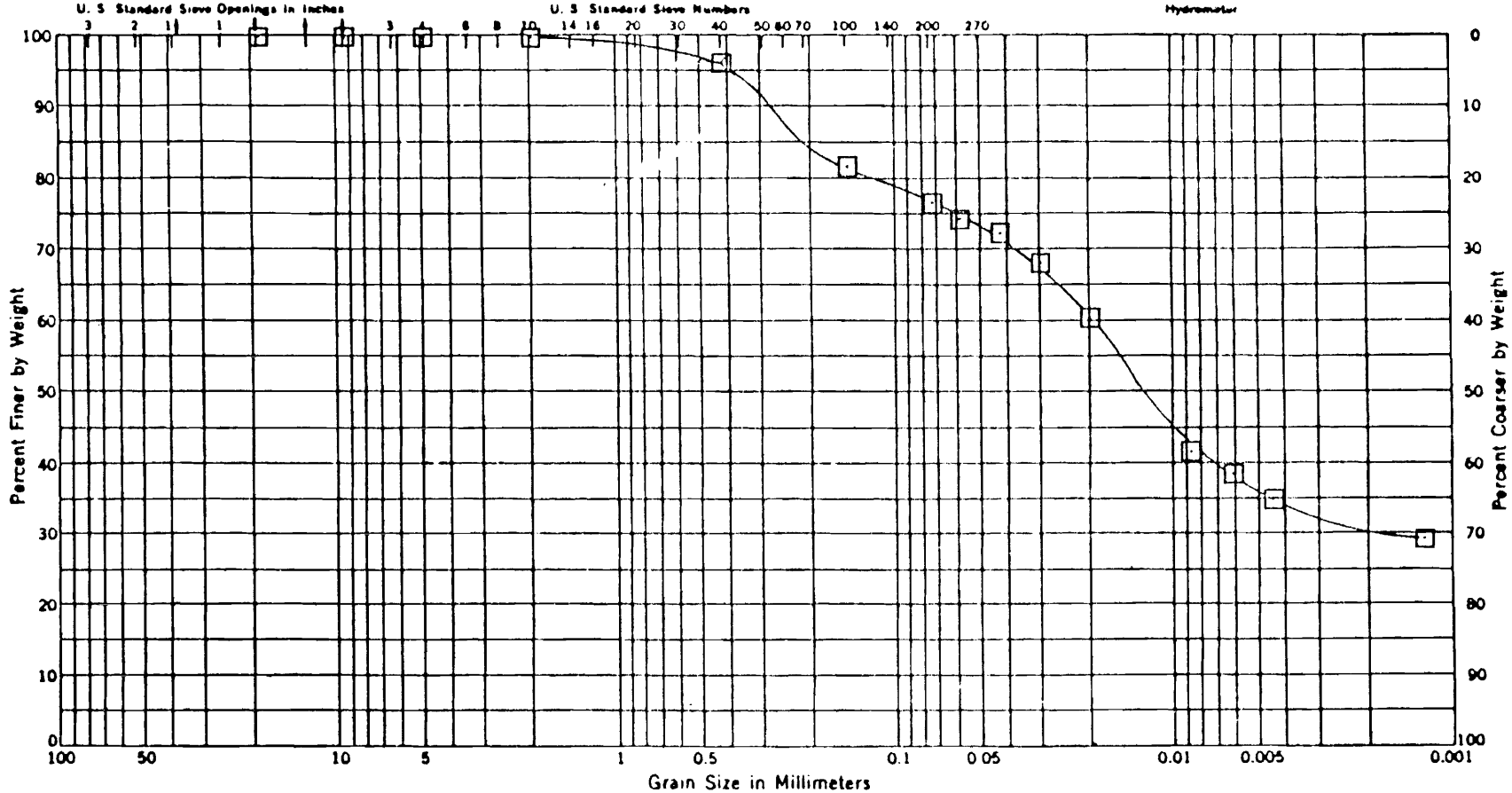
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 4 SAMPLE 9

DEPTH 43 - 45 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/16/81	680874



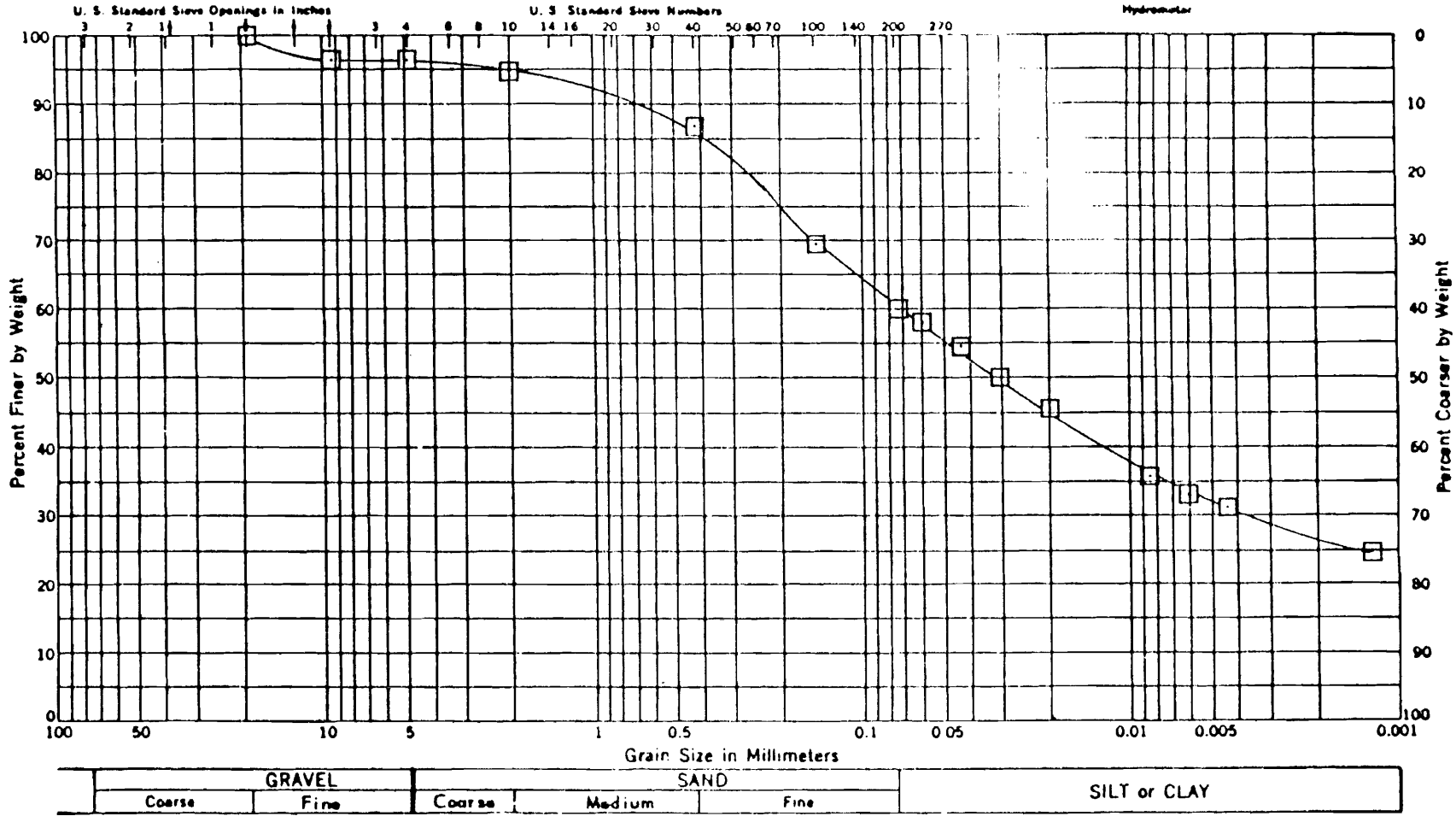
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		35	15	20	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 5 SAMPLE 2
DEPTH 8 - 10 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/16/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
8		30	13	17	
					UNIFIED CLASSIFICATION (CL)

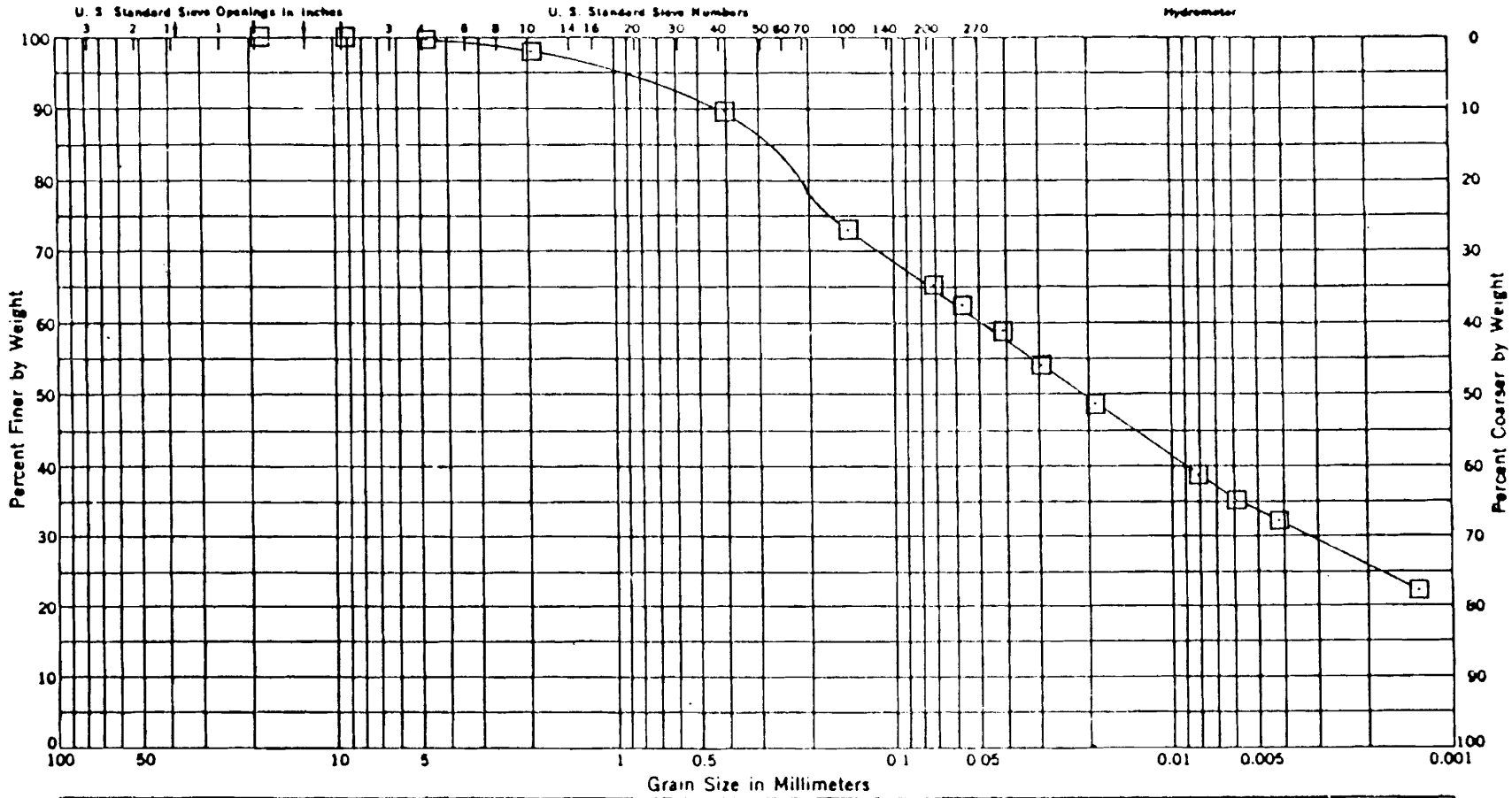
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 5 SAMPLE 8
DEPTH 38 - 40 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JEH	01/16/81	680874

212



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
10		37	15	22	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

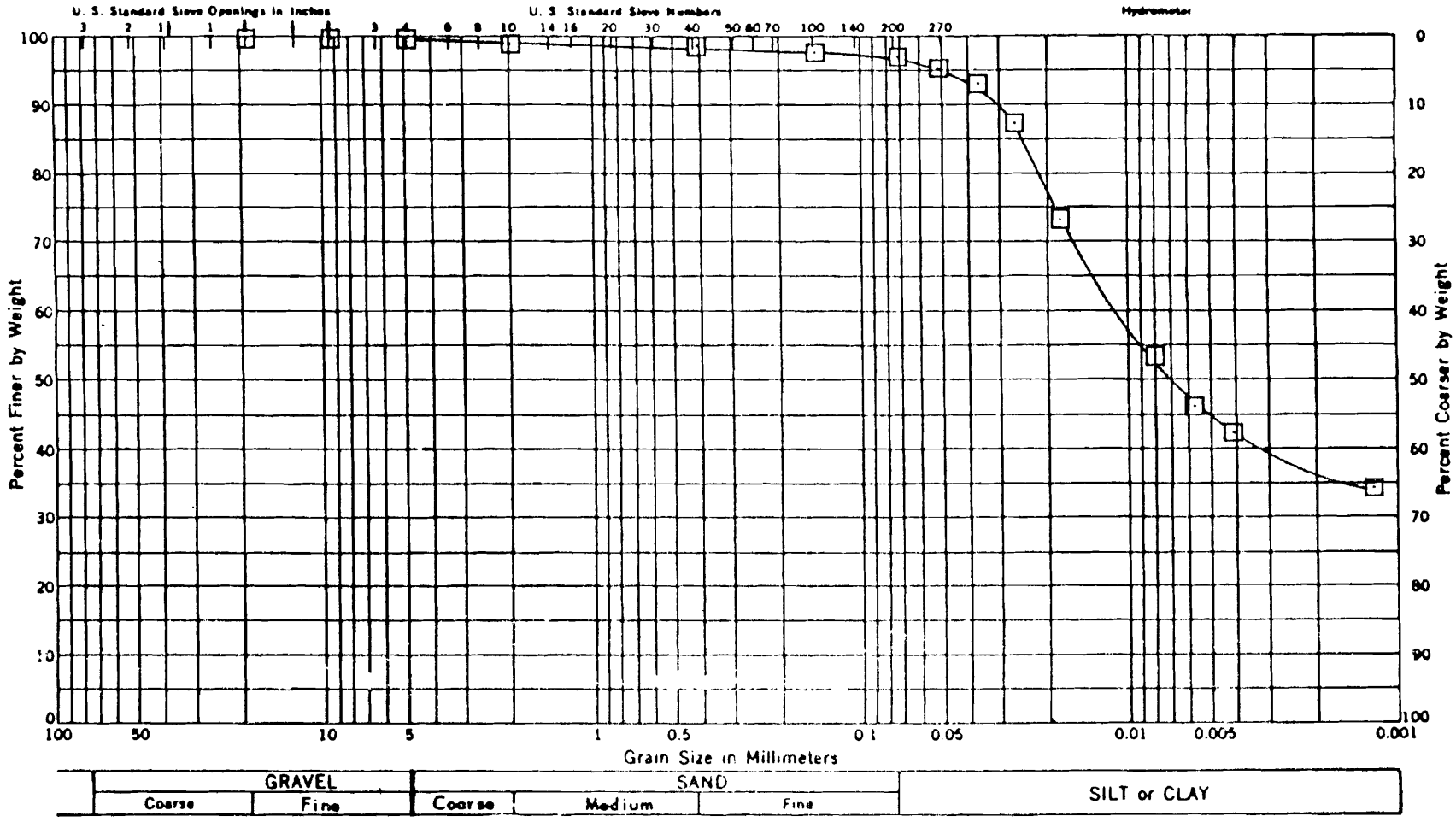
BORING 5 SAMPLE 10

DEPTH 48 - 50 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/19/81	680874

2/13



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		58	20	38	
					UNIFIED CLASSIFICATION (CH)

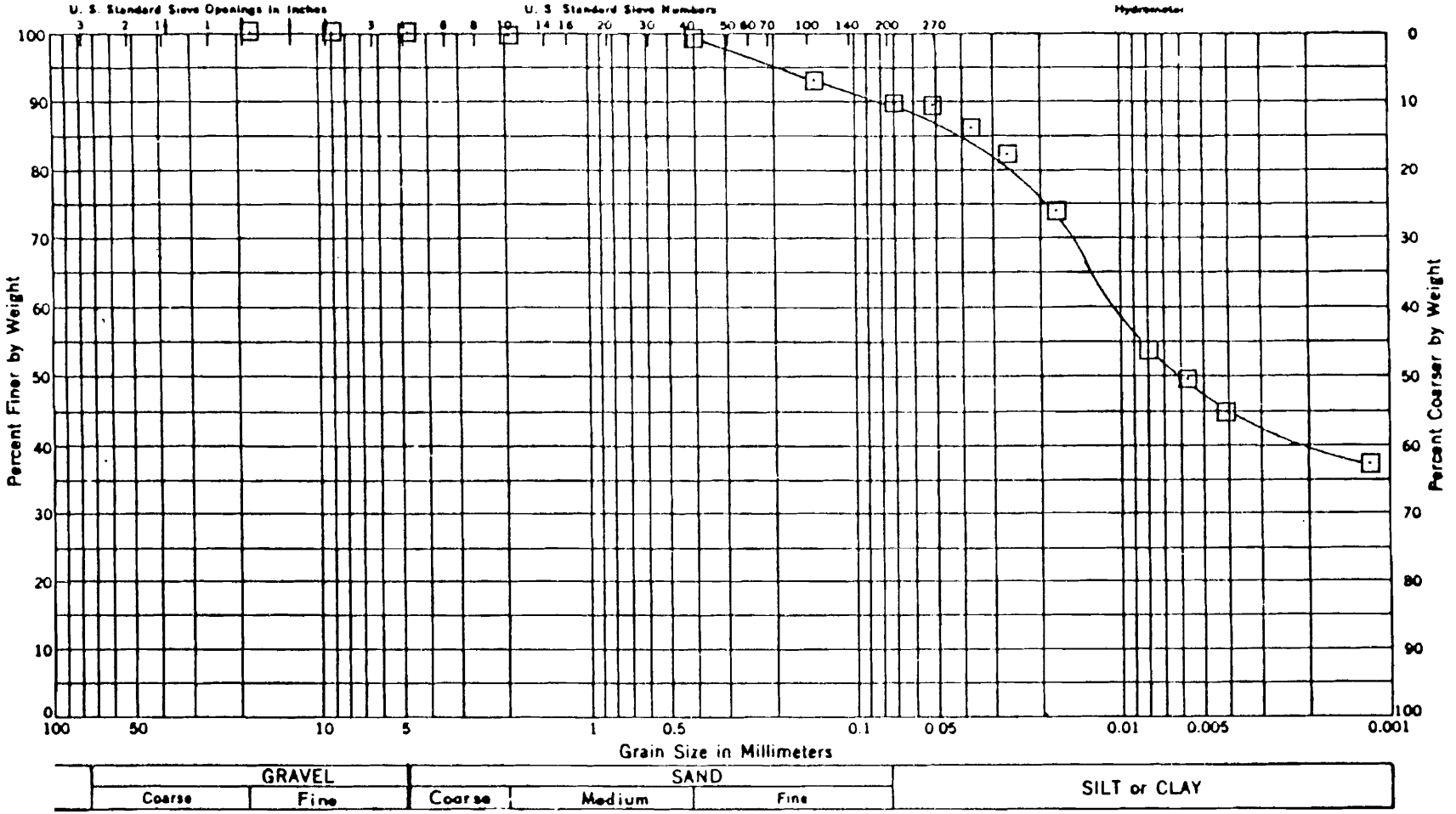
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 6 SAMPLE 1
DEPTH 3 - 5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/21/81	680874

214



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		49	20	29	
					UNIFIED CLASSIFICATION (CL)

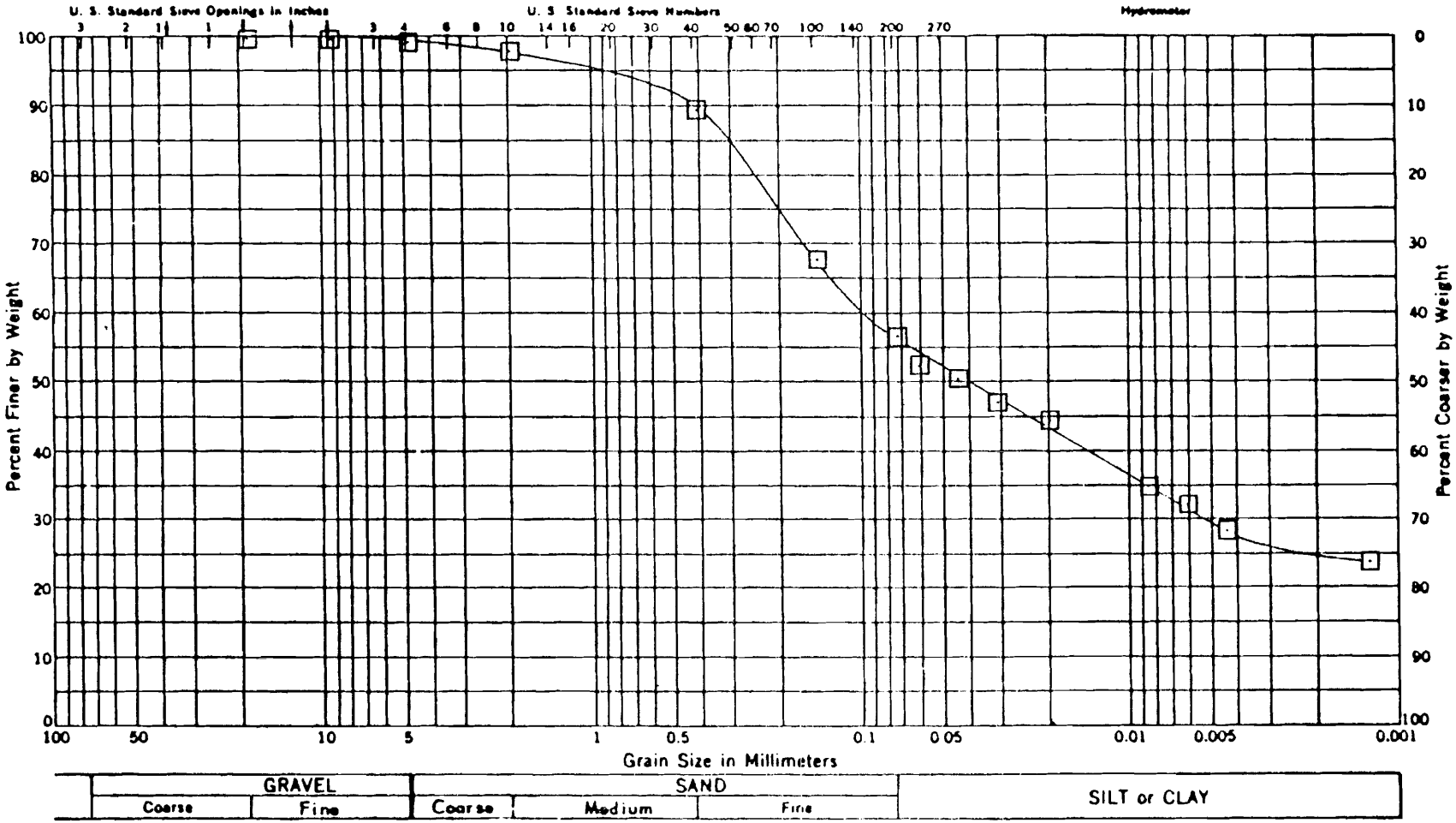
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 6 SAMPLE 2
DEPTH 8 - 10 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JEH	01/19/81	680874

215



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
6		32	17	15	
					UNIFIED CLASSIFICATION (CL)

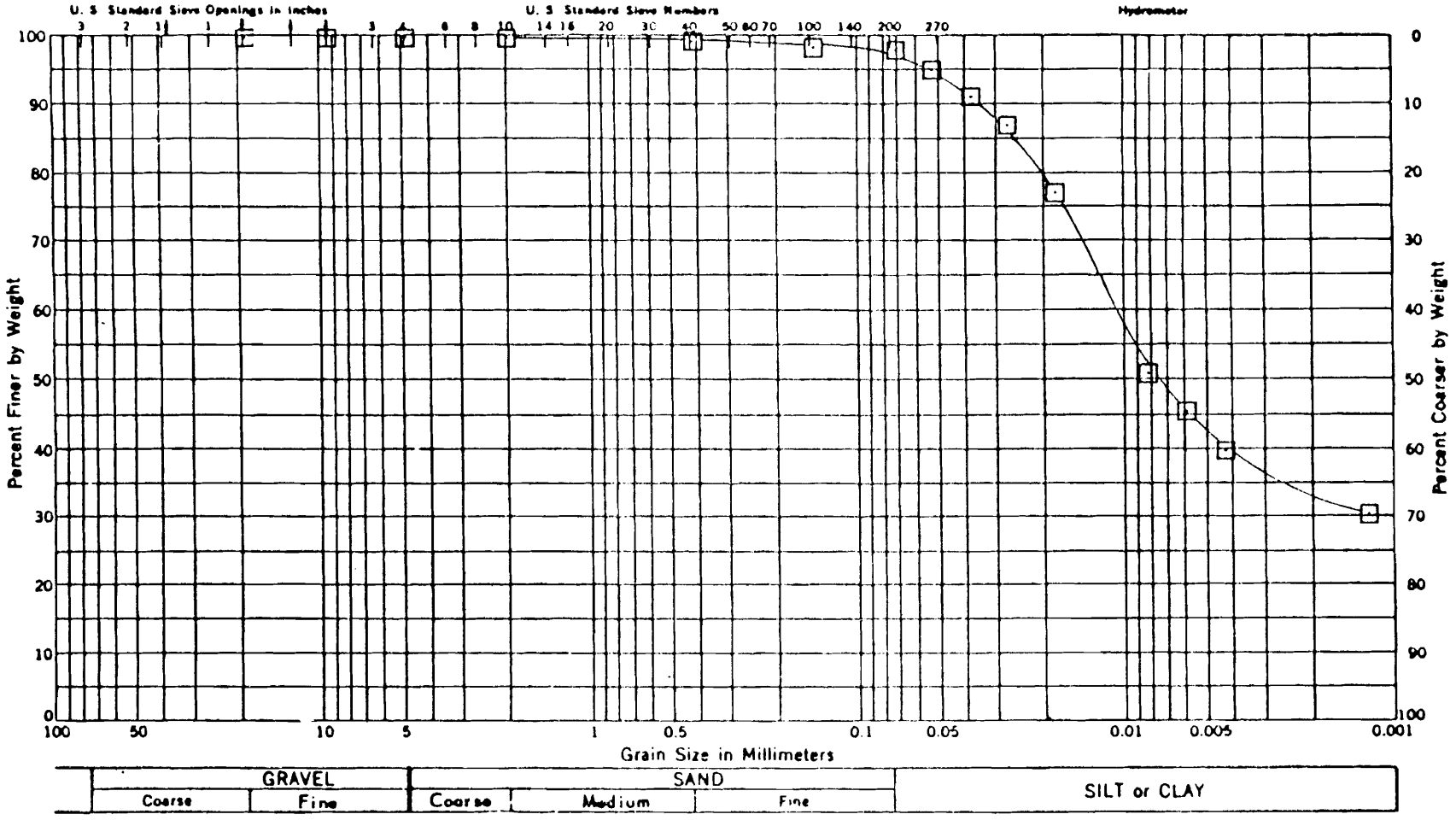
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 6 SAMPLE 6

DEPTH 28 - 30 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/19/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		49	18	31	
					UNIFIED CLASSIFICATION (CL)

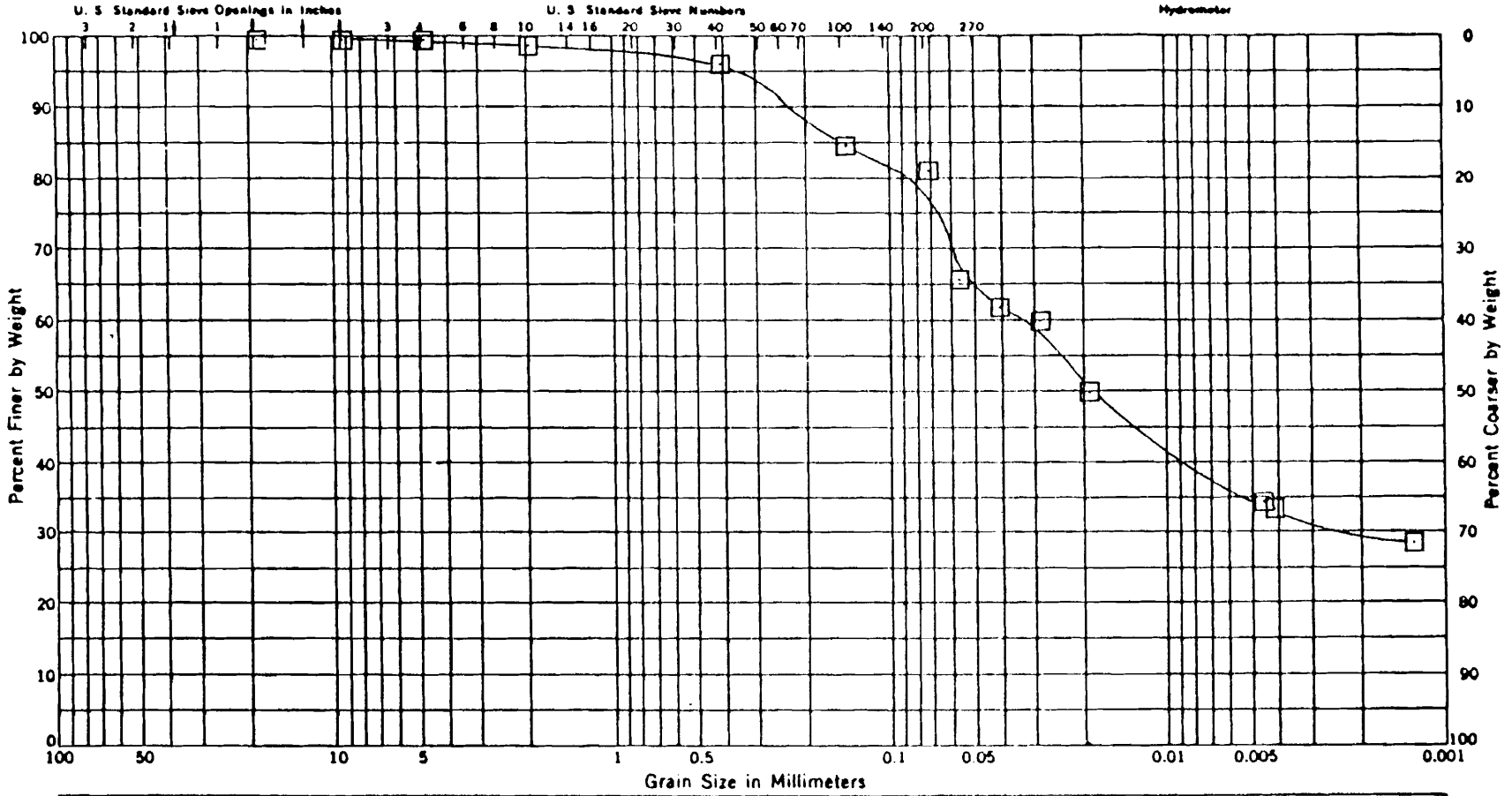
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 7 SAMPLE 1
DEPTH 2 - 4 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.E.H.	01/19/81	680874

217



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		54	19	35	
					UNIFIED CLASSIFICATION (CH)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

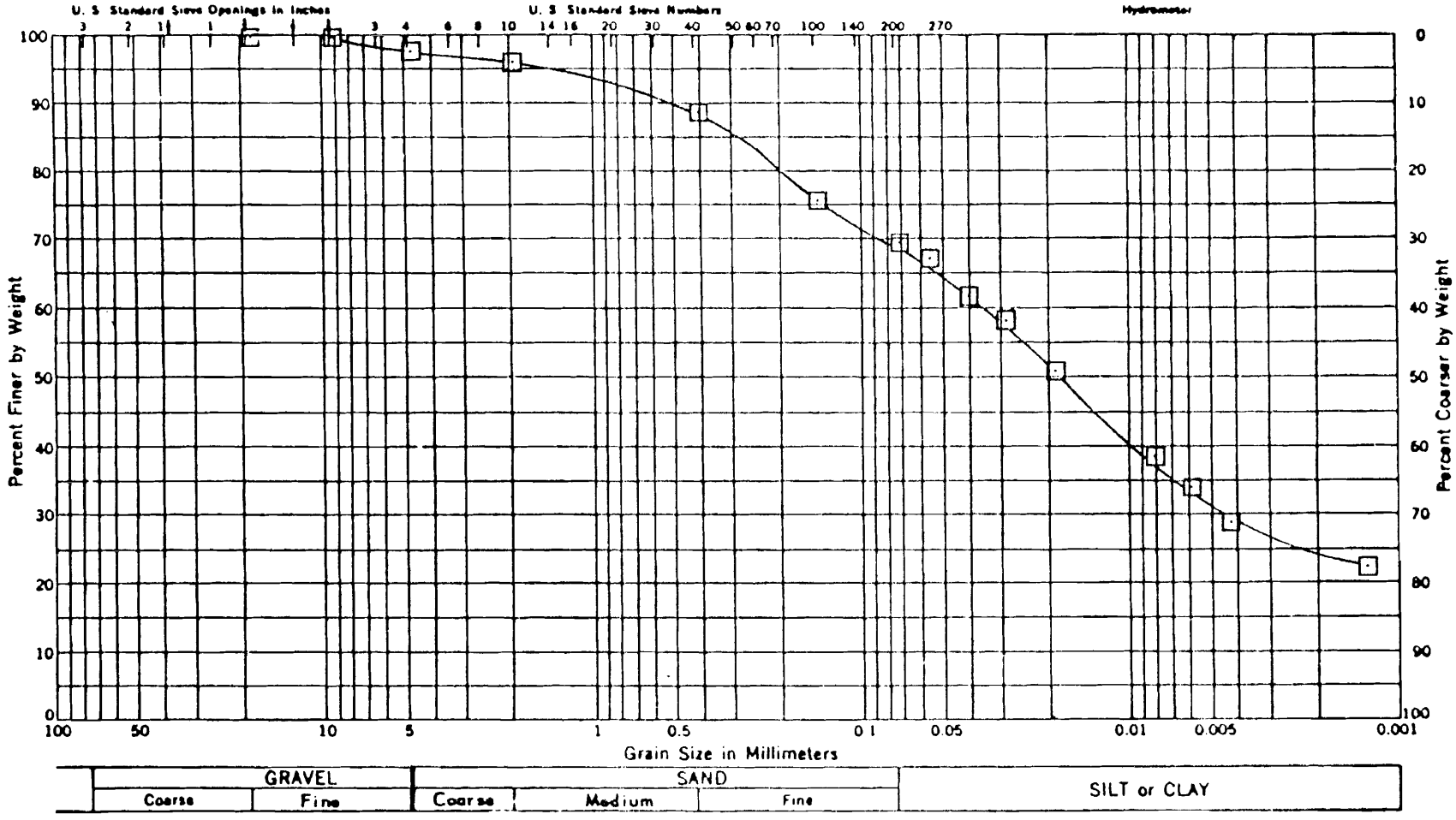
BORING 7 SAMPLE 3

DEPTH 12 - 14 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/19/81	680874

218



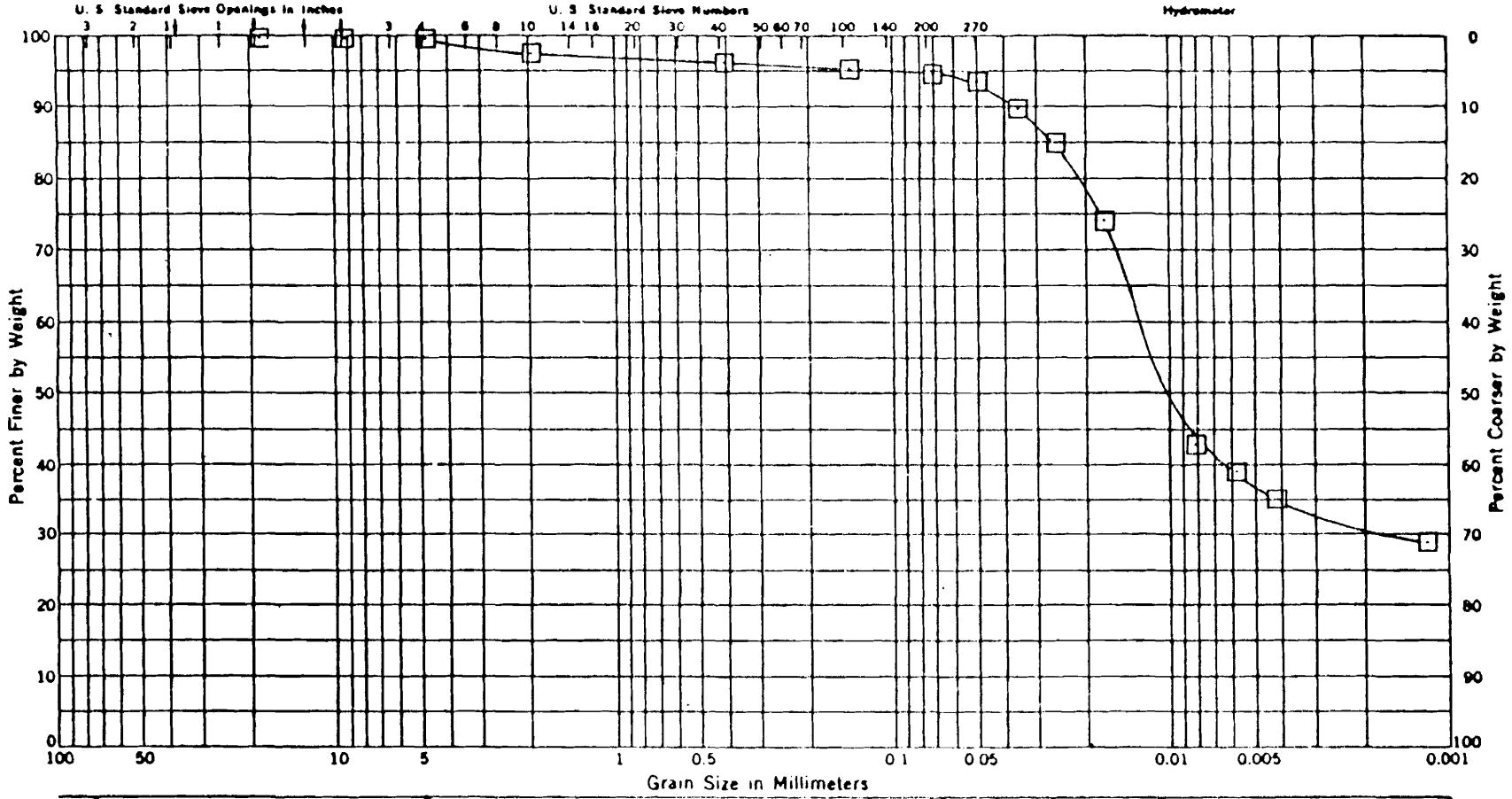
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
5		30	15	15	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 7 SAMPLE 5
DEPTH 22 - 24 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/19/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		51	22	29	
					UNIFIED CLASSIFICATION (CH)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

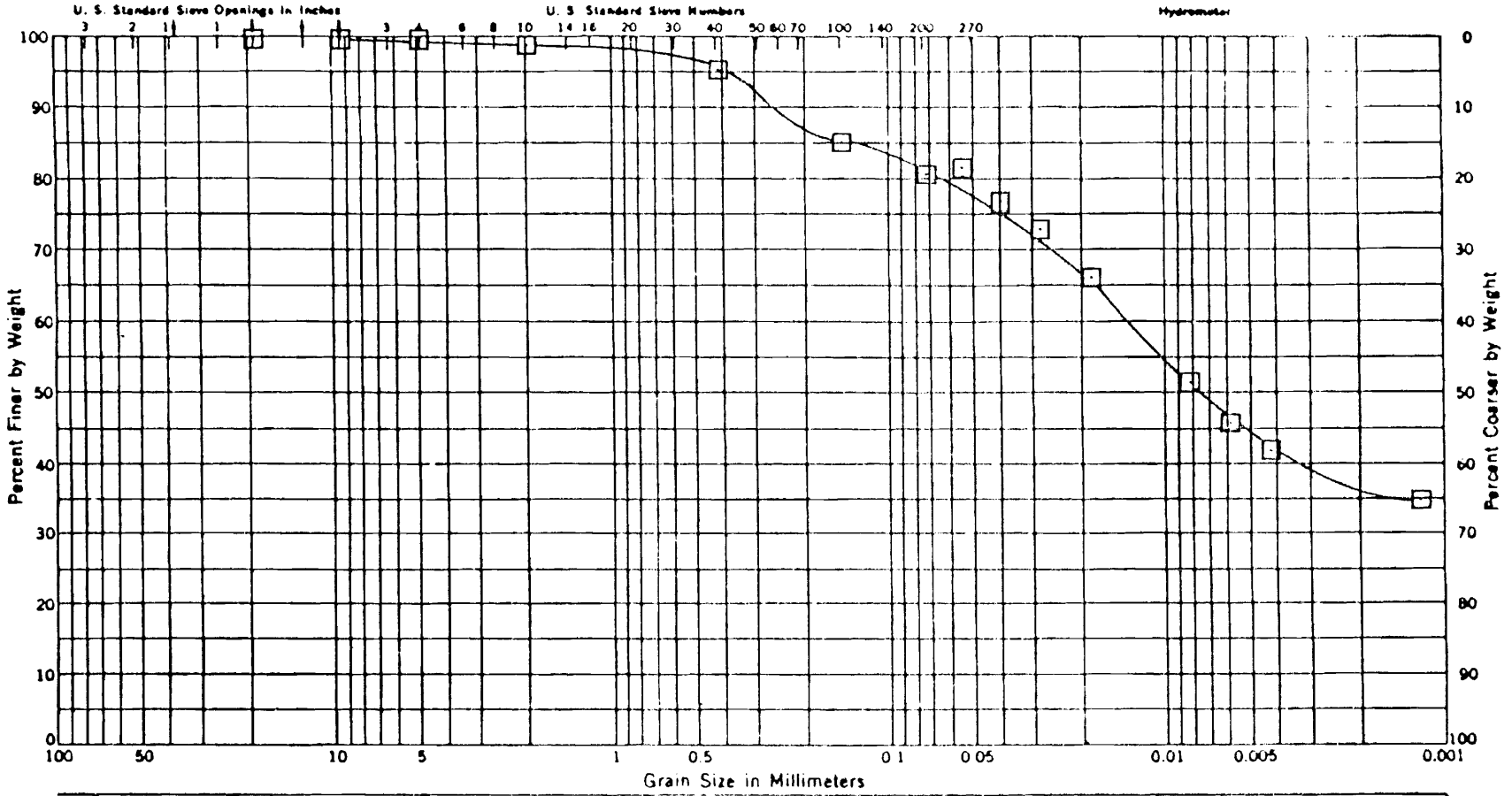
BORING 8 SAMPLE 1

DEPTH 3 - 5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/19/81	680874

220



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		42	18	24	
					UNIFIED CLASSIFICATION (CL)

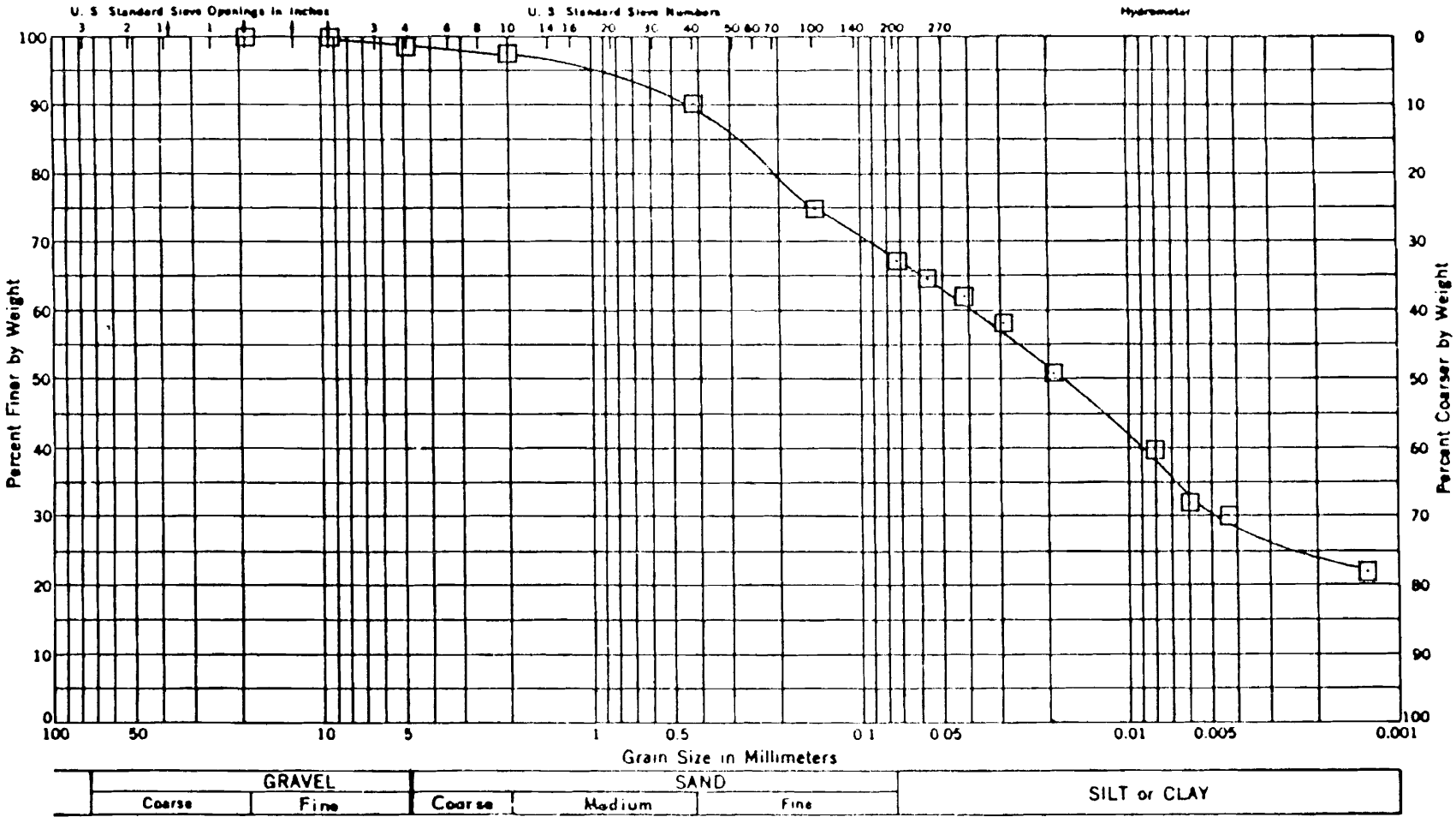
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 8 SAMPLE 2
DEPTH 8 - 10 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/21/81	680874

321



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		36	15	21	
					UNIFIED CLASSIFICATION (CL)

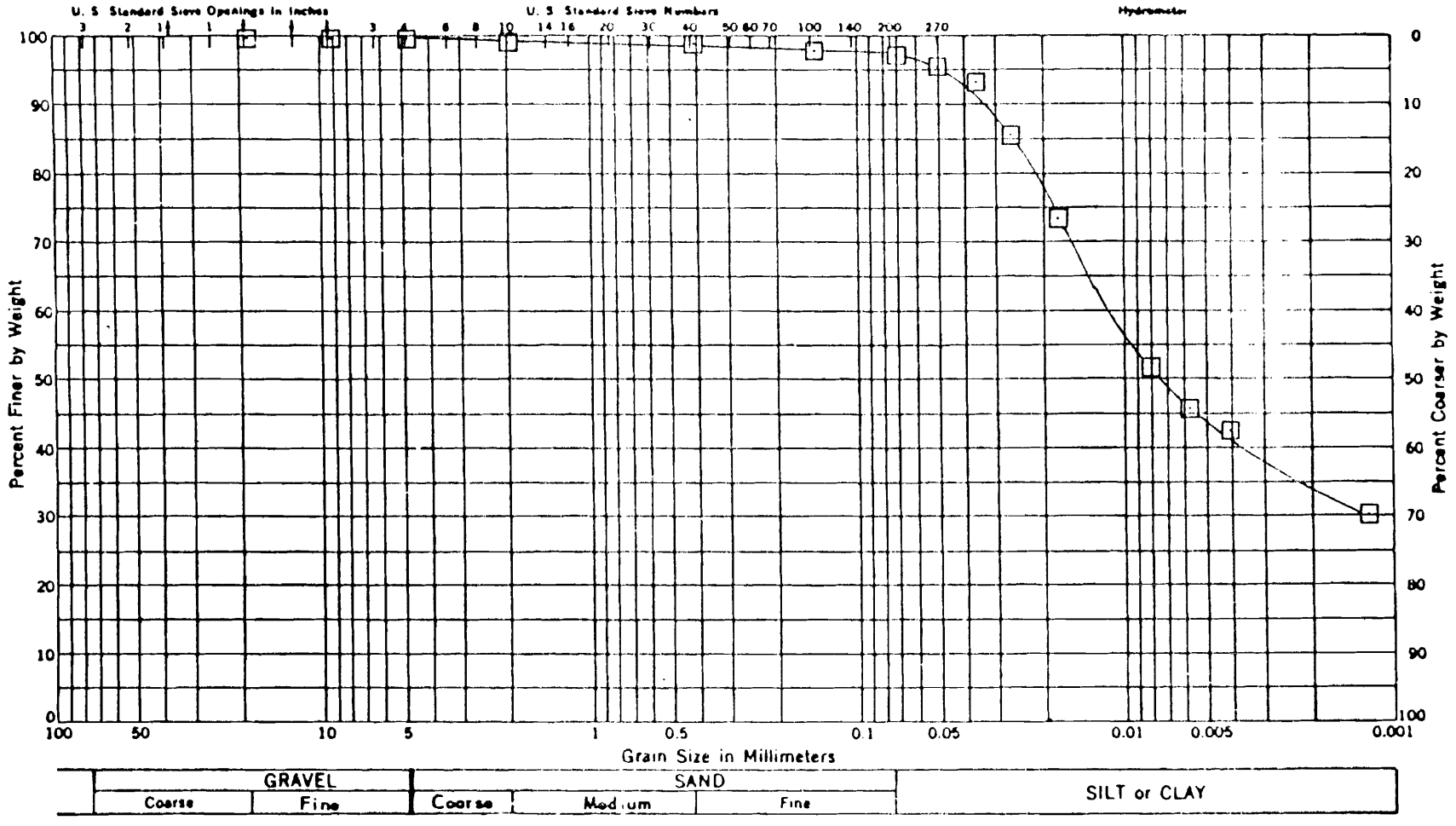
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 8 SAMPLE 3

DEPTH 13 - 15 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/21/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		58	26	32	
					UNIFIED CLASSIFICATION (CH)

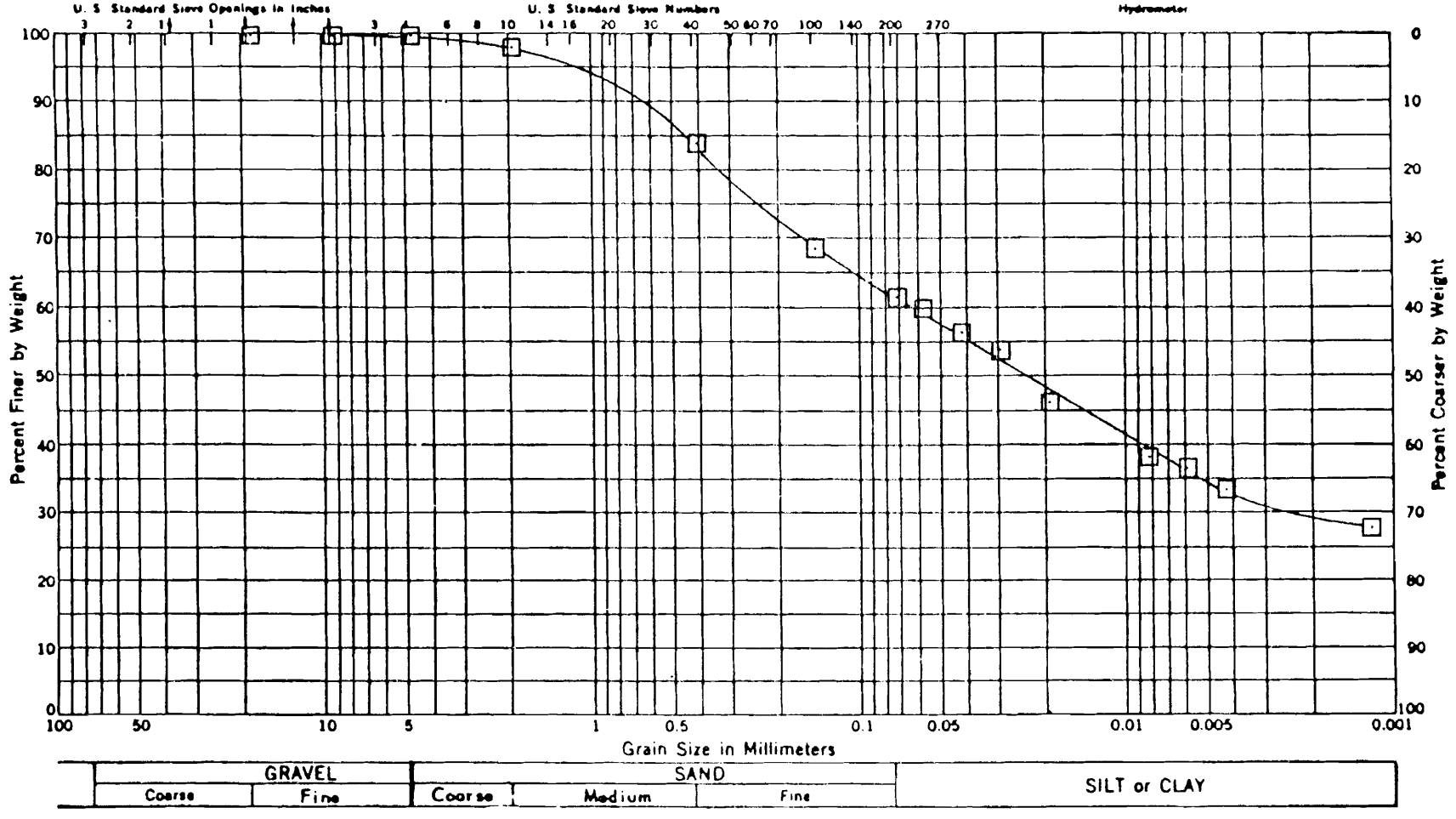
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 9 SAMPLE 1
DEPTH 2 - 4 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/19/81	680874

223



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		40	16	24	
					UNIFIED CLASSIFICATION (CL)

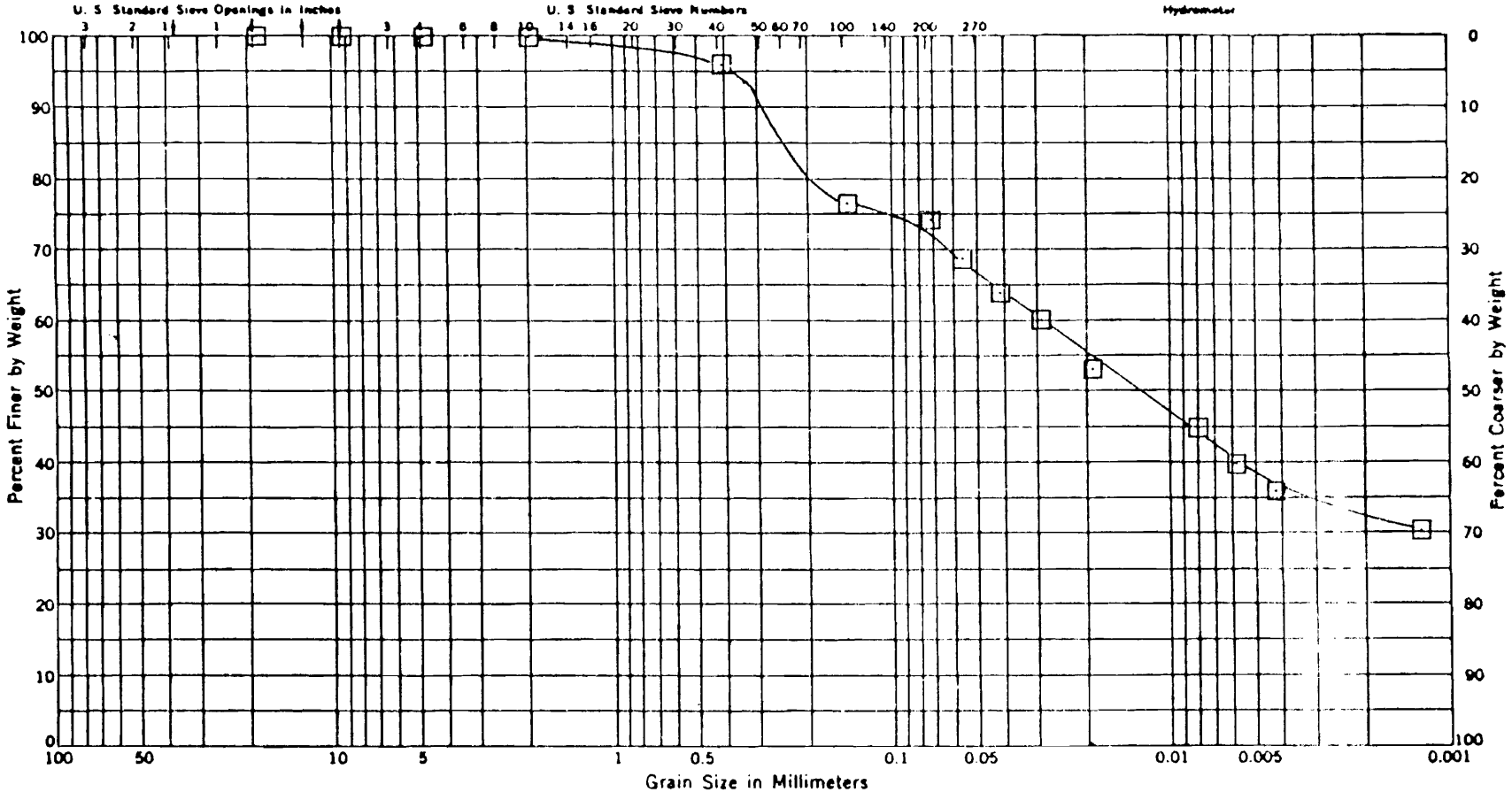
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 9 SAMPLE 3

DEPTH 12 - 14 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/19/81	680874



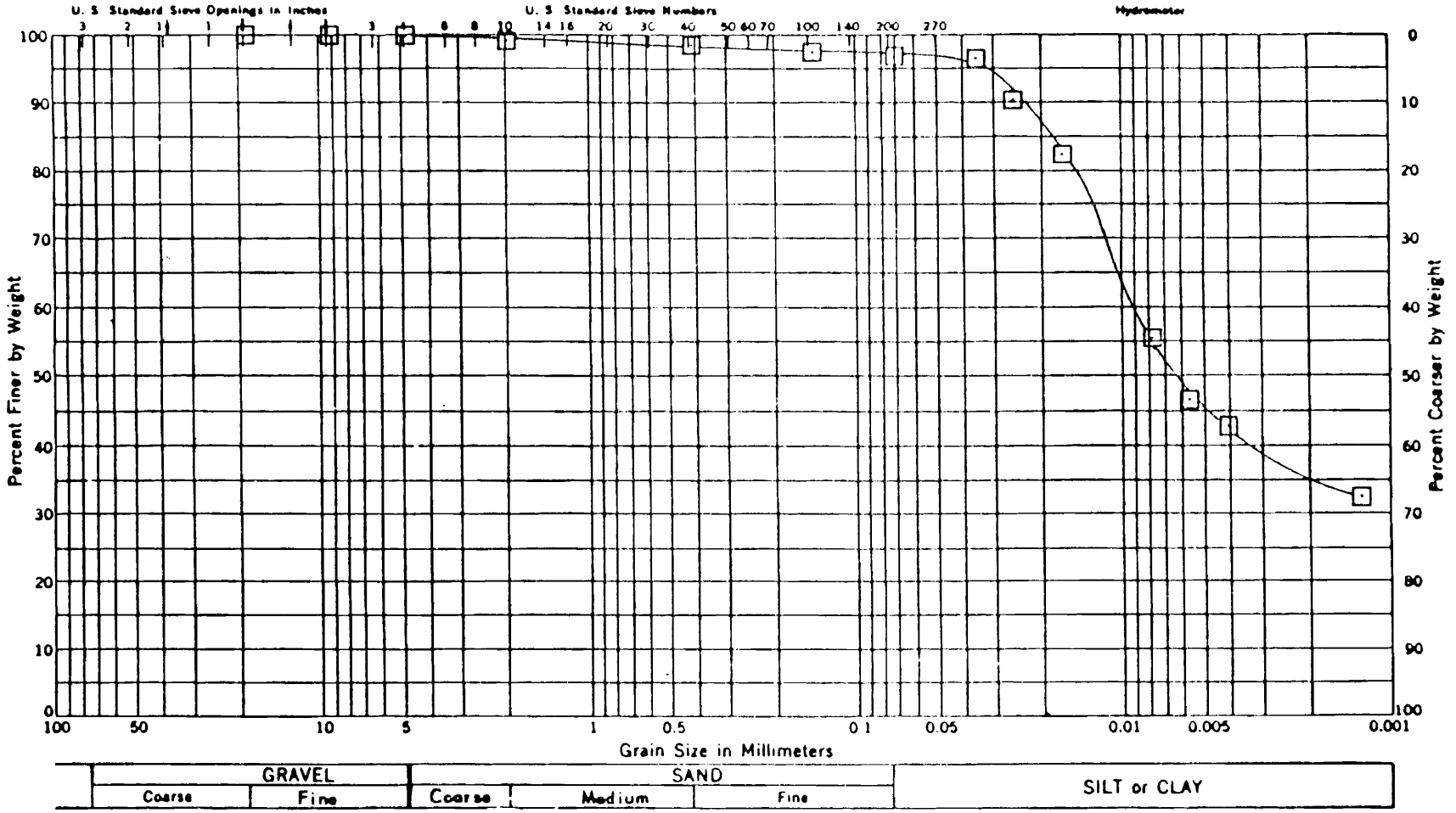
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
6		44	16	28	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 9 SAMPLE 6
DEPTH 28 - 30 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/19/81	680874



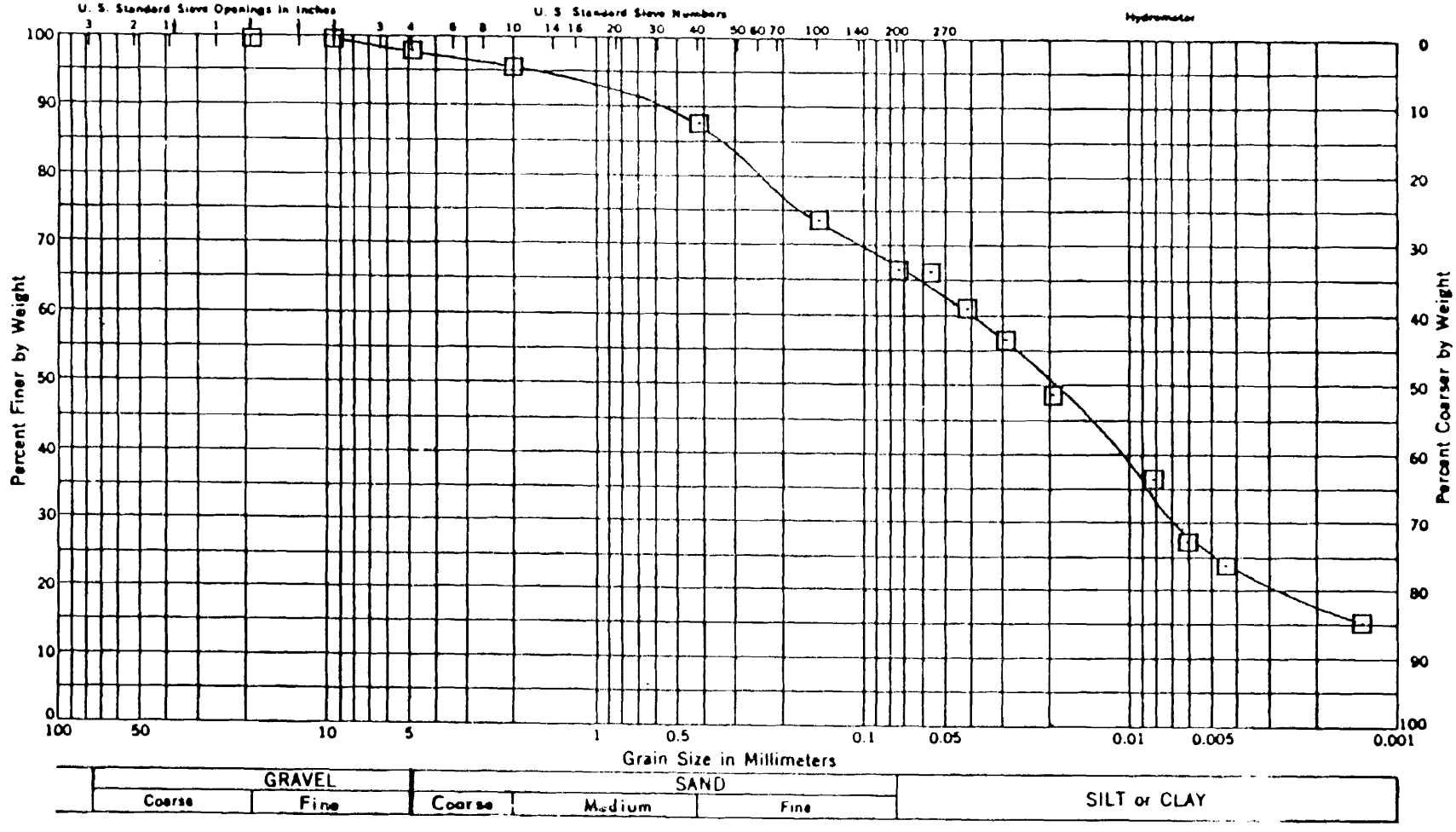
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		53	20	33	
					UNIFIED CLASSIFICATION (CH)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 10 SAMPLE 1
DEPTH 3 - 5 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/19/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
4		28	14	14	
					UNIFIED CLASSIFICATION (CL)

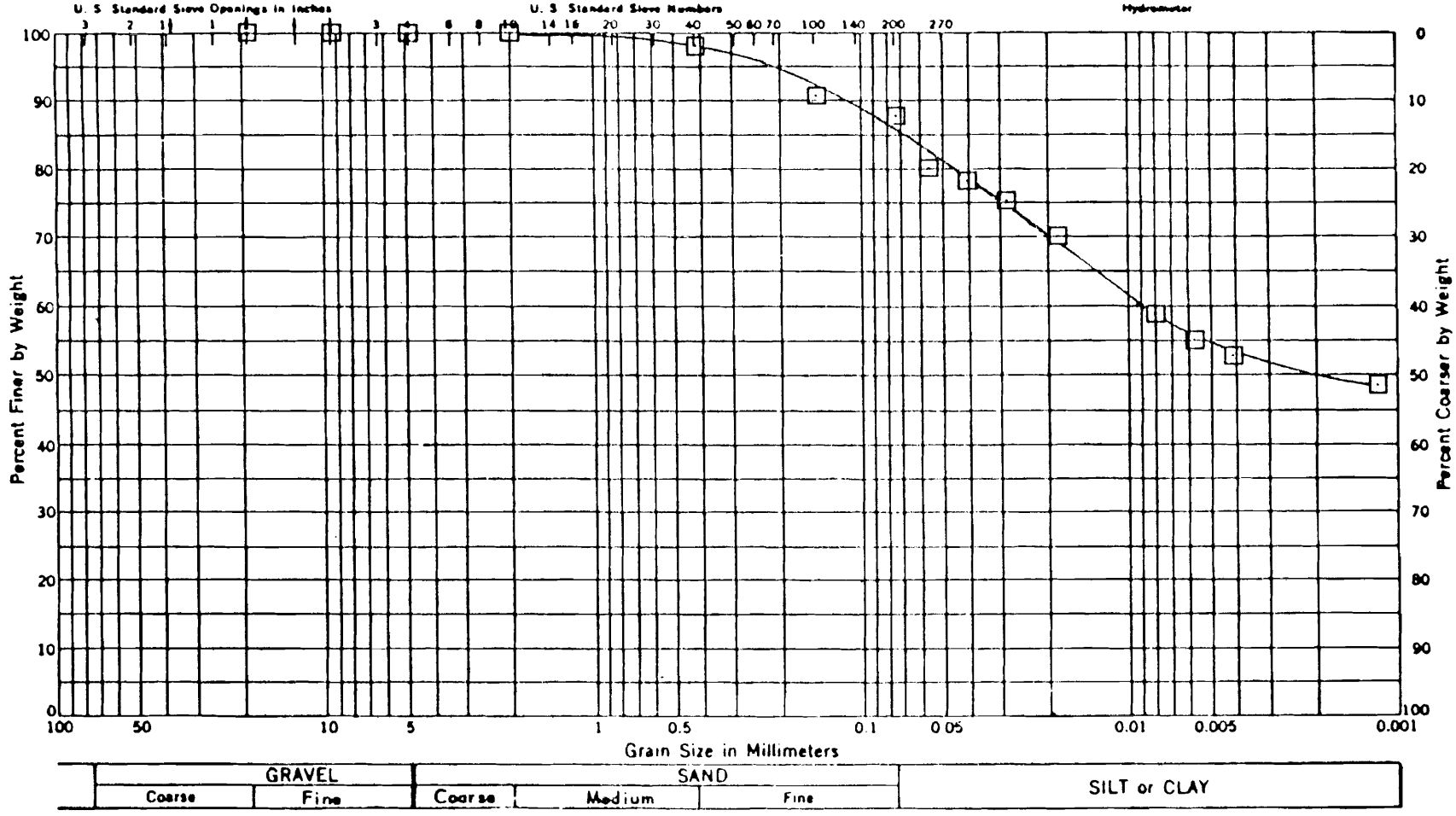
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 10 SAMPLE 4

DEPTH 18 - 20 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.H.	01/21/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
5		52	25	27	
					UNIFIED CLASSIFICATION (CH)

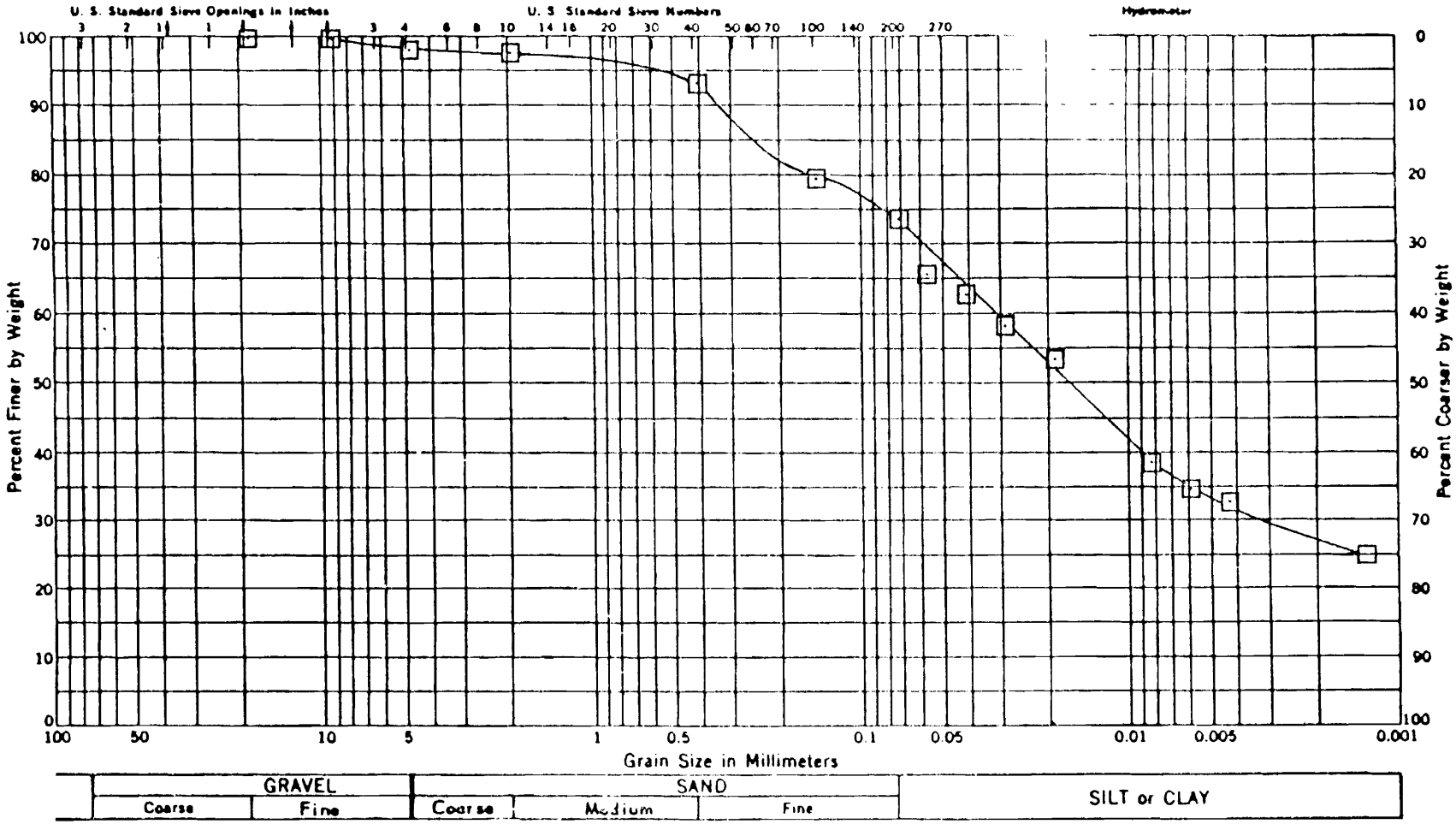
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 10 SAMPLE 5
DEPTH 23 - 25 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	02/05/81	680874

228



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		39	17	22	
					UNIFIED CLASSIFICATION (CL)

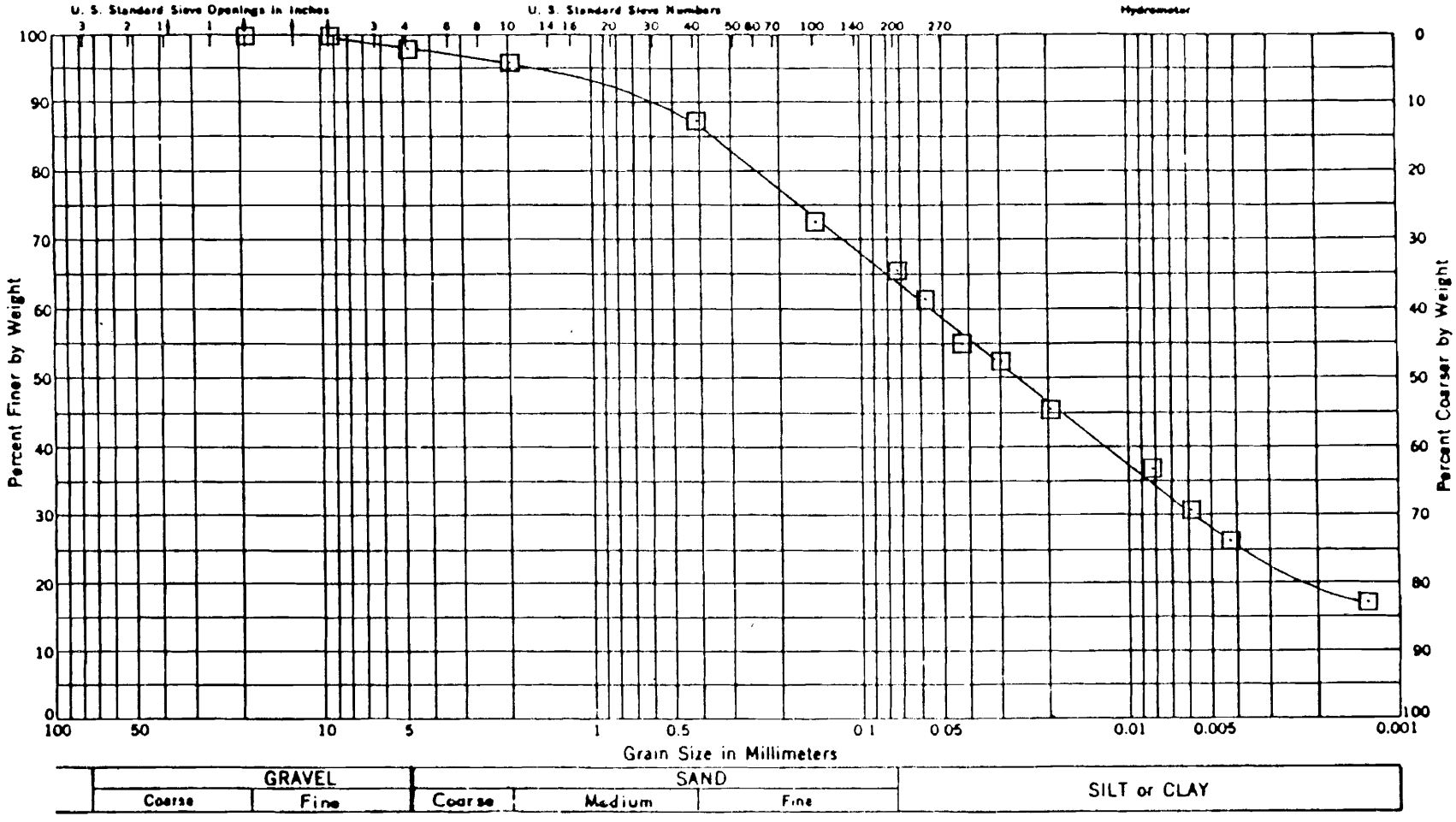
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 11 SAMPLE 3
DEPTH 13 - 15 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/19/81	680874

229



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
4		31	15	16	
					UNIFIED CLASSIFICATION (CL)

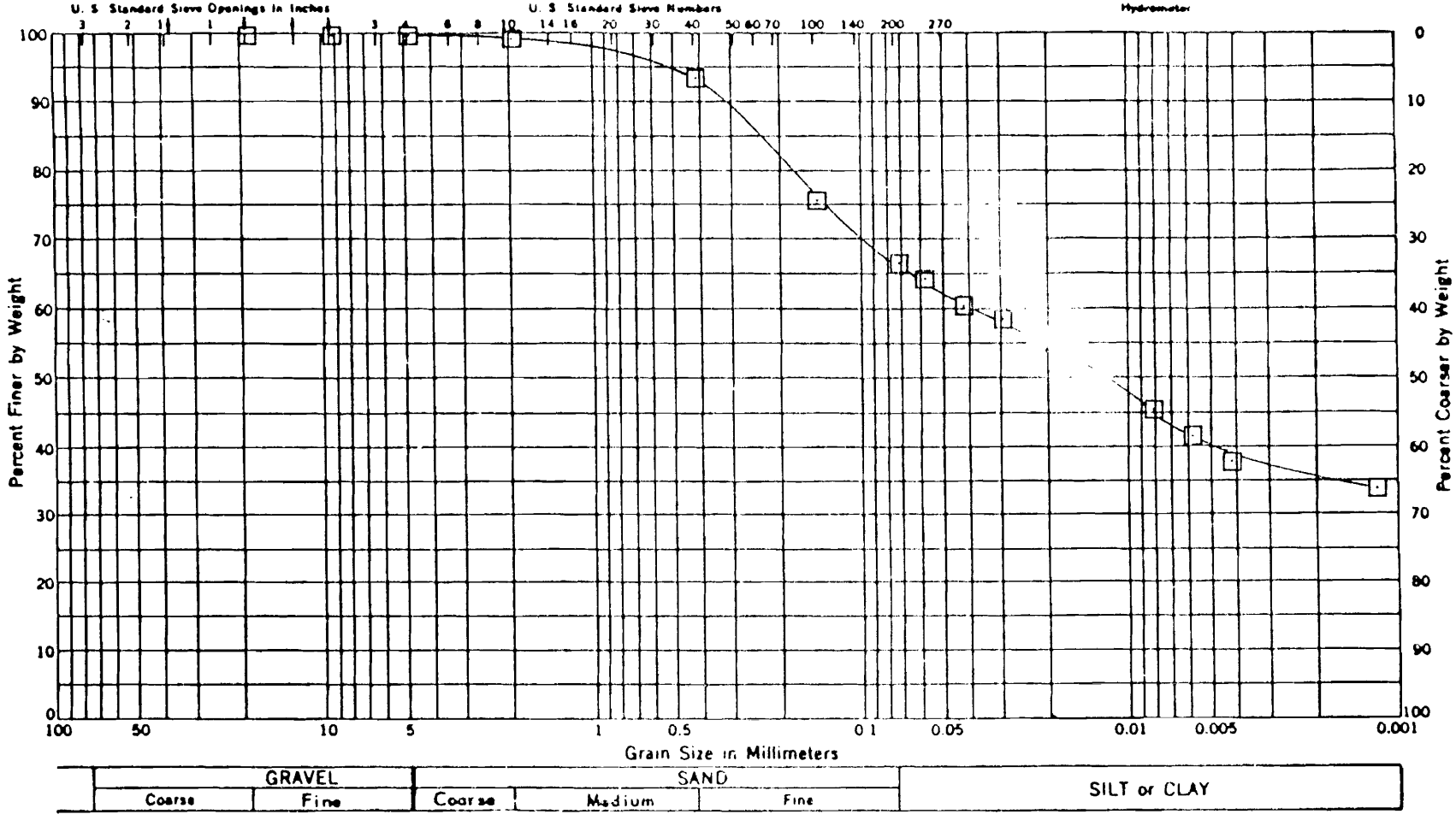
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 11 SAMPLE 4
DEPTH 18 - 20 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/21/81	680874

230



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
6		42	16	26	
					UNIFIED CLASSIFICATION (CL)

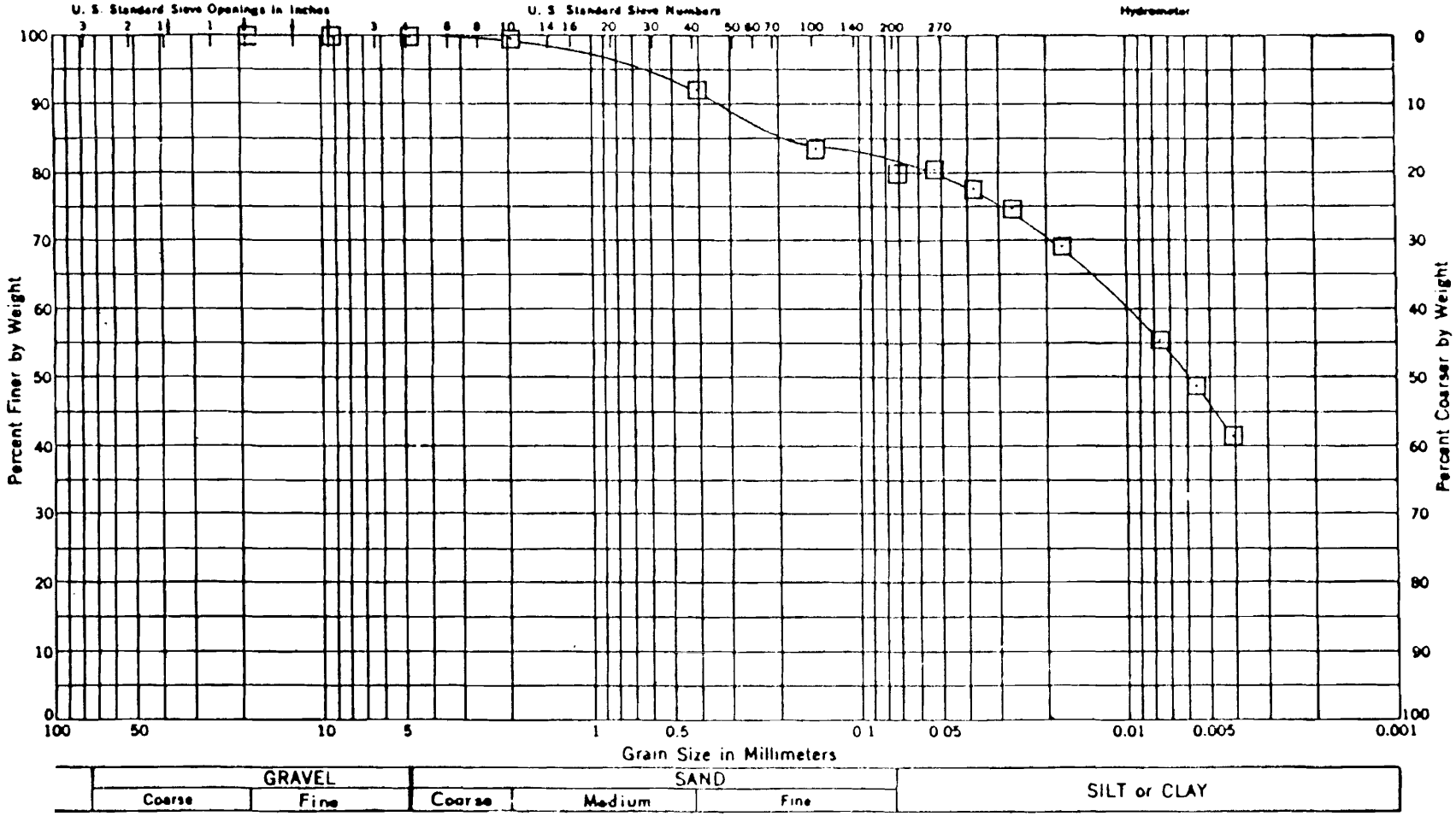
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 11 SAMPLE 6

DEPTH 28 - 30 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/19/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		43	16	27	
					UNIFIED CLASSIFICATION (CL)

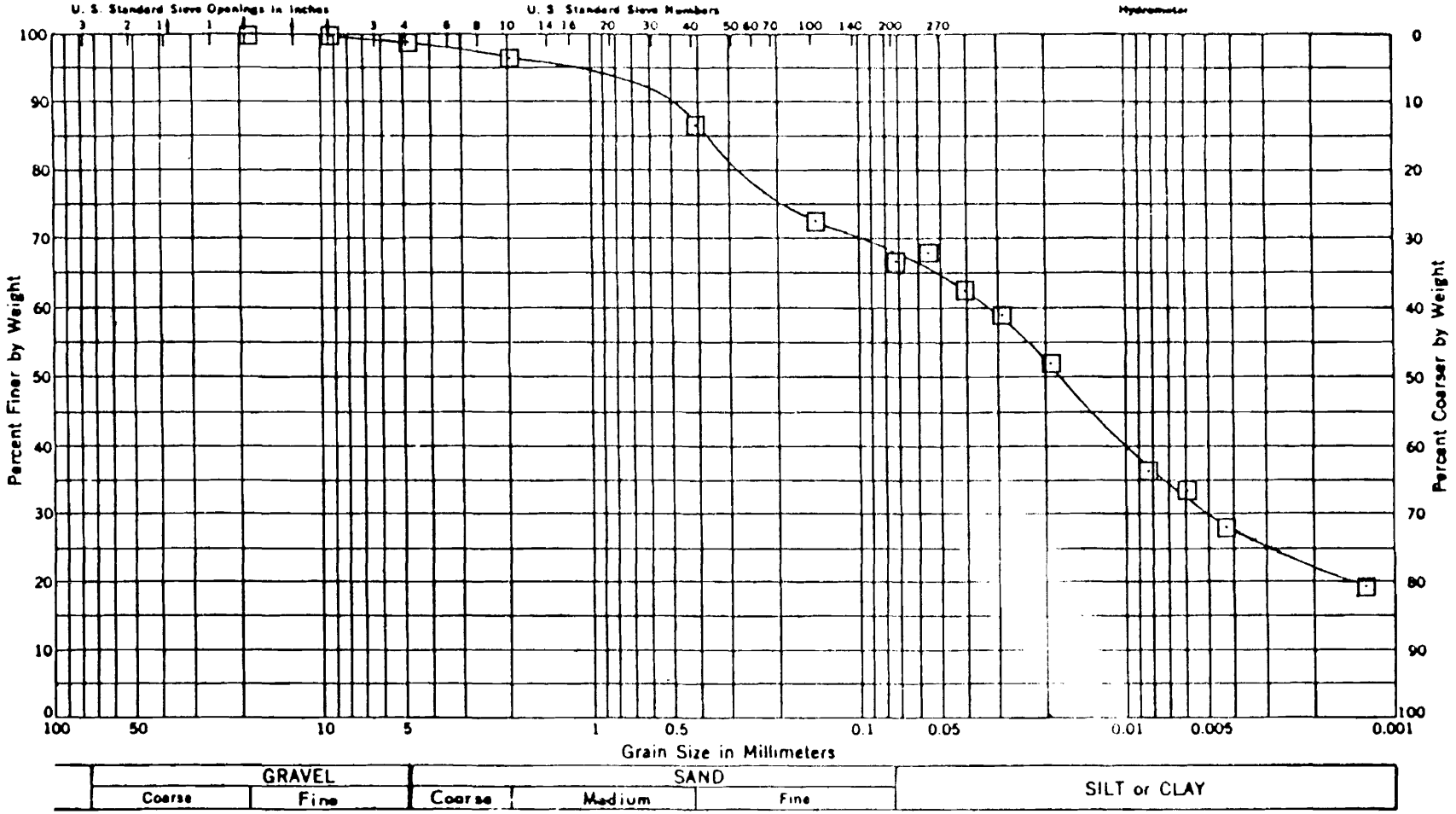
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 12 SAMPLE 2
DEPTH 9 - 11 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/19/81	680874

232



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
4		30	16	14	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

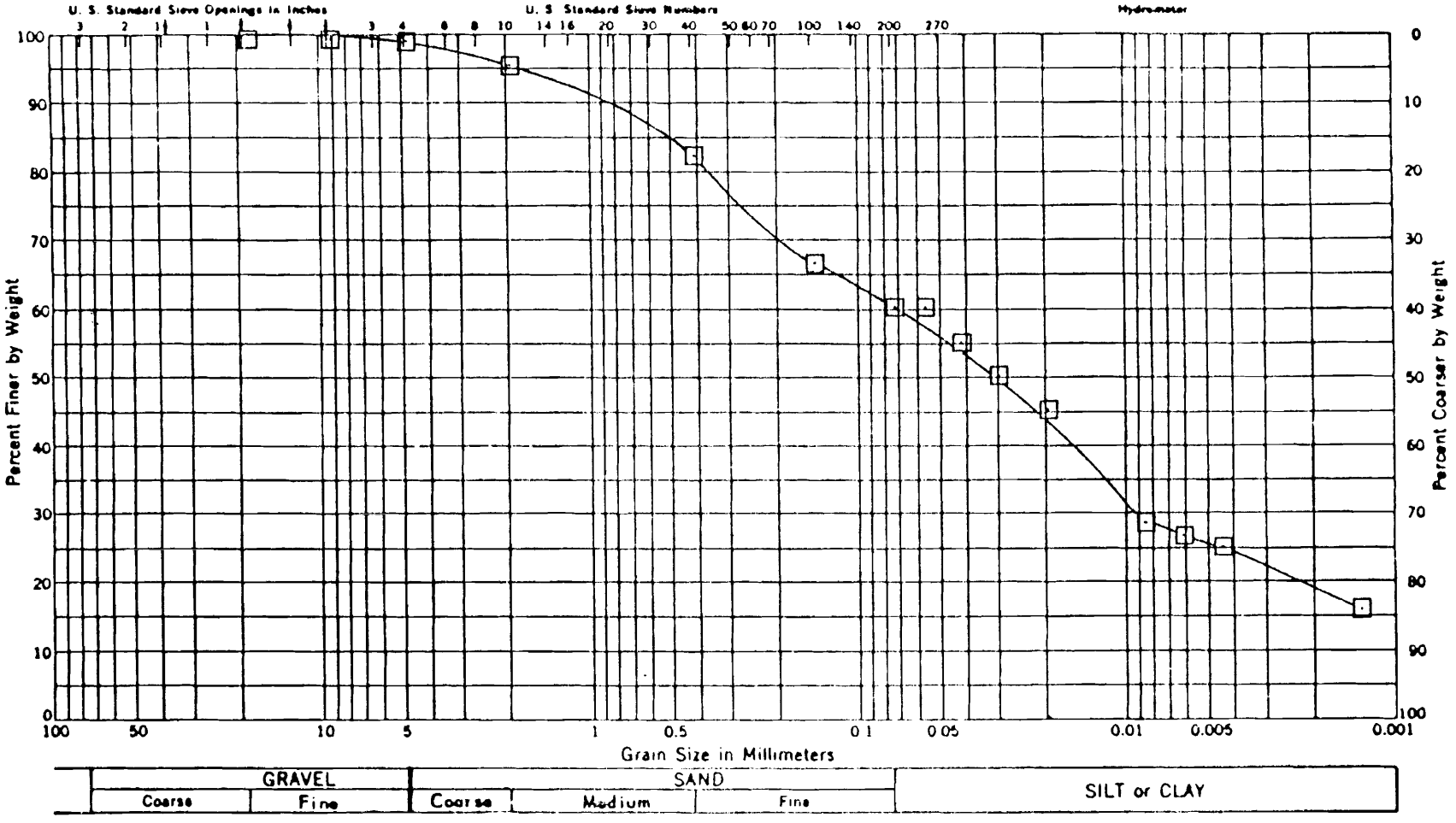
BORING 12 SAMPLE 4

DEPTH 19 - 21 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JEH	01/19/81	680874

253



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
5		30	15	15	
					UNIFIED CLASSIFICATION (CL)

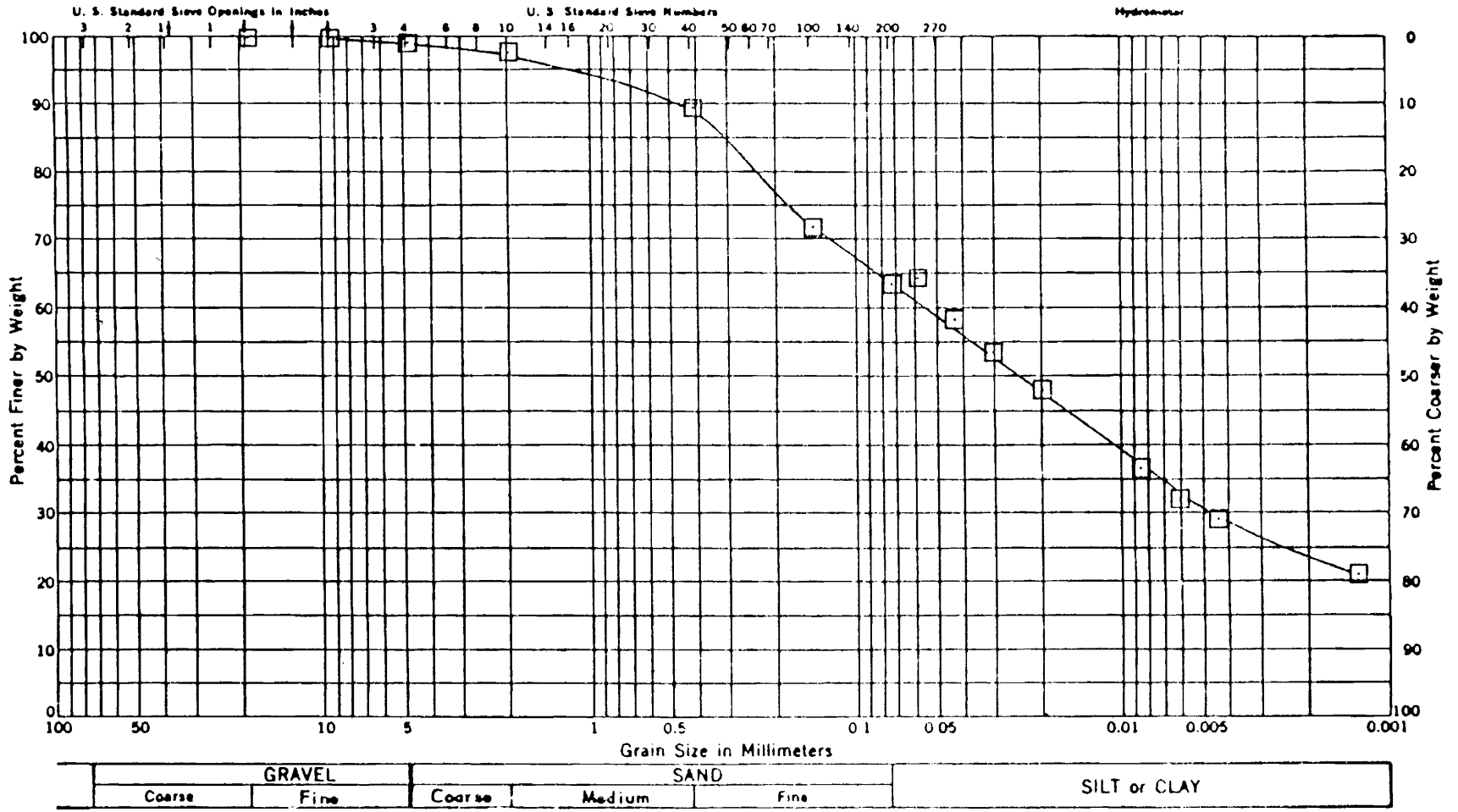
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 12 SAMPLE 5

DEPTH 24 - 26 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/19/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		30	13	17	
					UNIFIED CLASSIFICATION (CL)

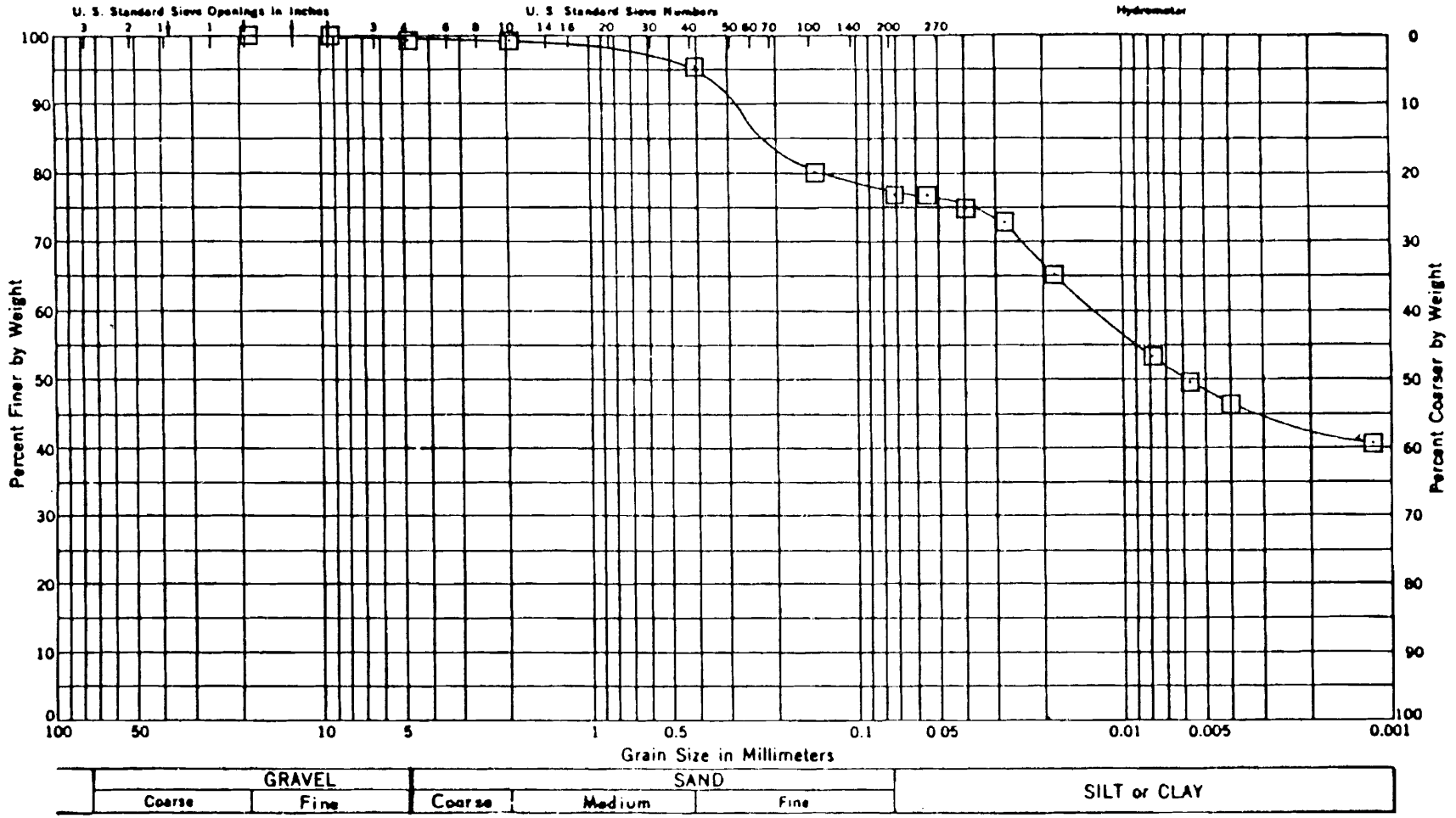
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 13 SAMPLE 2
DEPTH 9 - 11 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JBL	01/19/81	680874

235



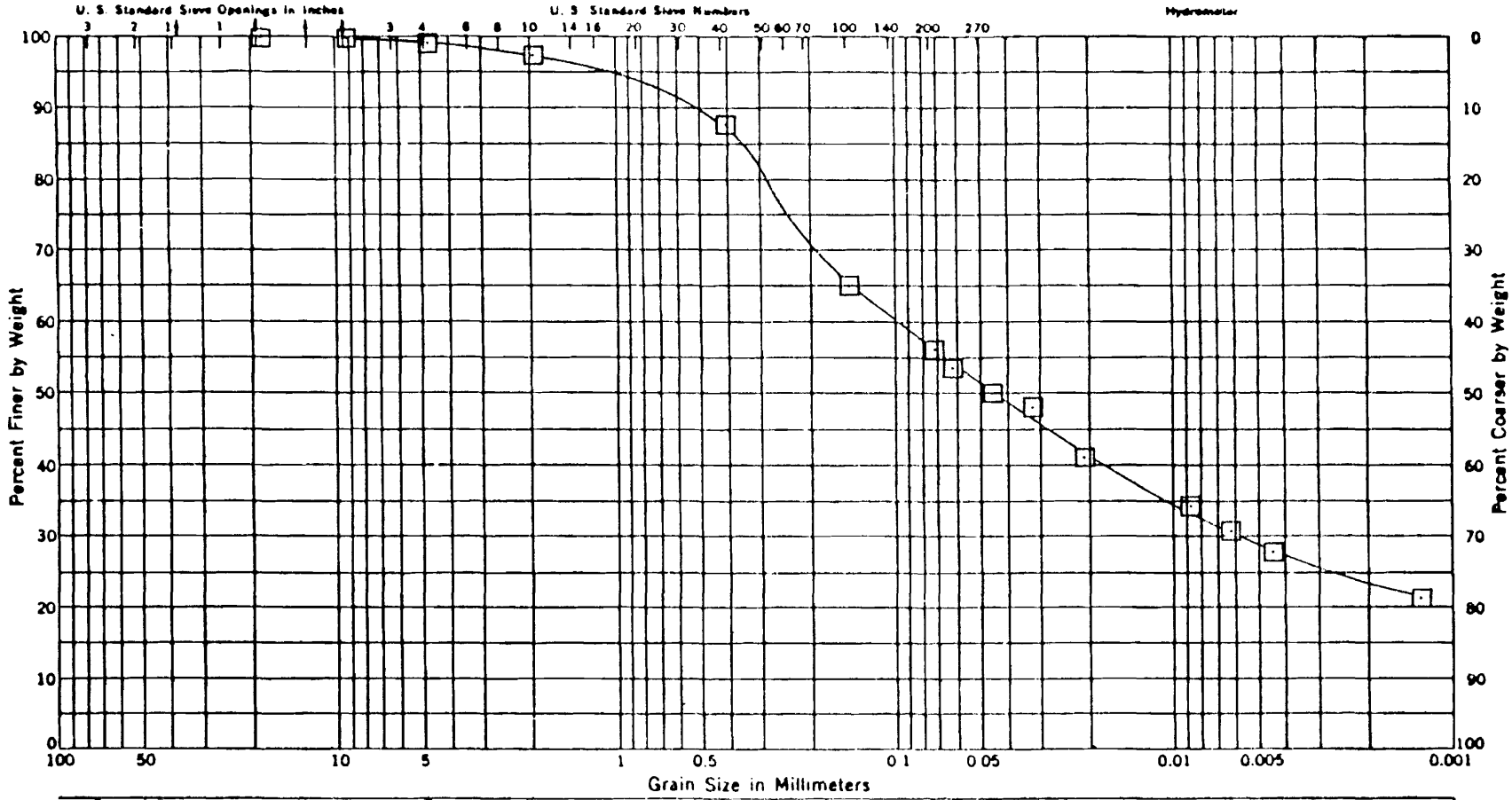
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		52	16	36	
					UNIFIED CLASSIFICATION (CH)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 13 SAMPLE 3
DEPTH 14 - 16 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JEH.	01/19/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
6		28	13	15	
					UNIFIED CLASSIFICATION (CL)

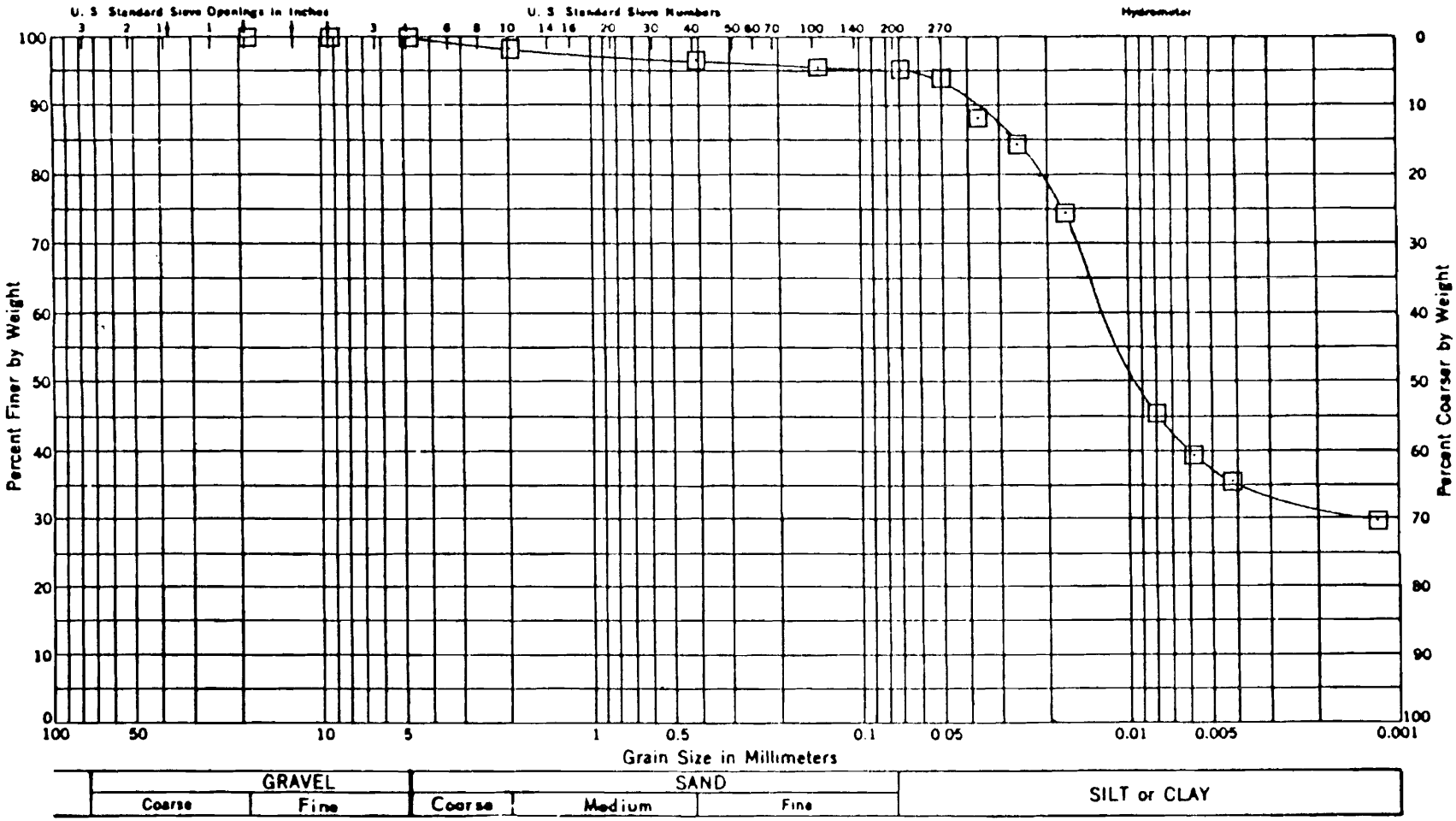
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 13 SAMPLE 6

DEPTH 28 - 30 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFL	01/19/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		54	21	33	
					UNIFIED CLASSIFICATION (CH)

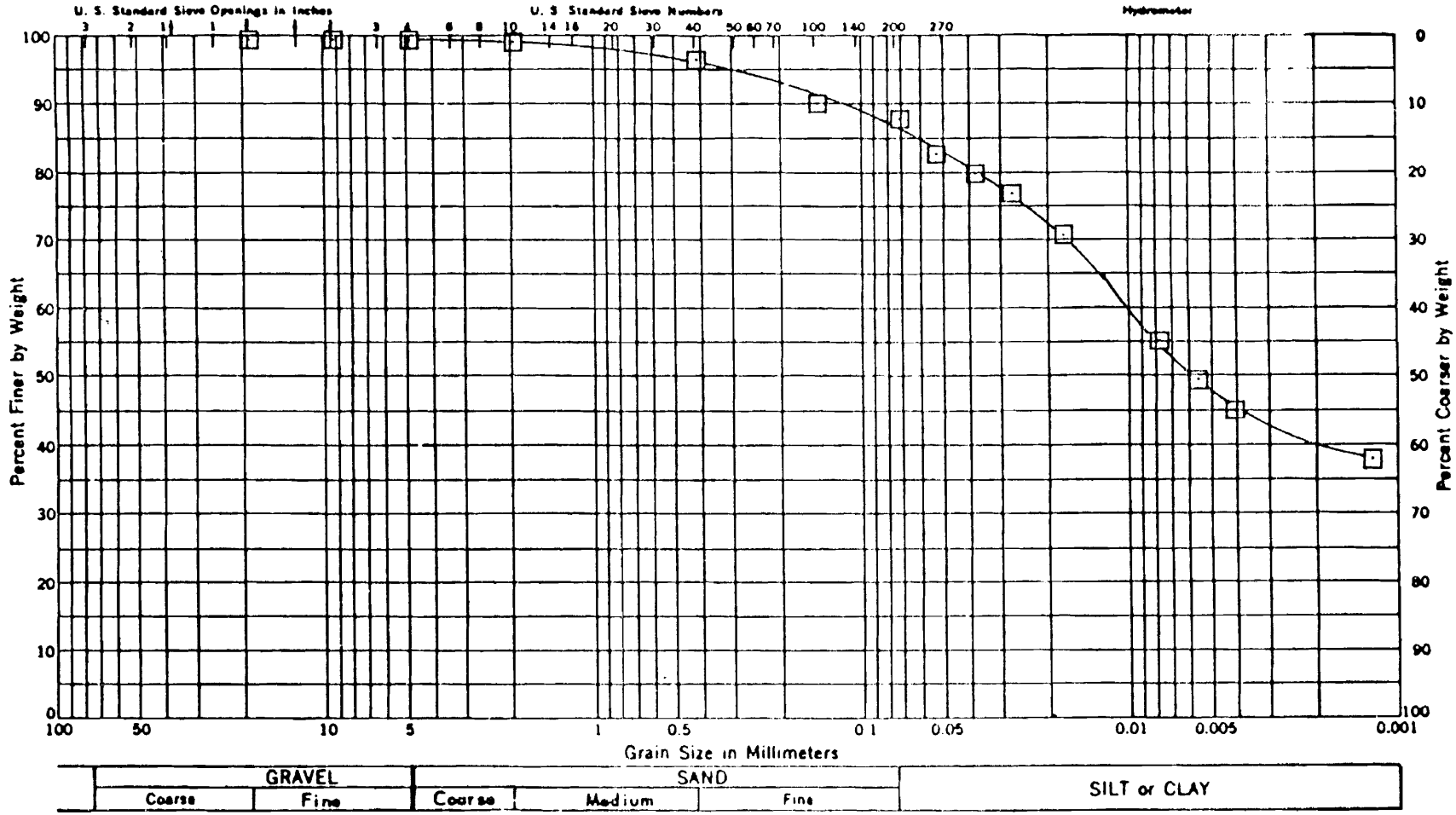
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 14 SAMPLE 1
DEPTH 2 - 4 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/19/81	680874

238



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		47	18	29	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

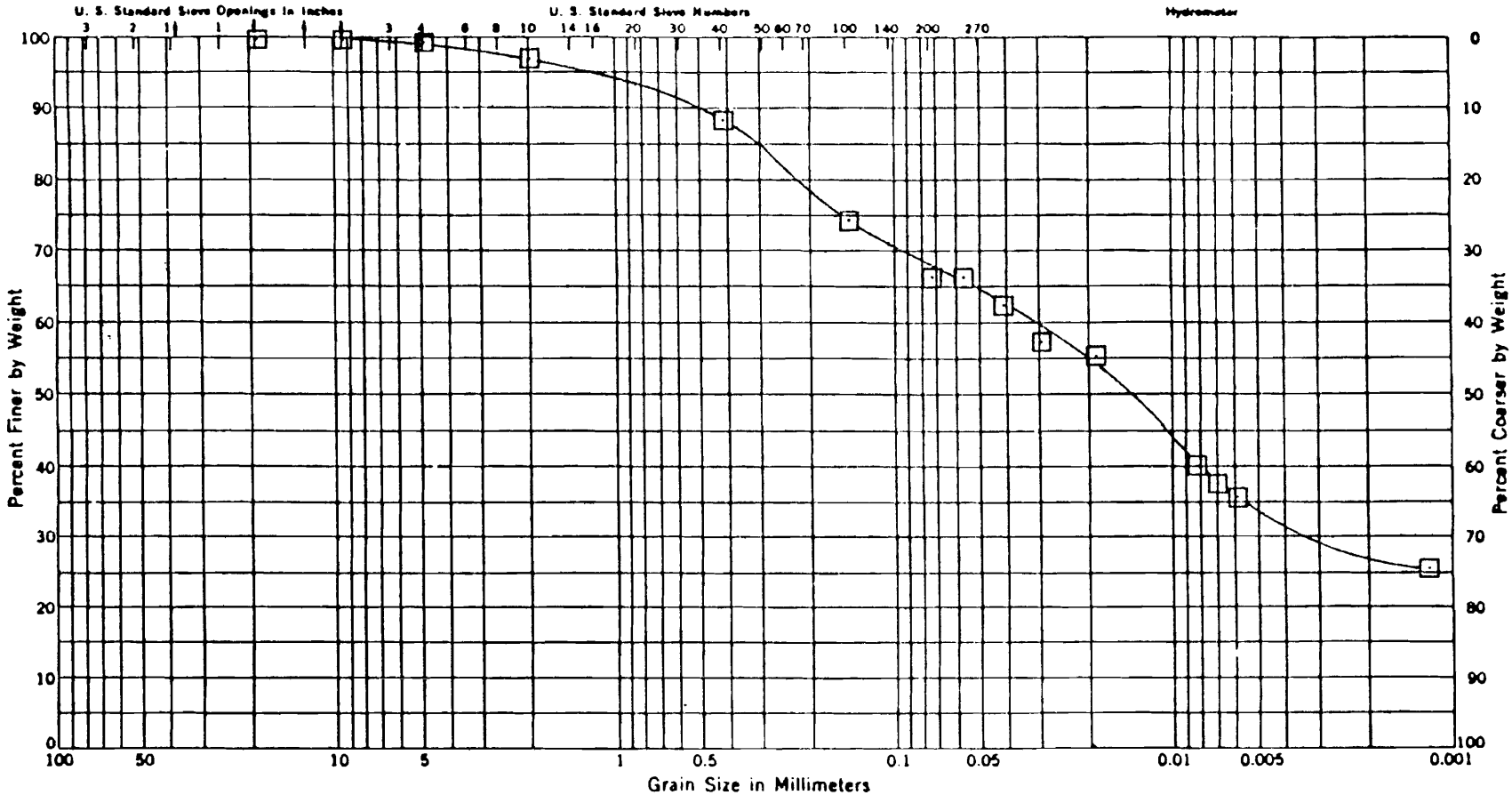
BORING 14 SAMPLE 2

DEPTH 7 - 9 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/19/81	880874

239



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
4		47	14	33	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

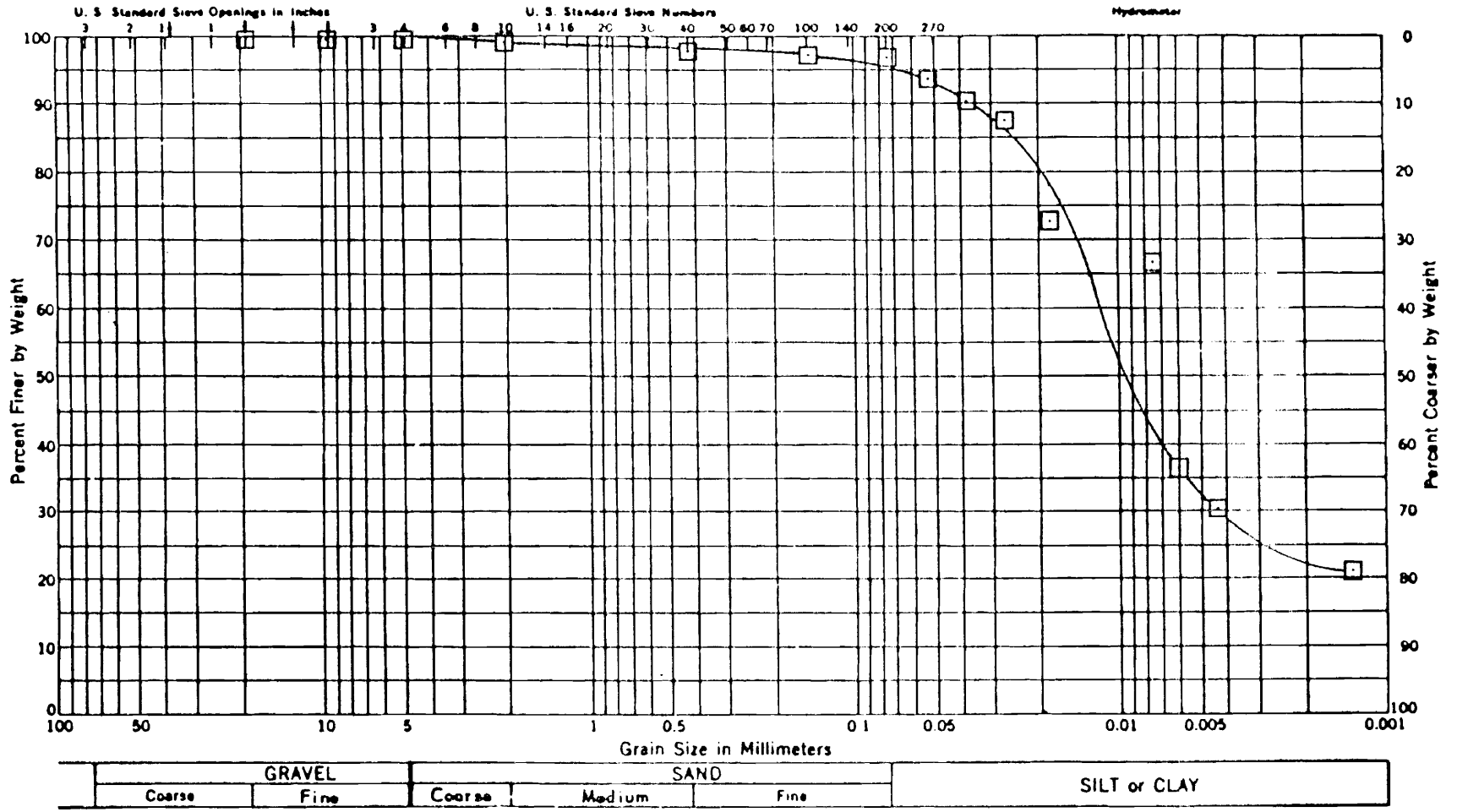
BORING 14 SAMPLE 4

DEPTH 17 - 19 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/19/81	680874

296



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		41	19	22	
					UNIFIED CLASSIFICATION (CL)

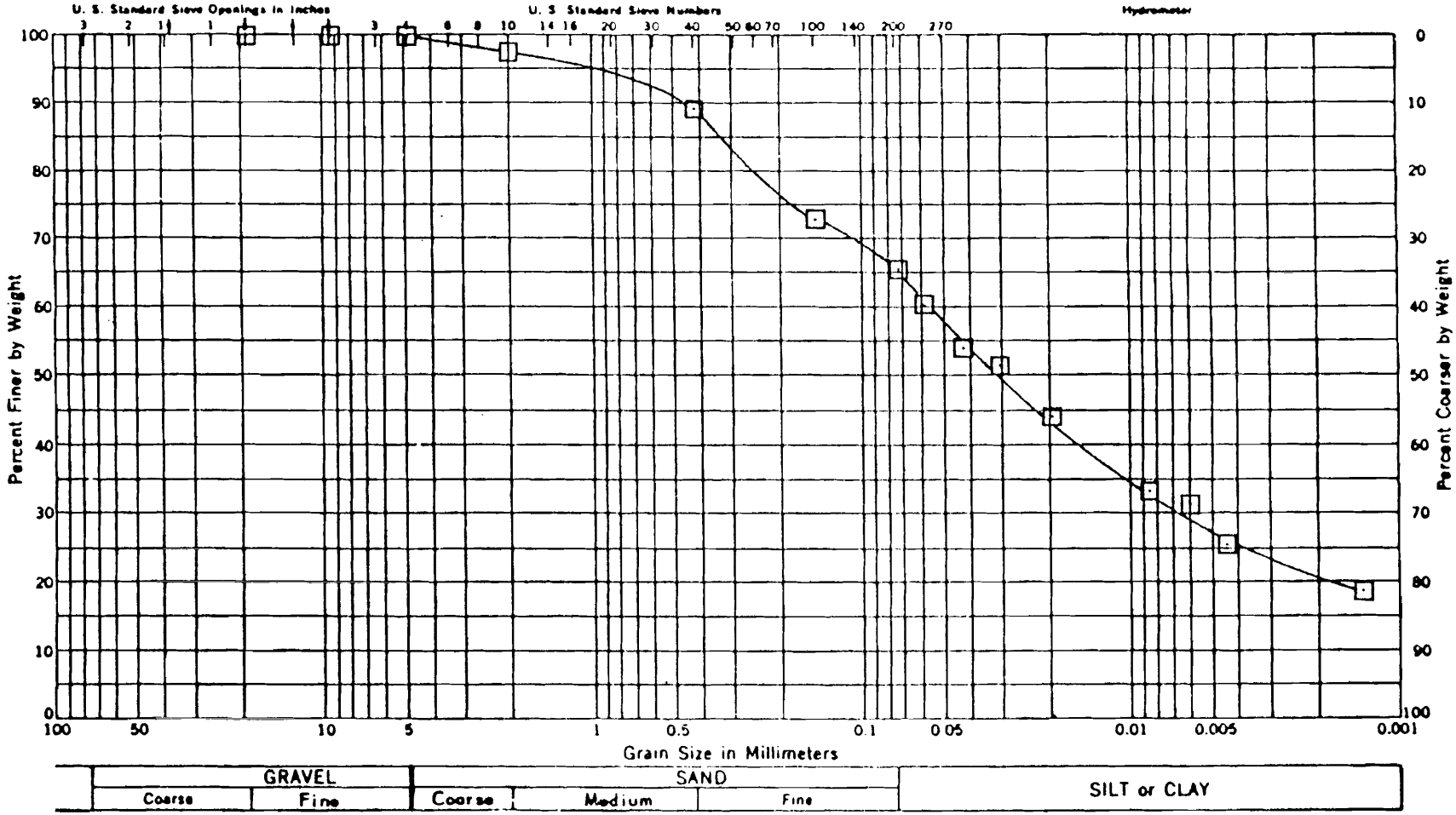
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 15 SAMPLE 2
DEPTH 7 - 9 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/20/81	680874

241



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
4		36	15	21	
					UNIFIED CLASSIFICATION (CL)

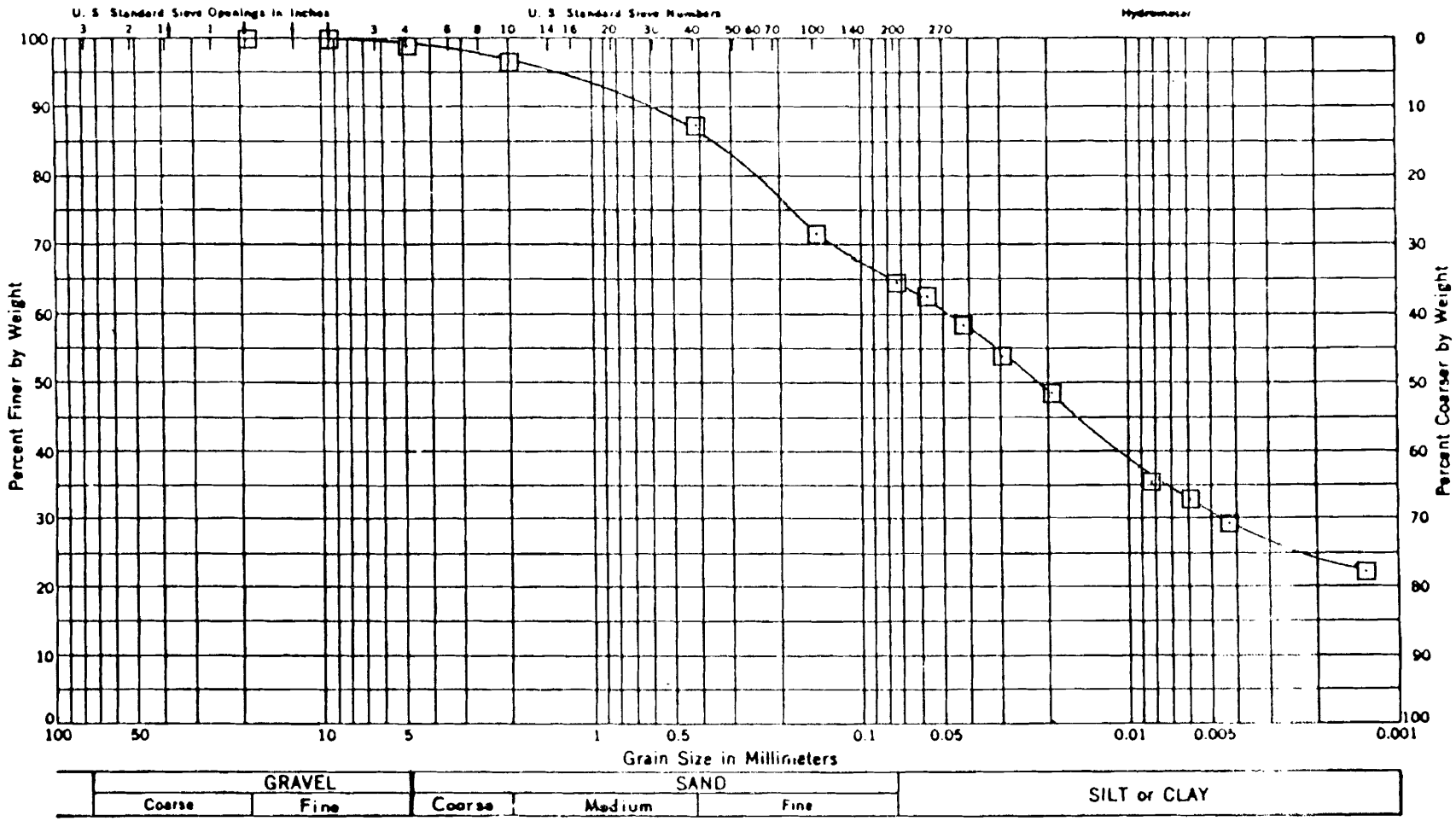
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 15 SAMPLE 4
DEPTH 17 - 19 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/20/81	680874

242



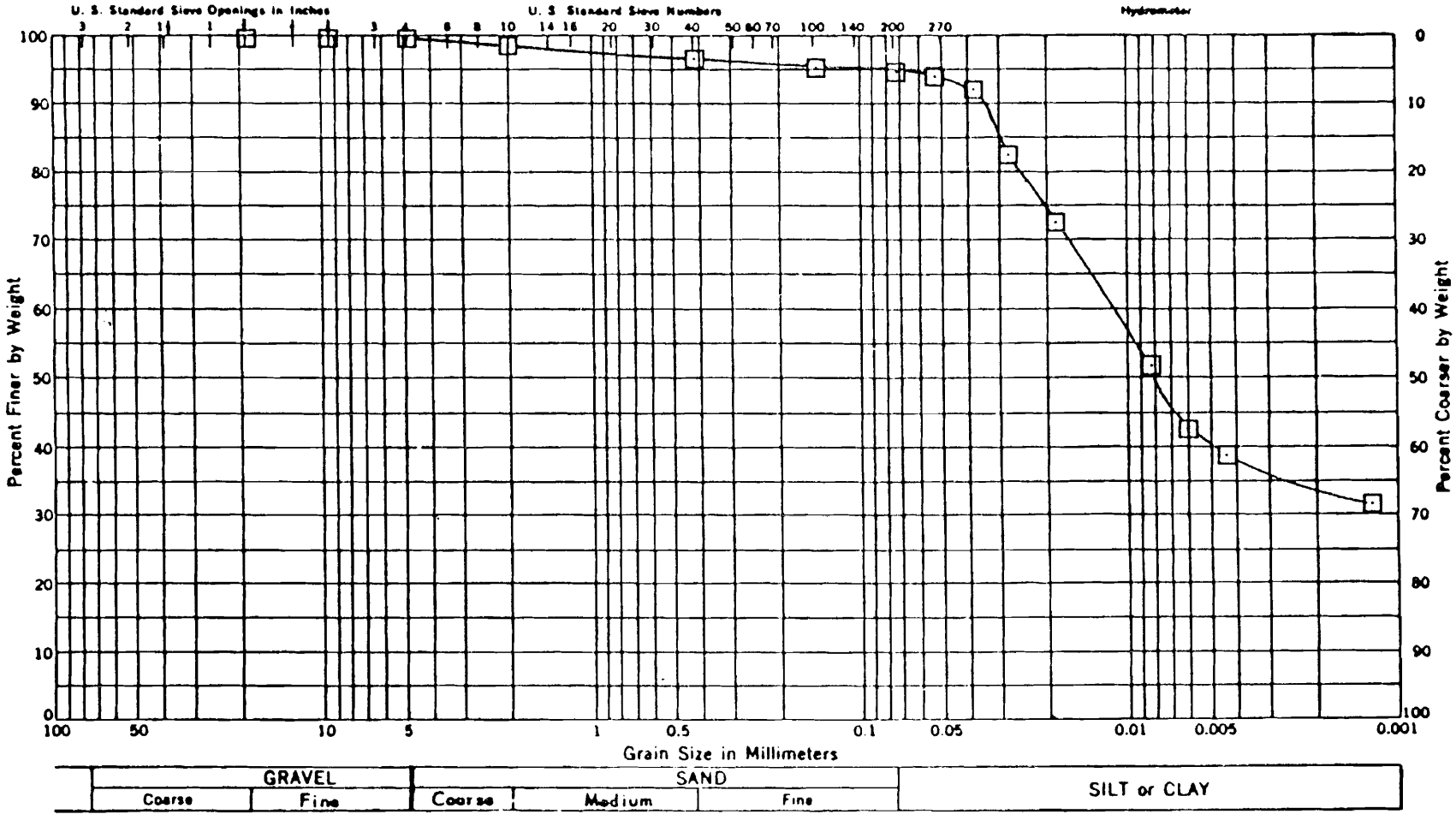
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
6		30	15	15	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 15 SAMPLE 6
DEPTH 28 - 30 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/20/81	680874



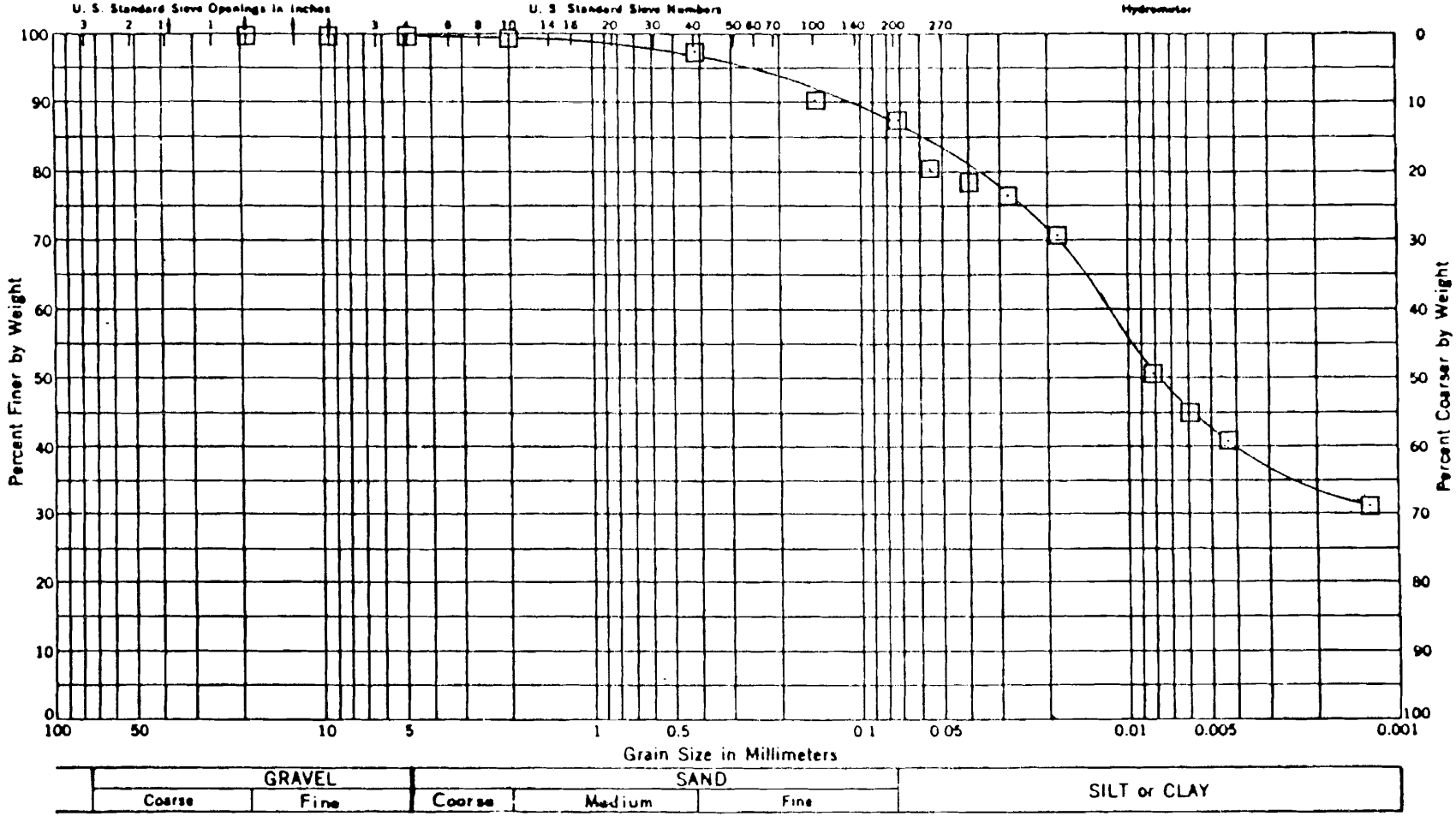
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		59	24	35	
					UNIFIED CLASSIFICATION (CH)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 16 SAMPLE 1
DEPTH 2 - 4 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/20/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		48	15	33	
					UNIFIED CLASSIFICATION (CL)

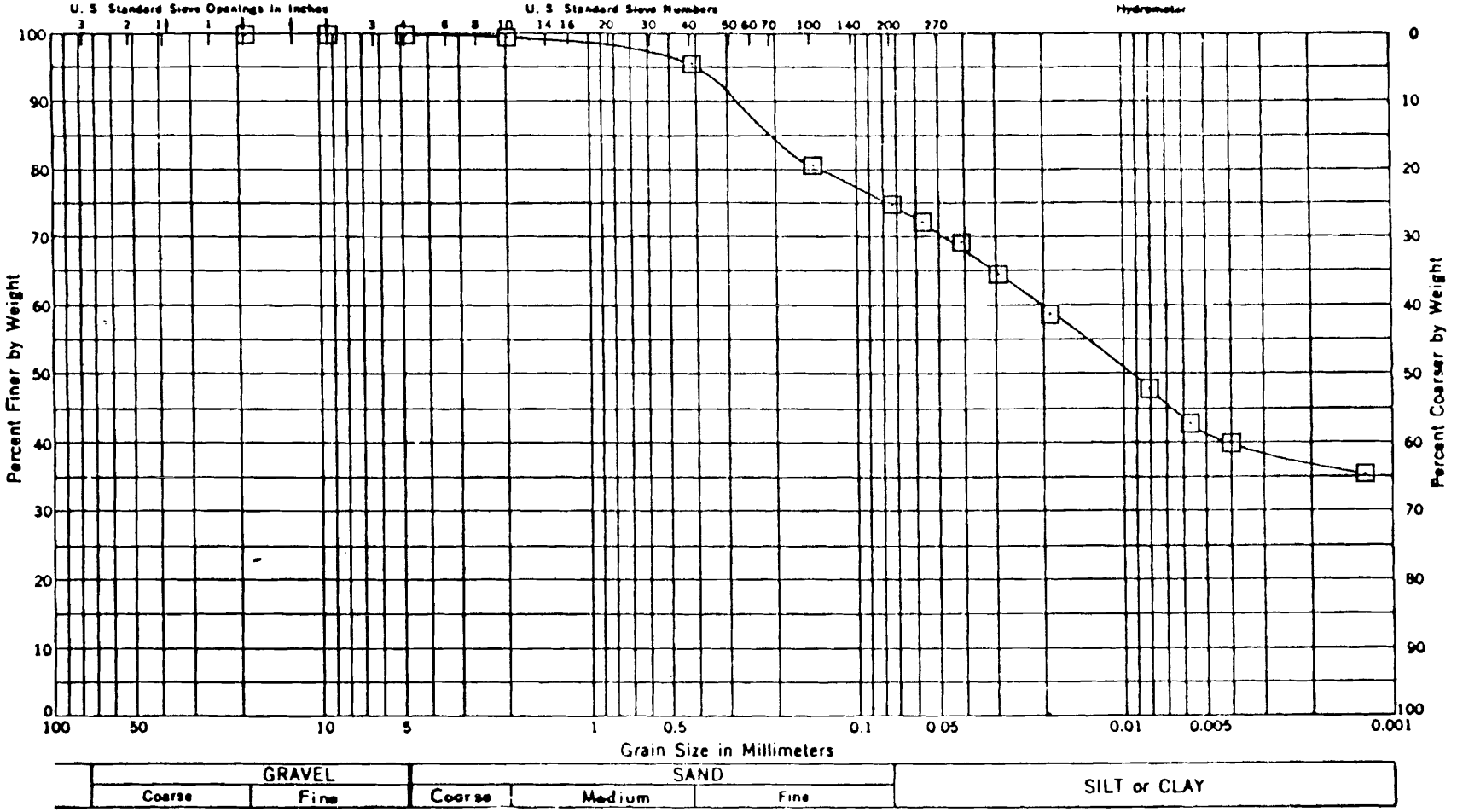
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 16 SAMPLE 2
DEPTH 7 - 8 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/20/81	680874

245



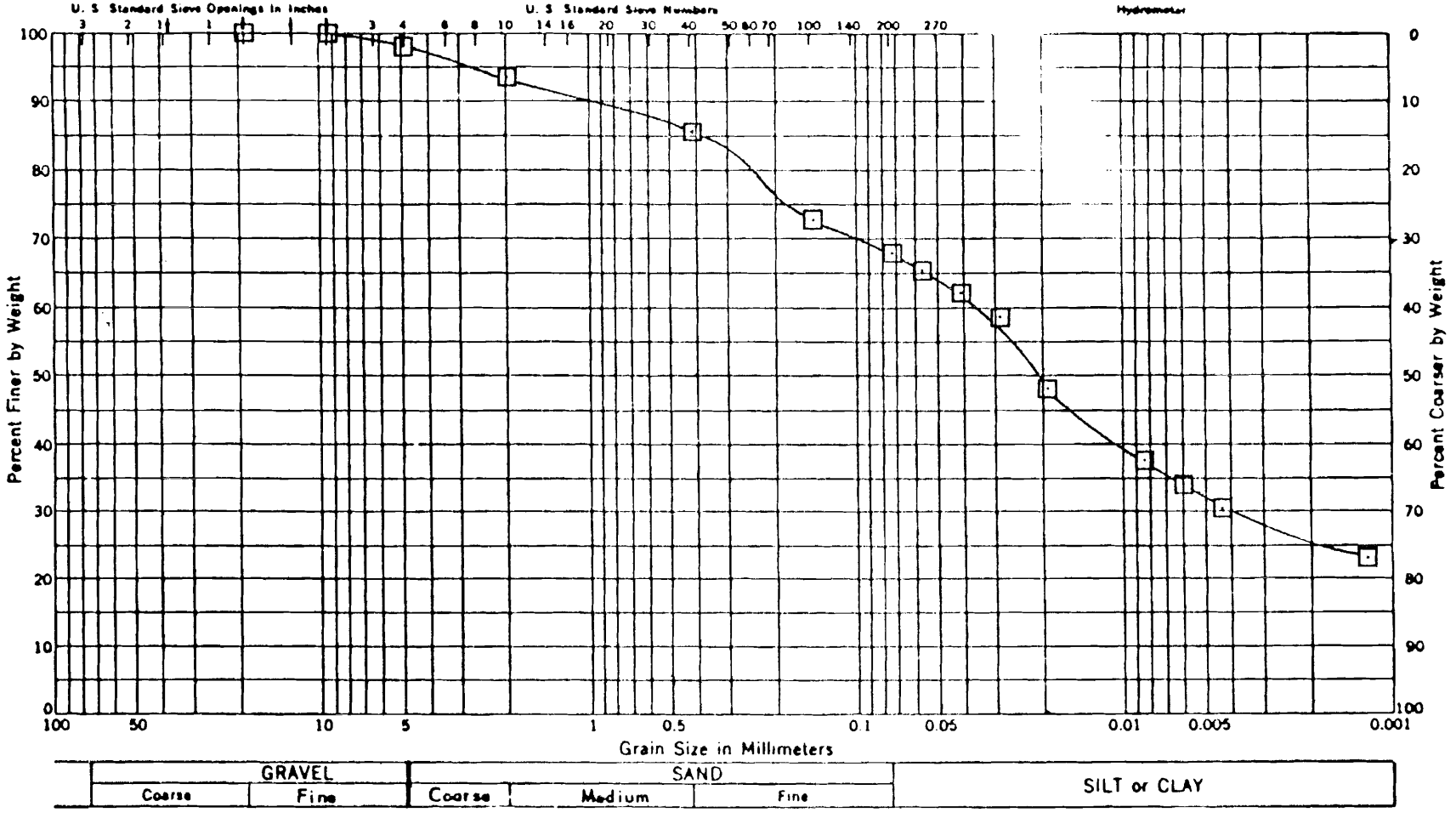
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
5		50	14	36	
					UNIFIED CLASSIFICATION (CH)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 16 SAMPLE 5
DEPTH 22 - 24 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/20/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
3		36	17	19	
					UNIFIED CLASSIFICATION (CL)

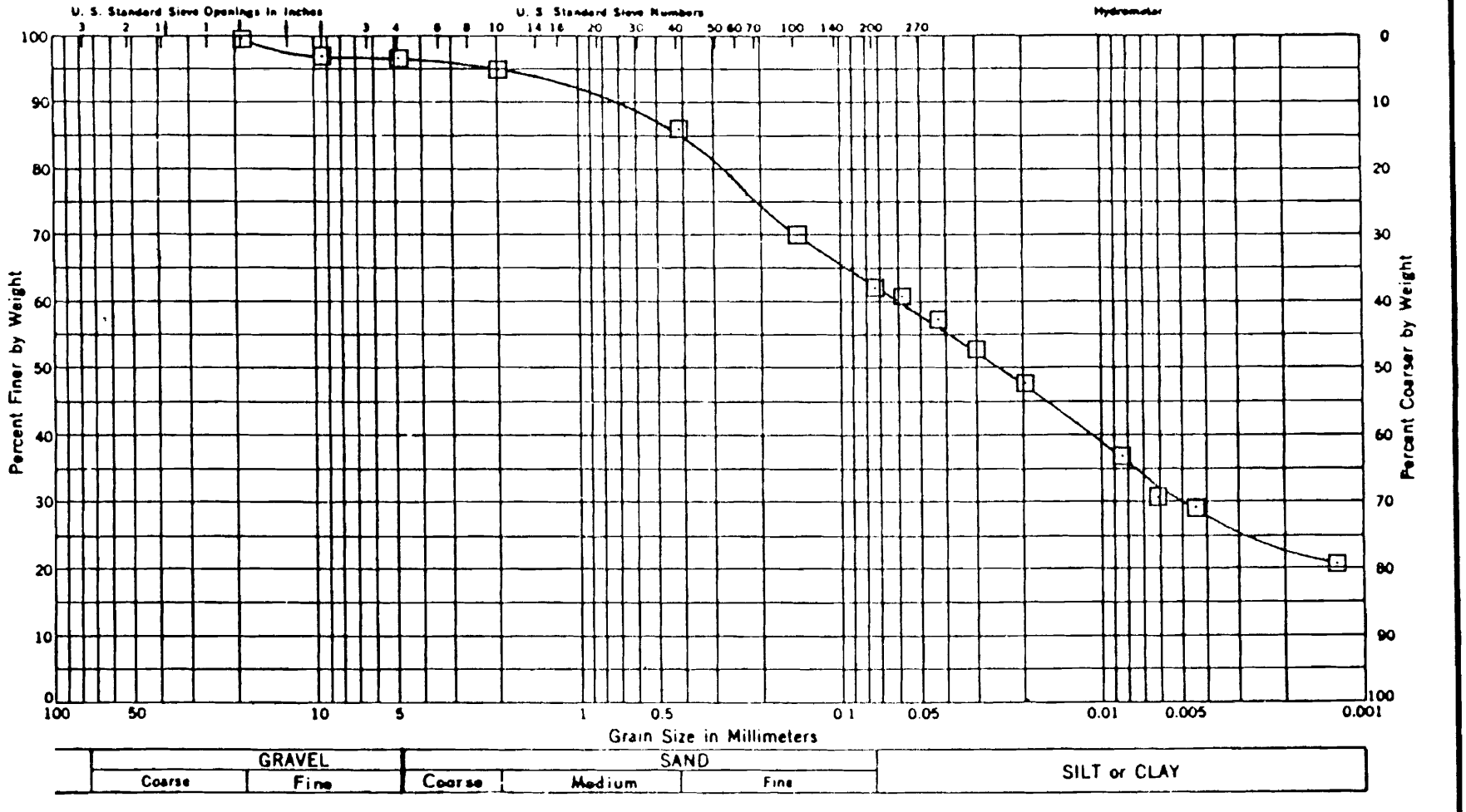
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 17 SAMPLE 3
DEPTH 12 - 14 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JPH	01/20/81	680874

247



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
4		26	15	11	
					UNIFIED CLASSIFICATION (CL)

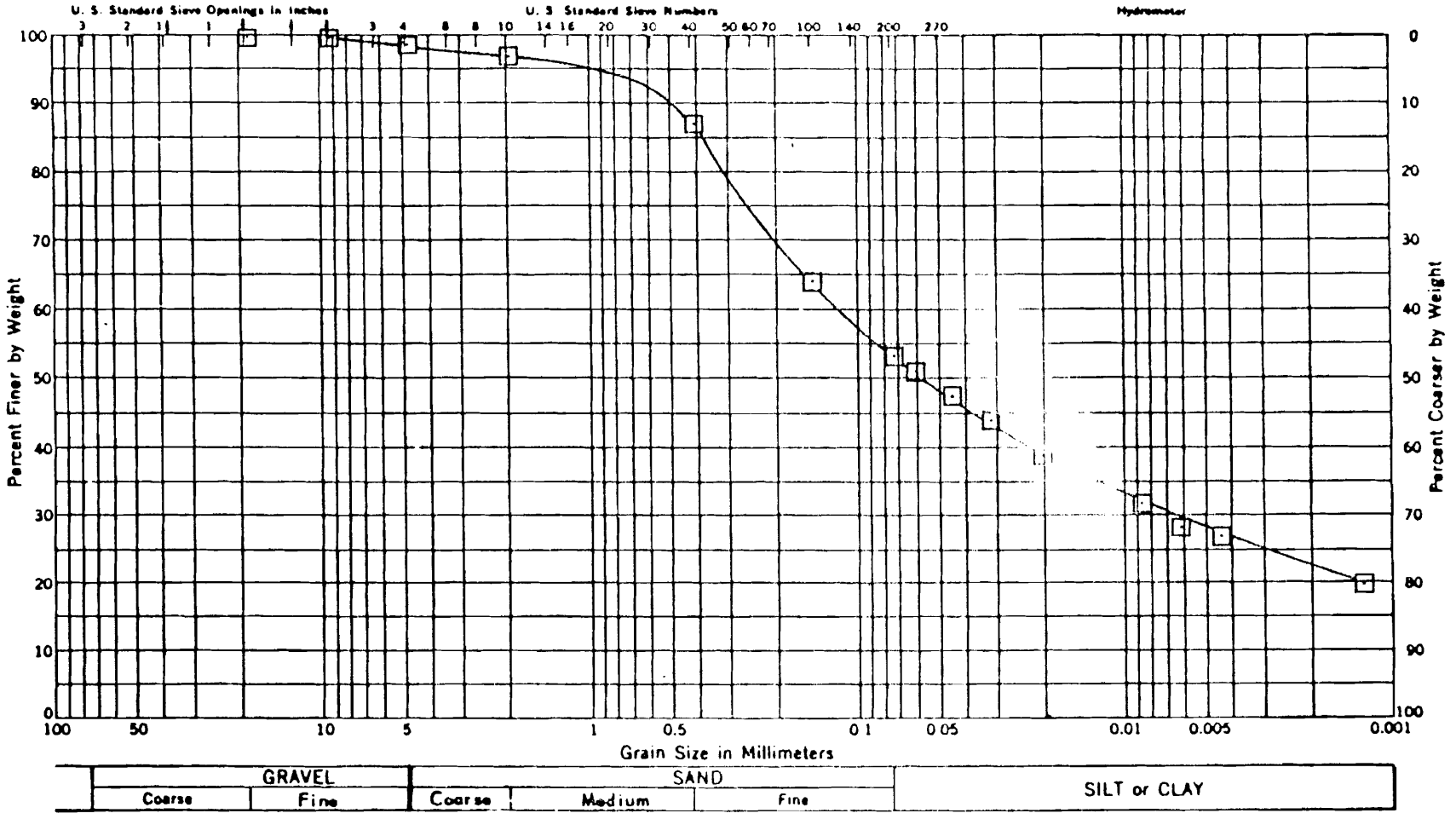
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 17 SAMPLE 4

DEPTH 17 - 19 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/20/81	680874



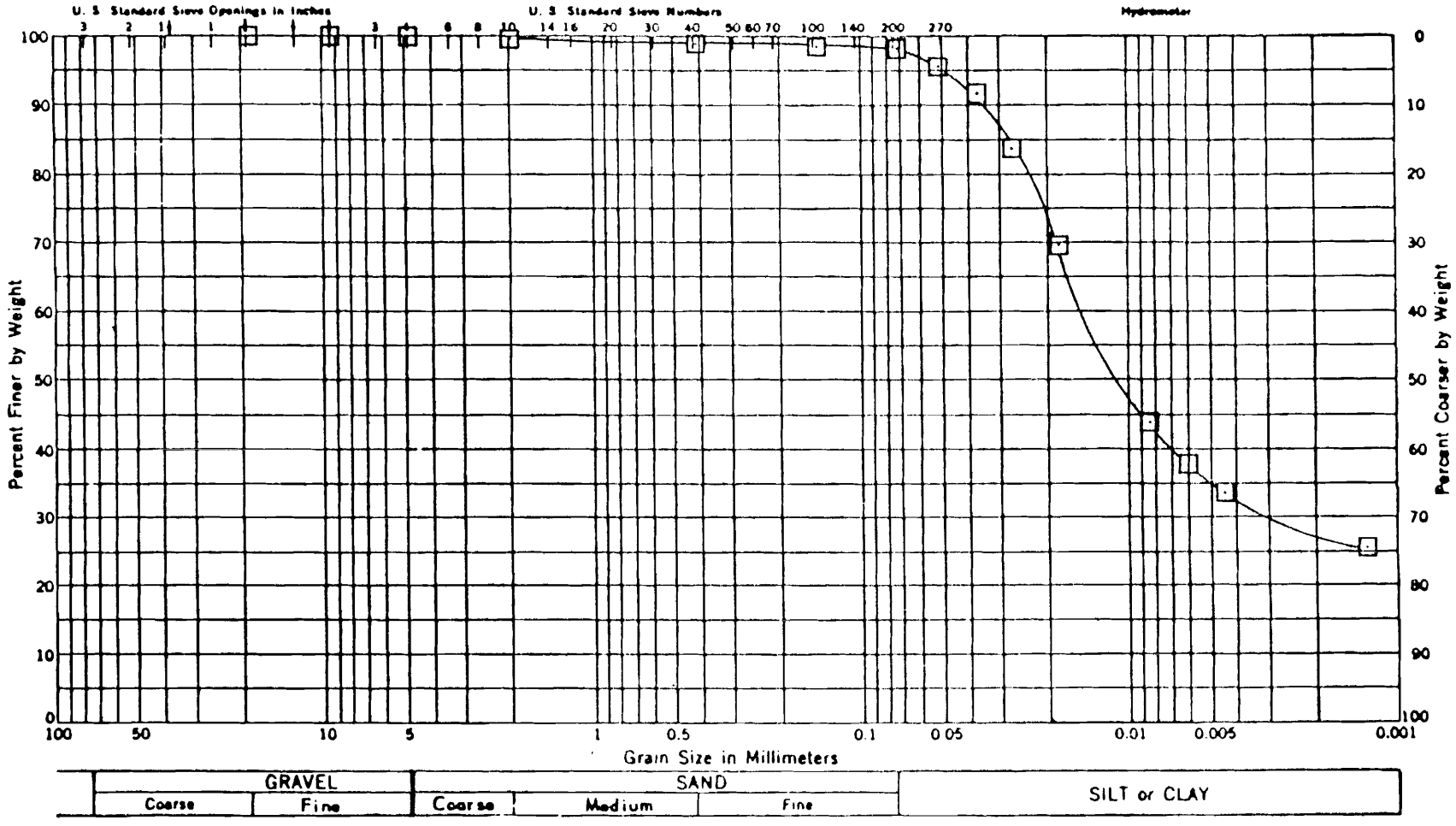
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
6		27	13	14	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 17 SAMPLE 6
DEPTH 28 - 30 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/20/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
1		44	21	23	
					UNIFIED CLASSIFICATION (CL)

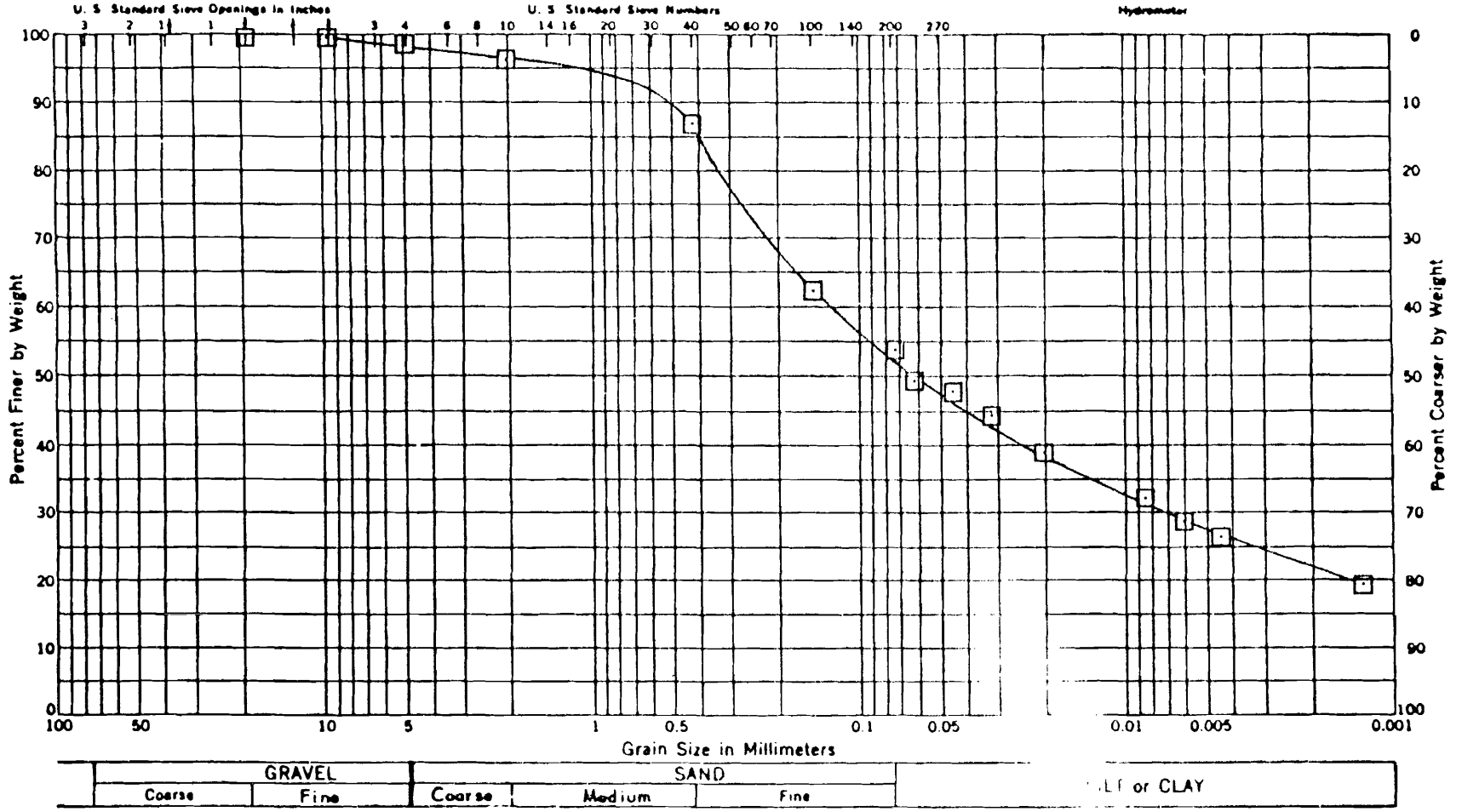
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 18 SAMPLE 1
DEPTH 4 - 6 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/20/81	680874

250



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
7		25	12	13	
					UNIFIED CLASSIFICATION (CL)

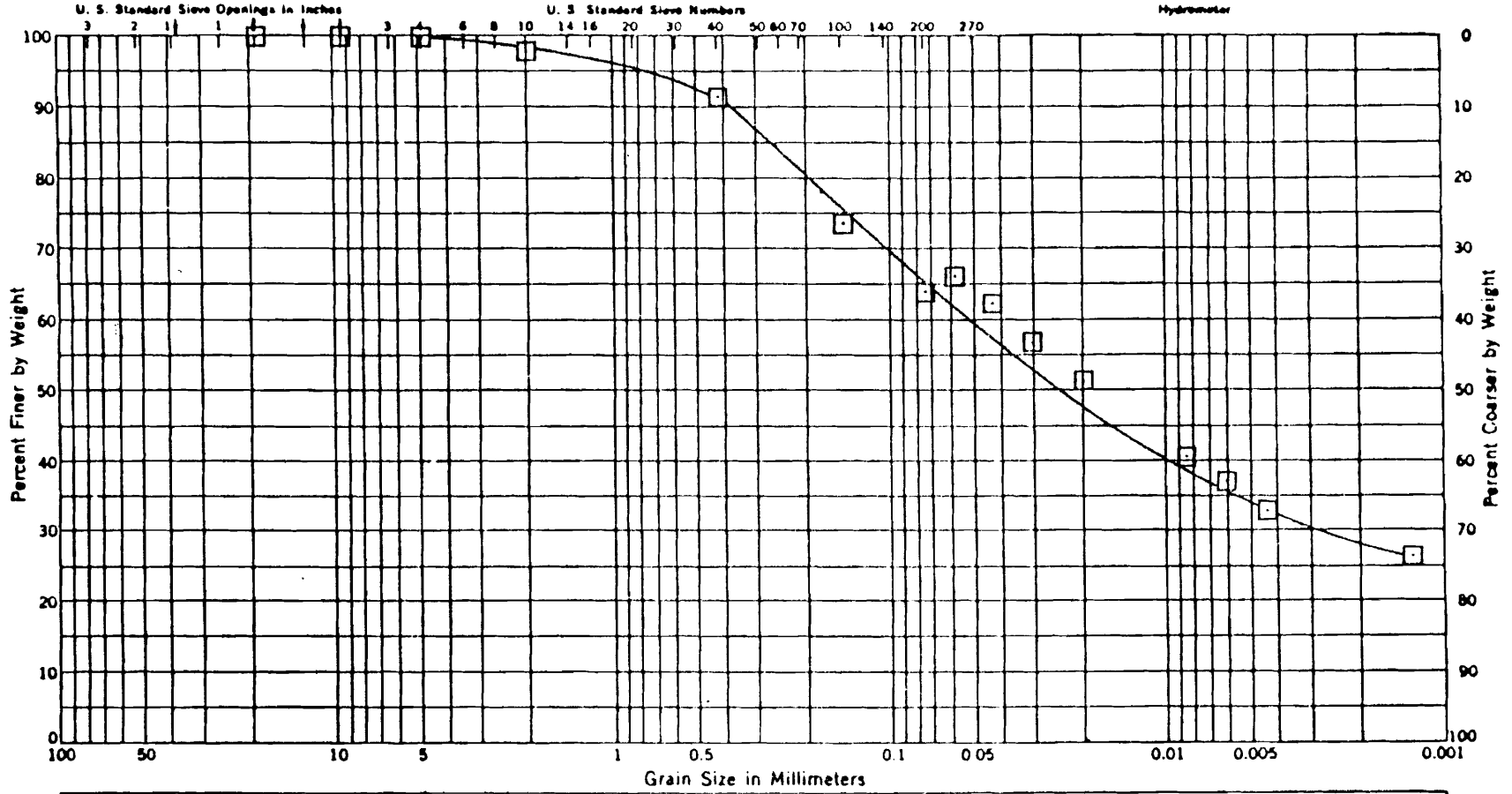
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 18 SAMPLE 7
DEPTH 34 - 36 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH.	01/20/81	680874

1st



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
9		32	12	20	
					UNIFIED CLASSIFICATION (CL)

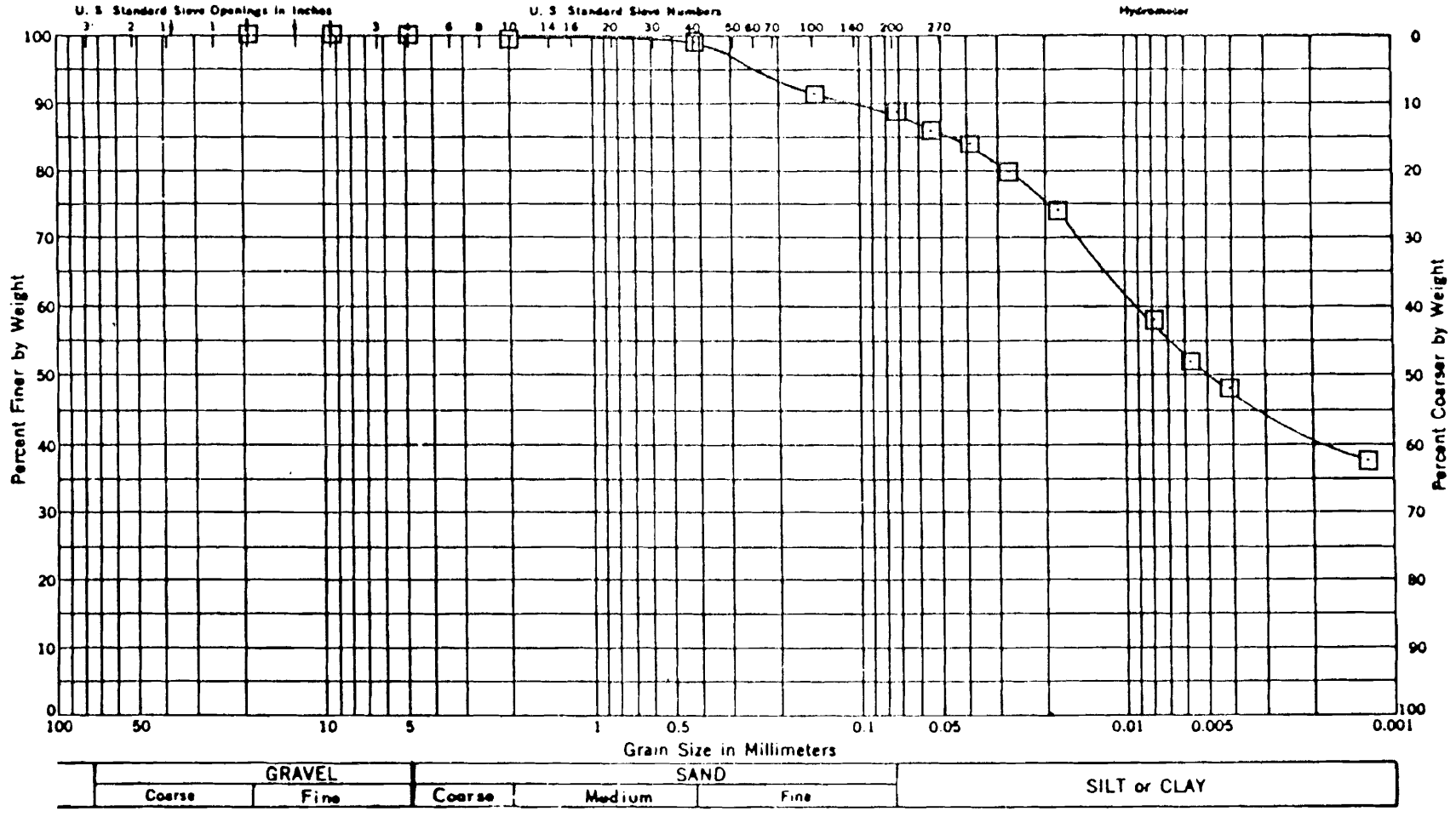
IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 18 SAMPLE 9
DEPTH 44 - 46 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/20/81	680874

252



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
2		50	19	31	
					UNIFIED CLASSIFICATION (CH)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

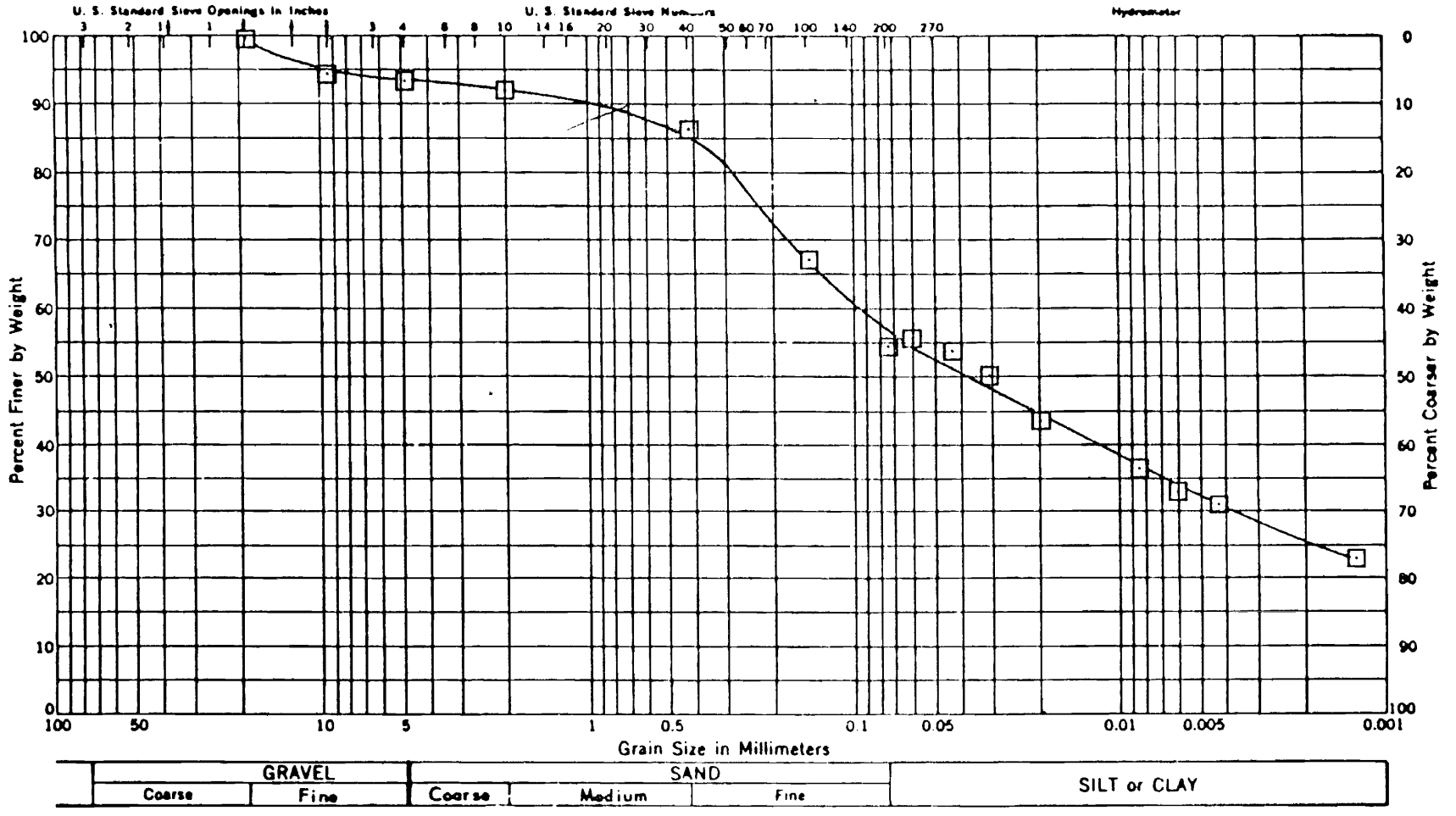
BORING 19 SAMPLE 2

DEPTH 9 - 11 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	JFH	01/20/81	680874

253



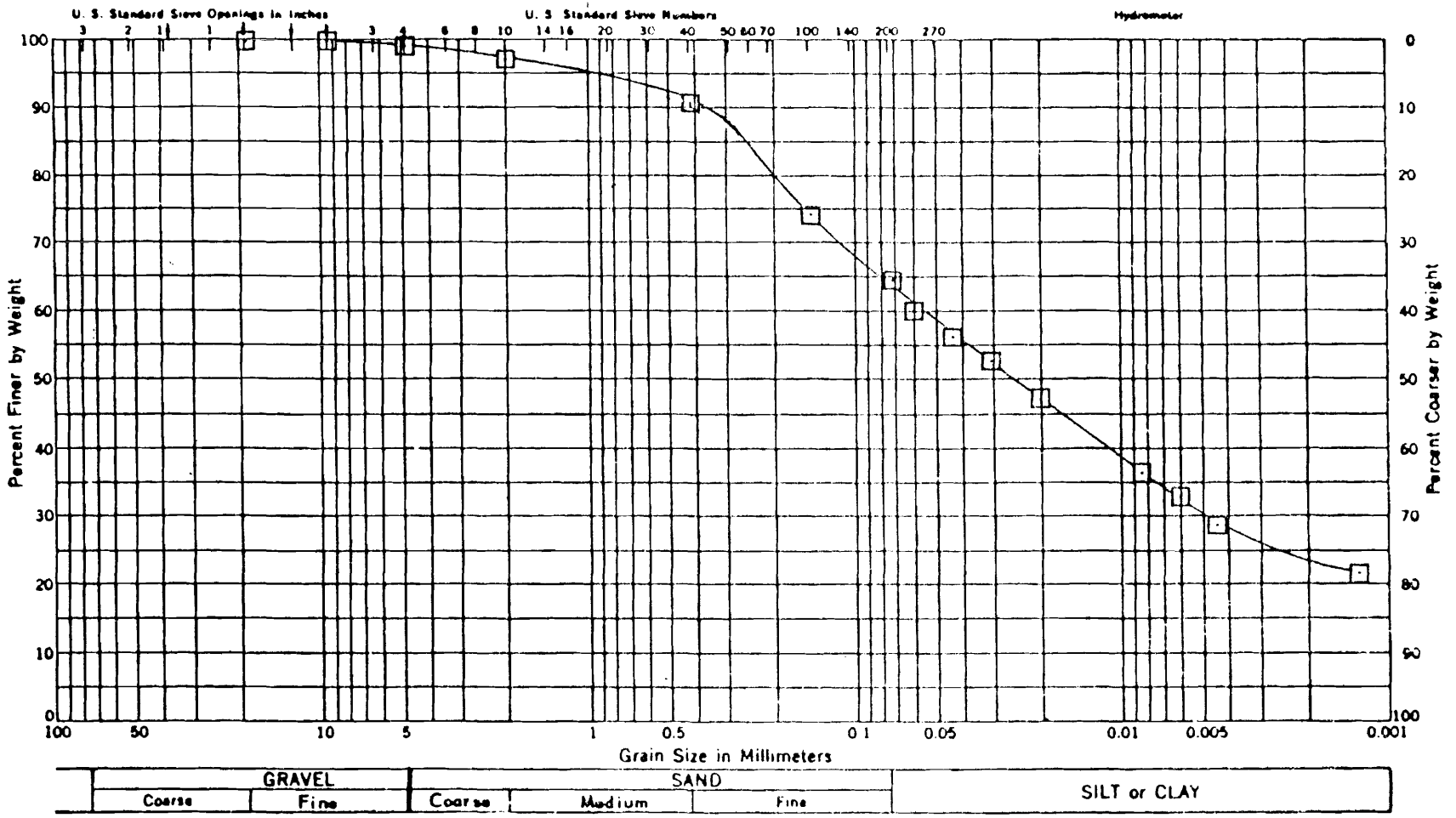
SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
8		35	13	22	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 19 SAMPLE 8
DEPTH 39 - 40 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/20/81	680874



SAMPLE NO.	W.C.	LL	PL	PI	CLASSIFICATION
10		35	13	22	
					UNIFIED CLASSIFICATION (CL)

IA. ARMY AMMUNITION PLT.
BURLINGTON, IOWA
SITE Z-2

BORING 10 SAMPLE 10
DEPTH 48 - 50 ft

Terracon Consultants, Inc.
Cedar Rapids Davenport Des Moines, IA
Kansas City Wichita, KS

DRAWN	APPROVED	DATE	JOB No.
	J.F.H.	01/20/81	880874

255

IOWA ARMY AMMUNITION PLANT

BURLINGTON, IOWA

JOB NO. 680574

CONSTANT HEAD PERMEABILITY TEST RESULTS

SITE Z-2

Boring	Sample	Depth (ft)	Moisture Content %	Dry Density pcf	Coefficient of Permeability cm/sec
1	1	3.0- 5.0	30.2	90.6	9.2×10^{-9}
1	3	13.0-15.0	19.3	109.1	3.8×10^{-8}
2	2	8.0-10.0	21.9	100.0	8.2×10^{-10}
2	4	18.0-20.0	13.5	111.5	1.3×10^{-8}
3	3	13.0-15.5	16.4	112.8	6.2×10^{-9}
3	5	23.0-25.0	15.7	108.5	5.0×10^{-9}
4	7	33.0-35.0	12.1	121.9	1.6×10^{-8}
4	9	43.0-45.0	25.3	100.6	1.6×10^{-9}
5	2	8.0-10.0	22.1	104.2	3.8×10^{-9}
5	8	38.0-40.0	15.4	115.0	3.4×10^{-9}
6	1	3.0- 5.0	28.6	90.5	1.1×10^{-8}
6	2	8.0-10.0	29.0	89.6	2.1×10^{-8}
7	1	2.0- 4.0	28.6	89.3	9.6×10^{-10}
7	5	22.0-24.0	17.9	111.6	1.0×10^{-8}
8	2	8.0-10.0	24.5	100.4	4.5×10^{-8}
8	3	13.0-15.0	21.8	103.7	1.4×10^{-8}
9	3	12.0-14.0	21.1	106.8	2.5×10^{-9}
9	6	28.0-30.0	19.7	107.9	3.1×10^{-9}
10	1	3.0-5.0	32.6	81.2	9.9×10^{-10}
10	4	18.0-20.0	17.5	115.7	7.4×10^{-8}

IOWA ARMY AMMUNITION PLANT

BURLINGTON, IOWA

JOB NO. 680574

CONSTANT HEAD PERMEABILITY TEST RESULTS

SITE Z-2

Boring	Sample	Depth (ft)	Moisture Content %	Dry Density pcf	Coefficient of Permeability cm/sec
11	3	13.0-15.0	23.2	96.5	8.3×10^{-9}
11	6	28.0-30.0	16.9	113.6	1.2×10^{-9}
12	4	19.0-21.0	13.2	120.3	6.1×10^{-9}
12	5	24.0-26.0	15.1	119.1	3.9×10^{-9}
13	2	9.0-11.0	19.5	108.3	3.4×10^{-8}
13	3	14.0-16.0	19.0	112.5	1.7×10^{-9}
14	1	2.0- 4.0	22.7	96.7	6.4×10^{-9}
14	2	7.0- 9.0	25.8	97.4	8.6×10^{-9}
15	4	17.0-19.0	17.4	113.5	3.3×10^{-8}
15	6	28.0-30.0	18.9	107.6	7.7×10^{-9}
16	2	7.0- 9.0	22.4	96.8	1.6×10^{-8}
16	5	22.0-24.0	13.8	118.9	5.4×10^{-10}
17	3	12.0-14.0	22.2	103.8	2.8×10^{-8}
17	6	28.0-30.0	13.1	123.2	1.5×10^{-8}
18	1	4.0- 6.0	28.2	91.3	2.0×10^{-8}
18	7	34.0-36.0	10.4	126.0	1.1×10^{-9}
19	2	9.0-11.0	25.4	97.7	2.4×10^{-9}
19	10	48.0-50.0	23.2	98.7	2.5×10^{-9}

Table

BORING AND WELL SURVEY DATA
SITE Z2 - DETONATOR LINE #6
IOWA ARMY AMMUNITION PLANT - BURLINGTON, IOWA
JOB NO. 680574 MARCH 31, 1981

Site	C.O.E. Local Coordinate N (ft)	C.O.E. Local Coordinate E (ft)	Elevation Natural Ground (ft)	Elevation Top of Pipe (ft)
Z2#1	8016	8182	722.7	725.4
Z2#2	5376	10010	698.4	692.6
Z2#3	7679	10234	716.9	-
Z2#4	7132	8066	713.8	-
Z2#5	6726	10628	710.6	-
Z2#6	7045	8473	712.8	-
Z2#7	7464	9756	715.8	-
Z2#8	7049	8695	712.7	-
Z2#9	7059	9769	714.3	-
Z2#10	7052	9081	713.5	-
Z2#11	7054	9318	711.2	-
Z2#12	7542	10792	713.7	-
Z2#13	6136	8211	704.9	-
Z2#14	6622	8683	709.5	-
Z2#15	6810	9839	711.7	-
Z2#16	6725	9539	709.7	-
Z2#17	7999	9523	719.0	-
Z2#18	6895	9173	712.4	716.0
Z2#18A	6924	9173	712.5	716.9
Z2#19	7192	10148	712.6	515.9

Table

WATER LEVEL OBSERVATIONS
SITE Z2
IOWA ARMY AMMUNITION PLANT - BURLINGTON, IOWA
JOB NO. 680574 MARCH 3, 1981

	Water Encountered			Water Level Records					
Site	Date	D.B. (ft)	A.B. (ft)	Date	WLE Elev(ft)	Date	WLE Elev(ft)	Date	WLE Elev(ft)
Z2#1	11-20-80	8	11.3	11-25-80	715.6	12-3-80	715.4	1-6-81	718.7
Z2#2	11-20-80	7.5	10.3	11-26-80	695.2	12-3-80	695.2	1-8-81	696.4
Z2#18	12-9-80	4.0	32.0	-	-	-	-	1-8-81	708.1
Z2#18A	12-10-80	4.0	-	-	-	-	-	1-8-81	709.3
Z2#19	12-10-80	18.0	42.0	-	-	-	-	1-8-81	709.3
Z2#3	11-21-80	9.0	8.1	11-25-80	712.2	12-3-80	712.0	1-6-81	714.6
Z2#4	11-21-80	3.5	3.75	11-25-80	710.5	12-3-80	711.0	1-6-81	711.2
Z2#5	11-21-80	7.0	WCI 11.5	11-26-80	706.9	12-3-80	706.6	1-7-81	706.9
Z2#6	11-22-80	6.0	4.75	11-25-80	708.5	12-3-80	708.6	1-6-81	708.4
Z2#7	11-24-80	8.7	20.0	11-26-80	710.3	12-3-80	710.5	1-6-81	711.0
Z2#8	11-22-80	7.0	17.2	11-25-80	707.4	12-3-80	707.4	1-6-81	707.1
Z2#9	11-24-80	6.5	10.7	11-25-80	708.6	12-3-80	707.4	1-6-81	709.4
Z2#10	11-22-80	4.0	6.0	11-25-80	709.8	12-3-80	709.8	1-6-81	710.4
Z2#11	11-22-80	5.0	9.75	11-25-80	709.0	12-3-80	709.0	1-6-81	709.0
Z2#12	12-4-80	7.0	8.5	11-25-80	-	-	-	1-7-81	711.5

Table

WATER LEVEL OBSERVATIONS
SITE Z2
IOWA ARMY AMMUNITION PLANT - BURLINGTON, IOWA
JOB NO. 680574 MARCH 3, 1981

	Water Encountered			Water Level Records					
Site	Date	D.B. (ft)	A.B. (ft)	Date	WLE Elev(ft)	Date	WLE Elev(ft)	Date	WLE Elev(ft)
Z2#13	12-5-80	2.0	8.5	-	-	-	-	1-6-81	704.9
Z2#14	11-25-80	17.5	21.0	-	-	12-3-80	704.3	1-6-81	705.5
Z2#15	11-25-80	5.5	5.5	11-25-80	706.9	12-3-80	704.3	1-6-81	707.8
Z2#16	11-25-80	6.0	26.0	11-25-80	706.4	12-3-80	707.8	1-6-81	706.6
Z2#17	11-24-80	7.7	10.0	11-25-80	714.1	12-3-80	712.3	1-6-81	714.9

Table

WATER SAMPLING OBSERVATIONS
SITE Z2
IOWA ARMY AMMUNITION PLANT - BURLINGTON, IOWA
JOB NO. 680574 MARCH 3, 1981

Water Sampling Records

Site	Date	WLE Elev(ft)	Temp °C	pH	Date	WLE Elev(ft)	Temp °C	pH	Date	WLE Elev(ft)	Temp °C	pH
Z2#1	1-27-81	709.7	8.5	7.6	1-28-81	685.2	8.5	7.1	1-29-81	685.0	8	7.2
Z2#2	1-27-81	687.3	7	7.1	1-28-81	687.3	8	7.1	1-29-81	-	-	-
Z2#18	-	-	-	-	-	-	-	-	-	-	-	-
Z1#18A	1-27-81	709.2	7	6.9	1-28-81	708.9	6	6.9	1-29-81	708	5	6.9
Z1*19	1-27-81	709.2	8.5	7.9	1-28-81	709.2	9	7.6	1-29-81	709.1	7.5	7.4

APPENDIX E

SITE Z_3 DATA

APPENDIX F

PRELIMINARY CLOSURE CONSTRUCTION COST ESTIMATES FOR SITES Z_1 AND Z_2

15-2-01

TO: MR-SM CO; PLT MGR; 3008
FM COR
OFC OF REC: SARIO - EN
DATE 3/4 INITIALS SJM
INFO ✓ NEC ACT
REPLY REQ. ___ DATE REQ. ___
REMARKS
1 cy inclosed

Final report yr. 3008 in cabinet.

1. COMPONENT	FY 19__ MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		Feb. 1982

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Site Z_1 Iowa Army Ammunition Plant	In-Situ Closure

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
• Channelization of Brush Creek	yd^3	2,700	20.0	54.0
• Perimeter diversionary dtiches	yd_3	2,623	15.0	39.3
• Clay/topsoil cover, 16 ac*	yd^3	38,720	3.00	116.2
• Grading slope and cover, 16 ac, 3 ft thick	yd^2	77,440	0.50	38.7
• Revegetation, 16 ac	yd^2	77,440	1.00	77.4
• Contingencies, 20% of above costs	-	-	-	65.1
				390.7

* The 16-ac contaminated area is estimated from low water area (4 ac), high water area (6 ac) and surrounding area (6 ac).

10. DESCRIPTION OF PROPOSED CONSTRUCTION

One of the closure scenarios is in-situ closure which will entail:

A. Desensitization of explosives in-situ (no estimate).

B. Surface water control.

C. Placement of final cover.

D. Revegetation of covered area.

E. Post-closure/site maintenance (no estimate).

F. Surface and ground water monitoring (no estimate).

Since the actual limits of contaminted sediments are not known and there is no detailed topographic survey available, the cost estimates at best are preliminary. Further engineering studies are needed.

1. COMPONENT	FY 19__ MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		Feb. 1982

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Site Z_1 Iowa Army Ammunition Plant	Sediment Removal/Site Closure

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
• Removal of desensitized sediments, 16 ac*	yd^3	24,200	1.90	46
• Disposal of desensitized sediments	yd^3	24,200	50.0	1,210
• Sedimentation basin, 2 ac	yd^3	12,017	2.20	26.4
• Clay/topsoil cover, 16 ac, 3 ft thick	yd^3	38,720	3.00	116.2
• Grading, 16 ac	yd^2	77,440	0.50	38.7
• Revegetation, 16 ac	yd^2	77,440	1.00	77.4
• Contingencies, 20% of above costs	-	-	-	302.9
				1,816.7

* Area of contamination is estimated to be 16 ac (4 ac low water area, 6 ac high water area, and 6 ac surrounding area).

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The recommended closure is the removal of contaminated sediments and burial in an approved landfill. The proposed procedure entails:

A. Desensitization of explosives in situ (no estimate).

B. Removal and burial of desensitized sediments.

C. Surface water control.

D. Placement of final cover.

E. Revegetation.

F. Post-closure site maintenance (no estimate).

Since the actual limits of contaminated sediments are not known and there is no detailed topographic survey available, the cost estimates at best are preliminary. Further engineering studies are needed.

1. COMPONENT	FY 19__ MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		Feb. 1982

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Z_2 Iowa Army Ammunition Plant	In-Situ Closure

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
• Removal of 11 sumps, 50 yd^3/sump	yd^3	550	1.90	1.05
• Backfielding	yd^3	550	3.80	2.09
• Surface water control through grading 0.63 ac	yd^2	3,056	0.50	1.53
• Perimeter ditches	yd	1,100	15.0	16.50
• Clay/topsoil cover, 0.63 ac, 3 ft thick	yd^3	3,056	3.00	9.17
• Revegetation, 0.63 ac	yd^2	3,056	1.00	3.06
• Contingencies, 20% of above costs	-	-	-	6.68
				40.08

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The proposed in-situ closure entails:

- Removal of eleven treatment sumps.
- Backfilling the holes with clayey borrow.
- Installation of ground water monitoring wells (no estimate).
- Post-closure site maintenance (no estimate).
- Improvement of surface drainage.
- Placement of final cover.
- Installation of perimeter ditch around covered site.
- Revegetation.

Since the actual limits of contaminated soils are not known, the cost estimates at best are preliminary. Further engineering studies are needed. In estimating, it is assumed that the area of co tamination is 2 x 11 sumps /beds 50' x 25', or 0.63 ac (3,056 yd^2).

1. COMPONENT	FY 19__ MILITARY CONSTRUCTION PROJECT DATA	2. DATE
ARMY		Feb. 1982

3. INSTALLATION AND LOCATION	4. PROJECT TITLE
Z_2 Iowa Army Ammunition Plant	Waste Removal and Site Closure

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)
• Removal of 11 sumps. 50 yd^3/sump	yd^3	550	1.90	1.05
• Removal of contaminated soil	yd^3	6,111	1.90	11.61
• Disposal of contaminated soil	yd^3	6,111	50.0	305.56
• Grading to improve surface drainage	yd^2	3,056	0.50	1.53
• Perimeter ditches	yd	1,100	15.0	16.5
• Final clay/topsoil cover, 0.63 ac, 3 ft. thick	yd^3	3,056	3.00	9.17
• Revegetation, 0.63 ac.	yd^2	3,056	1.00	3.06
• Contingencies, 20% of above costs	-	-	-	69.70
				418.18

10. DESCRIPTION OF PROPOSED CONSTRUCTION

The proposed procedures for removal and site closure entail:

- Removal of the sumps and leach beds.
- Removal and hauling to an approved landfill for disposal.
- Grading and placement of a final cover.
- Revegetation of the covered area.
- Grading to improve surface drainage.
- Installation of perimeter ditches.
- Post-closure site maintenance (no estimate).

Since the actual limits of contaminated soils are not known, the cost estimates at best are preliminary. Further engineering studies are needed. In estimating, the volume of contaminated material is 2 x 11 sump/beds x 50' x 25' x 6' (deep) or 6.111 yd^3.