Golder Associates
CONSULTING GEOTECHNICAL ENGINEERS

REPORT TO
KER PRIESTMAN & ASSOCIATES LTD.
RE:
TAILING STORAGE AND MINE PLANT FACILITIES
CADILLAC EXPLORATIONS LTD.

NORTHWEST TERRITORIES

N3L3 - 0932 Sept.'80

DISTRIBUTION:

6 copies - Ker Priestman & Associates Ltd.
Victoria, British Columbia

2 copies - Kilborn Engineering Ltd.
Vancouver, British Columbia

2 copies - Golder Associates
Vancouver, British Columbia

September 1980 802-1073

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

On the basis of previous Golder Associates (GA) work, and in consultation with Ker Priestman & Associates (KPA), Kilborn Engineering Ltd. (KEL) and Cadillac Explorations Ltd. (CEL), two potential tailing retention areas, namely T2 and T3, were selected for further study. These were two of nine possible sites detailed in GA Report 802-1073, dated May 1980. This report details the results of the field and laboratory investigation undertaken for the tailing storage areas and provides design and construction recommendations for the proposed construction.

The report also deals with mine plant foundations. Two areas, P1 and P2, had been selected for detailed investigation; however, on closer inspection in the field, site P1 was eliminated because of undesirable foundation and topographic conditions. Consequently, detailed investigation was carried out only at site P2 and, in particular, at a location selected in the field by CEL personnel.

Recommendations with respect to general flood control embankments for the mine and camp sites are made, together with comments regarding general foundation conditions for ancillary structures at the site. Recommendations are also made for spill control works for the fuel tank farm.

The mine site location is shown on the Key Plan, Figure 1, and the tailing disposal areas, plant site location, and other facilities dealt with in this report, are shown in detail on Figures 2, 3 and 4.

2.0 SITE LOCATION AND DESCRIPTION

The proposed mine and camp site are located in the Prairie Creek Valley at approximately 61° 34' North latitude, 124° 47' West longitude in the Northwest Territories. The area is typically mountainous and the topography and surface drainage patterns are controlled by the underlying rock units.

Alternative tailing retention area T2 is located on the floodplain of Prairie Creek near the existing camp site location, as shown on Figure 2. Alternative T3 is located approximately 1/2 mile downstream of the present camp site location on the floodplain on the left bank of Prairie Creek, as shown on Figure 4. The location of alternative plant site P2 and the proposed locations for ancillary construction and stream training works are shown on Figure 3.

3.0 SEISMICITY

The mine site is located near the boundary between Zones 1 and 2 of the National Building Code Seismic Zoning Map (1970). This implies a design earthquake acceleration of approximately 3 per cent gravity for a 100 year return period. According to the Pacific Geoscience Center, the closest recorded earthquake epicentre is approximately 350 miles to the northwest of the proposed mine site. Consequently, bedrock accelerations higher than 3 per cent gravity, due to local earthquakes, are not considered and this value is used for design calculations.

4.0 FIELD INVESTIGATION

4.1 Introduction

The field investigation was carried out between July 7th and September 3rd, 1980. Two tailing retention areas, T2 and T3, and one plant site area, P2, were selected for detailed subsurface investigation from the nine potential tailing retention areas and two potential plant site areas identified in our preliminary report (GA Report 802-1073, dated May 1980).

A total of 11 boreholes were put down in the three areas using a skid mounted Longyear 38 diamond drill supplied by Cadillac Explorations Ltd.

Samples obtained from the boreholes were air freighted to our Vancouver laboratory for detailed examination and testing. Descriptions of the soils encountered in the boreholes are presented on the Records of Boreholes in Appendix A. The locations of the boreholes are shown on Figures 2, 3 and 4.

Permanent water level and temperature sensing instrumentation has been installed in the 3 proposed construction areas and will be continuously monitored by mine personnel. The recovered data will provide further information regarding ground water level and ground temperature profile variations with time.

The field investigation was conducted under the full time supervision of a member of our engineering staff.

4.2 Tailing Retention Areas

4.2.1 Site T2

The proposed T2 tailing retention area is located on the floodplain of Prairie Creek immediately upstream* of the existing camp site, as shown on Figure 2. Five boreholes, 1 to 5 inclusive, were advanced in this area to depths ranging between 47 and 74 ft. The results of the subsurface investigation indicate that the surficial deposit of compact to dense alluvial sands and gravels with cobbles is between 10 and 20 ft. in thickness and overlies a stratum of very stiff, dark grey silty clay. The clay stratum was found to be between 22.5 and 31.5 ft. in thickness and was encountered at four of the borehole locations. At the location of borehole 1, immediately adjacent to the present course of Prairie Creek, the clay has

* In this report, north is considered to be upstream, and south is considered to be downstream.

been removed by a former channel of the creek. Underlying the clay is a further deposit of compact to dense alluvial sands and gravels extending to an undetermined depth.

The ground water level in the T2 area is controlled by Prairie Creek and was found to be at approximately elevation 2,839 ft. at the time of the investigation.

No permafrost was encountered at any of the boreholes and the minimum measured ground temperature was +3.6°C at a depth of approximately 25 ft.

4.2.2 Site T3

The proposed T3 tailing retention area is located on the Prairie Creek floodplain approximately 1/2 mile downstream from the existing camp site area. The T3 area is cut at approximately its north-south midpoint by a small stream which drains the tributary area to the east. Bedrock outcrops are visible in and immediately north of the midpoint stream. Four boreholes, 6 to 9 inclusive, were put down to depths varying between 10 and 56 ft. in the area north of the midpoint stream. The locations of the boreholes are shown on Figure 4. The stratigraphy encountered at the borehole locations is essentially the same as that found at the T2 area with a surficial layer of 10 to 15 ft. of compact to dense alluvial sands and gravels with some cobbles, overlying 28 to 32.5 ft. of very stiff, dark grey silty clay. Underlying the clay layer is an undetermined thickness of compact to dense alluvial sands and gravels. At the location of borehole 8, immediately north of the midpoint stream, bedrock was encountered at a depth of 8 ft. This borehole, together with the outcrops mentioned previously, indicate that the T3 area is cut across its midpoint by bedrock at shallow depth.

Standpipes installed in the boreholes north of the bedrock cut-off and sealed in the alluvial sands and gravels beneath the glacial clay stratum recorded excess hydrostatic heads of between 1 and 5 ft. relative to standing ground water levels in the area. This indicates that the clay stratum seals into the bedrock cut-off and is continuous across the valley for roughly 1/4 mile upstream of the cut-off. The standing ground water level, as at T2, is controlled by Prairie Creek water levels and was at approximately elevation 2,805 ft. at the time of the investigation.

No permafrost was encountered at any of the boreholes at the T3 site and the minimum measured ground temperature was +3.1°C at a depth of approximately 30 ft. beneath the ground surface.

4.3 Plant Site P2

The proposed P2 plant site area is located in the former course of Harrison Creek immediately south of Adit No. 2, as shown on Figure 3. Boreholes 10 and 11 were drilled in this area to depths of 52 and 55 ft., respectively. The stratigraphy consists of between 43 and 51 ft. of compact to dense alluvial sands and gravels with some cobbles and occasional boulders, overlying bedrock. Bedrock was encountered at elevation 2785 ft. and 2792 ft. at the north and south ends of the P2 site, respectively. The standing ground water level at this site was at elevation 2829 ft., approximately 7 ft. beneath the ground surface at the time of the investigation; however, it can be expected to vary with the water levels in Harrison Creek.

No permafrost was encountered in either borehole at the proposed P2 plant site and the minimum measured ground temperature was +4.6°C at a depth of approximately 40 ft. beneath the existing ground surface.

4.4 Conclusions

Both of the proposed tailing retention areas investigated are suitable for construction of tailing ponds. However the T2 area is superior to the T3 area for initial tailing retention development in several respects. The T2 area is immediately adjacent to the proposed plant site and has been substantially cleared of brush. It is also enclosed by existing river dykes which can be incorporated into the ultimate tailing embankment cross-sections. An impermeable clay stratum is present over most of the base area and is extensive enough to provide borrow material for construction of impervious clay seals which will be required in the perimeter embankments of the proposed tailing area.

We recommend construction of tailing retention ponds in the T2 area to provide tailing storage for the initial anticipated mine life.

The P2 area is suitable for the construction of the proposed mine plant with foundations bearing in the alluvial sands and gravels.

On the basis of the results of the field investigation, no permafrost exists within any of the foundation soils over, or in, which mine facility construction is to take place.

5.0 LABORATORY INVESTIGATION

5.1 Introduction

The laboratory testing program was restricted to clay samples obtained from the T2 tailing retention area, considered the most viable of the two alternative areas for initial development. No clay was encountered at the P2 plant site and hence no laboratory testing was required. The clay samples recovered from tailing retention area T3 have been carefully stored for testing if and as required and are expected to yield results similar to those obtained from the samples recovered from the T2 area.

The testing program included water content, Atterberg Limit and laboratory vane shear strength determinations on all samples. In addition, two consolidated, undrained triaxial shear strength tests with pore pressure measurements and two one-dimensional consolidation tests were performed on selected samples. The results of these tests have been influenced to some degree by sample disturbance, since all of the samples, which were air freighted from Prairie Creek to Vancouver, were unavoidably disturbed to some extent in transport.

The numerical results of the testing program are presented on the Records of Boreholes in Appendix A. A summary of the information obtained from the testing program is presented in the following sections and the test results are given graphically in Appendix B.

5.2 General Properties

The samples tested had liquid limits of from 30 to 58 per cent and plastic limits ranging from 18 to 22 per cent with average values of 49 and 21 per cent, respectively. The natural water content of the samples ranged from 25 to 38 per cent with an average of 30 per cent.

The results of the particle size analyses indicate the samples are composed of approximately 52 per cent clay sizes, 43 per cent silt sizes and 5 per cent sand sizes.

These results classify the soil as an inorganic silty clay of low plasticity, identified as type "CL" in the U.S.C. system.

5.3 Shear Strength

Several types of laboratory shear strength tests were performed on representative silty clay samples from the T2 tailing area. A series of laboratory vane shear tests resulted in average undisturbed and remoulded undrained shear strengths of 1,450 and 350 lb/sq.ft., respectively. These values are lower than the field values due to sample disturbance in transport. A "quick" unconsolidated-undrained triaxial test gave an undrained shear strength of 1,620 lb/sq.ft.

An undisturbed, undrained shear strength of 1,500 lb/sq.ft. can be used conseratively for design purposes. Whereas the silty clay can be considered relatively insenstive to disturbance, a disturbed shear strength of 500 psf is used in design consideration.

The consolidated-undrained triaxial tests with pore water pressure measurements yielded a cohesion intercept of approximately 200 lb/sq.ft. and an angle of shearing resistance of 25 degrees. These effective shear strength parameters were used for the design of the tailing embankments except where highly disturbed clays are integral parts of the embankments, such as in the clay seal cut-off ditch (see Section 6).

5.4 Consolidation

Void-ratio-pressure curves for consolidation tests on two representative samples of the T2 silty clay are given in Appendix B. The curves, although affected by sample disturbance, are typical of a clay which is overconsolidated, or has in the past been subjected to a vertical load greater than that which now exists. An additional historical overburden thickness of approximately 100 ft. of material is indicated by the curves.

The results of these consolidation tests indicate that maximum total settlement of the completed tailing pond could be of the order of 6 inches. The calculations are based on conservative premises; however, this amount of settlement is considered acceptable for structures of the type in question.

6.0 TAILING RETENTION AREAS

6.1 Introduction

On the basis of preliminary work (GA Report 802-1073, dated May 1980) two of the nine potential tailing retention areas dealt with in that report were selected for further more detailed study. These areas have been designated as T2 and T3 and their locations are shown on Figures 2 and 4, respectively.

Both of these areas are suited for development as tailing retention areas. They are each underlain at shallow depths below their existing ground surfaces by impervious clays and/or bedrock. Sufficient amounts of clay exist at both sites for use in the construction of impervious tailing dams.

Site T2 is ideally suited for development for the first phase of mine development insofar as its area and the optimum tailing embankment height are such that, at the anticipated rate of disposal of 110,000 cu.yd. per year into the ponds, the storage capacity of this area will be exhausted within approximately 7-8 years which is the initial anticipated mine life. Consequently, if the mine is closed at that time, overall mine facility construction will encompass a small area relative to that which would be included if initial development utilizes site T3.

Site T3 is also highly suitable for development of a tailing retention area. However, its development in the initial stages would be more costly than for that of T2 insofar as initial embankment construction would involve longer and, in some cases, higher sections. Moreover, advantage could not be taken of existing dyke construction such as exists at site T2. Approximate boundaries for tailing area T3 are shown on Figure 4. It should be noted that the actual available area for storage development within T3 is substantially greater than that shown on Figure 4 since the figure does not extend to the southern limit of T3.

It is strongly recommended that site T2 be developed in the initial stages of mine development and that T3 be developed later if mine life is to extend beyond initial expectations. Consequently, only site T2 is laid out in detail for presentation in this report. Whereas embankment sections and construction procedures for T3 will be similar to those for T2, staging of embankment development in both elevation and plan may be more complex in order to achieve the desired economy and efficiency for construction and operation.

6.2 Criteria Used for Tailing Embankment Design and Pond Layout

The tailing retention system has been designed to adhere to the following criteria:

(1) The tailing retention system is to allow for storage of 7-8 years of mine production waste which will produce approximately 110,000 cu.yds. of fine tails each year.

(2) The tailing embankments are to be built in stages with the first stage to allow for 3 to 4 years of tailing storage.

(3) The pond system is to be effectively impervious so that seepage from the ponds does not damage the chemical or physical environment of Prairie Creek.

(4) The overall area of T2 is to be divided by internal embankments into segments with surface areas not exceeding 3 to 4 acres so that alternate ponds can be used for summer/winter operation in order to minimize ice storage in the system.

(5) It is understood that all of the water that enters the tailing pond with the mill refuse is to be recirculated for use in the mill and that excess water in any given pond cell is to be decanted, siphoned or spilled into adjoining pond segments.

(6) The tailing retention area is to be adequately protected from encroachment by maximum probable flows in Prairie Creek.

6.3 Tailing Pond Layout

The proposed layout for tailing retention area T2 is shown in plan on Figure 2. The locations of the Prairie Creek perimeter embankments have been determined by the locations of the existing river dykes.

The development of area T2 will involve the excavation of approximately 420,000 cu.yd. of alluvial sands and gravels and glacial clays unless bedrock is encountered at elevations higher than the proposed base elevation of the ponds in which case excavation quantities will be less. The excavated materials can be used in their entirety for tailing embankment construction, for general stream training works around mine and camp sites, for general site grading at the camp and mill sites and at the site of the fuel tank farm. The total available storage volume of the T2 retention area is estimated to be approximately 940,000 cu.yds., including the volumes of the proposed internal separator dykes. The relationship between storage volume and embankment crest elevation for the proposed storage area is shown on Figure 5. (Similar relationships have not been generated for site T3 since gross storage requirements following the initial anticipated operating life for the mine are not known at this time.)

6.4 Tailing Pond Embankment Design

The tailing pond embankments have been designed in accordance with the criteria outlined in Chapter 9 ("Waste Embankments") "Pit Slope Manual", Department of Energy, Mines and Resources, Ottawa, 1977. Typical sections through various locations of the ultimate embankments are shown on Figure 6. Typical sections through the phases of Stage 1 embankment construction are shown on Figure 7.

The soil strength parameters used in assessing the stability of the tailing embankments as designed were as follows:

	c'	ϕ'	γ
In Situ Glacial Clays	200 psf	25°	120 pcf
Disturbed Glacial Clays	500 psf	0	100 pcf
Compacted Alluvial Sands and Gravels	0	37°	125 pcf
Uncompacted Alluvial Sands and Gravels (existing river dykes)	0	32°	120 pcf
Coarse Rock Bank Protection	0	40°	140 pcf

The factors of safety of the embankments against shear failure were assessed using the Simplified Bishop Method of Slices for static conditions and Sarma's method for pseudo-static (earthquake) conditions. A maximum horizontal ground acceleration of 3 per cent gravity was used in the pseudo-static analyses. The minimum factors of safety were calculated to be 1.3 and 1.2 for the static and earthquake conditions, respectively. These meet the minima recommended for acceptance for tailing embankments in the Pit Slope Manual and are considered adequate for the proposed construction.

6.5 Tailing Pond Embankment Construction

The proposed base level of the tailing pond system will vary between approximately elevation 2,825 ft. at its south end to elevation 2,830 ft. at its north end, as shown on Figure 2. The ground water level in the area is determined by the water levels in Prairie Creek and are at approximately elevation 2,839 ft. during normal stream flow levels. In order to excavate the necessary quantities of clay from within the pond area and to construct safe embankments, it will be necessary to seal the pond perimeter to a sufficient level before general excavation below the ground water table can be done.

Stage construction is to be used for the tailing embankments and Stage 1 is to allow for 3 to 4 years of tailing storage. This will require construction of an embankment section to elevation 2848 ft., approximately, allowing for about 3 ft. of freeboard above the level of stored tails. However, protection of the area from Prairie Creek maximum flow levels is also required. Consequently, whereas an impervious section to elevation 2845 ft., approximately, will suffice for the inside of the embankment structure, the outside of the section will have to be built to the estimated maximum flow levels in Prairie Creek, as given on Figure 8. Typical sections through successive phases of Stage 1 construction are shown on Figure 7. It should be noted that heavy rock armour is not required on the embankment along the southern boundary of the tailing area which does not border directly on Prairie Creek, as shown on Figure 6.

Construction for Stage 1 should take place in accordance with the following sequence and constraints, as shown on Figure 7.

(1) The T2 area should be cleared of all brush, debris and surface organic materials.

(2) Excavate all materials down to ground water level along the alignment of the required clay seal except along the backslope on the east side of the tailing storage area. The excavation will have to be of sufficient width to allow operation of construction equipment for ditch excavation below the ground water table for the purpose of placing the clay seal. Excavation for this phase should not be carried below the ground water table.

(3) Prepare an area or areas within the pond perimeter from which clay for the seal can be excavated. The amount of clay required for this phase of the construction is estimated to be approximately 15,000 cu.yds. The purpose of this phase is to prepare a seal to above the level of the ground water table along the dyke alignment to tie into bedrock at the north and south ends of the retention area so that see-

page into the pond area from Prairie Creek is effectively cut-off. It may be necessary to bulldoze clay to form temporary dykes around clay excavation areas within the pond area so that excavation of clay can proceed in the dry, unless a dragline is used, in which case underwater excavation can be carried out.

(4) Excavate a ditch along the seal alignment down to the underlying clay or bedrock and replace the excavated granular materials with the clay excavated from within the pond area. The ditch should be a minimum of 4 ft. and a maximum of 6 ft. in width at its invert. The excavation should be flooded at all times and the length of open excavation should be as short as possible so that sloughing of material from the sides into the bottom of the excavation is minimized. The upper surface of the clay fill should be taken to approximately 2 ft. above the ground water level, the clay being contained at its sides by the in situ sands and gravels. Compaction of the clay fill under these conditions would be extremely difficult; consequently, every effort should be made to break the excavated clay down as much as possible so that large voids are not left in the ditch seal. Since no compactive effort, per se, can be applied to this part of the clay fill, some consolidation of this portion of the seal can be expected to continue after it is placed. This will not deter from safe pond operation provided that the embankment crest elevations are periodically checked and

maintained as required until the consolidation is completed. Initial consolidation can be accelerated by placing a temporary surcharge over the ditch infill, as shown on Figure 7.

(5) Some areas near the proposed embankment alignment may be underlain by granular materials too great in thickness to allow the preparation of a ditch seal as described above. In these cases, excavation should be done over the affected areas only to the ground water level and a layer of clay approximately 2 ft. in thickness placed in 6 inch lifts over the area and compacted using a sheepsfoot roller. Subsequently, this seal can be connected to underlying clay or bedrock with a ditch seal as described in sub-paragraph (4) above. The 2 ft. thick layer of clay should be overlain by about 3 ft. of sand and gravel. A schematic view of this condition is shown on Figure 6.

(6) When the perimeter embankment seal is completed, the water in the pond area can be pumped into Prairie Creek and excavation, leaving an in situ sand and gravel berm, as shown on Figure 7, and construction of the embankments as designed, can continue. Excess materials excavated from within the pond area can be stockpiled for future stage construction or, alternatively, used for other construction requirements.

(7) Ground water entering the excavation from the backslope on the east side of the proposed storage area should be collec-

ted in ditches leading to sumps from where it can be pumped away from the pond area.

(8) Construction should not be carried out in freezing temperatures in order to avoid inadequate compaction of embankment soils.

(9) The clay seal for each phase of embankment construction should be raised only to an elevation 3 ft. below the crest elevation of each phase. The uppermost 3 ft. of each stage should consist of compacted sands and gravels. However, these materials must be removed and replaced with clay prior to construction of subsequent stages so that a continuous clay seal is maintained in the embankment.

(10) Subsequent stages for embankment construction will lead to a completed section as shown in Figure 7.

(11) If an ultimate crest width in excess of 16 ft. is desired for a roadway or any other purpose, then the entire cross-section of the embankment must be widened by the desired amount. The design width of 16 ft. is the minimum acceptable for a tailing embankment of the height in question, and is in accordance with criteria given in the Pit Slope Manual.

6.6 Internal Tailing Embankments

The division of the tailing pond into segments not exceeding 3 to 4 acres in surface area so that disposal can be alternated between pond segments for alternate summer/winter operation will minimize ice accumulation from winter tailing disposal insofar as winter accumulated ice can be allowed to melt over the summer period with the net result that little, if any, ice is permanently stored in the ponds. Ice accumulation, if unchecked, can reduce tailing pond storage efficiency substantially.

Suggested locations for internal tailing pond embankments are shown on Figure 2. Specific locations of these dykes is only important insofar as those segments of the overall pond system which are used for winter operation do not exceed 3 to 4 acres in surface area. Provided this criterion is met, the mine operators can locate the internal embankments at whatever locations are convenient.

Since the purpose of these embankments is only to control ice accumulation in the ponds, their construction does not have to include impervious sections nor is their stability of crucial import insofar as small embankment failures will not endanger the environment outside the perimeter of the T2 area.

Construction of the internal embankments can be carried out using the locally available alluvial sands and gravels, mine waste rock, coarse mine plant waste, or any other material that will maintain itself at a reasonable angle of repose when placed for embankment construction so that pond storage volumes which are lost due to internal embankment construction are minimal.

6.7 Surface Drainage Around Tailing Ponds

The flows from the small stream that exits into the T2 area from the valley on the east side of Prairie Creek are normally very small. However, in the interests of safety, it is recommended that these flows, together with any other surface water with potential for entering the pond area, be ditched away from the T2 area and directed into Prairie Creek.

6.8 Seepage from the Tailing Retention Area

Due to the presence of an in situ impervious clay layer on the base of the T2 tailing area and the construction of an impervious seal in the embankments, seepage from the T2 pond area into Prairie Creek will be small. During the early years of operation, the level of stored tails in the pond will be lower than the level of the water in Prairie Creek, consequently, any seepage flows will be into, not out of, the pond area. Once the tailing storage level exceeds approximately elevation 2845 ft., seepage, if any, will tend to flow from the pond into the Creek. When the ponds are full to their maximum capacity, that is to elevation approximately 2864 ft., seepage quantities are estimated to be of the order of 250 to 500 cu. ft. per year (approximately 0.8 to 1.6 x 10^{-5} cfs).

7.0 GENERAL STREAM TRAINING WORKS

Dykes will be required along Prairie Creek and Harrison Creek to provide flood protection for the mill and camp sites. These embankments can be constructed using the sands and gravels excavated from within tailing pond T2 and which are in excess of the materials required for building the T2 tailing embankments, or from sands and gravels excavated from other suitable borrow areas.

It is not considered necessary to construct impervious embankments for general flood protection since high flood levels in these streams will be of short duration and the amount of seepage through the embankments will, therefore, be limited. However, appropriate ditching within the embankment perimeter to collect any excess seepage water so that it can be sumped and subsequently pumped back into the streams would be prudent.

The flood protection dykes should be built and maintained to elevations at least 3 ft. above the elevations of the estimated 100 year flood levels in the streams as shown on Figure 8. The slopes of the embankments can be built with gradients of 1 1/2 horizontal to 1 vertical and the outside slopes should be protected with heavy rock for their full height.

Construction of the dykes should be carried out by placing the sands and gravels in lifts approximately 1 ft. in thickness. Adequate compaction for this construction will be achieved by equipment traffic during construction.

Typical sections showing the recommended embankment construction are shown on Figure 9.

8.0 MINE PLANT AND ANCILLARY STRUCTURE FOUNDATIONS

8.1 Mine Plant Foundations

Site P2 has been selected for construction of the mine plant. The foundation soils at this location consist of compact to dense alluvial sands and gravels with cobbles and some boulders, overlying bedrock at a depth of between 43 and 55 ft. beneath the ground surface.

An allowable bearing capacity of 4,000 lb/sq.ft. can be used for the design of spread footings for the mine plant. The footings should be founded at a depth of at least 10 ft. beneath the final outside ground surface elevation for frost protection. Most of the consolidation within the foundation soils due to structural loads will occur during construction. Subsequent settlements should be no more than 1/2 inch.

Individual mill units which will subject the foundation soils to vibratory loads should be analyzed independently prior to final foundation design.

Due to the presence of cobbles and boulders in the foundation soils, foundation locations should be over-excavated by approximately 1 ft. and the excavation brought up to the final desired footing base elevation with properly compacted sands and gravels. This will avoid undesirable stress concentrations on footing bases.

8.2 Ancillary Structures

No subsurface investigations have been carried out at the sites of the concentrate storage sheds or other ancillary structures. No serious problems are anticipated for these structures; however, it is recommended that prior to construction, exploratory drilling or test pitting be carried out at these sites to confirm that the conditions are favourable.

9.0 FUEL TANK FARM SPILL PROTECTION

Spill protection for the fuel tank farm can be achieved by lining its base and perimeter dykes with a layer of clay excavated from within the T2 or T3 tailing retention areas. The clay liner should be a minimum of 1 ft. in thickness and should be covered with a protective layer of sands and gravels at least 3 ft. in thickness so that heavy traffic does not reduce the effectiveness of the seal.

In the event that the tank farm is founded in an area that is underlain at a shallow depth by in situ clays, spill protection can be achieved by constructing a seepage cut-off joining the in situ clay layer to sealed perimeter embankments.

Schematic sections showing both of these alternatives are shown on Figure 10.

Both the in situ sands and gravels and the in situ clay deposits have adequate shear strength and consolidation characteristics to safely support the fuel tanks.

The foundation soils for the fuel tanks should be treated so that deleterious deflections due to loads from the filled tanks do not result in damage to the tanks. Ideally, a layer of 3/4 inch crushed stone at least 1 ft. in thickness should be placed at tank locations to provide suitable foundations. Alternatively, a minimum of 18 inches of well graded gravel with a maximum particle size of 1-1/2 inches, placed in 6 inch lifts and compacted to a density equivalent to 100 per cent standard Proctor density in accordance with ASTM-D-698 can be used. The treated foundation soils should be placed at tank foundation locations after all surface organic and other soft or loose earth materials are removed from these locations.

10.0 CONCRETE AGGREGATE ASSESSMENT

Samples from potential concrete aggregate sources were collected during the field program for assessment by B.H. Levelton & Associates Ltd. The samples were taken from the mine waste rock and from the alluvial gravel deposits at the location of tailing area T3.

Since the area of concrete technology is not within Golder Associates expertise, no comments with respect to the testing program are made; however, the B.H. Levelton report, received by GA on September 30th, 1980, is included, in its entirety, as Appendix C to this report.

11.0 CONTRACT DOCUMENTS

It is assumed that appropriate contract documents will be prepared for the work described in this report before construction begins. The contents of this report can serve as the geotechnical input for the preparation of such documents. Golder Associates would be pleased to review the geotechnical content of any contracts that are drawn up.

Yours very truly,

GOLDER ASSOCIATES

E.B. Fletcher, P. Eng.

D.J. Shirley

EBF/DJS/ba

802-1073

APPENDIX A

RECORDS OF BOREHOLES

Project No. 802-1073

RECORD OF BOREHOLE #1

LOCATION (See Figure 2)
BORING DATE July 27-29, 1980

BOREHOLE TYPE Rotary
BOREHOLE DIAMETER 4 1/2 in.

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.
DATUM Ker Preistman & Associates

SOIL PROFILE								
ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_P — W — W_L)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2841.1	Ground Surface							
0.0	Sandy GRAVEL with occ. cobbles & boulders							
2791.0 / 50.0'	End of Borehole.							

VERTICAL SCALE
1 inch to 10 feet

Golder Associates

DRAWN
CHECKED

Project No. 802-1073

RECORD OF BOREHOLE #2

LOCATION (See Figure 2) — BORING DATE July 30-Aug. 2, 1980

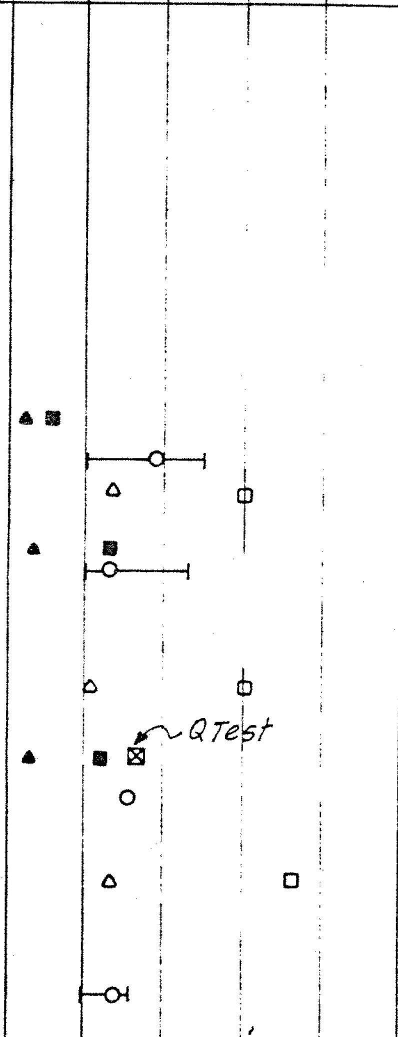
BOREHOLE TYPE Rotary — BOREHOLE DIAMETER 4½ in.

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN. — DATUM Ker Preistman & Associates

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	UNDRAINED SHEAR STRENGTH / WATER CONTENT PERCENT	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2846.2	Ground Surface							
0.0	Sandy GRAVEL with occ. cobbles							
2830.7 / 15.5'	Very stiff, dark grey silty CLAY		1	3½" T.O.	Ph			
			2	"	"			
			3	"	"			
			4	"	"			
2799.2 / 47.0'	Sandy GRAVEL with occ. cobbles							
2786.2 / 60.0'	End of Borehole.							

UNDRAINED SHEAR STRENGTH
IN SITU □ UNDISTURBED, △ REMOULDED
LAB ■ UNDISTURBED, ▲ REMOULDED
1000 2000 3000 4000 psf

WATER CONTENT PERCENT
W_P W W_L
20 40 60 80



VERTICAL SCALE 1 inch to 10 feet

Golder Associates

DRAWN
CHECKED

RECORD OF BOREHOLE #3

Project No. 802-1073

LOCATION (See Figure 2)

BORING DATE Aug. 3 - 5, 1980

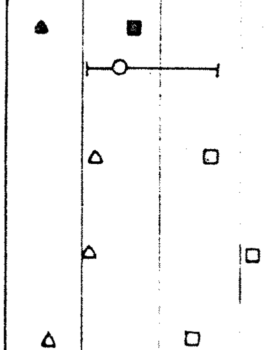
BOREHOLE TYPE Rotary

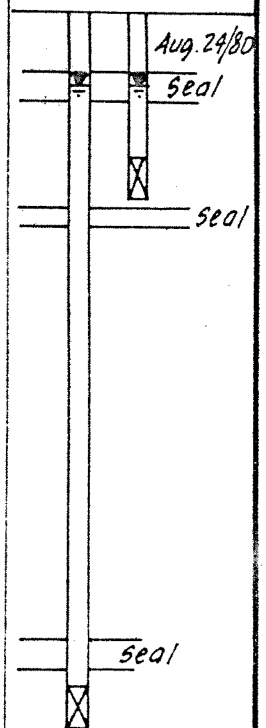
BOREHOLE DIAMETER 4½ in.

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

DATUM Ker Preistman & Associates

SOIL PROFILE: ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	UNDRAINED SHEAR STRENGTH (IN SITU □ UNDISTURBED, △ REMOULDED; LAB ■ UNDISTURBED, ▲ REMOULDED; 1000 2000 3000 4000 psf) / WATER CONTENT PERCENT (W_P W W_L; 20 40 60 80)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2843.4	Ground Surface							
0.0	Sandy GRAVEL with occ. cobbles & boulders							
2834.9 / 8.5	Very stiff, dark grey silty CLAY		1	3½" T.O.	Ph			
			2	"	"			
2805.9 / 37.5'	Sandy GRAVEL with occ. cobbles							
2796.4 / 47.0'	End of Borehole.							





VERTICAL SCALE
1 inch to 10 feet

Golder Associates

DRAWN
CHECKED DJS

RECORD OF BOREHOLE #4

Project No. 802-1073

LOCATION (See Figure 2)

BOREHOLE TYPE Rotary

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE Aug. 6-9, 1980

BOREHOLE DIAMETER 4½ in.

DATUM Ker Preistman & Associates

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	Temperature Profile (°C)	UNDRAINED SHEAR STRENGTH (IN SITU □ UNDISTURBED, △ REMOULDED; LAB ■ UNDISTURBED, ▲ REMOULDED; 1000 2000 3000 4000 psf) / WATER CONTENT PERCENT W_P W W_L (20 40 60 80)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2842.3	Ground Surface					Sept. 2, 1980		
0.0	SAND and GRAVEL with occ. cobbles					11.0, 7.8, 5.4, 3.8		Aug. 24, 1980; Seal; Seal
2820.3 / 22.0'	Hard, dark grey silty CLAY		1	3½" T.O.	Ph	3.6, 3.6, 3.6		Seal
2797.8 / 44.5'	Sandy GRAVEL with occ. cobbles and boulders							
2768.3 / 74.0'	End of Borehole.							

VERTICAL SCALE 1 inch to 10 feet

Golder Associates

DRAWN dm

CHECKED DJS

Project No. 802-1073

RECORD OF BOREHOLE #5

LOCATION (See Figure 2)

BOREHOLE TYPE Rotary

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE Aug. 10-12, 1980

BOREHOLE DIAMETER 4½ in.

DATUM Ker Preistman & Associates

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	UNDRAINED SHEAR STRENGTH (IN SITU: □ UNDISTURBED, △ REMOULDED; LAB: ■ UNDISTURBED, ▲ REMOULDED) 1000 2000 3000 4000 psf / WATER CONTENT PERCENT W_P W W_L 20 40 60 80	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2851.5	Ground Surface							
0.0	SAND and GRAVEL with trace clay & occ. boulders							
2829.0 / 22.5'	Very stiff, dark grey silty CLAY							
			1	3½" T.O.	Ph			
			2	"	"			
2804.5 / 47.0'	Sandy GRAVEL with occ. cobbles							
2793.5 / 58.0'	End of Borehole.							

VERTICAL SCALE 1 inch to 10 feet

Golder Associates

DRAWN [illegible]

CHECKED [illegible]

Project No. 802-1073

RECORD OF BOREHOLE #6

LOCATION (See Figure 4) | BORING DATE Aug. 13-14, 1980
BOREHOLE TYPE Rotary | BOREHOLE DIAMETER 4½ in.
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN. | DATUM Ker Preistman & Associates

ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	UNDRAINED SHEAR STRENGTH (IN SITU □ UNDISTURBED ○ REMOULDED; LAB ■ UNDISTURBED ● REMOULDED; 1000 2000 3000 4000 psf) / WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2810.7	Ground Surface							
0.0	SAND and GRAVEL with trace silt and occ. cobbles							Aug. 24, 1980 (Open Hole)
2799.2 / 11.5'	Very stiff, dark grey CLAY		1	3½" T.O.	Ph			
			2	"				
2766.7 / 44.0'	Sandy GRAVEL with occ. cobbles							
2754.7 / 56.0'	End of Borehole.							

VERTICAL SCALE 1 inch to 10 feet

Golder Associates

DRAWN [initials]
CHECKED DBS

Project No. 802-1073

RECORD OF BOREHOLE #7

LOCATION (See Figure 4)

BOREHOLE TYPE Rotary

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE Aug. 15-17, 1980

BOREHOLE DIAMETER 4 1/2 in.

DATUM Ker Preistman & Associates

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	Temperature Profile (°C)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2806.3	Ground Surface					Sept. 2, 1980	Aug. 24, 1980
0.0	Sandy GRAVEL with trace silt and occ. cobbles					-8.7 -6.2	
2791.8							Seal
14.5'	Very stiff, dark grey CLAY		1	3 1/2" T.O.	Ph	-3.9 -3.2 -3.3	Seal
			2	"	"	-3.1 -3.2	
2762.3							
44.0'	Sandy GRAVEL with occ. cobbles						
2752.3							
54.0'	End of Borehole.						

UNDRAINED SHEAR STRENGTH: IN SITU □ UNDISTURBED, △ REMOULDED; LAB ■ UNDISTURBED, ▲ REMOULDED; 1000 2000 3000 4000 psf

WATER CONTENT PERCENT: W_P W W_L; 20 40 60 80

VERTICAL SCALE 1 inch to 10 feet

Golder Associates

DRAWN
CHECKED DJS

Project No. 802-1073

RECORD OF BOREHOLE #8

LOCATION (See Figure 4)

BOREHOLE TYPE Rotary

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE Aug. 18, 1980

BOREHOLE DIAMETER 4½ in.

DATUM Ker Preistman & Associates

SOIL PROFILE								
ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2802.4	Ground Surface							
0.0	SAND and GRAVEL with occ. cobbles & boulders							Aug. 24, 1980 (Open Hole)
2793.4 / 9.0'	BEDROCK		1	H CORE				
10.0'	End of Borehole.							

VERTICAL SCALE 1 inch to 10 feet

Golder Associates

DRAWN [initials]
CHECKED DJS

Project No. 802-1073

RECORD OF BOREHOLE #9

LOCATION (See Figure 4)

BOREHOLE TYPE Rotary

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE Aug. 19-21, 1980

BOREHOLE DIAMETER 4½ in.

DATUM Ker Preistman & Associates

UNDRAINED SHEAR STRENGTH: IN SITU □ UNDISTURBED, △ REMOULDED; LAB ■ UNDISTURBED, ▲ REMOULDED; 1000 2000 3000 4000 psf

WATER CONTENT PERCENT: W_P W W_L

PIEZOMETER OR STANDPIPE INSTALLATION

ADDITIONAL LAB. TESTING

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2805.3	Ground Surface						
0.0	SAND and GRAVEL with trace silt and occ. cobbles						Aug. 24, 1980; Seal
2788.3 / 17.0'	Very stiff, dark grey CLAY		1	3½" T.O.	Ph		Seal
			2	"	"		
2760.3 / 45.0'	SAND and GRAVEL with occ. cobbles						
2750.3 / 55.0'	End of Borehole.						

VERTICAL SCALE 1 inch to 10 feet

Golder Associates

DRAWN

CHECKED

RECORD OF BOREHOLE #10

Project No. 802-1073

LOCATION (See Figure 3)

BOREHOLE TYPE Rotary

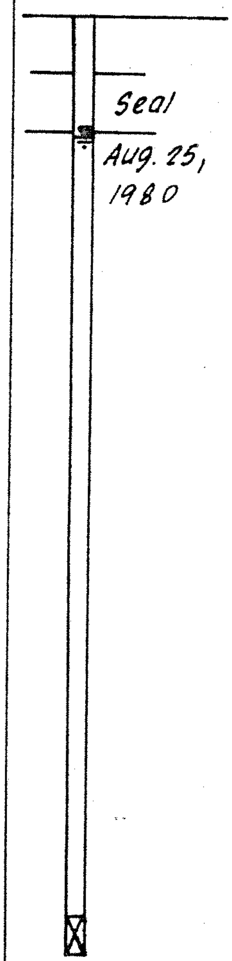
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE Aug. 22-25, 1980

BOREHOLE DIAMETER 4½ in.

DATUM Ker Preistman

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	Temperature Profile (°C)	WATER CONTENT PERCENT W_P — W — W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2834.9	Ground Surface					Sept. 2, 1980		
0.0	GRAVEL with some sand and occ. cobbles and boulders					7.2, 7.2, 5.9, 5.6, 5.4, 4.8, 4.6		Seal; Aug. 25, 1980
2791.9 / 43.0'	BEDROCK		1	1⅞" NQ CORE				
2782.9 / 52.0'	End of Borehole.							



VERTICAL SCALE
1 inch to 10 feet

Golder Associates

DRAWN [illegible]
CHECKED DJS

Project No. 802-1073

RECORD OF BOREHOLE #11

LOCATION (See Figure 3)
BORING DATE Aug. 26-27, 1980
BOREHOLE TYPE Rotary
BOREHOLE DIAMETER 4½ in.
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.
DATUM Ker Preistmun & Associates

SOIL PROFILE								
ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P — W — W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
2836.4	Ground Surface							
0.0	SAND & GRAVEL with trace silt & occ. cobbles							Aug. 24, 1980 (Open Hole)
2785.4 / 51.0'	BEDROCK							
2781.4 / 55.0'	End of Borehole.							

VERTICAL SCALE 1 inch to 10 feet

Golder Associates

DRAWN
CHECKED

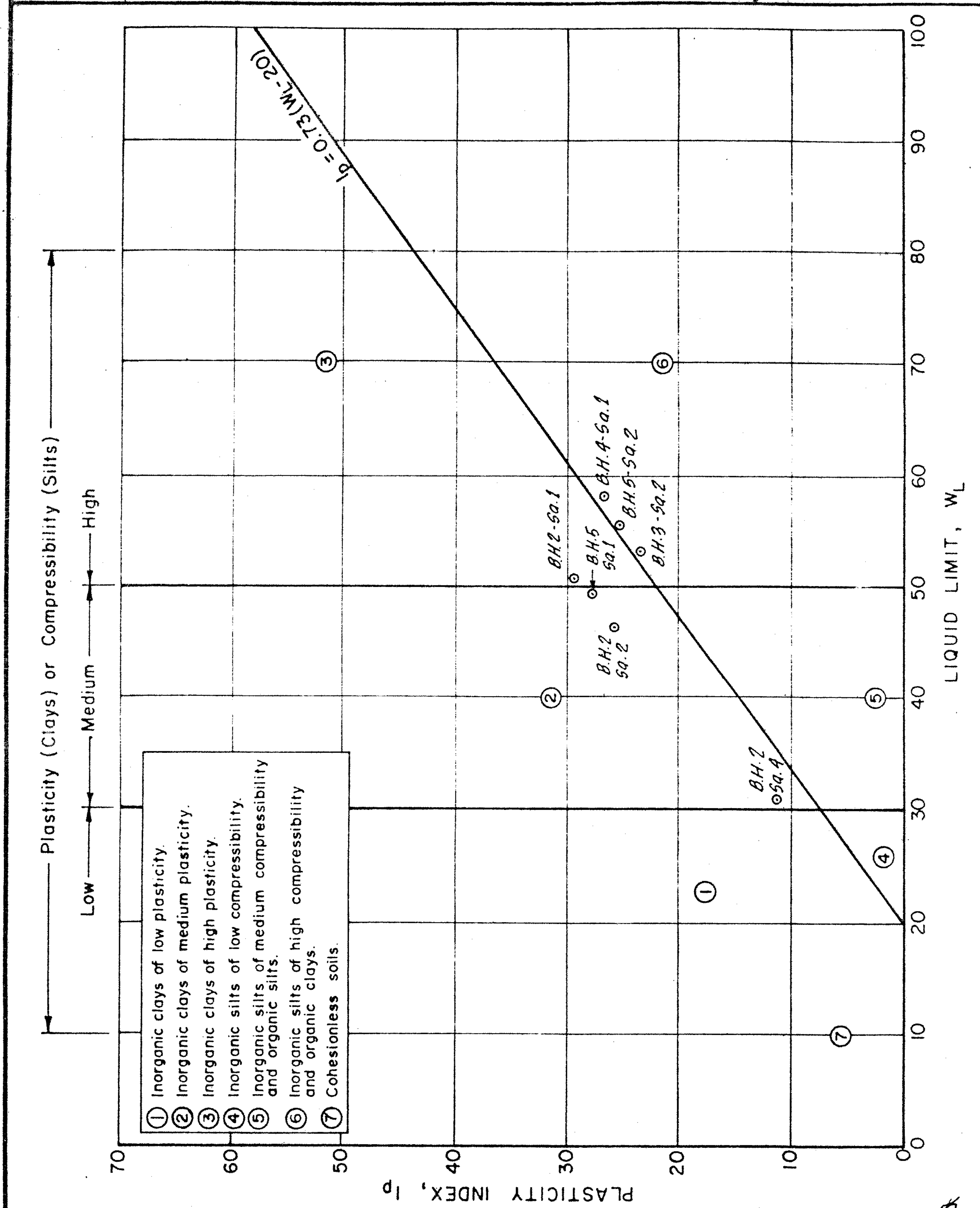
APPENDIX B

LABORATORY TEST RESULTS

PLASTICITY CHART

FIGURE B-1

Project No. 802-1073



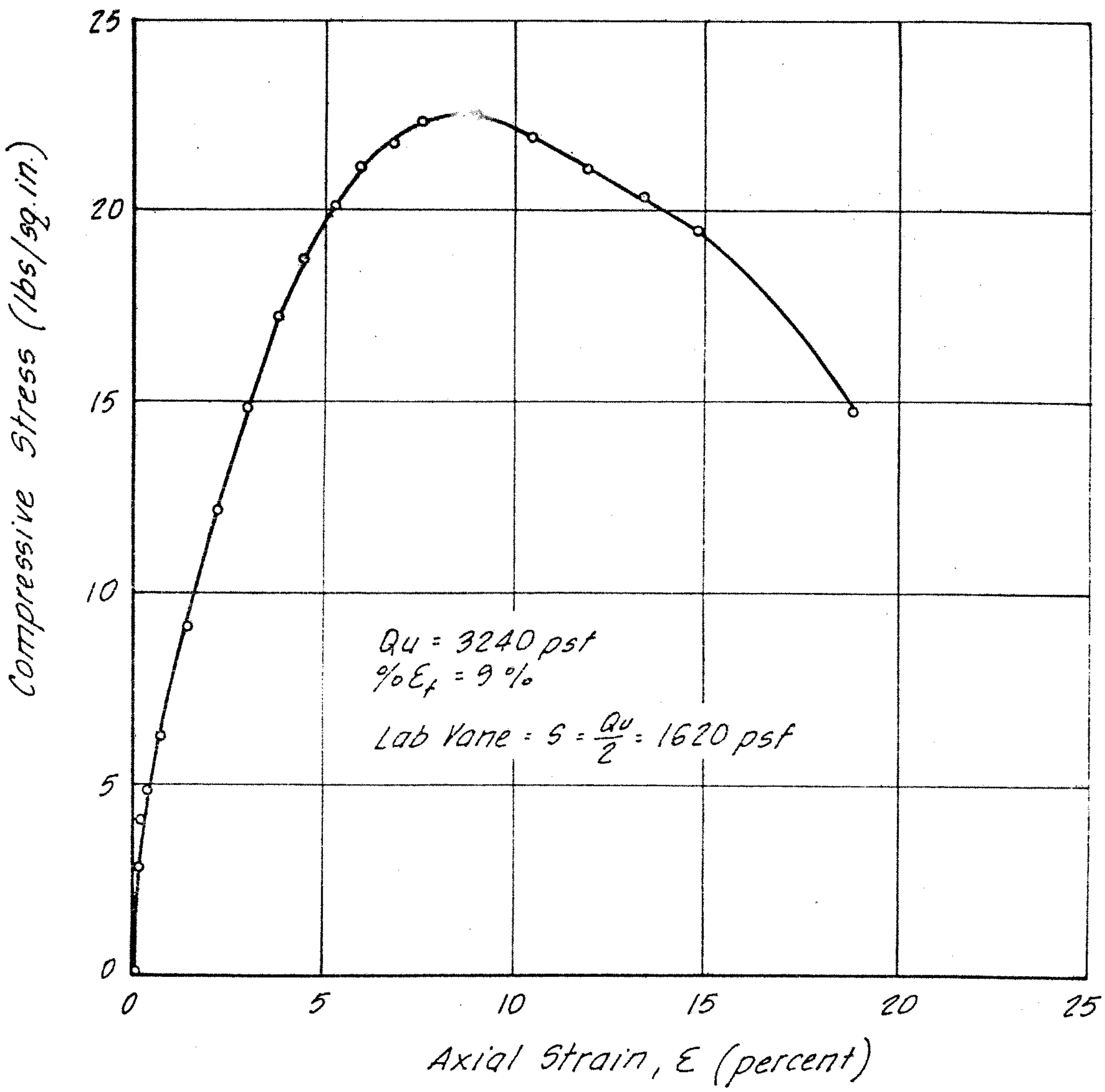
Golder Associates

Drawn ________
App'd ________
Date Sept '80

UNCONFINED COMPRESSION TEST RESULT

Figure B - 2

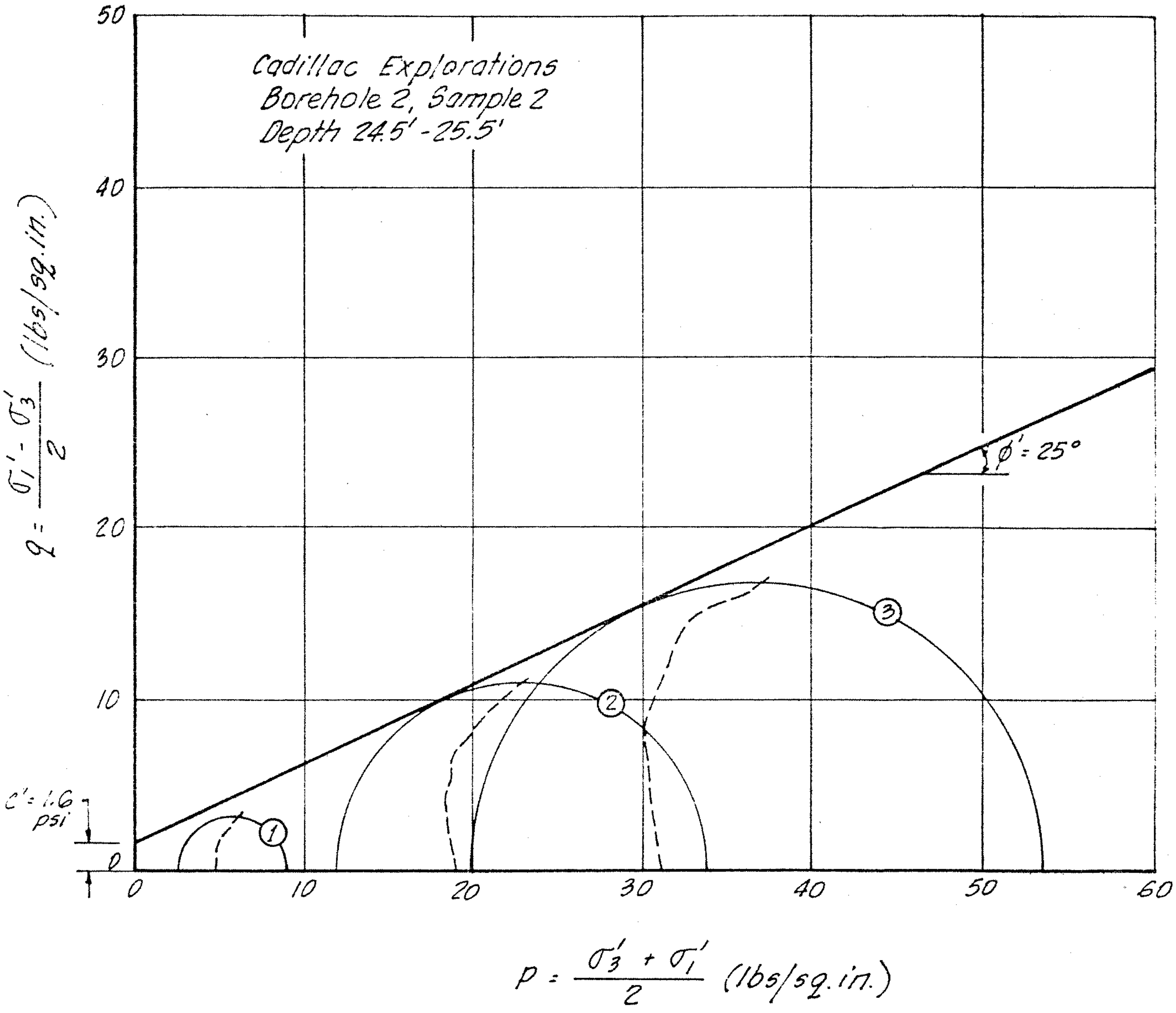
Cadillac Mines
B.H. 2, Sample 3, Depth 35'-37'



Project No. 802-1073 Drawn Reviewed Date Sept. '80

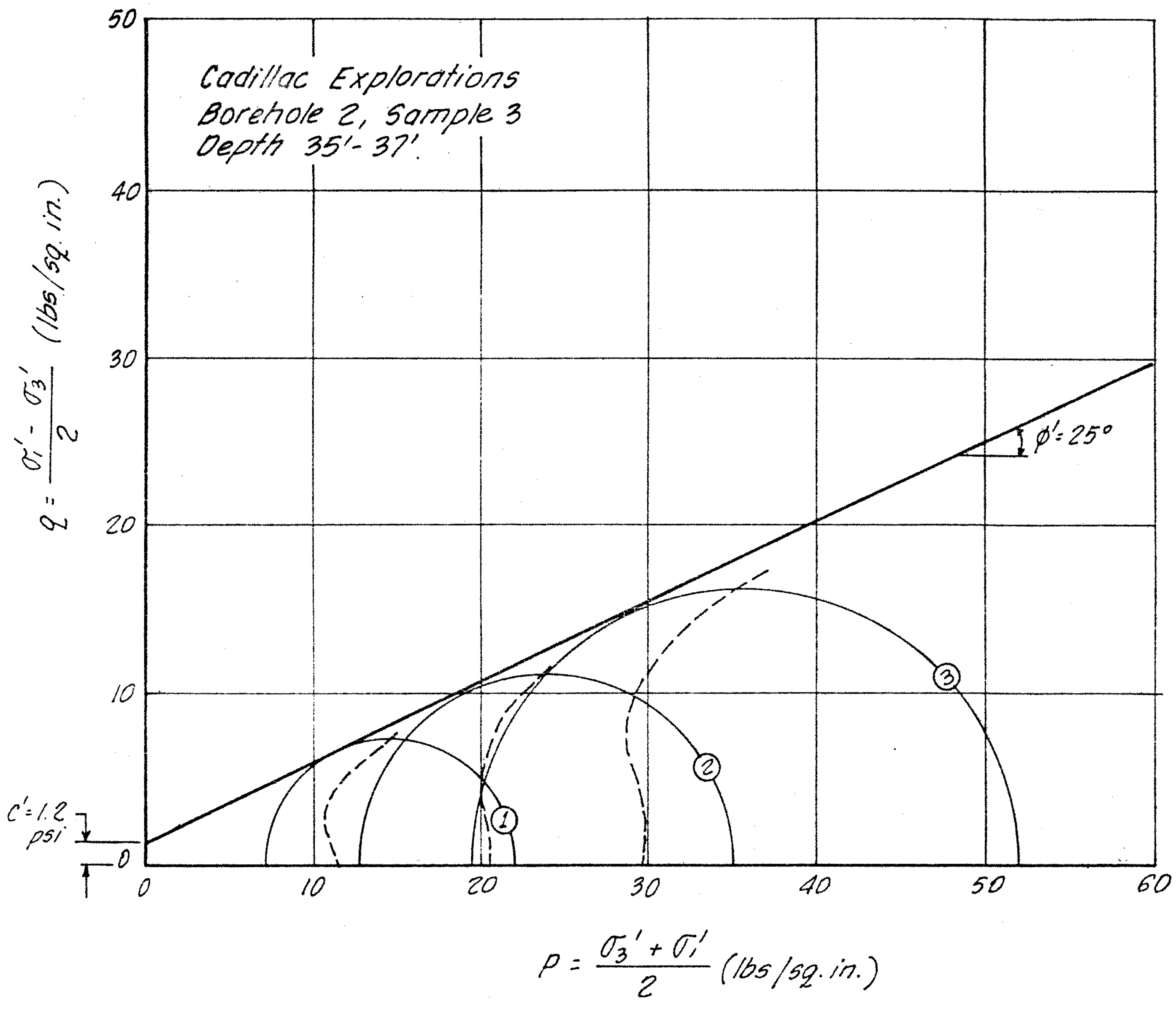
CONSOLIDATED UNDRAINED TRIAXIAL TESTING WITH PWP MEASUREMENT FAILURE ENVELOPE

Figure B-3



CONSOLIDATED UNDRAINED TRIAXIAL TESTING WITH PWP MEASUREMENT FAILURE ENVELOPE

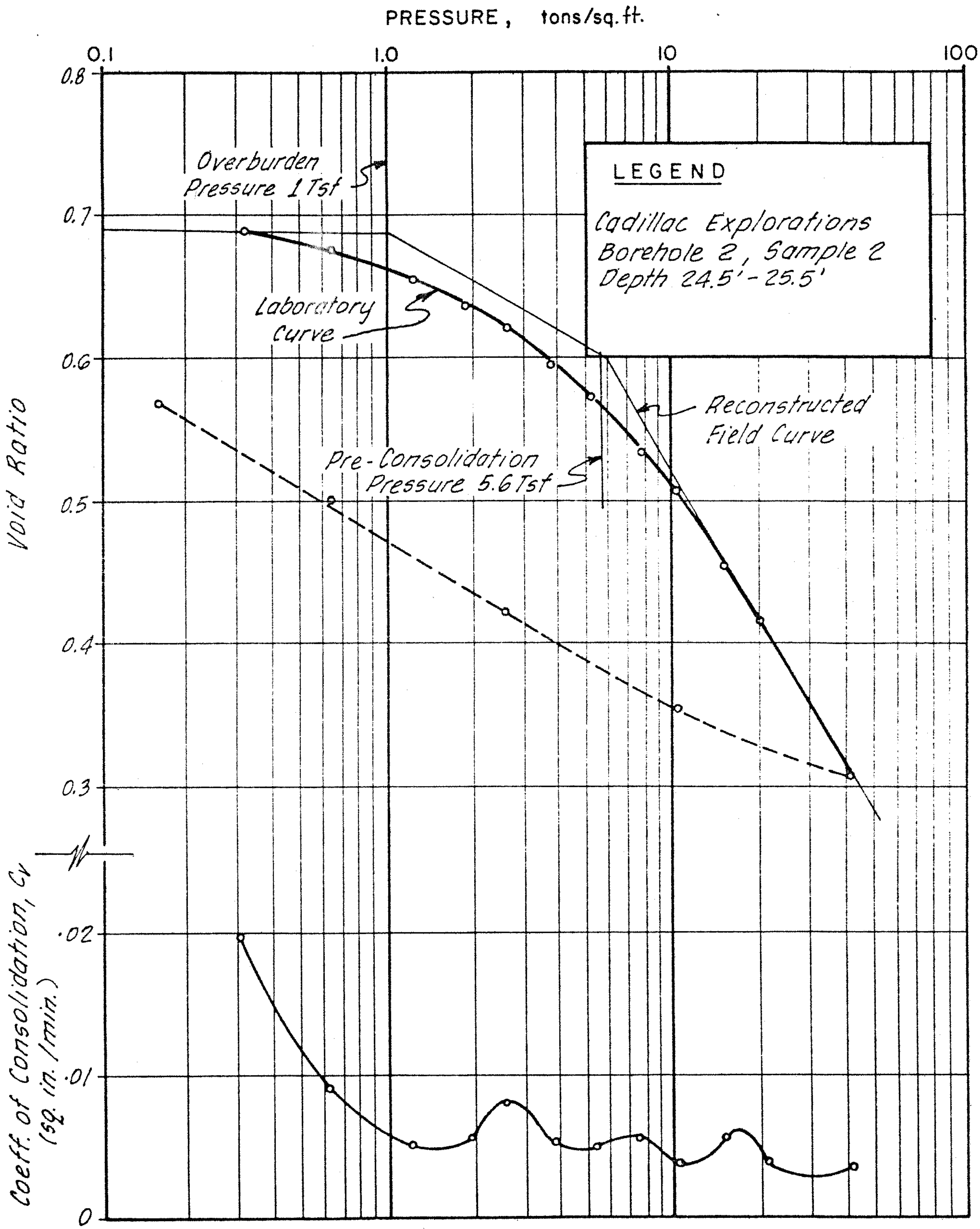
Figure B - 4



VOID RATIO - PRESSURE CURVES
CONSOLIDATION TEST

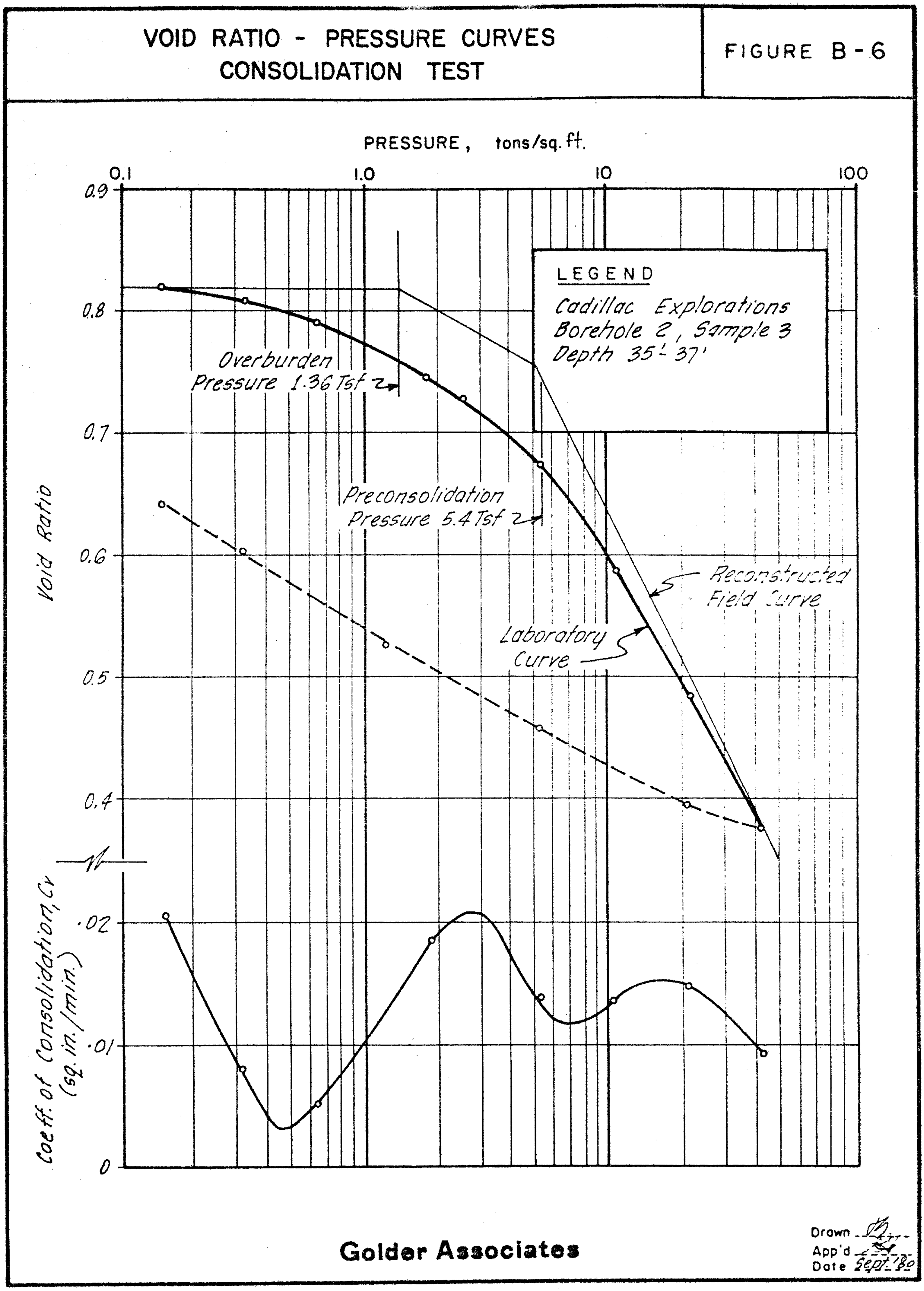
FIGURE B-5

Project No. ________



Golder Associates

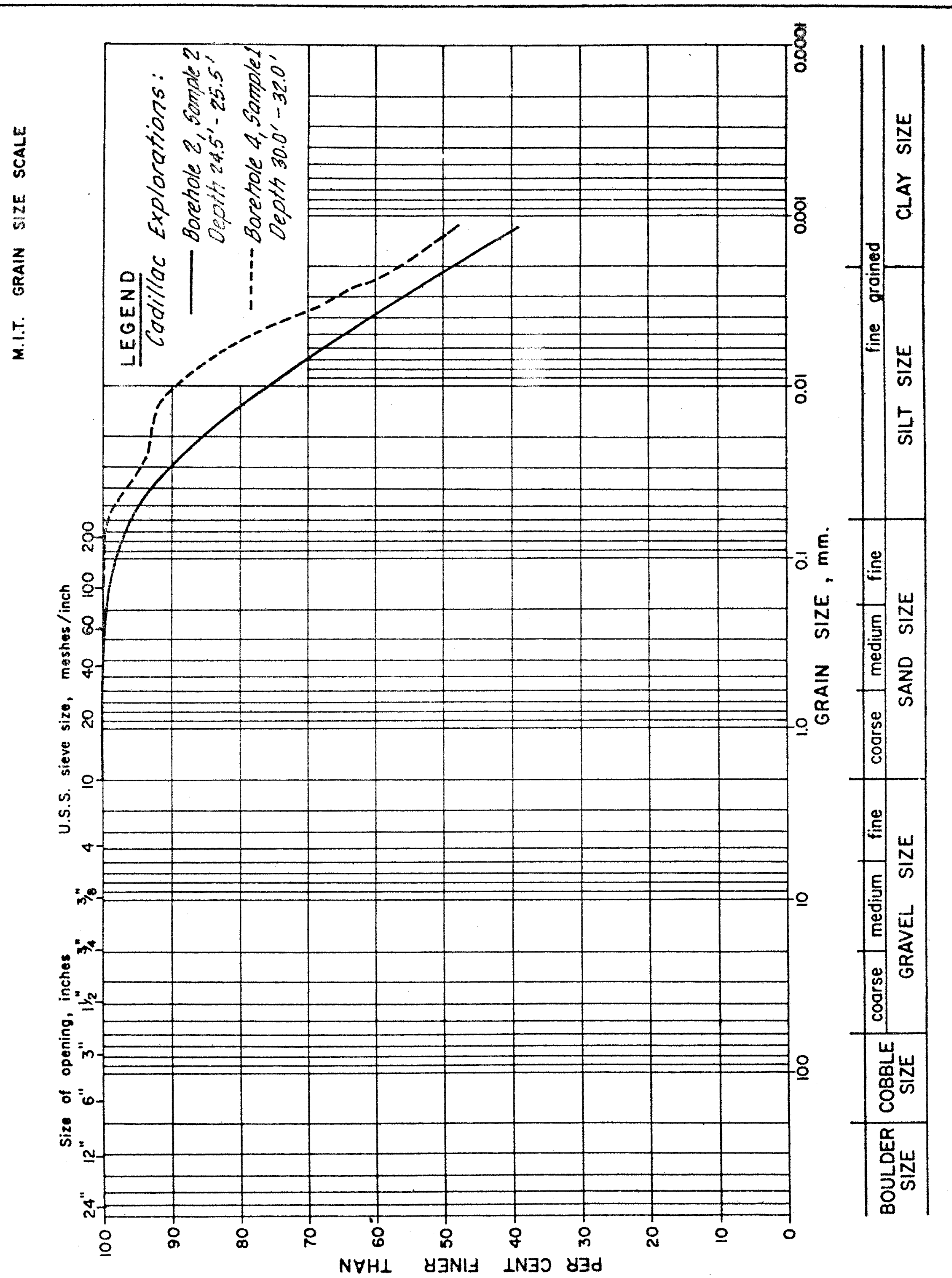
Drawn ________
App'd ________
Date Sept.'80



VOID RATIO - PRESSURE CURVES
CONSOLIDATION TEST
FIGURE B-6
Project No.
PRESSURE, tons/sq. ft.
0.1
1.0
10
100
0.9
0.8
0.7
0.6
0.5
0.4
.02
.01
0
Void Ratio
Coeff. of Consolidation, Cv (sq. in./min.)
LEGEND
Cadillac Explorations
Borehole 2, Sample 3
Depth 35'-37'
Overburden Pressure 1.36 Tsf
Preconsolidation Pressure 5.4 Tsf
Reconstructed Field Curve
Laboratory Curve
Golder Associates
Drawn
App'd
Date Sept '80

GRAIN SIZE DISTRIBUTION

Figure B - 7



Project No. 802-1073 Drawn [illegible] Reviewed [illegible] Date Sept '80

APPENDIX C

B.H. LEVELTON & ASSOCIATES LTD. - CONCRETE AGGREGATE EVALUATION

B. H. LEVELTON & ASSOCIATES LTD. 8805 Osler St., Vancouver, B.C. V6P 4G1 • 266-1411

September 24, 1980

File 80-514C

Golder & Associates
224 West 8th Avenue
Vancouver, B.C. V5Y 1N5

Attention: Mr. D. Shirley

PROJECT: Job 802-1073 Cadillac Explorations

SUBJECT: Concrete Aggregate Evaluation

Dear Sirs:

On September 10, 1980, B.H. Levelton & Associates Ltd. was commissioned to carry out aggregate quality assessment of material received that date from three identified sources related to Cadillac Explorations Ltd. The samples were not divided to coarse and fine aggregate fractions but were identified as "No. 1", "No. 2" and "No. 3". The bulk of process testing related to aggregate qualification and has been completed at this writing and this consitutes B.H. Levelton & Associates' interim report.

<u>SAMPLE "NO. 1"</u> (50 ft. N.E. of Borehole 9; alluvial sands & gravels)

Grading analysis of the sample as received is detailed on our Plate 1 attached. Thirty-eight percent of the material represents sand sizes less than 5 mm with 96 percent of the sample finer than 40 mm (industrially accepted upper limit for portland cement concretes). The fine aggregate fraction of the sample is detailed on Plate 4, showing generally acceptable concrete sand grading except that the material is at the highest limit of coarseness permitted by CSA A23.1 Table 1. The sample had a relative density of 2.60 for fine aggregate with an absorption of 2.8%. Organic impurities test on the sand fraction yielded a No. 1 colour, meeting the general requirements of Clause 5.3.3.2.2. of CSA A23.1. Magnesium sulphate soundness tests on the fine aggregate fraction are in progress at this writing and will be reported upon when complete.

The coarse aggregate fraction on the basis of material finer than 40 mm is shown on Plate 7 attached. For coarse aggregate, it can be assumed that 5 percent of the sample as received is oversize. The sample had a relative density of 2.687 and an absorption of 1.07 percent. Los Angeles Abrasion test results (CSA A23.2. - 16(a)) for Grading B yielded a total loss of 23.1 percent. CSA A23.1. specifies a maximum loss of 50 percent except where significant wear may occur when the loss shall be less than 35 percent. On the coarse aggregate fraction magnesium sulphate soundness tests are also in progress and will be reported upon under separate cover.

SAMPLE "NO. 2" (50 ft. West of Borehole 6; alluvial sands & gravels)

Grading analyses for the sample as received are detailed on Plate 2 attached. Thirty-seven percent of the sample is finer than 5 mm and 93 percent is finer than 40 mm.

The fine aggregate fraction grading is shown on Plate 5 attached. The sample does not meet the requirements of CSA A23.1. Table 1, being outside the limits of coarseness for concrete sands and having a fineness modulus of 3.40 (CSA limits between 2.3 and 3.1). The organic colour is No. 1 meeting the general requirements of Clause 5.3.3.2.2. of CSA A23.1. The sample had a relative density of 2.60 and an absorption of 2.6 percent. Magnesium sulphate soundness tests are in progress at this writing and will be reported upon when complete.

The coarse aggregate fraction finer than 40 mm demonstrated an oversize of 24 percent and generally conforms to the requirements of CSA A23.1. Group 1 for 40 mm x 5 mm aggregates with the sample being slightly finer than the grain size limit. Los Angeles abrasion test results (CSA A23.2. - 16A Grading B) yielded a percent loss of 25.9; within the significant wear maximum limits specified by CSA A23.1. Magnesium sulphate soundness tests on the coarse aggregate fraction are in process at this writing and will be reported upon when complete.

SAMPLE "NO. 3" (200 ft. North of 2850 ft. portal; mine waste)

The grading of this sample as received is detailed on Plate 3. The sample contained 22 percent finer than 5 mm and 93 percent finer than 40 mm. (This is the industrially considered upper limit for aggregate in portland cement concrete.) Please note that this sample contained a very small fraction of sand in contrast to the other samples. This would result in significant difficulties in creating a densely graded product without wastage in the sizes between 40 and 5 mm.

The fine aggregate fraction is shown on Plate 6. The grading is outside the CSA A23.1. Table 1 limits for fine aggregate, below the limits of coarseness for concrete sand. It is also notable that the fine aggregate contained more than 8 percent finer than 80 µm by wash (decant) method. The sample had a relative density of 2.73 and an absorption of 0.99 percent. Magnesium sulphate soundness tests are in progress at this writing and will be reported upon when complete. The organic impurity test for the fine aggregate fraction yielded a No. 1 colour, within the general requirement of Clause 5.3.3.2.2. of CSA A23.1.

A coarse aggregate fraction for 40 x 5 mm sizes is detailed on Plate 8 attached. The sample is within the grain size limits for that concrete aggregate fraction and demonstrated a relative density of 2.774 and an absorption of 0.76 percent. Eleven percent of the sample was oversize material. Los Angeles abrasion test results (CSA A23.2. - 16(a)) for Grading B yielded a loss of 21.8 percent, within the limits for concrete where significant wear may occur. Magnesium sulphate soundness tests are in process at this writing and will be reported upon when complete.

GENERAL REMARKS

The sand grading for all three sources of material as received indicates that they are at the extreme limits of coarseness for the manufacture of portland cement concrete. In the case of Sample 3, a high percentage of fines is also present. It is expected that washing of concrete aggregates or other separation techniques may be required in order to prepare the fine aggregate fraction, and further that a blending sand (fineness modulus approximating 2.0) may be required in quantity in order to improve the placement, finishing and strength improvement characteristics of the material.

Pending the results of sand sulphate tests, test program absorptions for Samples 1 and 2 indicate reasonably higher than usual values. While it is unlikely that sulphate losses will exceed those specified in CSA A23.1., the use of fine aggregates with fine absorptions, such as those demonstrated by these samples, suggests some expansive and reactive difficulties might be experienced in severe environments where portland cement concretes are manufactured. B.H. Levelton & Associates will be able to comment further on this parameter when sulphate tests have been concluded.

Coarse aggregate fractions for Samples 1 and 2 are round to subround and contain significant portions of oversize material. These samples may to some extent benefit from crushing operations to improve grading and strength characteristics of manufactured concrete. Sample 3 is subangular to angular and may produce difficulties in bleeding and finishing for portland cement concrete manufacture. This is also the source of material from which a small sand fraction was obtained (see remarks above).

After the magnesium sulphate soundness tests are reported, B.H. Levelton & Associates will be pleased to discuss separation equipment and techniques for the material preparation. It is stressed that our remarks herein are limited only in scope to the materials as received in the Vancouver laboratory.

Yours very truly,

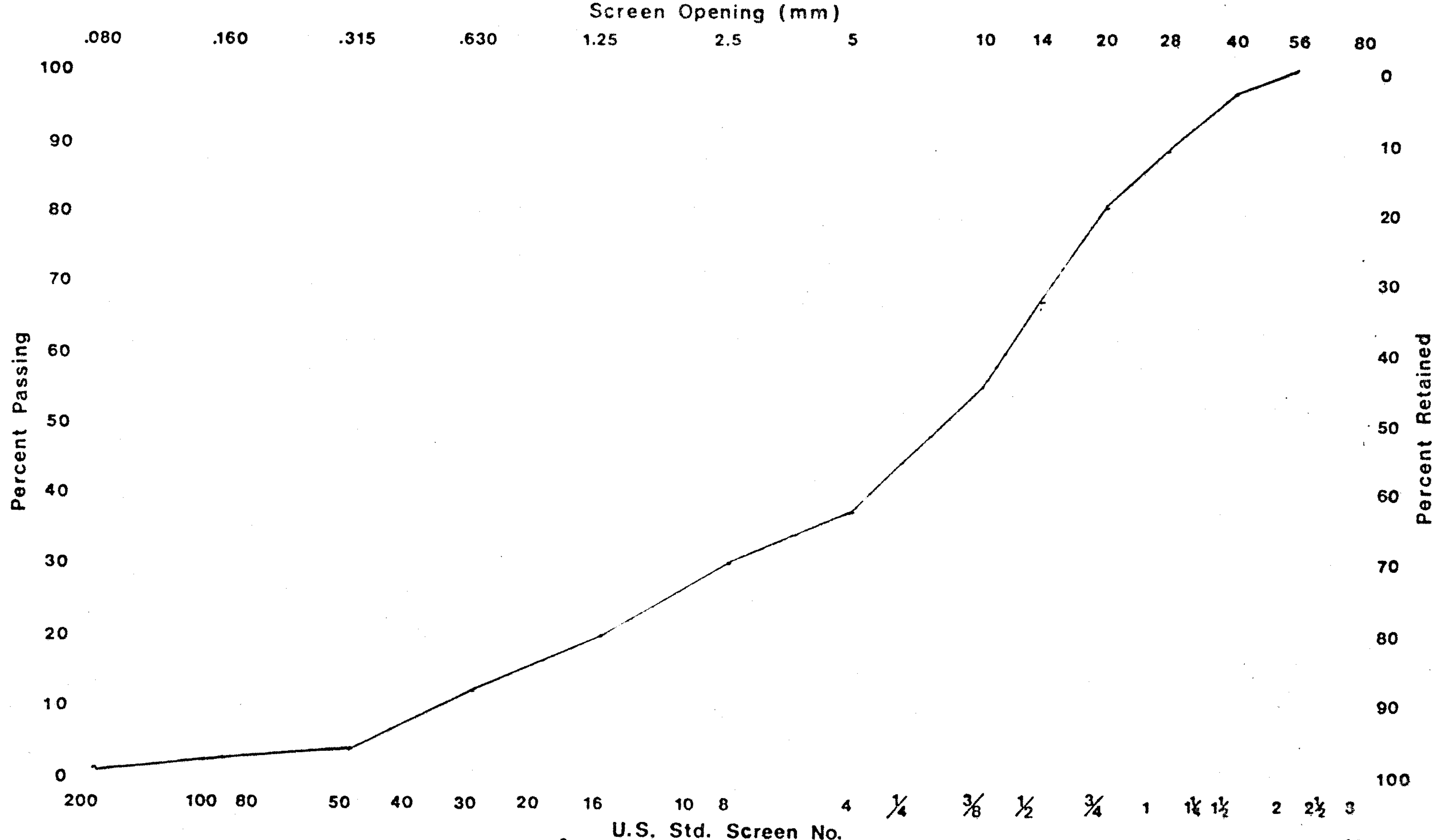
B.H. LEVELTON & ASSOCIATES LTD.

M.E. Seymour

M.E. Seymour, P.Eng.

MERS/mn

AGGREGATE GRADATION CHART



Project: Cadillac Explorations (Golder)

Material: Gravel Sandy (As Received)

Date Sampled: Submitted

Sample No.: #1

File No.: 80-514C

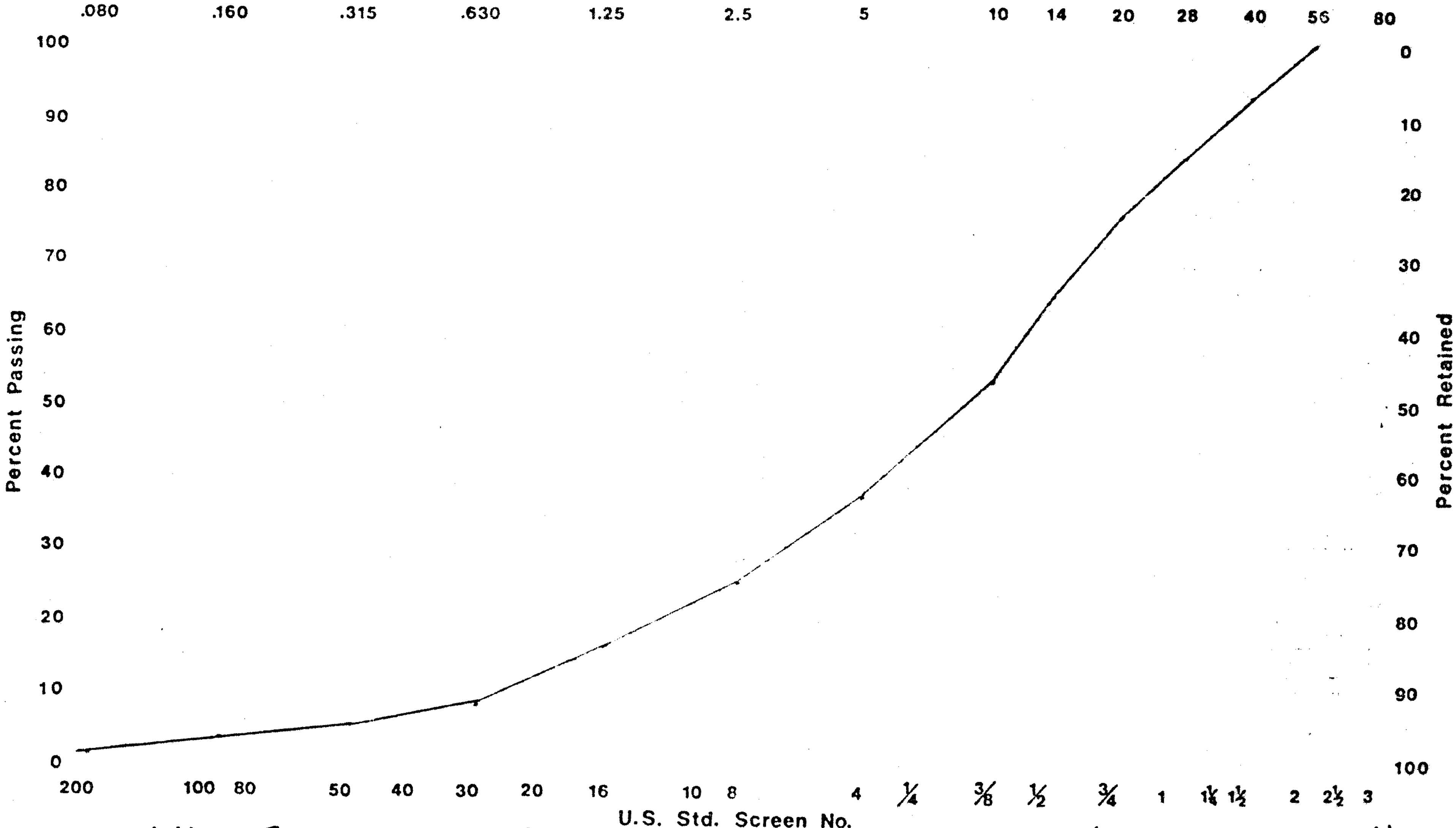
Specification: n/a

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER VICTORIA

Plate 1

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted

File No.: 80 514C

Specification: na

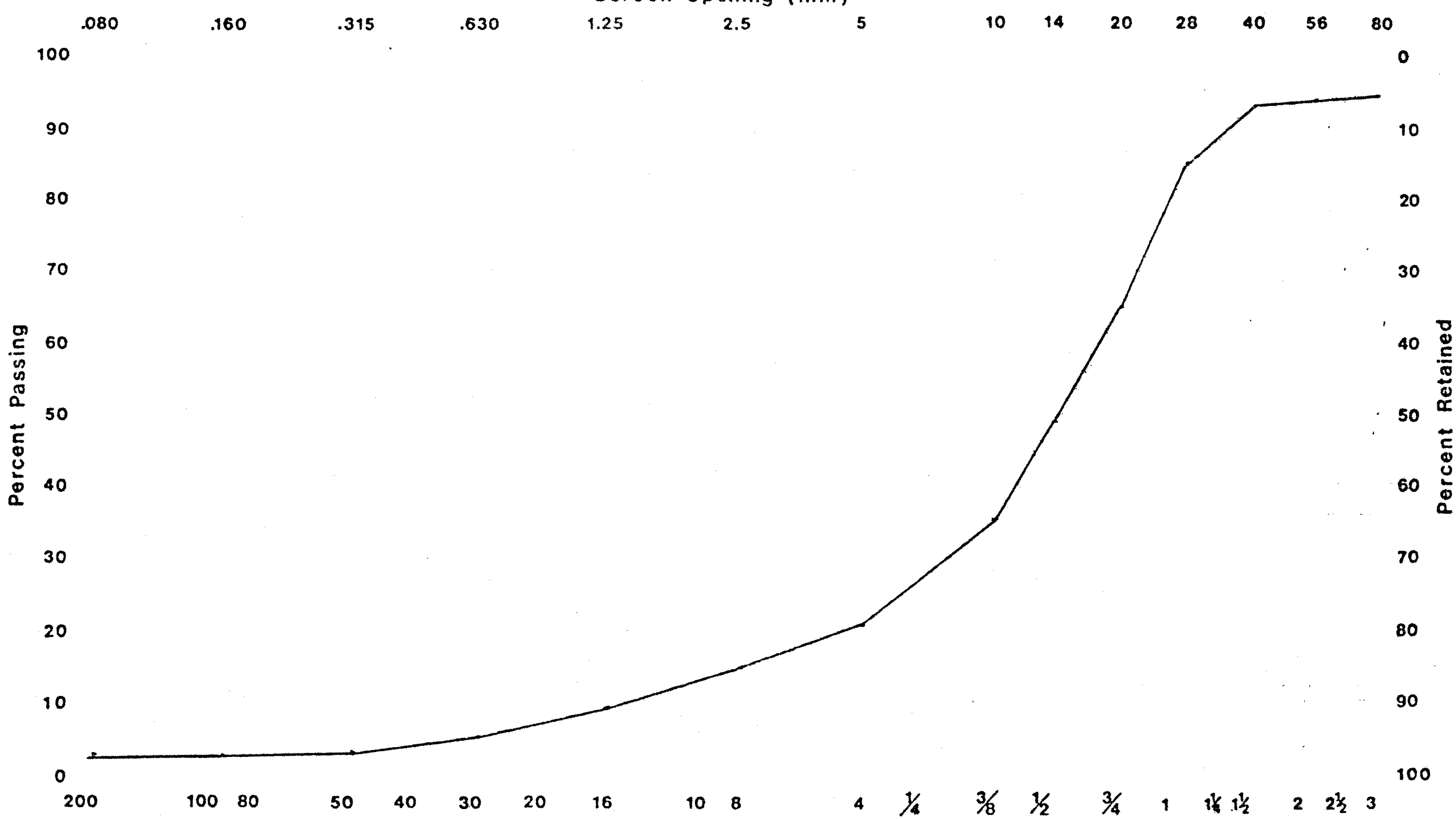
Material: Gravel, Sandy (As Received)

Sample No.: #2

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER VICTORIA

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted

File No.: 80-514C

Specification: na

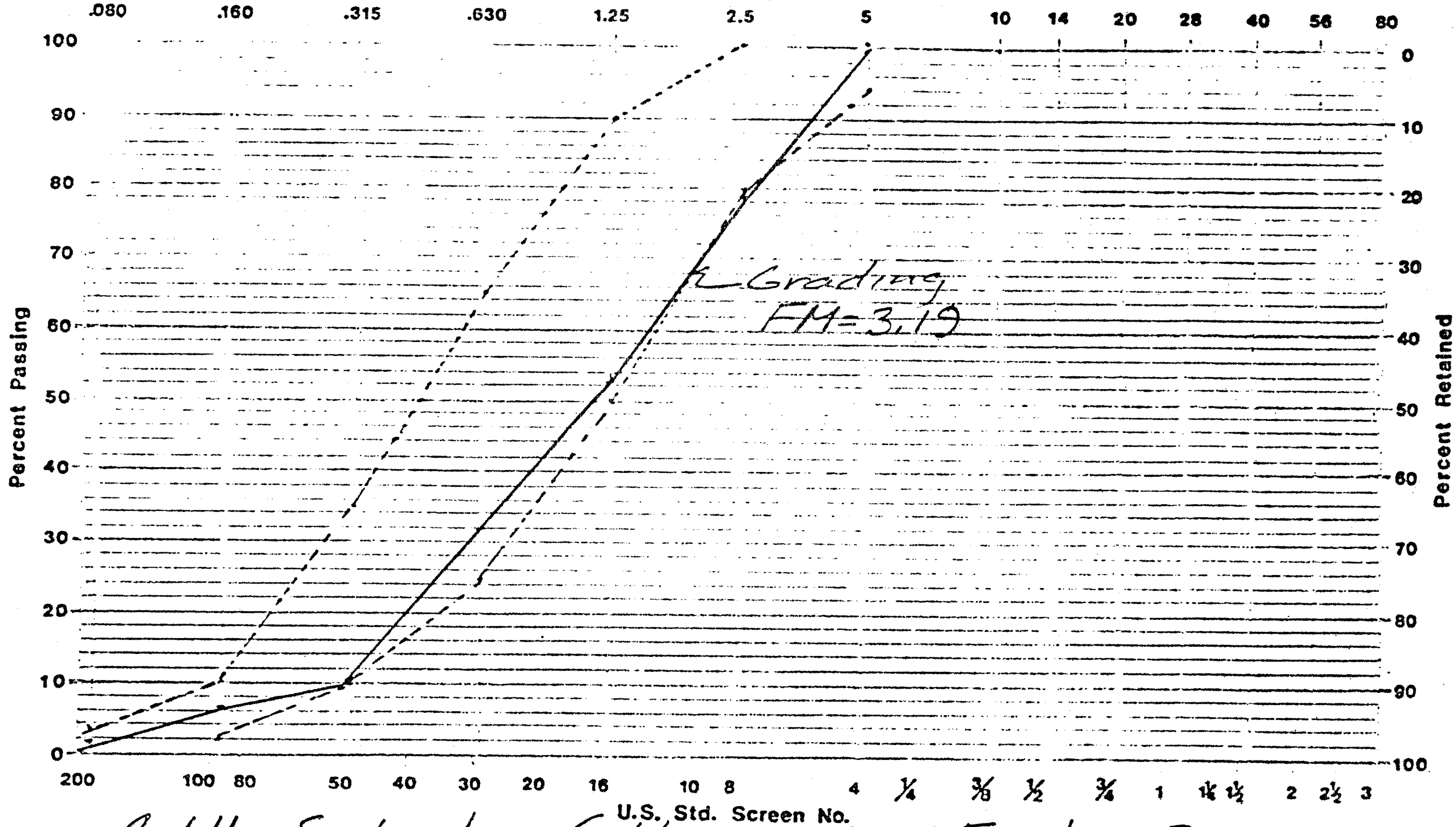
Material: Gravel Sandy (As Received)

Sample No.: #3

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER VICTORIA

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted.

File No.: EQ 514C

Specification: CSA A23.1 Table 1

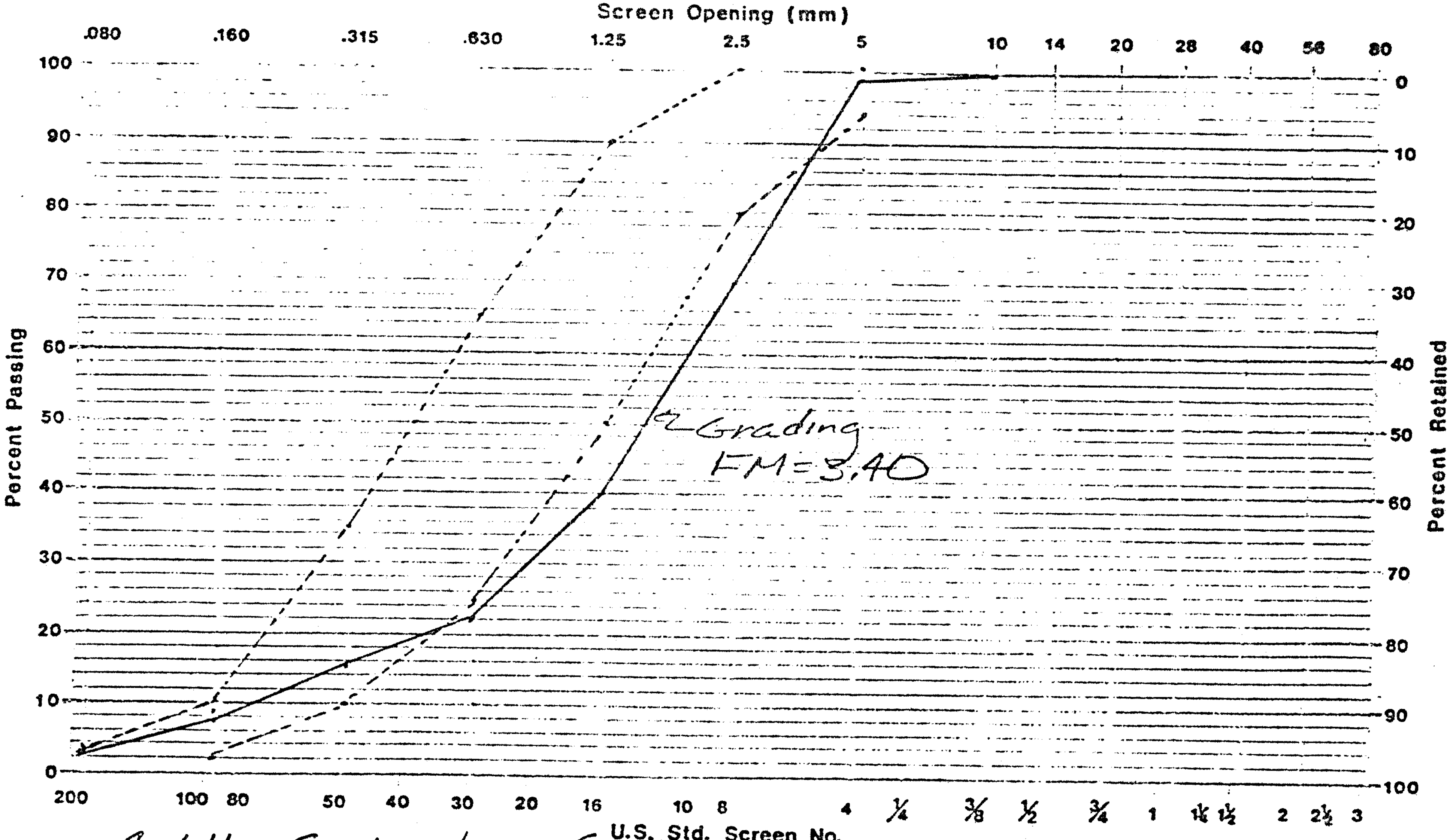
Material: Sand Fraction RD=2.60, A=2.8

Sample No.: #1; Organic No.1

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER VICTORIA

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted

File No.: EO 514C

Specification: CSA A23.1 Table 1

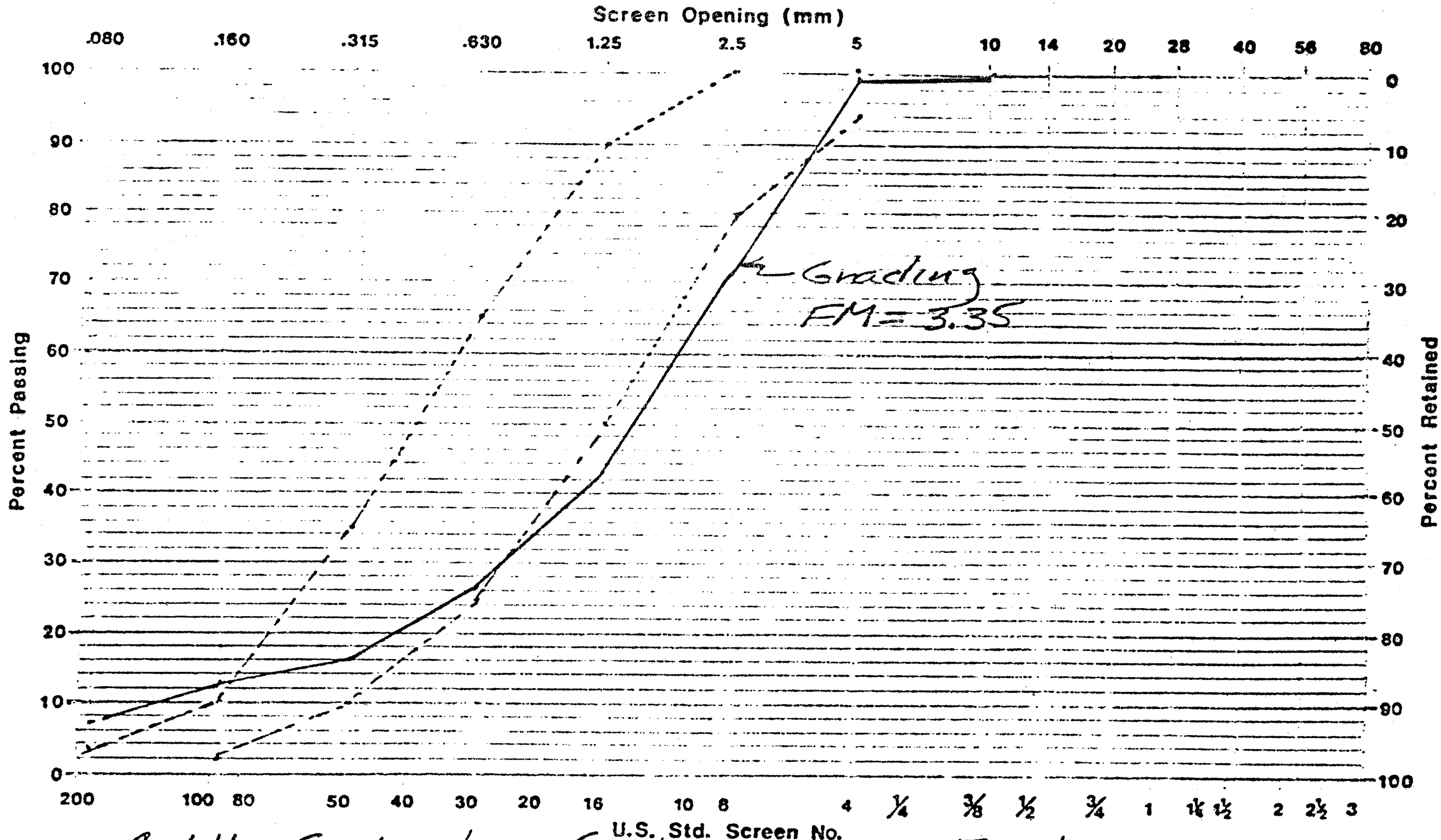
Material: Sand Fraction RD=2.60, A=2.6

Sample No.: #2 : Organic #1

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER VICTORIA

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted

File No.: 80 514C

Specification: CSA A23.1 Table 1

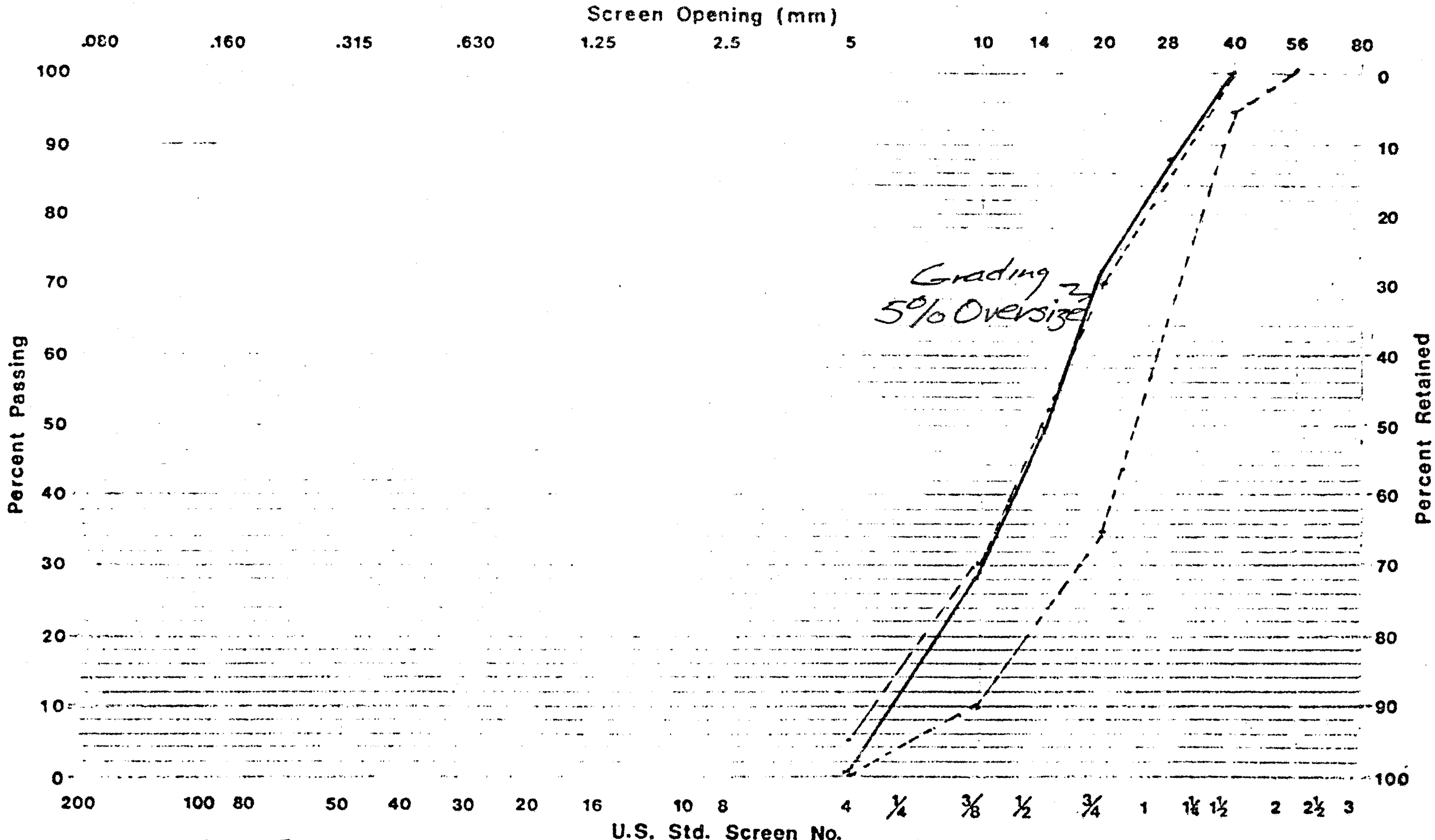
Material: Sand Fraction

Sample No.: #3: Organic No. 1

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER VICTORIA

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted

File No.: 80514C

Specification: CSA A23.1 Group I.

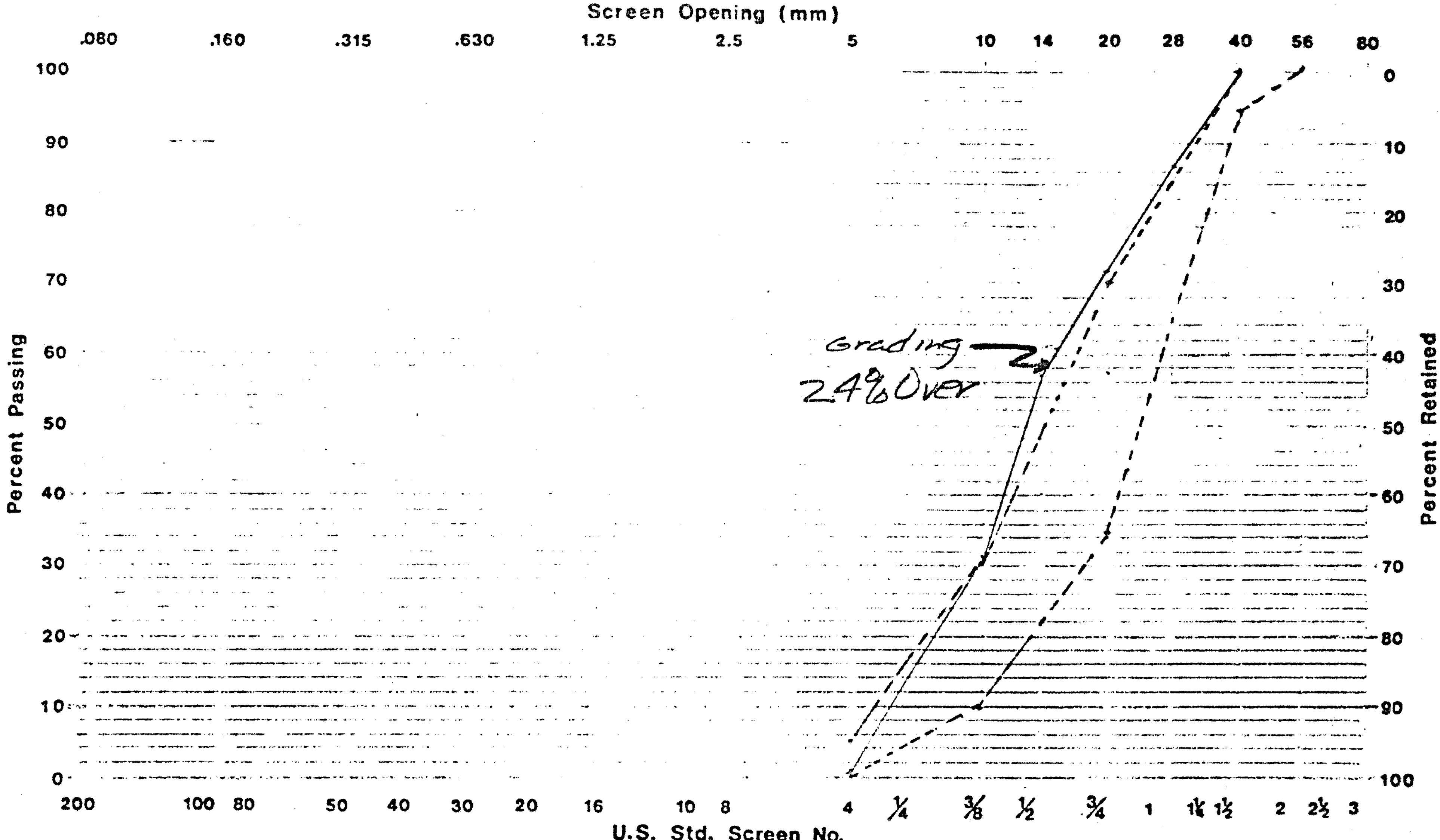
Material: Fraction 40 x 5mm

Sample No.: #1; RD=2.687, A=1.07%

B. H. LEVELTON & ASSOCIATES LTD.
VANCOUVER VICTORIA

Plate 7

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted

File No.: 80514C

Specification: CSA A23.1 Group I.

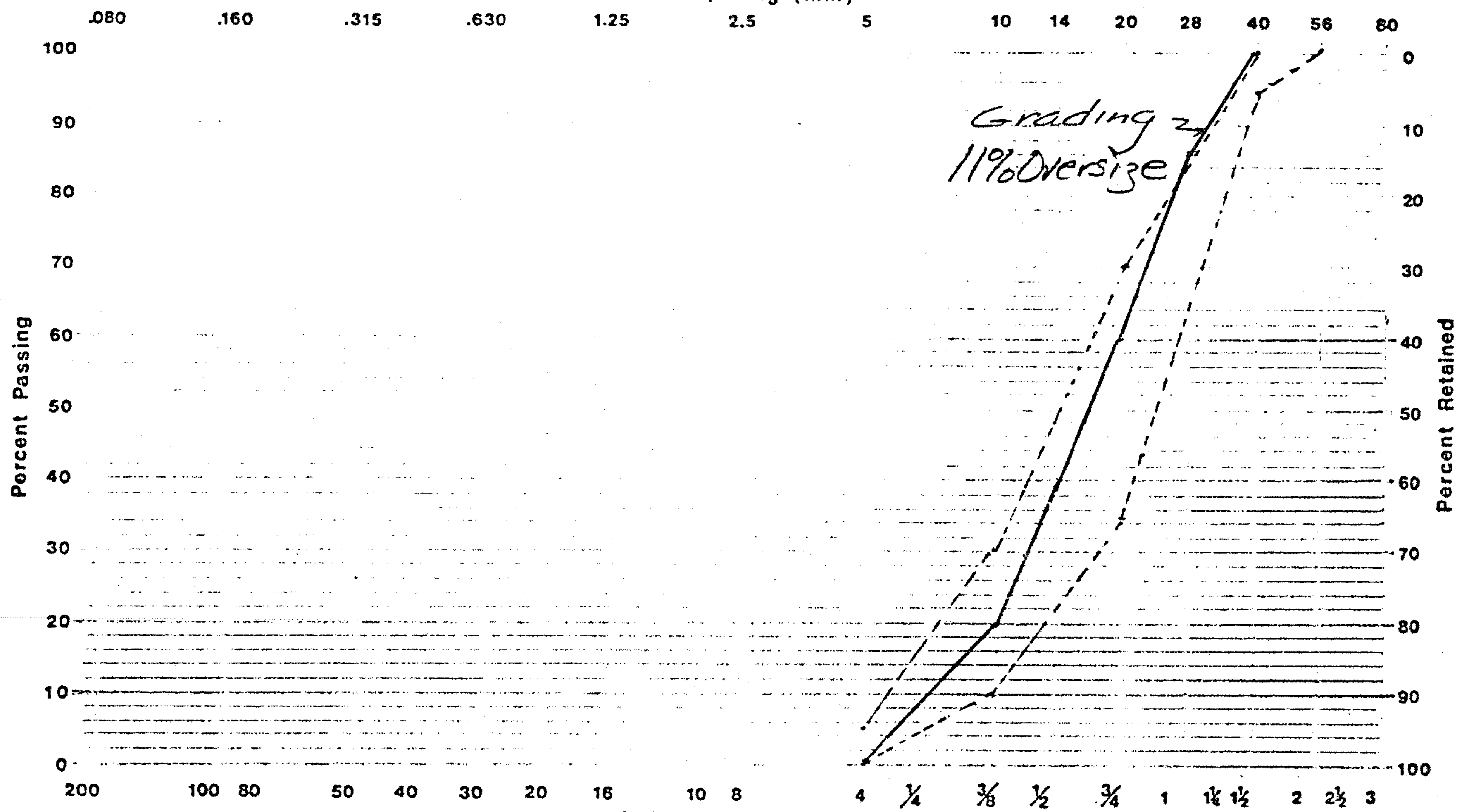
Material: Fraction 40 x 5mm

Sample No.: #2 RD2705A =.83

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER **VICTORIA**

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted

File No.: 80514C

Specification: CSA A23.1 Group I.

Material: Fraction 40 x 5mm

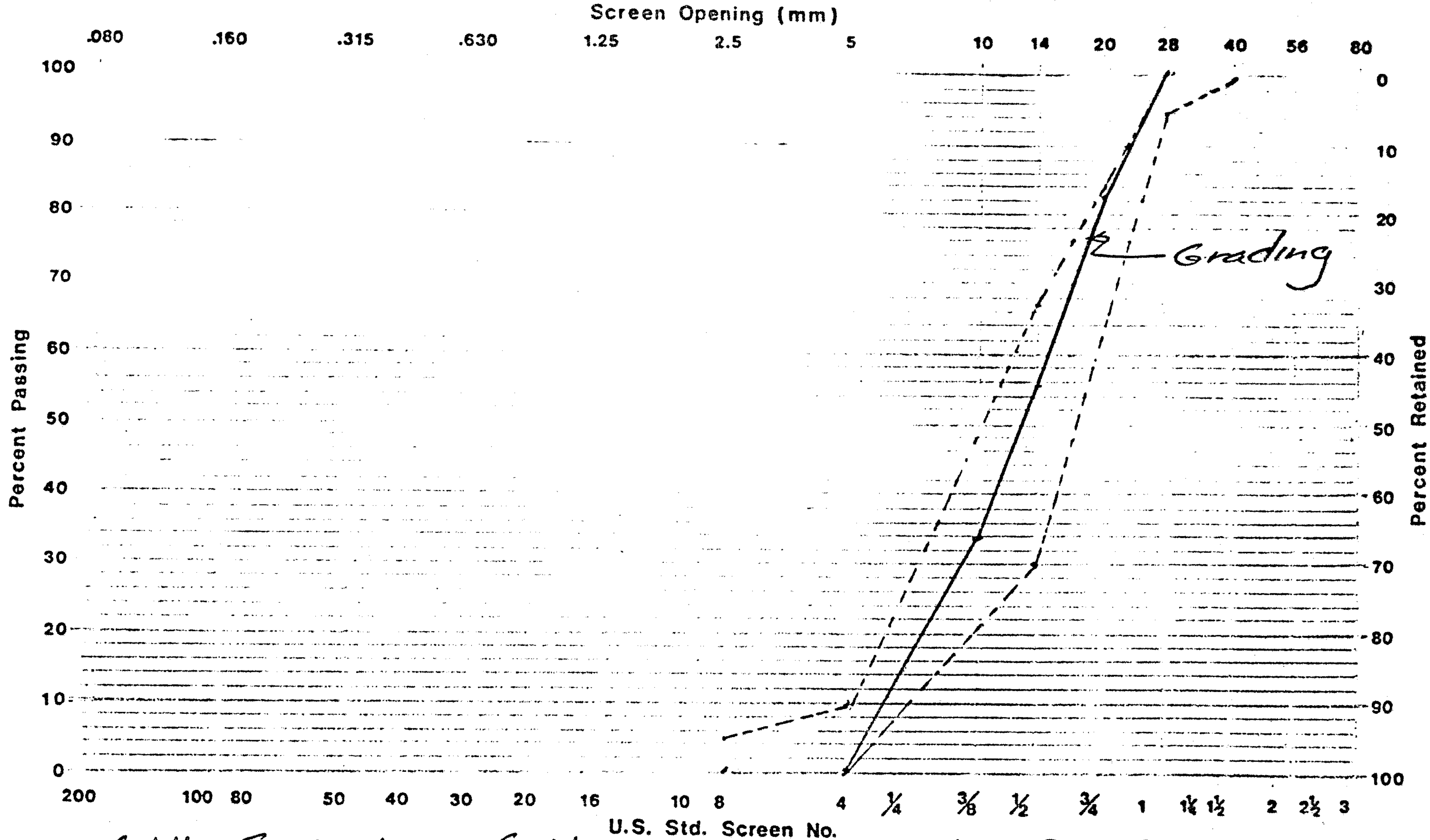
Sample No.: #3; RD=2.774 A=.78%

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER VICTORIA

Plate 8

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted

File No.: 80 514C

Specification: CSA A23.1 Table3 Group I

Material: Fraction 28x5mm.

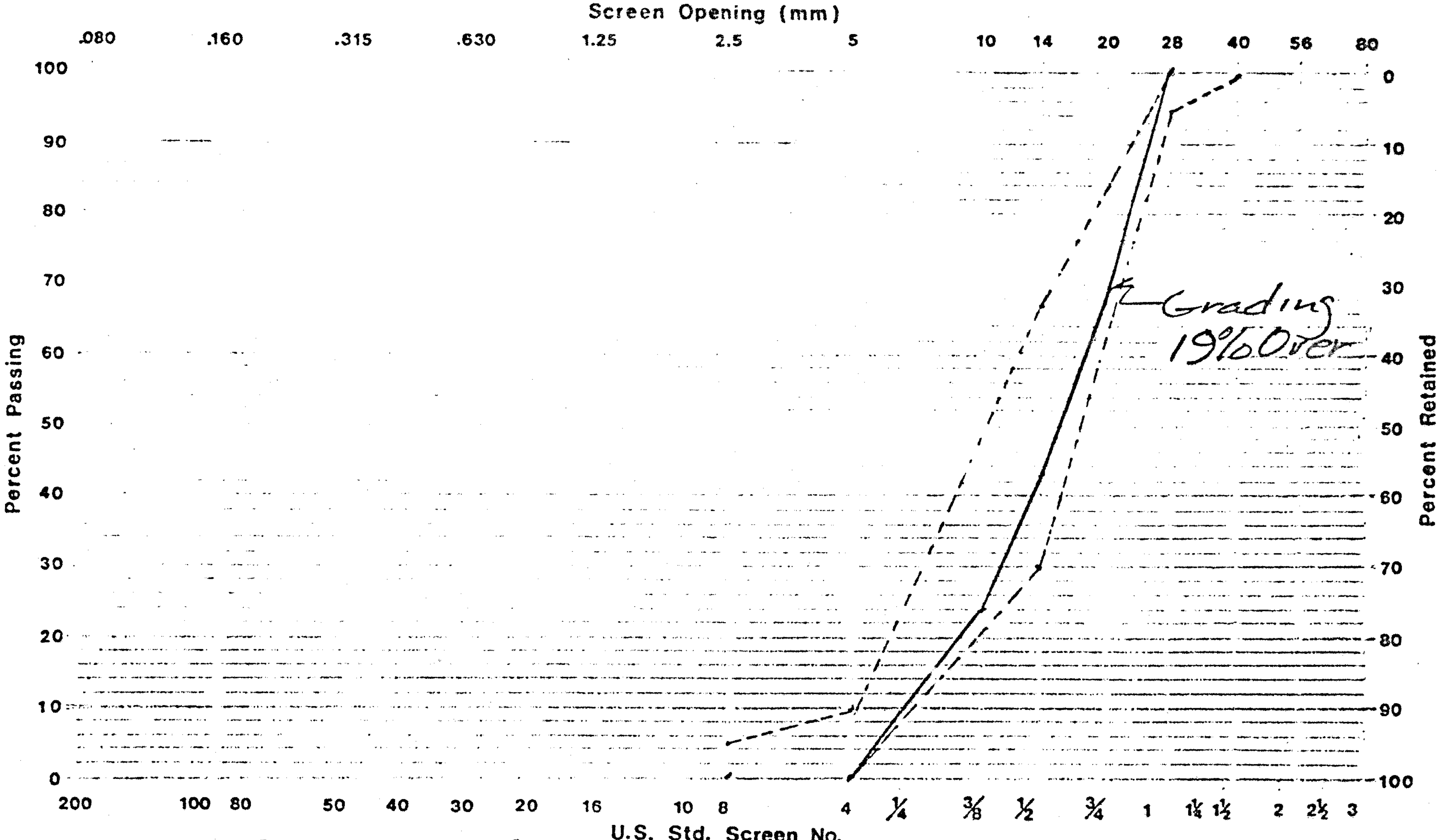
Sample No.: #1, 17% Oversize

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER VICTORIA

Plate 9

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted

File No.: 80 514C

Specification: CSA A23.1 Table3 Group I

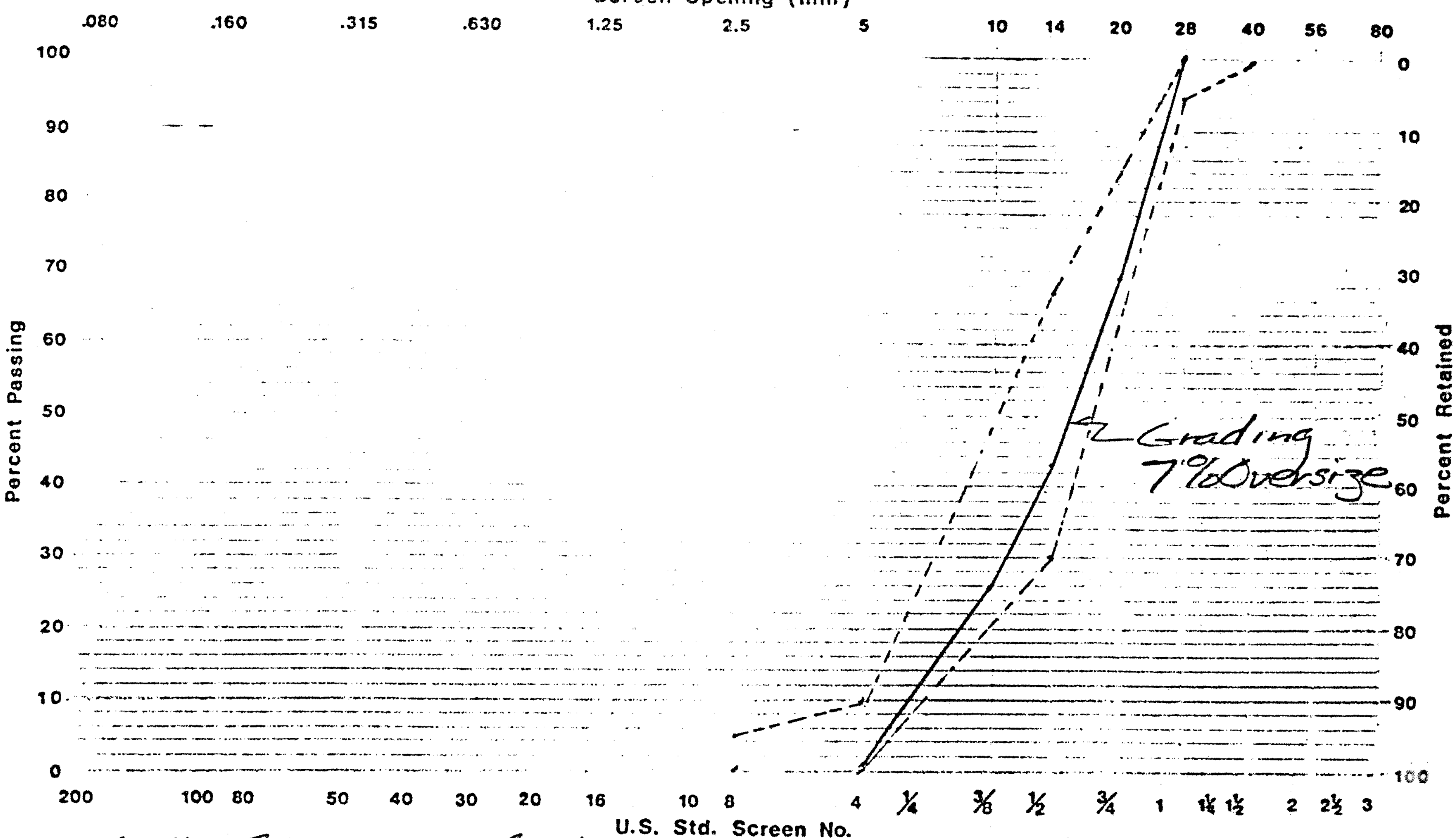
Material: Fraction 28×5mm.

Sample No.: #2

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER VICTORIA

AGGREGATE GRADATION CHART



Project: Cadillac Explorations Golder

Date Sampled: Submitted

File No.: 80 514C

Specification: CSA A23.1 Table 3 Group I

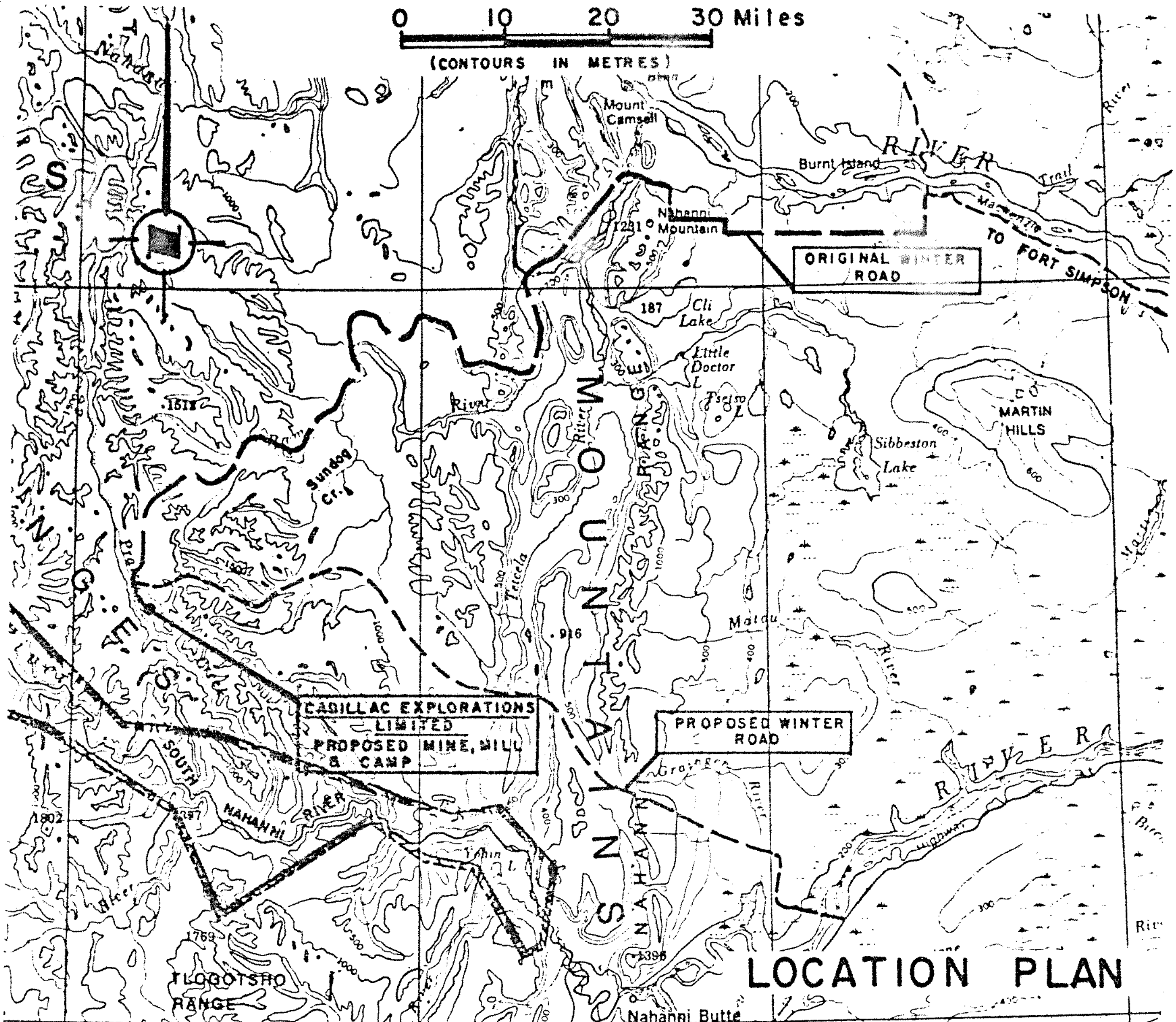
Material: Fraction 28x5mm.

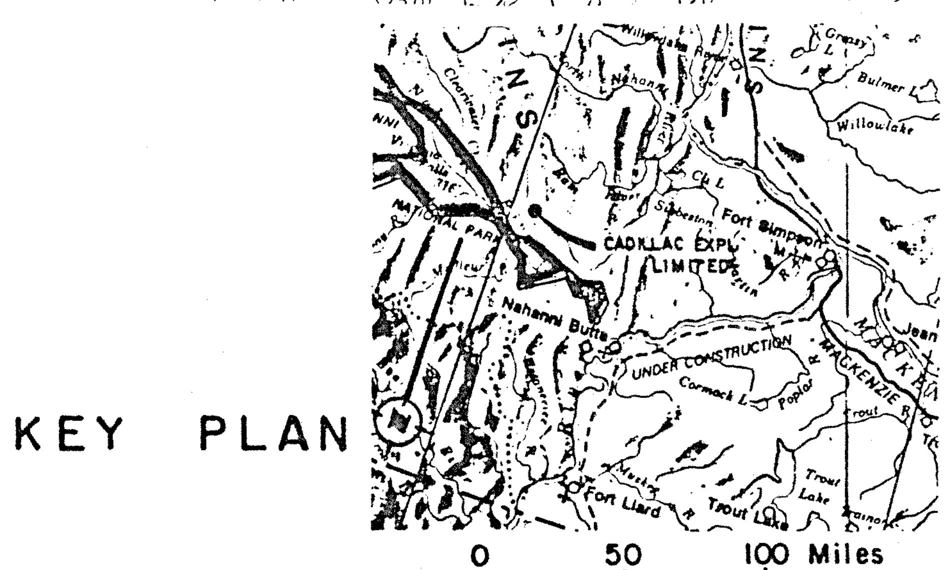
Sample No.: #3

B. H. LEVELTON & ASSOCIATES LTD.

VANCOUVER VICTORIA

LOCATION PLAN AND KEY PLAN **Figure 1**



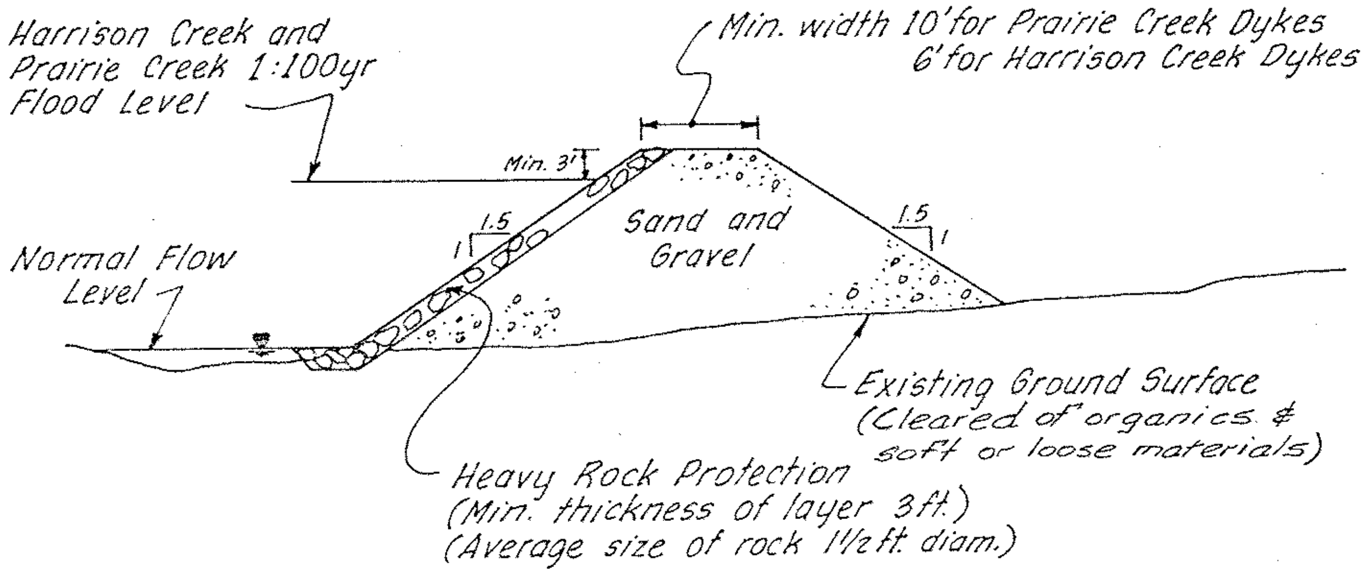


Golder Associates

Project No. 802 1073 Drawn [illegible] Checked [illegible] Reviewed [illegible] Date 1 May 80

TYPICAL SECTION - PRAIRIE CREEK & HARRISON CREEK FLOOD PROTECTION DYKES

Figure 9



Scale: 1 inch to 20 feet

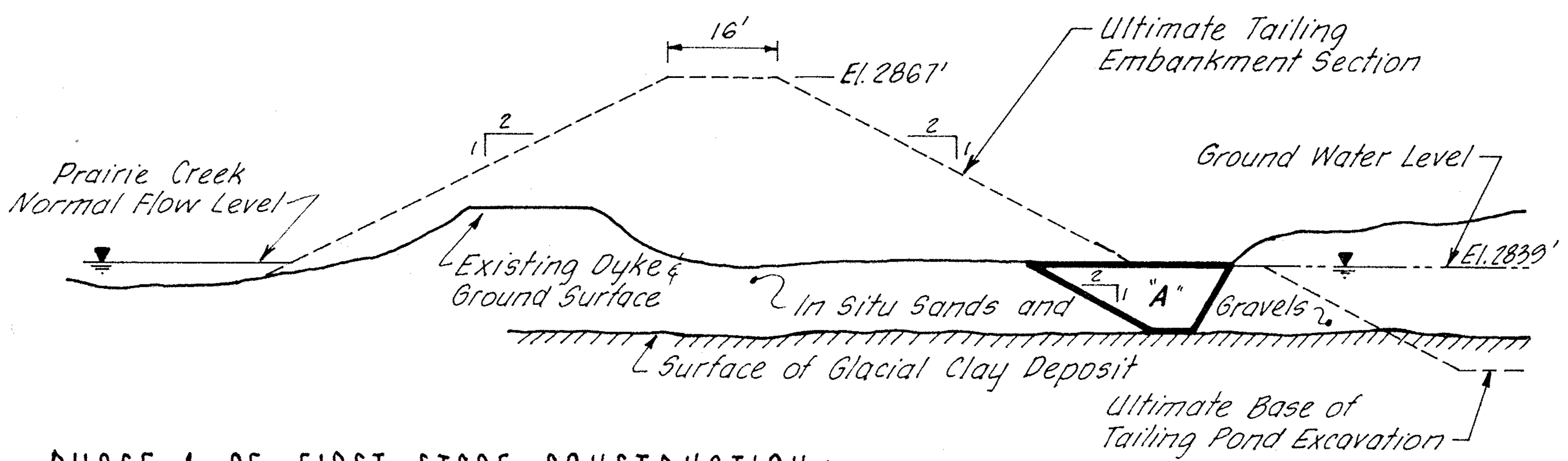
Project No. .... Drawn .... Reviewed .... Date

HORIZONTAL SCALE

200 100 0 200 400 FEET

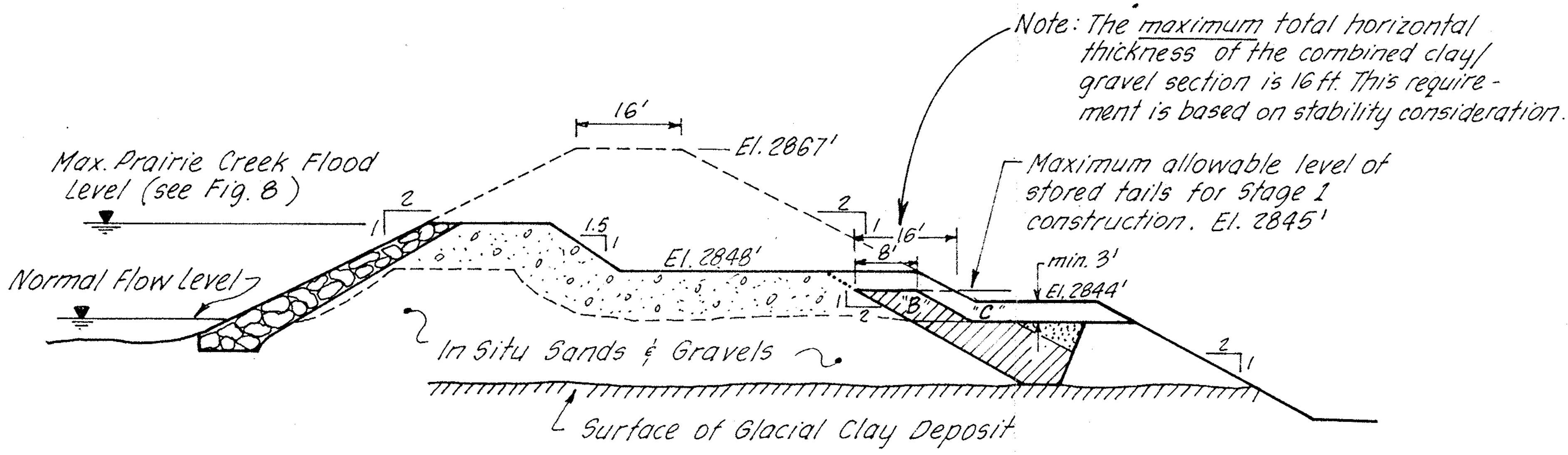
* REFERENCE KER, PRIESTMAN & ASSOCIATES OCTOBER 1980

Cadillac Explorations Ltd. Northwest Territories	
Golder Associates	
PRAIRIE CREEK ESTIMATED FLOOD LEVEL PROFILES *	
Drawn S.H.	Reviewed [signature]
Date SEPT. 1980	Project No. 802-1073 Fig. 8



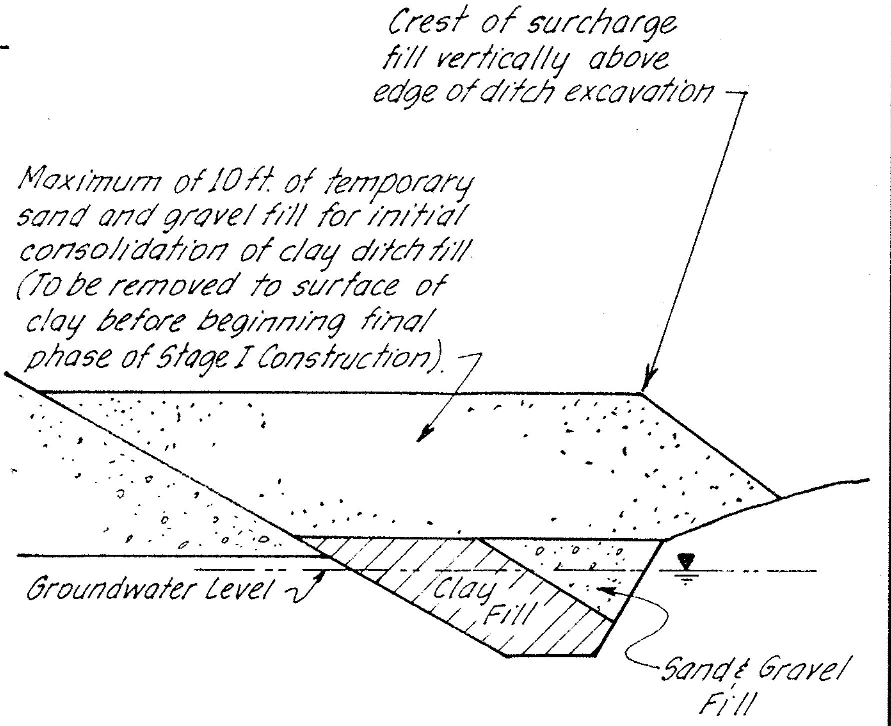
PHASE 1 OF FIRST STAGE CONSTRUCTION:

a) Excavate "A" to surface of clay (or bedrock) maintaining the outside slope of the excavation as steep as possible. Maintain water level to flood excavation so that sloughing of excavation sides is minimized.
b) Fill the excavation with clay excavated from within the pond area to a level above that of ground water.

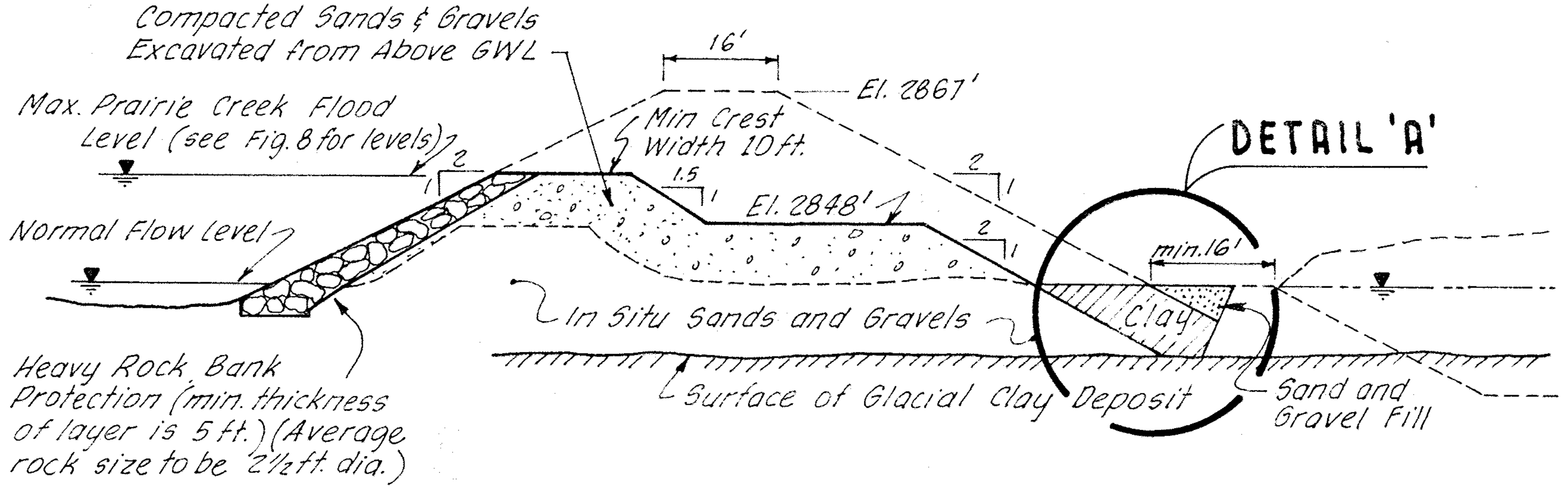


FINAL PHASE OF FIRST STAGE CONSTRUCTION:

a) Dewater and continue excavation of the pond area.
b) Place clay and sands and gravels at "B" and "C", respectively.
c) Excavated materials in excess of those required for First Stage construction can be stockpiled for construction of subsequent stages of the embankment and/or used for other construction requirements.



DETAIL 'A': TEMPORARY SURCHARGE FOR CONSOLIDATION OF CLAY FILL
(Not to Scale)

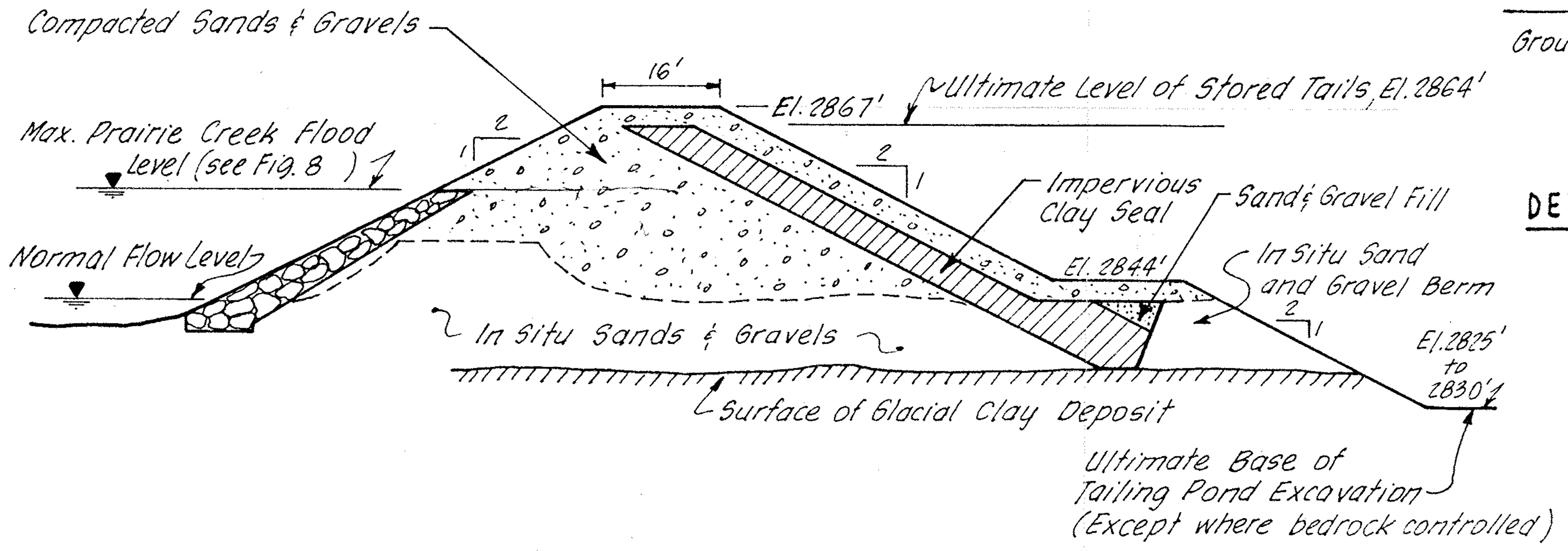


PHASE 2 OF FIRST STAGE CONSTRUCTION:

a) Excavate alluvial sands and gravels from within pond area and place as shown.

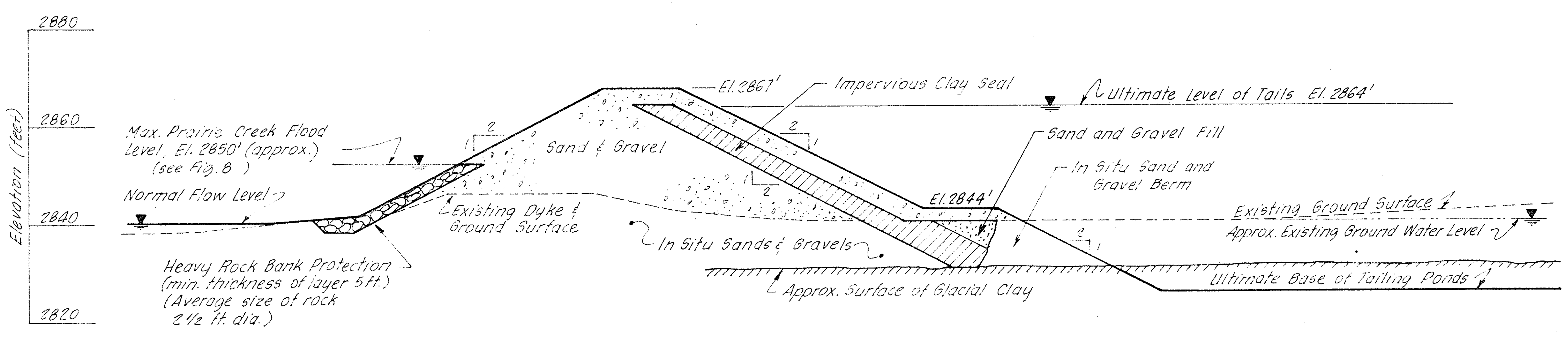
b) Place heavy rock on outside face of embankment to maximum Prairie Creek flood level.

Note: For those portions of the tailing embankments not bordering Prairie Creek, the rock armour is not required. However, all portions of the construction must be capable of resisting maximum flow levels in Prairie Creek.

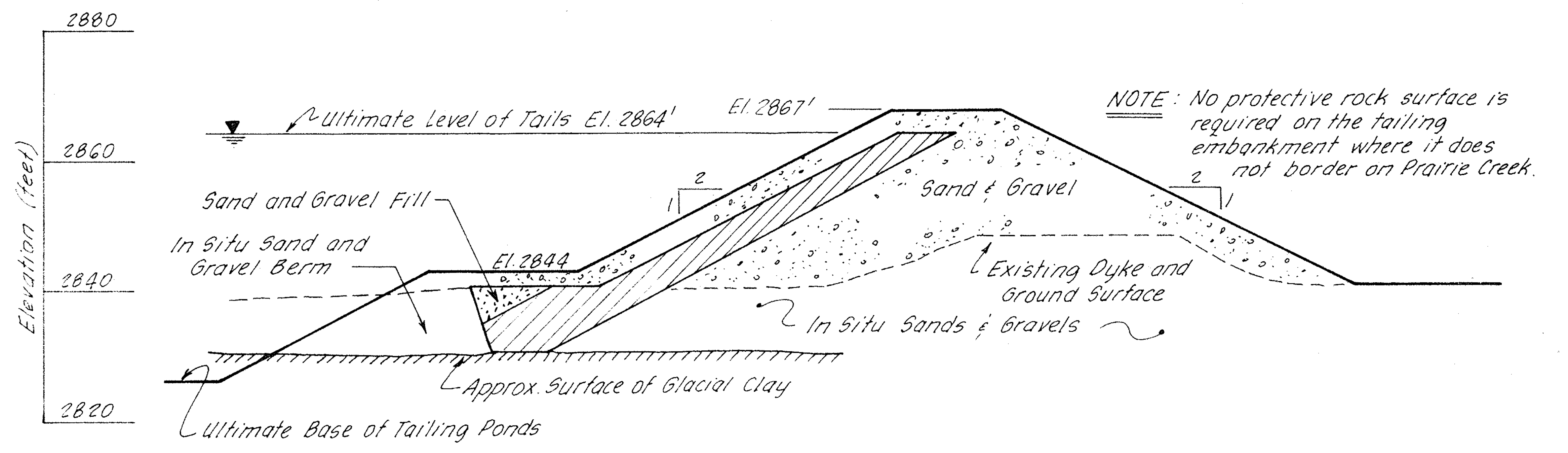


ULTIMATE EMBANKMENT SECTION AFTER ALL STAGES COMPLETED

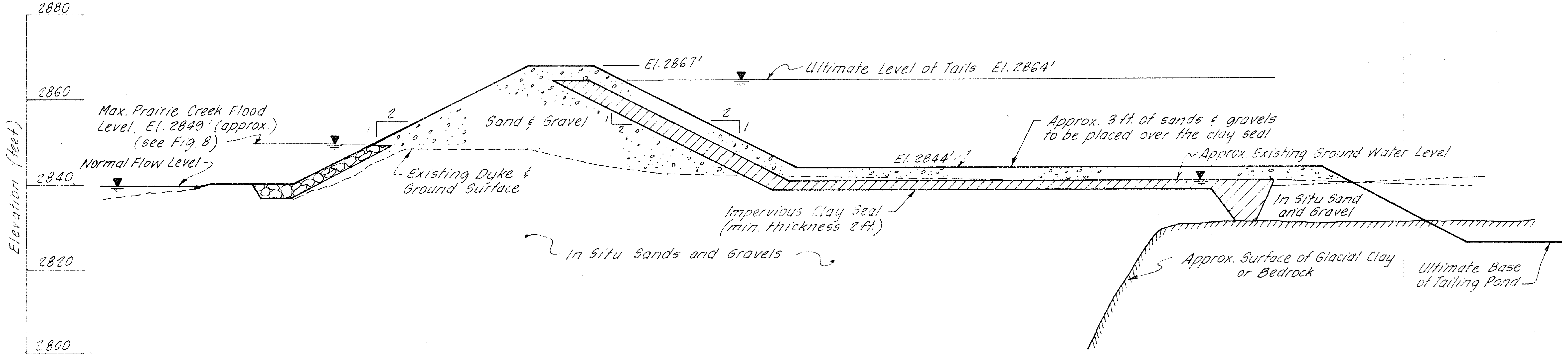
Cadillac Explorations Ltd. Northwest Territories	
Golder Associates	
SCHEMATIC SECTIONS FOR PHASES OF STAGE I EMBANKMENT CONSTRUCTION	
Drawn S.H.	Reviewed
Date SEPT. 1980	Project No. 802-1073 Fig. 7



SECTION A - A
PERIMETER EMBANKMENT



SECTION C - C
PERIMETER EMBANKMENT

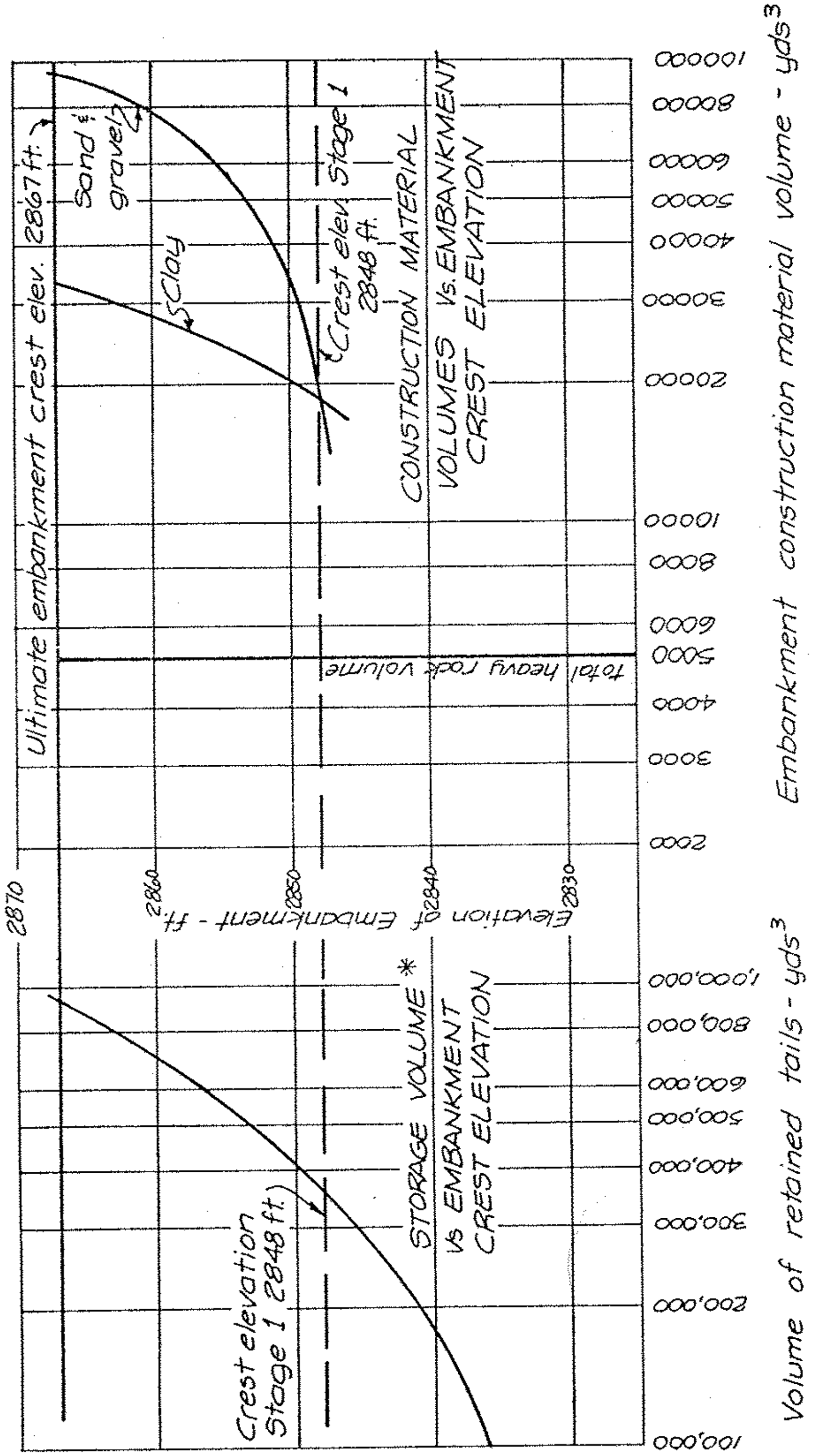


SECTION B - B
PERIMETER EMBANKMENT

Note: For location of sections see Fig. 2.

Cadillac Explorations Ltd. Northwest Territories	
Golder Associates	
TYPICAL ULTIMATE EMBANKMENT SECTIONS	
Drawn S.H.	Reviewed
Date SEPT. 1980	Project No. 802-1073 Fig. 6

T2 STORAGE VOLUMES AND CONSTRUCTION MATERIAL VOLUMES vs EMBANKMENT CREST ELEVATION **Figure 5**



* Storage to 3' below crest.

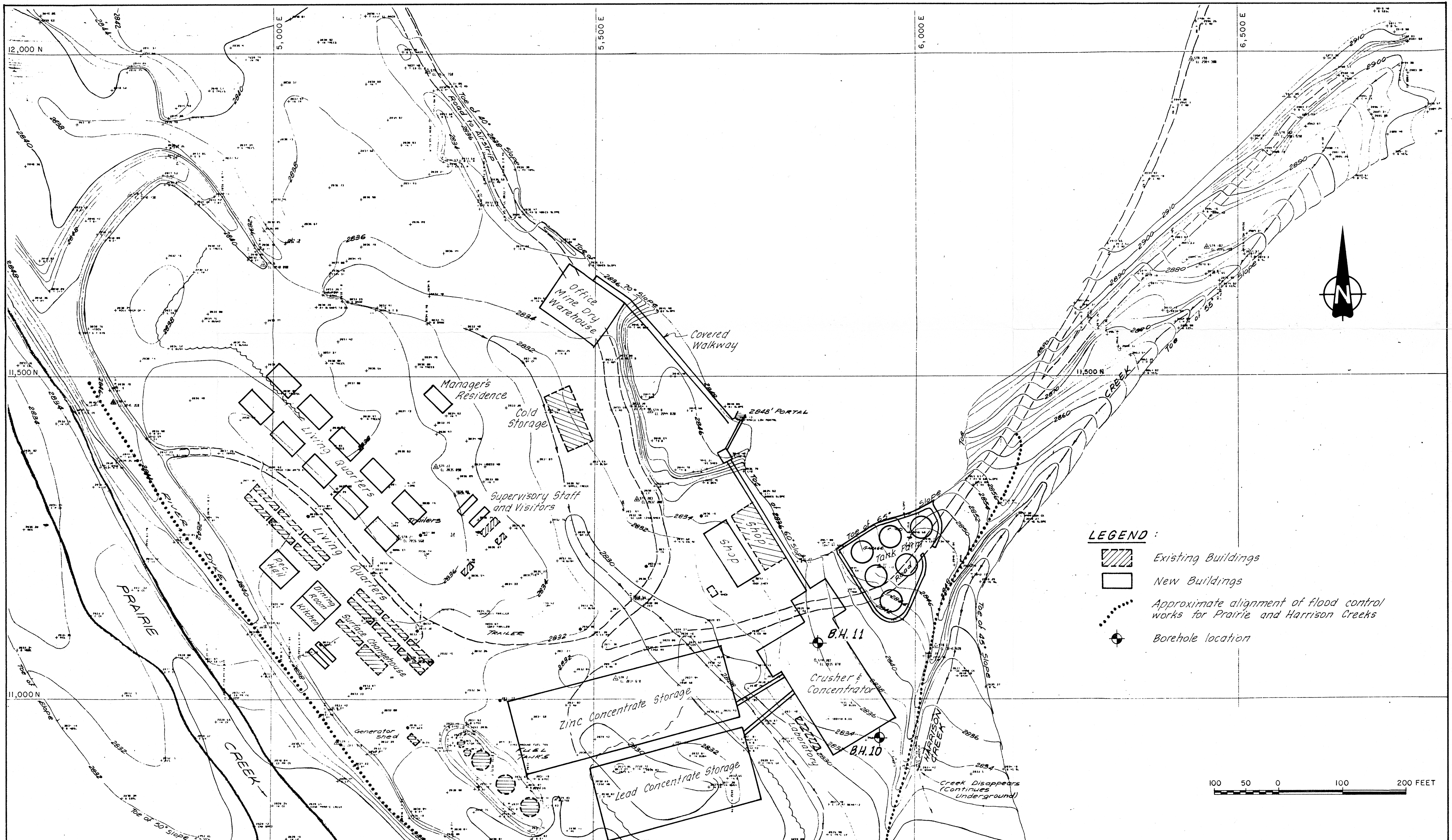
Project No. 802-1073 Drawn R.D. Reviewed Date Sept '80

Cadillac Explorations Ltd.
Northwest Territories

Golder Associates

POTENTIAL
TAILING AREA T-3

Drawn	S.H.	Reviewed	
Date	SEPT. 1980	Project No. 802-1073	Fig. 4



Cadillac Explorations Ltd. Northwest Territories	
Golder Associates	
MINE AND CAMPSITE LAYOUT	
Drawn S.H.	Reviewed
Date SEPT. 1980	Project No. 802-1073 Fig. 3

Cadillac Explorations Ltd. Northwest Territories	
Golder Associates	
TAILING RETENTION AREA T - 2	
Drawn: S.H.	Reviewed
Date: SEPT. 1980	Project No. 802 - 1073 Fig.2

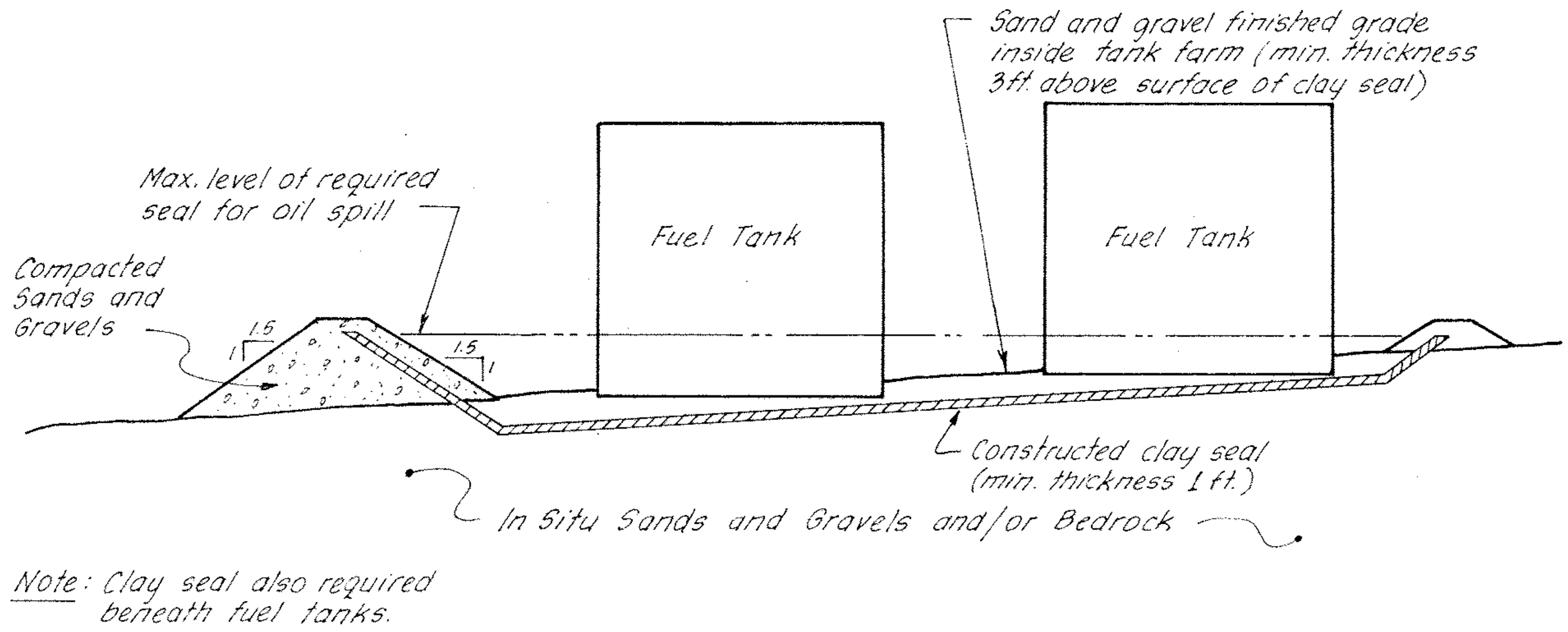


Fig. 10 a) SCHEMATIC SECTION OF TANK FARM AND CLAY SEAL SPILL PROTECTION WHERE FOUNDATION SOILS CONSIST OF PERVIOUS MEDIA

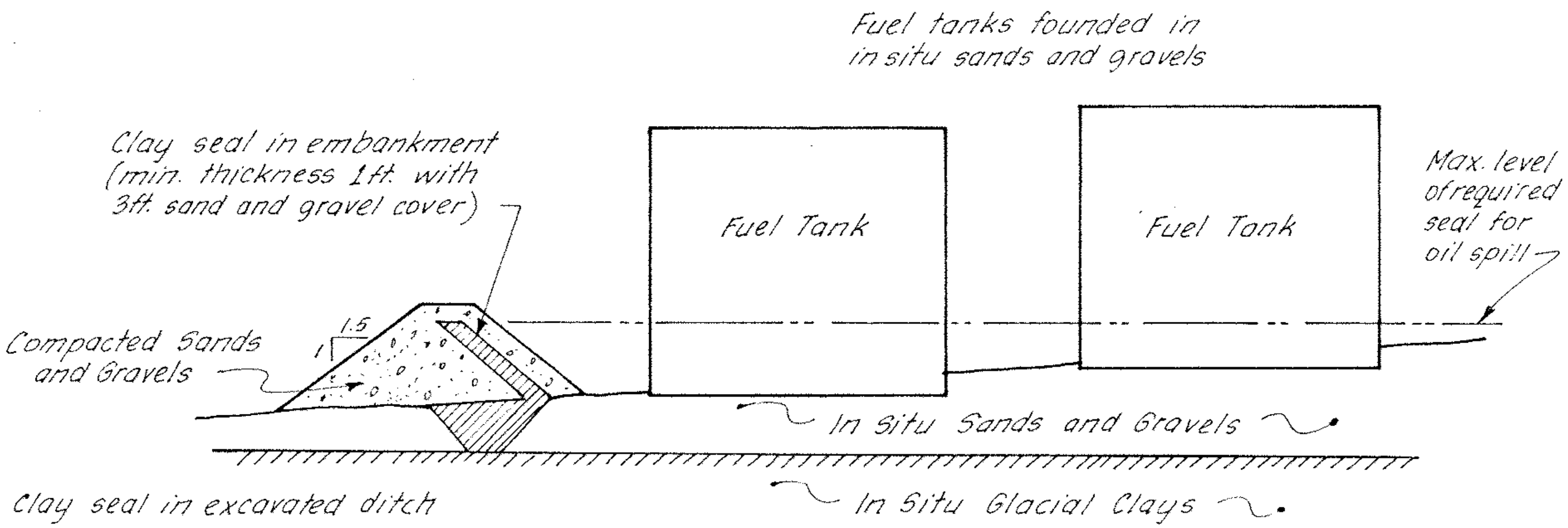


Fig. 10 b) SCHEMATIC SECTION OF TANK FARM AND FUEL SPILL PROTECTION FOR CASE WHERE IMPERVIOUS IN SITU CLAY EXISTS WITHIN EASY ACCESS FROM GROUND SURFACE

Cadillac Explorations Ltd.
Northwest Territories

Golder Associates

FUEL TANK FARM
SPILL CONTROL WORKS

Drawn S.H.	Reviewed		
Date SEPT. 1980	Project No. 802-1073	Fig. 10	