REPORT ON

ILLISARVIK AREA DRILLING PROGRAM

RICHARDS ISLAND, NORTHWEST TERRITORIES

WINTER 1983

PREPARED FOR:

DEPARTMENT OF SUPPLY AND SERVICES

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ON BEHALF OF

GEOLOGICAL SURVEY OF CANADA

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1.0 INTRODUCTION

Hardy Associates (1978) Ltd. was retained by the Department of Supply and Services, on behalf of the Geological Survey of Canada, to carry out a program of field drilling in the vicinity of Illisarvik, Richards Island, Northwest Territories. Formal authorization to proceed with components of the investigation was received, on February 26 and on March 29, 1983, in telexes from Mr. D.A. Wright, Department of Supply and Services.

1.1 SCOPE OF STUDY

In August 1982, Hardy Associates carried out surficial geology mapping of a 225 km^2 area centered on the Illisarvik experimental site, Richards Island, N.W.T. The prime objective of the present study, which forms a continuation of the mapping project, is to provide additional information relative to subsurface stratigraphy and permafrost and ground ice conditions. These data are intended to provide information on the three-dimensional distribution of these features and aid in further elucidating the Quaternary geologic history of the area. Multi-disciplinary studies of permafrost growth have been underway at Illisarvik since 1978.

1.2 TERMS OF REFERENCE

The requirements of the field program were discussed initially in a letter submitted as part of the mapping project on November 25, 1982. Subsequently, following discussions with Mr. J.A. Heginbottom, Scientific Authority, and receipt of a request for Proposal from DSS, terms of reference for the Winter 1983 drilling program were established in our proposal, dated February, 1983.

In summary, the program was to comprise (subject to the availability of funding) the following:

i) Drilling, logging and sampling of up to 26 boreholes in the vicinity of Illisarvik, Richards Island, N.W.T., to target depths of 100 m, 30 m, 10 m or 10 m below sea bed.

ii) Collection, storage and shipment to various destinations of selected samples (some in frozen state) for laboratory analysis and testing.

iii) Fabrication, installation and testing of multithermistor cables for measuring ground temperatures, using calibrated, high precision, thermistors.

iv) Testing of selected samples for frozen bulk density, natural water content, grain size distribution, Atterberg limits, and pore water salinity.

v) Presentation of the results in a short narrative report, with tabular logs for each borehole, showing surficial geology, permafrost and ground ice conditions, sample locations and the results of the laboratory tests.

1.3 APPROACH

The four-phase approach, described in detail in subsequent sections, is summarized below:

Firstly, thermistors were calibrated, in our Calgary laboratory, and the multi-thermistor cables were constructed. Two cables were fabricated, each 100 m long with 40 thermistor

beads evenly spaced, at 2.5 m intervals, throughout. Details of thermistor calibration procedures, multi-thermistor cable fabrication and installation are given in Appendix "E".

The field drilling program was carried out in mid-March, 1983. Drilling services were retained from Midnight Sun Drilling Ltd. of Whitehorse, Y.T., with support from a sled-mounted camp, subcontracted from Beautuk Marine Services of Tuktoyaktuk, N.W.T. In all, seven boreholes were drilled and sampled. Two thermistor cables were installed and tested. Details are provided in Section 3.0.

Samples were returned in the frozen state to the Calgary laboratory of Hardy Associates (1978) Ltd. for testing. Test procedures included determination of frozen bulk density, natural moisture content, grain size distribution, Atterberg Limits, and pore water salinity. Procedures are described and results presented in Section 4.0.

This data report was compiled as the final phase of the study. It provides an account of the field and laboratory testing programs, and presents the results. Main findings of the study are summarized in Section 5.0.

1.4 SCHEDULE

The schedule for the field investigation, laboratory testing and report preparation was a tight one.

Authorization to drill two deep boreholes at Illisarvik was received from DSS on February 26, 1983. Thermistor cable fabrication then commenced and preparations for the field program were finalized.

The drill rig, camp and crews were mobilized to Illisarvik on March 9, 1983, and drilling operations commenced the following day. Drilling of two deep boreholes was completed on March 17, 1983. On March 15 verbal authorization had been received to drill five additional, medium depth, borings. This second phase of the program was completed on March 19, 1983, when demobilization commenced. The field program was completed on March 20, 1983. Formal authorization to proceed with second drilling phase was received by telex on March 29, 1983.

Laboratory testing was carried out, on selected samples returned from the field, in late March and early April 1983. Analysis and report preparation were undertaken concurrently.

2.0 STUDY AREA

The 1983 Winter drilling program was carried out within the same approximately 225 km^2 area, centred on Illisarvik, as was studied during the 1982 surficial geology mapping program (and forms a continuation thereto). The area of interest is defined on the north and south by latitudes 69^{o} 32.5'N and 69^{o} 25'N, and on the east and west by latitudes 134^{o} 22.5'W and 134^{o} 45'W. The location of Illisarvik and the study area is indicated on Figure 1.

The geological setting for the present investigation has been described in detail in our report on surficial geology (Report CG10039, dated March, 1983), to which reference should be made. Available information on physiography, surficial geology and stratigraphy, and permafrost and ground ice is summarized briefly below, as a framework within which to present the results of the current study.

Insert Figure 1

Physiographically, the study area comprises sections of both the Modern Delta and Pleistocene Coastlands (Tununuk and Kittigazuit Low Hills subdivisions). The stratigraphy of the Modern Delta consists of a thick sequence of alluvial silt and fine sand, locally veneered by organics or recent marine deposits. Fine to medium sand, of marine-deltaic origin, occurs throughout the Pleistocene Coastlands. On ridges and uplands, it is overlain by diamicton (till and/or mudflow debris), in depressions by organics and recent lacustrine material.

With a mean annual ground temperature in the range -7^{o} to $-9^{o}C$, permafrost is continuous and in excess of 600 m thick in the Pleistocene Coastlands. It is discontinuous and thinner in the Modern Delta. Active layer thicknesses range from 30 cm to greater than 100 cm, depending on lithology and vegetation cover. Ground ice type and distribution are variable and frequently related to lithology, ranging from pore and vein ice, through ice wedges, to massive ground ice. Pingos are abundant in the Tununuk Low Hills.

Active geomorphic processes are associated with fluvial erosion and deposition, permafrost and ground ice, and marine processes. Permafrost-related activities include downslope movement by soil creep, ground ice formation and ice wedge growth, and pingo growth and decay. Coastline changes at Illisarvik has been significant, and is related to: retreat of coastal bluffs, erosion of tidal flats, and expansion of flats and spits. Erosion of tidal flats is apparently the dominant process.

3.0 FIELD INVESTIGATION

The field component of the 1983 winter drilling program was carried out between March 8 and 20, 1983. As described briefly below, it involved: mobilization/demobilization of a drill rig, camp and crews to Illisarvik, drilling of seven boreholes (including two in which multi-thermistor cable installations were made), and shipment of frozen samples to Calgary for laboratory testing.

3.1 MOBILIZATION

On March 8, 1983, the drill rig, camp and ancillary equipment were mobilized, from Inuvik and Tuktoyaktuk, to Bar C. The following day, this equipment moved, as one unit, via Middle, Harry and Swan Channels, to Illisarvik, arriving early on March 10. The Hardy Associates (1978) Ltd. field crew arrived on-site, following layout of boreholes, on March 9, 1983 (Section 3.3).

3.2 ON-SITE LOGISTICS

It was decided, at an early stage in planning for the field program, that an on-site camp would considerably simplify the logistics of the field operation, mitigate the anticipated severe climatic conditions, and permit drilling activities to be optimized. To this end, a skid-mounted trailer camp was subcontracted, via Midnight Sun Drilling Ltd., from Beautuk Marine Services Ltd. of Tuktoyaktuk. The camp was mobilized to Illisarvik using a 966D loader, that was also used for access clearance. The ten-man camp, consisting of 2 sleeper

units, one kitchen unit, a washroom unit, and fuel sloop, was sited a short distance south of the borehole HA83-D1 location (see Figure 2) for the duration of the field program.

3.3 BOREHOLE LAYOUT

Borehole locations were laid out and access routes reviewed by the Hardy field crew on March 9, 1983. Transportation from Inuvik was provided by a Bell 206 helicopter, retained from Okanagan Helicopters Ltd. As drilling operations proceeded, final borehole locations were modified, as required, to satisfy access constraints and the requirements of the Land Use authorities.

3.4 FIELD DRILLING PROGRAM

Locations of the seven boreholes that were put down during the winter 1983 program are indicated on Figure 2.

Details of the drilling program were as follows:

3.4.1 Drill Rig

Drilling services were provided by a CME 750 drill, retained from Midnight Sun Drilling Ltd., of Whitehorse, Y.T. The drill was mounted on an all-terrain carrier and totally enclosed in a rig tent. It was capable of drilling using both the "dry" augering and "wet" rotary techniques. These procedures were used for the "deep" and "medium depth" borings respectively. The rig was accompanied by a sled-mounted tool shed, carrying mud pump, light plant, spare parts, etc.

Insert Figure 2

3.4.2 Logging and Sampling

On-site supervision of the "double-shift" drilling operations was provided by a Hardy Associates (1978) Ltd. crew, consisting of a geologist and field technician. These personnel were also responsible for logging and sampling of the boreholes.

For each borehole, a detailed field log was compiled, indicating: soil type, ground ice type and occurence, and cored and sampled intervals. Soil types and ground ice were logged using the Unified Soil Classification and NRCC Ice Classification Systems, respectively (Plates C3 and C4 in Appendix "C").

Samples were obtained from all the boreholes in permafrost using a 152 mm I.D. CRREL core barrel. In general, samples were taken at a 5 m spacing in the medium depth holes and with a maximum 10 m spacing in the deep boreholes (sample intervals are indicated on the appropriate borehole logs in Appendix "A"). Bulk samples were taken at 5 m intervals in the unfrozen holes using a split-spoon penetrometer.

3.4.3 Thermistor Cable Installation

Multi-thermistor cables were installed at completion in the two "deep" boreholes (BH's HA83-D1 and HA83-D2). Initially, it was proposed to install each cable in a 50.8 mm PVC pipe filled with arctic-grade diesel fuel. Unfortunately, due to buoyancy effects, this did not prove possible and instead, the PVC pipe was put down to as great a depth as possible. The thermistor cables was then installed on the outside, weighted down with sections of "A" rod. In this way, the PVC pipe and

cable were installed to depths of 50 m and 69 m in borehole HA83-D1, and 70 m and 91.4 m in borehole HA83-D2.

Details of the thermistor cable installations are provided in Appendix "E".

3.4.4 Sample Shipment

On completion of field logging, all samples were sealed for shipment (without photographing, due to a camera malfunction). They were then transported in the frozen state (unfrozen samples were permitted to freeze) to Inuvik at the end of the program, and then to our laboratory in Calgary by air. On receipt, all frozen core samples were cleaned and photographed. A complete photographic record has been prepared and will be provided separately.

3.4.5 Demobilization

Drilling operations were completed on March 19, 1983, when demobilization from Illisarvik commenced. In general, the access route was reversed, so that the equipment and crews reached Bar C on the same day. On March 20, the loader, camp and crew were demobilized to Tuktoyaktuk, the drill rig and Hardy and Midnight Sun crews to Inuvik.

4.0 LABORATORY TESTING PROGRAM

A total of 55 samples was returned from the field to our Calgary laboratory for testing. With the exception of five unfrozen samples, from boreholes HA83-M2D and HA83-M4, the samples were frozen cores. Material remaining following testing is being stored in freezers, prior to shipment to

Ottawa, of selected cores when requested, for further detailed testing (e.g. thermal conductivity, stable isotopes, acoustic properties).

Objectives in this section are to briefly describe the test procedures and the results (presented on the appropriate borehole logs and summarized on Tables 1 to 7, Appendix "B").

4.1 TEST PROCEDURES

In accordance with the terms of reference, selected samples from each borehole were tested for: frozen bulk density, Atterberg Limits, natural moisture content, grain size distribution, and pore-water salinity. Brief descriptions of the procedures, carried out where applicable using current ASTM specifications, follow:

4.1.1 Frozen Bulk Density

The density or unit weight of a core, is determined in the frozen state using an oil submersion procedure.

In all, frozen bulk density was determined for 32 samples.

4.1.2 Atterberg Limits

Liquid Limit (D423-66)

The liquid limit of a soil is the moisture content, expressed as a percentage of the weight of oven-dried soil, at the boundary between liquid and plastic states.

Plastic Limit (D424-59)

The plastic limit of a soil is the moisture content, expressed as a percentage of the mass of oven-dried soil, at the boundary between the plastic and semi-solid states.

A total of 21 Atterberg Limits determinations were made.

4.1.3 Natural Moisture Content (ASTM D2216-7)

The moisture content of a soil is the ratio, expressed as a percentage, of the weight of water in a given mass of soil to the weight of solid particles.

In all, 61 natural moisture contents were determined.

4.1.4 Grain Size Distribution or Particle Size Analysis (D422-63)

The grain size analysis is the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 mm (retained on No. 200 sieve) is determined by sieving, whereas the distribution of smaller particle sizes is determined by a sedimentation process using a hydrometer.

In all, grain size distribution was determined for 22 samples.

4.1.5 Porewater Salinity

The conductance of a dilute sample of porewater is firstly measured using an electric conductance meter, and then correlated to a salinity. The original in-situ porewater

salinity is then calculated, taking into account the amount of distilled water that was initially added to the soil sample.

Porewater salinity was determined for 61 samples.

4.2 RESULTS

Laboratory test results are presented on the pertinent borehole logs in Appendix "A", and summarized for each on a series of tables (Tables 1 to 7) in Appendix "B". Grain size curves are also presented in Appendix "B", on Plates B1 to B23.

The sections that follow summarize and briefly describe the test results, according to main soil type.

4.2.1 Holocene Marine Sediments

Three samples of recent marine silt were recovered from borehole HA83-M4, drilled in the centre of Mallik Bay.

As shown on Table 6, the characteristics of the samples are variable. In general, the materials are low to high plastic clayey silts, with an average composition of: 7 percent sand, 71 percent silt and 22 percent clay. Both natural moisture content and porewater salinity decrease markedly with depth, averaging 38 percent (range: 46.4 to 23.6 percent) and 5.48 parts per thousand (ppt) (range: 10.01 to 3.01 ppt).

4.2.2 Alluvial Silt and Clay

Interbedded silts and silty clays, with minor sand, constitute the main nearsurface deposits encountered. Two types occur: those that are organic-rich and those that are not.

Only limited data are available for the organic-rich material. In summary, it is non to very slightly plastic silt, with a trace to some clay and sand. Moisture content averages about 98 percent (for four samples), while porewater salinity ranges from 0.86 to 1.19 ppt, averaging 0.98 ppt. For two samples, average frozen bulk density was 1235 kg/m^3.

Considerably more data exist for the "non organic" silts, silty clays and minor sands. Natural moisture content ranges from 23.7 percent to 76.5 percent, averaging 48.5 percent, and the average porewater salinity is 2.13 ppt (range: 0.70 ppt to 4.90 ppt). In terms of grain size distribution, the deposits are variable, ranging from almost pure silt (>90 percent silt) to silty and clayey sand. Similarly, frozen bulk density results exhibit wide variation, ranging from 1498.2 kg/m^3 to 1937.1 kg/m^3 and averaging 1655.3 kg/m^3.

4.2.3 Clay Till/Diamicton

The till/diamicton that is widespread in the vicinity of Illisarvik is a low to medium plastic, sandy and silty clay. In general, moisture content is in the range: 16 to 22 percent; in borehole HA83-M1, however, two values in excess of 50 percent were recorded. Frozen bulk density averages 1940.9 kg/m^3, with a range from 1623 kg/m^3 to 2082.3 kg/m^3.

Porewater salinity values are commonly in the range: 2 to 4.5 ppt; however, at a depth of about 5 m in borehole HA83-M2A (in unfrozen till beneath Swan Channel), a salinity of 22.11 ppt was measured.

4.2.4 Pleistocene Sand

In the order of 23 samples of sand were tested, distributed at varying depths throughout the study area.

The results indicate that the deposit consists almost entirely of fine to medium, silty, sand, with the following average composition: 79 percent sand, 14.5 percent silt, and 6.5 percent clay. Natural moisture contents are relatively low, ranging from 19.2 percent to 31.8 percent (average 24.3 percent), while porewater salinities range from 1.05 ppt to 9.62 ppt, with an average of 3.88 ppt. The sand is non-plastic and has an average frozen bulk density of 1947.2 kg/m^3 (range: 1815.6 kg/m^3 to 2047.3 k/m^3.

4.2.5 Intra-Sand Clay Layers

A review of the laboratory test data, presented on Tables 1 to 7, indicates that low plastic silty clay seams that occur within the sand are of some interest. Thus, for three samples, salinities of 11.39 to 14.39 ppt (average: 13.26 ppt) were measured. Natural moisture content for the clay averages about 30 percent.

5.0 SUBSURFACE CONDITIONS

Logs for the borings completed during the 1983 winter program are presented on Plates A1 to A24, in Appendix "A". The following sections briefly summarize the borehole data, in terms of: surficial geology and subsurface stratigraphy, permafrost and ground ice, and (where available) ground temperatures conditions, for each site. Borehole locations are indicated on Figure 2.

5.1 BOREHOLE HA83-D1

Borehole HA83-D1 was drilled to a depth of 80 m at a site in the "Alluvial Islands" section of the study area, some 5 km southwest of Illisarvik (Figure 2). Objective was to provide information on stratigraphy, permafrost and ground ice in the Modern Delta. The borehole log is presented on Plates A1 to A7, Appendix "A". Laboratory test data are summarized on Table 1, Appendix "B".

5.1.1 Surficial Geology and Stratigraphy

From the surface to a depth of about 7 m, an interbedded sequence of silt clay, and minor sand was intersected. These sediments are interpreted to be of recent alluvial origin, and are underlain by silty clay till/diamicton. The till/diamicton deposit, which is in the order of 4 m thick, rests in turn on a thick and uniform fine to medium sand sequence. The sand was drilled and sampled over an interval of nearly 70 m and is relatively uniform down to a depth of greater than 80 m below ground surface. Occasional silt and clay interbeds are distributed throughout.

5.1.2 Permafrost and Ground Ice

Ice-bonded permafrost extended from the surface to the limit of drilling at 80 m; preliminary ground temperature data are presented on Figure 3 and described in Section 5.1.3.

As far as ground ice is concerned, the near surface alluvial deposits and till/diamicton typically include 15 to 25 percent and 5 to 7 percent, respectively, of random, reticulate and stratified visible ice (Photos 1 and 2, Appendix "D"). The sands are well bonded but without visible ice, while the intra-sand clay seams may have very little visible ice or up to 30 to 40 percent random and reticulate visible ice (Photos 3 and 4).

5.1.3 Ground Temperatures

A multi-thermistor cable was installed to a depth of 69 m in borehole HA83-D1 on completion. Details are provided in Appendix "E". Preliminary (i.e. not yet equilibriated) data, from the initial two sets of readings are plotted on Figure 3. These indicate ground temperatures of -4° to $-5^{\circ}C$ between depths of 10 m and 65 m, and considerably lower values close to the ground surface.

5.2 BOREHOLE HA83-D2

This boring was completed to a final depth of 95.4 m, at a site some 300 m northwest of Illisarvik (Figure 2). Prime objective was to investigate subsurface stratigraphic and permafrost conditions within the Tununuk Low Hills (Pleistocene Delta) portion of the study area. Plates A8 to A16, in Appendix "A", show the log for the borehole, while

Insert Figure 3

laboratory test data are summarized on Table 2 (Appendix "B"). Preliminary ground temperature data are presented on Figure 4.

5.2.1 Surficial Geology and Stratigraphy

Beneath a shallow surficial peat and organic silt stratum, borehole HA83-D2 initially intersected some 4 m of interbedded silt and minor clay. These deposits are likely of alluvial, lacustrine or eolian origin. None of the material was identified, either visually or on the basis of laboratory testing, as till/diamicton. The silts and clays are underlain by a thick sequence of fine to medium Pleistocene sand. Except for a high ice content silty clay lens at a depth of around 20 m, the sands were logged, apparently without any great variation to the limit of drilling of 95.4 m (Plates A8 to A16).

5.2.2 Permafrost and Ground Ice

Ice-bonded permafrost was encountered throughout the depth interval drilled in borehole HA83-D2.

In the upper part, the interbedded silts and clays characteristically have visible random and stratified ground ice (Photo 5, Appendix "D"). Between depths of about 2 to 3 m, some ice crystals were present as well as sections of pure ice and high ice-content silt (Photo 6). The silty sands below a depth of about 4.6 m are well-bonded and generally lack visible ice. One exception is an ice-rich silty clay zone, at a depth of about 20 m to 22 m (Photo 7).

Insert Figure 4

5.2.3 Ground Temperatures

A 91.4 m long multi-thermistor cable was installed in this borehole at the completion of drilling; details of the installation are provided in Appendix "E". Due to the time constraints of the field program, it was only possible to measure ground temperatures on two occasions: after completion of the installation and prior to demobilization from the site. These initial readings, which have obviously not equilibriated, are plotted on Figure 4.

5.3 BOREHOLE HA83-M1

This borehole was located on an inlier of Pleistocene deltaic deposits, at a site some 6.5 km northwest of Illisarvik (Figure 2). The borehole log is presented on Plates A17 and A18, and a summary of the laboratory test data is provided on Table 3 (Appendix "B").

5.3.1 Surficial Geology and Stratigraphy

From the surface to a depth of about 3 m, borehole HA83-M1 encountered ice-rich alluvial silt. The silt was underlain by a clay till/diamicton deposit that was some 4 m thick. Beneath the till/diamicton, greater than 14 m of Pleistocene sand was intersected, extending to the limit of drilling at a depth of 21.0 m.

5.3.2 Permafrost and Ground Ice

Ice-bonded permafrost was presented for the full depth of the borehole. In general, random vein ice is characteristic of the silt and till/diamicton strata, while the sand is well

bonded and lacking visible ice. Two significant ground ice masses were also encountered: between 0.6 m and about 3 m, ice and silt separates the surficial silt and till deposits, and between 19.5 m and 20.3 m a mass of ice and silty sand occurs within the Pleistocene sand (Photo 8, Appendix "D").

5.4 BOREHOLE HA83-M2

This boring was intended to be located in the centre of Swan Channel. As shown on Figure 2, however, it was inadvertently located some 10 m too far east (borehole HA83-M2A was subsequently put down at the initially considered location). Subsurface conditions are shown on Plate A19, and laboratory testing data summarized on Table 4 (in Appendix "B").

5.4.1 Surficial Geology and Stratigraphy

Silt, of modern alluvial origin, was encountered from the ground surface at this location. Based on logging of auger cuttings, the silt is underlain, at a depth of about 3.5 m, by silty, medium plastic, clay till/diamicton. The till/diamicton rests in turn, on fine to medium grained silty Pleistocene sand. A clayey silt layer, likely a thin seam within the sand, was intersected at the bottom of the borehole.

5.4.2 Permafrost and Ground Ice

Although situated only a short distance from Swan Channel, permafrost and ground ice conditions are quite different from those beneath the channel (in borehole HA83-M2A).

Ice-bonded permafrost extends from the surface to the limit of drilling. Stratified ice is characteristic of the near-surface alluvial silt deposits. At greater depth, the till/diamicton and Pleistocene sand are well bonded, with no visible ice. A thin clayey silt seam encountered at the bottom of the borehole again exhibits stratified ice.

5.5 BOREHOLE HA83-M2A

This boring was put down in the centre of Swan Channel, a small distributary of the Mackenzie River that flows into Mallik Bay, approximately 4.5 km southwest of Illisarvik (Figure 2). Objectives were to investigate stratigraphy and the extent of talik zone development beneath the channel. The log for borehole HA83-M2A is presented on Plate A20; laboratory test data are summarized on Table 5, Appendix "B".

5.5.1 Surficial Geology and Stratigraphy

The borehole was drilled through 1.7 m of ice and 1 m of water to the channel bottom, below which some 1.8 m of alluvial silt was encountered, overlying approximately 3 m of silty clay till/diamicton. Logging of the boundary between the two deposits was difficult due to the soft to firm consistency of the deposits. Fine to medium, Pleistocene sand was encountered at a depth of 7.5 m, and extended to the limit of drilling at 10.6 m below ice surface.

5.5.2 Permafrost and Ground Ice

As shown on Plate A20, ice-bonded permafrost was encountered in borehole HA83-M2A at a depth of 9 m below ice surface. This suggests that a talik zone approximately 6.3 m thick is

present. The sand between a depth of 9 m and the bottom of the hole was well-bonded, with no visible ice.

5.6 BOREHOLE HA83-M4

This borehole was located close to the centre of Mallik Bay, some 3 km east of Illisarvik (Figure 2). It was drilled from the ice surface, through 1.6 m of ice and 10 m of water, into the sea bottom, which it penetrated to a depth of 11 m. Prime objective in drilling at this location was to provide data on the composition of the bottom sediments. The log for borehole HA83-M4 is presented on Plates A21 and A22. Laboratory test data are summarized on Table 6 (Appendix "B").

5.6.1 Surficial Geology and Stratigraphy

This boring intersected soft to very soft clayey silt deposits, from the sea bed to the limit of drilling. The deposits are dark grey to black in colour, are of variable, low to high, plasticity and tend to be organic-rich, especially close to the sea bed. The clayey silts are interpreted to be of recent (Holocene) marine origin.

5.6.2 Permafrost and Ground Ice

Ice-bonded permafrost material was not encountered in borehole HA83-M4. In view of the depth of water at the site (11.6 m), this is to be expected. Indeed, the water depth and width of Mallik Bay at this point would suggest that a through-going talik zone may be present beneath this site. At the same time, it is probable that permafrost underlies the shallower water around the margins of the bay.

5.7 BOREHOLE HA83-M8

The log for this boring is presented on Plate A23 and A24 (Appendix "A"). As shown on Figure 2, borehole HA83-M8 was located on the beach immediately west of the outlet from Illisarvik to investigate stratigraphy and permafrost conditions in an area of active coastal retreat. Laboratory test data are summarized on Table 7, in Appendix "B".

5.7.1 Surficial Geology and Stratigraphy

A uniform sequence of fine to medium sand, with silt laminations (Photo 9, Appendix "D") and occasional, generally, thin, silt and clay seams, was encountered from the surface to the limit of drilling at 20.8 m. At a depth of about 14 m to 16 m, a thicker lens of silt, low to medium plastic clay was also intersected.

5.7.2 Permafrost and Ground Ice

Borehole HA83-M8 penetrated frozen ground for its entire depth. In general, the sands were well bonded with no visible ice (Photo 9), while random ice veining was characteristic of the silty clay lens. The ice veins in the clay were up to about 10 mm thick, and constituted 15 to 20 percent of the sample (Photo 10).

6.0 CONCLUSIONS AND RECOMMENDATIONS

Overall, the main conclusion to be drawn on the basis of the results of this study is that subsurface stratigraphic, permafrost and ground ice conditions are similar to those described in our 1982 report on surficial geology mapping. At

part of the continuing studies at Illisarvik, the following additional work is recommended:

i) Monitoring of the multi-thermistor cables installed in boreholes HA83-D1 and HA83-D2 should be continued on a regular basis.

ii) In the event, drilling capability again exists at Illisarvik (for example, the EMR "jet drill"), consideration should be given to putting down a number of additional shallow borings. Possible sites would include: a site in the Kitigazuit Low Hills (not accessible during this study), and one within the tidal flats area west of Illisarvik (to investigate whether the till/diamicton occurs at this location).

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APPENDIX "A"

BOREHOLE LOGS

BOREHOLE LOG

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D1

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 1800 hrs. March 10	FINISH: 1900 hrs. March 14
PROJECT NO. CG10065	TERRAIN TYPE: fAd	LOCATION: UTM 511600E 7705100N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0	ML/OL		ICE and PEAT fibrous, brown	ICE		C1			Sn = 0.96‰
1			SILT low plastic, trace fine sand, abundant organics, grey – black	Vr 20-25%		C2			Sn = 1.19‰
			-- trace to some organics, laminated, grey			C3			
	ML		ICE + SILT	ICE+ ML					
2	ML		SILT as above, some ice veinlets (<1mm thick), grey	Vr 20-25%		C4			Sn = 0.86‰
				Vs 15-20%		C5			
3				Vs 5%		C6			Sand 2.5% Silt 90% Clay 7.5% Sn = 2.42‰
						C7			
4				Vs 20-25%		C8			Sn = 0.70‰
5	CL		CLAY silty, low plastic, little sand, grey	Nbn		C9			Sn = 1.75‰
	SP		SAND fine to medium grained, trace silt and gravel, brown, dense						
	ML		SILT clayey, low to medium plastic, grey			C10			
6	OL/ML		-trace sand and clay, peaty inclusions, odoriferous, dark grey			C11			Sn = 2.34‰
	SM		SAND fine to coarse, silty, little gravel (to 15mmϕ), trace organic silt	Vc < 3%					
7	CL		CLAY (Till) silty, low plastic, sandy, trace fine gravel, grey	Vr 5-7%		C12			Sand 36% Silt 41% Clay 23% Sn = 4.53‰
			-occasional ice lens to 4-5mm			C13			
8			-trace gravel, to 20mmϕ, rounded			C14			Sn =2.54‰
9									Sn = 2.12‰
			--- reticulate ice veining			C15			
10									Sn = 3.33‰
11	SM		SAND fine to medium, silty, dense, grey	Nbn					From cuttings

PLATE A1

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D1

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 1800 hrs. March 10	FINISH: 1900 hrs. March 14
PROJECT NO. CG10065	TERRAIN TYPE: fAd	LOCATION: UTM 511600E 7705100N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
12	SM		SAND fine to medium, silty, dense, grey	Nbn					
13									
14									
15									
16						C16			Sn = 1.24‰
			--- occasional silt laminations						
17									
18									
19									
20			--- occasional silt layers, to 15mm			C17			Sn = 1.77‰
21									
22									

PLATE A2

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D1

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 1800 hrs. March 10	FINISH: 1900 hrs. March 14
PROJECT NO. CG10065	TERRAIN TYPE: fAd	LOCATION: UTM 511600E 7705100N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
23	SM		SAND fine to medium, silty, dense, grey	Nbn					
24									
25						C18			Sand 78% Silt 16% Clay 6% Sn = 2.99‰
26									
27									
28									
29									
30			--- occasional silt laminations			C19			Sn = 3.25‰
31									
32									
33									
34									

2044.2

PLATE A3

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D1

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 1800 hrs. March 10	FINISH: 1900 hrs. March 14
PROJECT NO. CG10065	TERRAIN TYPE: fAd	LOCATION: UTM 511600E 7705100N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
35	SM		SAND fine to medium, silty, dense, grey						
			--- silt laminations, horizontal						Sn = 8.72‰
			--- organic layer (4mm)	Nbn		C20			
36									
37									
38									
39									
40									
41									
42									
43									
44									
45									

PLATE A4

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D1

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 1800 hrs. March 10	FINISH: 1900 hrs. March 14
PROJECT NO. CG10065	TERRAIN TYPE: fAd	LOCATION: UTM 511600E 7705100N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ● 1200 1400 1600 1800

MOISTURE CONTENT % 20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
46	SM		SAND fine to medium, silty, dense, grey	Nbn					
47									
48									
49									
50			occasional peat layers, and silt laminations			C21			Sn = 7.31‰
51	CL / SP		CLAY silty, medium, plastic, trace fine sand, grey, some reticulate ice SAND fine to medium, grey-brown, some silty interbeds, to 40mm, and organic inclusions	Vr 40% Nbn					
52									
53									
54									
55									
56									
57									

PLATE A5

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D1

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 1800 hrs. March 10	FINISH: 1900 hrs. March 14
PROJECT NO. CG10065	TERRAIN TYPE: fAd	LOCATION: UTM 511600E 7705100N	

W_p - ⊡ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
58	SP		SAND fine to medium, grey-brown, some silt interbeds and organic inclusions	Nbn					
59									
60									
61			--- clean, grey, faint foreset bedding (~15°)			C22			Sand 93% Silt 6.5% Clay 0.5% Sn = 1.93‰
62									
63									
64									
65									
66									
67									
68									
69									

PLATE A6

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D1

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 1800 hrs. March 10	FINISH: 1900 hrs. March 14
PROJECT NO. CG10065	TERRAIN TYPE: fAd	LOCATION: UTM 511600E 7705100N	

W_p - ⊡ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
69	SP		SAND fine to medium, grey-brown, some silt interbeds and organic inclusions	Nbn					
70	OL ML		SILT and CLAY trace fine sand, brown-grey, low to medium plastic, wood fragments to 5mmϕ, organic -1mm ice lens			C23			Sn = 15.76‰ Sand 3% Silt 72% Clay 25%
71			? ?	F					From drilling
72	SM		SAND						
73									
74									
75									
78									
79									
80			Bottom of Hole at 80.0m 51mm PVC pipe, filled with diesel, installed to 50.0m Thermistor cable installed to 69.0m						

PLATE A7

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D2

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 0300 hrs. March 15	FINISH: 0800 hrs. March 17
PROJECT NO. CG10065	TERRAIN TYPE: dMv/Md-$\overline{K}$	LOCATION: UTM 516200E 7708300N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0	Pt OL		PEAT fibrous, brown, occasional ice lenses, to 5mm some organic silt	Vr 10%		C1			Sn = 0.86‰ Sand 17% Silt 61% Clay 22%
	ML		SILT trace clay, non plastic, little fine sand, trace fine gravel, grey			C2			Sn = 1.40‰
1	CL		CLAY some silt, low plastic, little fine sand, brown	Vs 10-30%		C3			Sand 51% Silt 27% Clay 22% Sn = 1.94‰
2			SILT very sandy, little clay, non plastic, some rootlets and peat inclusions, brown						
	ML			Vx 10%	+	C4			Sn = 3.13‰
			ICE	ICE	+				
3	ML		ICE + SILT trace fine sand and gravel, brown	ICE + ML		C5			Sn = 0.53‰
	ML		SILT sandy, little clay, non plastic, occasional rootlets, shell fragments, grey occasional sand layers, fine to medium	Vr 10%		C6			Sn = 2.89‰
4			ice lens, 50mm thick			C7			Sand 44% Silt 38% Clay 18% Sn = 1.22‰
				Vr 15-20%		C8			Sn = 2.54‰
5	SM		SAND fine to medium, silty, non plastic brown, faint foreset bedding 30mm silty clay lens	Nbn					
6									
7			ice in cuttings indicate ice-rich zone						
8									
9									
10			occasional random ice lenses (1mm-2mm) and silt laminations			C9			Sand 70.5% Silt 23% Clay 6.5% Sn = 6.29‰
11									

114.9
1758.4

PLATE A8

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D2

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 0300 hrs. March 15	FINISH: 0800 hrs. March 17
PROJECT NO. CG10065	TERRAIN TYPE: dMv/Md-R	LOCATION: UTM 516200E 7708300N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
12	SM		SAND fine to medium, sitly, non plastic, brown	Nbn					
13									
14									
15									
16									
17									
18									
19									
20	SM		--- fine, very silty			C10			Sand 66% Silt 28% Clay 6% Sn = 7.99‰
21	CL		ICE + CLAY	ICE + CL					Sn = 14.99‰
22	SM		SAND fine to medium, silty, brown	Nbn					

⊙ 2040.7 ●

PLATE A9

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D2

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 0300 hrs. March 15	FINISH: 0800 hrs. March 17
PROJECT NO. CG10065	TERRAIN TYPE: dMv/Md-K	LOCATION: UTM 516200E 7708300N	

W_p - ⊡ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
24	SM		SAND fine to medium, silty, brown	Nbn					
25									
26									
27									
28									
29									
30						C11			Sn = 1.18‰
31									
32									
33									
34									

PLATE A10

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D2

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 0300 hrs. March 15	FINISH: 0800 hrs. March 17
PROJECT NO. CG10065	TERRAIN TYPE: dMv/Md-$\bar{K}$	LOCATION: UTM 516200E 7708300N	

W_p - ▫ W - ⊙ W_L - ▵

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
35	SM		SAND fine to medium, silty, brown	Nbn					
36									
37									
38									
39									
40									
41			--- 50mm silt layer, brown --- 5mm organic layer			C12			Sn = 1.14‰
42									
43									
44									
45									

○ 2047 ●

PLATE A11

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D2

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 0300 hrs. March 15	FINISH: 0800 hrs. March 17
PROJECT NO. CG10065	TERRAIN TYPE: dMv/Md-R	LOCATION: UTM 516200E 7708300N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
47	SM		SAND fine to medium, silty, brown	Nbn					
48									
49									
50									Sand 97% Fines 3%
51	SP		fine, very clean, grey	Nbn F		C13			Sn = 8.46‰
52									Remainder of hole logged from cuttings
53									
54									
55									
56									
57									

PLATE A12

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D2

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 0300 hrs. March 15	FINISH: 0800 hrs. March 17
PROJECT NO. CG10065	TERRAIN TYPE: dMv/Md-$\bar{K}$	LOCATION: UTM 516200E 7708300N	

W_p - ⊡ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
58	SM		SAND (cont'd)	F					Logged from cuttings
59									
60									
61									
62									
63									
64									
65									
66									
67									
68									

PLATE A13

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D2

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 0300 hrs. March 15	FINISH: 0800 hrs. March 17
PROJECT NO. CG10065	TERRAIN TYPE: dMv/Md-K	LOCATION: UTM 516200E 7708300N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
70	SM		SAND (cont'd)	F					Logged from cuttings
71									
72									
73									
74									
75									
76									
77									
78									
79									
80									

PLATE A14

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D2

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 0300 hrs. March 15	FINISH: 0800 hrs. March 17
PROJECT NO. CG10065	TERRAIN TYPE: dMv/Md- K	LOCATION: UTM 516200E 7708300N	

W_p - ⊡ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
81	SM		SAND (cont'd)	F					Logged from cuttings
82									
83									
84									
85									
86									
87									
88									
89									
90									
91									

PLATE A15

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-D2

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Tricone/CRREL	START: 0300 hrs. March 15	FINISH: 0800 hrs. March 17
PROJECT NO. CG10065	TERRAIN TYPE: dMv/Md-K	LOCATION: UTM 516200E 7708300N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
93	SM		SAND (cont'd)	F					Logged from cuttings
94									
95									
96			Bottom of Hole at 95.4m 50mm PVC pipe installed to 70m Thermistor cable installed to 91.5m						
97									
98									
99									
100									

PLATE A16

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-M1

LOGGED BY: MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Auger/CRREL	START: 0200 hrs. March 18	FINISH: 0720 hrs. March 18
PROJECT NO.: CG10065	TERRAIN TYPE: dMv/Md	LOCATION: UTM 512800E 771352N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0	OL		SILT organic, rootlets, brown	Vr 15%		C1			Sn = 0.93‰
	ML		SILT some fine sand, occasional peat layers and ice lenses to 10mm	Vr 20%					Sn = 1.11%
	ML		ICE + SILT	ICE +					
3	CL		CLAY (Till) silty, sandy, low plastic, trace fine gravel, grey-brown						From cuttings
5				Vr 20%		C2			Sn = 1.96‰ Sand 30% Silt 47% Clay 23% Sn = 3.05‰
7	SM		SAND fine to medium, trace to some silt, dense, brown, occasional ice veinlets (to 3mm)	Nbn					From cuttings
10						C3			Sn = 1.24‰

PLATE A17

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-M1

LOGGED BY: MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Auger/CRREL	START: 0200 hrs. March 18	FINISH: 0720 hrs. March 18
PROJECT NO.: CG10065	TERRAIN TYPE: dMv/Md	LOCATION: UTM 512800E 771352N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
12	SM		SAND fine to medium, trace to some silt, brown	Nbn					
13									
14									
15			fine to medium, some silt lenses, dense, brown			C4			Sand 83% Silt 12.5% Clay 4.5% Sn = 3.26‰
16									
17									
18									
19									
20			ICE with trace of silty sand	ICE +					Sn = 0.58‰
21			SAND fine to medium, some silt, grey, dense, occasional ice veins (ICE + from 20.55 to 20.65m)	Nbn / ICE + / Nbn		C5			Sn = 3.50‰
22			Bottom of Hole at 21.0m						

316.8

PLATE A18

BOREHOLE LOG

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-M2

LOGGED BY: MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Auger/CRREL	START: 2115 hrs. March 18	FINISH: 2330 hrs. March 18
PROJECT NO.: CG10065	TERRAIN TYPE: fMp	LOCATION: UTM 513704E 7703750N	

W_p - □ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
			ICE	ICE					Sand 0 Silt 89% Clay 11%
1	ML / MH		SILT trace clay, non to low plastic, occasional fine to medium sand lenses, grey --clayey, medium to high plastic, trace fine gravel, to 10mmϕ	Vs 10%					Sn = 1.47‰ Sn = 2.32‰ Sn = 4.9‰
2				Vs 10-15%					
3									From cuttings
4	CI		CLAY (Till) silty, medium plastic, some sand, trace gravel, grey, occasional ice veins, to 5-7mm						
5				Nbn		C2			Sn = 4.02‰ Sand 30% Silt 48% Clay 22%
6									Sn = 3.00‰
7	SM		SAND fine to medium, some silt, trace clay, dense, grey, occasional ice veins to 4mm						From cuttings
8				Nbn					
9									
10						C3			Sn = 1.05‰ Sn = 1.39‰
11	ML		SILT clayey, low plastic, trace fine sand, grey	Vs 10%					
			Bottom of Hole at 10.9m						

PLATE A19

BOREHOLE LOG

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-M2A

LOGGED BY: MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Auger/CRREL	START: 2345 hrs. March 18	FINISH: 0230 hrs. March 19
PROJECT NO. CG10065	TERRAIN TYPE:	LOCATION: UTM 513740E 7703750N	

W_p - ⊡ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
1		ICE	ICE					
2		WATER						
3	ML	SILT trace sand and clay, low plastic, soft, dark grey, wet	UF		B1			Sand 12% Silt 79.5% Clay 8.5% Sn = 2.61‰
4								
5	CI	CLAY (Till) silty, medium plastic, little sand, occasional coal particles, firm, brown, moist			B2			Sn = 22.11‰
6								
7								
8	SM	SAND fine to medium, silty, dense, grey						
9			Nbn					
10					C1			Sand 68% Silt 27% Clay 5% Sn = 1.42‰
11		Bottom of Hole at 10.6m						

PLATE A20

BOREHOLE LOG

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-M4

LOGGED BY: GD	DRAWN BY: AK	CHECKED: IJ	DATE: March 1983
RIG: CME 750	METHOD: Auger	START: 1210 hrs March 18	FINISH: 1635 hrs. March 18
PROJECT NO. CG10056	TERRAIN TYPE:	LOCATION: UTM 519500E 7707000N	

W_p - ▫ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
1			ICE	ICE					
2			WATER						
3									
4									
5									
6									
7									
11			WATER						
12	ML/OL		SILT organic, trace to some clay, black, very soft	UF		B1			Sand 0.5% Silt 82.5% Clay 17% Sn = 10.01%.
13									

PLATE A21

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-M4

LOGGED BY: GD	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Auger	START: 1210 hrs. March 18	FINISH: 1635 hrs. March 18
PROJECT NO.: CG10056	TERRAIN TYPE:	LOCATION: UTM 519500E 7707000N	

W_p - ⊡ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
14	ML/OL		SILT organic, trace to some clay, black, very soft	UF					
15	MH		clayey, trace fine sand, high plastic, dark grey, soft			B2			Sand 1.5% Silt 68.5% Clay 30% Sn = 3.34‰
16									
17									
18									
19									
20									
21									
22	CL		clayey, sandy, low plastic, dark grey, soft			A1			Sand 18% Silt 62% Clay 20% Sn = 3.01‰
			Bottom of Hole at 22.6m						

PLATE A22

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-M8

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Auger/CRREL	START: 1800 hrs. March 17	FINISH: 2330 hrs. March 17
PROJECT NO. CG10065	TERRAIN TYPE: fMp	LOCATION: UTM 515850E 7707900N	

W_p - ⊡ W - ⊙ W_L - ▵

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800

MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
			ICE	ICE					
1	SC		SAND fine to medium, trace clay, brown, horizontally laminated 20mm thick organic lens	Nbn		C1			Sn = 3.21‰
5			fine, trace to some clay			C2			Sand 84.5% Silt 3.5% Clay 12% Sn = 3.41‰
10	SM		trace to little silt, with occasional silt layers to 10mm			C3			Sn = 3.32‰

PLATE A23

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
GEOTECHNICAL DIVISION

BOREHOLE LOG

ILLISARVIK WINTER DRILLING PROGRAM

BOREHOLE NO. HA83-M8

LOGGED BY: GD/MM	DRAWN BY: AK	CHECKED: IJ	DATE: March, 1983
RIG: CME 750	METHOD: Auger/CRREL	START: 1800 hrs. March 17	FINISH: 2330 hrs. March 17
PROJECT NO.: CG10065	TERRAIN TYPE:	LOCATION: UTM 515850E 7707900N	

W_p - ⊡ W - ⊙ W_L - △

BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	SOIL GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	ICE GRAPHIC SYMBOL	SAMPLE TYPE & NO.	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
12	SC		SAND fine to medium, trace to little silt, with occasional silt layers to 10mm	Nbn					
13									
14	CI		CLAY silty, medium plastic, trace fine sand, grey						
15	SP		SAND fine to medium, trace silt, dense, grey			C4			Sand 12% Silt 65.5% Clay 22.5% Sn = 13.39‰ Sn = 11.39‰ Sn = 9.62‰
16	CL		CLAY silty, low plastic, occasional ice lenses to 10mm, occasional silt layers, grey	Vr 15-20%					
17	SM		SAND fine to medium, silty, dense, grey	Nbn					
18									
19									
20			--- 20mm thick silt lens			C5			Sn = 5.45‰
21			Bottom of Hole at 20.8m						
22									

PLATE A24

APPENDIX "B"

LABORATORY TEST RESULTS

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

TABLE I
SUMMARY OF LABORATORY TEST RESULTS
BOREHOLE HA83-D1

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS		
					ATTERBERG LIMITS			TEXTURE (%)					
SAMPLE Nº	DEPTH (m)	MODIFIED USC	SOIL DESCRIPTION	MOISTURE CONTENT (%)	LIQUID (WL)	PLASTIC (WP)	PLASTICITY INDEX (IP)	SAND	SILT	CLAY	BULK DENSITY (kg/m^3)	PORE WATER SALINITY (‰)	COMMENTS
C1B	0.35-0.5	ML-OL	SILT trace fine sand, low plastic, abundant organics, grey-black	98.9								0.96	
C2B	0.7-1.0	ML-OL	SILT trace fine sand, non plastic, abundant organics grey	137.9	N/P	N/P	N/P				1199.2	1.19	
C4	2.15-2.3	ML	SILT trace fine sand and organics, laminated, grey	55.1								0.86	
C6	3.25-3.4	ML	SILT trace fine sand and organics, laminated, grey	54.6	22.6	20.7	1.9	2.5	90.5	7.0	1505.9	2.42	Grain Size: Plate B1
C8	4.1-4.4	ML	SILT trace fine sand and organics, laminated grey	76.5								0.70	
C9	4.9-5.2	CL	CLAY silty, low plastic, little sand, grey	45.3								1.75	Top of core wasteslod
C11	6.0-6.6	ML	SILT trace sand and clay, peaty inclusions dark, grey	31.7							1818.7	2.34	
C12	7.2-7.5	CL	CLAY (Till) silty, sandy, trace fine gravel, low plastic, grey	16.3	29.6	13.4	16.2	36.0	41.0	23.0	2082.3	4.53	Grain Size: Plate B2

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

TABLE I
SUMMARY OF LABORATORY TEST RESULTS
BOREHOLE HA83-D1

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS		
					ATTERBERG LIMITS			TEXTURE (%)					
SAMPLE Nº	DEPTH (m)	MODIFIED USC	SOIL DESCRIPTION	MOISTURE CONTENT (%)	LIQUID (WL)	PLASTIC (WP)	PLASTICITY INDEX (IP)	SAND	SILT	CLAY	BULK DENSITY (kg/m^3)	PORE WATER SALINITY (‰)	COMMENTS
C14A	8.0-8.4	CL	CLAY (Till) silty, sandy, trace fine gravel, low plastic, grey	18.0								2.54	
C15A	9.0-9.4	CL	CLAY (Till) silty, sandy, trace fine gravel, low plastic, grey	18.7								2.12	
C15B	9.6-10.0	CL	CLAY (Till) silty, sandy, trace fine gravel, low plastic, grey	17.7							2072.8	3.33	
C16A	16.0-16.1	SM	SAND fine to medium, silty, occasional silt laminations	28.2								1.23	
C17C	20.65-20.9	SM	SAND fine to medium, silty, occasional silt laminations	25.8							1912.3	1.77	
C18	25.0-25.3	SM	SAND fine to medium, silty, occasional silt laminations	19.2	N/P	N/P	N/P	78.0	16.0	6.0		2.99	Grain Size: Plate B3
C19A	30.0-30.2	SM	SAND fine to medium silty, occasional silt laminations	19.7							2044.7	3.25	
C20A	35.0-35.5	SM	SAND fine to medium silty, occasional silt laminations	31.8							1815.6	8.72	

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE HA83-D1

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS		
					ATTERBERG LIMITS			TEXTURE (%)					
SAMPLE Nº	DEPTH (m)	MODIFIED USC	SOIL DESCRIPTION	MOISTURE CONTENT (%)	LIQUID (WL)	PLASTIC (WP)	PLASTICITY INDEX (IP)	SAND	SILT	CLAY	BULK DENSITY (kg/m^3)	PORE WATER SALINITY (‰)	COMMENTS
C21A	50.0-50.2	SM	SAND fine to medium, silty, occasional silt laminations	22.8							2006.0	7.31	
C22B	60.8-60.95	SP	SAND fine to medium, clean, grey	31.3				93.0	6.5	0.5	1854.1	1.93	Grain Size: Plate B4
C23B	70.5-71.0	OL-OH	SILT and CLAY, trace fine sand low to medium plastic, grey-brown, organic, wood to 5 mm Ø	39.8	55.8	47.3	8.5	3.0	72.0	25.0	1665.83	15.76	Grain Size: Plate B5

HARDY ASSOCIATES (1978) LTD.
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TABLE 2
SUMMARY OF LABORATORY TEST RESULTS
BOREHOLE HA83-D2

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS		
					ATTERBERG LIMITS			TEXTURE (%)					
SAMPLE Nº	DEPTH (m)	MODIFIED USC	SOIL DESCRIPTION	MOISTURE CONTENT (%)	LIQUID (WL)	PLASTIC (WP)	PLASTICITY INDEX (IP)	SAND	SILT	CLAY	BULK DENSITY (kg/m^3)	PORE WATER SALINITY (‰)	COMMENTS
C1B	0.5-0.7	OL	SILT organic, brown	114.9							1270.8	0.86	
C2	0.7-1.0	ML	SILT trace clay non plastic little fine sand, trace gravel, grey	42.7	25.9	15.15	10.75	17.0	61.0	22.0		1.40	Grain Size: Plate B6
C3C	1.6-1.8	CL	CLAY some silt, low plastic, little fine sand, brown	23.7	25.3	20.4	4.9	51.0	27.0	22.0	1937.1	1.94	Grain Size: Plate B7
C4A	2.0-2.3	CL	CLAY some silt, low plastic, little fine sand, brown	47.1							1640.7	3.13	
C5	2.7-2.9	ML	ICE + SILT trace fine sand and gravel, brown	1758.4								0.53	
C6B	3.2-3.5	CL ML	SILT sandy, trace clay, non to low plastic, grey	54.7							1599.5	2.89	
C7B	3.9-4.2	CL-ML	SILT sandy, trace clay, non to low plastic, grey	61.8	22.3	13.5	8.8	44.0	38.0	18.0	1498.2	1.22	Grain Size: Plate B8
C8C	4.8-5.0	CL-ML	SILT sandy, trace clay, non to low plastic, grey	67.1								2.54	
C9C	10.0-10.9	SM	SAND fine to medium, silty, brown	27.4				70.5	23.0	6.5	1874.4	6.29	Grain Size: Plate B9
C10A	20.0-20.2	SM	SAND fine to medium, silty, brown	19.5	N/P	N/P	N/P	66.0	28.0	6.0	2040.7	7.99	Grain Size: Plate B10
C10B	20.7-21.0	CL	CLAY silty, trace sand, low plastic, grey-brown	29.9								14.99	

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

TABLE 2
SUMMARY OF LABORATORY TEST RESULTS
BOREHOLE HA83-D2

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS		
					ATTERBERG LIMITS			TEXTURE (%)					
SAMPLE Nº	DEPTH (m)	MODIFIED USC	SOIL DESCRIPTION	MOISTURE CONTENT (%)	LIQUID (WL)	PLASTIC (WP)	PLASTICITY INDEX (IP)	SAND	SILT	CLAY	BULK DENSITY (kg/m^3)	PORE WATER SALINITY (‰)	COMMENTS
C11	30.7-31.0	SM	SAND fine to medium, silty, grey	24.5							1944.9	1.18	
C12A	40.1-40.3	SM	SAND fine to medium, silty, grey	20.7							2047.3	1.14	
C13B	50.5-51.0	SP	SAND fine, very clean, grey	24.0				97.0	--- 3.0 ---		1959.1	8.46	Grain Size: Plate B11

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

TABLE 3
SUMMARY OF LABORATORY TEST RESULTS
BOREHOLE HA83-MI

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS		
					ATTERBERG LIMITS			TEXTURE (%)					
SAMPLE Nº	DEPTH (m)	MODIFIED USC	SOIL DESCRIPTION	MOISTURE CONTENT (%)	LIQUID (WL)	PLASTIC (WP)	PLASTICITY INDEX (IP)	SAND	SILT	CLAY	BULK DENSITY (kg/m^3)	PORE WATER SALINITY (‰)	COMMENTS
C1A	0.0-0.2	OL	SILT organic, trace clay, brown	42.0								0.93	
C1B	0.2-0.6	ML	SILT some fine sand and organics, low plastic	47.6	38.9	29.7	9.2					1.11	
C2B	5.3-5.5	CL	CLAY (?TILL) silty, sandy, low plastic, trace fine gravel, grey-brown	58.2	29.3	16.9	12.4	30.0	47.0	23.0		1.96	Grain Size: Plate B12
C2C	5.5-5.8	CL	CLAY (?TILL) silty, sandy, low plastic, trace fine gravel, grey-brown	52.4							1623.0	3.05	
C3C	10.5-10.85	SM	SAND fine to medium, silty, grey	27.0							1860.0	1.24	
C4B	15.3-15.75	SM	SAND fine to medium, silty, grey	20.9				83.0	12.5	4.5		3.26	Grain Size: Plate B13
C5A	20.0-20.4	SM	ICE + SAND, silty	316.3								0.58	
C5C	20.7-21.0	SM	SAND, fine to medium silty, grey	25.3							1902.5	3.50	

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

TABLE 4

SUMMARY OF LABORATORY TEST RESULTS
BOREHOLE HA83-M2

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS		
					ATTERBERG LIMITS			TEXTURE (%)					
SAMPLE Nº	DEPTH (m)	MODIFIED USC	SOIL DESCRIPTION	MOISTURE CONTENT (%)	LIQUID (WL)	PLASTIC (WP)	PLASTICITY INDEX (IP)	SAND	SILT	CLAY	BULK DENSITY (kg/m^3)	PORE WATER SALINITY (‰)	COMMENTS
C1A	0.3-0.6	ML	SILT trace clay, non to low plastic grey, occas sand lens	47.7	N/P	N/P	N/P	0	89.0	11.0	1647.5	1.47	Grain Size: Plate B14
C1B	0.9-1.2	ML	SILT trace clay, non to low plastic grey, occas sand lens	49.1								2.32	
C1C	1.2-1.5	MH	SILT clayey, medium to high plastic	32.8	91.9	80.3	11.6				1758.0	4.90	
C2A	5.0-5.4	CI	CLAY (Till) silty, medium plastic, trace gravel, grey	20.9								3.00	
C2B	5.6-5.9	CI	CLAY (Till) silty, medium plastic, trace gravel, grey	21.7	32.7	15.4	17.3	30.0	48.0	22.0	1985.6	4.02	Grain Size: Plate B15
C3A	10.3-10.55	SM	SAND fine to medium, some silt and trace clay, grey	27.9								1.05	
C3B	10.55-10.9	SM	SAND fine to medium, some silt and trace clay, grey	24.5							1941.0	1.39	

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

TABLE 5
SUMMARY OF LABORATORY TEST RESULTS
BOREHOLE HA83-2A

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS		
					ATTERBERG LIMITS			TEXTURE (%)					
SAMPLE Nº	DEPTH (m)	MODIFIED USC	SOIL DESCRIPTION	MOISTURE CONTENT (%)	LIQUID (WL)	PLASTIC (WP)	PLASTICITY INDEX (IP)	SAND	SILT	CLAY	BULK DENSITY (kg/m^3)	PORE WATER SALINITY (‰)	COMMENTS
B1	2.7-3.15	ML	SILT trace sand and clay, low plastic, soft, dark grey	28.8	26.5	23.7	2.8	12.0	79.5	8.5		2.61	Unfrozen Grain Size: Plate B16
B2	5.0-5.15	CI	CLAY (Till) silty, little sand, low plastic, firm, brown	21.7								22.11	Unfrozen
C1A	10.0-10.3	SM	SAND fine to medium, silty, dense, grey	25.7	N/P	N/P	N/P	67.5	27.0	4.5	1998.6	1.42	Unfrozen Grain Size: Plate B17

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

TABLE 6

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE HA83-M4

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS		
					ATTERBERG LIMITS			TEXTURE (%)					
SAMPLE Nº	DEPTH (m)	MODIFIED USC	SOIL DESCRIPTION	MOISTURE CONTENT (%)	LIQUID (WL)	PLASTIC (WP)	PLASTICITY INDEX (IP)	SAND	SILT	CLAY	BULK DENSITY (kg/m^3)	PORE WATER SALINITY (‰)	COMMENTS
B1	11.6-14.6	ML	SILT organic, trace to	46.4	31.9	23.0	8.9	0.5	82.5	17.0		10.01	Unfrozen
		-OL	some clay, low plastic,										Grain Size:
			very soft										Plate B-18
B2	15.0-16.0	MH	SILT clayey, trace fine	44.0	76.7	38.5	38.2	1.5	68.5	30.0		3.34	Unfrozen
			sand, high plastic, dark										Grain Size:
			grey, soft										Plate B-19
A1	21.6-22.6	CL	SILT clayey, sandy, low	23.6	24.6	16.3	8.3	18.0	62.0	20.0		3.01	Unfrozen
			plastic, dark grey, soft										Grain Size:
													Plate B-20

HARDY ASSOCIATES (1978) LTD.
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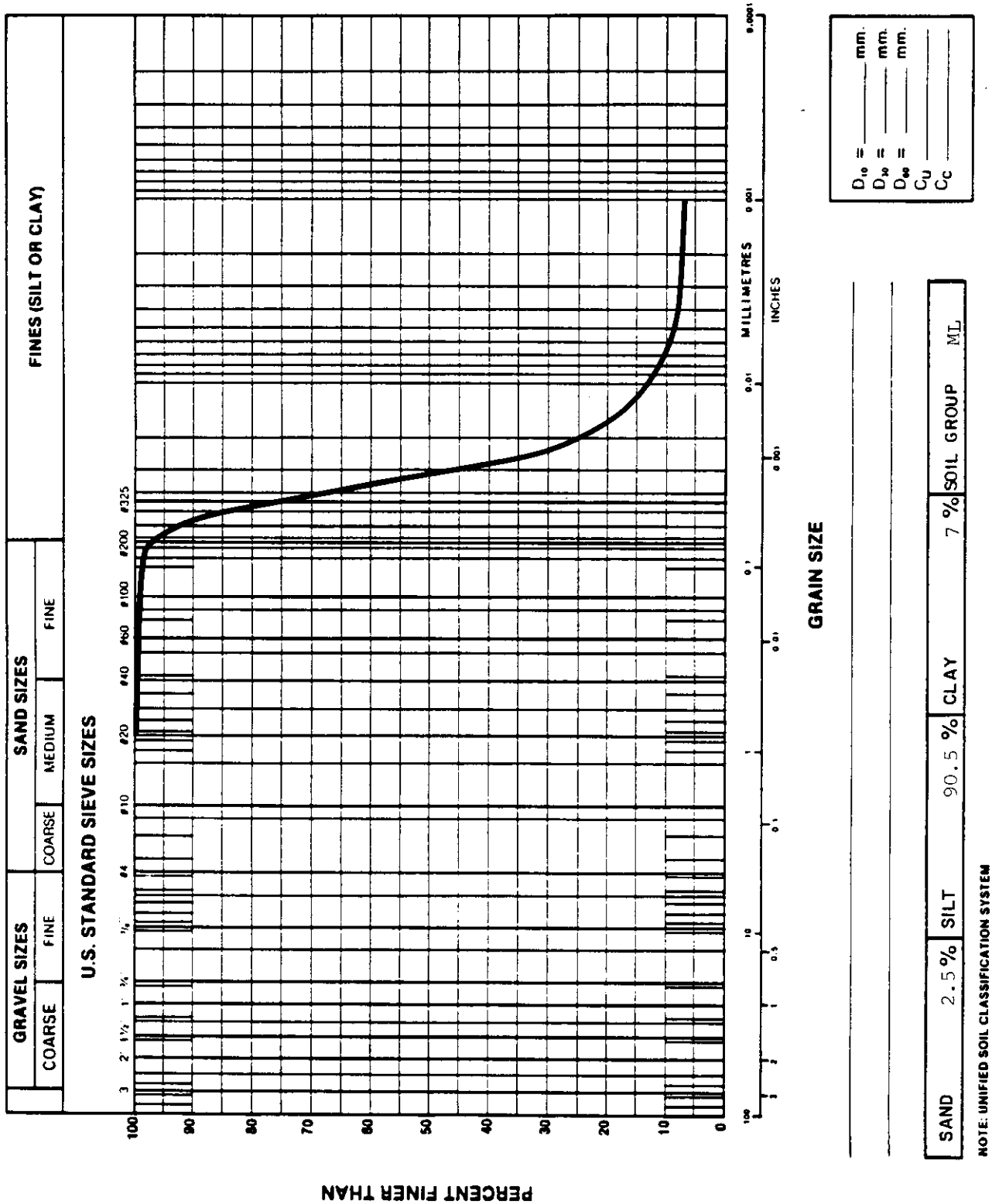
TABLE 7
SUMMARY OF LABORATORY TEST RESULTS
BOREHOLE HA83-M8

SAMPLE DATA					CLASSIFICATION TESTS						OTHER TESTS		
					ATTERBERG LIMITS			TEXTURE (%)					
SAMPLE Nº	DEPTH (m)	MODIFIED USC	SOIL DESCRIPTION	MOISTURE CONTENT (%)	LIQUID (WL)	PLASTIC (WP)	PLASTICITY INDEX (IP)	SAND	SILT	CLAY	BULK DENSITY (kg/m³)	PORE WATER SALINITY (‰)	COMMENTS
C1B	1.0-1.8	SC	SAND fine to medium, trace clay, brown	21.8								3.21	
C2B	5.3-5.55	SC	SAND fine to medium, trace clay, brown	23.9				84.5	3.5	12.0	1957.2	3.41	Grain Size: Plate B21
C3A	10.1-10.25	SC	SAND fine to medium, trace clay, brown	22.0								3.32	
C4A	15.0-15.15	CI	CLAY very silty, medium plastic, grey	29.9	32.7	21.0	11.7	12.0	65.5	22.5		13.39	Grain Size: Plate 22
C4B	15.15-15.4	SP	SAND fine to medium, trace silt, grey	25.1								9.62	
C4C	15.4-15.7	CL	CLAY silty, low plastic, dense, grey	32.1	28.8	21.7	7.1				1847.0	11.39	
C5B	20.4-20.7	SM	SAND fine to medium, silty, dense, grey	20.4							1996.7	5.45	

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-D1
SAMPLE	C6
DEPTH (m)	3.25/3.4
TECHNICIAN	TC
DATE TESTED	83-04-06



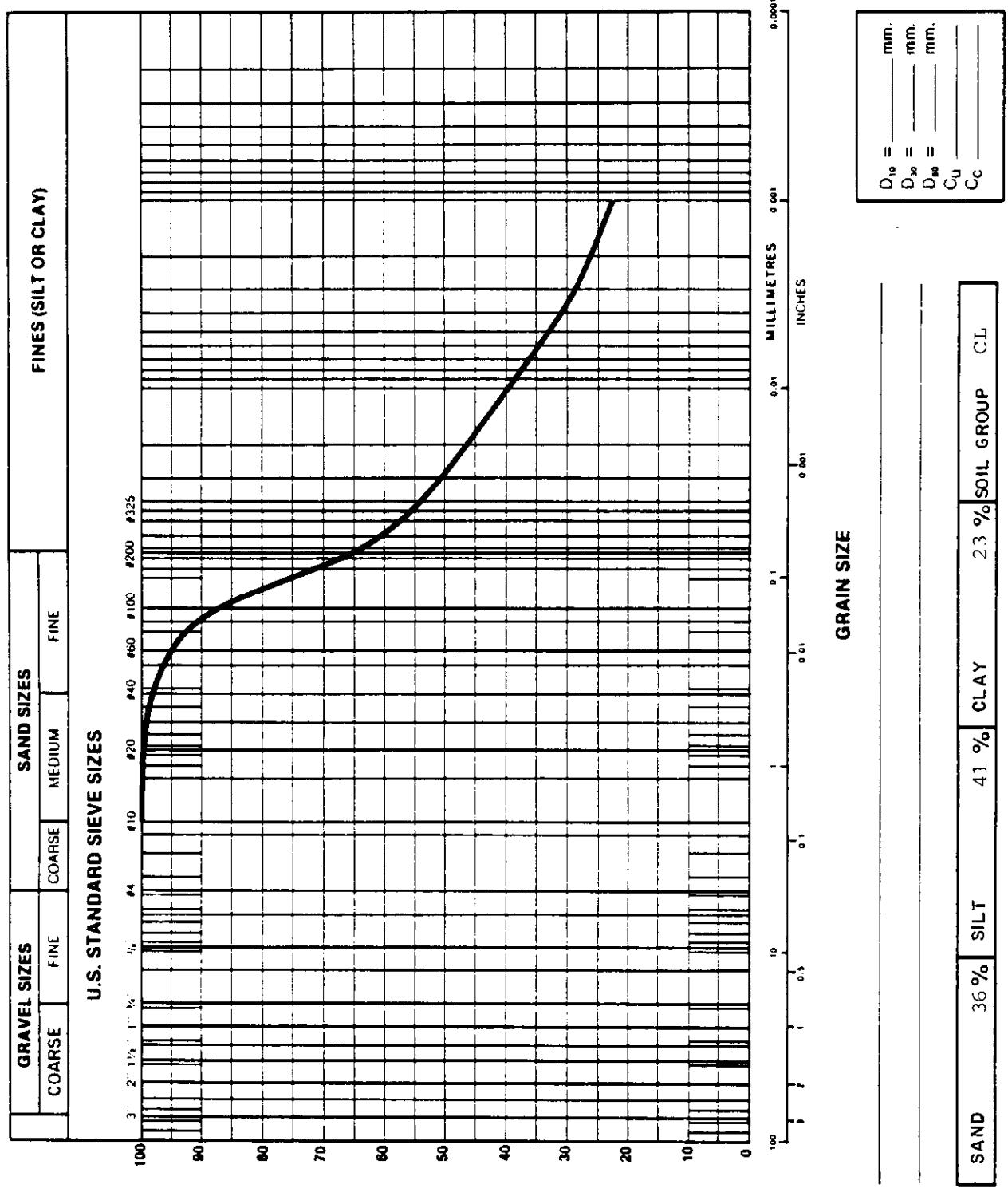
MT 64 80/11

PLATE B1

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-D1
SAMPLE	C 12
DEPTH (m)	7.2/7.5m
TECHNICIAN	TC
DATE TESTED	31-03-83



SAND	SILT	CLAY	SOIL GROUP
36 %	41 %	23 %	CL

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

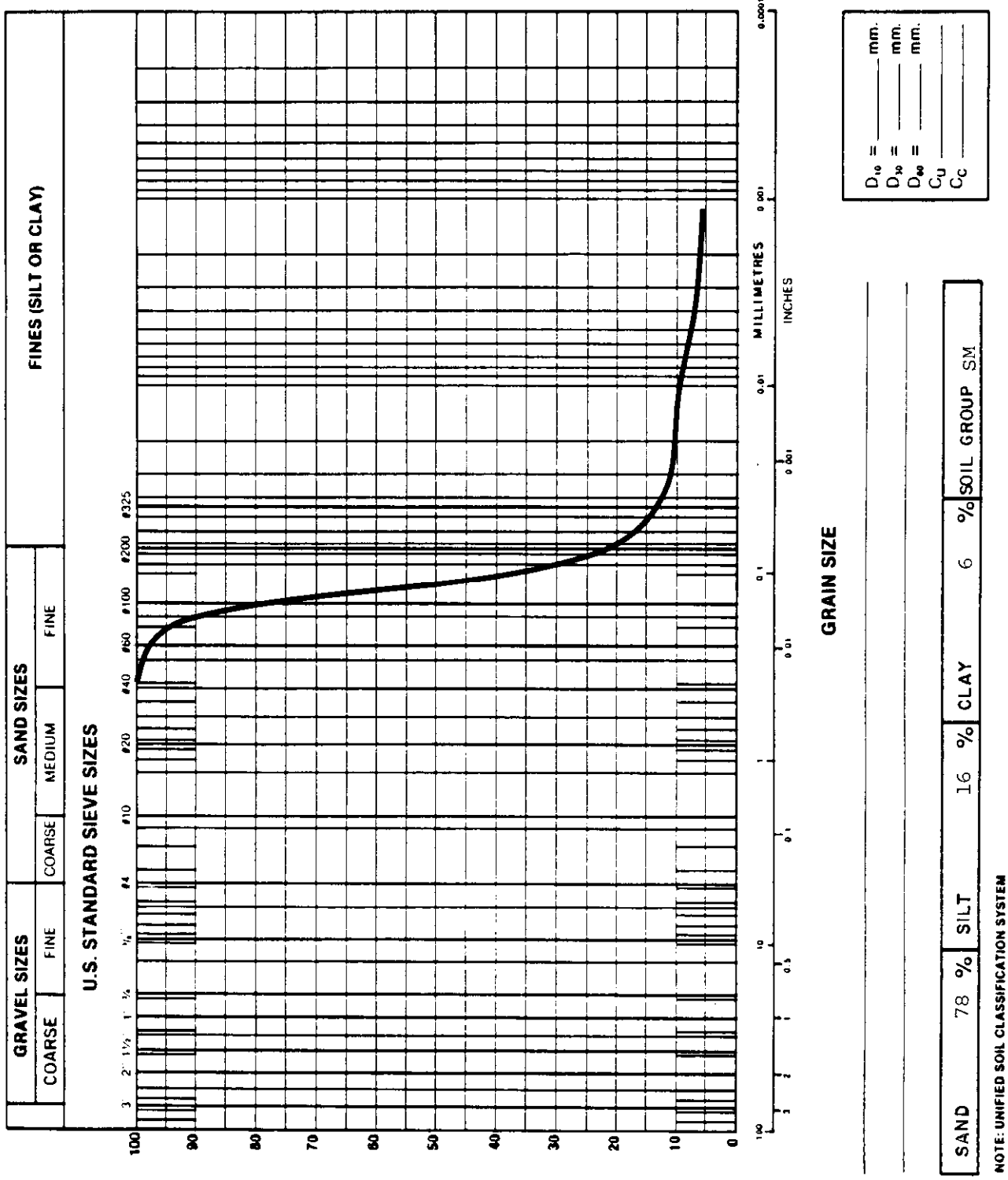
HT 64 60/11

PLATE B2

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-D1
SAMPLE	C 18
DEPTH (m)	25.0/25.3m
TECHNICIAN	TC
DATE TESTED	31-03-83



SAND	%	SILT	%	CLAY	%	SOIL GROUP
78		16		6		SM

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

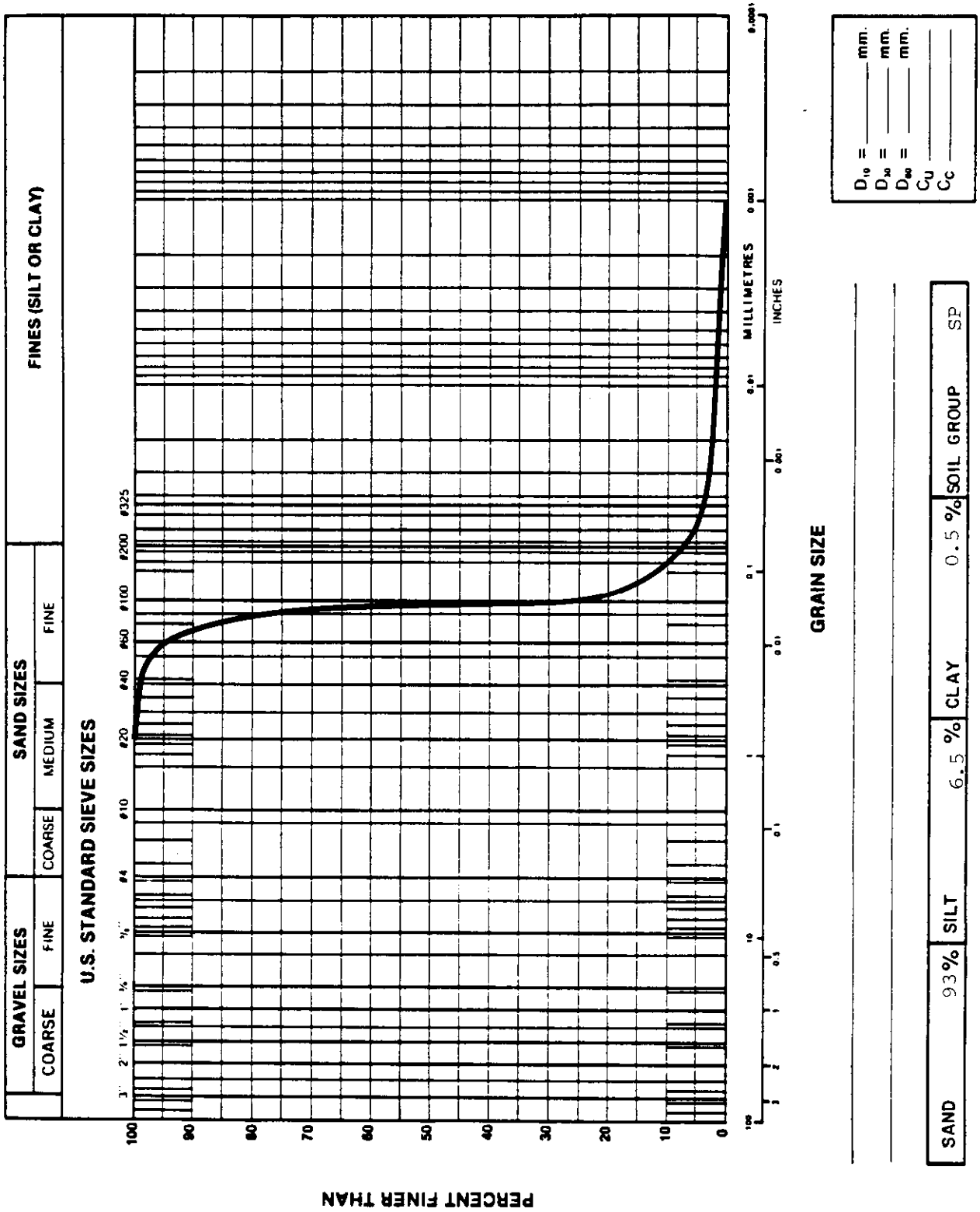
HT 64 80/11

PLATE B3

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-D1
SAMPLE	C22B
DEPTH (m)	60.8/60.95
TECHNICIAN	TC
DATE TESTED	83-04-05



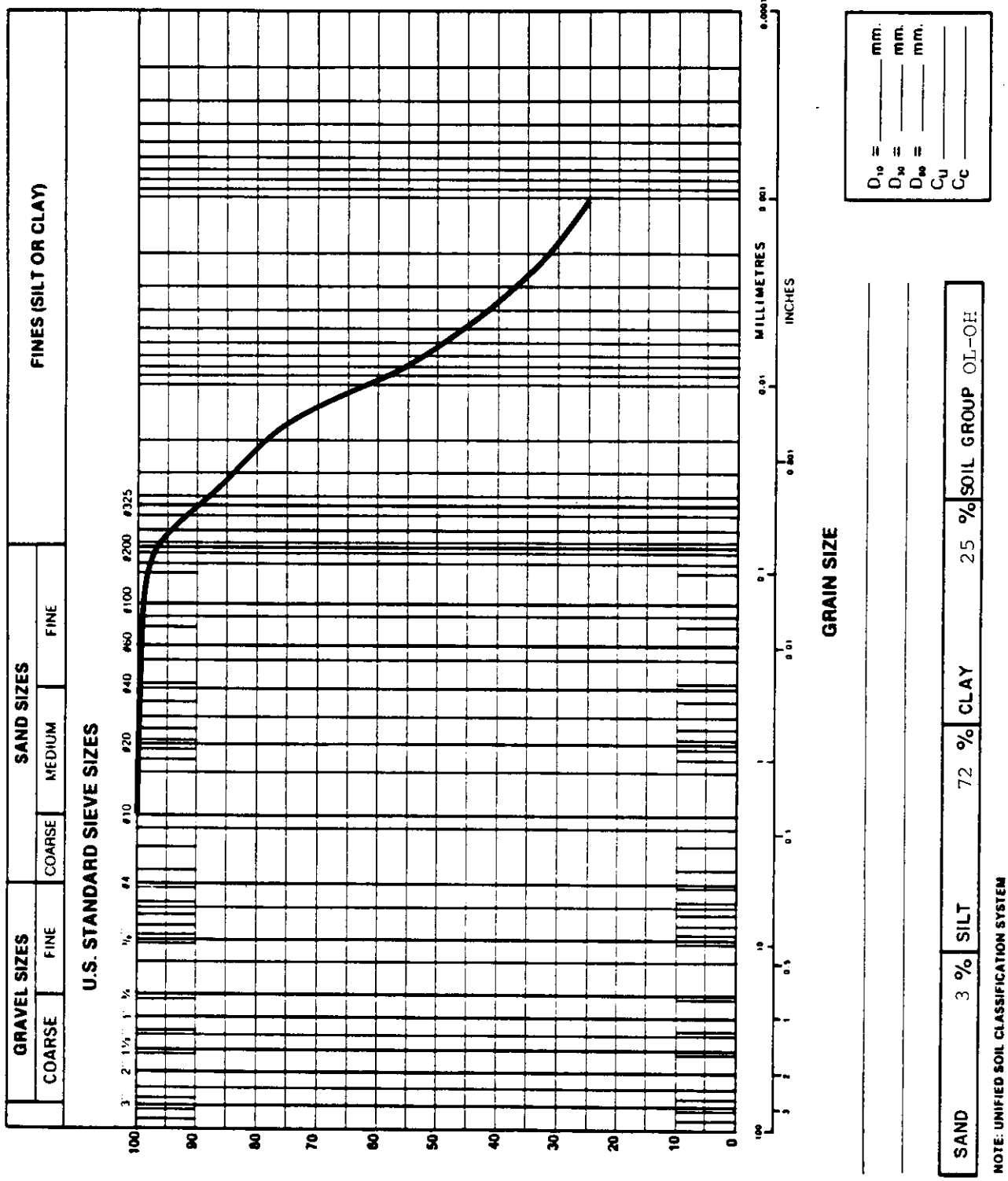
HT 64 80/11

PLATE B4

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-D1
SAMPLE	C23B
DEPTH (m)	70.5-71.0
TECHNICIAN	KS
DATE TESTED	83-04-18



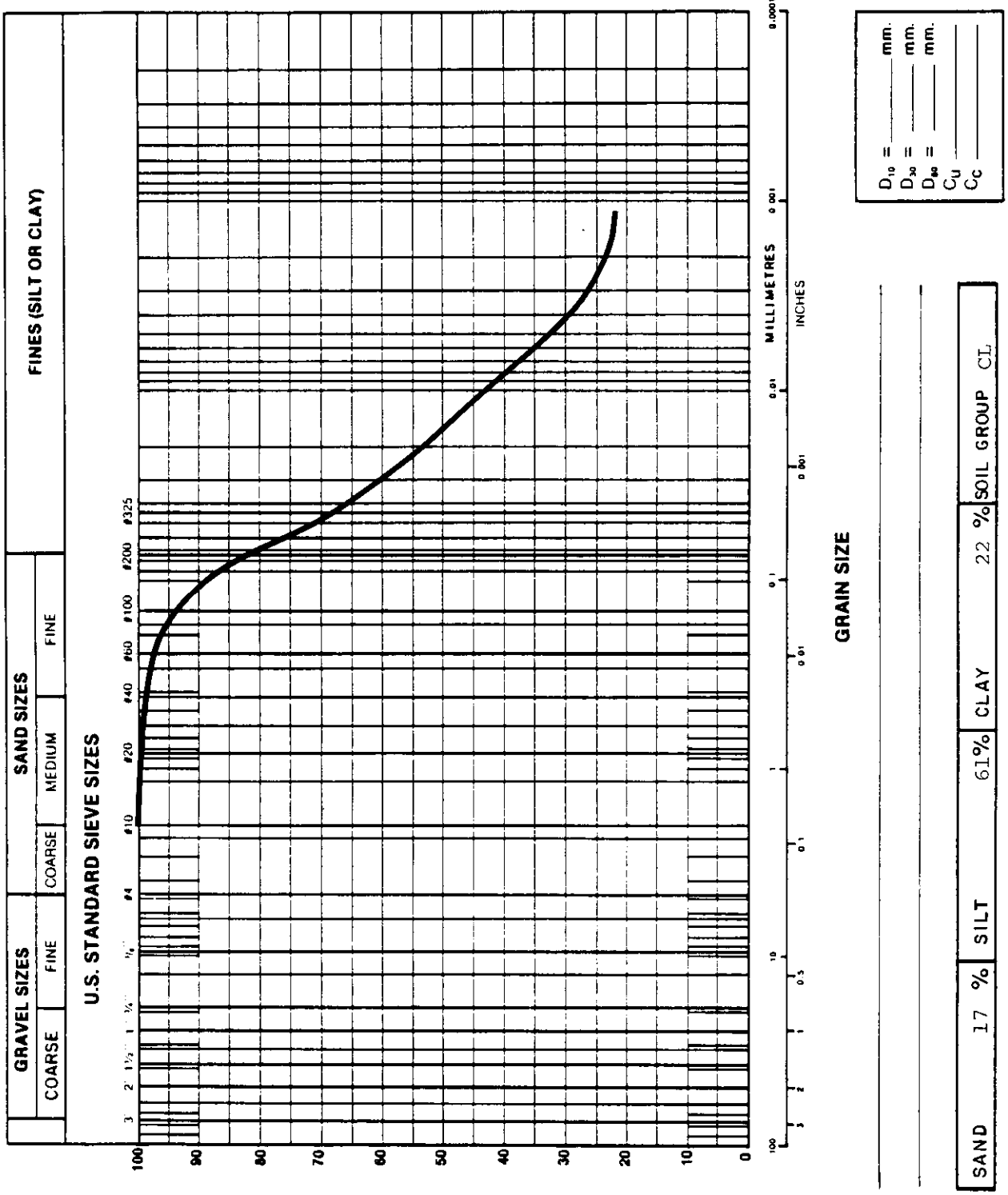
HT 64 80/11

PLATE B5

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-D2
SAMPLE	C2
DEPTH (m)	0.7/1.0m
TECHNICIAN	TC
DATE TESTED	83-04-04



SAND	%	SILT	CLAY	%	SOIL GROUP
	17		61%	22	CL

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

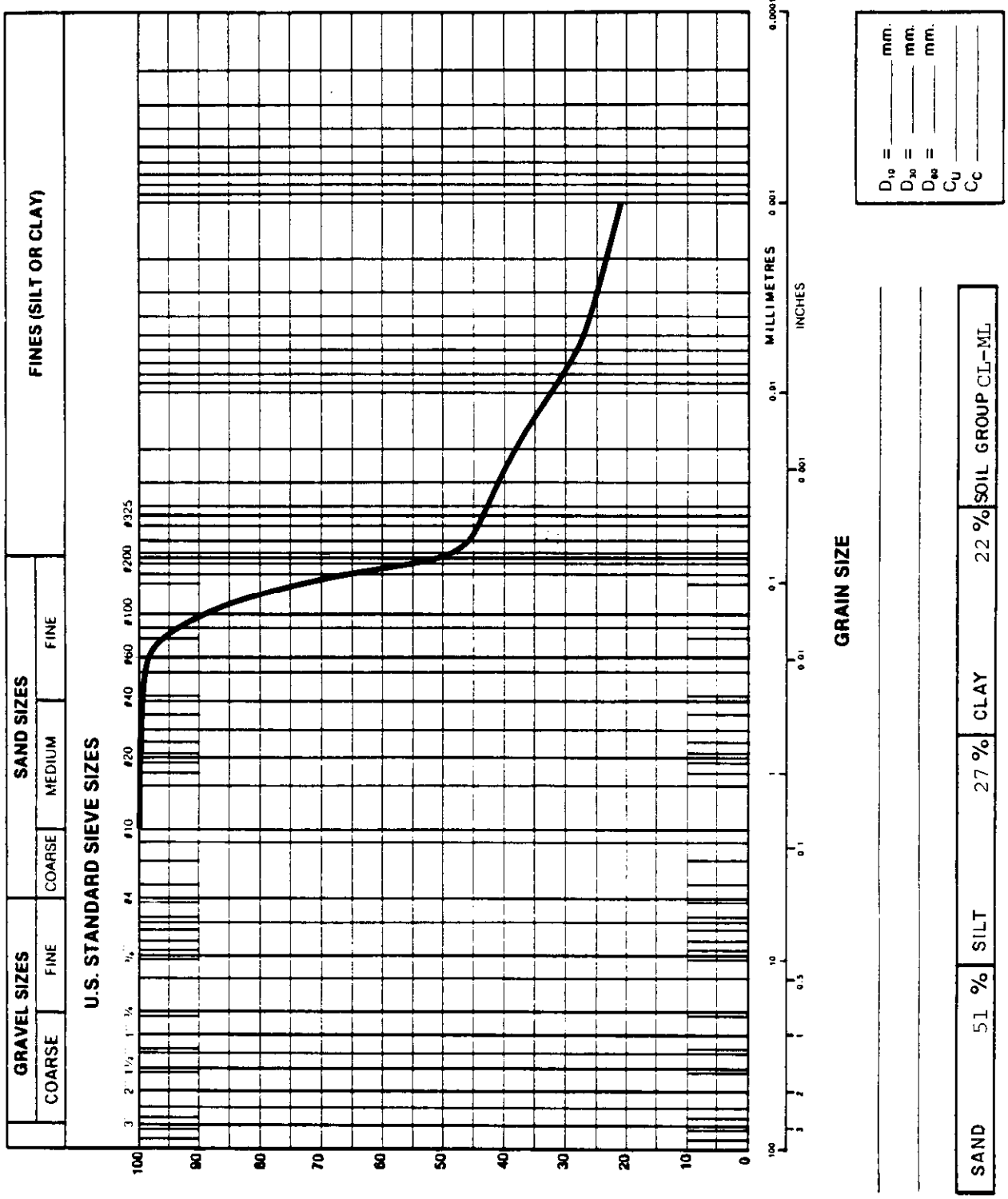
HT 64 80/11

PLATE B6

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-D2
SAMPLE	C3C
DEPTH (m)	1.6/1.8m
TECHNICIAN	TC
DATE TESTED	83-04-04



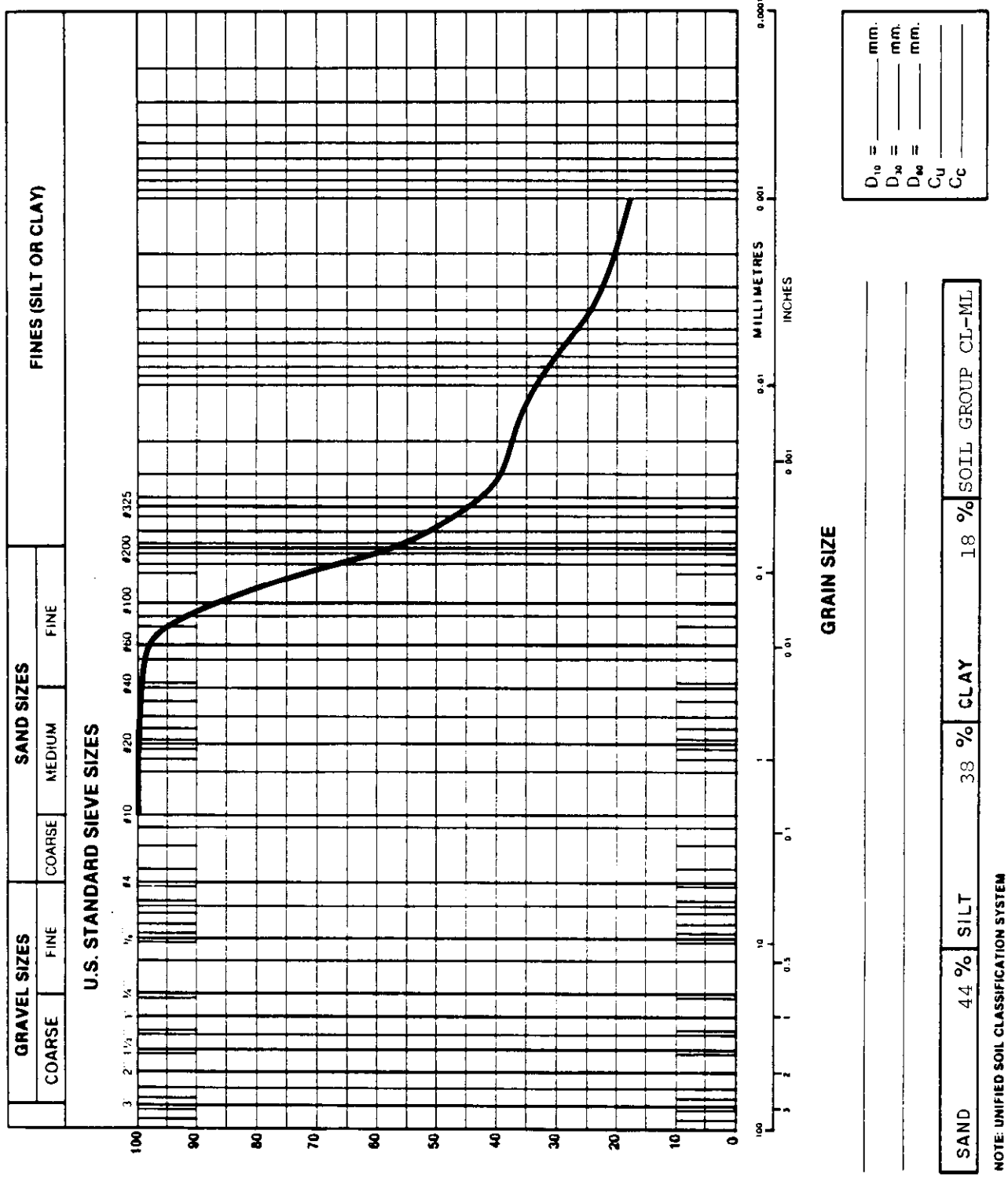
HT 64 80/11

PLATE B7

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-D2
SAMPLE	C 7B
DEPTH (m)	3.9m/4.2m
TECHNICIAN	TC
DATE TESTED	83-04-04



SAND	SILT	CLAY	SOIL GROUP
44 %	38 %	18 %	CL-ML

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

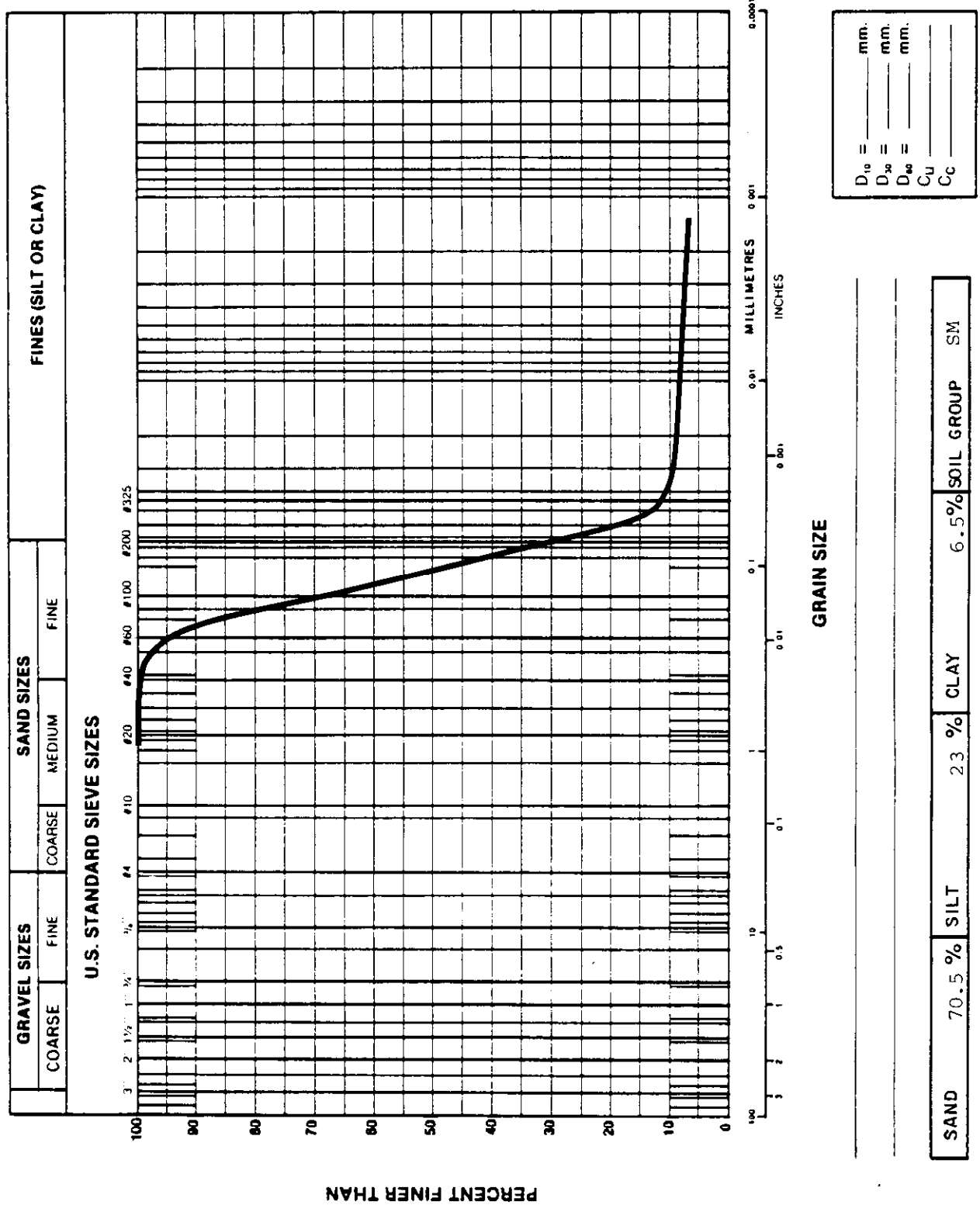
HT 64 80/11

PLATE B8

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG k0065
CLIENT	Illisarvik
BOREHOLE	HA83-D2
SAMPLE	C9C
DEPTH (m)	10.62/10.9m
TECHNICIAN	TC
DATE TESTED	83-04-04



SAND	SILT	CLAY	SOIL GROUP
70.5 %	23 %	6.5%	SM

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

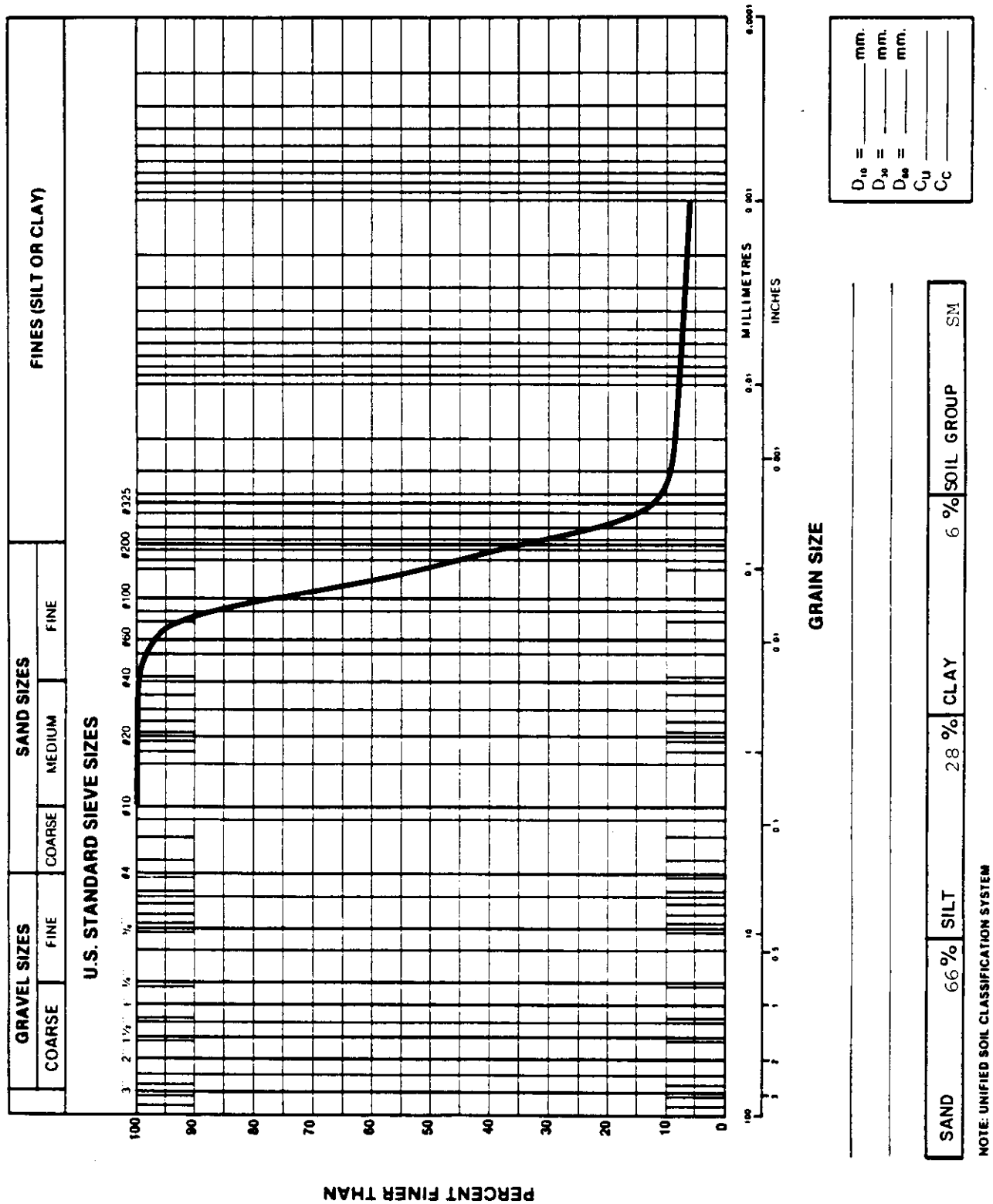
HT 64 80/11

PLATE B9

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-D2
SAMPLE	C10A
DEPTH (m)	20.0/20.2
TECHNICIAN TC	DATE TESTED 83-04-06



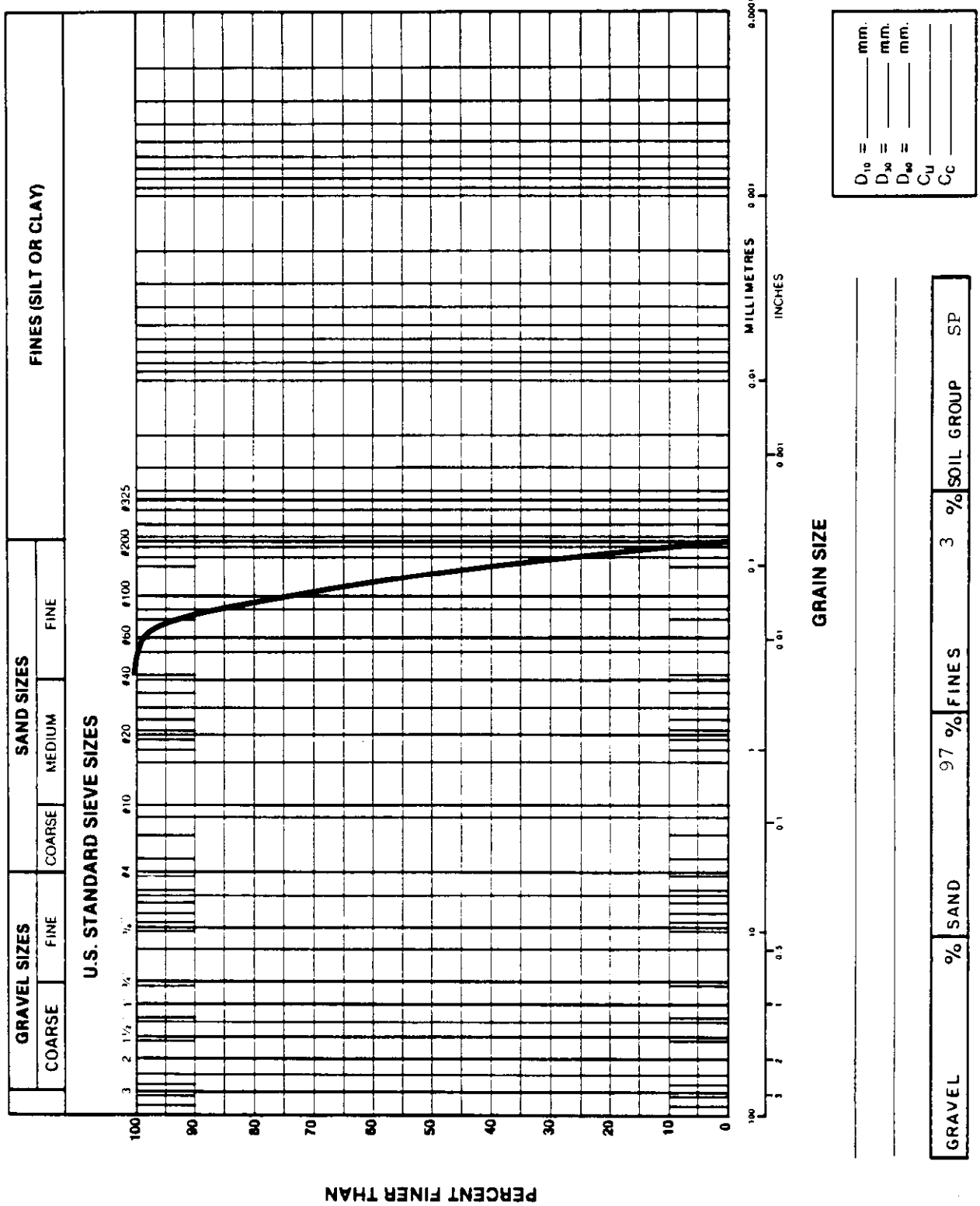
HT 64 80/11

PLATE B10

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-D2
SAMPLE	C13B
DEPTH (m)	50.5/51.0
TECHNICIAN	TC
DATE TESTED	83-04-04



GRAVEL %	SAND %	FINES %	SOIL GROUP
3	97		SP

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

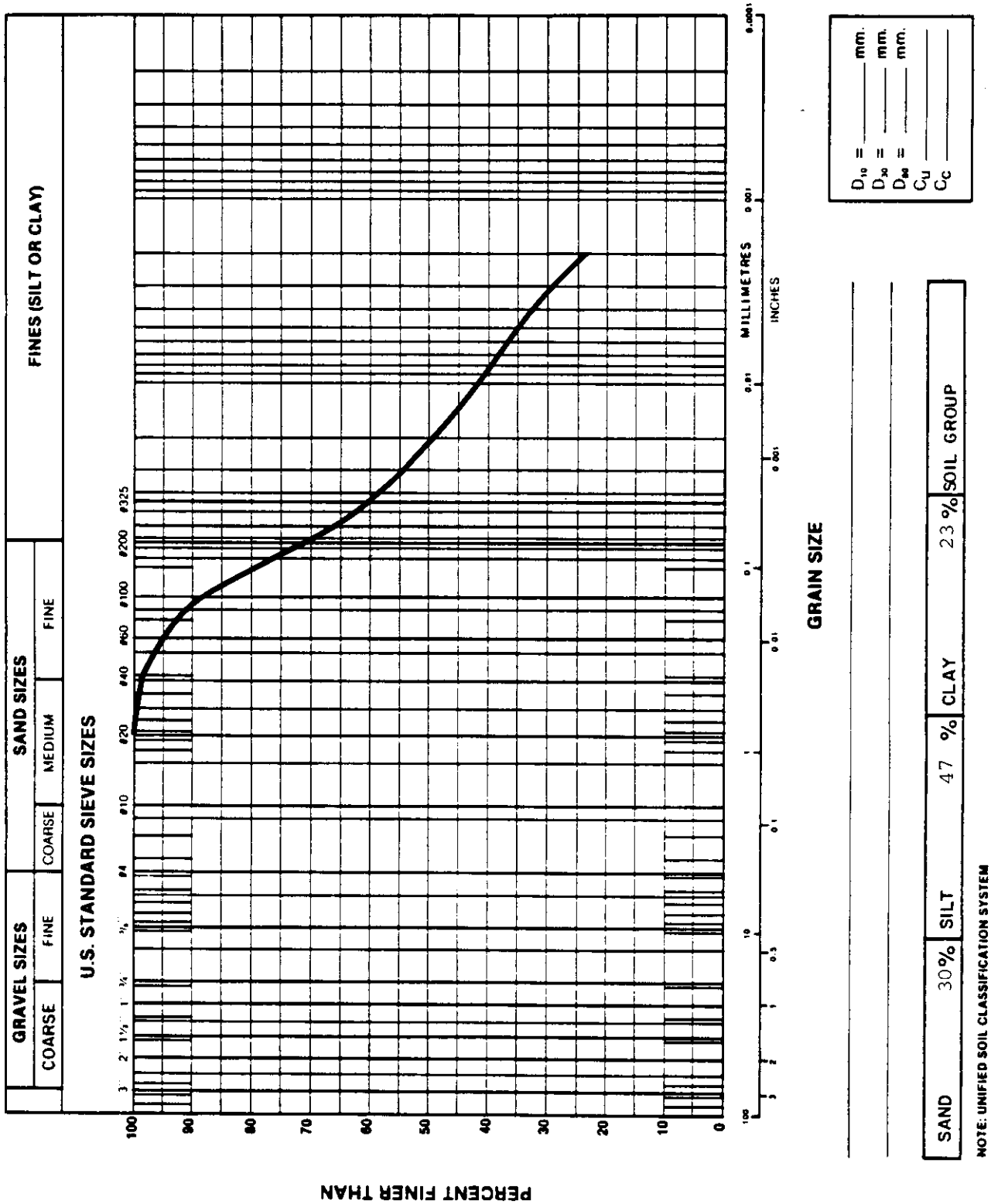
HT 64 80/11

PLATE B11

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA 83-M1
SAMPLE	C2B
DEPTH (m)	5.3/5.5
TECHNICIAN	TC
DATE TESTED	83-04-12



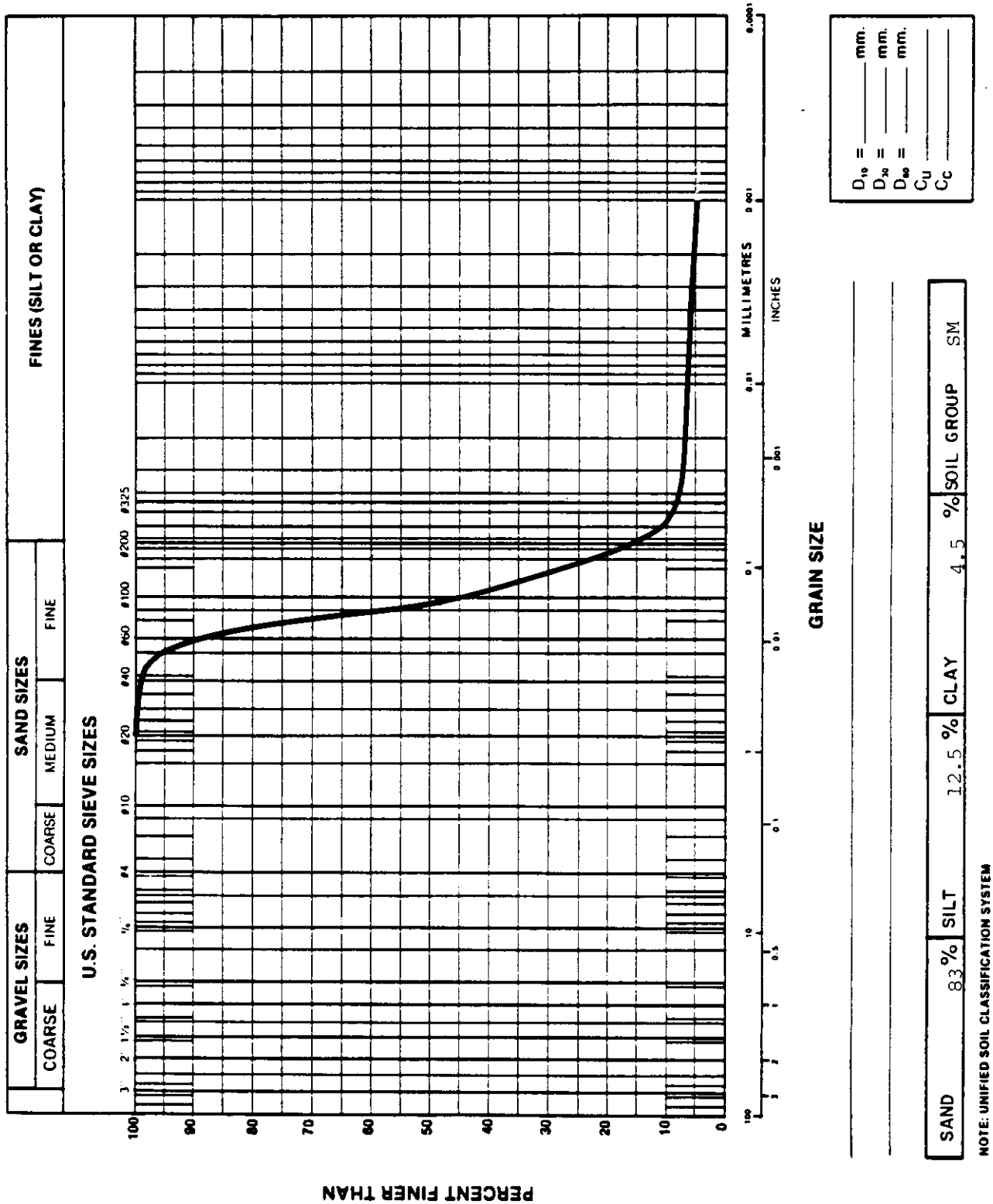
HT 64 80/11

PLATE B12

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-M1
SAMPLE	C4B
DEPTH (m)	15.3/15.75
TECHNICIAN	TC
DATE TESTED	83-04-05



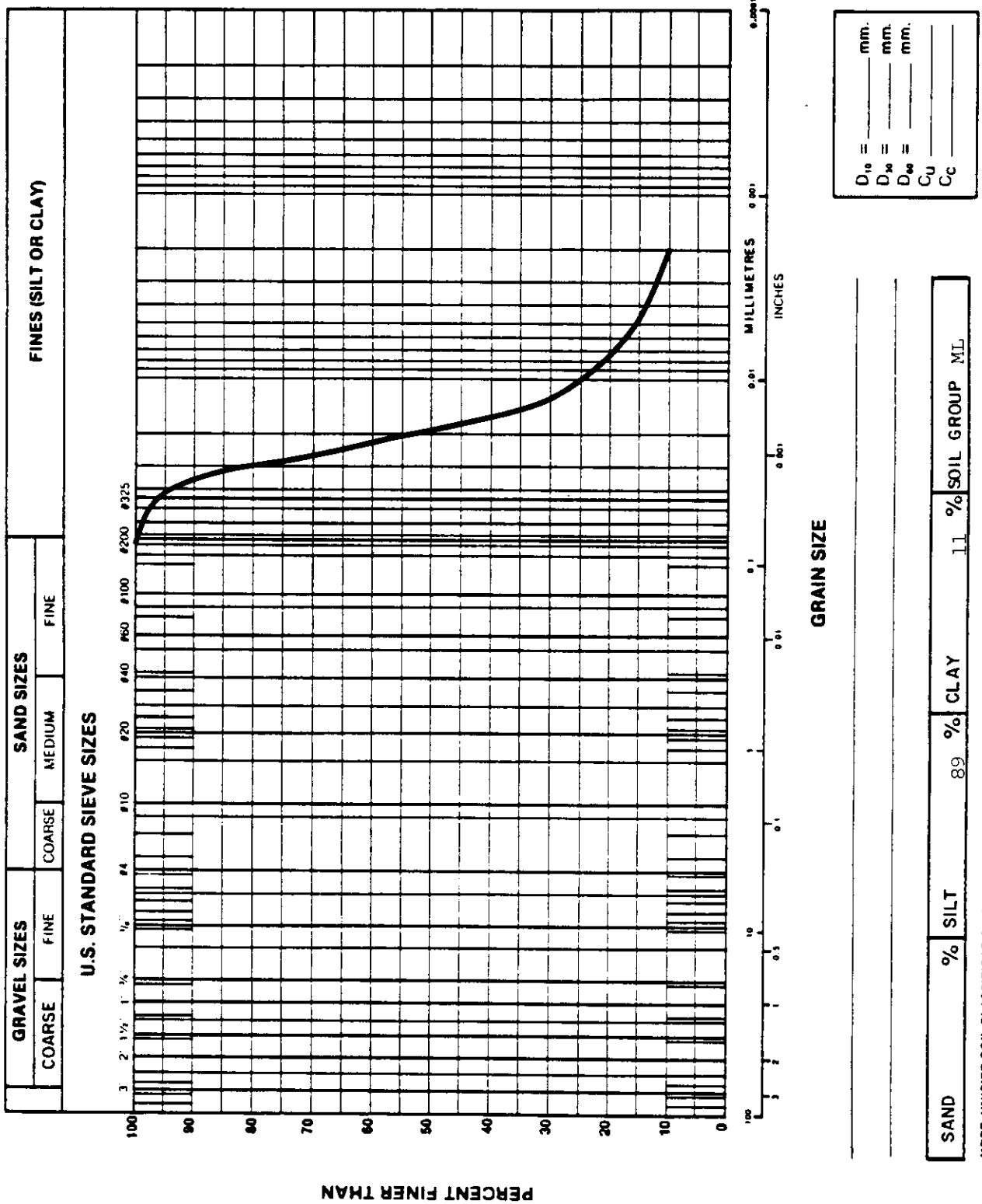
HT 84 80/11

PLATE B13

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-M2
SAMPLE	C1A
DEPTH (m)	0.3/0.6
TECHNICIAN	TC
DATE TESTED	83-04-11



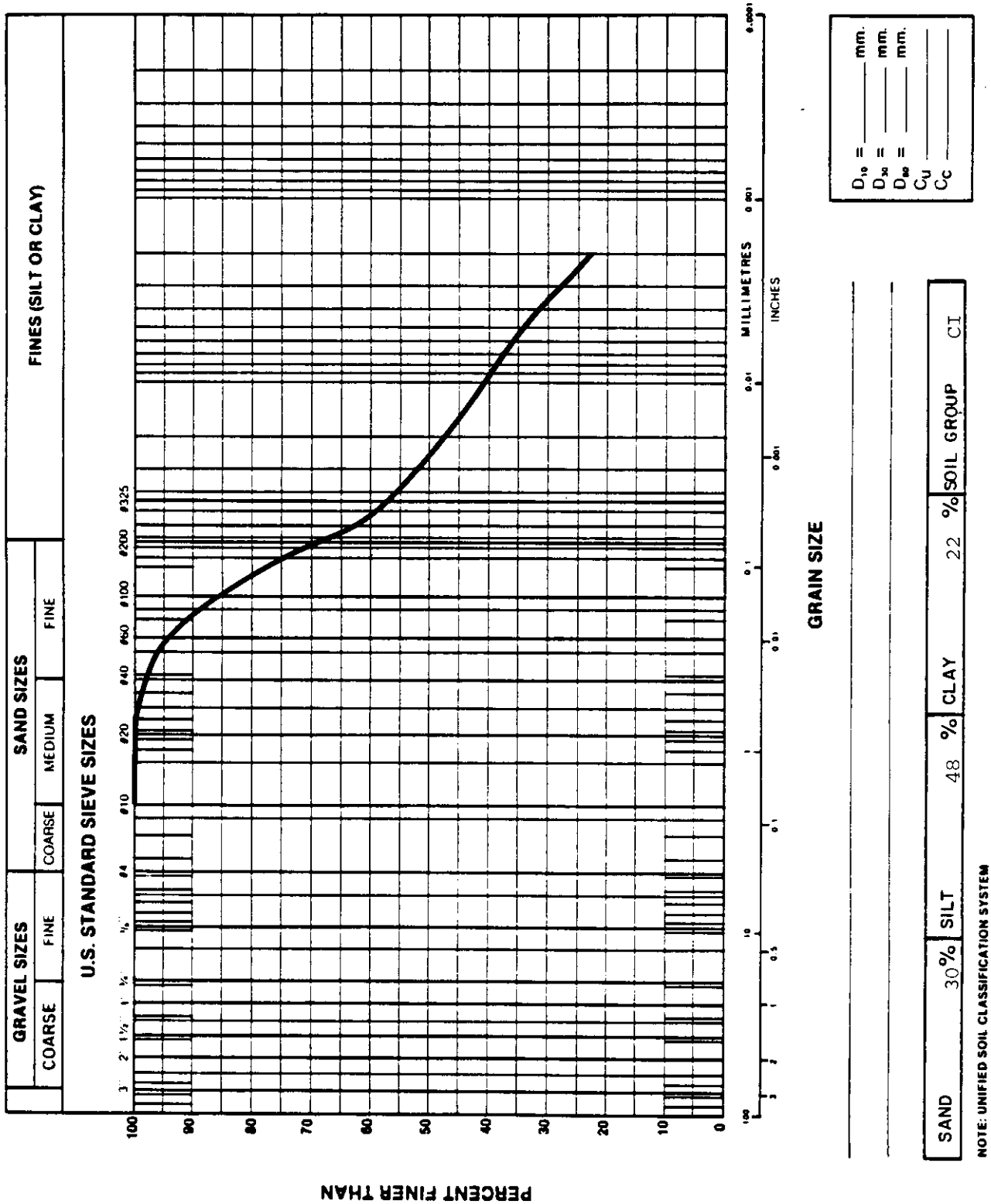
HT 64 80/11

PLATE B14

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-M2
SAMPLE	C2B
DEPTH (m)	5.6/5.9
TECHNICIAN	TC & KS
DATE TESTED	83-04-13



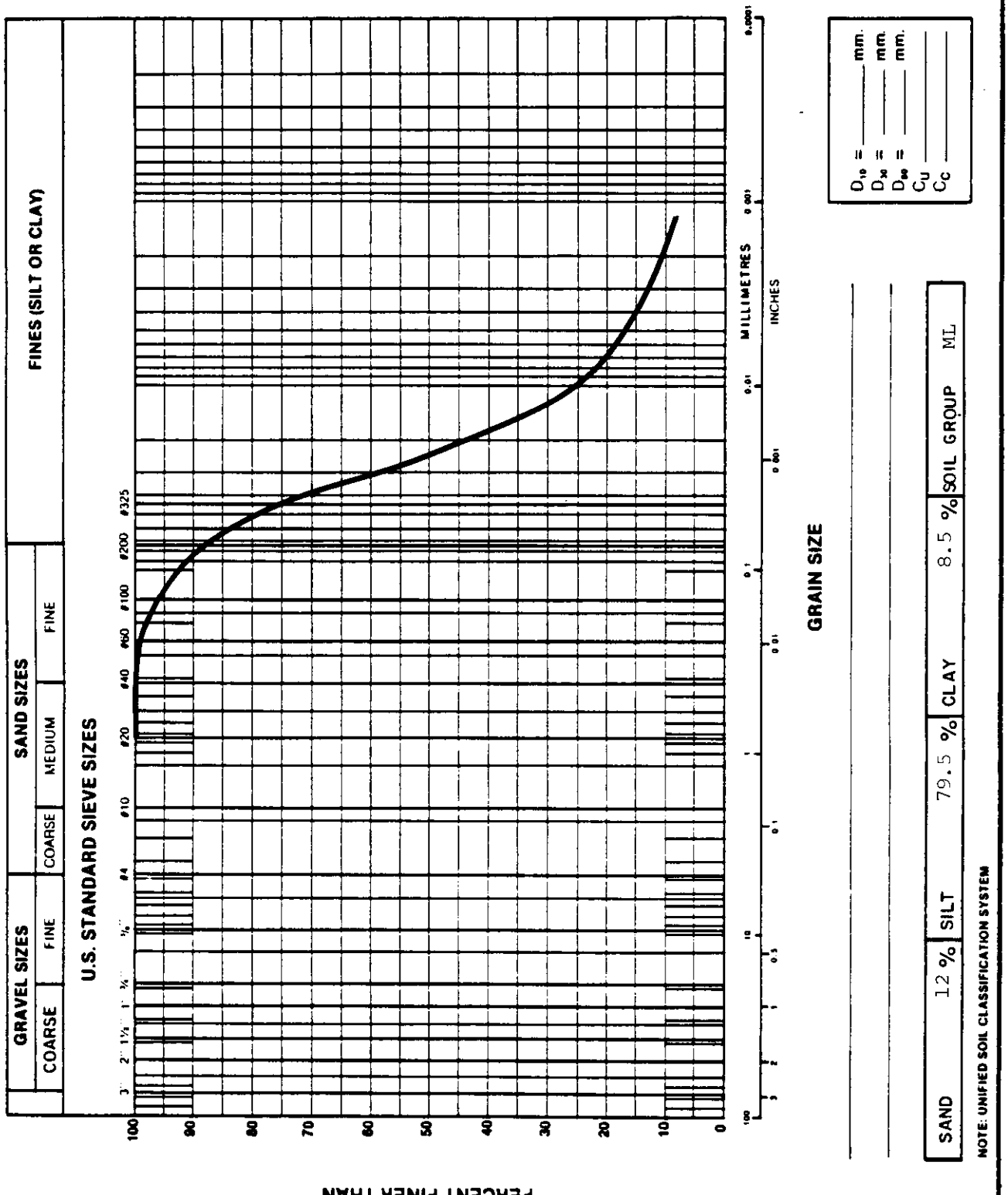
MT 84 80/11

PLATE B15

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-M2A
SAMPLE	B1
DEPTH (m)	2.7/3.15
TECHNICIAN	TC
DATE TESTED	83-04-06



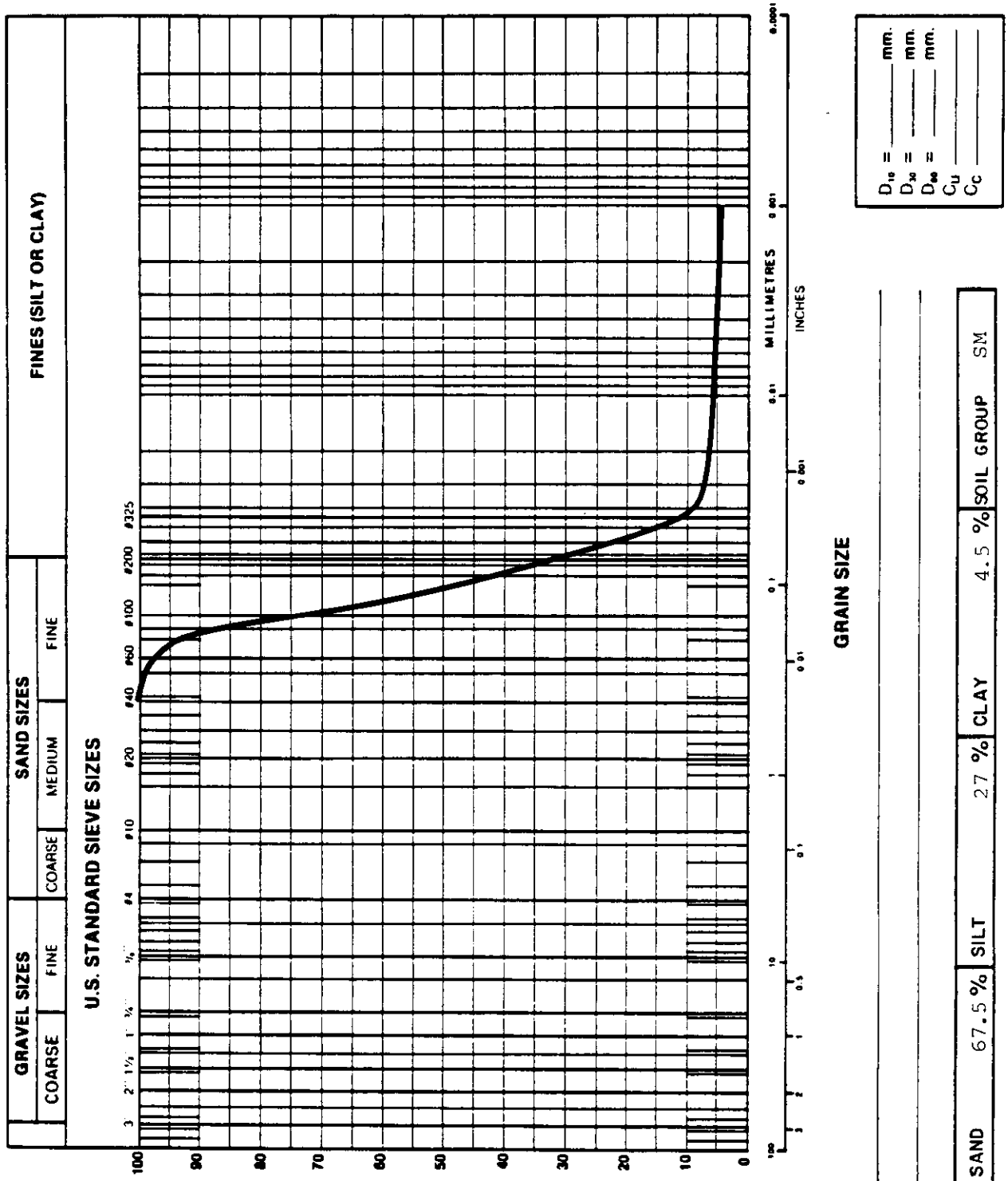
HT 64 80/11

PLATE B16

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-M2A
SAMPLE	C1A
DEPTH (m)	10.0/10.3
TECHNICIAN	TC
DATE TESTED	83-04-05



NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

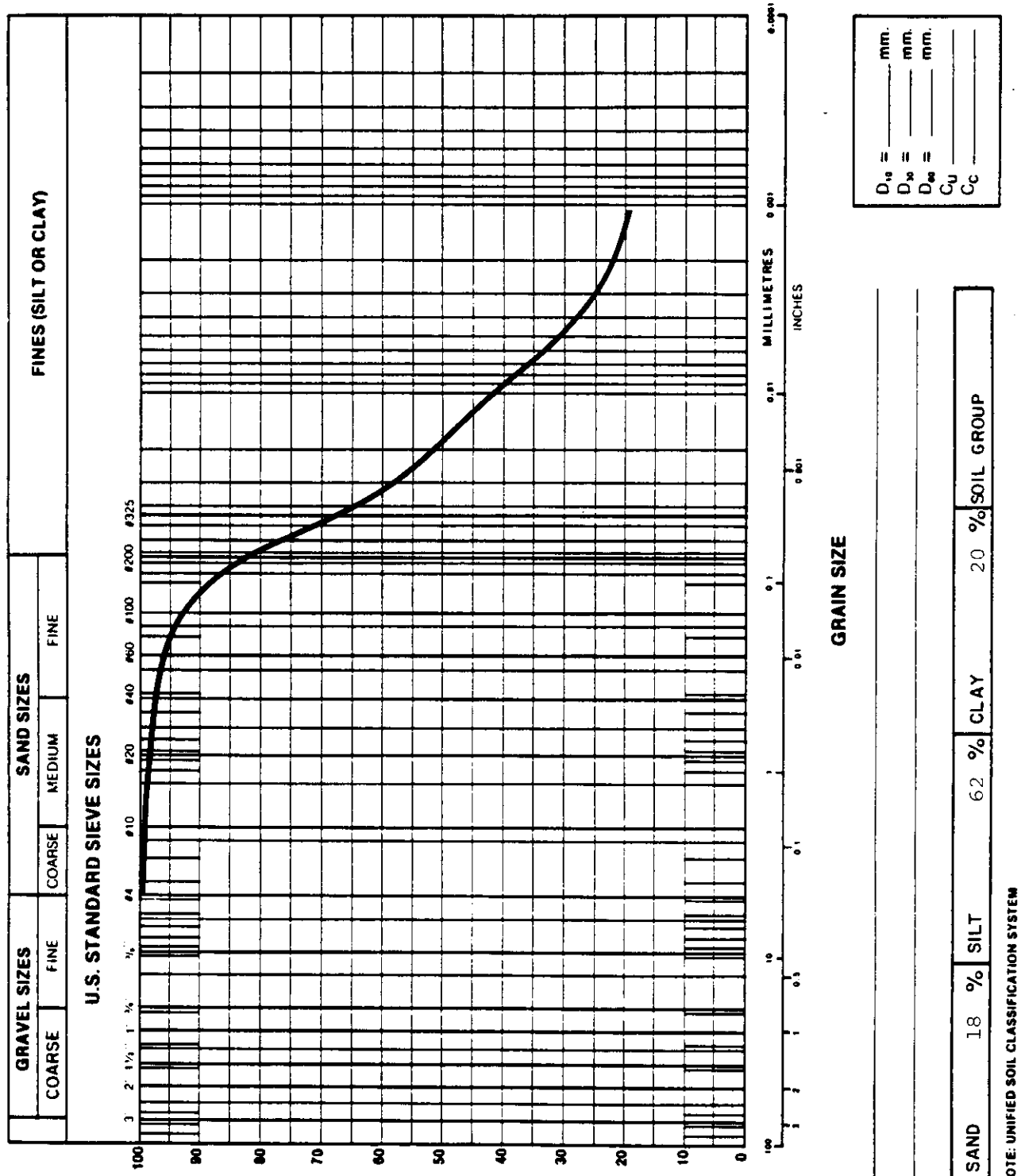
mT 64 80/11

PLATE B17

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-M4
SAMPLE	A1
DEPTH (m)	21.6/22.6
TECHNICIAN	TC
DATE TESTED	83-04-07



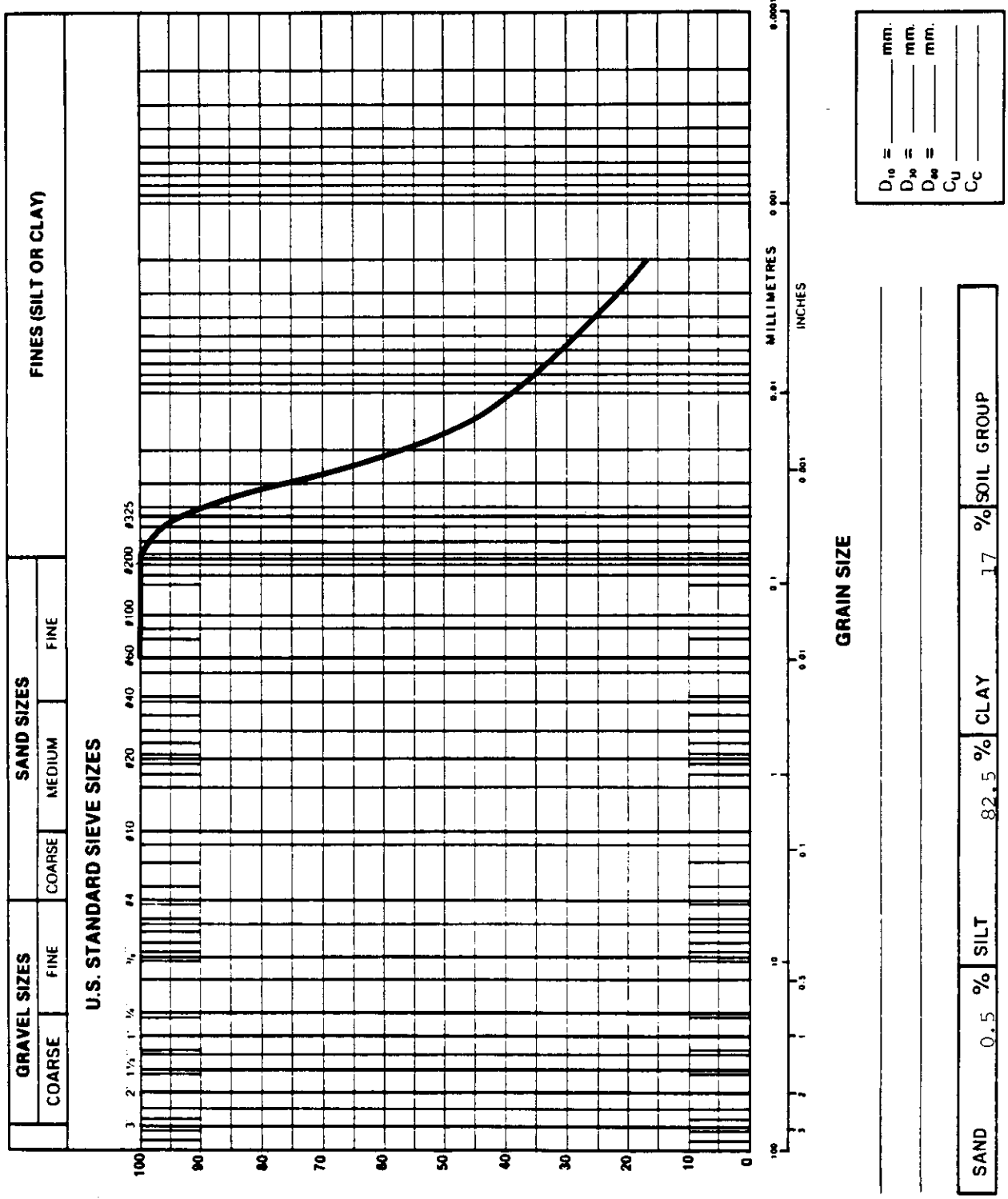
HT 64 80/11

PLATE B18

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-M4
SAMPLE	B1
DEPTH (m)	11.6/14.6
TECHNICIAN	TC & KS
DATE TESTED	83-04-13



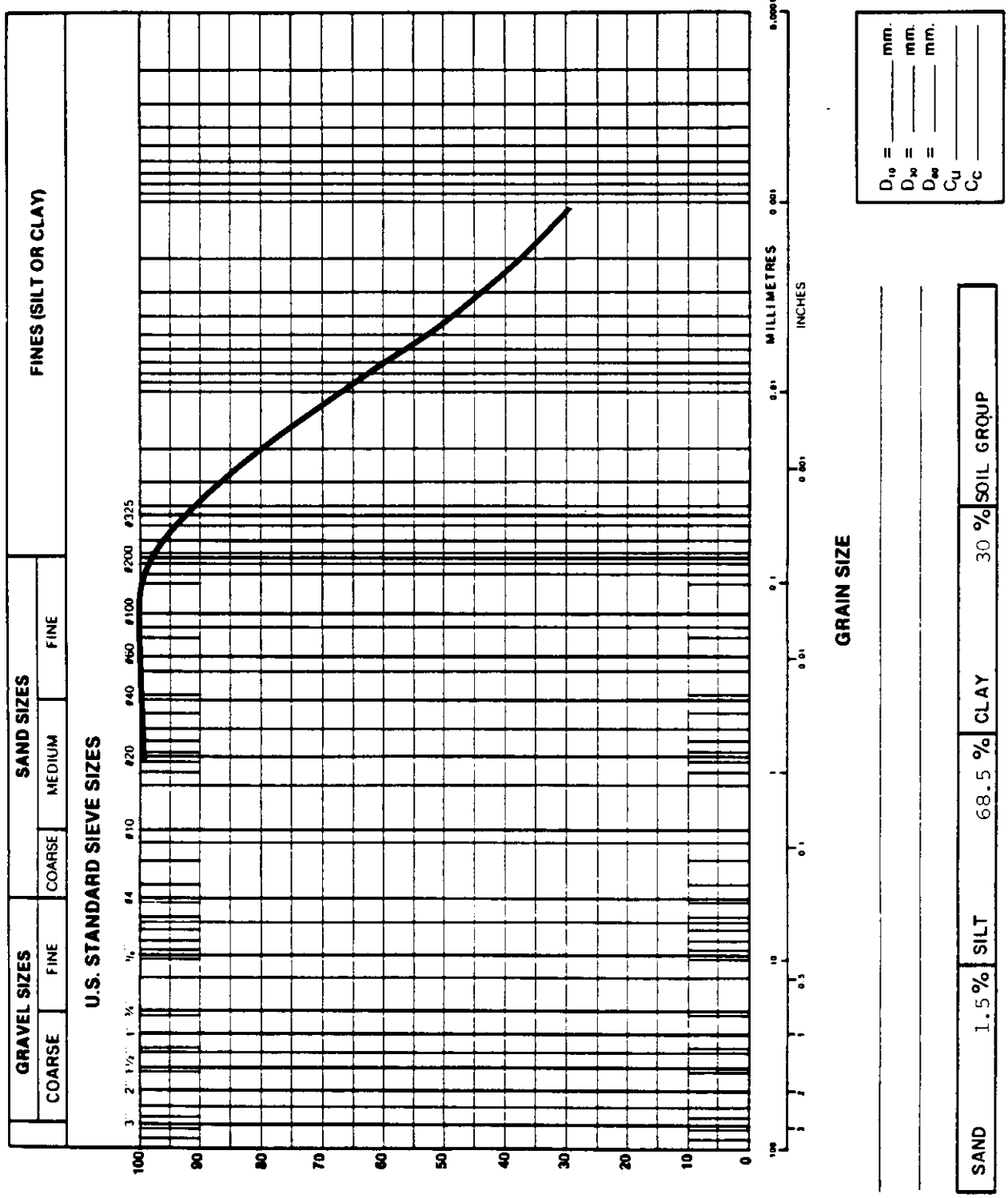
HT 64 80/11

PLATE B19

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-M4
SAMPLE	B2
DEPTH (m)	15.01/16.0
TECHNICIAN	BVL
DATE TESTED	83-04-07



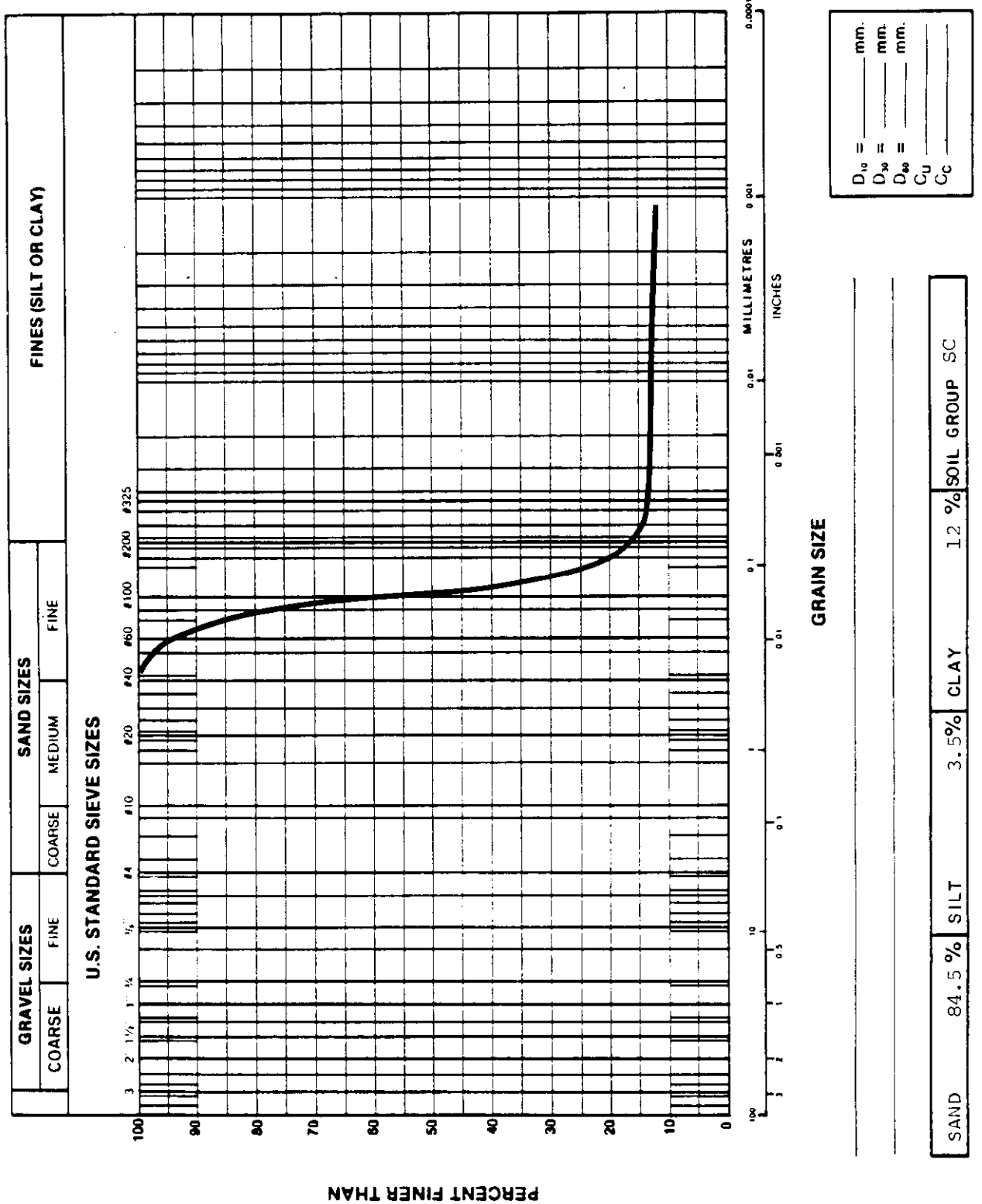
HT 64 80/11

PLATE B20

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-M8
SAMPLE	C2B
DEPTH (m)	5.3/5.55m
TECHNICIAN	TC
DATE TESTED	83-04-04



SAND	84.5 %	SILT	3.5%	CLAY	12 %	SOIL GROUP	SC

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

HT 64 80/11

PLATE B21

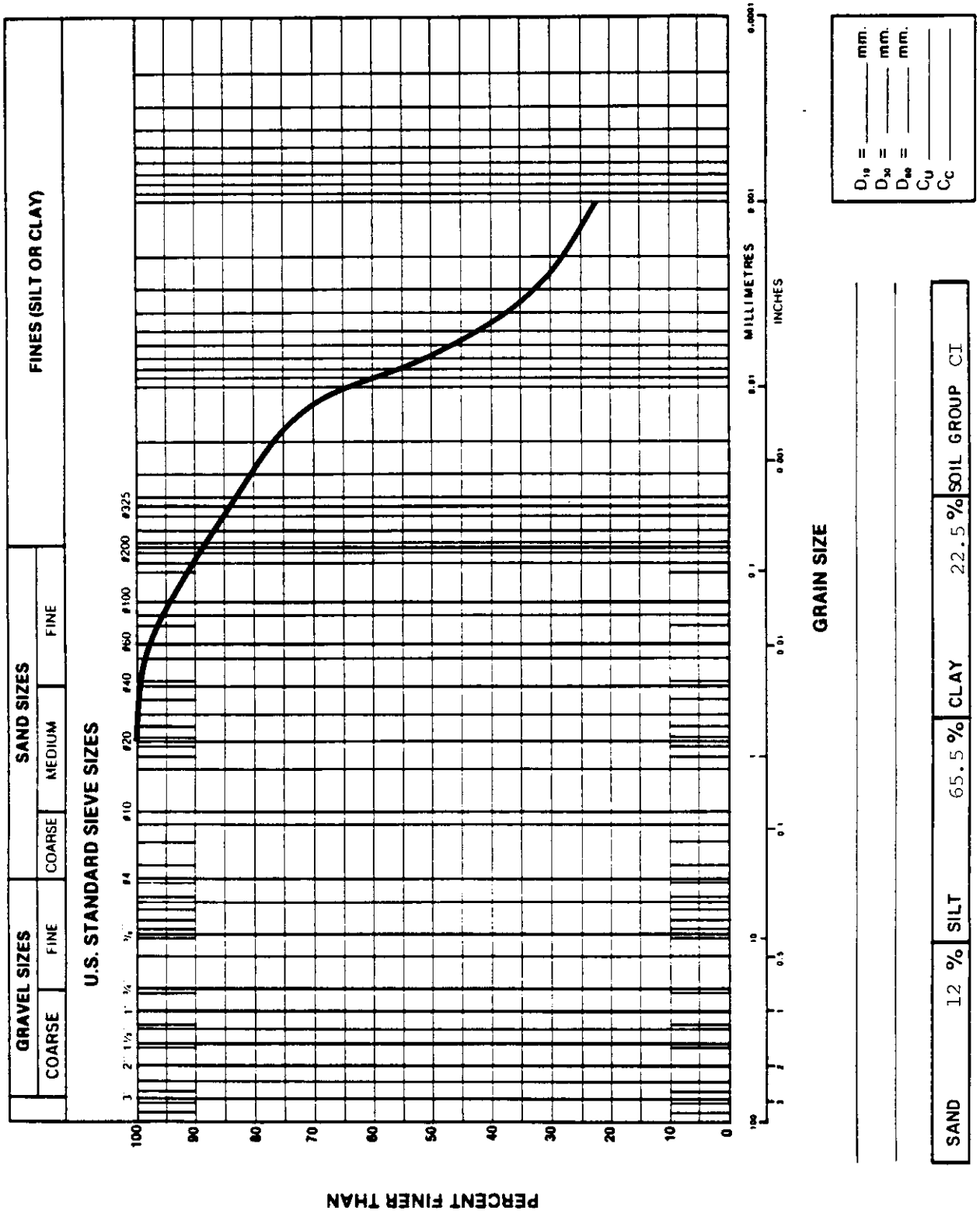
APPENDIX "C"

EXPLANATION SHEETS

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

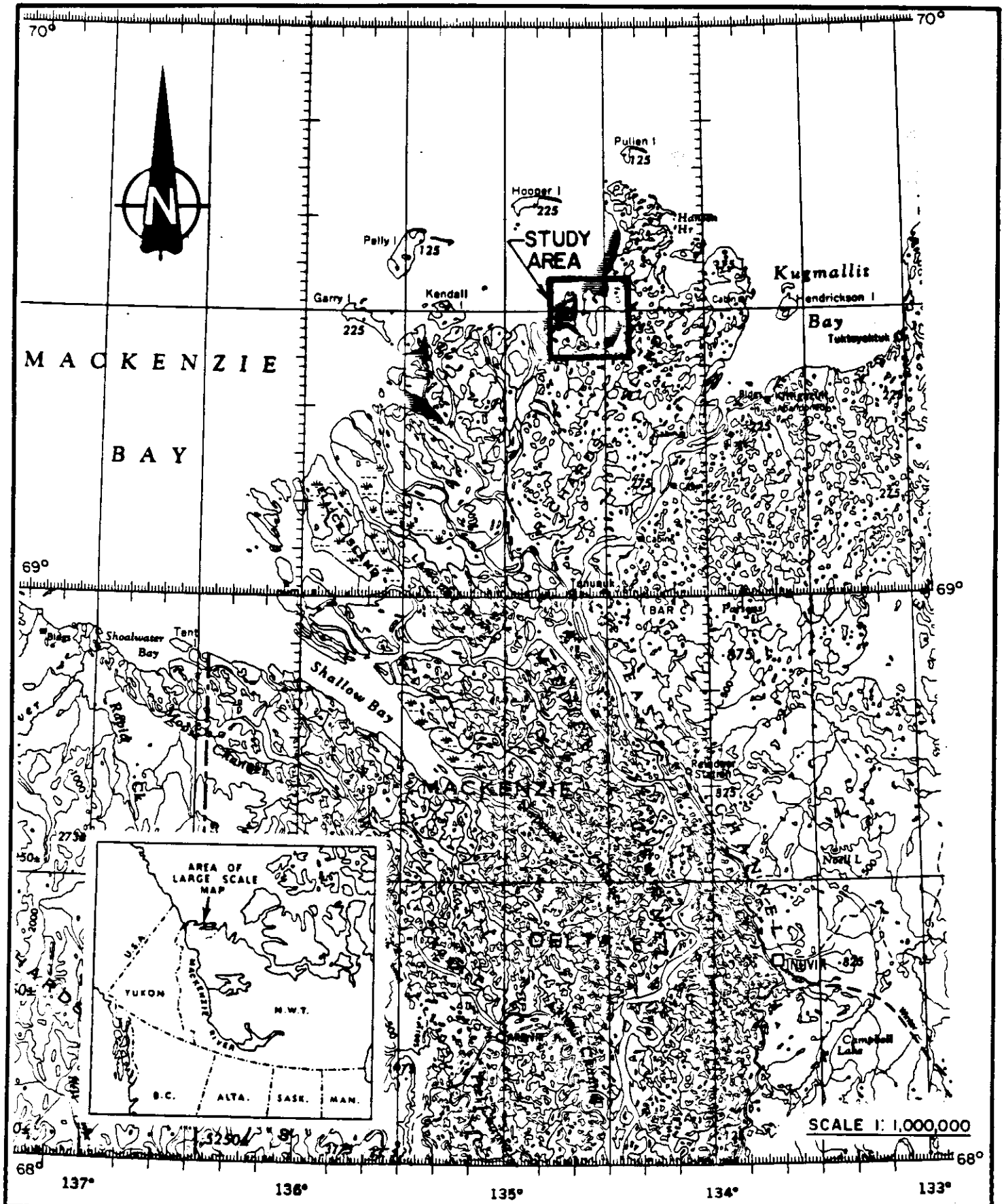
GRAIN SIZE CURVE

PROJECT NO.	CG 10065
CLIENT	Illisarvik
BOREHOLE	HA83-M8
SAMPLE	C4A
DEPTH (m)	15.0/15.5
TECHNICIAN	TC
DATE TESTED	83-04-06



HT 64 80/11

PLATE B22



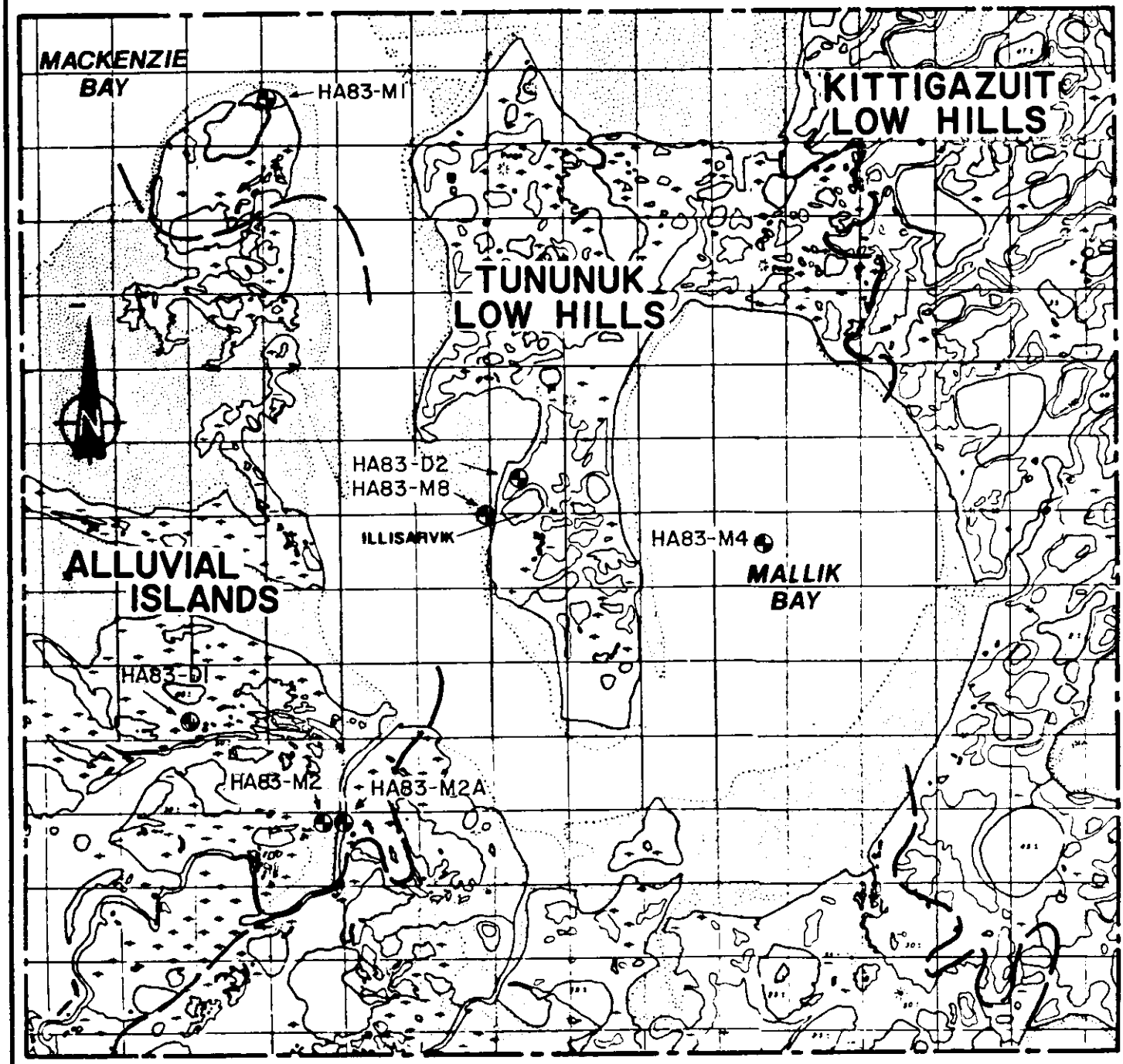
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

ILLISARVIK WINTER DRILLING PROGRAM STUDY AREA

CG10065

FIGURE 1

HT09 - 79/05



LEGEND

Study Area Boundary

Physiographic Boundary

HA83-D1 Borehole Location

NOTE : Physiographic Subdivisions Modified After Mackay (1963)

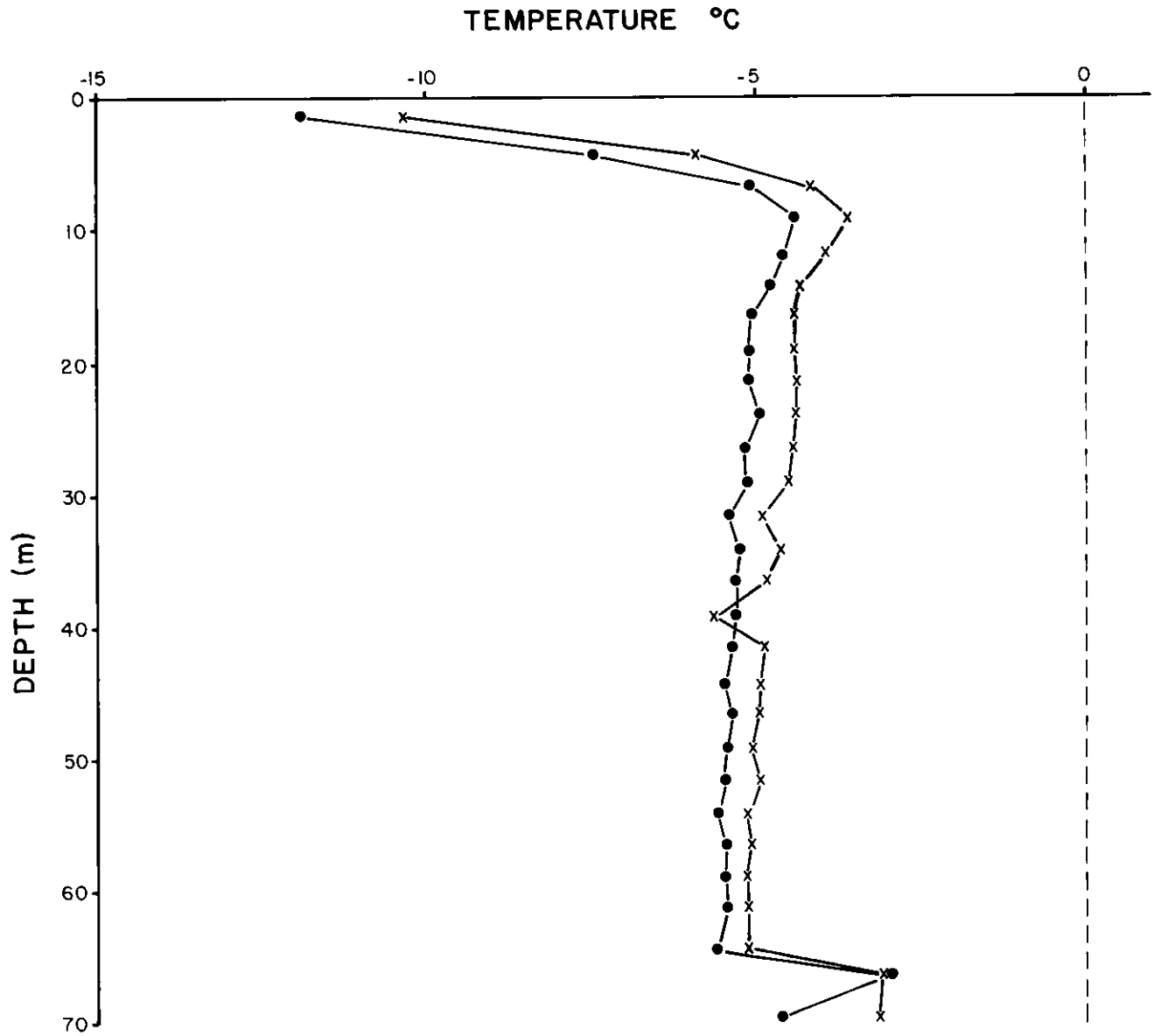
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

ILLISARVIK WINTER DRILLING PROGRAM
BOREHOLE LOCATION PLAN

CGI0065

FIGURE 2

HT09 - 79/05



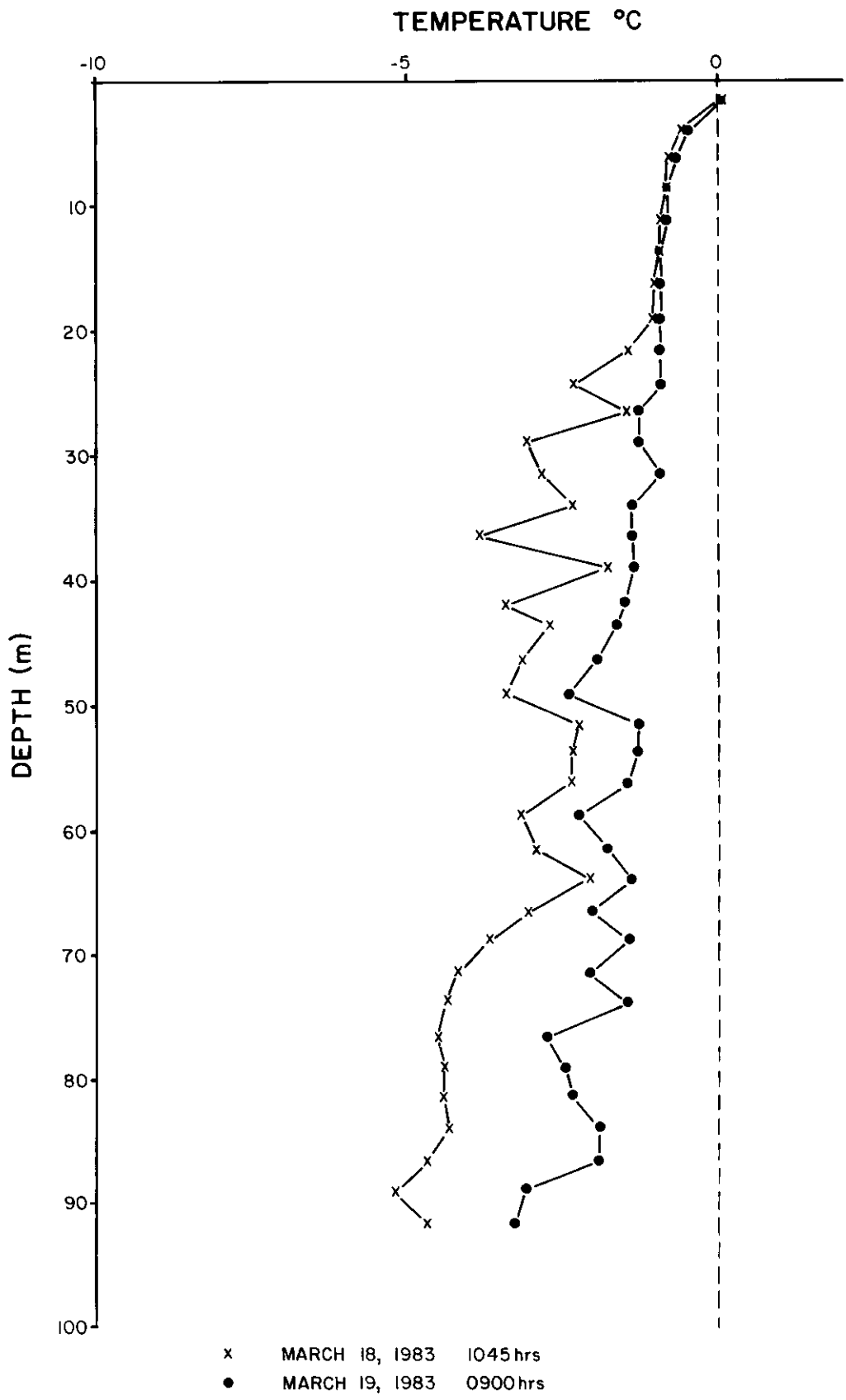
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

ILLISARVIK 1983 WINTER DRILLING PROGRAM

GROUND TEMPERATURE PROFILES BOREHOLE HA83-DI

CG 10065 FIG. 3

HT83-82/03



HARDY ASSOCIATES (1978) LTD
CONSULTING ENGINEERING & [illegible]

ILLISARVIK 1983 WINTER DRILLING PROGRAM

GROUND TEMPERATURE PROFILES BOREHOLE HA83-D2

CG 10065

FIG. 4

HT83-82/03

APPENDIX "D"

PHOTOGRAPHS

APPENDIX "D"

PHOTOGRAPHS

PHOTO 1: Low ice content core (Nbn), showing sharp, horizontal, contact between silty, low plastic, clay and fine to medium sand (Borehole HA83-D1, Sample C9).

PHOTO 2: Silty clay till/diamicton, with reticulate ice veins (Vr)(Borehole HA83-D1, Sample C15).

PHOTO 3: Medium plastic silty clay lens, with random and reticulate ice veins (Vr), overlying fine to medium, low ice content (Nbn) sand with silt interbeds and organic inclusions (Borehole HA83-C1, Sample C21).

PHOTO 4: Organic-rich clay with silt interbeds and organic inclusions (predominantly wood) (Borehole HA83-D1, Sample C23).

PHOTO 5: Silty low plastic clay, with prominent stratified visible ice (Vs) (Borehole HA83-D2, Sample C3).

PHOTO 6: Massive ground ice (ICE), with very minor inclusions of soil (Borehole HA83-D2, Sample C4).

PHOTO 7: Ice-rich silty, low plastic, clay (ICE+); upper 5 cm of core consists of ice-rich sand. Note: light brown, organic-rich interbeds towards bottom of core (Borehole HA83-D2 Sample C10).

PHOTO 8: Ice-rich core of silty, fine to medium, sand (ICE+). Bottom of core has no visible ice (Nbn) (Borehole HA83-M1, Sample C5).

PHOTO 9: Fine to medium silty sand, with prominent horizontal silt laminations (dark grey), and inclusions of organic material. This core has no visible ice (Nbn) (Borehole HA83-M8, Sample C1).

PHOTO 10: Silty clay, with brown silt lenses and random ice veins, up to 10 mm thick (Vr) (Borehole HA83-M8, Sample C4).

APPENDIX "E"

THERMISTOR CALIBRATIONS,

MULTITHERMISTOR CABLE INSTALLATIONS,

AND

INITIAL READINGS

APPENDIX "E"

THERMISTOR CALIBRATION, MULTI-THERMISTOR CABLE FABRICATION AND INSTALLATION, AND INITIAL READINGS

This Appendix details the work undertaken leading to the successful installation of multi-thermistor cables in boreholes HA83-D1 and HA83-D2.

E1. MULTI-THERMISTOR CABLE FABRICATION

Two, 100 m long, cables were fabricated in our Calgary laboratory for installation at Illisarvik. In each instance, #10993-50 (RP99-3) thermistor beads, supplied by York Instruments, and 15-conductor (GC-16-TCW-21) cable, from Geophysical Cable Mfg. Alberta Ltd., were used. The fabrication procedure was in agreement with the guidelines attached to the DSS proposal request. In all, 40 thermistor beads, at 2.5 m spacing, were included in each cable. A switch-box was attached for reading purposes.

E2. THERMISTOR CALIBRATION

Once cable fabrication was completed, the thermistors were calibrated by immersion of the cable in a crushed ice bath. The bath was mechanically agitated, so that its temperature would approach, as closely as possible, an isothermal steady-state condition at $0^{o}C$. After the cable had been immersed for at least 3 hours, a series of resistance measurements were taken, at approximately 30 minute intervals. Tables E1 and E2 present the resistance measurements, and average values that may be used for conversion purposes.

TABLE E1: ILLISARVIK THERMISTOR CALIBRATIONS

BOREHOLE HA83-D1 CABLE

Thermistor No.	Reading No. 1	Reading No. 2	Reading No. 3	Average Reading
1	16.23	16.23	16.24	16.23
2	16.25	16.25	16.25	16.25
3	16.25	16.25	16.25	16.25
4	16.23	16.24	16.23	16.23
5	16.21	16.21	16.21	16.21
6	16.19	16.20	16.19	16.19
7	16.18	16.18	16.18	16.18
8	16.23	16.23	16.23	16.23
9	16.23	16.23	16.23	16.23
10	16.25	16.24	16.25	16.25
11	16.23	16.23	16.22	16.23
12	16.20	16.20	16.19	16.20
13	16.23	16.23	16.23	16.23
14	16.26	16.27	16.26	16.26
15	16.23	16.24	16.23	16.23
16	16.29	16.28	16.28	16.28
17	16.25	16.26	16.26	16.26
18	18.18	16.19	16.18	16.18
19	16.27	16.26	16.27	16.27
20	16.24	16.24	16.24	16.24
21	16.24	16.24	16.24	16.24
22	16.23	16.23	16.23	16.23
23	16.26	16.26	16.25	16.26
24	16.24	16.24	16.24	16.24
25	16.24	16.24	16.24	16.24
26	16.25	16.25	16.26	16.25
27	16.22	16.22	16.22	16.22
28	16.24	16.24	16.24	16.24
29	16.23	16.23	16.22	16.23
30	16.21	16.22	16.21	16.21
31	16.23	16.23	16.23	16.23
32	16.25	16.25	16.25	16.25
33	16.26	16.25	16.26	16.26
34	16.25	16.25	16.25	16.25
35	16.23	16.23	16.23	16.23
36	16.24	16.24	16.23	16.24
37	16.23	16.23	16.23	16.23
38	16.24	16.24	16.24	16.24
39	16.25	16.25	16.24	16.25
40	16.24	16.25	16.24	16.24

Note: Numbers are thermistor counts from box, not depths.

TABLE E2: ILLISARVIK THERMISTOR CALIBRATIONS

BOREHOLE HA83-D2 CABLE

Thermistor No.	Reading No. 1	Reading No. 2	Reading No. 3	Average Reading
1	16.22	16.22	16.22	16.22
2	16.21	16.21	16.22	16.21
3	16.21	16.21	16.21	16.21
4	16.21	16.21	16.21	16.21
5	16.18	16.19	16.20	16.19
6	16.16	16.17	16.17	16.17
7	16.21	16.21	16.21	16.21
8	16.24	16.23	16.22	16.23
9	16.24	16.24	16.23	16.24
10	16.26	16.26	16.25	16.26
11	16.24	16.24	16.24	16.24
12	16.26	16.26	16.26	16.26
13	16.25	16.25	16.25	16.25
14	16.25	16.25	16.24	16.25
15	16.20	16.20	16.19	16.20
16	16.25	16.24	16.25	16.25
17	16.23	16.22	16.23	16.23
18	16.23	16.23	16.23	16.23
19	16.26	16.25	16.26	16.26
20	16.28	16.27	16.28	16.28
21	16.24	16.25	16.24	16.24
22	16.24	16.24	16.24	16.24
23	16.24	16.24	16.24	16.24
24	16.22	16.21	16.22	16.22
25	16.30	16.29	16.29	16.29
26	16.24	16.24	16.24	16.24
27	16.22	16.22	16.23	16.22
28	16.27	16.27	16.28	16.27
29	16.23	16.24	16.23	16.23
30	16.24	16.24	16.24	16.24
31	16.22	16.22	16.22	16.22
32	16.23	16.23	16.23	16.23
33	16.27	16.27	16.27	16.27
34	16.26	16.26	16.26	16.26
35	16.24	16.24	16.24	16.24
36	16.23	16.23	16.23	16.23
37	16.24	16.24	16.24	16.24
38	16.28	16.27	16.28	16.28
39	16.25	16.24	16.25	16.25
40	16.25	16.25	16.25	16.25

Note: Numbers are thermistor counts from box, not depths.

E3. CABLE INSTALLATION

The cables were installed at the completion of drilling, to depths of 69 m and 91.5 m, in borings HA83-D1 and HA83-D2, respectively. Simultaneously, 50.8 mm PVC pipes, filled with arctic diesel fuel, were installed to depths of 50 m and 70 m in the two boreholes.

The surface installation at each site was essentially the same. About 50 cm of PVC pipe protrudes from the ground, and the thermistor string, pipe and switching box are covered by a 5 gallon pail. Connecting wires for the switching boxes are provided at borehole HA83-D1 (the second set, intended for borehole HA83-D2 malfunctioned at the site). The connecting wires allow use of a Fluke ohm-meter which plugs into the switching box or, alternatively, may be connected by means of alligator clips (to the type of resistance bridge used by the Geological Survey and EMR).

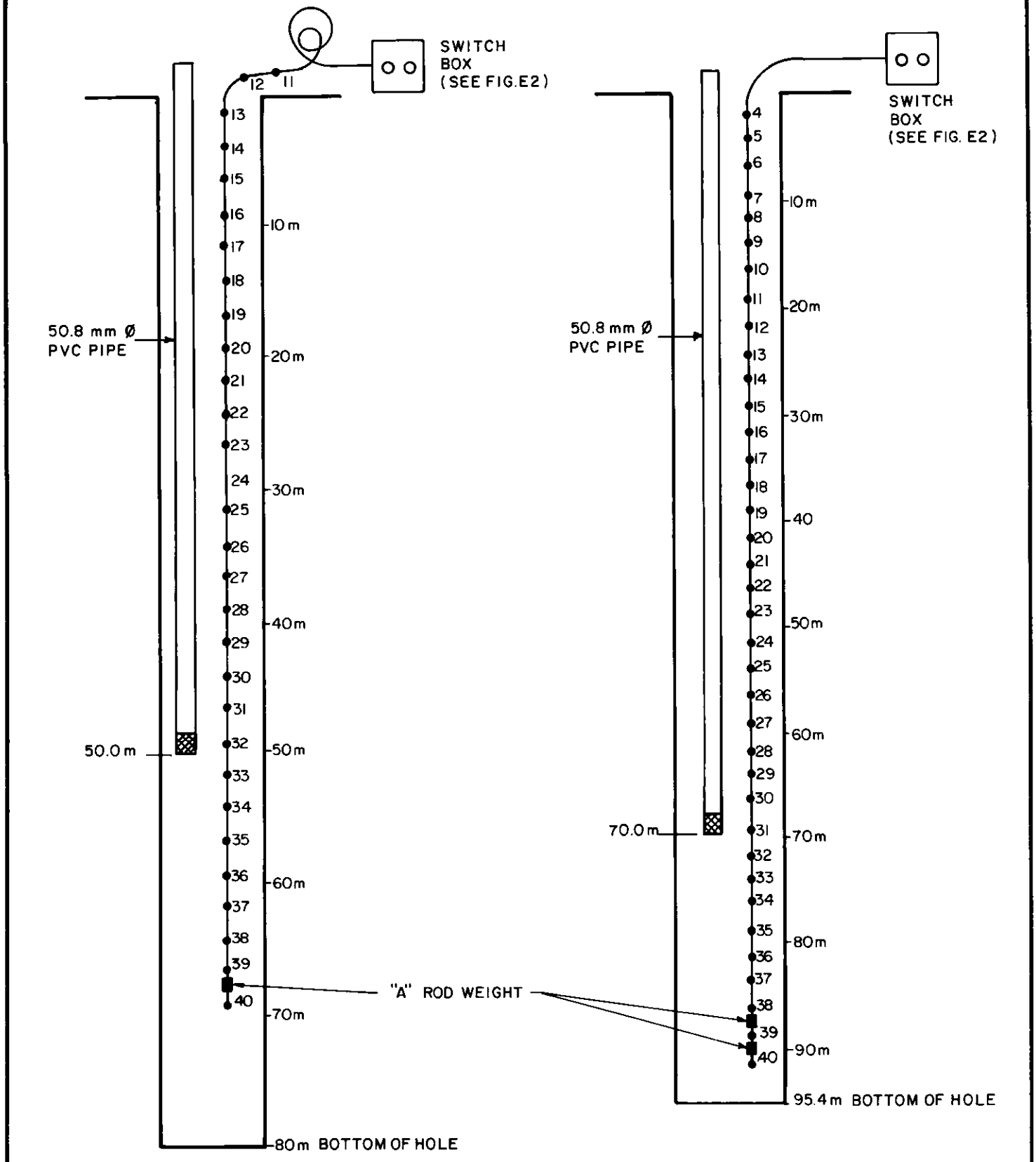
Figures E1 and E2 illustrate the multi-thermistor cable installations at each site and switchbox configuration respectively.

E4. INTITIAL READINGS

Two sets of readings have been measured for each multi-thermistor cable installation. These were taken on completion of cable installation and prior to demobilization from the site. Ground temperatures are shown plotted, for boreholes HA83-D1 and HA83-D2, on Figures 3 and 4, respectively, in the main text.

INSERT FIGURE E1

INSERT FIGURE E2



BOREHOLE HA83-D1
THERMISTOR STRING
INSTALLED TO 69 m

BOREHOLE HA83-D2
THERMISTOR STRING
INSTALLED TO 91.5 m

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BOREHOLE INSTALLATION

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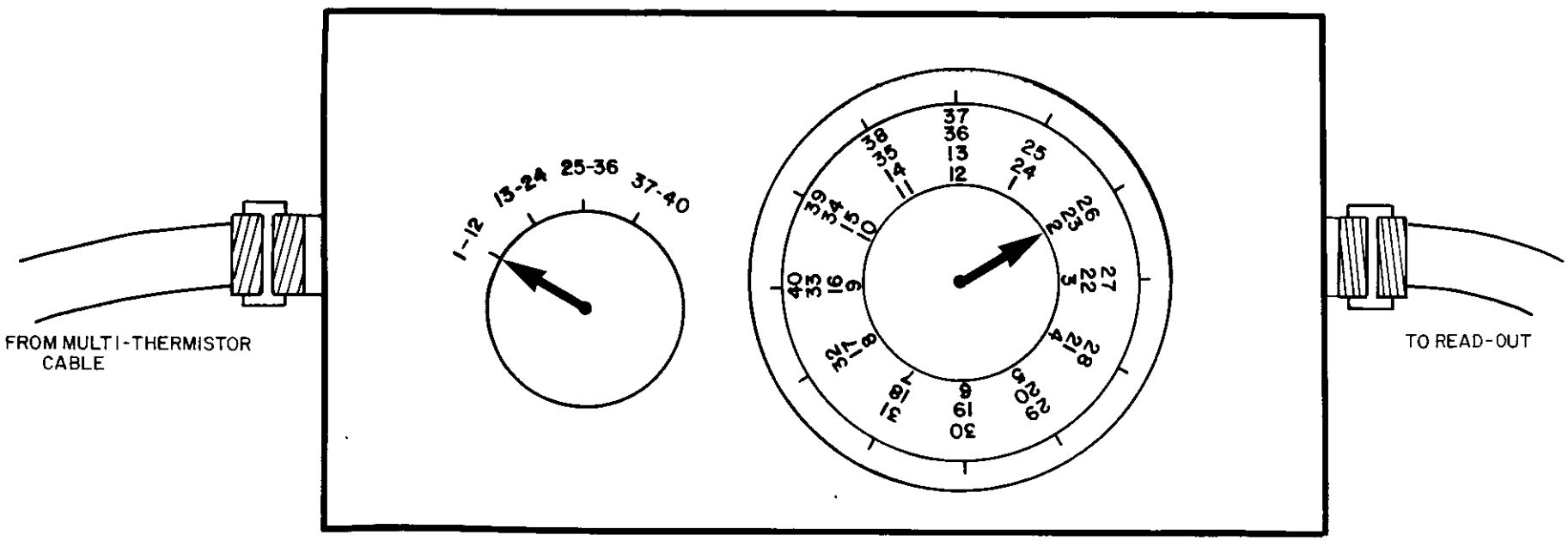
FIGURE E1

HT83-82/03



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SWITCH-BOX DETAIL (SCHEMATIC)

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FIGURE E2

HT10 - 79/05