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# TULSEQUAH CHIEF PROJECT

## NORTHWESTERN B.C.

## 1995 TAILINGS AND PLANT SITE EVALUATION PROGRAM: DIAMOND DRILLING, GEOLOGY, GEOPHYSICS and GEOTECHNICAL ASSESSMENT

**NTS 104K/12**
**Latitude: 58° 43' N, Longitude: 133° 35' W**

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VANCOUVER, B.C.

**for**

**REDFERN RESOURCES LTD.**
**205-10711 Cambie Road**
**Richmond, B.C.**
**V6X 3G5**

GEOLOGICAL BRANCH
ASSESSMENT REPORT

23,951

**T.E. Chandler, P.Geo., Redfern Resources Ltd.**

**June 15, 1995**

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# Introduction

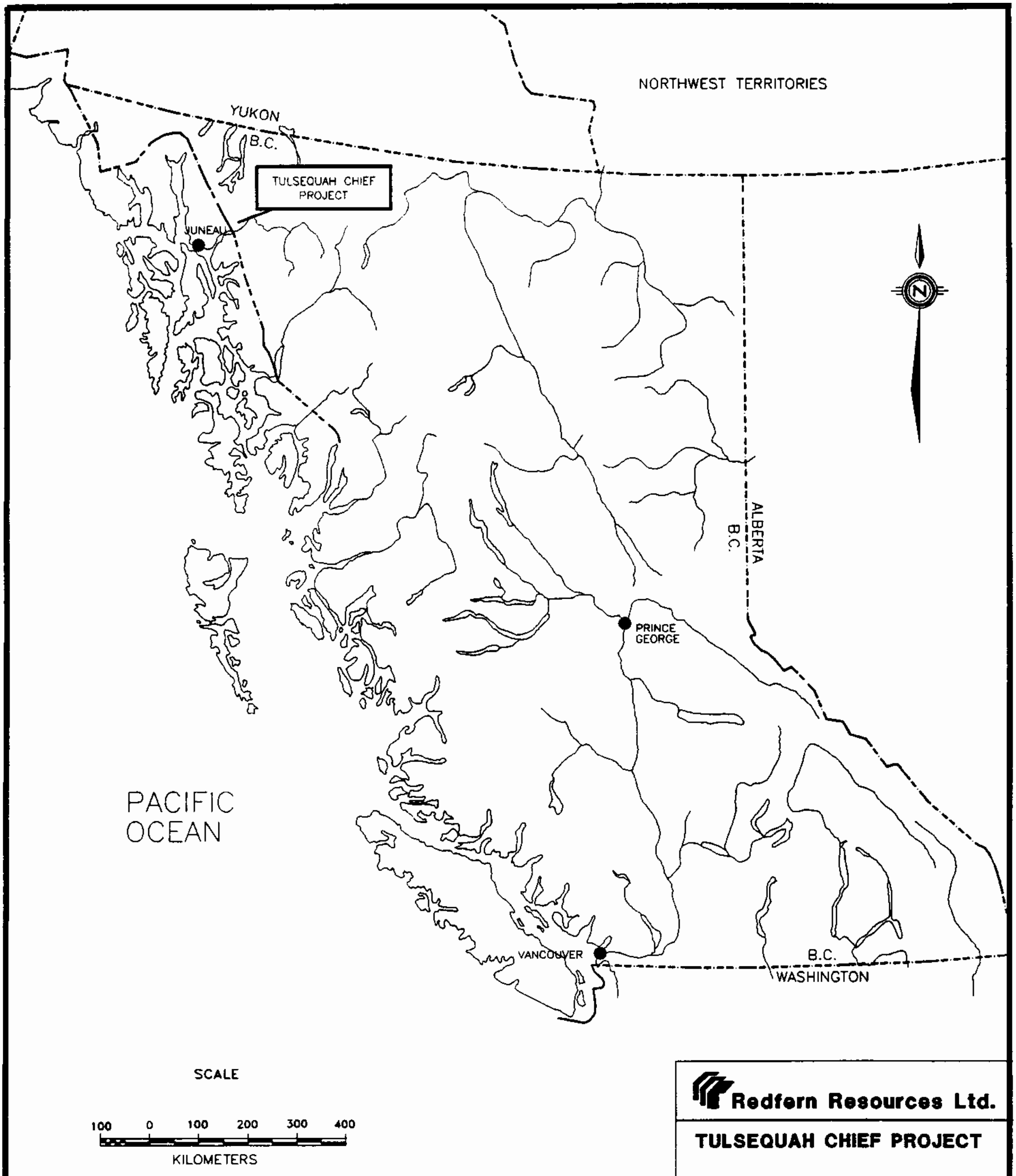
## Location and Access

The Tulsequah Chief property is situated along the Tulsequah River in Northwestern B.C. (Fig.. 1). It is centred on latitude 58°43'N and longitude 133°35'W (NTS 104K/12). Access is by air from Atlin, B.C. 100 km to the north, or by air from Juneau, Alaska, 64 km to the southwest. The exploration base camp is situated on the east bank of the Tulsequah River at an elevation of 108m above sea level. A gravel airstrip beside the Tulsequah River 7 km south of the Tulsequah Chief Mine site is suitable for aircraft up to DC-3 or Shorts SkyVan in size. The property is comprised of a total of 53 located mineral claims and 25 crown granted mineral claims for a total of 16,638.69 ha. (Fig.. 2)

## History of Exploration

The Tulsequah Chief deposit was discovered in 1923 by W. Kirkham of Juneau. He located high-grade barite, pyrite, sphalerite, galena, and chalcopyrite mineralization outcropping in a gully above the 6500 Level adit. Development of this showing between 1923 and 1929 attracted about 40 prospectors to the area. In 1929, V. Manville discovered the Big Bull massive sulphide deposit. Other discoveries that year included the Potlatch (Sparling), Banker and the Whitewater (Polaris Taku) vein deposits. The Erickson-Ashby sulphide deposit was discovered later in 1930.

Cominco Ltd. acquired the Tulsequah Chief and Big Bull deposits in 1946. Production started in 1951 and continued to 1957 when low metal prices closed the mine. Production averaged 482 tonnes (530 tons) per day. Total production was 935,536 tonnes comprised of 575,463 tonnes from the Tulsequah Chief and 360,073 tonnes from the Big Bull deposit. Average grade of ore was 1.59% Cu, 1.54% Pb, 7.0% Zn, 3.84 g/tonne Au, and 126.52 g/tonne Ag. The mines produced 14,756 tons Cu, 11,439 tons Pb, 54,910 tons Zn, 95,340 oz Au, and 3,329,938 oz Ag at a recovery of about 88% Cu, 94% Pb, 87% Zn, 77% Au, and 89% Ag. At shutdown, ore reserves at the Tulsequah Chief were 707,616 tonnes grading 1.3% Cu, 1.6% Pb, 8.0% Zn, 2.40 g/tonne Au, and 116.50 g/tonne Ag, and at the Big Bull were 57,541 tonnes grading 1.1% Cu, 1.5% Pb, 5.6% Zn, 3.43g/tonne Au, and 154.3 g/tonne Ag. Tulsequah Chief reserves consisted of 73,408 tonnes in the Upper Deposits (I horizon) and 634,208 tonnes in the Lower Deposits (H,AB2, AB1 horizons). In the Lower Deposits, 307,063 tonnes were above, and 327,145 tonnes were below the 5200 Level.



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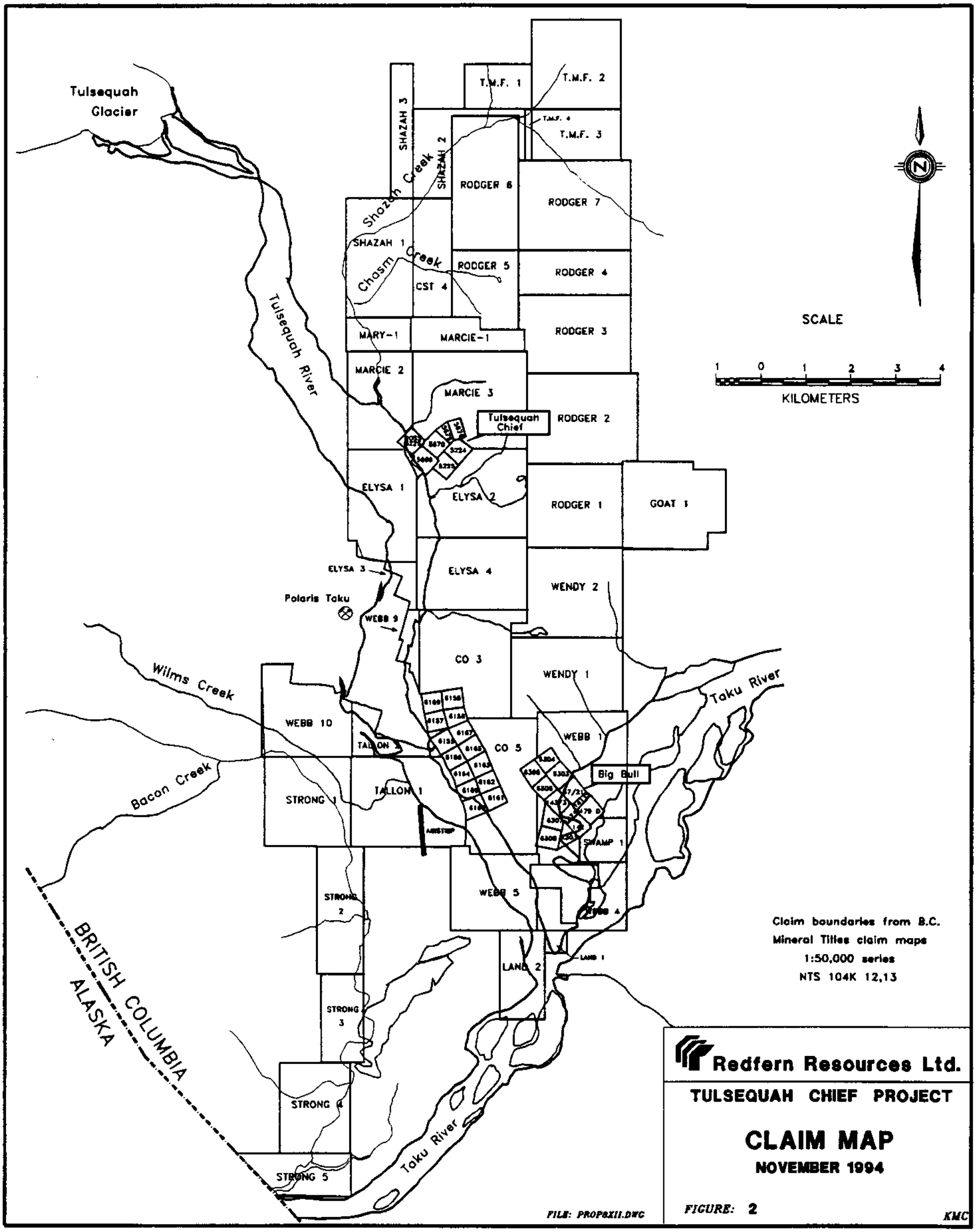
**Redfern Resources Ltd.**

## TULSEQUAH CHIEF PROJECT

## PROJECT LOCATION

*FIGURE:* 1



Claim boundaries from B.C.
Mineral Titles claim maps
1:50,000 series
NTS 104K 12,13

**Redfern Resources Ltd.**

**TULSEQUAH CHIEF PROJECT**

# CLAIM MAP

**NOVEMBER 1994**

FIGURE: 2

The Tulsequah Chief and Big Bull deposits lay dormant until 1971. At this time the deposits were interpreted as volcanogenic massive sulphides, rather than hydrothermal veins as originally described. Geological mapping (1:2500) over the Tulsequah Chief and Big Bull deposits was completed in 1981. The property was flown by Dighem and Input EM/Mag in 1982, however, these surveys failed to define any significant conductors. A joint venture between Cominco Ltd. and Redfern Resources Ltd. led to extensive exploration programs from 1987 to 1991.

Redfern Resources Ltd. purchased Cominco's interest (60%) in the Tulsequah Chief property in June, 1992. Consequently, Redfern Resources became the 100% owner of the Tulsequah Chief and Big Bull deposits and adjacent ground.

Redfern carried out further extensive exploration programs each season from 1992 through 1994. These have been documented in detailed assessment reports filed in 1993, 1994 and 1995. In 1994 Redfern commenced baseline environmental studies and final feasibility evaluation to determine the project's economic viability and provide the basis for a Mine Development Certificate application in 1995. The activities discussed in this report form a part of that feasibility evaluation specifically designed to test and evaluate potential plant and tailings impoundment sites in the project area.

**Evaluation Program**

Scope: Redfern contracted Bruce Geotechnical Consultants Inc. (BGCI) to plan and supervise the geotechnical evaluation of the site areas. BGCI conducted an initial terrain assessment and devised a test program of geotechnical drilling and seismic traverse and down-hole geophysics to obtain the necessary sample and test data for the geotechnical analysis of the sites. This report covers the preliminary geotechnical site assessment, drilling and geophysical data collection programs and results, interpretation of the test program data and initial geotechnical assessment of the specific tested site areas. The bulk of this data is presented in a self-contained report by BGCI which is included as Appendix A to this report. The geophysical work program is included as Appendix 1 of the BGCI report.

Technical Program: BGCI provided two experienced engineers to conduct the initial site assessment and devise the follow-up field test program. The evaluation was conducted in June and then in more detail in late August and early September of 1994. This was immediately followed by a test drilling program between September 7 and 28, 1994 which consisted of 11 geotechnical drillholes or wells in two potential tailings impundment areas and one potential plant site. This work was conducted by Foundex Explorations Ltd. of Surrey, B.C. using a helicopter transportable lightweight rig. Permeability, porosity and density tests were conducted on most of the holes and the drilled material was sampled and logged by the attending BGCI engineer. Two holes at each tailings site were lined with PVC pipe for subsequent downhole seismic surveys.

The seismic refraction survey program was conducted by Frontier Geosciences Inc. of North Vancouver, B.C. A three man crew and equipment was mobilized to site and completed the work program from September 23 to October 7, 1994 over seismic lines selected by BGCI to allow correlation with the drill hole data. Two holes were also selected for downhole seismic profiling. Redfern Resources Ltd. arranged for contract line-cutting services preparatory to the geophysical surveys and drilling for cut-line access and drill and helicopter pads.

The details of the technical program are covered in the BGCI report included herein as Appendix A.

## COST STATEMENT

Table 1 lists the individual cost items allocated to the subject program. Table 2 summarizes these cost items by type of expenditure and allocates the costs to the major types of work conducted in the program. Finally, Table 3 distributes the work costs by work unit for each claim covered in the program. A total of $203,416.23 was expended in this study.

Due to some adjustments to the amount of work and costs recorded in the completion of the work the amount of work expenditures allocated to claim Shazah 1 is slightly less than that recorded on the original statement of work filed March 20, 1995. The amount is still greatly in excess of the amount being applied to grouped claims.

## TABLE 1. Listing of costs incurred in the program by item

| Date | Vendor/Service | Inv/Ref. | Description | Code | Category | Amount | Code Total |
|---|---|---|---|---|---|---|---|
| 06-Sep-94 | Discovery Helicopters Ltd. | 932 | Foundex Mobilization | 320 | Helicopter charter | $1,100.00 | |
| 07-Sep-94 | Discovery Helicopters Ltd. | 933 | Foundex Mobilization | 320 | Helicopter charter | $2,200.00 | |
| 08-Sep-94 | Discovery Helicopters Ltd. | 934 | Foundex/BGC | 320 | Helicopter charter | $385.00 | |
| 09-Sep-94 | Discovery Helicopters Ltd. | 935 | Foundex/BGC | 320 | Helicopter charter | $385.00 | |
| 11-Sep-94 | Discovery Helicopters Ltd. | 903 | Foundex/BGC | 320 | Helicopter charter | $880.00 | |
| 12-Sep-94 | Discovery Helicopters Ltd. | 904 | Foundex/BGC | 320 | Helicopter charter | $770.00 | |
| 13-Sep-94 | Discovery Helicopters Ltd. | 905 | Foundex, linecutters | 320 | Helicopter charter | $1,595.00 | |
| 14-Sep-94 | Discovery Helicopters Ltd. | 942 | Foundex | 320 | Helicopter charter | $495.00 | |
| 14-Sep-94 | Discovery Helicopters Ltd. | 938 | Foundex, linecutters | 320 | Helicopter charter | $385.00 | |
| 15-Sep-94 | Discovery Helicopters Ltd. | 939 | Foundex, linecutters | 320 | Helicopter charter | $605.00 | |
| 16-Sep-94 | Discovery Helicopters Ltd. | 940 | Foundex, linecutters | 320 | Helicopter charter | $1,430.00 | |
| 17-Sep-94 | Discovery Helicopters Ltd. | 941 | Foundex | 320 | Helicopter charter | $1,155.00 | |
| 18-Sep-94 | Discovery Helicopters Ltd. | 945 | Foundex, drill move | 320 | Helicopter charter | $2,200.00 | |
| 18-Sep-94 | Discovery Helicopters Ltd. | 943 | Foundex, drill move | 320 | Helicopter charter | $2,255.00 | |
| 19-Sep-94 | Discovery Helicopters Ltd. | 946 | Foundex | 320 | Helicopter charter | $1,705.00 | |
| 20-Sep-94 | Discovery Helicopters Ltd. | 949 | Foundex, drill move | 320 | Helicopter charter | $3,630.00 | |
| 24-Sep-94 | Discovery Helicopters Ltd. | 950 | Foundex, drill move | 320 | Helicopter charter | $2,750.00 | |
| 25-Sep-94 | Discovery Helicopters Ltd. | 951 | Foundex, drill move | 320 | Helicopter charter | $6,160.00 | |
| 27-Sep-94 | Discovery Helicopters Ltd. | 948 | Foundex , linecutters | 320 | Helicopter charter | $1,100.00 | |
| 27-Sep-94 | Discovery Helicopters Ltd. | 952 | Foundex, drill move | 320 | Helicopter charter | $1,650.00 | |
| 28-Sep-94 | Discovery Helicopters Ltd. | 953 | Foundex, drill move | 320 | Helicopter charter | $3,025.00 | |
| 29-Sep-94 | Discovery Helicopters Ltd. | 954 | Foundex demobilization | 320 | Helicopter charter | $2,475.00 | |
| 30-Sep-94 | Discovery Helicopters Ltd. | 955 | Frontier geophysics | 320 | Helicopter charter | $1,292.50 | |
| 02-Oct-94 | Discovery Helicopters Ltd. | 962 | Frontier geophysics | 320 | Helicopter charter | $1,210.00 | |
| 04-Oct-94 | Discovery Helicopters Ltd. | 963 | Frontier geophysics | 320 | Helicopter charter | $2,200.00 | |
| 06-Oct-94 | Discovery Helicopters Ltd. | 964 | Frontier geophysics | 320 | Helicopter charter | $2,255.00 | |
| 07-Oct-94 | Discovery Helicopters Ltd. | 965 | Frontier geophysics | 320 | Helicopter charter | $550.00 | $45,842.50 |
| 08-Sep-94 | Pinetree Services Ltd. | 144761 | Drum Return | 325 | Helicopter fuel | ($390.00) | |
| 23-Sep-94 | Pinetree Services Ltd. | 145136 | Jet B | 325 | Helicopter fuel | $4,485.60 | |
| 23-Sep-94 | Pinetree Services Ltd. | 145157 | Drum Return | 325 | Helicopter fuel | ($624.00) | |
| 30-Sep-94 | Pinetree Services Ltd. | 145656 | Jet B | 325 | Helicopter fuel | $2,317.80 | |
| 30-Sep-94 | Pinetree Services Ltd. | 145408 | Drum Return | 325 | Helicopter fuel | ($748.80) | |
| 03-Oct-94 | Pinetree Services Ltd. | 145480 | Drum Return | 325 | Helicopter fuel | ($1,716.00) | |
| 09-Oct-94 | Pinetree Services Ltd. | 145628 | Drum Return | 325 | Helicopter fuel | ($468.00) | $2,856.60 |
| 06-Sep-94 | Summit Air | 6454 | Foundex Mobilization | 330 | Fixed Wing Charter | $851.40 | |
| 06-Sep-94 | Summit Air | 6417 | Foundex Mobilization | 330 | Fixed Wing Charter | $2,298.78 | |
| 06-Sep-94 | Summit Air | 6418 | Foundex Mobilization | 330 | Fixed Wing Charter | $851.40 | |
| 07-Sep-94 | Summit Air | 6419 | Foundex Mobilization | 330 | Fixed Wing Charter | $1,277.10 | |
| 08-Sep-94 | Summit Air | 6441 | Groceries | 330 | Fixed Wing Charter | $48.53 | |
| 10-Sep-94 | Summit Air | 6459 | Foundex/BGC mob. | 330 | Fixed Wing Charter | $205.92 | |
| 11-Sep-94 | Summit Air | 6462 | Foundex Fuel | 330 | Fixed Wing Charter | $212.85 | |
| 11-Sep-94 | Summit Air | 6478 | Foundex Fuel | 330 | Fixed Wing Charter | $638.55 | |
| 15-Sep-94 | Summit Air | 6481 | Groceries | 330 | Fixed Wing Charter | $107.55 | |
| 16-Sep-94 | Summit Air | 6530 | Fuel haul | 330 | Fixed Wing Charter | $425.70 | |
| 17-Sep-94 | Summit Air | 6553 | Fuel haul | 330 | Fixed Wing Charter | $171.60 | |
| 19-Sep-94 | Summit Air | 6557 | Fuel haul | 330 | Fixed Wing Charter | $132.92 | |
| 27-Sep-94 | Summit Air | 4943 | Fuel haul | 330 | Fixed Wing Charter | $171.60 | |
| 27-Sep-94 | Summit Air | 6602 | Foundex demobilization | 330 | Fixed Wing Charter | $1,553.20 | |
| 28-Sep-94 | Summit Air | 6500 | Foundex demobilization | 330 | Fixed Wing Charter | $851.40 | |
| 29-Sep-94 | Summit Air | 6601 | Foundex demobilization | 330 | Fixed Wing Charter | $1,553.20 | |
| 30-Sep-94 | Pinetree Services Ltd. | 145300 | Avgas | 330 | Fixed Wing fuel | $366.67 | |
| 07-Oct-94 | Summit Air | 6580 | Frontier demobilization | 330 | Fixed Wing Charter | $970.75 | $12,689.11 |
| 15-Mar-95 | Bruce geotechnical | | Supervision, analysis | 505 | Consulting | $26,800.00 | $26,800.00 |
| 20-Oct-94 | Frontier Geophysics | 94-37 | Mob/demob, daily charges | 515 | Geophysics | $22,630.00 | |
| 28-Dec-94 | Frontier Geophysics | 94-50 | Interpretation, plots, report | 515 | Geophysics | $9,190.00 | $31,820.00 |
| 09-Sep-94 | Pinetree Services Ltd. | 144641 | Diesel fuel | 530 | Drill fuel | $1,158.00 | |
| 19-Sep-94 | Foundex Explorations Ltd. | 1667 | Drilling, mob/demob | 530 | Drilling | $75,675.91 | $76,833.91 |
| 26-Sep-94 | Twin Mountain | | Linecutting for geophysics | 545 | Line-cutting | $6,502.50 | $6,502.50 |
| 07-Sep-94 | Pinetree Services Ltd. | 144723 | Gas | 735 | Camp fuel | $23.21 | |
| 11-Sep-94 | Pinetree Services Ltd. | 144839 | Propane | 735 | Camp fuel | $48.40 | $71.61 |
| | TOTALS | | | | | $203,416.23 | $203,416.23 |

## TABLE 2. ALLOCATION OF COSTS TO MAJOR WORK AREAS

| COST CATEGORY | DESCRIPTION | CATEGORY EXPENDITURES | SURFACE DRILLING | | LINE-CUTTING | | SURFACE GEOPHYSICS | | BOREHOLE GEOPHYSICS | | TOTALS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | % | Amount | % | Amount | % | Amount | % | Amount | % | Amount |
| Helicopter charter | Charter helicopter hours | $45,842.50 | 80% | $36,674.00 | 5% | $2,292.13 | 12% | $5,501.10 | 3% | $1,375.28 | 100% | $45,842.50 |
| Helicopter fuel | Charter helicopter fuel | $2,856.60 | 80% | $2,285.28 | 5% | $142.83 | 12% | $342.79 | 3% | $85.70 | 100% | $2,856.60 |
| Fixed Wing Charter | Fixed wing charters | $12,689.11 | 85% | $10,785.74 | 5% | $634.46 | 8% | $1,015.13 | 2% | $253.78 | 100% | $12,689.11 |
| Consulting | Geotechnical supervision, interpretation | $26,800.00 | 80% | $21,440.00 | 0% | $0.00 | 15% | $4,020.00 | 5% | $1,340.00 | 100% | $26,800.00 |
| Geophysics | Contract Geophysics - surface/DDH seismics | $31,820.00 | 0% | $0.00 | 0% | $0.00 | 90% | $28,638.00 | 10% | $3,182.00 | 100% | $31,820.00 |
| Line-cutting | Line-cutting, drill pads, heli-pads | $6,502.50 | 0% | $0.00 | 100% | $6,502.50 | 0% | $0.00 | 0% | $0.00 | 100% | $6,502.50 |
| Camp fuel | Diesel, propane, regular gas | $71.61 | 40% | $28.64 | 40% | $28.64 | 20% | $14.32 | 0% | $0.00 | 100% | $71.61 |
| Drilling | Direct contractor footage, time and materials | $76,833.91 | 100% | $76,833.91 | 0% | $0.00 | 0% | $0.00 | 0% | $0.00 | 100% | $76,833.91 |
| TOTAL | | $203,416.23 | | $148,047.58 | | $9,600.55 | | $39,531.34 | | $6,236.76 | | $203,416.23 |
| | | Units | metres | 209.55 | metres | 6,600.00 | metres | 6,300.00 | metres | 57.65 | | |
| | | Unit Costs | $/m | $706.50 | $/m | $1.45 | $/m | $6.27 | $/m | $108.18 | | |

## TABLE 3. ALLOCATION OF EXPENDITURES BY CLAIM

| Claim Name | Record # | Expiry Date ** | Drilling metres | Line Cutting metres | Geophysics metres | Drill hole Geophysics metres | Apportioned Expenditures by unit cost | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Drilling | Line Cutting | Geophysics | DDH seismic | TOTAL |
| Janet W. No. 2 | 6161 | 03-Jul-95 | 30.35 | 440.00 | 440.00 | 30.35 | $21,442.35 | $640.04 | $2,760.36 | $3,283.36 | $28,126.66 |
| Elysa 2 | 203390 | 05-Aug-2004 | | 150 | 150 | | $0.00 | $218.19 | $941.22 | $0.00 | $1,159.42 |
| Bull No. 5 | 6306 | 03-Jul-95 | | 70 | 70 | | $0.00 | $101.82 | $439.24 | $0.00 | $541.06 |
| Swamp 3 | 201928 | 23-jul-2004 | | 40 | 40 | | $0.00 | $58.19 | $250.99 | $0.00 | $309.18 |
| CO 5 | 201803 | 04-Mar-2004 | 57.00 | 900 | 900 | | $40,270.64 | $1,309.17 | $5,647.33 | $0.00 | $47,227.14 |
| Shazah 1 | 323102 | 22-Dec-2004 | 116.35 | 3000 | 3000 | 27.3 | $82,201.55 | $4,369.89 | $18,824.45 | $2,953.40 | $108,343.29 |
| Elysa 1 | 203389 | 05-Aug-2004 | | 1700 | 1700 | | $0.00 | $2,472.87 | $10,667.19 | $0.00 | $13,140.06 |
| CO 3 | 201802 | 04-Mar-2004 | 5.85 | 300 | | | $4,133.04 | $436.39 | $0.00 | $0.00 | $4,569.23 |
| TOTALS | | | 209.55 | 6600 | 6300 | 57.65 | $148,047.58 | $9,600.55 | $39,531.34 | $6,236.76 | $203,416.23 |
| | | Unit Cost | $706.50 | $1.45 | $6.27 | $108.18 | | | | | |

## STATEMENT OF QUALIFICATIONS

Terence E. Chandler

I, Terence E. Chandler do hereby certify:

- I hold a Bachelor of Science (Honours) degree in Geology granted by Carleton University, Ottawa in 1975
- I am a registered Professional Geoscientist with the Association of Professional Engineers and Geoscientists of British Columbia, Registration No. 20400
- I have worked continuously in the field of geology and mineral exploration for the past 19 years and have held senior positions with several major mining companies.
- I have been employed by Redfern Resources Ltd. since January, 1993 as Vice President, Exploration.
- I am personally aware of all of the work which is described in this report and I was on site to inspect BCGI's work during the field drilling and geophysical programs in September, 1994.

Dated at Richmond, B.C., this 15th day of June, 1995

T. E. CHANDLER

Terence E. Chandler, P.Geo

# APPENDIX A

## Bruce Geotechnical Consultants Inc. Report on Tailings and Plant sites Evaluation Tulsequah Chief Project NW B.C.

# TULSEQUAH CHIEF MINE FEASIBILITY STUDY

## Tailing Containment and Plant Site Evaluation

Bruce Geotechnical Consultants Inc.
Ste. 210, 1290 Hornby Street
Vancouver, B.C. V6Z 2G4

for

Redfern Resources Ltd.
Ste. 205, 10711 Cambie Road
Richmond, B.C. V6X 3G5

June 9, 1995

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R. Hillman, Frontier Geoscience Inc.

Appendix 2 Drill Hole Logs and Field test Results, Laboratory Test Results

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# 1. INTRODUCTION

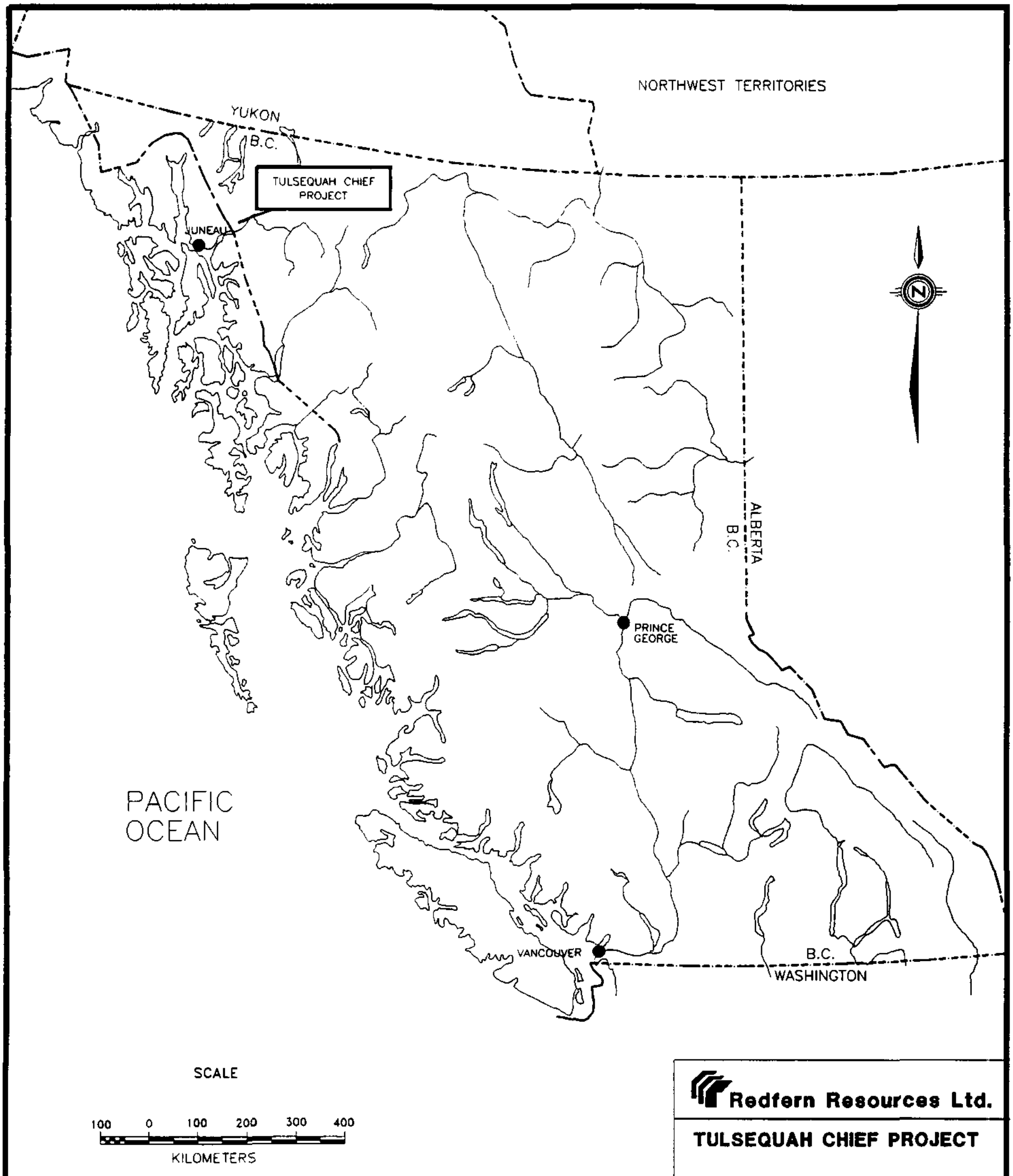
## 1.1 Scope of Work

Redfern Resources Ltd. is presently undertaking a feasibility study for reopening the Tulsequah Chief mine in north west British Columbia. The site lies approximately12 km west of the Canada - US border, approximately 70 km north-east of Juneau Alaska and 100 km south west of Atlin B.C. (Figure 1.1).

The proposed project will consist of an underground mine, surface mill, tailing pond and waste dump. Bruce Geotechnical Consultants Inc. (BGC) were retained to undertake the geotechnical investigations associated with the foundation assessment and siting requirements for both the plant site and the tailing dam locations.

A total of seven potential tailing dam and two plant sites were evaluated as part of this study. The potential sites are shown on Figure 1. 2. The sites were originally chosen from a 1:50,000 scale topographic map and low level black and white air photographs. Initial screening was undertaken by reconnaissance survey to assess the sites and identify the most favourable for detailed site investigations. The screening process for choosing two preferred tailing dam sites and appropriate plant Site areas is described in Section 3.0.

As a result of the screening process, two areas at Shazah Creek and Paddy's Flats were chosen for detailed work. The results of the field investigations are described in Section 4.0 of this report. Laboratory testing was limited but is described in section 5.0. Feasibility level design was initiated at both Paddy's Flats and a single site in Shazah Creek. However, in early 1995 it became clear that at least for the feasibility study, access would be from the north and Paddy's Flats would be a remote tailing dam site. Paddy's Flats while having the advantage of being well above any flood planes, and hence less susceptible to erosion, is closer to the only habitation in the area. In addition the area is dry and if flooding of the tailing dam becomes necessary, no supplemental water supplies are available. There is little or no catchment area above the pond to allow collection of precipitation and flooding. Consequently, following a preliminary assessment to define the capacity at Paddy's Flats, the feasibility design has focussed on Shazah Creek.



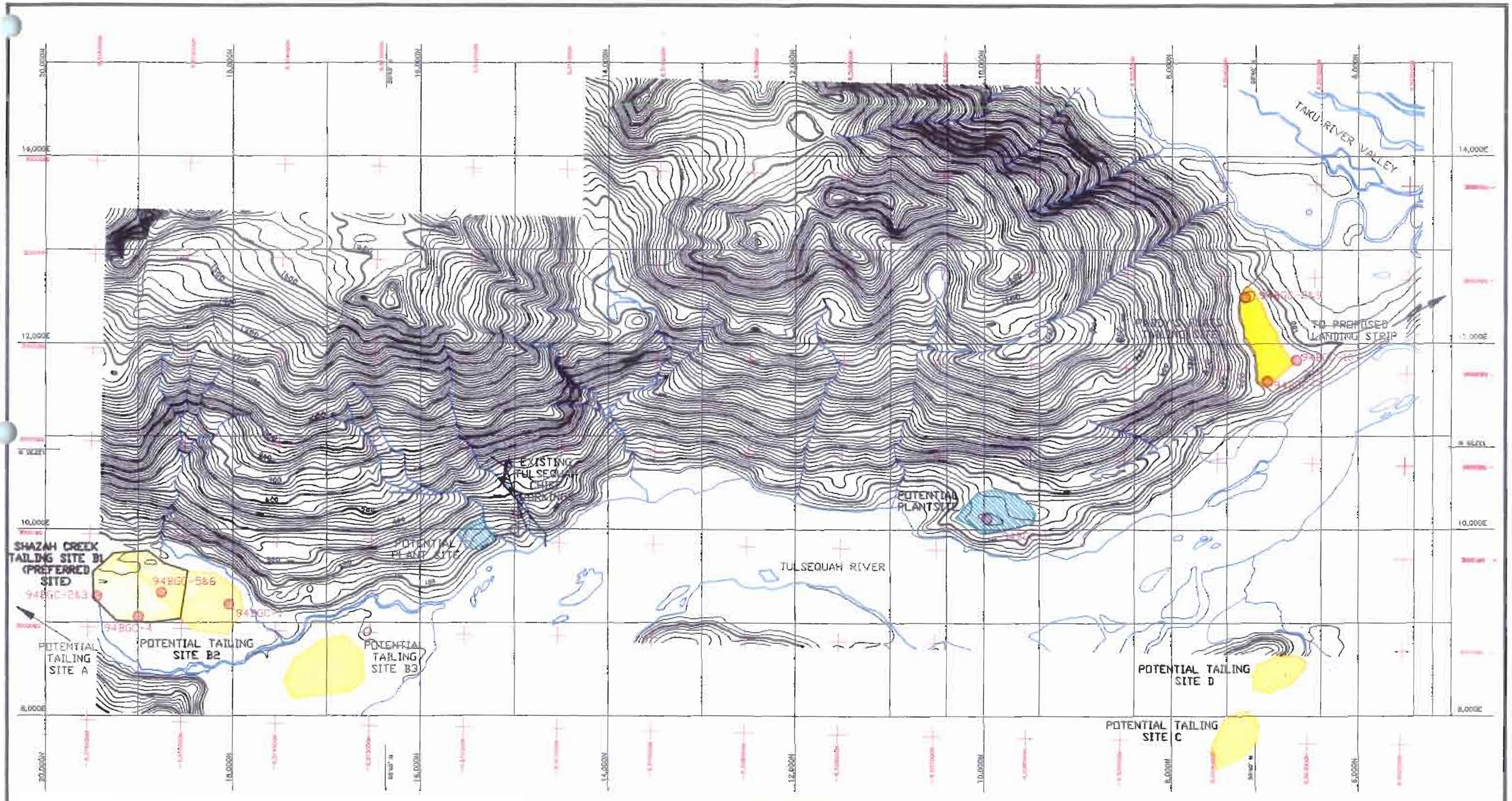
**Redfern Resources Ltd.**

**TULSEQUAH CHIEF PROJECT**

**PROJECT LOCATION**

*FIGURE:* 1.1

FILE: D:DWG:6a11:BCLOC



BGC BRUCE GEOTECHNICAL CONSULTANTS INC.
AN APPLIED EARTH SCIENCES COMPANY

| | |
|---|---|
| PROJECT | TULSEQUAH CHIEF PROJECT |
| TITLE | FEASIBILITY STUDY<br>SITE PLAN |

| CLIENT: | PROJECT No. | DWG. No. | REV. |
|---|---|---|---|
| REDFERN RESOURCES LTD. | 0060-001-01 | FIG. 1.2 | |

### 1.2 Project Description

The proposed project is currently being evaluated for a mine life of 10 years. During this period 8 million tonnes of ore will be processed at a rate of approximately 800,000 tonnes (800 kt) per year. The mine development will require that some of the mine tailings be returned underground as a structural fill. Cement paste backfill has been proposed. In addition, storage of uncemented tailing is also being considered to reduce the amount of tail finally stored on the surface and also to place sulphide rich tail underground below the water table where possible.

Mining has been undertaken at the Tulsequah Chief between 1951 and 1957. The mine closed in 1957 due to low metal prices. During operations ore was shipped across the Tulsequah river on bridges and processed at the Polaris Taku mine site on the west side of the Tulsequah River. The bridge was regularly replaced as a result of flooding and moving channels in the Tulsequah River.

The Tulsequah Chief site is presently accessed by air from Atlin using the landing strip at the Polaris Taku town site. Air, road and barge transport have all been considered by others as access options for this study but this feasibility level study has focussed on a road route from Atlin.

## 2. SITE CHARACTERIZATION

### 2.1 Regional Setting and Physiography

The Tulsequah River area is located in the rugged terrain of the Coast Mountains; the second largest metamorphic and plutonic belt in the Canadian Cordillera, stretching from the U.S. Border in the south to the Yukon border in the north. It is bounded by the Insular Mountains and Coastal Depressions, part of the Insular Belt to the west and the Interior Plateaus, the Stikine Plateaus and the Skeena Mountains, all of which is part of the Intermontaine Belt to the east. It was formed during the Cretaceous and early Tertiary time, probably as a result of the collision of the Intermontaine Belt with the Insular Belt. The slightly sinuous, northwest trend of the Coast Mountains is cut by westward flowing rivers. These rivers and their tributaries have effectively dissected the mountain belt into discrete groups of mountains with associated small ice fields or clusters of cirque glaciers. Peaks are steep and rugged, with saw-toothed ridges and jagged spires. The valley floors of the smaller rivers and streams are narrow, with steep sided, forested valley walls. The larger rivers, and some of the rivers of glacial origin, have braided river channels that meander across wide, flat flood plains. This is a result of changing flow regimes characterized by torrential runoff during the spring and early summer and lower flow volumes and velocities during the rest of the year. The local relief ranges up to 1500 m (5000 feet) with elevations along the Taku and Tulsequah Rivers below 30.0 m.a.s.l..

The headwaters of the Tulsequah River are at the toe of the Tulsequah Glacier, approximately 20 km northwest of its confluence with the westward flowing Taku River. The physiography of the Tulsequah River Valley is dominated by a 1 to 1.5 km wide flood plain surrounded by steep sided valley walls. Numerous small creeks drain into the valley from the surrounding highlands. Shazah Creek is located approximately 7.5 km downstream from the Tulsequah River headwaters and is one of the larger creeks. It cuts deeply into the underlying metavolcanics, flowing southwest in a steep walled, narrow valley. At the junction with the Tulsequah River, the valley in which it flows widens, forming a 1 km wide triangular shaped flood plain and swampy area. This area is one of the sites under consideration for the location of the tailing impoundment.

The Tulsequah River joins the Taku River approximately 20 km downstream from the Tulsequah Glacier, at a broad flat area called Flannigan Slough. West of the river, this area is swampy, with numerous small streams flowing roughly parallel to the Tulsequah River in a southerly direction. East of the Tulsequah River, as it enters the Taku River floodplain, is a remnant terrace, forming a triangular shaped area bordered by the Tulsequah River to the west, the floodplain of the Taku River to the east and the flanks of Mount Manville to the north. This elevated triangular shaped area referred to as Paddy's Flats is the second site under consideration for the location of the tailing impoundment.

## 2.2 General Geology

### 2.2.1 Bedrock Geology

The bedrock geology of the area is characterized by intensely folded and regionally metamorphosed Paleozoic to Mesozoic fault bound terranes unconformably separated from Tertiary sedimentary and volcanic rocks. The fault juxtaposed terranes exhibit varying degrees of metamorphism and deformation, ranging from phyllite and greenstone in the east to amphibolite in the west. The area is intruded by Coast Crystalline Belt Jurassic to Cretaceous age granitic stocks, and Tertiary dykes and plugs.

The rock units in and surrounding the Tulsequah River Valley are composed of Paleozoic or older, strongly deformed and metamorphosed rocks on the west consisting of fine grained, clastic sediments, intercalated volcanic rocks, and their metamorphosed equivalents. On the east, the Mount Eaton Block of Mississippian to Permian age rock, consists of predominantly mafic volcanics and volcanic sediments with lesser felsic volcanic belts and associated massive sulphide deposits. Outliers of limestone or marble, probably Mississippian in age, crop out on the east side of the Tulsequah River 5 km south of the mine. These rock units are overlain by Pleistocene and Recent glacial sediments.

The structures of the Tulsequah River Area can be related to two major episodes of deformation which culminated in the Upper Jurassic time. The earlier Mesozoic episode was a time of uplift, isoclinal folding on North trending axes, regional metamorphism and granitic intrusion. The folding associated with the Upper Jurassic episode is of lesser intensity and refolds the earlier deformation. On the east side of the Tulsequah River, the Chief Fault, the West Bull Fault and the 4400 E Fault have been identified as major faults probably related to the earliest phase of deformation. In the vicinity of the Tulsequah Chief Mine, the rocks are folded into northwest plunging, overturned to steeply west-dipping parasitic folds on the west limb of the Mount Eaton anticline.

### 2.2.2 Glacial History

The last major period of glaciation occurred during Wisconsin time when the Cordillera was covered by an ice sheet or a complex of coalescing ice domes, the core of which was located in the interior of the Cordillera. Ice flowed north and south in general but also east and west in places where it overtopped lower parts of the fringing mountain ranges. In the west, the ice extended into the Pacific Ocean as a series of ice shelves. In the Coast Mountains, only the gross features of Wisconsonian or other Pleistocene glaciation are preserved. The U-shaped valleys with their over-steepened walls, truncated spurs and hanging tributary valleys owe much of their present form to Pleistocene glaciation. Evidence of Pleistocene ice-movement in the Coast Mountains has largely been obscured by later alpine glaciers, many of which still occupy the higher cirques and valleys. The valleys have been greatly modified by ice that remained in the Coast Mountains long after the Cordilleran ice sheet had retreated.

There is evidence that after the retreat of the Cordilleran ice sheet, a long period of warm climate caused the retreat and in some instance disappearance of alpine ice. This warm period was followed by a relatively cooler period, which had its peak in the mid-19th century. This was accompanied by rejuvenation and advance of alpine glaciers in the Coast Mountains. Since then, a gradual retreat of alpine ice has occurred. However, throughout the region there are instances of discordant behavior of neighboring glaciers. A notable example is the Taku Glacier, which since 1900, has been steadily advancing while nearby glaciers have been receding.

### 2.2.3 Surficial Geology

The surficial geology of the Tulsequah River Valley is predominantly the result of glacio-fluvial and fluvial processes. Jukulhaups have resulted in a heterogeneous mixture of sediments downstream of the Tulsequah Glacier. High flow velocities during jukulhaups result in the transportation of cobbles and the reworking and transportation of gravel deposits along the flood plain. High flows in the spring will transport somewhat coarser material as compared to the rest of the year and channel stratigraphy is typical of braided stream deposits. The Tulsequah River is infilled with coarse gravels and sands.

Shazah Creek north of the Tulsequah Chief Mine and three creeks called Wilms Canyon and Bacon Creek, all south of the Polaris -Taku Mine are the main tributaries to the Tulsequah River between its source at the glacier and the confluence with the Taku. Numerous small creeks with poorly developed valleys and small catchments are also found on both sides of the Tulsequah River.

Shazah Creek follows a deeply incised straight stream profile which appears to be structurally controlled as it descends from the highlands. At the upper end of the Shazah Flats, the creek passes through a narrow bedrock controlled channel shown on Photograph 2. Below this gorge the topography changes from a deeply incised valley to a broad triangular plain as shown on Photograph 3. Shazah Creek is presently confined to a single channel on the northwest side of the triangular fan. Old scars indicating flood flows which have escaped the channel and flowed across the fan can be seen on air photographs.

The three creeks on the west side of the Tulsequah River also appear to be structurally controlled as they flow out of the highlands and into the Tulsequah River.

Sediments in the main tributary creeks are predominantly coarse sands or gravels, with occasional boulders and organic debris transported during spring runoff. Near the confluence with the Tulsequah River, where the hydraulic gradient drops off, the valleys widen and the creeks meander through flat swampy areas. The decrease in hydraulic gradient in the vicinity of the confluence of Shazah Creek and the Tulsequah River has resulted in the deposition of much of the sediment being transported by the creek. Relict channel scars are visible where the Tulsequah River has meandered within its floodplain or where Shazah Creek has flooded and escaped its banks.

The stratigraphy along the Taku River is characterized by braided channels with sand and gravel predominating in the stratigraphy. Interbeds of silts and sands are likely present throughout the stratigraphy, representing overbank deposition. Terraces of sand and gravel material are present along the banks of the river and at the confluence of the Taku and Tulsequah Rivers.

### 2.3 Climate and Hydrology

A program of site climate and hydrology data collection was established by Rescan Environmental Services Ltd. in 1994. Details of the program including data collection sites and summaries of the data are given in a separate report by Rescan. The hydrological characteristics of the tailings disposal area for this feasibility study have been developed based on the site data and correlation analysis with regional data collected by Canadian and American agencies including the Atmospheric Environment Service of Environment Canada, Water Survey of Canada, and the Alaska State Climate Centre in Anchorage, Alaska.

Precipitation data have been collected at or near the Tulsequah Chief project site for a total of 24 months in 1964, 1965, 1966 (by AES) and for five months in 1994 (by Rescan). Juneau Airport in Alaska has precipitation data available from 1949 to the present. Juneau is located about 70 kilometres southwest of the Tulsequah site and is the closest long-term climate station. Temperature and precipitation conditions for Tulsequah have been estimated based on the site data and correlation analysis with the Juneau Airport data.

### 2.3.1 Temperatures

Temperature data at Juneau indicate, on average, that mean monthly temperatures are below freezing from December through February, although minimum monthly temperatures may be below freezing from November through March. Correlation analysis was carried out by SRK between Juneau Airport and Tulsequah for the available data from 1964 to 1966. Table 2.1 summarizes historical mean monthly temperature data for Juneau and estimated mean monthly temperatures for Tulsequah.

Table 2.1 - Average Monthly Temperatures ($^0$C)

| Month | Juneau Mean Monthly | Tulsequah Mean Monthly |
|---|---|---|
| January | -5.7 | -11.6 |
| February | -2.3 | -5.8 |
| March | 0.4 | -2.1 |
| April | 3.9 | 3.6 |
| May | 8.1 | 8.4 |
| June | 11.5 | 12.7 |
| July | 13.2 | 14.0 |
| August | 12.6 | 13.0 |
| September | 9.6 | 9.4 |
| October | 5.4 | 3.5 |
| November | 0.4 | -2.4 |
| December | -2.9 | -7.4 |
| Year | 4.4 | 2.9 |

### 2.3.2 Precipitation

Correlation analysis of the 29 months of concurrent precipitation data for Juneau Airport and the Tulsequah site indicate that from April through August the Tulsequah area experiences lower monthly precipitation (82% on average), whereas from September through March monthly precipitation at Tulsequah has been about 175% of precipitation at Juneau Airport. Correlation coefficients ($R^2$) for the common months of precipitation data were 73% and 88% for the two seasonal periods, respectively.

Over the full 40 year period of record, Juneau Airport annual total precipitation has averaged 1400 mm with minimum and maximum years of 955 mm and 2160 mm. Based on the average monthly ratios for the concurrent data, annual average total precipitation for the Tulsequah area was estimated to be 2020 mm. Figure 2.1 shows average monthly precipitation recorded at Juneau Airport and estimated for the Tulsequah area based on the above seasonal ratios.

Assuming average monthly temperatures below freezing indicate, in general, snowfall rather than rainfall, snowfall may contribute about 48% of annual total precipitation. Average snowfall at Tulsequah may, therefore, be about 970 mm.

Frequency analysis of annual Juneau Airport total precipitation was carried out and the results, adjusted to apply to the Tulsequah area, are shown in Table 2.2. In order to define design water storage volumes for the tailings impoundment, frequency analyses of Juneau data were also carried out for the maximum two month period (September and October), the maximum month (October) and maximum daily precipitation. The results, adjusted to the Tulsequah area, are also shown on Table 2.2.

Table 2.2 - Extreme Precipitation (mm) - Tulsequah Area.

| Return Period (years) | Annual | Maximum 2 Month | Maximum Month | Maximum Day |
|---|---|---|---|---|
| 1.25 | 1640 | 505 | 230 | 65 |
| 2 | 1940 | 645 | 320 | 80 |
| 5 | 2320 | 810 | 430 | 97 |
| 10 | 2550 | 905 | 500 | 109 |
| 20 | 2760 | 985 | 570 | 118 |
| 50 | 3010 | 1080 | 650 | 138 |
| 100 | 3200 | 1140 | 710 | 140 |
| 200 | 3350 | 1190 | 770 | 146 |
| 500 | 3570 | 1250 | 840 | 155 |

September and September plus October precipitation recorded at Juneau in 1994 both corresponded to about ten year return period events. Heavy precipitation and stream flows were recorded at the Tulsequah site for these months. The stream flow gauges installed by Rescan on Shazah Creek and Canyon Creek were destroyed by high flows on September 23, 1994 following 110 mm of rainfall recorded on September 22. Total September 1994 site precipitation was 469 mm. From Table 2.2 above, both the maximum day recorded and the total precipitation for the month of September 1994 appear to have been about ten year return period events.

Probable Maximum Precipitation (PMP) was estimated using the statistical Hershfield method and the Juneau maximum daily precipitation data. The 24 hour duration PMP rainfall was estimated to be 430 mm. Tulsequah rainfall data recorded in 1994 indicated that, in the September/October period, maximum 72 hour rainfall was about 1.35 times maximum 24 hour rainfall. The 72 hour duration PMP was, therefore, estimated to be 580 mm.

### 2.3.3 Evaporation and Evapotranspiration

Losses of water from the tailings impoundment will result from evaporation from the freewater pond and evaporative losses from exposed tailings beaches. Annual freewater evaporation in the Tulsequah area was estimated to be 400 mm based on the Canadian Hydrological Atlas. Losses from exposed tailings beaches are expected to be less than freewater evaporation rates. An annual rate of 100 mm of water loss from exposed beaches was used in the water balance calculations.

### 2.3.4 Stream Flows

Water level recorders were originally installed in Shazah Creek and Wilms Creek in May of 1994 but both were destroyed during a storm on September 22, 1994. The recorder were subsequently re-installed in October by Rescan Environmental Ltd. Water level data have been collected and converted to stream flows by Rescan for the period of record and are summarized in a separate report.

Shazah Creek at the Tulsequah River has a catchment area of about 106 km$^2$. Upstream of the tailings area the catchment area is about 93 km$^2$. Peak flood flows for Shazah Creek were estimated using the methodology presented in the report "Magnitude and Frequency of Floods in Alaska and Conterminous Basins of Canada" (U.S. Geological Survey, Water Resources Investigation Report 93-4179, 1994). The results are presented in Table 2.3.

Table 2.3 - Flood Flows for Shazah Creek

| Return Period (years) | Flow ($m^3/s$) |
|---|---|
| 2 | 32 |
| 5 | 55 |
| 10 | 72 |
| 25 | 100 |
| 50 | 120 |
| 100 | 145 |
| 200 | 170 |
| 500 | 200 |

Maximum stages measured during the September 1994 storm before failure of the water level recorder indicated a peak flow of from 60 to 70 $m^3/s$. From Table 2.3, this estimated flow corresponds to about a ten year return period event, consistent with the estimated return periods for the maximum daily and maximum monthly precipitation recorded at the site in September 1994.

### 2.3.5 Regional Groundwater Flow Patterns

No attempt has been made to assess regional groundwater flows. However, in general terms the groundwater patterns are expected to be normal with groundwater recharge occurring as a result of rainfall and snow melt infiltrating sand and gravels at lower levels or colluvium at upper levels. The groundwater is expected to flow generally down slope into the gravel filled river and creek valleys. It is expected that flow will be towards the valley bottoms and that generally the streams found in the valleys will also act to recharge the groundwater flowing through the alluvial deposits which infill the valley profiles.

Groundwater within the mountains surrounding the mine site can be expected to be controlled by discontinuities within the bedrock, particularly along the major faults. Some seepage discharge has been noted in the cliffs surrounding the minesite and this is probably due to daylighting fractures capturing and transmitting the groundwater flow.

### 2.3.6 Groundwater Flow Patterns at the Shazah Creek Tailings Disposal Site

Groundwater flow through the Shazah Creek floodplain is expected to be in a downwards direction until the water table is reached, and then flow parallel to Shazah Creek. The water table was found to be near the ground surface at the lower end of the fan and at a depth of 9.2m in the topographically higher part of the fan. The ground appears to rise approximately 8 to 10 meters over this same length hence the water table appears to rise approximately 1 to 1.5 m over a horizontal distance of approximately 700 m.

Total groundwater flow through the valley cross section (Q) can be estimated by;

$$Q = KAi$$

where K is the permeability in m/sec, A is the valley cross section area and i is the hydraulic gradient. Assuming a valley width of 700m, a maximum depth of 100m, and a triangular cross-section, the groundwater must pass through an area of 35,000 $m^2$. Assuming an average head drop of 2m over 700m across the site, and a hydraulic conductivity of $2x10^{-4}$ m/s in the alluvial sediments, the groundwater flux passing through the valley profile would be 0.02 $m^3/s$. Estimates of volume may be out by as much as 1 or 2 orders of magnitude but even if the flux increases by two orders of magnitude, the groundwater flow is still calculated to be no greater than 1 to 2 cumec.

### 2.3.7 Groundwater flow at Paddy's Flats

An attempt was made to characterize the groundwater flow at Paddy's Flats using piezometers installed to depths of approximately 25 m. All of the boreholes were dry during drilling in September of 1994 and the piezometers measured following installation and in November 1994 by Rescan were also dry, indicating that the water table is at a depth of at least 25m. The deep groundwater table most likely has a low gradient from the cliffs to the north of the tailings site towards the confluence of the Taku and Tulsequah rivers. The depth to bedrock at the site is estimated to be 40 to 60m on the basis of geophysics data.

## 2.4 Baseline Water Quality

No attempt has been made to sample the water for baseline quality by BGC. However, we understand that Rescan Environmental have sampled the Piezometers and will be supplying this data to Redfern.

## 3.0 PRELIMINARY SCREENING ASSESSMENT

### 3.1 Introduction

A total of seven potential tailing containment areas and two potential plant sites were identified and briefly assessed on the basis of topographic maps, air photo interpretation and published information in May of 1994. A letter report was issued by BGC identifying the most suitable sites and recommending which sites could be assessed in detail for design. The sites are shown on Figure 1.2. A brief description and discussion of the suitability of each site as a tailing containment area is provided below.

### 3.2 Site A - Shazah Creek Cross Valley Dam

Site A was originally chosen on the basis of a 1:50,000 scale topographic map and an air photo review. The site lies in a narrow gorge of the Shazah creek. Rock was reportedly exposed on the left bank of the river. The site was originally considered promising for a flow through or overflow dam which could safely store a flooded tail.

Drilling and seismic geophysics were initially planned for this site to evaluate the foundation conditions for the proposed dam. However, mapping undertaken ahead of the detailed field program indicated that the right bank consists of rock blocks several meters across . Gaps between blocks were large and the debris as a whole appeared to be pervious and open. This was considered to be difficult to grout and was considered pervious enough without grouting to allow the passage of fine tailing.

A preliminary assessment of the creek flows undertaken by others (SRK, 1993) indicated a calculated peak flood flow in the Shazah Creek equivalent to the peak flood flow in the Capilano River in North Vancouver. Further assessment of the hydrology undertaken by Dr. Peter McCreath of Clearwater Consultants Ltd. on behalf of BGC, using flow data gathered by Rescan Environmental has decreased the predicted peak flows by approximately 50% but the predicted flows are still high and very peaky as outlined in section 2.3.4. Diversion of the river during construction would require a tunnel through the left bank at the very least and water handling facilities were considered to be technically difficult and expensive. It was also considered that the high flows could also re-suspend the fine tail stored behind the dam and flush it over the dam into the lower Shazah Creek.

In addition, bedload in Shazah Creek is high. Construction of a dam across the river would stop the flow of the debris and eventually fill the reservoir and possibly displace tailing.

Given the obviously poor foundation conditions on the right bank, the problem of diverting high flows in the creek, and the problems of filling the reservoir with gravels transported down stream, it was recommended that Site A not be studied further.

### 3.3 Sites B1, B2, B3 Shazah Creek Fan

Sites B1, B2 and B3 are located on a gravel fan of the lower Shazah Creek near the confluence with the Tulsequah River, (Figure 1.2).

Site B1 is located at the top end of a flat gravel fan that has formed within a wide rock walled valley. The area is covered by small alder with trunk diameters less than 10 cm. Top soil is virtually non-existent and gravels and cobbles are exposed at the surface. The topography shows a slight crowning of the gravels in the middle of the fan and there are no signs of surface creeks. There is evidence on air photographs that the Shazah Creek has flooded over the lower fan on occasion. However, it was considered the site could be protected from flooding with a berm and rip rap. This area was considered to be a good potential tailing containment area and was recommended for further exploration.

Site B2, lower down the Shazah Creek in the same general area, lies lower and closer to a swampy area with poor drainage and standing water. This area while not as attractive because of the high groundwater was also considered to be a potential site and was recommended for further work.

Site B3 lies on the flood plain formed by the confluence of Shazah Creek and the Tulsequah River. This area is underlain by granular soils with coarse gravels and cobbles exposed on the surface. The area shows signs of flooding from the Tulsequah River and there are several minor active channels that traverse the site. The area could possibly be inundated during a Jukulhaup from the Tulsequah River. This site was therefore not recommended for further work.

### 3.4 Sites C1 and C2

Sites C1and C2 are located on Wilms Creek on the west side of the Tulsequah downstream of the Polaris Taku townsite area. (Figure 1.2) C1 as proposed was a cross valley dam while C2 was a side valley dam located closer to the Tulsequah River.

Site C1 was investigated on the ground in May of 1994. The river valley is wide and the sides of the valley consist of talus. The valley bottom is covered with large boulders up to 0.3 m in diameter and the creek flows were estimated to be similar to the flows in Shazah Creek. Given the pervious nature of the talus and gravels, the high flows and obviously large quantity of material currently being transported down the river, no further work was recommended. In addition, the tailing would have to be transported across the Tulsequah River either by bridge or tunnel adding extra cost or risk to the project.

Site C2 was not originally considered but was assessed in the field due to the apparent water and sediment loading characteristics of the cross valley system anticipated at site C1. The site lies on a narrow flood plain formed against a rock ridge in the vicinity of the confluence with the Tulsequah River and Helms creek. The site however, lies directly upstream of Flannigan Slough, which we understand is a sensitive fish spawning area. The site is also considered to be prone to flooding. This coupled with the distance from the mine and the need to cross the Tulsequah River prompted the recommendation to not pursue this site farther.

### 3.5 Site D, (Paddy's Flats)

Site D, referred to as Paddy's Flats, lies above the flood plain of the Tulsequah river at its confluence with the Taku River. The area is a flat tree covered river terrace. We understand the trees at this site were previously logged for timber supports for the Big Bull Mine on the Taku River. The area lies well above river levels and was considered to be a potential tailing dam site. There are no apparent slope stability problems above the area, there is little or no surface flow in and around the area. Further work was therefore recommended for this site.

### 3.6 Plant Site Areas

Two plant site areas were assessed in the field during mapping in August of 1994. The sites are located on Figure 1.2. The sites were picked on the basis of topography, slope stability and apparent bedrock foundation conditions.

Mapping initially consisted of reconnaissance along a topographic bench from the north plant site south toward the mine. The topography consists of long linear ridges formed by differential erosion around north south trending faults. The ridges are approximately 10 to 20 m wide at the top and slope steeply down into narrow gullies which slope and drain gently to the north west. The slopes above the plant site are massive volcanics and considered to be stable. A single drill hole was recommended for this site, but due to access problems, was not drilled. Current plans indicate that the site is probably too distant from the mine and a revised location further south has been suggested on the basis of topography and air photo analysis. The revised site has not been assessed in detail.

The south plant site consists of a large flat topographic high with easy access to the Big Bull area but limited and possibly difficult road access to the Tulsequah Chief. The area is flat, stable and bedrock is exposed nearly everywhere at the surface. The area has likely been flattened by glacial erosion. A single drill hole was drilled at this site to confirm bedrock and test for permeability.

### 3.7 Summary

As a result of the reconnaissance mapping and air photo analysis, a geophysics program and drilling program were proposed to define subsurface conditions and assess foundation permeability of the tailing dam sites at Shazah Creek (sites B1 and B2), Paddy's Flats and both plant sites. A seismic refraction geophysics program was also recommended for the Tulsequah River to evaluate the possibility of tunnelling beneath the river. The exploration program undertaken is described in the following section.

## 4.0 Field Explorations

### 4.1 Geologic Mapping

Geologic mapping and reconnaissance survey was undertaken at all the potential tailing dam sites and plant sites identified in Figure 1.2 either as part of the reconnaissance study undertaken in May of 1994 or the detailed study undertaken in September of 1994. Access was provided by helicopter and traverses were taken across the areas and along the bank of the various creeks.

## 4.2 Geophysics

A geophysics program was undertaken by Frontier Geosciences Inc. between September 23 and October 7, 1994. The work consisted of seismic refraction and downhole shearwave velocity testing. The work was undertaken at the Shazah Creek B1 and B2 tailing dam sites, Paddy's Flats tailing dam site and across the Tulsequah River at a potential tunnel crossing location. The purpose of the seismic refraction investigation was to determine the thickness and composition of the overburden overlying bedrock and define, where possible, the depth to sound rock.

The downhole geophysics testing was undertaken at Shazah Creek and Paddy's Flats to determine *in situ* elastic modulii properties of the geological materials to assist in assessing the liquefaction potential of the soils. The full report provided by Frontier Geosciences is supplied in Appendix 1.

## 4.3 Drilling

A total of eleven boreholes were drilled at the two preferred tailing dam sites, Shazah Creek and Paddy's Flats and at the southern plant site. The holes were drilled using a heli-portable HT-700 drill rig flown in to the Polaris Taku airstrip and moved to each borehole location by Jet Ranger helicopter. The drilling was undertaken by Foundex Explorations of Surrey. All drilling and instrument installation was supervised by BGC personnel.

Plastic casing was installed and grouted into a single borehole at Shazah Creek and a single borehole at Paddy's Flats for later use in the downhole geophysics survey. Standpipe piezometers were installed in both deep and shallow holes to record groundwater levels and allow sampling for baseline water quality samples to be obtained by Rescan Environmental at a later date.

All drilling was undertaken with water where possible but in some zones the gravels were pervious and collapsed into the holes. A bentonite drilling mud was used to keep the hole open. The mud was flushed until clean water returned prior to the installation of all piezometers or prior to undertaking permeability tests. Borehole locations are summarized in Table 4.1 and shown on Figure 1.2. The borehole logs complete with field and laboratory test results are provided in Appendix 2.

Soil samples were recovered using a Standard Penetration Test (SPT) split spoon sampler. The sampler was driven using a conventional cat-head and hammer system. The blow counts derived from the SPT tests are used to assess the soil density and quantify the potential to liquefy under earthquake loadings.

The SPT sampler is driven a total of 45 cm. Blow counts are normally recorded for each of three 15 cm intervals and the blow count N is recorded as the sum of the last 30 cm of penetration. N values recorded using the standard cathead and pulley system are referred to as $N_{60}$ values to reflect the fact that only 60% of the theoretical energy applied to top of the drill rods actually reaches the tip.

In gravelly or cobbly soils, the sample often plugs off and the sampler is effectively driven closed ended. The blow count recorded is artificially high for the soil and does not truly represent the density. In order to overcome this problem, blow counts were recorded for every 2.5 cm of penetration of the split spoon sampler. The recovery of soil in the sampler was then used to determine if the standard blow count could be calculated normally or if the blow count had to be modified taking into account the soil recovery. The actual $N_{(60)}$ blow counts for each inch of penetration and the soil recovery percentages are shown on the borehole logs in Appendix 2.

If the sample recovered corresponded to the full 45 cm of driving the blow count was calculated in the standard method. If the sample recovery was less than 100% for instance 12 cm, the blow counts corresponding to the first 12cm were scaled up to 30 cm of penetration and the modified blow count used. The blow count values calculated using this method are conservative and tend to be lower than normal because the method utilizes the first 15 cm of penetration which is normally disregarded.

### Table 4.1

**Borehole Location Summary From GPS data**

| Borehole # | Northing | Easting | Depth to water Table |
|---|---|---|---|
| DH#1 | 6,514,494 | 580,251 | surface |
| DH#2 | 6,516,015 | 580,691 | 9.2 (Sept 28,94) |
| DH#3 | 6,516,015 | 580,691 | dry |
| DH#4 | 6,516,049 | 580,153 | na |
| DH#5 | 6,515,194 | 580,415 | 0.2m (Sept 28,94) |
| DH#6 | 6,515,194 | 580,415 | 2.0 m (Sept 28, 94) |
| DH#7 | 6,503,642 | 582,775 | 29 m during drilling |
| DH#8 | 6,503,840 | 583,544 | dry (Sept 28, 94) |
| DH#9 | 6,503,840 | 583,544 | dry (Sept 28, 94) |
| DH#10 | 6,503,371 | 583,077 | dry to 23 m during drilling |
| DH#11 | 6,506,750 | 581,165 | 0 |

## 4.4 Permeability Testing - Tailing Dam Sites

Falling head tests were attempted in the open upper 1.15 m of Drill Hole #94-BGC-DH1, but this gave no useful results since the depth of the water table was near surface and could not be accurately determined. Falling head tests were also attempted once the piezometers were in place, but were abandoned since water could not be added fast enough to raise the water level in the piezometer pipes due to the very pervious nature of the soil and the difficulty in bringing large quantities of water to the site. Permeabilities were therefore estimated using the piezometers to perform constant head tests under various pump pressures. Pump flow rates were adjusted at set pressures until a constant height of water in the piezometer pipe was maintained. A summary of the permeability test data is provided on Table 4.3.

The permeability of the material was also checked using Hazen's formula. This calculates the soil permeability based on the apparent grain size of the soil corresponding to the 10% passing on the total curve. The permeabilities calculated using the formulas corresponded well with the values calculated using the pump tests. Values are summarized on Table 4.4.

### 4.5 Piezometer Installation

Piezometers were installed in all holes except drillholes #4 and #7 which were used as the downhole seismic shear wave holes. The downhole seismic casing was grouted into place over the entire length of the hole hence water flow into the holes was prevented.

The remaining standpipes were installed with Casagrande style pervious tips glued onto the base of 19 mm ID PVC pipes. The tips were surrounded by river sands for a depth of 3 to 4 m then a thick cement grout was tremied into the borehole above the gravel pack. The hole was then backfilled with a cement bentonite mud slurry and sealed at the ground surface using bentonite chips.

**Table 4.3 Summary of Field Permeability Test Calculations**

| Drill Hole Number | Depth of Test Section (m) | Test Pressure (psi) | Permeability (cm/sec) |
|---|---|---|---|
| 94-BGC-DH2 | 10.5 - 14.6 | 5 | 6.8 x 10-3<br>5.2 x 10-3 |
| | | 10 | 1.3 x 10-2<br>9.9 x 10-3 |
| | | 15 | 1.3 x 10-2<br>5.2 x 10-3 |
| 94-BGC-DH3 | 2.43 - 3.81 | 0 | 1.2 x 10-3 |
| | | 5 | 5.6 x 10-4 |
| 94-BGC-DH6 | 2.43 - 4.0 | 2 | 3.9 x 10-3 |
| 94-BGC-DH8 | 22.2 - 25.9 | 4 | 3.6 x 10-5 |
| | | 10 | 5.2 x 10-5<br>3.1 x 10-5 |
| 94-BGC-DH10 | 2.3 - 4.3 | 5 | 2.0 x 10-4 |
| | | 10 | 1.4 x 10-4 |

**Table 4.4**
**Summary of Permeabilty Coefficients Estimated using Grain Size Curves.**

| Sample No. | Depth (m) | Grain Size Passing $D_{10}$ (cm) | Permeability (cm/sec) |
|---|---|---|---|
| DH 2 | 1.2 | 0.013 | 1.7 X $10^{-2}$ |
| DH 2 | 7.3 | 0.0075 | 5.5 X $10^{-3}$ |
| DH 2 | 14.8 | 0.0100 | 1.5 X $10^{-2}$ |
| DH 5 | 7.2 | 0.011 | 1.2 X $10^{-2}$ |
| DH 5 | 10.2 | 0.011 | 1.2 X $10^{-2}$ |
| DH 5 | 14.7 | 0.015 | 2.2 X $10^{-2}$ |
| DH 5 | 24 | 0.0075 | 5.5 X $10^{-3}$ |
| DH 7 | 5.8 | 0.010 | 1.5 X $10^{-2}$ |
| DH 7 | 21.0 | 0.010 | 1.5 X $10^{-2}$ |
| DH 7 | 14.8 | 0.010 | 1.5 X $10^{-2}$ |
| DH 7 | 10.3 | 0.010 | 1.0 X $10^{-2}$ |

## 5. LABORATORY TESTING

Laboratory testing was undertaken on samples of soil recovered from the split spoon sampler. The soils were reviewed to confirm field interpretation, to test for Atterberg Limits and primarily for grain size distribution of the cohesionless soils. The results of the laboratory testing were incorporated in to the boreholes where appropriate and the grain size curves are included as Appendix 3. All soils were cohesionless and non plastic. The samples tested were primarily sands with fine gravels and less than 9 to 5% silt sizes. The larger sized gravels and cobbles were of course not tested due to the sampling technique.

## 6. NATURAL HAZARD ASSESSMENT

### 6.1 General

The Tulsequah Chief mine site lies in a seismically active area of rugged terrain in northern British Columbia. Annual precipitation is high and creeks are prone to flash floods. The combination of rugged terrain and heavy snowfall means that parts of the area are prone to avalanche. The Tulsequah River is prone to cyclic flooding from Jukulhaups and debris torrents are possible on some of the tributary creeks. For this reason, the following section has been prepared to identify and address concerns on natural hazards which might impact on either tailing dam site or plant site.

## 6.2 Tulsequah River Jukulhaup Flooding

The Tulsequah Glacier is located approximately 20 km northwest of the intersection of the Tulsequah and Taku Rivers. It extends in a northwesterly direction for approximately 17 km where it meets the southern lobes of the Llewellyn Glacier. Tulsequah Lake is a 5 km long by 0.8 km wide glacier lake that occupies a steep walled valley dammed at one end by a short distributary arm of the Tulsequah Glacier. This lake fills with glacial meltwater a depth of 60 to 110 meters whereupon it exerts a buoyant force on the confining glacier and drains under the ice and discharges at the toe some 7 km away. As the lake empties, the buoyant support of the water is lost and the edge of the glacier collapses, leaving a dry lake bed strewn with icebergs. The discharge of impounded water beneath an uplifted ice dam is known as a jukulhaups. A jukulhaups typically occurs annually in the spring when runoff from melting snowpack and precipitation is highest but may occur whenever a sufficient volume of water is impounded. Drainage of Tulsequah Lake occurs in about three days, during which time up to 370 million cubic meters of water are poured into the Tulsequah Valley. A second lake, larger than Tulsequah Lake, is located farther upstream on the Tulsequah Glacier in an eastern valley and also causes jukulhaups. This second lake is known locally as Lake Nolake and drains over a period of one week to 8 days. During these periods of drainage, the broad flood plain of the Tulsequah River is inundated by a temporary flood that fills the entire valley with silt-laden water. Old water courses are plugged by gravel bars and new channels are carved in the shifting surface of the flood plain.

Jukulhaups have flooded the Tulsequah River over the past 90 years. During the operation of the Polaris Taku, Big Bull and Tulsequah Chief mines nearly all of the flat land in the Tulsequah Valley has been flooded, including the town site of the Polaris Taku Mine. Roads linking the town site and the mill on the west side of the river with the Big Bull and Tulsequah Chief mines on the east side were largely destroyed by each flood. Bridges across the channels of the Tulsequah River were either destroyed, buried in gravel or left redundant as the channels over which they crossed were left dry by the redirection of the river through newly carved channels.

The Jukulhaup flood has the potential to inundate the river valley but as the present mine works, all roads, both plants sites and the two potential tailing dam site at Shazah Creek or Paddy's Flats are all located above or remote from the Tulsequah river floodplain the Jukulhaup is not considered to pose a threat to the project.

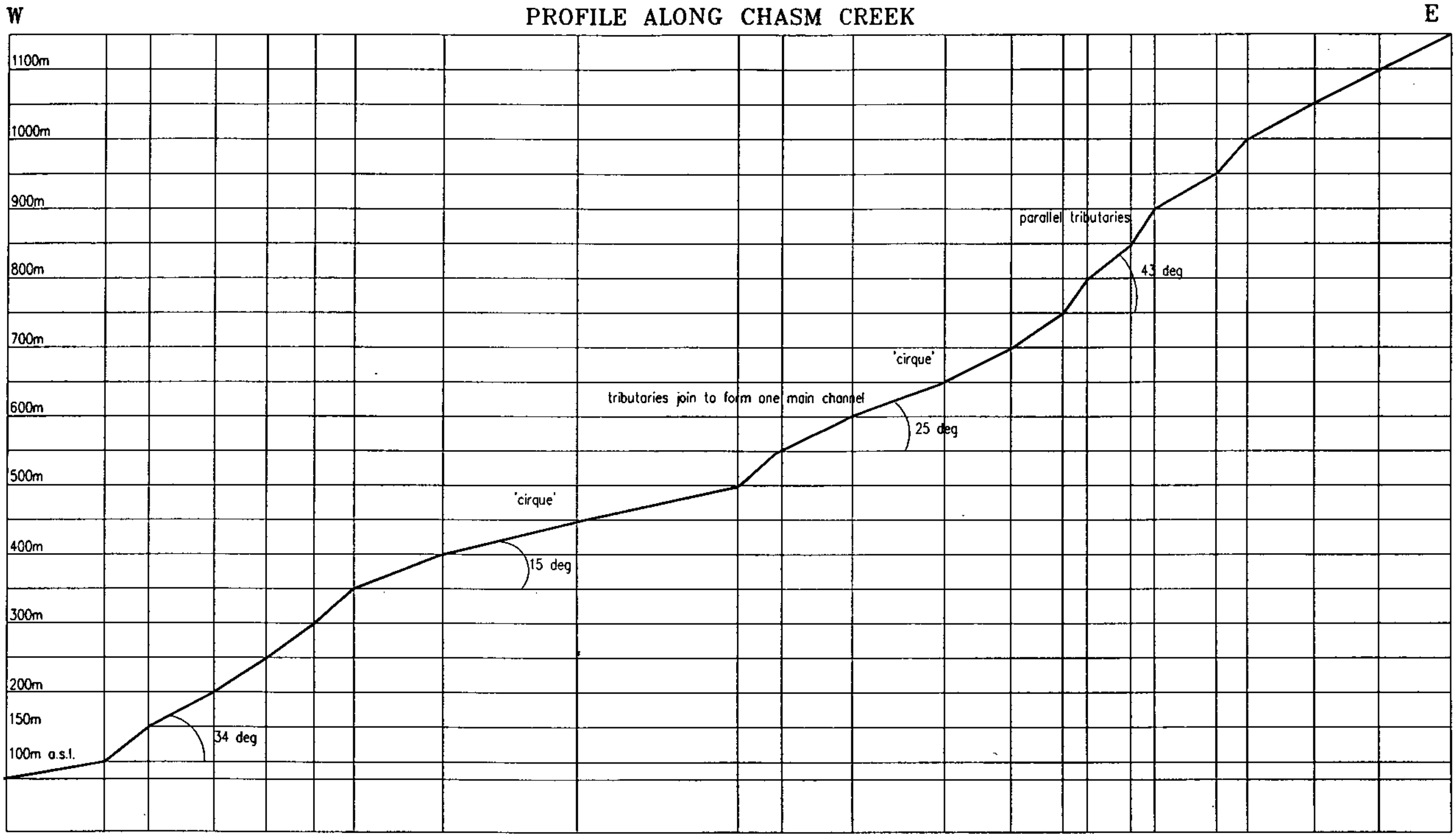
### 6.3 Debris Torrent Potential at Chasm Creek

The proposed tailing dam site at Shazah Flats lies north of Chasm Creek a short glacier fed creek with a relatively small catchment area. The creek flows north west off the side of Mt. Eaton then turns 90° and flows south west along the edge of the Shazah Creek fan, (Figure 1.2). The flow of Chasm Creek will be controlled by a combination of precipitation and glacial melt. The proposed tailing dam alignment has been maintained at least 50 m north of the creek so that any heavy flows or flooding will not impact on the dam.

The potential for a catastrophic flow or debris torrent out of the creek has been assessed. A debris torrent is defined as "a mass movement that involves water-charged, predominantly coarse-grained inorganic and organic material flowing rapidly down a steep, confined, pre-existing channel", (VanDine, 1985) Aerial photographs showing Chasm Creek were evaluated to determine if debris from this creek could be a hazard to the proposed tailing disposal area in the Shazah Creek floodplain. The climatic conditions affecting the creek are similar to areas which have experienced debris torrents such as the Squamish highway in southern B.C..

VanDine (1985) has identified conditions found in creeks which are conducive to the initiation of debris torrents. Creeks which are prone to debris torrents have similarities in drainage areas, creek profiles, sources of debris, and climatic conditions. Steep creeks with large volumes of debris and large flow events are prone to debris torrents. Even if the terrain and climatic conditions are suitable a triggering event, such as a critical discharge level or mass wasting into the creek, must occur in order for a debris torrent to initiate.

## PROFILE ALONG CHASM CREEK



**BGC** BRUCE GEOTECHNICAL CONSULTANTS INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT:
REDFERN RESOURCES LTD.

PROJECT
TULSEQUAH CHIEF PROJECT

TITLE
FEASIBILITY STUDY
PROFILE ALONG CHASM CREEK

| PROJECT No. | DWG. No. | REV. |
|---|---|---|
| 0060 001 01 | FIG. 6.1 | |

The collective drainage area of Chasm Creek is approximately 2.1 km$^2$, which is within the optimum range or recorded debris torrent events. However, the upper portion of the creek is drained by individual channels, many of which have catchment areas smaller than those that usually initiate debris torrents.

Initiation and transportation of the debris depends upon creek gradients, channel confinement, the material availability to create and sustain a debris torrent.

A large scale plan view of Chasm Creek is presented in Figure 1.2 and a profile along the creek channel is shown in Figure 6.1. The profile indicates that from its headwaters to the Shazah Creek floodplain the creek can be divided into four segments, with average gradients of 43°, 25°, 15°, and 34° respectively. The top section of the creek at 45°is steep enough to initiate a debris torrent, however the volume of debris in the creek bed can be expected to be minimal as the channels are incised into bedrock and there is little timber to create organic dams.

The next segment of the creek flattens to an angle of 25°as it enters the upper cirque. Cirques are erosional features and thus can be expected to have limited loose sediment available unless later infilling occurs. The appearance of braiding in Chasm Creek channel in this segment suggests that debris does exist in the valley floor, however the limited downcutting of the creek means it would be very difficult to mobilize this material. Initiation generally requires a gradient of greater than the 25° found in this segment. The unconfined nature of the creek, its low gradient, and lack of source debris in this segment suggests that initiation of a debris torrent is unlikely. The next segment of the channel passes through a lower cirque which has a gradient of 15°, which is too shallow to initiate a torrent but is near the minimum which will typically transport material. At 15°a debris torrent may begin to deposit levees, but formation of a fan usually begins at gradients less than 10°(VanDine, 1985). As the creek passes through the cirques its path is deflect by outcrops of bedrock. These changes in channel path are expected to dissipate energy from any material being transported downstream. The segment of Chasm Creek above the Shazah Creek floodplain is unconfined, shows no evidence of past debris torrents and is not expected to be a debris torrent hazard in itself.

Logs and woody debris often contribute to debris torrents by adding material to the channel and by damming creeks. The slopes above Chasm Creek are only partially tree covered and this is not expected to be a major source of debris for the creek.

Finally and most importantly, no evidence of past debris torrents originating from Chasm Creek such as a debris lobe, was observed on air photos, during helicopter flights over the Shazah Creek floodplain or during ground inspection. Debris torrents from Chasm Creek are not expected to be a hazard to the proposed tailing facility due to the absence of any field evidence of past events, the low volumes of debris in the initiation zones, and the debris 'catching' effects of the cirques because of their low gradients and the energy dissipation as torrents deflect around bedrock outcrops.

### 6.4 Floods and Avulsion in Shazah Creek

Concerns have been expressed that flooding of Shazah Creek could encroach on the proposed tailing facility or that large volumes of debris carried by the creek could be deposited in the creek forcing the creek to change direction and impinge on the tailing containment dyke. An inspection of the aerial photographs of Shazah Creek and the upstream drainage basin was undertaken to assess the potential for rock or soil instabilities which could form debris sources capable of accumulating in Shazah creek thereby causing an avulsion of the creek out of its present path. The main drainage into and along Shazah Creek follows straight drainage pattern which appear to be parallel to recorded faults and zones of weakness caused by tectonic activity. The slopes above the creek valley on both sides of the creek are heavily fractured and the broken rock has formed talus cones along the main creek course. The cones on the valley bottom cause the creek to meander on a local scale. The talus cones are tree covered and considered to be moderately stable. The slopes above the creek on the east side are dip slopes. The west slopes appear to be steeper and craggier and the tributary streams are more deeply incised. The talus cones on the west side of the river appear to be larger than the cones on the east.

Ongoing ravelling and talus cone buildup followed by erosion of the cones and transportation down river appears to be an ongoing steady state process. As the headwaters are incised into bedrock and the middle section of the creek winds past coarse talus the possibility for a large scale failure of the rock slopes which would dam the creek or act as a source of debris to the Shazah fan is considered minimal. As the creek gradient upstream of the tailing facility is a 6 to 8% gradient no major increase in transported material is expected. It appears from our site visit that under normal flow conditions most material being carried by the creek is not being deposited near the proposed tailing facility and is generally being transported through to the Tulsequah River.

Nevertheless, an armoured berm will be incorporated into the upslope face of the tailing facility as protection against scour from Shazah Creek and also to divert any flood flows that might escape the creek channel and flow across the existing gravel fan. There is evidence of scarring on the air photos which implies that some past floods have escaped the present creek course and flowed straight down over the existing fan. The same berm will also act to train the creek and confine it to a channel, thus further minimizing the deposition of bedload and preventing the avulsion of the creek as it passes the tailing facility.

## 6.5 Rockfalls and Snow Avalanches

There do not appear to be any hazards from rockfall or snow avalanches at any of the proposed plant sites or above Paddy's Flats tailing dam.

Single rockfall tracks are visible in the trees high above the Shazah Creek tailing containment area on the north flank of Mt. Eaton. The tracks are limited and not extensive and there is no evidence that the tracks run out onto the tailing dam area. The tracks are restricted to single blocks as opposed to large slides.

There is no sign of significant avalanche hazards above the proposed Shazah Creek tailing dam site. Trees on the flat area of the Shazah fan indicate that no runouts have ever extended into the tailing dam footprint. There is an area visible on the most recent air photographs which has low brush cover with single isolated trees in the middle. The area does not appear to be the result of snow avalanche processes and in fact may be the result of old glacial scour from the hanging valley in Chasm Creek. However, even in the worst case of assuming the scar was caused by avalanche, the tailing dam at this location is set over 50 m from the edge of the scar and hence any possible runout. In addition, the impact of a snow avalanche on any tailing containment area will be limited to simply depositing some extra snow into the containment.

There appears to be some potential for avalanches to release from the north slope of Mt. Eaton to the east of the tailing containment area. This area is described in detail by Thurber Consultants as part of the access road design. These avalanches will not impact on the tailing dam.

## 6.6 Seismic Hazard and Ground Motion

The proposed mine site is considered to be in a seismically active area. All the plant sites and tailing dam sites are considered to have the same exposure to seismic hazards so this discussion applies equally to all sites. Figure 6.2 shows a plot of the epicenters of recent earthquakes which occurred within 250 km of the site and whose magnitude is greater than M4. The plot was obtained from the National Geophysical Data Center in Boulder Colorado. The largest earthquake to have occurred within 20 km of the site during the last 50 years is M4.2. The maximum magnitude of the region surrounding the site is considered to be M5.0 (Basham et al).

### 6.6.1 Probabilistic Assessment of Design Earthquakes

A probabilistic seismic hazard estimate was obtained from the Pacific Geoscience Centre. The results are summarized as peak ground accelerations (pga) corresponding to particular exceedance probabilities or return periods in Table 6.1 below.

Table 6.1

Seismic Ground Motions

| Exceedance Probability (/yr) | Return Period (yrs) | PGA (g) |
|---|---|---|
| 0.005 | 200 | 0.088 |
| 0.0021 | 475 | 0.12 |
| 0.001 | 1000 | 0.16 |

# SEISMICITY WITHIN 250 KM OF 58N45' 133W37.5'

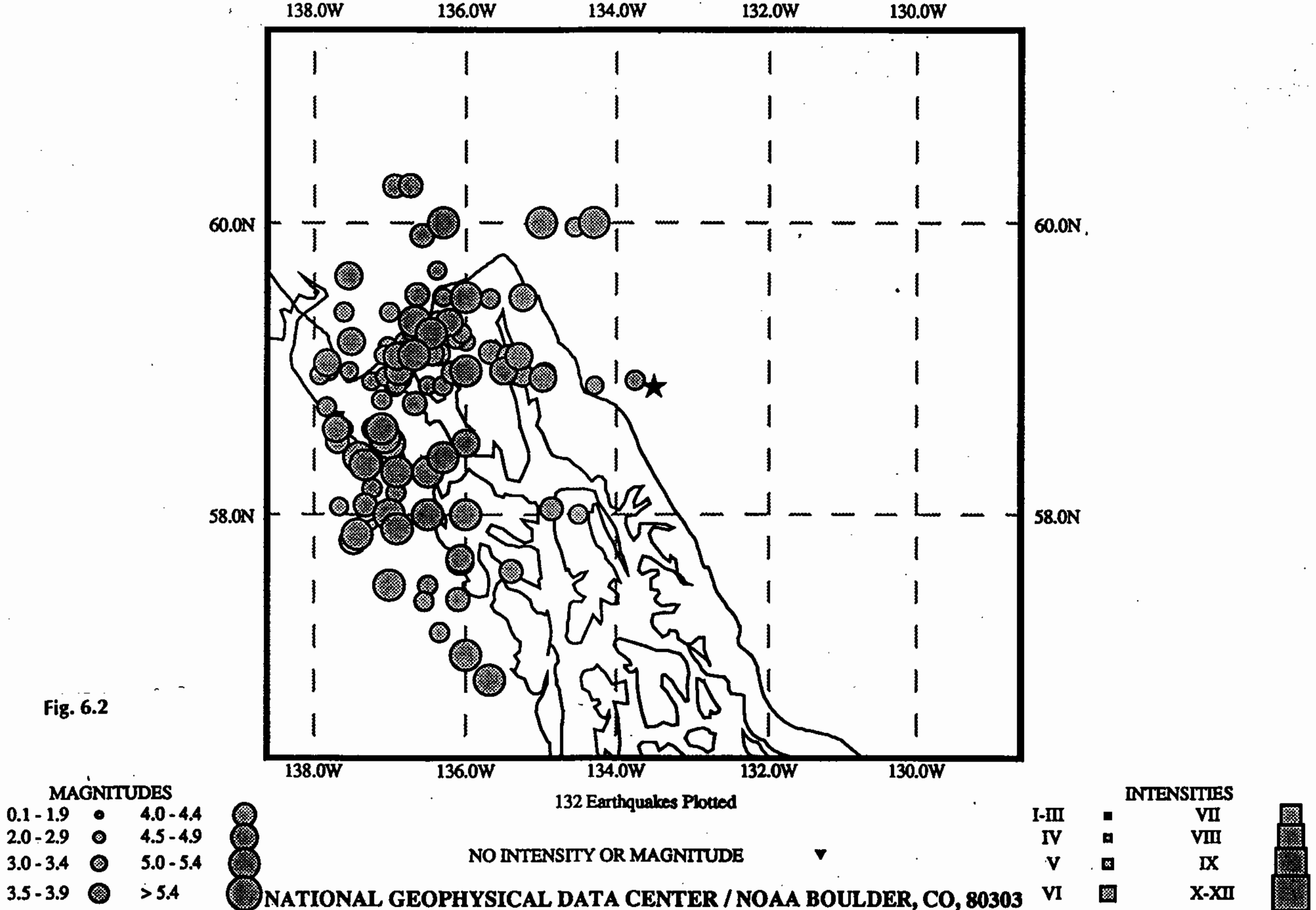


Fig. 6.2

The pga corresponding to a 10,000 year return period, often considered to be the Maximum Credible Earthquake or MCE (reference) has been estimated by extrapolation to have a pga value of between 0.25 and 0.26g.

### 6.6.2 Deterministic Assessment of Design Earthquakes

The seismic geology of major faults in Northwestern British Columbia is relatively well understood hence a deterministic assessment of the seismic risk has also been undertaken. Large seismic events equal to magnitude M6.5 are considered possible on the Chatham fault 60 km to the west of the site, while M8.5 is considered possible on the Fairweather fault 220 km to the west of the site (D. Campbell, 1992). The Fairweather fault is considered too distant to be of concern hence a deterministic assessment using only the Chatham fault as a source zone has been undertaken.

The Chatham fault is an extension of the active Denali fault. Assuming that the maximum magnitude on the Chatham fault could be M6.5, and using the attenuation relationships derived by Boore *et al* (1993) and K. Campbell (1990) a pga of 0.05g is calculated. The pga for a M7 event was also checked and found to be 0.07g. The amplitude of ground motion due to such an event is less than any of predicted design ground motion amplitudes determined from a probabilistic assessment on a near field event. For this reason, the effects of a near field smaller magnitude using the near field probabilistic calculations are considered more significant.

## 7.0 CONCLUSIONS

Seven locations were considered for the surface disposal of tailing. After an initial screening consisting of a site visit and airphoto interpretation two locations were chosen for investigation in greater detail. A field investigation program was then initiated in September, 1994 in preparation for design of a tailing storage facility. The stratigraphy at the sites was determined by coring and SPT sampling. Six boreholes were drilled in the Shazah Creek floodplain, three at Paddy's Flats, and one at a potential plant site. Both sites were found to be underlain by sands and gravels with occasional silt layers at depth. The plant site is founded on bedrock. Samples collected from the boreholes were tested in the laboratory for grain size distribution and moisture contents to be used in embankment design. Piezometers were installed at both tailing sites to measure the groundwater conditions. In the Shazah Creek floodplain the depth of the water table varied from surface to 10m, the water table at Paddy's flats was deeper than 25m. *In situ* permeability testing was combined with the grain size testing to evaluate the potential for seepage loses from any impoundments. A geophysical survey of the Shazah Creek floodplain determined the depth to bedrock and parameters to be used in a seismic hazard evaluation.

An evaluation of the seismic risk to structures was undertaken. The Shazah Creek floodplain was found to not be resistant to liquefaction with the design earthquakes for the region. The displacements in embankments resulting from seismic shaking were calculated to be used in design.

An airphoto study was performed to assess natural hazards. The entire Shazah Creek floodplain is prone to avulsions of the creek, and the area near the confluence with the Tulsequah River can be expected to be flooded during jukulhaups. It was found that the potential for a debris torrent in Chasm Creek is minimal. The proposed tailing site at Shazah Creek is not likely to be affected by snow or rock avalanches.

Detailed design of the tailing facility is continuing.

Bruce Geotechnical Consultants Inc.

Bill Burton, E.I.T.

Iain G. Bruce, Ph.D., P.Eng., P.Geo.

**Statement of Qualification**
Iain G. Bruce

I, Iain G. Bruce, do hereby certify that :

I hold a Bachelor of Applied Science degree from Queen's University in Kingston, granted 1973.

I hold a Ph.D. degree in Civil Engineering (Geotechnical) from the University of Alberta granted in 1978.

I have worked continuously as a geotechnical engineer specializing in consulting services to the Mining Industry since 1978.

I am presently president and senior geotechnical engineer at Bruce Geotechnical Consultants Inc.

This report is based on field and office work carried out between February 1994 and the present time.

Dated June 13, 1995.
Vancouver B.C.

Iain Bruce

IAIN BRUCE

I. G. BRUCE

Iain G. Bruce, Ph.D., P.Eng., P.Geo.
President

**Statement of Qualifications**

Bill Burton

I, Bill Burton, do hereby certify:

I hold a Bachelor of Applied Science in Geological Engineering granted by the University of British Columbia, Vancouver, in 1994.

I am registered as an Engineer In Training with the Association of Professional Engineers and Geoscientists of British Columbia.

I have worked continuously as a consulting geotechnical engineering since graduation.

Dated June 13, 1995.
Vancouver, B.C.

Bill Burton

Bill Burton, E.I.T.

# APPENDIX 1

## Report on Seismic Refraction and Down hole Seismic Surveys

## Tulsequah Chief Project, R. Hillman P. Eng. , Frontier Geosciences Inc.

# REDFERN RESOURCES LTD.

# REPORT ON
# SEISMIC REFRACTION AND DOWNHOLE SEISMIC SURVEY
# TULSEQUAH CHIEF PROJECT
# ATLIN AREA, B.C.

By

**Russell A. Hillman, P.Eng.**

**Our project FGI-224** **October, 1994**

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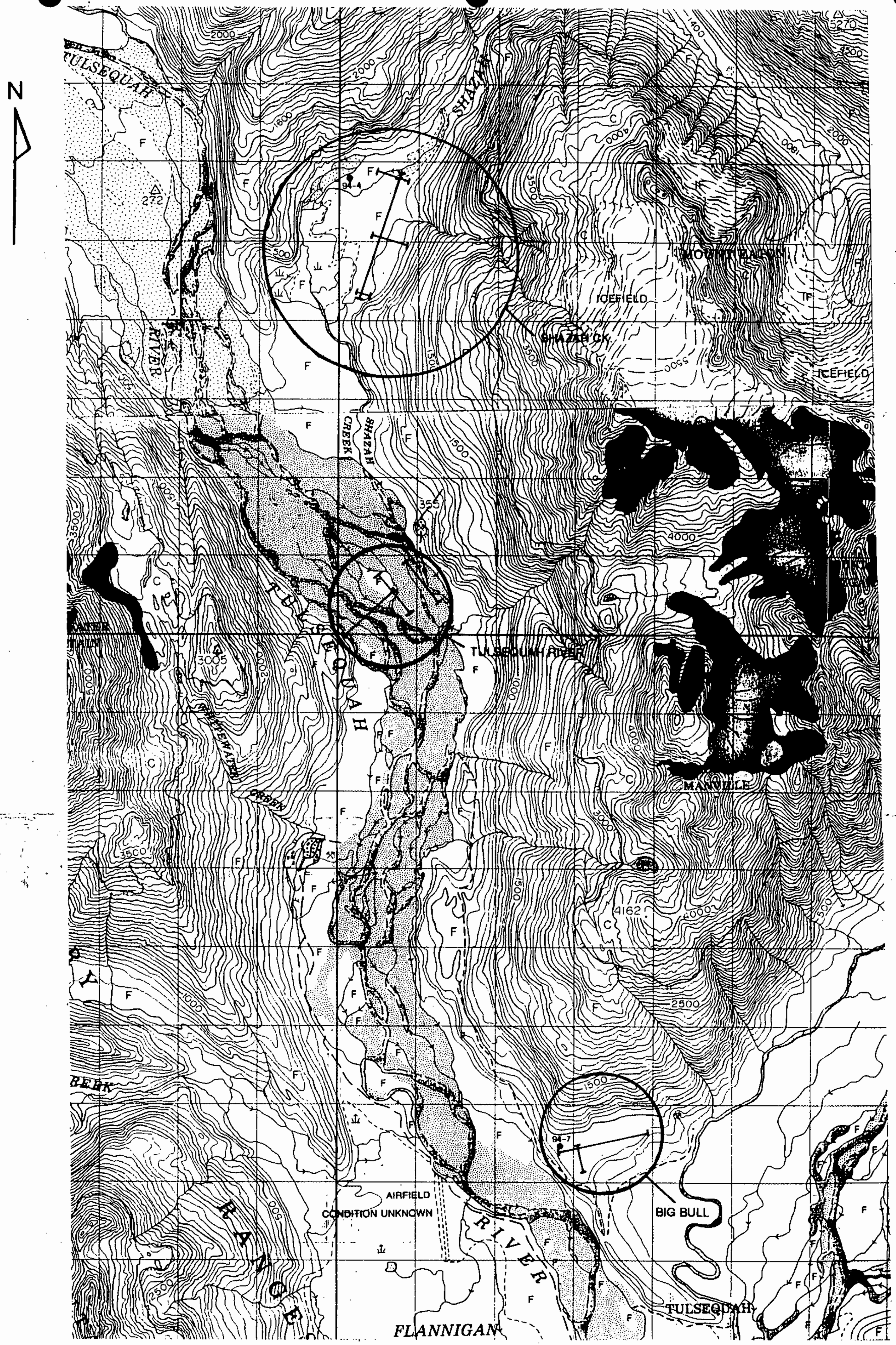

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| |
|---|
| REDFERN RESOURCES LTD. |
| **SEISMIC REFRACTION SURVEY** |
| SURVEY LOCATION PLAN |
| FRONTIER GEOSCIENCES INC. |

| | | |
|---|---|---|
| **DATE:** OCT. **1994** | | **FIG. 1** |

# 1. INTRODUCTION

In the period September 23 to October 7, 1994, Frontier Geosciences Inc. carried out a seismic refraction and downhole compressional (P) and shear (S) wave investigation for Redfern Resources Ltd. at the proposed Tulsequah chief mine project near Atlin, B.C. The work was carried out at two proposed tailings disposal areas at Big Bull and Shazah Creek and at a proposed tunnel crossing of the Tulsequah River. A Survey Location Plan showing the three areas is presented at 1:50,000 scale in Figure 1. This plan is a composite of NTS map sheets 104 K/12, "Tulsequah River" and 104 K/13, "Tulsequah Glacier." Site sketches of the Big Bull, Shazah Creek and Tulsequah River crossing survey areas are included in Appendices A, B and C.

The purpose of the seismic refraction investigation was to determine the thicknesses and compositions of overburden materials overlying bedrock and the depths ✓ to and configuration of, the competent bedrock surface. In total, approximately 7 km of seismic refraction work was completed along nine separate survey traverses. The downhole P and S wave logging of drillholes 94-4 and 94-7 at Shazah Creek and at Big Bull was carried out to determine in situ elastic moduli properties of the geological ✓ materials.

## 2. THE SEISMIC REFRACTION SURVEY METHOD

### 2.1. Equipment

The seismic refraction investigation was carried out utilizing an EG&G, Geometrics, Model ES-1225, 12 channel, signal enhancement seismograph and Mark Products Ltd. 12 $H_z$ geophones. Either a 150 metre or 300 metre multicored cable was used for the seismic refraction lines. Internal blast locations were placed mid-way between geophones in order to obtain greater resolution of near surface layering. Geophone spacings ranged from 7.5 m to 30 m along the seismic cables. Seismic blasting caps in explosive charges used for energy input, were detonated electrically using a Geometrics Model HVB-1, high voltage, capacitor-type blaster.

### 2.2 Survey Procedure

For each line, the seismic cable was stretched out and twelve geophones implanted. Five different shotholes were then excavated: one at either end of the 12 channel set-up, one at the mid-point, and one off each end of the line to ensure adequate coverage of the basal layer. In the Tulsequah River crossing, two 300 m, twelve channel cables were combined into pseudo-24 channel spreads in order to obtain greater depths of penetration. Shots consisting generally of one to thirty sticks of Power Primer were detonated individually and arrival times of the resultant seismic sound waves were automatically recorded in the seismograph. Hard copy records were made on electrically sensitive recording film. Data recorded during the field surveying operations was of good to excellent quality.

Throughout the survey, notes were recorded regarding seismic line positions in relation to topographic features, geological features and survey stations. Elevation surveying of the lines was carried out from geophone to geophone utilizing a Sunto inclinometer.

## 3. SEISMIC REFRACTION ANALYSIS

### 3.1 Interpretation

Interpreted geological conditions in general indicate shallow to very deep bedrock overlain by two layers of overburden. At the Tulsequah River crossing, the overburden was extremely deep. Overall, the velocity contrasts between refractive layers was more than adequate for interpretation. In the Appendices, interpreted boundaries between layers with different velocities are indicated by continuous lines in the profiles. In all cases, the basal line represents the interpreted competent bedrock surface.

### 3.2 Interpretive Method

The final interpretation of the seismic data was arrived at utilizing a ray-tracing technique. This method utilizes the travel times taken to travel to geophones from shotpoints located to either side of the geophones. These arrival times are assigned layer designations based on a knowledge of the geology and apparent velocities from time-distance plots of the data. Using the additional information of both shotpoint and geophone elevations and locations, "rays" are traced through the subsurface using Snells' Law. Subsurface refractor configurations are adjusted to "fit" the arrival time and velocity data. The redundancy of multiple shots and shock wave arrivals at twelve and twenty-four geophones provided a detailed assessment of subsurface layering.

### 3.3 Limitations

The depths to subsurface boundaries derived from seismic refraction surveys are generally accepted as accurate to within ten percent of the true depths to the boundaries. In some cases, unusual geological conditions may produce false or misleading seismic arrivals with the result that computed depths to subsurface refractors may be less accurate. These conditions may be caused by a "hidden layer" situation or by a velocity inversion. The first condition is caused by the inability to detect the existence of layers because of insufficient velocity contrasts or layer thicknesses. A velocity inversion exists when an underlying layer has a lower velocity than the layer directly above it.

At the Tulsequah river crossing, the bedrock was sufficiently deep that only limited depth information could be recovered from the data. This resulted in some cases, in minimum calculated depths to bedrock.

The results are interpretive in nature and are considered to be a reasonably accurate presentation of existing subsurface conditions within the limitations of the seismic refraction method.

# 4. DOWNHOLE SEISMIC SURVEY

## 4.1 Equipment and Field Procedure

The downhole seismic survey was carried out utilizing the EG&G Geometrics, ES-1225 seismograph. The receiver package was a Sensor Nederland B.V. SM-4 triaxial package with a vertical geophone for compressional wave recording and two horizontal, orthogonal shear wave geophones for detection of the shear wave arrivals. The geophone package was held against the casing wall by a spring steel carrier. A wooden beam secured under 45 gallon drums of rocks, sand and water was utilized as the impact source for the shear waves. A steel plate was positioned near the drillhole and struck vertically with a 3.6 kg sledgehammer to produce compressional waves.

Field procedure consisted of lowering the geophone package to the measuring point in the hole, and ensuring coupling of the geophones to the borehole wall. The beam was struck horizontally in order to produce an impact rich in shear wave energy. The steel plate was then struck vertically to produce a compressional wave. After identification of the seismic arrivals, the geophone package was moved to the next depth point where the procedure was repeated.

The data at each depth point was printed onto electrically sensitive recording film.

# 5. GEOPHYSICAL RESULTS

## 5.1 General

The resuslts of the seismic refraction interpretations are shown at either 1:2000 or 1:2500 scales in Appendices A, B and C. Figures 3, 4 and 5 show the results of the Big Bull seismic refraction lines with Figures 7 through 12 showing the Shazah Creek results. The Tulsequah River interpretations are shown in Figures 14, 15 and 16. Downhole compressional and shear wave arrival data for drillhole 94-4 and 94-7 are shown in Appendix B and A, respectively.

## 5.2 Big Bull Area

### 5.2.1 Discussion

The survey area at the Big Bill site is a relatively flat bench situated approximately 120 metres above the Tulsequah River. The seismic results indicate the site is underlain by two distinct overburden layers with velocities of 300 m/s and 900 m/s. The surficial 300 m/s layer has been directly correlated with shothole intersections of organics with some sand. The thicker, underlying intermediate 900 m/s velocity layer has been correlated in drillhole 94-7 with unsaturated, relatively dense to very dense, sand with a trace of silt and fine gravel. Interpreted thicknesses for this layer range from 23 m to 75 m with an obvious thickening to the south, away from the hillside.

The basal layer with velocities varying from 3942 m/s to 5000 m/s is the interpreted competent bedrock surface. The bedrock surface is apparently flat-lying with a gentle dip to the south.

### 5.2.2 **Drillhole 94-7**

The velocities calculated for the overburden layers are confirmed in the Compressional (P) wave logging of drillhole 94-7. The compressional wave values shown in Table I in Appendix A indicate two velocity layers within a few percent of the refraction calculated values. The shear wave data similarly show two major velocity layers with shear wave values in the surficial layer of 215 m/s and an average velocity in the underlying sand of 315 m/s.

## 5.3 **Shazah Creek Area**

### 5.3.1 **Discussion**

The Shazah Creek site is a flat area bounded at the south end by a swamp and along most of the east side by a small creek. Based on the seismic results and drillhole 94-4, the area is underlain by very thick overburden with two distinct seismic velocity zones.

The thin surficial layer varying in velocity from 437 m/s to 1010 m/s, has been directly correlated with surface exposures and shothole intersections of organic silt, sands, gravels, cobbles and occasional boulders and colluvium. Underlying this surficial velocity layer is a thicker intermediate layer with velocities of 1630 m/s to 2165 ms. This layer consistent with drillhole 94-4, is interpreted as saturated sands, gravels and cobbles. With calculated thicknesses of up to 100 metres to the south, this layer thins to the north were it rises to within 40 m of the ground surface.

The basal layer with velocities varying from 3729 m/s to 4729 m/s is the interpreted competent bedrock surface. The bedrock surface rises quickly from south to north and with the exception of Crossline 3, rises sharply to the east.

There was no evidence in the seismic data of the presence of faults or shear zones in the bedrock.

### 5.3.2 **Drillhole 94-4**

The compressional wave values in the seismic log of drillhole 94-4 are generally consistent with the seismic velocities calculated from the analysis of the seismic refraction data. The drillhole data indicate two velocity zones of 850 m/s and 1812 m/s. The shear wave data also indicate essentially two velocity zones. The thin surficial layer has a velocity of 225 m/s consistent with the 850 m/s compressional wave value. The thicker underlying 250 m/s and 265 m/s zones are consistent with the thick sequence of sands and gravels (1812 m/s compressional wave velocity) delineated in the seismic refraction survey and intersected by the drillhole.

## 5.4 Tulsequah River Crossing

The Tulsequah River Crossing site is a broad river flood plain that was known from limited drilling results, to be underlain by thick sequences of outwash materials. The seismic lines accordingly utilized very long seismic cables (300 m) combined into pseudo-24 channel spreads to record the refraction information from the deeply buried bedrock surface. The seismic surveying due to the cable lengths employed and the relatively high Tulsequah River flows, could not be continued across the valley and surveying was completed with lines parallel to the river.

The seismic results for lines 3, 4 and 5 show high overburden velocities with values ranging from 1032 m/s to 1936 m/s. The thin 1032 m/s surficial layer velocity on Seismic Line 5 was calculated using widely-spaced geophones and is considered erroneously high. The overall velocities indicate saturated materials, likely sands, gravels, cobbles and boulders. This layering is extremely thick with bedrock depths exceeding the depth capability of the long cable lengths employed.

Given the excessive overburden thicknesses, bedrock information was limited to minimum calculated bedrock depths and the west end of Seismic Line 3. To the west on SL-3, the bedrock surface rises quickly from approximately 190 m depth to approximately 75 m near the toe of the slope. To the east out into the middle of the flood plain, no refractions were recorded from the bedrock surface even though maximum shot to geophone separations of 790 m were employed.

At the three locations on Seismic Lines 3, 4 and 5, minimum depths to bedrock of 253 metres were calculated for the approximate positions indicated on the drawings.

Some limited bedrock depth information was also derived from apparent bedrock reflection events in the refraction records. Utilizing calculated refraction seismic velocities and one-way travel times yielded depths for Seismic Lines 3, 4 and 5 of 360 m, 430 m and 430 m, respectively, These depths roughly apply to the mid-points of the lines and should be considered approximate only.

## 6. RECOMMENDATIONS

The seismic refraction surveying carried out at Shazah Creek and Big Bull was successful in determining bedrock to the depths of interest. At the Tulsequah River crossing, the bedrock depths were excessive and only limited bedrock information was recorded.

A few of the seismograms recorded at the Tulsequah crossing displayed clear reflections even though the recording parameters were optimized for refraction surveying. The relatively flat ground surface, high water table and high velocity bedrock reflector are favourable conditions for seismic reflection surveying which contributed to reflections being recorded on the seismograms.

The bedrock profiling at the Tulsequah River crossing could likely be accomplished with high resolution seismic reflection surveying. The work would require tighter spacing of high frequency geophones and more frequent shot intervals together with 24 channel digital recording. The shots however, require much less energy and may be accomplished with an 8 gauge shotgun source. This source is powerful and inputs high frequencies into the subsurface which are optimal for high resolution profiling.

It is our recommendation that a test program of approximately 2 days duration be carried out. If the test results are favourable, the reflection seismic survey should be completed. We estimate the program would entail about 3.5 km of coverage at an estimated total cost per kilometre of approximately $6000.00 to $7000.00. The work if initiated, should be carried out in the early summer months to avoid high Tulsequah River levels and high noise levels from intense rains.

FOR: FRONTIER GEOSCIENCES INC.

Russell A. Hillman

Russell A. Hillman, P.Eng.

# TABLE I

## Compressional and Shear Wave Arrivals DH 94-7

| Hole Depth (m) | Compressional Wave Arrival (ms) | Compressional Wave Velocity (metres/second) | Shear Wave Arrival (ms) | Shear Wave Velocity (metres/second) |
|---|---|---|---|---|
| 1 | 2.4 | | 4.8 | |
| 2 | 4.8 | | 8.4 | |
| 3 | 7.0 | 460 m/s | 14.8 | 215 m/s |
| 4 | 9.2 | | 19.3 | |
| 5 | 10.0 | | 23.3 | —— |
| 6 | 10.8 | —— | 26 | |
| 7 | 11.4 | | 28.1 | |
| 8 | 12.3 | | 31.6 | |
| 9 | 13.0 | | 32.4 | 280 m/s |
| 10 | 13.0 | | 33.0 | |
| 11 | 13.4 | | 34.5 | —— |
| 12 | 14.4 | | 35.8 | |
| 13 | 14.9 | | 36.9 | |
| 14 | 14.9 | 875 m/s | 40.1 | |
| 15 | 15.6 | | 43.8 | |
| 16 | 16.6 | | 46.1 | |
| 17 | 17.6 | | 48.4 | |
| 18 | 19.6 | | 50.8 | |
| 19 | 20.2 | | 52.4 | 350 m/s |
| 20 | 21.0 | | 56.6 | |
| 21 | 22.2 | | 59.3 | |
| 22 | 22.8 | | 62.7 | |
| 23 | 24.4 | | 66.6 | |
| 24 | 25.4 | | 71.9 | |
| 25 | 27.0 | —— | 74.2 | —— |

## TABLE II

## Compressional and Shear Wave Arrivals DH 94-4

| Hole Depth (m) | Compressional Wave Arrival (ms) | Compressional Wave Velocity (metres/second) | Shear Wave Arrival (ms) | Shear Wave Velocity (metres/second) |
|---|---|---|---|---|
| 1 | 1.5 | | 5 | |
| 2 | 3 | 850 m/s | 9 | 225 m/s |
| 3 | 3.5 | | 13 | |
| 4 | 4.5 | ____ | 17 | ____ |
| 5 | 4.5 | | 20 | |
| 6 | 4.75 | | 24.5 | |
| 7 | 5 | | 27.3 | |
| 8 | 6 | | 33.5 | |
| 9 | 6.25 | | 37 | |
| 10 | 6.5 | | 40 | |
| 11 | 7.5 | | 44 | 250 m/s |
| 12 | 7.75 | | 49.5 | |
| 13 | 8 | 1812 m/s | 51 | |
| 14 | 9 | | 56 | |
| 15 | 9.5 | | 60 | |
| 16 | 10 | | 64 | |
| 17 | 10.25 | | 69 | |
| 18 | 10.5 | | 74 | |
| 19 | 11 | | 80 | |
| 20 | 11.5 | | 82 | |
| 21 | 12 | | 86 | |
| 22 | 12.25 | | 87.5 | ____ |
| 23 | 12.5 | | 90 | |
| 24 | 12.75 | | 92 | 265 m/s |
| 25 | 13 | ____ | 94.5 | ____ |

# APPENDIX 2

## Drill hole Logs and Field Test Results

## Laboratory Test Results

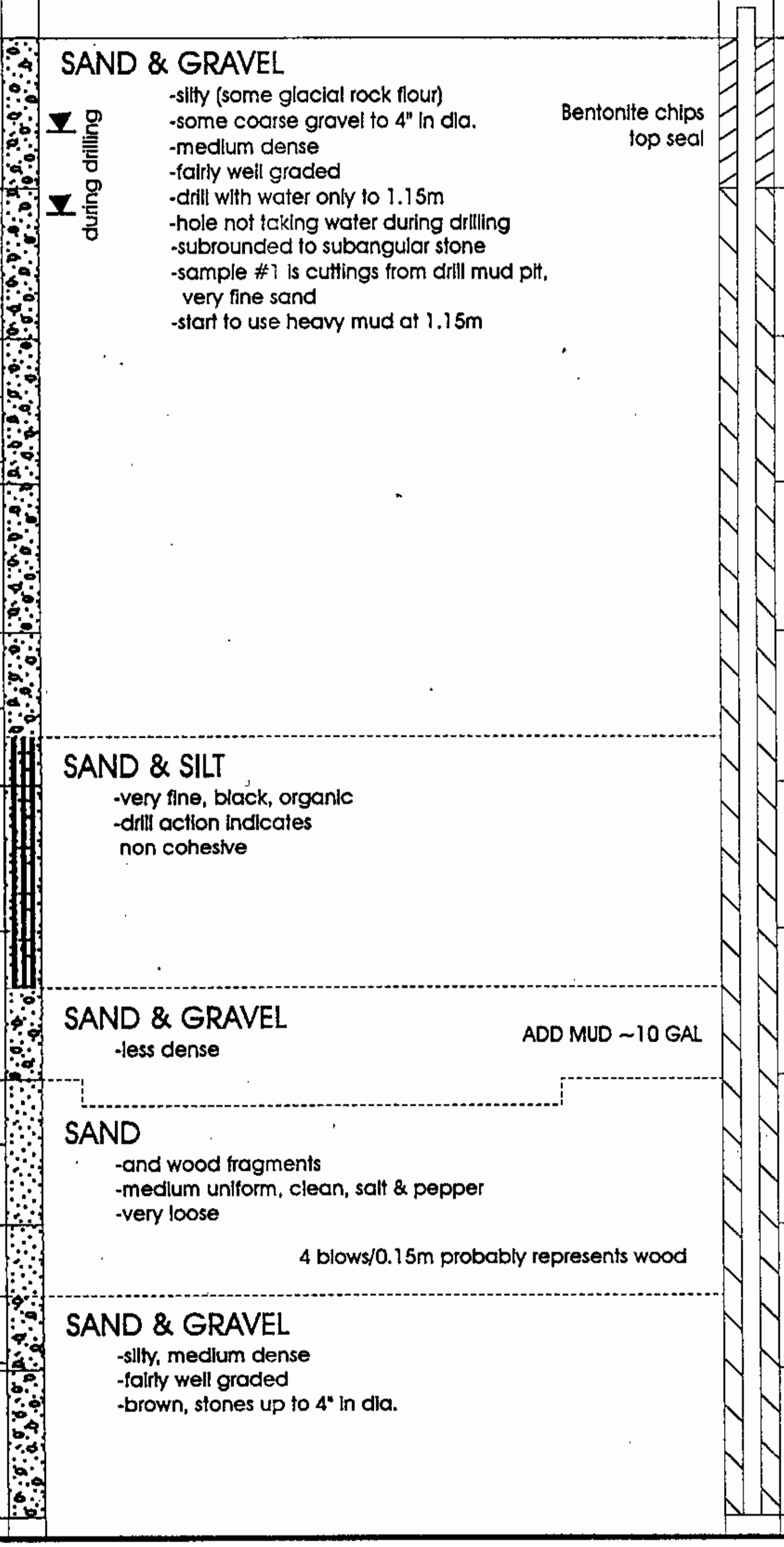
# DRILL HOLE # 94-BGC-DH1

Page 1 of 3
Project No.: 00100803

Date Drilled: Sept. 1994
Rig: HT-700
Contractor: FOUNDEX
Hammer Type: Cathead
LOCATION: SHAZAH CREEK
ELEVATION: ~65m
CO-ORDINATES:651449N 580251E

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

| D (m) | Recovery | Blows/6" | Sample # |
|---|---|---|---|
| 0.0–1.0 | | | 1 |
| 2.0–3.0 | 5/18 | 38/25/25 | 2 |
| 4.0–5.0 | 3/18 | 25/14/16 | 3 |
| 5.0–6.0 | 0/18 | 4/2/3 | 4 |
| 7.0–8.0 | 12/18 | 4/1/1 | 5 |
| 8.0–9.0 | 8/18 | 21/23/27 | 6 |



## SOIL DESCRIPTION

NOTES: 10cm surface organics over
sand & gravel

**0.0**

### SAND & GRAVEL

-silty (some glacial rock flour)
-some coarse gravel to 4" in dia.
-medium dense
-fairly well graded
-drill with water only to 1.15m
-hole not taking water during drilling
-subrounded to subangular stone
-sample #1 is cuttings from drill mud pit, very fine sand
-start to use heavy mud at 1.15m

Bentonite chips top seal

**1.0** **2.0** **3.0** **4.0**

### SAND & SILT

-very fine, black, organic
-drill action indicates non cohesive

**5.0** **6.0**

### SAND & GRAVEL

-less dense

ADD MUD ~10 GAL

**7.0**

### SAND

-and wood fragments
-medium uniform, clean, salt & pepper
-very loose

4 blows/0.15m probably represents wood

**8.0**

### SAND & GRAVEL

-silty, medium dense
-fairly well graded
-brown, stones up to 4" in dia.

**9.0** **10.0**

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# DRILL HOLE # 94-BGC-DH1

Project No.: 006000101

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: SHAZAH CREEK |
| Rig: HT-700 | ELEVATION: ~65m |
| Contractor: FOUNDEX | CO-ORDINATES: 651449N 580251E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa

VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa

MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

Instrument Installation

| Depth (m) | Recovery | Blows/0.15m | Sample # | Symbols | SOIL DESCRIPTION |
|---|---|---|---|---|---|
| 10.0 | 6/18 | 19/21/27 | 7 | | **SAND & GRAVEL**<br>-silty, medium dense<br>-fairly well graded<br>-stones to 4" in dia. |
| 11.0 | | | | | |
| | 5/18 | 23/15/11 | 8 | | |
| 12.0 | | | | | 11.6-13.1m-drill action indicates coarser material |
| 13.0 | | | | | -13.1m-mud to surface-Sept. 8/94, drops to 0.5m-Sept. 9/94 |
| 14.0 | | | | | |
| | 3/18 | | 9 | | |
| 15.0 | | | | | |
| 16.0 | | | | | |
| 17.0 | | | | | **SAND**<br>-medium, clean, uniform<br>-salt & pepper, wet, loose |
| 18.0 | 2/18 | | 10 | | ADD MUD ~25 GAL. |
| | | | | | **SAND & GRAVEL**<br>-stone to 4" in dia.<br>-drill as coarse material above |
| 19.0 | | | | | |
| 20.0 | | | | | |

| Blow Counts | | |
|---|---|---|
| 4 | 4 | 4 |
| 4 | 5 | 4 |
| 3 | 5 | 4 |
| 4 | 5 | 4 |
| 4 | 5 | 4 |
| 5 | 4 | 4 |

| Blow Counts | | |
|---|---|---|
| 4 | | |
| 4 | 4 | 3 |
| 3 | | |
| 1 | | |

# DRILL HOLE # 94-BGC-DH1

Page 3 of 3
Project No.: 006000101

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: SHAZAH CREEK |
| Rig: HT-700 | ELEVATION: ~65m |
| Contractor: FOUNDEX | CO-ORDINATES: 651449N 580251E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

Depth (m) | Rec | Blows/0.15m | Sample # | Symbols | Instrument Installation

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

20.0

**SAND & GRAVEL**
-stones to 4" in dia.
-some silt, fairly well graded
-grey, medium dense

21.0 — Rec 6/18 — Sample 11

| Blow Count | | |
|---|---|---|
| 4 | 4 | 4 |
| 5 | 4 | 4 |
| 4 | 4 | 4 |
| 4 | 3 | 4 |
| 4 | 3 | 3 |
| 4 | 4 | 4 |

22.0

**SAND, SILT (interlayered)**
-dense
(SAMPLE SPLIT A, B, C)
A-2" fine to coarse sand,some silt, black
B-3" fine sand, trace silt
C-1 1/2" silt, black, organic, slightly
THEN B AGAIN 1 1/2"
THEN C AGAIN 2"

Rec 12/18 — Sample 12

| Blow Count | | |
|---|---|---|
| 2 | 3 | 5 |
| 2 | 3 | 5 |
| 2 | 2 | 6 |
| 3 | 1 | 5 |
| 3 | 2 | 4 |
| 2 | 4 | 6 |

23.0

24.0

**SAND & GRAVEL**
-stones to 4" in dia.
-similar to above

RIVER SAND IMPORTED AS
PIEZO SAND-MEDIUM FINE
-FAIRLY WELL GRADED
-TRACE SILT, BROWN

CASAGRANDE TIP

25.0

BECOMING LESS DENSE (DRILL) @25.3m

**SILT** -black/brown, organics (wood fragments)
-trace clay, slightly plastic, moist

Rec 8/18 — Sample 13

**SAND** -wood fragments with medium sand
-some black silt

| Blow Count | | |
|---|---|---|
| 2 | | 1 |
| 2 | 5/4" | 1 |
| 1 | | 1 |
| 1 | | 1 |
| 1 | 5 | |
| 1 | 3 | 1/2" |

26.0

**SAND & GRAVEL**

**ROCK** -possible bedrock

SLOUGH AFTER FLUSH

27.0

**END OF HOLE 27.7m**

SAMPLE 2 USED 2-1/2" O.D. SPOON

28.0

29.0

30.0

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# DRILL HOLE # 94-BGC-DH2

Project No.: 006000101

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: SHAZAH CREEK |
| Rig: HT-700 | ELEVATION: ~80m |
| Contractor: FOUNDEX | CO-ORDINATES: 6,516,015N 580691E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa

VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa

MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

NOTES: Less than 5cm surface moss over sand & gravel

| Depth (m) | Rec | Blows/0.15m | Sample # | Blow Count | SOIL DESCRIPTION | Instrument Installation |
|---|---|---|---|---|---|---|
| 0.0 | | | 1 | | **SAND & GRAVEL**<br>-medium coarse, grey<br>-relatively clean, fairly well graded<br>-gravel sizes to 3"-rounded | |
| 1.0 | 6/18 | | 2* | 5 6 5<br>4 7 4<br>4 6 5<br>6 4 6<br>6 5 6<br>4 4 6 | -becoming silty below 1.4m<br>-cobbles up to 4" in dia. | -GROUT SETTLED TO 1.0m BELOW SURFACE, TOPPED UP ON SEPT. 13/94 |
| 2.0 | 6/18 | | 3 | 2 12 4<br>2 15 5<br>3 4 8<br>3 3 7<br>3 4 4<br>4 4 4 | -some silt, brown, moist<br>-fairly well graded<br>-more angular stone to 1" in dia. | |
| 3.0 | | | | | 3.65-3.95m less coarse material<br>3.95-5.5m coarser, slow drilling | |
| 4.0 | 8 | | 4 | 1 21<br>3 25<br>4 b<br>5 o<br>5 u<br>4 n<br>c<br>e | | USING HEAVY (THICK) DRILL MUD (BENTONITE) FROM SURFACE (3grout/1 1/2 bent./70 gal. water) |
| 5.0 | 0/18 | | 5* | 2 13<br>3 16<br>7 p<br>4 u<br>6 s<br>11 h<br>stone | 5.5-7.0m not as rough, stone to 4" in dia.<br>-faster drilling | -FALLING HEAD TEST PRIOR TO INSTALLING GROUT |
| 6.0 | | | | | | |
| 7.0 | 6/18 | | 6 | 3 4 5<br>5 6 5<br>5 5 6<br>4 6 5<br>5 5 5<br>4 6 5 | -some silt, angular stone, dense (in STP)<br>-well graded, brown, gravel sizes to 1"<br>-1 1/2" graphitic sand & gravel @7.45m | 3/4" PVC |
| 8.0 | | | | | -0.45m dia. boulder at 8.25m to 8.7m | |
| 9.0 | | | | | ▼ 9.2m-SEPT.28/94<br>-coarse gravel & cobbles to 9.9m | BENTONITE CHIPS<br>-9.7m WATER (MUD) LEVEL MEASURED AFTER ROD PULLED |
| 10.0 | | | | | | |

*-denotes large dia. SPT used,

- standard (2"/51mm O.D.) SPT used if not noted

# DRILL HOLE # 94-BGC-DH2

Project No.: 006000101

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: SHAZAH CREEK |
| Rig: HT-700 | ELEVATION: ~80m |
| Contractor: FOUNDEX | CO-ORDINATES: 6,516,015N 580691E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

Depth (m) | Rec | Blows/0.15m | Sample # | Symbols | Instrument Installation

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa

VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa

MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

10.0

Rec 8/18 — Sample 7

| Blow Count | | |
|---|---|---|
| 2 | 8 | 8 |
| 3 | 7 | b |
| 3 | 10 | o |
| 4 | 8 | u |
| 3 | 9 | n<br>c |
| 5 | 8 | e |

## SAND & GRAVEL

-silty, grey/brown, few oxidized fragments

-fairly well graded, stone fragments up to 1"+, angular

-relatively dense in SPT tube (corelike)

11.0

-less large gravel & cobbles to 11.6m

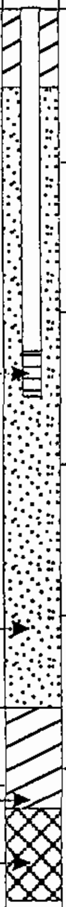
Rec 8/18 — Sample 8

| Blow Count | | |
|---|---|---|
| 4 | 4 | 2 |
| 4 | 3 | 2 |
| 5 | 2 | 2 |
| 3 | 3 | 2 |
| 3 | 2 | 3 |
| 3 | 3 | 2 |

-11.6-13.1m gravel, relatively fast & smoother

-less large sizes

12.0



CASAGRANDE TIP →

13.0

-13.1-13.7m cobbles & gravel, rough drilling

-13.7-14.6m smoother again, less cobbles

14.0

RIVER SAND →

Rec 6/18 — Sample 9

| Blow Count | | |
|---|---|---|
| 3 | 6 | 3 |
| 8 | 5 | 3 |
| 6 | 5 | 3 |
| 9 | 4 | 3 |
| 10 | 4 | 3 |
| 9 | 3 | 3 |

## SAND

-medium, poorly graded, some gravel

-subrounded, relatively clean, trace silt

15.0

BENTONITE CHIPS →

## SAND & GRAVEL

-cobbles to 4" in dia.

HOLE SLOUGHED WHEN DRILL BIT REMOVED →

16.0

-hole filled with heavy mud at end of shift

-no change in mud level overnight

-Good circulation to 17.4m

-Mud thinned out from 10.0-17.4m

-Complete circulation loss at 17.4m

-Sound mud level at 6.5m

Immediately after pipe pulled

17.0

Rec 9/18 — Sample 10

| Blow Count | | |
|---|---|---|
| 9 | 8 | 7 |
| 7 | 13 | 9 |
| 8 | 11 | 6 |
| 8 | 13 | 5 |
| 9 | 9 | 4 |
| 7 | 8 | 5 |

## GRAVEL

-trace sand, 1/4"-2"+ rounded

18.0

## SAND & GRAVEL

-cobbles to 4" in dia.

OPEN HOLE →

-AT 18.0m WITH HEAVY MUD CIRCULATION RETURNS

19.0

-coarse sand, gravel & cobbles to 4" down to 20.4m

20.0

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# DRILL HOLE # 94-BGC-DH2

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| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: SHAZAH CREEK |
| Rig: HT-700 | ELEVATION: ~80m |
| Contractor: FOUNDEX | CO-ORDINATES: 6,516,015N 580691E |
| Hammer Type: Cathead | |

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

| Dep(m) | Recovery | Blows/0.15m | Sample # | SOIL DESCRIPTION | Instrument Installation |
|---|---|---|---|---|---|
| 20.0 | | | | | |
| | | | | **SAND & GRAVEL & COBBLES**<br>-coarse, slow drilling | |
| | | | | **SAND & WOOD**<br>-COMPLETE MUD LOSS AT 20.4m AFTER SPT DRIVEN<br>-CIRCULATION NOT REGAINED<br>-loose | |
| 21.0 | 1/18 | | 11 | SPT-first attempt-1"-fine, silty, bedded brown sand<br>SPT-second attempt-2"-wood, sand & silt<br>-strong organic smell<br>-similar to DH-1<br>-very soft drilling, some resistance to wood<br>-no circulation | |
| 22.0 | | | | OPEN HOLE → | |
| | | | | **COBBLES & SAND & GRAVEL**<br>- loose cobbles<br>-COULD NOT PENETRATE THROUGH COBBLES-COULD NOT KEEP A HOLE | |
| 23.0 | | | | | |
| | | | | **END OF HOLE 23.2m**<br>-permeability testing done | |
| 24.0 | | | | | |
| 25.0 | | | | | |
| 26.0 | | | | | |
| 27.0 | | | | | |
| 28.0 | | | | | |
| 29.0 | | | | | |
| 30.0 | | | | | |

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# DRILL HOLE # 94-BGC-DH3

Page 1 of 1
Project No.: 006000101

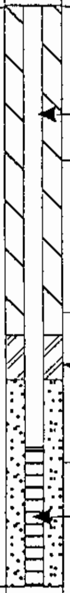
| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: SHAZAH CREEK |
| Rig: HT-700 | ELEVATION: ~80m |
| Contractor: FOUNDEX | CO-ORDINATES: 6,516,015N 580691E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

NOTES: This hole drilled approx. 3m S. of DH-2
Drilled with water only for permeability testing

| Depth (m) | Recovery | Blows/0.15m | Sample # | Soil Description |
|---|---|---|---|---|
| 0.0 | | | | -TOUGH DRILLING-VERY TIGHT<br>**SAND & GRAVEL**<br>-cobbles to 4" in dia.-coarse, rough drilling<br>-silt in water return for complete hole |
| 1.0 | | | | PIEZOMETER INSTALLATION<br>VERY THICK GROUT WITH BENTONITE<br>-2CEMENT/1 1/2 BENT./30 GAL. WATER<br>-GROUT WAS PUMPED THROUGH RODS AS THEY WERE PULLED BACK TO HELP LUBRICATE HOLE<br>-TREMI NOT POSSIBLE AS HOLE CAVING |
| 2.0 | 18/18 | 3/5/4 | 1 | -GROUT LOOKED AS IF IT LIFTED SAND &MIXED WITH SAME<br>-GOOD BOND TO SIDEWALL OF HOLE<br>-2 attempts to 13'-0", pulled back and had to fight back to 12'-6"<br>-could not go further-considerable risk of setting 4" steel pipe for good |
| 3.0 | | | | |
| 4.0 | | | | END OF HOLE 3.81m |
| 5.0 | | | | (AS OF SEPT. 28/94-DRY HOLE) |
| 6.0 | | | | |
| 7.0 | | | | |
| 8.0 | | | | |
| 9.0 | | | | |
| 10.0 | | | | |

Instrument Installation



3/4" DIA. PVC

2.13m-2.43m SOME BENTONITE CHIPS

HACKSAW SLOTTED 3/4" PVC PIPE WITH SCREEN NYLON

# DRILL HOLE # 94-BGC-DH4

Page 1 of 3
Project No.: 006000101

Date Drilled: Sept. 1994
Rig: HT-700
Contractor: FOUNDEX
Hammer Type: Cathead
LOCATION: SHAZAH CREEK
ELEVATION: ~73m
CO-ORDINATES: 6,516,049N 580153E

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

Instrument Installation

| Depth | Recovery | Blows/0.15m | Sample # | Symbols | SOIL DESCRIPTION |
|---|---|---|---|---|---|
| | | | | | NOTES:0-0.1m moss, roots & organics |
| 0.0 | | | | | **SAND** -fine, uniform, trace silt, brown, loose |
| | | | | | **SILT** -trace clay, organic, slightly plastic<br>-soft, wet (roots etc.), brown |
| 1.0 | 12/18 | | 1 | | |
| | | | | | **SAND & GRAVEL**<br>-few cobbles to 4" in dia., rough drilling<br>-brown, fairly well graded |
| 2.0 | 4/18 | | 2 | | -some silt, subangular stone to 1"+ |
| 3.0 | | | | | |
| 4.0 | 5/18 | | 3 | | -3.96-4.56m-less cobbles |
| 5.0 | 8/18 | | 4 | | -density increasing<br>-angular to subangular stone to 1"+ |
| 6.0 | | | | | -6.0-7.0m-very coarse cobbles &<br>a 12" boulder-back to back,<br>too coarse to sample |
| 7.0 | | | | | -7.0-8.5m-sand, gravel & few cobbles<br>to 4" in dia.-dense<br><br>-sample has higher % sand, less gravel<br>-rounded stone, some silt<br>-sand less dense<br>-likely interlayered sand & gravel of<br>varying gradation and silt content |
| 8.0 | 6/18 | | 5 | | |
| 9.0 | | | | | |
| 10.0 | | | | | |

Blow Count (Sample 2)

| | | |
|---|---|---|
| 2 | 4 | 7 |
| 4 | 5 | b |
| 4 | 4 | o |
| 4 | 5 | u |
| 5 | 5 | n<br>c |
| 4 | 8 | e |

Blow Count (Sample 3)

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 1 | 2 | 2 |
| 3 | 3 | 2 |
| 3 | 2 | 3 |
| 3 | 3 | 3 |
| 2 | 3 | 2 |

Blow Count (Sample 4)

| | | |
|---|---|---|
| 1 | 4 | 5 |
| 2 | 6 | 6 |
| 2 | 6 | 3 |
| 4 | 5 | 3 |
| 3 | 5 | 9 |
| 4 | 5 | 5 |

Blow Count (Sample 5)

| | | |
|---|---|---|
| 3 | 5 | 2 |
| 4 | 5 | 2 |
| 5 | 4 | 1 |
| 5 | 3 | 1 |
| 4 | 3 | 1 |
| 6 | 2 | 1 |

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# DRILL HOLE # 94-BGC-DH4

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: SHAZAH CREEK |
| Rig: HT-700 | ELEVATION: ~73m |
| Contractor: FOUNDEX | CO-ORDINATES: 6,516,049N 580153E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

Depth | Recovery | Blows/0.15m | Sample # | Symbols | Instrument Installation

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

NOTES:

10.0

Sample 6 — Recovery 8/18

| Blow Count | | |
|---|---|---|
| 3 | 4 | 5 |
| 3 | 6 | 5 |
| 3 | 13 | 6 |
| 4 | 8 | 6 |
| 5 | 4 | 10 |
| 5 | 5 | 7 |

**SAND, GRAVEL & COBBLES**
-dense
-silty, well graded, some oxidization
-moist to wet, subrounded gravel

11.0

-cobbles decrease in size and frequency

Sample 7 — Recovery 6/18

| Blow Count | | |
|---|---|---|
| 2 | 8 | 4 |
| 3 | 5 | 4 |
| 10 | 5 | 4 |
| 7 | 4 | 3 |
| 5 | 4 | 4 |
| 8 | 5 | 4 |

12.0

13.0

-13.7m becomes coarse again, 4"+
-rough drilling

14.0

Sample 8 — Recovery 6/18

| Blow Count | | |
|---|---|---|
| 8 | 7 | b |
| 7 | 8 | o |
| 9 | 9 | u |
| 7 | 7 | n |
| 9 | 8 | c |
| 7 | 7 | e |

-14.6m less cobbles, very dense

15.0

-15.5m cobbles again, rough drilling

-15.5m-END OF SHIFT SEPT. 14/94
HOLE MUDDED TO SURFACE
0800 SEPT. 15/94-NO MUD LOSS

16.0

17.0

Sample 9 — Recovery 9/18

| Blow Count | | |
|---|---|---|
| 2 | 1 | 2 |
| 2 | 1 | 1 |
| 2 | 1/2" | 1 |
| 1 | | 2 |
| 2 | 1/2" | 3 |
| 1 | | 2 |

18.0

**SILT** -grey/black, some sand, trace clay
-slightly plastic, some wood chips

**SAND & GRAVEL**
-cobbles, dense
-fewer cobbles below 19.2m

19.0

20.0

# DRILL HOLE # 94-BGC-DH4

Project No.: 006000101

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: SHAZAH CREEK |
| Rig: HT-700 | ELEVATION: ~73m |
| Contractor: FOUNDEX | CO-ORDINATES: 6,516,049N 580153E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa

VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa

MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

| Depth | Recovery | Blows/0.15m | Sample # | Symbols | Soil Description | Instrument Installation |
|---|---|---|---|---|---|---|
| 20.0 | | | | | | |
| | 5/18 | | 10 | | SAND & GRAVEL<br>-dense, few cobbles<br>-trace silt, brown<br>-coarse sand, fine gravel | |
| 21.0 | | | | | | |
| 22.0 | | | | | | |
| 23.0 | | | | | SILT<br>-trace sand, brown<br>-soft drilling | |
| | 1/18 | | 11 | | SAND & GRAVEL & COBBLES | |
| 24.0 | | | | | | |
| 25.0 | | | | | -12" boulder at 25.0m | |
| 26.0 | | | | | | |
| | 0/18 | | 12 | | 89'-0" (27.13m) 2" PVC INSTALLED (GROUTED) FOR DOWNHOLE GEOPHYSICS | |
| 27.0 | | | | | | |
| | | | | | END OF HOLE 27.25m | |
| 28.0 | | | | | | |
| 29.0 | | | | | | |
| 30.0 | | | | | | |

Blow Count (Sample 10)

| | | |
|---|---|---|
| 2 | 1 | 3 |
| 2 | 2 | 3 |
| 2 | 2 | 3 |
| 2 | 3 | 3 |
| 2 | 2 | 4 |
| 2 | 3 | 4 |

Blow Count (Sample 11)

| | |
|---|---|
| 1 | b |
| 2 | o |
| 3 | u |
| 8 | n |
| 12 | c |
| 15 | e |

Blow Count (Sample 12)

2
2
9
bounce

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# DRILL HOLE # 94-BGC-DH5

Project No.: 006000101

Date Drilled: Sept. 1994
LOCATION: SHAZAH CREEK
Rig: HT-700
ELEVATION: ~73m
Contractor: FOUNDEX
CO-ORDINATES: 6,515,194N 580415E
Hammer Type: Cathead

Depth | Recovery | Blows/0.15m | Sample # | Symbols | SOIL DESCRIPTION | Instrument Installation

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

NOTES: Surface vegetation- cottonwood & devils club
silt & sand, organic, fine surface soil

0.0

**SAND & SILT** -fine, organic, brown

**SAND & GRAVEL**

-relatively clean, slight trace silt
-damp, round stones to 1" in dia.
-fairly well graded
-10" boulder @ 0.5m
-cobbles to 4" (rough drilling)

1.0

Recovery 6/18 — Sample 1

| Blow Count | | |
|---|---|---|
| 4 | 4 | 4 |
| 3 | 4 | 4 |
| 4 | 4 | 4 |
| 3 | 3 | 3 |
| 4 | 3 | 3 |
| 4 | 3 | 3 |

▼ 2.0m-SEPT.28/94

2.0

3/4" DIA. PVC →

Recovery 2/9 — Sample 2

| Blow Count | |
|---|---|
| 2 | 5 |
| 2 | 9 |
| 2 | 8 |
| 3 | |
| 3 | |
| 3 | |

-HEAVY, THICK BENT./CEM. SLURRY →
-FELL TO ~ 0.6m A FEW HOURS
AFTER INSTALLATION

3.0

4.0

Recovery 6/18 — Sample 3

| Blow Count | | |
|---|---|---|
| 1 | 5 | 3 |
| 3 | 5 | 3 |
| 5 | 5 | 2 |
| 4 | 3 | 2 |
| 5 | 4 | 2 |
| 4 | 4 | 2 |

-END OF SHIFT-SEPT.16/94 @4.4m
HOLE MUDDED TO SURFACE
SEPT. 17/94-MUD TO SURFACE

5.0

**SAND** -some fine gravel
-some silt, brown
-(poor sample)

-SMOOTH DRILLING

Recovery 2/18 — Sample 4

| Blow Count | | |
|---|---|---|
| 1 / 2" | ↑ | 1 |
| | | 1 |
| 1 | 4 / 6" | 1 |
| 2 | | 2 |
| 1 / 2" | ↓ | 1 |
| | | 1 |

6.0

**SAND & GRAVEL**

-few cobbles to 4" in dia.
-silty
-subrounded stones to 1"+
-1-1/2" layer of graphitic silt & sand (black)

7.0

Recovery 6/18 — Sample 5

| Blow Count | | |
|---|---|---|
| 5 | 3 | 3 |
| 6 | 4 | 2 |
| 5 | 3 | 2 |
| 4 | 4 | 1 |
| 3 | 3 | 2 |
| 5 | 2 | 1 |

-7.3-7.45m-softer drilling-silt/sand

8.0

-7.6-8.6m-SOME CIRCULATION LOSS

Recovery 6/18 — Sample 6

| Blow Count | | |
|---|---|---|
| 3 | 3 | 2 |
| 3 | 3 | 2 |
| 4 | 3 | 2 |
| 3 | 3 | 3 |
| 3 | 3 | 3 |
| 4 | 3 | 3 |

-some silt, brown
-relatively dense
-subrounded stones to 1"+
-fairly well graded

9.0

-9.15-9.6m-loose sand & gravel layer

10.0

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# DRILL HOLE # 94-BGC-DH5

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: SHAZAH CREEK |
| Rig: HT-700 | ELEVATION: ~73m |
| Contractor: FOUNDEX | CO-ORDINATES: 6,515,194N 580415E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

Instrument Installation

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa

VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa

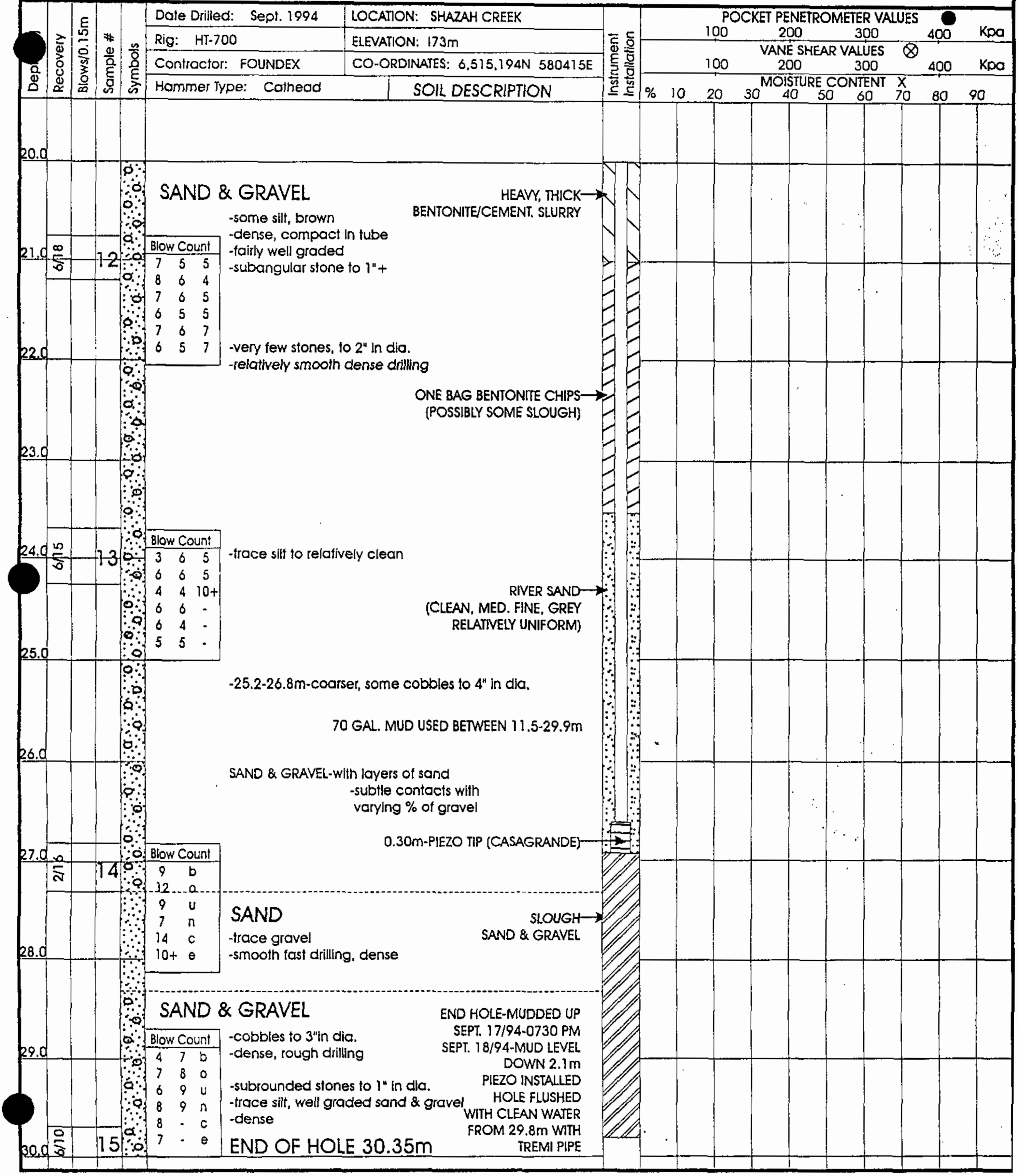
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

| Dep | Recovery | Blows/0.15m | Sample # | Blow Count | SOIL DESCRIPTION |
|---|---|---|---|---|---|
| | | | | | NOTES: |
| 10.0 | | | | | |
| | 6/18 | | 7 | 4 3 3<br>3 3 3<br>4 3 3<br>4 3 3<br>5 3 2<br>2 4 3 | SAND & GRAVEL<br>-trace to some silt, brown<br>-subrounded stone to 1"+<br>-fairly well graded, relatively dense<br>-few cobbles to 4" in dia. |
| 11.0 | | | | | |
| | 4/18 | | 8 | 1 2 1<br>2 1 2<br>3 1 1<br>3 2 2<br>4 2 3<br>3 1 2 | -trace silt<br>HEAVY, THICK BENTONITE/CEMENT. SLURRY→ |
| 12.0 | | | | | |
| 13.0 | | | | | |
| | 6/12 | | 9 | 2 5 b<br>4 6 o<br>6 7 u<br>6 6 n<br>6 6 c<br>6 10 e | -some silt<br>-no cobbles |
| 14.0 | | | | | |
| | 2/18 | | 10 | 3 5 2<br>4 4 2<br>4 4 1<br>3 3 2<br>3 2 1<br>3 2 2 | -less gravel<br>-sand lens - fine to medium<br>-less gravel, relatively smooth, fast drilling |
| 15.0 | | | | | |
| 16.0 | | | | | |
| 17.0 | 6/18 | | 11 | 2 1 3<br>1 3 4<br>1 2 5<br>1 3 5<br>1 3 6<br>1 3 4 | SAND & GRAVEL -fine gravel<br>-1" layer-fine, clean sand<br>-4" layer-black silt & sand<br>SAND & GRAVEL<br>-relatively dense<br>-18.3m-cobbles again |
| 18.0 | | | | | |
| 19.0 | | | | | -19.2m-few cobbles again |
| 20.0 | | | | | |

# DRILL HOLE # 94-BGC-DH5

Page 3 of 3
Project No.: 006000101

Date Drilled: Sept. 1994
LOCATION: SHAZAH CREEK
Rig: HT-700
ELEVATION: 173m
Contractor: FOUNDEX
CO-ORDINATES: 6,515,194N 580415E
Hammer Type: Cathead



## SAND & GRAVEL

-some silt, brown
-dense, compact in tube
-fairly well graded
-subangular stone to 1"+

| Blow Count | | |
|---|---|---|
| 7 | 5 | 5 |
| 8 | 6 | 4 |
| 7 | 6 | 5 |
| 6 | 5 | 5 |
| 7 | 6 | 7 |
| 6 | 5 | 7 |

-very few stones, to 2" in dia.
*-relatively smooth dense drilling*

HEAVY, THICK BENTONITE/CEMENT. SLURRY

ONE BAG BENTONITE CHIPS (POSSIBLY SOME SLOUGH)

| Blow Count | | |
|---|---|---|
| 3 | 6 | 5 |
| 6 | 6 | 5 |
| 4 | 4 | 10+ |
| 6 | 6 | - |
| 6 | 4 | - |
| 5 | 5 | - |

-trace silt to relatively clean

RIVER SAND (CLEAN, MED. FINE, GREY RELATIVELY UNIFORM)

-25.2-26.8m-coarser, some cobbles to 4" in dia.

70 GAL. MUD USED BETWEEN 11.5-29.9m

SAND & GRAVEL-with layers of sand
-subtle contacts with
varying % of gravel

0.30m-PIEZO TIP (CASAGRANDE)

| Blow Count | |
|---|---|
| 9 | b |
| 12 | o |
| 9 | u |
| 7 | n |
| 14 | c |
| 10+ | e |

## SAND

-trace gravel
-smooth fast drilling, dense

*SLOUGH* SAND & GRAVEL

## SAND & GRAVEL

-cobbles to 3"in dia.
-dense, rough drilling

| Blow Count | | |
|---|---|---|
| 4 | 7 | b |
| 7 | 8 | o |
| 6 | 9 | u |
| 8 | 9 | n |
| 8 | - | c |
| 7 | - | e |

-subrounded stones to 1" in dia.
*-trace silt, well graded sand & gravel*
-dense

END HOLE-MUDDED UP
SEPT. 17/94-0730 PM
SEPT. 18/94-MUD LEVEL
DOWN 2.1m
PIEZO INSTALLED
HOLE FLUSHED
WITH CLEAN WATER
FROM 29.8m WITH
TREMI PIPE

END OF HOLE 30.35m

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# DRILL HOLE # 94-BGC-DH6

Page 1 of 1
Project No.: 006000101

Date Drill: Sept.18, 1994
LOCATION: SHAZAH CREEK
Rig: HT-700
ELEVATION: ~73m
Contractor: FOUNDEX
CO-ORDINATES: 6,515,194N 580415E
Hammer Type: Cathead

| Depth (m) | Recovery | Blows/0.15m | Sample # | Symbols | SOIL DESCRIPTION | Instrument Installation | POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa<br>VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa<br>MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90 |
|---|---|---|---|---|---|---|---|
| | | | | | NOTES: This hole drilled approx. 3m N. of DH-5<br>Drilled with water only for permeability testing | | |
| 0.0 | | | | | -HW CASING ADVANCED THROUGH SAND & GRAVEL TO 4.0m (13'-0")<br>-SECTION OF HOLE BETWEEN 8'-0" AND 13'-0" EXPERIENCED CIRCULATION LOSS<br>-MEDIUM CLEAN, GREY SAND IN WATER RETURN-TRACE SILT, GREY | | |
| 1.0 | | | | | VERY THICK CEMENT/BENTONITE → | | |
| 2.0 | | | | | ▼ 2.0m-SEPT.28/94<br>BENTONITE CHIPS & SLOUGH → | | |
| 3.0 | | | | | INSITU WASHED SAND & GRAVEL SLOUGH → HOLE CAVING ON PIEZO AS CASING PULLED | | |
| 4.0 | | | | | | | |
| 5.0 | | | | | | | |
| 6.0 | | | | | | | |
| 7.0 | | | | | | | |
| 8.0 | | | | | | | |
| 9.0 | | | | | | | |
| 10.0 | | | | | | | |

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# DRILL HOLE # 94-BGC-DH7

Page 1 of 3
Project No.: 006000101

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: PADDY'S FLATS |
| Rig: HT-700 | ELEVATION: |
| Contractor: FOUNDEX | CO-ORDINATES: 6,503,642N 582775E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

Depth (m) | Recovery | Blows/0.15m | Sample # | Symbols | Instrument Installation

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

NOTES: Surface is Hemlock, Birch & Devils Club
-Humocky ground with roots etc.

0.0

?? ROOTS & DECOMPOSED LOGS

GRAB 1 SILT & SAND -grey/brown, damp

SAND -relatively loose
-one 3"-4" cobble
-some gravel, stone to 3/4" in dia., round
-medium coarse sand, brown
-fairly well graded, damp
-relatively clean
-few cobbles 4"-6" in dia.

1.0

8/18 2

| Blow Count | | |
|---|---|---|
| 2 | 1 | 2 |
| 1 | 1 | 1 |
| 2 | 2 | 2 |
| 1 | 2 | 1 |
| 2 | 1 | 1 |
| 1 | 2 | 2 |

2.0

4/18 3

| Blow Count | | |
|---|---|---|
| 1 | 2 | 1 |
| 2 | 1 | 2 |
| 2 | 1 | 1 |
| 1 | 1 | 1 |
| 1 | 1 | 1 |
| 2 | 1 | 1 |

3.0

4.0

5/18 4

| Blow Count | | |
|---|---|---|
| 2 | 2 | ↑ |
| 1 | 1 | |
| 1 | 1 | 5/6" |
| 1 | 1 | |
| 1 | 1 | |
| 1 | 1 | ↓ |

5.0

-SOME MUD LOSS

6/18 5

| Blow Count | | |
|---|---|---|
| 2 | 2 | 1 |
| ↑ | 1 | 1 |
| | ↑ | 1 |
| 7/5" | 4/4" | 1 |
| | | 1 |
| ↓ | ↓ | 1 |

-few layers of finer, clean, brown sand

6.0

-few cobbles and large stones to 4" in dia.

7.0

2/18 6

| Blow Count | | |
|---|---|---|
| 2 | ↑ | ↑ |
| 2 | | |
| 2 | 6 | |
| 1 | | 7 |
| 1 | | |
| 1 | ↓ | ↓ |

8.0

SILT & CLAY -tried to sample- only slight trace of material thin lamination (7A)
-some sand, relatively dense

6/18 7 7A

| Blow Count | | |
|---|---|---|
| 2 | 2 | 2 |
| 2 | 2 | 1 |
| 3 | 2 | 1 |
| 2 | 3 | 1 |
| 2 | 2 | 1 |
| 2 | 2 | 1 |

SAND -smooth, relatively dense drilling
-trace fine gravel

9.0

10.0

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# DRILL HOLE # 94-BGC-DH7

Date Drilled: Sept. 1994
LOCATION: PADDY'S FLATS
Rig: HT-700
ELEVATION:
Contractor: FOUNDEX
CO-ORDINATES: 6,503,642N 582775E
Hammer Type: Cathead
NOTES:

Dep | Recovery | Blows/0.15m | Sample # | Symbols | SOIL DESCRIPTION | Instrument Installation

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

10.0

Recovery 8/18 — Sample 8

| Blow Count | | |
|---|---|---|
| 2 | 2 | 3 |
| 2 | 2 | 3 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 3 |
| 2 | 3 | 3 |

**SAND**

- -medium coarse, poorly graded
- -few stones to 1" in dia., rounded
- -damp to moist, above water table
- -slight trace silt, brown

11.0

Recovery 10/18 — Sample 9

| Blow Count | | |
|---|---|---|
| 3 | 6 | 6 |
| 4 | 5 | 6 |
| 4 | 6 | 6 |
| 5 | 7 | 5 |
| 6 | 6 | 5 |
| 6 | 6 | 4 |

-density increasing

12.0

-very few stones to 2" in dia.

13.0

14.0

-slightly coarser @ 14.3-14.6m

Recovery 10/18 — Sample 10

| Blow Count | | |
|---|---|---|
| 4 | 3 | 6 |
| 4 | 3 | 5 |
| 4 | 3 | 6 |
| 4 | 4 | 6 |
| 4 | 4 | 4 |
| 4 | 5 | 5 |

15.0

16.0

17.0

Recovery 9/18 — Sample 11

| Blow Count | | |
|---|---|---|
| 2 | 10 | 5 |
| 3 | 9 | 4 |
| 3 | 4 | 6 |
| 3 | 5 | 6 |
| 4 | 5 | 7 |
| 6 | 5 | 5 |

- -4" layer of finer sand in sample
- -some gravel to 3/4" in dia.
- -relatively clean, brown
- -damp to moist, above water table

18.0

19.0

20.0

# DRILL HOLE # 94-BGC-DH7

Page 3 of 3
Project No.: 006000101

Date Drilled: Sept. 1994
Rig: HT-700
Contractor: FOUNDEX
Hammer Type: Cathead
LOCATION: PADDY'S FLATS
ELEVATION:
CO-ORDINATES: 6,503,642N 582775E

| Depth | Recovery | Blows/0.15m | Sample # | Symbols | SOIL DESCRIPTION | Instrument Installation |
|---|---|---|---|---|---|---|
| 20.0 | | | | | | |
| | | | | | **SAND** -medium coarse, brown<br>-poorly graded, relatively clean<br>-trace fine gravel, rounded stone<br>-very dense | |
| 21.0 | 9/18 | | 12 | | | |
| 22.0 | | | | | | |
| 23.0 | | | | | | 2" PVC INSTALLED FOR DOWN HOLE GEOPHYSICS |
| 24.0 | 8/12 | | 13 | | | |
| 25.0 | | | | | | |
| 26.0 | | | | | -3" dia. cobble at 26.2m | |
| 27.0 | 6/18 | | 14 | | -sample damp to moist above water table | |
| 28.0 | | | | | -29.2m-becoming coarser<br>-cobbles, sand & gravel<br>-circulation loss | |
| 29.0 | | | | | -poor recovery of sample 15 | LOST CIRCULATION AT 29.2m<br>MUD LEVEL SOUNDED AT 10m |
| 30.0 | 1/18 | | 15 | | END OF HOLE 30.35m | |

Blow Count (sample 12)

| | | |
|---|---|---|
| 4 | 5 | 5 |
| 4 | 5 | 6 |
| 4 | 4 | 5 |
| 4 | 5 | 6 |
| 5 | 5 | 5 |
| 4 | 5 | 4 |

Blow Count (sample 13)

| | | |
|---|---|---|
| 3 | 7 | + |
| 6 | 7 | + |
| 7 | 8 | + |
| 6 | 9 | + |
| 6 | 9 | + |
| 7 | 9 | + |

Blow Count (sample 14)

| | | |
|---|---|---|
| 3 | 6 | + |
| 6 | 8 | + |
| 7 | 7 | + |
| 5 | 6 | + |
| 6 | 6 | + |
| 6 | 6 | + |

Blow Count (sample 15)

| | | |
|---|---|---|
| 2 | 3 | 3 |
| 3 | 2 | 4 |
| 2 | 3 | 3 |
| 3 | 2 | 2 |
| 2 | 4 | 3 |
| 3 | 3 | 3 |

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

# DRILL HOLE # 94-BGC-DH8

Project No.: 006000101

Date Drilled: Sept. 1994
LOCATION: PADDY'S FLATS
Rig: HT-700
ELEVATION:
Contractor: FOUNDEX
CO-ORDINATES: 6,503,840N 583544E
Hammer Type: Cathead

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

| Depth (m) | Recovery | Blows/0.15m | Sample # | SOIL DESCRIPTION | Instrument Installation |
|---|---|---|---|---|---|
| | | | | NOTES: Surface is Devils Club, Fir & Cottonwood<br>-Roots, moss over organic silt | |
| 0.0 | | | | SILT -trace very fine sand, highly organic<br>-low unit weight, brown<br>-moist to wet, non plastic<br>-very soft | |
| 1.0 | 12/18 | | 1 | OLD SWAMP-INFILLED | |
| 2.0 | 4/18 | | 2 | SAND & GRAVEL -more resistance to drilling<br>SILT -AS ABOVE,some gravel, very soft<br>SAND & GRAVEL | |
| 3.0 | | | | -relatively loose, few cobbles to 4" in dia.<br>NOTE: CONSIDERABLE VIBRATION ON SURFACE AS DRILL GRINDS ON GRAVEL | |
| 4.0 | 9/18 | Blow Count<br>1/2"↑ 1<br>3 2<br>2 / 6" 1<br>1 │ 1<br>1 │ 2<br>1 ↓ 1 | 3 | SAND -coarse, poorly graded, brown<br>-some gravel, round stone to 1" in dia.<br>-relatively clean, moist (drill mud washed)<br>-no cobbles, relatively smooth drilling<br>-washed drill mud off of sample 3 with brush | |
| 5.0 | 8/18 | Blow Count<br>1 2 3<br>1 2 2<br>2 2 2<br>2 2 1<br>2 2 2<br>1 2 2 | 4 | | |
| 6.0 | | | | -ADD ~30 GAL. MUD | |
| 7.0 | 3/18 | Blow Count<br>1 2 1<br>2 1 1<br>2 1 1<br>2 2 1<br>2 1 1<br>2 1 1 | 5 | | THICK BENTONITE/CEMENT→<br>6 BAGS CEMENT, 2 BAGS BENTONITE, 130 GAL. OF WATER |
| 8.0 | 5/18 | Blow Count<br>2 1 1<br>1 1 1<br>1 2 2<br>2 1 1<br>1 1 1<br>1 1 1 | 6 | | |
| 9.0 | | | | | |
| 10.0 | | | | | |

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# DRILL HOLE # 94-BGC-DH8

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: PADDY'S FLATS |
| Rig: HT-700 | ELEVATION: |
| Contractor: FOUNDEX | CO-ORDINATES: 6,503,840N 583544E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

NOTES:

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

| Depth | Recovery | Blows/0.15m | Sample # | Blow Count | Soil Description | Instrument Installation |
|---|---|---|---|---|---|---|
| 10.0 | | | | | | |
| | 6/18 | | 7 | 2 1 1<br>1 1 1/2"<br>2 1 1<br>2 1 1<br>1 2 1<br>2 1 1 | **SAND & GRAVEL**<br>-sand is coarse, poorly graded, brown<br>-gravel is round, stone sizes to 1" in dia.<br>-relatively clean, moist | |
| 11.0 | | | | | -10.6-10.9m-soft to drill (silt?) | |
| 12.0 | 8/18 | | 8 | 2 2 2<br>2 1 2<br>1 2 2<br>2 2 2<br>2 2 2<br>2 2 2 | | THICK BENTONITE/CEMENT |
| 13.0 | | | | | | |
| | | | | | -becoming more dense to drill, similar gradation | |
| 14.0 | | | | | | |
| | | | | | -14.5m-ADD ~30 GAL. MUD | |
| | 8/18 | | 9 | 2 2 2<br>2 2 2<br>2 2 3<br>2 2 3<br>2 2 2<br>2 2 2 | -more sand, fairly well graded<br>-relatively clean, brown<br>-gravel stone sizes to 1" in dia., round | |
| 15.0 | | | | | | |
| 16.0 | | | | | | |
| 17.0 | | | | | -16.9m-4" cobble<br>-17.0m-density increase | |
| 18.0 | 9/18 | | 10 | 3 3 4<br>3 3 4<br>3 3 5<br>2 3 5<br>3 4 5<br>3 3 7 | -few stones to 2" in dia. | |
| 19.0 | | | | | | |
| 20.0 | | | | | | |

# DRILL HOLE # 94-BGC-DH8

Page 3 of 3
Project No.: 006000101

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: PADDY'S FLATS |
| Rig: HT-700 | ELEVATION: |
| Contractor: FOUNDEX | CO-ORDINATES: 6,503,840N 583544E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

Dep | Recovery | Blows/0.15m | Sample # | Symbols | Instrument Installation

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

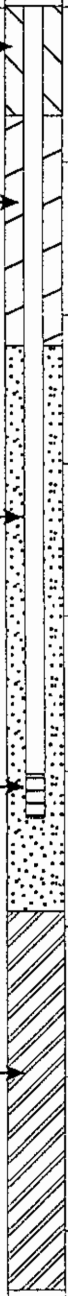
| Dep | Recovery | Blows/0.15m | Sample # | Symbols | SOIL DESCRIPTION |
|---|---|---|---|---|---|
| 20.0 | | | | | |
| | | | | | **SAND & GRAVEL**<br>-coarse sand & fine gravel<br>-fairly well graded, relatively clean, brown<br>-gravel sizes to 1" in dia., round<br>-moist, dense |
| 21.0 | 8/18 | | 11 | | |
| | | | | | -few stones to 2" in dia. |
| 22.0 | | | | | |
| 23.0 | | | | | |
| 24.0 | 6/12 | | 12 | | |
| 25.0 | | | | | -Hole dry-SEPT.28/94 |
| 26.0 | | | | | |
| 27.0 | | | | | -Dry |
| 28.0 | | | | | |
| | 6/18 | | 13 | | -slight trace silt in sand & gravel |
| 29.0 | | | | | **END OF HOLE 28.8m**<br>-DRILLING COMPLETE TO 28.3m<br>-SAMPLE TO 28.8m<br>-FLUSH HOLE WITH CLEAN WATER, FILL TO SURFACE SEPT. 23,1994<br>-SEPT. 24 ▼ AT 23.0m AFTER 13 HRS. |
| 30.0 | | | | | |

Blow Count (Sample 11)

| | | |
|---|---|---|
| 3 | 3 | 5 |
| 3 | 4 | 5 |
| 3 | 4 | 4 |
| 3 | 4 | 4 |
| 3 | 4 | 5 |
| 4 | 4 | 5 |

Blow Count (Sample 12)

| | |
|---|---|
| 3 | 4 |
| 4 | 5 |
| 5 | 7 |
| 4 | 6 |
| 5 | 5 |
| 4 | 5 |



THICK BENTONITE CEMENT →
BENTONITE PELLETS →
RIVER SAND → MEDIUM,UNIFORM, CLEAN
CASAGRANDE TIP →
SLOUGH →

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# DRILL HOLE # 94-BGC-DH9

Project No.: 006000101

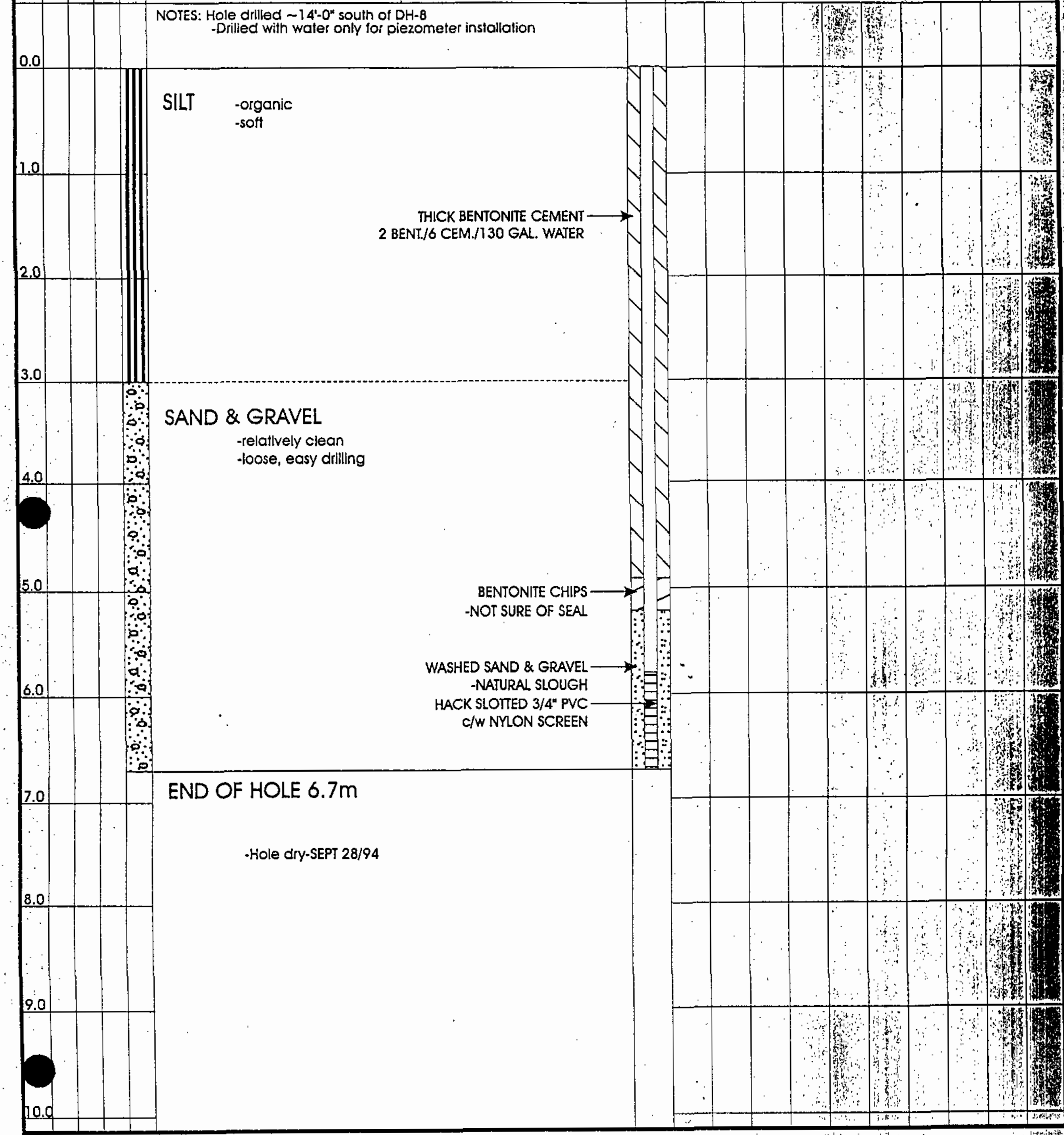
| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: PADDY'S FLATS |
| Rig: HT-700 | ELEVATION: |
| Contractor: FOUNDEX | CO-ORDINATES: 6,503,840N 853544E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa

VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa

MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

NOTES: Hole drilled ~14'-0" south of DH-8
-Drilled with water only for piezometer installation



**SILT** -organic
-soft

THICK BENTONITE CEMENT
2 BENT./6 CEM./130 GAL. WATER

**SAND & GRAVEL**
-relatively clean
-loose, easy drilling

BENTONITE CHIPS
-NOT SURE OF SEAL

WASHED SAND & GRAVEL
-NATURAL SLOUGH

HACK SLOTTED 3/4" PVC
c/w NYLON SCREEN

**END OF HOLE 6.7m**

-Hole dry-SEPT 28/94

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# DRILL HOLE # 94-BGC-DH10

Project No.: 006000101

| | |
|---|---|
| Date Drilled: Sept. 1994 | LOCATION: PADDY'S FLATS |
| Rig: HT-700 | ELEVATION: |
| Contractor: FOUNDEX | CO-ORDINATES: 6,503,371N 583077E |
| Hammer Type: Cathead | SOIL DESCRIPTION |

NOTES:

Depth (m) | Recovery | Blows/0.15m | Sample # | Symbols | Instrument Installation

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa

VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa

MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

0.0

## SAND & GRAVEL

-medium coarse sand, fairly well graded
-gravel rounded to 1" in dia.
-relatively clean, damp to moist
-(some mud contamination-typical of all samples this hole)

1.0

Sample 1 — Recovery 8/18

| Blow Count | | |
|---|---|---|
| 2 | 2 | 3 |
| 1 | 1 | 2 |
| 2 | 2 | 2 |
| 2 | 3 | 1 |
| 2 | 2 | 1 |
| 2 | 3 | 1 |

2.0

-less gravel, smooth fast drilling

3.0

Sample 2 — Recovery 6/18

| Blow Count | | |
|---|---|---|
| 4 | 5 | 4 |

-trace gravel to 1/2" in dia., loose to compact

4.0

Sample 3 — Recovery 6/18

| Blow Count | | |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 1 | 1 |
| 1 | 1 | 1 |
| 2 | 1 | 1 |
| 1 | 1 | 1 |
| 1 | 1 | 1 |

5.0

6.0

Sample 4 — Recovery 0/18

| Blow Count | | |
|---|---|---|
| 2 | 2 | 2 |
| 1 | 1 | 1 |
| 2 | 2 | 2 |
| 1 | 2 | 1 |
| 2 | 1 | 1 |
| 1 | 1 | 1 |

-trace gravel, stone to 1 1/2" in dia.

7.0

-density increase, more gravel sizes

Sample 5 — Recovery 4/18

| Blow Count | | |
|---|---|---|
| 2 | 2 | 3 |
| 2 | 2 | 3 |
| 2 | 2 | 10 |
| 2 | 2 | bounce |
| 2 | 2 | |
| 1 | 3 | |

8.0

-few cobbles to 3"-4" in dia.

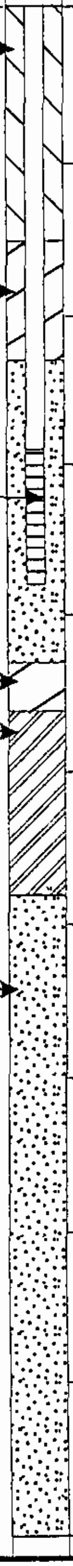
9.0

Sample 6 — Recovery 5/18

| Blow Count | | |
|---|---|---|
| 2 | 5 | 3 |
| 1 | 3 | 3 |
| 2 | 3 | 2 |
| 2 | 3 | 3 |
| 1 | 2 | 3 |
| 2 | 3 | 3 |

-sand & gravel sizes, poor recovery

10.0



GROUT & BENTONITE →

BENTONITE CHIPS →

SLOTTED WITH HACK-SAW (3'-0") AND NYLON SCREEN →

BENTONITE CHIPS →

SLOUGH →
-During reaming - water only hole caved
-overream hole from 4 3/4" dia. to 5 1/4" dia. to clean bentonite wall above 5.79m in depth

SAND FILL →

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# DRILL HOLE # 94-BGC-DH10

Page 2 of 3
Project No.: 006000101

Date Drilled: Sept. 1994
Rig: HT-700
Contractor: FOUNDEX
Hammer Type: Cathead
LOCATION: PADDY'S FLATS
ELEVATION:
CO-ORDINATES: 6,503,371N 583077E

Depth (m) | Recovery | Blows/0.15m | Sample # | Symbols | SOIL DESCRIPTION | Instrument Installation

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

NOTES:

10.0

## SAND & GRAVEL

- relatively clean, brown, very dense
- *fairly well graded*
- rounded gravel sizes to 1" in dia.
- moist

Sample 7 — Recovery 8/18

| Blow Count | | |
|---|---|---|
| 3 | 8 | 5 |
| 4 | 5 | 4 |
| 4 | 5 | 5 |
| 5 | 6 | 4 |
| 9 | 6 | 4 |
| 8 | 5 | 4 |

11.0

SAND FILL →

12.0

Sample 8 — Recovery 9/18

| Blow Count | | |
|---|---|---|
| 2 | 3 | 4 |
| 3 | 4 | 3 |
| 2 | 3 | 4 |
| 3 | 3 | 3 |
| 3 | 3 | 4 |
| 3 | 3 | 4 |

-BENTONITE CHIPS →
FLOAT & SWELL ON
HEAVY MUD
-MUD LEVEL FELL TO 12.8m

13.0

- smooth, dense, fast drilling
- less coarse material

14.0

VERY THICK DRILL MUD →

15.0

Sample 9 — Recovery 6/8

| Blow Count | |
|---|---|
| 4 | 7 |
| 5 | 7 |
| 7 | bounce |
| 7 | |
| 8 | |
| 6 | |

18.0m-END OF SHIFT SEPT. 25/94
MUD TO SURFACE
-SEPT. 26/94 MUD @ 4.5m
-HOLE SLOUGHED TO 16.5m

16.0

-16.15m-4" cobble

17.0

18.0

Sample 10 — Recovery 8/16

| Blow Count | | |
|---|---|---|
| 4 | 7 | 5 |
| 4 | 6 | 7 |
| 4 | 5 | 8 |
| 5 | 6 | 9 |
| 5 | 5 | [illegible] |
| 5 | 6 | |

19.0

20.0

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# DRILL HOLE # 94-BGC-DH10

Page 3 of 3
Project No.: 006000101

Date Drilled: Sept. 1994
LOCATION: PADDY'S FLATS
Rig: HT-700
ELEVATION:
Contractor: FOUNDEX
CO-ORDINATES: 6,503,371N 583077E
Hammer Type: Cathead

POCKET PENETROMETER VALUES ● 100 200 300 400 Kpa
VANE SHEAR VALUES ⊗ 100 200 300 400 Kpa
MOISTURE CONTENT X % 10 20 30 40 50 60 70 80 90

| Depth | Recovery | Blows/0.15m | Sample # | Symbols | SOIL DESCRIPTION | Instrument Installation |
|---|---|---|---|---|---|---|
| 20.0 | | | | | | |
| | | | | | SAND & GRAVEL -COMPLETE MUD LOSS AFTER PULL SAMPLER -MIX VERY THICK MUD,TRY TO ADVANCE HOLE,O.K. TO 21.3m AND ALL FLUSHED DOWN HOLE -MUD LEVEL FELL TO 12.8m | |
| 21.0 | | | | | | |
| | 2/18 | | 11 | | GRAVEL & COBBLES -open work, relatively loose | |
| | | | | | END OF HOLE 21.5m<br>-SUSPECT WATER TABLE AT 21.3m<br>-UPPER 20'-0" OF HOLE REAMED WITH OVERSIZE BIT TO CLEAN WALL OF HOLE<br>-PIEZO INSTALLED IN REAMED PORTION OF HOLE | |
| 22.0 | | | | | | |
| 23.0 | | | | | | |
| 24.0 | | | | | | |
| 25.0 | | | | | | |
| 26.0 | | | | | | |
| 27.0 | | | | | | |
| 28.0 | | | | | | |
| 29.0 | | | | | | |
| 30.0 | | | | | | |

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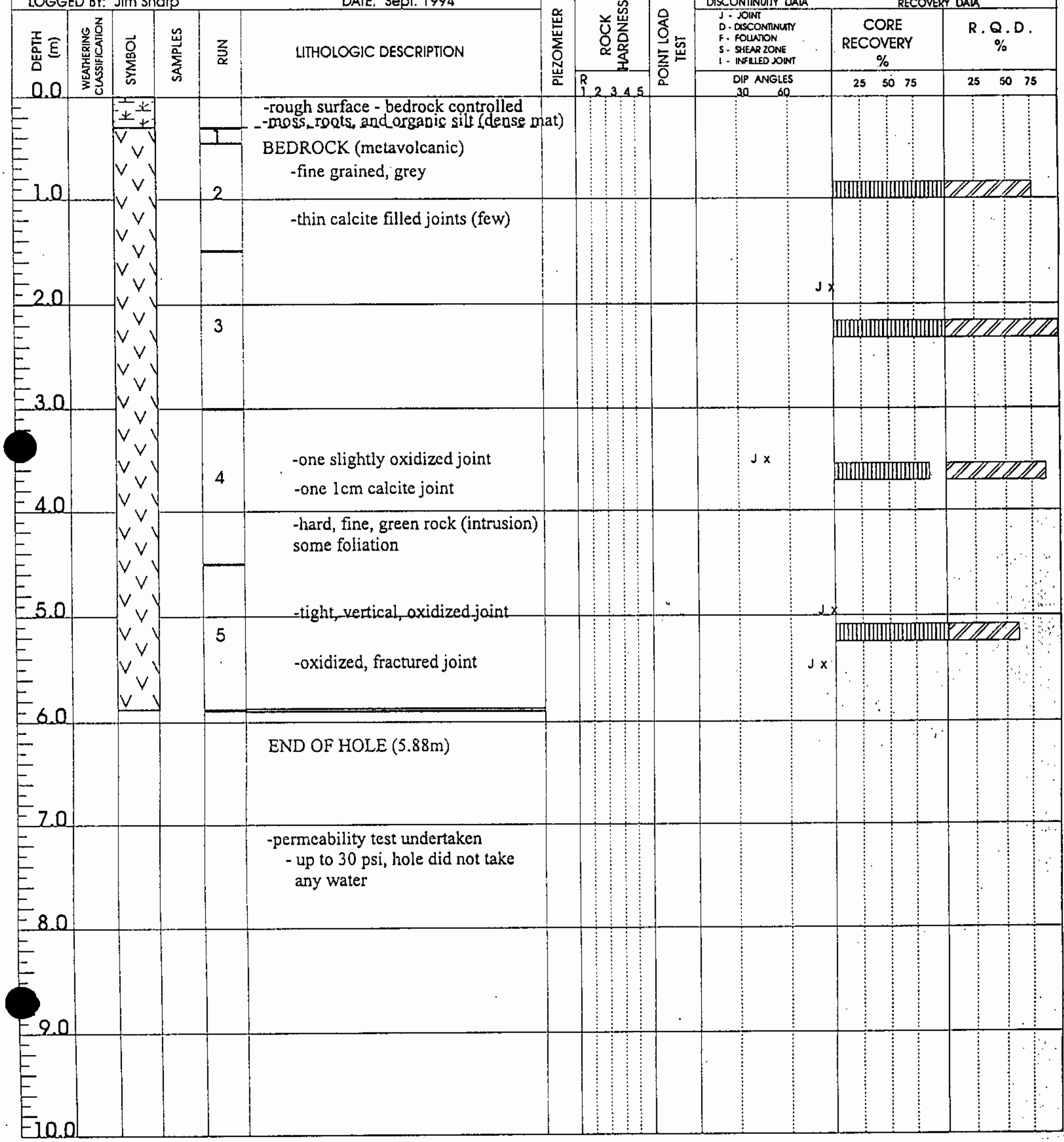
# GEOLOGIC LOG OF DRILL HOLE NO. 94BGC-11

| | |
|---|---|
| CLIENT: Redfern | JOB NO.: 060-001-01 |
| PROJECT: Tulsequah Chief | DATE HOLE STARTED: FINISHED: |
| LOCATION: Plant Site B | ELEVATION: |
| DIRECTION: BEARING: DIP: 90 | COORDINATES: 6 506 705 N, 581 165 E |
| MANUFACTURER'S DRILL DESIGNATION: ht-700 | DRILLING METHOD: CORE: CASING: |
| DRILLING CONTRACTOR: Foundex | FLUID: CASED TO: |
| LOGGED BY: Jim Sharp DATE: Sept. 1994 | |

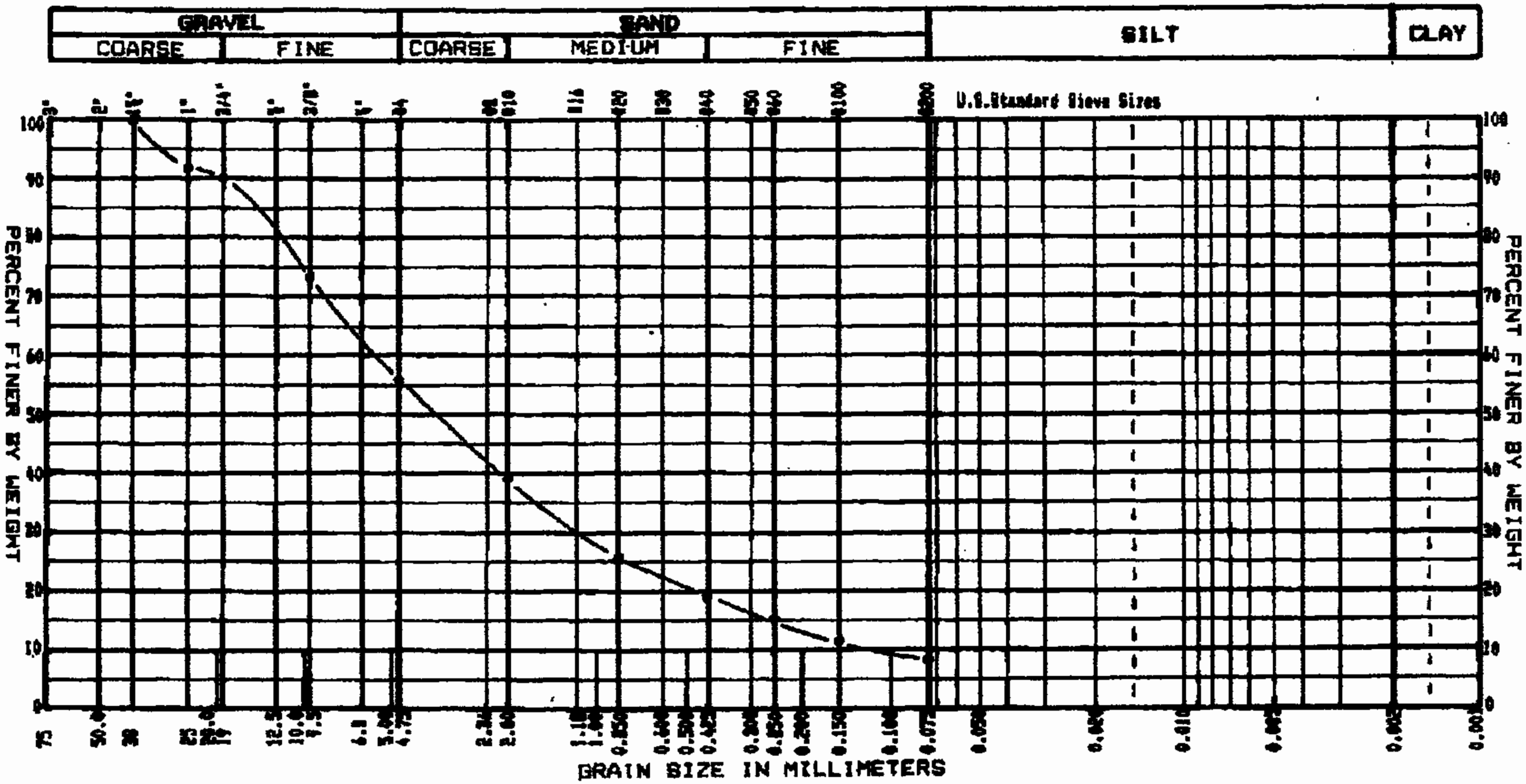


| DEPTH (m) | RUN | LITHOLOGIC DESCRIPTION |
|---|---|---|
| 0.0 | 1 | -rough surface - bedrock controlled<br>-moss, roots, and organic silt (dense mat)<br>BEDROCK (metavolcanic)<br>-fine grained, grey |
| 1.0 | 2 | -thin calcite filled joints (few) |
| 2.0 | 3 | |
| 3.0 | 4 | -one slightly oxidized joint<br>-one 1cm calcite joint |
| 4.0 | | -hard, fine, green rock (intrusion) some foliation<br>-tight, vertical, oxidized joint |
| 5.0 | 5 | -oxidized, fractured joint |
| 6.0 | | END OF HOLE (5.88m) |
| 7.0 | | -permeability test undertaken<br>- up to 30 psi, hole did not take any water |

# APPENDIX 3

## Grain Size Amalysis Curves

# GRAIN SIZE ANALYSIS



**Remarks:** Washed

| | | | |
|---|---|---|---|
| Nat Water Content | | | % |
| Liquid Limit | | | |
| Plastic Limit | | | |
| Plastic Index | | | |

| | | | |
|---|---|---|---|
| Clay<br>Silt | 8.5 | | % |
| Sand | 47.5 | | |
| Gravel | 44 | | |

**Classification:** SW - SM

Client:
Project: 060
Location: DH2 a .9 - 1.35 m
Sample: 2 Tested by: RED
Test Date: 0-/26/94 File No.: 8-1355-5

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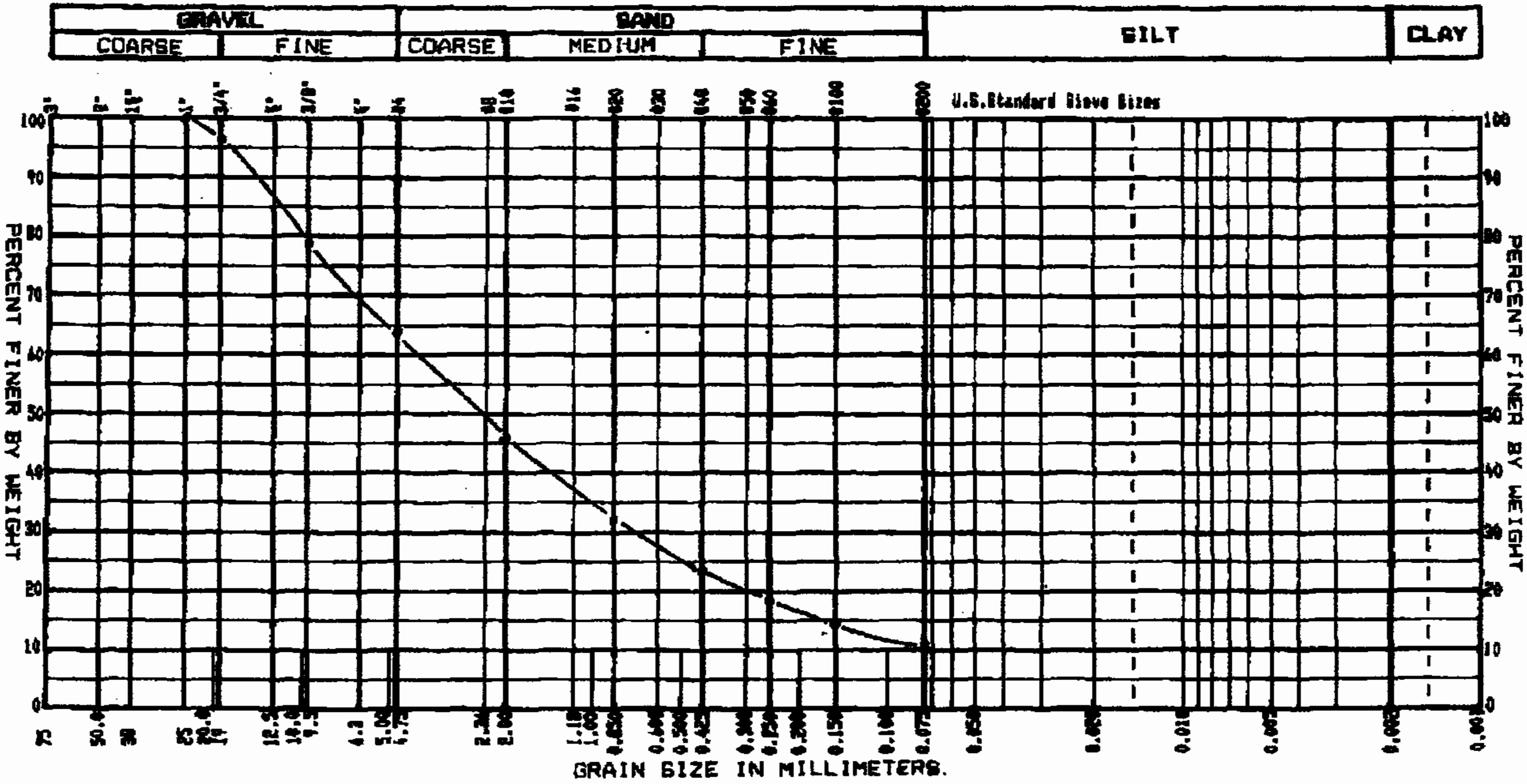
# GRAIN SIZE ANALYSIS



**Remarks:** Washed

| | | | |
|---|---|---|---|
| Nat Water Content | | | % |
| Liquid Limit | | | |
| Plastic Limit | | | |
| Plastic Index | | | |

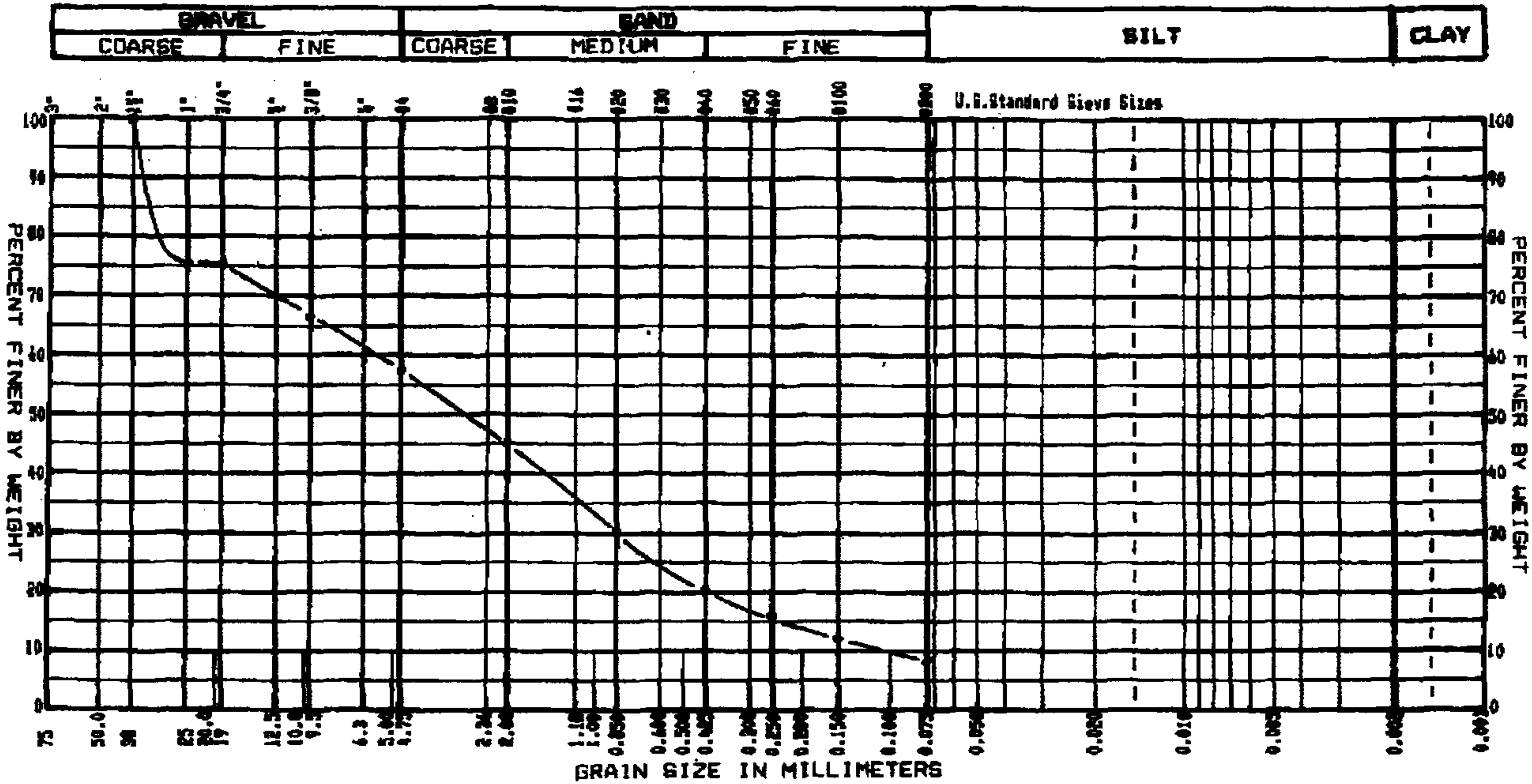
| | | | |
|---|---|---|---|
| Clay } Silt } | 10.5 | | % |
| Sand | 53 | | |
| Gravel | 36.5 | | |

**Classification:** SM - SW

Client:
Project: 060
Location: DH 2 Sa 6
Sample: @ 7-7.45m Tested by: RFD
Test Date: Oct 26/94 File No. 18-1355-5

C.N. RYZUK & ASSOCIATES LTD. Geotechnical Engineering

# GRAIN SIZE ANALYSIS



Remarks: Washed

| | | | |
|---|---|---|---|
| Nat Water Content | | | % |
| Liquid Limit | | | |
| Plastic Limit | | | |
| Plastic Index | | | |

| | | | |
|---|---|---|---|
| Clay } Silt } | 8.5 | | % |
| Sand | 48.5 | | |
| Gravel | 43 | | |

Classification: SM-SP

Client:

Project: 060

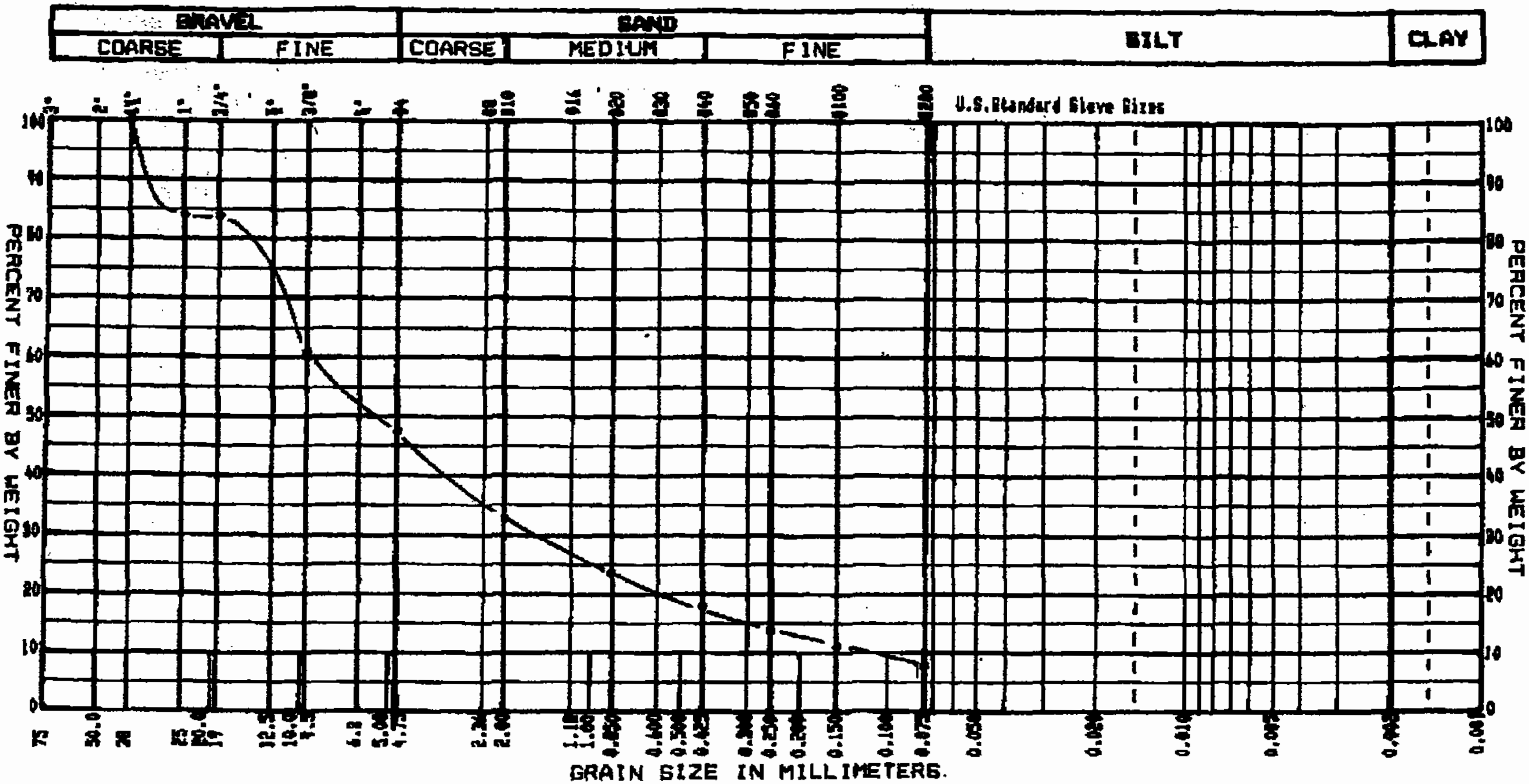
Location: DH2 Sa 9

Sample: @14.6-15.05m Tested by: RCD

Test Date: File No.: 8-1355-5

C.N. RYZUK & ASSOCIATES LTD. Geotechnical Engineering

# GRAIN SIZE ANALYSIS



Remarks: Washed

| | | | |
|---|---|---|---|
| Nat Water Content | | | % |
| Liquid Limit | | | |
| Plastic Limit | | | |
| Plastic Index | | | |

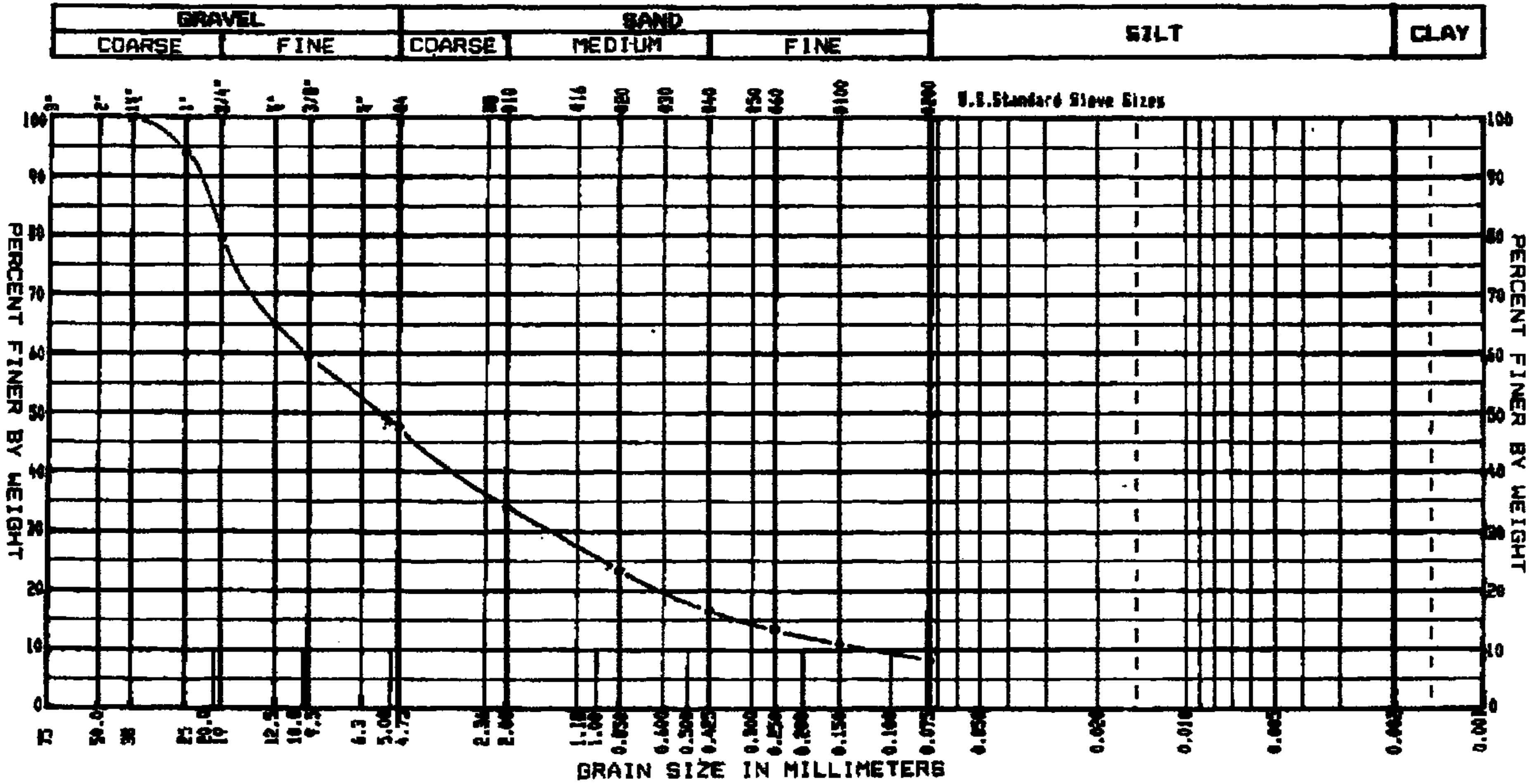
| | | | |
|---|---|---|---|
| Clay } Silt } | 7.5 | | % |
| Sand | 40 | | |
| Gravel | 52.5 | | |

Classification: GM - GP

Client:
Project: 060
Location: DH 5 Sa 5
Sample: 7-7.45 m Tested by: RED
Test Date: Oct 26/94 File No.: 8-1355-5

C.N. RYZUK & ASSOCIATES LTD. Geotechnical Engineering

# GRAIN SIZE ANALYSIS



| | | | |
|---|---|---|---|
| Nat Water Content | | | % |
| Liquid Limit | | | |
| Plastic Limit | | | |
| Plastic Index | | | |

| | | | |
|---|---|---|---|
| Clay<br>Silt | 8 | | % |
| Sand | 39 | | |
| Gravel | 53 | | |

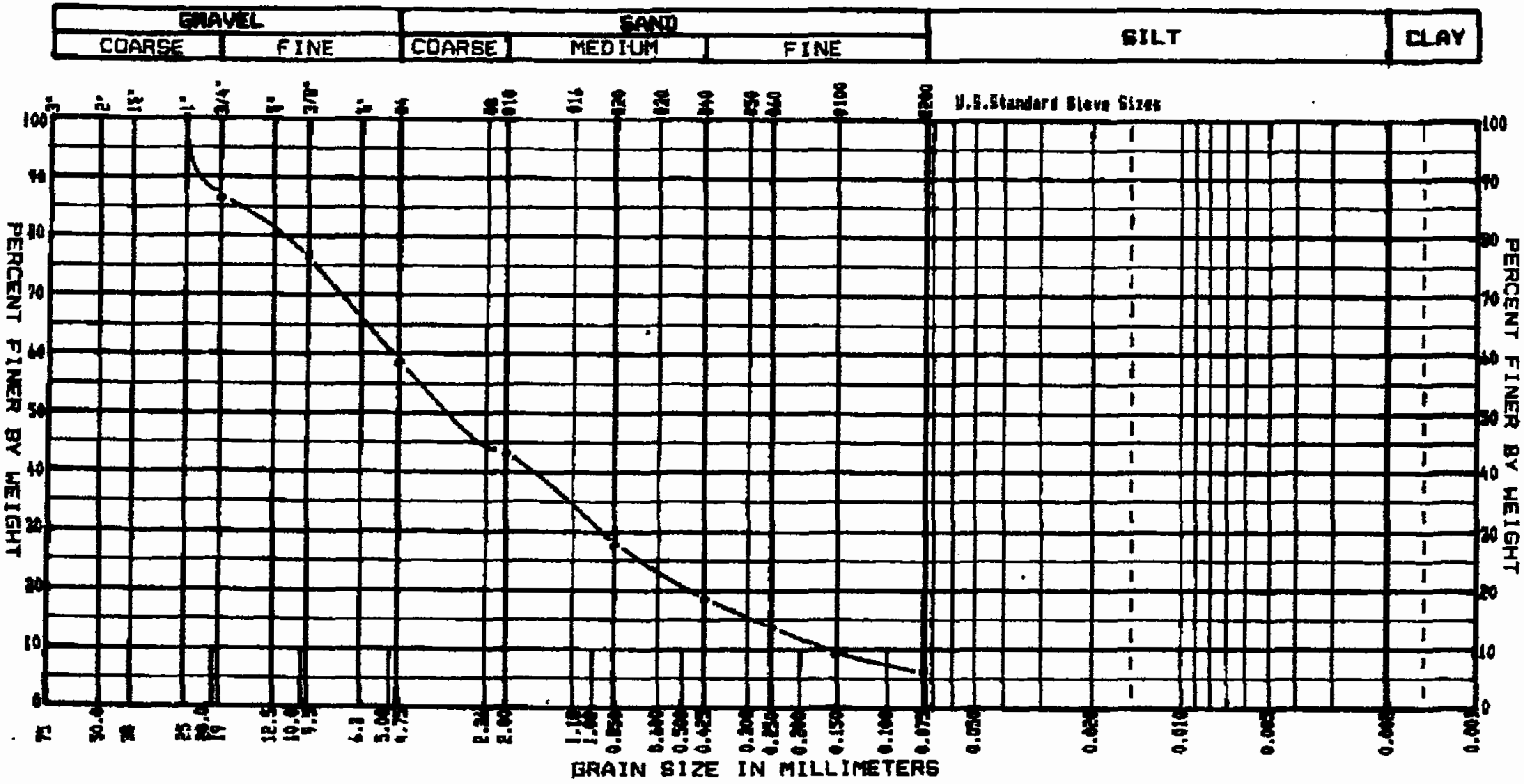
Classification: GM - GW

Remarks: Washed

Client:
Project: 060
Location: DH 5 Sa 7
Sample: @ 10.05-10.5m Tested by: RFD
Test Date: Oct 26/94 File No. 18-1355-S

C.N. RYZUK & ASSOCIATES LTD. Geotechnical Engineering

# GRAIN SIZE ANALYSIS



| | | | |
|---|---|---|---|
| Nat Water Content | | | % |
| Liquid Limit | | | |
| Plastic Limit | | | |
| Plastic Index | | | |

| | | | |
|---|---|---|---|
| Clay } Silt } | 6.5 | | % |
| Sand | 51.5 | | |
| Gravel | 42 | | |

Classification: SW

Remarks: Washed

Client:

Project: 060

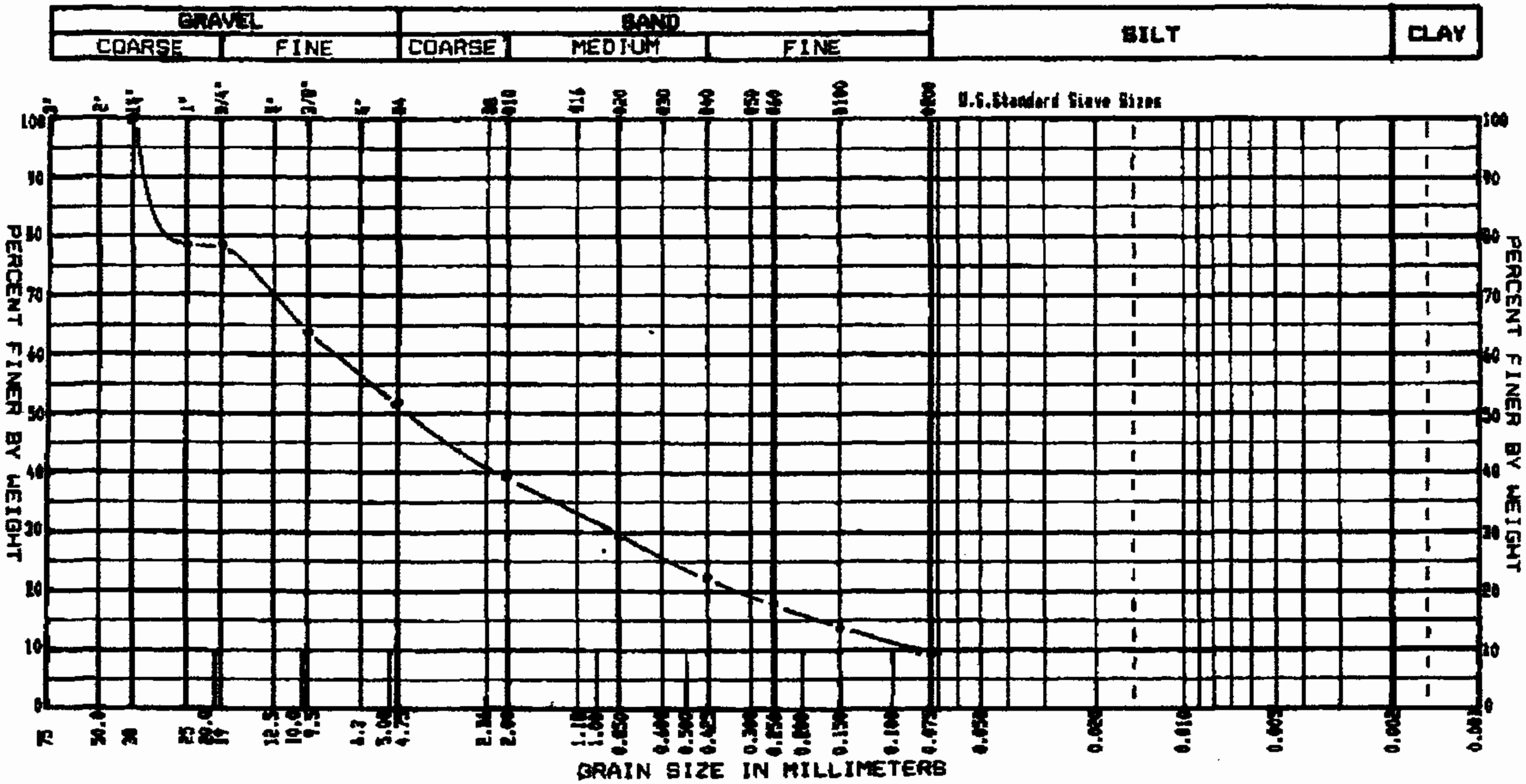
Location: DHS Sa 10

Sample: @ 14.5 - 14.95 m Tested by: RED

Test Date: Oct 26/94 File No.: 8-1355-5

C.N. RYZUK & ASSOCIATES LTD. Geotechnical Engineering

# GRAIN SIZE ANALYSIS



|  |  |  |  |
|---|---|---|---|
| Nat Water Content |  |  | % |
| Liquid Limit |  |  |  |
| Plastic Limit |  |  |  |
| Plastic Index |  |  |  |

|  |  |  |  |
|---|---|---|---|
| Clay} Silt} | 9.5 |  | % |
| Sand | 42.5 |  |  |
| Gravel | 48 |  |  |

Classification: GM-GP

Remarks: Washed

Client:

Project: 060

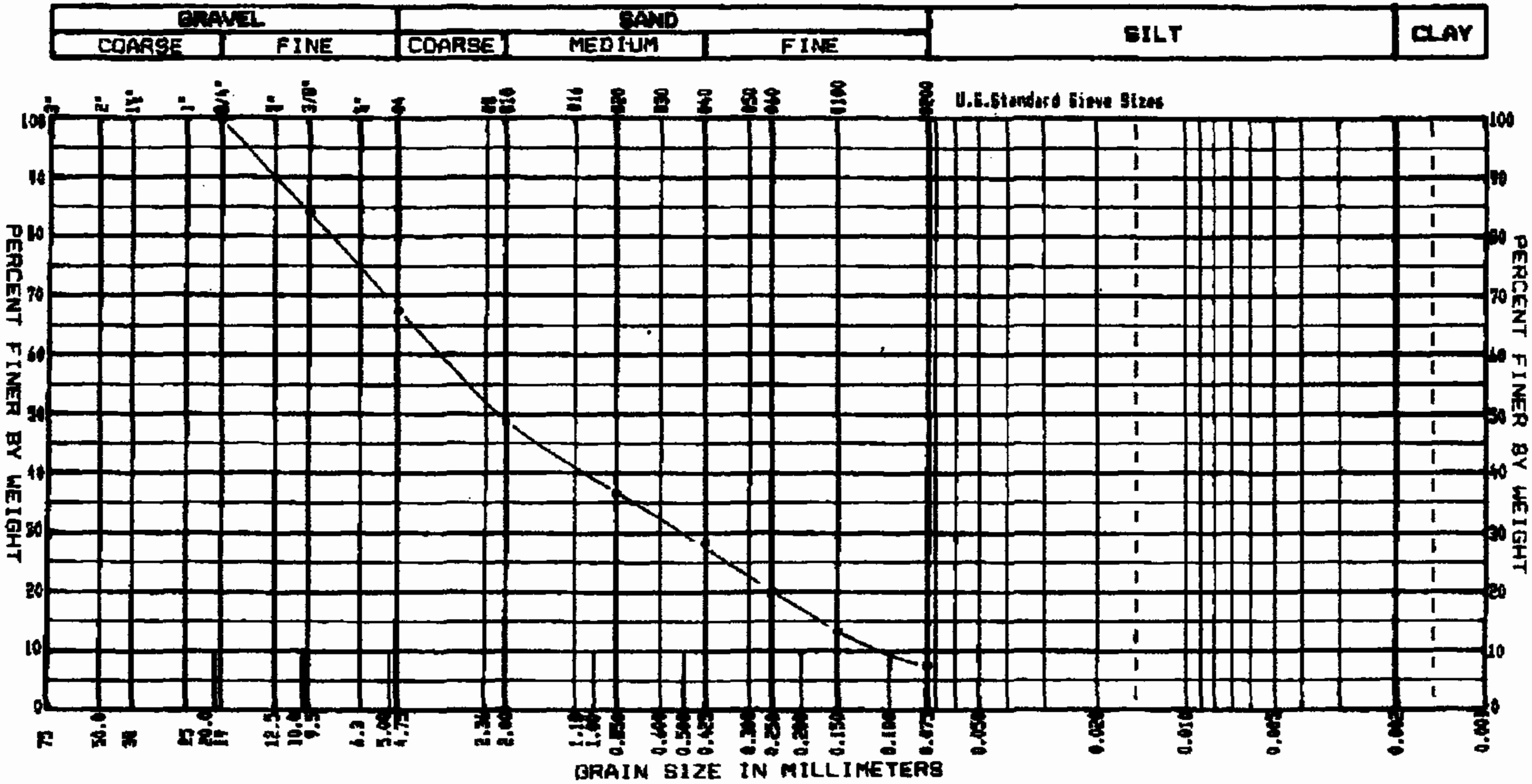
Location: DH 5 Sa 13

Sample: 23.8-24.25 m Tested by: RFD

Test Date: 06/26/94 File No. 18-1355-5

C.N. RYZUK & ASSOCIATES LTD. Geotechnical Engineering

# GRAIN SIZE ANALYSIS



**Remarks:** Washed

| | | | |
|---|---|---|---|
| Nat Water Content | | | % |
| Liquid Limit | | | |
| Plastic Limit | | | |
| Plastic Index | | | |

| | | | |
|---|---|---|---|
| Clay<br>Silt | 7.5 | | % |
| Sand | 60 | | |
| Gravel | 32.5 | | |

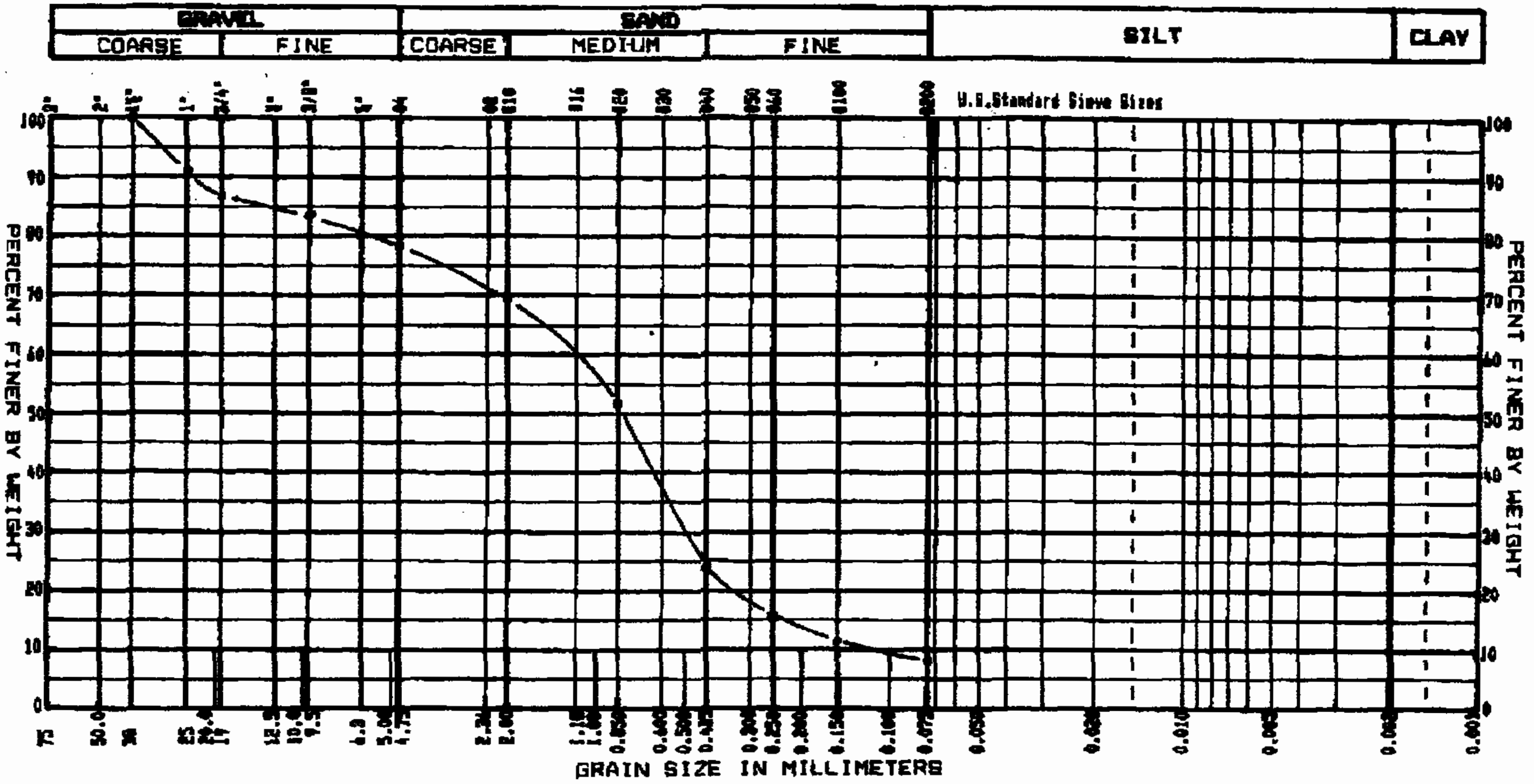
**Classification:** SW - SM

Client:
Project: 060
Location: DH 7 Sa 5
Sample: @ 5.5 - 5.95 m Tested by: RFD
Test Date: Oct 26/94 File No.: 8-1555-5

C.N. RYZUK & ASSOCIATES LTD. Geotechnical Engineering

4023

# GRAIN SIZE ANALYSIS



| | | | |
|---|---|---|---|
| Nat Water Content | | | % |
| Liquid Limit | | | |
| Plastic Limit | | | |
| Plastic Index | | | |

| | | | |
|---|---|---|---|
| Clay<br>Silt | 8 | | % |
| Sand | 70.5 | | |
| Gravel | 21.5 | | |

Classification: SP - SM

Remarks: Washed

Client:

Project: 060

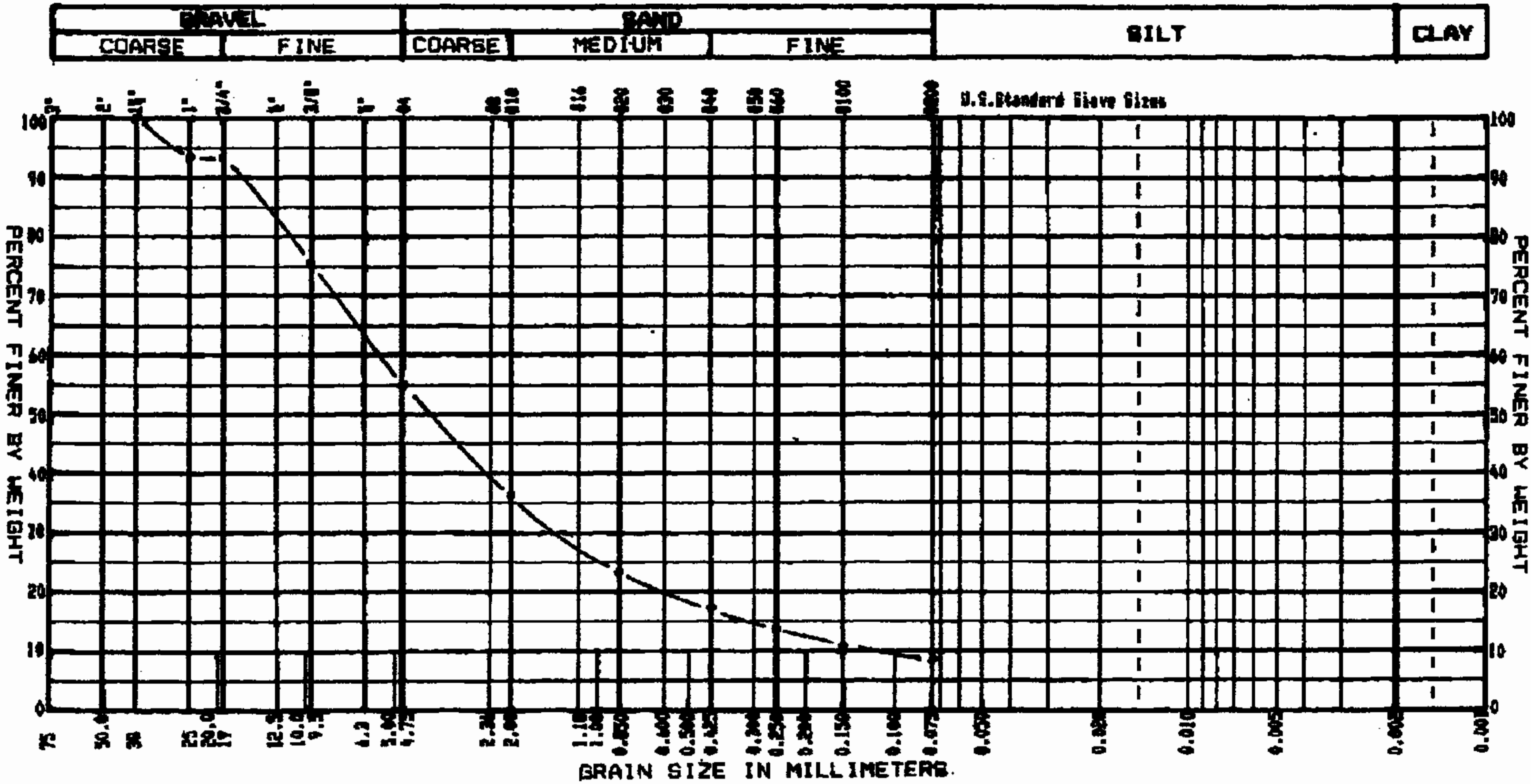
Location: DH7 Sa 8

Sample: @ 10.05-10.5 m Tested by: ERD

Test Date: Oct 27/94 File No.: 8-1355-5

C.N. RYZUK & ASSOCIATES LTD. Geotechnical Engineering

# GRAIN SIZE ANALYSIS



| | | | % |
|---|---|---|---|
| Wet Water Content | | | |
| Liquid Limit | | | |
| Plastic Limit | | | |
| Plastic Index | | | |

| | | | % |
|---|---|---|---|
| Clay } Silt } | 8 | | |
| Sand | 47 | | |
| Gravel | 45 | | |

Classification: GM - GP

Remarks: Washed

Client:

Project: OGO

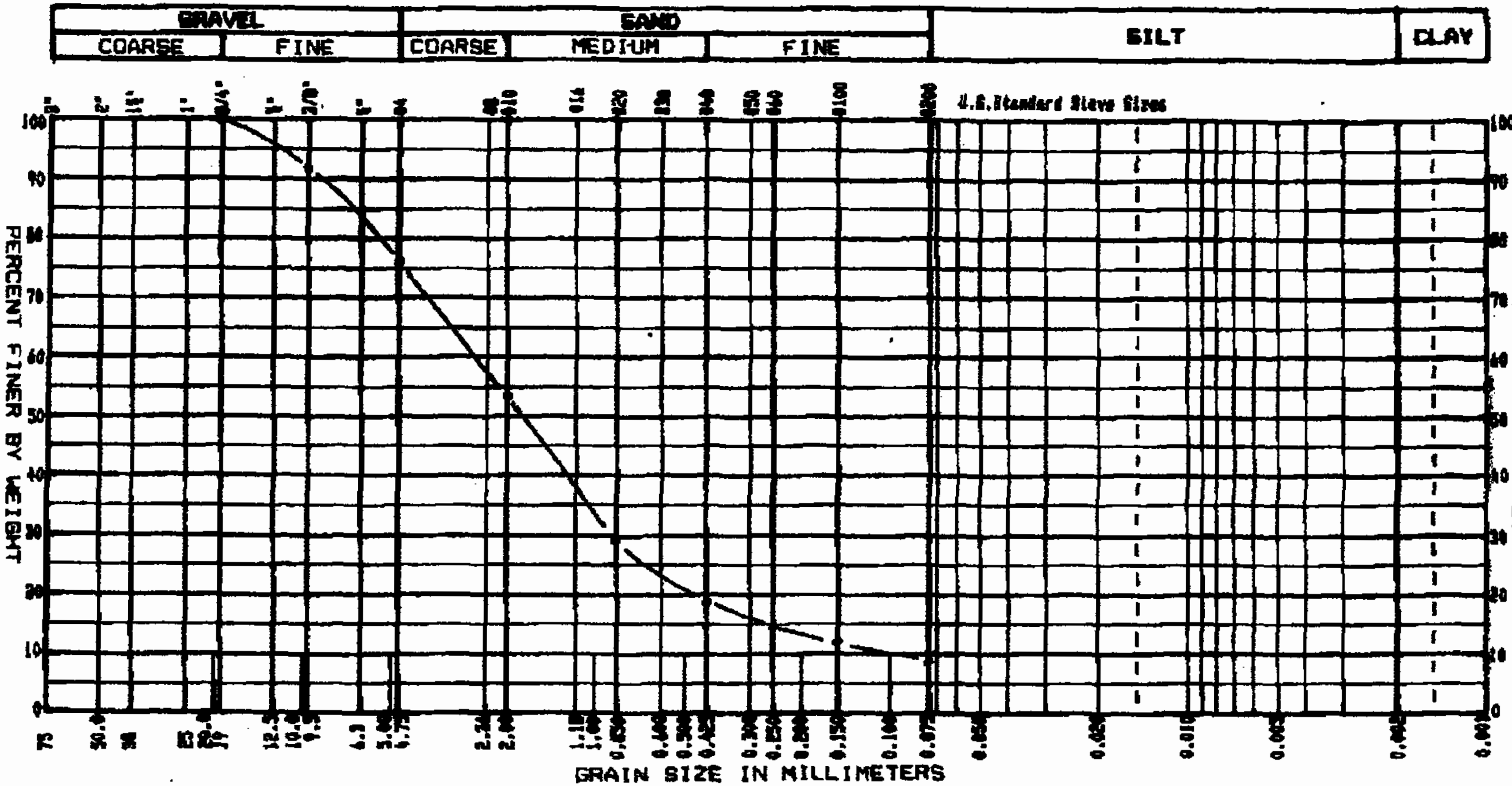
Location: DH 7 Sa 10

Sample: @ 14.5-14.95m Tested by:

Test Date: Oct 27/94 File No.: 8-355-5

C.N. RYZUK & ASSOCIATES LTD. Geotechnical Engineering

# GRAIN SIZE ANALYSIS



| | | | |
|---|---|---|---|
| Wet Water Content | | | % |
| Liquid Limit | | | |
| Plastic Limit | | | |
| Plastic Index | | | |

| | | | |
|---|---|---|---|
| Clay } Silt | 9 | | % |
| Sand | 66.5 | | |
| Gravel | 24.5 | | |

Classification: SM

Remarks: washed

Client:

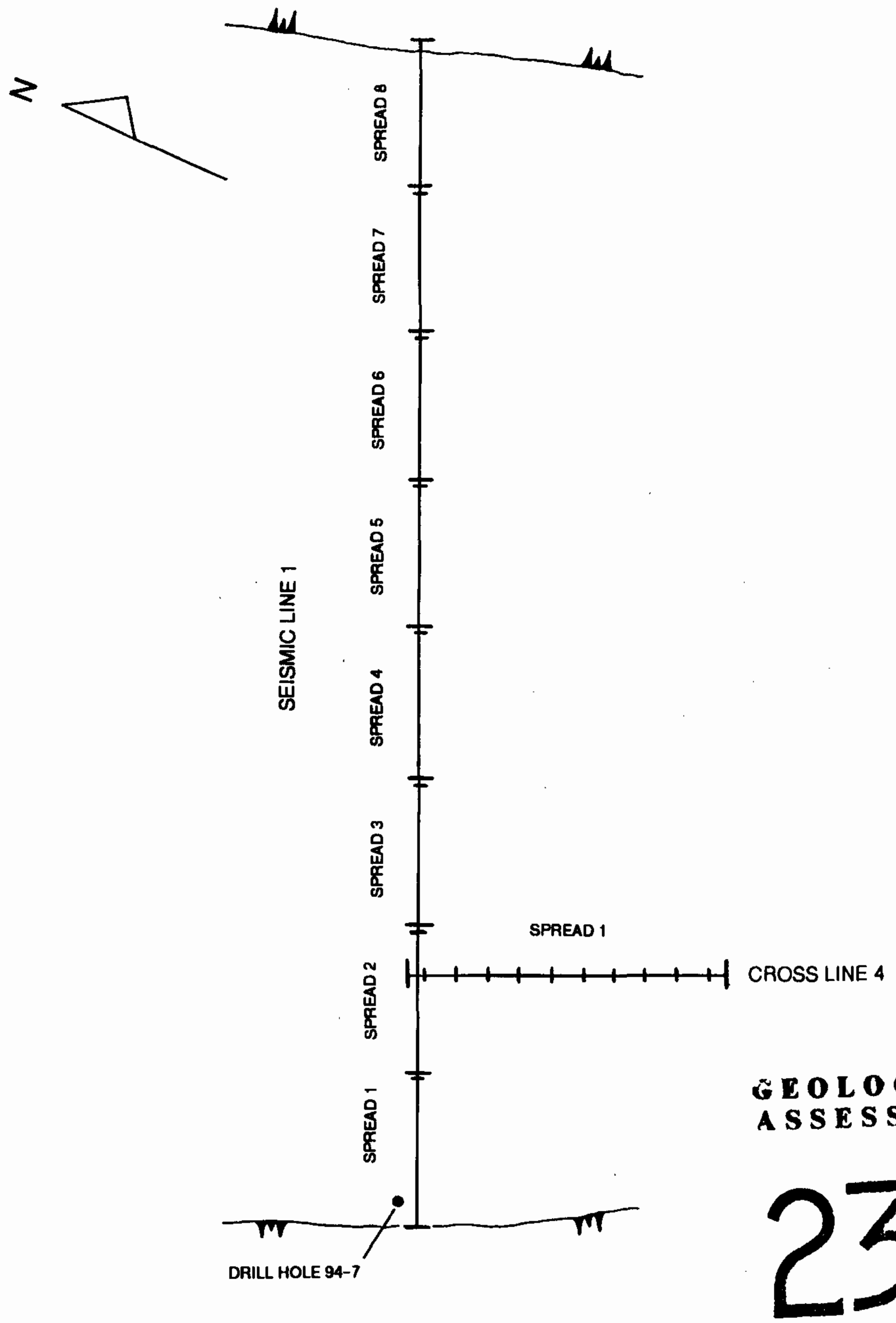
Project: 060

Location: DH 7 Sa 12

Sample: @ 20.75 - 21.2 m Tested by: RKD

Test Date: Oct 27/94 File No.: R-1555-5

C.N. RYZUK & ASSOCIATES LTD. Geotechnical Engineering



SCALE: 1:5000

GEOLOGICAL BRANCH
ASSESSMENT REPORT

23,951

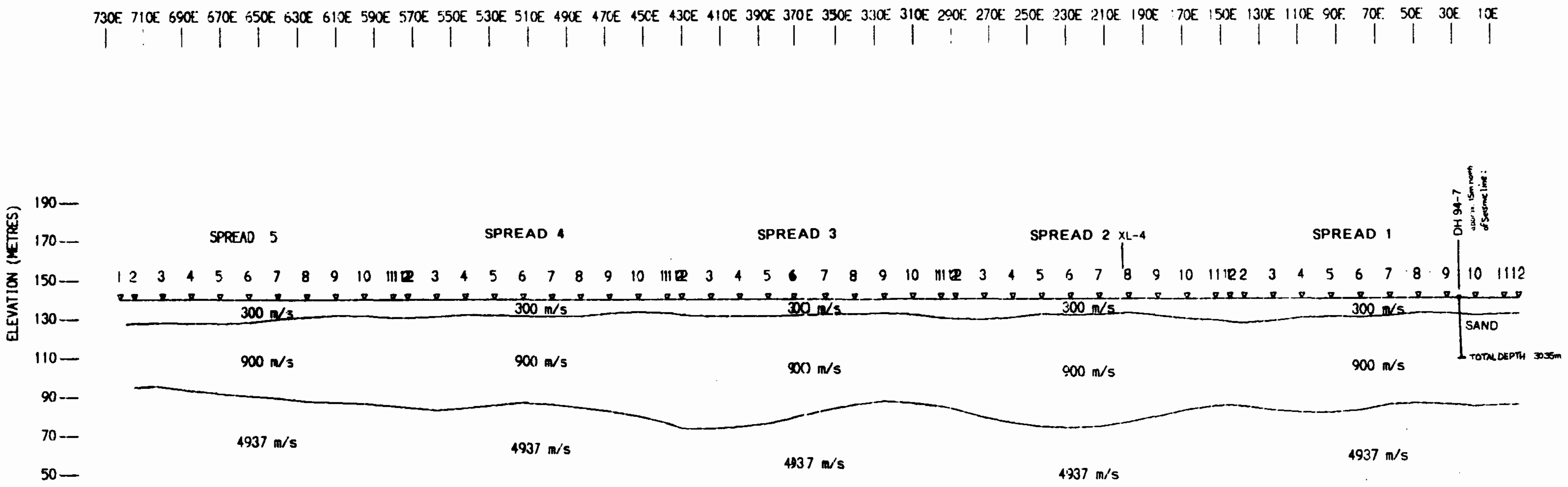
REDFERN RESOURCES LTD.
**BIG BULL AREA**

**SEISMIC REFRACTION SURVEY**

BIG BULL SITE SKETCH

FRONTIER GEOSCIENCES INC.

| | | |
|---|---|---|
| **DATE:** OCT. **1994** | | **FIG. 2** |



SEISMIC LINE 1

NOTES:
SCALE 1:2000 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

**REDFERN RESOURCES LTD.**
**BIG BULL AREA**

SEISMIC REFRACTION SURVEY

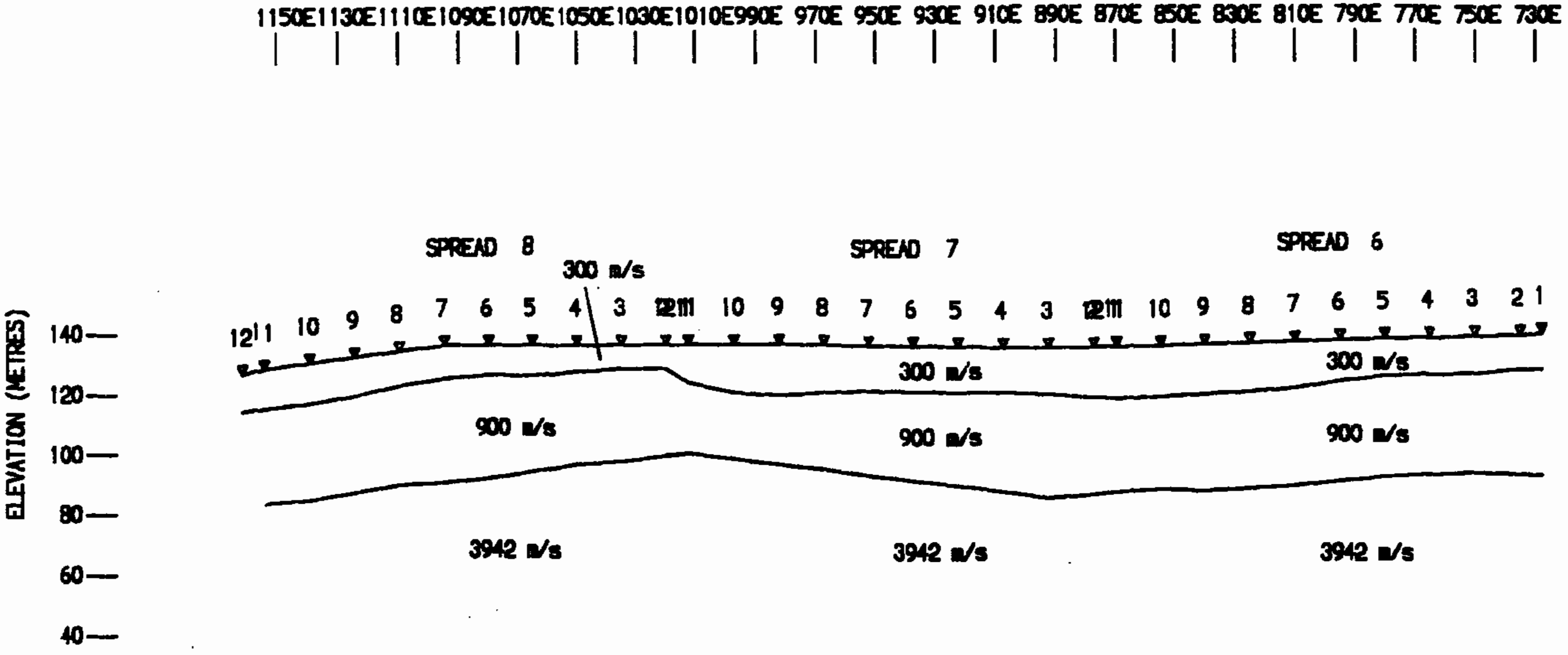
INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

DATE: OCT 1994 | FIG. 3

GEOLOGICAL BRANCH
ASSESSMENT REPORT

23,951



GEOLOGICAL BRANCH
ASSESSMENT REPORT

23,951

SEISMIC LINE 1

NOTES:
SCALE: 1:2000 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

REDFERN RESOURCES LTD.
BIG BULL AREA

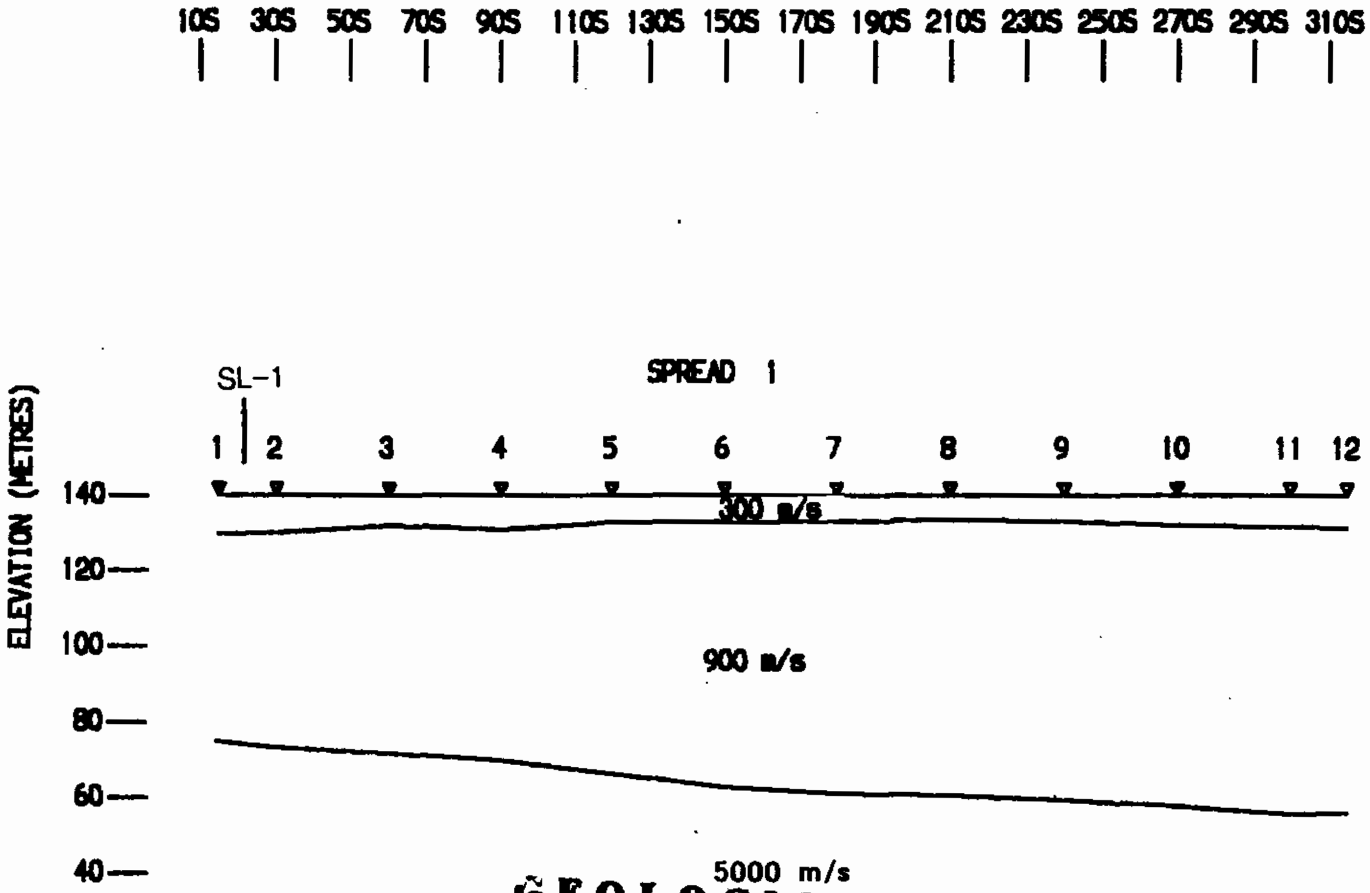
SEISMIC REFRACTION SURVEY

INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

DATE: OCT. 1994

FIG. 4



CROSS LINE 4

NOTES:
SCALE: 1:2000 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

REDFERN RESOURCES LTD.
BIG BULL AREA

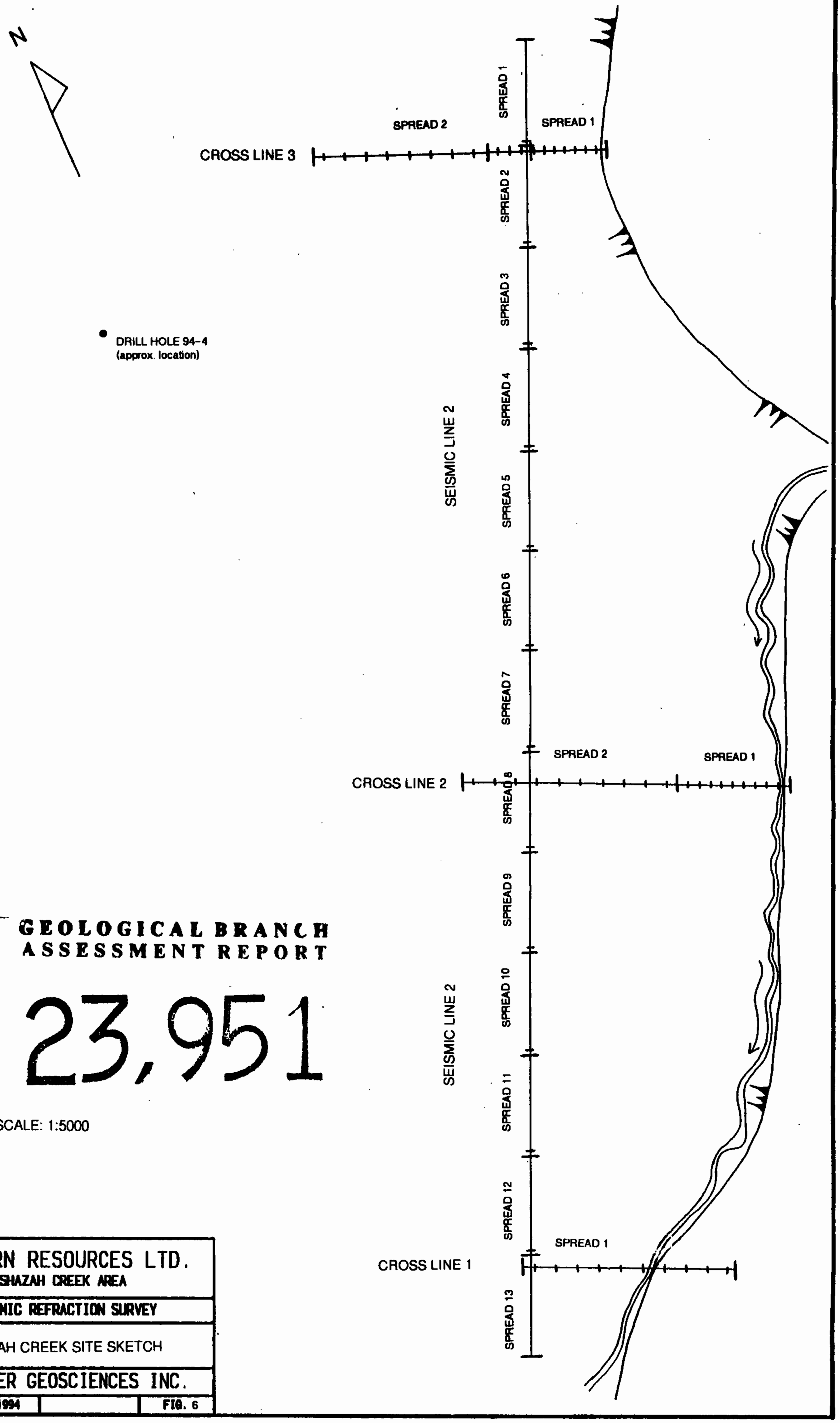
SEISMIC REFRACTION SURVEY

INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

DATE: OCT. 1994

FIG. 5



SCALE: 1:5000

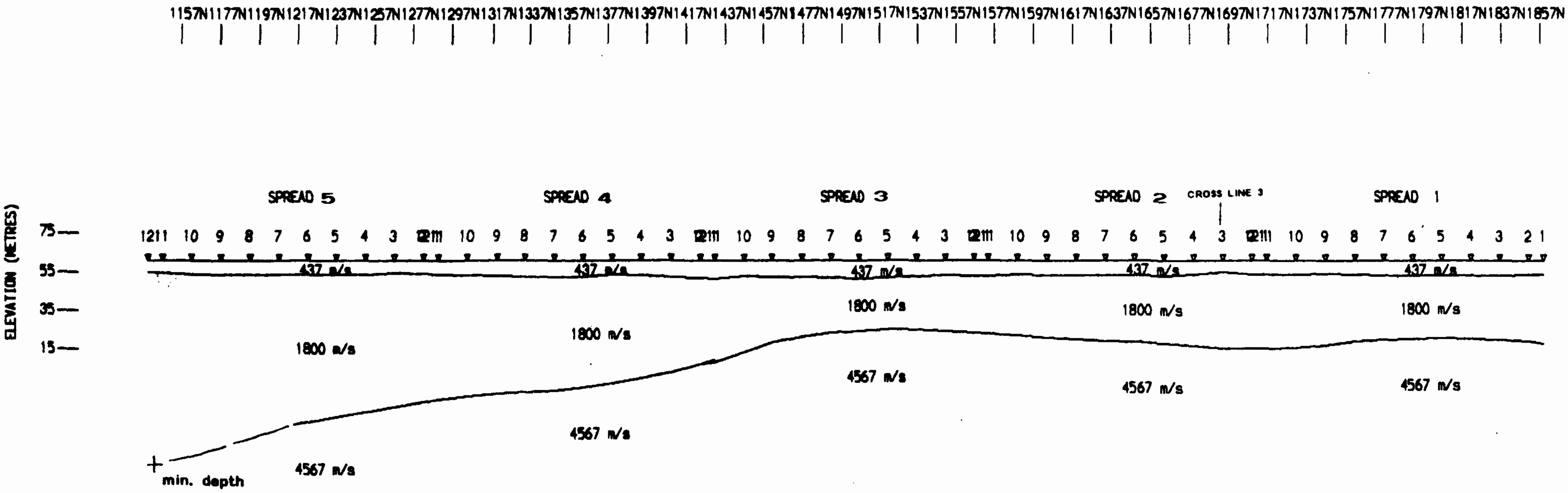
REDFERN RESOURCES LTD.
**SHAZAH CREEK AREA**

**SEISMIC REFRACTION SURVEY**

SHAZAH CREEK SITE SKETCH

FRONTIER GEOSCIENCES INC.

**DATE:** OCT. 1994 | **FIG. 6**



SEISMIC LINE 2

NOTES:
SCALE: 1:2000 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

REDFERN RESOURCES LTD.
SHAZAH CREEK AREA

SEISMIC REFRACTION SURVEY

INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

| DATE OCT 94 | | FIG. 7 |
|---|---|---|

GEOLOGICAL BRANCH
ASSESSMENT REPORT

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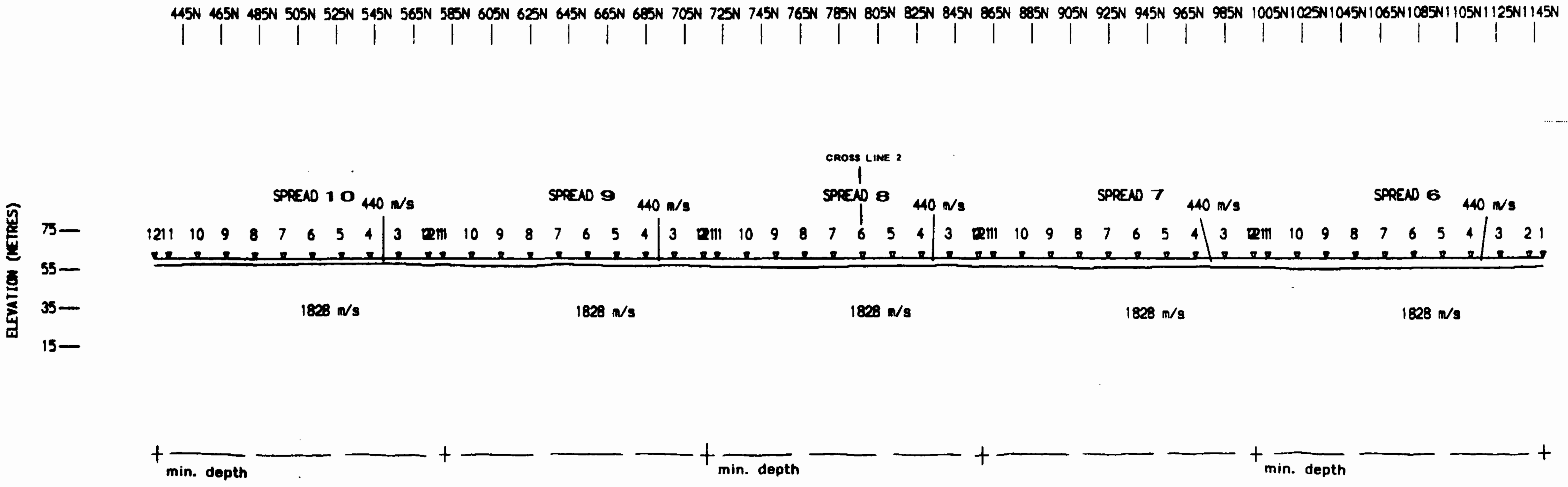


SEISMIC LINE 2

NOTES:
SCALE: 1:2000 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

REDFERN RESOURCES LTD.
SHAZAH CREEK AREA

SEISMIC REFRACTION SURVEY

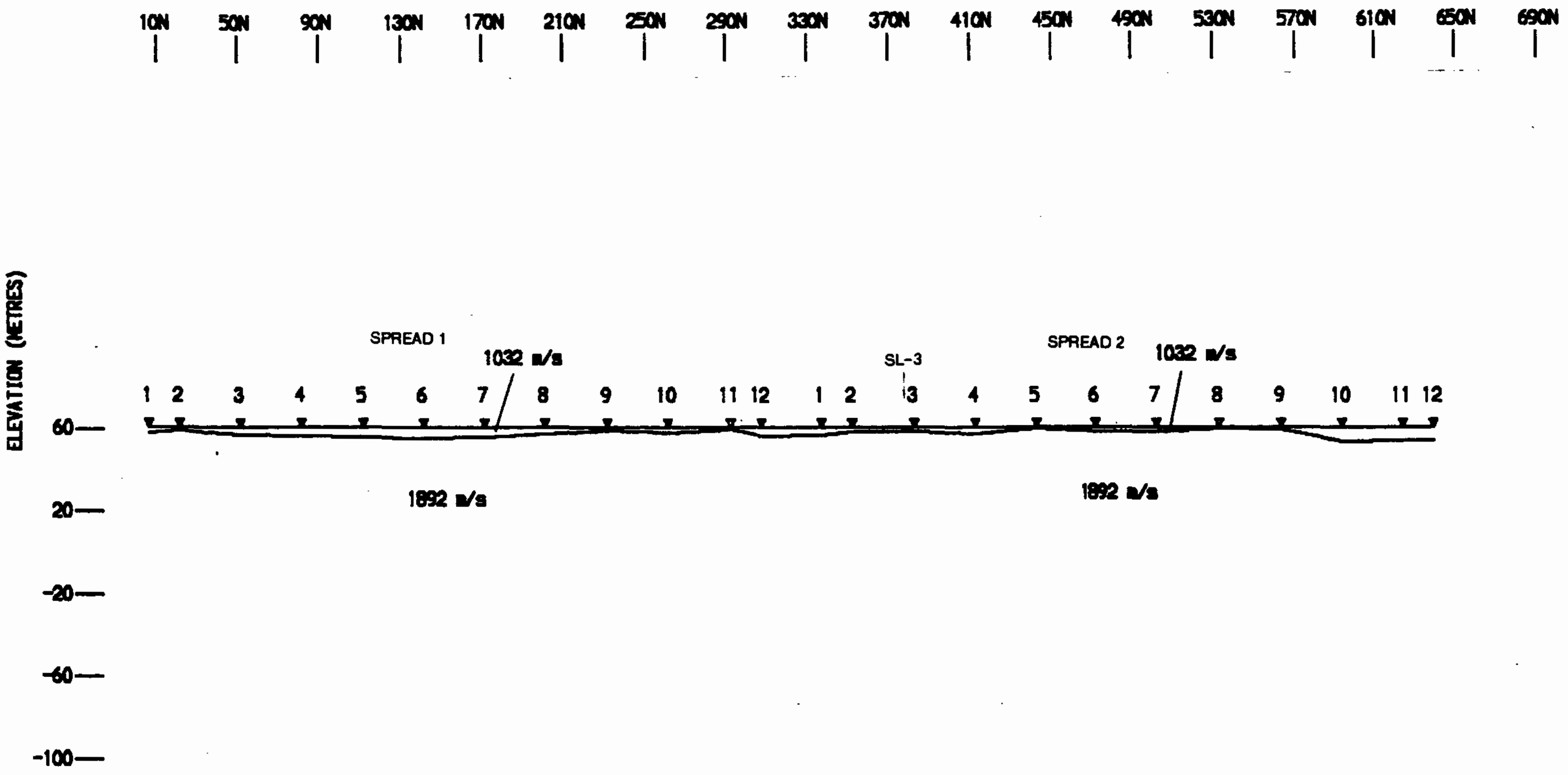
INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

| DATE OCT 94 | | FIG. 8 |
|---|---|---|

GEOLOGICAL BRANCH
ASSESSMENT REPORT

23,951



SEISMIC LINE 5

NOTE: CALC. MIN. DEPTH TO
BEDROCK APPROX. 253 metres

NOTES:
SCALE: 1:2500 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

REDFERN RESOURCES LTD.
TULSEQUAH RIVER CROSSING
SEISMIC REFRACTION SURVEY
INTERPRETED DEPTH PROFILE
FRONTIER GEOSCIENCES INC.
DATE: OCT. 94
FIG. 16

GEOLOGICAL BRANCH
ASSESSMENT REPORT

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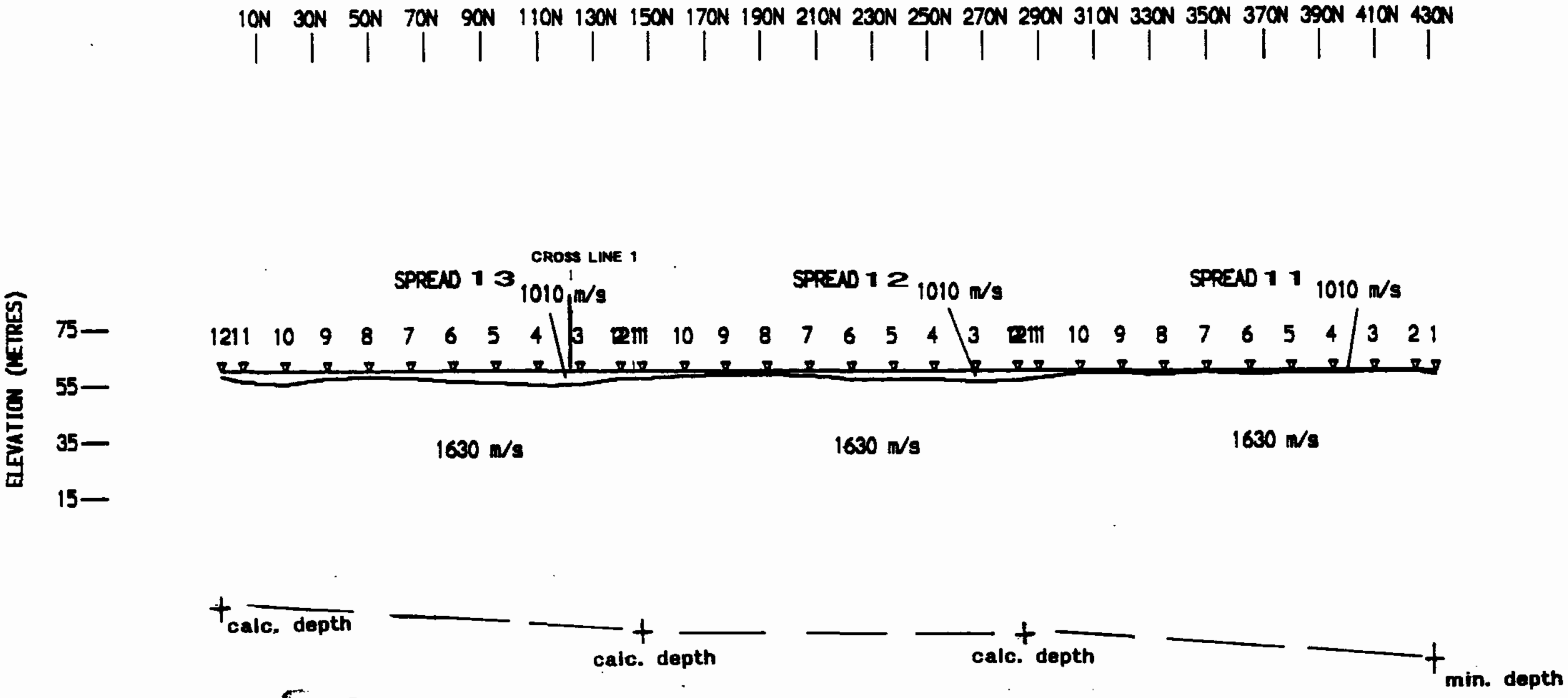


SEISMIC LINE 2

NOTES:
SCALE: 1:2000 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

REDFERN RESOURCES LTD.
SHAZAH CREEK AREA

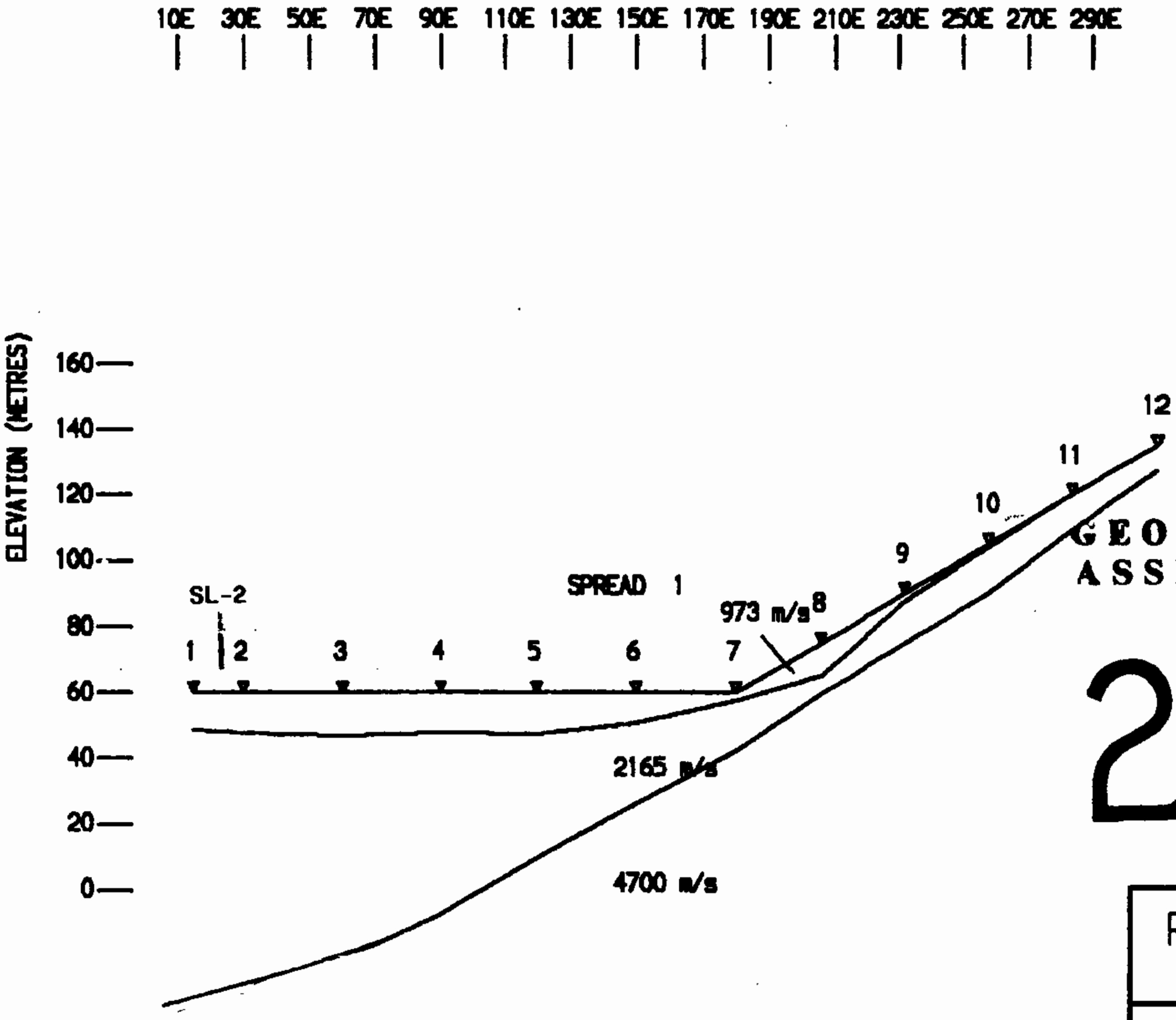
SEISMIC REFRACTION SURVEY

INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

DATE: OCT. 94

FIG. 9



CROSS LINE 1

NOTES:
SCALE: 1:2000 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

GEOLOGICAL BRANCH
ASSESSMENT REPORT

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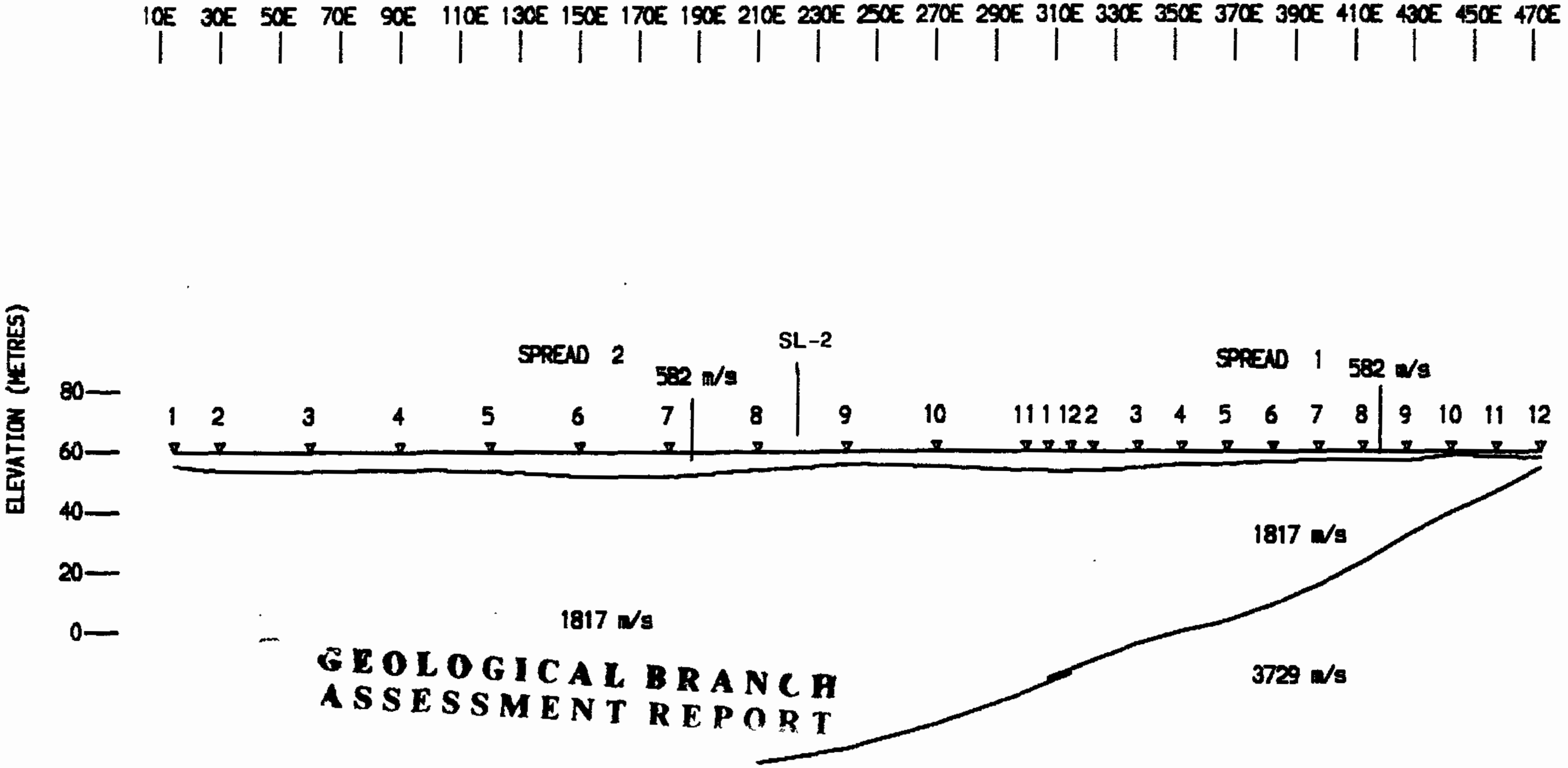
REDFERN RESOURCES LTD.
SHAZAH CREEK AREA

SEISMIC REFRACTION SURVEY

INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

| DATE: OCT. 94 | | FIG. 10 |
|---|---|---|



CROSS LINE 2

NOTES:
SCALE: 1:2000 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

REDFERN RESOURCES LTD.
SHAZAH CREEK AREA

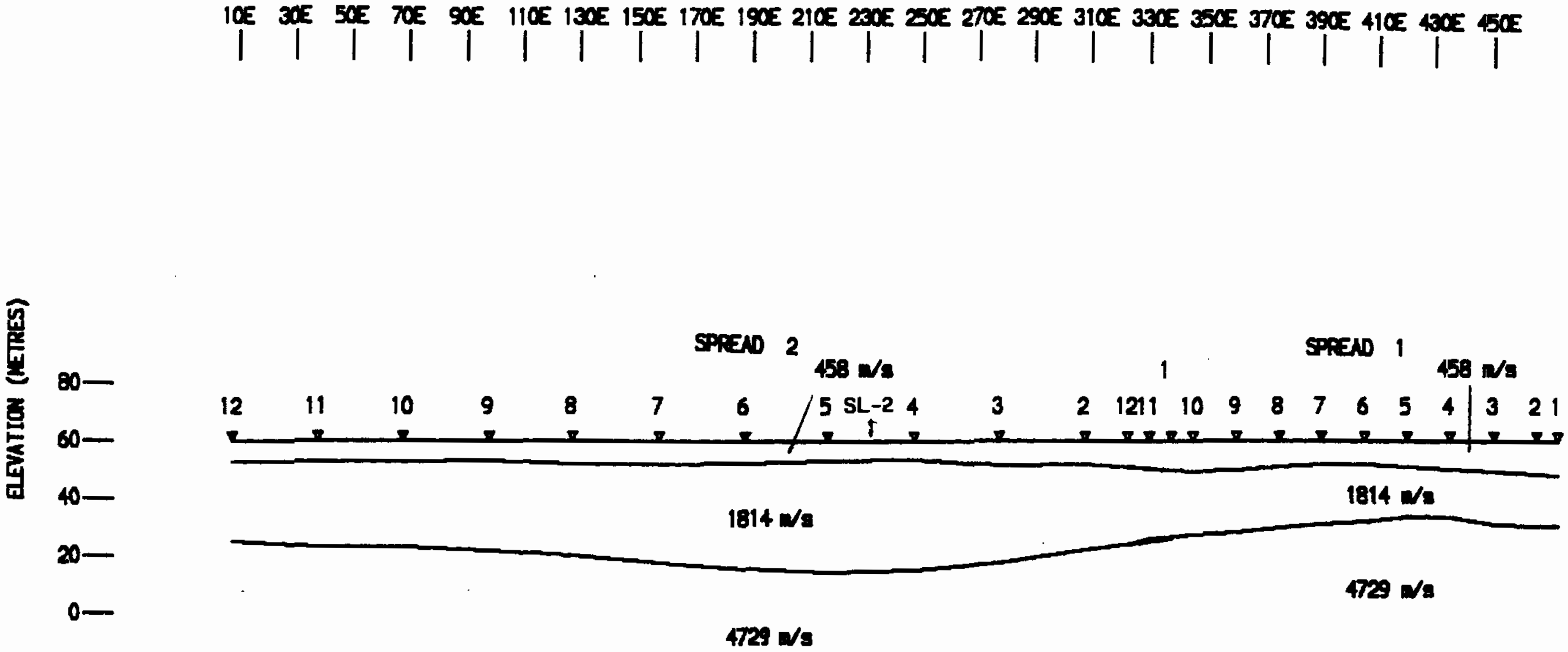
SEISMIC REFRACTION SURVEY

INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

DATE: OCT. 94

FIG. 11



CROSS LINE 3

NOTES:
SCALE: 1:2000 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

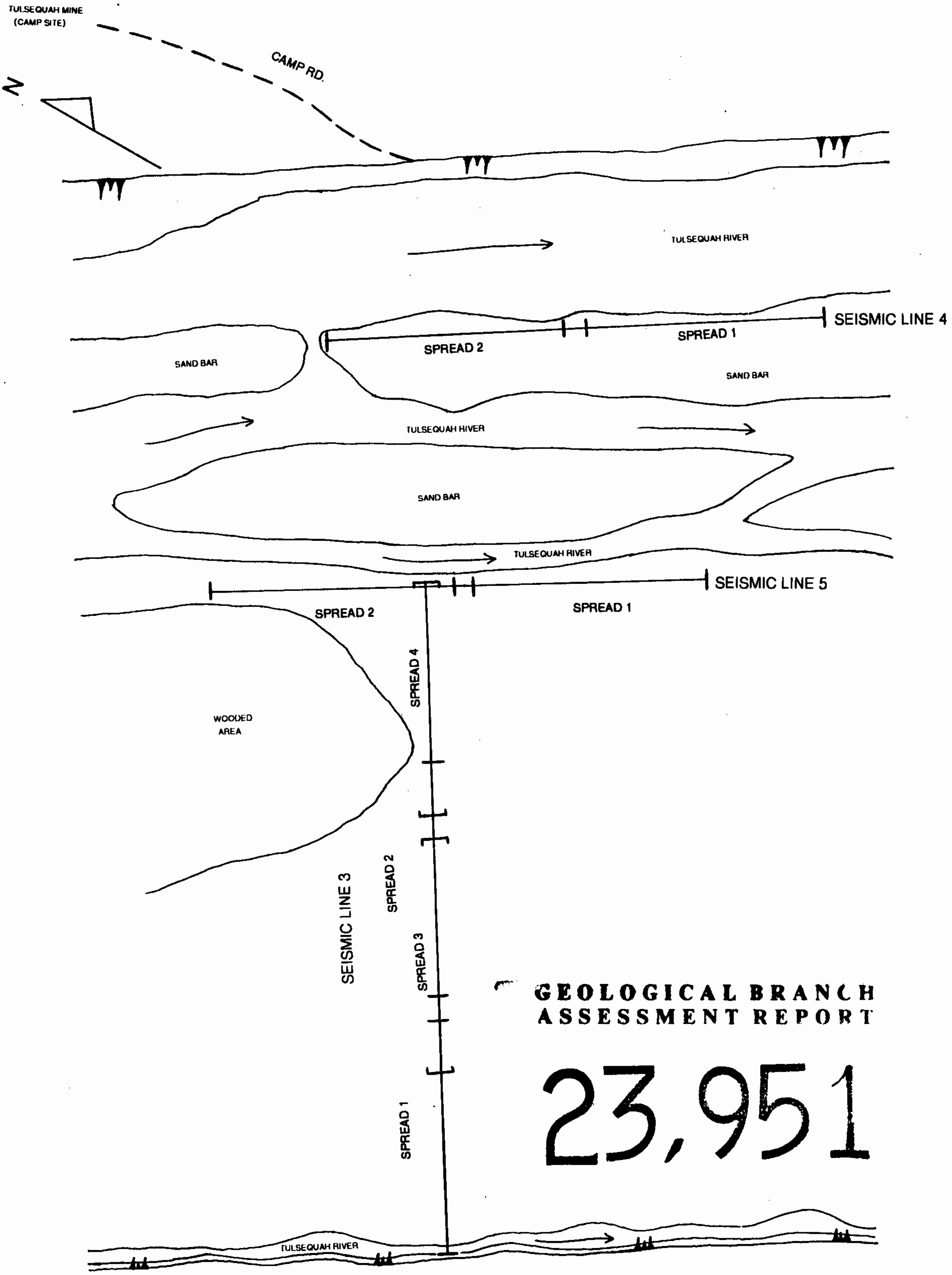
REDFERN RESOURCES LTD.
SHAZAH CREEK AREA

SEISMIC REFRACTION SURVEY

INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

| | | |
|---|---|---|
| DATE: OCT. 94 | | FIG. 12 |



GEOLOGICAL BRANCH
ASSESSMENT REPORT

23,951

SCALE: 1:5000

REDFERN RESOURCES LTD.
TULSEQUAH RIVER CROSSING

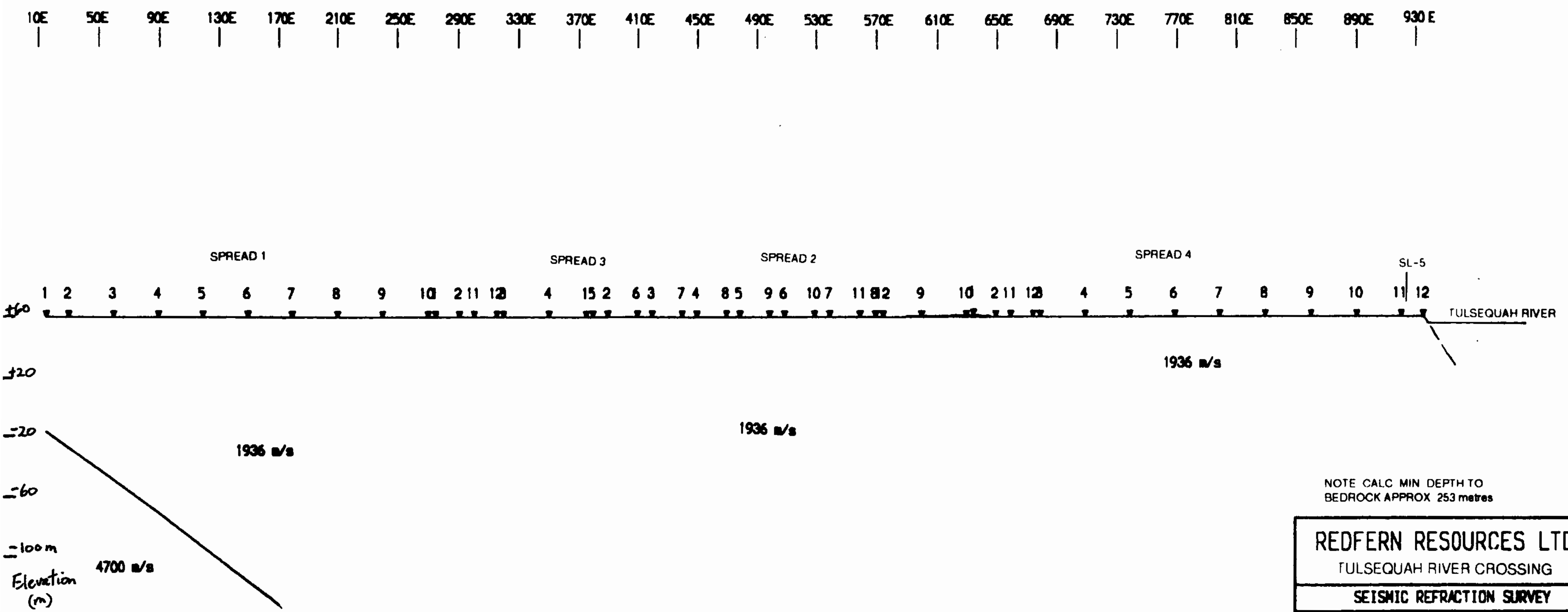
**SEISMIC REFRACTION SURVEY**

TULSEQUAH RIVER SITE SKETCH

FRONTIER GEOSCIENCES INC.

DATE: OCT.,94

**FIG. 13**



NOTE CALC MIN DEPTH TO
BEDROCK APPROX 253 metres

SEISMIC LINE 3

NOTES:
SCALE: 1:2500 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

REDFERN RESOURCES LTD.
TULSEQUAH RIVER CROSSING

SEISMIC REFRACTION SURVEY

INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

DATE OCT 94

FIG.14

GEOLOGICAL BRANCH
ASSESSMENT REPORT

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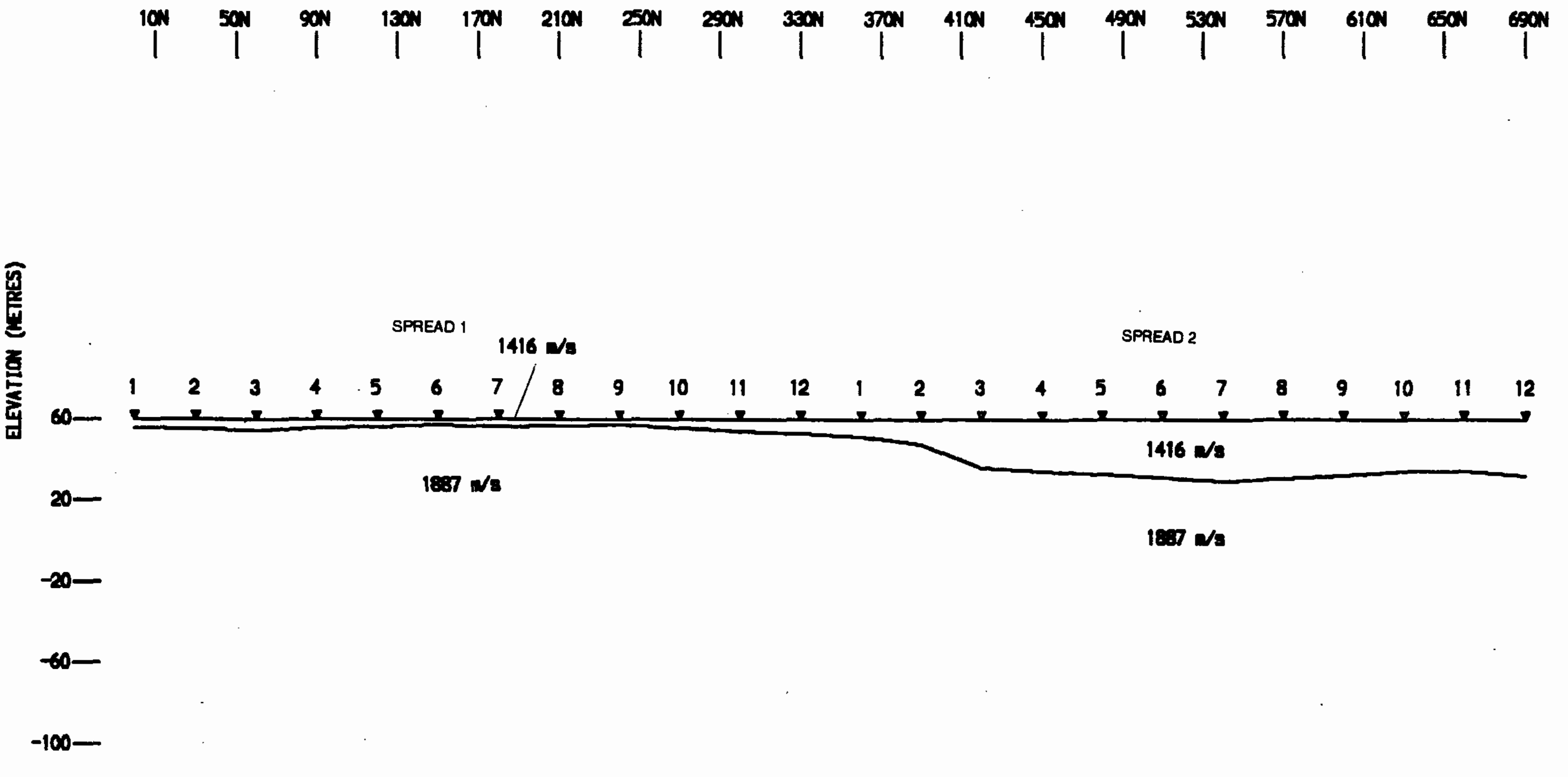

SEISMIC LINE 4

NOTE: CALC. MIN. DEPTH TO
BEDROCK APPROX. 253 metres

NOTES:
SCALE: 1:2500 METRIC
INSTRUMENT: GEOMETRICS ES1225 SEISMOGRAPH

REDFERN RESOURCES LTD.
TULSEQUAH RIVER CROSSING

SEISMIC REFRACTION SURVEY

INTERPRETED DEPTH PROFILE

FRONTIER GEOSCIENCES INC.

| | | |
|---|---|---|
| DATE: OCT. 94 | | FIG.15 |

GEOLOGICAL BRANCH
ASSESSMENT REPORT

23,951

SYMBOLS

Mineral Claim boundaries

UTM Grid based on North American Datum 1927 (NAD 27)

Mine Survey Grid Origin is BC Survey Monument "TAK" (#7953)

Origin established as: N 15,000 – E 10,000 .

| | | |
|---|---|---|
| NAD 27 | Latitude<br>Longitude | 58°44'15.79080" N<br>133°35'53.67550" E |
| | UTM<br>Zone 8 | 6,511,486.871 N<br>581,145.128 E |
| | Elevation: | 108.204 m |

Horizontal Control derived from BC Survey Monument "STUMP" (#7952)

| | | |
|---|---|---|
| NAD 27 | Latitude<br>Longitude | 58°43'23.32980" N<br>133°38'40.31090" E |
| | UTM<br>Zone 8 | 6,509,809.346 N<br>578,498.670 E |
| | Elevation: | 915.924 m |

Claim Boundary locations based on B.C.M.E.M.P.R. Mineral Title maps for map-sheets 104 K/11,12,13 as of November, 1994.

Topography base scanned from 1:10000 base maps
Produced by: Triathalon Mapping Corporation
(File: COM106), 1987

Contour Interval : 20 metres

SCALE 1:20,000

400 0 400 800 1200 1600

METRES

# REDFERN RESOURCES LTD.

Report by:
TEC

Date:
June 15, 1995

NTS:
104K

Mining Division
Atlin

Ref. #

## TULSEQUAH CHIEF PROJECT

## PROPERTY MAP
## AND
## TAILING/PLANTSITE
## EVALUATION WORK

GEOLOGICAL BRANCH
ASSESSMENT REPORT

Map:
3

23,951