Report on

GEOTECHNICAL STUDY RELATIVE TO PREPARATION OF QUARRY MANAGEMENT PLANS FOR THREE EXISTING PITS SALT MOUNTAIN NEAR FORT SMITH, N.W.T.

Prepared For

DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT, CANADA

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By

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SUMMARY

A detailed geotechnical investigation of three borrow areas, located at Salt Mountain, approximately 30 km west of Fort Smith, N.W.T., was undertaken to provide information on the quality and quantity of granular material. The overall objective of the study was to create detailed management plans for three existing gravel pits, based on geotechnical investigations, the current regulatory infrastructure and existing and projected usage.

Following a review of existing information, a comprehensive test pitting program was carried out; in all, 29 test pits were excavated within the three areas. Laboratory testing consisted of moisture content determinations and, on selected samples, sieve analysis and visual petrographic analysis. Testing suggests that the aggregate in Areas A and B is suitable for use as granular subbase, general backfill and material for equipment pads; that in Area C, as non-structural fill only. The aggregate in all three deposits is petrographically unsuitable for use as concrete or asphalt aggregate.

Management plans have been developed for each borrow area. Objectives of the plans are: to provide control over the amount of material excavated, to encourage development of the pits in an orderly and efficient manner, to limit the amount of granular material spoilage and to minimize the land requirements. Included in each plan are proposed working and overall pit boundaries, locations for brush piles and overburden stockpiles, and a proposed pit operation and reclamation plan.

It is concluded that all three areas contain sufficient granular reserves to warrant development. Reserves in Borrow Area A are estimated at 20 500 m^3 proven and 80 000 m^3 probable. Borrow Area B reserves are estimated at 11 800 m^3 proven and 18 000 m^3 probable. The granular reserves in Borrow Area C are estimated at 11 700 m^3 proven and 16 000 m^3 probable.

1.0 INTRODUCTION

Hardy Associates (1978) Ltd. was retained by the Department of Indian Affairs and Northern Development (DIAND) to undertake an assessment of granular material quantities and quality in three areas at Salt Mountain, N.W.T., and to develop management plans for the existing multi-user gravel pits. Formal authorization to proceed with the work, as outlined in our proposal, dated October 6, 1983, was received on November 8, 1983. The study was carried out under Contract No. YK-83-83-169.

1.1 TERMS OF REFERENCE

The overall objective of the study was to create detailed management plans for three existing multi-user gravel pits. It is intended that these should be compatible with existing and projected use requirements and the current regulatory infrastructure. To this end, detailed terms of reference were established as follows:

a) To review existing data and airphotos of the area, to provide information on the limits of the deposits.

b) To determine granular reserves and materials quality in each of three designated areas. This involved excavation of test pits, in adherence with the terms and conditions specified in Land Use Permit No. N83C988.

c) To provide a visual classification of the stratigraphy in the field, with a log to be included in the final report.

d) To undertake a program of laboratory testing.

e) To provide a detailed management plan for each area, addressing access, opening sequence, removal of overburden, excavation sequence and reclamation.

f) To address environmental concerns associated with opening, operating and reclamation of the proposed pit areas.

g) To hold discussions with interested parties for input relative to projected requirements and existing management infrastructure.

1.2 METHODOLOGY

The initial stage of the project involved a review of existing data (cited in the list of References) and airphoto interpretation. Black and white airphotos, at a scale of approximately 1:15 000, and field notes supplied to us by Mr. E. Hornby of DIAND were used to initially delimit potential source areas of granular material. A contour plan for each area was also compiled photogrammetrically from the stereo airphotos provided. The contour plans have been used as overall pit location maps and as a basis for development of the management plans.

A field reconnaissance was carried out on November 28, 1983 by our Mr. D. Korpach, M.Sc., P.Eng., in company with DIAND personnel. At that time, several existing pits, including the three areas under consideration for further investigation, were visited. Meetings with DIAND representatives were also held to discuss proposed test pit locations and land use

regulation requirements and to review the list of study contacts. On December 2, 1983, following the completion of the test pitting program, further meetings were held with Town of Fort Smith and DIAND representatives.

A detailed test pitting program was carried out between November 29 and December 1, 1983. In all, some 29 test pits were excavated using a D-7 Cat obtained from Steed Bros. Contracting of Fort Smith. With the exception of final clean up work, Hardy Associates personnel supervised all aspects of the field work. DIAND representatives were also present during most of the field operations.

Grab and bulk samples were returned to the Calgary laboratory of Hardy Associates for testing. Objectives were to determine the quality of the materials within the three sources.

In the office, field data were compiled and the extent of the granular material in each of the deposit areas was estimated. Total recoverable volumes of granular material were computed and the materials quality assessed. On this basis, a detailed management plan was developed for each area.

This report, presenting the results of the field investigation and laboratory testing, and describing the proposed management plans, was prepared as the final phase of the investigation.

2.0 GEOLOGICAL SETTING

The study areas, part of the previously described "Hill 1" deposit (Thurber Consultants Ltd., 1980), is situated in the vicinity of Salt Mountain, approximately 30 km west of Fort

Smith, N.W.T. (Figure 1). Geological conditions are briefly summarized below.

2.1 RELIEF AND TOPOGRAPHY

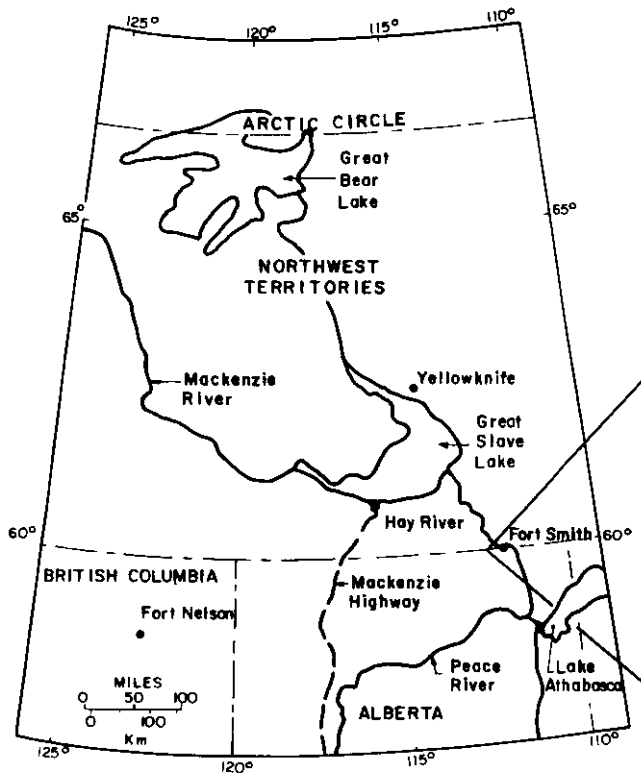
Physiographically, the study area forms part of the Slave River Upland. All three sites have gently sloping, locally ridged, topography, that is characterized by an abundance of sink holes and other karst features. Elevations within the area of interest range from about 180 to 225 m above sea level (asl). Relief is, thus, in the order of 45 m.

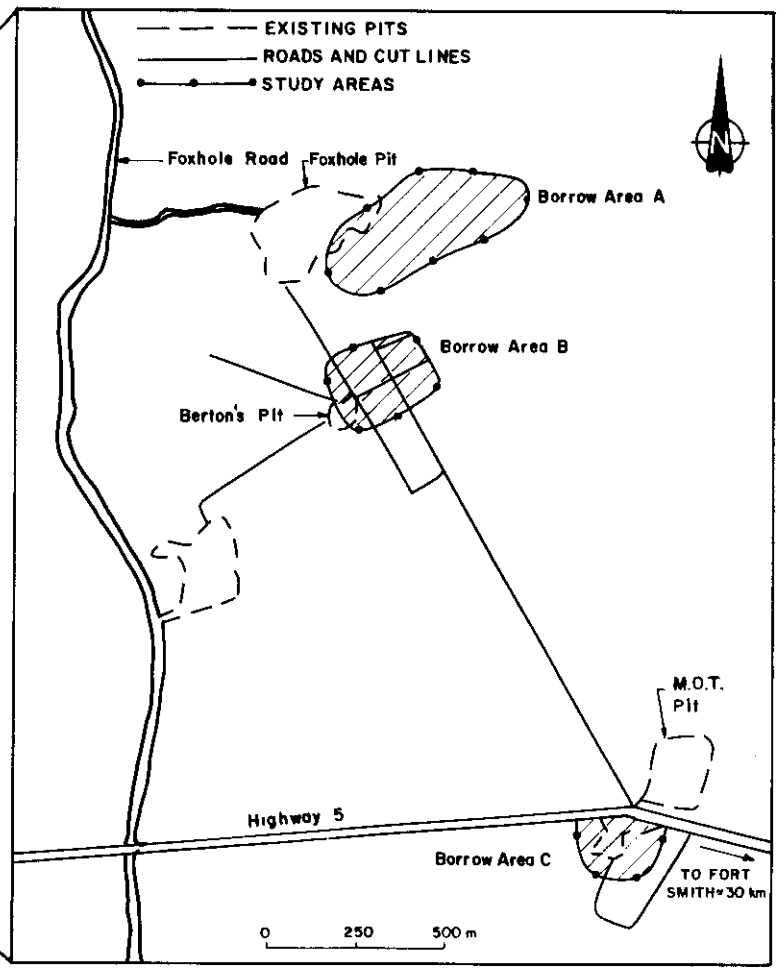
2.2 BEDROCK GEOLOGY

Near surface bedrock in the Salt Mountain area consists of resistant limestones and dolomites of the Middle Devonian Little Buffalo Formation. These strata are underlain by laminated gypsum, salt and fine-grained brown limestone and dolomite of the Chinchaga Formation. Solution of the gypsum of the Chinchaga Formation has resulted in the development of numerous karst features, ranging from large, steep-sided, sink holes to small depressions.

2.3 SURFICIAL GEOLOGY

Airphoto interpretation suggests that shallow ground moraine (till) overlying bedrock is the dominant surficial deposit within the general Salt Mountain area. Field observations indicate that the till has a clayey to sandy composition. Locally overlying the till, but generally resting on bedrock within the study area, is a clay and silt glaciolacustrine deposit. The proposed aggregate sources comprise beach ridge





HARDY ASSOCIATES (1978) LTD.
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GENERAL LOCATION PLAN

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FIGURE 1

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sands and gravels that were deposited during various stages of glacial Lake McConnell (Craig, 1965).

2.4 SURFACE DRAINAGE AND GROUNDWATER

With the exception of occasional small muskegs (that reflect local perched water table conditions), the study area is surficially well drained. The widespread occurrence of karst features, indicative of subsurface solution, suggests that underground drainage is dominant in the area.

3.0 FIELD PROGRAM

A total of 29 test pits were excavated: 11 test pits in Borrow Area A, 12 test pits in Borrow Area B and 6 test pits in Borrow Area C. In addition, one face of the existing pit in Area C was scraped clean and the stratigraphy logged. All test pits were excavated between November 29 and December 1, 1983. Test pit locations are shown on the site plans (Plates C1 and C2, Appendix "C").

3.1 METHODOLOGY

All test pits were excavated with a D-7 Cat, supplied by Steed Bros. Contracting of Fort Smith.

Initial proposed test pit locations were determined in the office, based on airphoto interpretation and the review of existing information. Final locations were then established in the field after consultation with DIAND personnel.

Test pitting, logging and sampling were carried out under the supervision of, and by, a Hardy Associates engineer. All but two of the test pits, A10 and C6, were extended to the bottom of the granular deposit and into the underlying clay. Test pits A10 and C6 were excavated to a depth of 3 m, at which point the Cat was unable to excavate deeper.

Grab samples were taken at intervals from each of the test pits to provide a moisture content profile. Bulk samples were also obtained from most test pits for more detailed laboratory testing (see Section 4.0).

Efforts were made to follow existing cut lines wherever possible to limit the requirements for clearing of new lines. Our proposal dated October 6, 1983 stated that all test pits would be backfilled upon completion of the field investigation; however, following discussions with DIAND representatives and the Land Use Inspector, it was agreed that leaving the test pits open would be beneficial. Clean up operations, in accordance with the land use regulations, took place following the test pitting program.

3.2 RESULTS

Test pit logs are presented on Plates A1 to A30 in Appendix "A". A description and evaluation of the granular material found in each area is given in Section 6.0.

4.0 LABORATORY TEST PROGRAM

Grab and bulk samples, retained from the test pits, were shipped to Hardy Associates' Calgary laboratory for detailed testing.

4.1 TEST PROCEDURES

Moisture content determinations (ASTM D2216) were performed on all grab samples. Grain size analyses (ASTM C136.82) were then done on several representative samples from each area. Representative samples from each deposit were also set aside for petrographic analysis. One detailed petrographic analysis (ASTM C295) was carried out on a coarse aggregate sample from Borrow Area A, and less detailed analyses on samples from the other two areas.

4.2 TEST RESULTS

Results of the laboratory testing program are presented on Plates B1 to B13 and Tables B1 to B3, in Appendix "B". Results of a previous petrographic analysis (Table B4) and sieve analysis results for a sample from the M.O.T. Pit (Plate B-14) are also presented.

5.0 GRANULAR MATERIAL REQUIREMENTS

5.1 PREVIOUS SOURCES

A detailed survey of users and potential users of gravel in the Fort Smith area was undertaken in early 1983 (Thurber Consultants Ltd., 1983). As part of the present study, the

list of contacts was reviewed with DIAND representatives and new contacts were suggested. The following provides a summary of the overall findings.

Early in 1983, Town of Fort Smith officials indicated that their granular material requirements were minimal and, to date, had generally been for maintenance and upgrading streets only. An existing 2000 m^3 stock pile was expected to last for three or four years. More recent discussions, between Town officials and Hardy Associates personnel, indicate that the stock pile still exists. Plans for a major road paving program over the next few years may, however, create a requirement for additional aggregate.

The local Highways Department has their own pit. Sufficient quantities are available to meet their needs for a considerable time. Previous requirements have been in the order of 10 000 m^3 per year.

Aggregate for the runways at the Fort Smith airport was obtained from the pit located north of Borrow Area C (M.O.T. Pit). Approximately 15 000 m^3 of material was hauled from this location and processed to 12.5 mm crush. One of the two runways was paved in 1982. It appears that more aggregate will be required for further paving in the near future.

Laboratory test data available from the M.O.T. Pit (immediately north of Area C) suggest that the granular material is too rounded and lacking in fines to be suitable for road surfacing material. A copy of a grain size curve previously determined for this material (by J.R. Payne and Associates Ltd.) is included on Plate B-14 (Appendix "B").

Excluding Highways and Transport Canada, approximately 15 permits were issued by the local office of DIAND over the past ten years to contractors for the extraction of granular material from Salt Mountain. Approximately 21 000 m^3 of granular material was extracted over this time period.

There is an existing pit on the east side of the Slave River in Alberta about 60 km from Fort Smith that has been used for obtaining better quality aggregate. The contractor hauling from this pit produced about 450 m^3 of concrete in 1982 (Thurber Consultants Ltd., 1983).

5.2 PROJECTED GRANULAR REQUIREMENTS

A recent study by Stanley Associates (quoted in Thurber Consultants Ltd., 1983) presented five possible development scenarios. Only the high and low demand cases will be summarized here.

For the low demand scenario (continuation of existing trends with no major external impacts), requirements would be similar to those of the past. Excluding Highways usage, the volume required would be in the order of 2000 m^3 to 2500 m^3 per year. Highway requirements are anticipated to be similar to those of previous years, approximately 10 000 m^3 per year.

The large scale development scenario would include construction of the Slave River hydro dam, and other developments that may increase the demand for residential and industrial land in the Town of Fort Smith. The estimated granular material requirements for a 10 year period for this development scenario are:

- Town of Fort Smith 100 000 m^3
- Highways and Airport 150 000 m^3

Since the material in the Salt Mountain area is generally unsuitable for use as concrete or asphalt aggregate, other sources (e.g. east of Slave River in Alberta) would have to be used for these purposes. Breaking the above down to a yearly demand, volumes required by the Town of Fort Smith would be in the order of 10 000 m^3 per year. It has been previously recommended that the Highways Department continue to operate in their existing area (Thurber Consultants Ltd., 1983).

For the purposes of the present study, sources for the balance of the 10 year granular materials requirements (which could vary, based on the above, from about 2500 m^3 to 10 000 m^3 per year) need to be identified.

6.0 DEPOSIT EVALUATIONS

Each of the deposits is evaluated below, in terms of suitability for different uses, with respect to available volumes, material type and quality and possible uses. A proposed management plan for each pit is outlined in detail in Section 7.0.

6.1 EVALUATION CRITERIA

In evaluating the materials as to possible uses, reference was firstly made to a granular materials classification, previously provided to us by DIAND (Table 1). Secondly, information contained in Indian and Northern Affairs Canada (1982), summarized on Table 2, was used.

TABLE 1

CLASSIFICATION OF GRANULAR MATERIALS
(After DIAND)

Source Quality Description	General Description of Material	Minimum Technical Identification Parameters	Suggested Uses of Material
Excellent	Well graded sands and gravel, suitable for use as aggregate with a minimum of processing	Petrographic Number: 160 max. Los Angeles Abrasion Loss: 35% maximum. Soundness Loss (Magnesium Sulphate): 12% maximum, and meeting other requirements of CSA A23.1-1973.	Portland cement, and asphaltic concrete aggregate, masonry sand, concrete block, surface coarse and roofing aggregate.
Good	Well graded sands and gravels, with varying quantities of silt.	Petrographic Number: 200 max. Los Angeles Abrasion Loss: 60% maximum. Fines greater than 10% passing the 200 sieve can be removed with minimum of processing.	Granular base and subbase. Winter sand backfill for trenches and slabs. Pads for structures. Select backfill.
Fair	Poorly graded sands and gravels, with or without substantial silt content	Petrographic Number: 250 max. Can be processed to meet local frost susceptibility criteria.	Granular subbase. General backfill material, pads for equipment.
Poor	Poorly graded granular soils of high silt content, possibly containing very weak particles and deleterious materials.	Nil	General non-structural fill.

TABLE 2

TYPICAL PROPERTIES OF GRANULAR MATERIALS OF DIFFERENT USES
(After Indian and Northern Affairs Canada, 1982)

Use	Typical Properties
Concrete Aggregate	- well graded sand and gravel - rounded particles - fine and coarse aggregate - clean - very low quantity of contaminants
Building Pads, Roads, Staging Sites, Airstrips	- well graded sand and gravel - less than 5% finer than No. 200 sieve
Road Surfacing	- well graded granular material - angular - maximum size of 2.5 cm - 10-25% finer than No. 200 sieve
Road Base and Sub-base	- well graded sandy gravel - angular - less than 8% finer than No. 200 sieve
Pipe/Culvert Bedding	- non frost-susceptible sand and gravel - free from large rocks, frozen lumps, ice and organic material
General Fill	- non frost-susceptible sand and gravel, quarried rock and clay till - free from organic material - free from ground ice
Rip Rap	- well graded cobbles and boulders - resistant to chemical and mechanical weathering

Detailed field surveys of the three potential borrow areas were not conducted as part of the field investigation. Surface areas for each borrow area were, therefore, calculated based on the contour maps, compiled photogrammetrically from uncontrolled aerial photographs. Deposit thicknesses were estimated based on the results of the test pitting program.

In view of the shallowness and relatively variable nature of the sources, both proven and probable reserves (and overburden volumes) have been computed for each deposit. The proven reserve was calculated assuming an average granular material thickness (based on observed thicknesses at the test pit locations) extrapolated over an area of approximately 25 m radius around the test pits. Overburden volumes were calculated in a similar manner. In Borrow Areas A and B, the total thickness of granular material was then reduced by 0.3 m (to account for the presence of a bouldery and cobbly layer at the base of the granular deposit) and a recoverable volume computed.

Probable reserves were calculated for each deposit using the same proven deposit thicknesses extrapolated over the total deposit surface area. They were calculated assuming the deposit to be continuous over the entire distance between the test pits.

6.2 BORROW AREA A

6.2.1 Deposit Description

This source is situated to the east of the existing Foxhole gravel pit, approximately 30 km west of Fort Smith and 2 km

north of Highway 5 along the old Foxhole Road (Figure 1).

The site gently slopes at an average of about 3 degrees to the northwest (Plate C1). The entire study area is covered by trees. During the field investigation the following observations were made:

a) Several well defined large sink holes are present. One exists just north of test pit A6 and another south of test pit A1. The ground surface is very uneven, with many small depressions and mounds. Elevations vary from about 200 to 215 m asl.

b) North of test pit A1, there is a drop in elevation.

6.2.2 Field Investigation

Eleven test pits (A1 to A11) were excavated on November 29, 1983. Test pit locations are shown on Plate C1 and the logs are presented on Plates A1 to A11, Appendix "A". Laboratory test results are presented on Plates B1 to B6 and Table B1 (Appendix "B").

6.2.3 Material Types

Granular materials are relatively uniform across the site, consisting of medium gravel with some organic lenses. Occasional cobbles and boulders are present and, at eight of the test pits, cobbles and boulders were encountered at the base of the granular deposit. Very few fines (approximately 4 percent) were evident in the deposit. In general, the material encountered in the north-central portion of the area

(for example, TP's A1 and A2) contained more frequent organic lenses.

Overburden at the site is also of relatively uniform thickness (approximately 0.3 m) and consists of an organic-rich silt, sand and gravel material with many roots. The granular material varies from about 1.0 to 1.5 m thick over the site, with somewhat greater thicknesses occurring in the southwest (in the vicinity of TP's A9 and A10). All test pits were dry on completion and two days later.

6.2.4 Available Reserves

Granular material is present over the entire investigated area.

The proven reserves cover an area of about 21 600 m^2, with an average thickness of 0.95 m (allowing for the basal boulder layer). On this basis, proven reserves are estimated at 20 500 m^3 of granular material.

Probable reserves extend over a much greater area, approximately 84 000 m^2 (outlined on Plates C1 and C3); again assuming an average thickness of 0.95 m over this area, the estimated probable reserves are 80 000 m^3. Considerably more material may be available, however, in the cobble and boulder layer at the bottom of the granular deposit. The recoverable volume, allowing for this material (based on an average thickness of 1.25 m), is estimated to be 105 000 m^3.

Overburden volume is estimated to be 26 000 m^3, giving a stripping ratio (overburden to granular material) of about 1:3.

The estimated probable volume of granular material makes no allowance for the presence of sink holes, two of which were observed during the field investigation. Others may exist within the deposit area.

It should also be noted that test pits excavated previously indicate that granular material exists outside the area delineated in this study. There are two reasons for defining the extent of the granular deposit: to provide, firstly, a realistic basis for the estimation of material volumes and, secondly, a defined "working pit" to form a basis for developing the management plan.

6.2.5 Material Quality

Moisture content of the gravel ranged from 2 to 7 percent, with an average of 3 percent. No moisture content determinations were carried out on overburden samples or the underlying clay.

Grain size analyses were conducted on six samples from this deposit; results are presented on Plates B1 to B6 (Appendix "B"). On average, the material consists of about 57 percent gravel sizes (range: 54-61 percent), 39 percent sand (range: 35-41 percent) and 4 percent fines (range: 3-5 percent).

Petrographic analysis of a sample from test pit A5 yielded a PN value of 213 (Table B1). A PN of 228 was obtained by others for a sample from test pit 81-16 (Plate C1), a short distance to the east.

6.2.6 Possible Uses

In terms of the DIAND classification (Table 1), the granular material from this deposit is of fair quality. On this basis, it is considered suitable for use as general fill, granular subbase and equipment pad construction material (Tables 1 and 2). A minimal amount of screening may be required for certain uses. Laboratory results suggest the material is unsuitable, petrographically, for use as concrete or asphalt aggregate.

A well-defined layer of topsoil was not encountered at any of the test pit locations. The overburden is of poor quality and is not recommended for use as topsoil or any type of fill. However, the material should be stockpiled for use in reclamation.

6.3 BORROW AREA B

6.3.1 Deposit Description

This deposit is located to the northeast of the existing Berton's borrow pit (Figure 1); the site slopes gently towards the northwest. Since the airphoto upon which the mapping was based was taken, additional clearing has been done in the area. In the order of 80 percent of the site has now been cleared of both brush and overburden. Stockpiles, containing a mixture of brush and overburden, exist near the edge of the

site (Plate C3). The following observations were made during the field investigation.

a) Immediately northwest of test pit B10, the topography drops off sharply.

b) The cleared area is relatively flat; however, at the edges of the clearing there is a slight drop in elevation that appears to mark the limits of the granular material.

c) To the northwest of the clearing there is a muskeg area; standing water is present during the summer months.

6.3.2 Field Investigation

Twelve test pits (B1 to B12) were excavated, on December 1, 1983, in this area. Test pit locations are shown on Plate C1, and the logs are presented on Plates A12 to A23, Appendix "A". Laboratory test results are presented in Appendix "B", Plates B7 to B9 and Table B2.

6.3.3 Material Types

Granular material was found in all the test pits, except TP B11; however, only six encountered material of sufficient thickness and adequate quality to warrant development. The granular material consists primarily of fine, poorly graded, gravel (with about 36 percent sand). Fines content is low (about 2 percent) and only a small amount of organic material was visible. Few cobbles or boulders were encountered, except near the bottom of the deposit (where a thin layer exists).

At the other locations (TP's B3 and B6 to B9), the granular material contained abundant organic lenses and was of a much poorer quality. It is believed that these (latter) test pits are located near the limit of the recoverable granular material.

Overburden is present near test pit B10 only; it is of similar composition to that encountered in Borrow Area A and approximately 0.3 m thick.

The thickness of the granular material is greatest in the northwest part of the site. All test pits were dry on completion of excavation; however, the clay underlying the gravel deposits was wet at some locations. Standing water exists in the muskeg northwest of the site in the summer.

6.3.4 Available Reserves

The proven resource covers an area of about 9800 m^2, with an average thickness of 1.2 m. Proven granular material reserves in Borrow Area B are estimated, on this basis, to be in the order of 11 800 m^3.

Probable reserves extend over a larger area (outlined on Plates C1 and C3), estimated at approximately 15 000 m^2. The recoverable average thickness of granular material again is taken as 1.2 m (the overall average thickness, including the layer of cobbles and boulders at the base of the deposit, is about 1.5 m). Estimated probable recoverable volume of granular material from the area is 18 000 m^3.

Overburden is present in only a small part of the site (due to previous stripping). The estimated volume is about 1000 m^3 in total.

6.3.5 Material Quality

Moisture content of the granular material ranges from about 2.4 to 6.5 percent, with an average of about 3 percent. Moisture contents of the overburden and the underlying clay are about 6.5 percent and 14 percent, respectively.

Grain size analyses were conducted on three samples from this deposit; results are presented on Plates B7 to B9 (Appendix "B"). The material consists, on average, of 62 percent gravel (range: 47-72 percent), 36 percent sand (range: 25-51 percent) and 2 percent fines.

A petrographic analysis performed on a sample from TP B4, yielded a PN value of 212.

6.3.6 Possible Uses

On the basis of the classification given in Table 1, the granular material from this deposit is rated as fair. Suggested uses for the granular material in this area include general fill, fill for equipment pads, granular subbase, and culvert/pipe bedding (Table 2). Some of the material may require screening prior to use. Composition of the granular material is relatively consistent over the area. Based on the results of the petrographic analysis, the material is considered unsuitable for use as concrete or asphalt aggregate.

Most of Borrow Area B has been cleared so that only a small volume of overburden is anticipated to be present. The overburden is similar in composition to that in Area A, and is not recommended for use as fill. The material can, however, be placed back into excavated areas during reclamation. A well-defined layer of topsoil was not found at any of the test pit locations.

6.4 BORROW AREA C

6.4.1 Deposit Description

Borrow Area C surrounds an existing pit on the south side of Highway 5, across the highway from the existing M.O.T. Pit (Figure 1). It is situated on a broad ridge (Plate C4). A portion of the site has already been cleared and stockpiles, consisting of a mixture of overburden and brush, are located to the northeast.

Due to the variability of the deposit, Area C has been subdivided into two parts. Section C1 (subsection A to F on Plate C4) includes granular material located within the ridge proper, while Section C2 consists of the small area at the west of the site that appears to lie outside the ridge.

6.4.2 Field Investigation

Six test pits (C1, C2 and C4 to C7) were excavated on November 30, 1983. The face of the existing pit was also cleaned and logged (considered as TP C3). Test pit locations are shown on Plate C2 and the logs are presented on Plates A24

to A30, Appendix "A". Laboratory test results are presented in Appendix "B", on Plates B10 to B13 and Table B3.

6.4.3 Material Types

Section C1 contains coarse, poorly graded, granular material, with frequent cobbles and boulders. As shown on Plate C2, the thickness of the deposit varies considerably across the site, from about 2.4 m on the east (TP C6) to 1.2 m on the west (TP U). A small percentage of fines (approximately 4 percent) is present. Occasional thin layers of pea gravel were visible within the existing pit face. Near the base of the ridge (e.g. TP C5), there are fewer cobbles and boulders and occasional thin organic lenses are found within the granular deposit. The thickness of the deposit also decreases considerably at the base of the ridge. Field investigations and information from existing test pits suggest that the limit of the granular deposit lies close to the base of the ridge; however, some shallow, dirty gravel is present at other test pit locations.

Overburden, extending to depths of about 0.6 m, and brush cover most of the deposit area. The overburden consists of a a mixture of organic debris, clay, silt and gravel sizes. All test pits in this area were dry upon completion of excavation.

Section C2 contains coarse, poorly graded, granular material with a few cobbles and boulders. Thickness of the gravel deposit in this area is in the order of 0.8 m. Approximately 10 percent fines are present. A small amount of organics was observed during the test pitting operation. South of TP C2, the thickness of the granular deposit decreases to 0.3 m, at

existing pit 23. The limit of this deposit to the west was not determined.

Overburden, of similar composition to that encountered previously, and trees cover the area. Overburden thickness is in the order of 0.4 to 0.6 m.

6.4.4 Available Reserves

Section C1 has a proven area of about 7800 m^2, with an average granular material thickness in the order of 1.5 m. On this basis, proven reserves of 11 700 m^3 are estimated.

Probable reserves cover an area of about 10 900 m^3 (outlined on Plates C2 and C4). The estimated probable volume is 16 000 m^3 of granular material.

Overburden covers a significant portion of the area and extends to depths of up to 0.6 m. Estimated volume is about 5000 m^3.

Section C2 has a proven area of about 1400 m^3. However, the guidelines for pit development (Indian and Northern Affairs Canada, 1982) suggest an adequate buffer strip of trees be left between the road right-of-way and the pit. The buffer zone width should be equal to or greater than the height of the trees and may extend for up to 30 m. Assuming such a zone is implemented, the proven area would be decreased to about 750 m^2.

Based on an average granular deposit thickness of 0.8 m, the volume would be about 1100 m^3 or 600 m^3 depending on whether

or not a buffer zone is implemented. Probable volumes cannot be calculated directly because the extent of the deposit was not determined; however, the field investigations suggested that probable volumes in the order of 2000 m^3 could be recovered from this area (with no buffer zone). Overburden volume is estimated to be 550 m^3, but will again vary depending on the buffer zone requirements.

6.4.5 Material Quality

Moisture content of the gravel ranges from 3.4 to 4.8 percent (average 4.3 percent) in Section C1 and 3.8 to 5.6 percent (average 4.5 percent) in Section C2.

Grain size analyses were conducted on four samples from Area C (two from Section C1 and two from Section C2); test results are presented on Plates B10 to B13, Appendix "B". In Section C1, the material consists, on average, of about 57 percent gravel (range: 52-61 percent), 39 percent sand (range: 36-42 percent) and 4 percent fines (range: 3-6 percent). The granular material in Section C2 consists, on average, of about 49 percent gravel (range: 46-52 percent), 41 percent sand (range: 36-47 percent) and 10 percent fines (range: 7-12 percent).

A petrographic analysis performed on a sample from TP C5 yielded a PN value of 268. On this basis, the material is considered petrographically unsuitable for use in concrete or asphalt.

6.4.6 Possible Uses

With reference to Table 1, granular material in Section C1 can be classified as poor (based on visual inspection and laboratory test results). Tables 1 and 2 suggest that the only possible use for the granular material in this area may be as general non-structural fill. Some of the coarser material, cobbles and boulders, might be suitable for use as rip rap. Screening of the material will generally be required.

The composition of the granular material found in Section C1 is similar to that of the M.O.T. Pit, directly across the road from Borrow Area C. Granular material from the M.O.T. Pit has been used previously for asphalt aggregate (for the Fort Smith airport runway). However, it is understood that problems with this asphalt are being experienced only two years after application. Laboratory test results (for one sample from Area C) suggest the material is petrographically unsuitable for asphalt aggregate.

Section C2 contains granular material that is classified as fair to poor (Table 1). It would be suitable for use in road surfacing as well as for general purpose fill since the additional fines content will provide a good binder.

Overburden from both sections of Area C is similar to that described previously and is not recommended for use as fill. The material can be used for reclamation purposes. A well-defined layer of topsoil was not found at any of the test pit locations.

7.0 PROPOSED MANAGEMENT PLANS

7.1 GENERAL CONSIDERATIONS

The following sections discuss gravel pit design, opening, operation and reclamation for the borrow source areas. The proposed management plans have been developed on the basis of the field and laboratory study results. Account has also been taken of supplementary information supplied to us by DIAND (included in Appendix "A"). Site-specific details of the considered development strategies for each pit are discussed separately in Section 7.2. Modifications to the proposed plans can be readily implemented to meet varying requirements.

7.1.1 Pit Boundaries

Two types of pit boundaries need to be defined. The working pit boundary reflects the extent of the granular material to be developed. It was defined, for each deposit, based on airphoto interpretation and the results of field testing. The working pit boundary provides a basis for developing the overall management plan.

The overall pit boundary, defined to limit the amount of land to be disturbed, includes the working pit together with additional space for overburden and topsoil stockpiles, temporary brush windrows, working space and a grading zone. A small area of standing timber is included.

Proposed overall and working pit boundaries for the three borrow areas are shown on Plates C3 and C4. These boundaries may have to be altered due to the presence of large sink holes

or where the topography drops off sharply. A schematic cross-section of the anticipated space requirements is shown on Figure 2.

7.1.2 Access

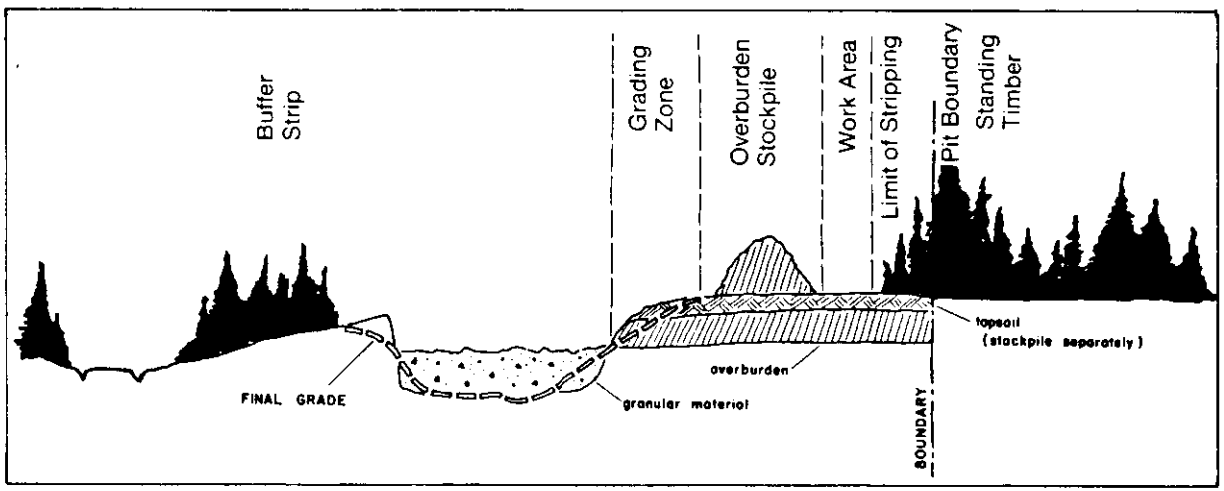
As far as possible, access to the borrow pits should be developed utilizing existing cut lines and other disturbed areas. Access routes proposed as part of the management plans are indicated on Plates C3 and C4.

7.1.3 Pit Boundary Marking

The overall and working pit boundaries should be adequately staked and flagged and control points established as the first stage of pit development. Existing cut lines and test pit locations may be used as an aid in establishing these boundaries. Following the establishment of the pit boundary, the limit of stripping should be flagged. Finally, the initial subsections should be defined. Each subsequent subsection can be laid out as new permit requests are received. This will allow for subsection division according to the present and future volume requirements of the permittee. The subsection divisions shown on Plates C3 and C4 represent a suggested area breakdown only.

7.1.4 Clearing, Grubbing and Brush Disposal

Based on the field observations and examination of the air photo, the amount of salvageable timber in the three borrow areas appears to be minimal. However, prior to opening each pit, the area should be inspected by the Land Use Inspector to



(AFTER : INDIAN AND NORTHERN AFFAIRS CANADA , 1982)

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TYPICAL WORKING SPACE REQUIREMENTS CLEARING TO ONE SIDE OF PIT

CG 10106

Figure 2

HT10 - 79/05

locate and mark any merchantable timber (if present) for salvage. If a sufficient quantity of merchantable timber is identified, it is suggested that a salvage operation be performed prior to commencing pit operations. Similar procedures would be appropriate for salvaging material suitable for firewood.

It is suggested that clearing of each subsection should be undertaken as required. Clearing should proceed from the overall pit boundary inwards until a strip of about 10 m has been cleared. This procedure limits disturbance to the surrounding vegetation. Brush from the designated subsection may then be cleared and placed in windrows at the approximate locations shown on Plates C3 and C4. The windrows should be compacted and either burned in a controlled manner before the fire season begins or saved for use during reclamation (subject to the approval of the Land Use Officer). Grubbing will probably be necessary to remove large roots and stumps from the soil.

7.1.5 Topsoil/Overburden Handling and Spoil Disposal

The surficial organic-rich overburden and/or topsoil (where present) should be stripped and stockpiled separately as the first phase of development. Stripping of overburden may then proceed. Proposed locations for topsoil and overburden stockpiles are indicated on Plates C3 and C4. All stockpiles should be placed a minimum of 5 m from standing timber.

7.1.6 Pit Operation

Operation of the pits should encourage development in an orderly and economic manner, limit the amount of granular material spoilage and minimize the land requirements. Detailed operating sequences for each borrow area are outlined in Section 7.2.

All of the test pits were dry following the completion of excavation, indicating that the present (winter) water table is below the base of the granular material. The apparent absence of water problems in the existing pits suggests that the summer water table is also below the base of the granular material.

Thus, it is anticipated that drainage problems will be minimal; limited to collection of surface runoff water in small depressions and sink holes.

It may be necessary to design the pits to handle surface runoff. To this end, drainage ditches along access roads and adjacent to working sections may be required to drain small amounts of water away from the working area. The ditches would drain into sumps located away from existing working areas.

If groundwater is encountered at any location, excavation should not extend below the water table and, preferably, to only within 0.5 to 1.0 m of the water table (Indian and Northern Affairs Canada, 1982).

7.1.7 Reclamation Sequence

Restoration requirements will vary depending on whether the pit is being abandoned permanently or only temporarily. Temporary pit abandonment restoration procedures are suggested for areas where substantial volumes of granular material are expected to be present outside the proposed working pit area; specifically, to the east of Borrow Area A, in the direction of the existing cut line shown on Plates C1 and C3.

For temporary abandonment, the working face must be left open for future access. Clean up and drainage and erosion control, as discussed in the following paragraphs, should be included in the restoration program. Revegetation, slope recontouring and replacement of overburden, granular waste material and topsoil stockpiles can be undertaken following permanent pit abandonment.

Post-development reclamation activities and procedures for permanently abandoned pits should include the following:

Site Inspection and Clean-up

A detailed examination should be conducted by the Land Use Inspector following extraction operations in each subsection.

Overburden and Waste Granular Replacement

Waste granular material and overburden generated by extraction activities and remaining in or surrounding the pit area should be spread over the floor of the pit and against the toe of the slopes prior to slope gradient construction. Surplus

overburden and waste granular materials remaining on the work or road areas should also be returned to the pit floor where practicable.

Site Grading and Contouring

All pit walls remaining after project borrow development activities should be reconstructed following final site development, use and clean up activities. Slope gradient reconstruction should involve the transfer of waste and overburden materials from waste pile areas to the slope toe prior to slope reconstruction.

Erosion and Drainage Control

Obstructions to natural drainage resulting from project activities should be removed where practicable. Drainage channels should be constructed where required to redirect the flow of water. Drainage channels should be constructed of granular materials. Ditch checks may be required for velocity control and sediment retention.

Topsoil Replacement

Topsoil should be replaced on all pit surfaces and side slopes. Soil should be pushed from the storage area across the regraded slope and spread over the pit floor. Soil should be replaced to the depth originally stripped.

Scarification

All exposed surfaces generated during project activities should be scarified where possible.

Revegetation

Consideration should be given assisting revegetation on all prepared bare soil surfaces generated during borrow development activities; especially those readily visible to the public. Furthermore, assisted revegetation serves as an aid to control erosion and improve wildlife habitat. Suggested assisted revegetation includes seeding with a standard seed mix and fertilizing with 10-30-10 at a rate of 250 kg/ha. A recommended seed that we have used with success in similar areas on previous occasions is shown on Table 3.

TABLE 3

RECOMMENDED SEED MIX FOR SALT MOUNTAIN QUARRY

Species	Variety	Mix % by Wt.	Application Rate kg/ha
Slender Wheat Grass	Revenue (Sodar Streambank)*	28	14.0
Creeping Red Fescue	Arctared (Boreal)	20	10.0
Crested Wheat Grass	Fairway	20	10.0
Sheep Fescue	Durar	15	7.5
Reed Canarygrass	Vantage	12	6.0
Timothy	Engmo (Climax)	5	2.5
		100	50.0

* Alternate variety if specified variety is not available.

The seeding and fertilizing would assist in controlling erosion while reducing the visual impact. The rates are such that natural revegetation will not be inhibited.

7.2 SPECIFIC CONSIDERATIONS

The following section discusses the site-specific considerations which apply to each borrow area. General considerations discussed in the previous section are applicable to all three areas.

7.2.1 Borrow Area A

Overall and working pit boundaries for Borrow Area A are shown on Plate C3. Techniques used in defining and marking these pit boundaries are discussed in Sections 7.1.1 and 7.1.3.

A buffer strip of thickness equal to or greater than the height of the trees (10-15 m) should be left between the existing and new pits. Alternatively, all the trees in this area could be removed.

Access to Borrow Area A is readily available through the existing pit as shown on Plate C3. Access should be developed within each working area and maintained until all the granular material from that area has been extracted.

Clearing and grubbing will be required for the entire area and should be conducted in accordance with procedures outlined in Section 7.1.4. Large sink holes may hamper clearing operations and it may be necessary to work around these areas. Brush should not be pushed into the sink holes.

Topsoil and overburden should be handled according to procedures outlined in Section 7.1.5. Overburden and topsoil should not be pushed into sink holes.

The Operation Sequence for Borrow Area A is shown on Plate C3. The quality of granular material found in this borrow area is relatively uniform across the site; therefore, separation into zones suitable for different uses is not warranted. Four distinct operating zones are defined, containing subsections A to F, G to L, M to P and Q to S (Plate C3). These subsection divisions represent a suggested breakdown only and can be readily altered to be more compatible with actual granular material requirements. The proposed plan is organized to allow simultaneous development of these four zones, with opening subsections A, G, M and Q and subsequently following the plan shown on Plate C3.

Underground collapse features, although not identified in the field, may be present in the area. Operators should be warned of this potential hazard.

Reclamation activities should be carried out in accordance with procedures outlined in Section 7.1.7.

Borrow Area A covers a large area and it is likely that considerable granular material exists beyond the working pit boundary at certain locations. Should this be the case, temporary pit abandonment restoration procedures may be performed in this area.

7.2.2 Borrow Area B

Overall and working pit boundaries for Borrow Area B are shown on Plate C3. General considerations pertaining to definition and marking of these boundaries are given in Sections 7.1.1 and 7.1.3.

Access to Borrow Area B is readily available along existing cut lines and through the existing pit (Plate C3). Access should be developed within each working area and maintained until all the granular material from that area has been extracted.

Clearing and grubbing will only be required for a small portion of this area since approximately 80% of Borrow Area B has already been cleared. General clearing and grubbing procedures are outlined in Section 7.1.4. Some existing brush piles are located within the proposed working pit boundaries and will need to be moved (Plate C3).

Topsoil and overburden, where present, should be handled according to procedures outlined in Section 7.1.5.

The Operation Sequence for Borrow Area B is shown on Plate C3. Granular material quality at Borrow Area B does not vary appreciably over the site with respect to suitability for different uses. Thus, separation into zones of different usage is again not justified.

The existing cleared area has been subdivided into suggested subsections, the boundaries of which can be adjusted to match actual volume requirements. It will also be possible to stake

this area off for much smaller volumes (comparable to those that have been required previously). The first permit issued in Borrow Area B would be for extraction from either subsection A or D, the two opening subsections. The issuer could outline an area that would provide sufficient volume (including a contingency factor) to fulfill the permit requirements. Place C3 shows a typical subdivision and operation scheme that could accommodate two users.

Underground collapse features, although not identified in the field, may be present in the area and operators should be warned of this potential hazard.

Reclamation activities should be carried out in accordance with procedures outlined in Section 7.1.7.

7.2.3 Borrow Area C

Overall and working pit boundaries for Borrow Area C are shown on Plate C3. Methods of defining and marking these boundaries have been discussed in Sections 7.1.1 and 7.1.3. Buffer strips adjacent to the roadway, with a width of up to approximately 30 m (Indian and Northern Affairs Canada, 1982), should be left (Plate C4).

Access is readily available through the existing pit and should be developed and maintained in each working area until granular material from that area has been completely removed.

Clearing and grubbing will be required and should be performed according to procedures outlined in Section 7.1.4. Some existing brush piles will have to be relocated (Plate C4).

Topsoil and overburden in Borrow Area C should be handled according to procedures discussed in Section 7.1.5.

The Operation Sequence for Borrow Area C is shown on Plate C4. Borrow Area C has been subdivided into two areas based on suitability for different uses. The two areas are shown on Plate C4: Area C1, consisting of subsections A to F inclusive, and Area C2.

Area C1 (designed as a single-user pit) has been subdivided into six arbitrary subsections. It would be preferable to open either subsection A or F first and then work around the pit in order to limit the amount of overburden stockpiling required (Plate C4).

Area C2 contains only a small volume of granular material and is also designed as a single-user pit. A proposed operation plan for this area is shown on Plate C4. It is only necessary to clear a section large enough to obtain the required volume of granular material.

Underground collapse features, although not identified in the field, may be present in the area and operators should be warned of this potential hazard.

Reclamation activities should be carried out in accordance with procedures discussed in Section 7.1.7.

8.0 ENVIRONMENTAL CONCERNS

Consideration and concerns identified during this study relate to: salvageable timber, loss and/or disruption of vegetation

and wildlife habitat, and preservation of archaeological resources. These topics are addressed briefly in the sections that follow.

8.1 SALVAGEABLE TIMBER

The vegetation near the three proposed borrow areas consists mainly of jack pine and trembling aspen, with some black spruce, white spruce and white birch. Although not identified in the field, some areas may contain stands of salvageable timber. In these areas, the recommendations for salvaging firewood and merchantable timber outlined in Section 7.1.4 should be followed.

8.2 LOSS/DISRUPTION OF VEGETATION AND WILDLIFE HABITAT

Existing pits adjoining each of the areas have already caused some environmental disturbance. Further development of these areas is expected to have minimal to negligible environmental effects.

No critical areas for wildlife are known to exist in the vicinity of the three areas.

Prior to pit development, the local Hunters and Trappers Association should be advised as to which areas are being designated as pits.

8.3 ARCHAEOLOGICAL RESOURCES

There are no known areas of archaeological significance within the proposed borrow sources. If artifacts are encountered,

however, activities should be restricted pending notification of the Land Use officer.

9.0 CONCLUSIONS

Findings of the study with respect to the three borrow pit areas are, in summary, as follows:

a) Borrow Area A contains the largest estimated volume of granular material: 20 500 m^3 proven and 80 000 m^3 probable. The material is of fair quality and is suitable for use as general fill, granular subbase and equipment pad construction.

b) Reserves at Borrow Area B are estimated at 11 800 m^3 proven and 18 000 m^3 probable, of fair quality aggregate. This material is suitable for use as general fill, equipment pads, granular subbase and culvert/pipe bedding.

c) Reserves at Borrow Area C1 are estimated at 11 700 m^3 proven and 16 000 m^3 probable, of poor quality material. Screening of the material will be required. The material is suitable for general fill and possibly rip rap.

   Within Borrow Area C2, available volume is estimated to be 600 m^3 proven of granular material, suitable for road surfacing and use as general fill.

Management plans have been developed for each borrow area. Borrow Areas A and B have been designed as multi-user pits whereas Area C is designed as a single-user pit (it can be readily adapted to accommodate several users). The plans

attempt to provide for economic and efficient development, while limiting the amount of land disturbance.

It is our opinion that development of all three areas is feasible.

Respectfully Submitted,

HARDY ASSOCIATES (1978) LTD.

Per:
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Per:
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Per:
M. Stepanek, M.Sc., P.Eng.

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APPENDIX "A"

Test Pit Logs and DIAND Field Notes

HARDY ASSOCIATES (1978) LTD.
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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 29, 1983	CG 10106	A1

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

OVERBURDEN sand, occasional gravel sizes, organics, roots

GRAVEL sandy, angular, dirty, dry, 0.25 m thick organic layer at 0.3 m

--clean, damp

1

A_1

--cobbly, occasional boulders to .6 m diameter

CLAY little silt, pink, soft, medium plastic, moist

2

Bottom of Pit @ 1.65 m
Dry on completion

Plate A-1

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BOREHOLE LOG

PROJECT
SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 29, 1983	CG 10106	A2

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION
DATUM
SURFACE ELEVATION

SOIL SAMPLE
CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

OVERBURDEN sandy and cobbly, organics, roots

GRAVEL fine, sandy, sub-angular, moist

—occasional cobbles, dirty, thin organic layer (.05m thick)

A2

Grain size (see Pl. B-1)

1

—layer of boulders (to 0.6m diameter)

CLAY pink

Bottom of Pit @ 1.6 m
Dry on completion

2

Plate A-2

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BOREH _E LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Nov 29, 1983 | JOB NO. CG 10106 | HOLE NO. A3

DRILL TYPE:

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		OVERBURDEN sandy (coarse) occasional gravel sizes, organics, roots				
		SAND coarse, some gravel, occasional cobbles, damp				
1		GRAVEL well graded, sandy, occasional cobbles, sub-angular, dry				
		thin layer of dirty pea gravel (.1 m)		A_3		Grain size (see Pl. B-2)
		CLAY pink				
2		Bottom of Pit @ 1.75 m Dry on completion				

Plate A-3

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 29, 1983	CG 10106	A4

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 60 80)

DRILL TYPE:

OTHER TESTS:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
		OVERBURDEN clayey, organic, roots occasional gravel sizes			
		GRAVEL fine, some sand, dirty, sub-angular, organics to .6 m			
		--coarse sand, gravelly (.2m thick), damp		A_4	
1		--occasional cobbles			
		-- cobbly, occasional boulders to 0.6 m diameter			
		CLAY pink, medium plastic, soft			
2		Bottom of Pit @ 1.7 m Dry on completion			

Plate A-4

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 29, 1983	CG 10106	A5

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0		OVERBURDEN sand, occasional pebbles, organics, roots				
		GRAVEL sandy, occasional cobbles dirty, dry, sub-angular				
		– organics interbedded (.1m thick some pea gravel sizes				
				A_5		Grain Size (See Pl. B-3) Petrographic Analysis (Table B-1)
1		– well graded				
		– occasional boulders				
		CLAY pink				
1.5		Bottom of Pit @ 1.5 m Dry on completion				
2						

Plate A-5

HT08 - 79/05

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BOREH .E LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 29, 1983	CG 10106	A6

WATER CONTENT: W_p - □ W - ○ W_L - △ PERCENT % (10 20 30 40 60 80)

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

0 — OVERBURDEN sand, organic, roots

GRAVEL fine, sandy, angular, dirty, dry
-- frequent cobbles and boulders

A6

1

CLAY pink

Bottom of Pit @ 1.1 m
Dry on completion

2

Plate A-6

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Nov 29, 1983 | JOB NO. CG 10106 | HOLE NO. A7

DRILL TYPE

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION
DATUM
SURFACE ELEVATION

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

OTHER TESTS

OVERBURDEN silty, some clay, organic, roots

GRAVEL fine, sandy, occasional pebbles to 5 cm, angular, dry

A7

Grain Size (see Pl. B-4)

1

—well graded, sub-rounded, clean

—layer of boulders

CLAY pink, saturated

2

Bottom of Pit @ 1.60 m
Dry on completion

Plate A-7

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Nov 29, 1983 | JOB NO. CG 10106 | HOLE NO. A8

DRILL TYPE:

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION
DATUM
SURFACE ELEVATION

SOIL SAMPLE
CONDITION | TYPE | PENETRATION RESISTANCE

OTHER TESTS

OVERBURDEN sand, occasional gravel sizes, organic, roots

GRAVEL well graded, some sand, occasional cobbles and boulders (to 0.6 m diameter) sub-angular, clean, dry

A8

1

CLAY pink

Bottom of Pit @ 1.40 m
Dry on completion

2

Plate A-8

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 29, 1983	CG 10106	A9

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		OVERBURDEN sandy, some gravel sizes, roots and organics				
		GRAVEL well-graded, sandy, sub-angular, some cobbles, clean, dry				
1				A_9		Grain Size (See Pl. B-5)
		-- damp to moist				
2		CLAY pink				
		Bottom of Pit @ 1.95 m Dry on completion				

Plate A-9

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 29, 1983	CG 10106	A10

WATER CONTENT: W_p - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		OVERBURDEN sand, some pebbles, organics, roots				
		GRAVEL sandy, sub-angular, occasional cobbles, dry				
		└ some organics interbedded (0.05 m thick)				
1		└ thin organic layer				
		└ clean, well graded gravel		A_{10}		Grain Size (See Pl. B-6)
2						
3		Bottom of Pit @ 3.0 m Dry on completion				

Plate A-10

HT.08 - 79.05

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BOREH LE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Nov 29, 1983 | JOB NO. CG 10106 | HOLE NO. A11

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DRILL TYPE

OTHER TESTS

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
0		OVERBURDEN sand, occasional pebbles, organic, roots			
		GRAVEL well-graded, sandy, sub-angular, clean, damp		A 11	
1		CLAY pink			
		Bottom of Pit @ 1.15 m Dry on completion			
2					

Plate A-11

HT08 - 79/05

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Dec 1, 1983	CG 10106	B1

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE:

OTHER TESTS:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
		DATUM SURFACE ELEVATION			
		GRAVEL fine, some sand, organics interbedded to 0.3 m, frozen			
		—moist		B_1	
		— coarser, occasional cobbles and boulders			
1		CLAY pink			
		Bottom of Pit @ 1.0 m Dry on completion Overburden removed			
		Note: Material on N.W. side of pit was coarser than on the N.E. side.			
2					

Plate A-12

HT08 - 79/05

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Dec 1, 1983	CG 10106	B2

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
0		GRAVEL fine, little sand, some roots, sub-angular, frozen				
		--moist				
		--organic layer		B_2		
		--coarser, occasional cobbles and boulders				
1		CLAY pink				
		Bottom of Pit @ 1.15 m Dry on completion Overburden removed				
2						

Plate A-13

HT08 - 79/05

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Dec 1, 1983	CG 10106	B3

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

DEPTH m	SOIL DESCRIPTION	SOIL SAMPLE TYPE
	GRAVEL poorly graded, some sand, occasional cobbles and boulders, sub-angular, dirty, moist	B_3
	CLAY pink	
1	Bottom of Pit @ 0.75 m Dry on completion Overburden removed	
2		

Plate A-14

HT08 - 79/05

BOREHOLE LOG

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PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

JOB NO. CG 10106 | HOLE NO. B4

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Dec 1, 1983 | DRILL TYPE

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m | SOIL SYMBOL | SOIL DESCRIPTION | SOIL SAMPLE: CONDITION, TYPE, PENETRATION RESISTANCE | OTHER TESTS

DATUM

SURFACE ELEVATION

GRAVEL fine, little sand, angular, red-brown, frozen

organic layer, moist

fine gravel lense

organic lense (.2 m thick)

1

coarser, cobbles and boulders

2

CLAY pink

Bottom of Pit @ 1.95 m
Dry on completion
Overburden removed

B_4

Grain Size (See Pl. B-7)
Petrographic Analysis (Table B-2)

Plate A-15

HT08 - 79/05

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BOREH .E LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Nov 30, 1983 | JOB NO. CG 10106 | HOLE NO. B5 | DRILL TYPE

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		SAND coarse, some fine gravel, reddish-brown, damp				
		--gravel lense				
		--moist				
1		GRAVEL fine, some sand, reddish-brown, moist				
		--very moist, larger sizes up to 7 cm		B_5		Grain Size (See Pl. B-8)
		--occasional cobbles and boulders				
		CLAY pink, soft, saturated				
2		Bottom of Pit @ 1.75 m Dry on completion Overburden removed				

Plate A-16

HT08 - 79/05

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Dec 1, 1983 | JOB NO. CG 10106 | HOLE NO. B6

DRILL TYPE

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		OVERBURDEN sandy, moss				
		SAND gravelly, occasional organics, trace clay, dirty, moist				
1		CLAY pink				
		Bottom of Pit @ 0.95 m Dry on completion				
2						

Plate A-17

HT08 - 79/05

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Dec 1, 1983 | JOB NO. CG 10106 | HOLE NO. B7 | DRILL TYPE

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS
		OVERBURDEN moss, sandy, roots				
		-- gravelly, highly organic				
		GRAVEL sandy, sub-angular, reddish-brown, clean, moist		B7		
1		-- cobbly, occasional boulders				
		CLAY pink				
		Bottom of Pit @ 1.2 m Dry on completion				
2						

Plate A-18

HT08 - 79/05

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Dec 1, 1983	CG 10106	B8

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE:

OTHER TESTS:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
		OVERBURDEN moss, occasional gravel sizes, organics			
		GRAVEL fine, sandy, occasional pebbles to 5 cm, dirty, roots and organics mixed in, dry		B8	
		--little sand			
1		CLAY pink			
		Bottom of Pit @ 1.1 m Dry on completion			
2					

Plate A-19

HT08 - 79/05

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BORE)LE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Dec 1, 1983	CG 10106	B9

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DATUM

SURFACE ELEVATION

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
		OVERBURDEN moss, organics, some gravel sizes			
		GRAVEL sandy, lots of pea size, occasional cobbles, dirty, damp			
		— some organics mixed in		B9	
1		CLAY pink, gravel inclusions			
		Bottom of Pit @ 1.1 m Dry on completion			
2					

DRILL TYPE

OTHER TESTS

Plate A-20

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Dec 1, 1983	CG 10106	B10

DRILL TYPE:

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION
DATUM
SURFACE ELEVATION

SOIL SAMPLE
CONDITION | TYPE | PENETRATION RESISTANCE

OTHER TESTS

OVERBURDEN sandy, moss

GRAVEL some sand, occasional clay lenses, organics to 0.6 m, dirty, moist, brown

1

–coarser, little sand, occasional cobbles

B10

Grain Size (See Pl. B-9)

2

CLAY pink

Bottom of Pit @ 2.05 m
Dry on completion

Plate A-21

HT08 - 79/05

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 30, 1983	CG 10106	B11

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	TYPE	PENETRATION RESISTANCE	OTHER TESTS
		OVERBURDEN moss, clayey, roots, occasional gravel sizes				
		CLAY pink, firm, damp				
1		Bottom of Pit @ 0.7 m Dry on completion				
2						

Plate A-22

HT08 - 79/05

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Dec 1, 1983	CG 10106	B12

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE:

OTHER TESTS:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
		GRAVEL fine, sandy, sub-angular, grey, dry			
		--organic lense (thin)			
		--moist, occasional cobbles		B12	
1		--coarser, occasional boulders, wet			
		CLAY pink			
2		Bottom of Pit @ 1.90 m Dry on completion Overburden removed			

Plate A-23

HT08 - 79/06

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BORE[illegible]OLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Nov 30, 1983 | JOB NO. CG 10106 | HOLE NO. C1

DRILL TYPE

WATER CONTENT — Wp - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

SOIL SAMPLE — CONDITION | TYPE | PENETRATION RESISTANCE

OTHER TESTS

DEPTH m	SOIL DESCRIPTION	SOIL SAMPLE	OTHER TESTS
	OVERBURDEN sand, clayey, gravel sizes, roots		
	SAND coarse, occasional gravel sizes, damp, reddish		
1	GRAVEL sandy, occasional cobbles, angular, dirty, dry	C_1	Grain Size (See Pl. B-10)
	—large boulder 0.9 m diameter		
	CLAY pink, firm, moist		
2	Bottom of Pit @ 1.60 m Dry on completion		

Plate A-24

HT08

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Nov 30, 1983 | JOB NO. CG 10106 | HOLE NO. C2

WATER CONTENT (Wp - □ W - ○ W_L - △, PERCENT %, 10 20 30 40 50 60)	DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	DRILL TYPE / OTHER TESTS
	0		OVERBURDEN clayey, pebbles, organics, roots				
			GRAVEL sandy, trace clay, occasional cobbles, dirty, dry		C_2		Grain Size (See Pl. B-11)
	1		CLAY pink, cobbly				
			Bottom of Pit @ 1.4 m Dry on completion				
	2						

Plate A-25

HT08 - 79/05

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BORE..OLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 30, 1983	CG 10106	C3

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DRILL TYPE:

OTHER TESTS:

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
0		GRAVEL pitrun, some sand, trace clay, cobbles, sub-angular, damp, occasional pea gravel layers		C3	
1					
2		Bottom of Pit @ 2.1 m Face and bottom of existing pit were frozen, Could not penetrate below this level. Overburden removed			

Plate A-26

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN. DK/CK | CKD. DK | DATE OF INVEST. Nov 30, 1983 | JOB NO. CG 10106 | HOLE NO. C4

DRILL TYPE

WATER CONTENT

Wp - □ W - ○ W_L - △

PERCENT %

10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

OTHER TESTS

DEPTH m	SOIL DESCRIPTION	SOIL SAMPLE TYPE
	OVERBURDEN highly organic occasional pebbles, roots	
	GRAVEL poorly graded, sandy, sub-angular, dirty, dry	C_4
1	CLAY pink, firm	
	Bottom of Pit @ 0.95 m Dry on completion	

Plate A-27

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 30, 1983	CG 10106	C5

WATER CONTENT: Wp - □ W - ○ W_L - △ PERCENT % (10 20 30 40 50 60)

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

SOIL SAMPLE: CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

OVERBURDEN mossy, roots

GRAVEL well graded, sandy, organic layers interbedded, occasional cobbles, sub-angular, dry

1

CLAY brown, firm, low plastic

Bottom of Pit @ 1.35 m
Dry on completion
Excavated at base of ridge

2

TYPE: C_5

Grain Size (See Pl. B-12)
Petrographic Analysis (Table B-3)

Plate A-28

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 30, 1983	CG 10106	C6

WATER CONTENT
Wp - □ W - ○ W_L - △
PERCENT %
10 20 30 40 50 60

DEPTH m

SOIL SYMBOL

SOIL DESCRIPTION
DATUM
SURFACE ELEVATION

SOIL SAMPLE
CONDITION | TYPE | PENETRATION RESISTANCE

DRILL TYPE

OTHER TESTS

OVERBURDEN moss, organic, roots, dirty

clay, gravelly, dirty, dry

GRAVEL fine, sandy, sub-rounded, damp

pit run, frequent cobbles and boulders

1

2

3

C_6

Grain Size (See Pl. B-13)

Bottom of Pit @ 3.0 m
Dry on completion

Plate A-29

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BOREHOLE LOG

PROJECT: SALT MOUNTAIN QUARRY MANAGEMENT

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.	HOLE NO.
DK/CK	DK	Nov 30, 1983	CG 10106	C7

WATER CONTENT — W_p - □ W - ○ W_L - △ — PERCENT % — 10 20 30 40 50 60

DEPTH m	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SOIL SAMPLE: CONDITION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE
		OVERBURDEN sand, organics, roots			
		GRAVEL sandy, some clay, roots, dirty		C7	
1		CLAY pink, gravel sizes, medium plastic, firm			
		brown			
		Bottom of Pit @ 1.30 m Dry on completion			
2					

DRILL TYPE

OTHER TESTS

Plate A-30

HT08 - 79/05

DIAND FIELD NOTES

(Provided by Mr. E. Hornby)

REPORT ON FIELD RECONNAISSANCE OF GRANULAR DEPOSITS AT SALT MOUNTAIN

From June 15 to 17, 1983, I visited the Salt Mountain Area to attain a familiarity with the relative abundance and disposition of granular materials in the area.

All found previous test pits were investigated, as were existing pit faces.

Illustrative photographs were taken and brief descriptions of the material present recorded.

The descriptive terms, depths and sizes were based on a subjective visual estimate, and serve best as rough guides to the presence or potential of granular material.

(More careful measurements and analysis could most probably result in changes in descriptions.)

SALT MOUNTAIN FIELD NOTES

JUNE 15, 16 AND 17, 1983

Location u — 4 feet of good fill-dirty well graded, would require screening of lots of cobble.

Note: Pit has been poorly opened with roots, fill and spoil pile mixed beside u.

Location 23 — 8 inches of sand, then 1 foot of dirty fill gravel, then pinkish sandy clay.

Would seem end of deposit.

Location 24 — 1 foot of dirty cobbly gravel, with few stones on a base of clay. Might be isolated, as it seems on top of a ridge.

Location v — 30 inches of a dirty well graded gravel on a pink clay base.

Location 25 — 8 inches of clayey sand then 20 inches of an increasingly clean sand on a clay base.

Location w — 6 feet of gravel ranging from washed cobbles to sandy pea at bottom; pit is in the middle of small esker-like ridge: may not be typical of area.

Location x — 3 feet of gravel on top of clean sand and stone. Some cobbles in gravel-would need screening.

Land drops off quickly to south, would expect shallower formation towards 24.

Beyond "MOT - Berton" pit, a cut line extends about 200 yds with 2 cross lines; visual indications of gravel at surface of esker-like formation which tends to follow cut line (except at North end).

I would imagine deposit thins as one proceeds North. Ridge flares onto a flat, which has no vegetation cover; normally associated with impeded drainage.

Location 27 — 6 inches sand; 8 inches gravelly sand then sandy clay. Located on edge of very slight rise.

Location z — much like 27, but boulders for bottom of pit. Of note is that nearly all material is of granite origin.

Location 28 — 12 inches dirty sand, 12 inches pea gravel coarse sand, then pink clay. This is located on a slight ridge.

Location aa — 1 foot of boulders on a clay base.

Location 29 — 18 inches of boulders and sand, then sandy clay, on top of impermeable clay (as witnessed by standing water).

Location bb — no gravel, clay under boulders.

Location ee — Skim of gravel and boulders on top of clay.

Location ff — 1 foot of gravel on top of clay - standing water present.

Location gg — 3 feet plus gravel, possible clay below (clay in spoil, but couldn't see clay horizon).

Location hh — One foot sand, 2 feet gravel, some water. Assume it is near the water table.

Location ii — 2 feet sandy gravel, very wet: either close to clay or water table.

Location jj — Like ii.

Location kk — 2½ feet of clean fine gravel, damp at bottom (suggesting close to clay); located on slight ridge.

Location ll — 4 feet of gravel, with lots of cobbles; would require screening - located on a ridge.

Location mm — 2 feet of gravel; bottom not seen.

Location 30 — 3½ feet of pea gravel coarse sand, overlying cobbles as in 31.

Location 31 — gravel and stone-pits; 30 & 31 are alike.

Location nn — 3 feet of gravel, mostly pea, some subrounded to 3 inch.

Location oo — 4 feet of mostly pea gravel and coarse sand, clay bottom at edge of sink hole.

Location 32 — 4 feet of sand and gravel, some cobbles, seems to lie on a ridge.

Location 33 — Pit has 3 feet of stoney gravel on clay.

Location pp — 6 feet of gravel and stone (cobbles); need screening, pit is near top of knob.

Location qq — 4 feet of gravel, lots of stone would need processing; not on any appparent ridge.

5/357

APPENDIX "B"

Laboratory Test Results

LABORATORY TEST RESULTS

B.1 GRAIN SIZE ANALYSIS (ASTM C136-82)

Sieve analysis of aggregate samples provides a gradation for the bulk natural material, which may be compared with ideal curves for concrete aggregate, asphalt, etc.

B.2 PETROGRAPHIC ANALYSIS (ASTM C-295)

Petrographic analysis consists of a visual examination of aggregate particles and identification on the basis of mineralogy. Particles are assigned a rating on the basis of the known soundness or deleterious nature of the mineral type, a rating of 1 being the best and 10 being the worst. The weighted percentage of each mineral type is then multiplied by this rating number to produce a petrographic number (PN) for the aggregate. The following classification, recommended by Ontario Hydro petrographers, is used in this report.

PN	RATING
100 - 110	Excellent
111 - 125	Good
126 - 140	Fair
141 - 155	Poor
155	Unsuitable

Los Angeles Abrasion Tests (ASTM C535-81) and Sulphate Soundness Tests (ASTM C88-76) were not performed because results from the petrographic analysis suggested that the material was unsuitable for use as aggregate for concrete or asphalt.

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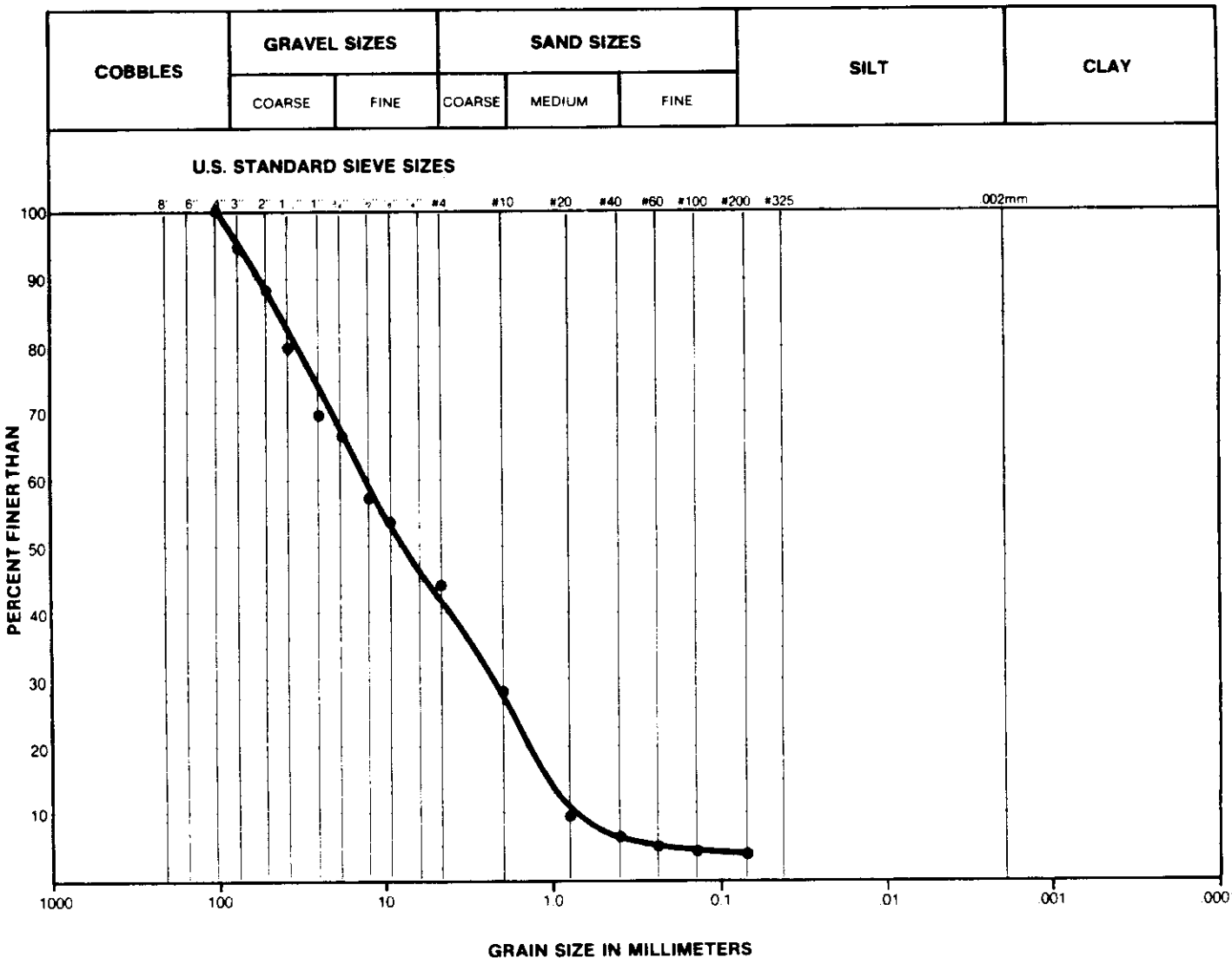
GRAIN SIZE CURVE

CLIENT: DIAND
PROJECT NUMBER: CG 10106
LAB. NUMBER:
LOCATION: SALT MOUNTAIN - STUDY AREA A
HOLE: A2 SAMPLE: A2
DEPTH: .7 - 1.2 m
TECHNICIAN: G.W. DATE: 83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	0.8 mm	GRAVEL	58 %
D_{30} =	2.2 mm	SAND	38 %
D_{60} =	15 mm	SILT + CLAY	4 %
C_U =	18.75		
C_C =	mm		

Plate B-1

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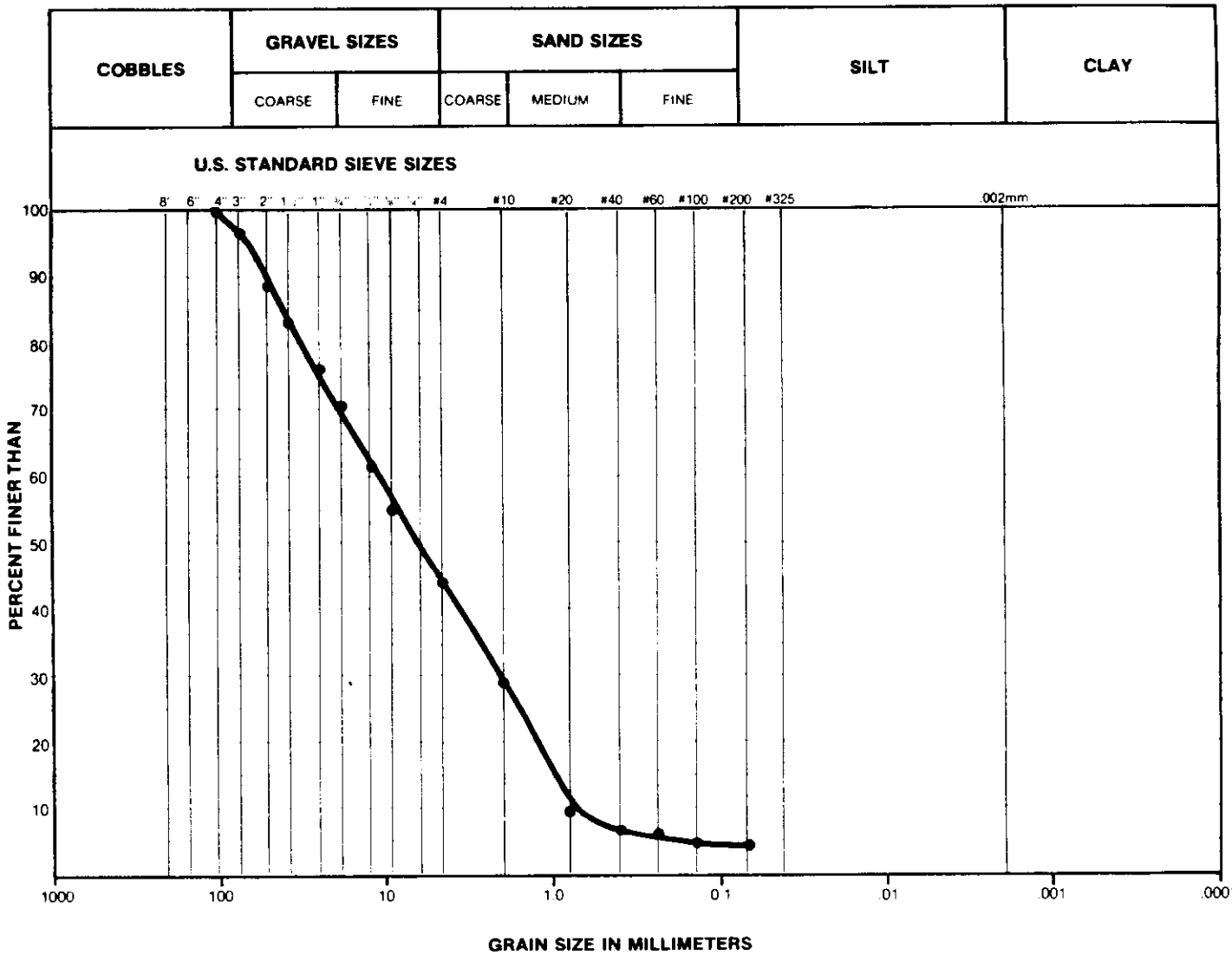
GRAIN SIZE CURVE

CLIENT:	DIAND
PROJECT NUMBER:	CG 10106
LAB. NUMBER:	
LOCATION:	SALT MOUNTAIN - STUDY AREA A
HOLE:	A3
SAMPLE:	A3
DEPTH:	.6 - 1.1 m
TECHNICIAN:	G.W.
DATE:	83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	0.8 mm	GRAVEL	57 %
D_{30} =	2.1 mm	SAND	38 %
D_{60} =	12 mm	SILT + CLAY	5 %
C_U =	15		
C_C =	mm		

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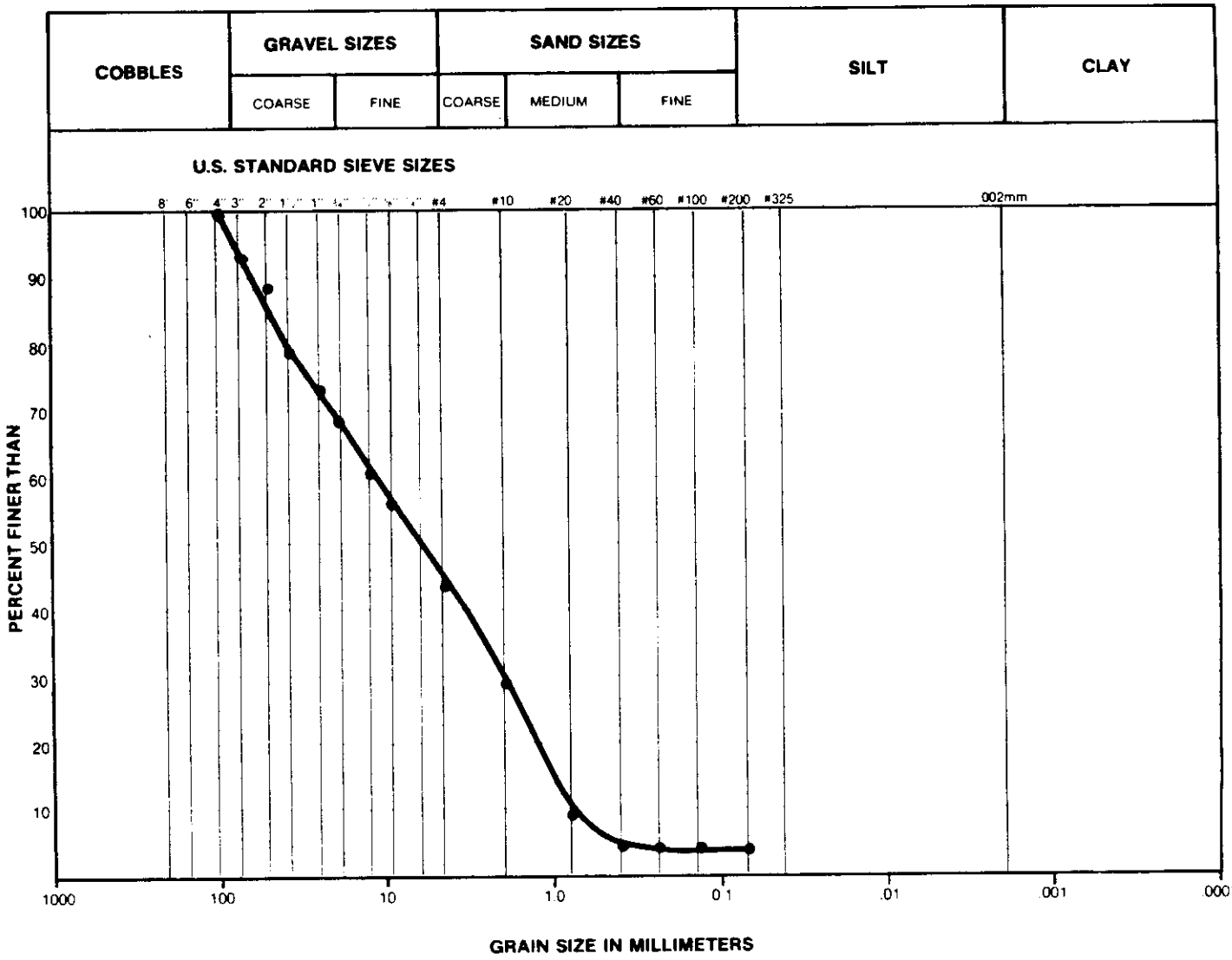
GRAIN SIZE CURVE

CLIENT:	DIAND
PROJECT NUMBER:	CG 10106
LAB. NUMBER:	
LOCATION:	SALT MOUNTAIN - STUDY AREA A
HOLE:	A5 SAMPLE: A5
DEPTH:	.6 - 1.1m
TECHNICIAN:	G.W. DATE: 83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	.82 mm	GRAVEL	56 %
D_{30} =	2.1 mm	SAND	40 %
D_{60} =	13 mm	SILT + CLAY	4 %
C_U =	15.85		
C_C =	mm		

TABLE NO. Table B-1

SUMMARY OF ROCK TYPES COARSE FRACTION

Test Pit A-5 Depth 0.6 m - 1.1 m

ROCK TYPE	CLASSIFICATION	WEIGHTED PERCENTAGES OF CONSTITUENTS IN EACH SIEVE FRACTION									Total Weighted Composition
		4"	3"	2"	1½"	1"	3/4"	½"	3/8"	#4	
Granite	GOOD				4.4	0.7	1.5	2.0	0.9	4.8	14.3
Granodiorite					1.3	2.0	2.6	3.6	1.0	3.0	13.5
Rhyolite					0.8	2.1	0.7	2.3	2.5	3.0	16.4
Limestone (slightly weathered)	FAIR				7.1	4.8	3.2	-	0.8	-	15.9
Sandstone (weathered, medium hard)					3.2	3.6	3.0	10.1	5.5	9.2	34.6
Metamorphosed Basic Igneous					4.2	0.3	-	-	0.3	-	4.8
Siltstone (weak)	POOR				-	0.5	-	-	-	-	0.5
					21.0	14.0	11.0	18.0	11.0	25.0	100.0

PN = 213.1

HARDY ASSOCIATES (1978) LTD.
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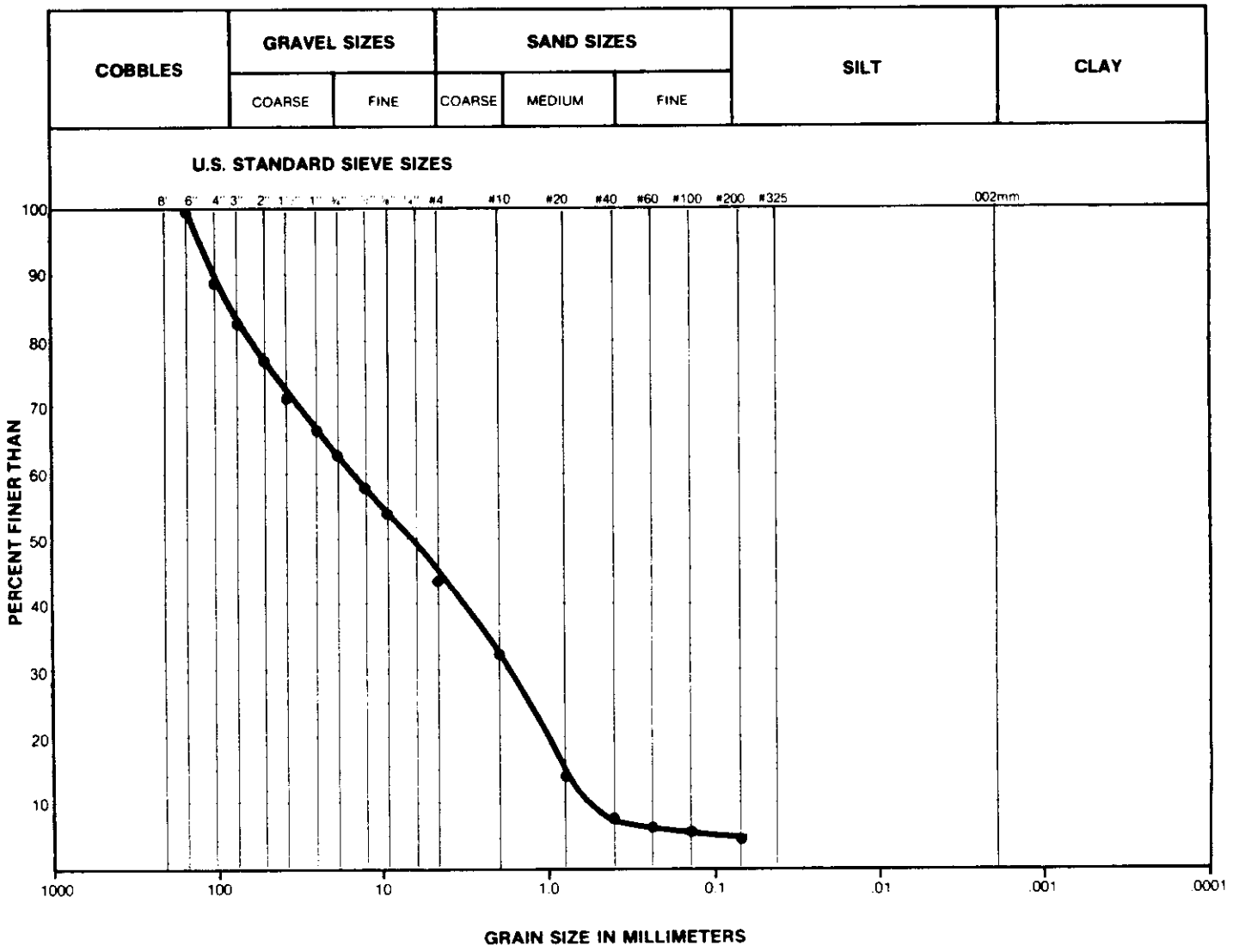
GRAIN SIZE CURVE

CLIENT: DIAND
PROJECT NUMBER: CG 10106
LAB. NUMBER:
LOCATION: SALT MOUNTAIN - STUDY AREA A
HOLE: A7 SAMPLE: A7
DEPTH: .6 - 1.1 m
TECHNICIAN: G.W. DATE: 83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	.70 mm	GRAVEL	54 %
D_{30} =	1.8 mm	SAND	41 %
D_{60} =	12 mm	SILT + CLAY	5 %
C_U =	17.1		
C_C =	mm		

Plate B-4

HARDY ASSOCIATES (1978) LTD.
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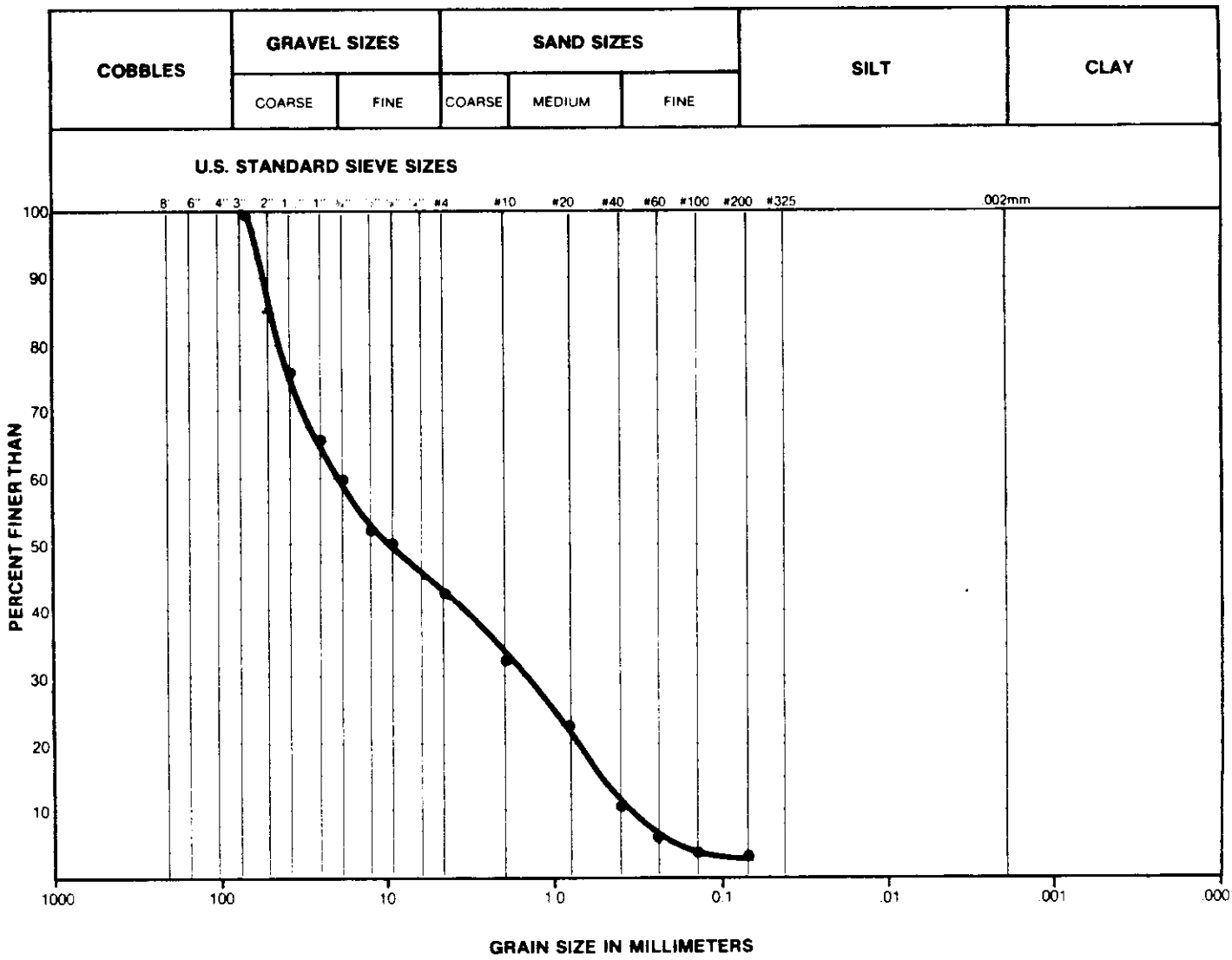
GRAIN SIZE CURVE

CLIENT:	DIAND
PROJECT NUMBER:	CG 10106
LAB. NUMBER:	
LOCATION:	SALT MOUNTAIN - STUDY AREA A
HOLE:	A9
SAMPLE:	A9
DEPTH:	.9 - 1.4 m
TECHNICIAN:	G.W.
DATE:	83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	.4 mm	GRAVEL	57 %
D_{30} =	1.5 mm	SAND	40 %
D_{60} =	20 mm	SILT + CLAY	3 %
C_U =	50		
C_C =	mm		

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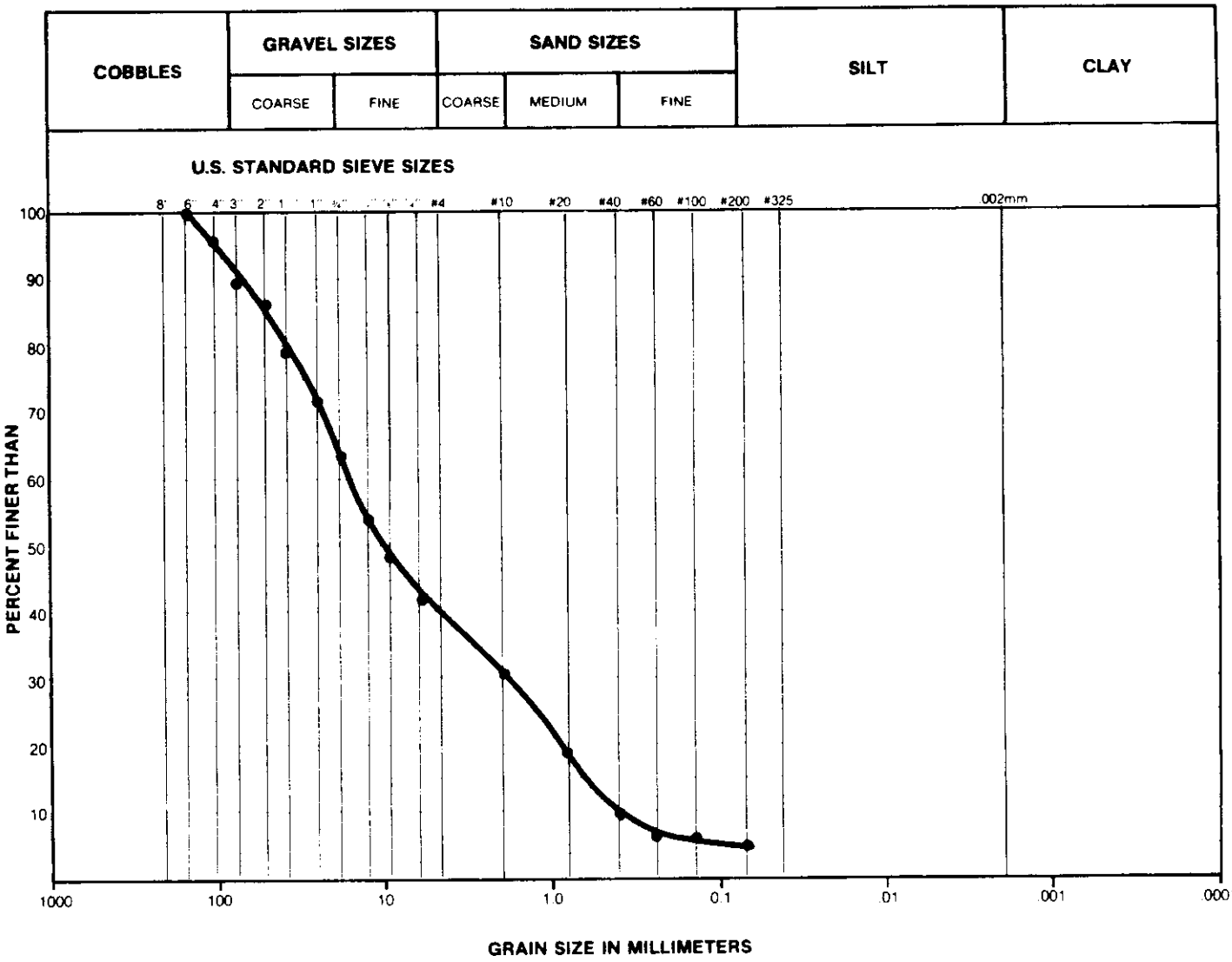
GRAIN SIZE CURVE

CLIENT:	DIAND
PROJECT NUMBER:	CG 10106
LAB. NUMBER:	
LOCATION:	SALT MOUNTAIN - STUDY AREA A
HOLE:	A 10
SAMPLE:	A 10
DEPTH:	1.4 - 1.9 m
TECHNICIAN:	G.W.
DATE:	83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

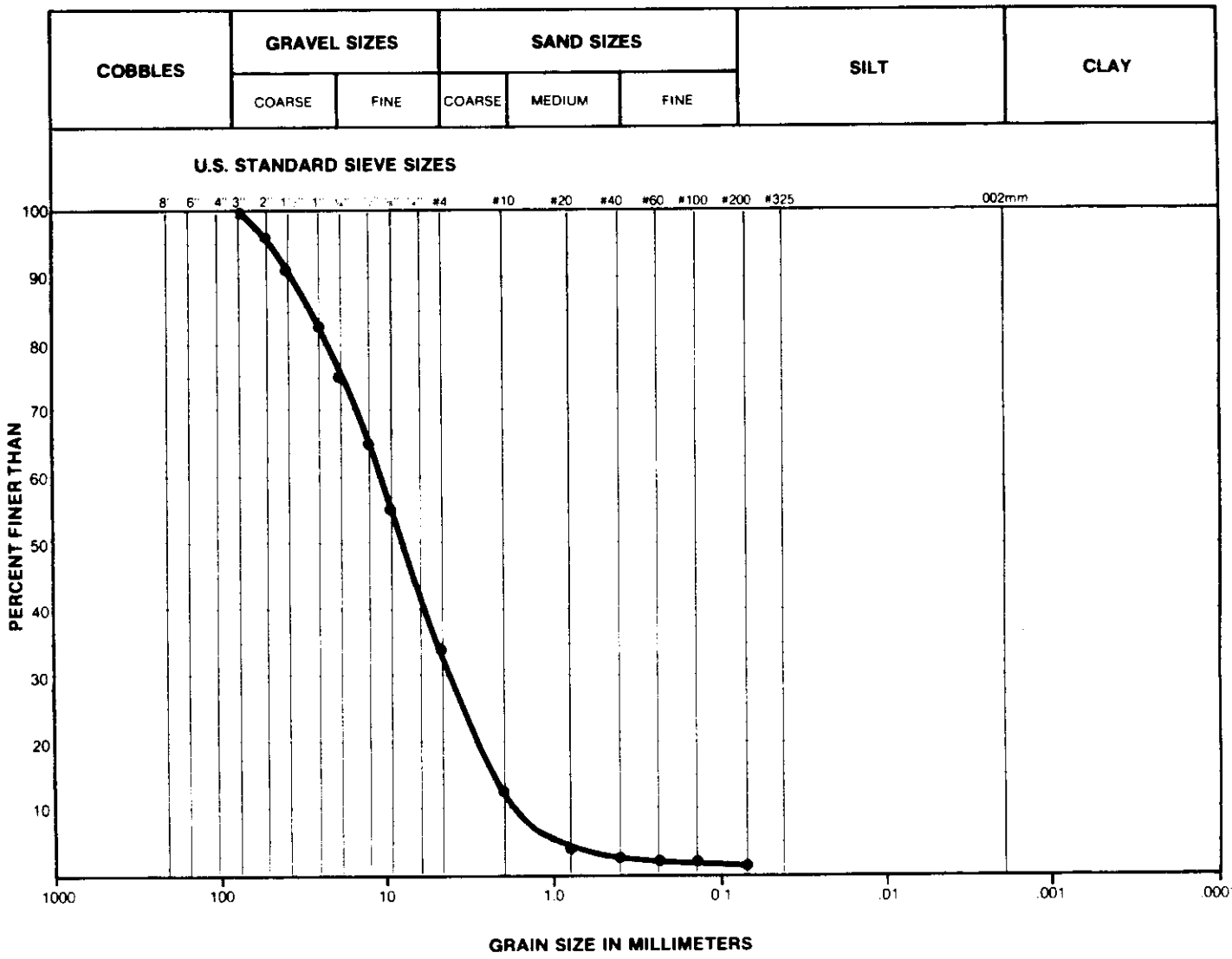
SUMMARY

D_{10} =	.4 mm	GRAVEL	61 %
D_{30} =	2.0 mm	SAND	35 %
D_{60} =	17 mm	SILT + CLAY	4 %
C_U =	42.5		
C_C =	mm		

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

GRAIN SIZE CURVE

CLIENT:	DIAND
PROJECT NUMBER:	CG 10106
LAB. NUMBER:	
LOCATION:	SALT MOUNTAIN - STUDY AREA B
HOLE:	B4 SAMPLE: B4
DEPTH:	.7 - 1.2 m
TECHNICIAN:	G.W. DATE: 83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	1.8 mm	GRAVEL	66 %
D_{30} =	4.1 mm	SAND	32 %
D_{60} =	10.5 mm	SILT + CLAY	2 %
C_U =	5.8		
C_C =	mm		

TABLE NO. Table B-2

SUMMARY OF ROCK TYPES COARSE FRACTION

Test Pit B-4 Depth 0.7 m - 1.2 m

ROCK TYPE	CLASSIFICATION	WEIGHTED PERCENTAGES OF CONSTITUENTS IN EACH SIEVE FRACTION									Total Weighted Composition
		4"	3"	2"	1½"	1"	3/4"	½"	3/8"	#4	
Granite, granodiorite, rhyolite and quarzite	GOOD				5.4	3.6	4.8	6.7	6.8	17.4	44.7
Limestone (slightly weathered)	FAIR				5.6	7.4	8.9	7.3	9.2	16.6	55.0
Sandstone (weathered, medium hard)											
Limestone (weak)	POOR				-	-	0.3	-	-	-	0.3
					11.0	11.0	14.0	14.0	16.0	34.0	100.0

PN = 211.5

HARDY ASSOCIATES (1978) LTD.
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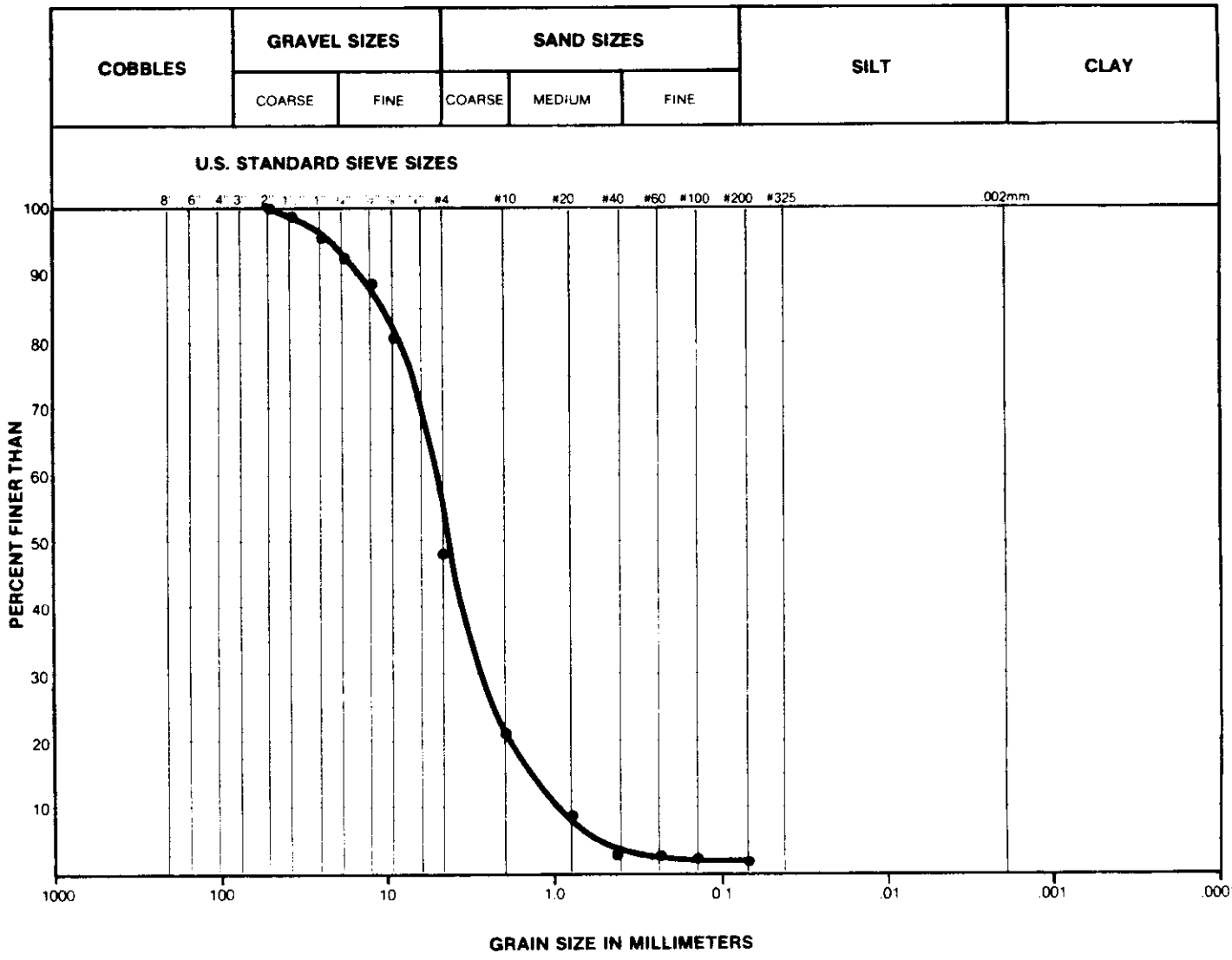
GRAIN SIZE CURVE

CLIENT:	DIAND
PROJECT NUMBER:	CG 10106
LAB. NUMBER:	
LOCATION:	SALT MOUNTAIN - STUDY AREA B
HOLE:	B5
SAMPLE:	B5
DEPTH:	1.0 - 1.5 m
TECHNICIAN:	G.W.
DATE:	83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	1.0 mm	GRAVEL	47 %
D_{30} =	3.0 mm	SAND	51 %
D_{60} =	5.0 mm	SILT	
C_U =	5.0 mm	CLAY	2 %
C_C =	mm		

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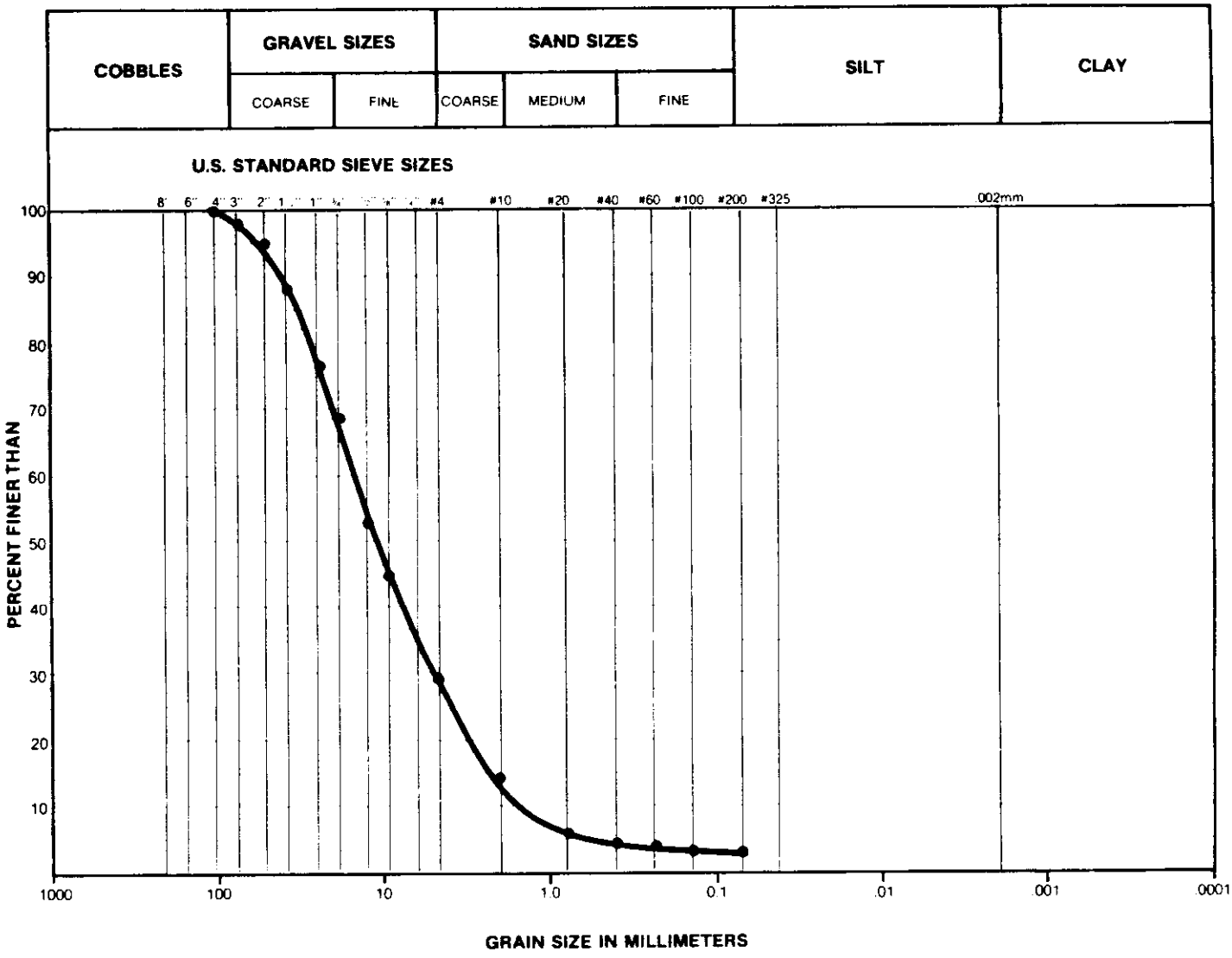
GRAIN SIZE CURVE

CLIENT: DIAND
PROJECT NUMBER: CG 10106
LAB. NUMBER:
LOCATION: SALT MOUNTAIN - STUDY AREA B
HOLE: B10 SAMPLE: B10
DEPTH: .9 - 1.4 m
TECHNICIAN: G.W. DATE: 83/10/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	1.8 mm	GRAVEL	72 %
D_{30} =	6.0 mm	SAND	25 %
D_{60} =	15 mm	SILT + CLAY	3 %
C_U =	8.3 mm		
C_C =	mm		

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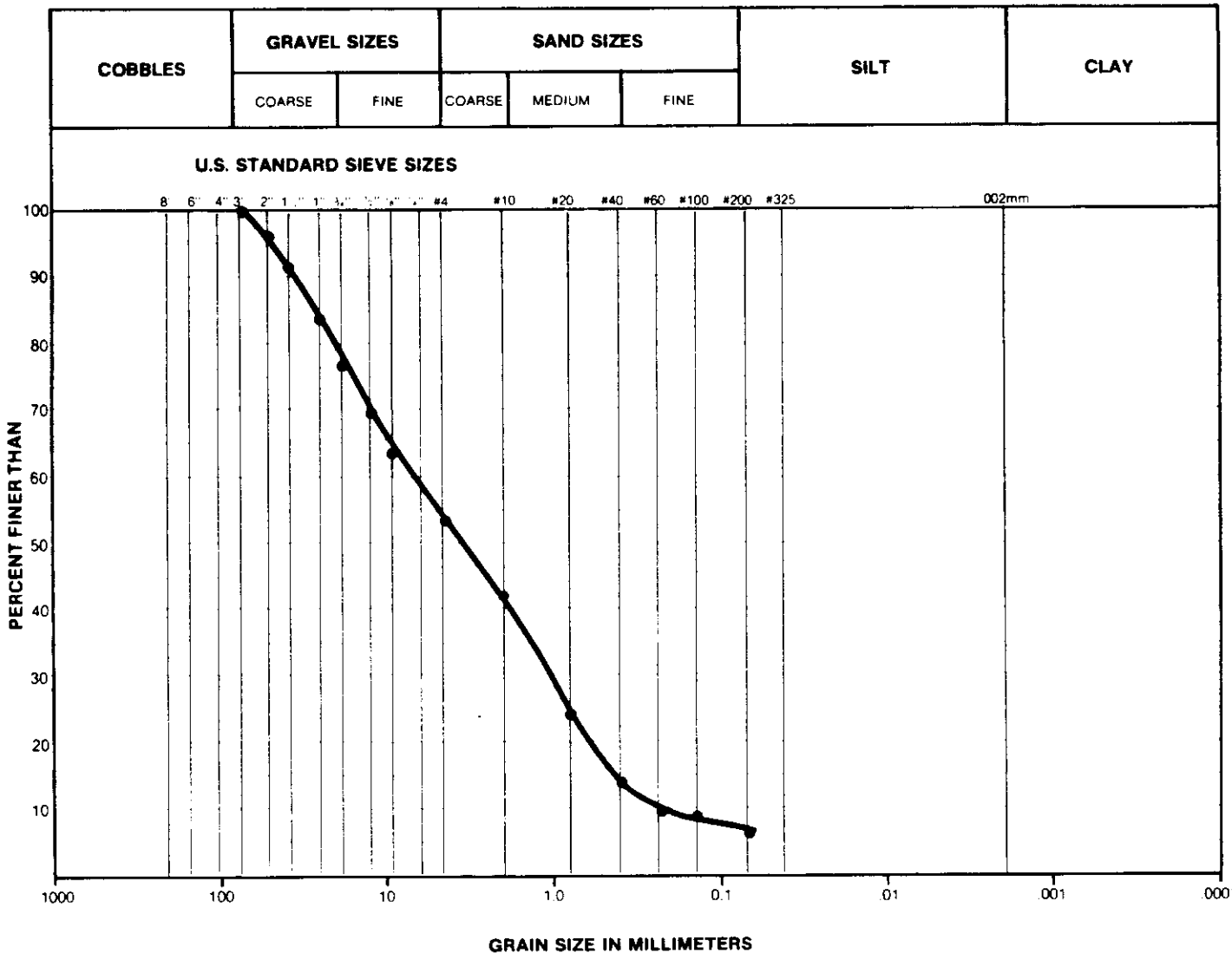
GRAIN SIZE CURVE

CLIENT:	DIAND
PROJECT NUMBER:	CG 10106
LAB. NUMBER:	
LOCATION:	SALT MOUNTAIN - STUDY AREA C
HOLE:	C1 SAMPLE: C1
DEPTH:	.9 - 1.4 m
TECHNICIAN:	G.W. DATE: 83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	.25 mm	GRAVEL	46 %
D_{30} =	1.0 mm	SAND	47 %
D_{60} =	7.0 mm	SILT	
C_U =	28 mm	CLAY	7 %
C_C =	mm		

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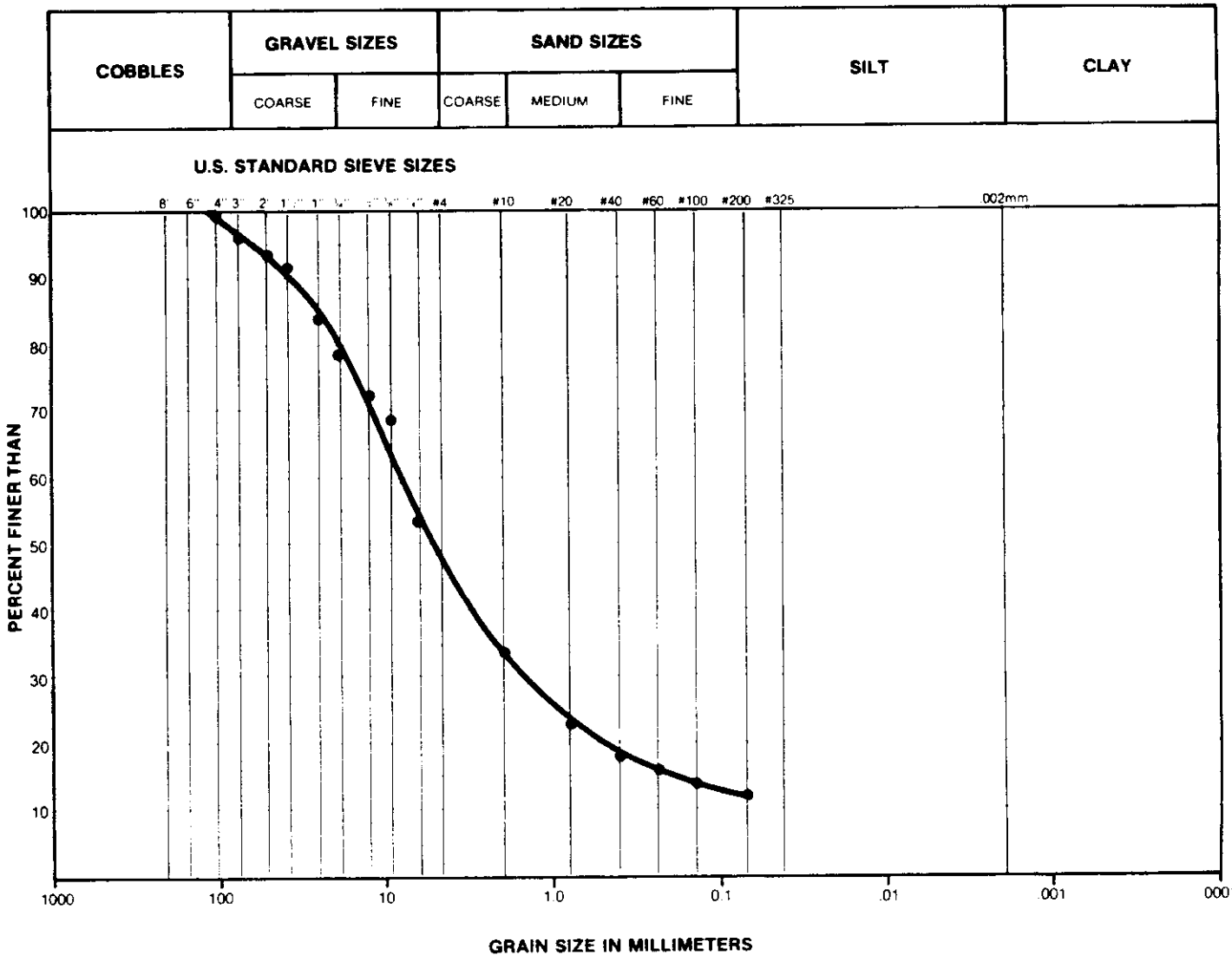
GRAIN SIZE CURVE

CLIENT:	DIAND
PROJECT NUMBER:	CG 10106
LAB. NUMBER:	
LOCATION:	SALT MOUNTAIN - STUDY AREA C
HOLE:	C2
SAMPLE:	C2
DEPTH:	.6 - 1.1 m
TECHNICIAN:	G.W.
DATE:	83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	- mm	GRAVEL	52 %
D_{30} =	1.8 mm	SAND	36 %
D_{60} =	8 mm	SILT + CLAY	12 %
C_U =	mm		
C_C =	mm		

HARDY ASSOCIATES (1978) LTD.
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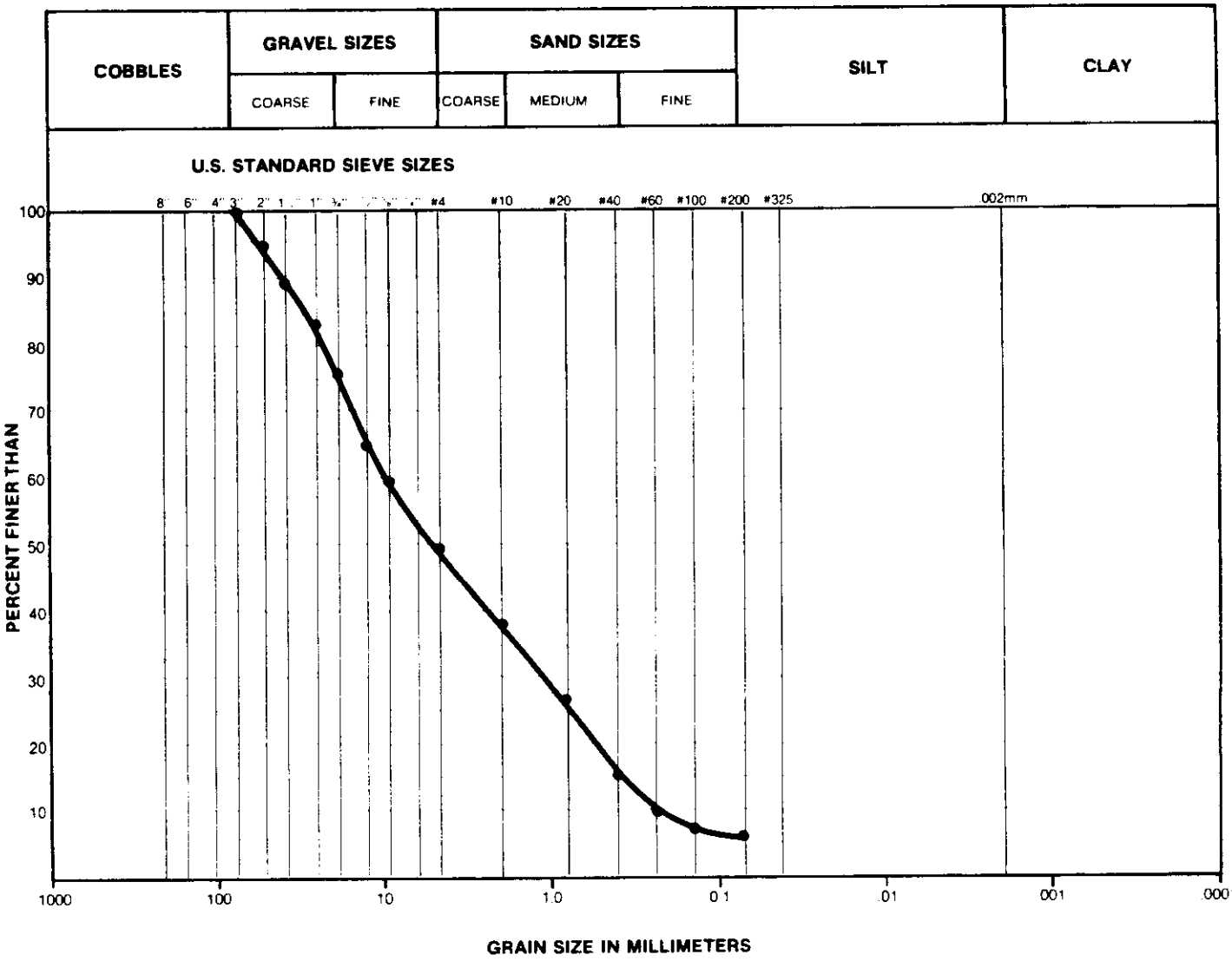
GRAIN SIZE CURVE

CLIENT:	DIAND
PROJECT NUMBER:	CG 10106
LAB. NUMBER:	
LOCATION:	SALT MOUNTAIN - STUDY AREA C
HOLE:	C5
SAMPLE:	C5
DEPTH:	.5 - 1.0 m
TECHNICIAN:	G.W.
DATE:	83/12/21



REMARKS:

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	.25 mm	GRAVEL	52 %
D_{30} =	1.1 mm	SAND	42 %
D_{60} =	10 mm	SILT + CLAY	6 %
C_U =	40 mm		
C_C =	____ mm		

Plate B-12

TABLE NO. B-3

SUMMARY OF ROCK TYPES COARSE FRACTION

Test Pit C-5 Depth 0.5 m - 1.0 m

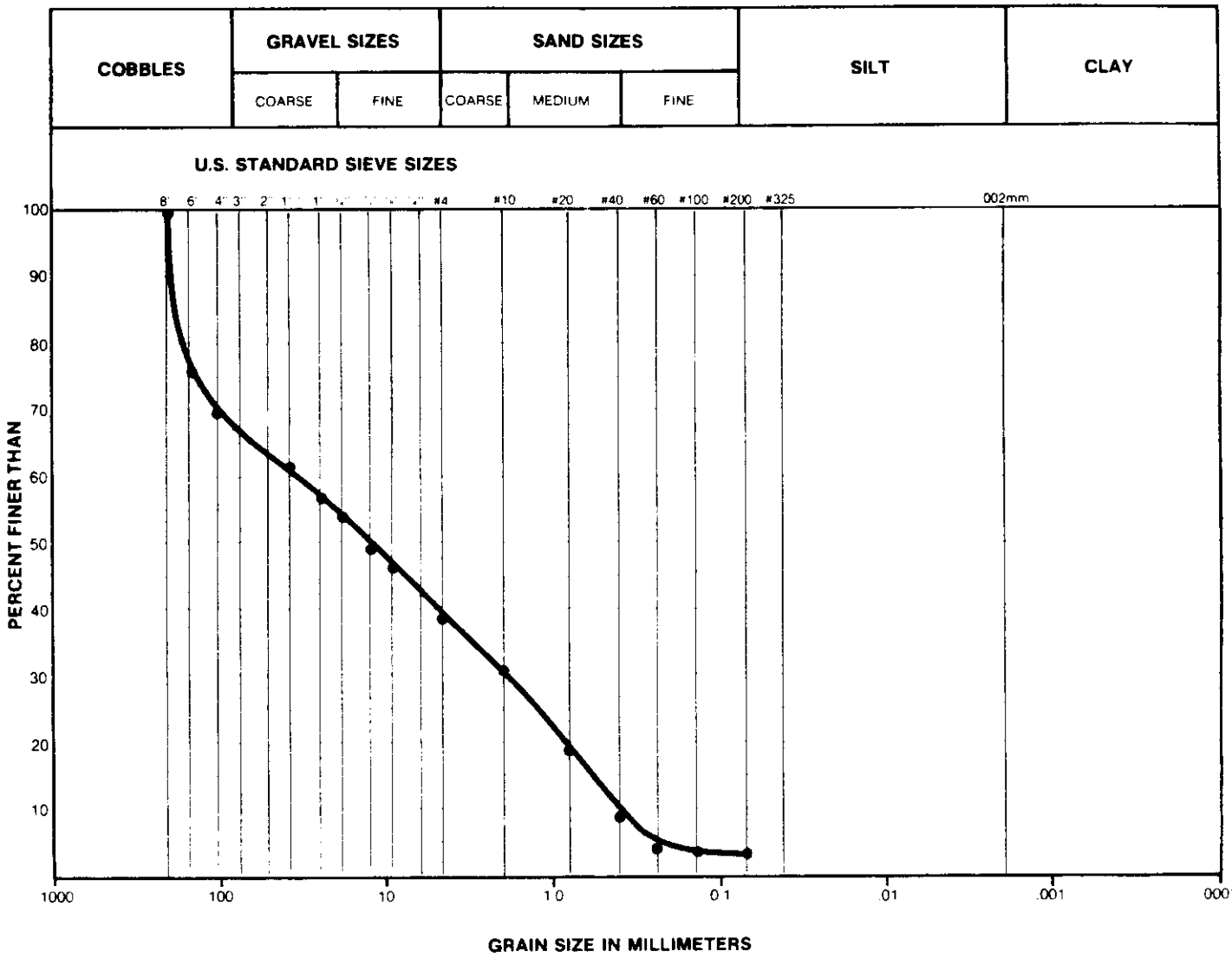
ROCK TYPE	CLASSIFICATION	WEIGHTED PERCENTAGES OF CONSTITUENTS IN EACH SIEVE FRACTION									Total Weighted Composition
		4"	3"	2"	1½"	1"	3/4"	½"	3/8"	#4	
Granite, granodiorite, rhyolite	GOOD				4.0	2.2	2.3	1.3	1.6	4.7	16.1
Limestone (slightly weathered)	FAIR				9.0	10.8	12.7	21.7	11.4	18.3	83.9
Sandstone (weathered, medium hard)											
					13.0	13.0	15.0	23.0	13.0	23.0	100.0

PN = 267.8

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

GRAIN SIZE CURVE

CLIENT: DIAND
PROJECT NUMBER: CG 10106
LAB. NUMBER:
LOCATION: SALT MOUNTAIN - STUDY AREA C
HOLE: C6 SAMPLE: C6
DEPTH: 1.5 - 2.0 m
TECHNICIAN: G.W. DATE: 83/12/21



REMARKS: 30% cobbles

NOTE UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	.4 mm	GRAVEL	61 %
D_{30} =	2.0 mm	SAND	36 %
D_{60} =	40 mm	SILT + CLAY	3 %
C_u =	mm		
C_c =	mm		

HT85-8-

Plate B-13

J. R. Paine & Associates Ltd.

CONSULTING AND TESTING ENGINEERS

SCREEN ANALYSIS

Client: Town of Fort Smith c/o GCG Engineering

Project: Fort Smith

Sample: ..... Depth: .....

Location: Fort Smith Pit

Made by: DR Job No. 1515-31

Ck'd by: LD Date: Sept. 15/83

Sieve No.	Size of Opening MM		Weight Retained gms	Total Wt. Finer Than gms	Percent Finer Than	% Finer Than Basis Orig Sample
40000	40.0					
25000	25.0					100.0
20000	20.0					96.3
14000	14.0					79.2
12500	12.5					75.0
10000	10.0					57.1
5000	5.0					14.3
2000	2.0					3.6
1250	1.250					2.9
800	0.800					2.7
630	0.630					2.6
400	0.400					2.5
250	0.250					2.4
160	0.160					2.3
63	0.063					1.9

Description of Sample: Pea Gravel

Time of Sieving: 12 Min.

Method of Preparation: Dry ..... Washed: X

Remarks: Moisture Content = 2.4%

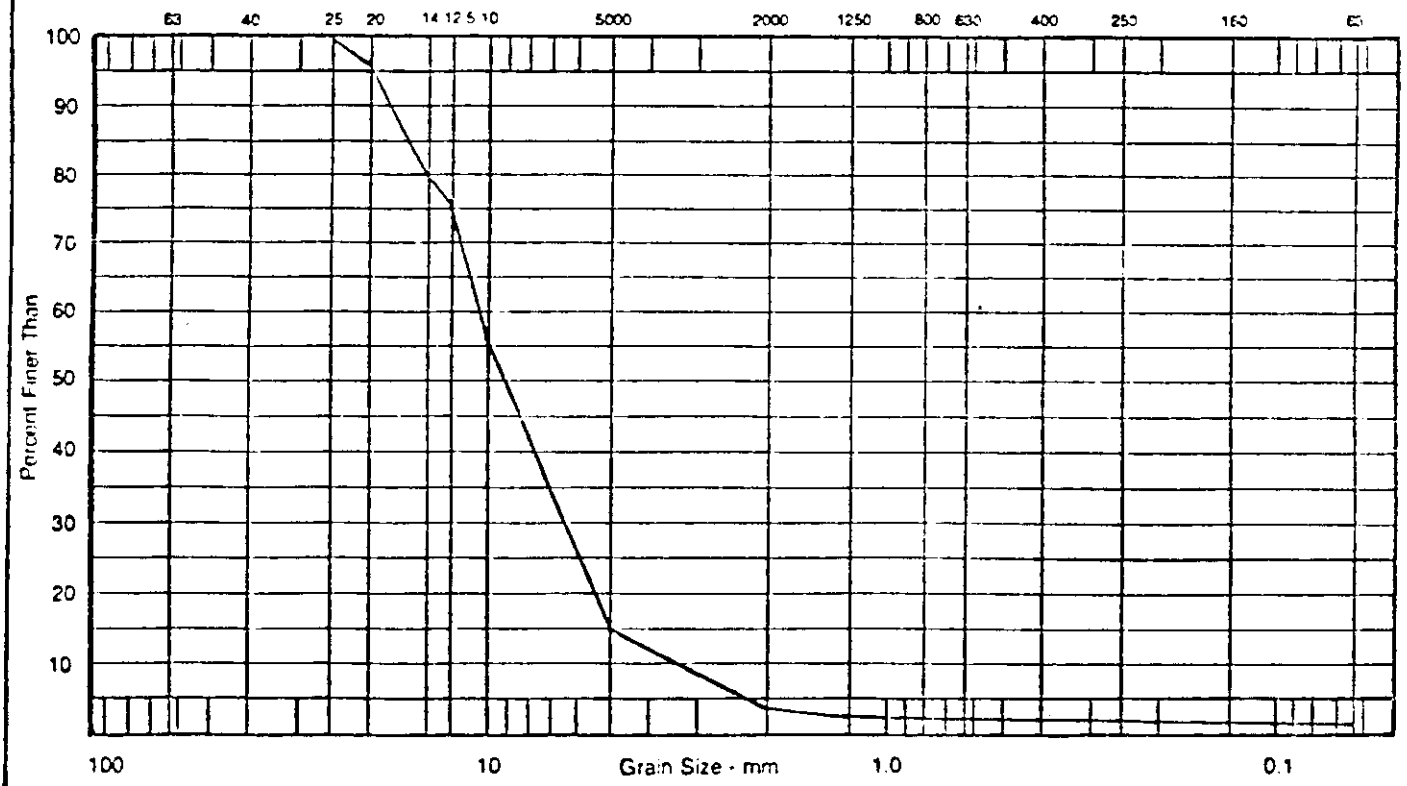


Plate B-14

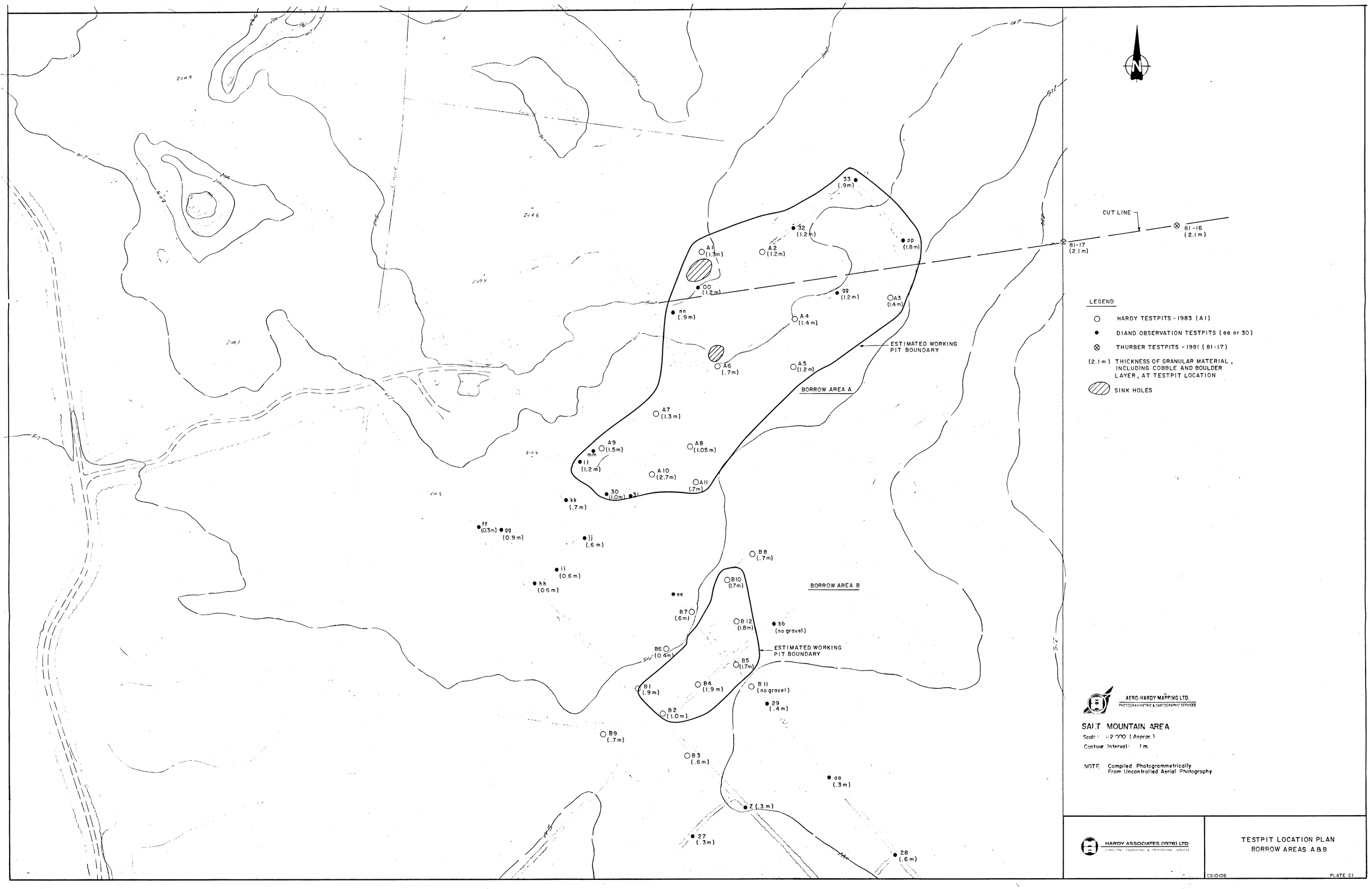
TABLE B-4

COARSE AGGREGATE PETROGRAPHIC ANALYSIS - HILL #1
(Performed by Thurber Consultants Ltd., 1981)

	Sample 81-16 (0.5-1.4 m) % by Weight	
Good Quality		
Carbonates (hard)	1.8	
Granite-Diorite	32.5	
Trap	1.9	
		36.2
Fair Quality		
Carbonates (slightly weathered)	39.7	
Carbonates (sandy, medium hard)	20.2	
Sandstone (medium hard)	2.1	
Granite (brittle)	1.9	
		63.9
Basic Petrographic No.	PN = 228	

APPENDIX "C"

Borrow Reserve Site Plans



LEGEND

- ○ HARDY TESTPITS - 1983 (A1)
- ● DIAND OBSERVATION TESTPITS (aa or 30)
- ⊗ THURBER TESTPITS - 1981 (81-17)
- (2.1m) THICKNESS OF GRANULAR MATERIAL, INCLUDING COBBLE AND BOULDER LAYER, AT TESTPIT LOCATION
- ▨ SINK HOLES

AERO-HARDY MAPPING LTD.
PHOTOGRAMMETRIC & CARTOGRAPHIC SERVICES

SALT MOUNTAIN AREA

Scale: 1:2000 (Approx.)

Contour Interval: 1m.

NOTE: Compiled Photogrammetrically From Uncontrolled Aerial Photography

HARDY ASSOCIATES (1978) LTD
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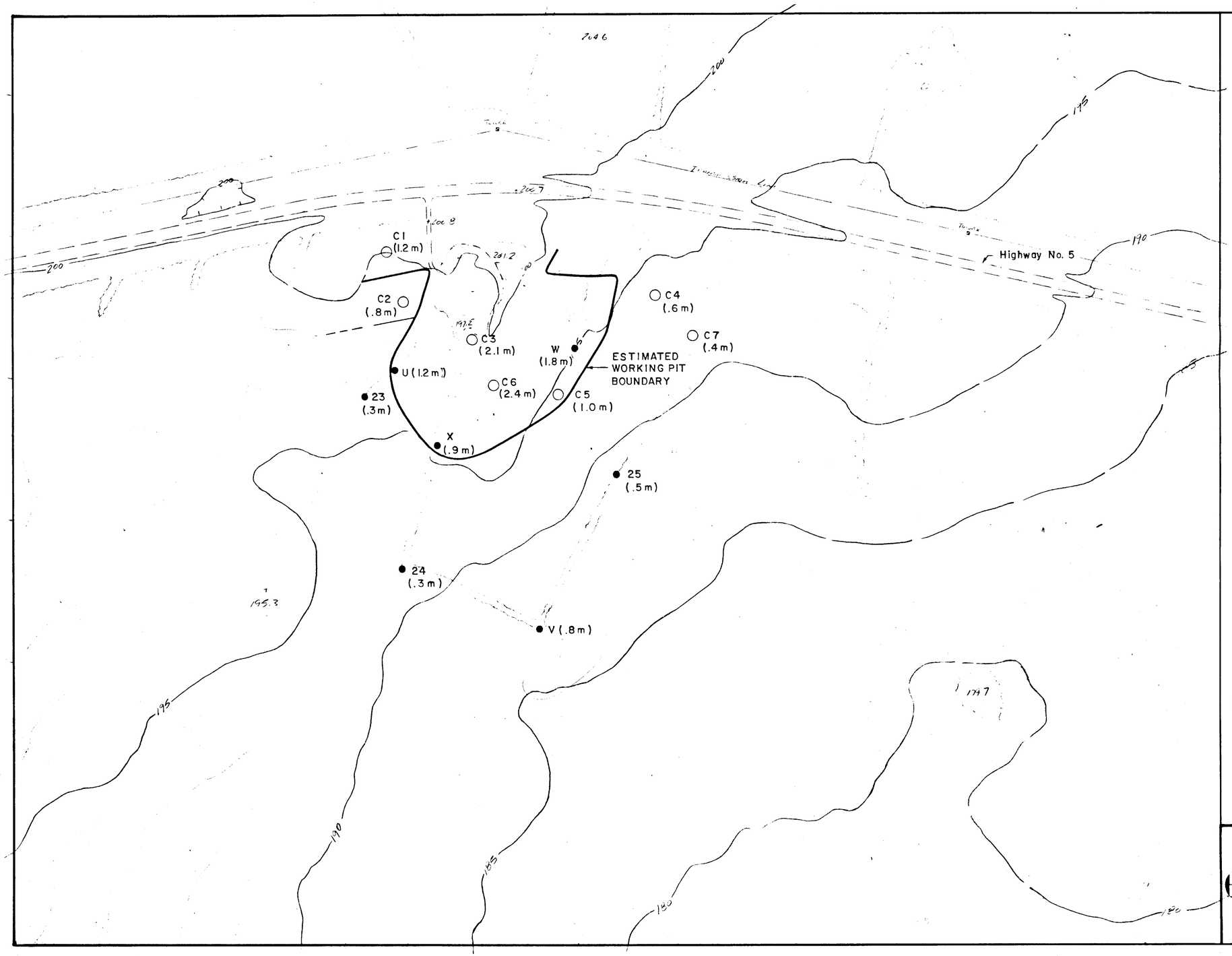
TESTPIT LOCATION PLAN BORROW AREAS A & B

CG10106

PLATE C1



LEGEND

- ○ HARDY TESTPITS - 1983 (C1)
- ● DIAND OBSERVATION TESTPITS (V or 24)
- (1.0 m) THICKNESS OF GRANULAR MATERIAL AT TESTPIT LOCATION

NOTES: 1) TESTPIT C5 AT BASE OF RIDGE ≃ 2.0 m BELOW PIT C6

2) TESTPIT C6 ≃ 1.2 m BELOW EXISTING PIT (C3)

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SALT MOUNTAIN AREA

Scale: 1:2 000 (Approx)

Contour Interval: 1 m.

NOTE: Compiled Photogrammetrically From Uncontrolled Aerial Photography.

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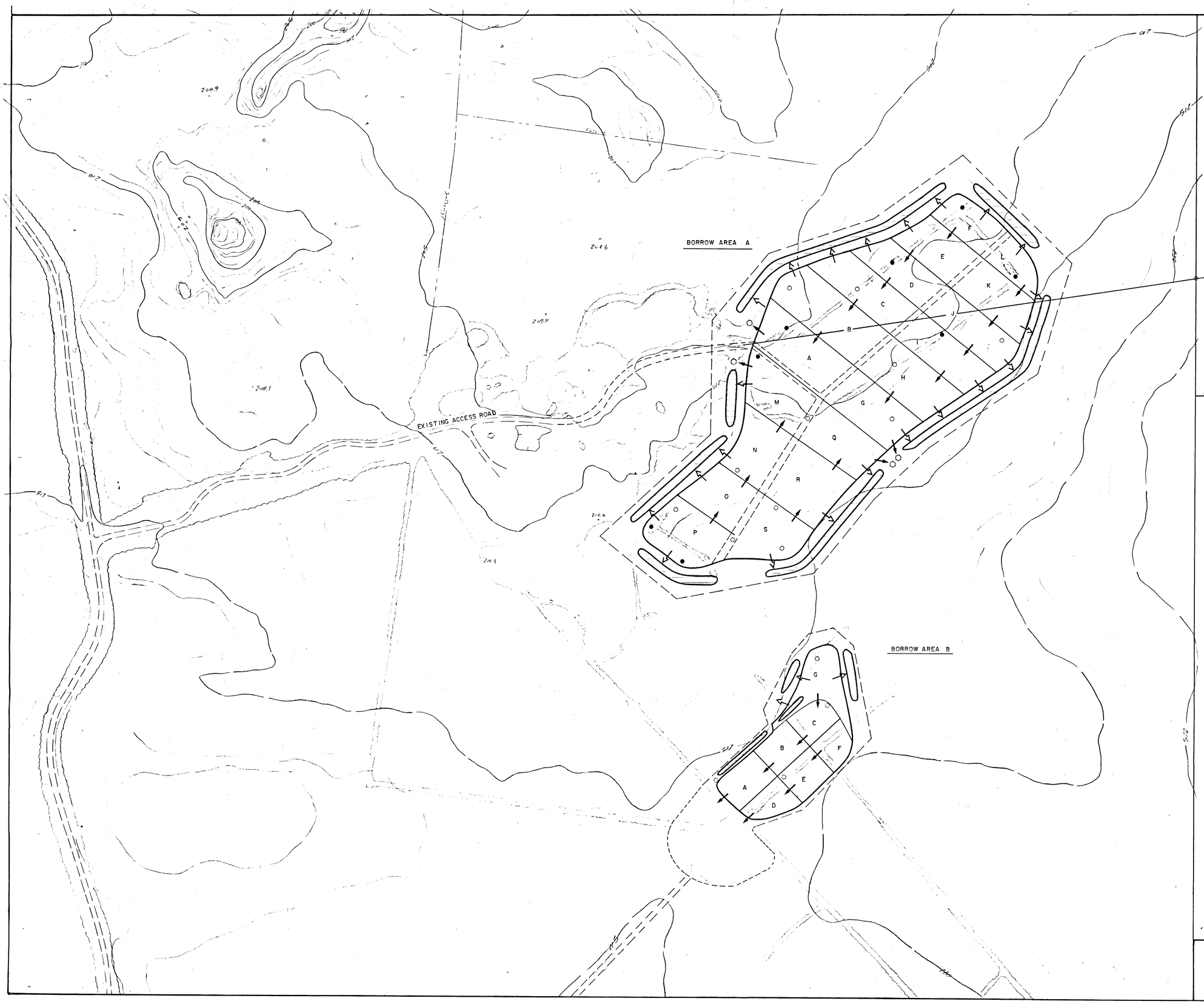
ENGINEERING CONSULTANTS & PROFESSIONAL SERVICES

TESTPIT LOCATION PLAN BORROW AREA C

CG10106

PLATE C2



N

LEGEND

- PROPOSED PIT BOUNDARY
- EXISTING PIT & CLEARING
- PROPOSED EXTENT OF WORKING PIT AND ARBITRARY SUBSECTION BOUNDARIES
- BRUSH WINDROWS
- EXISTING BRUSH WINDROWS
- OVERBURDEN STOCKPILES
- A — SUBSECTION DESIGNATION
- HARDY TEST PITS - 1983
- EXISTING DPW TEST PITS
- THURBER TEST PITS - 1981
- PROPOSED ACCESS

AERO-HARDY MAPPING LTD.
PHOTOGRAMMETRIC & CARTOGRAPHIC SERVICES

SALT MOUNTAIN AREA

Scale: 1:2 000 (Approx.)

Contour Interval: 1 m.

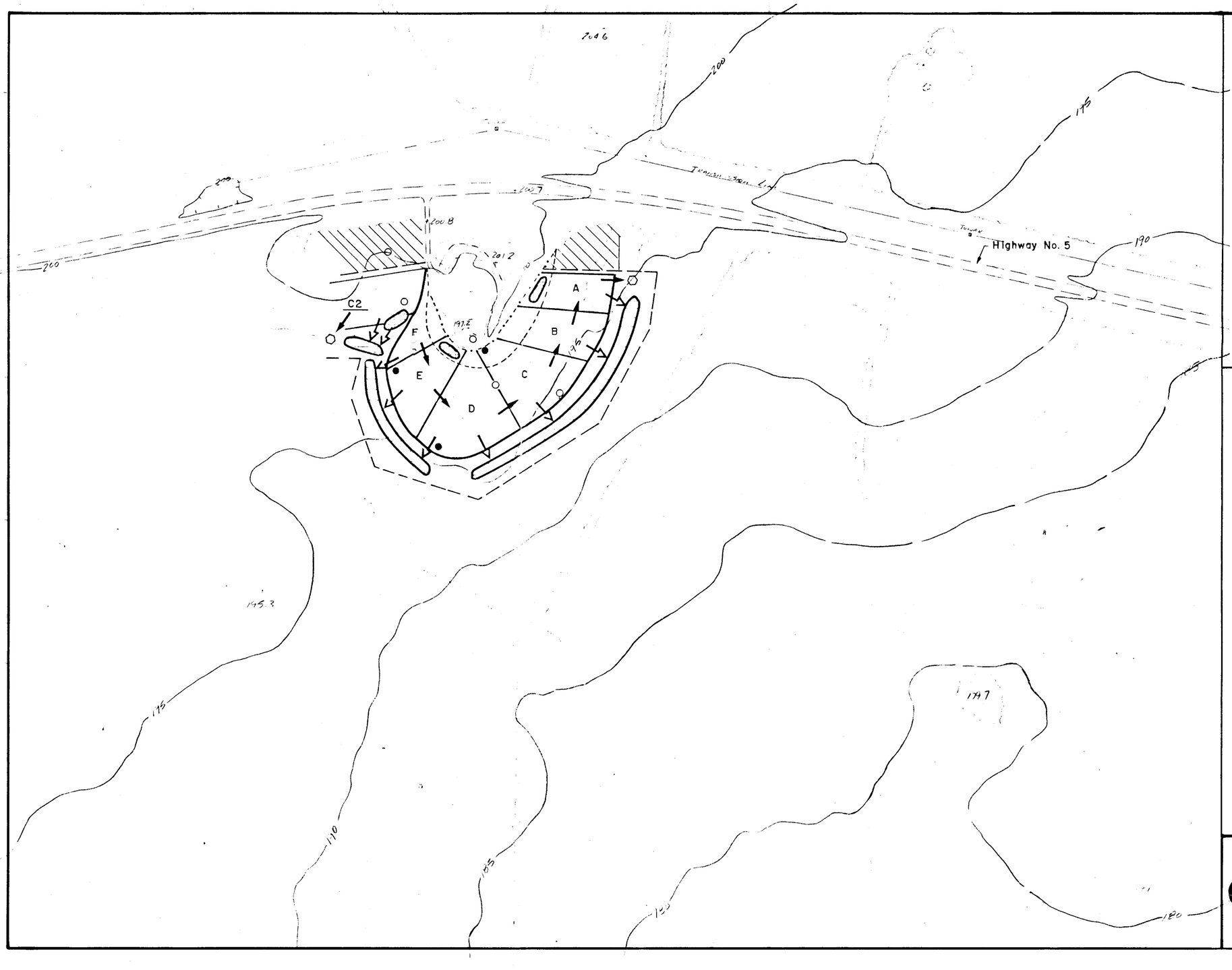
NOTE: Compiled Photogrammetrically From Uncontrolled Aerial Photography

HARDY ASSOCIATES (1978) LTD.
ENGINEERING, EXPLORATION & PROFESSIONAL SERVICES

PROPOSED PIT MANAGEMENT PLAN BORROW AREAS A & B

CG10106

PLATE C3



LEGEND

- BUFFER ZONE ADJACENT TO RIGHT OF WAY
- PROPOSED PIT BOUNDARY
- EXISTING PIT
- APPROXIMATE EXTENT OF CLEARING
- PROPOSED EXTENT OF WORKING PIT AND ARBITRARY SUBSECTION BOUNDARIES
- BRUSH WINDROWS
- EXISTING BRUSH WINDROWS
- OVERBURDEN STOCKPILES
- A SUBSECTION DESIGNATION
- ○ HARDY TEST PITS - 1983
- ● EXISTING DPW TEST PITS

AERO-HARDY MAPPING LTD.
PHOTOGRAMMETRIC & CARTOGRAPHIC SERVICES

SALT MOUNTAIN AREA

Scale: 1:2000 (Approx)

Contour Interval: 1m.

NOTE: Compiled Photogrammetrically From Uncontrolled Aerial Photography

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

PROPOSED PIT MANAGEMENT PLAN
BORROW PIT C

CG10106

PLATE C4