VANGORDA PLATEAU DEVELOPMENT
AS-BUILT CONSTRUCTION REPORT FOR LITTLE CREEK DAM

SRK REPORT 160636/1 MAY 1991

REPORT 160636/1

VANGORDA PLATEAU DEVELOPMENT
AS-BUILT CONSTRUCTION REPORT FOR
LITTLE CREEK DAM

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MAY 1991

REPORT 160636-1

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CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

REPORT 160636/1

VANGORDA PLATEAU DEVELOPMENT
AS-BUILT CONSTRUCTION REPORT FOR
LITTLE CREEK DAM

1.0 INTRODUCTION

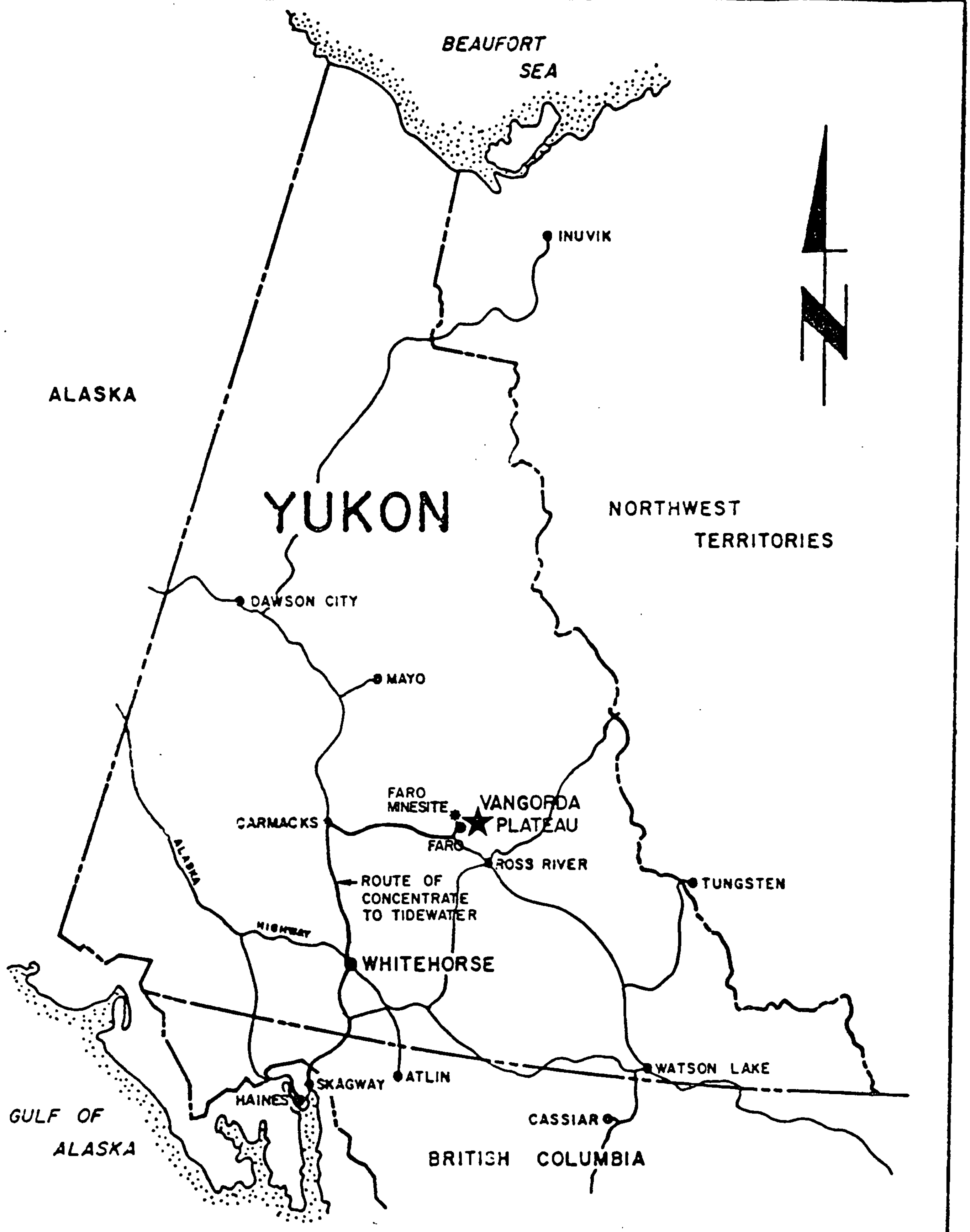
1.1 General

Curragh Resources Inc., which currently operates an open pit mine near Faro in the Yukon Territory, is developing additional orebodies on the Vangorda Plateau located 13 kilometres southeast of the Faro mine. Development of the Vangorda Plateau deposits, namely Vangorda and Grum, would supplement and eventually replace production from the Faro pit. The location of Faro and the Vangorda Plateau is shown on Figure 1.1. Figure 1.2 shows the relative locations of the Faro and the two Vangorda Plateau pits.

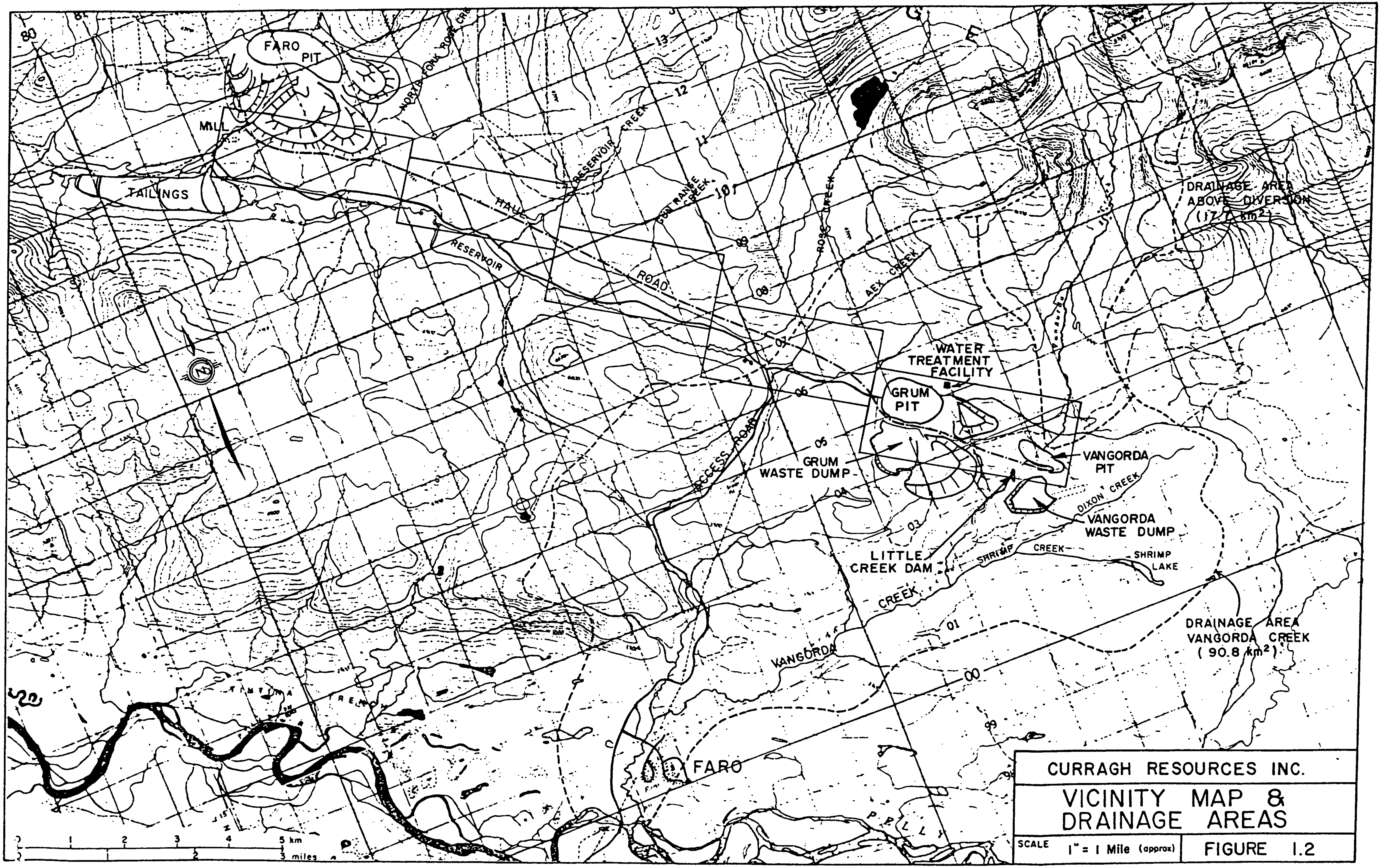
The development of the Vangorda deposit will produce a total of 3.4 million tonnes of sulphitic waste rock and 6.2 million tonnes of phyllitic waste rock, as well as 6.5 million tonnes of overburden (till). The waste materials will be transported to an engineered waste dump situated immediately south of the open pit (Figure 1.3).

Based on experience at the Faro minesite and preliminary laboratory testing of the drill core from the Vangorda minesite, acid rock drainage (ARD) could, as a consequence of interaction with air and water, develop from the sulphide-rich zones exposed in the walls of the open pit and from the sulphide-rich waste rock in the waste dump. Measures have been designed to minimize acid generation, leaching and transportation of acidic products and to allow the collection and treatment of ARD contaminated seepage. The measures designed to minimize acid generation are beyond the scope of this report. The measures to collect and treat ARD contaminated seepage are of direct relevance and are, therefore, discussed below.

The main components of the collection and treatment system are shown on Figure 1.3. They comprise the following: a system of underdrains and ditches to collect seepage from the waste dump and direct it to an ARD collection facility (Little Creek Pond) located in a small valley with a creek which is referred to in this report as Little Creek; a pump and pipeline to direct to Little Creek Pond the seepage, runoff and precipitation which collects in the Vangorda open pit; a dam (Little Creek Dam), engineered to retain the ARD from the waste dump and the open pit, which forms part of the ARD collection facility; a wet well, pump house and pipeline system to direct the water in Little Creek Pond to a water treatment facility; and a water treatment facility to treat the ARD before it is released into Vangorda Creek.



LOCATION PLAN
FIGURE 1.1
CURRAGH RESOURCES INC.

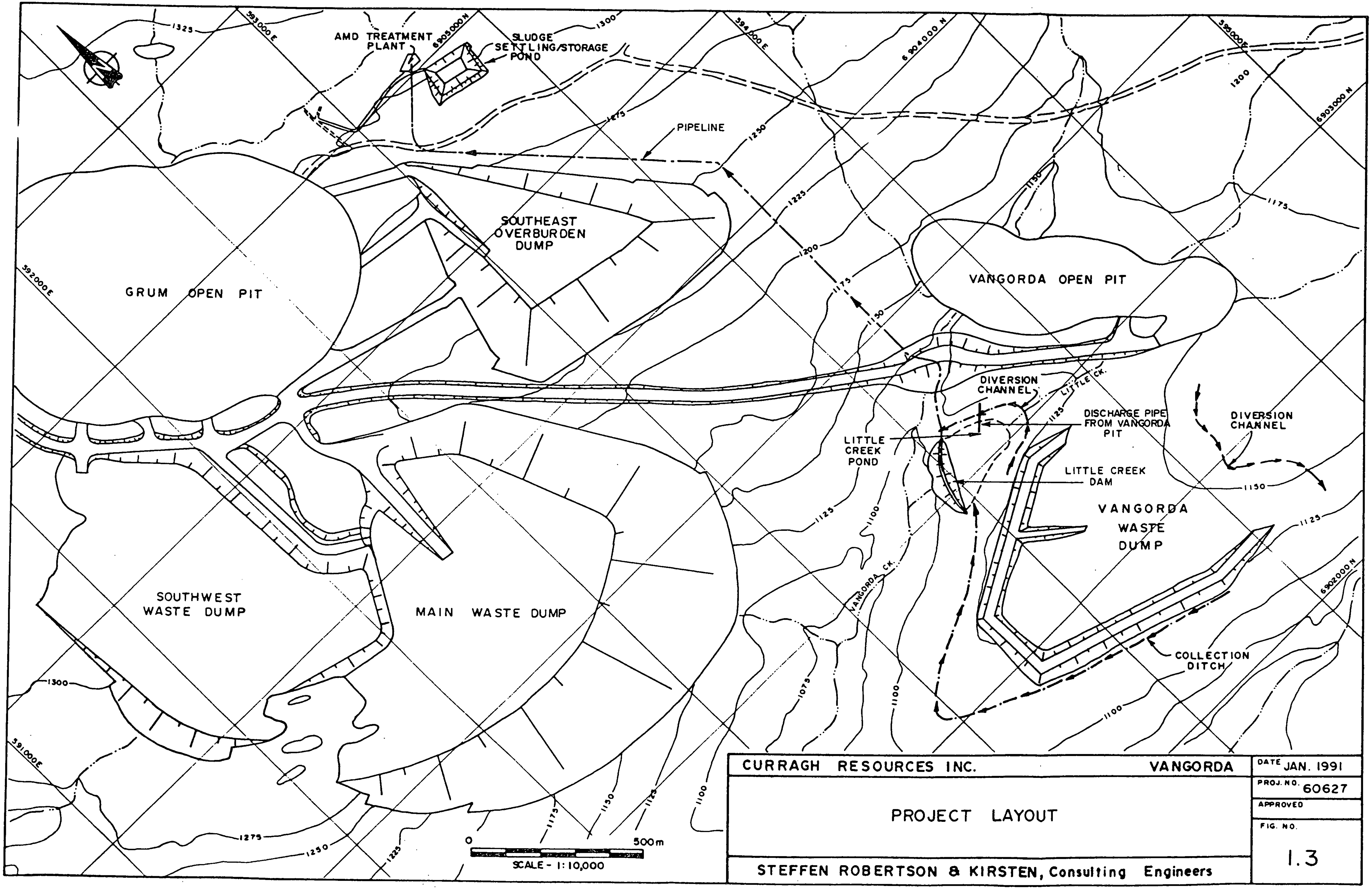


CURRAGH RESOURCES INC.

VICINITY MAP & DRAINAGE AREAS

SCALE 1" = 1 Mile (approx)

FIGURE 1.2



CURRAGH RESOURCES INC. VANGORDA

DATE JAN. 1991

PROJ. NO. 60627

APPROVED

PROJECT LAYOUT

FIG. NO.
1.3

STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers

The main components of the collection and treatment system were constructed in 1990, although relatively minor, specific components remain to be completed in 1991.

1.2 Description of Responsibilities

The responsibilities for the design, construction and inspection of the dam and ancillary facilities necessary for the development of the Little Creek Pond are described below.

1.2.1 Design

The dam, underdrains and collection ditches were design by Steffen Robertson and Kirsten (SRK) of Vancouver. The wet well and both pipelines and the water treatment facility were designed by Cominco Engineering Services Ltd. (CESL) of Vancouver.

1.2.2 Construction

The contractor responsible for the construction of the dam was Pelly Construction, of Whitehorse; survey work associated with dam construction was carried out during the course of construction by Lamerton Associates of Whitehorse; both companies were functioning as subcontractors to CESL.

The underdrains were constructed by Curragh personnel using mine equipment. Similarly, the surveying carried out for the construction of the underdrains was carried out by Curragh personnel.

The pipeline from the open pit to the collection pond was constructed by Curragh personnel. The pipeline from the collection pond to the water treatment facility was constructed by Kathy's Construction of Whitehorse; and surveying was provided by Lamerton Association of Whitehorse; both companies were functioning as subcontractors to CESL.

The water treatment facility was constructed by CESL through a number of subcontractors. Surveying associated with the construction of the water treatment facility was performed by Lamerton Associates of Whitehorse.

1.2.3 Inspection Services

Inspection services were provided by both SRK and CESL. SRK was responsible for the design of the dam and had technical control of the dam construction and fill placement. CESL provided inspection services for the construction of the two pipelines, stripping and clearing of the dam footprint and construction of the wet well and pumphouse.

Field and laboratory testing services for quality control were provided by EBA Engineering Ltd. of Whitehorse.

1.3 Contents of Report

This report describes the construction procedures and field design changes associated with the components designed by SRK. As-built drawings for the facilities, as well as the field and laboratory material test results, are presented in Appendices at the back of this report.

2.0 BACKGROUND INFORMATION

2.1 Reports

A series of investigative test pits and boreholes were completed in the vicinity of Little Creek Dam by SRK and others in 1990. The layout of these test pits was significantly affected by the local terrain and vegetation. Therefore, the geographical extent of the test pits and boreholes necessitated significant interpolation of the subsurface data in some areas. The design of Little Creek Dam proceeded with the expectation that modifications would likely be required during construction.

The design, summarized in a report included in Appendix A, called for a homogeneous till dam with drains and a cut-off trench. During the initial design stages, two water management scenarios were considered. The first assumed that the water collected in Little Creek Pond would be derived from both the Vangorda pit and the waste dump and would be pumped to the treatment plant on a continuous year-round basis. The required capacity for this scenario was 55,000 m^3. The second scenario also assumed that the discharge from Vangorda pit and the seepage from the Vangorda waste dump would be collected in Little Creek Pond, but that pumping during the winter months from November to March would be shutdown. This scenario required a storage volume of up to 120,000 m^3 to enable storage of the winter flows. The latter scenario was selected for construction because it provides greater operational flexibility.

2.2 Drawings

As-built drawings included in Appendix B of this report are as follows:

Drawing No.	Revision	Title
60627-01	C	General Arrangement Plan
60627-02	C	Layouts for Cut-off Trench Excavation and Drainage Blanket
60627-03	A	Profile along Longitudinal Section A-A
60627-04	C	Cross-Sections B-B, C-C, D-D & E-E

The drawings have been reduced 50% for inclusion in this report.

3.0 GEOLOGY AND STRATIGRAPHY

As a result of the excavation of additional test pits during the early stages of construction and the excavation of the cut-off trench, a better understanding of the sub-surface geology and ground conditions emerged than was available during the design stages.

Drawing No. 60627-03, Appendix B, shows the stratigraphy along the centreline of the dam between the south abutment at Station 0+020 and the north abutment at Station 0+220. The sub-surface geology in the northern section of the dam from Station 0+190 to Station 0+327 changed very little from the soil conditions presented in the original geotechnical report (included in Appendix A). However, soil conditions within segments of the southern section of the dam, particularly from Station 0+020 to Station 0+180, differed significantly from the original report. The following is a description of the sub-surface geology along the entire cut-off trench.

STA 0+020 to 0+070

Between Stations 0+020 and 0+70, a large zone of permafrost was encountered. The permafrost existed primarily in the brown till with infrequent occurrences in the top half metre of grey-black till. The thickness of the permafrost ranged between 2 metres at Station 0+070, and up to 7 metres at the south abutment of the dam (Sta 0+020). This zone was characterized by a moderate density of horizontal to sub-horizontal ice slivers. The slivers average 1 cm. thick, and up to 10 cm. in length. However, large blocks up to 1 metre thick and comprising ice with thin layers of silt were encountered occasionally during the course of excavation. The few tests carried out on samples of frozen soil indicated that the moisture content of this material was typically between 15 and 25 percent. However, where segregated ice comprised the main component and silt was present only in thin layers, moisture contents almost certainly approached 80 to 90 percent.

STA 0+070 to 0+150

Between Stations 0+070 and 0+0150, the sub-surface geology did not vary from the descriptions presented in the original geotechnical report. It typically comprised, in descending order, the following strata:

- two to three metres of stiff, olive-brown, well graded silt till over
- one to two metres of compact, red-brown sand and gravel (north of Station 0+100 only) over
- at least 1 metre of very stiff to hard, black-grey, well graded silt till (from Station 0+070 to 0+110) to very stiff to hard, blue-grey, well graded, clayey silt till (from Station 0+110 to 0+150).

Sporadic permafrost lenses up to 1 metre thick, were present in the olive-brown till. The character of the permafrost was similar to that which was encountered between Stations 0+020 and 0+070.

STA 0+150 to 0+180

At approximately Station 0+150, the sand and gravel layer bifurcates into an upper and lower limb. The north end of the lower sand and gravel layer pinched out at approximately Station 0+180. In addition, the olive-brown till pinches out at Station 0+150 but reappears between the upper and lower limbs of sand and gravel. Therefore, between Stations 0+150 and 0+180, the stratigraphy in descending order typically comprised the following:

- one to two metres of red-brown, compact sand and gravel over
- approximately one metre of stiff, olive-brown, well graded silt till over
- up to one and a half metres of very stiff, blue-grey, well graded clayey silt till over
- up to one metre of grey, compact sand and gravel over
- at least one metre of very stiff to hard, blue-grey till as above.

Sporadic permafrost in the form of lenses up to 1 metre thick were present in the olive-brown till.

STA 0+180 to 0+220

The thicknesses of the units between Stations 0+180 and 0+220 varied somewhat, but generally the stratigraphy (from original ground surface) was as follows:

- one metre of compact, red-brown sand and gravel over
- up to two metres of stiff, olive-brown silty till over
- at least one metre of very stiff to hard, blue-grey, well graded, silty and clayey till.

The sand and gravel layer pinches out at about Station 0+220.

STA 0+220 to 0+297

Between these stations, the sand and gravel was absent and the thickness of olive-brown silty till increased to at least three metres. The blue-grey till is present below the base of the olive-brown till but was not observed in the excavation for the cut-off trench between these stations.

4.0 DESIGN CHANGES

The changes in design outlined in the original geotechnical report were mainly due to the limited exploration program. In particular, the changes were a result of (a) the bifurcation in the sand and gravel layer in the vicinity of Station 0+150 that resulted in two sand and gravel layers between Stations 0+150 and 0+180, (b) the discovery of permafrost at the south abutment, (c) the need to found the wet well on original soil rather than fill, and (d) the practicality of placing drain material over a steep, sideslope comprising moist soils with a high percentage of fines.

4.1 Cut-off Trench

The depth of the cut-off trench was increased in the low part of the valley between Station 0+150 and 0+180. The increase in depth was necessary to cut off both the upper and lower sand and gravel layers, either of which could act as a conduit for seepage from the collection pond.

In addition to increasing the depth of the trench, a secondary trench was excavated upstream of the primary trench between Stations 0+165 and 0+180. This secondary trench became necessary when it was determined that the primary trench did not intersect the lower sand and gravel layer. As a result, the secondary trench was keyed into the primary trench and excavated northwards through the lower sand and gravel layer.

4.2 Permafrost Excavation

A zone of permafrost was completely removed from the footprint of the dam at the south abutment. The zone was excavated to a depth of two metres below original ground surface at Station 0+070 and to a depth of seven metres at the south abutment of the dam. The entire dam footprint between Stations 0+020 and 0+070 was excavated during excavation of the cut-off trench.

The entire permafrost zone was excavated because it was considered unsatisfactory as a foundation material. Any disturbance or stripping of the top layer would cause the ice to thaw, leaving the soil with a near liquid consistency and little or no strength.

In addition, sporadic lenses of permafrost were encountered between about Stations 0+070 and 0+180 to depths of about one metre . These lenses were removed during the course of stripping and grubbing of the dam footprint.

4.3 Wet Well Location

The location of the wet well according to the design report is Station 0+190, 2.5m upstream of the dam centreline. The as-built location of the wet well is Station 0+189.1, 7.5 metres upstream of the dam centreline. The basis for this move was to found the wet well on original soil upstream of the cut-off trench, thereby minimizing potential settlements of the wet well.

4.4 Drains

The blanket drains downstream of the dam centreline and on the north side of the dam were installed in general accordance with the original design. The south drains, however, were modified to include a series of finger drains. The reason for this change is discussed as follows:

1) Moist ground on the southern half of the dam would require that an excessively thick lift of drain material be placed in order to prevent the construction vehicles from punching through the filter fabric. This option was prohibitive logistically as well as financially.

2) The quality of the material used for the finger drains was such that their performance as a drain would be more than satisfactory.

5.0 LABORATORY AND FIELD TESTING

Lab and field testing were performed by EBA Engineering Ltd. of Whitehorse, Y.T. Results from lab testing and field compliance tests are included in Appendix C and D, respectively. The following is a summary of those tests.

5.1 Foundation Material

The foundation for the Little Creek Dam is described in the design report (Appendix A). In the valley bottom, it comprises gravelly sand (alluvium) overlying brown till (made up of clayey silty sand with a trace of gravel) overlying grey till (made up of clayey silty sand with some gravel). On the sides of the valley, the gravelly sand pinches out leaving brown till overlying grey till.

The gravelly sand was intersected by a cut-off trench. Gradation analyses taken from the floor of the cut-off trench are summarized in Appendix C (Figure C.1). That portion of the cut-off trench near the valley bottom comprised grey till which, based on two gradation analyses, comprised 9 to 25 percent gravel, 34 to 46 percent sand and 29 to 57 percent fines. Further away from the valley bottom, the material in the floor of the cut-off trench comprised brown till which, based on two gradation analyses, comprised 22 percent gravel, 39 to 55 percent sand and 23 to 39 percent fines.

Between Station 0+150 and 0+180, the gravelly sand layer is interlayered with the brown till. This sand layer is the same unit that is used as a drain on the north side of Little Creek. As a result, the gradation analysis for a sample of the lower limit of this gravel from Station 0+165 (Appendix C, Figure C.2) is very similar to the gradation of the drain material in the on the north side of the creek (Appendix C, Figure C.4).

5.2 Till Borrow

Till comprising brown to dark grey, clayey, silty sand with some gravel was used to construct the majority of the dam. This material was obtained from the Vangorda pit area as a result of stripping operations for development of the open pit. Till samples from four tests pits at the Vangorda pit showed similar gradations and compaction values. An additional sample obtained from the dam during construction compared favourably with the samples tested previously. The till is well graded with 15 to 26 percent gravel, 32 to 41 percent sand and 36 to 46 percent fines. A summary of the laboratory gradations is provided in Appendix C (Figure C.3). Natural moisture contents ranged from 9.7 to 12.3 with a mean value of 10.4 percent. The maximum dry density (Standard Proctor) achieved in the till was 2155 kg/m^3 at a moisture content of 8.8 percent. The till borrow was, therefore, slightly wet of optimum.

Field compliance tests for compaction of the borrow material were taken with a nuclear densometer by an EBA technician every two to three days or as construction progress dictated. The results of a total of 56 in situ compaction tests are included in Appendix D. According to EBA, a statistical analysis of the test results reveals that an average in place density of 2058 kg/m^3 with a standard deviation of 77 kg/m^3 was observed. This represents an average compaction level of 95.5 percent of the Modified Proctor maximum dry density (ASTM D1557) value that was determined from a sample of the fill material.

One constant head permeability test was conducted in the laboratory by EBA on a composite sample of the till borrow. The test was conducted at a constant head of 60 kPA (equivalent to 6 m of head) and a compacted density of 1983 kg/m^3. This density represents approximately one standard deviation below the average compacted field density. The result of this test was a permeability coefficient of 4.0 x 10^{-6} cm/sec.

5.3 Drain Material

Material used to construct the drains comprised either in situ sand and gravel occurring naturally in the valley bottom or sand and gravel obtained from the vicinity of the Grum pit. Material for the northern drains was a combination of natural and imported material with the material for the southern drains being entirely imported.

Gradation tests for the southern drains showed 7% passing the No. 200 sieve where the northern drains showed an average of about 10 percent passing the No. 200 sieve. These tests results are included in Appendix C (Figure C.4).

6.0 CONSTRUCTION PROCEDURES

6.1 General

Construction at the site of the Little Creek Dam started with site clearing in late August 1990. Fill placement was completed by early November 1990. However, further work related to the construction on the pumphouse and the pipelines continued into early December.

Photographs taken during the course of construction are included in Appendix E.

6.2 Main Embankment

The contractor cleared and stripped topsoil from the impoundment area and the footprint of the dam using a bulldozer. In general, material from the dam footprint was pushed downstream of the dam while material from the pond area was pushed upstream.

The main embankment was constructed as a homogeneous till dam with a seepage cut-off and drains. Construction equipment consisted of 4 to 6 scrapers assisted by a D9 bulldozer in the borrow area, two bulldozers (D9 and D6) to spread fill, a grader to level the fill, and a sheepsfoot and smooth drum rollers for compaction. Five to six passes were made over 0.3 metre lifts.

Construction of the main embankment began at Station 0+180 with the excavation of the cut-off trench. The excavation and filling of the trench proceeded northwards to Station 0+290. During this period, minor fill placement, levelling, and ground preparation for the drains were undertaken on the north end of the dam.

The trench was then extended southwards from Station 0+180 to the south abutment of the dam. The majority of fill placement was not commenced until the entire trench was excavated and filled, and the drains installed.

Soft ground on the downstream side of the south end was handled by first placing filter fabric over the in situ soil. The fabric enabled thinner lifts to be placed which, in turn, allowed for a more uniformly compacted fill.

Construction of the dam fill progressed as the weather permitted. Periods of heavy precipitation halted construction as the till quickly became unmanageable to work and compact. Soft, saturated fill was removed from the embankment prior to recommencement of fill placement.

Frost penetration occurred infrequently during those nights that the night shift did not operate. At the borrow area, frozen material was wasted. At the dam, equipment was driven over the fill to remove the frost, or when this didn't work, frozen fill was removed from the dam prior to further fill placement.

6.3 Drains

6.3.1 South Drains

Sand and gravel for the south drains was screened material provided by Curragh Resources Inc. The drains beneath the southern part of the dam consisted of three longitudinal finger drains (L1, L2, L3) and two transverse finger drains (T1, T2). The layout of these drains is shown on Drawing No. 60627-02.

All of the finger drains were completely encapsulated by filter fabric (top, sides and bottom) so as to prevent the migration of fines into the pore spaces.

Rock drains were placed at the downstream toe of the embankment at the western extensions of T1 and T2. The rock drains consist of boulders up to 0.5 metres diameter in a sand and gravel matrix. The purpose of the rock drains is to maintain flow from the finger drains in freezing weather.

The south drains are two to three metres in width and were placed using a front end loader.

6.3.2 North Drains

The drains beneath the norther part of the dam consisted of a blanket drain constructed from the existing in-place sand and gravel and a connecting finger drain constructed parallel to the cut-off trench using imported sand and gravel.

The blanket drain was constructed by spreading the in situ sand and gravel with a grader and the finger drain was placed with a backhoe. The sand and gravel was compacted by multiple passes of a vibrating roller driven compactor. The blanket drain was covered with geotextile filter fabric whereas the finger drain was encapsulated in filter fabric.

7.0 CONSTRUCTION TASKS REMAINING FOR 1991

The construction of the Little Creek dam commenced relatively late in the 1990 construction season. Although the dam was completed, it was impractical to complete all the ancillary details associated with the dam and collection pond. The list of items that remains to be completed in 1991 are as follows:

- The gravel layer on the dam crest;
- The diversion ditch above the right abutment of the dam;
- The collection ditches and seepage monitoring collection sump downstream of the dam;
- Stabilization (and probably revegetation) of the brown, moist, peaty soils that got pushed downstream of the dam during the course of stripping and clearing. It is appropriate that these soils be prevented from eroding into Vangorda Creek. Detailed reclamation procedures will be established following a site inspection next spring. It is likely, however, that a vegetative cover will be established by hydroseeding the surface of these soils and that a low berm may be required at their downstream toe;

- Instrumentation comprising piezometers, permanent survey hubs and thermistors to monitor piezometric levels, displacements and settlements, and the thermal regime near the crest of the dam;

- Installation of buried, flat-lying closed-cell insulation sheets extending radially outward from the pumphouse walls to control frost penetration in the wet well area.

The design details associated with each of these items will be determined as a result of field engineering after the snow has melted this spring. Actual construction will likely be delayed until the summer when the ground has significantly dried out.

8.0 CONCLUSIONS

It is expected that water from the Vangorda open pit and the waste rock dump will be contaminated with acidic products as a result of the natural interaction of sulphide-rich rock with air and water. Part of the plan to minimize the extent and effects of this problem involves the collection and treatment of ARD contaminated seepage.

A key feature of the collection and treatment system is a dam constructed in Little Creek to impound ARD contaminated seepage. Construction of the dam is the main subject of this report. The report discusses changes from the original design and presents the construction materials and procedures used to build the facility. As-built construction drawings for the dam are included in the appendices at the back of the report.

A series of test pits and boreholes completed in the vicinity of the dam during 1990 provided an outline of the soil stratigraphy below the dam footprint. However, due to access limitations during the original investigations, a complete understanding of the stratigraphy was not obtained until the construction period when further test pits and a cut-off trench were completed.

The soils in the vicinity of the dam consist typically of a brown, stiff, clayey, silty sand with some gravel overlying a blue to dark grey, very stiff, clayey sand with some gravel. In the valley bottom, there is a deposit of brown to reddish black sand and gravel that overlies the till and, at least in one location, is folded underneath a layer of till. Shallow occurrences (one to two metres) of permafrost were encountered in the valley bottom and on the lower parts of the south side of the valley. At higher elevations on the south side of the valley, the thickness of permafrost increased significantly (to as much as seven metres).

The dam is essentially a homogeneous dam constructed of till obtained from the stripping of overburden at the Vangorda open pit. Permafrost under the dam footprint was removed during construction. A cut-off trench, backfilled with compacted till, was constructed to restrict seepage beneath the dam. A system of drains, blanket and finger, have been installed to maintain the phreatic levels in the dam at safe levels.

Construction started late in 1990 and, as a result, several items will require completion during the 1991 construction season. These include the gravel road surface on the crest of the dam, the diversion ditch, the collection ditches and the seepage collection monitoring sump, stabilization measures for waste soils, instrumentation, and installation of insulation adjacent to the pumphouse.

This report, Number 160636/1, entitled Vangorda Plateau Development, As-built Report for Little Creek Dam, is respectfully submitted by:

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APPENDIX A

Report on Geotechnical Investigation
and
Design of Little Creek Collection Facility

REPORT 160627

VANGORDA PLATEAU DEVELOPMENT
LITTLE CREEK COLLECTION FACILITY
GEOTECHNICAL INVESTIGATION AND DESIGN

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SEPTEMBER 1990

REPORT 160627

VANGORDA PLATEAU DEVELOPMENT
LITTLE CREEK COLLECTION FACILITY
GEOTECHNICAL INVESTIGATION AND DESIGN

CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

REPORT 160627

VANGORDA PLATEAU DEVELOPMENT LITTLE CREEK COLLECTION FACILITY GEOTECHNICAL INVESTIGATION AND DESIGN

1.0 INTRODUCTION

Curragh Resources Inc. currently owns and operates an open pit mine near the town of Faro in the Yukon Territory. Curragh is presently developing additional orebodies, namely Vangorda and Grum, on the Vangorda Plateau located about 13 kilometres southeast of the Faro minesite.

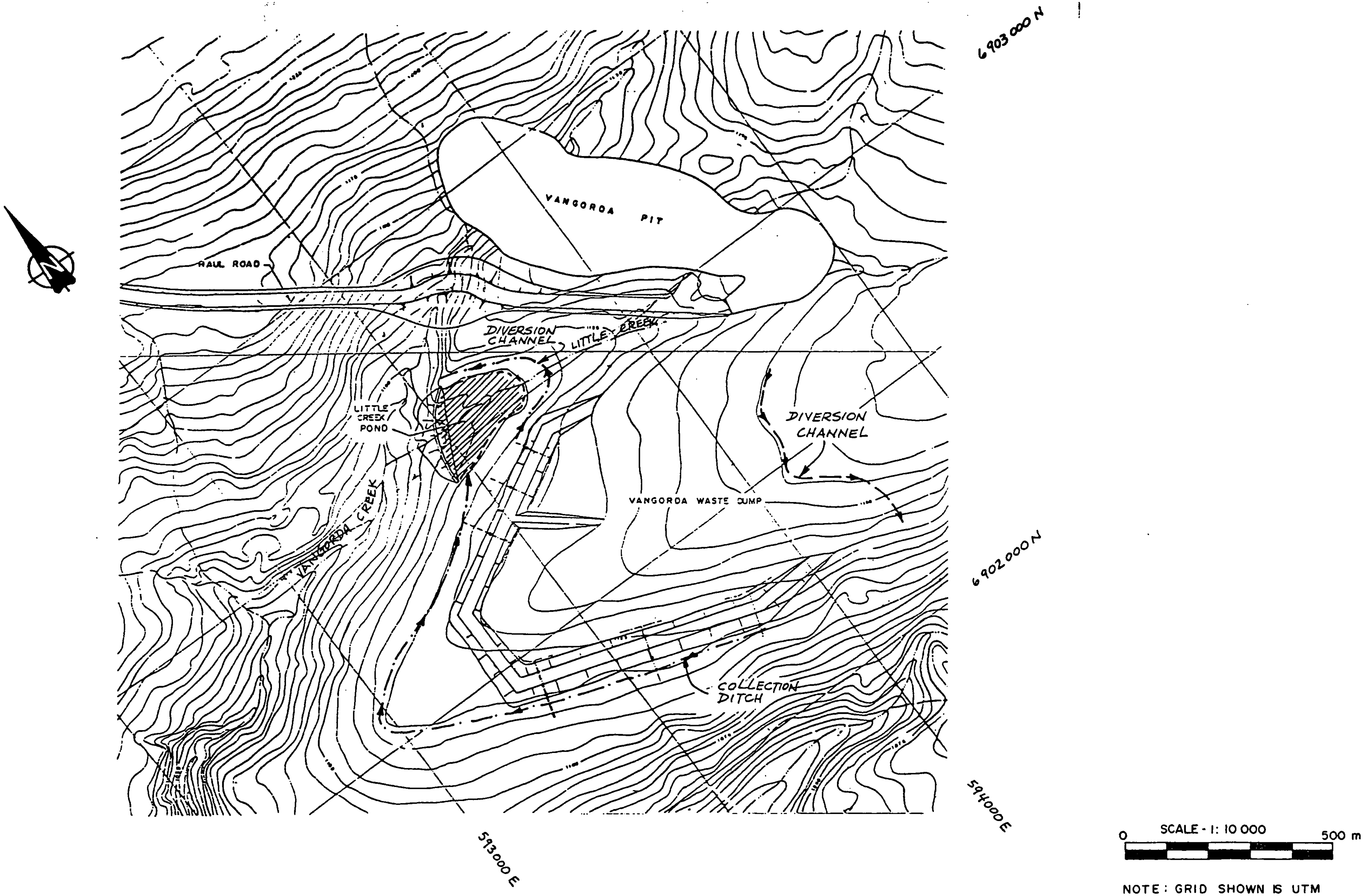
Current plans require acid generating waste rock from the Vangorda open pit to be placed in a dump immediately south of the open pit. Till dykes are being constructed around the perimeter of the dump to contain seepage from the waste rock, and direct it through a network of underdrains and collection ditches to a proposed acid rock drainage (ARD) collection facility to be developed in Little Creek. The collection facility will primarily comprise an earthfill dam behind which a pond will form. ARD which collects in the open pit during the course of mining will also be directed to the facility. Water will be drawn from the collection facility using a wet well and pumped on a regulated basis to a water treatment plant where it will be treated, as required, before subsequent release to the environment. The approximate layout of the open pit, waste dump and collection facility is shown on Figure 1.1.

This report discusses the investigation, design and recommended construction of the proposed Little Creek collection pond.

2.0 SITE INVESTIGATION

The investigation at the Little Creek water collection facility, which comprised drilling and backhoe test pits under the direction of Steffen, Robertson and Kirsten (B.C.) Inc. (SRK), was completed on two separate occasions. Additional backhoe test pits were also completed by EBA Engineering Consultants Ltd. (EBA). The locations of relevant boreholes and test pits are shown on Figure 2.1 and the respective logs are included in Appendix 1.

The first investigation was completed on May 11, 1990 under the direction of SRK and involved the excavation of two test pits (TP 90-5 and 90-6) as part of a preliminary site selection assessment for the collection facility. The test pits were excavated using a track-mounted backhoe in the general vicinity of the proposed water retention dam axis and extended to depths of 2.5 and 3.5 m, respectively. Three grab samples were obtained from each test pit for subsequent classification testing.



NOTE: GRID SHOWN IS UTM

CURRAGH RESOURCES INC.
LITTLE CK. COLLECTION POND

LAYOUT OF OPEN PIT,
WASTE DUMP & COLLECTION POND

STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers

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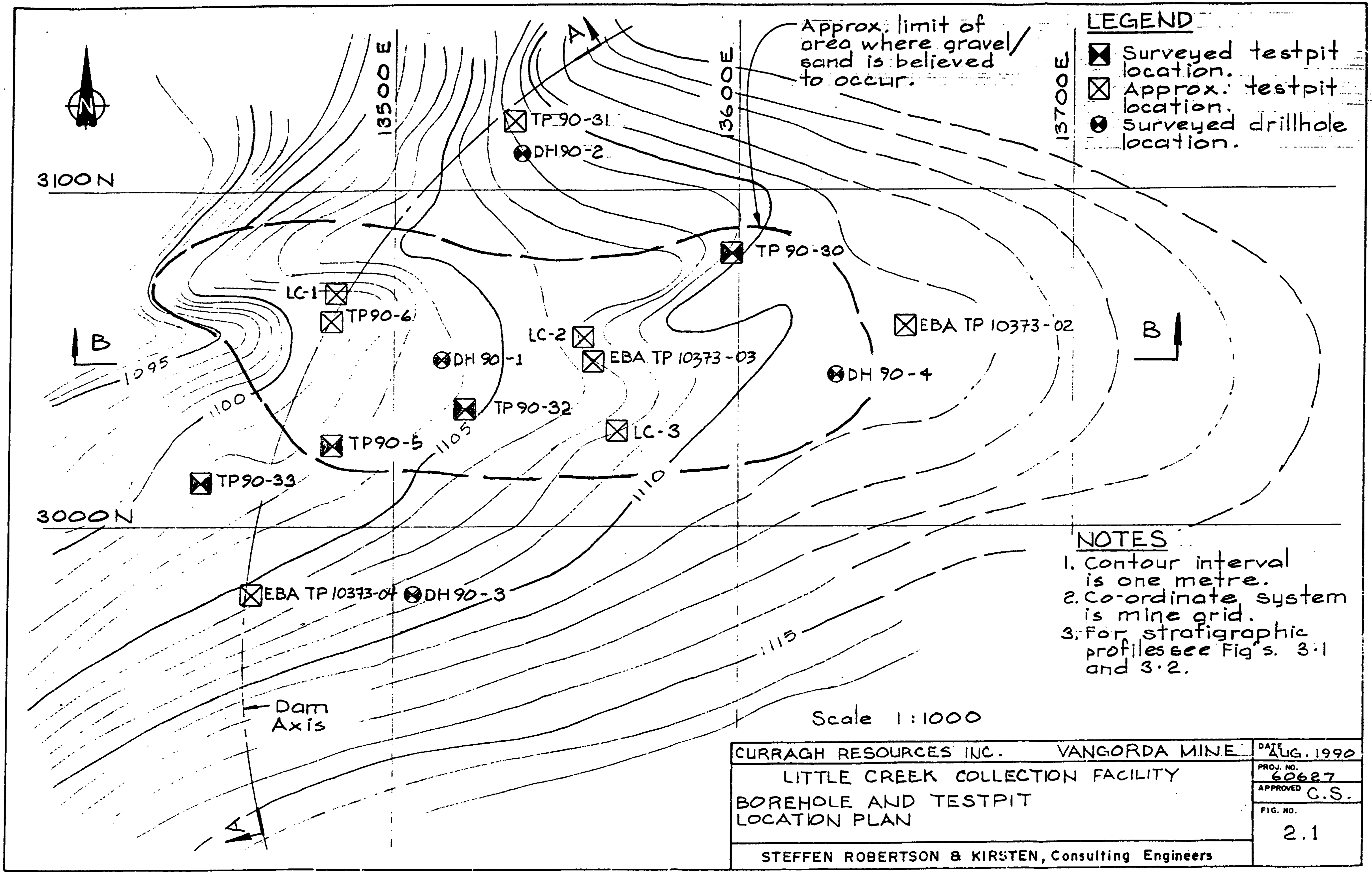
FIG. NO.
1.1



LEGEND

■ Surveyed testpit location.

☒ Approx. testpit location.

● Surveyed drillhole location.

NOTES

1. Contour interval is one metre.
2. Co-ordinate system is mine grid.
3. For stratigraphic profiles see Fig's. 3·1 and 3·2.

Scale 1:1000

CURRAGH RESOURCES INC. VANGORDA MINE	DATE AUG. 1990
LITTLE CREEK COLLECTION FACILITY	PROJ. NO. 60627
BOREHOLE AND TESTPIT LOCATION PLAN	APPROVED C.S.
	FIG. NO. 2.1
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers	

Between June 28 and July 7, 1990, a second site investigation was carried out under the direction of SRK at the proposed site of the collection facility. This investigation comprised four boreholes (DH 90-1 to 90-4) and four test pits (TP 90-30 to 90-33). In addition, three grab samples (LC1 to LC3) were obtained from small pits dug with a shovel. The boreholes were completed by Advanced Drilling Ltd. within the pond area. The holes ranged in depth from 10.5 to 15.7 m. Samples of the subsoils were obtained by coring and by Standard Penetration Tests. Standpipe piezometers were installed in three boreholes (DH 90-1 to 90-3). A falling head permeability test was carried out in each of these piezometers (Appendix 1). However, because of problems associated with bentonite balls bridging in the drill bit during installation of the seal in DH 90-1 and DH 90-2, the results of the falling head permeability tests in these two holes are questionable. The test pits were completed to depths of 3.2 to 4.5 m using a track-mounted backhoe. Grab samples of each of the main material types were obtained.

Three additional test pits (EBA TP 10373-2 to 10373-4) were completed by EBA as part of an independent investigation for the proposed pipeline (Figure 2.1).

The locations of DH 90-1 to 90-4 and TP 90-5, 90-30, 90-32 and 90-33 were determined by field survey carried out by Curragh Resources Inc. The locations of all other test pits shown on Figure 2.1, including those dug manually with a shovel, have been estimated by the SRK field engineer.

Samples from the SRK investigations were shipped to our laboratory in North Vancouver for further classification testing which included moisture content determinations and gradation analyses. The results of this laboratory testing are summarized on the borehole and test pit logs presented in Appendix 1. Results of the gradation analyses are presented in Appendix 2.

3.0 SITE DESCRIPTION

The site of the Little Creek collection facility is situated immediately northwest of the Vangorda waste dump, at an approximate elevation of 1100 m.

Upstream of the proposed site, Little Creek is intersected by the Vangorda pit and by the access road for the Vangorda waste dump. Approximately 90 metres downstream of the proposed site, Little Creek flows into Vangorda Creek.

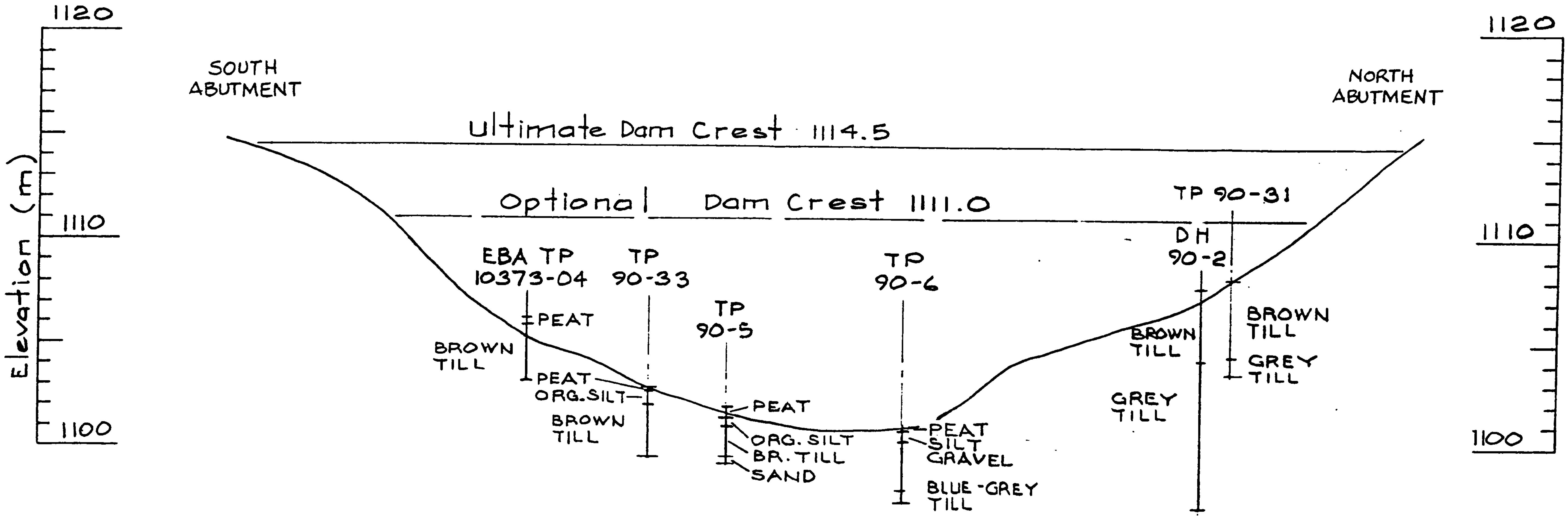
Slopes in the vicinity of the proposed dam have been quantified on the basis of local topographic mapping. Gradients down the centre of Little Creek, above the centreline of the dam, vary typically between about 1 and 3 degrees. Below the dam centreline, the gradient steepens significantly to about 25 to 30 degrees. In the vicinity of the proposed dam, the north side of the valley typically slopes at about 8 to 16 degrees with slopes locally as steep as about 22 degrees. The south side of the valley typically slopes at about 1 to 10 degrees. Profiles along the dam axis and along the creekbed through the dam are shown on Figure 3.1 and 3.2 respectively. The results of the boreholes and test pits that have been completed in the vicinity of the collection pond indicate that the near-surface soils vary across the valley. On the left (south) side of the valley, the soils comprise up to 0.2 m of peat overlying approximately 0.5 m of soft organic silt overlying brown, moist, firm to very stiff sand (till) overlying a grey, firm to hard silt (till). In the valley bottom, there is approximately 3 m of gravelly sand overlying either brown, wet silt and sand (till) which in turn overlies grey silt and sand (till) or, alternatively, the gravelly sand overlies grey, moist, stiff silt and sand (till). There is evidence to suggest that in the valley bottom, the gravelly sand may be interlayered with the brown sand (till). On the right (north) side of the valley, there is approximately 4 m of brown, moist, firm to stiff sand (till) overlying grey, hard silt (till). No bedrock was encountered during the investigation.

The gravelly sand comprises about 43 percent gravel, 53 percent sand and 4 percent silt and clay based on two gradation analyses. Moisture content determinations varied as a function of the relative position of the water table. The moisture content of three samples above the water table varied from 6 to 11 percent with a mean of 9 percent. A single sample of gravel below the water table registered a moisture content of 23 percent, though actual values in situ may well have been higher. Four Standard Penetration Tests performed in the gravelly sand resulted in blows per 300 mm of 5 to 10 with a mean of 7. These values are typical of loose material.

The brown till comprises up to about 2 percent gravel, 54 percent sand and 44 percent silt and clay based on one gradation analysis. Moisture content determinations on two samples were 13 and 14 percent. Six Standard Penetration Tests performed on the brown till ranged from 5 to 32 blows per 300 mm. However, most blowcount values were about 7 blows per 300 mm, indicative of a firm material.

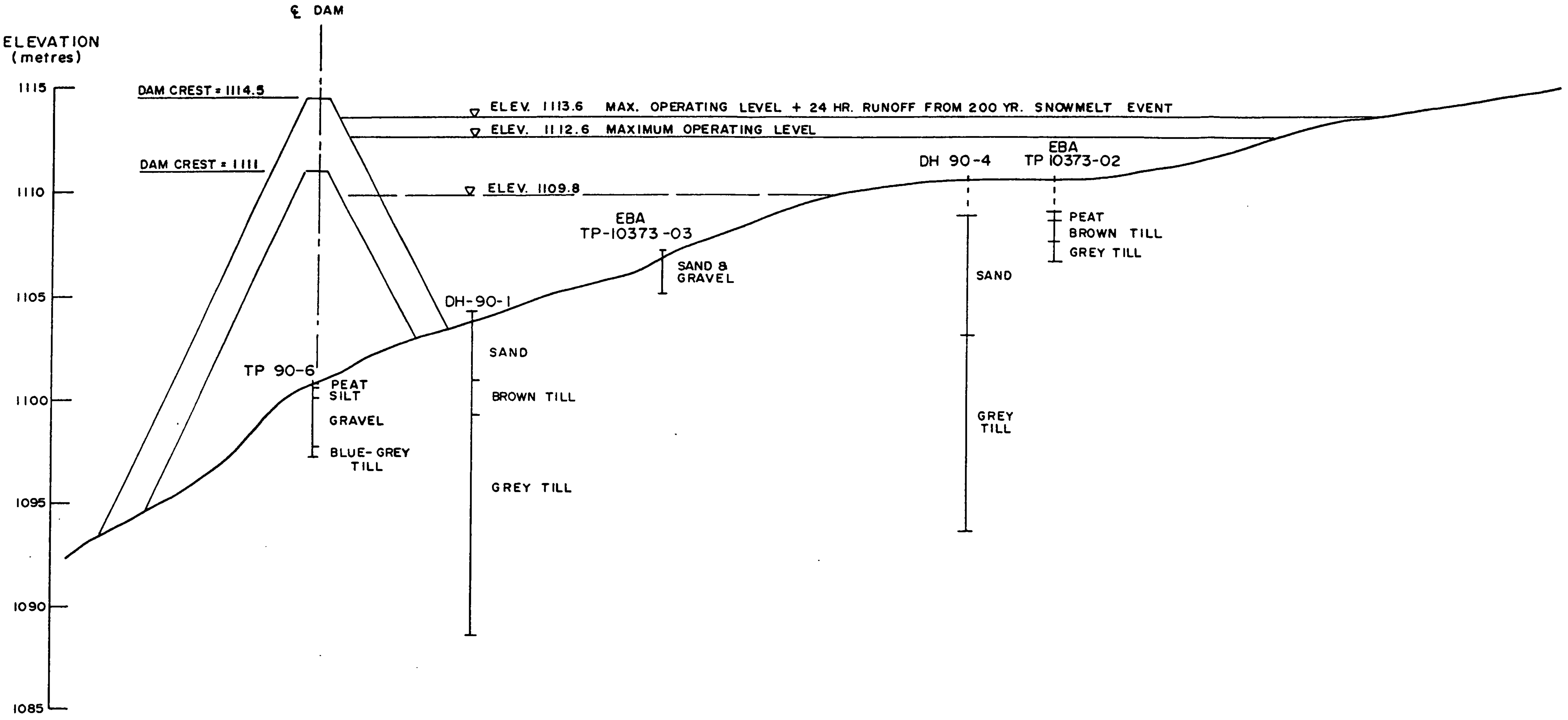
The grey till comprises 12 to 23 percent gravel, 28 to 44 percent sand and 44 to 54 percent silt and clay based on six gradation analyses. The average gradation from these six analyses is 16 percent gravel, 36 percent sand and 48 percent silt and clay. Six moisture content determinations resulted in a range from 7 to 12 percent with a mean at 10 percent. Nineteen Standard Penetration Tests were performed in the grey till. The blowcounts ranged from 13 to greater than 50 blows per 300 mm. In general, the penetration resistance increased with depth, usually with significant increases over a short interval. Using 50 as the maximum blowcount, the mean blowcount was 33 blows per 300 mm, though there were numerous values in the mid 20's. Assuming that the grey till is essentially a cohesive material, because of its high fines content, these blowcounts are typical of a stiff to hard material.

Seepage was observed in many of the test pits (ie. TP 90-5, 90-6, 90-32, 90-33 and EBA TP 10373-3). The inflow rates were not quantified but were greatest in TP 90-5 and 90-32 (noted as "abundant" in both test pits by the inspector). Conversely, only a trace of seepage was reported in TP 90-33.



Scale Hor. 1:1000
Vert. 1:200
5X VERTICAL EXAGGERATION

CURRAGH RESOURCES INC. VANGORDA MINE	DATE AUG. 1990
LITTLE CREEK COLLECTION FACILITY	PROJ. NO. 60627
PROFILE ALONG DAM AXIS (A-A)	APPROVED CS
	FIG. NO. 3.1
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers	



HORIZONTAL SCALE - 1:1000
VERTICAL SCALE —— 1:200 5 X VERTICAL EXAGGERATION

CURRAGH RESOURCES INC. VANGORDA

DATE AUG.1990
PROJ. NO. 60627
APPROVED
FIG. NO. 3.2

LITTLE CREEK COLLECTION FACILITY
PROFILE ALONG CENTER OF VALLEY (B-B)

STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers

4.0 DESIGN OF THE COLLECTION FACILITY

4.1 General

Two alternative scenarios are under consideration with respect to the required design capacity of the collection pond. The first scenario assumes that seepage from both the Vangorda waste dump and the Vangorda pit, for the period April through October, would be collected in the pond and pumped to the treatment plant. For the winter period from November to March, the treatment plant would be shut down and the seepage would be collected and stored in the collection pond. Under this scenario, the required storage capacity of the collection pond was estimated to be approximately 120,000 cubic metres. The design criteria for the second scenario was based on the assumption that, pumping from the facility to the treatment plant would occur year round and no allowance would be provided for winter storage. The required storage capacity for this scenario was estimated to be 55,000 cubic metres and was derived as follows:

Operating Volume:	21,000 cubic metres
Flood Storage:	28,000 cubic metres
Freeboard Volume:	6,000 cubic metres
Total Required Storage:	55,000 cubic metres

Although both scenarios were considered during the design stage for the purpose of this report, the remaining discussions will concentrate primarily on the 120,000 cubic metre scenario.

4.2 Layout

The layout of the collection ponds for the 55,000 and 120,000 cubic metre scenarios are shown on Figures 4.1 and 4.2, respectively. The pond will be developed by constructing an earthfill dam approximately 10 to 14 m high, depending on which of the two design scenarios is selected.

An insulated pumphouse, designed by Cominco Engineering Services Ltd. (CESL) will be constructed on the upstream shoulder of the crest of the dam. The pumphouse will have a 2.4 m diameter wet well with 0.4 m diameter intake pipe about 25 m long which will extend to the pond.

4.3 Storage Capacity

The storage capacity curve for the collection pond is shown on Figure 4.3. It should be noted that, because the coverage of the field survey was slightly less extensive than what was anticipated, the degree of accuracy of the topographic mapping above elevation 1110 m is less than below 1110 m. As a consequence, the contours on the maps used to generate the height-capacity curve (ie., Figures 4.1 and 4.2) are marked as "surveyed" up to elevation 1110 and "inferred" above elevation 1110 m. Despite these differences in the degree of accuracy, the height-capacity curve shown on Figure 4.3 is believed to be suitable for design purposes.

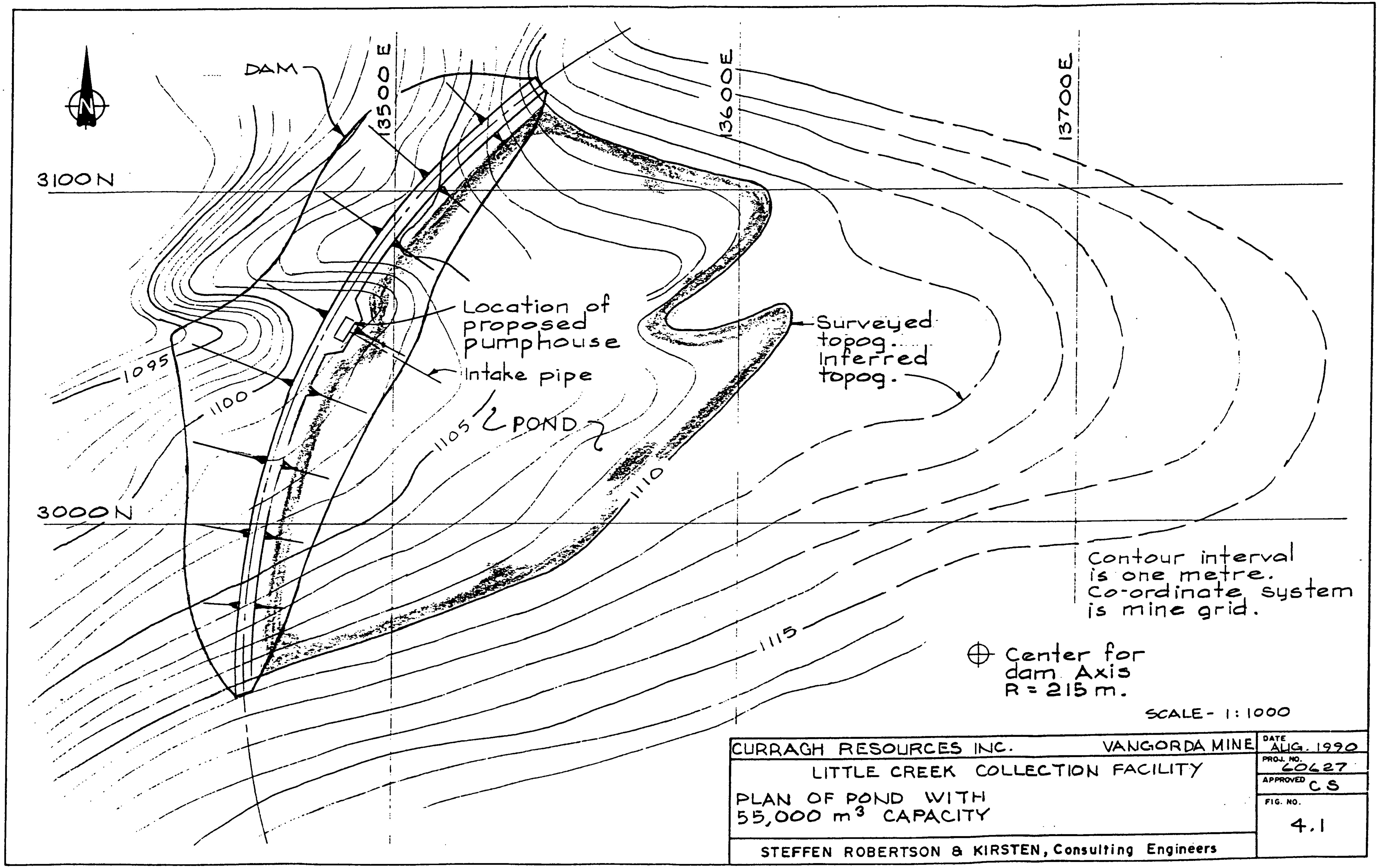
The design criteria for the larger pond was based on the requirement to store 120,000 cubic metres during the months of November to March, inclusive, when pumping to the treatment plant would be reduced to the minimum practical rate. A summary of the estimated mean monthly flows from the various sources that would be collected and discharged into the pond is as follows:

Mean Monthly Discharges
to Little Creek Collection Pond

Month	Drains from Van. Waste Dump (cu.m.)	Local* Runoff (cu.m.)	Vangorda Creek Seepage (cu.m.)	Precip. on Van. Pit (cu.m.)	Seepage into Van. Pit (cu.m.)	Ditch Leakage (cu.m.)	Runoff into Pit (cu.m.)	Total Discharge (cu.m.)
Nov.	2600	2,000	1,500	3,000	13,000	100	3,100	25,300
Dec.	1800	1,400	1,000	2,100	13,400	100	2,200	22,000
Jan.	1200	900	700	1,400	13,400	100	1,400	19,100
Feb.	800	700	500	1,000	12,200	0	1,000	16,200
Mar.	800	700	500	1,000	13,400	0	1,000	17,400
Total	7,200	5,700	4,200	8,500	65,400	300	8,700	100,000

* includes runoff from catchment above Little Creek Dam and below Waste Dump Dyke (0.26 sq km)
Van. = Vangorda

The invert of the intake pipe was established at Elevation 1105 metres. The minimum pond level was established at Elevation 1107 which would provide a buffer of almost a 2 metres to protect the intake pipe from the development of ice. The estimated storage to Elevation 1107, as shown on Figure 4.3, is about 18,000 cubic metres. The estimated live storage to Elevation 1112.6 would, therefore, be 102,000 cubic metres which will be sufficient to accommodate the estimated 100,000 cubic meters of water which will accumulate during the shutdown period from November to March. The dam crest has been designed to Elevation 1114.5 which would provide a 1.9 metre freeboard equivalent to storage of 60,000 cubic metres. To accommodate the estimated discharge of 100,000 m^3 over the five month winter period, the level in the pond would need to be of drawn down to Elevation 1107 at the end of October. The estimate of the seepage from the walls in Vangorda pit, which assumes that the pit is fully developed, was calculated at 10 litres per second. During the winter period, from November through March, it was assumed that this



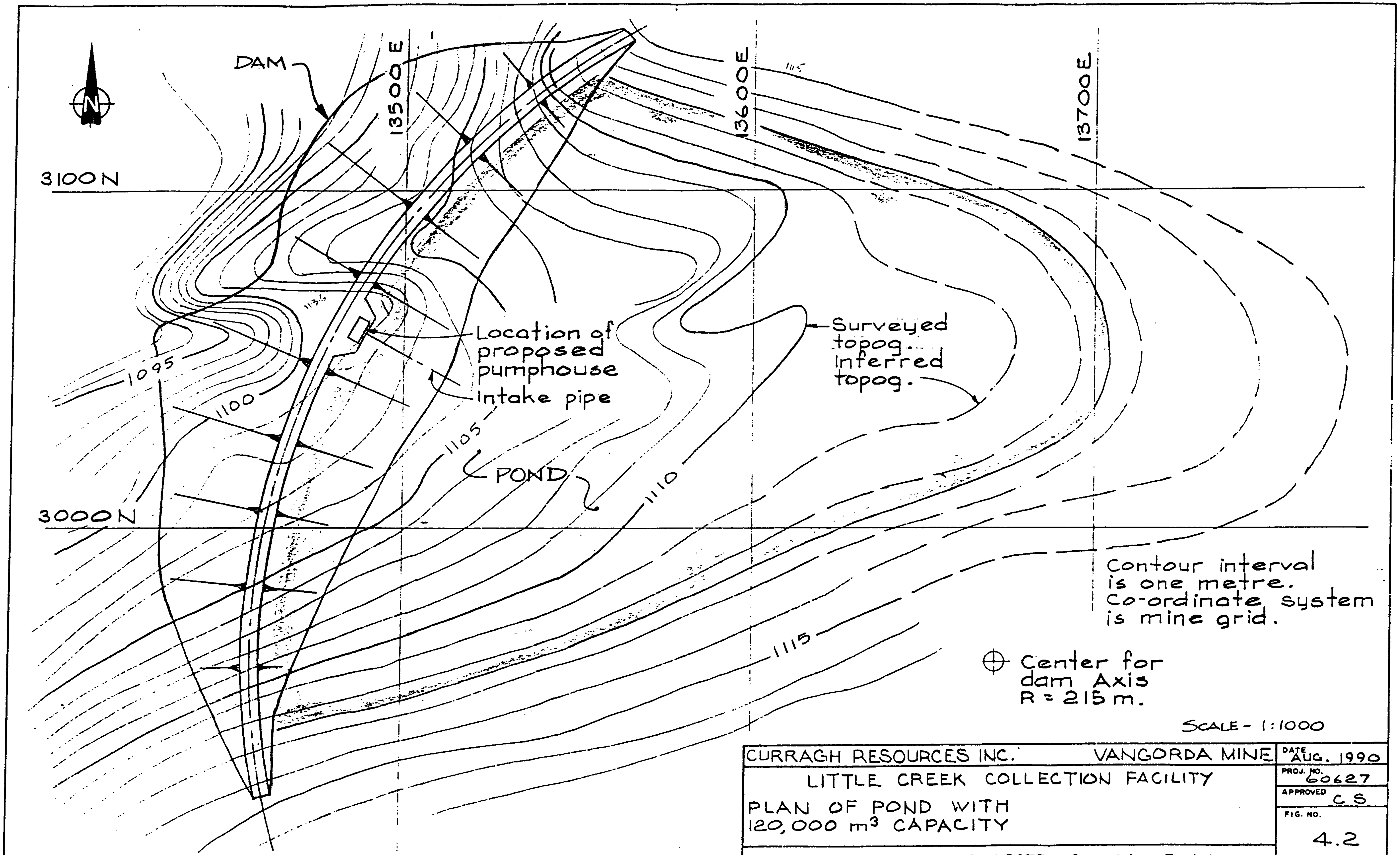
Contour interval is one metre.
Co-ordinate system is mine grid.

⊕ Center for dam Axis R = 215 m.

SCALE - 1:1000

CURRAGH RESOURCES INC. VANGORDA MINE
LITTLE CREEK COLLECTION FACILITY
PLAN OF POND WITH
55,000 m^3 CAPACITY
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers

DATE AUG. 1990
PROJ. NO. 60627
APPROVED C S
FIG. NO. 4.1



Contour interval is one metre.
Co-ordinate system is mine grid.

⊕ Center for dam Axis R = 215 m.

SCALE - 1:1000

CURRAGH RESOURCES INC. VANGORDA MINE

DATE AUG. 1990

LITTLE CREEK COLLECTION FACILITY

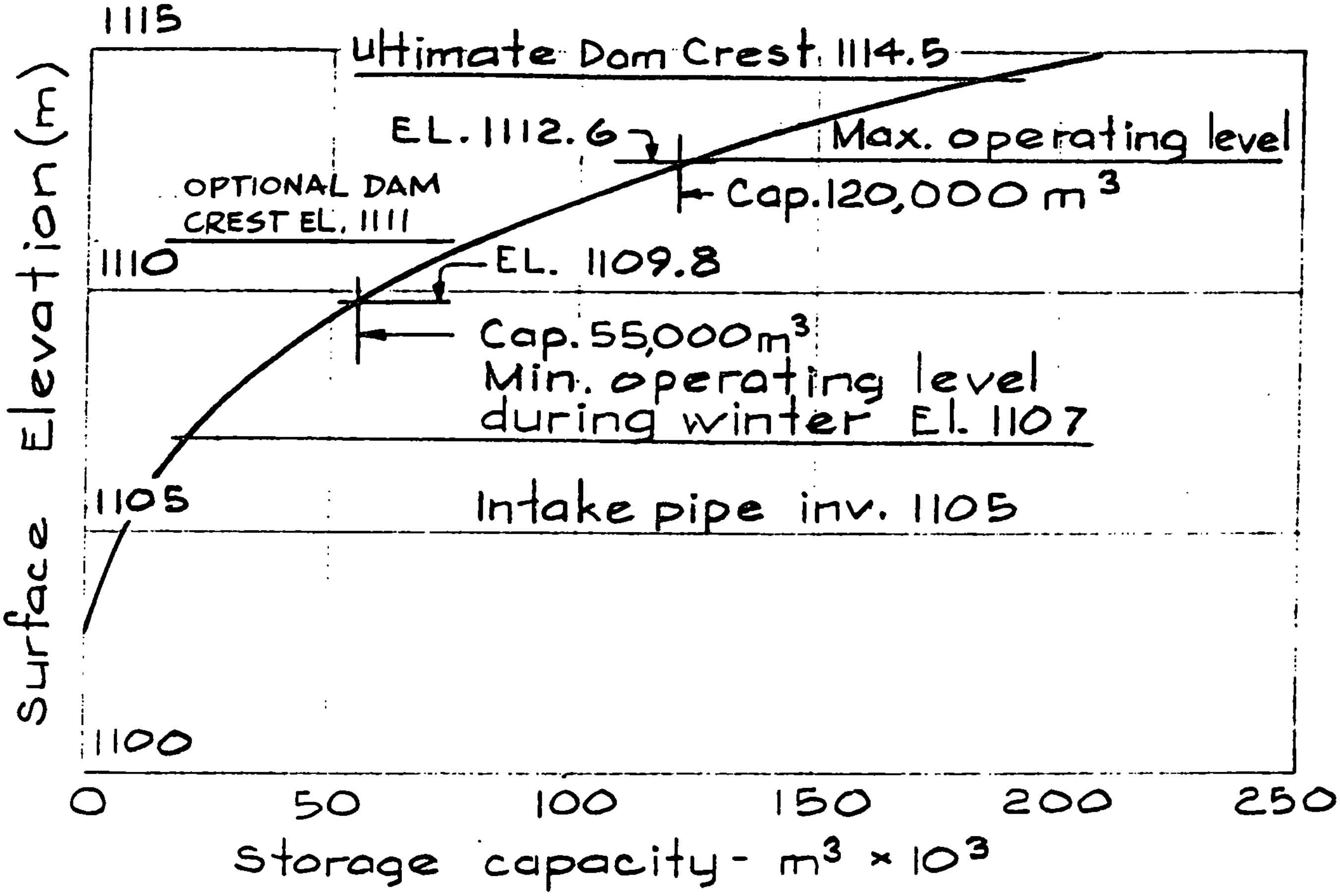
PROJ. NO. 60627

PLAN OF POND WITH
120,000 m^3 CAPACITY

APPROVED CS

FIG. NO. 4.2

STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers



NOTE

Above EL. 1110, the topographic data used to establish this curve are approximate.

CURRAGH RESOURCES INC. VANGORDA MINE	DATE AUG. 1990
LITTLE CREEK COLLECTION FACILITY	PROJ. NO. 60627
HEIGHT - CAPACITY CURVE	APPROVED CCS
	NO. 4.3
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers	

rate would decrease by about 50 percent to 5 litres per second. Consequently, the resultant volume of water that would seep into the pit and be subsequently discharged to the collection facility during the winter months was calculated at about 13,000 cubic metres per month. Total precipitation and runoff estimates were based on a mean annual precipitation (MAP) of 540 mm and a mean annual runoff (MAR) of 320 mm. A water balance based on the mean monthly inflows and outflows has been prepared for the Little Creek collection facility and is shown in Tables 4.1 and 4.2. Table 4.1 presents the mean monthly water balance based on average conditions. To assess the performance of the pond during the occurrence of flows higher than normal, the water balance was recalculated based on a wet year with a return period of 10 years. The results, which are shown in Table 4.2, indicate that under normalconditions, and a pumping rate of 900 USgpm, the pond has the capacity to accommodate flows during the April to October period and would store the estimated flows from both the pit and dump during the period from November to March. In a wet year, however, the water balance indicated that, based on the current seepage estimates, the period of pumping would need to be extended into November to avoid exceeding the maximum operating level established for the pond in March. As it will not be possible to predict a wet year ahead of the event, it is recommended that during the first year of operation, the rate of seepage be carefully monitored and compared with the estimated pit seepage predictions. The pumping schedule should be adjusted according to the actual seepage rates.

In addition to water storage, the dam has been designed to accommodate the 24 hour runoff from the 200 year snowmelt event. The catchment associated with this event includes the area between the ultimate crest of the waste dump and the collection ditch along the dump toe and the catchment of the collection pond below the diversion ditches. This area was estimated to be about 0.26 square kilometres. The total volume of water associated with this event was estimated to be 28,000 cubic metres. If the water level of the pond is assumed to be at Elevation 1112.6 (maximum operating level) when the design event occurs, the total runoff would be accommodated within the dam and still maintain a 1 metre freeboard below the dam crest. As the discharge estimates indicate that a 200 year runoff event can be accommodated within the impoundment, an emergency spillway has not been included in the design. During the first year of operation, however, as discharges from the various components are monitored, and more accurate seepage estimates are developed, the need for a spillway would be evaluated. In the interim, if pond levels rise above Elevation 1113.6 during a storm event, water levels would be controlled by reducing the discharge from Vangorda pit and by pumping water to the water treatment facility.

4.4 Dam Design

The dam at the collection pond has been designed as a homogeneous earthfill embankment with a drainage blanket, finger drains and a cut-off trench located beneath the centreline of the dam. The cut-off trench will extend through the sand and gravel deposits and the upper brown sand (till) to the lower grey gravelly silt (till). The dam will consist of glacial till stripped from within the outline of the Vangorda pit. A 0.5 m thick gravel blanket drain covered by geotextile filter fabric will be constructed to a maximum width of 15 metres downstream of the centreline of the dam in those areas where stripping reveals there to be

TABLE 4.1

Water Balance for Little Creek Collection Facility (Normal Runoff Conditions)

	INFLOW				OUTFLOW	
Month	Local Runoff (dam)^3	Ditch Leakage (dam)^3	Dyke Drain Discharge (dam)^3	Discharge from Pit (dam)^3	Discharge to Plant (dam)^3	Live Storage at End of Month (dam)^3
January	0.9	0.1	1.2	16.9	0.0	66.4
February	0.7	0.0	0.8	14.7	0.0	82.6
March	0.7	0.0	0.8	15.8	0.0	100.0
April	0.8	0.0	1.0	28.7	130.5	0.0
May	16.6	1.0	21.1	89.1	127.7	-0.0
June	26.0	1.5	33.0	123.5	147.2	36.8
July	13.2	0.8	16.8	76.4	144.0	-0.0
August	8.6	0.5	10.9	59.0	78.9	-0.0
September	7.0	0.4	8.9	52.2	68.4	-0.0
October	5.4	0.3	6.8	47.0	59.5	-0.0
November	2.0	0.1	2.6	20.6	0.0	25.3
December	1.4	0.1	1.8	18.7	0.0	47.3
Year	83.2	4.8	105.6	562.6	756.2	

(dam)^3 = cubic decameter = 1,000 cubic metres

TABLE 4.2

Water Balance For Little Creek Collection Pond (Wet Runoff Conditions - 10 year return period)

INFLOW					OUTFLOW	
Month	Local Runoff $(\text{dam})^3$	Ditch Leakage $(\text{dam})^3$	Dyke Drain Discharge $(\text{dam})^3$	Discharge from Pit $(\text{dam})^3$	Discharge to Plant $(\text{dam})^3$	Live Storage at End of Month $(\text{dam})^3$
January	1.3	0.1	1.7	18.2	0.0	46.4
February	0.9	0.1	1.2	15.6	0.0	64.2
March	0.9	0.1	1.2	16.7	0.0	83.1
April	1.1	0.1	1.3	29.8	115.3	0.0
May	23.3	1.3	29.6	111.7	152.1	13.9
June	36.6	2.1	46.4	147.2	147.2	99.0
July	18.6	1.1	23.6	106.1	152.1	96.3
August	12.1	0.7	15.3	70.7	152.1	42.9
September	9.8	0.6	12.5	61.7	127.4	0.0
October	7.6	0.4	9.6	54.3	71.8	0.0
November	2.9	0.2	3.6	23.4	30.0	0.0
December	2.0	0.1	2.5	20.6	0.0	25.2
Year	117.0	6.8	148.5	675.8	948.1	

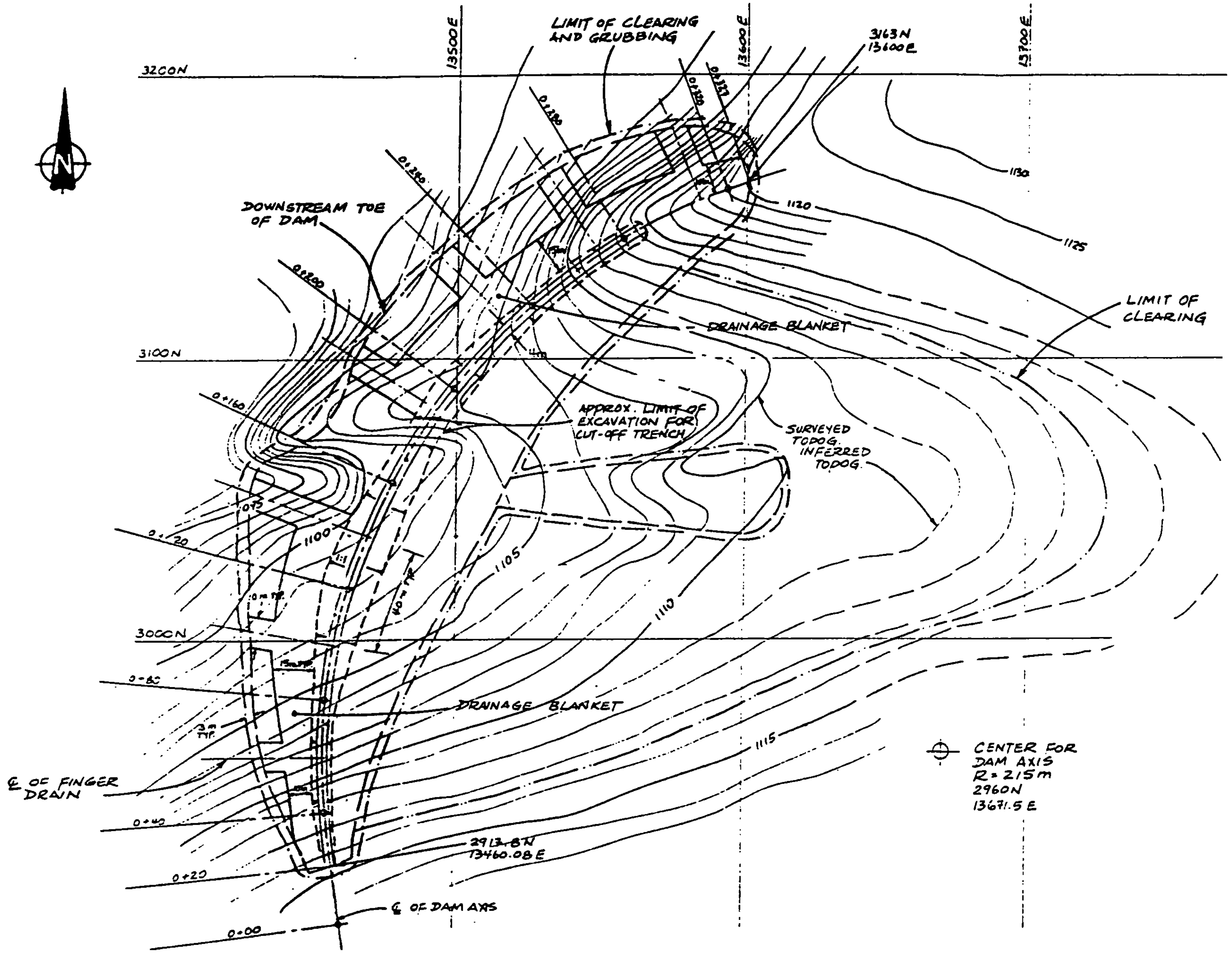
no significant gravel or sand deposits in the subsoils finger. Finger drains, 10 metres wide and 0.5 metres thick, will extend from the blanket drain at 40 metre centres. Along the downstream toe of the dam, a rock drain will be constructed to a maximum height of 4 metres. The proposed layout of the finger drains and cut-off trench is presented in Figure 4.4.

The dam was designed with a crest width of 10 metres and with upstream and downstream sideslopes of 2.0:1 (H:V) and 1.75:1 (H:V), respectively, as shown in Figure 4.5. In consideration of the potential for erosion or cracking due to frost action, the design calls for a freeboard of 1.9 metres above the maximum operating level of the pond. This freeboard, and the inclusion of blanket and finger drains within the dam, will help maintain a safe separation between from the theoretical phreatic surface and the downstream face. The 2.5:1 (H:V) sideslope on the upstream face will provide an adequate factor of safety against rapid drawdown in the pond.

Ice will form in the pond during the winter months and, as upward and downward movement of the ice cover is anticipated, it was thought that placement of a gravel or rip-rap surface on the upstream face would aggravate the ice movement and result in disturbance of the face. Consequently a gravel cover on the upstream face was not included in the dam design. The rock toe drain, which will extend along the entire toe of the dam, was included to provide protection against toe erosion and possible blockage of the finer grained finger drain by freezing.

As the glacial till may be susceptible to frost action, the dam may experience erosion and cracking of the near-surface material on the crest and on both the upstream and downstream faces. A gravel outershell was initially considered to provide protection against frost action in the till and, consequent, slope erosion and shallow cracking. However, it was found that sufficient gravel to construct these shells was not locally available. The current design, however, does not preclude the possibility that frost action may result in erosion and cracking of the dam structure. Consequently, a monitoring program would be initiated during the first year of operation to assess the performance of the dam. The monitoring program would include regular inspections of the upstream and downstream faces of the dam, and regular readings of piezometers and thermistors that would be installed in the dam during construction. In the event that a gravel shell is required on the downstream face to prevent erosion, either the downstream face, with its extra wide crest, could be trimmed to a flatter grade in order to place the gravel or a rock buttress could be placed over the existing face. Similarly, on the upstream face a gravel cover could readily be placed, if required. At the downstream toe, additional frost protection could be provided by constructing a rock berm if problems arise during the first year of operation.

The current design also provides for a seepage collection monitoring system along the toe of the dam. A collection ditch would discharge seepage into a 1 metre diameter slotted or perforated corrugated steel pipe (CSP) which would be installed to a depth of about 4 metres below grade and embedded in drain rock. After the first year of operation, and using actual flow data, an evaluation of whether a more



PLAN

SCALE - 1:2000

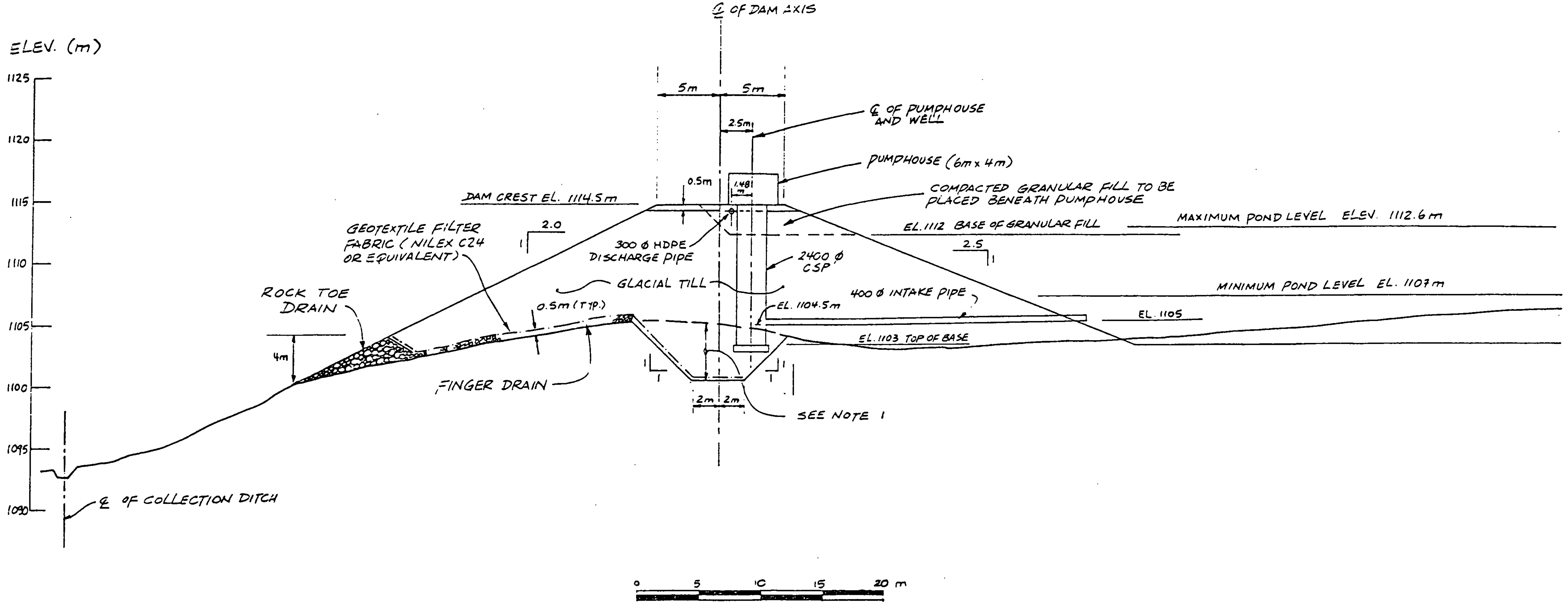
CONTOUR INTERVAL = 1 metre

0 10 20 30 40 50 metres

NOTES:

1. TOPOGRAPHY SUPPLIED BY OTHERS.
2. DASHED CONTOUR LINES REPRESENT INFERRED TOPOGRAPHY.

CURRAGH RESOURCES INC. VANGORDA	DATE AUG. 1990
VANGORDA COLLECTION POND LAYOUT OF DRAINS AND CUT-OFF TRENCH	PROJ. NO. 60627
	APPROVED
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers	FIG. NO. 4.4



NOTES:

1. Cut–off trench will extend 1m into grey till or other suitable soil. Actual depth will be determined by SRK field engineer.
2. The pumphouse, wet well and intake pipe were added to this section for illustrative purposes.

CURRAGH RESOURCES INC. VANGORDA

VANGORDA COLLECTION POND

TYPICAL DAM SECTION

STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers

DATE AUG. 1990

PROJ. NO. 60627

APPROVED

FIG. NO. 4.5

elaborate collection system is required would be completed. If high seepage flows are recorded, a seepage collection pond with an overflow spillway could be considered.

Seepage and runoff collected in Vangorda pit will be discharged into the Little Creek Pond through a 400 mm diameter buried pipeline. The invert elevation of the pipe at the outlet has been established at Elevation 1104 metres and would be located about 85 metres from the intake pipe at the toe of the dam. A trench would be excavated from the toe of the dam to the point of discharge to provide sufficient clearance below any ice which forms on the pond surface. The elevation of the trench is 1103 metres. Rip-rap protection would be required around the discharge pipe to reduce erosion. The trench would be excavated with a base width of 8 metres and sideslopes of 1.5:1 (H:V). The maximum depth of excavation for this trench is about 7 metres.

4.5 Embankment Volume

Based on the typical section shown in Figure 4.5, the volume of material necessary to construct the dams at the two different heights are as follows.

Summary of Embankment Fill Volumes

	Small Dam (cu.m)	Large Dam (cu.m)
Glacial Till	27,500	53,000
Gravelly Sand	7,000	13,500
Total volume in cubic metres	34,500	66,500

Of the total fill volumes listed above, the portions represented by the gravelly sand drain and the cut-off trench are estimated at approximately 500 cubic metres, and 4,000 to 5,000 cubic metres, respectively. The average depth of the cut-off has been assumed to be 4 metres, with a maximum depth of 6 m, based on the geotechnical investigation.

5.0 CONSTRUCTION

5.1 Borrow Materials

It is expected that the till for embankment construction will be obtained from the stripping operations at the Vangorda open pit. The gravelly sands required for the construction of the embankment shells and the drainage blanket will be obtained from inside the limits of the collection pond.

The till for construction of the dam at the collection pond should meet the following gradation:

U.S. Standard	Percent Passing by Weight
3 in.	90 - 100
3/4 in.	75 - 100
No. 4	50 - 95
No. 40	30 - 65
No. 200	30 - 50

Boulders in the till should not exceed 18 inches in diameter.

The sand and gravel for the drainage blanket should consist of hard durable fragments meeting the following gradation:

U.S. Standard Sieve	Percent Passing by Weight
1½ in.	100
3/4 in.	85 - 100
3/8 in.	50 - 90
No. 4	30 - 80
No. 16	10 - 30
No. 40	5 - 15
No. 100	0 - 10
No. 200	0 - 8

Gravel should not exceed 6 inches.

5.2 Trench Excavation

The trench excavation may encounter significant inflows of seepage. While these flows are expected to decrease in a matter of hours, the contractor should be prepared to manage significant flows. This is particularly critical when the till core is being placed because the silty nature of the till that will be used for core construction is difficult to handle when wet.

5.3 Embankment Construction

This is a water dam and, as such, will require relatively rigorous construction procedures. The embankment materials should be placed in horizontal lifts not exceeding 1 foot in thickness and compacted to 95 percent of Standard Proctor maximum dry density. Appendix 3 should be referred to for an indication of the compaction characteristics of the till in the vicinity of the Vangorda open pit.

6.0 CONCLUSIONS

We recommend that, to provide maximum flexibility during operations, the collection facility should allow storage during the winter months of flows from either the Vangorda pit and/or the waste dump. Therefore, the 120,000 cubic metre collection facility should be selected.

This report, Number 160627, entitled Vangorda Plateau Development, Little Creek Collection Facility, Geotechnical Investigation and Design, is respectfully submitted by:

STEFFEN, ROBERTSON AND KIRSTEN (B.C.) INC.

Cameron C. Scott, P. Eng.
Senior Geotechnical Engineer

Peter Healey, P. Eng.
Project Engineer

per Andrew MacG. Robertson, P. Eng.
Review Principal

APPENDIX 1

Borehole and Test Pit Logs And Field Permeability Test Results

60625

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers
LOG OF TEST PIT

TEST PIT NO. 90-5

LOCATION VANGORDA WASTE DUMP (SEEPAGE POND NO. 1)

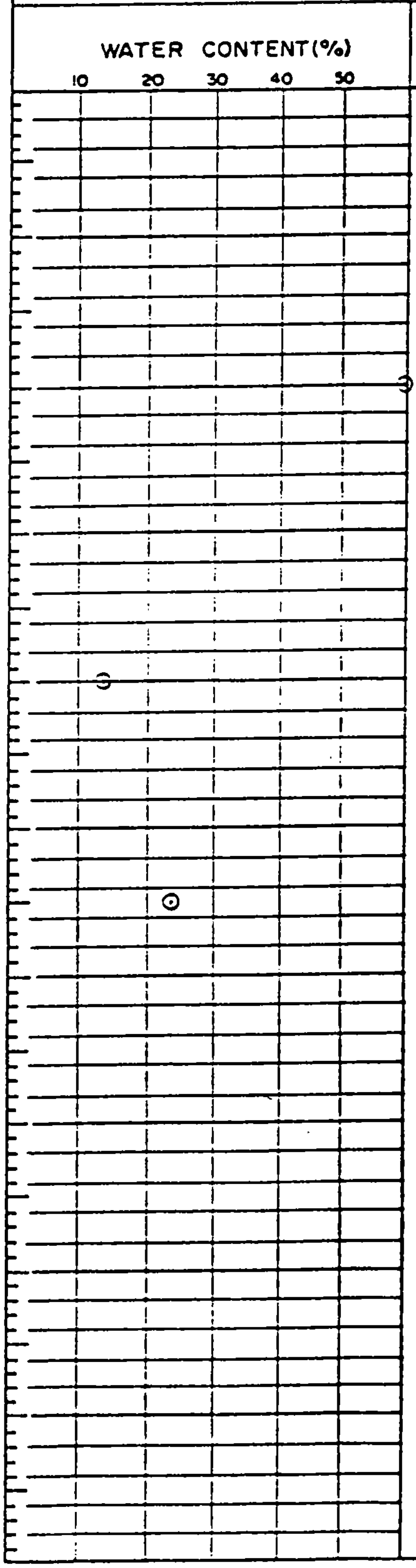
PROJECT CURRAGH RESOURCES VANGORDA WASTE DUMP

DATE MAY 11 1990

METHOD BACKHOE (CAT 235)

INSPECTOR R.C. OLAUSON

WATER CONTENT(%)



ELEV. (metres)	REMARKS	UNIFIED SOIL CLASSIFICATION SYSTEM	Sa.	TEST PIT LOG	DEPTH (metres)
	TOP OF PIT ELEV.				
	Water level at surface.	Pt		moss	
		Pt (Nb)		dark brown PEAT, frozen ± 50% excess ice	
	POCKET PEN.(tsf) TORE VANE (tsf)	ML -OL (Vs)		dark grey organic clayey silt, frozen. Visible segregated ice in lense network ~~SILT~~ (PHOTOS 17 & 18)	
				depth of frost = 0.7m	
	<0.25 1.0 to 1.5	ML -OL	1	dark grey organic clayey silt, as above, thawed, abundant rootlets and fine organics	1.0
	1.0 2.5 to 3.0	SC	2	TILL olive brown clayey gravelly silt and sand, very wet	2.0
	Abundant seepage below 2.1 m →	SP	3	red-brown slightly gravelly SAND. (PHOTOS 19 & 20)	
				END (2.5m) (Pit Caving)	

LEGEND
- Gs GRAINSIZE TESTING
- C COMPACTION TEST
- ☐ DISTURBED SAMPLE
- ■ UNDISTURBED SAMPLE
- W_L LIQUID LIMIT
- W_P PLASTIC LIMIT

60625

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers
LOG OF TEST PIT

TEST PIT NO. 90-6

LOCATION VANGOZDA WASTE DUMP
(SEEPAGE POND NO. 1 -
RAVINE AT RIGHT ABUTMENT)

PROJECT CURRAGH RESOURCES
VANGORDA WASTE DUMP
DATE MAY 11 1990
METHOD BACKHOE (CAT 235)
INSPECTOR R.C. OLAUSON

WATER CONTENT (%) 10 20 30 40 50	ELEV. (metres)	REMARKS TOP OF PIT ELEV.	UNIFIED SOIL CLASSIFICATION SYSTEM		TEST PIT LOG	DEPTH (metres)
			Pt		moss	
		Moisture content : 86%	ML -SM (Nb)	1	red-brown, clayey sandy silt with abundant rootlets, occasional well-rounded cobbles and boulders to 30cm dia Frozen, no visible excess ice.	
			GP -GM (Vc)		red-brown slightly silty sandy gravel with occasional cobbles, frozen, visible ice in interstices between pebbles.	1.0
			GP	2	red-brown sandy gravel and cobbles, dry, irregularly layered with seams of pebbles. ±35% larger than 75mm Max 40cm dia. (PHOTOS 21 & 22)	2.0
			GP		black-stained slightly sandy gravel <5% passing #200 slightly moist. no ice	3.0
		Seepage at top ∇ → of till POCKET PEN (tsf) 2.5 (remoulded) TORE VANE (tsf) >8		3	TILL: (till surface dips towards south) blue-grey clayey gravelly silt and sand, moist, stiff (PHOTO 23)	
					END (3.5m)	

LEGEND
- Gs GRAINSIZE TESTING
- C COMPACTION TEST
- ☐ DISTURBED SAMPLE
- ■ UNDISTURBED SAMPLE
- W_L LIQUID LIMIT
- W_P PLASTIC LIMIT

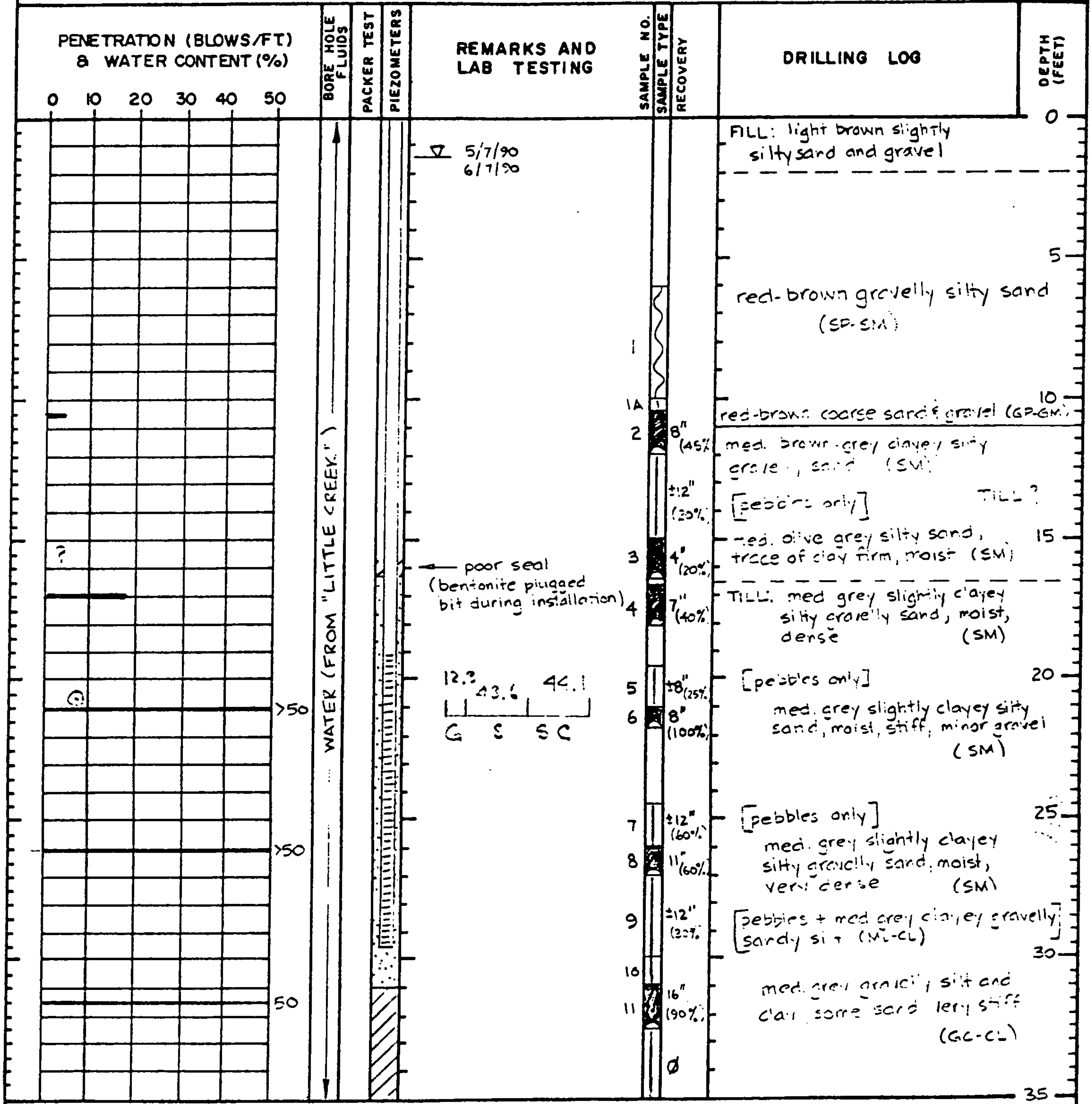
PREPARED BY
STEFFEN ROBERTSON & KIRSTEN
GEOTECHNICAL AND MINING ENGINEERS

CLIENT CURRAGH RESOURCES INC.
PROJECT VANGORDA
JOB NO. 60627
DATES DRILLED JULY 2-4, 1990
DRILLER ADVANCED (F. KOST)

TEST HOLE NO. DH-90-1
SHEET 1 **OF** 2
PREPARED BY RCO
INSPECTOR RCO

LOCATION "LITTLE CREEK" COLLECTION POND SITE . MID-CHANNEL
COORDINATES 3049.3 m N 13 513.7 m E (LOCAL GRID) **TOP OF HOLE ELEVATION** 1104.23 m

LOG OF TEST BORING



▽ 5/7/90
6/7/90

← poor seal (bentonite plugged bit during installation)

FILL: light brown slightly silty sand and gravel

red-brown gravelly silty sand (SP-SM)

red-brown coarse sand & gravel (GP-GM)

med. brown-grey clayey silty gravelly sand (SM)

[pebbles only] TILL?

med. olive grey silty sand, trace of clay firm, moist (SM)

TILL: med grey slightly clayey silty gravelly sand, moist, dense (SM)

[pebbles only]

med. grey slightly clayey silty sand, moist, stiff, minor gravel (SM)

[pebbles only]

med. grey slightly clayey silty gravelly sand, moist, very dense (SM)

[pebbles + med grey clayey gravelly sandy silt (ML-CL)]

med. grey gravelly silt and clay some sand very stiff (GC-CL)

CORE BARREL SAMPLE	LOSS ◀	PACKER TEST	C CONSOLIDATION TEST	PITCHER SAMPLE	SPLIT SPOON
	CONSTANT ▼	▨ SEAL	T TRIAXIAL TEST		
		▨ GRAVEL FILTER	A ATTERBERG LIMITS	TRICONE CUTTINGS	BULK SAMPLE
	GAIN ▶	▥ PIEZOMETER TIP	G GRAIN SIZE		
			D DIRECT SHEAR		

PREPARED BY

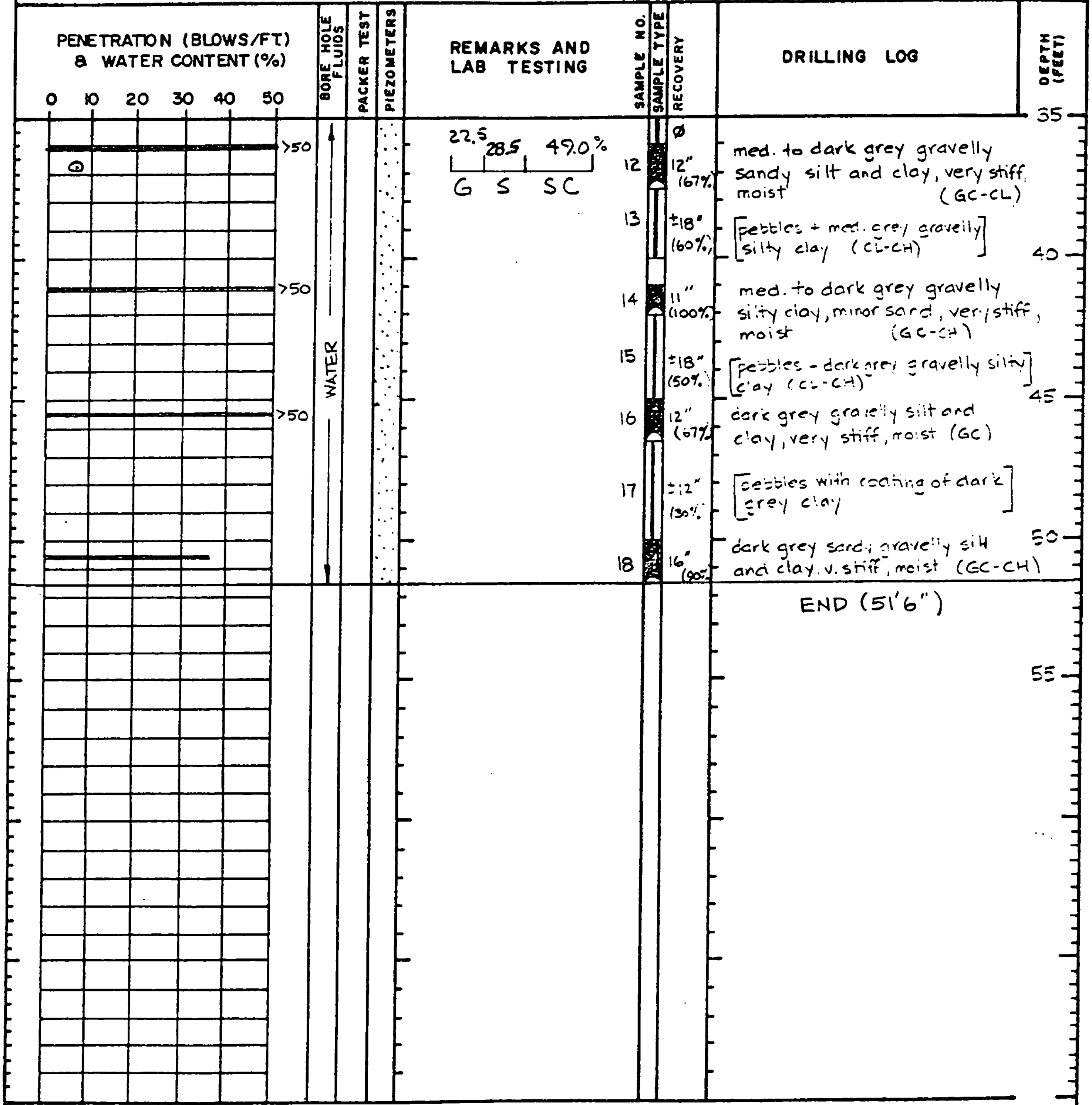
STEFFEN ROBERTSON & KIRSTEN
GEOTECHNICAL AND MINING ENGINEERS

CLIENT CURRAGH RESOURCES INC.		**TEST HOLE NO.** DH-90-1
PROJECT VANGORDA		
JOB NO. 60627		**SHEET** 2 **OF** 2
DATES DRILLED JULY 2-4, 1990		**PREPARED BY** RCO
DRILLER ADVANCED (F. KOST)		**INSPECTOR** RCO

LOCATION "LITTLE CREEK" COLLECTION POND SITE, MID-CHANNEL

COORDINATES 3049.34 m N 1353.73 m E (LOCAL) **TOP OF HOLE ELEVATION** 1104.23 m

LOG OF TEST BORING



REMARKS AND LAB TESTING

22.5 28.5 49.0%
G S SC

SAMPLE NO.	RECOVERY	DRILLING LOG
	Ø	
12	12" (67%)	med. to dark grey gravelly sandy silt and clay, very stiff, moist (GC-CL)
13	±18" (60%)	[pebbles + med. grey gravelly silty clay (CL-CH)]
14	11" (100%)	med. to dark grey gravelly silty clay, minor sand, very stiff, moist (GC-CH)
15	±18" (50%)	[pebbles - dark grey gravelly silty clay (CL-CH)]
16	12" (67%)	dark grey gravelly silt and clay, very stiff, moist (GC)
17	±12" (30%)	[pebbles with coating of dark grey clay]
18	16" (90%)	dark grey sandy gravelly silt and clay. v. stiff, moist (GC-CH)

END (51'6")

▯ CORE BARREL SAMPLE	LOSS ◀	I PACKER TEST	C CONSOLIDATION TEST	▨ PITCHER SAMPLE
	CONSTANT ▼	▨ SEAL	T TRIAXIAL TEST	▨ SPLIT SPOON
	GAIN ▶	▨ GRAVEL FILTER	A ATTERBERG LIMITS	⌇ TRICONE CUTTINGS
		▯ PIEZOMETER TIP	G GRAIN SIZE	☒ BULK SAMPLE
			D DIRECT SHEAR	

CURRAGH RESOURCES INC. 60627
VANGORDA COLLECTION POND 11 JULY 1990

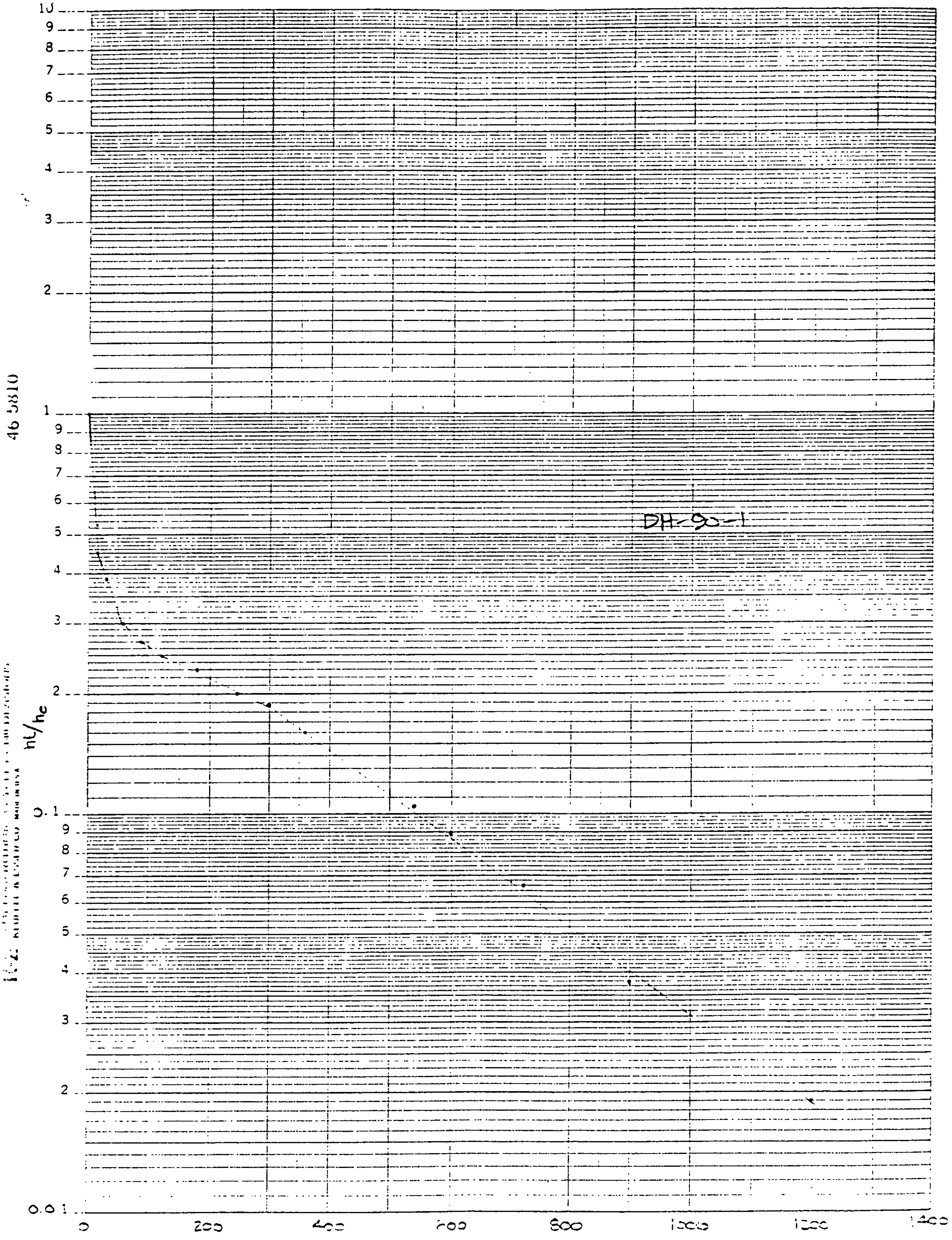
FALLING HEAD TEST — DH-90-1

Date of test : July 5, 1990
Depth to top of test section :
Length of test section, L : 4.48 m
Depth to ~~static~~ water level, Hw : 1.06 m
Borehole radius, R : 4.445 cm
Casing radius, r : 1.15 cm
Excess head, he : 1.06 m

All depth measured from top of casing

Time (s)	Depth to water (cm)	Excess head, ht (cm)	h_t/h_e
0	0	106	1
15	50, 58	56, 48	0.53, 0.45
30	65	41	0.39
60	74	32	0.30
90	77	29	0.27
120	79	27	0.25
180	82	24	0.23
245	84.5	21.5	0.20
300	86	20	0.189
360	89	17	0.160
540	95	11	0.104
600	96.5	9.5	0.090
720	99	7	0.066
900	102	4	0.038
1200	104	2	0.019
1500	106	0	0

60627



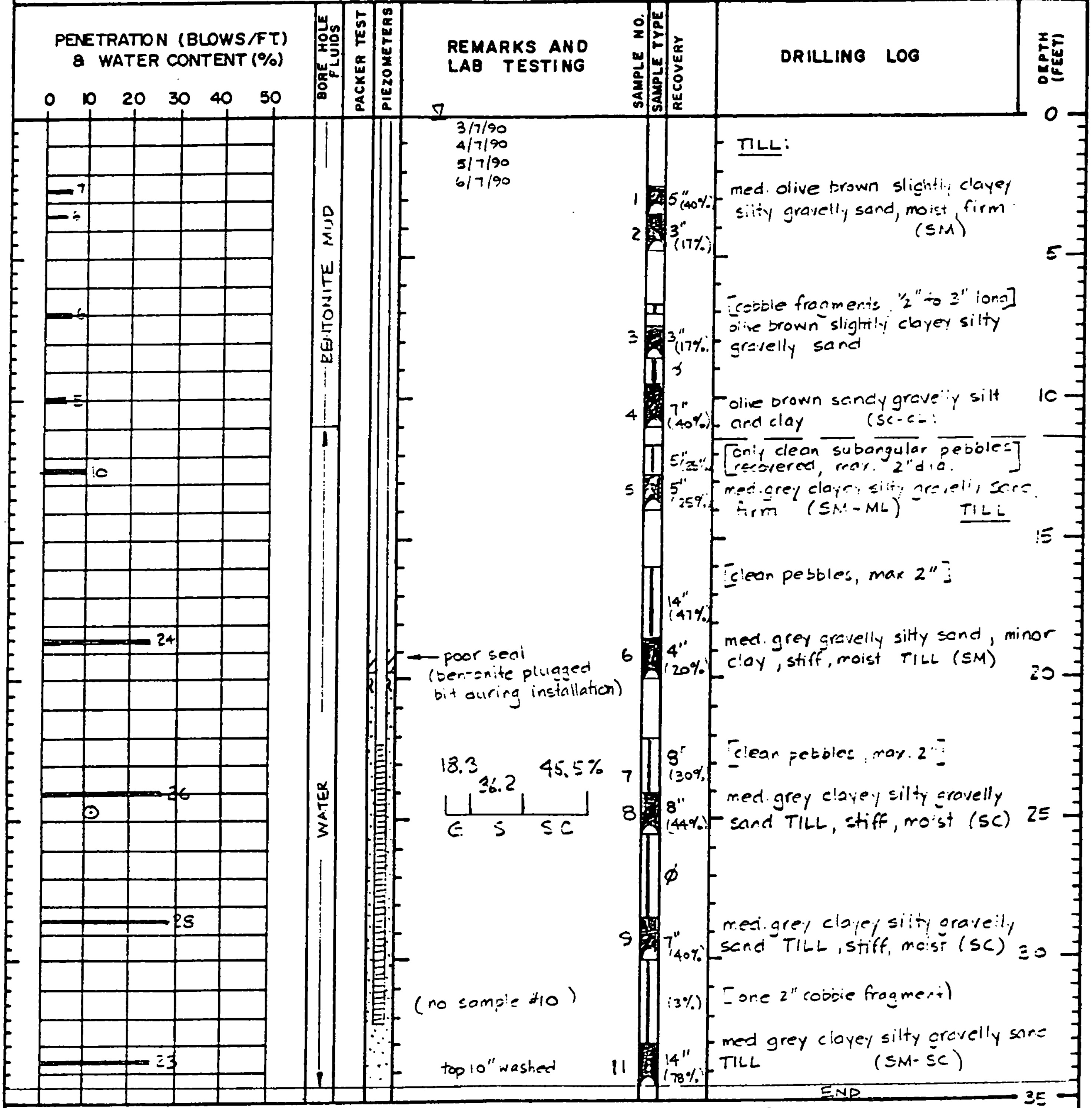
DH-90-1
ht/hc
46 5810
10
9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
0.1
9
8
7
6
5
4
3
2
0.01
0
200
400
600
800
1000
1200
1400

PREPARED BY
STEFFEN ROBERTSON & KIRSTEN
GEOTECHNICAL AND MINING ENGINEERS

CLIENT CURRAGH RESOURCES INC.
PROJECT VANGORDA DEVELOPMENT
JOB NO. 60627
DATES DRILLED JULY 1 & 2, 1990
DRILLER ADVANCED (F. KOST)
TEST HOLE NO. DH-90-2
SHEET 1 **OF** 1
PREPARED BY
INSPECTOR 2ro

LOCATION PROPOSED COLLECTION POND SITE, RIGHT ABUTMENT
COORDINATES 3110.9 m N 13536.9 m E (LOCAL) **TOP OF HOLE ELEVATION** 1107.76 m

LOG OF TEST BORING



← poor seal (bentonite plugged bit during installation)

(no sample #10)

top 10" washed

TILL:

med. olive brown slightly clayey silty gravelly sand, moist, firm (SM)

[cobble fragments ½" to 3" long]

olive brown slightly clayey silty gravelly sand

olive brown sandy gravelly silt and clay (SC-CL)

[only clean subangular pebbles recovered, max. 2" dia.]

med. grey clayey silty gravelly sand, firm (SM-ML) TILL

[clean pebbles, max 2"]

med. grey gravelly silty sand, minor clay, stiff, moist TILL (SM)

[clean pebbles, max. 2"]

med. grey clayey silty gravelly sand TILL, stiff, moist (SC)

med. grey clayey silty gravelly sand TILL, stiff, moist (SC)

[one 2" cobble fragment]

med grey clayey silty gravelly sand TILL (SM-SC)

END

LOSS ◀	PACKER TEST	C CONSOLIDATION TEST	PITCHER SAMPLE
CONSTANT ▼	SEAL	T TRIAXIAL TEST	SPLIT SPOON
GAIN ▶	GRAVEL FILTER	A ATTERBERG LIMITS	TRICONE CUTTINGS
	PIEZOMETER TIP	G GRAIN SIZE	BULK SAMPLE
		D DIRECT SHEAR	

CORE BARREL SAMPLE

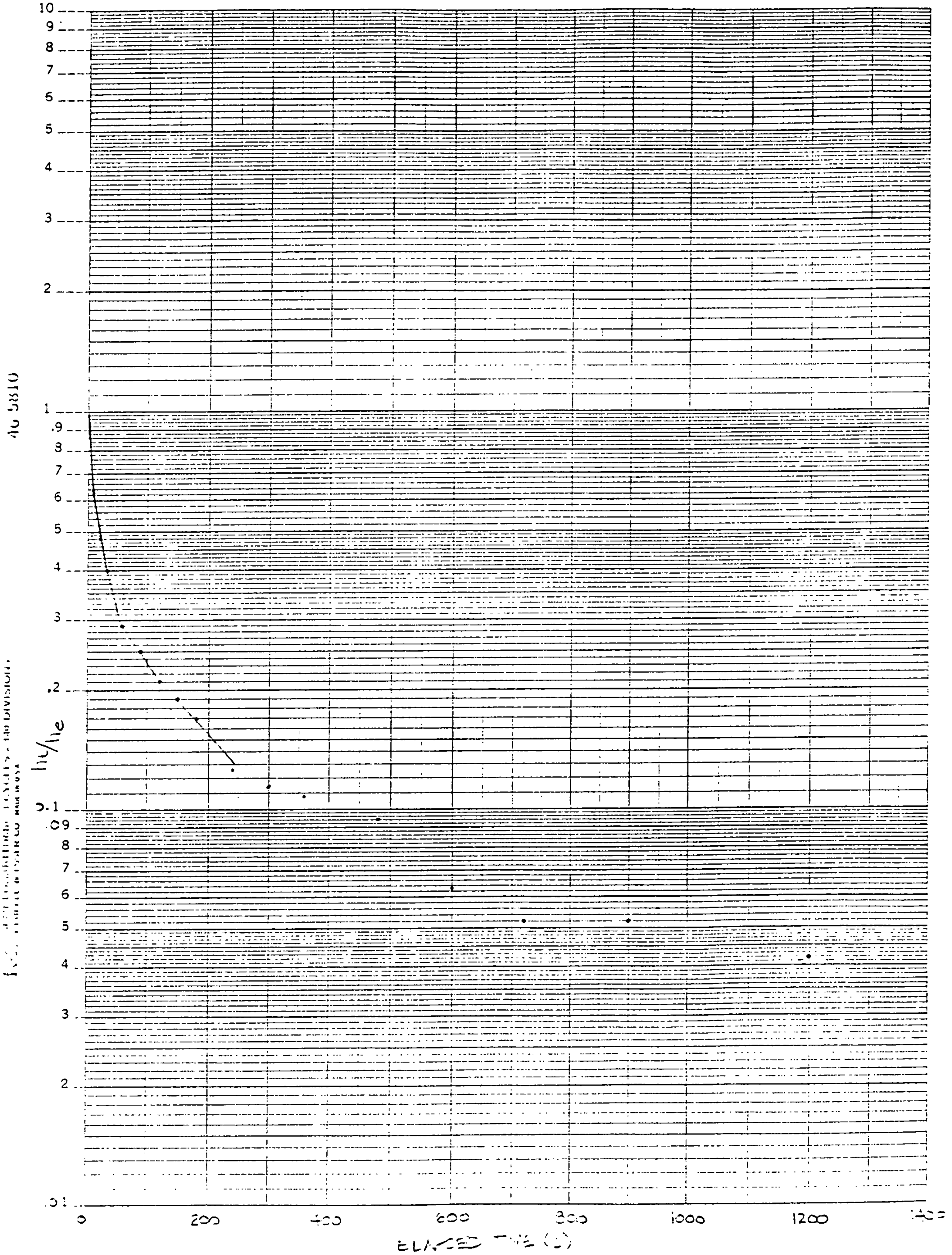
CURRAGH RESOURCES INC. 60627
VANGORDA COLLECTION POND 12 JULY 1990

FALLING HEAD TEST DH-90-2

Date of test: July 5, 1990
Depth to top of test section: ±20' (from ground surface)
Length of test section: ± 22.25' (6.78 m)
Depth to static water level: 0.48 m
Borehole radius, R (± 3⅛"/2) = 3.97 cm
Casing radius, r: 1.15 cm
Excess head, he: 0.48 m
(at start of test)

All depths measured from top of casing unless otherwise noted.

Elapsed Time (s)	Depth to water (cm)	Excess head, ht (cm)	ht/he
0	0	0	0
10	18	30	0.625
20	25	23	0.48
30	29	19	0.40
60	34	14	0.29
90	36	12	0.25
120	38	10	0.21
150	39	9	0.19
180	40	8	0.17
240	42	6	0.125
300	42.5	5.5	0.115
360	43	5	0.104
480	43.5	4.5	0.094
600	45	3	0.063
720	45.5	2.5	0.052
900	45.5	2.5	0.052
1200	46	2	0.042
1500	46.5	1.5	0.031
1800	47	1	
2400	47.5	0.5	


10
9
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6
5
4
3
2
.01
h/he
46 5810
0
200
400
600
800
1000
1200
1400
ELAPSED TIME (s)

PREPARED BY

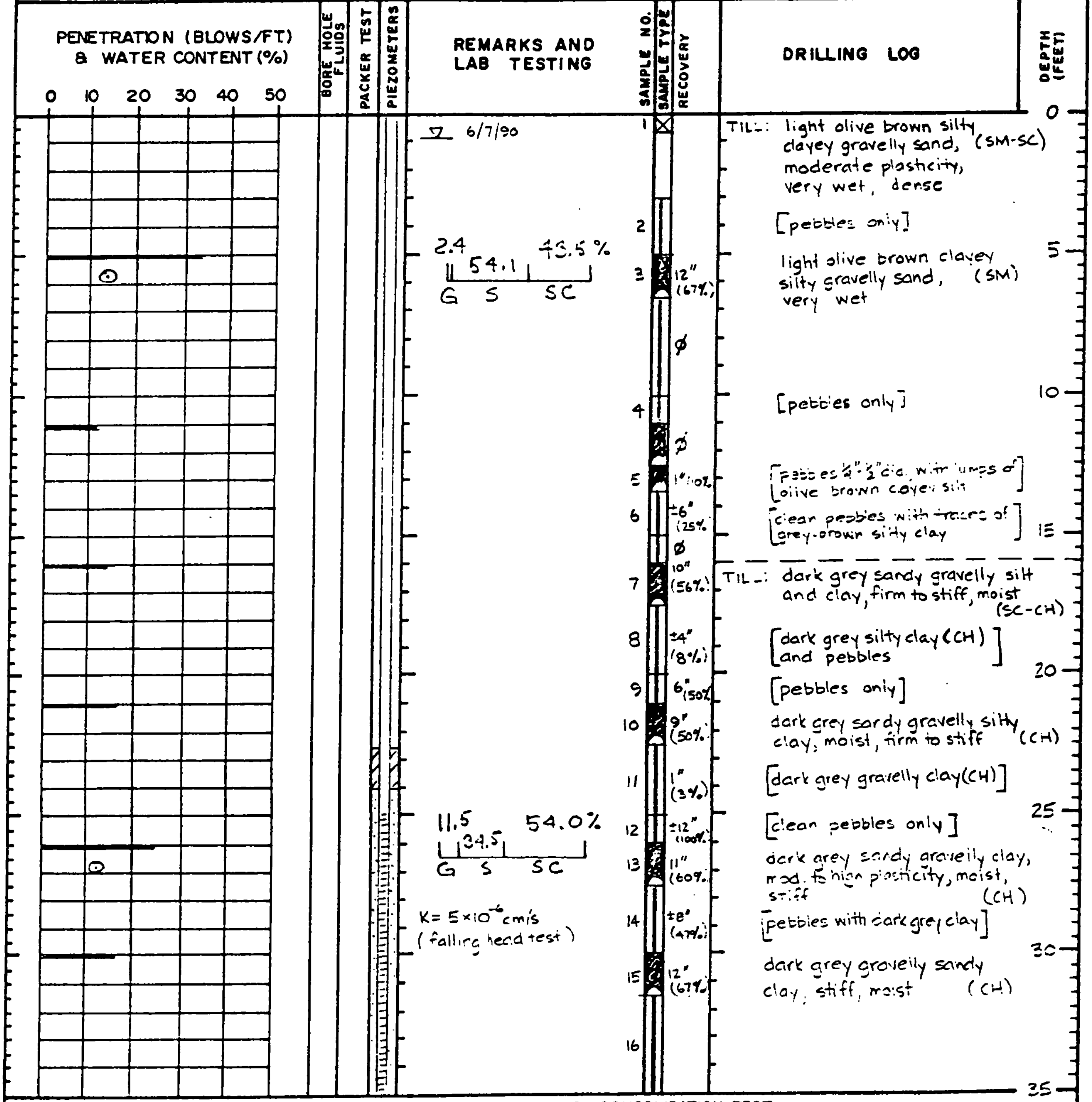
STEFFEN ROBERTSON & KIRSTEN
GEOTECHNICAL AND MINING ENGINEERS

CLIENT	CURRAGH RESOURCES INC.
PROJECT	VANGORDA
JOB NO.	60627
DATES DRILLED	JULY 4-5, 1990
DRILLER	ADVANCED (F. KOST)
TEST HOLE NO.	DH-90-3
SHEET	1 OF 2
PREPARED BY	RCO
INSPECTOR	RCO

LOCATION "LITTLE CREEK" COLLECTION POND SITE LEFT ABUTMENT

COORDINATES 2980.4 m N 13505.3 m E (LOCAL) **TOP OF HOLE ELEVATION** 1107.89 m

LOG OF TEST BORING



SAMPLE NO.	RECOVERY	REMARKS AND LAB TESTING	DRILLING LOG	DEPTH (FEET)
1		▽ 6/7/90	TILL: light olive brown silty clayey gravelly sand, (SM-SC) moderate plasticity, very wet, dense	0
2			[pebbles only]	
3	12" (67%)	2.4 / 54.1 / 43.5 % G / S / SC	light olive brown clayey silty gravelly sand, (SM) very wet	5
	ø			
4	ø		[pebbles only]	10
5	1" (10%		[pebbles ¼"-½" dia. with lumps of olive brown clayey silt]	
6	±6" (25%		[clean pebbles with traces of grey-brown silty clay]	15
	ø			
7	10" (56%)		TILL: dark grey sandy gravelly silt and clay, firm to stiff, moist (SC-CH)	
8	±4" (8%)		[dark grey silty clay (CH) and pebbles]	
9	6" (50%		[pebbles only]	20
10	9" (50%)		dark grey sandy gravelly silty clay, moist, firm to stiff (CH)	
11	1" (3%)		[dark grey gravelly clay(CH)]	
12	±12" (100%)	11.5 / 34.5 / 54.0% G / S / SC	[clean pebbles only]	25
13	11" (60%)		dark grey sandy gravelly clay, mod. to high plasticity, moist, stiff (CH)	
14	±8" (47%)	K= 5×10^{-6} cm/s (falling head test)	[pebbles with dark grey clay]	
15	12" (67%)		dark grey gravelly sandy clay, stiff, moist (CH)	30
16				35

CORE BARREL SAMPLE

LOSS ◀
CONSTANT ▼
GAIN ▶

I PACKER TEST
▨ SEAL
▨ GRAVEL FILTER
▤ PIEZOMETER TIP

C CONSOLIDATION TEST
T TRIAXIAL TEST
A ATTERBERG LIMITS
G GRAIN SIZE
D DIRECT SHEAR

PITCHER SAMPLE
SPLIT SPOON
TRICONE CUTTINGS
BULK SAMPLE

PREPARED BY

STEFFEN ROBERTSON & KIRSTEN
GEOTECHNICAL AND MINING ENGINEERS

CLIENT CURRAGH RESOURCES INC.
PROJECT VANGORDA
JOB NO. 60627
DATES DRILLED JULY 4-5, 1990
DRILLER ADVANCED (F. KOST)
TEST HOLE NO. DH-90-3
SHEET 2 **OF** 2
PREPARED BY RCO
INSPECTOR RCO

LOCATION
COORDINATES 2980.4 m N 13505.3 m E (LOCAL)
TOP OF HOLE ELEVATION 1107.89 m

LOG OF TEST BORING

PENETRATION (BLOWS/FT) & WATER CONTENT (%) 0 10 20 30 40 50	BORE HOLE FLUIDS	PACKER TEST	PIEZOMETERS	REMARKS AND LAB TESTING	SAMPLE NO.	SAMPLE TYPE	RECOVERY	DRILLING LOG	DEPTH (FEET)
									35
					17		9" (50%)	dark grey very clayey gravelly sand till, moist, very dense (SC-CH)	
								END (36.5')	

LOSS ◀
CONSTANT ▼
GAIN ▶

I PACKER TEST
▨ SEAL
GRAVEL FILTER
PIEZOMETER TIP

C CONSOLIDATION TEST
T TRIAXIAL TEST
A ATTERBERG LIMITS
G GRAIN SIZE
D DIRECT SHEAR

PITCHER SAMPLE
SPLIT SPOON
TRICONE CUTTINGS
☒ BULK SAMPLE

CURRAGH RESOURCES INC.
VANGORDA COLLECTION POND

60627
12 JULY 1990

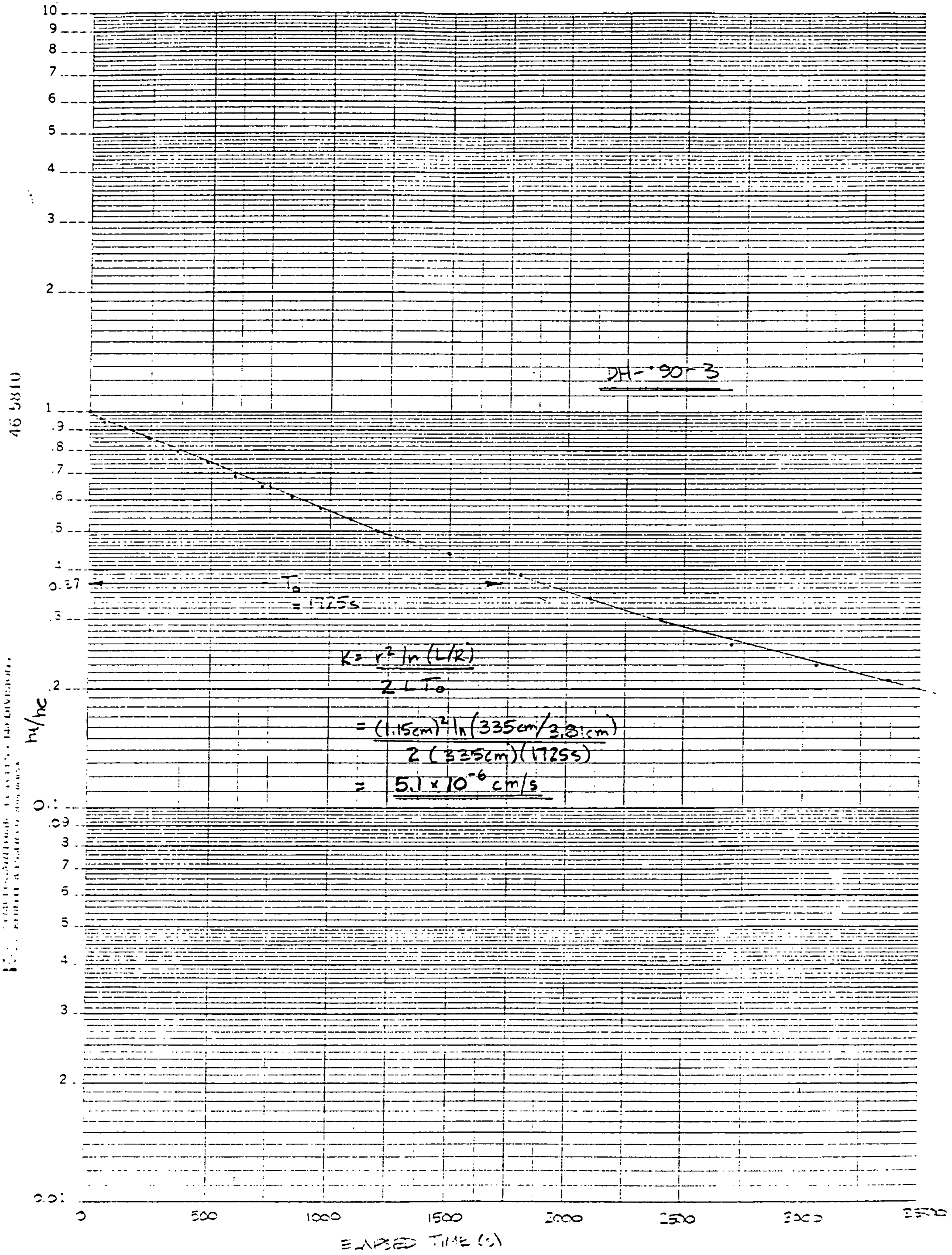
FALLING HEAD TEST DH-90-3

All depths from top of pvc casing unless otherwise noted

Date of test : July 6, 1990
Depth to top of test section : 24' (below ground surface.
Length of test section : 11' (3.35m)
Depth to water before start of test : 1.14m
(not sure if level had stabilized yet)
Borehole Radius, R : (3/2) = 3.81 cm
Casing radius, r : 1.15 cm
Excess head, he = 1.14 m
at start of test

Time (s)	Depth to water (cm)	Excess head ht (cm)	ht/he
0	0	114	1
10	1	113	0.99
40	5	109	0.96
60	7	107	0.94
120	10	104	0.91
240	16	98	0.86
360	23.5	90.5	0.79
480	29	85	0.75
600	35	79	0.69
720	40	74	0.65
840	45	69	0.61
960	49	65	0.57
1080	53	61	0.54
1200	56.5	57.5	0.50
1500	64	50	0.44
1800	70	44	0.39
2100	75	39	0.34
2400	80	34	0.30
2700	84	30	0.26
3060	88	26	0.23
3360	90.5	23.5	0.21
3600	92.5	21.5	0.19
4500	98	16	0.14
5400	103	11	0.096
6060	106	8	0.070

60627



$$K = \frac{r^2 \ln(L/R)}{2 L T_0}$$

$$= \frac{(1.15cm)^2 \ln(335cm/3.81cm)}{2(335cm)(1725s)}$$

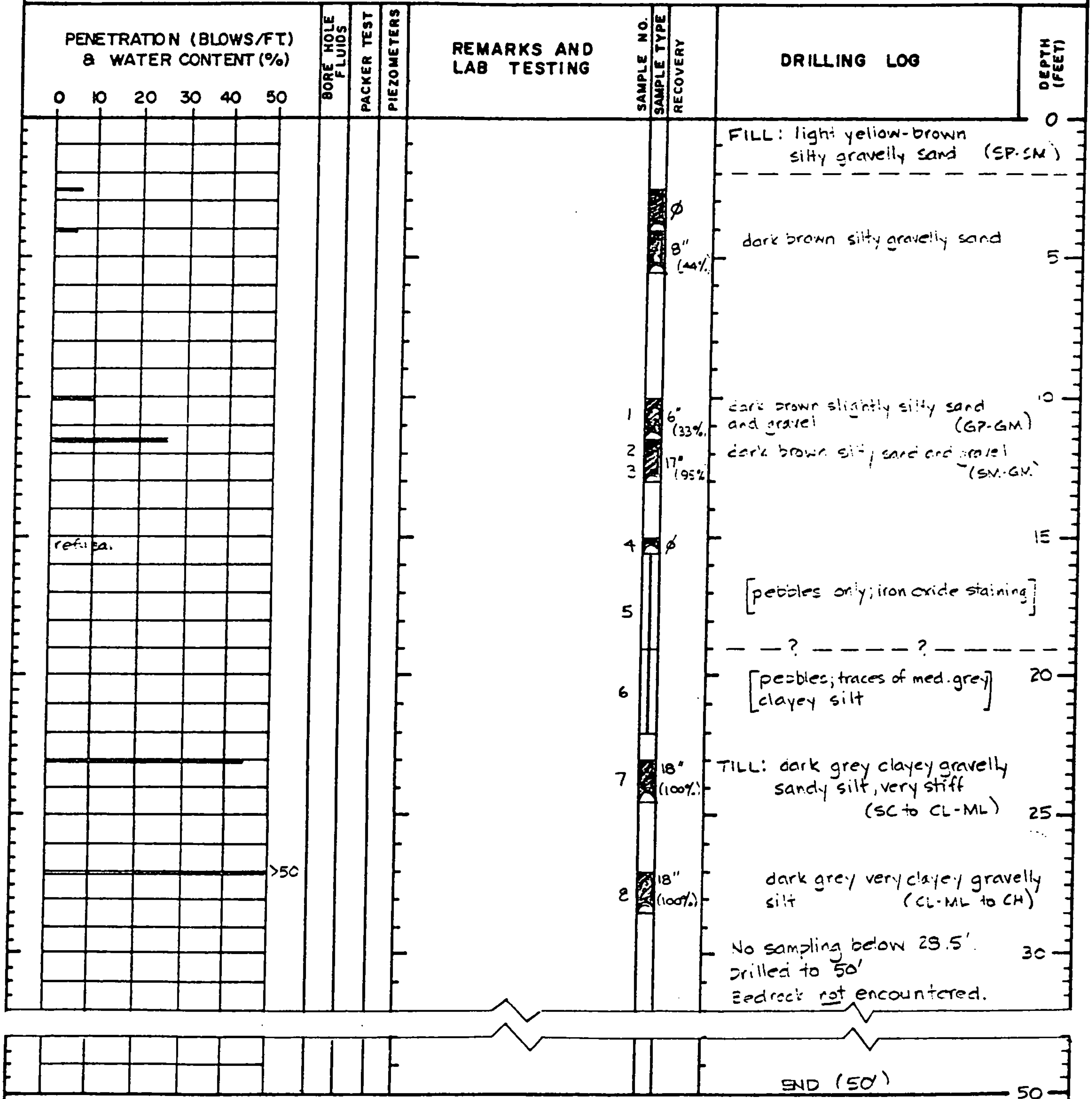
$$= \underline{\underline{5.1 \times 10^{-6} cm/s}}$$

PREPARED BY
STEFFEN ROBERTSON & KIRSTEN
GEOTECHNICAL AND MINING ENGINEERS

CLIENT CURRAGH RESOURCES INC.
PROJECT VANGORDA
JOB NO. 60627
DATES DRILLED 28 JUNE 1990
DRILLER ADVANCED (F. KOST)
TEST HOLE NO. DH-90-4
SHEET 1 **OF** 1
PREPARED BY RCO
INSPECTOR RM

LOCATION "LITTLE CREEK" COLLECTION POND SITE
COORDINATES 3045.17 m N 13 628.51 m E (LOCAL) **TOP OF HOLE ELEVATION** 1108.85 m

LOG OF TEST BORING



FILL: light yellow-brown silty gravelly sand (SP-SM)

dark brown silty gravelly sand

dark brown slightly silty sand and gravel (GP-GM)

dark brown silty sand and gravel (SM-GM)

[pebbles only; iron oxide staining]

— — ? — — — — ? — — —

[pebbles; traces of med. grey clayey silt]

TILL: dark grey clayey gravelly sandy silt, very stiff (SC to CL-ML)

dark grey very clayey gravelly silt (CL-ML to CH)

No sampling below 28.5'.
Drilled to 50'
Bedrock not encountered.

END (50')

LOSS ◀
CONSTANT ▼
GAIN ▶
I PACKER TEST
▨ SEAL
▨ GRAVEL FILTER
▯ PIEZOMETER TIP

C CONSOLIDATION TEST
T TRIAXIAL TEST
A ATTERBERG LIMITS
G GRAIN SIZE
D DIRECT SHEAR

▨ PITCHER SAMPLE
■ SPLIT SPOON
§ TRICONE CUTTINGS
☒ BULK SAMPLE

TEST PIT NO. 90-30

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers

LOG OF TEST PIT

LOCATION "LITTLE CREEK" SITE

3081.7m N 13 597.3mE (LOCAL GRID)

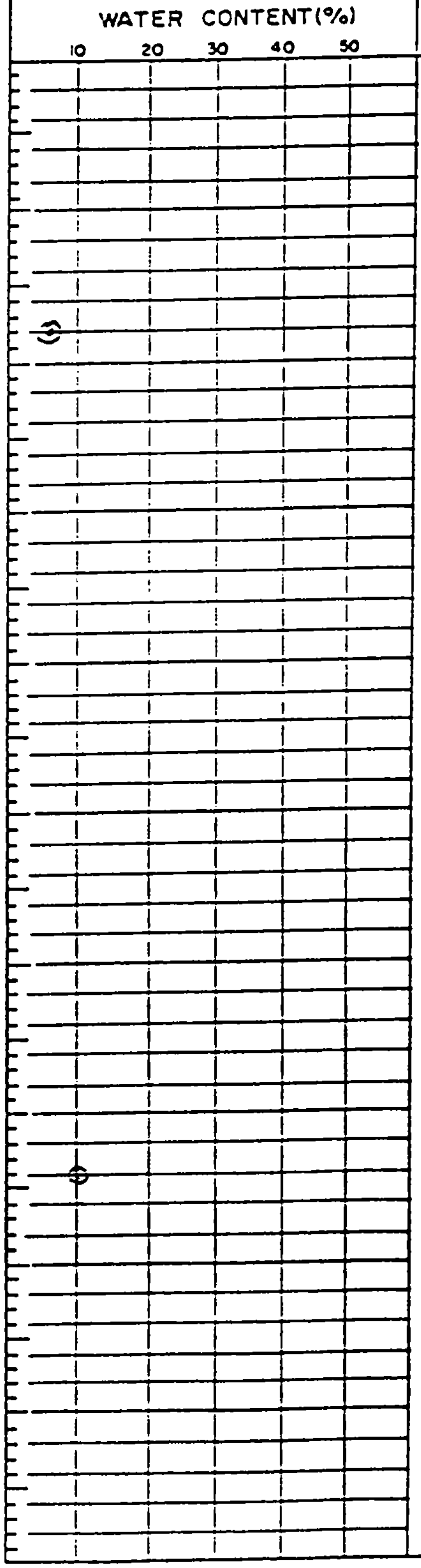
PROJECT 60627- VANGORDA SEEPAGE COLLECTION POND

DATE 7 JULY 1990

METHOD BACKHOE (CAT 235B)

INSPECTOR R. C. OLAUSON

WATER CONTENT (%)



ELEV. (metres)	REMARKS TOP OF PIT ELEV. 1109.84	UNIFIED SOIL CLASSIFICATION SYSTEM	SAMPLE	TEST PIT LOG	DEPTH (metres)
		Pt		moss	
		ML		very pale brown to white sandy silt, loose, moist	
	41.8 54.9 4.3% G S SC	GP	1	medium red-brown gravel and coarse-grained sand, moist, dense, <5% silt and clay, approx. 10% >75mm dia., max 0.3m dia.	1 2
	44.8 52.0 3.2% G S SC ▽ abundant seepage		2	dark brown coarse sand and gravel	3
		CH	3	TILL: olive brown gravelly silty clay, wet, stiff, moderate to high plasticity, cold to touch, no evidence of frost or excess ice. END (±3.2m) Cannot sound depths below 3.0m due to slough.	

LEGEND
- Gs GRAINSIZE TESTING
- C COMPACTION TEST
- ☐ DISTURBED SAMPLE
- ■ UNDISTURBED SAMPLE
- W_L LIQUID LIMIT
- W_P PLASTIC LIMIT

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers
LOG OF TEST PIT

TEST PIT NO. 90-31

LOCATION "LITTLE CREEK" SITE

PROJECT 60627 – VANGORDA SEEPAGE COLLECTION POND

DATE 7 JULY 1990

METHOD BACKHOE (CAT 235)

INSPECTOR R.C. OLAUSON

WATER CONTENT (%) 10 20 30 40 50

ELEV. (metres)

REMARKS

TOP OF PIT ELEV.

UNIFIED SOIL CLASSIFICATION SYSTEM

TEST PIT LOG

DEPTH (metres)

REMARKS			TEST PIT LOG	DEPTH (metres)
	SC	☐ 1	olive brown gravelly, sandy, silt and clay till, well-graded, moist, dense, some boulders up to 1m dia.	1 2 3
14.9 40.0 45.1 % G S SC trace of seepage →	SC	☐ 2	med. grey sandy gravelly silt and clay till, well-graded, wet dense	4
			END (4.5m)	5

LEGEND

Gs GRAINSIZE TESTING

C COMPACTION TEST

☐ DISTURBED SAMPLE

▨ UNDISTURBED SAMPLE

W_L LIQUID LIMIT

W_P PLASTIC LIMIT

STEFFEN ROBERTSON & KIRSTEN

Consulting Engineers

LOG OF TEST PIT

TEST PIT NO. 90-32

LOCATION "LITTLE CREEK" SITE

3032.3 m N 13520.7 m E (LOCAL GRID)

PROJECT 60627- VANGORDA SEEPAGE COLLECTION POND

DATE 7 JULY 1990

METHOD BACKHOE (CAT 235B)

INSPECTOR R.C. OLAUSON

WATER CONTENT (%) 10 20 30 40 50

ELEV. (metres)

TOP OF PIT ELEV. 1104.69

REMARKS	UNIFIED SOIL CLASSIFICATION SYSTEM	SAMPLE	TEST PIT LOG	DEPTH (metres)
	Pt		TOPSOIL	
	SP		med. brown clean medium- to coarse-grained sand, loose, saturated, occasional layers of dark grey silt	
▽ abundant seepage below 0.9m	SP		red-brown med.- to coarse-grained sand, loose, saturated	1
	GP		Black gravel with coarse sand soil, abundant organics	2
	SP		medium brown coarse-grained sand and gravel, saturated	3
	CH	☐ 1	TILL: light olive grey sandy gravelly clay, wet, soft to firm, irregular inclusions of clean sand (appear discontinuous) END (±3.5m)	

Cannot sound depths below 2.5m due to slough.

LEGEND

Gs GRAINSIZE TESTING

C COMPACTION TEST

☐ DISTURBED SAMPLE

■ UNDISTURBED SAMPLE

W_L LIQUID LIMIT

W_p PLASTIC LIMIT

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers
LOG OF TEST PIT

TEST PIT NO. 90-33

LOCATION "LITTLE CREEK" SITE

3012.6 m N 13442.0 m E (LOCAL GRID)

PROJECT 60627- VANGORDA
SEEPAGE COLLECTION POND

DATE 7 JULY 1990

METHOD BACKHOE (CAT 225B)

INSPECTOR R.C. CLAUSON

WATER CONTENT(%) 10 20 30 40 50

TOP OF PIT ELEV. 1101.28

REMARKS	UNIFIED SOIL CLASSIFICATION SYSTEM		TEST PIT LOG	DEPTH (metres)
	Pt		moss	
	OL	☐1	dark brown organic silty, clayey sand, moist, frozen above 0.4 m	
	SC	☐2	olive brown clayey sandy silt till, minor gravel, wet, soft becoming drier with depth grades to silty clayey gravelly sand cold to touch, but no evidence of frost	1 2
trace of seepage →		☐3		3
minor seepage →	CH	☐4	mottled grey and brown sandy gravelly clay till, very moist, firm, brown zones are somewhat sandier, occasional irregular zones of red-brown organics	

END (4.0 m)

LEGEND
- Gs GRAINSIZE TESTING
- C COMPACTION TEST
- ☐ DISTURBED SAMPLE
- ■ UNDISTURBED SAMPLE
- W_L LIQUID LIMIT
- W_P PLASTIC LIMIT

WATER COLLECTION PIPELINE	CLIENT: COMINCO ENGINEERING SERV. LTD.	BOREHOLE No. 10373-02
VANGORDA WASTE DUMP	BACKHOE: CAT 235	Project No: 0201-10373
CURRACH MINE, FARO, YT	UTM ZONE: 8 N6903060.00 E593650.00	ELEVATION 1109.00 (m)

SAMPLE TYPE ■ GRAB SAMPLE ◪ NO RECOVERY ☒ STANDARD PEN. ▤ 75 mm SPOON ◫ 75 mm CRREL ◫ 100 mm CRREL

DEPTH (m)	SAMPLE TYPE	SAMPLE NO	USC	SOIL DESCRIPTION	■ STANDARD PENETRATION ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	▲ PERCENT GRAVEL ▲ 20 40 60 80 ■ PERCENT SAND ■ 20 40 60 80 ◆ PERCENT FINES ◆ 20 40 60 80	DEPTH (ft)
0.0				ORGANIC ROOT MAT and organic silt, light brown, seasonal frost to 0.4 m - water flowing in pit at base of seasonal frost			0.0
				SILT(TILL) - sandy, some gravel, trace of clay, numerous cobbles and boulders to 300 mm in diameter, low plastic, saturated - olive brown to 1.5 m, dark grey below 1.5 m - sides of pit sloughing			2.0
1.0							4.0
2.0							6.0
				END OF TESTPIT AT 2.4 m NOTE: Testpit located at Sta. 0+203			8.0
3.0							10.0
							12.0
4.0							14.0
5.0							16.0

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

COMPLETION DEPTH 2.4 m	COMPLETE	
LOGGED BY JRT	DWG NO.	Page 1 of 1

WATER COLLECTION PIPELINE	CLIENT: COMINCO ENGINEERING SERV. LTD.	BOREHOLE No. 10373-03
VANGORDA WASTE DUMP	BACKHOE: CAT 235	Project No: 0201-10373
CURRAGH MINE, FARO, YT	UTM ZONE: 8 N6903050.00 E593560.00	ELEVATION 1107.21 (m)

SAMPLE TYPE ■ GRAB SAMPLE ◪ NO RECOVERY ☒ STANDARD PEN. ▤ 75 mm SPOON ▯ 75 mm CRREL ▯ 100 mm CRREL

DEPTH (m)	SAMPLE TYPE	SAMPLE NO	USC	SOIL DESCRIPTION	■ STANDARD PENETRATION ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	▲ PERCENT GRAVEL ▲ 20 40 60 80 ■ PERCENT SAND ■ 20 40 60 80 ◆ PERCENT FINES ◆ 20 40 60 80	DEPTH (ft)
0.0				SAND AND GRAVEL - clean, angular to subrounded fragments, cobbles and boulders throughout, grey			0.0
							2.0
1.0							
							4.0
				- water seeping into pit at 1.8 m, sides sloughing			6.0
2.0							
				END OF TESTPIT AT 2.2 NOTE: Testpit located at Sta. 0+300 - Pit location stripped to about 1.4 m depth (sidehill cut)			
							8.0
3.0							
							10.0
							12.0
4.0							
							14.0
5.0							16.0

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

COMPLETION DEPTH 2.2 m	COMPLETE
LOGGED BY JRT	DWG NO.
	Page 1 of 1

WATER COLLECTION PIPELINE	CLIENT: COMINCO ENGINEERING SERV. LTD.	BOREHOLE No. 10373-04
VANGORDA WASTE DUMP	BACKHOE: CAT 235	Project No: 0201-10373
CURRAGH MINE, FARO, YT	UTM ZONE: 8 N6902980.00 E593460.00	ELEVATION 1106.11 (m)

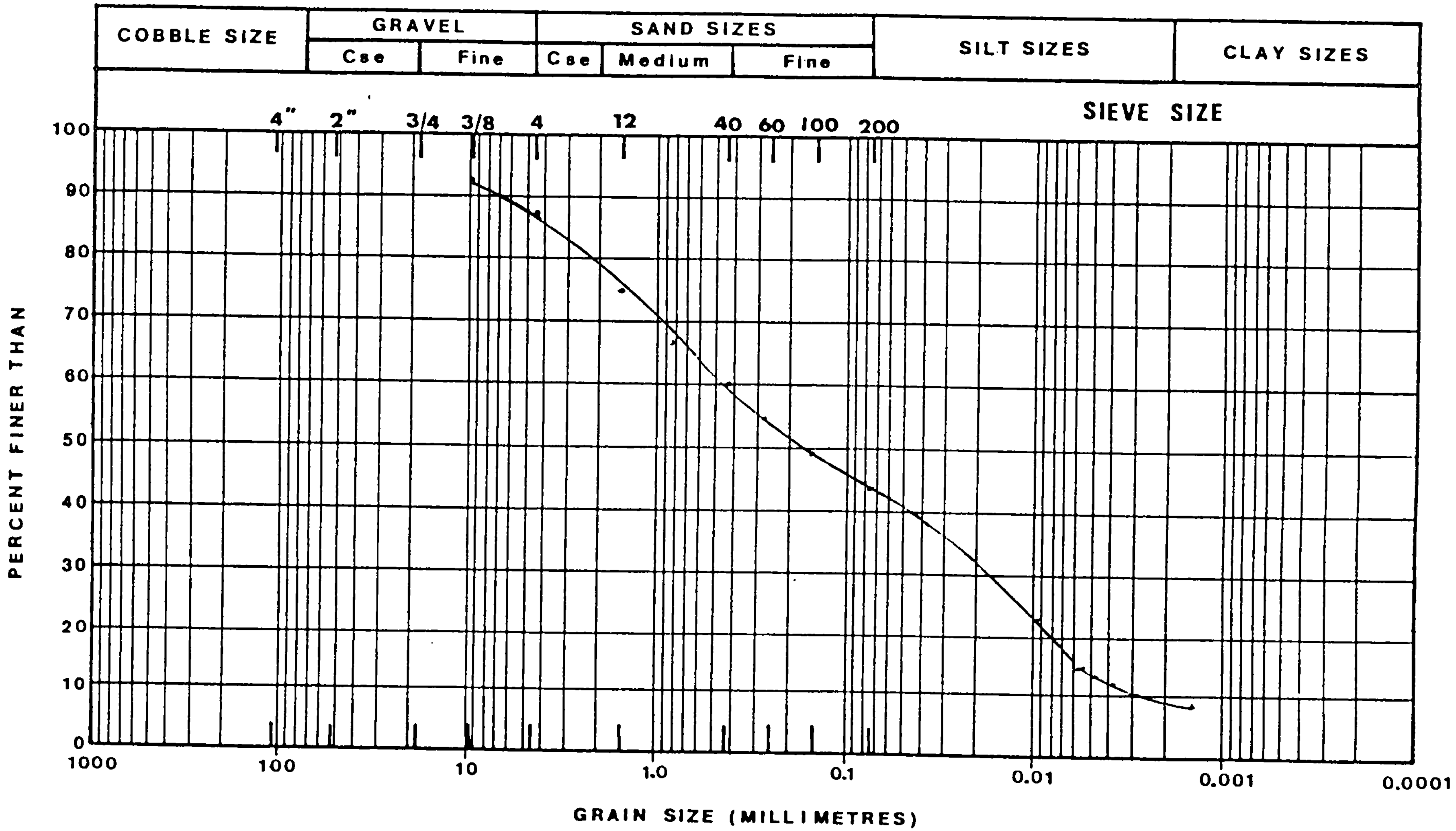
SAMPLE TYPE ■ GRAB SAMPLE ⧄ NO RECOVERY ☒ STANDARD PEN. ▤ 75 mm SPOON ◫ 75 mm CRREL ▯ 100 mm CRREL

DEPTH (m)	SAMPLE TYPE	SAMPLE NO	USC	SOIL DESCRIPTION	■ STANDARD PENETRATION ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	▲ PERCENT GRAVEL ▲ 20 40 60 80 ■ PERCENT SAND ■ 20 40 60 80 ◆ PERCENT FINES ◆ 20 40 60 80	DEPTH (ft)
0.0				ORGANIC ROOT MAT – seasonal frost to 0.5 m			0.0
				SILT(TILL) – sandy, some gravel, trace of clay, cobbles and boulders throughout, low plastic, damp, olive brown			2.0
1.0							4.0
2.0							6.0
							8.0
3.0				END OF TESTPIT AT 3.0 m NOTE: Testpit located at Sta. 0+416.5			10.0
							12.0
4.0							14.0
5.0							16.0

EBA Engineering Consultants Ltd. Whitehorse, Yukon	COMPLETION DEPTH 3.0 m	COMPLETE	
	LOGGED BY JRT	DWG NO.	Page 1 of 1

APPENDIX 2

Laboratory Test Results For Foundation Soils



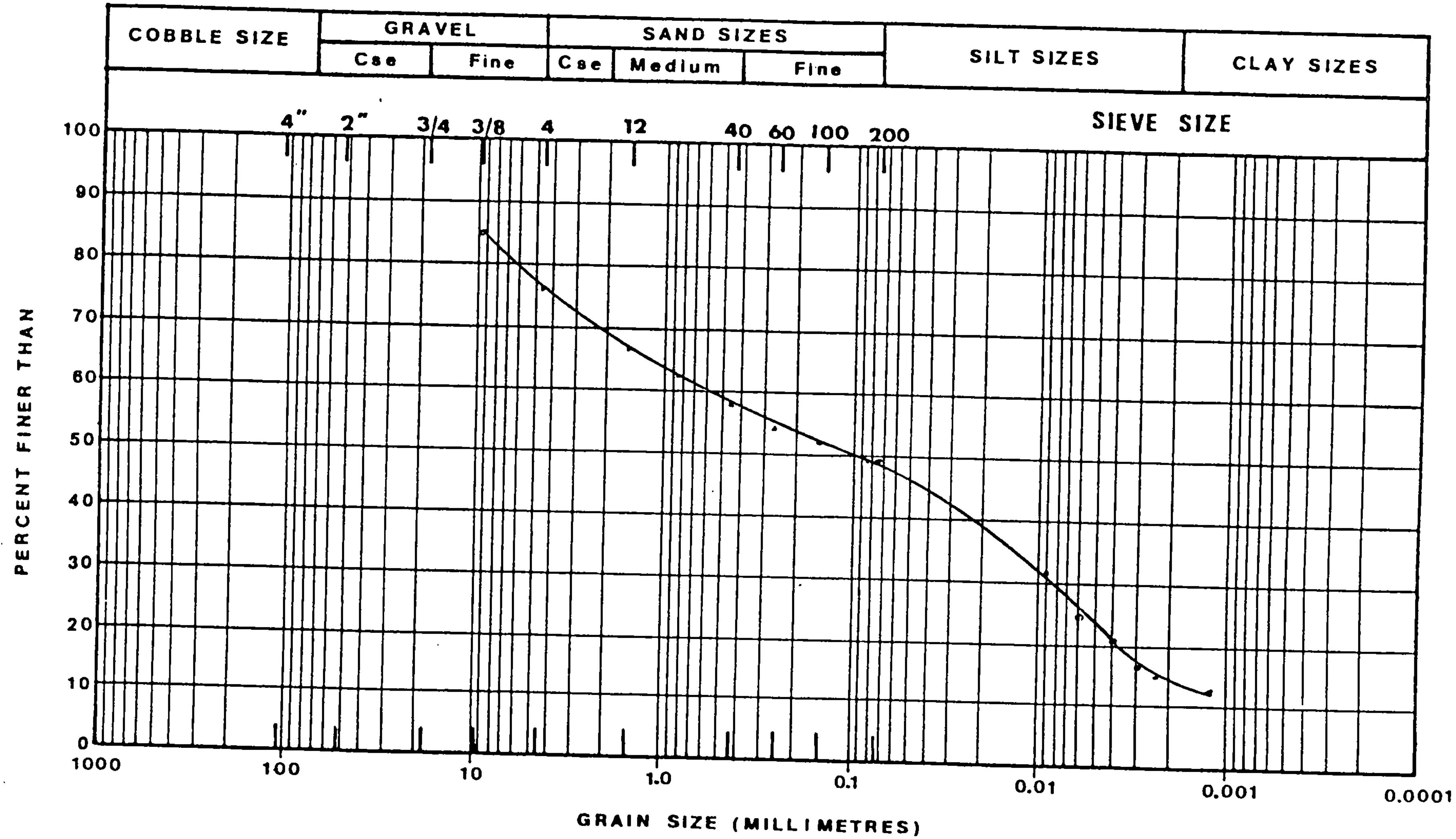
PROJECT No.	60627
DATE	July 1990
REVISION	

PREPARED BY:

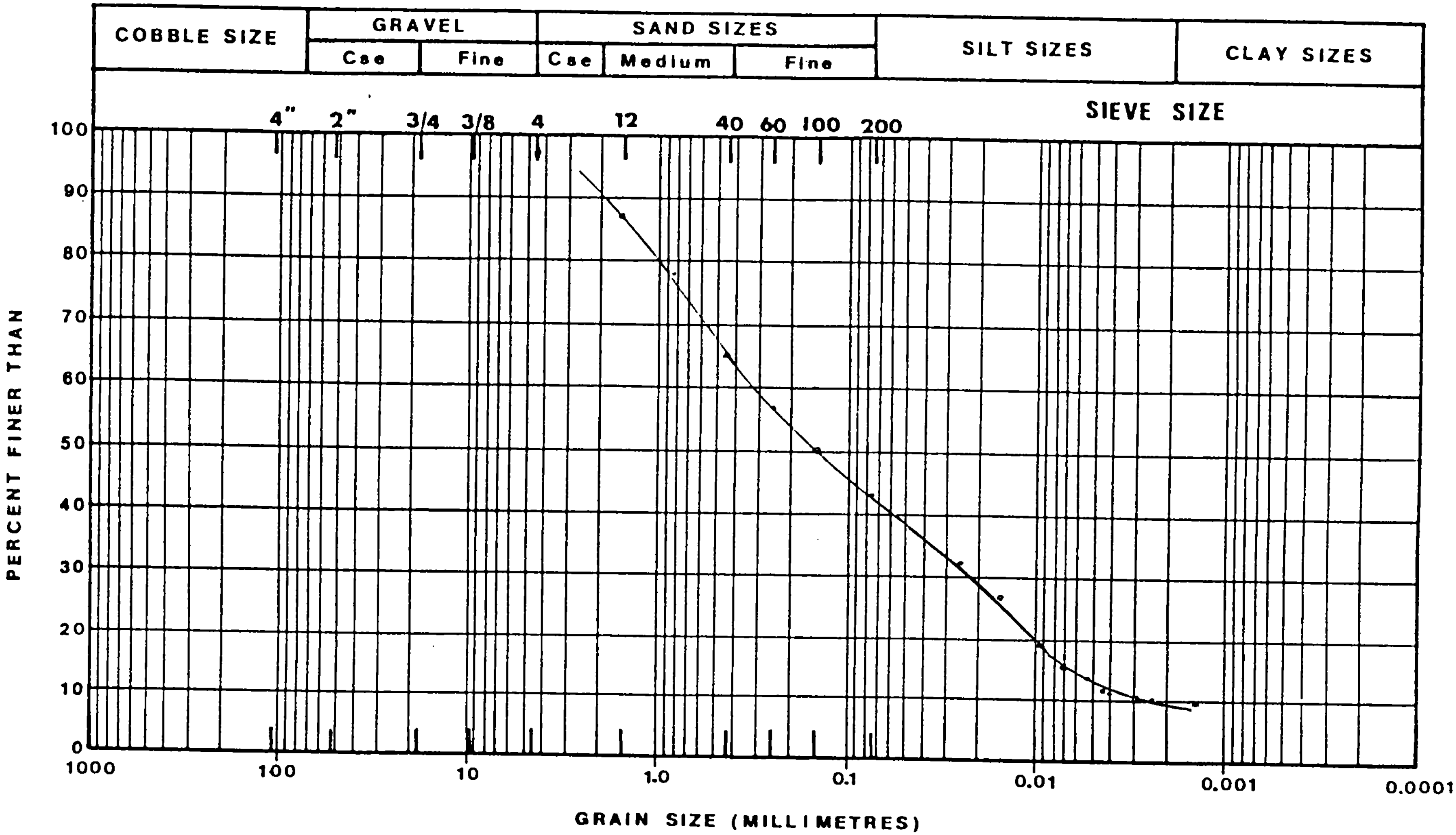
STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers

FIGURE A2.1

GRADATION CURVE : GREY TILL
DH 90-1, Sample #6
@ 22 ft. (6.7m)



PROJECT No.	PREPARED BY:	FIGURE A2.2
60627	STEFFEN ROBERTSON & KIRSTEN Consulting Engineers	GRADATION CURVE: GREY TILL DH 90-1, Sample # 12 @ 37 ft. (11.3 m)
DATE July 1990		
REVISION		



PROJECT No.
60627

DATE
July 1990

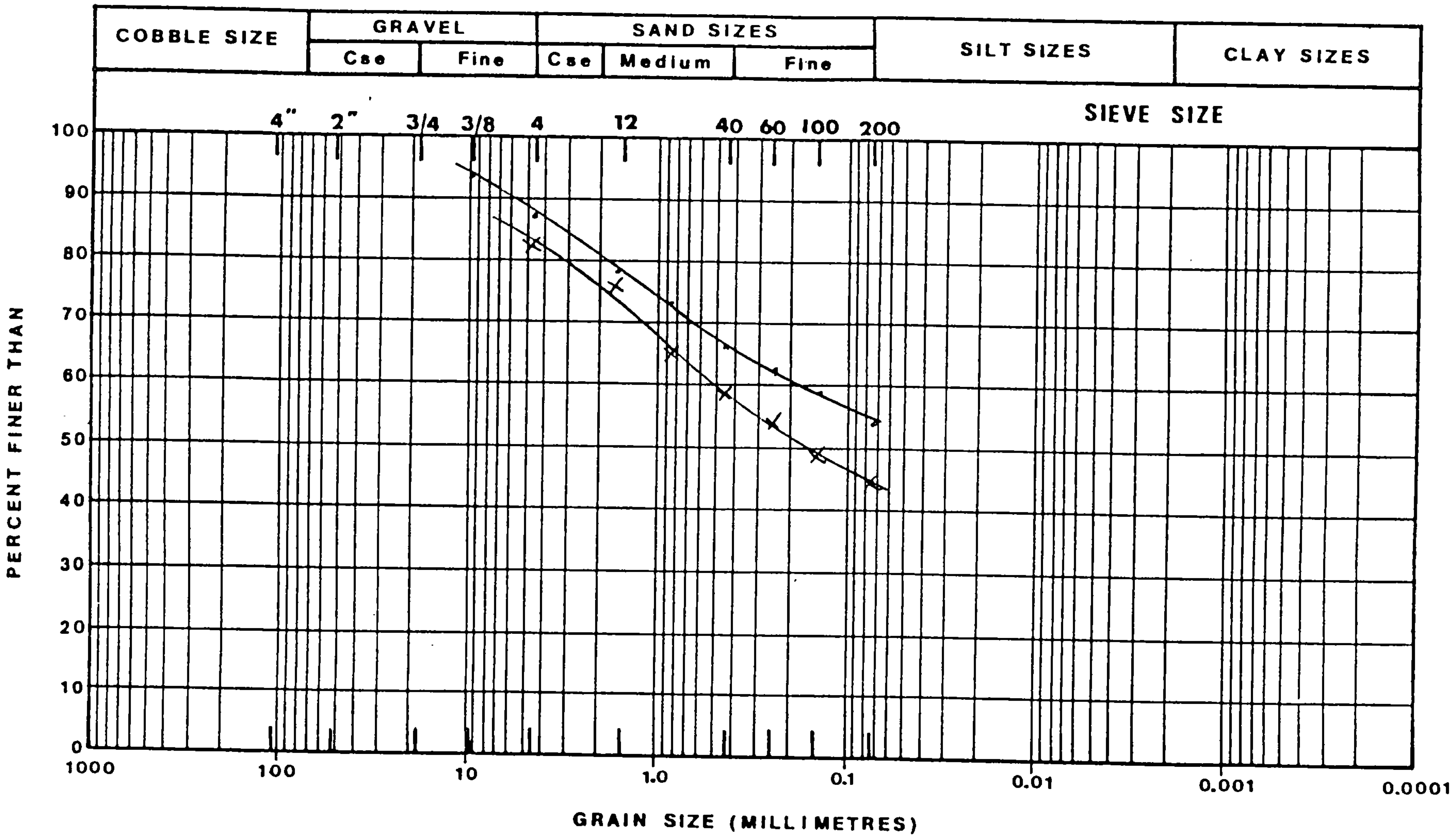
REVISION

PREPARED BY:

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers

FIGURE A2.3

GRADATION CURVE: BROWN TILL
DH 90-3, Sample #3
@ 6 ft. (1.8 m)



PROJECT No.
60627

DATE
July 1990

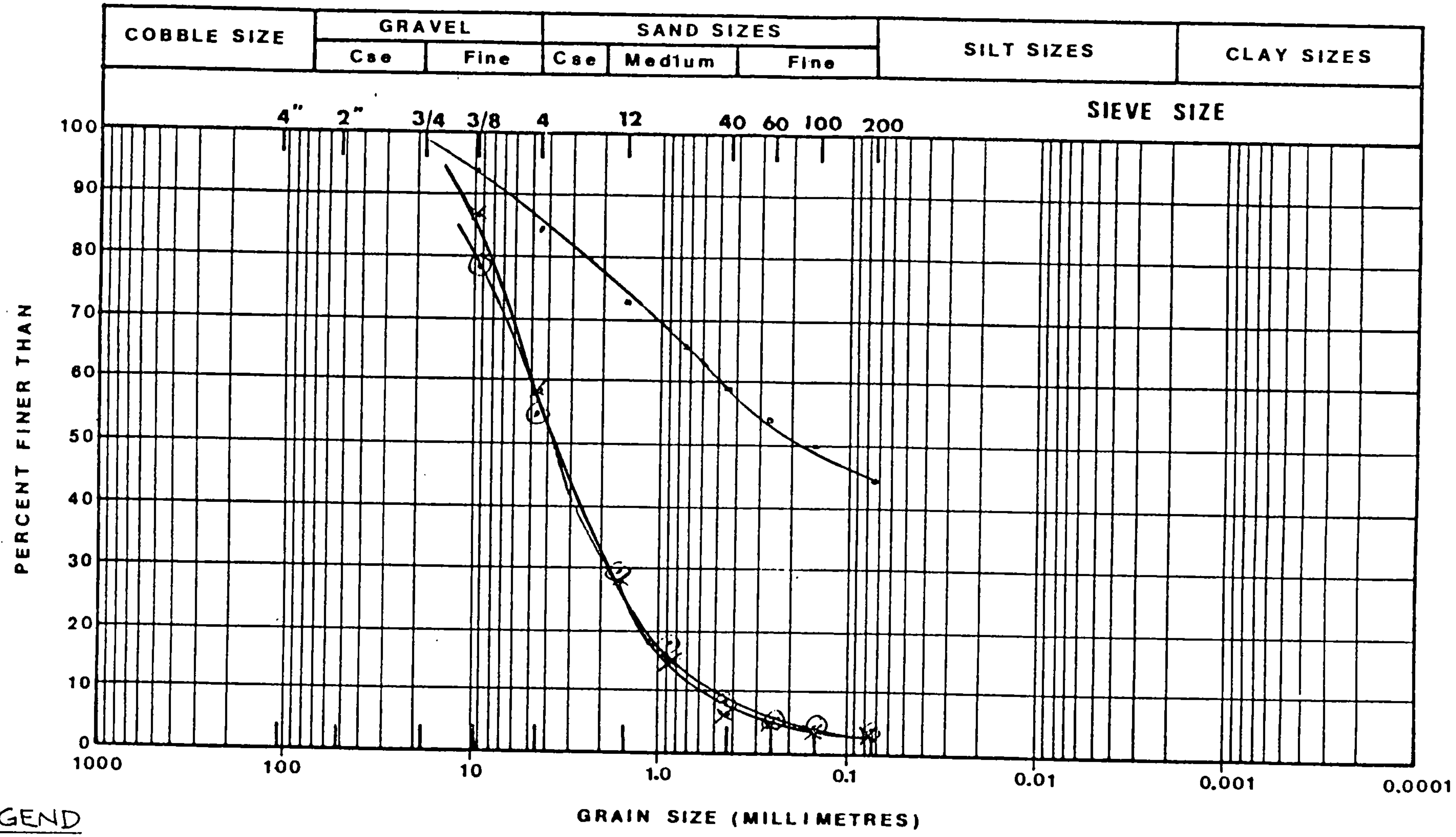
REVISION

PREPARED BY:

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers

FIGURE A2.4

GRADATION CURVE: GREY TILL
x DH 90-2, Sample #8, 25 ft. (7.6m)
• DH 90-3, Sample #13, 27 ft. (8.2m)



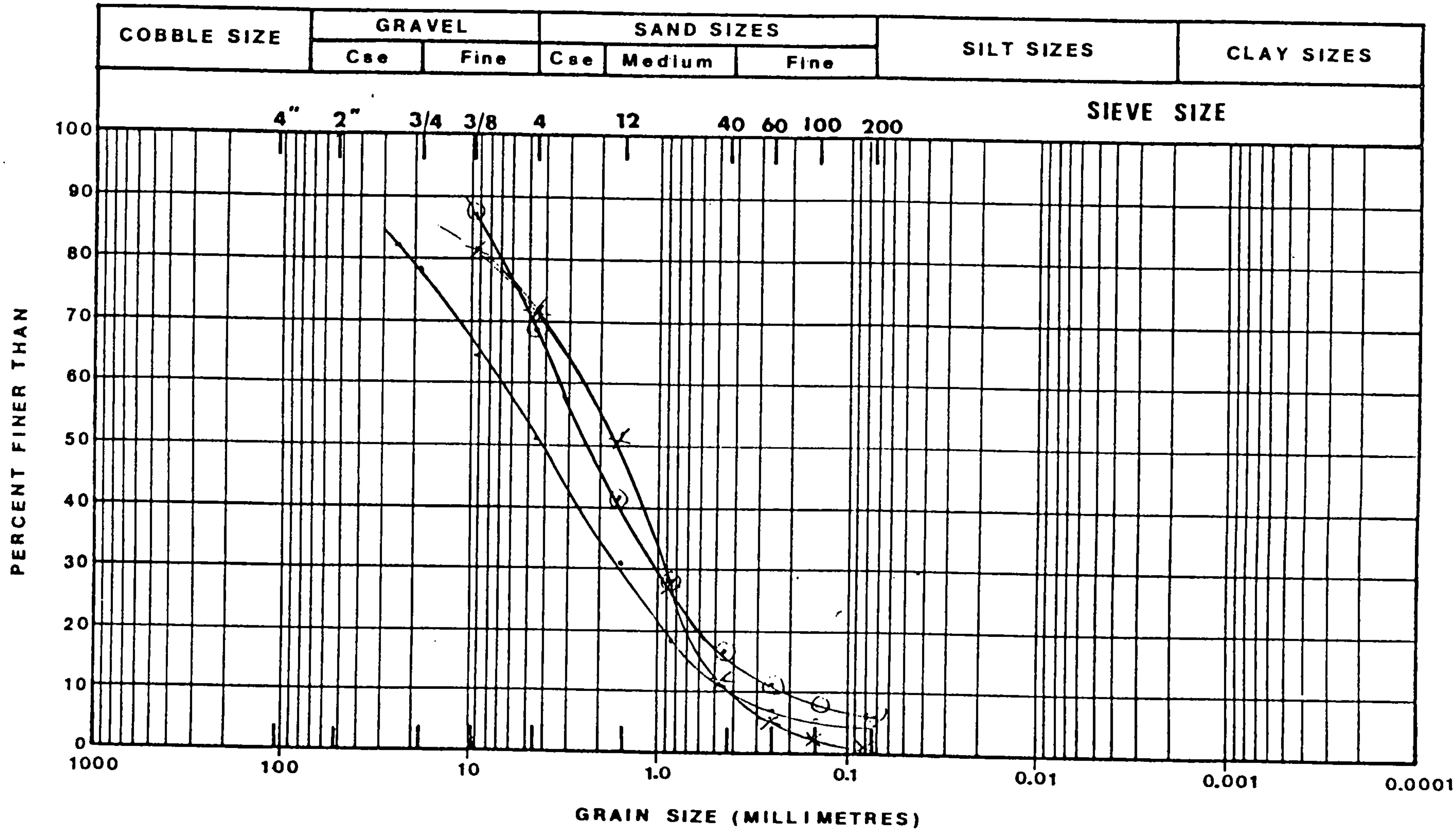
LEGEND

●——● TP90-31, Sample #2
13 ft. (3.9 m), Grey Till

×——× TP90-30, Sample #1,
2 ft (0.7 m), Sand/gravel

⊖——⊖ TP90-30, Sample #2
10 ft (3.0 m) Sand/Gravel

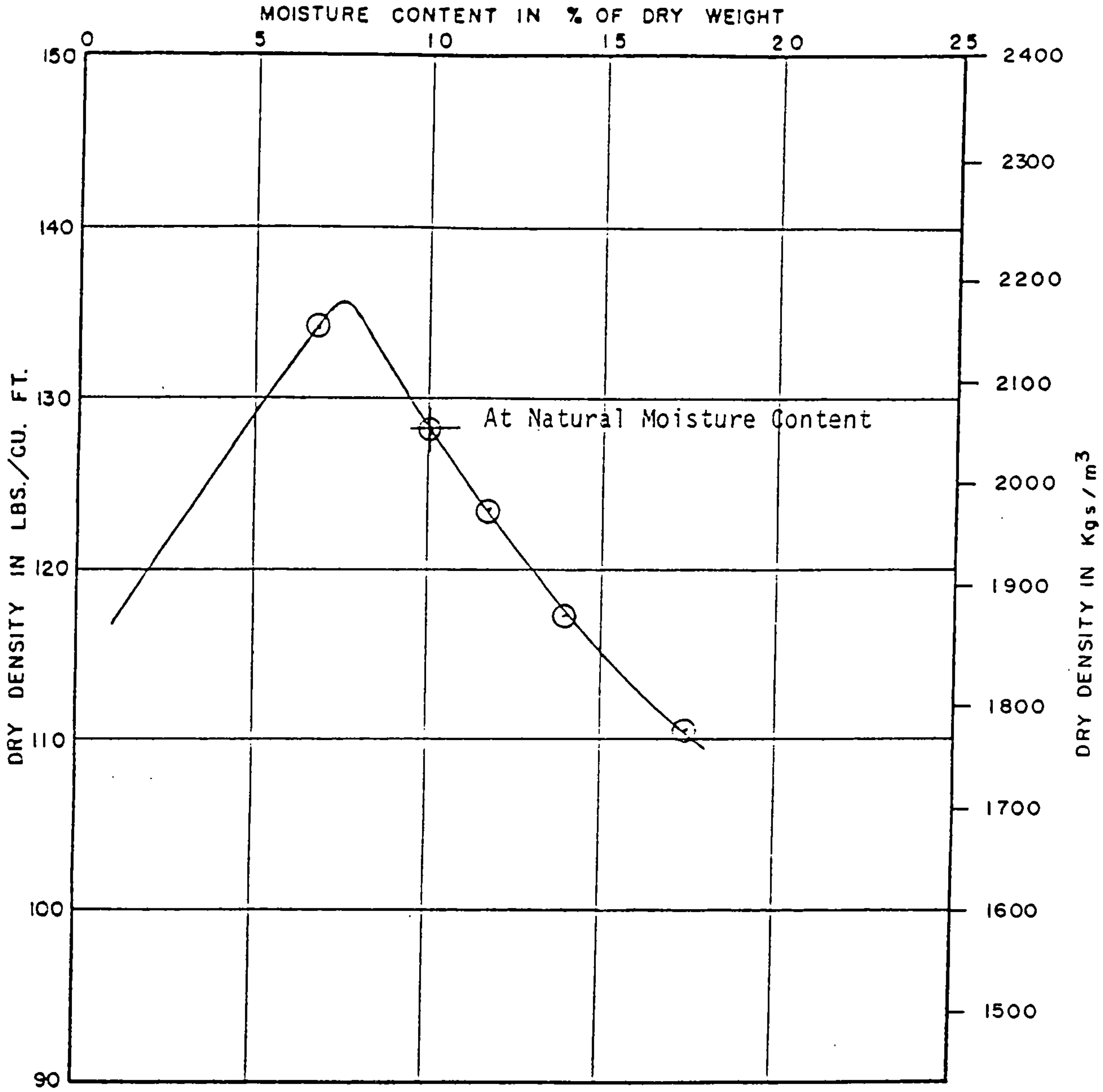
PROJECT No. 60627	PREPARED BY:	FIGURE A2.5 GRADATION CURVES (See legend)
DATE July 1990	STEFFEN ROBERTSON & KIRSTEN Consulting Engineers	
REVISION		



PROJECT No. 60627	PREPARED BY: STEFFEN ROBERTSON & KIRSTEN Consulting Engineers	**FIGURE** A2.6 GRADATION CURVE : SAND/GRAVEL —•— LC1 —x— LC2 —o— LC3
DATE July 1990		
REVISION		

APPENDIX 3

Laboratory Test Results for Fill Material



Soil Type: Olive brown clayey sand/gravel (composite initial moisture content 10.1%)

Optimum Moisture Content = 7.5%

Maximum Dry Density = 135.5 pcf (2,170.5 Kg/m^3)

* Tests completed in accordance with ASTM D1557-78, Modified Proctor Maximum Dry Density.

PROJECT No.
60625

DATE
May 23/90

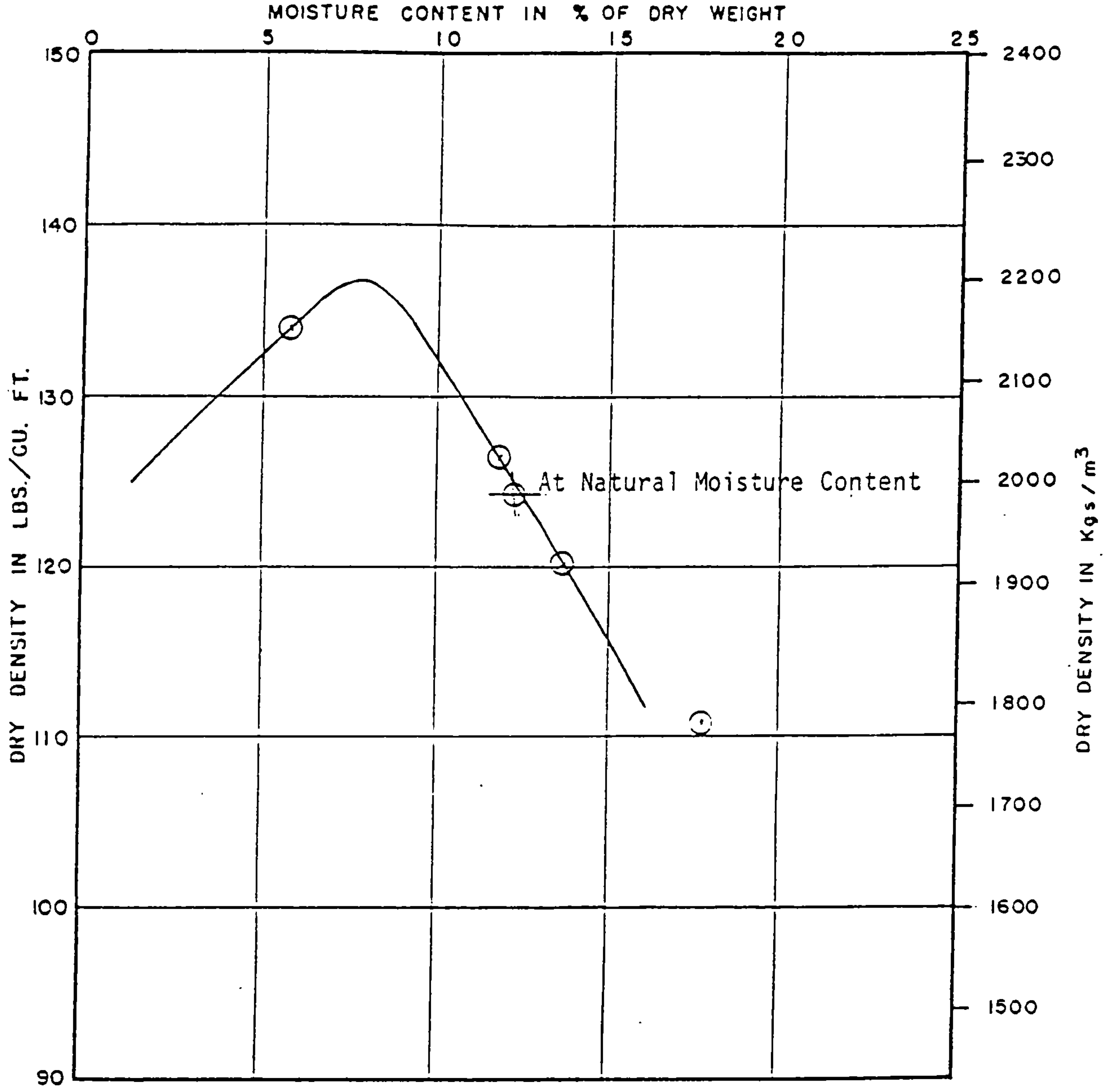
REVISION

PREPARED BY:

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers

FIGURE A3.1

COMPACTION CURVE FOR COMPOSITE
SAMPLES TP 90-24 (#1 and #2)



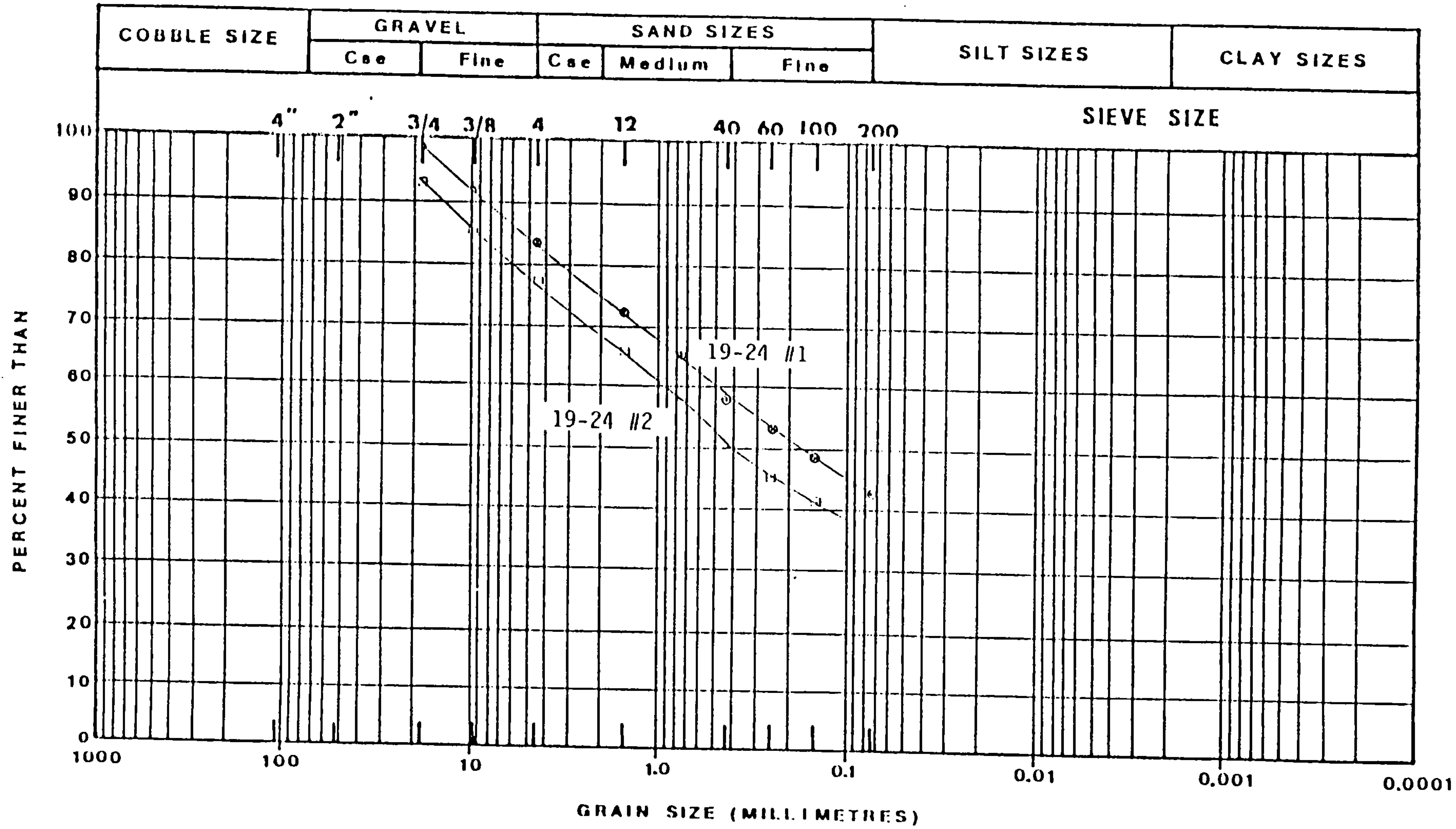
Soil Type: Olive brown clayey sand/gravel (composite initial moisture content 12.3%)

Optimum Moisture Content = 8%

Maximum Dry Density = 137.0 pcf (2,195 Kg / m^3)

* Tests completed in accordance with ASTM D1557-78, Modified Proctor Maximum Dry Density.

PROJECT No. 60625	PREPARED BY:	**FIGURE A3.2**
DATE May 24/90		COMPACTION CURVE FOR COMPOSITE SAMPLES TP 90-25 (#1 and #2)
REVISION	STEFFEN ROBERTSON & KIRSTEN Consulting Engineers	



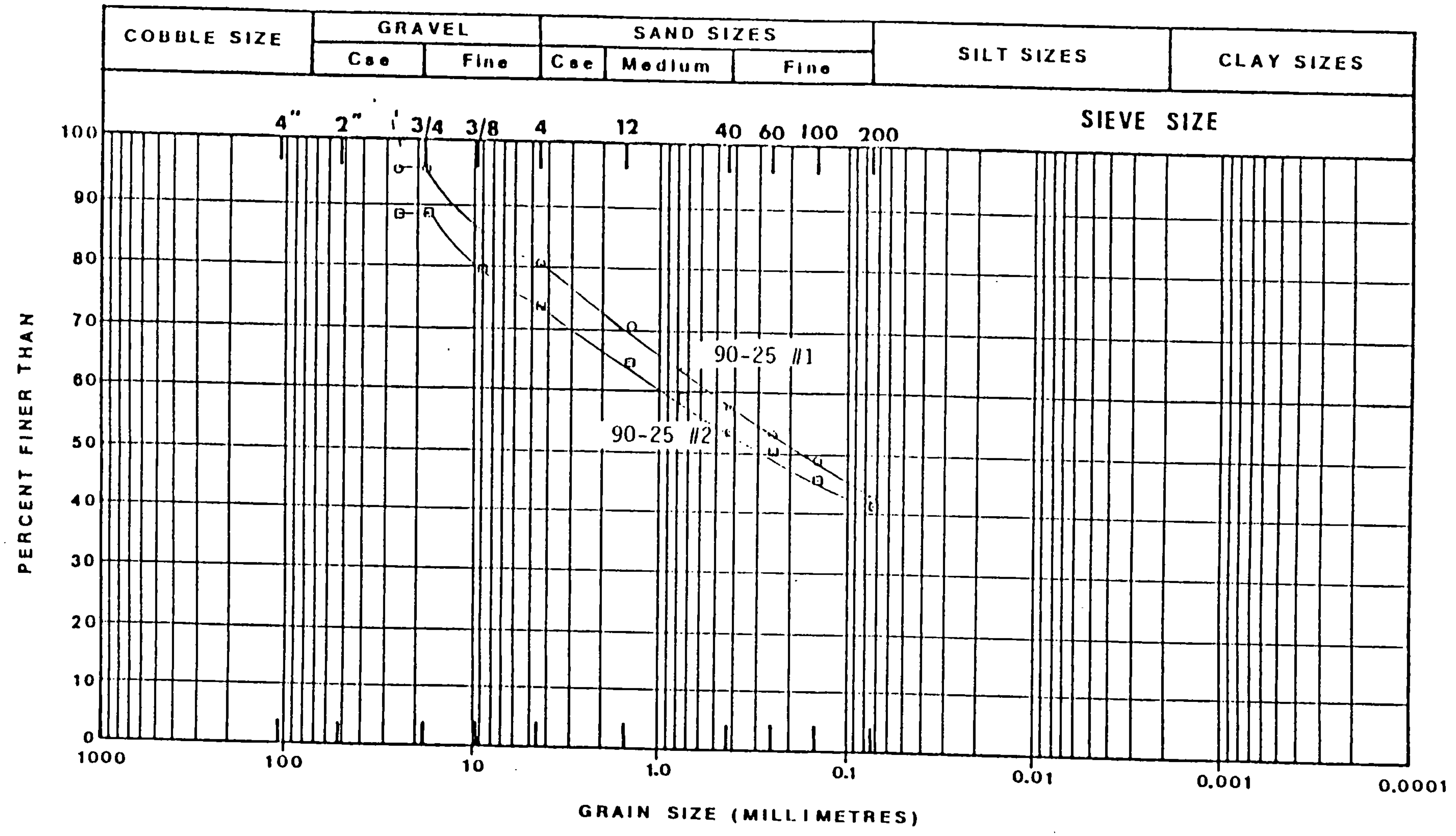
PROJECT No.
60625
DATE
May 24/90
REVISION

PREPARED BY:

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers

FIGURE A 3.3

GRADATION CURVE FOR
SAMPLES TP 19-24 (1, 2)



PROJECT No.
60625

DATE
May 24/90

REVISION

PREPARED BY:

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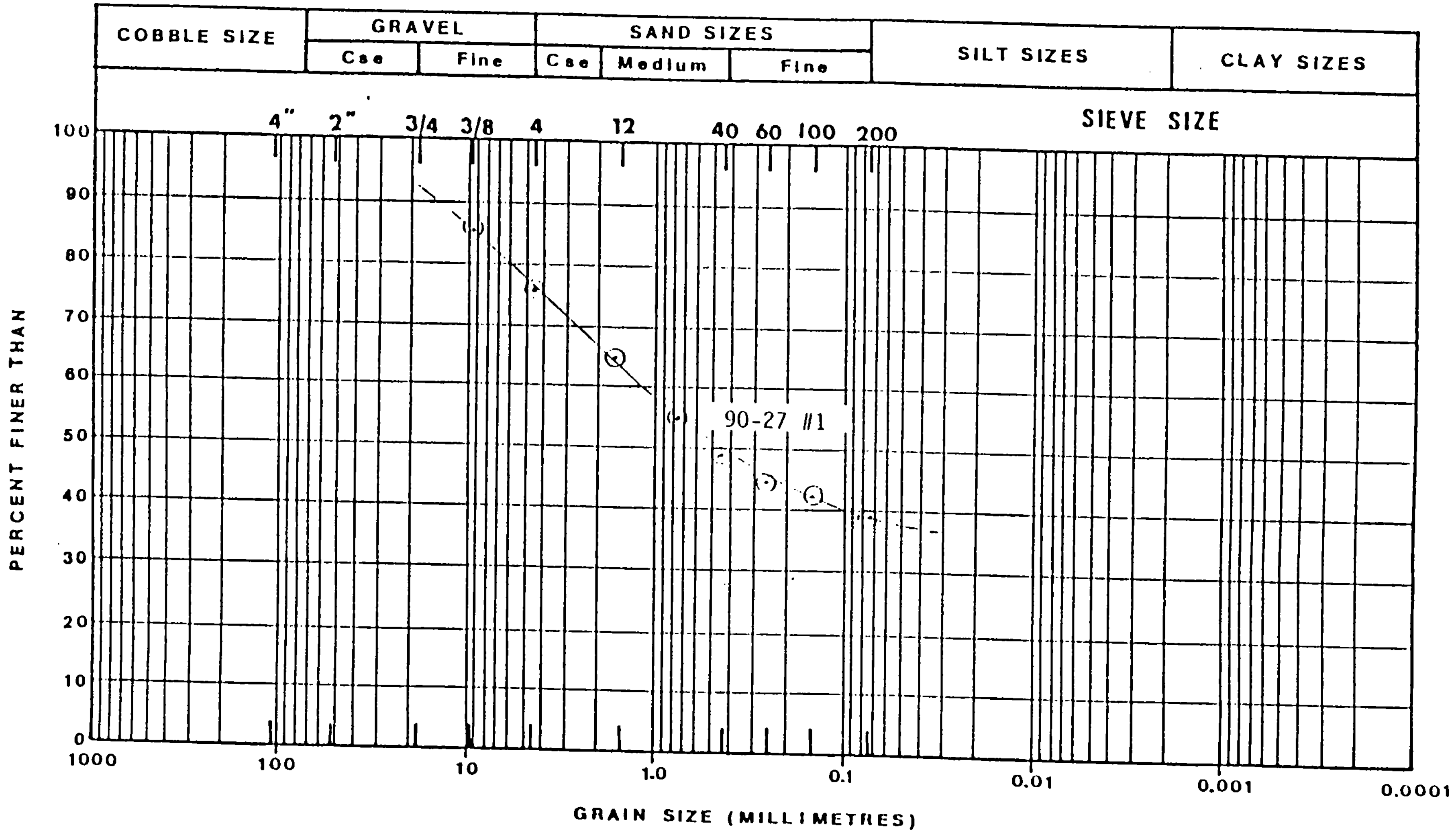
FIGURE A 3.4

GRADATION CURVE FOR
SAMPLES TP 90-25 (1, 2)



PROJECT No.
60625

DATE
May 24/90

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FIGURE A 3.5

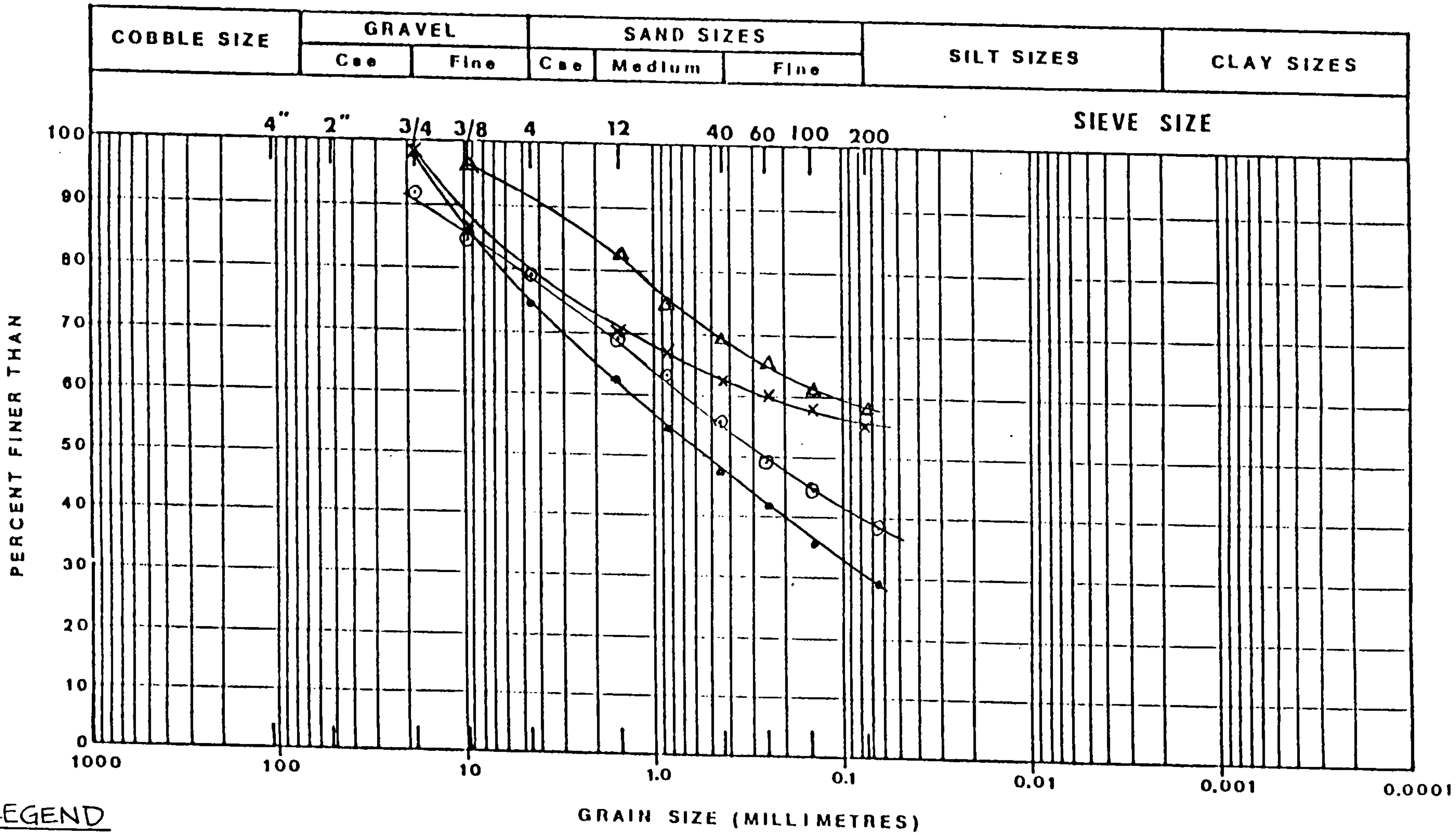
GRADATION CURVE FOR
SAMPLES TP 90-27 (1)

APPENDIX B

As-built Drawings

APPENDIX C

Results of Laboratory Testing



LEGEND

SYMBOL	STATION	TILL COLOR
●	0+150	GREY
⊙	0+275	BROWN
X	0+120	BLUE-GREY
△	0+040	OLIVE-BROWN

PROJECT No.
60625

DATE
May 24/90

REVISION

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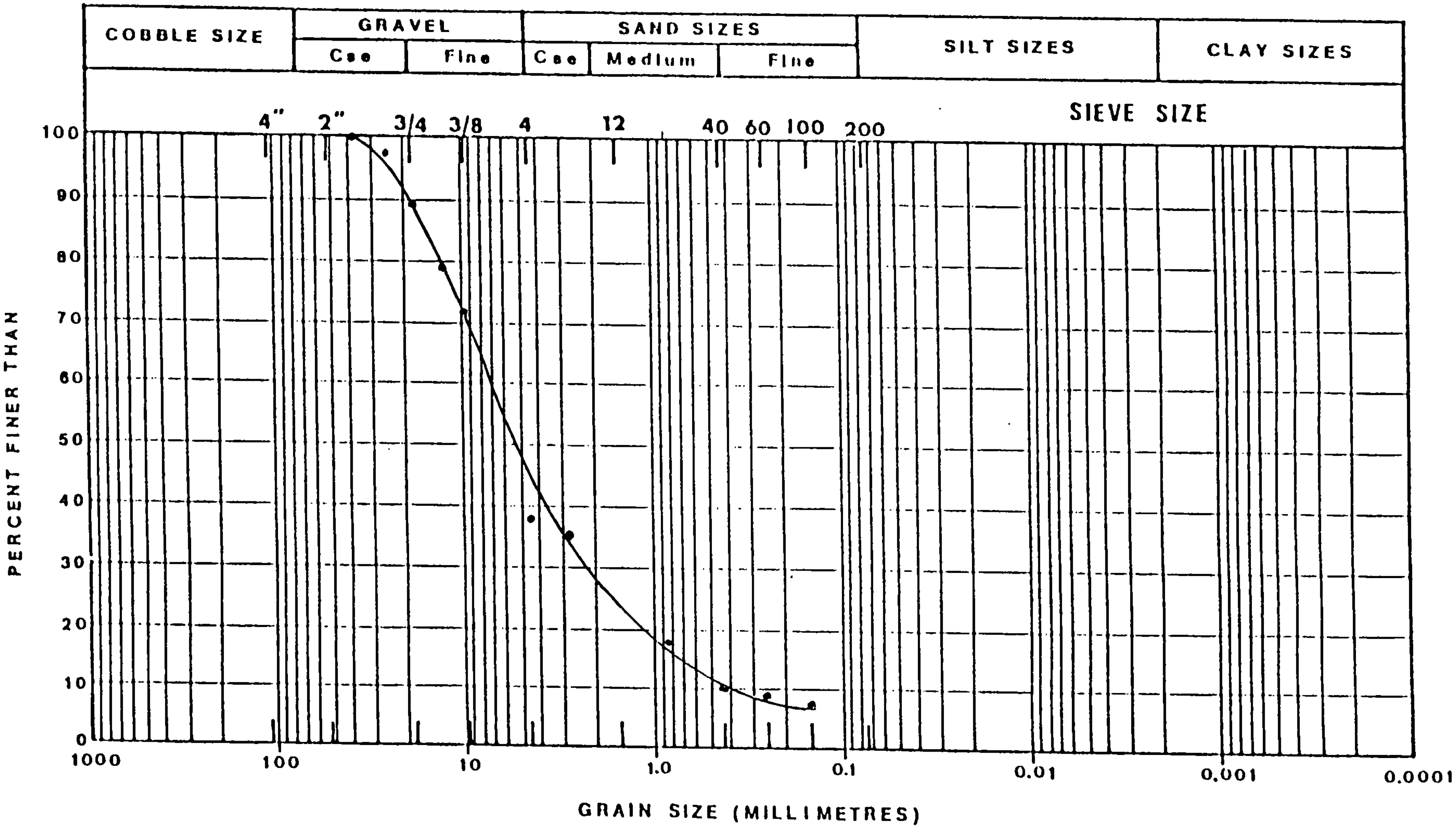
Consulting Engineers

FIGURE C.1

GRADATION CURVES -
FOUNDATION TILL
AT CUT-OFF



PROJECT No.
60625

DATE
May 24 /90

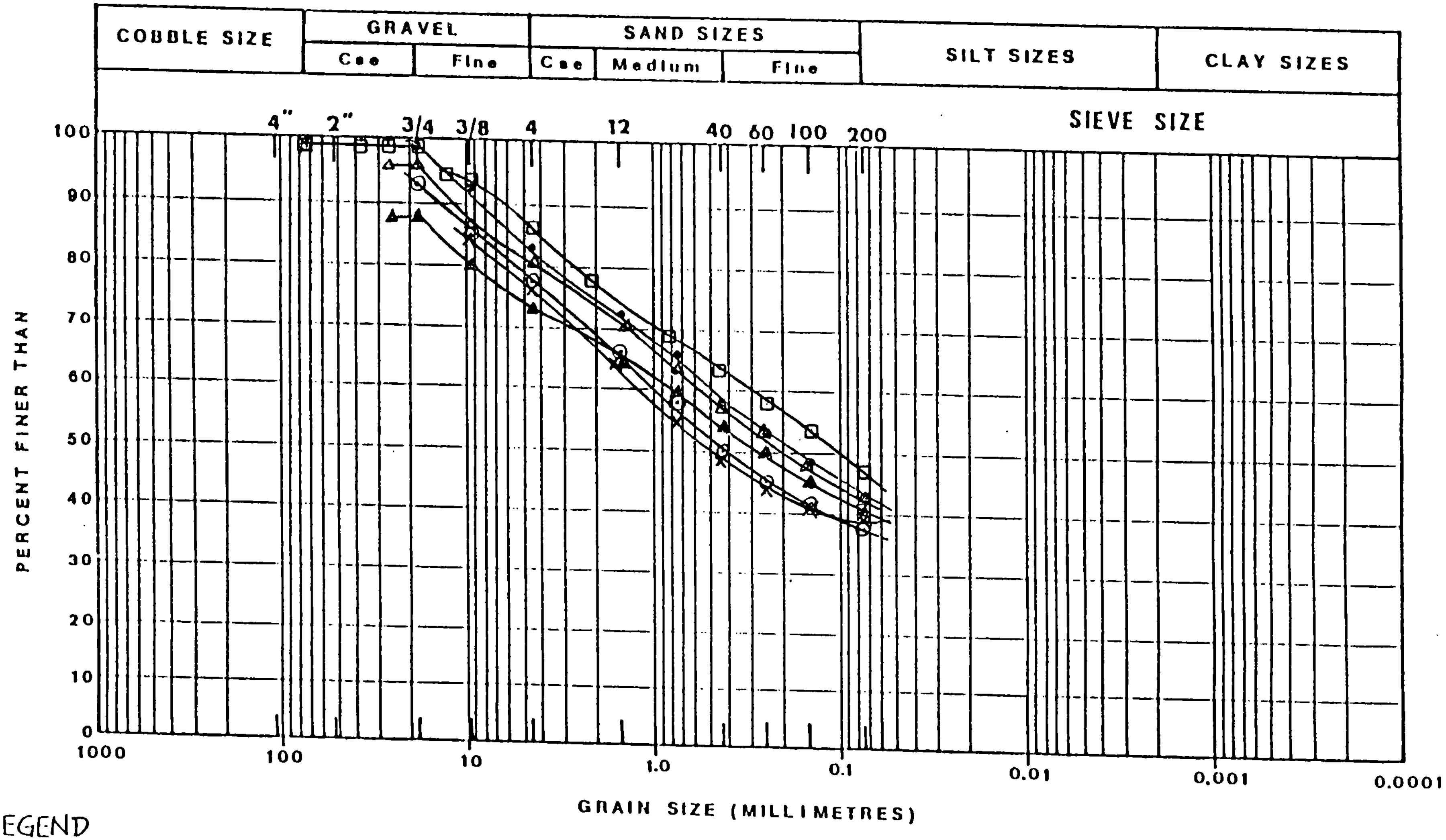
REVISION

PREPARED BY:

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers

FIGURE C.2

GRADATION CURVE - LOWER GRAVEL FROM MAIN TRENCH.



LEGEND

SYMBOL	T.P.	SAMPLE No.
•	19-24	#1
⊙	19-24	#2
△	90-25	#1
▲	90-25	#2
×	90-27	#1
□	EBA COMPOSITE SAMPLE	

PROJECT No.
60625

DATE
May 24/90

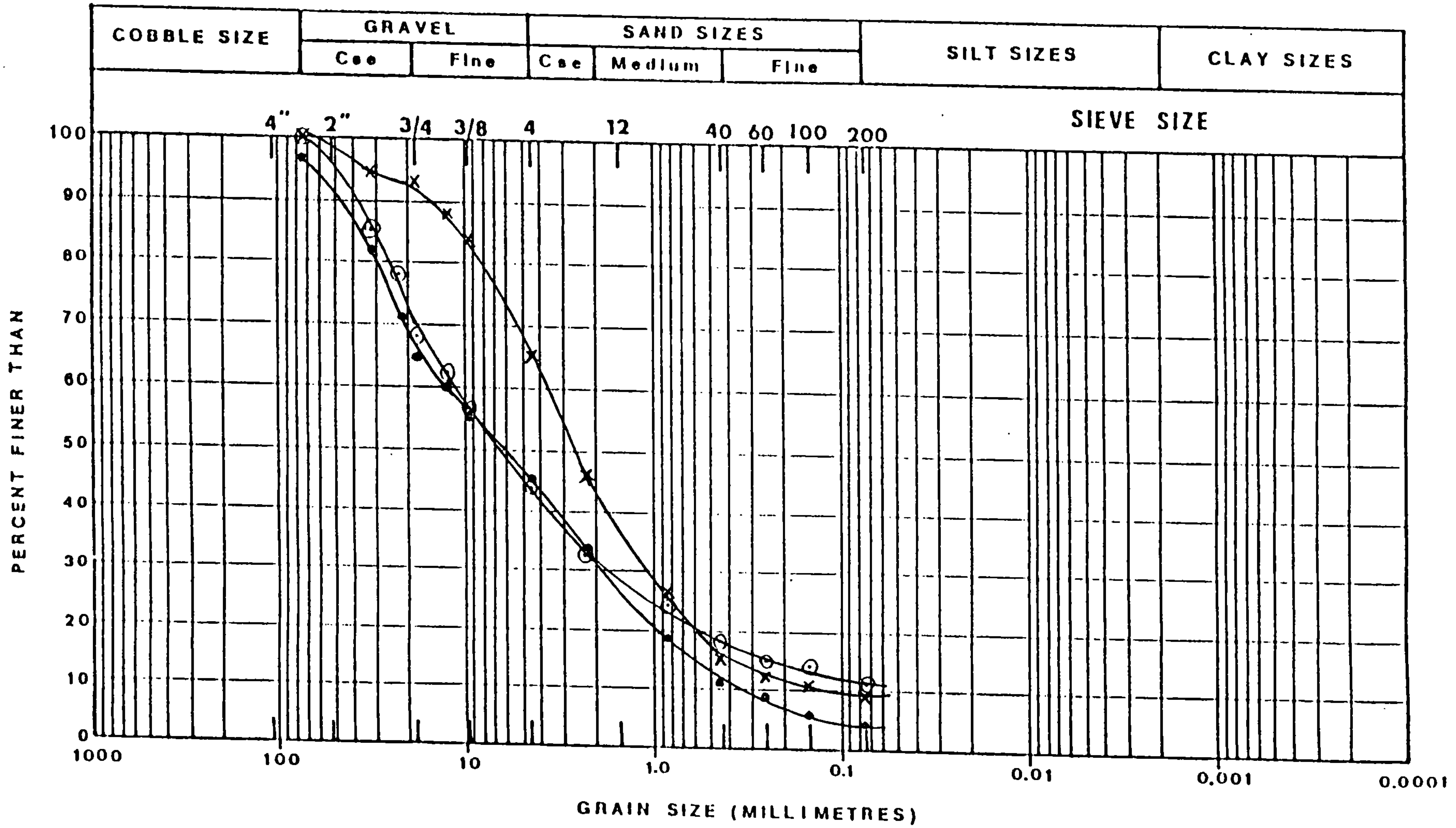
REVISION

PREPARED BY:

STEFFEN ROBERTSON & KIRSTEN
Consulting Engineers

FIGURE C.3

GRADATION CURVES -
TILL EMBANKMENT



LEGEND

- ● FINGER DRAINS SOUTH OF LITTLE CK. (STA. 0+080 to 0+120)
- ⊙ BLANKET DRAIN NORTH OF LITTLE CK. (UPSLOPE OF DAM)
- X BLANKET DRAIN NORTH OF LITTLE CK (DOWNSLOPE OF DAM, STA 0+175)

PROJECT No. 60625	PREPARED BY: STEFFEN ROBERTSON & KIRSTEN Consulting Engineers	FIGURE C.4 GRADATION CURVES - GRAVEL DRAINS
DATE May 24 / 90		
REVISION		

EBA Engineering Consultants Ltd.

Civil, Geotechnical and Materials Engineers

1990 12 06

Cominco Engineering Services Ltd.
100 - 1200 West 73rd Avenue
Vancouver, B.C.
V6P 6G5

EBA File No: 0201-10441

ATTENTION: Mr. T.D. Lee, P.Eng.
Project Manager

Dear Sir:

Subject: Little Creek Collection Pond
Laboratory and Field Testing Services
Vangorda Dewatering Project
Faro, Yukon

In compliance with your letter of 1990-09-14, EBA Engineering Consultants Ltd., have provided laboratory and field testing services in support of the Little creek Collection Dam project. The services were authorized and directed by your field manager Mr. Keith MacDonald and by your technical consultant, Steffen Robertson & Kirsten (B.C.) Inc. This letter summarizes the results of field compaction tests and presents final results from laboratory permeability testing of the embankment fill material.

COMPACTION TESTING SUMMARY

A total of 56 in situ compaction tests were conducted during five site visits over the period of 1990-09-14 to 1990-10-09. All trips involved travel to the Faro job site from EBA's Whitehorse office by Mr. Cord Hamilton, E.I.T. All compaction test results were issued to yourselves and to Steffen Robertson & Kirsten Inc. over the afore-mentioned period.

A statistical analysis f the test results reveals that an average in place density of 2058 kg/m^3 with a standard deviation of 77 kg/m^3 was observed. This represents an average compaction level of 95.5% of the Modified Proctor maximum dry density (ASTM D1557) value that was determined fro the fill material.

LABORATORY PERMEABILITY TESTING

At the request of Mr. Keith MacDonald, a composite sample of the embankment fill, obtained from two of the site visits, was submitted to EBA's Edmonton laboratory for constant head permeability testing. The test was conducted at a constant head of 59.8 kPa (8.7 psi or 20' of head) and a compacted density of 1983 kg/m^3. The density represents approximately one standard deviation below the average in situ field density.

The result of this test was a permeability coefficient of:

$$k = 4.0 \times 10^{-6} \text{ cm/s}$$

A grain size curve and modified proctor value were determined for the same sample and these have been attached for your records. Please note that the Modified Proctor maximum dry density of this sample was found to be approximately 1.5% above the value determined earlier; therefore the permeability test density represents a modified proctor value of 90.5%

I trust this information will be adequate for your records. Should you require further information or assistance please contact myself at your convenience.

Yours truly,

EBA Engineering Consultants Ltd.

C.R. Hamilton, E.I.T.

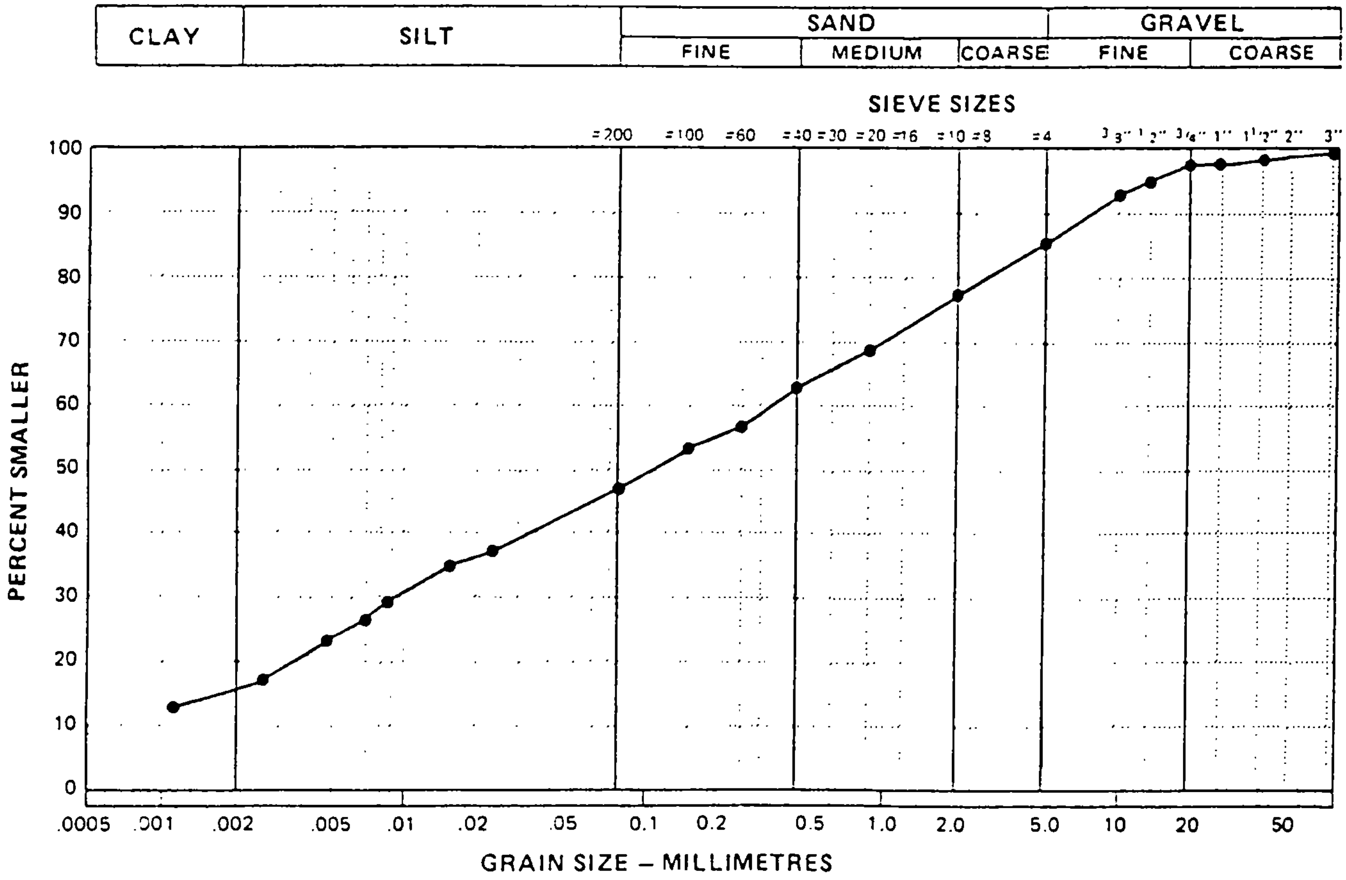
cc: Mr. Peter Healy, Steffen robertson & Kirsten (B.C.) Inc.

EBA Engineering Consultants Ltd.

PARTICLE - SIZE ANALYSIS OF SOILS

Project: Little Creek Collection Dam
Faro, Yukon
Project Number: 0201-10441
Date Tested: 1990-10-04
Borehole Number:
Depth:
Soil Description: SAND AND SILT(SM)-some clay, some gravel
Cu:
Cc:
Natural Moisture Content: %
Remarks:

SIEVE	PERCENTAGE PASSING
3"	99
$1^1/_2$"	98
1"	98
$^3/_4$"	98
$^1/_2$"	95
$^3/_8$"	93
No. 4	86
No. 10	77
No. 20	69
No. 40	63
No. 60	58
No. 100	53
No. 200	47



Tested in accordance with ASTM D422 unless otherwise noted.

APPENDIX D

Results of Field Testing

EI . Engineering Consultants "d.

eba

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441	Test Apparatus: NUCLEAR Mach. No.: 4004
Project: Little Creek Collection Pond Faro, Yukon	Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey
	Temperature Air: ______ ° C Soil: ______ ° C
Client: Cominco Eng. Serv. Ltd.	Specified Compaction: 95%
	Compaction Standard: MODIFIED PROCTOR
ATTN: Mr. Keith McDonald	Minimum Dry Density:
	Maximum Dry Density: 2155 kg/m3
	Optimum M.C.: 8.3%
	Date Tested: 1990-09-14 By: CRH

Test No. Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m³	% Compaction
1/200 mm	Cut off trench Sta. 2+35	-1.7 m	10.8	2139	99.3
	Lift #1				
2/200 mm	Cut off trench Sta. 2+20	-1.7 m	11.3	2065	95.7
	Lift #1				
3/200 mm	Cut off trench Sta. 2+05	-1.7 m	11.8	2047	95.0
	Lift #1				
4/200 mm	Cut off trench Sta. 1+95	-1.7 m	11.7	2078	96.4
	Lift #1				

Remarks: Base lift in cut off trench, 0.6 m thick, placed from Stations 1+90 to 2+50

Reviewed By: ______________________ P.Eng.

cc

EE Engineering Consultants ''d.

eba

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441

Project: Little Creek Collection Pond
Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004

Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey

Temperature Air: ° C Soil: ° C

Specified Compaction: 95%

Compaction Standard: MODIFIED PROCTOR

Minimum Dry Density:

Maximum Dry Density: 2155 kg/m3

Optimum M.C.: 8.8%

Date Tested: 1990-09-14 By: CRH

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m^3	% Compaction
5/200 mm	25 m left of centreline	GRADE	10.7	1983	87.8
	Sta. 2+00 - 4 static passes				
6/200 mm	25 m left of centreline	GRADE	11.1	1953	90.7
	Sta. 2+00 - 6 static passes				
7/200 mm	25 m left of centrelie	GRADE	12.1	1919	89.0
	Sta. 2+00 - 8 static passes				
8/200 mm	25 m left of centreline	GRADE	13.0	1899	88.1
	Sta. 2+00 - 8 static passes				
	2 vibratory passes				

Remarks: ROLLING PATTERN TEST PROGRAM: Note that due to subgrade conditions this test strip is useful for only relative comparisons.

Reviewed By: P.Eng. cc

EBA Engineering Consultants Ltd.

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441

Project: Little Creek Collection Pond
Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004

Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey

Temperature Air: ° C Soil: ° C

Specified Compaction: 95%

Compaction Standard: MODIFIED PROCTOR

Minimum Dry Density:

Maximum Dry Density: 2155 kg/m3

Optimum M.C.: 8.8%

Date Tested: 1990-09-14 By: CRH

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m³	% Compaction
9/200 mm	Cut off trench Sta. 2+20 Lift #2	-1.4 m	11.7	2076	96.3
10/200 mm	Cut off trench Sta. 1+95 Lift #2	-1.4 m	13.2	1930	89.6
11/200 mm	Cut off trench Sta. 2+35 Lift #3	-1.1 m	11.3	2062	95.7
12/200 mm	Cut off trench Sta. 2+10 Lift #3	-1.1 m	11.1	2005	93.0
13/200 mm	Cut off trench Sta. 2+30 Lift #4	-0.8 m	9.9	2111	98.0
14/200 mm	cut off trench Sta. 1+95 Lift #4	-0.8 m	9.7	2079	96.5

Remarks:

Reviewed By: P.Eng.

cc

EB Engineering Consultants Ltd.

eba

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441

Project: Little Creek Collection Pond
Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004

Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey

Temperature Air: ° C Soil: ° C

Specified Compaction: 95%

Compaction Standard: MODIFIED PROCTOR

Minimum Dry Density:

Maximum Dry Density: 2155 kg/m3

Optimum M.C.: 8.8%

Date Tested: 1990-09-14 By: CRH

Test No.. Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m^3	% Compaction
15/200 mm	Cut off trench Sta. 2+00	-0.5 m	8.9	2174	100.9
	Lift #5				
16/200 mm	Cut off trench Sta. 2+35	-0.5 m	9.9	2123	98.5
	Lift #5				

Remarks:

Reviewed By: P.Eng.

cc

EI Engineering Consultants ``d.

eba

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.:	0201-10441	Test Apparatus:	NUCLEAR Mach. No.: 4004
Project:	Little Creek Collection Pond Faro, Yukon	Soil Description:	SILT(TILL)-sandy, gravelly, some clay, grey
		Temperature	Air: ° C Soil: ° C
Client:	Cominco Eng. Serv. Ltd.	Specified Compaction:	95%
		Compaction Standard:	MODIFIED PROCTOR
	ATTN: Mr. Keith McDonald	Minimum Dry Density:	
		Maximum Dry Density:	2155 kg/m3
		Optimum M.C.:	8.8%
		Date Tested:	1990-09-14 By: CRH

Test No. Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m³	% Compaction
17/200 mm	Sta. 1+60	LIFT #1	11.5	1945	90.3
18/200 mm	Sta. 1+70-3 m fron D.S. toe	LIFT #1	13.4	1964	91.1
19/200 mm	Sta. 2+20-15 m from D.S. toe	LIFT #1	14.3	1937	89.9
20/200 mm	Sta. 2+10 cut off trench D.S. edge eleveation	LIFT #1	12.7	1951	90.5

Remarks:

Reviewed By: P.Eng.

cc

EB Engineering Consultants Ltd.

eba

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441

Project: Little Creek Collection Pond

Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004

Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey

Temperature Air: ____ °C Soil: ____ °C

Specified Compaction: 95%

Compaction Standard: MODIFIED PROCTOR

Minimum Dry Density: ____

Maximum Dry Density: 2155 kg/m3

Optimum M.C.: 8.8%

Date Tested: 1990-09-14 By: CRH

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m^3	% Compaction
21/200 mm	Sta. 2+00-3 m D.S. of cut off	LIFT #1	12.5	1964	91.1
	trench				
22/200 mm	Sta. 2+00-2 m U.S. of D.S	LIFT #1	12.1	2004	93.0
	toe				
23/200 mm	Sta. 2+65-4 m U.S. of D.S. toe	LIFT #1	11.7	2046	94.9

Remarks: TESTS #22, 23 were on ~~area~~ areas that were tested after further compaction of the area of Tests #17 - 20. Area of Test #21 received additional compaction.

Reviewed By: ____ P.Eng.

cc ____

EBA Engineering Consultants Ltd.

eba

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441

Project: Little Creek Collection Pond
Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004

Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey

Temperature Air: ____ °C Soil: ____ °C

Specified Compaction: 95%

Compaction Standard: MODIFIED PROCTOR

Minimum Dry Density:

Maximum Dry Density: 2155 kg/m3

Optimum M.C.: 8.8%

Date Tested: 1990-09-14 By: CRH

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m³	% Compaction
24/200 mm	UTM Coordinates 593500 E	GRADE	9.6	2136	99.1
	6903630 N				
25/200 mm	UTM Coordinates 593300 E	GRADE	8.3	2191	101.7
	6903500 N				
26/200 mm	UTM Coordinates 593350 E	GRADE	8.5	2167	100.6
	6903250 N				
27/200 mm	UTM Coordinates 593700 E	GRADE	10.1	2143	99.4
	6903100 N				
28/200 mm	UTM Coordinates 594000E	GRADE	8.2	21378	99.2
	6903100 N				

Remarks: Testing of travelled surface only, compaction of underlying materials not determined.

Reviewed By: ____ P.Eng.

cc

The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance of material suitability. Should engineering interpretation be required, EBA will provide it upon written request.

44 CONT '83

EE Engineering Consultants Ltd.

eba

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441

Project: Little Creek Collection Pond
Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004

Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey

Temperature Air: ° C Soil: ° C

Specified Compaction: 95%

Compaction Standard: MODIFIED PROCTOR

Minimum Dry Density:

Maximum Dry Density: 2155 kg/m3

Optimum M.C.: 8.8%

Date Tested: 1990-09-14 By: CRH

Test No.. Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m³	% Compaction
29/200 mm	Sta. 0+205-18 m D.S. of centreline	-11.5 m	15.4	1919	89.0
30/200 mm	Sta. 0+335-20 m D.S. of centreline	-9.0 m	11.5	2014	93.5
31/200 mm	Sta. 0+255-1.5 m D.S. of centreline	-4.0 m	10.3	2071	96.1
32/200 mm	Sta. 0+225-5 m U.S. of centreline	-10.0 m	8.3	2156	100.0

Remarks: Note high moisture content at location of Test #29, additional compaction at this location is not expected to significantly change the measured compaction

Reviewed By: P.Eng.

cc

EE Engineering Consultants Ltd.

eba

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441
Project: Little Creek Collection Pond
Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004
Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey
Temperature Air: ° C Soil: ° C
Specified Compaction: 95%
Compaction Standard: MODIFIED PROCTOR
Minimum Dry Density:
Maximum Dry Density: 2155 kg/m3
Optimum M.C.: 8.8%
Date Tested: 1990-10-01 By: CRH

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m³	% Compaction
33/200 mm	Sta. 0+40 2 m U.S. of centreline	-4.0 m	8.7	2061	95.6
34/200 mm	Sta. 0+50 2 m D.S. of centreline	-4.0 m	9.2	2089	96.9
35/200 mm	Sta. 0+70 10 m U.S. of centreline	-6.0 m	9.7	2072	96.1
36/200 mm	Sta. 0+90 18 m U.S. of centreline	-8.0 m	10.3	2097	97.3
37/200 mm	Sta. 1+20 centreline	-10.0 m	9.0	2161	100.3
38/200 mm	Sta. 1+20 15 m D.S. of centreline	-12.0 m	109	2165	100.5

Remarks:

Reviewed By: P.Eng.

cc

The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance of material suitability. Should engineering interpretation be required, EBA will provide it upon written request.

14- CONT/83

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DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441
Project: Little Creek Collection Pond
Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004
Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey
Temperature Air: ° C Soil: ° C
Specified Compaction: 95%
Compaction Standard: MODIFIED PROCTOR
Minimum Dry Density:
Maximum Dry Density: 2155 kg/m3
Optimum M.C.: 8.8%
Date Tested: 1990-10-01 By: CRH

Test No.. Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m³	% Compaction
39/200 mm	Sta. 1+00 20 m D.S. of centreline	-10.0 m	8.6		
40/200 mm	Sta. 0+90 15 m D.S. of centreline	-8.0 m	14.2	1993	92.4
41/200 mm	Sta. 0+75 3 m D.S. of centreline	-4.0 m	11.8	2098	97.4

Remarks: Material tested at location of Test #39 either contain a large rock or had a significantly higher rock contnt; therefore the proctor value is not valid for this test.

Reviewed By: P.Eng.

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EE Engineering Consultants Ltd.

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DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441

Project: Little Creek Collection Pond
Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004

Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey

Temperature Air: ______ ° C Soil: ______ ° C

Specified Compaction: 95%

Compaction Standard: MODIFIED PROCTOR

Minimum Dry Density: ______

Maximum Dry Density: 2155 kg/m3

Optimum M.C.: 8.8%

Date Tested: 1990-10-06 By: CRH

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m³	% Compaction
42/200 mm	Sta. 1+00 U.S. edge	-4.5 m	10.9	2107	97.8
43/200 mm	Sta. 1+40 U.S. edge	-5.0 m	7.9	1951	90.5
44/200 mm	Sta. 1+60 U.S. edge	-5.0 m	9.7	2097	97.3
45/200 mm	Sta. 1+95 2 m D.S. of U.S. edge	-5.0 m	9.8	2116	98.2
46/200 mm	Sta. 2+00 14 m D.S. of U.S. edge	-4.5 m	12.1	1995	92.6
47/200 mm	Sta. 2+30 7 m D.S. of U.S. edge	-4.0 m	11.5	2040	94.7

Remarks: ______

Reviewed By: ______ P.Eng.

cc ______

EBA Engineering Consultants Ltd.

eba

DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441

Project: Little Creek Collection Pond
Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004

Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey

Temperature Air: ° C Soil: ° C

Specified Compaction: 95%

Compaction Standard: MODIFIED PROCTOR

Minimum Dry Density:

Maximum Dry Density: 2155 kg/m3

Optimum M.C.: 8.8%

Date Tested: 1990-10-06 By: CRH

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m³	% Compaction
48/150 mm	Sta. 2+55 3 m D.S. of U.S.	-4.0 m	9.8	2039	94.6
	edge				
49/100 mm	Sta. 2+40 8 m U.S. of D.S.	-3.5 m	10.0	2148	99.7
	edge				
50/200 mm	Sta. 1+50 8 m U.S. of D.S.	-5.0 m	9.7	2036	94.5
	edge				

Remarks:

Reviewed By: P.Eng.

cc

44 CONT/83

EI Engineering Consultants ''d.

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DENSITY TEST RESULTS

ASTM Designation D2922 & D3017, or D1556

Project No.: 0201-10441
Project: Little Creek Collection Pond
Faro, Yukon

Client: Cominco Eng. Serv. Ltd.

ATTN: Mr. Keith McDonald

Test Apparatus: NUCLEAR Mach. No.: 4004
Soil Description: SILT(TILL)-sandy, gravelly, some clay, grey
Temperature Air: ° C Soil: ° C
Specified Compaction: 95%
Compaction Standard: MODIFIED PROCTOR
Minimum Dry Density:
Maximum Dry Density: 2155 kg/m3
Optimum M.C.: 8.8%
Date Tested: 1990-10-06 By: CRH

Test No./ Probe Depth	Location	Elevation	% Moisture Content	Dry Density Kg/m³	% Compaction
51/200 mm	Sta. 1+70 U.S. side	±3.5 m	10.7	2095	97.1
52/200 mm	Sta. 1+40 D.S. side	±3.5 m	10.0	2117	98.7
53/200 mm	Sta. 1+20 D.S. side	±3.0 m	8.8	2097	98.8
54/200 mm	Sta. 0+80 D.S. side	±3.0 m	10.7	2028	94.0
55/200 mm	Sta. 0+40 D.S. side	±3.0 m	11.0	2080	96.5
56/200 mm	STa. 0+60 U.S. side	±3.0 m	7.9	2110	97.8

Remarks:

Reviewed By: P.Eng.

cc

APPENDIX E

Photographs

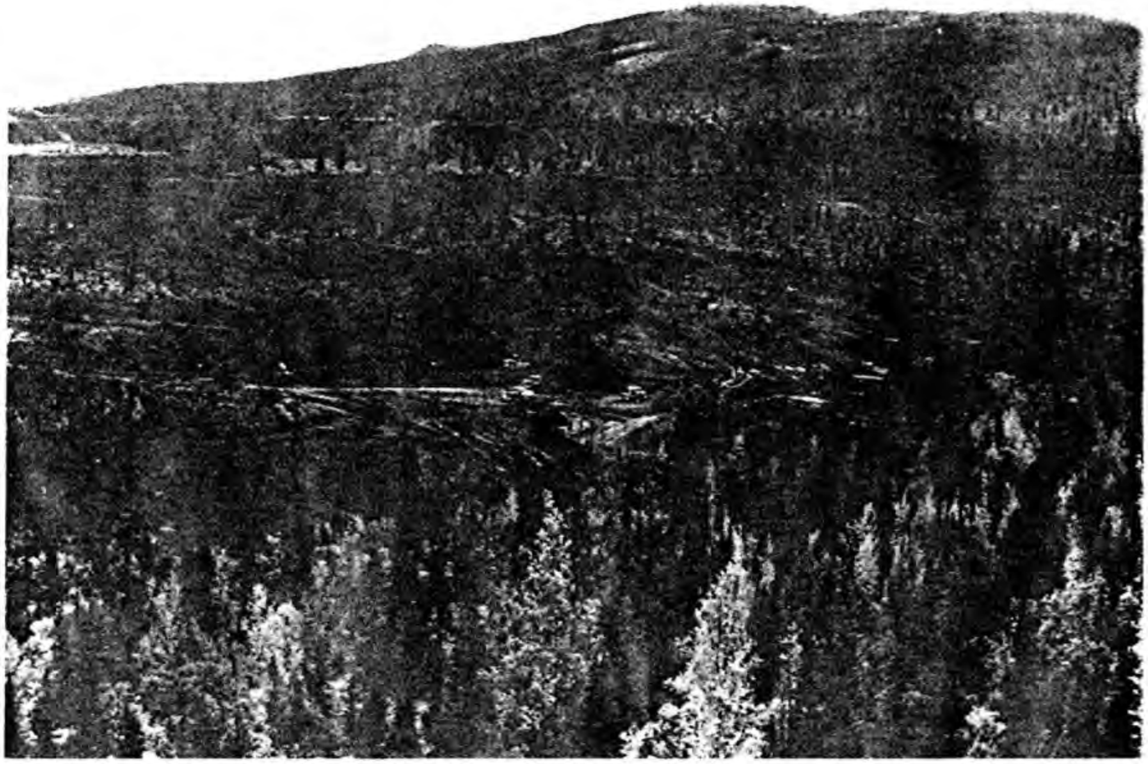


PLATE 1:

Sept. 12/90. View from the main haul road of the cleared footprint of the dam. Brownish soil in foreground of footprint is native sand and gravel; greyish soil in background of footprint is the native till. The flat embankment extending across the plate is the north limb of the starter dyke for the Vangorda waste dump.

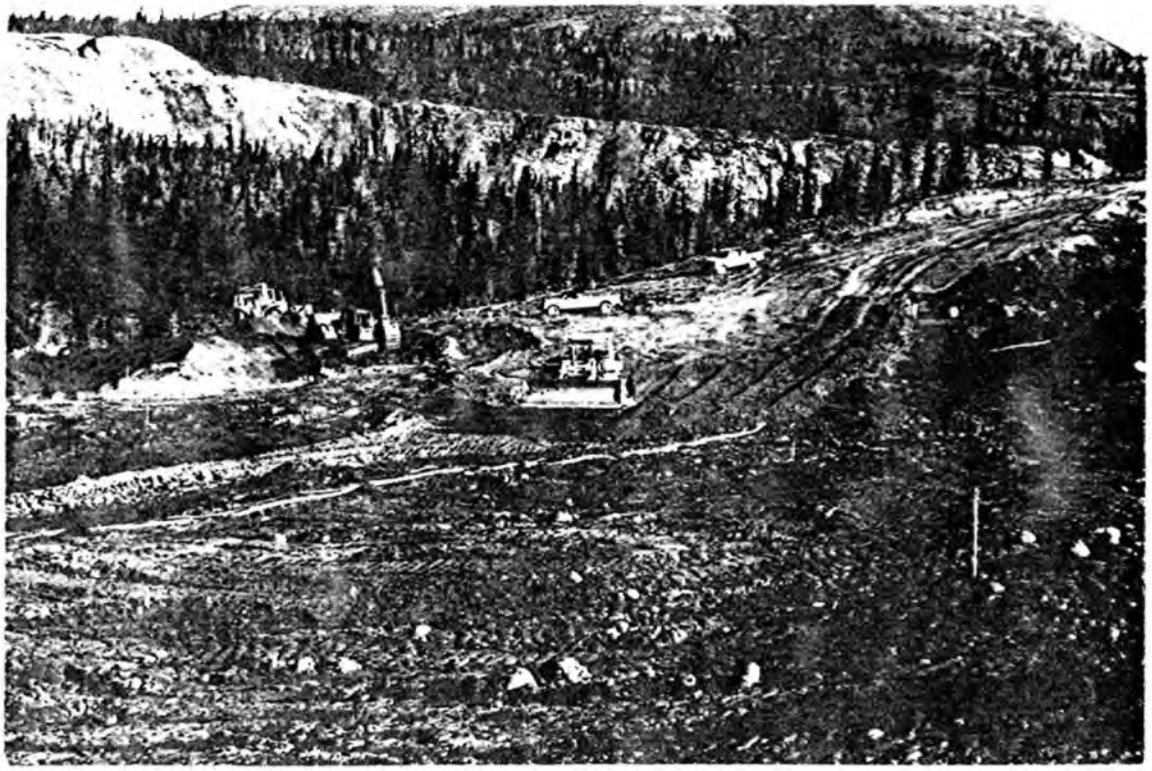


PLATE 2:

Sept. 13/90. Opposite view to Plate 1, from the south abutment of the dam. Excavation of the cutoff by the backhoe is underway and the area in valley bottom between the cutoff trench and the upstream toe of the dam is being covered with till from the stripping of Vangorda open pit.

PLATE 3:
Sept. 13/90. Northward view of completed cutoff trench between Sta. 0+180 (in foreground) and Sta. 0+210. Brown sand and gravel overlies olive till which, in turn, overlies grey till. Groundwater is evident near the base of the sand and gravel.

PLATE 4:
Sept. 14/90. Excavation of the cutoff trench between Sta. 0+180 and 0+235 is complete and filter fabric is being placed on the base and against the downstream face of the trench.

PLATE 5:
Sept. 14/90. The cutoff trench is then backfilled in thin lifts which are placed initially by the backhoe and then tracked down with a dozer in preparation for compaction.

PLATE 6:
Sept. 14/90. Each lift is compacted with 5 cycles of a Dynapac compactor.

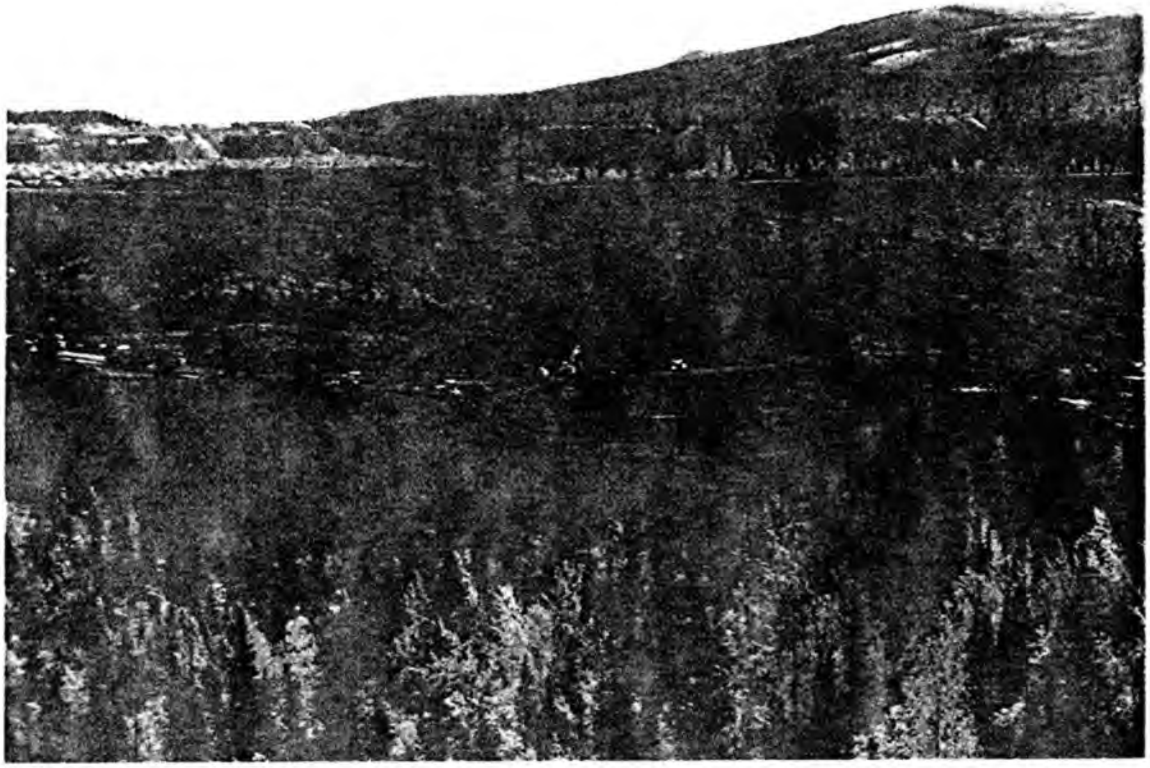


PLATE 7:

Sept. 15/90. View from the main haul road showing the scrapers hauling till. The brownish zone in the foreground of the footprint is the local sand and gravel which has been redistributed to develop part of the blanket drain and the downstream toe of the dam.

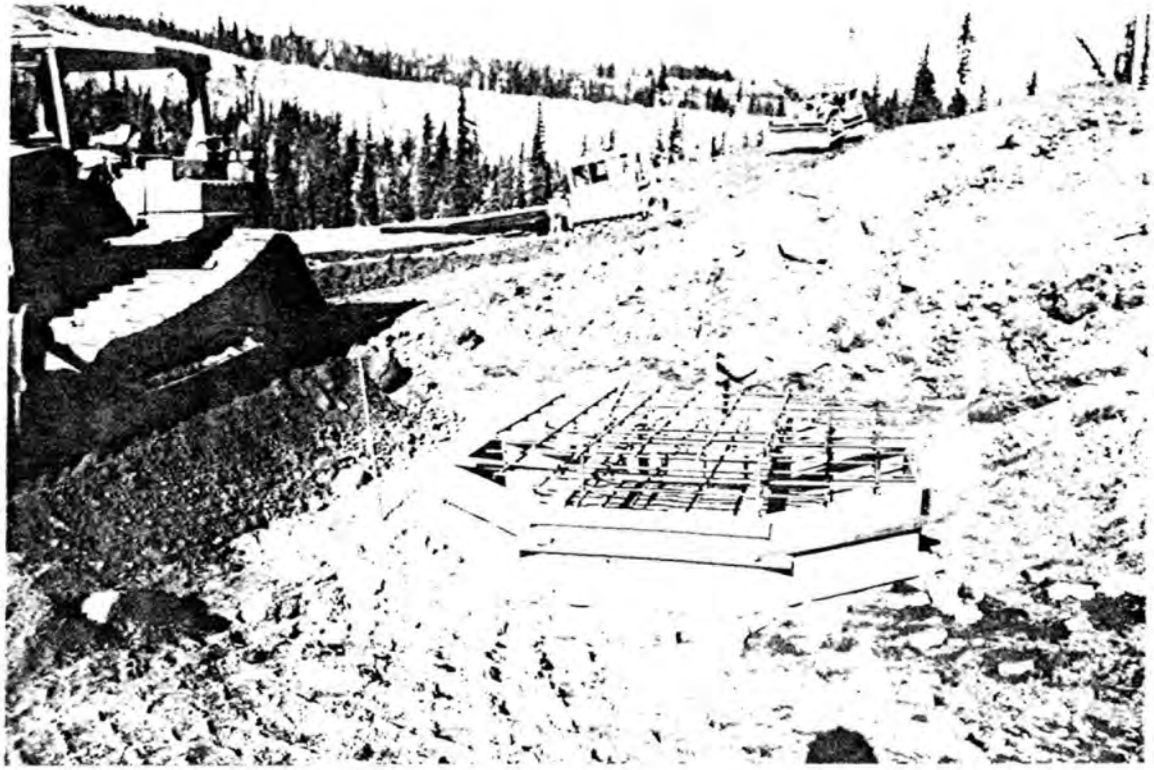


PLATE 8:

Sept. 17/90. Formwork for the base of the wet well in place on in situ sand and gravel. In background, filter fabric is partially in place over the blanket drain on the north side of the valley.

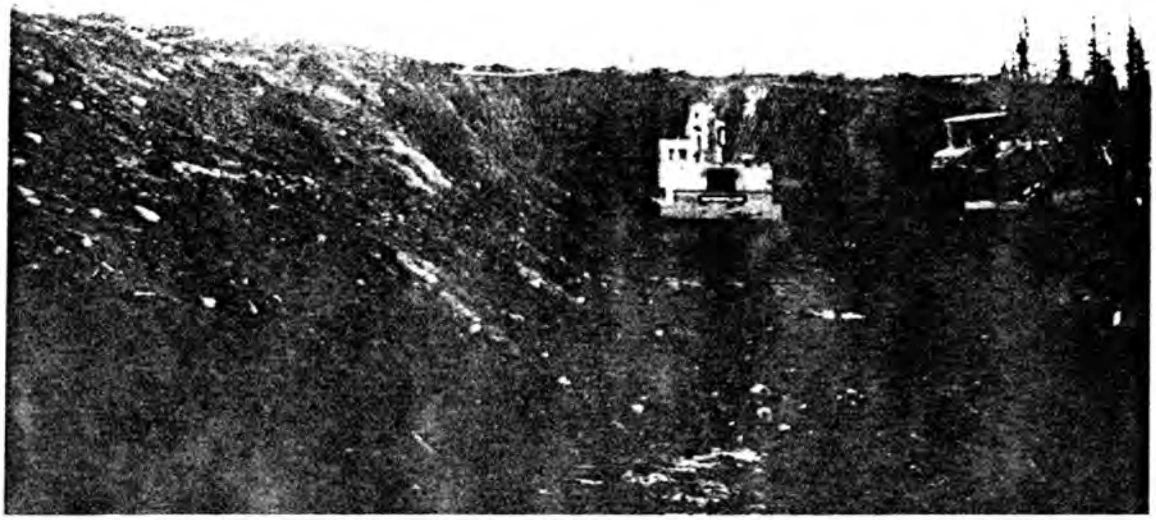


PLATE 9:
Sept. 29/90. Excavation of up to 7 m of permafrost from the footprint of the south abutment, between Sta. 0+020 and 0+070.

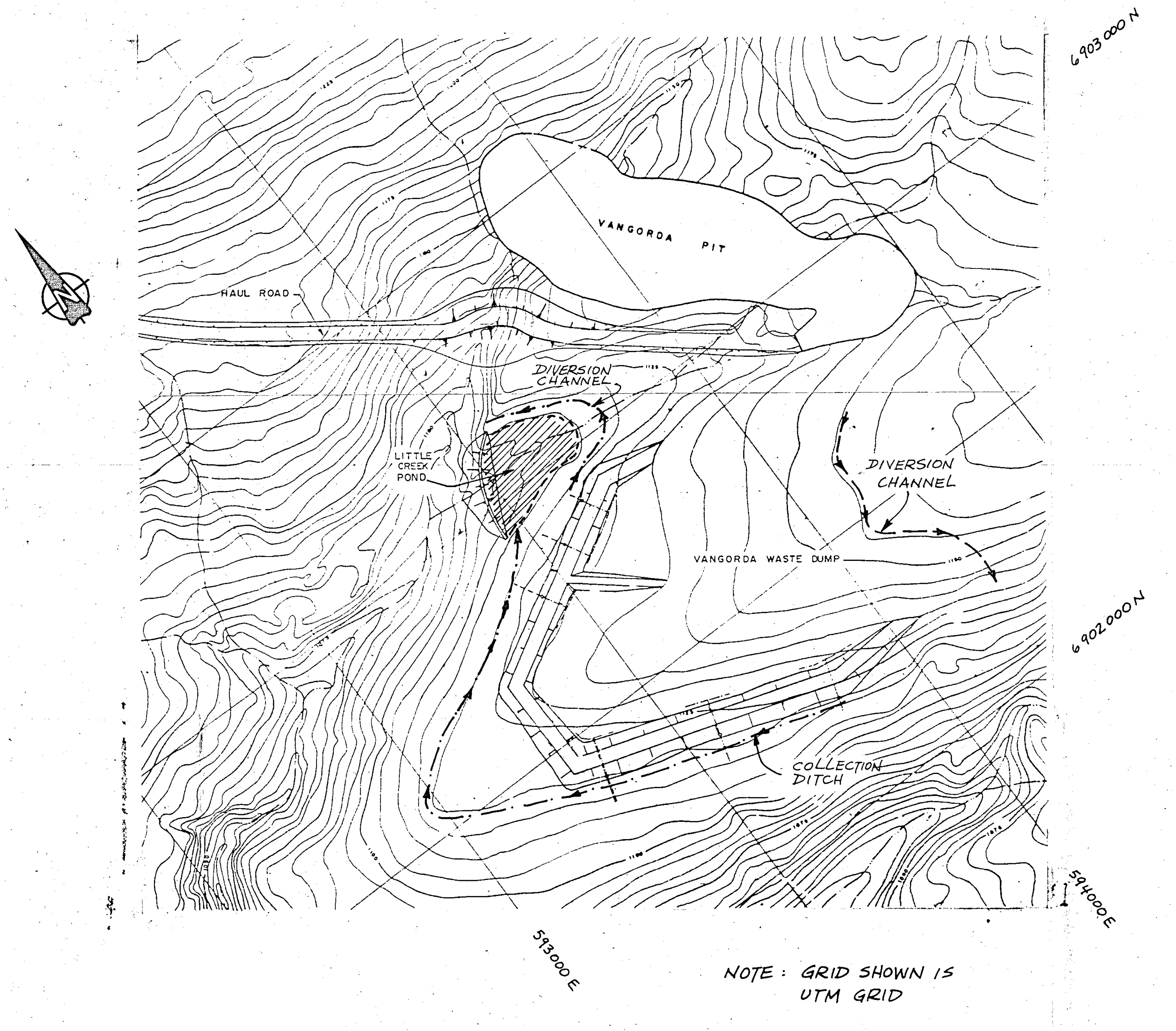
PLATE 10:
Sept. 30/90. Backfilling in thin compacted lifts of the area between Sta. 0+020 and 0+070 where the zone of permafrost was excavated.

PLATE 11:
Oct. 1/90. View northwards from Sta. 0+040 at the construction of finger drain "L1."

PLATE 12:
Oct. 3/90. Covering finger drains "T1" and "T2" with filter fabric and constructing the rock drain at the end of "T1."

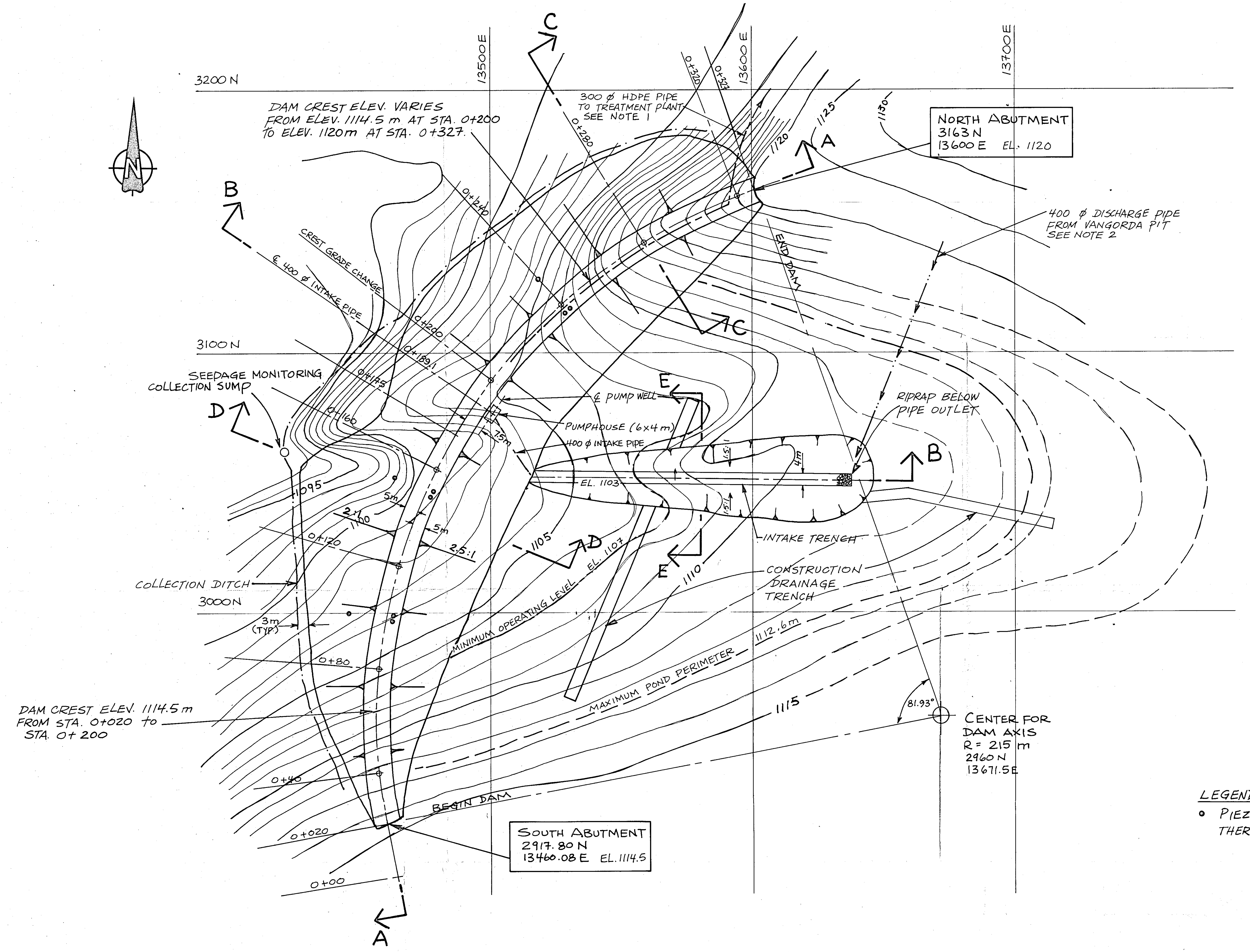
PLATE 13:
Oct. 3/90. Placement of till over top of the finger drains on the south side of the dam footprint.

PLATE 14:
Oct. 8/90. View from the main haul road. Crest of the dam is at Elev. 1112.



LOCATION PLAN

SCALE - 1:10 000



LEGEND

○ PIEZOMETERS AND THERMISTORS.

GENERAL ARRANGEMENT PLAN

SCALE - 1:1000

CONTOUR INTERVAL = 1 metre
GRID SHOWN IS MINE GRID

0 10 20 30 40 50 metres

NOTES:

1. Intake trench not surveyed.
2. Collection sump and collection ditch not yet constructed as of Jan./91.
3. Piezometers and thermistors to be installed.
4. Refer to drawing 60627-04 for cross-sections through dam.
5. Survey data by Lamerton Assoc.
6. Pipeline dimensions are in mm.
7. Diversion channel location to be determined in field.

20/8/90

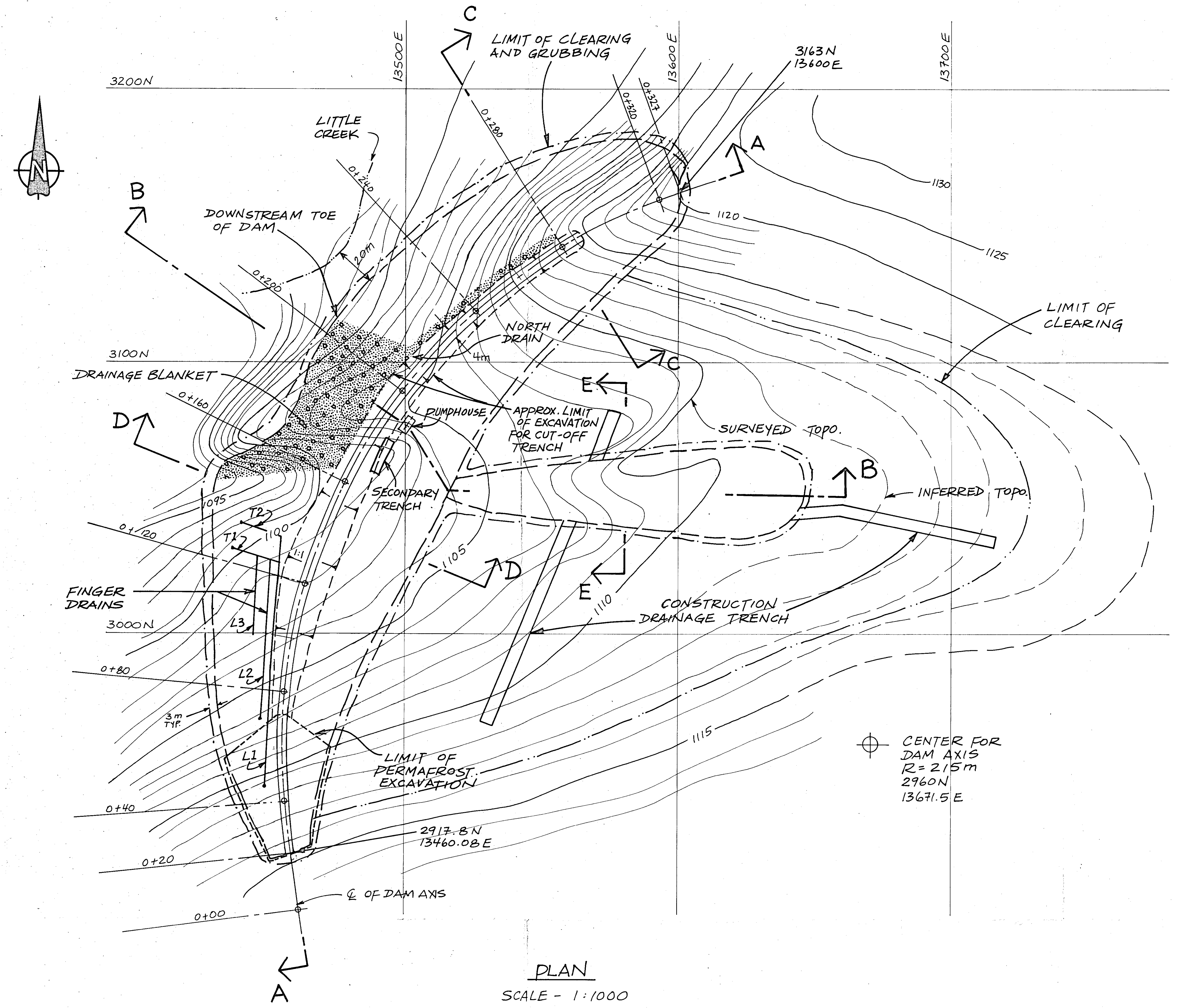
REVISIONS		
	APPROVED	DATE
A		Aug. 24/90
B		Sept. 7/90
C		Jan. 11/91

CURRAGH RESOURCES INC. VANGORDA

VANGORDA COLLECTION POND
GENERAL ARRANGEMENT PLAN

STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers

DATE AUG. 24/90
PROJ. NO. 60627
APPROVED
NO. 60627-01



PLAN

SCALE - 1:1000

CONTOUR INTERVAL = 1 metre

0 10 20 30 40 50 metres

AS-BUILT COORDINATES OF DAM

℄ AS-BUILT STATION	NORTHING	EASTING
0+080	2977.48	13458.14
0+120	3016.19	13466.47
0+160	3052.89	13481.05
0+200	3085.38	13500.95
0+240	3114.07	13528.14
0+280	3135.26	13561.46
0+320	3152.23	13597.99

SURVEYED TRENCH FLOOR LOCATIONS

STA.	ELEV.	NORTHING	EASTING
0+070	1103.5	2967.7	13457.1
0+080	1100.9	2976.5	13457.2
0+100	1098.8	2995.6	13459.8
0+120	1097.6	3018.6	13457.2

21/8/90

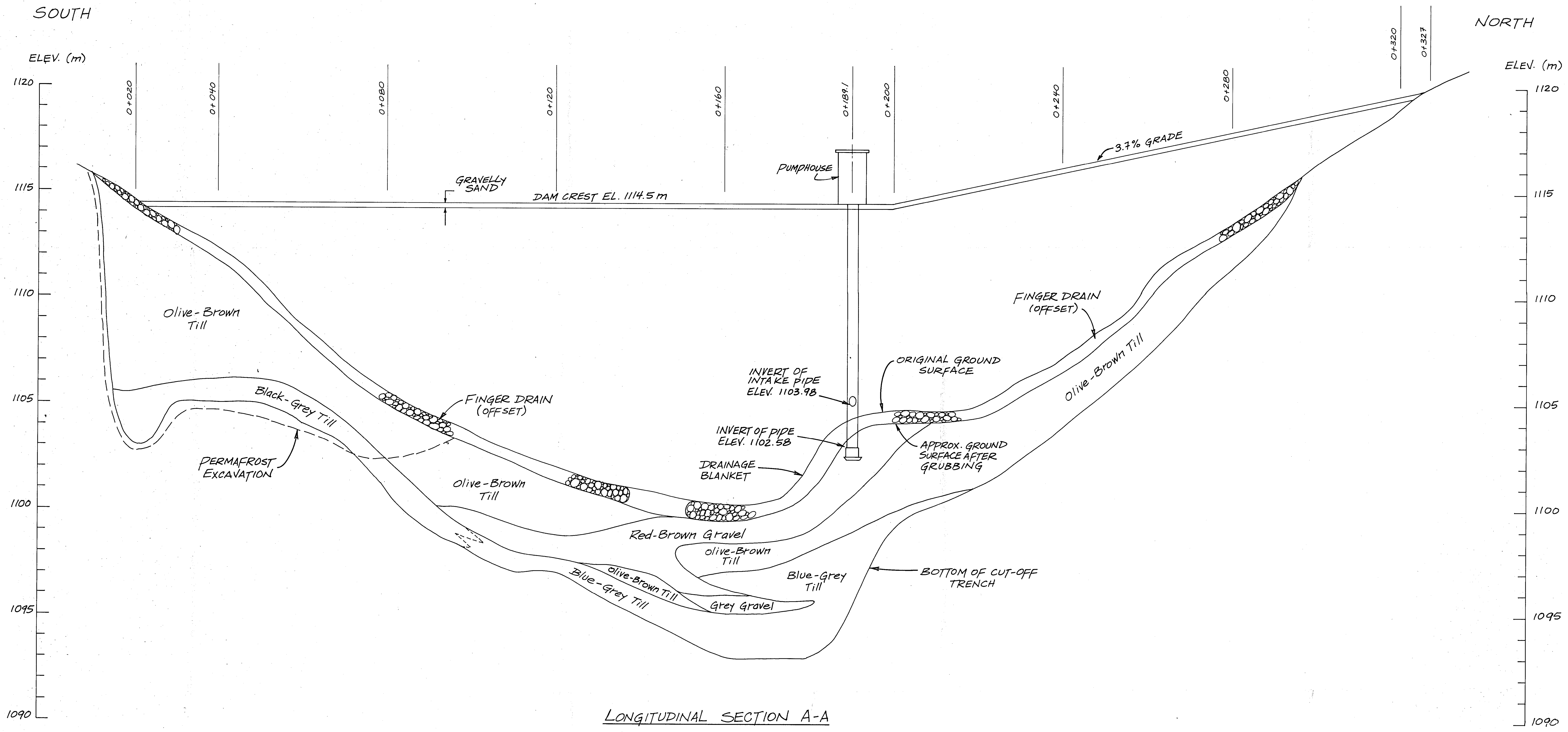
REVISIONS		
	APPROVED	DATE
A		Aug. 24/90
B		Sept. 7/90
C		Jan. 15/91

CURRAGH RESOURCES INC. VANGORDA

VANGORDA COLLECTION POND
LAYOUTS FOR CUT-OFF TRENCH EXCAVATION
AND DRAINAGE BLANKET

STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers

DATE AUG. 24/90
PROJ. NO. 60627
APPROVED
NO. 60627-02



LONGITUDINAL SECTION A-A

HORIZ. SCALE - 1:500
VERT. SCALE - 1:100

NOTES:

1. Stratigraphic profile is based on inspection of cut-off wall.
2. Drainage Blanket is offset 7-9 m downstream of section line.
3. Thickness of gravelly sand cover determined by CESL.
4. Wet well centerline is located 7.5 m upstream of dam centerline.

REVISIONS		
	APPROVED	DATE
A	Ms	JAN. 15/91

CURRAGH RESOURCES INC. VANGORDA

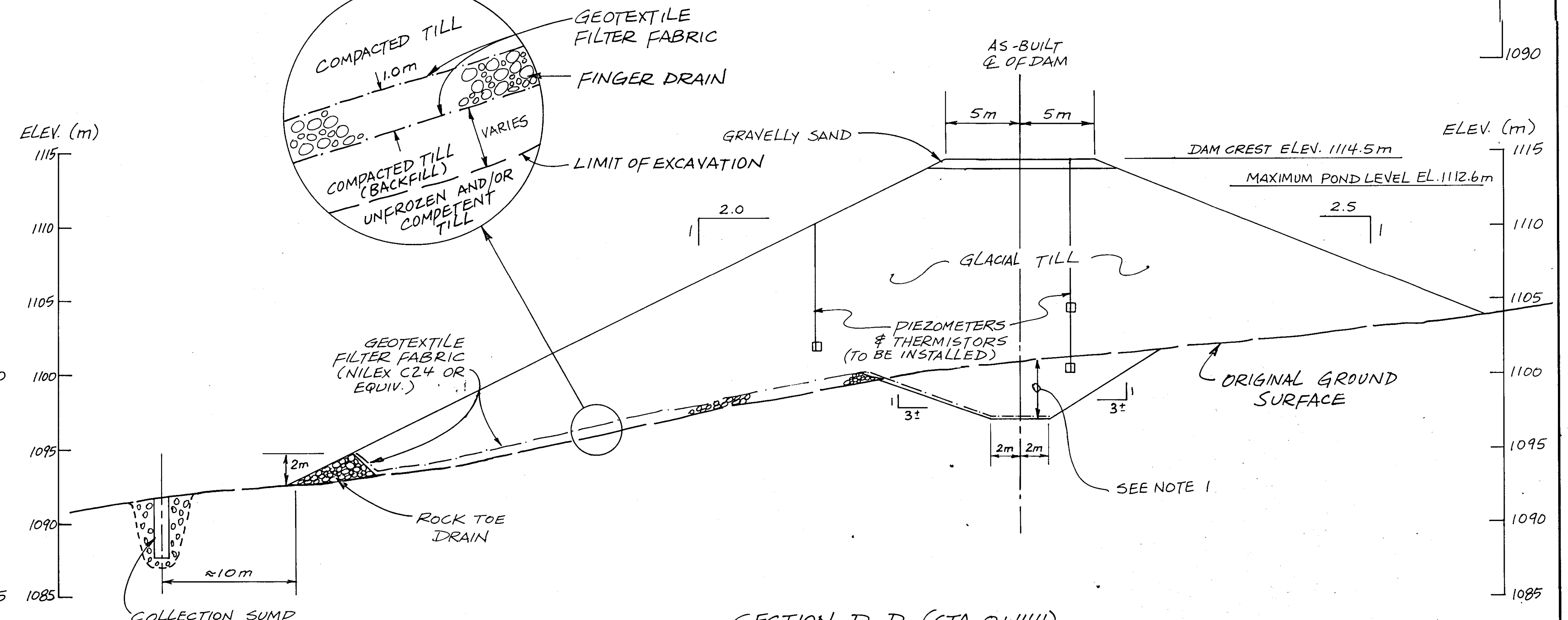
VANGORDA COLLECTION POND
PROFILE ALONG LONGITUDINAL SECTION A-A

STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers

DATE JAN. 1991
PROJ. NO. 60627
APPROVED
NO. 60627-03

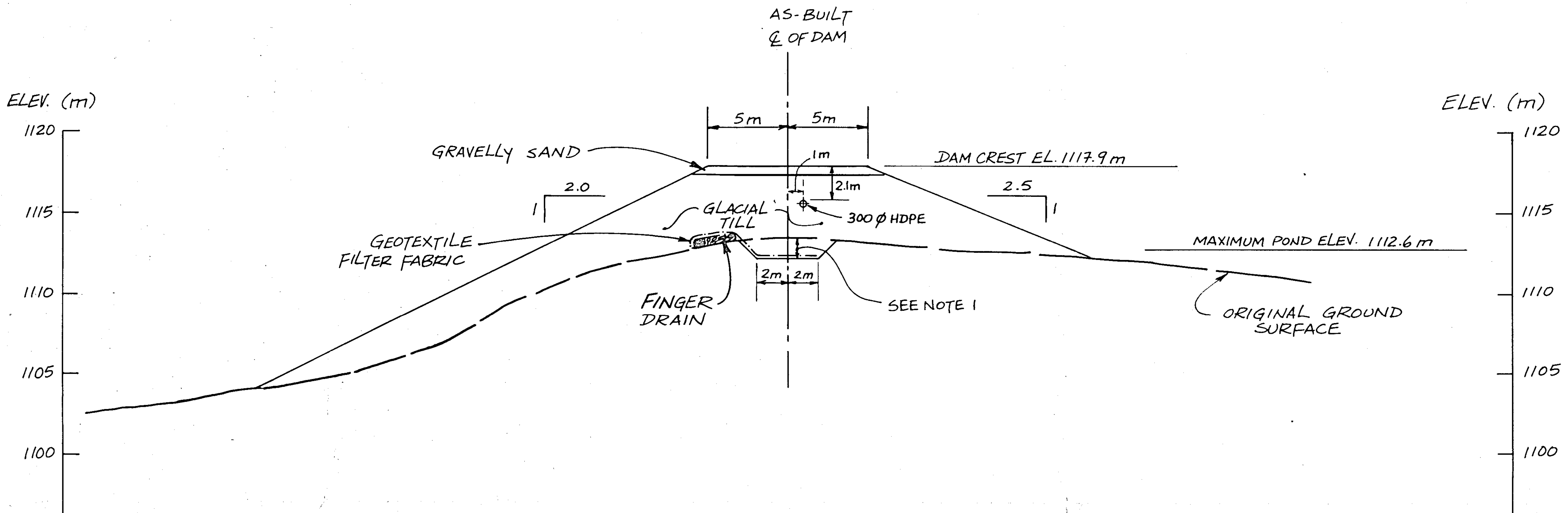
SECTION B-B (STA. 0+190)

SCALE - 1:250



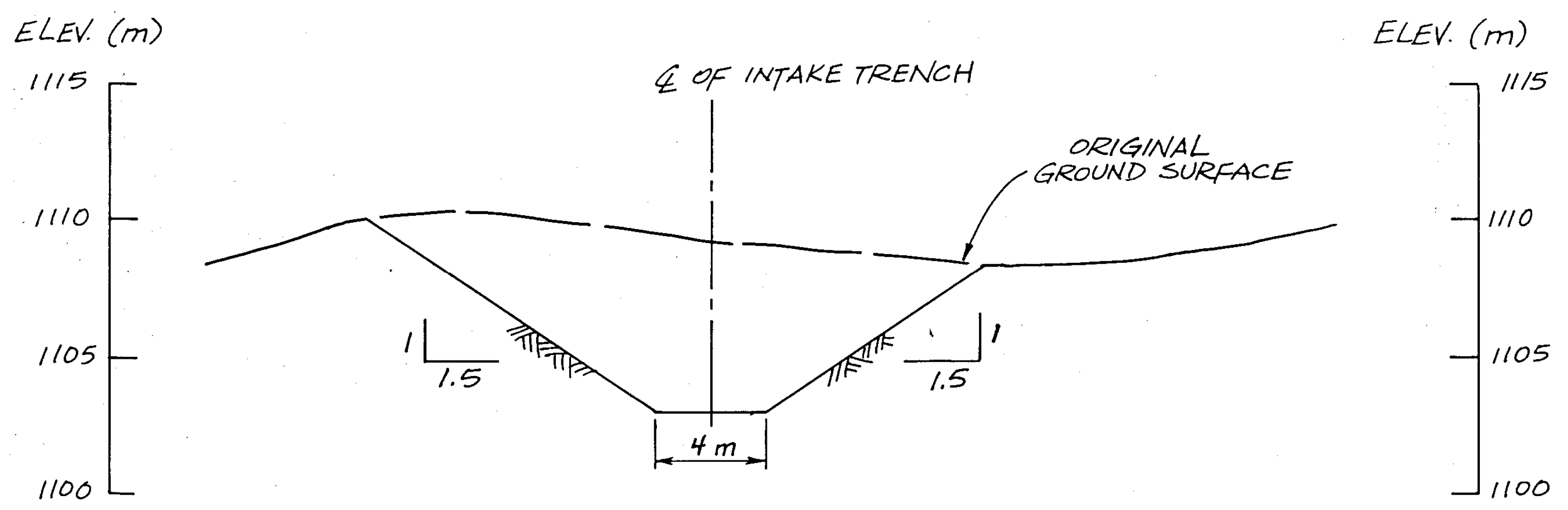
SECTION D-D (STA. 0+144)

SCALE - 1:250



SECTION C-C (STA. 0+280)

SCALE - 1:250



SECTION E-E

SCALE - 1:250

NOTES:

1. CUT-OFF TRENCH VARIES. SEE DRWG. NO. 60627-03. AS DETERMINED BY SRK FIELD ENGINEER.
2. GLACIAL TILL FILL MATERIAL COMPACTED TO 90 PERCENT OF THE MODIFIED PROCTOR MAXIMUM DRY DENSITY IN 0.3m LIFTS
3. RIPRAP MATERIAL SHALL COMPLY WITH GRADATION REQUIREMENTS IN THE TECHNICAL SPECIFICATIONS.
4. PIEZOMETERS, THERMISTORS, COLLECTION DITCH AND COLLECTION SUMP NOT INSTALLED AS AT JAN. 1991.

REVISIONS		
	APPROVED	DATE
A		Aug. 24/90
B		Sept. 7/90
C		Jan. 15/91

21/8/90

CURRAGH RESOURCES INC. VANGORDA

VANGORDA COLLECTION POND

CROSS-SECTIONS B-B, C-C, D-D, & E-E

STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers

DATE AUG. 24/90

PROJ. NO. 60627

APPROVED

NO. 60627-04