825869

REDFERN RESOURCES LTD.
TULSEQUAH CHIEF PROJECT

PRELIMINARY PLANS FOR CONTROL OF ACID ROCK DRAINAGE, ALTERNATIVE ABANDONMENT PLANS AND COST ESTIMATES FOR THE TULSEQUAH PROJECT SITE

Prepared for
REDFERN RESOURCES LTD.
166 - 10551 Shellbridge Way
Richmond, B.C.
V6X 2W9

Prepared by
HALLAM KNIGHT PIESOLD LTD.
Suite 658 United Kingdom Building
409 Granville Street
Vancouver, B.C.
V6C 1T2

April 1991

PRELIMINARY PLANS FOR CONTROL OF ACID ROCK DRAINAGE, ALTERNATIVE ABANDONMENT PLANS AND COST ESTIMATES FOR THE TULSEQUAH PROJECT SITE

PRELIMINARY PLANS FOR CONTROL OF ACID ROCK DRAINAGE, ALTERNATIVE ABANDONMENT PLANS AND COST ESTIMATES FOR THE TULSEQUAH PROJECT SITE

1.0 INTRODUCTION

Cominco Ltd. is presently engaged in an underground exploration program on the Tulsequah Chief property a joint venture between Cominco Ltd. (60%) and Redfern Resources Ltd. (40%). Cominco Ltd. are operator of the joint venture.

Tulsequah Chief, which is located approximately 65 km northeast of Juneau Alaska and 97 km south of Atlin (58°42"N and 133°37"W) at elevation 122 masl, is former gold, silver, copper, lead and zinc producer (600,000 tonnes) which operated between 1951 and 1957 (Figure 1). The property consists of 105 claim units covering an area of approximately 2025 ha (5000 ac). Current access is by helicopter from either Juneau or Atlin although there is a 1200 m airstrip 6.4 km south of the former Polaris-Taku townsite located on the opposite side of the river.

The deposit which measures approximately 425 m horizontally, 1500 m vertically, an average 7 m in thickness is a Kuroko type volcanogenic-polymetallic stratigraphically-controlled massive-sulphide deposit, dipping 70° to 75° to the north. Exploration which resumed in 1987 comprises underground mapping, stream sediment and rock chip geochemistry and geophysics. Over 12,000 m of diamond drilling and underground drifting have been completed. Preliminary geological reserve estimates as at March 1991 were placed at about 7 million tonnes (Redfern Resources Ltd.). However, a detailed mineable reserve has not been determined and a feasibility study has not been prepared for a proposed development. Exploration is continuing for purposes of delineating sufficient reserves to support an economically viable operation.

Waste from previous operations are presently stockpiled adjacent to the 5200, 5400, 5900 and 6400 level adits. Mine water from the 5200 and 5400 levels is released to the Tulsequah River, while mine water from the 5900 and 6400 levels drain toward Camp Creek, a tributary to the Tulsequah

River. Mine water is typically of large massive sulphide deposits and is characteristically low pH, high in total and dissolved copper and zinc and moderately high in sulphates.

If sufficient reserves are delineated to warrant a detailed feasibility study, the project would be registered with the B.C. Mine Development Review Process and a detailed studies program would be necessary for preparation of a Stage I Environmental Impact Assessment. Existing environmental concerns would be incorporated in to an overall mine plan.

Alternatively, if there are insufficient reserves to support an economically viable operation, an abandonment plan which is directed toward an appropriate long-term control strategy, would be necessary pursuant to Provincial legislation. However, decisions on whether or not to seal the underground workings, install passive treatment works, encapsulate and/or dispose of waste rock will depend, to a large extent, on future development plans.

This preliminary assessment presents alternative strategies and cost estimates for both an interim control plan to minimize impacts on the adjacent environment and a "walk away" reclamation plan which incorporates long term control over acid rock drainage from former underground workings and waste rock dumps.

Site recontouring, revegetation and return of all disturbed areas, as near as possible, to their former use and capability in accordance with the Mine Act would be in addition to costs estimates presented herein.

2.0 SCOPE OF ACID ROCK DRAINAGE

2.1 MINE WATER

For the most part mine water from the upper levels drains to the 5200 and 5400 levels via interconnecting raises and stopes and from there it is directed to the Tulsequah River. However, there is also a discharge from the 6400 Level which is joined by a minor flow originating at the 6500 Level which discharges to Camp Creek above the 5900 Level. There is little or no flow from the 5900 Level. Flows were measured on October 17, 1990 as follows:

5200 Level	0.0271 m^3/s	
5400 Level	0.0142 m^3/s	
5900 Level	- m^3/s	
6400 Level	0.0206 m^3/s	
6500 Level	0.0020 m^3/s	(estimated)
Total	0.0639 m^3/s	

Samples were obtained from the 5200 and 5400 level portals and analyzed by ASL Analytical Services Laboratories of Vancouver for comprehensive low level analyses in accordance with "Standard Methods for the Examination of Water and Waste Water" published by the American Public Health Association, 1985. Complete results were presented in a report entitled "A Preliminary Environmental Evaluation of the Tulsequah Chief Project Site" (Hallam Knight Piesold Ltd., September 1990), and can be summarized as follows:

5200 Level water was found to be low in pH (3.88), low in available alkalinity (<1.0 mg/L $CaCO_3$), relatively hard (289 mg/L $CaCO_3$), high in total and dissolved solids (Conductivity 930 umhos, TDS 550 mg/L, TSS 71.3 mg/L), high in sulphate content (312 mg/L), relatively turbid (117 NTU's) and high in total and dissolved metals. The absence of alkalinity, low pH and high sulphate content are typical of acid rock drainage.

The major metals of note were dissolved aluminum (9.01 mg/L), cadmium (0.24 mg/L), copper (13.2 mg/L), iron (2.89 mg/L), lead (0.105 mg/L), manganese (0.415 mg/L) and zinc (58.3 mg/L). There were little or no deleterions substances such as mercury, antimony, arsenic or chromium, molybdenum, nickel, selenium or silver.

5400 Level water was of similar but slightly better composition, low in pH (4.13), low in available alkalinity (< 1.0 mg/L $CaCO_3$), relatively hard (276 mg/L $CaCO_3$), high in total and dissolved solids (Cond. 762 umhos, TDS 490 mg/L, TSS 56.7 mg/L), high in sulphate content (318 mg/L), relatively turbid (89.0 NTU's) and high in total and dissolved metals.

The metals of concern, i.e. aluminum, cadmium, copper, iron, lead, manganese and zinc, were also somewhat lower than found in the 5200 Level water. Again there was little or no mercury, antimony, arsenic, chromium, molybdenum, nickel, selenium or silver present.

These data indicate that, although mine water is characteristic of acid rock drainage, it does not represent an acute situation in terms of quantity or quality.

A separate survey of water pH on the 5400 Level conducted in the fall of 1990 indicated that water entering the underground workings beyond the ore zone was of neutral pH. This water became contaminated enroute to the collar after passing the highly pyritized ore zone.

2.2 WASTE ROCK

Waste rock from former operations has been stockpiled mainly near the 5200 and 5400 level portals. Smaller but significant volumes of waste are located at the 5900 and 6400 level portals. Waste from the 1990 Crosscut, or extension of the 5400 Level workings generated during the 1990 underground exploration program has been placed on top of the existing 5400 Level waste.

On the basis of an average 3 m x 3 m drift and a swell ratio of 30%, estimates of waste rock storage at each of the four main levels are as follows:

a)	5200 Level	9,945 m^3
b)	5400 Level	32,468 m^3
c)	5900 Level	8,482 m^3
d)	6400 Level	11,700 m^3
Estimated Total		63,000 m^3 (113,000 tonnes)

In addition there are approximately 2,340 m^3 (4,200 tonnes) of fresh waste originating with the 5400 Level Extension (1990 Crosscut).

During mining approximately 660,000 tonnes of ore were extracted and milled at the Polaris-Taku site across the river, leaving a theoretical estimated 370,000 m^3 of void. An additional assumption is that about 50% of this volume occurs on the 5200 and 5400 levels.

A total of 15 samples of waste rock, representing oxidized and unoxidized material from the existing 5200 and 5400 level dumps, and various rock types from the 1990 exploration drift were analyzed by Coastech Research Inc. for acid-base characteristics. Results are presented in Table 1.

Fresh waste generated from the 1990 Crosscut underground exploration program is very low in sulphur. A composite sample (Sample 1) taken from the dump surface contained 0.17% sulphur and underground chip samples of various rock types contained an average 0.11% sulphur and ranged between 0.02% and 0.45% sulphur. Cherty sediments (samples 10 and 11) were highest in sulphur content (0.25 to 0.50%) while dacite, andesite, diorite, sloko and rhyolite materials (samples 6 to 9 and 12 to 15) contained very little sulphur (<0.1%). Theoretical acid production averaged 3.02 t/1000 t waste and ranged between 0.3 and 14.1 t/1000 t.

TABLE 1

RESULTS OF ACID-BASE ACCOUNTING OF WASTE ROCK SAMPLES COLLECTED FROM FORMER WASTE ROCK DUMPS AND 1990 CROSSCUT

Sample Number	Total Sulphur (%)	Total Sulphate (%)	Maximum Theoretical Acid Gen. (t/1000t)	Maximum Theoretical Neutral. (t/1000t)	Paste pH	Net Neut. Potential (t/1000t)
1	0.17	0.02	4.7	25.3	9.98	20.6
2	3.28	0.11	99.1	6.9	7.61	-92.2
3	2.70	0.06	82.5	24.2	8.14	-58.2
4	1.82	0.04	55.6	15.8	7.81	-39.8
5	0.51	0.04	14.7	38.2	8.98	23.5
6	0.06	0.01	1.6	15.0	9.80	13.4
7	0.03	0.01	0.6	19.1	9.64	18.4
8	0.05	0.01	1.3	29.2	9.48	28.0
9	0.07	0.01	1.9	29.5	9.40	27.7
10	0.25	0.03	6.9	11.2	10.11	4.3
11	0.46	0.01	14.1	13.5	9.92	- 0.5
12	0.06	0.01	1.6	19.3	9.49	17.7
13	0.08	0.01	2.2	22.9	9.55	20.7
14	0.02	0.01	0.3	13.8	9.64	13.5
15	0.03	0.01	0.6	15.0	9.45	14.4

Analyses performed by Coastech Research Inc.

Sulphur by Leco Furnace

This material was also found to be low in carbonate content and as a consequence low in acid consumption potential. Samples averaged 18.9 t/1000 t $CaCO_3$ equivalents (ranged 11.2 to 29.5 t/1000 t $CaCO_3$ equivalents), yielding an average net positive neutralization potential of 15.8 $CaCO_3$ equivalents. The composite sample collected from the waste rock dump indicated similar results. Theoretical acid generation potential was 4.7 t/1000 t, neutralization potential was 25.3 t/1000 t and net neutralization potential was 20.6 t/1000 t, and all samples were deemed to be non-acid generating.

Composite samples of former waste rock collected from surface stockpiles (samples 2 to 5) were found to contain significantly higher levels of sulphur but generally the same level of carbonate content as found in 1990 Crosscut waste. However, these materials originated close to the mineralized zones and were expected to be high in sulphides. For example, material on the 5400 Level ranges from 10% pyrite near the portal entrance, <1.0% pyrite between +25 to +225 m from the collar, 10% pyrite between +225 to +330 m from the collar, 15% pyrite between +330 to +400 m from the collar, and 20% (range 0 to 70%) pyrite near the ore zone.

Oxidized and unoxidized waste from the 5200 Level was found to contained 1.82% and 0.51% sulphur, respectively, while oxidized and unoxidized waste from the 5400 Level contained 2.70% and 3.28% sulphur, respectively.

Theoretical acid generating potential averaged 63.0 t/1000 t. Carbonate content averaged 21.3 t/1000 t $CaCO_3$ equivalents (range 6.9 to 38.2 t/1000 t), yielding a net neutralization deficit of -41.7 t/1000 t, and are regarded as acid generating. Generally rock with a net neutralization potential of $\pm$ 20 t/1000 t fall within what is termed a gray area from an acid generating perspective and highly dependant on NP:AP ratios. Rock with an NP:AP ratio of slightly less than 1 are unlikely to be acid generating. Rock with between - 20 and - 60 t/1000 t and an NP:AP ratio of between 1 and 0.1 are likely to be moderately acid generating and rock with an NP:AP ratio of <0.1 are regarded as highly reactive.

Dumps were constructed by end dumping from tracked side dump mine cars and as a consequence waste from specific sites are expected to relatively well distributed within each dump location. Segregation of the waste is believed to be impractical.

collection main will be sized to convey all contaminated water from each of the adits and waste dumps down slope to the water treatment plant. The pipelines will typically be corrugated polyethylene pipe anchored in place by tying to stakes driven into the ground. No specific bedding preparation would be required. The diameters, lengths and estimated costs for the pipe lines are given in Section 5.0.

3.3 WASTE ROCK DUMP RUNOFF

3.3.1 Isolation of Waste Dump Runoff Using Control Works

There are two sources of inflow of clean water into the waste rock dumps, surface infiltration (rainfall and snowmelt) and groundwater flows into the base of the dumps. It appears that there are no springs in the vicinity of the dumps which would preclude the later. Control of direct infiltration of precipitation in the short term is not possible if the dumps are to remain active. Removal of snow before it melts is a method of eliminating large quantities of infiltration during periods of thawing but maybe unrealistic because of cost.

Precipitation runoff from above the waste dumps, excluding any drainage from the stopes, could be readily diverted around the dumps in ditches and discharged to the natural drainages. Diversion ditches for each waste dump are shown schematically on Figure 3.1.

3.3.2 Collection of Runoff

Runoff and seepage through the waste dumps would be collected in ditches running along the down slope toes of the dumps. The ditches will discharge into sumps from which the water will be piped to the collection main. The collection ditches and sumps are shown schematically on Figure 3.1.

3.4 TREATMENT SYSTEM

The treatment system would comprise a conventional lime addition system and settling pond

3.0 APPROACH TO INTERIM CONTROL

3.1 GENERAL

The control of acid rock drainage from the waste dumps and underground workings in the short term requires that contaminated water and clean water be segregated to the maximum possible extent to minimize the size and the operating cost of the water treatment plant and associated settling ponds. This can be achieved by selectively intercepting and diverting clean water away from areas of acid generation and by collecting and isolating contaminated water for treatment and release.

3.2 Mine Water

3.2.1 Minimizing Mine Water Requiring Treatment

Water draining from the underground workings results from infiltration of precipitation at the surface. The steep terrain and difficult access would make the successful sealing of the surface improbable and would not therefore constitute a feasible interim control option.

An alternative would be to map inflows into the different areas of the workings for purposes of identifying flows which are of acceptable quality and could be isolated and piped to the surface for direct release. Contaminated water could then be collected at the various portals for treatment. Inflows into the 5400 adit above the mine stopes are an example of clean water which could be diverted through a pipe to the surface and released without treatment.

3.2.2 Collection of Mine Drainage

Current estimates of flows from each of the adits are summarized in Section 2.0. The flows would be collected in a sump as close to the adit portal as possible and conveyed a short distance by pipe to a common collection main. This collection main is shown schematically in Figure 3.1. The arrangement located in a relatively level area adjacent to the river approximately 400 m downstream of the project site. The lime addition system would consist of a 1 tonne lime hopper, variable speed feed with drive, and a mix tank.

Project order of magnitude costs for the proposed Interim Collection and Treatment System are presented in Section 5.0.

4.0 ALTERNATIVE ABANDONMENT STRATEGIES

4.1 MINE WATER CONTROL

4.1.1 Flooding Underground Workings

Two essential components for promotion of acid rock drainage are oxygen and water. For long-term suppression of acid drainage from the adits, it will be necessary to either flood the mineralized zones to exclude oxygen or to control the flow of water. As previously discussed, the control of infiltration of precipitation into the mine is not an option therefore, flooding the mine workings will be the most appropriate long term control measure.

Flooding of the mine workings will require the construction of plugs in each adit as close to the portals as possible. For this to be successful, the geology and permeability characteristics of the surrounding rock must be such that the head of water behind the plugs required to flood the mine will be maintained. This will be difficult to determine as only a few isolated defects could result in major water loses from the workings under the expected pressure heads. Investigations for the feasibility of flooding the mine workings must comprise detailed structural mapping of surface bedrock exposures and of the adit walls. Any joint sets, faults, etc. which could influence the ability to flood the mine must be identified and investigated.

An important aspect of flooding the mine workings is to ensure that all areas of the mine such as stopes are vented to allow complete flooding. It may be necessary to drill vent holes if required.

4.1.2 Bulkhead Design

The design of the bulkheads must comprise careful siting of each concrete plug near the entrance of each adit. Siting considerations are as follows:

- depth below ground surface to ensure no hydraulic fracturing

- the specific rock quality at the site of the bulkhead
- potential leakage pathways

A general arrangement of the concrete plugs are presented in Figure 4.1. The plugs would be similar for each adit except that the length of the keyway increases for the adits at lower elevations in order to resist the higher heads. The concrete plugs should be constructed by drilling and grouting a radial curtain at the chosen location of each bulkhead. A typical grouting pattern is shown on Figure 4.1. The keyway would then be excavated to the required length. A back form would be constructed and the adit drain pipe and grout pipes put in place. The adit drain pipe should be fitted with a corrosion resistant valve to allow the mine to be drained, if required, in the future. The drain pipe should be fitted with a pressure gauge to monitor the flooding of the mine workings and a sampling port to enable water samples to be taken. The grout pipes enable the rock-concrete interface to be pressure grouted after the concrete plug has been poured, set and completed shrinking.

4.2 WASTE ROCK DUMPS

4.2.1 Covering and Sealing

To eliminate acid drainage from the waste rock dumps it will be necessary to isolate the waste rock from water inflow. Cover materials usually comprise fine grained soils with low permeability which can be placed and compacted over the waste dumps. Initial assessment of site photographs and topographic maps indicate that it is unlikely that suitable material, such as fine grained till, would be readily available. An alternative cover materials such as finer graded alluvial sand could be obtained from the Tulsequah River and mixed with bentonite in a pug mill. Other covers such as high density polyethylene liners may be appropriate.

The waste dumps at the entrances of the 5900 and the 6400 level adits are in areas of steep terrain and difficult access. It is unlikely that it would be possible to construct a cover in place at these sites. In addition, it is possible that with the flooding of the mine, springs may occur to some extent which, if into the base of the dumps would cause further problems. If a cover is deemed appropriate, material from these two dumps would have to be relocated to a new permanent repository near the 5400 Level waste dump. The new repository should include an underdrain constructed from river alluvium to prevent the ingress of groundwater into the waste and a cover comprised of a sand bedding layer over the waste rock, a HDPE membrane liner and a protective layer of graded rockfill. The graded rockfill could be mine waste which has been determined to be benign.

4.2.2 Selective Disposal

Selective disposal of acid producing waste rock would require the segregation of the waste in each dump into acid producing and benign material for purposes of reducing the quantity of material requiring special treatment. It has been determined that this would be impossible to achieve due to the degree of blending of all the different waste types by the method of dump construction.

4.2.3 Disposal On-Site

Exploration staff advise that the majority of mine stopes and underground workings have collapsed and are in an unsafe condition. This would preclude the placement of all but small quantities of the waste rock underground using conventional equipment prior to flooding the mine and it would preclude any future exploration attempts from existing workings.

An alternative method for disposing of most of the material would to be to encapsulate the 5200 and 5400 levels waste under water in a bedrock excavation located below the 5400 Level dump. There would be insufficient space available to relocate small volumes of waste from the upper adits under this scenario and the proposed plan calls for the considerable rehandling of material.

An excavation measuring approximately 12 m deep, 120 m in length and 50 m in width would be required to accommodate the estimated 42,500 m^3 of waste material presently stockpiled at the lower portals. The excavation would be located near to and parallel to the toe of the 5400 Level dump. Rock from the excavation would be deposited along the downhill side of the excavation parallel to the Tulsequah River. Since the excavation will be in bedrock, dewatering facilities will be required.

Waste from the 5200 and 5400 levels would then be pushed down to, or trucked to the excavation, levelled and compacted by bulldozer. Material from the excavation would then be returned to the disposal site as capping material. Order of magnitude costs for this alternative are presented in Section 5.0.

4.2.4 Disposal in Flood Plain

Disposal of acid producing waste rock in a flooded environment is a recognized method of acid drainage control. The usual application is to construct a dam across a water course and place the waste rock in the impounded reservoir. Water flowing through the reservoir is discharged over a spillway maintaining a water level so that the waste rock remains saturated at all times. Inspection of topographical maps however, has indicated that no suitable site for a waste rock reservoir is available in the immediate proximity of the operations.

An alternative flooded environment for waste rock disposal is in the alluvial flood plain of the Tulsequah River. This would require the excavation of trenches 6 m deep covering 20 000 m^2. Excavation would be carried out with a dragline excavator. Waste rock would then be placed to a depth of 3 m and the trench would then be backfilled to original ground level with alluvium. The remaining spoil from the excavation will be placed and spread over the alluvial flood plain so that changes to the river dynamics are minimized. The highly porous nature of the river bed will result in the excavation being flooded at all times during the operation. A schematic of this disposal option is shown on figure 4.2.

Several concerns will need to be resolved before this option is considered feasible. These are:

- River Hydraulics

- Turbidity and sediment control
- Long term stability of the waste rock deposit
- Fisheries considerations

There would be significant turbidity generated during both the excavation and deposition stages of this option. It would be necessary to isolate the disposal area from the river flows and ensure that any turbid water resulting from the operation is retained for a sufficient period of time to allow the settlement of suspended solids. Operations would also have to be completed within a specific window relative to fisheries migrations and out burst flood events.

The alluvial flood plain is a dynamic feature with the river channel within the plain changing pathways constantly. The river is subject to high levels of flooding associated with the freshet and with the out burst flood events from Tulsequah Lake. It is within this context that it will be required to demonstrate that the waste rock will remain in place and beneath water in the long term.

5.0 COST ESTIMATES

5.1 INTERIM CONTROL STRATEGY

An order of magnitude cost estimate for the interim control strategy as presented in Section 3.0 are as follows:

Drainage and Collection

300 mm dia. corrugated polyethylene pipe	1500 m length	$ 75,000
150 mm dia. corrugated polyethylene pipe	250 m length	$ 10,000
Waste dump diversion ditches	600 m	$ 12,000
Waste dump collection ditches	600 m	$ 12,000
		$109,000

Water Treatment Plant

Lime treatment plant including:		
1 Tonne lime hopper	$ 5,000	
Variable speed feeder	$ 3,000	
Motor and electrics	$ 8,000	
Mix tank	$ 7,000	
Installation	$ 78,000	
	$100,000	
Ponds	$ 18,000	
On-going treatment costs	$200/day	
	Total	$227,000

5.2 ABANDONMENT STRATEGY

Order of magnitude cost estimates for the various options for long term abandonment are as follows:

Concrete Plug Bulkheads (4)			
Mobilization			$ 20,000
Grouting	1200 m		$ 60,000
Rock excavation	100 m^3		$ 50,000
Pipes, valves etc.			$ 6,000
Concrete	300 m^3		$ 15,000
		Total:	$ 151,000
Covering and Sealing Waste Rock Dumps			
Mobilization			$ 250,000
Haul waste rock to 5400 Level	20,000 m^3		$ 200,000
Grade dumps at 5400 Level			$ 150,000
Construct liner	12,000 m^2		$ 50,000
		Total:	$ 650,000
Disposal On-Site			
Mobilization			$ 50,000
Excavation (45,000 m^3)			$ 225,000
Disposal of Waste (45,000 m^3)			$ 135,000
Capping Material (10,000 m^3)			$ 30,000
Miscellaneous			$ 20,000
		Total:	$ 460,000

<u>Disposal in Flood Plain</u>

Roadworks, Site preparation		\$ 150,000
Excavate trenches in flood plain	140,000 m^3	\$ 500,000
Haul and dump waste in trenches	63,000 m^3	\$ 300,000
Backfill trenches with alluvium	77,000 m^3	\$ 150,000
Dispose and grade excess spoil	63,000 m^3	\$ 125,000
	Total:	\$1,225,000

6.0 RECOMMENDED FURTHER STUDY

This evaluation is based on preliminary information and is as a consequence conceptual in nature. Before an optimum approach to either an interim control plan or a final abandonment strategy can be selected and a feasibility study completed, additional information will be required. The following is a preliminary list of additional information requirements:

6.1 MINE WATER

a) Record of mine water flows relative to season and rainfall/snowmelt events. It is recommended that V-notch weirs be installed at the 5200 and 5400 level adits and mine water discharge rates recorded on a daily basis during the period of exploration. This information is required to determine the amount of mine water that may require treatment.

b) A mapping of mine water sources. On the basis of a report from exploration staff, a portion of the mine water inflow is uncontaminated. It is recommended that sources of mine water be mapped, quantified and tested for pH. It may be feasible to minimize the amount of water requiring collection and treatment.

c) A mapping of the underground workings for pyrite distribution to determine the areas where pyrite oxidation is occurring.

d) A detailed survey of the potential water treatment site and access corridor.

6.2 UNDERGROUND GEOLOGY

a) A mapping of the first 150 m of underground drifts on each level for fractures, faults, gouging and aspect is required to determine the optimum location for installation of bulkheads.

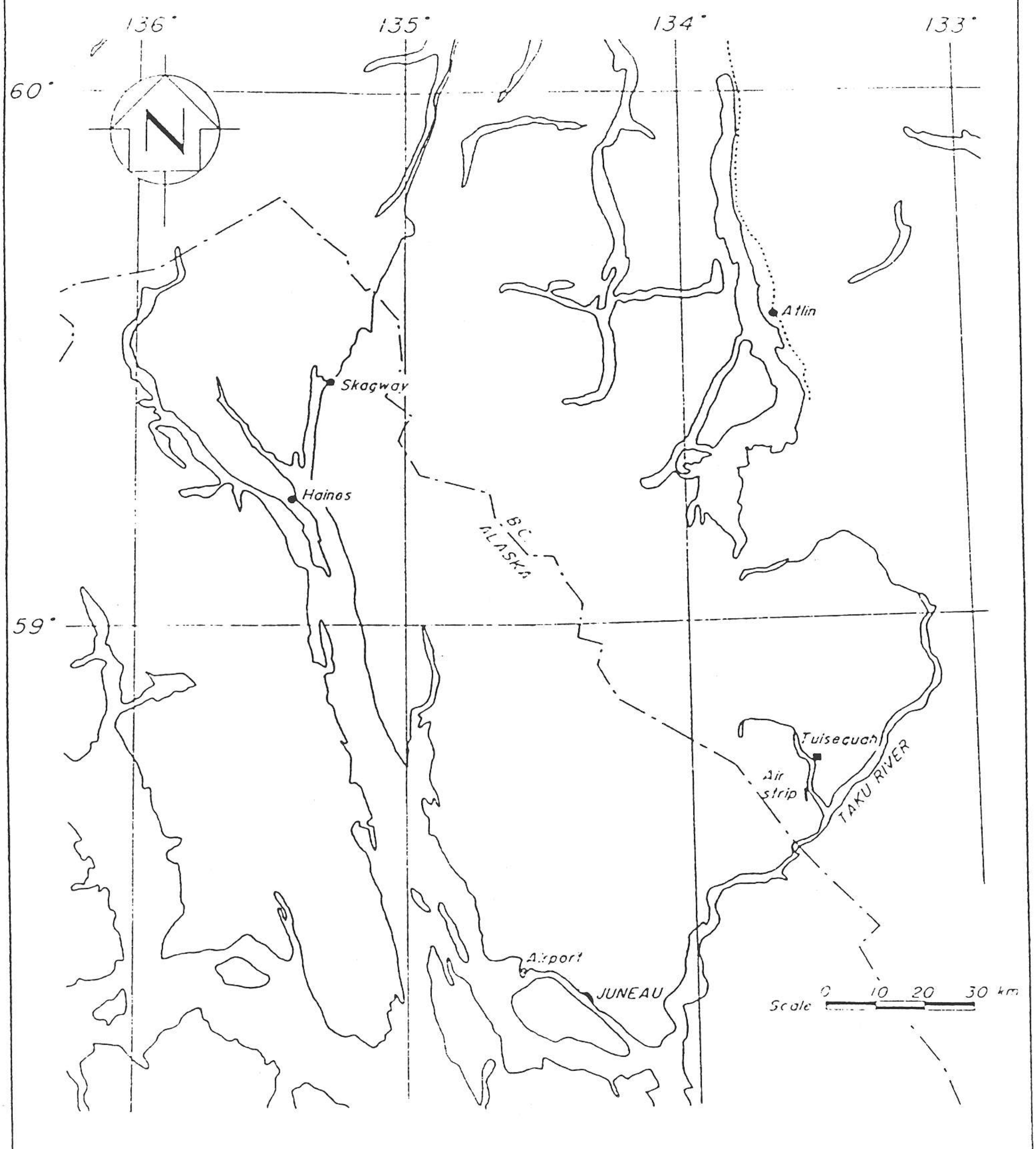
6.3 WASTE ROCK DUMPS

a) An more detailed estimate on the amount and characteristics of waste rock generated from former operations at each level, taken from level plans and lithology.

b) A cursory geotechnical assessment of each waste rock dump for composition, water table, depth.

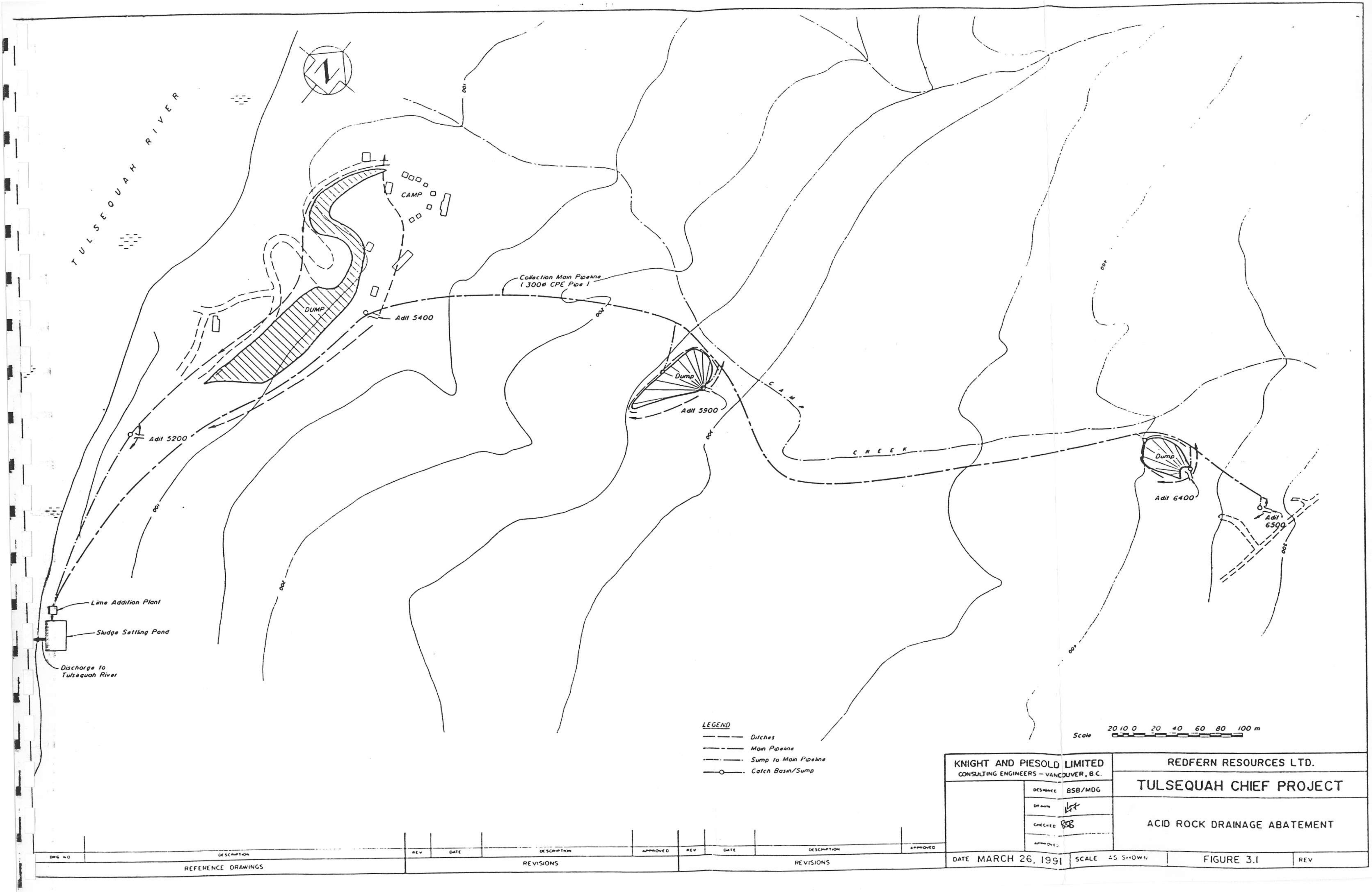
c) A survey to identify sources of potential concrete aggregate, impervious tills and other potential capping materials.

TULSEQUAH PROPERTY
LOCATION MAP



Hallam Knight Piésold Ltd
ENVIRONMENTAL CONSULTANTS

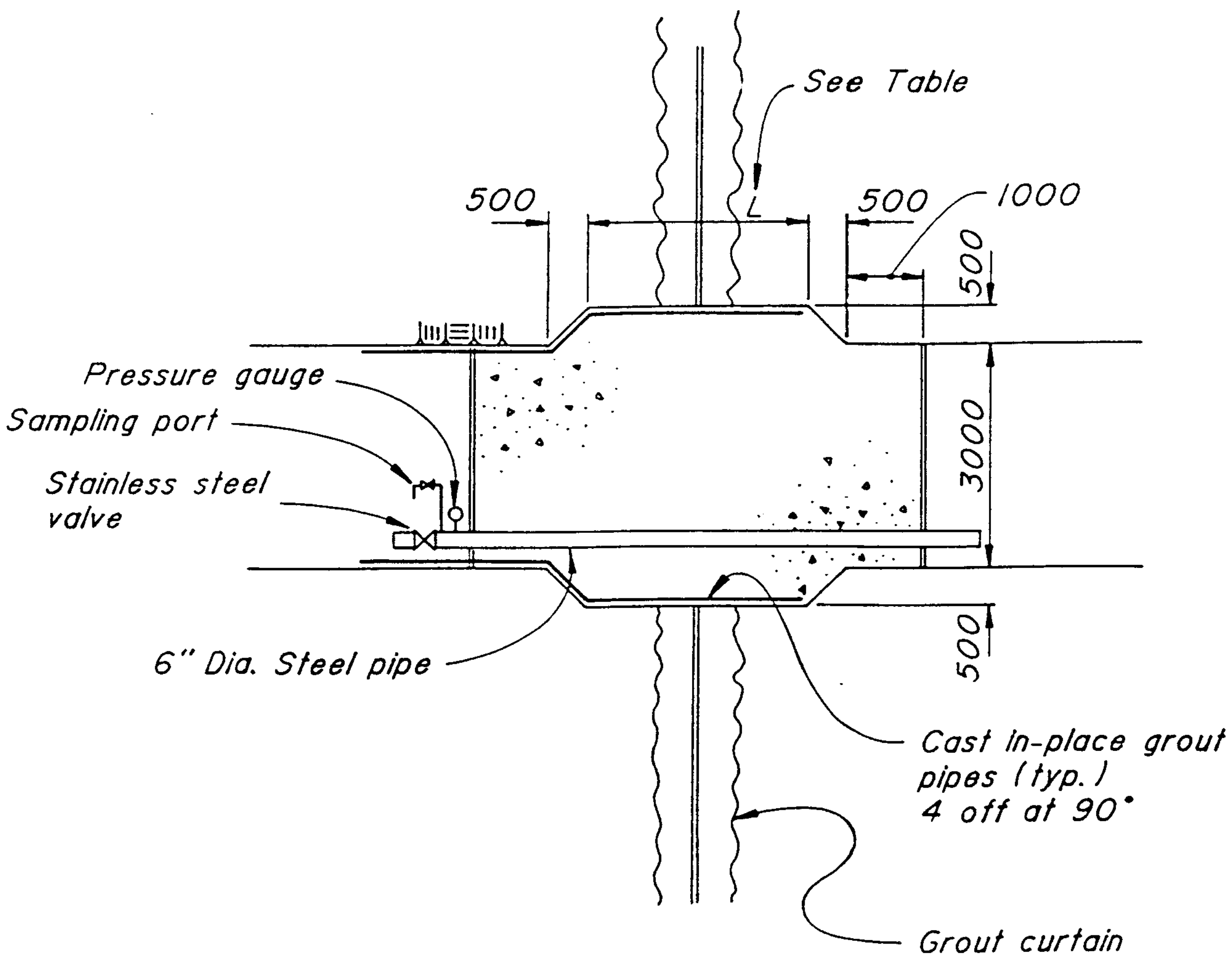
FIGURE 1


TULSEQUAH RIVER
CAMP
DUMP
Adit 5400
Collection Main Pipeline
(300ø CPE Pipe)
Dump
Adit 5900
CAMP
CREEK
Dump
Adit 6400
Adit 6500
Adit 5200
Lime Addition Plant
Sludge Settling Pond
Discharge to
Tulsequah River
LEGEND
Ditches
Main Pipeline
Sump to Main Pipeline
Catch Basin/Sump
Scale
20 10 0 20 40 60 80 100 m
KNIGHT AND PIESOLD LIMITED
CONSULTING ENGINEERS - VANCOUVER, B.C.
BSB/MDG
REDFERN RESOURCES LTD.
TULSEQUAH CHIEF PROJECT
ACID ROCK DRAINAGE ABATEMENT
REFERENCE DRAWINGS
REVISIONS
REVISIONS
DATE MARCH 26, 1991
SCALE AS SHOWN
FIGURE 3.1
REV

REDFERN RESOURCES LTD.

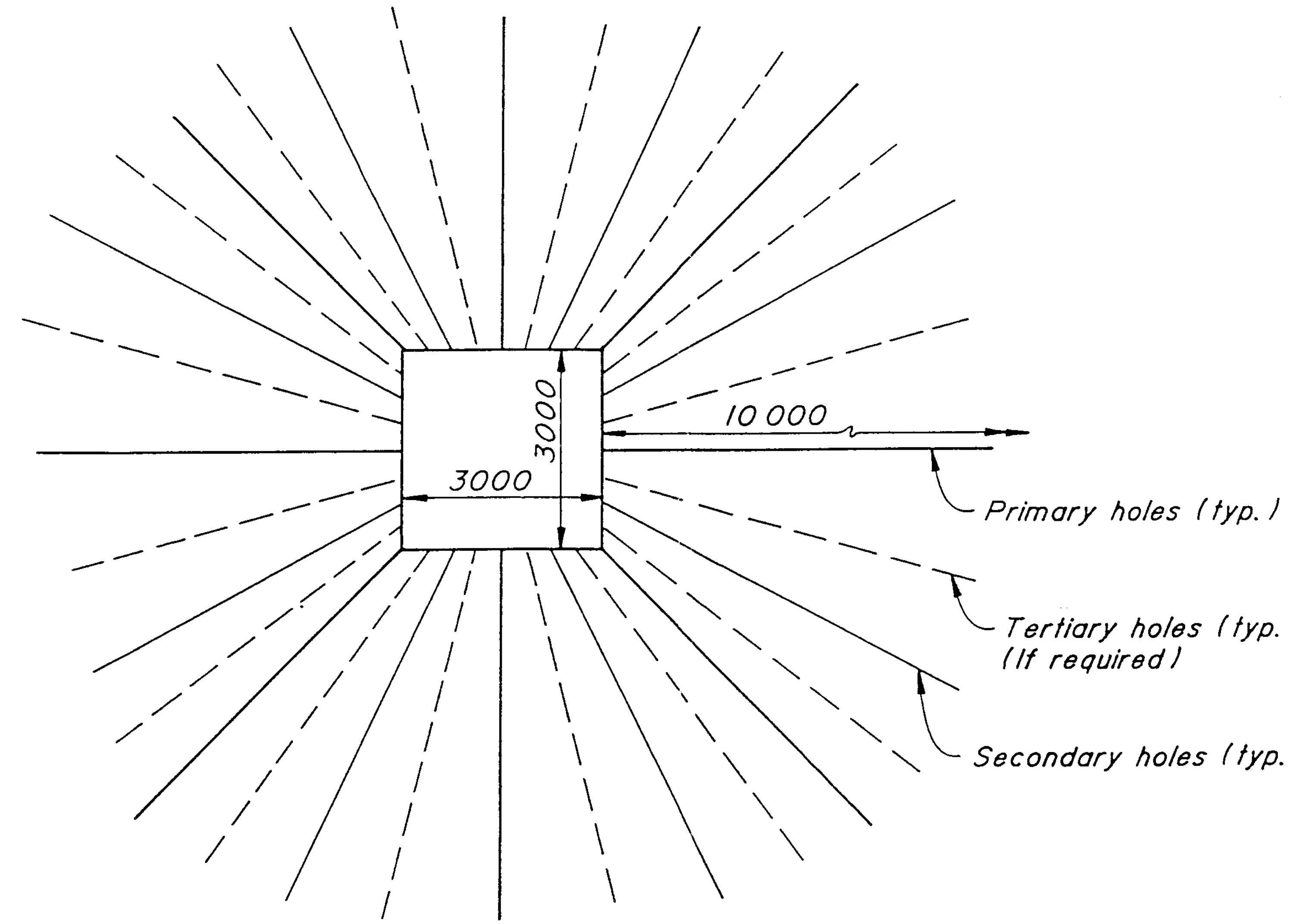
TULSEQUAH CHIEF PROJECT

ADIT BULKHEAD ARRANGEMENT



PLUG DESIGN

Adit	Key Length (L)
5200	3500
5400	3000
5900	2000
6400	2000



Grout hole length 10 000 (typ.)

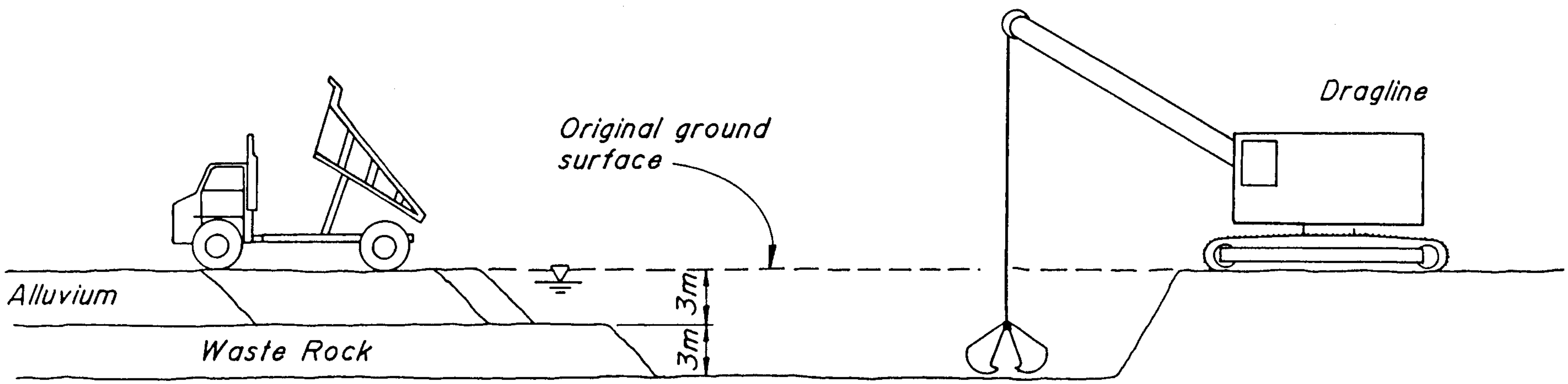
GROUTING PATTERN FOR PLUG CONSTRUCTION

NOTE: All dimensions in millimetres

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

FIGURE 4.1

REDFERN RESOURCES LTD.
TULSEQUAH CHIEF PROJECT
WASTE ROCK DISPOSAL IN FLOOD PLAIN SCHEMATIC



KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

FIGURE 4.2

1006.A1