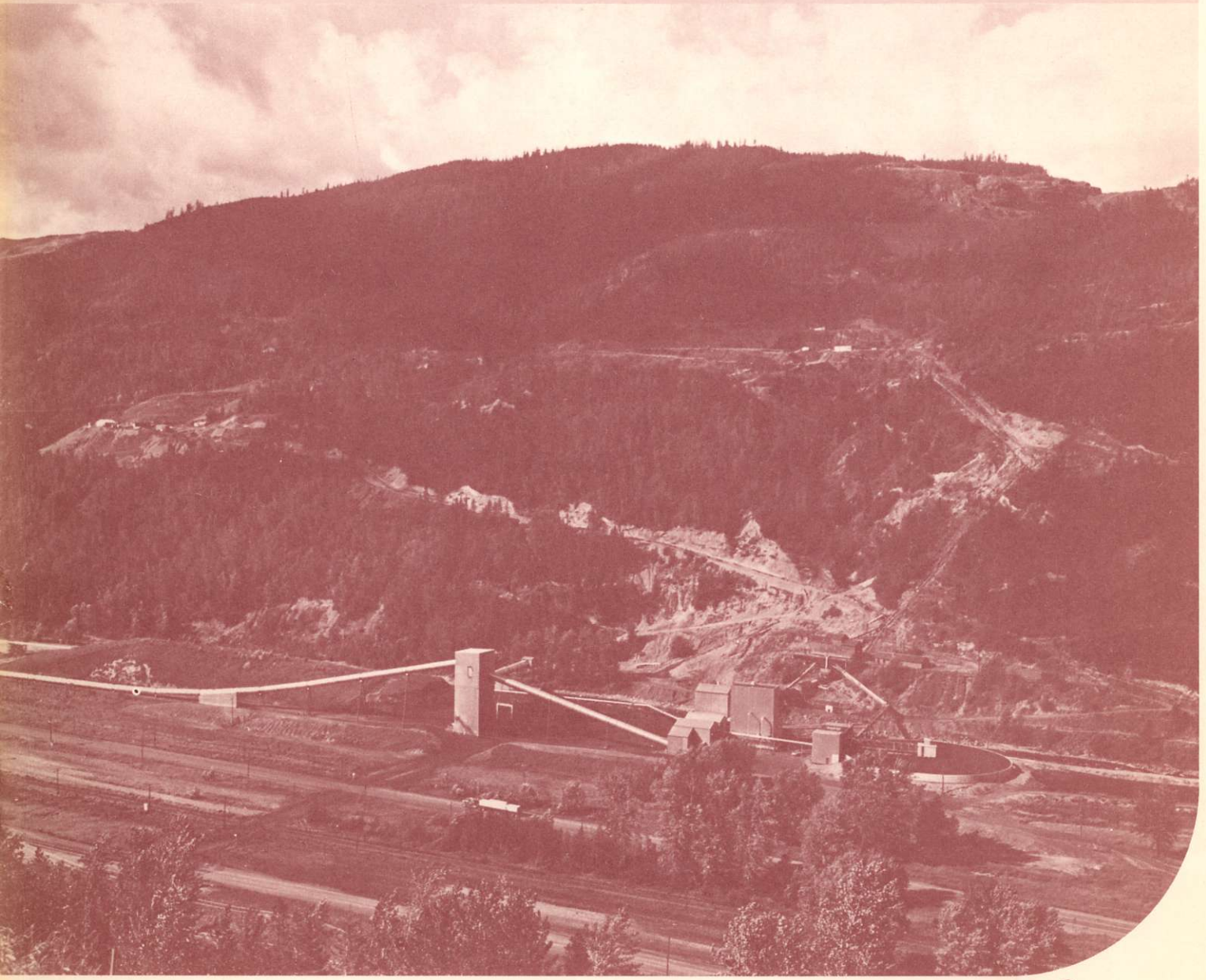
A Brief Submitted to the Royal Commission of Inquiry

Health and Environmental Protection Uranium Mining

September, 1979



PAPER 1980-8

Environmental Impact

BY THE INSPECTION AND ENGINEERING DIVISION
MINERAL RESOURCES BRANCH

Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources

SUBMISSION OF MINISTRY OF ENERGY MINES AND PETROLEUM RESOURCES TO ROYAL COMMISSION ON HEALTH AND ENVIRONMENTAL PROTECTION – URANIUM MINING

PHASE VI – ENVIRONMENTAL IMPACT

February 1980
Engineering and Inspection Division
Mineral Resources Branch

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SUMMARY

- Environmental protection on a mining property is the responsibility of a number of government agencies.

- The Ministry of Energy, Mines and Petroleum Resources is responsible for the approval of the mining system and has a role in coordinating government response to ensure that a mining development is designed with the minimum possible environmental impact.

- Coordination of approvals of new mine proposals is the responsibility of the Coal Guidelines Steering Committee for coal mining, the Metal Mining Steering Committee for metal mining, and the Uranium Mining Steering Committee for uranium mining.

- The Ministry of Energy, Mines and Petroleum Resources has at least one member on each of the committees.

- Reclamation is administered by the Ministry of Energy, Mines and Petroleum Resources, Inspection and Engineering Division, Reclamation Section, under section 11 of the *Mines Regulation Act.*

- Reclamation legislation requires that a surface work permit be obtained.

- To obtain and maintain a surface work permit requires a report, advertising, review by the Advisory Committee on Reclamation, bonding, issuance of the permit with special terms and conditions, and continued reclamation performance.

- Detailed industry-wide reclamation standards have not been set, although general reclamation guidelines have been prepared.

- Control of the terms and conditions of a surface work permit is exercised through a reclamation report which is submitted annually by each company and through inspection of properties by Ministry staff.

- The Technical and Research Committee on Reclamation, sponsored by the Ministry of Energy, Mines and Petroleum Resources and the Mining Association of British Columbia, has been formed to influence and coordinate the direction of mine reclamation research, to further communication of reclamation knowledge, and to select a recipient of the British Columbia mine Reclamation Award.

- Members of the Reclamation Section have attended a number of conferences to familiarize themselves with reclamation work elsewhere.

- The mine Reclamation Award, established to recognize outstanding achievement in mine reclamation in British Columbia, has been awarded to the following companies: Kaiser Resources Ltd. (1976), Cominco Ltd. (1977), and Kaiser Resources Ltd. (1978).

- Recent reclamation work undertaken in British Columbia is presented for the following properties: Bull River mine, Bluebell mine, Pinchi Lake mine, Princeton tailings pond, and Craigmont mine.

I. INTRODUCTION

The responsibilities of the Ministry of Energy, Mines and Petroleum Resources toward environmental impact of mines are two-fold. First, the Ministry is represented on several steering committees which coordinate licensing and approval of mine development. Second, the Ministry is responsible for ensuring that land disturbed through mining is reclaimed.

In this Phase VI portion of the Ministry's submission the regulatory and administrative framework relating to environmental impact of mining is briefly described. The largest portion of this submission deals with reclamation.

II. ENVIRONMENTAL PROTECTION

Environmental protection on a mining property is the responsibility of a number of government agencies. The Ministry of Energy, Mines and Petroleum Resources is responsible for approving the over-all mining system with respect to the safety of the operations, the maximization of mineral resource recovery, and the reclamation of the land surface.

The Pollution Control Branch is responsible for regulating effluents, emissions, and garbage disposal.

The Ministry of Energy, Mines and Petroleum Resources and the Pollution Control Branch are the major permitting agencies on a mining property, although other statutes may apply. Statutes that may affect environmental matters are the: *Health Act, Forest Act, Land Act, Water Act, Atomic Energy Control Act,* and *Fisheries Act.*

As well as individual statute requirements, assessment and review procedures have been established for companies who are applying to develop coal and mineral properties. These procedures are outlined in Phase III of the Ministry's submission.

The main objectives of these review procedures are:

(a) to provide a vehicle for over-all project approval by identifying the nature and magnitude of environmental, social, and economic impacts associated with a proposed development;
(b) to provide a procedure for solving problems not falling under existing regulatory responsibilities.

The Ministry of Energy, Mines and Petroleum Resources is represented on three steering committees (coal, metal mines, and uranium) which are responsible for coordination of each review process.

The responsibility for the coordination of matters relating to environmental protection for coal mining lies with the Coal Guidelines Steering Committee. This steering committee coordinates the procedures of the *Guidelines for Coal Development* (*see* Ministry's submission to Phase III, part 2.2).

The committee is composed of the following members:

J. O'Riordan,
Ministry of Environment,
Environment and Land Use Committee Secretariat,
Chairman

J. D. McDonald,
Ministry of Energy, Mines and Petroleum Resources,
Co-chairman

W. Malkinson,
Ministry of Economic Development

E. Caner,
Ministry of Economic Development

G. C. Harkness,
Ministry of Municipal Affairs

J. Clancy,
Ministry of Energy, Mines and Petroleum Resources

The Metal Mines Steering Committee is responsible for coordinating applications for metal mine development. The *Procedures for Obtaining Approval of Metal Mine Development* (*see* Ministry's submission to Phase III, part 2.3) outlines the methods currently used for an over-all approval and assessment of proposed mineral developments. The steering committee is composed of the following members:

A. J. Richardson,
Ministry of Energy, Mines and Petroleum Resources,
Chairman

J. D. McDonald,
Ministry of Energy, Mines and Petroleum Resources,
Co-chairman

G. I. Henderson,
Ministry of Environment,
Environment and Land Use Committee Secretariat

B. McRae,
Ministry of Enonomic Development

G. C. Harkness,
Ministry of Municipal Affairs

A. N. Boydell,
Ministry of Environment

The Uranium Mining Steering Committee was formed to coordinate Federal and Provincial approvals for uranium mining. The steering committee agreed to use the stage approval process as outlined in the *Guidelines for Coal Development* and to coordinate this with the licensing process as required by the Atomic Energy Control Board under Licensing Guide 31. The four members of the steering committee are:

J. D. McDonald,
Ministry of Energy, Mines and Petroleum Resources,
Chairman

J. O'Riordan,
Ministry of Environment,
Environment and Land Use Committee Secretariat

A. B. Dory,
Atomic Energy Control Board

A. McIntyre,
Environment Canada

This committee was functional only for a short period and is presently inactive while the moratorium on uranium mining is in effect.

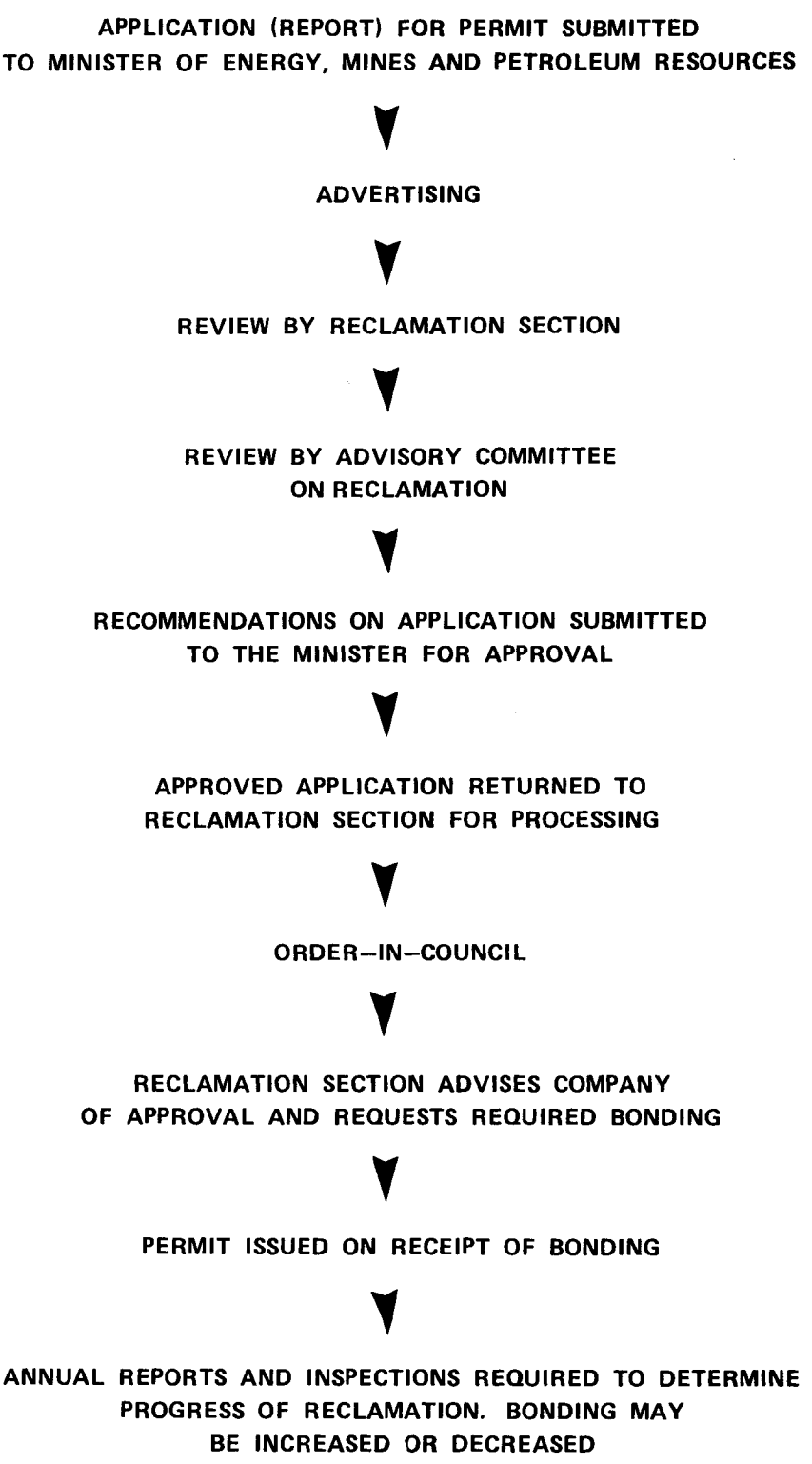


Figure 1. Procedure for obtaining a surface work permit.

III. RECLAMATION

3.1 Legislation

Reclamation of land disturbed by mining is administered by the Ministry of Energy, Mines and Petroleum Resources, Inspection and Engineering Division, Reclamation Section, under section 11 of the *Mines Regulation Act* (*see* Ministry's submission to Phase I). Legislation covers mineral exploration, placer mining, quarries, gravel pits, and metal mines.

As a basic statement of policy the Act begins [section 11(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 to the Minister . . .'

The Act requires that a surface work permit be obtained [section 11(5)]. The administrative procedure for obtaining a surface work permit is outlined on Figure 1 and requires the following.

Report: A report is to be submitted [sections 11(2) and 11(3)] to the Minister of Energy, Mines and Petroleum Resources prior to the commencement of operations containing:

(a) a map showing the location and extent of the mine, and the location of lakes, streams, and inhabited places in the vicinity;
(b) particulars of the nature of the mining operation including the anticipated area to be occupied during the lifetime of the mine;
(c) particulars on the nature and present uses of the land to be used;
(d) a program for land reclamation and conservation with particular reference to:
    (i) the location of the land;
    (ii) the effect of the program on livestock, wildlife, watercourses, farms, and inhabited places in the vicinity of the mine, and the appearance of the mine-site;
    (iii) the potential use of the land, having regard for its best and fullest use, and its importance for existing and future timber, grazing, water, recreation, wildlife, and mining.

Advertising: The company must advertise [section 11(4)] that it has filed an application for a surface work permit. This notice of filing must be advertised in the British Columbia Gazette and a local newspaper. The report, therefore, is a public document.

Review: The report is reviewed [sections 11(5) and 11(6)] by the Advisory Committee on Reclamation consisting of representatives from the Ministry of Energy, Mines and Petroleum Resources and other resource agencies, including the Ministry of Agriculture, Ministry of Forests, Ministry of Lands, Parks and Housing, and the Ministry of Environment.

Bonding: A bond is required [section 11(7)] not exceeding $1 000.00 per acre of disturbance. These funds are placed in trust and a receipt and agreement form is issued by the bank. Bonding is determined by:

(a) the amount of land disturbed;
(b) the degree of difficulty in reclamation;
(c) the type of land disturbed;
(d) environmental considerations;
(e) past performance of the company.

Present levels of bonding on metal mine properties vary from a minimum of $3 000.00 to a maximum of $400 000.00. A summary of security bonding is presented in Appendix 3.1.1.

Permit Issued: A surface work permit is issued with such special terms and conditions as the Minister sees fit to prescribe.

Performance: The surface must be continually and progressively reclaimed [section 11 (9)] or an additional sum of money deposited to provide the funds necessary to carry out the approved program.

3.2 Reclamation Standards

Because of the extreme variation in British Columbia mining areas, detailed, industry-wide reclamation standards have not been set. There are mines in level topography in the interior plateau and on the steep slopes of the Rocky Mountains. Mining occurs in the dry belt of the interior (40 millimetres of rainfall a year) and the rain forest of the coast (609 millimetres of rainfall a year). Mines operate from sea level up to elevations of 2 133 metres. For this reason the Ministry of Energy, Mines and Petroleum Resources has dealt with each minesite on a site-specific basis.

General guidelines have been prepared by the Ministry of Energy, Mines and Petroleum Resources. The guidelines were developed to inform mines, in existence prior to the enactment of reclamation legislation, of their responsibilities. These general guidelines provide for the following:

General:

(a) the mining company shall submit to the Chief Inspector a plan of total reclamation prior to shutdown;
(b) all buildings, machinery, and mobile equipment shall be removed. All scrap material shall be disposed of in a manner mutually acceptable to the Ministry of Energy, Mines and Petroleum Resources and the mine operator;
(c) concrete foundations and slabs may be left intact, and covered by overburden and revegetated where practical;
(d) all provisions of either the *Mines Regulation Act* or *Coal Mines Regulation Act* shall be complied with to the satisfaction of the District Inspector and Resident Engineer.

Tailings Ponds:

(a) a report shall be submitted to the Chief Inspector of Mines outlining the proposed post-operational state of the dam, related seepage control works, mine water deportment, and post-operational monitoring;
(b) where necessary a permanent spillway is required on or adjacent to the tailings dam. It must be capable of controlling runoff in the catchment area for the 200-year flood level;
(c) where practical the tailings pond shall be revegetated to a condition approved by the Reclamation Section of the Ministry of Energy, Mines and Petroleum Resources. If vegetation is to be established, it shall be done to a point where no maintenance of the vegetation is required. A minimum of three years' experience is necessary to determine the quality of vegetation;
(d) land use of the disturbed areas following mine abandonment shall be mutually agreed upon by the Ministry and the mine operator. They shall take into consideration the use of the land prior to mining, and the capability of the disturbed soil and/or mine waste in sustaining the pre-mining land use.

Waste Dumps – Metal:

(a) where possible, waste dumps should be sloped to an angle where vegetation can be maintained. If overburden is available, flat areas of the dumps shall be covered to a depth of 3 to 6 inches with overburden or top soil;
(b) all flat areas on the dumps shall be revegetated, and vegetation shall be established to a point where no maintenance is required. A minimum of three years' experience is necessary to determine the quality of vegetation;
(c) a plan of the drainage area surrounding the dumps shall be submitted to the Chief Inspector. Where possible all drainage should be directed away from the dumps;
(d) ultimate land use of the disturbed dump area shall be specified.

Pit Area:

(a) pits shall be backfilled whenever possible;
(b) a plan shall be submitted to the Chief Inspector showing how the pit area shall be left after completion of mining;
(c) where the pit area is going to be designated as a lake, a report shall be submitted to the Chief Inspector outlining source of water, drainage area, maximum level of water, water quality, access to lake, and plans for stocking of the lake;
(d) where the pit floor will be free from water, overburden shall be used wherever possible to provide sufficient cover to establish vegetation;
(e) pit walls shall be left in a safe manner to the satisfaction of the District Inspector of Mines.

3.3 Administration

Section 11 of the *Mines Regulation Act* is administered by the Ministry of Energy, Mines and Petroleum Resources, Inspection Division, Reclamation Section. The over-all structure of the

Inspection Division, its staff, and their qualifications has been presented in Phase II of the Ministry's submission. The Reclamation Section is staffed by three reclamation inspectors and three inspector-technicians as follows:

Inspectors	Title	Location	Duties
J. D. McDonald	Senior Reclamation Inspector	Victoria	Head, Reclamation Section.
D. M. Galbraith	Reclamation Inspector	Victoria	Civil Engineer, Province-wide inspection.
J. C. Errington	Reclamation Inspector	Victoria	Vegetation specialist, Province-wide inspection.

Inspector-Technicians	Title	Location	Duties
A. O'Bryan	Regional Inspector-Technician	Nelson	Inspections of coal and mineral properties in Nelson, Fernie, Okanagan, and Kamloops areas.
B. Gordon	Regional Inspector-Technician	Prince George	Inspection of placer mines, Province-wide
E. J. Hall	Regional Inspector-Technician	Fort St. John	Inspection of coal exploration, Peace River

The Senior Reclamation Inspector reports to the Deputy Chief Inspector, Coal and Special Services. Students have been employed in the summers of 1977, 1978, and 1979 to aid in field programs.

3.4 Inspection and Monitoring

Enforcement of the terms and conditions of a surface work permit is exercised through a reclamation report, submitted annually by each company, and through inspections of properties by Ministry staff.

Annual Reclamation Report: The annual report of reclamation provides a summary of work done in the past year and a projection of surface development over the next five years. It also outlines the past year's reclamation program providing detailed information on site preparation, seeding, planting, tending, native seed collection, and propagation. A summary of areas reclaimed and reclamation research undertaken is also required.

All surface work and reclamation is required to be documented on an air photo base. Appendix 3.4.1 contains the suggested sample format for the annual reclamation report.

Field Inspections and Monitoring: Inspections are made to ensure that all the conditions of the permit have been met and to assess the results of the reclamation program. A system has been developed to evaluate the status of revegetated areas. The system involves:

(a) permanent sample plots established over a revegetated area;
(b) recording of site conditions;
(c) recording of each species present including an estimate of cover (per cent), seed heads (per cent), height (centimetres), and vigour;
(d) information is recorded directly on computer coding sheets (Appendix 3.4.2) and a summary output is made for each site (Appendix 3.4.3).

The establishment of permanent plots allows for the re-evaluation of sites, to determine the rate of change in the composition and performance of vegetation, and ultimately will form the basis for an approval of reclaimed areas and the release of bonding. At present, it is anticipated that following the last reclamation treatment a minimum of three years will be necessary to allow a decision to be made.

The possibility that toxic substances will accumulate in vegetation is of concern at several mines. The Ministry of Energy, Mines and Petroleum Resources has asked several companies to assess the heavy metal content of vegetation growing on waste rock and tailings. The possible uptake of mercury at Cominco Ltd.'s Pinchi Lake operation has been well monitored by Cominco's environmental staff and a report on their findings is deposited in the commission's library (document accession number 1815A). The Ministry of Energy, Mines and Petroleum Resources commissioned the Department of Soil Science, University of British Columbia, to study the composition of tailings materials throughout British Columbia, including the accumulation of toxic materials in vegetation. Their results have been recorded in three reports (*see* part 3.5, Research).

In summary, these studies have shown that:

(a) tailings are heterogeneous both vertically and horizontally in their physical and chemical properties;
(b) tailings tend to have low-moisture storage capacities and are prone to wind and water erosion;
(c) pH is generally not a problem with the notable exception of the Sullivan mine;
(d) an evaluation of the trace element content of spoil material and support vegetation did not show any universal problem with toxicities;
(e) there is some indication that because of low copper-molybdenum ratios, vegetation established on some of the tailings materials may be detrimental to ruminants. However, this problem may be solved by keeping nitrogen fertilizer rates at a moderate level. This decreases the concentration of molybdenum in plant tissue and results in raising the copper-molybdenum ratio;

(f) in general, concentrations of nitrogen and phosphorus are too low to support plant growth on tailings materials.

3.5 Research and Information Exchange

Reclamation is a relatively new science and the technology has changed rapidly during the 10 years since mine reclamation legislation was first enacted in British Columbia.

To keep abreast of changes, the Reclamation Section has been active in promoting information exchange through formation of the Technical and Research Committee on Reclamation (Appendix 3.5.1). This committee, made up of members from government, industry, and universities, is sponsored by the Ministry of Energy, Mines and Petroleum Resources and the Mining Association of British Columbia. The objectives of the committee are:

(a) to influence and coordinate mine reclamation research in British Columbia;
(b) to further communication and development of knowledge among those concerned with mine reclamation;
(c) to appoint an awards subcommittee to select a recipient of the annual British Columbia mine Reclamation Award.

Research: Several companies have set up their own research programs in an attempt to define and overcome problems associated with their local site conditions. Both Cominco Ltd. and Kaiser Resources Ltd. have done excellent research work.

The Technical and Research Committee on Reclamation has been active in initiating, supporting, and conducting reclamation research. Studies that have been undertaken include:

Tailings Research Studies

(i) Tailings Research, Selected Mines, British Columbia. Department of Soil Science, University of British Columbia, 1976–77 (document accession number 1503A).
(ii) Reclamation of Abandoned Mine Spoils in British Columbia, 1977–78. Department of Soil Science, University of British Columbia and Ministry of Energy, Mines and Petroleum Resources, Inspection and Engineering Division, Paper 1978–7 (document accession number 1504A).
(iii) Schrierer, H. and Lavkulich, L. M., 1979, A Statistical Analysis of the Chemical Composition of British Columbia Mine Tailings. In Press (document accession number 1502A).

Coal Reclamation Research

(i) Hubbard, W. F., and Bell, M.A.M., 1977. Reclamation of Lands Disturbed by Mining in Mountainous and Northern Areas: A Synoptic Bibliography and Review Relevant to British Columbia and Adjacent areas. Prepared for British Columbia Ministry of Energy, Mines and Petroleum Resources, Inspection and Engineering Division (document accession number 1505A).

(ii) Revegetation of Disturbances in the Northeast Coal Block, Current Activities and State-of-the-art, 1977. Ministry of Energy, Mines and Petroleum Resources, Inspection and Engineering Division, Paper 1978–6 (document accession number 1506A).

(iii) Errington, J. C., 1978. Revegetation Studies in the Peace River Coal Block, 1978 (document accession number 1816A).

Currently the committee's priorities lie in the development of a reclamation techniques manual for use in the metal mining industry. The concept and budget requirements for the preparation of this manual are being draughted and funding is being sought.

Mine Reclamation Symposium: Mine reclamation symposia have been held annually since 1977. These symposia have been attended by a wide cross-section of participants from government, industry, university, and consultants. Sessions have been held on:

(a) environmental protection and reclamation of exploration disturbances;
(b) reclamation research;
(c) activities and policy of the Ministry of Energy, Mines and Petroleum Resources;
(d) reclamation planning as a part of mine planning;
(e) site preparation;
(f) resource problems and their solutions;
(g) reclamation of metal mine wastes.

Papers presented at these symposia are listed in Appendices 3.5.2 to 3.5.4.

The proceedings of these symposia have all been published, have had wide circulation in British Columbia, and are the major vehicles of information exchange. The proceedings of these symposia have been deposited in the commission's library (document accession numbers 1507A, 1508A, and 1509A).

In addition to presentations by speakers, each symposium has had one or more 'workshop' sessions where participants of varied backgrounds are assembled in small round-table discussion groups. This format has allowed participants a forum to exchange opinions on a variety of topics related to reclamation.

Participation in Conferences: Members of the Reclamation Section have participated in a variety of conferences to familiarize themselves with reclamation work performed outside British Columbia. An outline of conferences that have been attended by Ministry staff has been presented in Phase III, part 4.2 of the Ministry's submission.

3.6 Mine Reclamation Award

A mine Reclamation Award was established to recognize outstanding achievement in mine reclamation in British Columbia. Two citations are also presented. The terms of reference for these awards are outlined in Appendix 3.6.1. The winners of these awards, presented under the auspices of the British Columbia Ministry of Energy, Mines and Petroleum Resources and the Mining Association of British Columbia, are selected by an awards subcommittee from the

Technical and Research Committee on Reclamation and presentations have been made at the annual reclamation symposia (Appendices 3.6.2 to 3.6.4).

The Reclamation Award was presented to the following companies:

1976 Kaiser Resources Ltd.
1977 Cominco Ltd.
1978 Kaiser Resources Ltd.

Citations have been awarded to the following:

1976 Placid Oil Company, Bull River mine
1977 Elco Mining Limited
Kaiser Resources Ltd.
1978 Craigmont Mines Limited
Fording Coal Limited

3.7 Reclamation Programs Undertaken on British Columbia Metal Mines

Several examples are presented below to illustrate some of the current reclamation work being undertaken in British Columbia. The variety of examples given will show the techniques used throughout the Province.

Bull River Mine, Placid Oil Company: The Bull River mine is situated 23.3 kilometres due west of Fernie, British Columbia, north of Bull River.

It produced copper, silver, and gold by open-pit methods from 1970 to 1974. Waste types included tailings, rock, and glacial till overburden. The minesite, located on a southwest aspect, was environmentally sensitive because of wintering bighorn sheep, mule deer, and elk.

During mining, the company was able to minimize disturbance by leaving 'islands' of natural vegetation within the mining area and by progressively reclaiming disturbances. On completion of mining operations, the company resloped all their dumps, backfilled one small pit, and allowed a lake to form in the other pit. The entire minesite, a total of 40 hectares, was seeded and fertilized.

Bluebell Mine, Cominco Ltd.: The Bluebell mine is located within the Village of Riondel on the east shore of Kootenay Lake, about 50 kilometres east of Nelson, British Columbia. Lead and zinc were mined intermittently from the turn of the century until 1971, largely by underground methods.

Total disturbance was only 5 hectares consisting of the industrial site, a small waste rock dump, tailings disposal area, open pit, and mill site.

From 1972 to 1976 equipment was removed from the property and buildings were levelled to concrete foundations. Mine portals were sealed and the open pit and industrial site were fenced.

The site was revegetated during 1977 and 1978 and maintenance fertilizer was applied during 1979. Details of the methods used at Bluebell are presented in Appendix 3.7.1.

The Ministry of Energy, Mines and Petroleum Resources is now satisfied with the level of reclamation performed at Bluebell and procedures are underway for return of the bonding.

Pinchi Lake Mine, Cominco Ltd.: The Pinchi Lake mine is located on the north shore of Pinchi Lake, about 50 kilometres northwest of Fort St. James and 160 kilometres northwest of Prince George. The mine was first operated by Cominco between 1940 and 1944, and produced 53,000 flasks of mercury from 700,000 tons of ore (1 flask = 76 pounds). The mine was rebuilt in 1968 and produced close to 2.5 million tons of ore and 176,000 mercury flasks before shutdown in 1975. Cinnabar ore was mind by open-pit and underground methods from the Pinchi limestone outcrop and treated in a concentrator and roaster.

The total land disturbance at the Pinchi operation is 81 hectares, consisting of about 14 hectares of open pits and waste rock dumps, a 24-hectare tailings disposal area, and 43 hectares of other disturbances such as roads, the industrial site, lagoons, portals, etc. Twenty-five per cent of the disturbance consists of tailings, 25 per cent of waste rock, and about 50 per cent of glacial till materials.

Reclamation at Pinchi has been on-going for a number of years and details of this program are presented in Appendix 3.7.1. In 1971, roadcuts, a borrow pit, and portal entrances totalling 6 hectares were hydroseeded.

In 1973, the 2-hectare West Zone pit waste dump was revegetated using a pull-type fertilizer applicator and pickup truck. Maintenance fertilizer applications were surface broadcast using hand-operated cyclone seeders in May 1974 and 1975.

In May 1978, 31 hectares consisting of the tailings disposal area, open pits, waste rock dumps, and areas not likely to be disturbed during removal of surface structures were seeded and fertilized using a helicopter.

During mine shutdown hazardous chemicals were removed from the property, mine portals were blocked, the West Zone pit was fenced, the tailings dyke was raised, and a spillway was constructed to control drainage overflow from the tailings pond. A watchman-caretaker currently resides at the site.

Mercury content in vegetation has been monitored for several years. The mercury content of grasses and legumes grown on waste rock and tailings was slightly elevated compared to values reported for the same species grown on normal soils. The values were lower, however, than for vegetation growing in the vicinity of mercury mineralization in British Columbia.

The final reclamation of disturbances at Pinchi Lake is awaiting a decision from Cominco regarding the mine's future.

Princeton Tailings Pond: The reclamation program at Princeton is presented to the commission to exhibit one method that has been used in solving waste disposal problems involving both sewage effluent and mine tailings.

During 1978, the Ministry of Energy, Mines and Petroleum Resources obtained funding under the Accelerated Mineral Development Program to revegetate mining areas that were not covered by present reclamation legislation. Under this program, several areas were treated, including the old Granby tailings at Princeton, British Columbia.

The Princeton tailings project has involved irrigating a 16-hectare area of tailings materials with sewage effluent. This project simultaneously provides for:

(a) dust abatement from the tailings ponds;
(b) sewage disposal from the Princeton sewage ponds;
(c) growth of an agricultural crop.

The operation of the irrigation system has been contracted out to a local rancher who will pay the Village of Princeton a fixed cost per standing ton of alfalfa. Details of the project are presented in Appendix 3.7.2.

Craigmont Mine, Craigmont Mines Limited: Craigmont mine is located 12.8 kilometres northwest of Merritt, British Columbia, at an elevation of 1 140 to 1 260 metres. The mine is on an arid, south-facing slope. Craigmont has disturbed a total of 423 hectares, most of it during open-pit operations between 1961 and 1967, before the enactment of mine reclamation legislation. Because the open pit and waste dumps were disturbed before legislation, the Ministry of Energy, Mines and Petroleum Resources has no power to require revegetation of these areas.

Nevertheless, Craigmont has commenced a program to revegetate all waste dump surfaces and the tailings pond as part of their final shutdown plans. This program is outlined in Appendix 3.7.3.

APPENDICES

APPENDIX 3.1.1 TOTAL SECURITY BONDING HELD
as of July 12, 1979

	$
All producing coal and metal mines	3 623 000.00
Coal exploration	481 500.00
Quarries	84 200.00
Mineral exploration	205 500.00
Placer mining	39 550.00
SUB TOTAL	4 433 750.00
Sand and gravel permits	292 410.00
TOTAL	4 726 160.00

APPENDIX 3.4.1

FORMAT FOR ANNUAL RECLAMATION REPORT

Cover Page

Company name
Application for a reclamation permit and
Proposed Programme for Year _____.
Operation and Surface Work Permit No. _____.
Date

Table of Contents

1.0 Introduction
Objectives, future land use and short history of the Reclamation Program

2.0 Mining Programme

2.1 Surface development to date
2.2 Surface development in current year
2.3 Surface development projected over next five years

- areas should be shown on an airphoto overlay 1:10,000 and summarized in the attached table
- areas should be discussed with respect to:
  a. materials and depths to be deposited on the surface as a plant growth medium (discuss what has been done to identify the types of materials available, their physical and chemical characteristics and how these affect mine reclamation programs)
  b. plant species to be established
  c. the long-term land use objectives

3.0 Reclamation Programme

3.1 Reclamation facilities and staff
3.2 Past year's program
3.2.1 Site preparation
Ripping, resloping, terracing, harrowing, stock-piling and application of surface materials, mulches, binders
3.2.2 Seeding
Species, mixtures, fertilizer, rates, methods
3.2.3 Planting
Species, sources, age of seedlings

3.2.4 Tending
Irrigation and fertilizer

3.2.5 Seed collection of trees, shrubs & grasses
Table showing species, area collected from, and amount

3.2.6 Propagation, nursery, tending
Discuss nursery, species propagated and program

3.2.7 Summary of areas reclaimed:
Indicate on an airphoto and tabulate on the attached sheet the following:
area recontoured, area seeded/planted, area fertilized, area where vegetation has been established for one or more years

3.2.8 Reclamation Research
Report on any research programs carried out during the past year. Companies who have carried out detailed research programs may wish to submit a separate research report.

3.2 Reclamation programme for the following year
Indicate the nature of proposed reclamation program for the following year.

SUMMARY OF AREAS DISTURBED AND RECLAIMED TO DECEMBER 31, 1979

DISTURBANCE	MINING		RECLAMATION						
	AREA DISTURBED (ha)		AREA RECONTOURED (ha)		AREA SEEDED/PLANTED (ha)		AREA FERTILIZED (ha)		(ha) Area where vegetation has been established for one or more years.
	1979	TOTAL*	1979	TOTAL	1979	TOTAL	1979	TOTAL	TOTAL
ROADS									
ADMINISTRATION									
PLANT SITE									
PIT AREA									
WASTE DUMPS									
TAILINGS PONDS									
STOCKPILES									
OTHER									
TOTAL									

* Total up to December 31, 1979

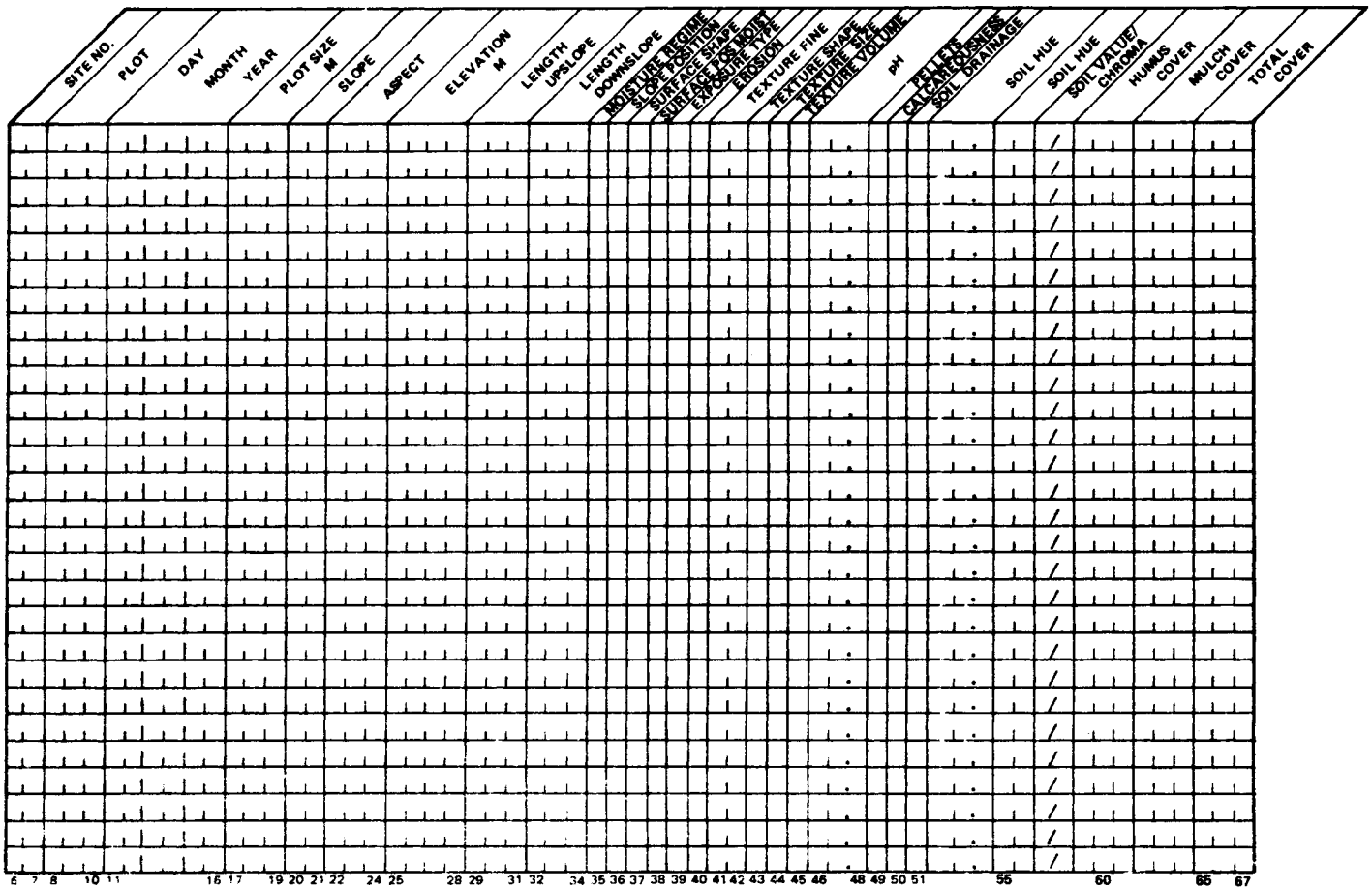
APPENDIX 3.4.2

CODING SHEETS USED IN ASSESSMENT OF REVEGETATED AREAS BY RECLAMATION INSPECTION PERSONNEL

A	MINE	CODE
1	2 4	5

CODES:
N = NEW DATA
C = CHANGE
D = DELETE DATA

MINES RECLAMATION

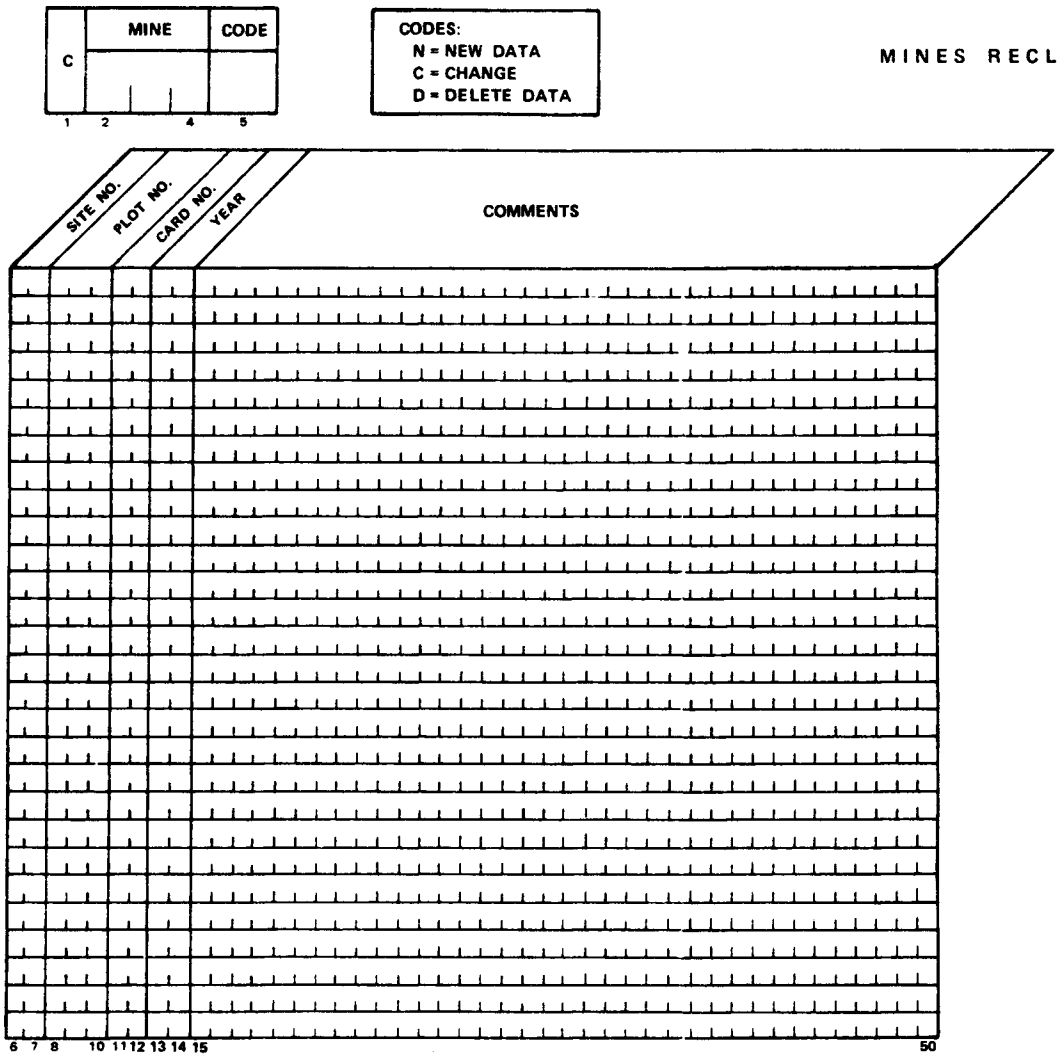


B	MINE	CODE
1	2 4	5

CODES:
N = NEW DATA
C = CHANGE
D = DELETE DATA

MINES RECLAMATION

SITE NO.	PLOT NO.	SPECIES	SPECIES NAME	COVER %	SEED HEADS %	HEIGHT CM	VIGOUR	SPECIES	SPECIES NAME	COVER %	SEED HEADS %	HEIGHT CM	VIGOUR	SPECIES	SPECIES NAME	COVER %	SEED HEADS %	HEIGHT CM	VIGOUR	SPECIES	SPECIES NAME	COVER %	SEED HEADS %	HEIGHT CM	VIGOUR	SPECIES	SPECIES NAME	COVER %	SEED HEADS %	HEIGHT CM	VIGOUR
6 7	8 10	11	14	15	16	17	19	20	22	23	24	25	28	29	30	31	33	34	36	37	38	39	42	43	44	45	47	50	51	52	53	56	57	58	59	61	62	64	66	67	70	71	72	73	75	76	78	79	80


C
MINE
CODE
1 2 4 5
CODES:
N = NEW DATA
C = CHANGE
D = DELETE DATA
SITE NO.
PLOT NO.
CARD NO.
YEAR
COMMENTS
6 7 8 10 11 12 13 14 15
50

APPENDIX 3.4.3

EXAMPLE OF COMPUTER OUTPUT FOR ASSESSMENT OF REVEGETATED AREAS NEWMONT MINES LTD., WASTE DUMP 3 'AIRSTRIP'

MINES RECLAMATION - INSPECTION STATISTICS WASTE DUMP 3 "AIRSTRIP" DATE OF RUN 02 FEB 1979

MINE NEWMONT MINES LTD. SITE 07

PLOT	001	002	003	004	005	006	007	008	009	010
DATE DAY/	27/	27/	27/	27/	27/	27/	27/	27/	27/	27/
MO/	07/	07/	07/	07/	07/	07/	07/	07/	07/	07/
YR	78	78	78	78	78	78	78	78	78	78
PLOT SIZE	016	016	016	016	016	016	016	016	016	016
SLOPE	37	00	01	00	02	05	00	03	00	00
ASPECT	340	000	170	000	210	110	000	060	000	000
ELEVATION	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
LENGTH UPSLOPE	025	000	000	000	000	000	000	000	000	000
LENGTH DOWNSLOPE	025	000	000	000	000	000	000	000	000	000
MOISTURE REGIME	5	6	6	6	6	6	6	6	6	6
SLOPE POSITION	3	3	3	3	3	3	3	3	3	3
SURFACE SHAPE	4	7	7	7	7	7	8	7	7	7
SLOPE POS MOIST	1	2	2	2	2	2	2	2	2	2
EXPOSURE TYPE	4	4	4	4	4	4	4	4	4	4
EROSION	0	0	0	0	0	0	0	0	0	0
TEXTURE FINE	04	04	04	04	04	04	04	04	04	04
TEXTURE SHAPE	2	2	2	2	2	2	2	2	2	2
TEXTURE SIZE	1	1	1	1	1	1	1	1	1	1
TEXTURE VOLUME	2	2	2	2	2	2	2	2	2	2
PH	08.0	08.0	08.0	08.0	08.0	08.0	08.0	08.0	08.0	08.0
PELLETS	0	0	0	0	0	0	0	0	0	0
CALCAREOUSNESS	0	0	0	0	0	0	0	0	0	0
SOIL DRAINAGE	2	2	2	2	2	2	2	2	2	2
SOIL HUE	10.0	02.5	02.5	02.5	10.0	10.0	10.0	10.0	02.5	02.5
SOIL HUE	YR	Y	Y	Y	YR	YR	YR	YR	Y	Y
SOIL VALUE/CHROMA	5/2	4/2	4/2	5/2	5/3	4/4	4/4	4/4	6/2	6/2
HUMUS COVER	002	001	002	001	001	001	001	001	000	001
MULCH COVER	000	000	000	000	000	000	000	000	000	000
TOTAL COVER	020	030	045	015	030	025	030	025	002	045

MINES RECLAMATION - INSPECTION STATISTICS WASTE DUMP 3 "AIRSTRIP" DATE OF RUN 02 FEB 1979

MINE NEWMONT MINES LTD. SITE 07

NUMBER OF PLOTS	010
MINIMUM TOTAL COVER %	002
MAXIMUM TOTAL COVER %	045
AVERAGE TOTAL COVER %	026
STANDARD DEVIATION	12.9

MINES RECLAMATION – INSPECTION STATISTICS — WASTE DUMP 3 "AIRSTRIP" — DATE OF RUN 02 FEB 1979

MINE NEWMONT MINES LTD. — SITE 07

PLOT	001	002	003	004	005	006	007	008	009	010	MIN	MAX	AVG	ST DEV
RED FESCUE														
COVER %	07	04	10	01	10	10	05	05	00	15	000	015	6.7	4.6
SEED HEADS %	070	050	050	050	050	060	070	050	080	050	030	080	58.0	11.3
HEIGHT CM	090	060	030	070	060	070	050	060	050	050	030	090	59.0	15.9
VIGOUR	18	16	16	01	16	16	01	16	16	01				
CANADA BLUEGRASS														
COVER %	03		05	02	05	06	05	01	01	20	000	020	4.8	5.7
SEED HEADS %	080		080	070	050	080	090	080	090	090	000	090	71.0	27.6
HEIGHT CM	050		050	035	050	050	040	040	040	040	000	050	39.5	14.9
VIGOUR	01		01	01	01	01	01	01	01	01				
PERENNIAL RYEGRASS														
COVER %			02	01	01	05	15	10		05	000	015	3.9	5.0
SEED HEADS %			050	050	050	080	090	090		070	000	090	48.0	36.4
HEIGHT CM			050	050	070	030	070	070		070	000	070	41.0	31.0
VIGOUR			01	01	01	01	01	01		01				
PUBESCENT WHEATGRASS														
COVER %	05	02	10	01	05	03				05	000	010	3.1	3.2
SEED HEADS %	070	090	080	070	080	090				090	000	090	57.0	40.0
HEIGHT CM	080	090	080	080	080	100				070	000	100	58.0	40.7
VIGOUR	01	01	01	01	01	01				01				
ALFALFA														
COVER %	01	10	03	02	05	08			00	01	000	010	3.0	3.5
SEED HEADS %	070	090	080	090	080	090			090	050	000	090	64.0	35.9
HEIGHT CM	060	070	070	080	090	070			040	060	000	090	54.0	31.3
VIGOUR	01	01	01	01	01	01			01	01				
CRESTED WHEATGRASS														
COVER %	04	03	10	02	04	02	02	02	00		000	010	2.9	2.8
SEED HEADS %	080	090	080	070	080	080	080	090	050		000	090	74.0	26.7
HEIGHT CM	090	070	050	081	070	060	070	090	080		000	090	66.1	26.3
VIGOUR	01	01	01	00	01	16	01	01	00					
COMMON SAINFOIN														
COVER %	01	10	04	01	05	03				01	000	010	2.5	3.1
SEED HEADS %	060	090	090	090	080	090				070	000	090	59.0	41.2
HEIGHT CM	070	080	080	070	090	070				080	000	090	54.0	37.7
VIGOUR	01	17	01	01	01	01				01				

MINES RECLAMATION - INSPECTION STATISTICS WASTE DUMP 3 "AIRSTRIP" DATE OF RUN 02 FEB 1979

MINE NEWMONT MINES LTD. SITE 07

PLOT	001	002	003	004	005	006	007	008	009	010	MIN	MAX	AVG	ST DEV
SMOOTH BROME														
COVER %	03	01	03		01	01	02	01		01	000	003	1.3	1.0
SEED HEADS %	070	070	070		080	080	050	090		070	000	090	58.0	32.2
HEIGHT CM	070	070	080		080	080	040	080		070	000	080	57.0	32.3
VIGOUR	01	18	18		18	18	01	18		18				
CHENOPODIUM ALBUM														
COVER %			05	01	02	01		00			000	005	0.9	1.5
SEED HEADS %			090	090	080	080		050			000	090	39.0	42.5
HEIGHT CM			070	070	060	050		050			000	070	30.0	32.3
VIGOUR			01	01	01	01		01						
DESCURAINIA SOPHIA														
COVER %			02				03	03	01		000	003	0.9	1.2
SEED HEADS %			090				090	090	090		000	090	36.0	40.4
HEIGHT CM			070				080	070	090		000	090	31.0	40.4
VIGOUR			01				01	01	01					
POLYGONUM AVICULARE														
COVER %		01	05	02							000	005	0.8	1.6
SEED HEADS %		100	090	090							000	100	28.0	45.1
HEIGHT CM		005	005	003							000	005	1.3	2.1
VIGOUR		01	01	01										
ERUCASTRUM GALLICUM														
COVER %				01				03			000	003	0.4	0.9
SEED HEADS %				080				050			000	080	13.0	28.3
HEIGHT CM				080				060			000	080	14.0	29.8
VIGOUR				01				01						
TALL WHEATGRASS														
COVER %	01			00	02			00			000	002	0.3	0.6
SEED HEADS %	070			080	080			090			000	090	32.0	41.5
HEIGHT CM	090			070	080			070			000	090	31.0	40.4
VIGOUR	01			01	01			01						
REDTOP														
COVER %	01					02					000	002	0.3	0.6
SEED HEADS %	050					050					000	050	10.0	21.0
HEIGHT CM	050					050					000	050	10.0	21.0
VIGOUR	01					01								

MINES RECLAMATION - INSPECTION STATISTICS — WASTE DUMP 3 "AIRSTRIP" — DATE OF RUN 12 FEB 1979

MINE NEWMONT MINES LTD. — SITE 07

PLOT	001	002	003	004	005	006	007	008	009	010	MIN	MAX	AVG	ST DEV
BRASSICA RAPA														
COVER %							01	02			000	002	0.3	0.6
SEED HEADS %							090	090			000	090	18.0	37.9
HEIGHT CM							050	070			000	070	12.0	25.7
VIGOUR							01	01						
CICER MILKVETCH														
COVER %				01		01			00		000	001	0.2	0.4
SEED HEADS %				080		090			090		000	090	20.0	41.9
HEIGHT CM				005		005			003		000	005	1.3	2.1
VIGOUR				01		01			01					
BROMUS JAPONICUS														
COVER %				00			02				000	002	0.2	0.6
SEED HEADS %				070			090				000	090	16.0	34.0
HEIGHT CM				050			060				000	060	11.0	23.3
VIGOUR				16			01							
CIRSIUM UNDULATUM														
COVER %					01		01				000	001	0.2	0.4
SEED HEADS %					080		090				000	090	17.0	35.9
HEIGHT CM					080		050				000	080	13.0	28.3
VIGOUR					01		01							
TARAXACUM OFFICINALE														
COVER %							01	01			000	001	0.2	0.4
SEED HEADS %							000	000			000	000	0.0	0.0
HEIGHT CM							015	015			000	015	3.0	6.3
VIGOUR							01	01						
ACHILLEA MILLEFOLIUM														
COVER %						02					000	002	0.2	0.6
SEED HEADS %						090					000	090	9.0	28.4
HEIGHT CM						080					000	080	8.0	25.2
VIGOUR						01								
CORONILLA VARIA														
COVER %						02					000	002	0.2	0.6
SEED HEADS %						090					000	090	9.0	28.4
HEIGHT CM						030					000	030	3.0	9.4
VIGOUR						01								

MINES RECLAMATION - INSPECTION STATISTICS WASTE DUMP 3 "AIRSTRIP" DATE OF RUN 02 FEB 1979

MINE NEWMONT MINES LTD. SITE 07

PLOT	001	002	003	004	005	006	007	008	009	010	MIN	MAX	AVG	SD DEV
VERBASCUM THAPSUS														
COVER %								02			000	002	0.2	0.6
SEED HEADS %								100			000	100	10.0	31.6
HEIGHT CM								150			000	150	15.0	47.4
VIGOUR								01						
COMMON TIMOTHY														
COVER %	01										000	001	0.1	0.3
SEED HEADS %	050										000	050	5.0	15.8
HEIGHT CM	080										000	080	8.0	25.2
VIGOUR	01													
INTERMEDIATE WHEATGRASS														
COVER %	01										000	001	0.1	0.3
SEED HEADS %	090										000	090	9.0	28.4
HEIGHT CM	090										000	090	9.0	28.4
VIGOUR	01													
SENECIO														
COVER %	01										000	001	0.1	0.3
SEED HEADS %	050										000	050	5.0	15.8
HEIGHT CM	020										000	020	2.0	6.3
VIGOUR	01													
EPILOBIUM ANGUSTIFOLIUM														
COVER %						01					000	001	0.1	0.3
SEED HEADS %						090					000	090	9.0	28.4
HEIGHT CM						060					000	060	6.0	18.9
VIGOUR						01								
TRAGOPOGON DUBIUS														
COVER %							01				000	001	0.1	0.3
SEED HEADS %							090				000	090	9.0	28.4
HEIGHT CM							020				000	020	2.0	6.3
VIGOUR							01							
VICIA AMERICANA														
COVER %							01				000	001	0.1	0.3
SEED HEADS %							090				000	090	9.0	28.4
HEIGHT CM							020				000	020	2.0	6.3
VIGOUR							01							

MINES RECLAMATION - INSPECTION STATISTICS — WASTE DUMP 3 "AIRSTRIP" — DATE OF RUN 02 FEB 1979

MINE NEWMONT MINES LTD. — SITE 07

PLOT	001	002	003	004	005	006	007	008	009	010	MIN	MAX	AVG	ST DEV
VICIA SATIVA														
COVER %							01				000	001	0.1	0.3
SEED HEADS %							090				000	090	9.0	28.4
HEIGHT CM							080				000	080	8.0	25.2
VIGOUR							01							
CIRSIUM VULGARE														
COVER %								01			000	001	0.1	0.3
SEED HEADS %								100			000	100	10.0	31.6
HEIGHT CM								030			000	030	3.0	9.4
VIGOUR								01						
WHITE CLOVER														
COVER %				00							000	000	0.0	0.0
SEED HEADS %				050							000	050	5.0	15.8
HEIGHT CM				010							000	010	1.0	3.1
VIGOUR				16										
ASTER FOLIACEUS														
COVER %						00					000	000	0.0	0.0
SEED HEADS %						090					000	090	9.0	28.4
HEIGHT CM						050					000	050	5.0	15.8
VIGOUR						01								
RED CLOVER														
COVER %						00					000	000	0.0	0.0
SEED HEADS %						090					000	090	9.0	28.4
HEIGHT CM						070					000	070	7.0	22.1
VIGOUR						01								
ARABIS HOLBOELLII														
COVER %									00		000	000	0.0	0.0
SEED HEADS %									090		000	090	9.0	28.4
HEIGHT CM									090		000	090	9.0	28.4
VIGOUR									16					

APPENDIX 3.5.1 MEMBERSHIP AND TERMS OF REFERENCE FOR THE TECHNICAL AND RESEARCH COMMITTEE ON RECLAMATION

Members:

A. Milligan, Kaiser Resources Ltd., Sparwood – Chairman

J. C. Errington, Ministry of Energy, Mines and Petroleum Resources, Victoria – Vice Chairman

N. Agnew, BP Explorations, Calgary

M. Bell, University of Victoria, Victoria

A. Bellamy, Bethlehem Copper, Highland Valley

R. Berdusco, Fording Coal, Elkford

B. van Drimmelen, Ministry of Environment, Fish and Wildlife Branch, Victoria

D. M. Galbraith, Ministry of Energy, Mines and Petroleum Resources, Victoria

R. Gardiner, Cominco Ltd., Trail

L. Lavkulich, University of British Columbia, Vancouver

J. D. McDonald, Ministry of Energy, Mines and Petroleum Resources, Victoria

A. O'Bryan, Ministry of Energy, Mines and Petroleum Resources, Nelson

C. Pelletier, Utah Mines, Port Hardy

Terms of Reference:

(a) Review progress to date of land reclamation in the mining industry of British Columbia;
(b) Establish problem areas in land reclamation and make recommendations for methods of solving these problems;
(c) Establish guidelines for land reclamation in the mining industry of British Columbia based on a realistic assessment of what is required and the capability to meet the requirements by the industry;
(d) Co-ordination of research efforts in reclamation and establish research programs in conjunction with governments, universities and other research agencies;
(e) Recommend research programs that should be developed in order of priority;
(f) Review the propagation and evaluation of native plant species and possibility of a central nursery for native plant species.

APPENDIX 3.5.2 1977 MINE RECLAMATION SYMPOSIUM
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APPENDIX 3.5.3 1978 MINE RECLAMATION SYMPOSIUM
TABLE OF CONTENTS

APPENDIX 3.5.4 1979 MINE RECLAMATION SYMPOSIUM
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APPENDIX 3.6.1 MINE RECLAMATION AWARDS

TERMS OF REFERENCE

Under the auspices of the British Columbia Ministry of Energy, Mines and Petroleum Resources and the Mining Association of British Columbia, a Reclamation Award has been established to recognize outstanding achievement in mine reclamation in British Columbia. In addition to this award, two citations are given to recognize merit in mining reclamation. The guidelines for these awards are as follows:

1. Nominations will be solicited from Ministry of Energy, Mines and Petroleum Resources' Inspectors. In addition, nominations may be made by companies with respect to their own work, or work done by individuals or organizations familiar with the goals of reclamation.

   Nominations should be submitted in writing to:

   Chairman, Awards Subcommittee
   c/o Technical and Research Committee
   Ministry of Energy, Mines and Petroleum Resources
   Minerals Resources Branch
   525 Superior Street
   Victoria, B.C.
   V8V 1T7

   In the nomination, documentation of the reclamation achievement must be outlined and reasons proposed why the project or program merits recognition.

2. The reclamation project may be major or minor in extent and may be the result of one person's activities.

3. The Technical and Research Committee will decide the winner of the Reclamation Award and the two Citations.

4. The Reclamation Award and Citations will be awarded each yeat at the annual Mine Reclamation Symposium.

5. The Reclamation Award cannot be won by a mining company two years in succession — Citations may be won in two successive years.

6. Deadline for receipt of nominations for the awards is January 31 of the year the award will be given.

APPENDIX 3.6.2

Report of the Awards Subcommittee
Technical and Research Committee
British Columbia Ministry of Energy, Mines and Petroleum Resources
and
The Mining Association of British Columbia

RECLAMATION AWARDS FOR 1976

MINE RECLAMATION AWARD

The first Annual Reclamation Award is presented to Kaiser Resources Ltd.

Kaiser's Reclamation Specialists have demonstrated that with effective application of current technology, alpine terrain disturbed by exploration and surface mining for coal can be stabilized and rehabilitated for wildlife habitat, an important resource in the Sparwood area. Government and industry continually use Kaiser's reclamation experience to educate both the mining industry and the public that surface mining for coal can proceed with minimal environmental impact. This is a critical issue for the Province of British Columbia at this point in time in light of proposed coal development in the north-east and south-east regions.

Kaiser also leads the mining industry in development of facilities and techniques for propagation of native woody plants for operational scale reclamation. Kaiser is contributing toward development of improved reclamation technology through financial contributions for graduate student research and a continuing in-house research program on topics of slope stability, plant species selection for high elevation reclamation, and plant nutrient cycling.

CITATION AWARD

In the opinion of the committee, it was felt that the Bull River Mine of Placid Oil Company should receive a citation for the reclamation work done.

The Bull River mine was a small open pit copper mine, located in the East Kootenay approximately 30 miles east of Cranbrook. On completion of mining operations the company has resloped all their dumps, back-filled one small pit and allowed a lake to form in the other pit. All areas have been seeded and fertilized. The company co-operated fully with the Ministry of Mines and worked with the Fish and Wildlife Branch in the matter of restoring wildlife habitat.

APPENDIX 3.6.3

Report of the Awards Subcommittee
Technical and Research Committee
British Columbia Ministry of Mines and Petroleum Resources
and
The Mining Association of British Columbia

RECLAMATION AWARDS FOR 1977

The Awards Subcommittee received a total of 12 nominations for the Reclamation Award and for Citations. These nominations came from the mining industry, Ministry of Mines and Petroleum Resources' Inspectors, related industrial representatives, university personnel, and the general public. The Awards Subcommittee evaluated the nominations and decided there would be two citations, one honourable mention and the award for 1977.

Reclamation award for 1977

The 1977 Reclamation Award is presented to the Reclamation Research Department of Cominco Limited at Trail, British Columbia. The Reclamation Research Department, formed in 1970, has made an outstanding contribution to mine reclamation research in British Columbia. This group has conducted research towards the development of reclamation techniques for Cominco and its subsidiary companies. Cominco has been prominent in information exchange and has made its research information available to the British Columbia mining industry.

Their research program has been thorough and well documented and is a blend of field trials, laboratory experimentation and chemical analyses. Cominco's mines research has been conducted towards a detailed assessment of waste materials as a plant growth medium, identification of growth limiting factors, selection and testing of plant species, and an assessment of cultural techniques. Cominco Reclamation Specialists have identified and are monitoring accumulation of potentially toxic metals by vegetation and are studying methods of overcoming potential problems.

Cominco Ltd. should be recognized for their continuity of effort, overall approach, and results obtained.

Two Citations for 1977

1. Elco Mining Limited

Elco Mining reclamation specialists have done an effective and satisfactory job of reclaiming and rehabilitating disturbed terrain.

Trenching was carried out by back-hoe thereby reducing the amount of land area disturbed in contrast to trenching by bulldozer. All disturbances including drill sites, camp sites, and roads were constructed and revegetated in compliance with the guidelines and field inspection instructions of the Reclamation Branch of the Ministry of Mines and Petroleum Resources.

Procedures for soil stabilization and erosion control were excellent and revegetation of disturbed sites was carried out during the same season that disturbance took place. The company cooperated fully with the Ministry of Mines and Petroleum Resources and worked well with other ministries in restoring wildlife habitat.

2. Kaiser Resources Ltd.

Kaiser Resources Limited at Sparwood British Columbia, winner of last years' Reclamation Award, has continued to excell in reclamation procedures and practices and in the application of technology and research to coal mine reclamation. The leadership demonstrated by their reclamation specialists in adopting new reclamation techniques and the evaluation of vegetation species, including native species, deserves special mention. In addition, Kaiser Resources Ltd. have shared their successes and failures with everyone concerned with reclamation.

Honourable Mention

Honourable Mention goes to Canex Placer Ltd. Over the years Canex Placer has demonstrated their genuine concern for reclamation in the Salmo area of British Columbia.

APPENDIX 3.6.4

Report of the Awards Subcommittee
Technical and Research Committee
British Columbia Ministry of Energy, Mines and Petroleum Resources
and
The Mining Association of British Columbia

RECLAMATION AWARDS FOR 1978

This year the selection committee had a particularly difficult task in determining the recipients of the awards because of the number of excellent nominations. This is surely a sign that the industry is serious about its reclamation programs.

Before presenting the Citations and the Reclamation Award, honourable mention for achievements in reclamation was awarded to:

1. Bluebell Mine – for reclaiming the mine site and maintaining the Riondel community.
2. Pacific Petroleum – for an excellent reclamation program in the Northeast Coal Block.
3. Coleman Collieries – for reclamation of exploration disturbances in the Southeast Coal Block.

1978 RECLAMATION AWARD

This year the Reclamation Award was presented to Kaiser Resources Ltd., Sparwood, B.C.

Kaiser Resources has continued its overall commitment to reclamation. Not only have they reclaimed large areas, but they have also increased their nursery by twenty acres for their tree and shrub programs, continued their nutrient-cycling studies, established a soil analytical facility, and are conducting wildlife studies.

Kaiser continues to produce results and lead the industry in the development of facilities and techniques for the propagation of native woody plants for operational scale reclamation.

CITATIONS

The First Citation was presented to Craigmont Mines Ltd. at Merritt, B.C. Craigmont is currently phasing out their operations and the company has filed their final reclamation plan. The mine area will be restored to a state of use and appearance that will be compatible with the surrounding environment.

The Second Citation was presented to Fording Coal Limited at Elkford, B.C. The present management and staff are dedicated to reclamation excellence. They have applied today's technology for rehabilitation of disturbed areas for fish and wildlife habitat. They are conducting research on slope stability of spoil piles, and are experimenting with seed mixtures, fertilizers and use of glacial till and other materials for ultimate reclamation applications. Their new laboratory, and their new twenty-acre nursery and greenhouse should make Fording a leader in environmental protection and reclamation.

APPENDIX 3.7.1

OPERATIONAL RECLAMATION EXPERIENCE AT COMINCO'S BLUEBELL AND PINCHI LAKE MINES

Paper prepared jointly
by:

J.E. Stathers and
R.T. Gardiner

Cominco Ltd.

OPERATIONAL RECLAMATION EXPERIENCE AT COMINCO'S BLUEBELL AND PINCHI LAKE MINES

INTRODUCTION

Operational reclamation experience at Cominco's lead-zinc and Pinchi Lake mercury properties will be described. The history of mining, ecological setting, land use capability, and the nature and extent of land disturbance will be briefly summarized. The objectives, approach, and method of implementing the reclamation plan including short-term results and costs will be discussed in more detail.

BLUEBELL MINE

Location and History

Bluebell is located within the village of Riondel on the east shore of Kootenay Lake, about 50 kilometres east of Nelson. The property has had a colourful mining history. Over a century ago Indians were reported to have smelted crude musket bullets using ore from the Bluebell outcrop (1). At the turn of the century about 8300 tons of ore were mined and treated in the nearby Pilot Bay mill and smelter. Before 1927 when Cominco acquired the property, about 560,000 tons of ore were mined and shipped to the Trail Smelter by barge and railway (2). During 1952-71 Bluebell produced about 4.8 million tons of ore grading about 5 percent lead and 6 percent zinc (3). Ore was mined by underground methods from sulphide replacements in limestone located under Kootenay Lake.

Ecological Setting and Land Use Capability

Bluebell is situated on Galena Bay at 560 metres elevation. The moderating climatic influence of Kootenay Lake provides more than 150

frost-free days per year and about 2 centimetres of precipitation per month during the growing season. Total annual precipitation is 90 centimetres (4). The mine is located within the Interior Western Hemlock Zone on a southern exposure (5). The soils have developed on colluvium from the bedrock outcrop and shallow glacial till. Forests are dominated by Douglas fir, white pine, cedar, larch, birch, and cottonwood.

Riondel land has a best physical capability for outdoor recreation and agriculture according to the Canada Land Inventory (6). Deer winter on the south-facing slopes in the area.

Nature and Extent of Land Disturbance

Total land disturbance at Bluebell was 13 acres. About 11 acres were occupied by the industrial site and a small waste rock dump. The remainder consisted of a small tailings spill, an open pit, and a mill site remaining from earlier mining activity. Tailings containing limestone, quartzite, schist, and smaller amounts of sulphides were deposited in Galena Bay.

During 1972-76, equipment was removed from the property, and buildings were levelled to concrete foundations. Mine portals were sealed and the open pit and industrial site were fenced.

Reclamation Plan

Objectives. The objectives of revegetation were to stabilize disturbed land surfaces against erosion, discourage refuse disposal, enhance lakeshore recreation potential, and improve the appearance of the site.

Approach. Plant species and fertilizer programs were selected for the reclamation plan based on the results of a modest field study program carried out during 1976-77. Chemical and physical properties of waste rock and disturbed soils were characterized using conventional soil

tests. The main plant growth limiting factors were deficiency of organic matter, lack of the essential plant nutrients nitrogen and phosphorus, compaction, and moisture deficiency. Species selection trials showed that grasses such as Timothy, Canada Bluegrass, Orchardgrass, and Redtop established themselves satisfactorily with fall seeding. Spring seeding was necessary for the establishment of legumes such as Alfalfa, Birdsfoot Trefoil, and Alsike Clover. Short-term fertilizer experiments showed that incorporation of the equivalent of 56 kilograms per hectare N, 112 kilograms per hectare P_2O_5, and 56 kilograms per hectare K_2O before seeding, resulted in satisfactory establishment of a grass-legume mixture.

Implementation. Operational reclamation was initiated in November 1977 based on a reclamation plan submitted to the Ministry of Mines and Petroleum Resources.

Site preparation was carried out using a D8 Caterpillar with rippers and a 3 cubic yard Caterpillar 950 Payloader. Waste dumps were resloped to 10^{o} slope angle and graded to blend with the lakeshore terrain. Cemented tailings and, where possible, concrete foundations were buried with a 45 centimetre depth of overburden. Metal objects, timber, and garbage were either removed from the site, burned or buried. The Payloader removed larger rocks exposed in ripping dump surfaces and left a tidy surface appearance. Site preparation was carried out in 7 days (21 man-days).

After resloping, ammonium phosphate fertilizer was broadcast on waste surfaces at 407 kilogrammes per hectare using an "Erocon" air applicator. Fertilizer was incorporated to a 15-30 centimetre depth by backblading with the Cat's brush blade, or by dragging back the teeth of the payloader bucket. Compact surfaces were scarified in two directions before applying the seed mixture. Creeping Red Fescue (40 percent), Canada Bluegrass (27 percent), Timothy (26 percent), and Redtop (7 percent) were surface broadcast at 34 kilograms per hectare

using Erocon applicator and cyclone spreaders. Seed was incorporated by payloader bucket leaving contour furrows for trapping moisture on the dump surface. Seed and fertilizer were applied in one day (27 man-hours).

In April 1978, Rambler Alfafa (50%) and Birdsfoot Trefoil (50%) were surface broadcast on all areas at 22 kilograms per hectare using cyclone spreaders. Later in June and September 1978, split maintenance fertilizer applications were broadcast at 224 kilograms per hectare in the form of a complete fertilizer (13-16-10). During the initial growing season the grass-legume mixture established and grew satisfactorily on areas having sufficient fines and was dominated by Creeping Red Fescue and Timothy.

About 1800 trees and shrubs were planted in April 1977-78 to screen the open pit and concrete foundations. Bare root 2+0 Douglas Fir, Ponderosa and Lodgepole Pine, and Paper Birch seedlings were supplied by the B.C. Forest Service in Nelson. Arnot Bristly Locust, a spiny acid-tolerant nitrogen fixing shrub, and Black Cottonwood were planted to restrict access to the open pit. A local resident donated 28 four-year old Eastern Maple trees. Trees were planted by hand, using picks.

Costs Reclamation costs since 1972 have totalled 35,000 dollars including 8,000 dollars spent on research and administration and 27,000 dollars spent on planning and implementing operational reclamation (Table 1).

Reclamation planned for 1979 will include application of maintenance fertilizer and additional tree planting. Total costs are projected at 45,000 dollars or 3,500 dollars per acre.

Although future plans for the property are currently undecided, revegetation has made the Bluebell compatible with neighbouring residential areas and has discouraged refuse disposal on the site.

TABLE 1

OPERATIONAL RECLAMATION COSTS AT COMINCO LTD.
BLUEBELL AND PINCHI LAKE OPERATIONS DURING 1978

Property	Task	$	$/acre	%
BlueBell				
	Site Preparation (including supervision)	15,000	1154	56
	Vegetation Establishment and Maintenance (materials, labour*, travel expenses	9,000	692	33
	Administration (reclamation plan, reporting results)	3,000	230	11
	Total	27,000	2,076	100
Pinchi Lake				
	Materials (including transportation)	12,600	166	41
	Administration (Planning, reporting, and analysis)	8,600	113	28
	Labour*	4,200	55	13
	Helicopter	2,900	38	9
	Travel Expenses	2,700	36	9
	Total	31,000	408	100

Note: *Cominco labour rates include overhead, vacation/sick leave, and administration levy costs.

Bluebell costs were incurred in 1977 and 1978.

PINCHI LAKE OPERATIONS

Location and History

Pinchi Lake Operations is located on the north shore of Pinchi Lake, about 50 kilometres northwest of Fort St. James and 160 kilometres northwest of Prince George. The mine was first operated by Cominco during 1940-44 and produced 53,000 flasks of mercury from 700,000 tons of ore (1 flask=76 pounds). The mine was re-built in 1968 and produced close to 2½ million tons of ore and 176,000 mercury flasks before shutdown in 1975 (7). Cinnabar ore was mined by open pit and underground methods from the Pinchi limestone outcrop and treated in a concentrator and roaster.

Ecological Setting and Land Use Capability

The mine is situated within the Sub-Boreal Spruce Zone at an elevation of 716-814 metres (5). The climate is characterized by cold winters and a short growing season. Annual precipitation averages 46 centimetres with 2.5-5 centimetres per month during the growing season (4). Forests on the Pinchi outcrop are dominated by Lodgepole Pine, Trembling Aspen, and scattered White Spruce, Black Spruce, Douglas Fir, Cottonwood, Birch, and Alder trees. Soil parent materials vary from fine-textured glacio-lacustrine silts near the lakeshore to shallow coarse-textured glacial till and colluvium at higher elevations (8).

The Pinchi Lake area is reported to have moderately high outdoor recreation capability near the lakeshore and is an important winter range for moose (9). Forest capability on the Pinchi outcrop is low.

Nature and Extent of Land Disturbance

The total land disturbance at Pinchi Operations is 200 acres consisting of about 34 acres of open pits and waste rock dumps, a 60 acre tailings

disposal area, and 106 acres of other disturbances such as roads, the industrial site, lagoons, portals, etc. Twenty-five percent of the disturbance consists of tailings, 25% of waste rock, and about 50% of disturbed soils.

During mine shutdown, hazardous chemicals were removed from the property, mine portals were blocked, the West Zone Pit was fenced, the tailings dyke was raised, and a spillway was constructed to control drainage overflow from the tailings pond. A watchman-caretaker currently resides at the site.

Reclamation Plan

Objectives. The objectives of revegetation were to improve plant growth conditions on disturbed mined-land to encourage succession of self-sustaining native and naturalized plant communities. An initial vegetative cover of suitably adapted grasses and legumes were established using commercial fertilizer. This was intended to rapidly stabilize waste surfaces against erosion and improve the appearance of the site.

Approach. The revegetation approach was based on a laboratory growth room and field research studies conducted since 1970, in accordance with the surface work permit. Pertinent results will be briefly summarized.

Disturbed soils and parent materials were revegetated naturally within 2-5 years following disturbance. Natural regeneration was unsatisfactory on waste rock and tailings. Application of the plant nutrients nitrogen and phosphorus as commercial fertilizer was essential for establishment and growth of both native and commercial plant species on waste rock and tailings.

Rambler Alfalfa, Alsike Clover, Canada Bluegrass, Creeping Red Fescue, Timothy, Hard Fescue, and Crested Wheatgrass were established and grew

satisfactorily on waste rock and tailings, and produced seed during seven growing seasons of evaluation. Grasses and legumes were established by broadcast application of seed and fertilizer with no site preparation. Legumes and legume-grass mixtures have provided satisfactory vegetative cover, biomass, and seed production for four growing seasons, since the discontinuation of maintenance fertilizer applications.

During the first few growing seasons, invasion of dense legume-grass cover by native plants was limited by competition. Eventually as cover decreased, invasion of native plants accelerated.

The mercury content of grasses and legumes grown on waste rock and tailings was slightly elevated compared to values reported for the same species grown on normal soils; but was lower than values for vegetation growing in the vicinity of mercury mineralization in B.C. (10, 11).

Implementation. Reclamation at Pinchi has been on-going for a number of years. In 1971, roadcuts, a borrow pit, and portal entrances totalling 15 acres were hydroseeded. Mulch, ammonium nitrate-phosphate fertilizer (24-24-0), and a seed mixture were broadcast at 1120, 233 and 84 kilograms per hectare respectively.

In 1973, the 4-acre West Zone Pit waste dump was revegetated using a pull-type fertilizer applicator and pick-up truck. Before seeding ammonium phosphate, ammonium nitrate and muriate of potash fertilizer were surface broadcast to supply 56 kilograms per hectare N, 112 kilograms per hectare P_2O_5, and 56 kilograms per hectare K_2O. The seed mixture was surface broadcast at 112 kilograms per hectare. Maintenance fertilizer applications of 466 and 233 kilograms per tare applied as 24-24-0 were surface broadcast using hand-operated cyclone spreaders in May 1974 and 1975.

In May 1978, 76 acres consisting of the tailings disposal area, open pits, waste rock dumps, and areas not likely to be disturbed during

removal of surface structures were revegetated using a Jet Ranger helicopter. Saturated tailings conditions in spring limited access of conventional seeding equipment.

Materials were broadcast on waste surfaces without site preparation. A complete fertilizer (13-16-10) was broadcast on waste rock and tailings at 431 and 862 kilograms per hectare respectively. A Rambler Alfalfa (30%), Alsike Clover (20%), Creeping Red Fescue (25%), Redtop (10%), and Canada Bluegrass (15%) mixture was broadcast at 56 kilograms per hectare.

Fertilizer and seed were applied as follows:

a) at the staging area a 4-man crew loaded 700 pounds of fertilizer or 300 pounds of seed in 30 seconds into two 45-gallon barrels attached to each side of the helicopter.

b) a fifth person lined up the flight path of the helicopter to control material application.

c) application rates were controlled by the helicopter engineer by sliding a metal plate to vary the size of opening on the bottom of each barrel, and by varying altitude and speed. At 200 feet altitude and 25 miles per hour, materials covered a 25-foot wide strip.

d) the total time required to load, fly to the site, apply materials, and return to the staging area varied from 4 1/2 to 5 minutes.

e) the staging area was generally about one half mile from the point of material application.

Twenty-five tons of fertilizer and 2.2 tons of seed were applied by helicopter in 7 hours; 1.6 hours were required to fly the helicopter to and from Prince George.

Seed and fertilizer applications were uneven in some areas. To improve coverage on these areas, cyclone spreaders were used. This will be remedied in the future by using two people to align the helicopter and by using proper cyclone applicators mounted on the helicopters.

By late October 1978, waste rock and tailings were covered with relatively uniform seedling populations. Seedlings did not establish satisfactorily on waste rock left at the natural angle of repose, or where seed and fertilizer applications were uneven. Fertilizer accelerated the regeneration of native conifer and deciduous seedlings on waste rock. On tailings, the invasion of native Nuttall's Alkaligrass was promoted by fertilizer. Establishment of Creeping Red Fescue and Redtop was satisfactory on portions of the tailings pond; but legume establishment was poor and confined to cracks. Relatively poor establishment of legumes on tailings was attributed to a drier than normal summer.

Costs. Reclamation costs since 1970 have totalled 108,000 dollars, including 69,000 dollars spent on research and administration and 39,000 dollars spent on operational reclamation. Reclamation costs during 1978 totalled 31,000 dollars or 408 dollars per acre (see Table 1).

The 1979 reclamation program will include helicopter application of maintenance fertilizer to areas seeded in 1978 and tree planting in selected locations.

Dismantling and removal of tailings and surface structures will begin in 1979. Reclamation of the remaining land disturbance will be carried out when site clean-up is completed.

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APPENDIX 3.7.2

IRRIGATION WITH SEWAGE EFFLUENT ON THE OLD GRANBY TAILINGS AT PRINCETON, B.C.

Paper presented jointly
by:

J.D. McDonald and D.P. Lane
Ministry of Energy, Mines and Petroleum Resources

IRRIGATION WITH SEWAGE EFFLUENT ON THE OLD GRANBY TAILINGS AT PRINCETON, B.C.

INTRODUCTION AND BACKGROUND

During 1978, the Ministry of Energy, Mines and Petroleum Resources obtained funding under the Accelerated Mineral Development Program to revegetate mining areas that were not covered by present reclamation legislation. Under this program, several areas were treated. This talk discusses the program conducted on the old Granby Tailings at Princeton, B.C.

The tailings at Princeton were produced by the Allenby concentrator, which processed the ore mined at Copper Mountain. The mine was active intermittently from 1919 to 1957. The ore mined at Copper Mountain consisted of basaltic and andesitic breccia, which had been intensely altered by biotization, foliation and fracturing. Copper was removed from the ore as a concentrate by crushing and flotation methods. Total production from Copper Mountain was 39,774,902 tons of ore, which produced approximately 1,043,247 tons of concentrate that averaged 33% copper. Approximately 33,731,655 tons of tailings were produced, the majority of which were deposited in the tailings ponds adjacent to Princeton.

The main tailings pond covers approximately 300 acres and was purchased by the Village of Princeton when mining operations terminated at Copper Mountain. Dust from the pond is often a source of irritation to the residents of Princeton during the summer months. This dust nuisance has resulted in many attempts at revegetation during the past twenty years. Treatments over small portions of the pond have included disposal of woodwaste on the surface, surface dressing of a portion of the pond with gravel, planting of trees and seeding of grass. Although most of these treatments met with some success, the funding necessary for an overall reduction of dust has never been available.

In 1960, the Village of Princeton constructed a sewage disposal system which terminates in sewage lagoons located immediately adjacent to the Princeton tailings pond. With the opening of new primary industrial plants

in the area since 1960, the population has grown, with consequent increases in input to the Village's sewage system. The larger volume of effluent has decreased the efficiency of the lagoon system and eventually it may reach levels in the future which will not meet pollution control requirements.

Given the foregoing conditions, the Village of Princeton Council realized that proper use of the tailings pond might permit simultaneous abatement of the dust nuisance and provide low cost disposal of sewage lagoon effluent.

In 1976, the Village of Princeton commissioned Shultz International Ltd. to prepare a study on the feasibility of a sewage spray irrigation program on the tailings ponds. The report entitled "Revegetation of the Princeton Tailings Pond Using Sewage Lagoon Effluent for Spray Irrigation, 1976 Pilot Project", proved that:

1. Commercial species of legumes, cereals and grasses can be established as ground cover for control of dust and surface erosion.
2. The sewage lagoon effluent is a good source of irrigation water, but the quality and quantity of effluent are unknown for heavy demands.

With this information, the Ministry began its program to reclaim the tailings pond by engaging the professional services of R.A. Nelson, P. Eng., to design a pumping and irrigation system.

The sewage pumping records for Princeton indicated that the average availability of effluent was about 12,928,000 U.S. gallons per month (or about 300 U.S. gallons per minute). Soil samples of the tailings pond were taken across the field in a diagonal transect to determine the maximum water application rate for irrigation. The samples were sent to the Kelowna Soil Testing Laboratory for analysis.

The results of the soil tests showed that there was considerable variation in surface textures and variable contents of silts and clays in subsoil layers with very fine categories of sands. Tests also indicated a general absence of organic matter.

PROJECT DESIGN

On the basis of soil sample results and sewage effluent availability, 40 acres of the 70-acre lower tailings bench will be supplied with water by the irrigation system. Of these 40 acres, 33 acres are the main portion of the field, 2.5 acres the sloping embankment bordering the sewage lagoons, and 4.4 acres the elbow on the northeast end of the tailings pond. (Figure 1).

Site Preparation

The surface of the tailings pond was levelled with a 966 front-end loader and a grader equipped with front-mounted rippers.

After recontouring, a Ministry of Highways' survey crew surveyed the tailings pond to define the mainline layout and mark the 60-foot set intervals of the irrigation laterals.

Fencing was constructed, where necessary, around the tailings pond area and sewage lagoons, to prevent access by cattle, all terrain vehicles and snow mobiles. The non-irrigated portion of the tailings pond was included in the fenced area to enable future expansion of the irrigation system.

Seeding Program

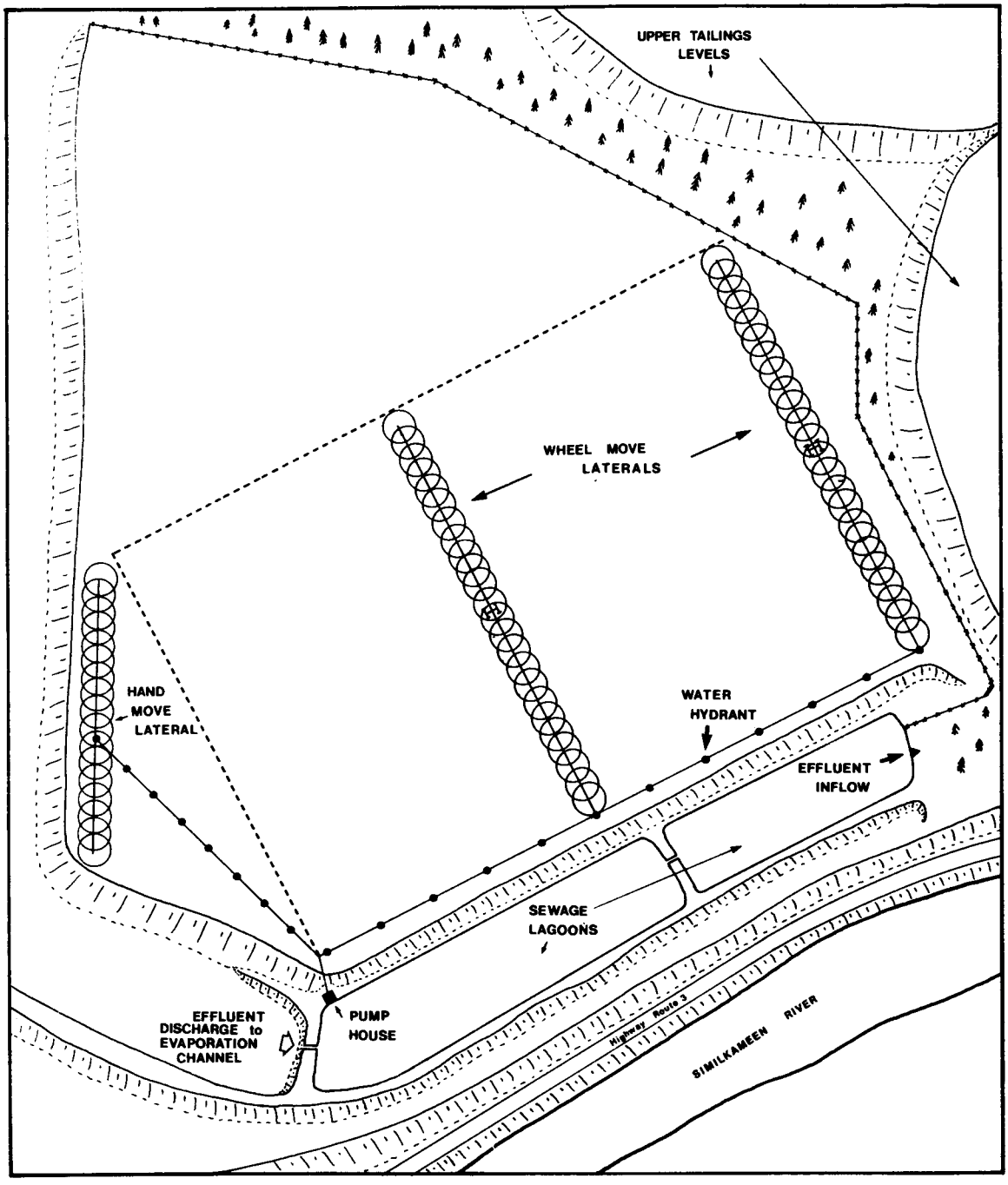
In September, the levelled portion of the field was seeded with Fall Rye. The Rye was used as it exhibits hardiness to low fall temperatures and can be expected to grow until the first snowfall. The ground cover established by the Rye will help to slow down the movement of the tailings by wind and provide some organic matter which can be incorporated into the soil for the Alfalfa crop in the following spring.

Before seeding the Rye,the field was fertilized with 300 pounds per acre of 13-16-10 and harrowed to a depth of one foot. The fertilizer

FIGURE 1

LAYOUT OF IRRIGATION SYSTEM

PRINCETON RECLAMATION PROJECT



was spread with a 10-foot fertilizer spreader and the field harrowed with a 10-foot vibra-shank cultivator. A 10-foot seed drill was used to seed the Fall Rye at a rate of 50 pounds per acre.

In the spring of 1979, the level area of the tailings pond will be seeded with Vernal Alfalfa at a rate of 30 pounds per acre. An additional fertilizer application will be made with 300 pounds per acre of 13-16-10 and 300 pounds per acre of 11-48-0.

In late September, the sloping embankment bordering the sewage lagoons was fertilized with 300 pounds per acre of 13-16-10 and seeded with 30 pounds per acre of the following seed mix:

Species	% of mix by weight
Creeping Red Fescue	20
Crested Wheatgrass	50
Drylander Alfalfa	15
Sainfoin	7
Sweet Clover	8

Both the seed and the fertilizer were spread, using a broadcasting unit mounted on the back of a tractor.

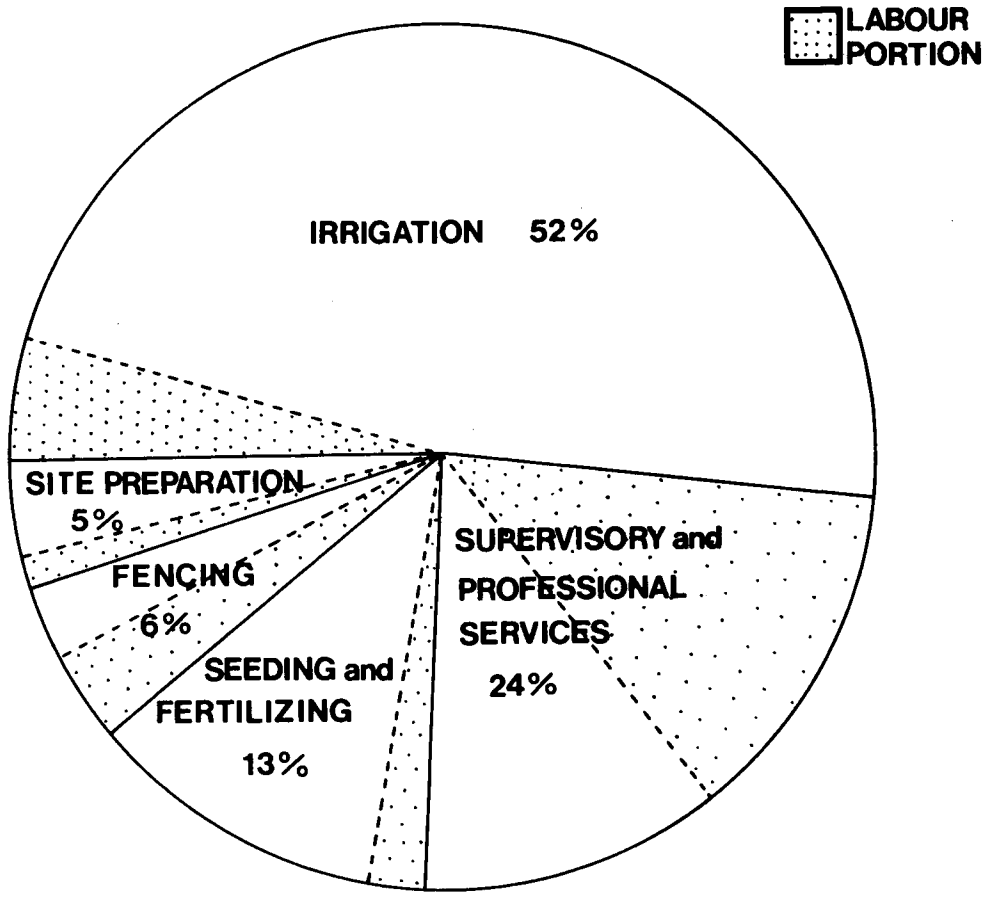
IRRIGATION SYSTEM

The main portion of the field will be irrigated with two 980-foot wheel-move lateral sprinkler systems, each with 24 5/32 inch x 3/32 inch sprinklers on a 40 foot x 60 foot spacing (Figure 1). The elbow on the northeast end of the tailings pond will be irrigated with a 640 foot hand-move lateral with 17 3/16 inch x 1/8 inch sprinklers mounted on 18-inch risers on a 40 foot x 60 foot spacing. The hand-move lateral is variable in length, due to the triangular shape of the elbow.

Irrigation on the sloping embankment bordering the sewage lagoons will be applied through a fixed system of twenty-four 75 foot x 3/4 inch diameter plastic pipes, each with two Rainbird #20 x 7.64 inch sprinklers mounted on stands with a sprinkler spacing of 40 foot x 60 foot. Water is supplied by one-inch gate valves that are attached to the hydrants supplying the wheel-move laterals.

FIGURE 2

COST BREAKDOWN OF B.C. M.E.M.P.R. RECLAMATION PROJECT ON THE PRINCETON TAILINGS POND.



The sewage effluent is pumped by a 25 horsepower vertical turbine with a pumping capacity of 300 U.S. gallons per minute. The water mainline is made from 20-foot sections of 6 inch diameter lightweight steel pipe coupled with victaulic fittings. Hydrants are spaced every 120 feet along the mainline supplying the wheel-move laterals and every 80 feet along the mainline supplying the hand-move lateral (Figure 1). The hydrants for the wheel-move laterals serve two successive settings through a 30-foot length of aluminum pipe and a 6-foot length of high pressure flex hose. The hand-move lateral has a centre connection to the hydrants which serve a single setting.

The pumping system has been designed for daily non-supervised pumping. There is a low pressure cut-out switch to prevent bank erosion by mainline pipe breaks, a high pressure cut-out switch to protect the motor from overloads arising from human error, and a liquid level regulator to prevent water from dropping to a level, in the lagoon, which could lower the effluent retention time to less than 30 days.

PROJECT COSTS

The total expenditure for the Princeton Reclamation Project was 52,000 dollars, creating a total of 1340 man-hours of employment. The cost per acre for the project was 1,300 dollars.

The largest portion of the cost is represented by irrigation which was 52% of the total (Figure 2). The rest of the cost was divided as follows: supervisory and professional services - 24%, seeding and fertilizing - 13%, fencing - 6%, and site preparation - 5%. The labour portion of each category represents a much smaller fraction of the cost than materials (Table 1).

OPERATIONAL ECONOMICS

The Ministry of Energy, Mines and Petroleum Resources will be signing ownership of the irrigation system over to the Village of Princeton, who have decided to lease the field to a local rancher. The rancher will be responsible for the care and harvesting of the crop. The Village will pay

TABLE 1

BREAKDOWN OF TOTAL COSTS BY MATERIALS AND LABOUR

Description	Cost ($)	Cost ($)
Irrigation		26,603.23
Equipment	24294.03	
Labour	2309.20	
Supervisory and Professional Services		12,408.50
Expenses	5708.50	
Labour	6700.00	
Seeding and Fertilizing		6,531.71
Seed and Fertilizer	5531.71	
Labour	1000.00	
Fencing		2,992.10
Materials	1392.10	
Labour	1600.00	
Site Preparation		2,804.00
Equipment	2168.08	
Labour	635.92	
	Total Cost	51,339.54

power and maintenance and recover these costs by charging the rancher a fee on a per-ton-of-hay-produced basis.

The power cost per year for the irrigation system has been estimated at 800 dollars. The maintenance cost may run as high as 1,100 dollars per year. Total yearly production of hay should be about 110 tons when the field becomes established. Using these figures, the Village of Princeton would charge 20 dollars per ton of hay.

Future expansion of the irrigation system on the tailings pond may be possible as the soil conditions in the irrigated area improve.

APPENDIX 3.7.3

CURRENT REVEGETATION TECHNIQUES AT CRAIGMONT MINE

Paper presented

by:

L. Gavelin

Craigmont Mines Ltd.

CURRENT REVEGETATION TECHNIQUES AT CRAIGMONT MINE

INTRODUCTION AND HISTORICAL BACKGROUND

Reclamation at Craigmont commenced in 1969. Dormant pit waste dumps and completed sections of the tailings toe dam were seeded and fertilized by aerial spraying; the method considered most economical and expedient at that time. A sprinkler irrigation system was installed on the tailings toe dam to maintain optimum moisture conditions during the dry period to sustain plant growth. The continuing reclamation program from 1969 to 1977, as outlined in Appendix I, basically consisted of maintenance of seeded areas as well as new seedings and fertilization as areas became available, including a test plot of hydroseeding on the dump slopes to determine if plant growth could be enhanced in this difficult area. The success of the reclamation program up to this time is best described as marginal, due to (1) the hit and miss nature of aerial spraying; (2) the compaction of the waste dump berms where either the seed was blown away or root development was impossible; and (3) overgrazing by cattle of the new plant life and subsequent loss of seed production. Very reasonable results were obtained on the tailings toe dam under irrigated conditions.

In 1978, a complete review of our program was undertaken and modifications made to hopefully improve and accelerate the results which would be conducive to returning the disturbed land to an economic use. The outcome was an intensified program to provide answers for our final reclamation program prior to our pending closure.

RECLAMATION IN 1978

The 1978 reclamation program consisted of:

1. the use of land-borne equipment to provide a more consistent plant cover.

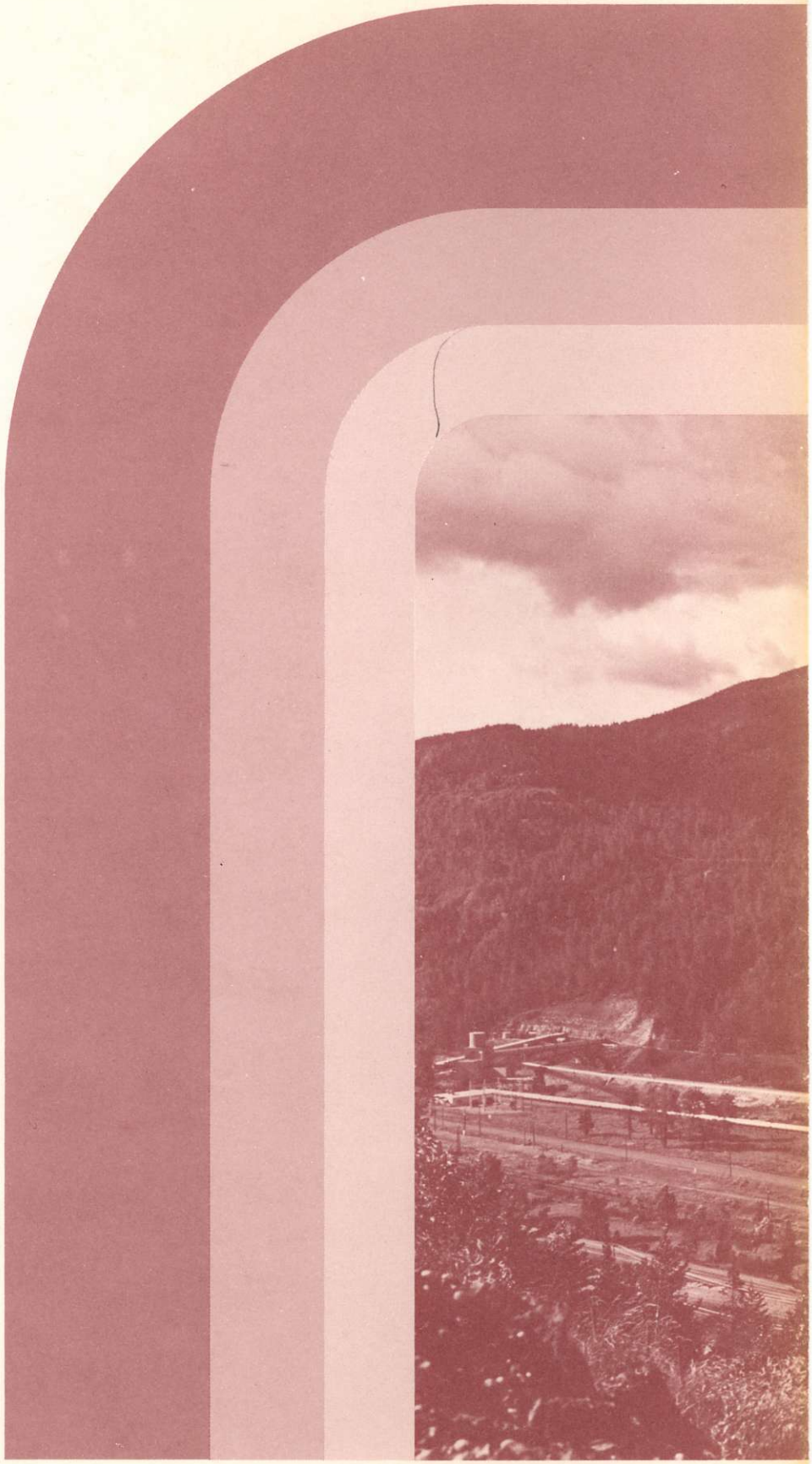
2. Scarification of the compacted surface to enhance seed germination and plant growth.

3. Fence construction around the pit waste dumps to keep the cattle from grazing the area.

4. The setting up of five large test plots on the tailings impoundment area to test possible economic use and methods of establishing a self-sustaining plant growth.

Comparisons and results of the 1978 reclamation program with respect to past practices will indicate that our re-evaluation and revised procedures have been well founded by the initial results obtained. However, a total assessment will require 2 to 3 years of follow up.

Technical details regarding the tailings impoundment test plots is attached as Appendix II, as well as various seeding application costs relative to work done at Craigmont which is attached as Appendix III.



Province of British Columbia

Ministry of
Energy, Mines and
Petroleum Resources