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GEOTECHNICAL INVESTIGATION
FOR THE PROPOSED HEAP LEACHING FACILITY
IN WEST GAS HILLS
FREMONT COUNTY, WYOMING

Prepared For
Union Carbide Corporation
Metals Division

Job No. 1-2664-3118
August 5, 1980

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Mr. William B. Paris
Union Carbide Corporation
P.O. Box 97
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Niagara Falls, New York 14302

June 30, 1980

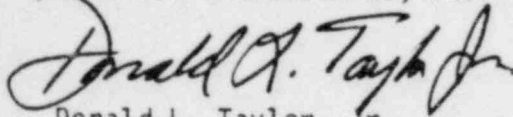
Job No. 1-2664-3118

Subject: Geotechnical Investigation for the Proposed Heap Leaching Facility in West Gas Hills, Fremont County, Wyoming

Dear Mr. Paris:

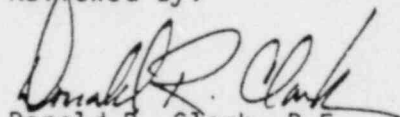
Transmitted herewith is our report for submittal to the NRC and Wyoming DEQ to accompany UCC's construction plans for the subject project. Our report and analyses are based upon the currently designed heap leach facility, which reflect the geotechnical criteria assessed during our preliminary investigations. We are available to assist you in supplying any additional criteria, should it be requested by the reviewing agencies. Please call when further consultation is required.

F.M. FOX & ASSOCIATES, INC.



Donald L. Taylor, Jr.
Geotechnical Engineer

Reviewed by:



Donald R. Clark, P.E.
Principal Geotechnical Engineer

DLT/pcs

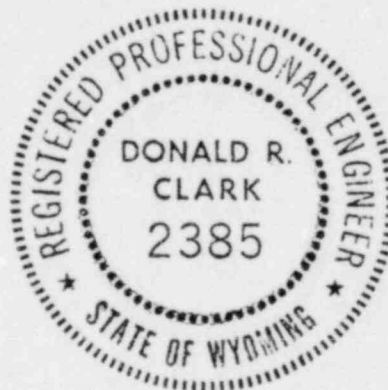


TABLE OF CONTENTS

LETTER OF TRANSMITTAL	Page	i
INTRODUCTION		1
SITE DESCRIPTION AND PROPOSED PROCESS DESCRIPTION		2
Transportation Accident Analysis		4
GEOLOGIC, SUBSOIL AND HYDROLOGIC CONDITIONS		5
Area Geology		5
Site Specific Subsoil Conditions		6
Area Seismicity		8
Table I - Regional Earthquake History (200 Mile Radius)		9
Table II - Hebgen Lake, Montana Event		10
Area Subsurface Hydrology		11
Site Specific Hydrologic Conditions		12
GEOTECHNICAL EVALUATION		15
Settlement Analysis		15
Site A Settlement		15
Site K-1 Settlement		15
Seepage Analysis		15
Site A Seepage		17
Site K-1 Seepage		18
Liner Construction		18
MONITORING PROGRAM		18
Table III - Ground Water Quality Parameters and Data		20
SITE VICINITY MAP	Figure	1
SITE, TEST HOLE AND MONITOR WELL LOCATION MAP		2
HEAP LEACH PLAN SITE A		3
CROSS SECTIONAL VIEW HEAP LEACH SITE A		4
HEAP LEACH PLAN SITE K-1		5
CROSS SECTIONAL VIEW HEAP LEACH SITE K-1		6
TYPICAL CROSS SECTION USED FOR SEEPAGE ANALYSIS		7
OPERATIONAL FLOW DIAGRAM		8
TYPICAL CROSS SECTION THROUGH FOUNDATION OF SITE A		9
TYPICAL CROSS SECTION THROUGH FOUNDATION OF SITE K-1		10

TABLE OF CONTENTS (cont.)

REGIONAL GROUND WATER PIEZOMETRIC CONTOUR MAP	Figure	11
TYPICAL HEAP CROSS SECTION SHOWING FLOW NET FOR SEEPAGE		12
APPENDIX A Lithological Logs	Figures	A-1 through A-21
APPENDIX B Laboratory Test Results	Figures	B-1 through B-49
APPENDIX C Seepage Calculations		C-1 through C-8

INTRODUCTION

The Metals Division of Union Carbide Corporation proposes to construct and operate a heap leach facility at their West Gas Hills Property, Fremont County, Wyoming. The facility will consist of two (2) below grade heaps with associated equipment necessary for treatment of the low grade ore and recovery of uranium from the leachate. Construction of this facility is planned to begin June 1981 with the operation commencing in April, 1982.

The heap leach process has proven to be an environmentally and economically sound method for recovering U_3O_8 from low grade minerals at the Maybell, Colorado and East Gas Hills, Wyoming sites. Technology acquired at these locations will be applied in the design and operation of the West Gas Hills Heap Leach facility.

The Draft Environmental Statement (DES) dated January, 1979 for Union Carbide Corporation's Gas Hills Uranium Mill proposes a West Gas Hills Heap Leach facility. Although the heap design is essentially the same as proposed in the DES, the scope of the project has changed. The facility will utilize solvent extraction instead of ion exchange for recovery of U_3O_8 and the facility will consist of two below grade heaps instead of one above grade heap. The proposed heaps are:

Site A - 1,000,000 tons

Site K-1 - 770,000 tons

On February 25, 1976, a Dames and Moore report entitled Environmental Assessment, Proposed Uranium Heap Leaching Project, West Gas Hills, Wyoming for Union Carbide Corporation was submitted to NRC as documentation supporting the proposal in the DES. This report is provided as a supplement to the Dames and Moore report, and it provides information on site specific geologic, subsoil, and hydrologic conditions.

SITE DESCRIPTION AND PROPOSED PROCESS DESCRIPTION

The two proposed heap leach operations, hereafter referred to as Site A and Site K-1, will be located in portions of Sections 31 and 32 of Township 33 North, Range 90 West of the 6th P.M., Fremont County, Wyoming. Refer to Figure 1 for the general site vicinity. Both proposed heap leach operations will be constructed in depleted and partially backfilled pits. Refer to Figure 2 for site plan view. Site A has been backfilled with mine waste to an approximate elevation of 6,560 feet. Refer to Figure 4 for a cross sectional view of Site A. Site K-1 has been backfilled with approximately 100 to 115 feet of mine waste material and to an elevation of approximately 6,500 feet. Refer to Figure 6 for a cross sectional view of Site K-1.

Proposed plan views for both heap leach sites are shown on Figures 3 and 5. Refer to Figure 7 for a typical cross sectional view through the proposed heaps. Both proposed heaps will be constructed approximately 30 feet in height and will be composed of mineral ore. The perimeter of the ore mineral pile will be enclosed by an 8 to 28 foot thick layer of mine waste. The heaps will be underlain with compacted clay liners, approximately 1 to 2 feet in thickness. In addition, a compacted clay berm will be constructed in conjunction with the liner and will underlie the waste layer. The berm will be approximately 3 feet in height and will help to contain any seepage from the heap to the outside face of the slope.

The top of each heap will be divided into equal compartments, and each compartment will be divided by small berms to allow for leaching of specific compartments. These berms will be constructed to maintain a minimum 2 foot freeboard. This will prevent overtopping of the heaps due to wave action and any anticipated hydrological events.

Leaching liquor will be distributed to each compartment on top of the

heaps by either a sprinkling or flooding system. Using this system, the fluid depth of liquor on top of the heaps will be limited to a few inches during the leaching process. The heap will be leached for approximately 7 months per year. The entire leaching process will take approximately three years. A drainage system will be installed on top of the clay liner beneath the mineral ore to retrieve the leachate. These drains will consist of 4 inch diameter perforated PVC or polyethylene pipe covered by a porous medium (i.e., sand or gravel), and will be spaced approximately 20 feet on center.

In addition to the proposed heap at Site A, two storage ponds will be constructed at the southeast corner of the abandoned pit, (refer to UCC drawing No. 223-1653 submitted separately, Figure 3 also applies). Site K-1 will include three small storage ponds, a large winter storage pond, reagent storage tanks, miscellaneous processing equipment, and a solvent extraction circuit; this will be located immediately to the west of the proposed K-1 heap, (refer to UCC drawing No. 223-1655 submitted separately, Figure 5 also applies but does not show ponds and processing facilities). There will be six pipelines connecting the two proposed heap leach areas. All ponds constructed at each site (a total of six) will be lined with a synthetic liner. Each pond will have a minimum 5 feet of freeboard and the sides will be sloped to the bottom on a 2.5 horizontal to 1 vertical.

The flow sheet for the heap leaching operations is shown on Figure 8.

The principal steps for the leaching process are as follows:

1. Water from nearby wells is pumped to the low grade surge ponds and is then converted to a 4-10% sulfuric acid solution by mixing with concentrated sulfuric acid with an in-line mixer.
2. The leach solution will be sprayed or pumped to the compartments on the top of each heap and applied by the distribution system for percolation down through the mineral ore for extraction.

3. The leach solution is recovered in the underdrains and sent to an area (site) high or medium grade surge pond based on U_3O_8 content. The medium grade liquor is reacidified and recycled on the heap leach surface.
4. The liquor in the high grade pond is pumped from the heap site to the processing site. Three mixer-settlers connected in series are used to extract the uranium values by an amine-kerosene solvent. The depleted leach liquor passes through a raffinate decant tank where any carry over of the organic phase separates out. The clean solution is reacidified and pumped to the heap.
5. The uranium values are stripped from the loaded organic phase with a 15% sodium carbonate solution. The lean organic is recycled through a surge tank to the extraction circuit.
6. The sodium carbonate solution containing approximately 5% U_3O_8 is transported to the mill for recovery of yellow cake in the plant circuit.
7. At the end of the operating season, the excess liquor in the system will be stored in the winter storage pond.

Product liquor from the solvent extraction process containing approximately 5% U_3O_8 will be shipped from the proposed West Gas Hills heap leach facility in 5,000 gallon tank trucks to the mill, a distance of approximately 12 miles. For the expected output of the heap leach facility, approximately 130 shipments will be required annually.

Transportation Accident

The likelihood of a truck shipment of product liquor being involved in an accident is approximately 4×10^{-3} /year or one every 250 years, (refer to pages 5 through 7 of the Gas Hills Final Environmental Statement dated July, 1980.) If a severe accident occurred, in which the contents of the vehicle were spilled, approximately 2,700 pounds of U_3O_8 representing approximately 0.74 curies of activity would be released to the environment.

The most likely impact of such a release would be contamination of surface soils which Union Carbide Corporation would clean up to background conditions. The contaminated soils would be processed through the mill.

GEOLOGIC, SUBSOIL AND HYDROLOGIC CONDITIONS

Area Geology

The Gas Hills area is located in the southern portion of the Wind River Basin adjacent to the northern portion of the Sweetwater Arch. Beaver Divide marks the southern-most extension of the Wind River Basin. Lithologies encountered during this investigation are part of the Wind River Formation. Geological materials at the site are derived from two episodes of the Sweetwater uplift. During the first episode in late Cretaceous time, coarse grain material was deposited north of the Gas Hills area in the deeper portions of the Wind River Basin. As the basin became filled with sediments, fine grained sand and silt were deposited in the Gas Hills area. The second episode of the Sweetwater uplift in early Eocene times resulted in erosion of a portion of the fine grained sand and silts, followed by a rapid deposition of new coarse grain materials in the Gas Hills area. These newly deposited alluvial fans have become the host rock for the Gas Hills uranium.

The older lower Wind River Formation consists mainly of fine grained sands, silts and clays with interbedded carbonaceous shale beds. This lower fine grained member varies in thickness between 100 to 150 feet. The upper younger Wind River Formation consists mainly of coarser grained material with occasional beds of conglomerates, siltstone, and claystone. The Wind River Formation is poorly undulated and virtually uncemented. It should also be noted, that in this portion of the site, the Wind River Formation underlies the upper cretaceous Cody Shale.

Site Specific Subsoil Conditions

The site specific subsoil conditions for both heap leach and processing facilities were obtained through a field investigation and sampling program. The field investigation for Site A consisted of drilling seven test holes at the locations shown on Figure 3. The field investigation for Site K-1 included drilling 8 test holes at the locations shown on Figure 5. The test holes were advanced with either a CME 45 drill rig or a CME 75 drill rig, both capable of auger drilling and sampling. All test holes were advanced with 6 inch diameter continuous flight hollow augers, with the exceptions of test holes A-6 and A-7 which were advanced with a 3 7/8 inch tricone bit. The Soil sampling was conducted with a 2 inch diameter Modified California Barrel Sampler. All test holes were sampled at regular intervals and lithologically logged at the time of drilling. Standard Penetration testing was also conducted at regular intervals in test holes A-6, A-7, K1-5 and K1-6 for use in the geotechnical analyses. Refer to Appendix A, Figure A-1 through A-15 for lithologic logs of all test holes drilled, and appropriate sampling locations.

Upon completion of the field investigation, the soil samples were returned to the Denver Laboratories of F.M. Fox & Associates, Inc. The soil samples were then carefully opened, cataloged, and classified by the project geotechnical engineer. Inspection of the samples followed the procedures outlined in ASTM D-2483, "Standard Recommended Practice for Description of Soils (Visual-Manual Procedures)". Samples were divided into groups of similar engineering characteristics for formulation of an appropriate laboratory testing program. Representative samples of each group were then chosen for testing. The laboratory testing program consisted of 26 Moisture-Density determinations, 26 Atterberg Limit Tests, 28 Mechanical Analysis Tests, 19 Falling Head Permeability Tests, 5 Direct Shear Tests, 5 Unconfined Compression

Tests, 5 Compaction Tests, 3 Swell-Consolidation Tests, 1 Time Consolidation Test, one 3 Point Triaxial Test, and 2 Specific Gravity Tests. All laboratory testing was conducted in accordance with the appropriate ASTM Standards. Information obtained from the laboratory investigation is included in Appendix B and is presented on the logs of test holes included in Appendix A.

Subsoil conditions encountered in the test holes can be classified into four general groups of fill materials:

Group I - Sandstone fill, fine to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow to brown.

Group II - Sandstone fill, fine to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense, gray.

Group III - Sandstone fill, fine to medium grained with traces of coarse grained material, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray.

Group IV - Siltstone and Mudstone fill, slightly clayey to slightly sandy, with traces of iron staining, medium moist, very stiff to hard, brown to gray.

The information obtained from these test holes was used to produce a geologic cross section of the foundation soils beneath both of the proposed heap leach facilities. These cross sections are shown on Figures 9 and 10.

The results of the field and laboratory investigations show that the fill beneath both sites exhibits uniform engineering properties. The foundation soils for the heaps, with the exception of the mudstones and claystones, are generally cohesionless materials with high shear strength at their in-place densities, and have moderate permeability. The mudstones and claystones

are cohesive, have high unconfined compressive strength, and have low to very low permeabilities.

Area Seismicity

Wyoming is located within a low seismic activity region with most of the seismic activity occurring at the extreme western portion of the state (S.T. Algermissen, et al). The seismic map of the United States (S.T. Algermissen) indicates that the Gas Hills area is a Zone 1 seismic area. Zone 1 has been assigned as an area that can expect minor earthquake damage from mild earthquake events. Recorded earthquakes within a 200 mile radius of the sites are tabulated on Table I. The earthquake epicenter location, date of occurrence, Modified Mercalli intensity, and the approximate distance from the epicenter to the Gas Hills, are included on this table. The information indicates that the highest intensity event recorded close to the site occurred in southwest Fremont County approximately 21 miles southwest of Gas Hills on April 21, 1973. The Modified Mercalli intensity of the epicenter was reported as V. Shoshone, Wyoming reported an intensity of IV from the event. No Modified Mercalli intensity was reported for the Gas Hills area. However, it is reasonable to assume that intensity III or IV was realized. To our knowledge, no damage to any existing structures (i.e., tailing dams, mill sites, etc.) occurred in the Gas Hills area as a result of this event. A second close event was recorded approximately 31 miles west of the Gas Hills on March 25, 1975 with an intensity of III reported in Jeffery City and Riverton, Wyoming.

The Hebgen Lake, Montana earthquake in August, 1959, was the largest recorded regional earthquake in the Wyoming area. The event was recorded at 7.1 on the Richter Magnitude Scale and has been assigned a Modified Mercalli intensity of X at the epicenter. Refer to Table II for recorded

TABLE I
REGIONAL EARTHQUAKE HISTORY (200 Mile Radius)

Date	Approx. Epicenter Location	Lat.	Long.	Modified Mercalli Intensity	Approx. Distance to Epicenter (miles)
1894 7-25	Casper, Wyoming	42.9N	106.3W	V	61
1897 11-04	Casper, Wyoming	42.9N	106.3W	VII	16
1910 7-26	Rock Springs, Wyo.	41.5N	109.3W	V	128
1917 12-12	Gray, Idaho	43.0N	111.3W	V	193
1923 3-24	Kelly, Wyoming	43.6N	110.6W	V	166
1925 11-18	N. Central Wyoming	44.6N	107.0W	V	127
1928 2-13	Central Wyoming	43.5N	108.2W	V	60
1930 6-12	Grover, Wyoming	42.6N	111.0W	VI	178
1932 1-26	Western Wyoming	43.6N	110.8W	V-VI	176
1933 11-02	Gray, Idaho	43.0N	111.3W	V	193
1934 11-23	Lander, Wyoming	43.0N	109.0W	V	62
1948 2-24	N.W. Wyoming	43.5N	111.0W	VI	183
1951 2-21	W. Central Wyoming	43.0N	110.0W	III	127
1953 6-04	N.W. Wyoming	44.5N	110.5W	VI	191
1954 1-20	S.E. Wyoming	41.5N	105.5W	V	135
1955 2-10	N.W. Wyoming	40.5N	107.0W	V	108
1956 10-03	S.W. Wyoming	41.5N	110.1W	IV	160
1957 11-03	W. Central Wyoming	42.5N	111.0W	IV	179
1958 8-07	Fox Park, Wyoming	41.1N	106.0W	IV	140
1959 12-25	Fox Park, Wyoming	41.1N	106.0W	V	140
1960 8-20	S.E. Idaho	42.3N	111.3W	V	196
1962 10-06	Western Wyoming	43.6N	110.8W	IV	176
1963 2-25	Western Wyoming	42.6N	109.2W	V	87
1963 3-05	S.E. Idaho	42.6N	111.3W	III	194
1963 3-08	Yellowstone Nat'l Park, Wyoming	44.8N	110.2W	VI	193
1963 4-18	Yellowstone Nat'l Park, Wyoming	44.8N	110.3W	V	197
1964 8-22	Eastern Wyoming	42.9N	104.7W	V	142
1967 2-14	Rangely, Colorado	40.1N	109.0W	V	195
1968 1-09	Central Wyoming	42.7N	106.8W	III-IV	36
1969 8-27	W. Central Wyoming	42.9N	110.8W	III	168
1970 4-21	Rangely, Colorado	40.1N	108.9W	V	199
1972 11-24	Idaho	42.5N	111.2W	IV	187
1973 4-22	S.E. Fremont County, Wyoming	42.6N	107.9W	V	21
1974 3-31	Northern Colorado	40.7N	107.1W	II	145
1974 9-19	N. Central Wyoming	44.1N	107.4W	V	91
1975 5-25	Central Wyoming	42.7N	108.1W	III	31
1975 5-16	S.W. So. Dakota	43.2N	103.7W	IV	196
1976 1-27	Rawlins, Wyoming	41.9N	107.2W	FELT	60
1976 9-03	Kaycee, Wyoming	44.0N	106.2W	FELT	109

Data compiled with the help of U.S. Department of Commerce,
National Oceanic and Atmospheric Administration

Table II

HEBGEN LAKE, MONTANA EVENT - AUGUST 17, 1959

EPICENTER - 44.83N, 111.08W
 RICHTER MAGNITUDE - 7.1
 MERCALLI INTENSITY - X

Earthquake intensity file - selected locations and Mercalli
 intensity at that location

LOCATION	MERCALLI INTENTISY	DISTANCE FROM EPICENTER (miles)	DISTANCE FROM GAS HILLS (miles)
Hebgen Lake, Montana	X	0	216
Yellowstone Nat'l Park, Wyoming	VIII	51	177
Cooke City, Wyoming	VI	57	196
Jackson Lake Dam, Wyoming	V	112	150
Buffalo, Wyoming	V	220	115
Cody, Wyor	V	101	143
Jackson, Wyoming	V	95	171
Pinedale, Wyoming	V	150	118
Thermopolis, Wyoming	V	164	69
Lander, Wyoming	IV	181	62
Worland, Wyoming	IV	163	88
Casper, Wyoming	III	275	59

Data obtained from 1959 addition of:

"United States Earthquakes", U.S. Department of Commerce,
 National Oceanic and Atmospheric Administration

intensities reported at various distances away from the Hebgen Lake epicenter. Lander, Wyoming (62 miles from the Gas Hills) and Casper, Wyoming (59 miles from the Gas Hills) recorded intensities of IV and III, respectively for that event. A maximum intensity of IV is postulated to have occurred in the Gas Hills areas from this event.

Historical information such as that discussed above and tabulated in Tables I and II for the Gas Hills area in the Wyoming region, indicates that the Gas Hills area probably has experienced a disturbance no greater than intensity IV. The largest earthquake which is likely to occur based on the existing seismic data, is not expected to exceed a Modified Mercalli intensity of IV. Based upon these data, maximum accelerations on structures, due to seismic events, have been estimated at less than 1% of gravitational acceleration. However, on the basis of information obtained from the USGS (S.T. Algermissen), values of gravitational acceleration have been estimated at less than 4%.

Area Subsurface Hydrology

The subsurface hydrology for both sites was investigated with the installation of 6 cased monitoring wells drilled on or close to the proposed heap leach facility. In addition, previously generated data (Dames and Moore, F.M. Fox & Associates, et al) was incorporated to produce the regional subsurface hydrological conditions.

The location of the monitor wells (designated MW-1 through MW-6), drilled during the course of this investigation, are shown on Figure 2. The lithologic logs of each well are shown in Appendix A, Figures A-16 through A-21. These wells were advanced with a Gardner Denver 1500 W drill rig to depths of 250 to 300 feet below the ground surface. The wells were drilled 8 inches in diameter and subsequently cased with slotted 4 inch I.D. perforated PVC

and then were subsequently gravel packed to the ground surface. Ground water was encountered in the monitor wells at depths of 163 to 256.5 feet. Water samples were retrieved from these wells by pumping for subsequent back-ground water quality analysis: refer to the section titled "Monitoring Program" (page 18).

On the basis of the ground water data obtained for this investigation and from previous reports, a regional ground water piezometric contour map was generated to show the regional ground water flow beneath the sites. The ground water contour map is presented on Figure 11. The data shows that regional ground water is flowing from the southeast to the northwest, at an approximate gradient of 80 to 100 feet per mile. The approximate elevation of the regional water table at the site is 6,375 feet.

Site Specific Surface Hydrologic Conditions

Surface hydrology of the proposed heap leach sites will be controlled by the grading of the pit backfill as shown by the contours on Figures 3 and 5. These maps were utilized to determine surface runoff conditions which will directly affect both heap leach construction areas. More specifically, the rainfall and surface runoff will be controlled in two specific areas on each site (i.e., that area outside of the base of the proposed heaps and that area specifically within the confines of each heap).

In accordance with NRC Regulatory Guide 3.11, a design flood was used to determine the surcharge capacity on both impoundment leach sites to prevent overtopping, and to calculate the amount of water to be diverted away from the outside of the impoundments. The probable maximum flood (PMF) series specified by the Regulatory Guide is comprised of two flood events: the flood produced by the probable maximum precipitation (PMP) and a flood equivalent to about 40% of the PMP occurring a few days prior to the main event.

A 24 hour probable maximum general storm and a 24 hour 100 year storm were used to determine the inflow design floods. Tables, figures and methods presented in the Bureau of Reclamation Publication "Design of Small Dams" and National Weather Service rainfall maps were used to estimate the 24 hour probable maximum precipitation and the 24 hour 100 year precipitation for the project area. The 24 hour PMP is estimated to be 14.7 inches and the 24 hour 100 year precipitation is 3.0 inches. Precipitation from a storm equivalent to 40% of the PMP is 5.9 inches.

Data compiled from the Soil Conservation Service soil survey of the project area and tables in the "Design of Small Dams" were used to estimate design runoff curve numbers assuming an antecedent moisture condition (AMC) of II. These data were used to determine that a runoff of 3.8 inches (SCS Tables) can be expected from a 40% PMP storm. Assuming that rainfall from the 40% PMP storm will cause nearly a saturated soil condition (AMC-III), an adjusted CN (Curve Number) of 92 was used to determine that a runoff of 13.7 and 2.2 inches will result from the PMP and 100 year storms respectively. Therefore, the total rainfall excess produced by the design flood series will be on the order of 19.7 inches.

The proposed heap leach surface area for Site A is approximately 20 acres. This area will receive direct rainfall assuming no losses. The water volume generated over this area by the PMF will be approximately 33 acre-feet. Therefore, the surcharge capacity for the proposed heap leach Site A must be adequate to store a total of 33 acre-feet. On the basis of this information, the design flood will raise the fluid elevation on top of the impoundment by approximately 2 feet. Therefore, a minimum freeboard of 2 feet will be maintained at all times.

The overland drainage area that is contributing runoff inflow to the

base of the proposed heap leach Site A embankment is approximately 40 acres. This is a very conservative number due to the continuous topographical changes in the mining area. The water volume generated by the PMF will be approximately 66 acre-feet for the given drainage area. This water volume will be diverted around the impoundment site.

On the basis of the proposed design, surface runoff outside of the impoundment area of Site A will be controlled by the slopes on the service roads and the downstream face of the embankment. This configuration will direct surface runoff by overland means to the east. Calculations show that given the surface area outside the heap, a maximum water elevation of 2 feet can be expected along the drainage slopes during the design flood.

The proposed leach surface area for Site K-1 is approximately 13.6 acres. This area will receive direct rainfall, assuming no losses. The volume of water generated over this area due to the PMF will be approximately 22 acre-feet. On the basis of this information, the design flood will raise the fluid elevation within the impoundment approximately 2 feet. Therefore, a minimum 2 foot freeboard will be maintained at all times.

The overland drainage area that could eventually contribute runoff inflow to the K-1 site is approximately 192 acres. This is a very conservative number due to the continual topographical changes occurring in the Site K-1 area. The water volume generated outside of the heap by the PMF will be approximately 315 acre-feet. This overland drainage runoff will be diverted around the site by the slopes on the service roads (all sides except to the east), the embankment (east only) and the pit currently being mined to the south.

Storm water impounded in both heap facilities will be allowed to percolate through the ore pile and will be subsequently recovered through the underdrain system and then stored for evaporation in the holding ponds.

GEOTECHNICAL EVALUATION

Settlement Analysis

A finite element computer model was used to determine settlement characteristics beneath the liner of each heap due the consolidation and additional load increases which will occur during or after construction of the proposed heap leach facilities. These analyses were carried out for both sites using wet densities and strength parameters determined from the laboratory testing as well as field Standard Penetration test results.

Site A Settlement

Foundation settlements on the order of approximately 0.3 feet at the outer toe of the embankment, to 0.9 feet beneath the center of the heap, are anticipated. This indicates a maximum differential settlement will occur within the outer 100 foot perimeter of the heap. The analysis also indicates that this portion of the liner will experience higher shear stresses due to the anticipated settlement.

Site K-1 Settlement

Foundation settlements are on the order of approximately 0.14 feet at the outer toe of the embankment, to 1.03 feet beneath the center of the heap. The analysis indicates a maximum differential settlement will occur within the outer 115 foot perimeter of the heap. The analysis also indicates that a portion of the liner will experience higher shear stresses due to the anticipated settlement.

On the basis of these analyses and to prevent liner degradation due to the differential settlements, the outer 100 foot perimeter of the clay liner of both heaps will be increased to 2 feet in thickness.

Seepage Analysis

The seepage analysis of both proposed heaps required specific engi-

neering parameters to be tested for during the field and laboratory investigations. Specifically, the most important parameter to be defined was the permeability of all materials through which seepage will take place. This required testing of ore material, the clay liner material, and the foundation soils. All permeability tests were conducted on samples using laboratory methods. Samples of the ore and clay liner were compacted in the lab to the densities and permeabilities which will be duplicated during construction. The clay liner material will be obtained from a predetermined stockpile at the site. The results of the testing are shown in Appendix B and summarized on Figure 7. The permeability testing was conducted with an actual acid solution as will be used in the leaching operation. The recommended permeability of the heap liners is 1×10^{-7} cm/sec.

Since seepage through the liner is likely to be the largest source of contamination, we have included a detailed seepage analysis for each site. The analyses were conducted following the procedures outlined by David B. McWhorter and John D. Nelson in "Unsaturated Flow Beneath Tailings Impoundments" in Uranium Mill Tailings Management, Vol. I, Proceedings of Symposium, November 20, 1978, at Colorado State University. This paper brings together analyses for flow through partially saturated porous media originally developed for problems in petroleum engineering, soil physics, hydrology, irrigation and drainage. This paper details an analysis for a situation in which there were no drains. The drains have been accounted for in this analysis by drawing a flow net (See Figure 12) using a drain spacing of 20 feet, and calculating the total head remaining on top of the liner midway between the drains. No attempt was made to account for decreased permeability due to deposition of compounds. The permeability of the liner may increase slightly due to the removal of sodium ions by the hydrogen ions.

The cross section flow net used for the seepage analysis beneath the heaps is shown on Figure 12. Actual seepage calculations were made using a minimum hydraulic conductivity (permeability) for the liner material of 1×10^{-7} cm/sec. In addition, the seepage calculations incorporated the laboratory analyses of porosity, initial moisture contents, dry densities, permeabilities and estimated values for the residual volumetric content (specific retention). Each calculation involving the hydraulic gradient across the liner takes into account the head on top of the liner, estimated from the flow net, and capillary driving forces beneath the liner. It was found that assuming a head of zero on top of the liner and a hydraulic gradient of one results in underestimating the seepage by about one-fourth beneath the drain pipes and by about one-tenth midway between the drains. The results given are based on the head midway between drains and is therefore an upper limit of the total amount of seepage. Equations and calculations for the analysis are presented in Appendix C.

The displacement pressure of the foundation material found at both sites (material underneath the liner) was estimated from an equation developed by David B. McWhorter and his procedure using Darcy's equation for multiple layers was used for estimating seepage velocities and distance traveled by the wetting front.

Site A Seepage

During the seven month leaching period beginning when the heap leach and liner are saturated, the wetting front would be restricted to a depth of 22 feet. The above value assumes free drainage. Since the volumetric water content above the wetting front was only slightly higher than the residual volumetric water content, further spreading of contaminated water after leaching activities are discontinued will be negligible. The total seepage quantity will be approximately 0.03 gallons per day per square foot.

Site K-1 Seepage

During the seven month leaching period, beginning when the heap leach and liner are saturated, the seepage would reach a depth of 12 feet. However, the volumetric water content of the wetting front is almost twice the residual volumetric water content so the water will continue to spread to a depth of about 22 feet after leaching is discontinued. The total seepage quantity will be approximately 0.06 gallons per day per square foot.

As currently planned, a monitor drain will be placed beneath each heap leach facility in order to determine if seepage is occurring. Based upon unsaturated flow conditions, the monitor drain will be constructed on top of a polyethylene moisture barrier placed in a concave configuration (See Figure 7).

Liner Construction

Based upon the seepage analysis, the controlling parameter for liner construction will be the permeability. The calculations are based upon maintaining a minimum permeability of 1×10^{-7} cm/sec. During construction, additional testing will be conducted to verify that the required permeability is achieved.

To prevent degradation of the liner, it will be necessary to cover the entire liner with a minimum of 12 inches of mineral ore to help prevent depletion of moisture content. However, if the liner is left exposed, it will be necessary to scarify and recompact the top 6 to 8 inches prior to subsequent mineral ore placement.

MONITORING PROGRAM

The water quality monitoring program will be conducted in accordance with Guideline No. 4 of Wyoming Department of Environmental Quality. The six monitor wells installed during this investigation and previously installed

wells (owned by adjacent mining companies) surrounding the sites will be sampled quarterly for the first year and semi-annually thereafter. All samples should be taken using a submersible pump lowered to a sufficient depth to allow continuous pumping. To insure that a sample is representative of formation water, a volume of water equal to or greater than twice the volume held in the well casing, when possible, will be discharged before a sample is taken.

To insure accurate and dependable results, some field measurements and handling of the samples is necessary. Specific conductance, temperature, and pH should be measured in the field on unfiltered sample water. All samples should be filtered in the field using a 0.45 micron filter membrane. Samples to be analyzed for dissolved metals and radioactive elements should be preserved with 6N HNO₃ (5 mls 6N HNO₃ per liter of sample). Samples to be analyzed for nitrogen species should be preserved with 6N H₂SO₄ (5 mls 6N H₂SO₄ per liter of sample). See Wyoming Department of Environmental Quality's "Guideline No. 4 Supportive Handout" for additional sample collection and preservation information.

A complete list of constituents to be measured is presented in Table III. This list will be adjusted after baseline water quality information has been reviewed. Results of all chemical analyses will be reported to the Wyoming Land Quality Division. The six wells which were installed in this investigation were sampled in January, 1980, by F.M. Fox & Associates in accordance with Guideline No. 4. The samples were analyzed by Union Carbide's laboratory in Grand Junction, Colorado. See Table III for results of the analyses.

Seepage from the proposed heap leach sites will be monitored by an under-drain system located beneath the compacted clay liners within the foundation

TABLE III GROUND WATER QUALITY PARAMETERS AND DATA

(values represent dissolved concentrations
reported in mg/L except where otherwise noted.)

PARAMETER	MW1	MW2	MW3	**MW4	MW5	MW6
pH	8.00	7.85	7.6		7.6	8.00
Total Dissolved Solids	1451	3290	1528		1197	1904
Temperature (°C)						
Total Meg, major cations						
Total Meg, major anions						
Charge Balance						
Conductivity (micromhos/cm @ 25°C)	1512	3150				2100
Ammonia (NH ₃)						
Nitrite (NO ₂)	<1	<1				<1
Nitrate (NO ₃)	<1	<1				<1
Bicarbonate (HCO ₃)	192	220				412
Carbonate (CO ₃)	<1	<1				<1
Calcium Carbonate (CaCO ₃)	158	180				338
Calcium (Ca)	240	530				360
Chloride (Cl)	19	104	5		<1	18
Boron (B)	<1	<1				<1
Flouride (F)	<1	<1	<1		<1	<1
Magnesium (Mg)	71	166				54
Potassium (K)	16.7	28.8				16.7
Sodium (Na)	43	88				90
Sulfate (SO ₄)	1957	983	964		632	568
Aluminum (Al)	<0.1	<0.1				<0.1
Aresnic (As) ppb	<4	<4				<4
Barium (Ba)	<0.10	<0.10				<0.10
Cadmium (Cd)	<0.01	<0.01	<0.01		0.01	<0.01
Chromium (Cr)	<0.01	<0.01				<0.01
Copper (Cu)	<0.01	<0.01				<0.01
Beryllium (Be)*	<0.01	<0.01				<0.01
Iron (Fe)	1.93	0.73				0.05
Lead -210 (Pb-210) pCi/L*	38.86 ± 8.51	41.38 ± 8.56				31.27 ± 8.38

TABLE III GROUND WATER QUALITY PARAMETERS AND DATA

(values represent dissolved concentrations
reported in mg/L except where otherwise noted.)

PARAMETER	MW1	MW2	MW3	*MW4	MW5	MW6
Lead (Pb)	<0.02	<0.02	<0.02		<0.02	<0.02
Maganese (Mn)	2.23	2.38				1.63
Zinc (Zn)	0.04	0.01				0.01
Mercury (Hg) ppb	<1	<1				<1
Thorium 230 (Th-230) UCi x 10^{-6} /ml*	0.002 \pm .002	0.002 \pm 0.002				0.015 \pm .004
Nickel (Ni)	<0.01	<0.01				<0.01
Polonium -210 (Po-210) pCi/L*	0.00 \pm 2.9	0.00 \pm 2.9				0.00 \pm 2.9
Selenium (Se)	<0.02	<0.02	0.02		<0.01	0.13
Uranium (U) UCi x 10^{-5} /ml	0.0005	0.0009				0.0009
Uranium (U) Suspended UCi x 10^{-5} /ml	0.1720	0.0142				0.0284
Molybdenum (Mo)	<0.03	<0.03	0.03		<0.03	<0.03
Vanadium (V)	<0.06	<0.06				<0.06
Radium -226 (Ra-226) pCi/L	39.73 \pm 1.65	7.80 \pm 0.75	1.18 \pm 0.28		3.34 \pm 0.44	16.99 \pm 1.09

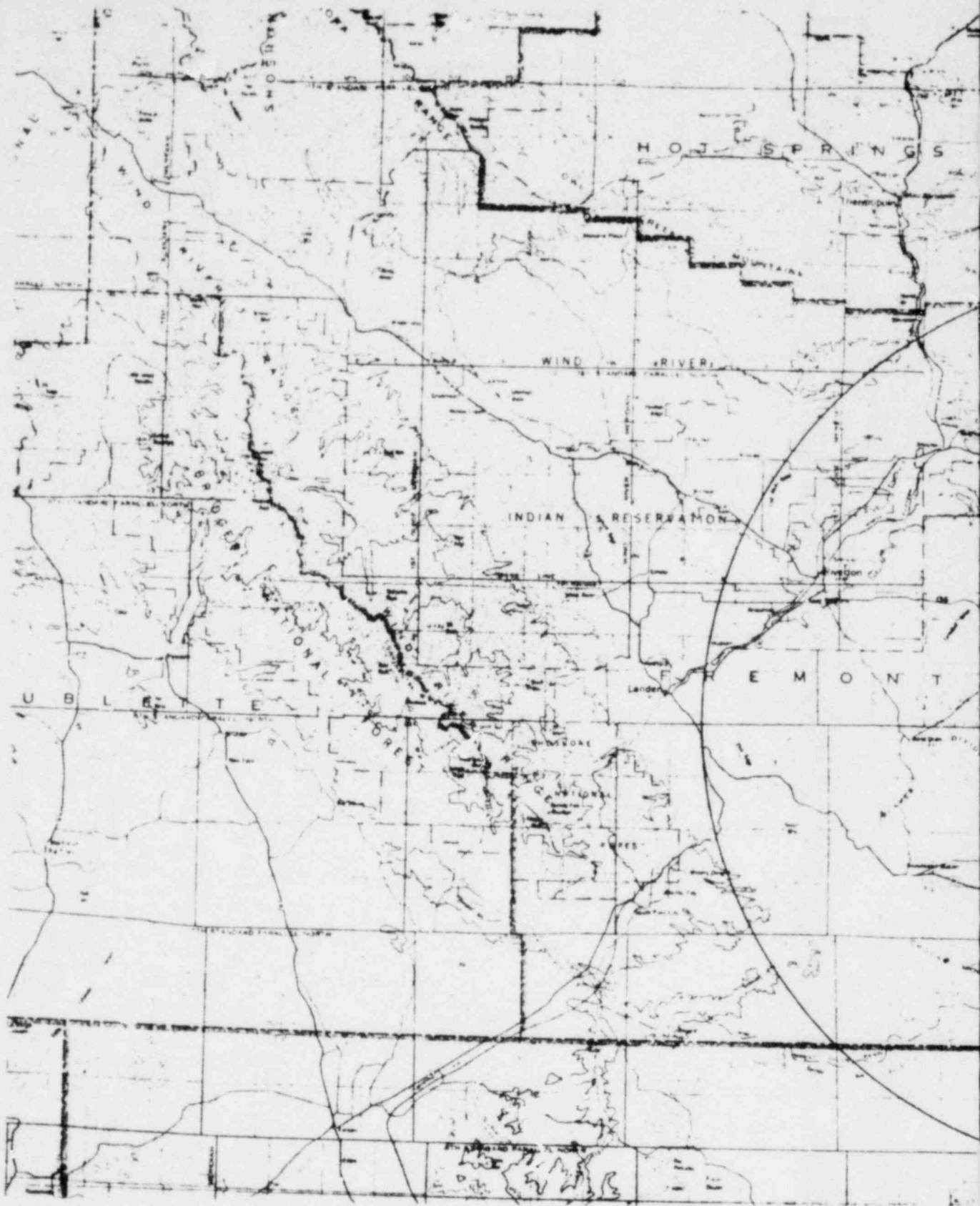
* Analysis not required by the Wyoming Department of Environmental Quality

** MW4 was not developed at the time the initial samples were taken

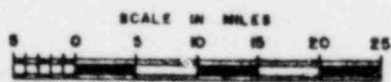
Note: All samples were collected January 1980.

material. The drain system will consist of 4 inch diameter perforated PVC or polyethylene pipe which will be covered with a porous medium (i.e., sand or gra . Seepage, if any, will be entrapped by the drain system and will be recovered for subsequent testing. Refer to Figure 7 for construction details.

Since the heap facility will be covered with mine waste fill, no specific monitoring program for windblown particulates will be required.

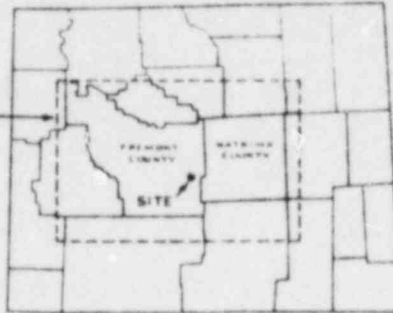


Reference: Dames & Moore location map,
Job No. 0022-067-26



CONTOUR INTERVAL 300 FEET

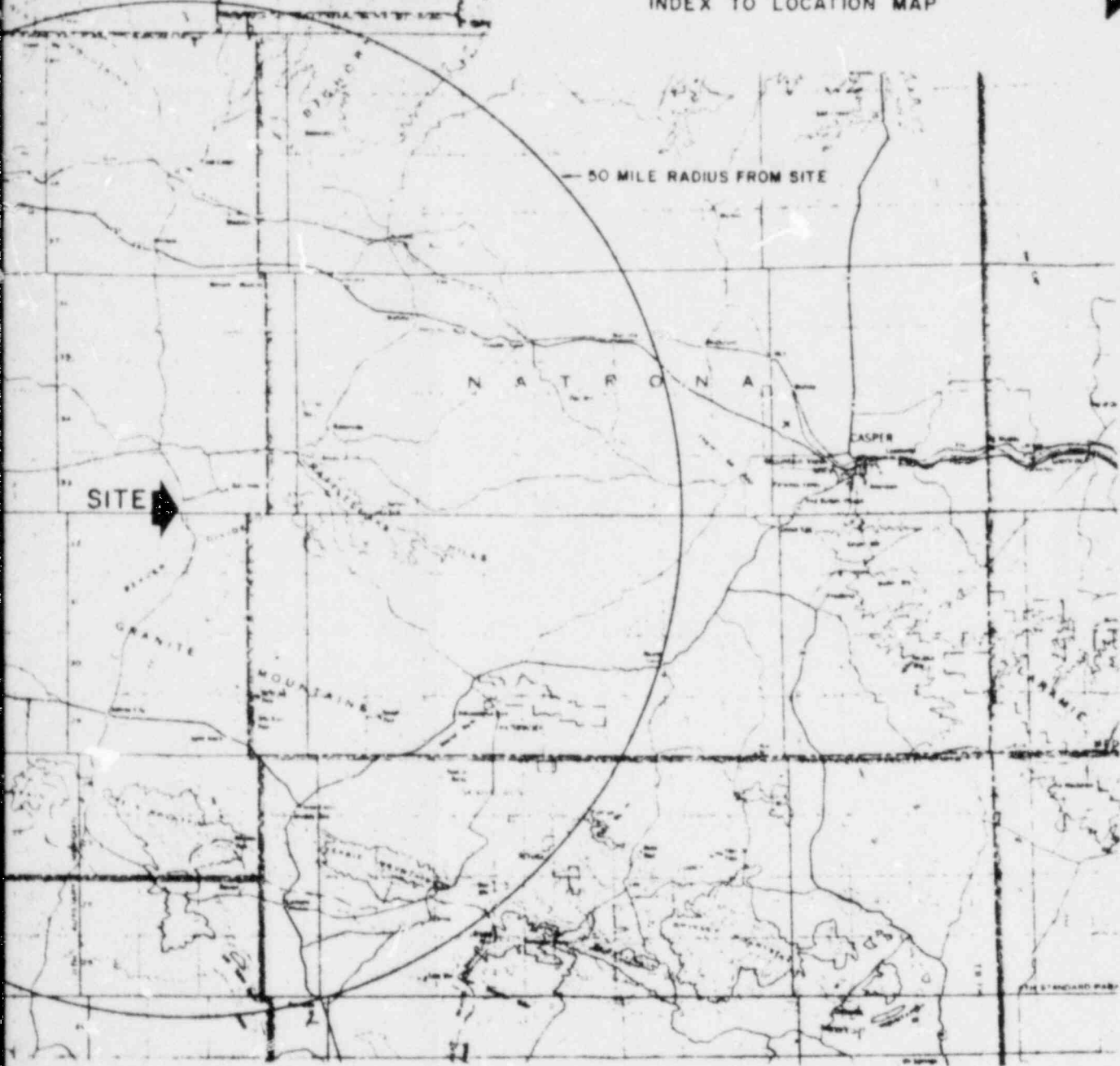
AREA OF
LOCATION
MAP



INDEX TO LOCATION MAP

— 50 MILE RADIUS FROM SITE

SITE



SITE VICINITY MAP



Consulting Engineers and Geologists

Job No. 1-2664-3118

Date: 8/8/80

Figure 1

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APPENDIX A
LITHOLOGICAL LOGS

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: Union Carbide Heap Leach Site A

PROJECT NO. 1-2664-3118

BORING NO. A-1

COLLAR ELEVATION: 6565.11

TOTAL DEPTH: 49'9"

DATE BEGUN: 12/12/79

DATE FINISHED: 12/12/79

LOGGED BY: John Dietzler

REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES	
SA	6565.11	4			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	32/12						29.10	19.4	0	26	112	
	6560	5															
	6555	10			Man-Made Fill, Siltstone and Mudstone, slightly clayey to slightly sandy, with traces of iron staining, medium moist, very stiff to hard, brown to gray	33/12											
	6550	15			Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	29/12											
	6545	20			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	36/12											
	6540	25				29/12										94	
	6535	30			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, gray	22/12											
	6530	35															
	6525	40			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	31/12											
	6520	45															
	6515.34	49'9"				56/12											

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS



- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-1

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: Union Carbide Heap Leach Site A

PROJECT NO. 1-2664-3118

BORING NO. A-2

COLLAR ELEVATION: 6565.68

TOTAL DEPTH: 49'5"

DATE BEGUN: 12/13/79

DATE FINISHED: 12/13/79

LOGGED BY: John Dietzler



REVIEWED BY: Don Taylor


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
SA	6565.68	0			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, gray	42/12					1.4*10 ³	14.4	0	26	103	
	6561	5														
	6556	10				31/12										
	6551	15			Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	22/12						40.3	21	24	99	
	6546	20			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, gray	33/12										
	6541	25				35/12									103	
	6536	30				28/12										
	6531	35														
	6526	40				32/12										
	6521	45			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown											
	6516.24	49'5"				60/6										

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

30 INCH FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-2

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: Union Carbide Heap Leach Site A PROJECT NO. 1-2664-3118 BORING NO. A-3
 COLLAR ELEVATION: 6560.85 TOTAL DEPTH: 49'F"
 DATE BEGUN: 12/12/79 DATE FINISHED: 12/12/79 LOGGED BY: John Dietzler REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
SA	6560.85	0			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	32/12						11.6	0	24	76	
	6556	5				32/14										
	6551	10				20/12										
	6546	15				28/12										
	6541	20			Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	28/12									112	
	6536	25				52/12										
	6531	30				100/6										
	6526	35				42/6										
	6521	40			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown											
	6516	45														
	6511.35	49'F"														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

INDICATES CORE RECOVERY

INDICATES CORE LOSS

INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS: NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-3

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: Union Carbide Head Leach Site A PROJECT NO. 1-2664-3118 BORING NO. A-4

COLLAR ELEVATION: 6550.93 TOTAL DEPTH: 49'6"

DATE BEGUN: 12/12/79 DATE FINISHED: 12/12/79 LOGGED BY: John Dietzler REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING # 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES	
SA	6558.83	4			Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	30/12					19.10	39.9	21	25	102		
	6554	5															
	6549	10					23/12									109	
	6544	15				Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	68/12										
	6539	20				Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	40/12										
	6534	25			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, gray	35/12											
	6529	30				58/12					13.3	22	23	99			
	6524	35															
	6519	40					20/6										
	6514	45				40/6											
	6509.33	49'6"			Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	42/6											

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

- INDICATES CORE RECOVERY
- INDICATES CORE LOSS

- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS, NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-4

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: Union Carbide Heap Leach Site A

PROJECT NO. 1-2664-3119

BORING NO. A-6

COLLAR ELEVATION: 6560.31

TOTAL DEPTH: 49'6"

DATE BEGUN: 12/13/79

DATE FINISHED: 12/13/79

LOGGED BY: John Dietzler

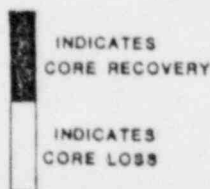
REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION ^o RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
SA	6560.31	4			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, gray	54/12										
	6555	5														
	6550	10				33/12										
	6545	15				60/12										
	6540	20			Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	29/12						39.9	23	24	114	
	6535	25			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, gray	36/12										
	6530	30				60/12						19.5	23	25	118	
	6525	35														
	6520	40			Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	35/12										
	6515	45														
	6510.8	49'6"			Man-Made Fill, Siltstone and Mudstone, slightly clayey to slightly sandy, with traces of iron staining, medium moist, very stiff to hard, brown to gray	62/12						57.3	21	29	121	

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-5

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 4

PROJECT: UNION CARBIDE HEAP LEACH

PROJECT NO. 1-2664-3129

BIRING NO. A-6

COLLAR ELEVATION: 6560.85

TOTAL DEPTH: 161'

DATE BEGUN: 2-18-80

DATE FINISHED: 2-21-80

LOGGED BY: Bill Root



REVIEWED BY: Don Taylor


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION [#] RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	6560.85	0			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	36/12										
	6556	5														
	6551	10			MAN-MADE FILL, SANDSTONE, fine grained to medium grained, with traces of coarse grained, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	29/12										
	6546	15			MAN-MADE FILL, SILTSTONE and MUDSTONE, slightly clayey to slightly sandy, with traces of iron staining, medium moist, very stiff to hard, brown to gray	21/12										
	6541	20			MAN-MADE FILL, SANDSTONE, fine grained to medium grained with traces of coarse grained, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	24/12										
	6536	25				30/12										
	6531	30				29/12										
	6526	35				48/12										
	6521	40			MAN-MADE FILL, SILTSTONE and MUDSTONE, slightly clayey to slightly sandy, with traces of iron staining, medium moist, very stiff to hard, brown to gray	48/12										
	6516	45				43/12										
	6511	50			MAN-MADE FILL, SANDSTONE, fine grained to medium grained, with traces of coarse grained, silty, slightly clayey, medium moist to moist, medium dense, brown to gray	34/12										

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCH. *S. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-6

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 2 OF 3

PROJECT: UNION CARBIDE HEAP LEACH PROJECT NO. 1-2664-3129 BORING NO. A-6

COLLAR ELEVATION: 6560.85 TOTAL DEPTH: 161'

DATE BEGUN: 2-18-80 DATE FINISHED: 2-21-80 LOGGED BY: Bill Root REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	R Q D (%)	CORE RECOVERY (%)	FEET SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	6511	50			MAN-MADE FILL, SANDSTONE, fine grained to medium grained, with traces of coarse gr. ned, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	60,6										
	6506	55			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	70,12										
	6501	60			MAN-MADE FILL, SANDSTONE, fine grained to medium grained, with traces of coarse grained, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	54,6										
	6495	65														
	6491	70			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	92,6										
	6486	75				57,12										
	6481	80				45,6										
	6476	85				100,6										
	6471	90				40,6										
	6466	95				100,										
	6461	100				60,12										

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

- INDICATES CORE RECOVERY
- INDICATES CORE LOSS

- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS. NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-6

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 3 OF 4

PROJECT: UNION CARBIDE HEAP LEACH PROJECT NO. 1-2664-129 BORING NO. A-6

COLLAR ELEVATION: 6560.95 TOTAL DEPTH: 161'



DATE BEGUN: 2-18-80 DATE FINISHED: 2-21-80 LOGGED BY: Bill Root REVIEWED BY: Don Taylor


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R 6"	6461	100			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown											
	6456	105														
	6451	110				40,6										
	6446	115			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, gray											
	6441	120				50,6										
	6436	125														
	6431	130				75,6										
	6426	135														
	6421	140														
	6416	145			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown											
	6411	150				125,6										

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

- * STANDARD PENETRATION TEST:
BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-6

F. M. FOX & ASSOCIATES, INC.
 SUBSURFACE EXPLORATION LOG

SHEET 4 OF 4

PROJECT: UNION CARBIDE HEAP LEACH

PROJECT NO. 1-2664-3129

BORING NO. A-6

COLLAR ELEVATION: 6560.85

TOTAL DEPTH: 161'

DATE BEGUN: 2-18-80

DATE FINISHED: 2-21-80

LOGGED BY: Bill Root

REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	6411	150			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	50,6										
	6400	155														
	6401	160														
	6399.85	161														
		165														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS



- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS, NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-6

F. M. FOX & ASSOCIATES, INC.
 SUBSURFACE EXPLORATION LOG

SHEET 1 OF 5

PROJECT: UNION CARBIDE HEAP LEACH PROJECT NO. 1-2664-3129 BORING NO. A-7

COLLAR ELEVATION: 6560.85 TOTAL DEPTH: 242' 6"

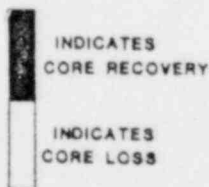
DATE BEGUN: 2-20-80 DATE FINISHED: 3-8-80 LOGGED BY: Bill Root REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE*	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	6560.85	0			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown											
	6556	5				38/6										
	6551	10				50/12										
	6546	15	▨		MAN-MADE FILL, SANDSTONE, fine grained to medium grained, with traces of coarse grained, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	39/12										
	6541	20	▨			44/12										
	6536	25	▨			20/12										
	6531	30	▨			61/12										
	6526	35	▨			48/12										
	6521	40	▨			60/12										
	6516	45			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	29/12										
	6511	50				56/12										

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



W/28 INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:
 BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-7

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 2 OF 5



PROJECT: UNION CARRIAGE HEAP LEACH PROJECT NO. 1-2664-2129 BORING NO. A-7
 COLLAR ELEVATION: 5560.85 TOTAL DEPTH: 232' 6"
 DATE BEGUN: 2-20-80 DATE FINISHED: 3-8-80 LOGGED BY: Bill Root REVIEWED BY: Don Taylor


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	5511	50			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	39,6										
	5506	55				73,6										
	5501	60				62,6										
	5496	65				70,6										
	5491	70				150,6										
	5486	75			MAN-MADE FILL, SANDSTONE, fine grained to medium grained, with traces of coarse grained, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	63,12										
	5481	80				64,6										
	5476	85				100,6										
	5471	90				66,6										
	5466	95				120,6										
	5461	100				66,6										

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST.

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-7

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 3 OF 5

PROJECT: UNION CARBIDE HEAP LEACH PROJECT NO. 1-2664-3129 BORING NO. A-7

COLLAR ELEVATION: 5560.85 TOTAL DEPTH: 232' 6"

DATE BEGUN: 2-20-80 DATE FINISHED: 3-8-80 LOGGED BY: Bill Root REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R 6"	6461	100			MAN-MADE FILL, SANDSTONE, fine grained to medium grained, with traces of coarse grained, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray											
	6456	105			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, gray											
	6451	110				90,6										
	6446	115														
	6441	120			MAN-MADE FILL, SANDSTONE, fine grained to medium grained, with traces of coarse grained, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	54,6 & 90,6										
	6436	125														
	6431	130				46,6										
	6426	135														
	6421	140			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist medium dense to dense, yellow brown to brown	62,6										
	6416	145														
	6411	150														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

- INDICATES CORE RECOVERY
- INDICATES CORE LOSS

- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST.

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-7

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 4 OF 5



PROJECT: UNION CARBIDE HEAP LEACH PROJECT NO. 1-2664-3129 BORING NO. A-7
 COLLAR ELEVATION: 6560.85 TOTAL DEPTH: 242' 6"
 DATE BEGUN: 2-20-80 DATE FINISHED: 3/8/80 LOGGED BY: Bill Root REVIEWED BY: Don Taylor


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R 6"	6411	150			MAN-MADE FILL, SANDSTONE, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, yellow to brown											
	6406	155														
	6401	160														
	6396	165			MAN-MADE FILL, SANDSTONE, fine grained to medium grained, with traces of coarse grained, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray											
	6391	170														
	6386	175														
	6381	180														
	6376	185														
	6371	190														
	6366	195														
	6361	200														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-7

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 5 OF 5

PROJECT: UNION CARBIDE HEAP LEACH

PROJECT NO. 1-266-3129

BORING NO. A-7

COLLAR ELEVATION: 6560.85

TOTAL DEPTH: 242' 6"

DATE BEGUN: 2-20-80

DATE FINISHED: 3-8-80

LOGGED BY: Bill Root

REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES		
R	6361	200	[Hatched pattern]		MAN-MADE FILL, SANDSTONE, fine grained to medium grained, with traces of coarse grained, silty slightly clayey, medium moist to moist, medium dense to dense, brown to gray	40/12												
	6356	205																
	6351	210																
	6346	215																
	6341	220						65/6										
	6336	225																
	6331	230																
	6326	235																
	6321	240																
	6318.35	242' 6"						40/6										
		245																

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS



- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-7

F. M. FOX & ASSOCIATES, INC.
 SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: Union Carbide Heap Leach Retention Pond PROJECT NO. 1-2664-3118 BORING NO. HP-1

COLLAR ELEVATION: 6491.45 TOTAL DEPTH: 49'



DATE BEGUN: 12/17/79 DATE FINISHED: 12/17/79 LOGGED BY: John Dietzler REVIEWED BY: Don Taylor


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
SA	6491.45				Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	28/12						58.0	32	33	121	Test Hole 5' below grade
	6486	5				19/12										
	6481	10			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, gray	28/12										
	6476	15				21/12										
	6471	20				33/12										
	6466	25			Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	58/12						46.4	25	33	105	
	6461	30			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	54/12						13.9	22	22	102	
	6456	35														
	6451	40				60/6										
	6446	45														
	6442.45	49														
		50														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

- * STANDARD PENETRATION TEST:
 BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-8

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: Union Carbide Heap Leach Retention Pond

PROJECT NO. 1-2664-3118

BORING NO. HP-2

COLLAR ELEVATION: 6498.65

TOTAL DEPTH: 49'4"

DATE BEGUN: 12/13/79

DATE FINISHED: 12/13/79

LOGGED BY: John Dietzler

REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION * RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES	
SA	6498.65	4			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown	32/12											
	6494	5				48/12					5.6*10 ⁻⁴	17.8	0	22	107		
	6489	10				41/12											
	6484	15				24/12											
	6479	20				46/12							10.7	23	21	104	
	6474	25			Man-Made Fill, Sandstone, fine grained to medium grained with traces of coarse grain, silty, slightly clayey, medium moist to moist, medium dense to dense, brown to gray	60/6											
	6469	30				22/12											
	6464	35			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, with traces of iron staining, medium moist to moist, medium dense to dense, yellow brown to brown												
	6459	40															
	6454	45			Man-Made Fill, Sandstone, fine grained to coarse grained, slightly clayey to slightly silty, medium moist to moist, medium dense to dense, gray												
	6449.32	49'4"				75/6							14.7	18	19	115	

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS

- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS: NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-9

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: UNION CARBIDE HEAP LEACH SITE K-1 PROJECT NO. 1-2664-3118 BORING NO. K1-1

COLLAR ELEVATION: 6.405 TOTAL DEPTH: 50 feet

DATE BEGUN: April 22, 1980 DATE FINISHED: April 22, 1980 LOGGED BY: Mike Unger REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION * RESISTANCE	R Q D (IN)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES		
HA 6.5	6455		[Diagonal hatching pattern]		MAN-MADE FILL, SANDSTONE, fine to medium grained with traces of coarse grains, silty, slightly clayey in part, medium moist, medium dense to dense, gray	28/12												
	6480	5																
	6475	10						40/12					4x10 ⁻⁷	24.1	0	23	107	
	6470	15						46/9 & 20/2										
	6465	20						24/12										
	6460	25						27/12										
	6455	30																
	6450	35												16.8	18	23		
	6445	40		[Dotted pattern]			MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray	20/6 & 30/6										
	6440	45							17/6 & 23/6									
	6435	50				21/6&32/6												

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- [Solid black rectangle] INDICATES CORE RECOVERY
- [Open white rectangle] INDICATES CORE LOSS

- [Wavy line symbol] INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

FIGURE A-10

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: UNION CARBIDE HEAP LEACH SITE K-1

PROJECT NO. 1-2664-3118

BORING NO. KL-2

COLLAR ELEVATION: 6.483

TOTAL DEPTH: 50 feet

DATE BEGUN: April 22, 1980

DATE FINISHED: April 22, 1980

LOGGED BY: Mike Unger

REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES		
HA	6483		[Dotted pattern]		MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray													
	6478	5				30/12												
	6473	10				35/12						1x10 ⁻⁶	23.9	0	23	117		
	6468	15				24/6 & 40/6												
	6463	20				53/12												
	6458	25				35/12												
	6453	30				56/10												
	6448	35				50/12												
	6443	40				38/12												
	6438	45				26/6 & 37/6												
	6433	50		33/12														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

- [Solid black bar] INDICATES CORE RECOVERY
- [White bar] INDICATES CORE LOSS

- [Symbol] INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

FIGURE A-11

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: UNION CARBIDE HEAP LEACH SITE K-1

PROJECT NO. 1-2664-3118

BORING NO. K1-3

COLLAR ELEVATION: 6,483.13

TOTAL DEPTH: 50 feet

DATE BEGUN: April 23, 1980

DATE FINISHED: April 23, 1980

LOGGED BY: Mike Unger

REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES	
HA 6"	6483.13				MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray												
	6478	5				21/6 & 35/6											
	6473	10				18/12						17.1	0	22			
	6468	15				30/12											
	6463	20				26/12											
	6458	25				41/12											
	6453	30				30/6 & 40/6											
	6448	35				46/12											
	6443	40				64/12											
	6438	45				35/12											
	6433	50				32 / 6 & 53/6											

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS



- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS, NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

FIGURE A-12

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: UNION CARBIDE HEAP LEACH SITE K-1

PROJECT NO. 1-2664-3118

BORING NO. K-4

COLLAR ELEVATION: 6,483

TOTAL DEPTH: 50 feet

DATE BEGUN: April 23, 1980

DATE FINISHED: April 23, 1980

LOGGED F.Y: Mike Unger

REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE*	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES	
HA	6483	0	[Diagonal hatching pattern]		MAN-MADE FILL, SANDSTONE, fine to medium grained with traces of coarse grains, silty, slightly clayey in part, medium moist, medium dense to dense, gray	34/12						46.3	16	26			
	6478	5					29/12										
	6473	10	[Dotted pattern]		MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium coarse to dense, gray	47/12											
	6468	15				44/12											
	6463	20				51/12											
	6458	25				45/12											
	6453	30				21/6 & 40/6											
	6448	35				56/12											
	6443	40				28/12											
	6438	45				MAN-MADE FILL, SANDSTONE, fine to medium grained with traces of coarse grains, silty, slightly clayey in part, medium moist, medium dense to dense, gray	29/12										
	6433	50		[Diagonal hatching pattern]													

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS



- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS, NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

FIGURE A-13











F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 2

PROJECT: UNION CARBIDE HEAP LEACH SITE K-1 PROJECT NO. 1-2664-3118 BORING NO. K1-5

COLLAR ELEVATION: 6,481.96 TOTAL DEPTH: 80 feet



DATE BEGUN: April 24, 1980 DATE FINISHED: April 24, 1980 LOGGED BY: Mike Unger REVIEWED BY: Don Taylor


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	R O D (IN)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
HA	6481.96	0														
	6477	5			MAN-MADE FILL, SANDSTONE, fine to medium grained with traces of coarse grains, silty, slightly clayey in part, medium moist, medium dense to dense, gray	21/12										
	6472	10				19/12										
	6467	15			MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray	40/12										
	6462	20				21/12										
	6457	25				26/9 & 30/3										
	6452	30				20/12										
	6447	35			MAN-MADE FILL, SANDSTONE, fine to medium grained with traces of coarse grains, silty, slightly clayey in part, medium moist, medium dense to dense, gray	38/12										
	6442	40				53/12										
	6437	45			MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray	45/12										
	6432	50				39/12										

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST.

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

FIGURE A-14

F. M. FOX & ASSOCIATES, INC.
 SUBSURFACE EXPLORATION LOG



PROJECT: UNION CARBIDE HEAP LEACH SITE K-1 PROJECT NO. 1-2664-3118 BORING NO. X1-5
 COLLAR ELEVATION: 6,481.95 TOTAL DEPTH: 80 feet
 DATE BEGUN: April 24, 1980 DATE FINISHED: April 24, 1980 LOGGED BY: Mike Unger REVIEWED BY: Don Taylor


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
HA 6"	6432	50			MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray	33/12										
	6427	55				33/12										
	6422	60				59/12										
	6417	61			MAN-MADE FILL, SANDSTONE, fine to medium grained with traces of coarse grains, silty, slightly clayey in part, medium moist, medium dense to dense, gray	48/12										
	6412	70			MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray	41/12										
	6407	75			MAN-MADE FILL, SANDSTONE, fine to medium grained with traces of coarse grains, silty, slightly clayey in part, medium moist, medium dense to dense, gray	54/12										
	6402	80			MAN-MADE FILL, SANDSTONE, fine to coarse grained with traces of gravel, silty and clay, medium moist, medium hard to hard, yellow brown to brown											

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

FIGURE A-14

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 2

PROJECT: UNION CARBIDE HEAP LEACH SITE K-1 PROJECT NO. 1-2664-3118 BORING NO. K1-6

COLLAR ELEVATION: 6,483.50 TOTAL DEPTH: 95 feet



DATE BEGUN: April 24, 1980 DATE FINISHED: April 25, 1980 LOGGED BY: Mike Unger REVIEWED BY: Gun Taylor


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION * RESISTANCE	P-O-D (IN)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
SA	6483.5	0			MAN-MADE FILL, SANDSTONE, fine to medium grained with traces of coarse grains, silty, slightly clayey in part, medium moist, medium dense to dense, gray	26/12										
	6479	5			MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray	18/12										
	6474	10														
	6469	15				20/6 & 32/6										
	6464	20			MAN-MADE FILL, SANDSTONE, fine to medium grained with traces of coarse grains, silty, slightly clayey in part, medium moist, medium dense to dense, gray	33/12										
	6459	25				34/12										
	6454	30			MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray	40/9 & 29/3										
	6449	35				28/12										
	6444	40				35/6 & 42/6										
	6439	45				37/12										
	6434	50				30/12										

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS: NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

FIGURE A-15

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 2 OF 2

PROJECT: UNION CARBIDE HEAP LEACH SITE K-1 PROJECT NO. 1-2664-3118 BORING NO. K1-6
 COLLAR ELEVATION: 6,483.50 TOTAL DEPTH: 95 feet
 DATE BEGUN: April 24, 1980 DATE FINISHED: April 25, 1980 LOGGED BY: Mike Unger REVIEWED BY: Don Taylor

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE*	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
HA 6"	4434	50	[Pattern]		MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray	39/12										
	4429	55	[Pattern]		MAN-MADE FILL, SANDSTONE, fine to medium grained with traces of coarse grains, silty, slightly clayey in part, medium moist, medium dense to dense, gray	45/12										
	4424	60	[Pattern]			46/12										
	4419	65	[Pattern]			52/12										
	4414	70	[Pattern]		MAN-MADE FILL, SANDSTONE, fine to coarse grained with white quartz grains, slightly silty to slightly clayey, medium moist, medium dense to dense, gray	52/12										
	4409	75	[Pattern]			37/12										
	4404	80	[Pattern]			67/12										
	6399	85	[Pattern]			78/12						18.1	0	18	117	
	6394	90	[Pattern]		MAN-MADE FILL, SANDSTONE, fine to coarse grained with traces of gravel, silt and clay, medium moist, medium hard to hard, yellow brown to brown	36/12										
	6389	95	[Pattern]													

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- [Solid Black Box] INDICATES CORE RECOVERY
- [White Box with Border] INDICATES CORE LOSS

INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

FIGURE A-15

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1

PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. 1W-41

COLLAR ELEVATION: 5568.8 TOTAL DEPTH: 250 feet



DATE BEGUN: 12/19/79 DATE FINISHED: 12/19/79 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	A Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	5555	0			Fill, Sand & Gravel, very silty, slightly clayey, light brown											7-7/8" bit
	5559	10														
	5549	20			Sand, fine grained with traces of coarse grains, clayey, silty, blue to brown											One bag Wolf One bag Loloss
	5539	30														
	5529	40														
	5519	50			Sand & Gravel with quartz grains, slightly silty, brown											42' much harder drilling
	5504	60														
	5499	70			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	5489	80														
	5479	90														
	5469	100														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 2 OF 3

PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. MW #1
 COLLAR ELEVATION: 6568.8 TOTAL DEPTH: 250 feet
 DATE BEGUN: 12/19/79 DATE FINISHED: 12/19/79 LOGGED BY: Dave Douglas REVIEWED BY: Donald R. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION * RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES		
R	6465	100			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown													
7.7	6459	110																
	6449	120																
	6439	130																
	6429	140																
	6419	150																
	6409	160																
	6399	170																Harder drilling
	6389	180																
	6379	190																
	6369	200			Interbedded Siltstone and Claystone, sandy, moderately to well cemented, blue													

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS



- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-16

F. M. FOX & ASSOCIATES, INC.
 SUBSURFACE EXPLORATION LOG

SHEET 3 OF 3

PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-31 BORING NO. MW #1

COLLAR ELEVATION: 6566.8 TOTAL DEPTH: 250 feet

DATE BEGUN: 12/13/79 DATE FINISHED: 12/19/79 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES			
R	6369	200			Interbedded Siltstone and Claystone, sandy, moderately to well cemented, blue														
	6359	210																	
	6349	220																	
	6339	230																	
	6329	240																	
	6319	250																	

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS



- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-16

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 3

PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. PH #2
 COLLAR ELEVATION: 657.8 TOTAL DEPTH: 250 feet
 DATE BEGUN: 12/20/79 DATE FINISHED: 12/20/79 LOGGED BY: Dave Douglass REVIEWED BY: Donald F. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	6573	0			Fill, Sand, fine grained with traces of gravel, silty, slightly clayey, some iron staining noted, brown to blue											7-7/8" bit 1/2 bag Wolf 1/2 bag Loloss
	6563	10														
	6553	20														
	6543	30														
	6533	40														
	6523	50														
	6513	60			Sand & Gravel with quartz grains, slightly silty, brown											
	6503	70			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	6493	80														
	6483	90														
	6473	100														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS



- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-17

F. M. FOX & ASSOCIATES, INC.
 SUBSURFACE EXPLORATION LOG

SHEET 2 OF 3

PROJECT: Union Carbide - Mean Leach PROJECT NO. 1-2664-3118 BORING NO. HW #2
 COLLAR ELEVATION: 6572.8 TOTAL DEPTH: 250 feet
 DATE BEGUN: 12/20/79 DATE FINISHED: 12/20/79 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE*	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES	
R	6473	100			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown												
	6463	110			Sandstone, coarse grained, slightly silty with quartz gravel, weakly cemented, blue to brown												
	6453	120															
	6443	130															Losing circulation added 1/2 bag Wolf 1 bag Loluss
	6433	140															Added 1 bag Wolf 2 bags Loluss
	6423	150															Hard drilling 150 to 160 feet
	6413	160															Added 1 bag Wolf 1 bag Loluss
	6403	170															
	6393	180															
	6383	190															Losing circulation
	6373	200															

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

- INDICATES CORE RECOVERY
- INDICATES CORE LOSS

- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS, NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-17

F. M. FOX & ASSOCIATES, INC.
 SUBSURFACE EXPLORATION LOG

SHEET 3 OF 3

PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. M₁ #2
 COLLAR ELEVATION: 6572.8 TOTAL DEPTH: 250 feet
 DATE BEGUN: 12/20/79 DATE FINISHED: 12/20/79 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES		
	6373	200			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown													
	6363	210																
	6353	220																
	6343	230																
	6333	240																
	6323	250																

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

INDICATES CORE RECOVERY

INDICATES CORE LOSS

INDICATES WATER LEVEL AND DATE RECORDED


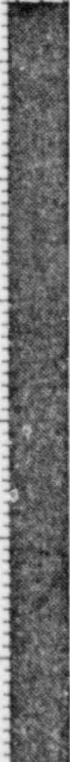
* STANDARD PENETRATION TEST:
 BLOWS/FOOT: RECORDED AS, NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-17

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 2

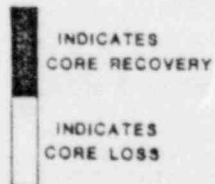
PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. NW #2
 COLLAR ELEVATION: 5567.29 TOTAL DEPTH: 250 feet
 DATE BEGUN: 1/7/80 DATE FINISHED: 1/7/80 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION* RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	5567.29	0			Fill, Sand, fine grained with traces of gravel, silty, slightly clayey, some iron staining noted, brown to blue											3 bags Wolf 6 bags Loluss
	5557	10														
	5547	20														
	5537	30														
	5527	40			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	5517	50														
	5507	60														
	5497	70														
	5487	80														
	5477	90														
	5467	100														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



 INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-18

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 2 OF 3

PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. M-13
 COLLAR ELEVATION: 6567.29 TOTAL DEPTH: 250 feet
 DATE BEGUN: 1/7/80 DATE FINISHED: 1/7/80 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION * RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES		
R	6457	100			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and annular quartz crystals, weakly to well cemented, blue to brown													
	6457	110																
	6447	120																
	6437	130																
	6427	140																
	6417	150																
	6407	160																
	6397	170																
	6387	180																
	6377	190																
	6367	200																

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

- INDICATES CORE RECOVERY
- INDICATES CORE LOSS

- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST.

BLOWS/FOOT: RECORDED AS, NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-18

F. M. FOX & ASSOCIATES, INC.
 SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1



PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2564-3118 BORING NO. MW #3
 COLLAR ELEVATION: 6567.29 TOTAL DEPTH: 250 feet
 DATE BEGUN: 1/7/80 DATE FINISHED: 1/7/80 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE*	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	6367	210			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals. ... cemented, blue to brown											
	6357	210														
	6347	220														
	6337	230														
	6327	240														
	6317	250														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS: NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-18

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 3

PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. 104 #4
 COLLAR ELEVATION: 6592.93 TOTAL DEPTH: 250 feet
 DATE BEGUN: 1/8/80 DATE FINISHED: 1/8/80 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
	6593	0			FILL, SAND, fine grained with traces of gravel, silty, slightly clayey, some iron staining noted, brown to blue											1 1/2 bags Wolf 2 bags Loloss
	6583	10			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	6573	20														
	6563	30														
	6553	40														
	6543	50			Interbedded Siltstone and Claystone, sandy, moderately to well cemented, blue											
	6533	60			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	6523	70														
	6513	80			Interbedded Siltstone and Claystone, sandy, moderately to well cemented, blue											
	6503	90			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	6493	100														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

INDICATES CORE RECOVERY

INDICATES CORE LOSS

INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-19

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 2 OF 3

PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. HW #4
 COLLAR ELEVATION: 6592.93 TOTAL DEPTH: 250 feet
 DATE BEGUN: 1/8/80 DATE FINISHED: 1/8/80 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION * RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES	
R	6493	100			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											Harder drilling	
	6483	110															
	6473	120															
	6463	130															
	6453	140			Sandstone, coarse grained, slightly silty with quartz gravel, weakly cemented, blue to brown												
	6443	150															
	6433	160															
	6423	170															
	6413	180															
	6403	190															
	6393	200															

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS

- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:


BLOWS/FOOT: RECORDED AS, NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES, REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-19

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 3 OF 3


PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. "W" #4
 COLLAR ELEVATION: 6592.93 TOTAL DEPTH: 250 feet
 DATE BEGUN: 1/8/80 DATE FINISHED: 1/8/80 LOGGED BY: Wade Downless REVIEWED BY: Donald B. Clark


TYPE AND SIZE OF HOLE (FEET)	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	6393	200			Sandstone, coarse grained, slightly silty with quartz gravel, weakly cemented, blue to brown											
	6383	210														
	6373	220														
	6363	230														
	6353	240														
	6343	250														


EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

 INDICATES CORE RECOVERY

 INDICATES CORE LOSS

 INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:






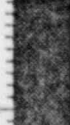
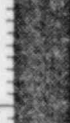



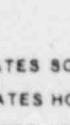
BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-19

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1



PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. MW #5
 COLLAR ELEVATION: 6653.65 TOTAL DEPTH: 250 feet
 DATE BEGUN: 1/3/80 DATE FINISHED: 1/3/80 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
	6654	0			Fill, Sand & Gravel, very silty, slightly clayey, light brown											1/2 bag Wolf 1 bag Loloss 7-7/8" bit
	6644	10			Sand, fine grained with traces of gravel, silty, slightly clayey, some iron staining noted, brown to blue											Drilling very slow - changed to a longer toothed bit
	6634	20														
	6624	30														
	6614	40														
	6604	50			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	6594	60														
	6584	70														
	6574	80			Sandstone, coarse grained, slightly silty with quartz gravel, weakly cemented, blue to brown											72-101 feet Harder drilling conglomerate
	6564	90														
	6554	100														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 2 OF 3

PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. W-5
 COLLAR ELEVATION: 5653.65 TOTAL DEPTH: 250 feet
 DATE BEGUN: 1/4/80 DATE FINISHED: 1/4/80 LOGGED BY: Dave Downess REVIEWED BY: Donald R. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE*	R O D (IN)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
	5554 100				Sandstone, coarse grained, slightly silty with quartz gravel, weakly cemented, blue to brown											110 feet - faster drilling
	5514 140				Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	5504 150															
	5494 160															
	5484 170															
	5474 180															
	5464 190															
	5454 200															

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS

- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-20

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 1 OF 1



PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. MW #5
 COLLAR ELEVATION: 6653.65 TOTAL DEPTH: 250 feet
 DATE BRGUN: 1/4/80 DATE FINISHED: 1/4/80 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES		
R	6454	200			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown													
	6444	210																
	6434	220																
	6424	230																
	6414	240																
	6404	250																
	6394	260																
	6384	270																
	6374	280																
	6364	290																
	6354	300																

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

 INDICATES CORE RECOVERY
 INDICATES CORE LOSS

 INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:
 BLOWS/FOOT: RECORDED AS: NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-20

F. M. FOX & ASSOCIATES, INC.
 SUBSURFACE EXPLORATION LOG

SHEET 1 OF 3



PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. MW #6
 COLLAR ELEVATION: 6611.54 TOTAL DEPTH: 250 feet
 DATE BEGUN: 1/5/80 DATE FINISHED: 1/5/80 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark


TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R O D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	6612	0			Sand, fine grained with traces of gravel, silty, slightly clayey, some iron staining noted, brown to blue											7-7/8" bit 1/2 bag Wolf 1 bag Loloss
	6602	10														
	6592	20														
	6582	30			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	6572	40														
	6562	50														52-76 feet - very hard drilling
	6552	60			Sandstone, coarse grained, slightly silty with quartz gravel, weakly cemented, blue to brown											
	6542	70														
	6532	80														
	6522	90														
	6512	100														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE

-  INDICATES CORE RECOVERY
-  INDICATES CORE LOSS

-  INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-21

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 2 OF 3

PROJECT: Union Carbide - Heap Leach

PROJECT NO. 1-2664-3118

BORING NO. MW #6

COLLAR ELEVATION: 6611.54












TOTAL DEPTH: 250 feet

DATE REGUN: 1/5/80

DATE FINISHED: 1/5/80

LOGGED BY: Dave Douglass

REVIEWED BY: Donald R. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE*	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES
R	6512.100	100			Sandstone, coarse grained, slightly silty with quartz gravel, weakly cemented, blue to brown											
	6502.110	110			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	6492.120	120			Sandstone, coarse grained, slightly silty with quartz gravel, weakly cemented, blue to brown											
	6482.130	130			Interbedded Siltstone and Claystone, sandy, moderately to well cemented, blue											
	6472.140	140			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown											
	6462.150	150														
	6452.160	160														
	6442.170	170														
	6432.180	180														
	6422.190	190														
	6412.200	200														

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS



- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-21

F. M. FOX & ASSOCIATES, INC.
SUBSURFACE EXPLORATION LOG

SHEET 3 OF 3

PROJECT: Union Carbide - Heap Leach PROJECT NO. 1-2664-3118 BORING NO. MW #6
 COLLAR ELEVATION: 6611.54 TOTAL DEPTH: 750 feet
 DATE BEGUN: 1/5/80 DATE FINISHED: 1/5/80 LOGGED BY: Dave Douglass REVIEWED BY: Donald R. Clark

TYPE AND SIZE OF HOLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	WATER LEVEL	LITHOLOGY AND PHYSICAL CONDITION	PENETRATION RESISTANCE	R Q D (%)	CORE RECOVERY (%)	TEST SECTIONS	FIELD PERMEABILITY CM./SEC.	LAB PERMEABILITY CM./SEC.	% PASSING 200	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	DRY DENSITY (PCF)	NOTES		
R	6412	200			Sandstone, fine grained with traces of coarse grains, silty, clayey with traces of iron staining and angular quartz crystals, weakly to well cemented, blue to brown													
	6402	210																
	6392	220																
	6382	230																
	6372	240																
	6362	250																

EXPLANATION

HOLE TYPES

- SA - INDICATES SOLID AUGER
- HA - INDICATES HOLLOW AUGER
- C - INDICATES CORE HOLE
- R - INDICATES ROTARY HOLE



- INDICATES CORE RECOVERY
- INDICATES CORE LOSS



- INDICATES WATER LEVEL AND DATE RECORDED

* STANDARD PENETRATION TEST:

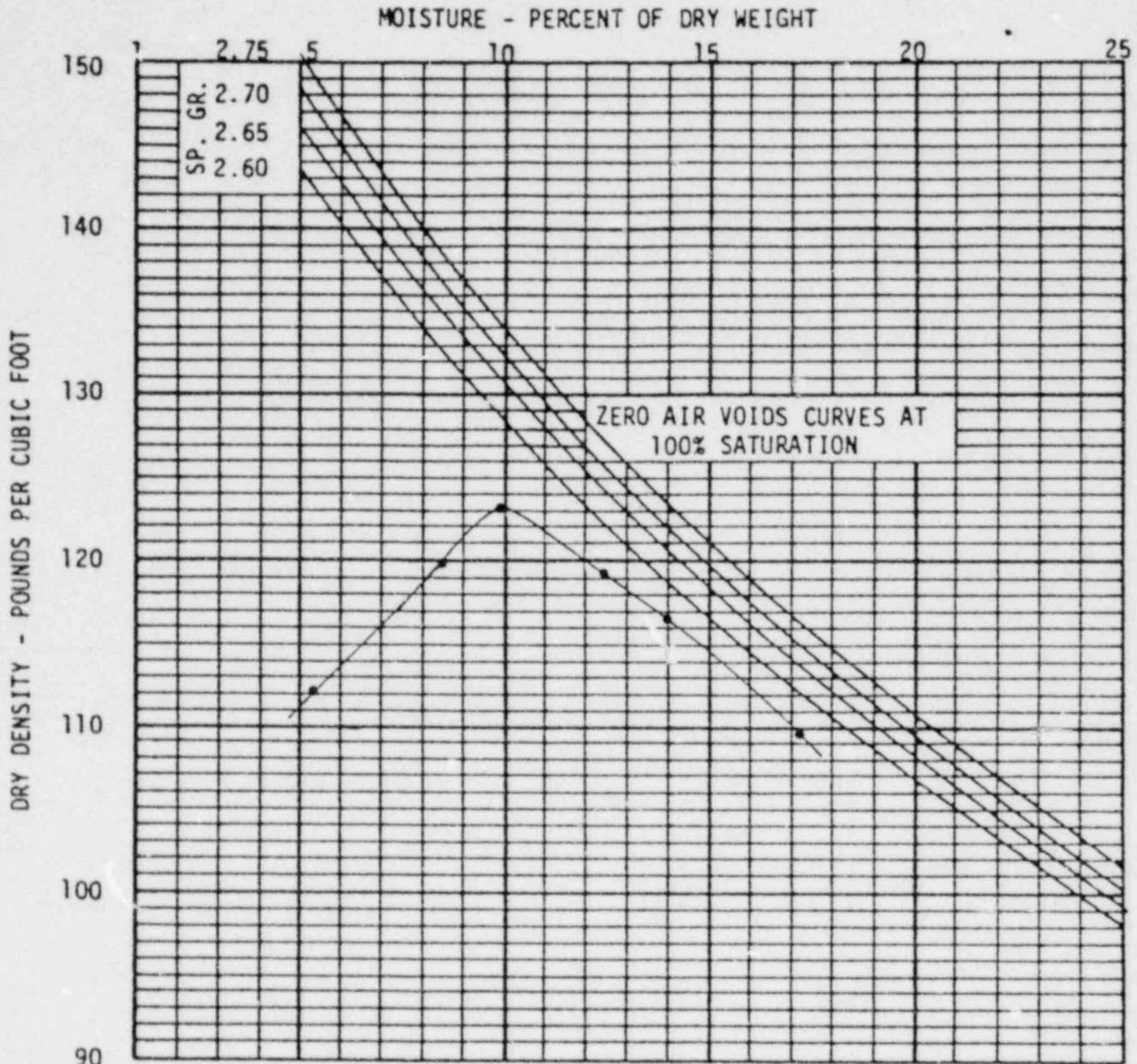
BLOWS/FOOT: RECORDED AS NUMBER OF BLOWS WITH A 140 POUND HAMMER, FALLING 30 INCHES. REQUIRED TO DRIVE A 2 INCH DIAMETER SAMPLER ONE FOOT.

Figure A-21

APPENDIX B
LABORATORY TEST RESULTS



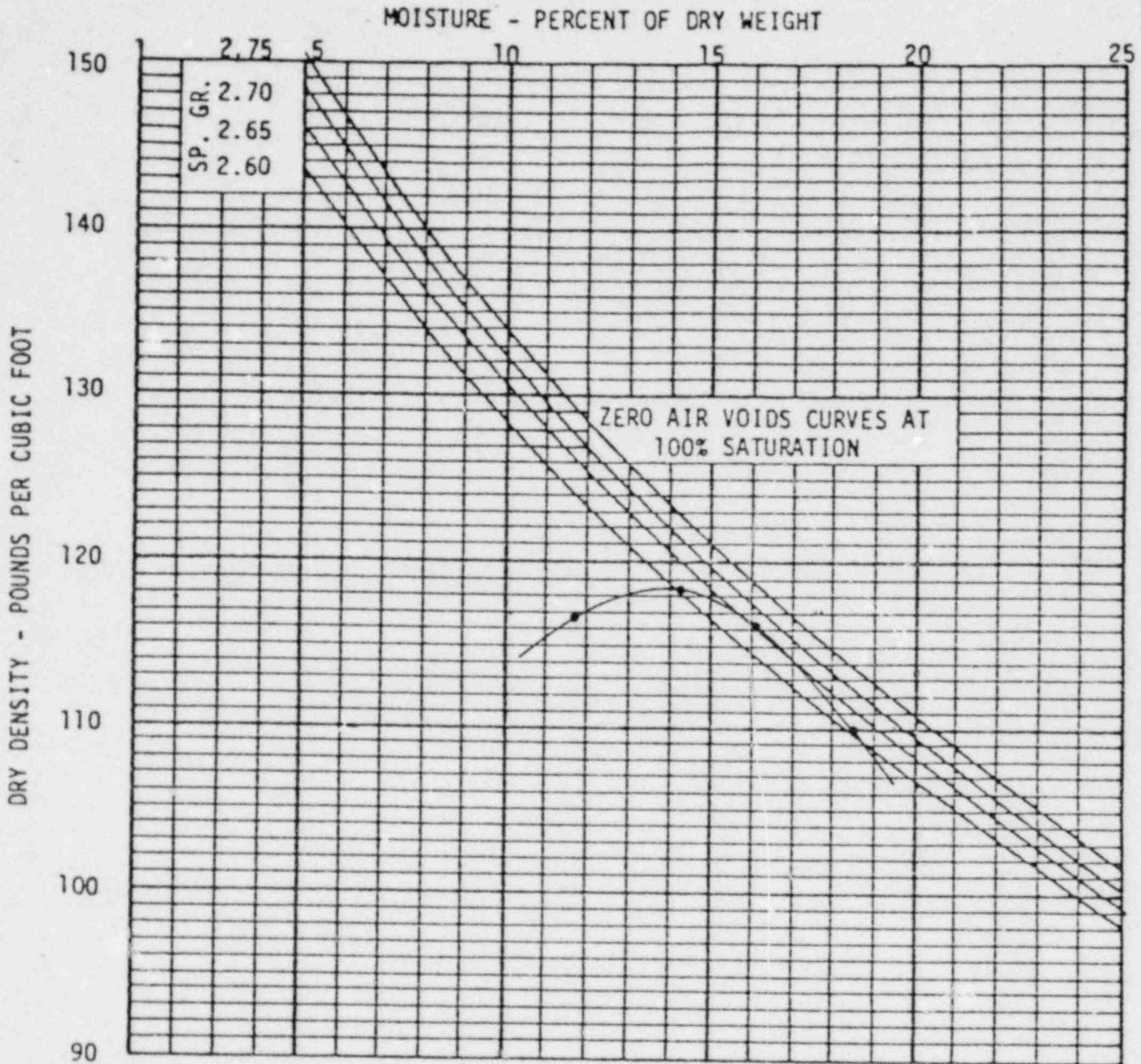
COMPACTION TEST RESULTS



MAXIMUM DRY DENSITY (PCF) 123 PROCTOR NUMBER _____
 OPTIMUM MOISTURE CONTENT (%) 10
 AMOUNT OF MATERIAL FINER THAN #200 SIEVE 60.7-74%
 ATTERBERG LIMITS: LL 30 PL 26 PI 4
 PERMABILITY TEST RESULTS: 6×10^{-5} cm/sec. Remolded to 90% modified.
 SAMPLE DESCRIPTION Clay Liner Material
 FROM _____ COMPACTION TEST PROCEDURE ASTM D-1557
 CHECK POINTS _____ PCF @ _____ %
 _____ PCF @ _____ %
 _____ PCF @ _____ %



COMPACTION TEST RESULTS



MAXIMUM DRY DENSITY (PCF) 118.5 PROCTOR NUMBER _____

OPTIMUM MOISTURE CONTENT (%) 14.0

AMOUNT OF MATERIAL FINER THAN #200 SIEVE 65.7-82.3

ATTERBERG LIMITS: LL 34-36 PL 21-23 PI 13

SWELL/CONSOLIDATION RESULTS: Liner material

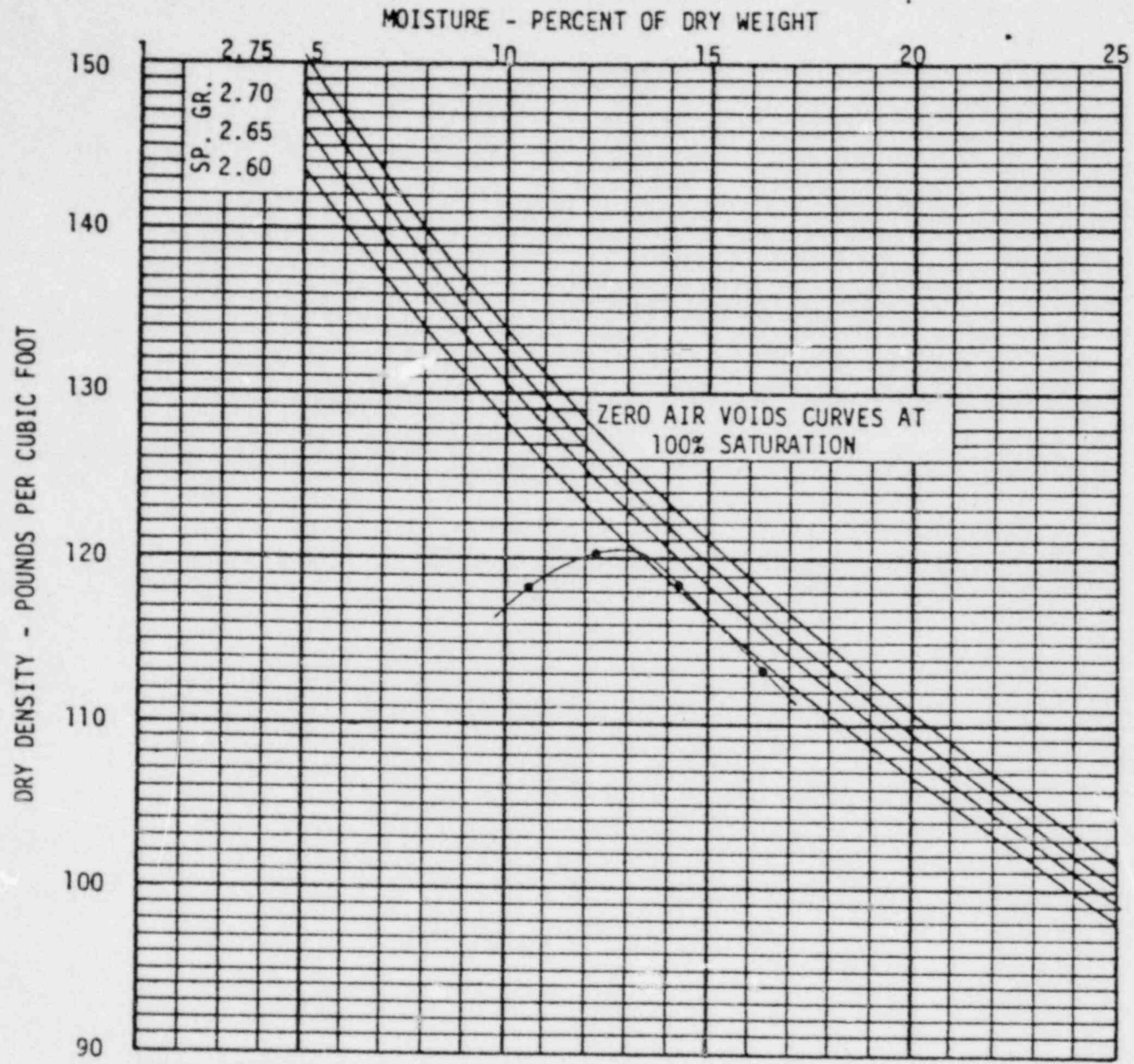
SAMPLE DESCRIPTION _____

FROM _____ COMPACTION TEST PROCEDURE ASTM D-1557

CHECK POINTS	_____ PCF @ _____ %	_____ PCF @ _____ %
	_____ PCF @ _____ %	_____ PCF @ _____ %
	_____ PCF @ _____ %	_____ PCF @ _____ %

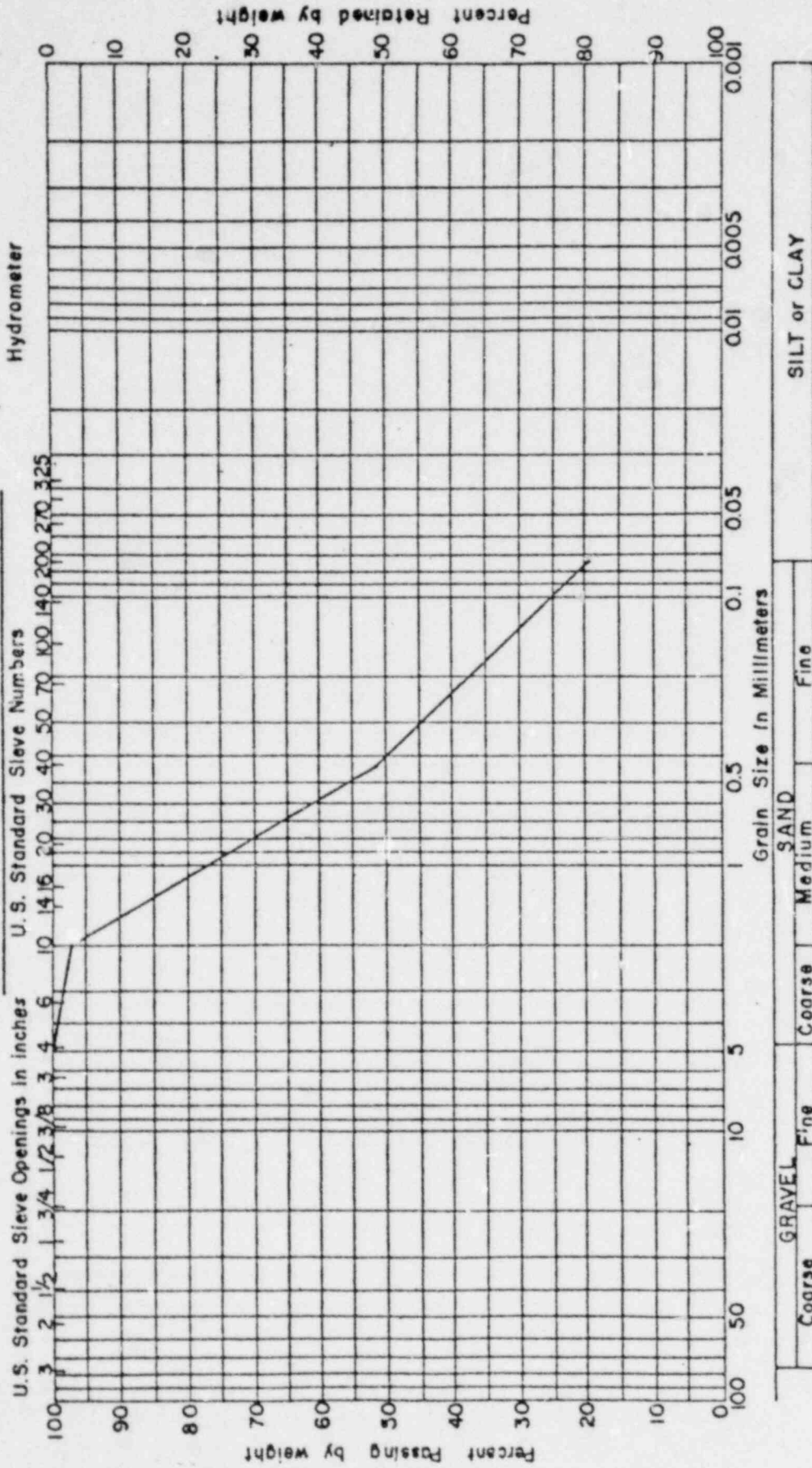


COMPACTION TEST RESULTS



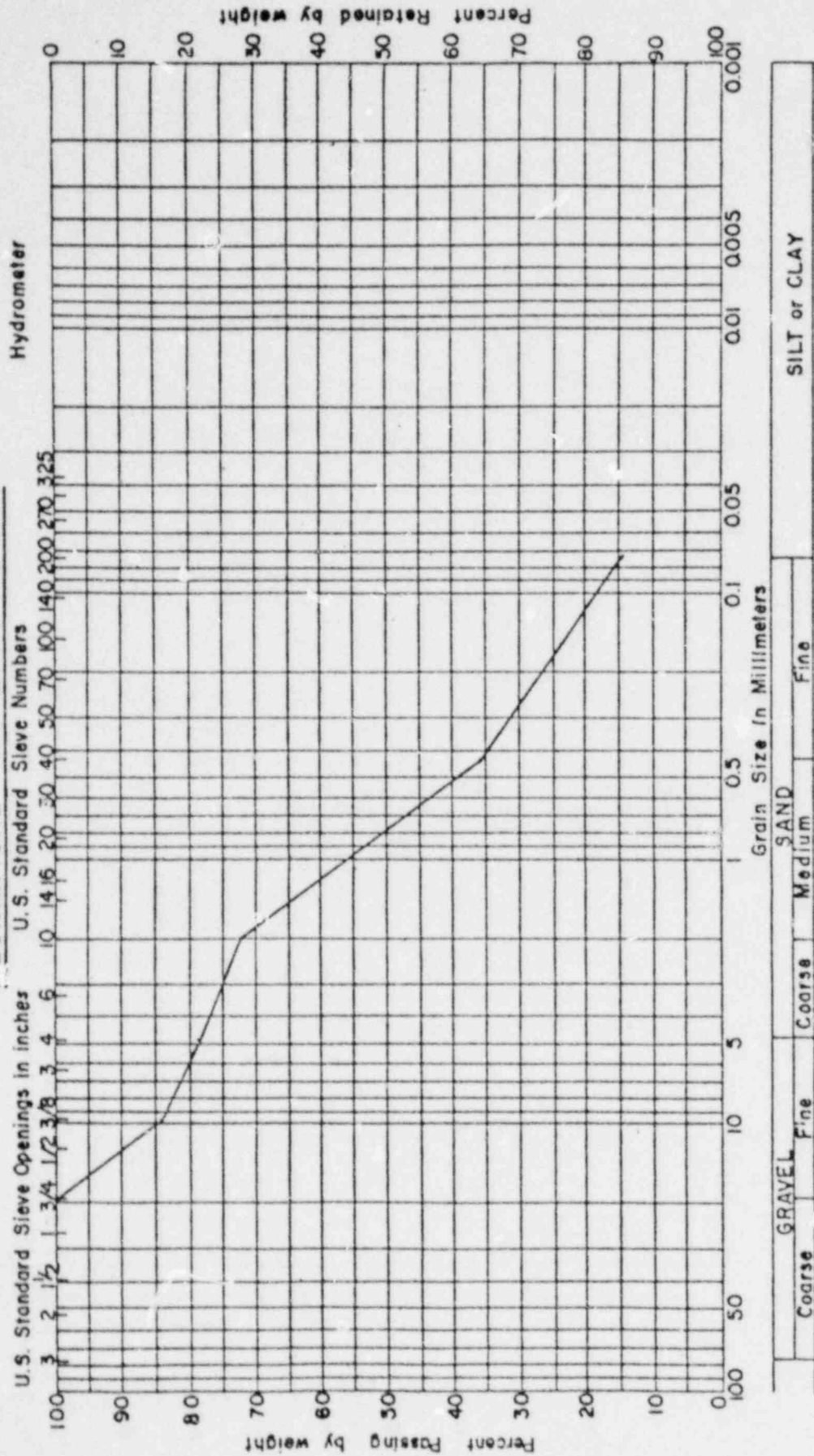
MAXIMUM DRY DENSITY (PCF) 120.5 PROCTOR NUMBER
OPTIMUM MOISTURE CONTENT (%) 13
AMOUNT OF MATERIAL FINER THAN #200 SIEVE 82.3%
ATTERBERG LIMITS: LL 36 PL 23 PI 13
PERMEABILITY TEST RESULTS 6x10^-8 cm/sec. Remolded to 95% modified.
SAMPLE DESCRIPTION Remolded Clay Liner Material
FROM COMPACTON TEST PROCEDURE ASTM D-1557
CHECK POINTS PCF @ %

MECHANICAL ANALYSIS CHART



Sample of Fill, silty SAND, from Test Hole A-1 at 4 feet (SM)

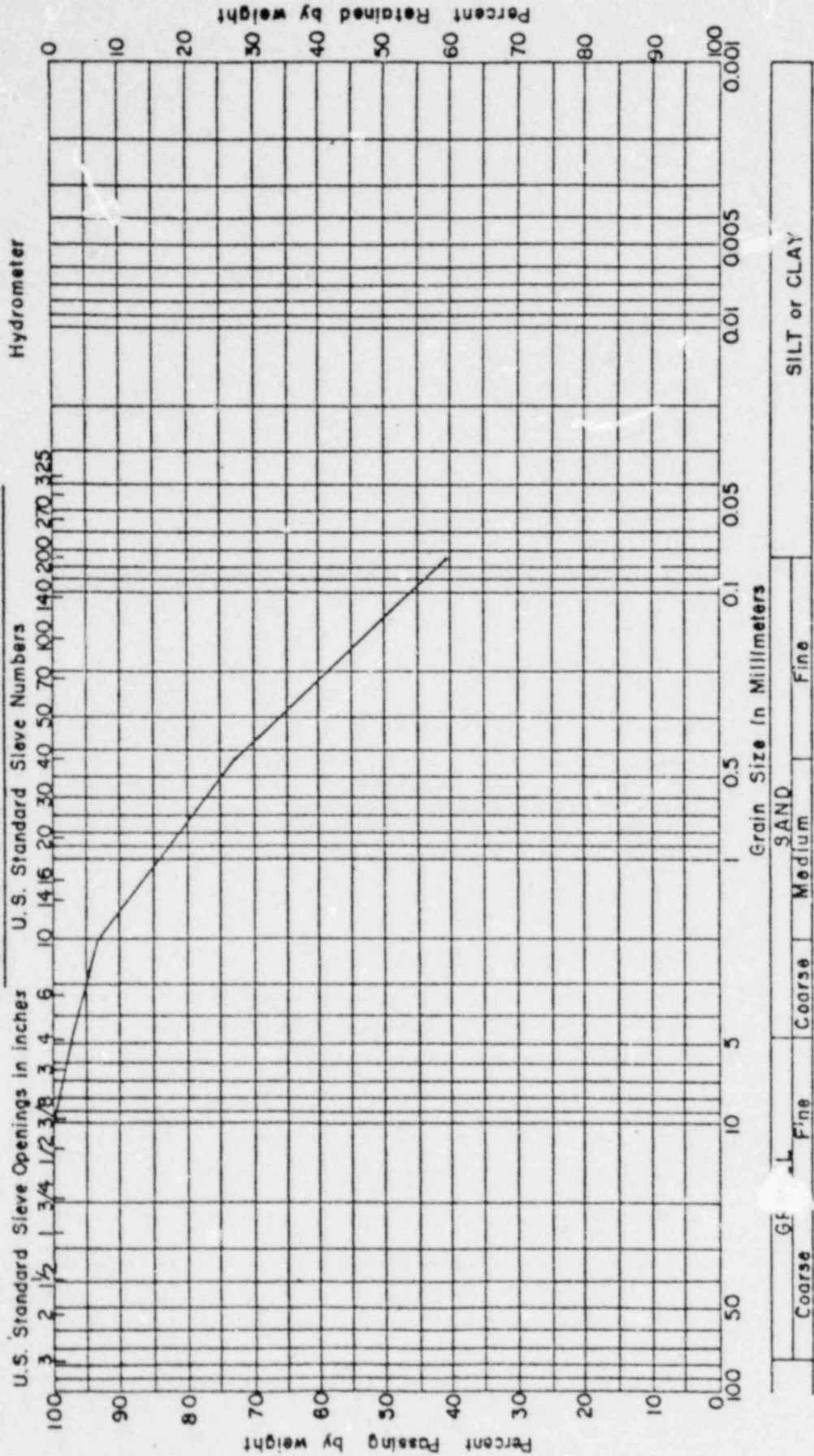
MECHANICAL ANALYSIS CHART



Sample of Fill, silty SAND, from Test Hole A-2 at 4 feet (SM)

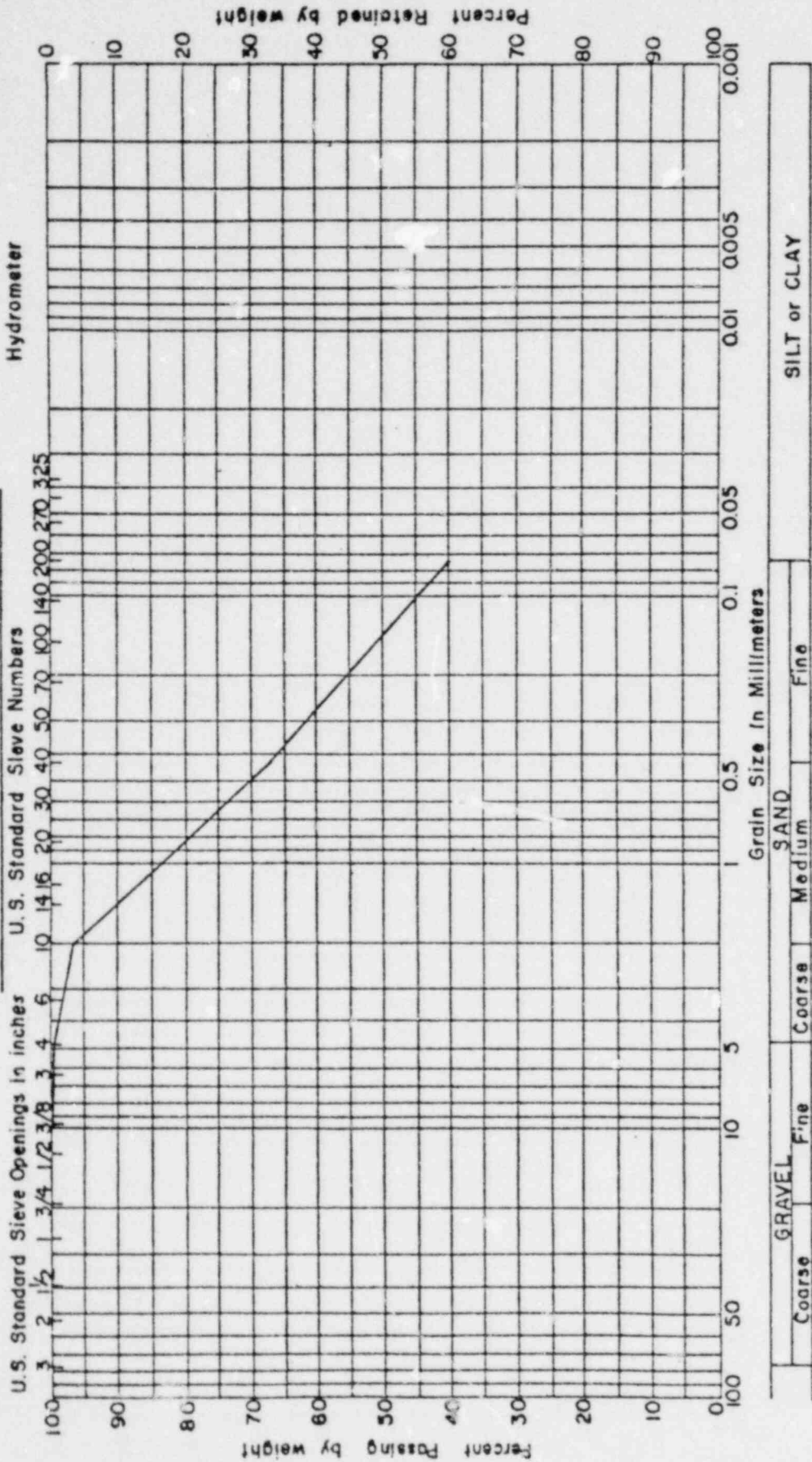
FIGURE B-5

MECHANICAL ANALYSIS CHART

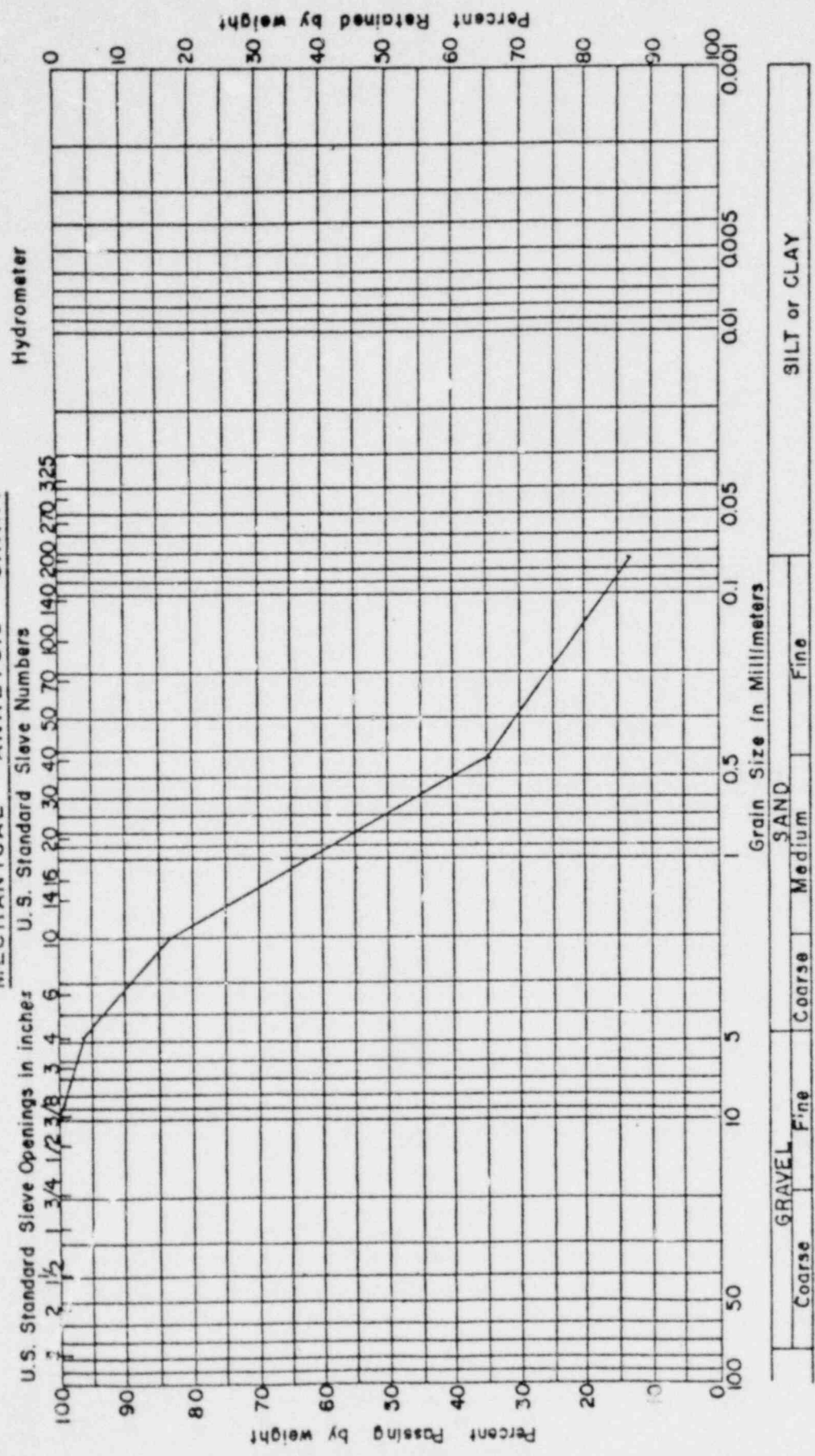


Sample of Fill, very silty SAND, from Test Hole A-2 at 14 feet (SM)

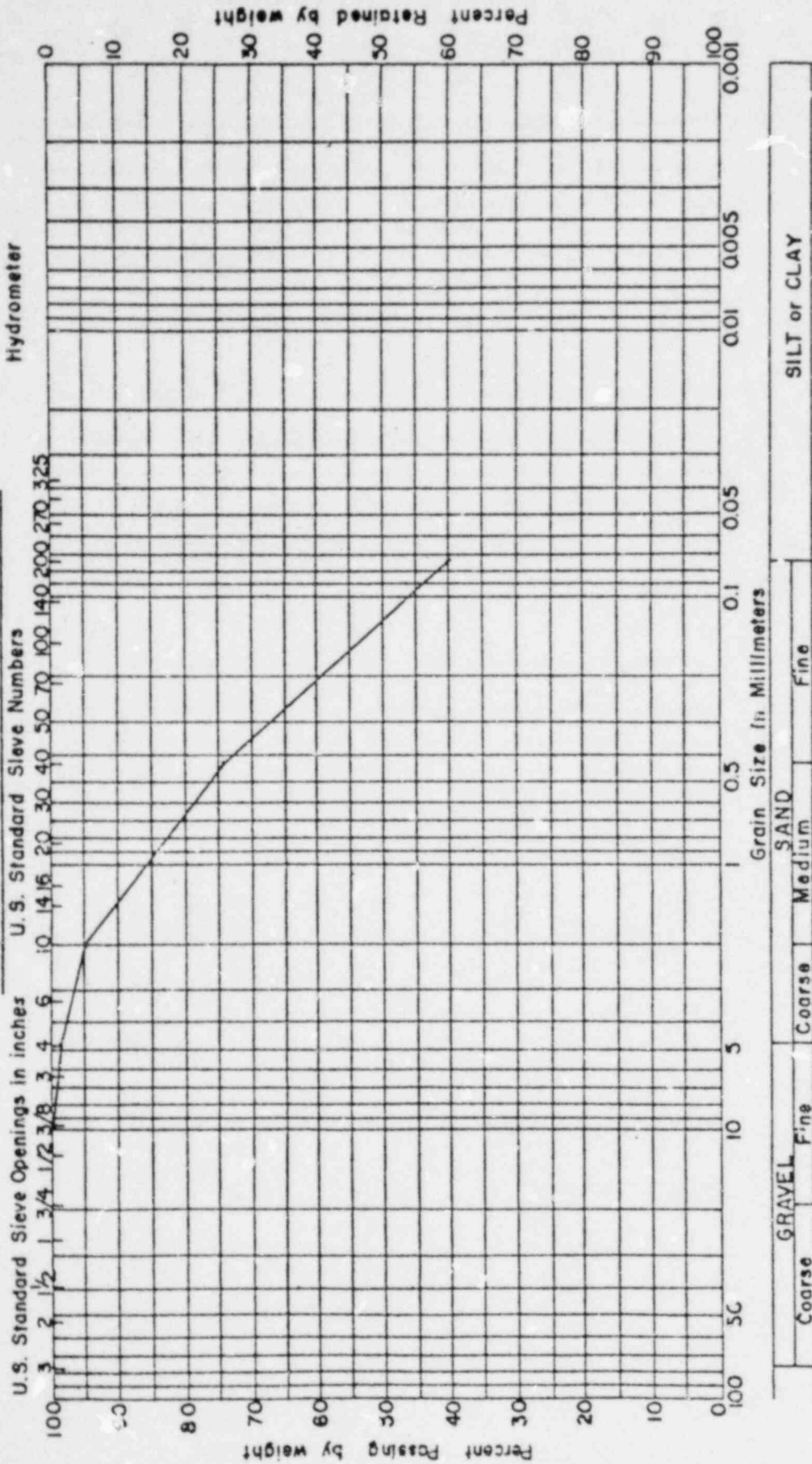
MECHANICAL ANALYSIS CHART



MECHANICAL ANALYSIS CHART

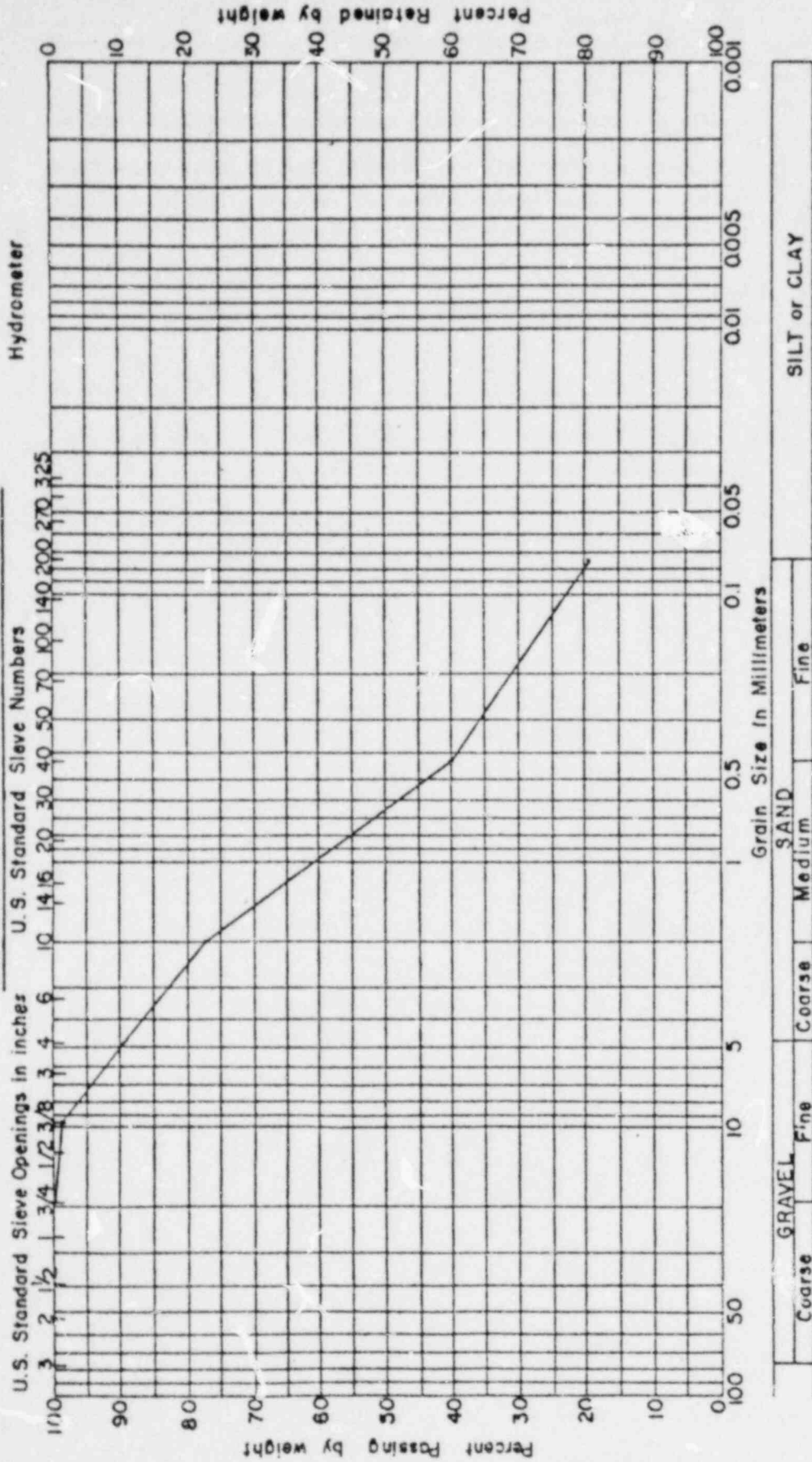


MECHANICAL ANALYSIS CHART

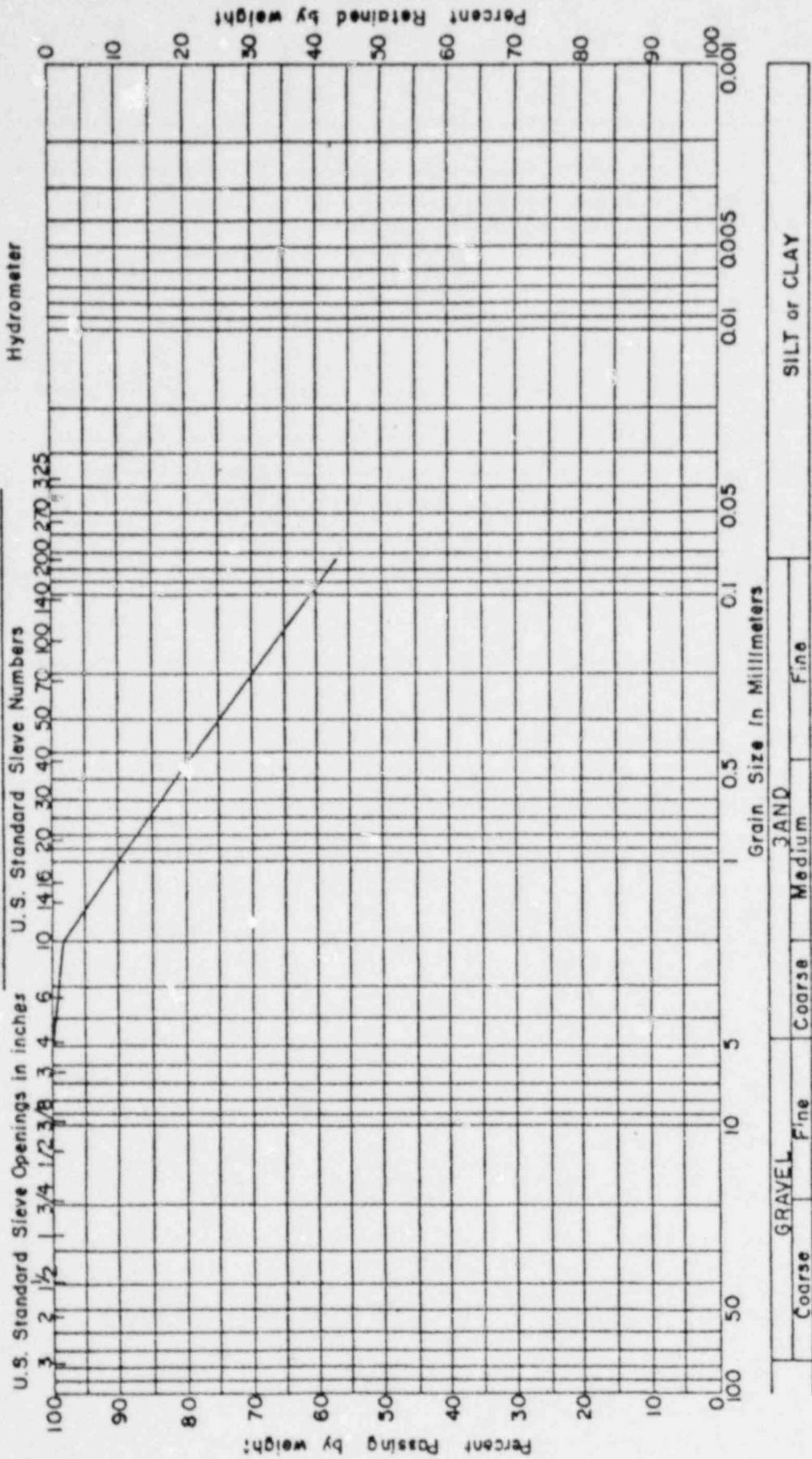


Sample of Fill, very silty SAND from Test Hole A-5 at 19 feet (SM)

MECHANICAL ANALYSIS CHART



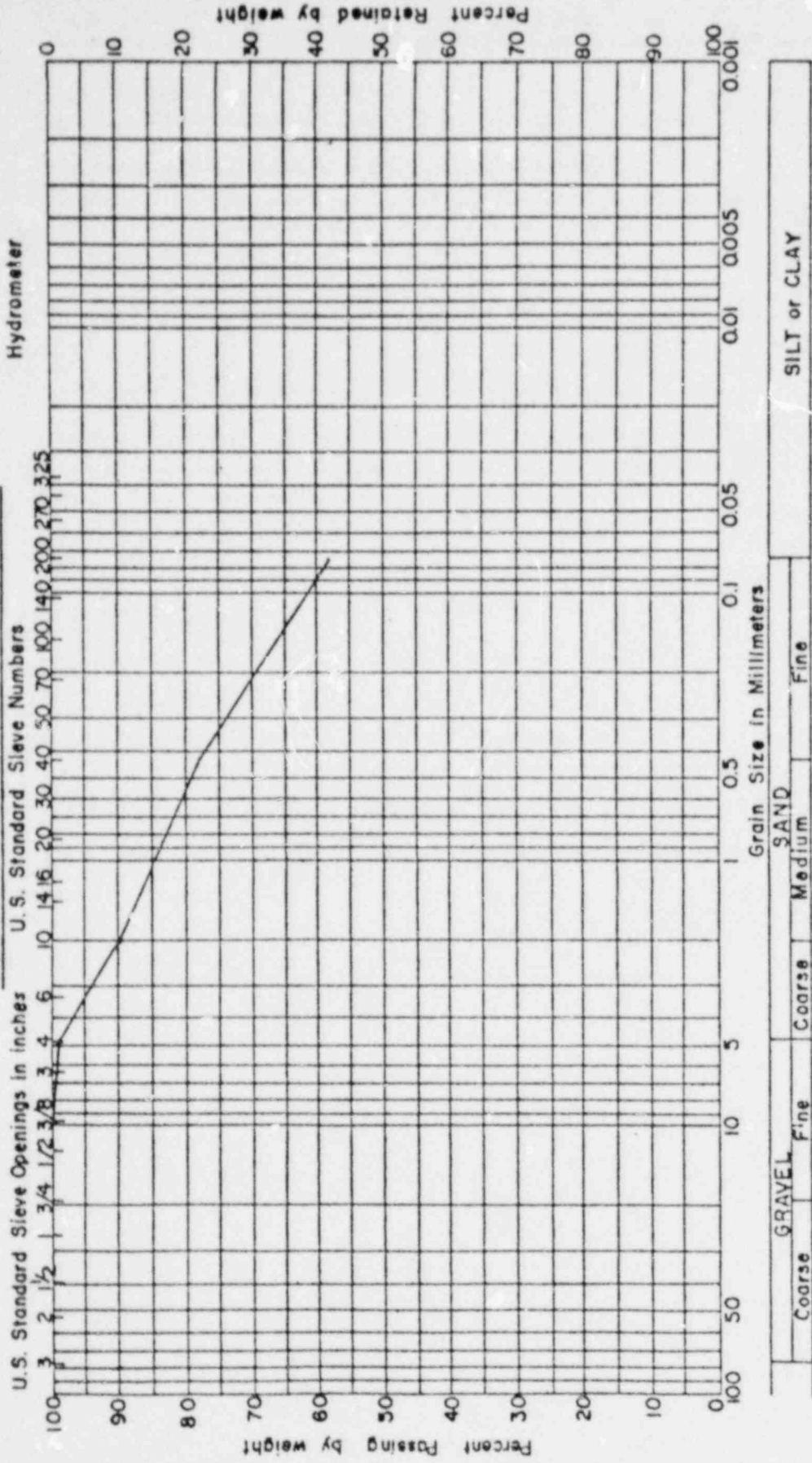
MECHANICAL ANALYSIS CHART



Sample of Fill, sandy Clay, from Test Hole A-5 at 49 feet (CL)

FIGURE B-12

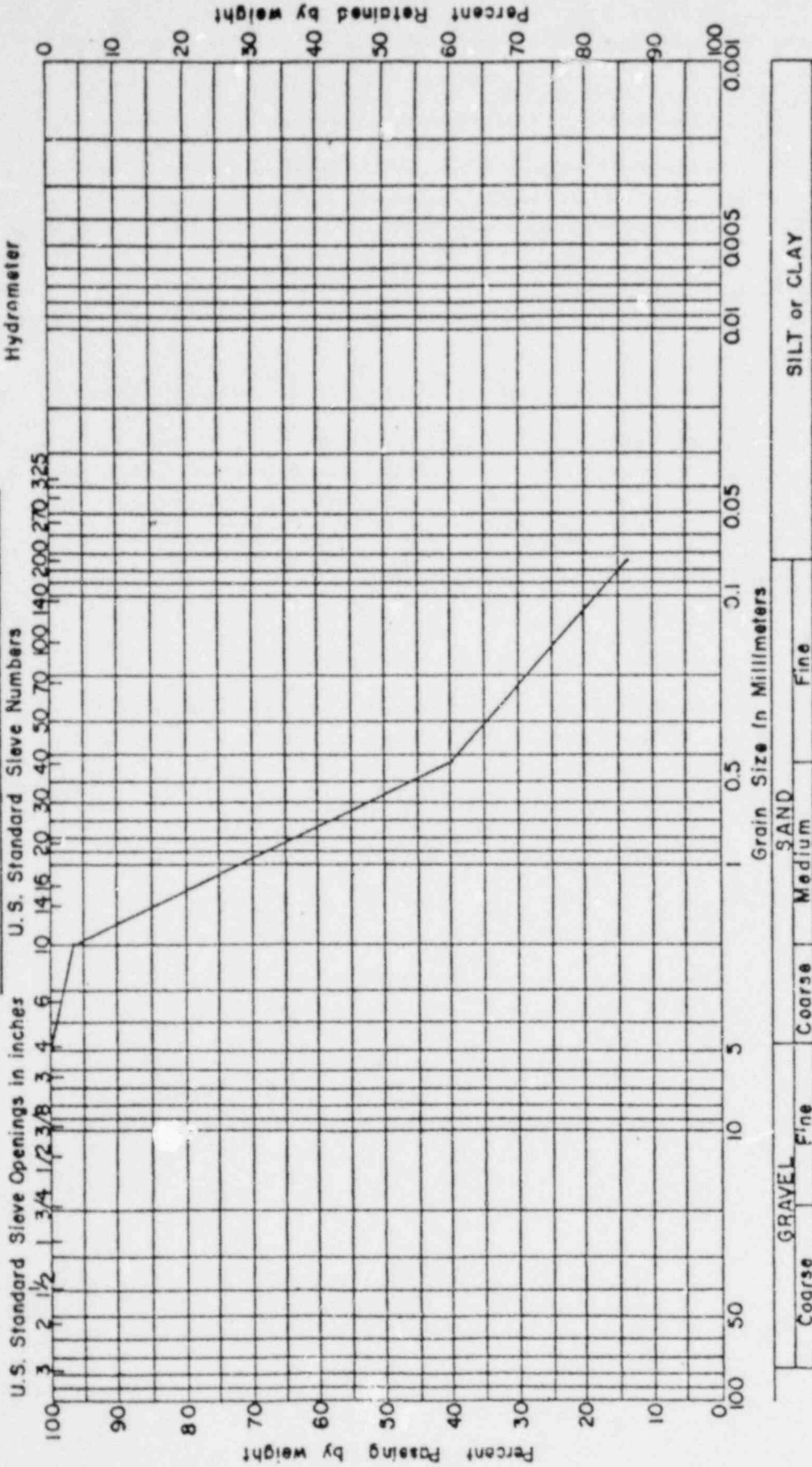
MECHANICAL ANALYSIS CHART



Sample of Fill, sandy SILT from Test Hole HP-1 at 0 feet (ML)

FIGURE B-13

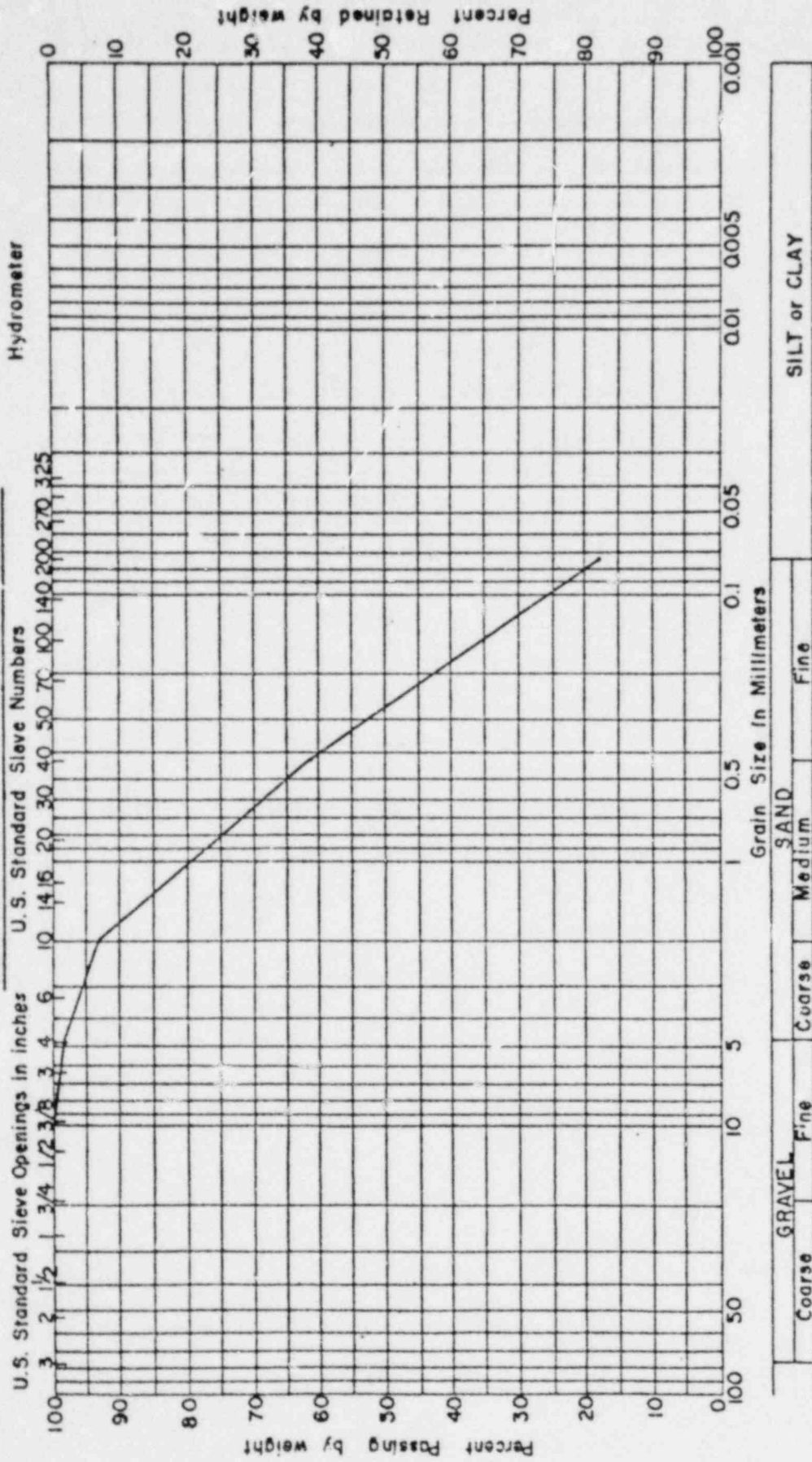
MECHANICAL ANALYSIS CHART



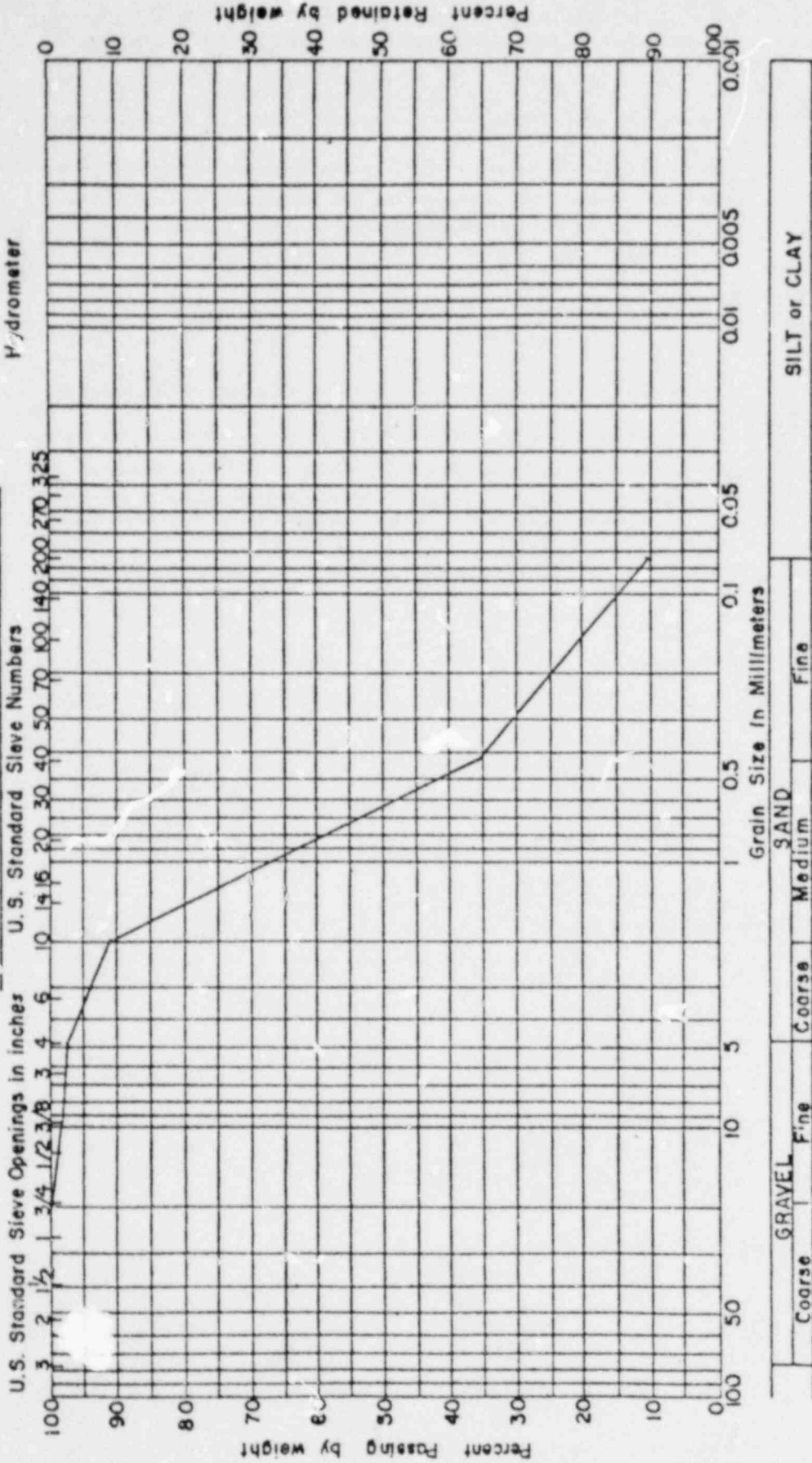
Sample of Fill, silty SAND from Test Hole HP-1 at 29 feet (SM)

FIGURE B-15

MECHANICAL ANALYSIS CHART

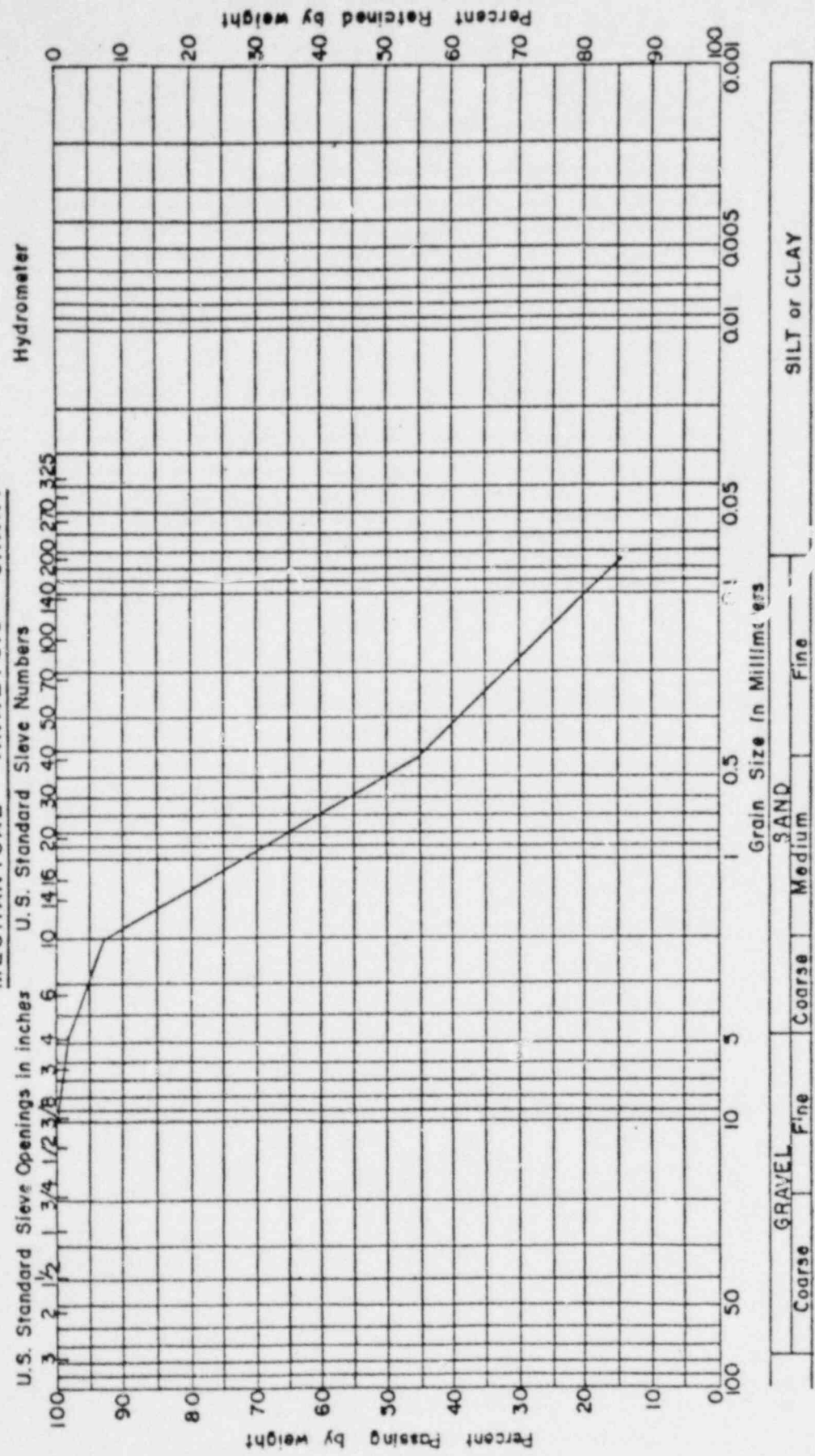


MECHANICAL ANALYSIS CHART



Sample of Fill, silty SAND, from Test Hole HP-2 at 24 feet (SP-SH)

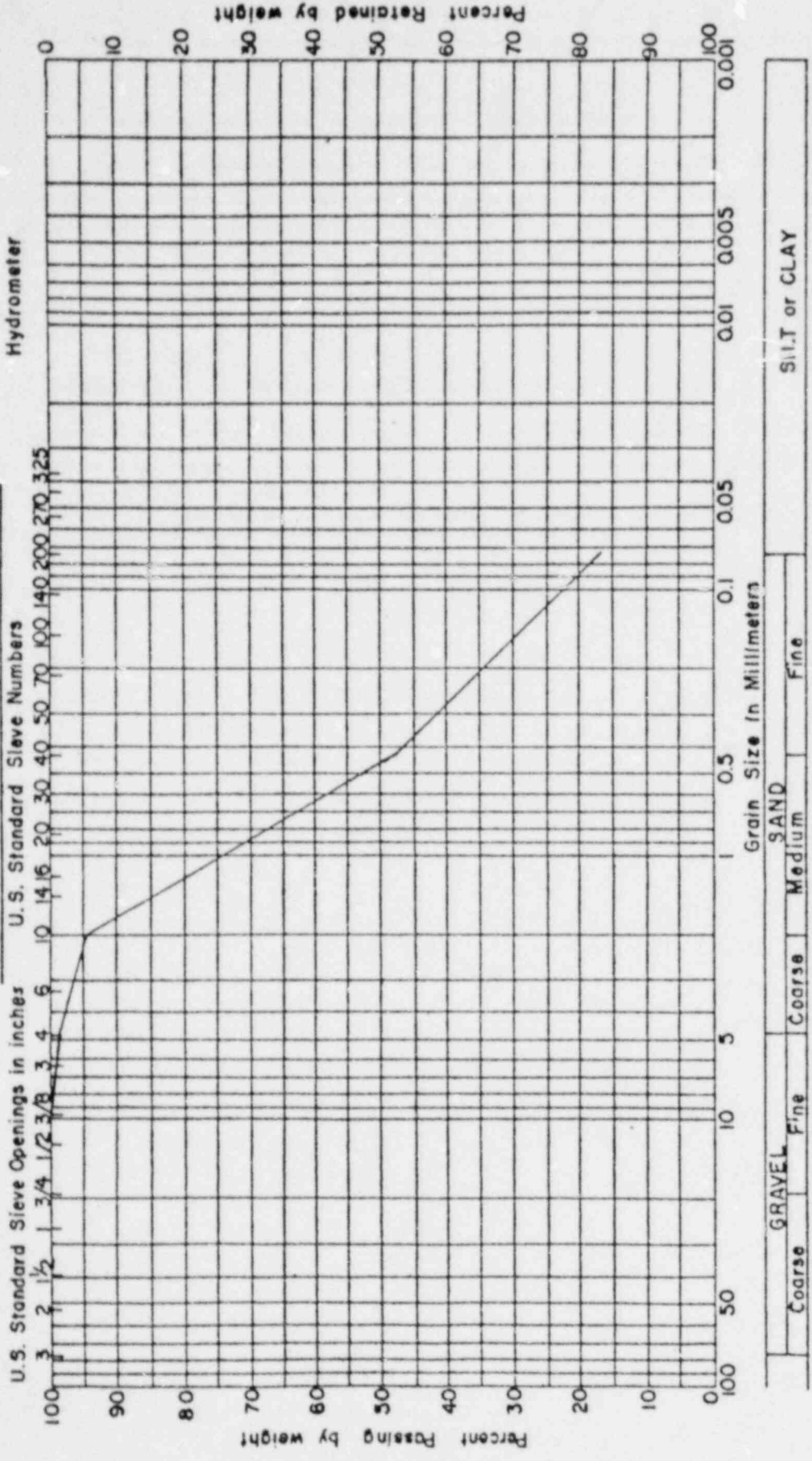
MECHANICAL ANALYSIS CHART



Sample of Fill, silty SAND, from Test Hole HP-2 at 49 feet (SM)

FIGURE B-18

MECHANICAL ANALYSIS CHART



Sample of fill, SAND, clayey to silty, from heap leach Site A (SC-SM)

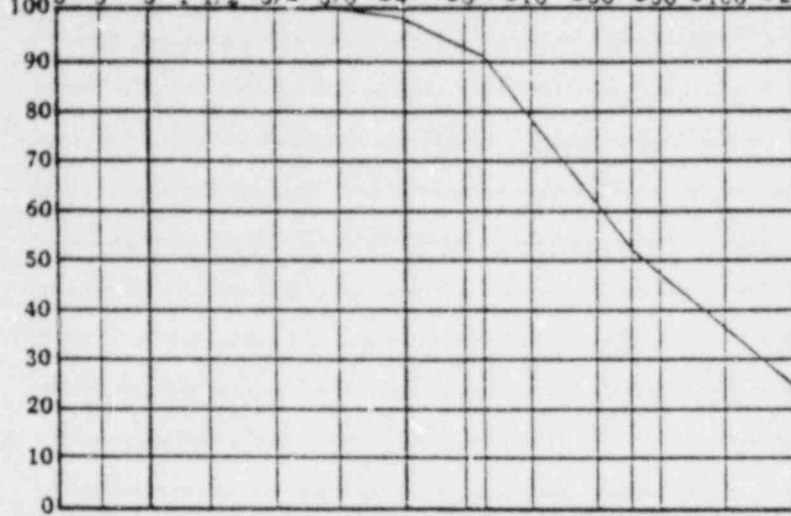
FIGURE B-19

SIEVE ANALYSIS

Cobbles	Gravel			Sand		
	coarse	fine		coarse	medium	fine
Clear Square Openings			U.S. Standard Series			

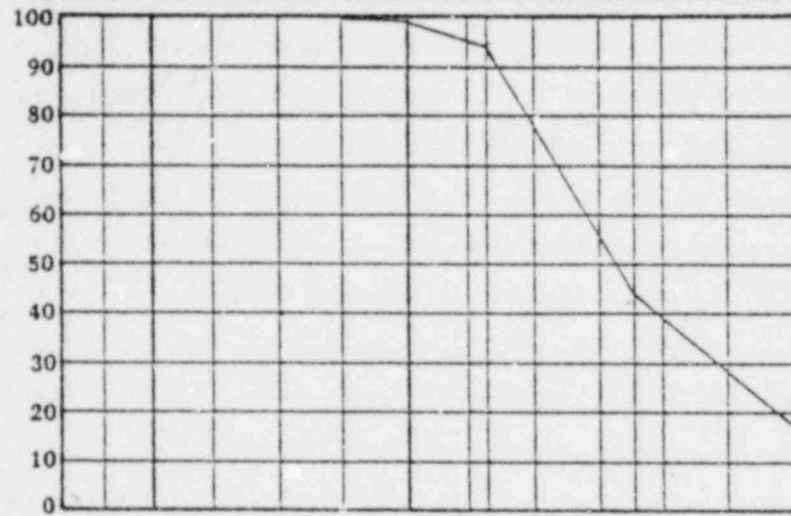
8" 5" 3" 1 1/2" 3/4" 3/8" #4 #8 #16 #30 #50 #100 #200

PERCENT PASSING



Sample of silty SAND
 from test hole K1-1
 at depth 9 & 19 feet.
 Atterberg limits:
 Liquid Limits 23
 Plasticity Index NP
 Classification: Unified SM
 AASHTO A-2-4
 Group Index 0

PERCENT PASSING



Sample of clayey SAND
 from test hole K1-1
 at depth 34 feet.
 Atterberg Limits:
 Liquid Limits 23
 Plasticity Index 18
 Classification: Unified SC-SM
 AASHTO A-1-6
 Group Index 0

PERCENT PASSING



Sample of silty SAND
 from test hole K1-2
 at depth 19 feet.
 Atterberg Limits:
 Liquid Limits 23
 Plasticity Index NP
 Classification: Unified SM
 AASHTO A-1-6
 Group Index 0

Grain Size in Millimeters

MECHANICAL ANALYSIS CHART

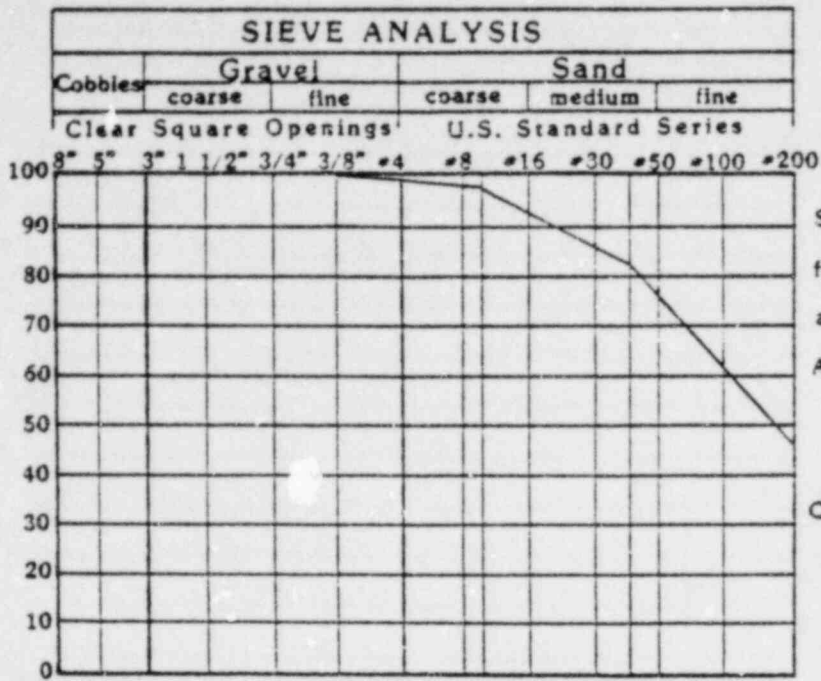
Job No: 1-2664-3118



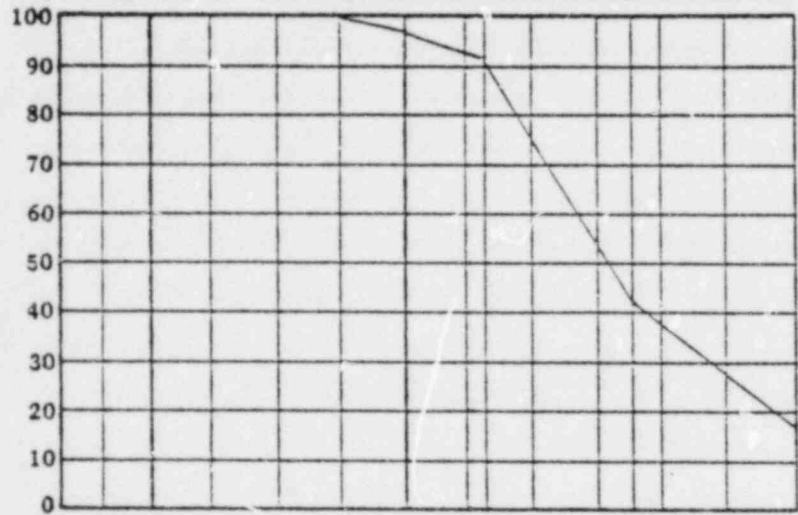
Consulting Engineers and Geologists

Date: 5/20/80

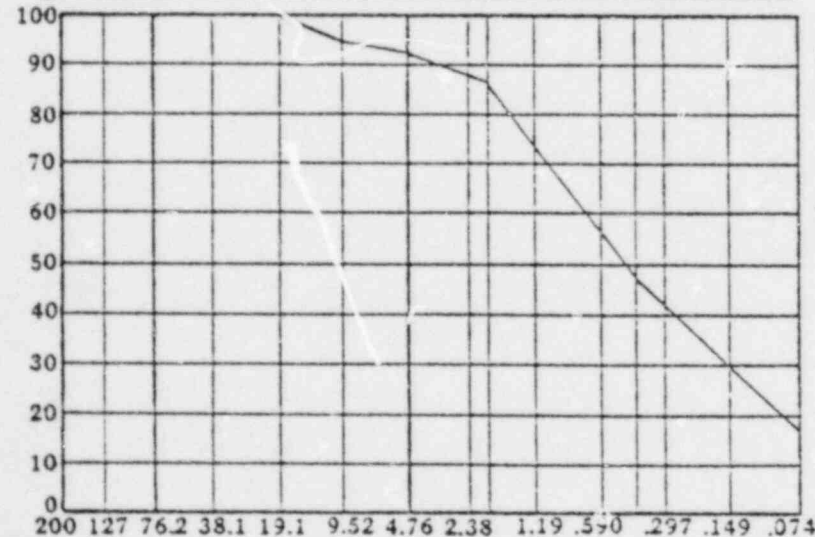
Figure B-20



Sample of clayey SAND
 from test hole K1-4
 at depth 4 feet.
 Atterberg limits:
 Liquid Limits 26
 Plasticity Index 8
 Classification: Unified SC
 AASHTO A-4
 Group Index 1



Sample of silty, SAND
 from test hole K1-5
 at depth 9 feet.
 Atterberg Limits:
 Liquid Limits 22
 Plasticity Index 2
 Classification: Unified SM
 AASHTO A-1-1
 Group Index 0



Sample of silty, SAND
 from test hole K1-7
 at depth 89 feet.
 Atterberg Limits:
 Liquid Limits 18
 Plasticity Index NP
 Classification: Unified SM
 AASHTO A-1-6
 Group Index 0

Grain Size in Millimeters

MECHANICAL ANALYSIS CHART

Job No: 1-2664-3118

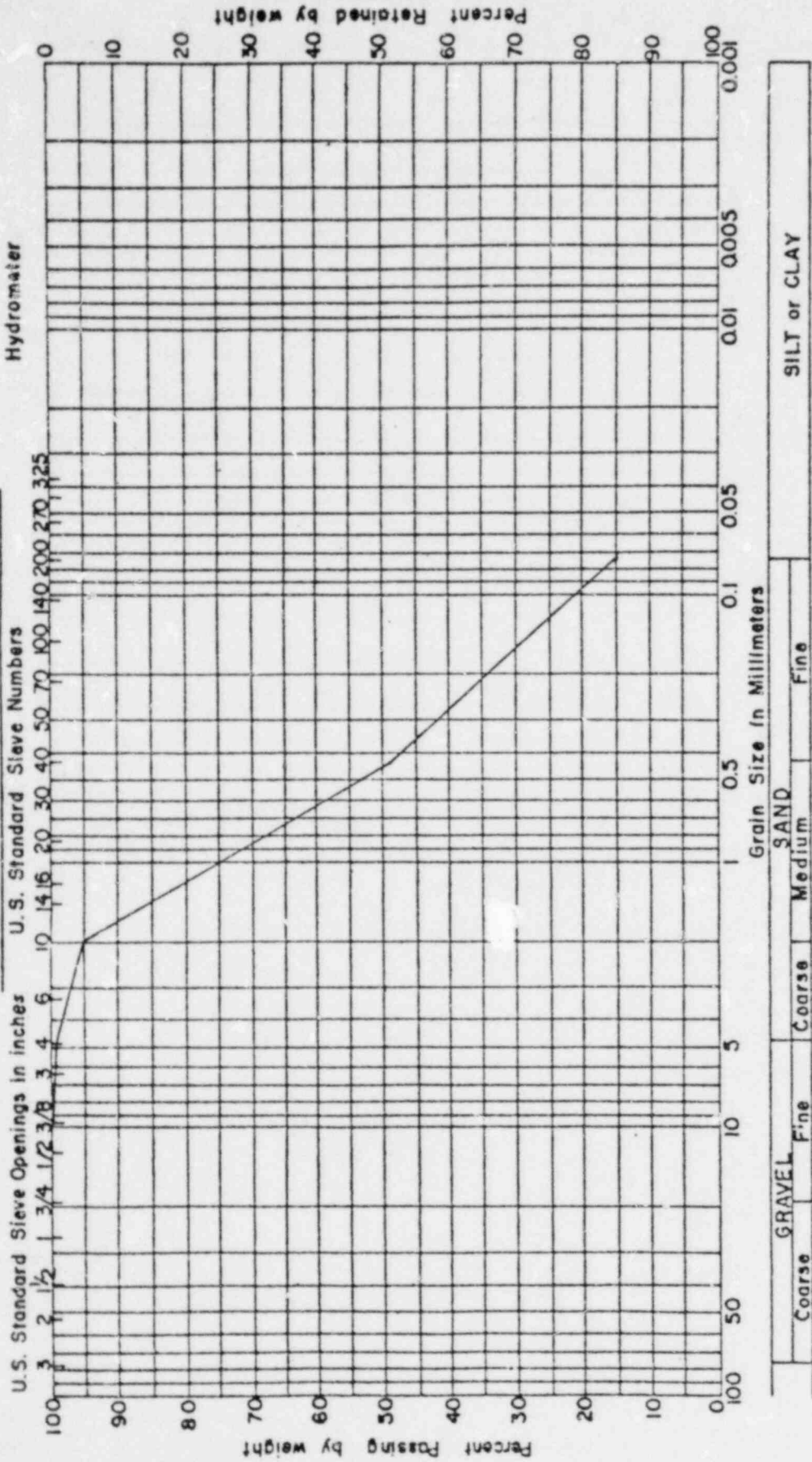


Consulting Engineers and Geologists

Date: 5/20/80

Figure B-21

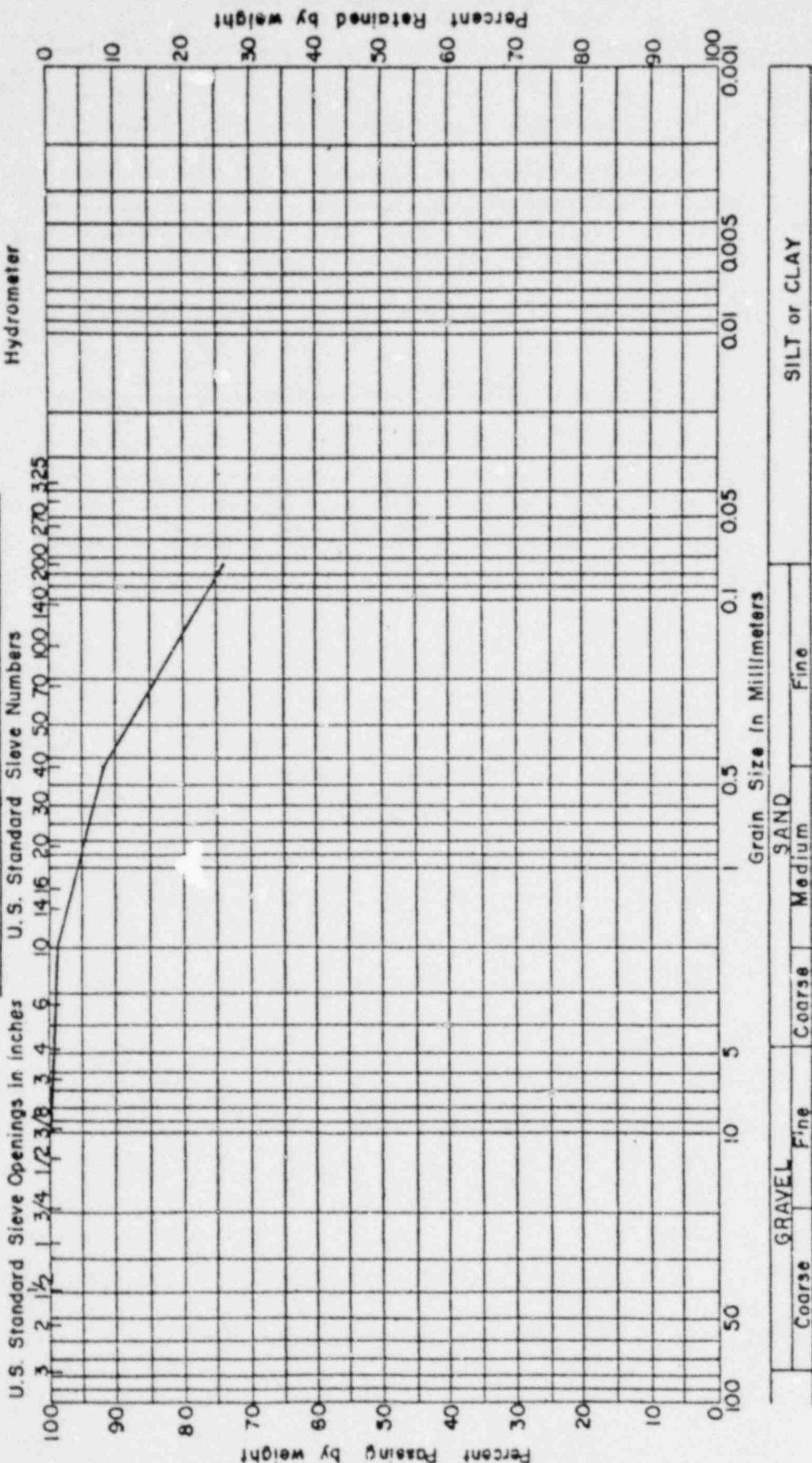
MECHANICAL ANALYSIS CHART



Sample of Fill, SAND, clayey to silty, from heap leach site K-1 (SC-SM)

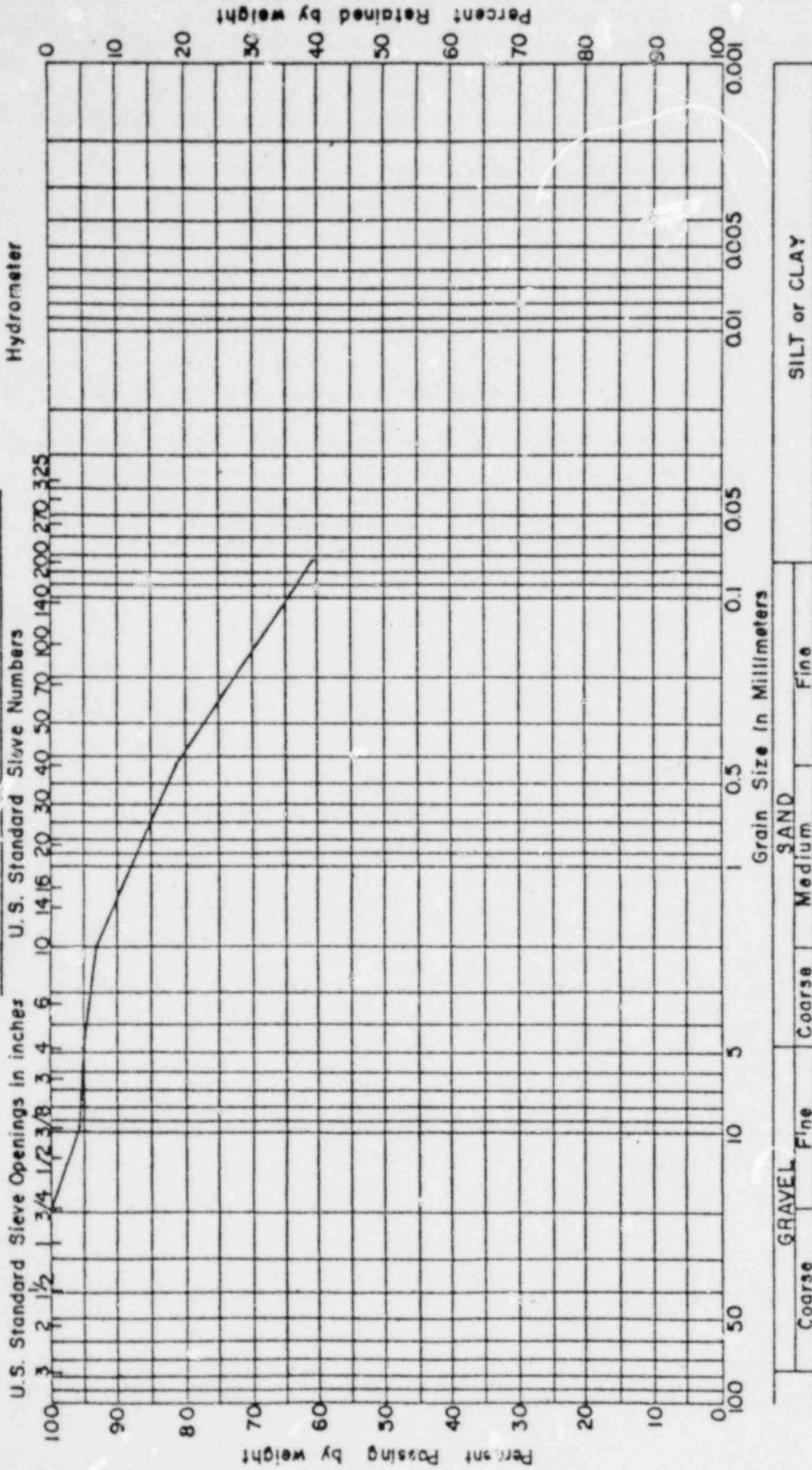
FIGURE B-22

MECHANICAL ANALYSIS CHART

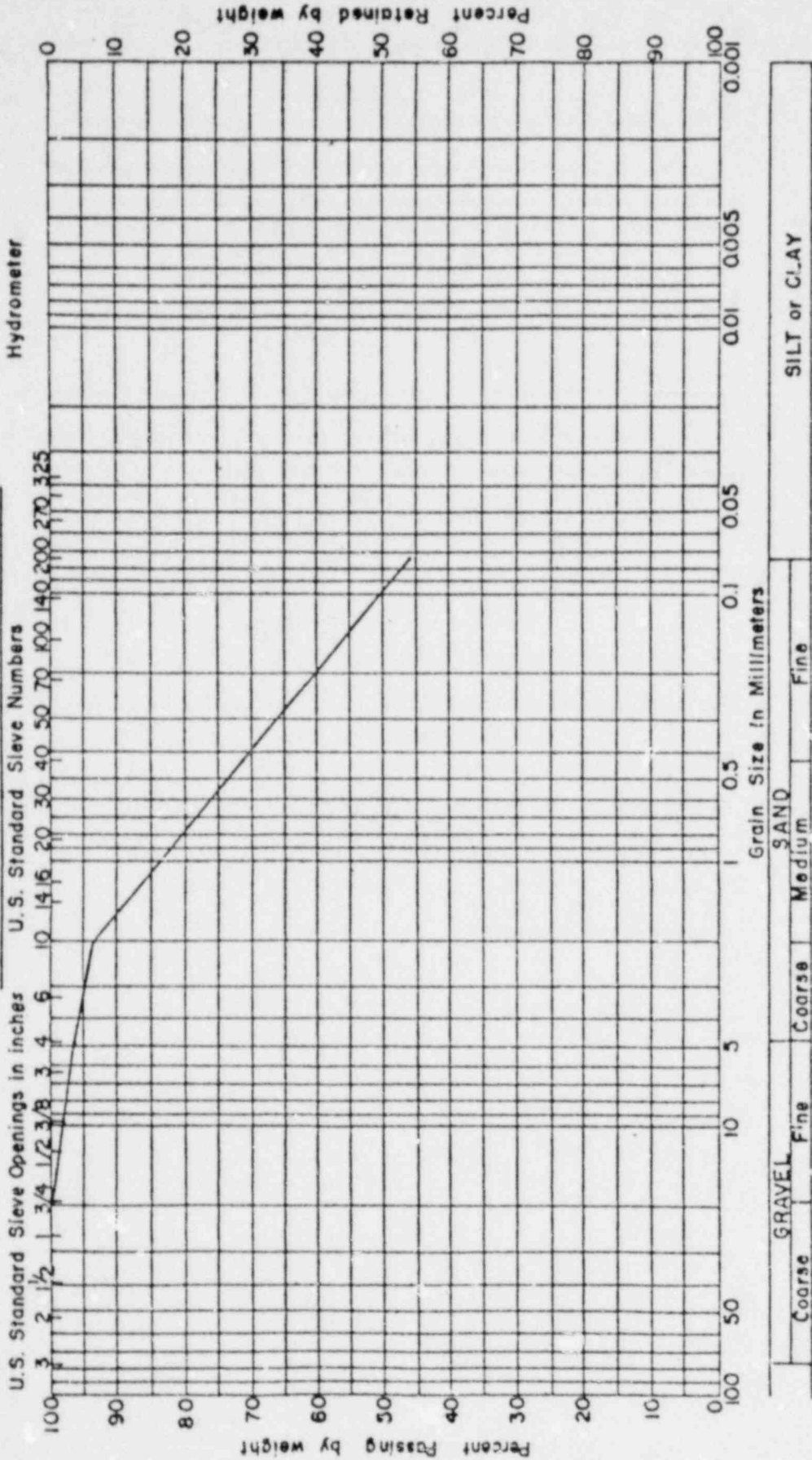


Sample of Remolded Clay Material (ML)

MECHANICAL ANALYSIS CHART

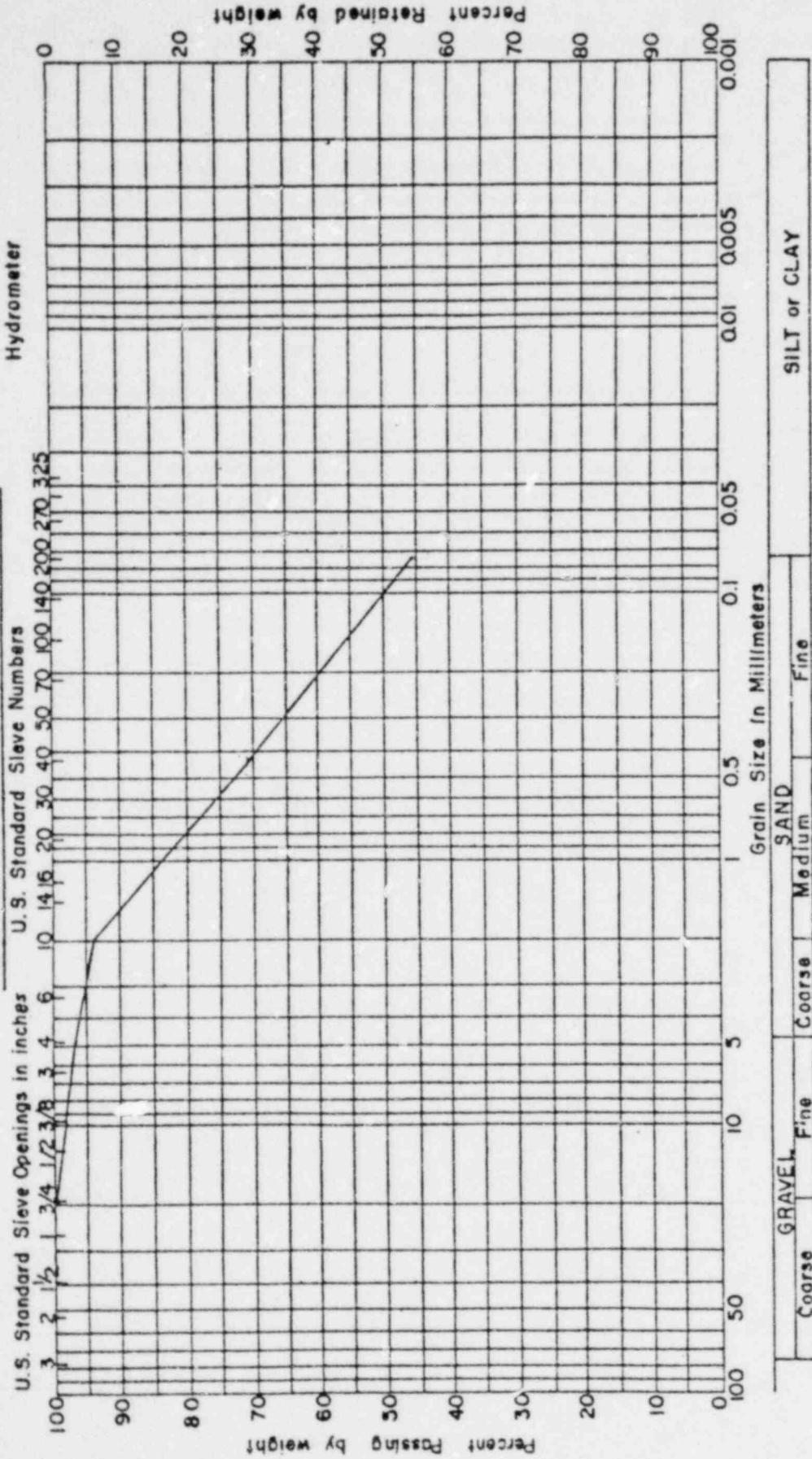


MECHANICAL ANALYSIS CHART



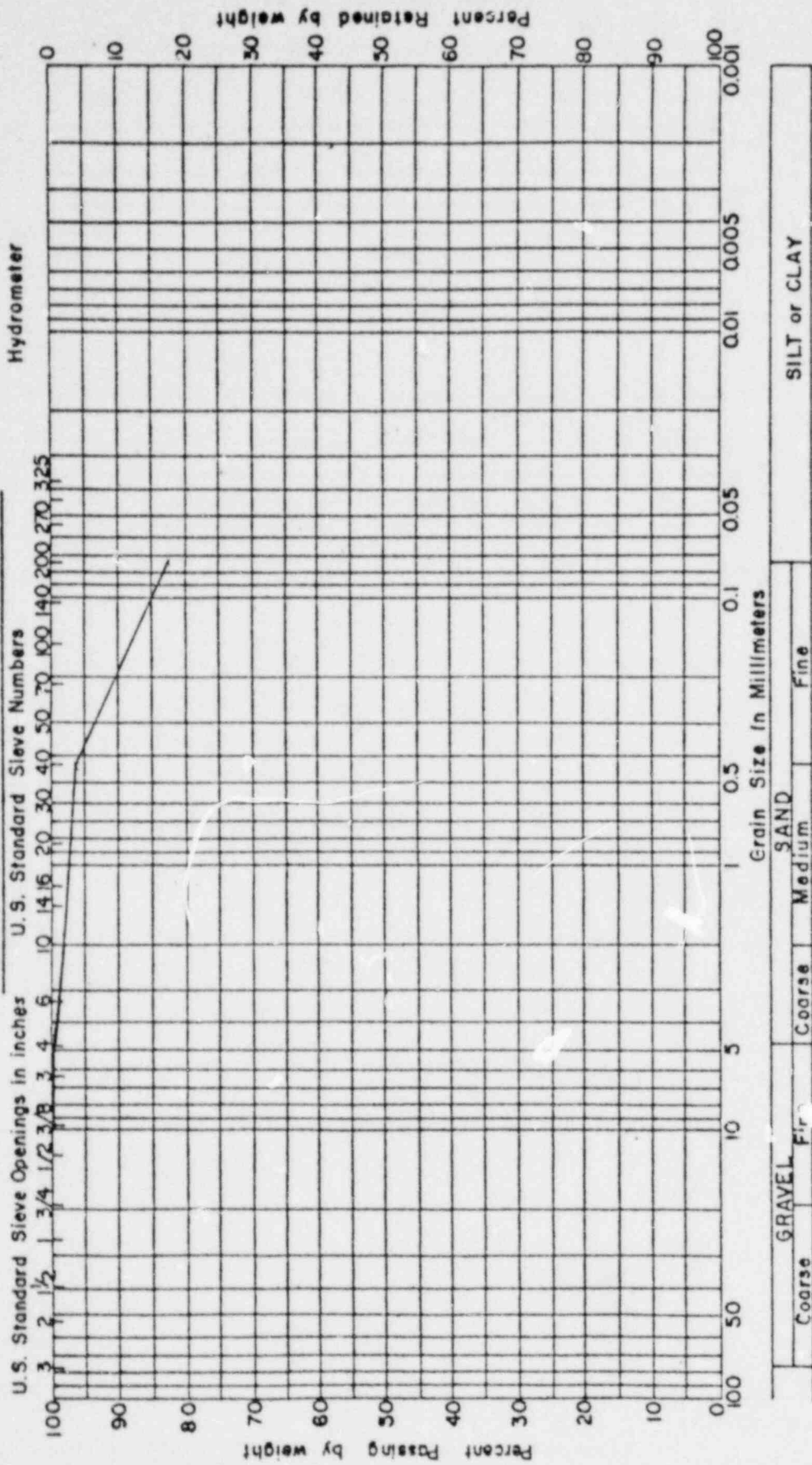
Sample of Heap Leach Ore Material. (SC)

MECHANICAL ANALYSIS CHART



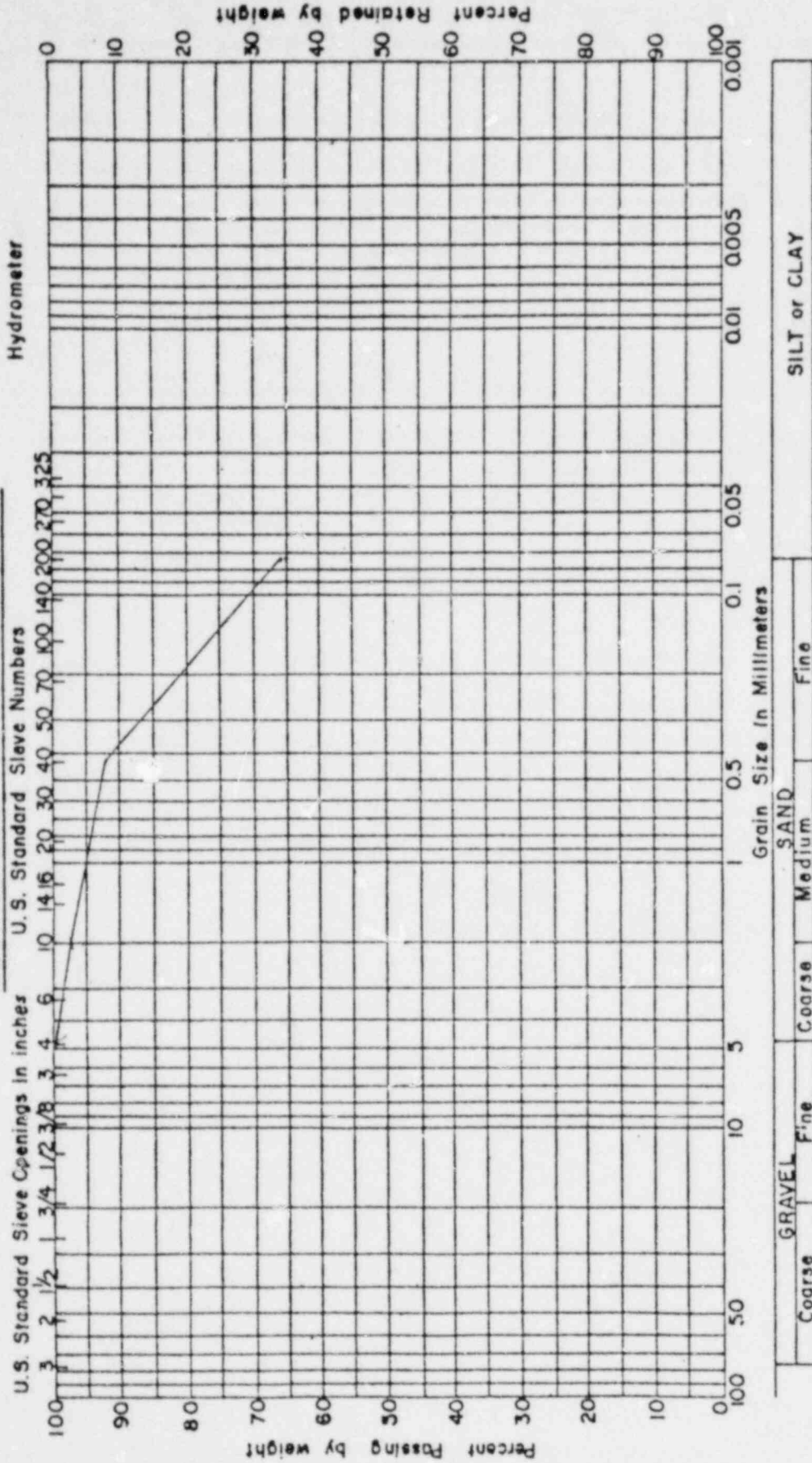
Sample of Heap Leach Ore Material (SC)

MECHANICAL ANALYSIS CHART



Sample of liner material (CL)

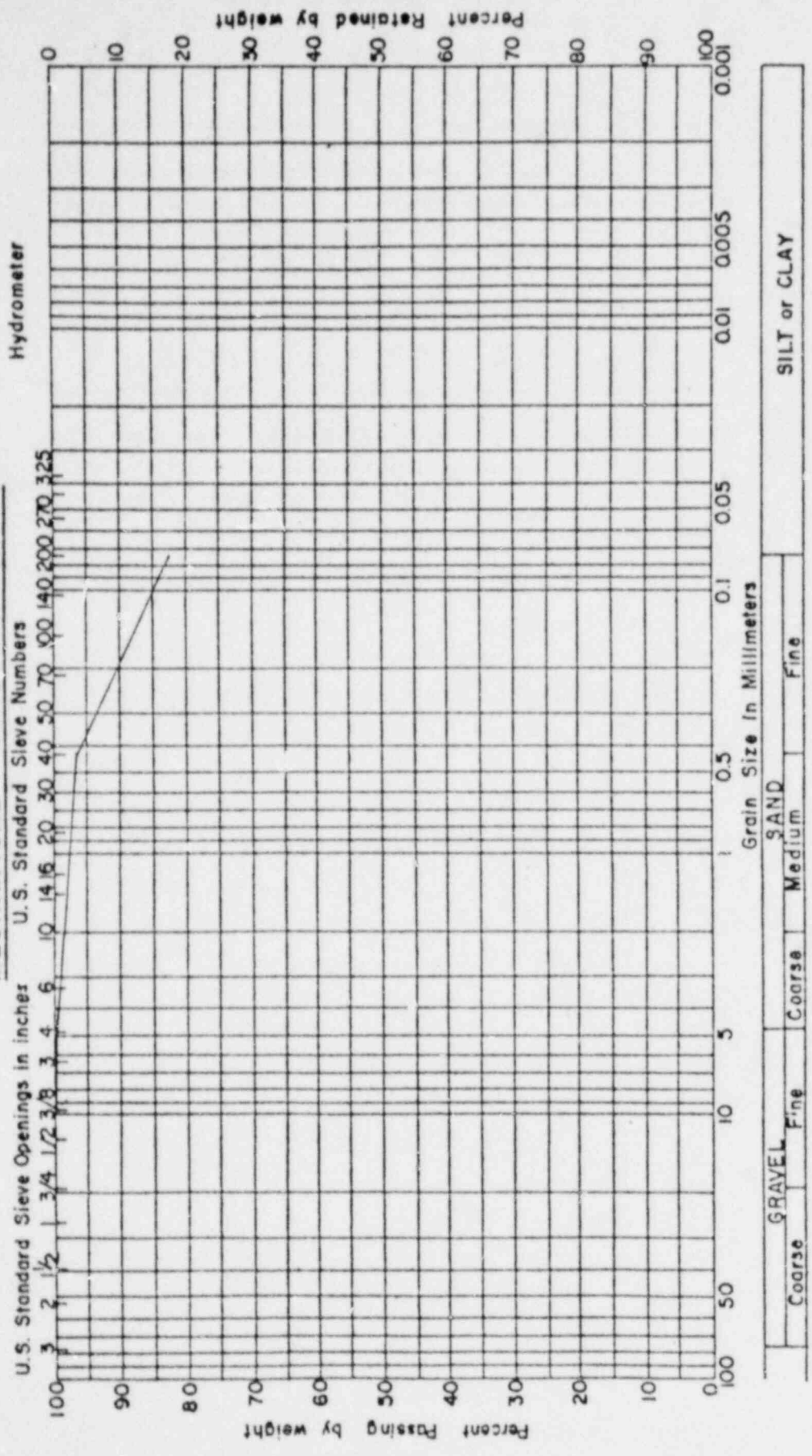
MECHANICAL ANALYSIS CHART



Sample of liner material (CL)

FIGURE B-28

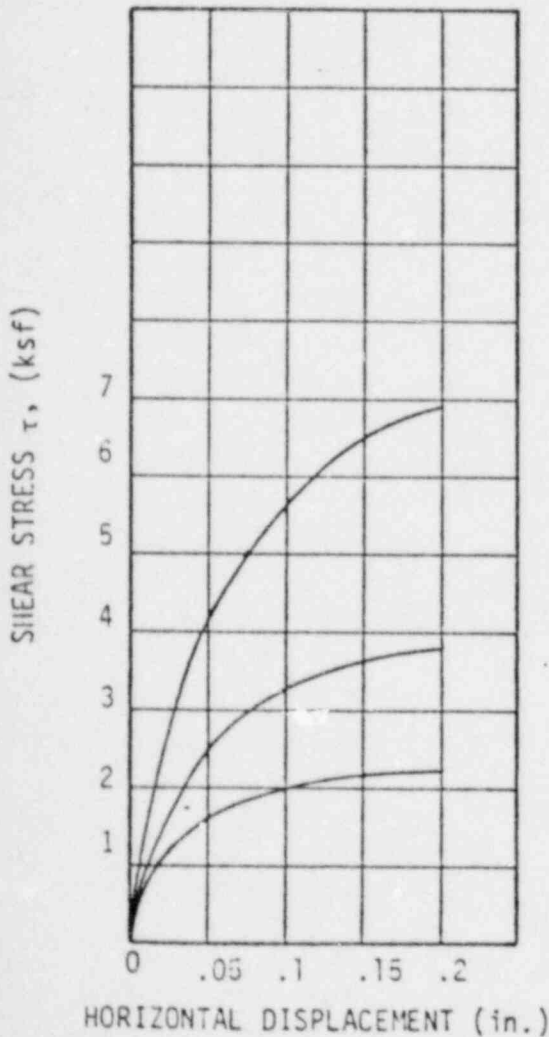
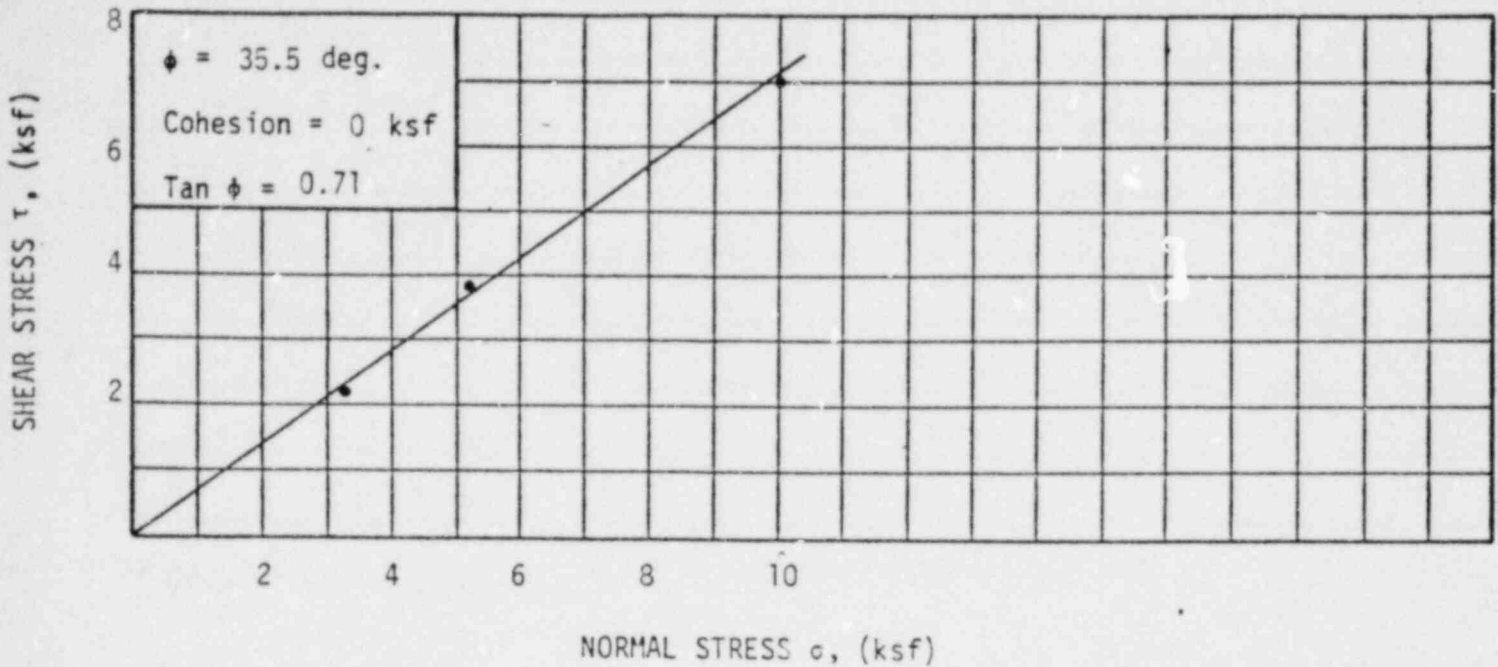
MECHANICAL ANALYSIS CHART



Sample of Remolded Clay Liner Material (CL)

FIGURE B-29

DIRECT SHEAR TEST RESULTS



Boring No. A-1 at Depth 19, 24 & 39 feet.

Sample of silty SAND

Type of Test Remolded-Natural Moisture

% Passing

No. 4	No. 10	No. 40	No. 200
100	99	36	17

LL = NP

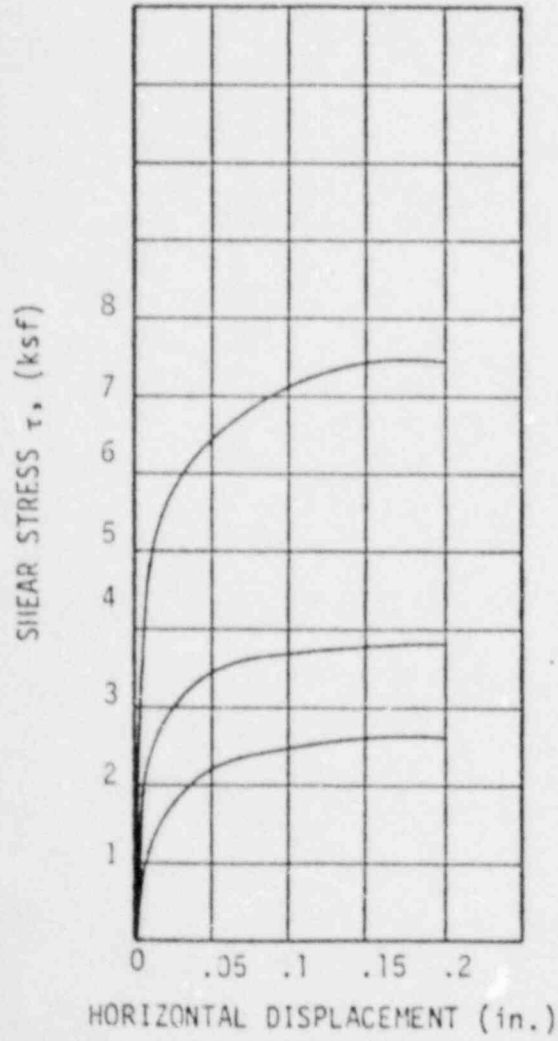
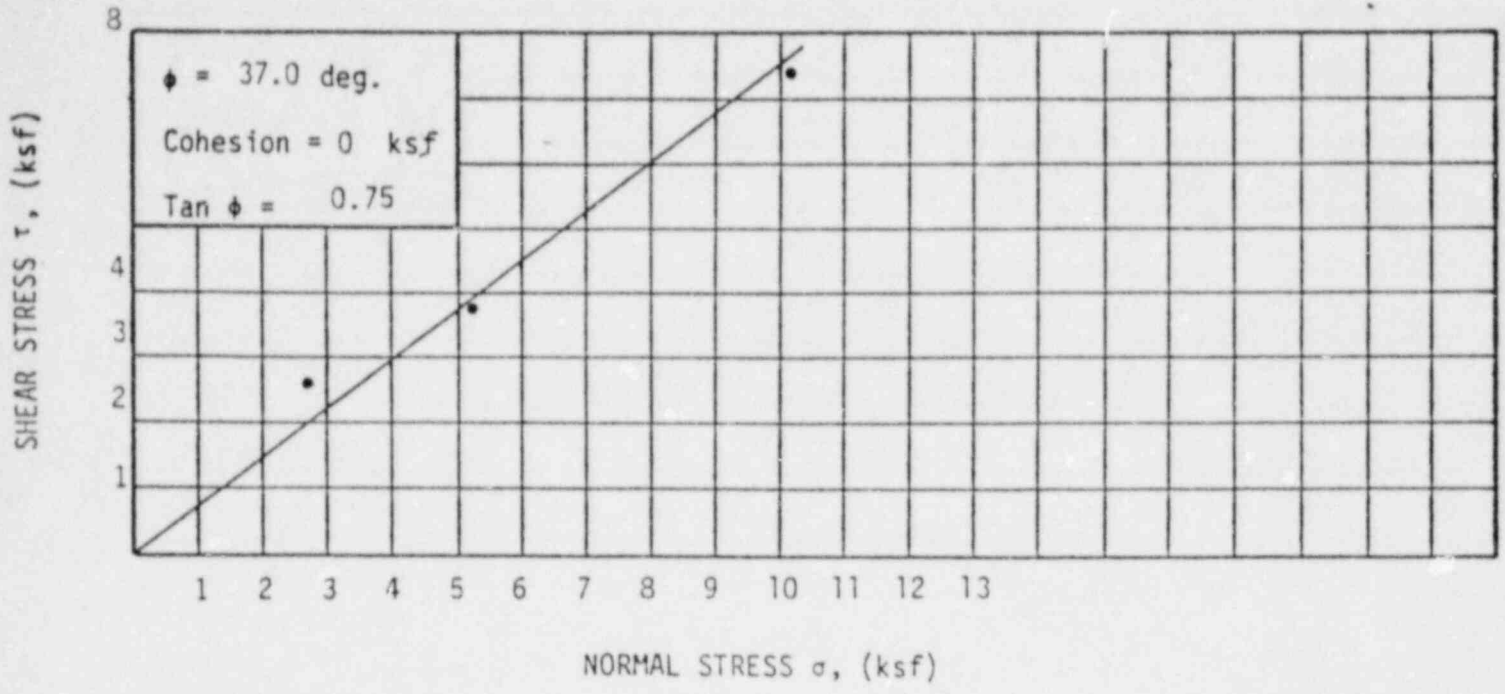
PI = NP

Test No.				
Height (in.)	H_0	.997	.992	.991
Area (in. ²)	A_0	4	4	4
Natural Water Content (%)	w_r	9.2	9.2	9.2
Dry Density (pcf)	γ_{d0}	94	94	94
Consolidation Pressure (ksf)	σ_c	2.73	5.02	10.0
Normal Stress (ksf)	σ	2.73	5.02	10.0
Maximum Shear Stress (ksf)	τ	2.21	3.90	6.49
Residual Shear Stress (ksf)	τ_r	2.21	3.90	6.49
Strain Rate (in./min.)		.0026	.0024	.0022

FIGURE B-30



DIRECT SHEAR TEST RESULTS

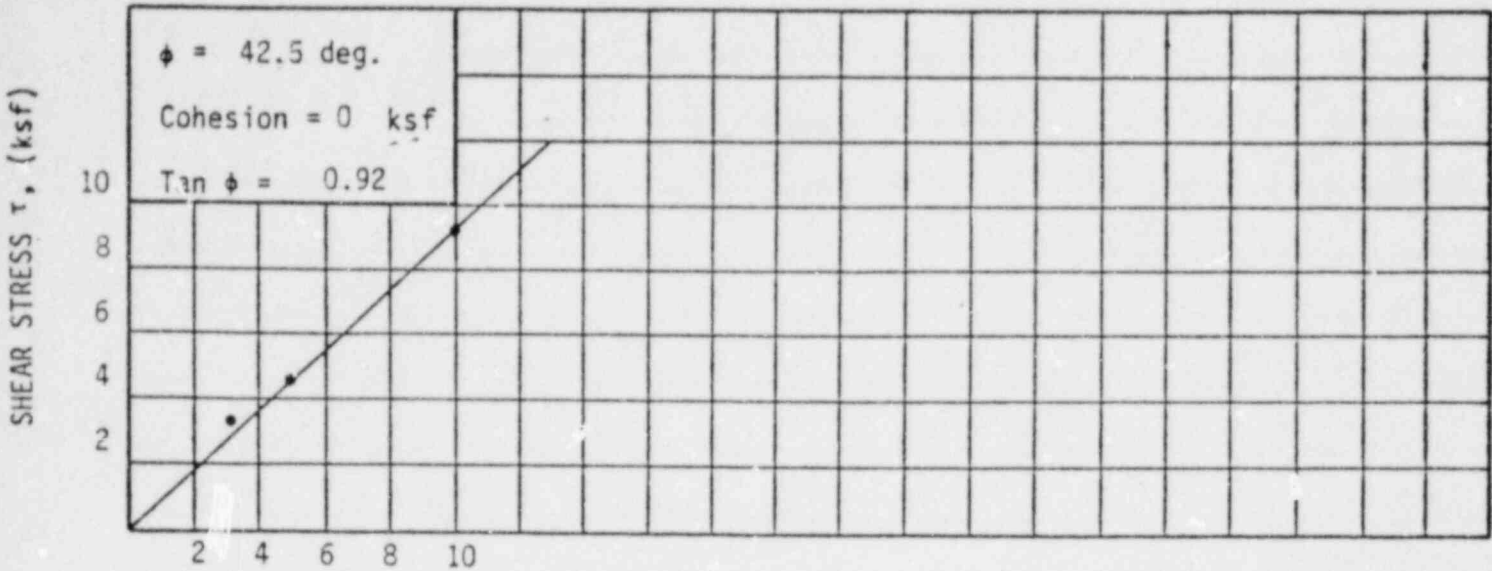


Boring No. A-2 at Depth 19,24 & 29 feet.
 Sample of silty SAND
 Type of Test Remolded-Natural Moisture
 %Passing
 No.4 99 No.10 95 No.40 64 No.200 24

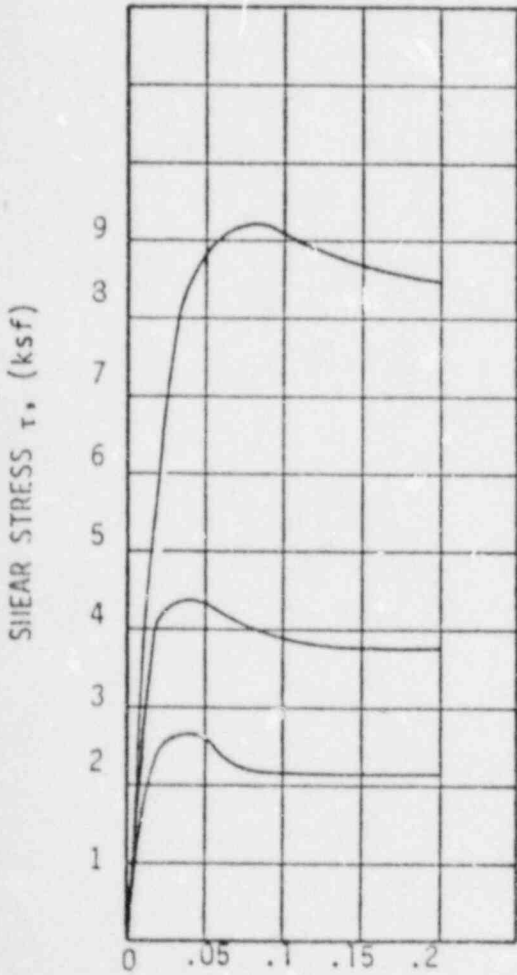
LL = NP PI = NP

Test No.				
Height (in.)	H _o	.992	.991	.983
Area (in. ²)	A _o	4	4	4
Natural Water Content (%)	w _n	7.2	7.2	7.2
Dry Density (pcf)	γ _{do}	103	103	103
Consolidation Pressure (ksf)	σ _c	2.73	5.02	10.0
Normal Stress (ksf)	σ	2.73	5.02	10.0
Maximum Shear Stress (ksf)	τ	2.48	3.61	7.47
Residual Shear Stress (ksf)	τ _r	2.48	3.61	7.47
Strain Rate (in./min.)		.0022	.0025	.0015

DIRECT SHEAR TEST RESULTS



NORMAL STRESS σ , (ksf)



HORIZONTAL DISPLACEMENT (in.)

Boring No. A-3 at Depth 19, 24 & 29 feet.

Sample of silty SAND

Type of Test Remolded-Natural Moisture

%Passing

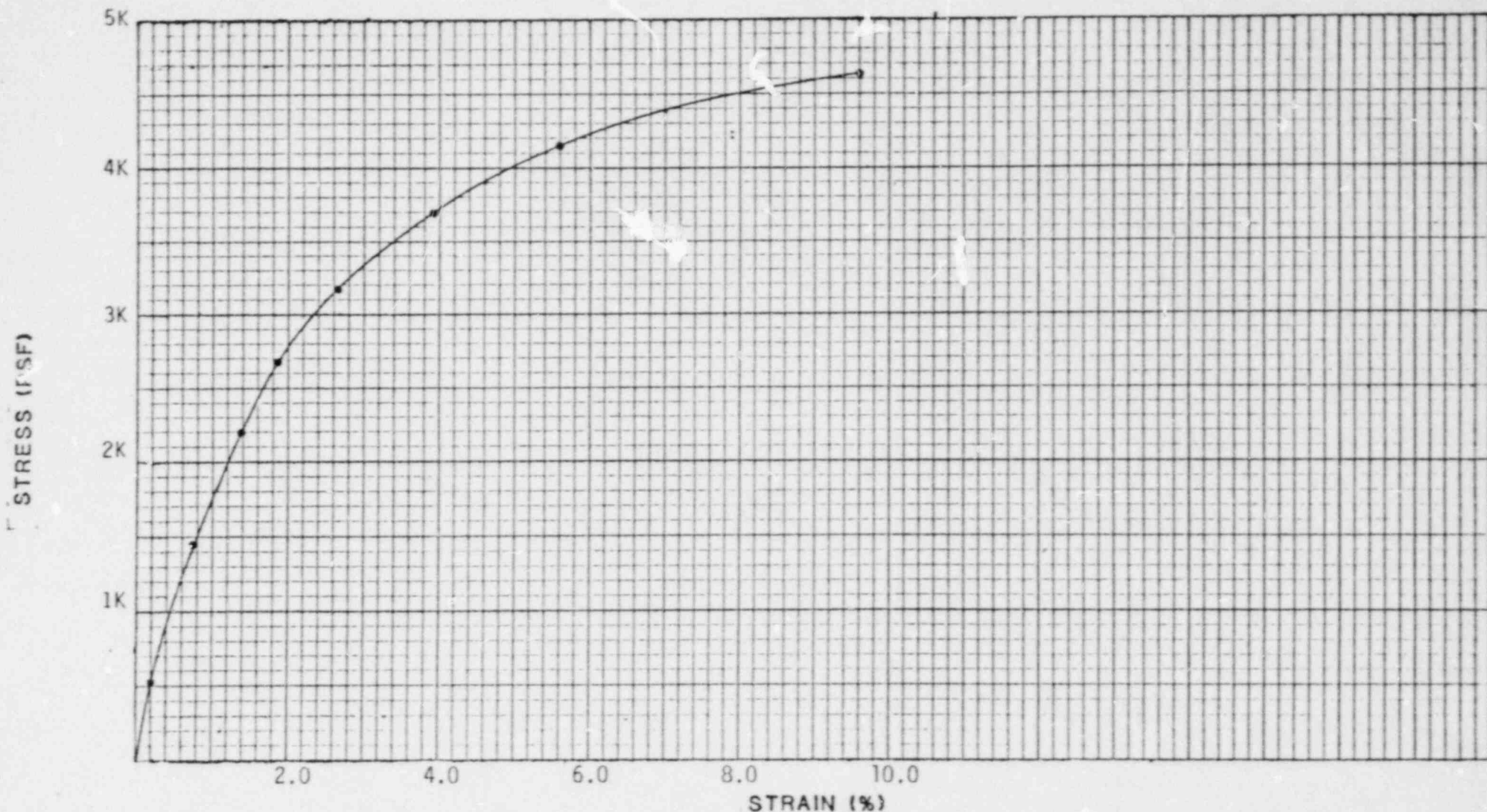
No. 4	No. 10	No. 40	No. 200
100	94	48	17

LL = NP

PI = NP

Test No.				
Height (in.)	H_0	.938	.992	.987
Area (in. ²)	A_0	4	4	4
Natural Water Content (%)	w_n	12.5	12.5	12.5
Dry Density (pcf)	γ_{d0}	112	112	112
Consolidation Pressure (ksf)	σ_c	2.73	5.02	10.0
Normal Stress (ksf)	σ	2.73	5.02	10.0
Maximum Shear Stress (ksf)	τ	2.71	4.50	9.27
Residual Shear Stress (ksf)	τ_r	2.10	3.75	8.52
Strain Rate (in./min.)		.0029	.0029	.0017

FIGURE B-32



Sample of silty, clayey, SAND from hole A-4 at depth 9 Moisture Content 18.3 %
 Unconfined Compressive Strength 4,650 psf Natural Wet Density 129 pcf

UNCONFINED COMPRESSION TEST RESULTS

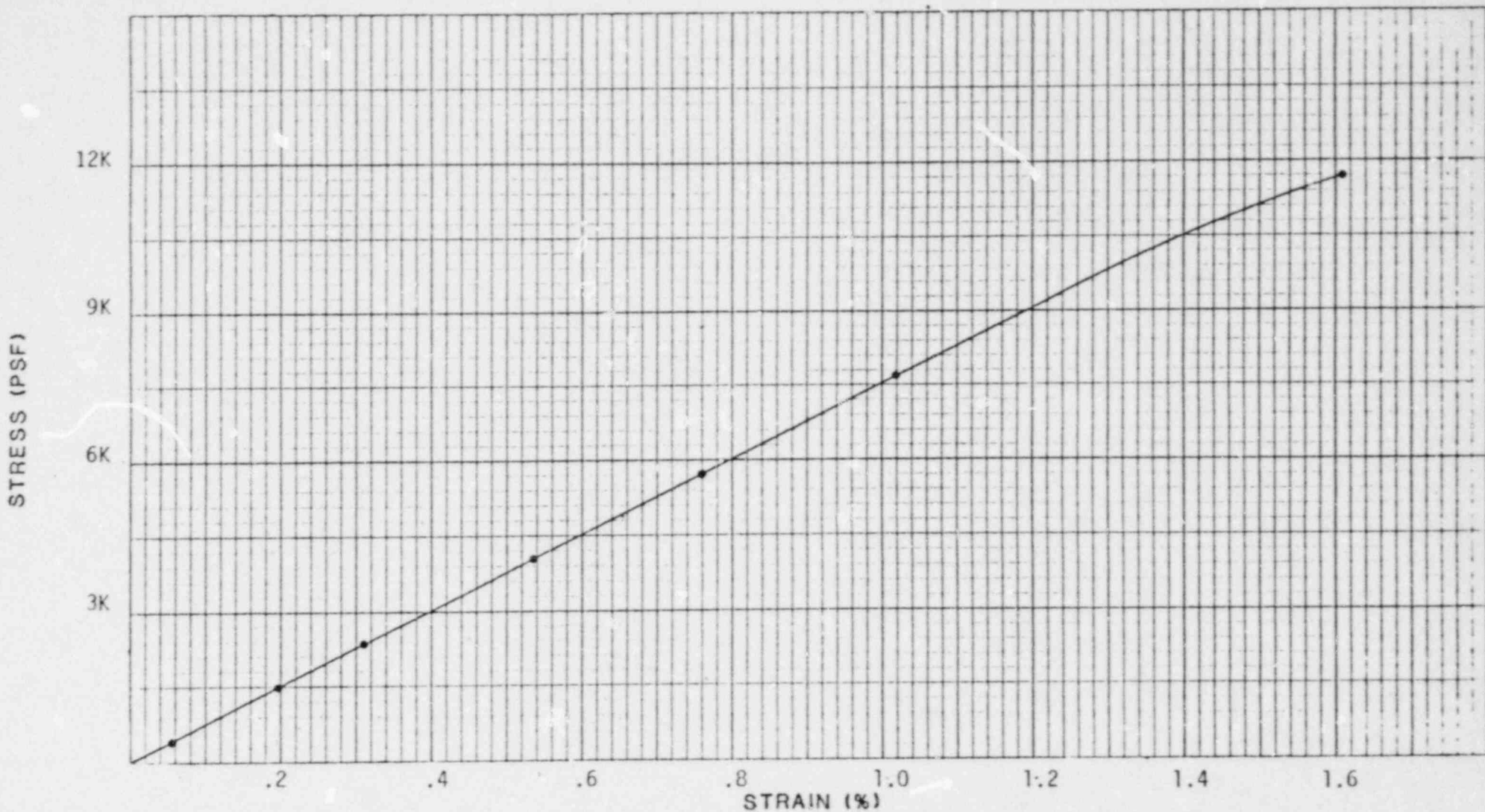
JOB NO. 1-2664-3118

DATE: 5/20/80

FIGURE B-33



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Sample of sandy CLAY from hole A-5 at depth 49 ft. Moisture Content 12.5 %
 Unconfined Compressive Strength 11,750 psf Dry Density 136 pcf

UNCONFINED COMPRESSION TEST RESULTS

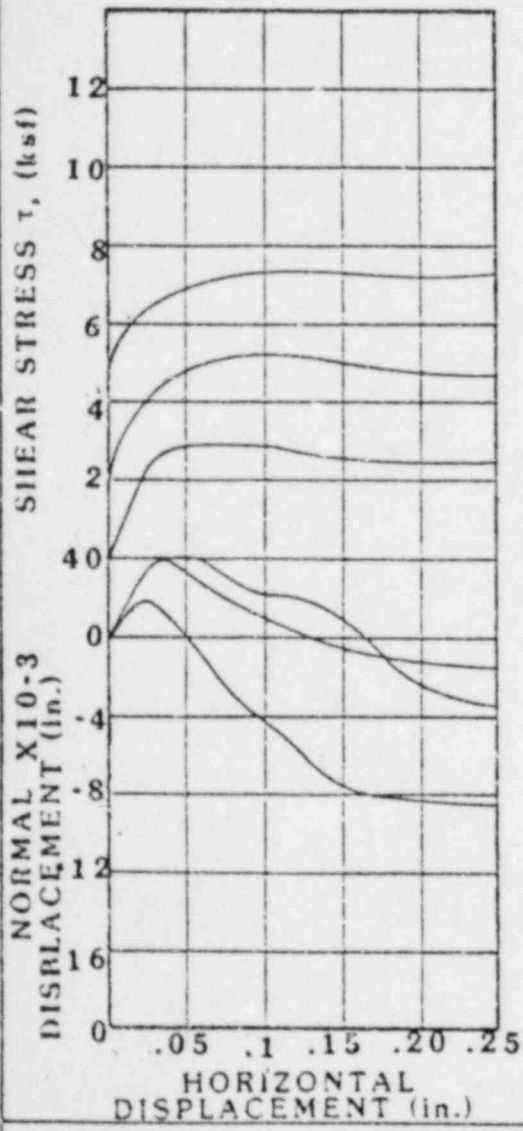
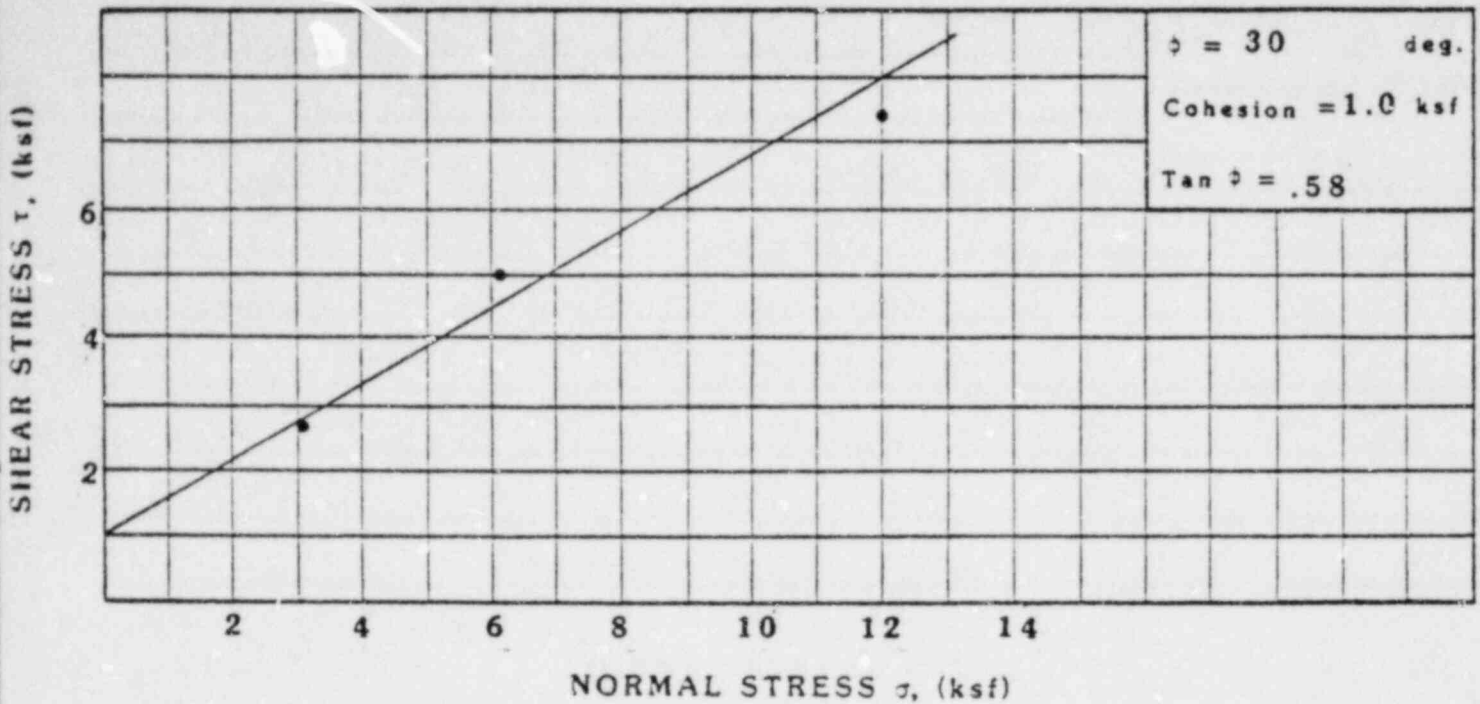
JOB NO. 1-2664-3118



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FIGURE B-34



Sample of SAND, silty from test hole K1-1
 at depth 19 feet.
 Type of Test Direct Shear

Test No.				
Height (in.)	H_o	.75	.75	.75
Area (in. ²)	A_o	4	4	4
Natural Moisture Content (%)	w_n	5.7	5.7	5.7
Dry Density (psf)	γ_{d_o}	107	107	107
Consolidation Pressure (ksf)	σ_c	3.016	6.032	12.064
Normal Stress (ksf)	σ	3.016	6.032	12.064
Maximum Shear Stress (ksf)	τ	2.7	5.0	7.4
Residual Shear Stress (ksf)	τ_r			
Strain Rate (in./min.)				

DIRECT SHEAR TEST RESULTS

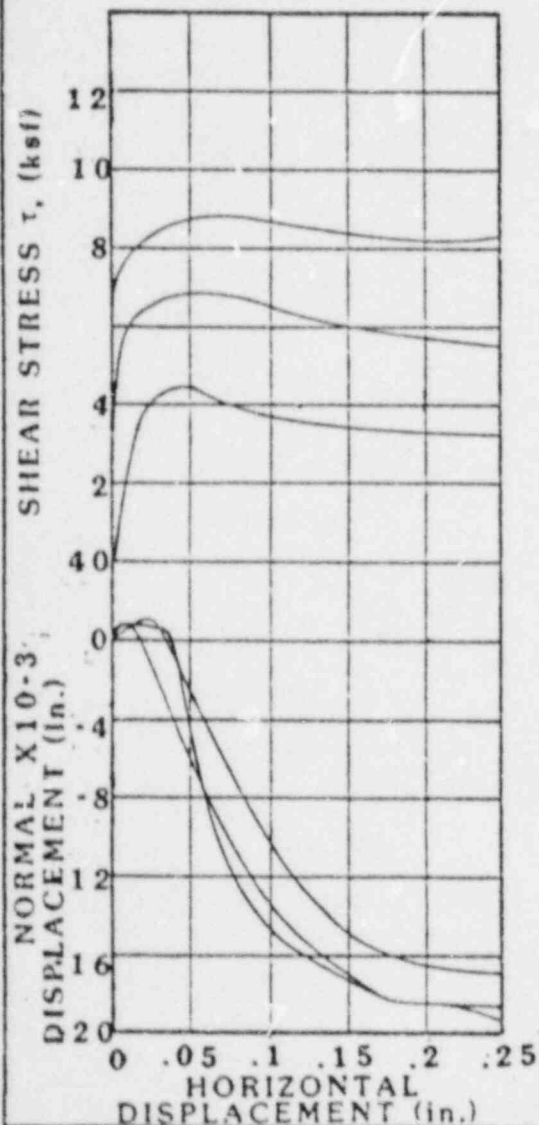
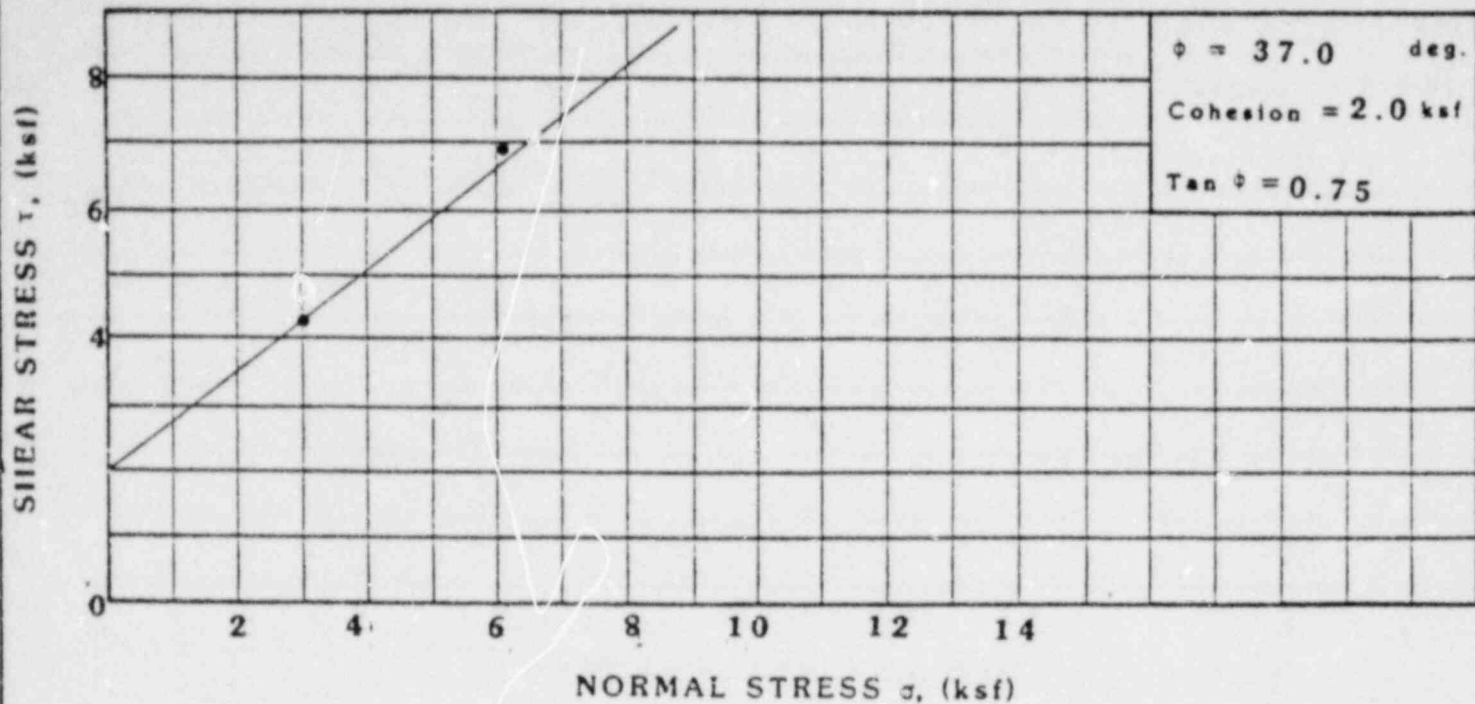
Job No: 1-2664-3118

Date: 5/20/80

Figure B-35



Consulting Engineers and Geologists



Sample of SAND, silty from test hole K1-2
 at depth 19 feet.
 Type of Test Direct Shear

Test No.				
Height (in.)	H_o	.75	.75	.75
Area (in. ²)	A_o	4	4	4
Natural Moisture Content (%)	w_n	7.6	7.6	7.6
Dry Density (pcf)	γ_{d_o}	117	117	117
Consolidation Pressure (ksf)	σ_c	3.016	6.032	12.064
Normal Stress (ksf)	σ	3.016	6.032	12.064
Maximum Shear Stress (ksf)	τ	4.3	6.9	8.9
Residual Shear Stress (ksf)	τ_r			
Strain Rate (in./min.)				

DIRECT SHEAR TEST RESULTS

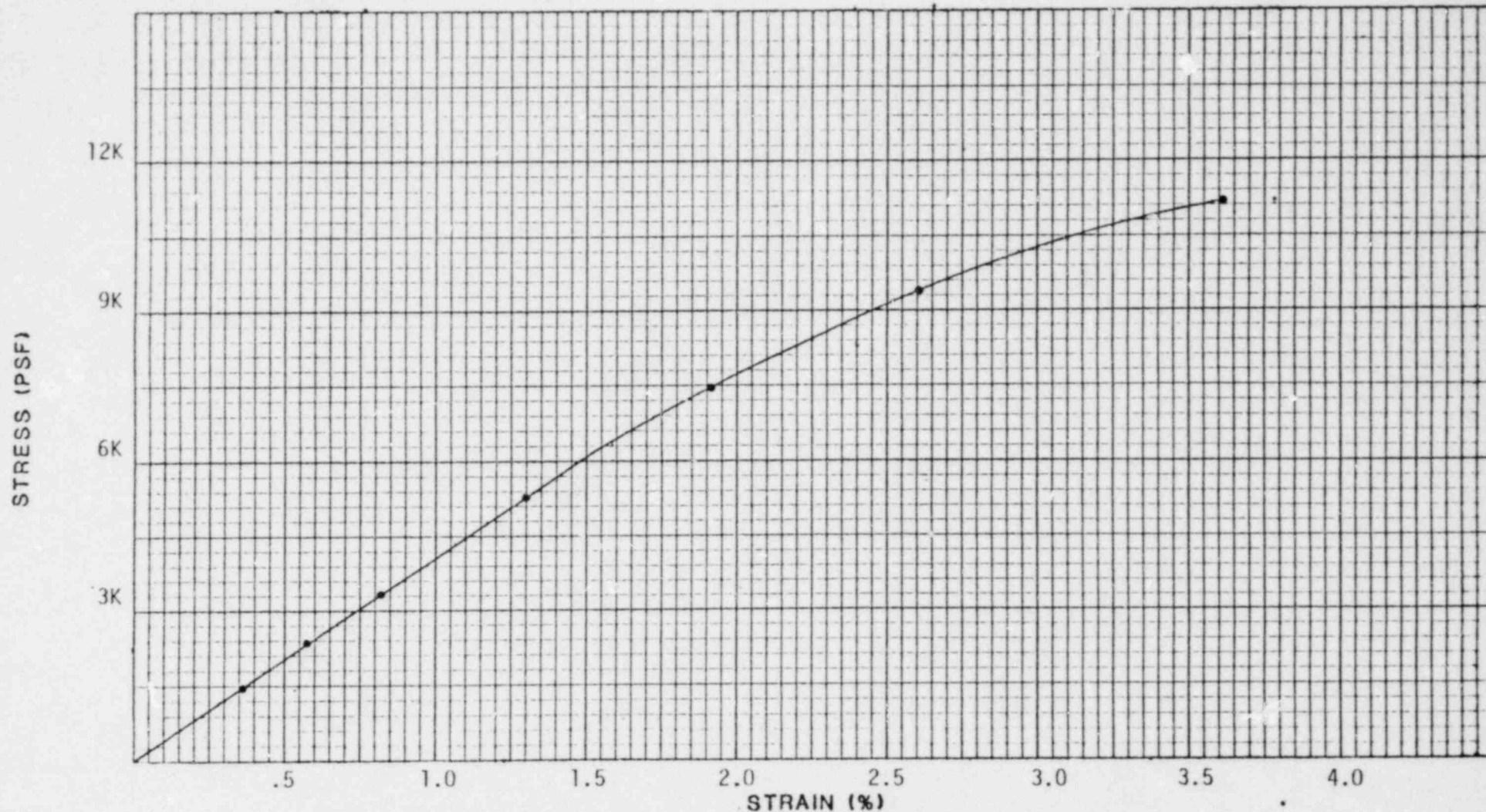
Job No: 1-2664-3118



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Date: 5/20/80

Figure B-36



Sample of Remolded Clay Material from hole _____ at depth _____ Moisture Content 11.3 %
 Unconfined Compressive Strength 11,000 psf Dry Density 130 pcf

UNCONFINED COMPRESSION TEST RESULTS

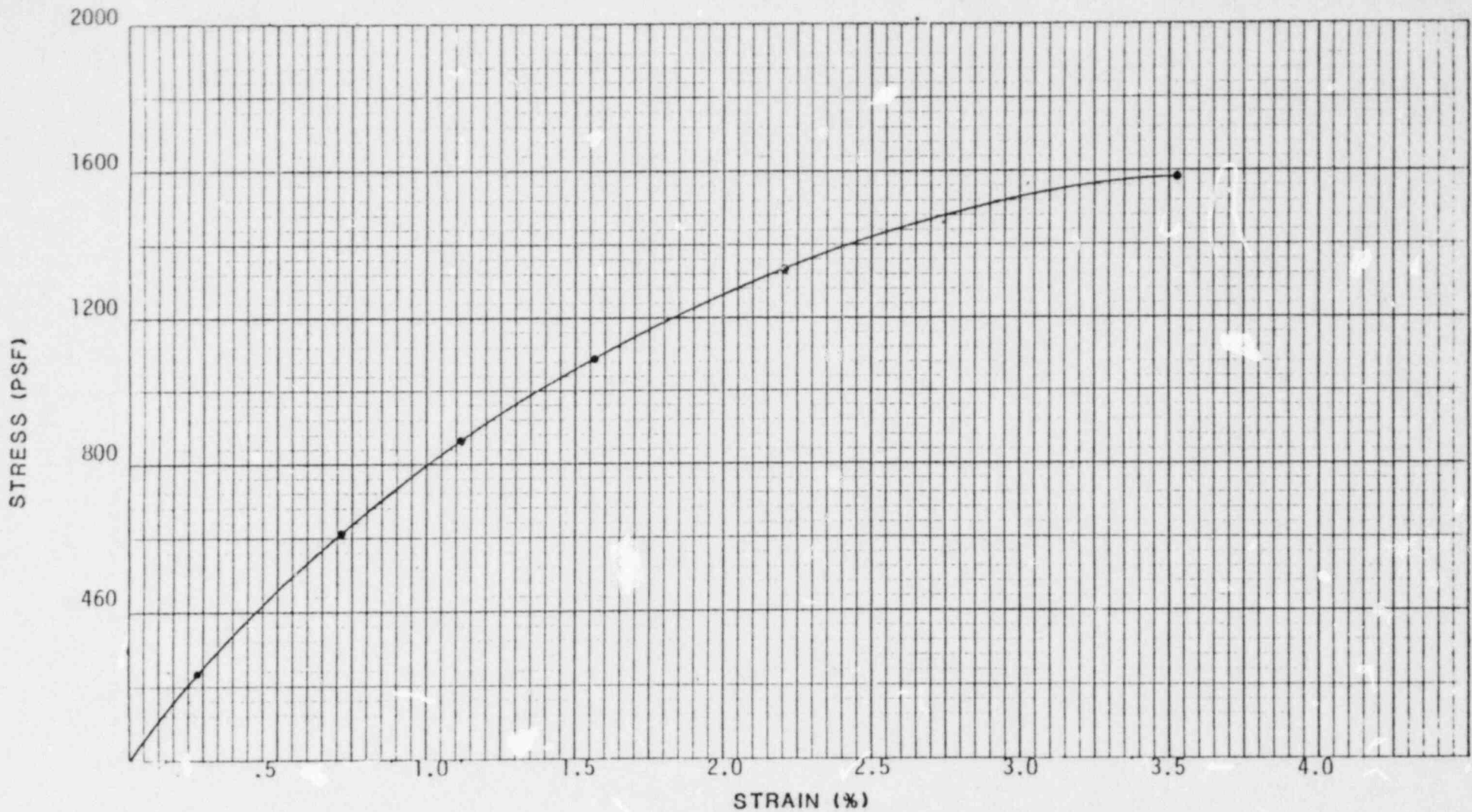
JOB NO., 1-2664-3118



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DATE: 5/20/80

FIGURE B-37



Sample of Heap Leach Ore from hole - at depth - Moisture Content 11.9 %
 Unconfined Compressive Strength 1,585 psf Natural Wet Density 124 pcf

UNCONFINED COMPRESSION TEST RESULTS

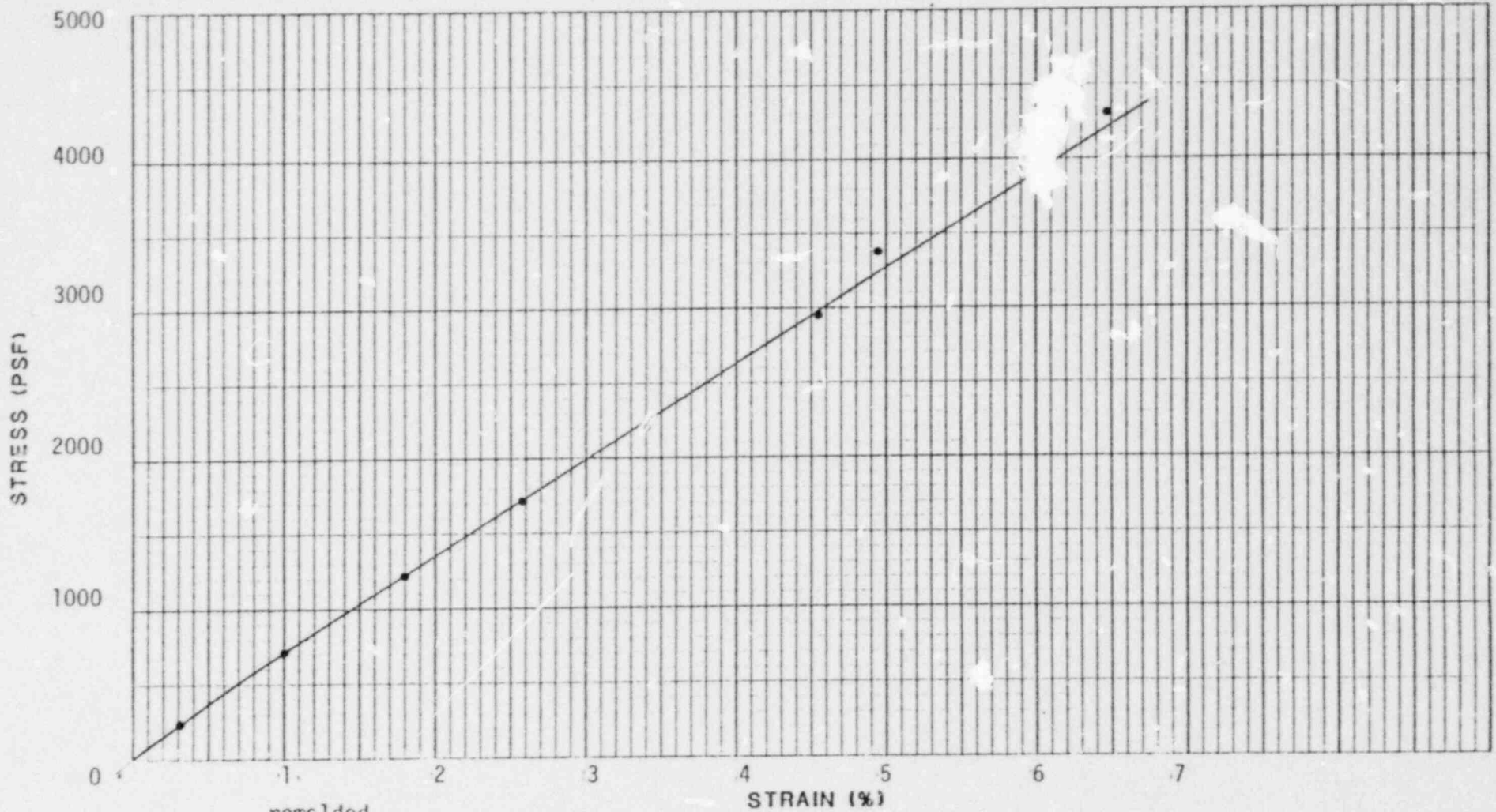
JOB NO. 1-2664-3118



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DATE: 5/20/80

FIGURE B-38



remolded
 Sample of clay liner material from hole _____ at depth _____ Degree of Saturation = 100%
 Unconfined Compressive Strength 4220 psf Dry Density = 112.9

UNCONFINED COMPRESSION TEST RESULTS

JOB NO. 1-2664-3118



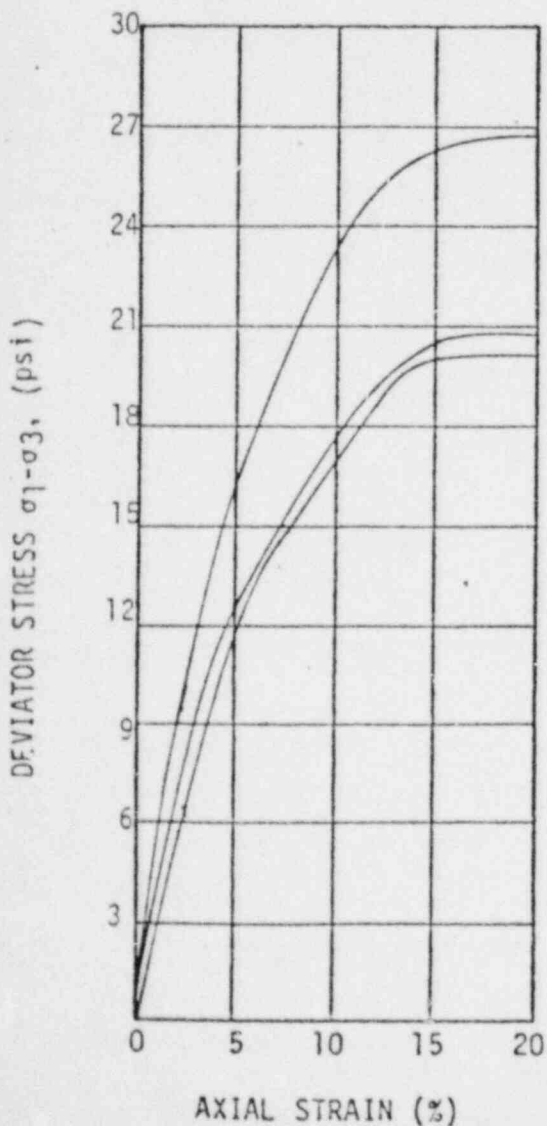
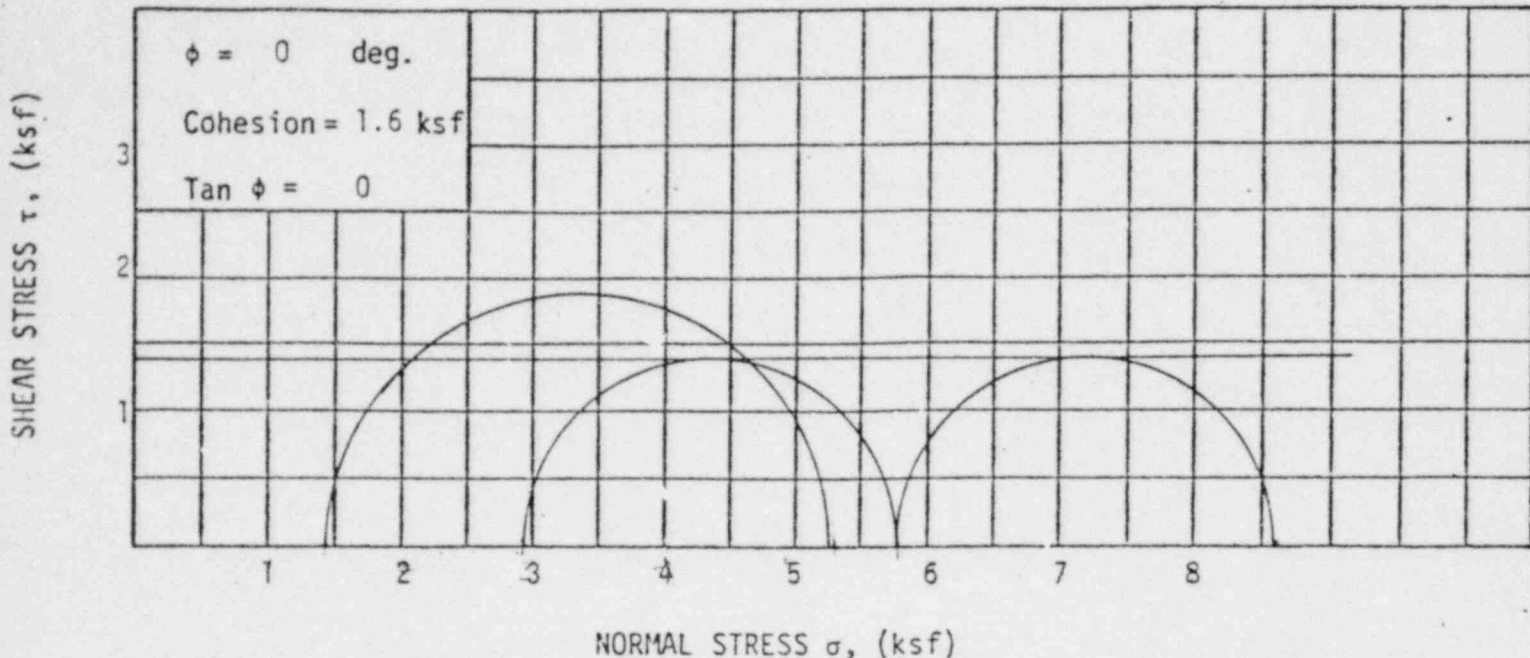
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FIGURE B-39



TRIAXIAL SHEAR TEST RESULTS

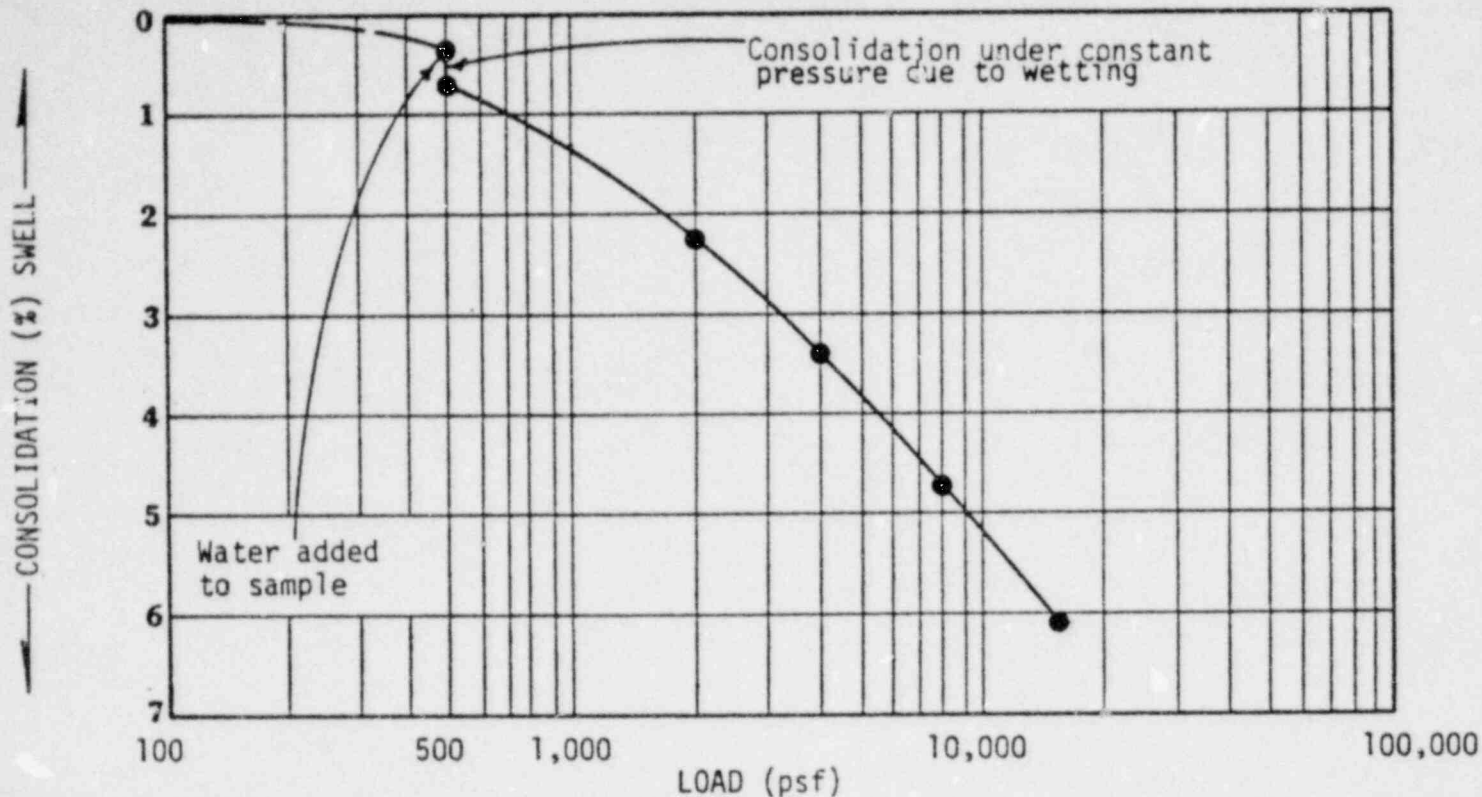


Boring No. _____ at Depth _____ feet.
 Sample of Heap Leach Ore Type of Test Unconsolidated/Undrained

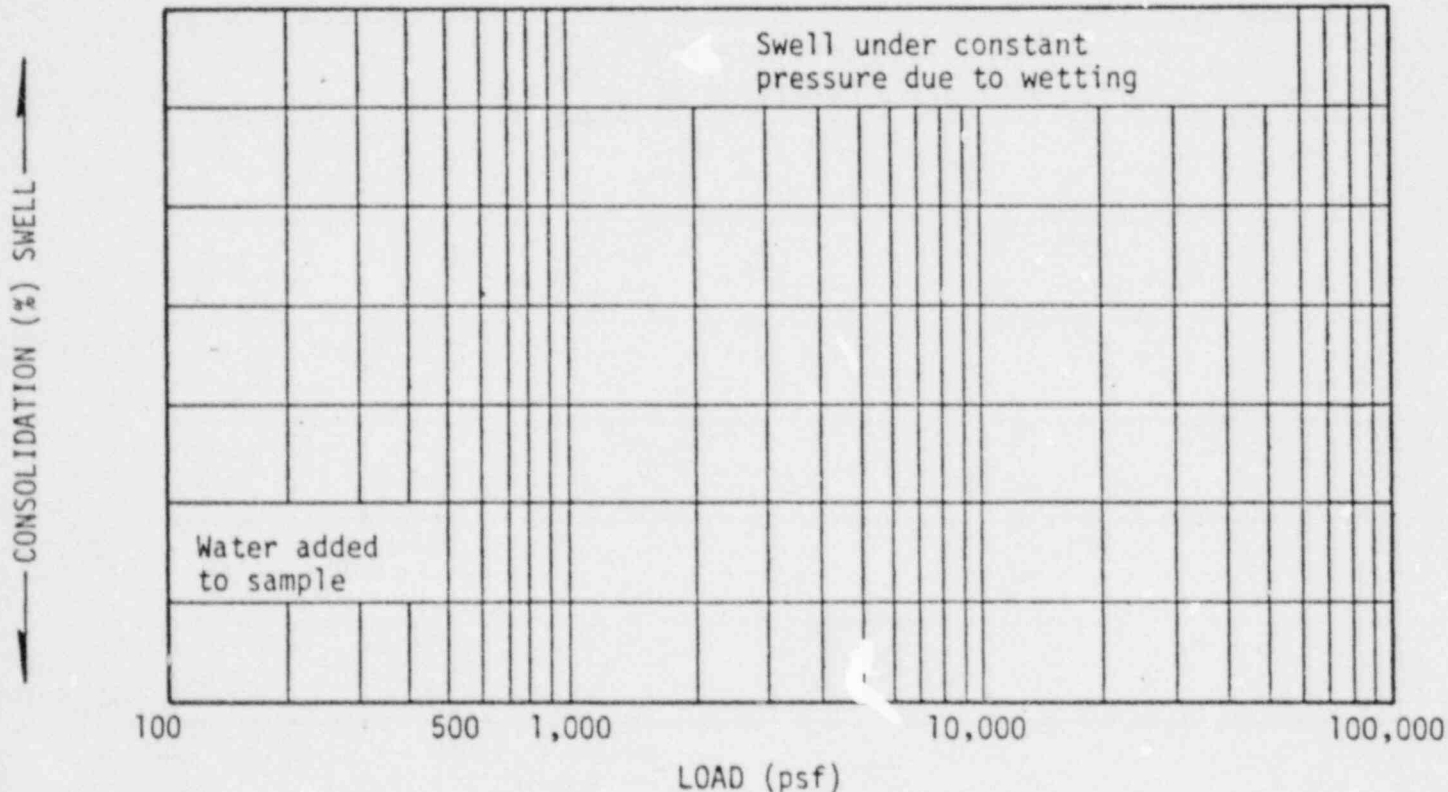
Test No.		1	2	3
Initial	Water Content (%)	w_o 16.5	16.7	17.0
	Dry Density (pcf)	γ_{do} 111.0	111.0	110.0
	Saturation (%)	S_o 95.0	92.7	94.1
	Void Ratio	e_o 0.45	0.47	0.47
Before Shear	Water Content (%)	w_c 16.6	17.4	17.1
	Dry Density (pcf)	γ_{dc} 111.0	110.0	110.0
	Saturation (%)	S_c 95.0	96.7	94.5
	Void Ratio	e_c 0.45	0.47	0.47
Final Back Pressure (ksf)		U_o 0.72	0.72	0.72
Minor Principal Stress (ksf)		σ_3 1.44	2.88	5.76
Maximum Deviator Stress ksf		$(\sigma_1 - \sigma_3)_{max}$ 3.84	2.93	2.95
Time to $(\sigma_1 - \sigma_3)_{max}$ min.		t_f 134	136	141
Ultimate Deviator Stress psi		$(\sigma_1 - \sigma_3)_{ult}$ 26.7	20.0	40.0
Initial Diameter, in.		D_o 2.85	2.85	2.85
Initial Height, in.		H_o 5.75	5.80	5.80
Controlled Strain Test @ 0.009 in/ min.				

Figure B-40

SWELL-CONSOLIDATION TESTS



Sample of silty SAND from test hole A-5 from depth 29 feet.
 Natural Moisture Content 7.5 % Natural Dry Density 118 pcf.



Sample of _____ from test hole _____ from depth _____ feet.
 Natural Moisture Content _____ % Natural Dry Density _____ pcf.

FIGURE B-41

SWELL-CONSOLIDATION TESTS

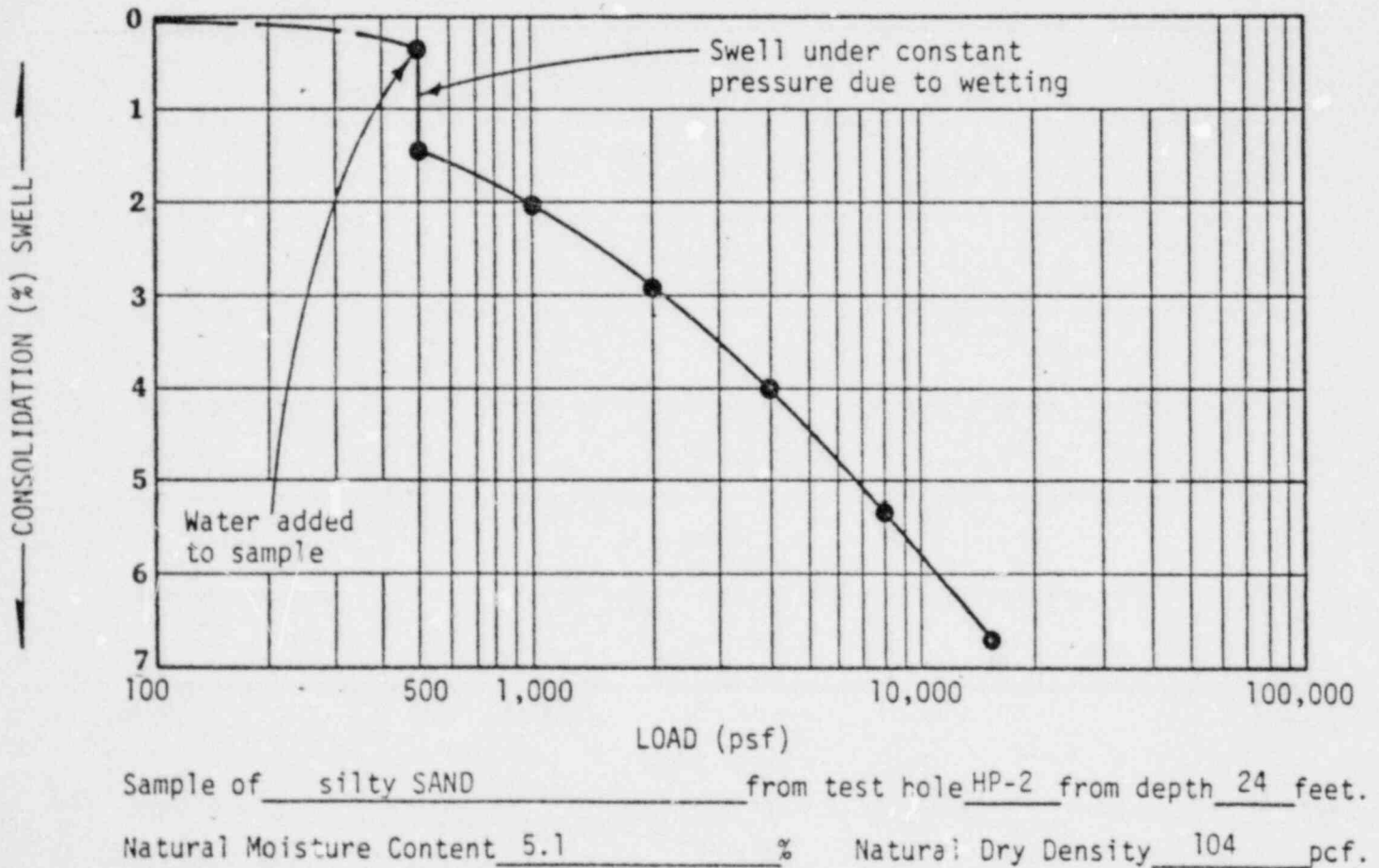
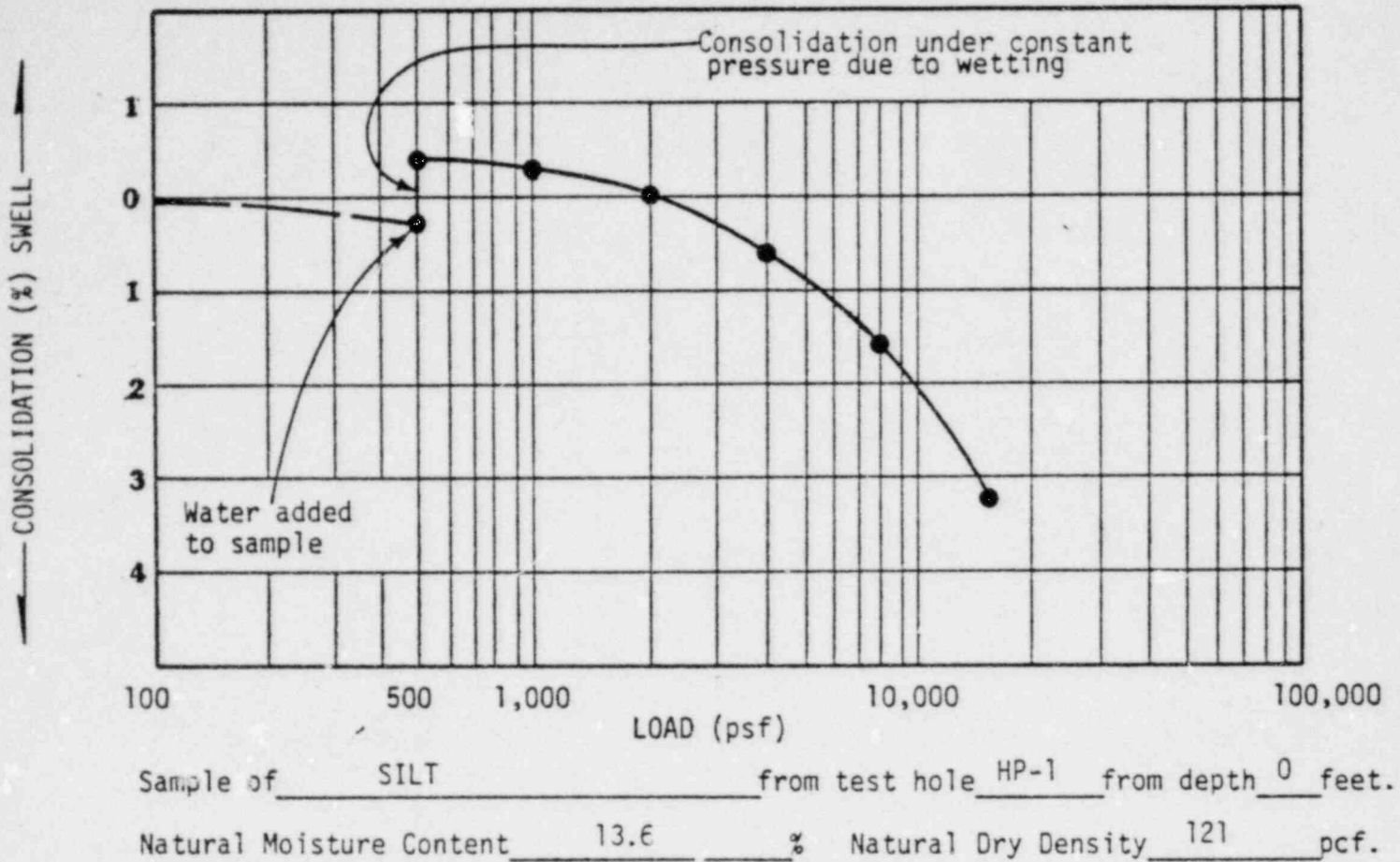
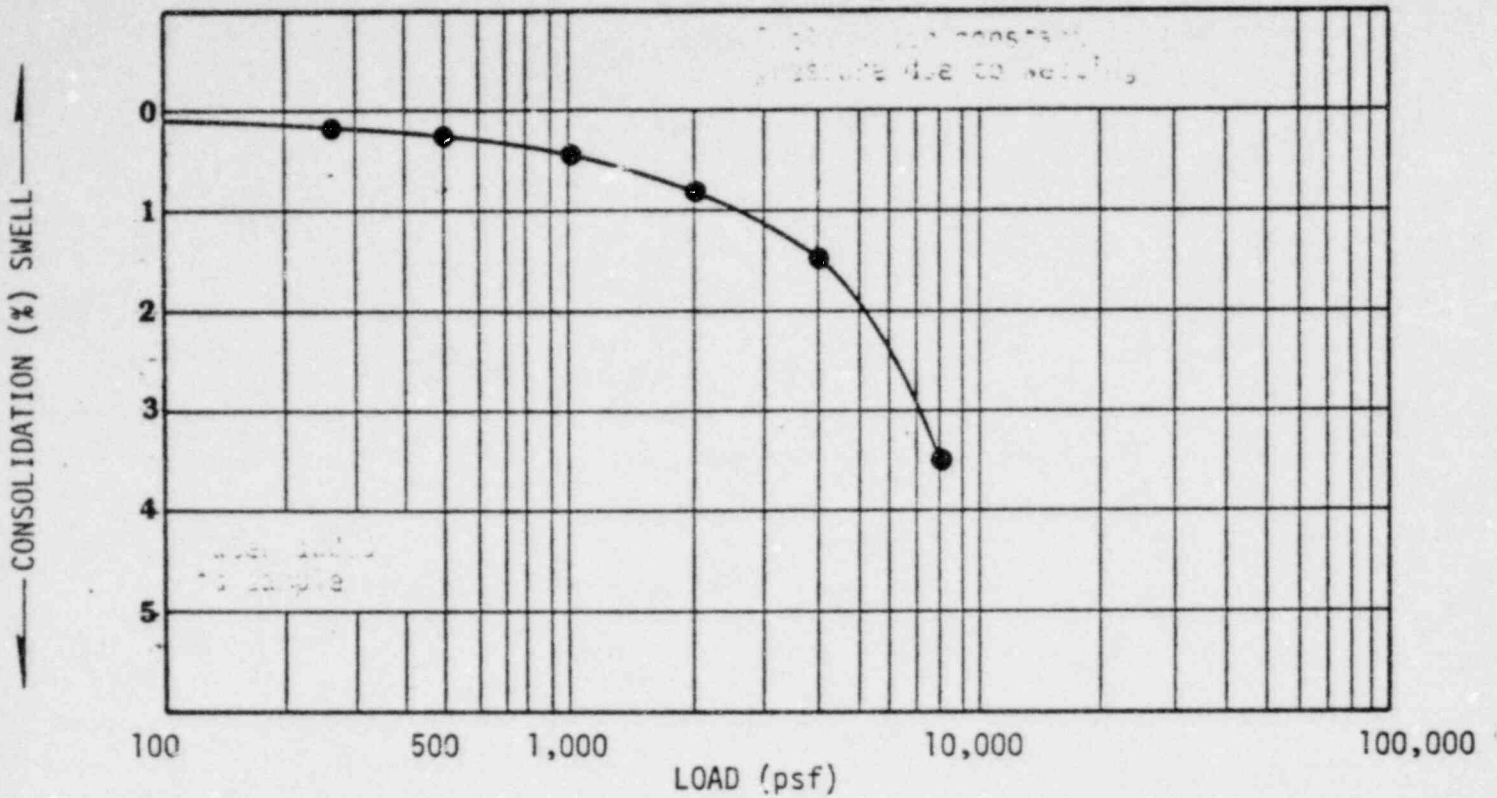
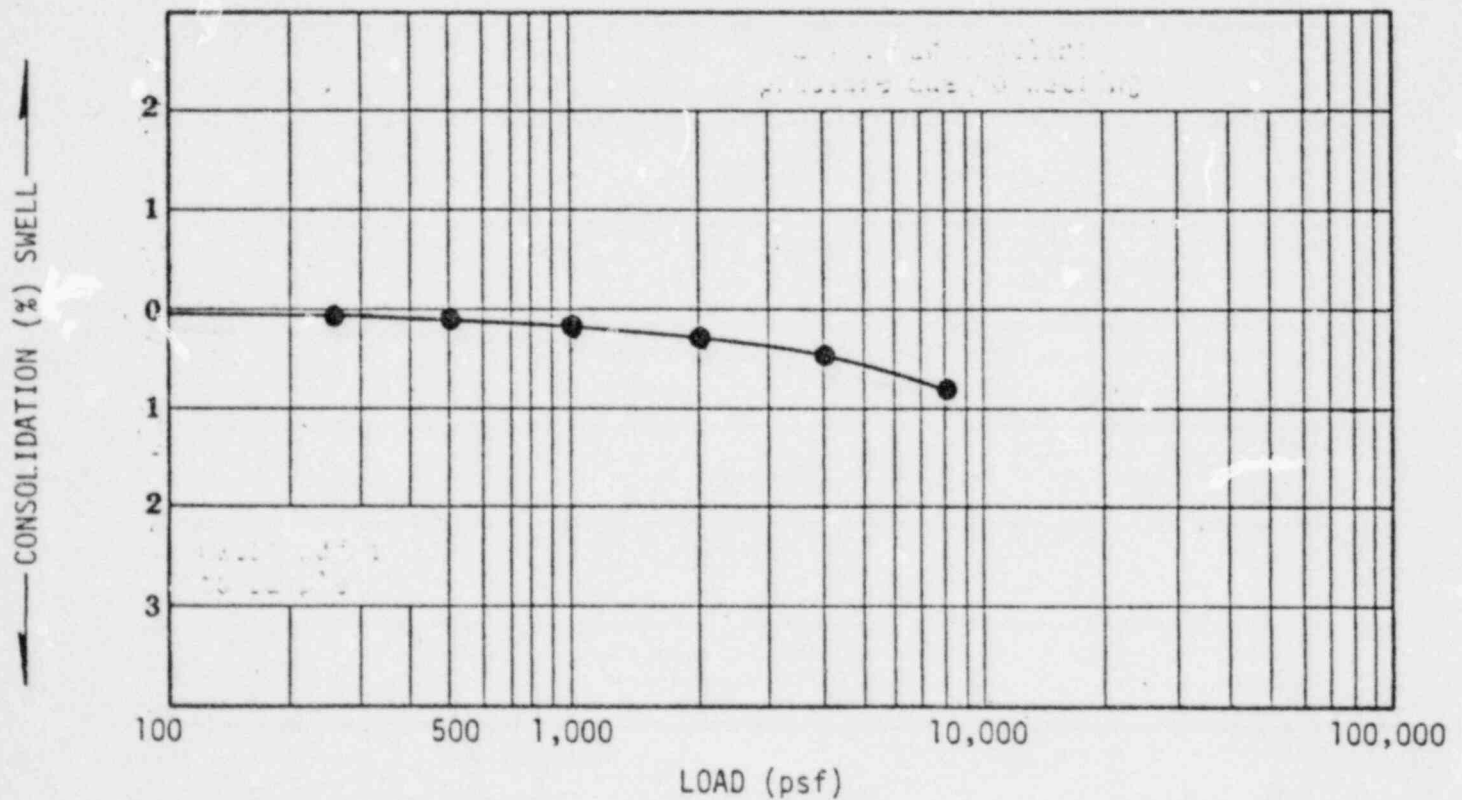


FIGURE B-42

SWELL-CONSOLIDATION TESTS

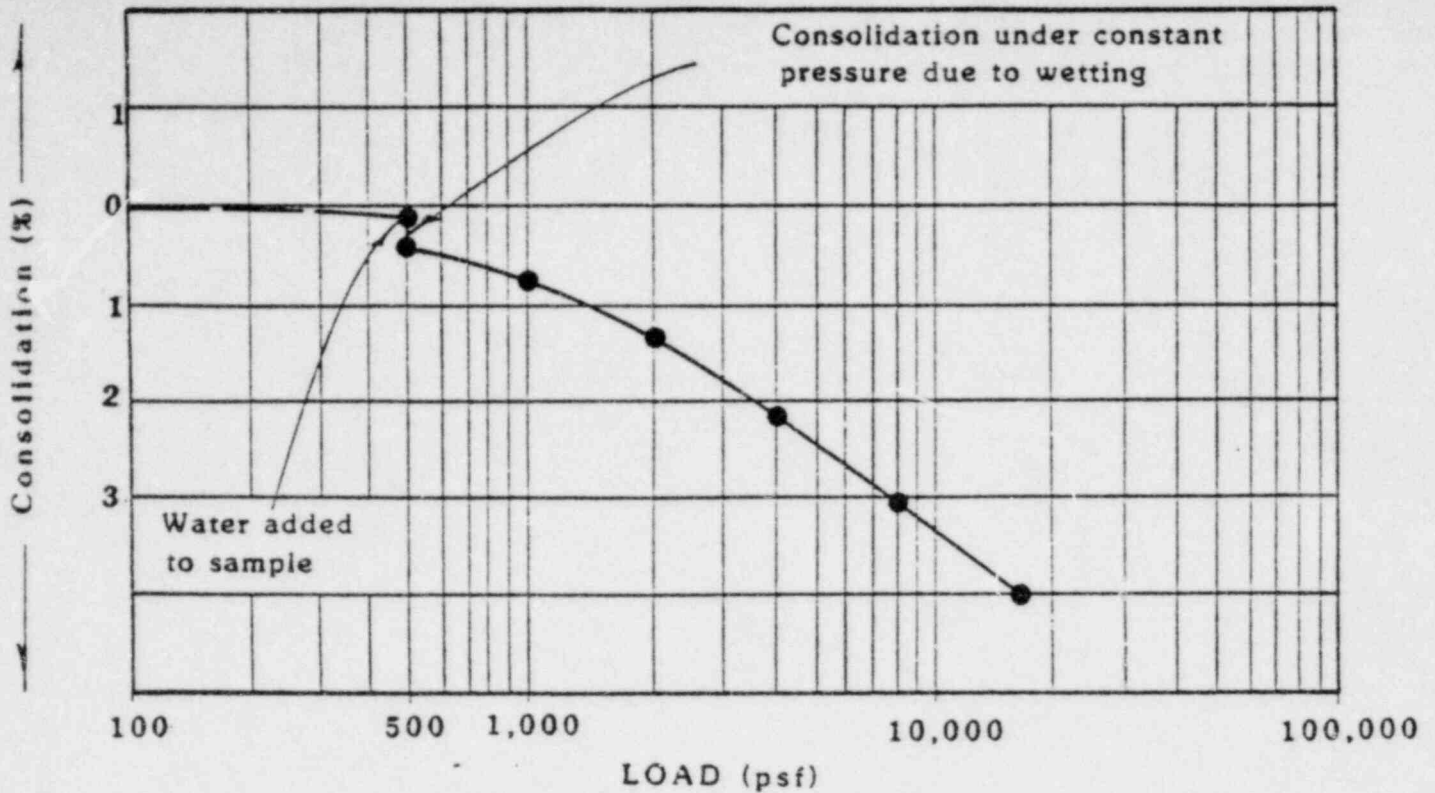


Sample of FILL, Site A from test hole - from depth feet.
 Natural Moisture Content 5.7 % Natural Dry Density 87.7 pcf.



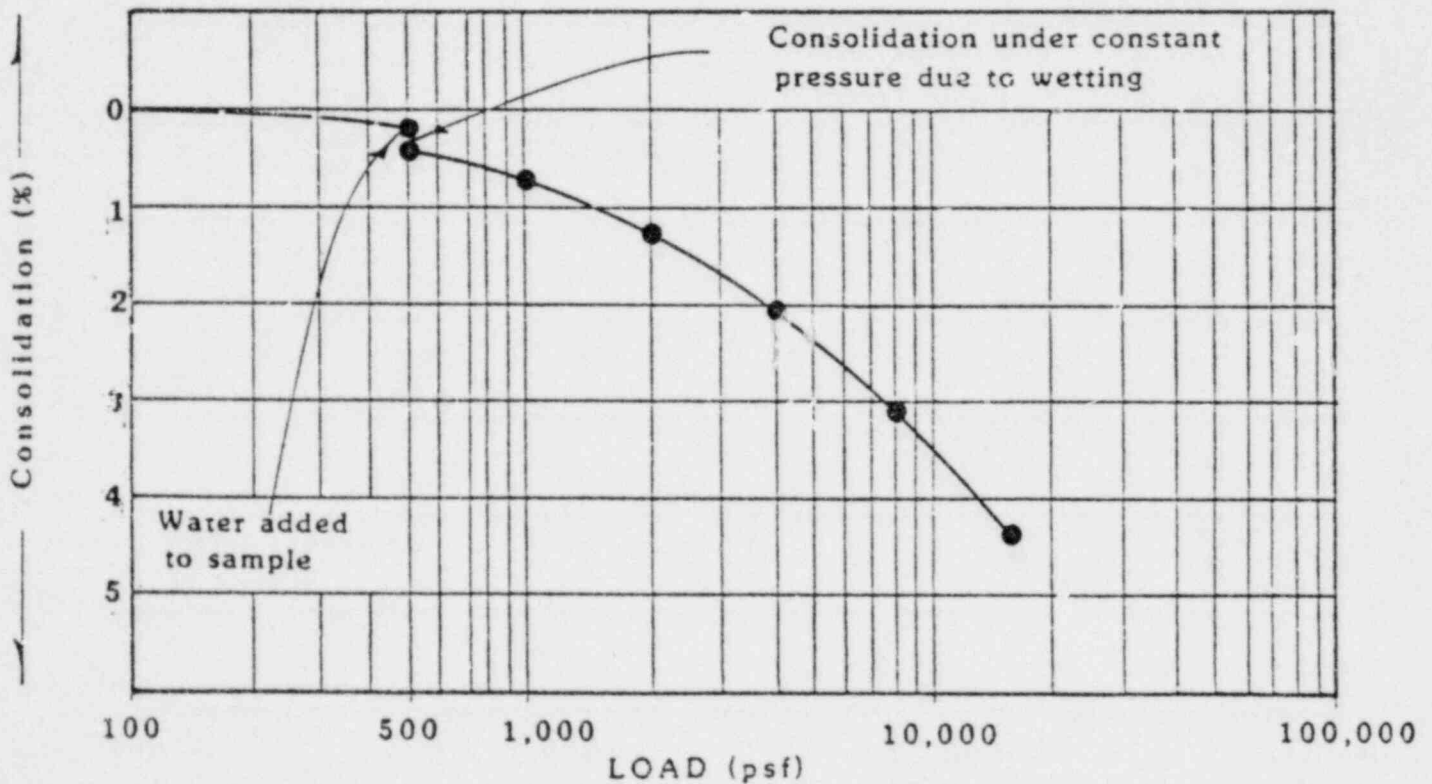
Sample of FILL, Site A from test hole - from depth feet.
 Natural Moisture Content 5.7 % Natural Dry Density 109.8 pcf.

FIGURE B-43



Sample of silty SAND from test hole KI-1 at depth 19 feet.

Natural Moisture Content 5.7 % Natural Dry Density 107 pcf.



Sample of silty SAND from test hole KI-2 at depth 19 feet.

Natural Moisture Content 7.6 % Natural Dry Density 117 pcf.

SWELL - CONSOLIDATION TESTS

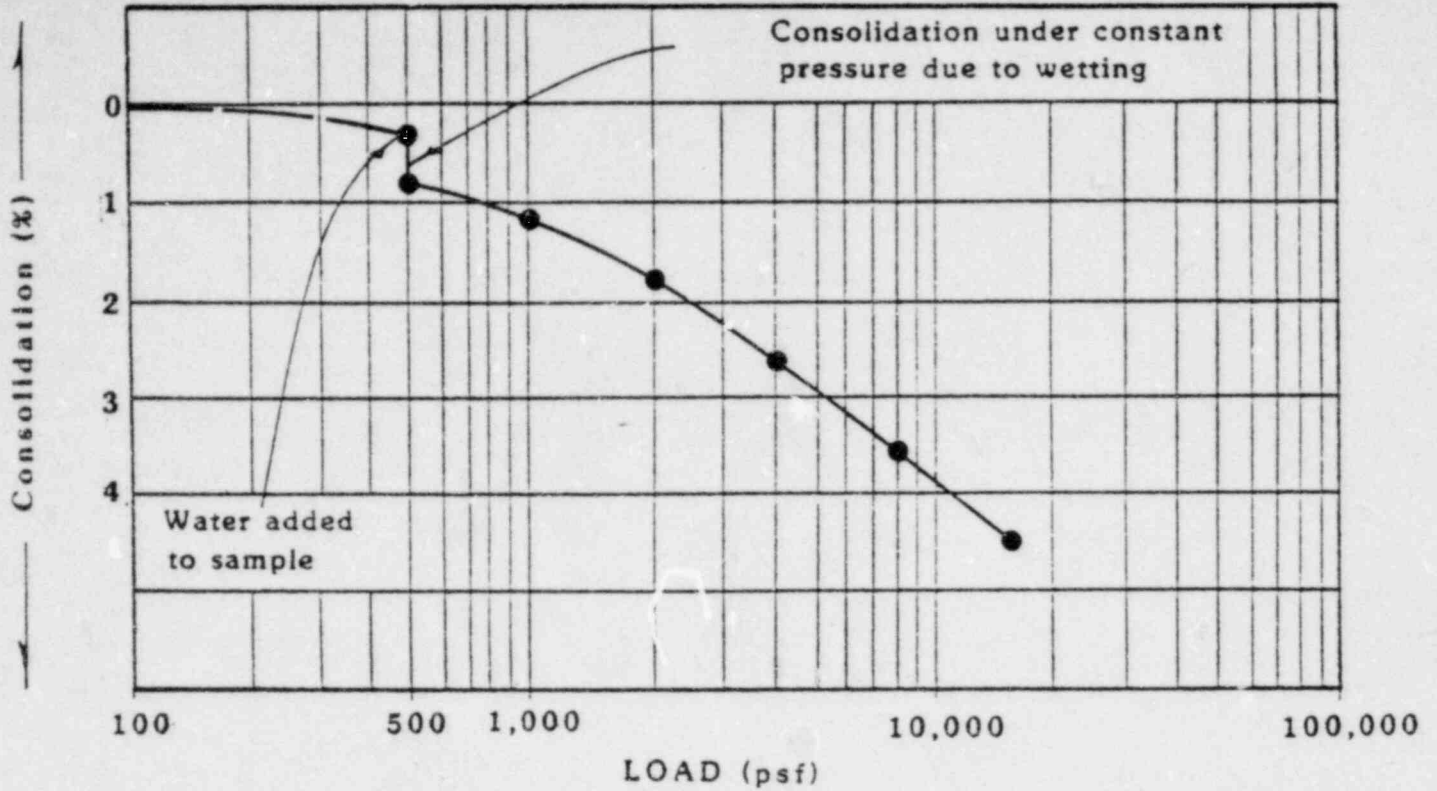
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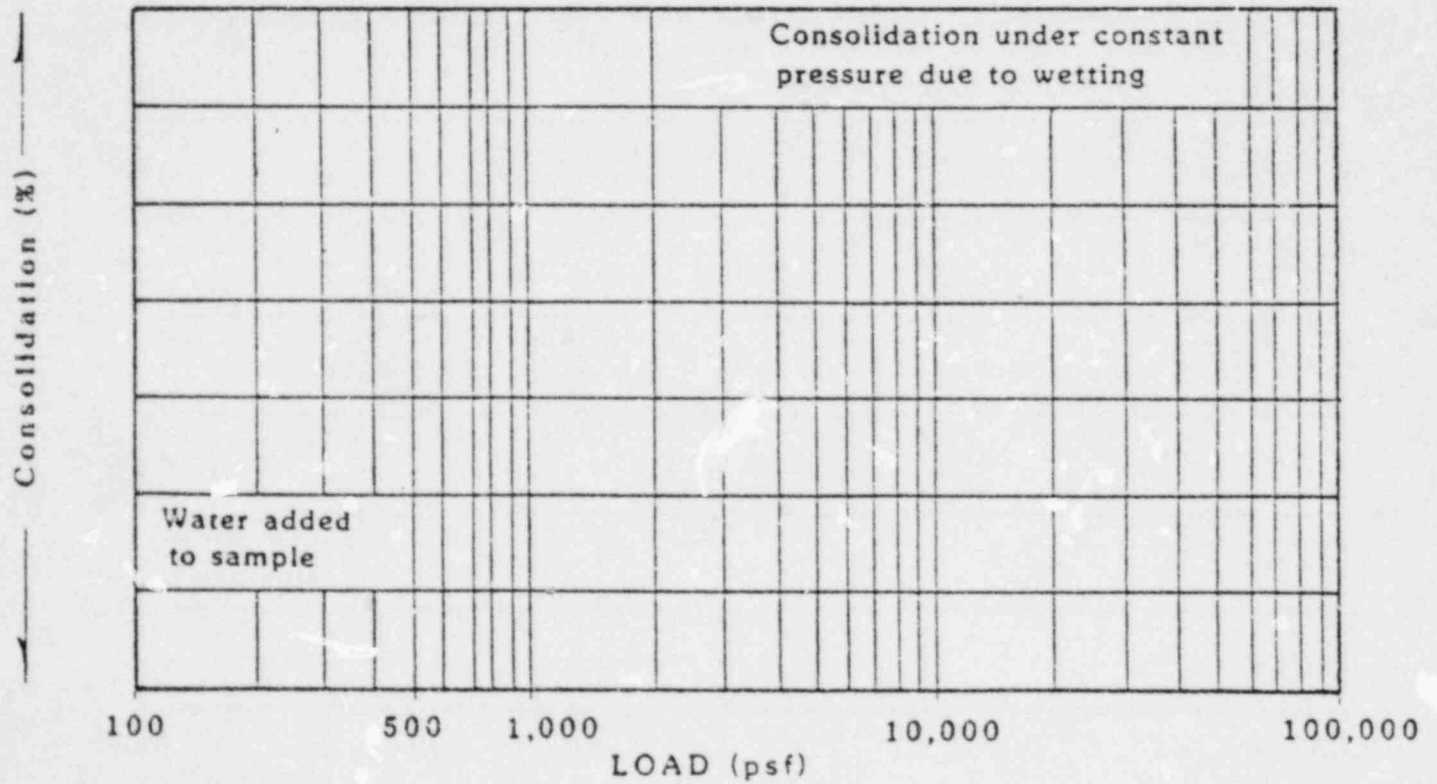
Date: 5/20/80

Figure B-44



Sample of silty SAND from test hole K1-7 at depth 89 feet.

Natural Moisture Content 7.1 % Natural Dry Density 117 pcf.



Sample of _____ from test hole _____ at depth _____ feet.

Natural Moisture Content _____ % Natural Dry Density _____ pcf.

SWELL - CONSOLIDATION TESTS

Job No: 1-2664-3118



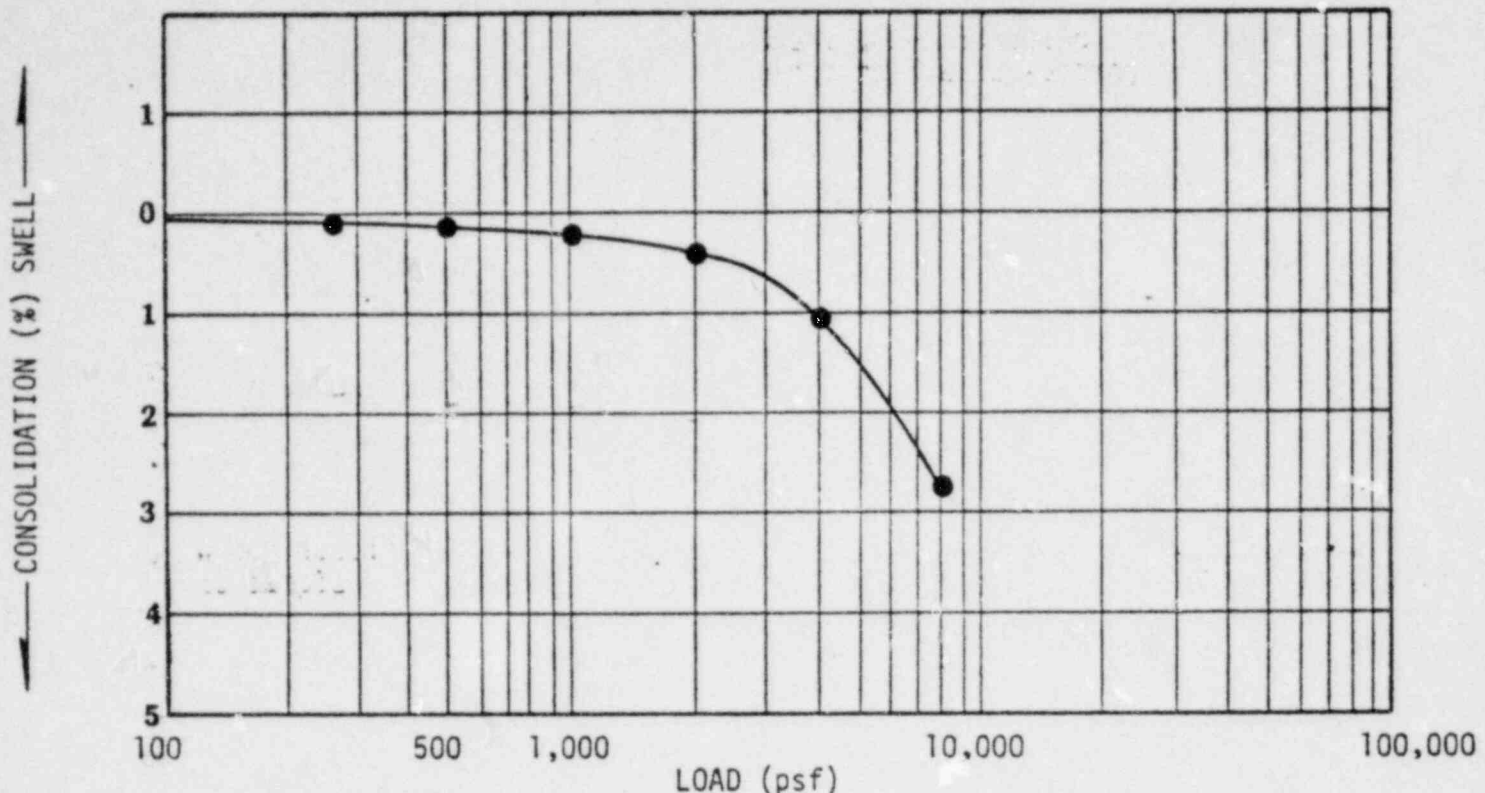
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Date: 5/20/80

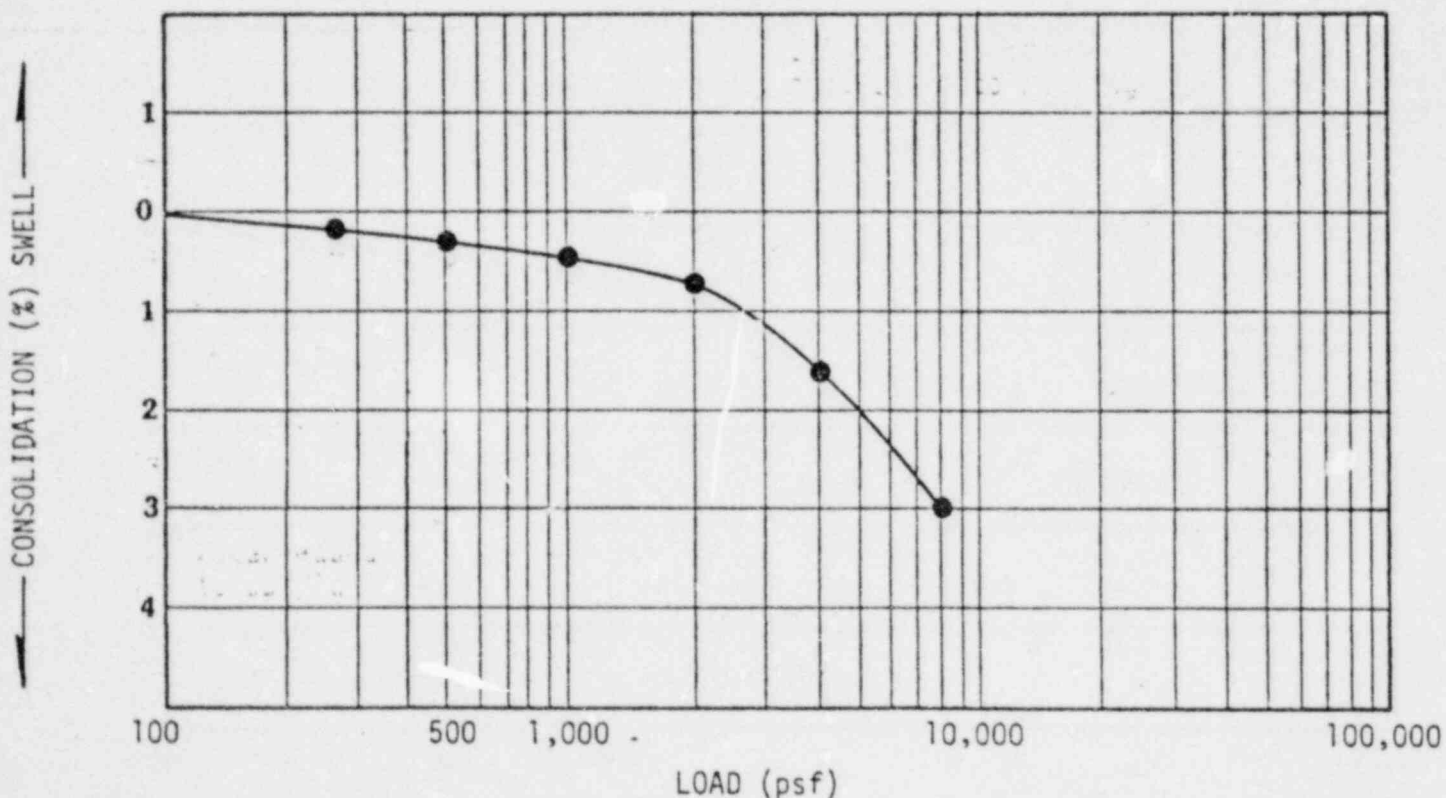
Figure B-45

Job No. _____ Hole _____

SWELL-CONSOLIDATION TESTS



Sample of FILL, K-1 Site from test hole - from depth - feet.
 Natural Moisture Content 4.9 % Natural Dry Density 87.4 pcf.



Sample of FILL, K-1 Site from test hole - from depth - feet.
 Natural Moisture Content 4.9 % Natural Dry Density 109.2 pcf.

FIGURE B-46

Hole Number	Depth of Sample (ft)	Natural Dry Density (pcf)	Natural Moisture Content (%)	Sieve Analysis (% passing)			Atterberg Limits		Specific Gravity	Triaxial Test Results	Direct Shear Test Results		Unconfined Compression Strength (ksf)	Laboratory Permeability (cm/sec)	Proctor Test Results		Unified Soil Classification	Remarks
				No. 10	No. 40	No. 200	LL (%)	PL			C (ksf)	ϕ°			Ed max (pcf)	w opt. (%)		
A1	4	112	11.1	97.5	50.8	19.4	26	NP			0	35.5	2.9×10^{-4}			SM	See Fig. 4 See Fig. 30	
A1	19 & 24 & 39	94	9.2															
A2	4	103	6.8	72.4	35.3	14.4	25	NP	2.626				1.4×10^{-3}			SM	See Fig. 5	
A2	14	99	13.6	93.0	72.7	40.3	24	21								SM	See Fig. 6	
A2	19 & 24 & 29	103	7.9								0	37.0				SM	See Fig. 31	
A3	4	76	4.8	89.9	33.2	11.6	24	NP	2.583							SP-SM	See Fig. 7	
A3	19 & 24 & 29	112	12.5								0	42.5					See Fig. 32	
A4	4	102	12.1	96.8	67.3	39.9	25	21	2.60				1.9×10^{-4}			SM	See Fig. 8	
A4	9	109	18.3														See Fig. 33	
A4	29	99	8.8	83.5	35.0	13.3	23	22									See Fig. 9	
A5	19	114	12.8	94.9	74.0	39.9	24	23									See Fig. 10	
A5	29	118	7.5	77.3	40.0	19.5	25	23									See Figs. 11, 41	
A5	49	121	12.5	98.0	79.8	57.3	29	21									See Figs. 12, 34	
HP1	0	121	13.6	89.8	77.8	58.0	33	32									See Figs. 13, 42	
HP1	24	105	15.1	83.0	64.0	46.4	33	25									See Fig. 14	
HP1	29	102	5.8	96.9	40.0	13.9	22	22									See Fig. 15	
HP2	9	107	7.0	93.3	60.9	17.8	22	NP					5.6×10^{-4}				See Fig. 16	
HP2	24	104	5.1	91.0	35.3	10.7	22	22									See Figs. 17, 42	
HP2	49	115	7.2	92.6	45.8	14.7	19	18									See Fig. 18	
Fill Site A		87-109	5.7	194.6	47.1	16.4												See Figs. 19, 43

Job No: 1-2664-3118

Date: 5/20/80

Figure B-47

SUMMARY OF LABORATORY TESTING

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Hole Number	Depth of Sample (ft)	Natural Dry Density (pcf)	Natural Moisture Content (%)	Sieve Analysis (% passing)			Atterberg Limits		Specific Gravity	Triaxial Test Results	Direct Shear Test Results		Unconfined Compression Strength (ksf)	Laboratory Permeability (cm/sec)	Proctor Test Results		Unified Soil Classification	Remarks
				No. 10	No. 40	No. 200	LL (%)	PL			Ed max (pcf)	w opt. (%)						
K1-1	9&19	107	5.7	90.9	51.4	24.1	23	0			1.0	30	4X10 ⁻⁷			SM	See Figs. 20, 35, 44	
K1-1	34		9.6	94.7	43.5	16.8	23	18			2.0	37	1X10 ⁻⁶			SC-SM	See Fig. 20	
K1-2	9&17	117	7.6	93.5	47.7	23.9	23	0								SM	See Figs. 20, 36, 44	
K1-3	9		7.8	91.6	42.2	17.1	22	0								SM	See Fig. 21	
K1-4	4		11.9	98.1	82.0	46.3	26	18								SC	See Fig. 21	
K1-6	89	117	7.1	98.3	47.4	18.1	18	0								SM	See Figs. 21, 45	
Fill K1		87-109	4.9	95.1	48.1	15.0										SC-SM	See Figs. 22, 46	

SUMMARY OF LABORATORY TESTING		Job No: 1-2664-3118
		Date: 5/20/80
		Figure B-48



Consulting Engineers and Geologists

Hole Number	Depth of Sample (ft)	Natural Dry Density (pcf)	Natural Moisture Content (%)	Sieve Analysis (% passing)			Atterberg Limits		Specific Gravity	Direct Shear Test Results	Triaxial Test Results		Unconfined Compression Strength (ksf)	Laboratory Permeability (cm/sec)	Proctor Test Results		Unified Soil Classification	Remarks
				No. 10	No. 40	No. 200	LL (%)	PL			C (ksf)	ϕ^*			gd max (pcf)	w opt. (%)		
Clay Bag		117	11.3	93.6	81.5	60.7	30	26					6x10 ⁻⁵	123.0	10.0	ML-CL	Figs. 24, 28, 1 90% mod. Figs. 23, 37	
Clay Rmd				98.9	92.3	74.3							5.0x10 ⁻⁸ 7.0x10 ⁻⁸	120.5	13.0	ML-CL	*95% mod. Acid sol., H2O sol.	
Clay Rmd				98.3	96.5	82.3	36	23						118.5	14.0	CL	Figs. 29, 39, 2	
Heap Leach Ore		111	11.9	94.1	70.6	45.2	27	17				1.585				CL		
Ore Rmd				93.6	71.7	45.7					1.6	0				CL	Figs. 38, 25, 26	
Ore Rmd				98.3	96.5	82.3	36	23								CL	90% mod. Fig. 40	
Clay Liner				97.1	92.1	65.3						4.22				CL	Fig. 28, 39	

Job No: 1-2664-3118

Date: 5/20/80

Figure B-49

SUMMARY OF LABORATORY TESTING

FOX Consulting Engineers and Geologists

APPENDIX C
Seepage Calculations

APPENDIX C - SEEPAGE CALCULATIONS

NOTATION:

f, l, t, - Subscripts denoting foundation material, liner, coarse tailings, respectively

n - porosity

k - hydraulic conductivity (cm/sec)

D - thickness of layer (cm)

y - head (cm)

θ - volumetric water content defined as volume of water per unit total volume of material where the subscripts i, f, r denote initial, above the wetting front and residual

h_d - displacement pressure head (cm)

q - Darcy' flux rate (cm/sec)

T - time required for wetting front to travel a given distance (various units)

h_f - head at wetting front

M.C. - moisture content defined as weight of water per unit weight of dry soil
x 100%

λ - pore size distribution index

SITE A

DATA

$$n_f = .37$$

$$K_f = 6.1 \times 10^{-4} \text{ cm/sec}$$

$$K_t = 5.4 \times 10^{-4} \text{ cm/sec}$$

$$K_L = 1 \times 10^{-7} \text{ cm/sec}$$

$$D_t = 25' = 762 \text{ cm}$$

$$D_L = 1' = 30.5 \text{ cm}$$

$$D \text{ to water table} = 160' - 190', 160' = 4,877 \text{ cm}$$

$$\theta_i \text{ for foundation} = .18$$

θ_r for foundation estimated to be .18 so that calculations for distance traveled by wetting front would represent the maximum distance traveled after mining operations are curtailed

$$y = 6.9' = 210 \text{ cm}$$

D_f is the distance from the liner to the wetting front at a particular time

λ is assumed to be 2

DISPLACEMENT PRESSURE

$$h_d = -9.66 \left[\frac{K_f}{n_f - \theta r} \right]^{-.401}$$

Applies only when K is in cm/sec since the equation is not dimensionally consistent otherwise.

$$h_d = -9.66 \left[\frac{6.1 \times 10^{-4}}{.37 - .18} \right]^{-.401} = -96.6 \text{ cm}$$

CRITERION FOR SATURATION OF FOUNDATION

$$y + D_2 - K_f \left(\frac{D_L}{K_L} \right) \begin{array}{l} < h_d \Rightarrow \text{unsaturated flow} \\ \geq h_d \Rightarrow \text{saturated flow} \end{array}$$

for $K_L = 1 \times 10^{-7}$ cm/sec:

$$\begin{aligned} y + D_L - K_f \left(\frac{D_L}{K_L} \right) &= 210 + 30.5 - 6.1 \times 10^{-4} \frac{30.5}{1 \times 10^{-7}} \\ &= -1.85 \times 10^5 < h_d = -96.6 \text{ unsaturated flow} \end{aligned}$$

Darcy's Flux Rate:

$$q = \frac{y + D_L - h_d (q/K_f)}{D_L/K_L} \quad \frac{-1}{2 + 3\lambda} \quad -0.125$$

$$= \frac{210 + 30.5 + 96.6 (q/6.1 \times 10^{-4})}{30.5/K_L}$$

$$q = \frac{240.5 + 38.3 \left(\frac{-0.125}{q} \right)}{30.5/K_L}$$

solving by trial and error:

$$q = 1.5 \times 10^{-6} \text{ cm/sec for } K_L = 1 \times 10^{-7}, Q = \frac{.03 \text{ gal}}{\text{day-ft.}^2}$$

DISTANCE TRAVELED BY WETTING FRONT

(After Liner is Saturated)

$$\theta_f = (N_f - \theta_r) \left(\frac{q}{K_f} \right)^{\frac{\lambda}{2 + 3\lambda}} + \theta_r$$

$$T = \frac{D_f (\theta_f - \theta_i)}{q}$$

for $K_L = 1 \times 10^{-7}$ cm/sec

$$\theta_f = (.37 - .18) (1.5 \times 10^{-6} / 6.1 \times 10^{-4})^{.25} + .18$$

$\theta_f = .22$ Note: Since $\theta_f \approx \theta_r$ the distance computed should also represent the total spreading after mining activities are discontinued

$$D_f = \frac{T q}{\theta_f - \theta_i} = \frac{7 \text{ mos.} \times \frac{30 \text{ day}}{1 \text{ mo.}} \times \frac{24 \text{ hr.}}{1 \text{ day}} \times \frac{3,600 \text{ sec.}}{1 \text{ hr.}} \times 1.5 \times 10^{-6}}{.22 - .18}$$

$$D_f = 680 \text{ cm} = 22 \text{ feet}$$

SITE K-1

DATA

$$N_f = .35$$

$$K_t = 5.4 \times 10^{-4} \text{ cm/sec}$$

$$K_f = 1 \times 10^{-5} \text{ cm/sec}$$

$$D_L = 1 \times 10^{-7} \text{ cm/sec}$$

$$D_t = 27' = 823 \text{ cm}$$

$$D \text{ to water table} = 67' = 2,042 \text{ cm}$$

$$\theta_i \text{ for foundation} = .16$$

θ_r for foundation estimated to be .16 so that calculations for distance traveled by wetting front would represent the maximum distance traveled after mining operations are curtailed

y is approximately 7.0 feet = 214 cm

D_f is the distance from the liner to the wetting front at a particular time

λ is assumed to be 2

DISPLACEMENT PRESSURES

$$h_{df} = -9.66 \left[\frac{K_f}{n_f - \theta_r} \right]^{-.401} = -9.66 \left[\frac{1 \times 10^{-5}}{.35 - .16} \right]^{-.401} = -502 \text{ cm}$$

CRITERION FOR SATURATION OF FOUNDATION

$$y + D_L - K_f \left(\frac{D_L}{K_L} \right) \begin{array}{l} < h_d \Rightarrow \text{unsaturated flow} \\ \geq h_d \Rightarrow \text{unsaturated flow} \end{array}$$

for $K_L = 1 \times 10^{-7}$ cm/sec and $K_f = 1 \times 10^{-5}$ cm/sec:

$$y + D_L - K_f \left(\frac{D_L}{K_L} \right) = 214 + 30.48 - 10^{-5} \left(\frac{30.48}{10^{-7}} \right) = -2.80 \times 10^{-3} \text{ cm}$$

$$-2.80 \times 10^3 < h_d = -502 \text{ cm} \Rightarrow \text{unsaturated flow}$$

DARCY'S FLUX

$$q = \frac{y + D_L - h_d (q/K_f)}{D_L/K_L} = \frac{214 + 30.48 + 502 (q/10^{-5})}{30.48/10^{-7}} \quad \text{---.125}$$

$$q = \frac{244.5 + 119 \left(q \right)^{-0.125}}{30.48 \times 10^{-8}}$$

$$q = 2.73 \times 10^{-6} \text{ cm/sec}, \quad Q = 21206 q = \frac{.06 \text{ gal}}{\text{day-ft.}^2}$$

DISTANCE TRAVELED BY WETTING FRONT

(After Liner is Saturated)

$$\theta_f = (N_f - \theta_r) (q/K_f) \frac{\lambda}{2 + 3\lambda} + \theta_r$$

$$\theta_f = (.35 - .16) (2.73 \times 10^{-6}/10^{-5})^{.25} + .16$$

$$\theta_f = .30$$

$$D_f = \frac{T q}{\theta_r - \theta_i} = 7 \text{ mos.} \times \frac{3,600 \times 24 \times 30 \text{ sec.}}{\text{mo.}} \frac{2.73 \times 10^{-6}}{(.30 - .16)}$$

$$D_f = 354 \text{ cm} = 11.6 \text{ feet (in 7 months)}$$

$$\text{Spreading Distance: } \left(\frac{\theta_f}{\theta_r}\right) D_f = \frac{.30}{.16} (11.6) = 22 \text{ feet}$$

Seepage:

$$q = \frac{y + D_t + D_L - hd (q/K_f)^{-.125}}{\left(\frac{D_t}{K_t}\right) + \left(\frac{D_L}{K_L}\right)}$$

$$q = \frac{30.5 + 823 + 30.5 - 502 (q/10^{-5})^{-.125}}{\frac{823}{5.4 \times 10^{-4}} + \frac{30.5}{10^{-7}}}$$

$$q = \frac{884 + 119q^{-.125}}{3.07 \times 10^8}$$

$$\bar{q} = 4.67 \times 10^{-6} \text{ cm/sec} \quad Q = \frac{.10 \text{ gal}}{\text{day} - \text{ft}^2}$$

$$\theta_f = (N_f - \theta_r) (q/K_f)^{.25} + \theta_i$$

$$\theta_f = (.35 - .16) (4.67 \times 10^{-6}/10^{-5})^{.25} + .16$$

$$\theta_f = .32$$

$$D_f = \frac{T q}{\theta_f - \theta_i} = \frac{24 \times 3,600 \times 4.67 \times 10^{-6}}{(.32 - .16)}$$

$$D_f = 2.52 \text{ cm} = 1 \text{ inch (for 24 hours)}$$

$$\left(\frac{\theta_f}{\theta_r}\right) D_f = 2 \text{ inches}$$

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