UNION CARBIDE CORPORATION
Niagara Falls, New York

PRELIMINARY GEOTECHNICAL INVESTIGATION OF THE PROPOSED SPRING CREEK MESA TAILINGS AND EFFLUENT DISPOSAL SITE NEAR URAVAN, COLORADO

MAY 1980

CONSULTING
ENGINEERS

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19 May 1980

Union Carbide Corporation
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Attention: Dr. T. J. Kagetsu
Assistant Director, Engineering Technology Dept.
Metals Division

Subject: Report on Preliminary Geotechnical Investigation
Proposed Tailings and Effluent Disposal Site
Spring Creek Mesa, Colorado

Gentlemen:

International Engineering Company, Inc. (IECO) is pleased to transmit five copies of its report entitled "Preliminary Geotechnical Investigation of the Proposed Uranium Tailings Disposal Site at Spring Creek Mesa, Colorado." This work was completed in accordance with the scope of work defined in Union Carbide Corporation's Purchase Order No. EC 615-5235 and as originally presented in IECO's proposal dated 22 February 1980.

The results of the geotechnical investigation indicate that the Spring Creek Mesa site is suitable for the safe disposal of uranium tailings from Union Carbide's milling operation near Uravan, Colorado. The location identified as the West Mesa has a sufficiently impermeable foundation for siting of the effluent pond, and the Airstrip Area is a feasible site for disposal of filtered tailings. Both sites will require impervious liners, and quantities of impervious material are available from excavation of the West Mesa Area and from an adjacent borrow area.

Further investigations that are recommended in the report include in situ permeability tests, preliminary embankment and pond liner design, and other studies of site conditions.

If you have any questions regarding this report and our recommendations for further work, we will be pleased to answer them.

Very truly yours,

Kenneth B King

Kenneth B. King, Jr.
Project Manager

Encl.: Report on Preliminary Geotechnical Investigation

Our 35th Year 1945-1980

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APPENDICES

1.1 SUMMARY

Preliminary geotechnical investigations were conducted at Spring Creek Mesa near Uravan, Colorado to determine the feasibility of constructing an effluent pond and a dry tailings pond for disposal of uranium milling wastes. The waste material will be produced by Union Carbide Corporation's active mill at Uravan. Geotechnical engineering services were performed by International Engineering Company, Inc. (IECO) and are described in the text and appendices of this report.

Results of the field reconnaissance and testing and laboratory testing indicate that the West Mesa Area is a feasible site for construction of an effluent pond. The site is sufficiently large for the required 250 acres of surface area of the pond that will evaporate the required amount of effluent and store the residue from the milling process. A near-surface shale layer and liner material at this site will provide a barrier against seepage with a permeability on the order of $1\text{x}10^{-6}$ to $1\text{x}10^{-7}$ cm per sec. Excavation of the West Mesa Area will provide construction materials for the ring embankment and an impervious pond liner. Because of the relatively impervious liner and shale foundation, only a minimal amount of seepage will occur.

The Airstrip Area is a feasible storage site for the 9 million tons of future filtered tailings. These tailings have a water content of approximately 25 percent. Excavation will provide construction materials for the ring-type containment dike, and excavation at the effluent pond or an adjacent borrow source must be used for impervious shale pond liner. The tailings can be placed and contoured so as to provide drainage of effluent to a collection system. The effluent can then be pumped then be pumped to the effluent pond. Overburden removed from the site can be stockpiled to cover the tailings in a program of periodic reclamation and eventual abandonment.

Preliminary studies of the borrow area indicate that impermeable shales are available in sufficient quantities to line the tailings pond at the Airstrip Area. This borrow source will supplement the shale excavation from the West Mesa Area.

IECO recommends further investigations of the Spring Creek Mesa site to include the following:

- Additional borings and test trenches in the West Mesa, Airstrip, and borrow areas and, particularly, in the western portion of the West Mesa Area.
- Field permeability tests of foundation and pond liner materials using water and tailings effluent.
- Office studies of potential seepage paths.
- Installation and monitoring of a system of ground-water wells to acquire baseline water quality data.
- Further design studies on hydrology, environmental baseline data, and abandonment.

1.2 AUTHORIZATION

At the request of Dr. T. J. Kagetsu of Union Carbide, IECO submitted a proposal dated 22 February 1980 for preliminary geotechnical services for evaluating the proposed Spring Creek Mesa tailings disposal site near Uravan, Colorado. Union Carbide authorized IECO to proceed with the studies with Purchase Order No. EC 615-5235 dated 24 March 1980.

1.3 SCOPE OF WORK

The scope of work consisted of developing and supervising a field exploration program to include soil borings, rock coring, and a test trench program to evaluate the site foundations and potential borrow sources. Geologic mapping and laboratory testing to define engineering parameters were required. A geotechnical field reconnaissance and office studies were completed to define site conditions. The report on the investigation was to summarize all findings, present field and laboratory data, discuss the suitability of the site for uranium tailings disposal, and present IECO's recommendations for further investigations. The detailed scope of work is described in IECO's proposal and Union Carbide's Purchase Order, which are referenced above.

SECTION 2
PROJECT DESCRIPTION

2.1 GENERAL

The Spring Creek Mesa site is one of several alternatives that Union Carbide Corporation is considering for disposal of tailings and effluent from its Uravan Uranium Mill. The tailings disposal site must accommodate a minimum of 9 million tons of tailings over the 17-year life of the project. The effluent pond must provide 250 acres of surface area to evaporate approximately 510 gallons per minute of liquid waste. The pond must also be sized to hold precipitation and the raffinate and solids that will crystallize out of the effluent.

2.2 LOCATIONS

The areas identified as the West Mesa Area and the Airstrip Area were selected during the geotechnical reconnaissance as appropriate sites for the investigations. The location of the project is shown on Figure 1, and the West Mesa and Airstrip Areas are illustrated on the Site Plan presented as Figure 3. Inspection of surface features indicated that the West Mesa Area would be a suitable site for the effluent pond because the shale bedrock is more impermeable than the sandstone foundation at the Airstrip Area. The shale is near the ground surface and would require minimal excavation of overburden. This overburden would be used as embankment construction material.

At the Airstrip, access to shale would require considerable excavation through hard rock to remove the more permeable sandstone layer. The sandstone does form a suitable foundation for disposal of filtered tailings, however; and excavation of overburden would provide embankment construction materials. The suitability of both the shale and sandstone tailings, however; and excavation of overburden would provide embankment construction materials. The suitability of both the shale and sandstone foundation materials at the respective disposal sites was confirmed through drilling, test trenches, field permeability tests, and laboratory testing. The investigation, sampling, and testing programs and their results are described in subsequent sections of this report.

SECTION 3
SITE CONDITIONS

3.1 SURFACE CONDITIONS

Spring Creek Mesa is capped by a sandstone formation. Where drainage patterns have eroded the sandstone, the underlying shales are exposed. The West Mesa and Airstrip Areas that were studied have few or no drainage channels. Because of the flat topography and the fact that separate embankments will completely surround the effluent pond and tailings pond, only precipitation that falls directly on each site needs to be considered; there will be no runoff into the ponds, and construction of the effluent and tailings ponds will not block or alter natural streams or drainage paths. Also, the Spring Creek Mesa site is advantageous because it is 1-1/2 miles from the nearest creek or river. This location reduces the possibility of the degradation of streams.

The mean annual rainfall in the vicinity of Uravan is approximately 10 inches per year. Further consideration of climatic conditions or surface hydrology was not included in this scope of work.

3.2 SUBSURFACE CONDITIONS

A. Regional Geology

Spring Creek Mesa is located in Montrose County, Colorado. The area is shown in the southwestern corner of the U.S. Geological Survey (USGS) Atkinson Creek Quadrangle, and the characteristics described below apply to the southern third of the quadrangle. The mesa is one of the many that has been cut from a larger plateau by steep-sided drainage courses. The surface of the plateau dips at a 5-degree angle toward the southwest.

The tops of most of the mesas in this vicinity are covered with a thin layer of reddish sandy silt that has been reworked by water in some places. This alluvium rarely exceeds 10 feet in thickness.

A series of sandstones and shales underlies the alluvium. These layers are part of the Dakota Sandstone formation, which was formed during the Cretaceous period. In the project area, it rarely exceeds 80 feet in thickness. The sandstones are fine-grained, yellowish, and often calcareous. The shales in this formation are generally black, moderately hard, and often calcareous and tend to air slake.

The Burro Canyon formation lies beneath the Dakota Sandstone and is exposed only in canyon walls in this area. The formation ranges from 100 to 120 feet in thickness and is comprised of sandstones, conglomerates, and shales.

The Morrison formation, which underlies the Burro Canyon formation, is the oldest exposed structure in the region. The shale, sandstone, mudstone, conglomerate, and thin limestone beds of the formation are exposed only in the larger drainage courses and are Upper Jurassic in age. The Brushy Basin shale is the upper member of the Morrison formation and makes up slightly over one-half of its 700- to 800-foot thickness. The Brushy Basin shale consists predominantly of varicolored bentonitic shales and mudstones.

The San Miguel Syncline is the final structure of interest. It bisects the southern third of the quadrangle in a northwest to southeast direction. The syncline dips gently to the northwest.

B. Site Geology

The portion of Spring Creek Mesa in the study site is flat and measures 2 miles square. It is located north of the San Miguel River between Spring Creek on the east and Atkinson Creek on the west. The surface lies about 800 feet above the San Miguel river at El. 5800 to El. 5900. Geologic features are illustrated on the Site Geology Map, Figure 2 and the site plan is shown in Figure 3.

A thin layer of alluvium that varies up to 10 feet and averages 5 feet in thickness covers the Dakota Sandstone formation that caps most of the mesa. The Dakota Sandstone is the primary formation of interest in this project. At the site, the formation consists of fine-grained, thin-bedded sandstones that vary in color from tan to gray and red and of interbedded gray and black carbonaceous shales with thin coal seams. In places, the sandstone has been converted to quartzite by silicification; however, these quartzites are confined to small areas both vertically and laterally. The shale and sandstone layers of the formation alternate, and a schematic representation of the layers is illustrated in Figure 4.

The thickness of each layer varies locally, as in the central part of the West Mesa Area where the upper sandstone is very thin or missing. In the Airstrip Area, the upper sandstone and shales are largely missing. Sandstone is at or near the surface and extends to a depth of 30 feet or more with only minor shale content. Bedding at the site generally strikes north 50 degrees west with dips of 2 degrees or less to the north. The main joint set is about N 35 degrees to 45 degrees W/85 degrees S.

C. Seismicity

The project area is characterized by low seismic activity. According to the Preliminary Map of Horizontal Acceleration of the United States prepared by S. T. Algermissen and D. M. Perkins (USGS Open Field Report 76-416), the seismic peak acceleration in this area is less than 0.04 g in a return period of 475 years. A peak ground acceleration of between 0.05 and 0.1 g would provide a return period of approximately 1000 years and would be adequate for this project.

D. Ground Water

Ground water lies at 650 to 750 feet below the surface of Spring Creek Mesa. Contamination of ground water would be unlikely due to this depth and to the presence of shale layers including the Brushy Basin Shale that overlies the saturated zone. This depth of ground water is based on measurements of wells near Atkinson Creek. Locally perched ground water may overlie the shale layers. A windmill within the project limits draws water from one of the perched lenses, which has no connection with the regional ground-water table.

SECTION 4
FIELD INVESTIGATIONS, SAMPLING, AND TESTING

4.1 GENERAL

The exploration, sampling, and field testing programs were performed at Spring Creek Mesa from 19 March through 4 April 1980. Technical direction of the field work was provided by Messrs. E. F. Axtmann, Senior Civil Engineer from IECO's San Francisco office and R. A. Caughey, Principal Geologist from IECO's Denver office. The CME-55 drill rig and operators were subcontracted to IECO by Custom Auger Drilling Service of Denver.

The exploration program consisted of drilling NX-size boreholes and auger holes and excavating test trenches. The locations of drill holes and test pits are shown on the Site Plan, Figure 3. In addition, Messrs. Axtmann and Caughey performed a site inspection of the West Mesa Area, the Airstrip location, and a potential borrow source. Results of the visual inspection are presented in Section 3, Site Conditions.

The sampling program consisted of retrieving samples of foundation soils and rock and borrow materials for laboratory testing. Appendix A includes Borehole Logs and Test Trench Logs. The laboratory testing program is described in Section 5.

4.2 WEST MESA AREA

The investigation of the West Mesa Area, which is the proposed site of the effluent pond, included drilling 11 NX holes totalling 290.4 linear feet, with the depths of holes ranging from 14.0 to 44.0 feet. Seven test trenches were excavated to allow visual examination of the alluvium, capping sandstone, and the underlying shale material. The overburden averages 3 feet in thickness and consists of sandy silt alluvium. It is anticipated that weathered sandstone and shale beneath the overburden can be excavated without blasting to the second shale layer at El. 5840. No drilling was performed in the western portion of the West Mesa Area; however, a visual inspection was made to confirm that the shale layer is continuous throughout the project area.

Field water pressure tests in the foundation shale materials showed permeabilities ranging from $1x10^{-3}$ cm per sec in TD-4 to $1x10^{-7}$ cm per sec in TD-10. Water pressure tests probably were measuring seepage and water losses along shrinkage and fracture planes within the foundation. Field permeability test results are shown on the logs and geologic sections.

4.3 AIRSTRIP AREA

Foundation investigations for the proposed tailings disposal site included seven NX drill holes totalling 194.9 linear feet and ranging in depth from 18.5 to 46.9 feet. Six test pits previously excavated at the site indicated that overburden is shallow, averaging about 2 feet. The drill holes show that, beneath the thin soils, a 25-to 35-foot thickness of sandstone overlies shale. The upper 3 to 5 feet of sandstone is weathered and varies in hardness.

Field water pressure tests were performed in the foundation sandstone at boreholes ED-3 and ED-7. Permeabilities were $1x10^{-5}$ and $2x10^{-4}$ cm per sec, respectively.

4.4 BORROW AREA

The field investigation consisted of sampling the selected borrow source directly north of the Airstrip. The potential borrow area is 0.25-mile wide by 0.5-mile long. The purpose of the field investigation of the borrow area was to locate sufficient quantities of impervious pond liner material, additional embankment construction materials, and material for future reclamation. The drilling program established that shale suitable for constructing impervious liners is present in the majority of the borrow area between El. 5780 and El. 5795, which is exposed along the perimeter slope of the borrow area, and was also identified at 24 feet below the surface at drill hole BH-1. Five trenches were excavated on the slopes that form the perimeter of the borrow area to confirm the limits of the source. The shale layer is 12 to 15 feet thick with a usable depth of 9 feet. The designated borrow area could supply more than 1 million cubic yards of suitable clayey shale construction material for the impervious liner.

It is estimated that there will be sufficient construction materials available for the pond liner, embankment construction materials, and future reclamation. This material would be available from the West Mesa Area and the borrow area. Impervious material is also available from the Brushy Basin Shale and could be investigated in final design if additional materials are required.

SECTION 5
LABORATORY TESTING

5.1 GENERAL

The purpose of the laboratory testing program was to determine the engineering properties of the foundation bedrock, embankment construction materials, and impervious pond liner to confirm the feasibility of constructing the tailings and effluent ponds at Spring Creek Mesa. Representative bulk samples were collected from test trenches, and a split barrel sampler was used to obtain samples of foundation materials in the boreholes. Testing in accordance with ASTM procedures was performed by CTL/Thompson, Inc., Denver and R. C. Harlan & Associates, San Francisco. The results of the testing program confirmed that the proposed materials are suitable. These results are summarized in Table B-1, Appendix B, and reports of laboratory testing by both testing firms are also included in Appendix B.

5.2 LABORATORY PERMEABILITY TESTS

Laboratory permeability tests by Harlan & Associates were conducted on compacted samples of shale materials to be used for the impervious liner. When samples of shale materials were compacted to 95 percent of Standard Proctor to a dry density of 102 lbs to 106 lbs per cubic foot, permeabilities ranged from $1.5\text{x}10^{-6}$ cm per sec to $3\text{x}10^{-6}$ cm per sec. At 97 percent of Modified Proctor compaction, permeability was $4.7\text{x}10^{-7}$ cm per sec with a dry density of 114 lbs per cubic foot. Moisture contents of the compacted specimens were at or near optimum moisture, which ranged from 15 to 17 percent.

Permeabilities of some of the compacted shale samples as tested by CTL/ Thompson were less than 1x10^{-7} cm per sec. These samples were compacted to 97 percent of Standard Proctor Compaction.

Permeability tests were run by Harlan and Associates on relatively undisturbed core samples of shale material. Permeability results were 2x10^{-6} cm per sec to 6x10^{-6} cm per sec and dry densities were 111 lbs per cu ft and 120 lbs per cu ft, respectively. The dry density of specimens used for triaxial shear testing varied from 118 lbs per cu ft to 129 lbs per cu ft.

5.3 SHEAR STRENGTH TESTS

Consolidated, undrained (CU) triaxial compression tests were performed on representative samples of foundation shales and borrow area materials. Soil cohesion (c) equaled zero and the angle of internal friction (ϕ) ranged from 17 to 20 degrees when the total stress parameters for the borrow area impervious materials were determined. Effective stress parameters equaled zero for soil cohesion (c') and 25 to 30 degrees for the angle of internal friction (ϕ'). The consolidated undrained triaxial compression tests on the foundation materials were inconclusive because the core samples were fractured and marked by slickensides.

Unconfined compression (UC) tests were performed on representative sandstone foundation samples. The unconfined compression strength (qu) of sandstone materials varied from 5650 lbs per sq in to 8700 lbs per sq in. Direct shear tests were also performed on sandstone core samples. The peak values of shearing angles were more than 45 degrees and the residual shearing angles ranged from 27 to 35 degrees.

5.4 OTHER LABORATORY TESTS

Other laboratory tests, the materials that were tested, and the values obtained are presented below.

A. Atterberg Limits

The Atterberg tests are used to determine soil consistency based on moisture content. For the borrow materials, liquid limits (LL) varied from 30 to 50 percent, and the plasticity index (PI) ranged from 13 to 23 percent. For foundation shales, liquid limits were 25 to 50 percent and the plasticity index varied from 15 to 34 percent.

B. Specific Gravity

The specific gravity of borrow materials ranged from 2.62 to 2.71. For the foundation materials, the specific gravity varied from 2.63 to 2.67.

C. Compaction Tests

Using Standard Proctor Compaction, the maximum dry density of borrow materials that will be used in embankment construction ranged from 105 to 110 lbs per cu foot. Using Modified Proctor Compaction, the dry density equaled 118 lbs per cu foot. Optimum moisture content varied from 12 to 15 percent in the Standard Proctor tests and equaled 14 percent in the Modified Proctor test. The in situ moisture content of borrow materials is dry of these optimal values.

D. Consolidation Test

A consolidation test was performed on a remolded sample of borrow material at 97 percent of Standard Proctor compaction and with near optimum moisture content. Consolidation parameters are shown in the laboratory testing data in Appendix B.

E. Swelling Tests

The swelling potential of shale foundation materials was tested to better define the permeability of the shale. When saturated, the shale material has a swelling potential of 3 percent of volume.

F. Visual Classification and Gradation Tests

All samples were visually classified. Gradation tests were performed to confirm classifications. Based on a combined grain size analysis, the shale borrow materials contained 3 to 10 percent fine sand, 37 to 47 percent silt, and 50 to 60 percent clay. The percent passing the No. 4 sieve was 100, and the No. 200 sieve passed an average of 97 percent.

G. Acidity - Alkalinity Tests

To determine the acidity or alkalinity of representative samples, pH tests were conducted. Borrow materials are slightly basic with pH values of 7.9 to 8.6. Foundation materials are slightly basic, with pH values of 7.5 to 8.0.

5.5 PERMEABILITY TEST RESULTS

The values of permeabilities obtained from laboratory testing of semi-disturbed shale core samples range from $2x10^{-6}$ cm per sec to $6x10^{-6}$ cm per sec. Permeability tests performed on remolded samples of the shale material indicate permeabilities from $1.5x10^{-6}$ cm per sec to less than 10^{-7} cm per sec. The values of permeabilities determined for remolded samples show that permeability is a function of the density. For example, a sample compacted at 95 percent of Standard Proctor compaction to a density of 102 to 106 lbs per cu ft gave permeabilities of $1.5x10^{-6}$ cm per sec to $3x10^{-6}$ cm per sec. The same shale material compacted to a density of 114 lbs per cu ft using 97 percent of Modified Proctor compaction gave a permeability value of $4.7x10^{-7}$ cm per sec.

The samples of shale material obtained from the borehole program and used for permeability and triaxial shear testing showed unit densities from 111 to 129 lbs per cu ft. The average density exceeded 120 lbs per cu ft. Based on these in situ densities and the recorded "swell" characteristics of shale material following saturation, it is concluded that field permeability tests measured water passage through fractures and along shrinkage cracks.

Comparison of unit density and permeability values suggest that saturation of the shale material, confined within the foundation zone beneath the proposed effluent pond, would result in seepage losses through shale material having a permeability value in the range of $1x10^{-6}$ cm per sec to $1x10^{-7}$ cm per sec.

SECTION 6
DESIGN

6.1 GENERAL

The design criteria presented in this report are based on tests, field investigations, and observations made within this scope of work. The preliminary geotechnical investigations indicate that the Spring Creek Mesa site is a feasible location for the proposed effluent pond and tailings disposal site. As described in Section 7, Conclusions and Recommendations for Further Investigations, additional studies must be performed before parameters can be proposed for a final design.

The uranium milling industry is regulated by Federal and State of Colorado guidelines. Accordingly, control of radon emission levels and seepage were considered carefully throughout this study, as described below.

6.2 EFFLUENT POND

A. Location

Generally, the Spring Creek Mesa is an ideal disposal site because of its proximity to the mill at Uravan but relative isolation from streams, rivers, and population centers. The topography of the Spring Creek Mesa separates disposal sites from neighboring drainage channels and ground water and virtually eliminates consideration of runoff and the need for diversion systems.

The West Mesa Area is the preferred location of the effluent pond because of the relatively impermeable shale foundation. There is little potential for seepage losses, contamination of ground water, or degradation of surface waters at this site. Figure 5 shows a schematic cross section of the effluent pond and protection against seepage.

B. Design

The area of the effluent pond was sized to evaporate the effluent waste, which is transported from the mill at a rate of 510 gallons per minute. Based on an annual average net evaporation rate of approximately 2 gallons per minute per acre, 250 acres are required for evaporation. The depth of the effluent pond was estimated at 15 feet to provide for the accumulation of precipitants during the 17-year project life. Five feet of freeboard were provided for rainfall (Probable Maximum Precipitation), wave height, and runup. The design of the effluent pond will be a zoned embankment with an impervious pond liner. The embankment will completely surround the effluent pond.

Although the shale foundation will limit seepage, an impervious liner will provide additional protection against seepage and percolation of water. Based on test borings, the shale foundation is believed to be continuous at the proposed pond site.

The maximum height of the embankment is approximately 45 feet with upstream slopes of 3H:1V and 2.5H:1V downstream (Figure 6). The estimated volume of the embankment is 1.5 million cubic yards of shell and transition material and 400,000 cubic yards of impervious zone material. The pond liner is estimated at 1.25 million cubic yards of impervious and 675,000 cubic yards of protective covering material over the impervious liner.

The effluent pond area will be excavated to about El. 5840 within the thick shale layer. This excavation will result in 7.3 million cubic yards of sandstone, shale, and overburden that can be used for constructing the embankment and pond liner and for reclaiming the pond.

The major portion of required construction materials is available within the perimeter of the proposed effluent pond. The overburden averages 3 feet in thickness. The upper 1.5 feet of overburden material can be stockpiled for eventual reclamation of the pond, and the remaining overburden, which is sandy silt alluvium, can be used in the embankment construction.

The thin sandstone layer immediately underneath the overburden will be excavated and used to construct the embankment shell zone. During excavation, the sandstone will break into pieces less than 12 inches in size, with an anticipated average size of 4 to 6 inches. Thus, excavation should provide free draining, high strength material for constructing the embankment.

Semi-impervious zones of the embankment can be constructed of coarse shale and smaller sandstone pieces obtained from the foundation excavation. Required excavation into the shale layers beneath the sandstone will be the source of impervious material for the pond liner. The thickness of the liner should be determined in design studies, including a seepage analysis, and could range from 1 to 3 feet thick. It would probably be covered with 18 inches of materials that would prevent cracking and erosion of the impervious liner and shale foundation. The upper 5 feet of the thicker shale layer would be excavated, processed, and conditioned to provide impervious fill suitable for these uses.

C. Seepage

Seepage losses from the effluent pond will be controlled by the proposed impervious liner and foundation shale layers. Seepage through the impervious liner will travel downward into the horizontal shale layer as shown on Figure 4. The natural shale layer will swell as moisture is absorbed, and swelling will reduce the passage of water along bedding planes and fractures. The impervious liner would be constructed to form a barrier of compacted shale material of similar permeability of from

1 to 3.5 feet in thickness. The natural shale directly beneath the placed impervious liner would exceed 5 feet in thickness and would provide an impervious zone with a permeability value in the range of $1x10^{-6}$ to $1x10^{-7}$ cm per sec. The combination of impervious liner constructed to high quality control standards and the thickness of natural shale layer is expected to be adequate for seepage control based on the laboratory tests performed and properties determined for the shale material.

D. Abandonment

When the effluent pond is abandoned the accumulated residue and contaminated impervious liner material will be covered with suitable clayey shale. Approximately 4.5 feet of cover material plus 1.5 feet of the stockpiled overburden would be placed over the pond area. The outside slopes of the embankment would be flattened to provide 5H:1V slopes, such that overburden material could be placed and vegetation could be established around the perimeter of the effluent pond. Placement of the cover material would provide a minimum 1 percent surface drainage slope to minimize percolation of precipitation into the residue within the pond area. These specifications are based on existing regulations for abandonment of hazardous waste deposits and will be subject to revised regulations at the time of abandonment.

Materials for abandonment would come from the material that would be stockpiled during excavation for construction of the effluent pond and tailings disposal site and the impervious borrow area. If necessary, additional clayey shale material can be obtained from the Brushy Basin Shale member of Morrison Formation. The Brushy Basin Shale lies at El. 5500 to El. 5600, which is 250 feet below the top of Spring Creek Mesa. Sources of suitable reclamation material are unlimited in the Atkinson Creek dry drainage channel directly north of the pond site and are exposed on the west flank slopes of Spring Creek Mesa.

6.3 TAILINGS POND

A. Location

The filtered tailings would be located in the Airstrip Area.

B. Design

An embankment ranging in height from 24 feet to 50 feet would be required to contain the required volume of filtered tailings. Approximately 9 million tons of filtered tailings would be stored in the Airstrip Area. Expansion of the Airstrip Area tailings disposal site could accommodate an additional 9 million tons of filtered tailings. The tailings would have a moisture content of approximately 25 percent and a dry density of 95 lbs per cu ft. About 840,000 cubic yards of pervious sandstone and semi-pervious construction material is needed to construct the embankment as shown in Figure 6. The impervious liner would require 532,000 cubic yards of clayey shale material obtained from the designated borrow area, and the protective cover for the impervious liner would require 525,000 cubic yards. The estimated stripping volume and excavation from within the tailings disposal area would result in 600,000 cubic yards of stockpiled overburden for later reclamation and 1.4 million cubic yards of usable construction material.

To obtain the impervious borrow material, the excavation of overlaying sandstone and interbedded shales and sandstones covering the borrow area shale layer would furnish protective cover material. The embankment would be constructed of suitable excavated material. The remaining 560,000 cubic yards of excavated material would be stockpiled for future reclamation work. An impervious liner would be constructed to provide a barrier against seepage. The operation of the pond should be designed to facilitate drainage of the tailings by a progressive system of deposition, drainage, and collection of effluent. The tailings should be placed to drain toward a location where a drainage collection system would pump the liquid to the effluent pond. Such a drainage system is facilitated by the ground elevation at this site and by the required impervious liner which would allow collection of drained liquid. This method of placement of tailings is illustrated in Figure 5. Periodic covering of tailings with earthfill would also prevent infiltration of precipitation, reduce potential seepage losses, and minimize wind erosion. Frequency and thickness of covering should be determined in further design studies. Final placement for reclamation is estimated to be 4.5 feet of clayey shale and a 1.5-foot thick layer of overburden material to prevent erosion.

The possibility of excavating an underground tailings disposal site was considered in this study. Subsurface disposal is advantageous in that tailings are completely contained. At this site, however, extensive excavation into sandstone would be required and an impervious liner would be necessary throughout the pit. Placing the impervious liner against the blocky, irregular surface of the sandstone excavation would be difficult, and the rate of seepage would not necessarily be improved. Both processes would probably be cost prohibitive with little or no benefit gained.

Unlike the West Mesa Area, construction materials for the tailings pond and impervious liner are not available from required excavation. Overburden that averages 2 feet in thickness would be stockpiled for eventual reclamation of the pond. Construction materials for the embankment would be imported from excavation of the effluent impoundment and from the borrow area. The required quantities of construction materials are available within reasonable haul distances.

The upper 3 to 5 feet of sandstone is weathered and of varying hardness and can be used for reclamation. The foundation sandstone can then be covered with impervious shale liner materials to prohibit seepage.

C. Seepage

The filtered tailings will be placed so that the water drains toward collection areas and can be pumped to the effluent pond if required. This method of placement will result in a minimal amount of water pressure on the liner and minimal seepage through the liner.

D. Abandonment

Tailings disposal and reclamation would be a progressive operation as indicated. The final reclamation would require 5H:1V slopes outside the embankment and a contoured covering such that a minimum 1 percent slope is provided for surface drainage. These specifications are based on existing regulations for abandonment of hazardous waste deposits and will be subject to revised regulations at the time of abandonment.

The embankment and tailings area will be covered with overburden, and vegetation will be established to stabilize the final ground surface. The integrity of the embankment must be assured by final reclamation work. With proper covering and grading to prevent infiltration of precipitation into the dewatered tailings, shear strength would increase over time and the tailings could become stable. Wind erosion must be controlled by protective covering over the tailings disposal area. Local sandy silt and sandstone material would be suitable for the protective cover.

SECTION 7
CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER INVESTIGATIONS

7.1 GENERAL

If the Spring Creek Mesa is selected as an alternative for further study, IECO recommends that more detailed field investigations and preliminary design studies be performed. Our conclusions and recommendations are presented below.

7.2 CONCLUSIONS

The field investigations and laboratory testing program provided engineering data for evaluation of the Spring Creek Mesa location for effluent and tailings disposal ponds. The studies show that the effluent pond and the tailings pond can be constructed with local materials and that minimal seepage would occur. The West Mesa Area is the preferred location for the effluent pond because relatively shallow shale layers within the foundation would help to control seepage losses. The tailings pond would be located in the Airstrip Area.

The construction of an impervious barrier and a seepage water collection system over the sandstone in a progressive manner would allow expansion of the tailings disposal area and could reduce initial construction costs. The Airstrip Area would allow for disposal of 9 million tons of tailings during the 17-year life of the project.

These investigations show that suitable materials are locally available to construct both the effluent pond and tailings disposal facilities.

7.3 FIELD INVESTIGATIONS

We recommend that a more detailed field investigation be performed to further define the quality and quantity of borrow material. Material from the Brushy Basin Shale member could be investigated during final design if additional materials are required.

Methods of excavation for construction should be determined in future work. Additional foundation explorations should be conducted based on Nuclear Regulatory Commission and State of Colorado requirements for sampling and depth and spacing of boreholes once the alignment of the embankment is determined.

Field investigations to confirm foundation conditions in the western part of the West Mesa Area are necessary prior to final design of the effluent pond. The thickness, location, and type of shale materials that will be excavated during construction would provide information for the effluent pond design.

The permeability after saturation and swelling of the shale foundation in the West Mesa Area should be studied. The design criteria for seepage analysis is most critical and permeability coefficients under field conditions are necessary. Alternative methods of controlling seepage can be considered when permeabilities in the field under anticipated operational conditions have been determined.

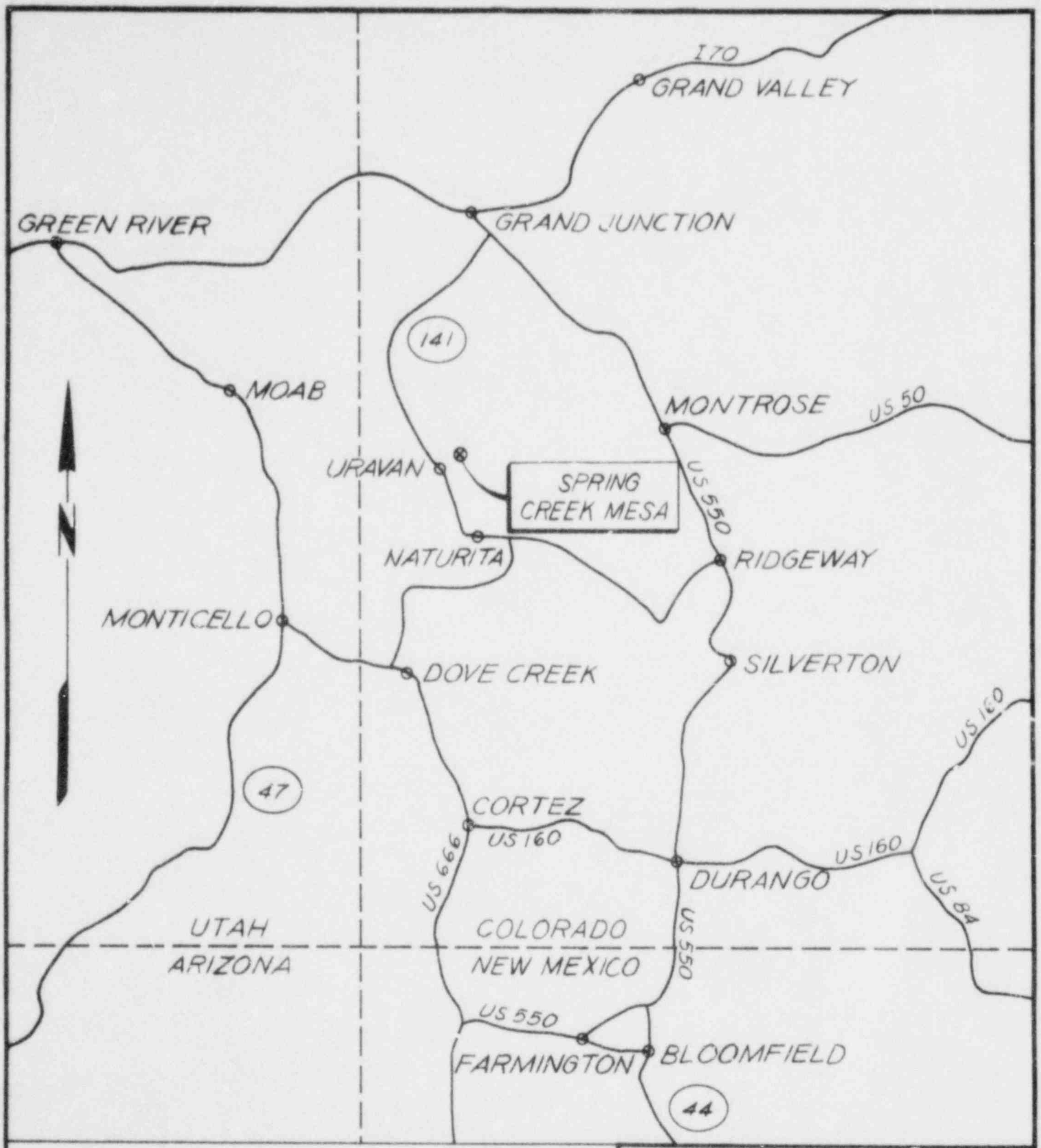
Observation wells should be installed to monitor ground-water conditions. Monitoring data should be recorded from installation of the wells until construction of the ponds to establish baseline water quality conditions. Observation wells should be located within the San Miguel Syncline trough and at locations along the maximum potential seepage gradients toward Spring Creek and Atkinson Creek.

We recommend that extensive field permeability tests be performed as part of the next phase of study to thoroughly evaluate the potential seepage. Preliminary permeability tests indicate that the compacted impervious shale material has a coefficient of permeability of about 1×10^{-6} to 1×10^{-7} cm per sec. Large scale permeability tests of foundation areas should be investigated to determine the permeability and the effect of swelling of the shale. Tests should be run with water and effluent from the mill. The Bureau of Reclamation falling head permeability test (USBR Earth Manual E-19) is one method that could be used.

The tendency of the shale to air slake, as mentioned in Section 3 on Site Conditions, should also be investigated, although this tendency is not expected to be detrimental because the shale will be protected from air by the embankment shell, impervious liner, and tailings or effluent.

7.4 OFFICE STUDIES

We recommend additional geotechnical office studies to supplement field investigations in the areas of hydrology, environmental studies, and seepage control. Alignments of the embankments should be determined so that detailed foundation investigations can be planned. Embankment sections and preliminary design parameters should be selected to confirm required construction quantities. Finally, the thickness of the impervious liners should be established, a monitoring program should be developed, and reclamation and abandonment plans should be devised in keeping with existing regulations. Seepage studies should be undertaken in final design.



SCALE 0 5 10 20 30 40 50 MILES

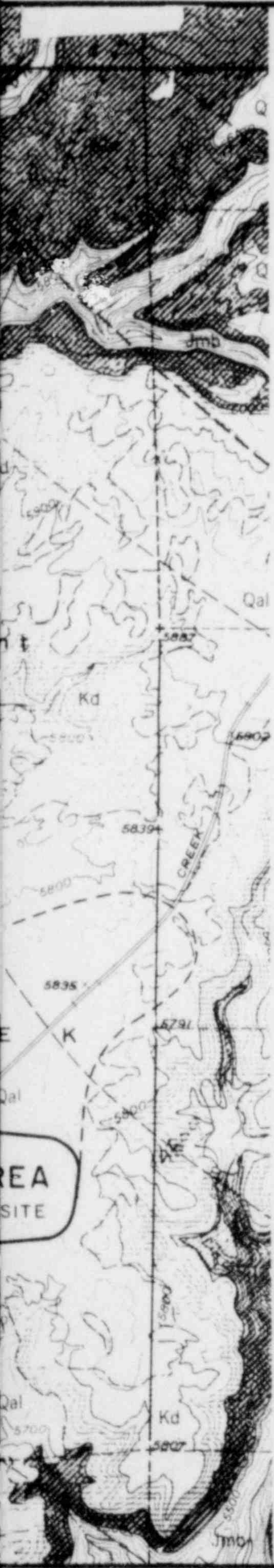
UNION CARBIDE CORPORATION

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
LOCATION MAP

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ______ INSPECTED ______
DRAWN LQL RECOMMENDED ______
CHECKED ______ APPROVED ______
DATE MAY 5, 1980
DRAWING NO. FIGURE 1


Qal
Jmb
Kd
Kdc
Hog Park
Hog Point
Hog Park Wash
Blue Springs Poi
Hog Creek
Atkinson
S P R I N G
C R E
M E S A
WEST MESA AREA
EFFLUENT POND SITE
AIRSTRIP AR
TAILINGS DISPOSAL
Jms
5862
5861
5855
5925
5905
5837
5800
5600
5500
5400
5300
34
35
36



LEGEND

Qal
Alluvium

Light-red wind-deposited sand and silt on benches and mesa tops, reworked in part by water; Recent valley fill and stream deposits.

Kd
Dakota sandstone

Yellowish, lenticular sandstone and conglomerate with interbedded carbonaceous shale and impure coal.

Kbc
Burro Canyon formation

White, gray, and red sandstone and conglomerate with interbedded green and purplish shale.

Jmb, Jms
Morrison formation

Variegated shale and mudstone; white, gray, rusty-red, and buff sandstone; rusty-red conglomerate; local thin limestone beds. At the top of the Brushy Basin shale member, Jmb, consisting largely of bentonitic shale but including some sandstone and conglomerate lenses, and at the base the Salt Wash sandstone member, Jms, with more numerous and thicker sandstone beds.

U
D

Fault

Dashed where approximately located; dotted where concealed.
U, upthrown side; D, downthrown side.

U
D

Inferred fault

U, upthrown side; D, downthrown side.

3

Strike and dip of beds

7500

Structure contours

Drawn on top of Entrada sandstone; dashed where approximately located; short dashes indicate projection above surface. Contour interval 100 feet. Datum is mean sea level.

SCALE IN FEET

0 2000 4000

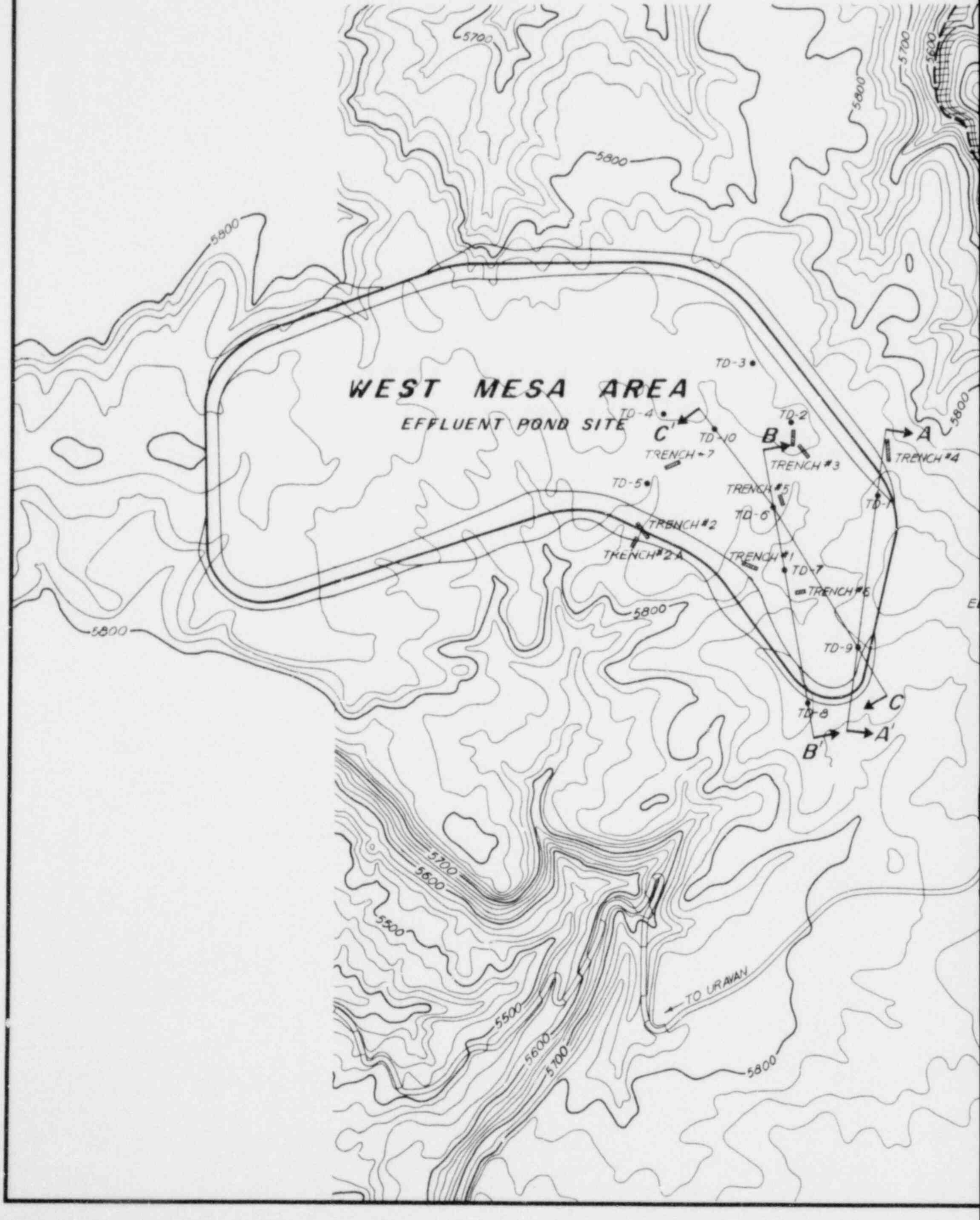
UNION CARBIDE CORPORATION

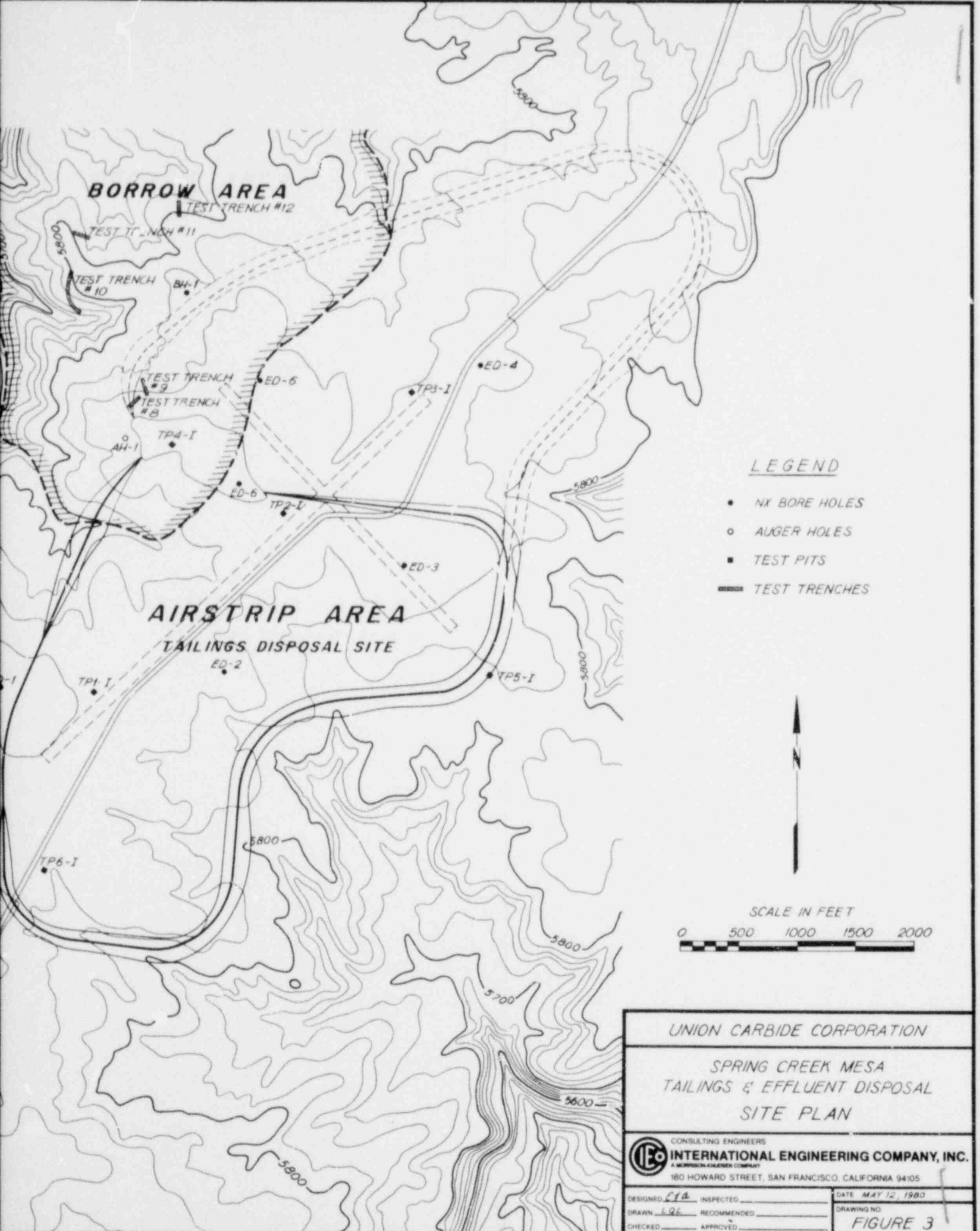
SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
SITE GEOLOGY

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ____ INSPECTED ____
DRAWN LQL RECOMMENDED ____
CHECKED ____ APPROVED ____
DATE MAY 12, 1980
DRAWING NO. FIGURE 2

TAILING & EFFLUENT DISPOSAL


WEST MESA AREA
EFFLUENT POND SITE
TD-1
TD-2
TD-3
TD-4
TD-5
TD-6
TD-7
TD-8
TD-9
TD-10
TRENCH #1
TRENCH #2
TRENCH #2 A
TRENCH #3
TRENCH #4
TRENCH #5
TRENCH #6
TRENCH #7
A
A'
B
B'
C
C'
TO URAVAN
5500
5600
5700
5800

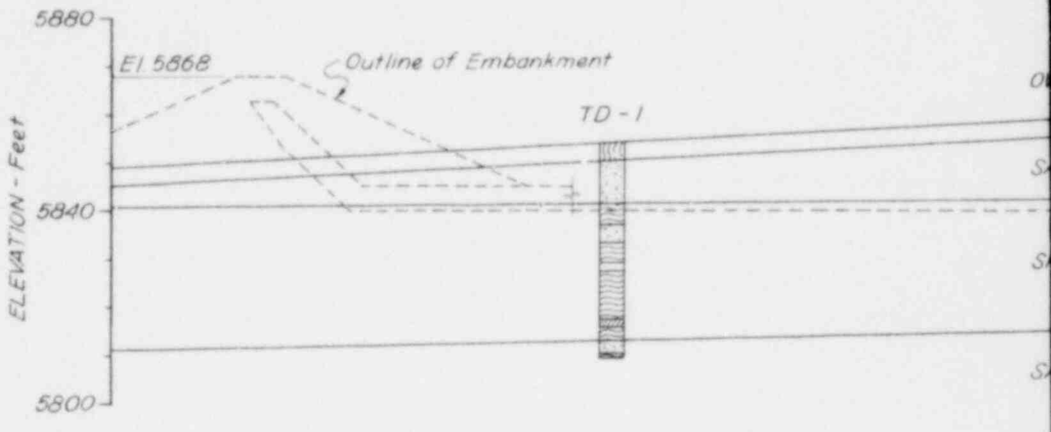


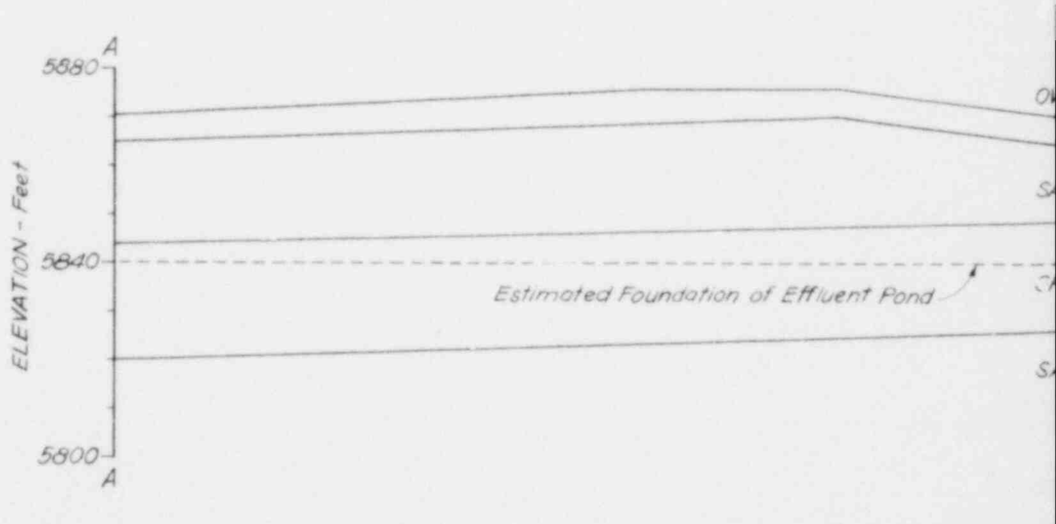
UNION CARBIDE CORPORATION

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
SITE PLAN

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED EJA INSPECTED ____
DRAWN LQL RECOMMENDED ____
CHECKED ____ APPROVED ____
DATE MAY 12, 1980
DRAWING NO. FIGURE 3

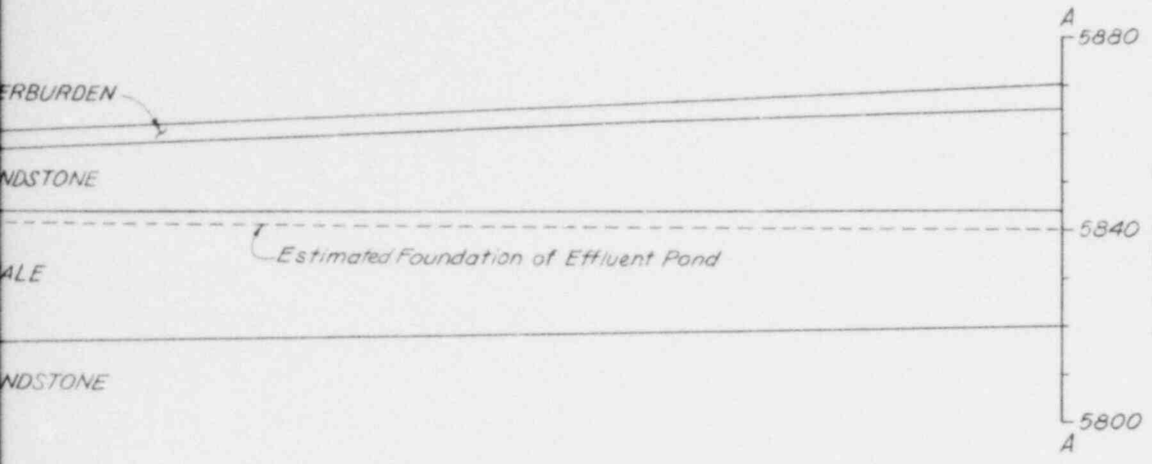


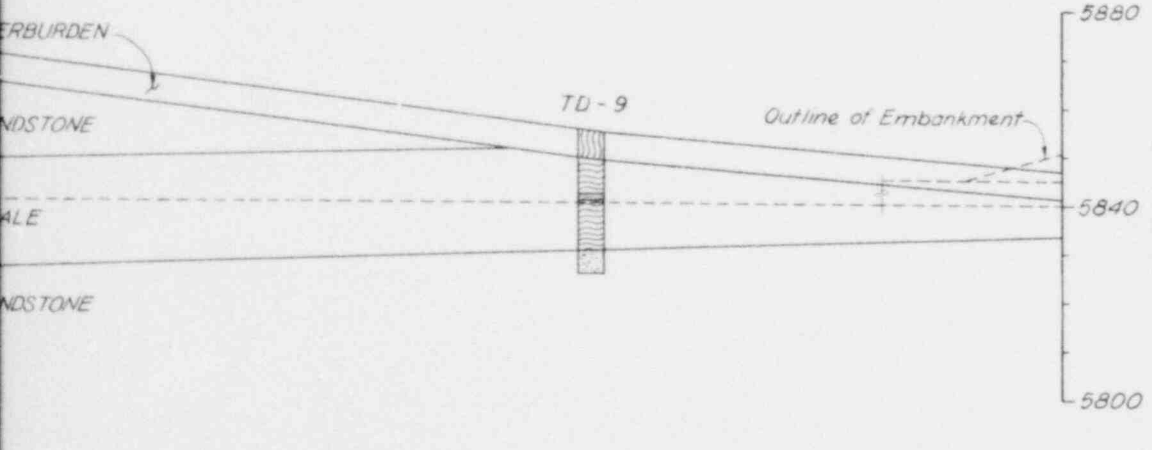


SE

HORIZON
2:1 VERTIC

▨ OVERBURDEN





CTION A - A'

AL SCALE 1" = 40'
AL EXAGGERATION

EGEND

▨ SHALE

░ SANDSTONE

UNION CARBIDE CORPORATION

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL

GEOLOGIC CROSS-SECTION A-A'

CONSULTING ENGINEERS
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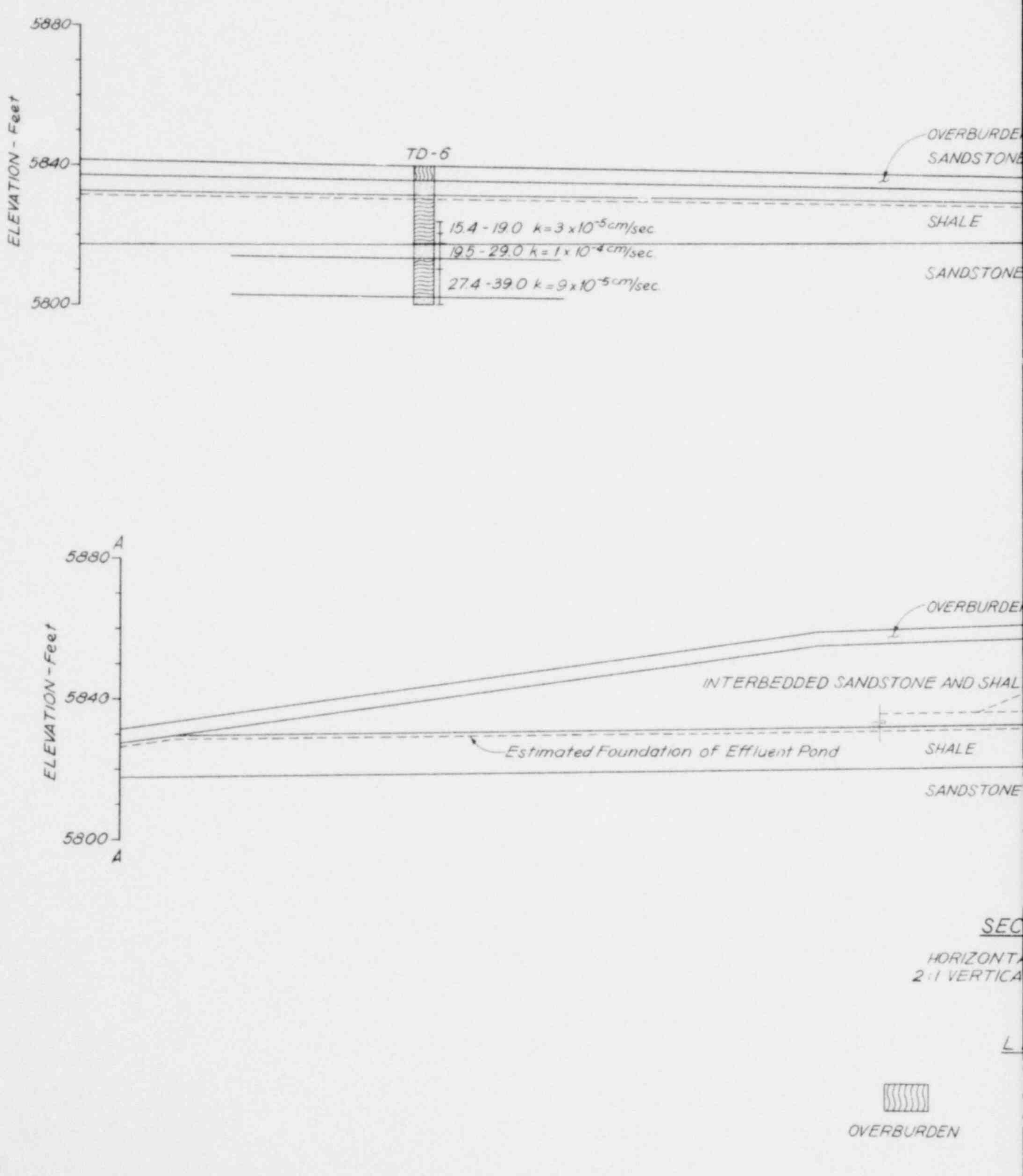
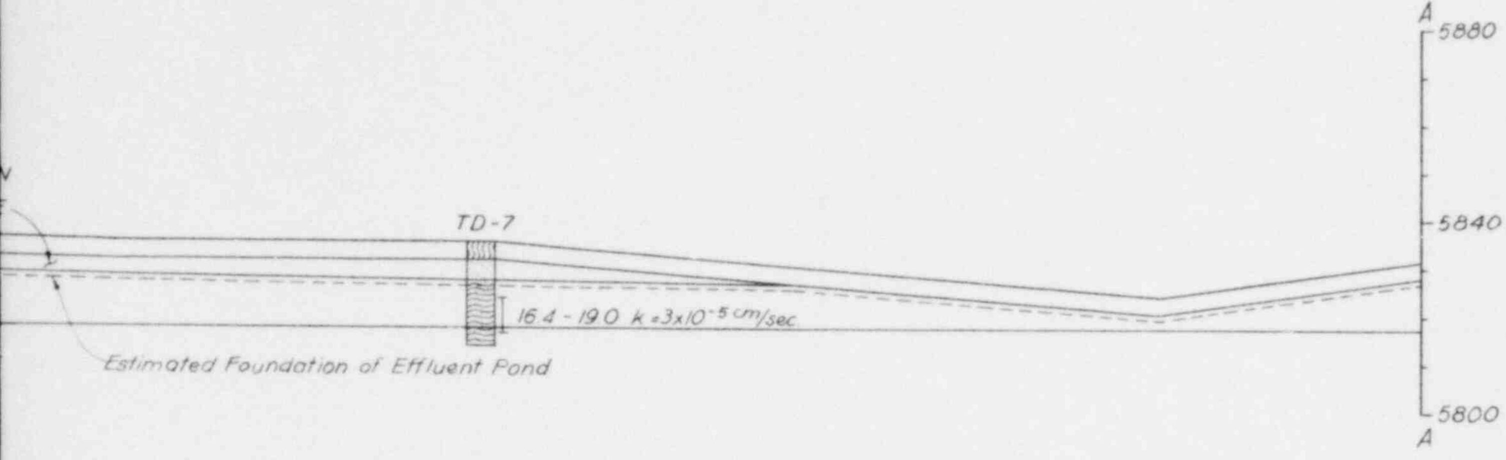
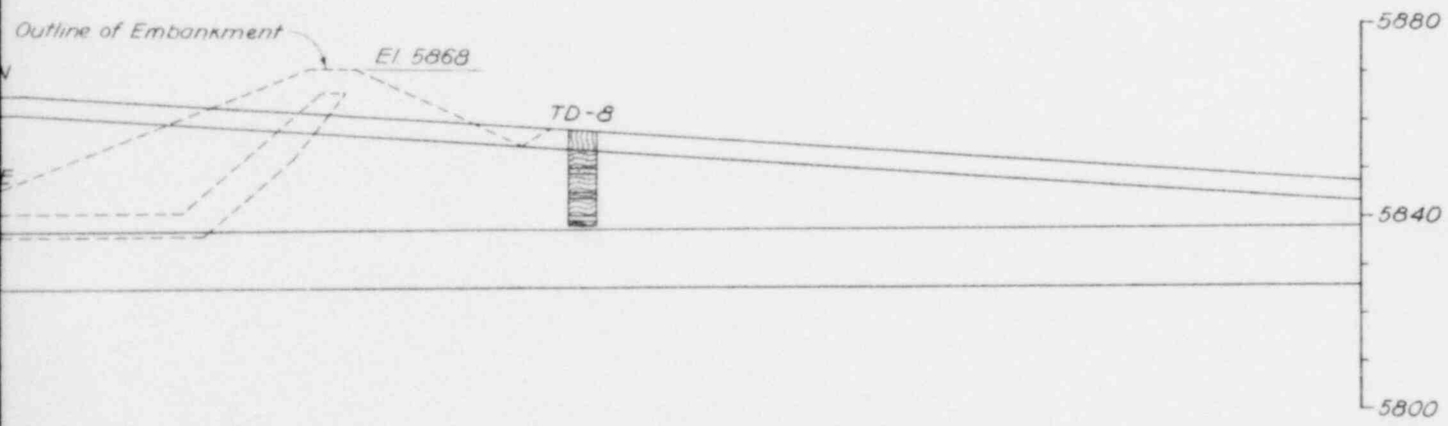
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED RCS INSPECTED
DRAWN LOL RECOMMENDED
CHECKED APPROVED

DATE MAY 7, 1980
DRAWING NO.
FIGURE 4A


5880
ELEVATION - Feet
5840
5800
TD-6
15.4 - 19.0 k=3x10^{-5}cm/sec
19.5 - 29.0 k=1x10^{-4}cm/sec
27.4 - 39.0 k=9x10^{-5}cm/sec
OVERBURDE
SANDSTONE
SHALE
SANDSTONE
A
5880
ELEVATION - Feet
5840
5800
A
OVERBURDE
INTERBEDDED SANDSTONE AND SHAL
Estimated Foundation of Effluent Pond
SHALE
SANDSTONE
SEC
HORIZONTA
2:1 VERTICA
L
OVERBURDEN





TION B - B'

L SCALE 1" = 40'
L EXAGGERATION

EGEND

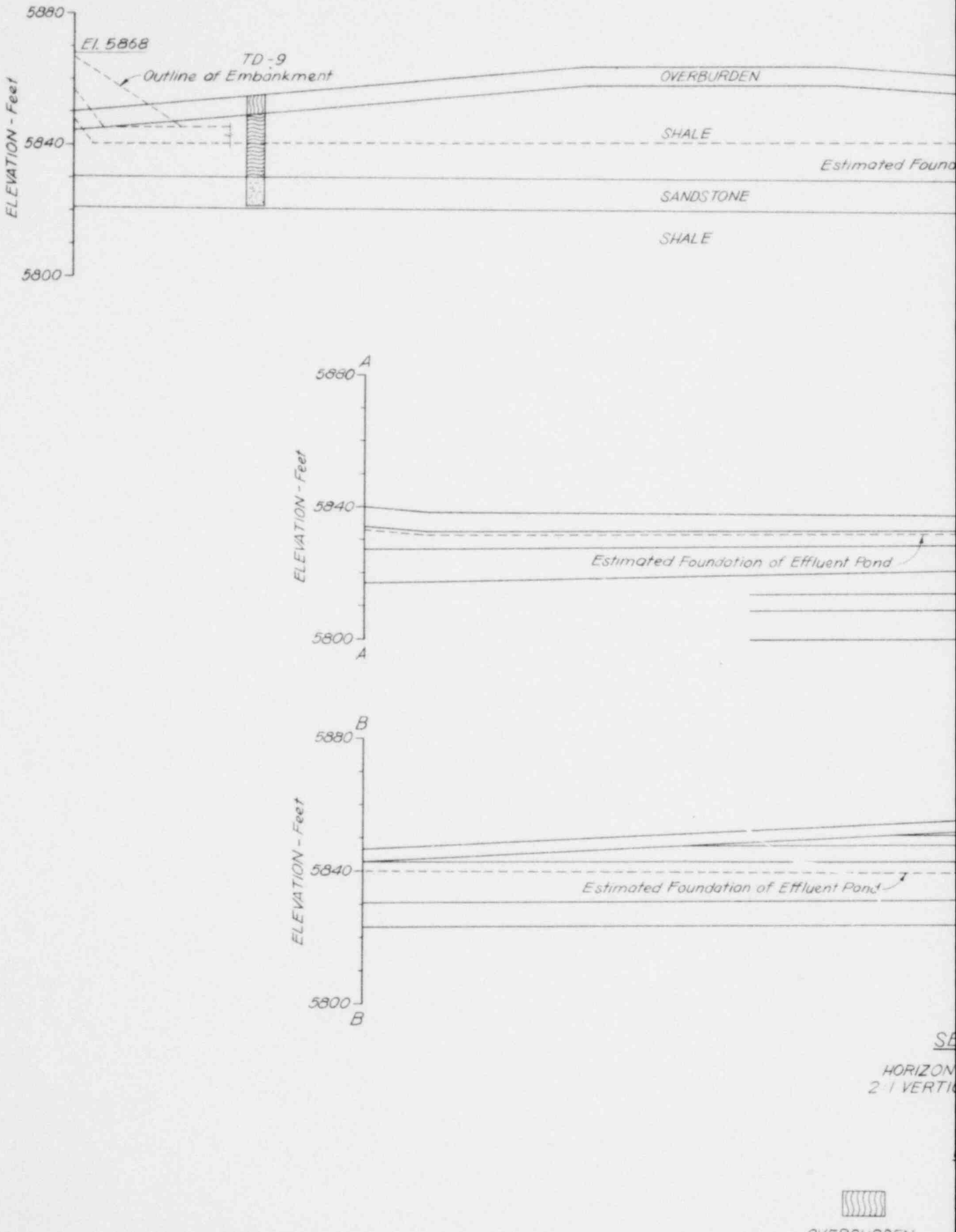
▤ SHALE　　▦ SANDSTONE

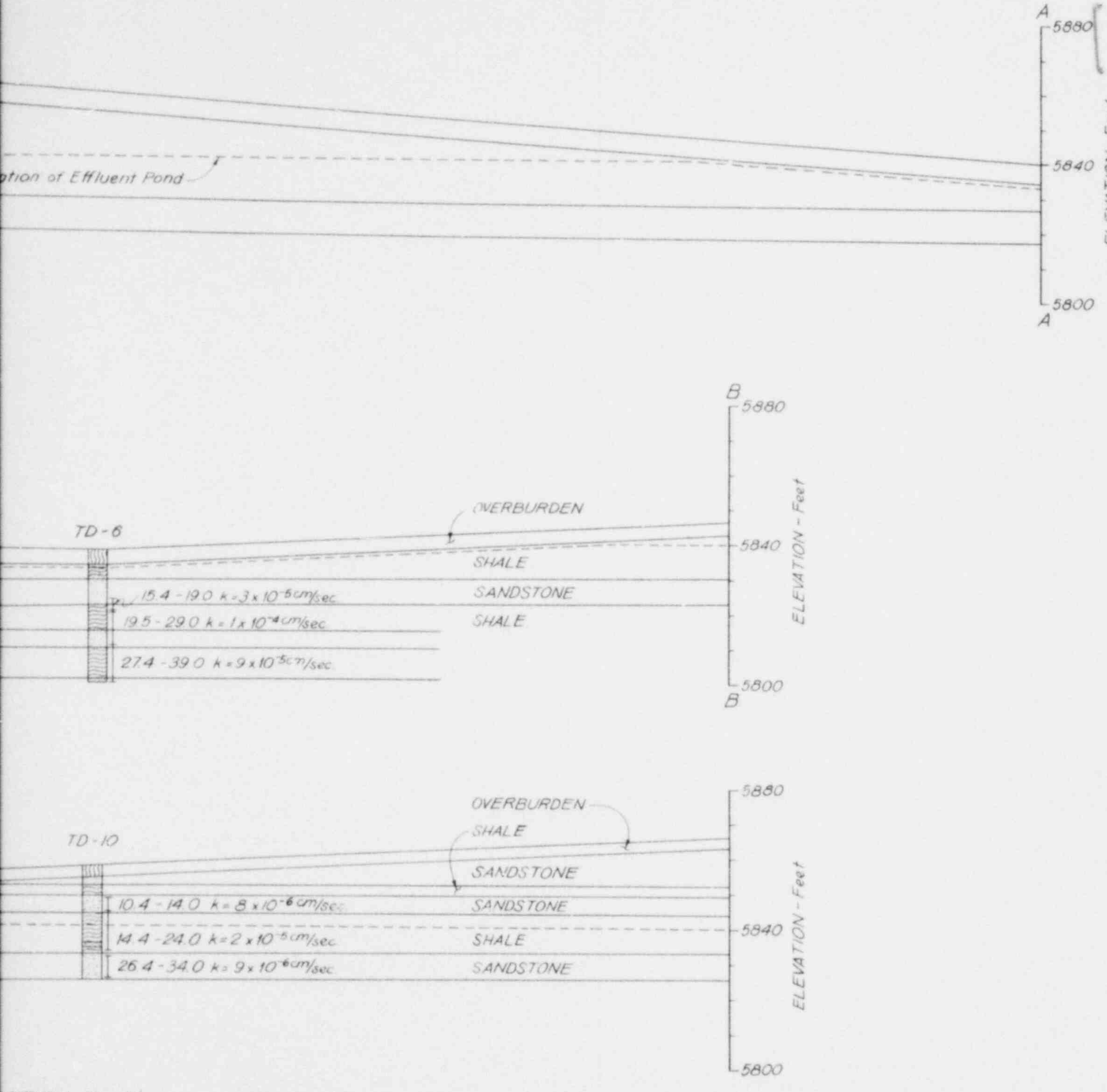
UNION CARBIDE CORPORATION

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
GEOLOGIC CROSS-SECTION B-B'

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED RCS　INSPECTED ____
DRAWN LQL　RECOMMENDED ____
CHECKED ____　APPROVED ____
DATE MAY 7, 1980
DRAWING NO. FIGURE 4B


5880
El. 5868
TD-9
Outline of Embankment
OVERBURDEN
SHALE
5840
Estimated Founa
SANDSTONE
SHALE
5800
ELEVATION - Feet
A
5880
5840
Estimated Foundation of Effluent Pond
5800
A
ELEVATION - Feet
B
5880
5840
Estimated Foundation of Effluent Pond
5800
B
ELEVATION - Feet
SE
HORIZON
2:1 VERTI
OVERBURDEN



CTION C - C'

TAL SCALE 1" = 40'
AL EXAGGERATION

LEGEND

- ▨ SHALE
- ░ SANDSTONE

UNION CARBIDE CORPORATION

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
GEOLOGIC CROSS-SECTION C-C'

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

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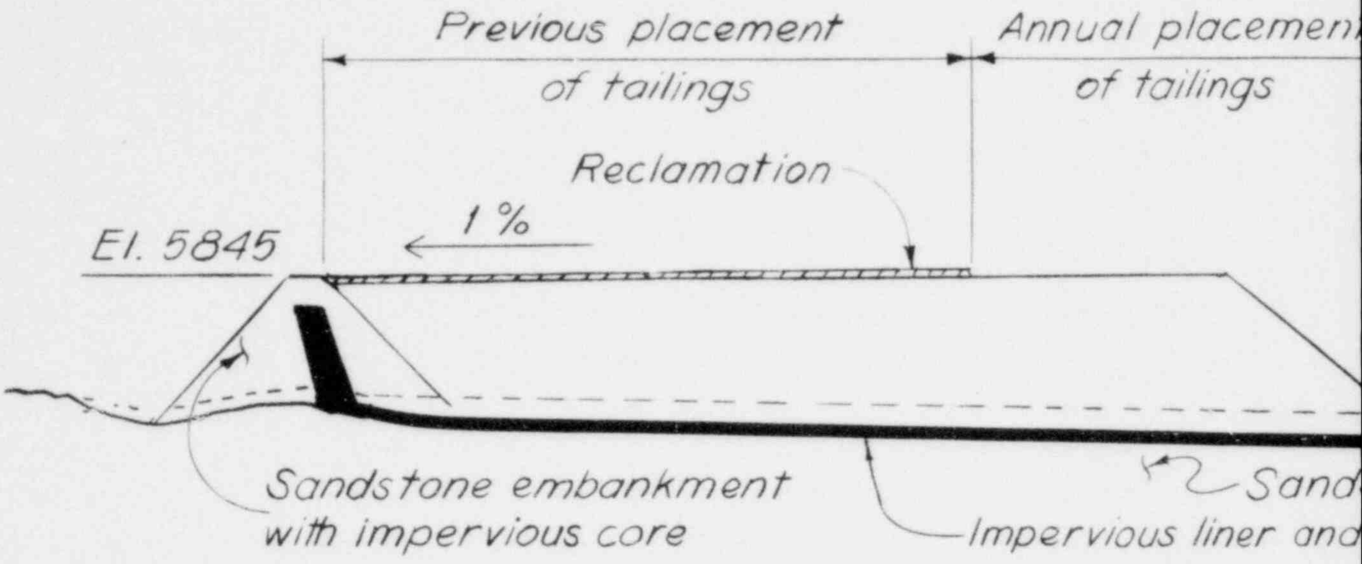
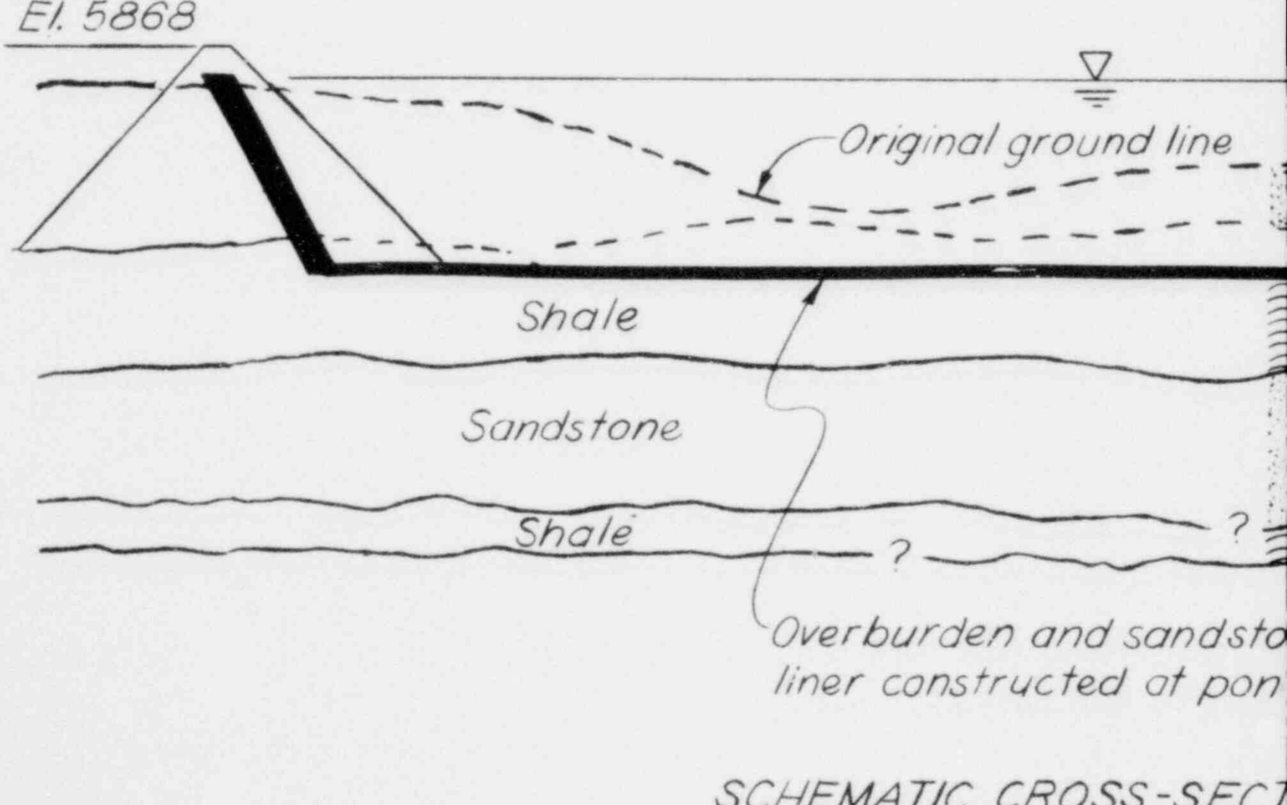
DRAWN LQL RECOMMENDED ______
CHECKED ______ APPROVED ______
DATE MAY 7, 1980
DRAWING NO. FIGURE 4C

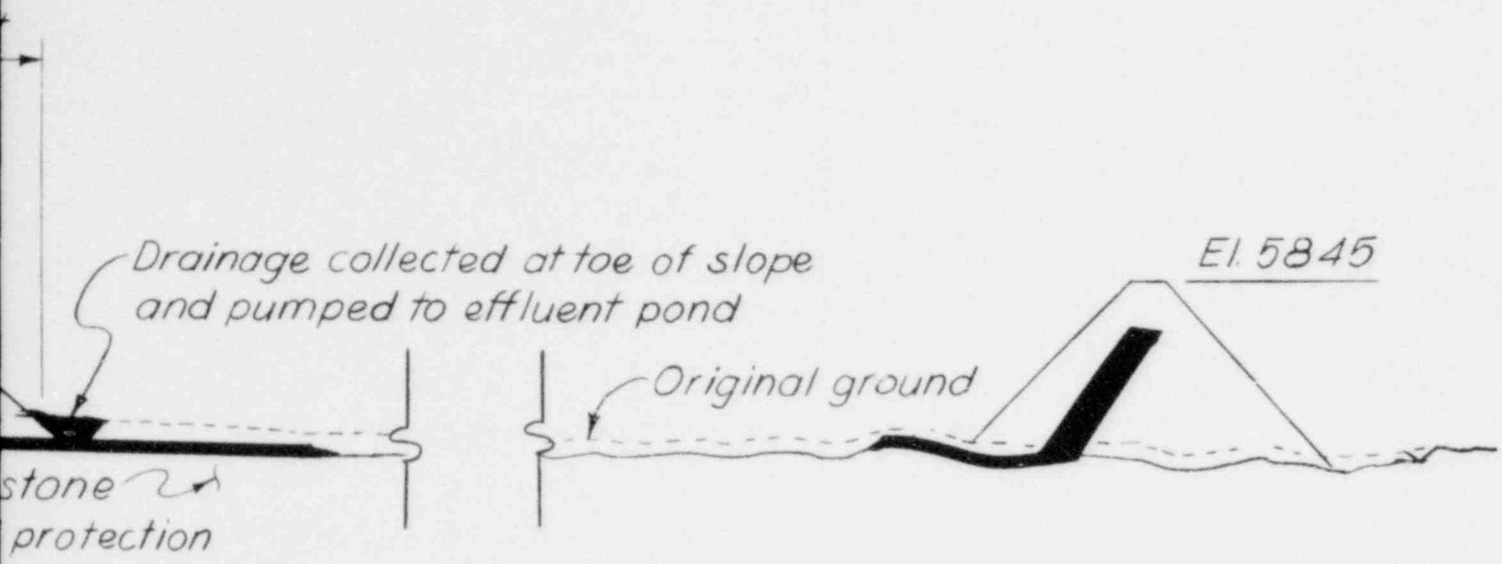


SCHEMATIC CROSS-SEC

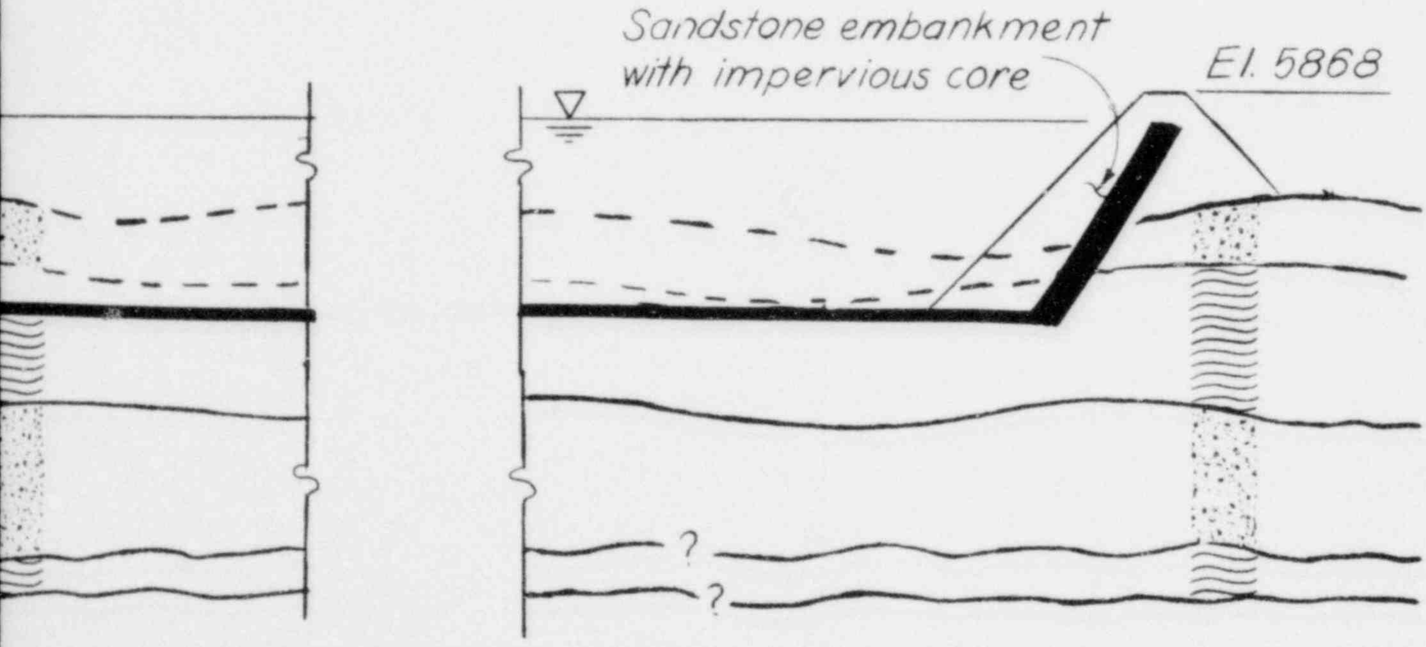


SCHEMATIC CROSS-SECT

Vert
Approximately



TION THROUGH TAILINGS POND



ne excavated to shale layer, and impervious d bottom from excavated shale

ION THROUGH EFFLUENT POND

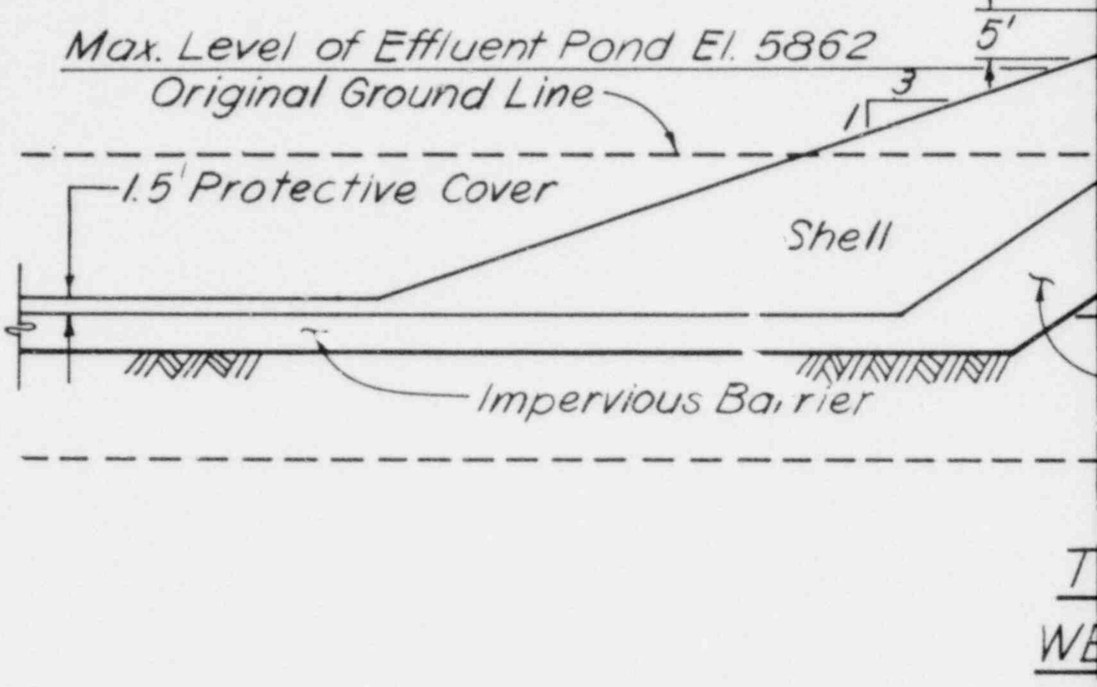
ical Scale is
3 times Horizontal

UNION CARBIDE CORPORATION

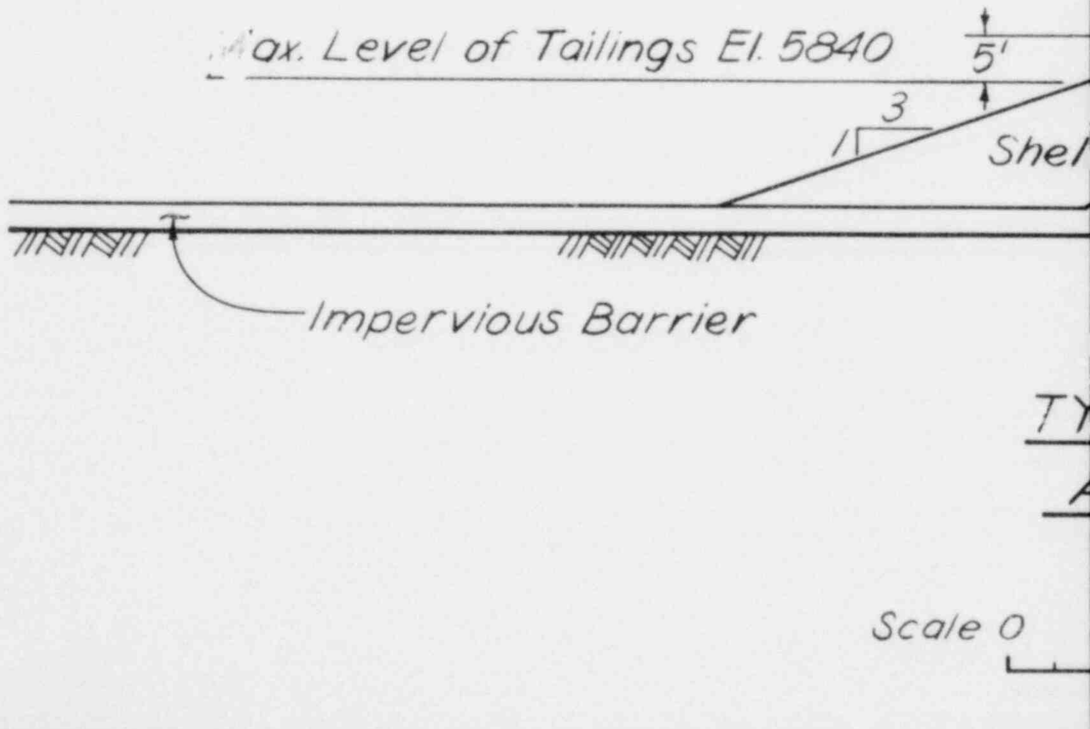
SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
SCHEMATIC CROSS-SECTIONS

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

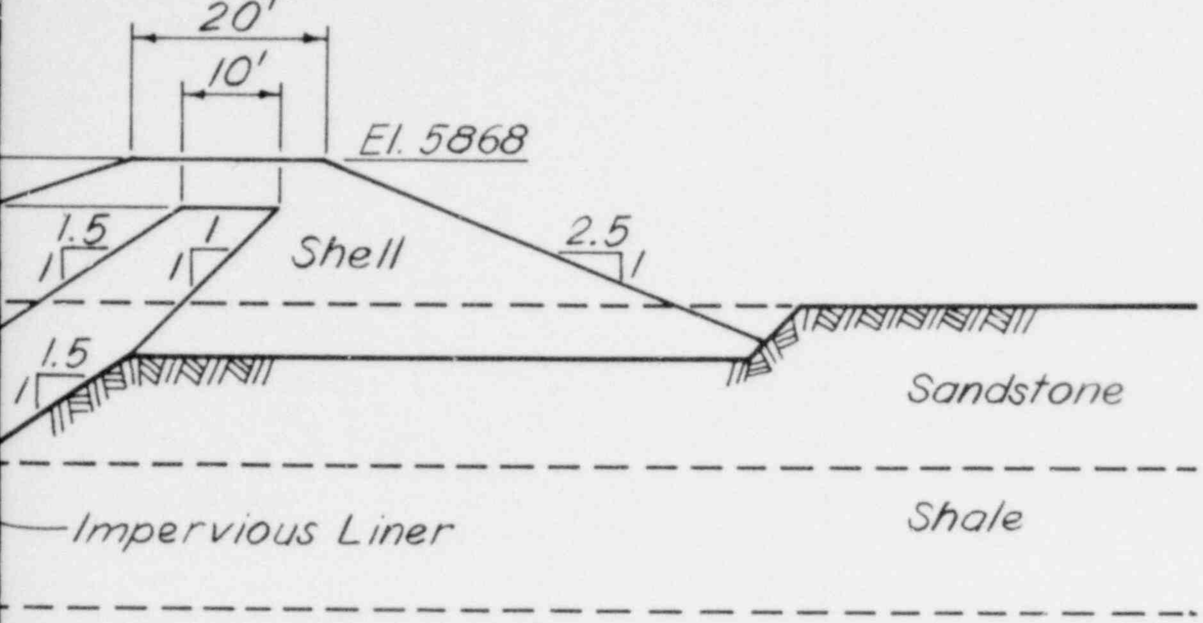
DESIGNED RCS INSPECTED
DRAWN RCS RECOMMENDED
CHECKED APPROVED
DATE MAY 8, 1980
DRAWING NO. FIGURE 5



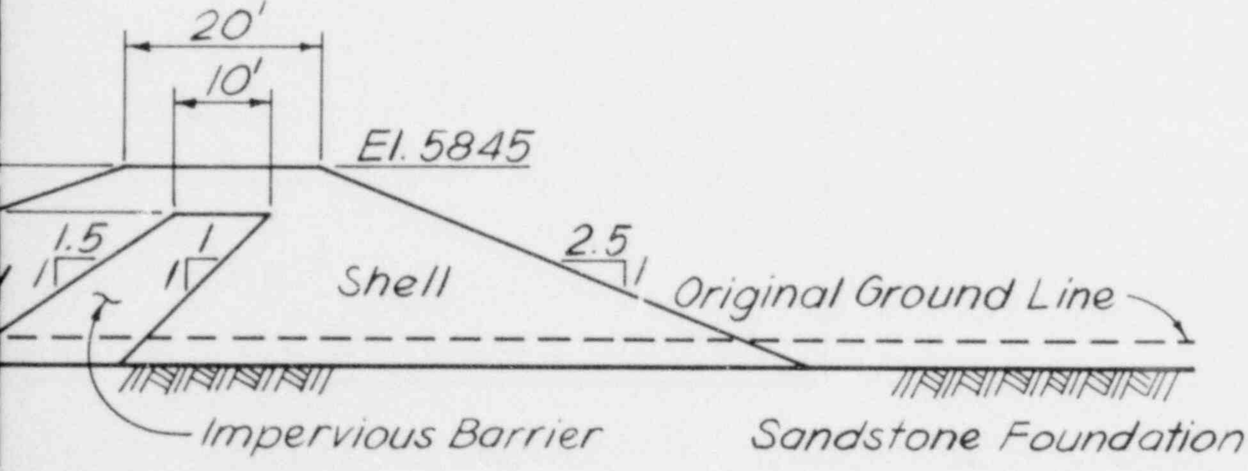
Max. Level of Effluent Pond El. 5862
5'
3
1
Original Ground Line
1.5' Protective Cover
Shell
Impervious Barrier
T
WE



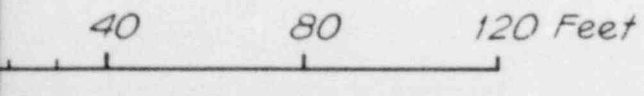
Max. Level of Tailings El. 5840
5'
3
1
Shel
Impervious Barrier
TY
A
Scale 0



YPICAL SECTION
EST MESA AREA



YPICAL SECTION
AIRFIELD AREA



UNION CARBIDE CORPORATION

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
EMBANKMENT SECTIONS

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED E7a INSPECTED
DRAWN LQL RECOMMENDED
CHECKED APPROVED
DATE MAY 4, 1980
DRAWING NO. FIGURE 6

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 2

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal
JOB NO 2014
HOLE NO TD-1
SITE West Mesa Area
BEGUN 3/18/80
COMPLETED 3/19/80
HOLE SIZE NX
ANGLE FROM HORIZ & BEARING Vertical
COORDINATES
DEPTH/EL GROUND WATER Not reached
GROUND EL. 5854
DEPTH/EL TOP OF ROCK 3.5 feet
DRILLING CONTRACTOR Custom Auger Drilling
CORE RECOV LENGTH/%
SAMPLES
CORE BOXES 4
DEPTH/EL BOTTOM OF HOLE 44 feet
DRILL MAKE AND MODEL CME 55
LOGGED BY RAC

SAMPLE DATA TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						2			0.0-3.5 overburden, sandy silt, tan
			1.95/4.0= 49%			4 6 8 10			3.5-12.0 Sandstone, tan, fine-grained, weathered RQD 8.0-12.0 = 0%
			100%			12 14 16			12.0-16.9 Shale, black, weathered, air slakes, bedding $\sim 5^0$. RQD 3.0/4.9 = 61%
			100%			18 20			16.9-20.6 Sandstone, tan, fine-grained, weathered RQD 0.5/3.7 = 14%
			100%			22 24			20.6-24.8 Shale, black, weathered, air slakes, bedding $\sim 5^0$. RQD 3.8/3.8 = 100%
			100%			26 28			24.8-25.4 Sandstone, gray, fine-grained, broken, Fe staining RQD 0% 25.4-26.8 Shale, black, weathered, air slakes, bedding $\sim 5^0$ 1/4" coal seam at 26.2 RQD 100%

HOLE NO TD-1

INTERNATIONAL ENGINEERING CO., INC. SHEET 2 OF 2

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal	JOB NO 2014	HOLE NO TD-1

SAMPLE DATA: TYPE TOOL AND DIA	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
			100%			28 30			26.8-30.2 shale, tan, weathered, bentonitic, 30° fractures 27.2; 27.4; 28';28.3 & 28.6 RQD 3.2/3/4=94%
			100%			32 34 36			30.2-36.2 shale, black, weathered, Fe stained 30° and 60° fractures with gypsum to 1/8" most partings Fe stained some yellow material (carnotite?) in bedding planes RQD 82%
			100%						36.2-38.0 coal
			100%			38 40			38.0-41' black shale,as above but harder without Fe staining RQD 2.0/3' = 65% 39.0-40.0 coal
			100%			42			41'-43.3 Sandstone,gray, fine-grained within (to 1/64") shale partings, some gypsum RQD 100%
			100%			44			43.3-44.0 black shale as above
									Total Depth 44.0

HOLE NO TD-1

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal		JOB NO 2014	HOLE NO TD-2
SITE West Mesa Area	BEGUN 3/19/80	COMPLETED 3/19/80	HOLE SIZE NX	ANGLE FROM HORIZ & BEARING Vertical
COORDINATES	DEPTH/EL GROUND WATER NA		GROUND EL 5857.5	DEPTH/EL TOP OF ROCK 1.0
DRILLING CONTRACTOR Custom Auger Drilling	CORE RECOV LENGTH/% 94%	SAMPLES	CORE BOXES	DEPTH/EL BOTTOM OF HOLE 14.0
DRILL MAKE AND MODEL CME 55	LOGGED BY R. A. C.			

SAMPLE DATA TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
									0.0-1.0 overburden - sandy silt
						2 4			1.0-6.0 Sandstone - not recovered
			100%	7.5		6 8			6.0-10.0 shale, black, weathered with Fe stains, air slakes, bedding ~5° RQD = 1.2/2.5 = 50%
			92%	10.0		10 12			10.0-14.0 shale, tan-gray mod.-severely weathered, all partings Fe stained. 60° fractures 10.9; 11.9; 12.0 & 12.3 RQD 3.1/3.8 = 82%
						14			Total Depth 14.0

HOLE NO TD-2

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO 2014

HOLE NO TD-3

SITE West Mesa Area

BEGUN 3/20/80

COMPLETED 3/20/80

HOLE SIZE NX

ANGLE FROM HORIZ & BEARING Vertical

COORDINATES

DEPTH/EL GROUND WATER NA

GROUND EL.

DEPTH/EL TOP OF ROCK 3.5

DRILLING CONTRACTOR Custom Auger Drilling

CORE RECOV LENGTH/% 9.95/11 = 90%

SAMPLES

CORE BOXES

DEPTH/EL BOTTOM OF HOLE 19.25

DRILL MAKE AND MODEL

LOGGED BY R. A. C.

SAMPLE DATA TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						2			0.0 - 3.5 overburden -sandy silt
						4 6 8			Sandstone not recovered
			96%			10			8.25-10.55 Sandstone, tan-brown, weathered, fine-grained, hard RQD 1.8/2.3 = 78%
			100% 1.8/2.75=65%	H_2O pressure Test 30 PSI $K=4 \times 10^{-4}$ cm/sec		12 14 16			10.55-16.5 shale, black, weathered, very broken (0% RQD), below 14.0 Fe stained, bedding ~ 5^0. Baked by drill action 15.85-16.5 RQD 1.6/5.95 = 27% Waterways blocked
						18			16.5-19.25 shale, gray, bentonitic, weathered, Fe stains, 16.5-16.65 baked by drill action previous run, broken RQD 1.2/2/75 =44%
						20			Total Depth 19.25

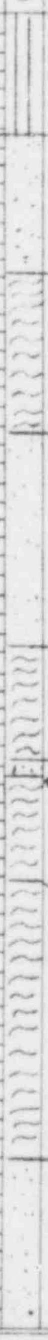
HOLE NO. TD-3

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal			JOB NO. 2014	HOLE NO. TD-4
SITE West Mesa Area	BEGUN 3/20/80	COMPLETED 3/21/80	HOLE SIZE NX	ANGLE FROM HORIZ &BEARING Vertical
COORDINATES	DEPTH/EL GROUND WATER NA		GROUND EL. 5850.0	DEPTH/EL TOP OF ROCK 2.5
DRILLING CONTRACTOR Custom Auger Drilling	CORE RECOV LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL BOTTOM OF HOLE 28.5
DRILL MAKE AND MODEL CME 55	LOGGED BY: RAC			



SAMPLE DATA TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						2			0.0-2.5 overburden, sandy silt
						4			2.5-5.5 Sandstone - not recovered
						6 8			5.5-9.0 shale - not recovered
			100%			10 12			9.0-13.5 Sandstone,brown,fine-grained,weathered, Fe stains hard,bedding~5^{0}; 70^{0} fracture 9.5-10.2, thin clay seams (To 1/22") 11.5-13.5 RQD 4.2/5.0 = 84%
			100%			14			13.5-15.9 shale,black,weathered, Fe stains, bedding~5^{0}. RQD 2.4/2.4 = 100%
			100%	H_2O Pressure Test 30 PSI K= 1 x 10^{-3} cm/sec		16 18			15.9-16.25 Sandstone,gray,fine-grained, weathered,Fe stains hard RQD 100% 16.25-18.5 shale,black,60^{0}fracture 17.65-18.05;30^{0} fracture 18.35 RQD 1.9/2.25 =84%
			100%			20 22 24			18.5-24.9 shale, gray, weathered, Fe stains RQD 100%
			100%			26 28			24.9-28.5 Sandstone,tan-reddish,bedding ~5^{0}, gypsum, hard RQD 2.7/3.6 = 75%

HOLE NO. TD-4

Total Depth 28.5

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal
JOB NO. 2014
HOLE NO TD-5
SITE West Mesa Area
BEGUN 3/21/80
COMPLETED 3/21/80
HOLE SIZE NX
ANGLE FROM HORIZ &BEARING Vertical
COORDINATES
DEPTH/EL GROUND WATER NA
GROUND EL. 5834.1
DEPTH/EL. TOP OF ROCK 2.0
DRILLING CONTRACTOR Custom Auger Drilling
CORE RECOV LENGTH/%
SAMPLES
CORE BOXES
DEPTH/EL. BOTTOM OF HOLE 14.75
DRILL MAKE AND MODEL CME 55
LOGGED BY RAC

SAMPLE DATA				REMARKS					
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY	WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
									0.0-2.0 overburden - sandy silt
						2			2.0-3.0 Sandstone-not recovered
						4 6 8			3.0-8.75 shale - not recovered
				Recovery 1.1/1.8 = 80%					8.75-10.05 Sandstone, fine-grained, hard, reddish RQD 0%
			100%	H$_2$O Pressure Test 10 PSI K = 4 x 10^{-4}cm/sec		10			10.05-11.85 interbedded Sandstone and sh. RQD 1.2/1.8 = 67%
			100%			12			11.85-14.45 Shale, black, weathered, RQD 100%
				100%		14			14.45-14.75 Sandstone, tan-reddish RQD 100%
						16			Total Depth 14.75

HOLE NO. TD-5

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 2

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO. 2014

HOLE NO. TD-6

SITE West Mesa Area

BEGUN 3/25/80

COMPLETED 3/26/80

HOLE SIZE NX

ANGLE FROM HORIZ & BEARING Vertical

COORDINATES

DEPTH/EL GROUND WATER NA

GROUND EL 5839

DEPTH/EL TOP OF ROCK 3.5

DRILLING CONTRACTOR Custom Auger Drilling

CORE RECOV LENGTH/%

SAMPLES

CORE BOXES

DEPTH/EL BOTTOM OF HOLE 39.0

DRILL MAKE AND MODEL CME 55

LOGGED BY RAC

SAMPLE DATA TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						0–4			0.0-4.0 overburden sandy silt
						4–8.5			4.0-8.5 interbedded Sandstone and Shale -not recovered
			9.8/10=98%			8.5–15.5			8.5-15.5 Sandstone, tan, fine-grained, hard, weathered, bedding $\sim 5^{0}$, broken, with black Shale partings at 0' intervals. RQD 8.5-14.0 + 1.9/5.5 = 35% 14.0-15.5 = 0.5/1.5 =33%
			8.3/8.3=100%	H_2O Pressure Test 15.4-19.0 14 PSI $K= 3 \times 10^{-5}$ cm/sec H_2O Pressure Test 19.5-29.0 20 PSI 1×10^{-4} cm/sec 30 PSI 1×10^{-4} cm/sec		15.5–23.8			15.5-23.0 Shale, black, weathered, Fe stains, along partings, beddings $\sim 5^{0}$, becoming lighter toward bottom RQD 6.0/8.3 = 72%
			100%			23.8–27.5			23.8-27.5 Sandstone, brown, fine-grained, hard, weathered RQD 76%

2 4 6 8 10 12 14 16 18 20 22 24 26 28

HOLE NO. TD-6

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal	JOB NO 2014	HOLE NO TD-6

SAMPLE DATA									
TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
			100%			28			27.5-29.0 siltstone
			100% 100%	100% H_2O Pressure Test 27.4-39.0 30 PSI K= 7 x 10^{-5} cm/sec 40 PSI K= 9 x 10^{-5} cm/sec		30 32 34 36			29.0-37.3 Shale, black, weathered, Fe staining, soft with a harder zone 32.5-35.8, 30° fractures 35.0; 35.8 and 37.3. 30.0-31.7 reddish, fine-grained, Sandstone, hard and weathered. RQD 5.3/8.3 = 64%
			100%			38			37.3-39.0 Sandstone, tan, hard, weathered, near vertical fracture 37.3-39.0 Fe stained RQD 1.2/1.3=71%
						40			Total Depth 39° Overall Recovery 30.3/30.5 = 99% RQD 19.21/30.5 = 63%

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal			JOB NO 2014	HOLE NO TD-7
SITE West Mesa Area	BEGUN 3/24/80	COMPLETED 3/24/80	HOLE SIZE NX	ANGLE FROM HORIZ & BEARING Vertical	
COORDINATES	DEPTH/EL GROUND WATER NA		GROUND EL. 5835	DEPTH/EL TOP OF ROCK 4.5	
DRILLING CONTRACTOR Custom Auger Drilling	CORE RECOV LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL BOTTOM OF HOLE 19.0	
DRILL MAKE AND MODEL CME 55	LOGGED BY E. Axtmann				

SAMPLE DATA									
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						2 4			0.0-4.5 Sandy silt, overburden
						6			4.5-7.5 Shale and Sandstone, weathered, not recovered
				Drilling steady with full water return Water loss 30%, (12.5-12.7) Full Water return Good water return and steady drilling H_2O Pressure Test 16.4-19.0 40 PSI K= 3 x 10^{-5} cm/sec		8 10 12 14 16 18			7.5-19.0 Shale and Sandstone, interbedded, drilling times indicate high Shale content
						20			Bottom of hole @ 19.0'

HOLE NO TD-7

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO 2014

HOLE NO TD-8

SITE West Mesa Area

BEGUN 3/24/80

COMPLETED

HOLE SIZE NX

ANGLE FROM HORIZ & BEARING Vertical

COORDINATES

DEPTH/EL GROUND WATER NA

GROUND EL 5856

DEPTH/EL TOP OF ROCK 4.0

DRILLING CONTRACTOR

CORE RECOV LENGTH/%

SAMPLES

CORE BOXES

DEPTH/EL BOTTOM OF HOLE 19.2

DRILL MAKE AND MODEL

LOGGED BY E. Axtmann

SAMPLE DATA TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						2		0.0-4.0 Sandy silt, overburden
						4 6		4.0-7.6 Clay and sand matrix, not recovered
			70	1.4/2.0 20% water loss		8		7.6-8.7 Sandstone, weak
						10		8.7-10.3 Shale,mod.hard,grey (9.0-10.3)
			92	4.6/5.0~5° bedding Plane fractures @ 10.6 and 12.3		12		10.3-12.8 Shaley Sandstone,severely weathered, tan, stained
				bedding~5° no fracture		14		12.8-14.0 Shale, soft to med. hard, grey
				Horizontal fracture 14.3				14.0-14.5 Sandstone, mod. hard, tan, fine-grained
				~5° bedding 30° fracture (16.7-16.8)		16		14.5-17.0 Clay Shale,mod.hard,black, mod.weathering & iron stains
						18		17.0-17.8 Sandstone, hard, fine-grained, reddish
						20		17.8-19.0 Shale, mod. hard, grey
								Bottom of hole @ 19.2'

HOLE NO TD-8

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 2

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO. 2014

HOLE NO. TD-9

SITE West Mesa Area

BEGUN 3/24/80

COMPLETED

HOLE SIZE NX

ANGLE FROM HORIZ & BEARING Vertical

COORDINATES

DEPTH/EL GROUND WATER

GROUND EL. 5856

DEPTH/EL TOP OF ROCK 6.0

DRILLING CONTRACTOR

CORE RECOV LENGTH/%

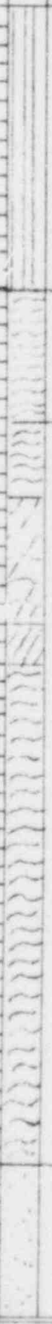
SAMPLES

CORE BOXES

DEPTH/EL BOTTOM OF HOLE 34.2

DRILL MAKE AND MODEL

LOGGED BY: E. Axtmann



SAMPLE DATA TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						2 4			0.0-6.0 Sandy silt, overburden
						6			6.0-24.7 Shale 6.0-8.9, weathered, not recovered
				8.9-14.0 very slow drilling at low water pressure and drilling pressure to core material		8 10 12			10.5-13.3, with coal seams
				@ 13.3 water loss 20-25%. The coal seams and variable hardness of Shale layers will plug core barrel unless drilled slowly with ample water circulation water loss varied 10 to 20% overrun Drilled steady @ 120 PSI water pressure, good water return		14 16 18 20			13.3-14.0, coal layer
			97←	4.85 / 5.00 little or no water loss		22 24			Shale, hard
			99←	No water loss 4.95 / 5.00		26 28			24.7-34.2 Sandstone

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO 2014

HOLE NO TD-9

SAMPLE DATA									
TYPE TOOL AND DIA	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
				Drilled steady only water loss @ 32.5 ft. very small water loss for run		28			
						30			
			99						
						32			
						34			
									Bottom of hole @ 34.2'

HOLE NO TD-9

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 2

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal	JOB NO 2014	HOLE NO TD-10

SITE West Mesa Area	BEGUN 4/2/80	COMPLETED 4/3/80	HOLE SIZE NX	ANGLE FROM HORIZ & BEARING Vertical
COORDINATES	DEPTH/EL GROUND WATER NA		GROUND EL. 5849.4	DEPTH/EL TOP OF ROCK 3.0
DRILLING CONTRACTOR Custom Auger Drilling	CORE RECOV LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL BOTTOM OF HOLE 34.0
DRILL MAKE AND MODEL CME 55	LOGGED BY RAC			

SAMPLE DATA				REMARKS					MATERIAL CLASSIFICATION
TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	PHYSICAL DESCRIPTION
						2			0.0-3.0 overburden sandy silt
						4			3.0-5.5 Sandstone, not recovered
						6			5.5-7.0 Shale - not recovered
		1.0/2.5=	48%			8			7.0-9.3 Shale, black, weathered, mod. hard RQD 1.1/2.3 = 48%
			98%	H_2O Pressure Test 10.4-14.0 10 PSI K= 8 x 10^{-6}cm/sec		10 12 14			9.3-14.7 Sandstone, tan, fine-grained, weathered, 11.7-12.5 interbeds of black Shale make up 30% of volume below 12.5- black Shale partings, RQD 3.4/5.4 63%
			100%	H_2O Pressure Test 14.4-24.0 20 PSI K= 2 x 10^{-5} cm/sec		16 18 20			14.7-21.4 Shale, black, weathered, (Fe stains) mod. soft, bedding ~5° RQD 100%
			100%			22			21.4-22.6 Sandstone, tan-gray, fine-grained, weathered, hard, RQD 100%
			100%			24			22.6-24.8 Shale, black, weathered RQD 0.5/2.2 = 23%
			100%			26 28			24.8-34.0 Sandstone, tan, fine-grained, weathered, 25.2-27.5 black Shale

HOLE NO. TD-10

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal	JOB NO	HOLE NO TD-10

SAMPLE DATA									
TYPE TOOL AND DIA	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
			100%	H_2O Pressure Test 26.4-34.0 30 PSI K= 9 x 10^{-6}cm/sec		28 30 32			Below 29° bedding approaches 30° gypsum seam (1/16") in bedding at 32° RQD 7.1/9.2 = 77%
						34			Total Depth 34°

HOLE NO TD-10

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal		JOB NO 2014	HOLE NO TD-10A
SITE West Mesa Area	BEGUN 4/3/80	COMPLETED 4/3/80	HOLE SIZE NX	ANGLE FROM HORIZ & BEARING Vertical
COORDINATES	DEPTH/EL GROUND WATER NA		GROUND EL 5849	DEPTH/EL TOP OF ROCK 3.0
DRILLING CONTRACTOR Custom Auger Drilling	CORE RECOV LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL BOTTOM OF HOLE 24.5
DRILL MAKE AND MODEL CME 55	LOGGED BY RAC			

SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						0.0-3.0			0.0-3.0 overburden sandy silt
		0.2/1.8=	11%			3.0-5.5			3.0-5.5 Sandstone - not recovered
						5.5-7.3			5.5-7.3 Sandstone, brown, broken, weathered, RQD 0%
		2.7/	8.2=84%			7.3-10.5			7.3-10.5 Shale, black, soft, weathered, bedding ~ 5°. 8.5-8.6 Sandstone, tan, weathered RQD 1.5/3.2 = 47%
			100%			10.5-13.0			10.5-13.0 Sandstone, tan, weathered, broken RQD 0%
			100%			13.0-24.5			13.0-24.5 Shale, black, mod. hard, 15.5-16.3 Sandstone, tan-gray. Shale gray-brown below 19.5. 20.6-21.1 Sandstone, tan weathered. RQD 10.6/11.15 =92%
						24.5			Total Depth 24.5

Depth scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26

HOLE NO TD-10A

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO. 2014

HOLE NO. ED-1

SITE Airstrip Area

BEGUN 1/4/80

COMPLETED 1/4/80

HOLE SIZE NX

ANGLE FROM HORIZ & BEARING Vertical

COORDINATES

DEPTH/EL GROUND WATER NH

GROUND EL.

DEPTH/EL TOP OF ROCK 3.0

DRILLING CONTRACTOR Custom Auger Drilling

CORE RECOV LENGTH/%

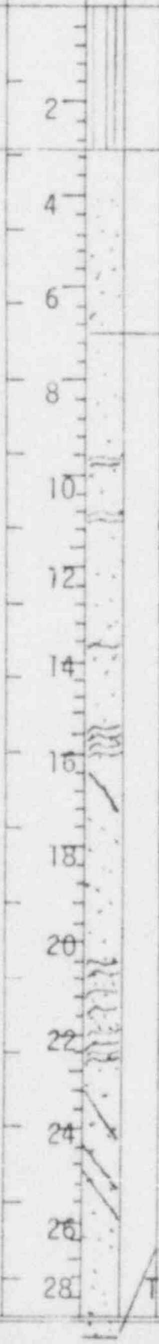
SAMPLES

CORE BOXES

DEPTH/EL BOTTOM OF HOLE 28.5

DRILL MAKE AND MODEL CME 55

LOGGED BY RAC



SAMPLE DATA: TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
									0.0-3.0 overburden, brown, sandy silt.
									3.0-7.0 Sandstone - not recovered
			21.2/21.5 = 99%						7.0-28.5 Sandstone, tan, fine-grained, hard, weathered, clay filled partings 9.7 10.7-10.9; 13.5 black Shale inclusions 15.5-16.0; 20.6-20.8 and 22.3-22.5. Thin (1/16") interbeds of Shale and Sandstone 21.6-22.2. Shale parting 28'; 60° fractures 16.4-16.9; 23.9 24.5 and 24.9 RQD 7.0-8.5 100% 8.5-13.5 3.9/5.0 =78% 13.5-18.5 100% 18.5-28.5 8.3/10 = 80%
									Total Depth 28.5

HOLE NO. ED-1

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 2

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO. 2014

HOLE NO. ED-2

SITE Airstrip Area

BEGUN

COMPLETED

HOLE SIZE NX

ANGLE FROM HORIZ & BEARING Vertical

COORDINATES

DEPTH/EL GROUND WATER NA

GROUND EL. 5835.5

DEPTH/EL TOP OF ROCK 1.0

DRILLING CONTRACTOR Custom Auger Drilling

CORE RECOV LENGTH/%

SAMPLES

CORE BOXES

DEPTH/EL BOTTOM OF HOLE 46.9

DRILL MAKE AND MODEL CME 55

LOGGED BY E. Axtmann

SAMPLE DATA									
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
	SPT								Overburden, sandy silt
	50/67 0			Augered thru ledge like layers. Material is good embankment, random.		2			Sandstone (weathered) and silty sand with pieces of Sandstone less than 3/8" size
	50/17 0			4.5-4.67:split spoon sample		4			Sandstone (weathered,decomposed) and silty sand
	50/27 0								Sandstone (weathered, decomposed) and silty sand. Light tan
	50/10 0			Augers easy and smoothly		6			Sandstone , weathered, light tan Sandstone, decomposed
				Good water return NX bit advancing smoothly and steady		8			
				Fast, easy drilling		10			Sandstone 9.0-12.0: light tan,over 6 pieces
				Full water return. Drilling steady					
			99	4.95 5.00		12			12.0-13.5: full stick of Sandstone, hard, fresh
						14			
				Full water return-Drilling steady to 18.0 Losing water after 18.0		16			Sandstone
				Average core length 1 ft.		18			
				Drilling fast & steady. Losing 1/2 drill water.		20			Sandstone 19.0-22.0: one 3 ft. stick of fresh Sandstone
						22			23.0-23.7: Shale looking zone, mod. hard
				Drilled steady 1/2-3/4 water loss.		24			Sandstone 24.0-25.0: fractured 25.0-28.0: hard, fresh,light tan
						26			
						28			28.0-29.8: fractured,w/vertical joint or fracture @ 28.6-29.6.Joint iron-stained and open.

HOLE NO. ED-2

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal	JOB NO 2014	HOLE NO ED-2

SAMPLE DATA TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
				Lost drill Water return		28			
						30			Sandstone
						32			
				No water return		34			35.0-39.0 One piece of hard, fresh Sandstone
						36			
						38			
									Sandstone and Shale
				No water return		40			41.4-43.0: Shale was washed away. No void, drill didn't drop or indicate void or soft zone.
			68 ← 3.4/5.0			42			
				Drilled fast					Sandstone and Shale. 44.3-45.6 - Sandstone 44.0-44.3 - joint filled with clay 44.6 Hort joint-open 45.9-46.9- Shale, black
				No water return		44			
						46			
						48			Bottom of hole @ 46.9

HOLE NO ED-2

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 2

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO 2014

HOLE NO. ED-3

SITE Airstrip Area

BEGUN 2/4/80

COMPLETED 2/4/80

HOLE SIZE NX

ANGLE FROM HORIZ & BEARING Vertical

COORDINATES

DEPTH/EL. GROUND WATER NA

GROUND EL. 5835.6

DEPTH/EL. TOP OF ROCK 3.0

DRILLING CONTRACTOR Custom Auger Drilling

CORE RECOV LENGTH/%

SAMPLES

CORE BOXES

DEPTH/EL. BOTTOM OF HOLE 29.5

DRILL MAKE AND MODEL CME 55

LOGGED BY. RAC

SAMPLE DATA									
TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						2			0.0-3.0 overburden, brown, sandy silt
						4 6			3.0-8.0 Sandstone - not recovered
			15.9/16.5 = 96%	H_2O Pressure Test 11.4-19.5 20 PSI $K = 1 \times 10^{-5} cm/sec$		8 10 12 14 16 18 20 22 24			8.0-24.5 Sandstone, brown, weathered, contains Shale partings increasing to ~30% Shale below 19.5. RQD 8.0-19.5 3.2/11.5 = 28% 19.5-24.5 5.0/5.0 = 100%
						26 28			24.5-29.5 Shale, brown, sandy, weathered, bedding ~5°

HOLE NO. ED-3

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO 2014

HOLE NO ED-3

SAMPLE DATA				REMARKS	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION
TYPE TOOL AND DIA	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH					PHYSICAL DESCRIPTION
						28			1/8" gypsum seams at 0.2 intervals along bedding below 27.4.
						30			Total Depth 29.5.

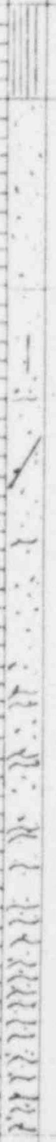
HOLE NO ED-3

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal
JOB NO 2014
HOLE NO ED-4
SITE Airstrip Area
BEGUN 2/4/80
COMPLETED 2/4/80
HOLE SIZE NX
ANGLE FROM HORIZ &BEARING Vertical
COORDINATES
DEPTH/EL GROUND WATER NA
GROUND EL 5844.5
DEPTH/EL TOP OF ROCK 2.0
DRILLING CONTRACTOR Custom Auger Drilling
CORE RECOV LENGTH/%
SAMPLES
CORE BOXES
DEPTH/EL BOTTOM OF HOLE 24.0
DRILL MAKE AND MODEL CME 55
LOGGED BY RAC



SAMPLE DATA									
TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						2			0.0-2.0 overburden, brown, sandy silt
						4 6			2.0-6.0 Sandstone- not recovered
			100%			8 10 12 14 16 18 20 22 24			6.0-24.0 Sandstone, brown, weathered, contains from ~5% Shale at 6.0 to ~50% Shale below 14.0. Bedding ~5° vertical fracture 7.6-7.8; 30° fracture 10.0 RQD 6.0-9.0 1.5/3.0 = 17% 9.0-24.0 14.1/15.0 = 94%
									Total Depth 24.0

HOLE NO. ED-4

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO 2014

HOLE NO. ED-5

SITE Airstrip Area

BEGUN 2/4/80

COMPLETED 2/4/80

HOLE SIZE NX

ANGLE FROM HORIZ &BEARING Vertical

COORDINATES

DEPTH/EL GROUND WATER N/A

GROUND EL 5835.0

DEPTH/EL TOP OF ROCK 2.0

DRILLING CONTRACTOR Custom Auger Drilling

CORE RECOV LENGTH/%

SAMPLES

CORE BOXES

DEPTH/EL BOTTOM OF HOLE 23.5

DRILL MAKE AND MODEL CME 55

LOGGED BY RAC

SAMPLE DATA									
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
									0.0-2.0 overburden, brown, sandy silt
						2 4 6			2.0-7.0 Sandstone - not recovered
			15.2/16.5 = 92%			8 10 12 14 16 18 20 22			7.0-23.5 Sandstone, brown, fine-grained, weathered, bedding ~ 5°. Calcareous, Shale content increases toward bottom RQD 7.0-13.5 3.7/6.5 = 57% 13.5-23.5 9.4/10 = 94%
						24			Total Depth 23.5

HOLE NO. ED-5

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal	JOB NO 2014	HOLE NO. ED-6

SITE Airstrip Area	BEGUN 1/4/80	COMPLETED 1/4/80	HOLE SIZE NX	ANGLE FROM HORIZ &BEARING Vertical
COORDINATES	DEPTH/EL GROUND WATER N/A	GROUND EL. 5856.2		DEPTH/EL TOP OF ROCK 1.0
DRILLING CONTRACTOR Custom Auger Drilling	CORE RECOV LENGTH/%	SAMPLES	CORE BOXES	DEPTH/EL BOTTOM OF HOLE 24.0
DRILL MAKE AND MODEL CME 55	LOGGED BY RAC			

SAMPLE DATA TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
									0.0-1.0 overburden,brown,sandy silt
						2			1.0-7.0 Sandstone - not recovered
						4			
						6			
			5.8/7.0 = 83%			8			7.0-24.0 Sandstone, brown, weathered, broken. Becomes interbedded with Shale below 10º.
						10			RQD 7.0-14.0 1.0/7.0 +14% 14.0-24.0 9.6/10.0 = 96%
						12			
						14			
			9.8/10.0 = 98%			16			
						13			
						20			
						22			
						24			Total Depth 24.0

HOLE NO. ED-6

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 1

DRILL LOG

PROJECT: Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO: 2014

HOLE NO: ED-7

SITE: Airstrip Area

BEGUN: 1/4/80

COMPLETED: 1/4/80

HOLE SIZE: NX

ANGLE FROM HORIZ BEARING: Vertical

COORDINATES:

DEPTH/EL GROUND WATER: NA

GROUND EL:

DEPTH/EL TOP OF ROCK: 2.0

DRILLING CONTRACTOR: Custom Auger Drilling

CORE RECOV LENGTH/%:

SAMPLES:

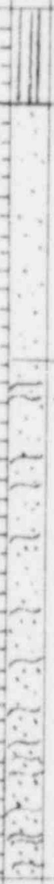
CORE BOXES:

DEPTH/EL BOTTOM OF HOLE: 18.5

DRILL MAKE AND MODEL: CME 55

LOGGED BY: RAC

SAMPLE DATA									
TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						2			0.0-2.0 overburden, brown sandy silt
						4 6			2.0-7.5 Sandstone - not recovered
			96%	H$_2$O Pressure Test 11.5-18.5 30 PSI K = 2 x 10^{-4} cm/sec		8 10 12 14 16 18			7/5-18.5 Sandstone, tan, weathered, hard, fine-grained. More broken and weathered 9.4-11.5. Below 9.4 partings contain black Shale, below 15.5 Shale content approaches 50%. RQD 7.5/8.5 0.4/1.0 = 40% 8.5/9.4 0.8/0.9 = 90% 9.4-11.5 0% 11.5-13.5 1.5/2.0 = 75% 13.5-18.5 3.8/5.0 = 96%
						20			Total Depth 18.5



HOLE NO. ED-7

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 2

DRILL LOG

PROJECT: Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal

JOB NO: 2014

HOLE NO: AH-1

SITE: Borrow Area

BEGUN: 27/3/80

COMPLETED: 27/3/80

HOLE SIZE: NX

ANGLE FROM HORIZ & BEARING: Vertical

COORDINATES:

DEPTH/EL GROUND WATER: N/A

GROUND EL.: 5867.6

DEPTH/EL TOP OF ROCK: 6.0

DRILLING CONTRACTOR: Custom Auger Drilling

CORE RECOV LENGTH/%:

SAMPLES:

CORE BOXES:

DEPTH/EL. BOTTOM OF HOLE: 39.0

DRILL MAKE AND MODEL: CME 55

LOGGED BY: E. Axtmann

SAMPLE DATA				REMARKS	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO.	MATERIAL CLASSIFICATION
TYPE TOOL AND DIA.	METHOD N. BLOW COUNT	ADVANCE	RECOVERY	WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH					PHYSICAL DESCRIPTION
									0.0-6.0 Sandy silt, overburden
						2			Piece of Sandstone
						4			Sandy silt, overburden
						6			
									6.0-24.0 Sandstone
						8			6.0-9.0 weathered
						10			9.0-14.0 tan, soft, fractured and weathered
			98	← $\frac{4.9}{5.0}$					
						12			
						14			
				14.0-19.0 Lost Drill Water					
						16			
						18			
						20			
						22			
						24			
									24.6-34.0
			98	← $\frac{4.9}{5.0}$		26			Shale, soft to mod. hard, gray
						28			

HOLE NO. AH-1

INTERNATIONAL ENGINEERING CO., INC.

SHEET 2 OF 2

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal	JOB NO 2014	HOLE NO AH-1

SAMPLE DATA TYPE TOOL AND DIA	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						28			Shale, soft to mod. hard, grey
						30			
						32			
			98	← $\frac{4.9}{5.0}$		34			34.0-35.5 Sandstone with Shale, weak
			94	← $\frac{4.7}{5.0}$		36			35.5-39.0 Shale, mod. hard to soft, black, appears tight
						38			
						40			Bottom of hole @ 39.0'

HOLE NO AH-1

INTERNATIONAL ENGINEERING CO., INC.

SHEET 1 OF 2

DRILL LOG

PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal		JOB NO 2014	HOLE NO. BH-1

SITE Borrow Area	BEGUN 3/26/80	COMPLETED 3/27/80	HOLE SIZE NX	ANGLE FROM HORIZ BEARING Vertical
COORDINATES 1,000 Ft. North of NW-SE Runway	DEPTH/EL GROUND WATER		GROUND EL 5819.6	DEPTH/EL TOP OF ROCK 2.5
DRILLING CONTRACTOR Custom Auger Drilling	CORE RECOV LENGTH/%	SAMPLES	CORE BOXES 4	DEPTH/EL BOTTOM OF HOLE
DRILL MAKE AND MODEL CM	LOGGED BY E. Axtmann			

SAMPLE DATA									
TYPE TOOL AND DIA.	METHOD N- BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
						2			0.0-2.5 overburden, sandy silt, tan w/pieces of Sandstone, slightly plastic w/moisture
						4 6			2.5-7.0 Sandstone, weathered, decomposed w/ broken pieces of tan Sandstone. Easily broken by mechanical force D-8 Dozer excavated with no problems. Set casing to 7.0.
			47	0.7/1.50		8			7.0-8.5 Sandstone-weathered zone, broken fractured. High water loss-no return
			80	4.0/5.0		10 12			8.5-12.6 Sandstone, tan, mod. hard with joints and fractures. Drilled steady and easy, 1/3 to 1/2 water loss.
						14			12.6-13.5 Shale, gray, soft weathered
			86	4.3/5.0		16 18			13.5-18.5 Sandstone, tan, mod. hard. Drilled fast and easy. 2/3 water return.
						20 22 24			18.5-24.5 Sandstone
			98	Drilling Time 24.5 tO 28.6 - 31 minutes 4.0/4.1 Note:Ran out of water and didn't complete 5' core run.		26 28			24.5-30.5 Shale, grey, mod. hard, very plastic with moisture and mechanical working.

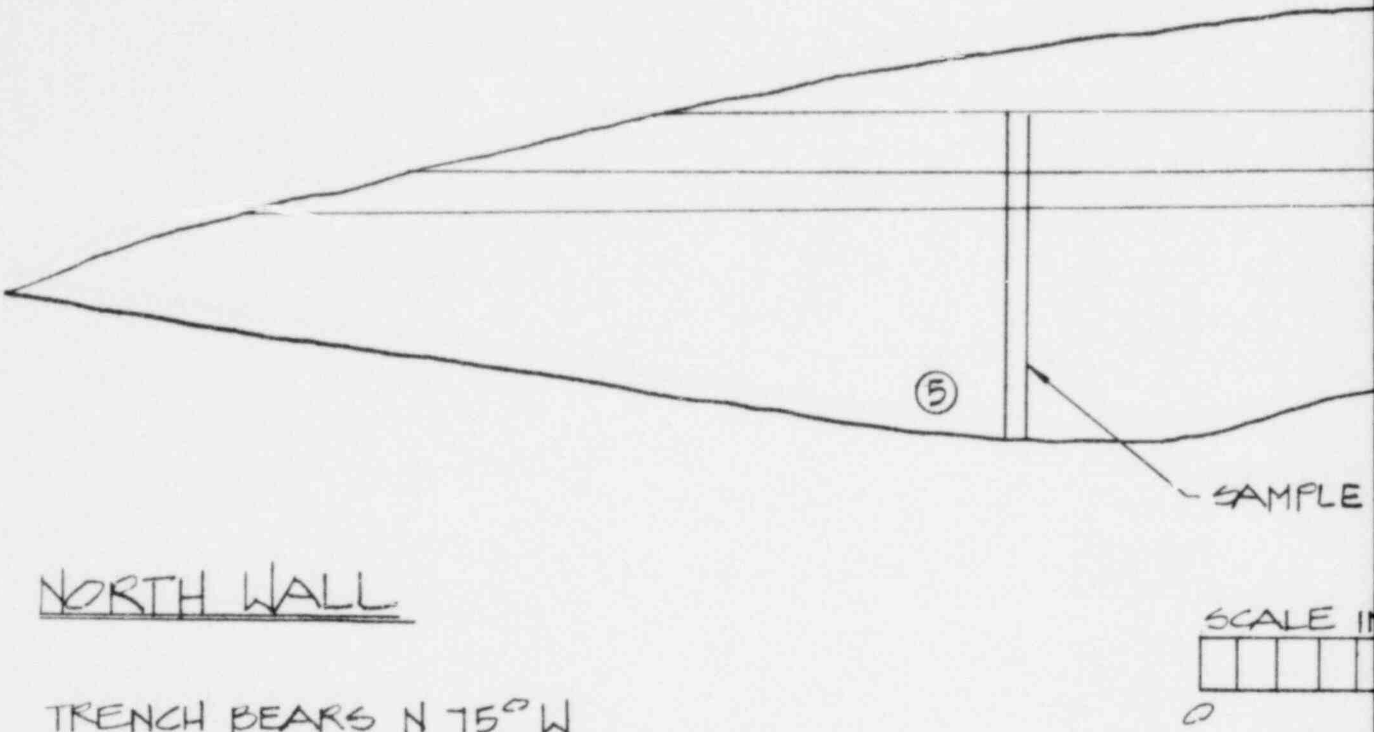
HOLE NO. BH-1

INTERNATIONAL ENGINEERING CO., INC. SHEET 2 OF 2

DRILL LOG	PROJECT Union Carbide Corp-Spring Creek Mesa Tailings and Effluent Disposal	JOB NO 2014	HOLE NO BH-1

SAMPLE DATA									
TYPE TOOL AND DIA.	METHOD N-BLOW COUNT	ADVANCE	RECOVERY	REMARKS WATER LEVELS WATER RETURN DRILLING FLUID CASING DEPTH	ELEVATION	DEPTH	GRAPHIC LOG	BOX/SAMPLE NO	MATERIAL CLASSIFICATION PHYSICAL DESCRIPTION
				Drilling Time 28.5-33.5 was 50 minutes		28 30			Shale, grey 22.7-33.7 grey Shale (1.5' of which is too hard for impervious material leaving 9.5 for borrow material.)
				Drilling Time 33.5-38.5 was 12 minutes		32			
						34 36			33.5 to 43.5 Sandstone, tan
						38			38.5-43.5 Sandstone, massive, firm but drilled fast and easy.
				Drilling Time 38.5-43.5 was 6 minutes		40 42			Note: 33.7 depth would be practical limitation for impervious borrow material depth.
						44			

HOLE NO BH-1



NORTH WALL

TRENCH BEARS N 75° W

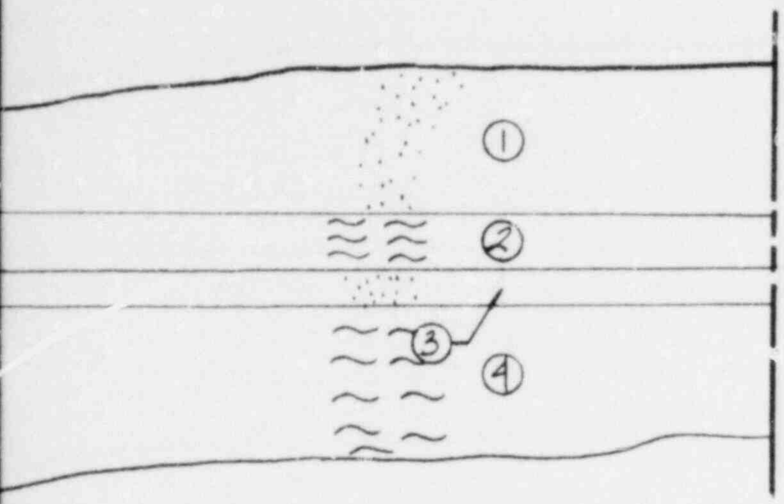
① SANDSTONE, FINE GRAINED, WEATHERED, BROKEN WITH CALCAREOUS COATINGS BEDDING N 50° E/5° SW. BEDDING 1"-2" MAJOR JOINT SET N 35° W/NEAR VERTICAL.

② SHALE, BLACK, MOD. HARD, AIR SLAKES

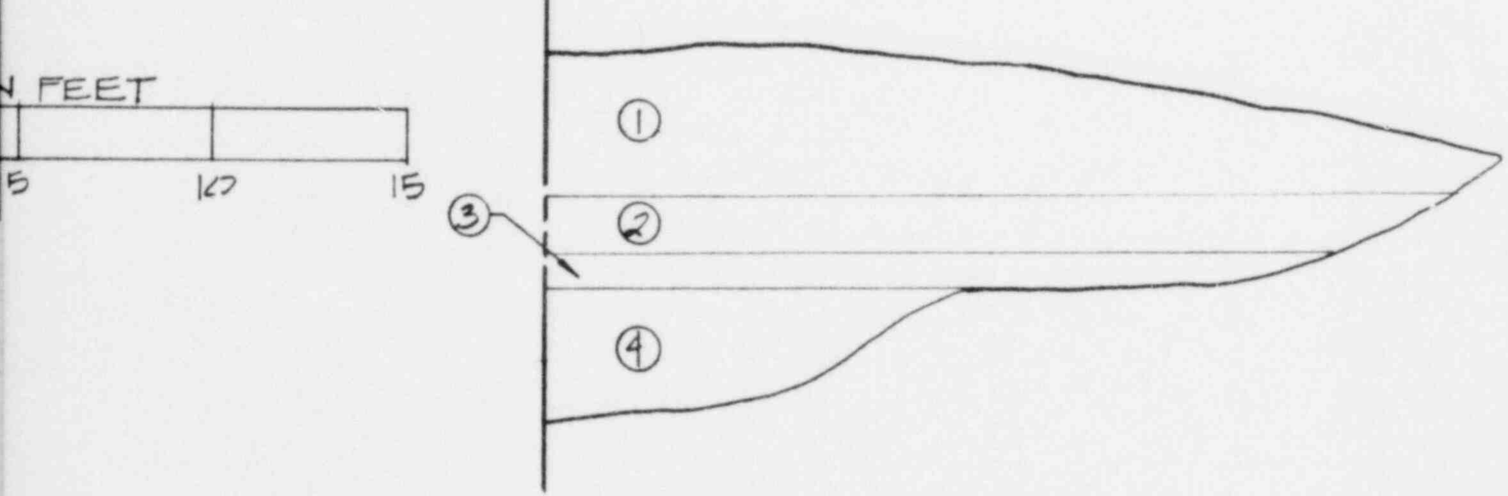
③ SANDSTONE, REDDISH, FINE GRAINED HARD.

④ SHALE, BLACK, MOD. HARD, AIR SLAKES

⑤ SHALE, AS ABOVE BUT WITH MORE FE STAINING.



TAKEN DEPTH 3.0 TO 10.0 FT.

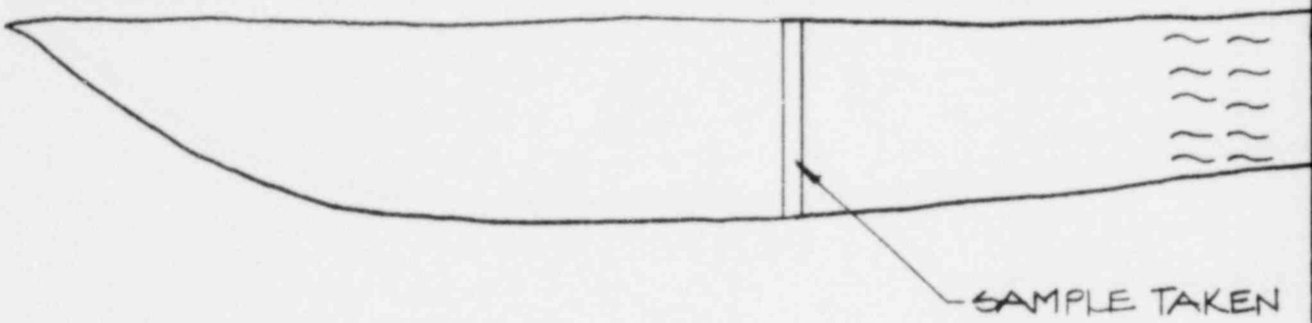


UNION CARBIDE CORP.

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
TEST TRENCH No. 1

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ____ INSPECTED ____
DRAWN RAC RECOMMENDED ____
CHECKED GTA APPROVED ____
DATE MAY 1980
DRAWING NO.



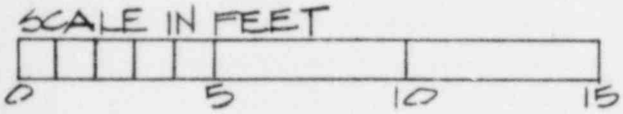
EAST WALL

TRENCH BEARS N 50° E

① SHALE, BLACK, MOD. HARD WEATHERED FE STAINS, AIR SLAKES, PARTINGS HAVE CALCAREOUS COATINGS.

ANOTHER 5 FEET OF SHALE EXPOSED IN NATURAL SLOPE BEHIND (EAST) OF TRENCH OVERLAIN BY HARD TAN SANDSTONE UP TO 8 FEET THICK.

DEPTH 3.0 TO 8.0 FT.

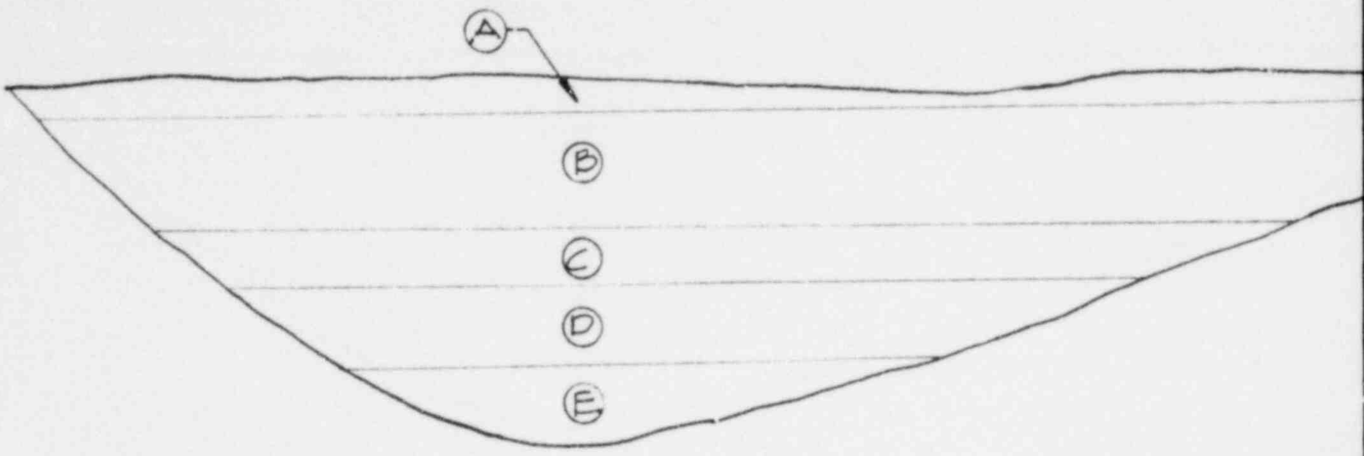


UNION CARBIDE CORP.

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
TEST TRENCH No. 2

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ______ INSPECTED ______
DRAWN RAC RECOMMENDED ______
CHECKED EJA APPROVED ______
DATE MAY 1980
DRAWING NO.

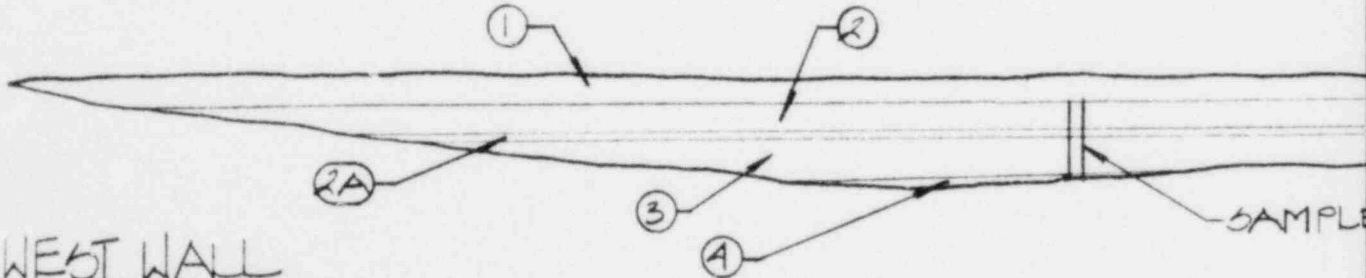


WEST WALL

TRENCH BEARS N 10°E

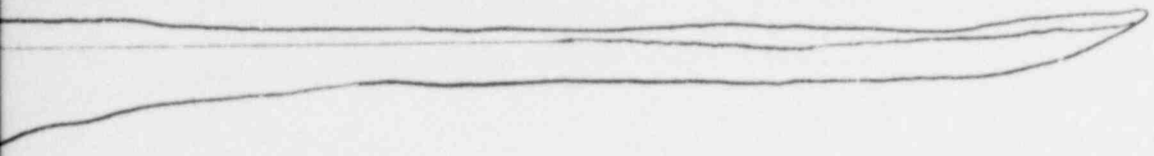
SCALE IN

0 5



WEST WALL

TRENCH BEARS N-5



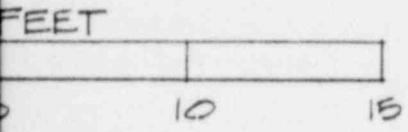
Ⓐ OVERBURDEN, BROWN, SANDY SILT ~6''

Ⓑ SHALE, BLACK, MOD. HARD, AIR SLAKES ~3'

Ⓒ CALCAREOUS, WHITE, POWDER ~18''

Ⓓ SHALE, BROWN-GRAY, PLASTIC ≈2'

Ⓔ SHALE, BLACK, MOD. HARD, AIR SLAKES ≈2' EXPOSED.



① OVERBURDEN, BROWN, SANDY SILT. ~12''

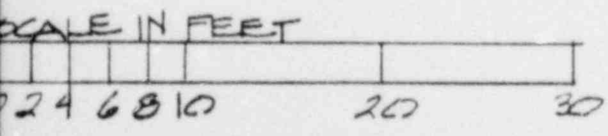
② SHALE, BLACK, MOD. HARD, AIR SLAKES. ≈18''

(2A) CALCAREOUS, WHITE, POWDER ≈3''

③ SHALE, BROWN-GRAY, PLASTIC ≈24''

④ COAL ≈3''

E TAKEN-DEPTH 1.5 TO 5.5 FT.



UNION CARBIDE CORP.

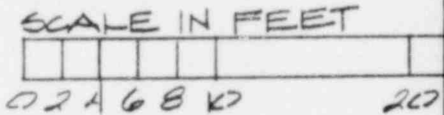
SPRINGS CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
TEST TRENCH No. 3

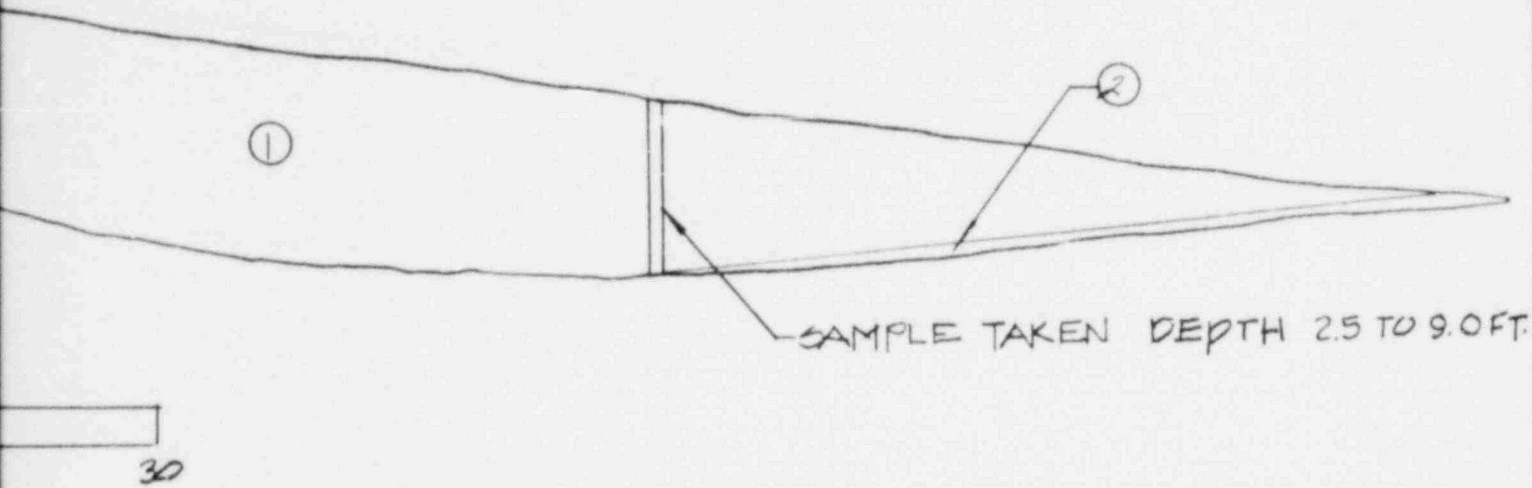
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ______ INSPECTED ______
DRAWN RAC RECOMMENDED ______
CHECKED EJG APPROVED ______
DATE MAY 1980
DRAWING NO.

WEST WALL

TRENCH BEARS N-5°-E





① OVERBURDEN, SANDY SILT UP TO 10' EXPOSED

② SANDSTONE, TAN BEDDING ~N 50°E/5°S ~6"

UNION CARBIDE CORP.

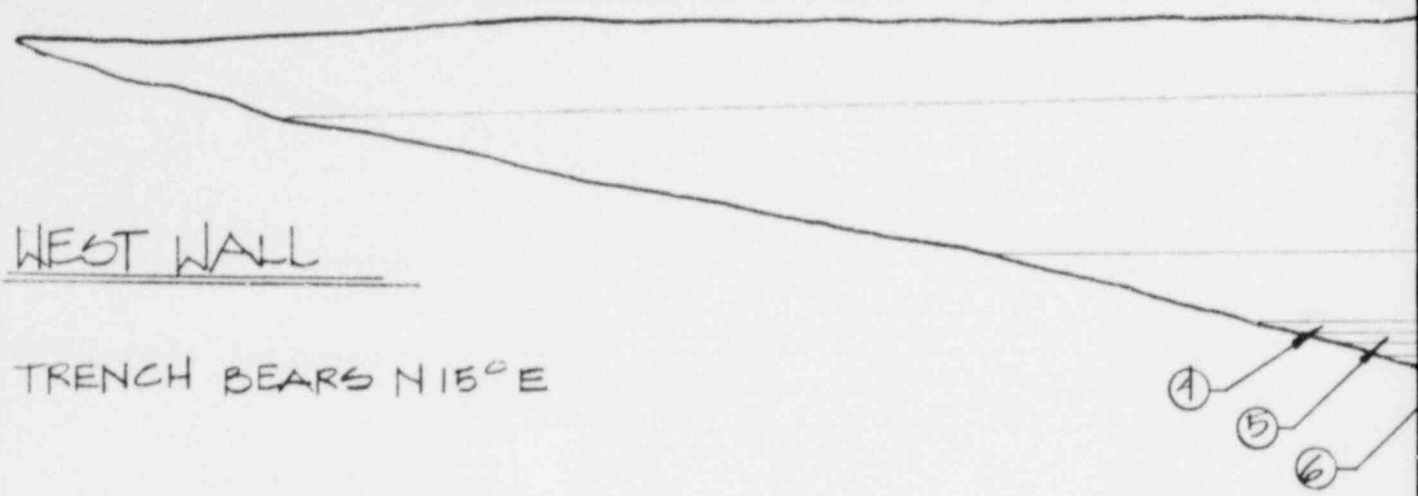
SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
TEST TRENCH NO. 4

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ______ INSPECTED ______
DRAWN RAC RECOMMENDED ______
CHECKED EFG APPROVED ______
DATE MAY 1980
DRAWING NO.

WEST WALL

TRENCH BEARS N 15° E



① OVERBURDEN, SANDY SILT, BROWN ~2'

② SANDSTONE, TAN, WEATHERED, CALCAREOUS, BEDDING 1"-3", BEDDING N 20° E/5° SW MAJOR JOINT SET N 45° W/85° S ~1

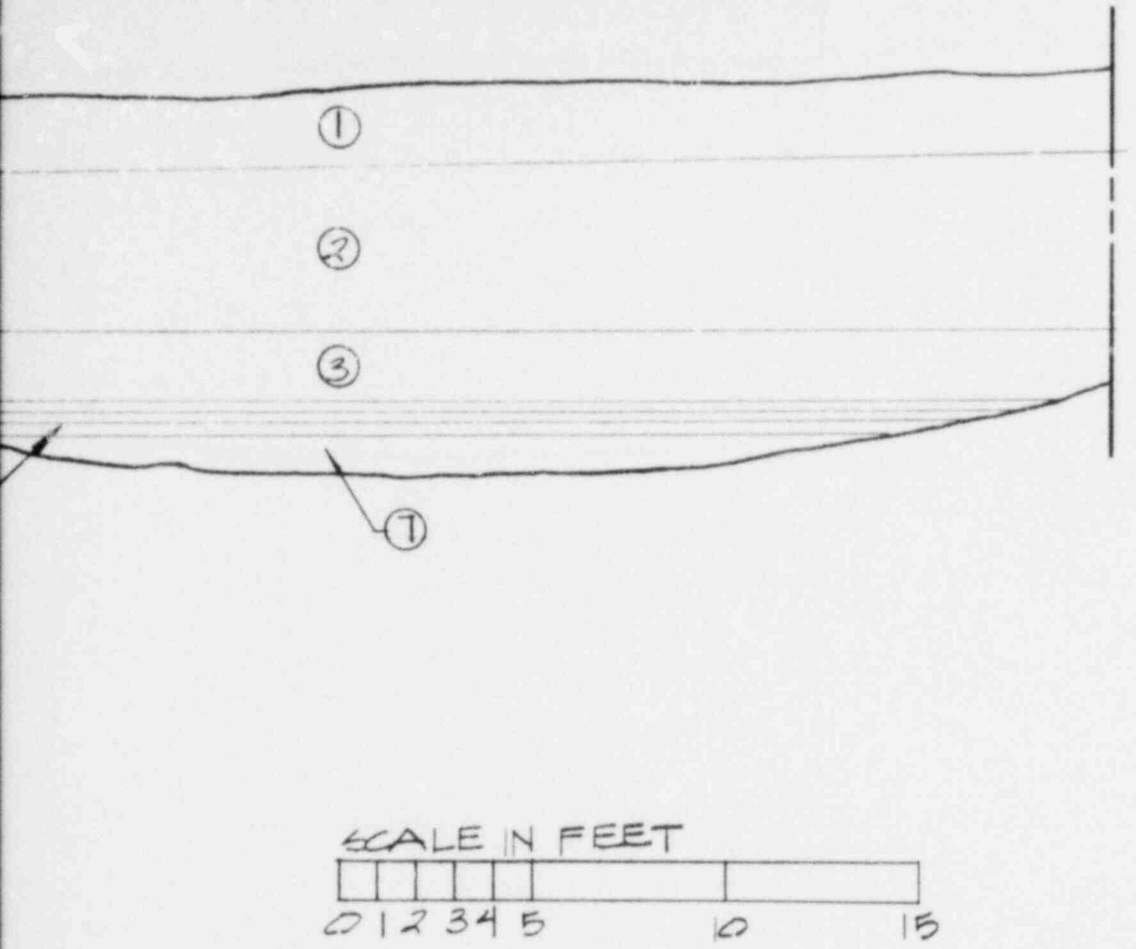
③ SHALE, BLACK, MOD. HARD, WEATHERED, FE STAINS ~2'

④ COAL POWDERED ~0.3'

⑤ SANDSTONE, TAN, FINE GRAINED, WEATHERED, FE STAINS, CALCAREOUS ~0.2'

⑥ COAL POWDERED ~0.1'

⑦ SHALE, BLACK, MOD. HARD, WEATHERED, FE STAINS ~1.2' EXPOSED.



UNION CARBIDE CORP.

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
TEST TRENCH NO. 5

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

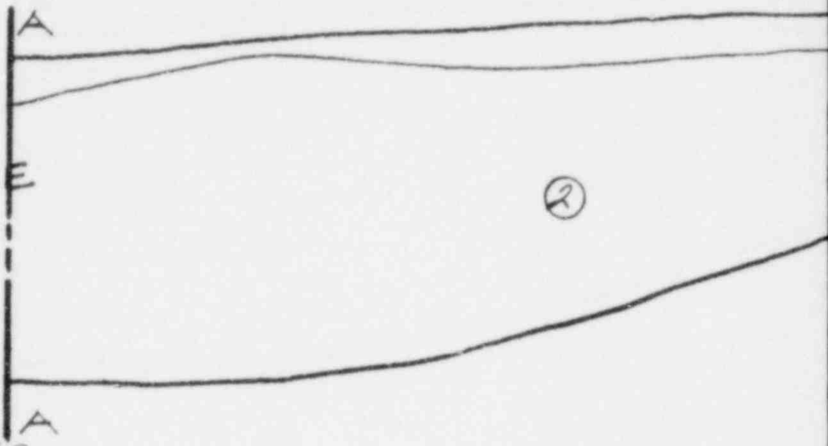
DESIGNED	INSPECTED	DATE MAY 1980
DRAWN RAC	RECOMMENDED	DRAWING NO.
CHECKED CTK	APPROVED	

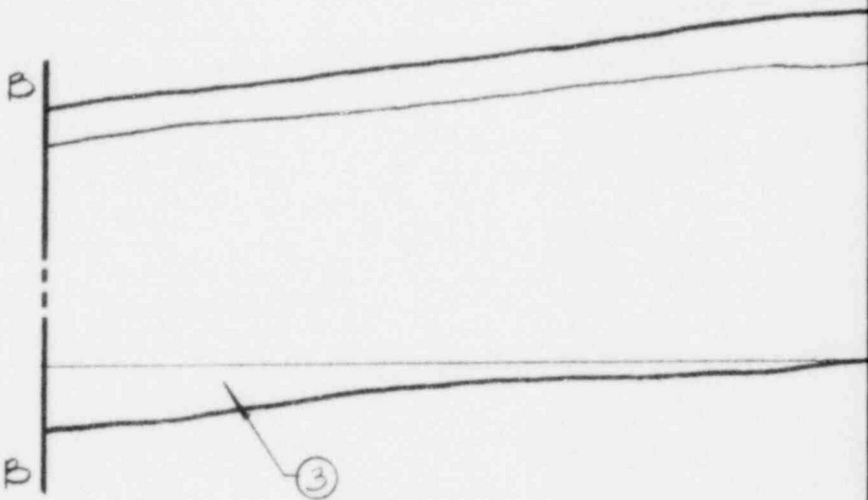
① OVERBURDEN, SANDY SILT, BROWN ~6"-18".

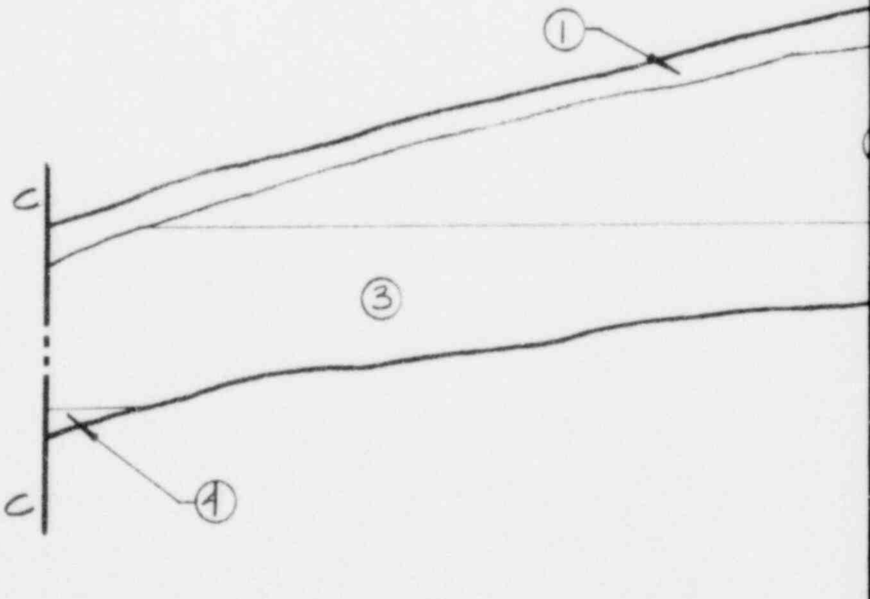
② INTERBEDDED SANDSTONE & SHALE INDIVIDUAL BEDS DO NOT EXCEED 3' IN THICKNESS. SANDSTONE PREDOMINATES.

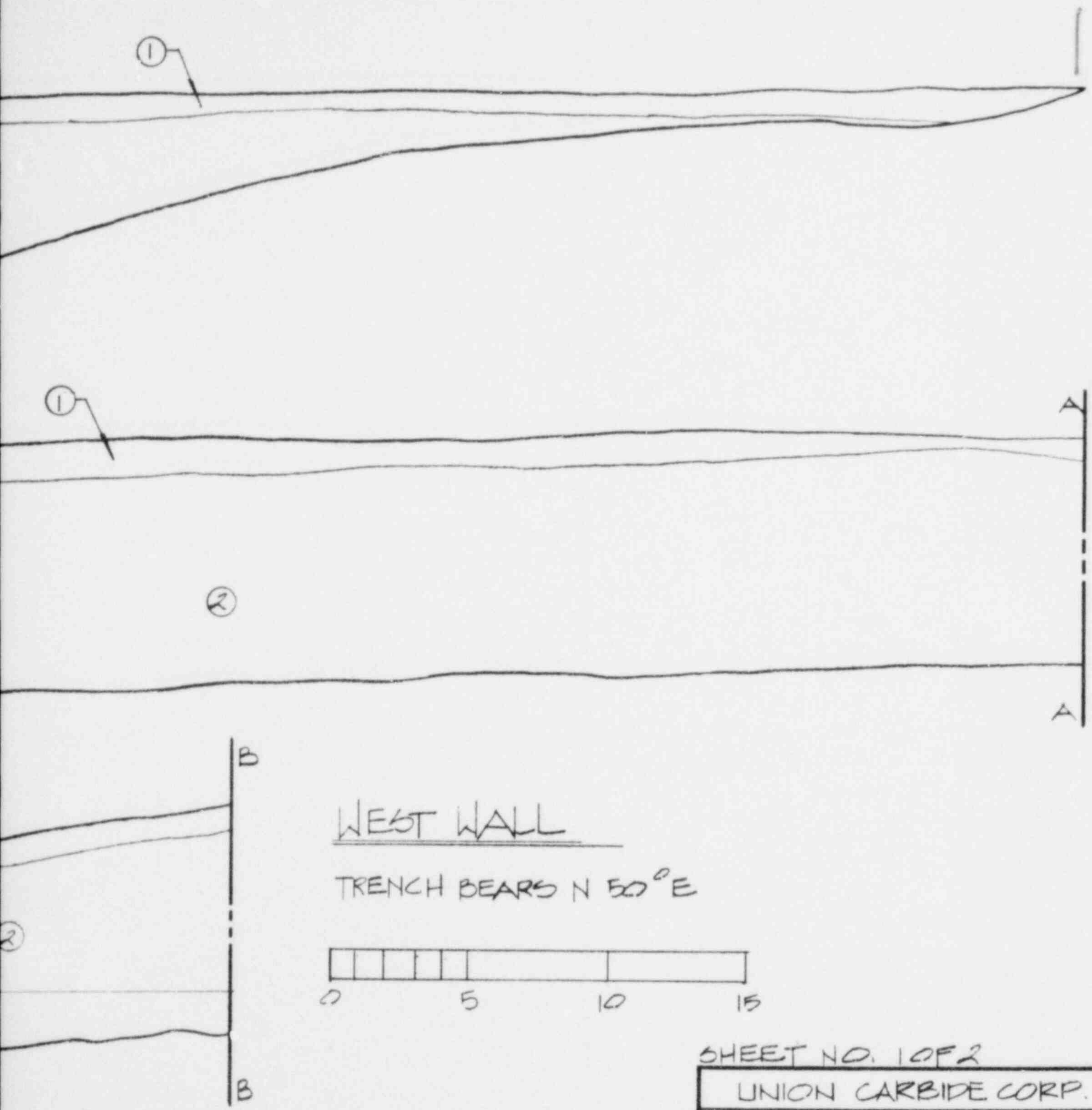
③ SANDSTONE, TAN, FINE GRAINED, WEATHERED, CALCAREOUS COATINGS ON PARTINGS.

④ SHALE, BLACK, MOD. HARD, WEATHERED, WITH THIN INTERBEDS OF TAN SANDSTONE









WEST WALL

TRENCH BEARS N 50°E

SHEET NO. 1 OF 2

UNION CARBIDE CORP.

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
TEST TRENCH NO. 6

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

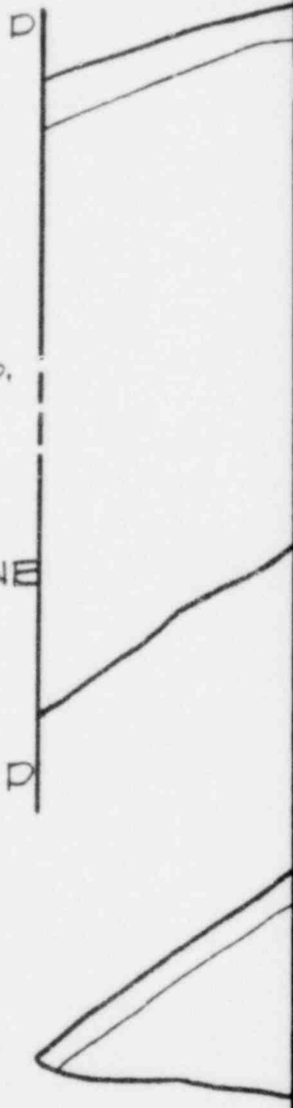
DESIGNED _____ INSPECTED _____
DRAWN RAC RECOMMENDED _____
CHECKED EJA APPROVED _____
DATE MAY 1980
DRAWING NO.

① OVERBURDEN, SANDY SILT, BROWN
~6"-18"

② INTERBEDDED SANDSTONE & SHALE, INDIVIDUAL BEDS DO NOT EXCEED 3' IN THICKNESS, SANDSTONE PREDOMINATES.

③ SANDSTONE, TAN, FINE GRAINED, WEATHERED, CALCAREOUS COATINGS ON PARTINGS.

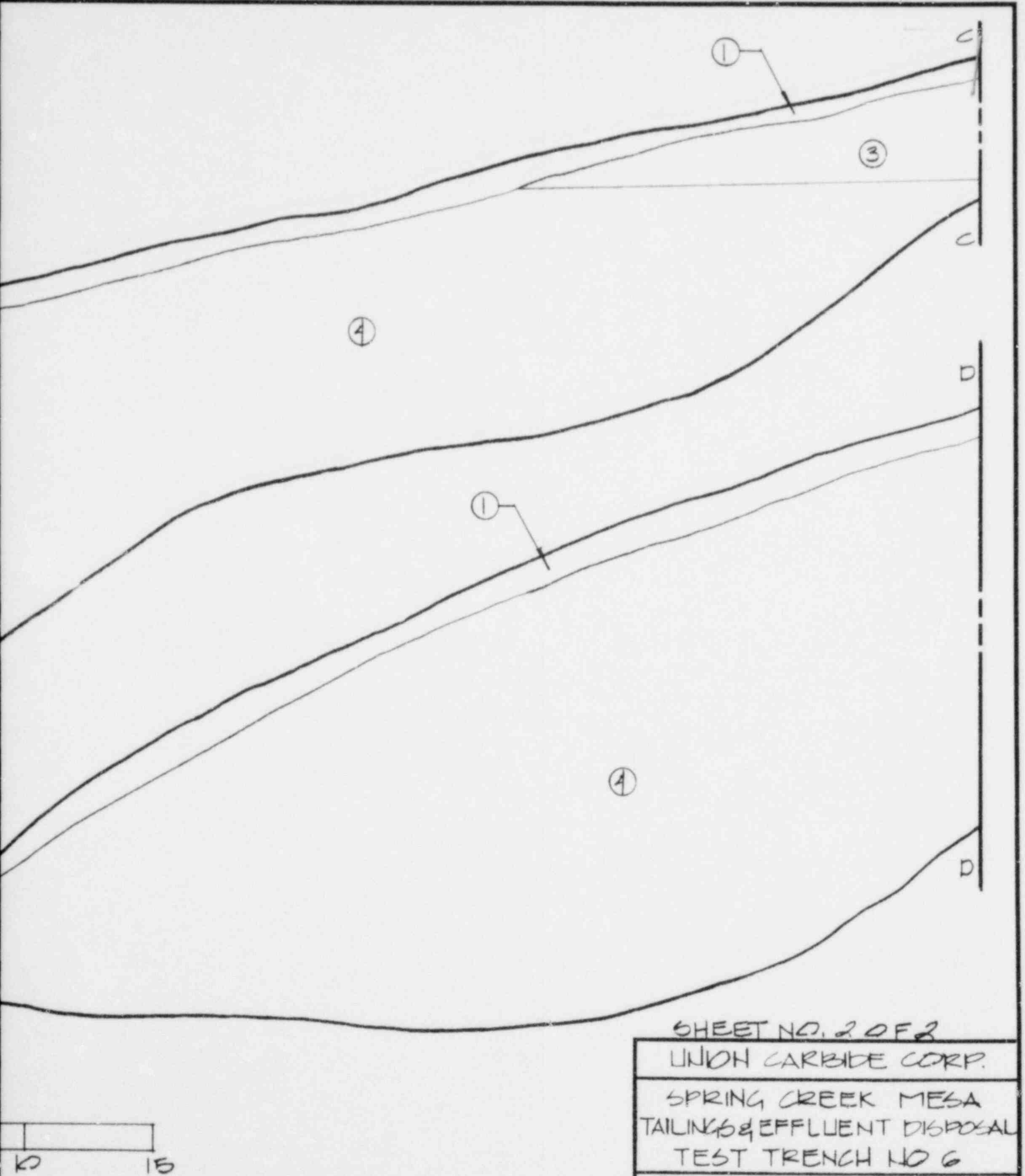
④ SHALE, BLACK, MOD. HARD, WEATHERED, WITH THIN INTERBEDS OF TAN SANDSTONE



WEST WALL

TRENCH BEARS N 50° E

SCALE IN FEET
0 5



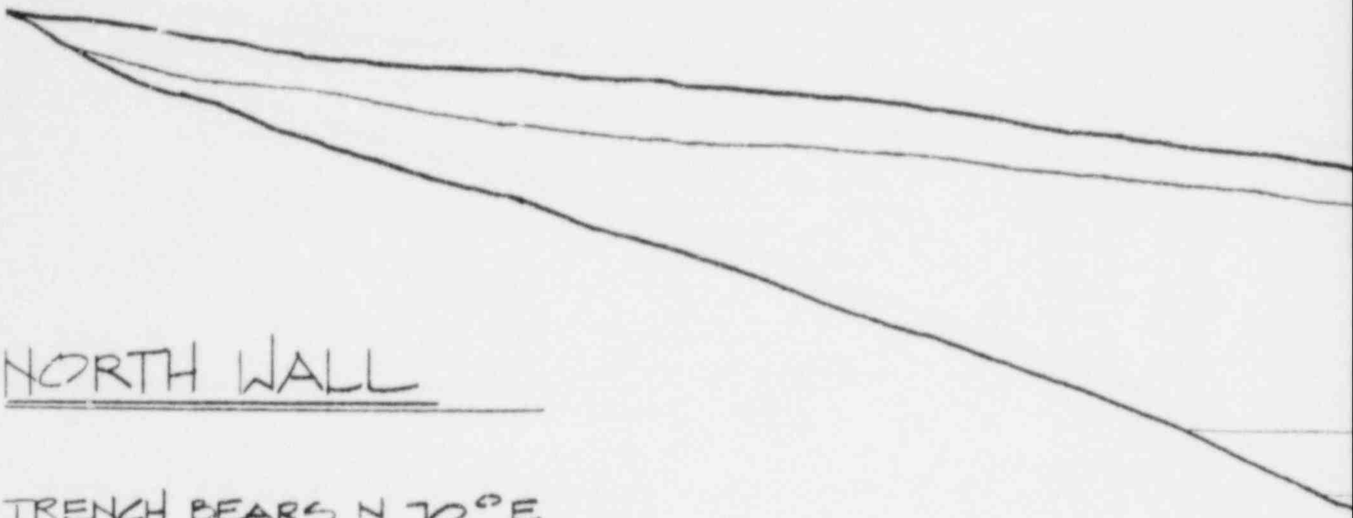
SHEET NO. 2 OF 2

UNION CARBIDE CORP.

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
TEST TRENCH NO 6

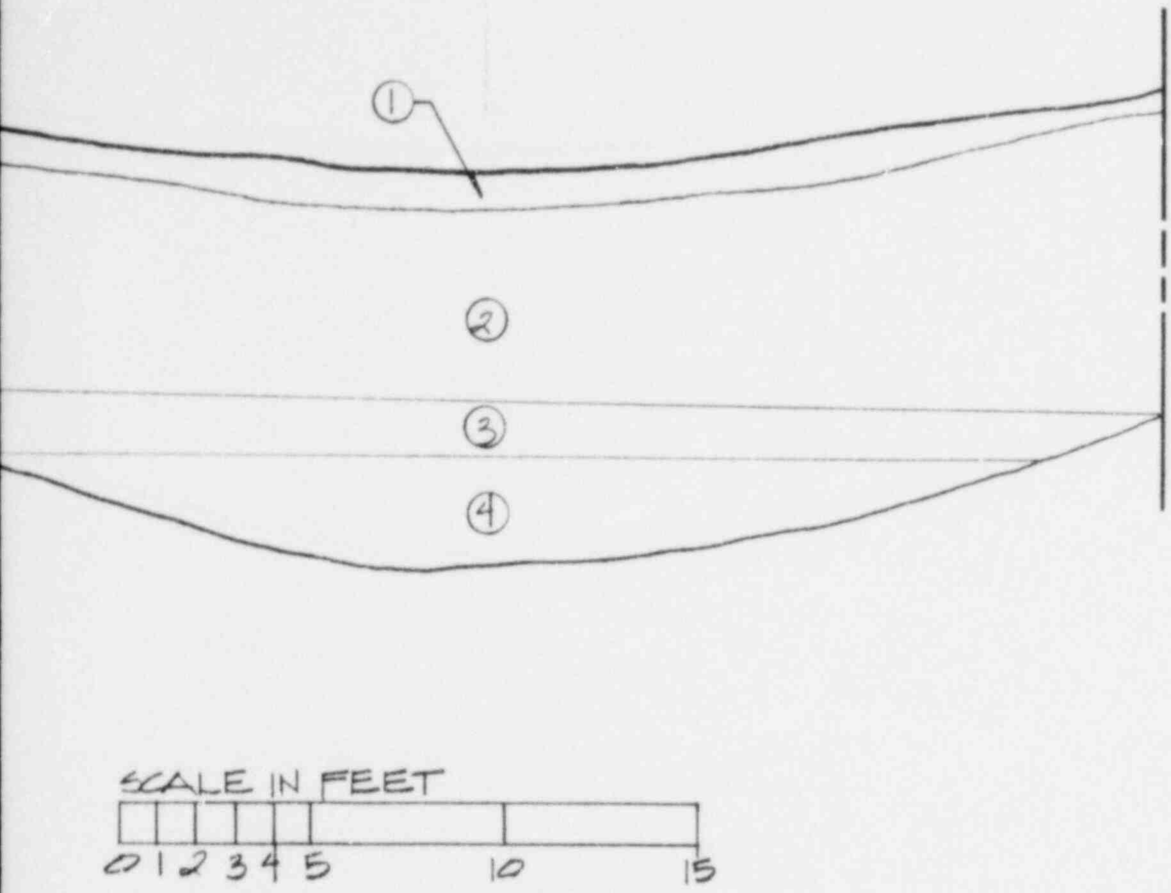
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ______ INSPECTED ______
DRAWN RAC RECOMMENDED ______
CHECKED EJa APPROVED ______
DATE MAY 1980
DRAWING NO.



NORTH WALL

TRENCH BEARS N 70° E



① OVERBURDEN, SANDY SILT ~ 12"-18"

② SHALE, GREEN-GRAY, CALCAREOUS, PLASTIC ~ 5'.

③ INTERBEDDED SANDSTONE & SHALE, TWO 3" BEDS OF SANDSTONE SEPARATED BY 12" OF GREEN PLASTIC SHALE.

④ SHALE, BLACK, MOD. HARD, WEATHERED ~2' EXPOSED.

UNION CARBIDE CORP.

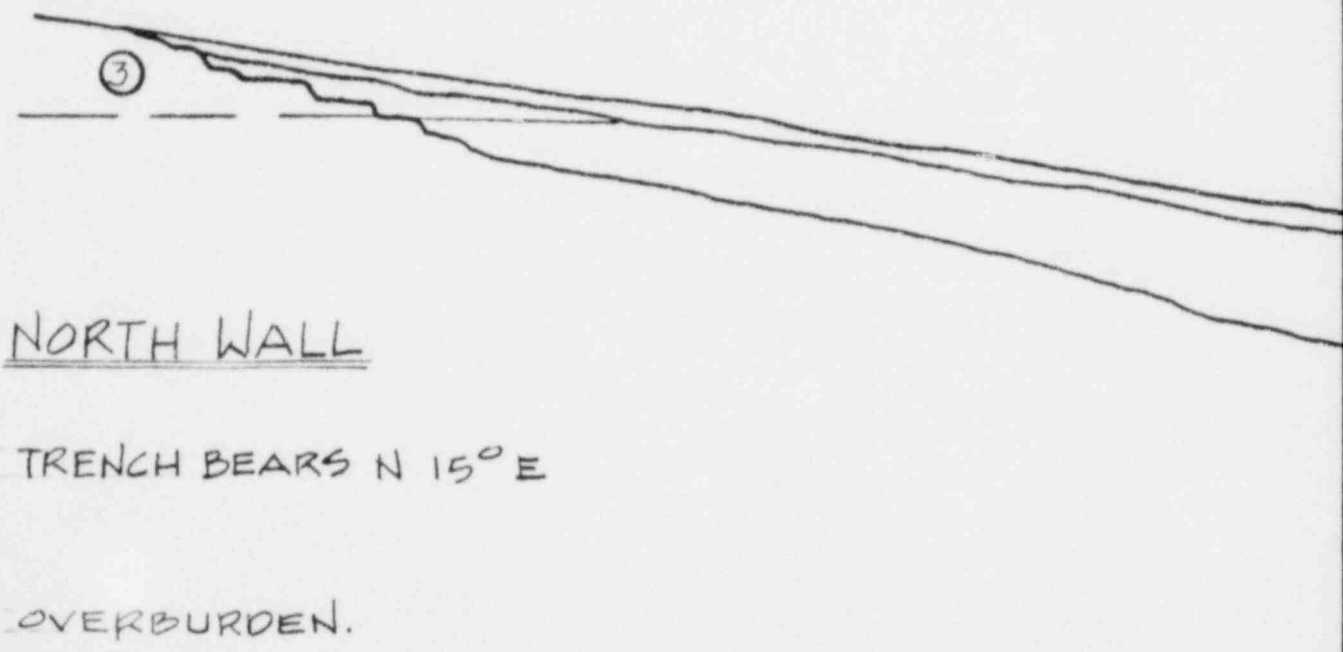
SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
TEST TRENCH NO. 7

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ____ INSPECTED ____
DRAWN RAC RECOMMENDED ____
CHECKED EJa APPROVED ____
DATE MAY 1980
DRAWING NO.

NORTH WALL

TRENCH BEARS N 60° E



NORTH WALL

TRENCH BEARS N 15° E

① OVERBURDEN.

② SHALE, BLACK, MOD. HARD.

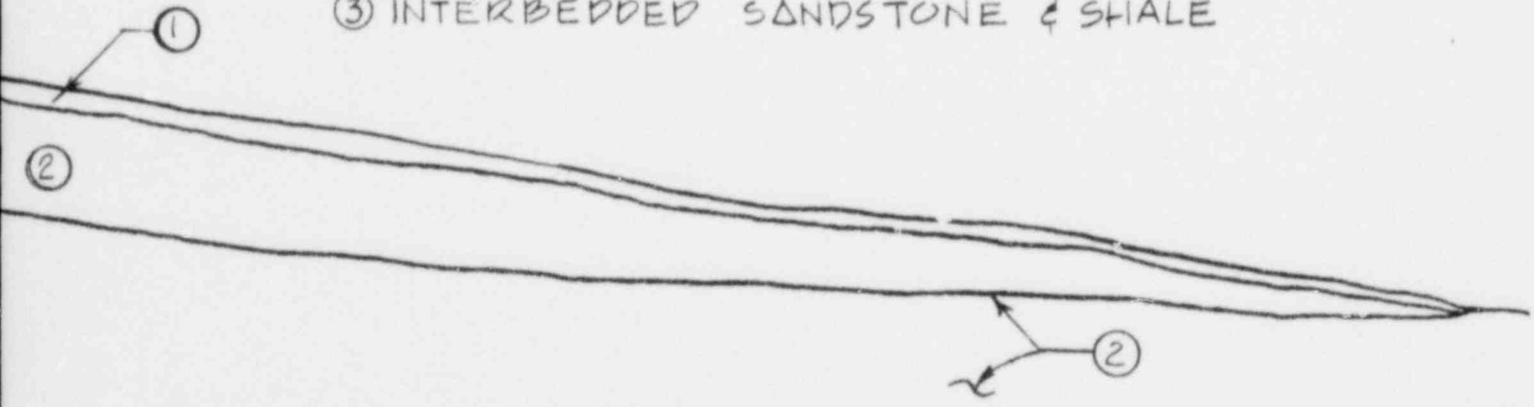
③ INTERBEDDED SANDSTONE & SHALE

TEST TRENCH Nº 8

① OVERBURDEN

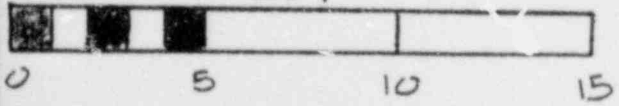
② SHALE, GREEN-GRAY CALCAREOUS

③ INTERBEDDED SANDSTONE & SHALE



TEST TRENCH Nº 9

SCALE IN FEET

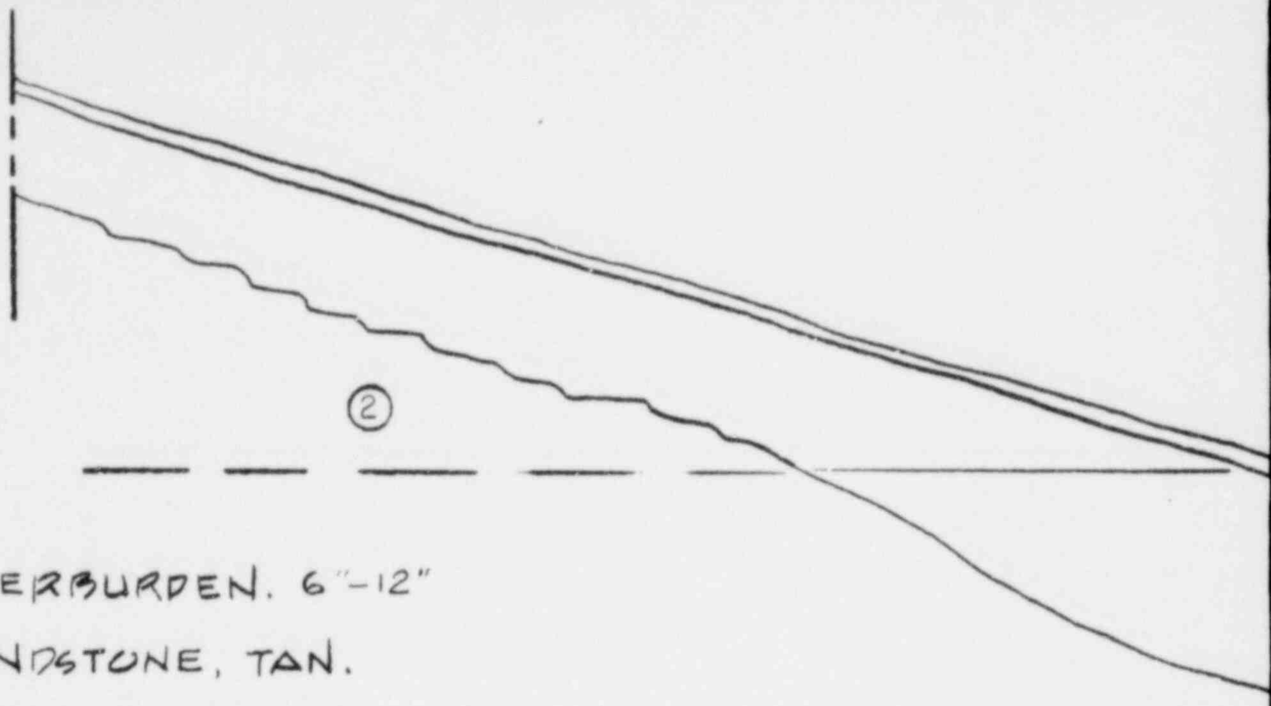


UNION CARBIDE CORP.

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
TEST TRENCH NO. 8 & 9

IECo CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

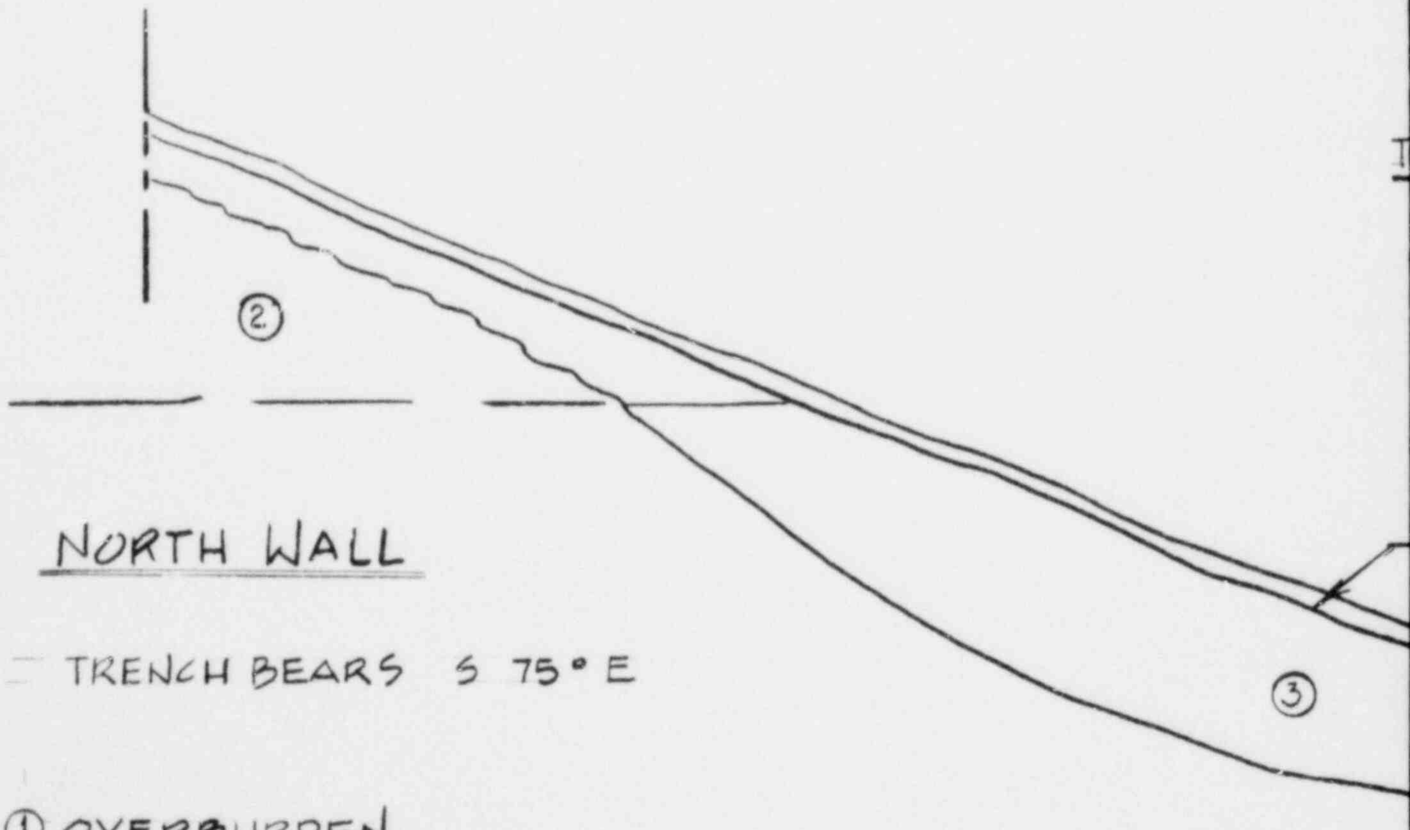
DESIGN ______ INSPECTED ______
DRAWN EFA RECOMMENDED ______
CHECKED EFA APPROVED ______
DATE MAY 1980
DRAWING NO.



① OVERBURDEN. 6"-12"

② SANDSTONE, TAN.

③ SHALE, BLACK, MOD. HARD.



NORTH WALL

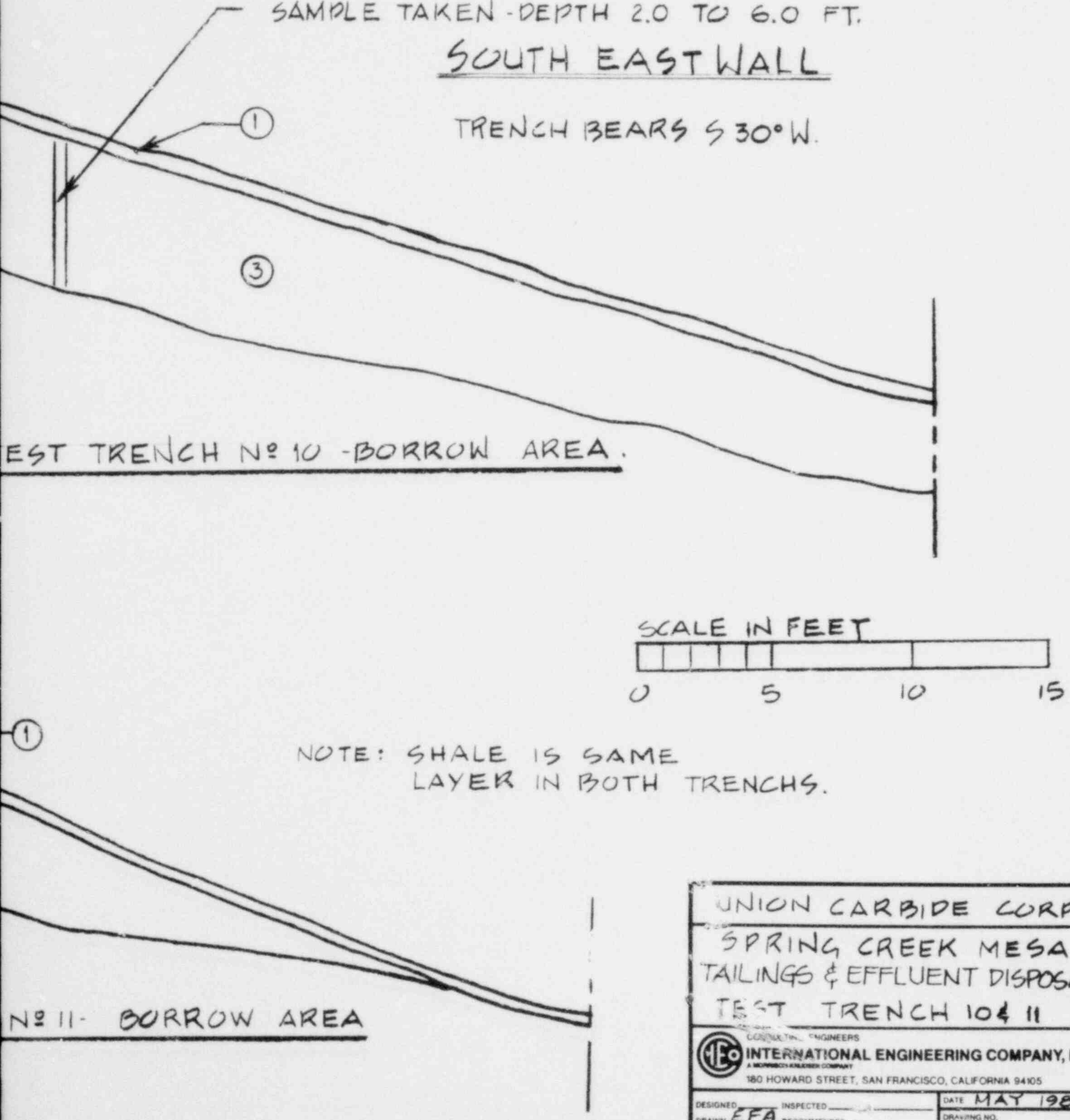
TRENCH BEARS S 75° E

① OVERBURDEN.

② SANDSTONE, TAN

③ SHALE, BLACK, MOD HARD.

TEST TRENCH



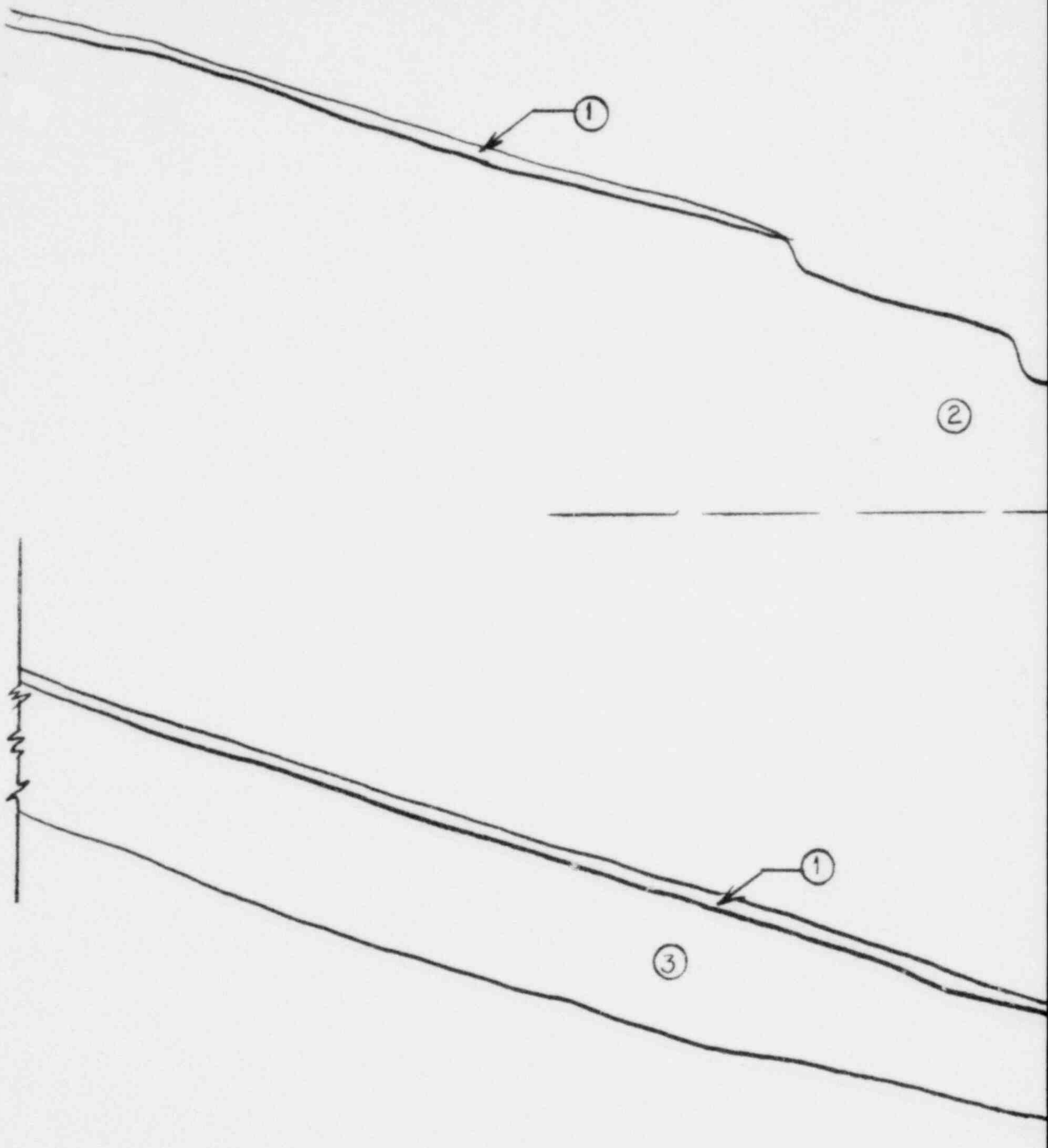
NOTE: SHALE IS SAME
LAYER IN BOTH TRENCHS.

UNION CARBIDE CORP.

SPRING CREEK MESA
TAILINGS & EFFLUENT DISPOSAL
TEST TRENCH 10 & 11

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED	INSPECTED	DATE MAY 1980	
DRAWN EFA	RECOMMENDED	DRAWING NO.	
CHECKED EJG	APPROVED		



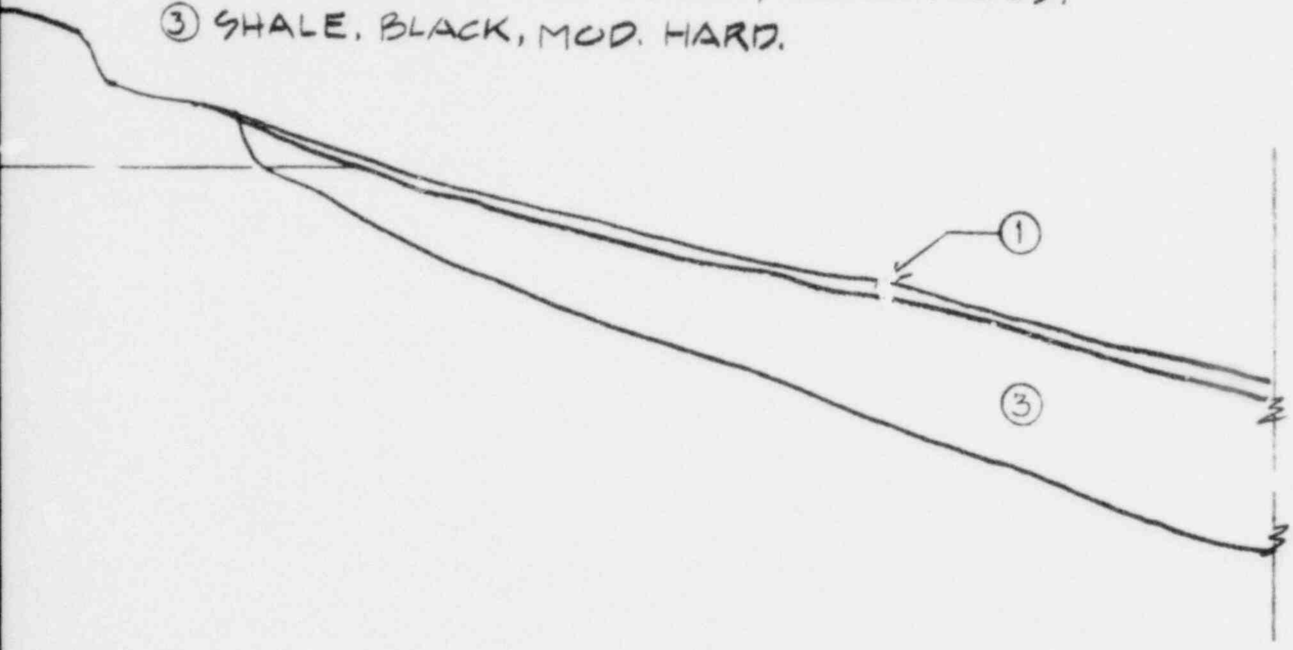
NORTH WEST WALL

TRENCH BEARS N 5° E

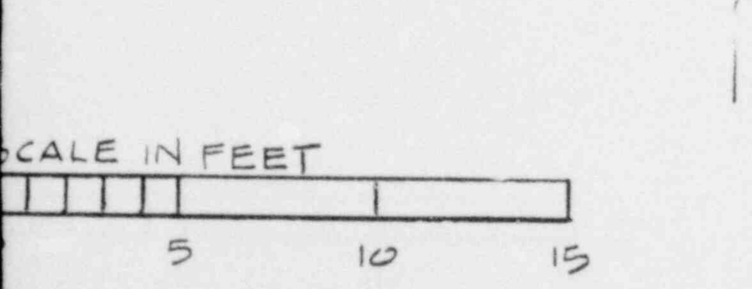
① OVERBURDEN

② SANDSTONE. TAN FINE GRAINED WEATHERED FE. STAINS, CALCAREOUS.

③ SHALE. BLACK, MOD. HARD.



NOTE: SHALE MATERIAL IS SAME AS SAMPLE TAKEN FROM TEST TRENCH. Nº 10.
SHALE THICKNESS EXCEEDS 20 FEET AND IS GOOD IMPERVIOUS BORROW SOURCE.



UNION CARBIDE CORP.

SPRING CREEK MESA
TAILING & EFFLUENT DISPOSAL
TEST TRENCH Nº 12

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
A MORRISON-KNUDSEN COMPANY
180 HOWARD STREET, SAN FRANCISCO, CALIFORNIA 94105

DESIGNED ______ INSPECTED ______
DRAWN EFA RECOMMENDED ______
CHECKED MJG APPROVED ______
DATE MAY 1980
DRAWING NO.

SUMMARY OF S

Job No 2014 Project Name UNION CARBIDE CORP - TAILI
SPRING CREEK MESA,

Hole or Trench Number	Sample Number	Depth		Laboratory Classification	Mechanical Analysis			Atterberg Limits		Specific Gravity G	Natural		Con
		From	To		Gravel	Sand	Fines	LL	PI		w %	γd	Test
TD-1	S-1	16.3'	19.6'	Claystone	0	23	77	25	15		6.2	-	-
TD-1	S-2	40.9'	41.7'	Sandstone	-	-	-	-	-	2.63	-	-	-
TD-4	-	8.8'	9.5'	Claystone	-	1	99	51	34	2.67	12	-	-
TD-4	-	18.2'	18.9'	Claystone	-	6	94	46	32	-		-	-
TD-5	-	13.5'	14.6'	Claystone	-	1	99	51	34	-	10	-	-
TD-7	Black Shale	-	-	Claystone	-	2	98	36	17	2.63	12	128.0	-
TD-9	Gray Shale	-	-	Claystone	-	2	98	39	17	2.63	12	128.0	-
TD-10	-	16.0'	17.0'	Claystone	-	3	97	43	25	2.66	12	-	-
TD-10A	-	8.5'	9.8'	Claystone	-	1	99	29	15	-	9	-	-
TD-10A	Gray Shale	16.7'	18.1'	Claystone	-	2	98	36	17	2.63	12	128.0	-
TD-10A	Black Shale	23.6'	24.5'	Claystone	-	1	99	39	15	2.59	12	122	-
TT-2	S-1	3.0'	8.0'	Claystone	-	11	89	31	13	2.62	13	106.5	SP
TT-2	S-2	3.0'	8.0'	Claystone	-	10	90	29	14	-	13	-	SP
TT-4	S-1	-	-	Silty Sandy Clay	-	30	70	24	9	-	-	-	SP
Borrow Area	S-1	2.0'	6.0'	Claystone	-	3	97	51	23	2.71	13	102.3	SP
Borrow Area	S-1	2.0'	6.0'	Claystone	-	3	97	51	23	2.71	13	102.3	MP
Borrow Area	S-2	2.0'	6.0'	Claystone	-	3	97	40	22	2.64	11	111.0	SP
Coke Oven Ranch Borrow		-	-	Claystone	-	8	92	39	22	-	23	-	SP

* Visual Classification

SP = Standard Proctor
MP = Modified Proctor
S = Special - See Text

TC = Triaxial Compression
UC = Unconfined Compression
DS = Direct Shear

UU = Unconsolidated Undrained
CU = Consolidated Undrained
CD = Consolidated Drained

SOIL TEST RESULTS

NGS & EFFLUENT DISPOSAL
URAVAN, COLORADO

Feature TABLE B-1

Date 4-28-80

paction		Shear Strength					Permeability		Consolidation			Notes
Optimum		Test	Initial		C (psf)	φ	γ_d	k cm/sec	C.	C.	P.	
w	γ_d		w	γ_d								
	-	-	-	-	-	-	-	-	-	-	-	PH = 7·9 2
	-	UC	-	-	q_u=	5650	-	-	-	-	-	- 2
	-	-	-	-	-	-	-	-	-	-	-	PH = 7·5 2
	-	-	-	-	-	-	-	-	-	-	-	PH = 7·5 2
	-	DS	10	130	400	ØR= 27°	-	-	-	-	-	pH = 7·9 2
	-	-	-	-	1000 2000	54° 36°	120.2	$6x10^{-6}$	-	-	-	- 3/ 1
	-	-	-	-	1000 2000	54° 36°	111.2	$2x10^{-6}$	-	-	-	- 3/ 1
	-	-	-	-	-	-	-	-	-	-	-	PH = 7·5 2
	-	DS	9	135	0	ØR= 35°	-	-	-	-	-	PH = 8·0 2
	-	-	11	-	1000 2000	54° 36°	-	-	-	-	-	- 1
	-	CU	12	126	1000 2000	55° 35°	-	-	-	-	-	- 1
2	110	CU	18	106.5	0 0	35° 20°	106.5	$3x10^{-6}$	-	-	-	PH = 6·0 4/ 2
5	114	-	-	-	-	-	-	$< 10^{-7}$	-	-	-	Soluble Sulphates = 310 PPM, PH = 8·6 4/ 2
3	117.5	-	-	-	-	-	-	-	-	-	-	- 2
5	105.5	CU	21	102.3	0 0	25° 17°	102.3	$1.5x10^{-6}$	-	-	-	- 4/ 1
4	117.8	CU	21	102.3	0 0	25° 17°	114.6	$4.7x10^{-7}$	-	-	-	- 4/ 1
.5	110.5	-	-	-	-	-	-	$< 10^{-7}$	-	0.01	600	Soluble Sulphates = 875 PPM PH = 8·7; Swell 2-1/2% 2
0	104	-	-	-	-	-	-	-	-	-	-	- 2

1 Test Conducted by R.C. Harlan and Associates
2 Test Conducted by CTL/Thompson Inc.
3/ Shale Core Sample
4/ Remolded Sample of Impervious Borrow

TABLE B-1

CTL/THOMPSON, INC.
CONSULTING GEOTECHNICAL AND MATERIALS ENGINEERS

April 25, 1980

International Engineering Company, Inc.
180 Howard Street
San Francisco, California 94105

Attention: Mr. Ethan Axtmann
Geotechnical Division

Subject: Laboratory Testing
Union Carbide Project
Uravan, Colorado
Project No. 6196

Gentlemen:

As requested, we are enclosing the results of laboratory testing for the subject project.

If you have any questions, please contact us.

Very truly yours,

CTL/THOMPSON, INC.

By William H. Koechlein
William H. Koechlein, P. E.

WILLIAM H. KOECHLEIN
15962

WHK:dm

Enc.

1701 SOUTH FEDERAL BLVD. • SUITE D • DENVER, COLORADO 80219 • (303) 934-5473

LABORATORY TESTS

The laboratory tests requested by International Engineering Company, Inc. San Francisco, California were performed by CTL/Thompson, Inc, Denver, Colorado. The following paragraphs reference the standard methods of laboratory testing used and describe the laboratory test procedures. The results of these tests are presented on the attached figures and the Table, Summary of Laboratory Test Results.

Applicable Standards:

The following standard methods of laboratory testing of soils and rock were used for performing the requested tests. The latest revisions and supplements of the American Society for Testing and Materials Standards (ASTM) and the Earth Manual, Second Edition by the U. S. Department of Interior, Bureau of Reclamation were used.

1. ASTM D 421-58 Dry Preparation of Soil Samples for Particle-Size Analysis and determination of soil constants.
2. ASTM D 422-63 Particle-size analysis of soils
3. ASTM D 423-66 Liquid limit of soils
4. ASTM D 424-59 Plastic limit and plasticity index of soils
5. ASTM D 698-78 Moisture-density relations of soils and soil-aggregate mixtures using 5.5-lb. (2.49-kg) Rammer and 12-inch (305 mm) drop
6. ASTM D 854-58 Specific Gravity of soils
7. ASTM D 2216-71 Laboratory determination of moisture content of soil
8. ASTM D 2217-66 Wet preparation of soil samples for particle-size analysis and determinations of soil constants
9. ASTM D 2435-70 One-dimensional consolidation properties of soils
10. ASTM D 2938-71a Unconfined compressive strength of rock core specimens
11. ASTM D 3080-72 Direct shear test of soils under consolidated drained conditions.
12. EM E-13, Permeability and settlement of soils

Laboratory Testing Procedures:

The following paragraphs describe the general testing procedures for each test performed.

Atterberg limits

1. The samples were prepared in accordance with ASTM D 2217 Procedure B.
2. Liquid limit test was a one-point test performed in accordance with ASTM D 423.
3. Plastic limit test was performed one (1) time on each specimen in accordance with ASTM D 423.

Particle-size Analysis

1. Particle-size analysis was performed in accordance with ASTM D422.
2. Sieve analysis: Series of sieves consisted of the following U.S. standard sieves: 1 1/2-inch, 3/4-inch, 3/8-inch, No. 4 (4.76mm), No. 8 (2.36mm), No. 16(1.18mm), No. 30 (600 micron), No. 50 (300 micron), No. 100 (150 micron), No. 200 (75 micron).
   Sieves conformed to ASTM E 11
3. Hydrometer Analysis: Conformed to ASTM E 100.

Natural Water Content and Dry Unit Weight

1. Natural water content tests were performed in accordance with ASTM D 2216.
2. Dry unit weight was determined by the Volumetric Method and individual test requirements.

Specific Gravity

1. Method of test conformed to ASTM D 854, with the use of a (100 ml Volumetric flask) pycnometer.

pH:

1. Test was performed with a Sergeant Welch Model No. RB electronic pH meter.

Sulfates:

1. Tests were performed in accordance with accepted chemical soil analysis procedures.

Compaction Test:

1. All tests were standard Proctor and were performed in accordance with ASTM D 698.
2. Method B was used for samples to be tested for consolidation and swelling characteristics. Method A was used for all other samples.

Unconfined Compression (Rock):

1. Preparation of test specimen and method of test was performed in accordance with ASTM D 2938.
2. A constant strain test was performed using a strain rate of 0.05 inch per minute.

Direct Shear:

1. Method of testing was performed in accordance with ASTM D 3080.
2. A constant strain test was performed using a strain rate of 0.05 inch per minute.
3. Normal stresses applied to specimens tests were 7.5 psi, 15 psi and 30 psi.
4. The normal stress was applied, water poured into the chamber and then the lateral stress was applied until the sample sheared.

5. The residual shear strength was obtained after shearing the sample. The normal stress was released, the sample was subjected to 10 cycles of manual shearing along the established shear plane, the same normal stress was applied again and then the lateral shear stress was applied.

Consolidation:

1. Test was performed on remolded sample at 98 percent of standard Proctor maximum dry density and near optimum moisture content.

2. The remolded moisture content was maintained for the duration of the test.

3. Deformation time readings were taken at consolidation loads of 0.8 ksf, 1.5 ksf, 3 ksf, 6 ksf, and 12 ksf, and then at rebound loads of 3 ksf and 0.8 ksf.

Swell Tests:

1. A sample measuring 1.95 inches in diameter and 1.0 inches in height was trimmed into a metal ring.

2. The sample and ring were placed in the dish on the swell machine frame.

3. A "0" reading was taken, then the initial pressure of 500 psf was applied to the sample and allowed to consolidate for approximately 8 hours, at which time a reading was taken and the sample dish was flooded with water.

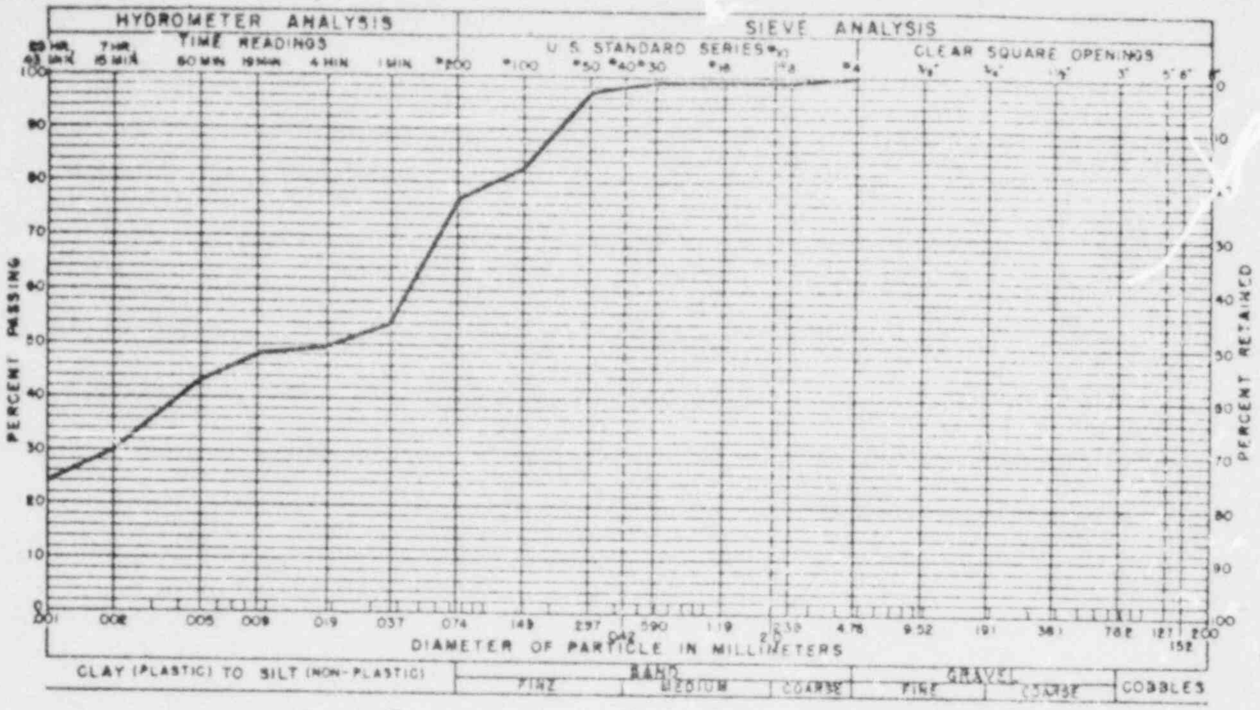
4. The sample was allowed to swell under constant pressure of 500 psf for 72 hours, and the reading of dial movement was recorded.

5. The sample was then loaded to 1, 3 and 5 ksf and allowed to consolidate under each pressure recording the dial movement for each pressure.

Permeability:

1. Samples were tested in accordance with Designation E-13, Paragraph 8 of Bureau of Reclamation Earth Manual, Second Edition.

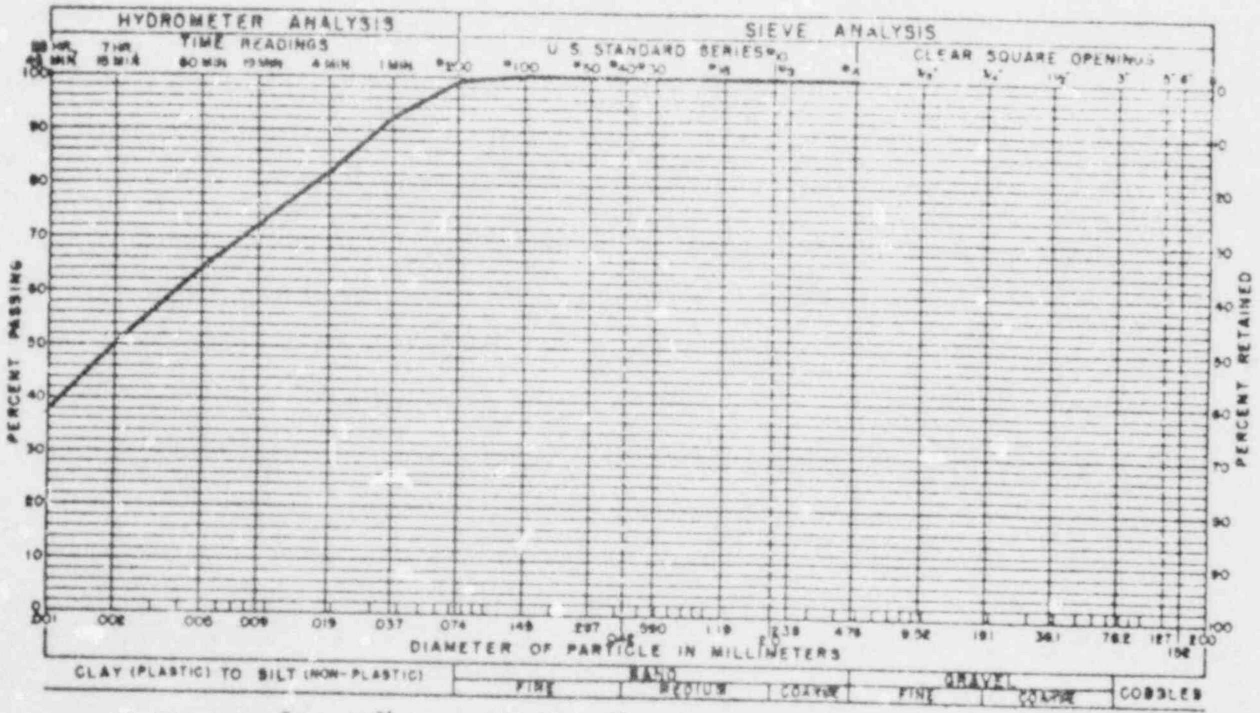
2. Tests were performed on samples remolded above 97 percent of the standard Proctor maximum dry density and near the optimum moisture content.
3. Specimen was remolded into a mold with a height of 4 inches and a diameter of 4 inches.
4. Sample was saturated using a falling head method.
5. Test was terminated at the end of 16 days due to no change in water head or no flow of water being observed during this period of time.



GRAVEL 0 % SAND 23 % SILT AND CLAY 77 %

LIQUID LIMIT 25 % PLASTICITY INDEX 15 %

SAMPLE OF TD-1 FROM 16.3 TO 16.9 FEET



GRAVEL 0 % SAND 1 % SILT AND CLAY 99 %

LIQUID LIMIT 50 % PLASTICITY INDEX 34 %

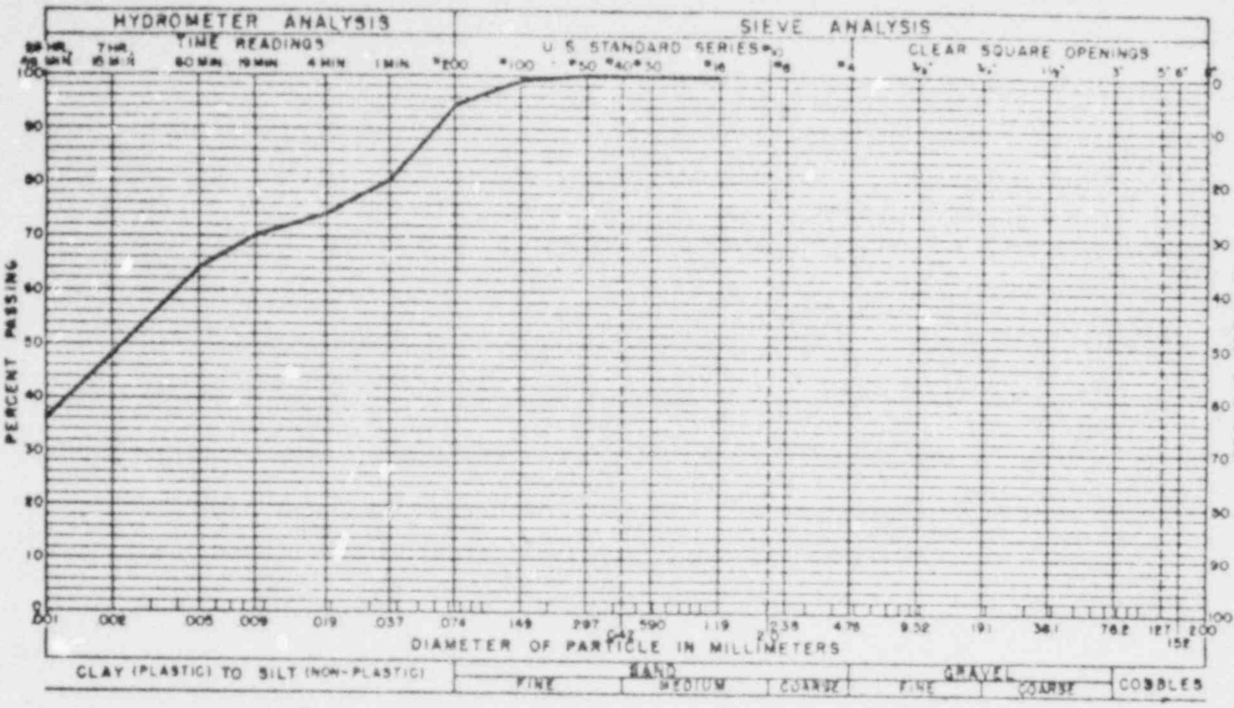
SAMPLE OF TD-4 FROM 8.8 TO 9.5 FEET

GRADATION TEST RESULTS

Form 12

JOB NO . 6196

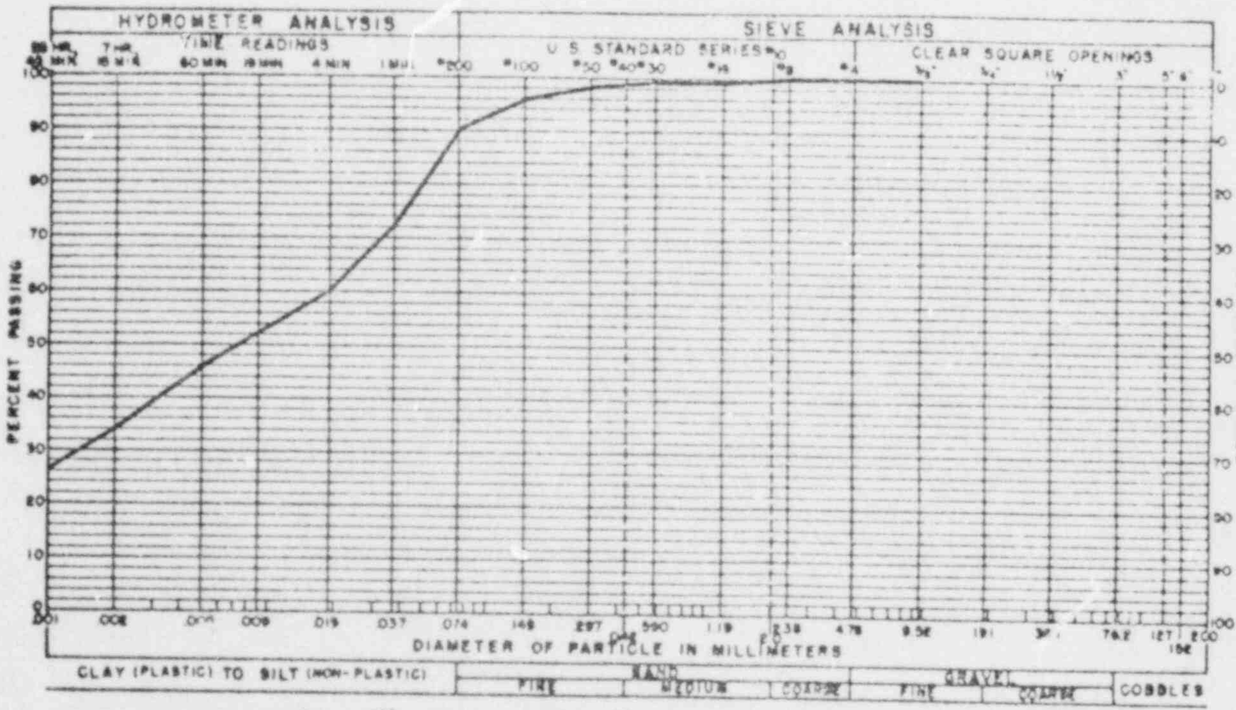
FIG. 1



GRAVEL 0 % SAND 6 % SILT AND CLAY 94 %

LIQUID LIMIT 46 % PLASTICITY INDEX 32 %

SAMPLE OF TD-4 FROM 18.2 TO 18.9 FEET



GRAVEL 0 % SAND 10 % SILT AND CLAY 90 %

LIQUID LIMIT 29 % PLASTICITY INDEX 14 %

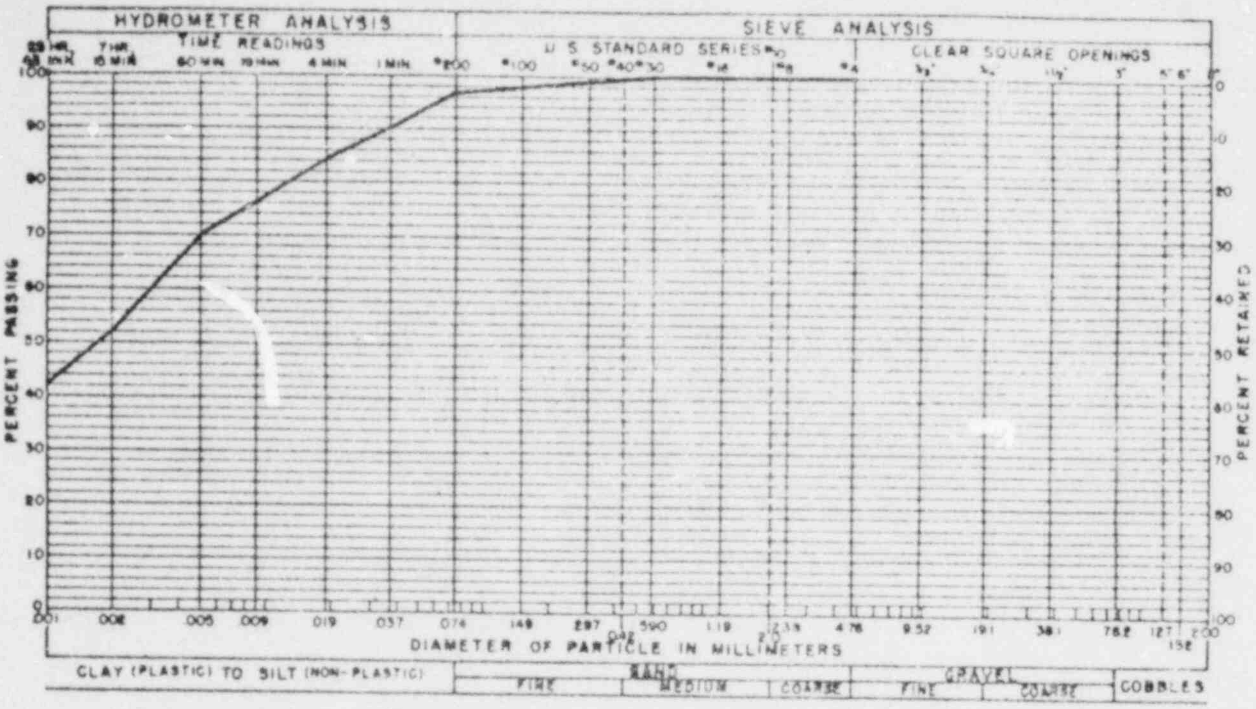
SAMPLE OF TT-2, S-2 FROM 3 TO 8 FEET

Form 12

GRADATION TEST RESULTS

JOB NO. 6196

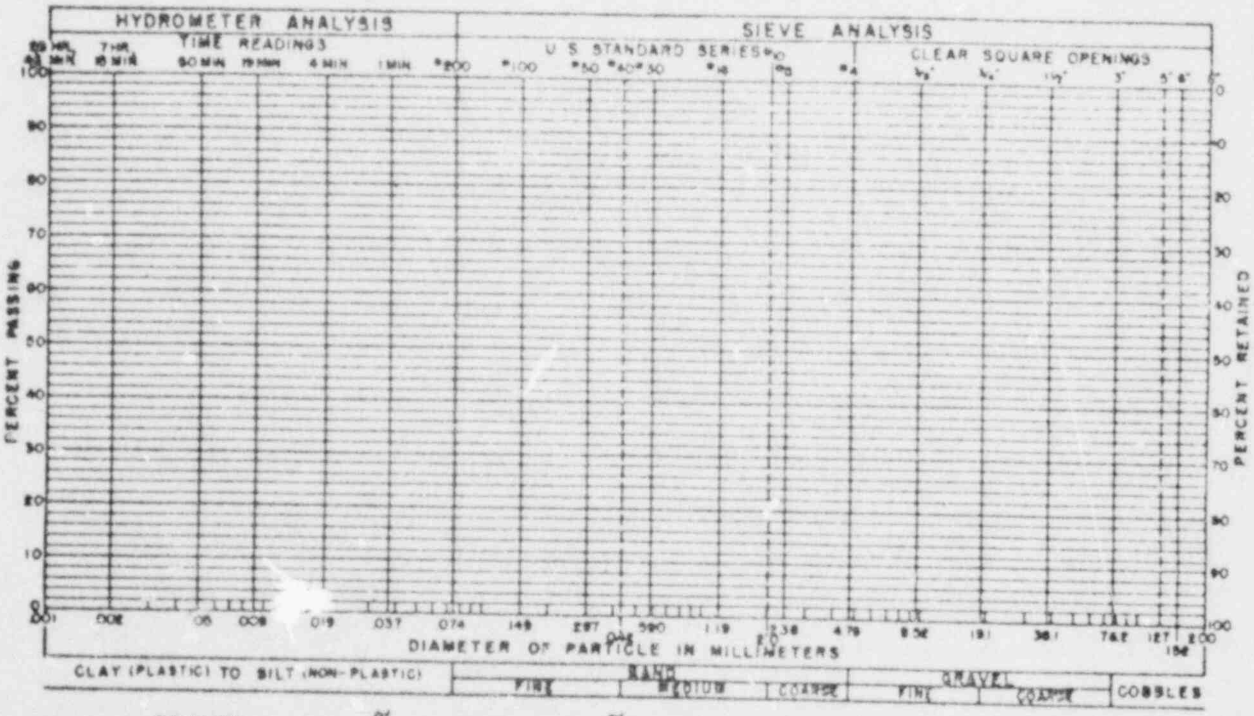
FIG. 2



GRAVEL 0 % SAND 3 % SILT AND CLAY 97 %

LIQUID LIMIT 40 % PLASTICITY INDEX 22 %

SAMPLE OF BORROW AREA S-2 FROM 2 TO 6 FEET



GRAVEL % SAND % SILT AND CLAY %

LIQUID LIMIT % PLASTICITY INDEX %

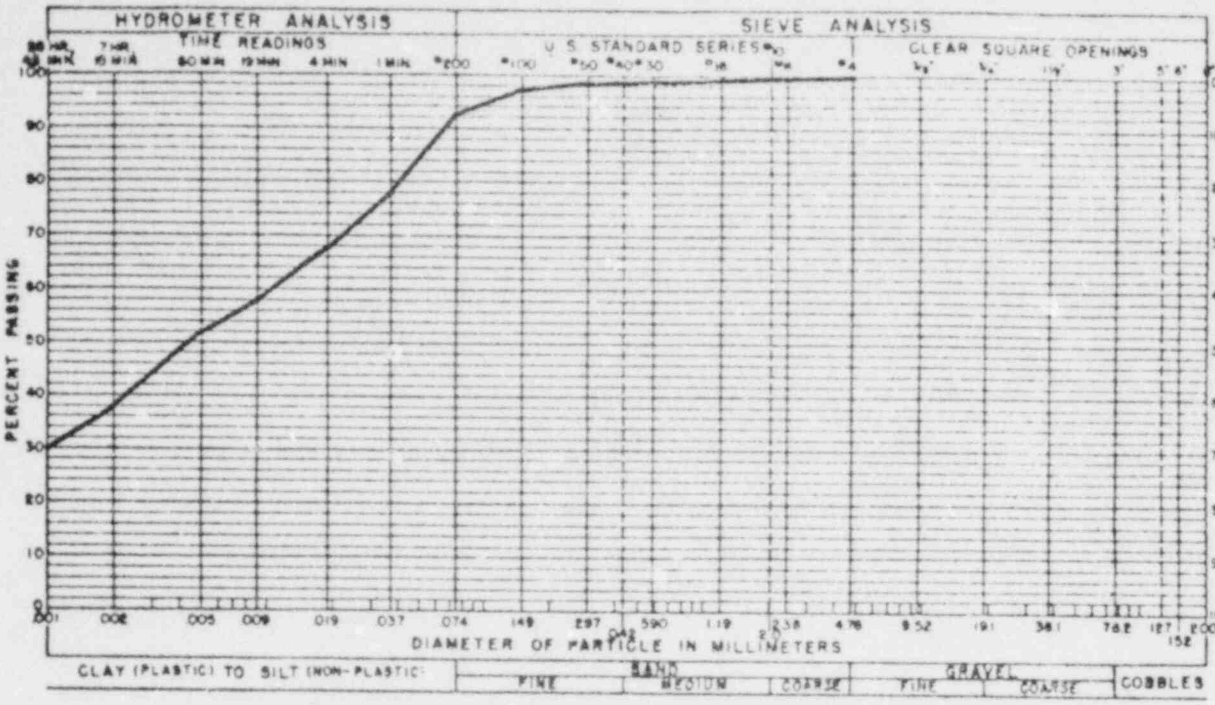
SAMPLE OF FROM

Form 12

GRADATION TEST RESULTS

JOB NO. 6196

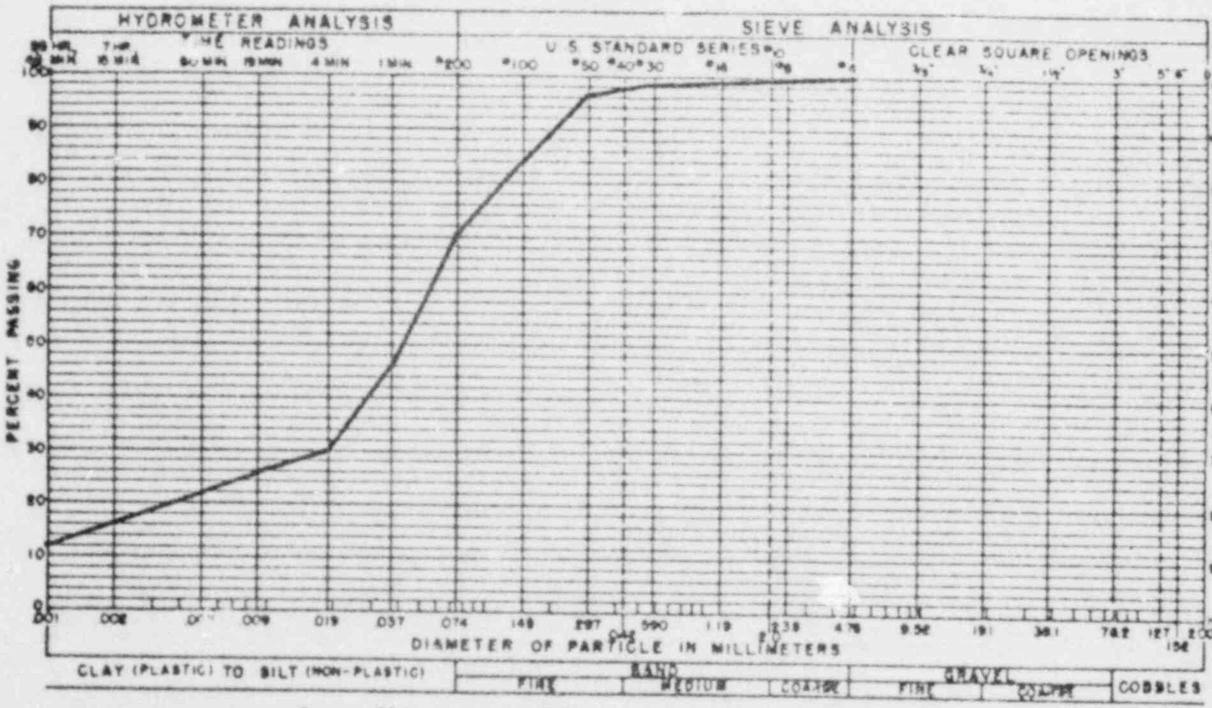
FIG. 3



GRAVEL 0 % SAND 8 % SILT AND CLAY 92 %

LIQUID LIMIT 39 % PLASTICITY INDEX 22 %

SAMPLE OF COKE OVEN RANCH BORROW FROM --



GRAVEL 0 % SAND 30 % SILT AND CLAY 70 %

LIQUID LIMIT 24 % PLASTICITY INDEX 9 %

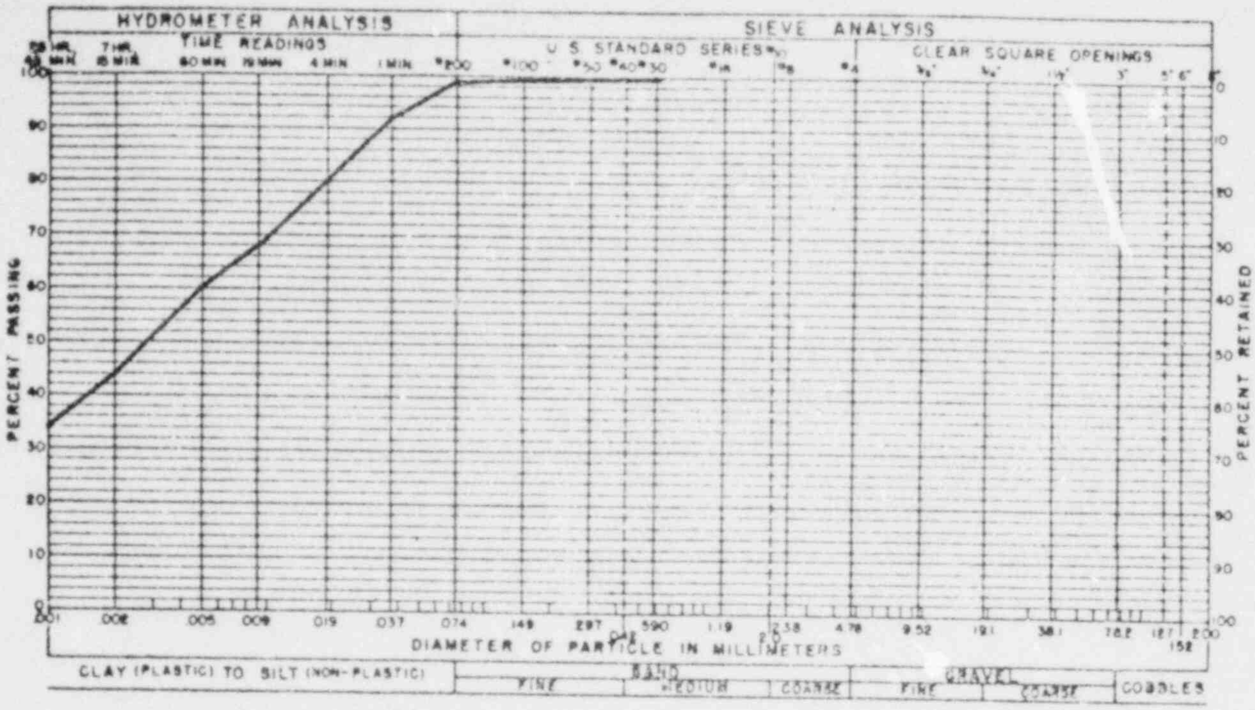
SAMPLE OF TT-4, S-1 FROM

Form 12

GRADATION TEST RESULTS

JOB NO. 6196

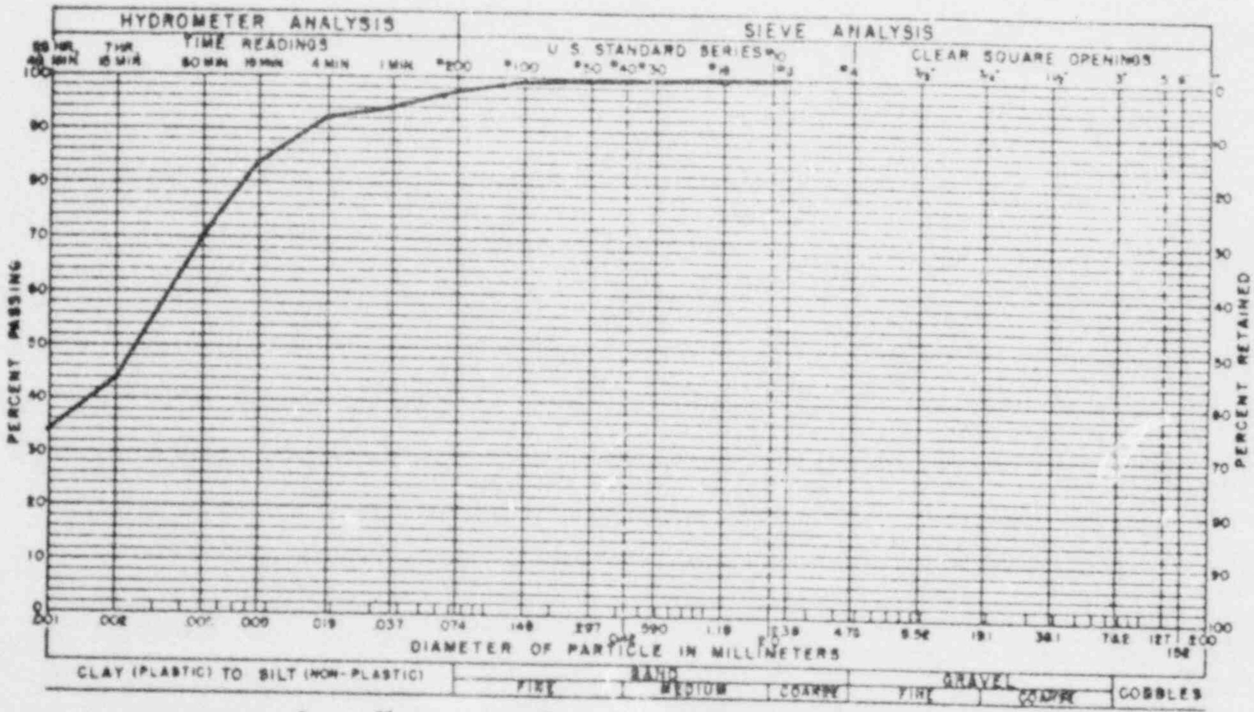
FIG. 4



GRAVEL 0 % SAND 1 % SILT AND CLAY 99 %

LIQUID LIMIT 51 % PLASTICITY INDEX 34 %

SAMPLE OF TD-5 FROM 13.5 - 14.6 FEET



GRAVEL 0 % SAND 3 % SILT AND CLAY 97 %

LIQUID LIMIT 43 % PLASTICITY INDEX 25 %

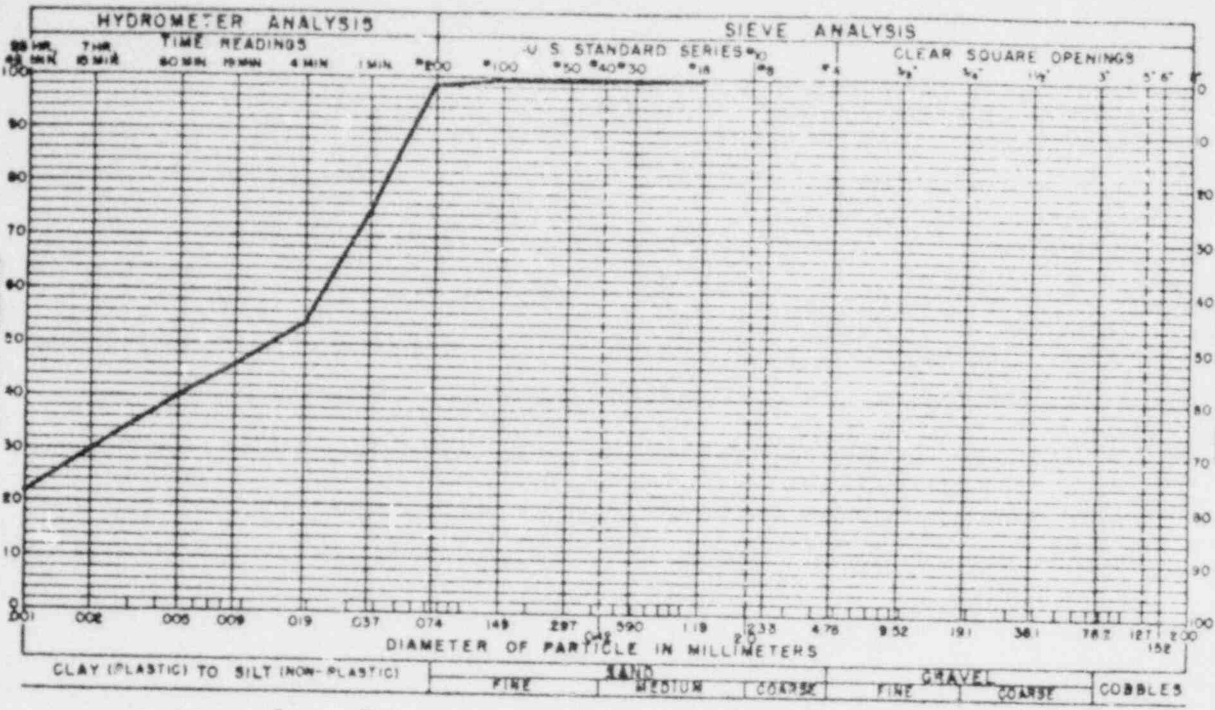
SAMPLE OF TD-10 FROM 16.0-17.0 FEET

Form 12

GRADATION TEST RESULTS

JOB NO. 6196

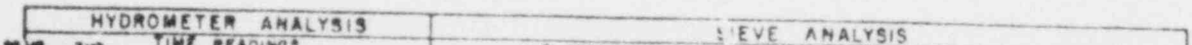
FIG. 5



GRAVEL 0 % SAND 1 % SILT AND CLAY 99 %

LIQUID LIMIT 29 % PLASTICITY INDEX 15 %

SAMPLE OF TD-10A FROM 8.5-9.8 FEET



GRAVEL % SAND % SILT AND CLAY %

LIQUID LIMIT % PLASTICITY INDEX %

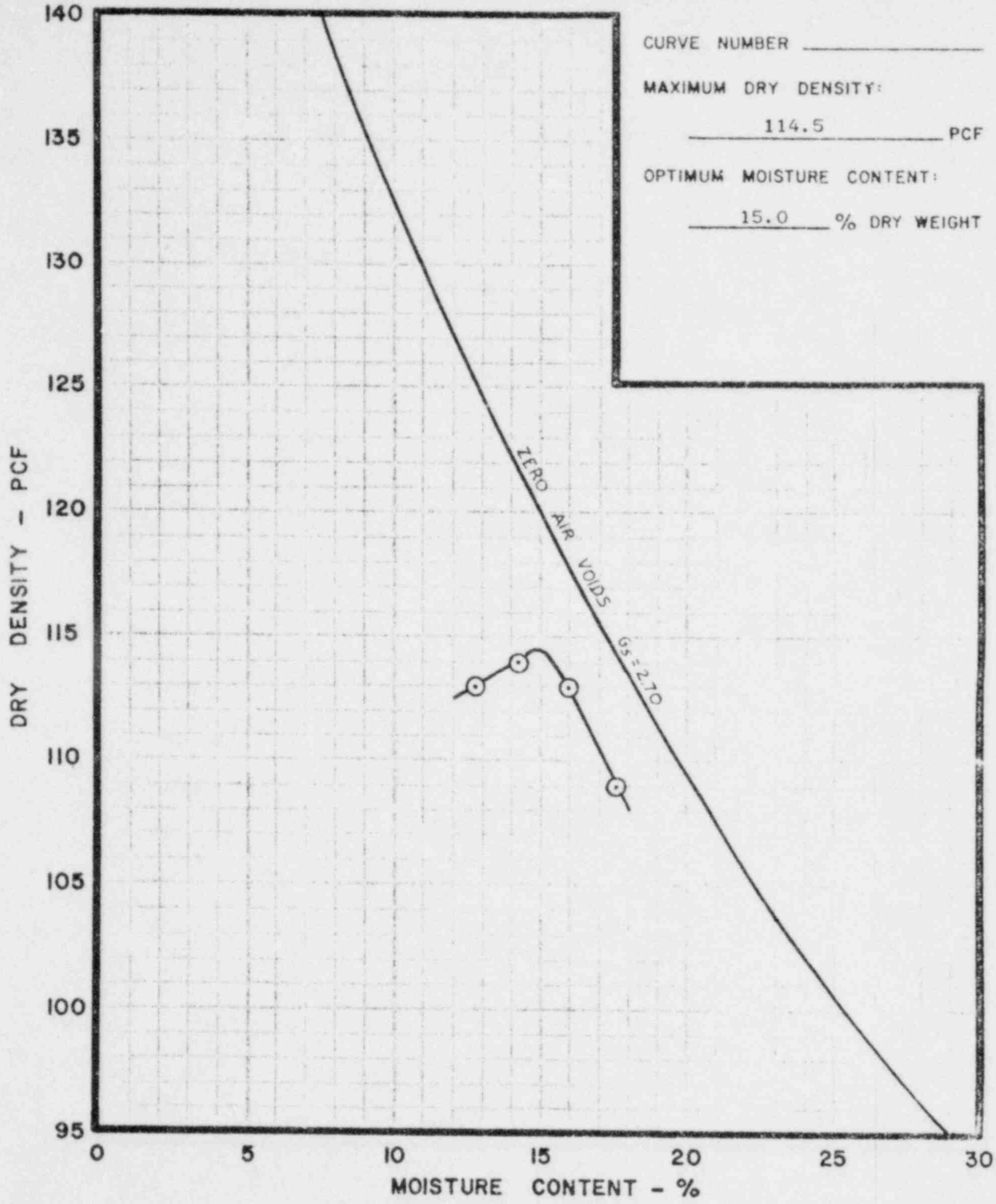
SAMPLE OF FROM

Form 12

GRADATION TEST RESULTS

JOB NO. 6196

FIG. 6



SAMPLE DESCRIPTION CLAY, SANDY, DARK BROWN

LOCATION TT-2, S-2 AT 3 TO 8 FEET

COMPACTION TEST PROCEDURE ASTM D 698-70, METHOD A

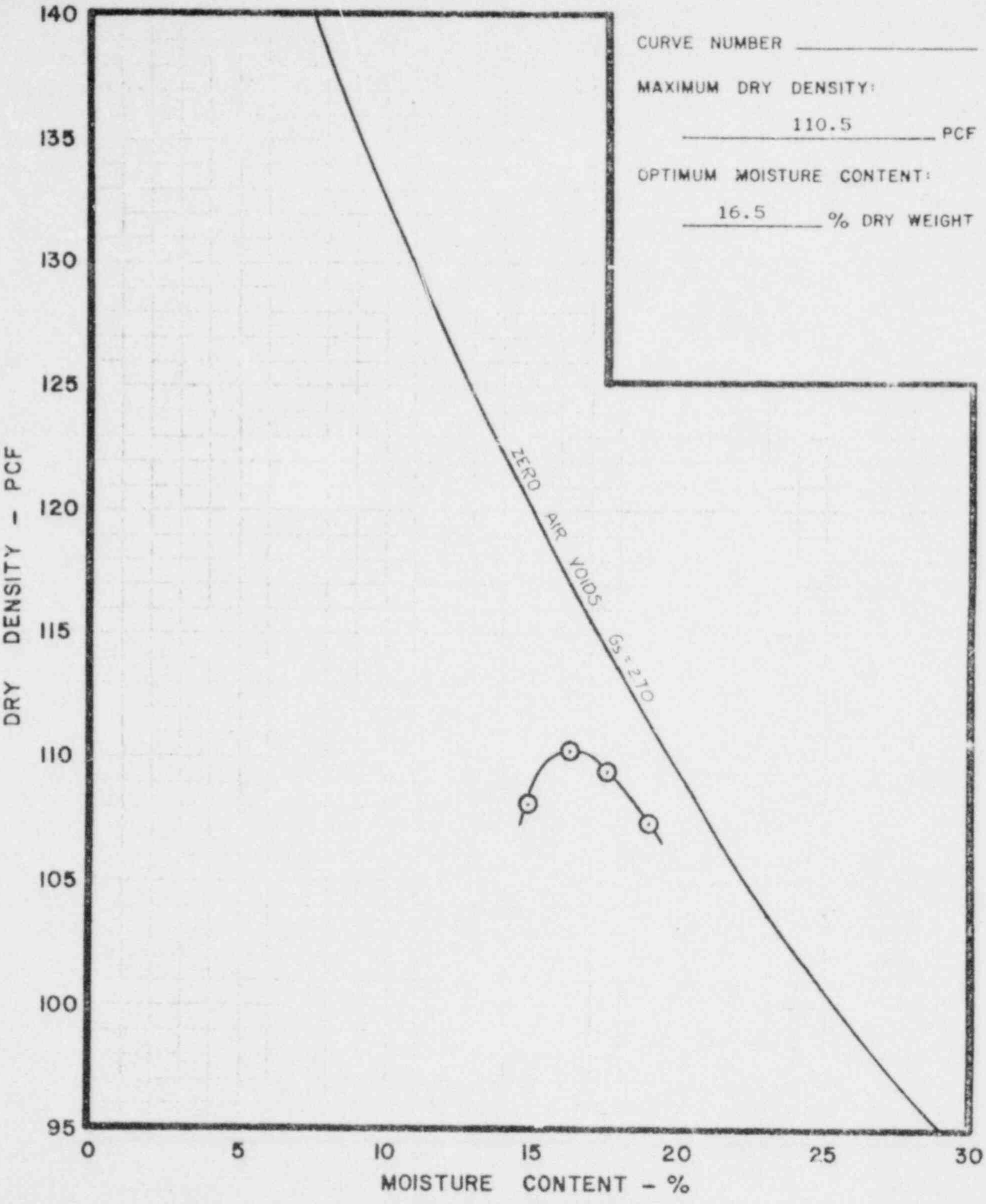
LIQUID LIMIT 29 % PLASTICITY INDEX 14 %

GRAVEL 0 % SAND 10 % SILT & CLAY 90 %

COMPACTION TEST RESULTS

JOB NO. 6196

FIG. 7



CURVE NUMBER ______

MAXIMUM DRY DENSITY: 110.5 PCF

OPTIMUM MOISTURE CONTENT: 16.5 % DRY WEIGHT

SAMPLE DESCRIPTION CLAYSTONE, SILTY, GRAY TO OLIVE

LOCATION BORROW AREA S-2 AT 2 TO 6 FEET

COMPACTION TEST PROCEDURE ASTM D 698-70, METHOD B

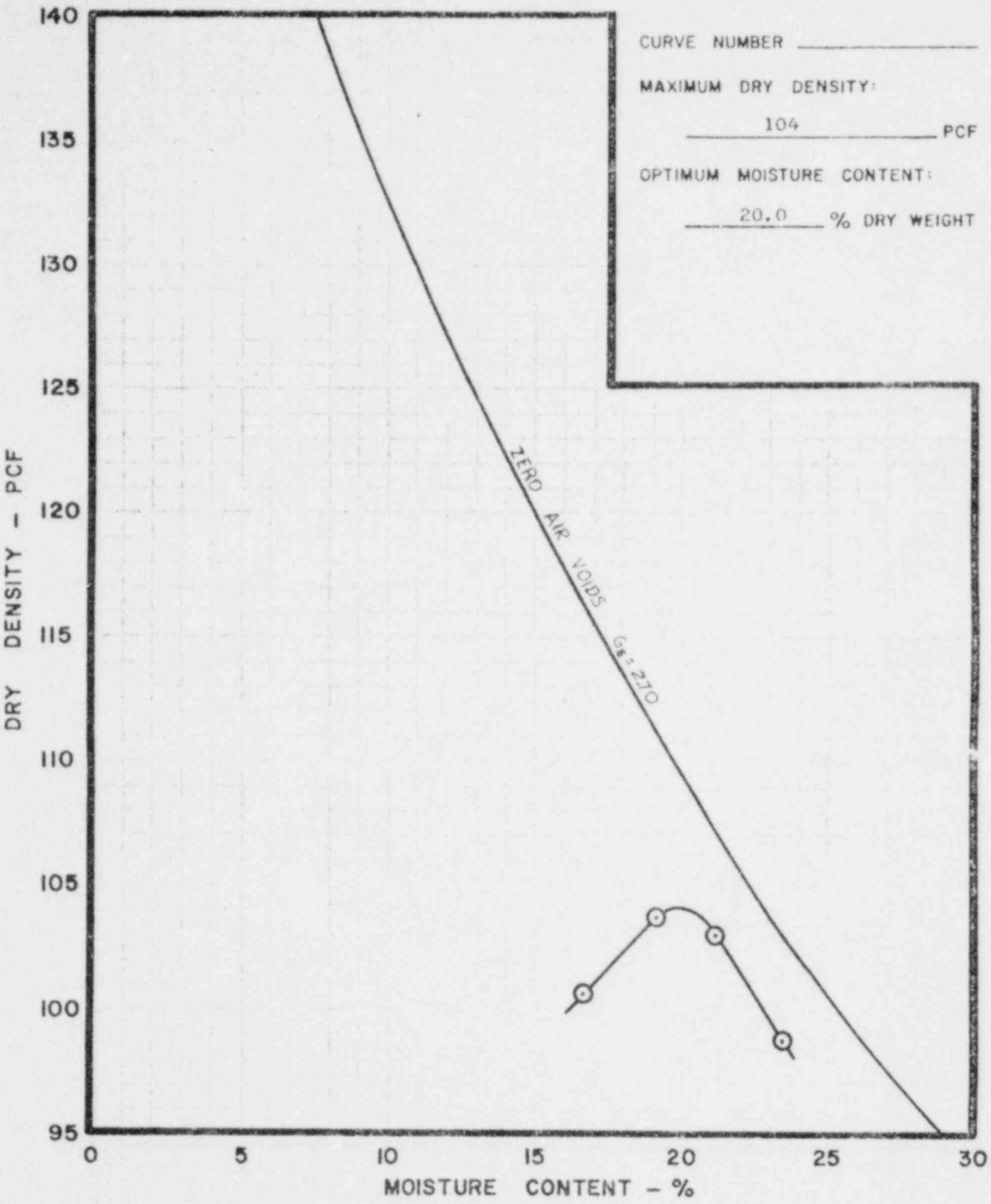
LIQUID LIMIT 40 % PLASTICITY INDEX 22 %

GRAVEL 0 % SAND 3 % SILT & CLAY 97 %

COMPACTION TEST RESULTS

JOB NO. 6196

FIG. 8



CURVE NUMBER ______

MAXIMUM DRY DENSITY:

104 PCF

OPTIMUM MOISTURE CONTENT:

20.0 % DRY WEIGHT

SAMPLE DESCRIPTION CLAYSTONE, SLIGHTLY SILTY, OLIVE BROWN TO GRAY GREEN

LOCATION COKE OVEN RANCH - BORROW

COMPACTION TEST PROCEDURE ASTM D 698-70, METHOD A

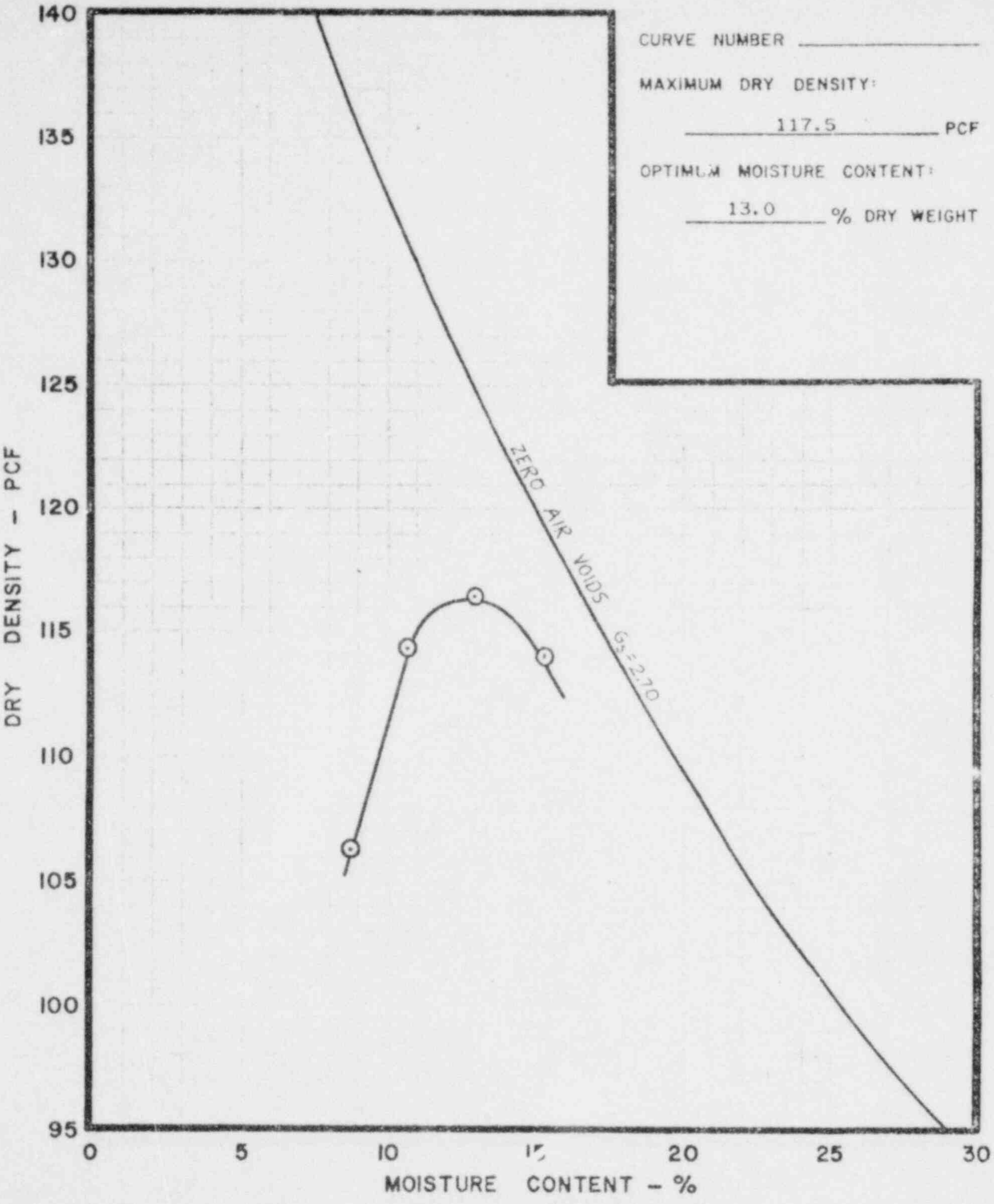
LIQUID LIMIT 39 % PLASTICITY INDEX 22 %

GRAVEL ______ % SAND ______ % SILT & CLAY ______ %

COMPACTION TEST RESULTS

JOB NO. 6196

FIG. 9



CURVE NUMBER ______

MAXIMUM DRY DENSITY: 117.5 PCF

OPTIMUM MOISTURE CONTENT: 13.0 % DRY WEIGHT

SAMPLE DESCRIPTION CLAY, SILTY, SANDY

LOCATION TT-4, S-1

COMPACTION TEST PROCEDURE ASTM D 698-70, METHOD A

LIQUID LIMIT 24 %   PLASTICITY INDEX 9 %

GRAVEL 0 %   SAND 30 %   SILT & CLAY 70 %

COMPACTION TEST RESULTS

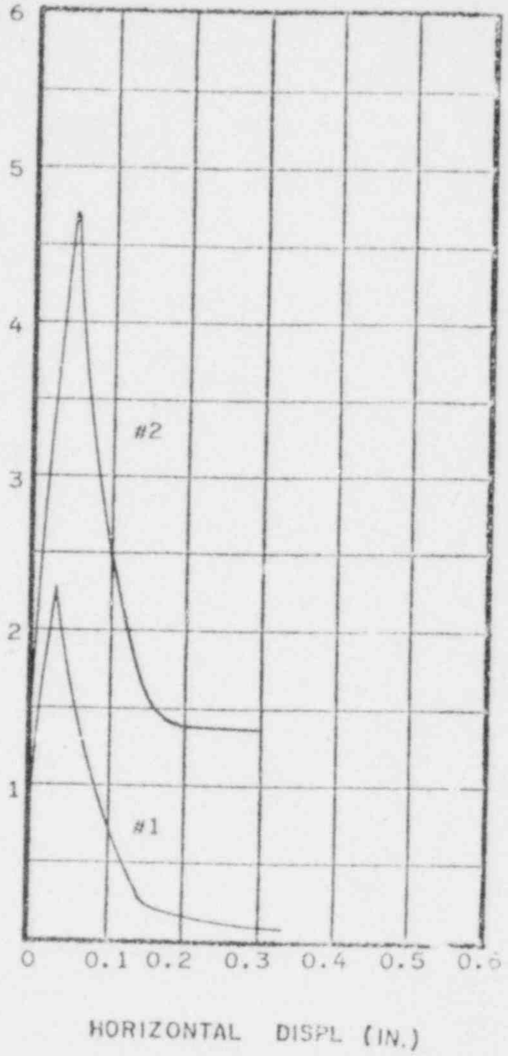
JOB NO. 6196

FIG. 10

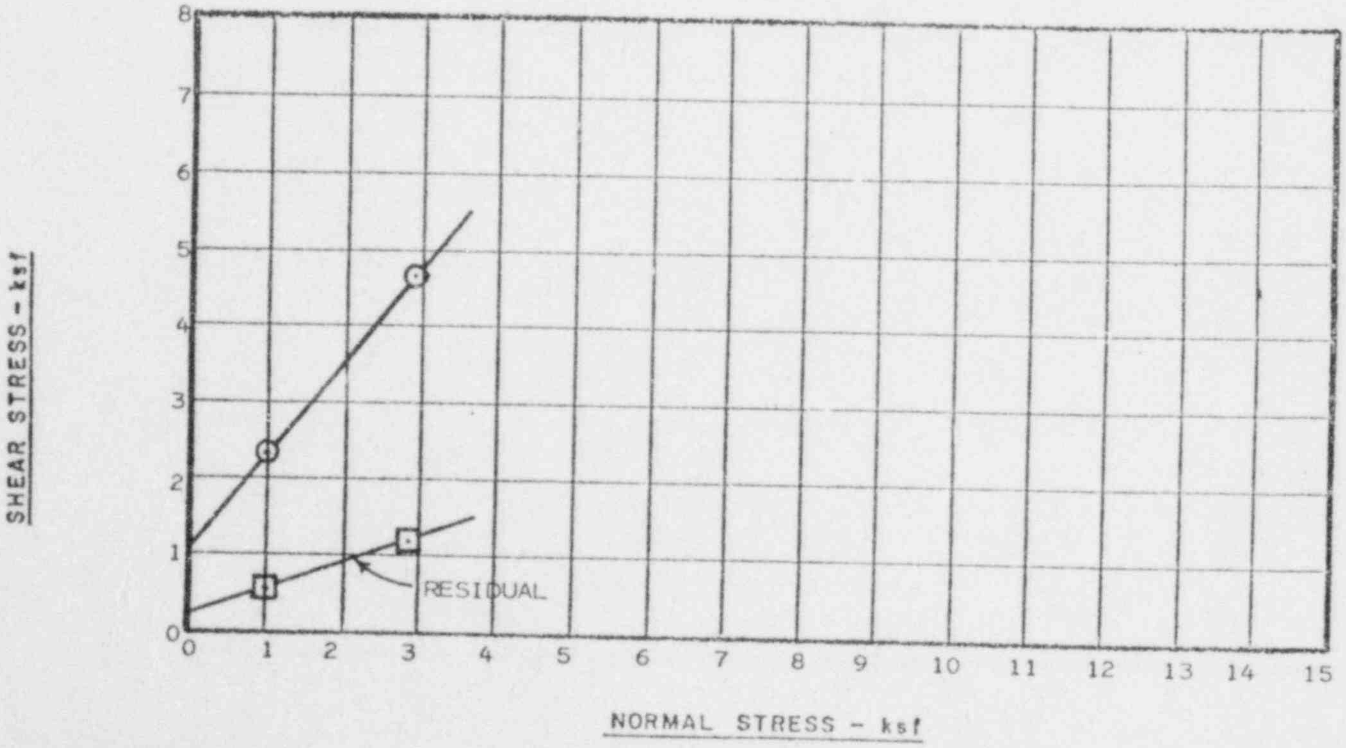
SAMPLE LOCATION	TD-5 AT 13.5 - 14.5'
TYPE OF SAMPLE	1.90 INCH CORE

DESCRIPTION

CLAYSTONE, HARD TO VERY HARD, BLOCKY,
LIGHT, MOIST, GRAY, RED BROWN



SAMPLE NO.	1	2	
MOISTURE %	10.0	10.0	
DRY DENSITY	134	127	
σ_N - ksf	1.0	2.9	
τ - ksf	2.3	4.7	

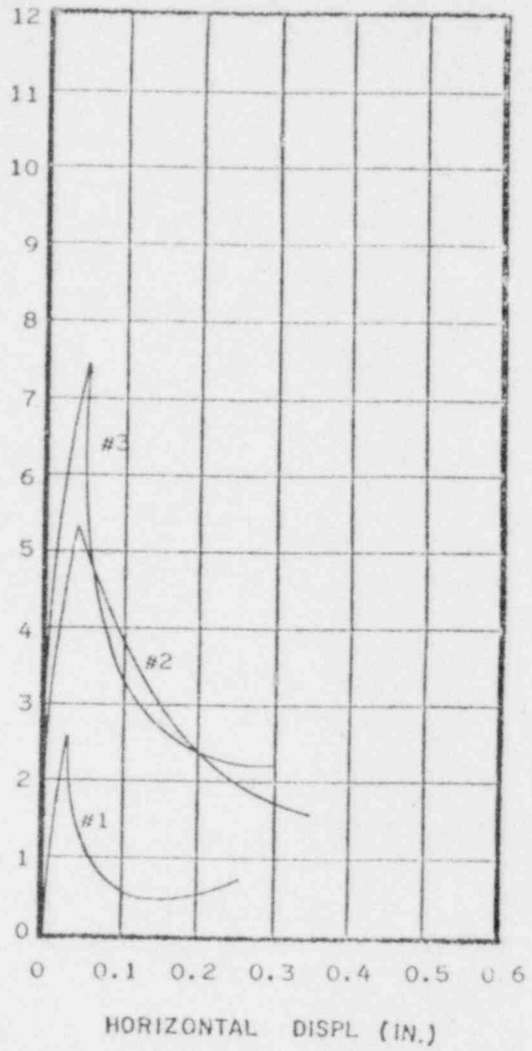


JOB NO. 6196

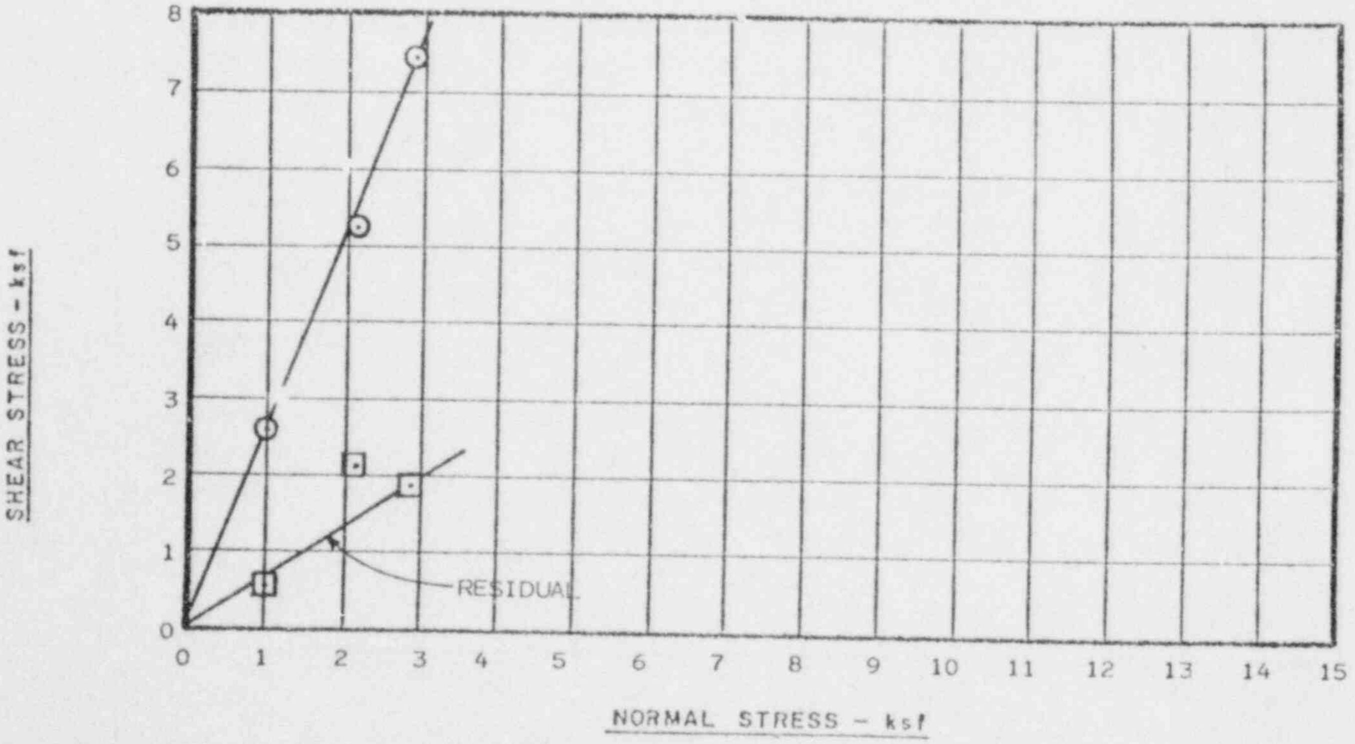
DIRECT SHEAR TEST RESULTS

FIG. 11

SAMPLE LOCATION	TD-10A AT 8.5-9.8'
TYPE OF SAMPLE	1.86 INCH CORE
DESCRIPTION	
CLAYSTONE HARD, BLOCKY, LIGHT, MOIST,	
GRAY	



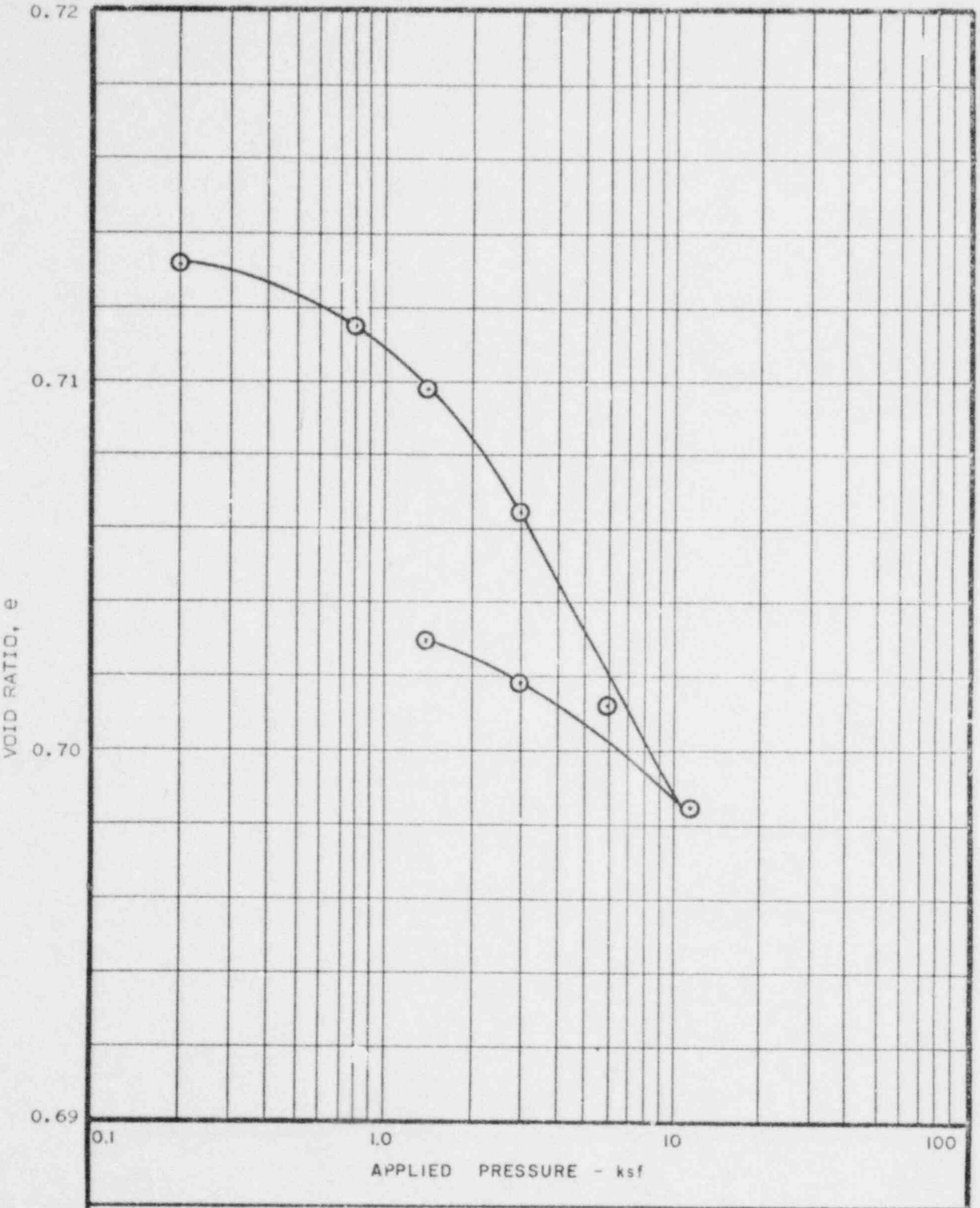
SAMPLE NO.	1	2	3
MOISTURE %	8.7	8.7	8.7
DRY DENSITY	131	141	132
σ_N - ksf	1.0	2.1	2.9
τ - ksf	2.6	5.3	7.5



DIRECT SHEAR TEST RESULTS

JOB NO. 6196

FIG. 12



Sample of REMOLDED CLAYSTONE, SANDY from S-2 AT 2 TO 6 FEET BORROW AREA

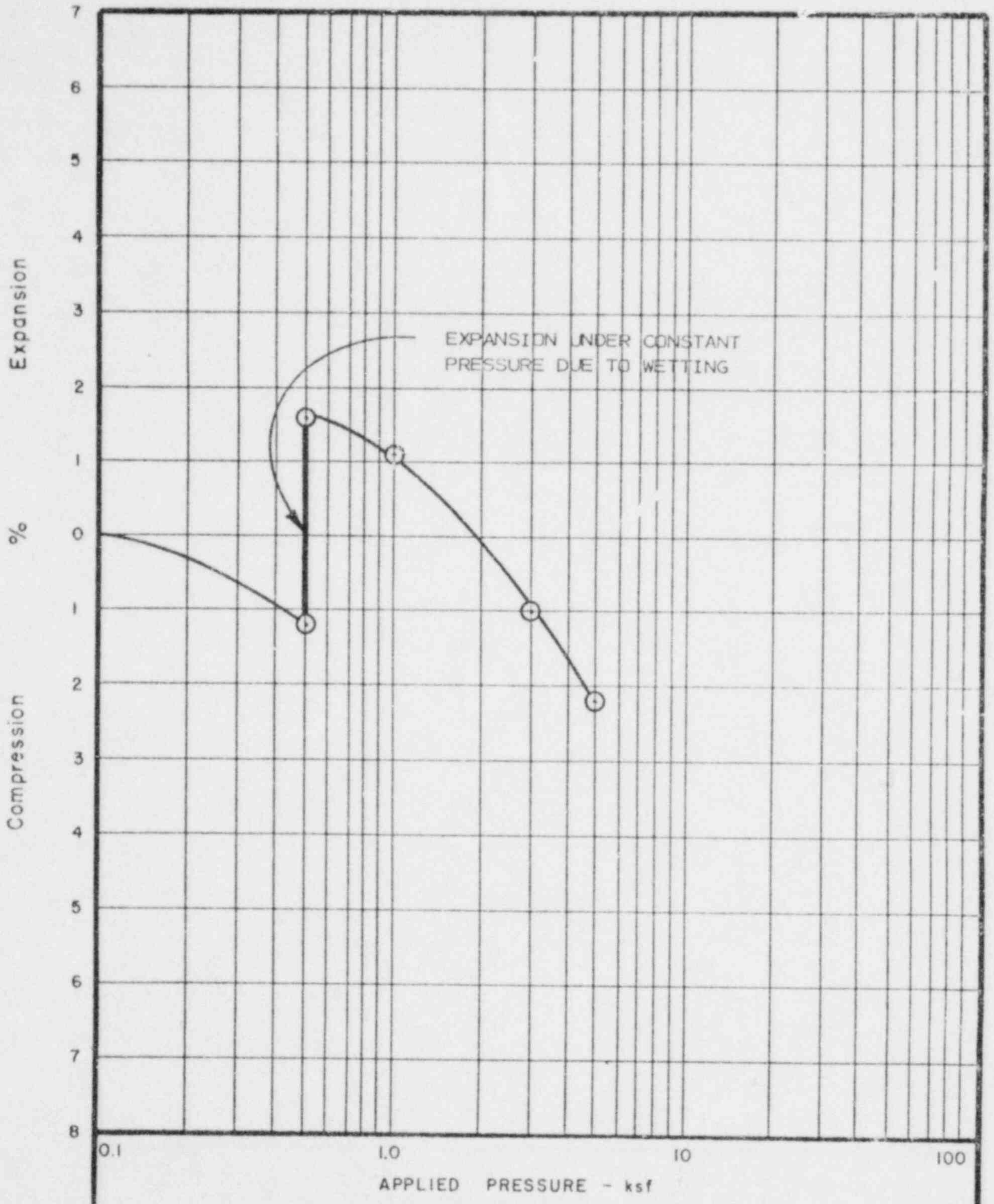
Dry Unit Weight = 96 pcf

Moisture Content = 15.0 percent

Swell - Consolidation Test Results

JOB NO. 6196

FIG. 13



Sample of CLAYSTONE (REMOLDED) from BORROW AREA S-2 AT 2 TO 6 FEET

Dry Unit Weight = 111 pcf

Moisture Content = 17.4 percent

Swell - Consolidation Test Results

JOB NO. 6196

FIG. 14

Form 10

JOB NO. 6196

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	SPECIFIC GRAVITY	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH	SOLUBLE SULFATES (PPM)	PH	PERMEABILITY (CM/SEC)	SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)					
TD-1	16.3-16.9	6.2		25	15			7.9		CLAYSTONE
* TD-1	40.9-41.7		2.63**			8705				SANDSTONE
TD-4	8.8-9.5	11.7	2.67	51	34			7.5		CLAYSTONE
TD-4	18.2-18.9			46	32			7.5		CLAYSTONE
TT-2,S-2	3-8	13.0		29	14		310	8.6	LESS THAN	CLAYSTONE
									10^{-7}	
BORROW									LESS THAN	
AREA S-2	2-6	11.3	2.64	40	22		875	8.7	10^{-7}	CLAYSTONE
COKE OVEN	--	22.7		39	22		125	7.9		CLAYSTONE, SANDY
RANCH BORROW										
TT-4,S-1				24	9					CLAY, SILTY, SANDY
TD-5	13.5-14.6	10.0		51	34			7.9		CLAYSTONE
TD-10	16.0-17.0	12.4	2.66	43	25			7.5		CLAYSTONE
TD-10A	8.5-9.8	8.7		29	15			8.0		CLAYSTONE

*NATURAL DENSITY IS 163 PCF

** APPARENT SPECIFIC GRAVITY

R.C. HARLAN AND ASSOCIATES *geotechnical consultants*
55 NEW MONTGOMERY STREET • MAILING ADDRESS P.O. BOX 7717 • SAN FRANCISCO, CALIFORNIA 94120 • (415) 434-3004

LETTER OF TRANSMITTAL

TO International Engineering Co, Inc.
180 Howard Street
San Francisco CA 94105

Date 5/8/80
Project No. 217.8
Attention Ethan Axtmann
Re: Union Carbide Uranium Ponds

Gentlemen:

WE ARE SENDING YOU ☒ Attached ☐ Under separate cover via ________ the following items:

☒ Report ☐ Prints ☐ Plans ☐ Specifications
☐ Copy of letter ☐ Change Order

Copies	Date	Description
1	5/8/80	Laboratory testing results

THESE ARE TRANSMITTED as checked below:

☐ For approval ☐ For your use ☒ As requested
☐ For review and comment

REMARKS

Copies:

Signed: Richard C. Harlan

Project No. 217.8 May 8, 1980

REPORT OF
LABORATORY TESTING

UNION CARBIDE URANIUM PONDS

INTRODUCTION

Laboratory testing was carried out on samples selected and shipped to our San Francisco Laboratory by International Engineering Co., Inc. Testing work was begun on April 2, 1980 and completed on April 16, 1980.

Specifications for the testing were provided by the staff of the Geotechnical Division of International Engineering Co., Inc.

A description of the test procedures and a summary of the test results are presented on the following pages, followed by the detailed test data sheets.

Moisture Content

Moisture content determination was accomplished with ASTM Designation D 2216-71.

Atterberg Limits

The liquid limit was determined in general accordance with ASTM Designation D 423-66 (Reapproved 1972). The plastic limit was determined in general accordance with ASTM Designation D 424-59 (Reapproved 1971).

Compaction

The moisture - density relationship was determined as outlined in ASTM Designation D 698-70, Method A and ASTM Designation D 1557, Method A.

Permeability - Remolded

Permeability was tested using a falling head permeameter. Specimens were compacted in a 2.5-inch mold at specific moisture contents and densities in 3 lifts. Specimens were saturated by back pressuring until a "B" parameter of 0.95 or better was measured. No consolidation pressures were applied. Effective head was measured and $K_{20}{}^{o}C$ calculated.

Permeability - Undisturbed

Permeability was tested using a falling head permeameter. Specimens were prepared from core samples that were 1.9 inches in diameter and the ends trimmed parallel and flat to a length of 4.0 cm. Saturation and other test procedures are identical with procedures outlined above.

PH Test

PH was determined by using pHydrion vivid 0.9 strips in the slurry that was mixed for the Atterberg Limits tests.

Particle Size Analysis

Combined particle size analyses were determined by using a representative portion of the oven dried sample which was soaked overnight in a deflocculating agent. The specimen was dispersed using an air-jet apparatus and the hydrometer readings were begun. After the final hydrometer reading, the suspension was washed on a No. 200 washing sieve, the retained portion was dried to a constant weight, and then dry-sieved to obtain the analysis of the sand sizes. The procedure is in general accordance with ASTM Designation D 422-63 (Reapproved 1972).

Triaxial Compression Test - Consolidated-Undrained, Undisturbed

Undisturbed specimens were prepared from 1.9 inch cores by cutting sections slightly larger than needed and trimming the ends flat and parallel to a length of 9.8 - 11.3 cm. A height-diameter ratio of at least 2.0 was maintained for all specimens. Saturation was achieved by seepage and back pressuring until a "B" parameter of 0.95 or better was measured. At the completion of saturation, chamber pressure, $\nabla 3$, was applied to consolidate the specimen. A record of volume change versus time was kept and plotted so that a determination could be made of the time for complete primary consolidation. After consolidation, valves at the ends of the specimen were closed and an axial stress applied at a constant rate of strain that depended on consolidation characteristics. Pore pressure was recorded and the tests were terminated (a) at strains well past the maximum principle stress difference, (b) at the maximum effective stress ratio.

After the test, the specimen is removed from the test chamber and oven-dried overnight or to a constant weight for moisture content determination.

Triaxial Compression Test - Consolidated-Undrained, Remolded

Specimens were remolded from bulk samples using minus No. 4 material in a 2.5-inch diameter mold. All specimens were compacted in 5 lifts at optimum moisture content and to a specific target density. A height-diameter ratio of 2.3 was maintained for all specimens. Saturation, consolidation, compression and other test procedures are identical with procedures outlined above.

Specific Gravity

The specific gravity was determined in general accordance with ASTM Designation D 854-58.

SUMMARY OF S

Job No 217.8   Project Name UNION CARBIDE URANIUM PONDS

Hole or Trench Number	Sample Number	Depth		Laboratory Classification	Mechanical Analysis			Atterberg Limits		Specific Gravity G	Natural		Compa	
		From	To		Gravel	Sand	Fines *	LL	PI		w %	γd	Test	Op w
TT-2	S-1	3'-0"	8'-0"	CL	-	11	47/42	31	13	2.62	13.0	106.5	SP	12
Borrow Area	S-1	2'-0"	6'-0"	CL	-	3	37/60	51	23	2.71	13.0	102.3	SP	15
Borrow Area	S-1	2'0-"	6'-0"	CL	-	3	37/60	51	23	2.71	13.0	102.3	MP	14
TD-10A	Shale Black	23.6'	24.5'	-CL	-	1	57/42	39	15	2.59	12	122.0	-	-
TD-10A	Shale Gray	16.7'	18.1'	-CL	-	2	43/55	36	[illegible]	2.63	12	128.0	-	-
TD-7	Shale Black			-CL		2	43/55	36	17	2.63	12	128.0	-	-
TD-9	Shale Gray			-CL		2	43/55	39	17	2.63	12	128.0	-	-

* Visual Classification

SP = Standard Proctor
MP = Modified Proctor
S = Special - See Text

TC = Triaxial Compression
UC = Unconfined Compression
DS = Direct Shear

UU = Unconsolidated Undrained
CU = Consolidated Undrained
CD = Consolidated Drained

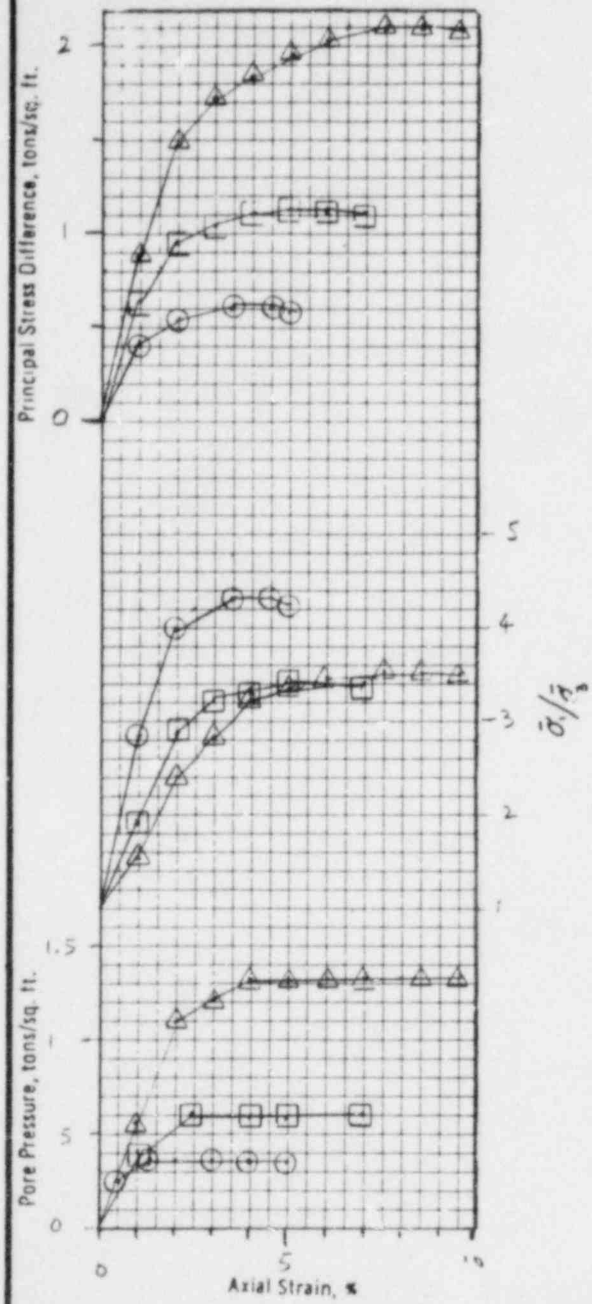
* Silt/Clay

OIL TEST RESULTS

Feature ______ Date April 21, 1980

ction	Shear Strength					Permeability		Consolidation			Notes
timum	Test	Initial		C	φ	γ_d	k	C_c	C_s	P_c	
γ_d		w	γ_d	(psF)			cm/sec				
110	CU	18	106.5	0 0	35° 20°	106.5	3×10^{-6}				PH~6
105.5	CU	21	102.3	0 0	25° 17°	102.3	1.5×10^{-6}				
117.8	CU	21	102.3	0 0	25° 17°	114.6	4.7×10^{-7}				
-		12									
-		11		1000 2000	54° 36°						
-				1000 2000	54° 36°	120.2	6×10^{-6}				
-				1000 2000	54° 36°	111.2	2×10^{-6}				

R.C. HARLAN AND ASSOCIATES INC.

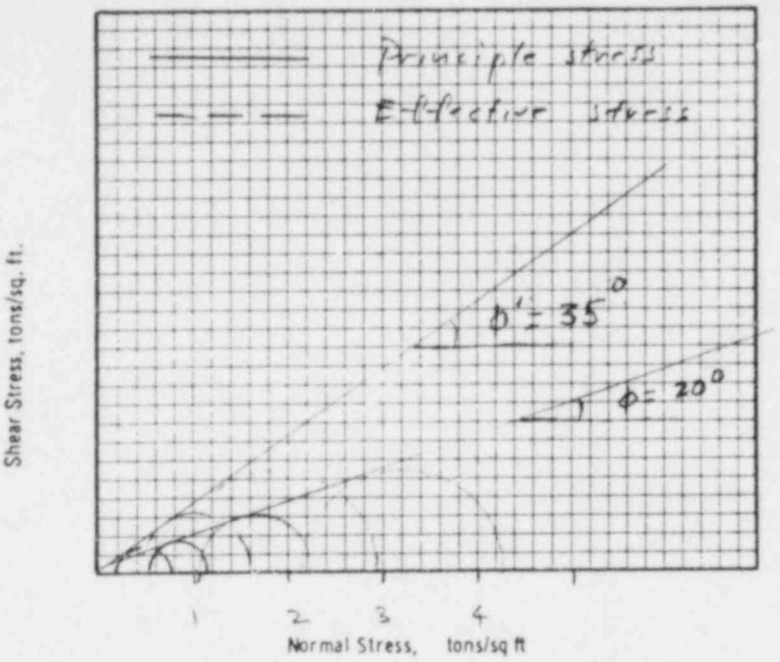


Shear Values

ø = ____

tan ø = ____

c = ____ tons/sq ft



Test No.			A	B	C	
Initial	Water content	w_o	12.7	12.6	12.5	
	Void ratio	e_o	0.536	0.535	0.536	
	Saturation	S_o	62	62	62	
	Dry density lb/cu ft	γ_d	106.4	106.5	106.4	
Before Test	Water content	w_c	19.5	18.1	17.0	
	Saturation	S_c	99	100	100	
	Consolidation press., tons/sq.ft.	$\bar{\sigma}_c$	0.54	1.08	2.16	
	Void ratio	e_c	0.513	0.471	0.436	
Final	Water content	w_f	19.5	18.1	17.0	
	Void ratio	e_f	0.513	0.471	0.436	
Major principal stress, tons/sq.ft.		σ_1	1.14	2.22	4.26	
Minor principal stress, tons/sq ft		σ_3	0.54	1.08	2.16	
Time to failure, min			135	282	421	
Initial diameter, cm			6.350	6.350	6.351	
Initial height, H_0, cm			14.6	14.6	14.6	

Remarks

○ Test A

□ Test B

△ Test C

Type Test Consolidated-undrained [✓ Controlled Strain] Controlled Stress

Method of Saturation Seepage - back saturation

Type of specimen Remolded

Rate of strain A 0.0015 B 0.001 C 0.001 in./min.

Classification

LL

PI

G 2.62

Hole No. TT-2

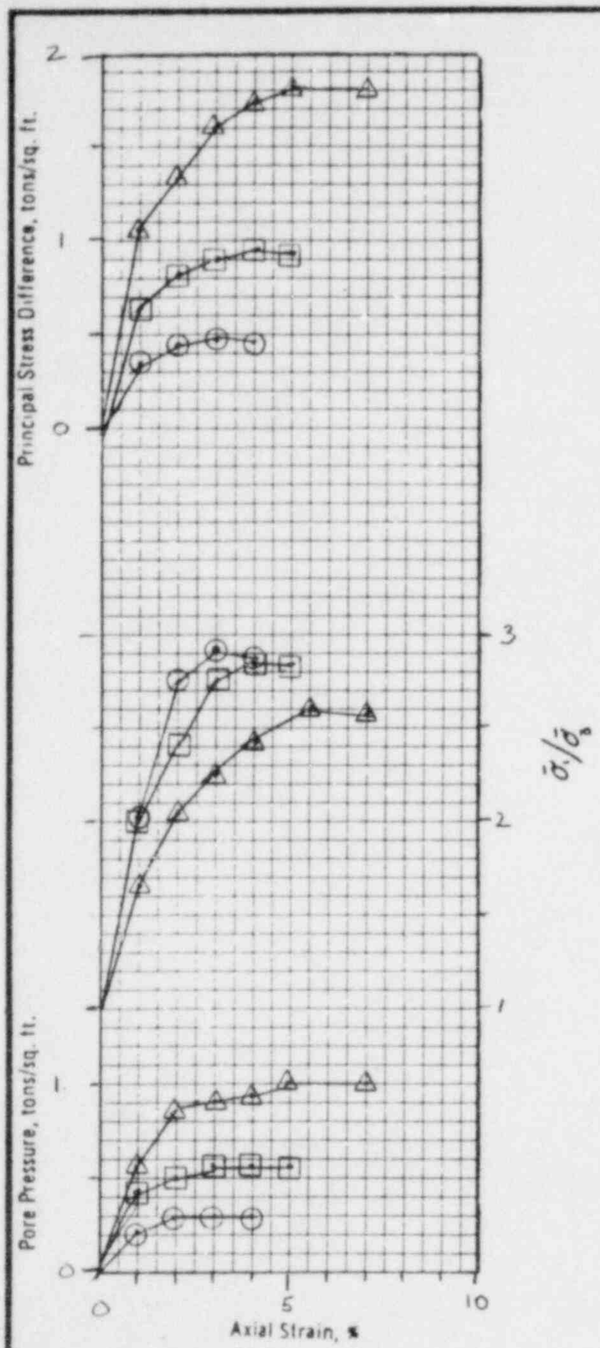
Sample no.

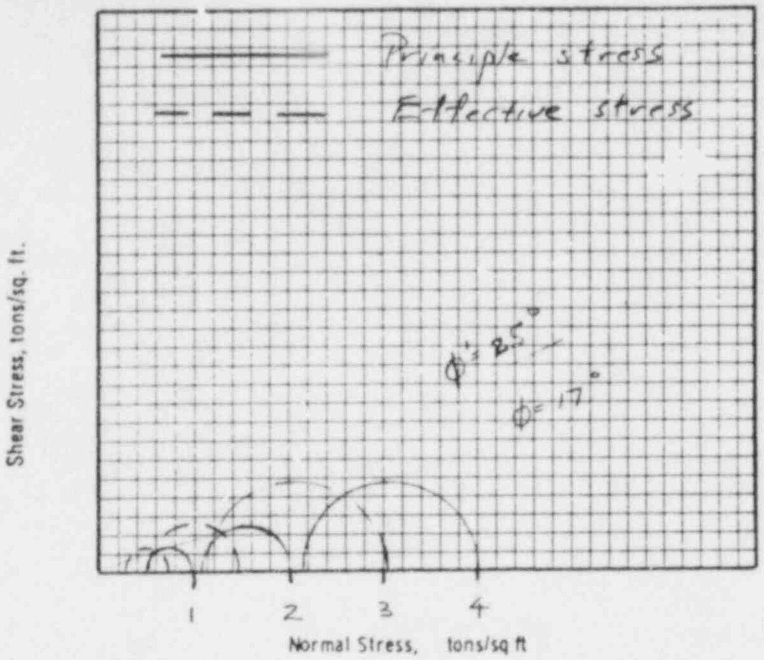
R. C. HARLAN AND ASSOCIATES
88 NEW MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94105

Proj. No. 217.8 Appr. ____ Date ____

TRIAXIAL COMPRESSION TEST REPORT
IEC0 - Union - Carbide
Uravan, Colo.

FIGURE





Shear Values

ø = __________

tan ø = __________

c = __________ tons/sq ft

Test No.			A	B	C	
Initial	Water content	w_o	15.0	15.1	15.1	
	Void ratio	e_o	0.652	0.654	0.654	
	Saturation	S_o	62	62	62	
	Dry density lb/cu ft	γ_0	102.3	102.2	102.3	
Before Test	Water content	w_c	23.4	21.4	19.5	
	Saturation	S_c	100	100	98	
	Consolidation press., tons/sq.ft.	σ_c	0.54	1.08	2.16	
	Void ratio	e_c	0.618	0.583	0.542	
Final	Water content	w_f	23.4	21.4	19.5	
	Void ratio	e_f	0.618	0.583	0.542	
Major principal stress, tons/sq.ft.		σ_1	1.02	2.03	4.00	
Minor principal stress, tons/sq ft		σ_3	0.54	1.08	2.16	
Time to failure, min			240	261	401	
Initial diameter, cm			6.351	6.350	6.351	
Initial height, H_0, cm			14.6	14.6	14.6	

Remarks

○ Test A

□ Test B

△ Test C

Type Test Consolidated-undrained [✓ Controlled Strain] Controlled Stress

Method of Saturation Seepage- back saturation

Type of specimen Remolded

Rate of strain A 0.0009 B .009 C 0.0008 in./min.

Classification

LL

PI

G 2.71

Hole No. Borrow

Sample no.

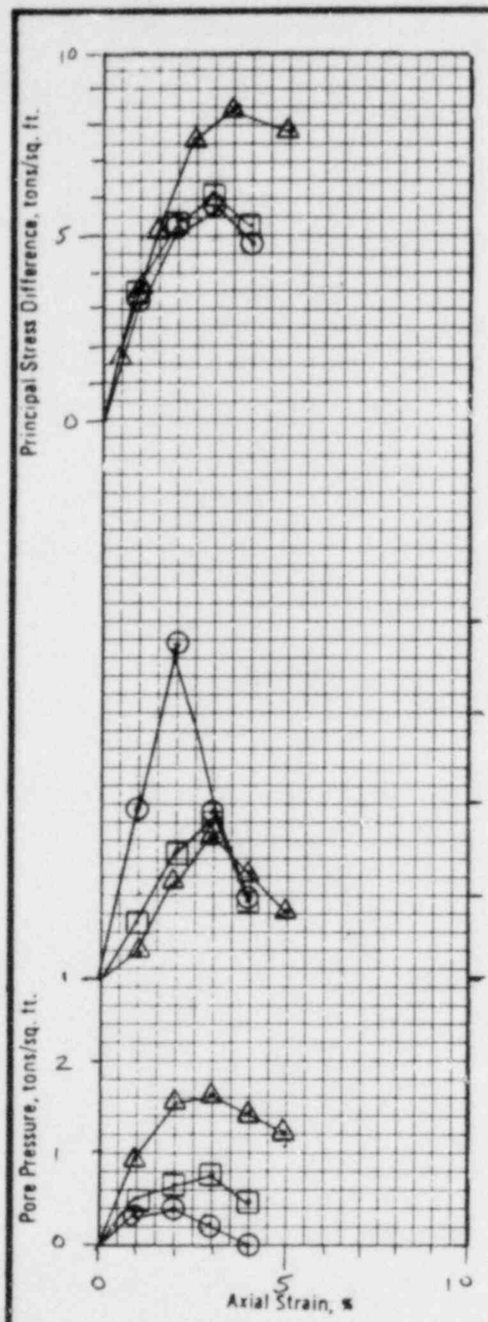
R. C. HARLAN AND ASSOCIATES

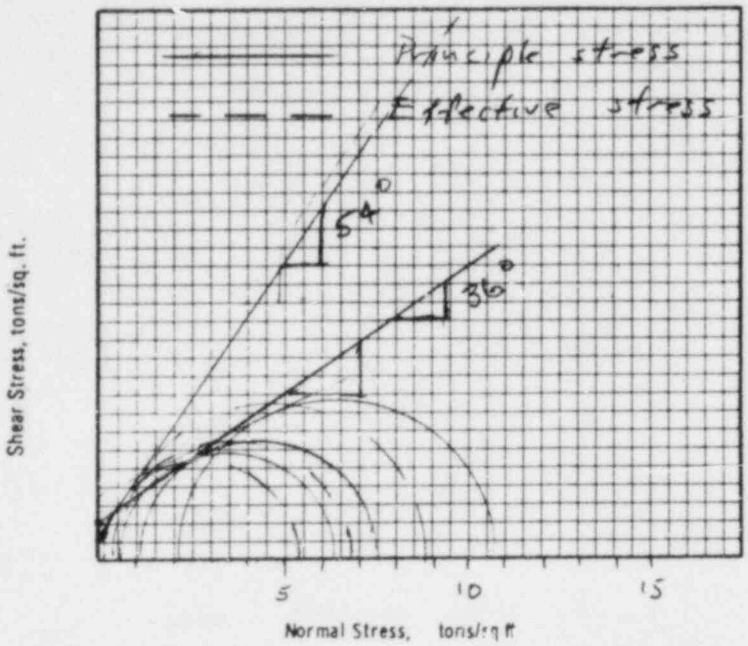
88 NEW MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94105

TRIAXIAL COMPRESSION TEST REPORT
IECO Union-Carbide

FIGURE

Proj. No. 217.8 Appr. ____ Date ______





Test No.			A	B	C	
Initial	Water content	w_o	10.0	10.5	14.0	
	Void ratio	e_o	0.292	0.267	0.255	
	Saturation	S_o	89	100	140	?
	Dry density lb/cu ft	γ_d	125.6	128.0	129.2	
Before Test	Water content	w_c	13.1	13.5	12.2	
	Saturation	S_c	136	150	144	?
	Consolidation press., tons/sq.ft.	σ_c	0.54	1.08	2.16	
	Void ratio	e_c	0.250	0.226	0.219	
Final	Water content	w_f	13.1	13.5	12.2	
	Void ratio	e_f	0.250	.226	0.219	
Major principal stress, tons/sq.ft.		σ_1	6.29	7.2	10.60	
Minor principal stress, tons/sq ft		σ_3	0.54	1.08	2.16	
Time to failure, min			30	77	53	
Initial diameter, cm			4.702	4.618	4.714	
Initial height, H_o, cm			10.15	9.85	11.55	

Shear Values

ø = ____________

tan ø = ____________

c = ____________ tons/sq ft

Remarks		
○	Test A	shale - gray (TD-9)
☐	Test B	TD-10A, 16'-18'
△	Test C	TD-10A, 16'-18'

Type Test Consolidated - undrained ✓ Controlled Strain Controlled Stress

Method of Saturation seepage - back saturation

Type of specimen Undisturbed

Rate of strain A 0.004 B .0015 C 0.003 in./min.

Classification

LL PI G 2.60 Assumed

Hole No. shale gray TD-10A

Sample no. 16'-18'

R. C. HARLAN AND ASSOCIATES
55 NEW MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94105

Proj. No. 217.8 Appr. ____ Date ________

TRIAXIAL COMPRESSION TEST REPORT
IECO Union Carbide - Uravan, Colo.

FIGURE

R.A. HARLAN AND ASSOCIATES
geotechnical consultants

WORK SHEET -- BACKPRESSURE PERMEABILITY TEST

Project IECO-Union Carbide-Uravan, Colo.		Date 4-8-80
Hole No. TT-2	Sample No. S-1 (217.8)	Depth 3'-8'
Direction of Permeability Horizontal ☐ Vertical ☑	Remolded @ 106.6 pcf @ 12.5 % moist. Undisturbed @ pcf % moist.	

Sample Description:

Weights and Moisture Contents

Item	Before	After Test	wash After Test
tare #		cc	217
Tare ~~No.~~ wt	706.2	164.9	161.2
Wet Soil + Tare, gm	1015.3	498.7	
Dry Soil + Tare, gm		438.9	161.9
Water, gm	34.4	59.8	
Wet Soil, gm	309.1		
Dry Soil, gm	274.7	274.0 274.7	.7
Moisture Content, %	12.5	21.8	

Specimen Dimensions

			0	62/60	
Area in cm^2	Top		31.70		
	Middle		31.70		
	Bottom		31.65		
	Average				
	Membrane Corr.				
	Net Area	A	31.68	32.00	
Height in cm	Incl. Ht. Corr.				
	Height Corr.			+.02	
	Net Height	L	5.08	5.10	

Saturation Data

Date	Hour	Pressures Interior, psi Top	Pressures Interior, psi Bott.	Burette Top cc	Burette Bott. cc

Consolidation Data

Chamber Pressure, psi	0	62/60		
Interior Burette				
Exterior Burette		+2.3		
Volume, cc	160.9	163.2		
Dry Density, pcf	106.5			

Test Data and Computations

Run No.	Temp. °C	Temp. Corr. R_T	Time	Time int. t sec.	Burette Reading cc Hi	Burette Reading cc Lo	Backpressure cm		Water Head cm	Effect. Back-press cmH$_2$0	Effect. Head cmH$_2$0 (H)	Apparatus Corr. (C)	K_{20}
0	~~21~~		250		90.3	28.3					62.0	1.0	
1	21.0	.976	305	900	86.5	31.0					55.5	↓	2.85×10^{-6}
2	21.0	.976	307/337	1800	80.9	37.7					43.2		3.22×10^{-6}
3	21.0	.976	340/440	3600	73.3	45.5					27.8		2.83×10^{-6}

Avg - 2.97×10^{-6}

Burettes Equivalent Level Small	Burettes Equivalent Level Large	Burettes Equivalent Level Small	Burettes Equivalent Level Large	$2.3 \times \frac{a_L a_s}{a_L + a_s}$
				0.3426

Formula:

$$k = 2.3 \times \frac{a_L a_s}{a_L + a_s} \times \frac{L}{At} \times \log \frac{H_1}{H_2} \times R_T \times C$$

Run No.	Dens. pcf	Void Ratio	$\frac{H_1}{H_2}$	Log $\frac{H_1}{H_2}$	Permeability 1 cm/sec = 2834.6 ft/day cm/sec	Permeability 1 cm/sec = 2834.6 ft/day ft/day
1			1.117	0.0481		
2			1.285	.1088		
3			1.554	.1914		

a_L = area of large burette

a_s = area of small burette

A_L 0.303 cm^2

A_S .293 cm^2

Tested by: WT

Computed by: WT

Checked by:

K.C. HARLAN AND ASSOCIATES
geotechnical consultants

WORK SHEET -- BACKPRESSURE PERMEABILITY TEST

Project IECO - Union Carbide, Uravan Colo. Date 4-7-80

~~Hole No.~~ Borrow Area Sample No. S-1 Depth 2'-6'

Direction of Permeability
Horizontal ☐ Vertical ☑

Remolded @ 102.3 pcf [illegible] 15 % moist.
Undisturbed @ pcf % moist.

Sample Description:

Weights and Moisture Contents

Item tare NO	Before	After Test H	Wash After Test 211
Tare ~~No.~~ wt	620.9	105.8	160.6
Wet Soil + Tare, gm	924.4	436.0	
Dry Soil + Tare, gr		368.2	161.5
Water, gm	40.2	67.8	
Wet Soil, gm	303.5		
Dry Soil, gm	263.3	262.4 263.3	.9
Moisture Content, %	15.3	25.8	

Specimen Dimensions

			0	52/50	
Area in cm^2	Top		31.70	~~50~~	
	Middle		31.65		
	Bottom		31.65		
	Average				
	Membrane Corr.				
	Net Area	A	31.67	32.21	
Height in cm	Incl. Ht. Corr.				
	Height Corr.			+0.04	
	Net Height	L	5.08	5.12	

Saturation Data

Date	Hour	Pressures Interior, psi		Burette	
		Top	Bott.	Top cc	Bott. cc

Consolidation Data

Chamber Pressure, psi	0	52/50		
Interior Burette				
Exterior Burette		+4.0		
Volume, cc	160.9	164.9		
Dry Density, pcf	102.1			

Test Data and Computations

Run No.	Temp. °C	Temp. Corr. R_T	Time	Time int. t sec.	Burette Reading cc		Backpressure cm		Water Head cm	Effect. Back-press cmH$_2$0	Effect. Head cmH$_2$0 (H)	Apparatus Corr. (C)	K_{20}
					Hi	Lo							
0			3^{15}		90.0	28.4					61.6	1.0	
1	20.7	.983	3^{30}	900	88.1	30.1					58.0		1.56×10^{-6}
2	20.7	.983	$3^{32}/4^{02}$	1800	84.9	33.2					51.7		1.48×10^{-6}
3	20.7	.983	$4^{05}/5^{05}$	3600	79.7	38.3					41.4		1.43×10^{-6}

Avg. 1.49×10^{-6}

Burettes Equivalent Level		Burettes Equivalent Level		$2.3 \times \frac{a_L a_s}{a_L + a_s}$
Small	Large	Small	Large	0.3426

Formula:

$$k = 2.3 \times \frac{a_L a_s}{a_L + a_s} \times \frac{L}{At} \times \log \frac{H_1}{H_2} \times R_T \times C$$

Run No.	Dens. pcf	Void Ratio	$\frac{H_1}{H_2}$	Log $\frac{H_1}{H_2}$	Permeability 1 cm/sec = 2834.6 ft/day	
					cm/sec	ft/day
1			1.062	0.0262		
2			1.122	.0499		
3			1.249	.0965		

a_L = area of large burette
a_s = area of small burette
A_L = 0.303 cm^2
A_s .293 cm^2

Tested by: WT
Computed by: WT
Checked by:

R.C. HARLAN AND ASSOCIATES
P. O. BOX 7717 • SAN FRANCISCO, CALIFORNIA 94120

WORK SHEET -- BACKPRESSURE PERMEABILITY TEST

Project IECO - Union Carbide, Uravan Colo!		Date 4-14-80
Hole No. Borrow (2) Area	Sample No. J-1 (2173)	Depth 2'-6'
Direction of Permeability Horizontal ☐ Vertical ☑	Target Remolded @ 102.3 pcf ± 17.5 % moist. Undisturbed @ pcf % moist.	

Sample Description: Batch same + ~ 2.5% greater MC than first Borrow

Weights and Moisture Contents

Item	Before	After Test	wash After Test
Tare #		J	213
Tare No. wT	709.1	103.6	157.6
Wet Soil + Tare, gm	1020.0	437.0	
Dry Soil + Tare, gm		367.1	158.0
Water, gm	47.0	69.9	
Wet Soil, gm	310.9		
Dry Soil, gm	263.9	263.5 263.9	.4
Moisture Content, %	17.8	26.5	

Specimen Dimensions

			0	52/50	
Area in cm^2	Top		31.65		
	Middle		31.65		
	Bottom		31.70		
	Average				
	Membrane Corr.				
	Net Area	A	31.67	32.11	
Height in cm	Incl. Ht. Corr.				
	Height Corr.			+.04	
	Net Height	L	5.08	5.12	

Saturation Data

Date	Hour	Pressures Interior, psi		Burette	
		Top	Bott.	Top cc	Bott. cc

Consolidation Data

Chamber Pressure, psi	0	52/50		
Interior Burette				
Exterior Burette		+3.5		
Volume, cc	160.9	164.4		
Dry Density, pcf	102.3			

Test Data and Computations

Run No.	Temp. °C	Temp. Corr. R_T	Time	Time int. t sec.	Burette Reading cc Hi	Burette Reading cc Lo	Backpressure cm		Water Head cm	Effect. Back-press cmH$_2$0	Effect. Head cmH$_2$0 (H)	Apparatus Corr. (C)	K_{20}
0			1045		88	30.2					58.6	1.0	
1	21.5	.965	1102	1020	86.8	32.0					54.8	↓	1.50×10^{-6}
2	21.5	.965	1103/1133	1800	83.6	35.1					48.5		1.55×10^{-6}
3	21.8	.958	1135	3600	78.7	39.9					38.8		1.41×10^{-6}
			1235										

Avg = 1.49×10^{-6}

Burettes Equivalent Level		Burettes Equivalent Level		$2.3 \times \frac{a_L a_s}{a_L + a_s}$
Small	Large	Small	Large	0.3426

Formula:

$$k = 2.3 \times \frac{a_L a_s}{a_L + a_s} \times \frac{L}{At} \times \log \frac{H_1}{H_2} \times R_T \times C$$

Run No.	Dens. pcf	Void Ratio	$\frac{H_1}{H_2}$	Log $\frac{H_1}{H_2}$	Permeability 1 cm/sec = 2834.6 ft/day cm/sec	ft/day
			1.069	0.0291		
			1.130	.0530		
			1.250	.0969		

a_L = area of large burette
a_s = area of small burette
A_L = 0.303 cm^2
A_s = .293

Tested by: WT
Computed by: WT
Checked by:

R.C. HARLAN AND ASSOCIATES
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WORK SHEET -- BACKPRESSURE PERMEABILITY TEST

Project IECO - Union Carbide, Uravan Colo.'
Date 4-16-80
~~Hole No.~~ Borrow Area
Sample No. 5-1
Depth 2'-6'

Direction of Permeability
Horizontal ☐ Vertical ☑

Remolded @ 114.3 pcf ~ 15 % moist.
Undisturbed @ pcf % moist.

Sample Description: Borrow material 97% of MAX D1557

Weights and Moisture Contents

Item	Before	After Test	Wash After Test
Tare #		M	A
Tare ~~No.~~ wt	708.8	101.5	110.9
Wet Soil + Tare, gm	1048.0	456.5	
Dry Soil + Tare, gm		396.8	111.0
Water, gm	43.8	59.7	
Wet Soil, gm	339.2		
Dry Soil, gm	295.4	295.3 295.4	.1
Moisture Content, %	14.8	20.2	

Specimen Dimensions

			0		
Area in cm²	Top		31.65		
	Middle		31.65		
	Bottom		31.70		
	Average				
	Membrane Corr.				
	Net Area	A	31.67	32.11	
Height in cm	Incl. Ht. Corr.				
	Height Corr.			+.04	
	Net Height	L	5.08	5.12	

Saturation Data

Date	Hour	Pressures Interior, psi Top	Pressures Interior, psi Bott.	Burette Top cc	Burette Bott. cc

Consolidation Data

Chamber Pressure, psi	0	52/50		
Interior Burette				
Exterior Burette		+3.5		
Volume, cc	160.9	164.4		
Dry Density, pcf	114.6			

Test Data and Computations

Run No.	Temp. °C	Temp. Corr. R_T	Time	Time int. t sec.	Burette Reading cc Hi	Burette Reading cc Lo	Backpressure cm		Water Head cm	Effect. Back-press cmH_2O	Effect. Head cmH_2O (H)	Apparatus Corr. (C)	K_{20}
0			109		90.0	28.3					61.7	1.0	
1	21.0°	.976	124	900	89.3	29.1					60.2		6.34×10^{-7}
2	21.0	.976	125/158	1980	88.3	30.4					57.9		4.58×10^{-7}
3	21.0	.976	200/300	3600	87.0	31.9					55.1		3.20×10^{-7}

Avg. 4.71×10^{-7}

Burettes Equivalent Level Small	Burettes Equivalent Level Large	Burettes Equivalent Level Small	Burettes Equivalent Level Large	$2.3 \times \frac{a_L a_s}{a_L + a_s}$
				0.3426

Formula:

$$k = 2.3 \times \frac{a_L a_s}{a_L + a_s} \times \frac{L}{At} \times \log \frac{H_1}{H_2} \times R_T \times C$$

Run No.	Dens. pcf	Void Ratio	$\frac{H_1}{H_2}$	$\log \frac{H_1}{H_2}$	Permeability (1 cm/sec = 2834.6 ft/day) cm/sec	Permeability (1 cm/sec = 2834.6 ft/day) ft/day
1			1.025	0.0107		
2			1.040	.0170		
3			1.051	.026		

a_L = area of large burette
a_s = area of small burette
A_L 0.303 cm^2
A .293

Tested by: WT
Computed by: WT
Checked by:

R. C. HARLAN AND ASSOCIATES
geotechnical consultants

WORK SHEET -- BACKPRESSURE PERMEABILITY TEST

Project IECO-Union Carbide, Uravan, Colo. | Date 4-9-80

Hole No. TD-7 Shale - block | Sample No. (217.8) | Depth

Direction of Permeability: Horizontal ☐ Vertical ☑

Remolded @ pcf % moist.

Undisturbed @ ✓ pcf % moist.

Sample Description:

Weights and Moisture Contents

Item	Before	After Test	Wash After Test
Tare #		Z	210
Tare ~~No.~~ wt		111.0	161.1
Wet Soil + Tare, gm		274.2	
Dry Soil + Tare, gm		252.1	162.6
Water, gm	15.7	22.1	
Wet Soil, gm	158.3		
Dry Soil, gm	142.6	141.1 142.6	1.5
Moisture Content, %	11.0	15.5	

Specimen Dimensions

			0		
Area in cm²	Top		18.50		
	Middle		18.50		
	Bottom		18.50		
	Average				
	Membrane Corr.				
	Net Area	A	18.5	19.01	
Height in cm	Incl. Ht. Corr.				
	Height Corr.			+.05	
	Net Height	L	4.0	4.05	

Saturation Data

Date	Hour	Pressures Interior, psi Top	Pressures Interior, psi Bott.	Burette Top cc	Burette Bott. cc

Consolidation Data

Chamber Pressure, psi	0	52/50		
Interior Burette				
Exterior Burette		+3.0		
Volume, cc	74.0	77.0		
Dry Density, pcf	120.2			

Test Data and Computations

Run No.	Temp. °C	Temp. Corr. R_T	Time	Time Int. t sec.	Burette Reading cc Hi	Burette Reading cc Lo	Backpressure cm		Water Head cm	Effect. Back-press cmH_2O	Effect. Head cmH_2O (H)	Apparatus Corr. (C)	K_{20}
0			11 45		90.1	28.1					62.0	1.0	
1	21.2	.972	12 02	900	83.8	34.3					49.5		7.71×10^{-6}
2	21.2	.972	12 02/12 32	1800	77.3	41.6					35.7		5.60×10^{-6}
3	21.5	.965	12 35	3600	70.4	49.1					21.3		4.39×10^{-6}
			1 35										

Avg. 5.90×10^{-6}

Burettes Equivalent Level Small	Burettes Equivalent Level Large	Burettes Equivalent Level Small	Burettes Equivalent Level Large	$2.3 \times \frac{a_L a_s}{a_L + a_s}$
				0.3426

Formula:

$$k = 2.3 \times \frac{a_L a_s}{a_L + a_s} \times \frac{L}{At} \times \log \frac{H_1}{H_2} \times R_T \times C$$

Run No.	Dens. pcf	Void Ratio	$\frac{H_1}{H_2}$	$\log \frac{H_1}{H_2}$	Permeability (1 cm/sec = 2834.6 ft/day) cm/sec	ft/day
1			1.293	0.1116		
2			1.387	.1421		
3			1.676	.2242		

a_L = area of large burette

a_s = area of small burette

A_L 0.303 cm²

A_S .293 cm²

Tested by: WT | Computed by: WT | Checked by:

R.C. HARLAN AND ASSOCIATES
geotechnical consultants

WORK SHEET -- BACKPRESSURE PERMEABILITY TEST

Project IECO – Union Carbide, Uravan Colo'		**Date** 4-3-80
Hole No. 7D-9 grey shale	**Sample No.**	**Depth**

Direction of Permeability
Horizontal ☐ Vertical ☑

Remolded @ pcf % moist.
Undisturbed @ ✓ pcf % moist.

Sample Description:

Weights and Moisture Contents

Item tare #	Before	After Test BB	wash After ∂Test
Tare ~~No.~~ wt		158.4	102.5
Wet Soil + Tare, gm		317.2	
Dry Soil + Tare, gm		292.1	
Water, gm	19.3	25.1	
Wet Soil, gm	154.2		
Dry Soil, gm	135.3	133.8 135.3	1.5
Moisture Content, %	14.3	18.6	

Specimen Dimensions

			0		
Area in cm^2	Top		18.50		
	Middle		18.50		
	Bottom		18.50		
	Average				
	Membrane Corr.				
	Net Area	A	18.50	18.50	
Height in cm	Incl. Ht. Corr.				
	Height Corr.			0	
	Net Height	L	4.10	4.10	

Saturation Data

Date	Hour	Pressures Interior, psi		Burette	
		Top	Bott.	Top cc	Bott. cc

Consolidation Data

Chamber Pressure, psi	0	12/60		
Interior Burette				
Exterior Burette		0		
Volume, cc	75.9	75.9		
Dry Density, pcf	111.2			

Test Data and Computations

Run No.	Temp. °C	Temp. Corr. R_T	Time	Time Int. sec.	Burette Reading cc Hi	Burette Reading cc Lo	Backpressure cm		Water Head cm	Effect. Back press cmH_20	Effect. Head cmH_20 (H)	Apparatus Corr. (C)	K_{20}
0			155		86.9	30.5					56.4	1.0	
1	20.0	1.00	255	3600	81.1	36.4					44.7		2.13×10^{-6}
2	20.0	1.00	257/327	1800	78.9	38.8					40.1		1.99×10^{-6}
3	20.2	.995	330/530	7200	72.4	45.6					26.8		1.84×10^{-6}

Avg. 1.99×10^{-6}

Burettes Equivalent Level Small	Burettes Equivalent Level Large	Burettes Equivalent Level Small	Burettes Equivalent Level Large	$2.3 \times \frac{a_L a_s}{a_L + a_s}$
				0.346

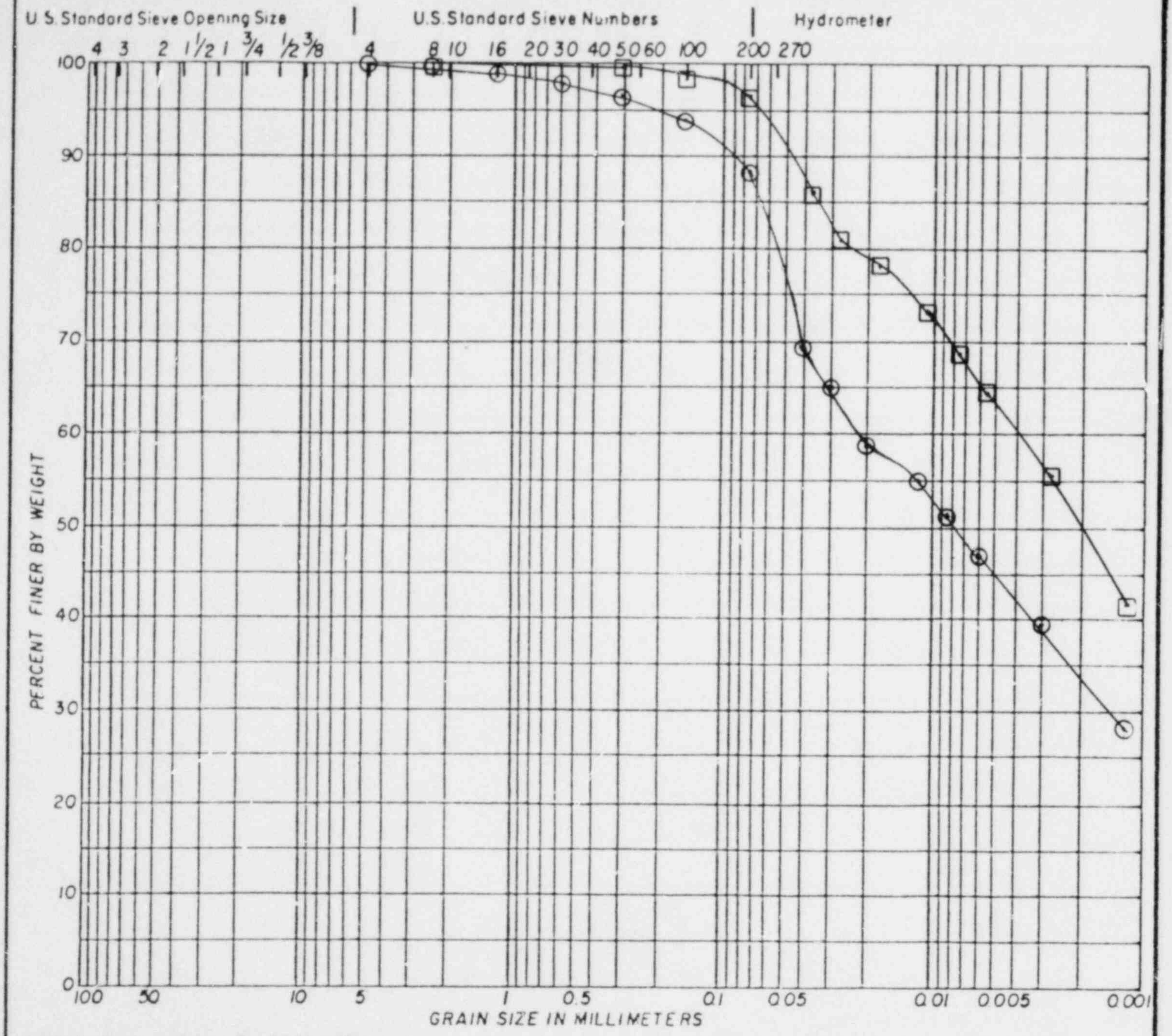
Formula:

$$k = 2.3 \times \frac{a_L a_s}{a_L + a_s} \times \frac{L}{At} \times \log \frac{H_1}{H_2} \times R_T \times C$$

Run No.	Dens. pcf	Void Ratio	$\frac{H_1}{H_2}$	$\log \frac{H_1}{H_2}$	Permeability 1 cm/sec = 2834.6 ft/day cm/sec	ft/day
1			1.262	0.1011		
2			1.115	.6473		
3			1.496	.1750		

a_L = area of large burette
a_s = area of small burette
A_L 0.303 cm^2
A_s .293

Tested by: WT
Computed by: WT
Checked by:



ASTM Designation: D 422-63

COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

3" #4 #10 #40 #200 0.005

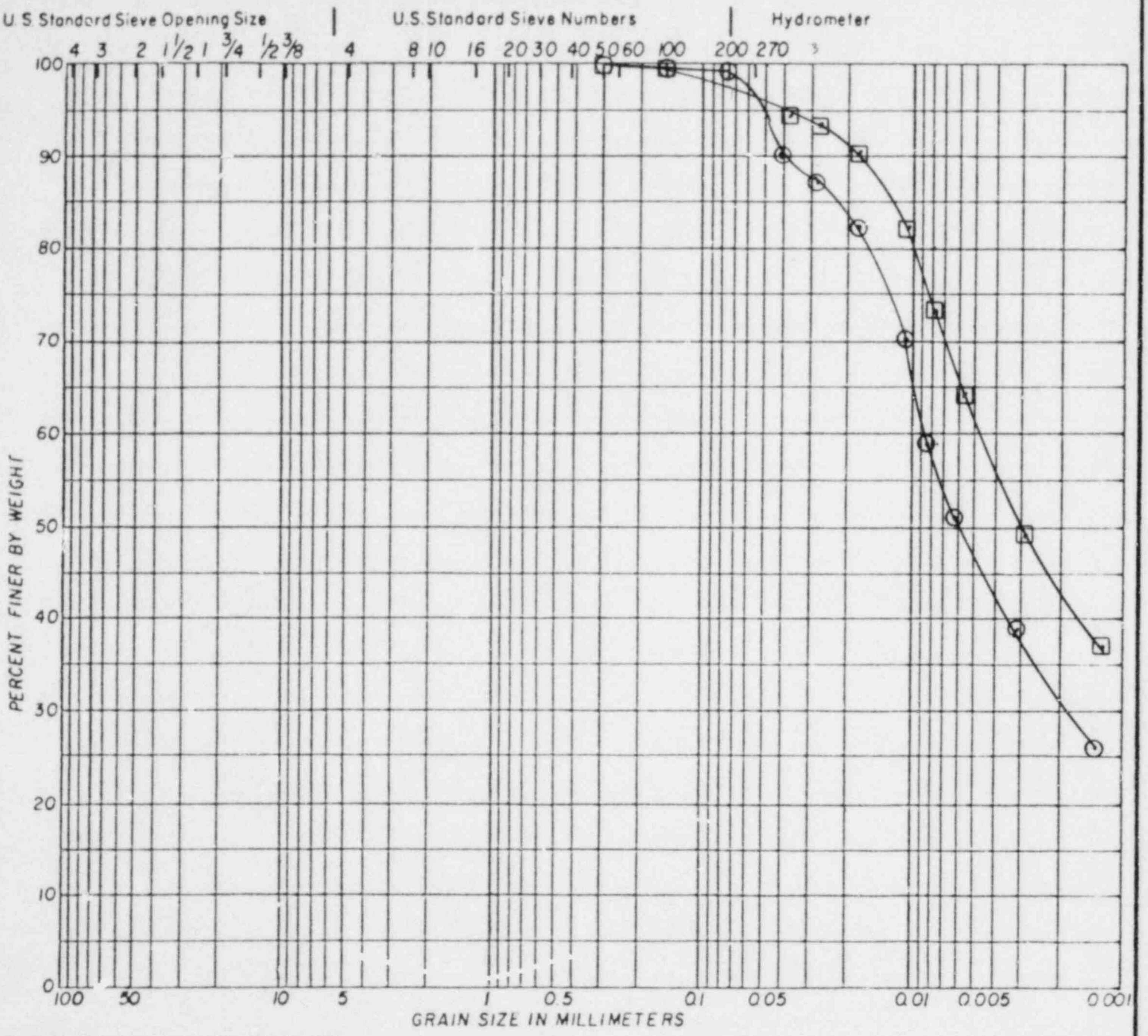
Symbol	Sample Source	Classification
○	TT-2 (5-1) - 3'-8' Depth	Dark brown sandy clay
☐	Borrow Area - 2'-6' Depth	Brownish-gray sandy clay

R.C. Harlan AND ASSOCIATES
San Francisco, California

Proj. No. 217.8 Appr. ____ Date ____

PARTICLE SIZE ANALYSIS
IECO, Union Carbide
Uravan, Colo.

FIGURE



ASTM Designation: D 422-63

COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

3"   #4   #10   #40   #200   0.005

Symbol	Sample Source	Classification
○	Shale - black TD-7	CL
□	Shale - grey TD-9	CL

R.C. Harlan AND ASSOCIATES
San Francisco, California

Proj. No. 217.8 Appr. ____ Date ____

PARTICLE SIZE ANALYSIS
IECO - Union Carbide
Uravan, Colo.

FIGURE

LABORATORY COMPACTION

ASTM ~~D1557~~ D 698

METHOD A

Project No. 217.8

Project Name IECO Union Carbide

Date 4-2-80

Tested By

Sample Source TT-2

Sample Description dark brown sandy clay

Test No.

Volume of Mold: 1/30

Rammer Weight: 5.5 lb

Drop: 12"

No. of Layers: 3

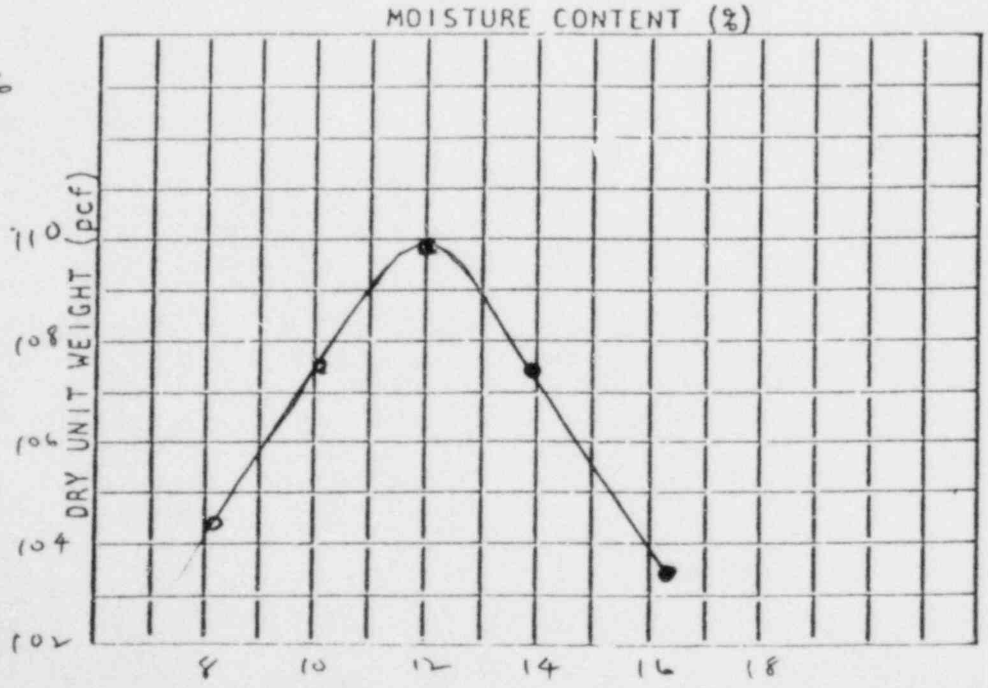
Blows/Layer: 25

Remarks:

all passing # 4

Trial No.	1	2	3	4	5
Estimated Moisture Content (%)	6	8	10	12	4
Tare No.	QQ	OO	RR	GG	5
Tare & wet weight (gm)	630.3	718.4	726.0	574.0	663.3
Tare & dry weight (gm)	590.2	661.2	661.0	520.1	623.3
Tare weight (gm.)	191.2	186.6	194.2	189.1	133.8
Weight of water (gm.)	40.1	57.2	65.0	53.9	40.0
Weight of dry soil (gm.)	399.0	474.6	466.8	331.0	489.5
Moisture content (%)	10.1	12.0	13.9	16.3	8.2
Wet weight of soil & mold (lbs.)	6250	6322	6307	6281	6168
Weight of mold (lbs.)	4460	→			
Weight of wet soil (lbs.)	3.946	4.10	4.071	4.014	3.765
Wet unit weight (lbs.)	118.4	123.1	122.2	120.4	113
Dry unit weight (lbs.)	107.5	109.9	107.3	103.5	104.4

97% γmax = 106.6 pcf



Max. γ_D

109.9 pcf

Optimum Moisture

12 %

LABORATORY COMPACTION

ASTM [redacted] D 698

METHOD A

Test No.

Project No. 217.8

Project Name IECO Union Carbide

Date 4-2-80

Tested By WT.

Sample Source Borrow-Area

Sample Description brownish-gray sandy clay

Volume of Molds: 1/30

Rammer Weight: 5.5

Drop: 12

No. of Layers: 3

Blows/Layer: 25

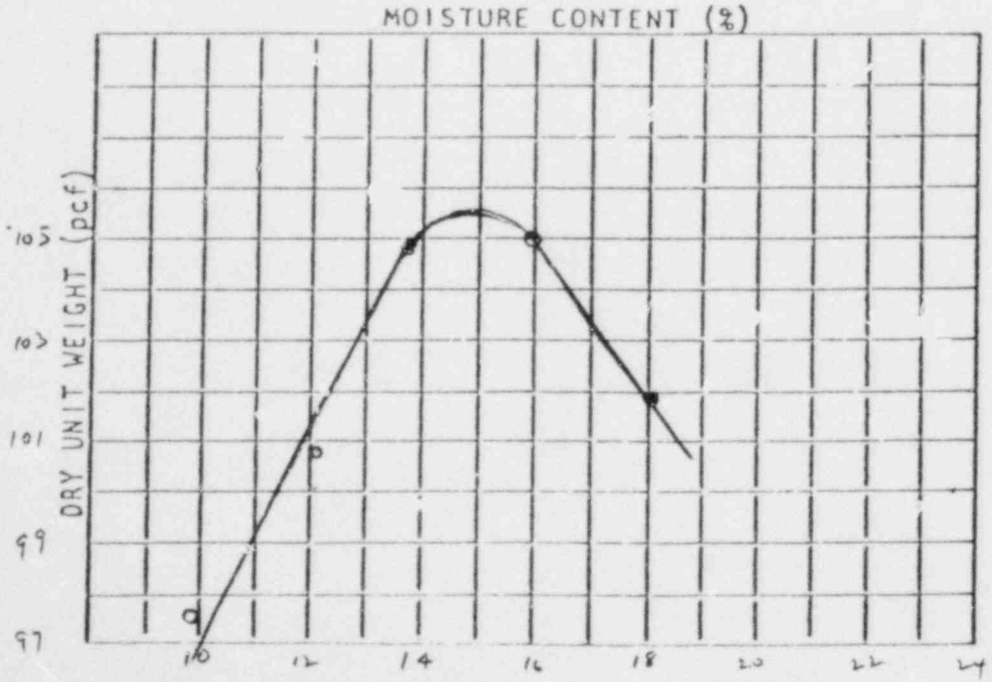
Remarks:

brownish-gray sandy clay

all passing # 4

97% max 102.3 pcf

Trial No.	1	2	3	4	5
Estimated Moisture Content (%)	6	8	10	12	4
Tare No.	EE	PP	FF	LL	E3
Tare & wet weight (gm)	778.7	699.3	697.3	735.9	609.7
Tare & dry weight (gm)	715.2	636.9	627.9	652.8	564.0
Tare weight (gm.)	191.8	184.1	191.3	193.9	105.1
Weight of water (gm.)	63.5	62.4	69.4	83.1	45.7
Weight of dry soil (gm.)	523.4	452.8	436.6	458.9	458.9
Moisture content (%)	12.1	13.8	15.9	18.1	9.9
Wet weight of soil & mold (lbs.)	6168	6265	6300	6281	6080
Weight of mold (lbs.)	4460				
Weight of wet soil (lbs.)	3.76.	.979	4.056	4.015	3.571
Wet unit weight (lbs.)	113.0	119.4	121.7	120.4	107.1
Dry unit weight (lbs.)	100.8	104.9	105.0	101.9	97.5



Max. γ_D 105.5 pcf

Optimum Moisture 15.0 %

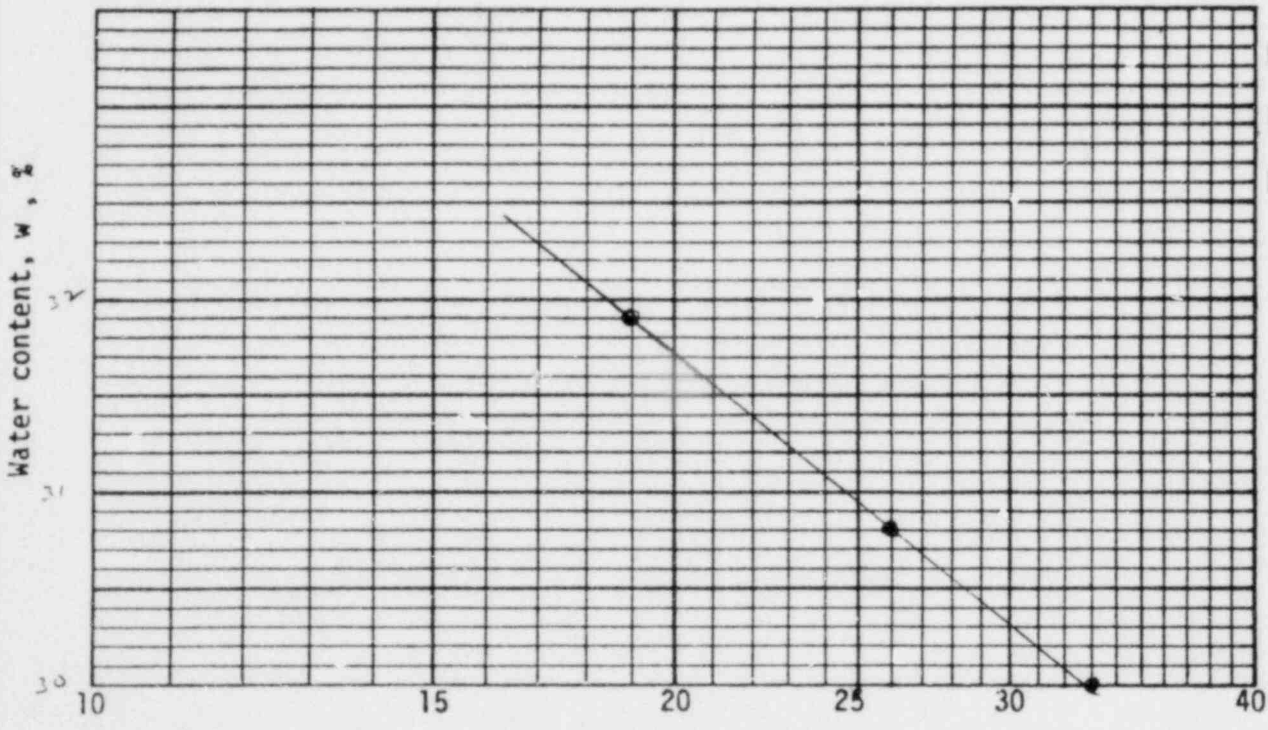
ATTERBERG LIMITS DETERMINATION

Project: IECO Union Carbide Uravan, Colo. Date: 4-3-80

~~Hole No~~. Borrow-TT-2 Sample No. (S-1) Job.No. 217.8

LIQUID LIMIT

	Run No.		1	2	3	4	5	6
	Tare No.		S-49	S 53	S-34			
Weight in grams	Tare plus wet soil		44658	36.520	37.650			
	Tare plus dry soil		36.829	30.791	31.825			
	Water	W_w	7.829	5.729	5.825			
	Tare		12.281	12.180	12.469			
	Dry Soil	W_s	24.548	18.611	19.356			
	Water content, %	w	31.9	30.8	30.0			
	Number of blows		19	26	33			



Number of Blows

LL 31

PL 18

PI 13

Soil Symbol from Plasticity Chart CL

PLASTIC LIMIT

	Run No.		1	2	3	4	5	Natural Water Content
	Tare No.		S-70	S-44				
Weight in grams	Tare plus wet soil		37.871	26.183				
	Tare plus dry soil		33.870	24.013				
	Water	W_w	4.001	2.170				
	Tare		12.151	12.288				
	Dry soil	W_s	21.719	11.725				
	Water content, %	w	18.4	18.5				
	Plastic Limit, w_p							

Remarks: PH-6

Tested by:
Computed by: WT
Checked by:

R.C. HARLAN AND ASSOCIATES
geotechnical consultants

ATTERBERG LIMITS DETERMINATION

Project: IECO – Union Carbide, Uravan Colo

Date: 4-2-80

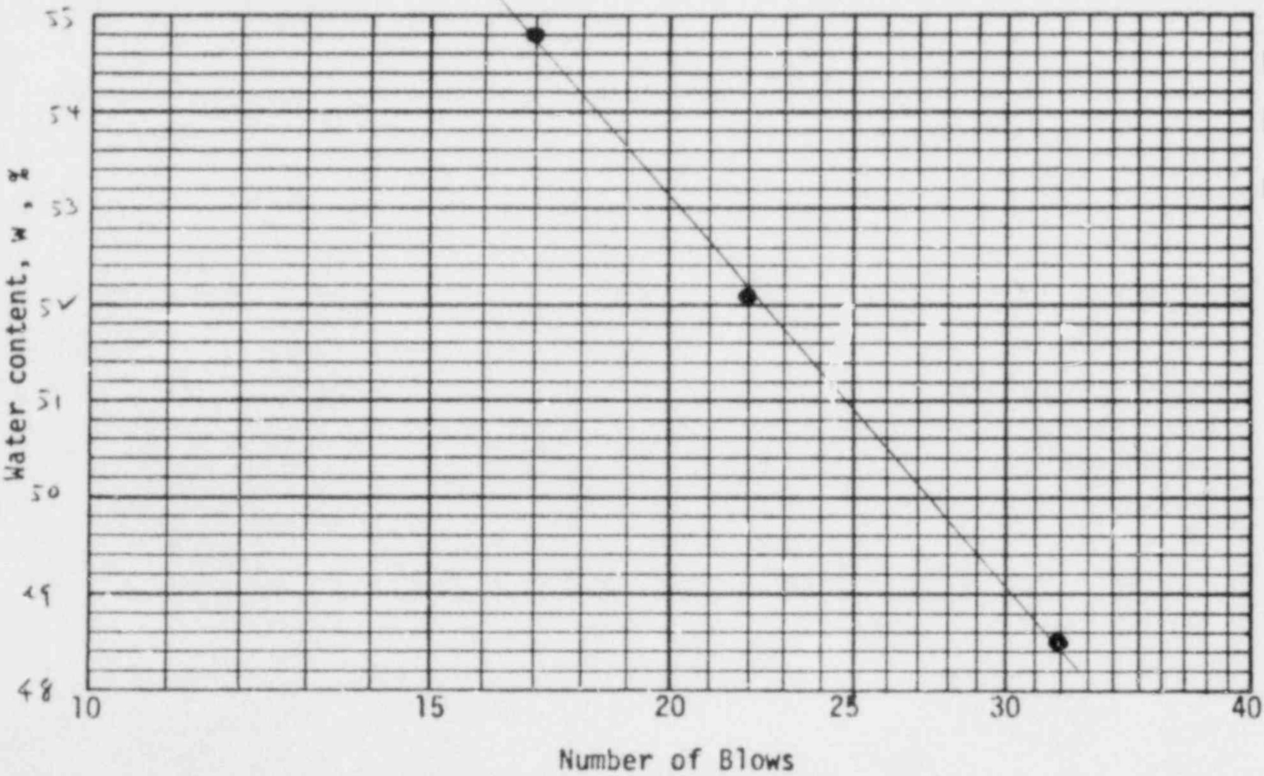
Hole No. Borrow Area

Sample No.

Job.No. 217.8

LIQUID LIMIT

	Run No.		1	2	3	4	5	6
	Tare No.		S-2	S-26	S-65			
Weight in grams	Tare plus wet soil		41.833	35.875	33.810			
	Tare plus dry soil		31.411	27.837	26.790			
	Water	W_w	10.422	8.038	7.020			
	Tare		12.390	12.401	12.303			
	Dry Soil	W_s	19.021	15.436	14.417			
	Water content, %	w	54.8	52.1	48.5			
	Number of blows		17	22	32			



LL 51

PL 28

PI 23

Soil Symbol from Plasticity Chart CH

PLASTIC LIMIT

	Run No.		1	2	3	4	5	Natural Water Content
	Tare No.		S-41	S-1				
Weight in grams	Tare plus wet soil		28.880	28.780				
	Tare plus dry soil		25.608	25.558				
	Water	W_w	3.272	3.222				
	Tare		12.339	12.339				
	Dry soil	W_s	13.269	13.219				
	Water content, %	w	24.7	27.4		2 5		
	Plastic Limit, w_p							

Remarks:
PH - 5

Tested by: WT
Computed by:
Checked by:

R.C. HARLAN AND ASSOCIATES
geotechnical consultants

ATTERBERG LIMITS DETERMINATION

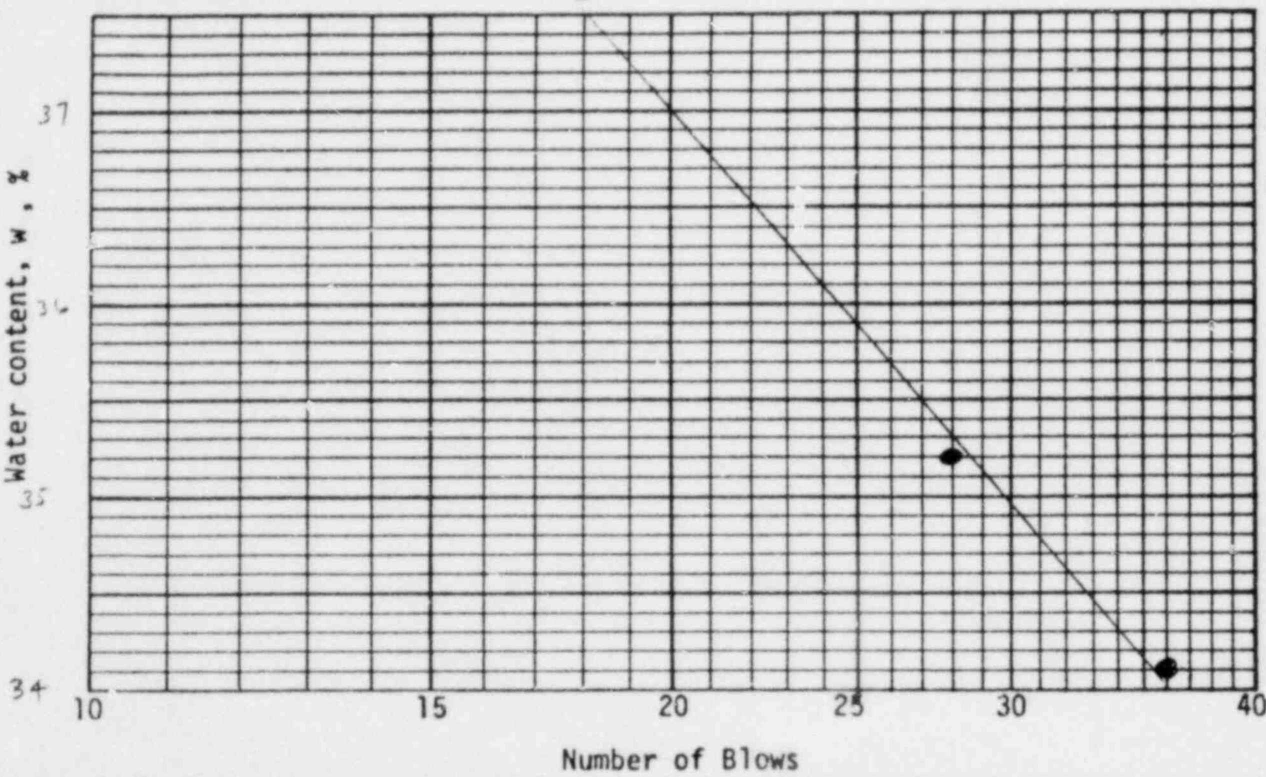
Project: (ECO- Union Carbide - Uravan, Colo | Date: 4-8-80

Hole No. TD - 7 | Sample No. (S-1) | Job.No. 217.8

Shale - grey - black

LIQUID LIMIT

	Run No.		1	2	3	4	5	6
	Tare No.		S-55	S-18	S-48			
Weight in grams	Tare plus wet soil		41.764	40.358	39.000			
	Tare plus dry soil		33.642	33.122	32.190			
	Water	W_w	8.122	7.236	6.810			
	Tare		12.112	12.577	12.253			
	Dry Soil	W_s	21.530	20.545	19.937			
	Water content, %	w	37.7	35.2	34.2			
	Number of blows		18	28	36			



LL 36

PL 19

PI 17

Soil Symbol from Plasticity Chart ______

PLASTIC LIMIT

	Run No.		1	2	3	4	5	Natural Water Content
	Tare No.		S-72	S-63				
Weight in grams	Tare plus wet soil		32.190	28.581				
	Tare plus dry soil		28.992	25.932				
	Water	W_w	3.198	2.649				
	Tare		12.272	12.197				
	Dry soil	W_s	16.720	13.735				
	Water content, %	w	19.1	19.3		19.2		
	Plastic Limit, w_p							

Remarks: PH - 5 When processing the gray shale, noticed brown clay interbedded w/shale. Processed sample was grayish-brown-

Tested by:
Computed by: WT
Checked by:

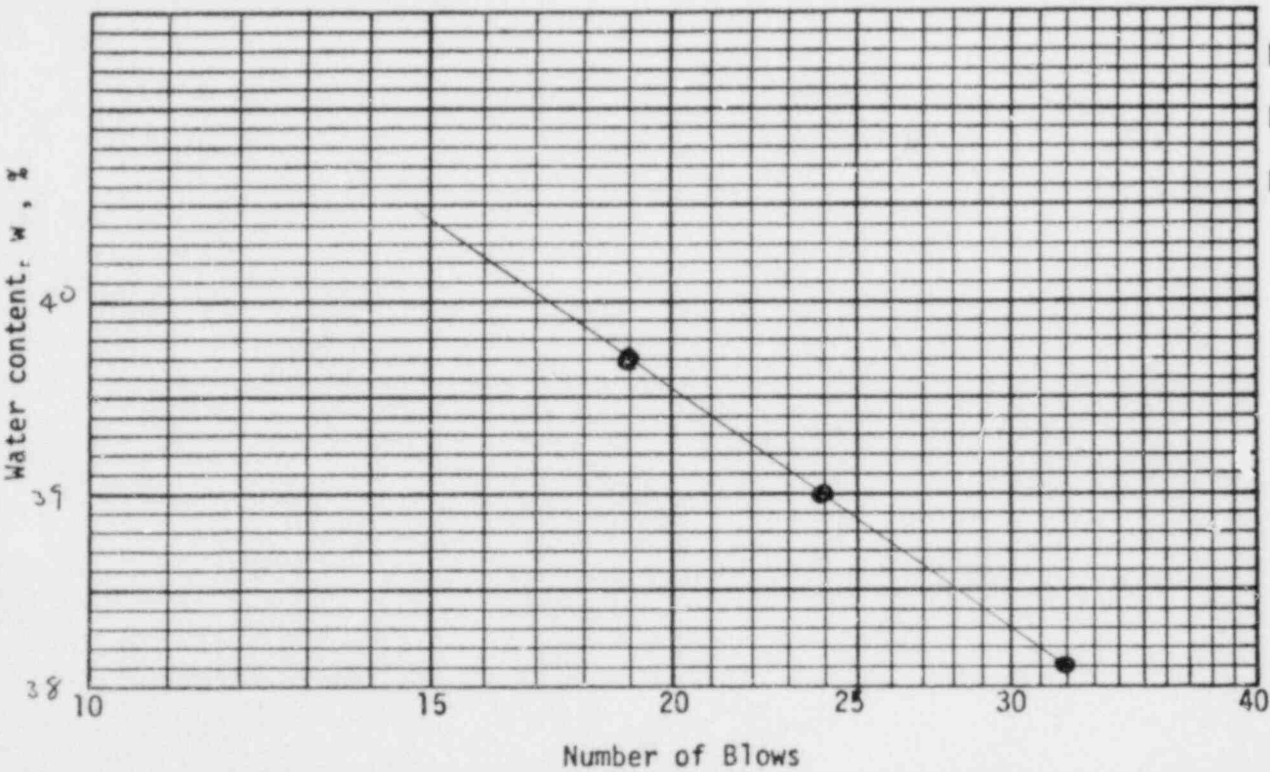
R.C. HARLAN AND ASSOCIATES
geotechnical consultants

ATTERBERG LIMITS DETERMINATION

Project: IECO - Union Carbide, Uravan Colo.		Date: 4-8-80
Hole No. Shale - black	~~Sample No.~~ TD-10A 236/24.5	Job.No. 417.8

LIQUID LIMIT

			1	2	3	4	5	6
	Run No.		1	2	3	4	5	6
	Tare No.		S-11	S-68	S-32			
Weight in grams	Tare plus wet soil		35.243	34.858	41.052			
	Tare plus dry soil		28.742	28.520	33.128			
	Water	W_w	6.501	6.338	7.924			
	Tare		12.378	12.272	12.333			
	Dry Soil	W_s	16.364	16.248	20.795			
	Water content, %	w	39.7	39.0	38.1			
	Number of blows		19	24	32			



LL 39

PL 24

PI 15

Soil Symbol from Plasticity Chart ______

PLASTIC LIMIT

	Run No.		1	2	3	4	5	Natural Water Content
	Tare No.		S-38	S-50				
Weight in grams	Tare plus wet soil		30.930	29.952				
	Tare plus dry soil		27.378	26.582				
	Water	W_w	3.552	3.370				
	Tare		12.361	12.243				
	Dry soil	W_s	15.017	14.339				
	Water content, %	w	23.7	23.5	23.6			
	Plastic Limit, w_p							

Remarks: PH-5

Tested by:
Computed by: WT
Checked by:

DETERMINATION OF
NATURAL WATER CONTENT AND DRY DENSITY

R. C. HARLAN AND ASSOCIATES

PROJECT IECO PROJECT NO. Union Carbide — DATE 4-2-80

SAMPLE DESCRIPTION ____ SAMPLE LOCATION ____ TESTED BY WT

	as Rec'd		as Rec'd			as Rec'd		as Rec'd		
HOLE NUMBER	Borrow		TT-2			TD-9		TD-7		
DEPTH (feet)	Area					dark grey		Black		
LENGTH OF SAMPLE (inches)										
DIAMETER OF SAMPLE (inches)										
VOLUME OF SAMPLE (cubic feet)										
WET WEIGHT OF SAMPLE (gms)										
CUP NUMBER	204		CC			214		217		
WET WEIGHT + CUP (gms)	721.5		712.3			302.7		273.7		
DRY WEIGHT + CUP (gms)	656.2		650.8			287.2		261.6		
WEIGHT OF WATER (gms)	65.3		61.5			15.5		12.1		
WEIGHT CUP (gms)	158.3		164.9			159.9		161.2		
WEIGHT DRY SOIL (gms)	497.9		485.9			127.3		100.4		
MOISTURE CONTENT (percent)	13.1		12.7			12.2		12.1		
WET WEIGHT OF SAMPLE (lbs)										
NATURAL DENSITY OF SAMPLE (pcf)										
DRY WEIGHT OF SAMPLE (lbs)										
DRY DENSITY OF SAMPLE (pcf)										
Visual Description	Save for sieve-hydro - 5 ea									

WORK SHEET - SPECIFIC GRAVITY TESTS

Project: IECO Union-Carbide	Job No. 217.8	Hole No.	Date 4-3-80

SPECIFIC GRAVITY OF SOLIDS (G_s)

Sample No.			TT-2		Borrow Area			
Flask No.			374		377			
Temperature of Water and Soil, T, °C			21.0		21.0			
Pan No.								
Wt. in grams	Pan + Dry Soil							
	Pan							
	Dry Soil	W_s	102.8		115.1			
	Flask + Water at T, °C	W_{bw}	669.9		675.3			
	$W_s + W_{bw}$		772.7		790.4			
	Flask + Water + Immersed Soil	W_{bws}	733.5		748.0			
	Displaced Water, $W_s + W_{bw} - W_{bws}$		39.2		42.4			
Correction Factor		K	0.9998		0.9998			
$(W_sK) \div (W_s + W_{bw} - W_{bws})$		G_s	2.62		2.71			

APPARENT (G_a) AND BULK (G_m) SPECIFIC GRAVITY

						Temp. °C	Corr. Factor K
Sample No.							
Temperature of Water and Soil, T, °C						14	1.0010
Wt. in grams	Pan + Saturated Surface - Dry Soil					15	1.0009
	Tare Weight					16	1.0007
	Saturated Surface - Dry Soil	B				17	1.0006
	(Wire Basket + Soil) in Water					18	1.0004
	Wire Basket in Water					19	1.0002
	Saturated Soil in Water	C				20	1.0000
	Tare Weight + Dry Soil					21	0.9998
	Tare Weight					22	0.9996
	Dry Soil	A				23	0.9993
Correction Factor		K				24	0.9991
(AK) ÷ (A-C) (Apparent)		G_a				25	0.9988
(AK) ÷ (B-C) (Bulk)		G_m				26	0.9986
Remarks:						27	0.9983
						28	0.9980
						29	0.9977
						30	0.9974
						31	0.9971

Tested by;	Computed by:	Checked by: