

WHITEHORSE GRAVEL SURVEY

ALASKA HIGHWAY & MAYO ROAD

B4321

DECEMBER, 1978

*Geotechnical Copy*



**R.M. HARDY & ASSOCIATES LTD.**  
CONSULTING ENGINEERING AND PROFESSIONAL SERVICES



WHITEHORSE GRAVEL SURVEY  
ALASKA HIGHWAY & MAYO ROAD  
B4321                      DECEMBER, 1978

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Prepared for:  
Government of Yukon Territory  
Department of Local Government  
Whitehorse, Yukon

Prepared by:  
Hardy Associates (1978) Ltd.  
Edmonton, Alberta



GOVERNMENT  
of the  
YUKON TERRITORY

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1.0 INTRODUCTION

R. M. Hardy and Associates Limited, have been retained by the Department of Local Government, Government of Yukon Territory, under Contract M19/78 to assess the quality and quantity of granular materials in a large gravel and sand deposit near the junction of the Alaska Highway and Mayo Road north of the City of Whitehorse.

The designated deposit is referred to as area A in this report and was formerly designated as PWA-1 in a report entitled "Inventory of Gravel, Sand and Loam Deposits in the Whitehorse Metropolitan Area, Yukon Territory" by R. G. Hilker Limited, June, 1977. Because the designated deposit is adjacent to the new McPherson subdivision an additional area (Area B) further west was also investigated to determine the quantity of granular materials available.



## 2.0 SUMMARY

Because of the large area to be investigated, geophysical surveying techniques were employed to delineate the areal extent of the deposit and to estimate the thickness of granular materials. Grid lines were surveyed by Hosford, Impey and Welter Limited (Whitehorse), and the geophysical survey was conducted along these surveyed grid lines. The location of the study area is shown in Figure 1.

Test pits were excavated with a backhoe to obtain representative samples for quality testing and to confirm the geophysical interpretations.

The results of the geophysical surveys and test pitting indicate two extensive areas underlain by more than 20 meters of gravel and sand. Total volume of granular materials in Area A is estimated to be in excess of 40 million cubic meters. Of this total, it is estimated that more than 17.7 million cubic meters is recoverable coarse aggregate.

Area B contains at least 16 million cubic meters of gravel and sand of which a minimum of 7 million cubic meters is expected to be recoverable coarse aggregate.

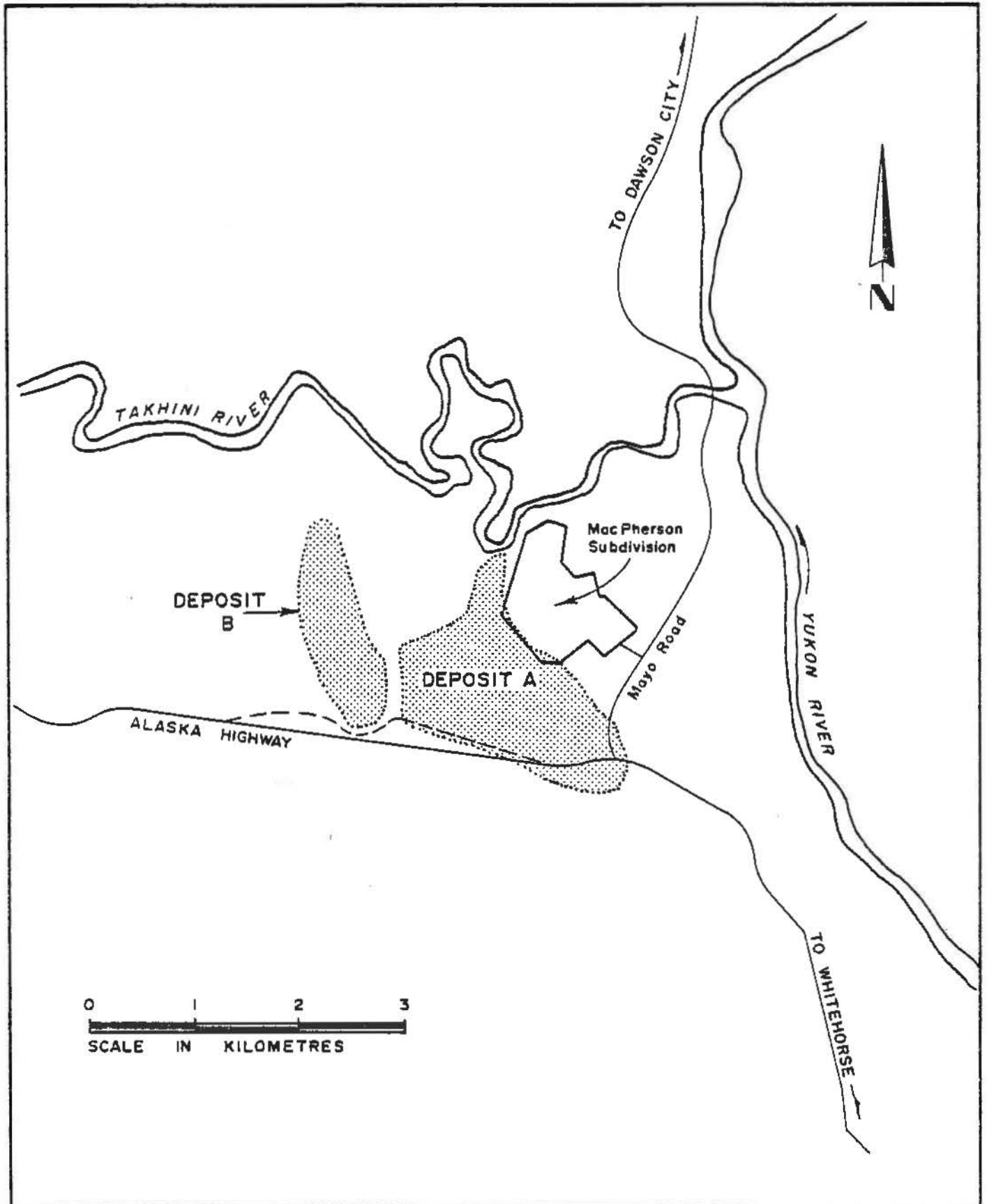
The geology and topographic setting suggest that the deposit may be up to 40 meters thick. Additional deep exploratory drilling is recommended to determine the actual thickness of the deposits.



Laboratory testing was carried out on samples obtained in the test pitting program. The results indicate that the gravel is variable in composition and varies from good quality concrete aggregate over most of the area to fair quality concrete aggregate on exposed south facing slopes where gravel particles are partially covered with calcite coatings. The gravel contains significant percentages of minerals which are potentially alkali reactive. Some alkali reaction testing is recommended.

The sand from the gravelly layers in the deposit appears to be of suitable size gradation and mineralogy for concrete sand. Large volumes of clean sand are also available for blending purposes.

Since there is no apparent reliable water source for washing operations in the immediate vicinity, a water supply investigation is recommended.



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**WHITEHORSE GRAVEL SURVEY  
 SITE LOCATION MAP**

SCALE _____	DATE _____	MADE _____	CHKD. _____	JOB: B-4321	FIG. 1
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### 3.0 PRELIMINARY STUDIES

Airphoto interpretation was used to define the limits of the designated deposit, hereafter referred to as Area A, and to lay out the area to be covered by the geophysical surveys. During this study, a second deposit, (Area B) was discovered. Because Area A is adjacent to the McPherson subdivision it was decided to investigate Area B also, although not to the same level of detail.

Both areas are mapped on existing surficial geology maps as hummocky glaciofluvial terraces.

The airphoto study indicated that there is no shortage of potential granular material in this general area. There is a potential gravel deposit due north of Area B between Area B and the Takhini River. Another potential gravel deposit occurs approximately 1.2 km west of Area B on the north side of the Alaska Highway.



#### 4.0 GEOLOGY

Deposits A and B are ice-contact glaciofluvial terraces with numerous kettleholes in the central area reflecting deposition of sediments on stagnant ice. Such deposits usually have complex stratification and contain lenses of coarse gravel separated by lenses of clean sand. This type of deposit usually contains silt layers and the sporadic occurrence of these silt layers should be expected in development of these areas for gravel extraction. In fact, silty layers up to 0.1 m thick were encountered in at least one test pit.

The schematic profile showing abbreviated test pit logs (Figure 14) illustrates the complex stratification in deposit A. Note that it is difficult to correlate strata between test pits due to the complex stratification and fairly wide spacing of test pits.

The significance of this complex stratification for gravel extraction planning is that it will be difficult to carry out selective mining operations. That is, it will be difficult to follow specific horizons of coarse material because they are expected to swell or pinch out over fairly short distances. It will probably be necessary to excavate the gravel and sand layers together and screen out the coarse aggregate. The stratigraphy of Area B is expected to be similar.



## 5.0 ELECTRICAL RESISTIVITY

### 5.1 INTRODUCTION

Because of the large area covered by the deposits, geophysical surveys were carried out on a surveyed grid to evaluate the two areas. The objectives of the geophysical surveys were to delineate the areal extent and depth of the deposit and to determine the thickness of overburden and variation in quality of granular material.

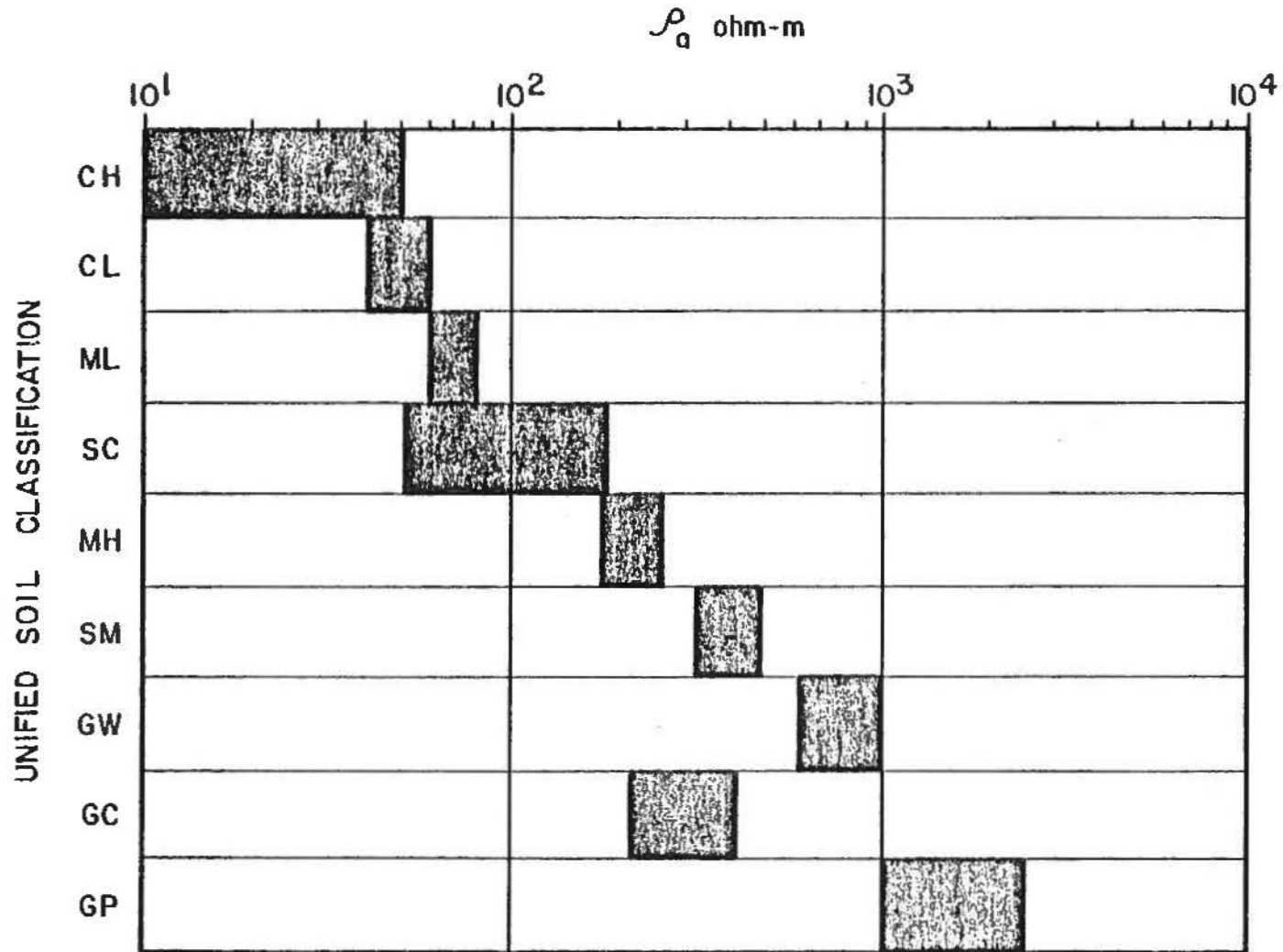
The geophysical field surveys were conducted from August 28, 1978, to September 2, 1978, by a three man crew.

### 5.2 PRINCIPLES OF ELECTROMAGNETIC RESISTIVITY

#### 5.2.1 Electrical Resistivity and Soil Type

Soil types differ in their values of electrical resistivity. The relationship between the soil types of the unified soil classification system and ranges of electrical resistivity is shown in Figure 2. The dominant soil parameter influencing resistivity is the amount of clay size material while other factors such as water content and density affect resistivity in a minor way. Figure 2 shows that ranges of electrical resistivity of different soil types may overlap but that granular materials can easily be distinguished from silts and clays.

The resistivity of the bedrock was determined in this area by taking readings on nearby bedrock outcrops. There is some overlap in the values of resistivity between



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RESISTIVITY RANGE VERSUS SOIL TYPES  
CITY OF WHITEHORSE  
GRAVEL SURVEY

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FIG. 2

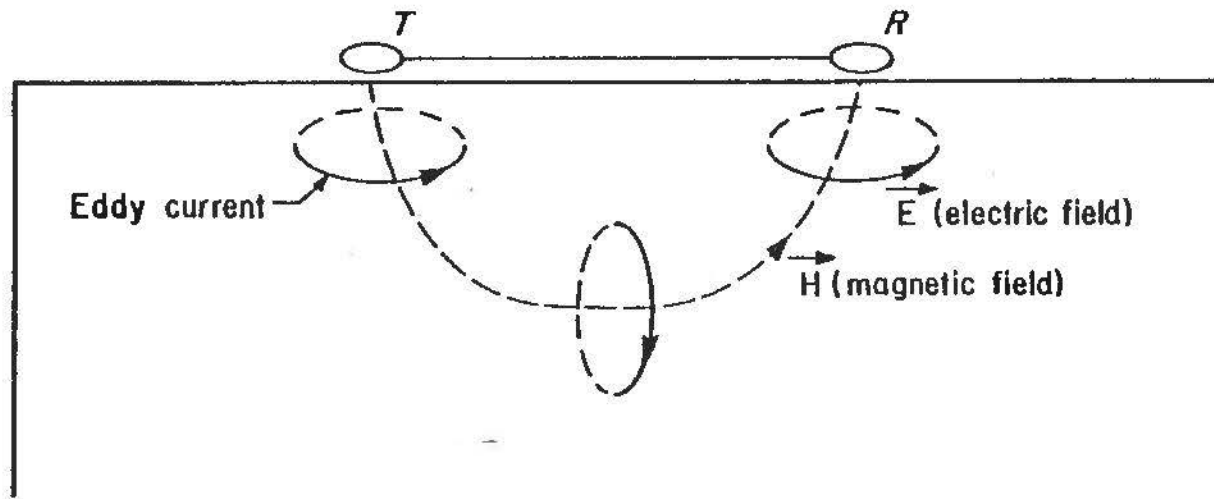


sand, gravel and bedrock but in general the bedrock can be distinguished by its higher resistivity.

### 5.2.2 Methods for Measuring Electrical Resistivity

There are several methods available to measure the resistivity of subsurface strata from surface determinations. A combination of galvanic and magnetic induction methods were selected for the survey at Whitehorse. The magnetic induction methods were selected for their high productivity of surveying.

In magnetic induction methods, a transmitter loop antenna induces small eddy currents to flow in the ground (see Figure 3). These eddy currents in turn cause a secondary electromagnetic field to form and the receiver loop measures the phase and amplitude of that secondary field. For the survey instruments employed, the effective depths of exploration are determined mainly by the separation distance of the transmitter and receiver antenna. For the Geonics EM31 (Figure 4) and the Geonics EM34 (Figure 5) the effective depth of exploration is 7 and 20 m respectively. By taking measurements with both instruments over the same survey lines the ground is explored (sampled) to different depths and, by comparing results of both instruments, an interpretation of subsurface stratification often can be made. When ground is uniform in resistivity with depth, the instrument measures

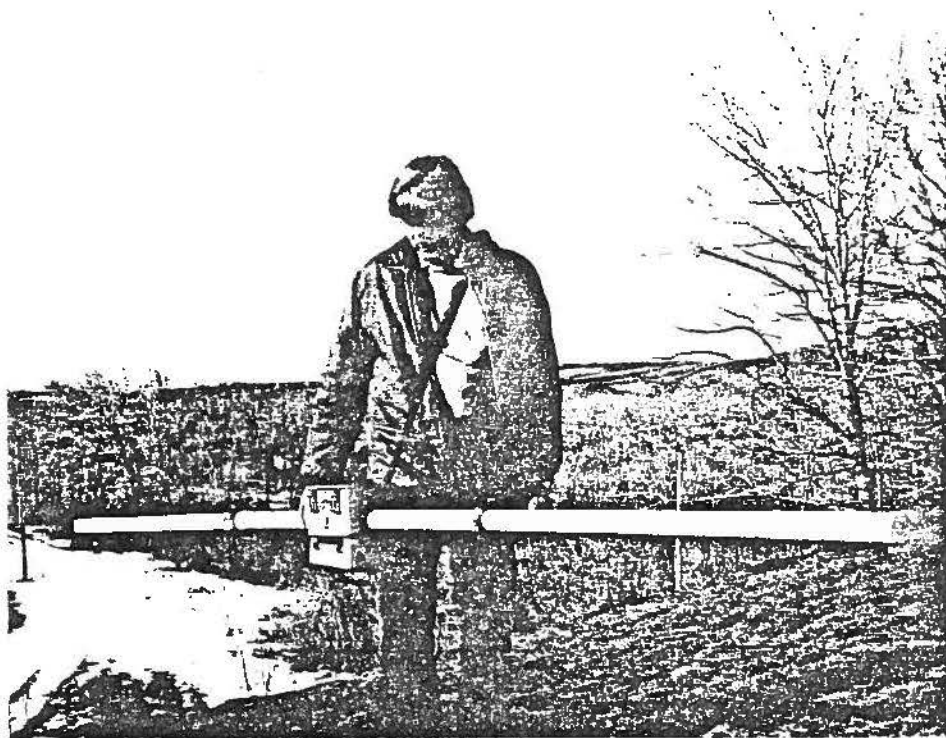


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SCHEMATIC PRINCIPLE - MAGNETIC INDUCTION  
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FIG. 3



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PHOTOGRAPH OF GEONICS EM 31  
CITY OF WHITEHORSE  
GRAVEL SURVEY

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FIG. 4



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PHOTOGRAPH OF GEONICS EM 34  
CITY OF WHITEHORSE  
GRAVEL SURVEY

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FIG. 5



the true ground resistivity. In stratified ground, each subsurface layer within the effective depth of exploration of the instrument influences the reading made at the surface. The contribution of each layer to the apparent resistivity measured follows known mathematical relationships.

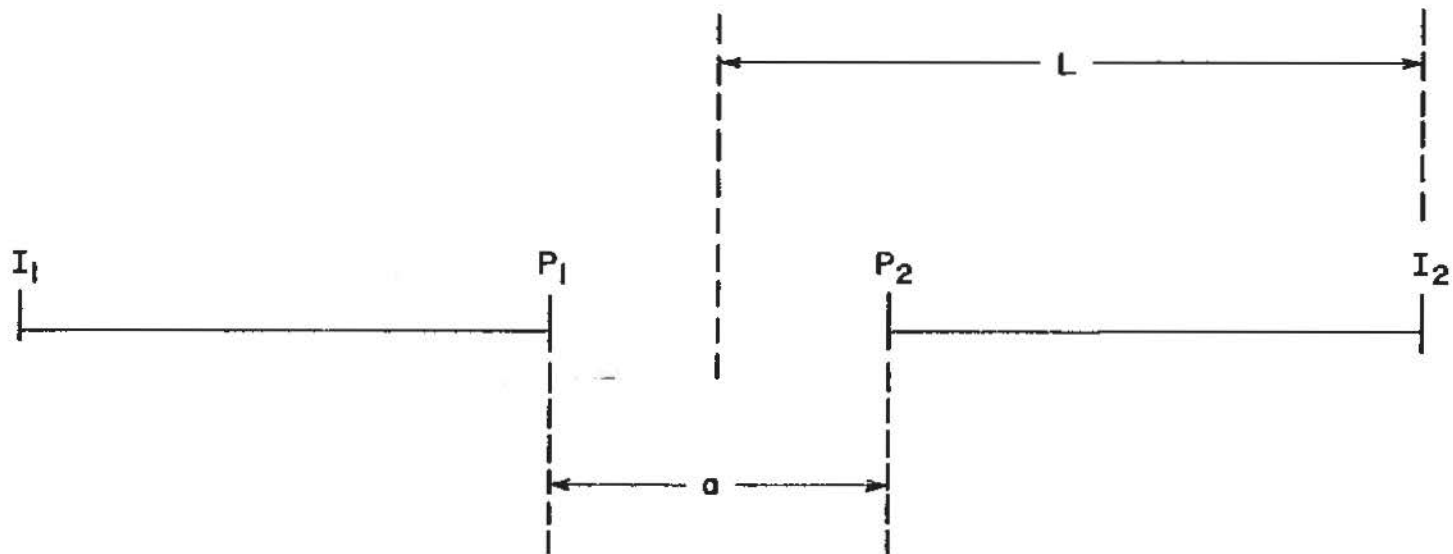
The galvanic (or 4-probe) method was selected to aid in the determination of the depth of the granular materials. In the galvanic method, current is driven into the ground between the two outer probes ( $I_1$  and  $I_2$ ) and the induced voltage is measured between the two inner probes ( $P_1$  and  $P_2$ ) (Figure 6). By enlarging the spacing between the current probes, the depth of exploration is increased. An interpretation of subsurface stratification is made by varying the probe spacings.

### 5.3 DATA ACQUISITION

Geophysical measurements were carried out on the surveyed lines shown on Figure 15 (in pocket).

Lines 1 to 15 were surveyed and flagged at 25 m intervals by Hosford, Impey, and Welter of Whitehorse. Lines B1 to B9 were surveyed with a compass and hip chain by the geophysical crew and these lines were also flagged at 25 m intervals.

The geophysical crew consisted of three men, two geophysical technicians and one local labourer. The geophysical



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GRAVEL SURVEY  
SCHLUMBERGER ELECTRODE CONFIGURATION**

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Figure 6



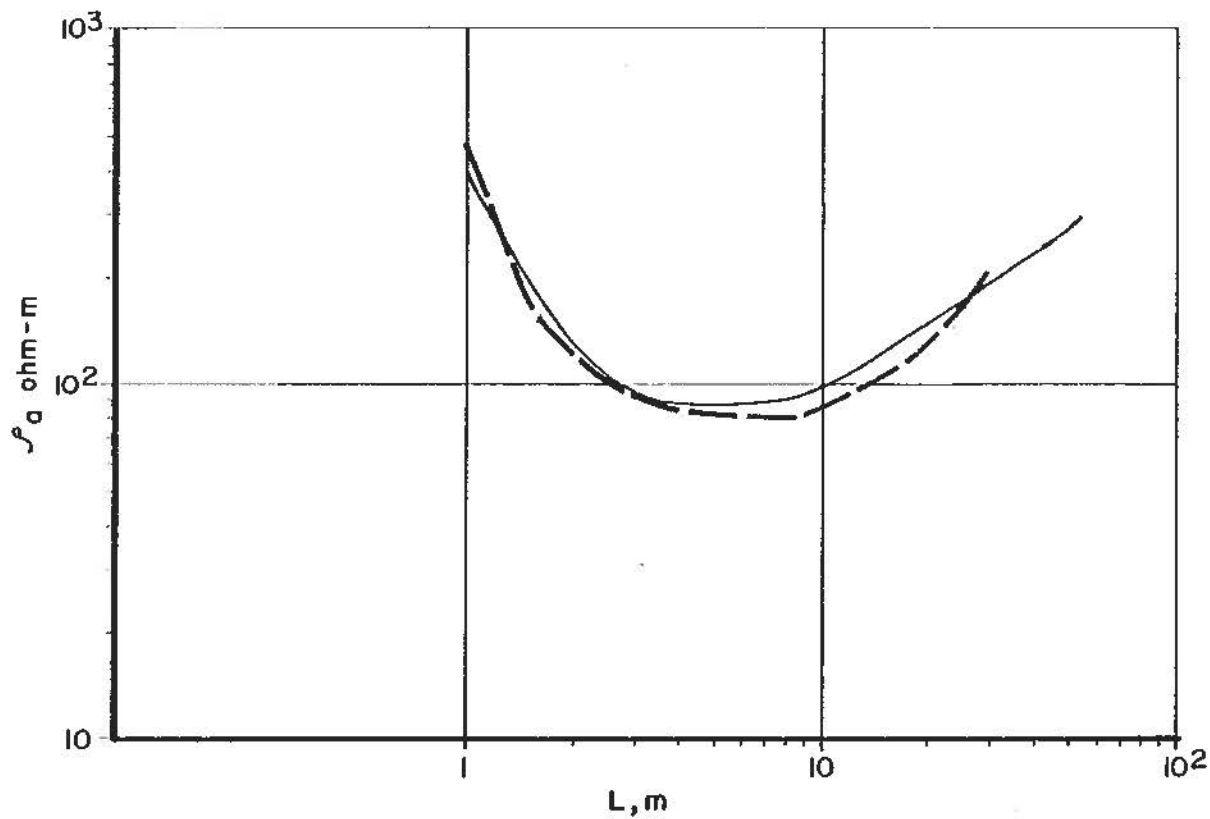
survey was started on August 28, 1978, and was completed on September 2, 1978.

Three types of measurements were made:

- a) measurements with the Geonics EM31 with readings taken along each line at intervals of 12.5 m
- b) measurements with the Geonics EM34 with readings taken along each line at intervals of 25 m
- c) measurements with the galvanic method with readings taken at specific locations based on the results obtained with the Geonics EM31 and the Geonics EM34. The locations of these measurements are shown on Figure 15.

#### 5.4 DATA PROCESSING

The readings with the Geonics EM31 and EM34 are converted to apparent resistivity by use of simple calibration charts. The values of apparent resistivity measured were plotted along the survey lines and the data was subsequently contoured. The contour resistivity maps for the Geonics EM31 and EM34 are shown in Figures 7 and 8 respectively (in map pocket). To amplify the significance and detail available from the geophysical surveys, resistivity line profiles along lines 3, 6 and 9 are shown in Figures 9, 10 and 11.



$d_1 = 0.5 \text{ m}$   $\rho_1 = 500 \text{ ohm-m}$  sand

$d_2 = 9.0 \text{ m}$   $\rho_2 = 80 \text{ ohm-m}$  silt

$d_3 = 100.0 \text{ m}$   $\rho_3 = 750 \text{ ohm-m}$  gravel

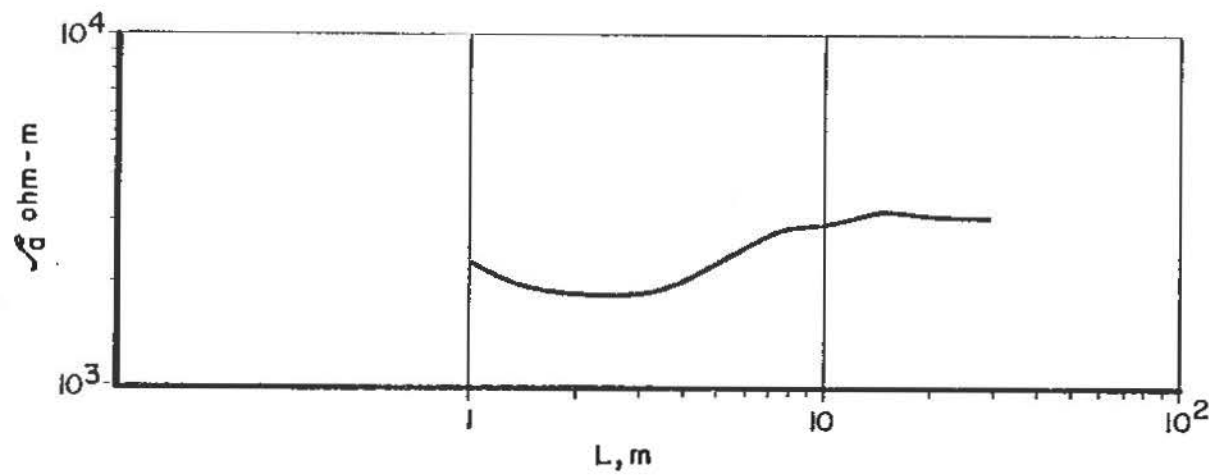


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GRAVEL SURVEY  
VERTICAL SOUNDING (GALVANIC)  
LINE 6 STATION 8+37.5

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Figure 12



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**CITY OF WHITEHORSE  
 GRAVEL SURVEY  
 VERTICAL SOUNDING (GALVANIC)  
 LINE 9 STATION 6+75**

No. B 4321

Figure 13



Typical results with the galvanic method are shown in Figures 12 and 13. To determine the resistivity stratification of the subsurface from this data, computer models are fitted to the experimental data. The dashed lines on Figure 12 represent the computer model, the points represent the experimental data. The resistivity stratification giving the best fit is also shown on Figure 12.

## 5.5 DATA INTERPRETATION

### 5.5.1 Depth of Overburden

Two types of overburden appear to overlay the gravel deposit in the surveyed area:

- a) An overburden of organic and fine material. This overburden is recognized by lower readings with the EM31 than with the EM34. This type of overburden is mainly found at the perimeter of the surveyed area. On the basis of computation it is expected that an apparent resistivity less than 150 ohm-metres is indicative of overburden thickness greater than 1 m. The thickness of overburden increases with decreasing values of resistivity. The areas of organic and fine grained overburden are shown on the contour resistivity map of the EM31 in Figure 7. The overburden thickens away from the centre of the deposit as shown on the profile in Figure 10.



- b) An overburden of dry sands. This overburden is recognized by higher readings with the EM31 than with the EM34, because dry sands have very high resistivities. This type of overburden is found in localized areas shown on the contour resistivity map of the EM31 in Figure 7.

#### 5.5.2 Depth to Bedrock

Bedrock is expected within 10 m of the surface in the vicinity of the junction of the Klondike and Alaska Highways on lines 2, 3 and 4 (see Figure 8 for location). Readings were taken with the EM31 over bedrock outcrops to establish the resistivity of the bedrock. The bedrock is recognized by higher values of resistivity for the instrument with the greater depth of exploration (EM34). Since the shallow looking instrument (EM31) varies only slightly in this area, it appears that the bedrock is overlain by 5 to 10 m of gravel. The depth to bedrock in the rest of the area covered by geophysical surveys is expected to be greater than 20 m.

#### 5.5.3 Depth of Gravel

In most areas, the EM31 and the EM34 readings are similar indicating uniform material within the effective depths of exploration for the instruments (see Figure 9 in pocket). The depth of gravel and sand appears to be less



than 20 m only in the area of relatively shallow bedrock (see Figure 8). Figure 13 illustrates the results obtained with the galvanic method at station 6+95 on Line 9. The resistivity is uniform with depth indicating gravel over the entire depth of exploration (20 m).

#### 5.6 CONCLUSIONS OF GEOPHYSICAL INTERPRETATIONS

The contour resistivity maps produced from the geophysical surveys show that an extensive area has been interpreted as gravel in excess of 20 m. The resistivity high anomalies with the EM31 were interpreted as sand while the resistivity high anomalies with the EM34 were interpreted as bedrock. Over most of the area, subsurface conditions are expected to be relatively uniform with very little variation in the percentage of fines in the gravel.



## 6.0 TEST PITTING

Test pitting operations were carried out from October 11 to October 14, 1978. Test pitting was initially attempted with a large track-mounted backhoe with a 6 m depth capability but, due to equipment breakdowns, a smaller backhoe was used to complete the testing program.

Thirteen test pits were dug to an average depth of 5 or 6 m. In two locations it was possible to expose up to 10 m of sand and gravel by cleaning off a fresh face in an existing borrow pit and then excavating a hole in the floor of the borrow pit. The test pit logs are included in Appendix A. Several holes were dug with a shovel in Area B to confirm the presence of granular materials.

Because of kettleholes and other terrain irregularities, it was possible to sample different horizons within the deposit (see Figure 14 in pocket). It appears there are several alternating layers of gravel and clean sand. The central portion of deposit A on grid lines 6 to 13 appears to contain the coarsest material.

In general, the test pit data correlates extremely well with the geophysical interpretations. The central area of the deposit was found to be mainly gravel and sand with very little silt or organic overburden. Test Pit 11 shows that the dry sand overburden may be more extensive than the areas indicated on Figure 7 from geophysical predictions.



## 7.0 QUALITY OF MATERIALS

### 7.1 Gravel

As can be seen from the sieve analyses and petrographic analyses in Appendix B, the gravel in Area A is suitable for concrete aggregate. Most of the gravel is good quality concrete aggregate but, on the south facing slopes and exposed high areas with little vegetation, calcite coatings on the gravel particles are common and the gravel is rated as fair quality aggregate (e.g. hole #2, and #5). These calcite coatings are believed to be caused by excessive evaporation of pore water from the exposed areas, particularly south-facing slopes. The zone of calcite coatings is expected to be several metres thick in these exposed areas. It is recommended that calcite coated gravel from these exposed areas not be used for concrete where structural strength and durability is required because of potential poor bonding properties.

The petrographic analyses reveal significant percentages of volcanics, fine-grained andesites, and amorphous quartzite. These minerals are potentially reactive with high alkali cement. Often, the use of low alkali cement will prevent alkali reaction problems with these minerals. However, it is recommended that alkali reaction testing be undertaken with the cement mixture most commonly used by contractors in Whitehorse. Crushed aggregate samples have been retained for this purpose.



Los Angeles abrasion tests, summarized in Appendix B, indicate that the coarse aggregate is resistant to abrasion and is suitable for either asphalt or concrete pavement.

#### 7.2 Sand

The sand from the gravelly layers appears to be of suitable mineralogy for concrete sand. In some samples, the grain size distribution fell within the specifications for concrete sand (see grain size curves, Appendix B). In addition, large quantities of clean sand of various grain sizes are available for blending to reach optimum grain size distribution.



## 8.0 QUANTITY OF GRANULAR MATERIALS

The following table summarizes the estimated quantities of granular materials in Area A based on geophysical surveys and test pit data. The quantities for Area B were estimated on the assumption that the stratigraphy is similar to that of Area A. With the equipment available at the time of the test pitting program, it was not possible to dig test pits in Area B except for #7 and #8 which are located on existing access trails. These two holes are not representative of Area B as field reconnaissance and shallow hand excavated holes indicate most of Area B is gravel (see Holes #15, 16, 17).

It is recommended that some test pitting or test drilling be attempted in this area when snow cover will enable easier access.

For purposes of quantity calculations, the minimum depth of gravel and sand in the two deposits is 20 m, i.e. the minimum depth indicated by the geophysical surveys. However, the geology and topographic setting suggest that the gravel and sand may be up to 40 m thick. Deep drill holes are recommended to determine the actual thickness of these deposits.



TABLE I  
Quantity of Granular Materials

AREA A

Surface Area: 200 hectares (492 acres)

Thickness: More than 20 m of gravel and sand\*

Estimated minimum volume of pit run gravel is 26 million cubic meters, of which 17.7 million cubic meters is coarse aggregate.

Estimated minimum volume of clean sand is 14 million cubic meters.

Total volume of gravel and sand: More than 40 million cubic meters (52 million cubic yards).

AREA B

Surface Area: 80 hectares (198 acres)

Thickness: More than 20 m of gravel and sand\*

Estimated minimum volume of pit run gravel is 10.4 million cubic meters, of which 7 million cubic meters is expected to be coarse aggregate.

Estimated minimum volume of clean sand is 5.6 million cubic meters.

Total volume of gravel and sand: More than 16 million cubic meters (21 million cubic yards).

\*The thickness used for calculation purposes is the minimum thickness as defined by geophysical surveys, and calculated volumes are minimum quantities. The geology and topographic setting suggest that the total thickness of each area could be 40 meters.



9.0 CONCLUSIONS

1. Area A and Area B are extensive deposits of gravel and sand. The gravel appears to be suitable for both concrete aggregate and asphalt aggregate. The sand appears to be suitable for concrete sand and general fill. Quantity estimates are included in section 8.0 of this report.



## 10.0 RECOMMENDATIONS

1. Deep drill holes are recommended in both Area A and Area B to determine the full thickness of the gravel and sand deposits. A minimum of two drill holes in each area would be required.

Alternatively, test pit sampling of the lower strata beyond the penetration depth of the resistivity surveys and test pits in this report (20 m) could be carried out after extraction of the upper layers of gravel and sand.

2. Test pitting plus laboratory testing of samples is recommended to more accurately determine the quality of materials available in Area B. This activity would be best attempted when snow cover will enable easier access on track-mounted vehicles.

3. The gravel contains a significant percentage of minerals that are potentially alkali reactive. It is recommended that alkali reaction testing be undertaken with the cement mixture most commonly used by contractors in Whitehorse. Crushed aggregate samples have been retained for this purpose.

4. There is no apparent reliable water source at either area to facilitate washing operations. It is recommended that a search for a reliable water source (ground-



water or piped surface water) be carried out. The Takhini River is a short distance from the north end of Area A but pumping operations would be required to handle a vertical lift of more than 80 m.

Respectfully submitted,  
HARDY ASSOCIATES (1978) LTD.,

Per:

J. Rennie, P.Geol.

JR:ngs



APPENDIX A  
Test Hole Logs



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**LOG OF TEST HOLE 1**

PROJECT Whitehorse Gravel Survey

PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct. 11/78

TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_

END \_\_\_\_\_ TYPE OF DRILLING Test Pit.

DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe

RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO	TYPE, COMPOSITION, CONSIST./REL. DEN., STRUCTURE PLASTICITY, COLOUR, INCLUSIONS, WATER, ETC.	TYPE	FROM - TO ( M )	N or Recov.
			Highway Cut.			
0		.3	SILT, trace sand, nonplastic, dry tan, roots.			
0.3		0.6	GRAVEL, sandy, trace silt, cemented, 50% > # 4, pebbles to 75 mm			
0.6		1.0	GRAVEL & SILT, 30 % > #4, pebbles to 100 mm light brown.			
1.0		3.0	GRAVEL, sandy trace silt, cemented, 70%-80% >#4, pebbles to 200 mm, subrounded, some silty sand, light grey.			
			END OF HOLE@ 3.0 m	X	2.5	
			Photos taken			



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# LOG OF TEST HOLE 2

PROJECT Whitehorse Gravel Survey

PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct. 11/78

TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_

END \_\_\_\_\_ TYPE OF DRILLING Test Pit. =

DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe

RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO ( M )	N or Recov.
0		0.3	SILT, nonplastic, dry tan.			
0.3		5	GRAVEL & SAND, 60% >#4 pebbles to 150 mm, coarse sand, clean	X X X	1.0 3.0	
5		10	SAND, coarse, 20% gravel sizes clean, brown possible concrete sand.			
NOTE: Existing exposure at the top of the deposit.						



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# LOG OF TEST HOLE 3

PROJECT Whitehorse Gravel Survey  
 PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct. 12/78  
 TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
 END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
 DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe  
 RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO	N or Recov.
0		0.5	COBBLES & SILT, 30% >#4 Gap graded cobbles not touching, cobbles approx. 200 mm.			
0.5		1.5	GRAVEL, sandy, well graded to 100 mm, cemented.			
1.5		7.0	SAND, very coarse grained, layered with 50 mm gravel, well graded (photos)	X	4.0	
6.0		7.0	COARSE SAND, no pebbles			
7.0		10	SAND, fine grained, uniform, brown.  END HOLE 10m  NOTE: existing borrow pit face plus test pit in pit bottom.			



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LOG OF TEST HOLE 4

PROJECT Whitehorse Gravel Survey

PROJECT NO. B4324 PROJECT ENG. J.R. DATE Oct. 12/78

TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_

END \_\_\_\_\_ TYPE OF DRILLING Test Pit

DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe

RECORDER AN DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO	TYPE, COMPOSITION, CONSIST./REL. DEN., STRUCTURE PLASTICITY, COLOUR, INCLUSIONS, WATER, ETC.	TYPE	FROM - TO ( M )	N or Recov.
0		0.5	GRAVEL, silty, sandy 50% >#4 dry.			
0.5		2.5	GRAVEL, sandy (coarse), 70% >#4 cobbles to 150mm, wellgraded dense.	X	1.0 - 1.5	
2.5		3.5	GRAVEL coarse cobbles to 500 mm, 80% >25mm dense, dry.			
3.5		6.0	GRAVEL, coarse sand, well graded 70% >#4 cobbles to 150 mm, dense, dry.			
			HOLE COLLAPSED @ 6M, Photos.			



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# LOG OF TEST HOLE 5

PROJECT Whitehorse Gravel Survey

PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct 13/78

TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_

END \_\_\_\_\_ TYPE OF DRILLING Test Pit.

DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe.

RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO ( M )	N or Recov.
0		2	GRAVEL, well graded, sandy, cobbles to 100 mm. occasionally larger, dense.	X	1.5	
2		3	coarse SAND lense, gravelly			
3		5	GRAVEL, coarse, very dense, to 200 mm very sandy (fine grained)			
5		6	SAND & GRAVEL, gap graded, 300 mm cobbles & fine grained sand	X	6.0	
			END HOLE @ 6.0 m			



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**LOG OF TEST HOLE 6**

PROJECT Whitehorse Gravel Survey  
PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct 13/78  
TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe  
RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS (M)			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO (M)	N or Recov.
0		0.5	SILT, occasional cobble, dry, light brown			
0.5		1.5	GRAVEL, max 100 mm, some sand well graded.	X	0.5-1.0	
1.5		2.0	Cobbly GRAVEL to 500 mm size			
2.0		2.5	SAND & GRAVEL, max 50 mm, grey, wellgraded clean.	X	2.0	
			Photos			
			END OF HOLE @ 2.5 m			



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## LOG OF TEST HOLE 7

PROJECT Whitehorse Gravel Survey  
PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct. 14/78  
TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe  
RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO ( M )	N or Recov.
0		1	SAND, fine, clean, uniform, brown, compact.			
1		3	SAND, medium, clean uniform.  No sample or photos  END OF HOLE @ 3.0m			



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**LOG OF TEST HOLE** 8

PROJECT Whitehorse Gravel Survey  
 PROJECT NO. B4321 PROJECT ENG. J.P. DATE Oct. 14/78  
 TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
 END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
 DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe  
 RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO	TYPE, COMPOSITION, CONSIST./REL. DEN., STRUCTURE PLASTICITY, COLOUR, INCLUSIONS, WATER, ETC.	TYPE	FROM - TO ( M )	N or Recov.
0		1	SAND, fine grained, clean, uniform, brown.			
1		4	SAND, fine grained, clean, uniform, grey.			
4		4.5	CLAY, high plastic, no sand, no silt, light grey, wet, (free water).  No photo or sample  END OF HOLE @ 4.5m			



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**LOG OF TEST HOLE 9**

PROJECT Whitehorse Gravel Survey  
 PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct. 14/78  
 TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
 END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
 DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe  
 RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO ( M )	N or Recov.
0		0.2	SILT, dry, brown.			
0.2		3.0	GRAVEL, well graded, fully rounded sandy, max 100 mm  HOLE WILL NOT STAND Sample & Photos  END OF HOLE @ 3.0 m due to collapsing.	X	1.0	



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**LOG OF TEST HOLE 10**

PROJECT Whitehorse Gravel Survey  
 PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct. 14/78  
 TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
 END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
 DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe  
 RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO ( M )	N or Recov.
0		.2	SILT			
.2		.8	GRAVEL, well graded, sandy, trace silt max 50 mm, dense, brown			
.8		1.0	Coarse Grey SAND, clean			
1.0		2.5	GRAVEL, coarse, gap graded max 200 mm, grey, very sandy occasional cobble to 400 mm.			
	2.0					
2.5		3.0	Coarse grey clean SAND, uniform.			
3.0		3.5	Medium grey clean SAND, uniform.			
3.5		4.0	Fine grey clean SAND, uniform.			
4.0		4.2	Very fine, light grey clean SAND.			
			HOLE END @ 4.2m			



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CONSULTING ENGINEERING & TESTING

# LOG OF TEST HOLE 11

PROJECT Whithorse Gravel Survey  
 PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct. 14/78  
 TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
 END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
 DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe  
 RECORDER .AN. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO ( M )	N or Recov.
0		0.5	SAND & GRAVEL, silty max 100 mm			
0.5		2.5	SAND, fine grained, grey compact, clean.			
2.5		4.0	GRAVEL, coarse, max 200 mm, coarse sand, well graded, dense			
	3.5	4.0	Very sandy, dry.  Photos taken  END OF HOLE @ 4.0 m			



**R.M.HARDY & ASSOCIATES LTD.**

CONSULTING ENGINEERING & TESTING

# LOG OF TEST HOLE 12

PROJECT Whitehorse Gravel Survey  
 PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct. 14/78  
 TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
 END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
 DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe  
 RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO (M)	N or Recov.
0		0.2	SILT.			
0.2		3.0	GRAVEL, coarse, gap graded to 150 mm			
3.0		3.1	Thin clayey silty layer.			
3.1		3.5	Coarse SAND, clean.			
3.5		4.5	GRAVEL, max 50 mm, grey, very sandy,			
4.5		6.0	Probably gravel, section is hidden.			
6.0		8.0	SAND, med grained, clean, grey, uniform.			
			NOTE: Existing pit face plus additional test pit in pit bottom.			
			END OF HOLE @ 8.0 m			



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# LOG OF TEST HOLE 13

PROJECT Whithorse Gravel Survey  
PROJECT NO. B4321 PROJECT ENG. J.P. DATE Oct. 14/78  
TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe  
RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO ( M )	N or Recov.
0		4	GRAVEL, very coarse, to 300 mm silty, sandy, sub rounded, dry.  No photos or samples Hole stood vertical (Particles layered).  END OF HOLE @ 4.0 m,			



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CONSULTING ENGINEERING & TESTING

# LOG OF TEST HOLE 14

PROJECT Whitehorse Gravel Survey  
PROJECT NO. B4321 PROJECT ENG. J.R. DATE Oct. 14/78  
TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
DRILLING CONTRACTOR \_\_\_\_\_ RIG Backhoe  
RECORDER A.N. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO ( M )	N or Recov.
0		0.5	SILT & COBBLES.			
0.5		1.5	SAND, fine grained clean, uniform grey.			
1.5		9	GRAVEL, to 100 mm, gap graded, coarse sand, rounded			
	7.5	9	Coarser to 200 mm.			
			Hole would not stand vertical, sloughing occurred.			
			NOTE: Existing pit face plus test pit in pit bottom.			
			END OF HOLE @ 9.0 m.			



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**LOG OF TEST HOLE 15**

PROJECT Whitehorse Gravel Survey  
 PROJECT NO. B-4321 PROJECT ENG. J.R. DATE Nov. 1, 1978  
 TIME: START \_\_\_\_\_ LOCATION Alaska Hwy & Mayo Road  
 END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
 DRILLING CONTRACTOR \_\_\_\_\_ RIG Shovel  
 RECORDER J.R. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO ( M )	N or Recov.
0		0.5	GRAVEL, silty, trace coarse sand.  Gravel is 5 mm to 80 mm.  END OF HOLE @ 0.5 m  NOTE: Representative of entire slope 20 m high.			



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## LOG OF TEST HOLE 16

PROJECT Whitehorse Gravel Survey  
PROJECT NO. B-4321 PROJECT ENG. J.R. DATE Nov. 1, 1978  
TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
DRILLING CONTRACTOR \_\_\_\_\_ RIG Shovel  
RECORDER J.R. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS ( M )			SOIL DESCRIPTION and REMARKS	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO ( M )	N or Recov.
0		0.3	SAND, Coarse, some fine gravel, silty. Frost penetration makes digging difficult.  NOTE: Representative of most of the area between #15 and #17.			



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## LOG OF TEST HOLE 17

PROJECT Whitehorse Gravel Survey  
PROJECT NO. \_\_\_\_\_ PROJECT ENG. J.R. DATE Nov. 1, 1978  
TIME: START \_\_\_\_\_ LOCATION \_\_\_\_\_  
END \_\_\_\_\_ TYPE OF DRILLING Test Pit  
DRILLING CONTRACTOR \_\_\_\_\_ RIG Shovel  
RECORDER J.R. DATUM \_\_\_\_\_ SURFACE ELEV. \_\_\_\_\_

DEPTHS (M )			SOIL DESCRIPTION and REMARKS TYPE, COMPOSITION, CONSIST./REL. DEN., STRUCTURE PLASTICITY, COLOUR, INCLUSIONS, WATER, ETC.	SAMPLING		
FROM	AT	TO		TYPE	FROM - TO (M )	N or Recov.
0		0.6	GRAVEL, some coarse sand, silty from 0 to 0.4 m. Gravel is 5 mm to 100 mm.  NOTE: Representative of entire slope 35 metres high.	X	0.3-0.6	



APPENDIX B

Laboratory Test Results

# SUMMARY OF LABORATORY TEST DATA FOR SUITABILITY OF AGGREGATES

## SODIUM SULPHATE SOUNDNESS ASTM C-88, 5 CYCLES

Sample	% Loss Coarse Aggregate	% Loss Fine Aggregate	Evaluation
#2 @ 3.0 m	1.117 %	3.614 %	Good quality for concrete aggregate. (Acceptable limit is usually 8 %)
#3 @ 4.0 m	0.178 %	2.928 %	
#5 @ 1.5 m	0.732 %	3.468 %	
#6 @ 0.5 m	0.352 %	2.374 %	
#9 @ 1.0 m	0.874 %	4.110 %	

## SPECIFIC GRAVITY AND ABSORPTION ASTM C127

Sample	Material	Coarse Aggregate		Fine Aggregate	
		Specific Gravity/SSD	% Absorption	Specific Gravity/SSD	% Absorption
#2 @ 3.0 m	Gravel	2.71	0.85 %	2.58	2.47 %
#3 @ 4.0 m	Gravel	2.70	0.67 %	2.64	1.04 %
#5 @ 1.5 m	Gravel	2.70	0.78 %	2.63	1.69 %
#6 @ 0.5 m	Gravel	2.74	0.81 %	2.63	1.46 %
#9 @ 1.0 m	Gravel	2.68	0.96 %	2.60	1.76 %

## LIGHT WEIGHT PIECES ASTM C123

Sample	Material	% Light Weight Pieces
#2 @ 3.0 m	Gravel	0.17 %
#3 @ 4.0 m	Gravel	0.05 %
#5 @ 1.5 m	Gravel	0.03 %
#6 @ 0.5 m	Gravel	0.15 %
#9 @ 1.0 m	Gravel	0.15 %

## LOS ANGELES ABRASION TEST ASTM C131, GRADING "B"

Sample	% Loss	Evaluation
#2 @ 3.0 m	15.7 %	Good aggregate for either concrete or asphalt (Acceptable limit for concrete is usually 40 %)
#5 @ 1.5 m	15.2 %	
#6 @ 0.5 m	12.9 %	



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CONSULTING ENGINEERING AND PROFESSIONAL SERVICES

B4321

WHITEHORSE GRAVEL SURVEY

# SUMMARY OF LABORATORY TEST DATA FOR SUITABILITY OF AGGREGATES


## SPECIFIC GRAVITY AND ABSORPTION ASTM C127

Sample	Material	Coarse Aggregate		Fine Aggregate	
		Specific Gravity	SSD Absorption %	Specific Gravity	SSD Absorption %
#7 @ 1.0 m	Sand	NA	NA	2.60	1.20%





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WHITEHORSE GRAVEL SURVEY

B4321



# PETROGRAPHIC ANALYSIS

**COARSE AGGREGATE:** Crushed, #4 Sieve to +1" sizes after crushing

ROCK TYPE	CLASSIFICATION	TOTAL WEIGHTED COMPONENT %
Quartz, Quartzite, Quartz Sandstone	GOOD, but 25% of particles have a CaCO <sub>3</sub> coating on one side. This is largely responsible for the high PN number	42.7
Granite, Syenite, Gneiss		18.4
Hard Metamorphic Sediments		18.4
Basalt & Gabbro		9.7
Diorite & Andesite		5.3
Hard Carbonates		2.7
Hard Volcanics		0.4
-----		
Weathered Syenite, Granite	FAIR	0.9
Med. Hard Schist		0.4
Med. Hard Carbonate		0.1
-----		
Soft Schist	POOR	0.4
-----		
PN = 123.6	INTERPRETATION: Fair Quality Aggregate	100.0

**FINE AGGREGATE:** #100 sieve to #4 sieve

ROCK TYPE	CLASSIFICATION	TOTAL WEIGHTED COMPONENT %
Quartz, Quarzite, Quartz Sandstone )	GOOD	80 (approx.)
Feldspar, Granite, Gneiss )		
Basalt, Diorite & Metamorphics		16 (approx.)
Hard Carbonates		4 (approx.)
-----		
Micas, Soft Schist		trace
-----		
PN = less than 105	INTERPRETATION: Good Quality Concrete Sand	100.0



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WHITEHORSE GRAVEL SURVEY

PROSPECT NO.  
TEST PIT NO. 2 @ 3.0 m  
SAMPLE NO.

PROJECT NO. B-4321



# PETROGRAPHIC ANALYSIS

COARSE AGGREGATE: Crushed, #4 sieve to +1" sizes after crushing

ROCK TYPE	CLASSIFICATION	TOTAL WEIGHTED COMPONENT %
Granite, Syenite, Gneiss	GOOD	36.8
Metamorphic Quartzites, Sandstone, etc.		16.5
Diorite & Andesite		10.5
Quartz, Quartzite, Quartz Sandstone		7.7
Basalt & Gabbro		6.2
Hard Volcanics		0.5
Hard Carbonates		0.5
Feldspar - Hornblende Porphyry	FAIR	13.9
Weathered Syenite, Granite, etc.		5.8
Jasper		0.3
Soft Schist	POOR	0.3
Badly Weathered Volcanics, Syenite		1.2
PN = 145.5	INTERPRETATION: Fair Quality Aggregate	100.0

FINE AGGREGATE: #100 sieve to #4 sieve

ROCK TYPE	CLASSIFICATION	TOTAL WEIGHTED COMPONENT %
Granite, Syenite, Feldspar	GOOD	41.8
Quartz, Quartzite, Quartz Sandstone		21.6
Basalt & Gabbro, Pyroxenes		12.9
Diorite & Andesite		7.8
Metamorphic Quartzites, Sandstones, etc.		7.6
Weathered Syenite, Granite, etc.	FAIR	4.7
Feldspar - Hornblende Porphyry		0.6
Mica Schist, Mica	POOR	0.2
Badly Weathered Particles		0.8
Organics	DELETERIOUS	0.3
PN = 118.3	INTERPRETATION: Fair Quality Concrete Sand	100.0



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WHITEHORSE GRAVEL SURVEY

PROSPECT NO.  
TEST PIT NO. 6 @ 0.5 m  
SAMPLE NO.

PROJECT NO. B-4321



# PETROGRAPHIC ANALYSIS

**COARSE AGGREGATE:** Crushed, #4 Sieve to +1" sizes after crushing

ROCK TYPE	CLASSIFICATION	TOTAL WEIGHTED COMPONENT %
Quartz, Quartzite, Quartz Sandstone	GOOD	43.0
Granite, Syenite, Gneiss		17.1
Metamorphic Sandstones, Sediments		16.1
Basalt & Gabbro		9.1
Diorite & Andesite		4.5
Hard Volcanics		3.8
Hard Carbonates		2.9
-----		
Weathered Particles	FAIR	1.4
Med.-Hard Schist		1.0
-----		
Soft Carbonate	POOR	0.6
Badly Weathered Particles		0.3
-----		
PN = 109.3	INTERPRETATION: Good Quality Aggregate	100.0

**FINE AGGREGATE:** #100 Sieve to #4 Sieve

ROCK TYPE	CLASSIFICATION	TOTAL WEIGHTED COMPONENT %
Quartz, Quartzite, Quartz Sandstone	GOOD	55.8
Granite, Syenite, Feldspar		16.3
Metamorphic Sandstones, Sediments		12.3
Basalt & Gabbro		12.0
Diorite & Andesite		1.7
-----		
Med. Hard Carbonate	FAIR	0.7
-----		
Badly Weathered Particles	POOR	1.3
Micas		trace
-----		
-----		
-----		
-----		
-----		
PN = 107.9	INTERPRETATION: Good Quality Concrete Sand	100.0



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WHITEHORSE GRAVEL SURVEY

PROSPECT NO.  
TEST PIT NO. 9 @ 1.0 m  
SAMPLE NO.

PROJECT NO. B-4321



TO Government of Yukon Territory  
Department of Local Government  
Whitehorse, Yukon Territory

OFFICE Edmonton  
FILE B-4321  
DATE November 3, 1978  
CLIENT P.O. M 19/78  
C.C.

PROJECT

SOURCE: #1 @ 2.5 m

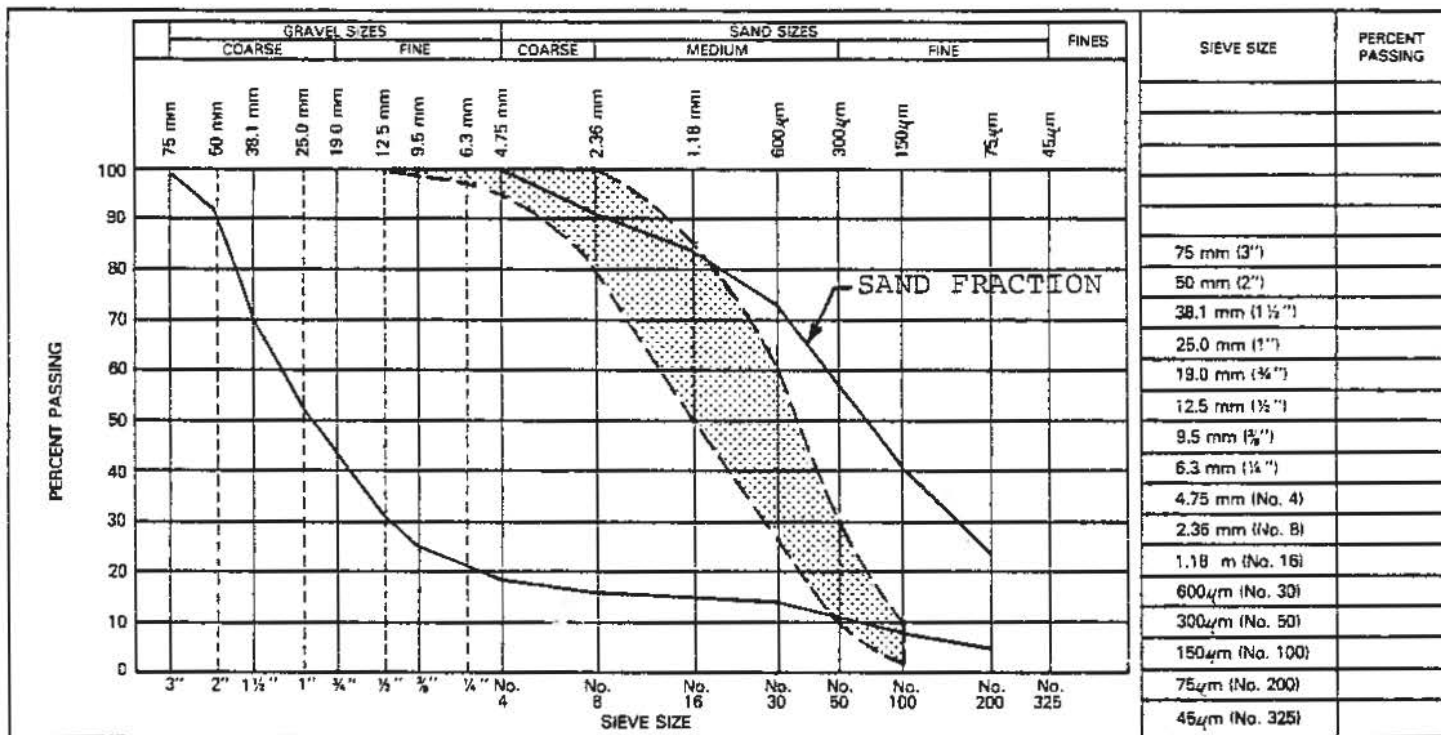
TYPE OF SAMPLE: Disturbed

SAMPLED BY: A.N.

DATE SAMPLED:

DATE REC'D:

DATE TESTED: Oct. 25/78



COMMENTS



--- Ideal gradation range for concrete sand.



**R.M.HARDY & ASSOCIATES LTD.**

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

**SIEVE ANALYSIS REPORT**

TO Government of Yukon Territory  
 Department of Local Government  
 Whitehorse, Yukon Territory

OFFICE Edmonton  
 FILE B-4321  
 DATE November 3, 1978  
 CLIENT P.O. M 19/78  
 C.C.

**PROJECT**

SOURCE: #2 @ 3.0 m

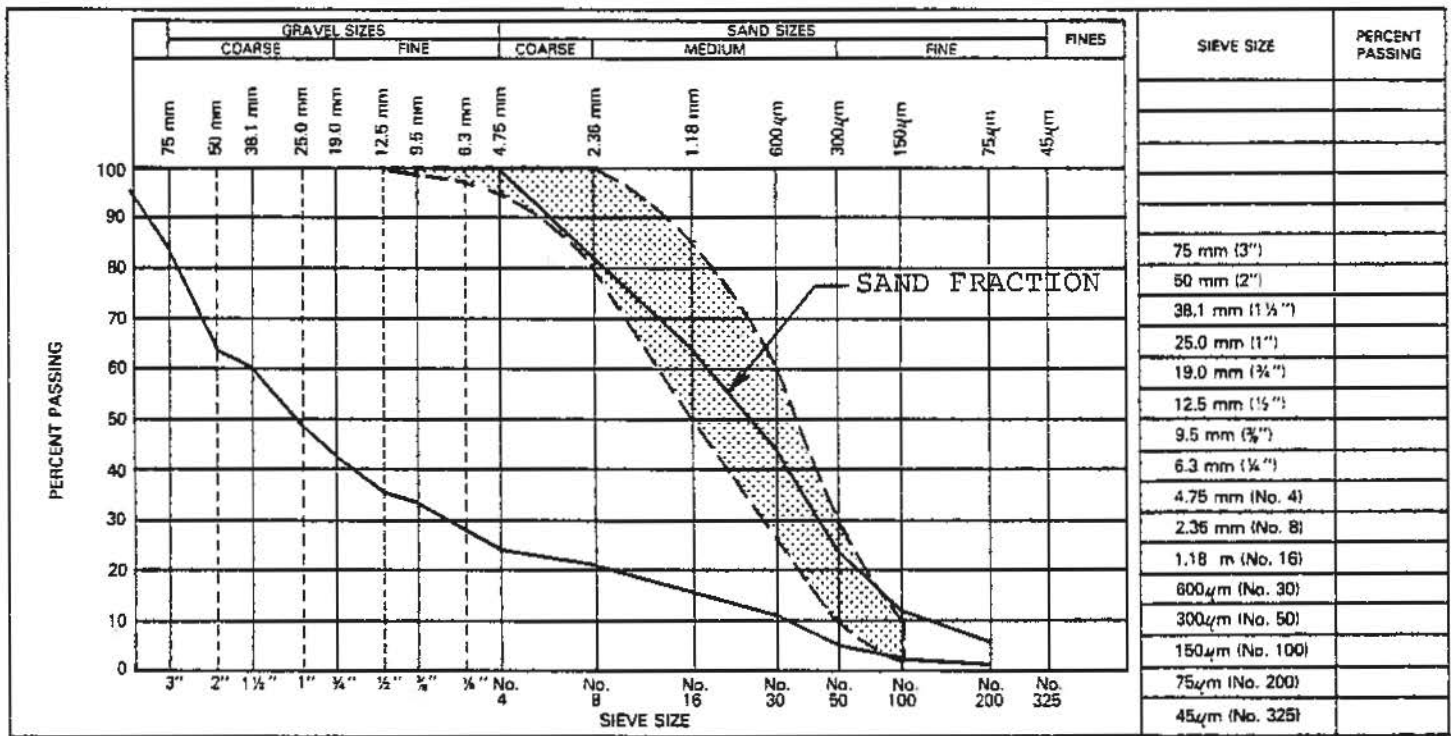
TYPE OF SAMPLE: Disturbed

SAMPLED BY: A.N.


DATE SAMPLED:

DATE REC'D:

DATE TESTED: Oct. 25/78



COMMENTS White carbonate coating on many particles

 --- Ideal gradation range for concrete sand.

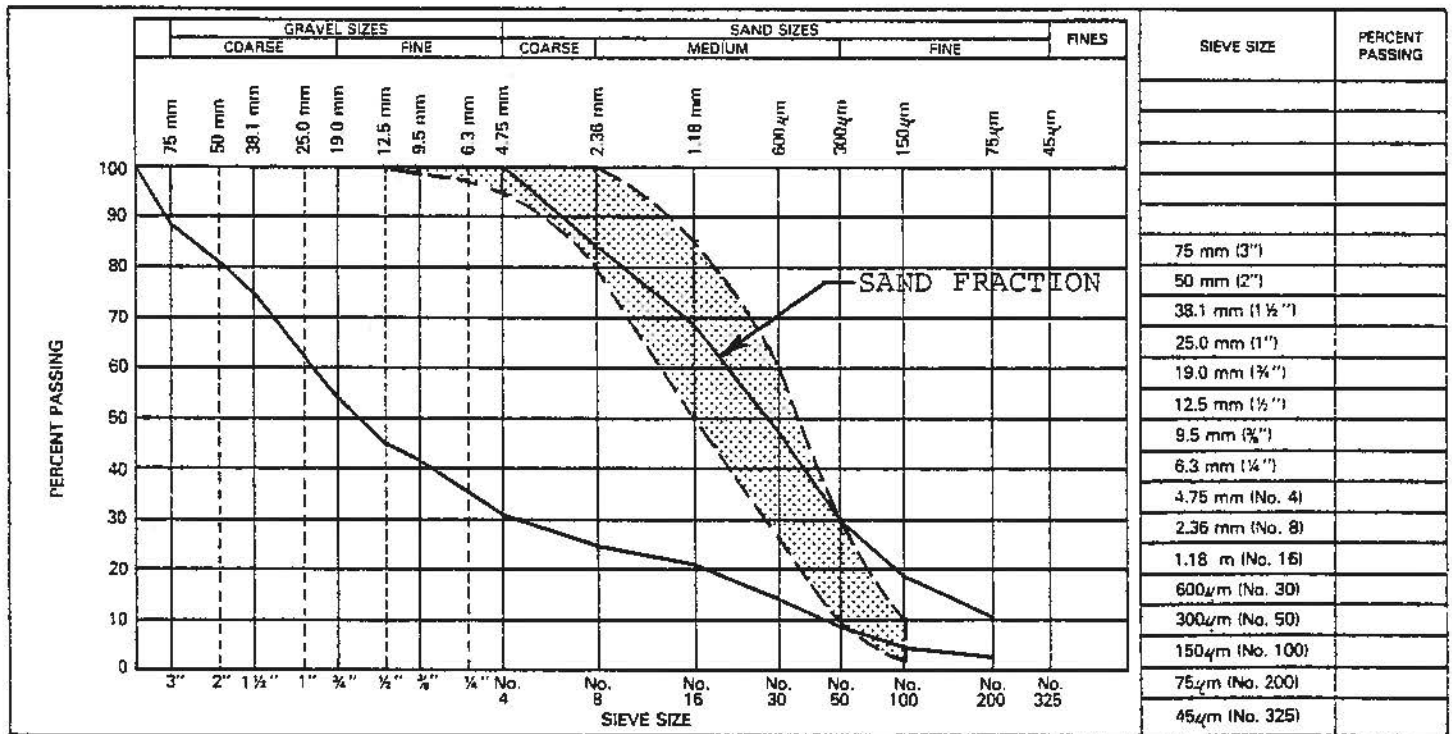


TO Government of Yukon Territory  
Department of Local Government  
Whitehorse, Yukon Territory

OFFICE Edmonton  
FILE B-4321  
DATE November 3, 1978  
CLIENT P.O. M 19/78  
C.C.

**PROJECT**

SOURCE: #4 @ 1 - 1.5 m TYPE OF SAMPLE: Disturbed SAMPLED BY: A.N.  
DATE SAMPLED: DATE REC'D: DATE TESTED: Oct. 25/78



COMMENTS White carbonate coating on many particles



--- Ideal gradation range for concrete sand.



TO Government of Yukon Territory  
Department of Local Government  
Whitehorse, Yukon Territory

OFFICE Edmonton  
FILE B-4321  
DATE November 3, 1978  
CLIENT P.O. M 19/78  
C.C.

PROJECT

SOURCE: #6 @ 0.5 m

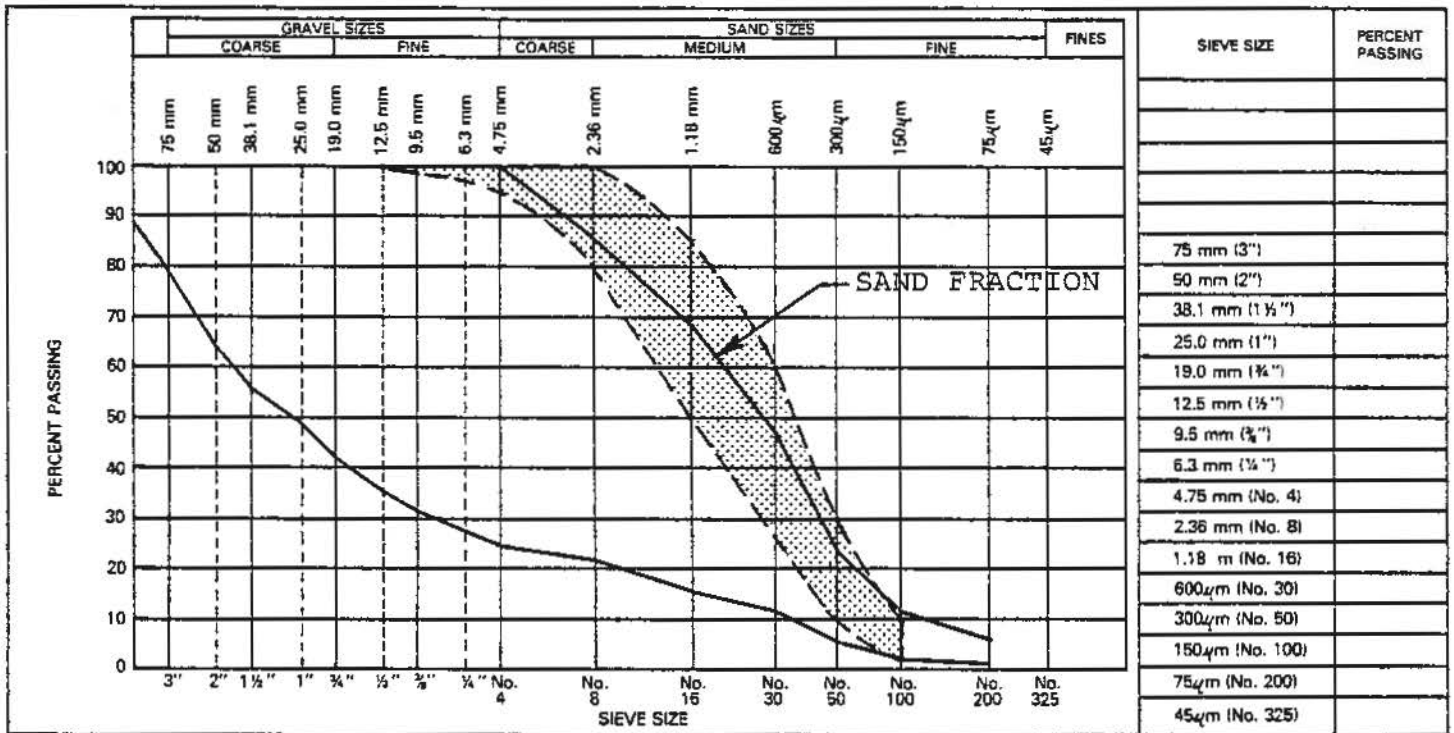
TYPE OF SAMPLE: Disturbed

SAMPLED BY: A.N.

DATE SAMPLED:

DATE REC'D:

DATE TESTED: Oct. 25/78



COMMENTS



--- Ideal gradation range for concrete sand.



TO  
Government of Yukon Territory  
Department of Local Government  
Whitehorse, Yukon Territory

OFFICE Edmonton  
FILE B-4321  
DATE November 3, 1978  
CLIENT P.O. M 19/78  
C.C.

PROJECT

SOURCE: #9 @ 1.0 m

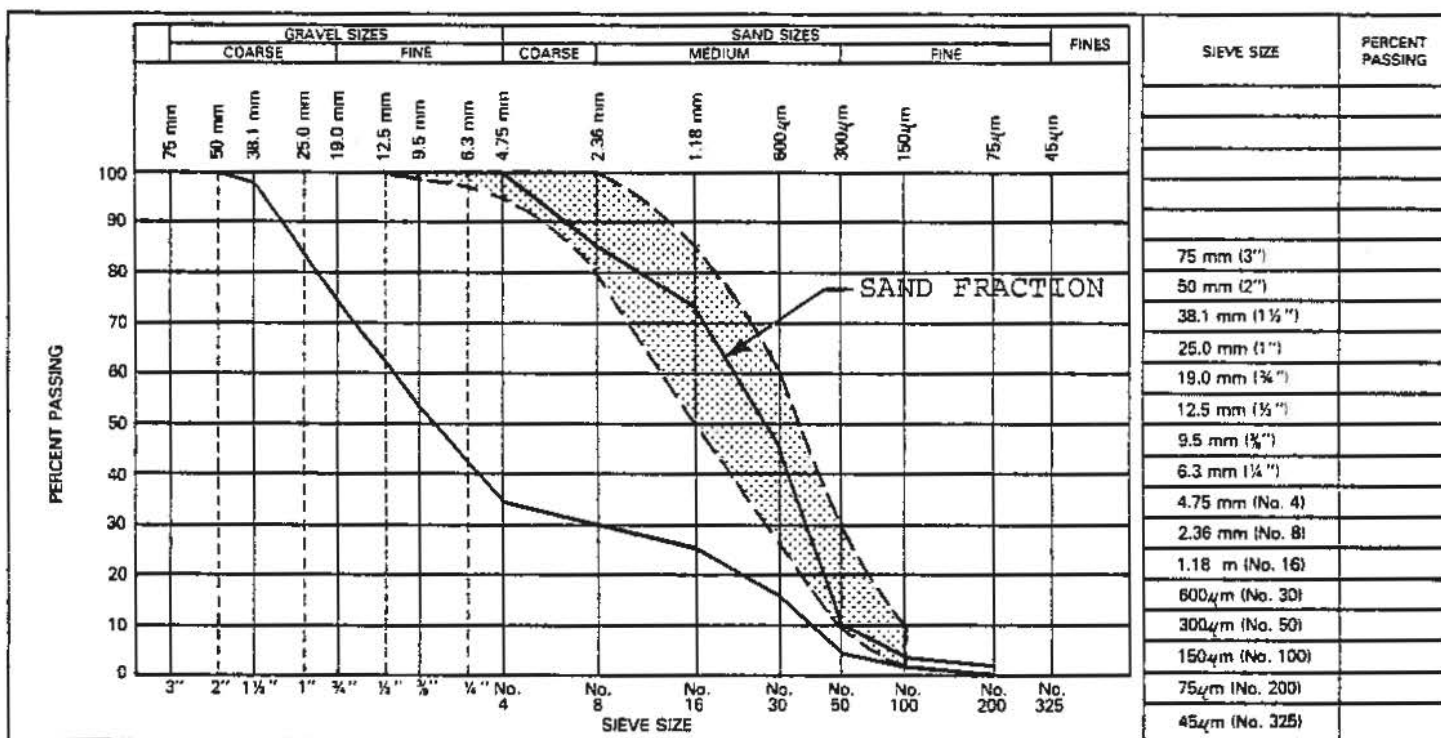
TYPE OF SAMPLE: Disturbed

SAMPLED BY: A.N.

DATE SAMPLED:

DATE REC'D:

DATE TESTED: Oct. 25/78



COMMENTS



--- Ideal gradation range for concrete sand.



**R.M.HARDY & ASSOCIATES LTD.**

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

**LOS ANGELES ABRASION  
TEST REPORT**

OFFICE Calgary  
FILE 1051-J2207  
DATE November 22, 1978  
CLIENT P.O.  
C.C.  
IRS #0910

TO: Mr. J. Rennie  
R. M. Hardy & Associates Ltd.  
P.O. Box 746  
EDMONTON, Alberta  
T5J 2L4

PROJECT: Government of Yukon - Job # B4321

SOURCE #2 @ 3.0 M TYPE OF SAMPLE <sup>-3/4" to</sup> +3/8" Agg. SAMPLED BY Client  
DATE SAMPLED November, 1978. DATE RECEIVED Nov. 10, 1978 DATE TESTED November 15, 1978

MATERIAL GRADING: <u>ASTM C131 "B"</u>			
ACTUAL SIEVE SIZES		AMOUNT	
—	+		g
—	3/4 + 1/2"	2498.6	g
—	1/2 + 3/8"	2498.5	g
—	+		g
		TOTAL SAMPLE 4997.1	g
NO. OF REVOLUTIONS	500		
NO. OF SPHERES	11	TOTAL SAMPLE 4997.1	g
WT. OF SPHERES	4589.2 g	+ # 12 MATERIAL AFTER 4211.5	g
		- # 12 MATERIAL AFTER 785.6	g
LOSS = $\frac{- \# 12}{\text{TOTAL SAMPLE}} \times 100 = \frac{785.6}{4997.1} \times 100 = 15.7\%$			

COMMENTS: Meets L.A. Abrasion requirements of CSA A.23 and ASTM C-33.

REPORT CERTIFIED *R.M. Gillingwater*  
R.W. Gillingwater, C.E.T. TECHNICIAN K.S.



**R.M.HARDY & ASSOCIATES LTD.**

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

**LOS ANGELES ABRASION  
TEST REPORT**

OFFICE Calgary  
FILE 1051-J2207  
DATE November 23, 1978  
IRS #0910  
C.C.

TO: Mr. J. Rennie  
R. M. Hardy & Associates Ltd.  
P.O. Box 746  
EDMONTON, Alberta  
T5J 2L4

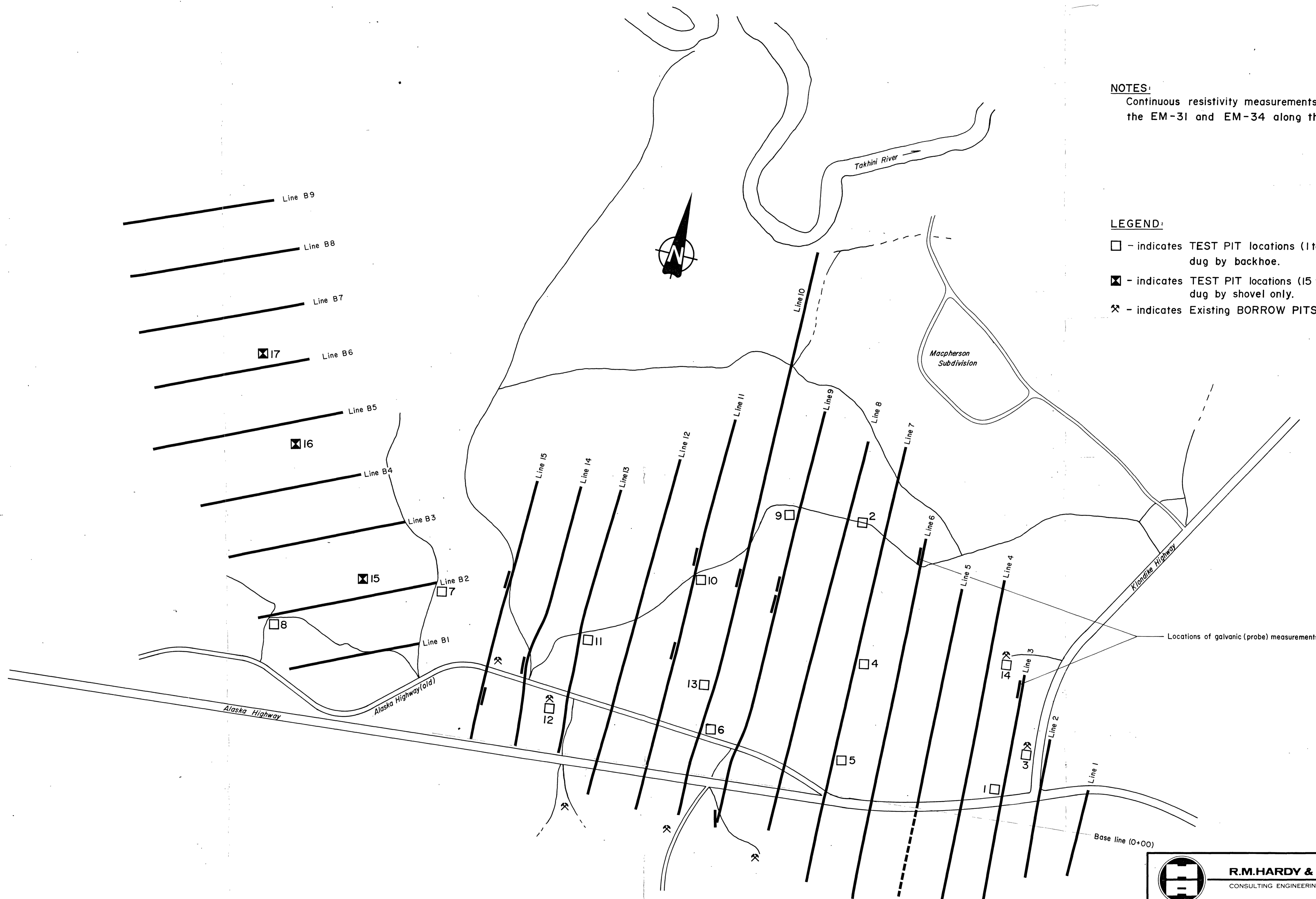
PROJECT: Government of Yukon - Job #B4321

SOURCE #6 @ 0.5 M TYPE OF SAMPLE -3/4" to 3/8 Agg. SAMPLED BY Client  
DATE SAMPLED November, 1978 . DATE RECEIVED NOV. 10, 1978 DATE TESTED November 15, 1978

MATERIAL GRADING: <u>ASTM C131 "B"</u>	
ACTUAL SIEVE SIZES	AMOUNT
— +	g
— -3/4" + 1/2"	2500.2 g
— 1/2" + 3/8"	2499.1 g
— +	g
	TOTAL SAMPLE 4999.3 g
NO. OF REVOLUTIONS 500	
NO. OF SPHERES 11	TOTAL SAMPLE 4999.3 g
WT. OF SPHERES 4589.2 g	+ # 12 MATERIAL AFTER 4353.2 g
	- # 12 MATERIAL AFTER 646.1 g
LOSS = $\frac{- \# 12}{\text{TOTAL SAMPLE}} \times 100 = \frac{646.1}{4999.3} \times 100 = 12.9 \%$	

COMMENTS: Meets L.A. Abrasion Requirements of CSA A.23 and ASTM C33.

REPORT CERTIFIED *R.M. Gillingwater* - K.W. Gillingwater, C.E.T. TECHNICIAN K.S.



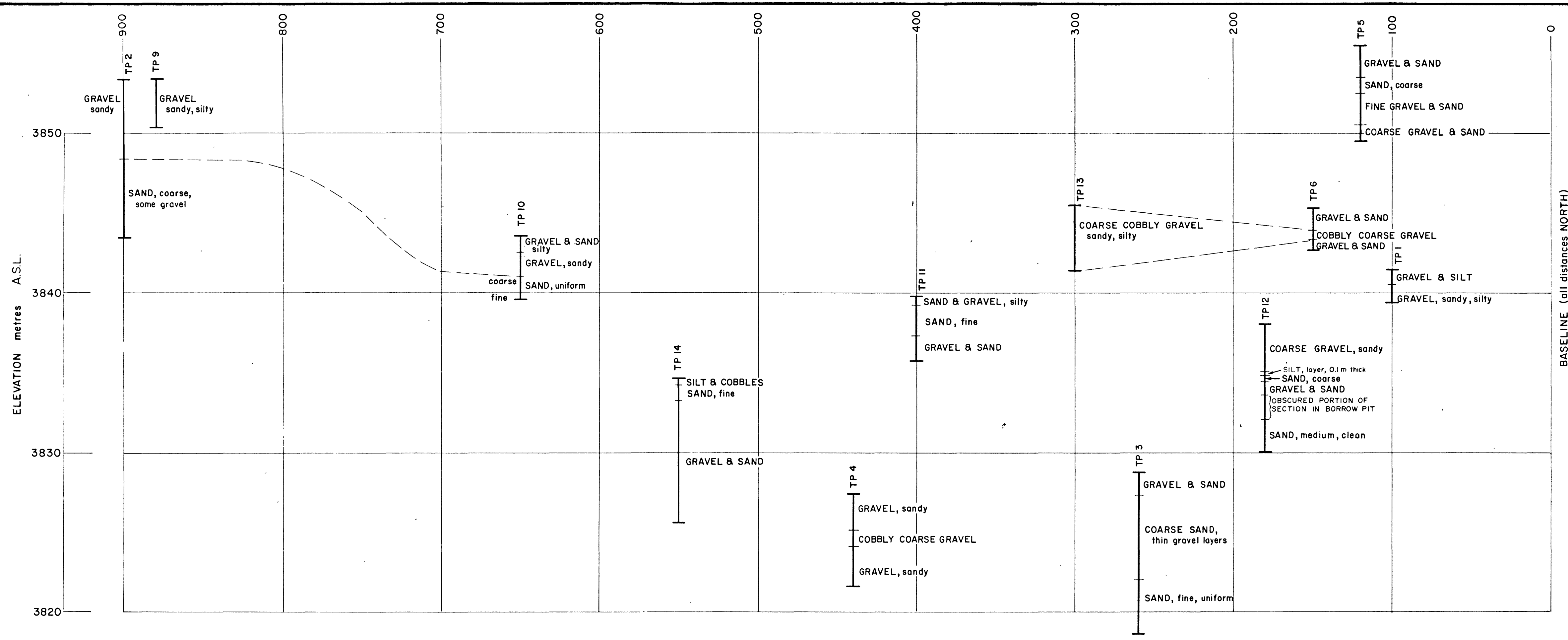
**NOTES:**  
 Continuous resistivity measurements were taken with the EM-31 and EM-34 along the solid grid lines.

**LEGEND:**  
 □ - indicates TEST PIT locations (1 to 14 inclusive), dug by backhoe.  
 ⊠ - indicates TEST PIT locations (15 to 17 inclusive), dug by shovel only.  
 ✕ - indicates Existing BORROW PITS.

Locations of galvanic (probe) measurements

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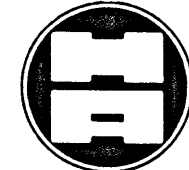
**CITY OF WHITEHORSE  
 GRAVEL SURVEY  
 SITE LOCATION MAP**



- NOTES
1. ALL ELEVATIONS AND DISTANCES ARE IN METRES.
  2. ELEVATIONS ARE APPROX., AS THEY WERE DETERMINED WITH PARALLAX BAR ON AERIAL PHOTOGRAPHY.

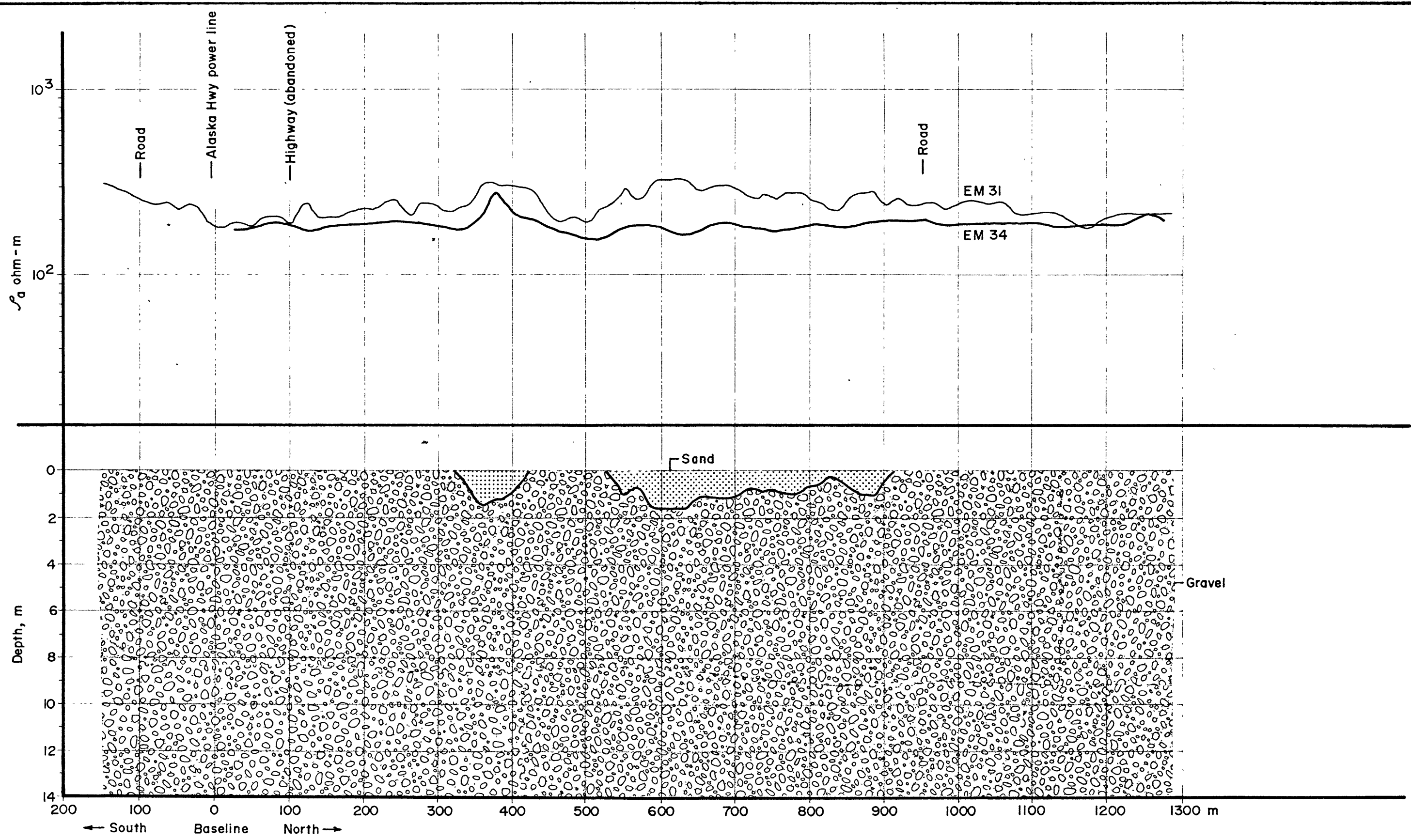
No	REVISION	DATE	BY

REFERENCES



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**WHITEHORSE GRAVEL SURVEY  
SCHEMATIC PROFILE OF TEST PITS**



REVISIONS

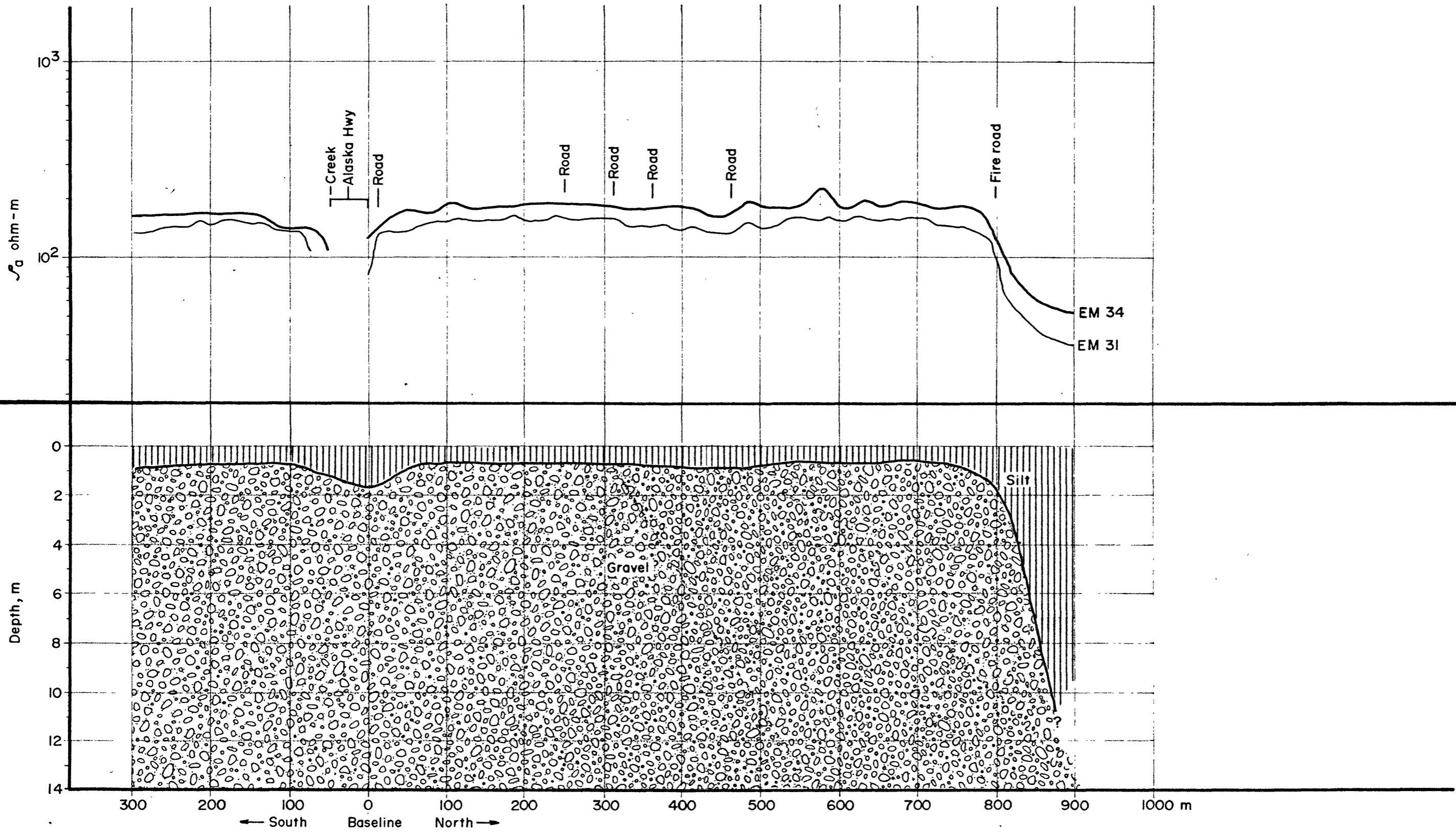
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DATE _____
MADE _____
CHKD. _____
APPD. _____



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CITY OF WHITEHORSE GROUND SURVEY RESISTIVITY PROFILE, LINE 9	
No. B 4321	Figure II
	REV.



REVISIONS

REFERENCES

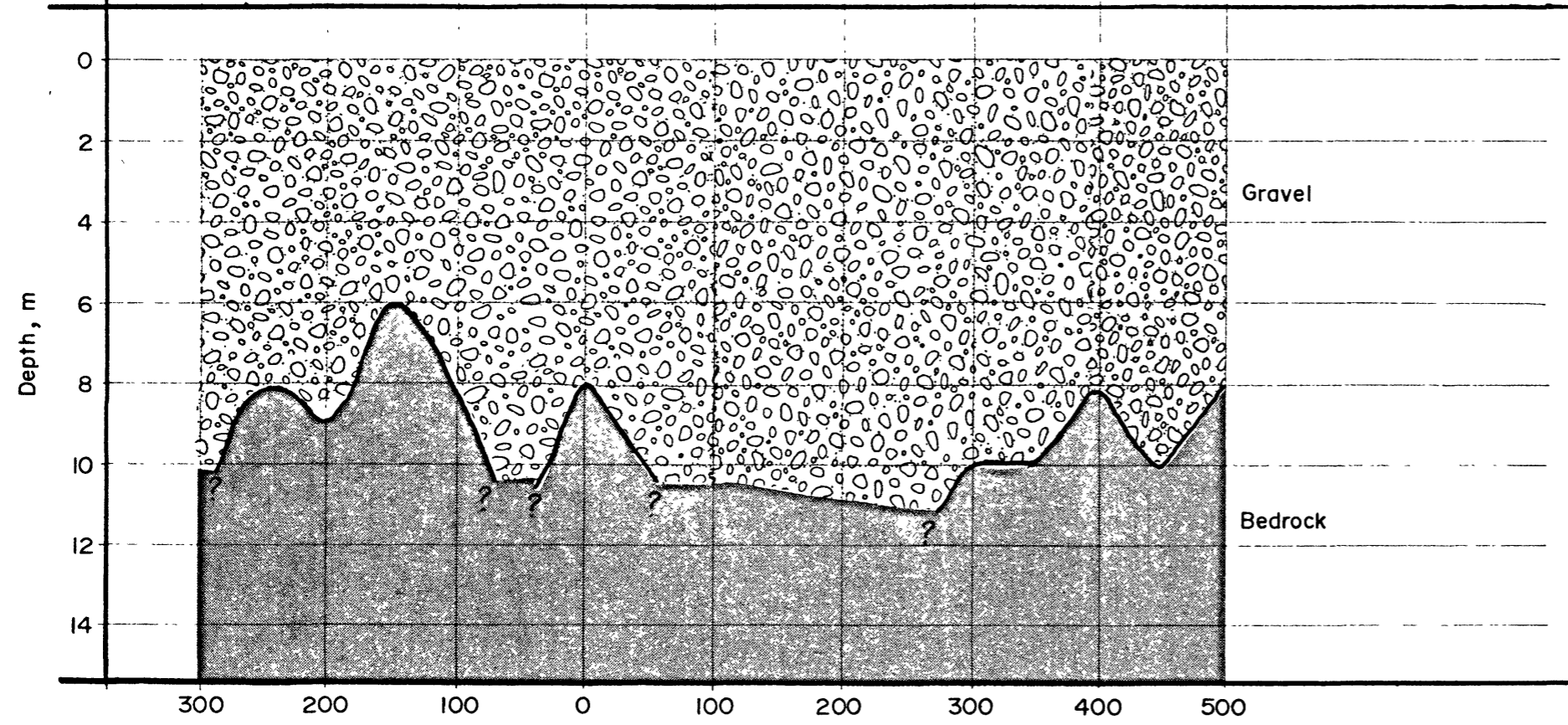
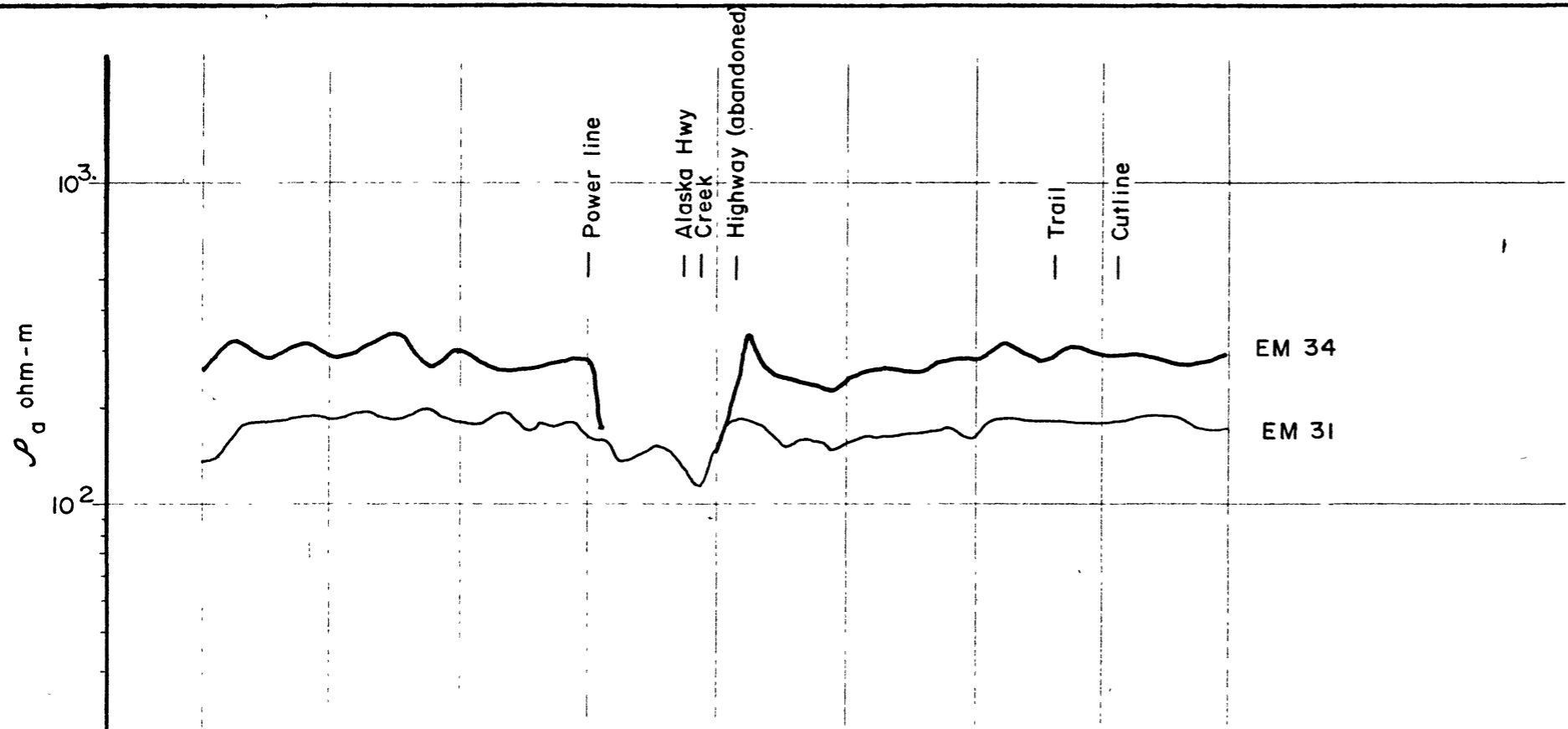
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**CITY OF WHITEHORSE  
GRAVEL SURVEY  
RESISTIVITY PROFILE, LINE 6**

No. B 4321 Figure 10 REV.



REVISIONS

REFERENCES

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DATE _____
MADE _____
CHKD. _____
APPD. _____




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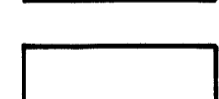
**CITY OF WHITEHORSE  
GRAVEL SURVEY  
RESISTIVITY PROFILE, LINE 3**

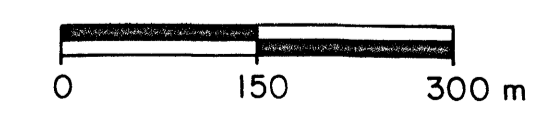
<b>No. B432I</b>	<b>Figure 9</b>	<b>REV.</b>
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**LEGEND**

 > 275 ohm-m > 5m and < 10m to bedrock

 < 275 ohm-m > 10m to bedrock

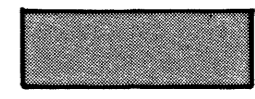
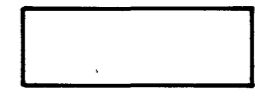
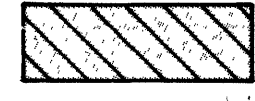


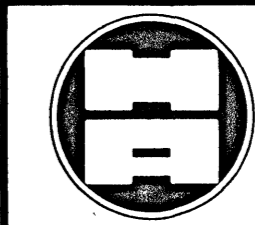
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**CITY OF WHITEHORSE  
GRAVEL SURVEY  
CONTOUR RESISTIVITY MAP EM34**



**LEGEND**

-  < 150 ohm-m > 1m of overburden over gravel
-  150 - 275 ohm-m < 1m of overburden over gravel, > 20m of gravel
-  > 275 ohm-m 1 to 3 m of sand over gravel



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**CITY OF WHITEHORSE  
GRAVEL SURVEY  
CONTOUR RESISTIVITY MAP EM 31**

GR-01  
008