A MANAGEMENT PLAN FOR THE REHABILITATION OF SURFACE MINED COAL LANDS IN THE EAST KOOTENAY, BRITISH COLUMBIA

BY

JOHN HOWARD DICK
B.Sc. University of British Columbia, 1964

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The University of British Columbia
Vancouver, B.C.
V6T 1W5

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ABSTRACT

The concept of this thesis was developed during the author's two years of work with the British Columbia Ministry of Mines and Petroleum Resources as a Reclamation Inspector. During that period (1973-75) one of the author's major duties was to review reclamation plans prepared by mining companies, pursuant to Section 8 of the *Coal Mines Regulation Act*, as applications for either surface mining permits or permit extensions. The quality of these reports varied greatly, with few being really comprehensive. No uniform standard of reclamation report was achieved by industry or, perhaps even more important, demanded by the Ministry. Reclamation programmes on many mining operations were suffering from an obvious lack of management planning. Work was being undertaken without clear objectives, and no apparent attempt was being made to develop an ongoing planning process.

The author contends that the following characteristics are implicit in the term "management planning":

1. A stated management period;
2. An initial collection of facts and a description of the area to be managed;
3. An analysis of the facts and an assessment of management options;

4. The designation of management objectives;

5. The design of a programme to accomplish the objectives; and

6. A record of results and a collection of further information by inventory and research to be used in formulating the plan for the next management period.

He further explains that, by intent, Section 8 of the *Coal Mines Regulation Act* would appear at present to require most of these elements of a management process in the preparation of a reclamation report.

The object of this thesis is to develop and illustrate a management plan format that reflects the continuous planning process outlined above. As a basis for the plan the experience and information gained by the author at Kaiser Resources Ltd.'s mining operation in Sparwood during the period 1971-1973 are summarized and interpreted, and management prescriptions formed from that synthesis. The thesis is written as though it were a management plan prepared in early 1975 for the management period 1975-1978. In summary, the format of the plan is essentially as follows:

1. An initial collection of facts and description of the area to be managed.

This portion of the plan consists of two chapters; a description of the biophysical characteristics of the mining area, and a description of the mining environment

to be reclaimed. The biophysical description includes topography, drainage, bedrock and surficial geology, soils, climate, vegetation and fauna. The description of the mining environment deals with the history of coal mining in the East Kootenay, the tenure of the mining area, and the location, extent and nature of mining, milling and exploration operations.

2. An assessment of Management Options.

Two items are considered to be important in assessing reclamation management options; the environmental impact of the mining operation, and the legal responsibilities of the mining company for reclamation. Basically, reclamation is undertaken in order to mitigate some of the adverse effects of mining on the natural environment. For this reason, a discussion of the major impacts of mining, concentrating on those that can be mitigated by reclamation, is a prerequisite to the formulation of management objectives. This chapter of the plan contains a description of land capability for forestry, agriculture, wildlife and recreation, and a discussion of the impact of mining on land capability, water quality and the fishery resource. The second chapter of this portion of the plan deals with the legislative and administrative framework for reclamation in British Columbia. The *Coal Mines Regulation Act* currently states that

reclamation must be carried out to a level satisfactory to the Minister, without defining what that level is. This chapter discusses present interpretations of the Act, the administrative procedures for reclamation enforcement, and speculates on the form that eventual reclamation standards might take.

3. The designation of management objectives.

Management objectives are defined on the basis of the environmental impacts of the mining operation and on the legal requirements for reclamation. For the Kaiser Resources Ltd. operation the overall reclamation management objectives are defined as:

i. To re-establish watershed values, by either mechanical means or the establishment of a self-sustaining vegetation cover, as soon as possible after the cessation of mining activities on any particular parcel of land.

ii. To accomplish watershed rehabilitation in a manner that is compatible with the potential prime surface use of the land and consistent with post-mining site conditions.

On the basis of the description of both the mining environment and land capability, two land use objectives are proposed:

a. To provide food and, ultimately, cover for mule deer, Rocky Mountain elk and moose through the establishment of appropriate plant communities.

b. To re-establish aesthetic values on all disturbed lands and, where possible, to enhance opportunities for outdoor recreation.

4. The design of a programme to accomplish the objectives.

This section of the plan consists of a discussion of the major constraints to successful reclamation and a description of the various components of the reclamation programme. The most significant constraints to reclamation on the Kaiser Resources Ltd. operation are considered to be, in decreasing order of importance: surface instability, soil temperature, soil compaction, soil chemistry, and increasing elevation. Seven components of the reclamation programme are described - species selection, seed collection, plant propagation, site preparation, seeding, planting, and tending. In each case, past experience, including cost information, is summarized, and major prescriptions proposed for the coming management period.

5. Assessment of Results.

The assessment programme relates to the management objectives, and focuses primarily on watershed and wildlife habitat parameters. Parameters to be measured relate to water quality, protective cover, species composition, the degree of ungulate use, forage quantity and forage quality.

The management plan thus prepared provides the framework for the two final steps in the management process for any particular management period; the subdivision of the area for management purposes, and the preparation of operational plans. The management area is divided, primarily for record keeping, into compartments, which are permanent units based on topography, access or mining operations, and sub-compartments, which are temporary subdivisions of compartments based on treatment. Each compartment should be subject to a specific land-use objective. Sub-compartments may be combined or further subdivided in the light of future operations. The last step in the process is the preparation of annual operational plans. These outline, for each year of the management period, the specific operations to be undertaken and the projected costs of each. Operational plans become the basis for the development of annual budgets.

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CHAPTER I

INTRODUCTION

In 1968 the Kaiser Steel Corporation of Oakland, California, announced plans for developing extensive coal deposits in the Fernie Coal Basin through a wholly owned subsidiary company to be known as Kaiser Coal Ltd. (later renamed Kaiser Resources Ltd.). Though a few open-pit metal mines were already operating in the province, notably those of Bethlehem Copper Corporation Ltd. in the Highland Valley and of Craigmont Mines Ltd. near Merritt, this new development was to be surface mining on a considerably larger scale. To meet the initial contract of approximately 6 million tons of clean coal annually, over 800 hectares of mountain land were to be stripped and mined during the first fifteen years of operation. Additionally, Kaiser Coal Ltd. acquired mining rights to a selected two-thirds of 44,440 hectares of crown-granted coal lands in the vicinity of the mine.

The storm of controversy surrounding this move to establish the largest surface mine in Western Canada, spurred by the spectre of Appalachia and an extremely antagonistic news media, was almost unprecedented in the history

of natural resource use in B.C. It is fair to say that this conflict, more than any other factor, prompted the enactment of the provincial mine reclamation legislation; specifically, Section 8 of the *Coal Mines Regulation Act 1969*, and Section 11 of the *Mines Regulation Act*.

The most important provision of both Acts is that before mining commences, a reclamation programme report must be filed with the Minister of Mines and Petroleum Resources as an application for a surface work permit. The first three subsections of Section 8 of the Coal Mine Regulation Act read as follows:

> (1) It is the duty of every owner, agent, or manager of a mine to institute and carry out a programme for the protection and reclamation of the surface of the land and watercourses affected thereby, and, on the discontinuance or abandonment of a mine, to undertake and complete the programme to leave the land and watercourses in a condition satisfactory; and such a programme shall be submitted to and approved by the minister as hereinafter provided.
>
> (2) The owner, agent, or manager shall file with the minister a report in such a form and containing such information as the minister shall proscribe before commencing
>
> (a) exploratory work at a mine
>
> . . .
>
> (b) preparatory work for production from a mine.
>
> (3) The report shall include the following:

(a) A map showing the location and extent of the mine, and the location of any lakes, streams, and inhabited places in the vicinity;

(b) Particulars of the nature of the mine and the extent of the area to be occupied during the probable duration of the mining operation;

(c) Particulars of the nature and present uses of the land to be used;

(d) A programme for reclamation and conservation of the land during, and on the discontinuance or abandonment of, the mining operation, with particular reference to:

(i) the location of the land,

(ii) the effect of the programme on livestock or wildlife, watercourses, farms, inhabited places in the vicinity of the mine, and the appearance of the site of the mine, and

(iii) the potential use of the land, having regard to its best and fullest use, and its importance for existing and future timber, grazing, water, recreation, wildlife or mineral use.

The surface work permit granted on the basis of this report is for a three year period, and at the end of this time another report must be prepared as an application for a permit extension.

Clearly, the report as outlined in the Act has all of the elements of a classical land management plan as defined, in a forestry context, by Osmaston (1968):

1. A specified management period.

2. Initial collection of facts and a description of the area to be managed.

3. Analysis of the facts and an assessment of management options.

4. Designation of management objectives.

5. Design of a programme to accomplish the objectives.

6. Record of results, collection of facts by inventory and research to be used in formulating the plan for the next management period.

During the two years in which I worked for the Reclamation Section of the Department of Mines and Petroleum Resources, one of my main duties was to review reclamation programme reports. The quality of these reports varied greatly. Some documents have been very comprehensive, others very much the reverse. A notable characteristic is that while in many instances the engineering aspects, i.e. the mining method, waste disposal systems, macro slope stability, and facilities design, are dealt with in considerable detail, the ecology of the mine area and the actual process by which the site is to be revegetated are treated much more lightly. Often there has been little more than a declaration of intent that the area shall be reclaimed. It is obvious from a review of the reports prepared to date that no uniform standard has been either achieved, or, perhaps more important, demanded by the

Department of Mines and Petroleum Resources. The reclamation programmes on many mining operations are suffering from an obvious lack of management planning. Work is being undertaken without clear objectives, and no attempt has been made to develop the planning process for which the Act so clearly calls.

In 1975, in the light of proposed coal developments in both the East Kootenay and the Peace River areas, the Environment and Land Use Committee, a Cabinet Committee of the British Columbia government, sanctioned the preparation of a set of guidelines for coal development. The preparation of these guidelines was to be coordinated by the E.L.U.C. Secretariat, the executive arm of the Cabinet Committee, and the objective was to set standards for the preparation of environmental impact assessments of coal mine developments. All aspects of development, both on and off site, and the impacts on both the bio-physical and the socio-economic environments were to be considered. The most recent draft of these guidelines is included in this report as Appendix I.

The "Guidelines for Coal Development" are a welcome and long overdue step towards the rationalization of coal mine development in this province. If enforced by the Environment and Land Use Committee, they can provide a framework for the collection of baseline data, promote

the orderly initial development of mine projects, and establish a basis for mitigation and compensation for impacts on other resources. They do not, however, institute an ongoing management process for reclamation and environmental control over the life of the mine. In terms of reclamation, only Section 8, of the *Coal Mines Regulation Act* makes provision for this process through the requirement of a reclamation report each time the permit authorizing surface work is renewed. My intention in this thesis is to develop a management plan format that reflects this continuous planning process. In specific terms, I will attempt to produce both the framework for the current management plan and a system for collection and analysis of the data necessary for the preparation of subsequent plans. As a basis for the plan, the experience and information gained at Kaiser Resources Ltd.'s operation in Sparwood during the period 1970-1974 is interpreted and summarized, and management prescriptions formulated from that synthesis. Much information exists that was generated subsequent to my departure from the company in 1973, and I have no access to most of this. In any case, it was not my intention to produce *the* definitive management statement for the Kaiser Resources Ltd. reclamation programme. Rather, as far as this thesis is concerned, it is the process of management plan development that is important;

the information contained herein is merely the vehicle by which that process is illustrated.

The plan is written for the 3-year management period 1975-78. As such, it summarized past management information and proposes general prescriptions for the coming management period. I have tried, for the most part, to write it as though it was prepared in early 1975, without benefit of hindsight. The one exception to this is the information included in the section entitled "Assessment of Results" (6.12). During the writing of the thesis, quantitative information on the success of some of the reclamation operations described became available. I decided to add that information because it illustrated many of the assessment procedures that I wished to propose. Some references are more recent than 1975, however, these either cite the final publication of papers that existed in draft form in 1975, or are confirmations of information obtained earlier in personal communications. Some sections of the plan will, in retrospect, appear dated. Many of the judgements and statements in Chapter V on the legal and institutional framework for reclamation, for example; are no longer valid. They are, however, of value as an historical perspective against which to measure subsequent progress.

CHAPTER II

A DESCRIPTION OF THE AREA

2.1 Location

Kaiser Resources Ltd.'s coal properties are located in the extreme southeastern portion of the province between latitudes 49°15' and 50°08' N, and longitudes 114°41' and 115°00' W (see Map 1a). The major governmental administrative subdivisions in which the property lies are as follows:

Resource Region:
Kootenay (Administrative Centre: Nelson)

Land District:
Kootenay (Administrative Centre: Nelson)

Land Recording District:
Fernie (Land Commissioner: Fernie)

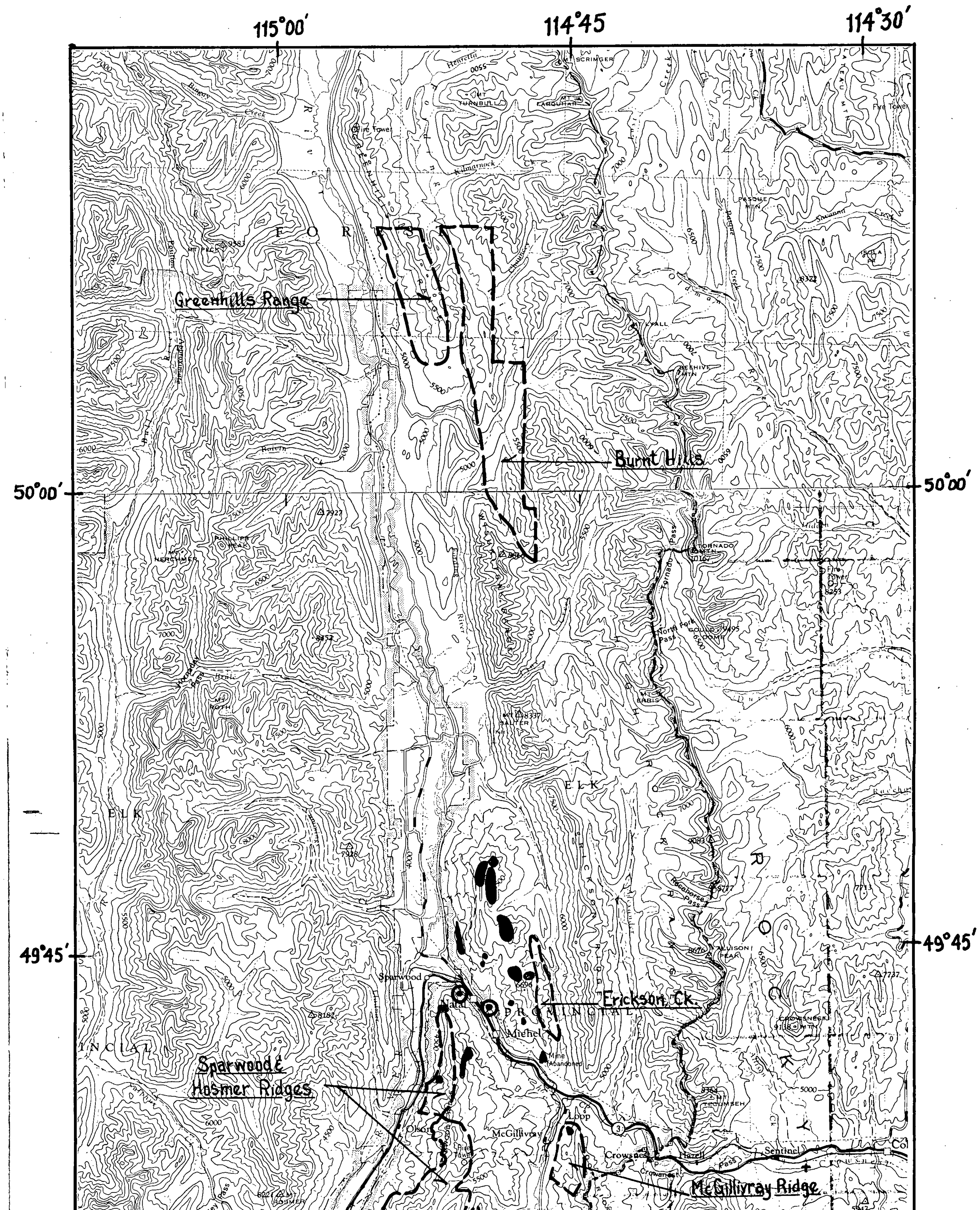
Land Registration District:
Nelson (Land Registry Office: Nelson)

Mining Division:
Fort Steel (Mining Recorder: Cranbrook)

Mining District:
East Kootenay (District Mines Inspector: Fernie)

Electoral District: Kootenay

Forest District:
Nelson (District Forester: Nelson)



LEGEND

Scale 1:250,000

CENTRES OF MINING AND EXPLORATION ACTIVITY

⌐ ⌐	Exploration operations.
◎	Underground mines. } See Map 2.e. for details
●	Surface mines } See Map 2.e. for details

MAP 1.a.

Source:- N.T.S. 82G & J.

Regional District:
East Kootenay (R.D. Office: Cranbrook)

Water District: Fernie
(District Engineer: Cranbrook)
(Pollution Control Engineer: Cranbrook)
(Water Recorder: Fernie)

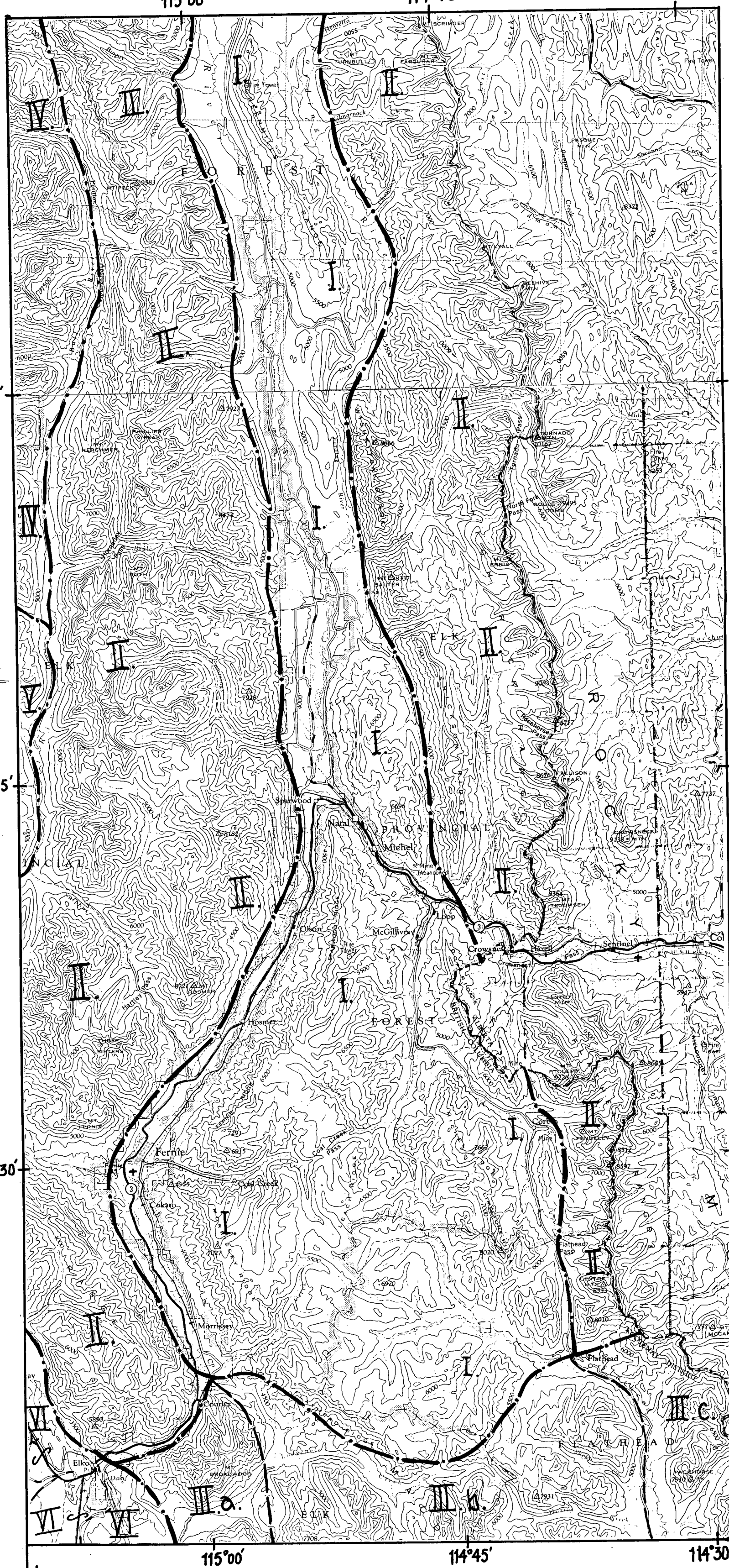
Fish and Wildlife Subdivisions:
Region 4 Management
Unit 23 (Regional Office: Nelson)

The administrative and residential centre for the mining operation is the municipality of Sparwood, situated on the southern trans-provincial highway (No. 3) 19 kilometres by road from the B.C.-Alberta Border, and 80 kilometres due north of the international boundary. Map 1a shows the areas which have been mined by the company, both surface and underground, and the major centres of exploration activity.

2.2 Topography and Drainage

This part of the East Kootenay is dominated by two major land forms; the Fernie Basin, and the Front Ranges of the Rocky Mountain System (Holland, 1964). (See Map 1b).

The Fernie Basin is an area of soft, sandy and shaly Mesozoic rocks lying between the Elk River and the ranges of the Continental Divide. It is approximately 104 km. in length and a maximum of 24 km. in width at the south end. Both the eastern and western boundaries of the Basin are fault controlled. In the south, the Fernie Basin comprises a triangle of land bounded by the Elk River on the west,



LEGEND MAJOR LAND FORMS Scale 1:250,000

—·— Major units — — — sub-units.

I. Fernie Basin.
II. Front Ranges.
III. Border Ranges.
  III.a. Galton Range.
  III.b. MacDonald Range.
  III.c. Clark Range.

IV Park Ranges.
V Kootenay Ranges.
VI Rocky Mountain Trench.

Map 1.b.

Landform interpretations from Holland (1964).

Source:- N.T.S. 82G & J.

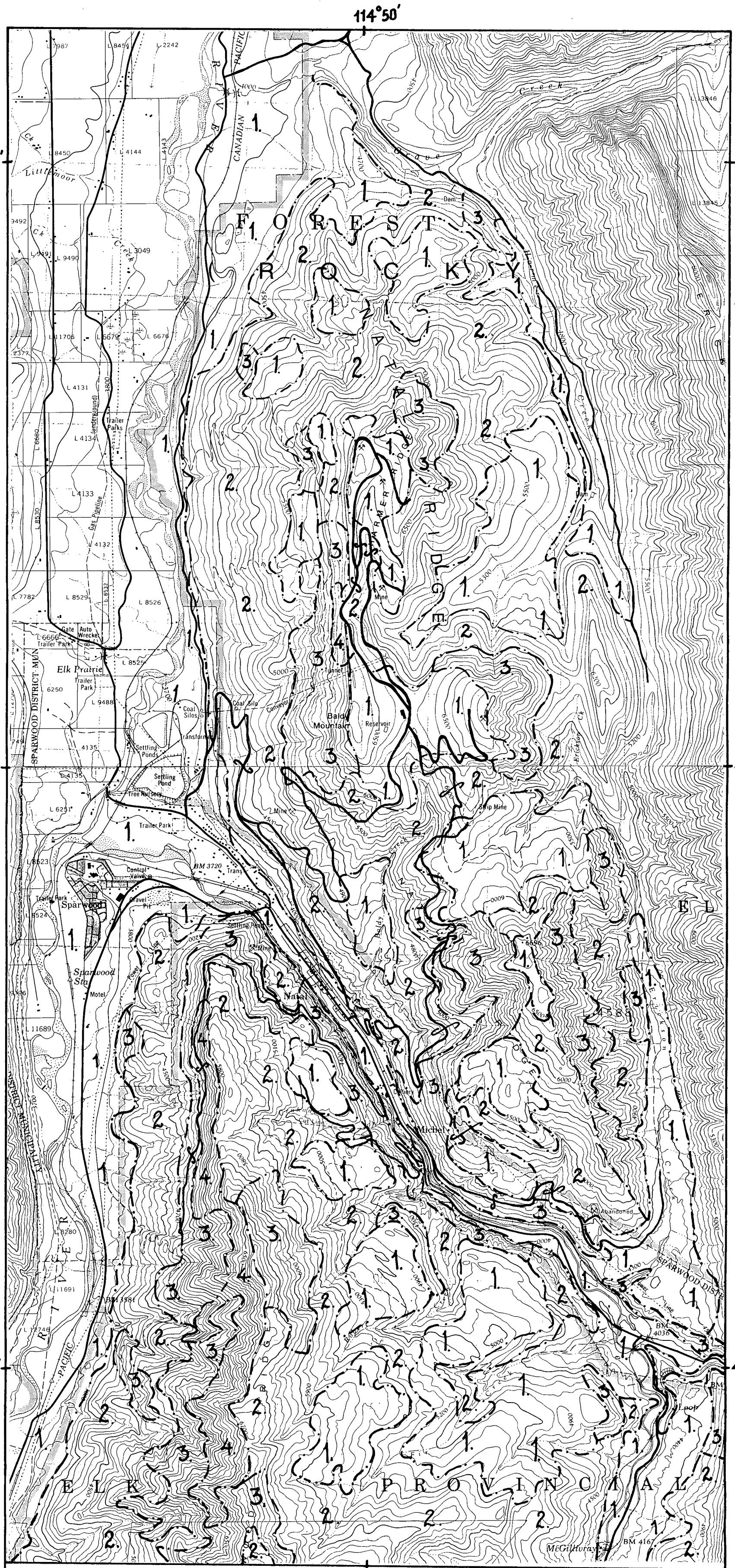
Lodgepole Creek and the upper tributaries of the Flathead River in the south, and Michel Creek on the north and east. North of Michel Creek, the Basin narrows and becomes, largely, the Elk River valley and a series of low, flanking ridges to the east; Natal Ridge, Harmer Ridge, Fording Mountain and the Greenhills Range. The general aspect of the Basin is one of moderate relief, in which gently rolling uplands descend by more abrupt slopes to the levels of the Elk and Fording Rivers, and Michel Creek. The maximum elevation reached in the Fernie Basin is approximately 2260 m. with the majority of the upland area lying between 1680 and 2135 m.

The Front Ranges form the eastern, western and northern boundaries of the Fernie Basin, and consist of a number of north-south longitudinal ridges. These ranges were formed when limestones and other Paleozoic rocks were thrust from west to east over younger Mesozoic formations. A number of southwesterly dipping faults separate these limestone formations into distinct blocks and subsequent erosion and glacial action have produced the numerous parallel ridges which constitute the Front Ranges. Because of their southwesterly dip, the limestone strata of these ridges typically erode to form 30 to 40 degree slopes facing westward and steep scarp slopes facing eastward. To the east of the Fernie Basin the Front Ranges comprise the

High Rock Range of the continental divide, the Wisukitsak Range, Erikson Ridge and the Flathead Range. On the west flank of the Basin, the Front Ranges consist of a series of mountains, the most prominent of which are Mt. Peck, Mt. Kuleski, Hosmer Mountain, the Three Sisters, and the Lizard Range. The heights of the Front Range mountains vary between 2440 and 3050 m., with those to the west of the Fernie Basin being generally higher than those to the east.

To date, all of Kaiser Resources' activities, except for three exploration operations, have been confined to areas of the Fernie Basin. The main aspects of these areas are north-east and south-west. The active mining area is contained wholly within the Basin and the topography conforms to the general description previously given; gently to moderately rolling upland, steep valley walls, and flat alluvial plains. Map 2a shows the topography of the mining area as a function of slope class. Distribution of land area by slope class is as follows:

Slope Class	Area (ha.)	Percent of Total
Flat to gently rolling (0-15°)	7085	41 %
Moderately sloping (16-25°)	7485	43 %
Steeply sloping (26-35°)	2480	14 %
Very steeply sloping (35°+)	400	2 %
TOTAL	17440	100



LEGEND

Scale 1:50,000

SLOPE CLASSES ON THE MINING AREA

1.	0-15°	3.	26-35°
2.	16-25°	4.	35°+

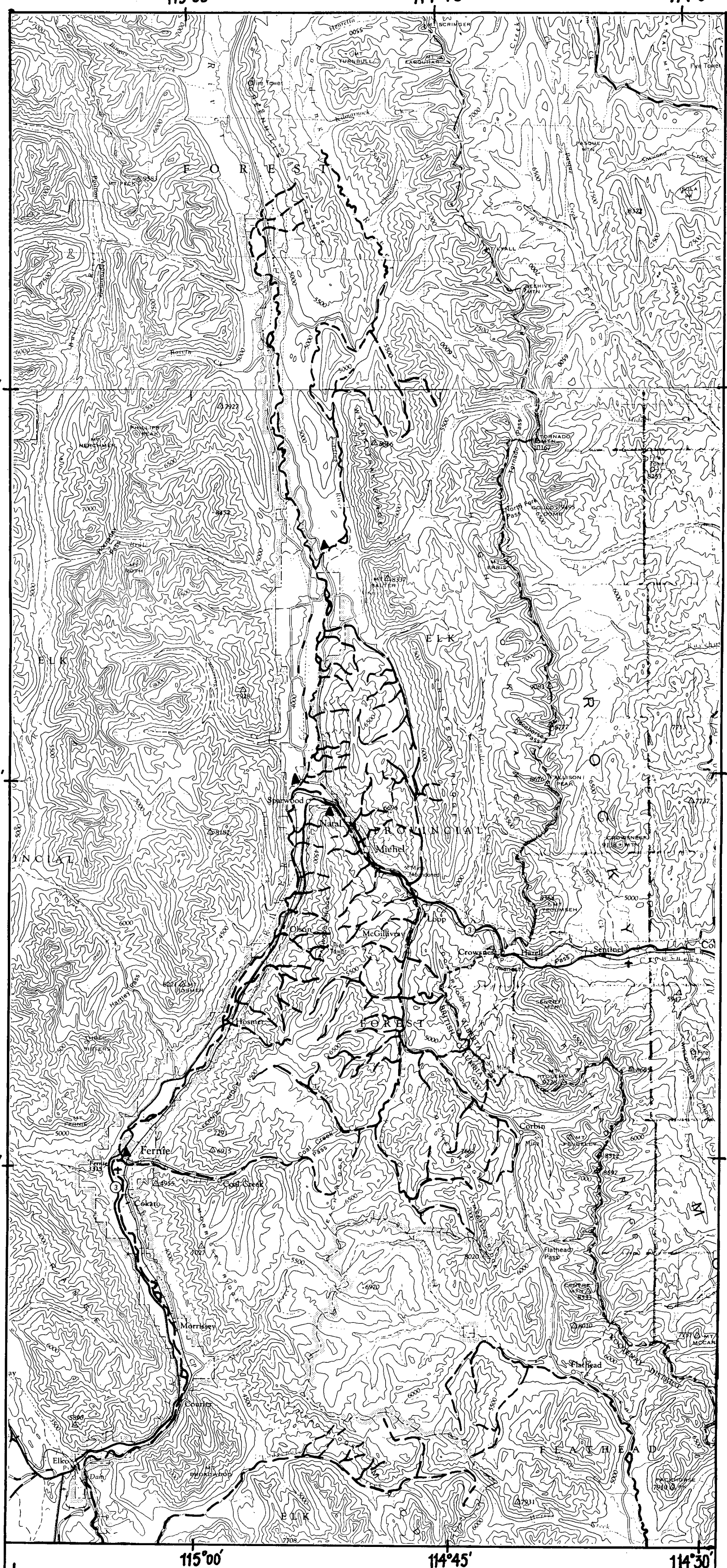
MAP 2.a.

Source:- N.T.S. 82-10 & 15

The drainage system of Kaiser Resources coal properties is almost entirely tributary to the Elk River, which in turn flows into the Kootenay River south of Waldo. The only exception to this is a small area located in the upper watershed of the Flathead River. Virtually all of the major water courses are associated with faults, and underlain by easily erodible Mesozoic shales and sandstones. Map 1c illustrates the drainge system of the whole coal area, and Map 2b the detailed drainage of the mining area. In each case, average stream gradients between various points on the drainage system are shown.

Hydrologic data for the area are available from four stations established by the Water Investigations Branch of Environment Canada. These stations were set up in 1970 at the request of the provincial Pollution Control Branch. In the same year, Kaiser Resources Ltd. began an extensive monitoring programme of both surface and ground water quality on the mining area, as required under the terms of various water licences and pollution control permits.

Average discharge rates and levels of suspended solids, over the four years for which data are available from Environment Canada, are shown in Tables 1 and 2 respectively. Annual data appears in Appendix I and the location of the four stations is shown on Map 1c. These data indicate that peak streamflow usually occurs between mid-May and mid-June. The magnitude of the spring freshet is extremely



LEGEND

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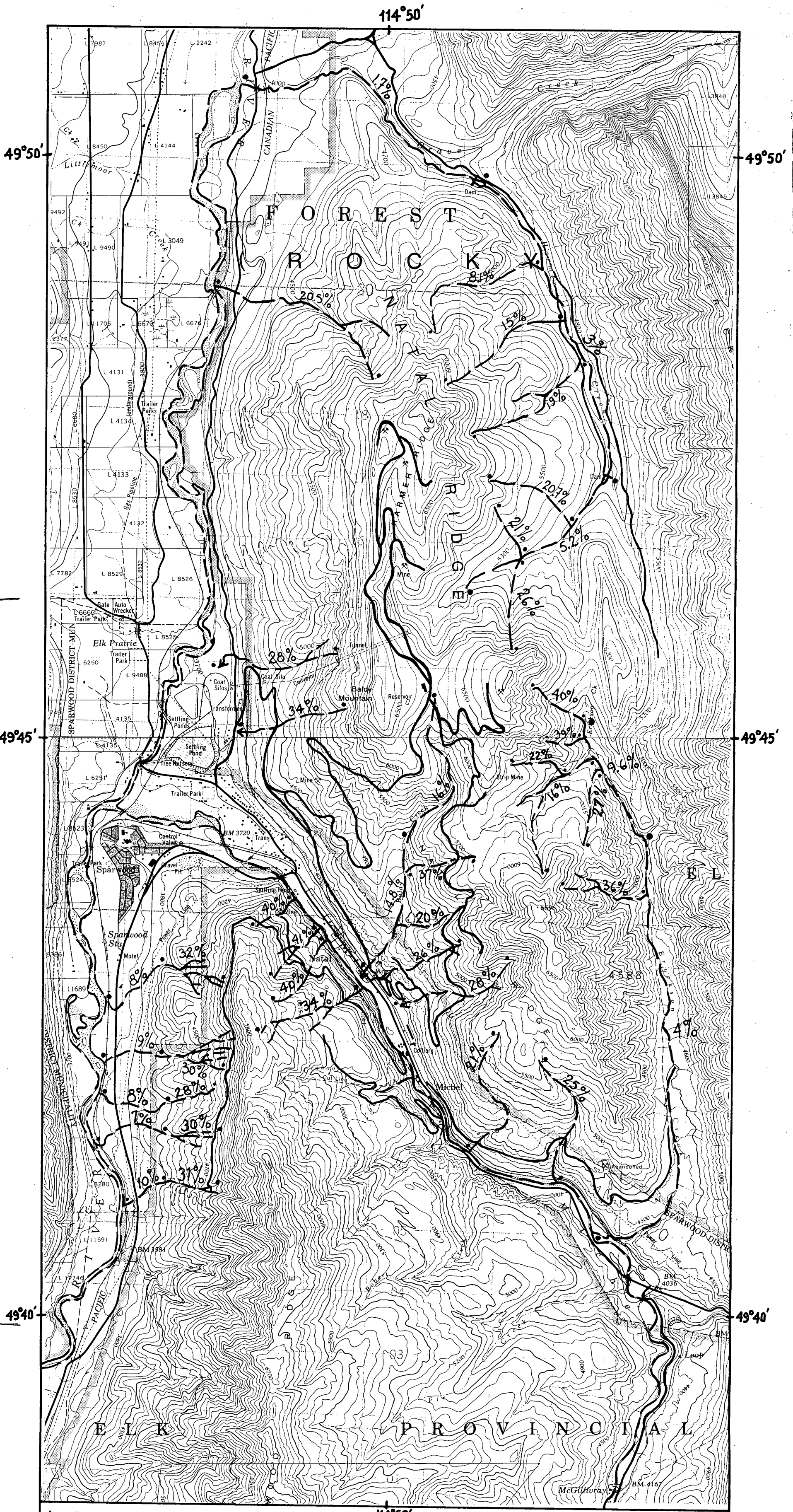
DRAINAGE SYSTEMS OF THE MINING AND EXPLORATION AREAS

- - - - Streams draining mining and exploration areas.

▲ Stream gauging stations.

MAP 1.c.

Source :- N.T.S. 82G & J.



LEGEND

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DRAINAGE OF THE MINING AREA

— — — Streams draining areas of mining disturbance.

• 26% • Average stream gradient between points.

MAP 2.b.

Source:- N.T.S. 82-10&15

variable and depends on the depth of snowpack, the rate of snowmelt, and seasonal precipitation. Lowest flows appear to occur in January and early February.

As might be expected, annual variations in sediment load closely follow seasonal patterns of streamflow, with one exception. While peak sediment loads coincide with the periods of highest runoff in mid-May to mid-June, times of lowest sediment yields appear to be late summer and fall, possibly because this is the period of lowest precipitation.

Changes in flow regime and water quality often reflect changes in land use patterns, and, in a mining context, can be used to measure the effectiveness of mitigation programmes such as reclamation and erosion control. However, an accurate picture of the effects of mining and exploration on surface runoff patterns and sediment loads can be obtained only through long-term hydrologic and climatic monitoring. The existing sampling network, consisting of four stations on a watershed of 3100 km^2 is completely inadequate to monitor an area as complex as the Fernie Coal Basin. In addition, sampling commenced two years after the first open pit development on Hamer Ridge, and four years after the beginning of intensive coal exploration in the Fernie and Upper Elk Coal Basins. Thus no baseline data exist. While nothing can be done about the lack of baseline data, Kaiser Resources Ltd. should expand the water sampling network on its own lands as soon as possible.

Table 1

Average Daily Rates of Flow (m^3/sec.) For The Period 1970-1973

Location of Station	Watershed Size (Km^2)	Average Daily Rates of Flow (m^3/sec.)												Maximum Recorded Flow Rate (m^3/sec.)	Minimum Recorded Flow Rate (m^3/sec.)
		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec		
Fording River above confluence with Elk River	620	1.8	1.6	1.6	2.5	20.6	35.2	9.5	4.8	3.6	3.2	2.4	1.9	79.3 (June 9/71)	1.0 (Jan 7, 1970)
Michel Creek below Natal	640	1.9	1.9	2.2	4.0	37.0	40.5	9.6	3.9	3.3	3.1	3.1	2.2	109.3 (May 13/71)	1.1 (Feb 14, 1970)
Elk River near Natal	1870	6.1	5.6	7.2	9.3	64.5	117.8	51.4	26.3	16.6	12.6	9.5	7.0	291.8 (June 2/72)	3.9 (Jan 8, 1970)
Elk River at Fernie	3130	12.4	13.6	17.2	26.8	135.5	209.3	82.0	42.4	27.0	21.4	20.2	14.1	507.1 (June 3/72)	6.8 (Jan 6, 1971)

N.B. Neither station 1 nor 2 were operating during 1972 the year of peak run-off during this period.

Table 2

Average Monthly Sediment Load (Metric tonnes) For The Period 1970-1973

Location of Station	Watershed Size (Km^2)	Average Monthly Sediment Load (Tonnes)												Maximum Recorded Flow Rate Daily Load (tonnes)	Minimum Recorded Daily Load (tonnes)
		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec		
Fording River above confluence with Elk River	620	40.9	29.5	34.2	126.2	4,119.6	807.0	117.9	63.5	62.0	62.4	31.2	10.5	943.3 (May 26/70)	0 (Nov 19/73)
Michel Creek below Natal	640	168.1	159.5	290.9	1,271.1	15,879.8	5,448.1	184.7	414.0	145.0	125.2	73.7	44.2	4,018 (May 26/70)	0 (Oct 6/73)
Elk River near Natal	1,870	147.1	90.6	209.2	375.8	21,758.0	48,552.6	9,545.8	394.7	227.6	248.5	184.6	136.1	10,158 (June 19/72)	0 (Nov 4/72)
Elk River at Fernie		497.8	779.4	2,364.5	4,451.6	121,109.9	110,751.0	12,415.9	708.6	534.8	684.8	1,014.8	331.5	55,871 (May 31/72)	0 (Aug 9/72)

N.B. Neither station 1 nor 2 were operating during 1972, a year when, during peak run-off, sediment loads were from 2 to 8 times higher than in other years.

2.3 Geology and Soils

Bedrock Geology

The following discussion is summarized from Newmarch (1953) and Price (1962). The Fernie Basin is a broad doubly-plunging, complex, synclinal fold in rock strata of the Jurassic and Cretaceous periods. The eastern and western boundaries of the Basin are fault-controlled, and the rocks which form the periphery are the Paleozoic limestones, dolomites, quartzites and sandstones of the Front Ranges of the Rocky Mountains.

The Fernie Basin is one of three "basins" that form a belt of coal-bearing lands running approximately 160 km. northward from the international boundary. These three areas are generally designated the Flathead River, the Crowsnest, and the Upper Elk coal fields. These coal measures and the associated, soft, Mesozoic rocks have been protected from erosion by the long "structural troughs" in which they occur.

Within the Fernie Basin the main stratigraphic units of interest are, from the top down, the Blairmore, the Kootenay, and the Elk Formations. The Kootenay is the coal-bearing formation and is further subdivided into three "members"; the Elk, the Coal-bearing, and the Moose Mountain.

The *Blairmore Formation* is a Lower Cretaceous statum composed of light coloured feldspathic sandstones, vari-

coloured (green, maroon, yellow and grey) siltstones and mudstones, and conglomerate. Its lower limit is generally considered to be a 12 m. thick band of non-feldspathic conglomerate which distinguishes it from the Elk Member of the Kootenay Formation.

The *Kootenay Formation* is generally considered to be Upper Jurassic or Lower Cretaceous in age, attempts to date it more precisely being inconclusive. The *Elk Member* is the uppermost and is composed of cherty conglomerates, coarse grained sandstones, and grey to black calcareous shales. Because of this composition it often forms predominant cliffs where exposed. The *Coal-bearing Member* is composed of grey to black carbonaceous shales, fine to medium grained sandstones, a few bands of pebble conglomerate and a varying number of coal seams. Sandstones and conglomerate make up about thiry per cent of the formation with the balance either coal or shale. The Coal-bearing Member varies in thickness from 560 m. to 1100 m. (at Michel) and contains as many as 24 workable coal seams. The coal is low to medium volatile bituminous with moderate to strong coking characteristics, and an extremely low sulphur content (0.3 - 0.5%). The chemical and physical properties of the coals vary with the location of the seam. In general, seam widths and ash content increase, and volatility and coking characteristics decrease, going progressively

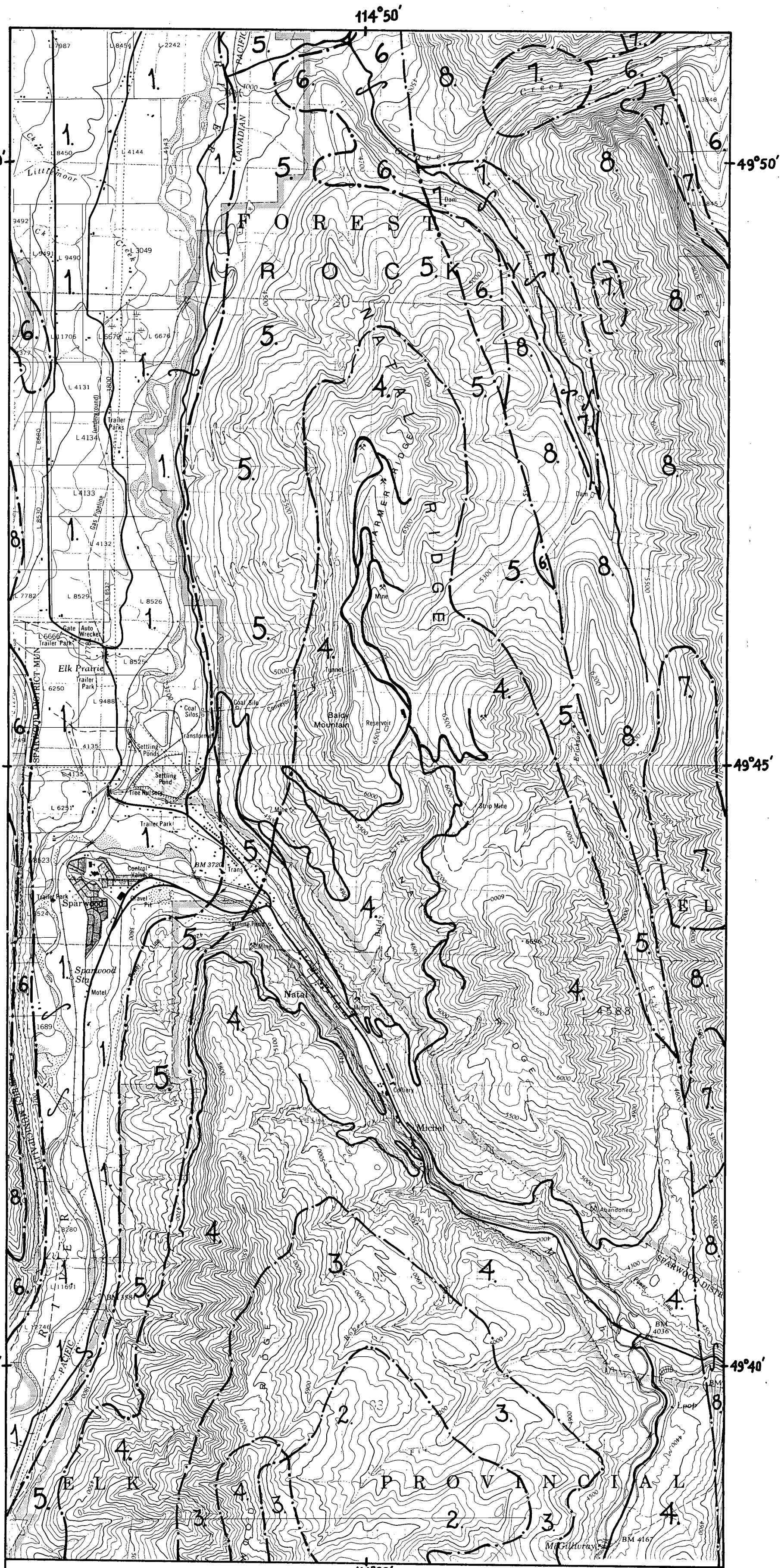
downward in sequence. The most widely accepted estimate of reserves for the Fernie Coal Basin as a whole, using only seams 1 m. or greater in thickness and a maximum cover of 760 m., is 8.2 billion long tons of coking and non-coking coal. A massive basal sandstone known as the *Moose Mountain Member* forms the lower limit of the Kootenay Formation. It is very distinctive and, because it outcrops quite commonly, has been used as an indication of the position of the Kootenay Formation during preliminary geological mapping.

The *Fernie Formation* is of Jurassic age and marine in origin. It is composed of grey to black calcareous shales with some interbedded limestone, siltstone and fine grained sandstone.

Map 2c shows the distribution of these various rock strata on the mining area.

Surficial Geology

The surficial geology of the East Kootenay is complex and, as yet, very incompletely studied. The glacial and post-glacial history of the region has resulted in a wide range of surficial deposits, the distribution and physical properties of which have a significant effect on all phases of the mining operation, and on the location of access corridors and residential areas. Given this, it is difficult to understand why a complete mapping of deposits



LEGEND

BEDROCK GEOLOGY

Scale 1:50,000

Mesozoic

1. Pleistocene & recent; till, gravel, sand, silt.
2. Upper Blairmore; mud & silt-stone, feldspathic sandstn.
3. Lower Blairmore; non-feldspathic conglomerate.
4. Kootenay; coal, sandstone, siltstone, conglomerate.
5. Fernie; shale, siltstone, sandstone, limestone.
6. Spray River; silty shale, dolomitic siltstone.

Paleozoic

7. Rocky Mtn; quartzitic, dolomitic & calcareous sandstone, dolomite.
8. Rundle Group; limestone, dolomite, red shale, siltstone, breccia.

MAP 2.C.

Geology from Price (1962).

Source:- N.T.S. 82J10 & 15

and the determination of their engineering and physical properties was not undertaken prior to mining development. Indications are that a complete surficial geology study of the Elk Valley may be completed in early 1978 by the Resource Analysis Unit of the Environment and Land Use Committee Secretariat as part of a biophysical land classification study. However, as will be noted later in this paper, a high price has already been paid for this neglect. The discussion that follows is taken largely from Kelly and Sprout (1956) and Harrison (1974).

Except for the peaks of the Front Ranges, the entire area was glaciated. Till on the uplands is thin and discontinuous and these areas are dominated by exposed bedrock and colluvium. The only significant till deposits at elevations over 1700 m. are in gullies and depressions. Most of the ablation till is found at middle elevations on the sides of the valley, and distinctive dark grey till which occurs in gullies and stream channels around 1500 m. on the eastern slopes of the Elk Valley and in the Michel Valley, has been responsible for numerous minor road failures.

During glaciation, ice flowed south down the Elk Valley and pushed a side tongue up the Michel Valley to approximately the junction of Michel and Alexander Creeks. A glacier originating in the Flathead and Taylor Ranges

flowed northward down the Michel Valley to meet the Elk Valley ice in the vicinity of McGillivray. As the glaciers began to retreat, a pro-glacial lake was formed between the tongue and the Crowsnest Pass. Along the Alexander Creek valley to the Pass this lake was filled with sand, gravel and silt, and these materials form terraces some 60 m. thick above the present creek bed and Highway 3.

As the ice retreated further down the Michel Valley it left a series of moraines across the valley which were subsequently covered by lacustrine silts and sands to a depth of approximately 30 m. These lake sediments now form conspicuous benches between Michel and Loop and can be seen as typical varved deposits in road cuts in the vicinity of the Erikson surface mine.

Between Michel and Sparwood, the retreat of the glacier was accompanied by the construction of kame terraces between the ice mass and the steep valley walls. These gravel deposits were exposed during the construction of the main Harmer haul road and the highly unstable cut-banks that resulted necessitate almost continual maintenance to keep the inside road ditches clear.

As the glaciers disappeared from the Elk Valley, a dam, perhaps formed by ice remaining in the canyon at Elko, caused the formation of a post-glacial lake which stretched to north of Elkford. Silts and clays deposited in this lake

have caused numerous problems in road and rail construction and in residential housing developments in both Fernie and Sparwood.

After the drainage of the post-glacial lake the major rivers and creeks re-established their channels by cutting down through the glacial deposits. The materials eroded by the rivers were sorted, the fine sediments were carried away, and the sand, gravel and stones remained to form the flood plain and the gravelly terraces that now characterize the valley bottom topography. A number of alluvial fans have been formed where secondary streams enter the main valleys and where there are abrupt changes in stream or river gradient. As might be expected, these deposits vary from coarse textured gravels at the apex of the fan to sands and silts at the edge.

Soils

Except in the valley bottoms, the soils of the East Kootenay are not well studied. Only two surveys have been completed; an intensive study of the lowland agricultural soils of the Upper Kootenay and Elk River Valleys by Kelly and Sprout (1956) and a broad reconnaissance survey by Canada Land Inventory staff during the Land Capability Mapping programme (1966-1969). If the biophysical land classification alluded to in the last section is undertaken,

far more detailed information on the soils of the study area will be available within the next two years.

Generally the soils of the East Kootenay region are youthful and soil processes have only weakly modified the various soil parent materials. Because of this and the rather complex glacial and post-glacial history, considerable soil variability exists. An interesting example of this variability is soil reaction, a factor which has considerable effect on the choice of species for reclamation. Figure 1 shows soil pH, determined on 44 samples collected on the mine site, as a function of altitude. As can be seen, a strong inverse correlation exists between soil pH and altitude. Between 1000 m. and 1370 m. elevation soils are weakly to moderately alkaline, between 1370 m. and 1500 m. considerable variation exists and above 1500 m. soils are weakly to moderately acid. This may be partially explained by higher rates of precipitation and, therefore, heavier leaching at upper elevations, however, another explanation must not be discounted. As previously stated, 1500 m. is approximately the upper limit of glacial deposits in the area. Above this elevation soils are largely derived *in situ* from colluvium and bedrock. Glacial till and glacial lacustrine deposits probably contain much material derived from glacial erosion of the paleozoic limestones and dolomite which surround the

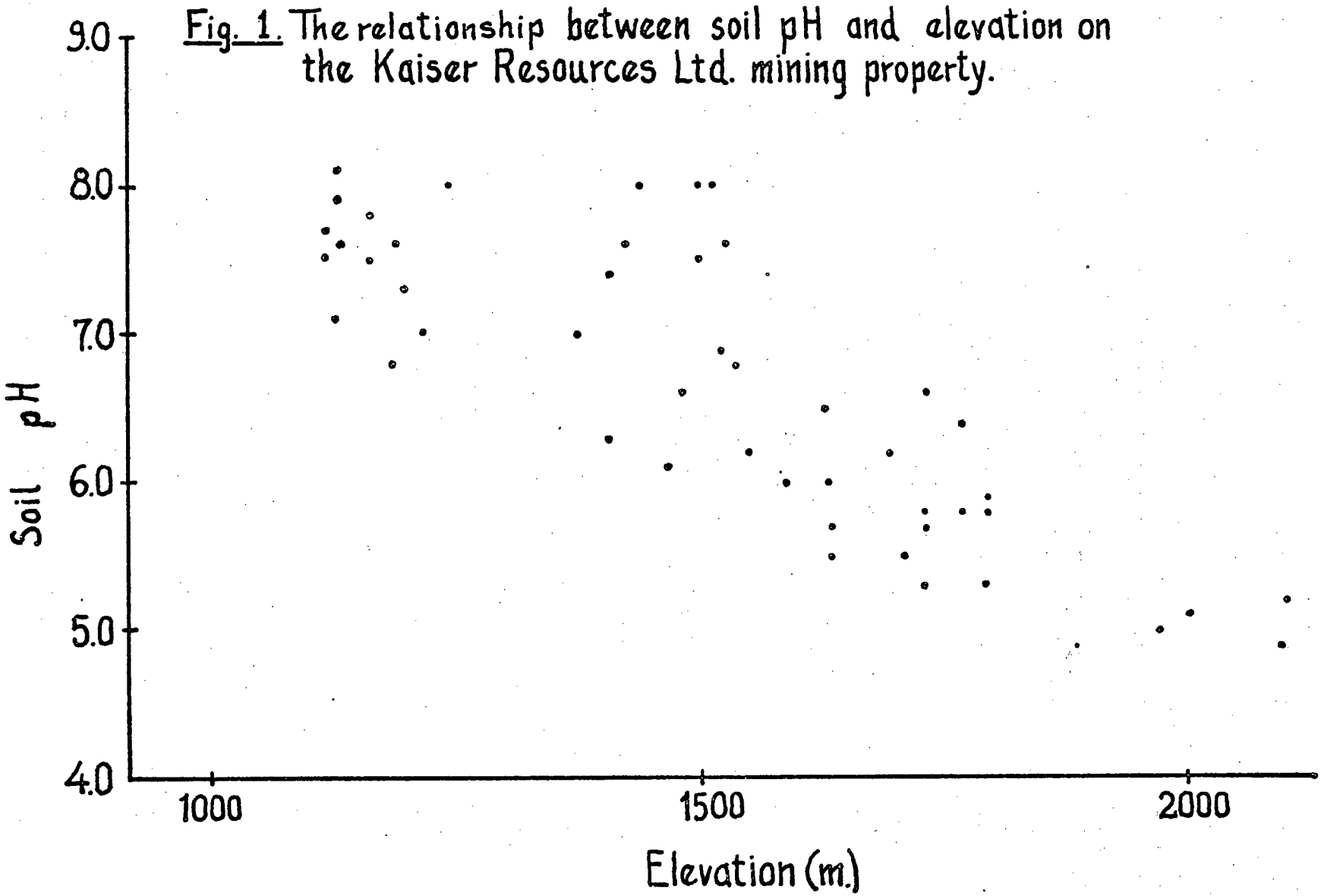


Fig. 1. The relationship between soil pH and elevation on the Kaiser Resources Ltd. mining property.

Fernie Basin. Soils developing from such deposits could be expected to have a much higher base status than those derived from the weakly or non-calcareous strata of the Kootenay and Elk formations.

The following broad soil associations are present on the study area (Wittneben 1969):

	Landform, Vegetation or Parent Material	Soil Type
1.	Valley bottoms, coarse textured alluvium	- Dystric and Eutric Brunisols
2.	Valley bottoms and lower elevations, fine textured glacio-lacustrine deposits	- Bisequa Gray-brown Luvisols
3.	Middle and lower elevations, till parent material	- Dystric Brunisols - Mini and Orthic, Humo-Ferric Podzols
4.	Middle elevations, glacio-lacustrine materials	- Gray-brown Luvisols
5.	Middle elevations on South or Southwest aspects (grass/ shrub communities)	- Eutric Brunisols - (more rarely) Dark brown or Dark-gray Chernozems
6.	High elevations (1500 m.+)	- Mini and Ortho Humo-Ferric Podzols, Alpine Dystric Brunosols, alternating with exposed bedrock and Regosols on unstable colluvium

Mapping of soil and landform deposits of the Flathead, Fernie and Upper Elk Coal Basins at a scale of 1:50,000 is currently being done by the Resource Analysis Unit of the Environment and Land Use Secretariat. Preliminary manuscript

map sheets of the K.R.L. coal lands should be available in June or July of 1978.

2.4 Climate

The East Kootenay Region of British Columbia probably contains more climatic variation than any area of similar size in Canada. As an example of this variation, five climatic parameters are contrasted for Sparwood, Fernie and Elko in the following table:

Station	Annual Precipitation Cm.	Temperature (°C) Mean Annual	Mean Winter	Mean Summer	Frost Free Period
Sparwood	57.9	3.8	- 7.2	14.8	80 days
Fernie	104.1	4.4	- 6.6	14.9	101 days
Elko	51.0	5.0	- 7.2	16.1	95 days

Climatic patterns in the Region are influenced by three main types of air masses: maritime tropical, maritime pacific, and continental arctic (Marshall, 1969). The maritime tropical air masses arise in the Pacific Ocean at latitudes 30-35°N. This type of system arrives in the East Kootenay somewhat cooled by its passage over the North Pacific and usually "riding" on a cool marine stratum. Because of this, and the tendency for this air mass to ride over cooler continental air,

it seldom reaches the surface. Maritime Pacific air originates in the Gulf of Alaska as a modification of polar continental air which, through a long passage over the North Pacific, acquires marine characteristics. Occurrances of this type of weather system are common in the Kootenays, particularly during the winter months, and result in most of the annual precipitation. Continental Arctic air influences the study area only infrequently because the ranges of the continental divide form a barrier to its westward spread. Occasionally, however, "polar outbreaks" occur, and tongues of cold air flow westward through the main river valleys. These outbreaks bring exceptionally low minimum temperatures of -35°C or less.

On the mining area the climate can be classified, after Köppen, as continental sub-humid (Dfb) at lower elevations, and continental cold humid (Dfc) at higher elevations. Two weather stations have been established on the mining area, one at the reclamation office/nursery complex in the Elk Valley at an elevation of 1125 m. and one at the engineering office on Harmer Ridge at an elevation of 1920 m. Data from the two stations are summarized in Tables 3 and 4, and annual data is shown in Appendix III.

At lower elevations, precipitation occurs in the form of rain in all months of the year, and in the form of snow in all but the three summer months. Approximately

TABLE Weather Summary for the Year(s): 1969-1974
Station: Natal-Kaiser Resources

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January	-6.5	-15.-	-10.8	9.4	-35.6	2.7	91.8	11.9
February	1.9	- 9.9	- 4.0	12.8	-31.7	1.6	35.0	5.1
March	4.2	- 6.7	- 1.2	14.4	-27.2	2.5	22.2	4.7
April	9.8	- 2.1	3.8	20.0	-11.7	3.8	16.0	5.4
May	16.5	0.1	8.3	28.9	- 7.2	3.0	2.5	3.3
June	20.8	5.8	13.3	32.8	- 2.2	5.3	-	5.3
July	24.8	6.4	15.4	34.4	- 2.2	3.7	-	3.7
August	24.9	6.3	15.6	34.4	- 2.8	2.1	-	2.1
September	17.1	2.0	9.6	30.6	- 7.2	2.6	3.5	2.9
October	10.5	- 1.6	4.4	21.7	-19.4	1.1	7.1	1.8
November	2.9	- 6.2	- 1.7	10.0	-30.0	2.6	33.0	5.9
December	- 2.0	-11.4	- 6.7	10.0	-35.6	1.5	43.8	5.8

Mean monthly temperature (°C): - 3.8
Mean monthly temperature for January: - -10.8
Mean monthly temperature for July: - 15.4
Months above 10°C: - 3
Months above 5°C: - 5
Months below 0°C: - 5
Frost free days (period): - 80 days
Total annual precipitation (cm): - 57.9
Annual snowfall (cm): - 254.9
Seasonal occurrence of precipitation: -
Wet Season Winter (39%)
Wettest Month January
Dry Season Fall (18%)
Dryest Month October

TABLE Weather Summary for the Year(s): 1971-1974
Station: Natal - Harmer Ridge

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January	- 9.6	- 16.8	- 13.2	2.7	-33.9	-	141.2	14.1
February	- 4.5	- 11.8	- 8.2	5.0	-28.9	-	79.6	8.0
March	- 1.0	- 9.5	- 5.2	7.8	-24.4	trace	58.8	5.9
April	2.0	- 6.4	- 2.2	9.4	-18.9	trace	62.1	6.2
May	7.9	- 0.6	3.6	21.1	-10.5	1.2	27.6	4.0
June	14.1	4.4	9.2	26.7	- 2.8	4.2	8.5	5.0
July	17.3	6.3	11.8	26.1	- 1.7	6.1	1.6	6.3
August	18.9	8.0	13.4	30.0	- 1.1	4.2	2.8	4.5
September	9.7	0.8	5.2	23.3	-11.7	2.6	30.1	5.6
October	5.4	- 3.1	1.2	16.7	-22.2	0.6	42.7	4.7
November	- 3.4	- 9.1	- 6.2	5.6	-22.2	-	116.8	11.7
December	- 7.3	- 13.2	- 10.2	1.7	-32.8	-	112.3	11.2

Mean monthly temperature (°C): - 0
Mean monthly temperature for January: - -13.2
Mean monthly temperature for July: - 11.8
Months above 10°C: - 2
Months above 5°C: - 4
Months below 0°C: - 6
Frost free days (period): - 61 days
Total annual precipitation (cm): - 87.4
Annual snowfall (cm): - 683.1
Seasonal occurrence of precipitation: -
Wet Season Winter (38% of ppt.)
Wettest Month January
Dry Season Summer (18% of ppt.)
Dryest Month May

forty-four per cent of the annual precipitation falls as snow. Heaviest precipitation occurs from late fall, through winter to early spring. The driest periods are in late spring (mid-April to the end of May) and from mid-summer to early fall. Usually a short period of fairly intensive rainfall occurs in June and early July. At higher elevations, snow occurs in all months of the year and accounts for approximately seventy-eight per cent of the annual precipitation. Precipitation is heaviest from November to February, and is relatively evenly distributed throughout the rest of the year.

Mean monthly, and extreme maximum temperatures are invariably higher at lower elevations. Extreme minimum temperatures are often lower in the valley bottoms for two reasons, first because of temperature inversions that commonly form during periods of still air, and second, during out-breaks of polar continental air, the cold air tends to concentrate and flow at low elevations in the valleys.

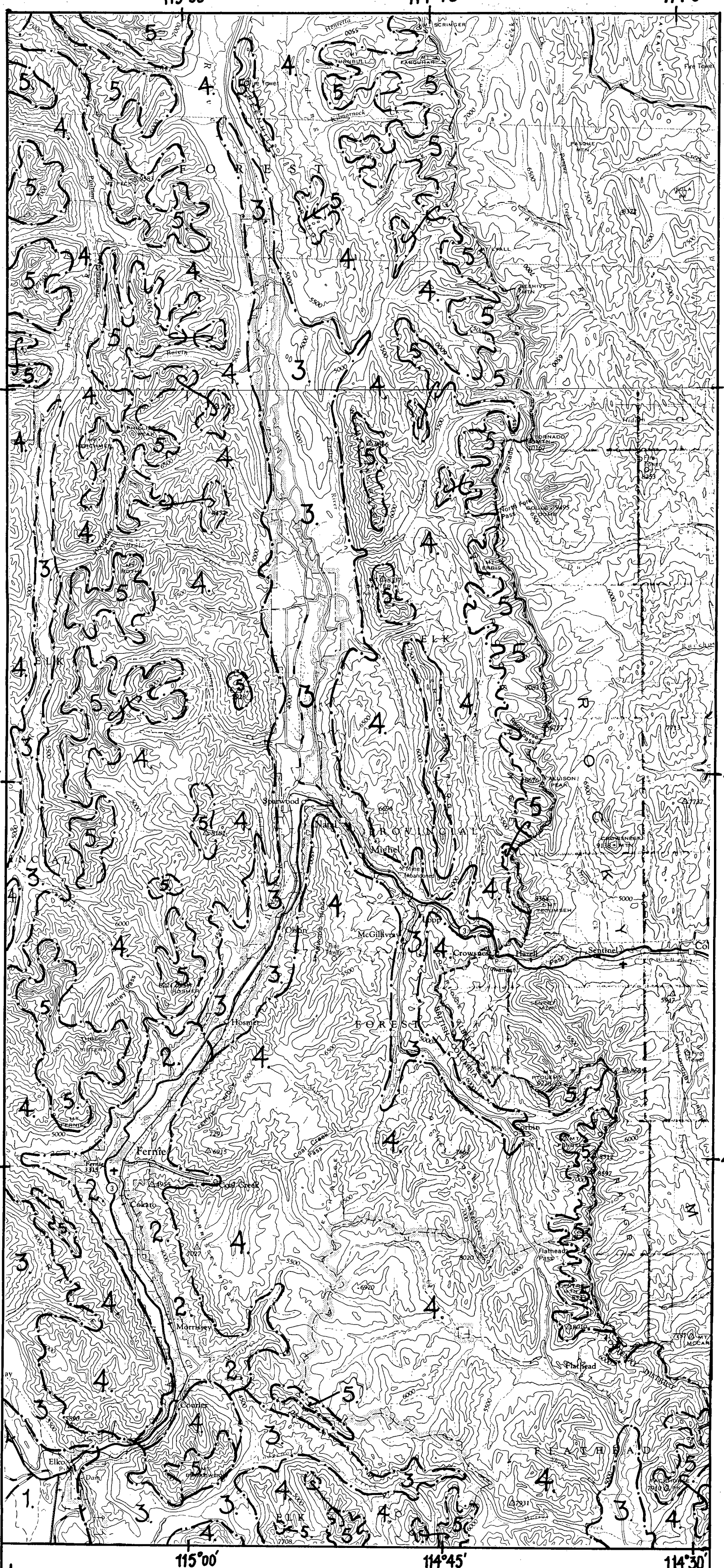
Average Frost free periods for the valley bottom and Harmer Ridge are 80 and 61 days respectively. Growing season for hardy perennial plants, defined as those months with a mean temperature of 5° centigrade or higher, averages 5 months for the Elk Valley and 4 months for Harmer Ridge.

Prevailing wind directions at Sparwood are from the southeast down the Michel Valley and from the southwest up the Elk Valley. Two anemometers have been installed by the Company, one at Sparwood and the other at Michel, as part of the air quality monitoring programme. Data from these stations are not available for inclusion in this thesis.

2.5 Vegetation

Within a 50 km. radius of Sparwood, are represented five of the eleven biogeoclimatic zones described for British Columbia by Krajina (1964); specifically, the Ponderosa Pine-Bunchgrass zone, the Interior Douglas-fir zone, the Interior Western Hemlock zone, the Engelmann Spruce - Subalpine Fir zone and the Alpine Tundra zone (See Map 1d).

At Elko, 48 km. southwest of Sparwood on Highway No. 3, the plant community is typical of the wet subzone of the Ponderosa Pine - Bunchgrass zone. This zone occurs in the Rocky Mountain Trench south of a line from Wardner to Elko. Zonal and sub-zonal plant indicators include ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), bitterbrush (*Purshia tridentata*), rabbit bush (*Chrysothamnus nauseosus*) and fringed sage (*Artemisia frigida*).



LEGEND

Scale 1:250,000

BIOGEOCLIMATIC ZONES* OF THE FERNIE COAL BASIN

1. Ponderosa Pine - Bunchgrass Zone.
2. Interior Western Hemlock Zone.
3. Interior Douglas-fir Zone.
4. Engelmann Spruce - Subalpine Fir Zone.
5. Alpine Tundra and Rock.

* After Krajina (1964)

MAP 1.d.

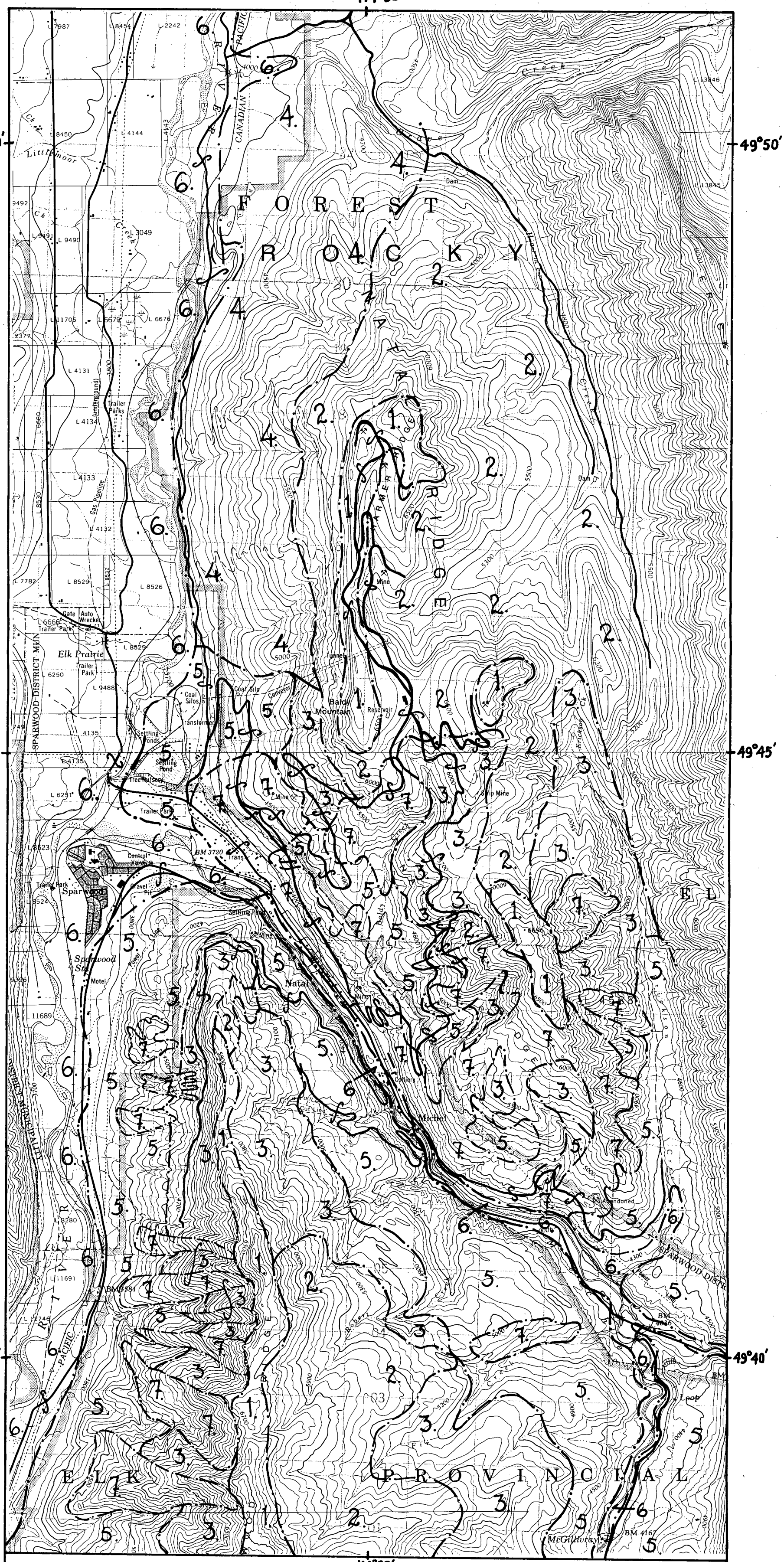
Source :- N.T.S. 82G & J.

Northeast of Elko, along the Elk River valley, the vegetation changes very abruptly to the dry sub-zone of the Interior Western Hemlock zone. Zonal and subzonal plant indicators that occur commonly in the vicinity of Fernie and Morrissey include western red cedar (*Thuja plicata*), western white pine (*Pinus monticola*), western larch (*Larix occidentalis*), western yew (*Taxus brevifolia*), bunchberry (*Cornus canadensis*), and black hawthorn (*Crataegus douglasii*).

Between Fernie and Sparwood, in response to decreasing precipitation, there is a gradual transition from the dry sub-zone of the Interior Western Hemlock zone to the wet sub-zone of the Interior Douglas-fir zone.

Throughout the area there is a transition to the Engelmann Spruce - Subalpine Fir zone above 1375 m. elevation, and to the Alpine Tundra zone above 2125 m.

Two biogeoclimatic zones occur on the Kaiser Resources Ltd. mining area; the Interior Douglas-fir zone at elevations from 1125 m. to approximately 1525 m., and the Engelmann Spruce-Subalpine Fir zone from approximately 1525 m. to 2100 m. Within these two zones are eight clearly distinguishable plant communities which reflect both physiographic influences and variations in successional history. In the following sections these eight communities will be briefly described. Detailed species lists appear in Appendix IV, and the distribution of the communities on the mining area is shown on Map 2d.



LEGEND

Scale 1:50,000

VEGETATION TYPES OF THE MINING AREA*

1. Sub-alpine forest parkland.
2. Sub-alpine, closed canopy climax forest.
3. Sub-alpine, even-aged seral forest.
4. Low elevation, all-aged mixed forest.
5. Low elevation, even-aged seral forest.
6. Valley-bottom, floodplain communities.
7. Physiographic sub-climax shrub/herb communities.

Map. 2.d.

Source:- N.T.S. 82-10 & 15

* Estimated distribution in the absence of logging & mining.

A. Engelmann Spruce - Subalpine Fir Zone

(1) Open Subalpine Forest "Parkland"

This is a shrub, herb and stunted conifer community of rich species diversity occurring on high elevation ridge tops and unconsolidated colluvial deposits. Typical soil types are alpine dystric brunisols, regosols and localized areas of wet organics. The tree component of this community consists of subalpine fir (*Abies lasiocarpa*), white bark pine (*Pinus albicaulis*), and lodgepole pine (*Pinus contorta var latifolia*). Under denser canopy the understory vegetation is dominated by white rhododendron (*Rhododendron albiflorum*) and false azalea (*Menziesia ferruginea*). Areas of more open canopy, and small meadows support an array of shrubs (primarily *Vaccinium* spp), sedges, grasses (particularly *Poa* spp) and forbs. Kinnikinnik (*Arctostaphylos uva-ursi*), Scouler's penstemon (*Penstemon fruticosus var scouleri*) and common juniper (*Juniperus communis* var *communis*) are the main species occurring on unconsolidated colluvium.

(2) Closed-canopy Subalpine Climax Forest

The transition to this forest type occurs between elevations of 1525-1675 m. on westerly and southerly aspects and 1375-1525 m. on northerly and easterly aspects. The major soil types of the closed subalpine forest are mini and orthic humo-ferric podzols, alpine dystric brunisols, and regosols. This community is dominated by subalpine fir

(*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*). Lodgepole pine, whitebark pine and alpine larch (*Larix lyallii*) are present as scattered individuals. Of interesting, though very rare, occurrence is mountain hemlock (*Tsuga mertensiana*). This may be the most easterly distribution of this species in B.C.

White rhododendron and false azalea are the main understory species except in stream courses where Sitka alder (*Alnus sinuata*) forms thickets. Forbs, grasses and other shrubs are restricted to areas of open canopy and the species tend to be similar to those occurring in the "parkland" type.

(3) Fire-induced, Evenaged Seral Forest

Seral lodgepole pine stands occur commonly in the Crowsnest area as a result of widespread fires during the 1930's. At all elevations the stands are densely stocked, usually in the range of 1500-2000 stems per ha. For the purposes of this discussion, a distinction will be made between those lodgepole pine stands in the subalpine and those at lower elevations on the basis of understory vegetation. In the subalpine, the understory of these stands is dominated by grouseberry (*Vaccinium scoparium*) almost to the exclusion of other species. The only other common species are Sitka alder in the stream courses and scattered individuals of sticky current (*Ribes viscosissimum*) and

broadleaf arnica (*Arnica latifolia*).

B. Interior Douglas-fir Zone

(1) All-aged, Mixed Forest

This vegetation type occurs, for the most part, on westerly, northerly and easterly aspects. These areas were probably burned by the same fires that created the lodgepole pine stands but, because of the cooler, moister aspect, regenerated to a mixed forest rather than pure lodgepole pine. The most common soil types are dystric brunisols on drier sites and mini humoferric podzols on the moister northerly aspects. Douglas-fir (*Pseudotsuga menziesii*) veterans of 100+ years occur throughout the area either as scattered individuals or in small stands where topography has given them some protection from fire. The younger tree growth is dominated by Douglas-fir, western larch (*Larix occidentalis*), and trembling aspen (*Populus tremuloides*). Paper birch (*Betula papyrifera*) and Rocky Mountain juniper (*Juniperus scopulorum*) are common throughout this type, and black cottonwood (*Populus trichocarpa*) is associated with water courses and seepage sites.

This vegetation type supports a rich understory because of the openness of the canopy. Twenty-one species of shrub, nine species of grass and twenty-three forbs have been identified.

(2) Fire-induced, Evenaged Seral Forest

Lodgepole pine forests at low elevations differ from those in the subalpine primarily in understory vegetation. The shrubs that are most representative of this type are squashberry (*Viburnum edule*) and false box (*Pachistima myrsinites*). The dominant ground vegetation is pinegrass (*Calamagrostis rubescens*), with wild strawberry (*Fragaria virginiana*), heartleafed arnica (*Arnica cordifolia*), and prince's pine (*Chimaphilia umbellata*) also common.

(3) Valley-bottom, Flood-plain Communities on Fluvial Deposits

The vegetation of river flood plains in this area is a mosaic of meadows, shrub thickets, and mixed deciduous and coniferous forests. The most common tree species of the valley bottom are black cottonwood, trembling aspen and white spruce (*Picea glauca*). Columbia hawthorn (*Crataegus columbiana*), white clematus (*Clematus lingustifolia*), silverberry (*Elaeagnus commutata*), chokecherry (*Prunus virginiana*), three species of rose, and waxberry (*Symphoricarpos albus*) are the common shrub species on drier sites. Sandbar willows (4 species) and redosier dogwood (*Cornus stolonifera*) are the main species on areas of annual flooding.

The grass and forb component of this vegetation type is very diverse and requires further study.

C. Vegetation Communities That Occur Throughout The Range of Elevations on the Mining Area

(1) South and Southwest Aspect, Physiographic Sub-Climax Shrub/Herb Community

These communities are found throughout the region on steep south and southwest facing slopes that are either too dry or too unstable to support tree growth. On the mining area these shrub meadows occur on the western slopes of Natal and Harmer Ridges. The composition of these communities appears to be quite variable depending upon elevation, aspect, parent material and available moisture. In view of the critical importance of these areas to wintering wildlife (see section 2.6) more study and further subdivision of this type is required.

(2) Plant Communities Developed on Areas of Industrial Disturbance

The study of these communities has significant application to the selection of native species for reclamation. Five tree species, twelve shrubs, two grasses, twenty-five forbs and a horsetail (*Equisitum* sp.) have been found growing on areas of deep soil disturbances. Further study of disturbed areas is required, and species composition on such areas must be related to environmental factors such as elevation, slope, aspect, and soil material before any rational decisions can be made on the suitability of these species for reclamation.

The main value of vegetation studies in a reclamation programme is to provide baseline information against which to assess the effectiveness of revegetation measures. In order to provide meaningful baseline data, permanent plots must be established on which to measure parameters such as species composition, ground and foliage cover, biomass production and chemical content. These studies must be sufficiently long-term as to establish the magnitude of natural variability due to climatic and pedogenic fluctuations. Sample plots must be located in vegetation units of sufficient size (> 5 ha.) that they are relatively stable over a 20 year period.

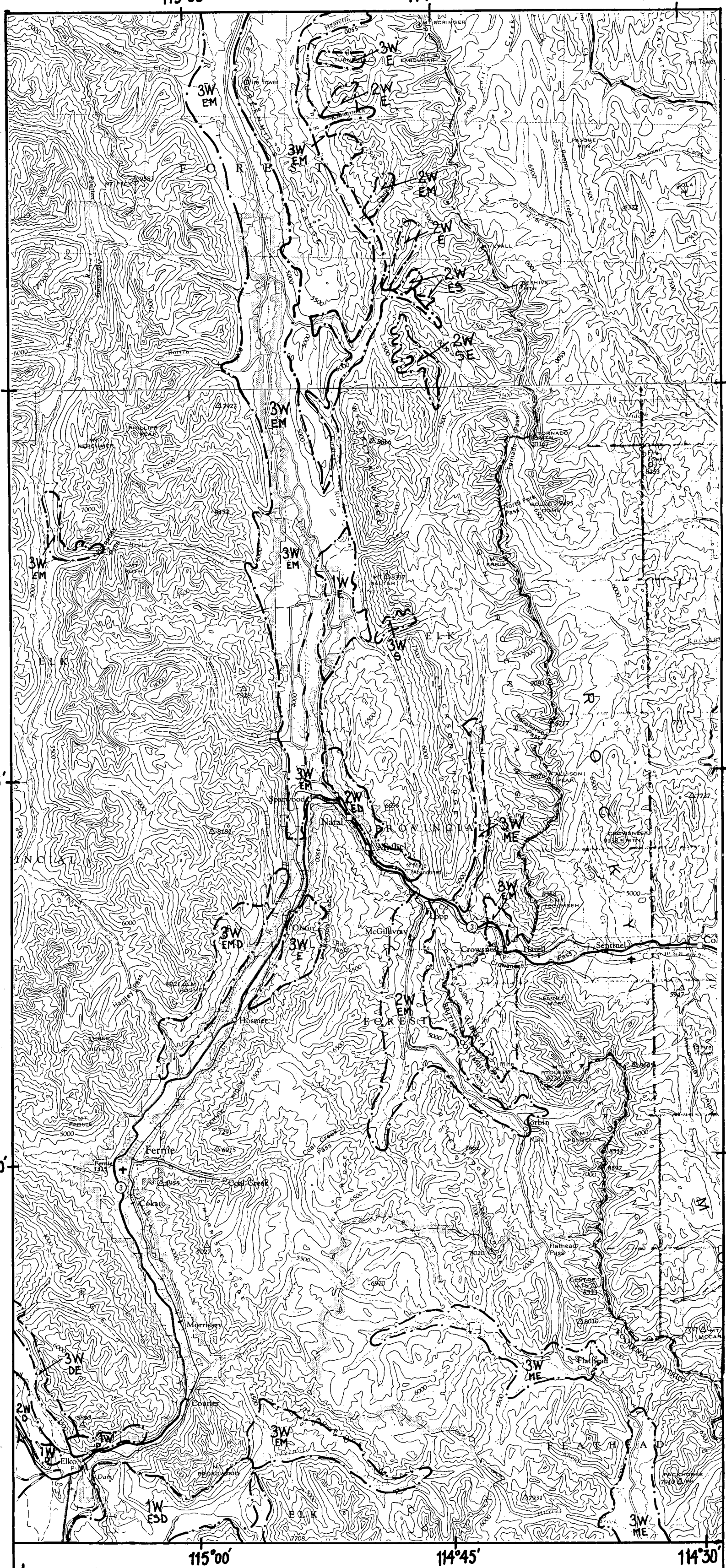
2.6 Wildlife and Fish

Because of its variation in landforms and vegetation, the East Kootenay supports perhaps the greatest diversity of wildlife species in British Columbia. The Fernie and Upper Elk coal basins fall within the ranges of forty-nine species and sub-species of mammals (Cowan and Guiguet, 1965). This total includes three species of shrew, three species of bats, two species of the order *Lagomorpha* (hares and pikas), nineteen species of rodents, six species of ungulates, and fourteen species of carnivores (see Appendix V).

In terms of distribution and habitat utilization, the most intensively studied component of this wildlife resource is the large ungulates; Rocky Mountain elk, moose, mule deer,

white-tailed deer, Rocky Mountain bighorn sheep, and mountain goat. Available winter range is considered to be the single most important habitat factor limiting ungulate numbers in the Northern Rocky Mountains (Stelfox and Taber, 1969). Demarchi (1967) estimates that summer range exceeds the amount of tenable winter range by a ratio of 10:1 within the Elk River watershed. Winter ranges are confined to riparian habitats along the major water courses, and to southerly aspects where wind and temperature moderate snow depth. These later areas tend to remain in seral and subclimax herb/shrub communities for long periods following fire or other forms of disturbance, and thus produce significant quantities of available forage for ungulates. Major winter ranges within the East Kootenay coal area have been identified through a series of aerial surveys conducted between 1962 and 1968. The results of these studies have been summarized in two publications by the Fish and Wildlife Branch (Demarchi, 1967 and 1968). These winter ranges are shown on Map le and the average number of animals observed over the period 1962 to 1975 are shown in Table 5. Within the Kaiser Resources Ltd. coal properties, the most significant winter concentrations of animals occur on the following areas:

1. Immediately to the north of Harmer Ridge there occurs an area of flat to gently



LEGEND

Scale 1:250,000

MAJOR UNGULATE WINTER RANGES

Class 1. Lands with no significant limitations to the production of ungulates.

Class 2. Lands with very slight limitations to the production of ungulates.

Class 3. Lands with slight limitations to the production of ungulates.

D=deer E=Rocky Mtn. elk M=Moose S=Rocky Mtn. bighorn sheep.

MAP 1.e.

Capability interpretations generalized from B.C. Land Inventory.

Source:- N.T.S. 82G & J.

Table 5

Animal-Use of the Major Winter Ranges in the Fernie and Upper Elk Coal Basins. Observed on Late Winter Classified Counts During the Period 1966-1975*

Name of Winter Range		Number of Animals By Species							
		Elk		Sheep		Deer		Moose	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Grave Prairie		92	17	-	-	8	3	4	0
Sheep Mountain		48	3	41	14	14	11	-	-
Sparwood/Hosmer Ridge		77	4	-	-	2	0	10	0
Natal Ridge		82	5	-	-	39	1	-	-
McGillivray Ridge		15	6	-	-	-	-	-	-
Ewan Creek	North	41	5	40	11	-	-	-	-
	South	47	2	119	57	-	-	-	-
Chauncey Creek		31	2	-	-	-	-	2	0
Tod Hunter Creek		57	21	29	22	-	-	2	0
Lyne Mountain		48	11	76	N/A	-	-	-	-
Coal Creek		74	13	-	-	2	0	1	0
Riparian Ranges	Elk River: Fernie-Sparwood	61	13	-	-	5	0	19	2
	Elk River: Sparwood-North	49	9	-	-	18	3	32	8
	Fording River	35	19	-	-	-	-	16	1
	Michel Creek	3	0	-	-	-	-	-	-

*N.B. Classified winter counts can *not* be considered a total population inventory. Flights are normally done only one day a year and the number of animals seen varies with the severity of the winter, the experience of the observers, and the weather at the time of observation.

rolling topography bounded by Line Creek in the north, the Elk River on the west and Grave Lake on the east. This area supports an aspen/mixed forest community with a rich shrub and herb understory, and is utilized primarily by mule deer and Rocky Mountain elk.

2. The south and westerly aspects of Natal, Sparwood, Fernie and McGillivray Ridges support fire-induced, sub-climax herb/shrub communities that receive heavy use by mule deer and Rocky Mountain elk.

3. The riparian habitat in the Elk, Fording, Michel, Alexander and Erikson Valley bottoms are utilized primarily by moose and Rocky Mountain elk. One of the main concentrations of moose in the area occurs on the east bank of the Elk River along the base of the Greenhills Range. Scattered groups of white-tailed deer use the Elk River flood plain from Elko to a few miles north of Sparwood.

4. A number of critical winter ranges for elk and bighorn sheep are associated with five westerly flowing tributaries of the Fording River. Specifically these areas are the alpine and grassland ranges on the south-facing slopes of

Grace, Ewin, Tod Hunter, Chauncey, Kilmarnock, Clode and Henrietta Creeks. The area between Grace and Ewin Creeks, a portion of which is occupied by K.R.L. coal licence 6746 (see Map 1f) is considered to be the most important alpine winter range for Rocky Mountain bighorn sheep in British Columbia (Demarchi, 1968). K.R.L. coal licences 6743, 6744 and 6747 contain portions of a grassland and open forest range, associated with Ewin and Tod Hunter Creeks, that is used by both elk and bighorn sheep. These grasslands exhibit chernozemic soil development as a result of periodic fires, and can be considered unique to the area (Wright, 1967).

The botanical diversity in the mining area provides a wide array of avian habitats, and a variety of bird species is likely to be present either as breeding or migrant populations. No comprehensive study of the birds of the Elk River drainage has yet been made, however, a preliminary species list has been compiled from records of the B.C. Provincial Museum (Campbell per. comm.) and this is included in Appendix V.

The major fish species in the Elk River system are Yellowstone cutthroat trout, Dolly Varden, and Rocky Mountain whitefish. Dolly Varden and Rocky Mountain whitefish are found in the lower reaches of the Elk River and Michel

Creek, while cutthroat trout occupy the upper reaches of both streams, the Fording River and all of the major tributaries in the system. Rainbow trout and kokanee, neither of which is native to the Elk River drainage, have been introduced to Grave Lake. Virtually no studies have been carried out to determine either fishery populations or important habitat in the Elk River system. In view of the significant sportfish recreation afforded to employees of the mining operations in the area, Kaiser Resources Ltd. could well afford to cooperate with the B.C. Fish and Wildlife Branch in a stream survey programme to determine both the present status of the resource and the effects on it of mining and exploration operations. In addition to the sportfish previously mentioned, six species of coarse fish inhabit streams and lakes in the area. A list of all species identified from the area is included in Appendix V.

2.7 Map and Airphoto References

Map and airphoto references are included in Appendix VI. Except where noted, the maps and photos are for the whole coal property. No central registry of aerial photography exists for British Columbia and, as a result, photography by private firms is difficult to locate. Airphoto references are, therefore, of government photography only.

CHAPTER III

THE KAISER RESOURCES LTD. OPERATION

3.1 Introduction

In 1966 the Kaiser Steel Corporation of Oakland, California, began to consider the possibilities of developing coal resources in the East Kootenay area to produce metallurgical coking coal for sale to the Japanese steel industry. An approach to Kaiser Steel by Crowsnest Industries Ltd., a long established coal and lumber producer in the area, to sell coal, resulted in negotiations by which Kaiser acquired mining rights to a selected two-thirds of C.N.I.'s 44550 ha. of crown-granted coal lands. In addition, the rights to a number of crown coal licences were also obtained. On July 31, 1967, the Kaiser Coal Company was incorporated as a wholly owned subsidiary of the Kaiser Steel Corporation. In 1969 the name was changed to Kaiser Resources Ltd. to reflect a broader interest in resource development.

Today the company is one of the major producers of metallurgical coal in Canada. Almost all of this coal production is sold, under long-term contract with the Mitsubishi Corporation, to supply the Japanese steel industry.

Initial contracts called for the production of 6,000,000 long tons per year, however, in 1973 the terms were renegotiated to 4,500,000 long tons per year, plus or minus 5 per cent at the buyer's option. The price of metallurgical coal has risen dramatically over the past five years with the most recent and largest increase coinciding with what is now commonly referred to as the "energy crisis". The following figures indicate the selling price to the nearest dollar since 1970: 1970 - 12.00; 1972 - 18.00; 1974 - 27.00; and 1976 - 52.00.

In addition to metallurgical coal, the company also produces smaller quantities of thermal coal, coke, and by-products such as coal tar. The thermal coal is sold under short-term contracts to power utilities in Eastern Canada and Europe. Coke made at Michel supplies a small domestic and U.S. market.

Of the total raw coal mined by K.R.L., approximately 85 per cent is produced by surface mining. The remainder is extracted in underground operations, mainly by the hydraulic method.

The raw metallurgical coal is cleaned on-site in a preparation plant complex to reduce "ash content" to the 9.5 per cent specified in the contracts. The average yield of clean coal from raw coal is 76 per cent. The clean coal is loaded into "unit" trains of 88 cars and transported

1100 rail km. to bulk loading facilities at the deep-water port of Westshore Terminals Ltd. at Roberts Bank. This company is a wholly-owned subsidiary of Kaiser Resources Ltd. The port has the capacity to stockpile up to one million tons of coal, and to accommodate ships of up to 150,000 tons.

The operations of Kaiser Resources and Westshore Terminals employ approximately 1,950 people directly.

3.2 A History of Coal Mining in the East Kootenay

The following section is based on historical sketches by Rickard (1942) and Newmarch (1953), and the annual reports of the Department of Mines and Petroleum Resources.

There appears to be some disagreement about who was the first European to discover coal in the Crowsnest area, however, the existence of these coal deposits seems to have been known since Europeans first entered the region. According to Rickard, the first man to prospect the Fernie Basin was a Michael Phillipps who investigated outcrops on Morrissey and Coal Creeks during the summers of 1873 and 1874. He carried news of the extent of these coal deposits back to Fort Steele, however, because of a lack of transportation to the area, little interest was taken in either his reports or those of the Geological Survey of Canada from 1880-1883 which substantiated his findings.

In 1887 William Fernie, an experienced miner, began to prospect in the basin. He was soon able to interest Colonel James Baker and Arthur Fenwick in financing a further eight years of work. As a result of the findings, a syndicate was formed in Victoria which obtained both a charter to build a railway and a grant of lands surrounding the coal prospects.

In 1897 the Crowsnest Pass Coal Company was incorporated and acquired a major interest in the Fernie-Baker-Fenwick syndicate. Initial production began in the same year from a mine on Coal Creek worked by twenty miners recruited from Cape Breton. In the following year a branch line was constructed by the Canadian Pacific Railway from Fort McLeod to Fernie. In 1899, the Crowsnest Pass Coal Company linked Coal Creek and Fernie and, thereafter, development of the Coal Creek Collieries progressed rapidly. By 1903, six mines had been opened and developed by the Company in the Coal Creek Valley.

In 1901 the Great Northern Railway Company acquired a substantial interest in the Crowsnest Pass Coal Company and financed the construction of a rail line from Gateway in Montana through Elko and Fernie to Michel. This line, connected with the Great Northern main line provided an important new market for East Kootenay coal.

Concurrent with the start of production from the Coal Creek mines, the Company undertook developments at both Michel and Morrissey. The mines at Morrissey (eight in all) ran from 1902 to 1909 under the name of the Carbonado Colliery, although entirely owned by the Company. A series of explosions from 1904 onward caused the deaths of scores of miners and finally resulted in the decision that the seams were too dangerous to work. The Carbonado Colliery ceased production in 1909. The Michel Colliery was brought into production in 1898, and is the only mine to have been worked continuously to the present.

In 1911 a seventh mine was opened in Coal Creek and it proved to be the largest producer to that date. In 1913 the output of the Coal Creek mines was 924,200 tons, a record annual production that was unsurpassed until 1941. The Coal Creek collieries were worked continuously until 1958 when they were finally closed.

Until 1968 there were only two operations in the Fernie Coal Basin that were not owned by the Crowsnest Pass Coal Company. In 1906 the Canadian Pacific Railway acquired six square miles (15.5 sq. km.) of coal lands on the western edge of the Basin 13 km. north of Fernie, and opened the Hosmer mines. Surface facilities included both an extensive preparation plant and a large battery of coke ovens. The latter may still be seen from Highway 3 a short distance

north of the Hosmer bridge. Many sharp folds, and extensive faulting complicated mining and the colliery was shut down in 1914. At Corbin, southeast of Michel, a colliery began producing in 1908. This mine was served by a 22.5 km. branch railway which joined the C.P.R. line at Loop Station. This was the site of the Region's first surface mine which was opened in 1913. Though it could not be operated during periods of deep snow, the open pit contributed significantly to the output of the mine from 1913 to 1920 and again from 1926 to 1935. In 1935 a violent strike culminated in an incident in which a bulldozer, being used to restrain an angry crowd of miners and their wives, went out of control and severely injured a number of people. The mine was closed and the rail line was dismantled. The surface mine was reopened for a short period from 1943 to 1948 and then lay dormant until 1974 when Byron Creek Collieries, a Coleman-based firm, resumed mining of thermal coal for sale to Eastern Canada.

The years between 1898 and 1968 have been a very unstable period for the East Kootenay coal industry. Table 6 and Figure 2 show gross coal production from the mines of the Fernie Coal Basin from 1898 to 1975. In the first two decades of this century, production exceeded one million short tons in 1909, 1910, 1912, 1913, and 1914, but declined in the later years of the First World War. Production hit lows

Table 6

Coal Produced at Mines in the Fernie Coal Basin 1898 - 1974 (Gross Output in Short Tons)*

		Crowsnest Pass Coal Company						
Year	Michel	Coal Creek	Morrissey/Carbonado	Corbin Colliery	Hosmer Colliery	Kaiser Resources	Fording Coal	Total
1898	-	11,148	-	-	-	-	-	11,148
1899	438	114,922	-	-	-	-	-	115,498
1900	11,162	220,457	-	-	-	-	-	231,619
1901	52,763	372,114	-	-	-	-	-	424,877
1902	127,515	267,429	46,292	-	-	-	-	441,236
1903	263,589	241,686	155,400	-	-	-	-	660,675
1904	263,486	387,409	91,311	-	-	-	-	742,207
1905	346,646	476,552	108,566	-	-	-	-	931,764
1906	306,317	478,008	22,578	-	No Records	-	-	806,903
1907	396,175	585,517	246	-	No Records	-	-	981,938
1908	461,647	493,924	26,072	4,604	2,942	-	-	989,189
1909	437,318	452,565	36,161	68,123	67,562	-	-	1,061,729
1910	512,491	697,272	-	142,073	177,098	-	-	1,528,934
1911	128,110	231,343	-	91,524	44,127	-	-	495,104
1912	284,325	780,466	-	136,935	210,832	-	-	1,412,558
1913	242,171	924,207	-	81,523	243,631	-	-	1,491,532
1914	225,236	646,575	-	83,229	114,764	-	-	1,069,804
1915	311,499	573,332	-	70,049	-	-	-	954,880
1916	273,413	637,427	-	77,302	-	-	-	988,142
1917	142,380	362,388	-	113,193	-	-	-	617,961
1918	231,181	450,759	-	138,868	-	-	-	820,808
1919	193,612	342,934	-	89,317	-	-	-	625,863
1920	296,343	483,597	-	169,136	-	-	-	949,076
1921	311,697	463,146	-	76,083	-	-	-	850,926
1922	242,668	326,672	-	51,545	-	-	-	620,885
1923	289,440	485,897	-	54,058	-	-	-	829,395
1924	165,541	109,788	-	31,011	-	-	-	306,340
1925	360,119	519,829	-	77,069	-	-	-	957,017
1926	407,450	409,981	-	132,831	-	-	-	950,262
1927	399,500	471,191	-	145,731	-	-	-	1,016,422
1928	402,693	518,261	-	200,752	-	-	-	1,131,706

Year	Michel	Crowsnest Pass Coal Company Coal Creek	Morrissey/Carbonado	Corbin Colliery	Hosmer Colliery	Kaiser Resources	Fording Coal	Total
1929	383,200	421,460	-	188,450	-	-	-	993,110
1930	297,429	235,493	-	239,021	-	-	-	771,943
1931	277,217	175,513	-	288,067	-	-	-	740,797
1932	240,022	104,024	-	314,375	-	-	-	658,421
1933	231,382	60,339	-	243,277	-	-	-	534,998
1934	327,070	102,596	-	273,267	-	-	-	702,933
1935	347,489	97,304	-	11,170	-	-	-	455,963
1936	424,436	102,642	-	-	-	-	-	527,078
1937	389,616	124,617	-	-	-	-	-	514,233
1938	367,732	118,424	-	-	-	-	-	486,156
1939	513,613	115,780	-	-	-	-	-	629,393
1940	730,862	138,839	-	-	-	-	-	869,701
1941	953,389	195,791	-	-	-	-	-	1,149,180
1942	972,250	201,189	-	-	-	-	-	1,173,439
1943	772,264	226,754	-	39,762	-	-	-	1,038,780
1944	728,665	340,952	-	185,528	-	-	-	1,255,145
1945	660,494	313,510	-	-	-	-	-	974,004
1946	649,256	315,640	-	1,294	-	-	-	966,190
1947	848,712	354,349	-	98,856	-	-	-	1,301,917
1948	844,690	293,857	-	150,638	-	-	-	1,289,185
1949	899,677	338,899	-	-	-	-	-	1,238,576
1950	808,696	304,943	-	-	-	-	-	1,138,389
1951	851,458	312,860	-	-	-	-	-	1,249,501
1952	888,856	303,235	-	-	-	-	-	1,197,549
1953	817,076	306,462	-	-	-	-	-	1,236,997
1954	757,373	281,315	-	-	-	-	-	1,169,788
1955	824,623	308,720	-	-	-	-	-	1,164,438
1956	888,952	299,182	-	-	-	-	-	1,302,584
1957	647,330	237,162	-	-	-	-	-	994,635
1958	644,263	16,235	-	-	-	-	-	691,642
1959	569,221	-	-	-	-	-	-	597,540
1960	672,705	-	-	-	-	-	-	672,705

Year	Michel	Crowsnest Pass Coal Company Coal Creek	Morrissey/Carbonado	Corbin Colliery	Hosmer Colliery	Kaiser Resources	Fording Coal	Total
1961	878,064	-	-	-	-	-	-	878,064
1962	823,785	-	-	-	-	-	-	823,785
1963	882,803	-	-	-	-	-	-	882,803
1964	979,235	-	-	-	-	-	-	979,235
1965	923,256	-	-	-	-	-	-	923,256
1966	1,058,679	-	-	-	-	-	-	1,058,679
1967	946,224	-	-	-	-	-	-	946,224
1968	731,419	-	-	-	-	365,710	-	1,097,129
1969	-	-	-	-	-	1,084,940	-	1,084,940
1970	-	-	-	-	-	3,480,631	-	3,480,631
1971	-	-	-	-	-	5,602,000	-	4,602,000
1972	-	-	-	-	-	6,307,285	2,659,418	8,966,703
1973	-	-	-	-	-	7,002,659	3,793,571	10,796,230
1974	-	-	-	248,000	-	7,601,200	2,777,600	10,626,800
1975	-	-	-	427,984	-	8,639,538	3,935,426	13,002,948
	35,540,427	20,257,882	486,626	4,744,644	860,956	40,083,963	13,166,015	115,140,500

* Metric Conversion:- 1 short ton = 0.9072 metric tonnes

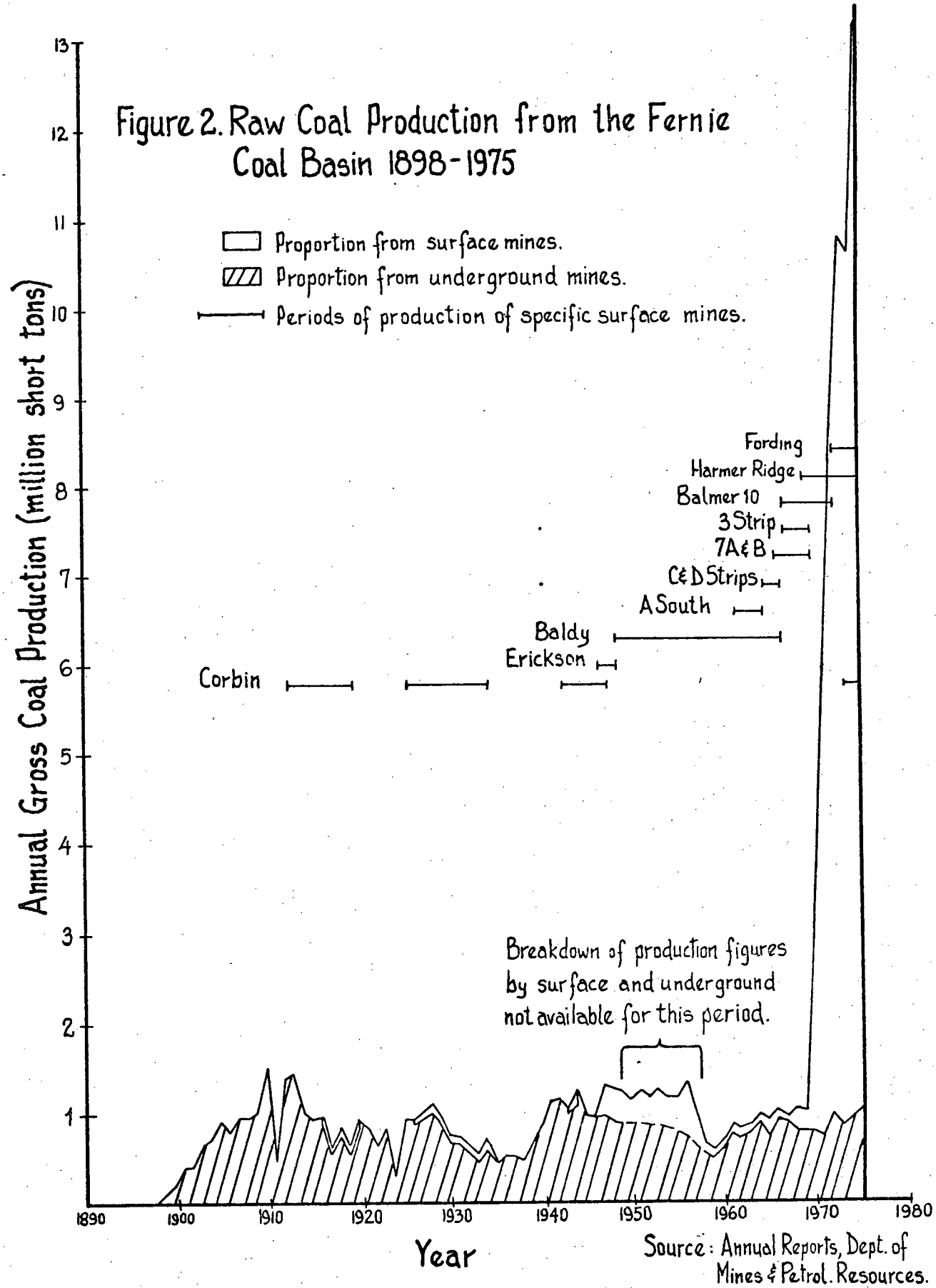


Figure 2. Raw Coal Production from the Fernie Coal Basin 1898-1975

Source: Annual Reports, Dept. of Mines & Petrol. Resources.

in the mid 1920's because of the conversion of Great Northern Railway locomotives to oil, through the 1930's because of the Great Depression, and from 1958 to 1961 during a minor world recession. Maximum production periods, between 1915 and 1968, occurred in the late 1920's and from 1941 to 1956.

From 1962 onwards, increasing demands for metallurgical coal generated renewed interest in coal exploration in the Fernie and upper Elk Coal Basins. This intensive exploration resulted in the opening of the Kaiser Resources Ltd. mine in 1969, and the Fording Coal Ltd. mine in 1972. Raw coal production has increased from 1,084,940 short tons in 1969 to 13,002,948 short tons in 1975. The statistic that best illustrates the magnitude of this dramatic increase is that 47 per cent of all the coal produced from the East Kootenay has been mined since 1969.

Four new mines are currently being proposed for the area: open pit mines on Cabin Creek in the Flathead Valley by Rio Tinto Mines Ltd.; on Line Creek by Crowsnest Industries Ltd.; and in the upper Elk Valley by Elko Mining Ltd., a Canadian company owned by a consortium of European steel mills; and an underground hydraulic mine on Hosmer and Wheeler Ridges by Kaiser Resources Ltd.

No history of mining in the area would be complete without a brief mention of the disasters, both natural and

man caused, that have plagued the area since the early years of settlement. In 1908 a bush fire blazed out of control and completely destroyed the town of Fernie, leaving at least 13 people dead and more than 3,000 homeless. Mine disasters have occurred with depressing frequency through the years: May 22, 1902 - 128 men killed in the Coal Creek Number 2 Colliery; October 14, 1903 - 4 killed at Morrissey; November 18, 1904 - 14 killed at Morrissey; January 8, 1904 - 7 killed at Michel; August 8, 1916 - 12 killed at Morrissey. The latest of many deadly explosions occurred on April 3, 1967 in the Balmer North Mine at Michel leaving 15 men dead and 40 seriously injured.

Quite apart from the disasters, the mines of the Crowsnest have taken the lives and the health of men through relentless, grinding attrition. Whether true or not, it is commonly believed by the residents of the area that a death or serious injury has occurred for each day that the mines have operated. The unsavory reputation of underground coal mining seriously affects the recuitment of personnel, even to relatively safe techniques such as hydraulic mining, and makes surface mining far more acceptable to the local resident than to the more environmentally conscious urban dweller.

3.3 Land Tenure

Kaiser Resources Ltd. has acquired either the coal rights, or the option to explore on three types of land in the Crowsnest area:

(1) Land owned in fee by Crowsnest Industries Ltd.

Between 1889 and 1903, 249,034.15 acres (100,858.83 ha.) of land were alienated to become, eventually, the property of the Crowsnest Pass Coal Company. This land was acquired in the form of crown grants and as "subsidy lands" under the *Railway Aid Act of 1890*. A historical outline of these acquisitions is as follows:

(a) Freehold Lands (Crown grants)

Year	Description	Area Acres	Area Hectares
1889	The British Columbia Government crown granted to E. Bray and others lots 81 to 86, Group 1, Kootenay District. These lots were located on Martin Creek. In the same year E. Bray *et al* deeded these lots to the Crowsnest Coal and Mineral Company.	2,409	975.6
1890	The British Columbia Government crown granted to the Crowsnest Coal and Minteral Co. lots 151 to 157, Group 1, Kootenay	7,800	3159

Year	Description	Area Acres	Hectares
	District on Martin and Michel Creeks; and lots 158 to 171, Group 1, Kootenay District on Coal Creek and Morrissey Ridge.		
1893	Crowsnest Coal and Mineral Co. conveys these 26 lots to the B.C. Coal, Petroleum and Mineral Co.		
1897	B.C. Coal, Petroleum and Mineral Co. deeded lands to the Kootenay Coal Co.		
1897	Corporate name of the Kootenay Co. changed to the Crowsnest Pass Coal Company Ltd.		
	TOTAL	10,209.00	
			4134.6

(b) Subsidy Lands (Railway Act grants)

Year	Description	Area Acres	Hectares
1888	E. Bray and others were incorporated as the Crowsnest and Kootenay Lake Railway. This company was granted a right of way in the Crowsnest Pass 99 feet (30 m) wide, plus such lands as were necessary for station, siding and terminal purposes.		

Year	Description	Area Acres	Area Hectares
1890	Railway Aid Act of 1890 granted the company 20,000 acres (8100 ha.) per mile of rail constructed, with a 20 mile (32 km.) frontage on the right of way.		
1891	Company changed its name to the British Columbia Southern Railway Co. Controlling interest in this company ultimately becomes the same as that in the Kootenay Coal Co.		
1897	Federal government granted a charter to the C.P.R. for construction of a railroad through the Crowsnest Pass at a subsidy of $11,000.00 per mile, and with the condition that, if the C.P.R. obtained land either through agreement with another company or with the British Columbia government, 50,000 acres (20,250 ha.) would be retained by the Federal Crown.		
1897	An agreement between the C.P.R., the B.C. Southern Railway, and the Kootenay Coal Company resulted in		

Year	Description	Area Acres	Area Hectares
	the following dispositions of land by the B.C. Southern Railway: ± 250,000 acres (101,250 ha.) to the Crowsnest Pass Coal Company, and 3480 acres (1410 ha.) to the C.P.R. In order to comply with the terms of the C.P.R. charter 50,000 acres (20,250 ha.) were conveyed by the B.C.S.R. to the Federal Crown. The lots that were deeded to the Coal Company were lots 4588 and 4589, Group 1, Kootenay District. However, the C.P.R. lands and 5,000 acres (2025 ha.) of the Federal Crown lands were contained within these lots. To compensate for this the B.C.S.R. conveyed a further 10,000 acres (4050 ha.) on Lodgepole Ridge to the Coal Company. These lands have subsequently been known as the "Deficiency Block".	227,838.95	92274.73
		10,000	4050
1900	The Fernie townsite block was conveyed to the Coal Company by the B.C.S.R. to "facilitate the former's business".	614.7	249.0

Year	Description	Area Acres	Hectares
1903	The Morrissey townsite block was conveyed under the same terms as the Fernie townsite.	371.5	150.5
	TOTAL	238,825.15	96724.18

Thus, by the end of 1903 the Crowsnest Pass Coal Company had acquired the following lands as a result of statutes, agreements and freehold grants:

		Acres	Hectares
1.	Crown grants	10,209.00	4134.60
2.	Railway Act grants from B.C.S.R.	227,838.95	92274.73
3.	Deficiency block	10,000.00	4050.00
4.	Fernie townsite	614.70	249.00
5.	Morrissey townsite	371.50	150.50
		249,034.15	100,858.87

The extent of these holdings is shown in Map 1f. Since 1903, parcels of Company land have been sold around Fernie, Natal, Cokato (south of Fernie), Michel, and Michel Prairie, primarily for residential and agricultural purposes. The total area disposed of in this way, mainly through the Crowsnest Pass Electric Light and Power Co. Ltd., was approximately 3900 acres (1580 ha.), leaving the Company with holdings

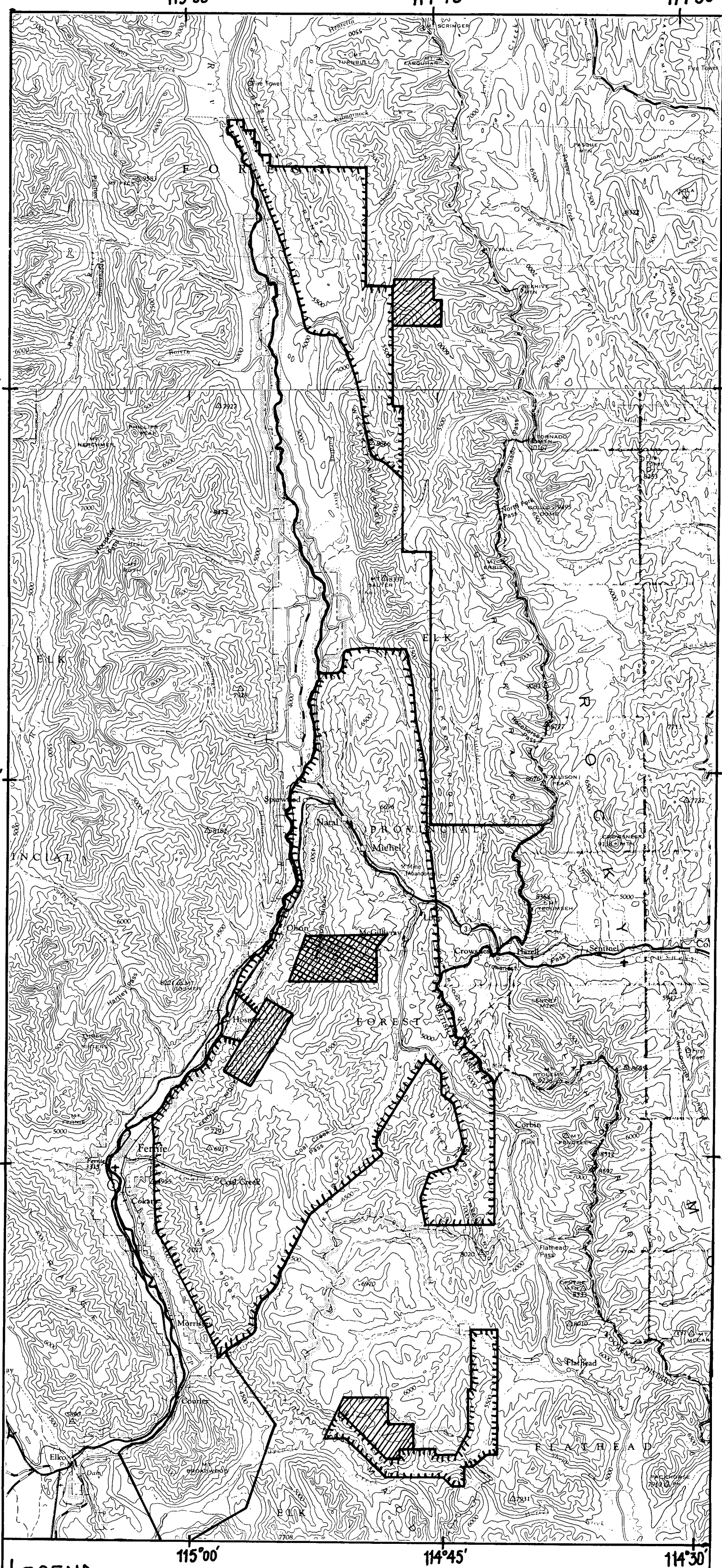
of about 245,135 acres (99,280 ha.) in the mid-sixties when the name of the corporation was changed to Crowsnest Industries Ltd. Of this total, approximately 110,000 acres (44,550 ha.) are coal-bearing. (See Map 1f). In 1967, Kaiser Resources Ltd. took option on the coal rights to a selected 68,000 acres (27,540 ha.) of these coal bearing lands. Under the terms of the agreement, K.R.L. committed itself to making this selection by 1976. Map 1f shows the boundary of the coal lands presently being investigated by the Company.

(2) Dominion Government Coal Lands

Kaiser Resources Ltd. has acquired, through negotiation with the federal government, prospecting rights over 5,000 acres (2,025 ha.) of the coal lands deeded to the federal crown in 1897. This area is located on Sparwood Ridge between Olsen and McGillivray. (See Map 1f).

(3) Coal Licences

Coal licences are granted by the provincial government under the provisions of the *Coal Act 1974*. The licencee is given the rights to explore for and develop coal properties, but not given surface rights or permission to mine coal except in those quantities required for the purpose of testing. K.R.L. has acquired licences in three areas shown on Map 1f; near the confluence of Ewen and Todhunter Creeks (4 licences), adjacent to the Deficiency Block on Lodgepole Creek, and west of Hosmer. This latter area is the 3480 acre (1,410 ha.) coal block conveyed to the



LEGEND

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KAISER RESOURCES LTD. PROPERTY STATUS

- Crows Nest Industries Ltd. Crown-granted lands.
- Portion of C.N.I. Ltd. lands under K.R.L. option.
- Provincial Government coal licences.
- Dominion (Federal) Government Coal Block.

MAP 1.f.

Source :- N.T.S. 82G & J.

Canadian Pacific Railway in 1897, and was the site of their Hosmer coal operation from 1906 to 1914. Upon termination of active mining, the railway let the parcel revert to the Province.

3.4 Nature and Extent of Mining Operations

3.4.1 A Glossary of Coal Mining Terms

These terms are used in the following sections of this thesis and a brief definition is included here for the benefit of those readers unfamiliar with coal mining.

Adit - A small shaft or tunnel driven during exploration operations to obtain large-volume coal samples for the testing of chemical and physical properties.

Angle of Repose - Physical - The greatest angle to the horizontal that any loose or friable solid material will stand without sliding; Biological - The slope angle above which surface soil movement prevents the establishment of an effective vegetation cover.

Anticline - A fold or fold system in rock strata in the form of an arc.

Area Mining - Strip mining that is carried out, usually using dragline equipment, in level to gently rolling topography on relatively large tracts.

Aspect - The direction towards which a slope faces. Exposure.

Backfill - The operation of refilling an excavation.

Bank - A mound of preparation plant coarse refuse.

Bench - The surface of a level, excavated area on which equipment can move or operate. A working road or base below a highwall as in contour mining for coal.

Bench Mining - A type of strip mining used to recover coal lying in beds parallel to the surface on moderate to steeply sloping ground. The overburden is removed in a series of benches constructed parallel to the strike of the seam. (See Figures 5, 6 and 7).

Berm - A pile of coarse material placed along the outside edge of a bench either to control water flow or for equipment safety. A pile of coarse material placed along the bottom of a spoil dump or a waste bank either to control runoff or to stabilize the material.

Breaker - A machine that crushes the mined coal to a specified size prior to its passage through the preparation plant.

Contour Mining - See outcrop mining.

Dip - The angle that an inclined coal seam makes with the horizontal. (See also "strike")

Disturbed Land - Land on which excavation has occurred or upon which overburden has been deposited.

Dragline - An excavating machine that utilizes a bucket operated and suspended by means of two lines or cables; one of which hoists or lowers the bucket from a boom; the other, from which the name is derived, allows the bucket to swing out or to be dragged toward the machine for loading.

Footwall - The surface left after the removal of the coal, and formed by the rock stratum which lays directly beneath the coal seam.

Haul Road - Road from the pit to a tipple, overburden dump or the preparation plant used for transporting mined material by truck.

Highwall - The unexcavated face of exposed overburden and coal on the uphill side of an outcrop or contour mine excavation.

Outcrop - Coal which appears at or near the surface; the intersection of a coal seam with the surface.

Outcrop Mining - The surface mining of a coal seam that outcrops or approaches the surface at approximately the same elevation in steep or mountainous country. (See Figures 3 and 4)

Outslope - The exposed area sloping away from a bench cut section.

Overburden - The earth, rock and other materials which lie above the coal.

Overburden Dump - An area on which overburden and other excavated spoil is deposited, usually by downhill dumping in surface mines on mountainous terrain.

Oxidized Coal - Coal at the outcrop of a seam or near the surface. It has lost its coking properties due to partial oxidation but may be used for thermal generation.

Preparation Plant - A plant complex in which the raw coal is cleaned to the required grade (usually by the removal of impurities such as rock, carbonaceous shales and high-ash coals) and dried to a specified moisture content.

Refuse - The solid waste generated from a preparation plant. Usually composed of a coarse fraction disposed of by trucks and dumped in banks, and a fine fraction (tailings) disposed of hydraulically into settling lagoons.

Scalping - The removal of vegetation and organic soil horizons prior to mining and overburden dumping.

Seam - A stratum or bed of coal.

Seam Crosscut - An exploration technique used in areas of multiple coal seams. Excavations are made perpendicular to and joining one or more seam traces to locate the position of intermediate coal seams.

Seam Trenching or Seam Tracing - An exploration technique in which a dozer is used to locate a coal seam by excavating the outcrop. In areas of multiple coal seams only the main seams are trenched and the others are located by cross-cutting.

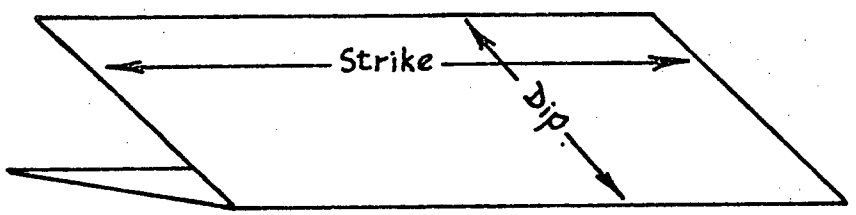
Slope Stability - Macro - The resistance of any inclined surface to failure by sliding or collapsing; Micro - the resistance of materials on the surface of a slope to movement by either the force of gravity or overland waterflow.

Spoil - The overburden or non-coal material removed in gaining access to the coal seam in surface mining.

Spoil Dump - See overburden dump.

Strip Mining - Refers to a procedure of mining which entails the complete removal of all material from over the product to be mined in a series of rows or strips, i.e. area and bench mining are two specific types of strip mine.

Strike - The direction in which a horizontal line can be drawn on a coal or rock stratum. Used to describe the general trend or run of coal seams, i.e., in the East Kootenay the general strike is north-south. The following diagram shows the distinction between strike and dip.



Stripping Ratio - The unit amount of overburden that must be removed to gain access to a similar unit amount of coal.

Subsidence - The surface depression over an underground mine that has been created by subsurface caving.

Surface Mining - A mining method whereby the overlying materials are removed to expose the coal for extraction, i.e. strip and contour mines are two specific types of surface mines.

Syncline - A fold of rock strata that is convex downwards.

Tailings - Fine refuse from a milling operation that is usually deposted from a water medium.

Tailings Lagoon or Empoundment - A dyked or dammed area to which a tailings slurry is transported. The solid tailings settle out and the water is decanted to be used again in the milling process.

Test Pit - A small open pit excavated during exploration operations for the collection of bulk coal samples for testing.

Tipple - The place where coal is off-loaded from a haul-vehicle, usually at the preparation plant.

Waste - See refuse.

3.4.2 Surface Mining

Surface coal mining began in the Natal area in 1947 with the opening of the Erickson Pit on the south end of Natal Ridge. Between 1947 and 1969 Crowsnest Industries Ltd. operated ten small surface mines, some of which were continued for a short time by Kaiser Resources Ltd. after its purchase of the properties. Production from these mines was highly variable and ranged between 10 and 25 per cent of annual production during the years in which they operated. Because of the limitations imposed by the size of equipment at that time, most of these surface mines were of the "contour" type. In this mining method the excavation of coal commences where the coal "outcrops" on a hillside, and continues into the hill until the stripping

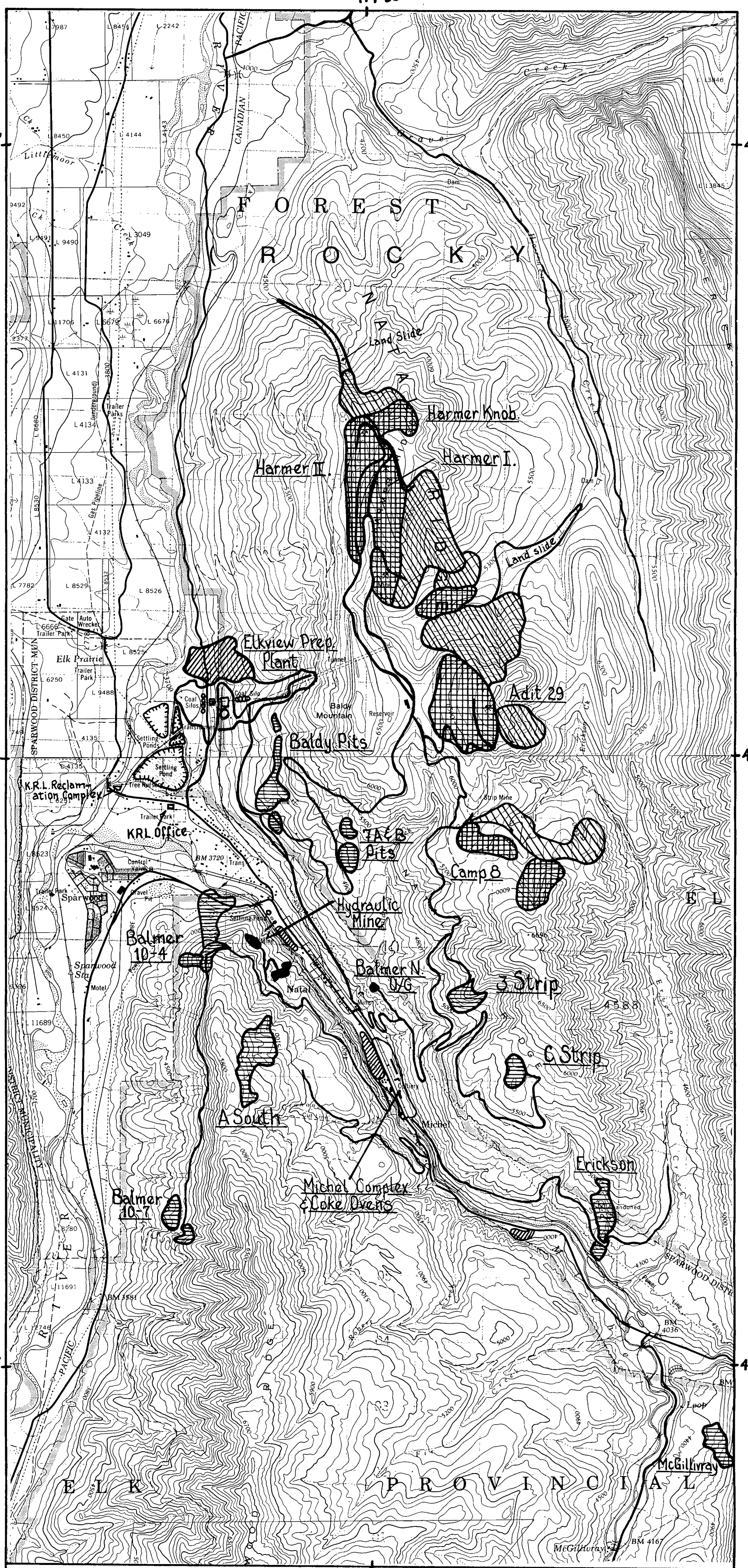
ratio becomes so large as to make further mining unprofitable. Waste materials are carried to the lip of the bench and dumped downhill. In some cases large horizontal augers are used to recover further coal from the unexcavated portion of the seam. A schematic cross section of a completed outcrop mine is shown in Figure 3 and a photographic example in Figure 4. Details of the ten outcrop pits are shown in Table 7, and their location is shown in Map 2e.

Highwall slopes vary from 35 to 45 degrees depending on the following factors:

1. height of wall
2. type of rock composing the wall
3. presence of seepage water
4. orientation of wall slope relative to the dip of the rock strata

The working bench is covered with varying amounts of spoil material and usually heavily compacted due to the action of mining equipment.

Waste dumps from contour mines seldom exceed a slope distance of 60 metres, and dump profiles depend, to a large extent, on the topography of the original ground surface. In moderately sloping topography, spoils are usually deposited in a series of gently rolling mounds. In steeply sloping topography where dumping has occurred downhill from the lip of the working bench, dumps usually form a continuous



LEGEND

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LOCATION OF MINING AND MILLING OPERATIONS.

- Contour Mines.
- Tailings Lagoon.
- Bench mine pit.
- Coarse Refuse Banks.
- Underground mine portal.
- Bench mine overburden dump.

MAP 2.e.

Source:- N.T.S. 82-10 & 15

Table 7

Details of the Outcrop Surface Mines in the Natal Vicinity

	Area (ha.)		Aspect	Elevation Range (m)	Period of Operation	Raw Coal - Production (Short Tons)†
Erickson	16.5	Natal Ridge	SW	1250 - 1465	1947-1949	+ 700,000
Baldy Pits	56.5	Harmer Ridge	W	1370-1525	1949-1967	1,502,950
A South	22.5	Sparwood Ridge	NE	1520-1700	1962-1965	365,037
C & D Pits	9.5	Natal Ridge	SW	1680-1740	1965-1967	64,550
7 A & B Pits	17.5	Harmer Ridge	S	1525-1650	1966-1970	495,840
3 Pit	14.0	Natal Ridge	SW	1525-1680	1967-1970	204,430
Balmer 10-4	35.0*	Sparwood Ridge	NW	1280-1495	1967-1969	No Figures Available
Balmer 10-7	7.0	Sparwood Ridge	W	1370-1465	1969-1973	No Figures Available
McGillivray	10.5	McGillivray Ridge	W	1370-1495	1969-1970	58,770
TOTAL	189.0					

*Includes 14 hectares of slide area.

†From Annual Reports of the Department of Mines and Petroleum Resources. Production records incomplete for the years 1969-1973.

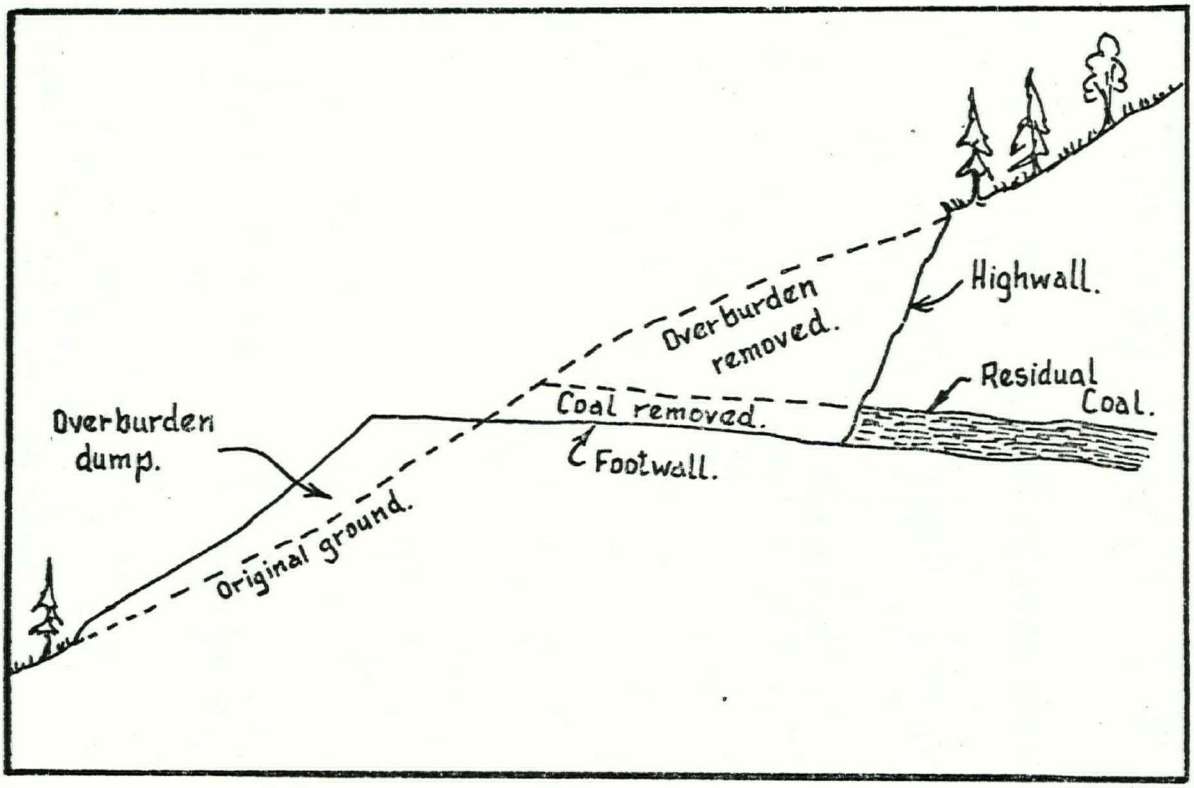


Figure 3. A schematic cross-section of an outcrop coal mine.

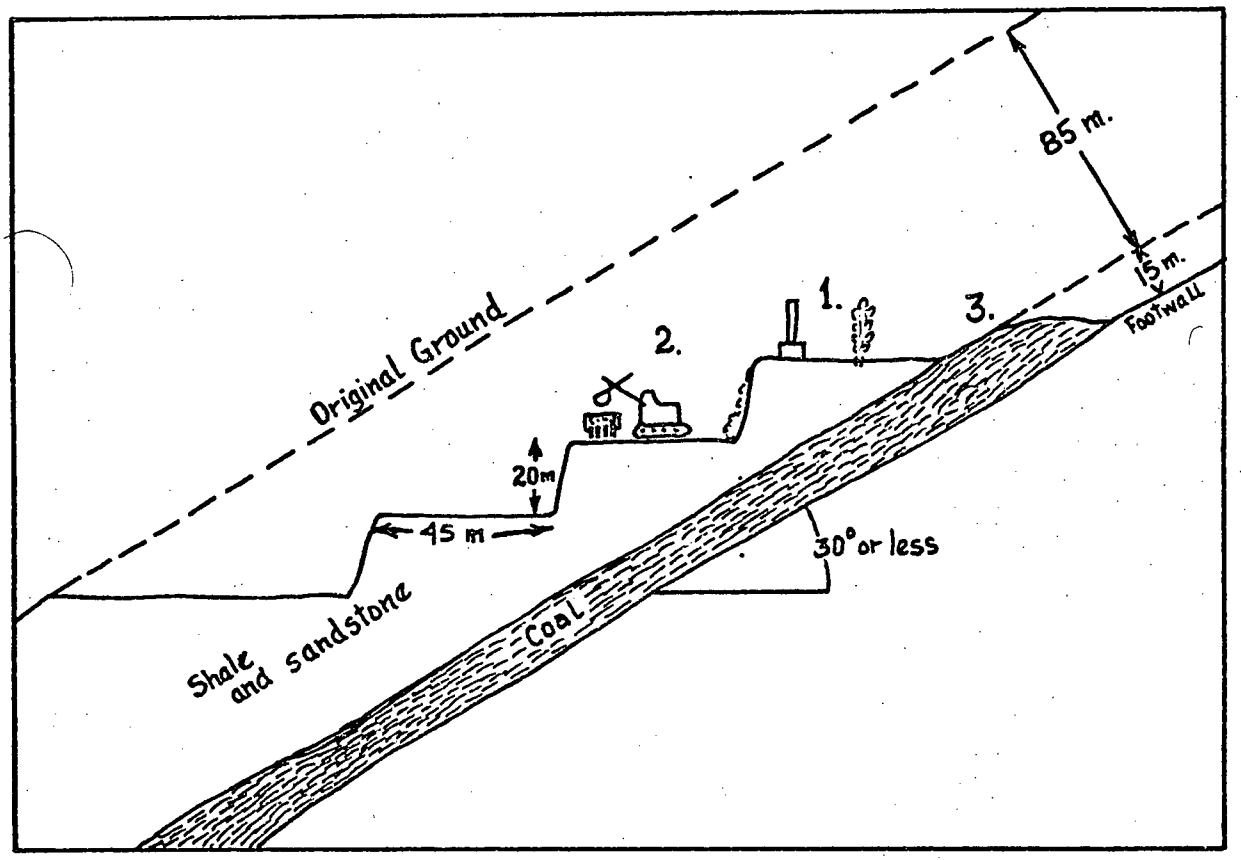
Figure 4. 3-Pit, Natal Ridge. An example of an outcrop mine.

concave slope with slope angles of 35°+ in the upper section, 25-35° in the middle sections, and gradually levelling to the original surface slope in the lower section. Because of gravitational sorting during dumping, the top of the dump is generally composed of fine material, and the spoil gets progressively coarser in the lower portions. An "apron" of large rocks usually forms at the toe of the dump.

Spoil samples have been collected from six of these older surface mines and analyzed at the Soils Laboratory, B.C. Department of Agriculture, Kelowna. The results of these analyses are shown in Table 8.

Large scale surface mining began in 1969 with the development of the Harmer, Dry Creek, Adit 29 and Camp 8 pits on Harmer Ridge (see Map 2e). The mining method used in these pits, known as the "bench" or "terrace" method (Dubnie, 1972), differs substantially from the earlier outcrop technique (see Figures 5, 6, and 7). The coal seam on Harmer Ridge is approximately 15 m. thick, and consists of a synclinal fold dipping at between 20° and 35°. The dip of the coal is approximately parallel to the surface and thus the overburden thickness is relatively constant, averaging approximately 85 m. Mining starts at the highest point of the pit and the overburden is removed in benches 45 m. wide and at 20 m. intervals. The overburden

FIGURE 5



Coal mining by the bench method on Harmer II (After Dubnie 1972)

1. Overburden drilled and blasted.
2. Shattered overburden excavated by shovel & trucked to dump.
3. Coal dug and loaded by front-end loader.

Figure 6. Harmer I and II Pits. Bench mining.

Figure 7. Adit 29. Bench mining.

is shattered by blasting, excavated by 25 cubic yard (19 m^3) shovels, and transported by 200 ton trucks beyond the pit limits for disposal. The overall overburden-to-coal ratio is 5 bank cubic yards (3.8 m^3) of rock to 1 short ton of coal or, on a tonnage basis, 11:1. Over the short term the annual development ratio is approximately 6.7 bank cubic yards*(5.1 m^3) to one ton of coal. This means that, until 1981, approximately 40 million bank cubic yards (30.6 million m^3) of spoil must be removed each year to achieve the annual production rate of 6 million short tons of raw coal (Livingstone, 1975).

As coal is uncovered on each bench by the shovels, bulldozers are used to push the remaining overburden from the surface of the seam. These dozers work parallel to the strike of the seam and have blades that are fitted with hydraulic slopers that allow the operator to vary the angle of the blade according to the dip of the coal. These same dozers are used eventually to clean the coal off the footwall. The coal is mined with front-end loaders and hauled in 100 ton trucks to a central breaker station where it is reduced in size to pieces 10 cm. in diameter or less before being transported by belt conveyor through a 4,390 m. tunnel to the raw coal silos of the preparation plant.

A variation of this mining technique was employed between 1970 and 1973 on the Harmer I pit. Shovels were

*A bank cubic yard refers to excavated material and accounts for the increase in volume due to excavation.

Table 8

Analysis* Of Spoils From Six Outcrop Mines

Mine Site		Soil Texture	O.M. Per Cent	pH	Soluble Salts (Mmhos/cm)	Available Nutrients (p.p.m.) P	K	Ca	Mg
Baldy Pit	1	Coal/shale	-	7.0	0.19	4	64	2250	300+
	2	Coal/shale	-	6.3	0.18	32	182	2100	300+
C & D Pits	1	Loam	15.0	5.8	0.16	134+	305	1000	102
	2	Loam	3.1	5.5	0.13	134+	261	600	100
	3	Loam	4.2	6.2	0.14	134+	215	400	94
7A & 7B Pits	1	Coal/shale	-	6.9	1.20	9	54	1000	270
	2	Loam	11.3	6.5	0.45	8	95	1900	300+
3 Pit	1	Loam	8.0	6.2	0.22	134+	368	1200	250
	2	Loam	20.0	6.8	0.35	9	95	2250	300+
	3	Loam	7.2	6.0	0.17	134+	178	750	134
	4	Silt loam	9.0	6.0	0.18	92	195	1350	190
Balmer 10-4	1	Sandy clay	9.0	7.6	0.42	42	130	1650	300
	2	Sandy clay	14.0	6.6	0.25	53	116	1200	246
Balmer 10-7	1	Sandy clay	3.1	6.1	0.10	134	289	850	135
	2	Clay loam	2.6	6.1	0.13	65	325	1500	250

* Analysis by the B.C. Department of Agriculture, Soils Laboratory, Kelowna.
For a description of analytical methods see Appendix VII.

used to construct working benches, and a 54 cubic yard (41 m^3) mobile dragline was then used to uncover the coal seam. The overburden thus removed was dumped on the excavated footwall immediately above the working bench. This method proved to be uneconomic and the dragline was not used after the Harmer I pit was completed.

The slope of the footwall will differ between pits depending upon the dip of the coal seam, and the footwalls will receive varying amounts of spoil. On Harmer I, where the dragline was used, the entire footwall is covered with loose material, while on the shovel pits only those areas level enough to permit access by truck will receive spoil. This will determine, to a great extent, the area of pit that can eventually be reclaimed.

Spoil is trucked from the pit area along haul roads that leave the pits at, or slightly below, the level of each working bench. Each successive dumping platform will traverse the existing dump slope to create, ultimately, a spoil dump terraced at approximately 20 m. intervals. Overburden from the Harmer II pit is currently being placed on the Harmer I footwall and, to date, two spoil terraces have been constructed. The only exceptions to this general spoil disposal system are the dumps at Harmer Knob and Camp 8, and the extreme north-eastern portion of the Harmer I dumps. In the case of Harmer Knob, spoil was tipped down the north face of Harmer Ridge

from three dumping platforms at 27 m. vertical intervals. This has resulted in three contiguous dumps with unbroken slopes of 230, 260 and 290 metre slope lengths respectively. Profiles of these three dumps are shown in Figures 8 a, b, and c. The Camp 8 mine comprises two adjacent pits and the spoil from both is transported along a haul road to the dumping area a few hundred yards away (see Figure 9b). This dump is being constructed by downhill tipping from a single dump platform and therefore will not be terraced. Since this dump is still active a profile has not yet been prepared for it, however, the ultimate configuration will be similar to that of the longest Harmer Knob dump. The original intention was to construct the Harmer I dump system in a series of terraces, however, the spoil would not stand at the angle anticipated and, therefore, the material available from the Harmer I pit was insufficient for terracing. Present plans are to use material from the lower levels of the Harmer II pit for terrace construction, however, it is unlikely that spoil will be available in sufficient quantities to allow terracing of the entire dump system. The north-eastern portion of these dumps is likely to retain a profile similar to the largest dump on Harmer Knob (see Figure 9a).

Very little attention was paid during the first six years of mining development either to dump stability or

Figures 8a,b&c. Profiles of three Harmer Knob overburden dumps.

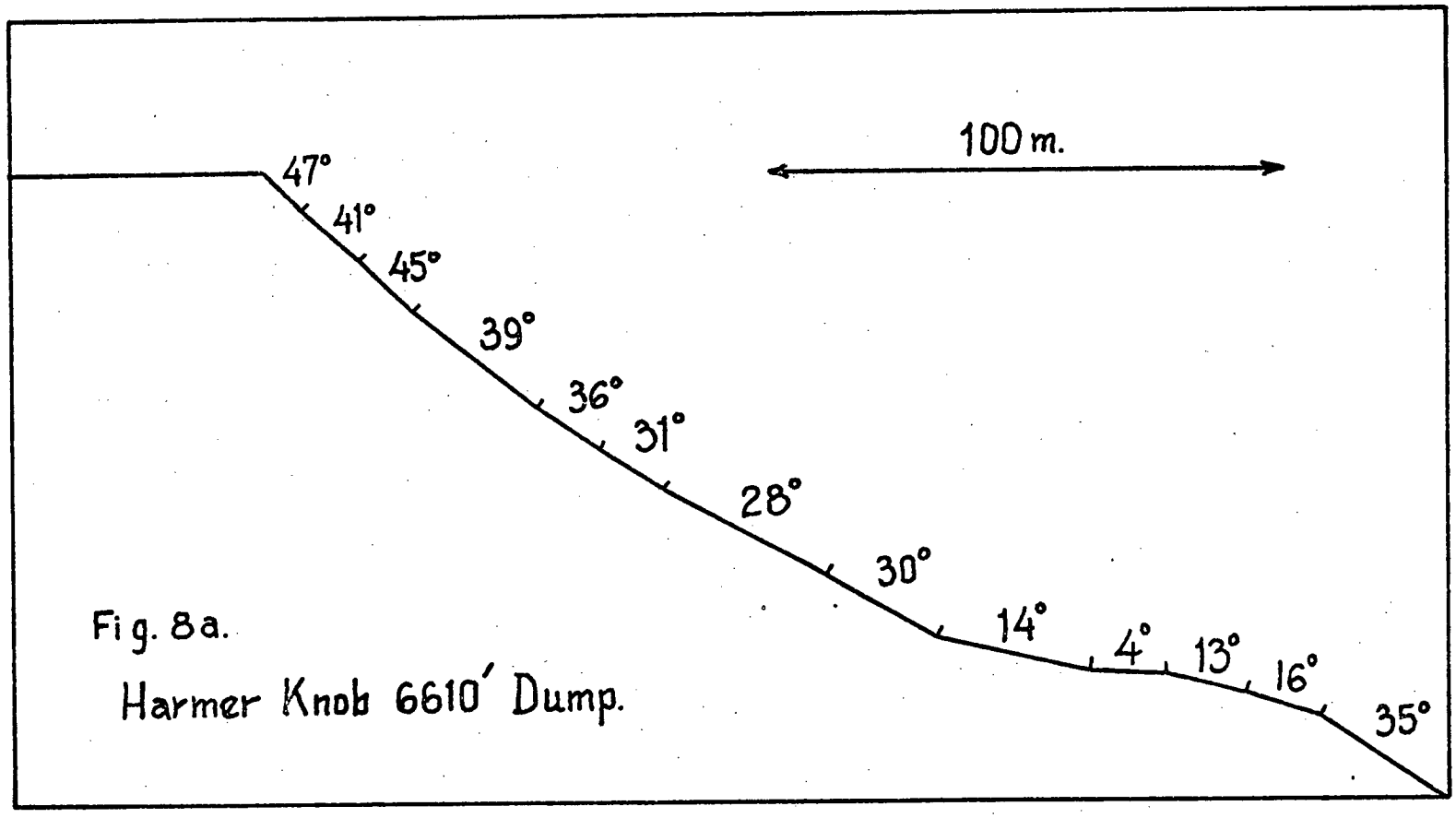


Fig. 8a.

Harmer Knob 6610′ Dump.

Figures 8a,b&c. Profiles of three Harmer Knob overburden dumps.

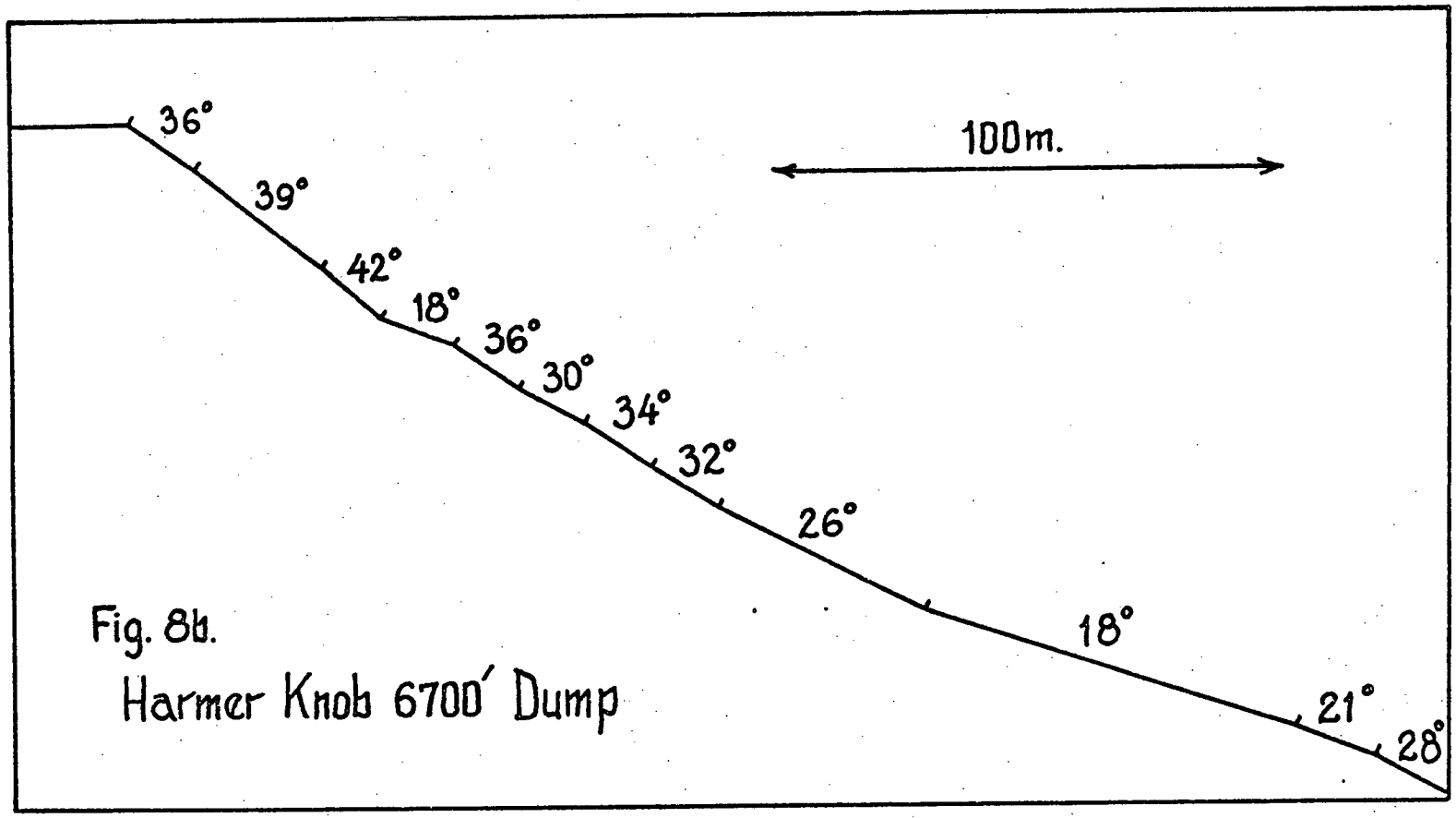


Fig. 8b.
Harmer Knob 6700′ Dump

Figures 8a,b&c. Profiles of three Harmer Knob Overburden dumps.

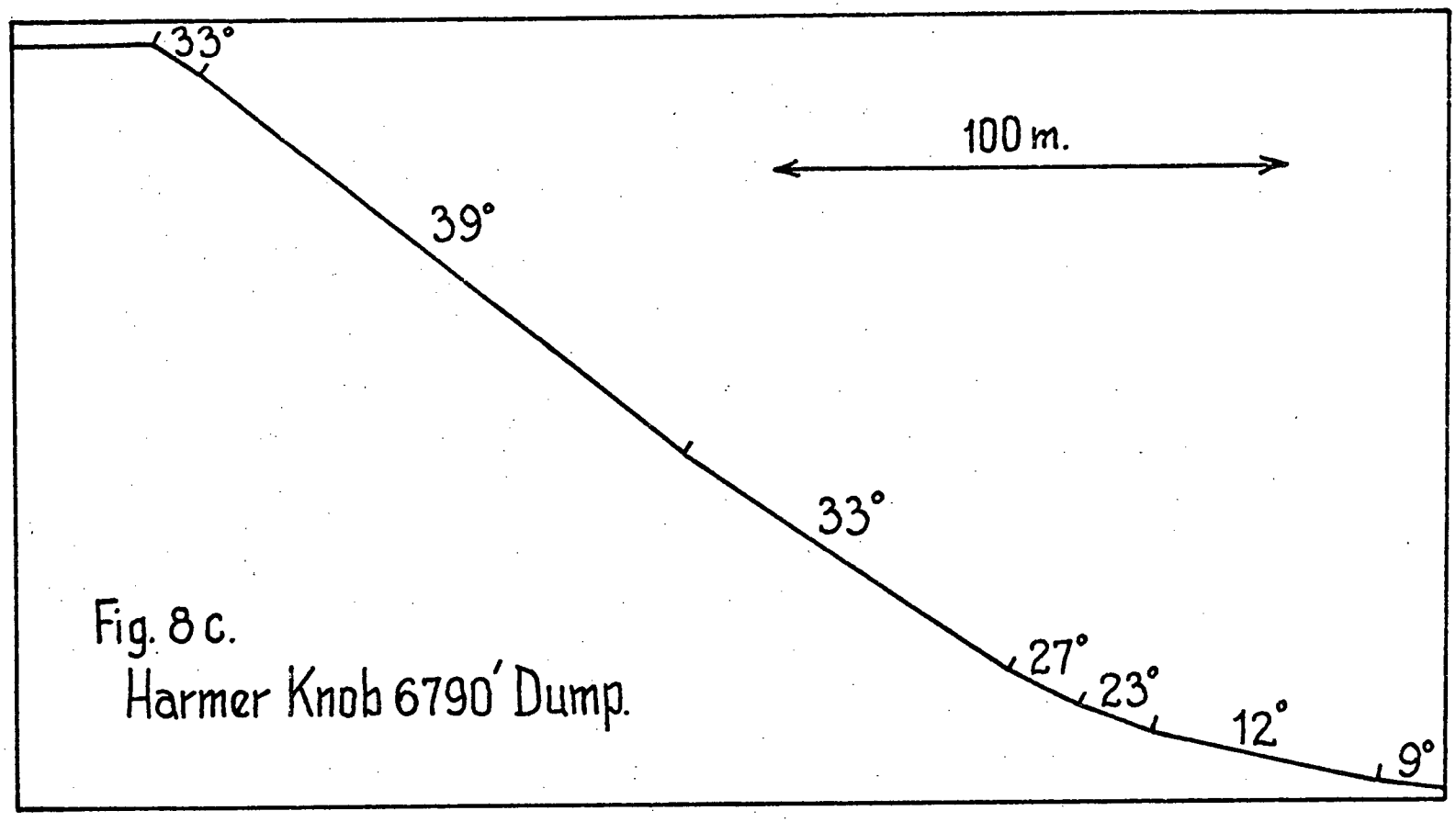


Fig. 8 c.
Harmer Knob 6790′ Dump.

Figure 9. Aerial views of the main Harmer Ridge overburden dumps.

a. Harmer I and II Dumps.

b. Camp 8 Dumps.

Figure 9. Cont'd.

c. Adit 29 Dumps.

to ultimate reclamation. During this period there were no investigations undertaken to determine the suitability of original surficial materials as foundations for spoil dumps, and as a result at least eight major earth failures have occurred (see Figures 9 a, b, and c); two resulting in deaths, and at least one other in a serious injury. These dump failures, and some preliminary experimentation to determine the costs of resloping the Harmer Knob dumps, appear to have led to a re-evaluation of dumping procedures. During the next three-year planning period, from 1976-1978 inclusive, the company intends to undertake a research and planning study on dump stability, and to carry out the following operations to enhance eventual reclamation:

1. Wherever possible, to back-fill dormant pits.
2. To construct all future dumps in a series of "wrap-around" terraces.
3. Each terrace will be resloped prior to the construction of the next lower terrace. This will lead to added stability through unweighting the crest and loading the toe of the dump, and will greatly reduce the amount of resloping required prior to reclamation.

The location of the various pits and dump systems on Harmer Ridge are shown on Map 2e. Details of the various mining features are shown in Table 9, and chemical analyses of spoil materials appear in Table 10.

3.4.3 Underground Mining

The underground mines of the Michel Colliery are the only coal operations in the province to have been worked continuously from the end of the last century. Production from the colliery has been in excess of 41 million tons from 1899 to the present. A total of six conventional underground mines have operated at Michel employing room and pillar, modified longwall, and caving techniques. Only one of these mines was in operation at the time that Kaiser Resources Ltd. obtained the coal properties of Crowsnest Industries Ltd. This mine, known as the Balmer North, commenced operations in the late 1950's and has used the room and pillar method to exploit a coal seam that averages approximately 3.5 m. in thickness. The only surface facilities directly associated with this mine are the portal and loading area, the coal conveyor and tipple, and the ventilation fans. The locations of these facilities are shown on Map 2e, and Table 11 shows the total surface disturbance from this mine to the end of 1975. Indications are that this operation will be gradually phased-out over the next few years, and that subsequently all underground

Table 9

Area, Elevations and Aspects of the Areas of Mining Disturbance on Harmer Ridge to the End of 1975

Name of Feature	Area (ha.) Mined	Spoiled	Other	Total	Elevation Range (Metres)	Aspect
Harmer Knob	18	23	-	41	1770 - 2105	N
Harmer I and II	168	130	-	298	1615 - 2045	NE & SW
Dry Creek	14	13	-	27	1555 - 1650	NE
Adit 29	136	131	-	267	1650 - 2045	Pit-SW, Dump NE&SE
Camp 8	43	64	-	107	1680 - 1860	NE
Dragline Pad	-	-	8	8	2045	Level
Coal Stockpiles	-	-	6	6	1740	N/A
Adit 29 Slide	-	-	30	30	1465 - 1650	NE
Harmer Knob Slide	-	-	6	6	*	NNW
Haul Roads +	-	-	61	61	1680 - 1860	N/A
Total	379	361	111	851		

N.B.: All areas are planimetric and do not account for slope distances.

* Spoil from this slide reached the Elk River in the form of mudflows via a narrow stream course.

\+ Includes only those roads beyond the Harmer Maintenance Complex which run over otherwise undisturbed land.

Table 10

Analysis of Spoil Materials from Harmer Ridge Surface Mines

Area and Sample*		Soil Texture	O.M. Per Cent	pH	Soluble Salts (Mmhos/cm)	Available Nutrients (p.p.m.) P	K	Ca	Mg
Harmer Complex	1	Sandy clay	2.2	5.1	0.13	110	150	200	41
	2	Silt loam	7.4	5.0	0.10	134-	182	300	66
	3	Loam	2.8	5.3	0.11	134-	200	200	65
	4	Silt loam	4.0	5.8	0.24	42	50	800	180
	5	Clay	2.3	5.9	0.12	22	87	950	300
Dry Creek	1	Loam	3.7	5.7	0.16	134-	150	300	41
	2	Clay	17.0	5.5	0.14	36	70	1450	195
	3	Clay	14.0	5.7	0.18	33	64	2350	212
Adit 29	1	Loam	5.2	5.7	0.16	83	60	1050	175
	2	Silt loam	4.0	6.4	0.17	129	92	1200	300+
	3	Silt loam	4.8	5.8	0.26	80		850	300+
Camp 8	1	Loam	2.6	5.3	0.12	134	70	250	52
	2	Loam	11.0	6.6	0.21	41	83	1600	300+

* Analysis by B.C. Department of Agriculture, Soils Laboratory, Kelowna. For a description of analytical methods see Appendix VII.

production will be by hydraulic mining.

The most recent underground operation at Michel is the Hydraulic Mine located on the southern side of Michel Creek opposite the northern boundary of the Natal townsite (see Map 2e). Hydraulic mining is a technique developed in Japan and modified under licence by Kaiser Resources Ltd. to exploit mountain coal seams. This method is presently being suggested as an alternative to surface mining in the Rocky Mountain coal belt because it approaches the coal recovery rate of surface methods with comparable production costs and much lower levels of environmental disturbance. It is, therefore, of value to include here a brief description of the technique, a discussion of the conditions under which it can be used, and its advantages and disadvantages. Much of the material in the following sections has been taken from a publication by Grimley (1974).

Basically the method employs a stream of water under very high pressure directed by a nozzle or monitor onto the coal seam. The water cuts the coal and conveys it into a loading and sizing machine called a feeder-breaker. With the coal sized and mixed it is then conveyed by flume in a water medium out of the mine to a de-watering plant. The water is fed back into the process.

During mine development, conventional underground equipment is used to excavate main-line roadways and, at

right angles to these, a series of "sub-level" shafts. The hydraulic monitor is set up at the end of each successive "sub-level" shaft and the coal is excavated as the monitor gradually "retreats" down the sub-level towards the main-line roadway. The result is very similar to the normal caving technique except that the coal is excavated by water rather than by blasting.

The principal requirements of the technique are:

1. The dip of the seam must be no less than seven degrees.
2. An adequate supply of water must be available.
3. The roof and floor of the coal seam must be reasonably strong to minimize contamination.
4. The coal must be soft and friable, and contain few hard bands.
5. The coal seam must be as thick as possible.

Hydraulic mining has the following advantages over conventional underground techniques:

(a) Safety

Thus far, hydraulic mining has experienced very low accident rates. There are basically three reasons for this:

1. Since there is no electricity or moving parts in the excavating area the chance of a spark occurring is very much reduced.

This is a great advantage in an area long troubled with methane and coal dust explosions.

2. As the cutting unit is water, no dry coal dust is produced. This reduces the possibility of coal dust explosions and simplifies the ventilation system.
3. The most dangerous place in a conventional mine is the coal face itself. In the hydraulic technique the operators of the monitor and feeder-breaker are situated in the supported sub-level some 10-30 m. from the face area.

(b) Productivity

Within areas in which conditions are amenable to the hydraulic technique, productivity per man shift is significantly higher than for conventional underground systems. Within the K.R.L. mine, productivity has averaged 500 tons per man shift (including development) compared to an average of 120 tons for conventional mines (James per. comm.).

(c) Adaptability

Steeply pitching or undulating seams are relatively easily accommodated by this system since, unlike the belt conveyors of conventional mines, flumes do not require straight passageways. Development can thus follow the seam at a set gradient with very little premining information.

(d) Ventilation

One of the main problems of underground mining is to provide adequate quantities of air to workers at the face, free of noxious or flamable gases and with permissable levels of coal dust.

In hydraulic mines, air passes down the sub-level and reaches the miners without picking up contaminants from equipment and before flowing through the production area. After passing the operating face it is returned to exit air flues through the mined or "gob" area. In addition, as previously mentioned, levels of coal dust are naturally lower because water is used for excavation.

(e) Coal Recovery

In the conventional mining of thick coal seams a quantity of coal must be left behind as "pillars" to support the roof of the shaft. By using a hydraulic monitor to cut and move the coal there is no need for either miners or machines to travel into unsupported or poorly supported areas. Mining can, therefore, continue in a working area until either all the coal is taken or the roof caves.

(f) Elimination of Nuisance Water

Most coal mines have problems with seepage water in shafts and roadways. Pumping is costly and time consuming. In a hydraulic mine, roadways can simply be designed to drain into the flumes and nuisance water

removed from the mine with the coal slurry and used in the mining process.

Disadvantages of the hydraulic technique are as follows:

(a) In seams that are interbedded with rock or impurities, selective mining of the coal is difficult. If the hardness of the rock forming the floor and roof of the seam is not substantially different than that of the coal, excessive levels of impurities in the mined coal can result in high processing costs.

(b) The mined coal, even after dewatering, has a higher moisture content than that produced by other underground mining methods. This can result in considerable handling difficulties, especially during the winter, and necessitates drying.

(c) The technique is very difficult to apply to level or gently sloping, and thin seams for reasons already explained.

Table 11 shows details of the land disturbances associated with the Hydraulic Mine to the end of 1975.

3.4.4 Supplementary Operations

Many past studies of the impact of coal mining on land based resources have concentrated on disturbances resulting from the mining operation itself. A public relations film produced by the Mining Association of British Columbia called

Table 11

Details of the Areas of Disturbance Associated With Underground Mining 1969-1975

Mine	Feature	Area (ha)	Elevation (m.)	Aspect
Balmer North	- Facilities (portal, loading area, fan coal conveyor and tipple)	1.6	1155-1215	SW
	- Disturbed by construction	1.2	1155-1215	SW
Hydraulic Mine	- Dewatering Plant			
	- Facilities	5.3	1125	NE
	- Disturbed by construction	9.3	1125	NE
	- Mines			
	- Portals and loading areas	3.2	1215-1550	NE
	- Surface flumes	2.0	1125-1305	NE
	- Disturbed by construction	6.5	1125-1305	-
	TOTAL	29.1		

Miners With Green Thumbs stated in 1969 that the mineral and coal wealth of the province was produced from a disturbed area of just 18 km^2 (1815 ha.), and Kaiser Resources Ltd. had indicated in many publications that its mining operation would disturb only slightly more than 8.5 km^2 (approximately 810 ha.). These figures ignore the considerable disturbance associated with facilities supplementary to the mining operation, which often equals or surpasses the area of mining disturbance.

3.4.4.1 Preparation Plants

The original preparation plant for the Michel Colliery was located at the facility's complex adjacent to the Michel townsite and operated from 1938 to 1968. In 1969 the Elkview Preparation Plant was constructed and, thereafter, the Michel Plant was used in association with the production of coke. Coke is produced at Michel in horizontal Curran-Knowles bye-product ovens, of which there are 4 batteries totalling 52 ovens. These ovens have a capacity to treat 245,000 tons of clean coal per year to produce 180,000 tons of coke. The only saleable bye-product of this process is coal tar which is sold periodically to the Canadian Pacific Railway for making creosote.

The Elkview Preparation Plant is located on the east bank of the Elk River approximately two miles north-east of Sparwood. Coal is delivered to four, 2000-ton raw coal

silos at the Plant by an 2,590 m. conveyor belt originating at the breaker station in the Harmer Pit. The conveyor passes through Harmer Ridge in a 1,465 m. tunnel. From the raw coal silos the coal is conveyed to the wash plant where it is screened into three size ranges: 20 mm. and greater, 0.5-20 mm., and less than 0.5 mm. These size ranges are separated from rock and other impurities on the basis of density by heavy media vessels, heavy media cyclones, and by a combination of water cyclones and flotation, respectively. The coal larger than 20 mm. in size is conveyed directly to four, 15,000 ton clean coal silos for storage and loading into unit trains. The finer coal fractions are diverted to a thermal dryer before entering the silos.

The waste generated by this system is essentially of two types, a fine fraction and a coarse fraction. The fine fraction has a particle size of less than .5 mm. and is composed of carbonaceous shales, clay particles and high-ash coals. It is removed from the plant in a water slurry and transported by pipe to settling lagoons. The water is decanted from the lagoons and returned to the plant process. Four such lagoons have been constructed to date and are shown on Map 2e. A, B, and C lagoons are now dormant and D lagoon will be used until the early 1980's. The coarse refuse is composed of coarse rock and shale,

and high ash coals and has a size range from 0.5 mm. - 101.6 mm. Within this size range approximately 59 per cent by volume is less than 9.5 mm. and 41 per cent is greater, though this ratio is subject to some fluctuation. This coarse refuse is collected from the wash-plant by pan-scrapers and deposited in a waste-bank area directly north of the plant site. This waste bank will be constructed in a series of 6 m. wide benches at vertical intervals of 15 m. Slope angle between benches will be approximately 35 degrees. Figure 10 shows the approximate configuration of this bank system, and the anticipated schedule of dumping.

Table 12 shows details of the areas disturbed by preparation plant operations to the end of 1975 and Table 13 shows the results of chemical analysis of refuse materials and some soils disturbed by construction activities. Map 2e shows the location of the preparation plants and associated facilities.

3.4.4.2 Access and Haul Roads

A total of 60.2 km. of access and haul roads service various portions of the operation and their location is shown on Map 2e. Table 14 gives details of those roads outside the areas disturbed by mining operations. The areas given for cut and fill slopes are estimates only based on sample measurements of road bank widths.

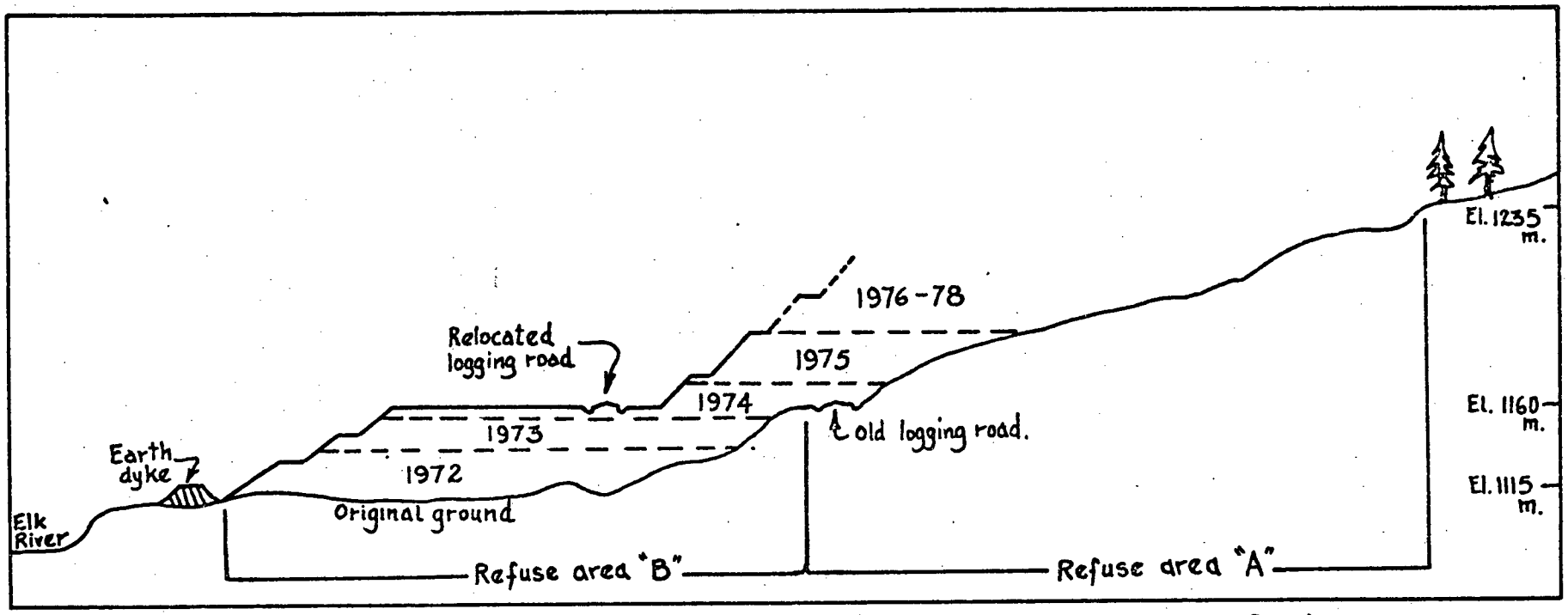


Figure 10. Profile of Elkview A & B Coarse Waste Banks.

Scale 1:3200

Table 12

Details of the Areas Disturbed by Preparation Plant Operations to the End of 1975

Plant	Feature	Area (ha)	Elevation (m.)	Aspect
Michel	- Tipple, Coke ovens, breeze drier, and fines plant	14	1160	-
	- Refuse disposal areas			
	- Michel Bank	9	1160	-
	- Michel-South Bank	4	1190	NE
	- Natal Bank	3	1145	-
	- Settling ponds	1	1160	-
Elkview	- Facilities, including warehouses, shops, offices, waste reservoirs	20	1100-1495	SW
	- Area disturbed by construction	51	1100-1495	SW
	- Coarse refuse banks	29	1130-1280	SW
	- Fine refuse lagoons A	4.5	1115	-
	B	6	1115	-
	C	17	1115	-
	D	44	1115	-
	- Rail Spurs: To Preparation Plant	35	1145-1235	SW
	- Coal loading circuit	3	1115-1130	-
	TOTAL	240.5		

Table 13

Analysis* of Refuse and Disturbed Soils Associated With Preparation Plants

Feature	Soil Texture	Organic Matter %	pH	Soluble Salts (Mmhos/cm)	Available Nutrients (p.p.m.) P	K	Ca	Mg
Elkview Refuse Lagoons	-	-	7.1	1.71	6.0	14.5	701	39
Coarse Refuse Banks								
Elkview	-	-	6.5	0.6	27.5	46	150	55
Michel South	-	-	7.3	0.67	39	64	700	73
Michel	-	-	7.6	0.49	41	50	700	90
	-	-	7.2	2.00	41	53	1050	62
Natal	-	-	7.6	0.70	22	32	300	70
	-	-	7.1	0.24	15	145	700	115
Elkview Construction Site	SC	2.5	8.0	0.35	2.5	87	3050	300 +
Railway Embankment	SC	2.5	8.1	0.54	4	64	2300	300

* Analysis by the British Columbia Department of Agriculture, Soils Laboratory, Kelowna. For a description of analytical methods, see Appendix VIII.

Table 14

Area Disturbed By Access and Haul Roads

Road Designation	Length (km.)	Road Width (m.)	Area of Road Surface (ha.)	Area of Road Banks (ha.)
Harmer Haul Road	11.7	8.5	10	130
Preparation Plant Roads	11.9	6.7	8	61
Hydraulic Mine Roads	6.1	5.5	3	69
Michel Plant Roads	1.8	5.5	1	2
Balmer North Mine Roads	2.9	6.7	2	3
Pit Access Roads				
-10-7 Pit	4.3	5.5	2	6
-3 Strip	7.2	5.5	4	9
- Harmer Ridge				
-Camp 8	2.1	15.2	3	30
-Adit 29	0.8	15.2	1	11
-Harmer I	1.8	15.2	3	25
-Harmer II	3.5	15.2	5	51
-Dry Creek	3.2	15.2	5	46
			47	443

3.4.4.3 Offices and Maintenance Structures

The main company office, and the reclamation office and nursery are located on the Elk Valley Road north of Sparwood across Michel Creek. Major maintenance complexes are located at Michel and on Harmer Ridge. Table 15 gives details of the areas occupied by these facilities and their location is shown on Map 2e.

3.4.5 Tabular Summary of Land Disturbances Associated With the Mining Operation

The total acreage disturbed by activities associated with mining and processing to the end of 1975 is shown in Table 16.

All of these operations are authorized under Section 8 of the Coal Mines Regulation Act by Surface Work Permit No. 2, first issued on May 9, 1970 and renewed in 1973. The reclamation bond covering disturbances to the end of 1975 was $300,000.00 or $166 per hectare ($67.00 per acre).

3.5 Nature and Extent of Exploration Activities

In 1968 Kaiser Resources Ltd. acquired mining rights to a selected two-thirds of Crowsnest Industries' 110,000 acres (44,550 ha.) of coal lands. Under the terms of this agreement, K.R.L. committed itself to making this selection by 1976. During the years 1968 to 1975, K.R.L. carried out one of the most ambitious and extensive coal exploration

Table 15

Details of the Area Occupied by Officers
And Maintenance Structures

Feature	Area (ha.)	Elevation (m.)	Aspect
Main Office - Including Reclamation Facilities	2	1115	-
Michel Office Complex	12	1160	-
Harmer Ridge Complex	17	1905	E
TOTAL	31		

Table 16

Total Area of Disturbance Associated With Mining and Processing to the End of 1975

Feature	Area by Type of Disturbance (ha)								
	Facilities	Pits	Spoil Dumps	Refuse Banks	Refuse Lagoons	Construction Disturbance	Road and Surface	Rail Banks	Total
Contour Mines	-	33	133	-	-	-	-	-	166
Bench Mines	6	379	395	-	-	9	20	40	849
Underground Mines	21	-	-	-	-	8	-	-	29
Preparation Plants	34	-	-	46	72	51	9	29	241
Access and Haul Roads	-	-	-	-	-	-	47	443	490
Office and Maintenance Structures	31	-	-	-	-	-	-	-	31
TOTAL	92	412	528	46	72	68	76	512	1,806

programmes ever undertaken in the East Kootenay coal belt. The main centres of activity in this programme have been the following:

(a) The southern part of the Greenhills Range in the Elk and Fording River watershed.

(b) The Burnt Hills area of the Wisukitsak Range in the Fording River watershed.

(c) The south-eastern slopes of Harmer Ridge in the Erickson Creek watershed.

(d) Sparwood Ridge in the Elk River and Michel Creek watersheds.

(e) The Marten-Leach-Michel Creek watershed from Coal Creek pass to McGillivray.

(f) Flathead Ridge in the Lodgepole Creek watershed.

Within these six main areas there are eleven distinct explorations, the locations of which are shown in Map 1a. Each exploration operation is serviced by an access road thirty feet (9 m.) wide, and from this main road a network of trenches or secondary roads is constructed to find and trace the coal seams. In areas of multiple coal seams only the most important are trenched, and the locations of the intermediate seams are established by "cross cuts" at right angles to the trench seams (Figure 11). Once the configuration of a seam is established by trenching, large

Figure 11. Aerial view of an exploration operation showing roads, trenches and cross-cuts.

volumes of coal are obtained for quality testing through the excavation of either test pits or small underground shafts called adits (Figures 12 and 13).

Table 17 shows the extent of disturbance from exploration activities to the end of 1975 for each of the nine operations and by the type of exploration work. This exploration programme is authorized, under Section 8 of the Coal Mines Regulation Act, by Surface Work Permit No. 80. The reclamation bond covering disturbances to the end of 1975 is $35,000.00 or $15.00 per acre ($37.00 per ha.). The areas given in Table 17 are estimates only since no attempt has ever been made to establish accurate measurements of the area disturbed by the programme. The estimates have been calculated using parameters from a Fish and Wildlife Branch publication by Stanlake and Stanlake (1975). In preliminary work on K.R.L.'s exploration operations they found that exploration roads disturb approximately 2.75 ha. per km. on south and west facing slopes that exceed 30° (ungulate winter ranges), and approximately 1.5 ha. per km. on areas that are either treed or of more moderate topography. Adits and drill sites were found to occupy 0.12-0.2 ha. and 0.04 ha. respectively.

During the years 1969-1972 there was very little pre-planning of exploration operations, and little consideration either of moderating the adverse environmental

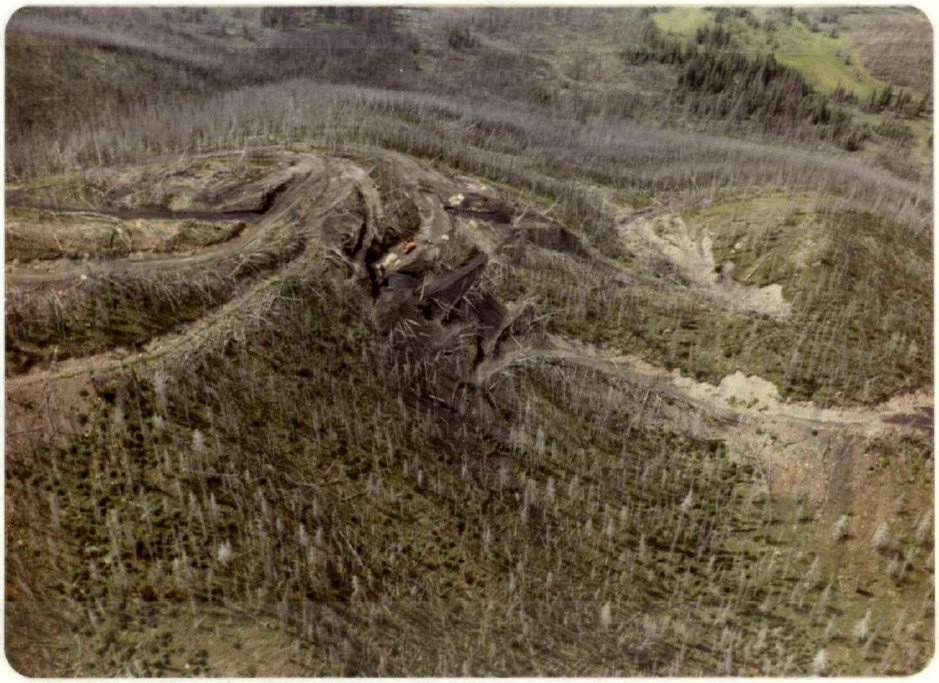


Figure 12. Aerial view of preparations for an adit site.

Figure 13. An adit during mining.

Table 17

Disturbances Associated With Exploration Activities 1969-1974

	Area By Type Of Activity (ha)					
	Roads	Seam Tracing	Cross Cutting	Adits	Drill Sites	Total
Greenhills	82	52	4	2	1	141
Burnt Hills	17	25	2	-	-	44
Sparwood Ridge	58	111	7	-	-	176
Erickson Creek	67	13	4	-	-	84
McGillivray Ridge	12	1	1	-	-	14
Tent Mountain	31	3	4	-	-	38
Carbon Creek	14	3	1	-	-	18
Marten Ridge	141	18	8	2	1	170
Coal Creek Pass	49	1	28	-	-	78
Mt. Taylor	47	1	2	2	1	53
Flathead Ridge	93	2	12	2	-	109
TOTAL	611	230	73	8	3	925

NB This is an estimate only based on "Report of Exploration Work on Coal Licences" forms on record at the Department of Mines and Petroleum Resources. No accurate determination of the area disturbed as a result of this programme has ever been attempted.

effects of exploration or of planning for eventual reclamation. Poor construction and maintenance practices have probably led to severe seasonal degradation of water quality throughout the Elk River drainage. Appendix VIII contains photographs that illustrate many of the poor practices that have characterized coal exploration in the East Kootenay.

There is some evidence to suggest that much of the exploration disturbance has been unnecessary, and could have been avoided through a better planning process. In 1972 the writer and two of K.R.L.'s exploration geologists undertook a study to compare the extent of disturbance on two of the nine exploration operations: the Mt. Taylor Area, where the main access road was constructed and preliminary geological mapping was completed the first season, and seam tracing and secondary road construction were carried out, under close supervision by a geologist, in the second year, after considerable pre-planning; and the Marten Ridge area, respresentative of most of the programme, where no preliminary mapping or pre-planning were done and supervision was minimal. In this study a number of assumptions were made:

1. That the areas were comparable. (This is difficult to assess, however, two factors were known; first, that the Mt. Taylor area was more geologically complex in that

there was substantially more folding and faulting; and second, that the Marten Ridge area contained seven coal seams while Mt. Taylor had only three. It was assumed that these two factors cancelled one another.)

2. A road was considered unnecessary where it gave access to other than coal-bearing formations, or where, by changing the location, a much shorter acceptable access to coal-bearing areas could be provided.
3. A trench was considered unnecessary where its function was duplicated by roads or other trenches, or where it was located in a non-coal bearing area and could have been eliminated by either preliminary mapping or closer supervision. A trench was considered necessary even if it did not uncover coal, where it was excavated for a specific reason, or where it provided information that could not be gained from other roads and trenches.

The results of this study were as follows:

		Marten Ridge	Mt. Taylor
1. Access roads outside the coal bearing formation	(a) Necessary	13,375 m.	5,870 m.
	(b) Unnecessary	6,130 m.	-
2. Access roads within the coal bearing formation	(a) Necessary	8,245 m.	8,135 m.
	(b) Unnecessary	440 m.	-
3. Trenching outside the coal bearing formation	(a) Necessary	None	None
	(b) Unnecessary	1,025 m.	None
4. Trenching within the coal bearing formation	(a) Necessary	1,115 m.	1,855 m.
	(b) Unnecessary	3,390 m.	-
5. Acreage of coal bearing area		113 ha.	209 ha.
6. Density of roads and trenches within the coal bearing area		116 m./ha.	47 m./ha.

Some of the more significant observations of this study were:

1. A large portion of the road network on Marten Ridge judged unnecessary gave access to non-coal bearing areas that could have been excluded by preliminary mapping.
2. Some trenches were judged unnecessary because access roads constructed later duplicated

their function. One very long trench would not have been excavated if the geologists could have been given time to analyze the results of other work before it was excavated.

3. Over one kilometre of trench outside the coal-bearing formtion on Marten Ridge was totally useless and could have been avoided by preliminary mapping.

Exploration personnel estimate that the cost of trenching and secondary road construction is $4.90 per metre. If the information obtained from this study is correct, $54,030.00 were wasted in unnecessary work on Marten Ridge in exploration operations alone. If we assume conservative reclamation costs of $490.00 per hectare, a further $15,010.00 would be required to rehabilitate unnecessary disturbances. It is apparent then that the Company itself has paid a heavy price for the lack of an effective exploration planning process.

In 1973, because of its concern about the environmental effects of the exploration programme, the Fish and Wildlife Branch formally objected through the Reclamation Land Use Advisory Committee (see Section 5.1) to the annual renewal of Surface Work Permit No. 80 until an environmental impact statement had been prepared and a programme of environmental protection had been instituted. B.C. Research carried out

the environmental impact statement, and among the recommendations made were:

1. That a site-specific planning process be set up for any future exploration programmes. In such a process the geologists and reclamation biologists would work together as equals on a planning team.
2. That future exploration works conform to a set of environmental protection guidelines. As an example, the first draft of a set of such guidelines, then being produced by the Department of Mines and Petroleum Resources, was appended to the study report.
3. That far greater on-site supervision of construction activity be provided in order to minimize environmental degradation and to facilitate eventual reclamation.

In December of 1973 the Department of Mines and Petroleum Resources published, *Reclamation Guidelines for Exploration* (McDonald and Dick, 1973), a copy of which is attached as Appendix IX. Compliance with these guidelines has been made a condition of all surface work permits for coal exploration.

CHAPTER IV

ENVIRONMENTAL IMPACT

4.1 Introduction

A major resource development such as coal mining and processing will invariably have a wide array of impacts on both the natural environment and local socio-economic conditions. Many of these impacts are beyond the scope of this thesis. The following discussion will be limited to those aspects of environmental impact which may be mitigated in part or in whole through a programme of land reclamation.

In 1976 the Environment and Land Use Committee imposed Guidelines for Coal Development (see Appendix 1) on all new mining ventures. These Guidelines make provision for an extensive four-stage, impact assessment and planning process related to the effect of the development on both the biophysical resource base and the local community infrastructure. This assessment process was not made retro-active to include existing mining operations and, thus, Kaiser Resources Ltd. was neither obliged by law, nor did it undertake voluntarily, to prepare a "hindsight" environmental impact assessment. The writer has, simply,

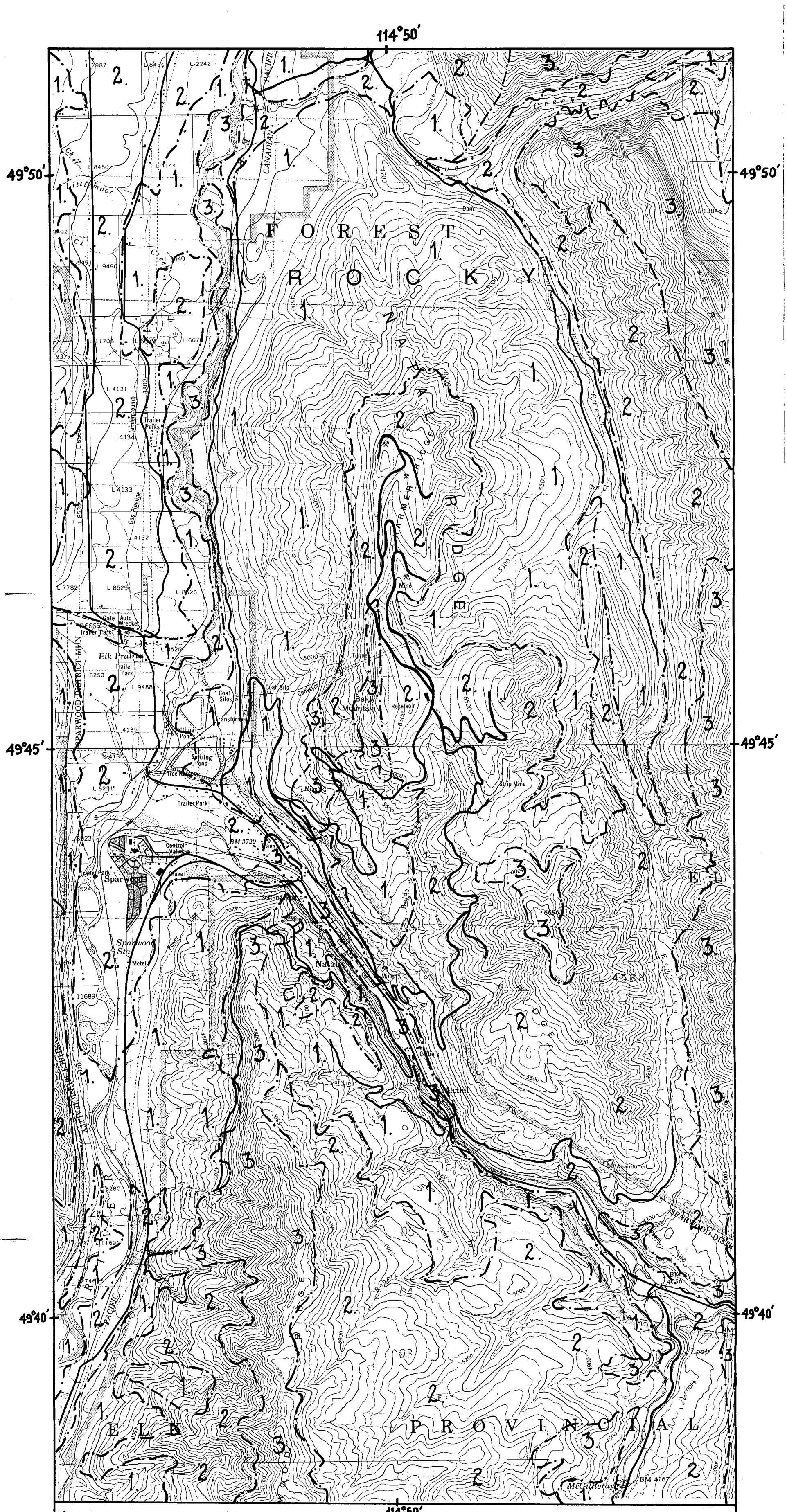
not had the resources to undertake such a study and, consequently, the following discussions of impact are necessarily both cursory and, to a large extent, speculative.

4.2 The Mining Operation

4.2.1 Land Use History

The main influence on settlement history in the Natal area has been coal mining. As noted in Section 3.2 above, mining development began at the Michel Colliery in 1898. The townsites of Michel and Natal were established in 1900 and 1908 respectively. Since that time, this portion of the Michel Creek valley has been continuously occupied by mining activities. In 1955, the new community of Sparwood was established in an attempt to site new residential development away from the dust of the coal processing plant and from the smoke and soot of the coke ovens.

Forestry has also played an important role in the commerce of the area, and Natal was the site of Crowsnest Industries Ltd.'s major sawmill until 1969, when the operation was moved to Elko. Most of the commercial timber in the vicinity of Natal was harvested prior to the development of Kaiser Resources Ltd.'s mining operation. Harvesting activities are now confined to areas north of Sparwood, and the timber is trucked by road to the Elko sawmill.



LEGEND

Scale 1:50,000

LAND CAPABILITY FOR FORESTRY

1. Productivity averages 7 m^3/ha./annum for eS & lP (B.C.L.I. classes 1, 2 & 3).
2. Productivity averages 4 m^3/ha./annum for eS, lP & alF (B.C.L.I. classes 4 & 5).
3. Productivity averages 1.5 m^3/ha./annum for eS, D, alF, lP (B.C.L.I. classes 6 & 7).

eS = Engelmann spruce, lP = lodgepole pine, alF = alpine fir,
D = Douglas-fir.

MAP 2.f.

Capability interpretations generalized from B.C. Land Inventory.

Source:- N.T.S. 82-10 & 15

Small farming operations have developed in the Elk Valley north of Sparwood, however, these are of a marginal nature due, primarily, to climatic limitations. Most of those engaged in agriculture have also been employed in either the mines or the logging industry, and farming is a part-time occupation. The results of the 1971 census, published by Statistics Canada indicate only 5 people who listed agriculture as their primary employment in the Sparwood area.

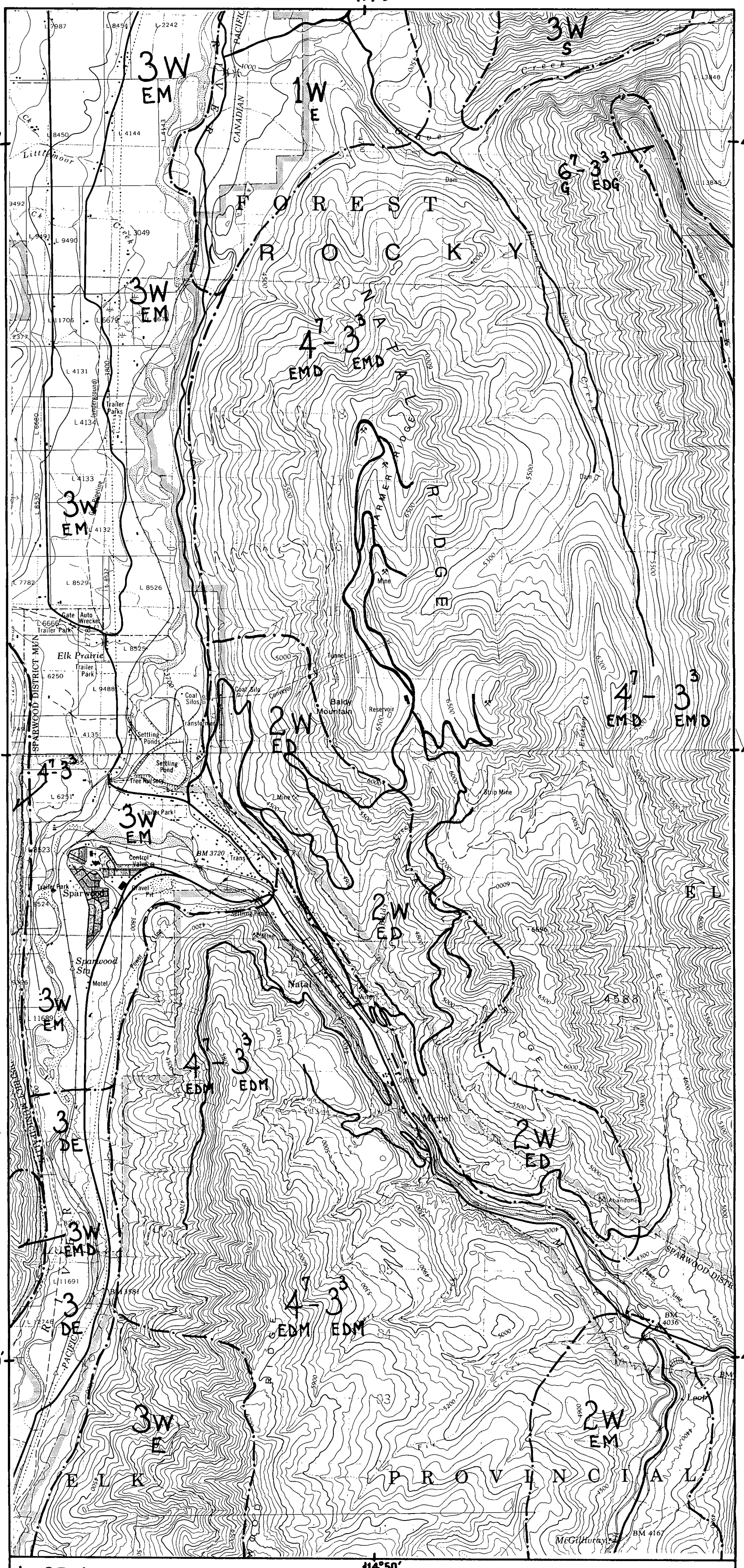
Recreation has been an important land use in the area. Fishing and hunting are the main recreational pursuits. Grave Lake, immediately north of the mining operation, is a popular centre for boating, camping and recreational cottage-site development.

4.2.2 Land Capability and Impact by Resource

4.2.2.1 Forestry

Land capability for forestry is shown on Map 2f. Of the lands most suited to forest production, mining and milling activities to the end of 1975 have disturbed the following area:

Class 1-3	(average productivity 7 m^3 per ha. per annum)	490 ha.
Class 4	(average productivity 4 m^3 per ha. per annum)	56 ha.
Class 5	(average productivity 3 m^3 per ha. per annum)	596 ha.



LEGEND

Scale 1:50,000

LAND CAPABILITY FOR UNGULATES

Class 1. Lands with no significant limitations to the production of ungulates.
Class 2. Lands with very slight limitations to the production of ungulates.
Class 3. Lands with slight limitations to the production of ungulates.
Class 4. Lands with moderate limitations to the production of ungulates.
W = Important winter ranges on which animals from surrounding areas depend.
D = deer E = Rocky Mtn. elk M = Moose S = Rocky Mtn. bighorn sheep.

MAP 2.g.

Capability interpretations generalized from B.C. Land Inventory.

Source:- N.T.S. 82J10 & 15

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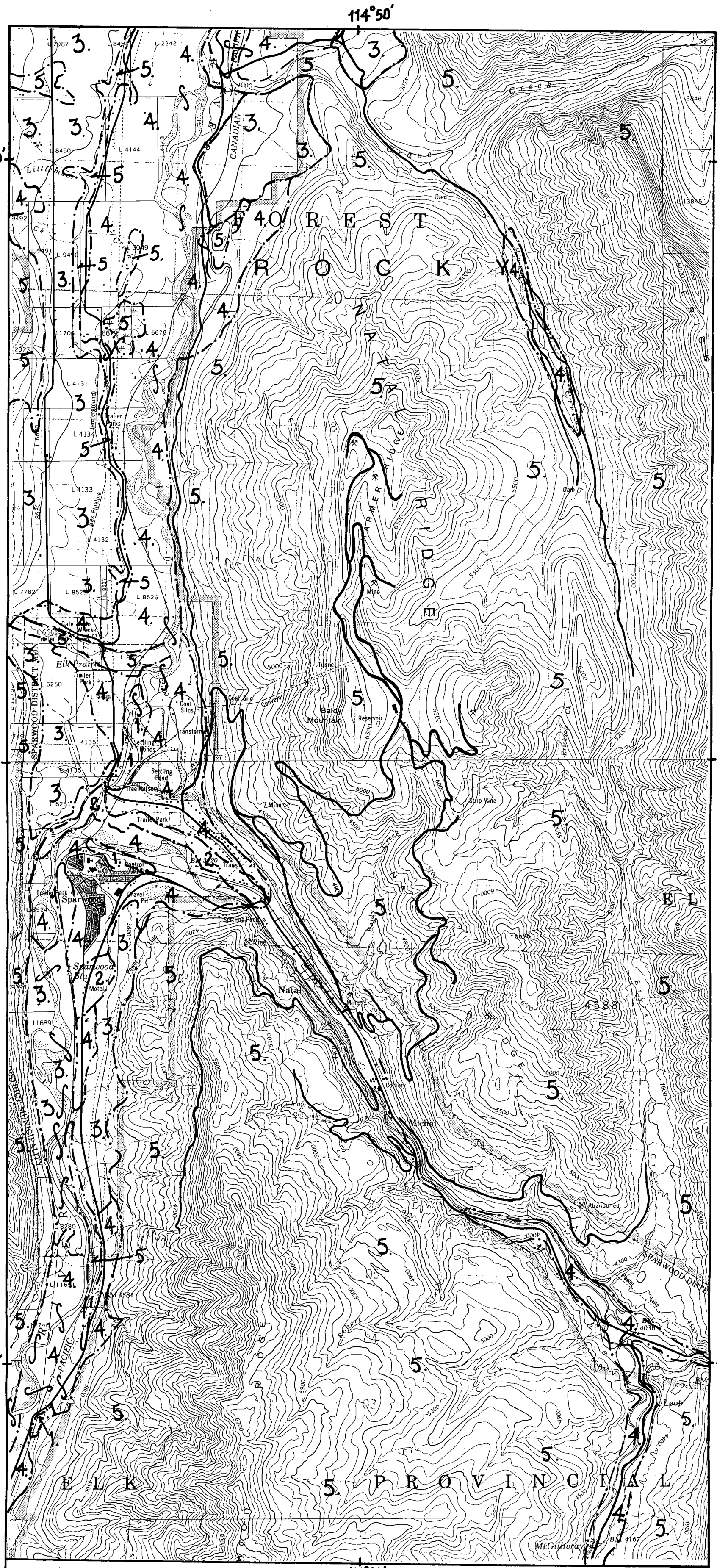
This represents an annual increment loss of approximately 5,442 m^3 (1,920 cunits). As discussed in previous sections of this thesis, because of the nature of surficial deposits in the area, mining spoils on the most productive low elevation sites tend to range from neutral to moderately alkaline. Such sites are unlikely to support coniferous regeneration for many decades.

4.2.2.2 Ungulates

The south-westerly slopes of Natal, Harmer and McGillivray Ridges and the Elk River floodplain are important ungulate winter ranges (see Map 2g). Mining and milling operations to date have destroyed approximately 355 ha. of class 2W and 3W in this habitat. The precise effect of this loss on the populations of mule deer and elk that use this range is difficult to quantify since little is known about the degree of habitat utilization. It is noteworthy, however, that the Fish and Wildlife Branch was recently awarded $1.8 million from the B.C. Hydro and Power Authority in compensation for the loss of 285 ha. of class 1 and 2 winter range resulting from the construction of a hydro-electric dam on the Pend d'Orelle River. This award was based on the destruction of habitat rather than on an attempt to estimate loss of animals.

An unknown factor at the present time is the influence of the activity of humans and machines on the behaviour and



LEGEND

Scale 1:50,000

LAND CAPABILITY FOR AGRICULTURE

1. Widest range of agricultural crops. (B.C.L.I. classes 1&2).
2. } Reduced range of crops caused by a number of limiting
3. } factors (topography, stoniness, moisture deficiency) (B.C.L.I. classes 3&4).
4. Permanent pasture only (B.C.L.I. class 5).
5. No agricultural capability. (B.C.L.I. classes 6&7).

MAP 2.h.

Capability interpretations generalized from B.C. Land Inventory.

Source:- N.T.S. 82J10&15

condition of wintering ungulates. It is recommended that Kaiser Resources Ltd. fund a study to closely monitor the deer and elk populations that winter on the mining property in an attempt to determine these effects.

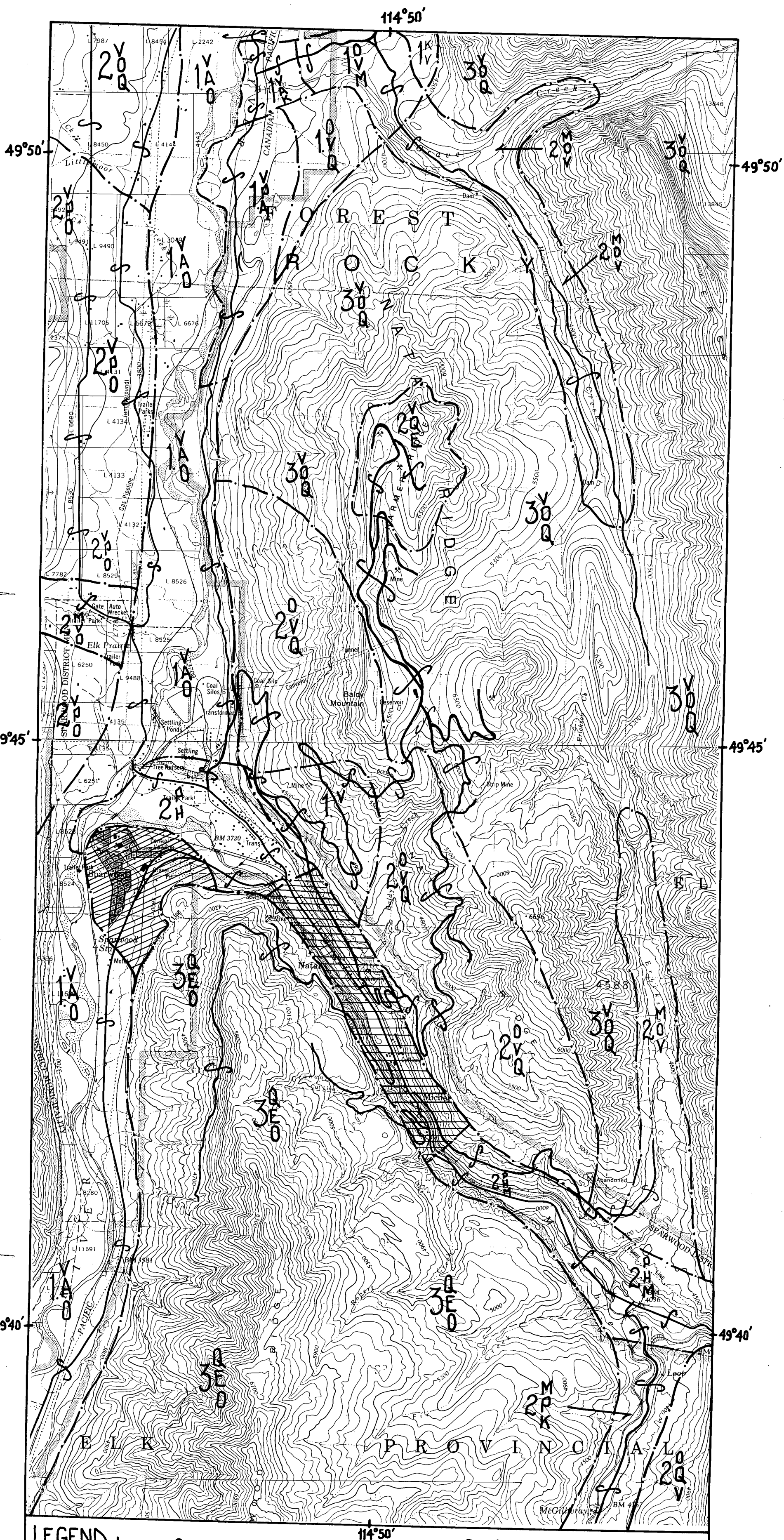
A firearms closure, ostensibly for safety reasons, has been in effect on the mining property since 1969. Given the direct loss of habitat and the probability that some portions of the ungulate winter range are not being used because of human activity, it may be desirable to reintroduce some controlled hunting activity in order to keep the number of wintering animals consistent with the remaining habitat until the mining areas are rehabilitated.

4.2.2.3 Agriculture

The potentially arable land on the mining property lies at the junction of Michel Creek and the Elk River (see Map 2h). Approximately 110 ha. of Class 5, and 2 ha. of a Class 4-5 complex have been disturbed by office construction and preparation plant operations. The agricultural capability of these lands is severely limited by climate and their loss to mining cannot be considered important in either a regional or a provincial context.

4.2.2.4 Recreation

Land capability for outdoor recreation for the vicinity of the mining property is shown on Map 2i. In general the area has a moderately low to low capability



LEGEND

LAND CAPABILITY FOR RECREATION

Scale 1:50,000

Classes

1. Moderate recreational capability (B.C.L.I. class 4).
2. Moderately low recreational capability (B.C.L.I. class 5).
3. Low recreational capability (B.C.L.I. class 6).

Sub-scripts

A ~ Angling.
E ~ Interesting vegetation.
H ~ Historic site.
K ~ Suitable for camping.
M ~ Stream-based recreation.
O ~ Upland wildlife.
P ~ Cultural landscape.
Q ~ Landscape variety.
V ~ Superior view.

MAP 2.i.

Capability interpretations generalized from B.C. Land Inventory.

Source:- N.T.S. 82J10 & 15

for outdoor recreation. No information is available on the extent to which the area was used for recreation prior to mining. The major adverse recreational impacts probably relate to the loss of hunting opportunity on Natal and Harmer Ridges, and of fishing opportunities on Harmer and Erickson Creeks.

4.2.2.5 Land Capability Analysis and Tabular Summary of Land Disturbance by Potential Prime Surface Use

The Canada Land Inventory, Land Capability Analysis is an attempt to determine the land's potential prime surface use through the rationalization of individual capability maps. The Land Capability Analysis for the mining property is shown on Map 2j and Table 18 shows the area of disturbance by potential prime surface use.

4.2.2.6 Impact on Water and the Fishery Resource

Obviously, any development that results in the deep disturbance of over 1,800 ha. of land in an area of highly erodible, shale-derived surface materials has the potential to degrade water quality severely, at least seasonally, in local stream and river systems. In order to mitigate this impact, Kaiser Resources Ltd. has built one settling pond on each of the two streams which drain the Harmer Ridge mining area; Harmer and Erickson Creeks.

The first of these dams was constructed in 1971 on Harmer Creek. The reservoir was designed for a 15 year life,

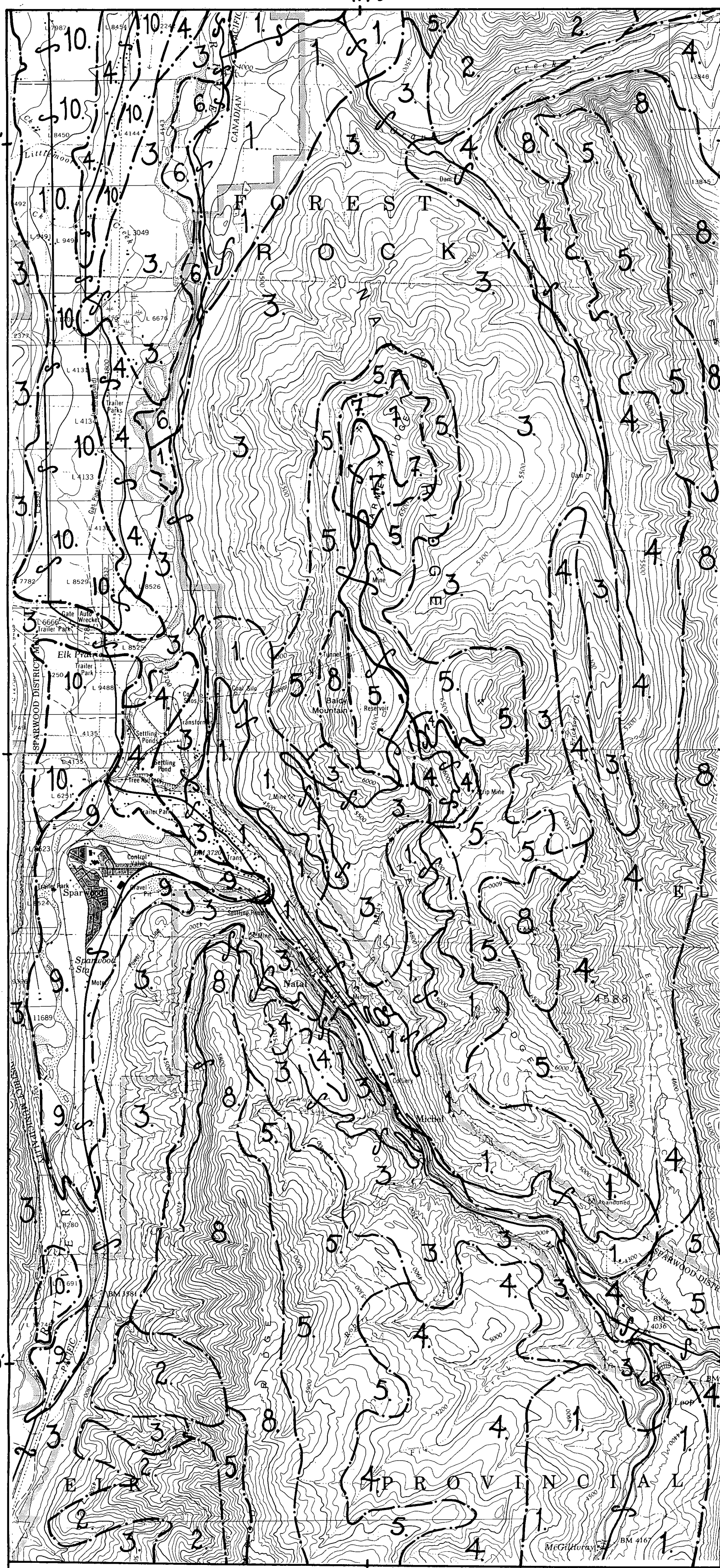
Table 18

Potential Prime Surface Uses* Of The Kaiser Resources Ltd. Mining Area

Potential Prime Surface Use	Area By Type of Disturbance (ha.)						
	Contour Mines	Bench Mines	Underground Mines	Preparation Plants	Access and Haul Roads	Office and Maintenance Facilities	Total
High Yield Forestry	41	266	8	25	147	-	487
Moderate Yield Forestry	15	10	-	-	31	-	56
Low Yield Forestry	12	384	-	-	183	17	596
Extensive Recreation	-	178	1	-	21	-	200
Prime Ungulate Range	98	11	20	107	108	12	356
Moderate Capability Agriculture	-	-	-	109	-	2	111
TOTAL	166	849	29	241	490	31	1806

*From Canada Land Inventory, Land Capability Analysis, East Kootenay Area.

High Yield Forestry: Productivity of from 5.0 to 9.0 m^3/ha/annum
Moderate Yield Forestry: Productivity of from 3.5 5o 4.9 m^3/ha/annum
Low Yield Forestry: Productivity of from 2 to 3.4 m^3/ha/annum
Extensive Recreation: Areas with a capability for a limited range of extensive recreation pursuits
Prime Ungulate Range: Lands that are important winter concentration ranges for wild ungulates (deer, moose, elk, sheep or goats) that summer over a widespread area.
Moderate Capability Agriculture: Lands where agriculture is restricted to a narrow range of cultivated field crops under irrigation.



LEGEND

LAND CAPABILITY ANALYSIS

Scale 1:50,000

1. High capability ungulate range.
2. Moderate capability ungulate range.
3. High yield forestry.
4. Moderate yield forestry.
5. Limited yield forestry.
6. Moderate recreation.
7. Extensive recreation.
8. Highlands.
9. High capability agriculture.
10. Moderate capability agriculture.

MAP 2.J.

Interpretation from Canada Land Inventory, Land Capability Analysis for the East Kootenay Area.

Source:- N.T.S. 82J10&15

however, the calculations unaccountably ignored the contribution of bed-load to sedimentation. Accelerated infilling of the reservoir has reduced water retention time and thus the efficiency of the settling pond in dealing with suspended solids. It is probable that the reservoir will require dredging in a few years time. The effect of this dredging on water quality in Harmer Creek and the Elk River is unknown but as the operation would probably be carried out at low-flow during the summer months, the effect is likely to be severe.

The Erickson settling pond was constructed in 1972-73. During reservoir clearing, fine alluvial and organic materials were removed from the site, exposing a large, coarse textured gravel fan deposit. Erickson Creek now flows underground through this deposit and emerges to the surface further down the valley. The gravel deposit presently acts as a large filter and, at least in part, protects downstream water values.

Even if the two settling ponds had worked as they were intended to, they would intercept sediment from only about half of the area disturbed by mining operations. Runoff waters from disturbances associated with most of the transportation network, a portion of the northerly part of the Harmer Ridge operation, all of the contour mines, and both preparation plants drain directly into either Michel Creek

or the Elk River. Standards of housekeeping on most of these operations have been minimal, and government agencies such as the Department of Mines and Petroleum Resources and the Pollution Control Branch have been reluctant to enforce better standards of sediment control. In 1971 the failure of the Harmer Knob waste dump resulted in large quantities of saturated till material flowing down Six Mile Creek directly into the Elk River. This creek still transports considerable quantities of soil material during spring freshet.

The Company presently maintains a programme of water quality sampling, of both surface and ground water associated with the mining operation. Data from this programme is unavailable for inclusion in this thesis.

J.E. Harrison, a Geologist with the Terrain Sciences Division of the Geological Survey of Canada, has carried out sampling of surface waters, water empounded in strip pits, and flows from underground mines in the area as part of an evaluation of environmental problems related to Rocky Mountain coal development. In a report of preliminary data (1977), he concludes that the impact of coal mining on water quality is to increase total dissolved solids, total alkalinity, total hardness, iron, and sulphate content. In addition, chemical oxygen demand may be very high under certain circumstances, and sampling results indicate that

suspended solids represent a serious threat to water quality.

The effect of this deterioration of water quality on benthic organisms and resident fish populations is unknown, but it is likely that the effects have been severe, particularly in the smaller streams and probably even in Michel Creek.

4.3 Exploration Operations

4.3.1 Wildlife

The potential effects of exploration operations on wildlife are twofold; first, the deterioration of habitat through physical disturbance, and second, the effects of increased access, and thus of human activity, on the animals themselves.

Approximately 12 per cent of the exploration activities carried out during the programme have taken place on class 2 and 3 ungulate winter ranges. This represents a total habitat loss of approximately 110 ha. spread over eleven distinct exploration areas. The effect of this habitat loss has probably been minor except, perhaps, in localized areas such as Flathead Ridge, Greenhills and Burnt Hills. A major concern of wildlife managers has been the effect on ungulate migration of contour roads located on winter ranges. It was thought that steep cutbanks (see Figure 14)

Figure 14. Cutbank on a contour exploration road.

could seriously impede vertical migration patterns, particularly in winter when the roads drifted full of snow. In a study which included the Kaiser exploration areas, Stanlake, Stanlake and Eastman (1977) concluded that, except for the occasional steep or overhung cutbank, exploration roads posed no serious barriers to animal movements. Where particularly steep cutbanks intersected an established migration trail, the animals simply detoured around the bank and rejoined the trail downslope.

Probably of more consequence than habitat destruction though far more difficult to quantify, is the effect of increased access on wildlife. Leege and Hickey (1977), in a study of elk habitat relationships in Idaho, found that elk use of clearcuts, where excellent forage was abundant, was lower than in mature brushfields, where forage quantity was lower. They concluded that "human activity via logging roads is sufficient to prevent elk from utilizing the abundant forage available in clearcuts." The proliferation of access, particularly near centres of population, can lead to over-hunting. Mountain goat, bighorn sheep and grizzly bear appear particularly vulnerable to over-exploitation, and small discrete populations can be exterminated in a very short time, often before the wildlife manager is aware of a problem.

Perhaps the greatest potential impact of exploration road systems is the access they provide for snow-machines during winter, and the attendant harassment, albeit unintentional, of ungulates on winter ranges. Within the Elk Valley suitable winter ranges appear to be the main factor limiting ungulate numbers (Demarchi, 1967). Energy demands are extremely high during winter and forage is of relatively low quality. Disturbance by man and machine may cause flight reactions, thus wasting vital energy reserves, or, if prolonged, the abandonment of portions of the winter range. Though it has yet to be proved, it is not inconceivable that this would result in both increased winter mortality and decreased spring natality.

The best method of mitigating these impacts, would be a programme of access planning which would include both the coordination of new road building activities, and the control of access on existing road systems. Such a programme would require the close cooperation of Kaiser Resources Ltd., Crowsnest Industries Ltd., the B.C. Forest Service, the B.C. Fish and Wildlife Branch, and local recreational groups.

4.3.2 Recreation

The effect of exploration operations on recreational use is a matter of conjecture. Ultimately it is a question of weighing the provision of recreational access against

intangible values such as aesthetics, privacy and the serenity that accompanies a "wilderness" recreational experience, and unmeasured values such as the deterioration of the fish and wildlife resource. Because such judgements are largely a question of personal values and perceptions, the determination of impact requires a study of recreational user attitudes. No such study has yet been undertaken.

4.3.3 Water and the Fishery Resource

Of all industrial activities, poorly planned secondary roads are the major sources of water turbidity (Packer, 1967; Dyrness, 1967). Roads incise deeply into the soil mantle, intersecting the natural drainage networks and opening up subsurface seepage flows. At the same time they expose large areas of raw mineral soil on both road surfaces and cut/fill slopes to the effects of rain and surface runoff. In a report to the Cabinet Committee on Coal Development entitled, *Coal In British Columbia: A Technical Appraisal* (1976), an interagency coal task group stated:

> Before 1971, little attention was given to soil erosion, water quality, and fisheries in coal exploration work, and this inattention resulted in considerable damage.

In fact, as noted elsewhere in this thesis, it is almost certain that poor exploration practices have led to a severe seasonal degradation of water quality throughout the Elk River

drainage. While the exact magnitude of the loss of water quality and the fishery resource will never be known because of a lack of baseline data, it probably represents the single greatest environmental impact resulting from exploration activities. Because of the slow pace of reclamation activities and the inherent instability of rock and soil materials in the Fernie Basin, this adverse impact is likely to persist for decades.

A secondary impact of exploration is the increased fishing pressure resulting from better road access. Resident river cutthroat trout fisheries in the Rocky Mountains of both B.C. and Alberta have been overfished wherever easy access is provided. Seasonal and alternate year fishery closures attempted in Alberta have done little to restore either the populations or the former high quality fishing (Ringstad per. comm.). Exploration access roads have subjected many portions of the Michel Creek watershed to heavy fishing pressure by both resident and tourist anglers.

4.4 Environmental Impact Matrix

A subjective evaluation of both the environmental impact, and the feasibility of mitigation through reclamation, of various components of the Kaiser Resources Ltd. operation is shown in matrix form in Table 19.

Table 19. Environmental Impact Matrix for the Kaiser Resources Ltd. mining & exploration operations.

Direct Environmental Impact	Potential for Mitigation by Reclamation
Severe	Poor
Moderate	Moderate
None or Slight	High
Beneficial	Long term (>10 yrs.)

Environmental Factors	Mining Activities: Exploration				Bench Mines			Contour Mines			Underground Mines			Elkview Prep. Plant			Michel Complex			Office & Mtce. Facilities
	Roads.	Test pits/Adits.	Drill sites.	Seam tracings.	Open pits.	Overburden dumps.	Roads.	Open pits.	Overburden dumps.	Roads.	Portals.	Roads.	Tipples & driers.	Plant facilities.	Refuse banks.	Settling lagoons.	Plant site.	Refuse banks.	Coking facilities	
Water quality.	S/M*	M/D*	N/H	S/M*	M/D	M-S/M*	M-S/D*	S/D	S/M*	S/M*	N/-	M/M*	M/M*	S/M*	M/M*	N/-	S/M**	S/M-D	S/D	M/M*
Fish.	S/M*	M/D*	N/H	S/M*	M/D	M-S/M*	M-S/D*	S/D	S/M*	S/M*	N/-	M/M*	M/M*	S/M*	M/M*	N/-	S/M*	S/M-D	S/D	M/M*
Ungulates.	M-S/M*	N/M	N/-	M-S/M*	M/D	N-M/M*	M-S/D*	S/D	S/H	S/M	N/-	N/-	N/-	S/H*	M/M*	S/H	N/-	N/-	N/-	N/-
Other wildlife.	M-S/M*	N/M	N/-	M-S/M*	M/D	N-M/M*	M-S/D*	M/D	M/M	M/M	N/-	N/-	-/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-
Agriculture.	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	M/D	N/-	N/-	N/-	N/-
Forestry.	N/-	N/-	N/-	N/-	M/D	M/M*	M/D*	N/D	N/D	N/D	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-
Outdoor recreation.	B(?)/-	M/D*	N/-	M/M*	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-	N/-

CHAPTER V

THE LEGAL AND INSTITUTIONAL FRAMEWORK FOR RECLAMATION IN BRITISH COLUMBIA

5.1 The Coal Mines Regulation Act

The legislation which provides for the reclamation of coal mines in British Columbia is Section 8 of the *Coal Mines Regulation Act* 1969, C. 3, s. 1. Section 8 was incorporated into the Act on April 2, 1969 and originally applied only to surface mines. The section has been amended three times: on April 23, 1971 it was applied to exploration operations; on August 24, 1972 it was applied to surface disturbances associated with underground mines; and on June 26th, 1975 the maximum reclamation bond was increased from $500. per acre (1,235 per ha.) to $1,000. per acre (2,470 per ha.).

As a statement of policy, Section 8 begins:

> It is the duty of every owner, agent or manager of a mine to institute and carry out a programme for the protection and reclamation of the surface of the land and watercourses affected thereby, and, on discontinuance or abandonment of a mine, to undertake and complete the programme to leave the land and watercourses in a condition satisfactory to the Minister . . . .

Briefly the Act provides for the following:

1. A report to be submitted to the Minister of Mines and Petroleum resources prior to the commencement of operations containing:
   (a) A map showing the location and extent of the mine or exploration, and the location of lakes, streams, and inhabited places in the vicinity.
   (b) Particulars of the nature of mining or exploration operations, including, in the case of producing mines, the anticipated area to be occupied during the lifetime of the mine.
   (c) Particulars of the nature of mining or explorations, including, in the case of producing mines, the anticipated area to be occupied during the lifetime of the mine.
   (d) Particulars of the nature and present uses of the land to be used.
   (e) A programme for land reclamation and conservation with particular reference to:
      (i) the location of the land,
      (ii) the effect of the programme on livestock, wildlife, watercourses, farms and inhabited places in the vicinity of the mine, and the appearance of the minesite,

(iii) the potential use of the land, having regard to its best and fullest use, and its importance for existing and future timber, grazing, water, recreation, wildlife and mining.

2. The company shall give notice of the submission of the report in the B.C. Gazette and in local newspapers designated by the Minister.

3. The Minister must consider representations and advice from other government departments, and, before exercising any powers under this section of the act, shall obtain approval of the programme for reclamation and conservation from the Ministers of Lands, Forests and Water Resources; Agriculture; and Recreation and Conservation.

4. Within thirty days after publication of notice, and after hearing any public representations resulting from that notice, the Minister may (a) approve (b) reject or (c) revise and then approve the report. If the Minister approves the report he then submits it to the Lieutenant Governor-in-Council for final government sanction.

5. After receiving the approval of the Lieutenant Governor-in-Council, the Minister shall issue a

permit authorizing the commencement or continuance of work, subject to compliance with the approved programme and such terms and conditions as he shall prescribe.

6. The Minister shall require as a condition of the issuance of a permit, that the operator of a mine deposit with the Minister of Finance security in such form and amount as the Lieutenant Governor-in-Council prescribes. In setting this bond, the nature of the land to be reclaimed will be considered, however, the sum shall not exceed $1,000.00 per acre ($2,470 per ha.) of land disturbed. This security shall be held pending satisfactory completion of the reclamation programme. If the programme is not carried out to the satisfaction of the Minister, all or part of the security may be applied towards the cost of reclamation.

7. During the life of the mine the operator shall carry out continuous and progressive reclamation.

8. A person is guilty of an offence against this Act who:

   (a) fails to comply with, or contravenes this section,

   (b) carries on production from a mine or exploration works without holding a valid permit under this section,

or (c) fails to comply with or contravenes the terms and conditions of the permit.

9. Any person convicted of an offence against the Act is liable to a fine not exceeding $1,000.00 for each offence. If written notice of an offence is given to an operator by the inspector, the operator is liable to a further fine, not exceeding $1,000.00 and not less than $100.00 for each day that the offence was committed after receipt of the notice.

10. In addition to the penalities described above, if an offence is repeated after notice from the Minister, the Minister may cancel the permit and order the closure of the mine.

The reclamation report, as outlined in the Act, is presently required only for producing mines. In 1972 the Department of Mines and Petroleum Resources published a *Directive: Exploration of Coal Properties* in which the full provisions of Section 8, including the reclamation report, were applied to exploration operations. However, this directive was neither followed by exploration operators, nor enforced by the Department and it was replaced in 1973 by *Coal Exploration Form 7-8* in order to standardize reporting procedure. This form is meant not only to satisfy the requirement for a reclamation report under Section 8, but

also to serve as the notice of commencement of operations required under Section 7. Copies of the original 1972 directive and of Form 7-8 are shown in Appendix X.

The provisions for both review of the reclamation reports by other Departments, and approval from the Ministers specified in the Act have been accommodated by the creation of a standing committee known as the Reclamation Land Use Advisory Committee. This committee is composed of representatives from the Fish and Wildlife Branch, Land Management Branch, Water Resources Service, Department of Agriculture, Range Division of the Forest Service, Department of Mines and Petroleum Resources and it must review and approve reclamation reports prior to submission to the Lieutenant Governor-in-Council.

Surface Work Permits for both exploration operations and producing mines are granted for a period of three years. In the case of exploration operations, however, works covered by the Permit must be applied for annually using Form 7-8. An example of a Surface Work Permit is shown in Appendix X. The most common terms and conditions prescribed in such permits are:

1. Topsoil stripped from the surface shall be conserved, as feasible, for possible usage in the reclamation of disturbed areas.

2. The permittee shall report to the Chief Inspector of Mines on the investigations and research on reclamation carried out

> during the calendar year, showing the results obtained therefrom. Such report is to be submitted by January 31st next following the end of the calendar year.
>
> 3. At the same time that the (annual) report is submitted . . . the permittee shall submit detailed plans of the investigations and research on reclamation that will be carried out during the next calendar year.

The usual condition of Surface Work Permits for exploration is that activities shall conform to the reclamation guidelines for exploration compiled by McDonald and Dick (1973).

Though the maximum bond allowed by the Act was $500.00 per acre ($1,235 per ha.) until 1975 when it was raised to $1,000.00 ($2,470 per ha.) actual bonds have averaged $130.00 per acre ($320 per ha.) and have never exceeded $200.00 ($495.00 per ha.). This token bond may well be in contravention of the Act which would seem to call for a sum sufficient to be used for reclamation should the company default. Annual reclamation reports indicate average costs of $300.00 to $500.00 per acre ($740 to $1,235 per ha.) for total reclamation under conditions of moderate topography, and in excess of $1,500.00 per acre ($3,700 per ha.) in mountainous terrain where considerable earth moving must be done to achieve surface stability.

In essence, the approach taken in formulating both the reclamation legislation, and the administrative procedure for review and licencing has been to avoid setting firm

regulations until investigation and research has been undertaken by each mining company to determine what must be done to adequately reclaim mined lands. In recognition of the varied geographic and environmental conditions that prevail across the province, the onus has been placed on the mining industry to develop reclamation technology, while the Department of Mines and Petroleum Resources has retained only an inspection function. In retrospect, after four years of close association with reclamation both in industry and government, I can only conclude that this approach has failed. Proposals and reports of activities submitted under the provisions of the Act have varied greatly, and no uniform standards have been either achieved by the industry or demanded by the Department. As noted in the Introduction to this thesis, a common characteristic of reports is that, while in many instances the engineering aspects of mining, facilities construction and waste disposal are treated in considerable detail, the ecology of the mine area, and the actual process by which the site is to be reclaimed are treated much more lightly. Often there has been little more than a declaration of intent, yet clearly the reclamation proposals are the core of the report.

Much of the responsibility for this failure must be borne by the Inspection and Engineering Division, the agency within the Department of Mines and Petroleum Resources

directly responsible for reclamation. There has been a noticeable reluctance on the part of the Division to reject reports which are clearly below standard, and the level of supervision has been inadequate. Staff levels commensurate with the task of reclamation inspection and extension have never been provided; for three of the first five years after enactment of the legislation only one man staffed the reclamation section, and total personnel at no time during that period exceeded two permanent and two seasonal. The Department has clearly been unable to make the necessary adjustments or reorientation to accommodate its new environmental responsibilities.

The Reclamation Land Use Advisory Committee has generally failed to provide the necessary balance in the process for three reasons:

1. The terms of reference for the committee have never been clearly established and the term "advisory" in the committee's name adds further to the ambiguity. The representation has changed so often that few members were aware until relatively recently that permits may not be issued without the approval of their respective Ministers.
2. The annual reports of reclamation activities, which often provide a clearer picture of a company's progress than the reclamation

reports, have never been reviewed on a formal basis by the committee.

3. While the committee reviews and approves reclamation reports, final approval of the actual reclamation, prior to the return of bond, is solely at the discretion of the Minister of Mines and Petroleum Resources. No formal procedure exists for the inspection and approval of reclaimed areas by other departments of government.

In 1975, the obvious inability of the Department of Mines and Petroleum Resources to deal adequately with the environmental and social aspects of mine development, and the possibility of seven new coal mines opening in the province by 1980, resulted in a decision by the Environment and Land Use Committee to have a set of interdisciplinary guidelines for coal development prepared. The objective was to ensure that an integrated review and planning process would be undertaken prior to any decisions on mine development. In addition to the environmental effects of development, these guidelines were to cover two aspects which had not previously been considered in mining legislation; first, the environmental impact of off-site developments such as transportation corridors and facilities, power transmission corridors, residential developments and

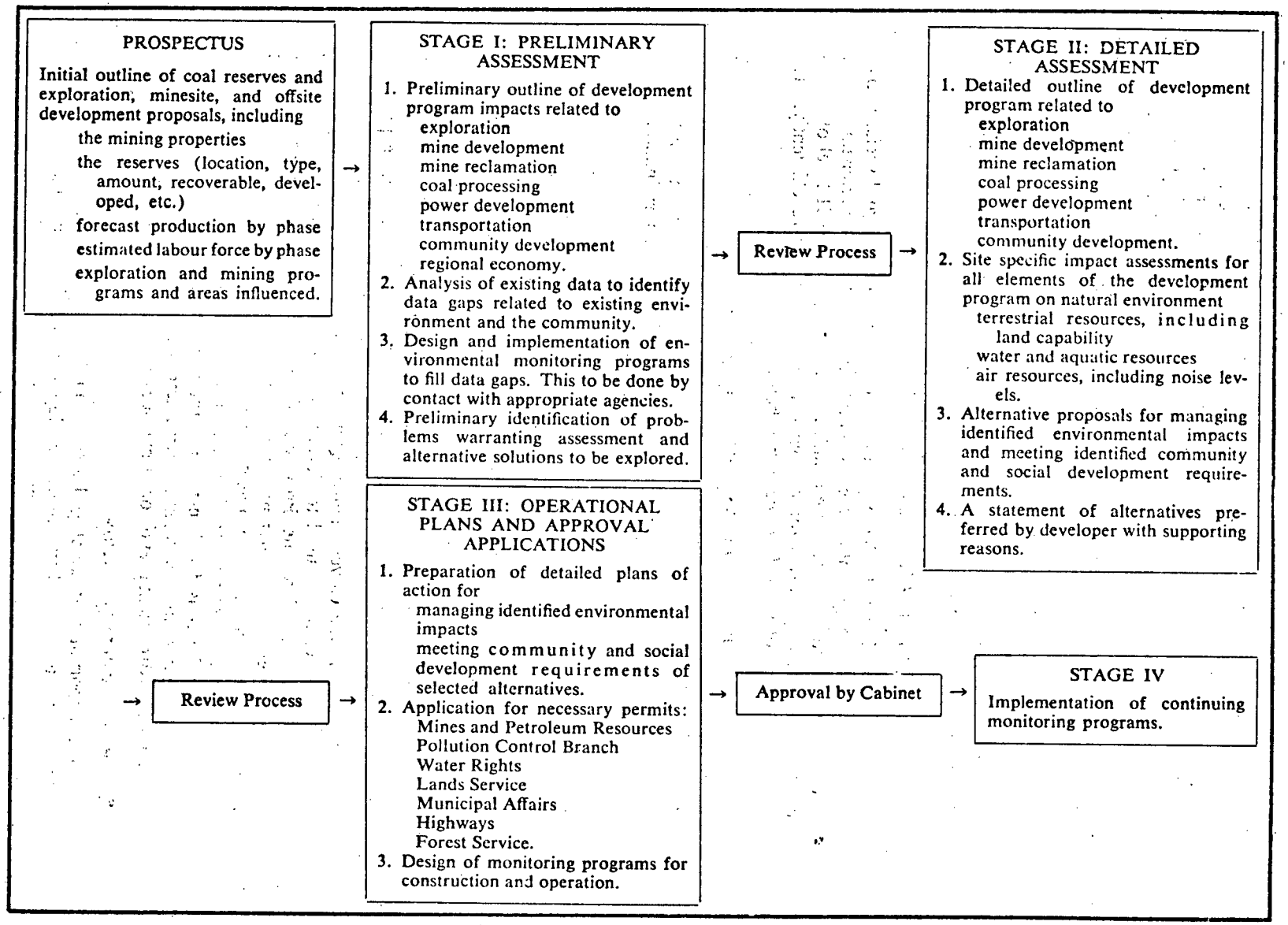
shipping terminals; and second, the social and economic implications of development to existing urban and rural communities in the area.

The preparation of these guidelines was to be co-ordinated by the Environment and Land Use Secretariat, the executive arm of the ministerial committee, and the review process established by the guidelines was to be administered by a steering committee comprised of the E.L.U.C. Secretariat, the Department of Economic Development, and the Department of Mines and Petroleum Resources.

These guidelines were finally completed in March 1976 and a copy is included in this thesis as Appendix I. The review process consists of the five-step procedure shown in Figure 15. While these guidelines are a long-overdue step towards the rationalization of coal development in B.C., they have two serious limitations:

1. They do not, at present, have any legislative base, and are considered "guidelines" in the literal sense. Their implementation is dependent upon both a number of provincial statutes, and the willingness of the various responsible agencies to enforce these. Presumably if an agency refused to co-operate in the process, the guidelines could be established as regulations of the

Figure 15. The review process for coal developments.



Source: Guidelines for Coal Development Environment and Land Use Committee March 1976.

Environment and Land Use Act, however, so far this has not been done.

2. While the guidelines establish a process for assessing environmental impact, they lack the jurisdiction to either limit environmental degradation or set standards for mitigative procedures.

In terms of reclamation, only the Department of Mines and Petroleum Resources has the jurisdiction to set standards and, as will be discussed in the next section, it has yet to address this subject in any meaningful way.

5.2 Standards of Reclamation

> It is the duty of every owner, agent, or manager of a surface mine to institute and carry out a programme for the protection and reclamation of the surface of the land and watercourses affected thereby, and, on the discontinuance or abandonment of a surface mine, to undertake and complete the programme to leave the land and watercourses *in a condition satisfactory to the minister* . . .
>
> Subsection (1) of Section 8, Coal Mines Regulation Act

In 1969 this section of the reclamation legislation was criticized by both environmentalists and the mining industry for its vagueness as to what constituted adequate reclamation. On the one hand, environmentalists felt that the vagueness would not guarantee environmental protection, while on the other hand, mine planners complained

that planning and budgeting for reclamation was impossible without clear objectives. Nine years after the introduction of the legislation reclamation standards have still not been set, and the Department of Mines and Petroleum Resources has yet to initiate the type of investigations that could produce effective, quantitative standards. The Department appears to recognize the necessity of standards but has yet to supply the Reclamation Section with the staff to carry out the necessary studies. B.C. probably has greater environmental diversity than any other political unit in North America, and blanket standards for the whole province will prove unworkable. Specific regulations will have to be set for each biogeoclimatic zone and possibly further refined for each mine site. To do this the Department will require regionally-based staff with both ecological/land-use expertise, and practical reclamation experience.

The lack of definitive reclamation standards has probably been the single greatest impediment to the development of reclamation technology in this province. Management of any kind is impossible without clear objectives, and reclamation is no exception. Until such time as reclamation regulations are established, it is necessary that each company speculate on the form that standards may eventually take, and plan reclamation

programmes accordingly. My intention in this section is to review the approaches to reclamation standards taken by state and federal governments in the U.S.A., to discuss their limitations, and to propose criteria for standards in B.C.

American regulations were chosen for this discussion because environmental conditions, mining techniques and public attitudes are probably closer to the British Columbian situation than are those of any other country. Generally, standards in the United States have been based on slope limitations, vegetative cover, or a combination of the two. The following are examples of each type of legislation:

(a) Standards Based on Slope Limitation

Slope limitations have been imposed either as the maximum slope that may be left when mining operations cease, or as the maximum slope that may be mined. The Mined Land Conservation and Reclamation Act (1968) of the State of Kansas is an example of a regulation imposing slope restrictions after mining. This Act requires the land to be sloped to a rolling terrain with appropriate drainage for all portions of the permit area. Grading specifications for the land are as follows:

(i) Maximum allowable slope: 25°

(ii) Maximum slope lengths:

Average Slope	Maximum Unterraced Slope Length (m.)
$0-4^{\circ}$	No limit
$4-8^{\circ}$	90 m.
$8-15^{\circ}$	45 m.
$15-25^{\circ}$	25 m.

The U.S. Coal Mine Surface Protection Act, a Federal statute, is an example of the type of regulation which limits the slope that can be mined. In this Act, overburden removal is banned on slopes greater than 20°, and no waste dumps may be constructed on slopes greater than 14°.

Even more restrictive is the controversial Bill S. 425-Surface Mining Legislation which first passed the U.S. Senate on October 9th, 1973 and has subsequently been vetoed twice by the President. This Bill applies to metal, phosphate, and coal mines and contains provisions for slope limitations on both final contours and the areas that may be mined. The return of the land to its original contour is cited as a preliminary objective of reclamation, and in addition, the Bill calls for an immediate, country-wide study of slope limitations. Provision is made to ban mining on areas that the Secretary of the Interior declares "unsuitable for mining" or where, in his opinion, "full" reclamation cannot be achieved. Grounds for such a ban

include excessive slope and areas of "critical environmental concern".

(b) Standards Based on Vegetation Cover

The reclamation regulations of the West Virginia Surface Mining Act 1967 contain some restrictions on slope, however, the main reclamation criteria are in the form of standards for vegetation cover as follows:

i. Standards for perennial grasses and legumes. Ground cover shall be at least 80%. Bare areas shall not exceed ¼ acre, nor total more than 20% of the area seeded.

ii. Standards for woody plants. A minimum survival of 600 trees and/or shrubs per acre is required. Distribution of plants shall be generally uniform, with no areas larger than ¼ acre of substandard stocking.

iii. Standards for mixtures of woody plants and grasses and legumes. Ground cover of grasses and legumes shall be at least 50% and a minimum survival of 360 trees and/or shrubs per acre is required. Bare areas shall not exceed ¼ acre in size nor total more than 30% of the area seeded or planted.

Though American reclamation statutes contain many good features, the general impression is that they have been hastily prepared to satisfy an increasing public demand for controls on surface mining. Some of the Federal and State regulations have been criticized by both industry and environmental groups as being so inflexible that good reclamation is frustrated, and unnecessarily costly to the

mining operator without achieving the desired objective of environmental protection because local conditions are not taken into account. In particular, the standard requiring regrading to original contour has been attacked on the grounds that at least partial retention of terraced dump systems on sloping ground will much more effectively control surface run-off and soil erosion.

In a British Columbian context, the blanket slope or vegetation standards that are common in many state regulations are of little value because of the relatively more complex nature of our soils, climate, and topography. Surface stability, while heavily dependent on slope, is influenced by a variety of other factors and thus slope design criteria must be site specific. Likewise, levels of natural ground cover are dependent upon a number of environmental variables and vegetation standards must take this into account.

The formulation of definitive reclamation standards for the province, or even for coal mining in the East Kootenay, is a number of years away, and will require a serious and well planned study programme involving the co-operation of government and industry. However, the criteria on which these standards should be based are already apparent and can be used in a subjective way to establish objectives for reclamation planning. Briefly these criteria are as follows:

(a) Reclamation Land-Use Objectives

Section 8 of the Coal Mines Regulation Act provides for the following discussion in the reclamation report:

> A programme for reclamation and conservation of the land . . . on the discontinuance or abandonment of the mining operation with particular reference to . . . the potential use of the land, having regard to its best and fullest use . . .

The intent of the legislation would seem to be that mined land will be returned to the best potential land-use consistent with local site conditions. It is important that land-use objectives be set before reclamation is attempted because these will determine both the final configuration of the land and the species mixtures used in revegetation. Land use objectives may vary from simply the restoration of watershed values on areas where the potential for other resources is low; through the establishment or restoration of wildlife habitat, range for domestic animals, commercial forests, or agriculture; to the provision of recreational, residential, or industrial facilities, on mines in an urban environment. There are, however, two implications of land-use objectives which must be accepted by both the public and the mining industry, and these are:

i. Some features of the mining environment, e.g. the pit itself, are unreclaimable

and therefore defy the setting of reclamation standards. The loss of this land is, presumably, a social cost that the public accepted when mining was allowed to proceed, however, the mining operator should accept the responsibility to compensate for this loss by restoring other areas to greater productivity or a higher use than existed before mining.

ii. Where it is desirable that a land area be returned to a use substantially higher than the premining condition, in excess of that necessary to compensate for unreclaimable areas, the mining operator cannot be expected to bear the full cost.

(b) Surface Drainage Control

Reclamation is, in large part, the reconstruction of a watershed, and provision for permanent surface drainage control is as important as revegetation. Slope and drainage design can be judged on a relatively subjective basis but the true measure is reflected in the regime and quality of surface water originating from the mine site. For this reason it is desirable that a comprehensive water monitoring programme be established below the mining area to assess stream conditions prior to mining, during mining, and throughout the reclamation/rehabilitation process. In the

case of established mines where baseline data has not been collected, hydrologic information should be collected from a comparable undisturbed watershed.

(c) Vegetation Cover

Total vegetation cover, measured as ground and foliage cover, is a gross measure of both erosion control and reclamation success. Standards of vegetation cover must be related to the degree of cover that existed on the site prior to mining, or where mining is already underway, on comparable areas adjacent to the mine.

(d) Ecological Stability

The stability of a man-made vegetation type is a function of the kinds of species present, species diversity, and the number of individual plants per unit area. The objective in reclamation should be to use native or adapted exotic species capable of growing on disturbed soils, and to establish as many of these species and as many individual plants as the area is capable of supporting. Like ground cover, species diversity is also dependent on a number of site-specific environmental factors. Standards of diversity must be related to vegetation types native to the mine site. Judgement of the suitability of the species used in reclamation will be, to a large extent, subjective.

(e) Plant Vigour

Before the return of a reclamation bond to a mining operator, it must be established that the vegetation community is in a healthy state and self perpetuating. Plant health, or vigour, may be measured in the following ways; biomass production, increases in ground and foliage cover, chemical composition, and the production of viable seeds. As with ground cover and diversity, plant vigour will have to be related to natural vegetation adjacent to the mine, both to establish natural levels of plant vigour, and to separate changes in plant vigour due, for example to nutrient deficiency on a mined site from those due to normal climatic fluctuations.

The assessment of land-use objectives is essentially subjective, and ultimately will be the responsibility of the Reclamation Land-Use Advisory Committee. The assessment of surface drainage control, vegetation cover, ecological stability and plant vigour is, in large part, objective, and will require the establishment of a comprehensive, continuous monitoring programme by the mining company.

CHAPTER VI

THE RECLAMATION PROGRAMME

6.1 Objectives of Reclamation

6.1.1 General Statement

The basic objective of Kaiser Resources Ltd.'s reclamation programme is the rehabilitation of all industrially disturbed lands in the Natal area associated with both past and present mining activity, and of all exploration areas disturbed by the Company's exploration programme.

In order to understand this objective it is necessary to make a clear distinction between reclamation or rehabilitation, two terms which are synonymous, and restoration. The former terms imply a process that returns the land to a form and productivity consistent with stated land-use objectives; including a self-perpetuating vegetation cover, and a stable ecological state that does not contribute substantially to environmental deterioration and is compatible with surrounding aesthetic values. The latter term implies a process by which mined land is returned to its pre-mining condition. Reclamation or rehabilitation is possible given good mine planning, and a well designed

reclamation programme. Restoration is beyond the scope of present technology and may never be possible given the nature of mountain coal mining.

6.1.2 Land Use Objectives

The reclamation of disturbed lands on the K.R.L. coal property will have two main goals:

1. To re-establish watershed values by either mechanical means or the establishment of a self sustaining vegetation cover as soon as possible after the cessation of mining activities on any particular parcel of land.

2. To accomplish watershed rehabilitation in a manner that is compatible with the potential prime surface use of the land and consistent with post-mining site conditions.

As discussed in Chapter IV, the main land uses prior to mining were forestry, marginal agriculture, and recreation. In addition, the area provided important winter and summer range for wild ungulates. Because of climatic constraints, agricultural production has never been significant even in a local context and thus agriculture will not be considered as a viable land-use objective in reclamation. The most productive forest sites in the area occur at elevations below 1,525 m., however, the calcareous nature of the parent materials at these elevations will probably preclude the re-establishment of coniferous trees in a reclamation programme except on the most lightly disturbed areas. Therefore, the main land-use objectives in the reclamation programme consistent with the primary goal of watershed

stabilization, will be:

1. To provide food and, ultimately, cover for mule deer, Rocky Mountain elk and moose through the establishment of appropriate plant communities.
2. To re-establish aesthetic values on all disturbed lands and, where possible, to enhance opportunities for recreation.

6.2 Constraints To Reclamation

Very little quantitative work has been undertaken in British Columbia on the factors affecting plant growth on spoil and refuse materials. However, visual observations of the success of both natural plant invasion and reclamation in the East Kootenay indicate that the main constraints to the reclamation of disturbances associated with coal mining are surface instability, excessively high soil temperatures, soil compaction and, to a lesser extent, both soil chemistry, and increasing elevation.

6.2.1 Surface Instability

The occurrence of major earth slides in overburden dumps on both the Kaiser Resources (see Figures 9 a, b, and c) and the Fording Coal operations are evidence of the existence of instability in the engineering context of deep-seated failures. However, even when dumps have reached

macro-stability, or where they have been so designed, the agencies of surface instability - rain drop impact and overland water-flow - can effectively prevent plant establishment. Two fairly comprehensive ecological studies, Brierly (1956) and Hall (1957), have been carried out on spoil dumps and refuse banks in Great Britain. Both studies concluded that surface instability was the most important factor limiting plant colonization. Brierly found vegetation establishment to be most severely hampered on steep piles comprised of either fine glacial materials, or structureless materials such as oxidized coal and shale. Ashley (1950) in Pennsylvania found that overland movement of weathered shale particles on steep ungraded mine spoils prevented plant establishment for 25 years after mining. In personal communication, H.R. Green of the Alberta Research Council has stated that studies by his organization have indicated that long dump outslopes standing at the angle of repose in the Northern Rockies of Alberta remain surface active for 30 years or more. Harrison (1974) has attempted crude measurements of surface movement on coal dumps in the East Kootenay. The degree of movement was expressed as the amount of material (gms.) that would pass across an imaginary line one metre long aligned with the strike of the slope in a 24 hour period. He found that for coal spoils of sand and pebble-sized material the soil

movement at different slopes was as follows:

Slope (^{o})	Soil Movement (gms/day/metre)
28	30
35	160
37	1600

He concluded that, for overburden materials in the East Kootenay, the maximum angle at which vegetation can be established (the "biological Angle of Repose") lies between 25° and 30°; 7° - 12° less than the physical angle of repose.

Probably the most comprehensive reclamation study available, and the one which most closely approaches the East Kootenay coal mine situation, was carried out by the U.S. Forest Service at the request of the phosphate mining companies of the Rocky Mountain Region of Idaho and Montana (Schultz and Ditmer, 1971). Among the recommendations and conclusions arising from this study were:

1. Growth and survival of trees and shrubs on 33° (65%) slopes are severely impaired by surface instability. Such slopes should be avoided wherever possible, and dumps either designed or resloped to 22° - 27° (40% - 50%).
2. Contour terracing is recommended where slope angle cannot be flattened to 22°. Terraces

should be constructed at 7.5 - 15 m. vertical intervals with check dams at 30 m. intervals along the terrace. Both terraces and cross dykes should be designed for storage of peak runoff.

On the Kaiser Resources Ltd. mining operation, as with other mountain coal mines in B.C., surface instability is likely to be the single most important factor limiting vegetation establishment on disturbed slopes steeper than 25° (Figures 16a and b). Some form of slope moderation is essential if reclamation is to be successful.

A localized problem of stability involves spoils and waste materials that contain considerable proportions of fine oxidized coal or carbonaceous shales. These materials, because of their dark colour, absorb heat and surface dry very quickly. Once dry, the low specific gravity and lack of internal cohesion leads to severe wind erosion. This problem is acute on tailings lagoons where the flat surfaces further aggravate the situation. The only solution appears to be to keep these materials moist until a vegetation cover is sufficiently established to control wind erosion.

6.2.2 Soil Temperature

Harrison (1974) has found, in studies in the Crowsnest area, that soil temperature varies with aspect, elevation, slope, and spoil type. Highest temperatures were

Figure 16. Erosion gullies on the face of the Harmer Knob Dumps.

recorded at lower elevations (1,070 - 1,525 m.), on southerly aspects sloping at 26°, and on dark coloured-spoil. The maximum temperature recorded in the top 2 cm. was 70° C; approximately 20°C above the thermal death point for plant tissues. Laboratory studies on a fine coal spoil with a 30 per cent ash content "reveal a thermal conductivity equivalent to loose snow and a specific heat close to the value of iron." Cooler temperatures were recorded with increasing elevation, lighter coloured spoils, decreasing slope, and other than southerly aspects. Of the four factors affecting temperature control, material type and aspect appear to be the most important.

Reclamation programmes in the East Kootenay coal belt must stress the disposal of black spoils or refuse on cooler aspects, the creation of micro-relief on southerly slopes, and, in extreme cases, irrigation until a vegetation cover is fully established.

6.2.3 Soil Compaction

Much of the existing quantitative data on the effects of soil compaction on plant growth relates to site disturbance during logging. A number of studies have concluded that soil compaction resulting from logging leads to serious soil erosion by decreasing soil permeability and has serious effects on subsequent seedling growth and survival. Steinbrenner and Gessel (1955-1) reported that tractor

logging resulted in a 93 per cent decrease in skid road permeability, while Tackle (1962) found skid road soils to have an infiltration rate only 4.1 per cent of adjacent undisturbed soils. Three studies, Steinbrenner and Gessel (1955-2), Foil (1965) and Youngberg (1959), found both stocking and growth of seedlings to be significantly lower on compacted areas than on undisturbed soil. Youngberg attributed this to poor soil aeration, mechanical root impedance, reduced organic matter, reduced nitrogen availability and moisture stress due to reduced infiltration.

Similar quantitative data are not available for mining operations, however, the degree of compaction on haul roads, dumping platforms, and service areas is likely to be even greater than that found on logging skid roads because of the much larger equipment and the longer period of use. Such sites will not only be difficult to revegetate but, by collecting and concentrating run-off water, will lead to instability and erosion of down-slope areas. Jones (per.comm.) in a study on the Baldy surface mine of the effects of slope and aspect on vegetation survival, found that both vegetation cover of grasses and survival of coniferous seedlings were very low on the flat or gently sloping dump terraces. He attributed this to soil compaction during dump construction. This condition has persisted for

approximately 20 years, since this portion of the Baldy surface mine was mined in the eary 1950's.

The extreme soil compaction occurring on haul roads, dump platforms and service areas will only be alleviated by ripping to a depth of 1 m. with a large bulldozer. Some soil compaction occurs during resloping operations but this is seldom serious and can be overcome by harrowing prior to seeding.

6.2.4 Soil Chemistry

During the years 1971-1975 representative soil samples were collected from the various types of waste materials on the Kaiser mining property. These samples were submitted to the Soil Analysis Laboratory, Field Crops Branch, B.C. Ministry of Agriculture for a standard agricultural soil analysis. In all, forty-two samples have been collected and the results of chemical analyses are shown in Table 20.

In the discussions below general value ratings are given according to the following tables:

(a) Relative values of pH (from Dawson and Kelly, 1965)

Moderately alkaline	8.0 - 9.0
Mildly alkaline	7.3 - 8.0
Neutral	6.5 - 7.3
Slightly acid	6.0 - 6.5
Moderately acid	5.5 - 6.0
Strongly acid	4.5 - 5.5

Table 20

Organic Matter, pH, Soluble Salts and Available Nutrients For Six Types of Mine Waste On The Kaiser Resources Ltd. Operation

Type of Waste Material	Soil Texture	No. of Samples	Organic Matter %	pH	Soluble Salts (mmhos/cm)	Available Nutrients (ppm)			
						P	K	Ca	Mg
Overburden: 3500-5000' Elevation	Loams	6	6.7±4.6	6.0±0.3	0.16±0.03	122.5±28.2	275.3±71.1	908±405.5	155±74.5
	Clays	3	8.9±5.5	6.8±0.8	0.26±0.16	76.2 ±50.4	178.5±95.9	1233.5±401.2	227.0±84.0
	Silts	1	9.0	6.0	0.18	92.0	195	1350	190
Overburden: 5000' + Elevation	Clays	4	8.9±7.7	5.6±0.34	0.14±0.02	30.7 ± 7.3	92.8±39.4	1237.5±902.2	187.1±107.7
	Loams	9	5.1±2.6	5.7±0.51	0.17±0.06	101.3 ±40.3	106.1±56.4	727.5±497.7	164.4±113.4
Oxidized Coal and Shale Spoil	-	5	-	6.7±0.3	0.47±0.42	7.8 ± 2.6	98.1±50.8	1900±523.15	294.0± 13.4
Coarse Coal Refuse	-	6	-	7.3±0.42	0.78±0.61	31.2 ±11.1	65.1±40.5	600±324.1	77.6± 21.7
Fine Coal Refuse[1]	-	Unknown	-	7.1	1.71	6.3	14.5	701.0	39.0
Sites Disturbed by Facilities Construction: Valley Bottoms	Sandy clays	2	2.5±0.40	8.5±0.07	0.45±0.13	3.3±1.1	75.5±16.3	2675.0±530.1	300+

1. Courtesy of D.L. Lavkulich, Department of Soil Science, Faculty of Agriculture, U.B.C. All other analyses were done by the Soils Laboratory, Field Crops Branch, British Columbia Ministry of Agriculture.

(b) Relative values of available nutrients (Neufeld, per. comm.)

Element	Relative Value (ppm) Low	Medium	High
Phosphorous	15	16 - 40	41 ≤
Potassium	75	76 - 125	126 ≤
Magnesium	25	26 - 50	51 ≤

These are very general interpretations and the actual values can vary depending on the type of vegetation and the management regime.

1. Soil Reaction

In general, overburden on the mining property varies from slightly acid to mildly alkaline below 1,525 m. elevation, and from strongly acid to slightly acid above 1,525 m. elevation. Refuse materials vary from neutral to mildly acid. Clays exposed during road and facilities construction in the Elkview area show the highest pH value recorded and can be rated as moderately alkaline.

2. Soluble Salts

An electrical conductivity value of 3 - 4 mmhos/cm. is usually considered to indicate a level of soluble salts high enough to interfere with plant growth. Only one sample contained a value of this level or higher and that sample is not included in Table 20. In a set of analyses done in 1969, one sample from the Michel East refuse dump showed an electrical conductivity value of

28.00 mmhos/cm. and a pH of 2.5. This anomaly was explained when it was discovered that the Canadian Pacific Railway had regularly used this area to dispose of sweepings from rail cars transporting sulphur from the natural gas fields of Southern Alberta.

3. Available Phosphorus

Phosphorus values are medium to high for all materials except those containing large quantities of oxidized coal and shale (both fine refuse and certain mine spoils) and the sandy clays in the Elkview area. In the later case, the low availability of phosphorus may well be due solely to high pH values.

4. Available Potassium

Potassium values are highly variable. Levels are clearly adequate only in the overburden materials below 1,525 m. elevation. Available potassium in fine coal refuse is extremely low and would appear to be limiting.

5. Available Magnesium

Magnesium levels are adequate in all materials except the high elevation spoils and the refuse materials.

6. Available Nitrogen

The Ministry of Agriculture does not normally include a nitrogen test in a standard agriculture analysis. Fertilizer recommendations for nitrogen are normally based on field trials, however, nitrogen is assumed to be

required on all sites.

While the standard agricultural analyses are satisfactory for agricultural soils, they do not provide sufficient information to evaluate the potential for long-term plant growth of mine spoils and refuse. Dr. L. Lavkulich of the Faculty of Agriculture, University of British Columbia has undertaken a comprehensive analysis of mine wastes in British Columbia. The soil parameters measured in his analyses are as follows (Lavkulich, per. comm.):

- pH; % organic matter; cation exchange capacity; cation saturation,
- % nitrogen; % sulphur; available phosphorus, calcium, magnesium, potassium, copper, zinc, iron and manganese,
- total elemental analysis; - calcium, magnesium, sodium, potassium, iron, manganese, aluminium, silicon, cadmium, cobalt, cromium, copper, molibdinium, nickel, lead, titanium and zinc,
- electrical conductivity and soluble salts: calcium, magnesium, solium, potassium, and carbonate and sulphuric ions,
- physical data on texture, particle density and water retention

The Kaiser mining property has been included in this study, and it is recommended that any further programmes of soil analysis be designed on the basis of a thorough assessment of Dr. Lavkulich's results.

6.2.5 Elevation

In the course of my work with both Kaiser Resources Ltd. and the Department of Mines and Petroleum Resources, I have had many discussions with professional colleagues, student groups and conservation organizations about the reclamation of mined-lands in the Rocky Mountain coal belt. In my experience, more concern has been expressed about "high" elevation as the most important factor limiting effective reclamation than for any other environmental factor.

Very little work has been undertaken in the Rocky Mountains on the effect of increasing elevation on reclamation success. While species sown in test plots at 2,100 m. on the Kaiser mining property (see Section 6.3 below) have grown well over five seasons, this does not demonstrate that a permanent plant community can be established. In the light of these comments I am aware that the following statement is, to a large degree, speculative, however, in my opinion, given a wise choice of species and the range of elevations encountered on the Kaiser mining property, elevation *per se* is not an important factor in reclamation success.

As previously discussed in Section 2.4 above, extreme minimum winter temperatures during the months of November to March are invariably lower in the valley bottoms than on Harmer Ridge. The greater snow depths at higher elevations provide added protection to overwintering vegetation since snow depth at lower elevations tends to be limited by wind action.

Growing season and the frost-free period on Harmer Ridge are not substantially different than those in the valley bottom, being 80 per cent and 75 per cent respectively. In addition, precipitation during the months May to September is 50 per cent higher on Harmer Ridge, and evapo-transpiration probably much lower. Casual observations over a two year period revealed substantial soil moisture within 1 cm. of the soil surface through the summer months on all but the coarsest soil types. For these reasons, it is my opinion that the sub-alpine areas on Harmer and Natal Ridges are far more hospitable sites for plant growth than the southerly aspects at lower elevations.

The main revegetation problems at higher elevations will probably occur on those areas of northerly and easterly aspect where snowpack persists well into the growing season. On Harmer Ridge such areas are very limited in extent and probably did not support a substantial vegetation cover under natural conditions prior to mining. These limited

areas will require stabilization by mechanical methods rather than by revegetation.

Needle ice action, frost thrusting and solifluction, noted by various authors as problems in high elevation revegetation (Brink, 1964; Gradwell, 1954; Ward, 1974) have not been observed on any of the areas seeded on Harmer Ridge.

6.3 Species Selection

6.3.1 Grasses and Forbs

Because of the difficulties of seed collection, the use of native grasses and forbs on a large scale is, as yet, impractical. In 1970 advice on mixtures of domestic grasses and legumes was sought from a number of agencies including the Faculty of Agricultural Sciences, University of British Columbia, the B.C. Department of Agriculture, and Buckerfield's Ltd. On the basis of recommendations obtained from these organizations, three seed mixtures were formulated which were subsequently used from 1970-75 inclusive. These mixtures are shown in Table 21. In general, mixture i has been used at elevations over 1,500 m. while all three mixtures have been used rather indiscriminantly at lower elevations.

During the last two years the need for more site-specific seed prescriptions has been recognized. Table 22

Table 21

Grass and Legume* Mixtures Used In The Reclamation Programme (1971-75)

i	Kentucky bluegrass var nugget	15 %
	Creeping red fescue	15 %
	Slender wheatgrass	10 %
	Crested wheatgrass	10 %
	Timothy	10 %
	Smooth brome	10 %
	Red top	5 %
	Sanfoin	10 %
	Mixed sweet clover	5 %
	Birdsfoot trefoil	5 %
	Alsike clover	5 %
ii	Kentucky bluegrass	15 %
	Timothy	10 %
	Smooth brome	30 %
	Alsike clover	15 %
	Crested wheatgrass var nordan	30 %
iii	Canada bluegrass	15 %
	Red top	10 %
	Perennial ryegrass	30 %
	Yellow sweet clover	25 %
	Crested wheatgrass var nordan	20 %

* For scientific names see Table 23.

shows the recommended seed mixtures for the next management period for various combinations of elevation and aspect. These mixtures are based on the results of Kaiser Resources Ltd.'s reclamation assessment programme, on information from recent publications (Elliott and Bolton, 1972; Berg, 1974; Haffenrichter *et al* 1968; and Anderson, 1975), and on inspection field notes compiled by the writer as Reclamation Inspector, B.C. Department of Mines and Petroleum Resources.

Despite some initial successes in operational seeding using broadly based seed mixtures, it is evident that considerably more attention must be paid to long-term species testing. Little is known about either the persistence or the ability to reproduce of common, commercially-available grasses and legumes at higher elevations. It is quite conceivable that vigorous, short-lived perennials within a seed mix may out-compete long-lived, better adapted species which are slow to establish, particularly given the high seeding rates common in reclamation operations. For this reason a series of long-term species trials has been proposed for the Kaiser Resources Ltd. mining area in which species will be planted singly in meter-square plots over the range of aspects, elevations and spoil types occurring there. Lists of grass and legume species to be included in this trial plot programme

Table 22

Suggested Seed Mixtures* For The
Kaiser Resources Ltd. Mining Area 1976-78

(a) Southerly Aspects at Elevations of 1,050 - 1,680 m.

Intermediate wheatgrass	20 %
Pubescent wheatgrass	20 %
Crested wheatgrass	15 %
Smooth brome	15 %
Hard fescue	10 %
Alfalfa	15 %
Sweet clover (mixed)	5 %

(b) Northerly Aspects at Elevations of 1,050 - 1,680 m.

Intermediate wheatgrass	20 %
Smooth brome	20 %
Canada bluegrass	10 %
Creeping red fescue	10 %
Red top	10 %
Timothy	10 %
Alfalfa	10 %
White dutch clover	5 %
Sweet clover (mixed)	5 %

(c) Alpine and Sub-alpine areas. All aspects, at elevations over 1,680 m.

Meadow foxtail	20 %
Smooth brome (vars Baylor or Manchar)	20 %
Pubescent wheatgrass	10 %
Slender wheatgrass	10 %
Timothy	5 %
Creeping red fescue (var Erica)	5 %
Orchardgrass (var Chinook)	5 %
Kentucky bluegrass (var Sydsport)	5 %
Red top	5 %
White clover	10 %
Birdsfoot trefoil	5 %

* For scientific names see Table 23.

are shown in Table 23 and Table 24 respectively. The first such trial was established on Harmer Ridge at an elevation of 6,900 feet in 1972 (Figure 17). Measurements of ground cover and plant height for each of the three years subsequent to sowing are shown in Table 25.

Further research should be undertaken to determine the feasibility of using native forbs and grasses in the programme. Should the long-term trials of commercial species show that they neither persist nor produce viable seeds on certain portions of the mining area, then they can be considered only as temporary nurse crops and soil conditioners, and the establishment of native species will have to be encouraged. While smaller disturbed areas may seed naturally, an 800 hectare surface mine obviously presents a formidable problem in natural seed dispersal. A number of mining companies in eastern Montana are using mini-combine harvesters to obtain seed from native ranges (Pendergast, per. comm.). It is suggested that investigations be undertaken during the present management period to determine the viability of native forb and grass seed, the periodicity of seed crops, and methods of collecting seed in bulk.

Table 23

Suggested Commercial Grass Species For Reclamation Testing

Agropyron cristatum (L.) Gaertn.	Crested wheatgrass
A. elongatum (Host) Beauv.	Tall wheatgrass
A. intermedium (Host) Beauv.	Intermediate wheatgrass
A. riparium	Streambank wheatgrass
A. trachycaulum Link (Malte)	Slender wheatgrass
A. trichophorum (Link) Richt.	Pubescent wheatgrass
Agrostis alba L.	Red top
Alopecuris pratensis L.	Meadow foxtail
A. arundinaceae	Creeping foxtail
Bromus inermis Leys	Smooth brome
Bromus spp.	Polar brome
Dactylis glomerata L.	Orchardgrass
Festuca arundinaceae Schreb.	Tall fescue
F. rubra L.	Creeping red fescue
F. rubra L. var *commutata* Gaud.	Chewings fescue
F. ovina L. var *duriscula*	Hard fescue
Lolium penerne L.	Perennial ryegrass
Phleum pratense L.	Timothy
Poa compressa L.	Canada bluegrass
P. pratense L.	Kentucky bluegrass

Table 24

Suggested Commercial Legume Species For Reclamation Testing

Lotus corniculatus L.	Birdsfoot trefoil
Medicago sativa L.	Alfalfa
Melitotus alba Desr.	White sweet clover
M. officinalis (L.) Lam.	Yellow sweet clover
Trifolium hybridum L.	Tetra alsike
T. pratense L.	Red clover
T. repens L.	White clover

Figure 17. Species trial on Harmer Ridge.

1972

1975

Table 25

Ground Cover and Plant Height For Fifteen Species of Grasses Sown in Trial Plots at an Elevation of 2,100 m.

Species	Ground Cover Percentage			Average Plant Height (cm.)		
	1972	1973	1974	1972	1973	1974
Crested wheatgrass var Nordan (Source No. 1)	39	30	5	4.6	10.2	38.1
Crested wheatgrass var Nordan (Source No. 2)	29	40	50	3.8	12.7	55.9
Tall wheatgrass (Source No. 1)	34	19	25	6.1	11.4	61.0
Tall wheatgrass (Source No. 2)	40	64	5	4.6	7.9	45.7
Pubescent wheatgrass	72	75	75	5.8	13.2	61.0
Red top (Source No. 1)	59	85	60	4.6	10.2	40.6
Red top (Source No. 2)	75	85	80	3.3	8.9	35.6
Meadow foxtail	83	95	90	4.8	16.3	61.0
Smooth brome var Manchar	85	90	70	7.1	12.7	30.5
Smooth brome var Baylor	44	50	90	8.1	11.7	35.6
Polar brome	58	80	75	6.1	15.7	40.6
Orchardgrass var Chinook	87	70	85	5.6	12.7	30.5
Tall fescue	33	15	2	3.6	5.1	25.4
Creeping red fescue var Dawson	58	70	60	3.0	5.1	20.3
Creeping red fescue var Erica	42	60	80	1.9	7.6	17.8
Creeping red fescue var Reptans	43	60	60	1.9	8.9	22.9
Chewings fescue var Highlight	44	70	60	1.3	3.8	15.2
Perennial ryegrass var Norlea	49	25	40	3.0	5.1	17.8
Timothy var Astra	43	50	15	1.3	5.1	17.8
Timothy var Sport creeping	41	55	55	1.3	2.5	17.8
Timothy var Climax	41	55	55	3.0	8.9	25.4
Canada bluegrass	4	12	10	0.8	2.5	15.2
Canada bluegrass var Canon	12	15	25	1.0	3.8	15.2
Kentucky bluegrass var Primo	60	55	55	2.0	3.8	15.2
Kentucky bluegrass var Sydsport	65	80	85	2.3	2.5	15.2
Kentucky bluegrass (Source No. 1)	12	15	10	1.3	3.8	10.2
Kentucky bluegrass (Source No. 2)	5	20	20	1.3	3.8	10.2
Kentucky bluegrass var Nugget	2	3	5	1.3	1.3	10.2

6.3.2 Trees and Shrubs

It is Kaiser Resources Ltd.'s policy to use indigenous tree and shrub species of local provenance wherever possible in the reclamation programme. Though this may initially involve greater expense and effort than the purchase of exotic planting stock, particularly in seed procurement and research on seed treatments, the end result is planting stock completely adapted to local climatic conditions. Exotic species will not be totally excluded from the reclamation programme since they have two distinct advantages over native species; first, seed is often available in quantity from commercial seed dealers, and second, methods of propagation are usually well established. However, exotics will be used with discretion and only after thorough testing to ensure that they are adaptable to local site conditions and do not have the capacity to become undesirable weed species.

In general, the following criteria, ranked in order of importance, will be used as a basis for the selection of woody plant species:

1. native or naturalized,
2. easily reproduceable in large quantities,
3. ability to regenerate on and stabilize disturbed land,
4. nitrogen fixing ability,

5. high value for a specific land-use objective,
6. proven effective in reclamation work elsewhere.

On the mining area there are a number of biological and physical factors which must be taken into consideration in the choice of a species mix for the revegetation of any particular site:

1. Ecological Succession

Ecological succession is the orderly process of vegetational change that occurs on a given site following a major disturbance (i.e. fire, logging, mining, disease or insect outbreaks). Typically succession begins with pioneer vegetation and moves through a series of more mature communities until a relatively stable community is evolved which is in equilibrium with local site conditions. The final or mature community is called the climax. In any particular locality, pioneer vegetation is generally more tolerant of adverse conditions such as poor nutrition and moisture stress, while climax communities establish only after these conditions have been modified through ecological succession. For reclamation purposes, species should be selected either from disturbed areas in the early stages of pioneer vegetation, or from areas of physiographic sub-climax where soil and microclimatic factors prevent the development of the common zonal climax. In the Natal vicinity, areas of past

disturbance include old industrial sites, logging clear-cuts, abandoned exploration operations, and some of the early surface mines. The sub-climax grass/shrub communities on southerly aspects in the area provide a variety of hardy, drought-tolerant and, in many instances, nitrogen-fixing species that have significant potential in a reclamation programme.

2. Climate and Topography

Variations of climate and topography can affect the adaptability of even native species, and this is a particularly important consideration on the Kaiser Resources Ltd. operation where mining activities span an altitudinal range of more than 1,070 m. It is essential that good records be kept during the collection of reproductive material, and that planting stock be used within ± 150 m. of the elevation from which the seeds or cuttings were collected.

3. Soils and Geology

The coniferous forests that occurred on many portions of Natal and Harmer Ridges prior to mining were a reflection of soil processes that took place over thousands of years. As described earlier in this thesis, deposits of calcareous glacial drift, probably originating from the Front Ranges of the Rocky Mountains, occur throughout the area at elevations below 1,680 m. Conifers, being "acid-loving",

invaded these areas only after the upper soil horizons had been gradually acidified by early successional communities. Thus the presence of glacial drift spoil material will, in most cases, preclude the use of conifers in reclamation. At higher elevations, soil appears to have been derived *in situ* from the neutral and acidic rocks of the Fernie Basin. Here, conifers, particularly lodgepole and whitebark pine, appear to be important components of pioneer vegetation and can be used in the reclamation of such sites.

As a general rule deciduous trees and shrubs will be used for the reclamation of sites below 1,680 m. Conifers will be used in the planting programme at lower elevations only on northerly aspects where organic soil horizons are largely intact. At elevations in excess of 1,680 m. a mixture of coniferous and deciduous species will be used.

Table 26 lists the native trees and shrubs presently being considered in the reclamation programme, their growth habit, the zone in which they will be used, and the prime value of each. Table 27 lists the exotic trees and shrubs under consideration. For the most part these are either naturalized in the Natal area or are closely related to native species in the area.

Table 26

Native Trees and Shrubs Considered For Reclamation Planting

Species Name: Scientific	Species Name: Common	Growth Habit	Zone*	Uses
Trees				
Abies lasiocarpa	Subalpine fir	Coniferous tree	ESSF	Aesthetics,wildlife cover
Betula papyrifera	Paper birch	Deciduous tree	IDF	Aesthetics,wildlife food
Larix occidentalis	Western larch	Coniferous tree	IDF	Aesthetics,wildlife cover
Picea engelmanii	Engelmann spruce	Coniferous tree	ESSF	Aesthetics,wildlife cover
Pinus albicaulus	Whitebark pine	Coniferous tree	ESSF	Aesthetics,wildlife cover
Pinus contorta	Lodgepole pine	Coniferous tree	ESSF & IDF	Aesthetics,wildlife cover
Pseutotsuga menziesii	Douglas fir	Coniferous tree	IDF	Aesthetics,wildlife cover
Populus tremuloides	Trembling aspen	Deciduous tree	ESSF & IDF	Ground cover,wildlife food
Populus trichocarpa	Black cottonwood	Deciduous tree	IDF - S	Ground cover,moderate wildlife food
Shrubs				
Acer glabrum var douglasii	Douglas maple	Large shrub	IDF - S	Prime wildlife food
Alnus sinuata	Sitka alder	Small shrub	ESSF	Nitrogen fixation
Alnus tenuifolia	Thinleaf alder	Shrub	IDF	Nitrogen fixation
Amelanchier alnifolia	Saskatoon	Shrub	IDF - S	Prime wildlife food
Arctostaphlos uva-ursi	Kinnikinnik	Trailing evergreen shrub	ESSF & IDS-S	Ground cover,wildlife food
Artemisia frigida	Fringed sage	Small woody perennial	IDF - S	Ground cover
Ceanothus velutinus	Sticky laurel	Evergreen shrub	IDF - S	Nitrogen fixation,wild food
Cornus stolonifera	Red-osier dogwood	Thicket-forming shrub	IDF	Grd cover,prime wild.food
Crataegus douglasii	Hqwthorn	Large shrub	IDF	Aesthetics,wildlife food
Elaeagnus commutata	Silverberry	Thicket-forming shrub	IDF	Nitrogen fixation
Juniperus communis	Common juniper	Evergreen shrub	IDF - S	Aesthetics,wildlife food
Mahonia repens	Oregon grape	Evergreen shrub	IDF - S	Ground cover, wild. food
Menziesia ferruginea	False azalea	Small shrub	ESSF	Ground cover
Penstemon davidsonii var menziesii	Menzies penstemon	Small evergreen shrub	IDF - S	Ground cover
Prunus vinginiana	Chokecherry	Large shrub	IDF - S	Ground cover,wild. food
Ribes cerceum	Sticky currant	Small shrub	IDF - ESSF	Ground cover, wild. food
Rosa spp.	Wild rose	Small, thick-forming shrub	IDF - S	Ground cover, wild. food
Salix spp.	Willow	Shrub	EFFS - IDF	Aesthetics, wildlife food
Sambucus glauca	Blueberry elder	Large shrub	IDF	Prime wildlife food
Shepherdia canadensis	Soopolallie	Shrub	ESSF - IDF-S	Aesthetics, nitro.fixation
Spirea lucida	Flat top spirea	Small woody perennial	IDF - S	Ground cover, wild. food
Symphoricarpos albus	Snowberry	Small thicket-forming shrub	IDF - S	Ground cover
Vaccinium vitis-idaeas	Mountain billberry	Low-growing shrub	ESSF	Ground cover, wild. food

* IDF = Interior Douglas-fir Zone

IDF - S = Southerly aspects, Interior Douglas-fir Zone

ESSF = Engelmann spruce - Subalpine-fir Zone

Table 27

Exotic Trees and Shrubs Being Considered For Reclamation Planting

Species Names				
Scientific	Common	Growth Habit	Zone*	Uses
Trees				
Acer negundo	Manitoba maple	Medium sized tree	IDF	Aesthetics, wildlife food and cover
Picea glauca	White spruce	Coniferous tree	IDF	Aesthetics, cover
Pinus mugo var mugus	Tyolian pine	Small coniferous tree	ESSF	Aesthetics, wildlife cover
Pinus mugo var pumilo	Swiss pine	Small coniferous tree	ESSF	Aesthetics, wildlife cover
Sorbus aucuparia	European mountain ash	Medium sized tree	IDF	Aesthetics, wildlife food
Shrubs				
Alnus glutinosa	European alder	Large shrub	IDF	Nitrogen fixation
Caragana arborescens	Siberian pea shrub	Large shrub	IDF - S	Nitrogen fixation
Cotoneaster acutifolia	Cotoneaster	Small shrub	IDF - S	Wildlife food, ground cover
Elaeagnus angustifolia	Russian olive	Small shrub	IDF - S	Nitrogen fixation
Lonicera tartarica	Tartarian honey suckle	Small shrub	IDF - S	Ground cover
Prunus pennsylvanica	Pincherry	Large shrub	IDF - S	Wildlife food
Shepherdia argentea	Buffaloberry	Small shrub	IDF - S	Nitrogen fixation

* IDF = Interior Douglas-fir Zone
IDF - S = Southerly aspects, Interior Douglas-fir Zone
ESSF = Engelmann spruce - Subalpine-fir Zone

6.4 Seed Collection

Seed demand for a reclamation programme of this size will be relatively small, and sufficient quantities of seed can be collected by hand-stripping fruits from bushes or felled trees. Table 28 gives the time of collection and the interval between good seed years for a number of native trees and shrubs. Of the species listed, only sticky laurel (*Ceanothus velutinus*) requires special collection techniques. If the seed pod clusters are removed from the bush prematurely, the seeds will not ripen. The recommended collection method is to tie cloth or paper bags over the clusters and allow the capsules to dehisce naturally. Though this might appear time consuming it does ultimately save considerable expense in seed extraction and cleaning.

The techniques of seed extraction and cleaning vary, depending on the type of fruit. Dry fruit can be either crushed by hand between bricks and the seeds screened out, or spread out in the sun or a warm room and the capsules allowed to dehisce. Pulpy fruits may be macerated either by hand, if small quantities are involved, or in a commercial blender. If the blender is used, the seeds are barely covered with water, and the machine is run for 15 - 45 seconds. In each case, the macerated fruit is added to an equal volume of water, the sound seeds are

Table 28

Fruit and Seed Characteristics of Native Trees and Shrubs

Species	Interval Between Seed Crops	Time of Collection	Kg. of Seed Per 100 kg. of fruit	No. of Seeds Per Kg. High	Low	Average	Remarks
Subalpine fir	2 - 3 yrs	Sept	N/A	53,600	41,500	47,600	
Paper birch	2 yrs	Aug/Sept	N/A	9,084,600	1,345,050	3,042,900	
Engelmann spruce	2 - 6 yrs	Aug/Sept	N/A	710,000	152,100	297,700	
Whitebark pine	3 - 5 yrs	Sept/Oct	N/A	6,600	4,900	5,700	
Lodgepole pine	Yearly	Aug/Sept	N/A	251,400	174,200	207,300	Cones persist on the tree for many years
Douglas-fir	3 - 11 yrs	July/Aug	N/A	117,500	62,800	97,600	
Douglas-maple	1 - 3 yrs	Aug/Oct	Seeds not separated	44,800	17,200	29,600	Fruit tends to persist for some time in the autumn
Alder	Yearly	Aug/Sept	29	N/A	N/A	1,488,400	Seeds should not be allowed to dry below 10% m.c.
Saskatoon	1 - 3 yrs	July/Aug	4 - 22*	250,900	80,000	180,800	*Certain fruit collections have yielded a large portion of unviable seeds
Kinnikinnik	1 - 5 yrs	July/Aug	N/A	83,600	59,100	71,400	
Sticky laurel	1 - 3 yrs	July/Aug	N/A	335,200	135,400	207,300	Seed pods will not ripen if removed too early. Cloth or paper bags should be tied over seed pod clusters before seeds are shed.
Red-osier dogwood	1 - 2 yrs	July/Aug	44	58,900	30,400	40,800	
Hawthorn	1 - 3 yrs	July/Aug	22 - 33	52,300	47,400	49,800	
Silverberry	1 - 2 yrs	Aug/Sept	20 - 65*	10,100	5,900	8,400	Fruit often persists on the tree through winter. *Highly variable depending upon time of seed collection
Common juniper	Irregular	Aug/Oct	35	120,200	56,100	80,500	Fruit persists on the tree for 2 years
Oregon grape	1 - 3 yrs	June/July	N/A	156,600	119,100	136,700	
Menzies penstemon	N/A	July/Aug	35	N/A	N/A	1,000,000+	
Choke cherry	1 - 2 yrs	July/Aug	40 - 55	18,500	6,000	10,000	
Wild rose	1 - 2 yrs	July/Aug	40	132,300	66,150	N/A	Some difference may exist among the three species of rose
Sticky current	2 - 3 yrs	Aug/Sept	9 - 18	749,700	441,000	595,400	
Blueberry elder	Annual	Aug/Sept	9 - 13	591,100	258,000	452,000	
Soopolallie	Annual	June/Aug*	26	147,700	39,700	90,400	* This species covers a very wide elevational range which affects ripening dates.
Waxberry	Annual	Aug/Sept	7	249,200	119,100	167,600	Fruit persists on the bush over winter.

N/A = information not available.

allowed to settle to the bottom of the container, and the pulp and empty seeds are then strained off. Conifer seeds present special problems in extraction, usually involving kiln drying and separation from the cones in a screen drum. This is best done by a qualified seed dealer. Table 28 indicates expected yield of seed in kg. per 100 kg. of fruit, and both the average and extremes of number of seeds per kg. for 25 native trees and shrubs.

Seed of most species should be air dried for a few days, and then stored in either polythene or cloth bags in the freezing compartment of a refrigerator until used.

A seed collection programme was initiated in 1971 and to date has included 5 species of coniferous trees and 15 species of deciduous trees and shrubs. The cost of seed collection and cleaning for the period 1971-74 is shown in Table 29. It should be noted that this was an experimental programme and therefore much of the cost data are probably inflated, however, it does provide an interesting comparison of the relative costs of different species. One of the major sources of cost variation was the amount of seed collected at any one time. Figure 18 shows the relationship between cost of cleaning and collection of seed, and the amount of seed collected. The general trend is for larger seed lots to show a much lower unit cost than small seed lots.

Table 29

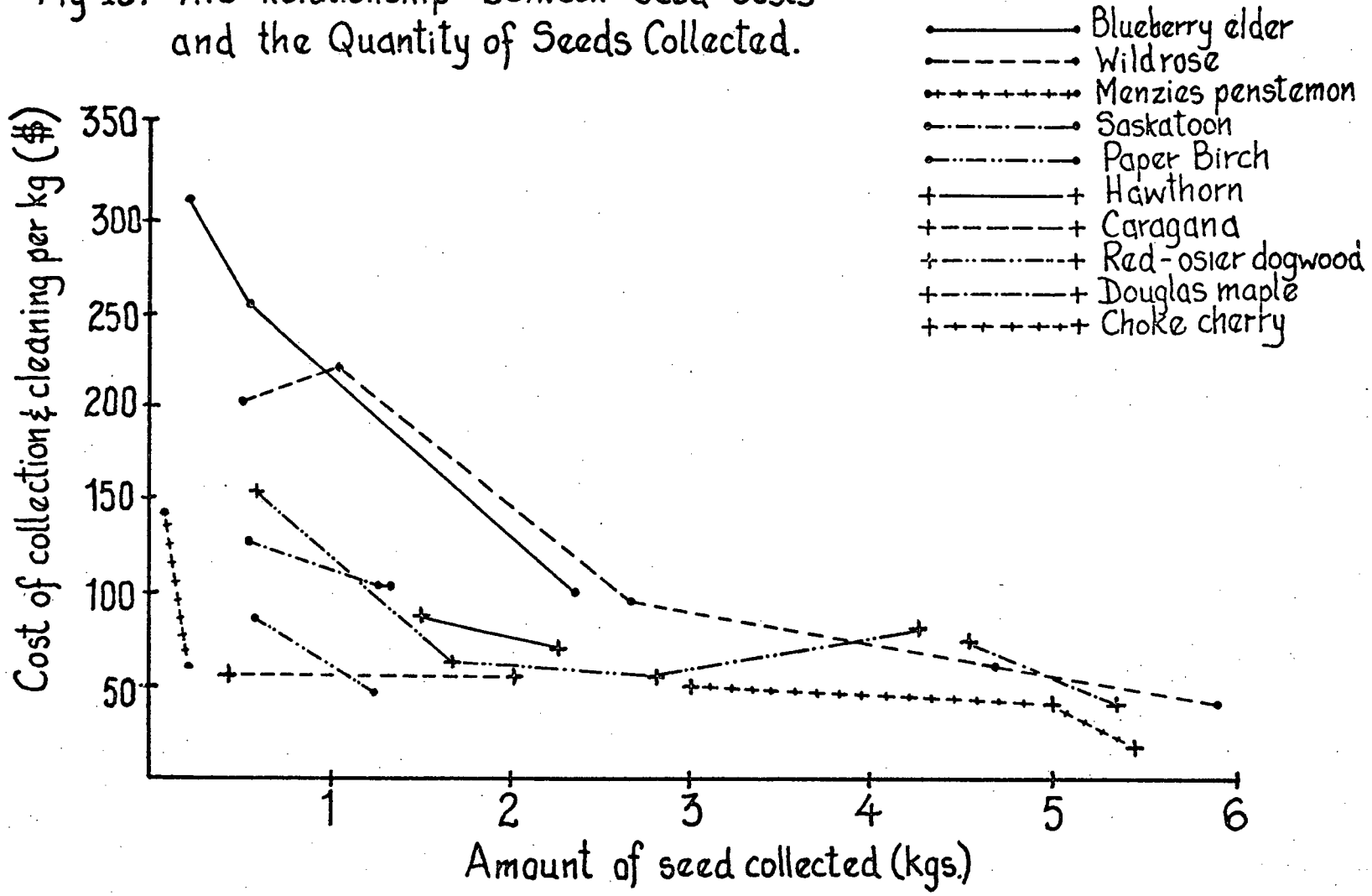
Seed Collection Data For Fifteen Deciduous Tree And Shrub Species 1971-73

	Cost of Collection per kg. of seed		Cost of Cleaning per kg. of seed		Total Cost per kg. of seed		Amount of Fruit per kg. of seed (kg.)	Amount of Seed Collected (kg.)	No. of Seeds Per Kg.	Total Cost per 1,000 seeds ($)
	Man Days	$	Man Days	$	Man Days	$				
Blueberry Elder	3.42	104.70	1.21	37.15	4.63	141.85	56.4	15.2	266,800	0.53
Choke cherry	0.40	12.15	0.66	20.25	1.06	32.40	11.5	73.9	12,800	2.54
Hawthorn	0.97	29.70	1.57	48.00	2.54	77.70	21.4	18.3	44,100	1.77
Manitoba maple	0.64	19.75	*	*	0.64	19.75	*	6.6	26,000	0.75
Menzies penstemon	2.78	84.90	*	*	2.78	84.90	13.5	1.6	2,425,500	0.04
Mountain ash	2.38	72.95	4.81	147.25	7.19	220.20	28.7	17.2	286,650	0.77
Red osier dogwood	1.74	53.15	0.71	21.60	2.45	74.75	11.0	45.5	41,200	1.81
Saskatoon	1.94	59.45	1.54	47.30	3.50	106.75	20.5	15.0	180,800	0.59
Caragana	1.10	33.80	0.79	24.30	1.90	58.10	11.2	21.8	37,500	1.55
Soopolallie	11.91	364.80	1.54	47.30	13.45	412.10	10.0	3.7	90,400	4.56
Wild rose	1.41	41.90	1.15	35.15	2.51	77.05	12.1	51.9	99,200	0.78
Paper birch	1.76	54.30	*	*	1.76	54.30	*	7.7	3,042,900	0.02
Douglas maple	1.76	53.50	*	*	1.72	53.05	*	48.1	40,100	1.32
Thinleaf alder	1.41	43.20	1.79	54.70	3.20	97.90	N/A	14.3	1,488,400	0.06
Silverberry	1.01	31.05	0.64	19.60	1.65	50.65	6.0	15.9	7,500	6.75

* Fruit and seeds not separated.

N.B. Average labour cost was $30.64 per day.

Fig 18. The Relationship Between Seed Costs and the Quantity of Seeds Collected.



The implications of Figure 18 are obvious. Once seed stocks have been built up to a working level, new collections should be made in volume and only in good seed years.

One aspect of the seed programme that has in the past been neglected is that of documentation and testing. Though records concerning seed collection have been kept, they are not well organized. No determination of seed characteristics such as purity and germination percentage has yet been undertaken. Until such parameters are measured, the determination of the quantities of seed required for annual nursery sowings remains largely a matter of guess work. During the present management period all seed stocks will be fully documented and annual seed testing will be carried out. Information for each seed lot will be recorded on the following three standard forms.

6.5 Plant Propagation

6.5.1 Sexual Propagation

The seed of most temperate species is dormant at the time of ripening in late summer or early fall. There exist two types of dormancy; embryo dormancy and seed coat dormancy, and seeds may exhibit either or both types. Embryo dormancy is the most common type and here the seed embryo must undergo physiological changes, which occur only under moist conditions at temperatures slightly above

RECORD OF SEED STOCK AND DISPOSAL

Species: Common Name:

Seed Stock No.: Storage Compartment No.:

If seeds purchased:

Supplier P.O. No.:

Date Received:

Quantity Received:

Cost Per Lb.:

Origin of Seed:

If Seeds Collected:

Location:

National Topog. Grid Ref.: Kaiser 1:12,000 Gird Ref.:

Latitude and Longitude:

Elevation:

Associated Species in Stand:

Date of Collection:

Method of Collection:

Number of trees/shrubs collected from:

Age of trees collected from (if applicable):

No. of bushels of cones/pds of fruit collected:

Method of extraction:

Quantity of seed obtained:

Cost per lb. of seed: Collection

Extraction and Cleaning _____

Total _____

per lb.

RECORD OF SEED STOCK AND DISPOSAL

Seed Analysis

Details of dormancy-breaking treatment:

Laboratory Tests:

Test No.	Date	Purity %	Germ. %	No. pure seed/lb. (,000)	No. Viable Seed/lb. (,000)	Empty Seed Seed %	Moisture Content %

RECORD OF SEED STOCK AND DISPOSAL

Allocations:

Date	Allocated to:	Debit	Balance

freezing (2-5°C), before it can germinate. The time period necessary for these changes is usually 3-6 weeks. Embryo dormancy is a mechanism to ensure that seeds do not germinate in the autumn only to be killed by frosts. Seed coat dormancy usually occurs in species whose fruit is eaten by animals and birds. The seed coat is thick, and impermeable to water. This serves to protect the seed while it passes through the animal's digestive tract. The action of the digestive juices, and subsequent weathering on the ground, breaks down the impermeability and allows the seed to absorb water and germinate.

The most common methods of breaking embryo dormancy are either to sow seeds out-doors in the autumn and allow dormancy to be broken naturally, or to soak seeds overnight in water and then store in the *cooling* compartment of a refrigerator for 1-6 months. Seed coat dormancy may be broken by acid treatment, mechanical scarification, warm stratification or soaking in near-boiling water. *Where both types of dormancy are present, seed coat dormancy must be broken first.*

Table 30 gives information on types of dormancy, and the recommended seed treatments for the 30 species of native trees and shrubs recommended for inclusion in the reclamation programme.

TABLE 30. Propagation techniques for thirty species of native trees and shrubs.

Species	Sexual Propagation: Types of Dormancy: Seedcoat	Sexual Propagation: Types of Dormancy: Embryo	Sexual Propagation: Treatment for † Seedcoat Dormancy	Sexual Propagation: Cold Stratification: Duration	Sexual Propagation: Cold Stratification: Temperature	Vegetative Propagation: Stem Cuttings*: Type	Vegetative Propagation: Stem Cuttings*: Season	Vegetative Propagation: Other*	Remarks
Trees									
Subalpine fir	No	Yes	None	6-8 weeks	2-5° C	—	—	—	Fall sowing possible. Seed viability varies between 25 & 40%.
Paper birch	No	Yes	None	60-70 days	5° C	—	—	—	Fall sowing possible. Broadcast seeds & cover lightly. Give light shade for 1st year. Seed viability = 15-20%.
Western larch	No	Yes	None	30-60 days	5° C	—	—	—	Fall sowing possible. Sow seeds 0.6 cm. deep.
Engelmann spruce	No	Yes	None	30-60 days	5° C	—	—	—	As above.
Whitebark pine	No	Yes	None	90-120 days	5° C	—	—	—	Fall sowing possible. Sow seeds 1.25 cm. deep.
Lodgepole pine	No	Yes	None	30-50 days	5° C	—	—	—	Fall sowing possible. Sow seeds 0.3 cm. deep.
Douglas-fir	No	Yes	None	30-60 days	5° C	—	—	—	Fall sowing possible. Sow seeds 0.6 cm. deep.
Trembling aspen	No	No	None	—	—	—	—	R	Catkin-bearing branches can be hung in enclosed nursery beds until seeds are shed. Beds must be kept moist.
Black cottonwood	No	No	None	—	—	H & S	H in Autumn S in Summer	—	
Shrub & woody forbs									
Douglas maple	Yes	Yes	WS for 180 days	180 days	2-5° C	—	—	—	Early fall sowing in a mulched bed also practical. Sow seed 0.6 cm. deep @ 135-270 seeds per m².
Sitka & thinleaf alder	No	See remarks	None	—	—	—	—	—	No stratification reqd. unless seed drys below 10% m.c. Sow seed 0.3-0.6 cm. deep in spring.
Mountain bilberry						H	Autumn		
Saskatoon	No (?)	Yes	None	180 days	2-5° C	—	—	Su & R	Sow seeds 0.6 cm. deep in rows @ 75 per m. Half-shade seedlings 1 year.
Kinnikinnik	Yes	Yes	H_2SO_4 3-5 hrs. WS-120 days	60-90 days	2-5° C	E	Autumn	—	Cuttings best method. Seed treatments too time consuming.
Fringed sage								Pd	
Sticky laurel	Yes	Yes	Soak in water @ 90°C	60-90 days	5° C	E	Autumn	R	Sow seeds 0.3-0.6 cm. deep in an acid planting medium (pH 6.5)
Red-osier dogwood	No	Yes	None	60-90 days	2-5° C	H & S	H in Autumn S in Summer	Su & R	Fall sowing possible. Sow seed 0.6-1.25 cm. deep.
Hawthorn	Yes	Yes	H_2SO_4 0.5-3 hrs.	80-120 days	5° C	H	Autumn	—	
Silverberry	No	Yes	None	60 days	5° C	H	Autumn	Su	Fall sowing possible. Sow seeds 1.0-2.0 cm. deep @ 180-270 seeds per m² in mulched beds. Soil splash an important source of mortality
Common juniper	Yes	Yes	WS for 45-90 days	90+ days	5° C	E	Autumn	—	Seeds may be sown in spring for germination the following spring
Oregon grape	Yes	Yes	30 days @ 2°C, 60 days @ 20°C	190 days	1° C	E	Autumn	R	Early fall sowing possible. Sow seeds 0.3-0.6 cm. deep.
Sticky currant	No	Yes	None	60-120 days	2° C	H	Autumn	Su & R	Fall sow wherever possible. Sow seeds 0.3-0.6 cm. deep @ 600 per m².
Menzies penstemon	No	No	None	—	—	E	Autumn	—	Sow seeds 0.4-0.8 cm. deep in fine peat & vermiculite.
Chokecherry	No	Yes	None	120-160 days	5° C	—	—	—	Fall sowing possible. Sow seeds 1.0 cm. deep @ 225 per m².
Wild rose	Yes	Yes	WS for 60-90 days	90-120 days	2-5° C	H & S	H in Autumn S in Summer	R	Either warm stratify and sow in fall or fully stratify and sow in spring. Sow seeds 0.6-1.8 cm. deep.
Willow	No	No	None	—	—	H & S	H in Autumn S in Summer	—	Seeding as with cottonwood & aspen may be possible.
Blueberry elder	Yes	Yes	60-90 days @ 20°C.	90+ days	5° C	H & S	as above	R	Sow seeds 0.6 cm. deep @ 350 seeds per m².
Soopolallie	Yes	Yes	H_2SO_4 for 20-30 min.	60 days	5° C	—	—	R	Fall sowing after acid treatment possible. Sow 0.6 cm. deep @ 350/m².
Flat-top spirea	No	No	None	—	—	—	—	R	Seed germinates at low temperatures. Sow in late fall or spring
Waxberry	Yes	Yes	60 days @ 20°C	180 days	5° C	H	Autumn	Su	Sow seeds 0.6 cm. deep @ 350 seeds per m².

N.B. A dash (-) under treatment indicates that it is not applicable to that species. A blank space under treatment indicates that its effectiveness is unknown.

†WS = Warm stratification at temperatures varying between 20 & 27°C.

* H = Hardwood cuttings.
S = Softwood cuttings.
E = Evergreen cuttings.
Su = Suckers.
Pd = Plant division.
R = Root cuttings.

Sources: Original research at K.R.L.
U.S.D.A. Forest Service (1948).

6.5.2 Vegetative Propagation

Many plants have the ability to reproduce themselves either by growing roots from portions of a branch or stem, or by sending up stems from portions of the root system. Such species can be easily propagated in quantity at relatively low cost. Table 30 indicates the most successful techniques of vegetative propagation for 20 species of native trees and shrubs.

Stem and root cuttings are the two most promising methods of vegetative propagation for a simple nursery operation. The common techniques used are as follows:

1. Stem Cuttings

Stem cuttings fall into three general categories, all of which have been used with some success in the reclamation programme:

(a) Hardwood Cuttings

These are taken in autumn or early spring from dormant shoots of the past season's growth. The shoots are cut into 15-20 cm. lengths, with the lower cut about 0.5 cm. below a bud and the upper about 1.5 cm. above a bud. If cuttings are taken in the fall after leaf drop, they can be bundled in batches of 50 or 100, kept at warm temperatures for a few weeks until the cut ends form callus tissue, and then stored outside in moist sand until spring. They can be planted in the nursery as soon as the ground

can be worked in the spring (Figure 19). Cuttings taken in the spring can be planted directly into nursery beds, though this method is usually successful only with very easily propagated species such as black cottonwood.

(b) Softwood Cuttings

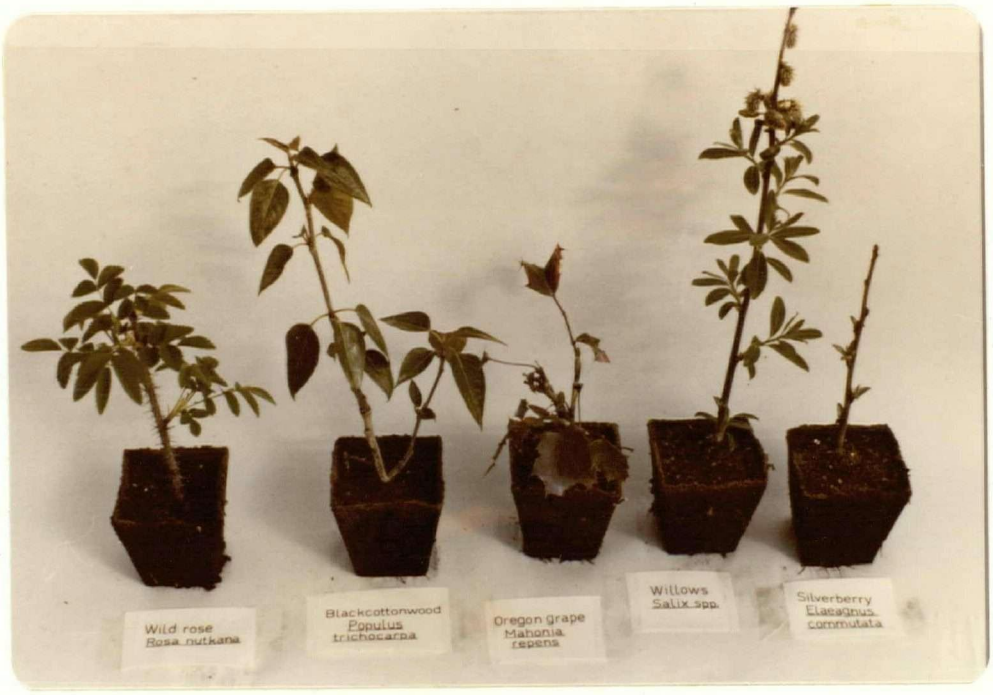
Softwood cuttings are leafy slips of current season's growth, either stripped or clipped from the branches of the plant in mid-summer. They will vary in length from 10-15 cm. and should have all but the top few leaves stripped off prior to planting.

The presence of leaves stimulates rooting, but the cutting must be protected from desiccation either in a partially shaded cold frame, or under an automatic misting system in a greenhouse (Figure 20).

(c) Evergreen Cuttings

Evergreen cuttings are commonly used in the propagation of either coniferous species of the family *Cupressaceae* (i.e. Common juniper) or broad-leaf evergreens such as sticky laurel and Kinnikinnik (Figure 20). They are essentially treated the same way as softwood cuttings except that they are prepared and planted in early fall after the first frost instead of mid-summer. Rooting generally occurs the following spring unless electric heating wires are placed in the rooting medium, in which case rooting begins immediately. If a greenhouse is used

Figure 19. Black cottonwood propagated from hardwood cuttings in nursery beds.



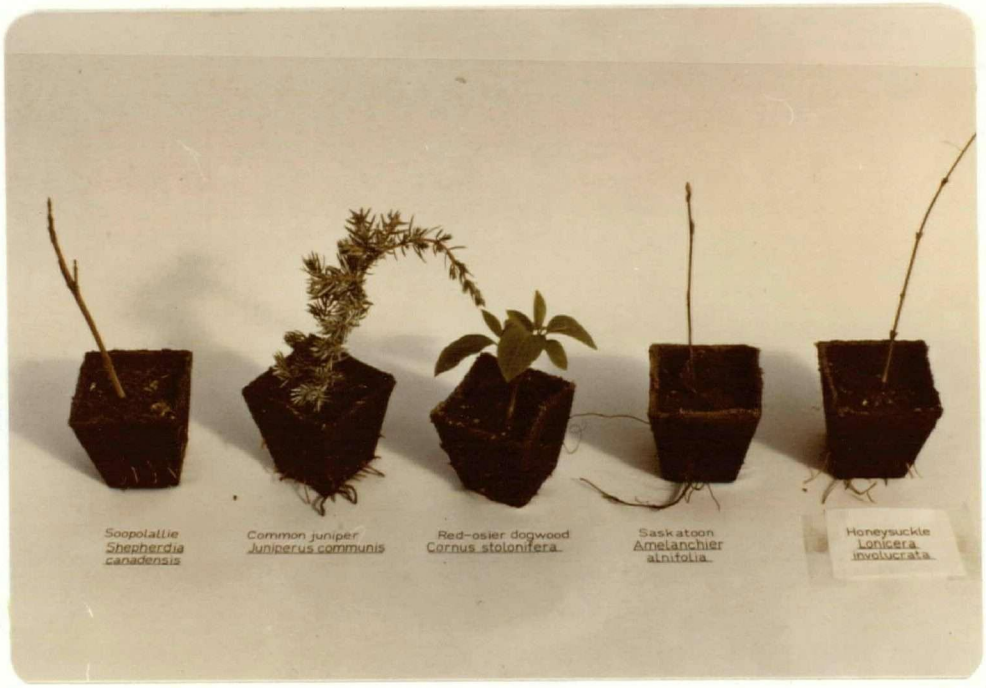


Figure 20. Plants raised from softwood and evergreen cuttings.

for the propagation of evergreen cuttings the air temperature should be maintained slightly above freezing throughout the winter. Misting systems are, of course, not used.

Rooting mediums are usually mixtures of peat and either sand or horticultural grade vermiculite. Rooting of all three types of cuttings is generally improved by wounding the base and treating the wounded areas with a preparation of rooting hormone. Hormone preparations are sold as powders in varying strengths under the trade names "Rootone" and "Seradix".

2. Root Cuttings

Many trees and shrubs have the ability to send up stems or "suckers" from shallow, horizontal root systems. To propagate such species, sections of root are dug up and cut away from the main plant. Vertical or "tap" roots should not be used, since these are difficult to obtain and usually yield rather poor results. Young roots are preferable for cuttings and about pencil thickness (7.5 mm. in diameter) is adequate, though this will obviously vary with species. The roots are cut into 5-8 cm. sections and these are planted 2-5 cm. deep in a moist, well aerated rooting medium. Cuttings may be planted either vertically or horizontally, however, if the former method is chosen, care must be taken to ensure that the end which was nearest the parent plant is upper-most for it is only from this surface that the new stem will arise.

6.5.3 Propagation Facilities

Plant propagation facilities are located on the east bank of the Elk River immediately upstream from the Elk Prairie bridge. The complex includes a 0.8 ha. nursery (Figure 21) and a fibre-glass greenhouse.

1. Nursery

The nursery was constructed in the spring and summer of 1970 with the initial objective of producing planting stock, mainly coniferous, for the 1972 planting season. Several mistakes were made both in the siting of the nursery and in the construction of nursery beds that severely hamper proper nursery management. These were as follows:

a. Because of the configuration of the Elk River at this point, the nursery is sited on a terrace at the base of a north-west facing slope. Prevailing winds in this area are from the south-east and south, with the result that the nursery site becomes an area of snow accumulation. The northerly aspect retards snow melt in the spring and the eastern half of the nursery is often snow covered until early April. This delays both the lifting of mature seedlings, and the planting of seeds and cuttings.

b. The soil on which the nursery is situated, designated the Michel sandy loam (Kelly and

Figure 21. Kaiser Resources Ltd.'s nursery.

Sprout, 1956), is one of the few associations in the Elk Valley without a substantial acidic surface horizon. The pH of the A horizon is described by Kelly and Sprout and later confirmed in tests carried out by the Reclamation Department, as ranging from 7.5 to 7.7. Over half the nursery was sown in 1970 to three species of conifer: lodgepole pine, Douglas-fir and white spruce. Despite attempts to acidify the nursery beds with peat moss and flowers of sulphur, subsequent survival and growth was very poor.

c. Raised, wooden nursery beds were constructed on half of the nursery. The sideboards were firmly staked to the ground which effectively prevented undercutting of the beds. Moreover, the beds were placed too close together to allow the passage of machinery, thus necessitating manual cultivation and weeding.

Coniferous planting stock in the nursery has gradually been phased out and in future this site will be used entirely for the production of broad-leafed trees and shrubs. The nursery has a capacity of approximately 300,000-500,000 plants, depending upon species and spacing. Table 31 shows the estimated number of man-days used each month for normal nursery tasks. These estimates are derived from

Table 31

Labour Costs (Man Days) Per Month For Normal Nursery Tasks

Operation	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Lifting and preparation of mature seedlings	-	-	60	48	-	-	-	-	-	-	-	-	108
Preparation of nursery beds	-	-	-	10	22	6	-	-	-	-	-	-	38
Transplanting seedings	-	-	-	-	45	139	-	-	-	-	-	-	184
Planting cuttings	-	-	-	-	30	8	-	-	-	-	-	-	38
Sowing beds	-	-	-	-	-	8	-	-	-	5	-	-	13
Weeding	-	-	-	-	8	68	32	56	-	-	-	-	164
Thinning beds	-	-	-	-	-	3	-	-	3	-	-	-	6
Tending Irrigation	-	-	-	-	1	2	1	3	-	-	-	-	7
Collection and preparation of cuttings	-	5	-	-	-	-	-	-	-	13	26	-	44
General Maintenance	-	-	6	-	-	-	31	1	5	-	-	-	43
Total Monthly	-	5	66	58	106	234	64	60	8	18	26	-	645

actual recorded work on the nursery from May 1971 to April 1973. It should be noted that this was a period of experimentation and development, and for this reason these estimates are not strictly applicable to a nursery with an established routine. They do, however, indicate the seasonal pattern of work on a small nursery.

Using cost data collected on the Kaiser nursery for the period May 1971 - April 1973, and making some broad assumptions on likely production, it is possible to calculate a rough cost per unit of production in 1974 dollars:

- Annual seedling production = 215,000

  assuming:

  - average nursery capacity is 350,000
  - 80,000 plants are produced annually as 1 + 0 stock
  - 135,000 plants are produced annually as 1 + 1 or 2 + 0 stock

- Annual nursery costs = $24,885 (in 1974 $)

- labour: 645 man days @ $35.00	=	22,575.00
- materials:	=	1,860.00
- maintenance:	=	200.00
- outside services:	=	250.00
		24,885.00

- Therefore, annual cost per thousand seedlings is approximately $116.00 at 1974 rates.

The present nursery is too small to support either an expanded planting programme, or present production levels if rotational fallowing is undertaken. There is also the possibility of sales of planting stock to other mining companies in the southern portion of the province. For these reasons, a second nursery site, approximately 6.5 ha. in extent, will be developed during the coming management period. Criteria used for the selection of a nursery site will include the following:

(a) Soil and Drainage

- a loamy sand of good drainage characteristics; silty and clayey soils to be avoided;
- pH 4.5-6. This range will allow for greater choice of species than the present nursery affords.
- Not less than 1.5 m. soil depth free of impeded drainge.
- Water table at least 1 m. below ground at *all* times of the year.

(b) Water Supply

- Water sources must be capable of providing 50,500 litres per ha. per day during the dry summer months.
- Ideally irrigation water for nurseries should be pH 7.0 or lower, however, in the East Kootenay

both surface and groundwater is highly alkaline (see Table 32). This is not considered a serious problem in soils with good drainage characteristics since rainfall and snowmelt probably provide adequate leaching.

(c) Topography

- site should be level, or have a uniform slope not greater than 6°.
- areas of snow accumulation and frost pockets should be avoided.

Table 32

Analysis of Irrigation Waters Used in the Kaiser Nursery

	Elk River Water	Ground Water
pH	8.0	7.8
Salts (Mmhos./cm)	0.30 (Low)	0.40 (Medium)
Potassium (ppm.)	1.0	1.0
Calcium (ppm.)	48.0	60.0
Magnesium (pp.m)	13.0	18.0
Sodium (ppm.)	4.0 (Low)	9.0 (Low)

2. Greenhouse

In the spring of 1971, Kaiser Resources Ltd. purchased and installed an Ickes-Braum fibreglass greenhouse measuring 15 m. by 8.5 m. It is equipped with a fully automatic misting system controlled by artificial "leaves" positioned on the planting benches. The water system on each bench

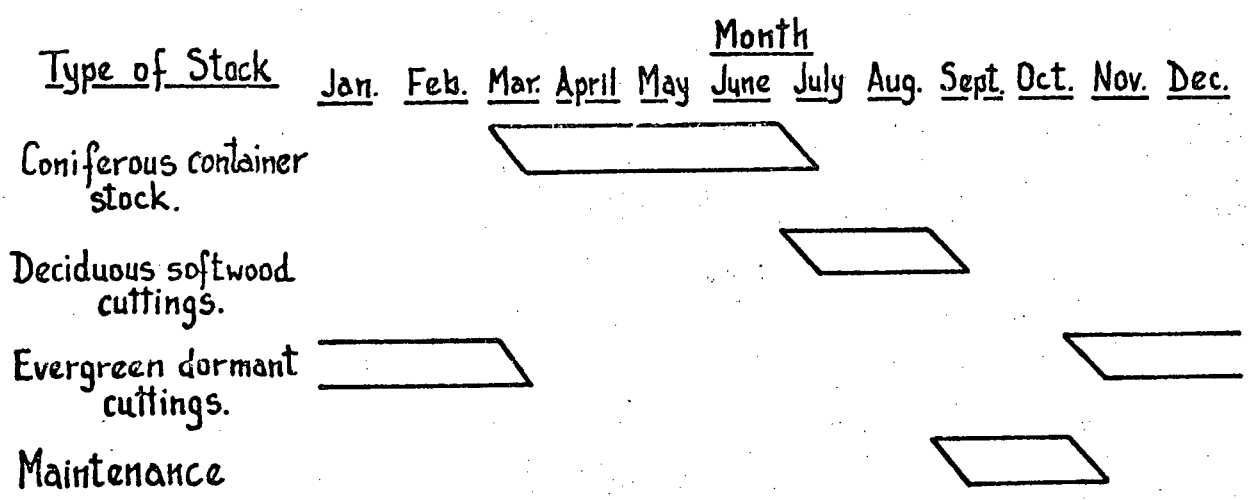
has an injector system which may be used to introduce water soluble fertilizers into the irrigation water.

The greenhouse was originally sited near the coal preparation plant and, though used intermittently during 1971, was not fully operational until the spring of 1972. It was used in that year for the production of coniferous stock in styro-block containers. During the spring of 1972 the Company decided that the land on which the greenhouse and the office complex were sited would be required for a fine-refuse lagoon. The office and the greenhouse were moved to the existing nursery site near the Elk River Bridge. Substantial damage was done to the greenhouse during the move, and extensive delays were encountered in the reconstruction of facilities. The greenhouse was not fully usable again until the summer of 1975. For this reason, no costs of greenhouse operations are available.

Considerable difficulties were encountered during the springs of 1971 and 1972 in attempts to raise coniferous container stock in the greenhouse due to the high alkalinity of the irrigation water. Each year, within a few months of sowing, the pH of the potting mixture had risen to levels of 6.5 to 7.5 and soil conductivity was from two to four times the acceptable level of 300 micromhos (Van Eerden, personal communication). Various methods were used in an attempt to moderate this situation; the use of

highly acid peat moss (pH 4.5) in the potting medium, applications of .05 Normal sulphuric acid in the irrigation water, and excessive leaching; however, none of these proved successful. Douglas-fir appeared to be the species most seriously affected by high alkalinity and salinity, with western larch and Engelmann spruce exhibiting varying degrees of tolerance. In 1975 the Company installed a reverse osmosis water purifier with a capacity of 1365 litres per day. Subsequent experimentation indicates that this has solved the problem, and acceptable seedlings can be grown with adequate fertilization.

During the coming management period a regime will be established to use the greenhouse to full capacity. In most years it should be possible to achieve three production rotations per year according to the following annual schedule:



Sowing of coniferous seed will commence in mid-March of each year and this stock will be carried in the greenhouse until late June or early July, after which it is transferred to a lath house. Deciduous softwood cuttings are collected and planted in late June and early July and held until early September when they are transferred to the lathhouse for hardening-off. A short period in September-October is reserved for greenhouse maintenance and fumigation. Dormant evergreen cuttings are collected in late October and rooted throughout the winter with the aid of soil-warming cables. During this period the air temperature in the greenhouse is maintained at approximately 5° C to prevent the cuttings from breaking dormancy.

6.6 Site Preparation

Site preparation to re-establish surface stability is one of the most important phases of the reclamation process and, on both refuse and overburden dumps, will undoubtedly be the key to successful revegetation. Observations on the Kaiser Resources Ltd. operation, and a review of reclamation literature, indicate that slopes over $30-35^{o}$ are unreclaimable if they exceed 15 m. in length. Among the recommendations and conclusions arising from the study of reclamation on phosphate mines in the Rocky Mountain region of Idaho and Montana

(Schultz and Ditmer, 1971) are:

1. Growth and survival of trees and shrubs on 33° (65%) slopes are severely impaired by surface instability. The construction of dumps at angles of over 30° should be avoided wherever possible, and slopes either designed or re-contoured to between 22 and 27° (40-50%).
2. Contour terracing is recommended where slope angles cannot be flattened to 22°. Terraces should be constructed at 25-100 foot (7-30 m.) intervals, depending on the degree of slope, with check dams at 100 foot (30 m.) intervals along the terrace. Both terraces and check dams should be designed for storage of peak runoff.

Two main physical factors affect the degree of resloping possible on refuse and overburden dumps: first, the configuration of the dump itself, and second, the topography and the nature of the area directly below the dump. Past resloping operations on some of the smaller contour surface mines at lower elevations, e.g. McGillivray (Figure 22) and 7A and B Pits, and the refuse dumps in the Michel Valley have been aimed at contouring the waste materials to blend with the surrounding landscape. Where

Figure 22. Resloping of the McGillivray surface mine.

resloping has not been possible, as was the case with the old refuse dumps on the edge of Michel Creek, partial slope stability has been achieved with the use of jute netting. With the overburden dumps on Harmer Ridge, however, the constraints are such that it is unlikely that the final slope can be reduced to less than 25°, and portions of the dumps will have to be left at over 30°. As slope angle increases, stability can be ensured only by reducing the distance between contour terraces. Until experience dictates otherwise the following *ad hoc* guidelines will be used:

Slope Angle	Vertical Interval Between Terraces
24 - 27°	25 - 30 m.
27 - 30°	15 - 25 m.
30+	7.5 - 15 m.

In each slope class the minimum contour interval will be used for highly erodible substances such as oxidized coal and finely weathered shale, and the maximum contour interval will be used for less erodible spoils such as glacial till and those containing a high proportion of coarse rock.

Because of the many variables involved, it is essential that each dump system be treated as a separate entity, and that site preparation operations be designed on this basis. An example of the type of design that will be required during resloping is shown in Figure 23a, b, and c.

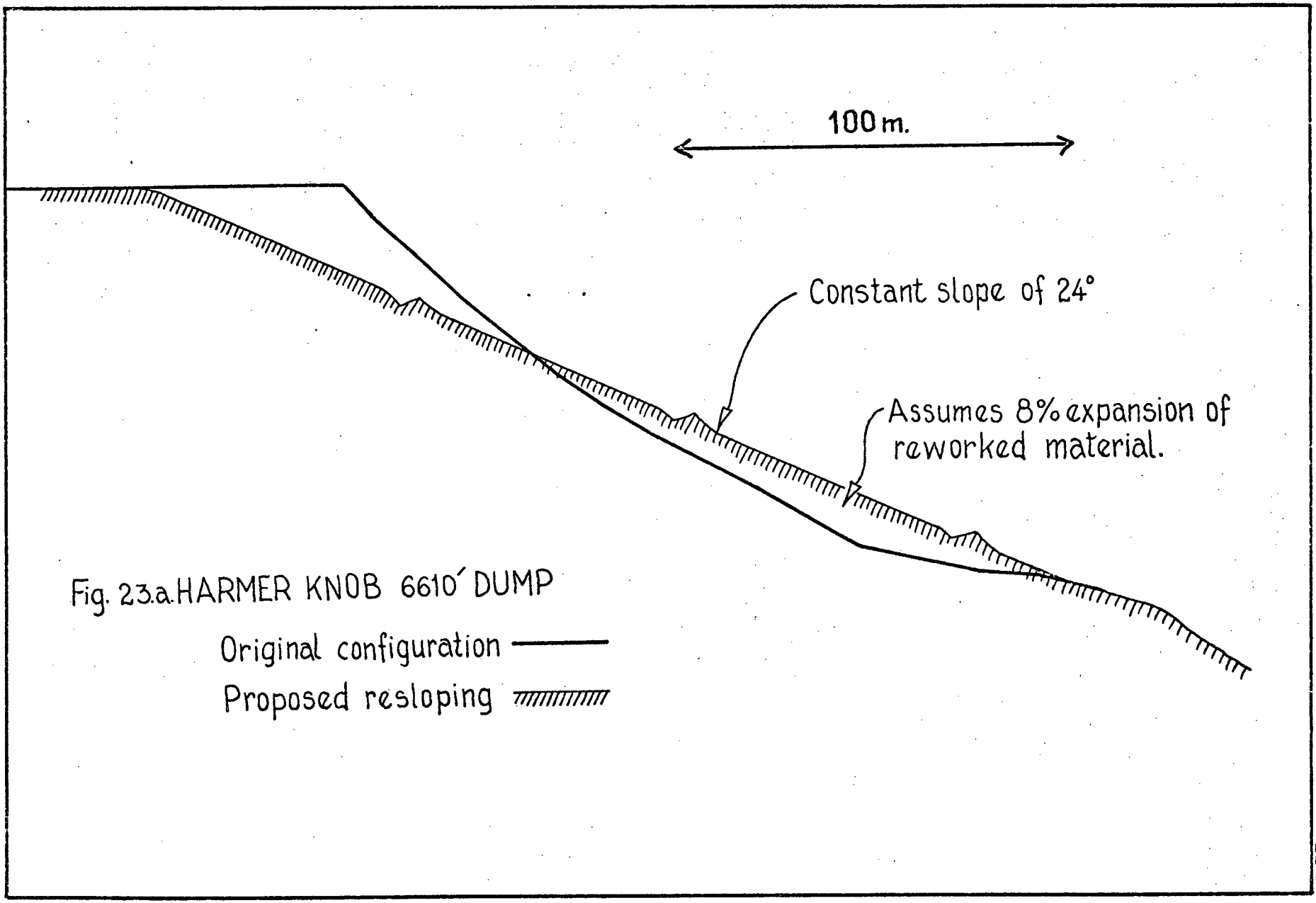


Fig. 23.a. HARMER KNOB 6610′ DUMP

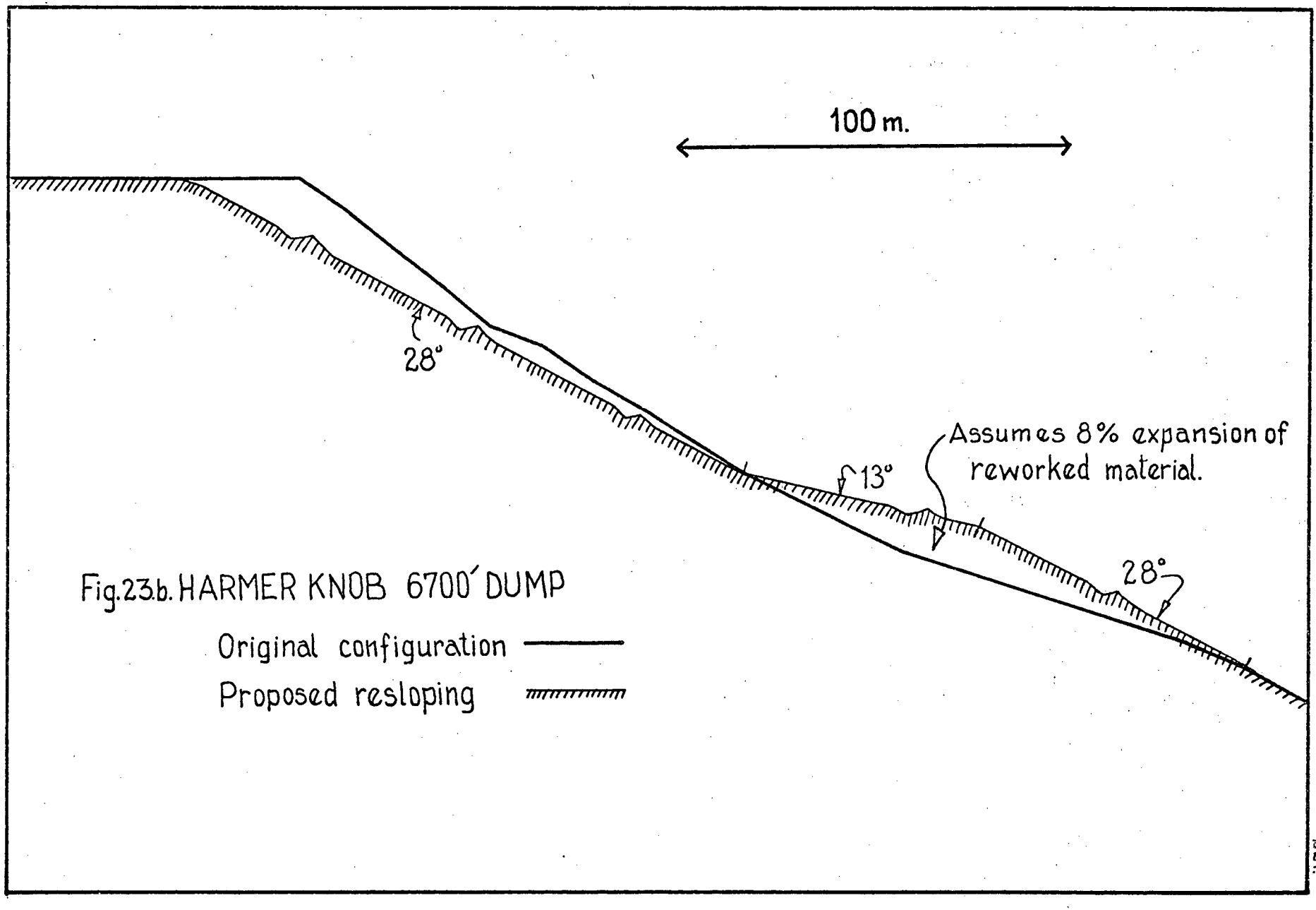


Fig.23b. HARMER KNOB 6700′ DUMP

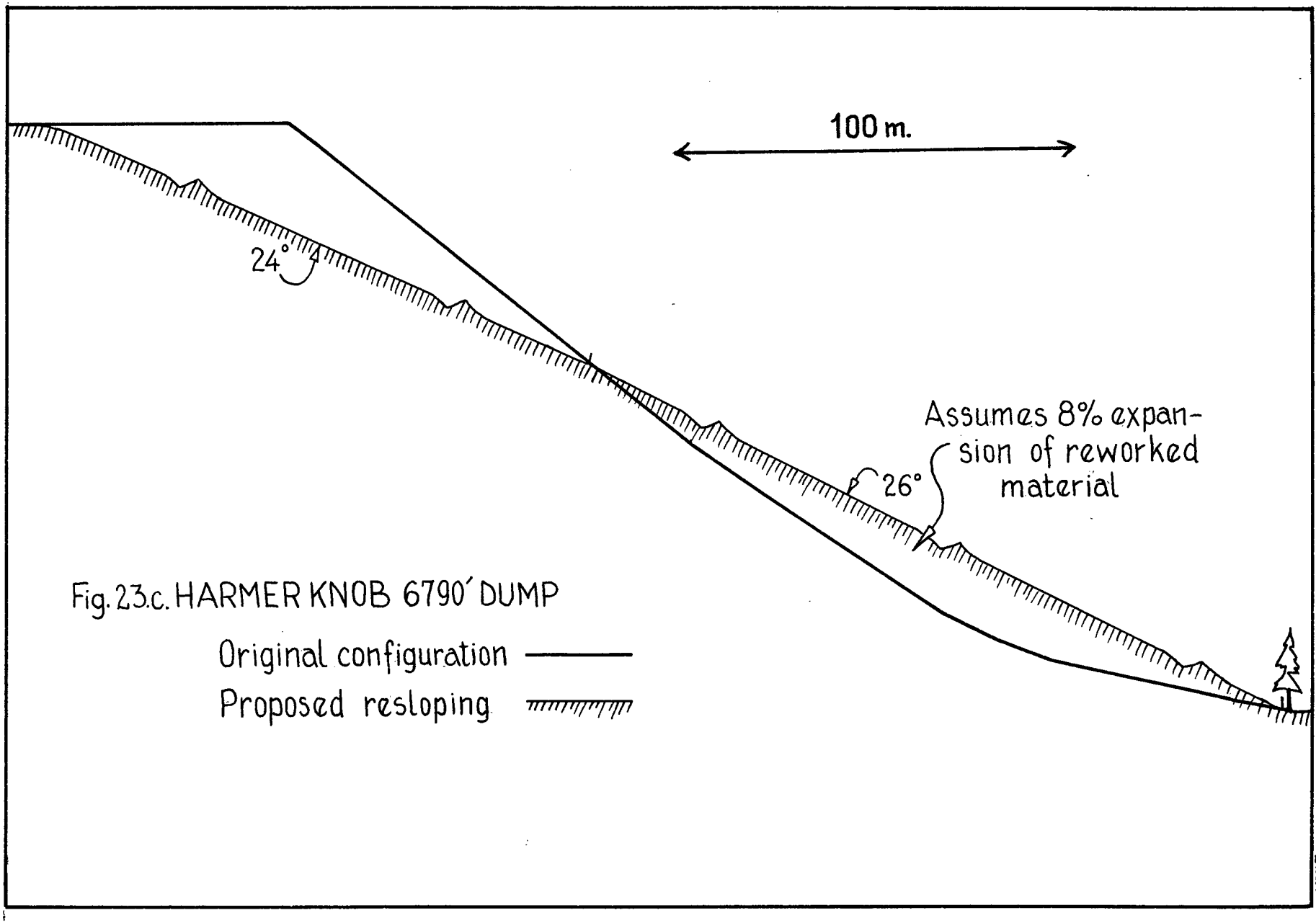


Fig. 23.c. HARMER KNOB 6790′ DUMP

These figures show initial and projected dump profiles for the three Harmer Knob dumps described in Section 3.4.2 above.

Roadways, dumping platforms, and maintenance areas become highly compacted during the operational phase of mining. Compaction also occurs, though to a lesser extent, during contouring and resloping, particularly where glacial till materials are reworked when moist. Such areas will be ripped with a dozer to a depth of 1 m. and harrowed before seeding and planting.

Resloping operations to date have been limited almost entirely to preparation plant refuse piles, and to the small outcrop mines at lower elevations. The only exception is an experimental resloping begun in 1972 on the Harmer Knob overburden dump. This experiment was terminated in 1974 when it appeared likely that the Harmer Knob mine would be reopened for the production of thermal coal. Computer simulations based on data collected from this experimental work estimate that the final cost of resloping these dumps will be approximately $3950 (6.3 D8 machine days) per hectare (Harrison, 1975; personal communication).

Resloping operations were carried out on seven outcrop mines and one refuse pile during the period 1971-75. Generally these operations involved reducing the slope angle of waste materials from in excess of 33° to 25°,

minor terracing, and back-filling of the pit. Machine days and costs in 1974 dollars for each of these areas is presented in Table 33.

Table 33

Resloping Costs For Seven Small Outcrop Mines And A Refuse Bank

	Area (ha.)	Total No. of Machine Days	Cost Per Hectare*
Preparation Plant Refuse Pile	7.0	19.5	$ 726
Baldy 1 and 2 Surface Mines	6.0	16.5	696
7 A Surface Mine	4.0	10.0	632
McGillivray Surface Mine	10.5	43.0	1045
Erickson Surface Mine	12.0	38.0	800
C Seam Surface Mine	5.5	18.0	813
Lower C. Seam Surface Mine	2.5	7.0	736
D Seam Surface Mine	1.5	4.0	842
	49.0	156.0	815

* Assuming 1974 owning and operating costs for a D8 Dozer of $256 per machine day.

The only experience to date in ripping to alleviate surface compaction has been work done on the former Michel Townsite. The old houses were demolished, and the resulting refuse burned and buried during 1970 and the early Spring of 1971. The demolition operations caused considerable soil compaction which necessitated ripping before seeding and planting could be accomplished. The area treated

totalled 6.5 ha. and required 1.8 machine days work. Cost per ha. was $72. at 1974 machine rates. In interpreting this cost, it should be noted that the soils in this area are gravelly alluvium and probably not subject to the degree of compaction one would find in till materials, however, the ripper blade was constantly fouling on buried wood and metal refuse which reduced operational efficiency considerably.

6.7 Seeding

Four methods of applying grass and legume seeds have been used since the inception of the reclamation programme in 1970. During the first two years, seed was either broadcast, using hand-operated seeders or helicopter, or applied with a hydroseeder. Because of the failure of broadcast seeding, and the expense of hydroseeding, there has been a tendency in subsequent years to use a modified agricultural technique of seeding and harrowing wherever the terrain is moderate enough to allow access by machinery.

6.7.1 Aerial Seeding

The only experience with aerial seeding in this reclamation programme occurred in 1970 when 55 ha. were treated with a helicopter chartered from an agricultural consultant in Calgary. The areas seeded were a number of sites disturbed during the construction of facilities, and

the slide area resulting from the failure of the waste dumps of the Balmer 10-4 surface mine. The cost of this seeding was as follows:

Seed: 4495 Kgs. @ $1.08	=	4,851.00	(82 kg/ha)
Ferrying Time: 4 hrs @ 150.00	=	900.00	
Seeding Time: $49.99 per ha.	=	2,700.00	
Labour (Loading seed hopper) 2 man days @ 29.00	=	58.00	
Total		8,509.00	
Cost per ha.		154.00	

It should be noted that this cost does not include fertilization. Had fertilizer been applied at 495 kg. per hectare, and the same per hectare application cost assumed, the total cost would have been approximately $230.00 per hectare.

The results of this operation were highly variable. A good growth of grass and legumes was established on moderately sloping areas disturbed during the construction of the coal preparation complex, particularly where organic soil horizons were largely intact. The seeding of slopes in excess of 25-30°, steep cutbanks, and the Balmer 10-4 slide resulted in total failure.

6.7.2 Hand Seeding

Eight sites, totalling 46 hectares, were seeded manually in 1970 and the early Spring of 1971 using hand-operated "Cyclone" seeders. The average cost per hectare of these operations was as follows:

Labour .36 man days @ 29.00	=	$10.40
Seed 25 kg. @ 0.88 per lb.	=	22.00
Fertilizer 90 kg. @ $0.11 per kg.	=	10.00
Total		42.40

Total cost per hectare for the eight slopes ranged from $99-121.

The results of these operations closely approximated those of aerial seeding: reasonable ground cover achieved on lightly disturbed areas of moderate slope; total failure on more severe sites. The use of hand seeding alone has been severely restricted in subsequent years.

6.7.3 Hydroseeding

A 1500 gallon (6825 litre) capacity hydroseeder was purchased by the Company in 1970. Initial plans were to use this machine for a wide array of seeding operations, however, in view of the high cost of this technique it has been limited almost entirely to the treatment of road embankments.

The technique of hydroseeding consists of the application of seed, fertilizer and a fibrous material, such as peat moss or wood pulp, in a water slurry (Figure 24). The machine owned by Kaiser Resources Ltd. is manufactured by the Bowie Corporation and consists of a 1500 gallon (6825 litre) tank mounted on a 10 ton Ford truck. The water tank contains an internal agitator to mix the slurry, and the slurry is applied by means of a hydraulic

Figure 24. The Hydroseeder in operation.

monitor mounted on top of the tank at the rear of the machine. The maximum seeding range indicated in the specifications for the machine is 45 m. at sea level. Effective seeding range at Sparwood seldom exceeds 25-30 m. due to a combination of elevation and wind conditions.

Normally, the slurry mixture contains 25 kg. of seed, 90 kg. of fertilizer, and 270 kg. of peat moss, however, the proportions of seed and peat moss are often varied according to local site conditions. Under ideal conditions, a 1500 gallon (6825 litre) load of slurry would treat 0.6 hectares, however, in practice the average area covered has been closer to 0.3 hectares.

In assessing the cost of hydroseeding it is useful to make a distinction between the initial treatment of disturbed areas, and the re-treatment or "beating-up" of previous seedings. During the years 1970-1972 inclusive, the majority of the areas hydro-seeded were of the former type. Costs of these operations are summarized on the following page.

From 1972 onwards an increasing proportion of the annual hydroseeding operation has consisted of the re-treatment of small portions of areas seeded in previous years. A summary of the cost of this activity in 1972, the only year for which costs are retrievable, is shown on the following page. A cost break-down for the period 1973-75

Initial Seeding Costs

Year	Labour Man Days	Labour Cost $	Vehicle Machine Days	Vehicle Cost $	Seed $	Peat Moss	Fertilizer	Total	Area Treated (ha.)	Cost Per Hectare
1970	51	1479	25.5	1785	2380	1683	1275	8602	33	260.00
1971	38	1216	19.0	1330	2000	1670	875	7091	23	308.00
1972	20	720	10.0	700	1500	686	345	3951	13	304.00
Reseeding Costs										
1972	13.5	486	6.75	472.50	575	336	165	2035	10.3	197.60

Labour Costs: 1970 - 29.00 per man day; 1971 - 32.00 per man day; 1972 - 36.00 per man day.

Seed Costs: 1970 - $0.88 per kg.; 1971 - $1.10 per kg.; 1972 - $1.32 per kg.

Peat Moss: $.073 per kg.

Fertilizer: $0.11 per kg.

Vehicle Cost: $70.00 per machine day.

is not available, however, per hectare costs averaged $186.70.

Hydroseeding has generally, been a very effective reclamation technique. The major failures experienced have been on either unstable slopes or highly compacted ground.

6.7.4 Seeding and Harrowing

Since 1971 a modification of the standard agricultural seeding and harrowing has been used on all areas accessible to machinery. On flat or gently sloping ground with light textured soils, a 4-wheel drive, 35 horse power tractor and light-weight, farm ("diamond") harrows are used. On moderate to steeply sloping land, rocky areas, or heavily compacted soils, a D8 dozer and a set of heavy, articulated, ground-breaking harrows (Figure 25) have proven most effective. On sloping ground, the harrowing must be done at right angles to the slope. The maximum angle at which this can be accomplished is approximately 26°.

Seed is spread prior to harrowing either by a truck or tractor-mounted, mechanized hopper, or manually using cyclone seeders. The latter method has proven most satisfactory given the uneven topography of most reclamation projects. Tractor-mounted hoppers have been used very efficiently in seeding tailings lagoons and disturbed industrial sites. The average seeding rate used has been

Figure 25. Heavy, articulated harrows.

has been approximately 56 kg. per hectare.

Average costs per hectare for the years 1971-73 for seeding and harrowing operations are shown in Table 34. It is apparent from this table that the seeding techniques varied somewhat between years. In 1971, operations were confined to the old Michel townsite in the valley bottom. The ground had been ripped to break surface compaction prior to seeding. Because the sites were level, seed was applied with a mechanical hopper and the entire area was harrowed with the 35 h.p. tractor and "diamond" harrows. In 1972, of the three areas treated, one was a surface mine and one was a coarse refuse dump. In these areas, steep slopes or rocky ground made machine seeding impossible and all seed was spread manually. Site conditions on about one-third of the area were too severe to allow harrowing by tractor, and a D8 dozer was used. In 1973 the majority of operations were on contour surface mines. All seeding was manual, and all harrowing was carried out with a D8 dozer and heavy articulated harrows.

It is worthy of note that though techniques used during the three years varied substantially, there was little difference in total cost per hectare, if costs are adjusted to 1972 rates. Adjusted per hectare costs for the three years are 193.90, 189.70 and 201.05 respectively - a range of only ± 3 per cent of the average cost.

Table 34

Average Costs Per Hectare For Seeding And Harrowing Operations

Year	Seeding Costs per ha.						Harrowing Costs per ha.						Average Total Cost Per Hectare	Area Treated (ha.)
	Labour		Machinery		Seed $	Fertilizer $	Labour		Tractor		D8 Dozer			
	Man Days	Cost $	Machine Days	Cost $			Man Days	Cost $	Machine Days	Cost $	Machine Days	Cost $		
1971	0.42	13.45	0.42	17.70	68.60	24.70	0.69	22.15	0.69	29.15	-	-	162.55	44
1972	1.26	42.85	-	-	83.00	24.70	0.42	14.80	0.37	15.8[illegible]	0.02	8.50	189.70	89
1973	1.98	71.15	-	-	86.45	24.70	0.12	4.95	-	-	0.12	30.60	217.85	203

Labour Costs: Machine operator: - 1971 - $32.00 per day, 1972 - $36.00 per day, 1973 - $40.00 per day.
Labourer (handseeding): - 1972 - $34.00 per day, 1973 - $36.00 per day.

Seed Costs: 1971 - $1.10 per kg., 1972 - $1.32 per kg., 1973 - $1.54.

Fertilizer: $0.11 per kg.

Equipment Costs: Tractor: $42.00 per machine day.
D8 Dozer: $248.00 per machine day.

The major reason for this is that the unit-cost of harrowing by D8 dozer is only 70 per cent of that for the tractor. The D8 dozer is able to treat six times the area at only 3.6 times the cost, per unit of time.

Seeding and harrowing has proved to be the most effective of the four seeding methods, and consistently good results have been obtained over a wide range of site conditions.

6.7.5 A Comparison of Methods

No quantitative assessment of the results of various seeding methods under various site conditions has yet been carried out. However, the four basic methods can be subjectively ranked in order of *decreasing* effectiveness as follows:

Method	Seeding and Fertilizing Cost Per Hectare (1972 Rates)
Seeding and Harrowing	189.70
Hydroseeding	314.90
Handseeding	135.85
Aerial Seeding (including fertilization and assuming 10% annual inflation rate)	276.65

Experience thus far in the programme indicates that except in the most lightly disturbed areas, broadcast seeding, whether by hand or air, must be repeated two to three times

to achieve the degree of vegetative cover from a single seeding and harrowing. Given these comparisons, the following use-prescriptions will apply to seeding operations during the next management period:

Seeding and Harrowing	- Will be used wherever possible
Hydroseeding	- Will be confined to slopes greater than 25° and less than 30 m. in length that are accessible by road
Handseeding	- Will be used only on lightly disturbed areas or sites inaccessible to equipment
Aerial Seeding	- Will be used only on lightly disturbed areas or sites inaccessible to equipment, where seeding time is a critical factor.

6.8 Planting

The first planting operations in the programme were carried out in the autumn of 1970 and the spring of 1971 by a reclamation contractor based at Fort Steele near Cranbrook. Six areas totalling 220 ha. were planted at a spacing of 2 x 2 m. Actual plant density varied from 2225 - 2965 seedlings per hectare. Planting stock was

bare-rooted and predominantly 3 + 0 Douglas-fir, though smaller quantities of 3 + 0 paper birch, 2 + 3 blue spruce, 2 + 3 Douglas-fir and 2 + 2 Scots pine were also used. The contract price for the six areas averaged $840 per ha. and varied from $805 - 915 per ha., depending upon topography and soil characteristics.

Survival counts during 1971 revealed very high seedling mortality on southern aspects - 50-60 per cent for spring plantings and in excess of 75 per cent for autumn plantings. The difference in survival between spring and fall planted stock is probably related to the very light snow cover on these aspects. Because of the action of wind, a high angle of solar interception and the dark colour of the spoil, snow depth on southerly slopes seldom exceeds a few cms. For much of the winter the foliage of the seedling is totally exposed and this inevitably leads to moisture loss, particularly on sunny days in late winter. The root systems of fall planted seedlings are probably completely frozen and unable to replace lost moisture, resulting in desiccation and death.

In 1970 a planting experiment was initiated in co-operation with the University of British Columbia. Three types of planting stock (bare-root, "styroblock" and "bullet") of three species (Douglas-fir, lodgepole pine and Engelmann spruce) were planted in both the fall of 1970 and the

spring of 1971. The experiment was replicated on eleven different sites ranging in elevation from 1130 m. to 2075 m. and in slope from 0 - 18°. Of the eleven sites, two were north facing, two were west facing, four were south facing, one was east facing and two were on level ground. The final assessment of this experiment was in the spring of 1972 and the results, presented by Lowenberger (1973), were as follows:

1. Survival of spring planted seedling was significantly higher than that for fall planting.
2. Lodgepole pine had better survival and growth rates than the other two species.
3. Growth and survival of styroblock seedlings was superior to the other two types of planting stock. Poorest results were obtained with bullet seedlings.
4. Survival and growth was poor for all combinations of planting stock, species, and planting season on south facing slopes, on compacted ground and at elevations below 1220 m.

As a result of these studies, fall planting was abandoned in 1971 and no further planting was done on direct southerly aspects. In 1972 the previous practice of planting at 2 x 2 m. spacing was discontinued and planting

crews were instructed to select planting sites on the basis of favourable micro-topography. Even on an area of generally southerly aspect, topographic variation is such that all aspects are present. In addition, trees are planted in the shade of rocks and hummocks, and in depressions where runoff waters collect. The number of trees planted per acre under this technique will obviously vary depending on the nature of the site. For example, the average number of trees per hectare for the 1972, 1973 and 1974 planting programmes were 1830, 1160 and 900 respectively. Initial assessments of these plantings indicate survival rates of between 65 and 85 per cent. Thus, in contrast to the original planting technique, it seems likely that the same member of vigorous trees per unit area can be obtained from between 30 and 60 per cent of the number of seedlings.

In 1972, 3 + 0 Douglas-fir was purchased from a local nursery at a cost of $35.00 per thousand. In 1973 and 1974 the Company nursery provided planting stock for the entire programme. The main species and ages used during these years were 1 + 0 black cottonwood, 2 + 0 Manitoba maple, 3 + 0 European white birch, 3 + 0 Douglas-fir and 3 + 0 lodgepole pine. If production costs for Company-raised stock are assumed at $110 per thousand, (see Section 6.5.3) planting costs for the three years were as follows:

Year	Area Planted (ha.)	Cost Per Hectare				Total Cost Per Ha.
		Labour		Seedlings		
		Man Days	Cost	No. Per Ha.	Cost	
1972	29.4	5.2	175.40	1830	64.20	239.60
1973	42.1	3.7	119.40	1160	127.70	247.10
1974	77.0	2.7	103.10	900	99.20	202.30

6.9 Tending

6.9.1 Irrigation

Fine refuse lagoons are composed almost entirely of carbonaceous shales and high-ash coals. These materials, being very dark in colour, surface-dry very quickly and their low density, friable texture and lack of internal cohesion makes them extremely susceptible to wind erosion. For this reason, attempts to seed the A and B fine refuse lagoons during the early spring of 1972 resulted in total failure. During the summer of 1972 an irrigation system was rented and used for four months on the B lagoon. The system consisted of a mainline laid down the centre of the lagoon and two sets of laterals. The lateral lines were moved by hand once or twice daily so that each area of the lagoon was irrigated every second or third day during dry weather. Total cost per hectare for the four months was $647, comprising $417 for equipment rental and $230

(6.9 man days) for the labour of moving pipes.

The refuse lagoons, located in the Elk Valley close to residential areas, are subject both to the air pollution by-laws of the District Municipality of Sparwood and to public pressure. Irrigation is a very effective method of dust abatement while vegetation is becoming established and, thus, a portion of the cost can be justified on the basis of its pollution control function.

6.9.2 Fertilization

Supplementary fertilization is carried out annually on all seeded and planted areas. Standard practice is the application of a balanced fertilizer such as 14.14.7 at 225 kg. per ha. using either "Cyclone" hand-seeders or the hydroseeder. The cost of application has ranged from an average of $43.95 per ha. in 1972 when 40.5 ha. were treated, to $56.80 per ha. in 1974 when 54 ha. were treated. Labour costs have averaged between 0.6 and 0.8 of a man day per ha.

The period over which supplementary fertilization will be required on various spoil types is unknown. Present practice is to permanently discontinue fertilization after three years unless plants show obvious signs of nutritional deficiencies. One of the major aspects of the assessment programme (see Section 6.12) will be to monitor both plant productivity and chemical composition in order to determine

if the nutrient status of a site is sufficient to support a permanent vegetation cover.

6.10 Total Reclamation Costs

Total costs per hectare of reclamation, and cost per hectare by treatment for eighteen sites are presented in Table 35. The inclusion of these sites in the table does not imply that they are fully reclaimed. The judgement of whether or not a site is reclaimed will be made by the assessment programme described below. These sites have, however, received the complete process of reclamation treatments and are now in the "tending stage". No further work will be done on these sites, except supplementary fertilization for three years, unless they fail in the assessment process to meet reclamation standards.

Two things must be kept in mind when interpreting the table:

1. Where only a portion of a site received a particular treatment, the per-hectare cost is related only to the treated area, i.e. average cost per ha. of resloping on the 7A surface mine is $632.00 based on work done on 4 hectares. When computing total cost per ha. for the site, all costs are related to the total area, i.e. total cost of resloping on the 7A surface mine

Table 35

Total Reclamation Cost and Cost by Operation for Eighteen Sites

Type and Name of Area	Total Area Treated (ha.)	Cost per ha. for various operations ($)						Total Cost of All Operations per ha. ($)	Year of Treatment
		Resloping	Ripping	Seeding*	Planting	Irrigation	Fertilization		
Contour Mines									
7A	9.8	632 (4.0)	-	183 (H)	118 (5.9)	-	128	640	1972
7B	5.3	-	-	54 (M)	225 (2.3)	-	109	388	1972
Baldy 1 and 2	6.1	696	-	175 (H)	365	-	133	1371	1972,73&74
Baldy 4	15.0	-	-	170 (M)	326 (9.1)	-	74	496	1972
McGillivray	10.5	1045	-	225 (H)	188	-	47	1504	1972&73
Erickson	16.6	1800 (12.1)	-	163 (H)	200 (12.2)	-	62	958	1973&74
C Seam	5.8	813	-	207 (H)	452	-	57	1529	1973&74
Lower C Seam	2.4	736	-	202 (H)	245	-	82	1265	1973
D Seam	1.6	842	-	160 (HO	326	-	54	1383	1973&74
Average cost per ha. by operation		795	-	170	272	-	84	1060	
Town and Industrial Sites									
Elkview Preparation Plant	14.8	-	-	156 (A)	840	-	185	1180	1970
Michel Townsite A	1.8	-	89	183 (H)	279	-	126	677	1971
Michel Townsite B	1.2	-	67	170 (H)	232	-	148	618	1971
Michel Townsite C	3.5	-	67	165 (H)	235	-	119	617	1971
Hydraulic Mine Site	3.7	-	140	138 (H)	-	-	163	442	1971
Elkview Conveyor	5.5	-	-	89 (M)	203	-	104	395	1972
Average cost per ha. by operation			91	151	358	-	141	655	
Refuse Banks									
Michel Preparation Plant	6.9	726	-	237 (H&Hy)	195	-	128	1287	1972&73
Refuse Lagoons									
A Lagoon	4.5	-	-	212 (H)	156	-	42	410	1973&74
B Lagoon	5.7	-	-	165 (H)	131	647	124	1065	1972&73
Average cost per ha. by operation				188	143	647	84	736	

is $2528.00 (4 ha. x $632.00). Thus the resloping component of the total cost per hectare is $258 ($2528.00 ÷ 9.8 hectares).

2. Average costs for each operation are based only on the specific area treated in that operation. Thus the average cost per ha. for irrigation is $647.00, based on the one lagoon that was irrigated. Average total cost of all operations, on the other hand, is based on the total area subject to reclamation.

Views of some of the areas included in Table 35 are shown in Figures 26 - 29.

6.11 Reclamation of Exploration Operations

The nature and history of Kaiser Resources Ltd.'s exploration programme has been described in Section 3.5 above. In summary: During the years 1968-75, the Company carried out one of the most ambitious and extensive coal exploration programmes ever undertaken in the East Kootenay coal belt. During the years 1969-72 there was very little preplanning of exploration either for operational efficiency or eventual reclamation, and minimal consideration of the adverse environmental effects of poor exploration practices. In 1973 the Department of Mines and Petroleum Resources refused to renew the Company's Surface Work Permit covering

Some areas which have received a full range of reclamation operations.

Figure 26. McGillivray surface mine.

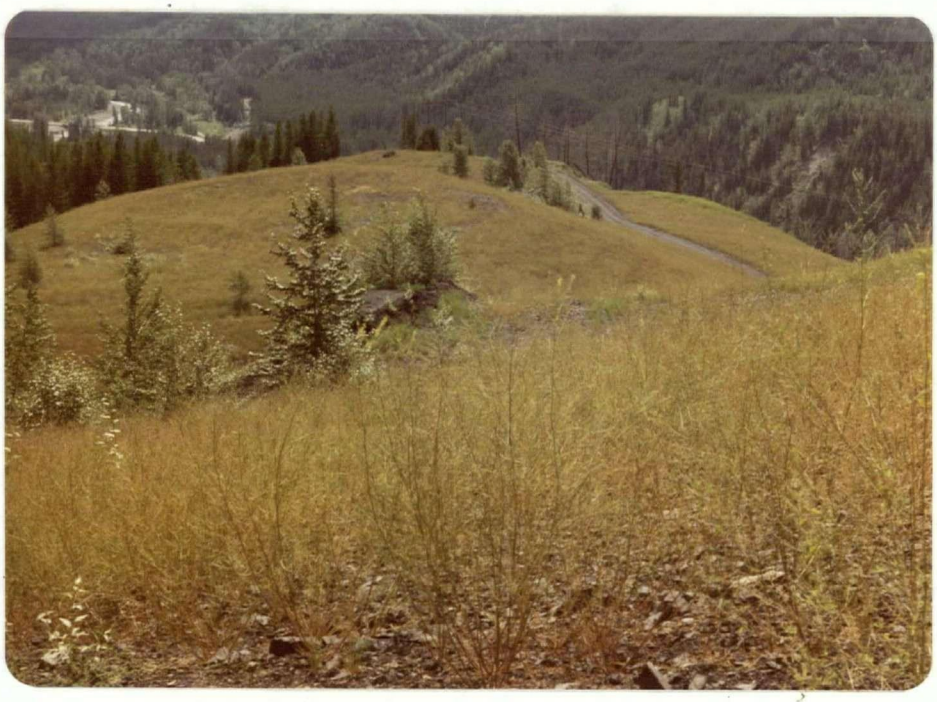


Figure 27. Erickson surface mine.

Figure 28. Tailings lagoon A.

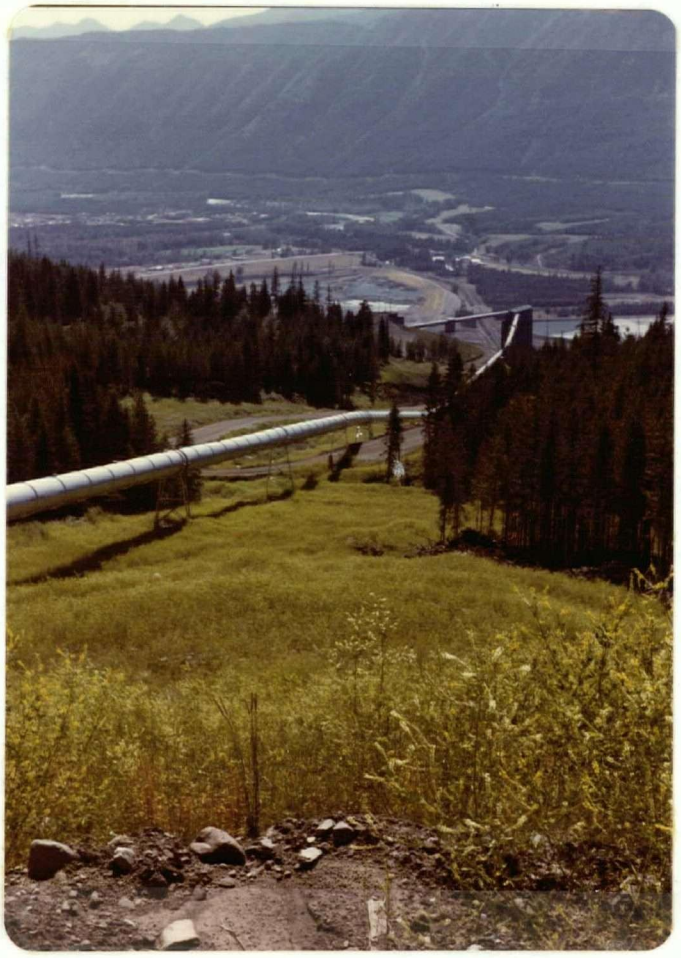


Figure 29. Elkview conveyor right-of-way.

exploration until an environmental impact statement had been prepared, and a programme of environmental protection had been instituted. B.C. Research carried out the study, which included an assessment of all past exploration and an environmental sensitivity rating for all six main centres of exploration activity. In addition, the report recommended that:

1. A site-specific planning process be set up for all future exploration programmes in which the coal geologist and the reclamation biologist work together as equals.
2. Greater on-site supervision be provided in order to minimize environmental degradation, and to facilitate eventual reclamation.
3. Future work should conform to "Reclamation Guidelines for Exploration" produced by the Department of Mines and Petroleum Resources (see Appendix IV).

The concept that reclamation necessarily begins with operational planning appears well established, at least in regard to exploration activities, with both Company management personnel and the Exploration Department. The following procedure has been used for exploration planning in 1974 and 1975 and will continue throughout the coming management period:

Each exploration area is assigned to a geologist, whose responsibility it is to ensure that environmentally compatible practices are employed. The geologist prepares a preliminary working plan, with operations mapped at a scale of 1:24,000. The preliminary plan is then reviewed with the reclamation biologist who may suggest amendments and will note areas of environmental sensitivity requiring more detailed planning. This detailed planning will then be carried out and mapped at a scale of 1:4800. Before construction begins, the location of all proposed activities will be delineated on the ground and a final on-site inspection carried out by biologist and geologist together. The reclamation biologist has the authority to stop any work which he feels is not up to the required standard, and to insist on corrective measures.

During the period of active exploration, adverse environmental effects will be mitigated by strict adherence to the construction and maintenance prescriptions contained in "Reclamation Guidelines For Exploration" (Appendix IX). Reclamation will be undertaken only when the geologist in charge of a given area declares it to be permanently dormant and unlikely to be mined. Both the B.C. Forest Service and Crowsnest Industries Co. Ltd. have indicated

their desire that the main exploration roads on land under their jurisdiction become permanent fire access roads. The selection of these permanent access roads will be made jointly by Kaiser Resources Ltd., Crowsnest Industries Co. Ltd., the B.C. Forest Service, and the B.C. Fish and Wildlife Branch. Drainage control will be established on these roads, and cut/fill slopes stabilized but the road surfaces will not be revegetated. Once stabilization measures are completed these fire access roads will be formally consigned to the pertinent agency. Secondary roads not selected for permanent access will be totally revegetated. Details of this road reclamation programme are as follows:

A. Measures to Control Erosion and Sediment Flow on all Roads.

1. Treatment of Road Surfaces

The object of drainage structures on road surfaces is to prevent the accumulation and flow of runoff water along the road surface. The two most common methods are:

(a) Cross Drains

The spacing of cross drains will vary depending upon soil type, aspect, road grade and the steepness of the slope above the road.

(b) Outsloping

All roads built on the contour or on near level grade will be outsloped except where deep fills exist.

2. Treatment of Cut and Fill Slopes

(a) Cut and fill slopes will be stabilized mechanically with windrows of brush and logs and then revegetated with shrubs and grass.

(b) Berms will be constructed on road edges above fill slopes to divert water onto more stable areas. Where this is not possible, downspouts will be built the length of the fill slope.

B. Treatment of Secondary Roads

1. All secondary roads will be ditched at their junction with permanent fire access roads to prevent vehicular access.

2. All stream channels will be restored by the removal of culverts and bridges.

3. All road surfaces will be revegetated after site preparation to break surface compaction. Trenches and test pits will be backfilled prior to revegetation wherever possible. Where backfilling is not practical, the area will be resloped. Surface runoff will

be diverted around pits and trenches by interceptor ditches.

Cut banks resulting from drill sites and adits will be back-filled as far as possible, and the waste material below the platform resloped to a maximum of 20°. Surface runoff will be diverted around such sites by interceptor ditches.

As a result of the indiscriminate exploration practices that characterized the programmes from 1969 to 1972, many areas of extreme instability have been created that are not amenable to conventional reclamation techniques. Stabilization of such areas will, of necessity, require site-specific design and treatment.

Species mixtures for exploration areas will be the same as those prescribed for the reclamation of mine sites (see Table 22, Section 6.3.1); however, exploration sites will receive an additional 20 pounds per acre of sweet clover as a temporary nurse crop and soil stabilizer. It is unlikely that the nurseries will be able to provide sufficient planting stock for exploration sites given the geographic and elevational diversity of these operations. It is recommended that trees and shrubs be transplanted from adjacent undisturbed areas either in early spring or late fall.

Very little reclamation has been accomplished to date on exploration areas. It is anticipated that exploration

reclamation will comprise a significant proportion of the reclamation programme during the coming management period.

6.12 Assessment of Results

The objectives of a management enterprise represent the desired end result of a given programme and, as such, must be formulated in such a way that they are measurable. One of the most important components of any management programme is a systematic approach to evaluating the effectiveness of the programme in terms of its stated objectives.

In Section 6.1 the objectives of this reclamation programme were stated as:

1. To re-establish watershed values as soon as possible after the cessation of mining activities on any specific area, and
2. To accomplish watershed rehabilitation in a manner that is compatible with the potential prime surface use of the land, and consistent with post-mining site conditions.

For reasons previously discussed, the most important surface-use objective on a large portion of the Kaiser mining property is the provision of food and cover for wildlife, particularly mule deer, Rocky mountain elk, and moose. On areas where the rehabilitation of wildlife

habitat is not practical, the major surface-use objective will be to create a visually-pleasing landscape.

The evaluation of this reclamation programme will focus primarily on watershed and wildlife habitat parameters.

(a) Watershed Restoration

Within the context of a reclamation programme the most pertinent watershed parameters are those relating to water quality and protective cover.

As noted elsewhere in this thesis, little baseline information on water quality exists for the Fernie Basin, particularly for the smaller watersheds on which reclamation assessment programmes would be carried out. It should be possible, however, to monitor any improvement in water quality on reclaimed watersheds. The parameters to be measured would include pH, dissolved oxygen, colour, turbidity (Jackson Turbidity Units), suspended solids (non-filterable residue) and dissolved solids (filterable residue) (Harrison, 1977). Such a programme could be carried out by Kaiser Resources Ltd.'s Pollution Control Section as an extension of the existing water quality sampling programme.

The second component of watershed stability is protective cover. Protective cover is defined by Gifford and Hawkins (1976) as follows:

> Protective cover is the fraction (per cent) of plant and/or litter cover on an aerial basis. Occasionally this definition includes small rocks. We assume that plant, litter, and rock cover are desirable from the standpoint of watershed protection. Other terms used . . . such as cover density, density, ground cover, and vegetation density all refer to protective cover as defined above.

Since 1974, staff of the Reclamation Department have been measuring protective cover on reclaimed sites. The method used has been the point frame sampling technique reviewed by Hutchings and Pase (1962). In using this technique, protective cover is further subdivided into *ground cover*, defined as the proportion of soil surface occupied by vegetation, litter or small rocks; and *foliage cover*, defined as the proportion of the soil surface covered by the vertical projection of herbage at a specified stage in annual plant growth. Using the point frame sampling technique it is possible to determine the species composition of both ground and foliage cover. A summary of 1974 protective cover measurements is shown in Table 36. Thus far, sampling has been limited to disturbed sites treated in the reclamation programme. Information is required on natural levels of protective cover on comparable undisturbed sites as a standard against which reclamation success can be judged.

Table 36

Protective Cover Measurements by Slope and Aspect for Three Reclamation Sites

(a) Ground Cover (%)

Aspect	Slope Class By Site					
	Michel Refuse Dump		McGillivray Surface Mine		Erickson Surface Mine	
	0 - 15°	15 - 30°	0 - 15°	15 - 30°	0 - 15°	15 - 30°
North	1.0	6.8 ± 1.4	7.4 ± 2.5	N.A.	5.0 ± 1.4	5.8 ± 1.3
East	5.0 ± 1.6	6.2 ± 1.8	N.A.	N.A.	3.8 ± 1.4	3.8 ± 1.3
South	6.3 ± 2.6	N.A.	N.A.	5.0 ± 1.7	N.A.	N.A.
West	7.2 ± 2.3	N.A.	11.4 ± 1.4	6.1 ± 2.2	6.3 ± 1.8	3.5 ± 1.4

(b) Foliage Cover (%)

Aspect	Slope Class By Site					
	Michel Refuse Dump		McGillivray Surface Mine		Erickson Surface Mine	
	0 - 15°	15 - 30°	0 - 15°	15 - 30°	0 - 15°	15 - 30°
North	29.0 ± 1.8	65.4 ± 7.4	77.9 ±	N.A.	50.8 ± 7.5	42.0 ± 7.8
East	61.8 ± 7.7	56.5 ± 8.2	N.A.	N.A.	48.8 ± 9.1	47.0 ± 3.9
South	23.8 ± 4.6	N.A.	N.A.	46.5 ± 6.7	N.A.	N.A.
West	47.8 ± 8.7	N.A.	80.6 ± 6.8	68.5 ± 9.1	53.2 ± 9.2	46.8 ± 9.0

(b) Rehabilitation of Ungulate Habitat

The most important parameters in assessing the rehabilitation of ungulate range are plant species composition, the degree of ungulate use, forage quantity and forage quality. During 1974, 1975 and 1976 the Wildlife Research Section of the B.C. Fish and Wildlife Branch carried out a study of ungulate use of reclaimed strip mines (Stanlake, Stanlake and Eastman, 1977). The following sections describe the methods used in that study and subsequent Kaiser Resources Ltd. programmes, and summarize the results achieved to date.

(i) Plant Species Composition

Species composition in the Fish and Wildlife Branch study was established by sampling permanent vegetation transects. Foliage-cover estimates by species were made in one-tenth square metre frames (20 x 50 cm) spaced at 10 metre intervals along the transects (as per Daubenmire, 1959). The results of this sampling on the Erickson and McGillivray surface mines are shown in Table 37.

Since 1974, Reclamation Section Staff have estimated species composition of ground and foliage cover using the point frame sampling technique, as part of the measurement of protective cover.

Table 37

Per Cent Foliage Cover by Species for the Erickson and McGillivray Surface Mines

Species	Canopy Coverage (%) By Area And Year					
	McGillivray Surface Mine			Erickson Surface Mine		
	1974	1975	1976	1974	1975	1976
Forbs						
Alfalfa	37	25	38	1	7	34
Sweet clover	45	3	13	77	3	15
Grasses						
Canada bluegrass	1	9	9	Tr	1	4
Creeping red fescue	18	8	26	-	-	-
Crested wheatgrass	11	3	2	4	3	12
Intermediate wheatgrass	9	1	Tr	4	3	5
Ryegrass	27	15	-	14	10	Tr
Smooth brome	5	Tr	3	Tr	1	6
Tall wheatgrass	6	1	2	3	1	1
Timothy	16	9	8	Tr	Tr	Tr
TOTAL	175	74	101	103	29	77

Source: Stanlake, Stanlake and Eastman, 1977.

(ii) Ungulate Use

In the Fish and Wildlife Branch study, ungulate use of both revegetated areas and adjacent undisturbed sites was estimated by counting faecal pellet groups. The sampling technique involved counting accumulated pellet groups on 100 sq. ft. (9.3 m^2) plots distributed systematically along transects covering both disturbed and undisturbed habitat. Pellet groups were separated by animal species into those from elk, moose and deer. The results of this study are summarized in Table 38. Ungulate use, as estimated by pellet group numbers, increased steadily on reseeded areas until, by the end of the third year, it equalled that on adjacent grass/shrub communities, and exceeded that in closed canopy forest. Ungulate use of areas not seeded remained relatively constant during the same period. The high ungulate use of recently reseeded areas could be due, in part, to high nutrient status resulting from fertilizer applications. It remains to be seen whether use is sustained after annual fertilization ceases.

(iii) Forage Quantity

Yields of forage were estimated in the Fish and Wildlife Branch study by clipping 1 meter square plots adjacent to the vegetation transects. Plant material was segregated into forbs and grasses, dried, and weighed to the nearest gram. Results for the two mine sites sampled

Table 38 Accumulated pellet groups from seeded and unseeded mined areas, and adjacent natural areas on the McGillivray and Erickson surface mines.

Mine Site	Type of Area	Accumulated Pellet Groups per hectare		
		1974	1975	1976
McGillivray	Disturbed and reseeded	151(120)	484(115)	1453(92)
	Undisturbed closed forest	425(200)	522(160)	766(128)
	Undisturbed grass/shrub community	1680(45)	1646(60)	1507(48)
Erickson	Disturbed but not reseeded	976(65)	1324(40)	1270(28)
	Disturbed and reseeded	299(115)	1572(128)	2207(96)
	Undisturbed shrub communities	2367(25)	2496(25)	2098(20)
	Undisturbed open grasslands	2199(110)	2414(80)	2011(60)
	Undisturbed closed forest	1485(90)	1260(75)	1744(60)

Bracketed numbers refer to the number of $9.3m^2$ plots sampled in each area.

Source: Stanlake, Eastman and Stanlake (1977).

are summarized as follows:

Mine Site	Yield of Forage (grs/m^2) By Year		
	1974	1975	1976
McGillivray	197	279	250
Erickson	178	109	180

Ziemkiewicz (1976) noted the time consuming nature of clipping techniques for estimated yield. Since 1975 he has used the Neal Capacitance Meter, Model 18-1000 (Neal and Neal, 1973) to estimate aerial production on reclamation sites on the Kaiser Resources Ltd. property. In this technique the clipping of every sixth plot is necessary for calibration. Ziemkiewicz's results for the year 1975 are summarized in Tables 39 and 40.

To date, no attempt has been made to estimate woody browse production on revegetated areas because of the early stage of development of both native and planted seedlings. As the woody component of the vegetation develops it will become desirable to include measures of production in forage quantity estimates.

(iv) Forage Quality

Thus far in the programme no assessment of forage quality has been undertaken. It may prove useful, to undertake such sampling at a later date in order to

Table 39

Aerial Standing Crop (kg/ha) as of Late July/Early August, 1975 of Thirteen Revegetation Species On Eight Reclamation Areas

Area Elevation (m) Aspect	Michel Pile 1,176 E. to N.	Baldy 1,413 S. W.	Erickson 1,610 South	McGillivray 1,610 North	Lower C 1,674 S. W.	C Seam 1,771 West	D Seam 1,868 West	Assembly Pad 2,190 O-West
Agropyron desertorum	347.9	21.2	133.4	106.2	36.4	16.3	26.0	0
Agropyron intermedium	0.5	29.8	137.0	95.1	9.4	3.4	14.4	0.1
Agrostis alba	14.3	21.4	4.3	2.7	9.4	2.3	12.9	0
Bromus inermis	18.8	118.8	30.1	36.4	38.7	33.7	61.3	3.9
Dactylis glomerata	0.4	5.1	0.4	0	228.9	127.7	164.3	19.7
Festuca rubra	4.9	55.4	19.4	89.9	7.4	18.9	37.7	0.6
Lolium perenne	0	2.3	124.3	469.1	402.9	230.8	501.3	88.6
Phleum pratense	41.3	29.9	49.3	300.8	0	0.4	0.1	15.1
Poa compressa	145.7	3.5	28.3	205.5	0	0	0	0
Medicago sativa	0.1	8.2	602.9	1,090.2	1,189.5	738.5	343.2	6.3
Melilotus officinalis	0	19.1	40.9	4.3	5.0	16.4	7.2	1.7
Trifolium pratense	0	0.5	0	0.6	504.4	209.5	112.6	0
Trifolium repens	0	7.0	6.4	0	226.4	99.6	119.5	0.3
TOTALS	573.9	322.2	1,176.7	2,392.8	2,658.4	1,497.5	1,400.5	136.3

Source: Zenkiewicz (1976)

Table 40

Forage Standing Crop Data of Some Range Types Floristically Similar To Those Found Adjacent To The Eight Reclamation Areas

Range Type	Aerial[1] Production (kg/ha)	Source	Reclamation Area	Aerial Production (kg/ha)
Mixed prairie (Manyberries, Alberta)	623	Smoliak, 1965	Michel Pile	573.9
Lodgepole Pine - Pinegrass (near Kamloops, B.C.)	561	Freyman and Van Rysnyk 1969	Baldy	322.2
			Erickson	1,176.7
			McGillivray	2,392.8
			Lower C	2,658.4
			C Seam	1,497.5
			D Seam	1,400.5
Mountain grassland (S.W. aspect, Montana)	813	Mueggler, 1977	Assembly Pad	136.3

[1] These data are presented only to aid in interpretation of the reclamation area production data and do not necessarily represent the true forage production on adjacent undisturbed areas in the Natal Area.

Source: Ziemkiewicz (1976).

interpret animal-use data. The most common estimate of forage quality is proximate analysis (Dietz, 1970). This analysis involves the determination of five forage components; crude fibre, crude protein, ash content, crude fat, and nitrogen-free extract.

The possibility exists that forage growing on mining disturbances may accumulate toxic ions such as heavy metals. Future investigations of forage chemical content may be undertaken in this context should the intensive soil sampling programme described in Section 6.2.4 indicate that they are warranted.

VII CONCLUSION

What has been attempted in this thesis is the development of a management plan format for mined-land reclamation which reflects the continuing process of management. It is the author's opinion that the major components of such a plan are:

1. a synthesis of existing information and identification of information deficiencies,
2. the interpretation of existing information and the determination of management needs and options,
3. the definition of management objectives for the management period,
4. the formulation of general prescriptions to meet the objectives; and
5. the development of inventory and evaluation programmes to collect needed information and assess the success of prescriptions.

At the end of the management period, the information collected item (5) replaces item (1) and the cycle repeats itself. For the purpose of this plan the management period chosen was three years (1975-1978). This period may seem short, and the development of a management plan every three years unnecessarily time-consuming, however, in general, the greater the uncertainties in a programme, the shorter should be the management period. Coal mining is a new activity in the Rocky Mountains with no precedents to give guidance, and it was the decision of both mining and reclamation staff that three years was the maximum period over which manage-

ment projections could be made with certainty.

The management plan provides the framework for two other components of the management process; the subdivision of the area for management purposes, and the preparation of operational plans. The management area is usually divided into compartments and sub-compartments, defined as follows:

> Compartments are *permanent* subdivisions of the area delineated on the basis of topography (i.e. watershed), access, or mining operation. Each compartment should be subject to a specific reclamation land-use objective.
>
> Sub-compartments are divisions of compartments differentiated for either treatment or special description. They are not usually permanent and may be combined or further subdivided in the light of future operations. As the standard unit of treatment, they become the basis for record-keeping.

The final step in the management process is the preparation of operational plans. These outline, for each year of the management period, the specific operations to be undertaken and the projected costs of each operation. Operational plans then become the basis for the development of annual budgets.

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APPENDIX I

Guidelines For Coal Development

GUIDELINES
FOR COAL DEVELOPMENT

ENVIRONMENT AND LAND USE COMMITTEE
BRITISH COLUMBIA

March 1976

Parliament Buildings
Victoria, B.C.

GUIDELINES FOR COAL DEVELOPMENT

ENVIRONMENT AND LAND USE COMMITTEE

CONTENTS

Second Printing
June 1976

INTRODUCTION

Major resource developments such as coal mining and processing will change environmental, social, and economic conditions in the region of development. Careful planning of large-scale coal developments is therefore necessary to ensure that a rational approach to managing land use, environmental and community impacts is undertaken prior to final decisions on coal and related developments being made.

The coal development guidelines set out in this document describe the planning process designed to achieve this rational approach. The guidelines identify the diversity of Provincial Government interests and public concerns associated with coal and related developments and establish a procedure for the developer, Government, and the public to assess and manage all major impacts.

The guidelines are prepared under the authority of the Environment and Land Use Committee, a Cabinet Committee of the Government of British Columbia. This committee is composed of nine ministries responsible for resource use and conservation as well as for major public facilities such as highways, settlement, and health services. In addition to providing procedural direction for impact assessment and management, the guidelines specify types of information required by the Provincial Government for the review of permit and licence applications required under various Provincial Statutes and regulations before coal mines can be developed.

This document is organized into two parts. Part I describes briefly the Provincial Government's four-stage project assessment process. Part II describes in more detail information required by various Government agencies in their review of coal and related developments.

There are also five Appendices. Appendix 1 summarizes key Provincial Government Statutes and regulations controlling coal development decisions. Appendix 2 describes in detail the main elements of the onsite mining development that will be considered by the Department of Mines and Petroleum Resources. The third Appendix lists the main Provincial Government contacts both in Victoria and in the major coal-bearing regions. The final two Appendices contain two matrices to assist in the assessment process—one for biophysical impacts and the other for socio-economic and community impacts.

PART I: THE PROJECT ASSESSMENT PROCESS

This section describes the Provincial Government's impact assessment and management process for new coal and related developments in the Province. To co-ordinate this review process, a Coal Steering Committee comprised of representatives from the Department of Mines and Petroleum Resources, the Department of Economic Development, and the Environment and Land Use Committee Secretariat has been formed. It will serve as a contact with the coal companies and their consultants, and will co-ordinate comments of the various agencies of Government responsible for aspects of coal development for the guidance of developers and their consultants.

The four-stage assessment process is outlined on Figure 1. The process systematically moves from a general overview of the project to more specific impact assessments and management proposals, with Government-developer review following each stage.

Throughout the assessment process, information related to both minesite and offsite aspects of each coal development proposal will be requested and should include:

Minesite: Pit areas, waste dump areas, drainage and road systems, processing and loading facilities, power and maintenance facilities, water supplies, etc.

Offsite: Community development, highway and railway linkages, shipping terminals, power supply corridors, etc.

Developers are encouraged to seek out public response to their projects before presentation to Government. The purpose of public involvement is to provide adequate exchange of information between the developer and the public; to enable public assessment of potential impacts and related public concerns; and to provide an evaluation of the public's perspectives on the social significance of the losses and gains associated with a proposed development. To ensure that they will have an adequate opportunity to review the development proposal, the developer should make contact with the public at the earliest possible date and inform them of the opportunities that will be available for public consultation during the assessment process.

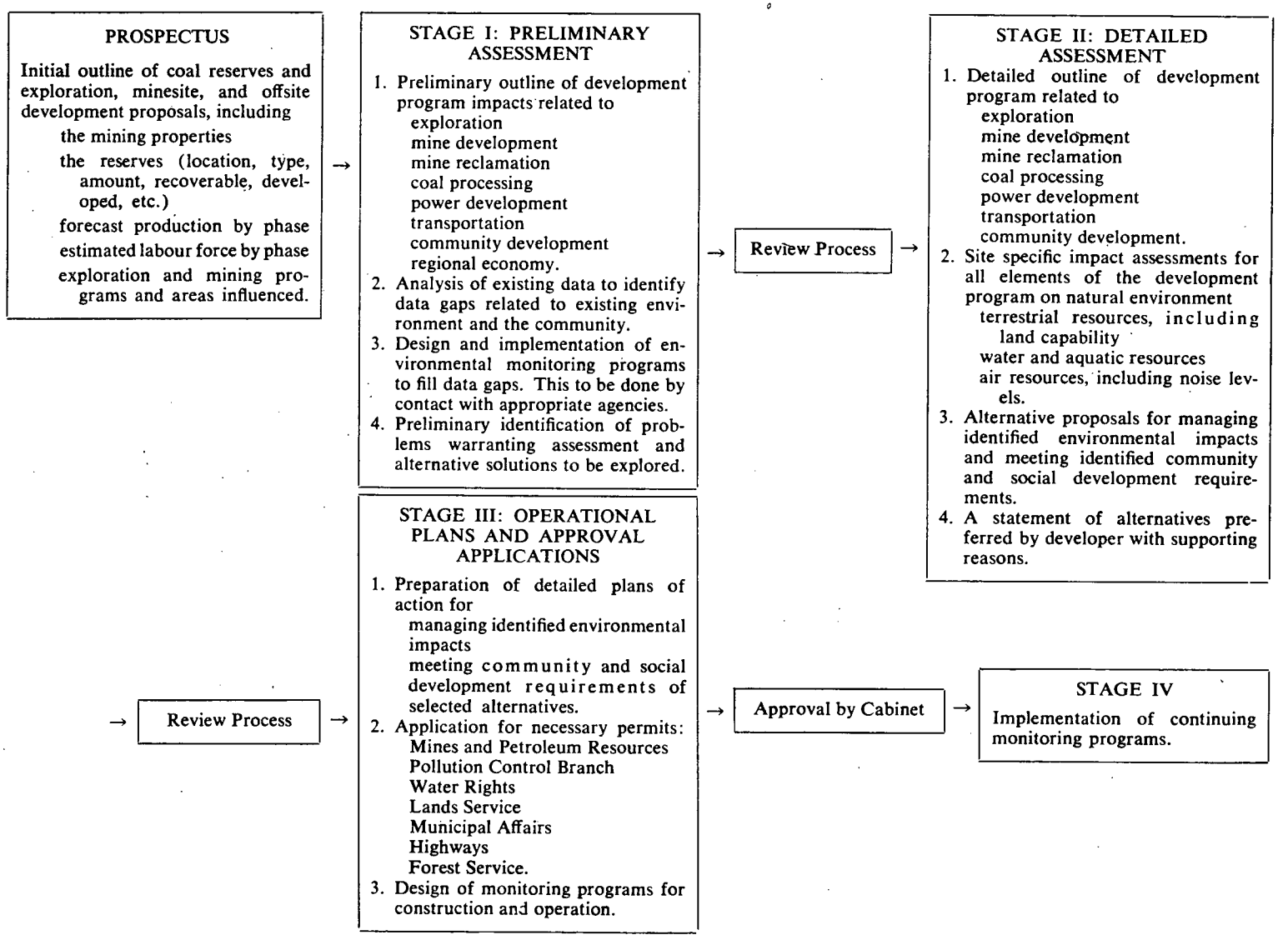
DETAILS OF THE IMPACT ASSESSMENT AND PLANNING PROCESS

PROSPECTUS

The assessment process begins with a prospectus which contains a general outline of the proposed exploration and mining programs. Its purpose is to introduce the concept and basic facts to various Government departments. The developer should submit this prospectus to the Deputy Minister of Mines and Petroleum Resources, who will forward it to the Coal Steering Committee for review.

The prospectus should describe the minesite operation; road and rail systems; operating, storage, and processing locations; maintenance areas and large buildings. Appropriate map scales should be used to locate the works within the area of development. Descriptions of the area and depth of excavation, total of overburden and wasterock, annual production of raw and clean coal, proposal for overburden and wasterock disposal, processing water requirements, and wastewater discharge are

Figure 1—Coal Development Assessment Procedure



to be included. Proposed offsite works and activities, such as shipping terminals, major transportation routes, size of labour force, townsite options, and power rights-of-way, should be included. (The elements of a mining development program listed as Appendix 2 may be of assistance in formulating the prospectus.)

A flow chart of the proposed operations indicating input of materials, the release of effluents from processing plants and tailing areas, and the disposition of finished and waste products would assist understanding. A broad schedule of planning indicating approximate time-span of exploration, construction, operation, and termination, is essential as is a description of the method of mining, coal-processing, and the minesite power supply.

The prospectus should be prepared as early as possible in the developer's planning process to give the Government agencies maximum lead time for compiling existing data sources and for preparing an information base to assist the proponent in Stage I studies.

STAGE I: PRELIMINARY ASSESSMENT

Stage I should identify the major economic, environmental, and social impact of the proposed development on the region in general. Then, Government and the developer can jointly prepare more detailed studies for the Stage II level of assessment to examine alternatives for resolving these problems more efficiently. The main components of Stage I are described below.

1.1 Outline of Proposed Development Program

This section would include a full description of all the onsite and offsite developments outlined in the prospectus. Up-to-date information on schedules for additional exploration, planning, construction, operation, and termination phases of the project is required.

1.2 Description of Existing Environment

Existing natural, social, and economic conditions within the zone of influence of the development should be described. As a result of the prospectus, Government agencies will be able to assist developers in assessing the existing information base quickly to identify major information gaps. (*See* Appendix 3 for principal Government contacts in Victoria and at regional offices.)

1.3 Filling of Information Gaps

The developer is expected to initiate studies and (or) monitoring programs to fill gaps identified during Stage I. These should be undertaken only after discussion with appropriate Government agencies to ensure consistency of approaches, standards, and definitions used to develop the present data base. Copies of all data shall be supplied to the Provincial Government as the study progresses. Monitoring programs need not necessarily be completed by the end of Stage I. Indeed, in certain instances, such as water quantity and quality studies, monitoring should be continued as required by the appropriate Provincial agencies.

Factors to be considered in this environmental and socio-economic baseline assessment are described in detail in Part 2 and are listed on the left-hand column of both the environmental and social matrices (Appendices 4 and 5).

1.4 Problem Identification

It is important that the Stage I assessment include a systematic documentation of the major interactions between the development and the environment. This may be most efficiently achieved by completing a number of "checklist" matrices (such

as suggested in Appendices 4 and 5). Separate matrices should be completed for minesite and offsite impacts on the biophysical environment as well as the social-community environment. The matrices included in this report serve only as guides and may well have to be modified to suit specific developments. (Value judgments will be expected both in the selection of activity and environmental factors and in the nature of impact. In some cases, the impacts may vary depending on the assumptions lying behind the activity factor, e.g., whether some design work which would reduce the impact is included.) The use of these matrices is described in Appendices 4 and 5.

1.5 Economic Evaluation

As coal mines and related facilities involve major investments and employ significant numbers of people, they have important economic implications for the Province and in the region of development. The Government, in seeking a balance between economic, social, and environmental aspects of such development, will assess the broad economic benefits of the project during Stage I. In order to conduct such an assessment, the developer is requested to provide preliminary estimates of gross anticipated enonomic benefits and minesite and offsite development costs.

Government will weigh economic benefits against the environmental and social costs resulting from the project: To ensure the over-all development contributes positively to the net well-being of the Province and the region; to permit initial assessment of the cost-sharing responsibilities regarding various facets of the project such as development of community and transportation facilities, other infrastructure requirements and environmental protection measures. Only preliminary benefit-cost analyses are expected in Stage I; more detailed studies should be included in Stage II.

1.6 Identification of Constructive Alternatives

Stage I should examine alternatives for mitigating or avoiding adverse environmental and social impacts. Opportunities for enhancing environmental and social conditions should also be identified.

Following this step, the developer is responsible for proposing alternative plans for managing these impacts to the satisfaction of Government agencies. At this stage, dialogue between the developer's environmental consultants and engineering design team is essential in defining alternative solutions.

1.7 Presentation of Stage I Report

The developer should send eight draft copies of the Stage I report to the Coal Steering Committee through the Deputy Minister of Mines and Petroleum Resources. This draft will be quickly reviewed by the Steering Committee to check that it generally conforms with these guidelines. If it does, the Coal Steering Committee will request 50 additional copies and send these to various Government agencies for review. (*See* Figure 2 for outline of Government agency review process.)

Depending on the type and scope of Government commentary, the Steering Committee may call a meeting between the developer and the Government agencies, or simply send a co-ordinated reply to the developer. If the initial draft report does not conform to these guidelines, the Steering Committee will so advise the developer and request a second draft. Government review of the developer's Stage I report should take between one and two months.

Acceptance of the Stage I report does not mean a decision-in-principle has been granted the developer. It simply means that the assessment is proceeding

according to approved guidelines and that the developer is in a position to embark on Stage II studies. Government response will indicate the apparent degree of success that identified alternatives are likely to have in meeting the environmental protection standards and other Government interests.

1.8 Public Consultation

At the end of Stage I, a preliminary assessment of environmental, social, and economic impacts is beginning to emerge, and some alternatives for managing these impacts will have been formulated. Developers should be prepared at this point to initiate their public consultation process with local government authorities that will be directly affected by the project (municipalities, regional districts, hospital authorities, school boards, etc.) as well as local interest groups (Chambers of Commerce, fish and wildlife associations, union locals, etc.) To ensure both organized and individual interests are involved it may be desirable to create continuing workshops or study groups representing a broad range of citizen interests to provide an in-depth consideration of particularly difficult aspects of the project proposal.

STAGE II: DETAILED ASSESSMENT

The Stage II report generally parallels the Stage I report in scope but requires more in-depth analysis. Its components are

- detailing of the development program outlined in Stage I;
- site specific analyses of impacts on the natural environment related to both minesite and offsite aspects of the proposed development program;
- analysis of alternative proposals for mitigating identified impacts on the biophysical environment using benefit-cost analysis;
- the cost-effectiveness of alternative proposals for mitigating or compensating for identified impacts on the biophysical environment;
- identification of alternative means of meeting identified community and social requirements;
- statement of the preferred approach for each aspect of the development.

Part II of this report outlines information required for environmental and social impact assessments expected in the Stage II report.

Where possible, benefit-cost analyses should be used to compare alternatives designed to mitigate impacts or plan developments in a rational way. (Example: Wasterock disposal or community settlement options.)

As a general rule, the Province is seeking a proposal from developers wherein economic, social, and environmental concerns are assessed, planned for, and "traded-off," to produce a balance that maximizes net social well-being in the region of development and to the Province. Thus, environmental impacts at a particular site might not necessarily be minimized if costs of such actions far outweigh the value of foregone resources. However, in cases where environment resource values are very high, special efforts for environmental protection are expected. Developers are expected to provide cost estimates of alternative proposals for reducing environmental impacts so that a satisfactory level of mitigation can be selected. Similarly, estimated costs of providing community services and infrastructure should be documented so that responsibilities for their provision can be assessed.

Public meetings to discuss this report should be anticipated, in which case the developer and its consultants would be expected to conduct such meetings, present its findings and answer questions from the public.

Review of the Stage II report will follow the same procedure outlined for Stage I. As this review requires careful assessment of preferred alternatives and leads to final operational planning, the review will take a minimum of eight weeks.

Figure 2—Procedure for Processing Impact Assessments of Proposed Coal Developments

PROSPECTUS (formulated by developer)

↓

Submission by Developer to Department of Mines and Petroleum Resources; related discussions

↓

Circulation to Provincial Government line departments by Coal Development Steering Committee*

↓

Receipt of agency comments by Steering Committee

↓

Consultation(s) with Developer's Representatives and (or) Consultants

↓

STAGE I: PRELIMINARY ASSESSMENT

(Contact as necessary with line departments throughout study stage)

↓

Submission of report to Mines Department

↓

Initial review by Steering Committee

↓

Circulation and review by line departments

↓

Consultation(s) between Developer's Representatives/Consultants and Steering Committee

↓

Integrated formal commentary to Developer's Representatives/Consultants by Steering Committee

↓

STAGE II: DETAILED ASSESSMENT

(Contact as necessary with line departments throughout study stage)

↓

Submission of report to Mines Department

↓

Initial review by Steering Committee

↓

Circulation and review by line departments

↓

Consultations between Developer's Representatives/Consultants and Steering Committee

↓

Integrated formal commentary to Developer's Representatives/Consultants by Steering Committee

↓

STAGE III: OPERATIONAL PLANS AND APPROVAL OF PERMIT APPLICATIONS

(Direct liaison with appropriate regulatory departments)

↓

Submission of detailed plans and analyses as required for statutory approvals by line departments

↓

Successful projects granted necessary permit approvals

* Consists of representatives of Departments of Mines and Petroleum Resources and Economic Development and the ELUC Secretariat.

STAGE III: OPERATIONAL PLANS AND APPROVAL APPLICATIONS

Acceptance of the Stage II report represents approval in principle for the environmental and community development aspects of the coal mine development. However, before the project can proceed, the developer must obtain various licences and permits, as required by various Statutes. Stage III represents the application and granting of such licences and permits. Detailed reclamation proposals must be formally submitted to the Department of Mines and Petroleum Resources for review by the Reclamation Committee in accordance with section 8 of the *Coal Mines Regulation Act* (Appendix 1). In addition, before the project can proceed the developer must obtain pollution control permits, water licences, land use permits, forestry approval, approval of the operating plan, and a production lease as required by various Statutes (Appendix 2).

It should be recognized that Stage III is not a duplication of Stages I and II, but rather these earlier assessments ensure that appropriate assessments and studies required for project evaluation, awarding of various permits, licences, and approvals are systematically undertaken. In cases where the review of a licence or permit application takes more than several months, formal application may be initiated during the Stage II assessment. Approval of certain permits such as the pollution control permit and water licence may involve public hearings, in which case, the developer will be required to participate. Pursuant to section 26 (3) of the *Coal Act,* approval of the production lease is given by the Lieutenant-Governor in Council upon the recommendation of the Minister of Mines and Petroleum Resources.

STAGE IV: PROJECT IMPLEMENTATION

Various Provincial Government agencies have specific and continuing responsibilities during development of the project into a producing mine and will continue to monitor specific aspects of the project. The developer is responsible for conforming with Government regulations in such key areas as air and water quality and surface reclamation. The same applies to offsite facilities. Most intensive monitoring can be anticipated through the development phase, during which accepted guidelines to mitigate construction impacts are enforced. Once operational, normal regulatory functions related to adequacy, safety, etc., are implemented.

PART II: INFORMATION REQUIREMENTS FOR PROJECT ASSESSMENT

The purpose of this section is to describe in more detail the types of information and analyses to be included in the various staged studies. This section is divided into two parts. The first part describes the array of biophysical information required, the second part relates to socio-economic and community impact requirements.

Environmental disruption or socio-economic and community impacts may be associated with any or all of the following activities:

Exploration (roads, adits, blasting):
Excavation (surface or underground):
Overburden and waste disposal:
Processing of coal:
Reclamation:
Transportation (roads, rail, marine access):
Community and ancillary developments:
Power requirements (generation, transmission).

1. Biophysical Impact Assessment

In the Stage I report, the main emphasis lies in the full description of the existing biophysical environment in accordance with the categories outlined in this subsection, an initial identification of the major impacts of coal developments on this resource base, and some alternative impact management plans. Not all environmental factors need to be described in equal detail. Developers should use their judgment concentrating on the significant impacts.

The main emphasis in the Stage II report involves the detailed evaluation of alternative programs to avoid or manage impacts. This task requires first an explicit documentation of the major biophysical changes created by the developments and, second, the evaluation of these impacts in socio-economic terms where possible. Benefit-cost analysis should be used to compare mitigatory alternatives, so that the costs of such alternatives (longer route alignments; more distant waste dumps, etc.) are weighed against the benefits (protection of fish, wildlife habitat, greater recreational opportunities).

Such assessments will require the developers to attempt some form of benefit-cost analysis of both "intangible" resources such as angling effort, hunter days, recreation opportunity, and "tangible" resources such as forestry, agriculture, and grazing. The Special Projects Unit of the ELUC Secretariat is currently preparing a manual of techniques for undertaking such benefit-cost analyses. This manual is expected to be completed in the spring 1976, but developers are invited to consult the Secretariat for guidance in the interim.

The intent of benefit-cost analysis is to ensure a more rational and orderly approach to evaluating alternatives. There are many problems in mensuration, especially of "intangibles," and developers should be careful that the costs of data acquisition are commensurate with the improved data analysis. Again this is a judgmental decision, and the Coal Steering Committee would be willing to advise developers during the preparation of the Stage II report.

The main purpose of Stage III is to prepare plans in sufficient detail for required approval of permits and licences. The developers should contact the appropriate line agencies during Stage II studies to determine the precise data requirements for licence application, as the approval process may take several months.

Components or factors of the biophysical environment which may be influenced by the mine exploration and development activities are as follows:

Land use and land capabilities:
Noise levels:
Water:
Aquatic resources:
Atmospheric conditions.

A matrix presented as Appendix 4 assists developers to array the biophysical impacts of the possible development activities on the five components of the biophysical environment. This matrix may serve as a graphic checklist or it may be used as a more sophisticated analytical tool, depending on the nature of the impacts.

1.1 LAND USE AND LAND CAPABILITIES

This information should assist in the analysis of land suitability for the location of various developments and to assess land capability to support alternative resource uses.

Physical Setting

Soils and landforms.
Depth to bedrock.
Surficial materials.
Existing and climax vegetation.
Climate (ppt, temps, wind, humidity, growing season).
Natural drainage.

Main source: Resource Analysis Unit, ELUC Secretariat, Victoria.

Land Capability and Present Use

Present and projected land use patterns in both the absence and presence of the coal mine and ancillary facilities should be carefully assessed. This requires evaluation of resource capability maps based on the biophysical data noted above, knowledge of existing and potential demands for various resources in the region, and an understanding of compatibility and incompatibility between the various resource uses. Land use and capabilities to be assessed include:

Minerals and petroleum.
Agriculture.
Recreation.
Grazing.
Forestry.
Wildlife.
Urban development.

Minerals and Petroleum

Coal reserves and major seams.
Geological conditions.
Nature and composition of overburden.
Petroleum resources and minerals other than coal.

Agriculture

Location of agricultural land reserves.
Present range of crops and productivities.
Agricultural land capabilities.
Relationship with other resource uses.

Main sources:

Resource Analysis Unit, ELUC Secretariat, Victoria.
Department of Agriculture, Victoria, Regions.

Recreation

Present recreation use:

Public facilities (camp-sites, parks, picnic sites, etc.).
Private facilities (camp-sites, trailer courts, etc.).
Access (roads, trails).
Undeveloped (wild or pastoral) areas for hiking, camping, etc.

Present and projected demands (visitor days, camper nights) by local residents and visitors (prior to and after mine development).

Probable impacts on existing facilities and features:

Increased use through improved access, population increase.

Loss of potential sites due to minesite development.

Recreational land use capabilities (features, physical carrying capacity).

Mitigatory measures:

Outdoor recreation (new trails, camp-sites).

Community recreation (*see* section on community impacts).

Main sources:

Parks Branch, Department of Recreation and Travel Industry, Victoria, Region.

Department of Travel Industry, Victoria.

Resource Analysis Unit, ELUC Secretariat, Victoria.

B.C. Forest Service, Victoria, Regions.

Grazing

Present carrying capacities (animal-unit months).

Potential carrying capacities (animal-unit months).

Relationships with forest and wildlife resource uses.

Main sources:

Grazing Division, Forest Service, Victoria, Regions.

Resource Analysis Unit, ELUC Secretariat, Victoria.

Forestry

Forest inventory and capability.

Present AAC and commitments.

Existing forest road patterns and projected developments.

Relationships with wildlife, fisheries, and grazing.

Impacts of development on forest resource:

New access, compatibility of logging and mining roads.

Loss of resource.

Increase in protection forests requirements (greenbelts).

Main sources:

B.C. Forest Service, Victoria, Regions.

Resource Analysis Unit, ELUC Secretariat, Victoria.

Wildlife (categories of assessment should include big game, small game, fur-bearers, upland birds, waterfowl, rare and endangered species)

Present population levels, seasonal habitat identification, migratory routes, and mineral licks.

Recreational use (consumptive, nonconsumptive).

Capability of habitat.

Direct and indirect impacts of development on habitat.

Present and projected hunting pressures with increased population and access, sustainability of wildlife populations.

Identification of mitigatory measures:

Short-term—during mining development.

Long-term—following reclamation.

Main sources:

B.C. Fish and Wildlife Branch, Department of Recreation and Travel Industry, Victoria, Regions.

Resource Analysis Unit, ELUC Secretariat, Victoria.

Urban Suitability

Use of biophysical maps to assess land stability, flood plain areas, suitability for sewage-waste disposal, transportation developments. (*See also* 1.6.)

Main sources:
- Water Resources Service, Victoria (floodplain maps).
- Resource Analysis Unit, ELUC Secretariat, Victoria.
- Department of Highways, Victoria.

Land Status

A map should be provided showing the present status of land:
- Crown land—reserves and alienations (leases and licences).
- Private land—ownership and leases.

Main sources:
- Lands Service, Land Registry Office, Forest Service.

1.2 Noise Levels

Decibel levels at various distances away from main sources:
- Minesite.
- Processing plant.
- Transportation routes.

Main Sources:

Workers' Compensation Board and *Mines Regulations Act* and (or) municipal and regional district by-laws:
- Frequency of noise.
- Impacts on local population, wildlife.
- Abatement measures.

1.3 Water Resources

Water Quantity

Surface:
- Hydrologic regime (note maximum and minimum flows)
- Present water licences and water use.
- Delineation of floodplain.

Groundwater:
- Shallow and deep aquifers.
- Natural filter depth.
- Relationships to surface water flows.
- Present use (well records).

Identification of source(s) of water supply for mine and community:
- Assess impacts of other consumptive and nonconsumptive users.
- Evaluate mitigatory measures.

Main sources:
- Water Survey of Canada, Department of Environment, Vancouver.
- B.C. Water Resources Service, Victoria.

Water Quality

Existing water quality in all streams that might be affected by the project should be sampled prior to any development. Developers should consult with B.C. Pollution Control Branch, Victoria, and Water Quality Section, Inland Waters, Department of Environment (Canada), Vancouver, for existing data, as well as advice on the following information for new monitoring studies:

Location, frequency, and analytical techniques.

Water quality parameters (the following are suggested):

pH.	Turbidity.
Total solids.	Specific conductance.
Dissolved solids.	Temperature.
Phenols.	Sulphate.
Total alkalinity.	Total iron.
Organic carbon.	Hardness.
Suspended sediments.	Acidity.

The above parameters form the core of a water quality monitoring program, and it may be necessary to add parameters to this list on a site-specific basis.

Identification of potential pollutants from:

Overburden disposal.	Transportation and access road construction.
Tailings ponds.	Sewage from community developments.
Coal processing.	

Presentation of detailed plans for pollution abatement measures:

All point source discharges require a permit from the B.C. Pollution Control Branch.

Location of roads and overburden must be detailed for mine reclamation permit.

Main sources:

B.C. Pollution Control Branch, Victoria.

Department of Mines and Petroleum Resources, Victoria.

1.4 Aquatic Resources

Benthic Fauna

Species distribution.

Pollution tolerance.

Utilization by fisheries.

Impact of suspended solids and other pollutants and species composition and productivity.

Impact of changes in benthic fauna on higher organisms.

Fisheries

Species composition, distribution, and population.

Resident, anadromous species.

Habitat assessment—rearing, spawning, migration.

Minimum flow requirements.

Present and projected angler use and success rates.

Probable impacts of development on habitat.

Assessment of management alternatives to replace lost habitat or mitigate habitat loss.

International implications, if any.

Main sources:

B.C. Fish and Wildlife Branch, Department of Recreation and Travel Industry, Victoria, Regions.

Fisheries Service, Department of Environment (Canada), Vancouver.

Resource Analysis Unit, ELUC Secretariat, Victoria.

Water Resources Service, Victoria.

1.5 Atmospheric Conditions

Existing air quality should be monitored before development begins. Air quality data are available from the B.C. Pollution Control Branch and the Atmospheric Environment Service, Department of Environment (Canada), Vancouver. Specifications for undertaking special monitoring programs to fill data gaps should be discussed with each of the above agencies prior to sampling.

The assimilative capacity of the airshed at site should be determined as best as possible. This will require the following information:

Temperatures.
Inversions—frequency, season, extent.
Precipitation (snow, rain).
Wind—speed, direction, diffusion capacity.

Potential sources of air pollutants should be identified:

Minesite.
Processing plant.
Ancillary activities.

Plans for pollution abatement measures must be approved by B.C. Pollution Control Branch as part of the pollution control permit.

Main sources:

B.C. Pollution Control Branch, Victoria.
Atmospheric Environment Service, D.O.E. (Canada), Vancouver.
Resource Analysis Unit, ELUC Secretariat, Victoria.

1.6 Environmental Hazards

Potential for landslides, snowslides, floods, fires.

2. Socio-economic and Community Impact Assessment

The three-stage assessment procedure should apply as follows:

Stage I: Identification of socio-economic/community development impacts.
Stage II: Outline of proposed (or alternative) plans and programs for impact management.
Stage III: Detailed plans and programs for impact management (community development, provision of physical and social services, etc.).

Reference should be made to all the following components or factors at each of the three stages in the assessment process:

Employment.
Population.
Housing.
Services.
Community land.
Community infrastructure.
Regional infrastructure.
Social adjustment.
Government revenues.

Those impacts related to population and employment factors should be identified as precisely as possible to ensure that predictions of impacts related to other social factors are reliable. The commencement and duration of predicted impacts should be indicated to facilitate their management.

The risk or uncertainty of positive and negative impacts occurring should be specified.

It is recognized that much of the information on impacts in this subsection must be based on experience in coal-mining communities in the area and elsewhere as well as other similar resource-based communities. Where such experiences are being used for projection, this should be noted.

In all cases information on impact should be compared to existing socio-economic conditions in the direct impact area of proposed minesite, i.e., the community or communities employees will live in, as well as those which will be used for higher levels of commercial, social, educational, and health services. This is necessary in order to determine the additive effects of coal development(s). Current deficiences and opportunities for overcoming these can thus also be identified. A general matrix is presented in Appendix 5 to assist in arraying the information.

2.1 Employment

New Employment

Number of new direct positions created by project during its phases of construction, operation, and post-operation.

Union, trade, and professional conditions related to hiring.

Education, training, and experience requirements.

Seasonality of employment.

Existing local union arrangements.

Timing of manpower and training requirements.

Cyclical pattern and general economic conditions related to coal markets which could cause future employment instability.

Employment in Social, Cultural, Education, Health Facilities

Number of employees by category (*see* section 2.4 following for detailed list).

Employment in Auxiliary (Support) Industrial Economic Activity

What goods and services does the developer expect to purchase in the area and what employment can be projected for these activities?

Expected required occupations.

Source of Labour Force and Training Requirements

Recruitment programs.

Most likely origin of new supply.

Effect on unemployed labour pool of local communities, region and Province (special attention should be paid to groups such as women, high school dropouts, etc., who have particular problems finding work). Identify scope within occupational structure for employment of this labour pool.

Effect on regional out-migration and school dropout rates.

What existing training programs can be employed locally, regionally and Provincially to meet employment needs? What new training programs will be required?

Distinction between industry (on the job) versus institutional training.

Income Levels

Estimate of total personal income generated by project over anticipated lifetime. Relate this to job categories:

Construction phase.

Operation phase (estimates of mine-related and service labour).

Effect and distribution of income on community and region.

Disparities, if any, between traditional wage levels in the region and wages associated with employment in the mine; and the anticipated effect of these disparities.

2.2 Population

Population impact: Predicted population totals of existing and projected communities (distinguish between population generated from direct (mine) and indirect (service) employment).

Age-sex characteristics of total population.

Household types anticipated (family size).

Dependent population (estimates):

Number of women/men brought into the area as a result of spouse's employment.

Number of children (approximate age, for example, pre-school, elementary school, secondary school).

Socio-cultural characteristics of incoming population, for example, ethnicity, educational level. (Refer to 2.8 and comment on implicating.)

2.3 Housing Development

Aggregate housing requirements for

mine-related employees and dependent population;

service employees and dependent population.

Type, tenure, and cost to householder of direct and indirect employee requirements: Breakdown according to rental versus owner-occupied, and single-family, multi-family, and "mobile" units.

The capacity of the existing housing market to meet housing requirements. The ability of the local construction sector to meet increases in housing demand, and identify source and amount of shortfall housing.

The availability of mortgage funding and applicant requirements. Analysis of the ability of labour force in both mine and mine operation-related jobs and as well as service sectors to afford proposed housing.

Proposed program for meeting housing requirements. Who will develop this housing? What forms of subsidy, if any, will be necessary? Anticipated investment in construction industry and region of investment.

Subdivision standards (*see* 2.6).

2.4 Services

Education

Number of school-age children expected.

Expansion in existing school facilities required.

Availability and demand for adult education.

Community and Regional Recreation Facilities and Services

Existing supply of facilities and patterns of use (pressures).

Change in type and amount of recreation activity required by new populations.

Commercial Services

Type and amount of expected commercial expenditures of population as indicated by experiences in other mining-based communities, personal income and availability of goods and services in community and region.

Which commercial services will likely be added to the commercial mix due to enlarged local payroll.

The impact on commercial services should consider regional implications, e.g., impact on facilities provided in Cranbrook in the case of the Southeast Kootenays, and in Dawson Creek, in the case of the northeast coal areas.

Medical and Health Facilities and Services

Based on population projections and past experience in coal-mining communities, specify by type of service, e.g., general practitioners, pædiatricians, dentists, public health, mental health, etc., and the type and amount of required facility development—hospitals, etc.

Cultural Facilities and Social Services

The expected demand for entertainment and cultural facilities such as restaurants, theatres, arts and crafts, churches, child care centres (relate to age structure of population and projected number of women in the workforce with children requiring child care).

Social and counselling services (social workers, marital counsellors, foster homes and transition houses, women's centres, alcoholism and drug treatment centres, and voluntary community services).

Communication Facilities and Services

Existing media and communication facilities and impact of new populations on demand.

Court and Judicial Services

The amount and type of demand for these services.

Fire and Police Protection

Incremental demand for these services.

Support Industrial Activities

Equipment sales and services to mining industry and resident population.

2.5 Community Land

Requirements for land for residential, commercial, industrial, institutional, and other uses.

Availability of land at the alternative locations and any problems with respect to physical supply and price.

2.6 Community Infrastructure

Sewage Disposal

Predicted demand on existing sewage-disposal systems and for new collection and treatment systems.

Environmental and cost considerations.

Development responsibilities, i.e., coal mine developer, municipality, other.

Water System

Predicted demand on existing water systems and need for new water systems resulting from project and increased population; resource and cost considerations.

Development responsibilities, i.e., coal-mine developer, municipality, other.

Subdivision Standards

What standards of subdivision are planned? Will these be curbs, gutters, sidewalks, underground wiring? How much will this affect the cost of houses to final purchasers?

2.7 Regional Infrastructure

Transportation

Predicted increased use of existing local and regional transportation systems (public and private) (discussion of safety, pollution, and noise factors to be included).

Expansion of existing transportation network which will be required (safety, pollution, æsthetic, and noise factors to be included as well as responsibility for development indicated).

New types of transportation services which may be required or desirable (e.g., transit between residential areas and commercial or recreational facilities).

Transportation from community to minesite operations.

Development responsibilities, for above, i.e., coal-mine developer, railway company, Federal and (or) Provincial Governments.

Energy

Power requirements and potential sources.

Power line rights-of-way locations.

2.8 Social and Economic Adjustment Considerations

(Note—Some of these considerations have already been listed under employment.)

Cultural Impact

Discuss social problems which may arise based on comparable situations (e.g., mental health problems among women, crime drug abuse, alcoholism, and marital breakdown); indicate the factors contributing to these problems and outline proposed approaches the developer feels should be taken to overcome these problems and who would be responsible for these.

Community Integration

Predicted areas of conflict between newcomers and existing population (based on experiences with similar developments) and proposals for resolving these.

Relocation

Will families be required to relocate to make way for mining operations (number of families and possible receiving communities)? What disturbance of traditional land use and way of life will occur?

Local Government Impact

What increased revenue through taxes will be available to the local governments as a result of the development. The detailed impact on fiscal position of local governments should be considered as part of the examination of alternatives in Stage II.

Impact on political structure of local government.

Archæological and Historic Sites

Sites which will be lost to society in general or to a community which places special value on them should be identified.

2.9 Community Design and Æsthetic Considerations

Townsite site selection factors: Sunlight, orientation, micro-climate.

Urban design factors: Environmental, social relationships, circulation, landscaping and maintenance of existing vegetation cover, housing design and finishes.

APPENDIX 1—SUMMARY OF STATUTORY REQUIREMENTS

SUMMARY OF STATUTORY REQUIREMENTS APPLICABLE TO COAL MINE DEVELOPMENT IN BRITISH COLUMBIA

This Appendix outlines some of the Acts of the Provincial Legislature and highlights sections which apply directly to coal mine development. It is not and should not be considered as a complete list of applicable Statutes or a full presentation of their applicable contents.

Coal Act

In all cases developers must refer to the Statutes and consult with individual departments regarding legislation, regulations, and departmental policy.

This Act defines the general conditions under which a person may receive and hold title to coal land. For the purposes of this Act, coal land is defined as "land in respect of which coal, or the right to explore for, develop, and produce coal, are vested in, or reserved to, the Crown."

To obtain such rights a person must hold a valid free miner's certificate as defined by the *Mineral Act*. Coal licences, issued at the discretion of the Minister of Mines and Petroleum Resources, are for exploration and the licensee is required to pay a rental, a land tax under the *Taxation Act*, and to perform work of a specified minimum value. No coal production is permitted from licences except in amounts less than 100 tons per day, for which a limited production permit, issued by the Minister, has been obtained. Leases issued by the Lieutenant-Governor in Council, on approval of the Minister, are required for coal production (CA sec. 26). Application for a coal licence or application for extension of a licence must be accompanied by a plan of exploration and development, which must be approved. Application for a lease must also be accompanied by a plan of operations, and the Minister, in considering the application, must be satisfied regarding efficient operation, optimum coal recovery, and minimum environmental effect.

Section 29 of the Act describes the coal royalties payable: "Every lessee and holder of a permit shall pay to the Crown, in respect of coal produced from the location of his lease or permit, such royalty as the Lieutenant-Governor in Council may at any time prescribe." As of November 1975, the royalty payment was $0.75 per ton of thermal coal produced, and $1.50 per ton of metallurgical coal produced. Coal royalties are administered by the Director, Mineral Revenue Division, Department of Mines and Petroleum Resources.

A coal lease allows exploration, development, *and production* (CA sec. 24 (1)) for up to 21 years (CA sec. 27 (1)). It also allows *use of surface area* for producing coal and entitles issuance of a licence to cut timber under the *Forest Act* (CA sec. 24 (3)).

Application for a coal lease must be accompanied by a plan of intended operations (CA sec. 26 (2*d*)), which must conform with sections 7 and 8 of the CMRA.

Coal Mines Regulation Act (CMRA)

This Act controls the operations of coal mines in both the exploratory and the production phases in every place regardless of the nature of the coal tenure. The Act is largely concerned with mine safety, but section 7 deals in part with conservation and section 8 regulates reclamation of the surface. Before any work can begin an operator must submit and have approved a report on proposed work showing what protection and reclamation of the land surface will be carried out (CMRA sec. 8 (1), (2), (3)).

These plans and reports must be reviewed by all departments affected by or interested in the proposal (CMRA sec. 8 (5)), and must be approved by the Ministers of *Environment, Recreation and Travel Industry, and Agriculture* (CMRA sec. 8 (6)). Guidelines under CMRA sec. 8 are in effect which are periodically upgraded to require developers to carry out modern reclamation practices.

Controlled Access Highway Act

This Act governs access to a designated controlled access highway. Where access is required, application must be made to the Department of Highways and Public Works.

For other provisions regarding roads and the subdivision of land, reference should be made to the *Municipal Act* and the *Land Registry Act*.

Corporation Capital Tax Act (consolidated December 15, 1973)

Environment and Land Use Act (Consolidated July 1, 1971)

This Act establishes the Environment and Land Use Committee, consisting of the Ministers of Environment (chairman), Mines and Petroleum Resources, Forests, Recreation and Travel

Industry, Highways, Health, Municipal Affairs, Economic Development, and Agriculture.

The Committee is empowered to "ensure that all aspects of preservation and maintenance of the natural environment are fully considered in the administration of land use and resource development commensurate with a maximum beneficial land use, and minimize and prevent waste of such resources, and despoliation of the environment occasioned thereby" (sec. 3 (*b*)). In that Act, "environment" is defined as "all external conditions or influences under which man, animals, and plants live or are developed" (sec. 1 (*b*)).

The Committee may hold public inquiries and hearings.

Orders in Council under this Act cannot be contravened by any Minister, department of Government, or agent of the Crown, and such orders or regulations are legally binding (secs. 6 and 7).

FOREST ACT (consolidated Dec. 13, 1974)

The *Forest Act* deals with Crown timber, defined as "any trees, timber, and products of the forest in respect whereof Her Majesty in right of the Province is entitled to demand and receive any royalty or revenue or money whatsoever."

The Act is administered by the Forest Service. Sections of the Act which have specific application to mine exploration and development include 24, 25A, 47, 33, 116, and 118.

Permits to cut Crown timber must be obtained from the Forest Service, and this timber is subject to the payment of stumpage, including royalty, and such terms and conditions as the Minister may prescribe (sec. 24). Free-use permits which exempt the payment of stumpage or royalties can also be applied for where timber is actually used in mine exploration, development, or operation (sec. 25A). For further details, refer to B.C. Reg. 8/59, which deals with the granting of free-use permits of timber on tree-farm licences.

In addition to Crown timber, the Forest Service has administrative responsibility for lands designated as forest reserves—lands delimited for the perpetual growing of timber, for grazing or recreational uses, or for other forest uses (sec. 33 (1)). Proclaimed forest reserves are withdrawn from sale, settlement, and occupancy under the provisions of the *Land Act* or *Taxation Act*, and, in respect of the *Mineral Act, Placer Mining Act, Coal Act,* and *Petroleum and Natural Gas Act,* their use is subject to such conditions as the Lieutenant-Governor in Council imposes (sec. 33 (2)).

Further to the provisions of the *Forest Act* regarding forest reserves, special regulations have been prepared for minerals, coal, petroleum, and natural gas exploration and development in these areas. These are found in Division 6 of the Forest Reserve Regulations (B.C. Regs. 7/59, 208/71). These regulations state that no buildings can be erected in a Provincial forest, and no surface rights will be granted for under any licence or lease under the *Coal Act* (or other mine-related Acts) while such lands are included within a Provincial forest.

Sections 116 and 118 deal primarily with management and protection of forest lands.

With reference to sections of the *Coal Act* dealing with licences to cut timber, it should be noted that the Forest Service prefers, whenever it is practical, both on a time basis and a geographic basis, that removal of the forest values be done through normal timber sale procedures.

INCOME TAX ACT (consolidated Dec. 15, 1973), INCOME TAX AMENDMENT ACT (assented to June 20, 1974)

Coal-mining ventures are subject to taxation under the normal provisions contained in these Acts.

LAND ACT (consolidated July 19, 1974)

It is not necessary for a company to obtain a lease under the *Land Act* to authorize the use of vacant Crown land for the purpose of developing a coal deposit. This is covered under the *Coal Act*. However, for uses of vacant Crown land related to the coal development such as a cleaning plant, crushing plant, or rights-of-way, leases must be obtained under section 9 of the *Land Act*.

Procedures for applications are set down in section 28. Applicants are required to submit detailed plans of the development proposed for Crown land, including a time schedule and cost estimate. Authority for this is section 31 of the *Land Act*. Detailed procedures and requirements under this section are set out in *Summary of General Guidelines for Environmental Impact Control of Development of British Columbia Crown Lands.* This can be obtained from the Environmental Service Unit of the Land Service. Developers are advised to consult with this unit to determine how these guidelines will be applied relative to the al development guidelines in the preceding text.

Final approval for a lease would include a requirement for the posting of a performance and (or) clean-up deposit under authority of section 32 of the *Land Act*. Land Management Circular Letter 78 explains the policy and procedure applied to these deposits. The minimum deposit for an industrial lease including a plant or smelter or like development would be $50,000.

LAND REGISTRY ACT

MINERAL LAND TAX ACT (consolidated Dec. 15, 1973)

Mineral land is defined under this Act as

". . . land, other than Crown land and land comprising a right-of-way, station ground, yard, or terminal of a railway, in respect of which

(i) any mineral is or may be situated; or

(ii) any person has the right to work, win, or carry away any material;"

The Lieutenant-Governor in Council may also "designate" other lands (including the above exemptions) as mineral land for the purposes of this Act. Mineral land may fall into the definition of "production area" or "production tract" (*see* secs. 1, 2, 3) and as a result be subject to different levels of taxation. Tax rates for mineral land are described in section 4, tax rates for mineral land in a production area are described under section 5. In the latter case, the per acre tax rate is higher than applied to a nonproduction area and is subject to an additional tax based on the assessed value of the designated land. The procedure for assessing the value of mineral land for the purposes of taxation is described in section 6. Liability for tax payment falls on the "owner" of mineral land, defined as "a person who has the right to work, win, or carry away minerals from any mineral land." This Act is administered by the Assessor of Mineral Land Tax. Further information is available from the Mineral Revenue Division, Department of Mines and Petroleum Resources. This Act applies to feehold on Crown-granted land carrying coal rights.

MINING TAX ACT (consolidated June 1, 1970)

Under the *Mining Tax Act*, every owner of a mine is assessed and taxed on his net income derived from mining operations. In this context, a "mine" includes any work or undertaking in which mineral ore is extracted or produced. The tax rate is set out in section 3 (2) and net income is defined in sections 4 and 5.

The Act is administered in the Department of Finance by the Commissioner of Income Tax.

MUNICIPAL ACT (consolidated Dec. 15, 1973)

Reference should be made to sections of the *Municipal Act* dealing with

Incorporation.

Assessment and Taxation.

Community Planning.

Special Areas Division (2) Regional Districts.

Section 10A of the *Municipal Act* provides for the incorporation of resource communities.

The *Municipal Act* also specifies the application of property taxation in incorporated areas and regional districts. It provides for community and regional district subdivision and zoning by-laws that must be recognized by mining companies whose development involves private lands. It is noted that regional districts also have referral provisions under other jurisdictions, although these are not specified in the *Municipal Act*.

PARK ACT (consolidated July 1, 1973)

This Act applies to Provincial parks and recreation areas, and should be consulted if resource uses other than those specified in the Act are being considered for these areas.

POLLUTION CONTROL ACT, 1967

The Pollution Control Branch enforces the requirements and regulations of the *Pollution Control Act, 1967* and regulations, as amended. The Act requires a permit or approval from the Director for each discharge of effluent, or refuse, or emission of air contaminants. Division (2) of the regulations describes the acquisition of permits, section 6 of the Act describes the amendment of permits, and section 7A of the Act describes the suspension and cancellation of permits.

The technical considerations and measures to meet the requirements of the *Pollution Control Act, 1967* as amended, have been formulated as minimum objectives for the various industries of British Columbia. The pertinent objectives for coal-mining and related developments are *Pollution Control Objectives for Mining, Mine-milling, and Smelting Industries of British Columbia.* The sections of particular interest for coal-mining are:

2.3 (*f*)—Control objectives applicable to coal-preparation plant, coke plant, and related bulk-loading facilities.
3.4—Coal washplant refuse.
4.2.5—Effluent objectives applicable to coal-preparation plants.
4.2.6—Effluent objectives applicable to coke plants.

TAXATION ACT

All leases and licences are subject to real property assessment and taxation under section 26 (3) of the *Taxation Act*—this is a land tax and subject to annual assessment. Buildings, machinery, and equipment at the minesite are assessable and taxable under the *Taxation Act* and the *Public Schools Act*. Buildings are assessed for both general and school purposes. Machinery is taxed for both school and other Government purposes.

It should also be noted development expenditures are subject to the social services tax at the rate of 5 per cent.

WATER ACT AND REGULATIONS (consolidated July 19, 1974)

The property in and the right to the use and flow of water is vested in the Crown in the right of the Province except where private rights have been established under licences issued under the *Water Act* or some former Act.

Sections 3, 5, 8, 9, 10, 11, 23, and 29 are the most applicable sections for consideration by coal mine development companies. Division (2), page 2, outlines permit acquisition procedures to use water and Division (3), page 3, outlines permit acquisition procedures to flood Crown land.

Applications for water licences can be made to the Comptroller of Water Rights for entitlement to the use and storage of water, related works, stream improvement or channelization, and measures for the conservation of fish and wildlife.

WILDLIFE ACT (consolidated July 19, 1973)

This Act provides for the conservation of game animals, birds, and fish which are specified in the Act. There are also provisions under the Act for action against those who, without authority, destroy or damage wildlife habitat in an area set aside for the purpose of wildlife management.

APPENDIX 2—ELEMENTS OF MINING DEVELOPMENT PROGRAM

DESCRIPTION OF COAL RESERVES

*A résumé of coal licences held by the developer and indicating
total reserves of coal;
mineable reserves of coal;
summary of geology of area;
possible extension of coal reserves and mineability, open pit and underground.

DESCRIPTION OF PROPOSED COAL-MINING OPERATION

A. Exploration Phase

* Proposed exploration program: Areas involved and phases; proposed access routes, camp location, and ancillary problems.

* Proposed methods of exploration: Indicate road construction to drill sites, adits, and trenches, with erosion controls to be practised.

* Proposed adits—trenches: Indicate methods of erosion control and restoration of disturbed areas as required.

* Public access: Indicate mine access routes with relation to the possibility of increasing hunting and fishing pressure on critical wildlife areas and fisheries. Alternately, the relief of pressure on presently overtaxed areas. Possibility of hunting restrictions to be considered during exploration, construction, and production of coal mine resources.

B. Construction Phase of Minesite Development

* Proposed construction plans by phases: Timing of each phase with estimated employment and category for each phase.

* Camp location and sizes: Indicate sewage and garbage disposal.

* Proposed access by roads: Indicate standards required for moving in equipment and machinery; indicate drainage control and settling ponds for all aspects of the construction phase in respect to roads.

Drainage control: Possible relocation of watercourses in major building areas; to avoid runoff of continually disturbed raw earthroads, excavations, dam construction; to design for potential groundwater problems.

Proposed overburden, stripping of pit area and plant site: Indicate scheduling, amounts, and capability for stockpiling for reclamation.

C. Mine Operation

* Proposed mining development plans by phase: Timing of each phase with relation to stripping, waste disposal, and tonnage mined; estimate employment by occupational category for each phase (i.e., increased tonnage; phasing in underground with open pit); indicate annual production of raw and clean coal for each phase.

* Proposed methods of extraction: Indicate mining method and related machinery and manpower.

* Mine site area: Indicate total area of surface disturbance, indicating open pit excavation, waste dumps, coal reject lagoons, stockpiles, plant site, roads, and settling ponds.

Open pit mining: Indicate area of open pit, excavation and depth; indicate total waste material to be moved and total coal removed.

Waste or spoil dumps: Indicate preferred location from straight economic viewpoint and plan of operations; indicate geotechnical and watershed drainage studies of proposed location(s); indicate method of dumping and final configuration of dumps and their relation to reclamation (maximum angle of the slopes of spoil mines to be 26 degrees or less).

Surface drainage control, as in the construction phase but phasing into mining: Indicate location of interceptor ditches, culverts, bridges with relation to sediment control to be practised for roads, plant site, waste dumps, etc.

Pit draining control: Indicate method of interception, collection and disposal of ground and runoff water in the pit; indicate operational monitoring required.

* Transportation requirements by phase relating to method, route, and destination of the coal: Indicate transport facilities required and if presently operational or construction required; indicate environmental controls necessary for dust control, siltation, monitoring.

* These are key features of prospectus; other factors are dealt with in subsequent stages.

D. MINING RECLAMATION

Present programs (if any).

Overburden disposal proposals: Indicate economic capability of stockpiling for a long period of time and method of revegetation of overburden dumps until required; indicate possibility of not requiring overburden for revegetation; indicate nutrients content and pH of overburden and waste rock.

Waste rock (spoil piles) disposal proposals: Indicate the most economic method of disposal with reference to operational and final reclamation (spoil piles are not considered physically or biologically stable at the angle of repose).

Revegetation proposals: Indicate type of vegetation, proposed method of seeding or planting; indicate proposed method and length of management of the vegetation on the waste dumps, overburden, reject lagoons, roads, plant site, and portions of open pit.

Reclamation program during mining operation: Indicate proposed department requirements for staff, program, nurseries, research, and test work responsibilities.

Proposed land use and capability of reclaimed land: Indicate the potential land use in relation to the resources and sensitivities of the area (e.g., wildlife habitat, fisheries, forestry, grazing, etc.).

Siltation and sedimentation controls (as detailed previously).

E. COAL PROCESSING

* Proposed method(s) of processing raw coal: Indicate yield and summarize pollution control requirements.

Annual and total estimated waste and tailings disposal.

Processing water requirements: Indicate daily amount required, source, make up water requirements, closed circuit or not.

Proposed waste discharges: Indicate amount and location of effluents, discharges, air emissions as per permit application for Pollution Control Board requirements.

* These are key features of prospectus; other factors are dealt with in subsequent stages.

APPENDIX 3—PROVINCIAL GOVERNMENT AGENCY CONTACTS

The following lists the prime contacts in key Provincial Government resource and infrastructure agencies at the headquarters level in Victoria as well as the regional and local levels in the resource management regions of the Province where coal developments are under consideration. The developers should request a list of appropriate social service agency contacts from the Coal Steering Committee.

ENVIRONMENT AND LAND USE COMMITTEE SECRETARIAT

Victoria:
- Director.
- Assistant Director, Special Projects Unit.
- Assistant Director, Resource Planning Unit.
- Assistant Director, Resource Analysis Unit.
- Resource Analysis Co-ordinator, Resource Analysis Unit.

DEPARTMENT OF HIGHWAYS AND PUBLIC WORKS (HIGHWAYS)

Victoria:
- Chief Highway Engineer.
- Chief Planning Engineer.
- Senior Approving Officer.

Omineca/Peace: Regional Highway Engineer, Prince George.
Thompson/Okanagan: Regional Highway Engineer, Kamloops.
Kootenay: Regional Highway Engineer, Nelson.

DEPARTMENT OF MINES AND PETROLEUM RESOURCES

Victoria:
- Associate Deputy Minister, Mineral Resources Branch.
- Senior Reclamation Inspector, Inspection and Engineering Division.

Omineca/Peace: Inspector of Mines, Prince George.
Kootenay:
- Reclamation Engineer, Nelson.
- Inspector of Mines, Fernie.

LANDS SERVICE, DEPARTMENT OF ENVIRONMENT

Victoria:
- Assistant Deputy Minister, Lands Service.
- Assistant Director of Land Management, Southern Interior Regions.
- Land Management Branch.
- Co-ordinator of Environmental Services, Land Management Branch.

Omineca/Peace:
- Regional Land Inspector, Prince George.
- Land Inspector, Dawson Creek.

Thompson/Okanagan:
- Regional Land Inspector, Kamloops.
- Land Inspector, Kamloops.

Kootenay:
- Regional Land Inspector, Nelson.
- Land Inspector, Nelson.

DEPARTMENT OF AGRICULTURE

Victoria: Deputy Minister.
Omineca/Peace: District Agriculturist, Dawson Creek.
Thompson/Okanagan: District Agriculturist, Kamloops.
Kootenay: District Agriculturist, Nelson.

FISH AND WILDLIFE BRANCH

Victoria:
- Associate Deputy Minister (Fish and Wildlife, Marine Resources).
- Assistant Director, Environment and Enforcement.
- Fisheries Co-ordinator.
- Habitat Protection Co-ordinator.
- Habitat Protection Biologist.

Omineca/Peace:
- Regional Director, Prince George.
- Conservation Officer, Dawson Creek.

Thompson/Okanagan:
- Regional Director, Kamloops.
- Conservation Officer, Clinton.

Kootenay:
- Regional Director, Nelson.
- Conservation Officer, Fernie.

PARKS BRANCH

Victoria:
- Head, Northern District Section, Planning Division.
- Head, Central District Section, Planning Division.

Omineca/Peace: Regional Manager, Prince George.
Thompson/Okanagan: Regional Manager, Kamloops.
Kootenay: Regional Manager, Nelson.

FOREST SERVICE

Victoria:
- Chief Forester.
- Director, Range Management Division.

Omineca/Peace: District Forester, Prince George.
Thompson/Okanagan: District Forester, Kamloops.
Kootenay: Assistant District Forester, Nelson.

WATER RESOURCES SERVICE

Victoria:
- Director, Pollution Control Branch.
- Director, Water Investigations Branch.
- Comptroller of Water Rights, Water Rights Branch.
- Chief, Environmental Studies Division, Water Investigations Branch.

Omineca/Peace:
- Regional Engineer, Water Rights Branch, Prince George.
- Regional Manager, Pollution Control Branch, Prince George.

Thompson/Okanagan:
- Regional Engineer, Water Rights Branch, Kamloops.
- Regional Manager, Pollution Control Branch, Kamloops.

Kootenay:
- Regional Engineer, Nelson.
- Regional Manager, Pollution Control Branch, Nelson.

REGIONAL RESOURCE MANAGEMENT COMMITTEE CHAIRMEN

Omineca/Peace: Regional Land Inspector, Prince George.
Thompson/Okanagan: District Forester, Kamloops.
Kootenay: Assistant District Forester, Nelson.

APPENDIX 4—ENVIRONMENTAL IMPACT MATRIX

As mentioned in the main text, the environmental impact matrix is suggested as a means for documenting the major interactions between the development and the natural environment. It should only be used as a "checklist" and is not intended to replace benefit-cost analysis as a decision tool. Developers are expected to evaluate the major impacts of the development wherever possible in economic terms and fit these values into the social benefit-cost accounting framework.

Separate matrices should be completed for minesite and offsite developments on the biophysical environment. Preparation of each matrix should meet a number of general criteria:

(*a*) Factors on the activity (vertical) axis should be separated in sufficient detail to isolate locational, construction, and operational processes. This selection will require some initial judgmental decisions by the developer, though Governmental review of Stage I and Stage II studies will help define the appropriate level of analysis.

(*b*) Factors on the activity (vertical) axis should be broken down into subgroupings required to define all significant impacts.

Example: If a water supply reservoir provides habitat for a lake fishery, but also eliminates some stream spawning habitat, both impacts should be clearly identified.

(*c*) Impacts can be qualitatively assessed during Stage I using the following colour coding:

Red to indicate negative impacts.
Blue to indicate positive impacts.
Yellow to indicate uncertain or ambivalent impacts.
Blank to indicate no impact.

(*d*) Impacts should be quantitatively assessed during Stage III so they can be included in over-all project evaluation using benefit-cost analysis. Consequently, impact data should be assembled in a manner amenable to quantification and eventual evaluation in economic terms where practical.

ENVIRONMENTAL IMPACT MATRIX

Project:

Developer:

Negative impact
- major .... ☐ } Red
- minor .... ■ } Red

Beneficial impact
- major .... ☐ } Blue
- minor .... ■ } Blue

Ambivalent .... ☐—Yellow

No impact .... ☐

	Proposed Offsite Activities																																										
	Construction																								Operation													Post Operations					
	Townsite			Railroad Spur No. 1							Highway Route 1							Transport to Port			Port Expansion				Townsite				Railroad Spur No. 1		Highway Route 1			Transport to Port		Port							
Environmental Factors	Townsite Preparation	Townsite Water Supply	Sewage Disposal	Camps	Crew-site Activity	Tote Roads	Public Access	Temporary Crossings	Culverts	Cut/fill Surfaces	Camps	Crew-site Activity	Tote Roads	Public Access	Temporary Crossings	Culverts	Cut/fill Surfaces	Expansion of Railway	Cut/fill Surfaces	Temporary Crossings	Fill Areas	Source of Fill	Back-up Lands	Dredging	Site Occupancy	Storm Sewer	Sanitary Sewer	Water Withdrawal	Traffic Flows	Bank Stability	Traffic Flows	Emissions	Bank Stability	Traffic Flows	Bank Stability	Traffic Movement	Spills, Etc.	Slope Structure	Erosion Control	Drainage Control	Soil Replacement	Revegetation	Water Quality
Stream discharge																																											
Streamwater quality																																											
Groundwater table																																											
Groundwater quality																																											
Stream bottom fauna																																											
Fish																																											
Air quality																																											
Noise level																																											
Landform																																											
Soils																																											
Vegetation																																											
Ungulates																																											
Furbearers																																											
Waterfowl																																											
Other wildlife																																											
Rare and endangered																																											
Recreational feature (terrain)																																											
Heritage																																											
Agriculture																																											
Forestry																																											
Hunting																																											
Fishing																																											
Guiding																																											
Sightseeing, hiking, camping																																											
Micro-climate																																											

ENVIRONMENTAL IMPACT MATRIX

Project:

Developer:

Negative impact
major .... ☐ > Red
minor .... ■ > Red

Beneficial impact
major .... ☐ > Blue
minor .... ■ > Blue

Ambivalent .... ☐—Yellow

No impact .... ☐

	Proposed Minesite Activities																																												
	Exploration					Construction													Operation																					Post-operation					
						Pit							Plant			Power			Pit											Plant						Power									
Environmental Factors	Camp	Crew-site Activity	Road Construction	Adits, Trenches	Public Access	Camp	Crew-site Activity	Roads	Public Access	Drainage Disruption	Stripping	Surface Soil Stockpiling	Process Plant	Process Plant Water Supply	Tailings Lagoon	Thermal Plant	Thermal Plant Water Supply	Ash Disposal Lagoon	Overburden Waste Dump	Road Drainage System	Surface Drainage System	Pit Drainage	Shop Oil Waste Disposal	Other Refuse	Surface Soil Stockpiling	Slope Stabilization	Drainage Control	Soil Replacement	Revegetation	Tailings Lagoon	Water Supply	Roads	Surface Drainage	Stockpile	Loading Facility	Water Supply	Stack Emissions	Ash Lagoon	Area Drainage	Slope Structure	Erosion Control	Drainage Control	Soil Replacement	Revegetation	Water Quality
Stream discharge																																													
Streamwater quality																																													
Groundwater table																																													
Groundwater quality																																													
Stream bottom fauna																																													
Fish																																													
Air quality																																													
Noise level																																													
Landform																																													
Soils																																													
Vegetation																																													
Ungulates																																													
Furbearers																																													
Waterfowl																																													
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Recreational feature (terrain)																																													
Heritage																																													
Agriculture																																													
Forestry																																													
Hunting																																													
Fishing																																													
Guiding																																													
Sightseeing, hiking, camping																																													
Aesthetics																																													
Micro-climate																																													

APPENDIX 5—SOCIO-ECONOMIC AND COMMUNITY DEVELOPMENT IMPACT ASSESSMENT MATRIX

The matrix outline is designed as a checklist to help identify all relevant possible social impacts of a project. It can also provide an index to those wishing to examine the information collected on any particular type of impact. Obviously, all information on the social impacts of developments cannot be contained within the impact matrix itself, nor will cross-impacts necessarily occur between each activity and each social factor.

SOCIO-ECONOMIC LOCATIONAL IMPACT MATRIX

Factors	1. Exploration		2. Development			3. Operation			4. Post-operation		
	Nearest Town(s)	Regional Centre(s)	Minesite	Primary Employee Location (existing or new community(s))	Regional Centre(s)	Minesite	Primary Employee Location (existing or new community(s))	Regional Centre(s)	Minesite	Primary Employee Location (existing or new community(s))	Regional Centre(s)
1. Employment (nos. and income levels)—											
Direct employment											
Indirect employment in support industry											
Indirect employment in services											
2. Population (nos. by appropriate breakdown)—											
Age/Sex											
Households and size											
Dependents											
School-age children (by age)											
3. Housing (nos. and cross-tabulations)—											
Type mix											
Tenure mix											
Cost mix											
Standards											
4. Services (appropriate units and breakdowns)—											
Education (classrooms/grades)											
Recreation (community facilities)											
Commercial											
Health											
Social											
Cultural/Entertainment											
Communication											
Police and fire											
Legal and court											
Industrial (by type)											
5. Community Land (area requirements)—											
Housing											
Education/Health/Institutional											
Recreation (outdoor areas and facilities)											
Commercial and services											
Industrial											
6. Community Infrastructure (locational mapping, environmental impact, and costing)—											
Sewage collection and disposal											
Water supply and distribution											
7. Regional Infrastructure (locational mapping, environmental impact, and responsibility for cost)—											
Regional roads (public and private)											
Railroads											
Airport(s)											
Energy											
8. Social Adjustment Considerations subjective or verbal statement with support statistics where applicable/possible)—											
9. Community design and æsthetic considerations.											

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APPENDIX II

Stream Flow And Sediment Yields For The Elk And Fording Rivers and Michel Creek

Monthly Suspended Sediment Load (Tons)

1. Fording River At The Mouth

	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Total	
1970	7.57	5.95	12.3	9.59	3685.2	345.8	54.49	54.49	35.91	32.75	32.56	14.14	8160.9	Max 1040 May 26 Min 9.10 Jan 6
1971	64.2	57.9	71.5	355.6	5583.8	150.9	59.87	86.94	86.4	NA	NA	NA	NA	
1972	-	-	-	-	-	-	-	-	-	-	-	-	-	
1973	63.2	33.7	29.3	49.1	4357.3	2172.7	184.6	95.6	82.5	87.2	36.30	9.0	7200.7	Max 959 May 18 Min 0 Nov 19
Ave.	45.1	32.5	37.7	139.1	4542	889	130	70	68.4	68.8	34.4	11.6	6069.4	

2. Michel Creek Below Natal

	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Total	
1970	174.5	126.0	212.8	128.3	11,637.7	4545.1	208.0	1210.3	355.2	118.6	82.69	79.0	18878.2	Max 2140 May 17 Min 0.99 Nov 28
1971	NA	NA	463.1	3276.2	30,028	6417.9	264.1	84.7	55.4	202.9	NA	NA	NA	
1972	-	-	-	-	-	-	-	-	-	-	-	-	-	
1973	196.0	225.5	286.1	799.6	10,858	7057.1	139.0	74.5	69.0	92.4	79.9	18.4	19895.6	Max 2280 May 18 Min 0 Oct 6
Ave.	185.3	175.8	320.7	1401.4	17,507.9	6006.7	203.7	456.5	159.9	138	81.3	48.7	26685.9	

3. Elk River Near Natal

	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	Total	
1970	94.7	53.5	50.6	107.4	9026.2	19,246.9	934.8	304.0	193.2	232.8	150.7	88.9	30,483.7	Max 1940 June 5 Min 0.46 Feb 28
1971	231.0	176.3	183.5	1326.5	31673.4	34,477	2663.0	444.9	426.8	266.5	251.2	115.4	72,235.5	Max 2930 June 8 Min 1.7 Sept 6
1972	72.3	64.4	580.0	123.4	44248.4	143,555	4926.7	563.7	149.9	74.5	119.6	303.3	194,781.2	Max 11200 Jun 19 Min 0 Nov 4
1973	250.7	105.3	108.3	100.1	10987.0	16,847	2000.9	428.3	231.9	520.2	292.0	92.6	31,964	Max 1430 May 18 Min 0.82 Apr 19
Ave.	162.2	99.9	230.6	414.3	23,984	53,531	10,524.6	435.2	251	274	203.5	150	90,260.30	

4. Elk River at Fernie

	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	Total	
1970	505.0	382.7	1345.9	561.2	48,812.0	30,342	1548.1	181.3	420.3	765.6	1726.8	501.5	80,092.4	Max 7990 May 27 Min 1.6 Oct 18
1971	1318.1	2650.1	1026.2	11,497.9	201.853	89,110	3082.9	1574.8	1101.8	1748.8	2095.9	516.8	317,576.3	Max 28400 May 28 Min 3.2 Dec 28
1972	114.2	162.6	6937.2	6,264.8	254,670	317,579	8291.4	723.7	585.8	315.4	345.7	256.5	596,246.3	Max 61600 May 31 Min 0 Aug 19
1973	258.4	241.8	1118.9	1,306.6	35,778	51,399	1835.4	645.8	251.3	190.8	307.5	187.4	93,520.9	Max 11,600 Ju 9 Min 1.4 Dec 15
Ave.	548.8	859.3	2607	4,908	133,528	122,107	3689	781.3	589.7	755	1118.9	365.5	274,435	

Average Daily Rates of Flow (cfs)

1. Fording River at the Mouth (Watershed size = 239 sq. mi.)

	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	
1970	46.2	49.0	44.5	52.3	568	1230	325	122	99.3	99.9	72.7	57.2	Max 2230 June 7th Min 35.5 Jan 7th
1971	59.0	54.1	55.9	115	946	1480	440	230	141	134	99.1	71.1	
1972	-	-	-	-	-	-	-	-	-	-	-	-	Max 2800 June 9th Min 48.5 Feb 6th
1973	87.6	66.9	71.7	95.5	668	1020	333	156	138	108	84.2	79.0	Max 1700 May 18th Min 53.0 Jan 10th
Ave.	64.3	56.7	57.4	87.6	727.3	1243.3	366	169.3	126.1	114	853	69.1	

2. Michel Creek Below Natal (Watershed size = 246 sq. mi.)

	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	
1970	49	40.2	60	67.7	1400	1370	287	115	113	96.1	76.7	68.1	Max 2980 May 26th Min 37.4 Feb 14th
1971	78	91.4	82.6	219	2510	1760	477	202	148	144	143	79.5	
1972	-	-	-	-	-	-	-	-	-	-	-	-	Max 3860 May 13th Min 46.5 Jan 5th
1973	70.3	71.7	85.4	203	1280	1160	249	102	84.5	92.9	111	86.6	Max 3250 May 19th Min 49.2 Jan 10th
Ave.	65.8	67.8	76.0	104.6	1307.6	1430	337.7	139.7	115.2	111.0	111.2	78.1	

3. Elk River Near Natal (Watershed size = 723 sq. mi.)

	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	
1970	184	195	172	177	1380	3320	1450	662	472	345	256	200	Max 4840 June 7th Min 137 Jan 8
1971	198	172	167	492	3210	3900	1920	1040	568	440	342	245	
1972	206	204	436	323	2750	6160	2360	1280	771	600	430	288	Max 6100 June 9th Min 150 Feb 7th
1973	276	214	236	316	1770	3250	1530	726	529	394	309	259	Max 10300 June 2nd Min 184 Jan 14th
Ave.	216	196.3	252.8	327	2277.5	4157.5	1815	927	585	444.8	334.2	248	Max 4380 June 9th Min 165 Jan 10th

4. Elk River at Fernie (Watershed size = 1210 sq. mi.)

	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	
1970	377	403	428	549	3230	5360	2010	934	703	597	501	478	Max 8730 June 6th Min 280 Jan 8th
1971	453	673	377	1220	5700	7800	3210	1620	972	760	721	376	
1972	388	434	1080	1140	6150	10800	4090	2260	1300	1060	1040	635	Max 12600 May 29th Min 242 Jan 6th
1973	531	419	547	870	4050	5630	2270	1170	845	603	598	501	Max 17,900 June 3rd Min 319 Jan 27th and 28th
Ave.	437.2	482	608	945	4782	7390	2895	1496	955	755	715	498	Max 9920 June 10th Min 330 Jan 10th

APPENDIX III

Annual Weather Summaries for Climatic Stations Natal - Kaiser Resources (1969-1974) and Natal - Harmer Ridge (1971-1974)

TABLE Weather Summary for the Year(s): 1969
Station: Natal - Kaiser Resources

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January								
February								
March								
April								
May								
June	20.3	6.1	13.2	29.4	-2.2	9.56		9.58
July	23.3	5.6	14.4	28.8	+2.2	0.61	-	0.61
August	24.5	5.0	14.8	33.9	-1.7	0.25	-	0.25
September	19.4	4.8	12.1	30.6	-2.8	2.59	-	2.59
October	9.2	-1.1	4	18.9	-12.2	0.025	-	0.025
November	5.0	-3.3	.8	10	-14.4	1.70	4.44	2.16
December	-.8	-9.4	-5.1	7.2	-22.2	0.96	32.26	4.19

Mean monthly temperature (°C): -
Mean monthly temperature for January: -
Mean monthly temperature for July: -
Months above 10°C: -
Months above 5°C: -
Months below 0°C: -
Frost free days (period): - June 13th - August 29th (77 days)
Total annual precipitation (cm): -
Annual snowfall (cm): -
Seasonal occurrence of precipitation: -
Wet Season
Wettest Month
Dry Season
Dryest Month

TABLE Weather Summary for the Year(s): 1970
Station: Natal - Kaiser Resources

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January	- 7.6	-16	-11.7	5.0	-31.1	-	108.2	10.8
February	2.3	- 9.7	- 3.7	6.1	-17.8	-	10.7	1.06
March	2.4	-10.2	-3.9	8.9	-25.6	.0254	13.7	1.40
April	7.4	- 1.4	3.0	13.3	-10.6	3.4	22.9	5.70
May	18.7	- 3.9	11.3	25.6	- 0.6	2.7	-	2.70
June	24.2	9.1	16.7	32.8	3.9	4.7	-	4.70
July	27.6	9.3	18.4	34.4	2.8	2.7	-	2.69
August	-	-	-	-	-	-	-	-
September	-	-	-	-	-	-	-	(2.39*)
October	-	-	-	-	-	-	-	-
November	4.6	-10.2	-2.8	10.0	-30.0	1.7	41.4	5.84
December	1.3	-11.2	-6.2	5.6	-22.2	0.48	73.2	7.80

Mean monthly temperature (°C): - N/A
Mean monthly temperature for January: - -11.7
Mean monthly temperature for July: - 18.4
Months above 10°C: - -4
Months above 5°C: - 5
Months below 0°C: - 5 (?)
Frost free days (period): - May 17th - Sept 11th (116)
Total annual precipitation (cm): - N/A
Annual snowfall (cm): - N/A
Seasonal occurrence of precipitation: -
Wet Season N/A
Wettest Month N/A
Dry Season N/A
Dryest Month N/A

* Records incomplete

TABLE Weather Summary for the Year(s): 1971
Station: Natal - Kaiser Resources

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January	-4.94	-14.2	- 9.6	6.6	-31.7	3.96	81.33	12.09
February	2.0	- 8.6	- 3.3	8.3	-22.2	0.81	13.97	2.21
March	2.2	- 7.3	- 2.6	6.6	-22.2	0.38	29.97	3.38
April	12.6	-1.7	5.4	16.7	-11.1	0.99	-	.99
May	17.4	1.2	9.3	24.4	- 5.0	1.16	12.19	2.39
June	17.8	4.1	12.9	27.2	0.6	1.35	-	1.35
July	25.2	5.9	15.6	31.7	0	3.33	-	3.33
August	28.6	7.8	18.2	34.4	2.2	2.24	-	2.24
September	16.2	-0.4	8.2	23.9	-5.0	1.22	4.57	1.68
October	9.4	-2.5	3.5	21.7	-19.4	.89	23.11	3.20
November	3.2	-4.1	-0.4	8.9	-19.4	1.83	31.24	4.95
December	-6.4	-15.8	-11.1	3.3	-30.6	0.69	50.80	5.76

Mean monthly temperature (°C): - 3.9
Mean monthly temperature for January: - -9.6
Mean monthly temperature for July: - 15.6
Months above 10°C: - 3
Months above 5°C: - 6
Months below 0°C: - 5
Frost free days (period): - May 12th - Sept 10th (120)
Total annual precipitation (cm): - 43.56
Annual snowfall (cm): - 247.19
Seasonal occurrence of precipitation: -
Wet Season Winter (40% of ppt.)
Wettest Month January 12.09
Dry Season Spring (10% of ppt.)
Dryest Month April 0.99

TABLE Weather Summary for the Year(s): 1972
Station: Natal - Kaiser Resources

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January	- 8.3	-16.4	-12.2	4.4	-35.6	-	169.7	17.0
February	2.4	-11.6	- 4.6	8.3	-31.7	6.4	61.0	12.5
March	6.4	- 4.6	0.8	14.4	-16.7	4.7	19.3	6.6
April	8.1	- 4.1	2.0	19.4	-11.7	4.5	44.9	9.0
May	16.7	0.5	8.6	28.9	- 7.2	2.2	-	2.2
June	19.7	5.3	12.5	28.9	0.5	4.3	-	4.3
July	21.6	5.1	13.4	28.9	0	7.4	-	7.4
August	24.5	7.7	16.1	31.7	3.3	2.5	-	2.5
September	13.7	0.5	7.1	25.0	-7.2	5.3	12.7	6.6
October	8.7	-3.7	2.5	17.2	-15.6	2.2	12.3	3.4
November	3.2	-4.3	-0.6	8.3	-15.0	0.2	3.6	0.5
December	-6.1	-15.4	-10.7	5.6	-35.6	3.2	44.3	7.7

Mean monthly temperature (°C): - 2.9
Mean monthly temperature for January: - -12.2
Mean monthly temperature for July: - 13.4
Months above 10°C: - 3
Months above 5°C: - 5
Months below 0°C: - 4
Frost free days (period): - May 25th - Sept 1st (98)
Total annual precipitation (cm): - 79.7
Annual snowfall (cm): - 327.4
Seasonal occurrence of precipitation: -
Wet Season Winter (45% of ppt.)
Wettest Month January 17.0 cm
Dry Season Autumn (14% of ppt.)
Dryest Month November 0.5 cm

TABLE Weather Summary for the Year(s): 1973
Station: Natal - Kaiser Resources

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January	- 4.2	-14.1	- 9.2	9.4	-33.3	2.4	23.9	4.8
February	0.7	-12.3	- 5.8	12.8	-31.4	0.2	29.2	3.1
March	6.0	- 3.7	1.2	12.2	- 8.9	1.3	11.9	2.5
April	9.2	- 2.0	3.6	16.7	-10.6	3.7	9.9	4.7
May	17.5	0.5	9.0	28.3	- 5.6	1.1	.2	1.1
June	19.7	4.9	12.3	31.1	- 2.2	8.4	-	8.4
July	25.6	6.7	16.1	32.2	- 2.2	4.0	-	4.0
August	24.9	6.1	15.5	32.8	0	3.3	-	3.3
September	17.8	3.8	10.8	29.4	- 6.1	1.3	-	1.3
October	10.2	0.6	5.4	17.8	- 7.2	2.6	-	2.6
November	-1.7	-8.9	-5.3	6.1	-23.3	3.2	109.7	14.2
December	-0.3	-7.6	-4.1	10.0	-22.2	1.6	23.7	4.0

Mean monthly temperature (°C): - 4.1
Mean monthly temperature for January: - -9.2
Mean monthly temperature for July: - 16.1
Months above 10°C: - 4
Months above 5°C: - 6
Months below 0°C: - 4
Frost free days (period): - Aug. 18th - Sept 2nd (27 days)
Total annual precipitation (cm): - 54.0
Annual snowfall (cm): - 208.5 cm
Seasonal occurrence of precipitation: -
Wet Season Fall (39% of total)
Wettest Month November 14.2 cm
Dry Season Summer (16% of total)
Dryest Month May 1.1 cm

TABLE Weather Summary for the Year(s): 1974
Station: Natal - Kaiser Resources

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January	- 7.6	-14.1	-10.9	6.7	-33.3	7.3	75.9	14.9
February	2.3	- 7.3	- 2.5	6.1	-17.8	.4	60.2	6.4
March	3.8	- 7.9	- 2.0	11.1	-27.2	6.2	36.1	9.8
April	11.6	- 1.5	5.1	20.0	- 6.7	6.6	2.4	6.8
May	12.2	1.1	6.7	20.0	- 2.8	7.7	-	7.7
June	23.2	5.6	14.4	32.2	- 0.6	3.7	-	3.7
July	23.5	5.8	14.6	31.1	- 0.6	4.0	-	4.0
August	21.9	4.9	13.4	31.7	- 2.8	4.4	-	4.4
September	18.3	1.2	9.7	25.5	- 5.6	2.5	-	2.5
October	14.9	-1.2	6.9	20.6	-12.2	0.2	-	0.2
November	3.0	-6.2	-1.6	10.0	-15.6	6.1	7.9	6.9
December	0.3	-8.7	-4.2	4.4	-20.6	2.2	38.7	6.1

Mean monthly temperature (°C): - 4.1
Mean monthly temperature for January: - -10.9
Mean monthly temperature for July: - 14.7
Months above 10°C: - 3
Months above 5°C: - 7
Months below 0°C: - 5
Frost free days (period): - 40 days (July 3rd to August 12th)
Total annual precipitation (cm): - 73.4
Annual snowfall (cm): - 221.2
Seasonal occurrence of precipitation: -
Wet Season Winter 39.2% of ppt.
Wettest Month January (14.9 cm)
Dry Season Summer 13.7% of ppt.
Dryest Month October 0.2 inches

TABLE Weather Summary for the Year(s): 1971
Station: Natal - Harmer Ridge

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January								
February								
March								
April								
May								
June								
July								
August	22.0	10.9	18.3	28.3	2.8	4.3	-	4.3
September	7.7	0.2	5.5	17.2	-5.0	2.0	44.5	6.5
October	5.1	-5.0	0	16.7	-22.2	0.6	84.1	9.0
November	-2.8	-9.5	-6.2	3.3	-20.6	-	115.8	11.6
December	-9.3	-16.4	-12.9	-4.4	-26.1	-	146.8	14.7

Mean monthly temperature (°C): -
Mean monthly temperature for January: -
Mean monthly temperature for July: -
Months above 10°C: -
Months above 5°C: -
Months below 0°C: -
Frost free days (period): -
Total annual precipitation (cm): -
Annual snowfall (cm): -
Seasonal occurrence of precipitation: -
Wet Season
Wettest Month
Dry Season
Dryest Month

TABLE Weather Summary for the Year(s): 1972
Station: Natal - Harmer Ridge

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January	-11.7	-20.2	-16.0	-2.8	-33.9	-	153.7	15.4
February	-5.4	-13.5	- 9.4	1.7	-28.9	-	81.0	8.1
March	0.2	- 8.2	- 4.0	7.8	-17.2	0.1	32.3	3.3
April	-0.1	- 9.4	- 4.8	5.5	-18.9	-	58.4	5.8
May	8.4	0	4.2	21.1	- 8.3	0.5	24.6	2.9
June	13.4	4.6	9.0	26.7	- 1.1	4.8	3.3	5.1
July	15.2	5.8	10.5	24.4	0.6	9.4	4.8	9.9
August	19.7	9.2	14.4	26.1	3.3	3.0	-	3.0
September	6.6	- 1.1	2.7	18.3	-11.7	4.7	66.3	11.3
October	4.0	- 4.5	-0.3	12.8	-15.6	0.2	63.0	6.5
November	-2.3	- 7.1	-4.7	2.2	-15.0	-	19.8	2.0
December	-9.9	-15.7	-12.8	1.7	-32.8	-	126.0	12.6

Mean monthly temperature (°C): - -0.9
Mean monthly temperature for January: - 0°
Mean monthly temperature for July: - 10.5
Months above 10°C: - 2
Months above 5°C: - 3
Months below 0°C: - 7
Frost free days (period): - June 12th - Sept 6th (86 days)
Total annual precipitation (cm): - 85.9
Annual snowfall (cm): - 633.2
Seasonal occurrence of precipitation: -
Wet Season Winter (31% of ppt.)
Wettest Month January 15.4 cm
Dry Season Spring (16% of ppt.)
Dryest Month November 2.0 cm

TABLE Weather Summary for the Year(s): 1973
Station: Natal - Harmer Ridge

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January	- 7.9	-14.6	-11.2	2.7	- 27.2	-	69.8	7.0
February	- 3.5	-11.9	- 7.7	5.0	- 27.2	-	51.1	5.1
March	- 0.3	- 8.8	- 4.5	4.4	- 13.9	-	59.9	6.0
April	2.7	- 5.9	- 1.6	8.8	- 15.0	0.1	43.2	4.4
May	10.7	0.5	5.6	20.6	-10.5	1.6	19.3	3.5
June	13.7	3.4	8.5	25.6	- 2.8	4.8	6.8	5.5
July	19.6	7.0	13.3	26.1	- 1.7	3.5	-	3.5
August	18.7	7.1	12.9	26.7	- .6	3.2	11.2	4.3
September	11.8	2.5	7.2	23.3	- 5.0	2.1	0.5	2.2
October	3.5	- 2.1	0.7	10.6	- 8.3	0.9	17.5	2.7
November	- 5.9	-11.3	- 8.6	3.9	-22.2	-	165.6	16.6
December	- 4.9	-10.2	- 7.6	0	-22.8	-	90.9	9.1

Mean monthly temperature (°C): - 0.6
Mean monthly temperature for January: -11.2
Mean monthly temperature for July: - 13.3
Months above 10°C: - 2
Months above 5°C: - 5
Months below 0°C: - 6
Frost free days (period): - July - August (31 days
Total annual precipitation (cm): - 69.9
Annual snowfall (cm): - 537.7
Seasonal occurrence of precipitation: -
Wet Season Fall 40.55%
Wettest Month November 16.6 cm
Dry Season Summer 14.2 %
Dryest Month September 2.2 cm

TABLE Weather Summary for the Year(s): 1974
Station: Natal - Harmer Ridge

Month	Temp °C					Precipitation (cm)		
	Means			Extremes				
	Max.	Min.	Ave.	Max.	Min.	Rain	Snow	Total
January	- 9.3	-15.8	-12.6	1.7	-32.2	-	200.2	20.0
February	- 4.7	-10.1	- 7.4	-2.2	-16.1	-	106.7	10.7
March	- 2.9	-11.5	- 7.2	4.4	-24.4	-	84.3	8.4
April	3.3	- 4.0	- 0.3	9.4	-10.6	.1	84.8	8.5
May	4.7	- 2.3	1.2	10.0	- 7.2	1.5	38.9	5.5
June	15.3	5.1	10.2	23.9	- 1.7	3.1	15.5	4.7
July	17.0	6.1	11.5	25.6	0.6	5.3	-	5.3
August	15.2	4.8	10.0	30.0	- 1.1	6.2	-	6.2
September	12.7	1.4	7.1	18.9	- 7.2	1.5	9.1	2.4
October	9.1	- 0.6	4.3	15.6	-11.7	0.8	6.6	1.5
November	- 2.8	- 8.5	- 5.6	5.6	-18.9	-	165.9	16.6
December	- 4.9	-10.6	- 7.7	0	-20.0	-	85.6	8.6

Mean monthly temperature (°C): - 0.3
Mean monthly temperature for January: - -12.6
Mean monthly temperature for July: - 11.5
Months above 10°C: - 3
Months above 5°C: - 4
Months below 0°C: - 6
Frost free days (period): - June 9th to August 14th (66 days)
Total annual precipitation (cm): - 98.4
Annual snowfall (cm): - 794.6
Seasonal occurrence of precipitation: -
Wet Season Winter (39.9% of ppt.)
Wettest Month January 20.0 cm
Dry Season Summer (14.2 % of ppt.)
Dryest Month October 2.4 cm

APPENDIX IV

Species Lists[1] For The Main Vegetation Communities On The Kaiser Resources Ltd. Map Area. (See Map No.

1. Latin names after Hichcock and Cronquist, 1973.

A. Engelman Spruce - Subalpine Fir Zone

1. Oper Sub-alpine Forest Parkland

Trees:

Abies lasiocarpa (Hook.) Nutt	Subalpine fir
Pinus albicaulis Engelm.	Whitebark pine
Pinus contorta Dougl. var *latifolia* Engelm.	Lodgepole pine

Shrubs:

Arctostaphlos uva-ursi (L.) Spreng.	Kinnikinnik
Juniperus communis L. var *communis*	Commonjuniper
Menziesia ferruginea Smith	False azalea
Penstemon fruitocosus (Pursh.) Green var *scouleri* (Lindl.) Cronq.	Scouler's penstemon
Rhododendron albiflorum Hook.	White rhododendron
Vaccinium myrtillus L.	Whortleberry
Vaccinium scoparium Leiberg.	Grouseberry

Grasses and Sedges:

Agropyron caninum (L.) Beauv.	Bearded wheatgrass
Bromus carinatus H. and A.	California brome
Calamagrostis rubescens Buckl.	Pinegrass
Carex rossii Boott.	Ross's sedge
C. phaeocephala Piper	Mountain hare sedge
Festuca idahoensis Elmer	Idaho fescue
Poa alpina L.	Alpine bluegrass
P. glaucifolia Scribn. and Will.	Pale-leaf bluegrass
P. gracillima Vasey	Slender bluegrass
P. nemoralis L.	Woods bluegrass
P. nevadensis Vasey	Nevada bluegrass
P. rupicola Nash.	Timberline bluegrass
P. scabrella (Thurb.) Benth.	Pine bluegrass
Triset um spicatum (L.) Richter	Downy oatgrass

Forbs:

Achillea millefolium	Yarrow
Allium cernuum	Nodding Onion
Arnica latifolia	Broad-leaf arnica
Campanula rotundifolia	Bluebell
Castilleja hispida	Indian paintbrush
Epilobium paniculatum	Fireweed
Erigeron grandiflorus	Fleabane
Erigeron speciosus	Fleabane
Eriogonum umbellatum	Sulphur eriogonun

Geranium bichnellii Britt.	Bicknell's geranium
Heuchera cylindrica Douglas	Oval-leaf alumroot
Hieracium gracile Hooker	Slender hawkweed
Lupinus sericeus Pursh.	Lupine
Oxytropis sericea Nutt.	Silky crazyweed
Pedicularis bracteosa Bentham	Wood betony
Pedicularis racemosa Douglas var *alba* (Pennell) Cronq.	Sickletop lousewort
Potentilla diversifolia Lehman	Cinquefoil
Saxifraga bronchialis L.	Spotted saxifrage
Sedum lanceolatum Torr.	Stonecrop
Spirea betulifolia Pall.	Flat-top spirea
Veratrum viride Ait.	False hellebore

2. Closed-canopy Sub-alpine Climax Forest

Trees:

Abies lasiocarpa (Hook.) Nutt.	Sub-alpine fir
Larix lyallii Parl.	Alpine larch
Picea engelmannii Parry	Engelmann spruce
Pinus albicaulis Engelm.	Whitebark pine
Pinus contorta Dougl. var *latifolia* Engelm.	Lodgepole pine
Tsuga mertensiana (Bong.) Carr.	Mountain hemlock

Shrubs:

Alnus sinuata (Regel.) Rydb.	Sitka Alder
Linnaea borealis L.	Twinflower
Menziesia ferruginea Smith	False azalea
Ribes viscosissimum Pursh.	Sticky current
Rhododendron albiflorum Hook.	White rhododendron
Sambucus racemosa var *melanocarpa* (Gray) McMinn	Black-berry Elder
Sorbus sitchensis Roemer	Sitka mountain ash
V. membranaceum Dougl. (ex Hook.)	Black huckleberry
Vaccinium scoparium Leiberg	Grouseberry

Forbs:

Agoseris aurantiaca (Hook.) Grass	Orange-flowered agoseris
Arnica fulgens Pursh.	Hillside arnica
Eriogonum umbellatum Torrey	Sulphur eriogonum
Goodyera oblongifolia Raf.	Rattlesnake plantain
Lupinus sericeus Pursh.	Silky lupine
Pyrola secunda L.	One-sided wintergreen
Valeriana sitchensis Bong.	Mountain valerian

3. Fire Induced, Even-aged Seral Forest

Trees:

Pinus contorta Dougl. var *latifolia* Engelm.	Lodgepole pine

Shrubs:

Alnus sinuata (Regel) Rydb.	Sitka alder
Ribes viscosissimum Pursh.	Sticky current
Rubus parviflorus Nutt.	Thimbleberry
Symphoricarpos albus (L.) Blake	Waxberry
Vaccinium scoparium Leiberg	Grouseberry

Forbs:

Arnica latifolia Bong.	Broadleaf arnica
Rubus pedatus J.E. Smith	Trailing rubus

B. Interior Douglas-fir Zone

1. All-aged, mixed forest

Trees:

Betula papyrifera Marsh	Paper birch
Juniperus scopulorum Sarg.	Rocky mountain juniper
Larix occidentalis Nutt.	Western larch
Pinus contorta Douglas. var *latifolia* Engelm.	Lodgepole pine
Populus tremuloides Michx.	Trembling aspen
Pseudotsuga menziesii (Mirbel) Franco.	Douglas fir

Shrubs:

Acer glabrum Torr. var *douglasii* (Hook.) Dippel	Douglas maple
Amelanchier alnifolia Nutt.	Saskatoon
Arctostaphlos ura-ursi (L.) Spreng.	Kinnikinnik
Berberis repens Lindl.	Creeping Oregon grape
Crataegus columbiana Howell	Colombia hawthorn
Linnaea borealis L.	Twinflower
Lonicera involucrata (Rich.) Banks	Black twin-berry
Pachistima myrsinites (Pursh.) Raf.	False box
Prunus virginiana L. var. *melanocarpa* (Nels) Sarg.	Chokecherry
Ribes oxyacanthoides L.	Smooth gooseberry
Rosa arichularis Lindl.	Prickly rose
R. gymnocarpa Nutt.	Woodland rose
R. nutkana Crepen var *hispida* Fern.	Nootka rose
Rubus parviflorus Nutt.	Thimbleberry
Salix bebbiana Sarg.	Bebb willow

Salix scouleriana Barrat ex Hook.	Scouler willow
Sambucus cerulea Raf.	Blue elder
Shepherdia canadensis (L.) Nutt.	Soopolallie
Spirea betulifolia Pall.	Flat-top Spirea
S. pyramidata Greene	Pyramidal spirea
Symphoricarpos albus (L.) Blake	Waxberry

Grasses:

Agropyron spicatum (Pursh) Scribner & Smith	Bluebunch wheatgrass
Agropyron caninum (L.) Beavois	Bearded wheatgrass
Bromus carinatus H. & A.	California brome
Calamagrostis purpurescens R. Br.	Purple pinegrass
Calamagrostis rubescens Buckl.	Pinegrass
Festuca idahoensis Elmer	Idaho fescue
Poa interior Rhberg.	Inland bluegrass
P. leptocoma Trinium	Bog bluegrass
P. scabrella (Thurber) Bentham	Pine bluegrass

Forbs:

Achillea millefolium L.	Yarrow
Agoseris glauca (Pursh.(Ref.	Smooth Agoseris
Anaphalis margaritacea (L.) B. and H.	Pearly everlasting
Antennaris anaphaloides Rydb.	White pussytoes
Arabis glabra (L.) Bernh.	Tower mustard
Arnica cordifolia Hook.	Heart leafed arnica
Aster ciliolatus Lindl.	Lindley aster
Aster conspicuus Lindl.	Showy aster
Castilleja miniata Dougl.	Common paintbrush
Castilleja cervina Greenm.	Deer paintbrush
Calochortus apiculatus Baker	Baker's mariposa lily
Epilobium angustifolium L.	Fireweed
Fragaria virginiana Duch.	Wild strawberry
Geranium bichnellii Britt.	Bicknell's geranium
Heuchera cylindrica Dougl.	Oval-leaf alumroot
Lathyrus nevadensis Wats.	Nuttal's peavine
Lathyrus ochroleucus Hook.	Yellow pea
Lupinus sericeus Pursh	Lupine
Penstemon albertinus Greene	Alberta penstemon
Phacelia hastata Dougl. var *leucophylla* (Torr.) Cronq.	White-leafed phacelia
Smilacina racemosa (L.) Desf.	False solomon's seal
Smilacina stellata (L.) Desf.	Solomon's seal
Sedum lanceolatum Torr.	Stone crop

2. Fire-induced, even-aged seral forest.

Trees:

Picea glauca (Moench) Voss.	White spruce
Pinus contorta Dougl. var *latifolia* Engelm.	Lodgepole pine
Populus tremuloides Michx.	Trembling aspen

Shrubs:

Berberis repens Lindl.	Creeping Oregon grape
Elaeagnus commutata Bernh.	Silverberry
Pachistima myrsinites (Pursch.) Raf.	False box
Rubus parviflorus Nutt.	Thimbleberry
Viburnum edule (Michx.) Raf.	Squashberry

Grasses:

Calamagrostis rubescens	Pinegrass

Forbs:

Arnica cordifolia Hook.	Heartleafed arnica
Chimaphilia umbellata (L.) Bart.	Prince's Pine
Clintonia uniflora (Schutt.) Kunth.	Queen's cup
Fragaria virginiana Duch.	Wild strawberry
Lupinus sericeus Pursh.	Lupine

3. Valley bottom, flood-plain community on alluvial deposits.

Trees:

Betula papyrifera Marsh.	Paper birch
Picea glauca (Moench) Voss.	White spruce
Pinus contorta Dougl. var *latifolia* Engelm.	Lodgepole pine
Populus tremuloides Michx.	Trembling aspen
Populus trichocarpa T. & G.	Black cottonwood

Shrubs:

Acer glabrum var *douglassii* (Hook.) Dippel	Douglas maple
Alnus incana	Thinleaf alder
Clematus ligusticifolia	White clematis
Cornus stolonifera	Red osier dogwood
Crataegus columbiana	Columbia hawthorn
Elaeagnus commutata	Silverberry
Lonicera involucrata	Black twinberry
Prunus virginiana L. var *melanocarpa* (Nels.) Sarg.	Chokeberry

Rosa gymnocarpa Crepen	Woodland rose
R. nutkana Crepen	Common wild rose
R. woodsii Lindl.	Woods rose
Salix amygdaloides Anders.	Peachleaf
S. argophylla Nutt.	Silverleaf willow
S. lutea Nutt.	Yellow willow
S. melanopsis Nutt.	Dusky willow
Symphoricarpos albus (L.) Blake	Waxberry

Grasses:

Agropyron dasytachyum (Hook.) Scribn.	Downy wheatgrass
Elymus cinereus Scribn. and Merr.	Giant wild rye

Forbs:

Aquilegia formosa Fisch.	Sitka columbine
Fragaria virginiana Duch.	Wild strawberry
Heracleum lanatum Michx.	Cow parsnip
Lupinus burkei S. Wats.	Burke's lupine
Lupinus sericeus Pursh.	Silky lupine
Smilacina stellata	Star-flowered Solomon's seal
Solidago canadensis L. var *salebrosa* (Piper) Jones	Thin goldenrod

4. South and Southwest aspect, physiographic climax, Shrub/herb Community

Shrubs:

Acer glabrum Torr. var *douglasii* (Hook.) Dippel	Douglas maple
Amelanchier alnifolia	Saskatoon
Berberis repens	Creeping Oregon grape
Ceanothus velutinus	Sticky laurel
Juniperus communis	Common juniper
Populus tremuloides	Trembling aspen
Rubus idaeus	Red raspberry
Salix bebbiana	Bebb willow
S. scouleriana	Scouler willow
Sambucus racemosa var *melanocarpa* (Grey) McMimm	Blackberry elder
Sambucus cerulea	Blue elder
Shepherdia canadensis	Soopolallie
Spirea betulifolia	Flat-top spirea
S. pyramidata	Pyramidal spirea

Grasses and Sedges:

Agropyron caninum (L.) Beauvois	Bearded wheatgrass
Agropyron spicatum (Pursh) Scribner & Smith	Bluebunch wheatgrass
Bromus carinatus Hooker & Arnot	California bromegrass
Calamagrostis rubescens Buckley	Pinegrass
Carex phaeocephala Piper	Mountain hare sedge
Festuca idahoensis Elmer	Idaho fescue
Hordeum jubatum L.	Foxtail barley
Melica spectabilis Scribner	Showy oniongrass
Poa alpina L.	Alpine bluegrass
P. interior Rydberg	Inland bluegrass
P. glaucifolia Scribner & Williams	Pale leaf bluegrass
P. leptocoma Trinius	Bog bluegrass
P. nemoralis L.	Woods bluegrass
P. nevadensis Vasey	Nevada bluegrass
P. rupicola Nash	Timberland bluegrass
P. scabrella (Thurber) Bentham	Pine bluegrass
Stipa occidentalis ver *minor* (Vasey) C.L. Hitchcock	Small needlegrass
Trisetum spicatum (L.) Richter	Downey oatgrass

Forbs:

Agoseris aurantiaca (Hooker) Greene	Orange-flowered agoseris
Agoseris glauca (Pursh) Raf.	Smooth agoseris
Allium cernuum Roth.	Nodding onion
Anaphalis margaritacea L. Bentham & Hooker	Pearly everlasting
Aster conspicuus Lindley	Purple aster
Epilobium angustifoloum L.	Fireweed
E. glandulosum Lehm.	Common willowherb
E. paniculatum Nutt.	Autumn willowherb
Erigeron speciosus (Lindley) D.C. var *macranthus* (Nutt.) Cronq.	Large purple fleabane
Eriogonum umbellatum Torrey var *aridum* (Greene) Hitchcock	Sulphur eriogonum
Geranium viscosissimum F. and M.	Wild geranium
Heuchers cylindrica Douglas	Oval-leaft alumroot
Hieracium albertinum Farr.	Hawkweed
Linaria vulgaris Hill	Butter and Eggs
Lupinus sericeus Pursh.	Lupine
Oxytropis sericeus Nutt.	Locoweed
Penstemon confertus Douglas	Yellow penstemon
Phacelia hastata Douglas var *compacta* (Brand) Cronq.	Silverleaf phacelia
Sedum lanceolatum Torrey	Stonecrop
Senecio pauperculus Michaux var *thomsoniensis* (Greenman) Boivan	Balsam groundsel
Senecio megacephalus Nutt.	Large-headed butterweed
Smilacina stellata (L.) Desf.	Solomon's seal
Verbascum thapsus L.	Great mullein

5. Plant communities developed on areas of industrial disturbance i.e. logging, road cuts, surface mining, facilities construction.

Trees:

Betula papyrifera Marsh.	Paper birch
Larix occidentalis Nutt.	Western Larch
Pinus contorta Dougl. var *latifolia* Engelm.	Lodgepole pine
Populus tremuloides Michx.	Trembling aspen
Populus trichocarpa T. & G.	Black cottonwood

Shrubs:

Amelanchier alnifolia Nutt.	Saskatoon
Arctostaphlos uva-ursi (L.) Spreng.	Kinnikinnik
Artemisia frigida Willd.	Fringed sage
Berberis repens Lindl.	Creeping Oregon grape
Penstemon fruticosus (Pursh) Greene var *scouleri* (Lindl.) Cronq.	Scouler's penstemon
Rosa nutkana Crepen var *hispida* Fern.	Nootka rose
Rosa gymnocarpa Nutt.	Woodland rose
Rubus idaeus L.	Wild raspberry
Sambucus cerulea Raf.	Blue elder
Shepherdia canadensis Nutt.	Soopolallie
Spirea betulifolia Pall.	Flat-top spirea
Symphoricarpos albus (L.) Blake	Waxberry

Grasses:

Bromus tectorum L.	Cheatgrass
Hordeum jubatum L.	Foxtail

Forbs:

Achillea millefolium L.	Yarrow
Antennaria anaphaloides Rydb.	White pusseytoes
Antennaria microphylla Rydb.	Pink pusseytoes
Arctium minus (Hill) Bernh.	Common burdock
Capsella bursa-pastoris (L.) Medic.	Shepherd's purse
Chenopodium album L.	Lamb's quarters
Chenopodium capitatum (L.) Asch.	Strawberry blight
Cirsium arvense (L.) Scop.	Canada thistle
Cirsium vulgare (Savi.) Tenore	Bull thistle
Crysanthemum leucanthemum L.	Oxeye daisy
Epilobium augustifolium L.	Fireweed
Fragaria virginiana Duch.	Wild strawberry
Heuchera cylindrica Dougl.	Oval-leaf alumroot
Heuchera parvifolia Nutt.	Alumroot
Lappula echinata Gilib.	Blue bur
Lupinus burkei S. Wats.	Burke's Lupine
Lupinus sericeus Pursh.	Silky lupine
Lychnis alba Mill.	White cockle

Phacelia hastata Dougl. var *leucophylla* (Torr.) Cronq.	White-leafed Phacelia
Plantago major L.	Common plantain
Salsola kali L.	Russian thistle
Silene dichotoma Ehrh.	Catchfly
Thlaspi arvense L.	Stinkweed
Tragopogon pratensis L.	Goatsbeard
Verbascum thapsus L.	Great mullein

Ferns and Fern Allies:

Equisetum arvense L.	Horsetail

APPENDIX V

Wildlife And Fish Species Of The East Kootenay Area

Mammals*

Order Insectivora (Shrews and moles)

Cinereus shrew	*Sorex cinereus cinereus* Kerr
Wandering shrew	*S. vagrans obscurus* Merriam
Navigator shrew	*S. palustris navigator* Baird

Order Chiroptera (Bats)

Long-eared Myotis	*Myotis evotis evotis* Allen
Little brown Myotis	*M. lucifugus lucifugus* LeConte
	M. lucifugus alascensis Miller
Long-legged Myotis	*M. volans longicrus* True

Order Lagomorpha (Pikas, Hares and Rabbits)

Rocky Mountain Pika	*Ochotona princeps princeps* Bangs
Snowshoe hare	*Lepus americanus columbiensis* Rhoads

Order Rodentia (Rodents)

Hoary marmot	*Marmota caligata okanagana* King
Columbian groundsquirrel	*Spermophilus columbianus columbianus* Ord
Mantled groundsquirrel	*S. lateralis tescorum* Hollister
Northwestern chipmunk	*Eutamias amoenus luteiventris* Allen
Red Squirrel	*Tamiasciurus hudsonicus richardsoni* Bachman
Flying Squirrel	*Glaucomys sabrinus latipes* Howell
Pocket gopher	*Thomomys talpoides cognatus* Johnstone
American beaver	*Castor canadensis leucodontus* Gray
Deer mouse	*Peromyscus maniculatus artemisiae* Rhoads
Pack rat	*Neutoma cinerea cinerea* Ord
Northern bog-lemming	*Synaptomys borealis chapmani* Allen
Mountain heather-vole	*Phenacomys intermedius intermedius* Merriam
Redback vole	*Clethrionomys gapperi athabascas* Preble
Meadow vole	*Microtus pennsylvanicus drummondi* Audubon and Bachman
Richardson's vole	*Microtus richardsoni richardsoni* DeKay
Longtailed vole	*Microtus longicaudus vellerosus* Allen
Muskrat	*Ondatra zibethica osoyoosensis* Lord
Western jumping mouse	*Zapus princeps idahoensis* Davis
Porcupine	*Erethizon dorsatum nigrescens* Allen

Order Carnivora (Carnivors)

Coyote	*Canus latrans lestes* Merriam
Wolf	*C. lupus columbianus* Goldman
Redfox	*Vulpes fulva cascadensis* Merriam
Black bear	*Ursus americanus cinnamomum* Audubon and Bachman
Grizzly Bear	*Urses arctos horribilis* Ord
Marten	*Martes americana abietinoids* Grey
Short-tailed weasel	*Mustela erminea invicta* Hall
Long-tailed weasel	*M. frenata oribasus* Bangs
Wolverine	*Gulo luscus luscus* Linnaeus
Striped skunk	*Mephitis mephitis hudsonica* Richardson
River otter	*Lutra canadensis evexa* Goldman
Cougar	*Felis concolor missoulensis* Goldman
Lynx	*Lynx canadensis canadensis* Kerr
Bobcat	*L. rufus pallescens* Merriam

Order Artiodactyla (Ungulates)

Rocky Mountain elk	*Cervus canadensis nelsoni* Bailey
Mule deer	*Odocoileus hemionus hemionus* Rafinesque
White-tailed deer	*O. virginianus ochrourus* Bailey
American moose	*Alces alces andersoni* Peterson
Mountain goat	*Oreamnos americanus americanus* Blainville
Rocky Mountain bighorn sheep	*Ovis canadensis canadensis* Shaw

* Sources: Fish and Wildlife Branch, Department of Recreation and Conservation. Cowan and Guiget (Fifth Edition, 1973).

Fish*

Family Coregonidae (Whitefishes)

Rocky Mountain whitefish	*Prosopium williamsoni* Girard

Family Salmonidae (Salmon, Trout and Char)

Yellowstone cutthroat trout	*Salmo clarki lewisi* Girard
Rainbow trout	*Salmo gairdneri*
Dolly Varden Char	*Salvelinus malva* Walbaum
Kokanee	*Oncorhynchus nerka* Walbaum

Family Catostomidae (Suckers)

Largescale sucker	*Catostomus macrocheilus* Girard

Family Cyprinidae (Minnows)

Redside shiner	*Richardsonius balteatus* Richardson
Northern squawfish	*Ptychocheilus oregonensis* Richardson
Peamouth chub	*Mylocheilus caurinus* Richardson
Longnosed dace	*Rhinichthys cataractae* Valenciennes

Family Cottidae (Sculpins)

Slimy sculpin	*Cottus cognatus* Richardson

*Sources: Fish and Wildlife Branch, Department of Recreation and Conservation. Carl, Clemens and Lindsey (1959).

APPENDIX VI

Aerial Photography
Map and Duplicate References

(a) Map References

Scale	Source	Sheet Numbers
1:12,000	Kaiser Resources	1 sheet for mining area
1:24,000	Kaiser Resources	8 sheets for coal properties
1:50,000	National Topographic Series	82 G-6, 7, 10, 11, 14, 15 82 J-2 and 3
1:125,000	National Topographic Series	82 G-NW, NE, SW, SE 82 J, SW
1:250,000	National Topographic Series	82 G and 82 J
1:500,000	National Topographic Series	82 SE and 82 NE
1:100,000	National Topographic Series	NM 11
1:15,840	Planimetric Mapping (B.C. Land Management Branch)	82 G-6, 7, 10, 11, 14, 15 82 J2 and 3

(b) Airphoto References

Year	Scale	Project N^{o}	Photo Numbers
1962	1:15,840	B.C. 4056	1-139
		B.C. 4057	1-178
		B.C. 4075	1-186
		B.C. 4082	65-130
		B.C. 4083	153-180
		B.C. 4087	1-163

Year	Scale	Project N°	Photo Numbers
1962	1:15,840	B.C. 4094	1-36, 51-79, 93-121, 156-182
		B.C. 4095	9-37, 75-102, 117-147, 189-202
		B.C. 4098	1-13
		B.C. 4099	5-34, 48-81
		B.C. 4100	19-46
		B.C. 4105	39-59, 96-122, 140-168
		B.C. 4106	109-138, 170-195
		B.C. 4107	50-77, 113-142, 169-195
		B.C. 4108	43-73, 111-160
1972	1:15,840	B.C. 7415	1-284
		B.C. 7416	121-284
		B.C. 7417	1-34, 60-126, 156-190, 212-245
		B.C. 7418	20-52, 93-126, 165-202
		B.C. 7422	1-108
		B.C. 7423	151-191, 192-242
		B.C. 7424	195-134
		B.C. 7425	109-145, 174-250
		B.C. 7426	65-146, 250-290
		B.C. 7427	1-40, 90-231
		B.C. 7428	161-173, 259-275

Year	Scale	Project N°	Photo Numbers
1975	1:20,000	B.C. 7760	1-3
		B.C. 7770	123-125
		B.C. 7771	43-52, 137-141, 246-254
		B.C. 7777	1-3, 86-93
		B.C. 7799	154-173, 291-300
		B.C. 7800	1-8, 128-143, 266-268
		B.C. 7819	103, 127-134
		B.C. 7821	116-124
		B.C. 7826	257-260
1952	1:31,680	B.C. 1536	21-40, 79-112
		B.C. 1537	37-56, 59-87, 92-117
		B.C. 1538	1-40, 49-78, 81-115
		B.C. 1539	1-62
		B.C. 1478	63-96
		B.C. 1479	5-22
		B.C. 1488	1-18, 25-83, 88-116
		B.C. 1491	1-14, 40-51
1968-69	1:31,680	B.C. 5299	45-56, 76-104, 126-150, 173-178
		B.C. 5309	220-236, 256-259
		B.C. 5313	223-256
		B.C. 5353	56-69
		B.C. 5354	1-124
		B.C. 5356	196-265

Year	Scale	Project N°	Photo Numbers
1972	1:63,360	B.C. 5489	232-238, 244-259
		B.C. 5490	22-28, 36-42, 87-93, 100-106, 140-146, 169-175
		B.C. 5491	105-111

APPENDIX VII

Analytical Methods Used in Soil Analysis By The Soils Laboratory, Ministry of Agriculture, Kelowna

Analytical Methods For Field Soils

1. Organic Matter

The method employed is a modification of the Wakley Black method. In this method the organic matter is partially oxidized with sodium dichromate and sulfuric acid under specific conditions. The residual organic matter in solution is measured photometrically. Results are calibrated against organic matter determined by the standard Wakley Black method. Results are reported in percent organic matter by weight.

2. Soil Texture is done by the "feel" method.

3. pH - with pH meter, 1:2 soil water mixture, equilibrium time 30 minutes.

4. Conductivity - Saturation extract technique.

The electrical conductance is measured on the same soil water mixture as the pH using a conductivity meter and a micro type glass dip cell. Readings are converted to conductivity on a saturation extract by use of a prepared calibrated conversion table. These tables are reliable up to a conductivity of 1.00 Mmhos/cm. Soils with conductivity higher than 1.00 are repeated using the saturation extract technique.

5. Nitrate-Nitrogen (Modified Phenoldisulfonic acid method - colorimetric)

   (a) Extracting solution is 0.02 N $CuSO_4$ and 0.007 N $AgSO_4$.

   (b) Soil to solution ratio 1:10[1] by volume.

   (c) Shaking time 10 minutes.

   (d) Levels determined colorimetric using phenol - 2:4 - disulfonic acid as color reagent.

6. Phosphorus - Bray P-1 colorimetric method

   (a) Extracting solution is 0.025 N HCl and 0.03 N NHF

   (b) Soil solution ratio 1:10 by volume

   (c) Shaking time 1 minute

   (d) Determination - colorimetric using 1 amino - 2 naphthol - 4 sulfonic acid

7. Potassium, Calcium, Magnesium, Sodium

   (a) Extracting solution is Neutral, Normal Ammonium Acetate

   (b) Soil solution ratio 1:10 by volume

   (c) Shaking time 1 minute

   (d) Determination by atomic absorption spectrophotometer

8. Boron - colorimetric water soluble

9. Sulfate Sulfur - Modified Johnson Nishita procedure

List of a Few Basic References For Test Methods

Methods of Soil Analysis, Agronomy No. 9, Part 2 Edited by C.A. Black et al, American Society of Agronomy, Madison, Wisconsin, 1965

Homer D. Chapman and Parke F. Pratt, Methods of Analysis for Soils, Plants and Waters, University of California, Division of Agricultural Science, 1961

M.L. Jackson, Soil Chemical Analysis, Prentice Hall, Englewood Cliffs, N.J., 1958

J.A. Carson et al, A Sulfate-Sulfer Method Used to Delineate the Sulfur Status of Soils, Canadian Journal of Soil Science 52:278-281, (June 1972)

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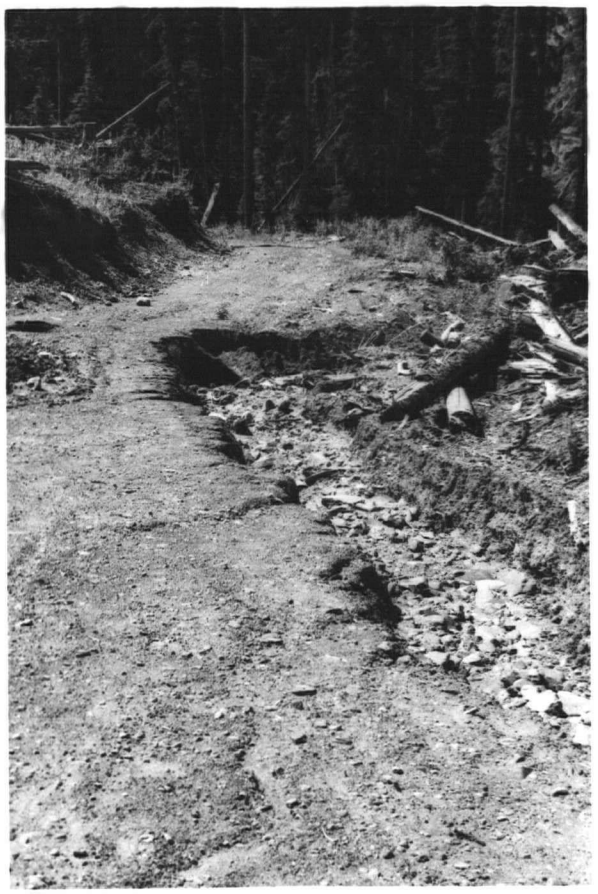
[1] In this laboratory 2 size spoons are used to measure soil volumes - a 2.4 c.c. capacity is assumed to be 2.5 grams and a 4.8 c.c. capacity which is assumed to be 5 grams of soil.

Soils Laboratory
Ministry of Agriculture
Kelowna

APPENDIX VIII

Photographs of Poor Exploration Practices Commonly Encountered in the Fernie Coal Basin

The Marten Ridge exploration operation. This is the area described on pages 120-123 of the text. Poorly planned exploration work, much of it unnecessary, has resulted in a highly disturbed and unstable watershed.



Inadequate culverting and the lack of rolled grades at a stream crossing has caused the diversion of a stream onto the road surface. In this case the stream followed the road for approximately 300 m. before leaving it at this point.

Common practice has been to place adit sites in ephemeral stream courses because the coal is closer to the surface and the length of tunnel is thus shorter. Excavated material is dumped downslope. During spring runoff such sites contribute significantly to sediments in adjacent streams. In this case the adit site was constructed but never used.

These pictures show a test pit on a ridge-top and the excavated material from the pit pushed down-slope into a stream. The material, at one time, must have partially blocked the stream, which subsequently cut a wider channel during spring freshette.

APPENDIX IX

Reclamation Guidelines For Exploration

BRITISH COLUMBIA DEPARTMENT OF MINES
AND PETROLEUM RESOURCES

Hon. Leo T. Nimsick, *Minister* John E. McMynn, *Deputy Minister*

INSPECTION AND ENGINEERING DIVISION

RECLAMATION BRANCH

RECLAMATION GUIDELINES FOR EXPLORATION

Prepared by: J.D. McDonald P. Eng.
Senior Reclamation Inspector
J. Dick P. Ag.
Reclamation Inspector

Printed by K. M. MacDonald, Printer to the Queen's Most Excellent Majesty
in right of the Province of British Columbia.
1973

TABLE OF CONTENTS

INTRODUCTION

In the short time that mineral and coal exploration has come under reclamation permits, it is evident that the industry is in need of direction. There is an apparent lack of knowledge by industry of reclamation and environmental requirements of the Government. This is partly the fault of Government Agencies who have had difficulty in setting up the administration, and providing information which follows legislation. The following guidelines are set forth as requirements which industry is to strive for.

British Columbia is a complex Province in respect to climate, topography, soils, and vegetation, and it would be difficult to set definite parameters within which the industry would have to work. Exploration activities must take into account other resources which are important to the Province from a watershed, game management, fisheries protection, water quality, and soil erosion, as well as aesthetic, and recreational viewpoints. Plant communities are fragile, and what has taken ten thousand years to achieve can be destroyed in seconds with a bulldozer or erosion.

A high standard of environmental protection will be required during exploration operations, and all disturbed earth surfaces shall be stabilized and revegetated when work terminates. Particular care should be taken to limit disturbances in the vicinity of watercourses and on alpine ranges. Roads and trenches on alpine areas remain visible for many years because of the absence of screening trees, and the slow rate of recovery of vegetation at these elevations. Two practices which are prohibited except by special permission are the establishment of grid lines by dozer and the hydraulic removal of overburden.

The following guidelines are to be used in planning both exploration and subsequent reclamation for effective environmental protection:

NOTICE OF OPENING AND CLOSING AND APPLICATION FOR RECLAMATION PERMITS

MINERAL AND COAL EXPLORATION

Pursuant to Section 10 and 11 of the Mines Regulation Act, and Section 7 and 8 of the Coal Mines Regulation Act.

1. The following forms have been drawn up to eliminate paper work; establish better communications with other Government departments, and expedite approval of reclamation permits. The forms are effective April 1, 1974.

   Form - Mineral Exploration, 10-11

   Form - Coal Exploration, 7-8

2 General Exploration Reclamation Permits can be issued to those companies in the mineral exploration field which have a number of exploration projects in British Columbia. The permit is issued for a three-year period, and covers all the company's exploration projects. The company is still required to submit Form 10-11, which is Notice of Opening and Closing, and Report of WORK TO BE DONE AND WORK DONE.

   The Permit can be obtained by applying by letter to the Chief Inspector of Mines. On approval of the Chief Inspector, and the posting of a $5,000 security bond, the Permit will be issued. The Permit holder is responsible to follow the reclamation guidelines.

3 PROCEDURE ON COMPLETING FORMS MINERAL EXPLORATION 10-11, and COAL EXPLORATION 7-8.

SECTION A - NOTICE OF WORK

(1) Section A - To be completed by all companies or individuals carrying out exploration work. To be submitted prior to starting work, and on completion of work, and copies forwarded to the four designated agencies listed.

(2) Line cutting will require approval of Forestry, and a "license to cut" or a "free use permit" will be required where timber is to be cut.

(3) No Reclamation Permit is required when only the following work is being done: line cutting, geological mapping, small test pits done by hand, geochemical surveys, geophysical surveys.

(4) If there is land disturbance but is thought to be minimal, complete Section B, and you will be advised if a Permit is necessary.

(5) On completion of the exploration programme Section A should again be completed.

SECTION B - RECLAMATION

(1) This section of the form is to be used for either:

(a) Application for Reclamation Permit.

(b) Report of Work Done on a mineral property.

(c) Report of Work to be Done or Work Done for "General Exploration Permits".

(2) Forestry reserves the right to withhold a "license to cut" or a "free use permit" until a reclamation permit is approved. Where cattle grazing is involved a check with Forestry should be made as this is under their jurisdiction.

(3) Regional offices of the Fish and Wildlife Branch should be contacted to determine if there are any conflicts with fish, wildlife, recreational areas, and ecological reserves in the proposed exploration programme. Most problems can be settled at the local level, but if this is not possible the problem is to be referred to the Senior Reclamation Inspector who will, if necessary, refer it to the Chief Inspector of Mines for a decision.

(4) Other Government Departments should be contacted where applicable. These might be the Water Resources Branch, Department of Agriculture, or the Department of Lands.

(5) Where a Reclamation Permit has been issued Section B should be completed each year for the exploration project, and a final report submitted when no future work is to be done. This will allow for inspection, and return of bonding on evidence of satisfactory reclamation.

Note: see Appendix for Addresses

ROADS

Of all industrial operations, poorly planned secondary roads are the major source of water turbidity. Even when no longer in use, such roads can continue to be a source of stream sediments unless measures are taken to re-establish drainage patterns and to stabilize bare-earth surfaces. On the other hand a well planned road may save considerable money in construction and maintenance, will have only minor adverse effects on water quality and may be a definite asset to the area after exploration operations cease. The following are fifteen rules for reducing erosion on secondary roads:-

A. Location and Design

(1) Plan road systems for the shortest possible distance consistent with needs and good road design. Use existing roads wherever possible. Build the narrowest road possible consistent with safety and traffic needs.

(2) When locating a road, utilize natural benches, ridgetops and flatter slopes to enhance road stability and avoid heavy cuts. Look for and avoid areas of seepage and natural erosion as they are often evidence of unstable soil types. In road location work use all existing topographic soil and surficial geology maps and the most recent aerial photographs available.

(3) Other factors being equal, roads on south and west aspects require more intensive measures for preventing erosion than do roads on north and east aspects. Grasslands have less capacity for absorbing overland sediment flow than forested or shrub covered areas.

(4) Except for crossings, no road should be constructed within 150 feet of a watercourse. Where heavy cuts are necessary at the approach to a stream, cut material should be "end-hauled" to a safe bench location or used in "through" fills by raising their elevation.

(5) Only one crossing shall be constructed at an intersection between road and stream, and this shall be at right angles to the watercourse at a location where bank disturbance is minimized. Road grade should be "rolled" at the approach to the stream. (i.e., a gentle dip to the stream crossing on each side. See Figure 1). Culverts and bridges should be large enough to accommodate peak stream flow for the life of the road. Coarse rock-fill crossings should not be used.

(6) Hold to the lowest grades possible except where a steep road section will avert a heavy cut and fill.

B. Construction and Maintenance

(1) Build water drainage structures as part of the road construction programme, and complete these structures on all newly built roads before the autumn rains begin.

(2) Do not allow the low point of a road grade break to occur on deep fills or on unstable natural slopes if this can be avoided. Where this cannot be avoided, build down-spouts the entire length of the slope (See Figure 2).

(3) Roads should be in-sloped only on steeper grades, and above deep fills or unstable natural slopes. On such roads a berm should be constructed and maintained on the outside road edge, and the inside edge should be adequately ditched (See Figure 3). Water should be carried off the road ditch as soon as this can safely be done by suitably spaced cross drains, water bars or road dips (See Figure 5).

(4) All contour or gently graded roads should be out-sloped, except where deep fills exist, and should be left unbermed (See Figure 4). Water should be diverted off the road surface by suitably spaced cross drains, water bars or road dips (See Figure 5).

(5) Surface drainage structures should discharge only on stable areas.

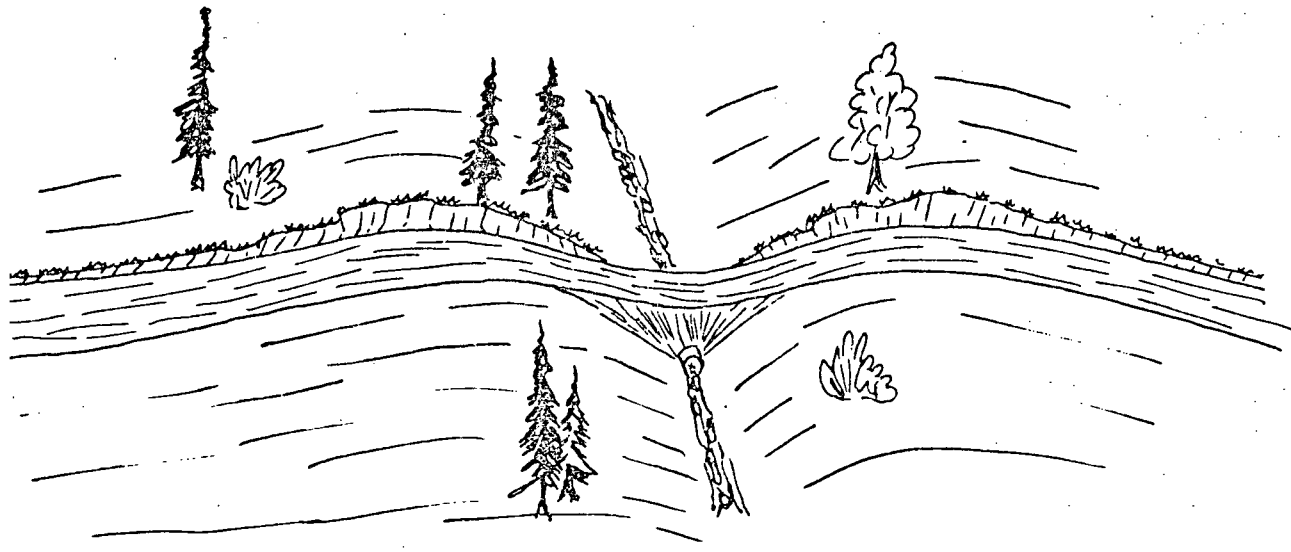


Fig.1. Rolled grade at a culverted stream crossing.

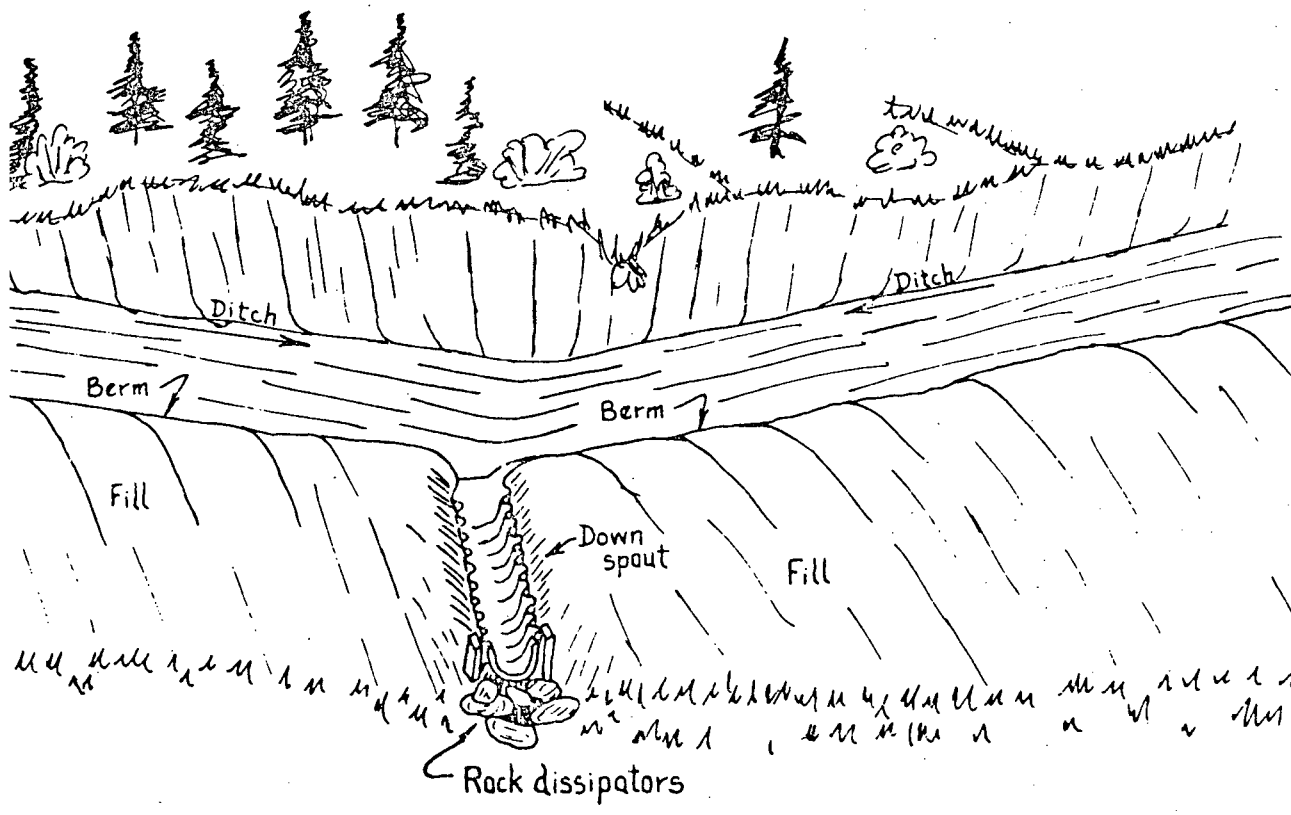


Fig. 2. Down spout protecting fill slope on grade break.

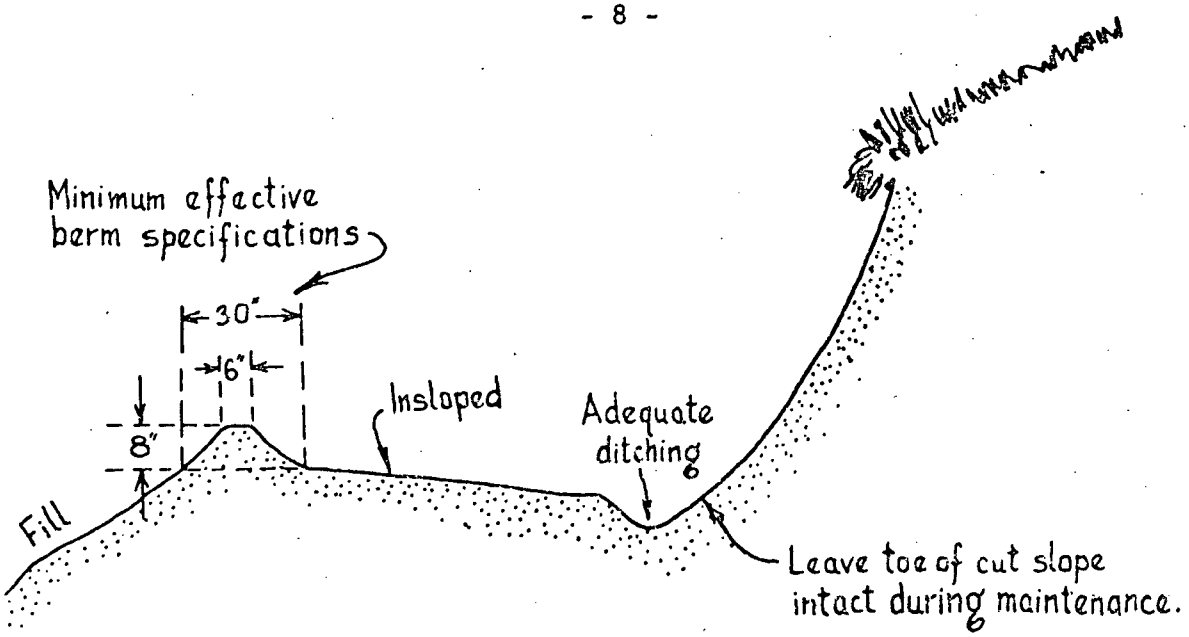


Fig. 3. Cross-section of road construction on steep grades or over long fill slopes.

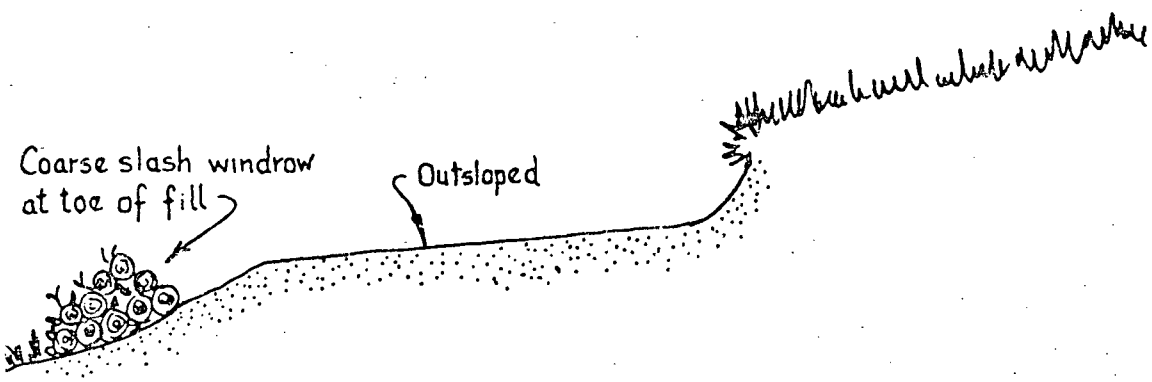


Fig. 4. Cross-section of road construction on gentle or contour grades.

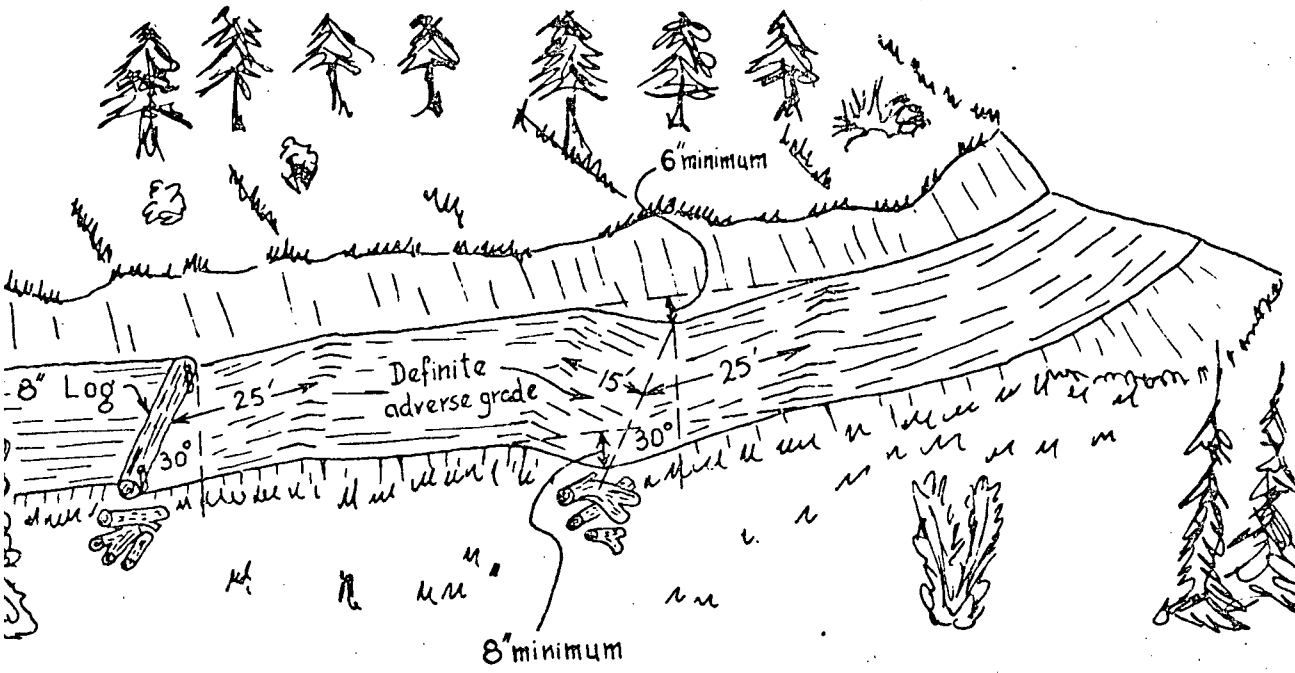


Fig. 5. Road drainage structures on an outsloped, contour road. Water bar (left) and cross-drain (right).

(6) During maintenance, leave the berms on insloped roads, and the toe of cut slopes intact. Do not allow berms to form on outsloped roads.

(7) Do not place woody or other organic debris in the fill of any road.

(8) Windrow unmerchantable logs and coarser slash from road right-of-way timber along the toe of fill slopes (but see note below).

NOTE: The District Forest Ranger has the power to insist that road rights-of-way be cleared before road construction begins. In practice. however this regulation has been relaxed providing slash is cleaned up within a reasonable time. In windrowing material along the toe of fill slopes be sure to use only the coarse slash and logs, and have the Ranger check for fire hazard. Fine slash should be burned or buried.

(9) Whenever possible, check the road surfaces after a heavy run-off to determine if drainage control is adequate.

CLEARING, STRIPPING AND TRENCHING

(1) Clearing, stripping and trenching operations should be pre-planned to disturb the smallest possible surface area.

(2) Overburden material from stripping and test pits will be conserved for backfilling. Under no condition whall it be bulldozed downhill.

(3) No stripping or trenching shall be done within 150 feet of a watercourse, either permanent or ephemeral, without approval from the Inspector of Mines. Where approval is granted the onus shall be on the operator to ensure that waste material does not reach the watercourse.

(4) Trenches on level ground or slopes up to 15 degrees will be backfilled when geological examination is completed. Trenches on sidehills greater than 15 degrees are essentially roads and the guidelines under 1. A and B, above shall apply to them.

(5) Unless absolutely necessary no trenching shall be done on slopes exceeding 20 degrees. Where this cannot be avoided, the gradient of the trench shall not exceed 20 degrees.

ADITS AND DRILLSITES

(1) No adit or drillsite shall be constructed within 150 feet of a watercourse (either permanent or ephemeral) unless approval is obtained from the Inspector. Where approval is granted the onus shall be on the operator to ensure that soil and waste material does not reach the watercourse.

(2) Adits or drillsites on sidehills will be protected by a ditch or ditches on the uphill side which will divert run-off waters either into existing watercourses or onto stable areas adjacent to the site. Ditch gradient should not exceed 5 degrees.

(3) No adit or rock tunnel shall be driven on slopes exceeding 20 degrees without the approval of the Inspector. Adit refuse dumps will not exceed a slope of 25 degrees and will be bermed at the cessation of tunnelling. Adit platforms on sidehills shall be insloped and provisions made to carry runoff waters onto stable, vegetated areas adjacent to the adit.

CONDITION OF THE OPERATION AT THE END OF THE WORK SEASON

(1) All water drainage structures should be completed when exploration crews withdraw in the autumn.

(2) Since many culverts are installed to accommodate only summer water flow, consideration should be given to lifting smaller culverts and re-establishing the stream channels as the crew withdraws in the autumn. Even larger culverts may plug with debris during spring run-off and overflow unless brush catchers are installed upstream. This

situation is most serious on climbing roads where the grade has not been "rolled" at the stream crossing. If the culvert is too small or plugs, water is diverted onto the road surface causing serious erosion and costly reconstruction the following exploration season.

CONDITION OF THE LAND ON TERMINATION OF EXPLORATION OPERATIONS

(1) Campsites will be completely dismantled at the end of operations and all refuse burned and buried. The site shall be ripped, if necessary, to break surface compaction and seeded to a mixture of perennial grasses and legumes.

(2) Some portions of the exploration road system may be required by the Forest Service for permanent fire access. It is in the operator's interest to contact the Forest Service in this regard. Such roads need not be reclaimed provided that permanent drainage has been established, and cut and fill slopes stabilized.

(3) All other roads and trenches must be ditched at their junction with permanent roads to prevent access. The road or trench surface and the cut and fill slopes must be seeded to a mixture of perennial grasses and legumes adapted to the area (See Table 1). Adequate drainage will prevent erosion and hasten the establishment of vegetation.

(4) Drill sites, adit platforms and waste dumps must be stabilized and seeded to a mixture of perennial grasses and legumes (See Table 1). Cutbanks should be backfilled as far as possible. In mountainous terrain a portion of the cutbank will remain after partial backfilling, and this is often too steep to be revegetated. It can be left providing the bank is stable and interceptor ditches have been established above the site.

Table 1. Suggested Seed Mixtures for Reclamation of Exploration Operations

Area	Altitude	Rainfall	Type Vegetation	Seed Mixture
I Coastal	0-3000'	25-35"	Douglas-fir/Shore pine/Arbutus.	Canada bluegrass 20%, Creeping red fescue 15%, Orchardgrass 15%, Timothy 15% Perennial ryegrass 10%, Red top 10%, Alfalfa 5% White clover 10%.
		35"+	Hemlock/Cedar	Reed canary grass 20%, Orchardgrass 15% Creeping red fescue 15%, Timothy 15%, Red top 10%, Canada bluegrass 15%, Alsike 5%, Ladino clover 5%
II Southern Interior	900'-2500'	15" or less	Ponderosa pine/bunchgrass/Sagebrush.	Nordan crested wheatgrass 30%, Streambank wheatgrass 20%, Pubescent wheatgrass 20%, Red top 10%, Canada bluegrass 10%, Alfalfa 10%
	1500-4500'	15-25"	Douglas-fir/Pinegrass/Ponderosa pine.	Intermediate wheatgrass 25%, Pubescent wheatgrass 25%, Smooth brome 20%, Hard fescue 10%, Alfalfa 15%, Sweet clover 5%
	1200-5000'	25-35"	Douglas-fir/Western larch/Lodgepole pine/Cedar.	Intermediate wheatgrass 20%, Smooth brome 20%, Canada bluegrass 15%, Creeping red fescue 15%, Climax timothy 10%, Alfalfa 10%, White dutch clover 5%, Sweet clover 5%.
	1200-5000'	35-65"	Hemlock/Cedar/White pine/Western larch	Intermediate wheatgrass 20%, Smooth brome 15% Orchardgrass 15%, Timothy 15%, Creeping red fescue 15%, Red top 10%, Alsike 5%, Alfalfa 5%
III North-Central Interior	1700-3000'	20-50"	Douglas-fir & Aspen Parklands/White spruce/Black spruce/Birch	Timothy 30%, Smooth brome 20%, Boreal creeping red fescue 20%, Intermediate wheatgrass 15%, alsike 5%, alfalfa 10%
IV Alpine & Sub-Alpine areas province-wide. The Far North.	3000-7000'	25-100"	Engelmann spruce/Subalpine fir, Alpine meadows & Tundra.	Pubescent wheatgrass 20%, Meadow foxtail 20%, Crested wheatgrass 15%, Smooth brome 15% Hard fescue 10%, Tall wheatgrass 10%, Boreal creeping red fescue 10%.

(5) Test pits, stripping and trenches on gentle terrain shall be backfilled to original contour as far as possible and seeded to perennial grasses and legumes (See Table 1).

(6) Seeding shall be done at a rate of not less than 30 pounds per acre. Suggested seed mixtures for various areas of the Province are shown in Table 1. These mixtures are meant as a guide only and can be modified for specific sites. In addition, the following should be noted:

(a) All legumes should be innoculated.

(b) Rhyzomatous or creeping varieties of alfalfa should be used in the Interior.

(c) Birdsfoot trefoil may be substituted for alfalfa in wetter areas.

Seedings should be fertilized with a composite fertilizer such as 20-24-15 at a rate not less than 150 pounds per acre.

(7) Seeding and fertilizing is best done in the early spring after snow melt. Trenches, test pits, campsites, drill and adit sites are probably easiest treated with a "Cyclone" hand seeder. Road systems may be treated either with a hand seeder or a power take-off "Cyclone" seeder mounted on a 4-wheel drive vehicle.

PLACER MINING GUIDELINES

Compliance with Section 11 of the Mines Regulation Act does not relieve the placer miner of his duties and obligations under other Government regulations. The most important of these are the following:

The Placer Mining Act

The Water Act

The Water Act states that any person wishing to divert or use water from any stream for mining purposes must first obtain a water license. The procedure for acquiring a licence is described in Section 8 of this Act, and further information can be obtained from the office of the Regional Water Rights Engineer.

In addition, the Comptroller of Water Rights must approve all proposals for stream diversions or working in a stream pursuant to Section 7 of the Act.

Section 5, Pollution Control Act

This Act states that no person shall discharge waste material either onto the surface of the land or into any water without a Pollution Control Permit. The procedure and the information needed to apply for a permit is described in Section 5 of this Act, and further information may be obtained from the office of the District Pollution Control Engineer.

Canada Fisheries Act

Section 33 of this Act states that it is an offence to discharge soil material into water containing fish or into waters which flow into bodies of water containing fish. Placer operations on stream systems containing fish will require more stringent environmental control facilities than on streams which are not important to the fishing resource.

Forest Act - Free Use Permits

The following guidelines are intended to help the placer operator in planning the operation for minimal environmental disturbance, and subsequent reclamation in the most effective manner.

Those placer operations using ponding, settling ponds, and recirculation of water are looked upon favourably by all Government Departments. Adequate berms, dykes, and settling ponds are required.

The following placer mining methods require the approval of the Chief Inspector of Mines, a Permit issued under Section 7 of the Water Resources Act, and approval of the Fish and Wildlife Branch.

(a) Dredging in, or removal of gravel from the stream bed itself.

(b) Re-chaneling or diversion of streams.

(c) Stripping of overburden and gravels by hydraulic techniques, either by monitor or stream diversion.

There shall be no discharge of silt-laden waters in excess of 50 milligrams of suspended solids per litre into any stream without permission of the Regional Fisheries Biologist.

Water Intake Structures

Where water is diverted from a fishery stream for mining purposes, the intake shall be screened to prevent the entry of juvenile fish. Where water use if one c.f.s. or less the intake can be of the types shown in Appendix B. If water intake is greater than this the screening facility should be designed specifically for the site in consultation with local Fish and Wildlife personnel.

Excavations

(a) Plan activities so as to disturb only as much land as is absolutely necessary for the mining operation.

(b) Conserve topsoil from excavated areas for eventual use in reclamation.

(c) Protect the stream or river by constructing a berm, 20-foot minimum, between it and the area of disturbance. Channel run-off water from the excavations into the settling pond system.

(d) Upon completion of work the area should be re-sloped and stabilized. Excavations on level ground should be filled as completely as possible with waste gravel and spread with topsoil. Excavations in a sidehill should be back-filled as far as possible and should have the crown collapsed.

6. Settling Ponds

(a) All waste water will require clarification in settling ponds before being returned to the stream.

(b) Settling ponds must be situated above the highwater margin of the stream to prevent inundation during floods.

7. Roads (See Pages 4,5)

8. Reclamation

(a) All disturbed surfaces including excavations, working areas, roads, and drained water impoundments will be stabilized and reseeded upon completion of mining operations.

(b) Heavily compacted surfaces such as roads and working areas will require ripping before reseeding.

(c) Excavations will be backfilled as far as possible with waste gravel material and topsoil conserved during stripping operations will be spread on the surface.

(d) Seeding shall be done at a rate not less then 35 pounds per acre, and the following seed mixtures and fertilizer prescriptions shall be used (See Page 13)

APPENDIX A

ADDRESSES

Department of Mines and Petroleum Resources

Chief Inspector of Mines - 1837 Fort St., Victoria	387-3781, 82
Senior Reclamation Inspector - 1837 Fort St.,	387-3630

District Mine Inspectors and Resident Engineers:

CITY	ADDRESS	PHONE
Nanaimo	2226 Brotherstone Rd.	758-2342
Vancouver	2747 East Hastings St.	254-7171
Prince Rupert	Court House	624-2121
Smithers	Box 877	847-3704
Prince George	1652 Quinn St.	562-2111 (Local 322)
Kamloops	Fulton Field, R.R. 1	376-2059
Nelson	701 Front St.	352-2211 (Local 213)
Fernie	Box 1290	423-6222

Fish and Wildlife Branch - Regional Directors

Nanaimo	Court House	754-2111 (Local 234)
Burnaby	4529 Canada Way	437-4137
Kamloops	523 Columbia	374-4112 (Local 132)
Nelson	303 Victoria St.	352-2111 (Local 240)
Prince George	1600 - 3rd Ave.	562-2111 (Local 232)
Smithers	Court House	847-3702
Penticton	152 Main St.	492-6018

Water Rights Branch - Regional Offices

Kamloops	523 Columbia St.	374-4112 (Local 191/2/3
Kelowna	Court House	762-2404
New Westminster	313 - 6th St.	521-9641 (Local 281)
Nelson	Box 730	352-2211 (Local 275)
Prince George	1600 - 3rd Ave.	562-2111 (Local 236)
Victoria	Parliament Buildings	387-3416

Pollution Control Branch - District Managers

Victoria	1088 Fort St.	387-5321
Cranbrook	1617 Baker St.	426-7203
Vernon	Court House	542-2351
Kamloops	1050 West Columbia	374-4112 (Local 219)
Prince George	3691 - 15th Ave.	562-2111 (Local 238/9)
New Westminster	313 - 6th St.	521-9641 (Local 279)

Forestry Districts	Phone
Vancouver	684-2321
Prince Rupert	624-2121
Prince George	562-2111
Kamloops	374-4112
Nelson	352-2211
Cariboo	392-6501

APPENDIX X

Directive: Exploration of Coal Properties
Coal Exploration Form 7-8
Surface Work Permit

DIRECTIVE

Exploration of Coal Properties

and

Section 8, Coal Mines Regulation Act

By Order-in-Council No. 1390, approved April 23, 1971, the provisions of Section 8 of the Coal Mines Regulation Act were applied to all coal mines in the exploration stage which began operations after April 2, 1969 where the employment of mechanical equipment has disturbed or will disturb the surface of the land in clearing, stripping, trenching and such other operations as have or may be considered to be likely to cause significant disturbance of the surface of the land.

To comply with subsections (1), (2) and (3) of Section 8 of the Act, the following are required:

1(a). Report to the Minister of Planned Coal Exploration.

A report of the planned coal exploration work is to be filed with the Minister of Mines and Petroleum Resources, using the form "Report of Exploration Work on Coal Licences". The report is to be submitted annually and prior to the start of coal exploration work.

1(b). Copies to District Inspector and Forest Ranger.

One copy of this report is to be forwarded to the District Inspector of Mines and one copy to the District Forest Ranger at the same time that the original is submitted to the Minister.

Note: This replaces the use of the form "Notice of Opening of a Mine or Quarry, or of Work on a Mineral Property" for this purpose.

1(c). Follow-Up Report to the Minister.

At the conclusion of the coal exploration work, or at the time of filing the next annual report with the Minister, whichever is first, a follow-up report is to be submitted (using the same report form), listing the actual work which was done.

1(d). Report to the Minister of Previous Coal Exploration.

Licencees who have performed coal exploration work between April 2, 1969 (the date of enactment of Section 8 of the Act) and the date of filing of the initial Item 1(a) report must file a separate report (using the same report form) covering such previous work.

2. Map to Accompany Reports.

Each Item 1 report is to be accompanied by a map of the area of the licences held under the Coal Act. The map, at a suitable scale, is to show the full extent of the coal exploration work as listed in Item 8 of the report.

It is to include lakes, streams, and inhabited places in the vicinity. It should show the topography and other physical features of the area. As a small scale insert in this map, show the location of the property.

Note: For administrative purposes, seven copies of the map are required with the report filed with the Minister.

3. Reclamation Programme and Report.

A reclamation report is to be filed with the Minister, covering the following:

(a) The nature and present uses of the land as included in the map area. Discuss the nature of the land, with reference to soils, rocks, vegetation, water, climate, topography, and the environment. Describe past and present land usage of the area in the fields of mining, timber, agriculture, fish and wildlife, recreation, water resources, etc.

(b) Describe the probable effect of the exploration work on: livestock and grazing, fish and wildlife, water-courses, timber, farms and inhabited places in the vicinity, recreation, the appearance of the exploration site, and the environment of the area.

(c) Discuss the potential use of the land, having regard to its best and fullest use, and its importance for existing and future timber, grazing, water, recreation, wildlife, or mineral use. Describe the reclamation plans

and actions which will be taken to ensure that the potential is attained at the earliest possible time.

Note: This Item 3 reclamation report is to be filed (one time only) covering the group of coal licences as listed in the initial report, Item 1(a) above. It is to be filed with the Item 1(a) initial report. If, however, the data required for this Item 3 reclamation report is not available at the time of filing of the Item 1(a) report, a reasonable deferment, not exceeding six months, may be obtained by making written application to the Chief Inspector of Mines.

4. Topsoil and Overburden Soil.

Topsoil and overburden soil stripped from the surface shall be conserved, as feasible, for potential use in the reclamation of disturbed areas.

5. Roads.

The location of roads is to be planned for minimum disturbance of the surface of the land and watercourses. Roads are to be properly constructed, ditched, and culverted to adequately control erosion and silting of watercourses. With the permission of the owner, maximum use should be made of existing roads in the area.

6. Clearing, Stripping and Trenching.

Clearing, stripping and trenching should be planned for minimum disturbance of the surface of the land and watercourses, commensurate with good coal exploration practice. Erosion control of these areas is to be provided as may be necessary to prevent silting of watercourses.

7. Condition of Land at Termination of Coal Exploration.

At the termination of coal exploration each year, the disturbed areas are to be left in a neat, clean, and safe condition.

8. Contact With Other Departments.

Subsection 5(a) of Section 8 of the Coal Mines Regulation Act reads: "The Minister (of Mines and Petroleum Resources) shall, before exercising the powers in this section, obtain approval of the programme for reclamation and conservation from the Minister of Lands, Forests, and Water Resources, the Minister of Recreation and Conservation, and the Minister of Agriculture in so far as the programme affects in any way the ministerial responsibilities of those Ministers."

When the planned coal exploration work will affect in any manner the responsibilities of any of the foregoing provincial governmental departments, it is recommended that the affected departments be contacted prior to the start of the coal exploration work. Contact may be made as follows:

Department of Mines and Petroleum Resources

Chief Inspector of Mines)
Inspector of Mines, Reclamation) Victoria and/or
District Inspector of Mines

Department of Lands, Forests, and Water Resources

Director of Lands)
Director of Grazing) Victoria and/or
Comptroller of Water Rights)
Director of Pollution Control)
District Forester and/or
Local Forest Service Officer (Ranger)

Department of Recreation and Conservation
Director of Fish and Wildlife, Victoria and/or
Local Conservation Officer

Department of Agriculture
Commissioner of Field Crops, Victoria and/or
District Agriculturist

Only by contacting the appropriate officials as listed above can the owner, agent, or manager of the coal exploration programme ensure that the requirements of the Coal Act, the Coal Mines Regulation Act, the Land Act, the Water Act, the Pollution Control Act, 1967, the Forest Act, the Fisheries Act, the Wildlife Act, the Park Act, the Environment and Land Use Act, the Noxious Weeds Act, and of other departmental jurisdictions and responsibilities, as they apply to coal exploration operations, will be satisfactorily met.

February, 1972

COAL EXPLORATION FORM 7–8

DEPARTMENT OF MINES AND PETROLEUM RESOURCES
MINERAL RESOURCES BRANCH
INSPECTION AND ENGINEERING DIVISION

NOTICE OF WORK ON A COAL LICENCE

Pursuant to section 7 of the *Coal Mines Regulation Act* this notice is to be completed by all companies or individuals carrying out exploration work prior to commencement of work, and within one month of cessation of work and one copy is to be sent to each of the following:

Senior Reclamation Inspector, Victoria
District Inspector of Mines
Regional Water Rights Engineer
District Forester or Forest Ranger
Regional Fish and Wildlife Office

PERMIT NO. _____

1. NAME OF PROPERTY: _____

Coal Licence Numbers: _____

2. LOCATION: Mining Division _____ NTS Map Sheet (e.g., 82E/9E) _____

Lat. ____° ____' Long. ____° ____' Locality and Access _____

3. OWNER: Name _____ Free Miner's Cert. No. _____

Address _____ City _____ Prov. _____

4. OPERATOR: Name _____ Free Miner's Cert. No. _____

Company _____ Telephone No. _____

Address _____ City _____ Prov. _____

5. ESTIMATED DURATION OF WORK: From _____ to _____

6. ACTUAL DATE WORK COMPLETED: Day _____ Month _____ 19____

7. APPROXIMATE NUMBER OF MEN EMPLOYED: _____

8. EXPLORATION WORK: Proposed ☐ Completed ☐ (Use metric measure – 1 metre = 3.3 feet.)

Linecutting (distance, width, method) _____
(Requires approval of Forest Service. 'Licence to Cut' or 'Free Use Permit' may be withheld until Reclamation Permit approval.)

Drilling – No. of Sites _____ Total Area _____ square metres

Road Construction – Total Length _____ metres Approximate Width _____ metres

Underground Exploration _____ (type)

Trenching – Number _____ Total Length _____ metres Width _____ metres

Test Pitting – Number _____ Total Disturbed Area _____ square metres

Work by Self ☐ OR Name of Contractor _____
(Owner is responsible for ensuring the Contractor complies with pertinent regulations, *see* section 8, *Coal Mines Regulation Act*.)

9. DATE FOREST SERVICE ADVISED BY OPERATOR: _____

Name and Title of Forest Official _____

Address _____

NOTE: Pursuant to section 8, subsection 2(a) of the *Coal Mines Regulation Act*, '...where the employment of mechanical equipment is likely to disturb the surface of the land in clearing, stripping, trenching...' the Application for a Reclamation Permit on the reverse side is also to be submitted.

SIGNATURE OF APPLICANT _____ TITLE _____

PRINT NAME _____ DATE _____

COAL EXPLORATION FORM 7–8

THE GOVERNMENT OF THE PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF MINES AND PETROLEUM RESOURCES
MINERAL RESOURCES BRANCH
INSPECTION AND ENGINEERING DIVISION

APPLICATION FOR A RECLAMATION PERMIT ON A COAL LICENCE

Pursuant to section 8 of the *Coal Mines Regulation Act*, this form is to be completed when applying for a Reclamation Permit, when renewing same, or when reporting exploration work to be done. When reporting on work which has been done, *see* instructions at the bottom of the page. For recommended methods of reclamation and environmental control, *see* booklet entitled, *Guidelines for Coal and Mineral Exploration*, which is available at the office of the District Inspector of Mines.

PERMIT NO. _____

1. THIS IS: An Initial Application ☐ Renewal ☐ Report of Proposed Exploration Work ☐

2. PRESENT STATE OF LAND ON WHICH EXPLORATION WILL BE DONE IS:

Canada Land Inventory (where possible) _____

Present Land Use (ranching, timber, etc.) _____

Type of Vegetation _____

Access Roads (present use, condition) _____

Campsites, Old Workings (location, condition) _____

NOTE: Items shown above should be indicated on the NTS maps which are required for the following section.

3. PROPOSED SURFACE WORK: (Attach 7 copies of 1:50,000 NTS map with full extent of exploration work noted – Coal Titles Reference Maps.) (Use metric measure – 1 metre = 3.3 feet.)

Roads: Total length _____ metres — Total disturbed area _____ square metres

Test Pits: Total No. _____ — Total disturbed area _____ square metres

Trenches: Total No. _____ — Total disturbed area _____ square metres
(Include ground slope at trench on NTS map)

Adits: Total No. _____ — Total disturbed area _____ square metres

Drill Sites: Total No. _____ — Total disturbed area _____ square metres

Other: _____ — Total disturbed area _____ square metres

Total Disturbed Area (square metres): _____ square metres

Total Disturbed Area (hectares): _____ hectares
(1 hectare = 10 000 square metres)

4. EQUIPMENT TO BE USED (list size, capacity, and number):

(a) _____ (d) _____

(b) _____ (e) _____

(c) _____ (f) _____

5. GOVERNMENT CLEARANCES INITIATED AT REGIONAL/DISTRICT LEVEL:

	Forestry	Fish and Wildlife	Water Rights
Name of Official			
Title			
Location			
Date Notified			

6. SIGNATURE OF APPLICANT _____ DATE _____

Title _____ Company _____

FOR DEPARTMENT OF MINES USE ONLY

Terms and Conditions other than Guidelines _____

Bonding Required (Permit is issued on receipt of bonding.) _____

Approved by Advisory Committee _____ Date _____

Approved by Sr. Reclamation Inspector _____ Date _____

Date of Minister's Approval _____ Order-in-Council _____

Date Permit Issued _____

NOTE: When geotechnical and reclamation work have been completed for the calendar year, a Reclamation Report should be submitted to the Senior Reclamation Inspector in Victoria. For a sample of the format to be used *see* the Appendix of the booklet entitled, *Guidelines for Coal and Mineral Exploration*. The Reclamation Report will describe all work done and the details of the reclamation which was achieved. Two 1:50,000 NTS maps are required for the Report.

THE GOVERNMENT OF
THE PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF MINES AND PETROLEUM RESOURCES

COAL MINES REGULATION ACT

PERMIT

AUTHORIZING SURFACE WORK

(Issued pursuant to section 8 of the *Coal Mines Regulation Act*)

Permit No._____

Issued to_____

_____

_____

for surface work at the_____

_____

_____mine(s).

Located at_____

_____

_____

and subject to the appended terms and conditions, all of which are applicable to this permit.

Issued at Victoria, British Columbia, this_____day of_____ in the year_____

_____

Minister of Mines and Petroleum Resources

TERMS AND CONDITIONS

1. This permit is issued subject to all the terms and conditions of section 8 of the *Coal Mines Regulation Act.*

2. The permit is for a period of.....years. It is renewable on application, and upon evidence of satisfactory performance.

3. Pursuant to subsections (6) and (7) of section 8 of the Act, security as specified by Order in Council No....., approved on the.....day of....., 19....., has been deposited with the Minister of Finance in the amount of.....

.....dollars ($.....).

4. The report, dated....., as filed with the Minister pursuant to subsection (2) of section 8 of the *Coal Mines Regulation Act,* together with all revisions and amendments thereto, and as approved by the Minister, is an integral part of this permit.

OTHER

NOTE—This permit applies only to the requirements under section 8 of the *Coal Mines Regulation Act.* Other legislation may be applicable to the mining operations, and this permit in no way abrogates the responsibility and obligation of the permittee under such other legislation.

100-571-4159