CHEVRON CANADA RESOURCES LIMITED

FINAL REPORT

DESIGN AND BORROW INVESTIGATION
MOUNTAIN RIVER AIRSTRIP

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON CANADA RESOURCES LIMITED

FINAL REPORT

DESIGN AND BORROW INVESTIGATION
MOUNTAIN RIVER AIRSTRIP

Hardy BBT Limited

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON CANADA RESOURCES LIMITED
FINAL REPORT
DESIGN AND BORROW INVESTIGATION
MOUNTAIN RIVER AIRSTRIP

Prepare for:

CHEVRON CANADA RESOURCES LIMITED

500 FIFTH AVENUE S.W.

CALGARY, ALBERTA

Prepared by:

HARDY BBT LIMITED

CALGARY, ALBERTA

April, 1988

CG14123

TALBE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

1.0 INTRODUCTION

In August 1987, Chevron Canada Resources Limited retained Hardy BBT Limited to examine the feasibility of constructing an all-season, gravel airstrip suitable for HS 748 or Hercules aircraft. Based upon some preliminary field reconnaissance and surveys, together with some geothermal analyses, a tentative design was presented in a report dated October 21, 1987. The conclusion was that an airstrip was certainly feasible pending confirmation of certain design assumptions and of the availability of sufficient, suitable gravel at a reasonable haul distance. A copy of this report is contained in Appendix A for completeness.

In December 1987 and January 1988 a two-part drilling program investigated both the design issues and the borrow sources. A preliminary report was issued, March 7, 1988 summarizing the results of the drilling investigations, confirming some design issues and recommending borrow sources. This report further confirms and elaborates upon certain aspects of that preliminary report. In addition, the recommended borrow sources and some suggested development plans are included, based upon decisions made during a review meeting with Chevron on April 18, 1988.

1.1 PROPOSED AIRSTRIP

The proposed airstrip development, which is to have a design life of about 5 years, is shown on Figure 1, at the end of the text. The initial objective is to

construct a 3000 ft. (914 m) all-season runway for a Twin Otter, which is to be extended to a 5000 foot (1524 m) runway suitable for winter landing of a HS 748 or Hercules aircraft. A later stage may consist of upgrading the entire 5000 foot runway to permit all-season landing for a HS 748 or Hercules.

As indicated on Figure 1, in addition to the runway there will be a 500 foot (152 m) long over-run at each end of the extended runway. Since the north over-run will be used as access to the parking ramp, this over-run will have to be good quality. The south over-run can be of lower quality. Shoulders 25 foot (8 m) wide are required for the full extent of runway and over-runs.

The parking ramp is to be a 200 x 100 foot (60 x 20 m) good quality pad. The parking ramp will butt up against the existing access road.

2.0 FIELD INVESTIGATIONS

The total scope of the investigation and all borehole locations are shown on Figures 2 to 4. All borehole logs and the results of laboratory tests are contained in Appendix B and C for the design boreholes and borrow boreholes respectively. An explanation of terms and symbols used on the logs is presented in Appendix D.

2.1 DECEMBER INVESTIGATION

Five test pits, 1 to 5 on Figure 4, were excavated using a D6 cat and were logged by Chevron personnel. Test Pits

1, 2 and 5 encountered coarse clean gravel at 1.5, 1.8 and 3.0 m depth, respectively. The overburden consisted of sandy silt. The gravel extended to the full depth of the test pits, up to 3.7 m.

A drilling program, using a seismic drill, consisted of seven design and ten borrow boreholes. Design boreholes were drilled through the camp pad (BH 1 to 3B, Figure 2) and through the road (BH 4 and 5, Figure 2) at the north end of the airstrip. The borrow boreholes (BH 5 to 15 on Figure 4) investigated the onshore potential borrow in more detail. These boreholes encountered gravel in all cases, however, the overburden thickness varied from 2.1 to 6.1 m. The overburden thickness is least towards the Mountain River and gradually increases southwards, see Figure 4.

Two additional test pits were excavated following the drilling, to examine the quality of the gravel. Test Pit 6 encountered very good gravel at 1.3 m below the surface. In Test Pit 7, a layer of frozen silt was encountered at 1.4 m. The cat was not equipped with a ripper and the blade was barely able to penetrate the frozen silt. The location was further investigated using the drill. Gravel was encountered at 3.0 m.

2.2 JANUARY INVESTIGATION

A second phase investigation had been planned at the outset to drill a series of holes off the ice to search for gravel in the near offshore. It had not been possible to drill some design investigation boreholes

along the old seismic line and the proposed airstrip alignment in December, so these were postponed to January. Some additional drilling based on the results of the December program consisted of installing thermistor strings in the camp pad and the road as well as coring of the frozen overburden in portions of the onshore borrow area to determine whether excavation through the frozen silt might be too difficult. A CRREL barrel was used for this coring.

The design information will be discussed in the next section. The borrow boreholes encountered gravel along most of the beach and near offshore, north of the wharf, Figure 3.

3.0 DESIGN DISCUSSION

This section discusses the information obtained for the purposes of confirming design issues. The main issues are the thaw depth, thaw settlement prediction and confirmation of the required design section for the airstrip.

3.1 THAW DEPTHS

Based on a review of the February 4 and March 28, 1988, thermistor readings there appears to be about 9 m of thaw beneath the camp pad which is about 35 m wide. The thaw beneath the road at the north end of the airstrip is not confirmed by the thermistor which was placed off the edge of the road. Thaw to 3 m was logged in Borehole 2-1a in

the centre of the road. The road is 7 m wide at this point.

Thaw beneath the seismic line appears to vary between 4 to 5 m based on the two thermistor strings installed. The logging of the boreholes indicated less thaw.

The thaw depth beneath the camp pad, of 9 m in about 17 years, provides a good long term data point for comparison with geothermal predictions. This value for the camp pad is more representative because the airstrip will be 46 m wide, compared to the camp pad at about 35 m.

The thermistor string installed in the airstrip clearing indicates a mean ground temperature at depth of -1.2°C compared to an assumed value of -1.0°C in our earlier design analyses. The geothermal predictions presented in our report (Appendix A) appear to be substantiated.

3.2 THAW SETTLEMENT

A survey across the road at the north end of the proposed airstrip indicates 0.6 m of thaw settlement beneath the road, in about 17 years. Previous surveys indicated 0.0 to 0.9 m settlement beneath the seismic line, at nine surveyed sections. The age of the seismic line is unknown. A survey across the camp pad was not considered feasible due to the camp and sump disturbance. For a wider clearing, the thaw penetration and therefore the potential thaw settlement would be greater in the long term.

Ice contents in the terrain beneath the airstrip are moderate to high in the upper 1 m (10 to 30%). Beneath this upper zone the majority of the silt and sand strata contain 5 to 10% visible excess ice. The generally higher ice contents in Borehole 4-1 are expected to be quite local, being related to a 60 m long terrain feature.

For a design thaw of 3 m in 5 years (beneath a 1.5 m thick airstrip, Figure 1 Appendix A), the thaw settlement could be as high as 0.8 m. Settlement would be variable and may be greater than 0.8 m in local areas (e.g. near Borehole 4-1). Some settlement will continue after five years, however at a reduced rate due to a slower thaw progression and lower ice contents at depth.

3.3 DUNE-LIKE FEATURES ON AIRSTRIP ALIGNMENT

A total of three boreholes were drilled in two small, 1 m high features projecting onto the airstrip alignment from the west (Boreholes 5-1, 2 and 3, Figure 2). The soil stratigraphy is very similar to the surrounding terrain. There was, however, negligible organic cover and very little excess ice. It should be possible to grade these features down to permit the full design thickness of granular fill.

3.4 AIRSTRIP SECTION

Based upon the predicted thaw settlement and the relatively poor peat and silt subgrade the design section

for the runway and other load bearing areas is 1.5 m of gravel. This thickness should provide a reasonably stable runway for most of the year. During spring and early summer, the runway may be unserviceable for a period as the frost thaws. In the early winter, differential heave may require some levelling to maintain a suitable surface.

Figure 5 shows the layout of the airstrip with the grades of the various construction materials required, in plan and in some sections. All load bearing areas have full depth gravel. A surface course (Class A) is specified which should contain 15 to 25% fines to act as a binder. The main structural fill (Class B) should contain very little fines, if possible, to reduce frost heave potential. The selection and control on these materials will require careful inspection. Significant concentrations of fine grained soils in the load bearing portions of the airstrip could cause considerable heave and frost boil problems.

Since the shoulders and the south over-run are less critical, it is proposed that the lower portion of the fill could consist of overburden sand and silt. This must be placed at a moisture content close to optimum and therefore dredged sands and silts will not be suitable.

A 1.5% surface crowning is recommended to shed water off the surface.

3.5 DRAINAGE CULVERTS

Several low points along the airstrip were identified as creeks during the September 1987, survey (Appendix A). While not considered major, intermittent flow must be assumed and should be accommodated. Four likely locations can be identified from the longitudinal profile, Plate 1, Appendix A. It is recommended that 610 mm corrugated metal pipe be used and that material for 4 culverts be provided by the contractor.

4.0 BORROW SOURCES

4.1 GENERAL

Drilling along the beach and the nearshore has confirmed that the gravel initially encountered around the airstrip extends under the beach and up to 15 m offshore (relative to winter ice level). The December test pits and boreholes indicated very good coarse gravel between 2 and 3 m thick beneath 1.5 to 4 m of silty overburden. The boreholes on the beach indicate a similar thickness of gravel with very little overburden, except on the upper beach towards the airstrip. The investigation was not extended much south of the wharf (Figure 3) as finer sands and silts were being encountered and the logistics of working along that bank would be difficult.

Some typical stratigraphic sections shown on Figures 6 and 7 illustrate the typical geological nature of the borrow source at the beach area. Based upon sections drawn up for each series of boreholes, the total volume

of potentially available gravel between the existing airstrip and the river, Borrow Area A on Figure 8, is estimated at about 200,000 m^3. In addition, a certain amount of the overburden in this area can be used in the shoulders and the south over-run.

The quantity of gravel that can be successfully obtained will depend on the actual river level at the time of excavation as well as the actual development plan adopted. Because of the finite thickness of gravel and the undesirable nature of the strata above and below the gravel, strict control will be required to ensure selective excavation. Much of the gravel will probably be under water in the summer months which will add to the difficulty of quality control.

4.2 RIVER LEVEL RECORDS

To assess the impact of higher summer river levels, the Water Survey of Canada water levels for Norman Wells have been evaluated over the period from January 1988 back to 1976. The main questions were:

(a) was the river level in late January 1988 (when the drilling was done) similar to previous years?

(b) by how much were the July, August and September water levels higher or lower than in late January each year?

The following summarizes some of the data reviewed for Norman Wells:

RIVER LEVELS (m)

	January 26-31st	July Mean	August Mean	September Mean
High	5.3	6.4	5.6	5.0
Low	4.8	5.0	4.6	3.9
Mean	5.0	5.8	5.1	4.5
(No. of values)	8	10	11	12

The data for late January is only available for eight years. The level in late January, 1988 was 5.1 m or 0.1 m above the mean for the eight years. The range between highest and lowest mean monthly levels is not as great as expected.

The difference between summer and late January river levels for each year summarized as follows:

RIVER LEVEL COMPARED TO LATE JANUARY

	July	August	September
High	+1.5 m	+0.7 m	+0.1 m
Low	+0.5 m	-0.1 m	-0.6 m
Mean	+1.1 m	+0.2 m	-0.3 m
No. of values	7	7	7

In seven years data for July, the mean monthly river level was between 0.5 and 1.5m higher than the late January level. The mean for the seven years examined is 1.1 m. It is not certain that the river at Mountain River will fluctuate identically. A 1.5 m higher level should be assumed possible and perhaps even an extreme of 2 m for early July when excavation is expected to start. The river levels drop quite significantly in August and September. If really extreme river levels are experienced this summer, start-up could possibly be delayed till mid-July. Construction should be feasible into mid-September at least.

4.3 REQUIRED VOLUMES

For the construction of the Twin Otter runway with a winter extension as shown in Figure 5, the material requirements are as follows:

Class A	14,000 m^3	
Class B	98,000 m^3	
Class A + B	112,000 m^3	112,000 m^3
Class C		30,000 m^3
	TOTAL BORROW	142,000 m^3

If the south extension were to be constructed to full thickness at this stage the following materials would be required.

	Additional for Extension
Class A	8,000 m^3
Class B	10,000 m^3
Class A + B	18,000 m^3
Class C	NIL

It would therefore not be much additional effort to build the entire airstrip to full thickness, which could be considered if the initial work proceeds successfully.

Class A and B materials will be essentially from the same sources. It will be therefore important that each material is appropriately identified during excavation and be hauled and placed in the proper location on the airstrip. The proper management of the available sources and control of the placement of each material will be essential to the construction of an airstrip which will have minimal maintenance problems.

The quality of the available materials is not known in great detail as only a small number of test pits, revealed the undisturbed deposit. It is difficult to predict exactly what quality of material will be dredged from the beach and near offshore.

Class C material will be preferably more sandy overburden that has been excavated above the water table. Saturated sands and silts from below water will not be usable.

4.4 ACTUAL BORROW SOURCE

It is understood that the Fort Good Hope Band would like the fishing camp at the mouth of the Mountain River protected. Chevron have agreed to leave a 60 m zone back from the Mountain River undisturbed.

It will be necessary to provide about 10 m of undisturbed ground all along the existing airstrip. All vegetation should be left intact in these two zones.

Borrow Area A, as identified on Figure 8, is the prime borrow source. It is believed that all of the required airstrip material can be obtained from this area as long as river levels are not extremely high. A very high river level in early July may limit the effective width of the beach however, as river levels recede, a greater width will become available.

Borrow Areas B and C (Figure 8) have been identified as potential sources, however, it is not expected that these areas will need to be developed.

5.0 BORROW PIT DEVELOPMENT

5.1 DEVELOPMENT APPROACH

All aspects of the borrow pit development must be consistent with the conditions of the Quarrying Permit, issued December 31, 1987. There is one basic approach suggested for the development of the borrow pit.

Figure 9 illustrates a progressive approach to excavation/stockpiling/draining/loading/hauling. This scheme requires modification at the north end of the beach where it has been agreed some protection will be provided for the fishing camp. Some protection dykes of undisturbed gravel will be left on the beach as shown on Figure 9 to deflect the river current away from the fishing camp. The area between these dykes will be backfilled with unsuitable or excess overburden. It is not expected that these dykes will guarantee protection indefinitely, however, they will act as a warning system for future potential erosion along that portion of the river bank.

For the remainder of the borrow pit, the excavation would start at Pit 1 close to the rivers edge. This and all pits will be excavated to 4 to 5 m maximum depth depending upon the thickness of gravel actually encountered. The gravels will be placed in Stockpile 1 and allowed to drain. It remains to be seen how long drainage will take, however, gravels similar to those encountered in Test Pits 1 and 2 will tend to drain in a day or so. Certainly, the drainage time for clean gravel is expected to be in the order of days rather than weeks.

The stockpile is positioned on the upslope side of the pit so that water will drain towards the pit. This will reduce the potential of saturating the upslope side where haul trucks will have to be loaded. Once the stockpile has been partially hauled away the excavation for Pit 2 can start. With progression upslope from the rivers edge the pits will become partially above water. The shallow

material will probably be suitable for direct haul to the airstrip. Likewise, overburden excavated above the water table can be directly hauled for the shoulders. This direct haul is also illustrated on Figure 9. Some direct haul may consist of saturated silts and sands, unsuitable for any portion of the airstrip. This material would be hauled to the backfill zone at the north end of the borrow pit.

There may be several variations to the above approach which should be considered with the contractor. It is probable that many refinements and improvements can and will be made during excavation. The basic approach, however, is believed to be a means of optimising gravel extraction.

5.2 BORROW PIT RESTORATION

Much of the borrow pit will be under water at the time of excavation. It will not be possible to obtain a uniform base to the pit at that time. As the river level recedes some of the base may become exposed. Where possible the base of the pit should be rough graded to provide a reasonably level surface.

The backslope of the pit parallel to the existing airstrip should be trimmed to a uniform slope at 3H:1V. Any other exposed faces should be similarly trimmed.

The area that is to be backfilled at the north end of the pit should be contoured similar to the adjacent undisturbed terrain. The area should be gradually sloped

down to the river level. All of this area and any other exposed surface which previously supported natural vegetation should be seeded and fertilized.

6.0 AIRSTRIP CONSTRUCTION

6.1 SURFACE PREPARATION

The majority of the proposed airstrip alignment has been cleared this past winter. An additional 1000' (300 m) requires clearing at the south end, for a portion of the winter runway extension and the over-run. Timber debris is actually desirable beneath the gravel fill. The new clearing will presumably be hand cleared. The trees should be cut at ground level. Branches should be cut, as required, to ensure the trunks and branches lay flat on the ground.

The low areas requiring culverts may need some debris removed to permit culvert placement. The culverts should actually be placed once sufficient airstrip fill has been placed to permit access by the required equipment.

The low, dune-line mounds referred to in Section 3.3 should be cut down to the level of the surrounding grade within the central 100'(30 m) portion of the runway to permit the full thickness of gravel fill. The mounds can be left as is in the shoulder, as long as they do not rise above the surrounding shoulder.

6.2 FILL PLACEMENT AND COMPACTION

Placement of fill will start at the north end beside the access road. Placement will have to be by dumping and spreading out over the ground. The first lift will have to be 60 to 90 cm thick to provide a working base depending on the quality of the material and the equipment requiring support. Every effort must be made to track-pack all of the fill as it is placed. It will be very difficult to obtain a firm surface if the base is too loose.

After the initial lift, subsequent layers of the Class B gravel should be placed in 30 cm lifts and thoroughly packed. A smooth-drum roller or rubber-tired roller should be used to compact the top 60 cm of the runway. Each lift of the shoulders and the south over-run should be track-packed.

The surface of the airstrip should be crowned with a 1.5% gradient to each side of the centerline. This will reduce the thickness of fill by 35 cm at the edge of the shoulders. Sections showing the various materials are contained on Figure 5. It is believed the transition from 1.5 to 1.0 m of fill between the two portions of the airstrip can be accommodated over 50 m. This should be optimised in the field. The side slopes of the shoulders should be 3H:1V.

The design calls for a gravel thickness of 1.5 m for the Otter runway and 1.0 m for the winter extension. Because of the relief along the alignment the actual fill

thickness will tend to vary. While it is not intended to construct a perfectly flat airstrip there will be some infilling of low areas with additional fill. Except for very short sections of high ground, the design fill thickness is to be considered a minimum. Culverts should have a minimum of 1 m cover on top of the pipes.

It is recommended that prior to placement of material, the design objectives be reviewed on site to optimize the grade of the runway. Also the requirements and location of culverts should be confirmed at that time.

7.0 EQUIPMENT

We suggest the contractor should provide at least the following equipment for carrying out this work:

Task		Equipment
Borrow Excavation		
Excavating and stockpiling	-	245 hoe with long boom
Loading from stockpiling	-	preferably 325 hoe c/w wide bucket or front end loader.
Maintaining access, rough grading, stockpile cleanup spreading backfill, etc.	-	D6 or 7 c/w winch.
Hauling	-	3 end-dumps
	-	2 tandems

Placement/Grading/Compaction

for rough spreading/packing	-	D6 - 7 c/w winch (possible wide track)
for finer grading	-	Grader
for compaction	-	water truck
	-	Smooth-drum or rubber-tired roller.

The equipment to be provide will to some extent depend on the borrow development plan adopted and this should be reviewed by all parties, on site, prior to mobilization.

8.0 INSPECTION

There are several aspects of this construction project that require close geotechnical quality control. Other aspects of inspection relate to overall direction to the contractor with respect to approved borrow areas and establishing the construction boundaries and grades. Depending upon the contractual arrangements some means of monitoring quantities of material and survey of completed volumes and finished grades will probably be needed. Time-keeping and equipment reports may also be required.

It is believed that good geotechnical quality control will be required through-out the construction of the airstrip. It will be very important that the stockpiles do not contain significant amounts of silts and sands as this material would drain very slowly and be quite inferior in the load bearing areas. Such materials

should be wasted directly as excavated unless they are dry enough to be placed and packed in the shoulders.

The distinction between Class A and B material is not very great but will be very significant to the performance of the airstrip. The identification of these two classes of material as they are excavated will be required to ensure proper placement in the airstrip. It is believed that a geotechnical appreciation of the granular deposits and the required qualities of the classes of fill material is important on this project.

We recommend the services of our Mr. Alex Costin, who has considerable arctic construction experience. In addition to all geotechnical matters Mr. Costin has much experience in construction management having been the sole owners representative on site on many occasions. Mr. Costin is also a very experienced surveyor, and therefore would be able to conduct virtually all aspects of project control for Chevron, if required.

9.0 MAINTENANCE

It must be recognized that in the first few years the airstrip will experience significant distress due to differential thaw settlement. Maintenance will be an ongoing requirement. Apart from the potential loose conditions during spring thaw, the whole airstrip will probably require regrading for most of the thaw season. Significant differential thaw will require re-grading.

In early winter differential heave may result from frost action in poor quality gravel fill or in the natural subgrade. The surface will likely be frozen at this time and therefore regrading will be more difficult. It may be more feasible to use snow for levelling in winter.

As thaw settlement occurs, natural ditches will develop along each shoulder of the airstrip. Water accumulating in these ditches will adversely affect the performance of the airstrip in summer and winter. If problem areas coincide with water trapped in the ditches, some drainage measures may be required.

10.0 CLOSURE

The design and borrow investigation have certainly proven that this proposed airstrip is feasible. The drilling along the airstrip alignment has shown that the terrain is not particularly ice rich and the existing pads and seismic lines indicate thaw settlement can be reasonable.

The borrow investigation has indicated that more than sufficient granular materials exist on the beach and terrace. It is expected that the required construction volumes can be obtained on the beach side of the existing airstrip.

Construction in July and August should be feasible provided river levels are not too extreme.

Respectfully submitted

Hardy BBT Limited

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF THE NORTHWEST TERRITORIES
PERMIT NUMBER
P 047
HARDY BBT LIMITED

REGISTERED PROFESSIONAL ENGINEER
A. J. HANNA
LICENSEE
N.W.T.

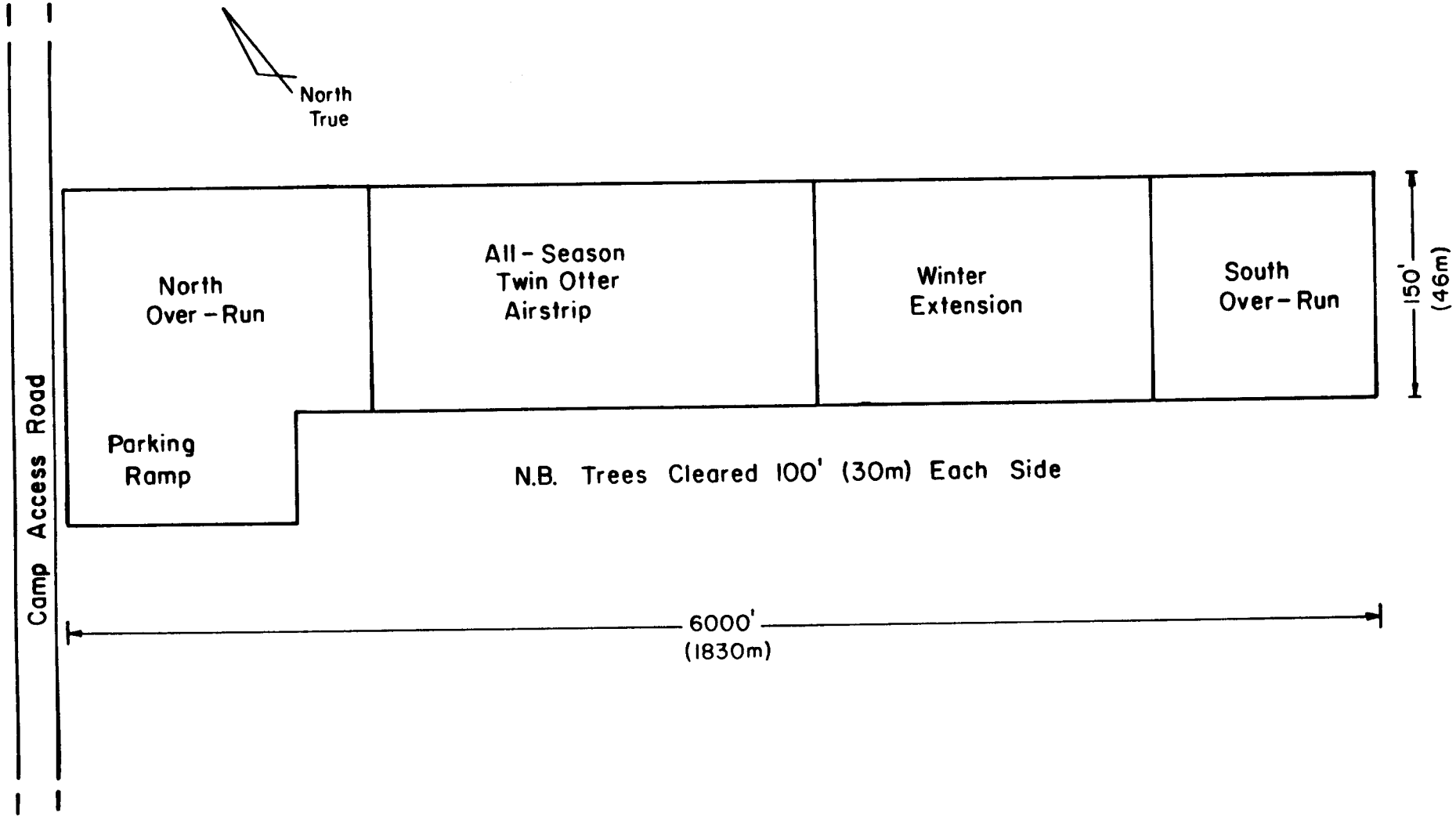
Per:

A.J. Hanna, M.A.Sc., P.Eng.
Manager, Northern Operations

REGISTERED PROFESSIONAL ENGINEER
W. A. Slusarchuk
LICENSEE
N.W.T.

Reviewed by:

W.A. Slusarchuk, Ph.D., P.Eng.
President & C.E.O.



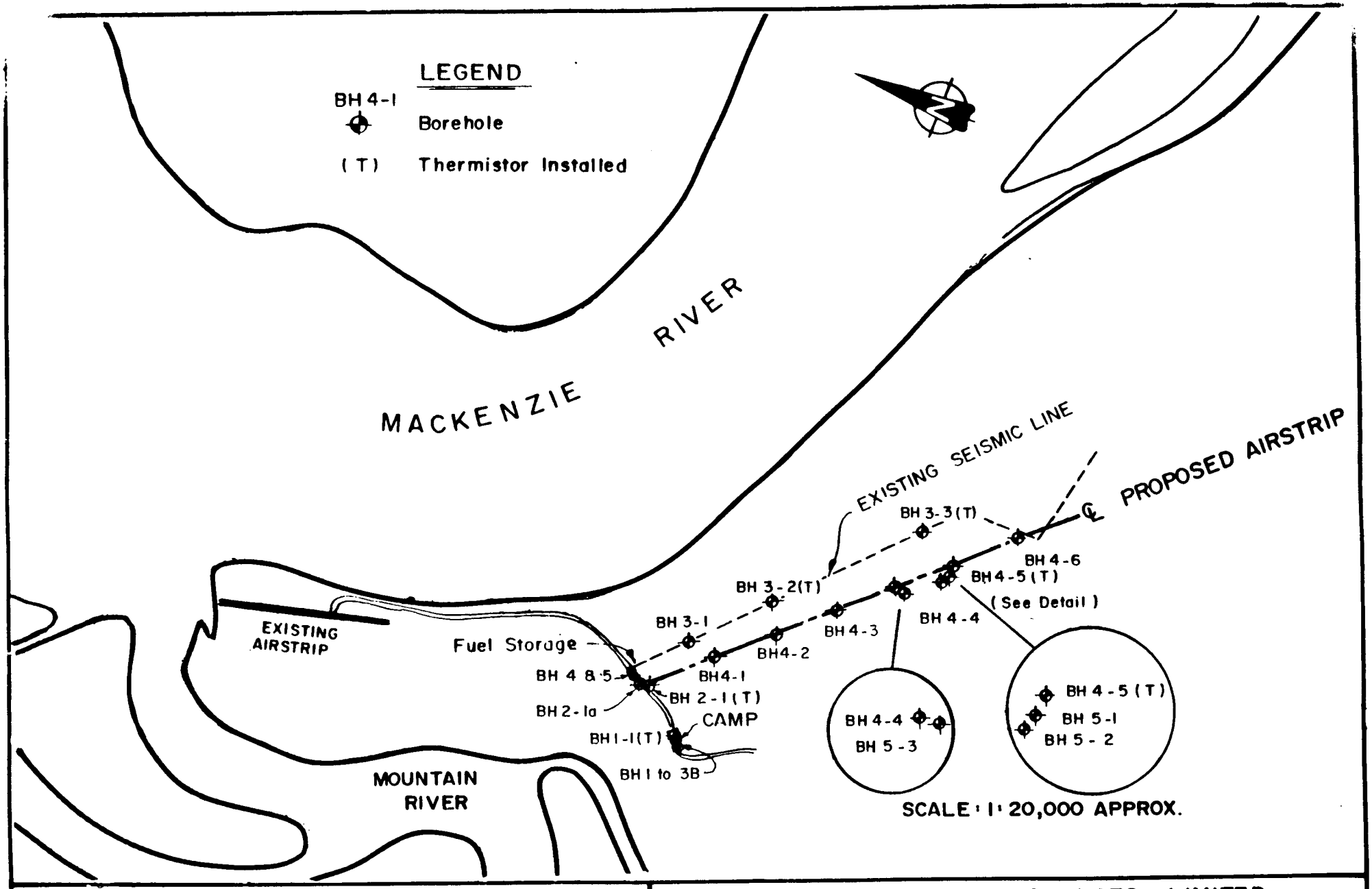
HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON CANADA RESOURCES LIMITED
PROPOSED AIRSTRIP
MOUNTAIN RIVER, N.W.T.

CG14123

Figure 1.

HT84-82/03



Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

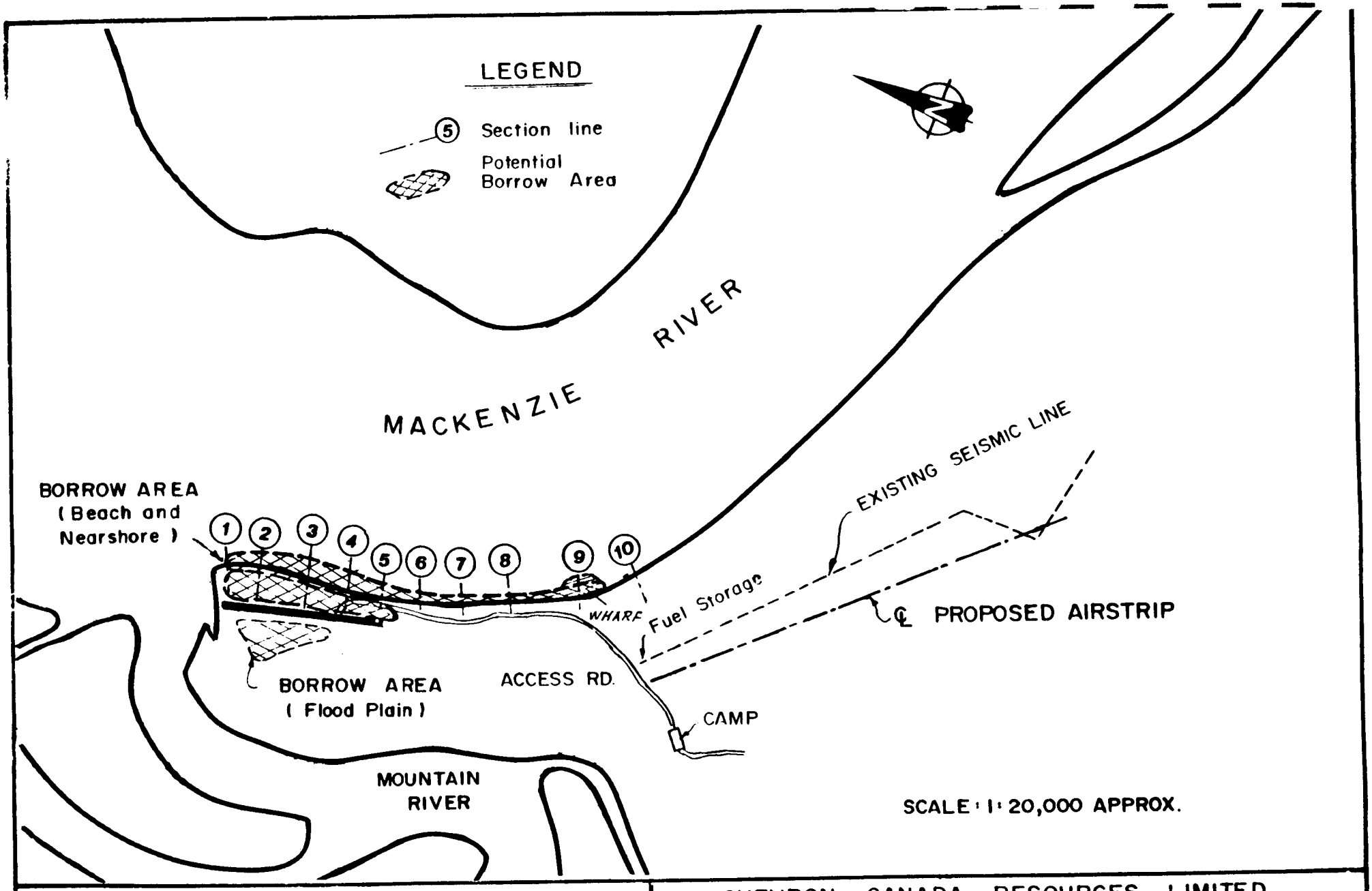
CHEVRON CANADA RESOURCES LIMITED

PROPOSED MOUNTAIN RIVER AIRSTRIP
DESIGN INVESTIGATION

CG 14123

FIGURE 2

HBLT 15 - 87/05



Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

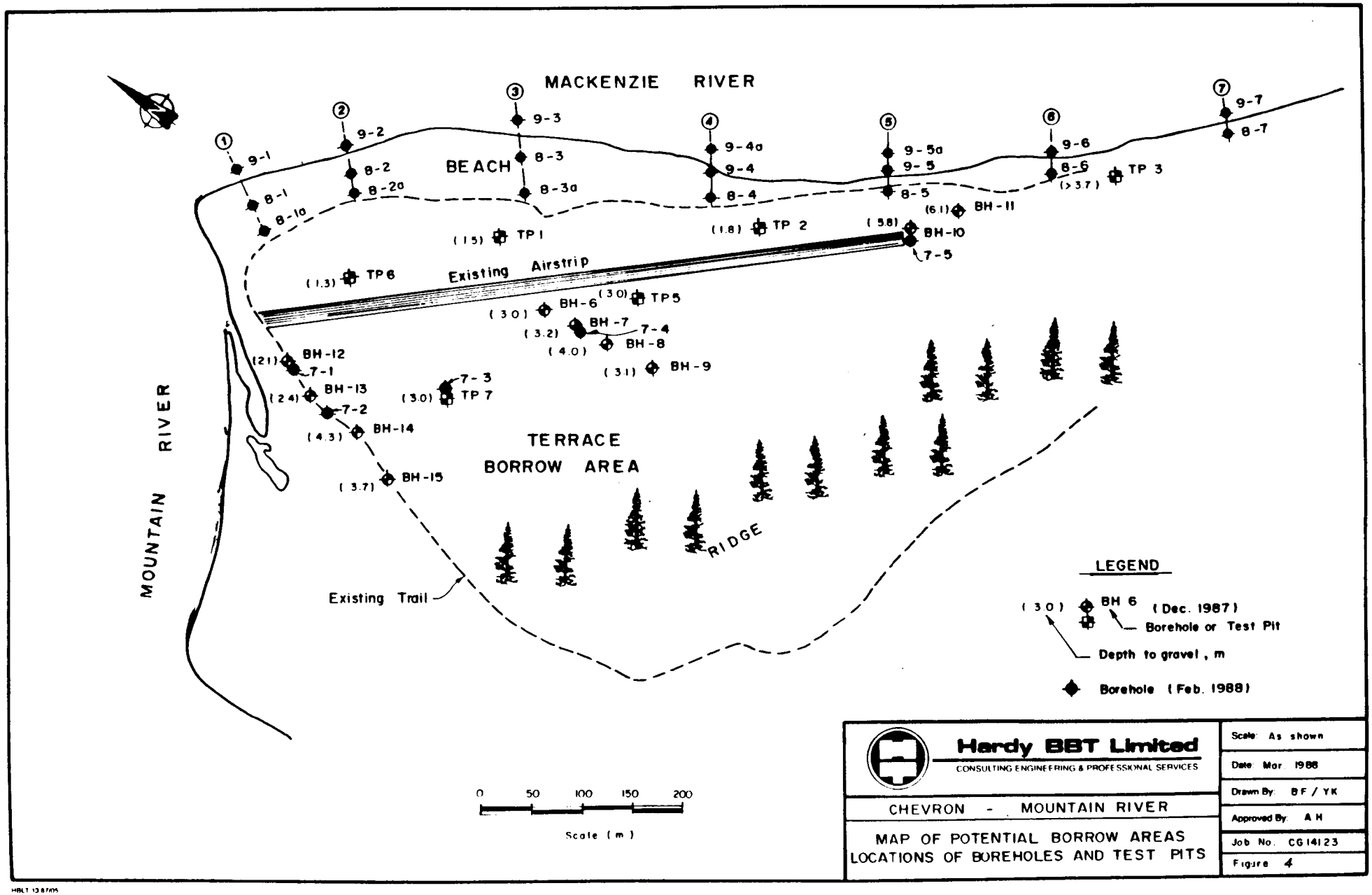
CHEVRON CANADA RESOURCES LIMITED

PROPOSED MOUNTAIN RIVER AIRSTRIP
BORROW INVESTIGATION
(Beach and Nearshore)

CG 14123

FIGURE 3

HBLT 15 - 87/05



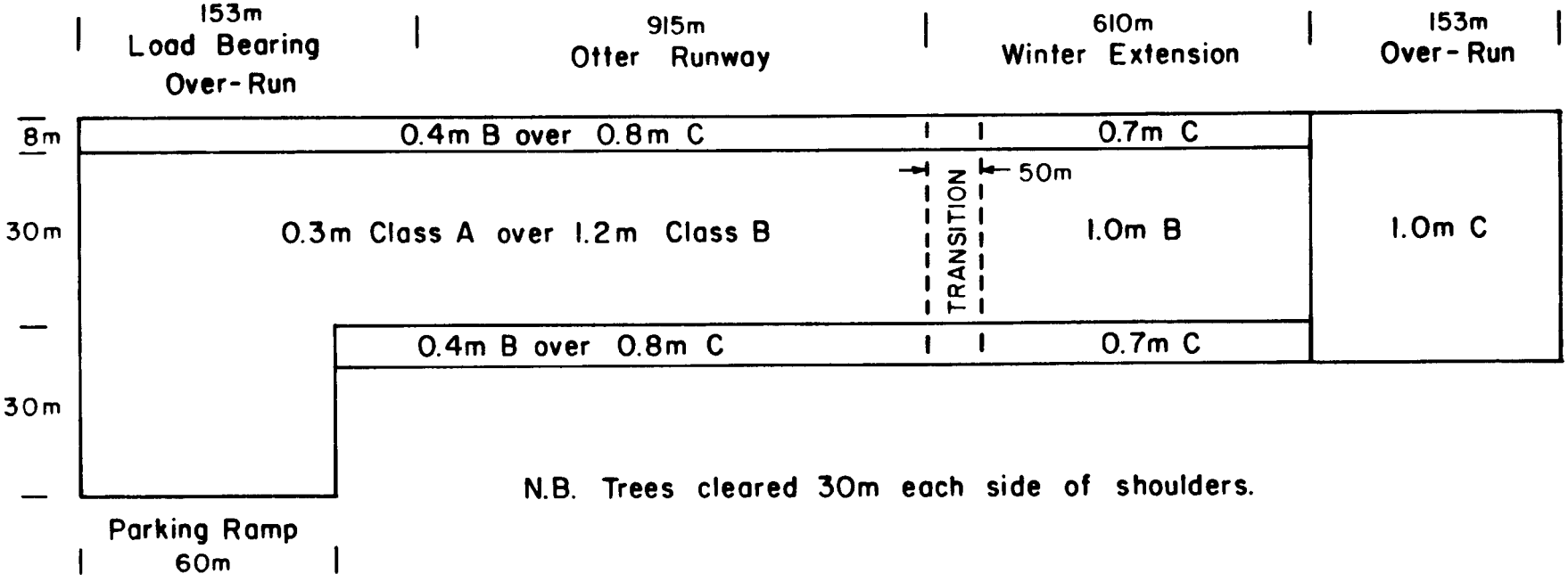
Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MOUNTAIN RIVER

MAP OF POTENTIAL BORROW AREAS
LOCATIONS OF BOREHOLES AND TEST PITS

Scale:	As shown
Date:	Mar. 1988
Drawn By:	BF / YK
Approved By:	A H
Job No.	CG14123
Figure	4

HBLT 13.87/05



N.B. Trees cleared 30m each side of shoulders.

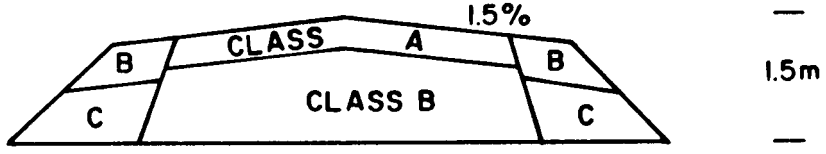
MATERIAL DEFINITION

Class A: Surface material - well graded gravel with 15 to 25% silt.

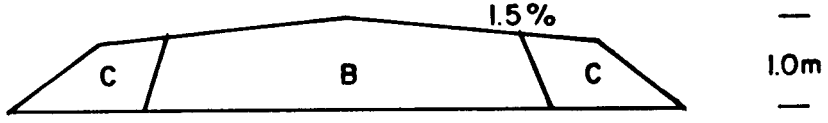
Class B: Structural fill - gravel with less than 5% fines.

Class C: Non-structural fill — sufficiently dry sand and silt overburden.

Otter Runway Section



Extension Section



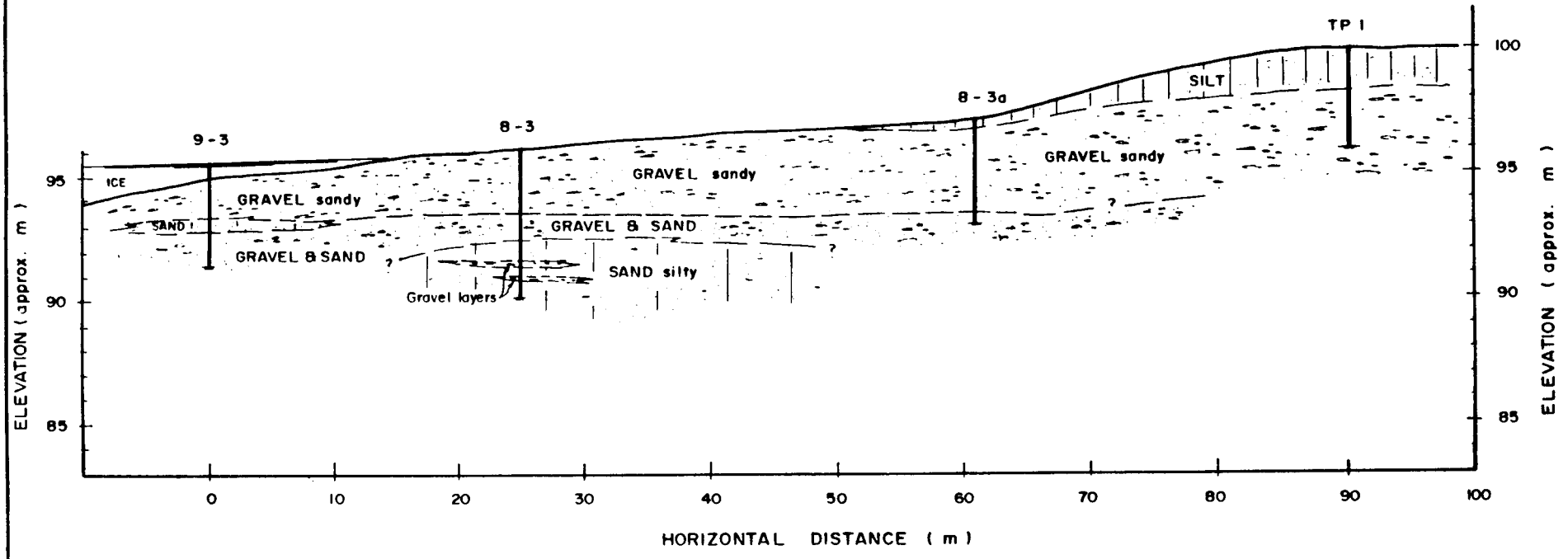
Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON CANADA RESOURCES LIMITED
PROPOSED AIRSTRIP
MATERIALS REQUIREMENTS

CGI4123

Figure 5.

HBLT 15 - 87/05



SECTION 3

(Figure 3)

NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown

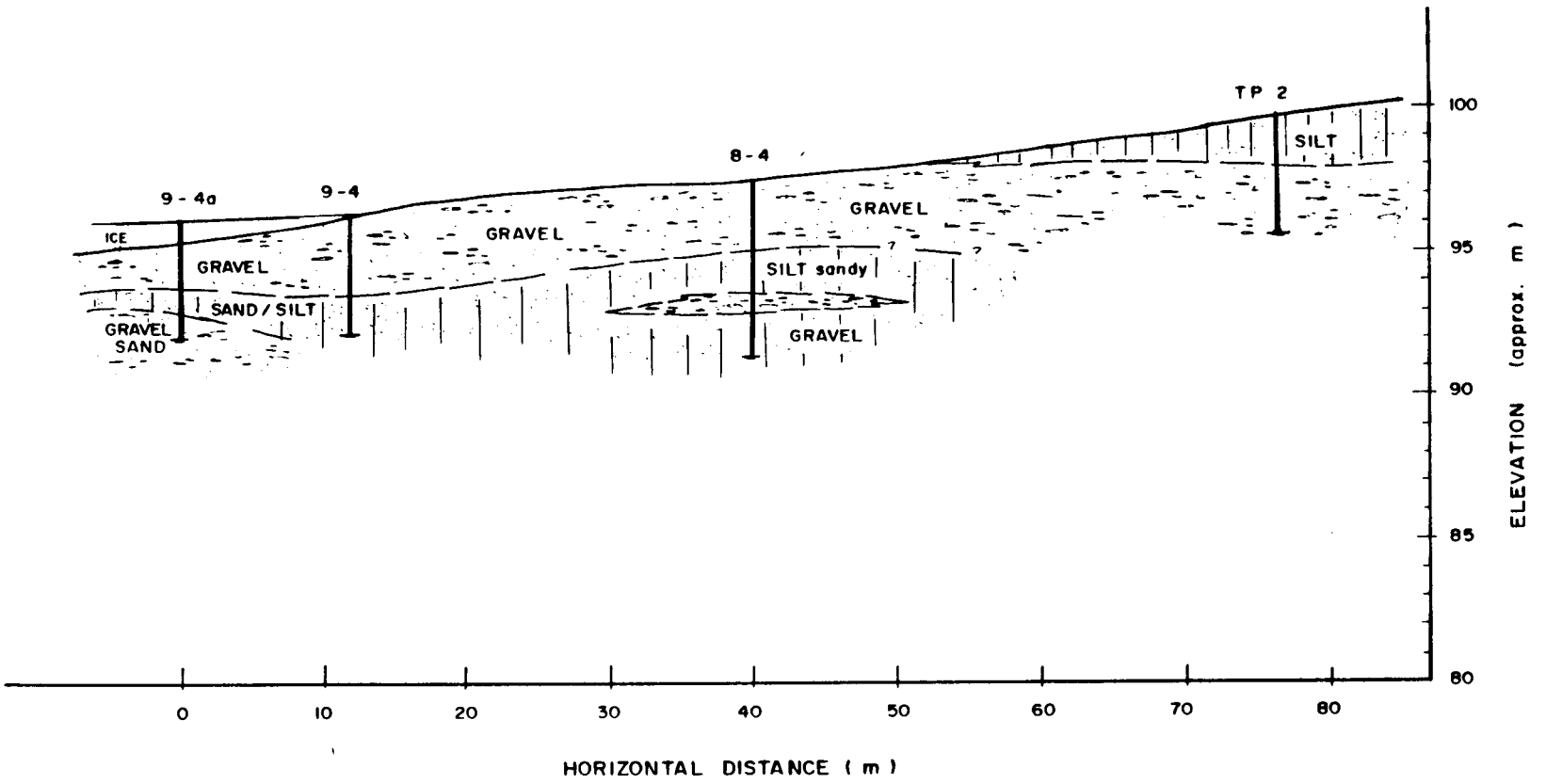
Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MOUNTAIN RIVER

INFERRED GEOLOGICAL PROFILE

Scale	As Shown
Date	Mar. / 88
Drawn By	AC / YK
Approved By	AH
Job No.	CG 14123
Figure	6

HBLT 13.87/05



SECTION 4

(Figure 3)

NOTE: Data concerning the various strata have been obtained at the borehole locations only. The soil stratigraphy between boreholes has been inferred from geological evidence and so may vary from that shown.

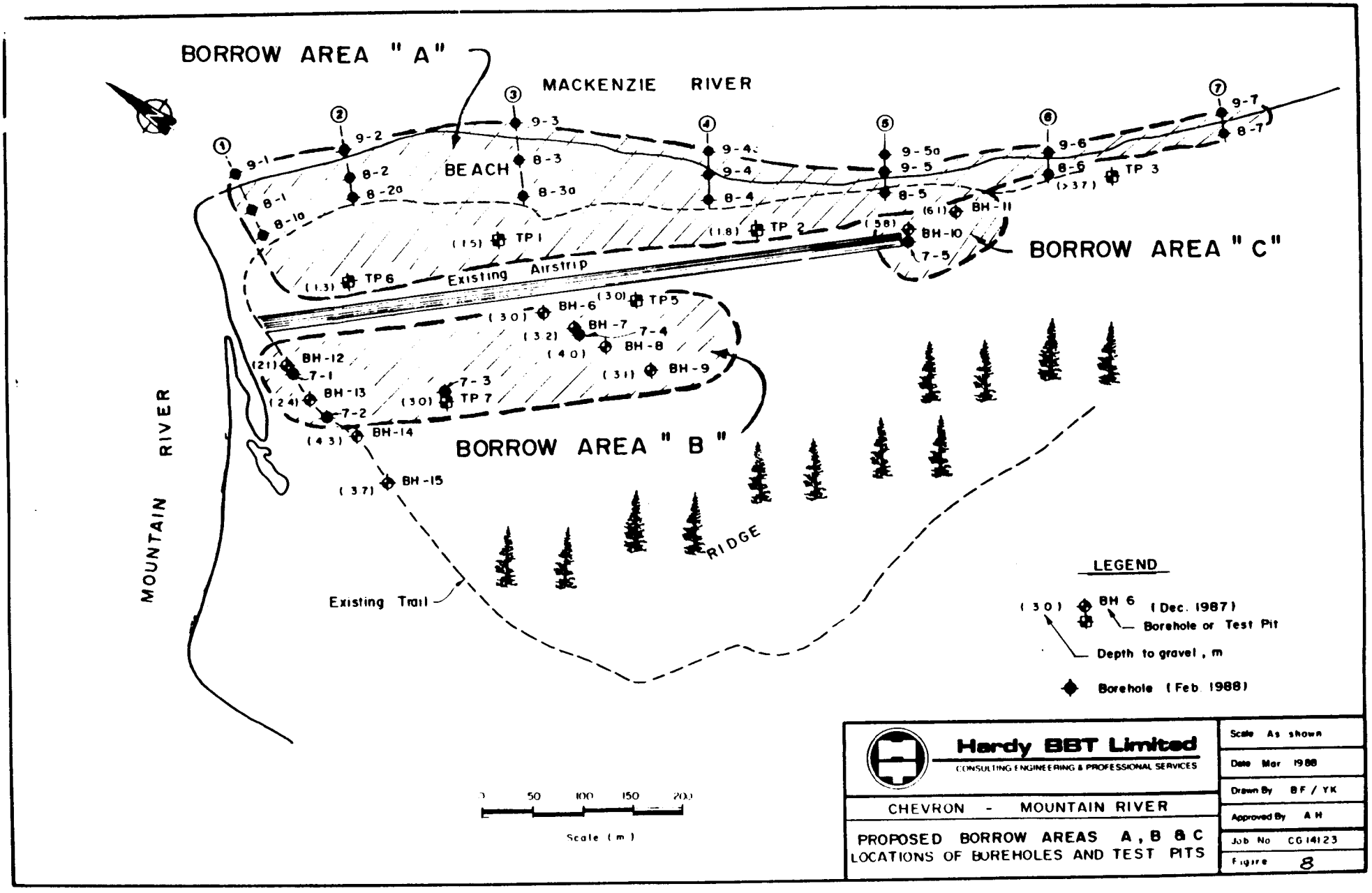
Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MOUNTAIN RIVER

INFERRED GEOLOGICAL PROFILE

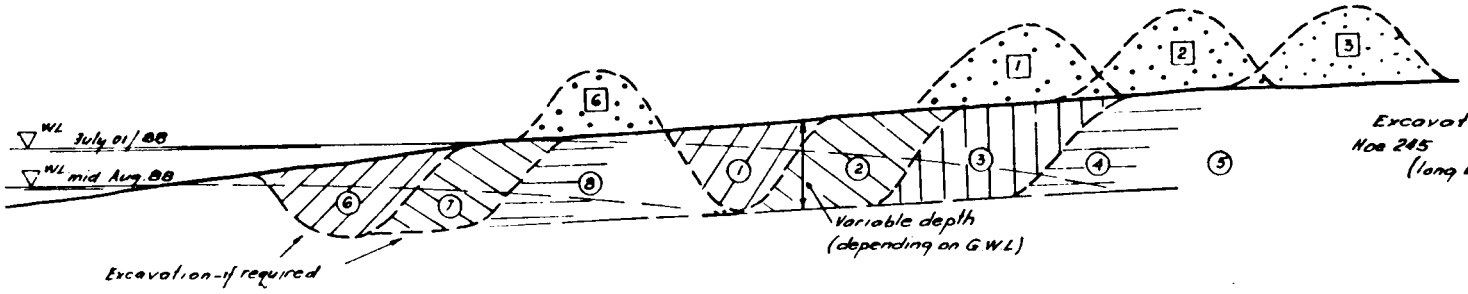
Scale	As Shown
Date	Mar /88
Drawn By	AC / YK
Approved By	AH
Job No	CG 14123
Figure	7

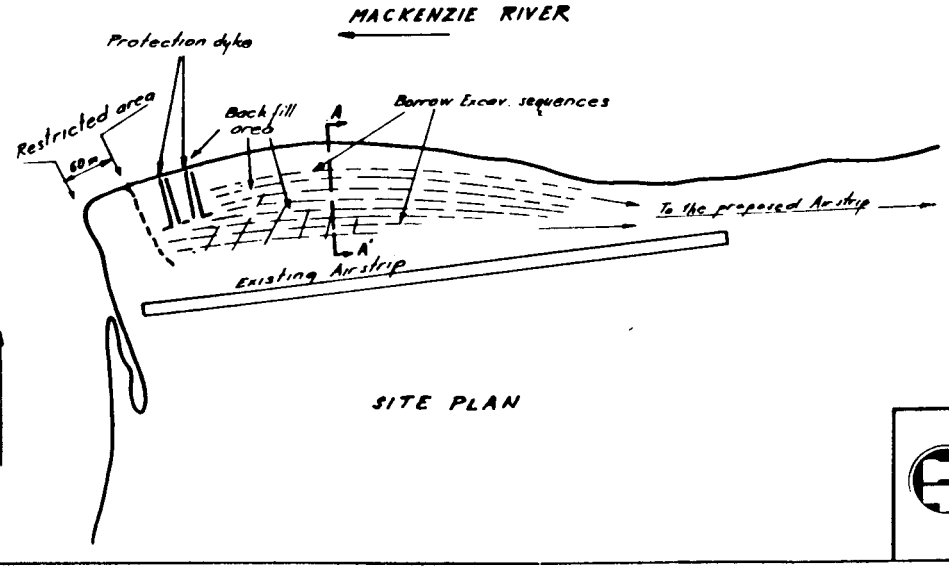
HBLT 13.87/05


BORROW AREA " A"
MACKENZIE RIVER
BEACH
BORROW AREA " C"
BORROW AREA " B "
Existing Airstrip
MOUNTAIN RIVER
RIDGE
Existing Trail
9-1
9-2
9-3
9-4a
9-4
9-5a
9-5
9-6
9-7
8-1
8-1a
8-2
8-2a
8-3
8-3a
8-4
8-5
8-6
8-7
TP 1
TP 2
TP 3
TP 5
TP 6
TP 7
BH-6
BH-7
BH-8
BH-9
BH-10
BH-11
BH-12
BH-13
BH-14
BH-15
7-1
7-2
7-3
7-4
7-5
LEGEND
(30) BH 6 (Dec. 1987)
Borehole or Test Pit
Depth to gravel , m
Borehole (Feb. 1988)
0 50 100 150 200
Scale (m)
Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES
CHEVRON - MOUNTAIN RIVER
PROPOSED BORROW AREAS A , B & C
LOCATIONS OF BOREHOLES AND TEST PITS
Scale As shown
Date Mar 1988
Drawn By BF / YK
Approved By A H
Job No CG 14123
Figure 8

SEQUENCES OF BORROW EXCAVATION AND STOCK PILE PROCEDURE

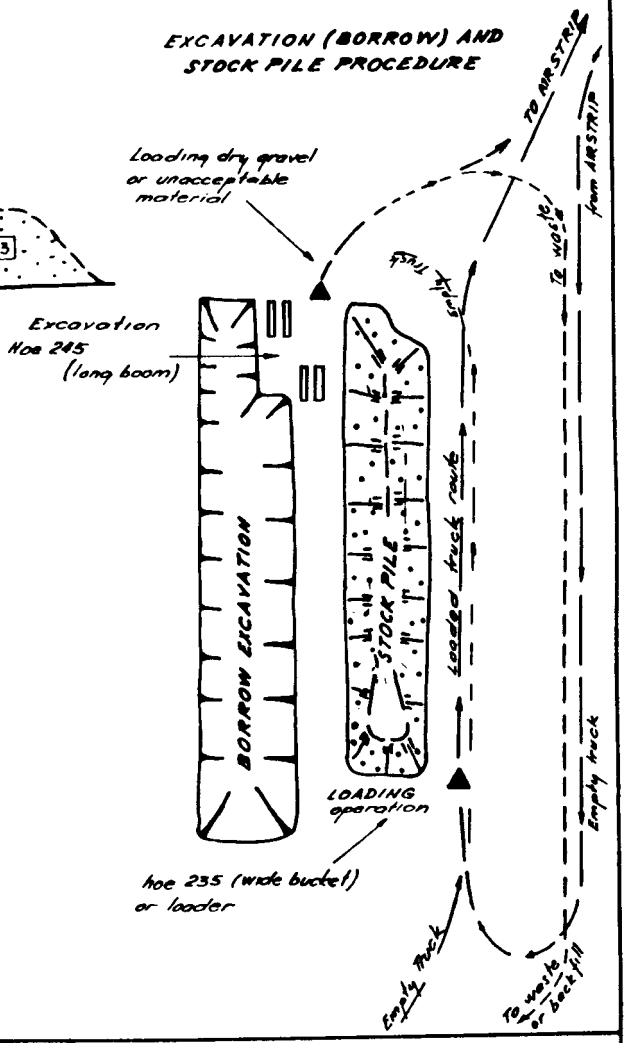
SECTION A-A'





SITE PLAN

EXCAVATION (BORROW) AND STOCK PILE PROCEDURE



Hardy BBT Limited

CHEVRON CANADA RESOURCES LIMITED

BORROW PIT DEVELOPMENT PLAN

CO. 14123

Fig. 9

APPENDIX A

October 1987 Report

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

MOUNTAIN RIVER AIRSTRIP
NORTHWEST TERRITORIES

Prepared for:
CHEVRON CANADA RESOURCES LIMITED
Calgary, Alberta

Prepared by:
Hardy BBT Limited
Calgary, Alberta

October, 1987
CE00965

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

Our Project No.
Your Reference No.

Our ref: CE00965

October 21, 1987

Mr. Len Bzdel
Chevron Canada Resources Ltd.
500-5 Avenue S.W.
Calgary, Alberta
T2P 3L5

Dear Mr. Bzdel:

Re: Airstrip at Mountain River Camp

I have enclosed six copies of our report on the proposed airstrip at the Chevron Mountain River Camp. The purpose of this report is to provide you with airstrip siting and preliminary design recommendations, along with a general cost estimate.

I trust this report covers the objectives set out in our proposal to you dated 29 July, 1987. If you have any questions, please contact me at your convenience at 248-4331 in Calgary.

It was a pleasure doing this work for you and we look forward to being of assistance in the future if this project goes forward.

Yours truly,

Hardy BBT Limited

Per:

W.A. Slusarchuk, Ph.D., P.Eng.
President and Chief Executive Officer

WAS/bac
11/33

TABLE OF CONTENTS

1.0 INTRODUCTION

Hardy BBT Limited were retained by Chevron Canada Resources Limited to provide airstrip siting and design recommendations, along with a general cost estimate, for an airstrip to be constructed at the Mountain River Camp, NWT. A proposal was submitted on 29 July, 1987 and the proposal was accepted by a letter dated August 21, 1987.

2.0 PROJECT DATA

2.1 BACKGROUND

The site is located on the high ground just above the west shore of the Mackenzie River a little upstream of the Mountain River, see airphoto inset on Plate 1 (in map pocket). The airstrip is to be 5,000 feet (1,524 m) long with a 500 ft (152.4 m) overrun on each end for a total length of 6,000 ft (1829 m). The airstrip is to be 100 ft (30.5 m) wide with 25 ft (7.6 m) shoulders on each side for a total width of 150 ft (45.8 m). Trees are to be cleared for a distance of 100 ft (30.5 m) on each side of the airstrip. The site is to be located near the actual camp but not close to East or West Mountain. The airstrip is to have a gravel surface and have a design life from 4 to 8 years. This airstrip is to be used by a Hawker Siddeley 748 aircraft with a maximum weight of 45,000 lbs and tire loading of 104 lb/in^2. The airstrip is not to be designed to be of top quality but to be serviceable (though spongy at times) for 48 to 50 weeks of the year. Ongoing maintenance of the strip will be required.

2.2 GENERAL TERRAIN CONDITION

In-house data reports pertaining to the Mountain River site were reviewed. In essence, the terrain in the area of the airstrip is covered by about 0.3 m of peat and is underlain by fine-grained ice-rich permafrost except near the rivers (Mackenzie, Mountain and Carcajou). Near the rivers the ground is unfrozen on and near the active flood plains with the soil being a mixture of mainly sands, silts and gravels. This information was used to plan the field site visit, to determine a typical soil stratigraphy for a geothermal (thawing) analysis of the airstrip cross-section and to establish potential borrow areas.

3.0 LOCATION AND ELEVATIONS OF AIRSTRIP

The airstrip and parking apron are shown on the airphoto on Plate 1. This location was selected in the field during the site visit of 8-10 September, 1987. More detailed information on the location of the centreline of the airstrip is also shown on the same drawing. The centreline changes in elevation are shown at the top left hand corner of the drawing. These elevations show that the northern end of the airstrip is about 3 m higher than the southern end. There are two main changes in elevation of the runway which are located between stations 8+00 and 12+50, and between stations 16+00 and 17+25. The changes in elevations in terms of angles and gradients are as follows:

- Station 8+00 to 12+50: angle of 0.4°, gradient of 0.7%
- Station 16+00 to 17+25: angle of 0.6°, gradient of 1.0%

Based on discussions with Mr. Moser, Manager, Aviation Services and Mr. Fisher, Chief Pilot for Chevron, acceptable angle changes along this type of a runway are up to about 1.5° (2.6% gradient). Since the angle changes at the proposed location are less than 1.5° the "flatness" of the airstrip is acceptable. Mr. Moser and Mr. Fisher also advised that the general location with respect to the rivers, camp, fuel storage areas and East and West Mountains are satisfactory from their point of view as well.

On the lower portion of Plate 1, the elevation differences across the width (15 m either side of centreline) of the airstrip are shown. The west side is generally higher and there is an average elevation difference of about 0.5 m over the width of the airstrip. This represents an angle of about 0.9° or a gradient of 1.7. The maximum cross slope is at station 8+00 where the angle is 1.7° with a gradient of 2.9%. These values were judged to be satisfactory by Mr. Moser and Mr. Fisher.

There are four low areas along the airstrip, identified on Plate 1 as creeks, where cross drainages exist. Culverts will be required to maintain this drainage.

The location and elevation survey was carried out by Waberski Walker Darrow Ltd., through Mr. Peter Walker. His assistance in this matter is gratefully acknowledged.

4.0 PERMAFROST AND THAW SETTLEMENT

While in the field many locations along the airstrip were probed for permafrost. Except at the creek crossings, generally 30-60 cm beneath the surface of the ground. Because of this, and because the review of in-house terrain data in the area indicated ice-rich permafrost was present, the survey crew was requested to survey sections across the old seismic cut line that is nearby the airstrip. In this area the simple act of removing trees and disturbing the ground surface will cause the permafrost to thaw out to some depth. This thawing (assumed to be to a depth of about 3-4 m) will cause the ground surface to settle as the ice turns to water and percolates to the surface. It is important to know the amount of settlement that has occurred, so nine sections were surveyed across the settled cut line. These results are shown on Plate 2 (in map pocket). The results show that thaw settlements from 0.5 m to 0.9 m occurred at eight locations, while 0.0 m of settlement occurred at one location (Station 4+62S). As a result it is clear that the airstrip will also settle and the amount will probably be in the order of 0.6 m or more over a 4 to 8 year period.

5.0 PRELIMINARY DESIGN STUDY

In order to estimate the amount of thawing of permafrost under the granular airstrip, geothermal analyses were carried out based on our previous experience in the area. The amount of thawed permafrost determines, in general:

(1) the amount of settlement, and
(2) the amount of weak soil supporting the airstrip

The results of the geothermal analyses are shown on Figure 1. Two gravel pad thicknesses were analyzed, one being 1.05 m (3.5 ft) thick (the thinnest layer that should be considered) and the other being 1.8 m (6.0 ft) thick (the thickest layer that should be considered).

The results show that the amount of thaw under the gravel pad will be from about 2.4 m to 2.7 m at year 4 to about 4.0 m to 4.3 m at year 8 for the 1.8 m and 1.05 m thick pads respectively. This information indicates that settlements of 0.5 m to 0.8 m can be expected by year 4 and year 8 respectively. The location of the seasonal frost front is also shown on Figure 1 and the distance between the frost front and thaw front at any time gives the depth of unfrozen gravel and thawed weak subsoil. A borehole program is recommended in Section 6.1.4 following so that the analyses can be verified or further analyses undertaken.

The gradual degradation of the permafrost as well as seasonal thawing of the upper soil profile will result in ongoing settlement of the airstrip. There will be differential settlement and some stress on the surface of the strip during periods of maximum settlement (late summer). It must be understood that regrading and surface improvement will be an ongoing seasonal requirement.

Insulation in the cross-section was not analyzed because the material costs for a 1" thickness of insulation under the airstrip is about 0.5 million dollars. Insulation would help to make the airstrip of a higher quality, with some reducton

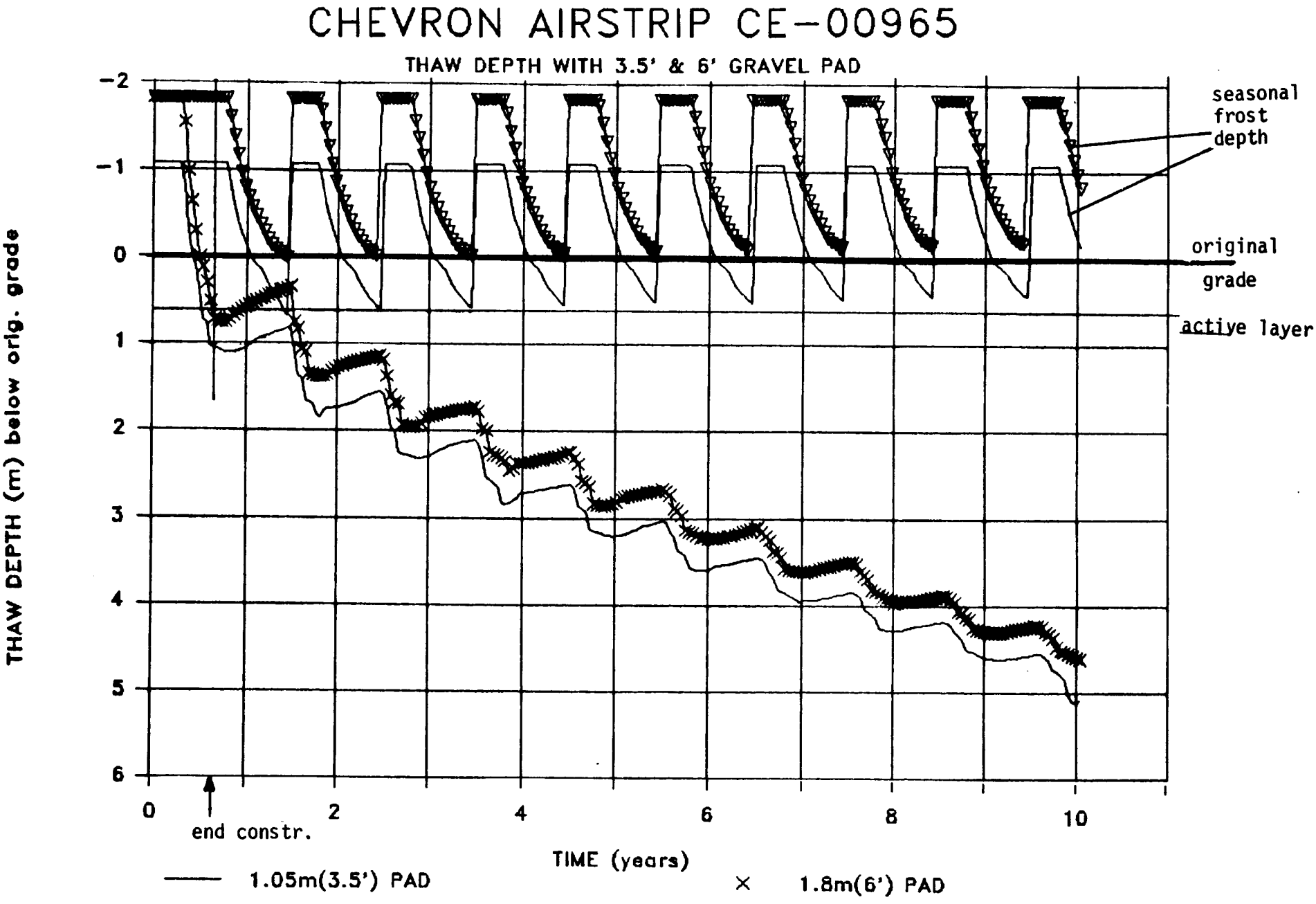

CHEVRON AIRSTRIP CE-00965
THAW DEPTH WITH 3.5' & 6' GRAVEL PAD
THAW DEPTH (m) below orig. grade
-2
-1
0
1
2
3
4
5
6
seasonal frost depth
original grade
active layer
0
2
4
6
8
10
end constr.
TIME (years)
1.05m(3.5') PAD
1.8m(6') PAD

Figure 1

in gravel (about 0.3 to 0.5 m) if about 2" of insulation would be used - a cost of roughly $1 million for the insulation alone.

Consideration has been given to using a geotextile at the base of the granular section as a means of reducing the granular thickness. Preliminary assessment indicates little economic benefit provided the required granular materials are found to be available at the locations discussed below.

5.1 PRELIMINARY DESIGN RECOMMENDATIONS

It is recommended that, for costing purposes, a 1.5 m (4.9 ft) granular fill thickness, with no insulation, be used.

6.0 POSSIBLE BORROW SOURCES

Approximately 140,000 m^3 of borrow is required. It is believed that there is good quality borrow that can be dredged from the Mackenzie River - at least 70,000 m^3 of this material should be proved up in a winter drilling program. Lower quality borrow material is available along the banks of the Mackenzie alongside the present roadway and airstrip. Even lower quality borrow material is available on land in the area of the present airstrip. This material is sandy in nature but is unfrozen even though it is on land away from the unvegetated shore. At least 80,000 m^3 of these two lower quality borrow materials together should be proved up shortly. Once these materials have been proved up and some additional tests carried out on them, a final design could be prepared for review and subsequent tender.

6.1 RECOMMENDED BORROW AND DRILLING PROGRAM

6.1.1 High quality borrow under Mackenzie River - This drilling needs to be done from the ice, probably in February or March. About 10-12 holes to a depth of 5 m below the river bed are required as a minimum.

6.1.2 Lower quality borrow along unvegetated shore - This investigation can be done now or in the next few weeks using a dozer that Chevron has at the site. About four trenches would be excavated to a depth of about 2-3 m. These trenches would be backfilled immediately after inspection by a geotechnical engineer or technician.

6.1.3 Lowest quality borrow in the vegetated, sandy region by the present airstrip - this could be done now or in a few weeks using a seismic drill rig and the local dozer. About 6 to 8 holes to a depth of 5 m would be required as well as two trenches to about 3 m. The trenches would be filled in immediately after investigation.

6.1.4 In order to verify the geothermal analyses, and our own opinions about the depth of thaw under the old seismic cut line, gravel road and the larger gravel pad, it is recommended that the following boreholes be drilled as soon as practical with one of the seismic rigs at the camp:

(a) A borehole at stations 2+62S, 8+62S, 12+62S and 16+62S along the seismic line shown on Plate 2. The depth of unfrozen material over the permafrost is the information required.

(b) Two boreholes on the roadway at the end of the proposed airstrip. The thickness of the gravel road, the thickness of the compressed peat, and the depth of the unfrozen ground above the permafrost is the information required. The present height of the top of gravel above the adjacent undisturbed ground surface is also needed.

(c) Three holes near the middle zone of the large pad near the camp office. The thickness of gravel, thickness of insulation (if any), thickness of compressed peat, and the depth of the unfrozen ground above the permafrost is the information required. The present height of the top of the gravel above the adjacent undisturbed ground surface is also needed. The thaw depth under this large gravel pad, if no insulation is present, is expected to be greater than the thaw depth under the narrower roadway. It is this difference that is of interest.

7.0 APPROXIMATE COST ESTIMATE

The following cost estimate is preliminary as only a small amount of effort was put into it. Further the borrow has not been proven nor has the design been finalized. Nevertheless, the cost estimate can be used for budget and project feasibility purposes.

7.1 ASSUMPTIONS

It has been assumed that Chevron would provide the dozers required for construction and borrow development as well as one front end loader for about 50% of the time. Accommodation would be provided by Chevron at the existing camp.

About 140,000 m^3 of borrow is required to be obtained and placed. About 70,000 m^3 of borrow would be high quality borrow from the Mackenzie River. Construction would take place in July/August 1988.

A dragline or a hoe would have to be barged to the site from Norman Wells. Several trucks and one or two front-end loaders would also be required, as would a water truck and a grader. The dragline operation would begin in early July so that the material could be stockpiled along the shore and allowed to drain for 2-4 weeks. Four culverts would be placed at the base of the granular section at the locations identified as existing cross drainages.

7.2 APPROXIMATE COSTS

The costs are based on preliminary verbal information obtained from three contractors in Norman Wells as well as from some of our recent experience in the area on the Norman Wells Oil Pipeline. The average prices are \$4/m^3 in place for the low quality material and \$6/m^3 in place for the fill obtained from the Mackenzie River.

It is recommended that a cost estimate of \$750,000 be used realizing that it could escalate up to about \$950,000 if there is plenty of work available for contractors in Norman Wells next summer or if complications develop with the Mackenzie River borrow recovery program. This cost estimate does not include the cost of purchasing the borrow material.

The cost of using a geotextile to reduce the fill thickness, if sufficient quantities of good borrow material are not

proven along the Mackenzie River, is not expected to significantly alter the total cost estimate. The economics could be examined closer after the borrow investigation, if warranted.

If you have any questions, please contact me or Alan Hanna at your convenience at 248-4331 in Calgary.

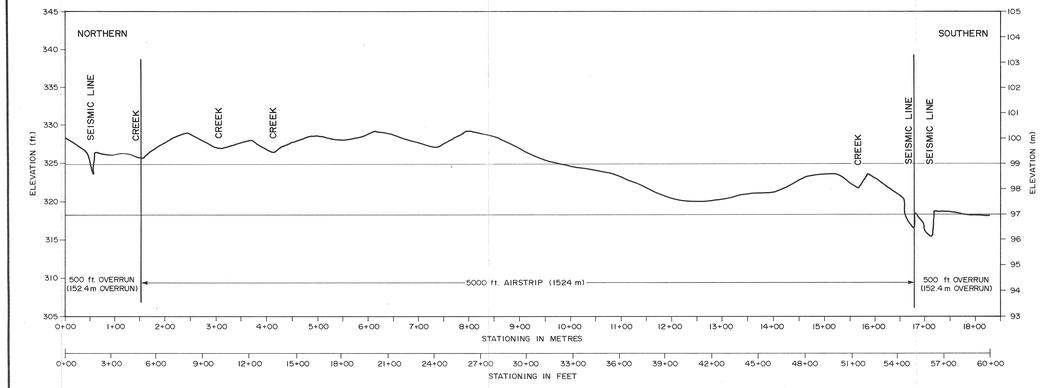
Respectfully submitted,

Hardy BBT Limited

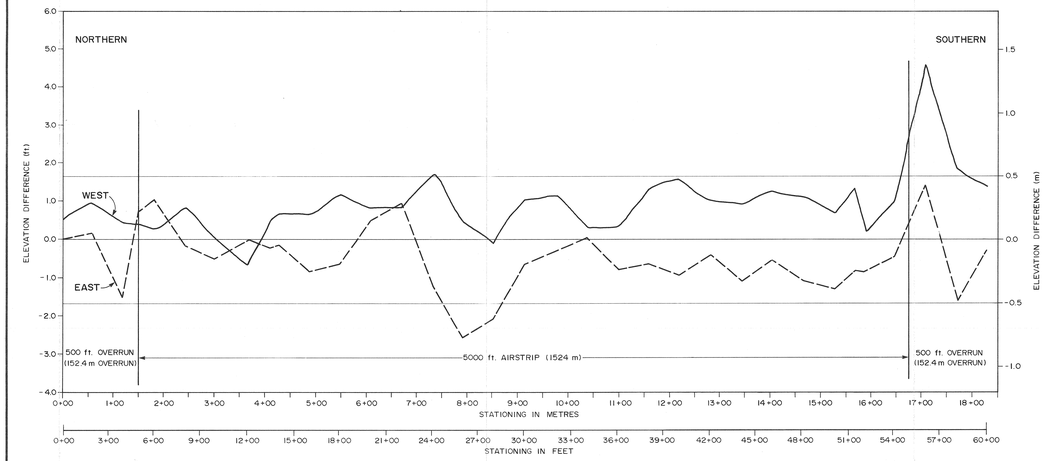
W.A. Slusarchuk, Ph.D., P.Eng.
President and Chief Executive Officer

Reviewed by:

A.J. Hanna, M.A.Sc., P.Eng.

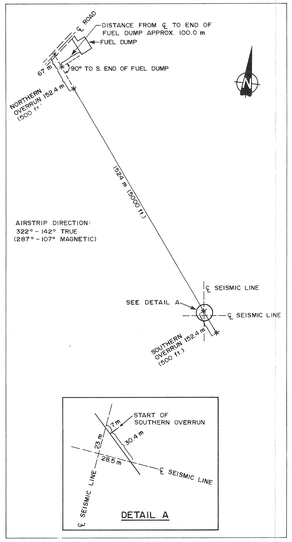


CENTRELINE ELEVATION



ELEVATION DIFFERENCE BETWEEN CENTRELINE AND EAST/WEST SIDE OF AIRSTRIP

GENERAL LOCATION OF AIRSTRIP



LOCATION OF CENTRELINE OF AIRSTRIP

NOTE: ELEVATIONS ASSUMED BASED ON A STARTING POINT ELEVATION OF 100.0 m

No.	REVISION	DATE	BY

REFERENCES

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

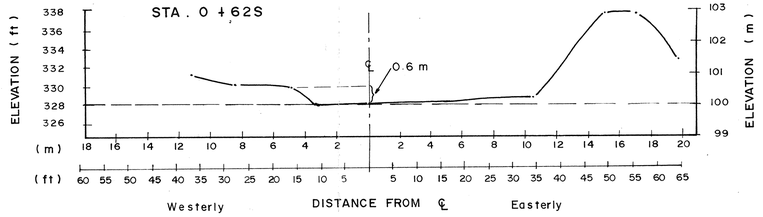
CHEVRON CANADA RESOURCES LTD.

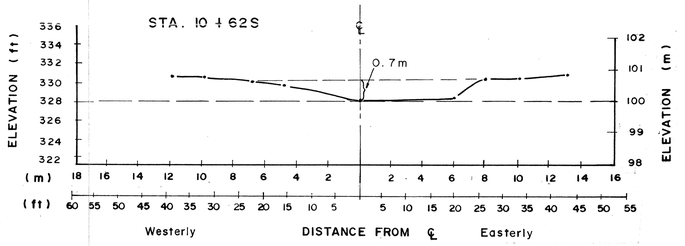
MOUNTAIN RIVER AIRSTRIP
LOCATION AND ELEVATIONS

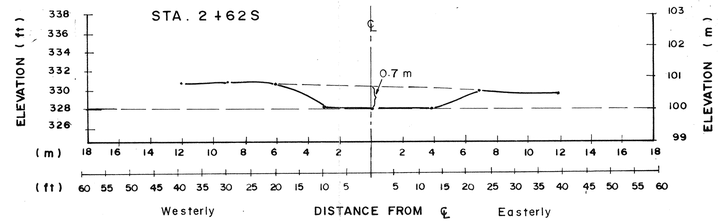
SCALE	DATE	MADE	CKHD	APPD

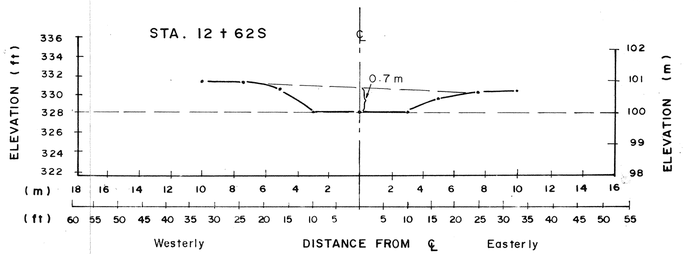
No. CE00965 PLATE 1 REV.

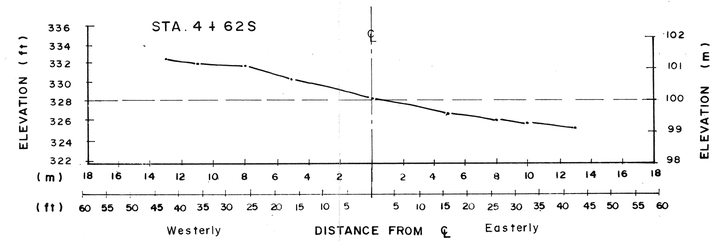
HT67-79/12

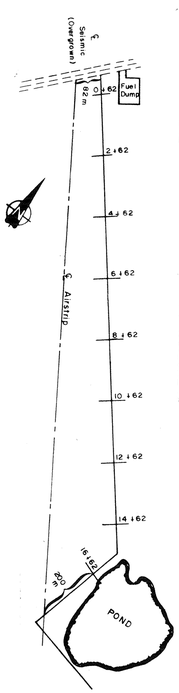




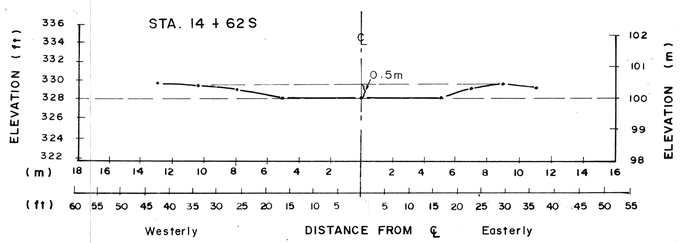


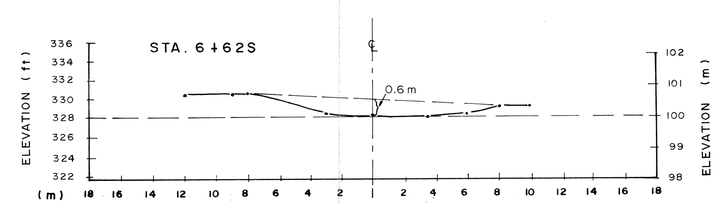


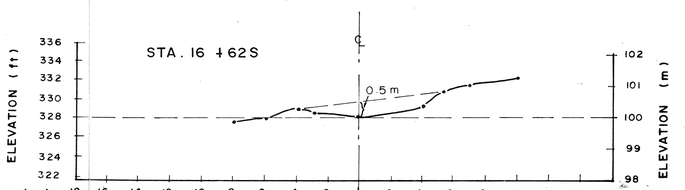


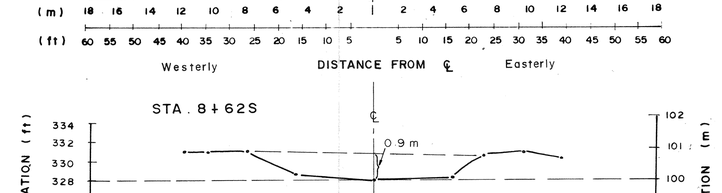


SCHEMATIC SHOWING LOCATION OF SEISMIC LINE CROSS SECTIONS









NOTE: ELEVATIONS ASSUMED BASED ON SURVEY STARTING POINT ELEVATION OF 100.0 m AT EACH LOCATION.

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON CANADA RESOURCES LTD

MOUNTAIN RIVER AIRSTRIP
THAW SETTLEMENT OF OLD SEISMIC LINE

Scale:	As shown
Date:	Sept. / 87
Drawn By:	JH / YK
Approved By:	W.A.S.
	CE00965
	PLATE 2

HBLT 16 - 87/05

APPENDIX B

Design Borehole Logs

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-1

CHEVRON - MT. RIVER

LOGGED/DWN. BF/YK	CKD. A.H.	DATE OF INVEST. December 9, 1987	JOB NO. CG14123

DRILL TYPE: Track Mounted Rotary

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
0		GRAVEL (FILL) - dense, hard drilling, sandy, silty, dry		
1				
2		SILT - clayey, sandy, stiff, brown, unfrozen, organics and some gravel fill at top of unit		
3				
4				
5		-- very sandy - very wet		
6		SAND - fine to medium grained, silty, brown, saturated (water bearing)		
7				
8		--- moist sand, occasional clumps of silt, sand moist		
9		--- sand harder drilling possibly frozen		
10		End of Hole at 9.2m • Unable to continue because of sloughing from surface gravel and wet sand		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-2

CHEVRON - MT. RIVER

LOGGED/DWN. BF/YK | CKD. A.H. | DATE OF INVEST. December 9, 1987 | JOB NO. CG14123

DRILL TYPE Track Mounted Rotary

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
0		GRAVEL (FILL) - hard drilling, dry occasional boulders switched to rock bit removed once through gravel		
1		-- bits of wood (wood chips) organics, silty		
2		SILT - unfrozen, sandy, clayey, slightly plastic, brown, saturated organic material from 1.2 to 1.5m		
3				
4				
5		SAND - silty, water bearing, brown, numerous lumps of silt, possibly occasional frozen pockets, moist at 5.0m		
6		sloughing sand		
7				
8				
9				
10		End of Hole at 9.2m . Could not advance past 9.2m due to sloughing of wet sand at 6.0m		

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-3

CHEVRON - MT. RIVER

LOGGED/DWN. BF/YK | CKD. A.H. | DATE OF INVEST. December 9, 1987 | JOB NO. CG14123

DRILL TYPE Track Mounting Rotary

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SAMPLE TYPE	OTHER TESTS: N
0		GRAVEL (FILL) - occasional boulders, hard drilling, dry,		
1		wood chips, organics		
		SILT - unfrozen, sandy, clayey, slightly plastic, brown, saturated (158%)		
2		organics, wood chips from 1.3 to 1.6m		
3		very sandy at 3.1m		
4		SAND - silty, brown, saturated		
5		no frozen material observed		
6				
7				
8				
9				
10		End of Hole at 9.2m • Could not drill deeper than 9.2m due to sloughing of wet sand		

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-3A

CHEVRON - MT. RIVER

LOGGED/DWN.	BF/YK	CKD.	A.H.	DATE OF INVEST.	December 11, 1987	JOB NO.	CG14123

DRILL TYPE: Track Mounted Rotary

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
0		GRAVEL (FILL) - hard drilling, dry		
1		SILT - sandy, slightly plastic, brown, damp-wet	⊠	
2				
3		SAND - fine to medium grained, silty, saturated	⊠	
4		-- fine to medium grained, non silty, saturated	⊠	
5			⊠	
6				
7		--- non silty, moist sand	⊠	
8			⊠	
9		-- slight sloughing at 9.2m		
10		-- fine grained sand, moist-wet	⊠	

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-3A

CHEVRON - MT. RIVER

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 11, 1987	CG14123

DRILL TYPE: Track Mounted Rotary

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N	OTHER TESTS
		DATUM SURFACE ELEVATION			
11		SAND - continued			
		fine to medium grained sand, saturated-wet easy drilling, few cuttings	☒		
12					
13					
14		End of Hole at 13.7m . Could not advance deeper due to sloughing sand from 6.1 to 9.2m			
15					

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-3B

CHEVRON - MT. RIVER

LOGGED/DWN. BF/YK | CKD. A.H. | DATE OF INVEST. December 11, 1987 | JOB NO. CG14123

DRILL TYPE Track Mounted Rotary

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
0		GRAVEL (FILL) - hard drilling, dry		
1		SILT - sandy, non to slightly plastic, brown, saturated-wet		
2			⊠	
3		SAND - fine to medium grained, silty, brown, occasional pebbles, saturated-wet		
4				
5			⊠	
6			⊠	
7			⊠	
8			⊠	
9		sand sloughed in, difficult to advance beyond 9.2m – easy drilling, no cutting		
10				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-3B

CHEVRON - MT. RIVER

LOGGED/DWN.	BF/YK	CKD.	A.H.	DATE OF INVEST.	December 11, 1987	JOB NO.	CG14123

DRILL TYPE Track Mounted Rotary

DATUM

SURFACE ELEVATION

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

DEPTH (m)

SOIL SYMBOL

SOIL DESCRIPTION

SAMPLE TYPE

OTHER TESTS — N

SAND - continued

easy drilling, no cuttings

11

12

13

harder drilling

easier drilling - no cuttings

14

15

hard drilling - no cuttings
probably frozen material

16

17

18

End of Hole at 18.3m

19

20

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-4

CHEVRON - MT. RIVER

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 10, 1987	CG14123

DRILL TYPE: Track Mounted Rotary

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SAMPLE TYPE	OTHER TESTS: N
0		GRAVEL (FILL) - dense, hard drilling, dry		
1		ORGANICS - frozen, brown-black	⊠	
2		SILT - saturated-wet, sandy, clayey, brown	⊠	
3		SAND - fine to medium grained, brown, dry-moist, occasional bits of ice	⊠	
4		--- water in cuttings while adding stem at 4.6m		
5		--- sand, saturated-wet	⊠	
6		--- frozen silty sand, numerous bits of ice in cuttings	⊠	
7		--- silty sand saturated-wet	⊠	
8		--- sand dry-moist, possibly frozen	⊠	
9				
10			⊠	

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-4

CHEVRON - MT. RIVER

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 10, 1987	CG14123

DRILL TYPE: Track Mounted Rotary

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
11		SAND - fine to medium grained, silty, brown, frozen		
		hard drilling few cuttings	⊠	
12				
13				
14		End of Hole at 13.7m		
15				
16				

LOG OF BOREHOLE No. BH-5

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MT. RIVER

LOGGED/DWN. BF/YK | CKD. A.H. | DATE OF INVEST. December 10, 1987 | JOB NO. CG14123

DRILL TYPE Track Mounted Rotary

WATER CONTENT% (Wp-□ W-○ W_L-△) 10 20 30 40 50 60	DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SAMPLE TYPE	OTHER TESTS: N
	1		GRAVEL (FILL) - hard drilling, dry		
			ORGANICS - frozen, black, bits of wood		
⊙	2		SILT - unfrozen, sandy, clayey, brown, moist to wet		
⊙	3		SANDS - silty, moist, fine to medium grained, brown		
⊙	4		--- possibly frozen, dry - moist		
⊙	5		--- sand, moist to wet numerous mica crystals, caving		
⊙	6		--- sand saturated-wet		
⊙	7		--- moist-damp sand to end of hole		
⊙	8				
⊙	9				
	10		End of Hole at 9.2m • Could not go deeper due to sloughing		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 1-1

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 29, 1988	CG14123

DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
1		FILL - gravel, little sand, frozen		
		ORGANIC - black, silty, frozen		
2		SILT - sandy, trace to non clay, frozen		
		--- unfrozen, sandy, silty, wet to very wet		
		10cm frozen layer		
3		--- frozen, sand, silty, (Nbn)		
4				
5		--- fine sand, little silt, moist, poorly bonded		
6				
7				
8				
9				
10				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 1-1 (con't)

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN. AC/YK	CKD. AH	DATE OF INVEST. January 29, 1988	JOB NO. CG14123

DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)

SOIL SYMBOL

SOIL DESCRIPTION

SAMPLE TYPE

OTHER TESTS — N

11

12

13

SILT - con't

└ some sand

End of Hole at 12.5m
Thermister String 185
Installed to 12.0m

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 2-1

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN. AC/YK	CKD. AH	DATE OF INVEST. January 29, 1988	JOB NO. CG14123

DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		ORGANIC - roots, black		
1		SILT - sandy		
2		SAND - silty		
		--- trace silt, fine grained		
3				
4				
5				
6				
7				
9		--- cobble or boulder		
10		GRAVEL - very sandy, predominatly 25-50mmϕ		
		End of Hole at 10.5m Thermistor string 186 installed (10m)		

(11.4 %)

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 2-1a

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN. AC/YK	CKD. AH	DATE OF INVEST. January 29, 1988	JOB NO. CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		DATUM SURFACE ELEVATION		
		FILL - gravel		
1		ORGANIC		
2		SILT/SAND - sandy, silty		
		-- unfrozen		
3		--- frozen (permafrost)		
		End of Hole at 3.5m		
4				
5				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 3-1

CHEVRON - MOUNTAIN RIVER
GRANULAR STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 30, 1988	CG14123

DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
1		MUSKEG - frozen		
		ORGANIC - unfrozen		
2		CLAY - (frozen) silty, grey		
3				
4				
5				
6				
		End of Hole at 6.0m		
7				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 3-2

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 30, 1988	CG14123

DRILL TYPE: Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
0		MUSKEG - frozen		
1		ORGANIC - unfrozen		
2		CLAY - (frozen) silty, grey		
3				
4				
5				
6				
7				
8		End of Hole at 8.0m Thermistor string 187 installed to 8.0m		
9				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 3-3

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN. AC/YK	CKD. AH	DATE OF INVEST. January 30, 1988	JOB NO. CG14123

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

DEPTH (m)

SOIL SYMBOL

DRILL TYPE

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

SAMPLE TYPE

OTHER TESTS

N

DEPTH (m)	SOIL DESCRIPTION
	MUSKEG - frozen
1	ORGANIC MOSS - unfrozen
2	FROZEN - predominantly ice, little organics
3	CLAY - silty (frozen) grey
4	
5	
6	
7	
8	End of Hole at 8.0m Thermistor string 188 installed to 8.0m
9	

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

CHEVRON - MOUNTAIN RIVER AIRSTRIP | BOREHOLE No. 4-1

LOGGED BY: AC	DRAWN BY: YK	CHECKED: AH	DATE: January 29, 1988
RIG:	METHOD:	START:	FINISH:
PROJECT No. CG14123	LOCATION:	ELEVATION:	OFFSET:

w_p-⊡ w_L-△ w-⊙
BULK DENSITY (kg/m³) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
1			ORGANICS	Vs/Vr Vx 10-20%	.7	1			
				Vs/Vr 30-40	.9				
			SILT - trace sand	Nbe/ Nbn/Vs 10-20%	1.7	2			
2			SAND	Nbn/Vx 5-10		3			
			– Vs 12mm		2.6				
			SAND/SILT - occasional Vs 1.2mm	Vs/Vr Nbe 10-20		4			
3			– sand layers						
			– Vs 18mm		3.5				
			frequent Vs	Vs Nbe 20-30	3.8	5			
4					4.0				
			– Vs 15mm sandier	10-20	4.5	6			
				Vs Nbe 10-15%					
5					5.6	7			
6			SAND - little silt	Nbn 5-10					Moistures
			End of Hole at 6m						
7									
8									
9									
10									
11									
12									

(1077)

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

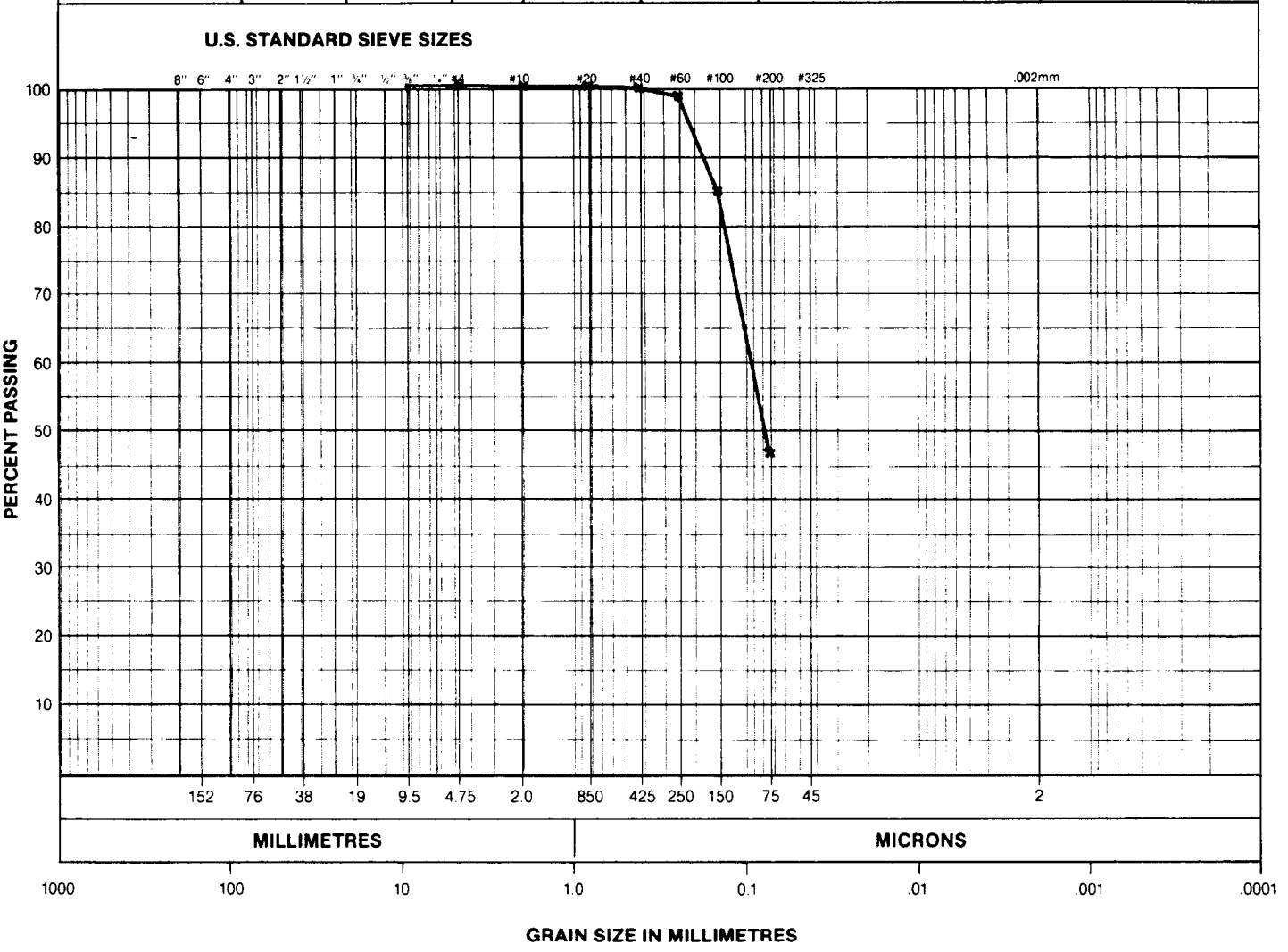
CHEVRON - MOUNTAIN RIVER AIRSTRIP | BOREHOLE No. 4-2

LOGGED BY:	DRAWN BY: YK	CHECKED :	DATE : January 29, 1988
RIG :	METHOD :	START :	FINISH :
PROJECT No. CG14123	LOCATION :	ELEVATION :	OFFSET :

w_p-⊡ w_L-△ w-⊙
BULK DENSITY (kg/m³) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0			ORGANIC	Vr/Vx Nbe 10-20%		C1			
1			SILT - little sand	Vs/Vr 20-30%		C2			
			SAND - little silt, occasional thick Vs 10-15mm	Nb 5-10%		C3			
2			SILT - SAND	Nbn 5-10%					
3						C4			
4			SAND - little silt, moist	Nb 5%		C5			
5			-- siltier			C6			
6						C7			
7			End of Hole at 6.0m						
8									
9									
10									
11									
12									

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	0 %
D_{30} =	mm	SAND	53 %
D_{60} =	mm	SILT	%
C_U =	mm	CLAY	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON AIR STRIP

Test Hole No. 4-2 Sample 3 Depth 3m

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123

HBLT 27-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

CHEVRON - MOUNTAIN RIVER AIRSTRIP

BOREHOLE No. 4-3

LOGGED BY: AC	DRAWN BY: YK	CHECKED: AH	DATE: January 29, 1988
RIG:	METHOD:	START:	FINISH:
PROJECT No. CG14123	LOCATION:	ELEVATION:	OFFSET:

W_p-⊡ W_L-△
W-⊙
BULK DENSITY (kg/m³) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0			ORGANIC	Vr 10-15					
1			SILT - little sand Vs 2-5mm Vs 4m Vs 10-15mm sandier	Vs 20-30 Nbn/Vx 10% Nbn 5-10% Nbn 5%		C1 C2 C3			
4			SAND	Nbn 5%		C4 C5 C6			
6			End of Hole at 6m						
7									
8									
9									
10									
11									
12									

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

CHEVRON - MOUNTAIN RIVER AIRSTRIP | BOREHOLE No. 4-4

LOGGED BY: AC	DRAWN BY: YK	CHECKED: AH	DATE: January 29, 1988
RIG:	METHOD:	START:	FINISH:
PROJECT No. CG14123	LOCATION:	ELEVATION:	OFFSET:

W_p-⊡ W_L-△ W-⊙ BULK DENSITY (kg/m³) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0			ORGANIC	Vr/Vx Nbn 10%					
			SILT └Vs 10 - 20mm - - Vs 5 - 10mm └Occasional Vs	Vs/Vx 10-15 Vs/Nbn 10-15		M1			
1									
2			SAND - little silt	Nbn 5-10%		M2			
3						M3			
4						M4			
5			___trace silt, poorly bonded			M5			
6						M6			
			End of Hole at 6.0m						
7									
8									
9									
10									
11									
12									

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

CHEVRON - MOUNTAIN RIVER AIRSTRIP

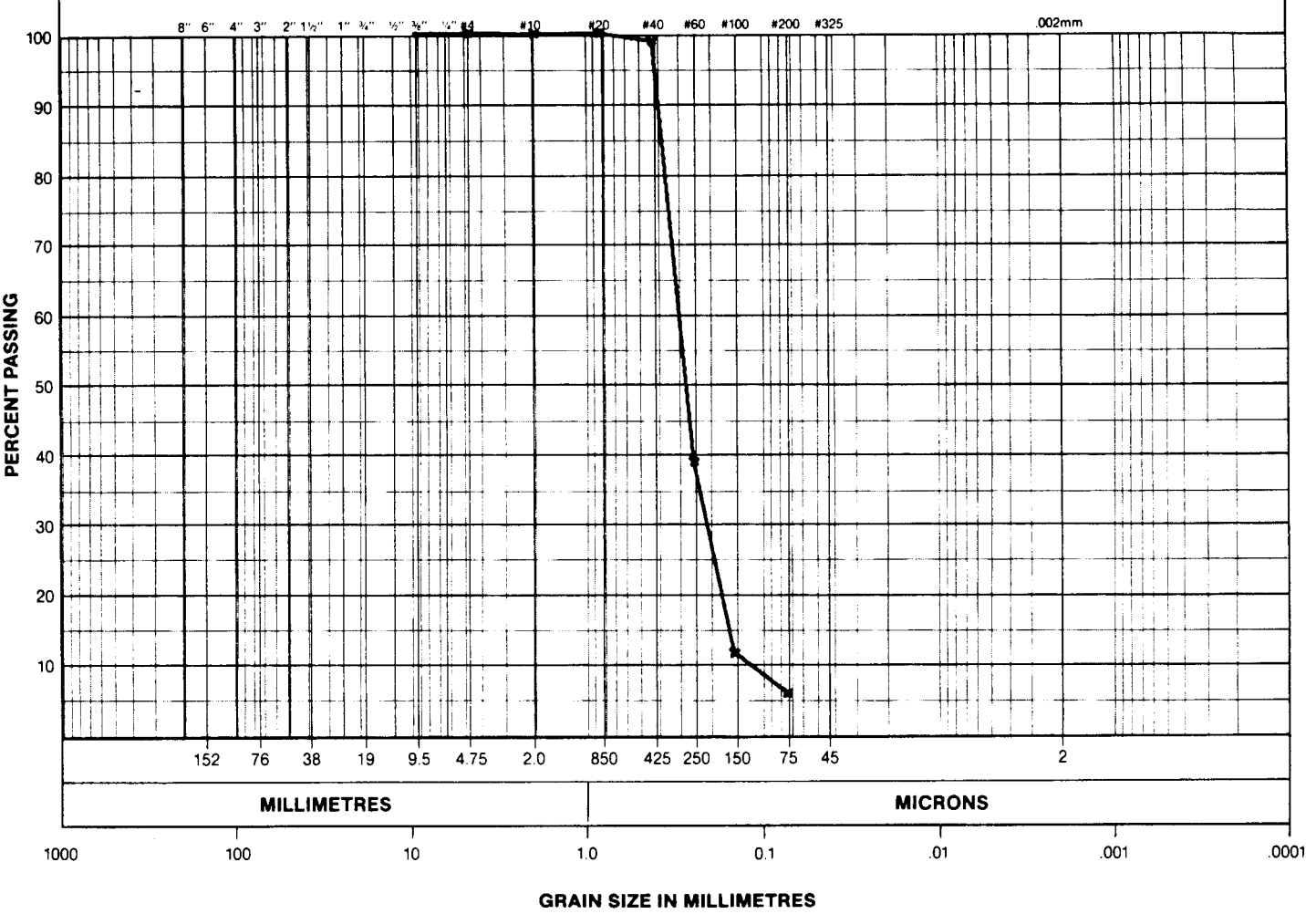
BOREHOLE No. 4-5

LOGGED BY: AC	DRAWN BY: YK	CHECKED : AH	DATE : January 29, 1988
RIG :	METHOD :	START :	FINISH :
PROJECT No. CG14123	LOCATION :	ELEVATION :	OFFSET :

W_p-⊡ W_L-△ W-⊙ BULK DENSITY (kg/m³) ● 1200 1400 1600 1800 MOISTURE CONTENT % 20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
165.1			ORGANIC — Vs 15-20mm	Vr/Vx Vs 10-20%					
1			SILT - sandy	Vs/Vr Vx 15-20% Vs/Vx		M1			
2			— slightly frozen (active - PF interface)	Nbn 5-10% Nb		M2			
3			SAND - little fine silt	Nbn 5%		M3			
4						M4			
5						M5			
6						M6			
7									
8									
9									
10			End of Hole at 10.0m Thermistor string 189 installed to 10m						
11									
12									

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	0 %
D_{30} =	mm	SAND	94 %
D_{60} =	mm	SILT	%
C_U =	mm	CLAY	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON AIR STRIP

Test Hole No. 4-5 Sample 3 Depth 3m

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123

HBLT 27-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

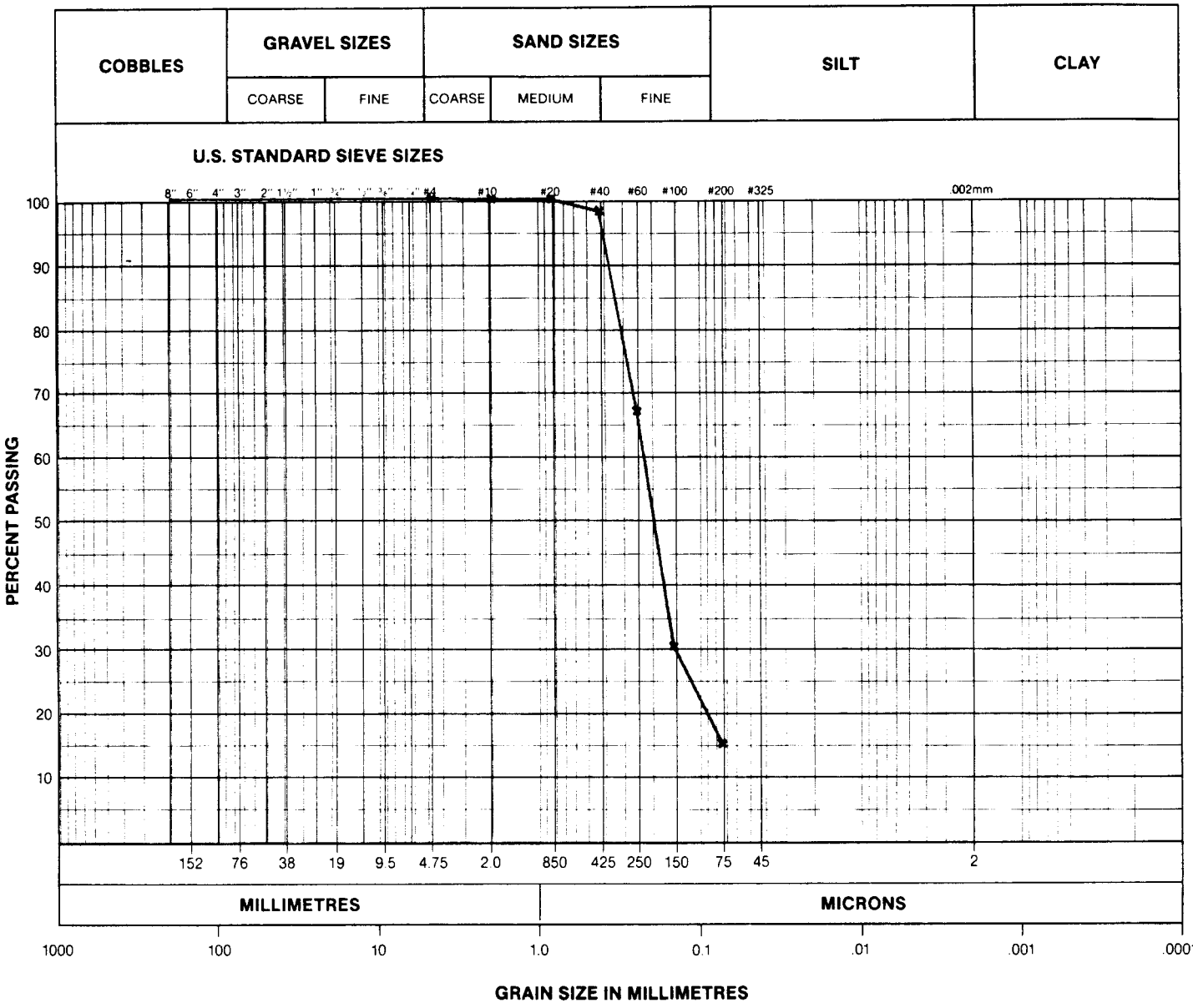
BOREHOLE LOG

CHEVRON - MOUNTAIN RIVER AIRSTRIP | BOREHOLE No. 4-6

LOGGED BY: AC	DRAWN BY: YK	CHECKED: AH	DATE: January 30, 1988
RIG:	METHOD:	START:	FINISH:
PROJECT No. CG14123	LOCATION: DEPOSIT 155	ELEVATION:	OFFSET:

W_p-⊡ W_L-△ W-⊙ BULK DENSITY (kg/m³) ● 1200 1400 1600 1800 MOISTURE CONTENT % 20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0			ORGANIC	Vr/Vx 10-20					
			SILT - little sand	Vs/Vx Vr 5-10%		M1			
			---Vs						
1									
2			SAND - fine, little silt	Nbn 5%		M2			
3									
			---fine, occasional poorly bonded	Nbn 5%		M4			
4			---some silt layering						
5									
6						M6			
			End of Hole at 6.0m						
7									
8									
9									
10									
11									
12									



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	0 %
D_{30} =	mm	SAND	84 %
D_{60} =	mm	SILT	%
C_U =	mm	CLAY	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON AIR STRIP

Test Hole No. 4-6 Sample 2 Depth 2m

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123

HBLT 27-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 5-1

CEHVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 30, 1988	CG14123

DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		SILT - sand, very little ice, poorly bonded		
1		SAND - little silt		
2				
3		End of Hole at 2.5m		
4				

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 5-2

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 30, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		DATUM SURFACE ELEVATION		
		SILT - sandy, very little ice, poorly bonded		
1		SAND - little silt, Nbn 5%		
2		End of Hole at 2.0m		
3				

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 5-3

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN. AC/YK	CKD. AH	DATE OF INVEST. January 30, 1988	JOB NO. CG14123

DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		SILT - sandy, poorly bonded, Nbn 5%		
1		SAND - some silt Nbn		
2				
3		End of Hole at 3.0m		
4				

APPENDIX C

Borrow Borehole Logs

TEST PITS LOGGED BY CHEVRON CANADA PERSONNEL

Test Pit	Description
1 and 2	0 - 1.8 m Silt 1.8 - 3.7 m Gravel, wet at 3 m 3.7 m end of pit
3	0 - 3.6 m Silt 3.6 m end of pit
4	0 - 0.5 m Peat 0.5 end of pit (permafrost)
5	0 - 3.0 m Silt 3.0 - 4.3 m Gravel 3.4 end of pit

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

REMARKS: _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	15 %
D_{30} =	mm	SAND	31 %
D_{60} =	mm	SILT	48 %
C_U =	mm	CLAY	6 %
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON MT. RIVER

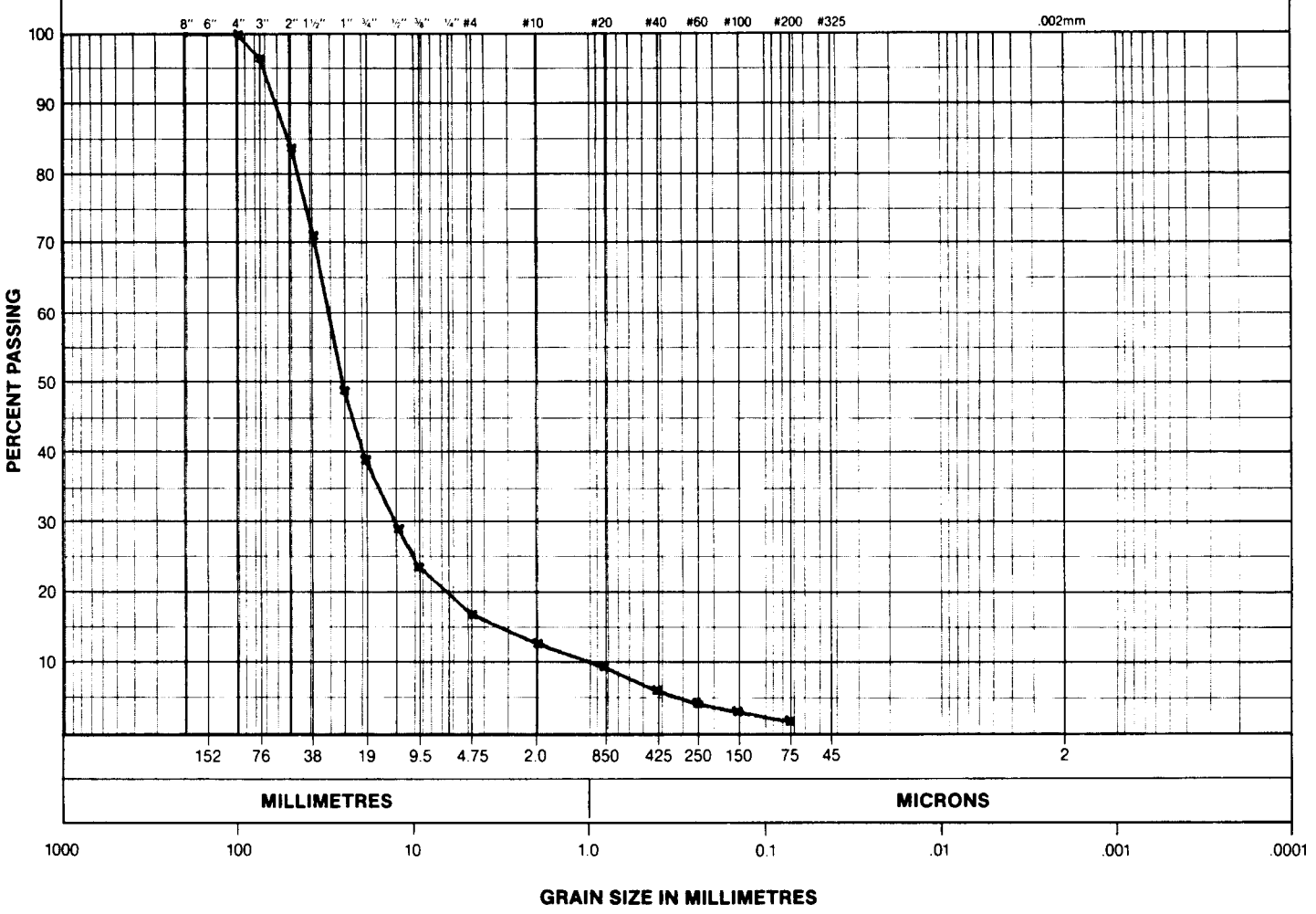
Test Hole No. TP.1 Sample SILT Depth 1.0 M.

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123 | 88.01.07

T 27-87/05

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	82 %
D_{30} =	mm	SAND	15 %
D_{60} =	mm	SILT	%
C_U =	mm	CLAY	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MT. RIVER

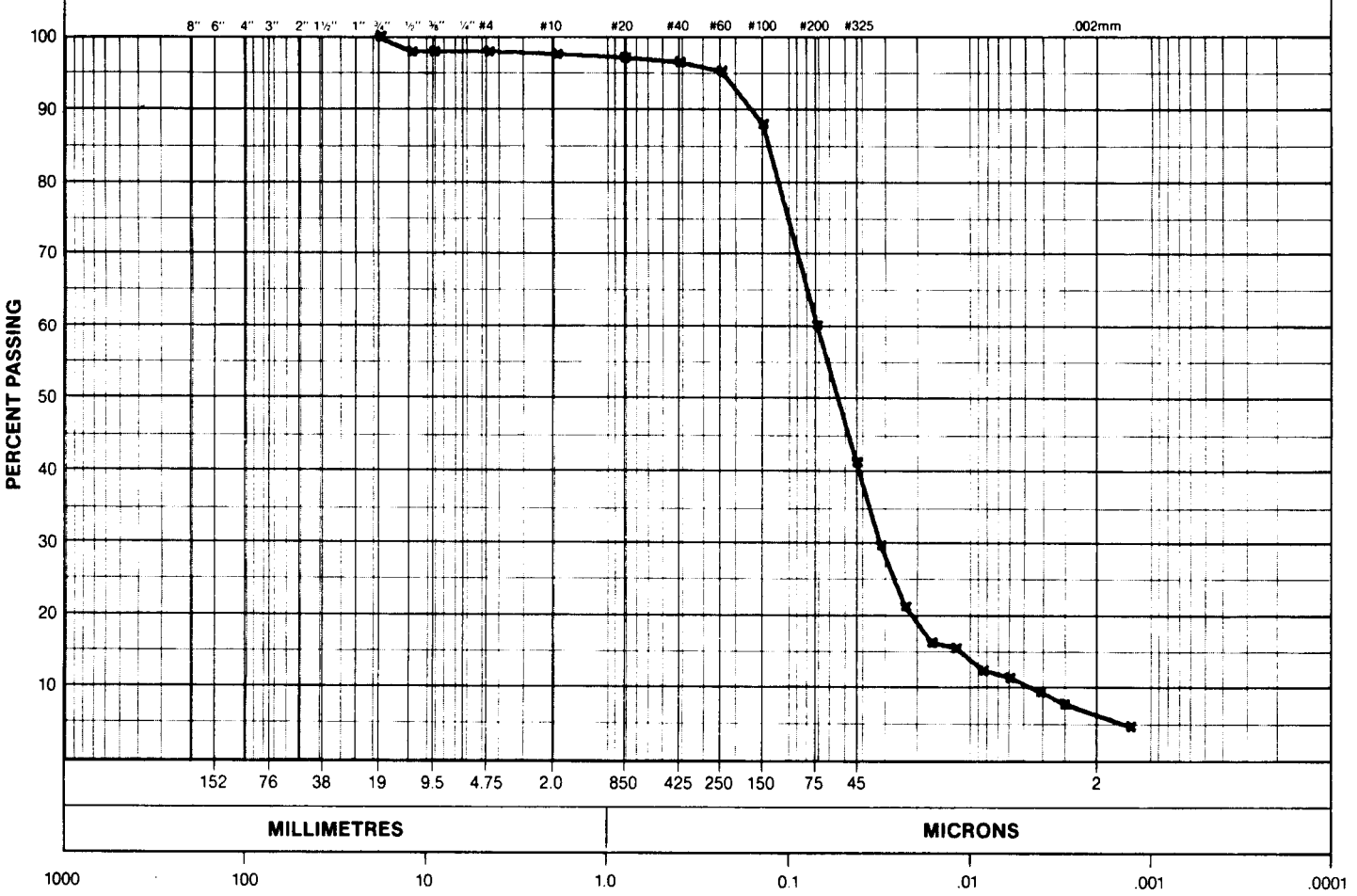
Test Hole No. TP. 1 Sample G Depth 2.5-3.0 m

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123 | 87/12/23

HBLT 27-87/05

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS: _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	2 %
D_{30} =	mm	SAND	38 %
D_{60} =	mm	SILT	54 %
C_U =	mm	CLAY	6 %
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON MT. RIVER

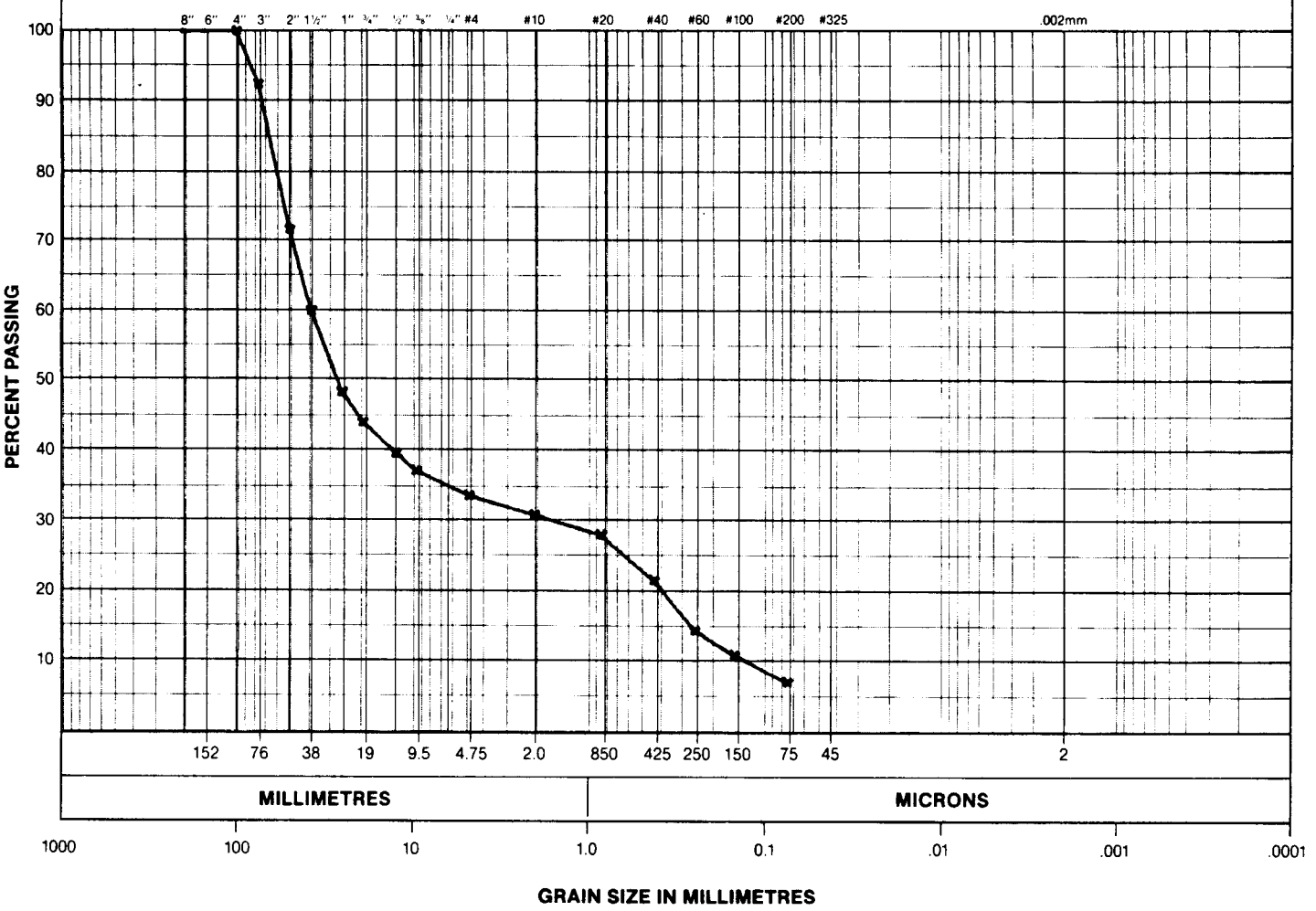
Test Hole No. TP2 Sample SILT Depth 1.0M.

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123 88.01.07

HBLT 27-87/05

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS: _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL 66	%
D_{30} =	mm	SAND 26	%
D_{60} =	mm	SILT	%
C_U =	mm	CLAY	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MT. RIVER

Test Hole No. TP. 2 Sample G Depth 2.5-3.0 m

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123 | 87/12/23

HBLT 27-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-6

CHEVRON - MT. RIVER

LOGGED/DWN. BF/YK | CKD. A.H. | DATE OF INVEST. December 10, 1987 | JOB NO. CG14123

DRILL TYPE Track Mounted Rotary

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SAMPLE TYPE	N	OTHER TESTS
0				
	SILT - dry, numerous bits of ice, organics	⊠		
1				
	SILT - some fine grained sand, moist-dry, brown	⊠		Grain Size Curve
2				
3	GRAVEL - sandy, hard drilling, few cuttings, dry-damp			
4				
5		⊠		
	tended to slough wet gravel			
6				
	End of Hole at 6.1m			
7				
8				
9				
10				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-7

CHEVERON - MT. RIVER

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF /YK	A.H.	December 10, 1987	CG14123

DRILL TYPE: Track Mounted Rotary

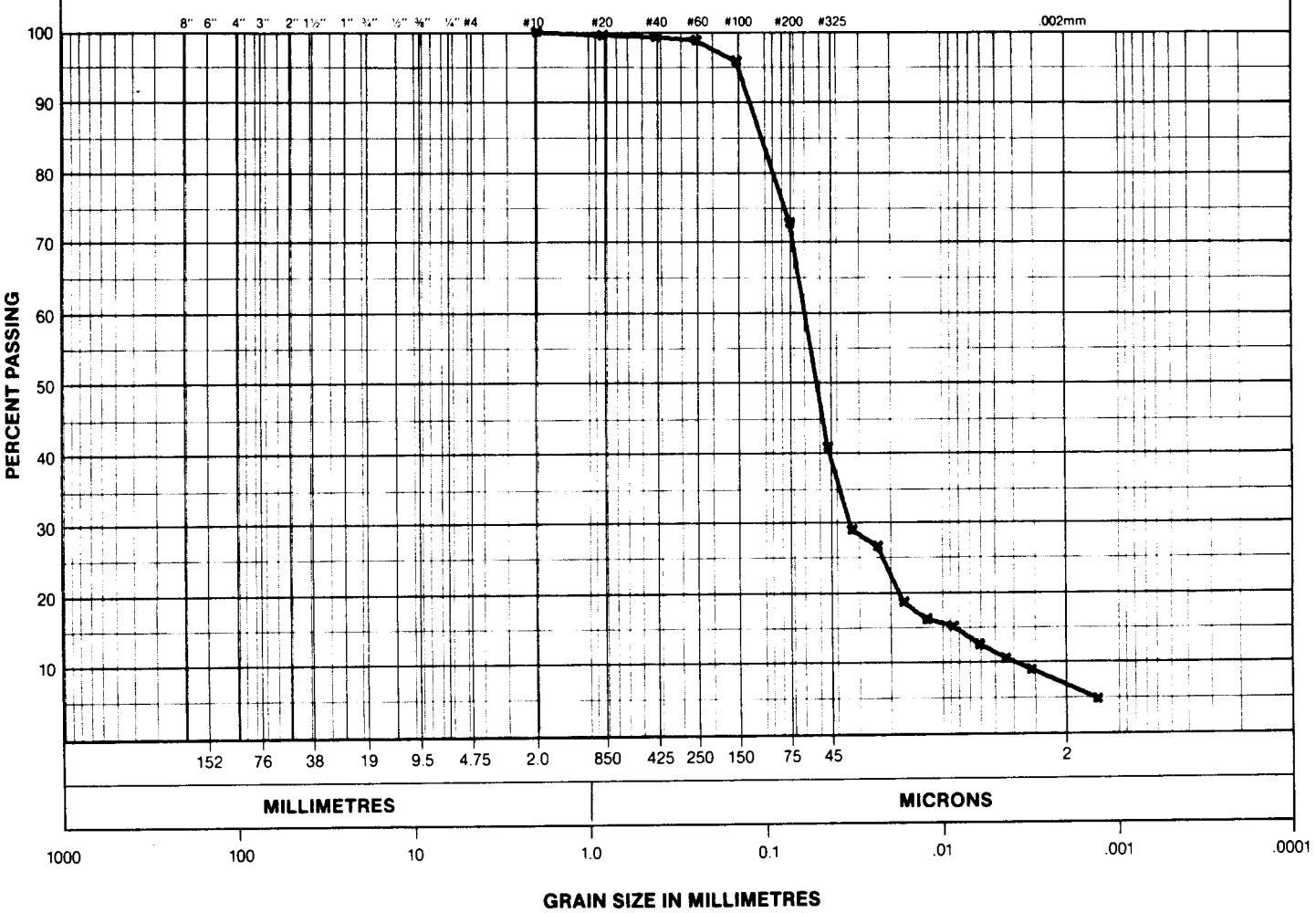
DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	N	OTHER TESTS
0		SILT - some fine grained sand, brown, dry-moist	⊠		Grain Size Curve
3		GRAVEL - hard drilling, sandy, dry to damp	⊠		
5			⊠		
6		gravel cuttings, coarser with depth	⊠		
7		End of Hole at 7.0m			
10					

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS: _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	%
D_{30} =	mm	SAND 27	%
D_{60} =	mm	SILT 67	%
C_U =	mm	CLAY 6	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON -MT. RIVER

Test Hole No. 6 & 7 Sample 2 & 1 Depth 2.0 &1.8

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123

87.12.19

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-8

CHEVRON - MT. RIVER

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 10, 1987	CG14123

DRILL TYPE: Track Mounted Rotary

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N	OTHER TESTS
0		DATUM SURFACE ELEVATION			
1		SILT - some fine sand, brown, dry-moist			
2			⊠		Grain Size Curve
3		gravel lense			
4					
5		GRAVEL - very sandy, dry, hard drilling, damp-wet			
6		water bearing	⊠		
7		End of Hole at 6.1m			
8					
9					
10					

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-9

CHEVRON - MT. RIVER

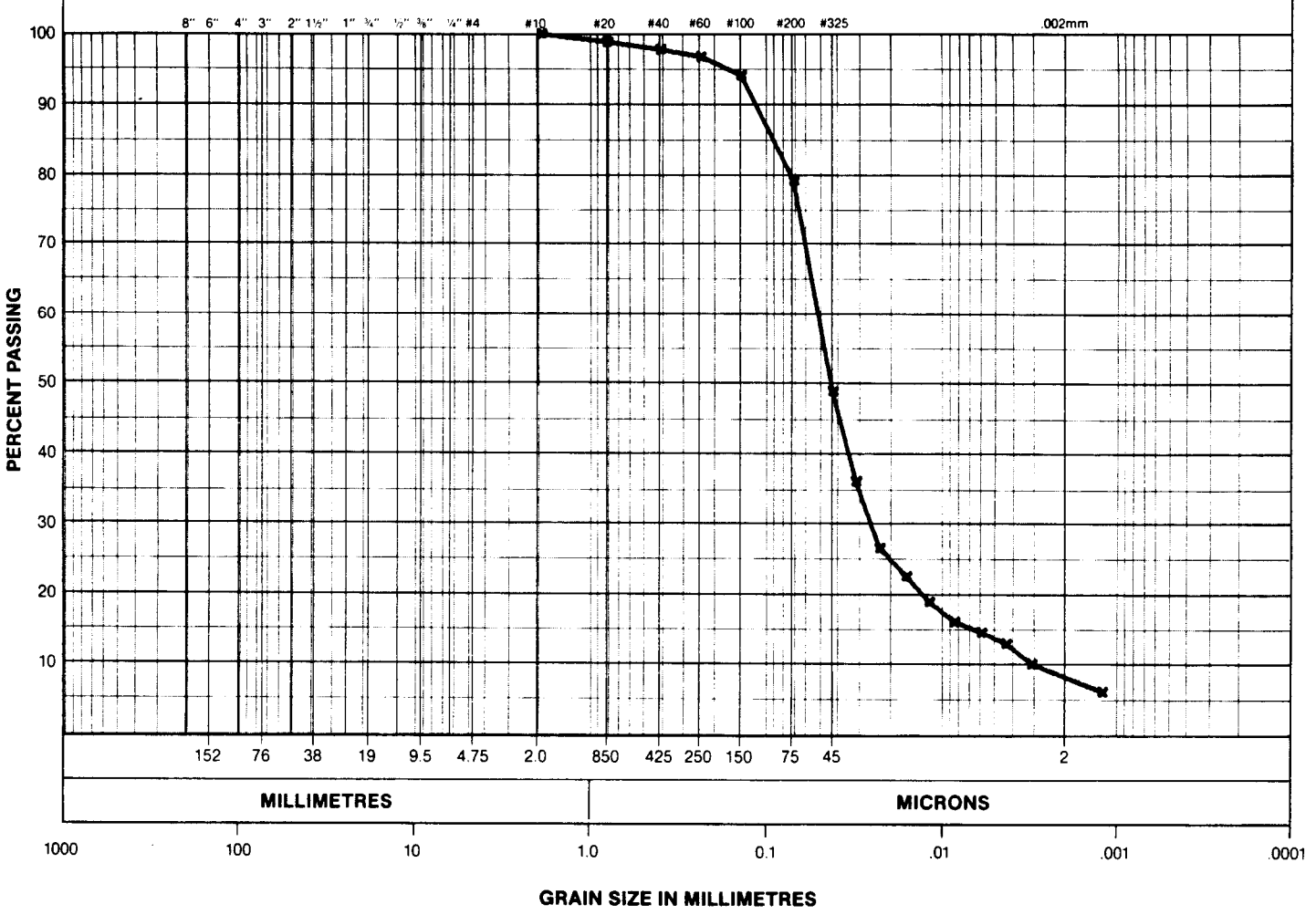
LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 9, 1987	CG14123

DRILL TYPE: Track Mounted Rotary

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	N	OTHER TESTS
		DATUM SURFACE ELEVATION			
1		SILT - some fine grained sand, brown, dry to moist	⊠		Grain Size Curve
2			⊠		
3					
4		GRAVEL - sandy, hard drilling, dry			
		easier drilling to 5.0m			
5		hard drilling to 6.1m few cuttings not sampled			
6					
		End of Hole at 6.1m			
7					

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	%
D_{30} =	mm	SAND 21	%
D_{60} =	mm	SILT 71	%
C_U =	mm	CLAY 8	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MT. RIVER

Test Hole No. 8&9 Sample 1-1-2 Depth 1.8-2.4

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123 87.12.19

HBLT 27-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-10

CHEVRON - MT. RIVER

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 10, 1987	CG14123

DRILL TYPE Rotary

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	N	OTHER TESTS
		DATUM			
		SURFACE ELEVATION			
1		SILT & SAND - fine grained, brown, occasional bits of ice, moist	⊠		Grain Size Curve
2					
3		SILT - sandy, slightly plastic, brown-black, saturated-wet, some organics			
4			⊠		
5					
6		GRAVEL - hard drilling, few cuttings			
7		End of Hole at 6.1m			
8					
9					
10					

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-11

CHEVRON - MT. RIVER

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 10, 1987	CG14123

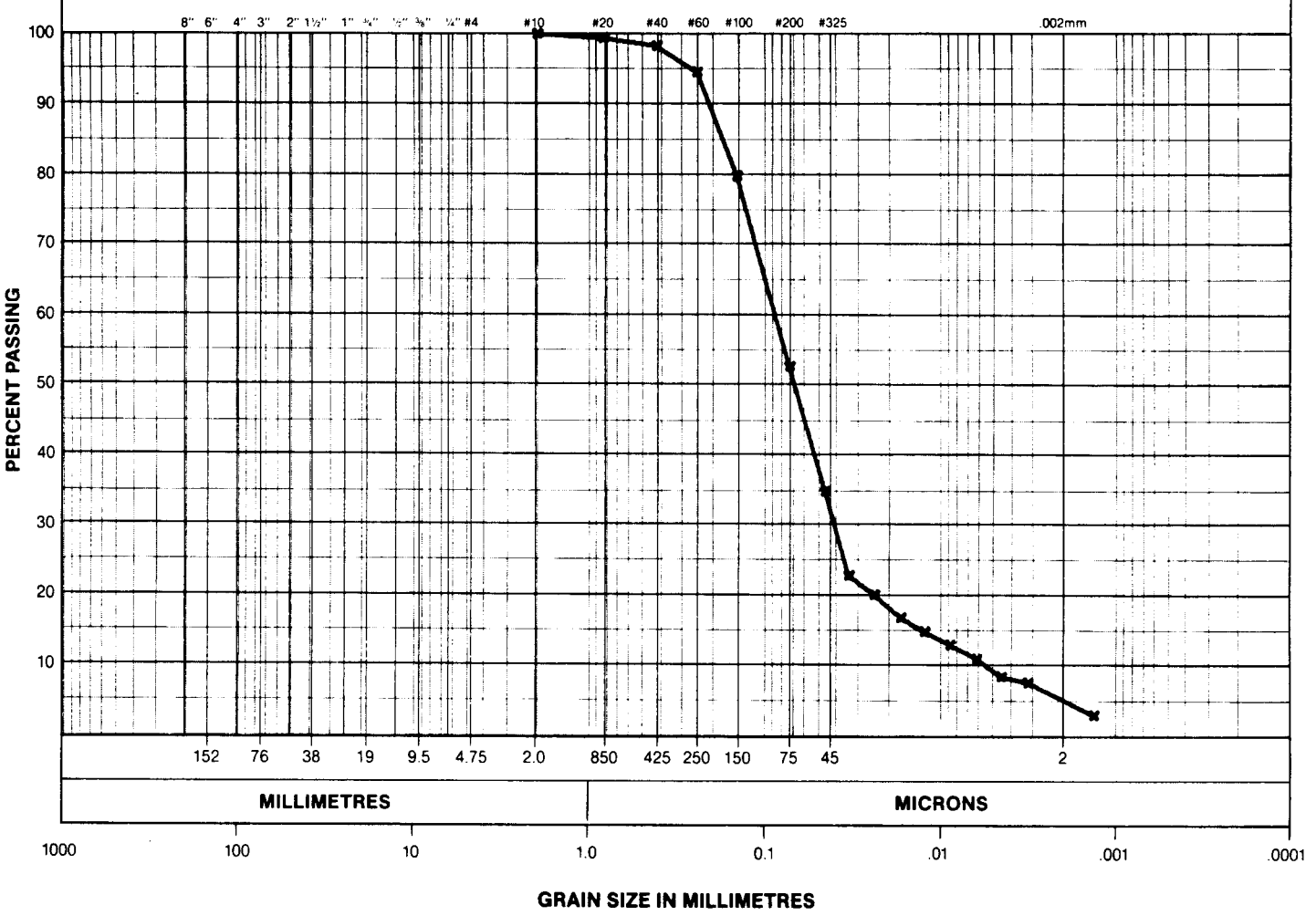
DRILL TYPE Track Mounted Rotary

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N	OTHER TESTS
		DATUM SURFACE ELEVATION			
1		SILT & SAND - fine grained, brown, moist-dry			
2			⊠		Grain Size Curve
3					
4					
5		--- fine to medium grained, silty, occasional organics, saturated-wet	⊠		
6		GRAVEL - hard drilling			
7		End of Hole at 6.1m			
8					
9					
10					

HBLT 10-87/05

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS: _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	%
D_{30} =	mm	SAND 47	%
D_{60} =	mm	SILT 48	%
C_U =	mm	CLAY 5	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MT. RIVER

Test Hole No. 10&11 Sample 1 Depth 1.8-2.1

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123

87.12.19

HBLT 27-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-12

CHEVRON - MT. RIVER

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 11, 1987	CG14123

DRILL TYPE: Track Mounted Rotary

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N	OTHER TESTS
1		SILT - sandy, brown, frozen at top, non plastic, moist	☒		Grain Size Curve
2					
3		GRAVEL - sandy, moist-damp, moderately easy drilling; tended to slough	☒		
4					
5		End of Hole at 4.6m • Could not advance deeper due to sloughing gravel			
6					
7					
8					
9					
10					

DATUM

SURFACE ELEVATION

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-13

CHEVRON - MT. RIVER

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 11, 1987	CG14123

DRILL TYPE Track Mounted Rotary

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N	OTHER TESTS
0		DATUM SURFACE ELEVATION			
1		SILT - sandy, moist-dry, non plastic, frozen at top	⊠		Grain Size Curve
2					
3		GRAVEL - sandy, few cuttings, moderately easy drilling, moist-damp	⊠		
4					
5		End of Hole at 4.6m • Could not advance due to sloughing gravel			
6					
7					
8					
9					
10					

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-14

CHEVRON - MT. RIVER

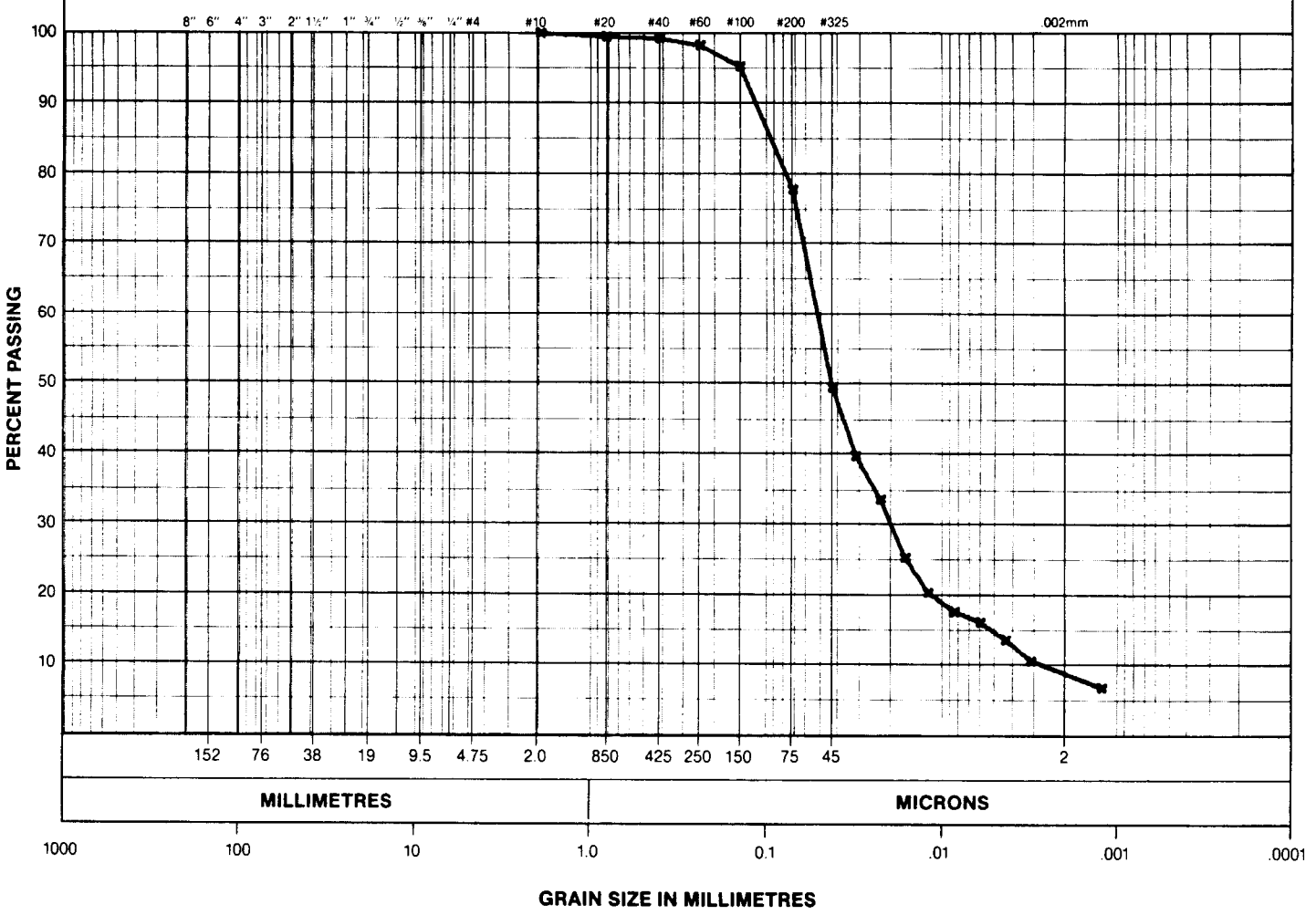
LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 11, 1987	CG14123

DRILL TYPE Track Mounted Rotary

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION DATUM SURFACE ELEVATION	SAMPLE TYPE	N	OTHER TESTS
		GRAVEL (FILL) - frozen, hard drilling			
1		SILT - sandy, slightly plastic, brown, moist			
2					
3		sandy, non plastic, moist			Grain Size Curve
4					
5		GRAVEL - hard drilling, few cuttings very sandy, moderately easy drilling few cuttings, no samples			
6					
7		End of Hole at 6.1m			
8					
9					
10					

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	%
D_{30} =	mm	SAND 22	%
D_{60} =	mm	SILT 69	%
C_U =	mm	CLAY 9	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MT. RIVER

Test Hole No. 12-14 Sample 1&2 Depth 10-3.1

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123 | 87.12.19

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. BH-15

CHEVRON - MT. RIVER

LOGGED/DWN.	BF/YK	CKD.	A.H.	DATE OF INVEST.	December 11, 1987	JOB NO.	CG14123

DRILL TYPE: Track Mounted Rotary

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
0		SILT - sandy, clayey, gravel fill and organics in first meter, (partially frozen)		
1			⊠	
2				
3		--- gravel lense at 2.7m	⊠	
4		GRAVEL - sandy, moderately easy drilling		
5			⊠	
6		End of Hole at 5.0m • could not advance due to slough blocking circulation		
7				
8				
9				
10				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. TP-6

CHEVRON - MT. RIVER

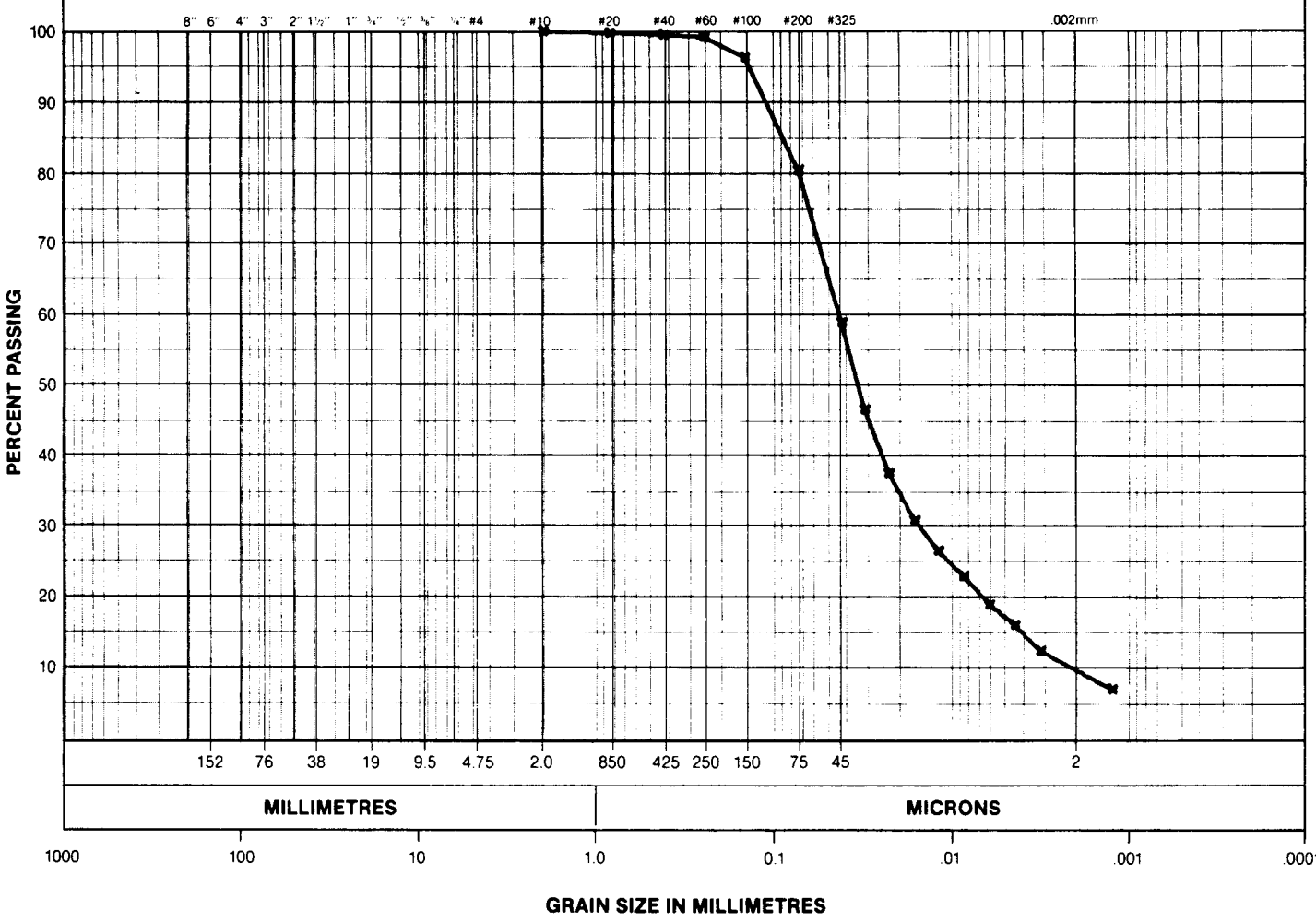
LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
BF/YK	A.H.	December 12, 1987	CG14123

DRILL TYPE Cat

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	N	OTHER TESTS
		DATUM SURFACE ELEVATION			
		SILT - sandy, non plastic, brown, organics, frost in top 0.6m, moist,			Grain Size Curve
1					
		GRAVEL - sandy, damp-moist, dense,			Grain Size
2		gravel saturated-wet			Grain Size
		inflow of water into test pit			
3		End of Hole at 2.4m			
4					
5					
6					

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	%
D_{30} =	mm	SAND 20	%
D_{60} =	mm	SILT 70	%
C_U =	mm	CLAY 10	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

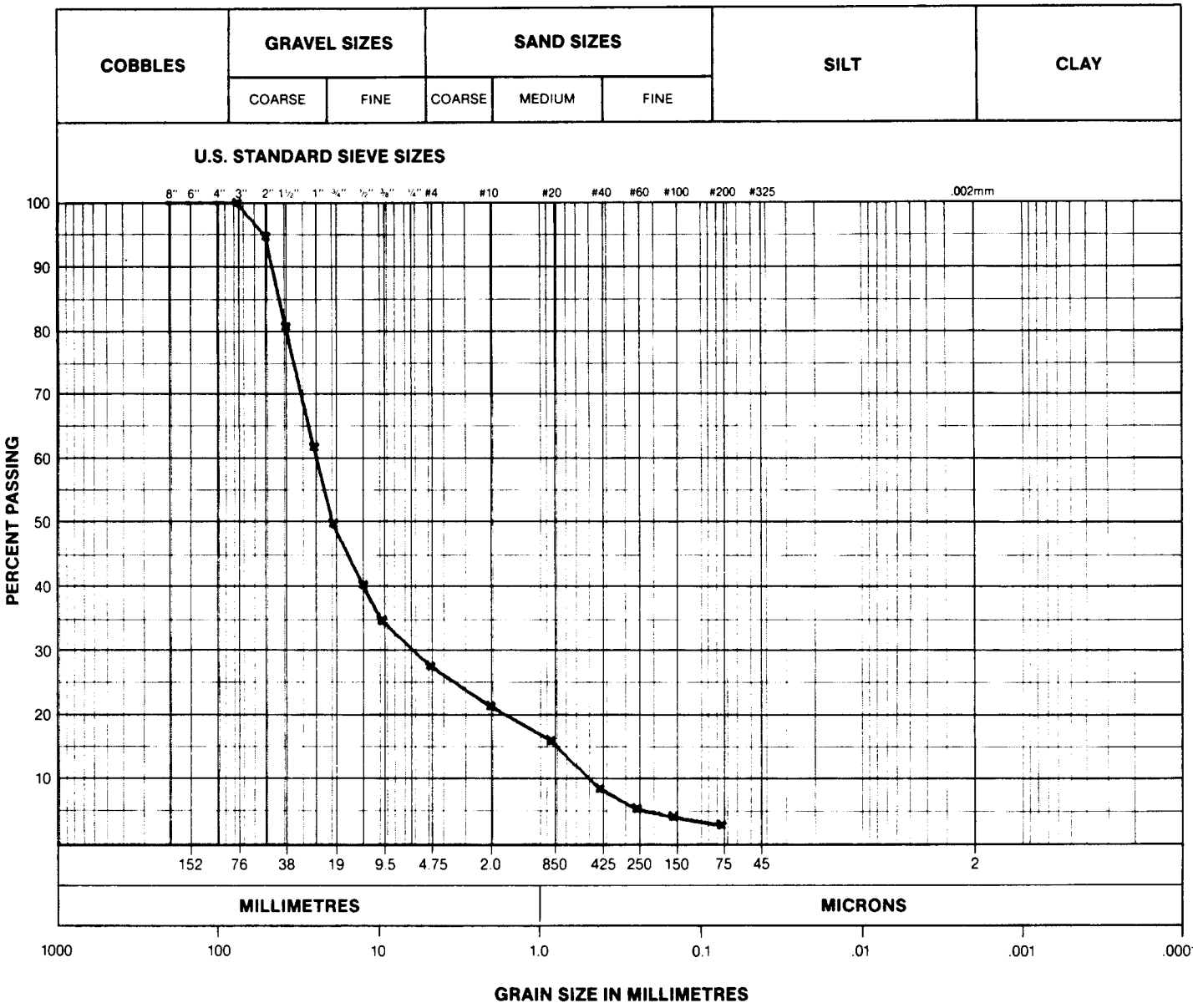
CHEVRON - MT. RIVER

Test Hole No. T.P. 6 Sample 1 Depth 0.8-1.1

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123 87.12.19

HBLT 27-87/05



REMARKS: _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL 72	%
D_{30} =	mm	SAND 24	%
D_{60} =	mm	SILT	%
C_U =	mm	CLAY	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

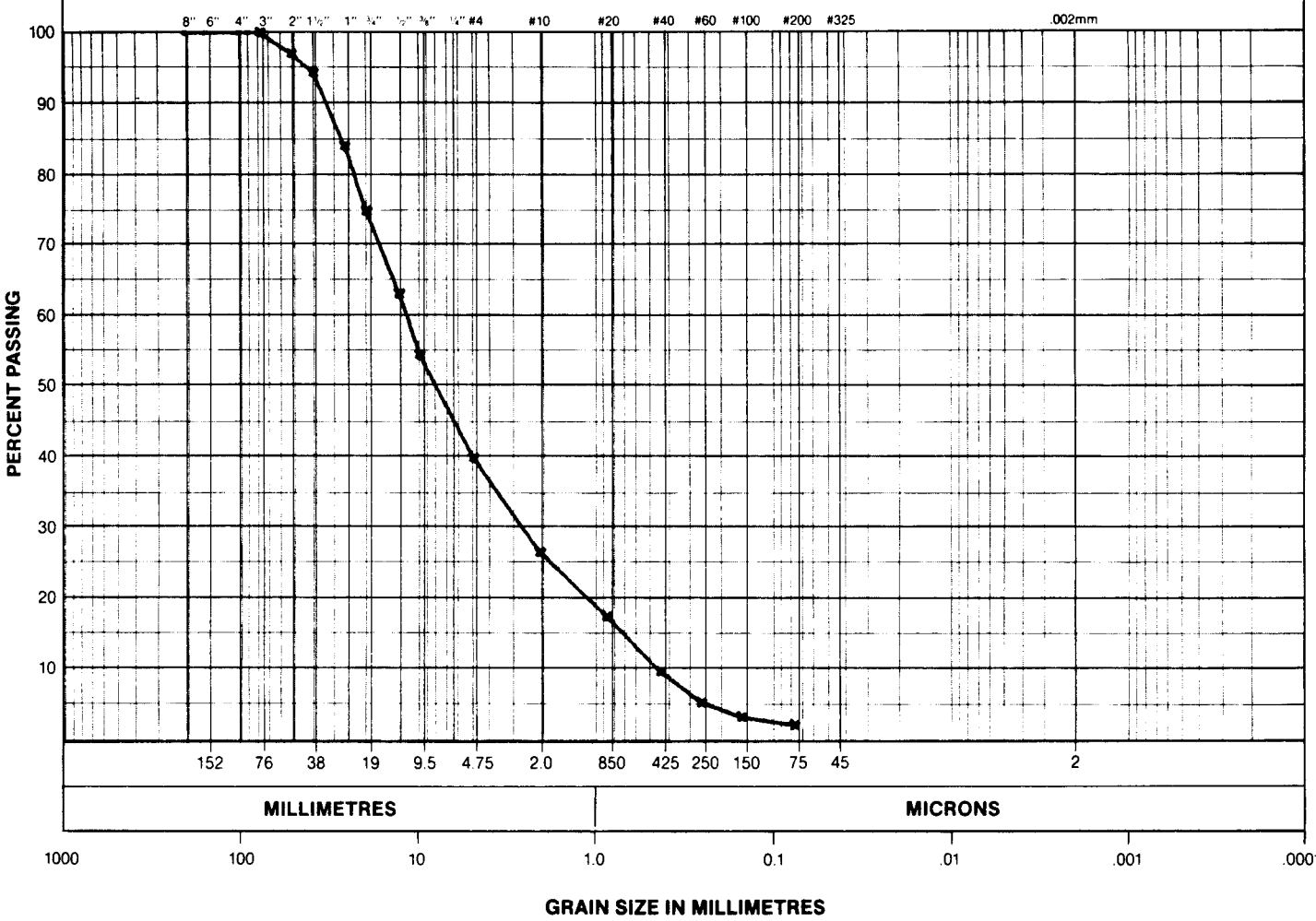
CHEVRON - MT. RIVER

Test Hole No. TP. 6 Sample 2 Depth 1.5-1.8

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123 87/12/23

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	59 %
D_{30} =	mm	SAND	37 %
D_{60} =	mm	SILT	%
C_U =	mm	CLAY	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MT. RIVER

Test Hole No. TP. 6 Sample 3 Depth 2.1-2.4

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123

87/12/23

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. TP-7

CHEVRON - MT. RIVER

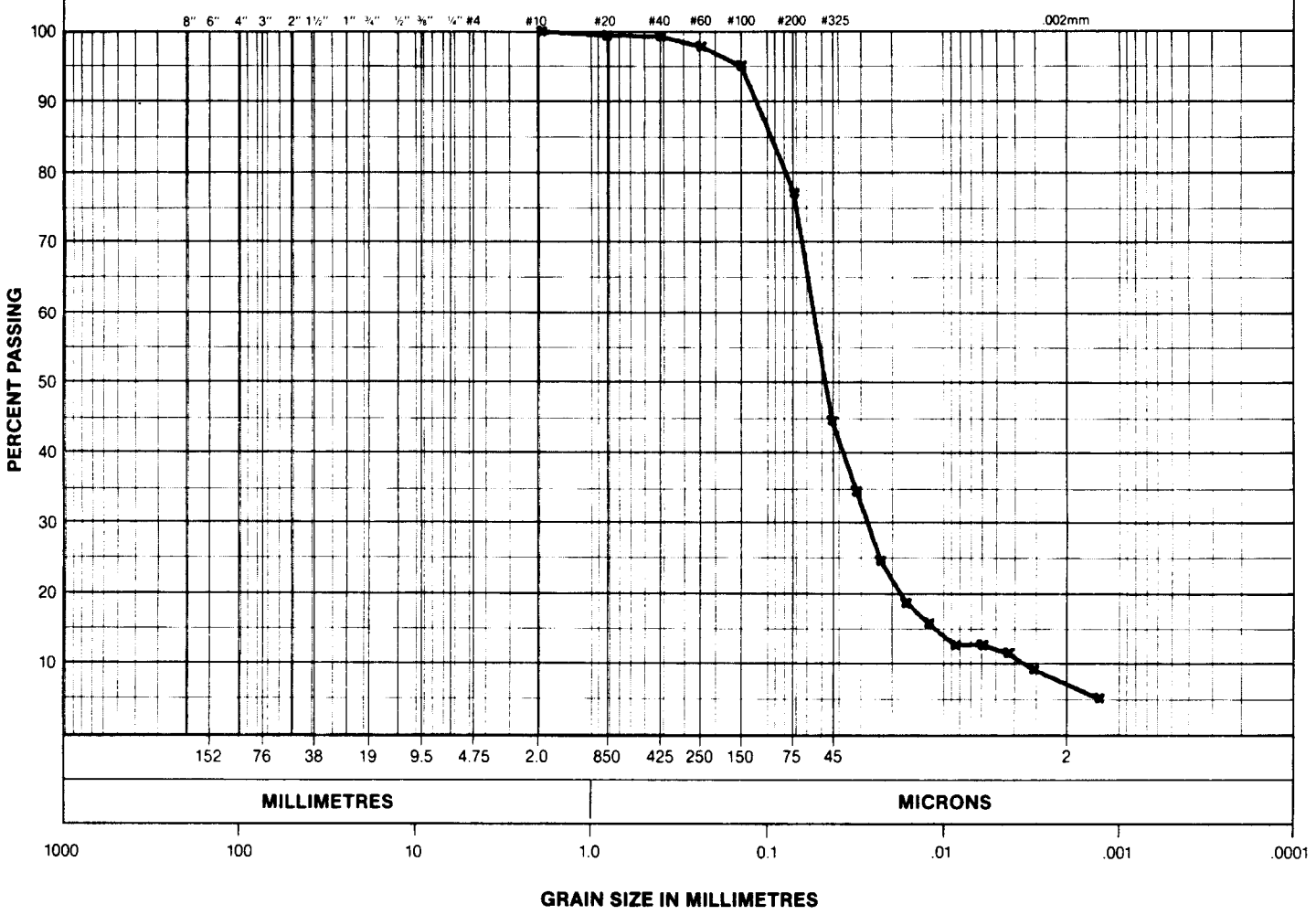
LOGGED/DWN. BF/YK | CKD. A.H. | DATE OF INVEST. December 13, 1987 | JOB NO. CG14123

DRILL TYPE Track Mounted Rotary/cat

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SAMPLE TYPE	N	OTHER TESTS
		SILT - sandy, frozen, numerous roots			
1		SILT - sandy, non plastic, brown, moist			Grain Size Curve
2		SILT - clayey, frozen, hard, numerous pieces of wood and organics Cat could not penetrate further, hole advanced further by rotary drill			
3		GRAVEL - sandy, damp-moist dense			
4					
5					
6		End of Hole at 5.8m NOTE: Test pit excavated to 1.4m. Cat could not penetrate frozen silt - continued with borehole to 5.8m.			
7					
8					
9					
10					

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS: _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} = _____	mm	GRAVEL _____	%
D_{30} = _____	mm	SAND 23	%
D_{60} = _____	mm	SILT 70	%
C_U = _____	mm	CLAY 7	%
C_C = _____	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON - MT. RIVER

Test Hole No. T.P. 7 Sample 1 Depth 0.9 -1.2

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123 | 87.12.18

HBLT 27-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

CHEVRON - MOUNTAIN RIVER AIRSTRIP | BOREHOLE No. 7-1

LOGGED BY: AC	DRAWN BY: YK	CHECKED: AH	DATE: January 30, 1988
RIG:	METHOD:	START:	FINISH:
PROJECT No. CG14123	LOCATION:	ELEVATION:	OFFSET:

W_p-⊡ W_L-△ W-⊙ BULK DENSITY (kg/m³) ● 1200 1400 1600 1800 MOISTURE CONTENT % 20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0			FILL - (Road Gravel)						
			SILT - little sand, non to trace clay, occasional Vs/mm	Vs/Nbn 5-8		C1			Seasonal frost
1			--- poorly bonded			C2			
				Nbn >5%					
2			SAND - trace silt, very moist to wet	UF		C3			
			GRAVEL - UF						
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

CHEVRON - MOUNTAIN RIVER AIRSTRIP | BOREHOLE No. 7-2

LOGGED BY: AC	DRAWN BY: YK	CHECKED: AH	DATE: January 30, 1988
RIG:	METHOD:	START:	FINISH:
PROJECT No. CG14123	LOCATION:	ELEVATION:	OFFSET:

w_p-⊡ w_L-△ w-⊙ BULK DENSITY (kg/m³) ● 1200 1400 1600 1800 MOISTURE CONTENT % 20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
			FILL - gravel sandy						
94.3			SAND - silty (thin Vs)	Vs/Vx Nbn 5-10%		M1			Seasonal frost
1			SILT - sandy	Vs/Nbn 5-10%		M2			
2			SAND - silty, moist to very moist, UF						
3									
			GRAVEL - UF						
4									
5									
6									
7									
8									
9									
10									
11									
12									

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

CHEVRON - MOUNTAIN RIVER AIRSTRIP | BOREHOLE No. 7-3

LOGGED BY: AC	DRAWN BY: YK	CHECKED : AH	DATE : January 30, 1988
RIG :	METHOD :	START :	FINISH :
PROJECT No. CG14123	LOCATION :	ELEVATION :	OFFSET :

w_p-⊡ w_L-△ w-⊙ BULK DENSITY (kg/m³) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0			ORGANIC	Vs/Nb 5-10%		C1			
1			SILT - little fine sand			C2			
			--- UF	UF					
2			SAND - silty, trace clay	Nb 5%		C3			Possible permafrost
			— poorly bonded						
3			GRAVEL - loose						
4									
5									
6									
7									
8									
9									
10									
11									
12									

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

CHEVRON - MOUNTAIN RIVER AIRSTRIP

BOREHOLE No. 7-4

LOGGED BY: AC	DRAWN BY: YK	CHECKED: AH	DATE: January 30, 1988
RIG:	METHOD:	START:	FINISH:
PROJECT No. CG14123	LOCATION:	ELEVATION:	OFFSET:

W_p-⊡ W_L-△
W-⊙
BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0			ORGANIC	Vr/Vs 10%		C1			Seasonal frost
1			SILT - little sand	Vs/Vr 5-10%		C2			
			occasional Vx						
			UF	UF					
2			SAND - silty, very moist						
3									
			GRAVEL						
4									
5									
6									
7									
8									
9									
10									
11									
12									

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

BOREHOLE LOG

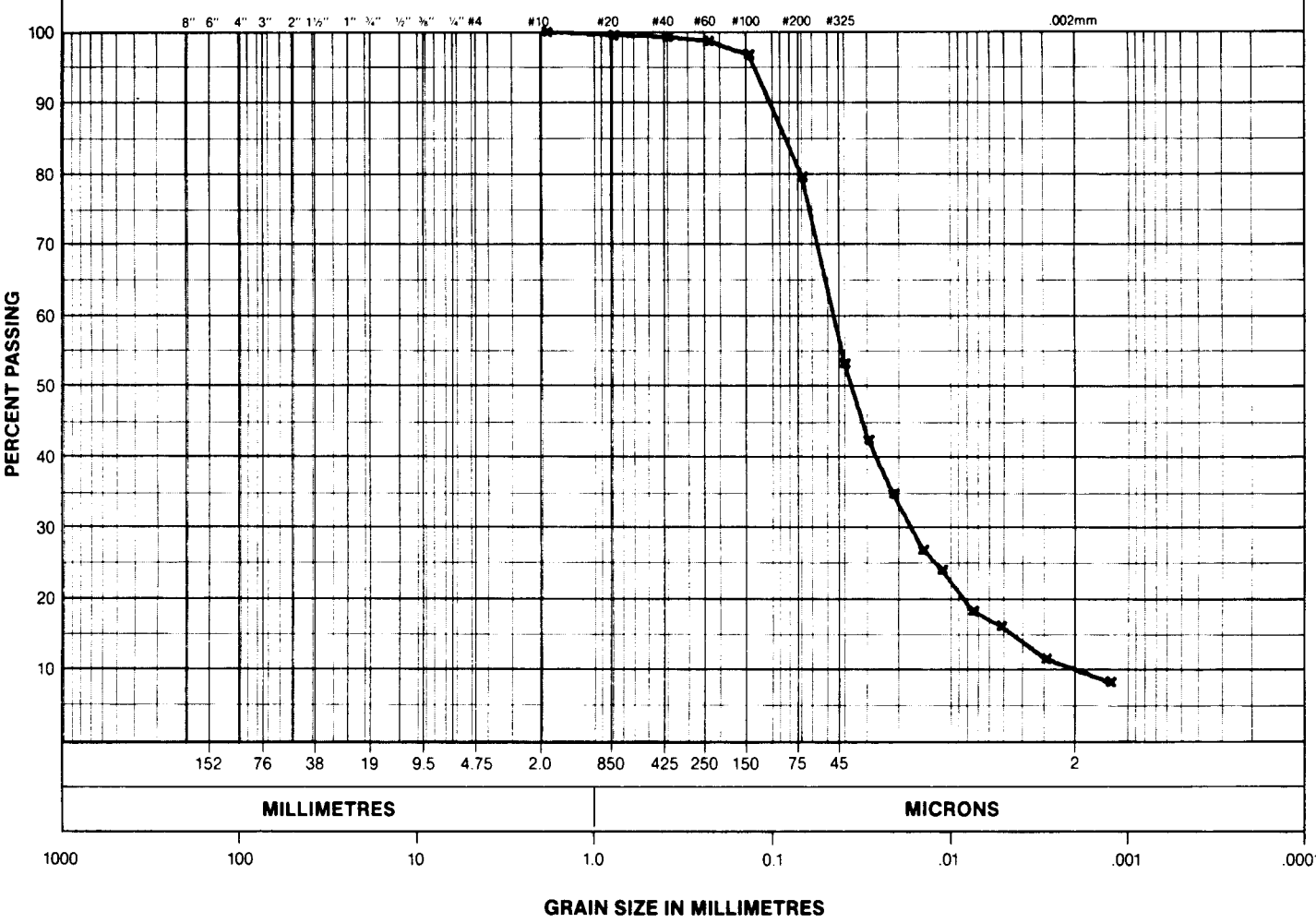
CHEVRON - MOUNTAIN RIVER AIRSTRIP | BOREHOLE No. 7-5

LOGGED BY:	DRAWN BY: YK	CHECKED :	DATE : January 30, 1988
RIG :	METHOD :	START :	FINISH :
PROJECT No. CG14123	LOCATION :	ELEVATION :	OFFSET :

w_p-⊡ w_L-△ w-⊙ BULK DENSITY (kg/m^3) ●
1200 1400 1600 1800
MOISTURE CONTENT %
20 40 60 80

DEPTH (metres)	SOIL GROUP SYMBOL	GRAPHIC LOG	DESCRIPTION	NRC ICE TYPE VISUAL ICE	DEPTH (metres)	SAMPLE TYPE & No	SAMPLE CONDITION	SAMPLE RETAINED	OTHER INFORMATION
0			SAND - silt Vs≥ 1mm	Vs/Nbn 5%		C1			Seasonal frost
1			SILT - little sand			C2			
2			SAND - fine silt (alternating)	UF					
3									
4									
5									
6			GRAVEL						
7									
8									

COBBLES	GRAVEL SIZES		SAND SIZES			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		



REMARKS:

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL	%
D_{30} =	mm	SAND 21	%
D_{60} =	mm	SILT 69	%
C_U =	mm	CLAY 10	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON AIR STRIP

Test Hole No. 7-5 Sample 1&2 Depth 1M&1.8M

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123

88.02.16

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-1

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	February 1, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		DATUM SURFACE ELEVATION		
1		GRAVEL - silty, sandy, frequent cobble sizes — fine to medium gravel, sandy, little silt, rounded.		
2				
3		— predominantly fine, rounded, sandy, little silt		
4		End of Hole at 4.0m Hole sloughing.		
5				

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-1a

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	February 1, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION DATUM SURFACE ELEVATION	SAMPLE TYPE	OTHER TESTS N
		SILT - sandy, little to trace of gravel		
1		GRAVEL - fine to medium grained, some sand, little silt		
2		-- predominantly fine gravel, sandy, occasional cobble sizes, some silt		
3				
4		End of Hole at 4.0m Hole sloughing.		
5				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-2

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN. AC/YK | CKD. AH | DATE OF INVEST. February 1, 1988 | JOB NO. CG14123

DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
0		GRAVEL - cobbly, sandy, silty		
		-- fine to medium grained, sandy, silty		
1				
2				
3		-- predominantly fine, rounded, little sand and silt		
4		End of Hole at 4.0m Hole sloughing in.		
5				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-2a

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN. AC/KK | CKD. AH | DATE OF INVEST. February 01, 1988 | JOB NO. CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SAMPLE TYPE	OTHER TESTS: N
		SILT - sandy		
1		GRAVEL - fine to medium grained, sandy, little silt		
2				
3		SAND - silty, some fine rounded gravel		
4		End of Hole at 4.0m. Hole sloughing in.		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-3

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	February 1, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION DATUM SURFACE ELEVATION	SAMPLE TYPE	OTHER TESTS N
1		GRAVEL - medium grained, sandy, little silt, (cobbly)		
2		-- fine to medium grained, sandy, little silt, (predominantly rounded)		
3		GRAVEL/SAND - alternating gravel and silty sand layers, trace clay		
4		SAND - fine to medium grained, silty, some fine gravel layers		
5				
6		End of Hole at 6m		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-3a

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	February 1, 1988	CG14123

DRILL TYPE Seismic (Air)

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		SILT- sandy, trace clay		
		GRAVEL - very sandy, some silt, fine to medium grained		
1				
2				
3		-- predominantly medium grained, (cobbly gravel) occasional boulders, sandy, little silt		
		-- fine, rounded gravel, sandy, silty		
4				
		End of Hole at 4.0m Hole sloughing in.		
5				

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-4

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 31, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		DATUM SURFACE ELEVATION		
1		GRAVEL - sandy, little silt, predominantly fine to medium grained, occasional boulder sizes.		
2				
3		SILT - sandy, little clay		
4		GRAVEL LAYER		
5		SILT - sandy, clayey		
6		End of Hole at 6.0m		
7				

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-5

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 31, 1988	CG14123

DRILL TYPE: Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SAMPLE TYPE	OTHER TESTS: N
1		SILT - sandy, trace clay, occasional gravel sizes		
2		GRAVEL - sandy, little silt, trace clay, (coarse gravel upper zone) predominantly fine to medium size gravel – some silty sand layers		
3				
4				
5		SAND - very silty, trace to little clay, occasional gravel sizes (hole sloughing in)		
6		End of Hole at 6.0m		
7				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-6

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/KK	AH	January 31, 1988	CG14123

DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		GRAVEL - sandy, some silt, occasional cobble sizes.		
1		SAND - silty, little fine gravel		
2		GRAVEL - sandy, little silt, predominantly rounded to 3-5cmϕ, fine to medium grained. - unfrozen occasional cobble sizes		
3		- more sand and silt, trace clay		
4		SAND - very silty (return), gravelly 2-4cmϕ		
5		Hole sloughing badly at 3.0m. (Hard to interpret the return from from the lower part of the hole)		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-7

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/KK	AH	January 31, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION DATUM SURFACE ELEVATION	SAMPLE TYPE	OTHER TESTS N
1		GRAVEL - sandy, a little silt predominantly cobbly		
		--- fine to medium grained, less sand and silt (predominantly coarse sand)		
2				
3		--- predominantly 2-4cmϕ clean gravel (very poor return)		
4		Hole sloughing in - could not go deeper End of Hole 4.0m		

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-8

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/KK	AH	January 31, 1988	CG14123

DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
0		SILT - sandy, trace clay, occasional gravel sizes to 5-10 cm ϕ		
2		GRAVEL - very sandy and silty		
4		SILT - sandy, little clay, some interbedded fine gravel layers or lensing		
5		some gravel (return), possible layer		
6		End of Hole at 6m (Poor potential)		

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-9

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN. AC/YK	CKD. AH	DATE OF INVEST. January 31, 1988	JOB NO. CG14123

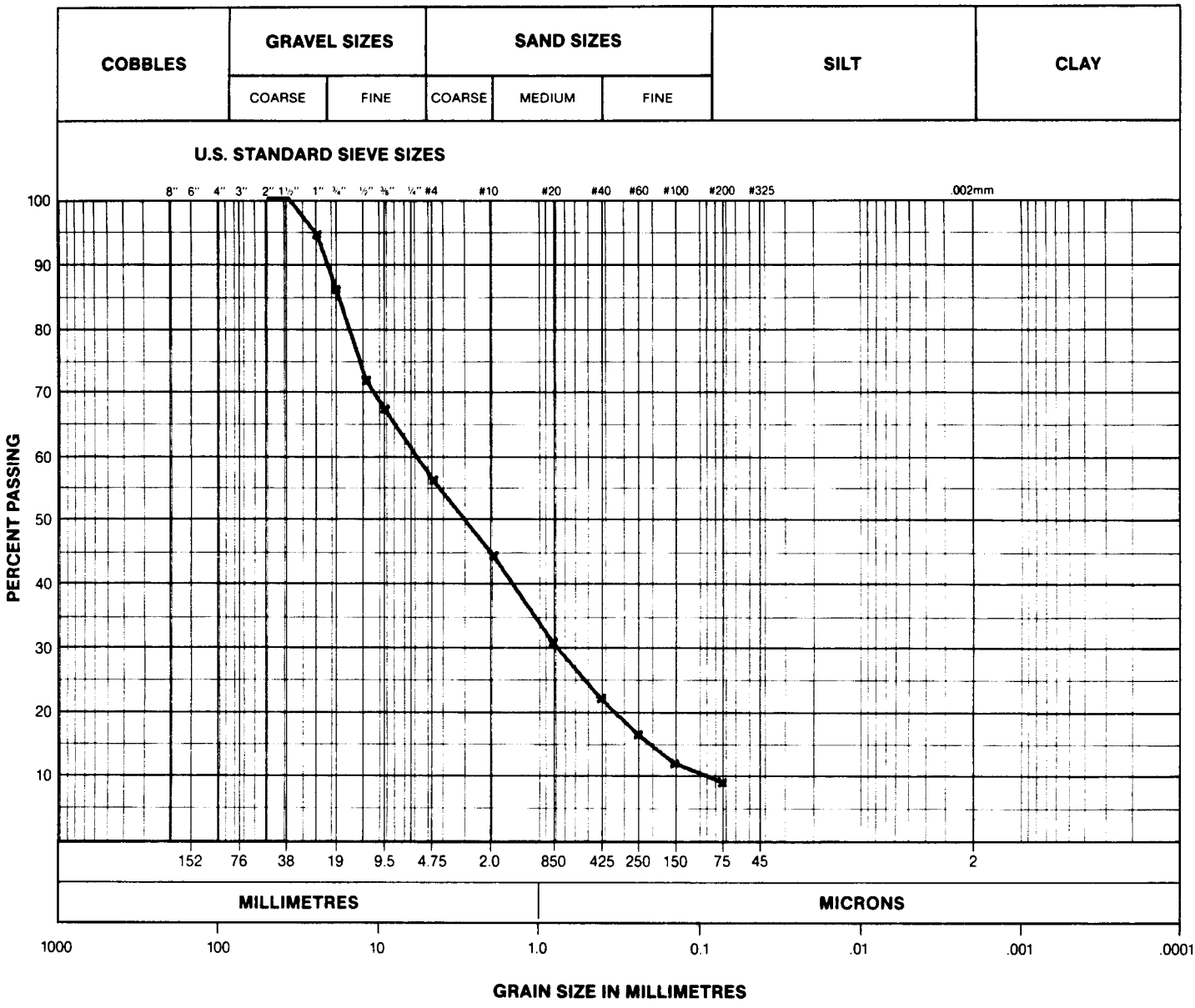
DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N	OTHER TESTS
		SILT - sandy, mixed with some cobbly gravel			
1		SAND - medium to coarse (predominantly coarse) little to no silt, 20-30% fine gravel			GRAIN SIZE
2					
3		---- sand and silt (little) trace clay, some fine to medium gravel (return)			
4		Hole sloughing (could not go deeper) End of Hole at 4.0m			
5					



REMARKS: _____

NOTE: UNIFIED SOIL CLASSIFICATION SYSTEM

SUMMARY

D_{10} =	mm	GRAVEL 44	%
D_{30} =	mm	SAND 47	%
D_{60} =	mm	SILT	%
C_U =	mm	CLAY	%
C_C =	mm		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CHEVRON AIR STRIP

Test Hole No. 8-9 Sample ..... Depth .....

GRAIN SIZE DISTRIBUTION

JOB NO. CG14123

HBLT 27-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 8-10

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 31, 1988	CG14123

DRILL TYPE: Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
1		SILT - sandy, fine, trace to little clay, occasional gravel sizes		
2				
3				
4		End of Hole at 4.0m		
5				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-1

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/KK	AH	February 01, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		DATUM		
		SURFACE ELEVATION		
		ICE		
1		SILT - little clay, sandy, trace gravel		
2		GRAVEL - fine to medium grained, sandy, frequent cobbles, little silt		
3		--- predominantly fine gravel mixed with very silty sands		
4		End of Hole at 4.0m. Hole sloughing (could not go deeper)		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-2

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN. AC/KK	CKD. AH	DATE OF INVEST. February 01, 1988	JOB NO. CG14123

DRILL TYPE Seismic (Air)

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
1		SILT - sand, some gravel layers		
2				
3				
4		End of Hole at 4.0m.		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-3

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	February 1, 1988	CG14123

DRILL TYPE: Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		DATUM SURFACE ELEVATION		
		ICE		
1		GRAVEL - sandy, little silt		
2				
		SAND - silty layer		
3		GRAVEL/SAND - silty, predominantly fine rounded gravel		
4				
		End of Hole at 4.0 m Hole sloughing in.		
5				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-4

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 31, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION DATUM SURFACE ELEVATION	SAMPLE TYPE	OTHER TESTS N
		ICE		
1		GRAVEL - sandy, little silt, fine to medium grained		
2				
3		SAND/SILT - trace to little clay, occasional gravel sizes,		
4		End of Hole at 4.0m Hole sloughing.		
5				

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-4a

CHEVRON - MOUNTAIN RIVER, GRAVEL

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC	AH	January 31, 1988	CG14123

DRILL TYPE: Air

DATUM

SURFACE ELEVATION

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		ICE		
1		GRAVEL - sandy, little silt (predominatly fine to medium gravel)		
2				
3		SAND - silty, trace clay, fine to coarse		
4		GRAVEL and SAND - silty		
5		Hole sloughing End of Hole at 4.0m		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-5

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 31, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION DATUM SURFACE ELEVATION	SAMPLE TYPE	OTHER TESTS N
		ICE		
1		GRAVEL - sandy, trace to little silt, fine to medium grained, (occasional larger sizes)		
2				
3				
		--- some sand layers, 0.2-0.3m thick		
4				
5		SAND - silty, little gravel, (very hard to determine the bottom part, too much water blowing out)		
6		End of Hole at 6.0m		
7				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-5a

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/KK	AH	January 31, 1988	CG14123

DRILL TYPE: Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SAMPLE TYPE	OTHER TESTS: N	OTHER TESTS
		ICE			
1		GRAVEL - (Hole could not be logged, too much water) apparently well graded gravel			
2					
3		--- cobbly - bouldery			
4		Hole sloughing in. End of Hole at 4.0m			

HBLT 10-87/05

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-6

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/KK	AH	January 31, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	OTHER TESTS: N
		DATUM SURFACE ELEVATION		
		ICE		
1		GRAVEL - sandy. little silt, fine to medium grained, occasional larger sizes.		
2		--- unfrozen, water, very poor recovery on fines		
3		--- cobbly or bouldery, very little return on fines		
4		End of Hole at 4.0m		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-7

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 31, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SAMPLE TYPE	OTHER TESTS: N
		ICE		
1		GRAVEL - sandy, medium to coarse grained, little silt, predominantly fine to medium gravel		
2				
3				
4		SAND/GRAVEL - little silt		
5		End of Hole at 4.0m Hole sloughing in.		

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-8

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 31, 1988	CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION DATUM SURFACE ELEVATION	SAMPLE TYPE	OTHER TESTS N
		ICE		
1		SILT - sandy, trace clay, occasional gravel sizes		
2		GRAVEL - sandy, silty, fine to medium grained.		
3		SILT/SAND - little clay interbedded, gravel layers or lensing.		
4		End of Hole at 4.0m (Hole sloughing).		
5				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-9

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN. AC/YK | CKD. AH | DATE OF INVEST. January 31, 1988 | JOB NO. CG14123

DRILL TYPE Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION (DATUM / SURFACE ELEVATION)	SAMPLE TYPE	OTHER TESTS: N
		ICE		
1		SILT - sandy, occasional small gravel sizes		
2		SAND - predominantly coarse little silt, some fine to medium gravel		
3				
		SAND/SILT - little fine to medium gravel sizes		
4		End of Hole at 4.0m. Hole sloughing in Good potential.		
5				

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 9-10

CHEVRON - MOUNTAIN RIVER
GRAVEL STUDY

LOGGED/DWN.	CKD.	DATE OF INVEST.	JOB NO.
AC/YK	AH	January 31, 1988	CG14123

DRILL TYPE: Seismic (Air)

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

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION DATUM SURFACE ELEVATION	SAMPLE TYPE	OTHER TESTS N
		ICE		
1		SILT - little fine to medium sand, trace clay		
2		SAND - predominantly coarse, some fine rounded gravel, trace silt --- fine gravel		
3		SILT/SAND - little fine gravel, some low to medium plastic, clayey layers		
4		End of Hole at 4.0m		
5				

APPENDIX D

Explanation of Terms and Symbols

EXPLANATION OF TERMS AND SYMBOLS

The terms and symbols used on the borehole logs to summarize the results of field investigation and subsequent laboratory testing are described in these pages.

It should be noted that materials, boundaries and conditions have been established only at the borehole locations at the time of investigation and are not necessarily representative of subsurface conditions elsewhere across the site.

TEST DATA

Data obtained during the field investigation and from laboratory testing are shown at the appropriate depth interval.

Abbreviations, graphic symbols, and relevant test method designations are as follows:

*C	Consolidation test	*ST	Swelling test
D_R	Relative density (formerly specific gravity)	TV	Torvane shear strength
Fines	Percentage by weight smaller than #200 sieve	VS	Vane shear strength (undisturbed-remolded)
k	Permeability coefficient	w	Natural moisture content (ASTM D 2216)
*MA	Mechanical grain size analysis and hydrometer test	w_l	Liquid limit (ASTM D 423)
		w_p	Plastic limit (ASTM D 424)
N	Standard penetration test (CSA A119.1-60)	ε_f	Unit strain at failure
N_d	Dynamic cone penetration test	γ	Unit weight of soil or rock
NP	Non plastic soil	γ_d	Dry unit weight of soil or rock
pp	Pocket penetrometer strength	ρ	Density of soil or rock
*q	Triaxial compression test	ρ_d	Dry density of soil or rock
q_u	Unconfined compressive strength		
*SB	Shearbox test	→	seepage
SO_4	Concentration of water-soluble sulphate	▼	observed water level

**The results of these tests usually are reported separately*

SOIL CLASSIFICATION AND DESCRIPTION

Soils are classified and described according to their engineering properties and behaviour.

The soil of each stratum is described using the Unified Soil Classification System[1] modified slightly so that an inorganic clay of "medium plasticity" is recognized.

The use of modifying adjectives may be employed to define the actual or estimated percentage range by weight of minor components. This is similar to a system developed by D.M. Burmister.[2]

The soil classification system is shown in greater detail on page 2.

SAMPLE TYPE — The type of sample is shown at the appropriate depth interval using the following abbreviations:

A auger sample
B block sample
C rock core, or frozen soil core
D drive sample
P pitcher tube sample
U tube sample (usually thin-walled)
W wash or air return sample
O other (see report text)
▨ indicates no sample recovery

1. "Unified Soil Classification System", Technical Memorandum 3-357 prepared for Office, Chief of Engineering, by Waterways Experiment Station, Vicksburg, Mississippi, Corps of Engineers, U.S. Army. Vol 1, March 1953.
2. American Society for Testing and Materials. Procedures for Testing Soils, "Suggested Methods of Testing for Identification of Soils", 4th Ed; pp 221-233, Dec. 1964.

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	COLOR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 200 SIEVE)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		RED	WELL GRADED GRAVELS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 4$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3
			GP		RED	POORLY GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY GRAVELS (WITH SOME FINES)	GM		YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%: ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			GC		YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	CONTENT OF FINES EXCEEDS 12%: ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
	SANDS MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW		RED	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 6$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3
			SP		RED	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY SANDS (WITH SOME FINES)	SM		YELLOW	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%: ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4
			SC		YELLOW	CLAYEY SANDS, SAND-CLAY MIXTURES	CONTENT OF FINES EXCEEDS 12%: ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES 200 SIEVE)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML		GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (see below)
		$W_L > 50\%$	MH		BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL		GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	
		$30\% < W_L < 50\%$	CI		GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS	
		$W_L > 50\%$	CH		BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	ORGANIC SILTS & CLAYS BELOW "A" LINE ON CHART	$W_L < 50\%$	OL		GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINE CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY
		$W_L > 50\%$	OH		BLUE	ORGANIC CLAYS OF HIGH PLASTICITY	
HIGHLY ORGANIC SOILS			Pt		ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE

SPECIAL SYMBOLS

BEDROCK (Undifferentiated)

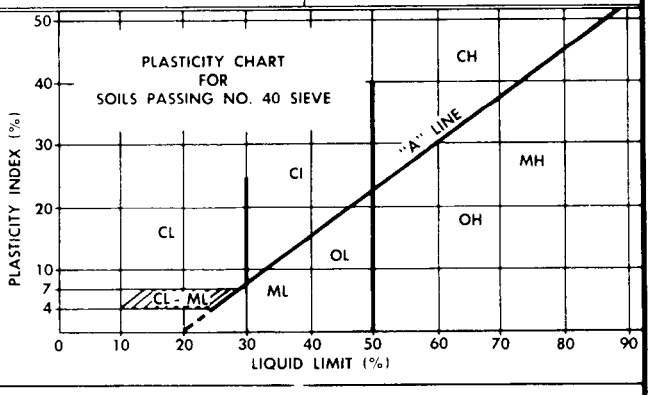
VOLCANIC ASH

SOIL COMPONENTS

FRACTION	U S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
	PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL			50 - 35	and
coarse	76 mm	19 mm		
fine	19 mm	No 4		
SAND			35 - 20	some
coarse	4.75 mm	2.00 mm		
medium	2.00 mm	425 μm	20 - 10	little
fine	425 μm	75 μm		
SILT (non plastic) or CLAY (plastic)	75 μm		10 - 1	trace

OVERSIZE MATERIAL

Rounded or subrounded	Not rounded
COBBLES 76 mm to 203 mm	ROCK FRAGMENTS > 76 mm
BOULDERS > 203 mm	ROCKS > 0·76 cubic metre in volume



1. ALL SIEVE SIZES MENTIONED ON THIS CHART ARE U.S. STANDARD, A.S.T.M. E.11.
2. BOUNDARY CLASSIFICATIONS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE GIVEN COMBINED GROUP SYMBOLS, E.G. GW-GC IS A WELL GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5% AND 12%.

Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES