SAGE CREEK COAL LIMITED
FLATHEAD VALLEY, B.C.

GEOTECHNICAL AND HYDROLOGICAL WORK ON THE DIVERSION OF HOWELL CREEK

N.T.S. 82-G-2

February, 1980 P. Bedford

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Maree Mining Ltd. of Blairmore, Alberta, constructed the road and excavated the test pits.

Aresco (B.C.) Ltd. of Alberta were retained to conduct archaeological studies of the area - this included the Upper Flathead Valley and the old Morrissey townsite at Morrissey.

FIELD WORK

An access road was driven on Licences # 4560, 4561, 4562 and 4564.

The road followed the proposed Howell Creek diversion from approximately 17,864,000 N, 584,000 E to 17,857,000 N 595,000 E. Test pits were dug as shown on drawing # X2392-5. Various samples were taken from these pits by Klohn Leonoff Consultants Ltd. to assist in the determination of the permeability and hydrology of the area.

Test pits were also excavated and soil samples taken from typical areas within the proposed settling pond requirements as shown in drawing # E-2423-3.

Field permeability tests were also conducted to estimate the possible amount of water that could be lost to ground water.

Bush trails were cut to test pits outlined by Golder Associates of Vancouver. These test pits are shown on Figure 3 enclosed herewith. The pits were excavated and samples taken by a Golder representative; these samples were analyzed to assist in determining the stability of the areas.

Aresco Ltd. had two archaeologists in the field the full six week period. They examined the area which would be disturbed by the development of the coal property and regions north and south of the proposed development areas.

RECLAMATION

All the test pits were reclaimed and put back to the original contours.

The bush through the access road was cut and cleaned up. All areas were reseeded, harrowed and fertilized by Allan Lamb Interior Reforestation Ltd. of British Columbia.

P. Bedford,
Project Engineer

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
H. W. MARSH

H. W. Marsh
Professional Engineer

PB/wc

February 22, 1980

REFERENCES (Reports Attached)

Klohn Leonoff Consultants Ltd., Vancouver, B.C.

September 1979 - "Site Drainage"

1978 - "Howell Creek Diversion"

Golder Associates, Vancouver, B.C.

August 1979 - "Stability of Proposed Waste Dumps"

Aresco Ltd., Calgary, Alberta

1979 - "Heritage Resource Inventory and Impact Assessment"

DRAWINGS (Drawings appended to reports)

Klohn Leonoff Consultants - Access Road and Test Pit Locations
- Drawing # X2392-5

Klohn Leonoff Consultants - Site Drainage Study
- Drawing # E-2423-3

Golder Associates - Location of Test Pits and Sections
- Figure 3

REPORT

Klohn Leonoff Consultants Ltd.

CIVIL • GEOTECHNICAL • HYDRAULIC

Project:	Site Drainage	
Location:	Southeastern British Columbia	
Client:	Sage Creek Coal Ltd.	
Our File:	VA 2423	September 13, 1979

KLOHN LEONOFF CONSULTANTS LTD.
Civil · Geotechnical · Hydraulic

Our File: VA 2423

September 13, 1979

Sage Creek Coal Ltd.
#2600 - 120 Adelaide Street W.
Toronto, Ontario
M5H 1W5

Mr. J.E. Moyle

Sage Creek Coal Ltd.
Site Drainage and Sedimentation Ponds

Dear Sir:

We are pleased to submit two copies of our report "Sage Creek Coal Ltd. - Site Drainage" dated September 13, 1979. This report includes results of our work conducted in 1978 as well as the test pitting done in June 1979.

A copy of this report has been sent directly to B.C. Research for their reference in preparing the Stage 2 Environmental Report.

We have enjoyed working on this project with your staff and hope that we may be of service in the future.

Yours very truly,
KLOHN LEONOFF CONSULTANTS LTD.

E.A. PORTFORS, P. Eng.
Head, Hydraulics Division

cc: 2 - B. Burge (Sage Creek, Vancouver)
1 - R. Hawes (B.C. Research)

EAP/ceo

10180 Shellbridge Way, Richmond B.C. Canada V6X 2W7 · Telephone: (604) 273-0311 · Telex: 04-355520

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APPENDIX I

DRAWINGS

1. INTRODUCTION

As part of the continuing design work for their proposed open pit coal mine in southeastern British Columbia, Sage Creek Coal Ltd. retained Klohn Leonoff Consultants Ltd. to carry out limited site investigation and preliminary design for the site drainage and settlement pond system. This work supplemented prior Klohn Leonoff studies of Howell Creek Diversion and a 1978 hydrology data collection program.

The work conducted by Klohn Leonoff included a hydrologic assessment, suspended sediment data collection and analysis, layout of a drainage system and settlement ponds, test pitting and limited field permeability testing. Details of the work programs were outlined in Klohn Leonoff letters to Sage Creek dated June 2, 1978 and April 6, 1979. The suspended sediment data were collected in May and June 1978 and the test pitting was conducted in late June 1979. This report includes results of both programs.

2. SEDIMENT CHARACTERISTICS

2.1 Sources of Sediment

Construction and operation of an open pit coal mine, plant facilities, and product transportation corridor creates an extreme potential for generating high sediment loads in natural drainage courses. A recent study[1] of existing coal mining operations in the East Kootenay area listed the following as the major sediment producers (not in order of importance):

1. Slides in mine overburden dumps which introduce material into streams both during the initial slide and during subsequent erosion of the slide material. Direct erosion of dumps also is a major source of sediment.

2. Erosion and bank sloughing of diversion or interceptor ditches constructed to carry uncontaminated surface runoff around the mine site.

3. Surface erosion of large land areas logged prior to mining.

4. Haul and access roads which intercept and concentrate runoff in larger, more erosive streams. In addition, lack of road surfacing allows production of large quantities of suspended solids as vehicle traffic churns the road surfaces into mud during wet weather.

5. Inadequately sized settlement ponds which allow outflows carrying high proportions of solids.

6. Overtopping and failure of drainage ditches and settlement ponds which were not sized to handle major flood peaks.

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(1) References listed at the end of the report.

Minimizing the risk of unacceptable discharges of solids into natural streams then depends on two basic factors:

1. A tidy mining operation with control of erosion will limit the production of large quantities of suspended solids.
2. Adequate design of the drainage system to avoid failures.

2.2 Available Sediment Data

During the 1978 site investigation program, a number of suspended sediment samples were obtained to provide data on the characteristics of solids that are expected to be carried by the site drainage as the mine is developed. These samples were analyzed for suspended sediment concentrations and turbidity. Table 2-1 summarizes these data.

It must be recognized that these data are spot measurements only and therefore cannot be considered as necessarily indicative of long term trends. However, the data are useful as they show the wide range of sediment concentrations possible.

Sediment concentrations that can be produced by disturbance of unsurfaced access roads are demonstrated from samples 25-3 and 25-4 taken from road runoff after passage of a truck. Concentrations measured were roughly 8500 mg/l and 50 000 mg/l respectively. Similarly, the effect of road disturbance on a small tributary is shown by samples 31-1 and 31-2 where the sediment concentration above the road runoff entry point was less than 1 mg/l whereas below the inflow point the concentration increased to 114 mg/l.

Grain size distributions of samples 25-3 and -4 are shown in Drawing A-2423-1. In both cases, essentially all the suspended material was in the silt size range with the median diameter of sample 25-3 being 0.003 mm and sample 25-4 being 0.01 mm.

TABLE 2-1

SUSPENDED SEDIMENT DATA

Sample	Date	Suspended Solids (mg/l)	Turbidity (J.T.U.)	Location & Remarks
25-1	May 25/78	38	270	From roadside ditch at crossing point of tributary G-2[1]
25-2	May 25/78	89	33	Cabin Creek above North Bridge
25-3	May 25/78	8490	> 1000	Runoff from road near tributary F-14 culvert after vehicle disturbance
25-4	May 25/78	50 130	> 1000	Runoff from disturbed road at camp
31-1	May 31/78	< 1	0.5	Tributary F-14 upstream of road crossing
31-2	May 31/78	114	67	Tributary F-14 downstream of road crossing
31-3	May 31/78	2	0.9	Howell Creek at Bridge

(1) Tributary data included in Klohn Leonoff report "Sage Creek Coal, Site Hydrology, 1978 Program" dated August 1978.

TABLE 2-2

SETTLING TIMES - SAMPLE 25-4

Time	Suspended Solids (mg/l)	Turbidity (J.T.U.)
Start	50 130	> 1000
1 hour	820	350
1 day	28	58
2 days	15	28
5 days	12	25

Note: Sample tested by B.C. Research

Reduction of sediment concentrations with settling time for sample 25-4 are listed in Table 2-2. These data indicate that in the laboratory, the material settles rapidly, with the concentration dropping from the initial 50 000 mg/l to 28 mg/l in 24 hours. According to Stokes Law, the D_{50} particle size of 0.01 mm from this sample has a settling velocity of about 0.06 mm/s, or 5 m/day. Because of the concentration, actual settling velocities will be slightly lower, however, by proper design of a settling pond, it appears that this material could be successfully settled to reduce concentration in a decant outflow system to less than the allowable limits of 50 mg/l.

A sample of coal taken from an exploration core was ground by pestle and mortar and the fine dust subjected to grain size analysis. The typical median particle diameter for the portion passing a No. 200 sieve was 0.01 mm which has an average settling velocity of about 1.6 m/day. Thus settling of the finer coal fractions will be very slow and, circulation currents within the settling ponds may be sufficient to inhibit complete settling.

2.3 Estimated Sediment Yields

The overall sediment yield from the mine site will depend upon the sediment control measures implemented. A study[2] conducted in an open pit mining area in Kentucky where apparently little or no effort was made to control sedimentation indicated an average annual sediment yield of about 9 450 tonnes/km^2/year. Unmined areas in the same locality yielded about 8.8 tonnes/km^2/year. The principal sediment sources apparently were waste dumps and haul/access roads.

Some forestry studies[3] have indicated that roads may yield 1 900 tonnes/km^2/year while areas disturbed by cutting and skidding yielded 14 tonnes/km^2/year. Other studies in the eastern Foothills of Alberta have shown that where some care is taken in logging and road construction, sediment yields may drop to 2.8 tonnes/km^2/year.

Based on the results of these previous studies, for the present feasibility level design, sediment yields from various portions of the site have been estimated as follows:

Initial stripping of overburden for new mine areas	5 300 tonnes/km^2/year
Active mining areas, dumps, roads	3 500 tonnes/km^2/year
Inactive mine areas, dumps, roads	900 tonnes/km^2/year
Forested areas, with limited access roads	9 tonnes/km^2/year

3. DESIGN FLOODS

3.1 Previous Work

Previous hydrological studies carried out by Northwest Hydraulic Consultants[4] and Klohn Leonoff Consultants[5] have provided base information on floods in the project area. This previous work has been used herein to establish design discharges for the diversion ditches and settlement ponds.

3.2 Snowmelt

Snowmelt unit discharges for the area were originally estimated by Northwest Hydraulics with the values confirmed in the 1978 Klohn Leonoff hydrology report. These estimates were for floods having recurrence intervals up to 100 years. Current British Columbia design practice is to consider the 200 year recurrence flood, and consequently the previous flood estimates have been extended to this larger return period. Results are listed in Table 3-1.

Extreme conditions yielding a probable maximum flood resulting from snowmelt combined with rainfall have previously[4] given a unit discharge of 10.3 $m^3/s/km^2$.

TABLE 3-1

SNOWMELT UNIT DISCHARGE ESTIMATES

Return Period (years)	Mean Daily Flood Flow ($m^3/s/km^2$)	Instantaneous Flood Peak ($m^3/s/km^2$)	
		Major Creeks	Small Tributaries
Mean Annual	0.20	0.22	0.24
5	0.24	0.26	0.30
10	0.30	0.33	0.37
20	0.36	0.39	0.45
50	0.46	0.50	0.57
100	0.55	0.60	0.68
200	0.65	0.71	0.81

3.3 Rainfall

Rainfall intensities were estimated in the Northwest Hydraulics study for recurrence intervals up to 50 years based on limited intensity duration data from the Cranbrook Airport. These data have also been extended herein to the 200 year recurrence interval to allow comparison with the snowmelt runoff estimates. It must be emphasized that the rainfall estimates are very approximate because of the extreme lack of data.

The adopted rainfall intensity estimates are listed in Table 3-2.

Runoff from rainfall on the very small basins at the Sage Creek site have been estimated using the Rational method. This procedure is very simple but as the available data is limited, more complex analyses are not warranted.

TABLE 3-2

ESTIMATED RAINFALL INTENSITIES

Rainfall Duration	Intensity (mm/h) Return Period (years) 2	5	10	50	100	200
5 minutes	41.0	53.0	69.0	94.0	104.0	114.0
10 minutes	30.0	38.0	48.0	64.0	68.0	76.0
15 minutes	23.0	30.0	36.0	46.0	51.0	56.0
30 minutes	13.0	18.0	20.0	28.0	30.0	33.0
1 hour	7.6	9.7	11.0	15.0	16.0	20.0
2 hours	5.0	6.3	7.4	8.9	9.6	10.0
6 hours	2.5	3.0	3.6	4.6	4.8	5.3
12 hours	1.5	2.0	2.3	2.8	3.0	3.3

4. DRAINAGE DITCH DESIGN

4.1 Clean Water Diversions

Diversion ditches have been laid out so that a maximum amount of runoff from undisturbed areas is directed away from the disturbed mine site. These diversions will thereby reduce the flows in the contaminated water drainage ditches, thereby limiting erosive velocities, and reducing the water volume that must be handled in the settling ponds.

The diversion ditches will be routed directly to Howell and Cabin Creeks and will be designed to avoid self erosion during operation. This will require careful routing to incorporate as many natural drainages as possible, vegetation of the mild slope portions of the ditches, selective lining of moderate slope portions, and rock check dams and drop structures on very steep reaches.

The clean water diversions are located above the open pits on North and South Hill, and above the waste dump areas. As the pits and dump areas will expand with each year of operation, the diversion ditch system would also be regularly expanded, and moved uphill. Using this concept, the undeveloped areas that do not drain into clean water ditches can be kept small, the amount of contaminated water to be handled in settling ponds minimized, and possible future layout changes to development of pits and dumps easily accommodated by changes to the ditch system.

If flows in a clean water ditch exceeded the ditch design capacity, the excess water would overtop the ditch and flow either into the open pits, or under the waste dumps. In the former case, the water would then be pumped out to the settling ponds, while in the latter case, there would be temporary retention as the water flowed through the waste rock voids ultimately reaching the contaminated water ditches. The short term life of the ditches in any one given location before moving (say perhaps 5 years), and the minor consequences of overtopping allows the diversion ditches to be designed for a relatively short recurrence interval flood event. Therefore, these ditches have been designed for a 50 year recurrence rainfall storm which produces a larger peak discharge than the snowmelt flood.

Ditch cross-sections have been designed with 3H:1V side slopes to be excavated by bulldozer. Excavated materials would be placed as a berm on the downhill side of the ditch, recontoured and revegetated. Where possible, the longitudinal ditch slopes have been limited to 0.0015, to keep maximum velocities below about 1 m/s and allow provision of erosion protection by vegetation. In these areas, 0.3 m of freeboard above design water level is provided. Where slopes must be steeper due to topography, freeboard would be increased to 0.6 m and as noted earlier, rock riprap lining or drop structures provided. The freeboard provides protection against wave splash over and, for snowmelt floods, the freeboard provides space for a portion of the ditch to be blocked by ice or snow.

Drawing E-2423-3 shows the layout of clean water ditches for the ultimate mine development and Table 4-1 their design capacity and dimensions. The ditch system for the mine development at intermediate stages is not shown; it would be similar in concept to the ultimate development layout.

4.2 Contaminated Water Ditches

Ditches to pick up surface water that may have been contaminated by material from the open pits, plant, waste dumps, roads or other activities is an important feature of the Sage Creek project.

TABLE 4-1

CLEAN WATER DIVERSION DITCHES
(Ultimate Mine Development)

Ditch	Location	Drainage Area (km^2)	Design Discharge 50 yr rain (m^3/s)	Average Ditch Depth (m) Steep Sections	Flat Sections
101	Above North Hill pit and northern waste dump. Drains to Howell diversion channel.	1.8	3.3	1.2	1.4
102	Above North Hill pit and western waste dump. Drains to Cabin Creek.	0.65	1.2	0.9	1.0
103	Above South Hill western waste dump. Drains to Cabin Creek.	0.85	1.6	1.0	1.1
104	Above South Hill pit and southern waste dump. Drains to Flathead River.	2.6	4.7	1.35	1.6

Drawing E-2423-3 shows the proposed contaminated water ditch system for the ultimate mine development which has been laid out to protect each portion of the project area. As well as the major ditches shown, smaller feeder ditches will be required along the toe of waste dumps, road cuts, etc.

Similar to the clean water diversion ditches, some modification of the contaminated water ditches probably will be required as mine development proceeds. For example, in the initial development, North Hill only will be mined and some of the ditching around South Hill would not be needed. Construction of the ditches would then be staged. However, in most cases, the routing of these ditches will not be changed during the life of the mine.

Some of the contaminated water ditches are in critical locations, and overtopping or other failure must be avoided. For example, the ditches that carry contaminated water parallel to Cabin Creek to the settlement ponds must be designed with a low probability of overtopping since failure of these ditches would allow contaminated water to flow directly into Cabin Creek.

These critical ditches are designed for the 200 year recurrence flood event. It is also assumed that any clean water ditches above these ditches overtop, allowing the entire watershed to drain to the contaminated water ditch.

Ditches which could overtop, or otherwise fail, but do not allow discharge into a natural stream, are designed for a 50 year recurrence event.

Table 4-2 shows the adopted design discharges and dimensions for the contaminated water ditches.

Design criteria for the contaminated water ditches is similar to criteria for the clean water ditches. Side slopes are provided at 3H:1V and longitudinal slopes are limited to 0.0015 wherever possible to limit velocities and allow the side slopes to be vegetated. Freeboard of 0.6 m has been provided on all contaminated water ditches. Some ditches do not drain appreciable areas; these have been designed with a nominal 1 m depth.

TABLE 4-2

CONTAMINATED WATER DRAINAGE DITCHES

Ditch	Location	Drainage Area (km^2)	Design Discharge (m^3/s)		Average Ditch Depth (m)	
			50 yr rain	200 yr rain	Steep Sections	Flat Sections
1	Toe of North Hill northern waste dump	2.8	1.2	---	1.0	1.2
2	Between North Hill pit and northern waste dump	Nominal	---	---	1.0	1.0
3	Between North Hill pit and western waste dump	Nominal	---	---	1.0	1.0
4	Below North Hill western waste dump and Cabin Creek	1.55(1)	---	4.2	1.3	1.8
5	From Pond 5 to Pond 6 below North Hill pit	3.45(1)	---	6.9	1.5	2.2
6	Around plant site	Nominal	---	---	1.0	1.0
7	Below South Hill pit and waste dumps	6.4(2)	---	17.6	1.8	3.0
8	Below South Hill southern waste dump	3.2(3)	---	6.0	1.4	2.1
9	Between South Hill pit and waste dump	Nominal	---	---	1.0	1.0
10	Between South Hill pit and waste dump	Nominal	---	---	1.0	1.0

(1) Design flow assumes contribution from failed Diversion Ditch 102.
(2) Design flow assumes contribution from failed Diversion Ditch 103 and one-half of 104.
(3) Design flow assumes contribution from one-half of failed Diversion Ditch 104.

5. SETTLEMENT POND DESIGN

5.1 Design Philosophy

Settlement ponds are designed to trap the contaminated surface water resulting from snowmelt or rainstorm discharge flowing over the developed mine area, and allow suspended sediment to settle. Generally, snowmelt will produce floods that are of long duration but normally not having extremely high peak discharges. This is especially true when forest cover provides shade to slow snowmelting and assist infiltration of water as the snow melts. Snowmelt water volumes may be high and the runoff can last for several weeks. Thus for efficient settlement pond operation, the ponds should be large enough so that flow through time is slow to allow settlement of the suspended solids. Design assumes a constant snowmelt inflow and corresponding clear water decant outflow over a period of several weeks, that is, no temporary storage in the pond is assumed to be provided to retain the snowmelt flood while settlement takes place. The ponds have been designed on the basis that as a minimum, they should be large enough to provide settlement time for a 50 year recurrence snowmelt flood.

Rainstorm floods are generally of shorter duration, having high peak flows and therefore often contain very high suspended sediment concentrations. These floods often are the events which overload settlement ponds and allow large releases of suspended sediment downstream into natural streams. Settlement ponds sizing for rainstorm floods has been based on providing temporary storage of part of the flood by setting normal maximum water levels below the spillway invert by use of a decant outlet set below the spillway level. Thus some flood storage will be available to store part of the rainstorm flood before flow over the spillway would occur. Similar to the snowmelt floods, ponds have been sized so that the minimum storage capacity available is capable of storing the 50 year rainfall flood. Generally this storage can be provided by setting the decant outlet 1 m below the spillway level.

Based on available data on usual suspended solids, it is anticipated that natural settlement, without use of flocculation agents will be adequate. However, if large volumes of very fine coal particles are present, some chemical treatment in the ponds may be required.

To ensure project safety, each pond would be provided with a free overflow spillway capable of passing the 200 year recurrence flood inflow assuming that the reservoir is full to the spillway crest level prior to start of the flood. During passage of such a major flood, settlement of solids in the ponds will continue, but due to the large design discharges, efficiency of the pond to trap solids will be decreased.

As noted above, after settlement of solids has taken place, water would be released back to natural drainages via decant facilities. In addition to the overflow decant release, water will be lost by seepage through the dams and by seepage into groundwater.

Settlement pond dams would be constructed of local sand and gravels with internal filters to control seepage. The dams will not be designed as water retention but rather to allow limited seepage, well controlled to avoid danger of piping or uncontrolled water loss. Thus some pond water will be lost to the downstream by seepage and the pond water levels may remain below the decant release facility level. In addition, water will be lost directly to groundwater from the pond.

During the June 1979 field program, soil samples were taken from typical areas within the proposed ponds, and field permeability tests conducted to estimate the possible amount of water that could be lost to groundwater. Results of this program are discussed below.

Appendix I contains the logs of the test pits and Drawing A-2423-2 typical grain size curves from a number of subsoil samples that were obtained. The following section contains a brief description of the subsurface conditions within each settlement pond and at the site of each settlement pond dam.

5.2 Physical Layout and Subsurface Conditions

Drawing E-2423-3 shows the location of the proposed settlement ponds and the location of the test pits dug in June 1979. Key dimensions of the ponds are shown in Table 5-1 and of the dams in Table 5-2.

5.2.1 Pond No. 1

Settlement Pond No. 1 is located south of the plant site on a fluvial terrace. This pond is a principal settlement pond as it will receive contaminated water from the interceptor ditches around South Hill and overflow from Pond No. 2. The bottom of the pond is flat, and presently a small stream drains to the south to the Flathead. The left (east) dam abutment will be in a reworked moraine lying between the terrace and the Flathead Valley, while the right (west) abutment will be located on till along the base of South Hill.

Test pit S-7 was located within the pond area, S-8 on the left abutment, S-9 and S-10 on the dam centreline.

The terrace which will form the pond bottom has a surface layer of about 0.6 m of fine silt overlying a gravel till. The gravel layer is quite pervious and carries water. This material would certainly allow seepage from the pond into groundwater except that the fine silt provides a low permeability barrier.

At the dam axis, test pit S-10 showed the silt over gravel till whereas S-9, near the moraine of the left abutment did not show the silt layer. This silt probably has resulted from flooding of the creek in the area and occurs only on the lower levels. Thus water loss through the abutments is a definite possibility.

The decant outflow from Pond No. 1 will flow south in the present creek channel ultimately reaching the Flathead River. Emergency spill from the pond, which would occur only in the event of a large rainstorm flood, would be directed over natural ground to the north into Cabin Creek. As this spillway is not expected to operate except during extreme rainfall, only major obstructions would be removed from the spillway location. Trees or other vegetation would not be removed, thus even in the event of spillway operation, a great deal of natural filtering of suspended sediment would occur.

5.2.2 Pond No. 2

Pond No. 2 is a small pond which will receive contaminated water from drainage around the plant site. It is anticipated that this water will contain only silt and coal solids and not petroleum or chemical wastes. Fueling depots, equipment maintenance areas, etc. would have local drainage to trap any of these types of spills.

The pond would be located upstream from Pond No. 1 in the same terrace. In this location the flat valley bottom is much narrower than at Dam No. 1. Decant outflow from Pond No. 2 would flow south in the abandoned stream channel, ultimately reaching Pond No. 1.

Test pit S-6 at the dam centreline showed gravel till overlain by organics. The silt layer found on the bottom of the Pond No. 1 was not present.

In the event of an extreme flood, emergency discharge from Pond No. 2 would be to Cabin Creek, similar to Pond No. 1. The likelihood of such an event is quite remote.

5.2.3 Pond Nos. 3 and 4

These two ponds are designed to hold emergency spills of coal tailings from the plant. After such a spill, the tailings would be re-processed in the plant. As there is no surface drainage into these ponds, and as they do not discharge into natural water course or other ponds, they are not considered further herein.

5.2.4 Pond No. 5

Pond No. 5 is located on the north side of Cabin Creek and intercepts contaminated drainage from the North Hill westerly waste dump. The pond is relatively small, but provides a convenient location for some settling rather than carrying all the contaminated flow downstream to the large Pond No. 6. Outflow from Pond No. 5 is carried to Pond No. 6. Similarly, in the event of a large flood, spill would also be carried to Pond No. 6 where a large settlement capacity is available. There would be no outflow from Pond No. 5 directly to Cabin Creek.

Test pits S-4 and S-5 showed dense gravel till overlain by organics and less dense weathered brown till. Some seepage through the gravel tills is expected. Other work on similar gravel tills along the Howell Creek diversion showed a permeability of about 3×10^{-2} cm/s which is considered indicative of relatively permeable material.

5.2.5 Pond No. 6

This pond, along with Pond No. 1, is a principal settlement pond. It will trap all contaminated runoff from the North Hill pit and waste dumps on North Hill, including the outflow from Pond No. 5.

The pond is located in the abandoned floodplain of Howell Creek, after the Howell Creek diversion is operational.

Till is located on both abutments at the dam site and along the flanks of the pond. Test pit S-1 was located in the upper reaches of the pond, within the wide, flat Howell Creek floodplain at the base of the hill forming the left abutment. Surficial materials were silt, underlain by dense gravel till. The silt layer probably resulted from historic flooding of Howell Creek. Currently, near the creek, there is evidence of silt deposits resulting from the 1979 freshet. The right abutment is also dense gravel till overlain by weathered brown till. Test pit S-2, located beside Howell Creek on the proposed dam axis showed 0.5 m of fine sand and silt overlying gravel. The gravel varied in size from pea gravel to 8 mm with the material deposited in segregated pockets showing the effects of the creek deposition. A field permeability test was conducted in the gravel which yielded an estimated permeability of 7.0×10^{-1} cm/s which is indicative of clean sand and gravel.

This gravel would allow a great deal of settlement pond water to discharge to groundwater, except that a great deal of the gravel deposit is covered with a layer of fine silt which has a low permeability. Normal decant outflow would be released into the old Howell Channel where it would flow to Cabin Creek.

Because of its location in the abandoned Howell Creek channel, a spillway must be excavated for Pond No. 6. It is anticipated that this spillway would take the form of an excavated channel through the right abutment. The spillway would have a minimum width of 5 m and would be cut on a slope of 0.002 to limit velocities and inhibit erosion. Test pit S-3 was dug in the proposed spillway area.

5.3 Design Discharges

As noted earlier, the primary concern for settling pond efficiency is that adequate capacity be provided to pass snowmelt floods and retain rainfall floods. Table 5-3 shows the estimated mean daily snowmelt flood peak flows and rainstorm volumes for a 6 hour storm for each settling pond based on the flood and rainfall estimates listed earlier, and the estimated drainage areas.

For safety of the structures, each pond has been provided with a free crest spillway that is capable of passing the 200 year flood. Because of the large surface areas of the ponds, there will be a great deal of attenuation of flood peaks by natural flood water storage in the ponds. Thus, the required spillway capacities are smaller than the inflow flood peak. Table 5-3 shows the 200 year recurrence interval floods used for spillway sizing.

5.4 Settling Pond Capacities

As a preliminary assessment of pond efficiency in settling out suspended solids, each settlement pond has been reviewed to determine the time required to pass the peak snowmelt flood through the pond, assuming an average pond width and average depth, and the rainstorm flood volume to be stored. Design capacities were taken from Table 5-2 and physical pond characteristics from the general layout of Drawing E-2423-3. Results of the theoretical travel time and volume calculations are shown in Table 5-4.

Estimates of settlement efficiences can be made by comparison of the snowmelt flood travel time to the time required for the median particle size of the suspended solids to fall a distance equal to the average depth of the pond. These times are also listed in Table 5-4. It must be emphasized that the fall time is based on laboratory analysis and does not include pond effects such as high velocity water currents, thermal currents, wind generated waves, or density currents. All these factors will decrease the vertical distance actually travelled by suspended particles.

Similarly, estimates of the efficiency of storage of rainstorm floods can be made by comparison of the minimum flood volume to the flood storage available between the decant outlet level and the spillway level. These are shown on Table 5-5.

TABLE 5-1
SETTLEMENT POND CHARACTERISTICS

Pond	Length (m)	Max. Width (m)	Max. Depth (m)	Full Supply Level (ft)	Full Supply Level (m)
1	1130	670	7.6	4215	1285
2	460	210	4.6	4275	1303
5	275	180	6.1	4395	1340
6	910	300	12.2	4300	1311

TABLE 5-2
SETTLEMENT DAM DIMENSIONS

Dam	Length (m)	Height (m)	Top Elevation (ft)	Top Elevation (m)
1	440	13	4225	1288
2	170	8	4281	1305
5	490	11	4405	1343
6	395	16	4310	1314

TABLE 5-3

DESIGN DISCHARGE CAPACITIES

Pond	Drainage Area (km^2)	50 Yr Snowmelt Flood Peak (m^3/s)	50 Yr Rainfall Flood Volume (10^3m^3)	Spillway Design Flood Peak* (m^3/s)
1	7.5	3.5	207	23.6
2	0.36	0.17	9.9	0.5
5	1.6	0.71	44	4.2
6	7.1	3.3	196	11.1

* Assumptions:

(1) Clean water interceptor ditches fail and runoff from entire site is diverted via settlement ponds.

(2) No attenuation of flood peak in pond.

TABLE 5-4

SNOWMELT FLOOD RETENTION

Pond	50 Yr Flood Travel Time (hour)	Time for Mean Particle to Settle (hour)	Ratio Travel Time: Settle Time
1	164	17	9.6
2	290	11	26
5	40	21	1.9
6	82	28	2.9

Assumptions:

(1) Flood retention times based on uniform flow through entire settlement pond.

(2) Settling time based on D_{50} = 0.01 mm for silt particle. Coal particles not considered.

TABLE 5-5

RAINSTORM VOLUME RETENTION

Pond	50 Yr Flood Volume (m^3)	Pond Volume 1 m depth (m^3)	Ratio Storage: Flood Volume
1	207	500	2.4
2	9.9	64	6.5
5	44	33	0.8
6	196	204	1.04

6. CONCLUSIONS AND RECOMMENDATIONS

The work to date indicates that the settlement ponds as presently envisioned are capable of settling the majority of the suspended sediment picked up by water flow from around the mine site. Actual settlement efficiencies are dependent upon the grain size of the actual material and the true efficiency of the settlement ponds. Ponds No. 1 and No. 6 are large, and provide a great deal of flexibility in the final methods of operation, thus it is expected that most suspended solids can be removed from the discharge waters.

Based on limited field investigation work, it appears that some seepage to groundwater will occur. If this is the case, settlement efficiency will improve dramatically. However, the addition of fine silt settled onto the pond bottom will reduce permeability and ultimately reduce seepage. In the long term, it is safer to assume that no seepage loss occurs and all water must be released through the decant facilities.

As part of the final design, some further foundation work will be required to completely design the settlement pond dams and spillways and based on final mine plans, drainage feature layouts may require slight modification.

KLOHN LEONOFF CONSULTANTS LTD.

Ernst A. Portfors

E.A. PORTFORS, P.Eng.
Head, Hydraulics Division

EAP/ceo

REFERENCES

(1) "Report on Sediment Production in the Vicinity of East Kootenay Coal Mining Operations", August 1978, Crozier, R.J., B.C. Ministry of the Environment, Pollution Control Branch.

(2) "Sedimentation Engineering", Varoni, V.A., Editor, A.S.C.E., 1975.

(3) "Suspended Sediment and Soil Disturbance in a Small Mountain Watershed after Road Construction and Logging", R. Rothwell, University of Alberta, Alberta Watershed Research Program Symposium Proceedings, 1977.

(4) "Sage Creek Coal, Site Hydrology", Northwest Hydraulic Consultants Ltd., July 1976.

(5) "Sage Creek Coal, Site Hydrology, 1978 Program", Klohn Leonoff Consultants Ltd., August 1978.

(6) "Effectiveness of Surface Mine Sedimentation Ponds", Hittman Associates Inc., Columbia, Ill., U.S. Department of Commerce, PB. 258 - 917.

APPENDIX I

TEST HOLE LOG

VERTICAL SCALE	DATE DRILLED
SAMPLE DATA	DRILL TYPE
WEIGHT HAMMER	ELEVATION GROUND
WEIGHT DROP	CO-ORD. LOCATION

SYMBOL — PEIZOMETER DETAILS

COHESION kPa: 20 40 60 80 100 — ●FIELD VANE △LAB VANE ■UNCONF

PLASTIC LIMIT ×------ WATER CONTENT O ------ LIQUID LIMIT × — 10 30 50 70 90

DEPTH / ELEV.	O.D. / I.D.	BLOWS / 30 CM.	NO.	DESCRIPTION OF MATERIAL
				1" ORGANICS
12"				SILT - brown - clayey - sample taken
24"				18" GRAVEL TILL - grey - very dense
36"				30"
				Pit located in Pond No. 6. Trees have stabilized terrace.

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JOB No.	VA 2423
PROJECT	Sage Creek Coal
LOCATION	
HOLE No.	TP-S1
DATE	21 June 79 PLATE

TEST HOLE LOG

VERTICAL SCALE	DATE DRILLED
SAMPLE DATA	DRILL TYPE
WEIGHT HAMMER	ELEVATION GROUND
WEIGHT DROP	CO-ORD. LOCATION

SYMBOL

PEIZOMETER DETAILS

COHESION kPa

20 40 60 80 100

● FIELD VANE △ LAB VANE ■ UNCONF

PLASTIC LIMIT × — WATER CONTENT O — LIQUID LIMIT ×

10 30 50 70 90

DEPTH ELEV.	O.D. I.D.	BLOWS 30 CM.	NO.	DESCRIPTION OF MATERIAL
				SILT
				- with fine sand
12"				- damp
				18"
				GRAVEL
24"				- silty
				- pea gravel to 2-3" size
				- pockets of segregated sizes
				- sample taken
36"				36"
				Test pit located 10 ft from Howell Creek in Pond No. 6. Field permeability test gave $k = 7.0 \times 10^{-1}$ cm/s

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JOB No.	VA 2423
PROJECT	Sage Creek Coal
LOCATION	
HOLE No.	TP-S2
DATE	21 June 79 PLATE

TEST HOLE LOG

VERTICAL SCALE	DATE DRILLED
SAMPLE DATA	DRILL TYPE
WEIGHT HAMMER	ELEVATION GROUND
WEIGHT DROP	CO-ORD. LOCATION

PEIZOMETER DETAILS

COHESION kPa: 20 40 60 80 100 — ●FIELD VANE △LAB VANE ■UNCONF

PLASTIC LIMIT ×------O------× WATER CONTENT LIQUID LIMIT: 10 30 50 70 90 %

DEPTH / ELEV.	O.D. / I.D.	BLOWS / 30 CM.	NO.	SYMBOL	DESCRIPTION OF MATERIAL
					4" ORGANICS
12"					10" CLAY TILL - silty - brown - occasional boulders
24"					GRAVEL TILL - grey - silty 30" - very dense - sample taken
36"					
					Pit in proposed spillway area for Pond No. 6

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JOB No.	VA 2423
PROJECT	Sage Creek Coal
LOCATION	
HOLE No.	TP-S3
DATE	21 June 79 PLATE

TEST HOLE LOG

VERTICAL SCALE	DATE DRILLED	PEIZOMETER DETAILS	COHESION kPa
SAMPLE DATA	DRILL TYPE		20 40 60 80 100 ●FIELD VANE △LAB VANE ■UNCONF
WEIGHT HAMMER	ELEVATION GROUND		PLASTIC LIMIT × WATER CONTENT ○ LIQUID LIMIT ×
WEIGHT DROP	CO-ORD. LOCATION		10 30 50 70 90

DEPTH / ELEV.	O.D. / I.D.	BLOWS / 30 CM.	NO.	SYMBOL	DESCRIPTION OF MATERIAL
					2" ORGANICS
					<u>CLAY TILL</u>
12"					- brown
					- some gravel
					14"
					<u>GRAVEL TILL</u>
24"					- grey
					- silty
					30" - very dense
					- 2-3" gravel
36"					- sample taken
					Pit located on axis of Dam 5. Heavy dead falls and low brush

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JOB No. VA 2423
PROJECT Sage Creek Coal
LOCATION
HOLE No. TP-S4
DATE 21 June 79 PLATE

TEST HOLE LOG

VERTICAL SCALE	DATE DRILLED	PEIZOMETER DETAILS	COHESION kPa
SAMPLE DATA	DRILL TYPE		20 40 60 80 100
WEIGHT HAMMER	ELEVATION GROUND		● FIELD VANE △ LAB VANE ■ UNCONF
WEIGHT DROP	CO-ORD. LOCATION		PLASTIC LIMIT × WATER CONTENT O LIQUID LIMIT ×
DEPTH / ELEV. | O.D. / I.D. | BLOWS / 30 CM. | NO. | SYMBOL	DESCRIPTION OF MATERIAL		10 30 50 70 90

DEPTH ELEV.	DESCRIPTION OF MATERIAL
	2" ORGANICS
	CLAY TILL
12"	12" - brown - silty
24"	GRAVEL TILL - grey - pieces of coaly shale - very dense - sample taken
36"	
48"	48"
	Pit along side of road near Pond 5

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JOB No. VA 2423
PROJECT Sage Creek Coal
LOCATION
HOLE No. TP-S5
DATE 21 June 79 PLATE

TEST HOLE LOG

VERTICAL SCALE	DATE DRILLED
SAMPLE DATA	DRILL TYPE
WEIGHT HAMMER	ELEVATION GROUND
WEIGHT DROP	CO-ORD. LOCATION

PEIZOMETER DETAILS

COHESION kPa: 20 40 60 80 10[illegible]

● FIELD VANE △ LAB VANE ■ UNCON[illegible]

PLASTIC LIMIT ×------ WATER CONTENT O ------× LIQU[illegible] LIMIT

10 30 50 70 90

DEPTH / ELEV.	O.D. / I.D.	BLOWS / 30 CM.	NO.	SYMBOL	DESCRIPTION OF MATERIAL
					CLAY TILL - brown - organics - roots in soil
12"					
					18"
					CLAY TILL - grey - some gravel - very dense - sample taken
24"					
36"					36"
					Pit near stream at site of Pond 2. Gravel till exposed in creek banks.

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JOB No. VA 2423
PROJECT Sage Creek Coal
LOCATION
HOLE No. TP-S6
DATE 20 June 79 PLATE

TEST HOLE LOG

VERTICAL SCALE	DATE DRILLED
SAMPLE DATA	DRILL TYPE
WEIGHT HAMMER	ELEVATION GROUND
WEIGHT DROP	CO-ORD. LOCATION

SYMBOL | PEIZOMETER DETAILS

COHESION kPa: 20 40 60 80 100 — ● FIELD VANE △ LAB VANE ■ UNCONF

PLASTIC LIMIT ×-------O-------× WATER CONTENT, LIQUID LIMIT: 10 30 50 70 90

DEPTH / ELEV.	O.D. / I.D.	BLOWS / 30 CM.	NO.	SYMBOL		DESCRIPTION OF MATERIAL
					4"	ORGANICS
						CLAY
12"						- black - damp - organics - silty
					20"	- sample taken
24"						GRAVEL TILL
						- black/brown - water bearing
36"					36"	
						Pit located in Pond 1 near small stream. When pit opened gravel layer some water entered then rose rapidly to 18" below surface.

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JOB No.	VA 2423
PROJECT	Sage Creek Coal
LOCATION	
HOLE No.	TP-S7
DATE	20 June 79 PLATE

TEST HOLE LOG

VERTICAL SCALE	
DATE DRILLED	
DRILL TYPE	
ELEVATION GROUND	
CO-ORD. LOCATION	

SAMPLE DATA

WEIGHT HAMMER

WEIGHT DROP

PEIZOMETER DETAILS

COHESION kPa: 20 40 60 80 10[illegible]

●FIELD VANE △LAB VANE ■UNCO[illegible]

PLASTIC LIMIT × - - - - - WATER CONTENT O - - - - - LIQU[illegible] LIM[illegible] ×

10 30 50 70 90

DEPTH / ELEV.	O.D. / I.D.	BLOWS / 30 CM.	NO.	SYMBOL	DESCRIPTION OF MATERIAL
					2" ORGANICS
					<u>CLAY TILL</u>
12"					12" - red/brown - silty - roots - 2-3" stones
24"					<u>GRAVEL TILL</u>
					- grey/brown - occasional 6" boulders - 2-3" gravel - very dense
36"					36" - sample taken
					Pit in ridge between Pond 1 and Flathead River

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JOB No.	VA 2423
PROJECT	Sage Creek Coal
LOCATION	
HOLE No.	TP-S8
DATE	20 [illegible] 7[illegible]
PLATE	

TEST HOLE LOG

VERTICAL SCALE	DATE DRILLED
SAMPLE DATA	DRILL TYPE
WEIGHT HAMMER	ELEVATION GROUND
WEIGHT DROP	CO-ORD. LOCATION

PEIZOMETER DETAILS

COHESION kPa: 20 40 60 80 100 — ●FIELD VANE △ LAB VANE ■UNCONF

PLASTIC LIMIT × - - - - O - - - - × LIQUID LIMIT (WATER CONTENT): 10 30 50 70 90

DEPTH / ELEV.	O.D. / I.D.	BLOWS / 30 CM.	NO.	SYMBOL	DESCRIPTION OF MATERIAL
					2" ORGANICS
					GRAVEL TILL
12"					- brown - silty - damp - 2-3" gravel - sample taken
24"					
36"					36"

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JOB No.	VA 2423
PROJECT	Sage Creek Coal
LOCATION	
HOLE No.	TP-S9
DATE	20 June 79 PLATE

TEST HOLE LOG

VERTICAL SCALE	DATE DRILLED	
SAMPLE DATA	DRILL TYPE	
WEIGHT HAMMER	ELEVATION GROUND	
WEIGHT DROP	CO-ORD. LOCATION	

PEIZOMETER DETAILS

COHESION kPa: 20 40 60 80 100 — ● FIELD VANE △ LAB VANE ■ UNCONF

PLASTIC LIMIT ×- - - - - - WATER CONTENT ○ - - - - - - × LIQUID LIMIT: 10 30 50 70 90

DEPTH / ELEV.	O.D. / I.D.	BLOWS / 30 CM.	NO.	SYMBOL	DESCRIPTION OF MATERIAL
					ORGANICS
					6"
12"					CLAY - black - silty - organics
24"					24"
					GRAVEL TILL - black - silty - water bearing
36"					
					Test pit about 100 ft from small creek. Water rose quickly from gravel layer.

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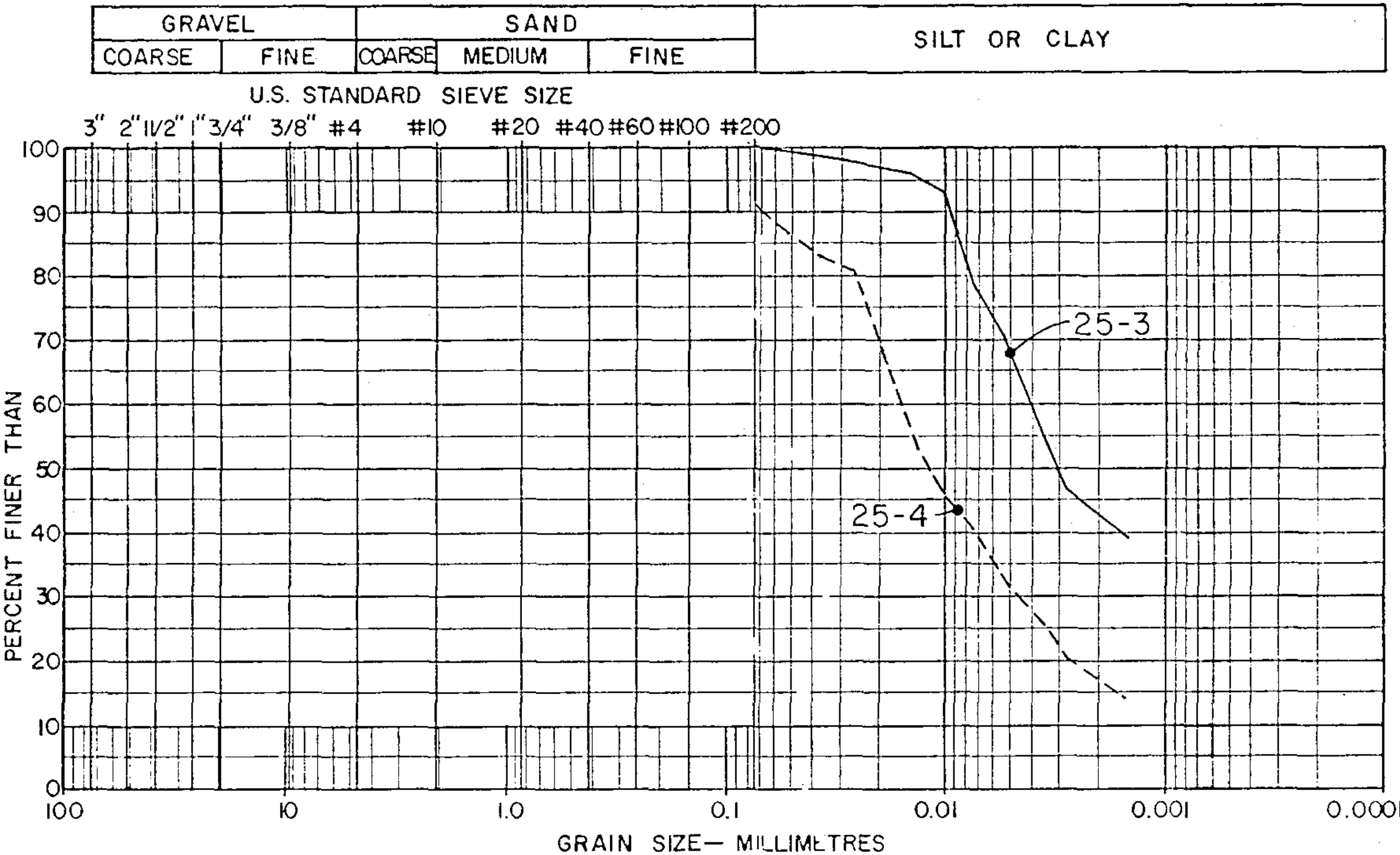
JOB No.	VA 2423
PROJECT	Sage Creek Coal
LOCATION	
HOLE No.	TP-S10
DATE	[illegible]
PLATE	

DRAWINGS

GRAIN SIZE CURVE



REMARKS: 25-3 – RUN OFF FROM ROAD AT TRIBUTARY F-13.

25-4 – RUN OFF FROM ROAD NEAR CAMP.

SAMPLES COLLECTED JUNE 6, 1978

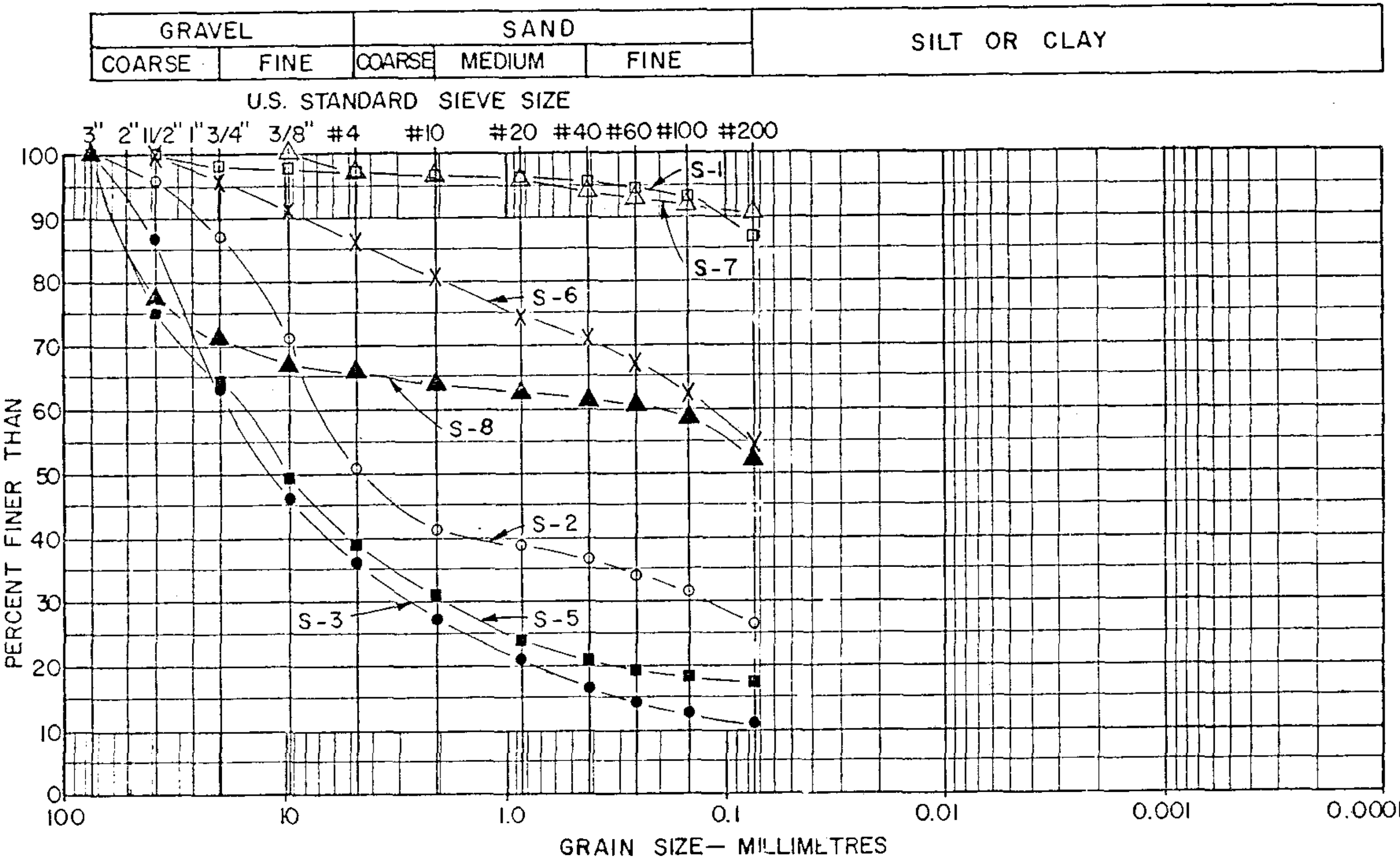
Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No. VA 2423
PROJECT SAGE CREEK SEDIMENTATION
LOCATION
HOLE No.
DEPTH
DATE Aug. 31, 1979
A-2423-1

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No. VA 2423
PROJECT SAGE CREEK SEDIMENTATIO[illegible]
LOCATION
HOLE No. DEPTH
DATE Aug. 31, 1979 A-2423-2

GRAIN SIZE CURVE



REMARKS: Test pit locations shown on Drawing E-2423-3

PROPOSED DIVERSION ROU
BERYL
10+00
24+00
36+00
40+00
POTENTIAL POND
52+00
67+00
75+00
93+00
105+00
120+00
126+00
148+00
165+00
P
HOWELL CREEK
CABIN CREEK
WATER SURVY GAUGE

373

"Howell Creek Diversion Alternatives"

K-Sage Creek 79(2)*A *(10)

TO BE READ WITH KLOHN LEONOFF CONSULTANTS LTD. REPORT DATE NOV 1978

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Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS
VANCOUVER - CALGARY - WINNIPEG, CANADA

REV.	DATE	REVISION DETAILS	
DESIGN	DRAWN A C	DATE AUG 1978	SCALES

CLIENT: SAGE CREEK COAL LTD.

PROJECT: HOWELL CREEK DIVERSION

TITLE: ROUTE LAYOUT (M1)

DATE OF ISSUE	PROJECT No.	DWG No.	REV.
NOV/78	VA 2392	X-2392-3	

APPROVED: [signature]

PROPOSED
DIVERSION
ROU
BERYL L
POTENTIAL POND
APPROXIMATE LOCATION OF ACCESS ROAD
TP-D9
TP-D8
TP-D7
TP-D6
TP-D5
TP-D4
10+00
24+00
40+00
52+00
67+00
75+00
93+00
126+00
148+00
165+00
HOWELL
CREEK
CABIN
CREEK
WATER SURVEY GAUGE

FLATHEAD RIVER
DIVERSION ROUTE
TP-D8
40+00
POTENTIAL POND
75+00
TP-D7
67+00
93+00
P
120+00
126+00
TP-D5
105+00
TP-D6
BERYL LAKE
MARL LAKE
148+00
APPROXIMATE LOCATION OF ACCESS ROAD
165+00
TP-D4
192+00
201+00
TP-D3
TP-D2
240+00
258+00
CREEK
FLATHEAD BACK CHANNEL
WATER SURVEY GAUGE
EEK
LEGEND
TP-D2
TEST PIT LOCATION
DYKE
DEVELOPED FLOOD PLAIN
POTENTIAL SECONDARY CHANNEL
P
POND
200 0 200 400 600 800 1000 1200 FEET
M2
373
"Site Drainage"
K-Sage Creek 79 (2) A (10)
REV.
DATE
REVISION DETAILS
DESIGN
DRAWN A C
DATE AUG. 1978
SCALES As shown
TO BE READ WITH KLOHN LEONOFF CONSULTANTS LTD. REPORT DATE AUG. 1979.
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Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS
VANCOUVER - CALGARY - WINNIPEG, CANADA
CLIENT: SAGE CREEK COAL LTD.
PROJECT: HOWELL CREEK DIVERSION
TITLE: ACCESS ROAD AND TEST PIT LOCATIONS
DATE OF ISSUE AUG./79
APPROVED
PROJECT No. VA 2392
DWG. No. X-2392-5
REV.

REPORT

Klohn Leonoff Consultants Ltd.
CIVIL • GEOTECHNICAL • HYDRAULIC

HOWELL CREEK
DIVERSION ALTERNATIVES

SAGE CREEK COAL LTD

NOVEMBER, 1978

CONFIDENTIAL

KLOHN LEONOFF CONSULTANTS LTD.
Civil · Geotechnical · Hydraulic

Our File: VA 2392 November 23, 1978

Sage Creek Coal Limited
#202 - 580 Granville Street
Vancouver, B.C.
V6C 1W8

Mr. D. Little

Howell Creek Diversion

Dear Sir:

Enclosed are copies of our report, "Howell Creek, Diversion Alternatives". The report briefly reviews the two earlier alternatives for diversion of Howell Creek around the Sage Creek mine site and describe; a new proposal which, we believe, answers the principal concerns expressed about the previous designs.

Yours very truly,
KLOHN LEONOFF CONSULTANTS LTD.

E.A. PORTFORS, P. Eng.

EAP/ceo

10180 Shellbridge Way, Richmond B.C. Canada V6X 2W7 · Telephone: (604) 273-0311 · Telex: 04-355520

HOWELL CREEK

DIVERSION ALTERNATIVES

SAGE CREEK COAL LTD

NOVEMBER, 1978

TABLE OF CONTENTS

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DRAWINGS

Our File: VA 2392 November, 1978

1. INTRODUCTION

Development of the proposed Sage Creek Coal Ltd open pit mine in the Flathead valley of southeastern British Columbia will require diversion of Howell Creek away from the open pit and waste dump areas. Howell Creek rises on the western edge of the Flathead basin, flows south and east, entering the main Flathead Valley about 8 km above its confluence with the Flathead. Cabin Creek joins Howell about 2 km upstream of the Flathead confluence. A map of the general area is shown in Drawing A-2392-1.

The proposed Howell diversion would intercept the original creek near the point where Howell enters the Flathead Valley, and extends eastward toward the Flathead north of the mine site areas. The new channel would be completely removed from the mine development area.

A total of 21,000 feet of existing Howell channel (measured along the creek thalweg) would be eliminated by the diversion. In addition, 8,000 feet of channel below the Cabin-Howell confluence would have flows appreciably reduced by removal of the Howell flow contribution.

Diversion of Howell Creek was briefly discussed in the July 1976 Environmental Impact Assessment, Stage 1 Report. At that time, the project designers anticipated that the diversion would follow a fairly straight route through Beryl and Marl Lakes to the Flathead. It was recognized that whereas the mine would have a finite economic life, in the order of 20 years, the Howell diversion would be a permanent feature. Therefore, to avoid continuous maintenance, the diversion should be constructed with the characteristics of a natural channel.

Northwest Hydraulic Consultants studied the creek routing and in July 1976, issued a report which outlined the design requirements for the permanent diversion and recommended a route to the south of Beryl and Marl Lakes. This report formed part of the Addendum to Preliminary Environmental Impact Assessment, dated September 1, 1976. A summary of the Northwest Hydraulics proposed route is contained in Appendix I of this report.

Several concerns were raised by Provincial regulatory bodies regarding the provisions for fish spawning and rearing in the Northwest Hydraulics proposed diversion. In January 1978, the Provincial Ministry of Mines and Petroleum Resources suggested a diversion route north of Beryl and Marl Lakes. This proposal consisted of an excavated wide floodplain containing a meandering main flow channel to provide the same channel slope and length as the existing Howell channel. A description of this proposal is included in Appendix II.

In March 1978, Sage Creek Coal Ltd retained Klohn Leonoff Consultants Ltd to review the previous Howell diversion proposals and to develop an alternate route which would overcome the objections to the previously suggested routes. A description of this proposed route is included herein.

2. STUDY SCOPE

Terms of reference for this study were as follows:

1. Review the Northwest Hydraulics proposed design in light of the objections raised by the Provincial regulatory agencies.

2. Review the Mines Department proposed diversion route and prepare an estimate of construction cost.

3. Lay out a route which would overcome objections to earlier designs, prepare a report on alternatives, and finalize a route and design acceptable to the Controller of Water Rights and to the Environmental Land Use Committee.

In addition to the Howell diversion assessment, Klohn Leonoff were retained by Sage Creek to gather site hydrologic data. During the trips to the site for hydrologic data collection, the opportunity was also taken to collect additional information on the proposed diversion route. The additional work included:

1. Inspection of alternate routes by helicopter.

2. Collection of surficial soil samples along the route.

3. Visits to other coal properties in south eastern British Columbia to inspect stream diversions and methods of handling site water.

3. PROPOSED DIVERSION ROUTE

3.1 Background

Review of the Northwest Hydraulics diversion alternative (see Appendix I) and the suggested route of the Mines Department (see Appendix II) indicated that the principal drawbacks to these schemes were:

1. The Northwest Hydraulics proposal did not adequately address the overall need for fish habitat to replace that lost in the original Howell Creek channel.

2. The Mines Department proposal did not completely account for the natural ground topography and hence had several layout constraints and a high estimated construction cost.

The Northwest Hydraulics design made use of the existing topography to minimize construction cost while still providing flat enough stream slopes to allow upstream fish migration. However, final slopes were still appreciably steeper than in the existing channel and fishery habitat was not provided to replace lost habitat.

The present proposal has been developed from the Northwest Hydraulics route by improving fisheries habitat. This has resulted in a longer route, flatter average slope, creation of ponds and varied habitat, and enhancement of spawning areas. In this regard, several design concepts have been adopted from the Mines Department proposal.

Mapping of the route area is available with 5 foot contour intervals at a scale of 1 inch equals 200 feet. This mapping shows the hummocky terrain and the number of small gullies and depressions that could be used to form part of the diversion channel. Stereo aerial photographs were used to supplement the mapping to lay out a route that used the natural topography to best advantage in avoiding deep cuts which are difficult to develop into good fish habitat as well as being expensive to construct.

Surficial geological mapping of the area indicates the terrain as having a glacio-fluvial origin. Inspection of the route confirmed that sands and gravels exist at or near the surface which would form a good basis for developing fishery habitat in the stream bed and banks. Two surficial material samples were taken from the natural depressions along the proposed route. A grain size gradation curve for one sample is shown in Figure A-2392-2. The extent and gradation of alluvial subsurface materials along the entire route must be determined prior to final design.

Indications are that the groundwater level is close to the ground surface along the diversion route. If this is correct, seepage from the channel may not be a serious concern. Again, detail site data are required to establish groundwater levels before final design.

3.2 Technical Aspects

Layout of the proposed route is shown on Drawing X-2392-3 and the profile on Drawing X-2392-4.

Engineering design features of the diversion are as follows:

1. The length of the new channel from the diversion point on the existing Howell channel to the Flathead River is 25,300 feet. This compares with 21,000 feet of existing Howell channel that will be lost because of the diversion.

2. Average slope of the diversion channel is 0.9%, identical to the existing average Howell slope.

3. The main channel has been sized to contain low to moderate flows without overbank discharge. At higher discharges, flow would spill out of the main channel

onto the adjacent low areas, similar to behaviour of the existing Howell channel. In several areas, deeper cut is required because of topographic constraints, in these areas bank overspill will not regularly occur.

The adopted non-overbank spill discharge selected was 500 cfs, compared to the estimated mean annual flood peak of 900 cfs. Photos 1 and 2 show the existing Howell channel on May 31, 1978 at a discharge of 330 cfs (preliminary Water Survey of Canada estimate).

4. The main channel dimensions would be:

bed width	35 feet
channel depth	2 to 3 feet
side slopes	2H:1V

5. The main channel would be routed through low areas in the topography to reduce deep cut reaches. The layout shown on Drawings -3 and -4 has been developed using the existing 5 foot contour interval mapping supplemented by study of stereo air photos.

6. Natural ridges and constructed dykes would contain floods within a generally defined route for discharges up to the 1000 year recurrence flood. Dykes would be constructed with 4H:1V side slopes and would be vegetated with grass and trees so that if infrequent overtopping did occur, there would be little possibility of breaching the dykes and subsequent diverting of the channel to a new route.

7. The maximum slope of the proposed route is 1.6%, compared to 2.3% in the existing Howell channel. The existing steep section of Howell is located near the Cabin confluence just upstream from the Water Survey gauging station. This section of creek flows in a well defined single channel with higher banks. There was no overbank flow in this reach at the time of the site visit on May 31, 1978 (see Photos 3 and 4).

3.3 Fishery Habitat Enhancement

The proposed layout lends itself to detail design modifications which would enhance fishery spawning and rearing habitat. In general, the features to be developed are described below. Table 1 indicates the design features for each particular reach of the route.

1. In reaches where topography is relatively flat and the required excavation is small a wide shallow channel would be cut. Within this channel, braided low flow channels would be excavated. Floods would overtop the low flow channels regularly and flow over the wide channel as in a natural floodplain. If the native sands and gravels are of proper size and gradation (lack of silt sizes), the wide channel would be loosened using a bulldozer and ripper so that flows would quickly re-sort the sands and gravels to provide spawning habitat. At this time it is not known if the native sands and gravels are acceptable for spawning habitat. Consequently within this report, it has been assumed that native materials would be excavated from the low flow channel banks and replaced with graded sand and gravel

to produce spawning habitat. The wide channel would then not be loosened and the silt available for stream transport would be limited. The aim would be to develop a channel similar to Howell as seen in Photos 1 and 2.

2. Development of secondary channels has been a natural occurrence in the Howell floodplain, see Photo 5. These channels provide good fish rearing habitat in their pools and lower velocity sections. In some reaches of the diversion route, topography allows splitting the flow into two or more channels. Secondary channels would be constructed where possible, pools developed in these channels, and restrictions provided to limit velocities. A total of about 3,200 feet of secondary channel can be developed along the route.

3. Designing the main channel for a relatively small flood peak will result in frequent overtopping and spill onto adjoining areas. This spill will promote development of adjacent low terrain into floodplain-like areas even though the soils will not be water-sorted sands and gravels (some of the existing Howell floodplain consists of fine silt, see Photo 6). To promote floodplain development, some selective clearing of trees and under-brush would be done. Flow in the diversion channel will result in some natural bank erosion and resorting of bank sands and gravels into bars, and development of deeper pools. In early years the process will be more rapid than now occurs in the Howell channel, but the new channel will quickly stabilize and act as a natural stream.

4. At least 11 ponds would be developed along the route by making use of existing ponds and depressions. These will provide settling areas for the finer materials eroded from the channel during initial operation and will provide natural resting and feeding areas for fish. A typical area for development of a pond is shown in Photo 7. The surficial material sample of Drawing -2 was taken from this area.

5. Along some portions of the route, deep excavation cannot be avoided. The maximum depth of cut will be about 20 feet, and in order to keep construction costs to reasonable limits, in these areas only a single well defined channel will be provided. The maximum slope through any given reach is 1.6% which if developed as a simple channel, would result in high velocities, serious bank and bed erosion, as well as a restriction to fish passage.

In these single channel areas, main channel slopes would be limited to 0.5% and rock sections of rapids constructed to dissipate the excess head. The 0.5% slope was chosen to limit velocities and erosion of the banks and bed in the single channel reaches. The flat slope-steep slope sections would develop natural areas of alternating slow velocities and riffles.

The 1.6% slope is less than the 2.3% slope which presently exists in Howell just above the Cabin confluence, see Photos 3 and 4.

6. Large boulders would be placed in the stream bed within the single channel portions. The boulders will direct the flows locally within the main channel producing mid-channel gravel bars and adjacent deep channels which will carry low flows at adequate depths for fish survival. Log jams in the existing Howell channel serve much the same purpose, see Photo 8.

7. Channel banks in the deep cut areas would be re-vegetated with grasses and with fast growing willows and other brush to provide shade and limit water temperature rise during the summer. The present Howell floodplain contains both willows and other trees, see Photos 1 to 6 and 8.

In addition to the above measures for improving and developing fishery habitat in the main diversion channel, additional habitat can be developed by diverting Howell Creek into a Flathead River back channel which is located on the right side of the Flathead floodplain, see Drawing X-2392-3. This back channel is of approximately the same size and configuration as existing Howell Creek, see Photos 9 and 10. It has low banks, numerous sub-channels, sand and gravel bed and banks and several meander loops. Little construction work would be required to convert the channel into part of the diversion route since presently during periods of high Flathead flow, water enters this channel from the main Flathead channel. The bed materials may not be adequate for spawning because of historic Flathead sorting of materials, however, the rearing habitat should be good and, if required, select gravels could be added to develop spawning areas. Total length of the back channel that could be developed is 9,000 feet at an average slope of 0.5%.

The entrace to the channel from the Flathead is restricted by a large log jam, See Photo 11, and if this jam were shifted or if a large flood occurred, a significant portion of the Flathead flow could be diverted to the back channel, thereby destroying its usefulness as part of the Howell diversion. Consideration would have to be given to providing a more substantial blockage at the Flathead entrance to limit the possibility of channel switching. This may take the form of a low rockfilled dyke with flat side slopes to allow overtopping during extreme floods but limit the possibility of washout.

3.4 Cost Estimate

A quantity and cost estimate has been developed for this alternative using the available topography. As the contour interval on the mapping is 5 feet, and the minimum channel excavation is 2 to 3 feet, it is not possible to develop accurate quantity estimates. Quantities have been taken from the cut depths as defined by Drawing -4, modified subjectively by study of the aerial photographs.

The cost estimate is as follows:

Item	Quantity (yd^3)	Unit Cost ($/$yd^3$)	Amount ($)
Channel cut	330,000	$ 2.50	825,000
Dyke fill	50,000	2.00	100,000
Rip rap	30,000	10.00	300,000
Diversion dam	35,000	2.00	70,000
Spawning gravel	2,500	10.00	25,000
		Total estimated cost	$1,320,000

4. COMPARISON OF ALTERNATIVES

Appendices I and II contain summaries of the Northwest Hydraulics and Mine Department proposed routes respectively. The key features of these proposals, and the present proposal are summarized in Table 2.

The presently proposed channel is longer than the portion of Howell lost by the diversion, and has provision for development of fishery habitat for spawning and rearing. Spawning gravels of correct gradation would be initially placed in the channel so that the channel would be productive from commencement of diversion.

On the basis of the comparison of Table 2, it is recommended that the presently proposed channel be adopted for diversion of Howell Creek.

When a decision to proceed with mine development is made, a detail topographical survey should be done of the route corridor. Using the detailed survey, the final route would be developed making best use of the micro-topography of the region.

KLOHN LEONOFF CONSULTANTS LTD

A. H. Rowland

A. H. ROWLAND

E. A. Portfors

E. A. PORTFORS, P. Eng.

AHR/EAP/bl

TABLE 1

CHANNEL DETAILS

PROPOSED HOWELL DIVERSION

REACH (feet)	SLOPE (%)	CHANNEL CONFIGURATION	FISHERY ENHANCEMENT DETAILS
00+00 to 10+00	0.5	Single channel 17 ft cut max	Spawning areas in resorted sands and gravels, boulders in bed.
10+00 24+00	0.5	Wide braided channel	Spawning areas in resorted sands and gravels, optional addition of spawning gravels.
24+00 36+00	1.6	Single channel 16 ft cut max	Boulders, rock rapids alternating with low velocity sections.
36+00 40+00	0	Pond	Rearing habitat
40+00 67+00	1.6	Main channel plus secondary channels	Rearing habitat in secondary channels.
67+00 72+00	0.5	Low flow channel with overbank flooding	Spawning habitat
72+00 75+00	0.0	Pond	Rearing habitat
75+00 79+00	1.0	Riffle	Spawning habitat
79+00 82+00	0.0	Pond	Spawning & rearing habitat

TABLE 1 Con't

82+00 89+00	1.0	Main channel plus possible secondary channels.	Rearing in secondary channels.
89+00 93+00	0	Ponds & marsh	Rearing habitat.
93+00 99+00	1.0	Single channel 12 ft cut maximum	Transit
99+00 105+00	0	Pond	Rearing habitat
105+00 109+00	0.5	Low flow channel with overbank flooding	Spawning habitat
109+00 126+00	1.0	Single channel with multiple riffles	Transit & rearing
126+00 148+00	0.2	Ponds & riffles (4)	Rearing & spawning habitat
148+00 165+00	0.9	Single channel with possible secondary channel	Rearing in secondary channel
165+00 167+00	0	Large pond	Rearing
167+00 192+00	1.4	Single channel with boulders alternating slow, fast sections	Transit

TABLE 1 Con't

192+00 215+00	0.2	Multiple ponds and riffles	Spawning & rearing habitat
215+00 240+00	1.0	Wide shallow braided channel with excavated floodplains	Transit, possible spawning
240+00 263+00	0.5	Low flow channel in Flathead floodplain	Spawning habitat

TABLE 2
HOWELL DIVERSION ALTERNATIVES

ITEM	NORTHWEST HYDRAULICS	MINISTRY OF MINES	KLOHN LEONOFF
Channel length (feet)	16,400	18,500 to 23,500	25,800
Average slope	1.3 %	0.9 %	0.9 %
Steepest slope	2.25 %	0.9 %	1.6 %
Main channel -width (feet) -depth (feet)	 35 5	 30 to 40 3 to 5	 35 2 to 3
Floodplain -width (ft)	Nil	200 to 300	100 + natural areas
Secondary or back channels (ft)	Nil	Nil	3,200
Ponds	Nil	Nil	11 min.
Bank erosion potential	Stable	Unstable	Stable in deep cut sections, Bank material re-sorting in shallow areas.
Bed aggradation/ degradation	Stable	Unstable	Stable
Fish spawning habitat	Poor	Good (may need to add some gravels)	Good (may need to add some gravels)
Fish rearing habitat	Poor	Moderate	Good
Fish passage provision	Moderate	Very Good	Good
Channel character	Simple, single channel. Pools and riffles in steep areas	Single meandering channel in floodplain. Constant slope.	Varied, multiple channels. varied slope, pools and riffles, larger ponds.
Extreme flood capabilities	Good	Poor	Good

REFERENCES

1. "Preliminary Environmental Impact Assessment of the Proposed Sage Creek Coal Project, Stage 1 Report", B.R. Hinton and Associates Ltd, Henry J. Kaiser (Canada) Ltd, Rio Algom Ltd, The Unecon Partnership, July 1976.

2. "Sage Creek Coal, Site Hydrology", Northwest Hydraulic Consultants Ltd, July 1976.

3. "The Sage Creek Climatological Program, September 1975 - October 1976", K.F. Harry, May 1977.

4. "Fisheries Investigations in the Flathead River Drainage, British Columbia", G.J. Mann, Aquatic Environments Limited, December 1976.

5. "Sage Creek Coal Study, Draft Report on Fisheries of the Mine Site Vicinity", Aquatics Environmental Consultants Ltd, December 1976.

<u>APPENDIX I</u>

Northwest Hydraulic Consultants
Proposed Route

APPENDIX I

Northwest Hydraulics Consultants Proposed Route

1. DESIGN SUMMARY

The Northwest Hydraulics July 1976 report[1] was a preliminary engineering study of the proposed diversion. Basic diversion design criteria were:

1. Provision of a stable channel. Such a channel would have little long term tendency to generally aggrade, degrade, widen, become narrower or to develop major changes in the meander pattern. Thus the channel should be essentially maintenance free. However, localized changes to the channel geometry would be expected similar to changes that occur in natural channels.

2. Provision of a channel which would allow fish to migrate up the diverted creek and which contained fish habitat for spawning and rearing. It was considered feasible to develop spawning and rearing habitat in various locations within the diversion channel, and possibly also in artificial channels nearby; consequently the criteria of ensuring fish passage upstream was considered most critical.

3. Development of a diversion with a realistic capital cost.

(1) Northwest Hydraulics Consultants Ltd "Sage Creek Coal, Howell Diversion", July, 1976.

Details of the proposed diversion are as follows:

1. Hydrologic studies yielded the following estimated mean daily flood discharges for Howell Creek:

Mean annual flood	900 cfs
5 year recurrence	1100 cfs
10 year recurrence	1350 cfs
50 year recurrence	2100 cfs
100 year recurrence	2500 cfs

   Design floods adopted were 1200 cfs as the regime or channel formative discharge (the flood which determines the character of the channel), and 2500 cfs as the peak flood to be passed.

2. A single channel was provided with the following dimensions:

bed width	35 feet
channel depth	5 feet
side slopes	2H:1V

3. The regime or stable channel slope was calculated as 0.5%. The general existing Howell slope is 0.9% but as the existing channel has log jams, numerous back channels and contains tortuous meanders, it is expected that the stable slope of the single, gently meandering diversion channel would be about one half that of the natural channel.

4. Total length of new channel was 16,400 feet compared to 21,000 feet of original Howell channel above the Cabin confluence and 8,000 feet of channel affected between the Cabin-Howell confluence and the Flathead.

5. Average slope of the diversion channel was 1.3% with the steepest sections being 2.25%.

6. To provide for fish passage up the steep portions, alternate lengths of 0.5% and 4% slope would be provided. The mild slope portions would provide resting areas after the steep, high velocity reaches. The 4% sections would be a maximum of 25 feet long to allow Cutthroat trout to swim upstream at a maximum discharge of 1000 cfs.

   On average, flows are expected to exceed 1000 cfs once every 4 years for a total of 3½ days. During these periods, passage of fish would be restricted.

7. Spawning and rearing habitat were not specifically provided in the design. However, a reach about 3,600 feet long south of Beryl and Marl Lakes was identified as having potential for detail routing of the channel through depressions and ponds to develop habitat. An abandoned Flathead back channel with a length of about 10,000 feet was also identified as having potential for development of fish habitat.

2. DESIGN COMMENTS

Concerns of the Provincial regulatory agencies appear to centre around the loss from fishery use of 21,000 feet of original Howell channel between the diversion point and the Cabin confluence. In this reach, Howell meanders in a floodplain about 700 feet wide and has numerous sand and gravel bars, back channels, split channels, low gravel banks, good tree cover, alternating pools and riffles, etc, all of which make the reach good fish spawning and rearing habitat.

The proposed diversion channel would be a relatively straight single canal, in deep cut in some areas, have little or no floodplain, a lack of pools and riffles, few sand and gravel bars, a steeper average slope and therefore higher velocities; features which generally appear to provide poor fish habitat.

3. COST ESTIMATE

The estimated construction cost of the Northwest Hydraulics alternative was $760,000 in July 1976. Updating the estimated costs to comparable 1978 levels results in the following total cost estimate:

Item	Quantity (yd^3)	Unit Cost ($\$/yd^3$)	Amount ($)
Canal Cut	220,000	$ 2.50	550,000
Dyke fill (incl. diversion dam)	90,000	2.00	180,000
Rip rap	25,000	10.00	250,000
		Total estimated cost	$980,000

APPENDIX II

Ministry of Mines and
Petroleum Resources
Proposed Route

APPENDIX II

Ministry of Mines and
Petroleum Resources Proposed Route

1. DESIGN SUMMARY

The January 1978 proposal from the Ministry of Mines and Petroleum Resources(2) was to route the channel from the previous adopted diversion point on Howell, eastward to the Flathead north of Beryl and Marl Lakes. Main elements of the suggestion were:

1. Provision of a 200 to 300 foot wide excavated floodplain with a 1% slope toward the main flow channel. The uphill cut slope would be 2:1 and the downhill dyke fill slope 3:1.

2. Within the excavated floodplain, the main channel would be cut with a meandering pattern. Characteristics would be:

width	30 to 40 feet
depth	3 to 5 feet
slope*	0.9%
meander amplitude	200 to 300 feet

* This is the proposed floodplain slope, the main channel would meander within the floodplain and therefore have a flatter slope.

(2) Letter D.M. Galbraith (Ministry of Mines and Petroleum Resources) to D. Little, (Sage Creek Coal Ltd) January 19, 1978.

3. Options were presented for terminating the channel directly into the Flathead, into Marl Lake or into the Flathead back channel. Diversion channel lengths would be:

Termination	Channel Length
Flathead	18,500 feet
Marl Lake	23,500 feet
Flathead back channel	23,500 feet

With the Marl Lake alternative, the drainage out of the Lake to the Flathead would add channel that could be improved as habitat. In addition the Flathead back channel could be developed as habitat.

2. DESIGN COMMENTS

This alternative has the advantage of providing a wide floodplain area and a channel with low banks within the floodplain. However, the excavated floodplain would not contain natural, sorted sands and gravels found in natural floodplains, but would consist of the insitu deposits. Spawning sands and gravels would either have to be added or allowed to develop over time by natural sorting processes. Similarly, pools and riffles would develop slowly.

In a number of areas, the main channel impinges upon the floodplain dykes on the downhill side. As channel bank erosion is expected, extensive rip rap protection of the dykes will be required.

The route crosses the natural drainage from the mountain ridge on the north into Beryl and Marl Lakes. Drainage patterns in this area are poorly defined and the diversion channel may be subject either to large surface water lateral inflow or groundwater leakage into the lakes. This aspect would have to be investigated in detail.

3. COST ESTIMATE

A quantity or cost estimate for this alternative was not made by Mines Department. As part of the overall assessment of diversion alternatives, Klohn Leonoff reviewed the layout and made a preliminary estimate of quantities. Because the area traversed by the route is rolling and inclined to the south, earthwork quantities are very large and the alternative is expensive. The cost estimate, based on a nominal 250 ft wide flood plain, is as follows:

Item	Quantity (yd^3)	Unit Cost ($/$yd^3$)	Amount ($)
Floodplain cut	900,000	$ 2.50	2,250,000
Main Channel cut	240,000	2.50	600,000
Dyke Fill	125,000	2.00	250,000
Rip rap	40,000	10.00	400,000
Diversion dam	35,000	2.00	70,000
Spawning gravel	2,500	10.00	25,000
		Total estimated cost	$3,595,000

APPENDIX III

Photographs

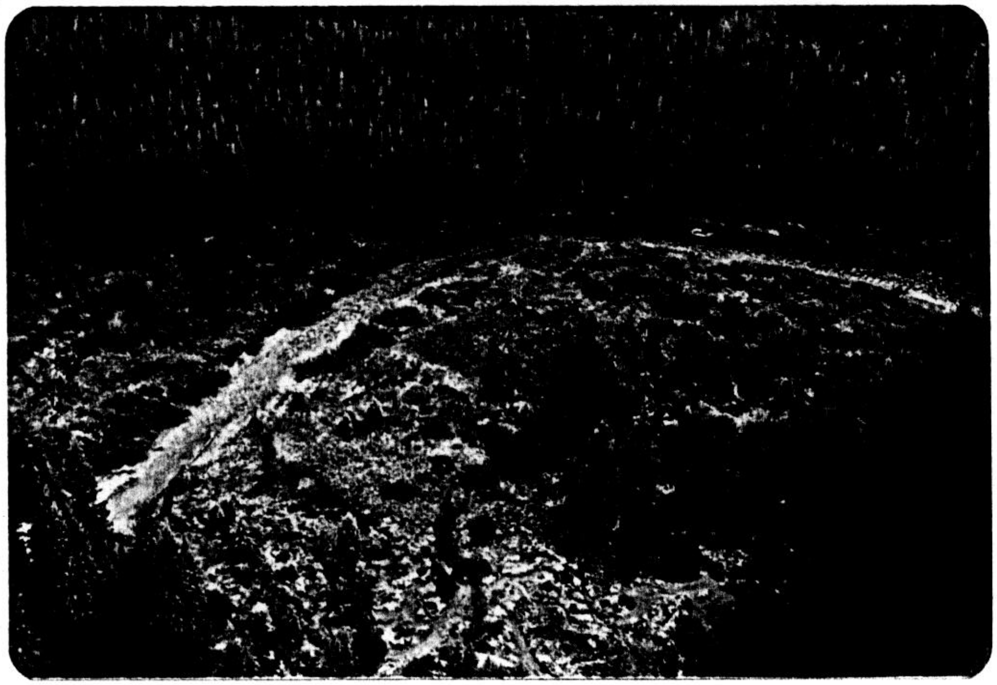


Photo 1
May 31, 1978

Howell Creek showing overbank flow. Discharge 330 cfs.

Photo 2
May 31, 1978

Howell Creek showing overbank flow.

Photo 3
May 31, 1978

Howell - Cabin confluence. Water Survey gauging station on Howell is at extreme top of photo.

Photo 4
May 31, 1978

Howell Creek looking downstream from a location just above the WSC station.

Photo 5
May 31, 1978

Howell Creek showing secondary channels and log jams.

Photo 6
May 31, 1978

Howell secondary channel showing heavy grass on silt bank and gravel bed.

Photo 7
May 31, 1978

Potential pond in proposed diversion route. Location of soil sample of Drawing 2392-2.

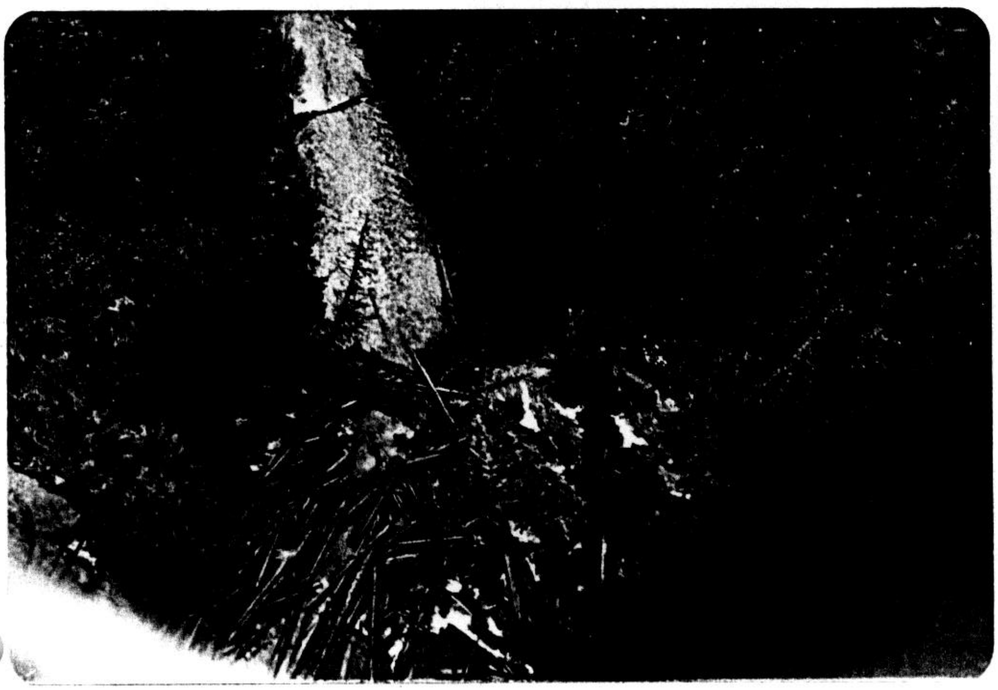


Photo 8
May 31, 1978

Major log jam in Howell Creek.

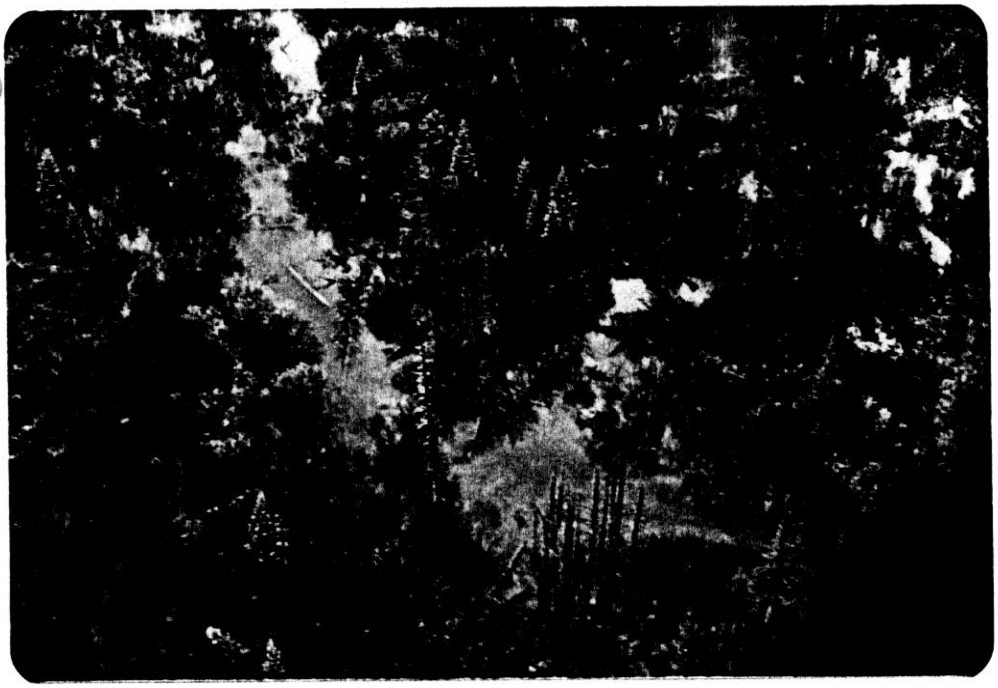


Photo 9
May 31, 1978

Flathead flood plain in vicinity of back channel.

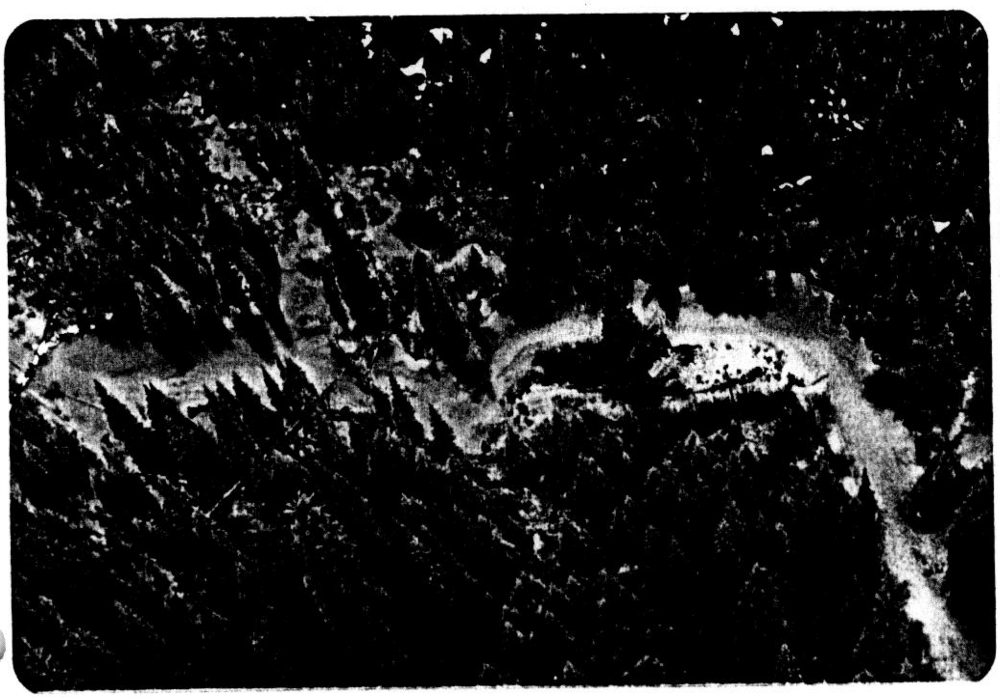


Photo 10
May 31, 1978

Flathead back channel showing gravel bars, secondary channels, etc.

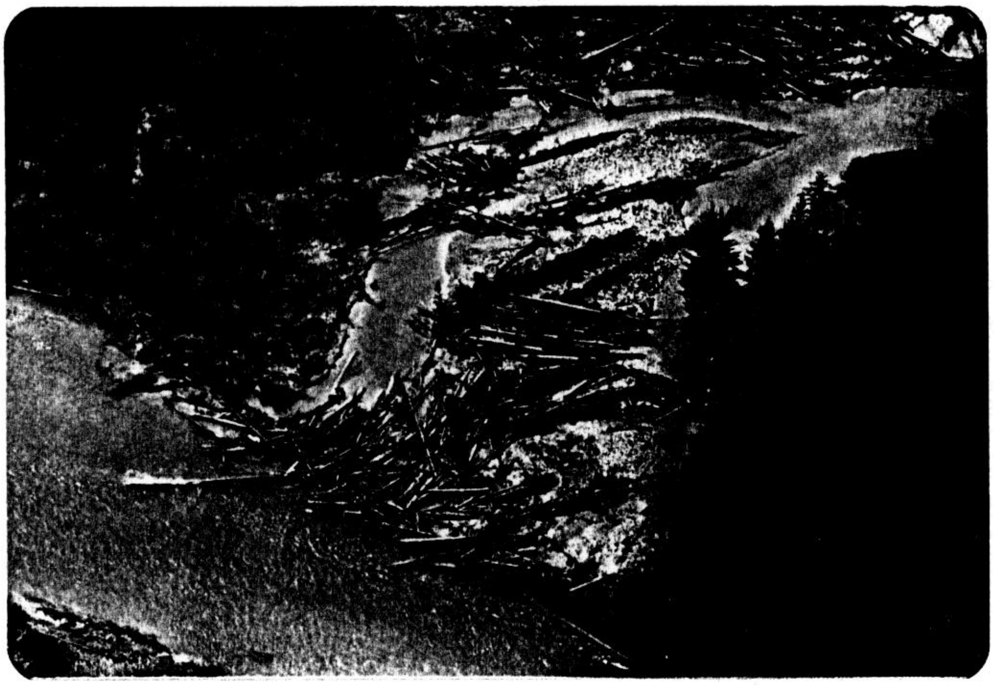
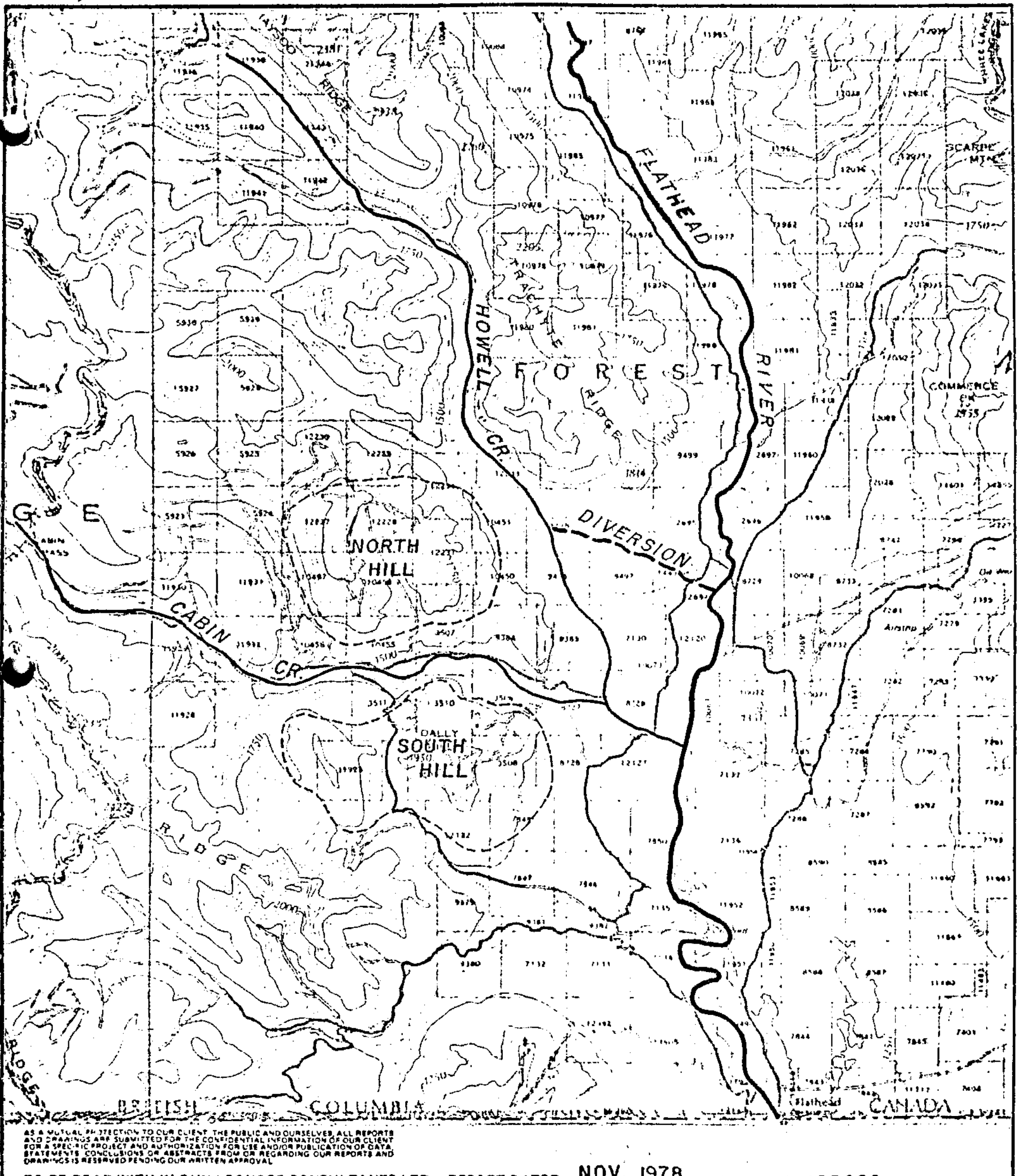


Photo 11
May 31, 1978

Entrance to Flathead back channel.

DRAWINGS

A-2392-1	Site Map
A-2392-2	Grain Size Curve
X-2392-3	Diversion Layout
X-2392-4	Route Profile



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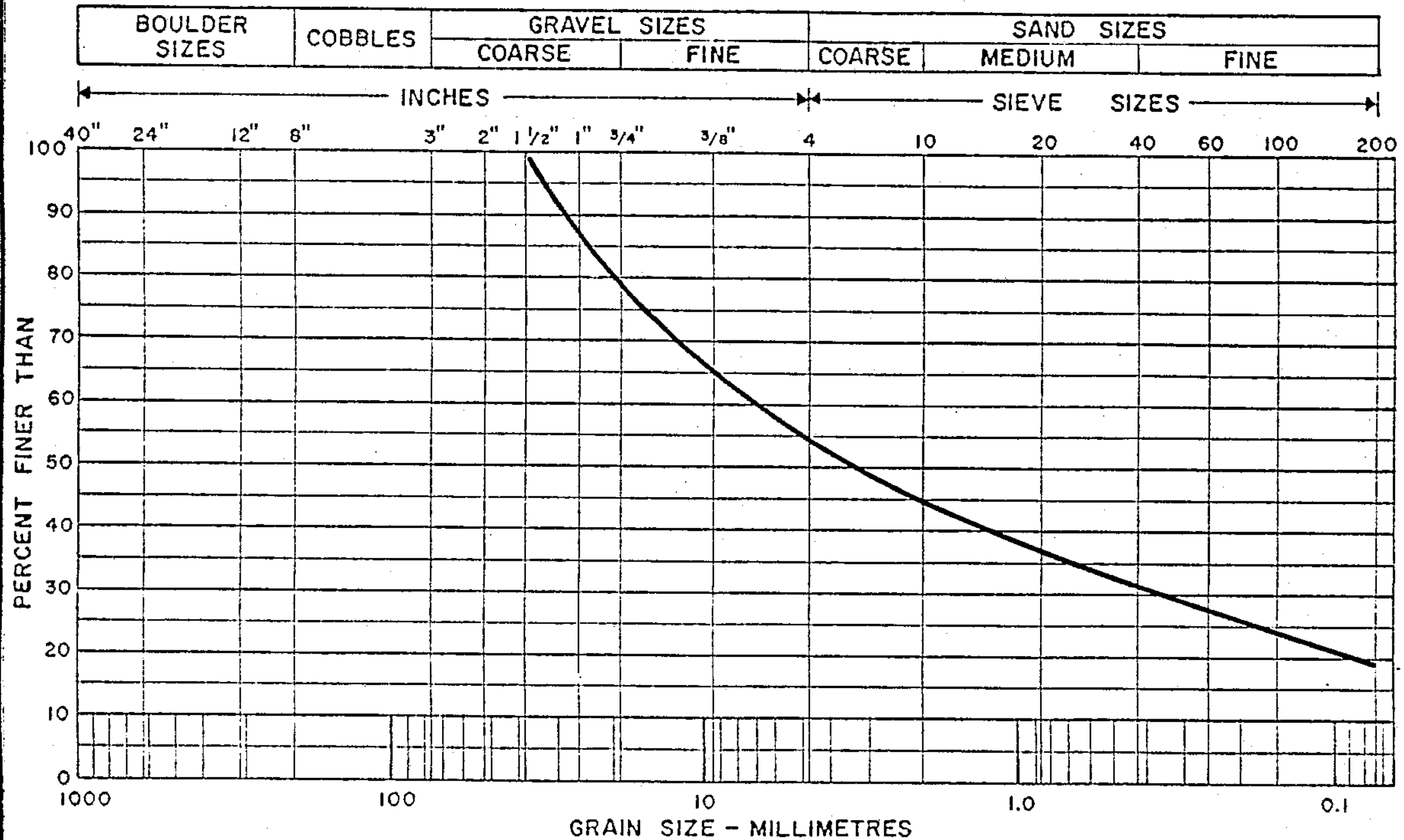
HOWELL CREEK DIVERSION

SITE MAP

CLIENT: SAGE CREEK COAL LTD.	APPD.	DWN. A.C.	DATE NOV/78	A-2392-1

GRAIN SIZE CURVE
GRANULAR SOILS



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HOWELL CREEK DIVERSION

GRAIN SIZE CURVE

APPR'D: [illegible] | DWN. A.C. | DATE NOV/78 | A- 2392-2

LEGEND

------	TENTATIVE INVERT
——	PRESENT SURFACE PROFILE

373

"Howell Creek Diversion Alternatives"

K - Sage Creek 79(2*) A * (10)

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	TITLE ROUTE PROFILE		
CLIENT SAGE CREEK COAL LTD.	DATE OF ISSUE NOV/78 APPROVED	PROJECT No. VA 2392	DWG. No. X-2392-4 REV.

M3

Golder Associates
CONSULTING GEOTECHNICAL ENGINEERS

REPORT TO
SAGE CREEK COAL LTD.
RE
STABILITY OF PROPOSED WASTE DUMPS
SAGE CREEK PROPERTY

FLATHEAD VALLEY BRITISH COLUMBIA

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August 1979 782-1145

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ABSTRACT

Studies have been carried out to assess the stability of proposed mine waste rock dumps that will be developed on steeply sloping foundations within areas adjacent to the proposed North Hill and South Hill open pit coal mines at the Sage Creek Coal Ltd. property in the Flathead Valley of Southeastern British Columbia. The results of the waste dump stability assessment are presented, together with the results of field and laboratory investigation carried out as part of this study.

1.0 INTRODUCTION

This report presents an assessment of the stability of proposed mine waste dumps that will be developed in conjunction with open pit mining operations at the Sage Creek Coal Property in the Flathead Valley, Southeastern British Columbia. Authorization for this assessment of the stability of the proposed waste dumps, and for preparation of this report were given by Sage Creek Coal Ltd.

2.0 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Four waste rock dumps will be developed on sloping foundations within areas adjacent to the proposed open pit coal mines at North Hill and South Hill. The topographic profiles within the foundation areas of the proposed dumps are generally concave in form. Foundation slopes beneath the upper regions of the dump are generally in the range of 26 to 28 degrees, although at some localized areas within the upper region of the South Hill northwest dump are as steep as 37 degrees. Beneath the toe region of the proposed dumps, the topography ranges from essentially flat to as steep as 18 degrees.

The majority of the dump foundation areas are mantled by glacial till. At some locations within the upper regions of the dumps, the glacial till is absent, and the upper surface of bedrock is virtually coincident with the ground surface. At locations where the glacial till is absent, the upper surface of bedrock is mantled by a veneer of colluvium consisting of silty sand with angular rock fragments.

The proposed dumps will be developed in a series of benches spaced at vertical intervals of approximatley 100 ft. During the initial stages of the mining operations, the waste rock will be utilized in development of benches above the steep topographic slopes within the upper regions of the dumps. While these initial benches are expected to remain stable, they will not have a high degree of stability with respect to en masse downslope movement as a result of shearing along their bases. Factors of safety for these initial benches will be of the order of 1.2. Successive development of benches over the flatter topographic slopes at lower elevation will provide lateral support for benches constructed on the relatively steep topography at higher elevations, thereby improving stability with respect to base sliding. Thus, the overall stability of the waste dumps will increase as dump development progresses onto the flatter topographic slopes toward the toe regions of the dump. Each of the completed waste dumps will all have an adequate margin of safety with respect to base sliding.

Occasional localized failures can be expected to occur from time to time throughout development of the dumps. If dumping operations were to proceed without heed to impending instability, such failures could represent a hazard to men and equipment engaged in dumping operations. Experience with the performance of waste rock dumps shows conclusively that these localized failures do not occur without warning. They are always proceeded by a period of at least a few days during which the rate of displacement at the crest of the waste pile increases progressively. In the interest of operating safety, rates of movement at the operating crests of the dumps should be monitored to warn of impending localized failures. The observational data will indicate those areas where dumping operations should be temporarily suspended, as well as areas where dumping operations may be resumed following a period of temporary suspension.

3.0 DESCRIPTION OF PROJECT

The Sage Creek Coal Ltd. Property is located in Southeastern British Columbia at latitude 49° 06", longtitude 214° 33" W, approximately. The geographical location of the site is indicated on Figure 1.

The Sage Creek coal reserves occur within two promininant hills on the west side of the Flathead River valley. These two hills are referred to in this report as North Hill and South Hill, the designations used by Sage Creek Coal Company Ltd. North Hill is bounded on its northeast side by Howell Creek, and on the south by Cabin Creek which joins Howell Creek approximately 1 mile upstream of the point where Howell Creek discharges into the Flathead River. South Hill is located immediately to the south of Cabin Creek. The elevation of the valley floor is approximately 4400 ft. The top of North Hill is approximately 990 ft. above valley floor, and the top of South Hill is approximately 750 ft. above valley floor.

Large volumes of waste rock will be generated in the course of the proposed open pit coal mining operations at North Hill and South Hill. This waste rock will be consigned to waste dumps which will be developed adjacent to the perimeter of the proposed open pits. According the present mining proposal, four separate waste dumps will be developed, two at North Hill and two at South Hill. For purposes of discussion in this report, the proposed waste dumps at North Hill have been designated North Hill North Dump, and North Hill West Dump. The dumps associated with the South Hill pit have been designated South Hill North-west dump and South Hill Southeast dump. The location of these dumps relative to the proposed open pits are indicated on Figure 2. The existing topography within the foundation area of the proposed waste dumps, as well as within the perimeter of the proposed open pits is shown on Figure 3.

4.0 CHARACTERISTICS OF WASTE DUMPS CONSTRUCTED BY END DUMPING

The proposed open pit mining operations will be carried out using truck and shovel. Waste rock will be loaded into trucks at the pit, and the trucks will haul the waste rock to the waste dumps where the material will be disposed of by end dumping at the crest of the waste pile. Each of the waste dumps will be developed in a series of level benches. In general, the surface of these benches will be at 100 ft. intervals in elevation. Owing to the relatively steep topographic slopes within some segments of the foundation area of the dumps, the difference in vertical elevation between the crest and the toe of the developing benches will at times be as high as 400 ft.

Disposal of waste rock by end dumping at the crest of the waste pile implies that the face of the waste pile during development will be maintained at the angle of repose for the material. Experience with waste dumps comprising similar materials in the East Kootenay area of Southeastern British Columbia shows that the angle of repose for the end dumped waste rock is approximately 37 degrees (1.33 horizontal to 1 vertical).

When a waste dump is developed by end dumping at the crest of the dump, the face of the dump advances by the process of gradual accretion of material that rolls and slides down the face of the waste pile. As the end dumped rock rolls and slides down the face of the waste pile, significant segregation of particle sizes occurs. As a result, the largest and most durable fraction of the rock fragments roll to, and come to rest at the toe of the advancing face of the dump. As the dump is developed progressively, and the face advances, this segregated coarse material at the toe becomes covered, to form a coarse, pervious, and well filtered zone within the base of the dump. This coarse zone at the base of the dump promotes internal downward drainage within the body of the waste rock and precludes the development of high pore water pressures at the base of the dump.

Collector ditches are proposed around the uphill limits of the waste dump to intercept surface run-off water, and to conduct this surface run-off water around the ultimate perimeter of the proposed dumps. Thus, the surface run-off interceptor ditches will preclude entry to the foundation area of the dumps, of surface run-off from outside areas. As a result, each individual waste dump will receive only that precipitation which falls within its perimeter. This fact, together with the coarse segregated rock zone which will form the coarse drainage layer at the base of the dump precludes development of pore water pressures within the base of the dump, which pore water pressures could adversely affect stability.

A waste rock spoil pile developed by end dumping at the crest can be subject to the following types of failure:-

1) Sliver failure near the crest.

2) Slumping of the face of the waste pile as a result of yielding at the toe.

3) Failure on the face of the waste pile as a result of rapid loss of support at the toe.

4) En masse downslope movement of the waste pile as a result of sliding on its base.

These types of potential failures are discussed briefly in Appendix A.

Type 1, and to a lesser extent Type 2 failures can occur irrespective of the slope of the foundation on which the dump is constructed. Type 3 and Type 4 failures are governed primarily by the topographic slopes within the foundation area of the dump, and by the shear strength characteristics of the surficial materials at shallow depth below ground surface.

Types 1, 2, and 3 failures can occur during dump development. If dump development were to proceed without heed to the rates of movement, the occurrence of these types of failures could represent a potential hazard to men and equipment engaged in dumping operations at the crest of the waste pile. In the interest of operating safety, displacements at the crest of the waste pile should be monitored, particularly during periods when the dump is being developed over the steeper segments of the topography. A simple method of monitoring displacements at the crest of the dump is discussed in Section 9.

5.0 NORTH HILL NORTH DUMP

5.1 General Description

The location of the proposed North Hill north dump is indicated on Figure 2, and the topography within the foundation area of the dump is shown on Figure 3, and plans showing the layout of the North Hill dumps are shown on Figures 4 and 5. The North Hill north dump will occupy an area of approximately 780 acres. As shown on Figure 3, the northeastern limit of this dump extends beyond the present location of Howell Creek. A diversion channel will be constructed to divert Howell Creek around the northeastern limit of this dump.

The topographic slope within the foundation area of the North Hill north dump varies from a maximum of approximately 26 degrees near the southwestern limit of the dump, to virtually flat within the northern portion of the dump which will be located on the Howell Creek floodplain and in the glacial till plain between Howell Creek and the Flathead River. In general, topographic slopes decrease from the upper limit of the dump with decreasing elevation toward the Howell Creek floodplain.

The maximum difference in elevation between the crest and the toe of the completed dump will be approximately 770 ft. The average overall slope on the face of the completed dump will be between 8 and 9 degrees. Typical sections through the North Hill north dump are shown on Figure 8. As indicated on the figure, the dump will be developed in two stages. During stage 1, a series of benches will be constructed on the sloping hillside within the southern region of the dump. The maximum height of slope (i.e. the difference between crest and toe elevation) for individual benches is approximately 400 ft.

5.2 Foundation Conditions

Beneath the upper region of the North Hill north dump, the upper surface of bedrock is approximately coincident with ground surface, although at isolated locations hard glacial till soils mantle the upper surface of rock. The glacial till consists of a matrix of very dense clay, silt, and sand size particles with scattered stone generally to 1 inch size, but with occasional cobbles and boulders. At locations where the glacial till is absent, the upper surface of rock is mantled by a thin veneer of colluvial soil composed predominantly of silty sand with scattered angular rock fragments throughout.

The glacial till soils underlie virtually the whole of the foundation area of the North Hill north dump. Beneath the flat ground below elevation 4450 approximately, the glacial till is mantled by clayey silt floodplain deposits, and on either side of Howell Creek by floodplain gravels. Although the glacial till mantles the lower region of the natural slope, the till deposit is relatively thin as evidenced by the fact that extensions of faults as mapped within the North Hill pit area can be traced on the air photographs across the foundation area of the dump. That is, expressions of the faults in the underlying bedrock are evident on the ground surface within areas mantled by glacial till.

5.3 Stability

The cross-sections through the North Hill north dump as shown on Figure 8 have been drawn along the "fall lines" of the topographic slope, and therefore show the steepest segment of the foundation on which the dump will be constructed. As shown on Figure 8, the average overall slope on the surface of the completed dump is approximately 6 horizontal to 1 vertical. The completed dump will be unquestionably safe with respect to sliding on its base.

We have examined the stability of the stage 1 dump during its sequential development. The method of stability analyses employed, and an explanation of the results of the anayses as presented on the cross-section A-A Figure 8, is included in Appendix B. The results of the stability analyses show conclusively that with successive bench construction onto the flatter topographic slopes, the angle of internal friction required for a given factor of safety decreases. Alternatively, the factor of safety of the dump with respect to sliding on its base increases significantly as the toe region of the dump is advanced onto progressively flatter ground.

The results of laboratory shear strength tests on representative samples of the glacial till soils are included in Appendix D. The test results indicate that the effective angle of internal friction of these materials is in the range 30 to 35 degrees. These tests were conducted on reconstituted specimens, as opposed to test specimens prepared from undisturbed intact samples of glacial till soil. The undisturbed in situ glacial till will have somewhat higher shear strenght characteristics than those indicated by the laboratory test results conducted on the disturbed and reconstituted test specimens. We expect that the in situ surficial soils will have a friction angle of 35 degrees or slightly higher. The upper surface of the glacial till soils are weathered, and form a zone 1 to 2 ft. thick of silty sand over the surface of the till. The angle of internal friction within this weathered zone can be expected to be approximately 35 degrees.

The results of the stability analyses for section AA, as summrized on Figure 8, indicate that for a factor of safety of 1, the required friction angle at the base of the dump ranges from 19.5 degrees for the stage 1 bench at elevation 4950, to 15 degrees for the 4950, 4900, and 4800 benches together. For a factor of safety of 1.3, the corresponding required angles of internal friction are 24.5 and 19.5 degrees. Based on the results of the stability analyses, together with the probable in situ shear strength parameters for the in situ soils as noted above, we conclude that during initial stages of dump development, while benches are being constructed over the steeper segments of the topography, these segments will remain stable, and will not be subject to en masse downslope sliding as a result of shearing along the base. As successive benches are developed at progressively lower elevations, the dump will become progressively more stable.

The completed dump will have a very large factor of safety with respect to downslope sliding on its base. That is, Type 4 failures (reference Appendix A) of the completed dump will not occur.

6.0 NORTH HILL - WEST DUMP

6.1 General Description

As indicated on Figure 2, the North Hill west dump will be located to the west of the proposed North Hill Pit, on the steeply sloping ground above the left hand side of Cabin Creek. The proposed dump will occupy an area of approximately 330 acres.

The topographic slopes within the foundation area of the proposed North Hill west dump range from a maximum of approximately 28 degrees beneath the elevation 5200 bench, to approximately 5-1/2 degrees beneath the toe region of the dump. The ground surface profile is concave upward. Base slopes beneath the dump become progressively flatter with decreasing elevation.

The proposed dump will be developed in a series of benches. During stage 1, four benches will be developed on the upper region of the slope and five benches on the lower slopes. During stage 2, additional waste rock will be placed within the lower region of the dump (see Figures 4 and 5, and Figure 9).

6.2 Foundation Conditions

Within the upper region of the dump, the upper surface of bedrock is virtually coincident with ground surface. Within this region, the upper surface of rock is mantled by a thin veneer of colluvium consisting of silty sand and angular rock fragments. Within the lower region of the dump bedrock is masked by hard glacial till soils. A prominant exposure on the left hand side of Cabin Creek indicates that the thickness of glacial till beneath the toe region of the dump in at least some locations may be greater than 100 ft.

Bedrock within the foundation area of the North Hill west dump consists of rock of the Fernie Group. The dip of the sedimentary unit beneath the upper region of the dump ranges between 30 and 35 degrees, with the dip direction toward the southeast. The strike of the sedimentary rock units is approximately perpendicular to the topographic slope, hence the bedding dip of the sedimentary rock units is not an adverse factor relative to the stability of the upper region of the dump. The sedimentary rock units are intersected by cross-joints that dip at angles ranging between 65 and 80 degrees. The dip direction of these cross-joints is subparallel to the topographic slope.

6.3 Stability

The stability of the dump during intermediate stages of development was investigated using the Janbu method of stability analyses. The results of these analyses are summarized in graphical form on Figure 9 which shows the effective angle of internal friction required at the base of the dump for factors of safety of 1.0 and 1.3 for successive stages of development (see Appendix B).

The mobilized friction angles determined by the stability analyses, and plotted on Figure 9 show that the stability of the dump increases as the lower regions of the dump are developed onto progressively flatter topographic slopes. Hence the stability of the dump with respect to base sliding improves progressively as the dump is developed onto flatter ground.

As noted in the previous section, the in situ glacial till soils are expected to exhibit effective angles of internal friction of approximately 35 degrees. The friction angle for the silty sand colluvium that mantles the upper surface of the bedrock within the upper region of the dump is of the same order, i.e. approximatley 35 degrees. The stability analyses indicate that the completed North Hill west dump will have an adequate factor of safety. Although the stability of the upper regions of the eastern portion of the dump will be low during initial stages of development, we do not anticipate that the initial benches will be subject to en masse downslope movement as a result of shearing along the base of the dump.

7.0 SOUTH HILL - NORTHWEST DUMP

7.1 General Description

As shown on Figure 2, the South Hill northwest dump will be located west northwest of the proposed South Hill open pit. This dump will be fully developed in the course of the stage 1 mining operations at South Hill, and as presently proposed, the dump will occupy an area of approximately 390 acres.

The dump will be developed in a series of benches. The uppermost bench will be at elevation 5300, and the lowest bench will be at elevation

4700. The average overall slope of the surface of the completed dump will be approximately 16 degrees.

Of the four waste rock dumps proposed at the Sage Creek property, the steepest topographic slope occur beneath the South Hill southwest dump. Three fall-line sections through this dump are shown on Figure 10. Beneath parts of the uphill limit of the proposed dump, topographic slopes are as steep as 37 degrees. The topographic slopes beneath some segments of the toe region of the dump vary between 12 and 18 degrees.

7.2 Foundation Conditions

Within the upper region of the South Hill northwest dump, the upper surface of bedrock is approximately coincident with ground surface. The soil mantle in this region consists of silty sand colluvium with angular rock fragments. Within the mid slope region of the dump foundation, the becrock is mantled by glacial till soils consisting of a heterogeneous assortment of clay, sand, and silt size particles with scattered gravel and occasional cobbles and rounded boulders. The thickness of the glacial till mantle within the mid slope region of the dump foundation area has not been determined since the test pits in this region (test pits 4 and 5, Appendix C) did not extend through the glacial till. The till cover is judged to be relatively thin since joint patterns in the underlying bedrock are evident on the aerial photographs within the mid region of the dump.

Near the location of test pit No. 5, spring activity on the hillside has been responsible for development of a localized area of soft surficial organic soils.

Jurassic rocks of the Fernie group underlie the foundation area of the proposed dump. Geologic mapping within the area of the proposed South

Hill Pit, as well as rock joint patterns discernable on the aerial photographs indicate that the stratigraphic dip of the sedimentary units is toward the east. Thus, the strike of the sedimentary beds is approximately perpendicular to the topographic slope within the foundation area of the dump.

7.3 Stability

Three fall-line sections showing the natural topographic slope, and the configuration on the surface of the proposed dump are shown on Figure 10. At section EE, the slope of the natural ground surface beneath the elevation 5300 bench, and beneath part of the elevation 5200 bench is approximately 37 degrees. At least part of this steep topographic slope is formed by the resistant sandstone strata that underlie the No. 5 coal seam. If construction of the level 5300 and level 5200 benches is undertaken before the level 5100 bench is in place, failure of the 5300 and 5200 benches may occur as a result of downslope sliding of this segment of the bench on its base (the Type 4 failure discussed in Appendix A). If such a failure were to occur, the slide debris would come to rest in the draw at the base of this steep segment of the slope. We do not expect that the slide debris would travel downslope as far as the proposed ultimate lower limit of the dump. The remainder of the topographic slope at section DD is sufficiently flat that the segment of the dump below, and including the elevation 5000 bench can be expected to remain stable.

Section DD on Figure 10 shows a fall-line profile at a location where the sandstone stratum beneath the No. 5 seam coal forms a ridge that juts into, and forms an indentation in the upper limit of the foundation area of the dump. As shown on section DD, the ground surface profile is concave upward. The topographic slope beneath the upper region of the dump is approximately 28 degrees, and the slope becomes progressively flatter with decreasing elevation. Beneath the toe of this segment of the dump the topographic slope is approximately 13 degrees.

Stability analyses were carried out for section DD, Figure 10, using the method of analyses described in Appendix B. The results of the stability anlayses for this section are shown in graphical form on the figure. If development of the dump commences within the upper region and successively lower benches are constructed in sequence, the stability analyses show that the factor of safety with respect to base sliding (Type 4 failure as per Appendix A) increases progressively with time. The completed dump will have an adequate factor of safety, and there is no possibility that the completed dump will undergo en masse downslope movement as a result of sliding on its base.

As noted previously, spring activity in the vicinity of test pit 5 has resulted in development of soft organic soils within a localized area. When the toe region of the dump advances into this area, Type 2 failures as described in Appendix A may be expected to occur. In the event of such an occurrence, we expect that the failure would be localized, and would take the form of slumping on the face of the waste pile. We do not expect that the slide debris would travel any appreciable distance downslope. The slide debris would remain within the design limits of the completed dump.

Within the area immediately to the southeast of line YZ as marked on Figure 3, the resistant sandstone unit that underlies the No. 5 coal seam forms topographic slopes as steep as 37 degrees. If a segment of the waste dump is advanced onto these steep slopes before lower benches are in place, occasional Type 3 failures (as described in Appendix A) may occur.

Slide debris form a Type 3 failure can attain high velocity, and may come to rest at a surprisingly large distance from the position occupied by the toe of the waste pile prior to the failure. The run-out distance of a Type 3 slide cannot be calculated. However, empirical data for Type 3 slides from the face of waste piles composed of rocks similar to those that will be consigned to this waste dump indicate a relationship between the Fahrboshung or run-out angle, and the height of the waste dump. The crest-to-toe height of an individual bench at the proposed South Hill northwest dump would not exceed approximately 400 ft. The empirical data shown on Figure A-3(f) indicate that for a 400 ft. high segment of the waste dump the cotangent of the Fahrboshung would probably not exceed 2.5, which corresponds to an angle of approximately 22 degrees. Applying this angle, the reach of the slide debris from a Type 3 failure would lie within the ultimate perimeter of the dump. Although some Type 3 failures may occur at the South Hill northwest dump, the slide debris from such failure does not propose a threat to Cabin Creek.

It has been suggested by others that the lines marked XY and ZY on Figure 3 represent the approximate lateral limits of an old slide, the failure surface of which is located within the Fernie rocks. No subsurface investigations in the form of drilling have been carried out to investigate the possible presence and depth below surface of the potential failure zone. Our investigations have been limited to visual examination of the area, and study of both vertical and oblique aerial photographs. Based on this study, we are of the opinion that the area is not an old slide. The steep topographic slopes on the right hand side of the drainage course along line YZ as marked on Figure 3, are formed by the resistant sandstone beds that underlie the No. 5 coal seam.

Upstream of the Cabin Creek bridge which connects the road systems of North Hill and South Hill, a segment of the Cabin Creek channel is relatively straight. This straight segment of the stream channel appears to be coincident with a fault. What appears on the aerial photographs to be a surface expression of the upstream extension of this fault crosses the toe region of the proposed dump. If any significant mass movement of the rocks within the area bounded by the lines XY and ZY (Figure 3) had occurred in the past, the alignment of the fault would have been displaced, or alternatively would have been obliterated across the toe region of the postulated slide. Mass movement has certainly not occurred recently as evidenced by the fact that the channel of Cabin Creek at this particular location is flowing on the right hand side of the floodplain, adjacent to the toe of the slope. Although the topography is suggestive of mass movements, we are of the opinion that no slide has in fact taken place in this area.

8.0 SOUTH HILL - SOUTHEAST DUMP

8.1 General Description

The proposed South Hill southeast dump is located southeast of the proposed South Hill Pit as shown on Figure 2. This dump will occupy an area of approximately 1100 acres. The dump will be developed in a series of benches. The uppermost bench will be at elevation 5300, and the lowest bench will be at elevation 4400. The maximum difference in elevation between the uppermost bench and the toe of the dump will be approximately 1000 ft. However, the average overall slope on the surface of the completed dump will be less than 8 degrees.

Over most of the foundation area of the dump, the topographic slope is less than 14 degrees. Within a small segment beneath the upper region of the dump the existing topographic slope is as steep as 26 degrees. Beneath the toe region of the dump the natural topography slopes at approximately 3 degrees.

8.2 Foundation Conditions

Most of the foundation area of the proposed South Hill southeast dump is mantled by glacial till soils. Glacial till is exposed at several locations along an existing roadway that traverses the lower region of the dump, and glacial till was encountered in test pits located within the upper region of the dump. The locations of test pits excavated within the foundation area of this dump are shown on Figure 3, and the logs of these test pits are included in Appendix C.

The glacial till is underlain by the Tertiary Kishenehn clays. Test pit 7A, which was excavated at a location within 50 ft. of test pit 7, encountered the Kishenehn clays. At this location the glacial till was absent.

While glacial till is believed to mantle most of the foundation area of the proposed dump, the till is believed to be relatively thin. This conclusion is based on the fact that surface expressions of the southward extensions of faults as mapped within the area of the proposed South Hill Pit can be traced across the foundation area of the dump. The fault system within the underlying rocks form a northwest-southeast linear pattern on the aerial photographs. The fault system within the underlying rock at some locations has sufficiently strong topographic expression to control the natural drainage pattern within the foundation area of the dump.

Within the toe region of the dump, local minor depressions appear to be coincident with the fault system in the underlying rock. Since the topographic slope is relatively flat, these localized minor depressions are poorly drained and are infilled with peat and soft organic soils.

8.3 Stability

Two typical cross-sections through the dump are shown on Figure 11. The sections are along the fall-line of the slope and represent the steepest sections of the foundation profile within the dump. With the exception of the upper part of the profile on section GG, the slope of the ground surface is so gentle that stability analyses did not appear warranted. The completed dump will be very stable, and there will be no possibility that the dump will undergoe en masse movement as a result of shearing along its base.

As the dump is developed progressively, and the toe region advances onto localized areas that are occupied by poorly drained soft organic soils, occasional Type 2 failures (see Appendix A) can be expected to occur. These failures will result in displacement of soft soils at the toe of the dump, and in slumping on the face below the crest of the active bench.

9.0 MONITORING OF CREST MOVEMENTS

Occasional failures can be expected to occur from time to time at the operating crests of the benches during their development. If development of the dumps were to proceed without heed to impending instability, such failures could represent a hazard to men and equipment engaged in dumping operations.

Experience shows that failures at the operating crests of waste dumps do not occur without warning. The failures are always preceded by a period of at least a few days during which crest displacements develop at progressively increasing rates. Thus, if the movements at the crest of the pile are monitored continuously, interpretation of the recorded rates of movement will give ample warning of an impending failure. The recording and interpretation of movement data on a daily basis should be considered as an integral part of dump development. It will not be sufficient to make casual observations of surface cracking adjacent to the crest of the pile since, if dumping operations are confined to a limited area, evidence of crack development and/or subsidence may be obscured or erased by truck traffic and by bulldozing operations, in which case accelerating crest movements might not be detected.

Records of the rates of crest movements should be maintained from the outset of dump development to provide advance warning of impending instability on the face of the waste pile. The device suggested for monitoring of crest movements is illustrated schematically on Figure 12. The device consists of a pin driven into the face of the slope at a point below the crest of the waste pile. A light flexible wire attached to the pin is run through pulleys attached to light portable stands. The stand farthest from the crest is located on stable ground, and a weight is suspended from the end of the wire. As displacements occur on the face of the pile, the end of the wire attached to the pin is pulled downslope, raising the suspended weight. A record of the rate of movement is obtained by taking periodic measurements of the vertical distance between the suspended weight and a reference point on the base of the stand.

The measuring device is crude. However, experience has shown that in many instances, rates of movement in excess of 3 ft. per day, and total crest movements in excess of 30 ft. have occurred which did not lead to mass sliding. Considering the large magnitude, and rates of movements that normally precede failure on the face of a waste rock dump, the crude monitoring devices provide data of sufficient accuracy.

The operating principal of the monitoring devices is simple. They are inexpensive, can be installed quickly, and they can easily be moved to a new location when required. The movement readings can be taken by one person (a survey crew is not required) and the movement progression can easily be watched by the dump foreman during periods when relatively rapid crest movements are occurring at a particular location, and close monitoring of the rate of movement is advisable.

Waste disposal operations should be temporarily suspended at locations where the measured rate of displacement at the crest of the waste pile is greater than 1.5 ft. per day. Following a period of temporary suspension, spoiling operations can be resumed when the recorded rate of displacement is equal to or less than 1.5 ft. per day, provided also that the recorded rates of displacement are decreasing progressively with time.

Careful observation and interpretation of crest movement data will permit appropriate selection of locations where dumping operations can proceed without danger, where operations should be temporarily suspended, and where dumping may be resumed after a period of temporary suspension because of excessive movements at the crest.

9.1 Zone of Crack Formation

The light portable stand farthest from the crest of the dump (Figure 12) should be positioned on stable ground. The materials deposited on the face of the waste pile will be loose and, subject to compression under the weight of subsequent layers of waste rock added to the face of the pile. As a result, vertical settlement of the surface of the waste pile will take place within the region adjacent to its crest. The face of the waste pile will be maintained at its angle of repose (approximately 37 degrees) during development, which implies that the factor of safety for potential failure surfaces located at shallow depth below the face of the dump are at all times only marginally greater than unity. Under these stress conditions, the waste materials undergo shearing strains which are manifested in the form of vertical and, horizontal displacements, and cracking on the operating surface of the dump within the region adjacent to the crest of the slope.

Theoretical considerations indicate, and field observations confirm, that the width of the zone adjacent to the crest within which cracking and displacement occur is a function of the vertical height of the slope. Figure 13 shows a summary of empirical observations obtained at operating mines in the East Kootenay region of B.C. These data indicate that the width of the zone of cracking at the crest of a waste dump is roughly proportional to the height of the waste pile. For a bench having a crest to toe height of approximately 400 ft. (approximately the maximum height of proposed individual benches) and a slope angle of 37 degrees, Figure 13 indicates that the zone of cracking could extend a maximum distance of approximately 80 ft. back from the crest.

10.0 TOPSOIL

There is a paucity of topsoil within the foundation area of the proposed waste dumps. The natural organic litter on the forest floor appears to have been destroyed by the forest fire that swept the area in the

1930's. As a result, the organic topsoil is virtually absent, and soil suitable for reclamation work and/or landscaping is scarce.

The flat area located between Howell Creek and the toe of North Hill appears to be one location where soil suitable for landscaping purposes could be obtained if such is required. Based on the materials as exposed in test pits 1 and 2, it appears that the upper 2 ft. (approximately) of the soil mantle within this area would be suitable for landscaping and/or reclamation work. It would be necessary to strip these soils well ahead of the advance of the toe of the dump into this area. We wish to point out however, that stripping and removal of soils from this area is not required for dump stability. Stripping of the upper 2 ft. of soil from this area would not adversely affect dump stability.

Alternative sources of organic soil are located within the southeastern region of the South Hill southeast dump. While the materials have not been investigated, we expect that organic soils could be recovered from the localized poorly drained depressions in this area. We expect that the soils contained in these poorly drained depressions are soft, and that they are probably incapable of supporting pneumatic tire mounted equipment. Excavation of these soils probably be a dragline operation. Since these materials could be expected to be soft and saturated, stockpiling of these soils for later use would be difficult.

Yours very truly

GOLDER ASSOCIATES

David B. Campbell

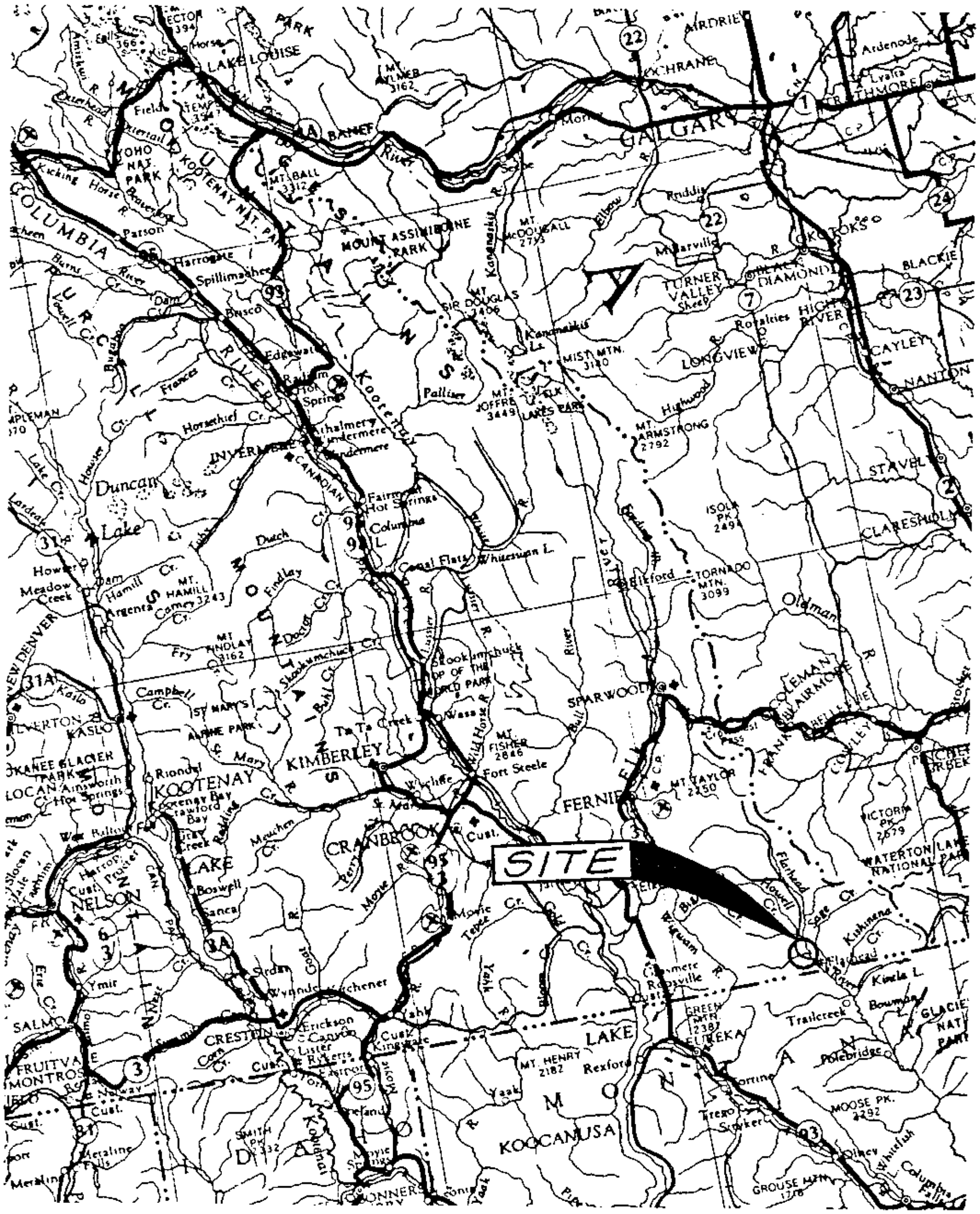
Per: David B. Campbell, P. Eng.

DBC:rme

782-1145

KEY PLAN

Figure 1



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Miles 20 10 0 20 40 60 80 100 Miles

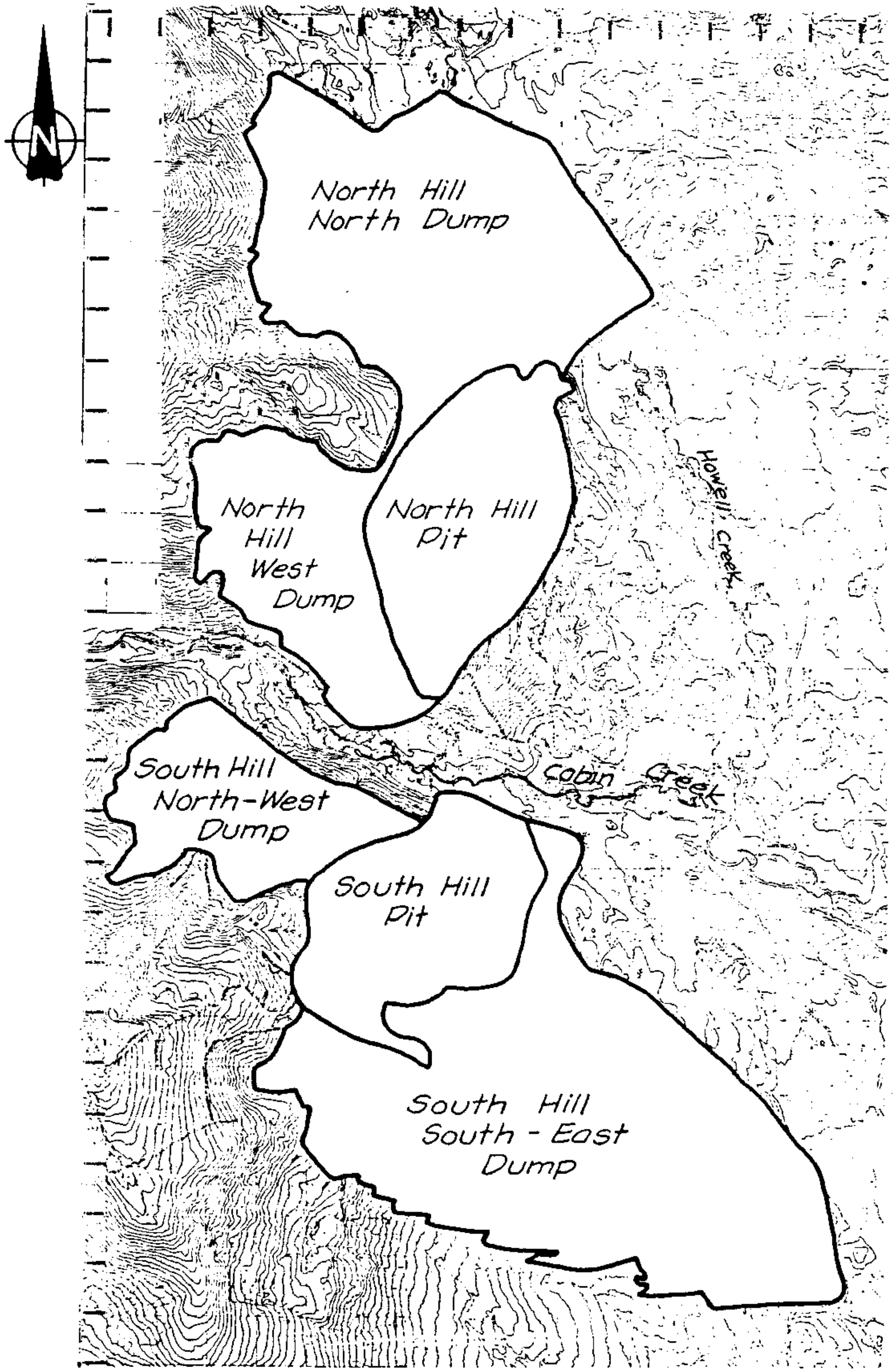
Project No. 782-1145 Drawn R.D. Reviewed Date Aug. 79

"Stability

Golder Associates K-Sage Creek 79(2)A #10

LOCATION OF PROPOSED WASTE DUMPS IN RELATION TO OPEN PITS

Figure 2



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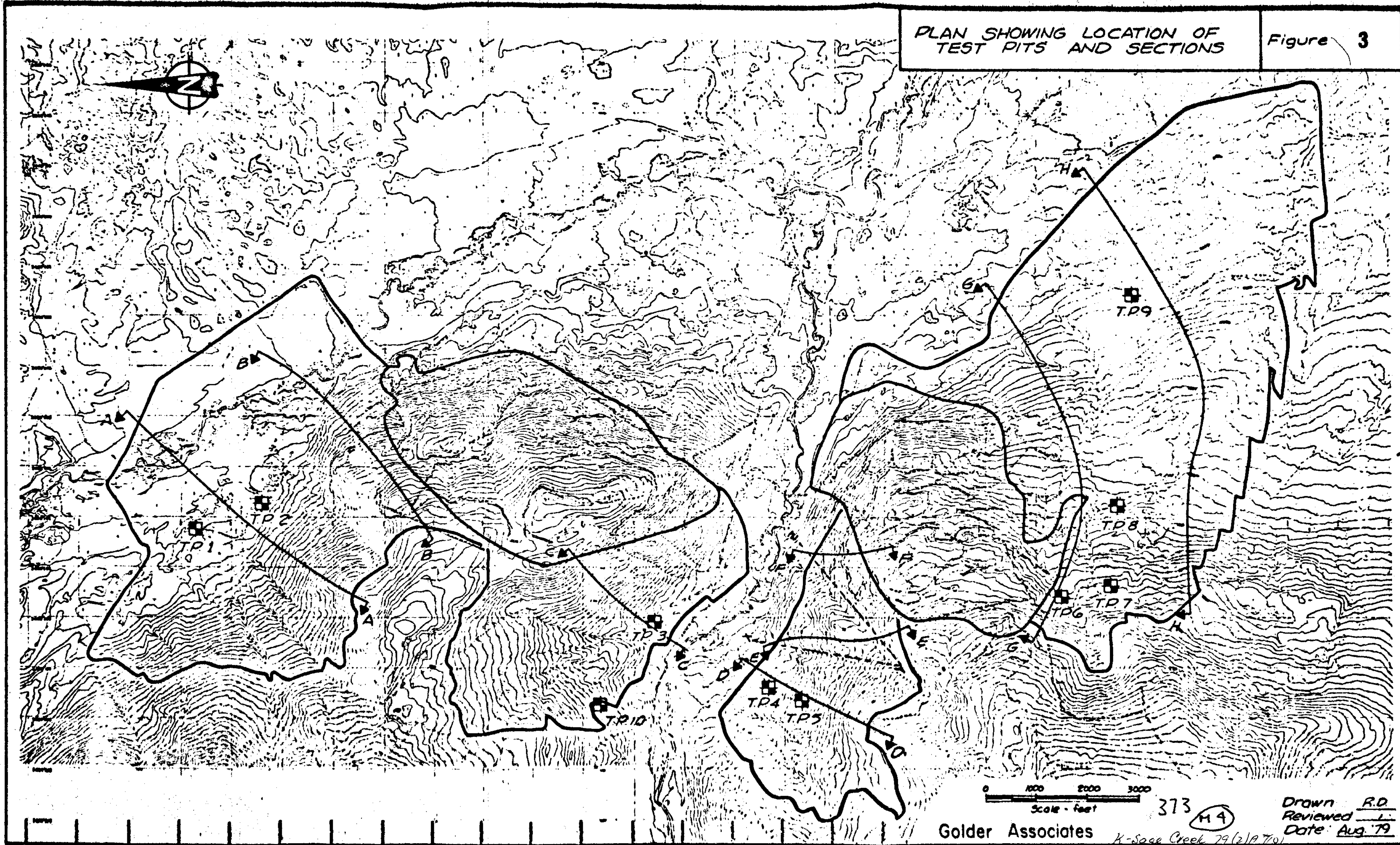

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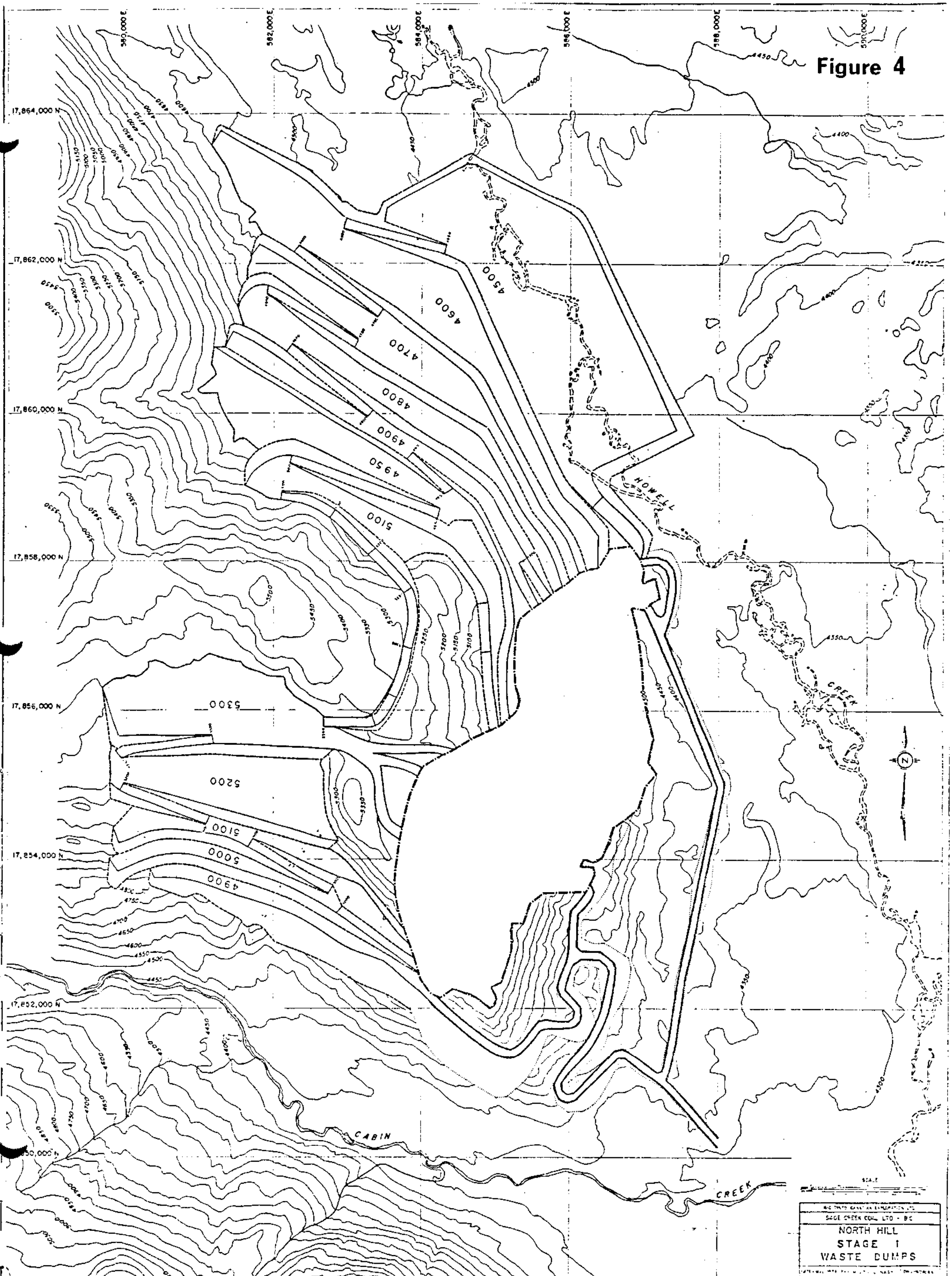
Figure 4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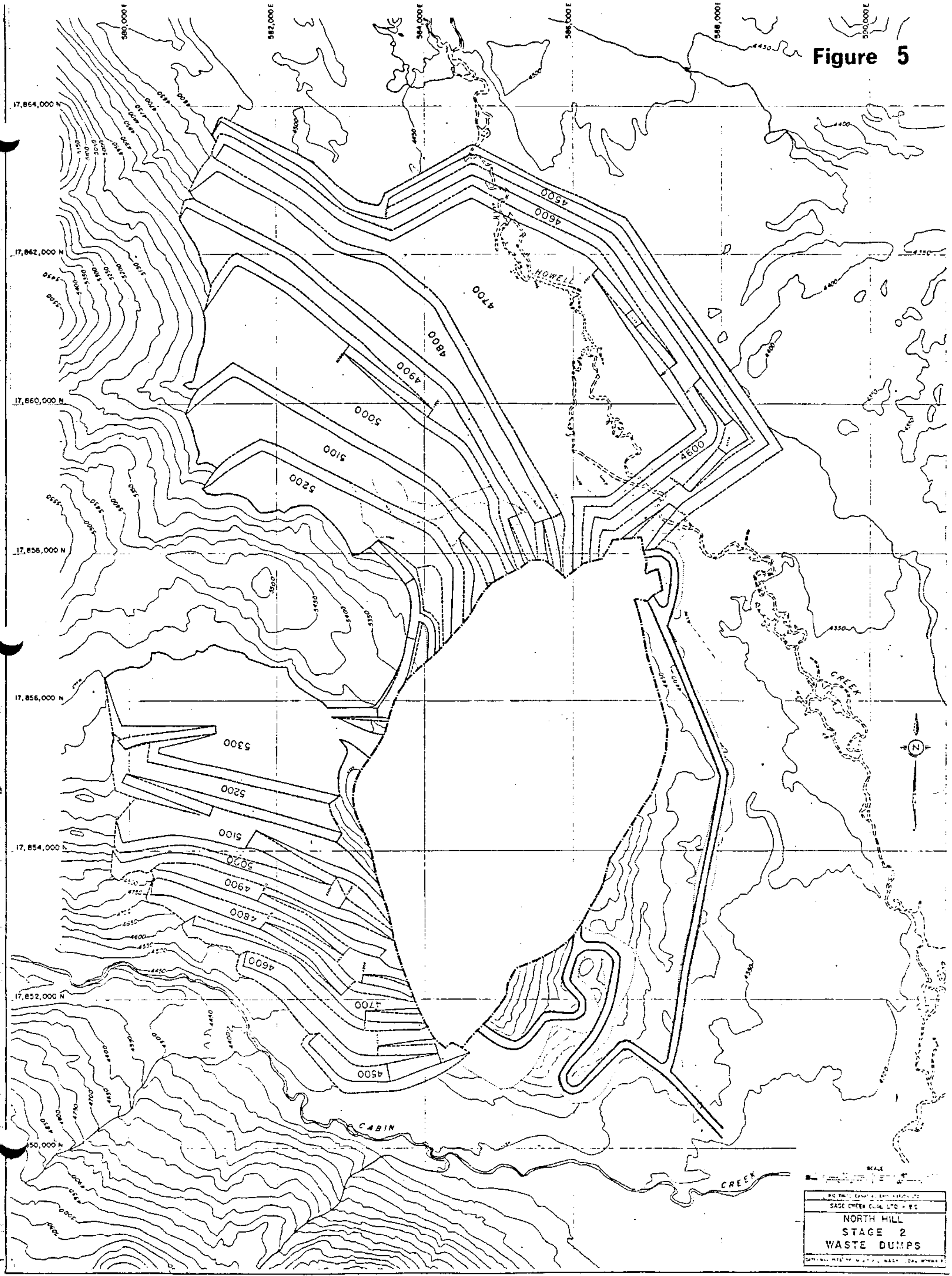
5200
5100
5000
4900
HOWELL
CREEK
CABIN
CREEK
SAGE CREEK COAL LTD - BC
NORTH HILL
STAGE 1
WASTE DUMPS

Figure 5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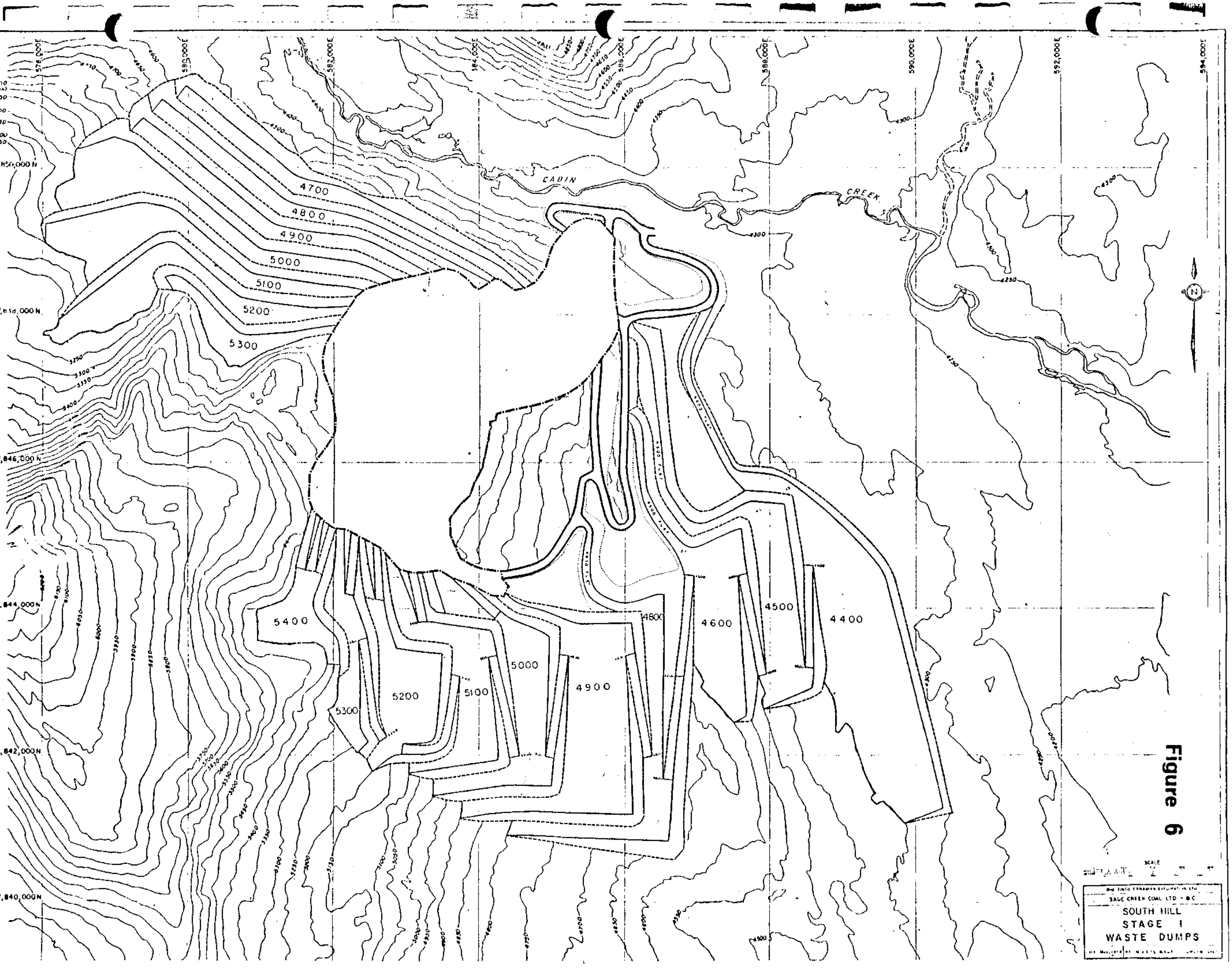
SAGE CREEK COAL LTD. - B.C.
NORTH HILL
STAGE 2
WASTE DUMPS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4600
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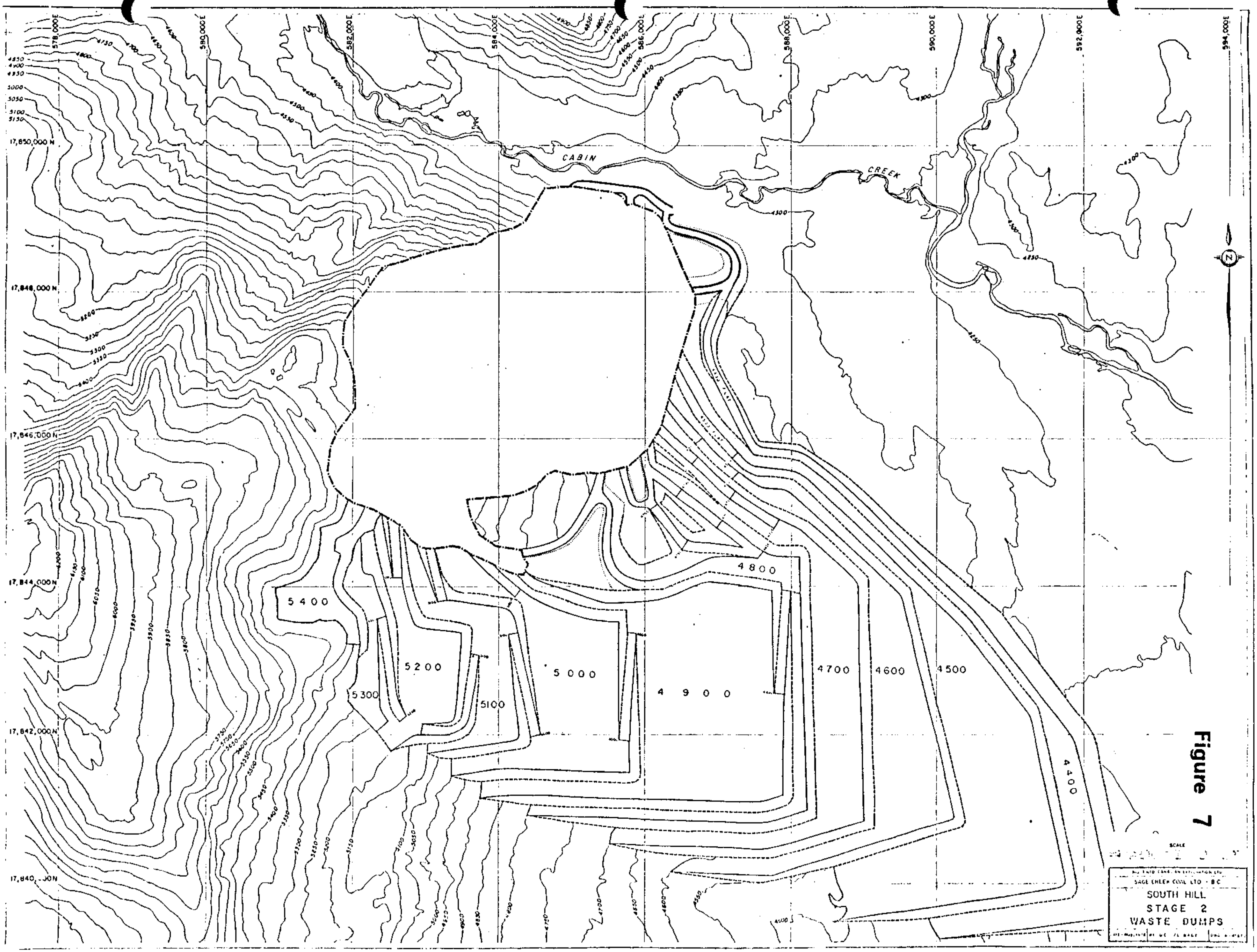
4400
N
SCALE
SAGE CREEK COAL LTD - B.C.
SOUTH HILL
STAGE I
WASTE DUMPS

Figure 6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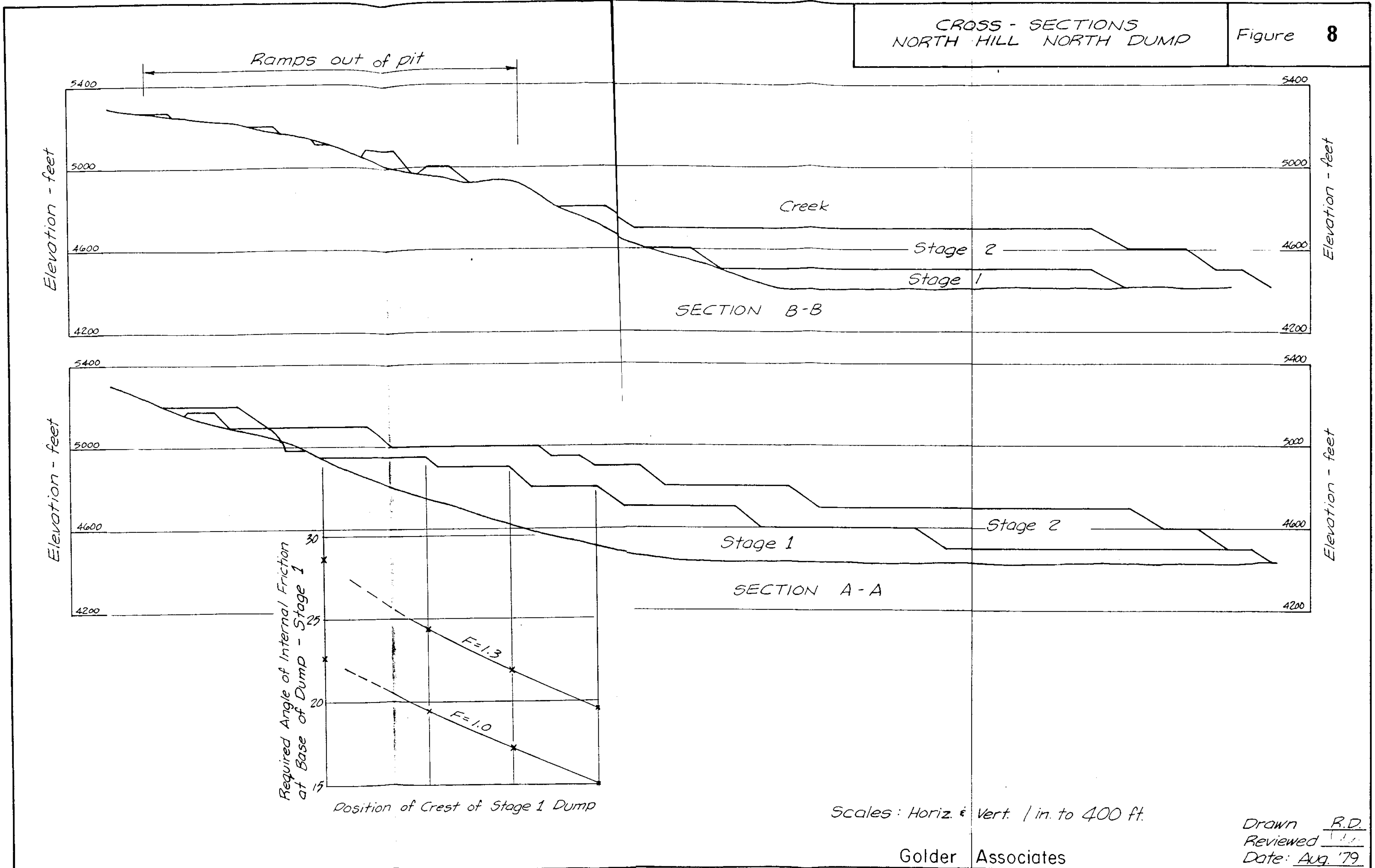
SAGE CREEK COAL LTD · B.C.
SOUTH HILL
STAGE 2
WASTE DUMPS

Figure 7

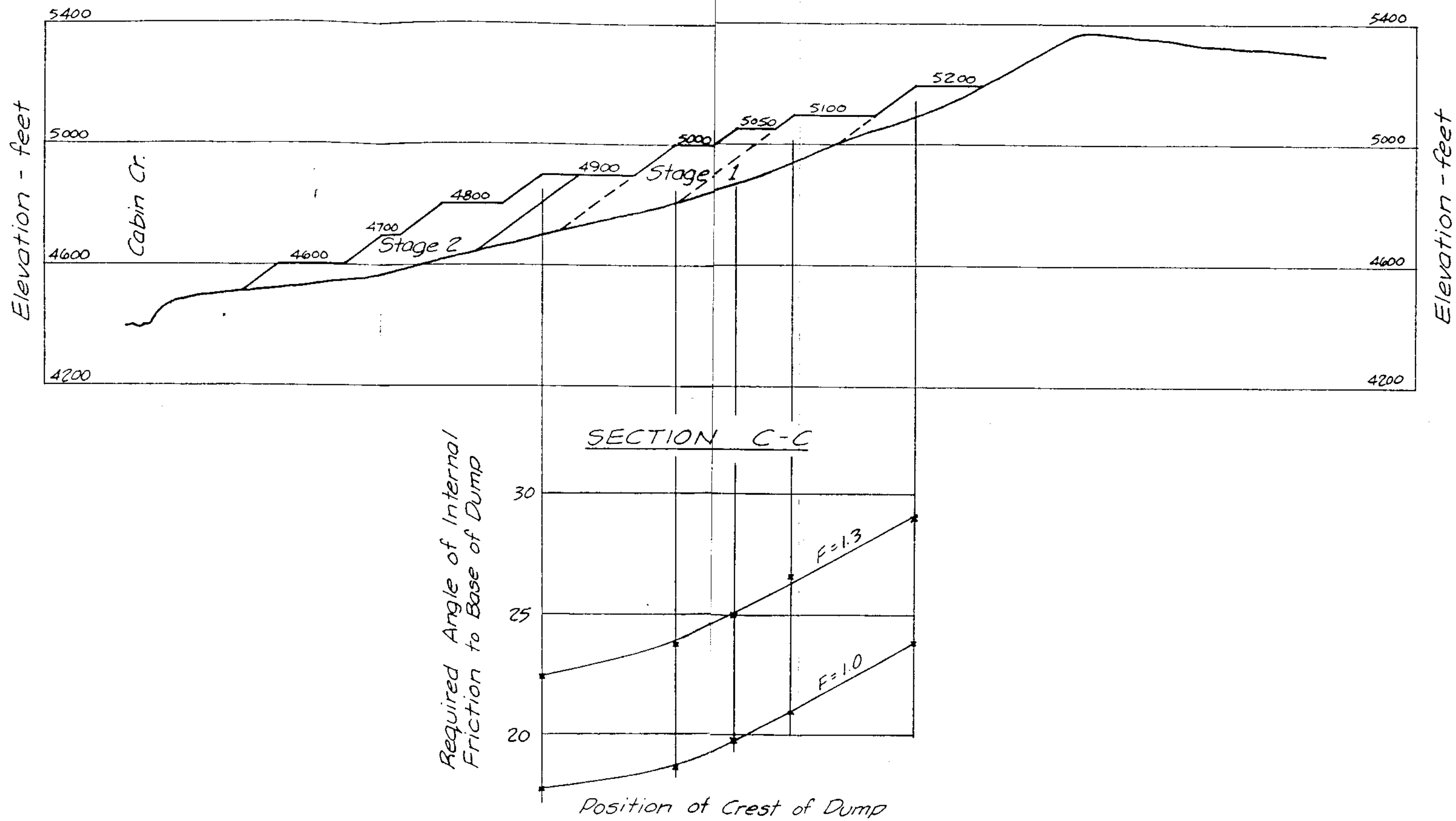


CROSS - SECTIONS NORTH HILL NORTH DUMP

Figure 8

CROSS - SECTION
NORTH HILL WEST DUMP

Figure 9



Scales : Horiz. & Vert. 1 in. to 400 ft.

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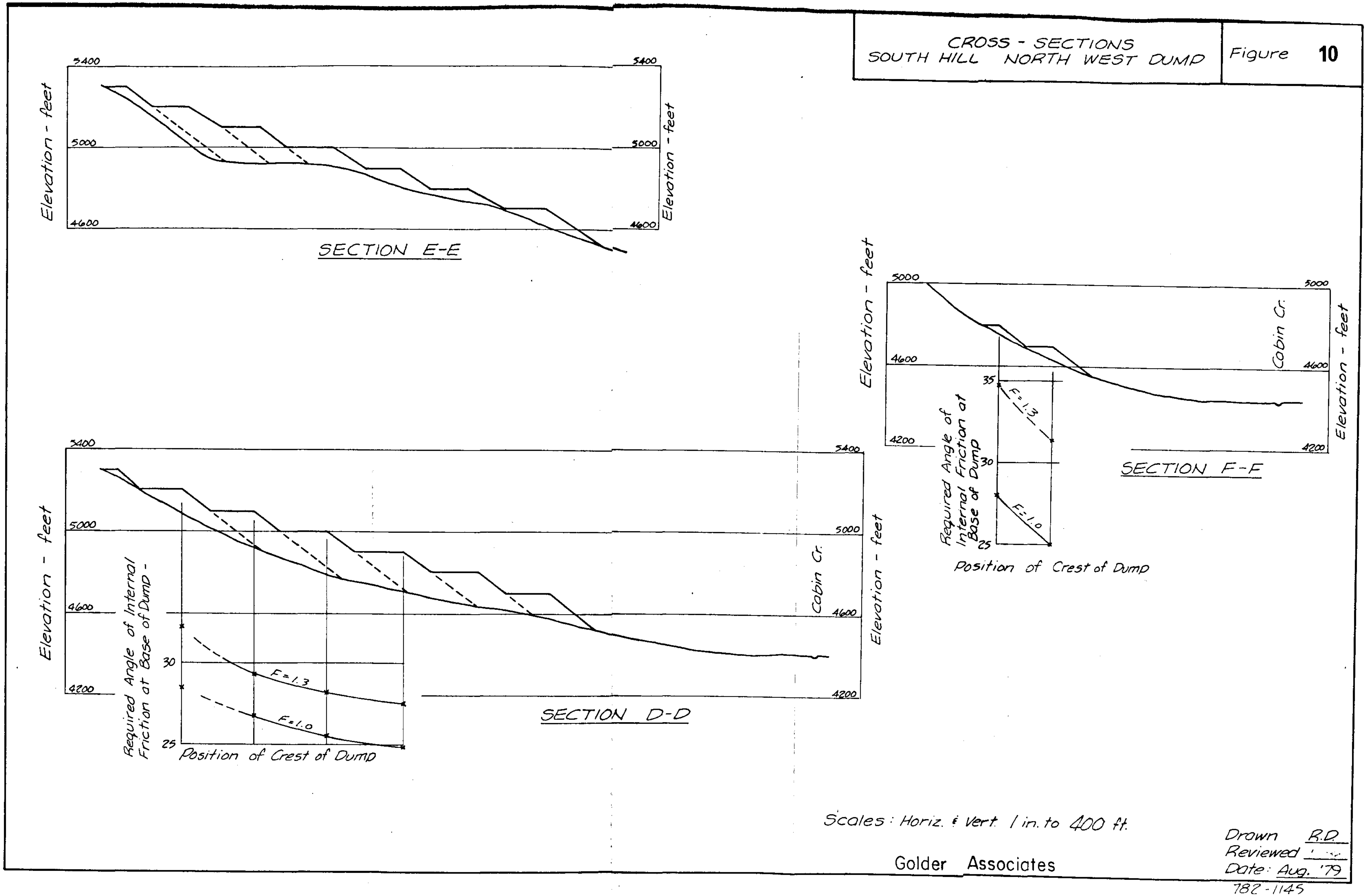
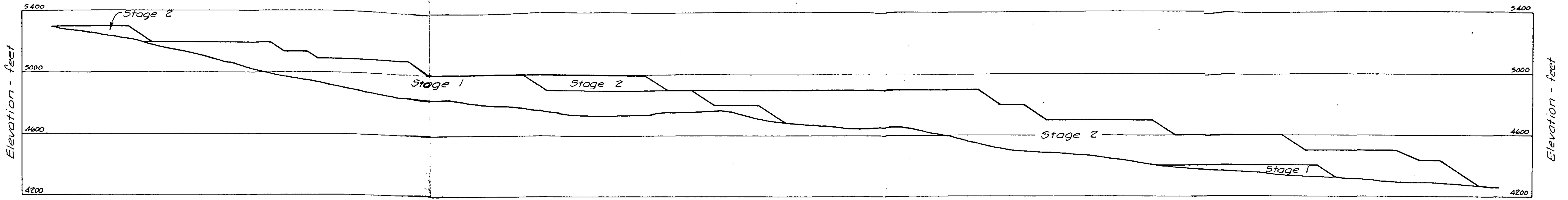
Reviewed
Date : Aug. '79

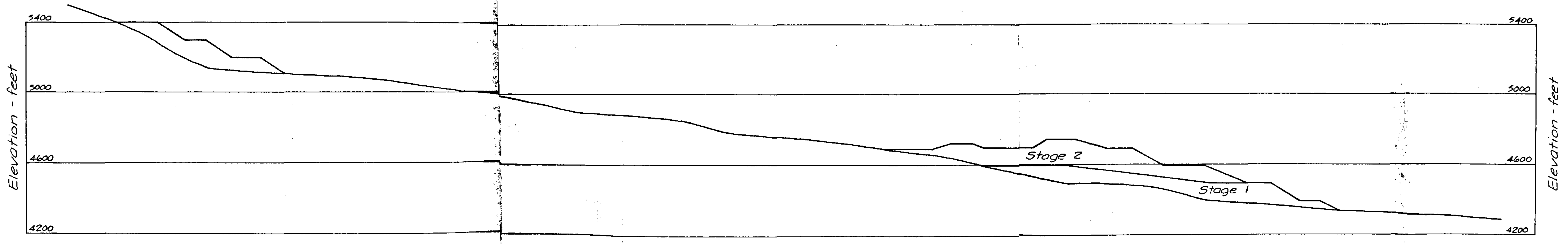

CROSS - SECTIONS
SOUTH HILL NORTH WEST DUMP
Figure 10
SECTION E-E
SECTION D-D
SECTION F-F
Elevation - feet
5400
5000
4600
4200
35
30
25
Required Angle of Internal Friction at Base of Dump -
F=1.3
F=1.0
Position of Crest of Dump
Cabin Cr.
Scales: Horiz. & Vert. 1 in. to 400 ft.
Golder Associates
Drawn R.D.
Reviewed
Date: Aug. '79
782-1145

CROSS - SECTIONS
SOUTH HILL SOUTH-EAST DUMP

Figure **11**



SECTION H-H



SECTION G-G

Scales: Horiz. & Vert. 1 in. to 400 ft.

373
pg. 138

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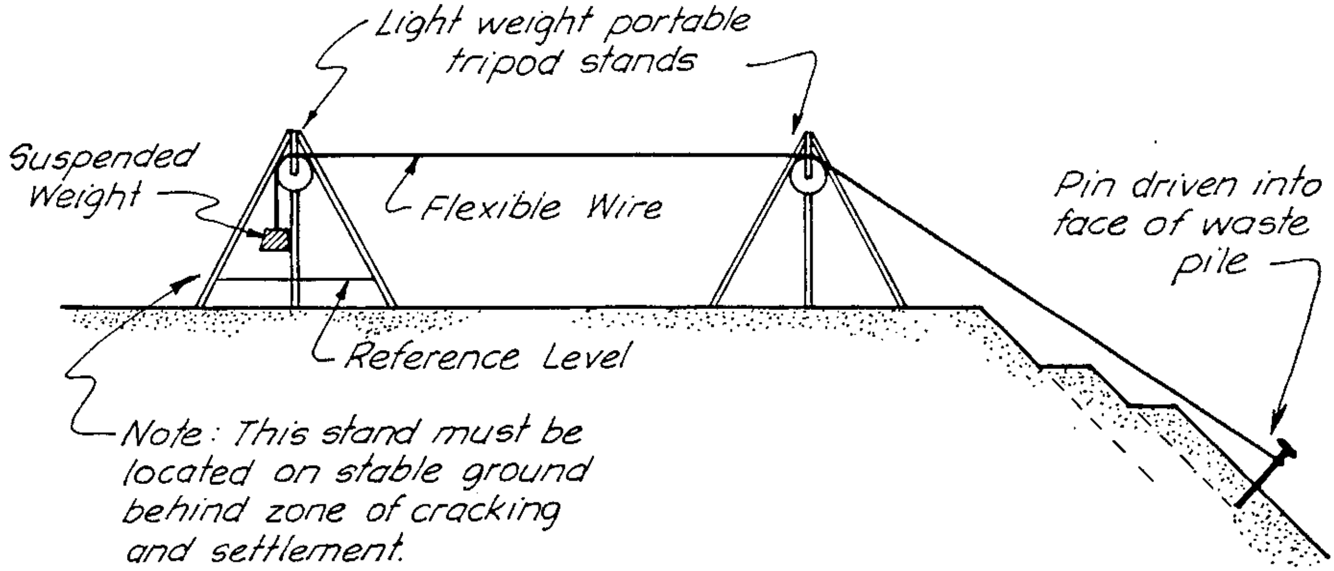
Reviewed
Date: Aug. '79
787-1145

SKETCH ILLUSTRATING DEVICE FOR MONITORING CREST MOVEMENTS ON WASTE PILES

Figure 12

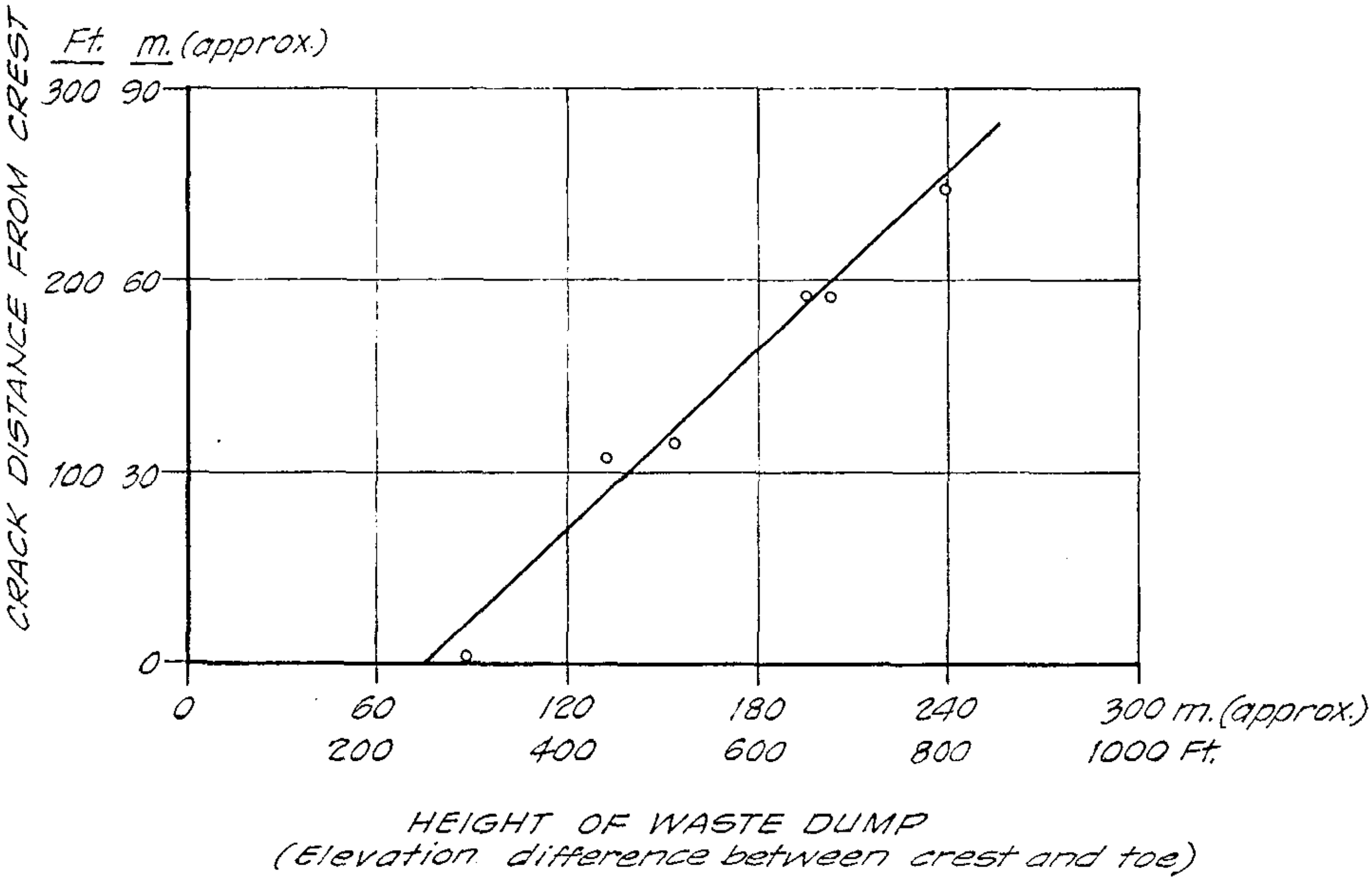


Not to Scale.

Project No. 782-1119 Drawn [illegible] Reviewed [illegible] Date Apr. '79

WIDTH OF ZONE OF CRACKING ADJACENT TO CREST OF WASTE DUMP

Figure 13



NOTE:
Data from Kaiser Resources Ltd. and Fording Coal operations in southeastern B.C.

Project No. 782-1019 Drawn Fg. Reviewed Date Feb./79.

APPENDIX A

Types of Waste Dump Failures

APPENDIX A

TYPES OF WASTE DUMP FAILURES

TYPE I - Sliver Failure at Operating Crest of Waste Pile

When a dump comprising waste rock is developed by end dumping at the crest, segregation of particle sizes occurs as the material rolls and slides down the face of the waste pile. As a result, there is a paucity of fine particles within the lower region of the waste pile, and a greater-than-average percentage of fines within the material near the crest. The presence of fines near the crest of the waste pile contributes a small amount of cohesion which enables the face of the pile immediately below the crest to stand at an angle slightly steeper than the angle of repose for the waste rock. This is illustrated on Figure A-1(a). On this figure, ac represents a potential surface of sliding for the elongated triangle abc.

Figure A-1(b) shows an elemental segment of the potential failure mass abc, together with the forces that act on its base. The forces acting on the sides of elemental column are approximately equal in magnitude and opposite in direction, and may therefore neglected without introducing serious error.

The general shape of the stress-strain curve for the material along the potential failure surface ac is illustrated on Figure A-1(c).

The applied shearing force along potential failure surface ac due to the weight of triangle abc is $\Sigma W\sin\alpha$. The maximum force available to resist sliding is $\Sigma(c' + W\cos\alpha \tan\phi')$.

As the face of the waste pile advances to the position a'b' (Figure C-1(a)) ΣW increases. As ΣW increases, the applied shearing force on potential failure surface ac increases in the manner illustrated by curve 1, Figure A-1(d). The maximum available shear resistance increases as illustrated by curve 2. As shown on the figure, curves 1 and 2 converge as ΣW increases, and when ΣW reaches the value W_c, curves 1 and 2 are coincident. At this point, the applied shear force on ac is equal to the maximum available shearing resistance, i.e. the factor of safety equals 1.0, and failure of the sliver is immenent.

When failure occurs, the material moves down the face of the waste pile at a quasi-uniform rate and comes to rest at the toe.

Since the stress-strain curve for the material along potential failure surface ac has the general shape illustrated on Figure C-1(c), as the factor of safety approaches 1.0, the triangle abc undergoes considerable deformation and downslope displacement. This displacement is manifest by cracking on the surface of the dump at c, and by horizontal and vertical displacement of the surface bc. As the factor of safety approaches 1.0, the rate of displacement increases. Type 1 failures, i.e. the sliver failures at the crest of the waste pile are independent of the slope of the foundation.

Although small failures may occur on the face of the waste pile from time-to-time, the slide debris resulting from such failures can be expected to come to rest approximately at the position of the toe of the waste pile prior to the occurrence.

TYPE 2 FAILURE - Slumping of Face of Waste Pile due to Lateral Yielding of the Toe

In Figure A-2(a) the toe of the waste pile has advanced onto a localized area of soft soil. This soft soil has lower shear strength characteristics than the soils within the general foundation area of the waste pile. The stress-strain curve for the soft soil has the general shape illustrated on Figure A-2(b).

Stresses imposed by the toe region of the waste pile result in displacement of the soft soil toward the left, and yielding of the toe. Yielding of the toe is accompanied by slumping on the face.

This type of failure does not occur without warning, it is preceded by a period during which the rate of displacement at the crest of the waste pile increases progressively.

TYPE 3 FAILURE - The Sturzstrom-Type Slide

Figure A-3(a) illustrates a segment of waste dump that is being developed on a steeply sloping foundation. The toe region of the waste pile has advanced onto a localized steeper-than-averate segment of the slope. The shear strength parameters for the in situ foundation materials located at shallow depth below ground surface are lower than those for the waste rock. Figure A-3(b) shows an elemental segment of the toe region of the waste dump, together with the forces acting on the base of the element. Forces acting on the vertical sides of the element are approximately equal in magnitude and opposite in direction and therefore may be neglected without introducing serious error.

The stress-strain curve for the in situ material located at shallow depth below the base of the dump is illustrated on Figure A-3(c). As illustrated, after the material undergoes moderate deformation, the shearing resistance reaches a peak value. As strain continues, the shearing resistance of the material drops to a residual value which is considerably lower than the peak strength. The peak and residual Mohr rupture envelopes for the in situ foundation material are as illustrated on Figure A-3(d). The Mohr rupture envelope representing peak strength has a cohesion intercept, and a relatively high angle of internal friction. The Mohr rupture envelope representing residual strength has a considerably lower angle of internal friction, and no cohesion.

As the face of the waste pile as illustrated on Figure A-3(a) advances, W increases, and both applied shear and maximum available shearing resistance increase in the manner illustrated by curves 1 and 2 on Figure A-3(e). At the value W_c on this figure, curves 1 and 2 are coincident, i.e. the factor of safety is 1.0. As shearing takes place, the shearing resistance along that segment of the failure surface located within in situ material at shallow depth below the base of the dump reaches a peak value as illustrated on Figure A-3(c). As the shearing displacements increase, the shearing resistance within this segment of the failure surface is suddenly reduced to the residual strength, i.e. the shearing resistance suddenly drops from curve 2 to curve 3 (Figure A-3(e)), but the applied shear remains at the value indicated by curve 1. The difference in these two forces, shown as F_a on Figure A-3(e) is an unbalanced force that results in acceleration of the segment of the toe region of the dump marked 1 on A-3(a). This segment undergoes rapid movement in the downslope direction, removes lateral support for the segment marked 2 which also fails, accelerates, and attains high velocity.

The dynamic distance to motion of the rapidly moving slide debris is a small fraction of its static resistance. This low dynamic friction is believed to be the result of kinetic particle-to-particle transfer of energy within the rapidly moving mass. Because of the low dynamic friction slides of the type illustrated on Figure A-3 can attain high velocity, and the distal portion of the slide debris may come to rest at a surprisingly large distance from the position that the toe of the waste pile occupied prior to the occurrence of the slide. This is referred to as sturzstrom-type failure.

The vertical angle subtended by the line of site between the crest of the waste pile prior to the sturzstrom-type slide, and the distal portion (or farthest point of travel) of the slide debris is known as the Fahrboschung. Empirical observations indicate that the Fahrboschung varies inversely with the difference in elevation of the toe and the crest prior to failure. The empirical data for sturzstrom-type failure on the face of waste rock dumps are shown on Figure A-3(f). The lowest fahrboschung so far observed is approximately 11 degrees.

TYPE 4 FAILURE - Overall Stability

Figure C-4(a) illustrates a section through a completed waste dump. The stability of the dump with respect to en masse sliding on its base is considered. Figure C-4(b) illustrates an elemental vertical segment through the dump, together with the forces acting on the base of the vertical element. The forces acting on the vertical boundaries of the element are equal in magnitude and opposite in direction, and can therefore neglected without introducing serious error.

The applied shearing force on the base of the element due to its weight is W $\sin\alpha$, where α is the inclination of the base of the element. The mobilized shearing resistance on the base of the element is:-

$$c/F + W \cos\alpha \tan\phi'/F$$

where:- F = the factor of safety.

The overall factor of safety is:-

$$F = \frac{\Sigma\ c'/F + W \cos\alpha \tan\phi'/F}{\Sigma\ W \sin\alpha}$$

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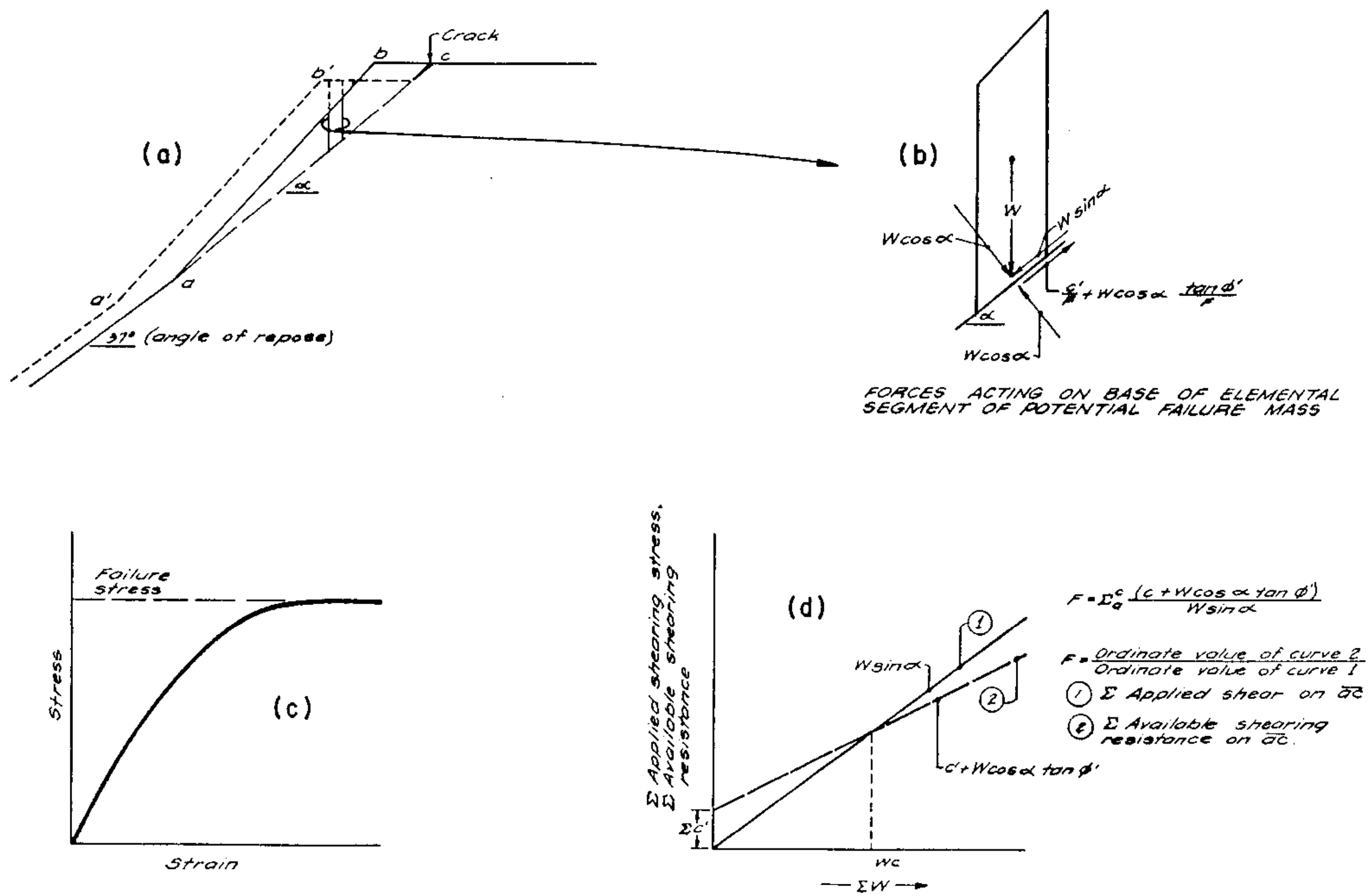


FORCES ACTING ON BASE OF ELEMENTAL SEGMENT OF POTENTIAL FAILURE MASS

SHAPE OF STRESS-STRAIN CURVE

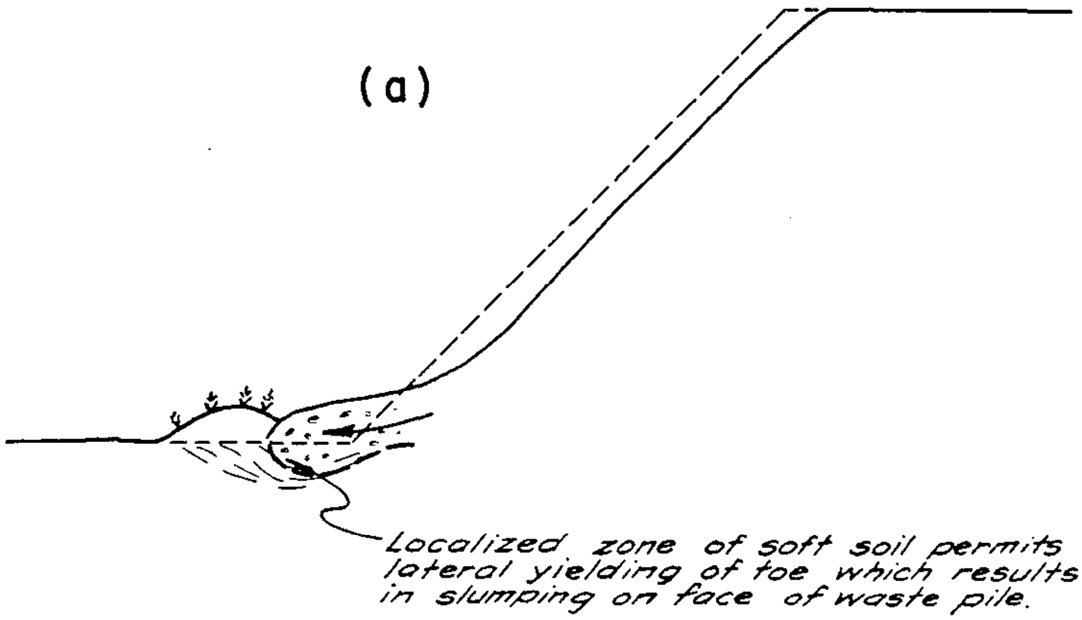
TYPE 1 FAILURE

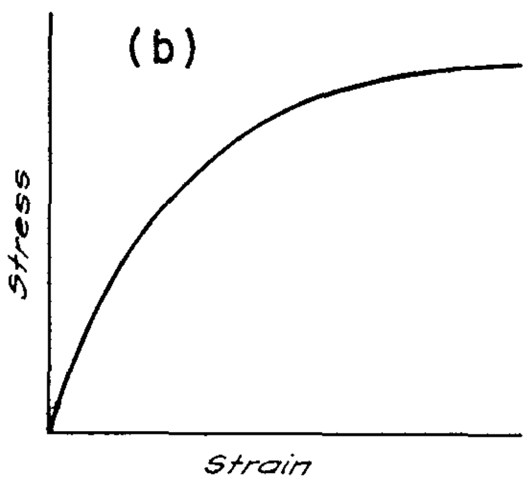
Figure A-1

Golder Associates

TYPE 2 FAILURE - SLUMPING ON FACE DUE TO LATERAL YIELDING AT THE TOE

Figure A - 2

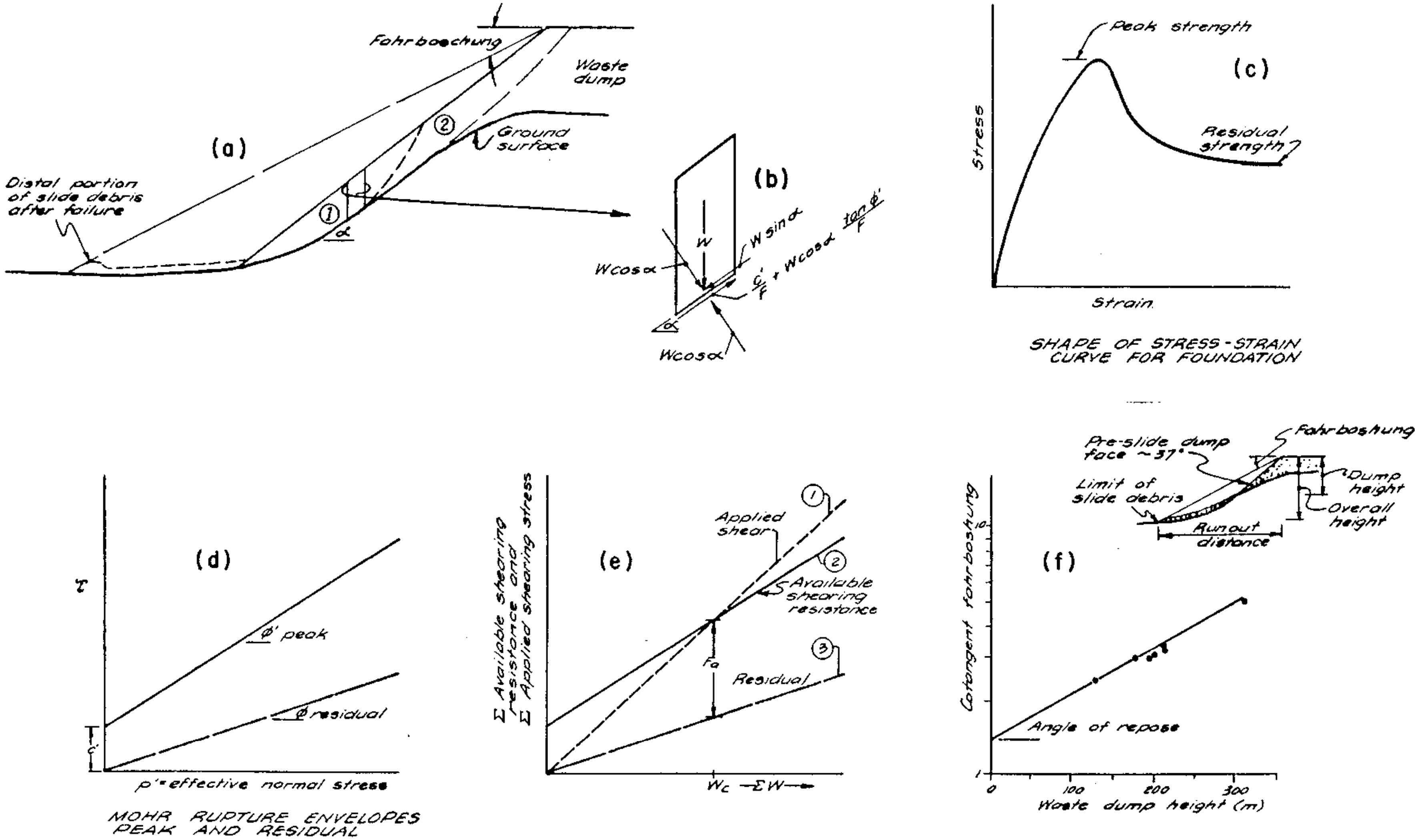




SHAPE OF STRESS-STRAIN CURVE FOR SOFT SOIL

Project No. 192-1139 Drawn W.T. Reviewed Date Aug. '79

Project No. 792-1139 Drawn W.T. Reviewed DB Date Aug. '79



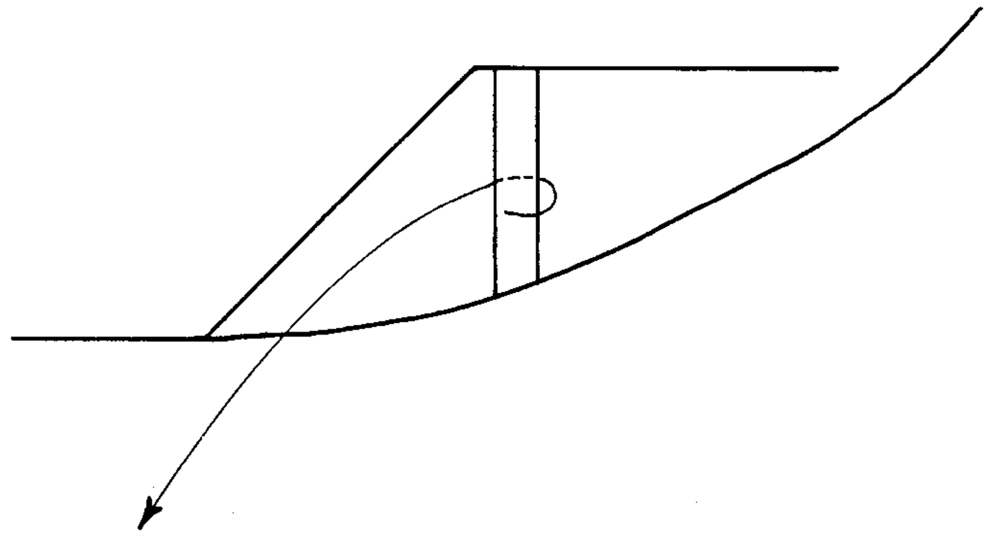
TYPE 3 FAILURE

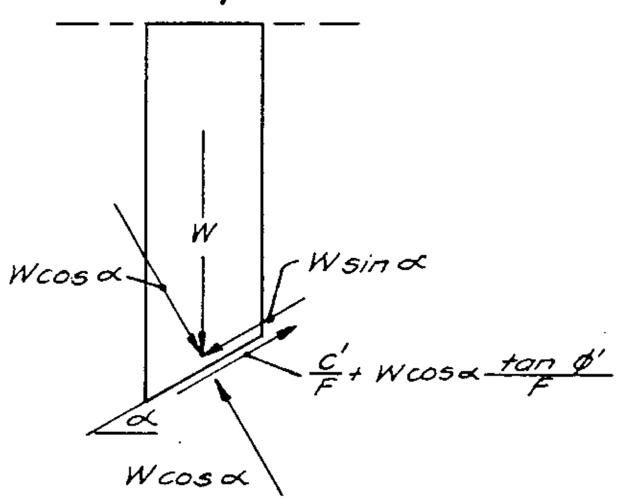
Figure A-3

Golder Associates

OVERALL STABILITY WITH RESPECT TO TYPE 4 FAILURE - ENMASSE SLIDING OF DUMP ON ITS BASE

Figure A - 4





W = weight of an elemental vertical slice through the dump.

α = inclination of the base of the elemental slice

c' & φ' = the effective cohesion and effective angle of internal friction of the formation at shallow depth below base of dump.

F = factor of safety.

Overall factor of safety, $F = \dfrac{\Sigma\ \frac{c'}{F} + W\cos\alpha\ \frac{\tan\phi'}{F}}{\Sigma\ W\sin\alpha}$

Project No. 792-1139 Drawn W.T. Reviewed [illegible] Date Aug. '79

APPENDIX B

Methods of Stability Analyses

APPENDIX B

Methods of Stability Analyses

In considering the stability of the proposed waste dumps, it was assumed that mining operations would commence at or near the top of the North and South Hills. Access between open pits and waste dumps are commonly developed in the manner which minimizes uphill and downhill haul. Waste rock generated during the initial stages of mining operations was assumed to be disposed of within the benches located within the upper region of the dump. As mining in the pit proceeds to progressively lower levels, the waste rock would be consigned to benches located at corresponding lower levels in the dump.

In assessment of the dump stability it was assumed that benches on the steep upper slopes would be developed prior to placement of material within the benches on the lower flatter slopes. The materials consigned to the lower benches on the flatter slopes will provide lateral support to the toe region of the benches constructed on the steep upper slope, thereby improving the stability of the dump with respect to en masse sliding on its base. As a result, factor of safety of dump with respect to base sliding improves with progressive development of the dump.

The Janbu* method was used to analyze the stability of the dump with respect to en masse sliding on its base during initial stages of development. Assuming zero cohesion within the soil that mantles the ground surface within the foundation area of the dump and a phreatic surface coincicent with ground surface, the angle of internal friction required for a

* "Application of Composite Slip Surface For Stability Analyses", Proceedings European Conference on Stability of Earth Slopes, Volume 3, Page 43, 1955.

factor of safety of 1.0, and a factor of 1.3 were calculated. The angle of internal friction required for a factor of safety of 1.0 is the mobilized friction angle, ϕ_m.

$$\tan \phi_m = \tan \phi'/F$$

where:- ϕ' = the true angle of internal friction for the surficial soils that mantle the foundation area of the dump.

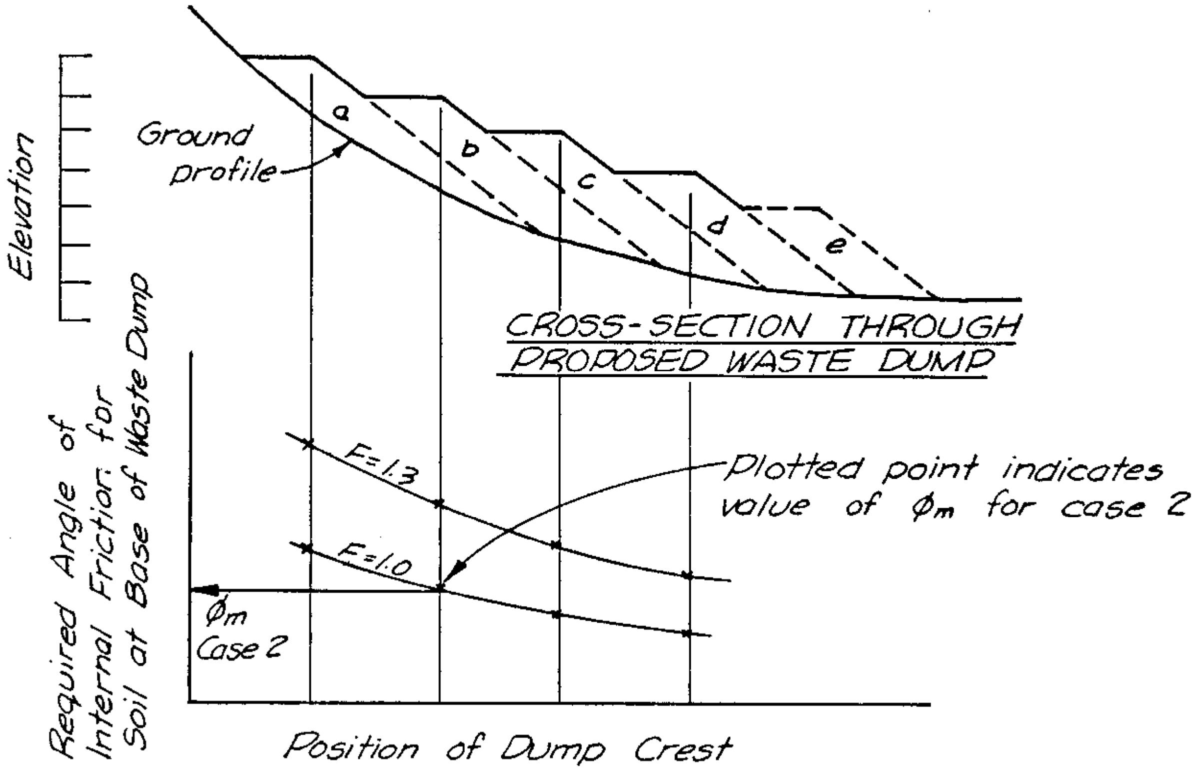
F = the factor of safety with respect to downslope sliding of the dump on its base.

The factor of safety is approximately equal to $\tan \phi'/\tan \phi_m$.

The cases analyzed are summarized in the table on Figure B1.

The results of the stability analyses are presented in graphical form on the appropriate cross-sections (Figures 8 to 11, inclusive) in the form of required angle of internal friction versus the position of the crest of the dump, as illustrated on Figure B-1.

DETAILS OF STABILITY ANALYSES AS PRESENTED ON CROSS-SECTIONS FIGS. 8,9 & 10 | **Figure B1**



Cases Analyzed	Segment of the Dump Assumed to be in Place	Segments of the Dump yet to be Constructed
Case 1	a	b, c, & d ...
Case 2	a & b	c & d ...
Case 3	a, b, & c	d ...
Case 4	a, b, c, & d	e ...

APPENDIX C

Test Pit Logs

APPENDIX C

TEST PIT LOGS

North Hill - North Dump

Test Pit No. 1

Depth (ft.)	Description of Material
0.0 - 0.7	Silty clay with organic matter.
0.7 - 2.0	Silty clay, stratified light brown and dark bands approximately 2 inches thick.
2.0 - 4.0	Glacial till, dense silty clay with scattered angular to subangular stone fragments to 2 inch size.

Test Pit No. 2

0.0 - 2.8	Silt, slightly sandy and clayey, stratified light brown and dark bands 1 inch to 2 inches thick.
2.8 - 3.3	Clay, hard, dark brown, unconfined compression strength approximately 4 tons per sq. ft.

TEST PIT LOGS

North Hill - West Dump

Depth (ft.)	Description of Material
Test Pit No. 3	
0.0 - 1.2	Silty sand, with organic matter, scattered stone fragments.
1.2 - 5.9	Glacial till, silt-sand-gravel mixture with scattered cobbles and small boulders.
Test Pit No. 10	
0.0 - 0.25	Topsoil.
0.25- 4.9	Sand, silty with angular to subangular gravel.
4.9 -14.0	Glacial till, silty, sandy, clay matrix, hard, with scattered angular gravel and cobbles.

TEST PIT LOGS

South Hill - Northwest Dump

Test Pit No. 4

Depth (ft.)	Description of Material
0.0 - 0.6	Sand, fine, silty with organic matter.
0.6 - 3.5	Glacial till, silty fine sand with scattered angular to subangular stone to 3 inches size.

Test Pit No. 5

Depth (ft.)	Description of Material
0.0 - 0.3	Topsoil.
0.3 - 3.7	Sand, silty clayey grading into hard till-like soil consisting of a hard silty clay matrix with scattered stone.

TEST PIT LOGS

South Hill - Southeast Dump

Test Pit No. 6

Depth (ft.)	Description of Material
0.0 - 2.5	Silt, organic, stratified light and dark bands approximately 2 inches thick.
2.5 - 4.0	Silt, sandy, dense, with scattered angular gravel. Water seeping into bottom of test pit.

Test Pit No. 7

0.0 - 4.0	Glacial till, very dense silty sand matrix with gravel to 2 inch size. Occasional boulders to 1 ft. size.

Test Pit No. 7A

0.0 - 0.2	Topsoil, dark grey silty char.
0.2 - 3.0	Silty clay, light brown to tan, jointed, very hard. Grading into jointed Kishenehn clay (shale).

Test Pit No. 8

0.0 - 4.0	Glacial till, hard silty sandy clay matrix with scattered stone generally less than 6 inches size. Occasional rounded boulders to 3 ft. diameter.

Test Pit No. 9

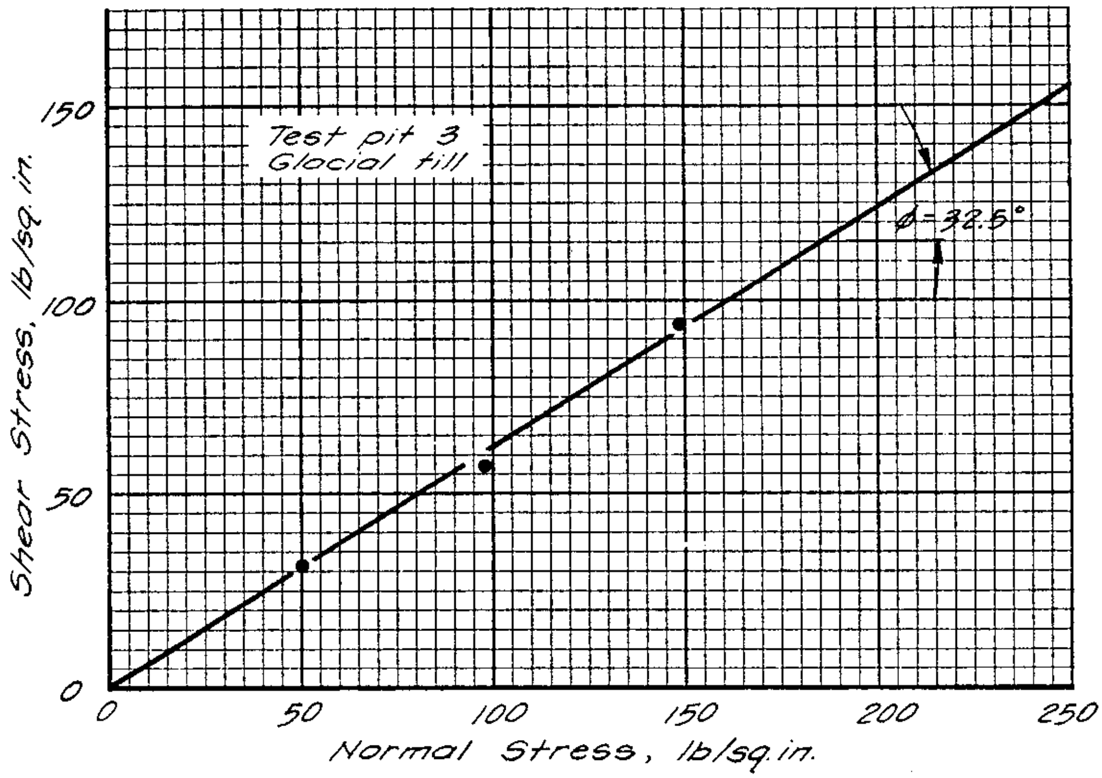
0.0 - 3.6	Glacial till, hard silty clay matrix with stone fragments to 1 inch size and scattered larger stone.

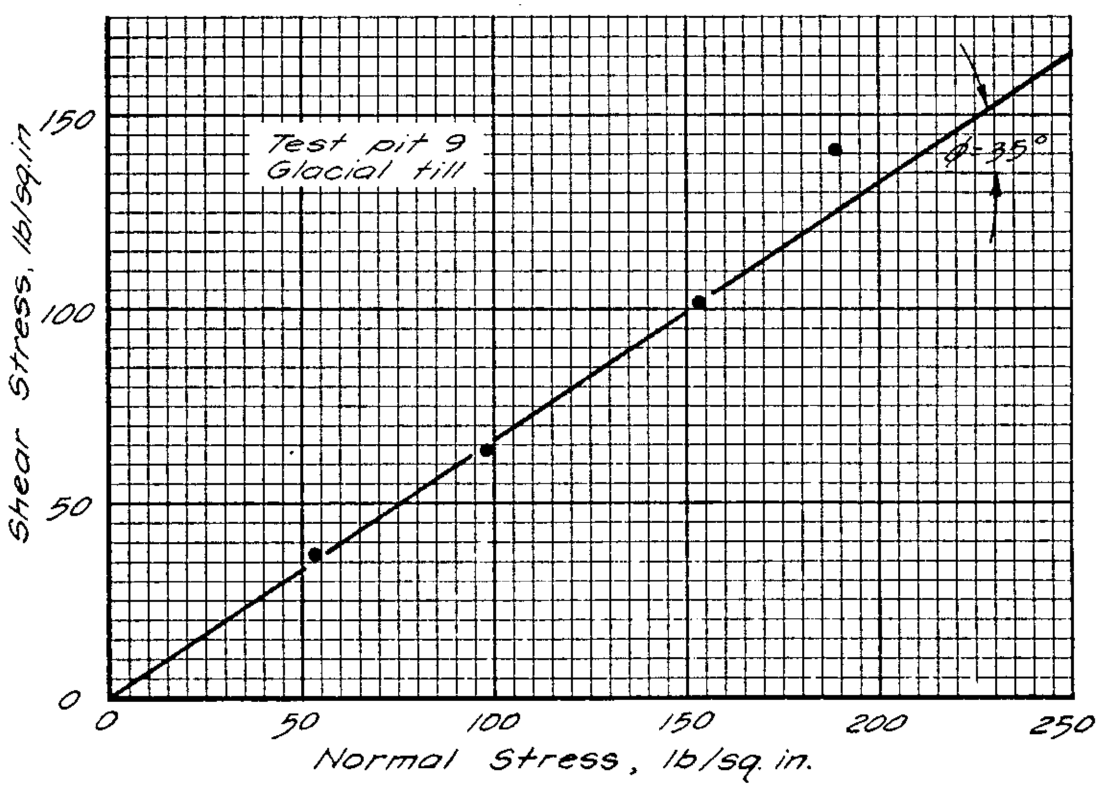
APPENDIX D

Laboratory Test Data

DIRECT SHEAR TEST RESULTS

Figure D-1





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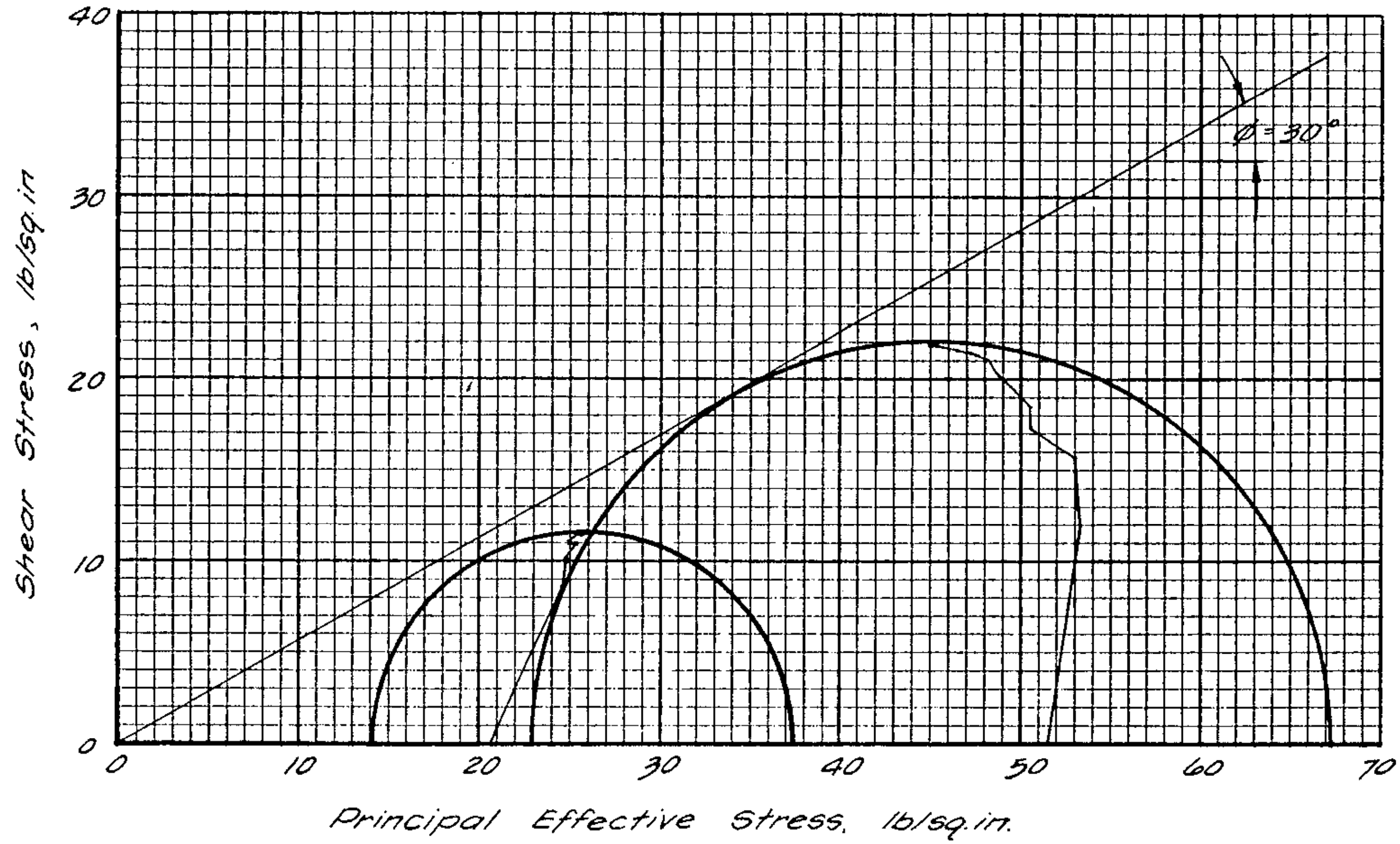
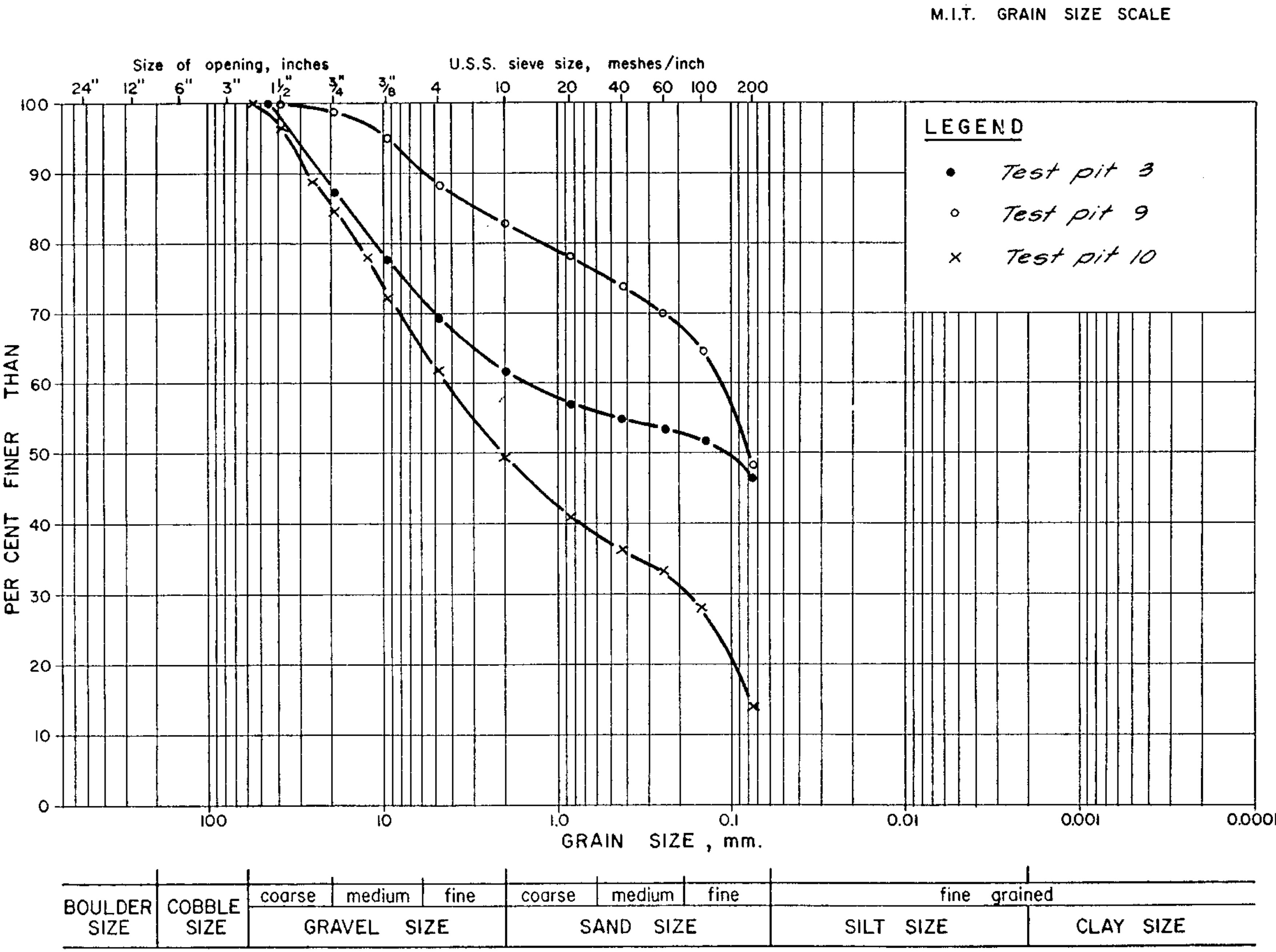


Test pit No. 3
Minus No. 4 material.

MULTI-STAGE $\bar{R}$ TEST
GLACIAL TILL SOIL

Figure D-2

Golder Associates



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GRAIN SIZE DISTRIBUTION

Figure D-3

HERITAGE RESOURCE INVENTORY AND IMPACT ASSESSMENT

OF THE

PROPOSED

SAGE CREEK COAL DEVELOPMENT

1979

CONFIDENTIAL

OPEN FILE

HERITAGE RESOURCES INVENTORY AND IMPACT ASSESSMENT

OF THE

PROPOSED

SAGE CREEK COAL DEVELOPMENT

prepared for

Sage Creek Coal Development
c/o Lornex Mining Corporation Ltd.
Suite 510, 580 Granville Street
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by

ARESCO (B.C.) LTD.
1235 G - 40th Avenue N.E.
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T2E 6M9

July 1979

EXECUTIVE SUMMARY

In June 1979, the Historical Resource Management Division of ARESCO (B.C.) Ltd. conducted a heritage resource inventory and impact assessment of the proposed Sage Creek Coal development in the Upper Flathead Valley of southeastern British Columbia. The following report details the objectives, procedures, results and recommendations of the study. These are briefly summarized below.

Objectives

- To gather data about previous research and known sites in the study area.
- To evaluate from source material and on the basis of field inspection, the heritage resource potential of all development areas.
- To locate and evaluate all heritage resource sites to be impacted by the development and to recommend mitigative measures where appropriate.

Research Methodology

- Areas deemed to hold the highest potential for heritage resource sites (river/stream terraces) were given 100% intensive on-ground coverage while low and negative priority areas consisting of wet lands and steep slopes were given from 25% to 0% coverage.

Results

- A total of seven historic period sites was located during the course of the field program. The sites included two oil well sites (DgPp- H-2 and 3), the townsite of Morrissey (DgPr- H-1), the Morrissey Mines Coking ovens (DgPr- H-2), the townsite of Carbonado (DgPr- H-3), the Morrissey Cemetery (DgPr- H-4), the townsite of Morrissey Junction and Morrissey Station (DgPs- H-1).
- No prehistoric sites were located.

Impact Assessment

- Only one site, DgPp- H-3, falls within the specified impact zones. All sites are presently suffering impact from vandalism as well as natural forces. Some attempt should be made by the proper authorities to curb this degradation.

Recommendations

- As no impact to six of the sites will occur through mining operations no further work is recommended.
- At DgPp- H-3, and to a lesser extent at DgPs- H-1 where the site is in close proximity to a development boundary avoidance is recommended.

CREDITS

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HERITAGE RESOURCE INVENTORY AND IMPACT ASSESSMENT

OF THE

PROPOSED

SAGE CREEK COAL DEVELOPMENT

1. INTRODUCTION

At the request of Sage Creek Coal Ltd., ARESCO (B.C.) Ltd. conducted a heritage resource impact evaluation of a proposed coal development in the East Kootenay region of southeastern British Columbia. The proposed development calls for an open pit mine operation and related plant site, dump areas, settling ponds and access roads to be constructed near the mouths of Cabin and Howell creeks in the Upper Flathead Valley. An additional load-out facility is proposed in the Morrissey area of the Elk River Valley approximately 13 km south of the town of Fernie.

In accordance with the Stage II requirements of the Guidelines for Coal Development, issued by the Environment and Land Use Committee (1976) of the Government of British Columbia, the purposes of this study were as follows:

- To inventory heritage resources within the proposed development areas;
- To assess all heritage resources recorded in light of potential adverse impact from proposed mining activities; and
- To recommend impact mitigation measures should they be required.

Field work was carried out from June 4 to June 14, 1979 and was authorized under Permit No. 1979-18, issued by the Heritage Conservation Branch of British Columbia.

2. PROJECT DESCRIPTION AND LOCATION

The proposed mine development is located in the Upper Flathead Valley area of southeastern British Columbia (Figure 1, page 3). More specifically, the development will involve an open pit mine on the northeast slope of Dalley Hill, west of the Flathead river along the south bank of Cabin Creek. This area is referred to by the developers as the 'South Hill'. A second open pit operation is proposed for the eastern end of a ridge running north of Cabin Creek and south of Howell Creek, again on the west side of the Flathead Valley. This area is referred to as the 'North Hill'.

Both the North and South Hill developments will encompass surface areas of approximately 1.7 km^2 each and will be accompanied by relatively large overburden dump areas on the North and South Flanks, covering a surface area of close to 10.28 km^2. Associated with the mining operations will be a 0.3 km^2 plant site located near the confluence of Howell and Cabin Creeks, 6 settling pond localities along Howell and Cabin Creeks and a major diversion channel re-directing Howell Creek into the Flathead River some 366 m north of its present confluence. Figure 3, page 11 shows a schematic plan of the proposed mining development.

PROJECT	TITLE
SAGE CREEK COAL DEVELOPMENT	PROJECT LOCATION MAP
ARESCO Ltd. CALGARY ALBERTA	FIGURE 1

Aside from the primary mine and plant sites, a coal load-out facility has been proposed to cover an approximate 0.12 km^2 area in the vicinity of Morrissey on the east bank of the Elk River approximately 13 km south of the town of Fernie. Figure 2, page 7 shows the Morrissey load-out area.

Both of the study areas fall within Holland's (1964) Border Ranges division of the Rocky Mountain Area which comprises the eastern system of the Canadian Cordillera. The dominant features of the Border Ranges are the Galton and MacDonald Mountains (or White Fish Range) on the west and the Clarke Mountains on the east, centrally divided by the Flathead fault which is presently characterized by the relatively broad Flathead Valley.

The primary bedrock features of the Galton and MacDonald ranges are Proterozoic argilliceous sedimentary rocks, silty rocks and limestones with argillite, siltstone, sandstone, limestone and quartzite characterizing the Clarke range to the east (Holland 1964:85).

Topographic relief is very pronounced with the Flathead Valley lying at an elevation of ca. 1372.5 m (4500 ft) above sea level, bordered on the east by the Clarke Range with peaks reaching elevations of 2623 m (8600 ft) and the MacDonald and Galton ranges on the west with peaks averaging 2287.5 (7500 ft). The Flatheat Valley, however, exhibits relatively low, even relief. The valley is approximately 10 km wide in the vicinity of Cabin and Howell Creeks.

The study areas fall within Lyon's (1952:9) Sub Alpine Forest Zone and Cowan & Guigets (1965) Sub Alpine Forest Biotic Area. The heavy forest cover is comprised of western larch *Larix occidentalis*, aspen *Populus tremuloides*, mountain alder *Alnus tenuifolia*, sitka alder *Alnus sinuata*, northern black cottonwood *Populus trichocarpa*, water birch *Betula occidentalis*, white spruce *Picea glauca sp. glauca*, Engelmann Spruce *Pica glauces ssp engelmannii*, lodgepole pine *Pinus contorta latifolia* and western pine *Pinus monticola*. A great variety of shrubs are present in this area and even more numberous varieties of flowers are native to the region. The reader is referred to Lyons (1952:9-10) for a comprehensive listing of flora in the area. A large variety of mammals were observed within this region, the most important to man being: Yellowstone moose *Alces alces shirasi;*

Rocky Mountain elk *Cervus canadensis nelsoni;* whitetail deer *Odocoileus virginianus ochrourus;* black bear *Ursus americanus;* grizzly bear *Ursus arctos horribilis;* American beaver *Castor canadensis lencodontus;* and porcupine *Erethizon dorsatum nigrescens.*

3. HISTORICAL OVERVIEW

3.1 ETHNOGRAPHY

The upper Flathead Valley and Elk River areas of southeastern British Columbia fall within the territory known ethnographically to have been occupied by Kootenai-speaking peoples known as the Yaket-Ahno-Klatak-Makanay or Tobacco Plains Kootenai(Tolmie & Dawson 1883, Chamberlain 1892, Turney-High 1941). A number of fairly detailed ethnographic accounts of the Kootenai in general are available in the following sources: Tolmie and Dawson (1883), Chamberlain (1892, 1905), Teit (1930), Turney-High (1941), and Johnson (1969).

The Tobacco Plains Kootenai are a sub-tribe of the Upper Kootenai and as the name suggests, were geographically centered in the Tobacco Plains region of the Kootenay Valley on both sides of the international border near Roosville, B.C. No ethnographic accounts specifically indicate aboriginal occupation of the upper Flathead Valley proper, however, early accounts such as Chamberlain (1892) as well as the latter work of Turney-High (1941) do observe that the Kootenai made regular expeditions three times a year to the eastern foothills of the Rocky Mountains to hunt bison. Foster (1978:14) on the other hand, cites a local story of a smallpox epidemic among the Mountain Stoney Indians apparently living in the vicinity of the Kishinena Valley on the eastern flank of the Flathead.

The origin and history of the Kootenai remains in doubt. Most accounts however, suggest that the Kootenai Indians originated on the Plains (Chamberlain (1892:575) and were relatively late arrivals in the Rocky Mountain region. The Tunaxa (Turney-High 1941:18) or Tona'xa (Teit 1930:625) were a Plains group often cited as the parent stock of the Kootenai.

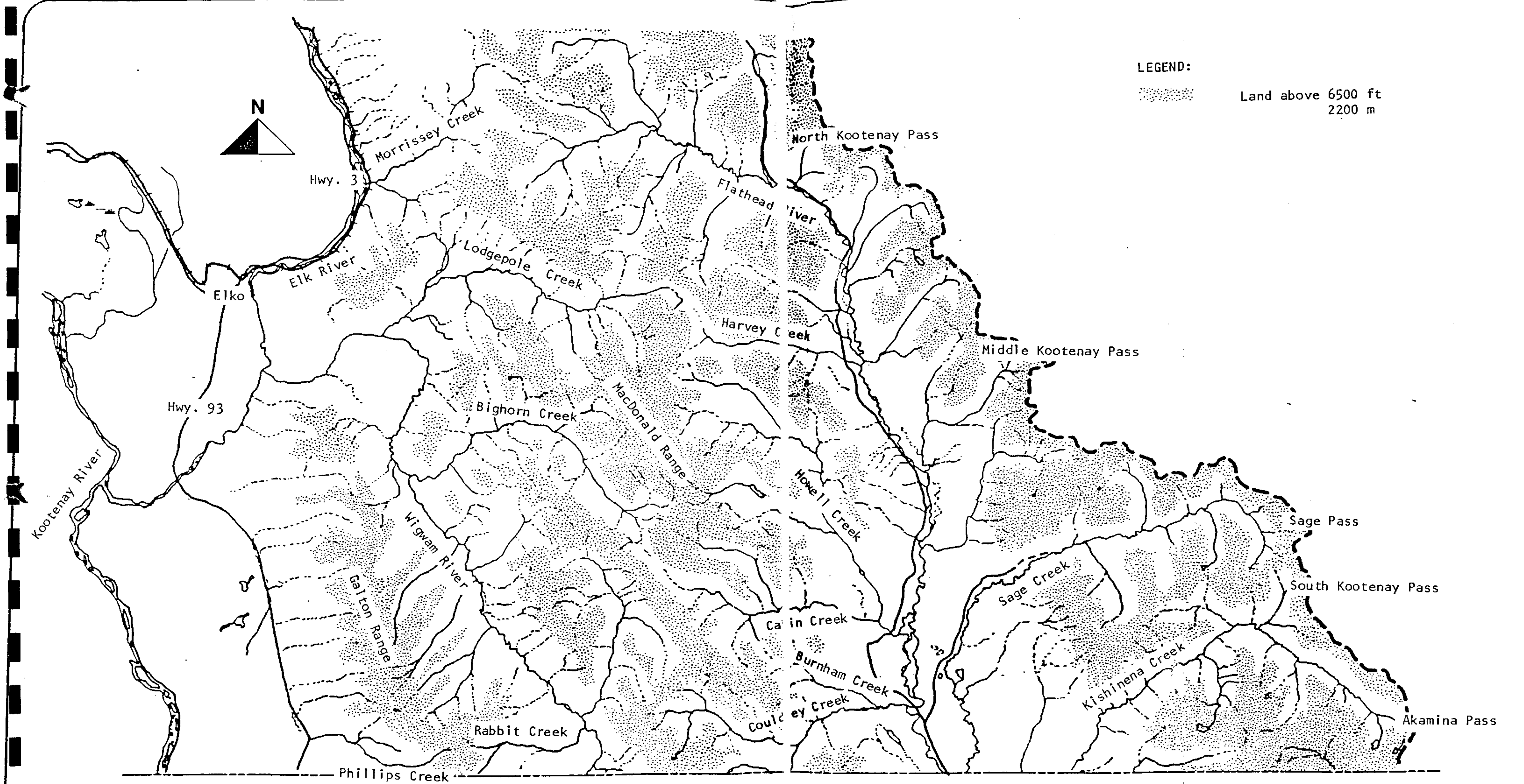
Of particular interest to this study is the thrice-yearly hunting forays to the eastern flanks of the Rockies. Brumley's work in the Waterton Lakes area suggests that the Kootenai used the South Kootenay Pass and possibly the Akamina Pass during these trips (Brumley 1971:3). This is also referred to by Reeves (1972:28) as the "Buffalo Trail". This then suggests a major travel route in close proximity to the Cabin-Howell Creek mining area under consideration here. (See Figure 2, page 7)

3.2 EURO-CANADIAN HISTORY

The earliest record of Eruo-Canadian presence in the east Kootenays is David Thompson's journeys down the Columbia between 1807-1812 (Hopwood 1971). Although the influences of the Hudson's Bay Company were undoubtedly felt throughout southeastern British Columbia subsequent to Thompson's activities, he did not actually visit the vicinity of the study area. The first European to enter the Flathead area was probably Lieutenant Blakiston who was exploring the "British Cootenay Passes" in 1858 under the direction of Captain Palliser (Palliser 1859). The first Boundary Commission set up a camp in the Flathead Valley in 1861 (Dawson 1886:49) and George Dawson later visited the area as part of the Second International Boundary Commission Survey of 1872-74 (Dawson 1886).

Although the Flathead Valley was out of the mainstream of activity during the late 1800's, the Kootenay and Elk River Valleys were experiencing increasing white occupation. In 1864, placer mining operations were begun on the Wildhorse River which marked the beginning of the short-lived "Wild Horse Gold Rush". In 1865, the Dewdney Trail was completed. The influx of people to the East Kootenays during the 1860's resulted in increased expansion in the fields of mine prospecting, fur trade and lumber.

In 1873, Michael Phillips and John Collins visited the upper Elk River region prospecting for gold, at which time they discovered the Crowsnest Pass (Fernie & District 1977:17). In 1874, Phillips returned to the Elk Valley with three others, including Jim Morrissey. The party camped on the creek now bearing Morrissey's name. It was during this trip that coal was discovered on Morrissey Creek (Fernie and District 1977:19). Between 1876 and 1879, a trail was completed from Galbraithe's Ferry (now Fort Steele) to Crowsnest Pass. Begun by Phillips, the trail was finished by Peter Fernie.



PROJECT

SAGE CREEK COAL DEVELOPMENT

ARESCO Ltd.
CALGARY ALBERTA

TITLE

DRAINAGE PATTERNS AND PASSES

SCALE 1:250,000 FIGURE 2

The town of Fernie was establihsed in 1879. However, it remained a simple collection of shacks until the late 1890's and was eventually incorporated as a city in 1904 (Fernie & District 1977:69). In 1885 the Canadian Pacific Railway was completed.

The Crow's Nest Coal and Mineral Company incorporated in 1889 and was granted leases on 2,409 acres of coal land on Martin Creek. In 1890 they received 7,800 acres along Morrissey and Martin Ridges. However, in 1893, all lands were deeded to the British Columbia Coal, Petroleum and Mineral Company. The Crow's Nest Pass Coal Company Ltd. came into being in 1897 and later received all the deeded lands under the control of the British Columbia Coal, Petroleum and Mineral Company of which the Morrissey Creek area was a part.

Mining operations were begun along Morrissey Creek in 1901 and abandoned in 1905 due to unsafe mining conditions and a deterioration in quality of the coal seams. The mines were later re-opened in 1908 but finally abandoned for good in 1909 (Grieve 1979:8-9).

During the period of mining operations at Morrissey Creek, a small company town was established near the mine site which later became known as Carbonado. The mines were serviced by the Morriseey, Fernie and Michel Railway. Three of the original cars from this line are on display in Heritage Park in Calgary, Alberta.

A townsite was laid out on Morrissey Creek approximately 1.6 km downstream from the mine site, and a total of 240 coke ovens were constructed between the Morrissey Townsite and Carbonado during the mining years of 1901-1905. The Morrissey area has seen little development since the closing of the mines in 1905. Logging has been carried on in the area by Crows--nest Industries Ltd., and some small ranching is carried out.

Returning to the Flathead area, no major activity has been recorded for the area until oil was discovered in a valley west of Waterton Lake in 1889-90 (Rodney 1969:168). In 1900, Kootenai Brown and Archie McVittie laid out oil claims in the Sage and Kishinena Creek areas (Rodney 1969:180).

Oil drilling was sporadically carried out in the Flathead Valley until the late 1930's although some well sites were maintained until the early 1950's (Foster 1979:Appendix D). According to local informants (Holley, Wright, Dvorak, pers. comm.) no major drilling activities have been carried out in the Flathead, other than seismic explorations, since the 1950's. Coal exploration related to the present study have been carried out in the Howell/Cabin Creek areas only over the past eight years (P.Bedford:pers. comm.).

4. PREVIOUS HERITAGE RESOURCE STUDIES

Very few organized heritage studies have been undertaken in the Flathead Valley and Morrissey area. A brief library study was conducted in 1976 as part of a preliminary environmental impact study for the Sage Creek Coal project (Unecon 1976). In many respects the present study can be viewed as a continuance or follow-up of the project. The Fernie and District Historical Society (1977) has published a book on early settlement in the Elk River Valley and Crowsnest Pass. Otherwise, the only other work conducted within the study area was a heritage resource inventory of the Akamina-Kishinena Valley system in 1978 (Foster 1978).

A number of archaeological investigations have been carried out in related areas adjacent to the study region. The Kootenay Valley as initially surveyed in 1954 by Dr. C.E. Borden (1954), and later survey and excavation programs were carried out by Wayne Choquette (1971; 1972a, b; 1973a, b; 1974a, b; 1976, Bussey 1977). Archaeological excavations were carried out by Blake and Chapman in 1975 on the Wildhorse River (Blake 1976), to the north of the study area. A number of survey and excavation projects have been undertaken in the Crowsnest Pass area (Reeves 1972a, b; 1974a, b; Reeves and Choquette 1977). The Narrows site in Waterton Lakes National Park was excavated in 1968-69 (Brumley 1971); and to the south, an archaeological survey of the Libby Dam pondage was carried out in 1950 under the auspices of the Smithsonian Institution (Taylor 1973).

In summary, the prehistory of the study area is not well known.

5. PROCEDURES

5.1 PREFIELD STUDIES

A brief library search was conducted prior to fieldwork to familiarize the researchers with the study area. A search was made of the site files in the office of the Provincial Archaeologist for information on any previously recorded sites in the area. None had been recorded.

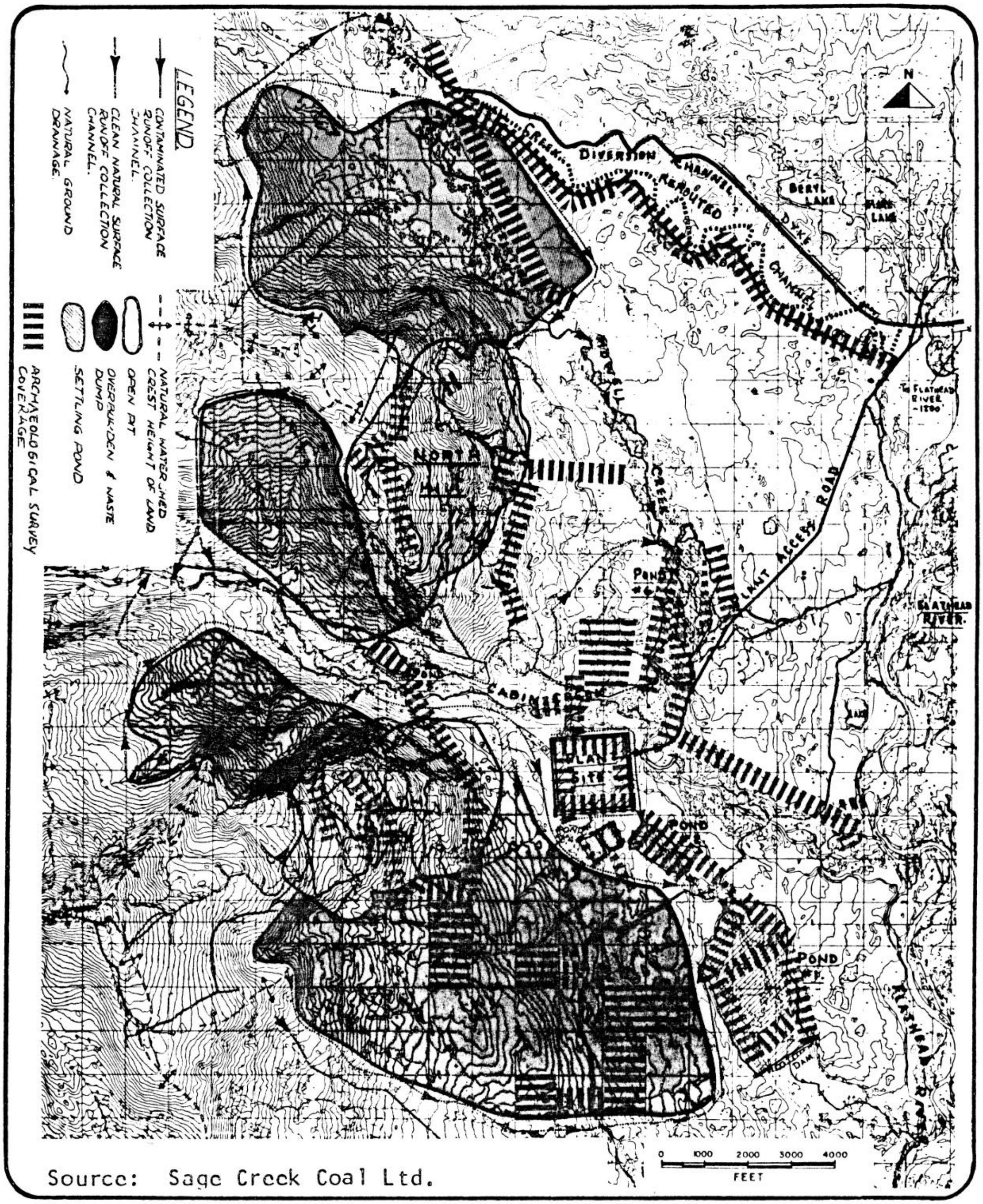
Air photos and proposed development plans were used as a basis for establishing a working field research design. Within the overall development area, specific 'high priority' localities expected to have the greatest potential for the occurrence of archaeological sites were plotted. These areas included terraces along present river courses as well as 'fossil land forms' (old river terraces). A 1:2400 scale topographic map showing 25 ft contours of the area was used to further evaluate the general potential of specific development areas considered to be of 'low priority' from the air photo analysis. Within the latter areas, a further breakdown into 'low priority' and 'negative priority' (areas considered to be of no value to the study) was undertaken. The 'negative priority' areas were basically restricted to steep side slopes (those having a slope of 27% or greater).

It was expected that 'high priority' areas would receive 100% intensive on-ground coverage, whereas low priority areas would receive 25% random coverage and negative priority areas would not be covered unless obvious breaks in slope affording potential cultural use-...ness were observed in the field.

5.2 FIELD RECONNAISSANCE

Upon arrival in the field, minor alterations to the previously ...ected survey approach were deemed necessary. The pondage areas were covered in a non-random fashion, since natural drainage features were being employed for the proposed pondages. Terraces (top and bottom) of these were intensively examined. The proposed plant access road was not surveyed and thus was not flagged or centre cut. We learned that the proposed road may not be constructed and if it were, it may not follow the route indicated in our plans. The proposed road was therefore not examined.

After our arrival in the field, it was learned that the proposed diversion of Howell Creek was also not surveyed. In addition, the proposed diversion course was altered from the original plans. Associated with the diversion channel, a parallel access road was to be constructed to facilitate soil sampling. This road was not anticipated from our prefield studies and thus had to be inspected as it was under construction. We were also informed that the proposed plant site may also be moved to the north side of Cabin Creek. (See Figure 3, page 11, for map of Development Areas and Areas of Archaeological Survey).



Source: Sage Creek Coal Ltd.

PROJECT	TITLE
SAGE CREEK COAL DEVELOPMENT	SURVEY COVERAGE OF PROPOSED DEVELOPMENT AREA
ARESCO Ltd. CALGARY ALBERTA	SCALE Approx. 1:4500 FIGURE 3

Upon re-assessment in the field, the survey coverage was altered to the following: the high ridge-tops of both mining areas (North and South Hills) were examined as high altitude sites are known in the general East Kootenay area (Choquette 1974a); the majority of the 'Dump area' were considered too steep (average slopes of 27%+) to require coverage, with the exception of the south ridge of 'South Hill'. On this south ridge, 350 x 350 m quadrats were established using a development plan base map provided by Sage Creek Coal Ltd. Twenty-five percent (8 quadrats) of the area with less than a 27% slope were randomly chosen, and then located by pace and compass. These areas were then intensively examined. The proposed plant sites and all pondages were also located by compass and pacing, and were examined with particular attention paid to high, well-drained areas. The major terrace system along the north bank of Howell Creek from its confluence with Cabin Creek to the Flathead River was walked. The terrace system along the northeast bank of Howell Creek through the dump area on the north side of North Hill was also archaeologically surveyed.

During the construction of the road paralleling the Howell Creek diversion, foot survey was done in front of the bulldozer with the agreement that should sites be encountered, the road would be diverted. The road was later re-examined after completion of construction as total surface clearance allowed for a cross-check on the original inspection.

In the Morrissey area, the entire load-out area was to be walked. However, it was found that the majority of the area was inundated by beaver ponding. Therefore, only the terrace systems along the north edge and higher, well-drained areas were observed.

During foot traverses, all natural exposures, (i.e. game trails, uprootals, terrace edges, roadways, drill hole clearings, etc.) were inspected. Ground cover was often heavy, so occasional shovel tests and surface clearing were done.

6. SITE SPECIFIC RESULTS AND RECOMMENDATIONS

During the course of the field inspection historic period sites were recorded (DgPp- H-2, H-3, DgPr- H-1, H-2, H-3, and H-4, DgPs-H-1), only one of which (DgPp- H-3) fell within an area of impact. No prehistoric sites were encountered. (Figure 4, Page 14). Each site is described below. See Appendix A, site forms.

6.1 DgPp- H-2

6.1.1 Location

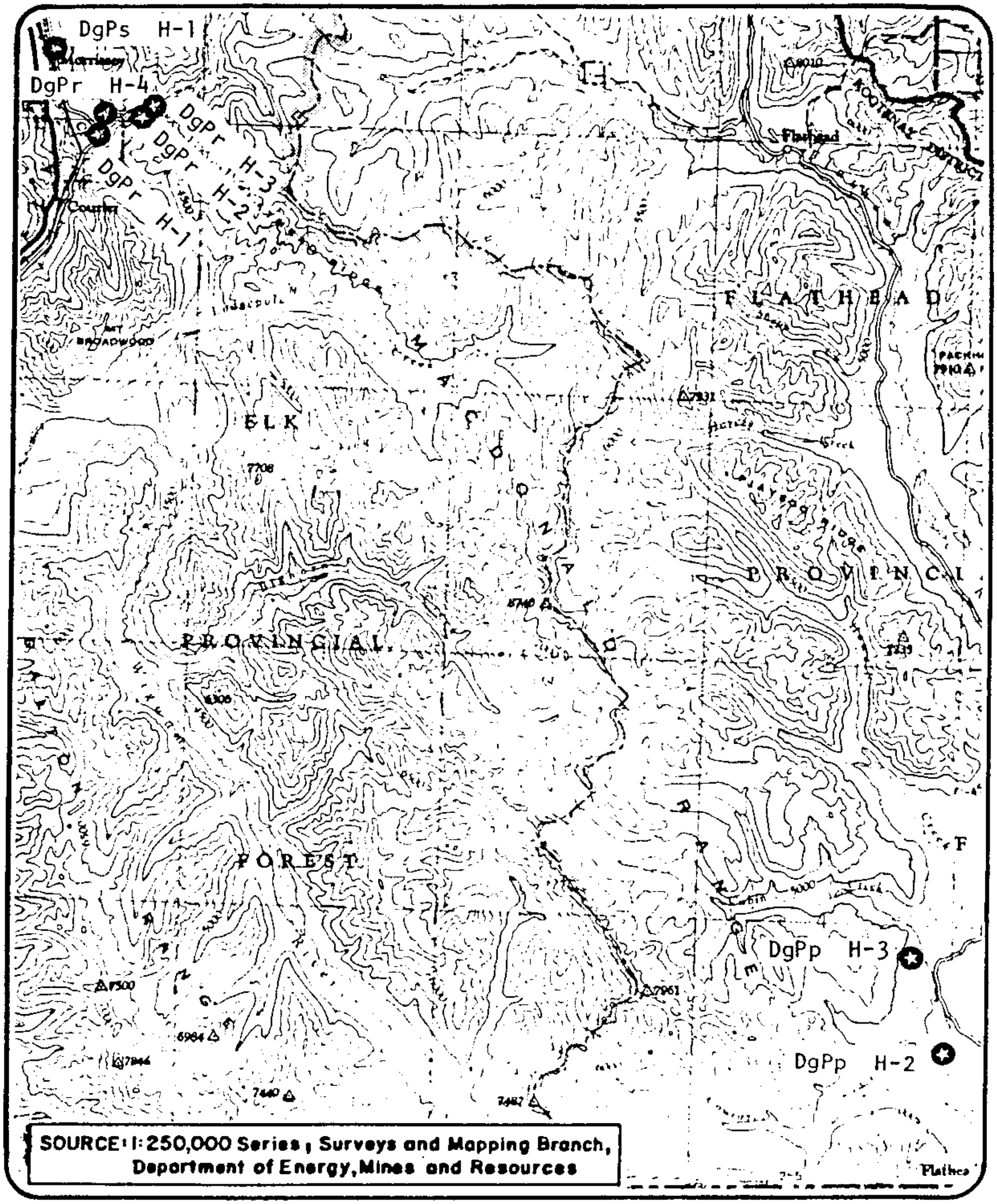
This site is located about 400 m north of Burnham Creek and approximately 3 km west of the Flathead River along the Burnham Creek road. The 1:50,000 U.T.M. map co-ordinates are 11UPE799356.5.

6.1.2 Description

DgPp- H-2 is an historic oil well site dating back to 1913 and was operated by the B.C. Oil and Coal Company, according to a B.C. Forest Service sign posted at the site. According to the B.C. Ministry of Mines and Petroleum Resources 1973 map of well locations in the Flathead Valley (Foster and Brolley 1979:63-64), this site was in fact established in 1939 as 'Border No. 1' by Border Oils Incorporated. It was later abandoned on July 25, 1949.

A wooden derrick and pump-house complex are still standing above the well head (Plate 1, page 25). Also present and scattered about the site area are various pieces of rigging including drill shafts and fly-wheels. Two small cabins are located 125 m west of the well head (Plate 2, page 25). We were told by a local resident (Ralph Wright: pers. comm.) that the cabins are recent, and were constructed by hunters from lumber taken from the derrick-pump house. Upon inspection, the cabins showed evidence of occupation (i.e. newspapers dated to 1978, cut firewood, etc.) which verified the recency of use. However, behind the cabins is an old root cellar with a collapsed roof, which suggests a greater age and more general use for the cabin site than simply a hunting camp. The cellar is presently being used as a dump.

It is possible that the cabins were originally constructed at the time of drilling operations and have been subsequently re-built by hunters.



PROJECT

SAGE CREEK COAL DEVELOPMENT

ARESCO Ltd.

CALGARY **ALBERTA**

TITLE

STUDY AREA MAP WITH SITE LOCATIONS

SCALE 1:250000 **FIGURE** 4

6.1.3 Recommendations

This site is well beyond the area of concern and therefore will not require further mitigative work by Sage Creek Coal Ltd. The site is, however, a significant historical link with the early pioneer days of oil exploration in the Flathead Valley. There is a danger that an increase in the human use of the Flathead Valley which is likely to occur should the mining development become a reality, may indirectly result in adverse impact to this site. Such impact would most likely take the form of vandalism and decay through 'relic-hunting'.

We therefore recommend that the Heritage Conservation Branch be advised to monitor this site should the mining development continue. Since the B.C. Forest Service has already posted the site it would appear that a jointly sponsored monitoring program might be possible between the Heritage Conservation Branch and the Forest Service.

6.2 DgPp- H-3

6.2.1 Location

This site is situated on the east slope of Dalley Hill approximately 1.5 km south of Cabin Creek and 3.3 km west of the Flathead River at an elevation of about 1,487 m above sea level. The site is located on the north bank of a tributary stream of the Flathead River, which drains the west slope of Dalley Hill. The 1:50,000 U.T.M. map co-ordinates are 11UPE7825390.5.

6.2.2 Description

DgPp- H-3 is also an historic oil well site, consisting of a well head, quantities of rigging (i.e., casings, drill shafts, etc.) and a boiler for a steam operated drilling engine. No derrick stands at this site nor is there any indication of who drilled the well or when it was drilled. Local informants (T. Holley, F. Dvorak, R. Wright:pers. comm.) suggest that it would not post date the 1930's, as it appears that most active oil drilling ceased in the Flathead Valley during that decade.

This site has been distrubed over the past few years as a result of coal testing explorations on the "South Hill" by Sage Creek Coal Ltd. A 'drill site' clearing is present less than 100 m northeast of the site, and the boiler has been moved into that clearing. A steam water pump, drilling engine and drill drive have been removed from the site and are presently situated at the Sage Creek Coal Ltd. explorations camp site near the confluence of Cabin and Howell Creeks.

6.2.3 Recommendations

DgPp- H-3 falls within the proposed impact zone on the South Hill. It is however, not within the proposed mining area, but rather that area designated for overburden dumping and therefore should be possible to avoid. However, in consideration of the dramatic alterations the mining activity will have on the surrounding countryside and the limited significance of the site, we do not feel that avoidance is necessary.

The artifacts associated with this site however, are still in fairly recognizable form (Plate 3, page 26), and should be collected and offered to the local museum at Fernie as a display of early oil exploration in Flathead Valley. An historical search should be made to gain information concerning the company or companies involved in the drilling operations with a written history to accompany the artifacts on display. This could probably be done by the local museum staff.

6.3 DgPr- H-1

6.3.1 Location

This site is located 18.5 km southeast of Fernie on the west bank of Morrissey Creek 1.6 km upstream from its mouth. Lodgepole Road borders the site on the north. The 1:50,000 UTM map coordinates are 11UPE462701.

6.3.2 Description

DgPr- H-1 represents the historic townsite of Morrissey built at the turn of the century in response to the opening of the Morrissey Mines in 1901. According to the Fernie and District Historical Society (1977:61) the town was laid out with water and power systems, 5 avenues, 2 streets, hotels, stores, a post office and printing office.

Nothing exists at the site today (Plate 4, page 26). According to Mr. Frank Dvorak (pers. comm.) a one time resident of Morrissey, the area was levelled by Crowsnest Industries in preparation for a sawmill. The mill was never built.

Early maps, original legal surveys and town plans of Morrissey townsite are presently on file with the lands division of Crowsnest Industries in Fernie.

6.3.3 Recommendations

DgPr- H-1 falls outside the area of potential impact as it has been proposed by Sage Creek Coal Ltd. and therefore requires no further mitigative work on their behalf.

6.4 DgPr- H-2

6.4.1 Location

This site is located on the north bank of Morrissey Creek approximately 2.8 km upstream from its mouth, and 1.2 km upstream from the Morrissey townsite (DgPr- H-1). The 1:50,000 UTM coordinates are 11UPE476705.5.

6.4.2 Description

DgPr- H-2 consists of the remains of 240 coking ovens associated with the Morrissey Mines operations of the Crow's Nest Pass Coal Company from 1901 to 1905. The ovens were constructed with bricks imported from France according to one local informant (Dvorak pers. comm.). Each oven is dome-shaped (similar to a bee-hive) and measures 3 meters in diameter at the base and stands an equivalent 3 meters at the centre of the dome where a small round (ca. 20 cm) air vent is located (Plate 5, page 27). The ovens were constructed in pairs paralleling the creek, and a railway (Morrissey, Fernie and Michel Railway) ran between the ovens and the creek bed.

A road has been pushed through the northern end of the ovens, and every oven has been vandalized. According to local informants (Dvorak and Wright pers. comm.) the oven bricks are continually taken by collectors. The entire brickwork is missing from some of the ovens.

6.4.3 Recommendations

DgPr- H-2 also falls outside the proposed impact area and thus does not require further work by Sage Creek Coal Company. This site is significant however, as it is one of the last links with the early mining activities along Morrissey Creek. Therefore the Heritage Conservation Branch should be advised to look into the possibility of monitoring this site to prevent further destruction. The Fernie and District Historical Society may be a useful and willing participant in such a program if approached.

The site is presently on land under the control of Crowsnest Industries who may also be useful in helping to establish a conservation program for this site.

6.5 DgPr- H-3

6.5.1 Location

This site is located on the north bank of Morrissey Creek 3.55 km upstream from its mouth and 1.95 km upstream from the Morrissey Townsite (DgPr- H-1). The 1:50,000 UTM coordinates are 11UPE481708.

6.5.2 Description

DgPr- H-3 is the historic townsite of Carbonado originally knonw as "Morrissey Mines" (Crabb and Crisafio 1978:8). As this site fell outside of the primary survey area, no intensive mapping was done. According to the Fernie and District Historical Society (1977:65), the town was owned by the Crow's Nest Pass Coal Company and at one time possessed 10 single and 35 double dwellings complete with light and water, as well as a hotel, church and store (Plate 6, page 27).

The town was built in response to the Morrissey mining operations of 1901 to 1905. After a brief one year attempt in 1908 to re-open the mines (Grieve 1979:9), they were completely closed down. After closing of the mines, the town was dismantled and most of the buildings were moved to Coal Creek (Crabb and Crisafio 1978:8).

An original legal survey and town plan is presently in the files of the lands division of Crowsnest Industries in Fernie.

6.5.3 Recommendations

DgPr- H-3 falls outside the area of proposed impact and thus requires no further mitigative work by Sage Creek Coal Ltd.

6.6 DgPr- H-4

6..6.1 Location

This site is located on the southwest slope of Morrissey Ridge approximately 800 m northwest of Morrissey Creek and 3.1 km southeast of the Morrissey Bridge over the Elk River. The 1:50,000 UTM coordinates are 11UPE460705.5.

6.6.2 Description

DgPr- H-4 is an historic burial site representing the cemetery associated with the townsite of Morrissey (DgPr- H-1). The cemetery is situated on a hill 40 meters above a new logging road. Five graves were noted but the cemetery is completely overgrown and difficult to observe. There is therefore a possibility of more graves being present. Since this site fell outside the specific area of interest, time did not permit intensive mapping. Of the five graves observed, two belonged to the Dvořak family, one dating to 1929 (Plate 7, page 28). All but the two Dvorak graves were encompassed by wooden pickets and marked with wooden crosses (Plate 8, page 28). The writing on the wooden crosses has been obliterated. The Dvorak graves were fenced with chain-link fencing and marked with granite stones.

No record of this cemetery was noted in any of the documentation compiled concerning Morrissey. The site was reported to us by Mr. Frank Dvorak of Fernie.

6.6.3 Recommendations

DgPr H-4 falls outside the proposed impact area and thus requires no further work by Sage Creek Coal Ltd. Logging operations are being carried out in the vicinity of DgPr H-4, by Crowsnest Industries, and could endanger this site. Mr. Bill Wilson of Crowsnest Industries has informed us that the company is aware of the site and will attempt to avoid any direct impact. The site has been flagged.

6.7 DgPs- H-1

6.7.1 Location

This site is located on both banks of the Elk River at the Morrissey Bridge crossing 13 km south of Fernie. The 1:50,000 UTM coordinates are 11UPE439572.6.

6.7.2 Description

DgPs- H-1 represents the original location of the townsite of Morrissey Junction (on the west side of the river) and Morrissey Station (on the east side of the river). Today nothing remains of these two related sites.

According to Frank Dvorak (pers. comm.) Morrissey Junction once consisted of a hotel, school house, store and a few houses. The B.C. Forest Service has developed a picnic site upon the old townsite.

Morrissey Station was situated on the east side of the Elk River and consisted of a train station and section house (Dvorak pers. comm.) at the junction of the C.P.R. and Morrissey, Fernie and Michel Railways. A short section of the old Morrissey, Fernie and Michel Railway bed still exists to the southeast of the site.

6.7.3 Recommendations

DgPs- H-1 falls outside the proposed impact area and therefore requires no further work by Sage Creek Coal Ltd. Attention should be given to the remnants of the Morrissey, Fernie, Michel Railway bed, however, as it is less than 200 meters from the proposed Morrissey load-out area. Care should be taken to ensure no damage to that portion of the site is incurred during development of the load-out facilities.

7. SUMMARY OF RECOMMENDATIONS AND DISCUSSION

Recommendations for the sites previously discussed as they relate to the Sage Creek Coal Ltd. proposal are summarized as follows:

- DgPp H-2

  This site is outside the development area. No further work by Sage Creek Coal Ltd.

- DgPp H-3

  This site falls within the proposed impact area of the "South Hill", and can be avoided. Artifacts related to this site should be collected and preserved. The historical background of this site should be recorded.

- DgPr H-1

  This site falls outside the development area. No further work is required by Sage Creek Coal Ltd.

- DgPr H-2

  This site falls outside the development area. No further work is required by Sage Creek Coal Ltd.

- DgPr H-3

  This site falls outside the development area. No further work is required by Sage Creek Coal Ltd.

- DgPr H-4

  This site falls outside the development area. No further work is required for Sage Creek Coal Ltd.

- DgPs H-1

  This site borders the proposed Morrissey load-out area but falls ouside it. Care must be taken to avoid damage to the last remnants (railway bed) of this site.

7.1 STUDY AREA INTERPRETATION

The lack of prehistoric sites in the study area appears to be quite surprising in light of the ethnographic descriptions of the Kootenai life style. Animal life in the Flathead Valley today is certainly plentiful and varied enough to support small hunting and gathering groups, and there is no indication that this has not been the case for several centuries. Since it is known that the Kootenai at least crossed through the upper Flathead if not occupied it, it should be expected that some evidence of their passing would be left. Why then was nothing observed?

Firstly, it may be a function of the study program. The study area hardly represents a significant portion of the valley proper. Ground cover was extremely dense and sampling techniques, although weighted heavily towards areas expected to have been of the highest potential for yielding archaeological sites (given prior knowledge of East Kootenay archaeology), failed to yield prehistoric sites. High potential areas, such as terraces, stream confluences, etc. were few in the study area. The majority of proposed developments were located on relatively steep side slopes, or within the bogs and swamps of existing drainage basins (Plates 9 to 12, pages 29 and 30).

It is more likely however, that the results of the survey reflect the true nature of the archaeological potential of the Howell and Cabin Creek areas. A review of the overall physiography of the Upper Flathead drainage may help to understand the low archaeological potential of the study area. As Brumley (1971:3) points out for the Waterton Lakes area "the physiography of the region determines the location of aboriginal trails".

Although there are a number of passes from the Flathead to the eastern foothills of the Rockies (i.e. North Kootenay, Middle Kootenay, South Kottenay, Sage, Akamina, etc.), there are very few allowing easy access from the Kootenay Valley into the Flathead. The primary barrier is the Galton Range between the Elk and Kootenay Rivers and the Wigwam River. Here the only major routes available are to the north up the Wigwam River from the Elk River into the Lodgepole Creek and Harvey Creek Valleys through to the Upper Flathead (north of the study area). The only other area is to the south near the border, up Phillips Creek and down Rabbit Creek into the headwaters of the Wigwam River and thence eastward down Couldrey Creek into the Flathead south of the study area.

Once into the Wigwam Valley, a fairly easy pass appears to exist through Bighorn Creek and Cabin Creek, entering the middle of the study area; however, once a person is into the Wigwam from either the north or south end, the use of the Bighorn would appear quite circuitous given the nearness of the Lodgepole Creek (north) and Couldrey Creek (south) passes. The Wigwam River itself is very treacherous along the central stretches and thus not conducive to easy traversing.

It is interesting to note that according to the Fernie and District Historical Society (1977:10), the Crow's Nest Pass was not used by the Kootenay and moreover was likely avoided. They quote Lt. Thomas Blakiston who explored the "British Kootenay Passes" in 1858 as saying that although the Indians knew of the Crow's Nest they considered it a "bad road". Reeves (1974:2) also makes note of Blakiston's comment. The Society goes on to point out that:

> The primary Kootenay trail, however (north of the American territory), was through the North Kootenay Pass - which was also accessable from three different places in the Elk Valley: the main trail up the Wigwam and Lodgepole Rivers from a point near Elko, into the Flathead and thence across North Kootenay Pass, appears to have been used almost exclusively... (1977:10).

It is suggested that the Phillips Creek-Rabbit Creek route would have been more appropriate for the bulk of the Tobacco Plains people due to its nearness and accessiblity. According to several local informants (T. Holley, pers. comm.; R. Wright, pers. comm.) the Phillips Creek-Rabbit Creek pass was often used by early pioneers, evidence of which can still be observed by way of an old wagon road. Reeves (1972:28) description of the "Buffalo Trail" would suggest that the Flathead Valley was crossed to the south of the study area for those entering from that direction:

> South Kootenay Pass was used by the Kootenay as a major travel route to the Plains. Access to the area could be gained by travelling via the Grave Creek trail (also called Tobacco Creek) up the south fork of the Flathead River to where it joins Kishinena Creek, some four miles below the border. From there a trail led up Kishinena Creek, past Mount Yarell and Akamina Meadows, up Kishinena to its headwaters and then over South Kootenay Pass and into Lone Brook in present day Alberta. This pass, known to the Kootenay Indians as the "Buffalo Trail", was used in historic times by. . . Kootenays and other intermontane groups such as Flathead, Nez Perce, Coeur D'Alene, Kalispell and Spokane to travel eastward to hunt buffalo on the Plains (Foster 1978:11).

7.2 DISCUSSION

It must be noted that the survey coverage was development specific and did not encompass a significant sample of the Upper Flathead Valley. However, the paucity of prehistoric sites in the study area is consistent with the results of the heritage resource survey conducted in the Akamena-Kishinena area in 1978 (Foster 1979). The Howell Creek - Cabin Creek area of the Upper Flathead Valley is therefore considered to be, in general, a low potential area with respect to heritage resources.

It is our impression that the plans for the actual locations of the Howell Creek diversion channel, plant access road as well as the pondange and plant sites are not finalized and may change. This report only recommends clearance for plans as they have been presented to ARESCO Ltd. at the time of the 1979 field program. It is our opinion however, that minor alterations within the general Cabin Creek - Howell Creek area will have little or no impact upon heritage resources.

PLATE 1

DgPp H-2. Close-up shot of the wooden derrick and pump house complex associated with this well site. The site was operated by the Border Oils Incorporated begun in 1939 and abandoned in 1949.

PLATE 2

DgPp H-2. Cabins located 125 m west of the well site. These structures probably postdate the well site and may not be in direct association.

PLATE 1

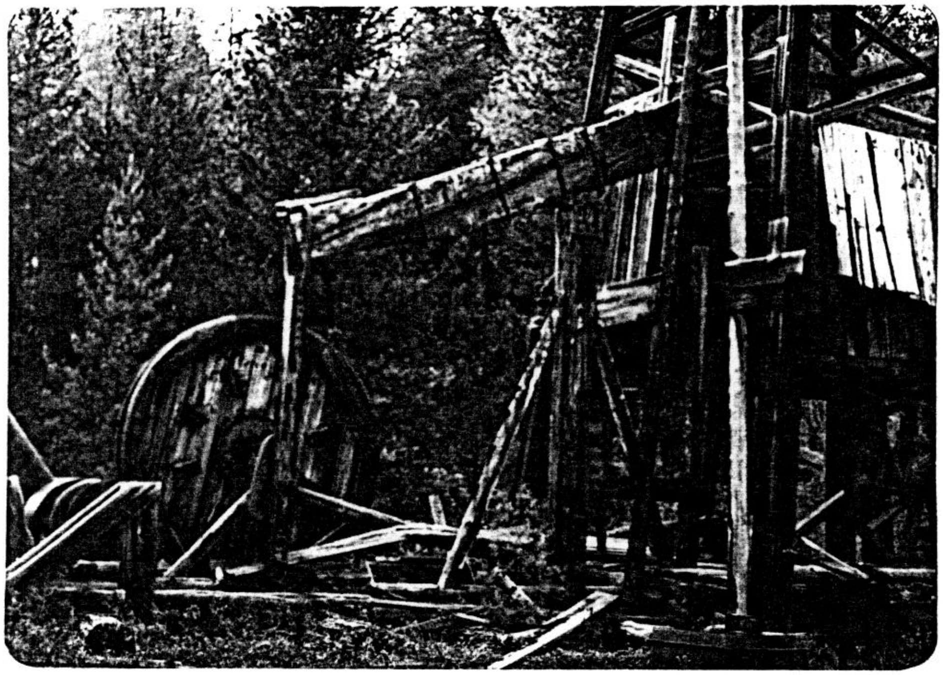


PLATE 2

PLATE 3 DgPp H-3. View of steam drill, drill drive and waterpump. These artifacts could be collected for interpretive purposes.

PLATE 4 DgPr H-1. The Morrissey townsite was located beyond the fenceline but has been destroyed by land levelling.

PLATE 3

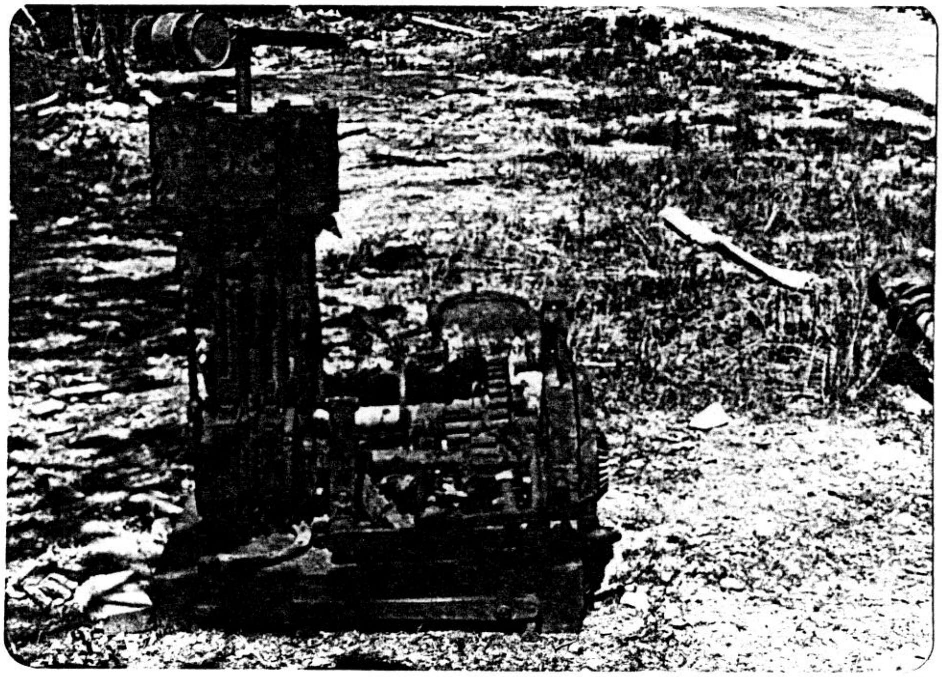


PLATE 4

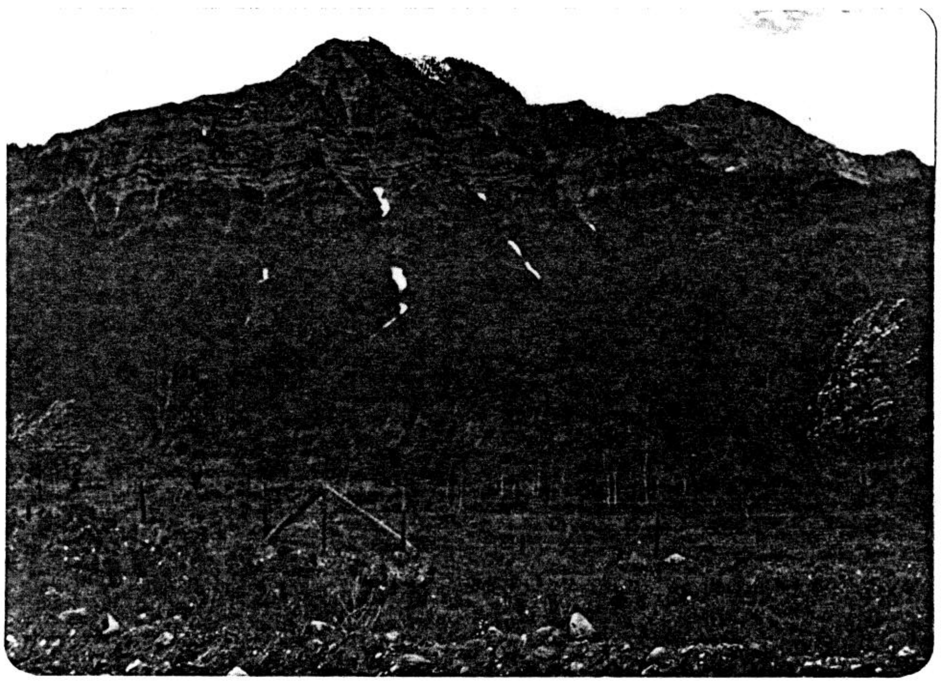


PLATE 5 DgPr H-2. Coking ovens associated with the Morrissey Mines operations.

PLATE 6 DgPr H-3. Old company house remains at Carbonado. This site, established by the Crow's Nest Pass Company, dates to about 1901.

PLATE 5

PLATE 6

PLATE 7 DgPr H-4. A tombstone found in the small Morrissey cemetery.

PLATE 8 DgPr H-4. One of the three Morrissey graves marked by a wooden cross and wooden picket fence.

PLATE 7

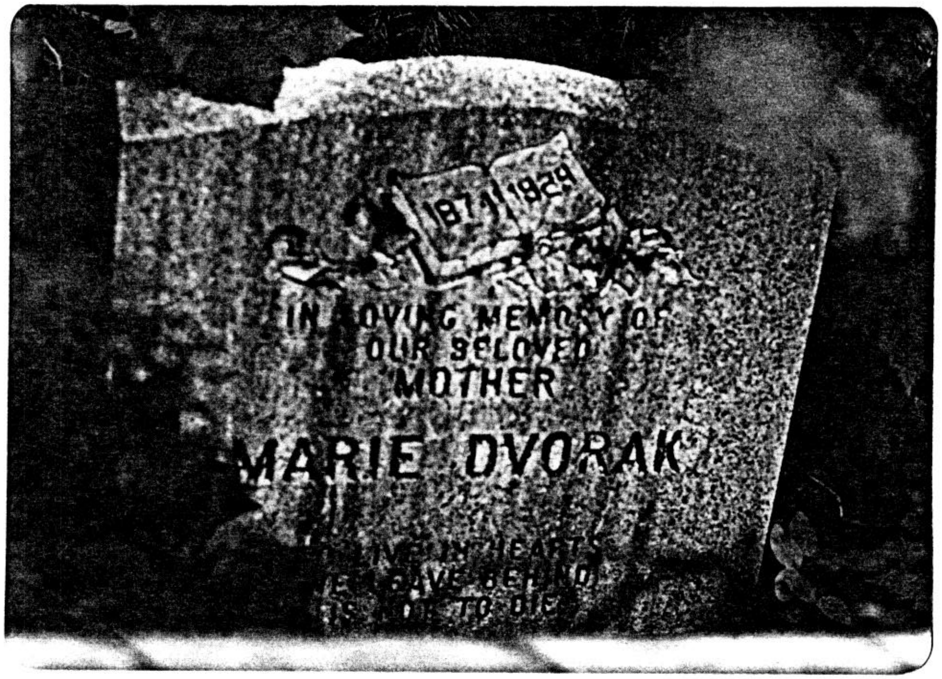


PLATE 8

PLATE 9 This photograph shows the "North Hill" Cabin Creek flows in the valley at the base of this hill. Note the steepness of this landform.

PLATE 10 A general overview of the study area taken from atop the "South Hill". Note the heavy forest cover.

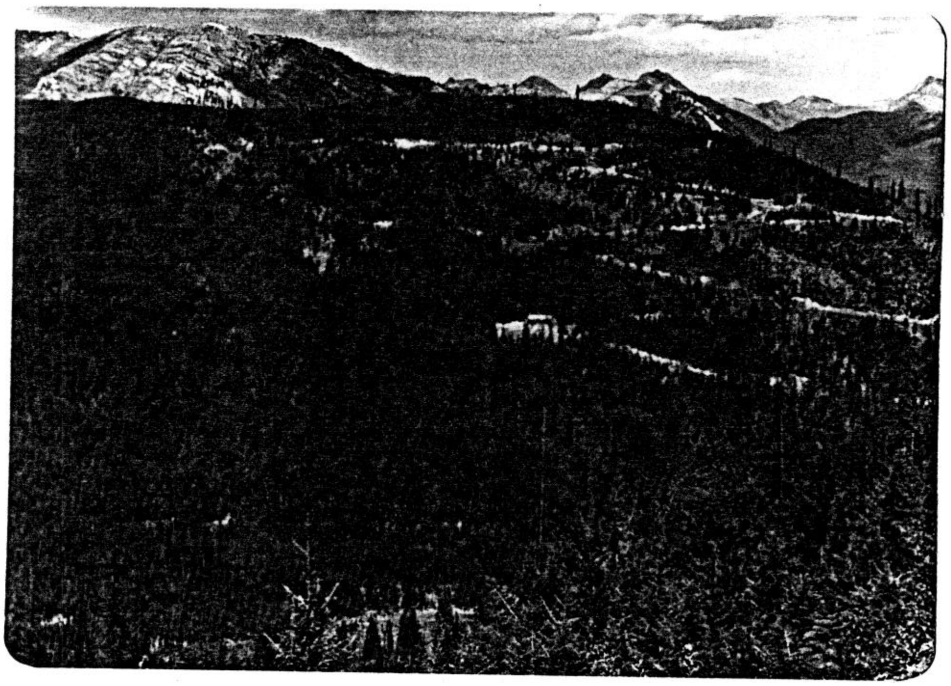


PLATE 9

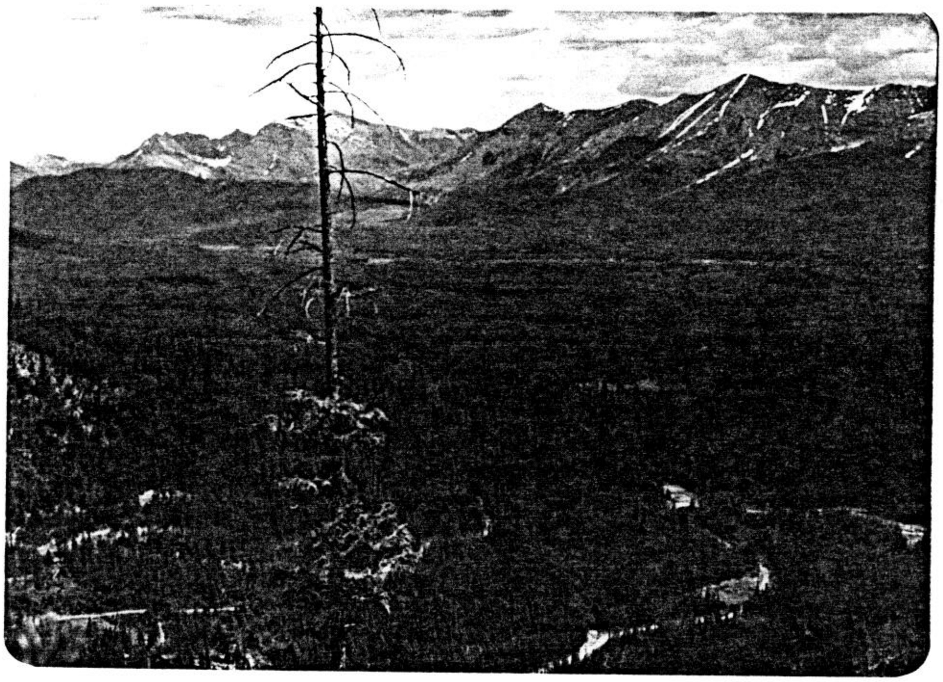


PLATE 10

PLATE 11 Area of the proposed plant site. Note the undifferentiated terrain and wet ground.

PLATE 12 View of Pondage No. 2 with the Cabin Creek Valley in the background. Note the boggy terrain and absence of terrace development.

PLATE 11

PLATE 12

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Mr. Ralph Wright — Cranbrook, British Columbia

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APPENDIX A

SITE FORMS

PLEASE CONSULT ACCOMPANYING GUIDE BEFORE COMPLETING

1. Site No. DgPp H-2

BRITISH COLUMBIA ARCHÆOLOGICAL SITE INVENTORY FORM

2. Previous designation(s)

3. Site name(s) Border No. 1

4. Location (a) Section Lot 7846 Plan

(b) This site is situated on the Burnham Creek road approximately 5 km due north of the International Boundary and 3 km west of the Flathead River (north fork). The site is situated in a small grass clearing.

5. Access Take Morrissey turnoff east from Highway #3 (14.2 km south of Elk River Bridge at Fernie) for 4.6 km until reach junction with Lodgepole Road. Take Lodgepole Road southeast to junction with Harvey Creek road. Take Harvey Creek road east to its termination with Flathead Valley road. Proceed down Flathead Valley road to Cabin Creek road also known as the "Border road" at 73 km post. Proceed south on "Border road" approximately 11 km to junction with Burnham Creek road. Turn west and proceed for approx. .4 km to site.

6. Administrative jurisdiction (a) Resource Management Region Kootenay

(b) Regional Dist. E. Kootenay (c) Forest/Grazing Dist. Nelson

(d) Highways Dist. Fernie (e) Prov. Park Dist. 2. E. Kootenay

7. Lat. 49 ° 02 ′ 55 ″ N. 8. Long. 114 ° 32 ′ 27 ″ W.

9. UTM 11UPE / 799356.5 10. Air photo N/A

11. Map (a) 82G/2 Lower Flathead (b)

12. Drainage (a) minor (North Fork) Flathead River (b) major 1

13. Elevation (a) Ca. 4300' A.S.L. (b) Ca. 30 m above Burnham Creek

14. Cultural affiliation (a) Euro Canadian (b) Historic

15. Site type Oil well

16. Dimensions (a) exact 200 m x 60 m (paced) (b) estimated

(c) original same

17. Condition (*a*) present 50% (*b*) future Posted by B. C. Forest Service bu

may be damaged - hunters & tourists 18. Priority

19. Detailed information (*a*) vegetation on site grasses, jack pine, western larch, Englemann spruce, aspen, sitka alder

(*b*) major vegetation

(*c*) cultural matrix n/a

(*d*) depth of cultural matrix n/a

(*e*) non-cultural matrix n/a

(*f*) water source n/a

20. Known finds and present location Oil derrick, well-head, steam pump, drills, shafts, old car, 2 cabins

21. Photo record ARESCO Ltd. (Calgary)

22. Published and unpublished references (*a*)

(*b*) H.C.P. Report 1978-8 (appendix d)

23. Site age and/or date (*a*) 1913 ☒ absolute ☐ relative

(*b*) Source B.C. Forest Service

24. Owner/Tenant Crown

25. (*a*) Informant n/a

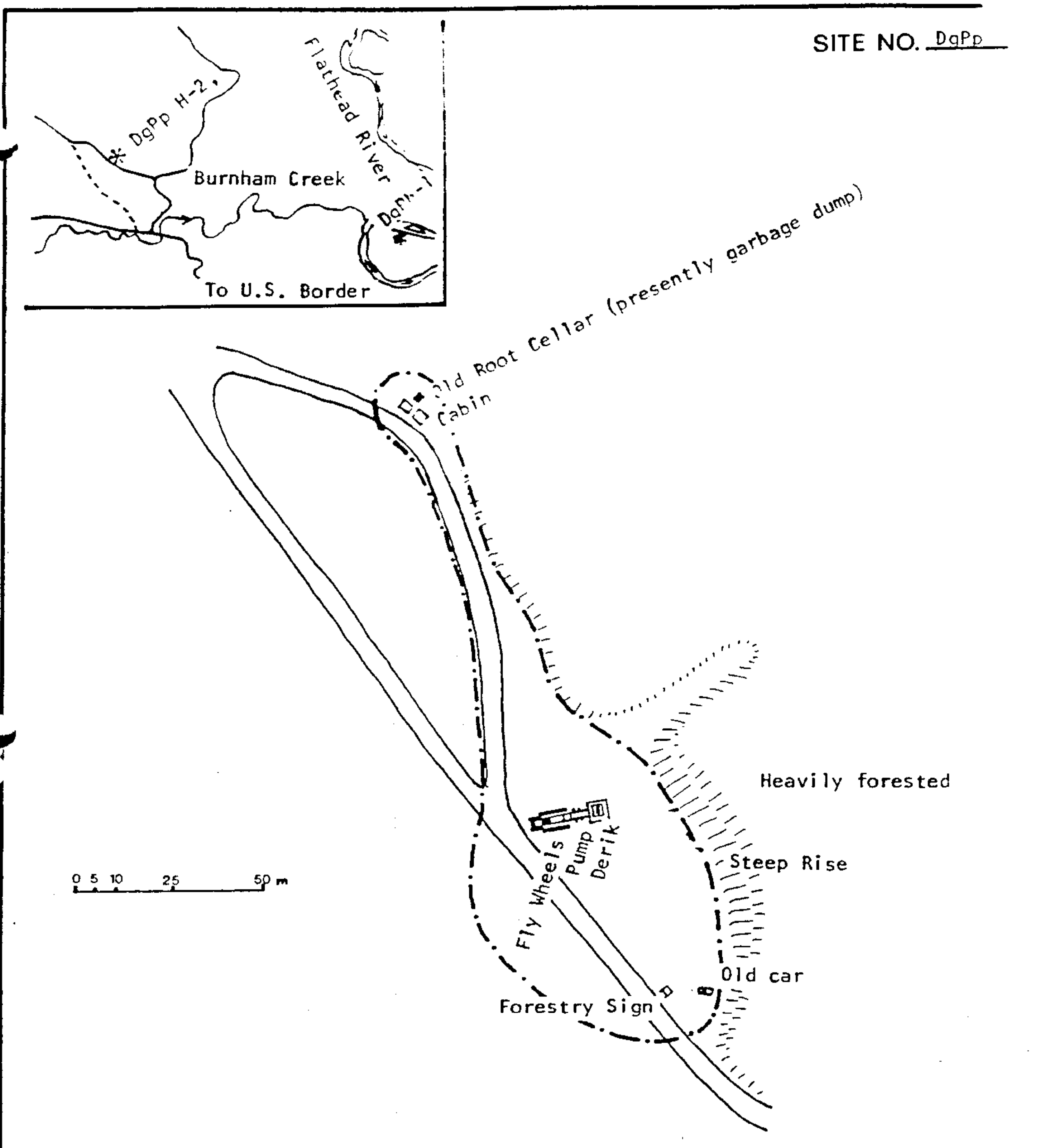
(*b*) Observed by B. Apland, J. Warner Date June 1979

(*c*) Recorded by B. Apland, J. Warner Date June 1979

(*d*) Revisited by Date

26. Remarks This site has been posted by the B. C. Forest Service as having been originally installed by the B. C. Oil and Coal Company in 1913. Accordin to the information concerning the locations of wells in the Flathead Valley presented by Foster (1978:64-65) this site was established in 1939 by Border Oils Incorporated and abandoned in 1949. The site was known as Border No. 1.

SITE NO. DgPp



EXTENT OF SITE

BUILDING

FOUNDATION

ROAD

TRAIL

RAILWAY

FENCE

RIVER/CREEK

STEEP RISE

ADDITIONAL LEGEND

1:50,000 MAP NO. 82G 2

LATITUDE 49°02'55"

LONGITUDE 114°32'27"

UTM GRID REF. 11U 799356.5

TRUE ☒ MAGNETIC ☐

DECLINATION USED 18°49.8'

DATE 1979

SCALE: 1 CM. = 15 M. 1:1500

0

PLEASE CONSULT ACCOMPANYING GUIDE BEFORE COMPLETING

1. Site No. DgPp H-3

BRITISH COLUMBIA ARCHÆOLOGICAL SITE INVENTORY FORM

2. Previous designation(s)

3. Site name(s)

4. Location (a) Section Lot L8728 Plan

(b) This site is situate: on the north side of a small stream draining the east slope of Dalley Hill approximately 206 m. above the Flathead river, on the western edge of Lot 8728.

5. Access Take Morrissey turnoff east from #3 highway (113 km south of Elk River bridge at Fernie). Follow Morrissey road for approximately 4.6 km then take Lodgepole Road to Harvey Creek road. Follow Harvey Creek road to its termination at Flathead Valley road. Go south along Flathead Valley road and take Border road south at 73 km post. Follow Border road past Butt's Patrol station to Cabin Creek road. Follow Cabin Creek road for 3.1 km and take turn off (south) across Cabin Creek. Follow bottom access road around south east slope of Dalley Hill for approximately 1.5 km.

6. Administrative jurisdiction (a) Resource Management Region Kootenay

(b) Regional Dist. E. Kootenay (c) Forest/Grazing Dist. Nelson

(d) Highways Dist. Fernie (e) Prov. Park Dist. 2 E. Kootenay

7. Lat. 49 ° 04 ′ 50 ″ N. 8. Long. 114 ° 33 ′ 50 ″ W.

9. UTM 11UPE /782.5390.5 10. Air photo n/a

11. Map (a) 82G/2 Lower Flathead (b)

12. Drainage (a) minor North Fork Flathead River (b) major 1

13. Elevation (a) ca. 1487 m A.S.L. (b) Adjacent to unnamed tributary of Flathead River

14. Cultural affiliation (a) Euro-Canadian (b) Historic

15. Site type Oil well

16. Dimensions (a) exact (b) estimated 10 m x 20 m (paced) (c) original same

coal mining 18. Priority

19. Detailed information (*a*) vegetation on site pine, grasses, western larch

(*b*) major vegetation Pine and larch forest

(*c*) cultural matrix n/a

(*d*) depth of cultural matrix n/a

(*e*) non-cultural matrix Glacial tills, limestone bedrock

(*f*) water source Small stream immediately to the south

20. Known finds and present location boiler, well-head and riggings, steam engine, drill drive and steam water pump

21. Photo record ARESCO Ltd. (Calgary)

22. Published and unpublished references (*a*)

(*b*)

23. Site age and/or date (*a*) Unknown (Historic) ☐ absolute ☐ relative

(*b*) Source

24. Owner/Tenant Rio-Algom Ltd.

25. (*a*) Informant Ralph Wright, Cranbrook, B. C.

(*b*) Observed by B. Apland, J. Warner Date June 1979

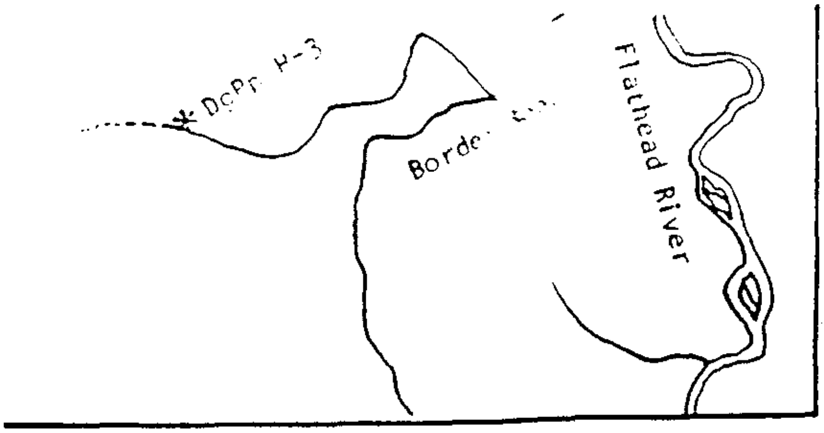
(*c*) Recorded by B. Apland, J. Warner Date June 1979

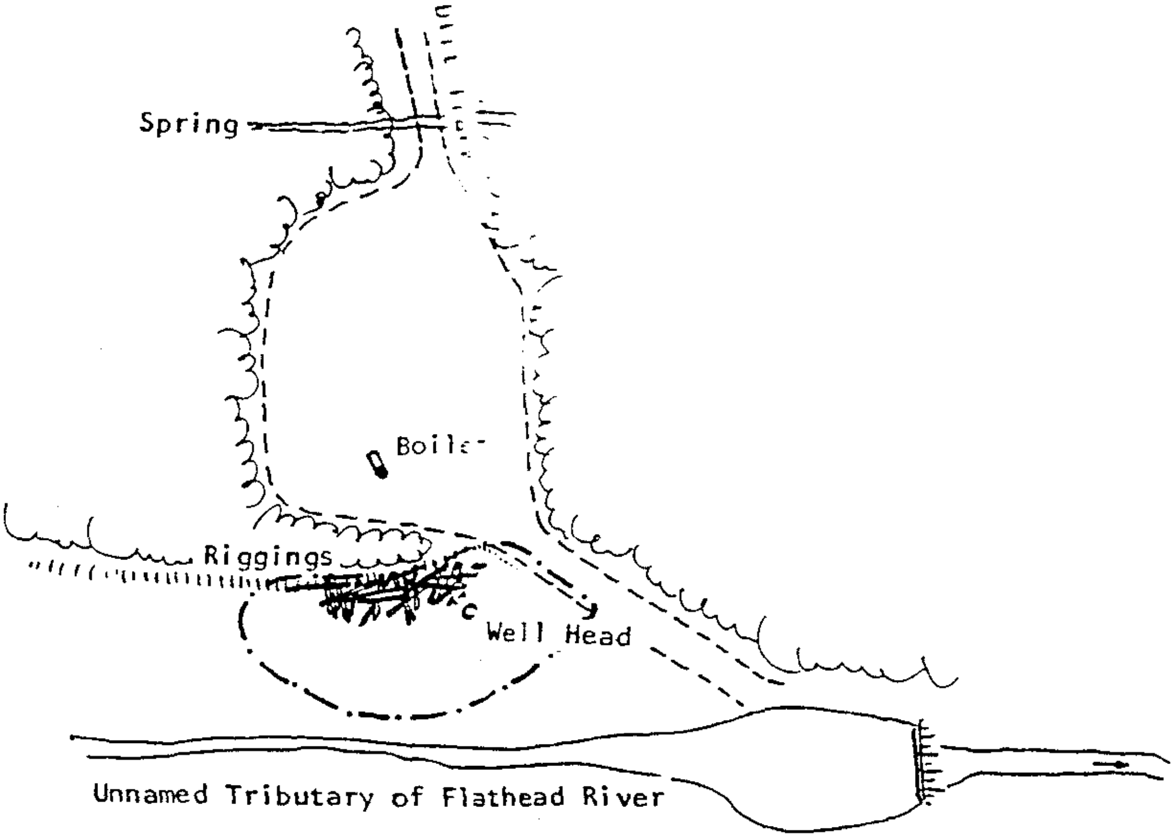
(*d*) Revisited by Date

26. Remarks The steam engine, drill drive and water pump have been removed from this site and are now situated at the Sage Creek Coal Exploration camp site on Cabin Creek near the confluence with Howell Creek.

The boiler was moved into a clearing ca. 25 m northwest of the site.

SITE NO. DgPp





EXTENT OF SITE	—·—·—·—
BUILDING	■
FOUNDATION	□
ROAD	═══ =====
TRAIL	— — — —
RAILWAY	┼┼┼┼┼
FENCE	–X–X–X–X–X–
RIVER/CREEK	
STEEP RISE	

ADDITIONAL LEGEND

1:50,000 MAP NO. 82G 2

LATITUDE 49°04'50"

LONGITUDE 114°33'50"

UTM GRID REF. 11UPE 782-5390-5

TRUE ☒ MAGNETIC ☐

DECLINATION USED 18°49.8'

DATE 1979

SCALE: 1 CM. = 10 M.

0

PLEASE CONSULT ACCOMPANYING GUIDE BEFORE COMPLETING

1. Site No. DgPr H-1

BRITISH COLUMBIA ARCHÆOLOGICAL SITE INVENTORY FORM

2. Previous designation(s)

3. Site name(s) Morrissey Townsite

4. Location (a) Section Lot L 4588 Plan

(b) On the west bank of Morrissey Creek approximately 1.6 km upstream from the confluence with the Elk River, and approximately 4.6 km southeast of the Morrissey crossing of the Elk River ca. 18.5 km southeast of the town of Fernie

5. Access Take the Morrissey Road exit east from #3 Highway (ca. 13 km south of the Elk River bridge at Fernie). Follow the Morrissey road to its junction with Lodgepole Road ca. 4.5 km. The site is situated on a flat area south of Lodgepole Road between the junction and Morrissey Creek.

6. Administrative jurisdiction (a) Resource Management Region Kootenay

(b) Regional Dist. East Kootenay (c) Forest/Grazing Dist. Nelson

(d) Highways Dist. Fernie (e) Prov. Park Dist. 3 Thompson-Okanagan

7. Lat. 49 ° 22 ' 00 " N. 8. Long. 114 ° 59 ' 00 " W.

9. UTM 11UPE 462701 10. Air photo

11. Map (a) 82G-7 Upper Flathead (b)

12. Drainage (a) minor Morrissey Creek-Elk River (b) major 2

13. Elevation (a) ca. 991 m A.S.L. (b) ca. 15-30 m above Morrissey Creek

14. Cultural affiliation (a) Historic (b)

15. Site type Historic townsite

16. Dimensions (a) exact 976 m E-W x 1098 m N-S (b) estimated

(c) original same

17. Condition (*a*) present Less tha- 5% (*b*) future

18. Priority

19. Detailed information (*a*) vegetation on site grasses, aspen

(*b*) major vegetation asper

(*c*) cultural matrix unknown

(*d*) depth of cultural matrix unknown

(*e*) non-cultural matrix glacial till

(*f*) water source Morrissey Creek 50 m to the east

20. Known finds and present location None

21. Photo record ARESCO Ltd. (Calgary)

22. Published and unpublished references (*a*) see remarks section

(*b*) see remarks section

23. Site age and/or date (*a*) 1901 -? ☒ absolute ☐ relative

(*b*) Source Historical documents

24. Owner/Tenant Crows Nest Industries

25. (*a*) Informant Mr. Frank Dvorak, Fernie, B. C.

(*b*) Observed by B. Apland, J. Warner Date June 1979

(*c*) Recorded by B. Apland, J. Warner Date June 1979

(*d*) Revisited by Date

21. Remarks The original townsite of Morrissey was situated at this locality. The town was established in 1901 in association with mining operations along Morrissey Creek, begun in 1901 and stopped in 1905. Also associated with this event were a series of coking ovens (DgPr H-2) and a small company town called Carbonado (DgPr H-3). The townsite was bulldozed level by Crow's Nest Industries in preparation for a sawmill which never materialized (F. Dvorak, pers. comm.)

22. References

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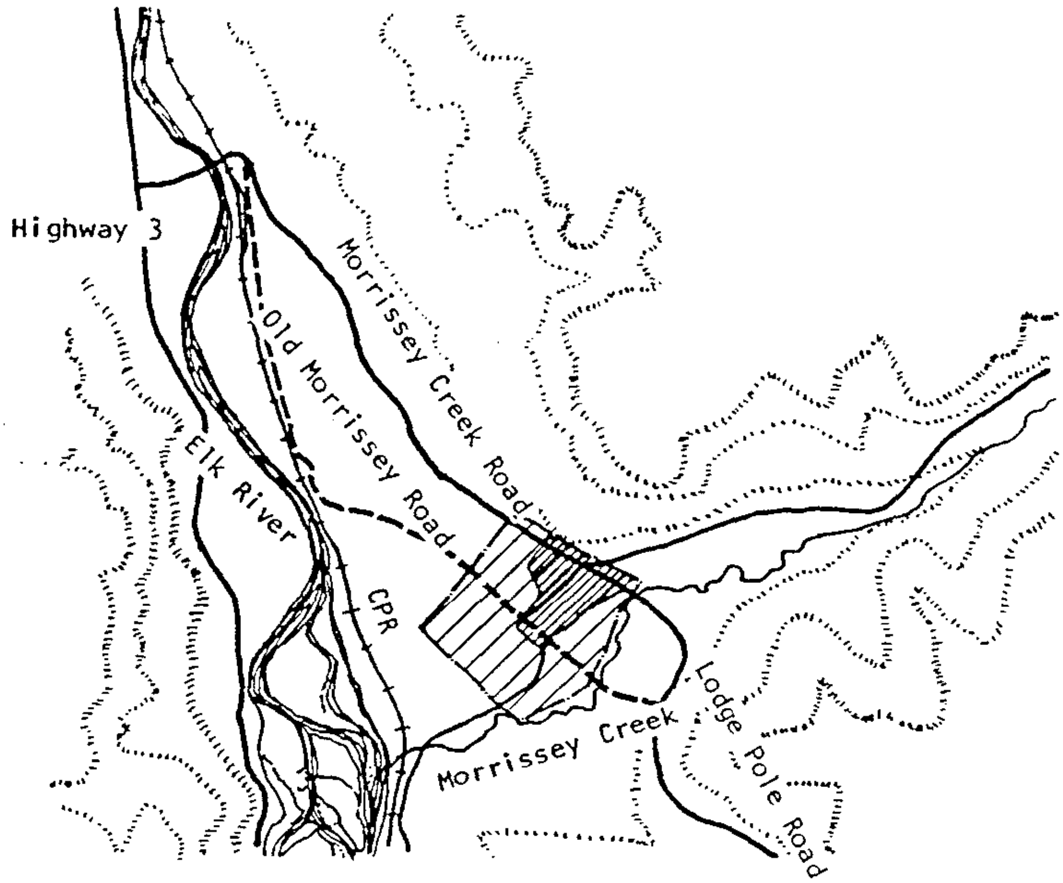
1977 <u>Back-tracking with Fernie & District Historical Society</u> The Herald Printers, Fernie, B. C.

Note: The Crowsnest Industries office in Fernie has the original legal map of Morrissey Townsite on file (1903).

SITE NO. DgPr H-1



Map based on NTS series 1:50,000

EXTENT OF SITE

BUILDING

FOUNDATION

ROAD

TRAIL

RAILWAY

FENCE —X—X—X—X—X—

R /ER/CREEK

RISE

ADDITIONAL LEGEND

Town Boundaries

Actually dev. town area

1:50,000 MAP NO. 82G 6 & 7

LATITUDE

LONGITUDE

UTM GRID REF.

TRUE ☐ MAGNETIC ☐

DECLINATION USED

DATE

SCALE: 1 CM. = ____ M.

0

PLEASE CONSULT ACCOMPANYING GUIDE BEFORE COMPLETING

1. Site No. DgPr H-2

BRITISH COLUMBIA ARCHÆOLOGICAL SITE INVENTORY FORM

2. Previous designation(s)

3. Site name(s) Morrissey Mines Coking Ovens

4. Location (a) Section Lot Plan

(b) On the north bank of Morrissey Creek approximately 2.8 km upstream from the confluence with the Elk River and 1.2 km upstream from the old townsite of Morrissey (DgPr h-1) or Lodgepole Road.

5. Access Take the Morrissey Road exit east from #3 highway (ca. 13 km south of the Elk River bridge at Fernie). The site is on the south side of the road approximately 5.6 km from the #3 highway and 1 km northeast of the junction with Lodgepole Road.

6. Administrative jurisdiction (a) Resource Management Region Kootenay

(b) Regional Dist. East Kootenay (c) Forest/Grazing Dist. Nelson

(d) Highways Dist. Fernie (e) Prov. Park Dist. 3 Thompson-Okanagan

7. Lat. 49 ° 22 ′ 15 ″ N. 8. Long. 114 ° 58 ′ 00 ″ W.

9. UTM 11UPE/476705.5 10. Air photo

11. Map (a) 82G-7 Upper Flathead (b)

12. Drainage (a) minor Morrissey Creek-Elk River (b) major 2

13. Elevation (a) 1021.75 m A.S.L. (b) ca. 13 m above Morrissey Creek

14. Cultural affiliation (a) Historic (b)

15. Site type Historic Mining

16. Dimensions (a) exact 533.75 m E-W x 15.25 m N-S (b) estimated

(c) original same

pirating of bricks

18. Priority

19. Detailed information (a) vegetation on site Grasses, sitka alder, aspen pine

(b) major vegetation Aspen forest

(c) cultural matrix n/a

(d) depth of cultural matrix n. a

(e) non-cultural matrix n/a

(f) water source Morrissey Creek 50 m to the east

20. Known finds and present location

The remains of 240 Coking Ovens

21. Photo record ARESCO Ltd. (Calgary)

22. Published and unpublished references (a) See DgPr H-1

(b) See DgPr H-1

23. Site age and/or date (a) A.D. 1901-1905 ☒ absolute ☐ relative

(b) Source Historical documents

24. Owner/Tenant Crows Nest Industries

25. (a) Informant Mr. Frank Dvorak, Fernie, B.C.

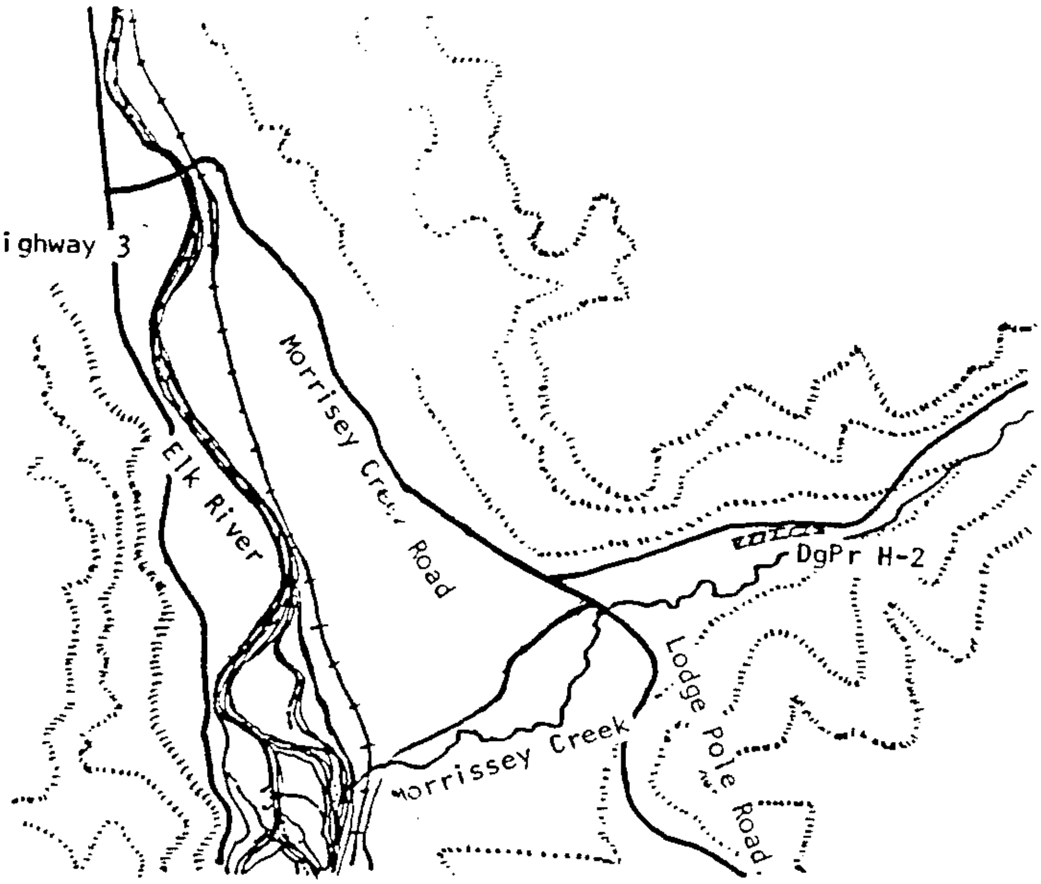
(b) Observed by B. Apland, J. Warner Date June 1979

(c) Recorded by B. Apland, J. Warner Date June 1979

(d) Revisited by Date

operations at Morrissey Creek from 1901 to 1905. The ovens were built from bricks reportedly imported from France (F. Dvorak pers. comm.). A road has already been pushed through the ovens at the eastern end, and most if not all the ovens have been broken into, many are still pretty well intact. The bricks from these ovens are slowly and continuously being robbed;a process which if left unchecked will result in the eventual loss of this artifact of the early coal mining in the East Kootenays.

SITE NO. DgPr



Map based on NTS 1:50,000 series

EXTENT OF SITE
BUILDING
FOUNDATION
ROAD
TRAIL
RAILWAY
FENCE
RIVER/CREEK
STEEP RISE

ADDITIONAL LEGEND

1:50,000 MAP NO. 82G 6 & 7
LATITUDE
LONGITUDE
UTM GRID REF.
TRUE ☐ MAGNETIC ☐
DECLINATION USED
DATE
SCALE: 1 CM. = ____ M.
0

PLEASE CONSULT ACCOMPANYING GUIDE BEFORE COMPLETING.

1. Site No. DgPr H-3

BRITISH COLUMBIA ARCHÆOLOGICAL SITE INVENTORY FORM

2. Previous designation(s)

3. Site name(s) Carbonarc

4. Location (a) Section ... Lot ... Plan ...

(b) On the north bank of Morrissey Creek 3.55 km upstream from its confluence with the Elk River and ca. 1.8 km east of Lodgepole Road on the Morrissey Creek road.

5. Access Take Morrissey Creek road exit from #3 highway (ca. 13 km south of the Elk River bridge at Fernie) and continue for 6 km. The site is on the west (uphill site of the road), 1.4 km up the Morrissey Creek road from the junction of Lodgepole Road and .4 km upstream from DgPr H-2.

6. Administrative jurisdiction (a) Resource Management Region Kootenay

(b) Regional Dist. East Kootenay (c) Forest/Grazing Dist. Nelson

(d) Highways Dist. Fernie (e) Prov. Park Dist. 3 Thompson-Okanagan

7. Lat. 49 ° 22 ′ 20 ″ N. 8. Long. 114 ° 57 ′ 40 ″ W.

9. UTM 11UPE /481708 10. Air photo

11. Map (a) 82G7 Upper Flathead (b)

12. Drainage (a) minor Morrissey Creek - Elk River (b) major 2

13. Elevation (a) 1052.25 m A.S.L. (b) ca. 45 m above Morrissey Creek

14. Cultural affiliation (a) Euro-Canadian (b)

15. Site type Historic mining camp

16. Dimensions (a) exact 213.5 m E-W x 427 m N-S (b) estimated

(c) original same

17. Condition (*a*) present Less than 10% (*b*) future Natural decay

18. Priority

19. Detailed information (*a*) vegetation on site Aspen, pine, sitka alder, mountain huckleberry, grasses

(*b*) major vegetation Aspen and pine forest

(*c*) cultural matrix n/a

(*d*) depth of cultural matrix n/a

(*e*) non-cultural matrix n/a

(*f*) water source Morrissey Creek 20 m to the east

20. Known finds and present location Remains of 35 company houses, 1 store and 1 dormitory

21. Photo record ARESCO Ltd. (Calgary)

22. Published and unpublished references (*a*) See DgPr H-1

(*b*) See DgPr H-1

23. Site age and/or date (*a*) 1901-1909 ☒ absolute ☐ relative

(*b*) Source Historic documents

24. Owner/Tenant Crows Nest Industries

25. (*a*) Informant

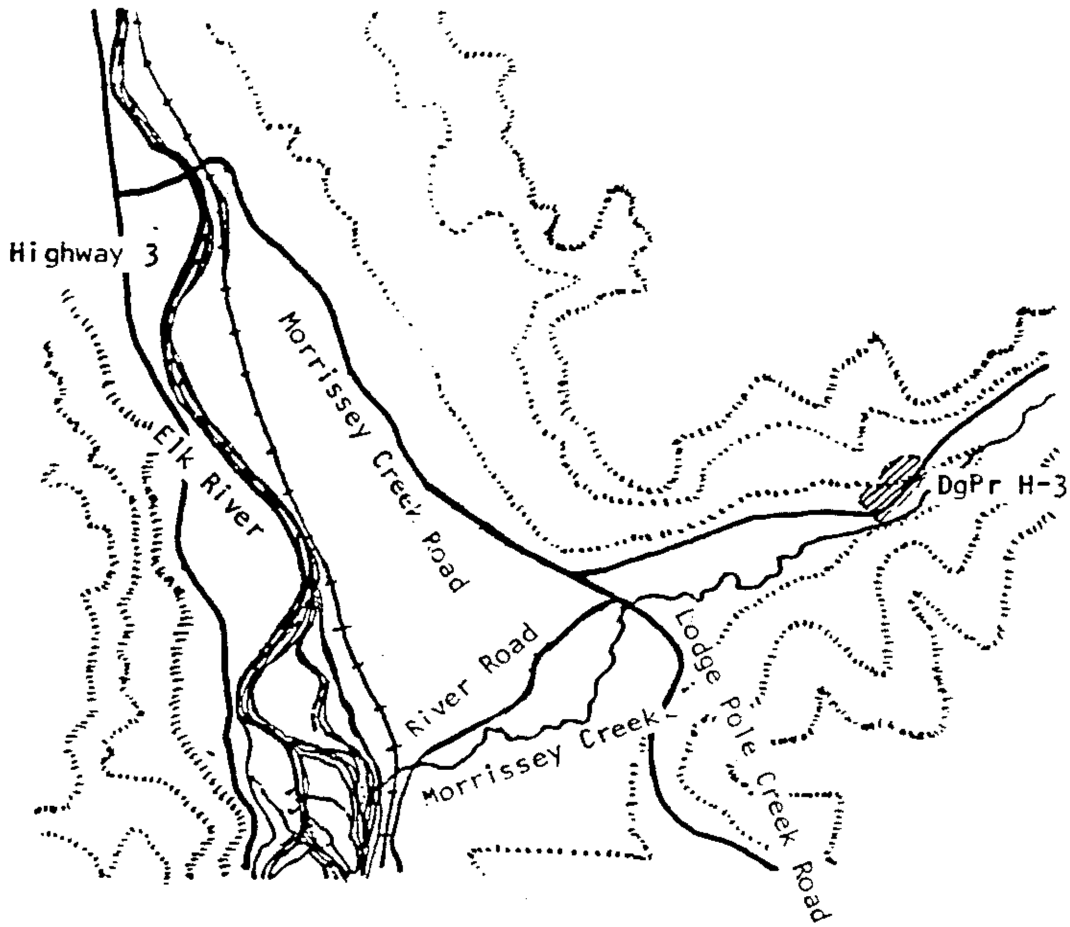
(*b*) Observed by B. Apland, J. Warner Date June 1979

(*c*) Recorded by B. Apland, J. Warner Date June 1979

(*d*) Revisited by Date

26. Remarks Crows Nest Industries has the original legal Plan map of Carbonado dated 1905 on file.

SITE NO. DgPr



Map based on NTS 1:50,000 series

EXTENT OF SITE
BUILDING
FOUNDATION
ROAD
TRAIL
RAILWAY
FENCE
RIVER/CREEK
STEEP RISE

ADDITIONAL LEGEND

1:50,000 MAP NO. 82 G 6 & 7
LATITUDE
LONGITUDE
UTM GRID REF.
TRUE ☐ MAGNETIC ☐
DECLINATION USED
DATE
SCALE: 1 CM. = ____ M.
0

PLEASE CONSULT ACCOMPANYING GUIDE BEFORE COMPLETING

1. Site No. DgPr H-4

BRITISH COLUMBIA ARCHÆOLOGICAL SITE INVENTORY FORM

2. Previous designation(s)

3. Site name(s) Morrissey Cemetery

4. Location (a) Section Lot Plan

(b) On the southwest slope of Morrissey Ridge approximately .8 km northwest of Morrissey Creek and 3.1 km southeast of the Morrissey Park on the Elk River.

5. Access Take Morrissey Creek road exit east from Highway #3 (ca. 13 km south of the Elk River Bridge at Fernie) and proceed to the Lodgepole Road junction (ca. 4.6 km). Take an access road back in a north, northwest direction for 410 m from the junction. The site is 40 m east (uphill) from the road.

6. Administrative jurisdiction (a) Resource Management Region Kootenay

(b) Regional Dist. East Kootenay (c) Forest/Grazing Dist. Nelson

(d) Highways Dist. Fernie (e) Prov. Park Dist. 3 Thompson-Okanagan

7. Lat. 49 ° 22 ′ 20 ″ N. 8. Long. 114 ° 59 ′ 12 ″ W.

9. UTM 11UPE / 450705.5 10. Air photo

11. Map (a) 82G7 Upper Flathead (b)

12. Drainage (a) minor Morrissey Creek - Elk River (b) major 2

13. Elevation (a) ca. 1030 m A.S.L. (b) ca. 45 m above Morrissey Creek

14. Cultural affiliation (a) Historic (b)

15. Site type Historic Burial

16. Dimensions (a) exact (b) estimated ca. 25 m x 25 m

(c) original

17. Condition (*a*) present 80% + (*b*) future Possible impact from logging act

18. Priority

19. Detailed information (*a*) vegetation on site Grasses, mountain huckleberry, aspen, pine

(*b*) major vegetation Pine and aspen forest

(*c*) cultural matrix N/A

(*d*) depth of cultural matrix N/A

(*e*) non-cultural matrix Glacial tills

(*f*) water source N/A

20. Known finds and present location Historic graves - 2 granite tombstones and steel-wiregrave fence dating to 1929, 1938, three wooden crosses and picket grave fences.

21. Photo record ARESCO Ltd. (Calgary)

22. Published and unpublished references (*a*)

(*b*)

23. Site age and/or date (*a*) 1901 - 1938 ☒ absolute ☐ relative

(*b*) Source Tombstones

24. Owner/Tenant Crows Nest Industries

25. (*a*) Informant Mr. Frank Dvorak, Fernie, B. C.

(*b*) Observed by B. Apland and J. Warner Date June 1979

(*c*) Recorded by B. Apland and J. Warner Date June 1979

(*d*) Revisited by Date

SAGE CREEK COAL LIMITED
FLATHEAD VALLEY, B.C.

GEOTECHNICAL AND HYDROLOGICAL WORK ON THE DIVERSION OF HOWELL CREEK

SUMMARY

A programme of work was conducted by Rio Algom Limited from the beginning of June to the middle of August 1979.

The work consisted of driving a six mile access road along the proposed Howell Creek diversion to determine hydrological data, suspended sediment data and analysis, test pits and field permeability.

Test pits were examined in areas for site drainage, settling ponds and waste dump areas.

A heritage resource inventory and impact assessment study of the development in the upper Flathead Valley of Southeast British Columbia was also conducted.

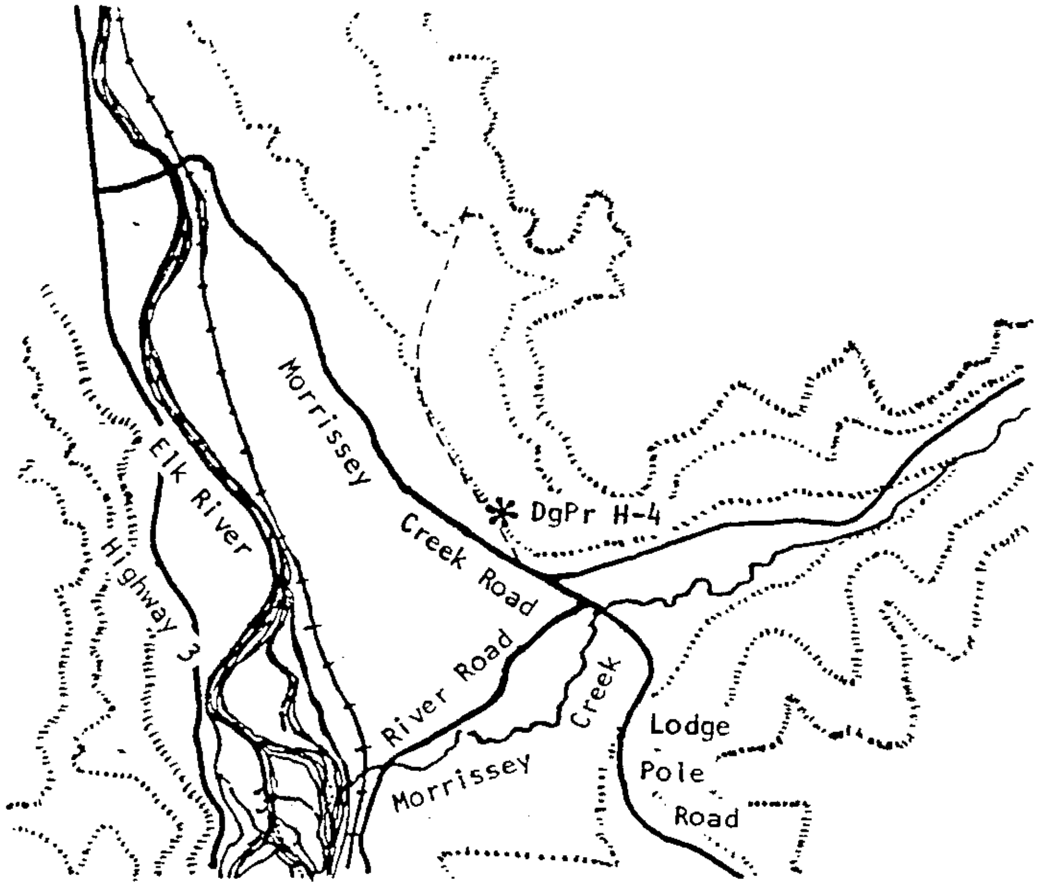
INTRODUCTION

As part of the continuing design work for Rio Algom's proposed open pit coal mine in Southeastern British Columbia, Sage Creek Coal Ltd. retained Klohn Leonoff Consultants and Golder Associates to carry out site investigation and design work for site drainage, settlement ponds system, Howell Creek diversion and waste dump stability.

McMeekin Construction Ltd. of Rocky Mountain House, Alberta, supplied the camp and catering facilities and Trina

26. Remarks This graveyard is completely overgrown and most of the graves were marked with wooden crosses and picket fences which have nearly all vanished through decay. The site was in danger from C.N.I. logging activities and road building, however the company has been informed of its existence and has taken steps (flagged) to ensure that it is not disturbed by their operations (F. Dvorak pers. comm.).

SITE NO. DgPr



Map based on NTS series 1:50,000

EXTENT OF SITE —·—·—·—·—·—
BUILDING ■
FOUNDATION □
ROAD
TRAIL
RAILWAY
FENCE —X—X—X—X—X—
RIVER/CREEK
STEEP RISE

ADDITIONAL LEGEND

1:50,000 MAP NO. 82G 6 & 7
LATITUDE
LONGITUDE
UTM GRID REF.
TRUE □ MAGNETIC □
DECLINATION USED
DATE
SCALE: 1 CM. = ___ M.
0

PLEASE CONSULT ACCOMPANYING GUIDE BEFORE COMPLETING

1. Site No. DgPs H-1

BRITISH COLUMBIA ARCHÆOLOGICAL SITE INVENTORY FORM

2. Previous designation(s)

3. Site name(s) Morrissey Junction, Morrissey

4. Location (a) Section Lot Plan

(b) On east and west banks of the Elk River at the Morrissey crossing (ca. 13 km south of Fernie)

5. Access Take Morrissey Creek road exit east from Highway #3 (ca. 13 km south of Elk River bridge at Fernie) and proceed to Elk River Crossing (.5 km). Morrissey Junction was situated on the west bank of the river at the present B. C. Forest Service picnic site and Morrissey section house and station was situated on the east bank of the river.

6. Administrative jurisdiction (a) Resource Management Region Kootenay

(b) Regional Dist. East Kootenay (c) Forest/Grazing Dist. Nelson

(d) Highways Dist. Fernie (e) Prov. Park Dist. 3 Thompson-Okanagan

7. Lat. 49° 23′ 32″ N. 8. Long. 115° 01′ 00″ W.

9. UTM 11UPE 439.5726 10. Air photo

11. Map (a) 82G6 ELKO (b)

12. Drainage (a) minor Elk River (b) major 2

13. Elevation (a) ca. 968 m A.S.L. (b) ca. 5 m above Elk River

14. Cultural affiliation (a) Euro-Canadian (b)

15. Site type Historic townsite, railroad station

16. Dimensions (a) exact uncertain (b) estimated uncertain

(c) original uncertain

17. Condition (a) present less than 2% (b) future Nothing left to destroy

18. Priority

19. Detailed information (a) vegetation on site grasses, cottonwood, aspen, Ponderosa pine, sitka alder, willow

(b) major vegetation Cottonwood, willow, alder

(c) cultural matrix n/a

(d) depth of cultural matrix n/a

(e) non-cultural matrix River silts and glacial till

(f) water source Elk River

20. Known finds and present location last remaining section of the Morrissey, Fernie and Michel Railway bed which serviced the Morrissey Creek Mines.

21. Photo record ARESCO Ltd. (Calgary)

22. Published and unpublished references (a) See DgPr H-1

(b) See DgPr H-1

23. Site age and/or date (a) 1901 -? ☒ absolute ☐ relative

(b) Source Historic documents

24. Owner/Tenant Crown, C.P.R. and Crows Nest Industries

25. (a) Informant Frank Dvorak, Fernie, B. C.

(b) Observed by B. Apland, J. Warner Date June 1979

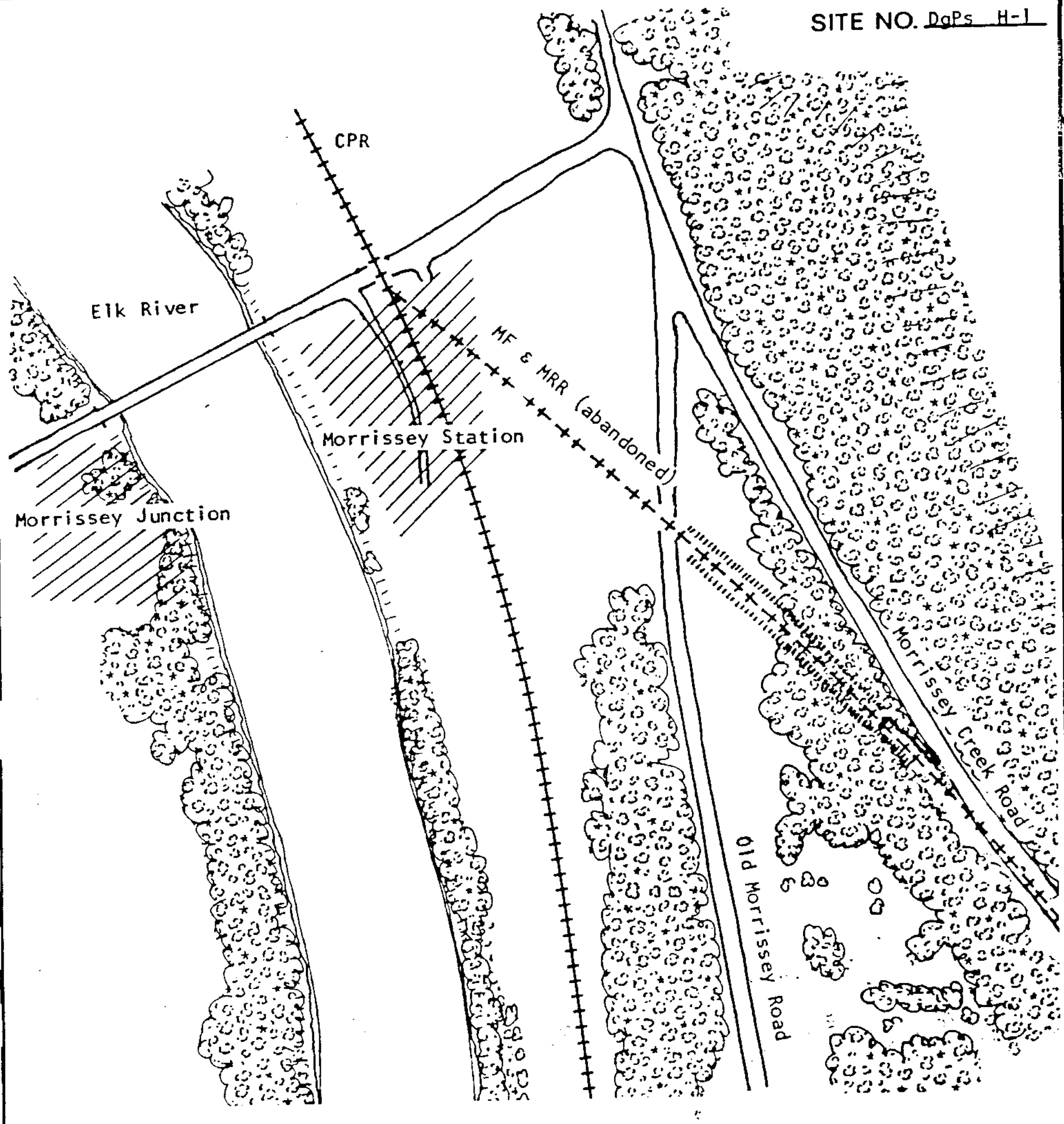
(c) Recorded by B. Apland, J. Warner Date June 1979

(d) Revisited by Date

26. Remarks The townsite of Morrissey Junction and the Morrissey section house and station have been destroyed. A picnic site has been developed by the B. C. Forest Service on the Morrissey Junction Townsite.

However on the east site of the river just southeast of the Morrissey Section house site, a small section of the original Morrissey Fernie Michel Railway bed still survives . This is the last remnant of that line, the remainder has been incorporated into the Morrissey Creek road

- Three cars from the Morrissey Fernie Michel Railway are presently on display at Heritage Park in Calgary, Alberta



EXTENT OF SITE

BUILDING

FOUNDATION

ROAD

TRAIL

RAILWAY

FENCE —X—X—X—X—X—

ER/CREEK

RISE

ADDITIONAL LEGEND

1:50,000 MAP NO. ____

LATITUDE ____

LONGITUDE ____

UTM GRID REF. ____ ____

TRUE ☐ MAGNETIC ☐

DECLINATION USED ____

DATE ____

SCALE: 1 CM. = ____ M.

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