# BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
# HAT CREEK PROJECT
# ENVIRONMENTAL IMPACT STATEMENT

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# Hat Creek Valley

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## PART I - PROJECT BACKGROUND

### Introduction

In order to help meet British Columbia's electricity demands, B.C. Hydro plans to apply to the government authorities for the necessary permits and licences to develop a 2000 MW coal-fired electricity generating plant in the Hat Creek valley.

Detailed government and public examination of the proposed project will precede project construction authorization. Permits and licences will set out environmental, health and socioeconomic conditions to be met by B.C. Hydro in the construction and operation of the project.

This Environmental Impact Statement (EIS) is based on the findings of extensive technical, environmental and socioeconomic studies and has been prepared by B.C. Hydro to provide information about the proposed Hat Creek project.

The information contained here, and the findings of the supporting studies, are for use by the public and by licensing agencies in determining whether the project should be authorized.

A full library of supporting reports as detailed in the list of references at the back of this EIS is available at major public libraries, or can be viewed by contacting B.C. Hydro's Hat Creek Information Officer at Box 12121 - 555 West Hastings Street, Vancouver, B.C., V6B 4T6, or 1390 Quartz Road, Box 760, Cache Creek, B.C., V0K 1H0.

### Commitment to Hat Creek

B.C. Hydro has the responsibility of meeting the electricity demands of British Columbians. To do so, it must plan far in advance, identifying generating potential and taking steps to have that potential developed in time to meet demand.

Since 1957, the corporation has actively considered the potential of mining and burning Hat Creek coal for thermal generation of electricity. The decision to seek approval to develop this potential has come now because:

1. The project's power is needed to meet British Columbia's demand for electricity, which grows as population and economic activity increase. Electricity load forecasts at the end of 1980 indicated clearly that the first power from the Hat Creek Project will be needed in the province before the end of 1988.

2. The findings of extensive research have demonstrated that the Hat Creek Project can proceed without adversely affecting human health and with relatively minor environmental impacts.

**Study Background**

B.C. Hydro's active consideration of the Hat Creek coal deposits for thermal electricity generation led to a preliminary environmental impact study being commissioned in 1974. This was submitted in August 1975 and made public. It recommended that more detailed studies and evaluations of impacts be carried out.

This detailed work began in 1976 and has continued through to completion of this Environmental Impact Statement. The studies upon which the EIS is based have made the data of the 1975 preliminary environmental impact study obsolete.

The studies commissioned for this project are among the most extensive environmental investigations ever carried out in advance of a project such as that proposed at Hat Creek. They have led to design decisions which support the conclusion that the project can be built and operated in compliance with the Pollution Control Board (PCB) Objectives and within standards that safeguard the environment and human health.

Various highly qualified and internationally recognized consulting firms, under the direction of a co-ordinating consultant, have conducted the studies. The firms involved are identified in this EIS. The results of the studies and of subsequent "bridging" documents are summarized in this statement.

Over the same period of time, B.C. Hydro has carried out information programs aimed at acquainting the people of the region with the nature of what was being done and at offering opportunities for public participation in the planning process. The public release of this EIS is an extension of those information programs. They will continue through the licensing process which will also bring additional opportunities for direct public participation.

Included in the Hat Creek region are the communities of Ashcroft, Cache Creek, Clinton, Lillooet and Lytton which lie in the area surrounding the valley, Kamloops 90 km to the east of the valley, and several Native Indian reserves. About ten families live on ranches in the valley itself and two Native Indian bands have reserves near the valley's north end. Two other reserves are a short distance to the east.

The Hat Creek valley is a broad grassland flanked by subdued mountains with sparse forests. The predominant land uses have been agriculture, forestry and wildlife habitat. There is little evidence of resource development apart from coal exploration activity, the effects of which have largely been offset by reclamation.

Two major coal deposits are found there. Deposit No. 1, development of which is proposed in this project, is near the north end, while the larger No. 2 deposit is to the south. The deposits vary in quality but on average rank between sub-bituminous and lignite type coals. The coal is relatively low in heating value, high in ash, high in moisture content and relatively low in sulphur (compared to eastern North American coal).

The total resource in both deposits could reach 15 billion tonnes (Gt), making this one of the world's largest known deposits occurring in such a small area.

## PART II - PROJECT DESCRIPTION

### Project Components

The proposed Hat Creek project has three basic components: a mine and a powerplant, to be located in the area at the north end of the Hat Creek valley; and, associated with these, offsite facilities which include a water supply system, a pipeline, a reservoir, access roads and creek diversions.

B.C. Hydro proposes that construction be started in early 1983, to ensure meeting the schedule for first power production in late 1988. Coal would be mined in a large open pit, blended near the pit and then transported by a conveyor system to the powerplant site some 4 km northeast of and 500 m above the mine. The powerplant would burn the coal to produce steam to power turbine generators to produce electricity, a proven thermal generating operation.

The four 500 MW units in the powerplant (to be phased in at approximately 1 year intervals) would represent electrical capacity of 2000 MW (net), an amount roughly equal to the present demand of the British Columbia lower mainland.

During the preliminary design phase of the project, many project alternatives were studied. They include alternative powerplant sites, air quality control systems and ash disposal methods. Details of these and other alternative systems are presented. All components of the proposed project include design and operational measures to mitigate environmental impacts and the flexibility to incorporate alternative systems and technology as conditions require.

For the purpose of planning, the project has been given a nominal operating life of 35 years. By the end of that period, B.C. Hydro would have determined whether electrical generation was still a suitable use of the coal resource and, following government approval, acted accordingly to extend the life of the project or develop alternative uses.

Regardless of such future options, the plan includes a comprehensive reclamation and revegetation program, which would start early in the construction phase, continue throughout the operational phase and end ten years after powerplant decommissioning. It would restore about 64 percent of the land used in the project to its former uses.

## The Mine

The proposed mining operations would include five basic components, the most significant being the open pit mine. This would be developed in a series of benches and would extend approximately 3 km across and 230 m deep after 35 years of production. The mine would produce about 340 million tonnes (Mt) of blended coal and 430 million cubic metres of waste.

Other components of the mine complex include: the waste disposal areas, located at Houth Meadows and Medicine Creek; the coal blending, storage and handling facility at the north end of the mine pit; the conveyor system; and the administration and maintenance centre.

Two major environmental control systems are included in the mine complex design - one to maintain downstream water quality and the other to control dust.

## The Powerplant

The powerplant complex would be located on a broad hilltop, near Harry Lake, 500 m above and 4 km northeast of the mine area. This high site has been selected to provide better dispersion of flue gases from the 366 m high multi-flue stack.

Environmental protection systems are an integral part of the powerplant's basic components. These include the coal handling system, boilers, turbine generators, condensers to recover water from the spent steam, feed water systems, cooling towers, stack, ash-handling and disposal systems and an air quality control system (AQCS).

The latter is designed to maintain regional air quality through the use of electrostatic precipitators, a high stack and partial flue gas desulphurization (FGD). The powerplant design has built-in flexibility, to accomodate any conditions determined through the licensing process and attached to Pollution Control permits. Modifications to the proposed powerplant could also be made to take advantage of technological advances made during construction and operation and to respond to needs identified by operating experience.

Environmental protection measures also include a water management and control system, which would reuse all process water (zero-discharge system), and a solid-ash and FGD sludge disposal system.

## Offsite Facilities

Offsite facilities are project components located outside the actual mine and powerplant complexes. Major offsite facilities include access roads, the powerplant reservoir and water supply system (which includes a pipeline from the Thompson River), transmission lines, an airstrip, an equipment unloading facility at a rail location, creek diversions and temporary construction camps.

## Proposed Project Costs

The proposed project is estimated to require a capital expenditure of about $5 256 million when inflation, interest during construction and corporate overhead are included. In 1980 dollars, this capital cost would total about $2 294 million.

## Field Activities

The project field activities can be divided into three phases: construction, operation and reclamation.

Construction would involve a peak labour force of approximately 2800 workers and last from 1983 to 1992.

The scheduled 35 years of commercial operation would begin in 1988 and involve a peak labour force of about 1200 workers in the mine and powerplant.

Final reclamation would start in the year 2023 and would continue to the year 2033, and would involve 13 workers in revegetating the project areas.

## Land Requirements

The mine, powerplant, and offsite facilities would cover a total of approximately 2500 ha (6200 acres). This is less than four percent of the 66 600 ha area of the Hat Creek watershed. At the end of 45 years, about 64 percent of the disturbed lands would be reclaimed and restored to production. The remainder would include the open pit mine which would not be reclaimed at that time because more than half the mineable coal would remain.

# PART III - IMPACT ASSESSMENT

## Introduction

*Extensive studies of environmental, health and socioeconomic impacts of the* proposed project have been completed. In addition to producing needed electricity for British Columbia as a whole, the project would provide economic stimulation to the local and regional economies through employment and purchase of goods and services for both the construction and the operational phases, with relatively minor environmental damage. Trade-offs are involved in achieving these benefits and they are identified in detail in the various sections of this EIS.

Primary sources of information for the EIS were the consultants' detailed environmental studies. In turn, data sources for the consultants' reports included literature reviews, monitoring programs, field work, an extensive test burn of Hat Creek coal in an operating powerplant, simulation modeling studies for certain aspects, and interviews with members of the public and special interest groups.

## Air Quality

In assessing the project's potential impact on the environment and health, the effects on air quality are important factors. These effects, principally from powerplant emissions, determine impacts on human health, wildlife and other resources.

The findings are based on conservative (pessimistic) assumptions and they indicate that environment and health safeguards would be met even with these pessimistic assumptions.

The impacts were assessed on a local and a regional basis; "local" being defined generally as that area within a 25 km radius centred on the powerplant, and "regional" as that area within a 100 km radius centred on the powerplant.

Mathematical simulation models were the major tool used to predict the ground level concentrations of powerplant emissions - and the resulting predictions are based on conservative assumptions. For example, for these studies, it was assumed that the powerplant would operate at full load 100 percent of the time. In fact, the powerplant would come on stream in stages and over its 35 year operating life would operate on average at 65 percent of capacity.

The predicted ground level concentrations of sulphur dioxide (SO2), nitrogen oxides (NOX), total suspended particulates (TSP), trace elements, and other contaminants are set out in tables in this report. The predicted ambient air quality and stack emission levels will fall within the ranges specified by the Pollution Control Board (PCB) for coal fired powerboilers. Adverse environmental impacts are not predicted to occur beyond the immediate vicinity of the mine and powerplant.

Exhaustive and detailed studies of the "acid precipitation" phenomenon were undertaken by one of the leading consultants in this field. Modelling studies indicated that the acid (pH) ratings of precipitation in areas up to 50 km downwind of the powerplant could change from an estimated level of approximately 5.65 down to a level of about 5.06, indicating an increase in acidity. In the long-range area 50 to 200 km downwind, pH levels of precipitation would be less affected. These studies concluded that, because much of the surrounding area contains soils and water with neutralization capacities, deposition of airborne materials emitted from the proposed project would produce no significant direct or indirect environmental effects in the aquatic systems and their biological communities.

## Water Quality

The effects of the project upon water quality and hydrology would be relatively small, and would be insignificant beyond the local area. Comprehensive drainage and water management systems have been designed to collect water-borne pollutants. Thus all process water unsuitable for return to Hat Creek would be disposed of by reuse or evaporation.

Alterations in groundwater resources would be minor. Although the Hat Creek valley aquifer (groundwater flow) would be cut by the mine pit and diversion system, it would be re-established to essentially its present flow a short distance downstream of the northern perimeter of the mine pit. Water quality of this aquifer would show a total increase in dissolved solids of less than 22 percent as a result of the increased fraction of Marble Canyon aquifer flow and seepage from the Houth Meadows waste disposal area. This water would remain acceptable for human and livestock consumption or for irrigation purposes.

The effects upon surface water resources would primarily occur from the diversion of stream channels in the Hat Creek and Medicine Creek watersheds. Minor flow modifications would occur in Hat Creek because of the retention of essentially all of the Medicine Creek flow by an existing irrigation diversion system, and of the remainder by the downstream powerplant water supply reservoir. Medicine Creek flows would however be released to Hat Creek during the summer months (July - August) to increase the normally low flows occuring during that period and to maintain suitable water temperatures for resident fish.

Predicted changes in Hat Creek water quality are minor and generally fall within the range presently experienced. This water would remain satisfactory as a potable supply, for irrigation and livestock use. Effects of changes in flow or water quality on systems downstream of Hat Creek would be negligible.

### Vegetation

The effects of the project on vegetation are expected to be low in the local and regional areas. Dust emissions and leachates from coal, mine waste and ash piles would be contained within the local project area and are expected to have minimal effects on the environment. Sulphur dioxide emissions could cause localized injury to certain vegetation species in a few isolated high terrain areas (Cornwall Hills and Clear Range).

### Agriculture and Forestry

*Agriculture and forestry would be primarily affected by the direct loss of land* needed for the mine, powerplant and offsite facilities.

### Wildlife and Fisheries

The direct loss of areas of habitat to project installations would be the main effect on wildlife resources. A decline in the valley's deer population and waterfowl production could occur if no specific management measures are taken. Significant increases in hunting demand are expected to occur due to the increase in workforce. No adverse effects upon wildlife from toxic materials are anticipated.

In the immediate vicinity of the project, fisheries and aquatic life would be affected by the diversion of Hat Creek around the open pit mine. Increases in silt loads would be minimized, and are not expected to cause significant impacts. Increased pressure from greater numbers of people fishing could occur, and, without proper management, reduce local fish populations. Based on modeling studies, local and regional effects on fisheries due to acid precipitation and trace element deposition are predicted to be insignificant.

## Noise

Noise from the project during construction and operation would create adverse impacts on a few nearby residences in the immediate vicinity of the mine. A small area of land would be rendered unsuitable for grazing. During construction of some offsite facilities, adjacent residents would also experience some annoyance due to a temporary increase of noise levels.

## Recreation

The main effect on recreational activities in the local area would be alienation of land in the valley by project components, along with reductions in hunting and fishing opportunities. The visual quality of sightseeing could be impaired by the visibility of project components. However, the project could also be an attraction and may well cause a net increase in local sightseeing as a result. Regional recreation impacts would likely be minor, based on the prediction that regional fisheries would not be perceptibly affected by stack emissions. The project would create a major increase in regional recreation activity, due to the associated population growth.

## Other Resources

Other factors such as effects on archaeology, aesthetics and mineral resources are summarized in the text. Economic evaluations of resource impacts are also presented.

## Socioeconomic Factors

The impacts of the project upon socioeconomic conditions and community resources were examined. Major considerations are the effects of the project's labour force upon regional income and employment, and social and physical services in nearby communities. The effects of the project's emissions upon regional health are also discussed.

A major factor in generating socioeconomic impacts would be growth in employment as a result of the project. While union and skill requirements would place constraints on direct employment of local and regional residents, for project construction and project operation significant job opportunities would occur. Based on estimates of regional labour availability and the extent of these constraints, estimates of direct local and regional employment upon the project are contained in the text. Direct employment of regional residents is estimated to peak at about 1450 jobs in 1987. During the 35 year operating phase it is estimated that at least 300 jobs will be taken by regional residents. Indirect and induced employment due to project purchases and worker spending in local communities is estimated at a maximum of 700 jobs. These estimates indicate that significant long term employment benefits would occur in the regional economy due to the Hat Creek project.

Project effects on the regional population would be determined by the number of in-migrants attracted to the local area. Alternative population forecasts have been prepared under two scenarios of settlement patterns, as shown in the text. Demographic characteristics of in-migrants during the operation phase would be similar to those of the labour forces of other regional mining operations.

The effects on regional income are expected to be substantial, due to direct income received by the project workforce and to their spending of much of it in the local economy. Income distribution would shift upward in the local area, revenues would increase in local businesses, and some local prices would increase.

The effects of the project upon the socioeconomic conditions of Native Indian people cannot be accurately predicted. Initiatives would have to be undertaken for an affirmative action employment program to bring about significant Native Indian participation in direct project employment. B.C. Hydro will make every effort in association with Native Indian organizations, government agencies and the construction and operating unions, to maximize Native Indian participation in the project. Opportunities for wage employment in local communities would be expanded. Native Indian populations may increase if regional employment opportunities are attractive enough to reduce migration to urban areas.

Three residences in the Hat Creek valley would have to relocate as a direct result of land requirements for the mine and noise impacts. Several others including residences on the Bonaparte Indian Reserve No. 1 would be affected by noise. The Hat Creek valley population would experience a disruption of their traditional lifestyle.

The project's work force would create an identifiable need for expansion in community social services, commercial goods and services, and housing. It is possible that this rapid growth could lead to a period of excess demand causing disruption and overloading of services. This is a potential problem particularly with regard to housing where it is likely that there could be a temporary shortage of housing in the initial project years.

The project would also create changes in the local area's social environment due, in part, to adjustments necessary to accommodate the increases in local population.

## Human Health

The effects on human health (epidemiology) were thoroughly studied. The study considered both primary contaminants such as sulphur dioxide, nitrogen oxides, and particulate matter; and secondary contaminants such as sulphates, nitrates and ozone, produced by atmospheric chemical reactions with the primary contaminants. Also considered were a large number of trace elements including radioactive elements. In all cases the study concludes that project emissions are not predicted to have adverse effects on human health.

## PART IV - MANAGEMENT OF IMPACTS

B.C. Hydro plans to manage the impacts of this project in three different ways.

1. By selected design and operational mitigation measures to reduce the adverse impacts of the project.

2. By a compensation policy for impacts which cannot be mitigated.

3. By monitoring of impacts to ensure that the project's effects do not exceed the levels predicted in this analysis or deemed acceptable by the licensing agencies.

The major mitigation measures considered for this project included alternative powerplant locations, alternative designs for the mine, powerplant and offsite facilities, alternative air quality control systems (AQCS), alternative transportation corridors, and alternative socioeconomic management plans. Information is presented in the text regarding the environmental and economic implications of these alternatives, and the basis for B.C. Hydro's choice of the proposed systems is explained. A benefit/cost analysis of the proposed AQCS is presented.

Monitoring would be undertaken to quantify the actual impacts of the project, to provide a basis for mitigation of unacceptable impacts if any. Monitoring would begin well before development activities start at Hat Creek. Natural systems to be monitored include atmospheric, terrestrial and water resources. Noise and socioeconomic effects would also be monitored.

## CONCLUSIONS

The environmental studies involved in B.C. Hydro's assessment of the proposed Hat Creek thermal project are among the most exhaustive and detailed ever undertaken in support of a thermal electric generating project.

These studies indicate that the "Proposed Project" could be constructed and operated in compliance with all PCB Objectives, within limits which safeguard human health, and with relatively minor environmental impacts.

On this basis, B.C. Hydro seeks approval to proceed with the proposed project in order to increase its electricity-generating capacity in keeping with its legislated responsibility to provide for British Columbia's electricity requirements.

# SECTION 1. THE PLANNING PROCESS

## 1.1 INTRODUCTION TO THE ENVIRONMENTAL IMPACT STATEMENT (EIS)

### (a)Objectives.

This EIS has been prepared by B.C. Hydro to present a summary of technical, environmental and economic information about the proposed Hat Creek development. In keeping with the Energy Review Process of the Utilities Commission Act - Bill 52-1980 (1)[1], this report is intended to fulfill the technical information requirements for project approval. That is, the report presents:

1. Details of the project and development program.
2. Details of available project component alternatives.
3. Analyses of impacts of the mine, powerplant and offsite facilities on the environment.
4. Analyses of proposals for mitigating identified impacts on the environment.
5. Analyses of impacts on regional and community social and economic conditions.
6. Identification of means of meeting community and social requirements.
7. Statements outlining the preferred approach for each aspect of the development.

The Hat Creek EIS has been written to provide information for two different groups. Firstly, it is designed to meet the needs of the general public by describing the project and explaining the advantages and disadvantages of the proposal. In this regard the EIS can serve as a reference document to provide a basis for discussion between B.C. Hydro and those individuals and groups affected by or interested in the project. Opportunities will be provided for the communities to express their perceptions of the requirements and these will be recorded and presented in a separate document. Secondly, the EIS provides information to support applications for licences in the public hearing and approval process. Technical information about the project and its environmental impacts will be reviewed by the licensing agencies, who will assess and evaluate B.C. Hydro's approaches to the control of impacts.

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[1] Numbers in brackets refer to Reference Section - page 27-1.

The Hat Creek project falls under the jurisdiction of the new Energy Review Process, which was established in the Utilities Commission Act of 1980. The process is shown schematically in Figure 1-1. Under this process an application for an Energy Project Certificate is submitted to the Minister of Energy, Mines and Petroleum Resources who, together with the Minister of the Environment, would conduct an initial appraisal of the application and jointly establish terms of reference for a public hearing review.[2] Public hearings would be conducted by the British Columbia Utilities Commission.

Following the hearing and consideration of evidence, the appointed commissioners report their findings and recommendations to the Lieutenant-Governor in council. Under the Act, Cabinet makes a decision on the issuance of the Energy Project Certificate, and other licences or permits, if applicable, together with terms and conditions to be applied. The ultimate form, timing and extent of the proposed project may be altered as a result of these approval procedures.

(b) Organization

This report consists of four Parts:

Part I provides background information to establish the context of the EIS. Section 1.0 outlines the planning process for the proposed development, while Section 2.0 discusses the Hat Creek valley and its resources. Part II gives a technical description of the proposed project and briefly describes possible project component alternatives. In Part III, the impact assessments are detailed. For clarity, the assessments are grouped so that environmental resource impacts are found in Part III-A, while socioeconomic and community resource impacts are considered in Part III-B. Finally, Part IV presents evaluations of environmental impact control alternatives, and presents B.C. Hydro's proposals for mitigation and compensation of impacts.

(c) The Proposed Project

After extensive research, B.C. Hydro has selected and refined its preferred project design for the Hat Creek proposal. This "Proposed Project" is described in Part II of this report, and the impact assessment has been conducted on the assumption that a project of this nature would be constructed and operated at the selected site. Of course, various alternative components would have effects on predicted environmental impacts. Of particular importance are the choices between alternative systems for control of powerplant emissions. The provincial review of the Hat Creek proposal may require that changes are made in the project design before necessary permits are issued.

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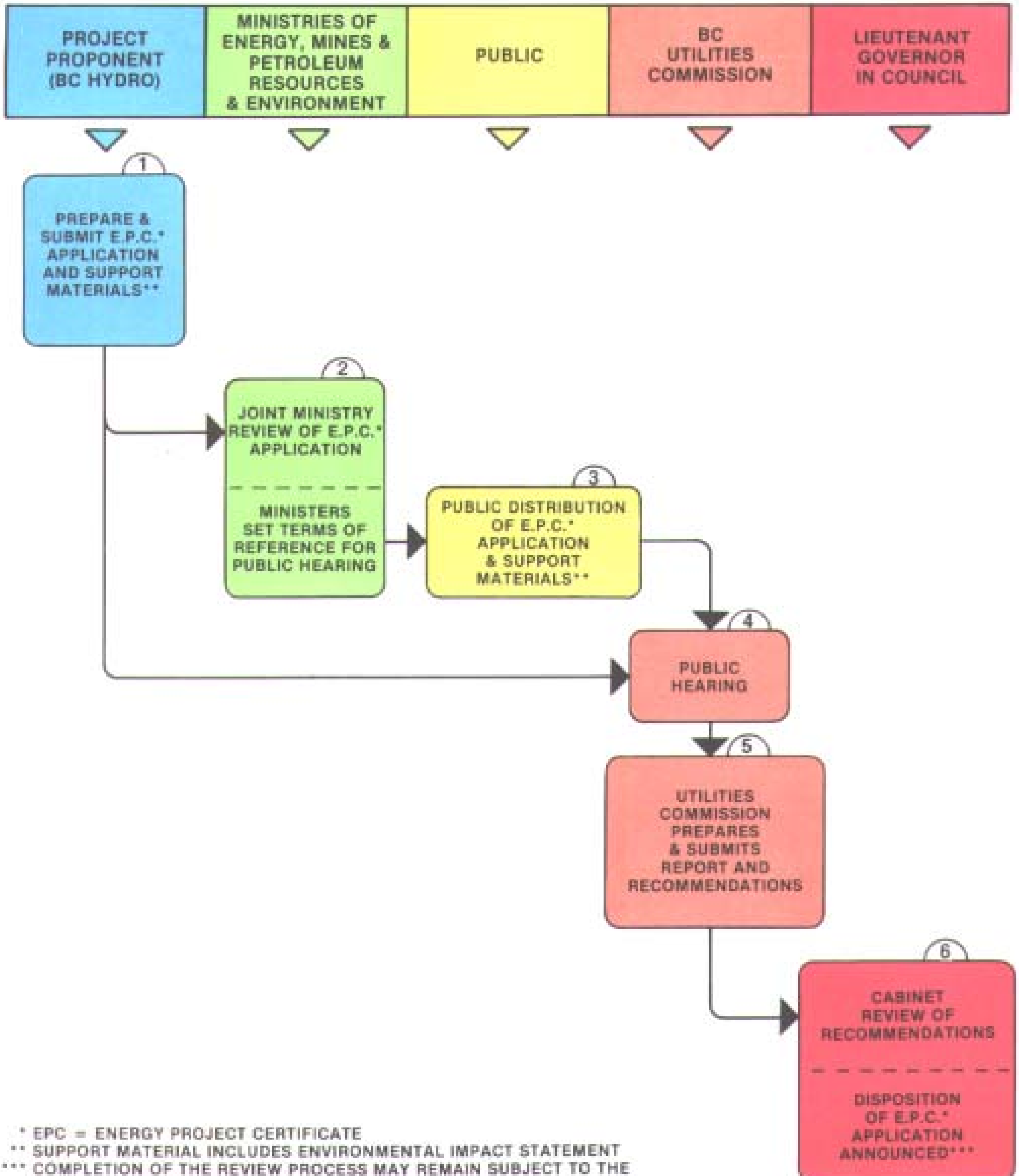
[2] The ministers can jointly decide to exempt a project from the public hearing requirement after an initial appraisal. This may occur in cases where the project was considered to have relatively minor environmental or social impact and was clearly justified on energy grounds.




* EPC = ENERGY PROJECT CERTIFICATE
** SUPPORT MATERIAL INCLUDES ENVIRONMENTAL IMPACT STATEMENT
*** COMPLETION OF THE REVIEW PROCESS MAY REMAIN SUBJECT TO THE APPLICATION OF OTHER STATUTES.

HAT CREEK PROJECT

FIGURE 1.1

MAJOR STEPS IN THE ENERGY REVIEW PROCESS

## 1.2 NEED FOR THE PROJECT

(a) Introduction

B.C. Hydro's forecast of electrical energy demand provides the basis for scheduling the addition of new generating resources. The September 1980 load forecast indicates a probable average annual growth rate for the total power system of 6.1 percent per year for the period 1979/80 to 1990/91. This includes meeting projected future deficiencies in the West Kootenay Power and Light system. Projects already committed to construction will only meet forecast needs up to 1985/86.

B.C. Hydro's current plans for power system development to meet load growth after 1985/86 rely on construction of the Peace Site C project for service in 1987, and the first unit of the Hat Creek thermal power project in August 1988. These are the estimated earliest feasible in-service dates for these projects. Even with the construction of both projects at the earliest practical time, B.C. Hydro system capability will not meet the projected load requirements and it is likely that significant amounts of energy will have to be purchased from sources outside the B.C. Hydro system starting in 1986/87.

(b) Energy and Electrical Power Supply

(i) Energy Use in British Columbia

Electricity, natural gas, petroleum fuels, wood and coal all contribute towards the supply of energy in British Columbia. The share of total primary energy consumption of these energy sources in British Columbia in 1978 has been estimated as shown below:

| | |
|---|---|
| Oil products | 44% |
| Natural Gas | 18% |
| Coal | 1% |
| Wood wastes | 21% |
| Electricity | 16% |

British Columbia must import about 77 percent of its oil requirements, but is presently self-sufficient in its other energy consumption.

The share of electricity as a preferred energy source has been growing steadily over the past decades, due to its convenience and versatility. Consequently, the rate of growth of demand for electricity has been more rapid than the growth of demand for most other energy sources.

The B.C. Hydro Task Force Report of 1975[3] showed that the demand for total energy in British Columbia during the period 1953 to 1973 grew at an average rate of 5.6 percent annually, which was almost the same as the provincial economic growth rate of 5.9 percent annually. However, the total provincial demand for electricity over the same period grew at 8.1 percent annually, and the demand on the B.C. Hydro system grew at 11 percent annually. Studies of historic United States energy demands also showed that total energy demand grew at approximately the same rate as

[3] British Columbia Hydro and Power Authority - Alternatives, 1975-1990 - Report of the Task Force on Future Generation and Transmission Requirements - 1975.

total economic growth, but total electricity demand grew at approximately 1.7 times this rate.

Future growth rates for total energy demand relative to economic growth may decline due to increased energy costs and increased conservation efforts. However, the demand for electricity is still expected to grow more rapidly than total energy demand, due to its convenience and versatility, and due to the increasing reliance in the future on electricity, coal and renewable energy resources, as oil and natural gas supplies are reduced.

(ii) Electrical Power Supply in British Columbia

In 1978, electricity supplied approximately 16.3 percent of the province's total energy requirements. About 90 percent of this electricity was generated by hydro power and the remainder was generated by natural gas, oil and hog fuel.

Electrical energy is generated in the province by B.C. Hydro, by a number of industries including Alcan and Cominco for their own use, by the city of Nelson, and by the West Kootenay Power and Light Company, a private utility owned by Cominco. The generation installed by Alcan, Cominco, the West Kootenay Power and Light company and the city of Nelson is all hydroelectric. The generation installed by industries other than Alcan and Cominco is predominantly thermal-electric. Most of this other generation is installed in the pulp and paper industry in conjunction with process heat facilities and is fuelled by waste wood, oil and natural gas.

In 1978, total electricity generation for domestic consumption in British Columbia was 40 010 GW.h. Of this total, B.C. Hydro generated 28 530 GW.h, or about 71 percent, and the remaining 29 percent was generated by private industry and other utilities.

B.C. Hydro presently provides residential electric power service to 92 percent of the population in British Columbia. Almost all of the future load growth in British Columbia will be served by B.C. Hydro. The only prospects for a future increase in private power generation are the possible expansion of Alcan's Kemano hydro project, small additions to Cominco's generating facilities on the Kootenay and Pend-d'Oreille rivers, and some limited development of additional self-generation facilities by the forestry industry.

B.C. Hydro now has one major power project under construction, the Revelstoke hydro project, and when it is completed by 1984, the total energy capability of the B.C. Hydro power system will be as itemized in Table 1-1. In 1984, 88 percent of B.C. Hydro's generating capacity will be hydroelectric, and almost all of the energy generation will be hydroelectric. The firm energy that B.C. Hydro's power system can generate during a low streamflow period will be 45 700 GW.h/annum by 1984, and average hydro generation at that time will be about 46 510 GW.h/annum, as shown in Table 1-1.

(iii) B.C. Hydro's Role in Meeting Provincial Power Needs

Electric power loads on the B.C. Hydro system have more than doubled in the last ten years. The demand for electricity is increasing continuously with the growth of the economy, and the power demands on most electric utilities in North America have doubled almost every ten years at historic rates of growth. This growth has led to a significant risk of

TABLE 1-1
B.C. HYDRO INTEGRATED POWER SYSTEM CAPABILITY - 1984

| Project | Dependable Capacity[1] (MW) | Nameplate Capacity (MW) | Average Energy (GW.h/annum) | Firm Energy (GW.h/annum) |
|---|---|---|---|---|
| HYDRO | | | | |
| Existing | | | | |
| G.M. Shrum (Peace) | 2 680 | 2 416.0 | 13 180 | 13 420 |
| Mica | 1 600 | 1 736.0 | 7 640 | 6 760 |
| Kootenay Canal | 529 | 529.2 | 3 150 | 2 160 |
| Other Hydro | 1 594 | 1 513.0 | 8 170 | 7 160 |
| Peace Canyon | 700 | 700.0 | 3 340 | 3 510 |
| Seven Mile | 529 | 607.5 | 3 140 | 2 640 |
| Subtotal | 7 632 | 7 501.7 | 38 620 | 35 650 |
| Under Construction | | | | |
| Revelstoke (4 units)(1983) | 1 800 | 1 843.0 | 7 890 | 6 880 |
| Total Hydro | 9 432 | 9 344.7 | 46 510 | 42 530 |
| THERMAL | | | | |
| Burrard[2] | 0 | 912.5 | variable | 3 170 |
| Gas Turbines | 331 | 332.4 | | 0 |
| Total Thermal | 331 | 1 244.9 | | 3 170 |
| TOTAL SYSTEM | 9 763 | 10 589.6 | | 45 700 |

1. All capabilities shown are dependable winter peak capabilities and include losses due to reservoir drawdown under critical water conditions.

2. Burrard firm energy capability is based on use of summer "valley" gas only. In the winter months, a gas supply for Burrard is not assured and therefore the Burrard generating capacity is not considered dependable.

future power shortages in the next decade for many electric utilities in North America due both to the rapid growth of power demands and also the increasing difficulty and delays in licensing and building new powerplants.

Many people are concerned about the scale and rate of future economic growth and its accompanying consumption of limited natural resources and effects on the environment. Opposition to the expansion of electric energy supply as an inevitable consequence of economic growth is just one aspect of that concern. It is clear that unconstrained exponential growth of the economy and its power demands cannot continue forever at historic rates; the questions of more immediate concern are, "Will growth continue in the near future?" and, "At what rate?".

B.C. Hydro has the responsibility of serving the public by supplying future power demands at the minimum cost consistent with the reliability, safety and public acceptability of new sources of power supply. B.C. Hydro can and does promote electricity conservation, but such conservation is entirely voluntary. Current expectations are that the growth rates of future power demands will be significantly lower than historic growth rates; this is reflected in B.C. Hydro's forecast.

## (c) Forecasting the Requirements for Electrical Energy

### (i) Load Forecast Procedure

B.C. Hydro's forecast of future energy requirements has been derived in accordance with conventional utility forecasting techniques. It is based on an extrapolation of past trends of demand, modified as considered appropriate by known or expected developments in patterns of energy use.

B.C. Hydro annually prepares estimates of electrical energy sales, transmission losses, gross energy requirements and peak demands for a 10-year budget period and a further 10-year planning period. Energy forecasts are made first and peak demand estimates are then established by applying appropriate load factors to forecast energy demands. The peak demand estimates are based on normal weather, and these normal winter peak demands may be exceeded by as much as 6 percent if colder weather occurs with a probability of about one year out of ten. For the 10 to 20-year planning period, a general extension of total load projections is made consistent with population estimates and related economic indicators.

Projections become progressively more uncertain as they are extended into the future. They are not targets, but rather a considered expectation of what may reasonably occur under given sets of conditions. They provide a rational basis for specific short-range planning and general planning for the longer term. In order that forecasts may reasonably reflect changing conditions, they are reviewed and updated annually.

### (ii) B.C. Hydro Load Forecast, 1980 to 2000

B.C. Hydro's most recent forecast of future loads on the B.C. Hydro system is shown in Table 1-2. This forecast shows the expected electric loads on the total B.C. Hydro system, including all transmission and distribution losses, and including all future deficits expected by the West Kootenay Power and Light Company. The expected average annual rate of load growth for energy is 6.1 percent from 1980 to 1990, and about 5.2 percent from 1980 to 2000, as shown in Table 1-2.

The forecast rate of growth of peak power demands is slightly higher than for average energy demands, as shown in Table 1-2. However, future peak loads will have no effect in determining the scheduling of new generation projects in the forecast period, because new generation projects will be required to provide firm energy generation rather than for their peaking capacity. The actual peaking capacity provided is determined by the plant capacity required to optimize energy production from the available water.

TABLE 1-2
B.C. HYDRO 1980 PROBABLE FORECAST
ELECTRIC GROSS LOAD REQUIREMENTS[1]

| Fiscal Year | Total B.C. Hydro Peak (MW) | Total B.C. Hydro Energy (GW.h) | Integrated System Peak (MW) | Integrated System Energy (GW.h) |
|---|---|---|---|---|
| 1979/80 (Actual) | 5 231 | 29 913 | 5 198 | 29 762 |
| 1980/81 | 5 540 | 31 450 | 5 500 | 31 285 |
| 1981/82 | 6 040 | 34 160 | 6 000 | 33 985 |
| 1982/83 | 6 600 | 37 340 | 6 560 | 37 155 |
| 1983/84 | 7 150 | 40 510 | 7 100 | 40 315 |
| 1984/85 | 7 680 | 43 690 | 7 630 | 43 485 |
| 1985/86 | 8 090 | 46 010 | 8 040 | 45 790 |
| 1986/87 | 8 560 | 48 250 | 8 500 | 48 015 |
| 1987/88 | 9 020 | 51 130 | 8 960 | 50 880 |
| 1988/89 | 9 410 | 53 150 | 9 340 | 52 885 |
| 1989/90 | 9 830 | 55 170 | 9 760 | 54 890 |
| 1990/91 | 10 300 | 57 580 | 10 230 | 57 280 |
| 11-Year Av. Growth 1979/80:1990/91 | 6.4% | 6.1% | 6.3% | 6.1% |
| 1991/92 | 10 800 | 60 500 | 10 730 | 60 200 |
| 1992/93 | 11 300 | 63 100 | 11 230 | 62 800 |
| 1993/94 | 11 800 | 65 800 | 11 730 | 65 500 |
| 1994/95 | 12 300 | 68 400 | 12 230 | 68 100 |
| 1995/96 | 12 800 | 71 200 | 12 730 | 70 900 |
| 1996/97 | 13 300 | 74 100 | 13 220 | 73 700 |
| 1997/98 | 13 900 | 77 200 | 13 820 | 76 800 |
| 1998/99 | 14 500 | 80 300 | 14 420 | 79 900 |
| 1999/00 | 15 100 | 83 400 | 15 020 | 83 000 |
| 2000/01 | 15 700 | 86 500 | 15 620 | 86 100 |
| 21-Year Av. Growth 1979/80:2000/01 | 5.4% | 5.2% | 5.4% | 5.2% |

Prepared September 1980

1. Forecast includes West Kootenay Power & Light Co. Ltd. and Cominco requirements and all losses except thermal station service at major thermal plants and assumes natural gas on Vancouver Island by 1985/86.

The forecast of future residential electrical power demands takes into account an increasing trend towards use of electricity for space heating. However, it also recognizes several factors which are expected to moderate future growth in residential use: increased conservation efforts, increased efficiency in new appliances, some supplemental solar heating, expected legislation concerning insulation in new dwellings, and the expected future supply of natural gas to Vancouver Island.

The electric forecast of 6.1 percent is in effect Hydro's "best informed estimate" as to how future loads will develop, taking into account anticipated economic conditions and developments and such factors as the relative costs of various forms of energy and growing public awareness of energy conservation. B.C. Hydro also prepares a low and a high forecast of growth in electric loads as the minimum and the maximum reasonable estimates of future load growth. B.C. Hydro's low forecast shows an average annual growth rate of at least 4.5 percent from 1980 to 1990, and the high forecast shows an average annual growth rate of at most 8.2 percent from 1980 to 1990.

(iii) The Consequences of Over- or Under-planning

The Ministry of Energy, Mines and Petroleum Resources has also recently prepared forecasts of future provincial economic growth, future energy demands and future electricity demands in British Columbia. The Ministry's forecasts have differed significantly from B.C. Hydro's forecast of future electricity demand. In view of these differences, it is worth considering the problem of uncertainty in load forecasting, and the *consequences of over- or under-planning* to meet future power demands.

No single load forecast can be a perfect estimate of exactly what will happen in the future. B.C. Hydro's probable load forecast represents what we consider the most probable development of future loads, but the uncertainty of this load forecast is recognized by bracketing it with a high and a low load forecast.

In the face of such uncertainty regarding future load growth, which forecast would be most appropriate for planning purposes? When there is doubt as to the future level of energy consumption, it is considered more prudent to plan to meet a higher forecast than a lower one. If projects are begun too soon, it is usually possible to delay completion to coincide with a subsequently reduced load forecast. Some additional costs might be incurred if schedules have to be delayed once started, but the costs would be much less than the alternative if the load requirements are suddenly recognized as having been underestimated and projects have to be accelerated using crash construction schedules with premium construction pay.

If future load growth is over-estimated, it is also very likely that all the surplus electricity generation from any new projects that are completed before they are absolutely required in British Columbia could be exported to the United States on a short-term basis at a price that would more than cover their annual costs, thus effectively reducing future rates for B.C. customers.

If, on the other hand, future load growth is under-estimated, there is no assurance that construction and manufacturing schedules could be accelerated sufficiently to meet such increased loads, and if they could, such an accelerated construction program would certainly result in a large increase in costs. If a new project cannot be completed by the time it is required, then at best B.C. Hydro would be faced with heavier reliance on costly thermal generation from the gas-fired Burrard powerplant. At worst, if gas supplies and options for power purchases are limited, B.C. Hydro and its customers would face a shortage of electricity with all its consequences for expanding industry and jobs.

We would conclude that B.C. Hydro's probable load forecast should be used for planning future power supplies. This forecast provides an adequate assurance of being able to meet uncertain future power demands in a reliable and economic manner, and does not impose undue economic penalties. To plan for any forecast that is significantly less than this would involve a high risk of future power shortages and the prospect of increased costs for new electric generation.

In this context it is important to appreciate that B.C. Hydro revises and updates its load forecast annually in light of the most recent experience of the actual load on the system, and if future load forecasts are reduced before major project commitments are made, then those future projects will be rescheduled and deferred as necessary.

### (d) Criteria for Planning to Meet Forecast Loads

#### (i) Introduction

Having estimated the future demand for electricity from the B.C. Hydro system, it is necessary to establish both the optimum sequence of installation of new generating plants and the in-service schedule for each project. First of all an inventory of potential projects is compiled, together with preliminary estimates of their costs, including cost estimates for the associated transmission additions expected to be required to meet the increasing load on the system.

By considering these projects in relation to the technical and economic criteria developed for planning, and taking into consideration all environmental and socioeconomic implications of development which are known at this stage of the planning process, an optimum sequence of new power developments is selected. This generation program, extending some 15 years into the future, provides the basis for recommending the next project or projects for development in the B.C. Hydro power system.

#### (ii) Environmental and Socioeconomic Considerations

The environmental effects of energy resource development have social and economic implications for the public at large, and are therefore of concern to government. The formal interest of the government in these matters is embodied in various statutes of the provincial and federal governments, the provisions of which must be adhered to by B.C. Hydro before facilities can be constructed.

The planning of new generation facilities, including related studies and investigations, must be initiated several years before application is made under relevant legislation to allow construction to begin. Not all potential projects in the inventory can be studied in depth at one time. The planning process is progressive, with the projects which are apparently more economic and less disturbing to the environment receiving earliest study attention. Projects which have been included for construction in the early years of the generation program will have received extensive study, whereas those in later years may only have been studied in a preliminary manner.

The length of time required for environmental and engineering planning studies and licensing of new projects often constitutes an important constraint on the estimated earliest feasible in-service dates of those projects, and consequently may govern whether or not those projects are really feasible alternatives for early development.

(iii)Technical Planning Criteria

Given a forecast of demand for electricity, the scheduling of generation projects is determined primarily by the planning requirements of supplying the forecast peak load and energy demands in a reliable and economic manner.

A. Energy Requirements

Additions of generating plant are scheduled so that the firm energy capability of the system will be equal to or greater than the forecast electric energy demand including transmission and distribution losses.

The firm energy capability of the hydro-electric generation on the system is established by the average energy available during the worst drought in the historic streamflow record. This drought, referred to as the critical period, occurred from 1942 to 1946 and resulted in an average energy capability for those years of approximately eight percent less than the average capability over the longer period of record from 1940 to 1975.

B. Peak Load Requirements

In addition to supplying the average energy demand, the B.C. Hydro power system must be able to meet the peak power loads each winter, and it must also have a minimum margin of reserve generating capacity (usually 12 to 15 percent of peak load) over and above the forecast peak to allow for scheduled and unscheduled outages of equipment. The exact amount of capacity reserve required is based on a statistical analysis of the probability of outages on each unit in the system.

The B.C. Hydro system currently has a high level of total generating capacity relative to its firm energy capability. Hence, the need for new generation plants is determined by the need for additional firm energy rather than peak generating capacity.

(iv)Economic Planning Criteria

In scheduling new plant additions, the capital costs and annual costs (including fuel) of alternative projects and sequences of power system development are evaluated using a discounted cash flow analysis to establish the most economic sequence and timing of new generation projects. Computer models are used to simulate the system operation for projected loads with the sequence under consideration. This is to confirm the capability of the proposed system to meet energy and capacity requirements, and also to determine the quantity of natural gas which might have to be burned at

Burrard Thermal Plant, near Vancouver, to make up the difference between the forecast energy demand and the supply from hydroelectric sources, which depends upon streamflow and future weather.

(e) The Need for the Hat Creek Project

(i) Required In-service Date for Next Project

The need for a new project is illustrated graphically by the load/resources balance in Figure 1-2 which shows the committed system capability compared to forecast loads. This load resources balance assumes that the Peace Site C project will be approved and constructed for a 1987 in-service date. Three load forecasts are shown, high, probable and low, together with the committed system capability under long-term average water conditions, and critical water conditions corresponding to the period from September 1942 through April 1946. The high-cost thermal energy which may be available from the Burrard Thermal Plant is shown with cross-hatching at the top of the blue and red bars, indicating that it is generated only when absolutely essential due to the high operating cost of the plant. Moreover, the availability of natural gas to operate the plant cannot be assured.

From Figure 1-2 it is evident that additional generating capacity will be required to meet the forecast probable load growth as soon as possible after the Peace Site C project is commissioned in October 1987. Even with a 1987 in-service date for Peace Site C, Figure 1-2 shows that B.C. would run a risk of significant firm energy deficits after 1985/86. This risk could be reduced if: 1) future load demands are less than the current probable forecast; or 2) average or above average water conditions occur in 1986 to 1988; or 3) firm energy imports and purchases are feasible in 1986 to 1988.

Due to the uncertainty of future firm energy purchases, B.C. Hydro must plan to have available additional generating capacity as soon as possible after commissioning the Peace Site C project in 1987. The alternative projects available for this additional power supply are described in the following section.

(ii) Alternative Projects Available

The number of feasible alternatives to the Hat Creek project is limited. Although there are many potential future hydro and thermal power projects in British Columbia, most of them are not sufficiently advanced that they can be considered as practical and feasible alternatives to the Hat Creek project. The earliest feasible in-service dates of new generation projects that B.C. Hydro has under study for future construction following Peace Site C are summarized in Table 1-3.

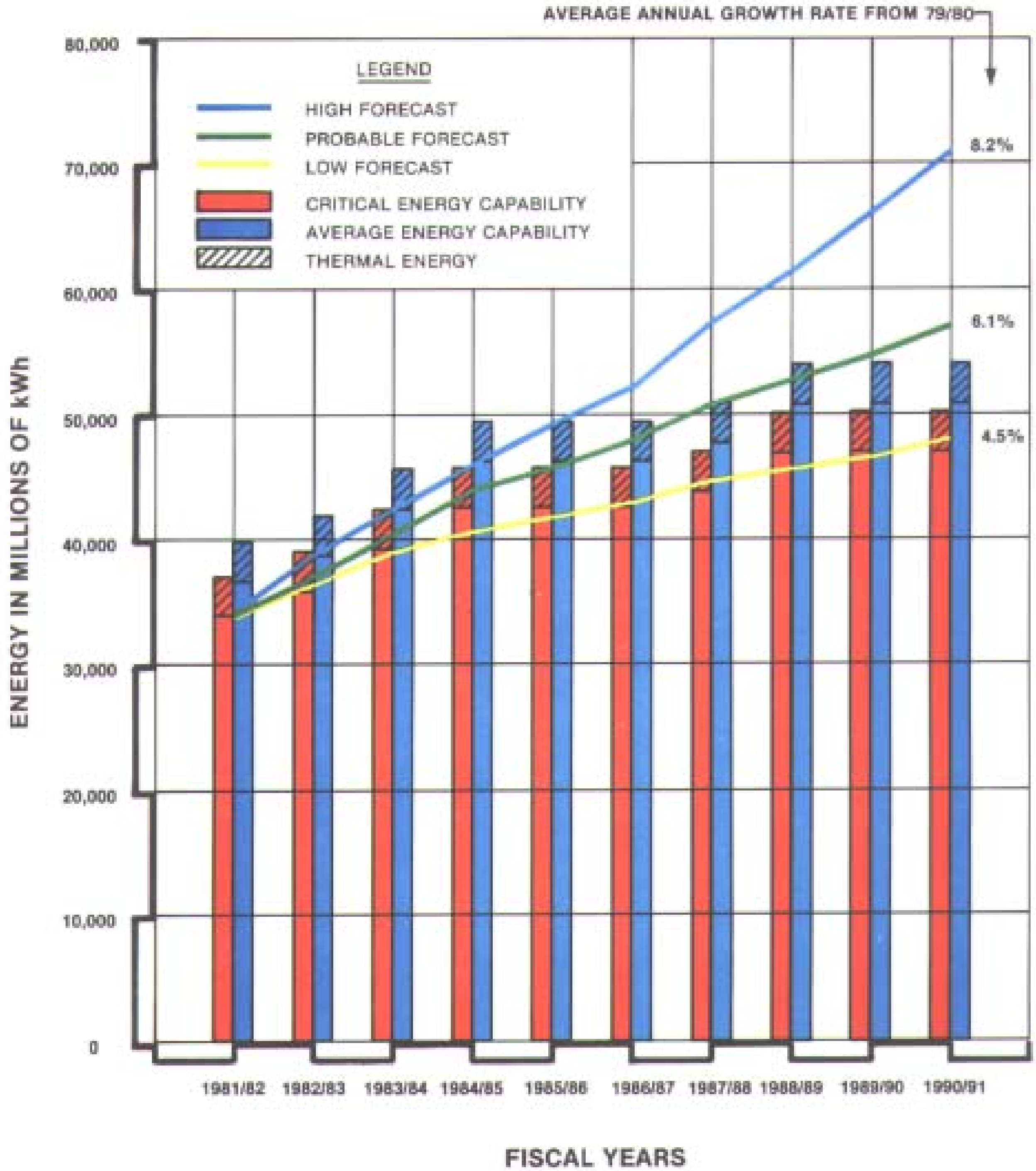
The firm energy capabilities and the average energy costs of the projects shown in Table 1-3 are summarized in Figure 1-3. The average energy costs shown in Figure 1-3, which are relative to the Revelstoke hydro project, are all at equivalent price levels, and include the costs of major project transmission lines required to deliver power to the integrated transmission system, as well as the effect of transmission losses. Although B.C. Hydro has no specific plans for a future nuclear powerplant in British Columbia, nuclear power is included in Figure 1-3 for purposes of comparison with other potential power sources.

## TABLE 1-3
## POSSIBLE NEW GENERATION PROJECTS FOLLOWING PEACE SITE C

| Project | Earliest In-service Date | Nominal Generation Capacity (MW) | Firm Energy (GW.h/a) |
|---|---|---|---|
| Hydro | | | |
| Kootenay Diversion | March 1987 | 0 | 790 |
| Murphy Creek | October 1989 | 400 | 1 780 |
| Iskut sites | October 1990 | 935 | 4 050 |
| Stikine sites | October 1992 | 1 830 | 8 970 |
| Liard sites | October 1993 | 4 760 | 23 900 |
| Thermal | | | |
| Hat Creek | August 1988 | 2 000 | 13 140 |
| East Kootenay | October 1989 | 600 | 3 940 |
| Nuclear | July 1996 | 1 260 | 8 600 |

With the exception of nuclear power, initial overview studies have been completed on all of the projects listed in Table 1-3, which show that the development of these projects should be feasible. Although there are many other potential future hydro and thermal power projects in British Columbia, the studies for these other alternatives are not sufficiently advanced so that they could definitely be considered as feasible alternatives at this time. These other hydro and thermal alternatives have therefore been omitted from the following discussion of feasible alternatives to meet load growth in the near future.

For the same reason, non-conventional power sources such as solar power, wind power and tidal power have also been excluded. Utility-scale versions of these non-conventional sources are still in the research and development stage. Furthermore, preliminary cost estimates indicate that with current technology, these alternatives would be much more expensive than conventional power sources. Unless these costs can be reduced through further research and development, and until the technical feasibility and reliable operation of these alternatives is demonstrated with large scale commercial demonstration projects, B.C. Hydro must concentrate its studies of future power sources on more cost-effective conventional alternatives. B.C. Hydro is currently conducting studies on geothermal power generation, but the technical feasibility and costs have not yet been established to the point where it can be considered as a realistic major new energy source within the next decade.



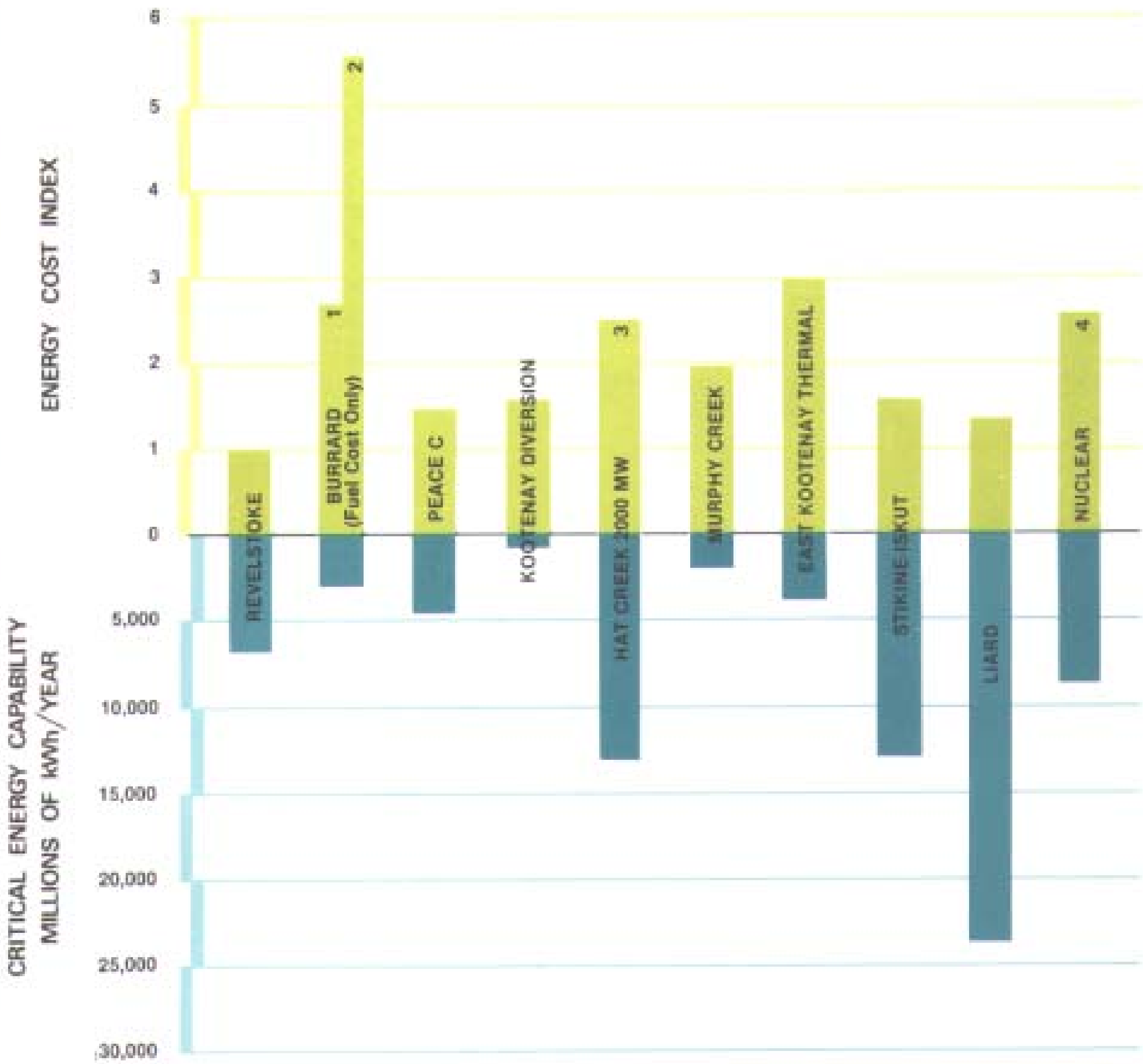

NOTE: Energy Capability in 1981/82 and 1982/83 has been adjusted to reflect the Storage Deficit in Williston Reservoir in the Fall of 1980.

HAT CREEK PROJECT

**FIGURE 1.2**

# COMMITTED SYSTEM PLUS PEACE SITE C ENERGY CAPABILITY COMPARED TO FORECAST LOADS

*SOURCE: British Columbia Hydro and Power Authority*




NOTE: All energy costs are compared with energy costs for the Revelstoke Project (4 Units) on the Columbia River (i.e. Revelstoke has an energy cost index of 1.0)

1. Cost based on current Domestic Price for Natural Gas
2. Cost based on current Export Price for Natural Gas
3. Cost based on design with 50% Flue Gas Desulphurization using wet scrubbing.
4. Although B.C. Hydro has no specific plans for a future nuclear powerplant in British Columbia, the average energy cost of nuclear power is included for purposes of comparison with other potential power sources.

## COMPARISON OF LONG TERM ENERGY COSTS AND CRITICAL ENERGY CAPABILITIES FOR EXISTING AND POTENTIAL PROJECTS

HAT CREEK PROJECT

FIGURE 1.3

# RELATIVE PROJECT COSTS

*SOURCE: British Columbia Hydro and Power Authority*

(iii) Reasons for Recommending Hat Creek

Figure 1-3 shows that, in general, the estimated average energy costs of future hydro developments under consideration would be significantly less than the costs of energy from coal-fired thermal developments. B.C. Hydro's plans for future power system expansion will therefore rely primarily on new hydro developments. However, it is not feasible to develop enough low cost hydroelectric power in time to meet all of the load growth predicted for the late 1980s by the current probable load forecast, due to the long lead time required for the planning, licensing and construction of new hydro developments.

The only feasible powerplants which could be brought into service by the late 1980s would be the Kootenay diversion in 1987, the Hat Creek project in 1988, the East Kootenay project in 1989 and the Murphy Creek project in 1989.

Among these alternatives, the Kootenay diversion has the lowest average energy cost, but it is relatively small and could provide only a small part of the future energy requirements.

The northern hydro developments of the Stikine-Iskut rivers and the Liard River both offer large blocks of energy at relatively low cost, but these projects could not be developed soon enough for a 1988 in-service date with the current schedules for continuing engineering and environmental feasibility studies, project licensing procedures and project construction.

Besides Hat Creek, the only sizeable alternative power projects available for an early in-service date would be the 600 MW East Kootenay thermal powerplant in 1989 and the 400 MW Murphy Creek hydroelectric project in 1989. The Murphy Creek project would have a lower average energy cost than Hat Creek, but it is not large enough to serve all of the anticipated load growth in the late 1980s. Additional energy supply will be required as well. Figure 1-2 indicates that by fiscal year 1989/90 total firm energy supply will have to be increased by about 4500 GW.h/annum to meet the probable load forecast (i.e. by 1989/90, the forecast probable load will be about 4500 GW.h/annum higher than the firm energy capability of the committed power system plus Peace Site C).

The 600 MW East Kootenay project could supply some of this additional power, but it could not be developed soon enough to meet all of the probable load forecast in the late 1980s. The already serious firm energy deficits anticipated in the mid and late 1980s would be increased even further if the Hat Creek development in 1988 were replaced with the East Kootenay and Murphy projects in 1989.

Even if future load forecasts are reduced slightly and the East Kootenay project becomes a feasible alternative to Hat Creek, it would be a less attractive project than Hat Creek for a number of reasons. The average energy costs for East Kootenay are slightly higher than those for Hat Creek, as shown in Figure 1-3. Furthermore the coal supply for the East Kootenay project is not assured, since the project would rely on refuse coal which is now a waste by-product of the B.C. Coal Company's metallurgical coal mining operations at Sparwood. A uniform quality and a continuing reliable supply of this refuse coal throughout the 35-year project lifetime cannot be guaranteed. Due to the low quality of East Kootenay coal, a beneficiation plant for washing the coal would probably be required and this has been included in the project costs. Separately mined good quality thermal coal could be used as a back-up coal supply in case of a shortage of future refuse coal supplies, but this would raise the average fuel costs for the East Kootenay project.

Other alternative sources of power supply without Hat Creek could also be considered, such as the Kootenay Diversion, the purchase of surplus power from Alcan's proposed Kemano completion project, the possible purchase of surplus power from Alberta, or an increase in firm power supply from the Burrard powerplant with a firm gas supply contract for the winter months.

However, the feasibility and the costs of these other alternatives have not as yet been established to the level of confidence required to consider them as realistic and feasible alternatives to Hat Creek. In the future, as these alternatives are better defined, and as the load forecast is revised, these alternatives will be reviewed. At this time however, the Hat Creek project remains the only reasonably assured source of power supply which is large enough and which can be constructed soon enough to supply a large part of the forecast probable load growth after 1987.

B.C. Hydro's *current system development plan, shown in* Figure 1-4, therefore proposes to develop the Hat Creek project as the next major project after Peace Site C at its earliest in-service date, with the first commercial energy being generated in August 1988. It is proposed that the 2000 MW development be licensed with the four units following at one year intervals. However, because of the uncertainties of load forecast and the potential opportunity for the Murphy Creek and Stikine projects, flexible in-service dates for Units 3 and 4 may be required.

## 1.3 STUDY PROGRAM

### (a) Relevant Studies

B.C. Hydro's interest in Hat Creek coal as a potential fuel for electric energy generation was renewed in 1972. Monenco was commissioned by the British Columbia Energy Board to study and recommend the most attractive sequence of electrical plant construction up to 1990. Monenco's 1972 report[4] recommended a program of combined hydroelectric and thermal power development, with the thermal generation to utilize coals from either the East Kootenay or Hat Creek areas. A subsequent inventory of provincial coal resources by Dolmage, Campbell and Associates (1975)[5] indicated that the Hat Creek deposit has sufficient proven reserves to supply a 2000 MW coal-fired electric plant for at least 35 years.

The next impetus for Hat Creek development came from B.C. Hydro's Task Force on future generation projects. In its May 1975 report the Task

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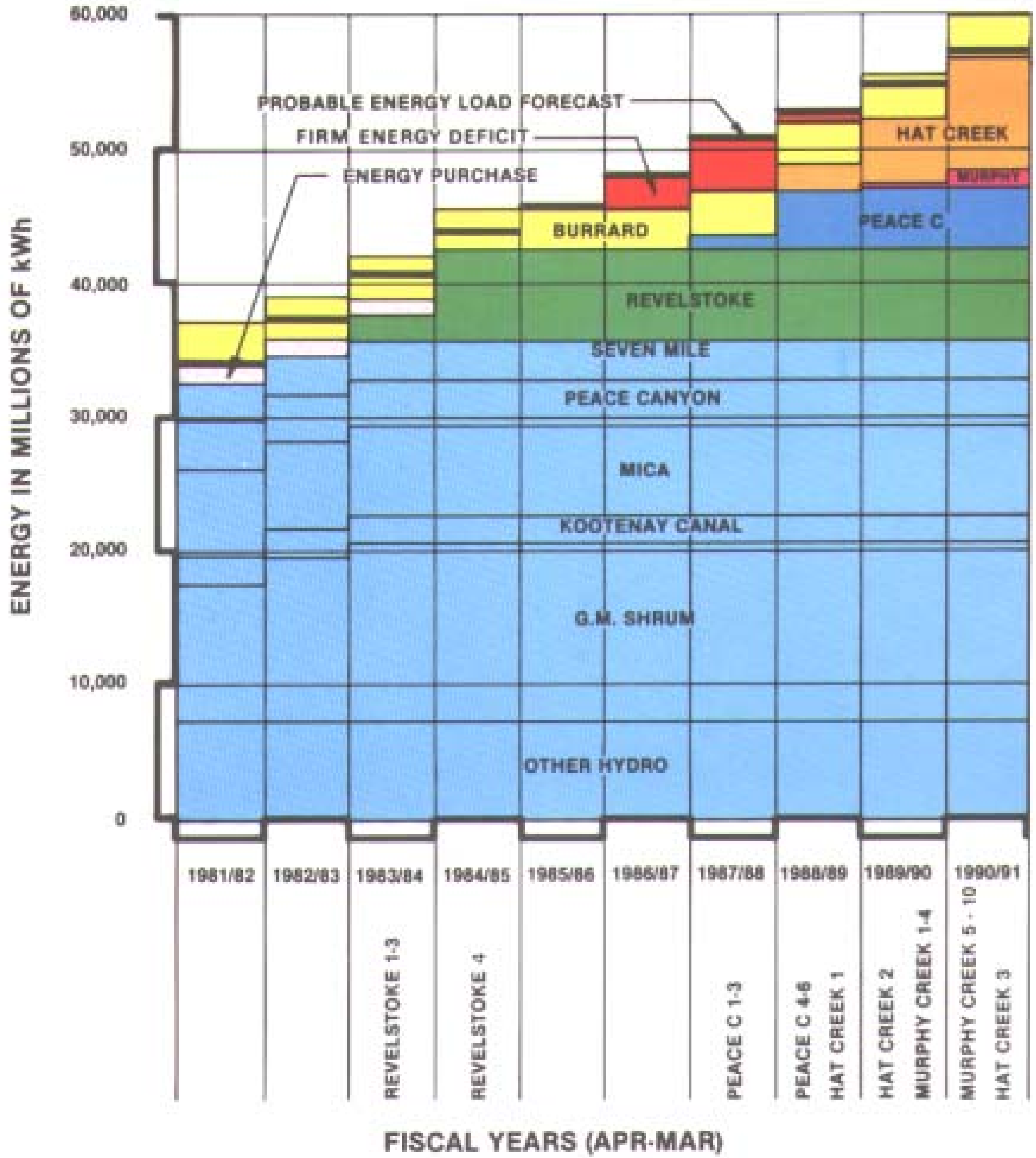
[4] Monenco Consultants Pacific Ltd. - Report on Electrical Energy Resources and Future Power Supply, British Columbia 1972-1990 - B.C. Energy Board - 1972.

[5] Dolmage, Campbell and Associates Ltd. - Coal Resources of British Columbia - 1975.




NOTES: (1) All Hydroelectric Plant Energy Capability Based on Critical Water Conditions

(2) Energy capability in 1981/82 and 1982/83 has been adjusted to reflect the storage deficit in Williston reservoir in the fall of 1980.

HAT CREEK PROJECT

## FIGURE 1.4

# LOAD FORECAST AND RESOURCES 1981/82 - 1990/91

*SOURCE: British Columbia Hydro and Power Authority*

Force concluded that, at the time, coal-fired thermal power at Hat Creek was the most economic way of meeting load growth in the province from 1983 to 1990.

On the strength of the Task Force recommendations, B.C. Hydro began to investigate the possibility of a thermal electric generating plant at Hat Creek more fully. It was recognized that the first major coal-fired thermal plant in the province would require close attention to its effects on the environment. To determine these effects, B.C. Hydro commissioned a preliminary environmental impact study jointly authored by B.C. Research and Dolmage, Campbell and Associates. The preliminary impact report, completed in August 1975,[6] assessed the environmental impacts of the mine and a powerplant located at various sites in the vicinity of the Hat Creek deposit. At that time several different sites were under consideration. The report identified environmental impacts for each of the various sites, but made no site selection recommendations.

Following the preliminary environmental study, the project appeared sufficiently feasible to merit detailed investigation. A detailed site evaluation study was undertaken by Integ-Ebasco(30) in order to choose the best powerplant location to meet both engineering and environmental criteria. Detailed environmental studies were assigned to several consulting firms in 1976. A co-ordinating consultant, Ebasco Services of Canada Ltd., Environmental Consultants (ESCLEC), was selected to direct the detailed studies and provide scheduling and reporting functions for B.C. Hydro.

The detailed environmental studies were divided into five major subgroups: land resources, water resources, socioeconomics, air quality and general aspects. Table 1-4 shows the consulting groups responsible for each component of the detailed environmental studies. In late 1978 ESCLEC produced their draft of the "Hat Creek Environmental Impact Assessment Report"(EIAR) (31), which summarized the environmental work that had been undertaken up to that point.

It should be noted that the project design continued to evolve during the course of the detailed environmental studies. When the detailed studies began in the fall of 1976, the consultants were instructed to assess the impacts of the project as it was tentatively defined at that time. Recommendations by engineering and environmental consultants were subsequently incorporated into the project design, sometimes resulting in major changes. Consequently, the detailed environmental studies did not in all cases address the finally selected project design upon which this report is based. To update the original impact studies, a number of smaller bridging documents have been prepared and these as well as other recent information have been included.

The final step in the sequence of studies is B.C. Hydro's production of this EIS report. This report is based upon information contained in the voluminous detailed environmental studies and the bridging documents. It summarizes all previous reports and outlines B.C. Hydro's selected project design. Background documents, including relevant engineering reports and detailed environmental studies, are referenced in this document. All this material is available for public review through B.C. Hydro or major public libraries throughout the province.

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[6] British Columbia Research, Dolmage Campbell and Associates Ltd. - Preliminary Environmental Impact Study of the Proposed Hat Creek Development - 1975.

TABLE 1-4

CONSULTING GROUPS RESPONSIBLE FOR DETAILED ENVIRONMENTAL STUDIES

| | | |
|---|---|---|
| Land Resources Subgroup | Physical Habitat and Range Vegetation | The Tera Environmental Resource Analyst Ltd. and Canadian Bio-Resources Consultants Ltd. |
| | Assessment of Impacts of Airborne Emissions on Vegetation | V.C. Runeckles |
| | Wildlife | The Tera Environmental Resource Analyst Ltd. |
| | Forests | Reid, Collins and Associates Ltd. |
| | Agriculture | Canadian Bio-Resources Consultants Ltd. |
| | Recreation | Ebasco Services of Canada Ltd.: Environmental Consultants; Bruce Howlett Inc. Consultant |
| | Solid Waste Disposal, Coal Storage and Land Reclamation | Acres Consulting Services Ltd. |
| Water Resources Subgroup | Hydrology, Drainage, Water Quality and Use | Beak Consultants Ltd. and Kellerhals Engineering Services Ltd. and Golder, Brawner & Associates Ltd. |
| | Fisheries and Benthic Fauna | Beak Consultants Ltd. |
| | Water Intake | Ebasco Services of Canada Ltd.: Environmental Consultants |
| Socio-Economic Subgroup | Impacts on Human Society ) <br> Impacts on Community Services and Infrastructure ) | Strong, Hall and Associates Ltd., Cornerstone Planning Group Ltd., and Urban Systems Ltd. |
| | Indian Socio-Economic Characteristics | Strong, Hall and Associates Ltd., and Bob Ward Management Services |
| | Resource Evaluation | Strong, Hall and Associates Ltd. |
| | Archaeological and Historic Sites | Dept. of Anthropology and Sociology, University of British Columbia |

TABLE 1-4 - (Cont'd)

| | | |
|---|---|---|
| Air Quality Subgroup | Fugitive Dust Evaluation | Cominco-Monenco Joint Venture |
| | Air Quality and Climatic Effects | |
| | - Summary | Environmental Research and Technology, Inc. |
| | - Meteorological and Air Quality Data | Environmental Research and Technology, Inc. |
| | - Modeling Methodology | Environmental Research and Technology, Inc. |
| | - Alternate Methods of Ambient $SO_2$ Control | Environmental Research and Technology, Inc. |
| | - Assessment of Atmospheric Effects and Drift Deposition Due to Alternate Cooling Tower Designs | Environmental Research and Technology, Inc. |
| | - Climatic Assessment | Environmental Research and Technology, Inc. |
| | - The Influence of the Project on Trace Elements in the Ecosystem | Environmental Research and Technology, Inc. |
| | - Epidemiology (Health) | Environmental Research and Technology, Inc., prepared by: Western Research and Development Ltd. and Greenfield, Attaway and Tyler, Inc. (Flow Resources) |
| | - Aerometric Monitoring | Environmental Research and Technology, Inc., prepared by: Western Research and Development Ltd. |
| | - Long Range Transport and Implications of Acid Precipitation | Environmental Research and Technology, Inc. |
| | Inventory of Sources and Emissions | B.H. Levelton and Associates Ltd. |
| | Plume Simulation Gas Tracer Studies | North American Weather Consultants |

TABLE 1-4 - (Cont'd)

| | | |
|---|---|---|
| General Subgroup | Noise | Harford, Kennedy, Wakefield Ltd., Acoustical Consultants |
| | Minerals and Petroleum | McCullough, P.T., System Engineering Division, B.C. Hydro and Power Authority |
| | Trace Elements | (1) Environmental Research and Technology, Inc. |
| | | (2) B.C. Hydro and Power Authority and James F. McLaren Ltd. |
| | Aesthetics | Toby, Russell, Buckwell and Partners, Architects |
| General Summary | Environmental Impact Assessment Report | Ebasco Services of Canada Ltd.: Environmental Consultants |

## (b) Community Relations

When engineering and environmental studies for the Hat Creek project were initiated in 1974, communication was established between B.C. Hydro and people resident in the region. This program had two main objectives: to provide timely information about the project to interested groups or individuals, and to provide a forum through which public concerns could be voiced during the project planning stage.

The program included provision of public information bulletins, distribution of background reports, and numerous meetings with concerned groups in the area. Five information bulletins were released through the course of the program to provide information about the environmental studies and about project features. Background reports, including the now superceded "Preliminary Environmental Impact Study" were distributed to government agencies and to the general public. Contact was initiated with local groups, including residents of the Hat Creek valley, local Native Indian bands, municipal officials, environmental groups and provincial government regional offices. The community relations program continued through 1977, at which time the project timing became uncertain.

Continued liaison will be maintained during the forthcoming review of this report and the period of licence application. Further information about the proposed Hat Creek development can be obtained from B.C. Hydro's Hat Creek Information Officer at Box 12121 - 555 West Hastings Street, Vancouver, B.C. V6B 4T6, or by visiting B.C. Hydro's Hat Creek information office in Cache Creek.

## 2.1 THE HAT CREEK VALLEY

### (a) Description

The Hat Creek valley forms part of the Thompson Plateau of British Columbia's central interior. This broad region between the Clear Range and the Shuswap Highlands consists of rolling uplands with a few deep valleys. Two major rivers, the Thompson and Fraser, and many smaller streams, have eroded the plateau and formed these valleys.

Hat Creek rises in the mountains within the "V" formed by the confluence of the Thompson and Fraser rivers, north of Lytton (see Figure 2-1). The creek traverses a broad, north trending grassland about 28 km in length. It is located about 200 km northeast of Vancouver and 90 km west of Kamloops. The Hat Creek valley varies in elevation from about 1675 m above mean sea level at its source to about 490 m at its northern end where Hat Creek joins the Bonaparte River, which in turn flows into the Thompson River just north of Ashcroft. Hat Creek is flanked by mountains that gradually rise to elevations of about 2300 m, 7.5 km to the west, and about 2070 m, 10.5 km to the east. The uplands are covered with open forests and meadows, while the valley bottom consists of sparsely treed open ranges of grass and sage.

### (b) Existing Activities

Predominant land uses of the Hat Creek valley are, at present, agriculture, forestry and wildlife habitat. Virtually all the valley bottom has been included in the provincial Agricultural Land Reserve. About 880 ha of irrigated hay land is found within the upper Hat Creek watershed, but the primary agricultural use is grazing of beef cattle. Privately owned lands, which cover major portions of the valley bottom, are supplemented by Crown grazing leases extending over both open ranges and forests. Some parts of the valley have been logged and further timber harvesting is planned. Wildlife occurs throughout the watershed, particularly along the creek bottoms and near various small lakes. Although the valley is picturesque and offers good potential for outdoor recreation, it is little used by non-residents. Recent coal exploration activities and a gravel pit represent the only evidence of non-renewable resource development.

The 30 to 40 permanent residents constitute about ten family groups. These families are distributed on ranches throughout the valley, and are nearly all active in agriculture.

Two Native Indian bands have reserves near the north end of the valley, namely the Bonaparte and Pavilion Bands. The Oregon Jack and Ashcroft Bands have reserves nearby to the east. The Native Indian bands participate in the agricultural and related activities of the area.

Access to the valley is easiest along Highway No. 12, which runs between Carquile and Lillooet. The towns of Ashcroft and Cache Creek, which are both on Highway No. 1, are the regional service centres nearest to the proposed Hat Creek project site.

## 2.2 THE COAL RESOURCE(20)

### (a) Background

The Hat Creek valley contains two major deposits of low grade coal. Coal outcrops were officially recorded in 1877 by G.M. Dawson of the Geological Survey of Canada. Attention centred on the creek banks where erosion had exposed coal in what is now called the No. 1 deposit. A limited amount of exploration and drilling had occurred by 1925, but commercial exploitation of the deposit did not begin until 1933. Between 1933 and 1942 a small amount of coal was mined for sale to local communities. Production ceased in 1942, and further significant activity did not occur until 1957, when a subsidiary of B.C. Electric Company Ltd. purchased an option on the property.

Ownership of the explored Crown grant and two coal licences on deposit No. 1 were transferred to B.C. Hydro when the Crown corporation was formed in 1962. No further exploration occurred until 1974, when B.C. Hydro began preliminary drilling of the known deposit. Later in 1974 and in 1975 B.C. Hydro obtained further coal licences for most of the upper Hat Creek valley. Subsequent exploration confirmed two deposits, the first at the northern end of the valley and the second further south in the upper valley. Detailed geological work on the No. 1 deposit continued into 1979, in an effort to increase and refine B.C. Hydro's knowledge of this major energy resource.

### (b) Hat Creek Geology

The upper Hat Creek valley is flanked by the Clear Range on the west, and by the Trachyte and Cornwall Hills on the east. Surface materials in the valley consist mainly of hummocky areas of till which were deposited by glaciers, and sand and gravel that were deposited by streams. The blanket of till tends to be thick in the valley, but is reduced to a thin veneer on hill tops and steep slopes. The bedrock consists of a wide variety of rock units as illustrated in Figure 2-2.

The upper Hat Creek valley is bordered by older rocks of varying geologic age from approximately 265 million to about 50 million years ago. Some 40 million years ago, towards the middle of the Eocene Epoch, a luxurious growth of subtropical forest flourished in the general area of Hat Creek valley. Slow subsidence of this broad north-trending swamp-marsh complex resulted in a continuous inflow of vegetation material leading to the thickest known low-grade coal deposit in the world.

The Hat Creek coal formation which contains the coal deposit attained a thickness of about 500 m in the No. 1 deposit. The differential rate of sinking of the valley floor and change in the inflow of vegetation material resulted in the development of two major waste zones.

The Medicine Creek formation which overlies the Hat Creek coal formation, consists of an immense thickness of bentonitic claystone and siltstone material.

Volcanic activities continued during the whole deposition cycle and are characterized by ash beds found between the coal beds which are used as marker beds for stratigraphical correlation. These activities were more pronounced during the Miocene Epoch, about 13 million years ago.


HAT CREEK PROJECT

## FIGURE 2.1
# PROJECT LOCATION

(c)Deposit Description

The smaller No. 1 deposit, development of which is proposed by B.C. Hydro for primarily economic reasons, is located near the north end of the valley, and is shown in the next section on Fig. 3.2. The larger deposit No. 2, located south of Anderson Creek, is also illustrated. Total resources in the valley are estimated at 10 to 15 Gt based on drilling and geophysics, making this one of the world's largest known coal resources in such a small area. By way of comparison, the province's total indicated reserves of the higher quality metallurgical coals were estimated at about 8 Gt in 1976.[7]

(d)Coal Quality(34)

The Hat Creek No. 1 deposit contains thermal coal of varying quality. On the scale of coal classification shown in Table 2-1, Hat Creek coal ranks on the borderline between sub-bituminous and lignite.

Because the Hat Creek deposits vary considerably in quality, it is necessary to discuss the average characteristics of the samples of coals which have been tested. The coal is low in heating value, high in ash, fairly high in moisture content and relatively low in sulphur (compared to Eastern North American coals). The presence of significant amounts of clay in the coal affects its physical characteristics, especially when wet. With a cut-off level of 9.3 MJ/kg (dry coal basis, see Section 3.2) coals from the various mine zones would be produced and blended, on a pre-planned program, to produce a uniform powerplant fuel having characteristics as shown in Table 2-2. However, the powerplant has the capability to receive and utilize even lower sulphur coal if required. (Table 2-3)

(e)Alternative Uses

With the rapid increase in world oil prices there has been renewed interest in synthetic fuels based on Hat Creek Coal. B.C. Hydro commissioned an update of the Stone and Webster report (Alternative Uses of Hat Creek Coal(33)) in August 1980, and the Province of British Columbia commissioned Fluor Canada Ltd. to undertake an engineering pre-feasibility study of coal liquefaction. These and other studies will be finalized by late Spring 1981.

Preliminary results indicate the technical feasibility of liquefaction using a Lurgi/Fischer Tropsch process. However there is a degree of uncertainty as to the economic viability of the liquefaction project due to the unpredictable nature of both world oil prices and plant costs. In any case, the development of a liquefaction plant is compatible with the parallel use of Hat Creek coal for thermal generation.

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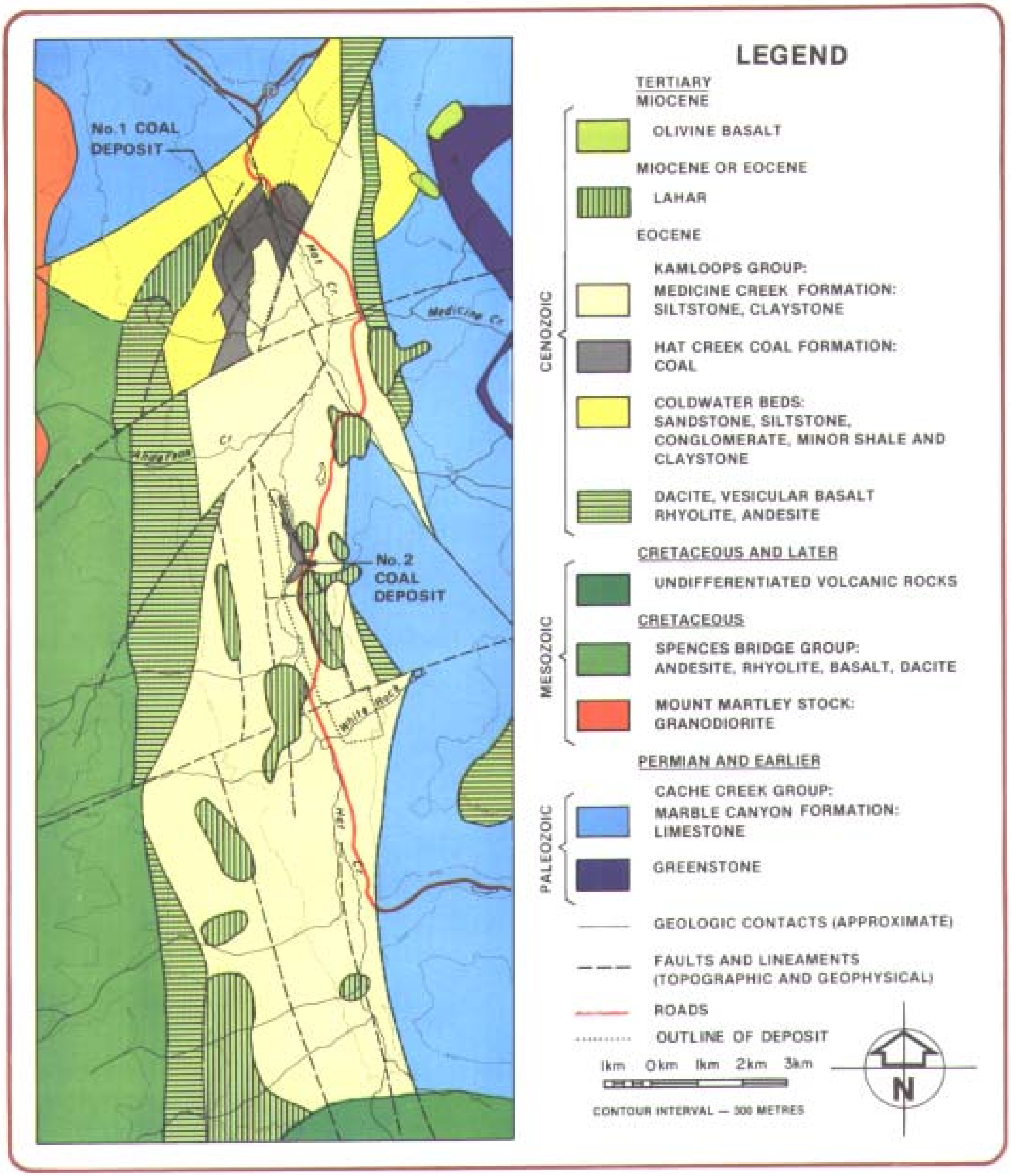
7 British Columbia Coal Task Force - Coal in British Columbia - A Technical Appraisal - February 1976.

TABLE 2-1
CLASSIFICATION AND CHARACTERISTICS OF HAT CREEK COAL (34)

| Group | Heating Value[1] (MJ/kg) | Remarks |
|---|---|---|
| Meta-anthracite | | |
| Anthracite | | |
| Semi-anthracite | | |
| Bituminous lv | | |
| Bituminous mv | | |
| Bituminous hv A | at least 32.56 | |
| Bituminous hv B | 30.24 to 32.56 | |
| Bituminous hv C | 24.42 to 30.24 | |
| Subbituminous | 24.42 to 26.75 | |
| Subbituminous B | 22.10 to 24.42 | |
| Subbituminous C | 19.31 to 22.10 | |
| Hat Creek Coal | 17.0 to 19.0 | "Performance Coal" |
| Lignite A | 14.65 to 19.31 | |
| Lignite B | Less than 14.65 | |
| Peat | Approximately 9.30 | |

1. Moist, mineral-matter-free basis (equilibrated at 30°C and 97 percent relative humidity).




## FIGURE 2.2
# GEOLOGICAL MAP

*SOURCE: British Columbia Hydro and Power Authority (20)*

TABLE 2-2
PERFORMANCE COAL (34)
Average Blended Coal Delivered to Powerplant

| | | As Received Basis (a.r.) | Dry Coal Basis (d.c.b.) |
|---|---|---|---|
| Total Moisture | %(by weight) | 23.5 | - |
| Volatile Matter | % | 25.2 | 32.9 |
| Fixed Carbon | % | 25.7 | 33.6 |
| Ash | % | 25.6 | 33.5 |
| Carbon | % | 35.3 | 46.1 |
| Hydrogen | % | 2.8 | 3.7 |
| Nitrogen | % | 0.7 | 0.92 |
| Chlorine | % | 0.02 | 0.03 |
| Sulphur | % | 0.39 | 0.51 |
| Oxygen(By Diff) | % | 11.69 | 15.30 |
| H.H.V. MJ/kg | | 13.85 | 18.1 |
| (Btu/lb) | | (5 955) | (7 784) |
| Hardgrove Grindability Index | | 45 | |
| Sulphur Forms - | Pyritic | 0.10% | |
| | Organic | 0.28% | |
| | Sulphate | 0.01% | |
| | Total | 0.39% | |
| | | ===== | |

Notes: Normal Variations from "performance" characteristics in the product of the blending operation are predicted to be:

High Heat Value 1 MJ/kg (d.c.b.)
i.e. range 17 to 19 MJ/kg (d.c.b.)

Sulphur 0.05% (d.c.b.) (Sulphur in Coal)
i.e. range 0.46% to 0.56% S (d.c.b.)

## TABLE 2-3
## LOW SULPHUR COAL (34)

| | | As Received Basis (a.r.) | Dry Coal Basis (d.c.b.) |
|---|---|---|---|
| Total Moisture | %(by weight) | 24.5 | - |
| Volatile Matter | % | 28.1 | 37.2 |
| Fixed Carbon | % | 28.9 | 38.3 |
| Ash | % | 18.5 | 24.5 |
| | | | |
| Carbon | % | 41.0 | 54.3 |
| Hydrogen | % | 3.0 | 3.97 |
| Nitrogen | % | 0.6 | 0.8 |
| Chlorine | % | 0.02 | 0.03 |
| Sulphur | % | 0.23 | 0.3 |
| Oxygen(By Diff) | % | 12.15 | 16.1 |
| | | | |
| High Heat Value | MJ/kg | 16.08 | 21.3 |
| | (Btu/lb) | (6 915) | (9 159) |
| | | | |
| Hardgrove Grindability Index | | 38 | |
| | | | |
| Sulphur Forms - | Pyritic | 0.03% | |
| | Organic | 0.18% | |
| | Sulphate | 0.02% | |
| | | | |
| | Total | 0.23% | |

## 3.1 GENERAL DESCRIPTION

The proposed Hat Creek thermal generation project would have three basic components, a mine and a powerplant, both located in the upper Hat Creek area, and various offsite facilities in the surrounding region. The project would involve: mining coal from a large open pit in the No. 1 coal deposit; blending the coal to an average quality (performance coal)(34); conveying it to the powerplant located on high ground about 4 km northeast of the mine; burning the coal to produce steam; and using the steam to turn turbines which power generators producing electricity for the provincial power grid. Figure 3-1 presents an artist's rendition of the project in place, showing the whole Hat Creek area complex. Figure 3-2 shows all major project features on a project complex map including the offsite facilities. Figure 3-3 is a detailed site layout map.

The powerplant would have a capacity of about 2000 MW (net) of electrical power, an amount roughly equal to the present demand of the B.C. lower mainland. At full load about 40,500 tonnes (t) of coal would be burned each day, and over its planned 35-year life, the powerplant would consume about 336 million tonnes or about one half of the known coal reserves in the No. 1 deposit.(43) The proposed diameter of the completed open pit would be approximately 3 km. Mine waste and powerplant ash would be deposited in disposal sites located in the adjacent side valleys. Both the powerplant and the mine are designed with pollution control systems to reduce adverse impacts on air, water and land. Total land requirements for project facilities are shown in Table 3-1.(35) The alienation of land at the end of the project is discussed in Section 4.3.

The project would be linked to the provincial power system grid through the Kelly Lake-Nicola 500 kV transmission line, which will be routed within 2 km of the Hat Creek project. This transmission line is planned regardless of the Hat Creek Project, and is fully discussed in other engineering reports and environmental studies. Its impact is therefore not considered in this report.

Project construction activities are proposed to begin in early 1983, with first commercial energy production scheduled for August 1988. As presently conceived, the project has a nominal life of 35 years, but that does not necessarily mean it would be shut down at the end of that period. After 35 years of operation major powerplant components could be worn and in need of refitting. B.C. Hydro would then re-evaluate the project to determine its economic and social viability. A decision would then be made on whether to refit the plant, to expand it, or to decommission it entirely. All current studies are concerned only with a 35-year operation period followed by decommissioning and reclamation of disturbed areas. However it should be noted that in locating the waste disposal areas care was taken to ensure that they were placed so as not to preclude further mining of the coal deposit.

The remainder of this Part presents descriptions of the project's components. Because these descriptions are to be used by provincial agencies for review in the licensing process they are, of necessity, complex. Sections 3.2, 3.3 and 3.4 describe the proposed project's major features, which include the mine, the powerplant and the offsite facilities respectively. Section 3.3(c)

TABLE 3-1
TOTAL LAND REQUIREMENTS FOR PROJECT FACILITIES
(DISTURBED AREAS)

| | Area (ha) | |
|---|---|---|
| **Powerplant** | | |
| Powerplant site | 99 | |
| Water supply reservoir and dam | 94 | |
| Powerplant construction camp | 11 | |
| Service roads and utility corridors | 43 | 247 |
| **Mine** | | |
| Mine pit (after 35 years) | 585 | |
| Waste disposal areas (after 35 years) | 1 028 | |
| Mine maintenance complex | 25 | |
| Coal blending area | 42 | |
| Lagoons | 23 | |
| Diversion drains | 46 | |
| Mine construction camp | 5 | |
| Service roads and utility corridors | 149 | 1 903 |
| **Offsite Facilities** | | |
| Main access road | 117 | |
| Pit rim reservoir and dam | 11 | |
| Headworks reservoir and dam | 6 | |
| Creek diversion canals | 49 | |
| Water supply pipeline | 35 | |
| Airstrip | 45 | |
| Off loading facility | 3 | |
| Service roads and utility corridors | 90 | 356 |
| TOTAL | | 2 506 |

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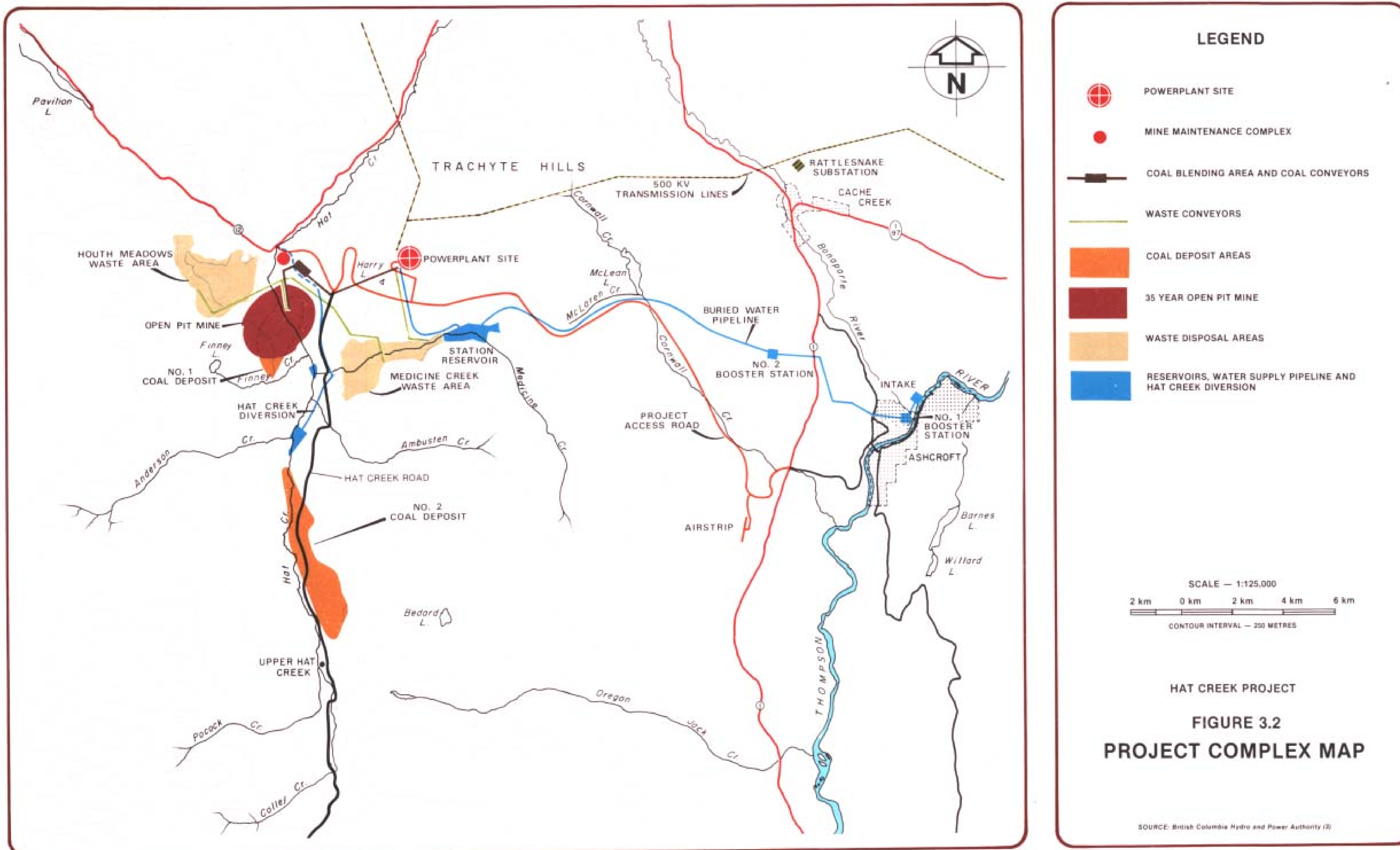
discusses the alternative air quality control systems (AQCS) which were considered in arriving at the proposed project. Sections 4.1, 4.2 and 4.3 discuss the project's three phases: construction, operation, and decommissioning including reclamation.

HAT CREEK PROJECT

FIGURE 3.1
## PROJECT OVERVIEW FROM SOUTH EAST

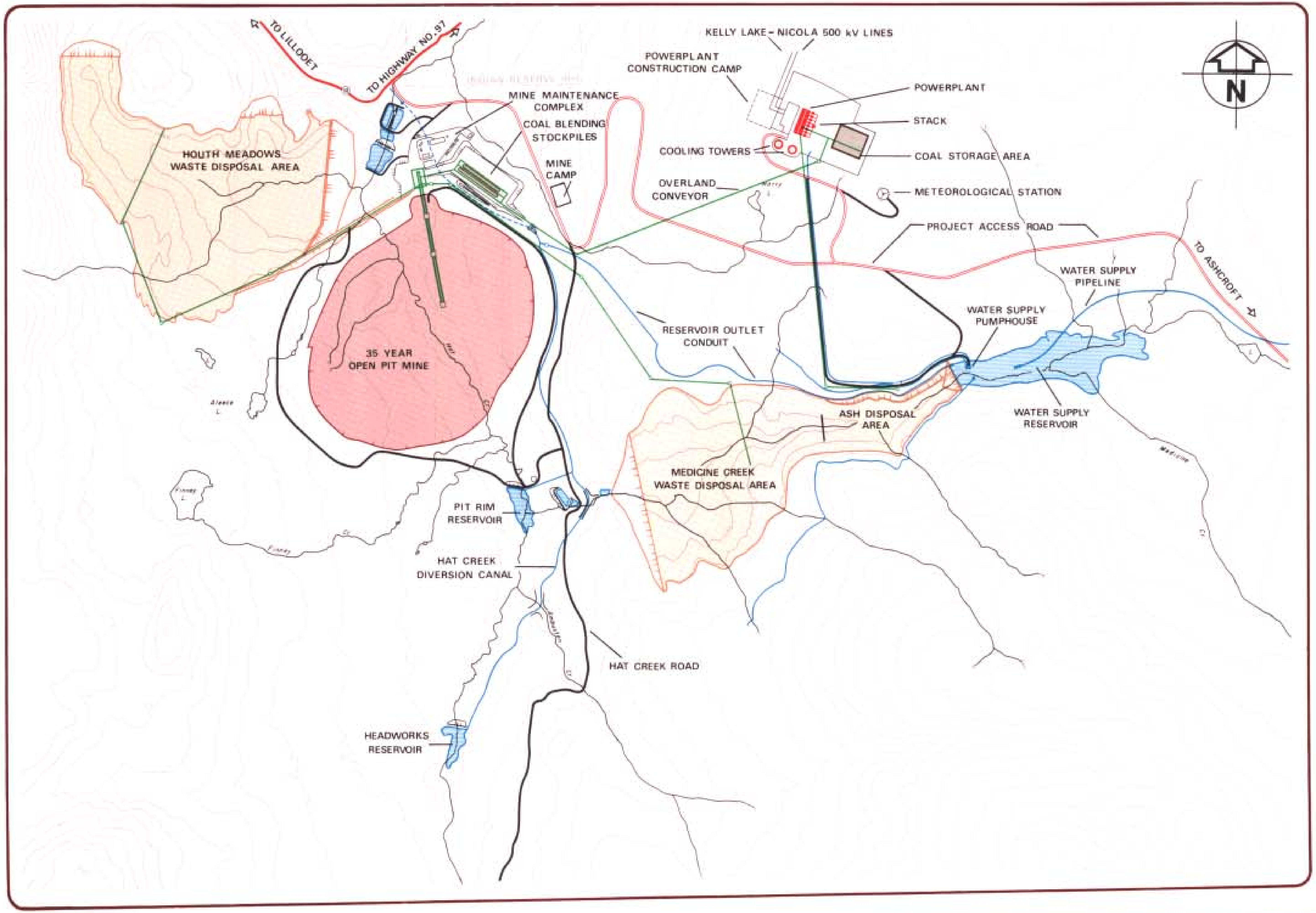
SOURCE: Toby, Russell, Buckwell and Partners Architects (2)




HAT CREEK PROJECT

FIGURE 3.2
PROJECT COMPLEX MAP

SOURCE: British Columbia Hydro and Power Authority (3)




HAT CREEK PROJECT

FIGURE 3.3
DETAILED SITE LAYOUT MAP

SOURCE: British Columbia Hydro and Power Authority (4)

## 3.2 THE MINE(34,43)

(a)Overview

As shown on Figure 3-3 the proposed mining complex would include five basic components.

(i)Mine

An open pit mine would be developed in a series of benches, which at the end of 35 year's production would extend approximately 230 m below the average valley floor.

(ii)Waste Disposal Areas

Waste disposal areas would be located at Houth Meadows and Medicine Creek and linked to the mine by overland conveyors.

(iii)Coal Handling

A coal crushing, stockpiling and blending facility would be constructed north of the mine and close to the pit rim.

(iv)Coal Delivery

A 4 km long single overland conveyor would carry coal from the mine to the powerplant.

(v)Administration

An administration and maintenance complex would be located north of the mine.

For purposes of mine planning, the various qualities of coal are defined as follows:

| Material Standards | Heating Values(34,43) (Dry Basis) |
|---|---|
| Coal | over 9.3 MJ/kg |
| Low grade coal | 7.0 to 9.3 MJ/kg |
| Waste material | less than 7.0 MJ/kg |

Details of coal quality which would be delivered to the powerplant are given on Table 2-2 of Section 2.0. Quantities of coal and waste to be mined over the project life can be found in Table 4-2 of Section 4.2.

(b)Mine Operating System(43)

(i)Mining System

For excavation in the mine a shovel and truck system simultaneously working several 15 m high benches would be employed (see Figure 3-4 and Figure 3-5). This approach allows an average grade and volume of coal to be mined over the project's life while providing continuous access to better quality coals if required for blending and "low sulphur" fuel supply (see Tables 2-2 & 2-3). A limited amount of the material would be drilled and blasted. Trucks would feed mined material into primary crushing stations located adjacent to the central conveyor system.

At the central conveyor ramp all material would be crushed to less than 200 mm size and loaded onto one of the four conveyor systems. Waste, low grade coal and powerplant coal would be transported via separate conveyors out of the mine area, using a northern exit. This system is shown schematically in Figure 3-6.

(ii)Waste Handling

Waste material, which would be composed of granular surficials, waste rock and waste coal, would be transported by conveyors to two different waste disposal areas; either Houth Meadows or Medicine Creek. Each conveyor would feed a stacker to place material in a predetermined sequence. Total land surface to be covered would be about 600 ha at Houth Meadows and 428 ha at Medicine Creek.

(iii)Coal Handling

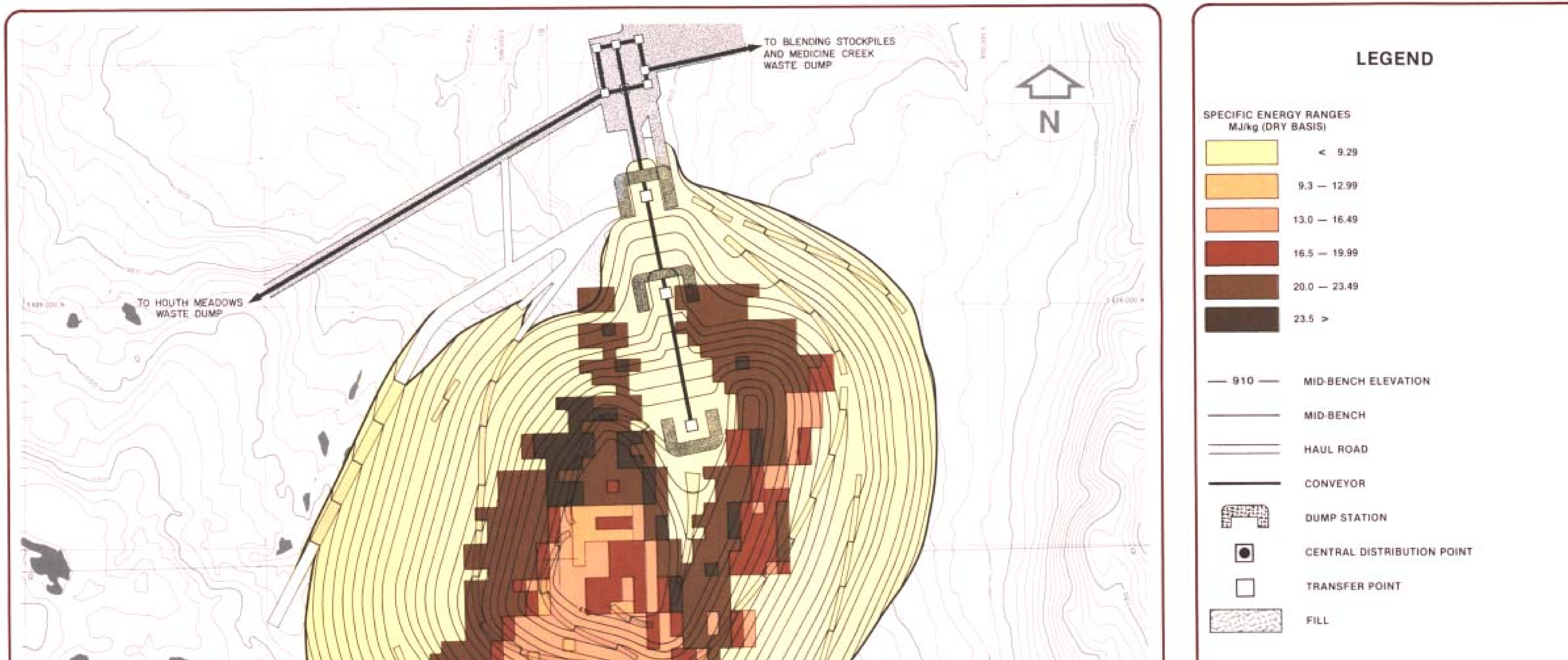
In order to provide a consistent powerplant fuel, the natural variability of the mined coal must be reduced. This would be accomplished by selecting which level of coal quality should be mined at a given time, and then mixing different quality coals to provide a consistent blend.

Blending would occur after the coal had been crushed to less than 50 mm size and conveyed to the blending yard, where a pile containing a 1-week powerplant supply would be constructed in layers. When the pile is completed it would be reclaimed by a bucket wheel reclaimer and loaded onto the overland conveyor for delivery to the powerplant. This blending procedure would effectively reduce fluctuations in coal quality that would occur over that week. Two blending piles would be used; one would be built while the other is being used to feed the powerplant.

(c)Water Systems

(i)Water Supply and Sewage

The total estimated water supply requirements of the mine are not large, since no significant consumption is involved in the mining processes. Potable water, fire protection, irrigation and dust control are the main requirements. Estimated daily demands at full production levels are shown in Table 3-2, along with sources of supply.

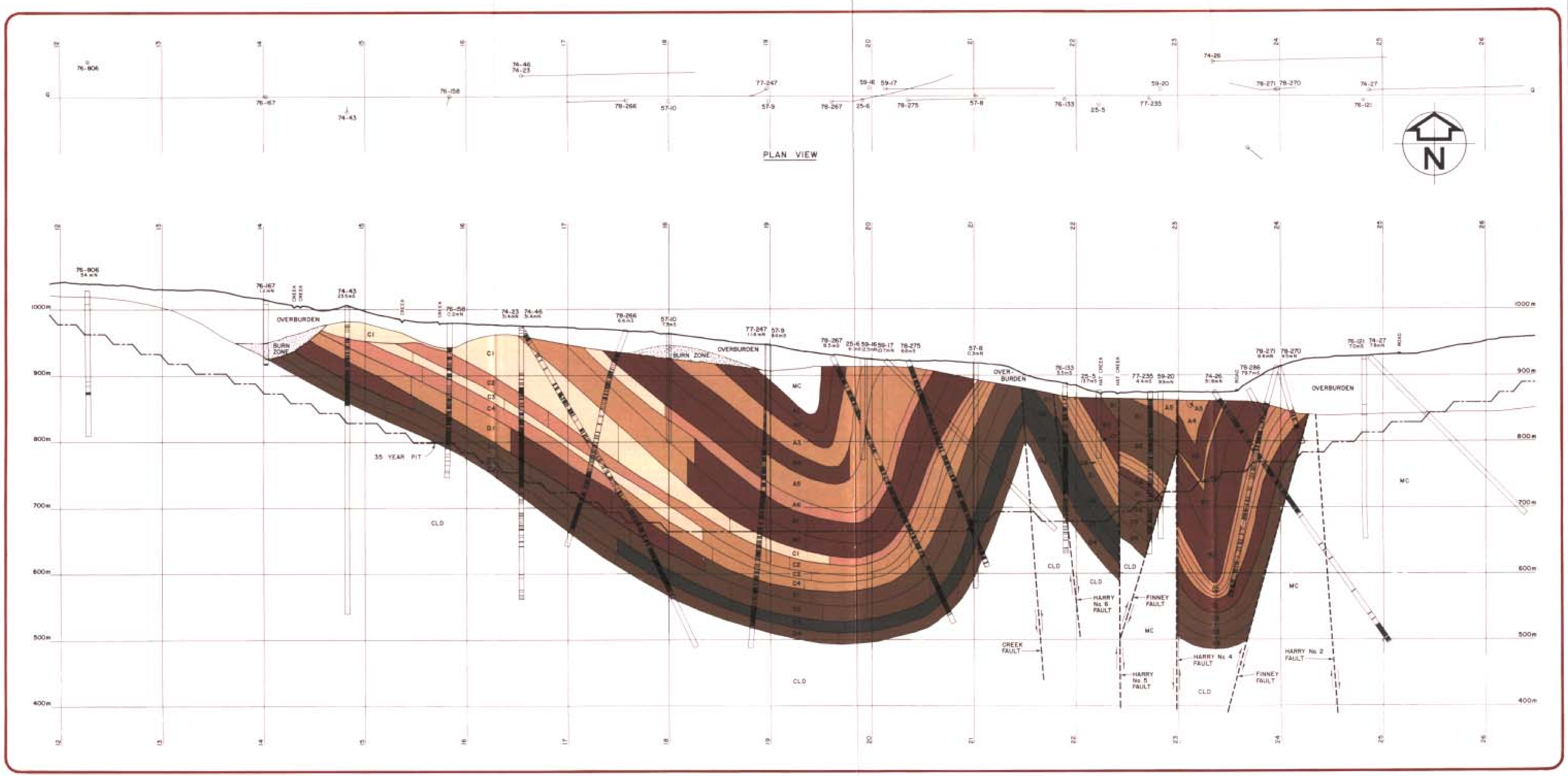


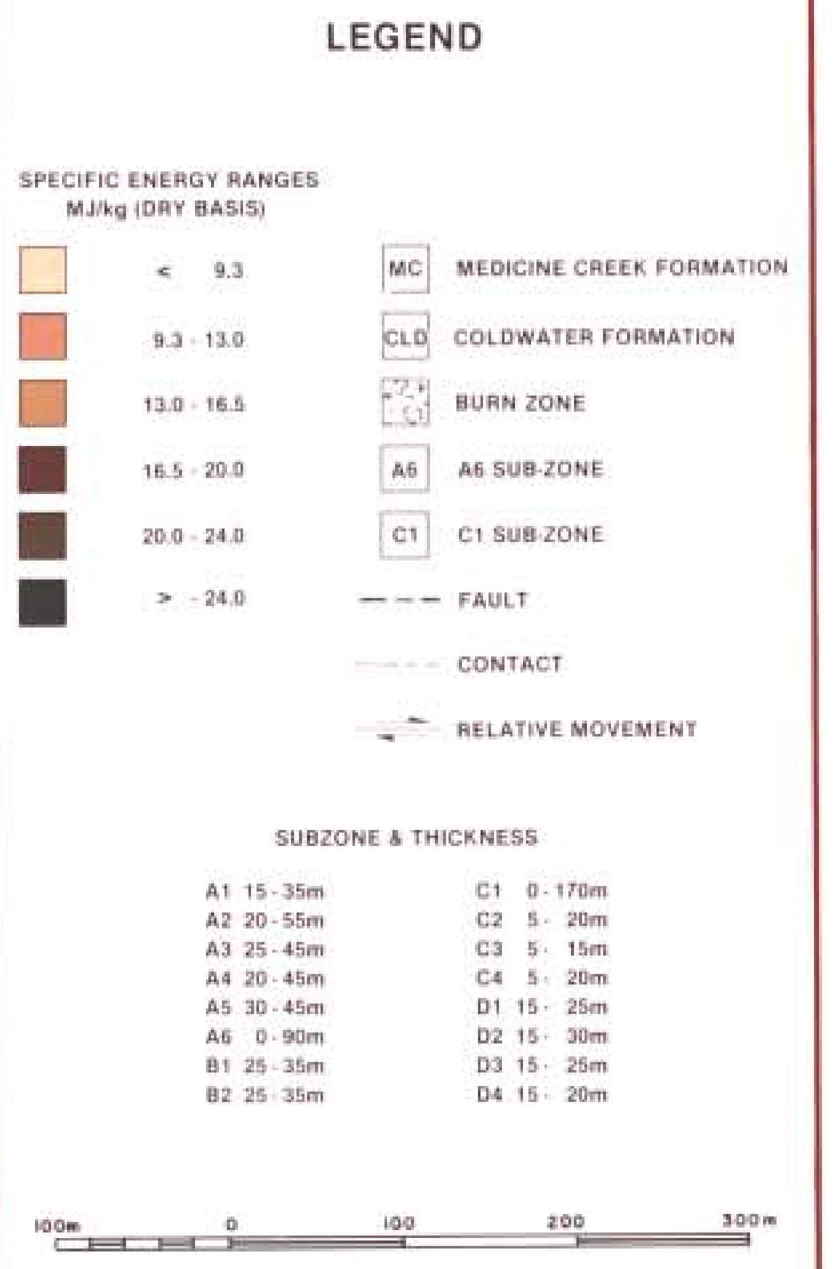

HAT CREEK PROJECT

FIGURE 3.4

**Pit Development Year 35**

SOURCE: British Columbia Hydro and Power Authority (43)

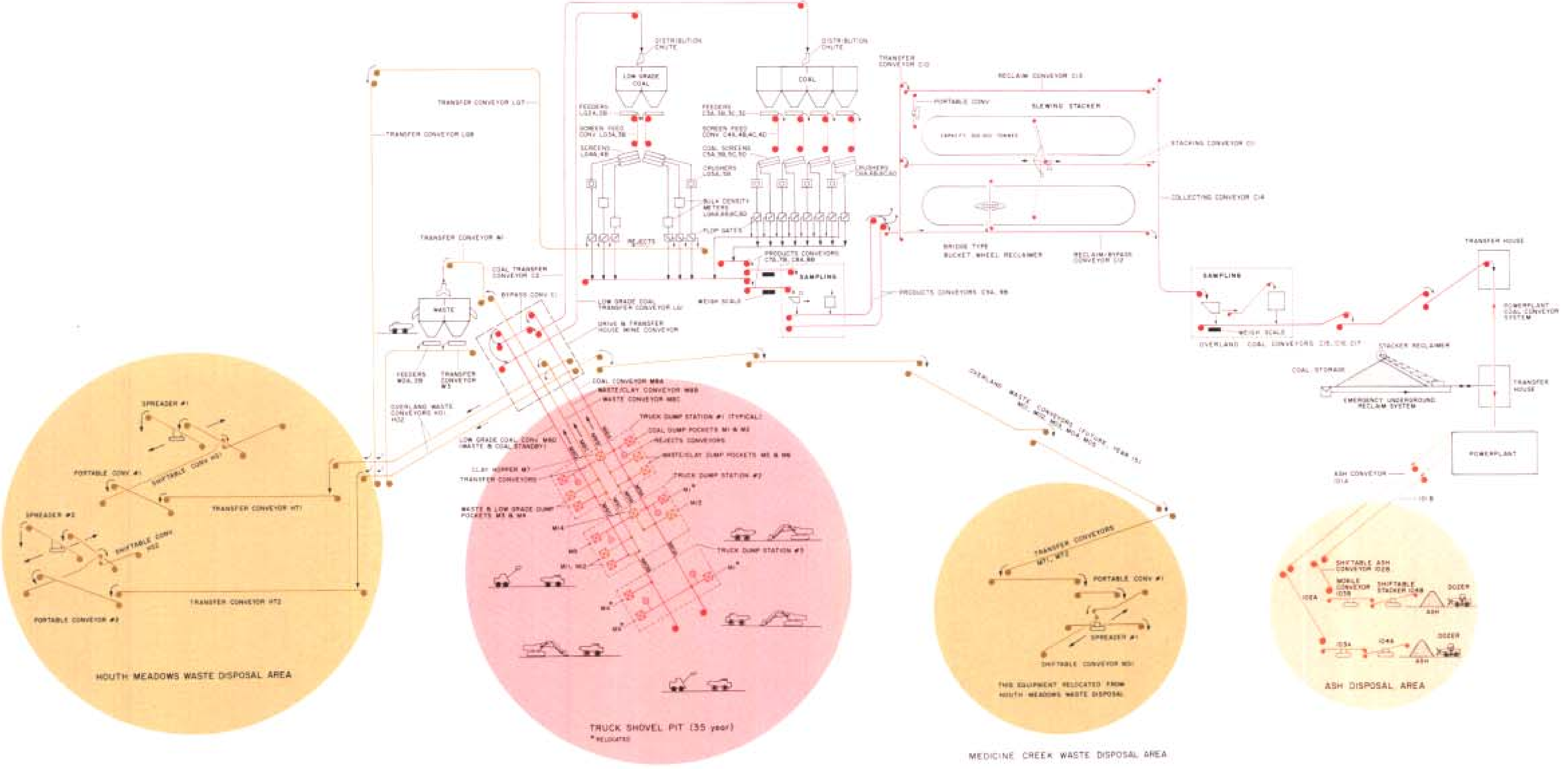



HAT CREEK PROJECT

FIGURE 3.5
GEOLOGICAL CROSS SECTION
SECTION Q
SECTION DRAWN LOOKING NORTH

SOURCE: British Columbia Hydro and Power Authority (43)




HAT CREEK PROJECT

FIGURE 3.6

## MATERIALS HANDLING SYSTEM FLOW DIAGRAM

SOURCE: British Columbia Hydro and Power Authority (43)

TABLE 3-2
MINE WATER SUPPLY(43)

| Demand | Daily Requirement ($m^3/d$) | Source |
|---|---|---|
| Potable water and fire protection | 235 | Offsite construction supply well |
| Irrigation | 620 | Pit rim reservoir on Hat Creek |
| Dust Control | 2 000 | Mine area drainage and dewatering, recycled waste water |
| TOTAL | 2 855 $m^3/d$ (33 L/s) | |

Sanitary sewage would be pretreated and recycled for dust control use on haul roads and coal stockpiles.(6)

(ii)Mine Drainage(6)

Because the mine would be a deep hole in the valley bottom, it would have to be drained to prevent water accumulation. Potential sources of mine drainage flow include direct precipitation and runoff, creek inflow, standing surface water from nearby lakes, underground flows and waste water. The drainage system shown on Figure 3-7 has been designed to divert floods, maintain conditions dry enough for mining, improve slope stability and protect the environment.

Included in the drainage system are the following features:

1. Diversion Drains - Runoff entering the mine area from upper Hat Creek valley, Houth Meadows and Medicine Creek would be collected by a system of canals and dams for discharge into Hat Creek downstream of the mine.

2. Slide Area Drainage - Measures to improve the stability of the south and west pit slopes include perimeter drains at the back of the slide area, drainage of 62 small lakes and ponds within the area, improvement of natural waterways and installation of 20 wells to drain and improve slope stability in critical areas.

3. Pit Drainage and Wastewater Treatment Systems - These aspects are discussed subsequently under Environmental Control Systems.

(d)Environmental Control Systems

Two major environmental control systems are included in the mine complex design; one to maintain downstream water quality and another to minimize dust. Revegetation and reclamation of disturbed areas would also be undertaken to restore environmental quality of land areas. Revegetation would occur during both the operation and reclamation phases, and is discussed in Section 4.3.

(i)Water Quality(6)

The water quality control system would comprise three systems; the diversion system, the sediment control system and the zero discharge system for water containing high levels of dissolved solids. The water quality control system would deal with diversion of natural creeks and with drainage and seepage from the mine, the coal storage piles and the mine waste piles.

Leachates would be handled through a "zero-discharge" drainage system. Drainage from the coal and bedrock in the lower pit, along with seepage from the waste disposal areas and coal stockpiles would be collected and pumped to leachate holding lagoons. This effluent would be recycled by spraying it on roads and coal stockpiles for dust control, and the excess disposed of by spray evaporation on waste disposal areas (see Figure 3-7 and Figure 3-8)

Water from surficial materials has a quality similar to that of Hat Creek during the summer low flow period when most of its flow emanates from ground water discharge. Water seeping into the upper levels of the mine drainage system through overburden would therefore have a quality suitable for discharge. However this seepage and runoff from disturbed land and the mine service area could contain high levels of suspended sediment which would be reduced to comply with PCB Objectives (50) before discharge. As shown in Figure 3-8, this water would be collected in drains and pumped to sedimentation lagoons. After sediment concentrations have been reduced, the water would be discharged into Hat Creek. All lagoons would be lined with impervious material to guard against seepage.

(ii)Dust(36)

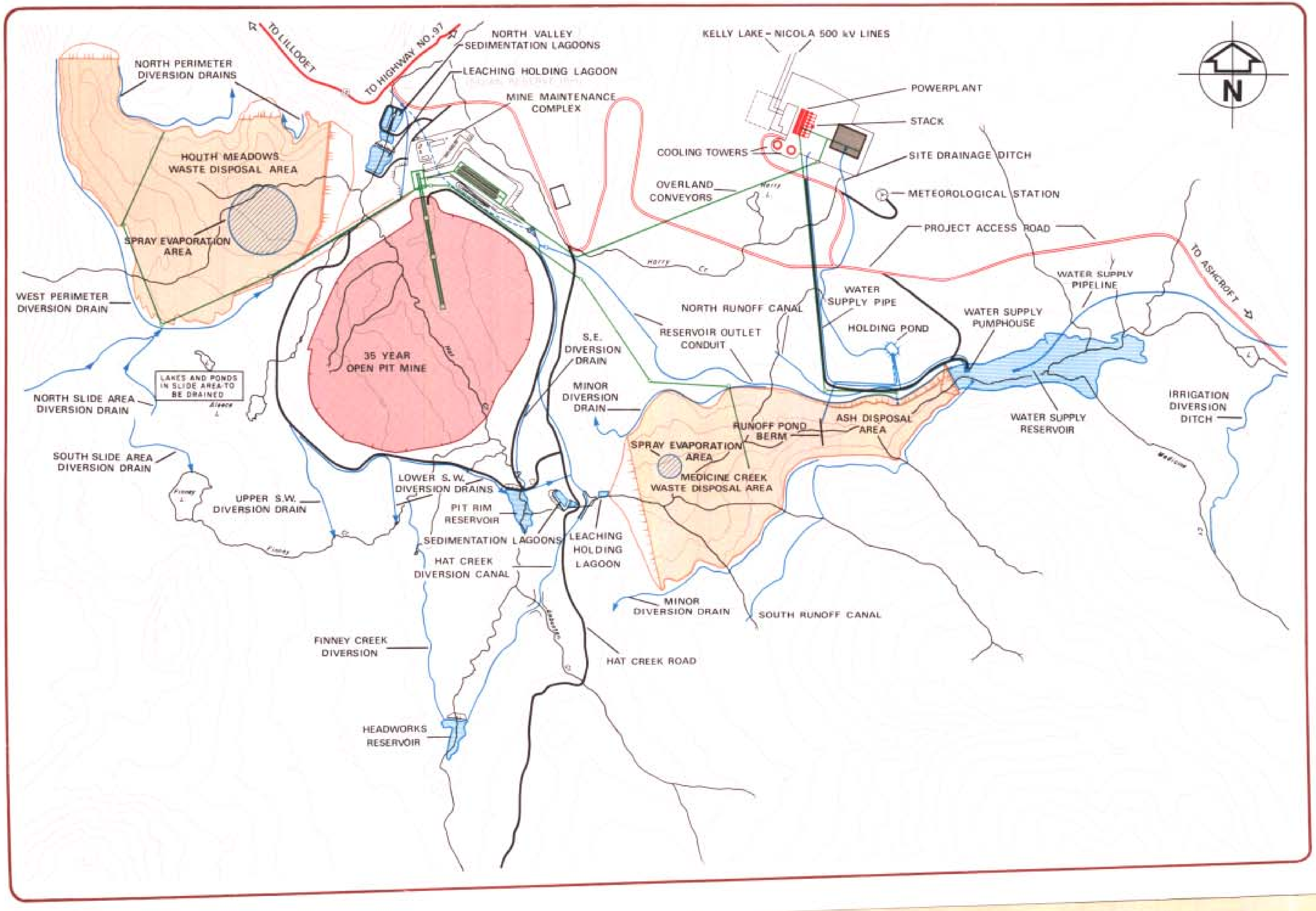
Studies indicate that dust would occur during both the construction and operation phases of the project. During the construction phase, earth-moving activities would be the major cause, while during the production phase, both the coal stockpile/blending processes and vehicle movements would be chief contributory factors. Dust control measures for the mine include the following components:

1. The blending area would be excavated into the adjacent hill, a protective embankment 20 m high would be constructed along the southwest edge of the area, and the coal piles would be suitably contoured to reduce erosion (Figure 3.3). An effective water spray system would be installed.

2. The area stripped of surface soils would at all times be minimized to reduce erosion potential. In addition stripping would be continued until non-friable (i.e., low dust potential) material was reached, if possible.

3. Binding agents would be used to control erosion where appropriate.

4. Areas that would remain stripped of surface material for extended periods of time would be revegetated.




## LEGEND

RESERVOIRS AND LAGOONS

DRAINAGE AND DIVERSION

SCALE — 1:40,000

1 km 0 km 1 km 2 km

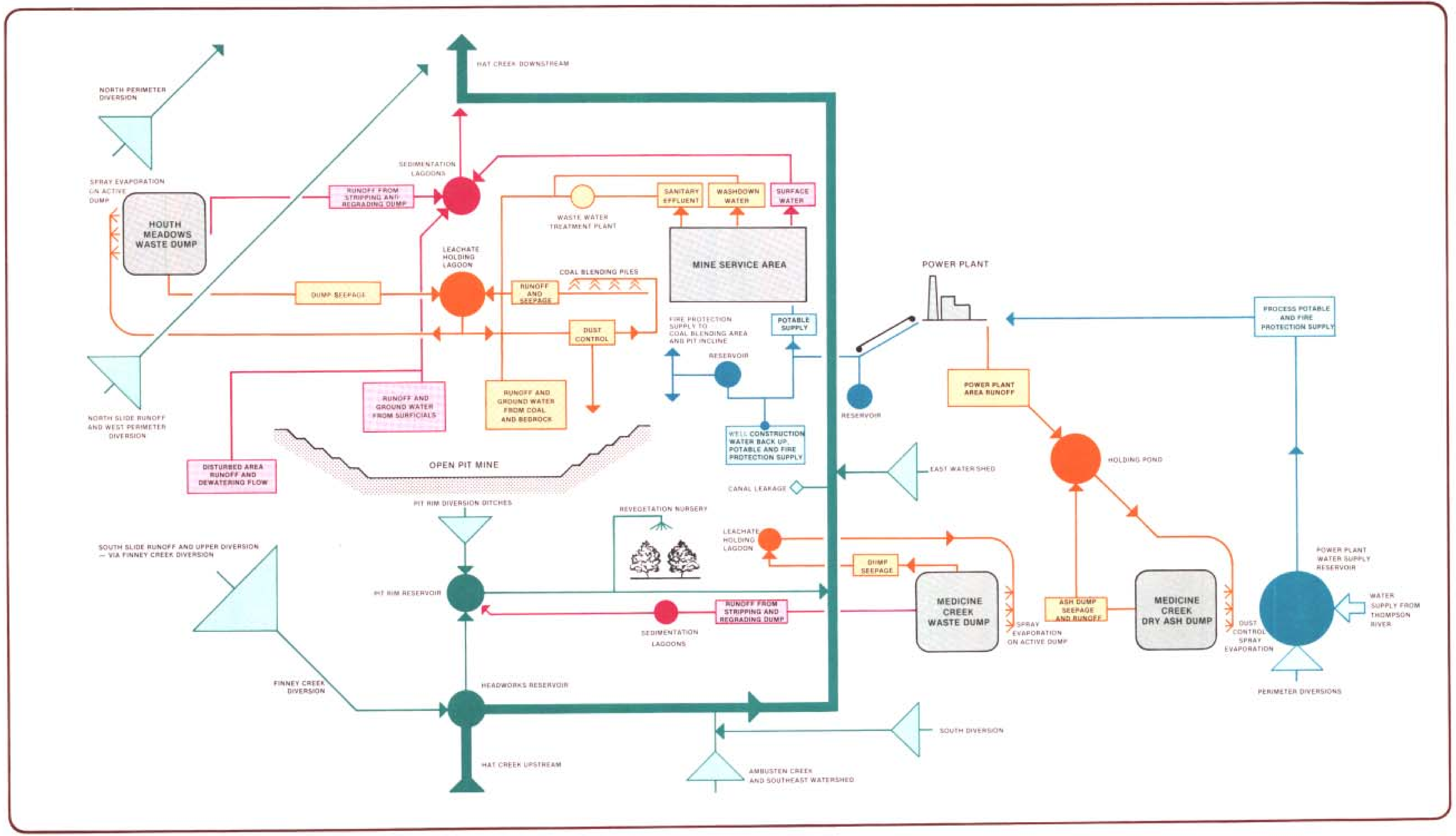
CONTOUR INTERVAL — 50 METRES

HAT CREEK PROJECT

FIGURE 3.7

# PROJECT DRAINAGE AND DIVERSION SYSTEM

SOURCE: Cominco — Monenco Joint Venture (6)




## LEGEND

- PROCESS POTABLE AND FIRE PROTECTION SUPPLY
- HAT CREEK AND NON-CONTAMINATED WATER
- WATER FROM DISTURBED AREAS REQUIRING TREATMENT
- WATER UNSUITABLE FOR DISCHARGE

HAT CREEK PROJECT

FIGURE 3.8

**PROJECT DRAINAGE AND WATER SUPPLY FLOW DIAGRAM**

SOURCE: Cominco - Monenco Joint Venture (6) & Intag - Ebasco (38)

## 3.3 THE POWERPLANT

### (a)Overview

The location of the powerplant would be on a broad hilltop overlooking the Hat Creek valley near Harry Lake, about 4 km northeast of the mine site. This site has been selected because its high elevation would provide better dispersion of the flue gases than sites in the valley bottom (see Sections 6.0 and 24.0). The elevation at the proposed site is about 1410 m above sea level, while existing ground level at the mine site is approximately 910 m.

Figure 3-9 is an artist's rendition of the powerplant. Figure 3-10 is a site plan of the powerplant layout, showing the location of major components. Details of the powerplant features, including the proposed environmental control systems and alternatives are discussed in subsequent sections.

Basic components of the powerplant include the following items.

(i)Coal Handling System

The system would be composed of conveyors to carry coal from the transfer house at the end of the overland conveyor from the mine. These conveyors would carry coal either to the powerplant coal storage area or to the boilerhouse bunkers. The bunkers would have storage capacity for eight hours of operation at full load.

(ii)Boilers

Four boilers, each about 90 m high and 18 m square, would burn the coal. Essentially a boiler is a huge water-cooled furnace in which water is converted to steam. At full load each boiler would consume approximately 422 t of "performance coal" per hour.

(iii)Turbine-Generators

High pressure steam from the four boilers would drive four turbines, which would in turn each drive electric generators. Each generator would deliver at full load approximately 500 MW of power after the powerplant's own requirements and those of the mine and water supply system have been met.

(iv)Condensers

A condenser at each turbine exhaust would condense the steam to water after its useful energy had been expended. This water would then return to the boilers for reconversion into steam. Condensers require large quantities of cold water flowing through them to condense the exhaust steam. In this process the cooling water itself is warmed.

(v)Cooling Towers

Heat absorbed by the cooling water in the condensers would be dissipated in two large hyperbolic natural draft cooling towers, each about 135 m high. Largely through evaporation, heat would be transferred to a natural upward stream of air flowing through drops of cooling water as they rain down inside the towers. The cooled water would then be collected in a pond below each cooling tower and recycled to the condensers. Some of the cooling water would evaporate from the towers to the atmosphere (see Figure 3-11). No water would be released to natural streams or to groundwater systems.(56) It would be necessary to continually add some "make-up" water to replace evaporation losses. This water would be obtained from the nearby water supply reservoir, which would be fed by water pumped from the Thompson River. This is described in Section 3.4(c) following.

(vi)Exhaust Stack

Combustion gases from the four boilers would be passed through eight electrostatic precipitators (ESPs), two for each boiler, which would remove fly ash from the exhaust gas. Approximately 60% of the exhaust gas would be passed through the flue gas desulphurization (FGD) system where 85% of the sulphur dioxide would be removed. This gas would then be recombined with the remaining gas (which bypassed the FGD system). The recombined gas would then travel through ducts to the stack. A single stack 366 m in height, with separate flues for each boiler, would discharge the gases to the atmosphere. The stack height may be less than 366 m dependent on continuing further flue gas dispersion/ambient air quality analyses.

(vii)Ash Handling System(38)

Fly ash collected in the ESPs and bottom ash collected at the bottom of the boilers would be transported in a moist state by conveyors, to the mid-Medicine Creek dry ash disposal site. This system is described in detail in Section 3.3(d).

(b)Air Quality Control System

The air quality control system (AQCS) is the powerplant system selected to reduce ambient (ground level) air quality problems that could be caused by the powerplant's flue gases, and to comply with the B.C. Pollution Control Objectives(50) for both emission and ambient levels. Primary components are the electrostatic precipitators (ESPs) and partial flue gas desulphurization (FGD) system described below. Figure 3-11 is a basic flow diagram of the major powerplant emissions to the atmosphere when four furnaces are using performance coal at full load.

(i)Electrostatic Precipitators (ESPs)

ESPs located between the boilers and the stack would remove ash particles from the gases. They would have a removal efficiency of about 99.8 percent, so that only 0.2 percent of the fly ash would remain in the gas when it is discharged to the atmosphere. Each precipitator would reduce the particulate loading of the emitted flue gas below 0.03 mg/kJ under all load conditions and burning any of the expected qualities of coal. (PCB Objective range = 0.01 to 0.04 mg/kJ).

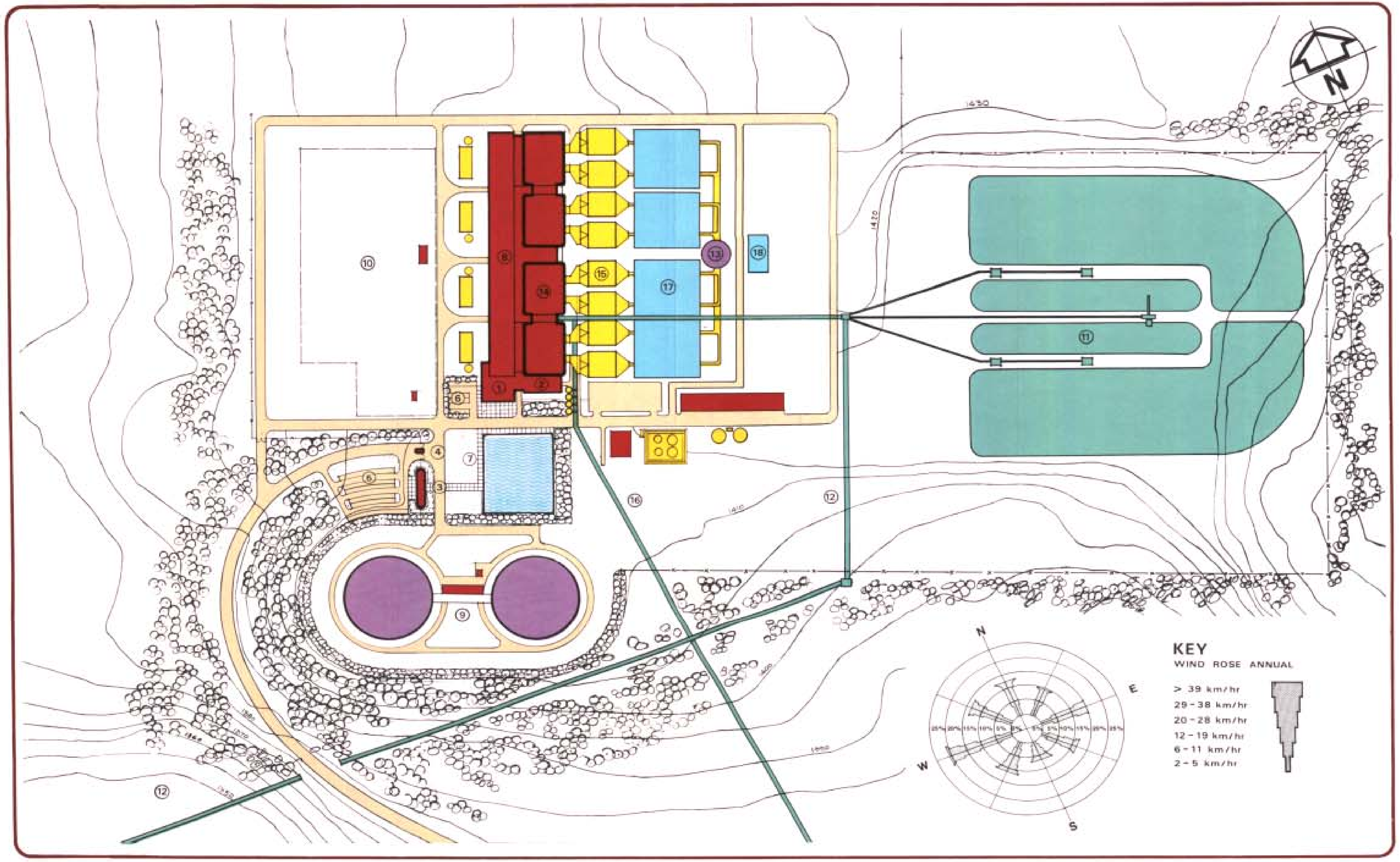
ESPs remove particles before they get to the stack by transmitting an electric charge to the suspended particles which then migrate to collecting plates. The collected fly ash is shaken off these plates into hoppers.

HAT CREEK PROJECT

FIGURE 3.9

**POWERPLANT FROM WEST**

SOURCE: Toby, Russell, Buckwell and Partners Architects (2)




## LEGEND

1. ADMINISTRATION BUILDING
2. WORKSHOP
3. TOURIST INFORMATION CENTRE
4. GUARD HOUSE
5. VISITOR PARKING
6. ADMINISTRATION PARKING
7. LANDSCAPED AREA WITH REFLECTING WATER SURFACE
8. TURBINE HOUSE
9. COOLING TOWERS
10. SWITCHYARD
11. COAL STORAGE
12. COAL OVERLAND CONVEYOR FROM MINE
13. STACK
14. BOILER HOUSE
15. ELECTROSTATIC PRECIPITATORS
16. ASH & SLUDGE DISPOSAL CONVEYORS
17. FLUE GAS DESULPHURIZATION SYSTEM
18. FGD SYSTEM SERVICES

SCALE — 1:400

50 m 0 m 50 m 100 m 200 m 300 m

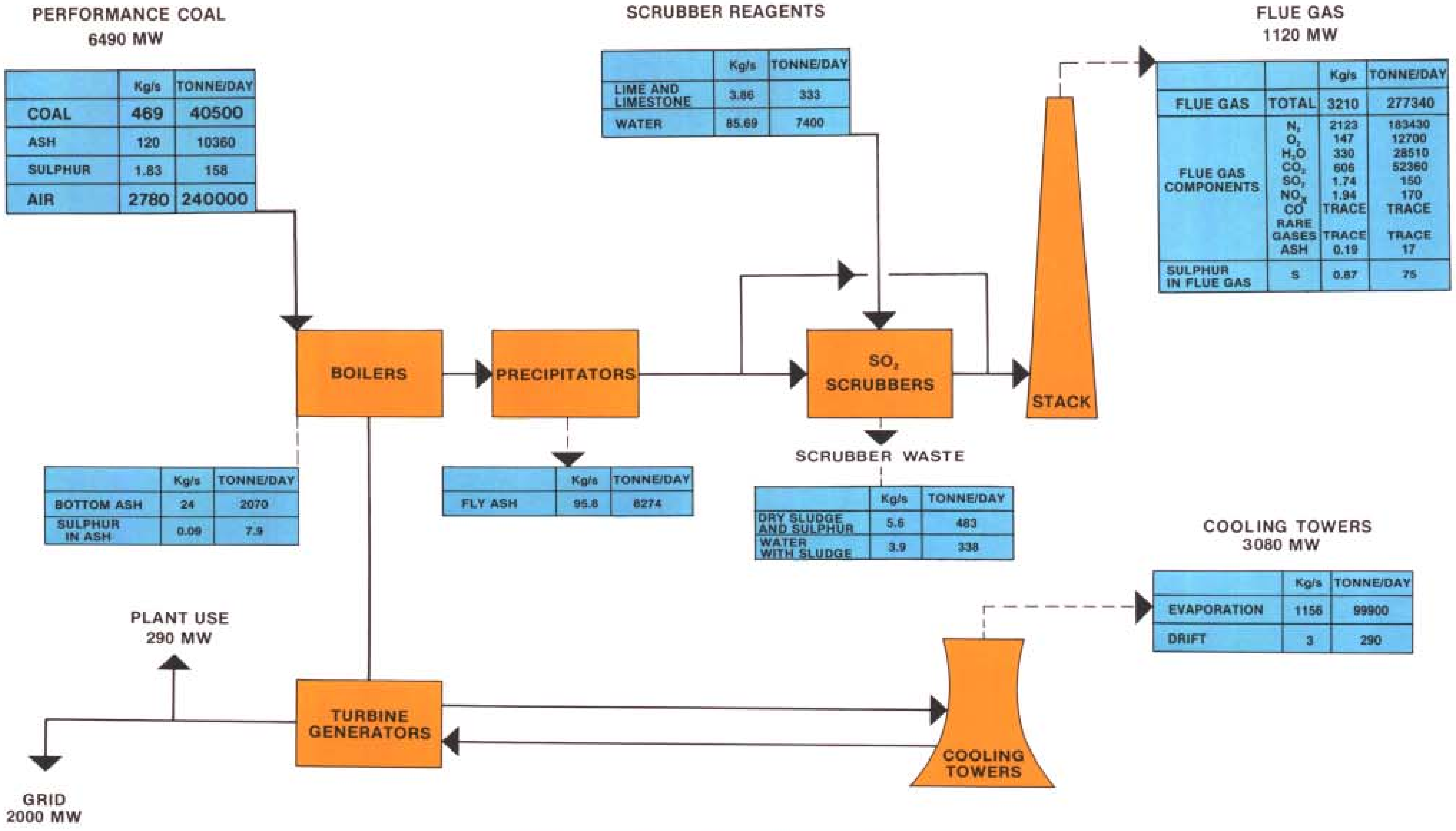
CONTOUR INTERVAL — 50 METRES

HAT CREEK PROJECT

FIGURE 3.10

POWERPLANT SITE PLANT

SOURCE: Toby, Russell, Buckwell and Partners Architects (2)




**PERFORMANCE COAL 6490 MW**

| | Kg/s | TONNE/DAY |
|---|---|---|
| COAL | 469 | 40500 |
| ASH | 120 | 10360 |
| SULPHUR | 1.83 | 158 |
| AIR | 2780 | 240000 |

**SCRUBBER REAGENTS**

| | Kg/s | TONNE/DAY |
|---|---|---|
| LIME AND LIMESTONE | 3.86 | 333 |
| WATER | 85.69 | 7400 |

**FLUE GAS 1120 MW**

| | | Kg/s | TONNE/DAY |
|---|---|---|---|
| FLUE GAS | TOTAL | 3210 | 277340 |
| FLUE GAS COMPONENTS | $N_2$ | 2123 | 183430 |
| | $O_2$ | 147 | 12700 |
| | $H_2O$ | 330 | 28510 |
| | $CO_2$ | 606 | 52360 |
| | $SO_2$ | 1.74 | 150 |
| | $NO_x$ | 1.94 | 170 |
| | CO | TRACE | TRACE |
| | RARE GASES | TRACE | TRACE |
| | ASH | 0.19 | 17 |
| SULPHUR IN FLUE GAS | S | 0.87 | 75 |

| | Kg/s | TONNE/DAY |
|---|---|---|
| BOTTOM ASH | 24 | 2070 |
| SULPHUR IN ASH | 0.09 | 7.9 |

| | Kg/s | TONNE/DAY |
|---|---|---|
| FLY ASH | 95.8 | 8274 |

**SCRUBBER WASTE**

| | Kg/s | TONNE/DAY |
|---|---|---|
| DRY SLUDGE AND SULPHUR | 5.6 | 483 |
| WATER WITH SLUDGE | 3.9 | 338 |

**COOLING TOWERS 3080 MW**

| | Kg/s | TONNE/DAY |
|---|---|---|
| EVAPORATION | 1156 | 99900 |
| DRIFT | 3 | 290 |

FIGURES REPRESENT APPROXIMATE FLOWS AT 2000 MW. NET.
(AMBIENT CONDITIONS: — WET BULB TEMP. 13.9°C, DRY BULB TEMP. 18.3°C)

HAT CREEK PROJECT

FIGURE 3.11

## POWERPLANT EMISSIONS TO ATMOSPHERE

SOURCE: Integ — Ebasco

(ii) Partial "Wet" Flue Gas Desulphurization (FGD) (Scrubbing) (29)

In the wet scrubbing systems, flue gas would leave the ESPs, pass through the FGD absorber modules for SO2 removal, and be subsequently discharged to the stack.

Limestone reagent would be delivered to the FGD modules in slurry form after preparation in a sub-system consisting primarily of dry storage silos, wet ball mills, slurry storage tanks and transfer pumps. The used slurry containing the absorbed SO2 would be dewatered in gravity thickeners, and then blended with fly ash, resulting in an essentially dry product which would be handled by the dry ash conveying system incorporated in the proposed ash handling system(29,38). Limestone reagent for the FGD modules is available in sufficient quantities from deposits in the Hat Creek area (333 t/day at 100% load).

The water management zero discharge system as described in section 3.3(e) and in references 38 and 56 is primarily concerned with the worst case meteorological control system (MCS)(see Section 3.3(c)) conditions. The water balances are presently being modified to include the FGD system.

For partial wet scrubbing approximately 60 percent of the flue gas would pass through the FGD absorber modules (two operating plus one spare) having an 85 percent SO2 removal efficiency. The resulting SO2 emissions would not exceed 0.27 mg/kJ (PCB Objective range = 0.09 to 0.34 mg/kJ(50)). Approximately 40% of the total gas flow would bypass the FGD modules at all times and recombine with the treated flue gas at the down-stream mixing chamber. Supplementary reheating of the flue gas is not envisaged.

(iii) Control of Other Emissions

Some of the nitrogen in the coal and in the air would convert to oxides of nitrogen (NOx) during combustion. Factors controlling NOx production in the boilers are flame temperature, percentage of excess air and turbulence in the furnace. Design of the steam generator components would limit NOx emissions.

Carbon monoxide and hydrocarbons emissions are primarily determined by boiler design. These emissions would also be limited by appropriate design.

## (c) Alternative Air Quality Control Systems (AQCS) Considered (14,29,37,44)

(i) Introduction

The previously described ESPs and FGD systems are the two major components of the selected air quality control system. A number of alternative components to control air impacts were also considered and evaluated by B.C. Hydro. These alternatives could be substituted for components within the AQCS, to provide different levels of environmental control, at different costs. The major alternatives include:

1. Meteorological Control System (MCS) - which would involve the use of low sulphur coal or load reductions to reduce emissions when it is

predicted that ground level (ambient) air quality may otherwise be impaired.

2. Coal Beneficiation - which would involve washing the coal to remove some of its impurities before burning.

3. Fabric Filters - which resemble extremely large vacuum cleaners, could possibly be substituted for the proposed ESPs to control particulates.

4. Full "Wet" Flue Gas Desulphurization (FGD) - which would involve removal of up to 85% of the $SO_2$ from the stack gases.

5. "Dry" Flue Gas Desulphurization (FGD) - which would involve removal of up to 85% of the $SO_2$ from the stack gases.

(ii)Meteorological Control System (MCS)(14,37)

A MCS is a set of operational procedures for the powerplant which could reduce emissions below normal operating levels. Occasionally adverse atmospheric conditions such as atmospheric inversions occur in the area, which could inhibit the usual dispersion of flue gases. At these times remedial measures indicated by the continuously functioning MCS could be employed.

A MCS consists of the following components:

1. A meteorological and ambient air quality instantaneous monitoring network.

2. A computer-based model to predict local meteorological conditions and resulting air quality at ground level.

3. Flexibility in plant operations to allow both reduction in the powerplant output and/or switching to low sulphur coal when conditions dictate.

When the monitoring and prediction models indicate that an ambient air quality problem may soon occur, the powerplant could either reduce generation output (load reduction) or switch to low sulphur coal (fuel switching). Seasonal load demands and the degree of emission control required determine which procedure is used. Low sulphur coal, with an average sulphur content of less than 0.23 percent, could be burnt during periods of potential poor meteorological dispersion. Fuel switching would be used primarily in winter months due to high load demand. During other seasons, reduction in load would often be the preferred measure.

It is estimated that if the MCS were adopted with a 244 m stack, rather than the proposed FGD system, load reduction would be used for 85 h/annum and fuel switching for 195 h/annum.

(iii)Coal Beneficiation

Coal beneficiation is a broad term which includes any process that improves the quality of coal. In dealing with boiler fuels, this generally implies raising the heating value and reducing the ash content of the coal. Beneficiation, however, can also be used to reduce the sulphur content. The majority of the proven beneficiation processes in use are wet, gravity-separation processes. Dry processes have been used in the past and new dry processes are under development.

Several alternative beneficiation schemes were examined but, for the purposes of evaluation, two wet gravity-separation schemes were studied and their costs were compared with the benefits which would accrue if either one was adopted. One scheme (partial washing) involves processing only the larger size fractions (particles larger than 13 mm) in a heavy medium bath while the other scheme (full washing) involves, similarly, processing the larger size fractions in a heavy medium bath, but also includes washing the smaller size fractions (particles smaller than 13 mm) in a water only cyclone.

The cost estimates resulting from this evaluation are shown on Table 24-4 in Section 24.3. Besides these costs, other conclusions from these evaluations are as follows:

1. Hat Creek coal can be beneficiated to produce a fuel averaging 21.0 MJ/kg, compared to 18.0 MJ/kg for "performance coal".

2. Sulphur dioxide emissions could be reduced by the following percentages, using beneficiated fuel:

| | Approximate Percent Reduction In Emissions of Sulphur Dioxide |
|---|---|
| Proposed Project Including Partial FGD | 50 |
| Partial washing | 9 |
| Full washing | 20 to 35 |

3. The disposal of clay tailings remains a major technical and economic problem, with potentially severe environmental impacts.

4. Coal resource utilization would be reduced by 5 to 8 percent because of coal losses to tailings. This loss is partially offset by improved boiler efficiency resulting from the higher grade coal feed, but the remaining losses must be made up by mining additional tonnages of coal.

(iv) Fabric Filters (Bag Houses)

Fabric filters are large box-like installations which remove particles before they get to the stack. The fly-ash-laden flue gas is passed through the fabric filters (bags) and the fly ash particles are collected on one side of the filter. The collected fly ash is shaken off these filters into hoppers. However it should be pointed out that a commitment to fabric filters in 1981 is considered by B.C. Hydro to involve too great a risk with Hat Creek coal and 500 MW units.

The arrangement of the plant elements would be similar to that for the ESPs of the proposed project except that fabric filters replace the ESPs. Due to the high inlet fly ash loading, it is provisionally considered that mechanical dust collectors would be required in order to pre-clean the gas and reduce the inlet dust loading to the fabric filters.

The above comments also apply if the fabric filter particulate system is combined with one of the FGD (scrubbing) processes. However, in the case of the fabric filter in combination with the spray dryer system (dry FGD) the mechanical collector would be located upstream and the fabric filters downstream of the spray dryers.

(v) Flue Gas Desulphurization (FGD)

A. Full "Wet" FGD (Scrubbing)

This system is similar to the proposed partial "wet" FGD system described in section 3.3(b)(ii).

In the full wet scrubbing case however, all the flue gas passes through the FGD absorber modules (three operating plus one spare) to remove 85 percent of the SO2. The resulting SO2 emissions would equal 0.09 mg/kJ (i.e. PCB Lower Emission Objective)(50). Hot air is injected into the treated flue gas in a downstream mixing chamber to raise the mixed gas temperature above the dewpoint thus preventing water fall-out within plant equipment.

B. "Dry" FGD

The dry scrubber system is located upstream of the particulate control device. For combination with fabric filters, the spray dryer vessels would be located between the mechanical collectors and filters. The mechanical collectors remove an estimated 85 percent of the particulates. The lime slurry injected in the spray dryers reacts with the SO2 to produce calcium sulphite and sulphate in a dry powder form; the reaction is considered to occur during or shortly after evaporation of the injected slurry water. The fabric filters receive the flue gas leaving the spray dryers to remove the calcium salts and further fly ash quantities. The waste material from fabric filter hoppers is in dry form and can be pneumatically conveyed to a central location for disposal via belt conveyors, which is consistent with the proposed powerplant's dry ash disposal scheme. The combined system of mechanical dust collectors, spray dryers and fabric filters is substantially larger than the proposed powerplant systems, requiring relocation of the chimney further away from the powerplant.

In the partial dry scrubbing case, approximately 50 percent of the flue gas must be treated to achieve the upper PCB Emission Objective for SO2 of 0.34 mg/kJ. The remaining 50 percent is bypassed and remixed with the spray dryer exit gas prior to the fabric filters.

In the full dry scrubbing case, all flue gas must be treated in order to achieve the lower PCB Emission Objective for SO2 of 0.09 mg/kJ(50).

C. Reagents

FGD systems consume either limestone or lime as reagents in the process of removing SO2. Depending on the particular process, these reagents chemically combine with SO2 and emerge as either a dry or wet waste product. Further treatment of the wet FGD scrubber waste product (sludge) makes it suitable for dry disposal, using the dry ash disposal system of the proposed project.

Limestone for the wet FGD system and lime for the dry FGD system are available in sufficient quantities from the local area.

D. Stack Design Considerations

The stack design for the proposed powerplant incorporates a single concrete shell with four independent liners. Mild steel liners are considered to be satisfactory for all but the wet scrubber cases. Mild steel liners are common within the industry and provide adequate protection against acid corrosion when the flue gas is above, or not substantially below, the acid dewpoint. These conditions normally exist with dry particulate collection and also with dry FGD processes. For the proposed partial FGD system and the full wet FGD case however, the stack liners would be constructed of acid- resistant material.

(v) Component Selection

B.C. Hydro's and the consultants' evaluations of these alternative AQCS components, and the rationale for selection of the proposed AQCS system with ESPs and partial FGD, are presented in Section 24.3.

<u>(d) Ash Handling Systems (38)</u>

The ash handling system would be required for disposal of bottom ash, which would be removed from the furnaces, fly ash, which would be collected by the precipitators, and sludge from the FGD system. Total daily ash production at full load operation would be about 10 350 t (dry weight) of which about 20 percent is expected to be bottom ash, and the remainder fly ash. FGD waste production would be about 483 t/day (dry weight), at full load. Total lifetime ash and FGD waste production for the four units is estimated as follows:

Fly & Bottom Ash - 86 Mt

FGD Waste - 4 Mt

Bottom ash would be removed from the furnaces using drag bar conveyors, while fly ash would be removed from the ESPs dry, using a pressure (pneumatic) system. FGD slurry would be dewatered to form a sludge and then blended with fly ash to form an essentially dry product. This stable mixture would then be moved with bottom ash by two belt conveyors to the Medicine Creek disposal site. Conveyors and transfer points would operate so that normally damp bottom ash would cover the damp fly ash and FGD sludge to further suppress dusting.

The Medicine Creek ash disposal area would be developed in stages, starting downstream of the planned water supply reservoir dam (see Figure 3-3). After preparing the disposal site by removing all vegetation and storing surface soil, the mixture of fly ash, bottom ash and FGD sludge would be distributed by means of movable conveyors, mobile stackers and large bulldozers. Natural runoff from areas above the disposal site would be intercepted by canals and channelled into the water supply reservoir.

After 3 years of ash disposal the first section of the ash dump would have reached its planned height. Surface material stripped earlier from the area would be used for reclamation, and the area would be seeded to prevent erosion. The depth of surface material required would be established through an on site test program. Further surface materials if required would be available from the mine operation. This ash pile reclamation process would continue over the life of the powerplant.

(e)Water Systems(56,38)

The powerplant water system has four main components: the water supply system, the circulating water system, the waste water system and the water treatment system. Because the water supply system is located outside the immediate Hat Creek area, it is described under Offsite Facilities in Section 3.4. The circulating water system and the cooling towers are described later in this section under "Heat Dissipation System".

The powerplant's water demands (or "make-up" water requirements) would equal water lost to both evaporation and waste water use. All waste water would be reused. Thus the powerplant would be designed to operate on a "zero-discharge" basis, that is, with no release of liquid effluent.(38,56)

(i)Waste Water Systems

Major sources of waste water from the powerplant complex would be blowdown from boilers and cooling towers, runoff drainage, sanitary waste water and floor drainage. Blowdown from the boilers would be added to the cooling water system. Cooling tower blowdown would be consumed mainly in the FGD system and ash handling system to condition (moisten) the dry fly ash. Rainfall runoff from the powerplant site and nearby coal storage area would be collected in drainage ditches, carried to a holding pond near the ash disposal area, stored and used for ash conditioning and dust suppression. Runoff and seepage from the ash pile would be collected behind an embankment downstream of the ash pile toe. This waste water would be pumped to the same holding pond and also used for dust suppression. The holding pond is large enough to accommodate the runoff from the estimated largest 24-hour rainfall occurrence from all three areas, occurring once in 10 years on average. Runoff exceeding this volume would be channelled to the water reservoir.

Sanitary waste water from the potable water system would be treated by an aeration treatment plant and then reused for ash conditioning and dust control. Floor drainage from the powerplant would be collected in a separate drainage system, treated in an oil/water separator facility and also reused in the ash disposal system.

(ii)Water Treatment System

This system would receive water from the water supply reservoir (see Section 3.4, offsite facilities) and purify it for use as potable water or demineralize it to produce high purity water to supply the powerplant steam cycle. A side-stream water treatment plant would be used to maintain cooling tower water quality and the "zero-discharge" condition.

(f)Heat Dissipation System

Steam would be exhausted from the turbines to the condensers, where its heat would be transferred to the condenser cooling water. The condensed steam would then return to the boilers, while the cooling water would proceed to the cooling towers. Normally each tower would serve two turbine units. Condenser cooling water would rain down inside the towers where a portion of it would evaporate to cool the remainder. At full load and given the cooling tower design conditions, evaporation from the two towers is estimated at approximately 1156

L/s (see Figure 3-11). This volume of water would be discharged to the atmosphere in vapour form. Spray ("drift") emissions of water in liquid droplet form from the cooling towers are estimated to be about 3.0 L/s under those conditions.(56,38)

(g)Sound Attenuating System

The Hat Creek powerplant would be designed to meet specific in-plant sound level requirements for protection of personnel and also to minimize the sound impact in nearby areas. Primary emphasis would be on noise control at the source by using reducing devices such as acoustic enclosures, silencers and sound insulation.

## 3.4 OFFSITE FACILITIES

(a)Overview

Offsite facilities are project components located outside the immediate Hat Creek valley, or not part of the scope of the proposed mine and powerplant complexes. Major offsite facilities include access roads, the powerplant water supply system including the reservoir, the 500 kV and 69 kV transmission lines, an airstrip, the equipment unloading facility, the creek diversions and the construction camps.

(b)Access Road(9)

Principal access to the Hat Creek project would be provided by a 31 km paved two-lane road which would commence at Highway No. 1 near the Ashcroft Manor, and proceed up Cornwall and MacLaren Creeks, rising about 900 m before descending along the north side of Medicine Creek past the powerplant site. It would then continue down past the mine mouth area and join Highway No. 12 at the north end of the upper Hat Creek valley. The proposed route of the access road is shown in full on Figure 3-2 and in more detail on Figure 3-3 and Figure 3-12.

A section of road approximately 1.5 km long would connect the powerplant site and the new access road. About 9 km of the existing Hat Creek valley road would be relocated around the east side of Open Pit No. 1. This relocated road would be adjacent to and follow the Hat Creek diversion canal. It would join the new project access road near the mine maintenance complex.

The main access road alignment would require nine creek crossings using culverts through the road embankments. Precautions would be taken during culvert installation to minimize disturbance to the creek beds, to maintain creek flows, and to avoid siltation and obstruction to aquatic organisms. Since it would link two provincial highways, the road would likely become part of the provincial highway system after the construction phase.

(c)Powerplant Water Supply System(8)

The water required for powerplant operation would be obtained from the Thompson River, upstream of Ashcroft, and pumped through a buried pipeline to a reservoir in the upper Medicine Creek valley. Thompson River water quality is such that no chemical treatment would be required before the water is received at the powerplant. Major components of the water supply system include:

1. A pier-type intake structure and pumphouse in the Thompson River just north of Ashcroft (see Figure 3.12).

2. A degritter-clarifier located between the intake and the No. 1 booster station and adjacent to No. 1 booster station.

3. Two booster stations containing high-pressure pumps, one (No. 1) near the intake and a second (No. 2) west of the Trans-Canada Highway.

4. A pipeline and related equipment linking the intake, booster stations and reservoir.

5. The reservoir in upper Medicine Creek valley adjacent to the powerplant.

The water supply system was determined from evaluation of alternative plans on the basis of environmental, economic and engineering considerations. Suitability of the intake type and location were critical factors in developing the selected system. Figure 3-2 shows the water supply system layout in general and Figure 3-3 and Figure 3-12 present more detail. The system's basic parameters are presented in Table 3-3.

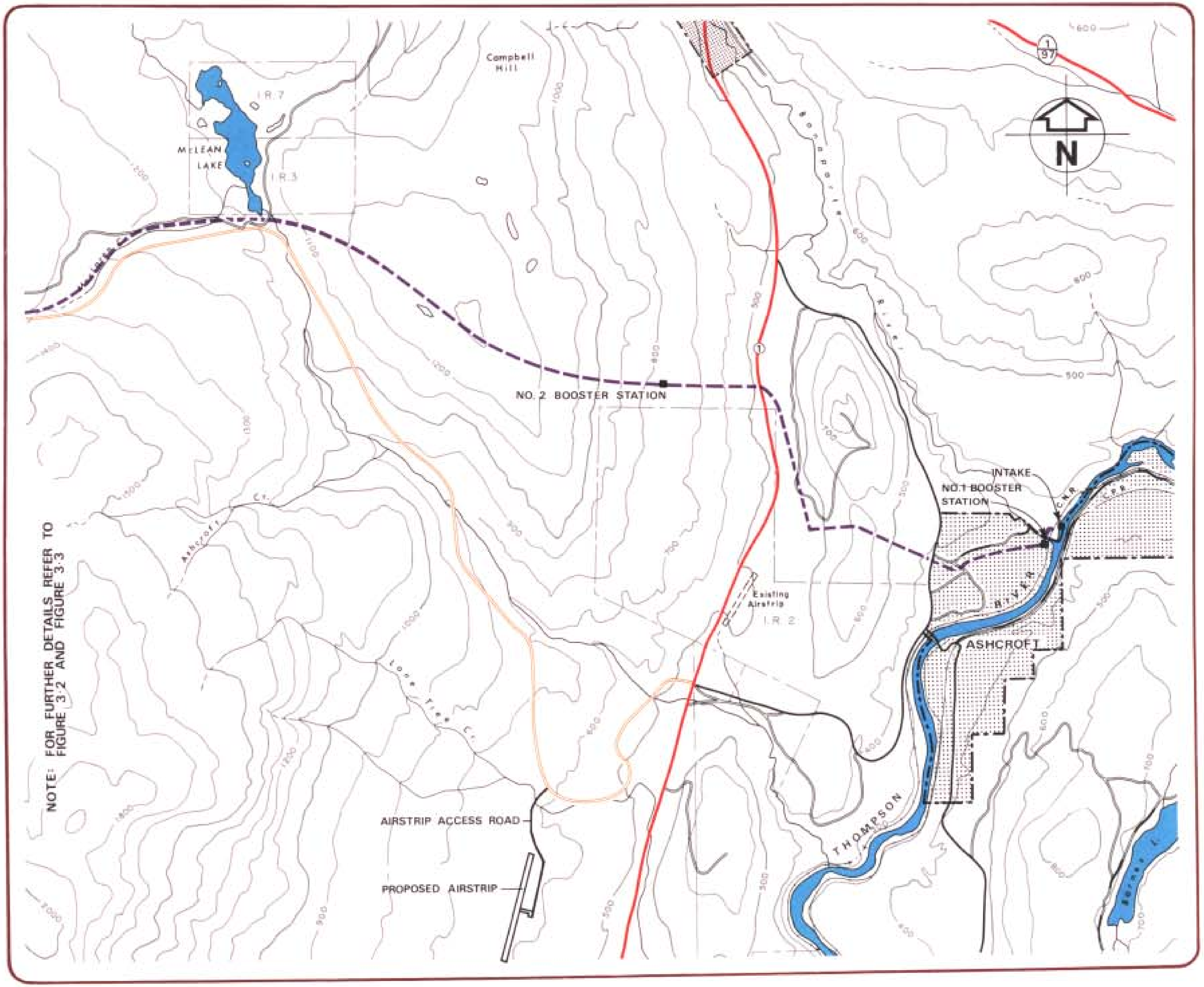
(i)Water Intake

The location of the intake structure would be adjacent to the west bank of the Thompson River, 350 m upstream from the mouth of the Bonaparte River, near the town of Ashcroft. At this point the Thompson River has a large flow compared with the proposed maximum water supply system demand. Maximum project requirements are less than 2 percent of the Thompson River's lowest flow and less than one half of 1 percent of the average flow at this point.

A pier-type intake structure composed of six cells would withdraw water from the river. Each cell would be protected from small debris by vertical travelling screens and the entire cell area would be protected from larger debris by a system of trashracks. The intake would be oriented parallel to the river flow and hence would use the sweeping action of the river current to carry away debris. The intake would be equipped with a bypass channel located between the trashracks and travelling screens, to allow river water to flow along the face of the travelling screens. This bypass arrangement would minimize entrapment of fish. Figure 3-13 shows a perspective drawing of this structure.

The component of the water intake approach velocity normal to the screens at minimum river water depth would not exceed 0.12 m/s. This low velocity component together with the more rapid bypass flow (0.21 m/s minimum) would minimize the possibility of impingement of salmon fry on the screens.

The water intake pumps and pipeline would deliver water to the degritter-clarifier located adjacent to the No. 1 booster station. Solids suspended in the water would be removed and returned to the Thompson River at mean concentrations of 50 mg/L. Booster No. 1 pumps would pump water from the clarifier to No. 2 booster station.




## LEGEND

BURIED WATER SUPPLY PIPELINE

PROJECT ACCESS ROAD

SCALE — 1:50,000

1 km 0 km 1 km 2 km 3 km

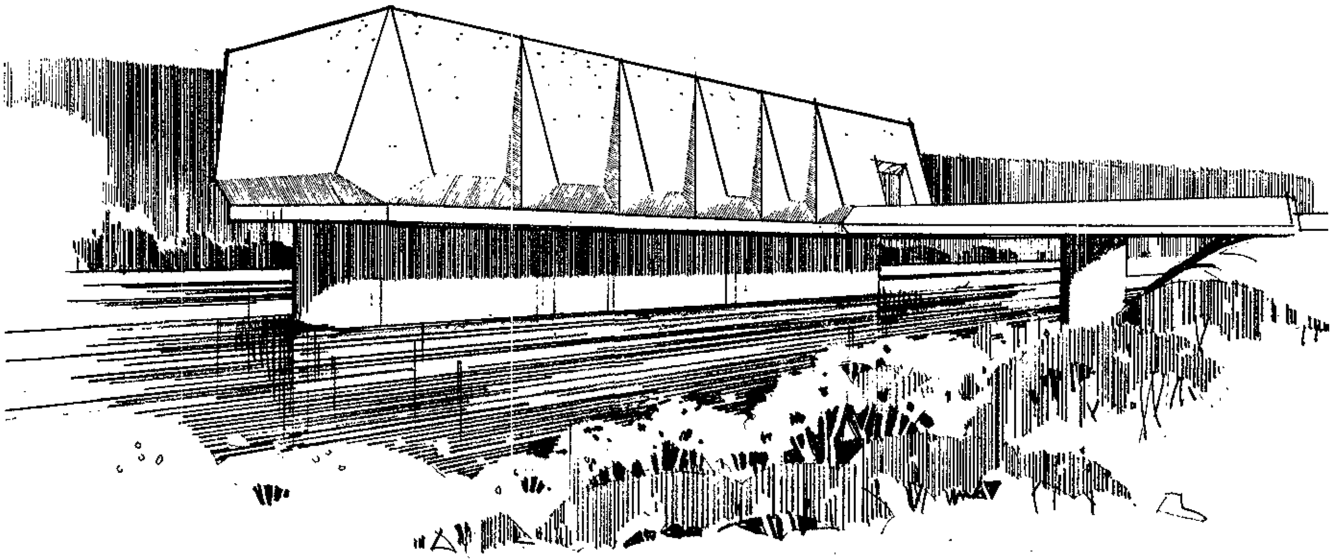
CONTOUR INTERVAL — 100 METRES

HAT CREEK PROJECT

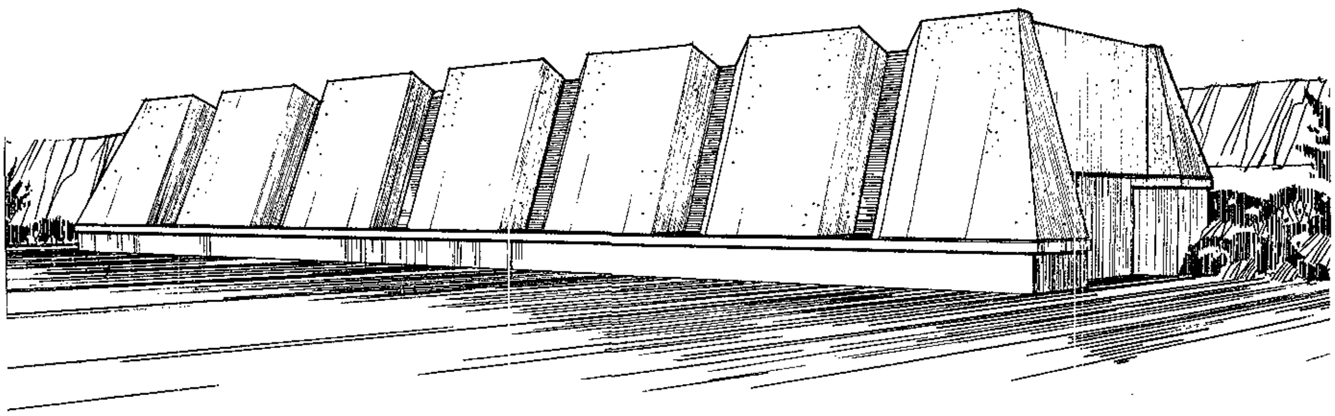
FIGURE 3.12

# GENERAL ARRANGEMENT PLAN WATER SUPPLY SYSTEM (PART) PROJECT ACCESS ROAD (PART) AIRSTRIP

SOURCE: Sandwell and Company Ltd. (8)
British Columbia Ministry of Highways (9)
Transport Canada (16)



INTAKE STRUCTURE



BOOSTER STATION

HAT CREEK PROJECT

## FIGURE 3.13
# WATER SUPPLY SYSTEM

*SOURCE: Toby, Russell, Buckwell and Partners Architects (2)*

TABLE 3-3
WATER SUPPLY SYSTEM
BASIC PARAMETERS(8)

| | |
|---|---|
| Maximum flow rate | 1580 L/s |
| Static lift | 1013 m |
| Pipeline length (along slope) | 21.4 km |
| Pipe diameter | 800 mm and 900 mm |
| Number of intake pumps | 5 |
| Intake pump motor rating (each) | 190 kW |
| Number of booster pumping stations | 2 |
| Number of booster pumps in each booster station | 4 |
| Booster pump motor power (each) | 3600 kW |

(ii) Booster Stations

The two booster stations would house major mechanical equipment, mainly pumps and motors. Since the pumping head and discharge would be equal for each station, the layout and equipment for the stations are identical. Booster pump motors would be water cooled (rather than air cooled) to assist in maintaining low ambient sound levels. Materials used for the booster stations' roof and wall construction would further reduce the sound level. Figure 3-13 shows a perspective drawing of these structures.

(iii) Pipeline

The 21 km route of the pipeline, shown on Figure 3-2, would cross a variety of terrain: agricultural land including Boston Flats; the rock-dominated slopes of the Trachyte Hills; and the forests sloping gently westward to the powerplant reservoir. At present, the suburb north of Ashcroft is the only inhabited area near the route. The current extent of development there lies, at its closest point, about 110 m to the south of the route.

The pipeline right-of-way would be about 18 m wide. It would contain a loose-surface access road, the buried pipeline, and a buried ductbank carrying the control cables and power cables. The right-of-way would require light clearing over most of its length, so that the total cleared area would be about 35 ha. Following installation, the right-of-way would be graded and revegetated, except for sections of the road which would be retained for maintenance access.

The proposed pipeline leak detection system would function continuously and consist of permanent acoustic sensors attached to the pipeline at intervals of 300 m. These sensors would detect unusual vibrations caused by even a small leak, and provide an alarm to the system operators. Valves could be closed to isolate the reservoir and surge tanks from the pipeline so that the maximum loss of water could be restricted to the amount in the pipeline.

The design of the pipeline right-of-way would include trenches, dykes and line drainage facilities to channel any leaking water toward natural watercourses to avoid erosion.

The dykes, trenches and associated works would be inconspicuous as they would be earth structures, small in scale, and planted with grass, brush and trees to minimize erosion and visual impact.

(iv)Water Supply Reservoir(39)

The powerplant water supply reservoir located in upper Medicine Creek (see Figure 3.3) would have a normal live storage capacity of 6.7 x $10^6$ $m^3$. An additional "free-board" storage capacity of 15 x $10^6$ $m^3$ would be provided, adequate to deal with the Probable Maximum Flood, which would be discharged in a controlled manner through the outlet works. The outlet works for flood protection would consist of 5.7 km of buried pipe discharging into the downstream end of the Hat Creek diversion canal. The reservoir would be operated so as to collect the normal Medicine Creek flow occuring during the spring freshet. This volume of water would be released as required to the downstream end of the Hat Creek diversion canal (via the outlet conduit) during the low flow summer months. The release of this relatively cool water to the Hat Creek diversion canal would reduce the otherwise high temperature of the water in the canal. The reservoir would be created by a 55 m high earthfill dam. Water for the powerplant would be pumped from the reservoir to the cooling tower basins via an intake, pumphouse (located within the reservoir) and steel pipeline.

The reservoir is designed with a storage capacity equal to 70 days of powerplant maximum water consumption. Thus, although the intake systems have been designed to avoid damage to migrating salmon, the water supply system could be shut down during the 14 to 21-day periods of the Thompson River salmon runs.

### (d) Transmission Systems

#### (i) 69 kV Transmission System(11)

Electric power would be supplied to the mine, powerplant construction, and the water supply system by 69 kV transmission lines carried on single wooden poles from various points in the existing local B.C. Hydro system.

Two connecting 69 kV lines would be required, one to supply the mine and powerplant construction and a second to supply the water supply pumping stations. Routes for the latter lines are shown on Figure 3-14. Power to the mine substation would be taken from an existing 69 kV line near Highway No. 12. Power for powerplant construction would be carried by a permanent 69 kV line between the powerplant and the mine.

Power for the water supply pumping stations would be carried from the proposed new 230/69 kV Rattlesnake Substation. This substation would be located about 1.5 km from a residential subdivision of Cache Creek. From this substation, the 69 kV line would cross Highway No.1 close to the town of Cache Creek, and follow the route shown on Figure 3-14 to the No. 1 booster station pumphouse adjacent to the Thompson River. The No. 2 booster pumping station would be supplied by tapping into this line. Along the section from the tap to the No. 2 booster pumping station, the line would be visible from Highway No. 1 and from the road linking Highway No. 1 and Ashcroft. It would also pass in the vicinity of several houses near Boston Flats.

#### (ii) 500 kV Transmission System

The 500 kV transmission line would run north from the switchyard (see Figure 3-2) about 2 km to join the then existing Kelly Lake to Nicola transmission line.

### (e) Airstrip(10)

An airstrip suitable for small jet aircraft would be needed near the project area. Based on Transport Canada's reconnaissance of potential sites, a probable location for the airstrip has been chosen within the Cameron Ranch, on the west side of Highway No. 1, between Ashcroft and Cache Creek, as shown on Figure 3-12. The airstrip would lie about 9 km from Ashcroft, 14 km from Cache Creek and 30 km from the mine, and would be available for use by local residents.

### (f) Equipment Unloading Facility(40)

During the construction phase, most materials and equipment for the project would be shipped from suppliers by rail. Because distance and terrain make it uneconomic to construct a spur line into the project site, all rail shipments must be trucked by road from a convenient unloading point on the railway. Possible sites on BCR, and CNR are under consideration; however, no final site has been chosen. A trans-shipping terminal would be required at that point to transfer materials from railcars onto trucks. The unloading facility would also be used as an interim storage yard.

### (g) Creek Diversions(39,41)

Because the open pit and the waste disposal areas would be located in valley bottoms, a number of streams would require diversion around them. Streams to be diverted include Hat Creek, Medicine Creek, the stream in Houth Meadows, Finney Creek, and those in the area adjacent to Aleece Lake. Figure 3-7 shows the locations of these diversions.

(i)Hat Creek(41)

Hat Creek would be the most significant of the diversions, having a drainage area of about 360 km². The proposed diversion canal scheme would comprise a 16 m high earthfill headworks dam on Hat Creek immediately downstream of Anderson Creek, a 6475 m lined canal on the east side of the valley and a 2060 m long buried discharge conduit to return the flow to Hat Creek downstream of the pit. Inflows downstream of the canal headworks would be intercepted by a 13 m high earthfill dam near the pit rim and would be pumped up to the diversion canal.

The diversion canal would be located generally along the 975 m contour in order to avoid the steep bluffs east of the pit and to minimize infringement of the pit perimeter. The canal would be sealed with impervious materials. The design capacity would be 18 000 L/s, with a maximum capacity of 27 000 L/s, which represent the expected floods with annual probabilities of 1:100 and 1:1000 respectively.

Including service and access roads, the overall width of the diversion canal would vary from about 36 to 60 m. With development of Open Pit No. 1 beyond the 12-year stage, pit infringement would require realignment of a portion of the canal, or partial replacement by a tunnel some 1700 m in length.

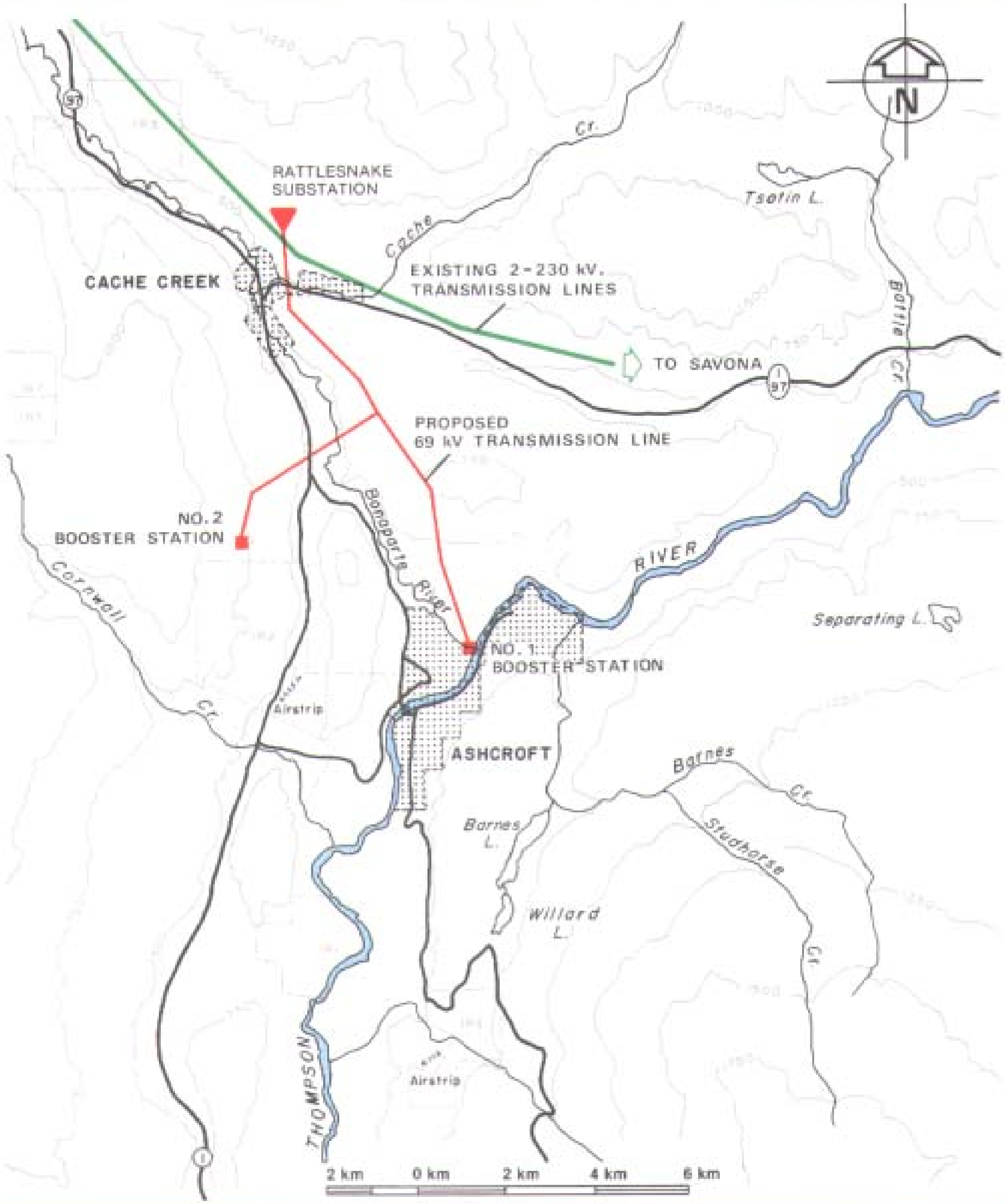
From the end of the diversion canal, which would be expanded and deepened slightly to provide a sedimentation basin, the diversion flows would pass through the conduit intake structure and the buried conduit, then discharge into energy-dissipating outlet works and flow via a short length of excavated open channel back to Hat Creek. The overall drop from the canal to Hat Creek would be about 155 m.

(ii)Medicine Creek(39)

A portion of Medicine Creek runoff would flow directly into the upper Medicine Creek water reservoir. This volume of water would be released as required to the downstream end of the Hat Creek diversion canal to reduce the otherwise high temperature of Hat Creek water during the low flow summer months. The quantity would depend on the use of an existing irrigation diversion system. Runoff downstream of the reservoir would require control. To ensure the security of the ash and mine disposal areas in mid and lower Medicine Creek, runoff canals designed to handle the Probable Maximum Flood would be provided on both sides of the disposal area. Both the north and south side runoff canals would flow in an easterly direction, discharging into the water supply reservoir.

(iii)Finney Creek and Aleece Lake Diversions(41)

Runoff from the Finney Creek drainage area of about 13 km² would be diverted by a canal into the Hat Creek headworks reservoir. Most of the runoff in the area to the west of the mine and in the vicinity of Aleece Lake, (a drainage area of about 31 km²), would be diverted around the south edge of the Houth Meadows waste disposal area and discharged into Hat Creek. To avoid concentrating the flow in this area, the northern




HAT CREEK PROJECT

## FIGURE 3.14
# 69 kV TRANSMISSION LINE SYSTEM

SOURCE: British Columbia Hydro and Power Authority (11)

portions of the Houth Meadows waste disposal area perimeter would be drained to the north.

(h) Construction Camps(42)

During the construction phase of the project, camps would be provided by B.C. Hydro for the construction work force needed at the mine and the powerplant. Because of different labour jurisdictions and travel distances, separate camps would be required for the mine and the powerplant. The camps, as located, (see Figure 3-3), offer the optimum combination of economical water supply, convenience of access and residential suitability.

The mine camp would be located northeast of the mine. A pine forest would screen it from the project access road, the transmission line and the conveyor. This facility would provide single status accommodation for up to 500 persons. The powerplant construction camp would be located on sloping ground on the west of the construction site, so that it would be within walking distance of work areas. The camp would provide facilities for up to 1820 single persons.

Water supply for the camps (and the powerplant construction needs) would be obtained from wells in the Hat Creek valley and pumped to storage near the camps.

Sanitary effluent from both construction camps would be treated in an aerated lagoon and disposed of to the ground by rapid infiltration. (62)

## 3.5 PROPOSED PROJECT COSTS

The proposed project includes the mine, offsite facilities and the powerplant (2000 MW net) with a 366 m high multi-flue stack, electrostatic precipitators and a flue gas desulphurization system.

Direct capital costs for the proposed project are given below in 1980 dollars and also in inflated dollars, based on a first unit in-service date of 1988 and the other units at 12-month intervals.

| | 1980[1] M$ | Inflated[2] M$ |
|---|---|---|
| Powerplant[3] | 1 821 | 4 199 |
| Mine | 454 | 1 010 |
| Transmission, Substations etc. | 19 | 47 |
| TOTAL DIRECT COST | 2 294 | 5 256 |

1. Millions of dollars, not including interest during construction and corporate overhead.

2. Millions of dollars, inflated to the year of expenditure and including interest during construction and corporate overhead.

3. Costs for offsite facilities have been divided between the powerplant and mine accounts.

## SECTION 4. PROJECT PHASES

Following the licensing phase of the project, for which this EIS is the main supporting document, and on the assumption that the project is approved by the government and people of British Columbia, project activities in the Hat Creek valley and adjoining project areas would be divided into three phases: construction/mine development, operation, and decommissioning/reclamation.

### 4.1 CONSTRUCTION/MINE DEVELOPMENT PHASE

Construction of the project would start immediately after project authorization and would include the following activities:

1. Letting of major contracts.
2. Setting up environmental monitoring facilities.
3. Providing construction-labour camps and related services.
4. Providing power, water, sewage facilities, construction access roads and lay-down areas for material stockpiles.
5. Constructing permanent roads and railroad off-loading facilities.
6. Excavating foundations for all structures.
7. Constructing buildings, structures, dams, dykes, drainage ditches and diversions.
8. Removing initial mine overburden and coal stockpiling.
9. Installation of all machinery, acceptance testing and commissioning.
10. Final clean-up, grading and revegetation.

Because the powerplant would consist of four units, which would be constructed sequentially to enter commercial service at 1 year intervals, the construction and operating phases would overlap. This overlap affects many aspects of the project and requires detailed scheduling. For the most part, facilities peripheral to the powerplant must be operational on or before the date when the first unit starts up. Subsequent to the first unit start-up most construction activities would be at the powerplant.

(a)Schedule(12)

Construction activities would start approximately 6 years before commercial operation of the first powerplant unit. The local access roads, construction electrical supply and a construction camp would be the first facilities installed. Construction activities would end with the clean-up, grading and revegetation work following completion of the fourth powerplant unit.

Details of the proposed schedule for all major items are given on Figure 4-1. It should be pointed out that the schedule presented anticipates the completion of powerplant units 1 to 4 in four consecutive years, for construction and commissioning optimization. If load growth or other factors require it, the timing of units 2, 3 and 4 could be changed to suit any reasonable development schedule.

(b)Labour Force(13)

Predicted direct employment requirements for the construction phase of the Hat Creek project are shown in Figure 4-2.

Construction activities are anticipated to involve one shift working 8 hours/day, 5 days a week. The early powerplant construction years would require primarily general labourers, operating engineers, carpenters and electrical workers, while the peak and wind-down periods would emphasize the inputs of plumbers, pipefitters, iron workers, electrical workers, insulators and boilermakers. The major trades required for mine development would be equipment operators, machinists/millwrights, miners and general labourers. Skills required for offsite construction include general earth moving and light construction skills, with the exception of the main water supply pipeline and pumping stations which would require more specialized skills.

(c)Construction Camps

The first stage of the powerplant camp would be completed by March 1984 to provide living accommodation for the powerplant contractor's workers.

The initial mine camp would be completed by December 1985 to provide accommodation for the workers assembling the mine equipment. Both camps would later be expanded to accommodate the construction labour force requirements. Use of the camps would be on a voluntary basis.

It is anticipated that at the height of the construction phase, the (single person) capacities of the camps would be as follows:

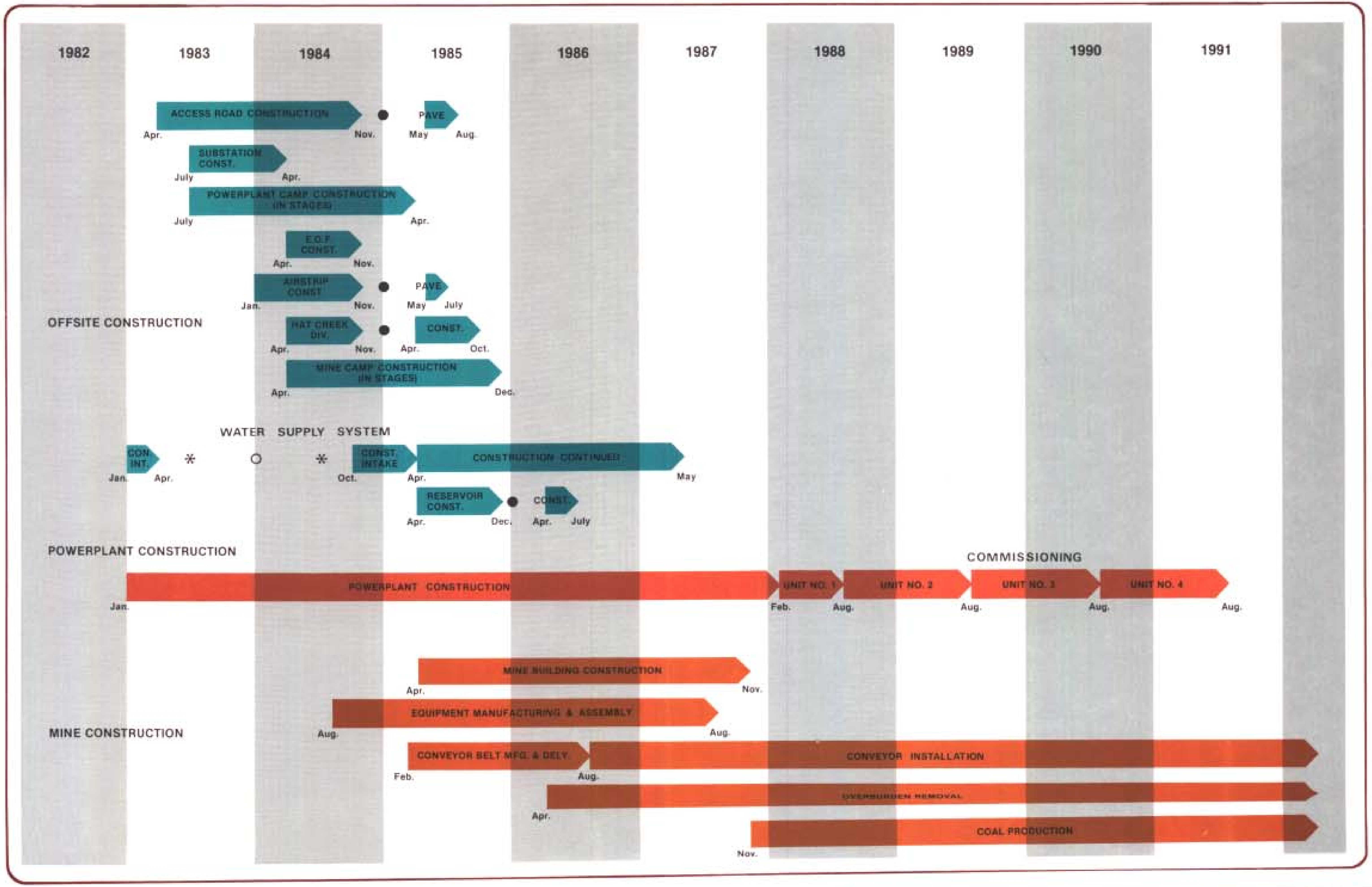
| | |
|---|---|
| Mine Camp | 500 |
| Powerplant Camp | 1820 |

(d)Environmental Protection(27)

An environmental group would be established at site immediately prior to the start of construction activities. The size and disciplinary diversity of this group would grow as project activities expand (Table 4-1).

The site environmental group has been designed at the outset to remain at site through the construction period into the operating phase. Thus there would be no interruption of these programs. Although this group would cover a wide range of disciplines, special assistance would be obtained from B.C. Hydro's head office and/or consultants as required. Environmental protection plans would be developed during detailed design of site construction activities to protect water and air (dust) quality; contingency plans would be developed to cope with accidental hazards. At all stages, attempts would be made to minimize disturbances to land and water bodies. The site environmental group would "operate" these environmental protection programs.

A comprehensive monitoring program has been developed for this project as described in Section 26.0. The site environmental group would develop this program and implement procedures for ongoing monitoring.




● WINTER BREAK

✳ HIGH WATER

○ SALMON SPAWNING

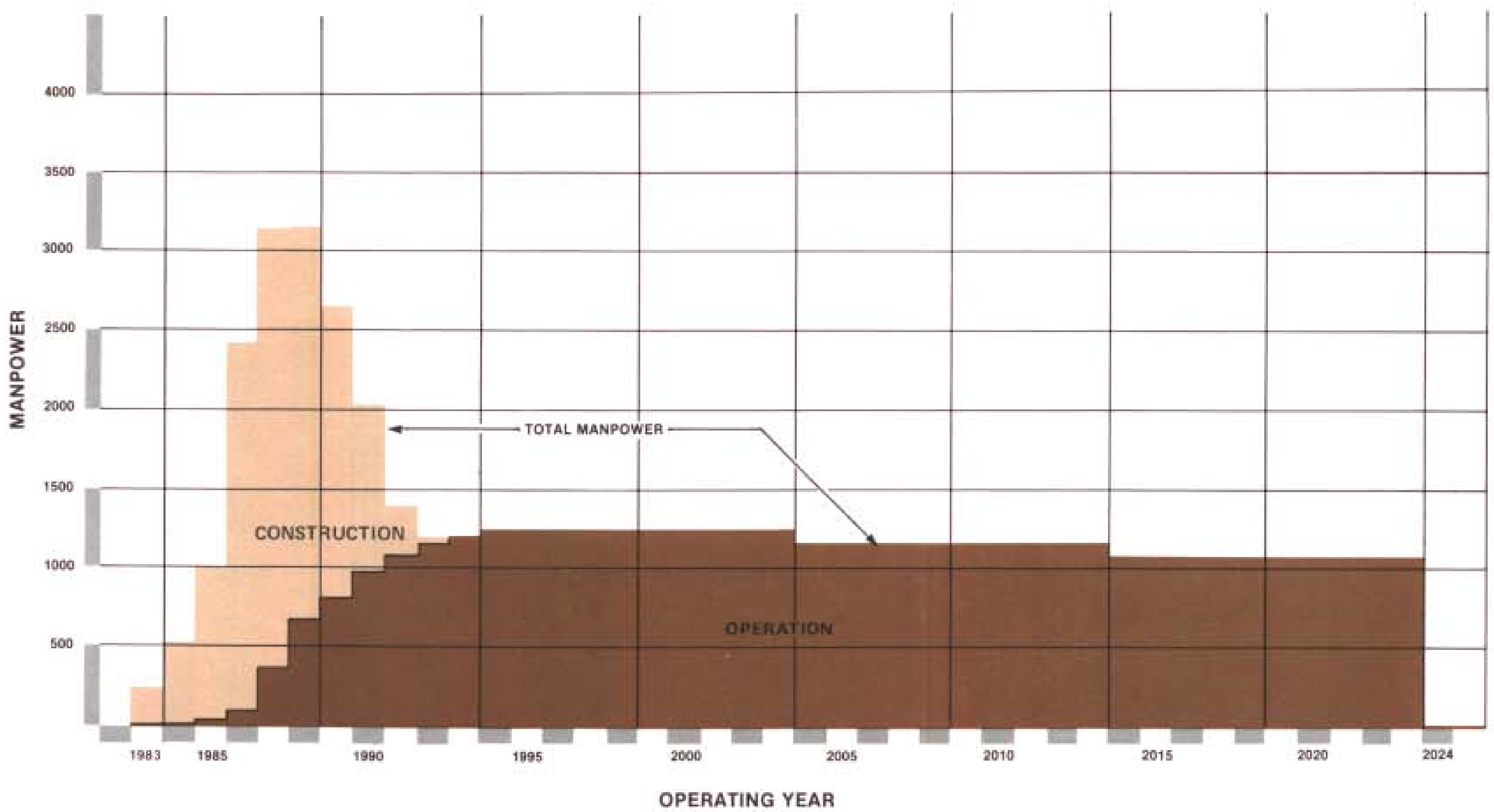
E.O.F. — EQUIPMENT OFFLOADING FACILITY

HAT CREEK PROJECT

FIGURE 4.1

CONSTRUCTION SCHEDULE

SOURCE: British Columbia Hydro and Power Authority (12)




HAT CREEK PROJECT

FIGURE 4.2

**MANPOWER REQUIREMENTS**

SOURCE: British Columbia Hydro and Power Authority

A major activity of the site environmental group would be the revegetation of those areas disturbed by the project. This is designed as an ongoing activity commencing as soon as is practical in the construction phase and proceeding through operation to decommissioning. A substantial effort has already been made in determining the suitability of materials and vegetation species for reclamation at Hat Creek. These studies and the proposals for reclamation of all disturbed areas are summarized below.

## Land Reclamation(27)

### On-site Reclamation Testing

Both laboratory and on-site testing have been undertaken to determine the properties of the waste materials as growth media and to evaluate a variety of grass and legume species for revegetation at Hat Creek. These studies have been under way since 1977.

Initial laboratory (greenhouse) studies were followed by detailed on-site reclamation testing, making use of materials generated during the 1977 Bulk Sample Program, to examine methods and materials to achieve B.C. Hydro's goals for reclamation at Hat Creek, namely:

Short-term goals
- Control of wind- and water-borne erosion
- Aesthetics
- Stabilization of waste

Long-term goals
- Self-sustaining vegetation
- Suitable end use - combined agriculture and wildlife

The field tests comprised two major programs, one to examine the revegetation potential of slopes at different angles of repose, and the other to examine the different materials and determine their characteristics as growth media. All waste dumps associated with the 1977 Bulk Sample Program were also reseeded and used as facilities for further testing.

The results from the slope test plots indicate that embankments at Houth Meadows and Medicine Creek could be constructed with stable and reclaimable slopes at least up to 30°.

Results from other test areas indicate that the mine waste material may be divided into three categories, namely: surficial materials such as colluvium, till, gravels, baked clay and topsoil; non-seam wastes such as sandstone (siltstone, claystone) and bentonitic clay; and seam wastes such as carbonaceous shale and other very low grade coaly waste.

The tests indicate that revegetation of surficial materials can be readily achieved, and also that these soils are suitable for reclamation purposes without the addition of topsoil. This result is noteworthy and indicates that the material selected for stripping and stockpiling for subsequent use as surface growth media may comprise surface materials such as gravel, colluvium, till, baked clay, and topsoil, either separately or in combination. The implication is that the separate stripping of topsoil has been shown to be unjustified in the presence of suitable quantities of other surficial materials.

TABLE 4-1
HAT CREEK PROJECT
DIRECT EMPLOYMENT BY SITE ENVIRONMENTAL PROTECTION GROUP
CONSTRUCTION-OPERATING AND RECLAMATION PHASES (13,27)

| Year | No. of Workers |
|---|---|
| 1983 | 1 |
| 1984 | 2 |
| 1985 | 2 |
| 1986 | 14 |
| 1987 | 17 |
| 1988 | 17 |
| 1989 | 17 |
| 1990 | 17 |
| 1991 | 17 |
| 1992 | 17 |
| 1993 | 17 |
| 1994-2023 | 17 |
| 2024-2033 | 13 |

Revegetation of seam and non-seam mine waste would be more difficult to achieve. A surface capping of surficial material would be required to satisfactorily revegetate these waste materials.

A wide variety of species of grass and legumes has been tested and several have been shown to be suitable for reclamation at Hat Creek. In addition to agronomic species, native shrubs and forbs considered essential in the reclamation of wildlife habitats would be transplanted and/or propagated in a nursery to be developed near the pit rim reservoir.

Revegetation of Disturbed Areas

Disturbed areas at Hat Creek would be progressively revegetated as and when available. Temporary reclamation would be carried out on areas stripped of vegetation, waste dump surfaces, or material stockpiles left inactive for several years. Retaining embankments would be constructed in lifts which allow for long-term reclamation concurrent with construction. Waste dump surfaces would be reclaimed as soon as the final surface elevation is reached. Other areas disturbed during construction, such as construction material borrow pits, transportation corridors, etc., would be revegetated as soon as possible following disturbance.

Waste dumps would be revegetated to an end use comparable with adjacent lands at similar elevation. Allowance has been made to cover waste material with approximately 1 m of surficial material, though the precise depth required would be established through further on-site testing. Details of the revegetation of the ash/FGD sludge waste dump is given in Section 3.3(d). Stockpiles of surficial material would be developed as necessary and temporarily revegetated. The topography and diversity of native species similar to pre-mining conditions cannot be duplicated, but reclamation of waste dumps will be designed to provide a revegetated, self-sustaining, stable surface composed of materials similar to, or better than, those of adjacent lands. Presently, land in the area is used for mixed wildlife and agricultural (mostly ranching) purposes. It is proposed to revegetate waste dump surfaces to suit similar uses.

## 4.2 OPERATION PHASE

### (a)Schedule

Operation of the mine is planned to begin in late 1987 and operation of the powerplant in early 1988 with the commissioning phase. This would be followed by commercial operation of the first 500 MW unit in August 1988. Commercial operation of the powerplant is planned for 35 years (1988 to 2023).

### (b)Labour Force(13)

Total direct employment requirements for the project's operational phase are shown in Figure 4-2, superimposed on the construction phase to give the total direct project employment requirements.

### (c)Operating Regime(65)

The powerplant and the mine would operate 24 hours a day, 365 days a year. To achieve this schedule, 21 shifts of 8 hours each would be required per week. The powerplant would operate at a maximum annual average capacity factor of approximately 75 percent, with a lifetime capacity factor of 65 percent. Shutdown of sections of the powerplant would be required for maintenance and repairs. Generation reductions would also be necessary during periods of low system demand. It is expected that by 1991 to 1992 the Hat Creek powerplant would supply approximately 17 percent of the B.C. Hydro system's energy requirements.

### (d)Materials to be Handled

Coal would be mined, crushed and blended to supply the powerplant with the quality and quantity of coal required for operation, via the overland conveyor system. Because coal stockpiles would exist at both the powerplant and the mine, their operation need not be synchronized.

The mining and burning of coal produces a number of waste products. From an operational point of view mine waste material would be transported to waste disposal areas (see Section 3.2). Fly ash, bottom ash and FGD sludge produced by burning coal in the powerplant would be collected and disposed of in the "dry" land fill disposal site in mid Medicine Creek (see Section 3.3).

Details of coal and mine waste excavation and ash production are shown in Table 4-2.

(e)Environmental Protection(27)

As described in Section 4.1(d), the environmental group developed at site during the construction phase would remain at site during the operating phase of the project. As before, this group would provide for ongoing environmental protection, e.g. the operation of the sedimentation and leachate lagoons, and monitoring (see Section 26.0) and would carry out the rehabilitation of disturbed areas and waste disposal areas.

## 4.3 DECOMMISSIONING AND RECLAMATION PHASE

At present the project plan calls for the powerplant and mine to operate over a 35 year period. However, this plan could be modified (with government approval) during the life of the project, depending on energy requirements and the economic viability of the coal fired thermal generating system.

Assuming a 35 year life span, all project structures would at the end of operation be dismantled and removed or otherwise permanently disposed of, with the exception of desirable features such as the water supply reservoir.

Reclamation plans for the decommissioning/reclamation phase are discussed below. This work would be carried out by the site environmental group during years 35 to 45 (2023 to 2033). Those areas which would be reclaimed by Year 45 are shown on Figure 4-3.

(a)Reclamation(27)

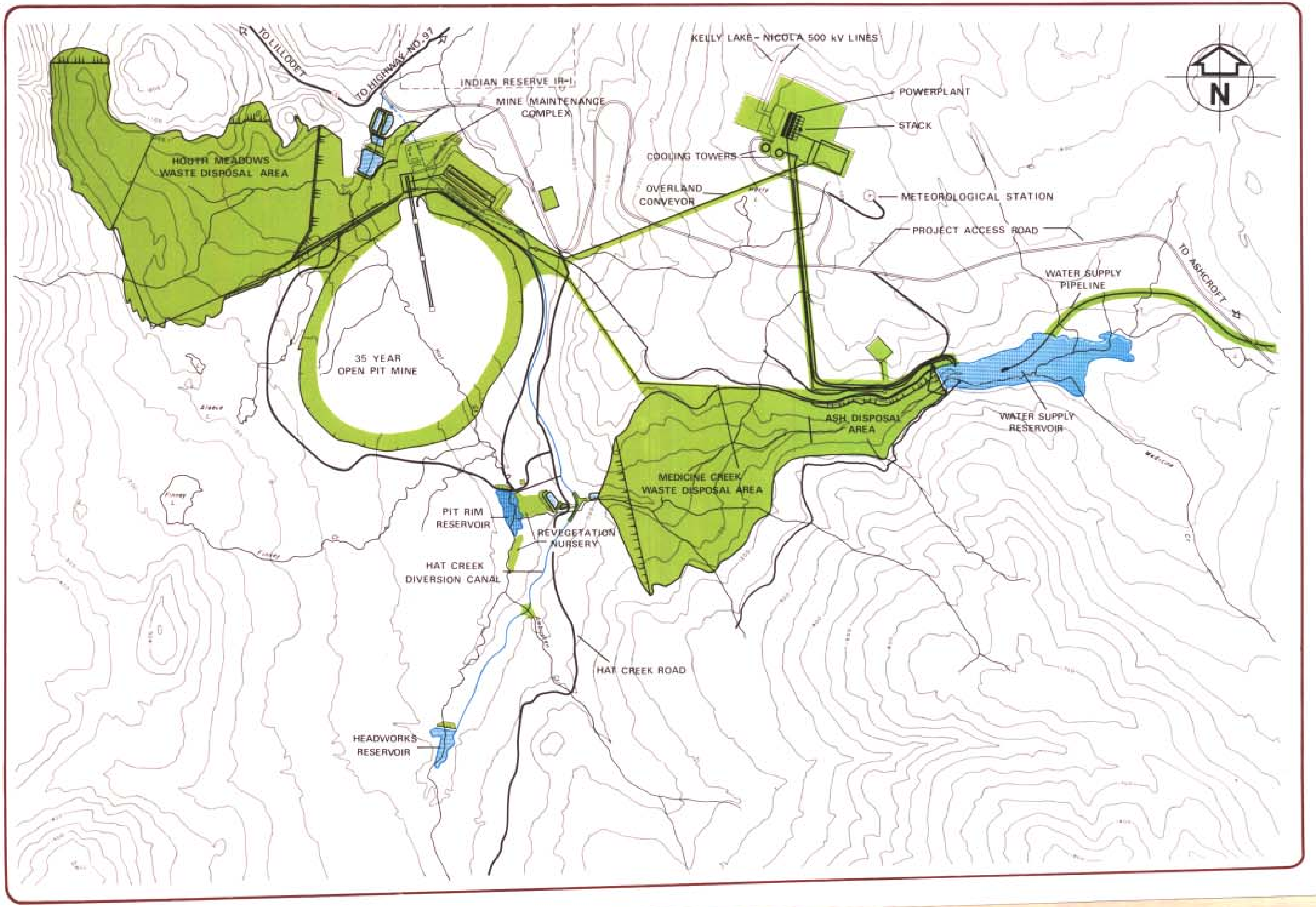
(i)Waste Disposal Areas and Embankments

All embankments and most of the surface area of waste dumps would have been revegetated by Year 35 (2023). The remaining areas would be contoured, surfaced with suitable material and seeded as soon as possible after operations cease. In the following years, maintenance of all waste dump areas would be continued in order to ensure that the vegetation cover would be self-sustaining after Year 45 (2033).

(ii)Material Storage Areas after Abandonment

The coal stockpiles and blending area would be levelled and sloped to harmonize with the surrounding topography. The contoured surfaces would then be covered with a buffering medium of non-sodic overburden and seeded.

The surficial soil stockpiles would decrease progressively as the soil is spread over disturbed lands throughout the various sites. The




## LEGEND

RECLAIMED AREA (MAJOR RECLAMATION)

SCALE — 1:40,000

1 km 0 km 1 km 2 km

CONTOUR INTERVAL — 50 METRES

HAT CREEK PROJECT

FIGURE 4.3

# RECLAMATION — YEAR 45

SOURCE: British Columbia Hydro and Power Authority (43)

TABLE 4-2
APPROXIMATE PRODUCTION STATISTICS (34,43)

| | | |
|---|---|---|
| <u>Coal</u> | | |
| Total mined over project life | 336 | million tonnes (Mt) |
| Peak annual production | 12 | Mt |
| <u>Mine Waste</u> | | |
| Total over project life | $430 \times 10^6$ | $m^3$ |
| Peak annual quantity | $20 \times 10^6$ | $m^3$ |
| <u>Ash & FGD Sludge</u> | | |
| Total production over project life | 90 | Mt |
| Peak annual production | 3 | Mt |

remains would be levelled, sloped to blend in with the surrounding topography and seeded.

(iii) Transportation Corridors

In the decommissioning/reclamation phase, conveyors, transmission lines, and culverts would be dismantled and removed. Wherever possible, corridors would be resloped to blend in with the surrounding topography. All roads (except main access roads) would be ripped to relieve compaction and seeded. Water barriers would be constructed on slopes with a potential for erosion.

(iv) Buildings

During the years following project decommissioning, buildings not retained for alternative uses would be dismantled, sold, and levelled to their foundations. Any areas littered would be cleared during the clean-up operation. Most of the service areas would then be ripped to relieve compaction, covered with 150 to 300 mm of soil and seeded. Where practical, slopes would be regraded to blend in with the surrounding topography. Where surface materials are unsuitable for plant growth, a suitable depth of overburden would be placed before soil coverage and seeding.

(v) The Open Pit Mine after Abandonment

A proposal to flood the pit and convert it into a lake was explored but rejected on the grounds of poor stability of the surrounding ground, the anticipated poor quality of the pit water, and the costly and possibly irrevocable nature of the decision. Flooding the pit would make it virtually impossible to reopen the pit at some future time in order to extract the substantial coal reserves which would remain.

The plan adopted provides for resloping the top three benches (about 115 ha) to provide a safer perimeter and lessen the visual impact. No resloping would be done below this level. After resloping, fertilizer and seed would be aerially broadcast on all pit benches. Germination is expected to take place readily on those portions which consist of non-sodic glacio-fluvial and glacial till overburden, less readily on those composed of saline land slide deposits, sodic siltstones, claystones and coal. In time, revegetated overburden and slide areas would be expected to creep and to slump into the pit.

A protective fence to restrict access would surround the pit perimeter and those areas to the southwest which may be susceptible to failure. Trees would be planted at selected points on the perimeter to screen the pit.

(vi) Drainage and Diversion Systems

The water supply reservoir in upper Medicine Creek and its overflow conduit would continue to intercept runoff and route it to the downstream end of the Hat Creek diversion system. It would have a significant positive impact on the area since it could be used for irrigation and recreational purposes.

The Hat Creek and associated diversion works would be maintained after the end of the life of the project, to continue downstream water releases and to prevent the mine pit from filling. The sedimentation lagoons would continue to operate for a few years, until revegetation is complete and runoff water quality is satisfactory for direct release to Hat Creek. The leachate lagoons would continue to collect the small quantity of seepage expected from the waste disposal areas. Evaporation from the lagoon surfaces is expected to be sufficient to dispose of all leachate inflows. However, overflow systems would be maintained and would route any excess water to the mine pit where it would evaporate.

(b) Disturbances and Possible Resource Losses

It should be stressed that in relation to the Hat Creek watershed as a whole (about 66 600 ha), the total mine area comprises only about 1 percent. A maximum of 2506 ha would, at one time or another, have been disturbed by Year 35 (see Table 3-1). By Year 45 however, approximately 64 percent (1600 ha) would have been restored. Unreclaimed areas include the open pit, access road, creek diversions, sedimentation lagoons, reservoirs, and remaining facilities for long-term environmental monitoring.

# SECTION 5. IMPACT ASSESSMENT INTRODUCTION

Detailed environmental studies of the Hat Creek project covering all major resource systems were undertaken from 1976 to 1978. These studies are some of the most detailed and exhaustive ever undertaken in support of the development of a thermal power generating project. The purpose of this Section of the EIS is to summarize the results of these studies.

When the detailed environmental studies were initiated, the project was still in the preliminary design stage and only a tentative project description was available. To provide a basis for the required impact assessment, the consultants were asked to consider the potential impacts of alternative designs which included:

1. 244 metre stack and meteorological control (244/MCS).

2. 366 metre stack and meteorological control (366/MCS).

3. 366 metre stack and approximately 50% SO2 removal (366/FGD).

Following completion of these detailed environmental studies, the project design was refined on the basis of engineering, environmental and economic criteria. As a result, this section of the EIS differs from the detailed environmental studies in that the environmental impacts related to the "Proposed Project" (366/FGD, see section 3.0) are emphasized. However for purposes of describing a range of impacts associated with the alternatives, an assessment of the 244 metre stack with meteorological control is also provided.

Primary sources of information for this EIS are the impact assessment sections of the detailed environmental studies, as well as the "bridging documents" (see Section 1.3). In turn, data sources for the consultants' reports generally consisted of reviews of available literature, field monitoring programs, field work, modeling studies of various technical aspects, and interviews. Terms of reference and impact assessment procedures for these studies were designed to meet requirements of provincial agencies.

It should be noted that a basic assumption of the detailed environmental studies was that the powerplant would operate continuously at 100 percent of its designed capacity for 35 years. Since the powerplant is only planned for operation at 65 percent of capacity on average over the life of the project, predicted long term impacts would likely be less than described.

The following sections are structured along the lines of the impact assessment format. For each resource, the existing conditions and outlook without the project are discussed first. Then the impacts of the project upon that resource are considered from local and regional perspectives. Part III-A is concerned with biophysical resources, while part III-B is concerned with socio-economic and community resources.

## 6.1 EXISTING SITUATION(14,15,24,47)

The climate of the Hat Creek region is greatly influenced by its topographic setting. Mountain ranges to the west shelter the area from marine air flows, causing a "continental" climatic regime.

Temperature and precipitation data, as recorded at the Atmospheric Environment Service (AES) climatological station at Hat Creek (Table 6-1a) show that, in general, the climate is relatively dry and that the temperature range is fairly large. Total mean annual precipitation is 317 mm, while mean winter and summer temperatures are -8.3°C and 13.9°C respectively.

Since 1974, B.C. Hydro has maintained a network of meteorological stations in the immediate vicinity of the Hat Creek Project site. On-site meteorological field programs have also been conducted on a seasonal basis to determine the temperature and wind characteristics above the Hat Creek valley area.

Surface winds in the Hat Creek valley are dominated by the valley's orientation. As shown in table 6-1b, winds blow mainly from the south, with a secondary frequency of north winds. The short-term record (Table 6-1c) from the 100 m level of the meteorological station near the proposed powerplant is in fairly good agreement with the long-term record from the AES station at Vernon, B.C. (Table 6-1d). These show that winds over south central B.C. blow mainly from a sector south through west.

In the Hat Creek valley, ground-based air temperature inversions are quite frequent during the night and in the early morning, while inversions aloft are fairly infrequent.

B.C. Hydro's air quality monitoring network began operating in 1977 to provide background air quality data. Although no historical records of measured air quality indicators are available, recent results from the air monitoring network show that no significant levels of contaminants exist in the atmosphere other than naturally-occurring ozone, which averaged 95 $\mu g/m^3$ during 1978 and 1979. Existing levels of suspended particles (dust) in the Hat Creek valley were measured to be approximately 10 $\mu g/m^3$, typical of a rural unindustrialized area. Existing regional ambient air quality differs widely, depending on proximity to industrial air pollutant emission sources in Kamloops and other areas.

TABLE 6-1a

HAT CREEK CLIMATOLOGICAL DATA (LEHMAN RANCH)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Daily Maximum Temperature (°C) | -5.1 | 1.0 | 4.6 | 10.6 | 16.9 | 20.1 | 23.9 | 22.9 | 18.9 | 10.7 | 1.9 | -2.9 | 10.3 |
| Mean Daily Minimum Temperature (°C) | -16.9 | -12.4 | -8.2 | -3.2 | 1.2 | 4.6 | 6.1 | 5.4 | 2.1 | -2.5 | -8.7 | -13.6 | -3.8 |
| Extreme Maximum Temperature (°C) | 11.7 | 13.3 | 17.2 | 21.1 | 27.8 | 33.9 | 34.4 | 34.4 | 31.1 | 23.3 | 12.2 | 10.0 | 34.4 |
| Extreme Minimum Temperature (°C) | -40.6 | -25.0 | -27.8 | -11.1 | -7.8 | -3.3 | -0.6 | -2.2 | -7.2 | -12.2 | -30.0 | -42.8 | -42.8 |
| Mean Rainfall (mm) | 2.5 | 2.8 | 5.3 | 8.1 | 17.8 | 35.1 | 29.0 | 31.8 | 20.1 | 21.3 | 6.6 | 3.6 | 184.0 |
| Mean Snowfall (cm) | 36.8 | 15.7 | 10.2 | 8.1 | 3.8 | 0 | 0 | 0 | 0.5 | 3.8 | 23.1 | 31.0 | 133.0 |
| Mean Total Precipitation (mm) | 39.4 | 18.5 | 15.5 | 16.3 | 21.6 | 35.1 | 29.0 | 31.8 | 20.6 | 25.1 | 29.7 | 34.5 | 317.1 |
| Greatest Rainfall in 24 hours (mm) | 10.2 | 5.1 | 3.0 | 8.1 | 16.5 | 22.6 | 38.9 | 30.0 | 26.7 | 17.5 | 5.3 | 7.6 | 38.9 |
| Greatest Snowfall in 24 hours (cm) | 42.4 | 8.4 | 9.1 | 11.9 | 9.4 | 0 | 0 | 0 | T | 8.6 | 19.1 | 22.1 | 42.4 |
| Greatest Precipitation in 24 hours (mm) | 42.4 | 10.2 | 9.1 | 15.7 | 16.5 | 22.6 | 38.9 | 30.0 | 26.7 | 17.5 | 19.1 | 22.1 | 42.4 |
| Number of Days with Measurable Rainfall | 1 | 2 | 2 | 4 | 6 | 7 | 8 | 7 | 6 | 5 | 2 | 1 | 51 |
| Number of Days with Measurable Snowfall | 10 | 5 | 5 | 3 | 1 | 0 | 0 | 0 | 0 | 1 | 7 | 10 | 42 |
| Number of Days with Measurable Precipitation | 10 | 6 | 6 | 5 | 7 | 7 | 8 | 7 | 6 | 6 | 9 | 11 | 88 |

Source: Canadian Normals 1941-1970, Environment Canada, Vol. 1 and 2.

TABLE 6-1b
HAT CREEK VALLEY METEOROLOGICAL STATION - PERCENTAGE FREQUENCY
WIND DIRECTION AND MEAN WIND SPEED BY MONTHS

| Direction | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | 11 | 13 | 14 | 14 | 11 | 11 | 11 | 14 | 17 | 17 | 14 | 11 |
| NE | 5 | 3 | 5 | 8 | 9 | 11 | 11 | 12 | 8 | 6 | 8 | 6 |
| E | 2 | 2 | 2 | 4 | 4 | 5 | 6 | 5 | 4 | 3 | 4 | 4 |
| SE | 4 | 2 | 2 | 4 | 4 | 5 | 5 | 5 | 4 | 3 | 3 | 3 |
| S | 35 | 35 | 38 | 39 | 39 | 31 | 36 | 35 | 39 | 37 | 36 | 43 |
| SW | 25 | 28 | 23 | 19 | 20 | 21 | 16 | 16 | 16 | 23 | 23 | 23 |
| W | 4 | 6 | 5 | 7 | 8 | 12 | 11 | 7 | 5 | 4 | 4 | 3 |
| NW | 5 | 6 | 5 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 4 |
| Calm | 9 | 5 | 6 | 1 | 1 | 0 | 0 | 1 | 2 | 2 | 3 | 3 |
| Wind Speed (km/h) | 5.5 | 8.9 | 8.8 | 8.4 | 13.1 | 11.2 | 8.9 | 9.3 | 9.1 | 8.2 | 7.9 | 8.0 |

Source: B.C. Hydro Climatological Records, Jan. 1975 to Dec. 1979.

TABLE 6-1c
POWERPLANT SITE METEOROLOGICAL STATION[1] - PERCENTAGE FREQUENCY
WIND DIRECTION AND MEAN WIND SPEED BY MONTHS

| Direction | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | 12 | 7 | 12 | 13 | 7 | 9 | 15 | 11 | 6 | 8 | 12 | 4 |
| NE | 5 | 2 | 1 | 11 | 4 | 5 | 10 | 8 | 3 | 6 | 2 | 1 |
| E | 6 | 7 | 5 | 5 | 7 | 5 | 6 | 4 | 4 | 4 | 7 | 3 |
| SE | 7 | 19 | 13 | 4 | 6 | 3 | 7 | 7 | 13 | 13 | 16 | 18 |
| S | 5 | 17 | 12 | 1 | 7 | 6 | 7 | 9 | 14 | 12 | 11 | 12 |
| SW | 15 | 21 | 21 | 20 | 18 | 22 | 14 | 21 | 25 | 22 | 15 | 25 |
| W | 11 | 15 | 15 | 24 | 36 | 34 | 24 | 21 | 15 | 13 | 14 | 19 |
| NW | 19 | 3 | 13 | 21 | 13 | 15 | 16 | 13 | 9 | 9 | 15 | 13 |
| Calm | 20 | 9 | 8 | 1 | 2 | 1 | 1 | 6 | 11 | 13 | 8 | 5 |
| Wind Speed (km/h) | 8.5 | 15.8 | 13.6 | 12.8 | 16.2 | 16.2 | 14.6 | 13.0 | 15.0 | 11.7 | 11.8 | 18.2 |

1. Meteorological Station - Located at ground elevation 1453 m AMSL near proposed powerplant site. Data from 100 m level.

Source: B.C. Hydro Meteorological Records, Aug. 1978 to Dec. 1979.

## TABLE 6-1d
## VERNON, B.C.[1] - PERCENTAGE FREQUENCY WIND DIRECTION AND MEAN WIND SPEED BY MONTHS AT 4811' AMSL

| Direction | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | 9 | 4 | 7 | 12 | 6 | 8 | 10 | 10 | 15 | 10 | 5 | 8 |
| NE | 3 | 3 | 1 | 4 | 3 | 4 | 3 | 4 | 3 | 3 | 4 | 2 |
| E | 1 | 4 | 2 | 4 | 3 | 4 | 5 | 2 | 3 | 2 | 4 | 2 |
| SE | 10 | 10 | 7 | 8 | 7 | 2 | 3 | 5 | 6 | 4 | 10 | 12 |
| S | 27 | 34 | 31 | 20 | 20 | 18 | 20 | 15 | 16 | 31 | 36 | 33 |
| SW | 25 | 26 | 28 | 25 | 33 | 35 | 33 | 32 | 25 | 27 | 21 | 21 |
| W | 9 | 8 | 9 | 9 | 13 | 15 | 11 | 13 | 11 | 8 | 6 | 7 |
| NW | 15 | 10 | 14 | 17 | 13 | 12 | 13 | 17 | 17 | 14 | 13 | 14 |
| Calm | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 4 | 1 | 1 | 1 |
| Wind Speed (km/h) | 23.7 | 21.4 | 20.0 | 17.6 | 16.2 | 16.2 | 14.7 | 13.9 | 15.4 | 22.6 | 21.1 | 21.8 |

1. Source: Atmospheric Environment Service Radiosonde Profiles, El. 1466 m AMSL, October 1971 to November 1976.

## 6.2 ASSESSMENT APPROACH

The Hat Creek air quality assessment was conducted by Environmental Research and Technology Inc. (ERT) with participation by Western Research and Development Ltd. and other consultants. These independent environmental consultants have proven expertise in the evaluation of impacts from large coal-fired projects. Primary objectives were to predict and evaluate the distribution of contaminants from the proposed mine and powerplant. Also analysed were the potential for production of contaminants by chemical reactions in the atmosphere and the potential changes in weather patterns due to the project.

### Powerplant

The effects of emissions were studied for three air quality control systems (AQCS). The scenerios studied included a 244 m stack with a meteorological control system (244/MCS), a 366 m stack with MCS (366/MCS), and a 366 m stack with flue-gas desulphurization (366/FGD). B.C. Hydro is proposing to construct the Hat Creek powerplant with flue-gas desulphurization units that will remove approximately 50% of the sulphur dioxide (SO2) and 99.8% of the particulates generated by the coal combustion process. This section describes predicted impact levels from both the proposed project and a project with 244/MCS. Impacts from a power plant with a 366 m stack and MCS would fall between the two scenerios described.

Mathematical modeling techniques were used to predict the effect of the powerplant emissions on air quality for a 1 year period. Concentrations of contaminants were calculated for each hour of 1975 within 25 km of the powerplant assuming four-unit full load operation. Credibility of these techniques was considerably enhanced by incorporating data from on-site plume simulation studies which were used to calibrate the computer model and by a comparative review of meteorological data from subsequent years. The calibrated model enabled the consultant to calculate ambient concentrations for various meteorological and powerplant operating conditions.

A regional evaluation for the area 25 km to 100 km from the powerplant was also carried out by computer modeling. Impacts of SO2 and sulphates were initially evaluated. However, increasing concern over acid precipitation resulted in a more detailed evaluation of sulphate and nitrate deposition as far as 200 km downwind of the powerplant.

*Computer modeling was used to evaluate the extent of the visible* plume and the effects of "drift" from the proposed natural draft cooling towers.

### Mine

Air quality effects of fugitive dust emissions resulting from mining activities were initially assessed by using a multiple source computer model. Results from the modeling study prompted a review and re-estimate of fugitive dust impacts based on existing coal mining operations in the northwest United States and Canada, following which, methods of dust control were proposed.

The mine impacts studied also included an evaluation of trace elements which are natural components of fugitive dust. Both ambient concentrations and depositions of trace elements were determined for powerplant and mining operations.

## 6.3 PROJECT ACTIONS

The greatest impact on air quality from the project would result from the release of products of coal combustion through the powerplant stack. As shown in Fig. 3.11 ash particles, sulphur dioxide (SO2), nitrogen oxides (NOx), elements in trace quantities, moisture, and other gases would be released into the atmosphere.

For the proposed project, design features to control the adverse effects of these emissions include the elevated site of the powerplant, electrostatic precipitators for particulate removal, flue gas desulphurization (FGD) units for removing approximately 50% of the sulphur dioxide, and a 366 m multiflue stack. By contrast the 244/MCS scenerio incorporated a 244 m stack and less efficient electrostatic precipitators, and replaced the FGD units with a meteorological control system (MCS) described in Section 3.3.

Other emissions associated with the routine operation of the powerplant include water vapour from the natural draft cooling towers, water vapour from the water reservoir, and dust from the ash disposal site.

Impacts from construction, mining and coal-handling operations would result primarily from fugitive dust. Operational procedures discussed in Section 6.5(d) would localize fugitive dust impacts.

## 6.4 POLLUTION CONTROL OBJECTIVES

Historically, in British Columbia air pollution control regulations have been applied to emissions at their source as well as to the resulting contaminant concentration measured at ground level (ambient concentrations). These regulations are important factors in determining the design and feasibility of thermal powerplants.

Not until after the Hat Creek preliminary design phase had been completed did the Pollution Control Board (PCB) issue specific air pollution control Objectives for large coal-fired powerboilers (50). Consequently, for preliminary design, the air quality criteria for other industries in British Columbia were reviewed by B.C. Hydro and compared with objectives and regulations in effect in Alberta, Ontario and the states of Washington, Idaho and Montana, as well as those of the Canadian and U.S. Federal agencies.

Based on these reviews, B.C. Hydro assumed the following primary ambient air quality objectives: an average ambient SO2 concentration at ground level of no more than 665 $\mu g/m^3$ for any 3-hour period, and a maximum average concentration of no more than 260 $\mu g/m^3$ for any 24-hour period. The justification for these ambient levels was presented by B.C. Hydro in a brief submitted to the public inquiry set up to review Pollution Control Objectives for the mining, mine-milling and smelting industries of British Columbia in January

1978.(49) Subsequently in 1979 the Pollution Control Board published ambient air quality and emission Objectives(50) for coal-fired powerplants.

B.C. Hydro's proposed project incorporates design features that will enable the powerplant to meet the 1979 PCB objectives for emissions and ambient air quality.

## 6.5 EFFECTS OF THE PROJECT

### (a) Powerplant

#### Stack Emissions:

Estimated average emissions from the powerplant stack are shown in Table 6-2, based upon the use of performance coal (Table 2-2). A conservative data base was used in the modeling, e.g. 100 percent capacity factor on all four units, with resultant emissions assumed to apply 24 hours/day and 365 days/annum. During actual operation of the powerplant, the capacity factor is expected to average 75 percent over any 1 year period and would average 65 percent over the 35-year life of the project.

##### Ambient Concentrations of SO2 and Other Major Contaminants from the Proposed Project (366 m Stack with FGD)

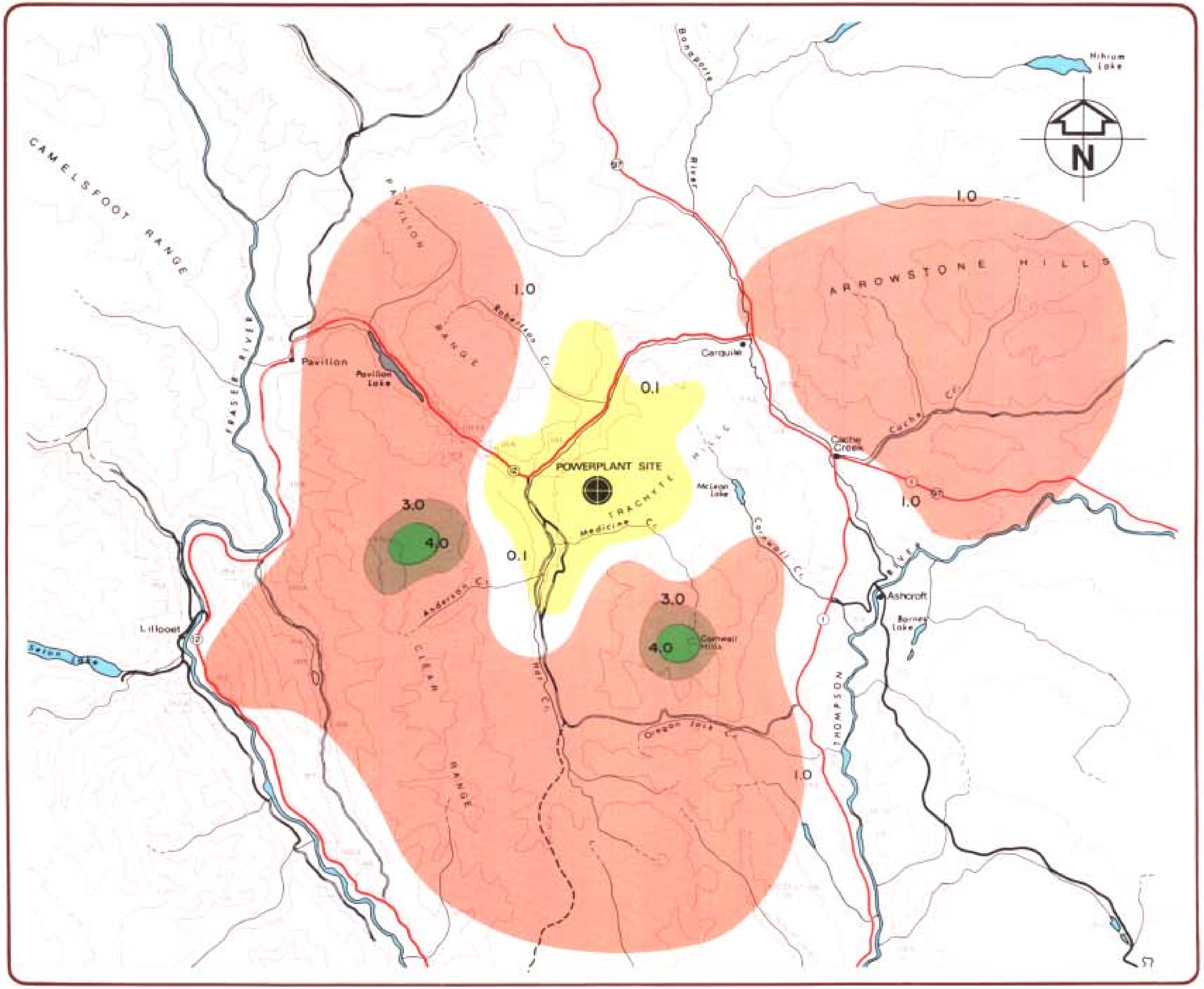
Mathematical modeling studies indicate that this proposal is expected to maintain ambient levels within the range of the 1979 PCB ambient objectives. Table 6-3 shows the maximum predicted ambient contaminant concentrations that could occur on the high terrain of the Clear Range and Cornwall Hills.

Figure 6-1 shows the predicted annual average pattern of ambient contaminant concentrations within 25 km of the powerplant over a typical year for sulphur dioxide, nitrogen dioxide, total suspended particulate, and fluorine.

The monitoring program described in Section 26.2 will provide for continuous measurement of emissions and ambient air quality.

#### Trace Elements(15)

Emissions of elements existing in trace quantities (less than 1000 parts per million) in Hat Creek coals were the subject of a detailed impact evaluation. Studies were carried out to identify quantities of trace elements normally occurring in the local ecosystem, quantities present in the coal, quantities to be released from powerplant and mining operations and the contamination and deposition of these elements to local and regional areas. Powerplant emission rates for the trace elements considered are shown in Table 6-2. These rates were determined by measurements taken during two test burns of Hat Creek coal and supplemented by knowledge of specific element behaviour. With the exception of fluorine, trace element emission rates have been predicted on the basis of a powerplant equipped with only electrostatic precipitators (i.e. 244/MCS scenerio). No credit has been taken for reducing particulate emission levels from 0.06 mg/KJ to 0.03 mg/KJ or for partial wet scrubbing. The impacts associated with the consultants' assessment for the unscrubbed case were considered so low




## LEGEND

| CONCENTRATION (ug/m³) — ZONES / CONTAMINANT | SULPHUR DIOXIDE ($SO_2$) | NITROGEN DIOXIDE ($NO_2$) | TOTAL SUSPENDED PARTICULATE (TSP) | FLUORINE (F) |
|---|---|---|---|---|
| A | < 0.1 | < 0.06 | < 0.01 | < 0.0007 |
| B | 0.1 TO 1.0 | 0.06 TO 0.6 | 0.01 TO 0.1 | 0.0007 TO 0.007 |
| C | 1.0 TO 3.0 | 0.6 TO 1.7 | 0.1 TO 0.3 | 0.007 TO 0.02 |
| D | 3.0 TO 4.0 | 1.7 TO 2.2 | 0.3 TO 0.4 | 0.02 TO 0.03 |
| E | > 4.0 | > 2.2 | > 0.4 | > 0.03 |

SCALE — 1:250,000

5 km 0 km 5 km 10 km 15 km

CONTOUR INTERVAL — 500 METRES

HAT CREEK PROJECT

FIGURE 6.1

# ANNUAL AVERAGE AMBIENT AIR CONCENTRATIONS OF MAJOR CONTAMINANTS FROM PROPOSED POWERPLANT

366 m STACK WITH FLUE GAS DESULPHURIZATION

SOURCE: Environmental Research and Technology Inc. (4.7) that a reanalysis for the 366 m stack with FGD was considered unnecessary. Fluorine is known to be effectively removed by the scrubbing process. It is estimated that the proposed project will retain 68 percent of the fluorine entering the plant in precipitator ash and FGD waste.

Dispersion modeling techniques were used to estimate trace element concentrations resulting from continuous full load operation. Table 6-4 indicates the maximum ambient concentrations of significant trace elements. Also shown are the PCB Objectives for ambient trace element concentrations. Maximum projected ambient concentrations of trace elements for the local area are below those of the PCB Objective values for 24-hour and annual averages. Most trace elements are more than an order of magnitude below any PCB Objective level. For the proposed project the maximum 24-hour average for fluorine of 1.6 $\mu g/m^3$ is 20 percent below the PCB Objective level of 2.0 $\mu g/m^3$.

There would be minor increases of trace elements in the local and regional soils due to powerplant and cooling tower emissions and subsequent deposition. Figure 6-2 shows the zones of projected annual trace element depositions from powerplant stack emissions over the local and regional areas, and Table 6-5 provides the predicted trace element accumulation in soil within these zones at the end of the 35-year lifetime of the powerplant.

The deposition of trace elements onto soils from cooling tower drift has also been estimated and would follow the salt deposition zones. All of these zones were found to be located within the B zone of trace element deposition as shown on Figure 6-2. Consequently, trace element contributions from cooling tower drift have been added to those in the B zone to provide the total trace element soil accumulation given in table 6-6. Generally, predicted trace element increases in local and regional soils represent less than one percent of background trace element levels after the 35-year lifetime of the powerplant.

The maximum 24-hour and annual average trace element ambient concentrations have been estimated. Contributions via deposition to soils are considered minimal as there is no real difference between trace element concentrations in coal-dust particles and those in soils near the mine. Table 6-7 provides the ambient trace element concentrations resulting from mine dust emissions near the mine. It would appear there would be insignificant impacts on the environment due to mine dust emissions since the ambient concentrations, for both the 24-hour and annual averages, are well below the Objective levels given in Table 6-4.

TABLE 6-2

POWERPLANT STACK EMISSION RATES AT FULL LOAD[1] (47, 50)

| Contaminant | | Units | PCB Objective | Powerplant with 244/MCS | Proposed Project with 366/FGD |
|---|---|---|---|---|---|
| Sulphur dioxide[2] | | mg/kJ fuel | 0.09 to 0.34 | 0.57 | 0.27 |
| Nitrogen oxides as $NO_2$ | | mg/kJ fuel | 0.15 to 0.3 | 0.3 | 0.3 |
| Total particulates[3] | | mg/kJ fuel | 0.01 to 0.04 | 0.06 | 0.03 |
| | | % opacity | 10 to 40 | 44 | 25 |
| Trace Elements | | | | Both Options | |
| Antimony | Sb | mg/mol | 0.16 to 0.27 | 0.000016 | |
| Arsenic | As | mg/mol | 0.16 to 0.27 | 0.0018 | |
| Beryllium | Be | mg/mol | [4] | 0.000032 | |
| Boron | B | mg/mol | [4] | 0.0030 | |
| Cadmium | Cd | mg/mol | 0.05 to 0.27 | 0.000023 | |
| Chromium | Cr | mg/mol | [4] | 0.0036 | |
| Cobalt | Co | mg/mol | [4] | 0.000058 | |
| Copper | Cu | mg/mol | 0.16 to 0.27 | 0.0028 | |
| Fluoride[5] | HF | mg/mol | 0.02 to 0.20 | 0.26 | 0.13 |
| Lead | Pb | mg/mol | 0.16 to 0.27 | 0.00056 | |
| Manganese | Mn | mg/mol | [4] | 0.0078 | |
| Mercury | Hg | mg/mol | 0.03 to 0.27 | 0.00044 | |
| Molybdenum | Mo | mg/mol | [4] | 0.00038 | |
| Nickel | Ni | mg/mol | [4] | 0.0008 | |
| Selenium | Se | mg/mol | [4] | 0.00064 | |
| Silver | Ag | mg/mol | [4] | 0.0000027 | |
| Thallium | Tl | mg/mol | [4] | 0.0000017 | |
| Thorium | Th | mg/mol | [4] | 0.000021 | |
| Tin | Sn | mg/mol | [4] | 0.000014 | |
| Tungsten | W | mg/mol | [4] | 0.0000033 | |
| Uranium | U | mg/mol | [4] | 0.000074 | |
| Vanadium | V | mg/mol | [4] | 0.0011 | |
| Zinc | Zn | mg/mol | 0.16 to 0.27 | 0.0018 | |

[1] Using Performance Coal and 100 percent Capacity Factor.

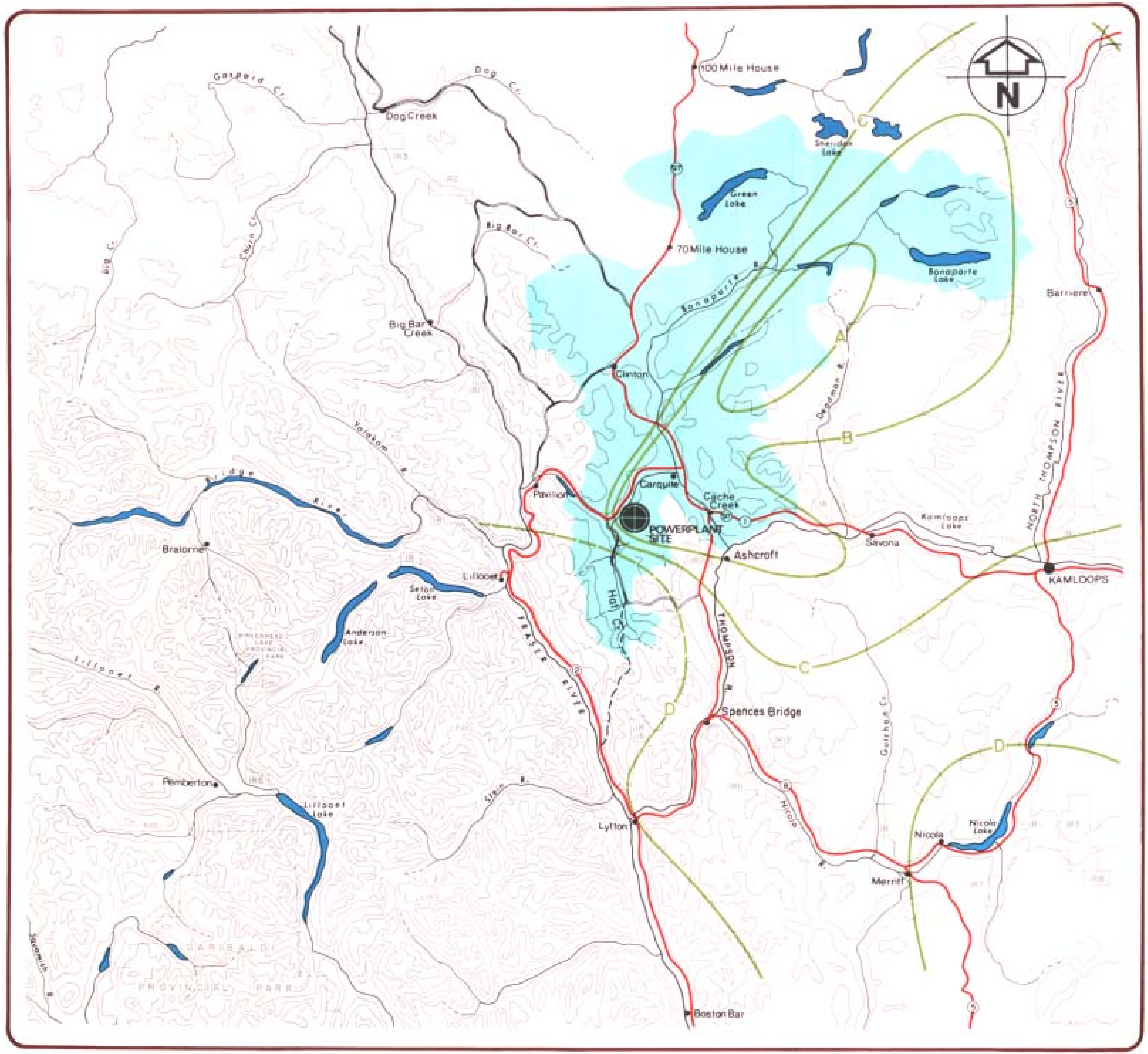
[2] Assuming all sulphur in coal goes to $SO_2$ for 244/MCS and approximately 50 percent $SO_2$ removal for 366/FGD.

[3] Opacity of one flue at full load.

[4] Emission level not defined in PCB Objectives.

[5] 244/MCS - 63 percent of fluorine entering the powerplant is emitted from the powerplant stack.

366/FGD - 32 percent of fluorine entering the powerplant is emitted from the powerplant stack.




## LEGEND

FOR TRACE ELEMENT LEVELS REFER TO TABLE 6.5

BONAPARTE RIVER WATERSHED

ZONE BOUNDARIES

SCALE 1:1,000,000

20 km 0 km 20 km 40 km 60 km

CONTOUR INTERVAL — 250 METRES

HAT CREEK PROJECT

FIGURE 6.2

# TRACE ELEMENT DEPOSITION PATTERNS FROM POWERPLANT EMISSIONS

SOURCE: British Columbia Hydro and Power Authority (15)

## TABLE 6-3
## MAXIMUM AMBIENT CONCENTRATIONS DUE TO POWERPLANT EMISSIONS[1] (47,50)

| Contaminant | Unit | British Columbia PCB Objective | Powerplant with 244/MCS | Proposed Project with 366/FGD |
|---|---|---|---|---|
| Sulphur Dioxide (SO2) | | | | |
| annual-average | $\mu g/m^3$ | 25 to 75 | 9.3 | 4.5 |
| 24-hour maximum | $\mu g/m^3$ | 160 to 260 | 260 | 208 |
| 3-hour maximum | $\mu g/m^3$ | 375 to 665 | 648 | 366 |
| 1 hour maximum | $\mu g/m^3$ | 450 to 900 | 1730 | 825 |
| Suspended Particulates (TSP) | | | | |
| annual-average | $\mu g/m^3$ | 60 to 70 | 1.0 | 0.5 |
| 24-hour maximum | $\mu g/m^3$ | 150 to 200 | 28 | 23 |
| Nitrogen Dioxide (NO2) | | [2] [3] | | |
| annual-average | $\mu g/m^3$ | | 2.4 | 2.5 |
| 24-hour maximum | $\mu g/m^3$ | | 67 | 116 |
| 1 hour maximum | $\mu g/m^3$ | | 446 | 460 |
| Carbon Monoxide | | [2] | | |
| annual-average | $\mu g/m^3$ | | 0.5 | 0.5 |
| 24-hour maximum | $\mu g/m^3$ | | 14 | 25 |
| 8-hour maximum | $\mu g/m^3$ | | 19 | 31 |
| 1 hour maximum | $\mu g/m^3$ | | 96 | 99 |
| Radon Daughter[4] | WL | less than 0.02 | 0.0007 | 0.0007 |
| Dustfall | $mg/dm^2/d$ | 1.7 to 2.9 | 0.024 | 0.020 |

---

1. 100% Capacity Factor.
2. Ambient level not defined in PCB Objectives.
3. Federal NO2 ambient guidelines for 1 hour, 24-hour and annual averages are 400, 200 and 100 $\mu g/m^3$ respectively.
4. Total project estimate, see Section 22.0

TABLE 6-4

AMBIENT CONCENTRATIONS OF TRACE ELEMENTS
DUE TO POWERPLANT STACK EMISSIONS[1] (15, 50)

| Element | | Powerplant with 244/MCS 24-hour (μg/m³) | Powerplant with 244/MCS Annual Average (μg/m³) | Proposed Project with 366/FGD 24-hour (μg/m³) | Proposed Project with 366/FGD Annual Average (μg/m³) | PCB Objectives[2] (μg/m³) |
|---|---|---|---|---|---|---|
| Antimony | Sb | 0.00012 | 0.0000043 | 0.00021 | 0.0000045 | 0.1 - 0.5 |
| Arsenic | As | 0.014 | 0.00049 | 0.024 | 0.00051 | 0.1 - 1.0 |
| Beryllium | Be | 0.00023 | 0.000008 | 0.00042 | 0.0000090 | 0.005 - 0.1 |
| Boron | B | 0.022 | 0.00077 | 0.039 | 0.00084 | [3] |
| Cadmium | Cd | 0.00017 | 0.000006 | 0.00029 | 0.0000063 | 0.05 - 0.3 |
| Chromium | Cr | 0.0026 | 0.000092 | 0.0046 | 0.000099 | 0.05 - 0.1 |
| Cobalt | Co | 0.00042 | 0.0000015 | 0.00075 | 0.000016 | [3] |
| Copper | Cu | 0.021 | 0.00075 | 0.036 | 0.00078 | 0.25 - 2.5 |
| Fluorine | F | 1.8 | 0.066 | 1.6 | 0.035 | 0.1 - 2.0 |
| Lead | Pb | 0.0041 | 0.00015 | 0.0072 | 0.00016 | 1.0 - 2.5 |
| Manganese | Mn | 0.056 | 0.002 | 0.10 | 0.0022 | [3] |
| Mercury | Hg | 0.0032 | 0.00012 | 0.0055 | 0.00012 | 0.1 - 1.0 |
| Molybdenum | Mo | 0.0028 | 0.0001 | 0.0048 | 0.00011 | 0.1 - 2.5 |
| Nickel | Ni | 0.0058 | 0.00021 | 0.010 | 0.00022 | 0.01 - 0.1 |
| Selenium | Se | 0.0047 | 0.00017 | 0.0082 | 0.00018 | 0.1 - 0.5 |
| Silver | Ag | 0.000016 | 0.00000057 | 0.000028 | 0.00000060 | [3] |
| Thallium | Tl | 0.000016 | 0.00000057 | 0.000028 | 0.00000060 | [3] |
| Thorium | Th | 0.00015 | 0.000005 | 0.00026 | 0.0000057 | [3] |
| Tin | Sn | 0.0001 | 0.0000037 | 0.00018 | 0.0000039 | [3] |
| Tungsten | W | 0.000024 | 0.00000086 | 0.000042 | 0.00000090 | [3] |
| Uranium | U | 0.00054 | 0.000019 | 0.00094 | 0.000020 | 0.01 - 6.0 |
| Vanadium | V | 0.0079 | 0.00028 | 0.014 | 0.00030 | 0.05 - 1.0 |
| Zinc | Zn | 0.013 | 0.00046 | 0.022 | 0.00048 | 1.0 - 2.5 |

[1] 100% Capacity Factor.

[2] Sampling will be in a form and manner over periods of time specified by the Director of Pollution Control.(50)

[3] Ambient level not defined in PCB Objectives.

TABLE 6-5
TRACE ELEMENT SOIL ACCUMULATIONS
AFTER 35 YEARS OPERATION DUE TO STACK EMISSION[1]
FROM THE PROPOSED POWERPLANT

| Element | | Concentration (μg/kg)[2] Zones[3] A | B | C | D |
|---|---|---|---|---|---|
| Antimony | Sb | 0.23 | 0.18 | 0.14 | 0.07 |
| Arsenic | As | 29 | 22 | 14 | 7.3 |
| Beryllium | Be | 0.52 | 0.39 | 0.25 | 0.01 |
| Boron | B | 44 | 33 | 22 | 11 |
| Cadmium | Cd | 0.32 | 0.25 | 0.16 | 0.07 |
| Chromium | Cr | 5.3 | 4 | 2.7 | 1.3 |
| Cobalt | Co | 0.91 | 0.68 | 0.46 | 0.20 |
| Copper | Cu | 38 | 29 | 20 | 9.6 |
| Fluorine[4] | F | 2000(4000) | 1500(3000) | 1000(2000) | 500(1000) |
| Lead | Pb | 8.7 | 6.6 | 4.3 | 2.2 |
| Manganese | Mn | 120 | 87 | 61 | 29 |
| Mercury | Hg | 6.8 | 5.2 | 3.4 | 1.6 |
| Molybdenum | Mo | 6.1 | 4.3 | 3.0 | 1.4 |
| Nickel | Ni | 12 | 9.1 | 6.1 | 3.2 |
| Selenium | Se | 10 | 7.3 | 5.2 | 2.5 |
| Silver | Ag | 0.034 | 0.025 | 0.015 | 0.009 |
| Thallium | Tl | 0.034 | 0.025 | 0.015 | 0.009 |
| Thorium | Th | 0.3 | 0.21 | 0.15 | 0.07 |
| Tin | Sn | 0.21 | 0.16 | 0.11 | 0.06 |
| Tungsten | W | 0.05 | 0.04 | 0.02 | 0.01 |
| Uranium | U | 1.2 | 0.91 | 0.61 | 0.32 |
| Vanadium | V | 16 | 13 | 8.2 | 4.2 |
| Zinc | Zn | 27 | 22 | 14 | 7.3 |

1. 65% Capacity Factor for 35 years.

2. Assumes that all deposited elements will remain in residence in top 30 mm of soil and that neither uptake by vegetation nor erosion of soil to watershed drainages will occur. Assumes a soil bulk density of 1.75 g/cm$^3$.

3. For trace element zones see Figure 6-2.

4. Bracketed numbers are for the "Powerplant with MCS" scenario.

TABLE 6-6
TOTAL TRACE ELEMENT ACCUMULATION IN SOIL
AFTER 35 YEARS OPERATION FROM STACK EMISSIONS
FROM THE PROPOSED POWERPLANT AND COOLING
TOWER DRIFT[1]

| Element | | Concentrations[2] (mg/kg) Zone Boundary Numbers[3] 4700[4] | 2240 | 560 | 112 |
|---|---|---|---|---|---|
| Arsenic | (As) | 0.96 | 0.47 | 0.13 | 0.044 |
| Cadmium | (Cd) | 0.0092 | 0.0045 | 0.0013 | 0.0004 |
| Chromium | (Cr) | 0.041 | 0.021 | 0.0083 | 0.0048 |
| Copper | (Cu) | 0.26 | 0.12 | 0.051 | 0.033 |
| Fluorine[5] | (F) | 3.4(4.9) | 2.4(3.9) | 1.8(3.3) | 1.6(3.1) |
| Lead | (Pb) | 0.95 | 0.45 | 0.12 | 0.029 |
| Mercury | (Hg) | 0.19 | 0.014 | 0.0072 | 0.0056 |
| Vanadium | (V) | 0.12 | 0.066 | 0.026 | 0.015 |
| Zinc | (Zn) | 0.59 | 0.31 | 0.09 | 0.035 |

1. 65% Capacity Factor for 35 years.

2. Assumes that all deposited elements will remain in residence in top 30 mm of soil and that neither uptake by vegetation nor erosion of soil to watershed drainages will occur. Assumes a soil bulk density of 1.75 g/cm$^3$.

3. Zone boundaries shown on Figure 6-4. Zone boundary numbers are salt deposition quantities from cooling towers (kg/km$^2$/a).

4. Point of maximum calculated deposition.

5. Bracketed numbers are for the "Powerplant with MCS" scenario.

## TABLE 6-7
## AMBIENT TRACE ELEMENT CONCENTRATIONS RESULTING FROM MINE DUST EMISSIONS
## (µg/m³)

| Element | | Maximum 24-hour | Annual Average[1] |
|---|---|---|---|
| Antimony | Sb | 0.000057 | 0.000023 |
| Arsenic | As | 0.00097 | 0.00039 |
| Beryllium | Be | 0.000073 | 0.000029 |
| Boron | B | 0.0021 | 0.00082 |
| Cadmium | Cd | 0.000038 | 0.000015 |
| Chromium | Cr | 0.0081 | 0.0032 |
| Cobalt | Co | 0.00066 | 0.00026 |
| Copper | Cu | 0.0048 | 0.0019 |
| Fluorine | F | 0.013 | 0.0054 |
| Lead | Pb | 0.00064 | 0.00026 |
| Manganese | Mn | 0.024 | 0.0097 |
| Mercury | Hg | 0.000015 | 0.0000059 |
| Molybdenum | Mo | 0.00026 | 0.000010 |
| Nickel | Ni | 0.0027 | 0.0011 |
| Selenium | Se | 0.000088 | 0.000035 |
| Silver | Ag | 0.000046 | 0.000018 |
| Thallium | Tl | 0.000057 | 0.000023 |
| Thorium | Th | 0.00065 | 0.00026 |
| Tin | Sn | 0.000095 | 0.000038 |
| Tungsten | W | 0.00011 | 0.000046 |
| Uranium | U | 0.00025 | 0.0001 |
| Vanadium | V | 0.012 | 0.005 |
| Zinc | Zn | 0.004 | 0.0016 |

1. Annual averages are arithmetic averages.

### (b) Local Effects of Cooling Tower Emissions

Mathematical modeling techniques were employed to estimate the seasonal and annual effects of emissions from the natural draft cooling towers. Since these emissions would be primarily in the form of water vapour, the studies were concerned with the potential for fog and ice formation, plume visibility and deposition of "drift" (water droplets). The study assumed continuous full load operation of the powerplant.

Waste heat and moisture from the two cooling towers are expected to produce slight increases in precipitation which may be beneficial, but no more than 1 percent yearly. Increased precipitation would primarily occur in the vicinity of the powerplant site but could potentially extend to a distance of 50 km. On rare occasions, localized snowfall may be increased by a few centimetres, and local cloud formation may occur during days with natural upward air flow.

Visible plumes from the cooling towers would occasionally extend more than 15 km from the powerplant, as shown on Figure 6-3. Shadows from the plumes are not expected to occur at any one location for more than 20 hours/annum beyond 2 km from the powerplant. Therefore, there would be no perceptible change in ground level solar radiation.

No ground level ice or fog formation is predicted to occur due to the plume exit height of over 130 m and the natural upward draft. The towers would, typically, increase the ground level humidity in their vicinity by less than one percent, although during particularly adverse meteorological conditions this increase could be 10 to 15 percent for short periods.

"Drift" and resulting deposition of salts from the cooling towers would occur at a maximum rate of 4700 $kg/km^2$/annum. The major portion of the salts would be deposited within 2 km of the powerplant site (Figure 6-4).

(c) Local Effects of the Powerplant Water Supply Reservoir

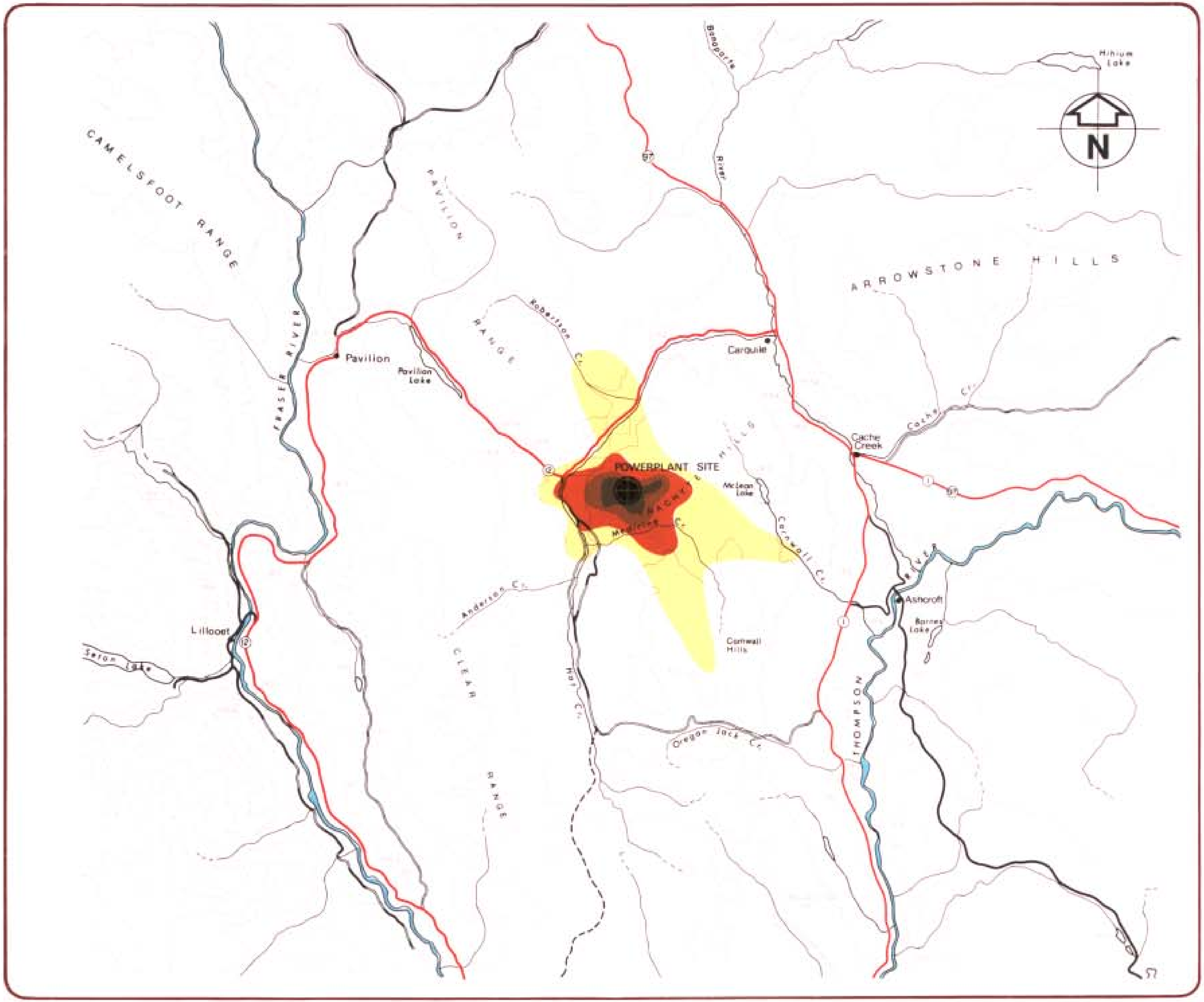
Evaporation from the water supply reservoir would increase the relative humidity within the vicinity of the reservoir. Increased moisture would occasionally produce fog at the reservoir surface which could persist for a few days during the late fall, winter and early spring.

(d) Local Effects of Fugitive Emissions from Construction, Mining, Ash and Waste Disposal, and Coal-handling Activities(15,36)

Fugitive dust emissions would result from activities during construction of the powerplant, coal mine and offsite facilities. Vehicular traffic would emit hydrocarbons, sulphur oxides, nitrogen oxides, carbon monoxide and particulate matter. Information regarding specific aspects of construction processes that would affect air quality has not been developed. However, it is expected that gaseous and particulate emissions would not produce excessive ambient concentrations. High localized particulate concentrations may occur as a result of dust from construction. However, dust suppression techniques would be implemented to minimize the effects. Since construction activities are short-term and limited in area, no significant adverse air quality impacts are expected beyond the immediate construction site.

Mining, coal-handling and coal storage activities during the production phase of the project would produce high concentrations of dust in the immediate vicinity of the activity sites. Specific control measures would be employed to minimize the emission of fugitive dust. Trees would be left where possible to act as wind breaks. Minimum advanced clearing and stripping would reduce exposure to eroding winds. Spraying techniques would be used on roads, coal piles and other areas subject to dust emissions. Care has been taken in locating the coal-blending area and coal stockpiles to minimize the eroding influences of prevailing winds (Section 3.2d). These measures are predicted to reduce ambient dust concentrations at distances greater than half a kilometre from these activity sites to below the PCB Objective levels (60 $\mu g/m^3$ for annual concentrations and 150 $\mu g/m^3$ for 24-hour concentrations). Dustfall levels are predicted to be less than 1.3 $mg/dm^2/d$ at distances greater than half a kilometre from the operations (PCB Objective range 1.7 to 2.9 $mg/dm^2/d$).

A slight, and very localized, average annual temperature decrease may occur directly at the mine due to scattering of sunlight by airborne dust within the pit. Model simulation of atmospheric processes supports this indication. Any effect of this kind would certainly be smaller in magnitude than

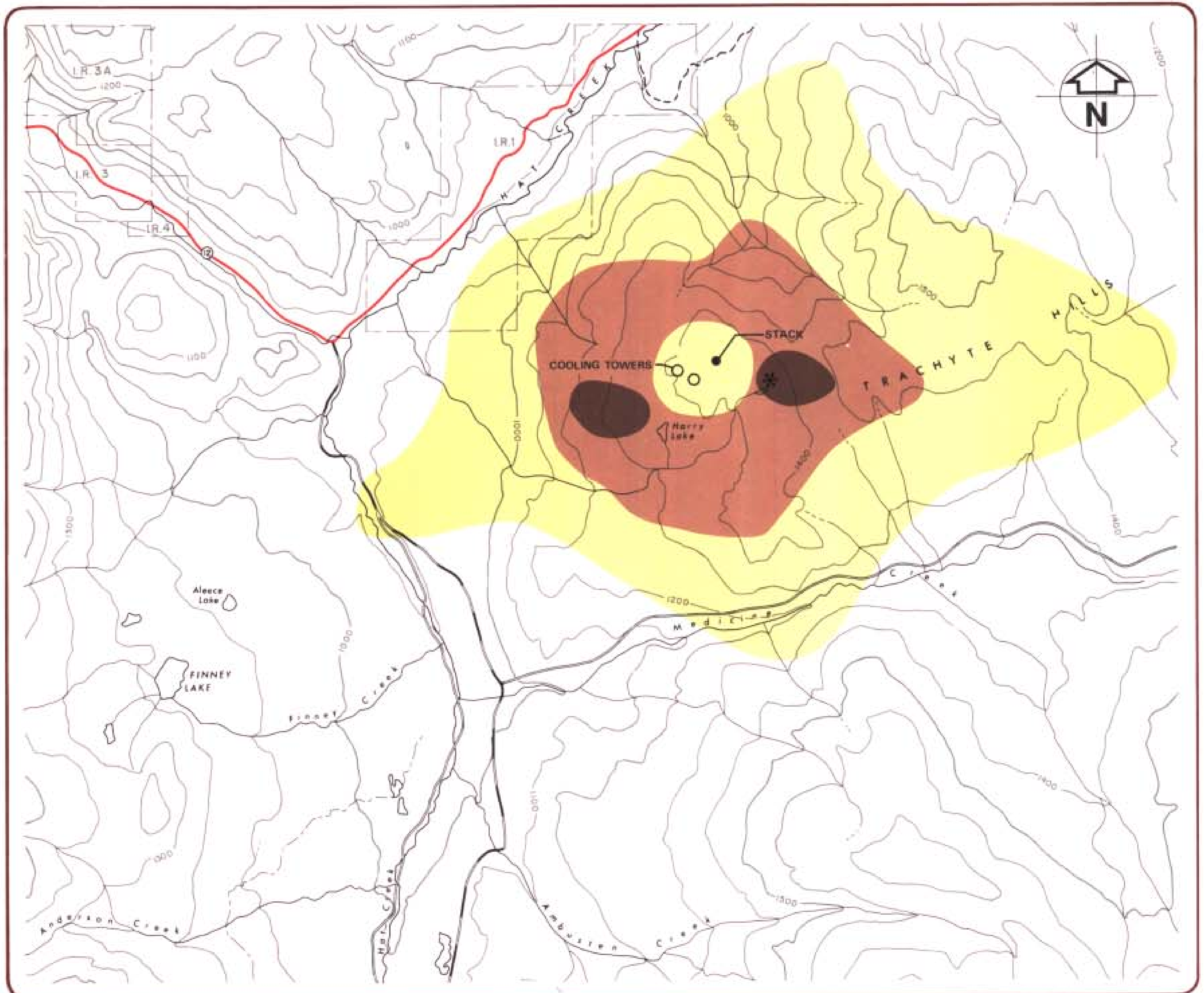



HAT CREEK PROJECT

FIGURE 6.3

## VISIBLE PLUME FROM COOLING TOWERS

SOURCE: Environmental Research and Technology Inc. (14)




**LEGEND**

DEPOSITION DUE TO WATER DROPLET "DRIFT" FROM THE COOLING TOWERS

- < 112 kg/km²/Year
- 112 to 560 kg/km²/Year
- 560 to 2240 kg/km²/Year
- > 2240 kg/km²/Year
- * = MAXIMUM: 4700 kg/km²/Year (42 lbs./acre/year)

SCALE — 1:50,000

1 km 0 km 1 km 2 km 3 km

CONTOUR INTERVAL — 100 METRES

HAT CREEK PROJECT

**FIGURE 6.4**

## SALT DEPOSITION FROM COOLING TOWERS (kg/km²/Year)

SOURCE: *Environmental Research and Technology Inc. (14)*

the natural year-to-year variability of annual average temperature and would have no significant impact on agricultural activities.

(e) Regional Effects (24)

Concentrations

Impacts on air quality outside the local area would result from powerplant stack emissions. These emissions would be released into the atmosphere where prevailing winds would disperse them, generally toward the north and east.

A regional computer simulation model was used to assess the impacts of powerplant stack emissions on ambient air quality. Maximum annual average concentrations in the regional area (25 km to 100 km radius), are shown in Table 6-8. The results of the regional modeling analysis, based on a 366 m stack with uncontrolled $SO_2$ emissions, indicate that the Hat Creek stack emissions would produce low ambient concentrations at distances beyond 25 km from the powerplant. The proposed project, with $SO_2$ emissions approximately half those of the uncontrolled case, would be expected to result in ambient concentrations substantially less than those shown in Table 6-8.

Potential for degradation of regional visibility as a result of sulphate and particulates is estimated to be 6 percent on an annual basis (i.e. the existing visible range over which details are discernible will be reduced by 6%).

TABLE 6-8
REGIONAL[1] MAXIMUM ANNUAL AVERAGE AMBIENT CONCENTRATION DUE TO POWERPLANT EMISSIONS[2]
($\mu g/m^3$) (24,50)

| Contaminant | British Columbia PCB Objective | Ambient Concentration |
|---|---|---|
| Sulphur Dioxide ($SO_2$) | 25 to 75 | 1.7 |
| Sulphate ($SO_4$) | [3] | 0.1 |
| Total Suspended Particulates (TSP) | 60 to 70 | 0.2 |
| Nitrogen Dioxide ($NO_2$) | [3] | 1.0 |

1. Results of regional modeling in range 25 to 100 km from powerplant with uncontrolled emissions from a 366 m stack.
2. 100% Capacity Factor.
3. Ambient level not defined in PCB Objective.

Deposition - Acid Precipitation

Long-range transportation of $SO_2$, $NO_2$ and other oxides is of concern since these compounds form acids in the atmosphere which subsequently reach the earth. Some background information is useful to understand this potential impact. Acidity of precipitation over certain regions of the world is currently receiving considerable attention. Reports by various committees and agencies have presented investigations of changes in the pH level of precipitation throughout the world. On the pH scale, a figure of 7.0 is neutral, while measurements below 7.0 grow progressively more acidic, and measurements above 7.0 are progressively more alkaline.

The "acid rain" phenomenon is most often related to large industrial emissions of sulphur and nitrogen oxides. Once released to the atmosphere, these oxides can undergo chemical transformations leading to the production of acidic compounds which return to earth in various forms of precipitation as well as by dry deposition. Acid depositions can have ecological effects on the natural environment, particularly lakes, rivers, fisheries and man-made structures. The magnitude of these environmental effects is related to the interaction of numerous factors, including total emissions of sulphur and nitrogen oxides, atmospheric diffusion characteristics, atmospheric chemistry, topography and climatology as well as certain soil, water chemistry and biological characteristics.

Increasing acidity of precipitation has been observed in Europe since 1950 and has been related to increased emission of sulphur and nitrogen oxides. By the 1960s, investigations by Scandinavian scientists indicated that streams and lakes in Sweden and Norway were experiencing a trend towards increasing acidity. The significance of similar occurrences in Eastern North America began to receive publicity in the 1970s. Investigators reported detrimental effects to ecosystems in the Adirondack Mountains in upstate New York and in Ontario that could be related to the occurrence of increased acid precipitation. More recently, acidic precipitation has been pointed to as a major environmental problem in eastern Canada. However, in Western Canada, concentrations of acidic compounds in precipitation are low, except downwind from Vancouver and from natural gas processing facilities in Alberta.(24)

The Hat Creek project was extensively studied to determine how it could affect the acidity of precipitation in the region, as well as how this increased acidity could affect the natural environment. Major factors affecting these impacts include the region's topography, the naturally occurring pH levels, the "buffering" ability (the ability to neutralize acid depositions) of the receiving soils and water bodies, and the quantity of powerplant emissions.

Results of the study (24) indicate that deposition of airborne materials from the Hat Creek project would produce no significant direct or indirect environmental effects in the aquatic systems and their biological communities as a result of project emissions.

This study (24) represents the first published attempt to develop quantitative estimates of pH reduction in lakes and streams due to emissions from a proposed source. In the absence of any verified methodology and in view of the importance of British Columbia's waterways in the economic and recreational life of the province, it has been necessary to adopt procedures that are: 1) based on established physical principles and 2) designed and implemented in a manner which ensures that error in the analysis will be in the direction of over-estimating the effects of the project on water chemistry in the surrounding area. This conservatism has been incorporated in the formulation of the simulation procedures themselves, as well as in the selection of input data for the various phases of the analysis, to compensate for the substantial uncertainties inherent in the application of new technologies.

Detailed studies(24) included preparation of mathematical models to simulate the dispersion, chemical changes, and deposition of acid-forming pollutants from the project. The studies also estimated the natural ability of the area's ecosystem to neutralize these compounds. The research indicates that the long-range transportation of acid-forming pollutants would primarily occur to the northeast of the project, with the heaviest annual deposition likely to occur within 50 km. Although long-range deposition could extend beyond 200 km, it would be of small magnitude. Figure 6-5 and Figure 6-6 show the maximum projected deposition of acids (in hydrogen ion form) per 24-hour period, and the average annual deposition, respectively (100% Capacity Factor).

The topography of the short-range area less than 50 km downwind from the powerplant is generally similar to that of the Hat Creek area, with gradual mountains and rolling hills. No sharp increases in elevation which would markedly increase precipitation are found. The soils within this area have been shown to be relatively alkaline. Thus they have high "buffering" capacities. Similarly the rivers and lakes in the short-range area have either moderate or high buffering capacities against acid deposition due to their relatively high alkaline content.

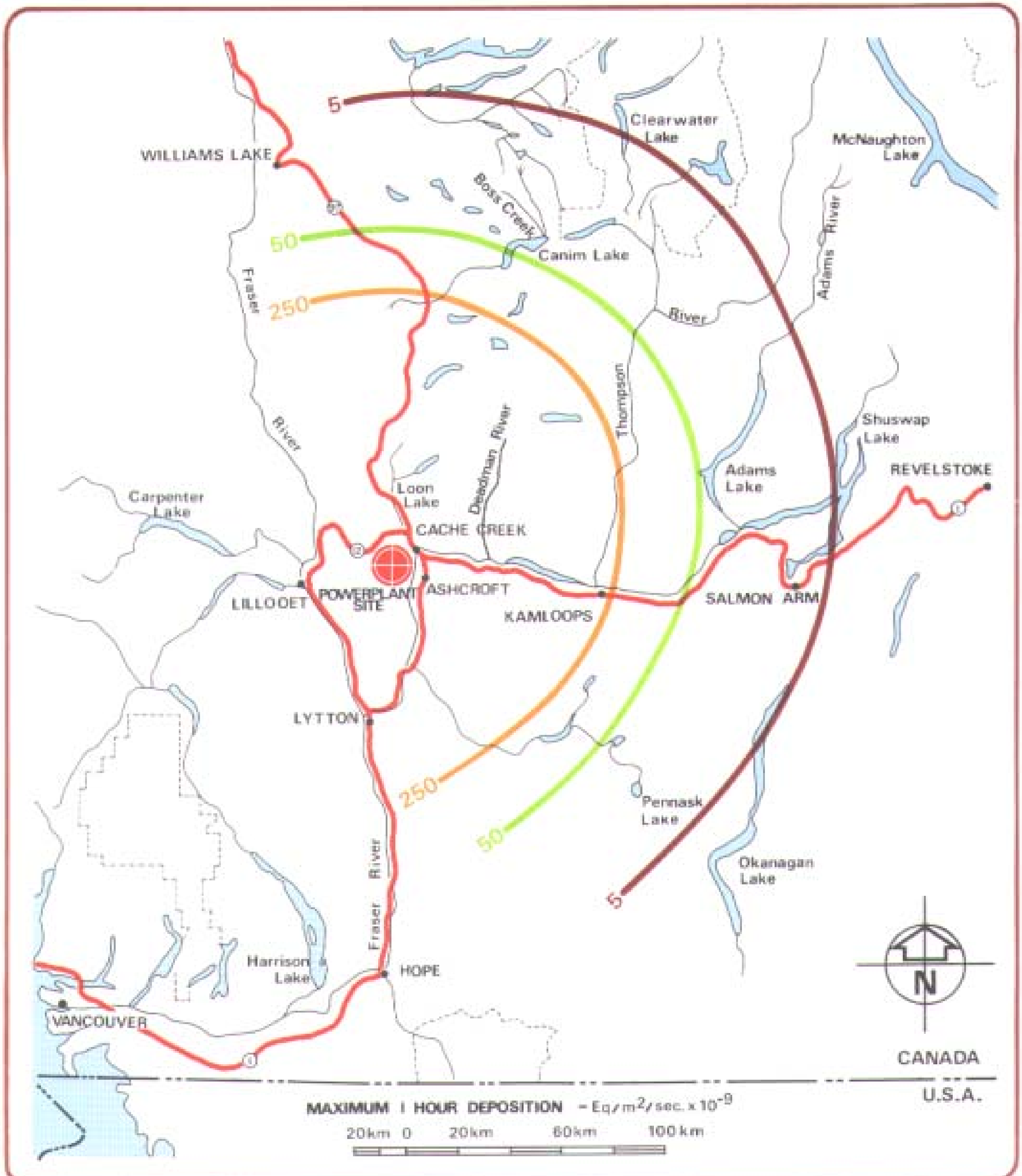
Conditions change in the long-range area, 50 to 200 km distant. This region includes mountainous terrain which causes an increase in precipitation and consequently receives an abundant snowpack. Accumulation of acidic compounds in this snowpack occurring during the winter, would mean a subsequent more concentrated release into river systems during the spring snowmelt. Soils and water in these mountainous regions, particularly those located 150 to 200 km downwind, have lower alkalinities and hence less capacity to buffer against acid precipitation.

Based on water quality data for 205 water systems in the region around Hat Creek, 43 water systems were identified as being potentially vulnerable to acidification. ERT selected five of the 43 water systems for detailed evaluation. These particular systems were chosen because of their economic and recreational importance, location relative to the powerplant and relatively limited buffering capacities. Two additional water systems were studied by ERT, namely Loon Lake and Deadman River. Even though these two systems are well buffered (pH 8.7 and 8.2) they are located in areas where it is estimated that deposition from powerplant emissions would be greatest (see Figure 6-5 and Figure 6-6).

Model calculations indicate that for the proposed project the pH of precipitation downwind of the powerplant would be reduced to about 5.58 for the long-range transport area and to about 5.06 for the short-range area. It is estimated that precipitation with these pH levels would have no significant effect on biophysical systems, including aquatic life. These predictions were based on a present precipitation pH of 5.65, determined by assuming the precipitation to be in equilibrium with atmospheric carbon dioxide. The projected pH levels for precipitation in the short-range and long-range areas are within the limits reported for precipitation occurring over the earth's surface.

Table 6-9 shows projected changes in pH levels, after 35 years of project operation, of water bodies selected for detailed analysis, for both the scrubbed and unscrubbed scenerios. The techniques used to predict cumulative effects of the proposed project emissions on water quality tend to overestimate such effects. However, after and as a result of the expected 35-year lifetime of this project, it is calculated that the pH of all water bodies would remain in the range required for viable aquatic populations.

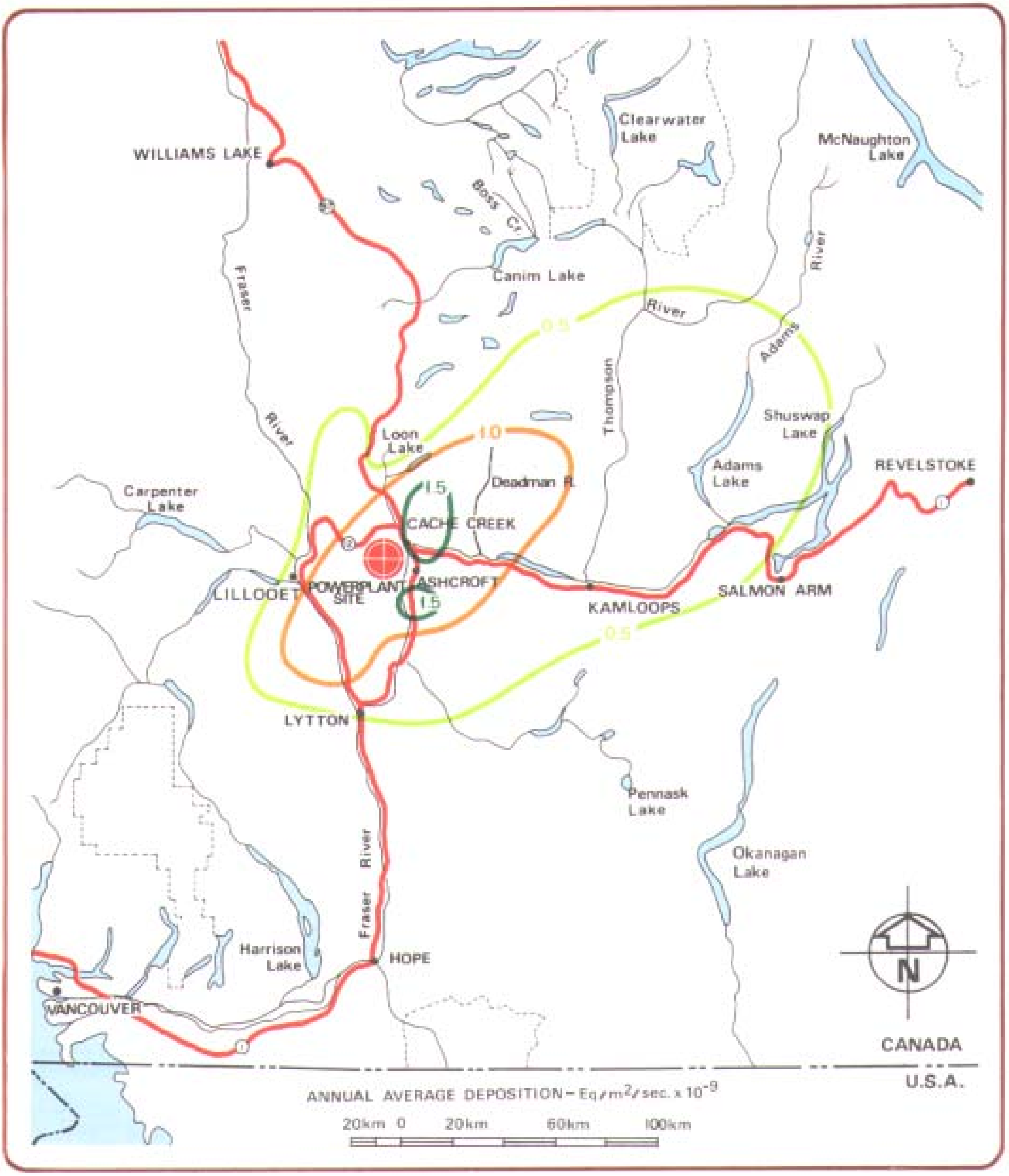
A thorough monitoring program covering a variety of sensitive sites would be used to identify significant trends in regional environmental acidity (see Section 26.0).




HAT CREEK PROJECT

## FIGURE 6.5
# MAXIMUM PROJECTED HYDROGEN ION DEPOSITION

SOURCE: *Environmental Research and Technology Inc.* (24)




HAT CREEK PROJECT

## FIGURE 6.6

# ANNUAL AVERAGE PROJECTED HYDROGEN ION DEPOSITION

FROM PROPOSED POWERPLANT: 366 m STACK WITH FLUE GAS DESULPHURIZATION

SOURCE: *Environmental Research and Technology, Inc. (24)*

TABLE 6-9

ESTIMATED LONG-TERM CHANGES IN ACIDITY OF WATER BODIES[1]

(After 35 Years of Project Operation) (24)

| Location | Existing Average pH | Calculated Change of pH | | Final Long-term Average pH | |
|---|---|---|---|---|---|
| | | Proposed Project 366/FGD | Powerplant with 244/MCS | Proposed Project 366/FGD | Powerplant with 244/MCS |
| Clearwater River | 7.56 | -0.02 | -0.02 | 7.54 | 7.54 |
| Pennask Lake | 7.6 | -0.07 | -0.10 | 7.53 | 7.50 |
| Loon Lake | 8.7 | -1.38 | -1.53 | 7.32 | 7.17 |
| Boss Creek | 7.1 | -0.02 | -0.02 | 7.08 | 7.08 |
| Adams River | 7.6 | -0.13 | -0.15 | 7.47 | 7.45 |
| Deadman River | 8.2 | -0.56 | -0.70 | 7.64 | 7.50 |
| Thompson River | 7.56 | -0.02 | -0.03 | 7.54 | 7.53 |

1. Powerplant assumed to operate at full load (100% Capacity Factor) for 35 years.

---

(f)Additive Effects

Little interaction between emissions from the cooling towers, powerplant stack and mine is expected primarily because of their different elevations. The base level of the powerplant complex would be approximately 500 m higher than the surface level at the mine, and the top of the stack is approximately 250 m higher than the top of the cooling towers. Occasional mingling of the plumes from the cooling tower and stack would occur. Natural draft cooling tower plumes have a relatively low initial vertical velocity, but, by virtue of their density, a very large buoyancy. The stack plume has a high exit velocity but its buoyancy excess is more quickly dissipated than that of cooling tower plumes. As a result, under infrequent meteorological conditions, both plumes could tend to level off at about the same height.

The oxidation rate of atmospheric $SO_2$ to form sulphate is believed to proceed more rapidly in a moist environment, perhaps by a factor of two or more. Thus, when the two plumes mix, $SO_2$ in the stack emissions could produce sulphates at an accelerated rate.

Existing sources of $SO_2$ are primarily located in the Kamloops area and these emissions are estimated by the Waste Management Branch to be approximately 6.8 tons/day.

Currently, there is little chance for interaction of the Hat Creek plume with the existing sources. The annual-average predictions for $SO_2$ concentrations in Kamloops resulting from the proposed project are less than 1.0 $\mu g/m^3$. This prediction was made assuming Kamloops to be at the same elevation as the stack base(48). In actuality, Kamloops is roughly 1000 m lower than the powerplant site elevation. It is, therefore, very unlikely that the Hat Creek plume would have any significant impact on the Kamloops area, which is approximately 90 km away from the plant.

The air quality assessment studies did not include speculation on what future industries may be drawn to the Hat Creek area, nor how they may contribute to air quality impacts.

## SECTION 7. VEGETATION (15,16,35,47)

### 7.1 EXISTING SITUATION

Climate, soils, topography (described in Section 2.0), fire history, and land use determine the pattern of existing vegetation of the Hat Creek valley. The vegetation cover is composed primarily of a mosaic of open forests and grasslands. Forest and grassland associations occurring within the local area are shown on Figure 7-1 and Figure 7-2(16) and listed in detail in Table 7-1.

Primary uses of vegetation in the Hat Creek area are forestry, agricultural grazing and wildlife habitat. Domestic livestock have made extensive use of range areas in the immediate vicinity of the proposed project. Grazing has been heaviest in the open range areas in the Hat Creek valley, upper Medicine Creek, lower Cornwall Creek, Thompson River valley and the alpine areas. Areas used for both forest and grazing activities have not been as severely disturbed as the open range, with the exception of the rangelands in the Cornwall Mountain area which have been depleted of most palatable forage vegetation species, primarily by cattle. Sections 8.0 (Forestry), 9.0 (Agriculture) and 10.0 (Wildlife) describe these uses and related project impacts in more detail.

No plant species considered as rare or endangered have been found within areas which would be directly impacted by the proposed development.

### 7.2 PROJECT ACTIONS

Project actions that could directly or indirectly affect the vegetation within the Hat Creek valley and surrounding regions are land alienation, dust, leaching and seepage of water, and powerplant stack and cooling tower emissions.

### 7.3 EFFECTS OF THE PROJECT

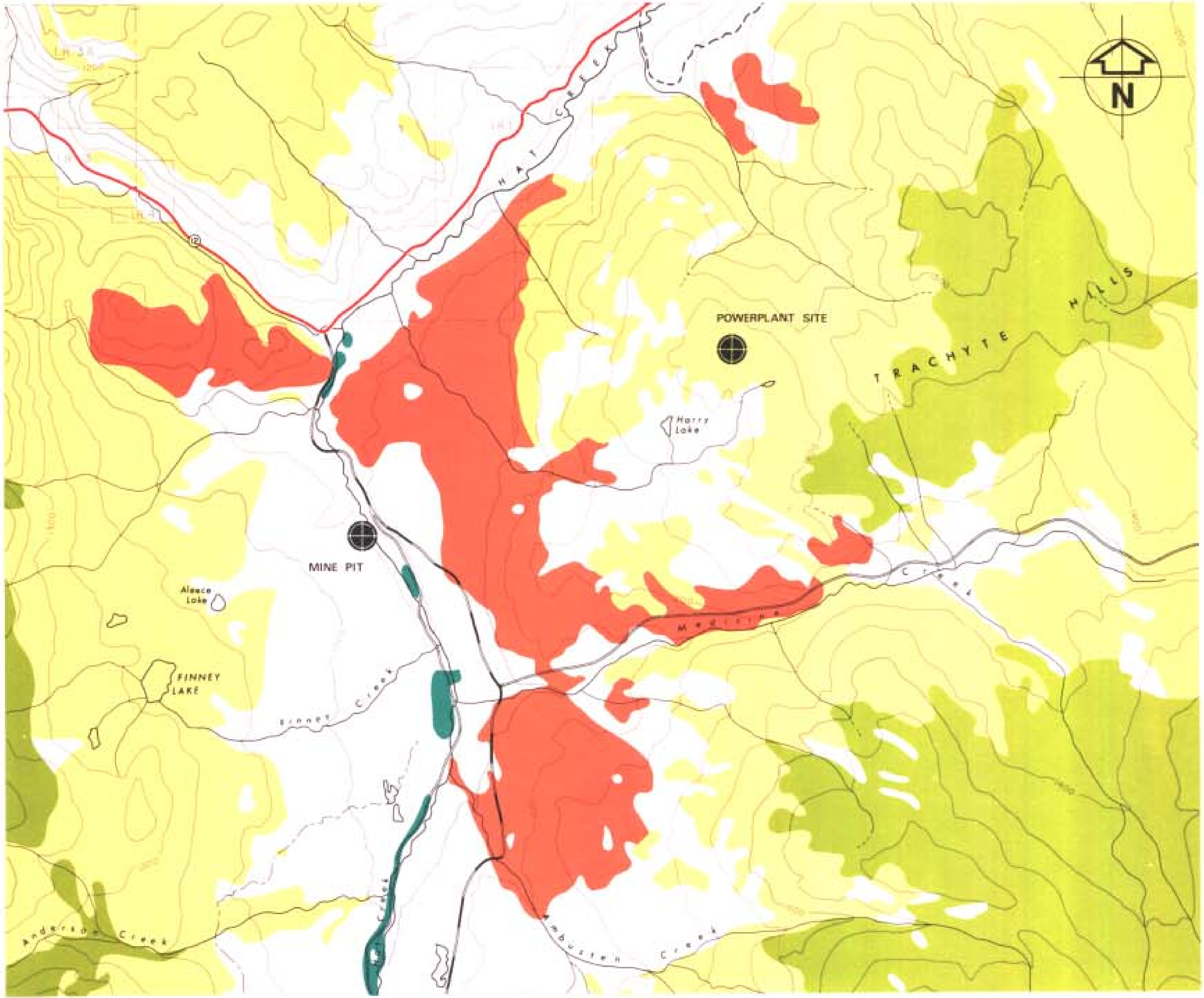
(a) Land Alienation

Construction activities would be restricted to the immediate vicinity of the various project facilities. A buffer zone around each facility has been included in computations of land alienated during construction and operation. All land to be occupied by a project component has been assumed as alienated. Table 7-2 summarizes the areas of each vegetation type expected to be alienated by the project.(35) Vegetation losses generally amount to a few percent of the various vegetation types occurring within a 25 km radius of the proposed project. A notable exception is the sagebrush-bluebunch wheatgrass vegetation type, of which more than half would be removed by mine pit development. The sagebrush-bluebunch wheatgrass vegetation type is locally unique and important wildlife habitat. With the exception of the sagebrush-bluebunch wheatgrass type all of the vegetation associations affected are common throughout the subalpine forest regions of interior British Columbia.

TABLE 7-1
VEGETATION ASSOCIATIONS
OCCURRING IN THE HAT CREEK LOCAL STUDY AREA[1] (16)

| Type | Vegetation Association | Area ($km^2$) | Percentage of Total Area |
|---|---|---|---|
| Forest | Engelmann Spruce - | | |
| | Grouseberry | 198 | 12.5 |
| | Grouseberry - Pinegrass | 183 | 11.5 |
| | Grouseberry - White Rhododendron | 58 | 3.6 |
| | Willow - Red Heather Barkland | 11 | 0.7 |
| | Grouseberry - Lupine | 30 | 1.9 |
| | Douglas fir - | | |
| | Pinegrass | 479 | 30.1 |
| | Bunchgrass | 33 | 2.1 |
| | Spirea - Bearberry | 1 | 0.1 |
| | Bunchgrass - Pinegrass | 143 | 9.0 |
| | Ponderosa Pine - | | |
| | Bunchgrass | 14 | 0.9 |
| | Riparian | 10 | 0.6 |
| | Engelmann Spruce - Horsetail | 6 | 0.3 |
| | Willow - Sedge Bog | 7 | 0.4 |
| | | 1 173 | 73.7 |
| Grassland | Highland | 9 | 0.6 |
| | Kentucky Bluegrass | 47 | 3.0 |
| | Bunchgrass - Kentucky Bluegrass | 26 | 1.6 |
| | Sagebrush - Bluebunch Wheatgrass | 7 | 0.4 |
| | Saline Depressions | <1 | <0.1 |
| | Big Sagebrush - Bunchgrass | 200 | 12.6 |
| | | 289 | 18.2 |
| Complexes | Bunchgrass - Kentucky Bluegrass - Saline Depressions | 22 | 1.4 |
| | Rock - Douglas fir - Spirea Bearberry - Pinegrass | 31 | 2.0 |
| | Mountain Avens - Sedge - Highland Grassland | 23 | 1.4 |
| | Kentucky Bluegrass - Riparian | 8 | 0.5 |
| | | 84 | 5.3 |
| Other | Cultivated Fields | 30 | 1.8 |
| | Water | 8 | 0.5 |
| | Rock | 7 | 0.5 |
| | | 45 | 2.8 |

1. The local study area for vegetation is a rectangular shape approximately 1600 $km^2$ in area.




LEGEND

RIPARIAN ASSOCIATION

ENGLEMANN SPRUCE — GROUSEBERRY — PINEGRASS ASSOCIATION

DOUGLAS FIR — PINEGRASS ASSOCIATION

DOUGLAS FIR — BUNCHGRASS — PINEGRASS ASSOCIATION

SHEET 1 SHEET 2

SCALE — 1:50,000

1 km 0 km 1 km 2 km 3 km

CONTOUR INTERVAL — 100 METRES

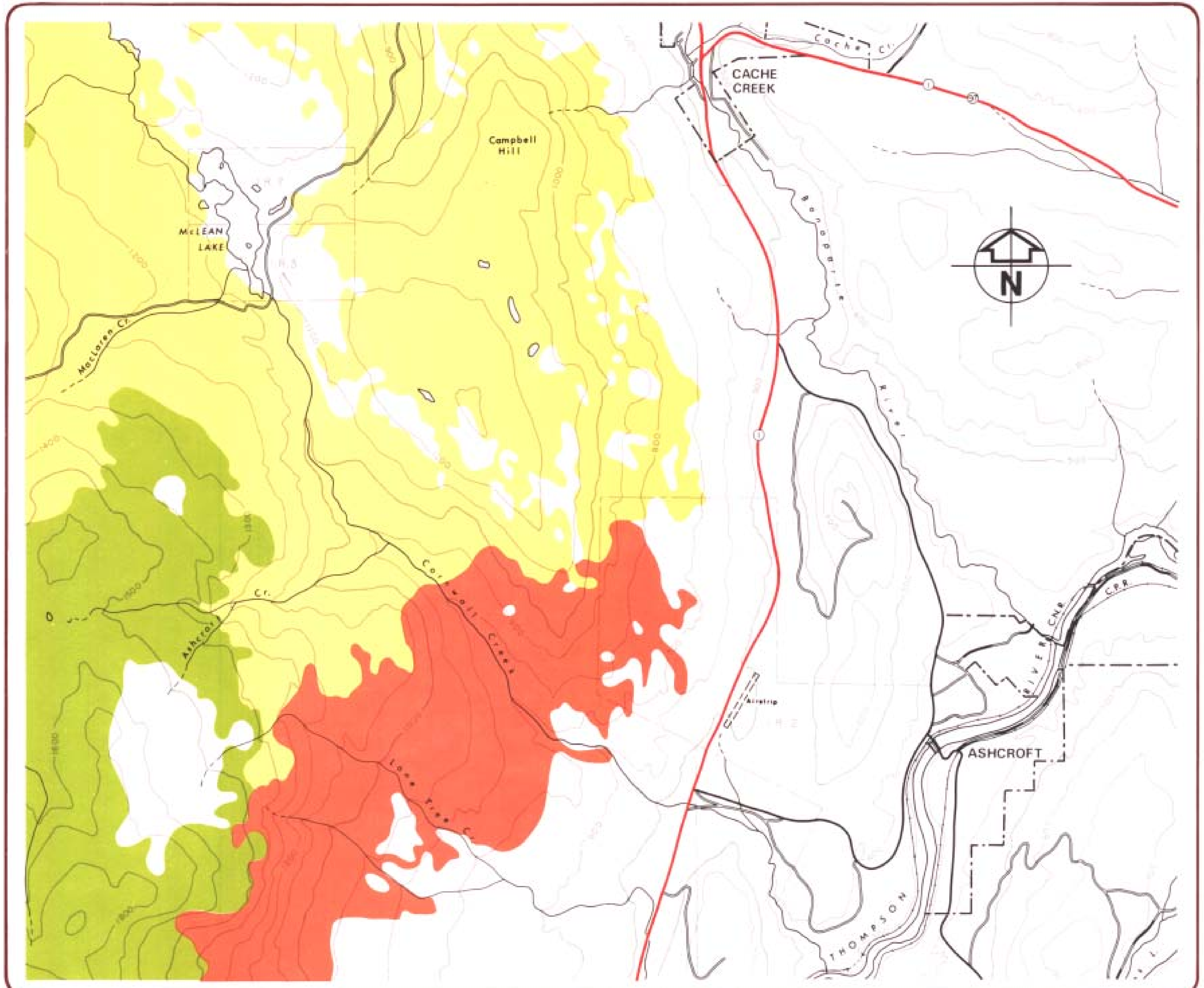
HAT CREEK PROJECT

FIGURE 7.1

# FOREST VEGETATION ASSOCIATIONS

SHEET 1 OF 2

SOURCE: Tera Environmental Resource Analyst Ltd. (16)




## LEGEND

- ENGLEMANN SPRUCE — GROUSEBERRY — PINEGRASS ASSOCIATION
- DOUGLAS FIR — PINEGRASS ASSOCIATION
- DOUGLAS FIR — BUNCHGRASS — PINEGRASS ASSOCIATION

SHEET 1 | SHEET 2

SCALE — 1:50,000

1 km 0 km 1 km 2 km 3 km

CONTOUR INTERVAL — 100 METRES

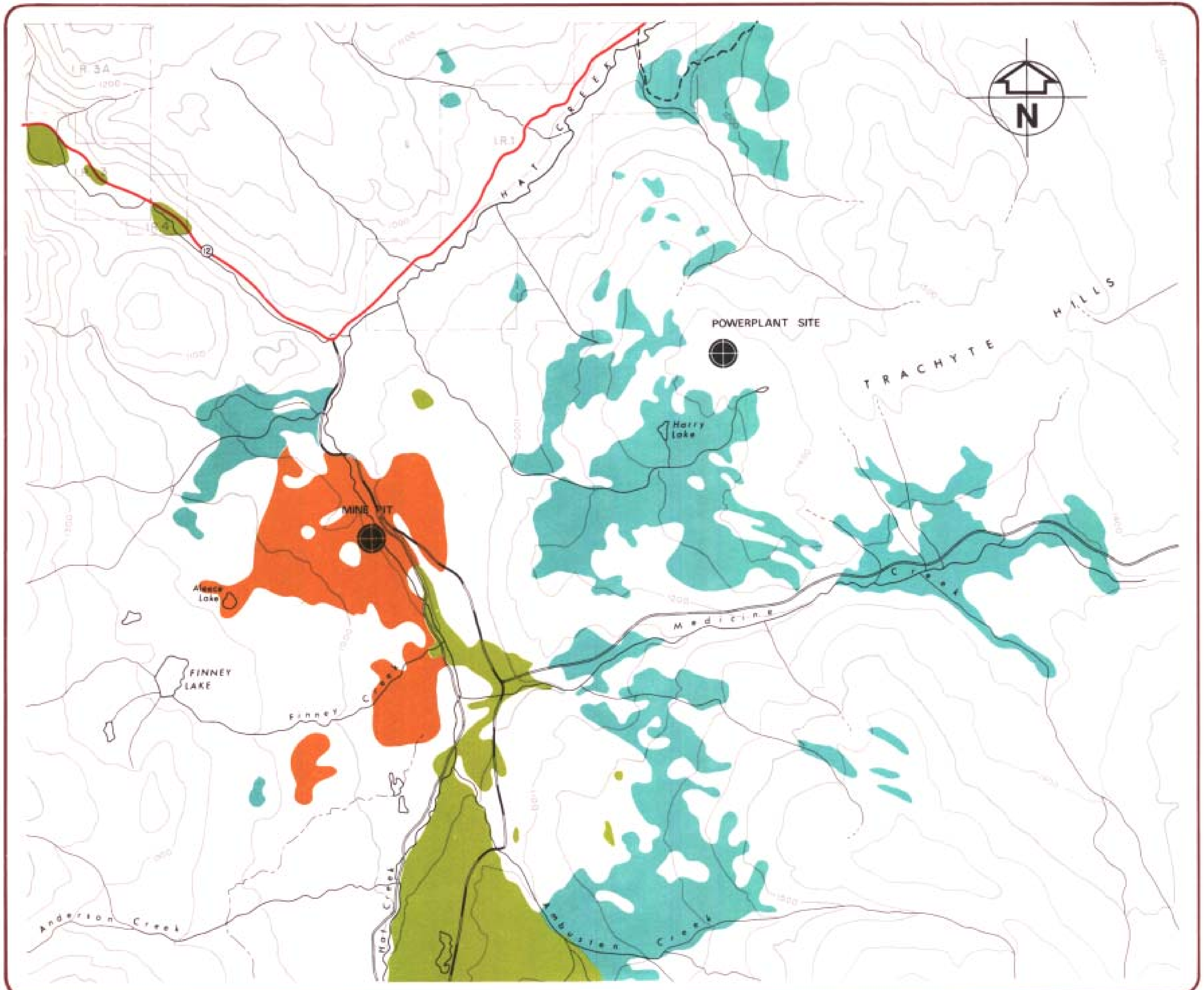
HAT CREEK PROJECT

# FIGURE 7.1

# FOREST VEGETATION ASSOCIATIONS

SHEET 2 of 2

*SOURCE: Tera Environmental Resource Analyst, Ltd. (16)*




## LEGEND

- KENTUCKY BLUEGRASS ASSOCIATION
- BUNCHGRASS — KENTUCKY BLUEGRASS ASSOCIATION
- SAGEBRUSH — BLUEBUNCH WHEATGRASS ASSOCIATION

SHEET 1 | SHEET 2

SCALE — 1:50,000

1 km 0 km 1 km 2 km 3 km

CONTOUR INTERVAL — 100 METRES

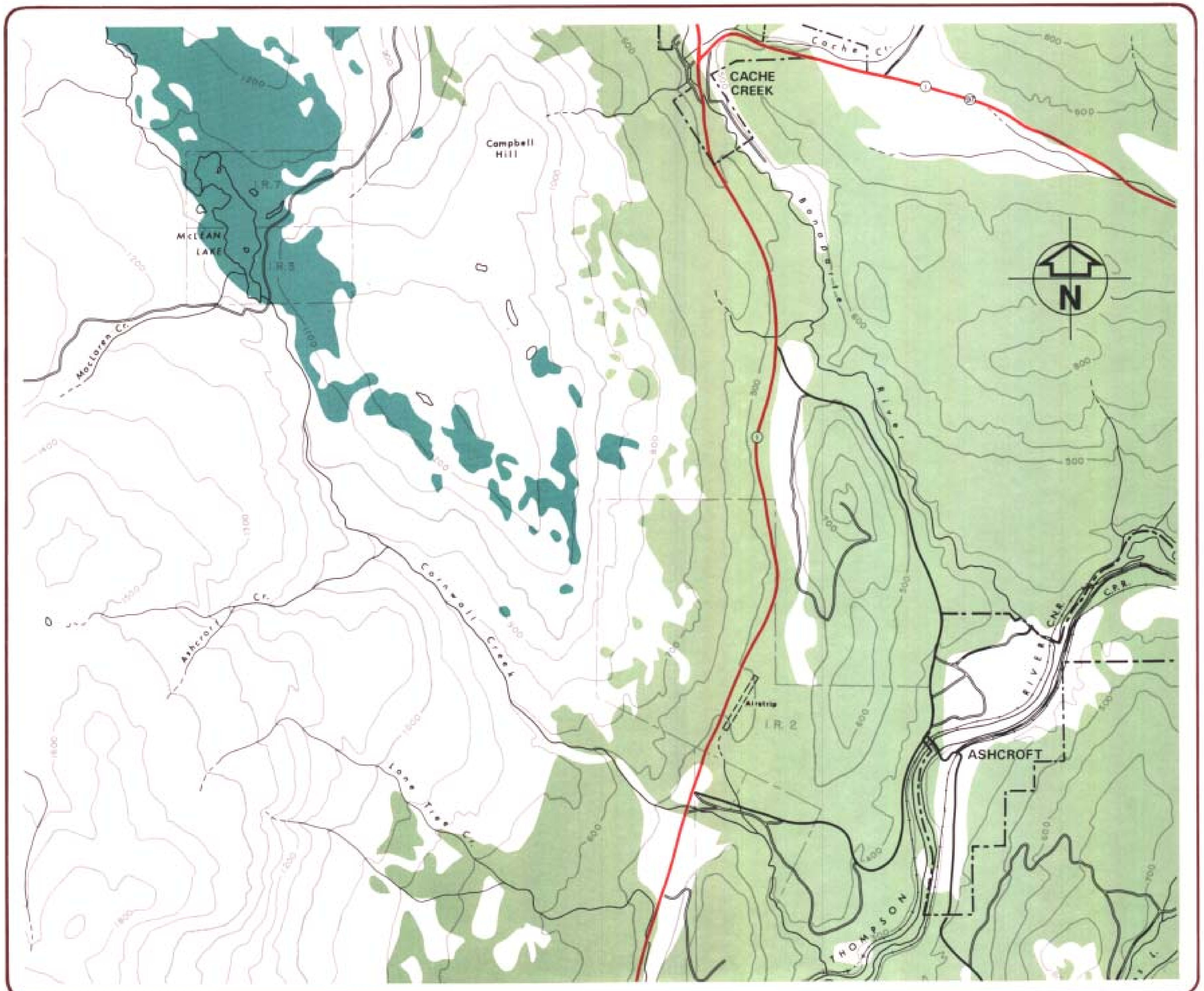
HAT CREEK PROJECT

## FIGURE 7.2

# GRASSLAND VEGETATION ASSOCIATIONS

SHEET 1 OF 2

*SOURCE: Tera Environmental Resource Analyst, Ltd. (16)*




## LEGEND

KENTUCKY BLUEGRASS ASSOCIATION

BIG SAGE — BUNCHGRASS ASSOCIATION

SHEET 1 | SHEET 2

SCALE — 1:50,000

1 km 0 km 1 km 2 km 3 km

CONTOUR INTERVAL — 100 METRES

HAT CREEK PROJECT

## FIGURE 7.2

# GRASSLAND VEGETATION ASSOCIATIONS

SHEET 2 OF 2

*SOURCE: Tera Environmental Resource Analyst, Ltd. (74)*

TABLE 7-2

VEGETATION ASSOCIATIONS EXPECTED TO BE ALIENATED
BY HAT CREEK MINE, POWERPLANT AND OFFSITE FACILITIES (35)
(ha)

| Type - Vegetation Association | Mine Open Pit[1] | Medicine Creek Waste Disposal | Houth Meadows Waste Disposal | Coal Handling Facilities | Lagoons | Maintenance Buildings | Powerplant Site[2] | Off-site Facilities[3] |
|---|---|---|---|---|---|---|---|---|
| **Forest** | | | | | | | | |
| Engelmann Spruce - Grouseberry | - | - | - | - | - | - | - | 10 |
| Douglas-fir - | | | | | | | | |
| Pinegrass | 26 | 71 | 372 | - | - | - | 95 | 125 |
| Bunchgrass | 50 | - | 14 | 5 | 3 | - | - | 13 |
| Bunchgrass - Pinegrass | 115 | 214 | - | 52 | 3 | 25 | 5 | 148 |
| Riparian | 9 | - | - | - | - | <1 | - | 1 |
| Willow - Sedge Bog | - | - | - | - | - | - | - | - |
| **Grassland** | | | | | | | | |
| Kentucky Bluegrass | - | 133 | 116 | 17 | 8 | - | 10 | 59 |
| Bunchgrass - Kentucky Bluegrass | 16 | 1 | - | 3 | 5 | - | - | 28 |
| Sagebrush - Bluebunch Wheatgrass | 358 | - | 8 | 5 | - | - | - | 16 |
| Saline Depressions | - | - | - | - | - | - | - | 3 |
| Big Sagebrush - Bunchgrass | - | - | - | - | - | - | - | 103 |
| **Complexes** | | | | | | | | |
| Bunchgrass - Kentucky Bluegrass/Saline Depressions | 16 | - | - | - | - | - | - | 8 |
| Douglas fir - Spirea - Bearberry/ Pinegrass | - | - | 90 | - | - | - | - | 2 |
| Kentucky Bluegrass/Riparian | - | - | - | - | 2 | - | - | - |

1 Includes mine construction camp and parking.

2 Includes plant site, construction camp, housing and parking.

3 Includes all roads, canals, ditches, transmission lines, pipelines, etc.

TABLE 7-2 - (Cont'd)

| Type - Vegetation Association | Reservoirs | Total Area Alienated | Percentage of Association Alienated Within 25 km Radius | Sensitivity of Disturbance |
|---|---|---|---|---|
| **Forest** | | | | |
| Engelmann Spruce - Grouseberry | - | 10 | <1 | Low |
| Douglas-fir - | | | | |
| Pinegrass | 11 | 700 | 2 | Low |
| Bunchgrass | - | 85 | 3 | Moderate |
| Bunchgrass - Pinegrass | - | 562 | 4 | Moderate |
| Riparian | 4 | 14 | 1 | High |
| Willow - Sedge Bog | 5 | 5 | 1 | High |
| **Grassland** | | | | |
| Kentucky Bluegrass | 78 | 421 | 9 | Low |
| Bunchgrass - Kentucky Bluegrass | 11 | 64 | 3 | Low |
| Sagebrush - Bluebunch Wheatgrass | - | 387 | 58 | High |
| Saline Depressions | - | 3 | 10 | Moderate |
| Big Sagebrush - Bunchgrass | - | 103 | <1 | Low |
| **Complexes** | | | | |
| Bunchgrass - Kentucky Bluegrass/Saline Depressions | 2 | 26 | 1 | Moderate |
| Douglas fir - Spirea - Bearberry/Pinegrass | - | 92 | 15 | High |
| Kentucky Bluegrass/Riparian | - | 2 | <1 | Moderate |

(b) Dust

Dust emissions from construction activities could have an adverse effect on the vegetation during dry periods. The accumulation of dust on vegetation, particularly on those varieties with pubescent leaves, could lead to slight reductions in photosynthetic activity and productivity, and could increase the frequency of insect infestations and diseases.

No quantitative estimate of the extent of this impact can be made. Dust control measures would be employed to limit the spread of dust so that accumulation causing adverse effects to vegetation would be limited to the immediate vicinity of construction or mining activities.

(c) Leaching and Seepage

Pumping of groundwater from the strata around the mine pit would reduce the total water table of the surrounding area. Although water tables are generally well below the ground surface (approx. 20 m), this reduction may lead to some measurable alteration in the composition of the willow-sedge bog and saline depression communities in the immediate vicinity of the mine pit.

Leaching of trace elements would occur from piles of overburden and waste coal. Migration of water soluble elements out of waste and ash disposal areas would be controlled by proper design and containment of runoff and seepage (see Section 11.0). The quality of the groundwater is not expected to decrease appreciably (see Section 11.0), and hence no significant increase in trace element uptake by natural vegetation outside the mine area complex is to be expected.

(d) Stack Emissions

The environmental contaminants contained in the powerplant stack emissions would include sulphur dioxide, nitrogen oxides, particulate matter and trace elements. As detailed below, sulphur dioxide would be the major contaminant emitted and could cause vegetation injury under specific conditions.

By way of definition and with particular reference to sulphur dioxide and nitrogen oxide emissions, injury to vegetation from exposure to air contaminants can be either acute or chronic. Acute injury usually occurs as the result of short-term exposures to high concentrations. Chronic injury on the other hand results from exposure to low concentrations over long periods of time. The term "injury" is generally used to describe all plant responses to air contaminant exposures. These would include reversible effects on metabolism, physiological processes, necrosis, senescence and growth and development modifications. Thus, the term "% injury" refers to the degree of response by a plant to air contaminant exposures where 0 percent injury represents a null response. The response could be measured, for example, in terms of induced foliar injury, reduced photosynthesis or reduced growth. "Damage", on the other hand, is used to define those injurious effects which would reduce the value of the plant for its intended economic or ecological use. Damage would not necessarily follow a case of vegetation injury. Due to the lack of specific information on the responses of vegetation species in the Hat Creek area to air contaminants, the impacts of the project were assessed primarily in terms of potential injury. The results of ambient air quality modeling (Section 6.0) were used as a basis for assessing potential stack emission impacts.

(i) Sulphur Dioxide ($SO_2$)

Impacts were assessed on the basis of published data on vegetation responses to $SO_2$, $NO_2$ and other emissions (51). Subjective weighting factors were applied to allow for increased impacts due to $SO_2$ and $NO_2$ possibly acting together (synergistic effect), high emission levels during early daylight hours, sequential exposures and winter deposition (51). Impact weighting factors were similarly applied to account for beneficial effects of elevated $CO_2$ levels and protection of lower vegetation by tree and shrub overstoreys, and to allow for the fact that higher levels of emissions are required to produce responses in natural vegetation than in similar vegetation under laboratory conditions (whence most response data are obtained)(51). The net impact assessment probably tends to overestimate the impacts.

Detailed data on hourly average concentrations occurring at 128 locations in the local area over a typical year and the threshold values presented in the literature were used as the basis to assess the potential maximum injury to the vegetation due to $SO_2$ and $NO_2$ together. Two air quality control cases are presented: 244 m stack with MCS and the proposed project (366 m stack with FGD). The results show that for the 244/MCS case (Table 7-3), 132.7 $km^2$ would be affected while for the proposed project 10.6 $km^2$ would be affected (Table 7-4). The most prevalent range of injury is 0-5% in both cases. It is evident that the amount of area affected and percent injury range is substantially lower for the proposed project.

The probability of vegetation injury actually occurring would remain low as long as the hourly average ambient $SO_2$ concentrations(51) remain below approximately 900 $\mu g/m^3$, a condition achieved under the 366/FGD option, the proposed project. The probability of more severe impacts to vegetation found at the higher elevations would increase if peak hourly average ambient $SO_2$ concentrations were to exceed 1000 $\mu g/m^3$. The maximum worst case ground level concentrations of $SO_2$ predicted to occur from the proposed powerplant emissions are shown in Table 6-3.

For both cases, the areas in which injury would most likely occur correspond to the higher elevation areas where ambient $SO_2$ concentrations would generally be highest (See Figure 6-1). Infrequent coincidence of stack emissions and cooling tower plumes might enhance $SO_2$ uptake by vegetation in such areas, which generally lie southwest and northeast of the power plant site.

In the absence of specific information on the responses of local vegetation species to ambient concentrations of contaminants, it is not possible to accurately predict long-term effects. Some measurable injury to tree and shrub species in the areas of highest $SO_2$ concentrations (see Figure 6-1) would probably occur. For the 244/MCS case cumulative injury to sensitive species such as willow (Salix spp.) would probably lead to changes in vegetation species composition and plant cover in the affected areas. Visible effects would most likely be observed in willow, moss (Pleurozium sp.), Kentucky bluegrass and trembling aspen. The 366 m FGD case would cause much less measurable injury to vegetation species. It is doubtful that visible injury symptoms would be noticeable or distinguishable from insect and/or other damage. Such changes would be closely monitored during the life of the project (see Section 26.0).

TABLE 7-3
PREDICTED ANNUAL AREA IMPACTED AS A FUNCTION OF THE PERCENT INJURY OF PLANT SPECIES AS A RESULT OF EMISSIONS OF NO2 AND SO2 FROM THE POWERPLANT
244 M STACK WITH MCS (16)

| Plant Species | Total Vegetative Cover Affected (km²)[1] | Predicted Percent Injury[2] 0-5 | >5-10 | >10-15 | >15-20 | >20-25 | >25-40 |
|---|---|---|---|---|---|---|---|
| Alpine fir (Abies lasiocarpa) | 1.6 | 1.4 | 0.2 | | | | |
| Englemann spruce (Picea engelmannii) | 15.6 | 15.6 | | | | | |
| Lodgepole pine (Pinus contorta) | 16.9 | 16.9 | | | | | |
| Ponderosa pine (Pinus ponderosa) | 1.8 | 1.8 | | | | | |
| Douglas fir (Pseudotsuga menziesii) | 16.7 | 16.7 | | | | | |
| Trembling aspen (Populus tremuloides) | 0.5 | 0.2 | 0.1 | 0.2 | | | |
| Black Cottonwood (Populus trichocarpa) | 0.2 | 0.2 | | | | | |
| Serviceberry (Amelanchier alnifolia) | 1.7 | 1.7 | | | | | |
| Willow (Salix spp.) | 34.4 | 20.9 | 7.8 | 3.2 | 0.2 | 0.5 | 1.8[3] |
| Kentucky bluegrass (Poa pratensis) | 2.2 | 1.7 | 0.2 | 0.3 | | | |
| Pleurozium schreberi | 38.4 | 38.4 | | | | | |
| Alectoria jubata | 2.7 | 2.7 | | | | | |
| | 132.7 | 118.2 | 8.3 | 3.7 | 0.2 | 0.5 | 1.8 |

1. Vegetative cover is the area of the ground surface under the live aerial parts of plants and is commonly used as a measure of foliage abundance.
2. Response of a plant to air pollution exposures including reversible effects on metabolism, effects on physiological processes, necrosis, senescence and modifications of growth and development.
3. For the 1.8 km² impacted at >25 percent injury, the area distribution is:

>25-30 percent - 1.5 km²
>30-35 percent - 0.2 km²
>35-40 percent - 0.1 km²

TABLE 7-4
PREDICTED ANNUAL AREA IMPACTED AS A FUNCTION OF THE PERCENT INJURY OF PLANT SPECIES AS A RESULT OF EMISSIONS OF NO2 AND SO2 FROM THE POWERPLANT
366 M STACK WITH FGD (16)

| Plant Species | Total Vegetative Cover Affected ($km^2$)[1] | Predicted Percent Injury[2] 0-5 | >5-10 | >10-15 | >15-20 | >20-25 | >25-40 |
|---|---|---|---|---|---|---|---|
| Alpine fir (Abies lasiocarpa) | | | | | | | |
| Englemann spruce (Picea engelmannii) | | | | | | | |
| Lodgepole pine (Pinus contorta) | | | | | | | |
| Ponderosa pine (Pinus ponderosa) | | | | | | | |
| Douglas fir (Pseudotsuga menziesii) | | | | | | | |
| Trembling aspen (Populus tremuloides) | | | | | | | |
| Black Cottonwood (Populus trichocarpa) | | | | | | | |
| Serviceberry (Amelanchier alnifolia) | | | | | | | |
| Willow (Salix spp.) | 1.0 | 0.9 | 0.1 | | | | |
| Kentucky bluegrass (Poa pratensis) | 0.2 | 0.2 | | | | | |
| Pleurozium schreberi | 9.4 | 9.4 | | | | | |
| Alectoria jubata | | | | | | | |
| | 10.6 | 10.5 | 0.1 | | | | |

1. Vegetative cover is the area of the ground surface under the live aerial parts of plants and is commonly used as a measure of foliage abundance.
2. Response of a plant to air pollution exposures including *reversible effects on metabolism, effects on physiological* processes, necrosis, senescence and modifications of growth and development.

(ii) Nitric Oxide and Nitrogen Dioxide

The concentrations of nitric oxide (NO) and nitrogen dioxide (NO2) known to produce visible injury to vegetation are much higher than the ground level concentrations predicted to occur from the powerplant emissions. No impacts to vegetation from NO or NO2 alone are therefore anticipated.(51) The effects of low concentrations of NO2 interacting with SO2 were discussed in Section (i) above.

(iii) Other Gaseous Emissions

The concentrations of other gaseous contaminants such as carbon monoxide (CO) emitted from the powerplant would be well below those known to cause vegetation injury.

(iv) Particulates

The rate of particulate emissions predicted from the powerplant at full load is 0.19 kg/s. On the basis of the available data in the literature, there is no evidence that resultant ground level concentrations would cause any impacts to occur to vegetation.

(v) Trace Elements

A large number of trace elements occur in coal and a small proportion of each would be emitted from the Hat Creek powerplant stack (Table 6-2). Fluorine and mercury may be released in a gaseous form whereas most of the others emitted from the stack would be in the form of particulate matter. Trace elements would also be deposited via the drifting plumes of water droplets (drift) from the cooling towers (Table 6-6). The concentrations of trace elements in soil, grasses and shrubs in the local area, and predicted increases in trace element occurrences as a result of project emissions are discussed in Section 6.0. With perhaps the exception of fluorine, these predicted levels of trace element increase are several orders of magnitude lower than existing background trace element concentrations. It is unlikely that any measurable effects on vegetation would occur. The effects of fluorine are discussed in later sections.

(vi) Acid Precipitation

Oxidation of SO2 and NO2 in the powerplant emissions would lead to the formation of acid precipitation (See Section 6.5). Little or no effect of this would occur on local or regional vegetation since rainfall acidity would remain well below that known to cause damage to sensitive species.(16)

(e) Cooling Tower Emissions

The extent and amount of salts deposited from cooling tower water vapour emissions are indicated in Figure 6-4. Such deposition is expected to have minimal adverse effect on vegetation.

## SECTION 8. FORESTRY(17,35)

### 8.1 EXISTING SITUATION

Forestry is the predominant land use and industry in the regional study area, shown in Figure 8-1. This region encompasses approximately 23 358 km² of which about 74 percent is forest land. It contains a total volume of about 135.6 million m³ of mature standing timber, or about 1.1 percent of the provincial timber resource. Principal commercial species are lodgepole pine, Douglas-fir, spruce, alpine fir and ponderosa pine.

The regional forest industry was comprised of 12 sawmills, three plywood plants and one pulp mill in 1976. Average employment in these operations was estimated at about 2400 people. The level of forest activity is governed by the Annual Allowable Cut (AAC) in the region's Public Sustained Yield Units (PSYU). Most of the present AAC of 1,875,500 m³ is fully allocated to forest companies, and current commitments do not represent an overcutting situation. Without the Hat Creek project the forest industry of the region is expected to remain stable, with little growth or contraction.

The local study area, also shown in Figure 8-1, is defined as a circle, 25 km in radius, centred on the proposed powerplant site. This area covers about 1964 km², of which about 75 percent is forest land. The mature standing timber volume in this area is approximately 10 472 500 m³ with a mean annual increment of 182 736 m³ and an estimated AAC of 146 189 m³.

### 8.2 PROJECT ACTIONS

The proposed project could affect the area's forest activity in two principal ways. First, land requirements of project components would alienate some forest land and withdraw it from production. Second, emissions from the powerplant stack could have the potential to reduce growth rates of nearby forests.

### 8.3 EFFECTS OF THE PROJECT

The project sites for the mine, powerplant and offsite facilities encompass about 2833 ha and contain an estimated 93 000 m³ of mature standing timber. This area includes 2506 ha of disturbed areas (see Table 3-1) plus 327 ha which represent a 20 m buffer strip around all facilities. All merchantable timber would be cleared and salvaged during construction activities.

In calculating the AAC of the region's PSYU, the B.C. Forest Service has anticipated the proposed development. An allowance has been made for withdrawal of forest land as a result of the project. Consequently there exists sufficient timber in the area to maintain the current allocated AAC when the construction phase of the project is completed. Thus the project's land requirements would have no effect on the forest industry's sustainable wood supply.

Under the proposed project (366m/FGD case) no forestry loss should occur due to $SO_2$ emissions. With the 244 m/MCS option, some injury from powerplant stack emissions would be expected in the local and regional areas. The impact of $SO_2$ emissions would be low-grade chronic injury, which would slightly slow forest growth. Some weaker individual trees may die outright; other more resistant ones would show no visible symptoms although they may suffer some growth reduction due to minor losses of photosynthetic production. It is estimated that the total reduction of forest growth in the local area would be about 132 $m^3$ of wood yearly, or 0.07 percent of the mean annual volume growth of trees in the local area. Air pollution which may weaken or injure trees may also make them more susceptible to insect attacks. This type of interactive effect cannot be quantified and no attempt has been made to do so.

Fluorine emissions could affect forest foliage in the local and regional study areas. Impacts would be dependent upon the level of fluorine in the coal burned, and the percentage emitted as hydrogen fluoride vapour. The impacts due to fluorine emissions were based on levels of fluorine emitted of 63 percent for the 244 m/MCS and 32 percent for the proposed project (Section 6.0). The 244 m/MCS option has a much greater impact on the forest resources. Estimates indicate that 53 100 $m^3$ annually of potential growth could be lost or 29 percent of the mean annual increment of the local study area. The value for the proposed project considers a total of 68 percent fluorine removal from the flue gases. For the proposed project, the impact of fluorine emissions could amount to a loss of approximately 1 800 $m^3$ annually of potential growth or one percent of the mean annual increment of the local study area. An economic evaluation of the project's impact on forestry resources on the above two cases is provided in Section 18.1.


HAT CREEK PROJECT

## FIGURE 8.1
# FORESTRY STUDY AREAS

## SECTION 9. AGRICULTURE (18,19,35,52,53)

### 9.1 EXISTING SITUATION

At present, agriculture in the regional area (Figure 9-1) is devoted primarily to a cow/calf type of beef enterprise. In 1976, about 5476 $km^2$ or 15 percent of the region was in use as farmland, which represents about 23 percent of the total farmland of the province. Twenty-five percent of the region is in Agricultural Land Reserves (ALRs), which represents 20 percent of all ALR land of the province. With regard to the Canada Land Inventory (CLI) classifications, 30 percent of the provincial total of class 1 lands is contained in the region. Twelve percent of the region is of high agricultural capability (CLI classes 1-4), 43 percent of grazing capability (CLI classes 5-6), and the remaining 45 percent is of limited or no agricultural value. The high capability lands, with the most favourable climates, are distributed mainly in the lower elevation valleys and on the benches of the Fraser and Thompson rivers. These benches are also found in the Nicola Lake and Kamloops Lake areas. High agricultural capability lands also occur on the plateaus of the northern part of the region. The region is ideally suited to beef cattle production because there is, mainly at the higher elevations, a large quantity of grazing land (16 000 $km^2$) in close proximity to these high capability lands. In 1976, the estimated number of beef cattle in the region was about 23 percent of the provincial total.

The chief constraints to agricultural production, in both the regional and local study areas (Figure 9-1), are low rainfall, especially at the lower elevations, and the short growing season, especially at the higher elevations. Irrigation is practical on an extensive scale, particularly in the Thompson River valley. However, available water in the Hat Creek valley is presently, in the absence of large storage facilities, almost fully committed to existing permit-holders.

Data on crop production were derived from the Thompson-Nicola census division. Although the boundaries of this census division do not exactly coincide with the regional area, the data are generally representative of the area. Hay is the principal forage crop with yields of 11.2 to 13.5 Mg/ha. Other forage crops such as silage corn and crested wheatgrass are of minor importance. Cereal grains, seed crops, potatoes, vegetables, tree fruits, small fruits and some other field crops are also raised in the area, but do not form any significant part of the province's total production.

The existing situation of the local area is similar to that of the regional area. However, because the Hat Creek valley is at a slightly higher altitude than most of the other major valleys in the region, it has a slightly less favourable climate for agricultural production. The areas, and percentages, of the local area with capabilities for irrigated agriculture and for grazing are shown in Table 9-1. Data are also shown in this table for the Hat Creek basin which, for the agricultural study, was defined as that portion of the Hat Creek watershed within the local study area. In the Hat Creek basin, 7.8 percent of the land is of high agricultural capability (CLI classes 1-4). The remaining 92.2 percent possesses grazing capability. Twenty-seven percent of the local area and 23 percent of the Hat Creek basin are under ALR status. Agriculture land use is shown on Table 9-2. Only 2.3 percent of the local area and 1.7 percent of the Hat Creek basin are presently in use for cultivated cropland or irrigated pasture. The rest is almost entirely rangeland.

TABLE 9-1
LAND CAPABILITY FOR AGRICULTURE
LOCAL STUDY AREA AND HAT CREEK BASIN

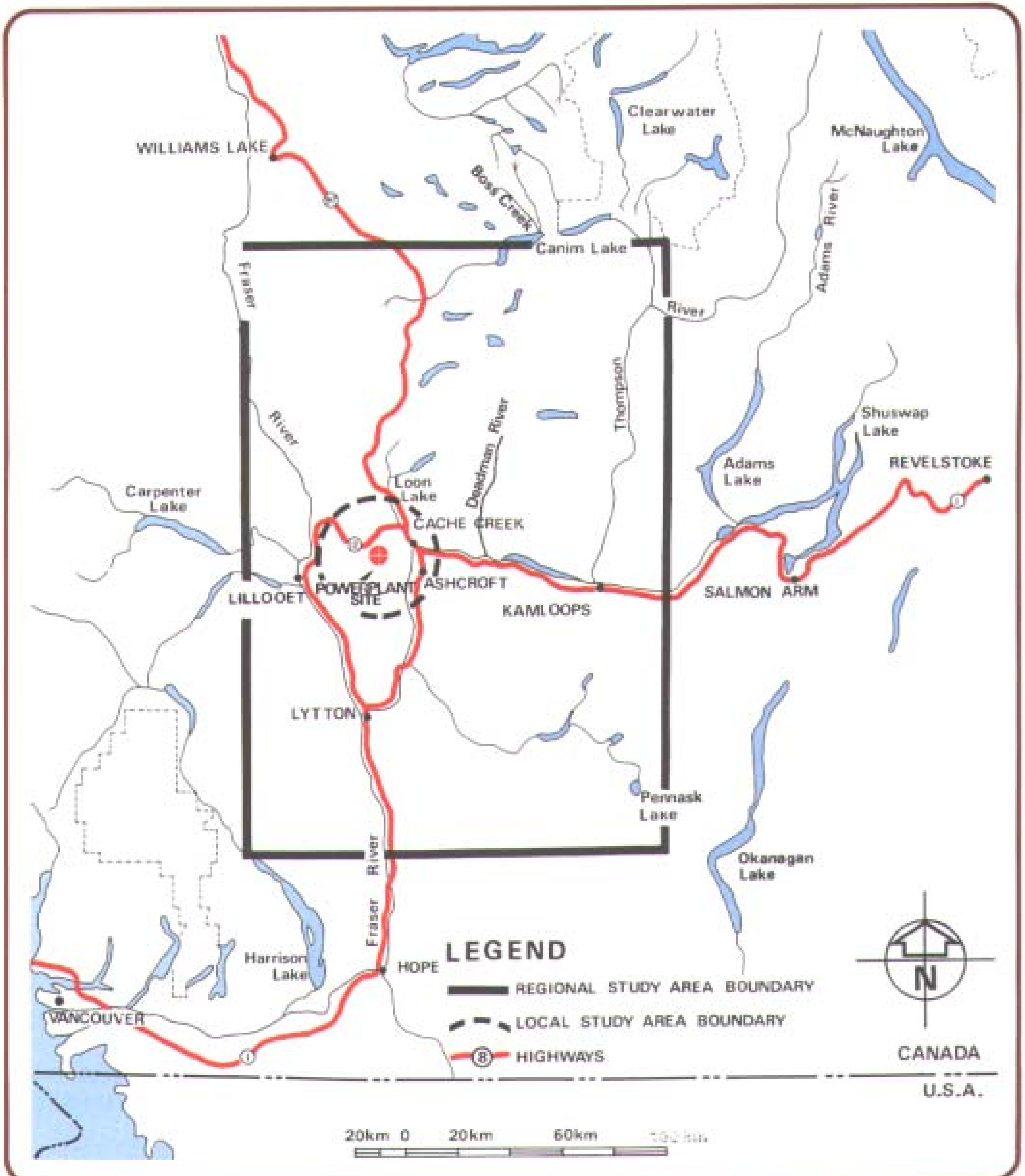
| Capability Class | Local Study Area Area[2] ($km^2$) | Local Study Area Percent | Hat Creek Basin[1] Area[2] ($km^2$) | Hat Creek Basin[1] Percent |
|---|---|---|---|---|
| Capability for Irrigated Agriculture: | | | | |
| CLI Ag. Capability 1 | 37 | 1.9 | 0 | 0 |
| CLI Ag. Capability 2 | 19 | 1.0 | 0 | 0 |
| CLI Ag. Capability 3 | 71 | 3.6 | 14 | 2.2 |
| CLI Ag. Capability 4 | 85 | 4.3 | 36 | 5.6 |
| CLI Ag. Capability 5 | 48 | 2.4 | 18 | 2.8 |
| SUBTOTAL | 260 | 13.2 | 68 | 10.6 |
| Capability for Grazing: | | | | |
| Grazing Capability 1 | 12 | 0.6 | 4 | 0.6 |
| Grazing Capability 2 | 593 | 30.2 | 232 | 36.2 |
| Grazing Capability 3 | 302 | 15.4 | 85 | 13.3 |
| Grazing Capability 4 | 465 | 23.7 | 124 | 19.3 |
| Grazing Capability 5 | 331 | 16.9 | 128 | 20.0 |
| SUBTOTAL | 1703 | 86.8 | 573 | 89.4 |
| TOTAL AREA | 1963 | 100.0 | 641 | 100.0 |

1. That portion of the Hat Creek watershed within the local study area.

2. Includes areas of water bodies, estimated to be 10 $km^2$ for the local study area and 1 $km^2$ for Hat Creek basin.

The crop types and their productivities are shown in Table 9-3 for the local area. Alfalfa is a valuable plant species to the agriculture of the area. It is grown by itself, or in conjunction with a grass as a hay crop.

Twelve farm units are present, to some extent, in the site-specific study area which is that portion of the local study area where the proposed mine, powerplant and offsite facilities are to be constructed. Eleven of these units are cattle ranching operations, and one is a commercial hay farm. Their present development is constrained by existing soils, climate and availability of irrigation water. There are two agricultural research plots within the site-specific study area.




HAT CREEK PROJECT

FIGURE 9.1

# AGRICULTURE STUDY AREAS

TABLE 9-2
PRESENT AGRICULTURE LAND USE
LOCAL STUDY AREA AND HAT CREEK BASIN

| | Local Study Area | | Hat Creek Basin | |
|---|---|---|---|---|
| | Area[1] (km²) | Percent | Area[1] (km²) | Percent |
| Cultivated Cropland and Irrigated Pasture: | | | | |
| Private and Leased | 43 | 2.2 | 9.5 | 1.7 |
| Indian Reserve | 2 | 0.1 | 1.3 | 0.2 |
| SUBTOTAL | 45 | 2.3 | 10.8 | 1.7 |
| Rangeland: | | | | |
| Private and Leased | 592 | 30.2 | 168.0 | 26.2 |
| Indian Reserve | 77 | 3.9 | 28.0 | 4.4 |
| Grazing Permits | 1211 | 61.7 | 434.0 | 67.7 |
| Non-agricultural | 38 | 1.9 | - | - |
| SUBTOTAL | 1918 | 97.7 | 630.0 | 98.3 |
| TOTAL | 1963 | 100.0 | 640.8 | 100.0 |
| Low Use Grazing Land (included in Rangeland categories) | 415 | 21.1 | 127 | 19.8 |

1. That portion of Hat Creek watershed within the local study area.

## 9.2 PROJECT ACTIONS

The five project actions that could affect the agriculture of the Hat Creek valley and the surrounding region are: land alienation, powerplant emissions, water quality changes, noise and dust. The regional and local effects of these actions are discussed in the next sections.

TABLE 9-3

PRESENT FORAGE AND FIELD CROPS - LOCAL STUDY AREA (52)

| Crop Type | Agricultural[1] Importance | Productivity |
|---|---|---|
| **Perennials** | | |
| *Legumes* | | |
| Alfalfa (Medicago sativa)<br>- varieties Rambler, Vernal | High | 6.7 - 15.7 Mg/ha<br>(hay) |
| Alsike Clover (Trifolium hybridum)<br>- varieties Aurora, Tetra | Medium | 4.5 - 11.2 Mg/ha<br>(grass hay mix) |
| White Clover (Trifolium repens)<br>- variety White Dutch | Low | 6.7 - 9.0 Mg/ha<br>(hay-meadow grass mix) |
| *Grasses* | | |
| Bromegrass (Bromus, arvensis, Bromus inermis)<br>- varieties Carlton, Magna | Low | 4.5 - 9.0 Mg/ha<br>(hay-legume mix) |
| Crested Wheatgrass (Agropyron cristatum)<br>- varieties Summit, Nordan | Medium | 0.2 - 0.4 ha/AUM<br>(pasture) |
| Orchardgrass (Dactylis glomerata L.)<br>- variety Sterling | High | 6.7 - 11.2 Mg/ha<br>(hay-legume mix) |
| Perennial Ryegrass (lolium)<br>- varieties Norlea and Tetraploid types | Low | 0.4 ha/AUM<br>(wetland pasture) |
| Reed Canary Grass (Phlaris arurdinacea L.)<br>- varieties Frontier, Castor | Medium | 6.7 - 11.2 Mg/ha<br>(hay) |
| Timothy (Phleum pratensis L.)<br>- varieties Climax, Champ | Medium | 6.7 Mg/ha<br>(hay) |
| **Annuals** | | |
| Corn (Zea mays L.)<br>- hybrid variety | Medium | 45 Mg/ha<br>(silage) |
| Potatoes (Solanum tuberosum) | Low | 27 Mg/ha |

[1] Refers to the relative agricultural importance of the crop in the local study area.

## 9.3 EFFECTS OF THE PROJECT

### (a) Regional Effects

The establishment of the proposed coal mine, powerplant and offsite facilities is expected to have little impact on the regional agriculture industry. Land alienation in the site-specific area, which would cause a reduction in rangeland and land for irrigated forage crops, is expected to have little impact on the regional beef industry. However, powerplant stack emissions of fluoride could potentially affect lands outside the local area, specifically in a north easterly direction towards the Arrowstone Hills and the Tranquille Plateau.(18) Beef cattle are a sensitive species and fluoride levels in their feed should be kept below 40 ppm to ensure their health. Conservative estimates of the fluorine that would be emitted from the stack are shown on Table 6-2. Analyses for the 244 m/MCS option indicate that no significant impacts on agriculture from the Hat Creek fluoride emissions are expected. Fluoride emissions will be even lower for the proposed project (366 m/FGD). Nevertheless, since environmental fluorine accumulation is difficult to predict, fluorine will be monitored in affected ecosystems as the project proceeds.

### (b) Local Effects

The local study area, which includes the Hat Creek basin, is shown in Figure 9-1. As discussed in Section 7.3, the potential maximum injury to vegetation due to SO2 and NO2 together was assessed. Under the 244 m/MCS option, Kentucky bluegrass would be affected over an area of 2.2 $km^2$, while the injury range would be between 1 and 14 percent (Table 7-3). With the proposed project, the powerplant emissions are expected to cause an injury level to Kentucky Bluegrass of less than 5 percent over an area of 0.2 $km^2$ (see Table 7-4). The exact effects of the emissions on all rangeland vegetation cannot be predicted in detail at this time since data indicating the response of rangeland grass species are now only available for Kentucky Bluegrass. However, other quantitative injury predictions for a few of the woody plant species important to livestock indicate impacts of lesser magnitude. The total effect of the powerplant emissions on the range resources cannot be predicted due to the lack of information for any other range species.

Ambient ground level concentrations of fluorine are shown in Table 6-4. As in the regional study area the cumulative patterns of fluorine are difficult to predict and the reliance on a monitoring program is mandatory. Table 6-4 indicates that ambient concentrations of fluorine are reduced for the proposed project (366 m/FGD) as opposed to the 244 m/MCS option.

For the 244 m/MCS option, powerplant emissions are also expected to affect the crops grown on the present and probable CLI irrigable land in the upper Hat Creek valley. The levels of ambient air concentrations are shown on Table 6-3 and Table 6-8. Increased concentrations tend to be present at higher elevations and not in the valley where irrigated agriculture is practised. The areas affected and their classification are given in Table 9-4. The impact on the 229 ha affected is postulated to slightly reduce productivities. Alfalfa is one of the more sensitive crops grown in the local area. The average injury level would be about 3.4 percent with a maximum injury level of 10 percent.(51) Some areas might receive a possible beneficial effect on alfalfa growth from SO2. With the proposed project (366/FGD) there will be no adverse effect on crops grown on the present and probable CLI irrigable land in the upper Hat Creek Valley.

Land alienation by the proposed project would be of two types. An "open" alienation would occur where agricultural use is partially restricted due to project features, such as transmission lines and buried pipelines. A "closed" alienation would occur where agricultural use is completely eliminated, such as land for the mine, powerplant and offsite buildings. The amounts of land involved are 123 ha for "open" alienation and 2771 ha for "closed" alienation. The 2771 ha of "closed" alienation include approximately 2500 ha of land directly alienated (see Table 3-1) and also land indirectly alienated (i.e. small areas of land isolated between project facilities such as conveyors and roads).

For the 366 m/FGD case, the combined impacts of air emissions and "closed" land alienation; a total of 234.8 ha of probable (predicted future uses without the project) irrigated lands will be affected in the upper Hat Creek valley. This represents about 15 percent of the total probable irrigated lands in the area for the without the project projections. The combined impact on rangeland, occurring only within the upper Hat Creek valley, affects 2251.3 ha. This represents about four percent of the rangeland in the Hat Creek basin. For the 244 m/MCS option, combined impacts on probable irrigated lands is increased to 250.4 hectares. The impact on rangeland remains the same (2251.3).

An analysis of the Hat Creek basin beef industry was prepared for three cases; "without" the project and "with" the two project options. The comparative results are summarized in Table 9-5 for feed production. The projected development of the beef industry is shown in Table 9-6. With regards to feed production, the reduction of 580 animal units in the spring season, for the 244 m/MCS option is the greatest difference between the "with" and "without" project cases. This represents a reduction of 12.3 percent in probable herd size. The impacts for the winter and summer seasons are less than 4 percent of probable herd sizes. With regard to the probable development of the Hat Creek basin beef industry, the data (Table 9-6 and Table 9-7) indicate that the impact is not of great magnitude for either the proposed project or the 244/MCS option. Tables 9-6 and 9-7 indicate that little change to the beef industry is expected between the proposed project and the 244 m/MCS option. This results from the importance of land alienation rather than air emissions in determining the impact on agriculture. An economic evaluation of beef production impacts is discussed in Section 18.2.

Four ranches in the Hat Creek valley are expected to be affected by noise from the various project construction activities. However, since the resultant noise levels at these ranches are not expected to exceed the YDNL 65 dB(A) level, all of the Hat Creek valley ranches would remain compatible for residential land use during the construction period. The noise criterion limiting cattle grazing would only be exceeded within 210 m of the powerplant fence and near No. 2 booster pumping station during the construction phase.

Although soils within the site-specific study area are moderately to highly susceptible to forming dust, it is anticipated that the dust would be reduced to acceptable levels by suppression techniques. The impact of dust on agriculture would consequently be insignificant.

TABLE 9-4
SO2 AND NO2 EMISSIONS: PRESENT AND PROBABLE CLI[1]
IRRIGABLE LAND AFFECTED IN THE LOCAL STUDY AREA (52)
(ha)
244 M STACK WITH MCS[2]

| | Hat Creek Valley | Pavilion Area | Arrowstone Hills | Cornwall Hills | Total |
|---|---|---|---|---|---|
| Present Irrigated | 11.1 | - | 5.6 | - | 16.7 |
| CLI 1 | - | - | 3.3 | - | 3.3 |
| CLI 2 | - | - | - | - | - |
| CLI 3 | 5.0 | - | 1.4 | 7.5 | 13.9 |
| CLI 4 | 34.2 | 0.9 | 54.4 | 14.8 | 104.3 |
| CLI 5 | 53.5 | - | 33.3 | 4.3 | 91.1 |
| TOTAL | 103.8 | 0.9 | 98.0 | 26.6 | 229.3 |

1. Canada Land Inventory.

2. For the 366 m stack, with FGD, impacts would be at the threshold level and may be beneficial.

TABLE 9-5
HAT CREEK BASIN[1] INDUSTRY: PROBABLE FEED PRODUCTION (52,35)
"WITHOUT" AND "WITH" THE PROJECT
SEASONAL RESOURCE SUMMARY

| Season | Feed Production[2] (Animal Unit Months) | | | Maximum Probable[2] Herd Size (Animal Units) | | |
|---|---|---|---|---|---|---|
| | Without | With | | Without | With | |
| | | 244m/MCS | 366m/FGD | | 244m/MCS | 366m/FGD |
| Winter (7 months) | 24 332 | 23 520 | 23 796 | 3 476 | 3 360 | 3 399 |
| Spring (2 months) | 9 465 | 8 306 | 8 323 | 4 733 | 4 153 | 4 162 |
| Summer (3 months) | 9 081 | 8 820 | 8 820 | 3 027 | 2 940 | 2 940 |

1. That portion of the Hat Creek watershed within the local study area.

2. Assuming no limitations or assistance from resources associated with other seasons.

## TABLE 9-6
## HAT CREEK BASIN[1] BEEF INDUSTRY: PROBABLE DEVELOPMENT "WITHOUT" AND "WITH" THE PROJECT[2] (52,35) 366 M STACK WITH FGD

| | 1977 | 1980 | 1990 | 2000 | 2020 |
|---|---|---|---|---|---|
| 1. Cows - from model analysis | 2000<br>(2000) | 2038<br>(2038) | 3005<br>(2900) | 3200<br>(3122) | 3300<br>(3225) |
| 2. Calves produced 85% of Item 1 above | 1700<br>(1700) | 1732<br>(1732) | 2554<br>(2465) | 2720<br>(2654) | 2805<br>(2741) |
| 3. Steer calves sold 50% of Item 2 above | 850<br>(850) | 866<br>(866) | 1277<br>(1233) | 1360<br>(1327) | 1403<br>(1371) |
| 4. Cow mortality 2% of Item 1 above | 40<br>(40) | 41<br>(41) | 60<br>(58) | 64<br>(62) | 66<br>(65) |
| 5. Cull cows sold 12% of Item 1 above | 240<br>(240) | 245<br>(245) | 361<br>(348) | 384<br>(375) | 396<br>(387) |
| 6. Heifer calves for replacement (Items 4 and 5 above) | 280<br>(280) | 286<br>(286) | 421<br>(406) | 448<br>(437) | 462<br>(452) |
| 7. Heifer calves sold (50% Items 2 - 6 above) | 570<br>(570) | 581<br>(581) | 856<br>(827) | 912<br>(890) | 941<br>(918) |

1. That portion of the Hat Creek watershed within the local study area.

2. Figures in parentheses are for the "with" project case: 366 m/FGD.

## TABLE 9-7
## HAT CREEK BASIN[1] BEEF INDUSTRY: PROBABLE DEVELOPMENT "WITHOUT" AND "WITH" THE PROJECT[2] (52,35)
## 244 M STACK WITH MCS

| | 1977 | 1980 | 1990 | 2000 | 2020 |
|---|---|---|---|---|---|
| 1. Cows - from model analysis | 2000 (2000) | 2038 (2038) | 3005 (2881) | 3200 (3081) | 3300 (3184) |
| 2. Calves produced 85% of Item 1 above | 1700 (1700) | 1732 (1732) | 2554 (2449) | 2720 (2619) | 2805 (2706) |
| 3. Steer calves sold 50% of Item 2 above | 850 (850) | 866 (866) | 1277 (1224) | 1360 (1309) | 1403 (1353) |
| 4. Cow mortality 2% of Item 1 above | 40 (40) | 41 (41) | 60 (58) | 64 (62) | 66 (64) |
| 5. Cull cows sold 12% of Item 1 above | 240 (240) | 245 (245) | 361 (346) | 384 (370) | 396 (382) |
| 6. Heifer calves for replacement (Items 4 and 5 above) | 280 (280) | 286 (286) | 421 (403) | 448 (431) | 462 (446) |
| 7. Heifer calves sold (50% Items 2 - 6 above) | 570 (570) | 581 (581) | 856 (821) | 912 (878) | 941 (907) |

1. That portion of the Hat Creek watershed within the local studt area.

2. Figures in parentheses are for the "with" project case: 244 m/MCS.

## SECTION 10. WILDLIFE(18,35)

### 10.1 EXISTING SITUATION

(a) Deer and Moose

Habitat in the Hat Creek valley is moderately well suited to deer and moose. About 13 percent of the watershed is rated as Class 3 deer and moose habitat, (slight limitations to production, Canada Land Inventory rating), while the remainder is rated as Class 4 habitat (moderate limitations to production). Poor soil moisture, inadequate soil depth, excessive snow depth and adverse exposure are the chief limitations on habitats in the area. About 11 percent of the area is deer winter range.

Mule deer make extensive use of the available low-elevation sagebrush habitats and also make some winter use of the forest-grassland associations on south-facing slopes. Deer are widely dispersed in summer and fall but tend to congregate in winter. Moose occur in small numbers in the subalpine and lower elevation wetlands dispersed in the southern and western portions of the Hat Creek valley. Figure 10-1 shows the vegetation types used as wildlife habitat in the Hat Creek valley. Cattle make use of most wildlife habitats within the Hat Creek valley.

(b) Birds

The distribution of wetland habitats in Hat Creek valley is indicated in Figure 10-2. Limitations to waterfowl nesting in these wetlands are primarily the general lack of marsh vegetation and the narrow marsh edges. Heavy cattle grazing in the valley has disturbed the shallow portions of wetlands, apparently preventing the establishment of emergent and marsh edge vegetation. The waterfowl breeding population has been estimated at approximately 260 pairs which produce an estimated 600 ducklings yearly. Mallards, teal and goldeneye are the most common species. Migrating waterfowl use the Hat Creek valley in fall and spring and several hundred birds are usually present at such times.

Sixty-eight different species of birds were recorded on breeding surveys conducted in five habitats in the Hat Creek valley. Highest numbers of individuals are found in the forested areas, while fewest are found in open ranges. Species diversity is highest in the riparian and aspen associations. Ruffed grouse and blue grouse are common in the upper Hat Creek valley, making use of the riparian and the forest and grassland associations. Mourning doves, spruce grouse, chukar partridge and blue grouse exist in various parts of the valley and surrounding areas.

(c) Small Mammals

The deer mouse is the most commonly encountered small mammal. Microtine rodents have not been found to be abundant, but they are subject to population cycles and their abundance is therefore highly variable. Red squirrels occupy all forested zones and chipmunks make use of most habitats. Riparian associations contain the greatest diversity of small mammal species.

Although the area potentially affected by the project's physical disturbances has no registered traplines, the upper Hat Creek valley has an abundance of furbearers. Beavers are found along Hat Creek and most of its tributaries.

(d)Wildlife Use

The primary use of wildlife in the regional study area (see Figure 8-1) is hunting. The majority of the deer and moose hunters using the region reside in the Kamloops area, with the second largest number residing in the lower mainland. The regional area was a small part of the former Game Management Areas 4, 14, and 15. Game Management areas were superceded by the much smaller Management Units in 1976, and the Hat Creek watershed constitutes approximately 60 percent of Management Unit 3-17. Table 10-1 summarizes the 1976 to 1979 wildlife harvest data for Management Unit 3-17. The Hat Creek watershed provides an average of 28 percent of the deer, 34 percent of the moose and 13 percent of the black bear annual harvest in Management Unit 3-17.

Trapping is presently not a major wildlife use in the Hat Creek area and this is unlikely to change in the future. Wildlife viewing is presently limited by lack of access within the Hat Creek valley.

## 10.2 PROJECT ACTIONS

The proposed project and related activities could affect wildlife resources in three principal ways: habitat alienation, disturbance and harassment, and toxicity from emissions and waste materials. The term "habitat alienation" is used here to denote alteration of an existing habitat so that indigenous species can no longer use it as before. Disturbance involves the effect of man's activities (noise, machinery operation and hunting) on wildlife resources.

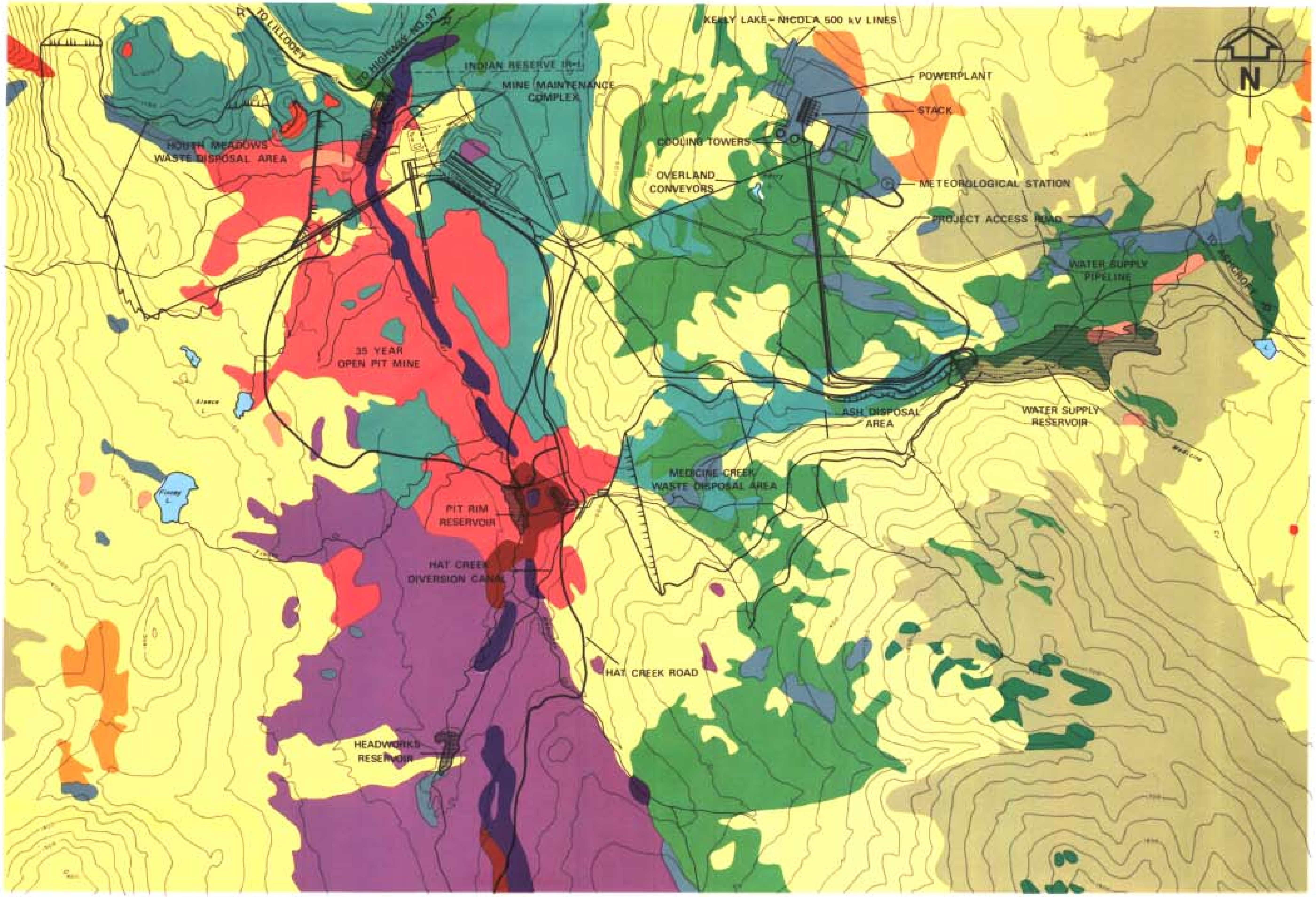
## 10.3 EFFECTS OF THE PROJECT

(a)Habitat Alienation

The areas of habitat that would be alienated by the project are detailed in Table 10-2 and Table 10-3. Wildlife most affected by habitat loss would be mule deer and waterfowl. More than 60 percent of the available local sagebrush habitat, which presently provides most of the deer winter range in the valley, would be alienated as the project develops. The effects of this habitat loss on the deer population would depend on management measures and the effects of other factors, particularly hunting. In the absence of any specific management measures, a population decline in the valley could be anticipated. Some of the wetlands alienated by the mine pit construction provide better quality waterfowl habitat than elsewhere in the valley. This decline in wetlands would probably mean a decline in waterfowl production in the valley bottom.

(b)Disturbance and Harassment

The noise and presence of operating machinery and vehicles would be relatively constant during the life of the mine. Most animals would probably adapt to these changed conditions in areas of preferred habitat near mine operations. Alteration of movement patterns rather than injury would be the primary impact. The powerplant stack and transmission lines would be located away from the




## LEGEND

- ASPEN OR MIXED ASPEN-CONIFER
- BRUSH
- CULTIVATED FIELD
- DOUGLAS FIR-PINEGRASS
- ENGELMAN SPRUCE — LODGEPOLE PINE
- ALPINE AND HIGH ELEVATION GRASSLAND
- MID-ELEVATION GRASSLAND
- LOW ELEVATION GRASSLAND
- SAGEBRUSH-BLUEBUNCH WHEATGRASS GRASSLAND
- ROCK
- PONDEROSA PINE — DOUGLAS FIR — BUNCHGRASS
- RIPARIAN
- BOG

SCALE — 1:40,000

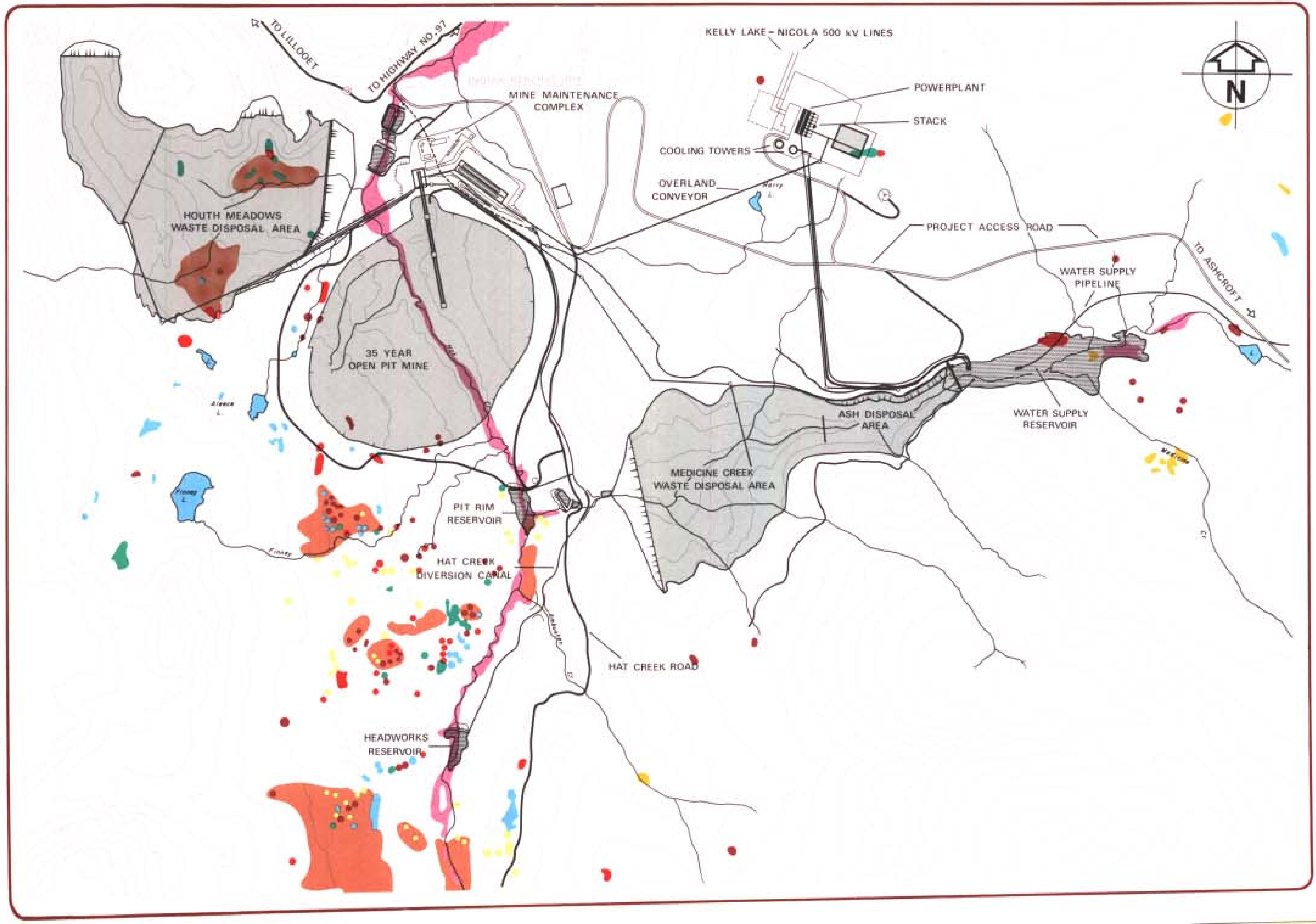
1 km 0 km 1 km 2 km

CONTOUR INTERVAL — 50 METRES

HAT CREEK PROJECT

FIGURE 10.1
**WILDLIFE HABITAT**

SOURCE: Tera Environmental Resource Analyst Ltd. (18)




LEGEND

- RIPARIAN ZONE
- SMALL, TEMPORARY OR EPHEMERAL WETLAND ZONE
- EPHEMERAL AND TEMPORARY POND
- INTERMITTENT, ALKALINE POND
- SEMI-PERMANENT POND
- PERMANENT POND WITH EDGE VEGETATION
- PERMANENT POND WITHOUT EDGE VEGETATION
- ALKALINE BOG

SCALE — 1:40,000

1 km 0 km 1 km 2 km

CONTOUR INTERVAL — 50 METRES

HAT CREEK PROJECT

FIGURE 10.2

WETLAND HABITAT

SOURCE: Terra Environmental Resource Analyst, Ltd. (18)

TABLE 10-1

WILDLIFE HARVESTED IN MANGEMENT UNIT 3-17[1]
IN 1976 TO 1979 (54)

| Species | Estimated Harvest[2] | | | | Estimated Hunters | | | | Estimated Hunter Days | | | | Hunter Days per Animal Harvested | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1976 | 1977 | 1978 | 1979 | 1976 | 1977 | 1978 | 1979 | 1976 | 1977 | 1978 | 1979 | 1976 | 1977 | 1978 | 1979 |
| Deer | 124 | 110 | 157 | 176 | 949 | 692 | 1010 | 922 | 4872 | 2251 | 3993 | 3783 | 39 | 20 | 25 | 21 |
| Moose | 20 | 13 | 19 | 0 | 86 | 85 | 99 | 111 | 511 | 361 | 530 | 55 | 26 | 28 | 28 | - |
| Black Bear | 6 | 27 | 34 | 28 | 29 | 75 | 73 | 77 | 150 | 237 | 215 | 440 | 25 | 9 | 6 | 16 |
| Mountain Sheep | 3 | 2 | 6 | 0 | 18 | 24 | 36 | 30 | 62 | 110 | 87 | 138 | 21 | 55 | 15 | - |
| Ducks | 195 | 19 | 154 | 78 | 69 | 19 | 52 | 195 | - | - | - | - | - | - | - | - |
| Blue Grouse | 1504 | 596 | 1313 | 1268 | 430 | 206 | 348 | 365 | - | - | - | - | - | - | - | - |
| Ruffed Grouse | 1151 | 524 | 862 | 1549 | 425 | 176 | 270 | 404 | - | - | - | - | - | - | - | - |
| Spruce Grouse | 676 | 413 | 826 | 882 | 362 | 112 | 239 | 276 | - | - | - | - | - | - | - | - |
| Chukar Partridge | 168 | 232 | 414 | 706 | 73 | 93 | 58 | 130 | - | - | - | - | - | - | - | - |

[1] The Hat Creek valley comprises about 60 percent of Management Unit 3-17.

[2] Estimates made by B.C. Fish and Wildlife Branch from mail questionnaires.

TABLE 10-2

WILDLIFE HABITATS EXPECTED TO BE ALIENATED
BY HAT CREEK MINE, POWERPLANT AND OFFSITE FACILITIES[1] (18, 35)
(ha)

| Habitat | Mine Open Pit[1] | Medicine Creek Waste Disposal | Houth Meadows Waste Disposal | Coal Handling Facilities | Lagoons | Maintenance Buildings | Powerplant Site | Off-site Facilities |
|---|---|---|---|---|---|---|---|---|
| Aspen and aspen/conifer | - | 17 | 22 | <1 | - | - | 69 | 10 |
| Douglas fir/pinegrass | 45 | 153 | 335 | 11 | 1 | 17 | 28 | 191 |
| Ponderosa pine/douglas fir/bunchgrass | 141 | 198 | 103 | 45 | <1 | 8 | - | 79 |
| Englemann spruce/lodgepole pine | - | - | - | - | - | - | - | 9 |
| Riparian | 26 | - | - | 4 | 8 | - | - | 1 |
| Mid-elevation grassland | - | 59 | 136 | - | <1 | - | 12 | 73 |
| Low-elevation grassland | 1 | - | - | 17 | 1 | - | - | 36 |
| Sagebrush/bluebunch wheatgrass | 377 | - | 3 | 5 | 11 | <1 | - | 20 |
| Big sage grassland | - | - | - | - | - | - | - | 98 |
| Brush | - | - | - | - | - | - | 2 | 7 |
| Bog | - | - | - | - | - | - | - | - |

1 Areas listed include construction camps, parking areas, housing, and right-of-ways for off-site facilities such as roads, canals, transmission lines and pipelines.

TABLE 10-2 - (Cont'd)

| Habitat | Reservoirs | Total Area Alienated | Percentage of Association Alienated Within 25 km Radius |
|---|---|---|---|
| Aspen and aspen/conifer | - | 118 | 4 |
| Douglas fir/pinegrass | 10 | 791 | 1 |
| Ponderosa pine/douglas fir/bunchgrass | - | 574 | 4 |
| Englemann spruce/lodge-pole pine | - | 9 | <1 |
| Riparian | 1 | 40 | 4 |
| Mid-elevation grassland | 80 | 360 | 7 |
| Low-elevation grassland | - | 55 | 1 |
| Sagebrush/bluebunch wheatgrass | 1 | 417 | 63 |
| Big sage grassland | - | 98 | <1 |
| Brush | - | 9 | <1 |
| Bog | 3 | 3 | <1 |

TABLE 10-3
ESTIMATED WETLAND ALIENATION AS A RESULT OF OPERATION AND CONSTRUCTION OF PROJECT FACILITIES (18,35)

| Wetland Type | Number of Wetlands | Area (ha) | Edge (km) |
|---|---|---|---|
| Temporary and ephemeral | 10 | 6.8 | 3.4 |
| Semi-permanent | 20 | 3.6 | 3.1 |
| Permanent with edge vegetation | 9 | 2.8 | 2.3 |
| Permanent without edge vegetation | 17 | 16.0 | 7.2 |
| Saline | 2 | 0.1 | 0.2 |
| Bog | 1 | 0.6 | 0.3 |
| TOTAL | 59 | 29.9 | 16.5 |
| PERCENTAGE OF HAT CREEK VALLEY TOTALS | 13.9 | 14.5 | 14.8 |

valley floor (Figure 3-2), and numbers of waterfowl and other birds striking these structures are not expected to be significant.

(c) Toxic Materials

Major sources of materials potentially toxic to wildlife would include leachates and run-off from the ash disposal area and mine waste piles, the leachate storage lagoons, and emissions from the powerplant stack. Trace elements would be the most important toxic substances from these sources. Strict control of run-off and leachates is a basic component of the project's environmental protection plan (see Section 11.0). Fencing and other controls to keep ungulates, birds and small mammals out of storage lagoons would be necessary.

Tables 6-4 to 6-6 indicate the expected levels of trace element ambient concentrations and cumulative depositions resulting from stack emissions and cooling tower plumes for the proposed project (366 m/FGD) and the 244 m/MCS air quality option. Ambient concentrations of trace elements would be within the PCB objectives for both cases (Table 6-4).

With respect to fluorine deposition in the regional study area, the increase in the soils within the zones of highest impact would be a few percent over the 35 year powerplant life, and hence the amounts absorbed by vegetation and ingested by herbivores are also expected to be well below toxic levels. Fluorine will probably accumulate in browse vegetation in proportion to the ambient air concentration but much of this element will be absorbed by soil and water. The projected low concentrations in plants grown within the greatest depositional zones should not cause fluorine toxicosis in animals.

Expected levels of ambient fluorine concentrations in the local area of influence (25 km from the plant) are indicated on Figure 6-1. The effect of these ambient concentrations on browse species is difficult to predict. The phenology of the various plant species and the leaching effect of precipitation play an important role in determining the amount of fluorine that is accumulated in the plant tissue. The areas affected by high ambient concentrations of fluorine are significantly reduced for the proposed project (366 m/FGD) in comparison to the 244 m/MCS option. The proposed monitoring program (Section 26.0) would be designed to identify fluorine accumulation patterns and locate problem areas.

Ambient levels of $SO_2$, $NO_x$ and other gaseous stack emissions would be well below levels known to directly affect wildlife. Any effects of such emissions on wildlife would be by indirect long term effects on habitats.

## 10.4 EFFECTS ON WILDLIFE USE

Table 10-4 presents estimates of existing and future hunter use both with and without the project in the local study area. These figures represent hunter demand, based on assumptions that the present rate of increase in the number of hunters, hunting preferences and areas of origin remain constant. In most cases, the added increase in regional demand brought about by the proposed project over and above that due to normal population growth would be approximately 2 to 4 percent. Local hunter demand in the Hat Creek valley would increase more rapidly and may exceed supportive capacity of game populations in some locales; the project's existence would contribute most highly to game bird hunting demand.

Impacts of these increases in hunting demand on wildlife populations and harvests depend to a large extent on how the wildlife resources are managed in the future and what other demands are placed upon them. Local deer harvests would decline, due to a drop in population following winter range alienation by the mine and the maintenance of a no-shooting zone around the mine and powerplant. Local waterfowl harvests would decline due to a loss of wetland habitats and increasing hunting pressure. Local moose harvests are presently small and would probably remain so. Local game bird harvests would decline due mainly to increased hunting pressure unless protective hunting restrictions are applied. Regional wildlife harvests would probably not be measureably affected.

TABLE 10-4
ESTIMATED INCREASE IN HUNTER USE OF HAT CREEK AREA AND IMMEDIATE SURROUNDINGS DURING POWERPLANT AND MINE CONSTRUCTION AND OPERATION (18)
(Number of Hunters)

| | Deer | Moose | Waterfowl | Game Birds |
|---|---|---|---|---|
| Existing Situation | | | | |
| 1976 hunters | 949 | 86 | 69 | 1 389 |
| 1988 | | | | |
| Hunters without project | 1 146 | 106 | 89 | 1 725 |
| Hunters with project (Construction) | 1 266 | 120 | 129 | 1 978 |
| Percentage increase due to project | 13 | 16 | 58 | 18 |
| 2000 | | | | |
| Hunters without project | 1 445 | 133 | 108 | 2 245 |
| Hunters with project (Operation) | 1 544 | 144 | 144 | 2 458 |
| Percentage increase due to project | 10 | 13 | 52 | 15 |

## 11.1 EXISTING SITUATION (19)

Water resources in the Hat Creek valley include both surface water found in lakes and streams and groundwater flowing in aquifers. Hat Creek is the main source of surface water in the area. A number of small lakes are located around the valley.

Surface runoff in the Hat Creek area is low during most of the year. Average flow in Hat Creek from late summer through to spring is less than 1 $m^3/s$. On occasion the creek has been known to go dry. The annual peak flows are generally due to snowmelt at the higher levels and reach 3 to 10 $m^3/s$ at the mine site. A snowmelt flood of 18 $m^3/s$ has been estimated to occur once in a hundred years, on average. Hat Creek water is hard, with relatively high levels of calcium and magnesium; this indicates an appreciable groundwater component in the flow. Water temperatures at the mouth of Hat Creek during the summer months are relatively high, making the stream only marginal as a habitat for cold water game fish. Other streams in the area have similar flow patterns and characteristics.

Due to the low permeability of the area's bedrock material, groundwater flows are primarily found in surface sediments. Generally the groundwater aquifers are small and cover only limited areas. Recharge of groundwater aquifers occurs in the surrounding hills at high elevations where precipitation is higher than in the valley bottom. Three major aquifers have been identified: the valley alluvial aquifer adjacent to Hat Creek itself, the buried bedrock aquifer to the northeast of upper Hat Creek valley, and the Marble Canyon aquifer.

The quality of groundwater varies widely in the valley area, depending on the rock chemistry of the source. However, nearly all samples taken from surficial materials were suitable for drinking purposes. Water from bedrock material characteristically displays high levels of total dissolved salts, alkalinity, sodium and sulphate.

Irrigation of forage crops is the major consumptive use of water in the area. Small quantities of water are also used for livestock and domestic purposes. Both Hat Creek surface water and groundwater collected in wells adjacent to the creek display high levels of coliforms, indicating the need for chlorination of potable supplies.

No major changes in either the surface or groundwater hydrology of the area are expected without the project. However, if irrigation use in the valley expands to its estimated potential, it would extend the duration of summer low flows. To fulfill this potential, storage and diversion works would be required. Water quality would be expected to remain much the same except for possible increased nutrient levels, due to greater agricultural land use and the attendant increases in fertilizer application.

## 11.2 ASSESSMENT APPROACH (19)

The consultant team conducted an intensive evaluation of groundwater resources to determine the locations, magnitude and water quality of major aquifers in the area. Geohydraulic examinations were also carried out in the mine and waste dump areas to determine the effect of these developments on groundwater levels, material permeability and water quality.

Similarly, runoff patterns and water quality of surface streams in the Hat Creek watershed were examined in detail. Extensive data on the runoff regime of Hat Creek were available and analysed. However, no data were available for its tributaries. Based on comparisons with other drainage basins in the southern interior of British Columbia and on short-term data collected specifically for the environmental studies, estimates were made of the flow regime of several Hat Creek tributaries in the general project area. Water quality data were collected in a program designed specifically for these environmental studies.

## 11.3 EFFECTS OF THE PROJECT (19)

### (a) Project Actions

Excavation of the mine, and development of the mine waste disposal areas and powerplant waste disposal area would result in major alterations to the drainage patterns of the Hat Creek valley adjacent to these developments. Creeks would require diversion, small lakes would be drained, and aquifers would be altered.(6) A comprehensive drainage scheme for these project features has been developed, as described in Sections 3.2, 3.3 and 3.4. This system has been designed to collect all water unsuitable for return to Hat Creek and dispose of it by reuse or evaporation. Diversions required for Hat Creek and its tributaries are described in Section 3.4. The powerplant has been designed to operate with no liquid (zero) discharge, so that waste-water from processes such as the cooling towers and boiler cycles would be reused in the ash disposal area, as described in Section 3.3.

### (b) Local Effects on Groundwater Resources (19)

Major concerns regarding impact on local groundwater resources are excavation of the open pit or other activities such as the development of waste dumps which would reduce the volume of flows, and seepage from certain areas which could alter water quality. These points are discussed below.

(i) Mine Area

To provide safe working conditions, it would be necessary to restrict the inflow of groundwater into the open pit, as detailed in Section 3.2. Excavation of the Hat Creek mine would cut the south flowing valley alluvial aquifer at the headworks dam. This aquifer would be re-established to essentially its present flow (on average 2300 $m^3$/day) a short distance downstream of the project. Negligible change would occur in its groundwater level. Drainage of lakes and ponds to the south and southwest of the pit would result in a minor impact on the pit area groundwater flow. Pumped wells around the pit perimeter would also extract water from the surficial and bedrock strata. These drainage schemes would not affect groundwater levels more than approximately 1 km from the pit perimeter in the more pervious surficial materials. In the very low-permeability bedrock, groundwater effects would not extend more than a few hundred metres from the pit perimeter at any stage. Groundwater tables are already well below the ground surface over the majority of this area. Hence the overall impact on groundwater at a distance greater than 2.5 km from the centre of the pit would be minor. Figure 11-1 shows the areas of potential change in groundwater flows due to the project.

Changes in groundwater quality due to altered groundwater drainage patterns in the mine area would be minor.

(ii) Waste Disposal Areas

Houth Meadows

As a result of placing mine waste in the Houth Meadows area, existing groundwater flow patterns would be altered. Placement of the low-permeability waste would restrict natural groundwater discharge in the northern part of the valley and hence groundwater tables in the adjacent limestone bedrock would rise at about the same rate as the dump surface. Once the groundwater divide (high point in bedrock) was crested, seepage would flow north into the Marble Canyon aquifer.

Seepage coming through the waste pile's main eastern embankment would be collected as indicated in Section 3.2 (see Figure 3-8). This system would carry the seepage to the leachate storage lagoons for recycling. Maximum seepage under this eastern embankment would be about 50 $m^3$/day of which 75 percent would reach the valley alluvial aquifer and 25 percent would enter the mine area drainage system. If it is assumed that all seepage flowing northward through and around the saddle embankments reaches the Marble Canyon aquifer, the total increase in groundwater flow in this aquifer would amount to 60 $m^3$/day, an increase of approximately 3 percent over present flows.

Estimates of the water quality of this seepage have been made on the basis of laboratory extraction studies. When these data are considered in relation to the quality of existing groundwater in that area, a total increase of less than 22 percent in the level of total dissolved solids is projected to occur in the Hat Creek alluvial groundwater system downstream of the project. A considerable portion of the change would be due to the Hat Creek alluvial aquifer conveying a greater proportion of water from the Marble Canyon area, which according to available data has a somewhat higher dissolved solids level. From this assessment, the groundwater in the alluvial aquifer downstream of the development would remain acceptable for human consumption and agricultural use.

Medicine Creek

The Medicine Creek valley would be intensively used for this project. Initially the powerplant water reservoir and power plant waste disposal area would be located in the eastern portion of the valley, and after about 15 years Medicine Creek mine waste disposal would begin (Section 3.0).

Ash wetted with powerplant wastewater combined with partially dewatered scrubber sludge would be placed immediately downstream of the water reservoir embankment in the ash disposal area.(38) Maximum initial seepage flows from the water reservoir into the ash/sludge dump are estimated at 432 $m^3$/day. Seepage and runoff from this storage area would be intercepted by a collection embankment and returned to a holding pond for disposal by spray evaporation and ash pile dust control. Beyond this collection system, which would normally be pumped out, seepage down the valley is expected to be minimal.

After 15 years of production, mine waste would be stored in the western end of the Medicine Creek valley, with the powerplant and mine waste disposal areas ultimately merging towards the end of the project life. The mine waste material would be essentially of the same composition as that deposited at Houth Meadows. Drains in the toe of the containment embankment would collect leachate and direct it to a collection system for on-site disposal by evaporation or reuse in dust control.(6)

Maximum seepage under the Medicine Creek mine waste embankment which would elude the collection system and enter the groundwater is estimated at 17 $m^3$/day at the end of the 35 year project life.

At present, flows of groundwater down Medicine Creek amount to 350 $m^3$/day. Thus the total estimated groundwater flows with the mine and powerplant waste in place would be markedly reduced to about one twentieth of the existing flow. The quality of this water would also be reduced, since it would contain leached solids.

The ultimate destination of this seepage would be divided between the pit rim dam and the open pit dewatering system. Estimates of the net effect of this leachate on the quality of surface water are not easy to make; the substantial travel distance through clayey material would be expected to modify (i.e. improve) the water quality of the seepage. Nevertheless a "worst case" assessment in which all 17 $m^3$/day of seepage from the Medicine Creek dump enters the pit rim reservoir together with other normal seepage indicates that an increase of less than 15 percent in the total dissolved solids content of the reservoir would occur. A worst case assessment of the effect of this change in pit rim reservoir water quality indicates that the total dissolved solids concentration of Hat Creek would increase by less than 2 percent. In addition to monitoring the quality of water from pit dewatering wells in the area, groundwater monitoring wells would be installed below the Medicine Creek embankment. If necessary, water from these wells could be disposed of via the leachate control system.

(iii) Other Areas

The effects of construction activities such as clearing, overburden stripping and camp sewage disposal are not expected to have a major impact on groundwater systems. The withdrawal of groundwater for potable and industrial use during the construction period would amount to approximately 1846 $m^3$/day. This amount would be withdrawn from the Marble Canyon, Hat Creek, and buried bedrock aquifers. These withdrawals represent about 39 percent of those combined groundwater resources considered to be available for use and would create a moderate but temporary impact.

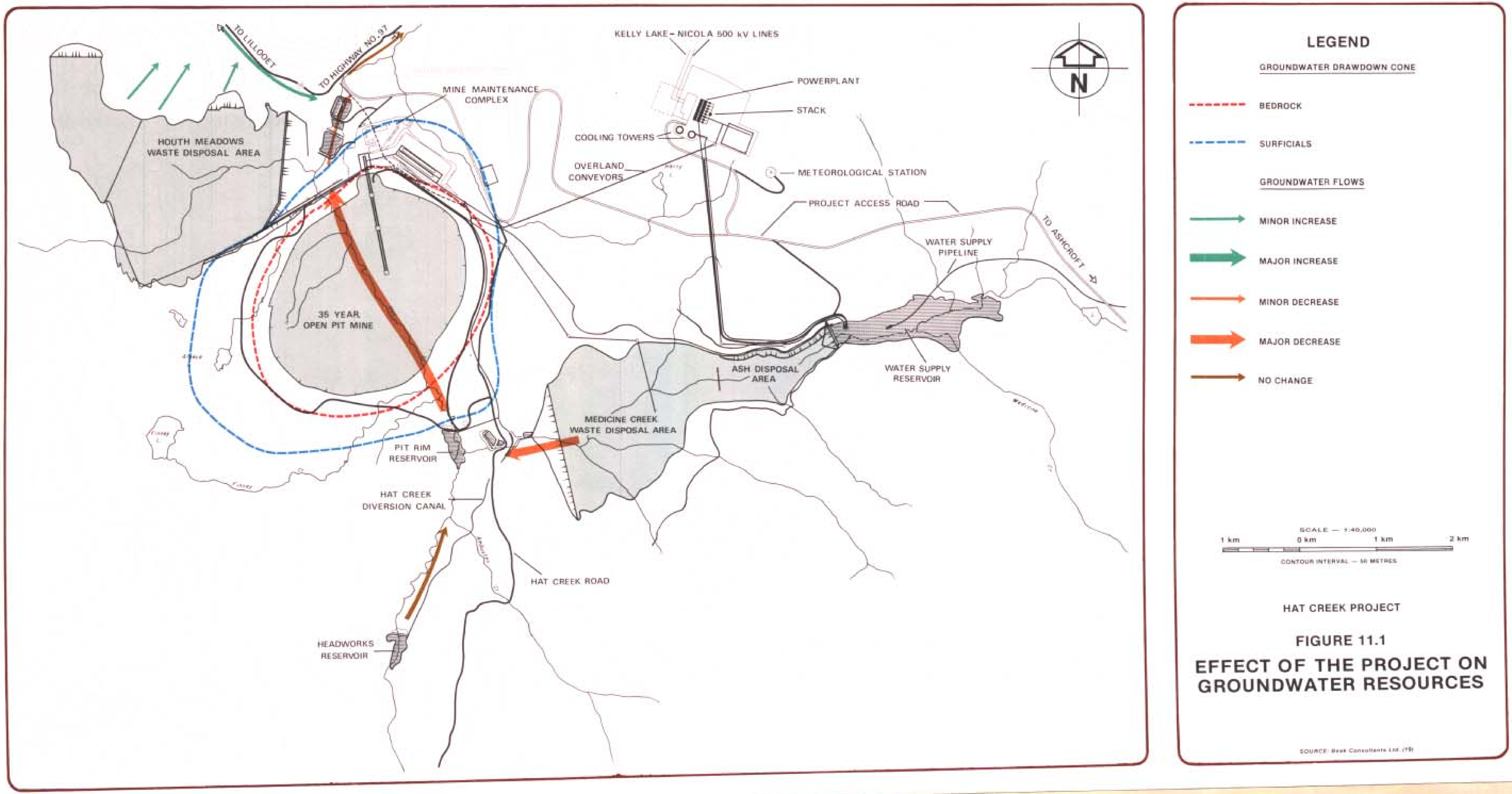



FIGURE 11.1

EFFECT OF THE PROJECT ON GROUNDWATER RESOURCES

Coal stockpile areas would be lined with low permeability material and drains would be installed to collect leachate and runoff (see Figure 3-8). Impacts on groundwater are therefore expected to be negligible. No effect would result from the diversion ditches surrounding the waste stockpiles.

(c) Local Effects on Surface Water (19)

A comprehensive surface water management system has been developed for the Hat Creek valley and adjacent hills. This system was devised with a view to preserving existing surface water quality and quantity downstream of the project.(6,38)

(i) Powerplant

Water required for powerplant operation would be pumped from the Thompson River to a storage reservoir in the upper Medicine Creek valley, as described in Section 3.4. Both the runoff canals and the water reservoir have been designed to accommodate the area's Probable Maximum Flood.(39) An overflow system at the reservoir dam would provide for the safe discharge of flood water into Hat Creek at the end of the open canal portion of the diversion system. The existing upper Medicine Creek irrigation diversion ditch is upstream of the project and hence would be unaffected by project actions. This diversion at present directs water to McLean Lake and Cornwall Creek. Thus there would be no interruption of this irrigation water supply to the Ashcroft Meadows area. The retention of all normal Medicine Creek flows downstream of the existing irrigation diversion for powerplant use would reduce peak flood flows in Hat Creek by an estimated maximum of 10 percent. As described in Section 3.4 it is proposed to release this collected water during the summer months (July/August) and thus increase the low flows which normally occur in Hat Creek during this period. Thus while the total annual runoff of Medicine Creek into Hat Creek would remain essentially unaltered, the flows would be regulated.

Seepage from the reservoir and seepage and runoff from the adjacent powerplant waste dump would be collected behind an embankment constructed of impervious material in Medicine Creek valley.(38) After a number of years of powerplant operation this would be covered by the eastward advancing mine waste dump. Suitable small collection ponds would then be constructed on the rising waste dump to collect surface runoff from the ash. These collection ponds would be designed to contain the heaviest 24-hour rainfall estimated to occur once every 10 years on average. These collection ponds would normally be pumped out to a site holding pond, where seepage would be minor.

The site holding pond would also collect runoff from the coal storage and powerplant yard drains. It would be constructed immediately northwest of the water supply reservoir, as shown on Figure 3-7. Water collecting in the holding pond would be disposed of during the summer months by spray evaporation on the powerplant waste dump. The holding pond would be large enough to contain all inflows including the 10-year heaviest 24-hour rainstorms. Should inflows exceed this level, the overflow system would route the excess runoff to the Medicine Creek water reservoir where, as a result of the large dilution available, water quality effects would be negligible.(38)

Wastewater from the powerplant's operating systems would be recycled for use in the ash/sludge disposal systems and dust control. The rate of production of wastewater has been balanced with its rate of use so that the powerplant would have no liquid discharges. (38,56)

As a result of the containment of all potentially contaminated water, surface water quality impacts from powerplant systems would be negligible.

(ii) Mine (6)

The mine area water management system has been based upon flow data for both surface and groundwater systems, and upon geotechnical information. Facilities involved in this scheme are outlined in the mine description, Section 3.2. The three types of water system comprised in this scheme are discussed below, along with the resultant impacts on water quality.

Flows Discharged Directly

Most surface streams would be simply redirected around the mine facilities and returned unaffected to existing downstream channels. Most notable in this category would be the diversion of Hat Creek, required because the existing creek bed lies directly over the coal deposit. Details of this diversion scheme are given in Section 3.4.

Flow regulation would not be provided and therefore major changes in existing downstream flow patterns would not occur. The canal system is designed to accept the heaviest flood predicted with an annual probability of 1:1000 i.e. 27 $m^3/s$ (1000-year flood). Floods in excess of this level would be safely spilled to the open pit. Consequently the Hat Creek diversion would provide a degree of flood protection, since flooding downstream above the 1:1000 flood level would be prevented.

Construction of the diversion canal and headworks facilities would occur over two summers with commissioning during the fall months (see Figure 4-1). The canal would be sealed at each end and filled with water from Medicine and Ambusten Creeks. During this period normal flows in Hat Creek would be maintained past the headworks dam through the construction bypass. When the canal has filled with water the headworks dam would be sealed and flow in Hat Creek would be maintained by slowly releasing stored water from the canal while the headworks dam filled with water from Hat Creek. The volume of water in the canal and the rate at which it is released would be controlled so that there would be no interruption to the flow of Hat Creek.

This method of commissioning would also avoid a rapid release of water down the dry canal. During normal operation the low gradient of the canal with resulting low water velocities ( $<1$ m/s) and the design of the buried conduit intake would essentially eliminate the generation and transport of entrained suspended material from the canal bed. Adverse impacts from downstream siltation would thus be avoided.

As a result of the canal's configuration and exposure, solar heating during low flow periods would increase the temperature of the diverted water. The maximum predicted water temperature at the end of the diversion canal is 31°C, which would make it unsuitable for aquatic organisms. However the addition of cool water released from the powerplant reservoir, ie. stored Medicine Creek water, to the end of the open canal portion of the diversion would return the water temperature well into the range suitable for resident fish.

Nitrogen supersaturation would likewise be avoided by the addition of cool water and careful design of the energy dissipating system at the canal/ conduit outfall. Drainage of lakes and ponds southwest of the proposed mine would be undertaken during the freshet period to minimize the enrichment of Hat Creek by the lake water, which may be high in nutrients.(6)

The diversion system, canal and headworks reservoir and powerplant reservoir would not be decommissioned. Regular maintenance on an ongoing basis would be required.

Flow Discharged Following Sediment Control

In addition to the draining of surface lakes and ponds, a network of wells would be installed to drain the surficial materials and further limit seepage into the open pit. This water, together with runoff from disturbed areas adjacent to the pit and runoff and seepage through surficial materials into the pit, would be directed to sedimentation lagoons. Runoff from waste disposal areas during the initial clearing and final contouring stages would also be collected in these lagoons. Runoff from active dumps would not occur due to the hummocky nature of the surface.(6)

Two sedimentation lagoon systems are planned. The north valley lagoons would collect runoff and seepage from the pit surficials and dewatering flows, local service roads and disturbed land. During the later stages of the project, runoff from the reclaimed land, notably the Houth Meadows waste disposal area, would also be collected in the north lagoons. The Medicine Creek lagoons would collect runoff from the disposal area surface. After retention, water from the Medicine Creek lagoon would be released into the pit rim reservoir and subsequently flow into Hat Creek via the diversion canal. The north valley lagoons would discharge to Hat Creek downstream of the project.

Treatment in these ponds would be sediment control by either natural or coagulant-aided settling. Hydrographs have been prepared to indicate lagoon inflows during the estimated 10-year, 24-hour rainfall event. A basic design criterion for the lagoon system has been that the overflow velocity during such a flood should be sufficiently low to keep sediment concentrations in the outflow below 50 mg/L. During larger floods the sedimentation process would be less efficient. However, careful design of the inlet manifold to prevent scouring and re-entrainment of previously settled solids, the large surface area and flow attenuation of the ponds would result in a reduction in the level of suspended solids although it may not be reduced below 50 mg/L. The sediment load on Hat Creek itself would be elevated following the 10-year, 24-hour rainfall event and therefore the net effect would be low. This situation is explicitly allowed for in the PCB 1979 Objectives.(50)

Based on the present water quality of inflowing streams, and the projected quality of effluent streams (Table 11-1), the resulting quality of Hat Creek has been estimated (Table 11-2). The tables show projected water quality for three cases, namely, the dry weather condition, spring runoff and following a summer rainstorm. Predicted changes in Hat Creek water quality are minor and generally fall within the range presently experienced.

The sedimentation lagoon system would receive careful operation during the life of the mine to achieve the required discharge water quality. Frequent sampling and chemical analysis of inflow and outflow would be undertaken to determine the rate of coagulant feed required. Daily checks on lagoon inlet and outlet would be undertaken during periods of high flow or at times when broken ice is on the ponds. Annual inspection and maintenance would be carried out on dykes, inlets and outlets, and emergency spillways and sediment build-up would be monitored. Although measures would be undertaken to prevent oil entering inflowing streams, oil collection booms would be provided on sedimentation lagoon surfaces.

During the construction period, and when the routing of runoff to the lagoons is impractical, sediment control would be provided by suitably located temporary lagoons designed to contain the runoff from the estimated 10-year 24-hour rainfall event from the area in question.

In the project's decommissioning and reclamation phase, the lagoon systems would remain in operation until land reclamation work in the valley has reduced to acceptable levels the sediment concentrations in runoff from disturbed areas. During this period the lagoon systems would be maintained by reclamation staff.(6)

Flows not Discharged

All leachate flows of unsuitable quality such as from coal pile drainage, lower mine pit seepage through bedrock, seepage from waste dumps, wastewater from mine services areas and treated sewage effluent would be collected in a "zero-discharge" lagoon system. These waters would be used during the summer months for dust control operations on coal stockpiles and on pit roads. Any surplus would be disposed of by spray evaporation on the waste dumps during summer months. The majority of leachate storage would be provided at the north valley location while the remainder would be located at the toe of the Medicine Creek dump.

As a result of the increasing flows over the mining period, the lagoon sizes would be increased progressively. In the event that higher flows than anticipated occur, lagoon expansion could be brought forward. If the reverse occurs then further expansion could be deferred.

Zero-discharge lagoons are designed to contain the extreme inflow made up of the maximum projected groundwater flow plus twice the expected mean inflow from surface runoff. The probability of having insufficient storage is estimated between 1/100 and 2/100 per annum.(6) However, there are further safety factors which reduce even this nominal risk. The bulk of the leachate lagoon inflow would be pumped from the open pit, hence pumping rates are under the control of operating staff. Should an extreme inflow occur, leachate could be stored in a sump in the pit bottom until capacity is available in the

TABLE 11-1

PROJECTED QUALITY IN mg/L OF DISCHARGES FROM SEDIMENTATION LAGOONS (19)

| | Dry Weather Condition | Spring Run-off Condition | | Summer Rainstorm Condition | | PCB Objectives (50) Range | |
|---|---|---|---|---|---|---|---|
| | North Lagoon | North Lagoon | Medicine Creek Lagoon | North Lagoon | Medicine Creek Lagoon | | |
| pH (Units) | 7.9 | 8.3 | 8.2 | 8.4 | 8.2 | 6.5-8.5 | 6.5-10 |
| Filterable Residue | 368 | 371 | 468 | 386 | 600 | 2500 | 5000 |
| Non-filterable Residue | ≤50 | ≤50 | ≤50 | ≤50 | ≤50 | 25 | 75 |
| Total Organic Carbon | 22 | 13 | 25 | 11 | 29 | - | - |
| Total Hardness (as $CaCO_3$) | 217 | 222 | 215 | 223 | 215 | - | - |
| Alkalinity (as $CaCO_3$) | 277 | 232 | 202 | 223 | 188 | - | - |
| Chloride | 4 | 2.3 | 5 | 2.3 | 8.3 | - | - |
| Fluoride | 0.2 | 0.17 | 0.11 | 0.16 | 0.10 | 2.5 | 10 |
| Total Nitrogen (N) | <0.56 | <0.5 | 1.0 | <0.43 | 1.5 | 10 | 15 |
| Phosphorus (P) | <0.03 | <0.05 | 0.06 | <0.05 | 0.10 | 2 | 10 |
| Sulphate | 60 | 59 | 54 | 61 | 78 | - | - |
| Arsenic (Total) | <0.005 | <0.007 | <0.017 | <0.008 | <0.03 | 0.10 | 1.0 |
| Boron | <0.10 | <0.10 | <0.09 | <0.10 | <0.09 | - | - |
| Cadmium | <0.005 | <0.005 | <0.005 | <0.005 | <0.004 | 0.01 | 0.10 |
| Calcium (as $CaCO_3$) | 149 | 144 | 124 | 141 | 120 | - | - |
| Chromium | <0.01 | <0.013 | <0.03 | <0.015 | <0.05 | 0.05 | 0.30 |
| Copper | <0.005 | <0.04 | <0.26 | <0.07 | <0.03[1] | 0.05 | 0.3 |
| Iron | <0.03 | <0.06 | <0.23 | <0.08 | <0.04 | 0.3 | 1.0 |
| Lead | <0.01 | <0.01 | <0.012 | <0.01 | <0.014 | 0.05 | 0.2 |
| Magnesium (as $CaCO_3$) | 67 | 76 | 90 | 78 | 94 | - | - |
| Mercury | <0.0003 | <0.0004 | <0.0007 | <0.0004 | <0.0008 | Nil | 0.005 |
| Sodium | 38 | 27 | 21 | 23 | 28 | - | - |
| Vanadium | <0.006 | <0.005 | <0.006 | <0.005 | <0.007 | - | - |
| Zinc | <0.04 | <0.018 | <0.035 | <0.014 | <0.052 | 0.2 | 1.0 |

[1] Consultants predicted a value of <0.44 mg/L. Monitoring would be carried out and if required ponds would be treated to maintain copper concentrations in the outflow <0.3 as indicated.

TABLE 11-2
HAT CREEK WATER QUALITY PROJECTIONS
IN mg/L (19)

| | Dry Weather Condition | | Spring Runoff Condition | | Summer Rainstorm Condition | |
|---|---|---|---|---|---|---|
| | Average Existing Hat Creek | Projected Hat Creek | Average Existing Hat Creek | Projected Hat Creek After Mixing | Existing Hat Creek | Projected Hat Creek After Mixing |
| pH (Units) | 8.4 | 8.3 | 8.4 | 8.4 | 8.4 | 8.4 |
| Filterable Residue | 342 | 345 | 342 | 355 | 342 | 362 |
| Non-filterable Residue | 6 | 12 | 12 | ≤18 | 95 | 79 |
| Total Organic Carbon | 9 | 11 | 9 | 10 | 9 | 10 |
| Total Hardness (as CaCO3) | 224 | 223 | 224 | 223 | 224 | 223 |
| Alkalinity (as CaCO3) | 226 | 233 | 226 | 226 | 226 | 224 |
| Chloride | 1.1 | 1.6 | 1.1 | 1.4 | 1.1 | 1.7 |
| Fluoride | 0.16 | 0.17 | 0.16 | 0.16 | 0.16 | 0.16 |
| Total Nitrogen (N) | 0.24 | <0.26 | 0.24 | <0.30 | 0.24 | <0.33 |
| Phosphorus (P) | 0.043 | <0.04 | 0.043 | <0.044 | <0.043 | <0.05 |
| Sulphate | 54 | 55 | 54 | 55 | 54 | 57 |
| Arsenic | <0.005 | <0.005 | <0.005 | <0.006 | <0.005 | <0.007 |
| Boron | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| Cadmium | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Calcium (as CaCO3) | 143 | 144 | 143 | 143 | 143 | 142 |
| Chromium | <0.01 | <0.01 | <0.01 | <0.011 | <0.010 | <0.013 |
| Copper | <0.005 | <0.005 | <0.005 | <0.016 | <0.005 | <0.036 |
| Iron | <0.026 | <0.028 | <0.026 | <0.035 | <0.026 | <0.05 |
| Lead | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.012 |
| Magnesium (as CaCO3) | 77 | 76 | 77 | 77 | 77 | 78 |
| Mercury | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0004 | <0.0005 |
| Sodium | 20 | 23 | 20 | 21 | 20 | 21 |
| Vanadium | <0.005 | <0.006 | <0.005 | <0.006 | <0.005 | <0.006 |
| Zinc | <0.007 | <0.01 | <0.007 | <0.009 | <0.007 | <0.01 |

lagoons. Finally, in the event that this lagoon did overflow as a result of flows from elsewhere it would do so via gravity drains back into the pit. Hence there would not be any discharge from the leachate lagoon to surface waters. Seepage into groundwater from the leachate collection lagoons would be prevented by impervious till and plastic linings.

Once in operation, the zero-discharge system would require minimum maintenance. Seasonal inspection of the pond lining would be carried out in late autumn when pond levels would be at their lowest.

In the decommissioning and reclamation phase of the project the mean annual north valley lagoon inflow would decrease from 470 000 $m^3$ to 25 000 $m^3$ as pumping from the pit would have been discontinued, the coal blending area reclaimed and the mine service facilities removed. The Medicine Creek system would remain in operation with leachate being disposed of by natural evaporation. In the north valley, natural evaporation from the leachate pond would be sufficient to dispose of the residual leachate from the Houth Meadows disposal area. In both cases overflow systems would still discharge to the pit.

(d) Water Use (35)

A simplified water use balance for the Hat Creek project is shown in Table 11-3. Of the 2100 ha.m/annum of water presently potentially available in the region of the mine site, a net total of 1056 ha.m/annum would be available downstream of the project. This allows for downstream fisheries requirements and includes allowances for the use of Medicine Creek water by the existing irrigation system to McLean Lake. The projected increase in irrigation would, without the project, result in the use of an additional 227 ha.m/annum of water. Project actions would preclude the development of part of this land and result in a reduction in the projected increase of water use of 130 ha.m/ annum. This water would, however, remain available for assignment elsewhere.

## 11.4 REGIONAL EFFECTS

(a) Mine and Powerplant - Development

Regional effects from changes in both ground and surface water characteristics would be negligible. In particular, the expected increase in dissolved solids in Hat Creek would have no significant effect upon the Bonaparte and Thompson rivers. Similarly, changes in the Hat Creek alluvial aquifer would have no significant effect upon groundwater resources outside the valley area.

(b) Trace Elements (15)

A major source of trace element additions to the aquatic environment is from the deposition of those elements emitted from the stack. Twenty-three elements were selected for environmental study based on the following characteristics:

1. *Implicated as being potentially toxic to the environment as specifically* related to coal-fired powerplants.

2. Essential to the physiological and biochemical processes of plants or animals.

TABLE 11-3

SIMPLIFIED WATER BALANCE FOR THE HAT CREEK PROJECT BASED ON WATER USE (35)
(ha.m/annum)

| Location | Without the Project | | | | With the Project | | |
|---|---|---|---|---|---|---|---|
| | Present Run-off | Fisheries[4] Requirements | Probable Use[1] Case - Projected Use for Future Development | Net Available Downstream | Impact[2] (Loss of Irrigated Land) | Consumptive[3] Use by the Project | Net Available Downstream |
| Upper Hat Creek (above gauging St. 08LF061) | 2100 | 911 | 227 | 962 | 130 | 36 | 1056 |
| Hat Creek at Carquille (above gauging St. 08LF015) | 2500 | 911 | 304 | 1285 | 130 | 36 | 1379 |

[1] Value includes additional water necessary for development of spring pasture and corn land. Present irrigation uses are not included in this figure since the present measured run-off reflects existing uses.(19, 52)

[2] Value represents water use alienated by project facilities. This water would not be lost since it is available for reassignment.(35)

[3] Losses due to evaporation from ponds, sedimentation lagoons, etc.(19)

[4] Information from BEAK, Investory Report.(19)

3. Potential toxicity to biotic receptors.

4. Volatilized during coal combustion.

In order to obtain an initial estimate of the impact of trace elements from stack emissions on the aquatic system a "worst case" analysis was undertaken. The conservative assumptions made to simplify the calculations are detailed below.

1. All of the trace elements that fall on the Bonaparte River watershed make their way into the aquatic system (for deposition pattern, see Figure 6-2).

2. All trace elements that enter the water dissolve completely.

Further detailed examinations were then made of those elements which, as a result of the initial overview, gave rise to environmental concern. Trace element depositions obtained from air quality studies are shown in Figure 6-2. The total depositions over 1 year were then divided by the total amount of surface water runoff in the Bonaparte River watershed to provide an estimate of concentrations for any given time during the powerplant's operation, considering that there is no accumulation. These concentrations were then added onto those observed for the Bonaparte River to obtain total projected water concentrations of the 23 trace elements during powerplant operation.

Using the "worst case" approach and the conservative assumptions discussed above, all concentrations except that of mercury (Hg) were calculated to be below guideline criteria expressed by a number of regulatory agencies. Predicted trace element concentrations in the Bonaparte River are shown in Table 11-4. Further examination of the fate of mercury indicated that only a small fraction of the total emitted would be present as dissolved mercury in the Bonaparte River. It is predicted that the projected concentration for mercury will not harm fish or aquatic life since the increase from existing background levels is relatively minor (4.2 percent).

It must be appreciated that studies to precisely determine the fate of trace element emissions are neither numerous nor complete. The monitoring program described in Section 26.0 would provide data on actual impacts.

TABLE 11-4
PREDICTED TRACE ELEMENT CONCENTRATIONS (15)

Trace element concentrations observed in the Bonaparte River relative to the projected water concentrations during operation of the Hat Creek powerplant

| Element | | Water Concentrations (µg/L)<br>Bonaparte River[1] | Projected Trace Element Additions (µg/L) | Projected Water Concentrations in the Bonaparte River (µg/L) |
|---|---|---|---|---|
| Antimony | Sb | (<2.2) | 0.013 | <2.213 |
| Arsenic | As | <5.0 | 1.426 | <6.426 |
| Beryllium | Be | (0.90) | 0.025 | 0.925 |
| Boron | B | (3.10) | 2.15 | 5.25 |
| Cadmium | Cd | <5.0 | 0.016 | <5.016 |
| Chromium | Cr | <10.0 | 0.263 | <10.263 |
| Cobalt | Co | (4.0) | 0.043 | 4.043 |
| Copper | Cu | <5.0 | 1.89 | <6.89 |
| Fluorine | F | (133.5) | 97.73 | 231.23 |
| Lead | Pb | <10.0 | 0.437 | <10.437 |
| Manganese | Mn | (0.012) | 6.16 | 6.172 |
| Mercury | Hg | <0.05 | 0.0021 | <0.0521 |
| Molybdenum | Mb | <20.0 | 0.437 | <20.437 |
| Nickel | Ni | (9.2) | 0.51 | 9.71 |
| Selenium | Se | <3.0 | 0.489 | <3.489 |
| Silver | Ag | (0.001) | 0.002 | 0.003 |
| Thallium | Tl | (<1.1) | 0.002 | <1.102 |
| Thorium | Th | (0.007) | 0.025 | 0.032 |
| Tin | Sn | (<61.6) | 0.04 | <62.0 |
| Tungsten | W | (0.001) | 0.002 | 0.003 |
| Uranium | U | (0.006) | 0.059 | 0.065 |
| Vanadium | V | <5.0 | 0.702 | <5.702 |
| Zinc | Zn | <23.0 | 1.412 | <24.412 |

1. Where data on trace element concentrations in the Bonaparte River were not available, values for Hat Creek were substituted as an approximation and are shown in parentheses.

## 12.1 EXISTING SITUATION

(a) Regional

Detailed field surveys and a literature review resulted in the identification of 25 species of fish resident within the regional study area (see Figure 8-1). Rainbow trout, steelhead, (the anadromous form of rainbow trout), and kokanee are the principal sport fish sought by anglers. Dolly Varden are not as popular. Brook trout and kokanee are not widely distributed within the region. No rare or endangered species were encountered.

In addition to the resident fish, five species of anadromous fish spawn and spend their early life stages within the regional study area. These are sockeye, pink, coho and chinook salmon and steelhead trout.

A large portion of Canada's and the United States' commercial salmon fishing is dependent upon the spawning and nursery grounds provided by the Fraser River/Thompson River system. Approximately 33 percent of the total salmon taken in British Columbia originates in this system; 23 percent being attributed to the Fraser River basin and 10 percent being attributed to the Thompson River basin. The regional study area includes a portion of the south Thompson River between Kamloops Lake and the Fraser River. This portion supports a major run of pink salmon which represents 17 percent of salmon of all species spawning in the entire Thompson River system.

Fish caught in the region's sport fishery are mostly salmonids, although some burbot are also taken. Pearse Bowden (1971) reported that rainbow trout, char (brook and lake trout), kokanee and steelhead accounted for 548 000, 57 000, 19 000 and 2000 respectively, of the 653 000 fish taken from 1969 to 1970 in the Kamloops area. The Kamloops area catch represented 7.6 percent of the total sport fish catch in British Columbia in that period. Within the region, 726 378 angler-days were expended fishing 228 lakes from 1969 to 1970.

In a number of water bodies the sport fishery is enhanced by stocking. In past years, rainbow trout, Atlantic salmon and lake trout have been stocked in the region. Many lakes in the region have the capability of sustaining increased angling pressure.

(b) Thompson River

The Thompson River is probably best known for its quality steelhead fishing and is considered one of the finest trophy producing rivers in British Columbia. An estimated 732 steelhead were taken from the river during the 1976/77 season at an average success rate of 0.122 fish/angler/day. Steelhead fishing in the river accounts for an estimated 84 percent of the effort expended in the regional study area.

The Thompson River in the immediate vicinity of the proposed water supply intake is characterized by a relatively deep channel, slow currents and boulders. There is no evidence that pink salmon spawn in this area. The main pink spawning area is located upstream from the proposed intake.(8)

(c) Bonaparte River

Seven species of resident fish have been identified in the Bonaparte River. The dominant species are longnose dace, bridgelip sucker and leopard dace. Rainbow trout, mountain whitefish, brook trout and redside shiners are present in smaller numbers.

There appears to be adequate rainbow trout spawning habitat in the Bonaparte River and some rainbow trout possibly move up into the lower reaches of Hat Creek to spawn. The lower section of the Bonaparte River also provides spawning habitat for a small run of pink salmon, estimated at 611 fish in 1977. It is likely that some chinook and steelhead trout also utilize the available habitat in the lower section of the river. The upper section of the Bonaparte River is presently unavailable for spawning by anadromous fish due to the physical barrier of the Bonaparte Falls.

(d) Hat Creek

Hat Creek contains a variety of aquatic habitats. Upper Hat Creek, which is defined as that portion of Hat Creek upstream from the junction of Highway 12 and the Hat Creek Road (above km 22.4) is characterized generally by water flowing slowly through a series of large pools and riffles. Beaver activity is extensive in some areas of the upper section of the creek. Lower Hat Creek (below km 22.4) exhibits a steeper gradient, with a greater proportion of riffles and swifter current compared to upper Hat Creek. The lower 8 km of Hat Creek, above the confluence with the Bonaparte River, run through a canyon. There are numerous beaver dams and man-made dams which are likely barriers to fish within this canyon area. Rainbow trout are the dominant fish species but mountain whitefish are also distributed in smaller numbers throughout most of Hat Creek. The other three species of fish collected during fisheries surveys were bridgelip sucker, longnose and leopard dace, but these were present in low numbers, and only in the lowermost section of Hat Creek. Bottom organisms in Hat Creek are typical of those in clean water environments.

Population estimates of rainbow trout in Hat Creek range from approximately 18 000 to 23 000 fish. From 35 to 45 percent of the total number of rainbow trout occurred in Lower Hat Creek (60 percent of the length of the entire stream). Estimates of numbers of mature rainbow trout above 150 mm total length ranged from 3500 to 5000. The ages of the fish ranged from the young of the year to 6 years. There appears to be suitable rainbow trout spawning habitat throughout the length of the stream.

Tributaries to Hat Creek provide negligible fish habitat compared to that in the creek. No fish were observed in Goose, Fish Hook or Finney lakes and none were reported from Aleece Lake.

## 12.2 PROJECT ACTIONS

Project actions on the fisheries and aquatic resources within the local study area (see Figure 8-1) include alienation and loss of physical habitat, siltation due to runoff from disturbed areas, potential water quality changes associated with lake dewatering and land reclamation (nutrients), materials storage (toxic materials), and waste disposal, coal stockpile and mine pit operations (leachates) and increased angling pressure by the project's work force.

Regionally, powerplant stack emissions and water withdrawal from the Thompson River could affect the fisheries and aquatic resources.

## 12.3 EFFECTS OF THE PROJECT

### (a) Local Effects

#### (i) Habitat Alienation

The primary impact of the development on the local aquatic resources would be associated with the diversion of Hat Creek around the mine pit. Seven kilometres of the natural Hat Creek channel would be replaced by 500 m of reservoir, 6.5 km of open canal and 2.1 km of buried conduit. The section of Hat Creek that would be lost represents approximately 17 percent of the available natural creek habitat. Within the section of the creek that would be bypassed, approximately 3000 to 5000 rainbow trout would be lost; of these, 1700 to 3300 would be one year or older and larger than 100 mm total length.

Hat Creek downstream of the diversion works would not be significantly affected. Water in the diversion canal could reach temperatures as high as 31°C during the summer months as a result of solar heating. However, regulated flows from the Medicine Creek Water Reservoir as described in Sections 3.4 and 11.3 would significantly reduce high temperatures during low flow periods (July/August). It is projected that waters below the Hat Creek diversion canal would be below the lethal temperature for rainbow trout.

The reservoir to be constructed near Anderson Creek as part of the diversion scheme may be suitable for trout rearing and overwintering. Although some stream spawning habitat would be lost within the reservoir area, spawning and nursery habitat would continue to be available in upstream sections of Hat Creek and in Anderson Creek. The reservoir should support at least as many trout as the number that presently occur in that section of Hat Creek to be inundated by the reservoir. Mountain whitefish may also find suitable habitat within the reservoir, and possibly be better adapted than rainbow trout to a reservoir habitat.

The dewatering of Aleece and other smaller lakes would result in a permanent loss of benthic and potential fish habitat. Aleece Lake has supported fish populations in the past. Clearing of Medicine Creek and the surrounding valley for use as a reservoir and a waste disposal area would also result in loss of aquatic habitat for benthic forms. At present fish likely cannot ascend beyond the lower 10 m because of a 2 m falls.

#### (ii) Siltation

During the construction phase, suitably located sedimentation basins would be built to limit siltation. Rainbow trout spawning and egg incubation activities take place in all parts of the creek within the period mid-June through late August or early September. Monitoring of project operations would be conducted to ensure that sedimentation facilities perform satisfactorily. Sedimentation facilities are discussed in Section 11.3. These sedimentation basins would minimize any increase in sediment entering the streams and are expected to have only a minor impact on the fisheries and benthic communities in Hat Creek or the Bonaparte River.

Gravel removal is not expected to have any serious impacts on the aquatic biota in the project area. Only designated or approved borrow areas would be used as a source of gravel. No gravel would be taken from within an active stream channel. Settling basins would be used, where necessary, to intercept any sediment-laden runoff from borrow areas.

Construction adjacent to, or crossing of, the Bonaparte River would be scheduled to avoid the period of major fish spawning activities.

(iii) Nutrients

The release of nutrient enriched water into Hat Creek from Aleece and other smaller lakes would be undertaken during freshet to minimize any short-term increase in attached algae growth. Progressive reclamation techniques and the minimization of fertilizer usage would limit the amount of nutrients reaching the creeks or streams in the project area. (19)

(iv) Toxic Materials

The location of storage areas for toxic materials such as petroleum products and the location of waste dumps for these materials would be strictly regulated to prevent the accidental release of these materials into watercourses.

(v) Leachate

Leachate from waste dumps, and leachate and runoff from coal stockpiles and the mine pit would not be chemically fit to be discharged to surface waters. Such waters would be collected by means of sub-soil drains, diversion ditches or dewatering wells, and would be stored in impervious leachate ponds. Surface drainage from other areas, and seepage from surficials within the mine pit would be treated in sedimentation lagoons prior to discharge to Hat Creek downstream of the mine (see Section 11.3). Effluents from the sedimentation lagoons discharged to receiving water would meet the B.C. Pollution Control Branch Objectives (50) for all parameters.

Although concentrations of a number of water quality chemical parameters are expected to increase slightly above existing natural levels (Table 11-2), no significant impact is expected on the aquatic biota in downstream areas due to these changes.

(vi) Angling Pressure

There is a high potential for impact upon the fisheries resources in the local project area due to increased angling pressure by the construction and operational work forces. If restrictions are not placed on angling during construction, the fisheries resource in Hat Creek and adjacent lakes would likely be greatly decreased. B.C. Hydro would consider creation of other recreational facilities or activities for the workforce as a means of reducing the angling pressure within the project area. The workforce could be encouraged to utilize other fishing opportunities which will better support the increased angling pressure, such as specially stocked lakes.

## (b) Regional Effects

### (i) Acidification

The recent evidence in Scandinavia and Eastern North America on the long range (meteorological) transport of air emissions alerted B.C. Hydro to the possibility of regional deposition of the Hat Creek project emissions. Scandinavian biologists have emphasized that acidification tends to have its greatest impact on aquatic environments. This phenomenon is discussed in Section 6.5. The results of a study by ERT(24) indicate that deposition of airborne materials from the Hat Creek project will produce no significant direct or indirect environmental effects in the aquatic systems and their biological communities as a result of the project emissions. B.C. Hydro recognizes that the ability to predict long range transport or acidic occurrences as a result of meteorological conditions is an imprecise science at this time. Because of this imprecision B.C. Hydro intends to monitor for "acid precipitation" effects (see Section 26.0) to assess potential problems in the aquatic systems.

### (ii) Trace Elements

Based on information presently available, the expected increase of trace elements in the water environment (see Section 11.4(b)) as a result of stack emissions are not expected to cause any significant impacts on the aquatic biota, on the wildlife and livestock that ingest the water, or on irrigated plants.(15) Due to interacting and changing environmental conditions, the actual distribution, mobility and bioaccumulation of many elements cannot be clearly defined. The possible movements and behaviour of these trace elements have, however, been addressed in a separate trace element report.(15)

Monitoring for selected trace elements would be conducted prior to and during powerplant operation to assess any potential problems in the aquatic systems.

### (iii) Salmon Entrapment

As a result of intake design (see Section 3.4) and the relatively small percentage of the Thompson River flow which would be extracted, the expected impact of the entrapment of juvenile pink salmon would be very small. The economic value of this impact is discussed in Section 18.3.

### (iv) Siltation

A water clarification plant is proposed to remove silt and debris from the water taken from the Thompson River. The return discharge from this clarification plant back into the Thompson River is expected to have only a minor impact on water quality in the immediate vicinity of the discharge due to its small volume of the discharge. This return discharge would meet the B.C. Pollution Control Branch Objectives.

## 13.1 EXISTING SITUATION

Inventories were compiled and impacts assessed for aggregate, limestone, claystone, baked claystone and potential by-product coaly waste (see Figure 13-1). No deposits of petroleum, natural gas, salts, base metals, precious metals, potential by-product trace elements or previously unmapped coal were found in the inventory process.

Five active aggregate quarries are located in the Hat Creek area. Two of these quarries have been used for several years on a regular basis; approximately 15 000 t/annum are excavated. All are used for road construction and maintenance. Extensive additional deposits of aggregate occur among the fluvial and alluvial fan deposits of the Thompson and upper Hat Creek valleys. Without the proposed project, the amount of aggregate excavated should decrease from present levels due to completion of improvements to the upper Hat Creek valley road. Repairs to Highway No. 12, near the upper Hat Creek valley road, would result in continued use of the upper Hat Creek quarry. The sand quarry in the Thompson valley would likely be used at the same rate in the future and the gravel quarry at Boston Flats would be used at an undetermined rate. Potential projects other than the proposed project could increase demand for gravel from Boston Flats.

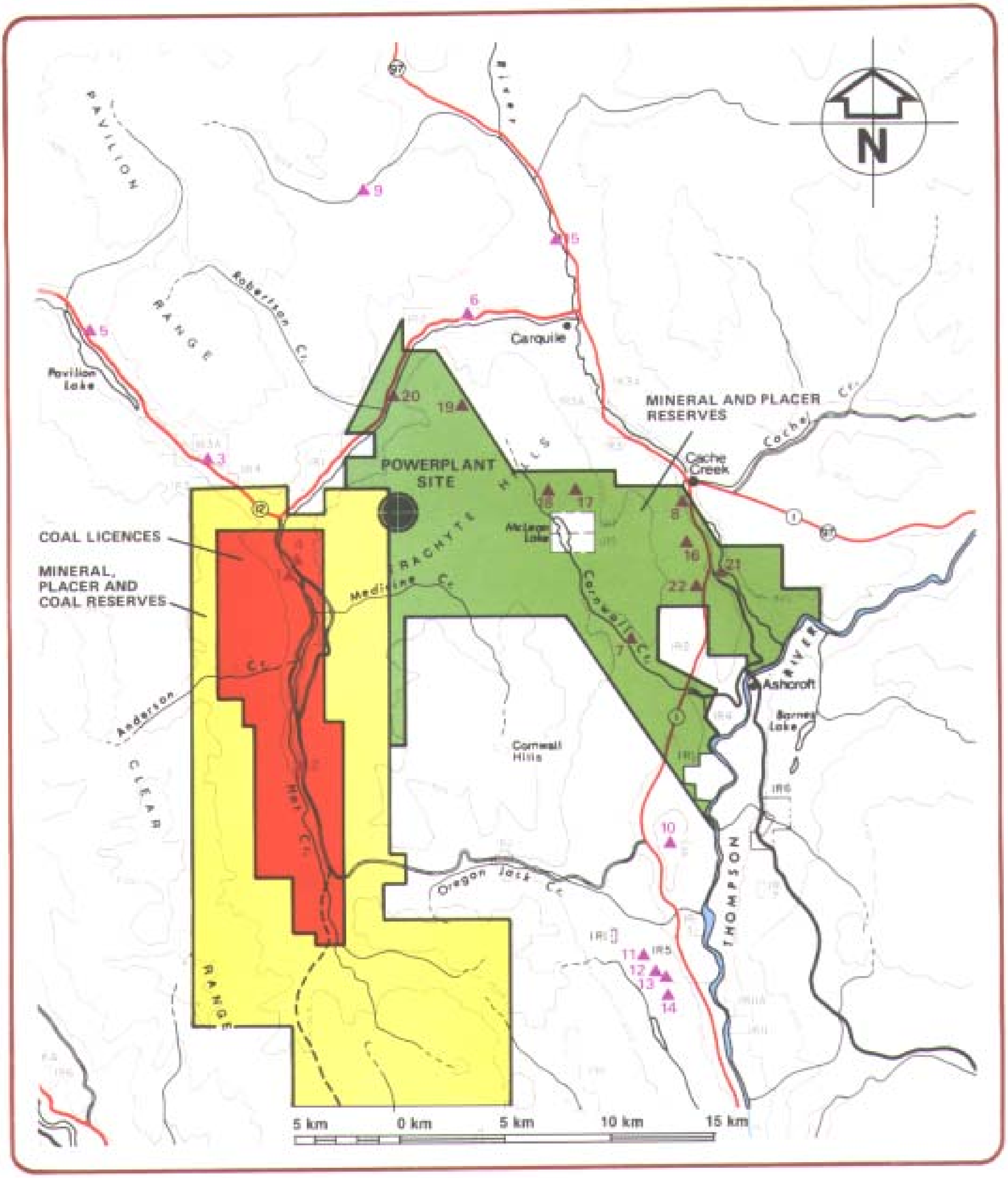
Large deposits of limestone are located near the upper Hat Creek valley. Steel Brothers Canada Limited operates a quarry in Marble Canyon, northwest of the upper Hat Creek valley; the rated capacity of that plant is 320 t/day. The lime is used principally as a neutralizing agent by nearby mine mills and pulp mills. Other limestone resources are exposed over an area of 165 $km^2$ in the vicinity of the Hat Creek valley. Although present demand for limestone and lime is low, the demand for limestone could increase significantly if new mines and a smelter were constructed in the Highland valley or near Clinton.

Unlithified claystone and siltstone comprise an appreciable thickness of the Medicine Creek and Hat Creek coal formations in the upper Hat Creek valley. Only the kaolinitic clay of the Hat Creek coal formation appears to be potentially useful, but there is insufficient information to estimate the quantities. The northeast and north central parts of the No. 1 deposit and an undetermined part of the No. 2 deposit are overlain by baked claystone. This material consists of red, orange and yellow, brick-like baked claystone and isolated pockets of grey clinker. The quantity of baked claystone is estimated conservatively at 16 Mt. The baking is the result of a natural coal fire which produced the baked claystone from partings and inherent ash associated with the coal.

Coaly waste occurs throughout the four zones of the No. 1 deposit which have been designated zones A, B, C and D. Assuming that material between 58 and 75 percent ash, (on a dry basis) is classed as coaly waste, then within the proposed 35-year mine pit, A zone consists of approximately 13.3 Mt of coaly waste, B zone 0.7 Mt, C zone 6.4 Mt and D zone no appreciable coaly waste.

## TABLE 13-1
## LEGEND FOR FIGURE 13-1

| No. | | Name - Product |
|---|---|---|
| 1 | - | Hat Creek No. 1 Deposit (coal) |
| 2 | - | Hat Creek No. 2 Deposit (coal) |
| 3 | - | Steel Brothers Canada Limited Quarry (limestone) |
| 4 | - | Upper Hat Creek Quarry (gravel) |
| 5 | - | Pavilion Lake Quarry (gravel) |
| 6 | - | Lower Hat Creek Quarry (gravel) |
| 7 | - | Cornwall (chromium) |
| 8 | - | Cache Creek (chromium) |
| 9 | - | AV (gold) |
| 10 | - | Red Hill (copper, silver) |
| 11 | - | Basque 1 (epsomite) |
| 12 | - | Basque 2 (epsomite) |
| 13 | - | Basque 3 (epsomite) |
| 14 | - | Basque 4 (epsomite) |
| 15 | - | Maggie Mine (copper, molybdenum, silver) |
| 16 | - | Midas (chromium) |
| 17 | - | McLean (unknown) |
| 18 | - | Joe (unknown) |
| 19 | - | Milk (unknown) |
| 20 | - | R (unknown) |
| 21 | - | Boston Flats No. 1 (gravel) |
| 22 | - | Boston Flats No. 2 (sand) |




HAT CREEK PROJECT

## FIGURE 13.1
# MINERAL AND AGGREGATE LOCATION MAP

*SOURCE: British Columbia Hydro and Power Authority (26)*

## 13.2 PROJECT ACTIONS

Project actions that would affect the mineral resources are mining and stockpiling, alienation by project facilities, alienation by formation of waste storage piles and construction material extraction.

## 13.3 EFFECTS OF THE PROJECT

Economic evaluations of resource impacts are discussed in Section 18.0.

Of the 320 million bank $m^3$ of ungraded aggregate in the bench northeast of the No. 1 deposit, about 183 million bank $m^3$ would be mined. Mine plans call for the separation of aggregate for use in pervious embankments to support mine waste. Aggregate underlying mining installations could not be recovered until mining and processing ceased at that location. However, accessible reserves should easily be able to meet future consumption of aggregate if the project proceeds.

Waste disposal in Houth Meadows would make approximately 280 Mt of limestone inaccessible. A wedge of limestone lies north of Houth Meadows and at a higher elevation than the proposed waste dump. This wedge contains approximately 230 Mt of limestone. For the powerplant scrubbers, limestone would be mined from a deposit close to the powerplant. Over the 35-year life of the powerplant, limestone requirements would total approximately 2.9 Mt. Because of the large area of limestone outcrops in the region, the effect of the project on development of limestone resources would not be significant.

Clay has not previously been mined at Hat Creek. Clayburn Industries Limited has expressed interest in purchasing the kaolinitic clay and the baked clay for use in bricks if the project proceeds. Plans call for the mining of baked claystone from 1 year before powerplant startup through to the 30th year of powerplant operations. Most of the baked claystone would be mined in the early years of operations. Current plans call for stockpiling the material until required for road maintenance or brick manufacture.

## 14.1 EXISTING SITUATION

Based on a sound level inventory taken during 1976, present background noise levels in the Hat Creek valley vary on average from a Yearly Day Night Average Noise Level (YDNL) of about 32 to 41 dBA in the areas away from Highway No. 12. Adjacent to this highway the noise levels range from YDNL 44 to 51 dBA.

Noise levels in the north Ashcroft area, in the region of the proposed water supply booster pumping station, are dominated by train noise from the CN/CP mainlines. Consequently the present levels which are about YDNL 56 dBA, are relatively high compared to other rural areas. At the proposed airstrip site on the Cameron Ranch, south of Cache Creek, present noise levels are estimated to be in the range of YDNL 35 to 45 dBA.

## 14.2 PROJECT ACTIONS

Noise sources from the project can be conveniently divided between the construction phase and operation phase, and would occur in both the local area (25 km radius) and the regional area (100 km radius).

(a)Local Area

(i)Construction Phase

Activities producing noise in the local area would include construction of both mine and powerplant facilities and their associated camps, the airstrip, the project access road and project-related traffic on Highway No. 12. Noise from these activities, which would be principally due to the movement of heavy equipment, would combine to produce varying degrees of impact throughout the Hat Creek valley. In addition, activity near the confluence of the Bonaparte and Thompson rivers which would include river bottom preparation and the construction of the water supply intake, pumping station and pipeline would result in increased noise levels in the Ashcroft area.

(ii)Operation Phase

Once the project becomes operational, noise from the powerplant, mine and offsite facilities such as the water supply system would be of an essentially constant and continuous nature.

(b)Regional Effects

In the regional area beyond 25 km the only noise would be that associated with the construction and operation of the equipment unloading facility, in particular truck traffic.

## 14.3 EFFECTS OF THE PROJECT

### (a) Local Effects

(i) Construction Phase

The Bonaparte Indian Reserve No. 1 would experience average construction noise levels ranging from YDNL 62 dBA in its southwest corner to YDNL 35 dBA in its northeast corner. The 62 dBA level would be very annoying if any residents were located in this area. However, the predicted level at the closest residence is approximately YDNL 56 dBA which would be moderately annoying. The 35 dBA level would be insignificant. Increased traffic along Highway No. 12 between Carquile and the project site would increase the YDNL 27 m from the highway by about 1.5 dBA. However, since there are no dwellings this close to the highway, this increase would be insignificant.

Sound levels at two Hat Creek valley ranches are expected to be affected by construction activity noise. Levels at the nearest ranch (E. Lehman) would increase from the present YDNL of between 35 and 40 dBA to about YDNL 60 dBA and would be very annoying. At the next nearest ranch (I. Lehman/Saulte) noise levels would reach YDNL 50 dBA which would be moderately annoying. Other ranches located further from the construction activity are not expected to experience any significant increase in noise levels.

Within 210 m of the powerplant fence, construction activity noise is expected to make the land unsuitable for cattle grazing. However, about 90 percent of the land is rated as low quality for forage use, so cattle grazing patterns would be unlikely to be seriously altered by construction noise. Steam line blow-outs could startle cattle grazing within 900 m of the fence.

The small residential community near the confluence of the Bonaparte and Thompson rivers would experience noise from several different, and at times concurrent, construction activities, namely the preparation of the river bottom and subsequent construction of the water supply intake, the construction of the No. 1 booster pumping station, construction of the water supply pipeline itself, and replacement of the existing bridge over the Bonaparte River. The effect of river bottom preparation would, depending on receiver location, increase present noise levels of YDNL 55 to 62 dBA by a maximum of 1 dBA. Although noticeable at times this slight increase would not be signicant. The construction of the water intake would result in an increase of 3 to 5 dBA from present noise levels while the construction of booster pumping station No. 1 is expected to raise the YDNL levels by about 1 to 4 dBA. Noise levels in this area are already high and therefore these further increases would be slightly to very annoying depending upon the proximity of any particular residence to the construction activity. Noise from the construction of the water supply pipeline would not result in any increase to the existing YDNL but for a period of a few days the noise levels could rise as high as 75 dBA. Similarly, replacement of the existing bridge across the Bonaparte River would not increase existing YDNL'S and no significant annoyance would result.

Noise from the construction of booster pumping station No. 2 would make a small area of land (0.3 $km^2$) incompatible with grazing for about 5 months.

In the north Ashcroft area construction of the pipeline would increase noise levels by 20 dBA for a few days. However, the yearly average noise level (YDNL) would increase by at most 2 dBA and would only be slightly annoying to the local residents.

Construction of the access road is expected to increase average noise levels at the southern edge of the McLean Lake Indian Reserve from a present estimated value of about average day night level (Ldn) 35 dBA to between Ldn 47 and 65 dBA over a period of approximately 50 working days. This could result in some annoyance to recreationists particularly if this construction occurs during the summer months.

Upon completion of the project access road, construction truck traffic past the McLean Lake Indian Reserve would result in some annoyance to recreationists. The peak noise level as a truck passes by is expected to be as high as 70 dBA at the southern edge of the reserve and 53 dBA at the northern edge. Yearly average day night noise levels would remain unchanged (or 35 dBA) except for a small area between McLean Lake itself and the access road where levels would reach YDNL 46 dBA.

(ii)Operation Phase

Noise from the mining operation would result principally from the movement of heavy equipment within and around the open pit operation and from the coal stacker-reclaimer, conveyors and crushers. Intermittently, impulsive noise from blasting and noise from the mine public address system would momentarily increase noise levels.

The southwestern portion of the Bonaparte Indian Reserve No. 1 would be affected primarily by noise from mining access road traffic and coal preparation. This area would receive noise levels as high as YDNL 62 dBA which would be very annoying if any residents were situated at this noisiest location. However, the predicted YDNL at the closest residence is approximately 57 dBA which would be moderately annoying. Project-related traffic noise on Highway No. 12 is not expected to add significantly to traffic noise which would occur without the project.

The two ranches nearest to the open pit, E. Lehman and I. Lehman/Saulte, would perceive mining noise levels of about YDNL 70 dBA and YDNL 63 dBA respectively, which would be extremely annoying; indeed these houses are expected to be displaced by the mining operation. The next two ranches (A. Parke and D. Ridlar/Baldwin) are expected to experience noise levels of YDNL 45 to 49 dBA, which would be moderately annoying to the residents. The next two ranches to the south (A. Pocock and G. Parke) are expected to experience plant noise of YDNL 41 to 42 dBA; however, since the present average level is YDNL 35 to 40 dBA, it is expected that the increase would be insignificant. Intermittent blasting noise could be startling up to a distance of about 8 km depending on atmospheric conditions and background noise levels. Residents on the Bonaparte Indian Reserve No. 1 and Hat Creek residences as far south as Ridlar/Baldwin could be affected.

In the region of the powerplant, noise would be generated from the boilerhouse and turbine building, fans, transformers and the two natural draft cooling towers. These noises would tend to be of a continuous nature with occasional intermittent noise from steam vents and circuit breakers. These sources make a minor contribution to the overall levels in the valley as discussed above. A small area of land in the Trachyte Hills (4 km$^2$) would be made incompatible with cattle grazing. However, the majority of this land (90%) has low grazing potential and therefore the useful grazing land lost would be minimal.

The noise from the operation of booster pumping station No. 1 is expected to have minimal effect on the nearby residences since low-noise water-cooled pumps would be used. Residences would be shielded from transformer noise by the pumping station building. Similar noise levels are predicted from booster pumping station No. 2; no impact is predicted on the adjacent grazing land.

Once the station is in full operation traffic noise past the Mclean Lake Indian Reserve could result in some annoyance to recreationists. Peak noise levels as a truck passes by could reach 70 dBA at the southern edge of the reserve and 53 dBA at the northern edge. However, the YDNL would remain unchanged except for a small area between McLean Lake itself and the access road where the level would read YDNL 42 dBA.

Rattlesnake Substation transformers located on the hillside north of Cache Creek are expected to produce about 40 dBA in the residential community 1.5 km away. Since noise levels in this community are presently YDNL 55 to 60 dBA, the transformer noise would be inaudible.

The airstrip is now expected to be located on a ranch southwest of Ashcroft. Although the noise from airstrip operations would extend through grazing and agricultural land, it would not reach populated areas. An insignificant impact on land use is predicted.

(b) Regional Effects

The final site for the equipment unloading facility has not yet been decided. However, where possible, truck routes would be selected to bypass residential areas and thereby minimize impacts.

Effects of the project upon outdoor recreation were analyzed by geographic areas as shown on Figure 15-1. Area A includes the powerplant, mine site and the immediate project area. Area B encompasses the Hat Creek valley and surrounding ranges and hills, where the greatest impacts could occur from the powerplant air emissions. Area C includes major highways and human settlements near the project. Area D extends beyond Area C to a radius of 100 km around the project site and contains the areas likely to be affected by powerplant air emissions. This last area includes a variety of recreational opportunities and facilities, some of which would be utilized by workers employed at the Hat Creek project.

## 15.1 EXISTING SITUATION

### (a) Recreational Assets

Within areas A and B, a variety of natural features can be found which are useful for recreational activity. Major recreational assets in the Hat Creek valley and adjacent areas are shown in Figure 15-2. In contrast to portions of the surrounding area, the Hat Creek valley is not normally a destination for sightseers although its pastoral charm provides a pleasant diversion. Pictographs found in Marble Canyon and along Oregon Jack Creek provide visible evidence of man's presence in prehistoric times. For the gem hunter, the Hat Creek valley possesses identified sites for agate, amber and opalite. Many of the lakes and streams in this area support fish and provide an important recreational resource for anglers. The flat to rolling terrain of the area is conducive to various recreational activities including backroad travel, snowmobiling and cross country skiing. At the higher elevations in the Pavilion and Clear ranges, hiking is possible with established trails available in some locations. A variety of animal life of interest to hunters is supported within the various vegetated zones.

For the active recreationist the principal assets of Area C are its streams and lakes. For the passive recreationist, the scenic beauty of the Thompson and Fraser River Canyons are important features. Important assets include the Clear Range with attractions for hikers, Botanie Mountain for naturalists and viewers, the Camelsfoot Range for hunters and the Thompson River for fishing, canoeing, rafting and viewing. The Thompson Canyon, arid with semi-desert vegetation, contrasts with the richness of the Fraser's coniferous forested slopes. The Bonaparte Canyon, minor by comparison, offers much less topographic relief but adds interest with a series of lakes scattered in the valley floor.

In Area D, active recreation is dominated by the numerous lakes used by anglers such as Kamloops Lake on the east and Seton Lake on the west. Hunting is important throughout the area and the species sought are related to terrain and topography. Scenic values are significant in some areas with the dominant snow-capped peaks of the Coastal Range creating an exciting visual experience.

## (b) Facilities

Recreational facilities within Hat Creek valley and nearby areas are shown in Figure 15-3. The only private facility in the vicinity is located on Pavilion Lake. Closer to the project site the Parks Branch maintains Marble Canyon Park. Physical constraints have limited development of new facilities at both Marble Canyon and Pavilion Lake.

In Area C motel-hotel and camping facilities are available in Cache Creek, Ashcroft, Clinton and Lillooet. Resort and ranch facilities can be found in the vicinity of Ashcroft, north of Cache Creek and south of Lillooet. Day use and overnight facilities exist at Parks Branch sites at Cayoosh, Kelly Lake and Kersey Lake parks. The Forest Service has campsites at Barnes and Willard lakes southeast of Ashcroft. A number of recreational reserves have been established throughout Area C. Excellent access in Area C is provided by highways 1, 97 and 12.

Area D is the dominant source of recreational facilities within the study region. Kamloops is the most important single site for tourist accommodation and many of the lakes north and south of this city contain hunting and fishing resorts. The Parks Branch maintains several major facilities in Area D including Loon Lake, Lac Le Jeune, Savona and Big Bar Lake parks.

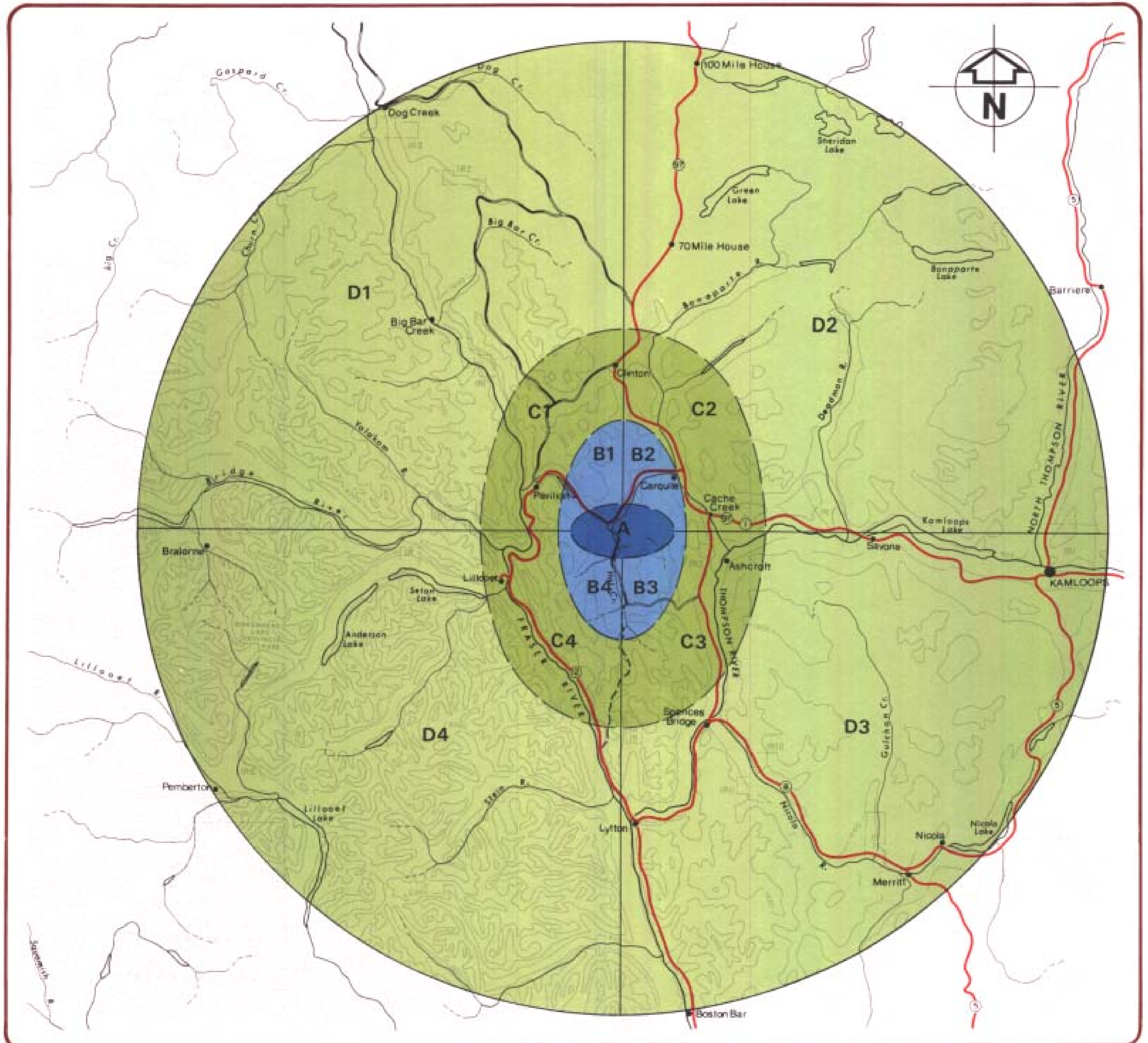
## (c) Recreational Activities

Because the resident population in Hat Creek valley is small and because there are few recreational attractions, current recreational activity in Area A (the immediate project area) is estimated to be low. Beyond the project area, Area B supports significant outdoor recreational activities, which are primarily pursued by non-residents. This area includes the popular Pavilion Lake and Marble Canyon sites.

Dominant activities in the Hat Creek valley and adjacent areas are hunting and backroad travel, which account for about 25 percent and 35 percent of all estimated activity days respectively. Hunting takes place throughout the area with location dependent on species sought. Backroad travel is believed to take place throughout the Hat Creek valley proper between the farms and the adjoining hills and mountains. Angling accounts for about 20 percent of all activity days, occurring predominantly at Pavilion Lake and Marble Canyon Park. Less than one-fifth of fishing activity occurs along Hat Creek and nearby small lakes. Other activities (excluding sightseeing) account for less than 20 percent of all activity days and occur primarily at Pavilion Lake and Marble Canyon Park where developed recreational facilities are found.

Area C is estimated to support about 40 percent of all local residents' recreational activity. The most popular local resident recreational activity in Area C is angling, estimated at about 35 percent of all activity, followed by backroad travel which accounts for about 30 percent. Hunting is the least important local resident activity in Area C, accounting for less than 3 percent of the total.

Although recreational data for Area D are not available, a home interview survey indicated that about 45 percent of all local residents in Clinton, Cache Creek and Ashcroft use Area D for their recreational pursuits. Local anglers appear to favour Loon, Green, Kelly and Big Bar Lakes and local hunters use the Loon Lake area as well as sites near Machete and Bonaparte Lakes. Green Lake is a favourite for "lake and shore" activities. Backroad travel is scattered widely with the Clinton-Loon Lake, Fraser-Lillooet and




## LEGEND

- AREA A
- AREAS B1, B2, B3 & B4
- AREAS C1, C2, C3 & C4
- AREAS D1, D2, D3 & D4

SCALE — 1:750,000

15 km 0 km 15 km 30 km 45 km

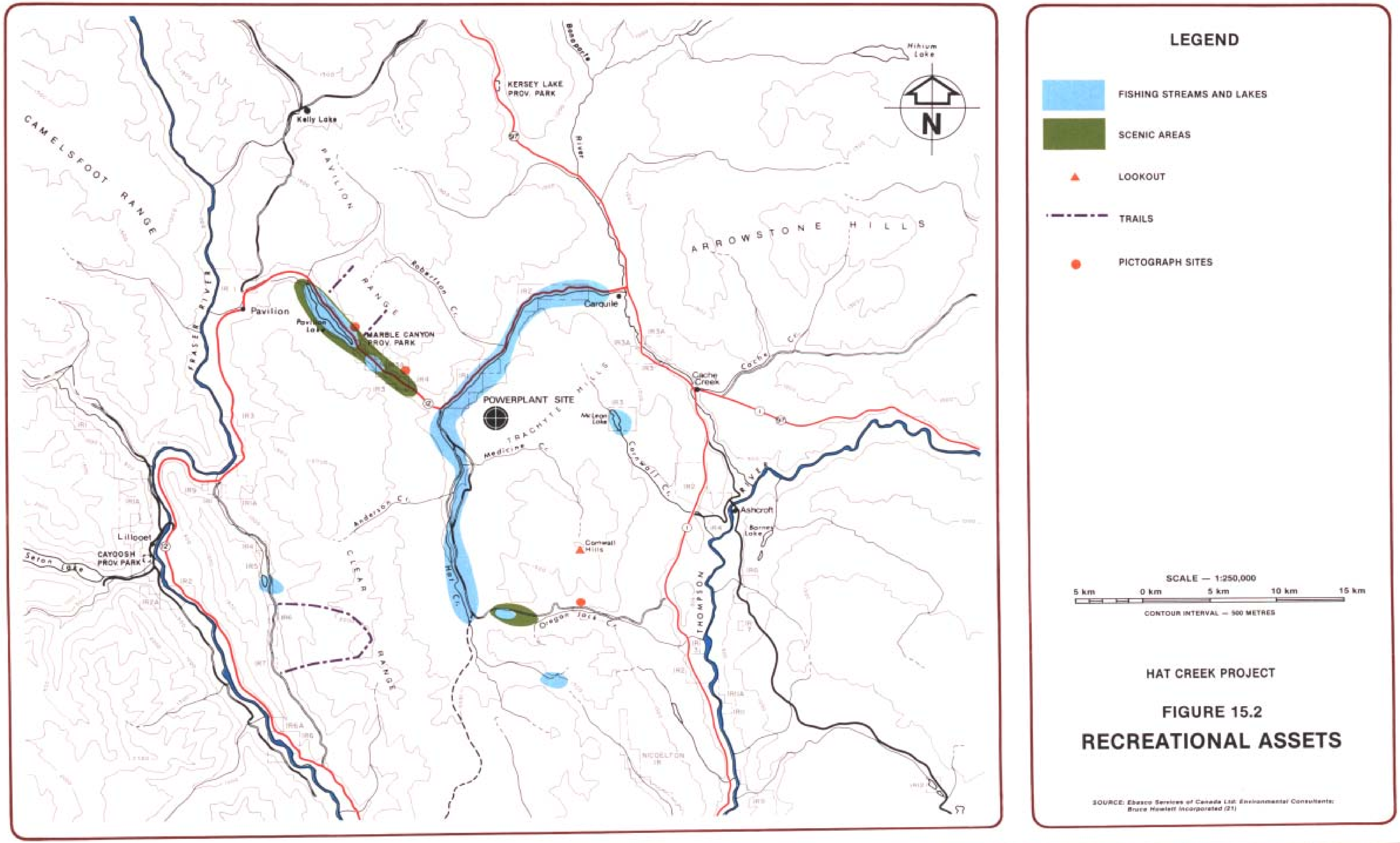
CONTOUR INTERVAL — 500 METRES

HAT CREEK PROJECT

FIGURE 15.1

# RECREATION STUDY AREAS

*SOURCE: Ebasco Services of Canada Ltd: Environmental Consultants; Bruce Howlett Incorporated (21)*

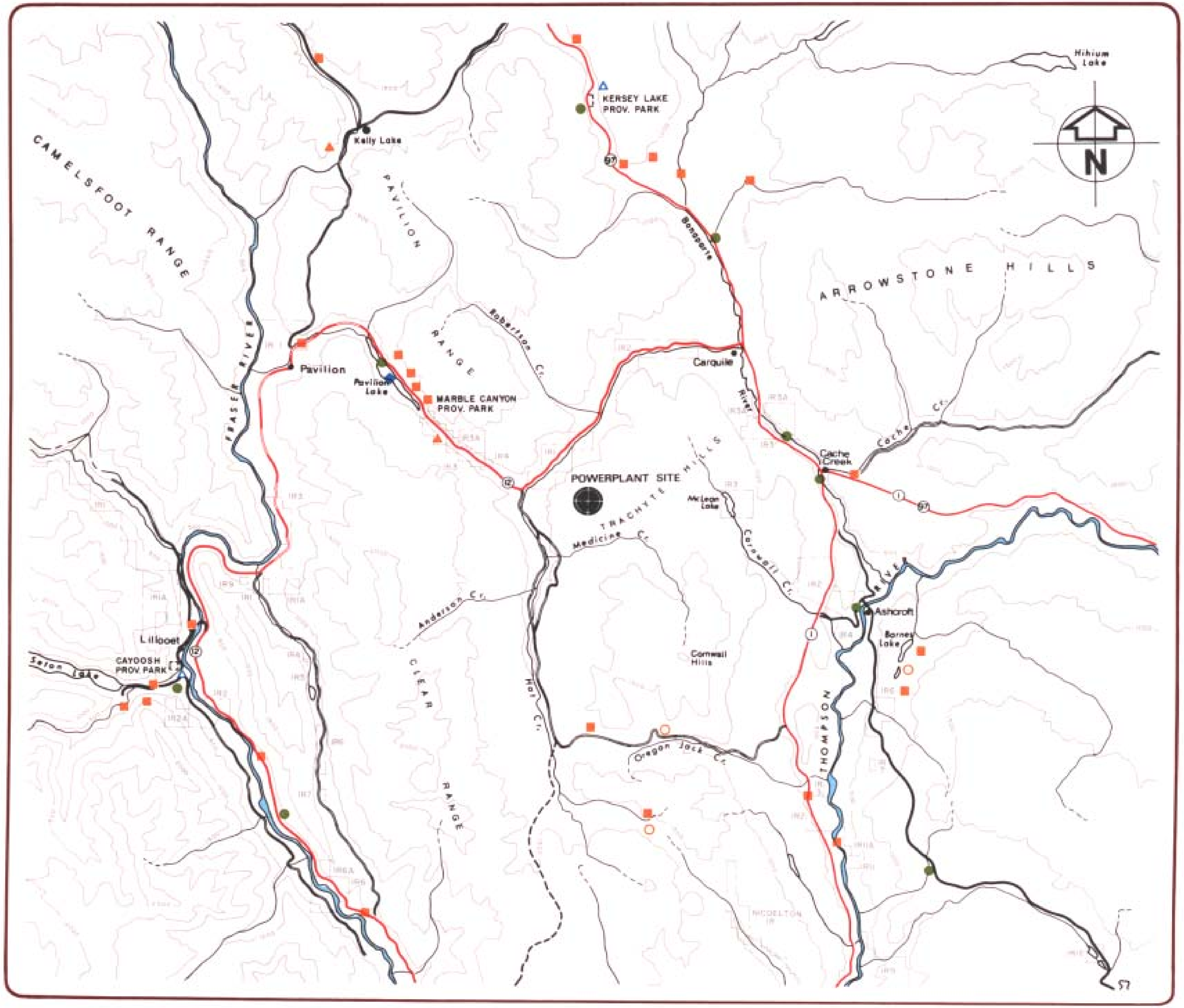



HAT CREEK PROJECT

FIGURE 15.2

## RECREATIONAL ASSETS

SOURCE: Ebasco Services of Canada Ltd: Environmental Consultants: Bruce Howlett Incorporated (21)




## LEGEND

- PARKS BRANCH DAY USE SITE
- PARKS BRANCH CAMPGROUND
- PRIVATE CAMPGROUND AND CABINS
- FOREST SERVICE CAMPGROUND
- RECREATION RESERVE
- BOAT LAUNCHING RAMP

SCALE — 1:250,000

5 km 0 km 5 km 10 km 15 km

CONTOUR INTERVAL — 500 METRES

HAT CREEK PROJECT

## FIGURE 15.3
# RECREATIONAL FACILITIES

SOURCE: Ebasco Services of Canada Ltd: Environmental Consultants; Bruce Howlett Incorporated (21)

Guichon-Highland valley areas most favoured. "Other" activities are concentrated at Loon Lake, Deadman River and the north Thompson-Kamloops area.

(d)Changes in Recreation without the Project

Without the project, it can be assumed that recreational activity in these areas would expand, with non-residents playing a progressively larger role. Recreational activity growth would be mainly due to population increases and more leisure time.

## 15.2 PROJECT ACTIONS

Project actions which would cause impacts upon local recreation can be divided into construction and operation phase activities. During construction, land surface disturbance would affect local recreational patterns in the Hat Creek area. Increased recreation demand by the construction labour force would also affect recreational patterns, since workers would utilize resources and facilities in the local area, creating much greater pressure than exists at present. Operation phase impacts could potentially occur in the local area as a result of the project's air and water emissions, as well as land use changes. Increased recreation demand due to the presence of the project labour force would also create recreational impacts in all four areas.

## 15.3 PROJECTED RECREATION CHANGES WITH THE PROJECT

Economic evaluations of resource impacts are discussed in Section 18.4.

(a)Construction-related Impacts

Construction-related impacts upon recreation would occur predominantly in Areas A, B-3 and C-3. The mine, powerplant and some offsite facilities are located in Areas A and B while the balance of the offsite facilities are found predominantly in Area C-3.

There are no specific recreational facilities that would be affected by project construction. Hunting, fishing, backroad travel and sightseeing activities which presently occur in disturbed site areas could be expected to move to other locations. However, gem hunting along Medicine Creek (which is an activity included as backroad travel) would be substantially reduced or eliminated.

Although the amount and type of game animals affected by the disturbed area cannot be accurately measured, it can be assumed that a net reduction in game population would occur due to habitat loss. It is possible that existing game may disperse to other areas as a result of project activities. Impacts on wildlife are discussed in Section 10.0.

Fish resources in Hat Creek would be disturbed over the approximately 8 km section of creek to be diverted. Diversion probably would result in the entire loss of fish in this section. Angling that formerly occurred in this section would be eliminated.

Backroad travel probably occurs in the area to be disturbed by the project, particularly in the Trachyte Hills which are somewhat more open than other nearby terrain. This activity would be constrained or eliminated.

Sightseeing of the natural environment in the project area would also be altered. The project would be most visible in the Medicine Creek valley and upper Hat Creek valley, with some project elements visible from Marble Canyon and Highway 12. It should be noted that sightseeing would not necessarily be adversely affected by the project. During the project construction phase it can be reasonably expected that both local residents and tourists would make special trips to view the activities taking place. It is possible that substantial increases in the amount of sightseeing could occur.

Table 15-1 presents estimates of the number of annual recreational activity days displaced by the project during the construction phase. The displacement would occur in the first year of construction and carry through the life of the project. The estimates in Table 15-1 do not take into account potential substitution effects, as these are very difficult to measure. The numbers in the table reflect a 1988 in-service date and thus are larger, due to population and participation growth, than those in the recreation report which assumed a 1984 in-service date. Annual losses would increase at the assumed growth rates throughout the life of the Project. At the beginning of the construction period, displaced recreational activity would amount to about 6 percent of the total activity in the Hat Creek valley and environs.

(b)Operation Related Impacts

Operation activities affecting recreational activities would include: gradual filling of the ash and mine waste disposal area; impacts to the surrounding vegetation caused by reduction in air quality; and dust, stack emissions and cooling tower plumes affecting scenic values beyond the physical presence of the project itself.

Gradual filling of ash disposal areas would predominantly affect backroad travel recreation in Area A. It is expected that backroad travel could continue in the unfilled portions of project disposal areas. Other activities including nature study, plant collecting and walking would be slightly affected due to the utilization of land during the operation phase. In total these precluded recreational activities are expected to amount to less than 100 days yearly.

Project facilities would adversely affect natural scenic viewing. Clarity of the air would be slightly reduced due to dust creation and to particulate emissions. Visibility of the powerplant stack plume and cooling tower plumes could also affect scenic values. Nevertheless the physical presence of the project should attract sightseers. It is therefore expected that the net impact of the project would be to increase sightseeing activity.

The impact of powerplant stack emissions on recreation is difficult to demonstrate or quantify. Stack emissions could have adverse effects upon some vegetation at higher elevations in the valley, as discussed in Section 7.0. However, potential visual impacts, resulting from the minor growth reduction of vegetation, are considered to be small. It is expected that stack emissions would not directly reduce visitation rates or activities in the upper reaches of the hills surrounding the valley.

It is expected that hunting activity would be completely prohibited in Area A and reduced in Area B, due to implementation of a "No Shooting" zone.

TABLE 15-1
ESTIMATED ANNUAL RECREATIONAL ACTIVITY DAYS DISPLACED BY THE PROPOSED PROJECT (21)

| Affected Activity | Construction Phase Areas A and B | | | Operation Phase Area A | | |
|---|---|---|---|---|---|---|
| | Amount | Quality | Impact Significance | Amount | Quality | Impact Significance |
| Hunting | 1060 | Undetermined | - | 130 | Undetermined | Low |
| Fishing | 1870 | Undetermined | High | - | Undetermined | - |
| Backroad Travel | 190 | Fair | Moderate | 320 | Fair | Low |
| Other | 60 | Undetermined | - | 130 | - | - |
| Sightseeing | NA[1] | Good | - | NA[1] | Good | - |

1. Sightseeing is expected to increase because of the project.

Adverse impacts on fisheries in Hat Creek would continue in the operation phase. Fishing would be lost along the length of the Hat Creek diversion.

It is possible that the impacts described in this section would simply create changes in the location of future recreational activity rather than an absolute loss. However the extent to which this substitution would occur has not been predicted although some increase to the Hat Creek fishery is anticipated with the development of the headworks dam. To avoid underestimating recreational impacts, the recreational activities displaced due to the project's operational phase are assumed to be net losses, with no substitution occurring. These estimates of displaced annual recreational activity are shown in the right-hand side of Table 15-1. They also have been modified from the recreation report to reflect a 1988 in-service date.

(c) Impacts of Project-related Recreation Demand

Increased recreational activities with and without the project are shown in Table 15-2. Without the project, recreational demand in the area would be expected to increase due to natural population growth and increased leisure time (shown as Local Population (non-project) on Table 15-2).

TABLE 15-2

PROJECT INDUCED INCREASES IN RECREATIONAL ACTIVITY
(Recreation Days)

| Activity Source[1] | 1980 | 1982 | 1984 | 1986 | 1988 | 1990 | 1992 |
|---|---|---|---|---|---|---|---|
| Project Population | - | 22 060 | 81 000 | 63 040 | 19 800 | 1 320 | 1 400 |
| Hat Creek Camps | - | 21 820 | 64 240 | 87 000 | 87 580 | 101 600 | 109 260 |
| Clinton | - | 2 600 | 7 560 | 10 230 | 10 240 | 12 000 | 12 950 |
| Other Areas | - | 1 300 | 3 740 | 5 120 | 5 040 | 6 030 | 6 410 |
| | - | 47 780 | 156 540 | 165 390 | 122 660 | 120 950 | 130 020 |
| Local Population (Non-project) | 125 200 | 135 630 | 146 060 | 156 500 | 166 950 | 177 400 | 187 850 |
| TOTAL | 125 200 | 183 410 | 302 600 | 321 890 | 289 610 | 298 350 | 317 870 |

1 Based on population forecasts presented in Strong Hall and Associates Ltd.(23) report.

With the project, recreational demand in the area would be expected to increase further due to the presence of the construction and operations work force and attendant population increase.

Table 15-2 shows that the total amount of recreational activity would be between 1.5 and 2 times higher in the early-1990s with the project than without it. This may have a larger impact on the quantity and quality of regional recreational resources than any direct project actions, but no attempt was made to evaluate the impact quantitatively.

## SECTION 16. AESTHETICS(22)

Consideration of aesthetic or visual effects is a relatively new aspect of project impact assessment. While there is an accepted methodology for classifying the visual quality of the existing natural environment, there is less agreement on how to measure the impacts of man-made changes in landscapes.

For this project, an analysis of visual impacts was made on the basis of methods accepted by the Resource Analysis Branch of the Provincial Ministry of the Environment. The methodology involved three steps. First, the existing visual qualities and sensitivity to change of the study area (see Figure 16-1) were assessed. Second, the potential causes of visual impact within the project were described and evaluated on the basis of projected effects upon viewers. Third, the importance of the impact was judged subjectively by considering the quality and magnitude of changes in the study area's visual environment. Measures were then recommended to minimize, enhance or mitigate the visual impact of the elements upon the existing landscape.

### 16.1 EXISTING ENVIRONMENT

An inventory of visual resources now existing within the study area was accomplished by dividing the area into "visual units". A visual unit was defined as an area "having a continuous sense of enclosure and containing scenic elements which provide unifying or distinctive qualities to the landscape". Visual units have boundaries, partial or complete, such as ridgelines, distinct slope changes or valley forms. After the visual units were identified they were ranked in a qualitative way so that their relative importance could be judged. Evaluation or ranking of the existing visual quality within the study area was based on the opinion that viewers are stimulated by variety, vividness and unity in the scenes viewed. Further, the components of those factors are boundary definition, general form, terrain pattern, visual features, vegetation, water presence and land use pattern.

Based on these criteria, visual units were defined and evaluated through the use of aerial photographs, maps, field work and site photographs. Ten visual units were delineated, as shown on Figure 16-1, which include Marble Canyon, upper Hat Creek valley, Medicine Creek valley, Cattle valley, Highway No. 12, Cache Creek, Thompson River, Highway No. 1, Oregon Jack and Langley. Two special features were also identified: Cornwall Lookout and the Trachyte Hills. These visual units were divided into four categories ranging from "outstanding" to "fair to poor" based on the quality of the visual landscape.

Table 16-1 shows the ranking for each of the 10 defined visual units. Two special features of the visual environment, Cornwall Lookout and the Trachyte Hills, received separate qualitative descriptions, since the general criteria for landscape components are not applicable to either of these elements.

The Cornwall Lookout provides a special and unique experience to the study area. Located on a high point within the study area, it produces a majestic panoramic view, extending from the snowcapped Coast Range on the west and southwest, to the Highland Valley and the Thompson River Valley to the east and northeast. Visual quality: outstanding.

TABLE 16-1
VISUAL UNITS IN THE HAT CREEK AREA (22)

| Visual Unit | Normalized Ranking of Visual Units[1] (by Assessors) Unity A B C | Variety A B C | Vividness A B C | Visual Quality Numerical Rank[2] | Level of Visual Quality |
|---|---|---|---|---|---|
| Marble Canyon | 7 6 7 | 7 5 5 | 7 6 7 | 57 | Outstanding |
| Langley | 6 6 7 | 7 7 6 | 6 7 5 | 57 | Outstanding |
| Oregon Jack | 6 4 7 | 6 7 6 | 6 5 5 | 52 | Outstanding |
| Upper Hat Creek Valley | 5 7 6 | 6 5 7 | 4 5 3 | 48 | Outstanding |
| Thompson River | 3 2 6 | 4 4 7 | 3 6 5 | 40 | High |
| Cattle Valley | 5 2 3 | 5 6 2 | 5 3 1 | 32 | High |
| Medicine Creek Valley | 3 6 1 | 2 7 2 | 2 5 2 | 30 | High |
| Highway 12 | 4 1 3 | 3 4 4 | 3 1 4 | 27 | Average |
| Cache Creek | 2 1 2 | 2 2 3 | 1 2 3 | 18 | Fair to Poor |
| Highway 1 | 1 4 1 | 1 2 1 | 1 4 1 | 16 | Fair to Poor |

1. A high ranking is considered "visually" good.

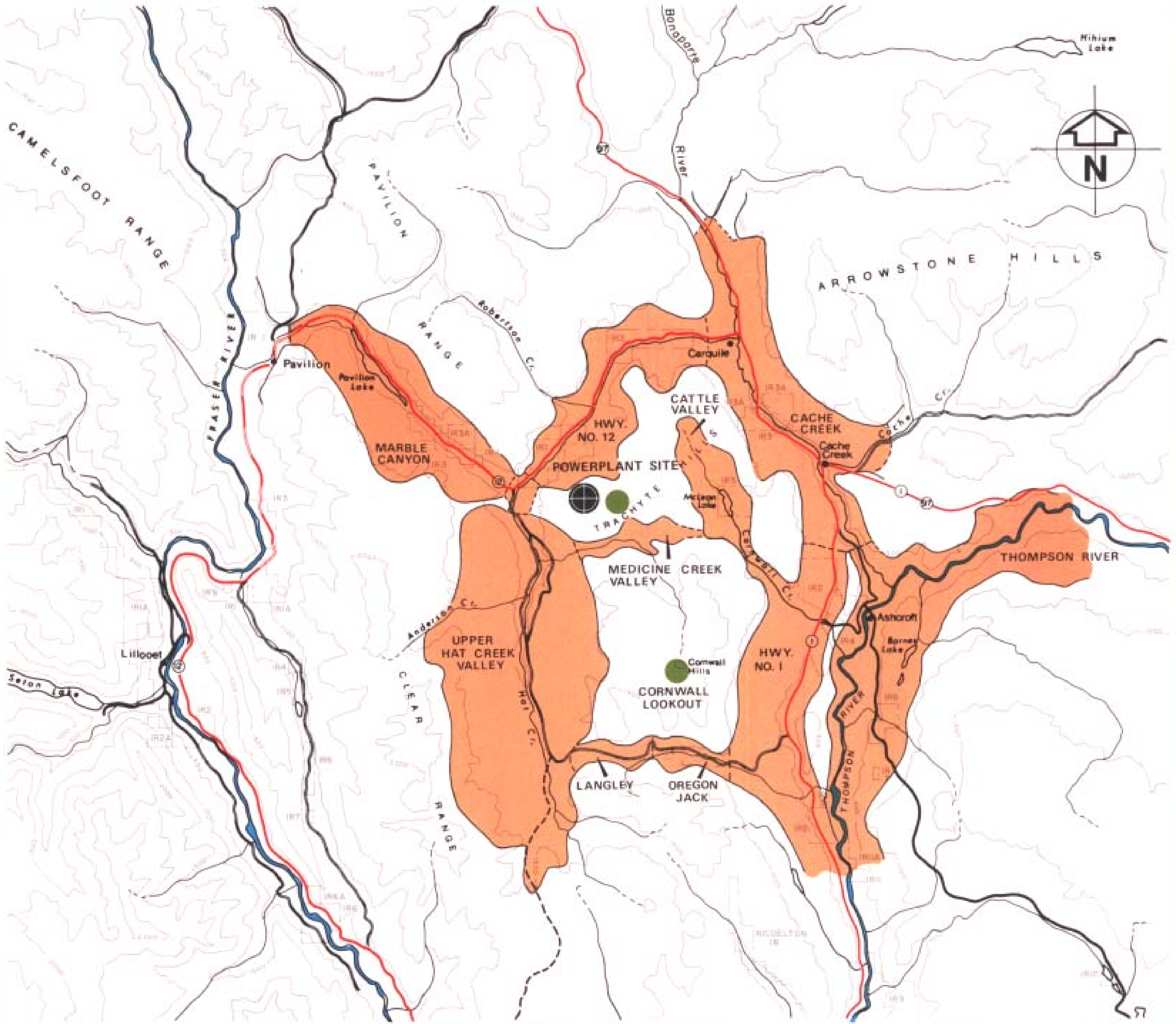
2. Represents the sum of normalized scores for unity, variety, and vividness.

The Trachyte Hills are significant because they contain the powerplant site. From various points around the proposed powerplant site, vistas of Highway 12, Marble Canyon, upper Hat Creek valley and Medicine Creek valley can be seen. Visual quality: high.

If the proposed project does not proceed, it is expected that the visual aspects of the Hat Creek valley and environs would change little from their present state. There may be further agricultural development, but it is unlikely that industrial development will occur that is of sufficient significance to affect the aesthetic qualities of the area.

## 16.2 PROJECT ACTIONS

Both the construction phase activities and operation phase project components would alter the aesthetic environment. However, the primary concern is with




## LEGEND

VISUAL UNITS

SPECIAL FEATURES

SCALE — 1:250,000

5 km 0 km 5 km 10 km 15 km

CONTOUR INTERVAL — 500 METRES

HAT CREEK PROJECT

## FIGURE 16.1

# VISUAL UNIT MAP

SOURCE: Toby, Russell, Buckwell and Partners Architects (22)

the latter phase, since during construction stages the visual impact would be too dynamic to propose meaningful mitigation or enhancement procedures. During operation of the project, the outline of powerplant facilities on the horizon would create a long-term change in the visual environment from a limited number of locations.

## 16.3 PROJECT EFFECTS

(a) Construction Phase

Construction activities would create short-term changes in the aesthetic qualities of the project site and environs. Heavy equipment, a large work force and the areas of land disturbance would mean that the existing quiet scene would be turned into one of extensive activity. Noise, dust, and debris in and around the construction areas would affect aesthetic qualities.

The magnitude of these impacts cannot be accurately measured, although they would not extend beyond the local area. Residences in the closest settlements (Pavilion and Carquile) would receive minimal impact since they are about 18 km away from the site. Since the construction activity would attract viewers to the area, some people would likely regard the construction activity as a positive change in the visual environment. Others would find these alterations a short-term negative impact.

(b) Operation Phase

When the project facilities are completed a number of its components would have a significant effect on the visual environment of the valley and surrounding area. Major components of the project which would have a visual impact are as follows: the powerplant and related facilities, including the stack, boiler house, turbine house and cooling towers; the open-pit mine and related facilities, including coal storage areas and ash and waste disposal areas; linkages, such as conveyor systems and roads; and the water supply intake facilities, booster pumping stations and water supply pipeline.

The impact cause matrix in Table 16-2 identifies the visually impacted areas and the project elements that cause that impact.

The most significant visual impacts would be caused by the elements associated with the open-pit mine and the blending facilities. These project elements would affect the visually sensitive junction of the Marble Canyon, upper Hat Creek and Highway 12 visual units.

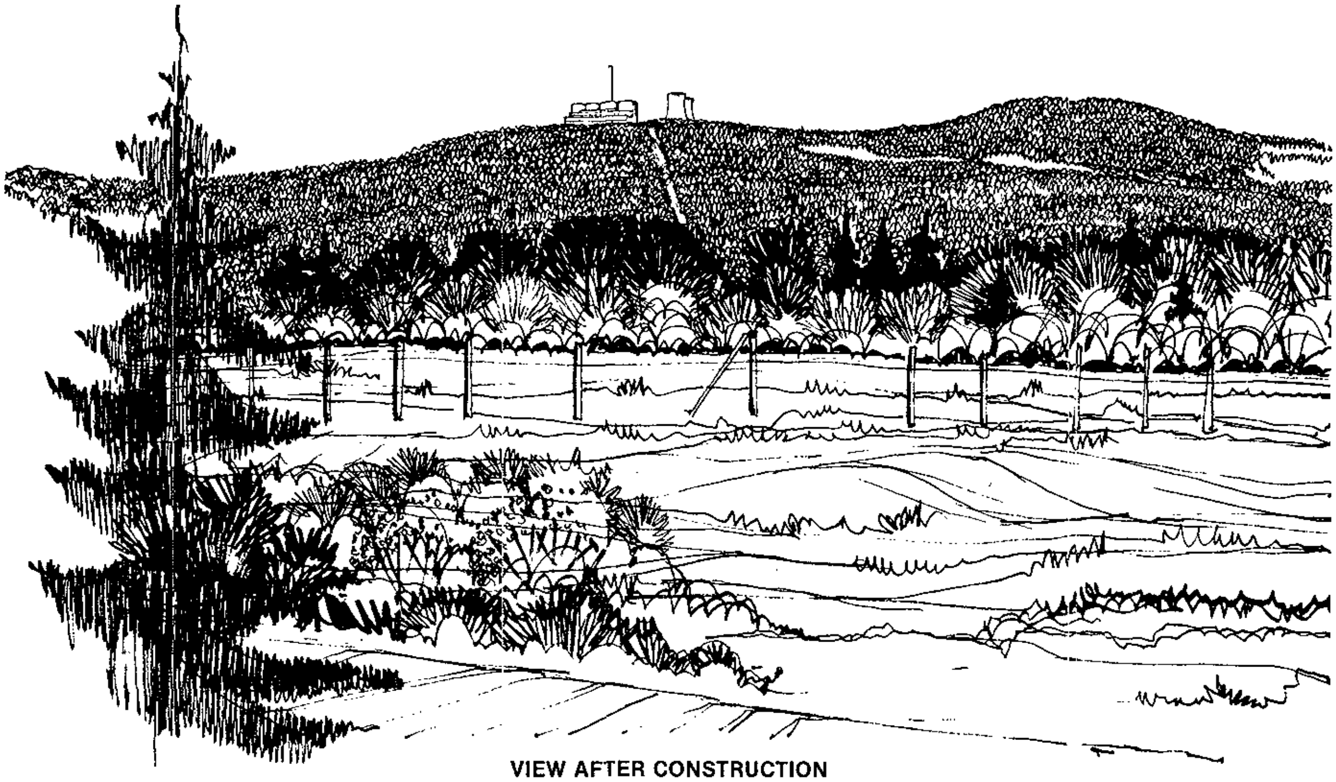
The next most significant impacts would be caused by the elements associated with the powerplant. These elements would dominate the surrounding landscape which includes the Trachyte Hills, Cornwall Lookout and the Medicine Creek valley visual units.

Figure 3-9 presents a view of the powerplant from the west and Figure 3-1 shows a project overview from the southeast. A sketch of the expected view of the powerplant from the eastern entrance to Marble Canyon is shown on Figure 16-2, while the view from Highway 12 is shown in Figure 16-3.

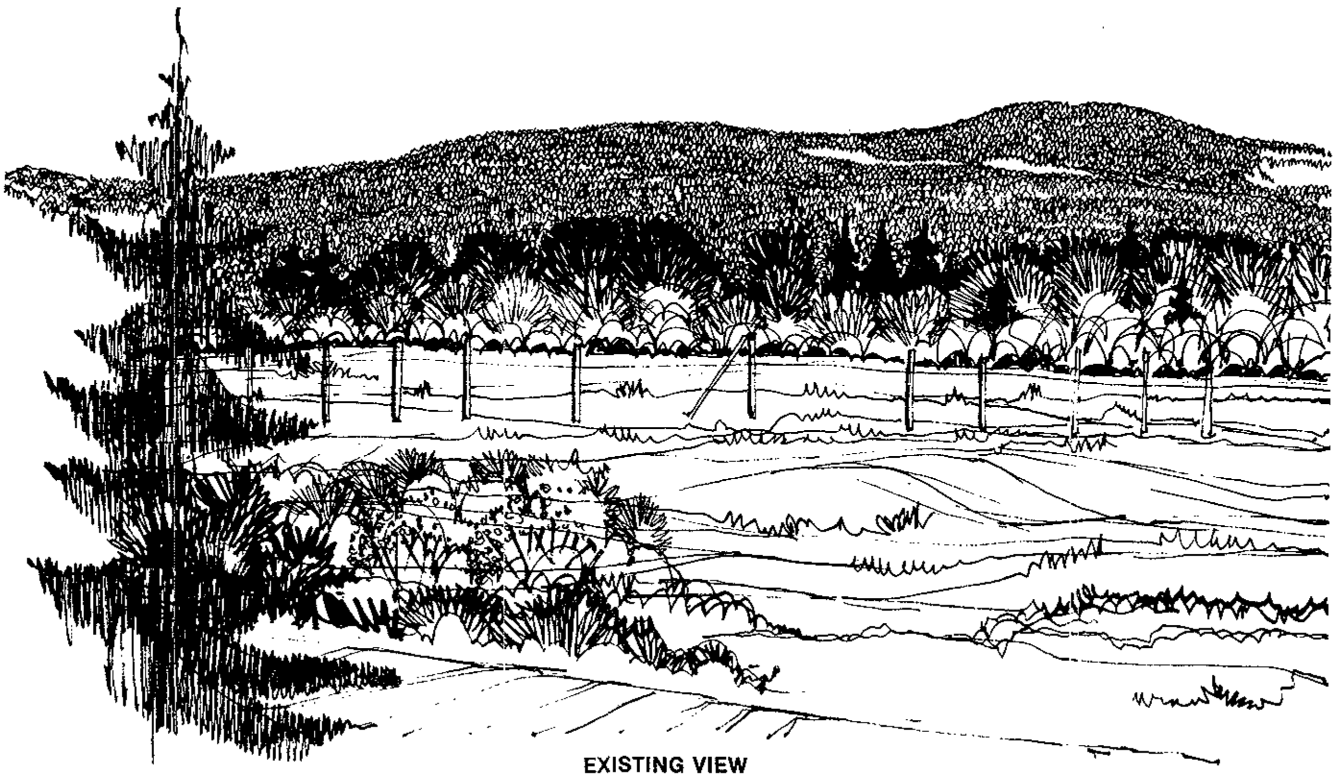
TABLE 16-2

IMPACT CAUSE MATRIX (22)

| | | Visual Units | | | | | | | | | | Special Features | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Marble Canyon | Upper Hat Creek Valley | Medicine Creek Valley | Cattle Valley | Highway 12 | Cache Creek | Thompson River | Highway 1 | Oregon Jack | Langley | Cornwall Lookout | Trachyte Hills |
| Powerplant and Related Facilities | Powerplant and cooling towers | * | * | * | * | * | | | | | | * | * |
| | Stack | * | * | * | * | * | | | * | | | * | * |
| | Ash disposal area | | | * | | | | | | | | * | * |
| | Water reservoir | | | * | | | | | | | | * | * |
| Pit and Related Facilities | Open-pit mine | | * | * | | * | | | | | | | * |
| | Blending facilities and stockpiles | * | * | * | | * | | | | | | | * |
| | Houth Meadow waste disposal area | * | * | * | | * | | | | | | * | * |
| | Medicine Creek waste disposal area | * | * | * | | | | | | | | | * |
| | Hat and Finney Creek diversions | | * | * | | | | | | | | | * |
| Linkages | Conveyor | * | * | * | | * | | | | | | | * |
| | Access road | * | * | * | * | * | | | * | | | * | * |
| | 500 kV transmission corridor | | | * | * | * | * | * | * | | | | * |
| | Water supply pipeline corridor | | | * | * | | | | * | | | * | * |
| | Airstrip | | | | | | | | * | | | | |
| Water Supply System | Water intake | | | | | | | * | | | | | |
| | Storage and pumping facilities | | | | | | | * | | | | | |
| Construction Facilities | Plant construction camp | | | * | | | | | | | | | * |
| | Mine construction camp | * | * | | | | | | | | | | * |



VIEW AFTER CONSTRUCTION

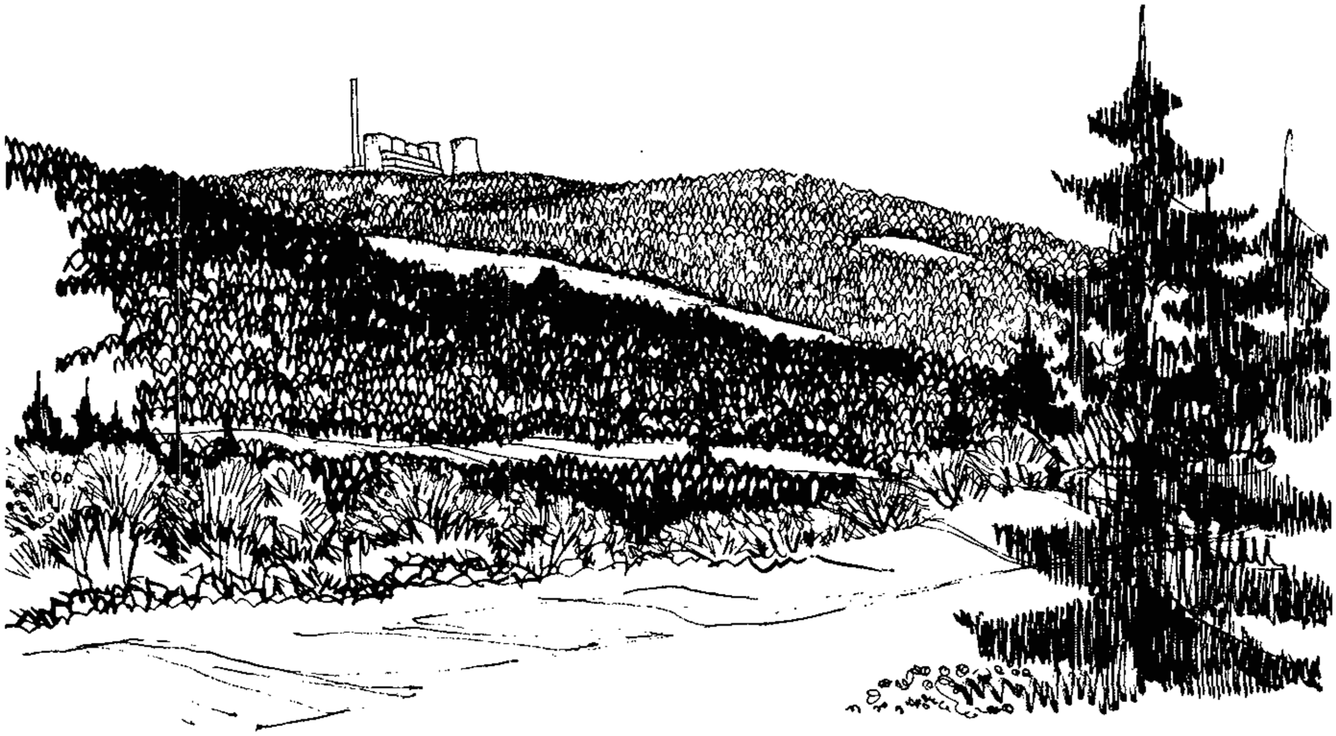


EXISTING VIEW

HAT CREEK PROJECT

## FIGURE 16.2
# POWERPLANT VIEW FROM MARBLE CANYON

*SOURCE: Toby, Russell, Buckwell and Partners Architects (22)*



VIEW AFTER CONSTRUCTION

EXISTING VIEW

HAT CREEK PROJECT

## FIGURE 16.3
# POWERPLANT VIEW FROM HIGHWAY 12

*SOURCE: Toby, Russell, Buckwell and Partners Architects (22)*

## 16.4 MITIGATION AND ENHANCEMENT

Alternatives and/or mitigation measures were proposed for each impacted area taking into consideration foreground, middleground and background views. These measures include suggested alternatives for the disposition of plant elements, approach roads, etc., the use of retaining embankments, terracing, berming and screening designed to relate the plant elements to the site, and the use of form, colour and texture in the case of the plant elements themselves.

Subsequent to the completion of the report on Aesthetic Considerations(22) and as a result of recommendations in that and other environmental and engineering reports, a number of changes were made which resulted in the "Proposed Project". The project modifications which affected the aesthetic impacts as outlined in the aesthetic report(22) are as follows:

1. Mine and Related Facilities (see Figure 3-3)

   a. The coal blending area was relocated further south, away from the junction of Highway 12 and the Hat Creek road. This modification increased the separation between the coal blending area and the entrance to Marble Canyon and Highway 12.

   b. A program of progressive revegetation of disturbed areas was developed to include berms and retaining embankments. These proposals are detailed in Section 4.3.

   c. The project access road was rerouted north of the coal blending facilities and mine maintenance complex. This modification has the effect of eliminating potential conflicts between public and service vehicles.

   d. The mine administration offices and maintenance buildings were relocated between the coal blending facilities and the access road. In addition the access road requires a major embankment between Harry Creek and Highway 12. This revegetated embankment would provide a partial screen between the mine facilities and Highway 12.

   e. The open-pit mine would include a strong identifiable edge with a perimeter service road and drainage ditch.

2. Powerplant and Related Facilities (see Figure 3-3)

   a. The initially proposed wet ash lagoon in upper Medicine Creek (370 ha) was replaced by a dry ash disposal land fill site in mid Medicine Creek (approximately 100 ha) which would be revegetated progressively during the operating phase of the project.

   b. The water supply reservoir was relocated from a small valley near the powerplant to the upper Medicine Creek valley, hence creating a visually attractive man made lake.

   c. The proposed project access road would be routed between the powerplant and the water supply reservoir, allowing easy access to and visual contrast between the high technology environment of the powerplant and the serenity of the man made lake.

3. Linkages (see Figure 3-2)

   a. The Kelly Lake to Nicola 500 kV transmission corridor was relocated north of project facilities and is not included with the Hat Creek Project. The short length (2 km) of 500 kV transmission line connecting the powerplant with the main B.C. Hydro grid would be integrated with the existing pattern of open and treed areas.

   b. The proposed project access road would minimize cut and fill and would take advantage of new vistas of natural and man made elements.

## 17.1 EXISTING SITUATION

Prehistoric and historic cultural heritage resources have been analyzed within a localized study area (117 $km^2$) in the upper Hat Creek valley. Less detailed studies have been undertaken for offsite facilities such as the pipeline, transmission line, or access road. In general the studies indicate that the prehistoric and historic cultural heritage resources of the valley have been little disturbed in the past because of the lack of industrial or residential development.

Pollen cores indicate that the upper Hat Creek valley became ice-free between 13 000 and 10 000 B.P. (Before Present). Studies in the region surrounding Hat Creek have established the following chronology of prehistoric occupation: Lochnore complex (? to 7000 B.P.), Early Nesikep period (7000 B.P. - 2800 B.P.) and Late Nesikep period (2800 B.P. to historic period). No sites in the study area are reliably dated to the Lochnore complex. On the basis of artifact similarities, many (20-25%) recorded sites date to Early Nesikep period. A number of sites (10%) have artifacts dating their occupation to the Late Nesikep period. The five cultural depressions which were test excavated have been dated through radiocarbon analysis to the Late Nesikep period as well. Dates obtained range from 2245 plus or minus 50 years B.P to 140 plus or minus 50 years B.P.

Most recorded archaeological sites in the Hat Creek study area are lithic scatters without cultural depressions. Less frequent are cultural depressions with or without surface lithic artifacts. Lithic debitage is the most common artifact type but many sites have intentionally modified stone tools. Site elevations range from 868 m to 1341 m ASL. Most sites are located on grassland-parkland and on plains or gentle slopes. Sites located in the northern upper Hat Creek bottomlands tend to be large and have high artifact densities compared to other sites in the valley. Sites in the Medicine and Harry Creek drainage areas tend to be small with low artifact densities.

Test excavations indicate that most of the cultural depressions appear to have been earth ovens, a feature which distinguishes Hat Creek from the Thompson and Fraser valleys. Earth ovens are not unique to Hat Creek, but nowhere else in the southern interior of B.C. have they been systematically recorded and studied. Some of the depressions, especially those near the Highway 12 junction, were used as pithouses.

Nineteen historical sites were located in the upper Hat Creek valley, including cabins, irrigation systems and depressions. Occupations span the period between 1880 and 1930.

## 17.2 EFFECTS OF THE PROJECT

The Hat Creek studies used a random sampling method to determine the numbers and types of sites in the valley and in specific proposed project development zones. The studies also identified 29 archaeological zones on the basis of environmental characteristics and the nature of cultural heritage resources. On the basis of the sample (7.8 percent and greater in some zones) approximately 1000 sites were predicted to exist in the Hat Creek valley. Of these, at least 198 may suffer direct adverse effects from the proposed development and about 300 sites in the valley may suffer indirect adverse effects from the proposed development. An undetermined number of potential impacts, that is those effects on subsurface cultural heritage resources which cannot be presently observed or predicted, can be expected whenever a proposed project activity exposes buried archaeological sites.

In addition to the studies of the Hat Creek and Medicine Creek areas, a reconnaissance survey of selected offsite facilities was conducted in late 1978. Results indicate that at least 11 sites lie on or near a proposed access road in the upper Hat Creek valley. Few sites were observed near the pipeline route, except in the vicinity of Ashcroft. Other offsite facilities may cause some direct adverse effects in 12 archaeological zones outside the valley.

Within the upper Hat Creek valley itself there is variation between the sites in the northern section, where most direct impacts would occur, and those in the southern section. Two-thirds of the estimated total number of sites in the valley would most likely be unaffected. However, the impact would be proportionally greater because more complex and diverse types of sites are located in the northern section in direct impact areas.

Most previous archaeological studies in the region have been concerned with the construction of prehistoric cultural chronologies. They were also basically restricted to those activities which had occurred in large multi-component sites situated in major river valleys. No substantial research has been done in the uplands, even though such areas had also likely been occupied. The study of Hat Creek cultural heritage resources is therefore significant in that such research has the potential to contribute to the knowledge of prehistoric adaptations to upland areas of the Southern Interior Plateau.

The upper Hat Creek valley is one of a number of upland valleys in the region. Other valley systems with environmental contexts similar to Hat Creek include the Botanie, upper Bonaparte and Nicola valleys. However, the cultural heritage resource base of these latter valleys is not as intact as is the case in Hat Creek. All have undergone modification in the lower slopes and bottomlands resulting in considerable disturbance of cultural heritage resources. No archaeological studies of similar areas have been published. Therefore, the distinctiveness of the Hat Creek cultural heritage resources is not known.

In the study area the direct impacts of specific project components on the cultural heritage resources, as measured by a number of scientific and other criteria, range from low to high. While two-thirds of the total number of archaeological sites in the valley would most likely be unaffected by the project, these sites do not duplicate the cultural heritage values which would be lost due to direct impacts of the project. In a regional context, the cultural heritage resources of Hat Creek are significant in the relatively high degree of integrity present. Thus, the overall impact of the project is judged to be moderate.

# SECTION 18. ECONOMIC EVALUATION OF RESOURCE IMPACTS(64)

The proposed project would affect some natural resource activities in the Hat Creek valley, such as forestry, agriculture and recreation. The foregone opportunity cost of these resources, that is, the value they would generate in the best alternative use, must be included as an identifiable cost incurred by the project. When evaluating a potential power development, it is necessary to consider all costs, including the value of lost resources, to ensure that the project is a worthwhile undertaking for the province. Thus an economic evaluation of the resource values with and without the project was undertaken to quantify the extent of these resource costs.

The following sections are based on the resource evaluation undertaken by Strong Hall and Associates as part of the impact assessment,(64) but revised for a 1988 in-service date for Unit No. 1[8]. All present worth values shown in the text are in 1980 dollars, using a 6 percent discount rate. (Sensitivity to the discount rate is shown in Table 18-1 and Table 18-2.) A 35-year project life was assumed.

## 18.1 FORESTRY

The proposed project would have an impact on the forestry resource through the permanent removal of lands used for the mine, powerplant and offsite facilities, and by the reduction of forest growth due to stack emissions. It is estimated by the forestry consultants that the maximum potential forestry losses would be about 3 600 $m^3$ of the annual forest harvest under the proposed project and 55 000 $m^3$ under the 244 m/MCS option.

The economic evaluation of forestry losses has been based on the potential reduction in both the net and gross annual allowable cut (AAC) for the Public Sustained Yield Unit (PSYU) in which the project is located.

The loss of forestry productivity due to the proposed project would reduce the physical amount of timber on which the gross AAC is calculated. The maximum value of this loss would be about $23 400/annum with a present worth of 0.3 M$ (Table 18-1). For the 244 m/MCS option, losses would approximate $357 500/annum with a present worth of 3.5 M$ (Table 18-2).

Alternatively, in calculating the net AAC within the Botanie PSYU, the B.C. Forest Service has made a specific deduction of 21 520 $m^3$/annum for open-pit mining and other developments within the Hat Creek drainage, of which 2205 $m^3$/annum is allocated to the proposed project. The change in resource allocation (that is the reduction in timber that could be harvested in other areas of the PSYU) would therefore be based on the amount by which the impacts of the project exceed the Hat Creek deduction. This interpretation would yield a maximum social cost of approximately $343 200/annum; the present worth of forestry losses in terms of net AAC would then be 3.3 M$, under the 244 m/MCS

[8] Unit values such as value in dollars per recreation day are presented in the same case as in the Resource Evaluation report(64). Adjustments to reflect changes in price levels to 1980 and changes in real value over time are made in the present worth calculations.

TABLE 18-1

ECONOMIC EVALUATION SUMMARY
NET PRESENT WORTH OF RESOURCE IMPACTS
(k$ 1980)
366 M STACK WITH MCS

| Resource | Discount Rate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3% | | | 6% | | | 10% | | |
| | Without Project | With Project | Net | Without Project | With Project | Net | Without Project | With Project | Net |
| Fishing | 14 000 | 12 040 | 1 960 | 5 300 | 4 590 | 710 | 2 470 | 2 170 | 300 |
| Hunting | 35 900 | 34 780 | 1 120 | 13 590 | 13 140 | 450 | 6 330 | 6 110 | 220 |
| General Recreation | 23 870 | 23 640 | 230 | 9 040 | 8 950 | 90 | 4 210 | 4 170 | 40 |
| Commercial Fishery[1] | | | 66 | | | 34 | | | 14 |
| Forestry | | | 581 | | | 296 | | | 164 |
| Agriculture | 6 520 | 6 372 | 148 | 3 350 | 3 274 | 76 | 2 020 | 1 974 | 46 |
| TOTAL | | | 4 105 | | | 1 656 | | | 784 |

[1] Value of losses to B.C. only.

TABLE 18-2

ECONOMIC EVALUATION SUMMARY
NET PRESENT WORTH OF RESOURCE IMPACTS
(k$ 1980)
244 M STACK WITH MCS

| Resource | Discount Rate 3% | | | Discount Rate 6% | | | Discount Rate 10% | | |
|---|---|---|---|---|---|---|---|---|---|
| | Without Project | With Project | Net | Without Project | With Project | Net | Without Project | With Project | Net |
| Fishing | 14 000 | 12 040 | 1 960 | 5 300 | 4 590 | 710 | 2 470 | 2 170 | 300 |
| Hunting | 35 900 | 34 780 | 1 120 | 13 590 | 13 140 | 450 | 6 330 | 6 110 | 220 |
| General Recreation | 23 870 | 23 640 | 230 | 9 040 | 8 950 | 90 | 4 210 | 4 170 | 40 |
| Commercial Fishery[1] | | | 66 | | | 34 | | | 14 |
| Forestry | | | 6 446 | | | 3 531 | | | 1 825 |
| Agriculture | 6 520 | 6 280 | 159 | 3 350 | 3 240 | 110 | 2 020 | 1 960 | 60 |
| TOTAL | | | 10 062 | | | 4 925 | | | 2 459 |

[1] Value of losses to B.C. only.

option. Annual losses with the proposed project would be $9 000 yielding a discounted present value of $87 000.

## 18.2 AGRICULTURE

Productivity of the agricultural land within the local area (Figure 9-1) would be affected by the project through direct land alienation by the powerplant, mine and offsite facilities, and through the potentially detrimental effects of stack emissions. Current and potential use of the affected land is primarily for beef production; consequently the evaluation of the opportunity costs of the project is based on the net economic value of beef cattle production.

It has been estimated that the land within the Hat Creek valley could support a herd of 3300 cattle by the year 2020 in the absence of the project. With the project, the reduced productivity of the land would result in a lower potential herd size of 3225 animals by the year 2020 (i.e. 75 animal loss), for the proposed project. Maximum herd size is projected to be 3184 animals in 2020 for the 244 m/MCS option.

The social cost of this annual loss in beef production was calculated using estimated economic values based on average cost and revenue figures. Based on an estimated annual net benefit per animal of $51.50 (at 1977 price levels), the present value of losses over a 100-year period would be about $76 000 (at 1980 price levels) for the proposed project. The present value of losses is estimated at $110 000 for the 244 m/MCS option.

## 18.3 COMMERCIAL FISHERY

The water supply reservoir is designed with a 70-day storage capacity for powerplant maximum water consumption, and since salmon runs last for 14 to 21 days, the water supply system would be shut down if the fish protection devices did not perform as intended.

However, under the "worst case" scenario, one in which the fish protection features that have been incorporated into the water intake design are not effective, and assuming that pumping continued, the major impact of the Hat Creek Project on the fishery resource would be through the impingement of juvenile pink salmon on the intake screens and entrainment in the intake flow. By assessing the "worst case" juvenile fish losses, and the subsequent loss of returning adults, it has been estimated that the maximum reduction in commercial catch could be about 5000 pinks in every odd-numbered year.

The economic value of these pink salmon losses was estimated using the 1978 unit landed value of the commercial pink catch ($2.12/fish). It was also assumed that the real price of landed fish would escalate at 1 percent/annum (net of inflation) over the 35-year period. The maximum total potential loss to the commercial fishery would therefore be $68 000 (at 1980 price levels).

Since the Fraser River commercial pink salmon catch is split between the U.S. and Canada, the maximum possible total 35-year provincial losses would actually be about $34 000 in present worth terms.

## 18.4 GENERAL RECREATION, FISHING AND HUNTING

It is expected that the impact on general recreation, sport fishing and hunting (with the Hat Creek Project) would occur primarily through direct displacement of land and water resources. While it is likely that total recreational activity in the area would increase as a result of the project-related population increases, the analysis has been based on an expected net decrease in activity from a provincial perspective, due to the following "worst case" key assumptions.

1. The increase in recreational activity in the Hat Creek area would be offset by decreases in activity elsewhere in the province, assuming the majority of the work force would come from British Columbia.

2. The loss of land and water resources would result in an absolute reduction in recreational activity, i.e. recreationists would not substitute new areas to replace displaced areas. Thus the assessment of recreational impacts has been based on a projection of net losses in activity days over the forecast period.

Recreational losses were evaluated using standard recreation day values for each particular activity. These values ($9.00/day for fishing, $22.50/day for hunting and $7.00/day for general recreation all at 1978 price levels) were drawn from other studies on recreation use within the province and were intended to approximate the user's willingness to pay to participate in each activity. The values of recreation losses were calculated over a 100-year period on the assumption that the affected resources would not return to their former state upon decommissioning of the plant and mine.

The present worth of these "worst case" recreation losses is estimated to be $710 000 for angling, $450 000 for hunting and $90 000 for general recreation.

## 18.5 MINERALS AND WATER RESOURCES

The Hat Creek project would affect several mineral resources in the area through partial isolation or utilization. However, the economic significance of these impacts is expected to be minimal as the supply of the affected resources in the area exceeds the foreseeable demand. In fact the project would increase the utilization of limestone (under the 366/FGD option) and gravel deposits (under either option) compared to use without the project. However, the potential increase in net economic values resulting from increased utilization of these mineral resources has not been evaluated, as it is not expected to be large.

In addition to the water resource impacts covered under the agriculture and recreation sections, the project would have a minor impact on domestic groundwater use in the area. No separate economic evaluation of this resource use was made since it was assumed that the value of groundwater use would be reflected in the market value of the individual properties affected. The negotiated price for the property rights would therefore include adequate compensation for domestic water values affected by the project, so that the value of precluded ground-water use need not be calculated separately.

# PART IIIB - SOCIOECONOMIC AND COMMUNITY RESOURCES

## INTRODUCTION

In this second half of Part III, the focus is upon impacts of the project upon regional economics, communities and inhabitants. A description of the existing situation is presented first. The effects of the project's construction and operation phases upon regional employment, income and population are then discussed. Next, the effects upon social and physical services of nearby communities are considered. Effects upon the social environment are then discussed followed by a summary of the socioeconomic impacts. Finally the human health effects (or epidemiological aspects) of the project's emissions are discussed.

The detailed studies on which Sections 19.0, 20.0 and 21.0 are based used 1977 data and the subsequent modifications discussed below were made between 1979 and 1981 to reflect changing powerplant in-service dates and modifications to the base project scheme. Recognizing that changes have occurred in the socioeconomic environment, and that data should be as up-to-date as possible when considering impact management systems, B.C. Hydro has decided to update the socioeconomic studies prior to any licensing hearing on the project. Since our data base is for 1977, the material presented in Sections 19.0, 20.0 and 21.0 of this EIS should, therefore, be taken as *indicative of socioeconomic impacts rather than definitive.*

Forecasts presented in the detailed study were derived by the consultants on the assumption that project construction would begin in 1978 for a first powerplant unit (500 MW) in-service date of 1984. Subsequently changes to the project design were made and the project schedule was revised with the construction start-up now planned for 1983 and a first unit in-service date of 1988. The original employment data were modified to reflect these changes and the revised data are used in the material presented in Sections 19.0, 20.0 and 21.0.

## SECTION 19. SOCIOECONOMIC CONDITIONS (61,63)

### 19.1 EXISTING SITUATION

For purposes of the socioeconomic study, the Hat Creek "regional" and "local" areas are shown on Figure 19-1. The details of the "existing situation" given here refer to all of the socioeconomic aspects as presented in Sections 19.0, 20.0 and 21.0.

The regional and local economies are based primarily on forestry, copper mining, ranching and tourism. Economic growth was relatively rapid in the post-war period, but is now moderate. Incomes are slightly below the provincial average with a few at the lowest levels.

With regard to the quality of life, the characteristics of the natural environment (climate, topography and recreational amenities) are perceived as important elements of a generally satisfying lifestyle.

Settlements in the local study area include the following:

1. The Hat Creek valley contains a small, socially cohesive ranching community of 30 to 40 persons, with some families dating from the original settlement of the 1860s. Most residents are freehold ranchers with Crown leases to supplement their operation, while others are employed as ranch hands. Some incomes are supplemented with local construction work or service employment in nearby communities. Approximately 30 to 40 houses are located at Pavilion Lake, the majority of which are used as summer recreational homes. About a dozen homes are inhabited by retired people.

2. The village of Ashcroft (1976 population 2030) is a service centre for the railways and agricultural hinterland, a local centre for government services, local shopping area, and "bedroom" community for nearby copper mines. Mining employment has generated the highest local area incomes and caused substantial migration. The municipal assessment base is relatively low, the mill rate high, and municipal finances are strained by excess capacity in the new sewer system and arena.

3. The economy of Cache Creek (1976 population 1050) is based on highway traffic service, along with goods and services for the area's industrial activities. A considerable percentage of employment is either seasonal or part-time, and incomes are below the provincial average. Social and community services are typical for a community of this size and municipal finances are strong. The sewer system and roads are adequate but the water system is deficient. Community identity and solidarity are strong with an energetic growth orientation. Social problems related to transiency and alcoholism are a concern.

4. Forestry, agriculture and highway service constitute the economic base of Clinton (1976 population 810). Unemployment and government transfer payments are high due to recent reductions in sawmill jobs. Incomes are the lowest in the study area, and out-migration from the labour force has occurred. Taxes are low but municipal financial capacity is limited. Sewers are adequate but the water system requires upgrading. A strong growth orientation exists because of the depressed economy and the desire to expand and diversify needed community services.

5. Four Native Indian bands, the Ashcroft, Bonaparte, Oregon Jack Creek and Pavilion Bands, comprising 23 reserves with approximately 620 members (354 living on the reserves), are located in the local project area. One reserve of the Bonaparte Band, accommodating approximately 35 residents, is situated within a few hundred metres of the proposed access road in the valley and about a kilometre from the proposed mine pit. An additional 11 bands with 2548 people (1655 on reserve) are found within a 50 km radius of the project site.

The 1971 Census statistics indicate that income levels for the Ashcroft and Oregon Jack Creek Native Indian Bands were above average for the general population of the study area, but that Bonaparte and Pavilion Band members had income levels significantly below that of the average for the area.

Although employment among local Native Indians was high in 1971 it is likely that in recent years both employment rates and income levels have decreased. Unemployment could now exceed 50 percent without government funded temporary work projects. Salmon fishing is probably significant both for food supply and income equivalent.

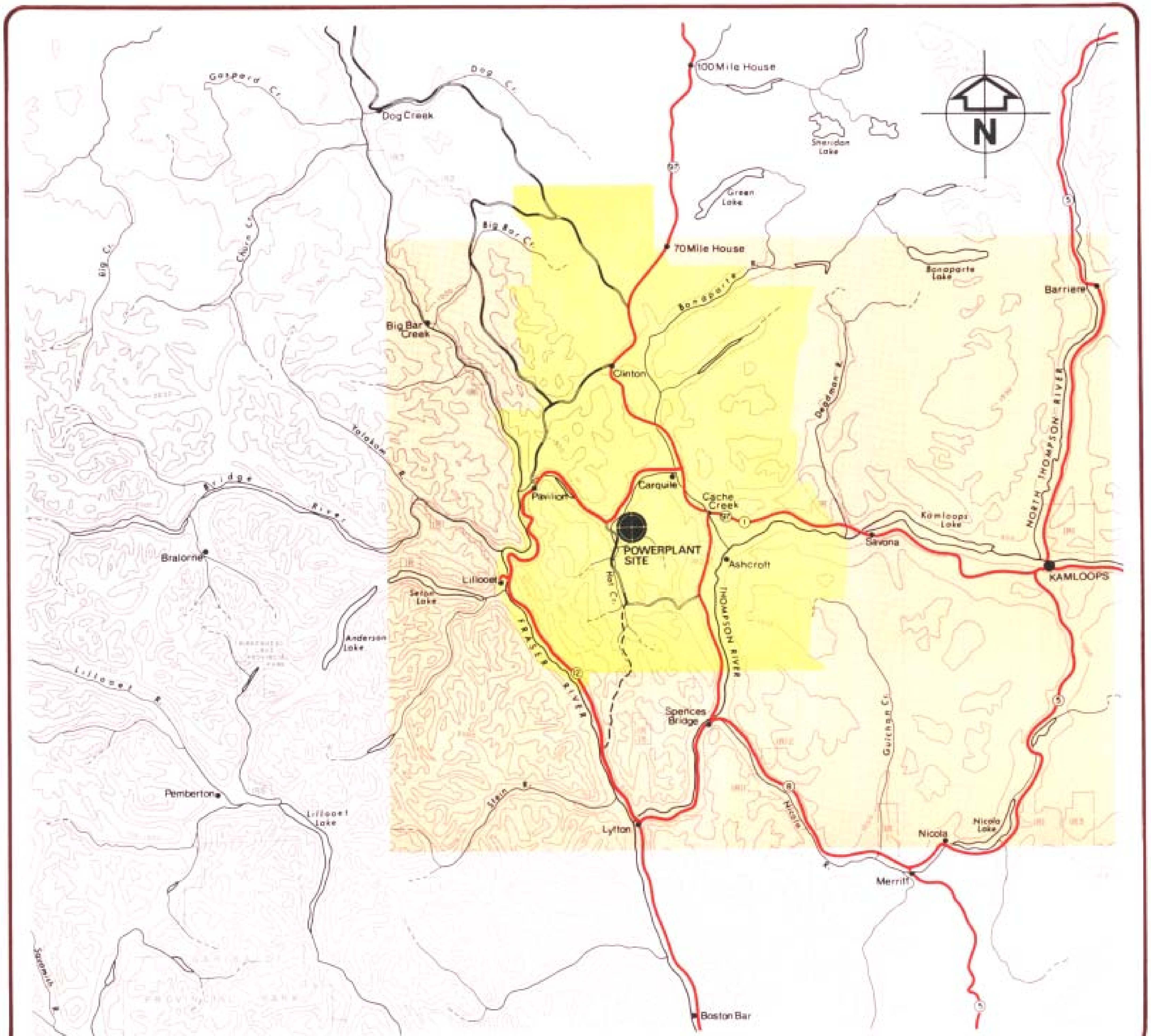
Reserve housing appears inadequate, but social indicators, such as crime rates and rates of children taken into care, show conditions similar to non-native communities.

Without the project the growth potential of the area would be dependent on expansions in the agriculture, mining and forest industries, and highway traffic. The major stimulus would be mining in the Highland valley. Long-term population growth of about 2 percent annually in the study area could be expected. The population in the Hat Creek valley would likely remain the same. Ranching may expand marginally through intensified management. Growth in Ashcroft would depend upon Highland valley mining developments. Cache Creek expansion would also depend upon mining development. Dependence on highway traffic would decrease and local population oriented businesses would expand. Little growth could be expected in Clinton without the project.

## 19.2 PROJECT ACTIONS

The major factor determining socioeconomic impacts would be the employment of local residents and immigrants. The project's labour force requirements in terms of jobs and skills have been discussed in Section 4.0. A construction and operating schedule (Figure 4-2) was also presented, indicating construction commencement in 1983, with peak requirements in 1988.

Operation of the plant is scheduled to begin in late 1988. The 35-year operation phase would involve a much more stable labour force than would construction, requiring between 1000 and 1200 workers annually after 1990.




LEGEND

REGIONAL STUDY AREA

LOCAL STUDY AREA

SCALE — 1:750,000

15 km 0 km 15 km 30 km 45 km

CONTOUR INTERVAL — 500 METRES

HAT CREEK PROJECT

FIGURE 19.1

# SOCIO-ECONOMIC STUDY AREAS

SOURCE: Strong, Hall and Associates Ltd., Cornerstone Planning Group Ltd., and Urban Systems Ltd. (23)

## 19.3 EFFECTS ON REGIONAL AND LOCAL EMPLOYMENT

### (a)Direct Employment

The powerplant, mine and other project field construction would be carried out by union labour. Because the British Columbia construction unions may experience relatively high levels of unemployment in the future, job openings for local residents who are not union members may be limited. The numbers of regional union members are, in most trade categories, insufficient to meet the project's labour requirements and hence union workers from elsewhere in the province would be required. The effective regional supply of construction workers in 1977 is shown in Table 19-1. Construction supervisory and engineering personnel would most likely be obtained from outside the region.

Job security, location, wages, fringe benefits and the uniqueness of the project would attract regional residents for potential employment during the operation phase of the powerplant. However a shortage of qualified skilled workers would limit regional labour force participation in the operation phase unless extensive job retraining occurred. Also, it is likely that some qualified regional residents would not obtain employment because of the hiring requirements of several collective union agreements to which B.C. Hydro is a party.

Regional labour force participation in mine operation would also be limited by skill shortages and by competition from experienced, unionized, non-regional workers.

Based upon analysis of regional labour availability and union hiring constraints, Table 19-2 provides an estimate of direct local and regional participation for the total project. At the peak of the construction period, about 1 450 regional residents are expected to obtain employment directly on the project while about 150 local residents are expected to obtain work. In the operation phase, regional participation is expected to reach about 300 jobs annually, with local residents likely to obtain about 150 jobs.

It is expected that access to union membership by regional residents could be most easily obtained in the clerical, general tradesman and operating and maintenance helpers' unions. These positions would account for about a quarter of the 340 jobs in the powerplant.

### (b)Indirect and Induced Employment

Indirect employment would stem from project expenditures on goods and services supplied from within the region. These expenditures would include earth-moving equipment, trucks, small tools and camp catering supplies. The local study area would not provide a significant amount of these requirements; Kamloops is the only community in the region capable of meeting these needs. Limited regional purchases outside Kamloops might include lumber from Clinton or Savona and bulk fuels from Ashcroft.

Communities in the local area as well as the regional centre of Kamloops should also benefit from induced employment. Induced employment has been defined by the consultants as employment stemming from spending by construction and permanent operation phase workers and by project-related indirect employees. In other words, it refers to increased employment in local service sectors.

TABLE 19-1
ESTIMATED EFFECTIVE REGIONAL SUPPLY
OF UNIONIZED CONSTRUCTION WORKERS (61)

| Union[1] | Estimated Regional Supply |
|---|---|
| General Labourers | 450 |
| Operating Engineers | 500 |
| Teamsters | 30 |
| Culinary Workers | 30 |
| Office and Technical Employees | 75 |
| Carpenters | 245 |
| Plumbers and Pipefitters | 200 |
| Electrical Workers (wiremen) | 175 |
| Iron Workers | 50 |
| Machinists/Millwrights | 25 |
| Boilermakers | 15 |
| Sheet Metal Workers | 20 |
| Others[2] | 60 |
| TOTAL REGIONAL SUPPLY | 1 875 |

1. As of Spring 1977, effective regional supply refers to those union members who traditionally work in heavy industrial construction throughout the province.

2. "Others" include Heat and Frost Workers, Bricklayers, Cement Masons and Finishers, and Painters.

TABLE 19-2
DIRECT LOCAL & REGIONAL EMPLOYMENT ON THE HAT CREEK PROJECT
(Jobs)

| | Construction and Operation | | |
|---|---|---|---|
| Year | Local[1] Area Residents | Total[2] Region Residents | Total Project Work Force |
| 1983 | 50 | 150 | 250 |
| 1984 | 100 | 400 | 500 |
| 1985 | 100 | 550 | 1 000 |
| 1986 | 150 | 950 | 2 450 |
| 1987 | 150 | 1 450 | 3 150 |
| 1988 | 150 | 1 450 | 3 150 |
| 1989 | 150 | 1 150 | 2 650 |
| 1990 | 150 | 900 | 2 050 |
| 1991 | 150 | 700 | 1 400 |
| 1992 | 150 | 600 | 1 200 |
| 1993 | 150 | 400 | 1 200 |
| 1994 | 150 | 400 | 1 200 |
| 2004 | 150 | 400 | 1 150 |
| 2014 | 150 | 300 | 1 100 |

1. Local and regional areas defined on Table 19-1.

2. Includes local area residents.

All data are rounded to nearest 50.

It is estimated that at maximum some 700 jobs would be created through indirect and induced activity associated with the proposed project within the study region. People would be attracted to the region in order to fill these indirect jobs since not all of this employment would accrue to people now resident in the region. More than one third of the indirect and induced jobs would probably go to regional residents.

(c) Labour Supply for Other Regional Industries

Employment opportunities created by the proposed project would result in some regional residents leaving their jobs to take up project employment. Regional employers would most likely experience personnel losses in the mining, transportation, forestry, local construction and pulp mill sectors. Major problems would arise if extensive switching occurs in the heavy mechanical, electrical, machining and station operating engineering trades. Higher turnover rates for Bethlehem Copper might occur because of the advantage of shorter travel distance on superior road conditions for residents of Ashcroft and Cache Creek.

(d) Effects on Indian Employment Opportunities (63)

Although the proposed project would expand the total amount of employment available in the region, it is unlikely that the number of direct project jobs filled by Native Indians would be significant. This view is based upon the current high levels of Native Indian unemployment, indicating a low level of job skills, and the general obstacles to union membership outlined previously. It appears that unless special steps, such as an employment training program for Native Indians, are taken to resolve their specific employment problems, direct employment of the local Native Indian people would be low, particularly in the short term.

The project would create indirect wage employment and business opportunities in the local economy, providing potential for indirect Indian employment benefits. On the other hand there might be some small loss of employment in the agriculture sector as a result of the project. A lack of reliable data precludes an accurate prediction of indirect employment changes for Native Indians.

## 19.4 EFFECTS ON POPULATION

(a) Population Growth

The size of regional population increases associated with the project would be determined by the number of in-migrating employees, their marital status and their dependents. The expected in-migrant population associated with direct, indirect and induced employment is shown by area of domicile in Table 19-3.

(b) Settlement Patterns

During the construction phase, more than three-quarters of the in-migrant direct employees would occupy single status construction camps proposed for the Hat Creek valley. The remainder would reside in the nearby communities as well as in the rural areas. It is expected that most of the supervisory and engineering staff would reside in the communities, seeking family accommodation. Operating employees would be expected to reside in nearby communities and rural areas.

Alternative places of residence within the local study area include Ashcroft, Cache Creek, Clinton, Lillooet, and rural areas. The actual distribution of in-migrants to these areas would be influenced by: commuting time and expense; housing costs and availability by type; property tax levels and utility rates; natural features of the community; and lifestyle preference. For the purposes of projecting population increases, it is estimated that 80 percent of new residents would settle in Ashcroft and Cache Creek, 15 percent in Clinton, and 5 percent in Lillooet and rural areas.

In order to assess the effects of population changes, two settlement scenarios have been constructed for Ashcroft and Cache Creek. Scenario 1 assumes that 70 percent of the designated Ashcroft/Cache Creek population would settle in Ashcroft and 30 percent in Cache Creek. Scenario 2 reverses this distribution. These are shown in Table 19-3.

(c)Demographic Characteristics

Based upon experience at other B.C. Hydro construction projects, it is expected that the labour force at Hat Creek would be older than provincial averages, with an estimated 35 percent age 45 or older. It is anticipated that three-quarters of the construction workers would be married, most of whom would live in the construction camp, choosing to leave their families at home. Of the married workers who chose to live in nearby communities or rural areas it is assumed they would have an average of 1.4 children.

Direct operating employees moving to the communities and rural areas would be about 25 percent single and 75 percent married, the latter family size assumed to be about 3.8 persons. This group would be relatively young with nearly one-third in the prime employment years, ages 25 to 44. The remainder would be children, young adults, and a small portion of persons over 45 years of age. Indirect and induced employment migrants would be expected to have marital and demographic characteristics similar to the direct operating employees.

## 19.5 EFFECTS ON INCOME

All figures referring to income in this sub-section are expressed in undiscounted 1980 dollar terms.

(a)Direct, Indirect and Induced Regional Income

"Direct income" is defined as wages and salaries paid directly to the project work force. Annual direct income estimates were derived from union wage rates updated to 1980 calculated over a 37.5-hour work week for 52 weeks per year. Total direct net income gains are estimated at about $340 million throughout the construction phase. About 80 percent of this total would accrue to local residents.

The study region would receive an estimated direct income gain of $1.3 billion during the 35-year life of the project.

TABLE 19-3

PROJECTED POPULATION OF NEARBY COMMUNITIES WITH THE HAT CREEK PROJECT (61)

| | Clinton | | Ashcroft | | | Cache Creek | | |
|---|---|---|---|---|---|---|---|---|
| Year | Without Project | With Project | Without Project | With Project Scenario No. 1 | With Project Scenario No. 2 | Without Project | With Project Scenario No. 1 | With Project Scenario No. 2 |
| 1983 | 1150 | 1200 | 2450 | 2500 | 2450 | 1200 | 1200 | 1200 |
| 1984 | 1150 | 1200 | 2700 | 2800 | 2700 | 1350 | 1400 | 1450 |
| 1985 | 1150 | 1250 | 2700 | 3000 | 2800 | 1350 | 1400 | 1650 |
| 1986 | 1150 | 1300 | 2850 | 3350 | 3050 | 1500 | 1700 | 1950 |
| 1987 | 1150 | 1600 | 2850 | 4800 | 3550 | 1500 | 2200 | 3100 |
| 1988 | 1150 | 1650 | 2850 | 4800 | 3700 | 1500 | 2300 | 3400 |
| 1989 | 1150 | 1700 | 3050 | 5250 | 4000 | 1600 | 2500 | 3800 |
| 1990 | 1150 | 1700 | 3100 | 5000 | 3900 | 1600 | 2500 | 3550 |
| 1991 | 1200 | 1700 | 3150 | 5100 | 3950 | 1650 | 2500 | 3600 |
| 1992 | 1200 | 1800 | 3200 | 5350 | 4100 | 1650 | 2600 | 3800 |
| 1993 | 1250 | 1800 | 3200 | 5350 | 4100 | 1700 | 2600 | 3800 |
| 1994 | 1250 | 1800 | 3300 | 5450 | 4200 | 1700 | 2650 | 3900 |
| 1995 | 1250 | 1850 | 3300 | 5500 | 4250 | 1750 | 2700 | 3900 |

Notes: Scenario No. 1 - Split of Ashcroft/Cache Creek incremental population - 70% Ashcroft, 30% Cache Creek.

Scenario No. 2 - Split of Ashcroft/Cache Creek incremental population - 30% Ashcroft, 70% Cache Creek.

Data are rounded to the nearest 50.

In total, the proposed project would significantly stimulate the expansion of income throughout the study region and the local area. The project would contribute in the range of $2 billion to the region and $1.5 billion to the local study area through direct, indirect and induced income gains over the construction and operation phases.

(b) Regional and Local Income Distribution

The western part of the region, including Ashcroft and Cache Creek, would expand its relative contribution to overall regional income levels and growth. Ashcroft and Cache Creek would be expected to obtain the largest share of total income benefits within the local area. Construction-related activities would result in an increase in the income of the region's construction work force, both union and non-union, and provide increased revenues for owners of commercial ventures. Local landowners would benefit from capital gains, (expected to be moderate) realized on the sale of their land.

It can be expected that the distribution of personal income would shift upwards in the local area. Also, the range of personal income would probably spread rather than narrow as a result of the proposed project.

Although price increases would occur for rural and municipal land, the increases would probably be moderate. The greatest land price increases might occur in lakeshore properties, such as at Pavilion and Loon lakes, in short supply in the vicinity of the project. Price increases are likely to take place in temporary accommodations and restaurants. However, it is expected that consumer prices in the area would increase only moderately.

# SECTION 20. COMMUNITY RESOURCES(23,61)

In this section, the impacts of project-related in-migration upon the resources of local communities are described. On the basis of project population forecasts, the changes which would be required in housing, social services, commercial facilities, infrastructures and governments are considered.

## 20.1 HOUSING

Workers choosing to live in the nearby communities would obtain their own accommodation based on their own preferences. No B.C. Hydro-owned housing would be provided aside from the two construction camps. Two projections have been made to indicate potential housing demand in Ashcroft and Cache Creek, corresponding to the two population scenarios of Table 19-3. As shown in Table 20-1 Ashcroft and Cache Creek would require 625 and 275 new housing units respectively under Scenario 1, and about the reverse under Scenario 2. About 150 units would be required in Clinton. Generally, housing demand would be greatest in the early years of construction and would peak about the fourth or fifth year. Projections of the mix of new housing types required for project-related migration are also shown in Table 20-1.

Under both scenarios it is possible for the entire housing supply process to be carried out in such a manner that supply shortages could be avoided. However, given the complexity of the process, it is likely that some delays might result in a temporary shortage of housing in the initial project years. In addition, the matching of available housing mix with the dwelling types demanded is likely to be fairly imprecise during this period.

## 20.2 SOCIAL AND COMMUNITY SERVICES

### (a) Education

Forecasts of elementary school enrollments in nearby communities over the period 1983 to 1989, with and without the project, are shown in Figure 20-1. The additional complement of teachers required to meet the predicted enrollment increases is shown in Table 20-2.

With the Hat Creek Project, the secondary education enrollment in the local study area (defined in Section 19.0) is expected to increase at a rate similar to that of the elementary enrollment. It is estimated that the secondary school in Ashcroft would have about a 70 percent increase in enrollment from 1983 to 1989. The projections for this school would be the same for both Scenario 1 and Scenario 2. About 15 additional classrooms and 20 teachers would be required for the project population. Clinton's junior secondary school could expect about a 30 percent increase in students from 1983 to 1989 with the project. About five additional teachers would be needed for the project but, since the school would not reach its designed capacity, no additional classrooms would be required.

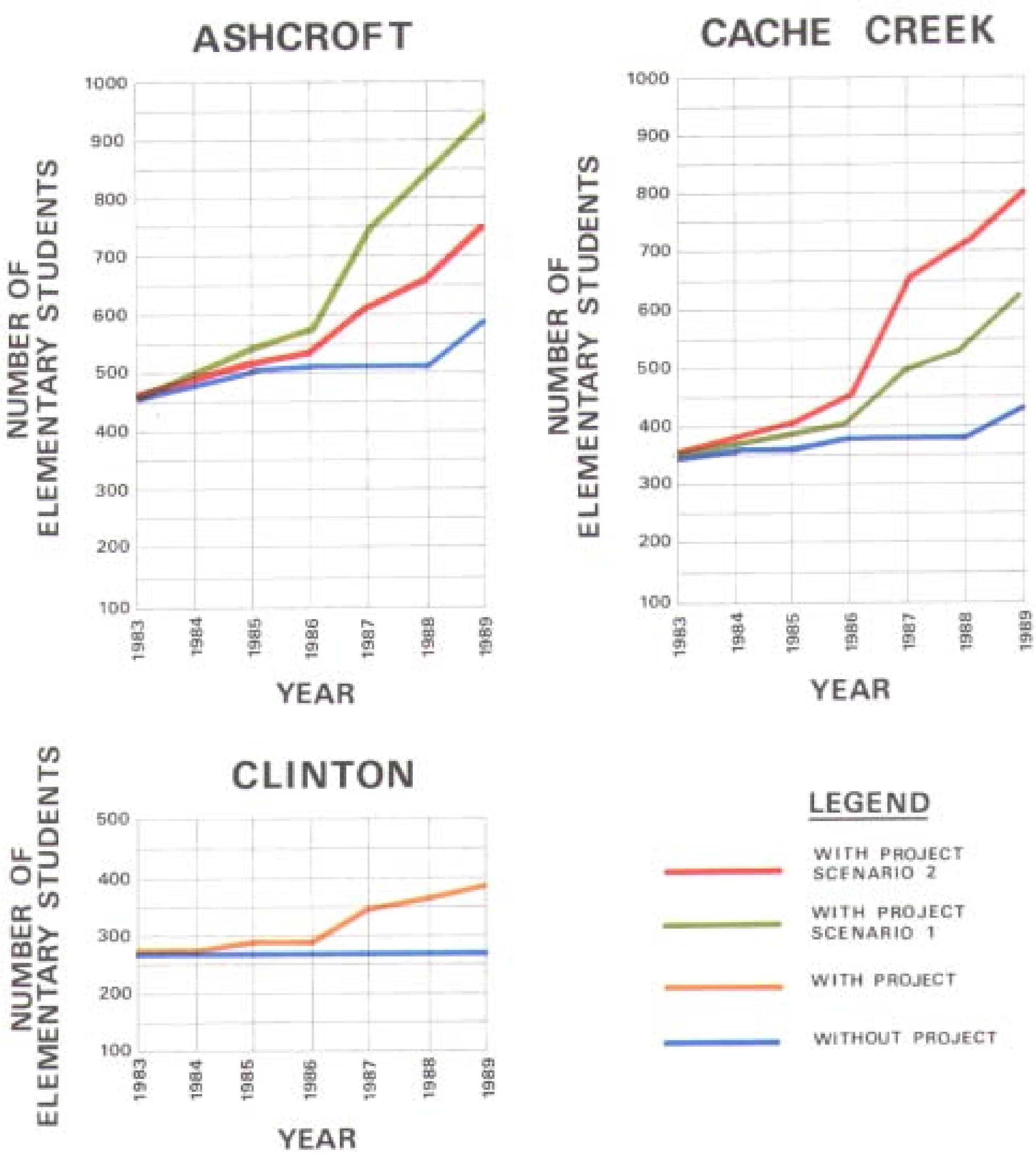
TABLE 20-1

PROJECTED DISTRIBUTION OF NEW HOUSING TYPES REQUIRED
BY PROJECT-RELATED POPULATION INCREASES (61)
(1983-1989)

| Housing Type | Village of Ashcroft | | | Village of Cache Creek | | | Village of Clinton | |
|---|---|---|---|---|---|---|---|---|
| | Percentage Distribution | No. of Units Scenario 1[1] | No. of Units Scenario 2 | Percentage Distribution | No. of Units Scenario 1 | No. of Units Scenario 2 | Percentage Distribution | No. of Units |
| Single and two family | 57% | 350 | 150 | 57% | 150 | 350 | 70% | 100 |
| Townhouses, Rowhouses | 5 | 25 | 25 | 5 | 25 | 25 | - | - |
| Apartments | 15 | 100 | 50 | 15 | 50 | 100 | 5 | 0 |
| Mobile Homes | 23 | 150 | 50 | 23 | 50 | 150 | 25 | 50 |
| TOTAL | 100% | 625 | 275 | 100% | 275 | 625 | 100% | 150 |

[1] Scenario 1 and 2 defined in Section 19.0.

Data are rounded to nearest 25.




HAT CREEK PROJECT

## FIGURE 20.1
# FORECASTS OF ELEMENTARY STUDENT ENROLMENT

SOURCE: *Strong, Hall and Associates Ltd., Cornerstone Planning Group Ltd., and Urban Systems Ltd. (23)*

TABLE 20-2
ADDITIONAL TEACHERS REQUIRED WITH THE HAT CREEK PROJECT (61)

| | Ashcroft | | Cache Creek | | Clinton |
|---|---|---|---|---|---|
| | Scenario 1[1] | Scenario 2 | Scenario 1 | Scenario 2 | |
| Elementary | 15 | 5 | 10 | 20 | 5 |
| Secondary | 20 | | 0 | | 5 |

1. Scenario 1 and 2 defined in Section 19.0.

Data are rounded to nearest 5.

(b) Health Facilities

The Ashcroft hospital is expected to be able to serve the increased population with the project to 1989. However, during the peak years of population increase from 1987 to 1989, the hospital may be operating at close to its capacity. Staff additions would be necessary to handle increases in hospital admissions.

Based on experiences with other similar projects in B.C., it is unlikely that the construction work force associated with the project would have a significant impact on the hospital occupancy rate up to 1989. Most injuries that would take place at the mine site or the plant would be treated by first aid or by the employee's own doctor.

Estimates of the various increases in health care capability needed to serve the added local population include four doctors, two dentists, one public health nurse, one mental health worker, and two ambulances.

(c) Recreation

In order to meet the needs of the population growth induced by the project, improvements and additions to community recreation services would be in order. Initially, community halls in Ashcroft, Cache Creek and Clinton would require upgrading and, possibly, enlarging. More open space in the form of parks would be needed in Ashcroft and Cache Creek under both scenarios. Additional recreational facilities such as a curling rink, bowling alley, indoor swimming pool, or multi-purpose facility might be required in Ashcroft, Cache Creek or Clinton with or without the project.

(d) Other Services

The list of estimates of other increases in social services to meet the needs of project-related population growth includes:

1. Two social service workers.

2. Added day care facilities.

3. Additional library space and staff.

4. One probation officer.

5. Minimum of seven RCMP officers in Ashcroft.

6. Two RCMP officers in Clinton.

7. One fire chief in Ashcroft.

## 20.3 COMMERCIAL AND INDUSTRIAL FACILITIES

(a) Commercial Services

By 1995 the combined population of Ashcroft and Cache Creek would be expected to reach about 8000 as a result of the project. In response to this increase in trading population, it is probable that existing businesses would expand and that new businesses would be established. It is probable that a broader range of commercial services and products would become available. Also, a trend toward increased involvement in the commercial sector by regional or national chains would likely arise, in the form of new outlets and the purchase of existing ones. New commercial space likely to be constructed in response to population increases has been estimated to be between 5000 and 7000 $m^2$.

(b) Industrial and Commercial Service

It is anticipated that in Ashcroft and Cache Creek there would be an expansion not only in the number of light industrial and commercial service establishments, but a broadening in the scope and range of services available as well. In the two communities, an estimated total of 10 to 20 ha of land would be required to adequately accommodate the demand. No constraints or restrictions on the supply of land are anticipated in either community.

## 20.4 COMMUNITY AND REGIONAL INFRASTRUCTURE

(a) Community Infrastructure

In Table 20-3 improvements required to upgrade community infrastructures to meet population growth created by the project are summarized. A lead time of 1 to 1.5 years before the start of construction would be needed to avoid delays in the delivery of new services.

(b) Regional Infrastructure

Each of the utility companies (B.C. Hydro, B.C. Telephone and Inland Natural Gas) indicates that no problems are anticipated in providing additional services in Ashcroft, Cache Creek and Clinton. A similar lead time to that mentioned above would be needed.

The project would necessitate an increase in both vehicular and truck traffic through the local communities as well as on the regional highway system.

TABLE 20-3
COMMUNITY INFRASTRUCTURE IMPROVEMENTS NEEDED TO SERVE PROJECT-RELATED POPULATION GROWTH

| Service | Community | Details |
|---|---|---|
| Water Systems | Ashcroft | Upgrade supply main and booster stations and expand reservoir to serve Mesa Vista bench. |
| | Cache Creek | New water intake and new reservoir in east sector; new main and reservoir to serve future development areas south of the village. |
| | Clinton | Main extension and expanded storage. |
| Sanitary Sewerage Systems | Ashcroft | Upgrade lift station and forcemain North Ashcroft; construct second outfall main Mesa Vista bench. |
| | Cache Creek | New trunk main to serve future development area south of the village. |
| | Clinton | Extend trunk mains to new development areas. |
| Roads | Ashcroft | Upgrade Thompson River bridge and access road to Mesa Vista. |
| | Cache Creek | Upgrade main access route to east sector; extend new south access road; extend Old Stage Road to Cariboo Highway |
| | Clinton | New access road to development area. |
| Solid Waste Disposal | All communities | None |
| Storm Drainage | All communities | None |

At present, Highway No. 12 provides the only access between the project, the main regional highways (No. 1 and No. 97) and nearby communities. The proposed project access road would follow the Medicine and Cornwall creeks and intersect Highway No. 1 near the south end of Ashcroft, as shown on Figure 3-2. This new route would minimize potential noise and safety hazards on Bonaparte Reserves Nos. 1 and 2.

The probable key traffic points would be at the junction of the project access road with Highway No. 1 and the junction of Highway No. 12 with Highway No. 97. The volume of traffic at these junctions would produce congestion and pose some safety hazards, particularly during periods of peak summer highway traffic. Truck movements, chiefly from the unloading facility to the site, would be expected to reach 50 vehicles per day during the construction phase.

## 20.5 LOCAL AND REGIONAL GOVERNMENT

### (a) Local Government Administration

The rapid growth rates projected for the communities, in particular Cache Creek and Ashcroft, would necessitate a greater level of planning and administrative activity. Some time lags in the provision of services and processing of development applications would probably occur in the initial years of community growth. A lead time of 1 to 1.5 years before the start of construction would be required to enable the municipalities to adequately prepare for the management of project-related expansion, even with a community plan and bylaws for its implementation in force.

### (b) Municipal Finance and Budgeting

A comparative evaluation of projected expenditures, revenues, assessments and tax rates for each municipality indicates that over the long term, each of the municipalities would be financially capable of carrying out its responsibility without imposing undue tax burdens on taxpayers. Temporary fiscal difficulties in Ashcroft and Cache Creek might result in excessive increases in general taxation level during the first few years after project commencement. The probable effects of the project on municipal taxes are outlined below.

Tax rates at Ashcroft are projected to rise rapidly in the initial period after project commencement. Tax rates are then expected to gradually decline, reaching a level comparable with rates projected without the project. A significant increase in tax rates would occur when the population reaches 5000 and policing becomes a local responsibility.

It is predicted that tax rates at Cache Creek would jump sharply in the first year following project commencement, reflecting the rapid expansion of the local government structure required to adequately handle the increased level of development activities in the community. Under Scenario 1, it is projected that within 3 or 4 years following project commencement, tax rates with the project would be roughly equivalent to tax rates without the project. Taxes would jump sharply when the population reaches 2500 and the welfare function becomes a local responsibility. Under Scenario 2, it is projected that tax rates would exceed rates without the project by an average of approximately 30 percent.

Tax rates for Clinton are projected to be only slightly higher (less than 1 mill) with the project than without it.

### (c) Regional District

The role of the regional district in this context would be planning for new development in the unorganized rural parts of the study areas. The Thompson-Nicola Regional District has recently embarked on a planning program which should culminate in the adoption of an official regional plan. The regional plan will establish policies and guidelines for coordinating new development in these unorganized areas. The regional district might participate with the member municipalities in the study areas to finance joint programs for certain services such as recreation and cultural services.

(d) B.C. Hydro's Contributions to Local Taxes

B.C. Hydro, with two exceptions, pays school taxes on the same basis as all other taxpayers in the province. The exceptions are generation and storage developments on the Peace and Columbia River systems. B.C. Hydro has been exempted by statute from all other property tax levies.

B.C. Hydro is authorized to pay annual grants in lieu of general, local improvement and regional district tax levies. These grants are calculated on a basis similar to the taxes levied on privately owned utilities in municipal areas. These computations include amounts equivalent to general, local improvement and regional district taxes levied in the prior year on land and buildings (generation and transmission buildings excluded) plus 1 percent of electric and gas revenues from sales within each taxing jurisdiction.

If construction of the Hat Creek project proceeds, B.C. Hydro expects, on the basis of current authorizations, to pay school tax levies on temporary facilities such as camps, field offices, warehouses, shops and batch plants during the construction period and on the powerplant and transmission lines when they are completed. Annual grants equivalent to general, local improvements and regional district levies in the prior year will also be paid on land and construction buildings required for the project, but B.C. Hydro is not authorized to include generating facilities in the grant calculations for any area or location.

# SECTION 21. SOCIAL ENVIRONMENT(23,61)

The proposed project would affect the social environment through changes in the natural environment; changes in economic structure; changes in populations and community expansion; and adjustment problems associated with rapid change and development. Social impacts of this project are viewed therefore in terms of probable alterations in quality of life. These changes would primarily occur in the local study area (see Figure 19-1), particularly in Ashcroft, Cache Creek, the Hat Creek valley and the Indian reserves adjacent to the valley. Minimal effects would occur among the population of the broader region.

Since the completion of the consultants' report, a mine camp has been added to the project scheme. The social impacts of the camp are not considered here but will be taken into account in the socioeconomic update study mentioned in Section 19-1.

## 21.1 IMPACTS RESULTING FROM CHANGES IN THE NATURAL ENVIRONMENT

The Hat Creek area is considered by residents, particularly ranchers, rural residents and farmers, to be a favourable place to live because of the climate, minimal air and water pollution and accessibility to a variety of recreational resources. The Native Indian people have a heritage that is integrally tied to the natural environment.

Changes in the natural environment arising from project components in the Hat Creek valley would include: reduction in the quantity and quality of agricultural, recreational and forest land; reduction in the quantity and quality of wildlife habitat; changes in the flow characteristics and quality of surface and groundwater supplies; reduction in Hat Creek fish population; increase in noise levels and alterations in noise characteristics and reduction in the quality of the ambient air. (Health effects are discussed in Section 22.0.)

The individuals affected include valley residents and other users of the valley. Three residences would have to relocate as a direct result of land alienation and noise impacts. The relocation of individuals can be expected to produce a sense of loss in those who leave and those who remain. While this sense of loss would be felt by relatively few people, it must be considered very important to those involved. Furthermore, since valley residents and Native Indians are used to relatively unrestricted mobility throughout the valley environs, land ownership status and restrictions on this mobility because of the project could be viewed as an important loss.

Surface waters, considered likely to be used for irrigation in the valley in the future without the project, would be disturbed and their availability reduced in a number of locations. These losses would reduce the viability of ranches already affected by land alienation, but would not likely affect any additional ranches in the area (see Section 11.0).

Water quality and quantity in Hat Creek, downstream of the open pit, would be altered as described in Section 11.0. These changes are not great; interruptions to domestic or agricultural supplies are therefore not expected. As noted in Section 11.0, chlorination of domestic supplies should be practised.

Noise and air quality impacts are discussed more fully in Sections 14.0 and 6.0 respectively. No adverse impacts on human health are predicted (Section 22.0). Increased noise levels would affect some residents and increased dust levels might reduce residential amenities north of Finney Creek and on the No. 1 Bonaparte Reserve.

The proposed access road, pipeline and transmission line corridor would alienate some of the forest, agricultural and recreational lands as well as causing some stream and fishery disruptions (see Section 8.0, 9.0, 12.0, 14.0 and 15.0). The social consequences of these changes are considered minimal. Similarly, the proposed airstrip is unlikely to generate significant negative social impacts. Residents of all study area communities generally favoured a proposed airstrip; the benefits would be derived by both commercial and non-commercial users of the facilities.

Increased truck movements during the construction period would affect residents in the vicinity of the proposed unloading facility. These individuals would experience disruptions and noise associated with additional traffic and loading activity in the area.

## 21.2 IMPACTS RESULTING FROM CHANGES IN ECONOMIC STRUCTURE AND OPPORTUNITY

The proposed project would create a large number of short and long-term employment opportunities, lower unemployment rates in the short run, create employment opportunities for individuals wanting to enter the local labour force and generate opportunities for individuals to improve their employment positions in the region.

The project would also raise the income and employment expectations of many residents in the study areas. However, the hiring practices of B.C. Hydro as set out in the labour management contracts and laws related to discrimination in hiring would inhibit maximizing local employment, although every effort would be made to work with the unions to improve this situation.

## 21.3 IMPACTS RESULTING FROM POPULATION CHANGES AND COMMUNITY EXPANSION

The project would result in a large and rapid population increase in the local area. These population changes would require a number of personal adjustments on the part of existing residents and would induce expansion in community social services, commercial goods and services, and housing and community infrastructure. If this rapid growth leads to a period of excess demand, then the study area residents might also experience changes in the availability and cost of housing, the cost, level and quality of services and the physical structure of the communities. These changes may in turn lead to over-crowding, feelings of loss or anxiety, increased turnover rates and a variety of other social or personal problems related to changing community characteristics.

Excess demand for services and housing in particular could result in overcrowding and disruption in services and create pressures on individuals involved in administration and delivery of services.

The existence of a large single-status construction population would create the potential for social conflict with valley and Indian Reserve residents during the construction period. The movement of heavy machinery and other vehicles and increased recreational use of the valley might cause disruptions. In addition to increases in safety hazards, the incidences of trespassing and property damage might increase.

Over the longer run, personal adjustments would occur and new social patterns would emerge. If the demand for community and social services is met, expanded services would provide benefits to the local people through greater choice than that likely to occur during the same time period without the project. For many residents of the study areas, changes in the physical character of the settlement communities would enhance the quality of life. For others the transformation in community life and quality might represent a decline in the quality of life.

## 21.4 SOCIAL AND COMMUNITY ADJUSTMENT PROBLEMS

Adjustment problems might occur as a result of changes in social behaviour, community stability, and community social stratification and structure. Inferences about potential social problems at Hat Creek were drawn from adjustment problems experienced on comparable projects.

From the experience of other communities, some social problems changes such as increases in petty crimes, might be expected. Also, the increased flow of unemployed job seekers would tend to increase transiency levels in the study area communities. Alcohol consumption would tend to increase among certain groups in the communities, as would alcohol-related problems. Some increase in juvenile delinquency, venereal disease and other social problems could also be expected.

New residents might question the values and behaviour of the established residents, possibly creating concerns in the community through the adjustment period. On the other hand, the project might reduce out-migration from the study areas and increase employment opportunities. In particular more local young people might remain in the communities with the project than without it, thus contributing to family stability.

Some social stratification could occur if new housing developments built in response to population increases primarily attract project employees. The major effect of this stratification would be to retard integration between newcomers and existing residents. Changes in local politics in terms of key individuals and the relative strengths of vested interest groups would likely occur. New organizations would probably be formed to meet the needs of community residents. New events and activities might increase the quality of life for some residents in the communities and assist the integration of different resident groups. However, the project would negatively affect those ranchers and rural people who value their traditional lifestyle.

## 21.5 IMPACTS ON NATIVE INDIANS

The influx of a large number of non-Native Indian people into the area would accentuate the ethnic minority status of the local Native Indian people. The increased pressure of a non-Native Indian culture and lifestyle would suggest a negative impact on Native Indian people, although the extent of these impacts can not be determined.

# SECTION 22. EPIDEMIOLOGY (HUMAN HEALTH)(58,7,14,47,36,66)

## 22.1 INTRODUCTION

B.C. Hydro recognizes that a variety of materials would be emitted from the powerplant and mining operations and it was appreciated that there would be public concern as to their effects on human health. Accordingly, a review of the epidemiological evidence was undertaken to address these concerns and to recommend ambient air quality objectives for the project which would protect health.

The epidemiology study reviewed ambient air objectives (also called guidelines, standards, criteria, regulations) for British Columbia, Alberta, Ontario, the states of Washington, Idaho and Montana and both the Canadian and United States federal governments. Both short-term and long-term ambient air objectives have been developed by these governments to protect health, vegetation, property and other factors. The epidemiology study for this project reviewed these objectives in conjunction with the existing epidemiological data base in order to recommend ambient air quality guidelines for the proposed project based on human health considerations.

Historically, attempts to identify specific levels of individual contaminants which cause health problems, in order to establish guidelines, have been frustrating. Seldom do contaminants occur in isolation; effects may therefore be due to a combination of contaminants as opposed to a specific one. In addition, at lower concentrations the ability to clearly establish cause-effect relationships between contaminants and resulting health impairment becomes extremely tenuous. As a result, this examination of epidemiology identified a range of individual concentrations which would be protective of human health, rather than a single value, which would have required a subjective weighting of data. The development of an objective level range is appropriate to human responses in general where the lower end of the range would apply to persons who, by virtue of their age (very young or very old), diet, nutritive or genetic makeup, may be more sensitive to exposure to atmospheric contaminants than the population at large.

The epidemiological studies considered both primary contaminants, such as sulphur dioxide, suspended particulate matter, carbon monoxide and nitrogen oxides, and secondary contaminants such as sulphates, nitrates and ozone, which may be produced due to atmospheric chemical reactions of primary emissions. Also considered were trace element emissions of arsenic, beryllium, cadmium, chromium, copper, fluorine, lead, manganese, mercury, nickel, selenium, uranium, zinc, vanadium, polycyclic organic matter and nitrosamines. In addition, a separate investigation of the health effects of radioactive trace contaminants was undertaken.(7)

In the following subsections the results of this overview of air quality objectives to protect health are briefly examined. It is recognized that, although the most up-to-date and complete information has been used in these assessments, in many instances the epidemiological and toxicity data base is limited. The compliance of the proposed project i.e. with the inclusion of partial flue gas desulphurization, with these objectives is discussed based on the predicted air contaminant concentrations. Also discussed are recent data from other areas which consider the health effects of pollutants, and are therefore relevant to the proposed project.

## 22.2 SULPHUR DIOXIDE

Following a review of available epidemiological data, a 24-hour average ambient S02 concentration of 300 to 400 μg/m³ and an annual average ambient concentration of 90 to 100 μg/m³ were recommended as ambient level concentrations which would not impair human health. Ambient concentration limits for periods less than 24 hours were not established because it was not possible to establish any scientifically proven relationship between concentrations for shorter periods and resulting health impairment.

More recently the U.S. National Academy of Sciences attempted to update their evaluation of air pollution from sulphur oxides[9]. They concluded that the present 24-hour U.S. primary standard for sulphur dioxide of 365 μg/m³ was sufficient to protect health, to the extent that the effect of sulphur dioxide could be separated from the effects of particulates.

The Environmental Research & Technology (ERT) report(14,47) concerned with air quality and climatic effects of the proposed project predicted maximum S02 concentrations as a result of continuous operation of the proposed powerplant, as discussed in Section 6.0. The maximum ground-level sulphur dioxide concentrations from the project are predicted to be 208 μg/m³ for a 24-hour averaging time, and an annual concentration of 4.5 μg/m³ (see table 6-3). Both predicted maximum concentrations are less than the recommended guidelines. Consequently, sulphur dioxide emissions from the proposed project are not predicted to adversely affect public health.

## 22.3 SUSPENDED PARTICULATE MATTER

Suspended particulates are the most complex of all atmospheric pollutants. Biological responses to particulates are determined not only by chemical composition but also by particle size and site of deposition. Some industries which produce high concentrations of fugitive dust, such as construction and mining, may exceed the guidelines proposed to protect public health on occasion. However, an examination of chemical species, particle size, and site of deposition reveals that many of the particles produced by these industrial sources are either too large to be inhaled or for other reasons are not retained in the upper regions of the respiratory tract. This distinction has led regulatory agencies to recognize differences between inhalable and non-inhalable particulates.

The U.S. Environmental Protection Agency (EPA) is currently moving toward establishment of a standard for inhalable particulates[10], which are defined as particles less than 15 μm aerodynamic mean diameter. The process for setting this standard has not been completed. Therefore, ambient particulate guidelines for the proposed project were recommended in terms of total suspended particulates, rather than on the basis of particle size. On the basis of existing epidemiological data, guidelines of 150 to 300 μg/m³ for the

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[9] NAS. 1978. Sulphur Oxides - National Academy of Sciences, Washington, D.C.

[10] EPA. 1978. Health Effects Considerations for Establishing a Standard for Inhalable Particulate. U.S. Environmental Protection Agency. Research Triangle Park. North Carolina.

24-hour average ambient level, and 60 to 100 μg/m³ on the annual average ambient level were identified as levels which would not impair human health.

Operation of the proposed project would produce atmospheric particulates, both from coal combustion and mining. The maximum predicted ground-level total suspended particulate concentrations from continuous operation of the powerplant stack are predicted by ERT(14,47) as 23 μg/m³, averaged over a 24-hour period, and 0.5 μg/m³ averaged over a 1-year period (see table 6-3). No concentrations approaching the 24-hour and annual guideline values are expected. Thus, the operation of this powerplant is not expected to produce concentrations of particulates which would impair human health.

Specific dust control measures have been developed for the mining operations at Hat Creek.(36) Based on these, it is ERT's best judgment that particle concentrations outside the pit, at distances greater than half a kilometre from the dust producing operation, should fall below the guideline values of 60 μg/m³ for annual concentrations and 150 μg/m³ for 24-hour maximum concentrations. These values are protective of human health and operation of the mine should not produce concentrations which would adversely affect human health.

## 22.4 NITROGEN OXIDES (AS NO2)

The relationship between ambient concentrations of nitrogen dioxide and adverse health effects is not sufficiently defined to allow recommendation of ambient guidelines for short-term exposures (1 to 2 hours). Existing data suggest a guideline range of 900 to 1000 μg/m³ for short periods. Although data for the establishment of longer term guidelines are likewise lacking, consultants consider that compliance with Environment Canada(66) "maximum acceptable" levels of 200 μg/m³ on the 24-hour average and 100 μg/m³ for the annual average ambient concentrations would be sufficient to protect public health.

Maximum predicted ground-level nitrogen dioxide concentrations from continuous operation of the powerplant have been estimated as 460 μg/m³, for a 1-hour averaging time, 116 μg/m³ over 24 hours and 2.5 μg/m³ for an annual average (see table 6-3). From these values it is apparent that N02 concentrations resulting from powerplant operation are expected to be very low, and therefore, would have no adverse effect on human health.

## 22.5 CARBON MONOXIDE (CO)

On the basis of existing epidemiological data, health protection guidelines for carbon monoxide of 40 to 60 mg/m³ for the 1-hour average ambient concentration and 15 to 20 mg/m³ for the 8-hour average concentration were recommended. Since carbon monoxide has diffuse physiological effects in sensitive segments of the population, it was recommended that an effort should be made to achieve concentrations at the lower end of the range. Compliance with Canadian Federal "maximum acceptable" guidelines (66) of 35 mg/m³ for 1 hour and 15 mg/m³ for 8 hours would be more than sufficient to protect public health.

Continuous operation of the proposed project is predicted to produce maximum ground-level carbon monoxide concentrations of 0.099 mg/m³ for a 1-hour averaging time, and 0.031 mg/m³ for an 8-hour averaging time. In comparison with the proposed guidelines, the predicted concentration levels are insignificant, and would not cause an adverse impact on public health.

## 22.6 OXIDANTS (AS O3)

Based on a review of existing health data, the guideline recommended for oxidants was 150 to 300 µg/m³ for short-term (1/2 to 2-hour) exposure. It was further recommended that an effort should be made to maintain the lowest practicable concentration in this range. The U.S. EPA has recently raised their primary standard from 150 µg/m³ to 235 µg/m³. Insufficient data exist to quantify the adverse effects of oxidant exposures for the 24-hour and annual time duration; it was therefore impossible to recommend guidelines for these periods. However, compliance with the Canadian Federal "maximum acceptable" guideline(66) of 50 µg/m³ over 24 hours is expected to be sufficient to protect public health.

Ozone is not a primary product of powerplant operation but rather a secondary product formed by solar photochemical or other reactions. Although the Canadian maximum acceptable level of 160 µg/m³ over 1-hour for ozone is exceeded naturally on occasion at Hat Creek, the powerplant is not expected to increase the ambient ozone concentrations. Thus, the concentrations of oxidants associated with the proposed project are not predicted to adversely impact public health.

## 22.7 POLLUTANTS IN COMBINATION

Recently attention has focused on the interaction of various pollutants, which in combination may cause effects which are different from when they are present individually. This concern has arisen because often a single pollution source will emit several different contaminants. Further, much of the epidemiological data available are based on this more realistic situation. Two combinations of pollutants have particular relevance to this proposed project, namely sulphur dioxide and particulates, and ozone and sulphur dioxide.

(a) Sulphur Dioxide/Particulates

Both Environment Canada and the U.S. Environmental Protection Agency have addressed the effects of sulphur dioxide and particulates in combination. Environment Canada(66) has proposed a maximum tolerable level of 125 000 (µg/m³)², calculated as the mathematical product of multiplying sulphur dioxide concentrations by particulate concentrations at the same location over a 24-hour

[11] Canada Gazette. 1976. Department of the Environment. Canada Gazette. Part 1. 7 August 1976.

[12] EPA. 1976. Project Plan: Air Quality Criteria for Particulate Matter and for Sulphur Oxides. U.S. Environmental Protection Agency. Research Triangle Park. North Carolina.

period[11]. The United States Environmental Protection Agency has recently begun to develop a single criteria document for the two pollutants[12].

When multiplied together, the proposed project's predicted maximum average $SO_2$ and particulate concentrations over 24 hours yield a product of 4992 $(\mu g/m^3)^2$ which is more than an order of magnitude less than the maximum tolerable level proposed by Environment Canada. Therefore these pollutants in combination are not predicted to present health problems.

(b)Ozone/Sulphur Dioxide

The scientific community has been concerned for some time about the health effects caused by an interaction of sulphur dioxide and ozone. In the studies by Bates et al.[13] involving the administration of sulphur dioxide and ozone, separately and in combination to a small group of healthy subjects, a significant and exaggerated impairment of breathing was reported when the two gases were combined. A collaborative study was undertaken at Rancho Los Amigos hospital in Los Angeles by Bell et al.[14] In this study, using Los Angeles residents as well as the original subjects of Bates' study, the results were less conclusive than those reported originally. The synergistic effects observed in Montreal were not observed in Los Angeles. The alterations in ventilatory performance were due entirely to ozone, with no changes due to sulphur dioxide. Recently a group in California[15] investigated the effects of sulphur dioxide in combination with ozone. The observed effect was so weak that the existence of any interaction could not be determined. These data indicate that sulphur dioxide and ozone do not produce a synergistic effect on pulmonary function in humans.

## 22.8 TRACE ELEMENTS

In addition to major contaminants emitted from the Hat Creek powerplant stack, sulphur and nitrogen oxides and particulates, there would be a variety of materials emitted in very small quantities - so called trace elements. From analyses of Hat Creek coal, monitoring during combustion tests and literature surveys, estimates of the quantities of trace contaminants emitted have been made. Consideration was given to sulphates and nitrates formed by secondary atmospheric reactions of sulphur and nitrogen oxides and possible emission of polycyclic organic matter and nitrosamines.

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[13] Bates, D.V. and M. Hazucha. 1973. The Short-term Effects of Ozone on the Human Lung. pp. 507-540. In National Academy of Sciences, National Research Council, Assembly of Life Sciences. Proceedings of the Conference on Health Effects of Air Pollutants. Washington, D.C. 3-5 October 1973. A report prepared for the Committee on Public Works, United States Senate, S. Res. 135. Serial No. 93-15. Washington, D.C.

Hazucha, M. and D.V. Bates. 1975. Combined Effect of Ozone and Sulphur Dioxide on Human Pulmonary Function. Nature. Vol. 257 . pp. 50-51.

[14] Bell, K.A., W.S. Linn, M. Hazucha, J.D. Hackney and D.V. Bates. 1977. Respiratory Effects of Exposure to Ozone plus Sulfur Dioxide in Southern Californians and Eastern Canadians. American Ind. Hyg. Association Journal. Vol. 38. pp. 696-706.

[15] IES. 1977. Interactions of Two Air Pollutants, Sulfur Dioxide and Ozone on Lung Functions. Work performed at the Institute of Environmental Stress. Santa Barbara, California.

The emission rates and maximum predicted 24-hour average concentrations of trace contaminants are shown in Section 6.0, together with ambient concentrations from the PCB Objectives. Based upon an analysis of the predicted values for trace elements and the available information on the health effects associated with these pollutants, no adverse health risk is foreseen from the proposed project.

The trace elements emitted from the powerplant stack include the radioactive elements uranium and thorium and their daughter radionuclides. A member of the public could receive a radiation dose as a result of inhaling radioactive gas and particulate matter, and as a result of ingesting radioactive materials that find their way into the food chain. Calculations of the inhalation dose were based on predicted maximum ground level ambient concentrations. Calculations of the ingestion dose were made for a person living continuously in the area having the highest concentrations of radioactivity in the soil and depending entirely on food grown at that location. The radiation dose from these two exposure pathways is estimated to be 0.2 mrem/annum. (7)

An additional estimate has been made of the radiation received by the most highly exposed individual, in this case a worker employed full time on the ash pile. His maximum dose was calculated to be 1.7 mrem/annum and is due principally to inhalation of radon that is given off by the ash. This too is a worst case analysis and is unlikely to be achieved in practice.

These dose levels may be compared to higher doses of about 130 mrem/annum received from natural sources by a person living at the same elevation as the powerplant. Further, the International Commission on Radiological Protection (ICRP) recommends a radiation dose limit of 500 mrem/annum for the protection of the public. As may be seen from predicted values, the radiological health impact of the Hat Creek Project is expected to be insignificant.

Many alternatives were evaluated in planning the proposed thermal-electric generating development. Choices were made as to component location, design, unit size, types of components, environmental control technology and other factors. Many of these choices have a bearing on the cost and on the environmental effects of the project. The primary purpose of Part IV is to present an evaluation of the major options for mitigating the impacts of the proposed project. Information is provided about the relative costs and likely benefits of various project alternatives. The principles of benefit-cost analysis suggest that it is not efficient to minimize environmental impacts at a particular site if costs of control far outweigh the value of foregone resources, although where environmental resource values are very high, special efforts for environmental protection would be expected. Under provincial guidelines, developers are expected to provide cost estimates of alternative proposals for reducing environmental impacts so that a satisfactory level of mitigation can be selected.

A second objective of Part IV is to explain B.C. Hydro's proposals for monitoring project impacts, and to discuss compensation for project-related impacts which cannot be mitigated. The first step is to explain what is meant by mitigation and compensation.

Mitigation measures are design alternatives that may be selected to reduce the adverse impacts of a project. In principle, mitigation measures should bring about a reduction in resource impact costs at least as valuable as the cost of the measures themselves. In practice, resource impacts associated with thermal powerplants are often difficult to either predict or measure in dollar terms. Thus, it is often difficult to make explicit comparisons between resource losses prevented and the costs of prevention. For example, a decision to locate a powerplant at a site which is more costly than others, but also more desirable because of smaller or fewer environmental impacts, may be viewed as an efficient mitigation measure, even though the benefits are not completely quantifiable.

Compensation refers to payments or programs to reimburse losses which cannot be prevented by mitigation measures. The general question of whether compensation should be paid by developers for losses to publicly owned resources is under discussion by provincial agencies, but precedents have been established by B.C. Hydro on three of its recent hydroelectric projects (Revelstoke, Seven Mile and Peace Canyon). In general terms, compensation can be discussed on the grounds of either economic efficiency or equity.

Economic efficiency is a measure of the return that resources earn in different uses. Generally speaking, resources are used in the most efficient or socially desirable manner when they generate the highest return and thus produce the maximum benefits to society. For resources to earn their full social value, and for developments to reflect full social cost, payments should be made for all resources used even if this is not the usual practice in normal market transactions. The efficiency requirement for compensation suggests that publicly-owned resources should be paid for or replaced if adversely affected by a development.

Equity factors are important because resource development projects affect certain groups within society to varying degrees. For example, some people living near a thermal project may benefit from employment opportunities, while others may be disadvantaged by adverse environmental effects. The implications of resource developments upon social equity form one basis for decisions by governments about compensation. Thus, compensation payments on equity grounds would be made for programs which are directed to people who are negatively affected.

The project's benefit/cost framework uses economic principles to analyze the desirability of investment in projects from a "social" or "public" standpoint. Social benefit/cost analysis is a method for comparing costs and returns of developments from different viewpoints.

Benefit/cost analysis differs from corporate financial analysis, or the "private" viewpoint, both in the types of costs and benefits considered and the ways in which costs and benefits are treated when market prices do not fully reflect social value. The Provincial Guidelines for Benefit/Cost Analysis (59) recommends that results be displayed on three separate accounts: provincial income (efficiency), regional income (equity) and the environmental account. In briefest terms, the provincial income account adds up the social benefits and costs of a project regardless of to whom they accrue within the province. The regional income account considers equity effects by specifying who gains and who loses. The environmental account is a description of environmental and socio-economic effects which can not be evaluated in income terms.

Part IV discusses B.C. Hydro's approach to management of impacts from the Hat Creek project. Section 24.0 discusses the mitigation measures incorporated into the project components. The main focus of this section is an assessment of the benefits and costs of alternative air quality control systems. Section 25.0 discusses B.C. Hydro's approach to compensation, while Section 26.0 outlines B.C. Hydro's proposals for monitoring of impacts.

(References: 14, 16, 17, 24, 25, 29, 30, 32, 36, 37, 38, 43, 44, 50, 51, 52, 55, 59)

In this section, some of the major mitigation alternatives available to B.C. Hydro are considered. There are a large number of decisions required when designing a major power facility which involve choices that could reduce impacts at a certain cost. The major alternatives discussed here include site selection, design, powerplant air quality control system and socio-economic mitigation measures. A benefit/cost analysis of mitigation alternatives is included for the powerplant air quality control systems (AQCS). However, all these decisions were assessed by comparing economic, environmental and social benefits to their dollar costs, following the conceptual framework of benefit/cost analysis.

The following analysis presents capital and operating costs of the various systems in discounted present value terms, at uninflated 1980 price levels. The reference point for discounting is a 1988 in-service date for Unit No. 1 of a 2000 MW (net) development. Present worth totals are shown at 3, 6 and 10 percent discount rates. These discount rates are net of inflation and correspond to B.C. Hydro's real cost of capital (3 percent), B.C. Hydro's estimate of the social opportunity cost of capital used in its projects (6 percent) and the rate recommended in the Provincial Guidelines(59) (10 percent).

## 24.1 SITE SELECTION

A site evaluation study was undertaken by Integ-Ebasco(30) for B.C. Hydro to determine the best location for a powerplant facility which would burn Hat Creek coal. Eight sites were considered in the detailed evaluation; of these, three were in proximity to the load centre of the Lower Mainland (Dunsmuir, Britannia Beach and Stave Lake), three were in proximity to the coal deposit (mine mouth, Harry Lake and Ashcroft) and two sites were in relatively undeveloped areas (Big Bar Creek and Soda Creek).

These sites were assessed by comparing their relative ranking from three different criteria, or "accounts": the environmental suitability account, the engineering economic account, and the engineering confidence account. In the environmental suitability account, an index was developed to indicate qualitatively the potential effects of the development at the various sites upon air quality, water resources, terrestrial and aquatic ecology, land use, aesthetics and socioeconomics. The engineering economic account was based upon an analysis of the comparative costs of the development at the various sites. The account analyzed both capital and operating costs of components which would differ from site to site, including powerplant water systems, coal transportation costs, powerplant access facilities, waste disposal areas and transmission lines. The engineering confidence account presented a qualitative assessment of the engineering characteristics of the various sites, including flexibility, ease of construction, availability of borrow areas, geotechnical stability, soil permeability and other factors.

Each account provided an independent ranking of the alternative sites, as shown in Table 24-1. The environmental suitability account favored three sites: Harry Lake, Big Bar Creek and Soda Creek. Powerplants at these locations would have lower ratings on the environmental impact index of Table 24-1, indicating better environmental compatibility than other sites.

In the engineering economics account, sites exhibiting relatively lower costs were the mine mouth, Harry Lake and Ashcroft. The mine mouth site, with obvious advantages in terms of transport costs, was considered the "base cost" location. Both the mine mouth and Ashcroft sites rated poorly in the environmental suitability account, due primarily to air quality considerations.

Finally, in the engineering confidence account, each of the three environmentally preferred sites rated highly. Because Harry Lake is adjacent to the mine development, it affords the greatest flexibility and fewest critical problems for reliable operation.

From all three viewpoints, the Harry Lake site was highly rated. Big Bar Creek and Soda Creek were considered attractive alternatives, but were burdened with higher costs. The lowest cost site, at the mine mouth, was rejected due to environmental factors. In selecting the Harry Lake site, the present worth of capital and operating costs were increased by 56.9 M$ (using a 6 percent discount rate)(55) in order to reduce the air quality impacts of the project (see Table 24-2).

## 24.2 DESIGN ALTERNATIVES

The two major areas of project design, other than powerplant AQCS, which have alternatives affecting environmental impacts are ash disposal and dust control.

### (a) Ash Disposal (32,38)

Three different schemes for disposal of powerplant ash were evaluated in detail, two involved "wet" disposal of ash, or ash mixed with water, and one scheme involved "dry" disposal. The choice of an ash disposal system is an important component of project planning, since ash leachates could adversely affect the local environment if the ash is not disposed of in an acceptable manner.

Table 24-3 shows the present worth of differential costs of "dry" vs "wet" disposal schemes. All three schemes would produce approximately the same benefits in terms of powerplant operation. Dry ash disposal is significantly less costly than wet (38); it is therefore the preferred system in terms of engineering costs. Dry ash disposal would also be the preferred system from most aspects of environmental impacts (32). It has advantages over wet disposal systems in terms of effects on water quality and land resources, a significant advantage in terms of visual impact, and shows good potential for reclamation.

Dry ash disposal is therefore the preferred system from both an economic and environmental standpoint. This approach has been incorporated into the proposed Project design.

### (b) Dust Control (14,36)

Two alternative designs were considered in successive stages of project

TABLE 24-1
ENVIRONMENTAL RANKING OF ALTERNATIVE SITES (30)

| Sites | Environmental Ranking Impact Index[1] |
|---|---|
| Britannia Beach | 100.0 |
| Stave Lake | 88.9 |
| Dunsmuir | 65.8 |
| Mine Mouth | 47.6 |
| Ashcroft | 37.8 |
| Soda Creek | 29.9 |
| Big Bar Creek | 27.9 |
| Harry Lake[2] | 26.2 |

1. Low values indicate environmental site compatibility.

2. The proposed site.

---

planning for the mine complex. These alternatives have different implications for dust control. In an early stage of evaluation, the layout of the mine complex was organized such that there could have been potentially significant impacts from dust (14). After preliminary studies, B.C. Hydro had its consultants prepare a plan for reducing dust from the mine area (36). The plan includes measures for dust control such as use of windbreaks, minimum exposure of erosion surfaces, and water spraying on roads (see Section 3.2d). The additional costs for these dust control measures are estimated at between 2 M$ and 3 M$.

## 24.3 BENEFIT/COST ANALYSIS OF AIR QUALITY CONTROL SYSTEMS (25,29,37,50)

### (a) Introduction

Throughout the impact assessment (Part III), the discussion of air quality effects of the project has been mainly based on the proposed air quality control systems (AQCS), which consist of electrostatic precipitators and flue gas desulphurization (FGD). Other pollution control technologies were also considered for this project,(14,29) which would involve alternative costs and different levels of reliability and protection. These systems received both engineering and environmental consideration. The engineering aspects are presented in Section 3.3(c) while the costs and environmental considerations are presented in this section. Although B.C. Hydro has made a recommendation, (the "Proposed Project") having considered all aspects, the final decision remains with the

TABLE 24-2
PRESENT WORTH OF DIFFERENTIAL COSTS OF HARRY LAKE VS MINE MOUTH SITE (55)
(M$ 1980)

| Discount Rate (%/annum) | Extra Cost of Harry Lake Site |
|---|---|
| 3 | 77.6 |
| 6 | 56.9 |
| 10 | 42.1 |

government through the licensing process. The question addressed in this section is how the proposed combination of control systems was selected over other possibilities.

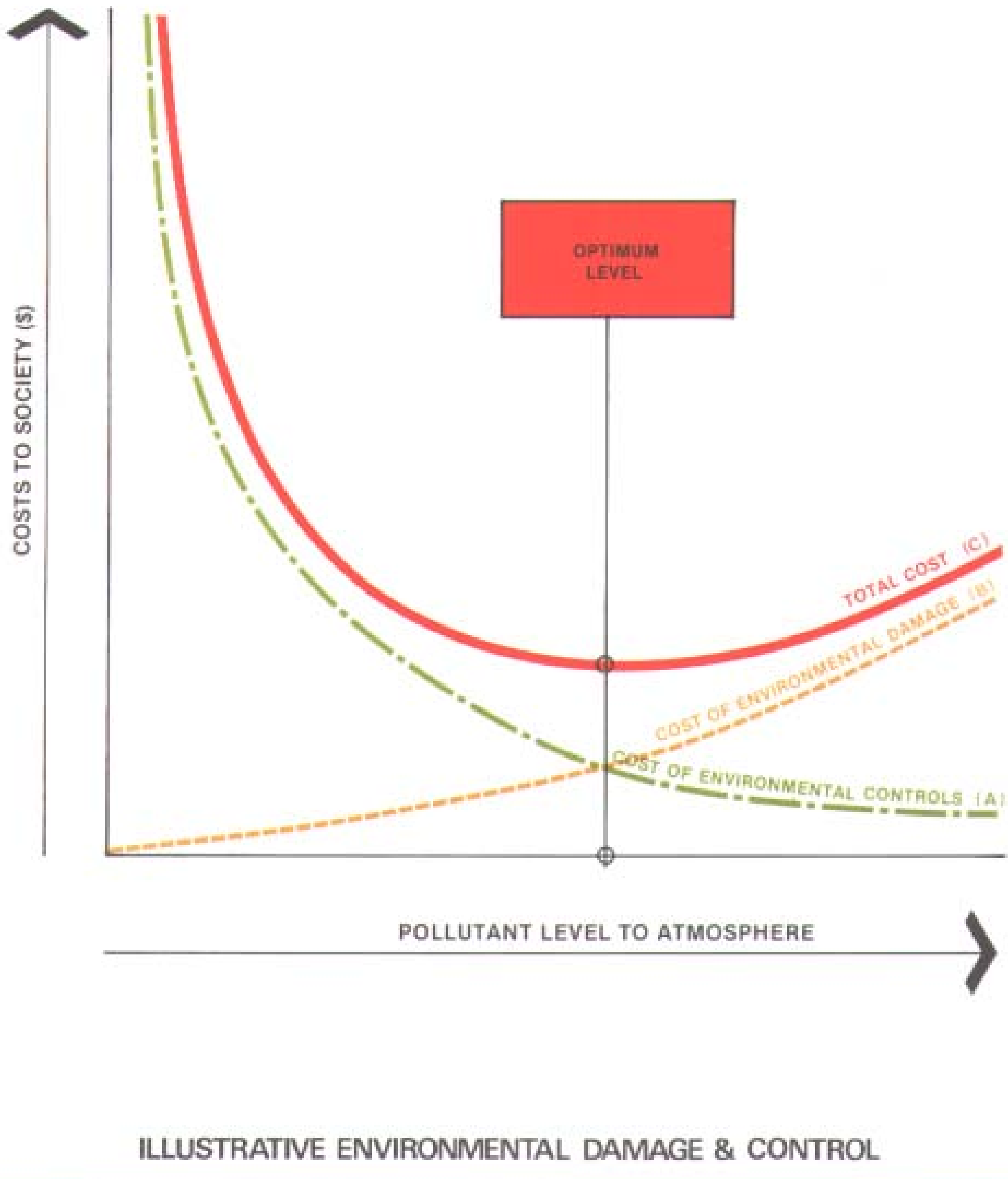
Decisions on expenditures for the control of air pollutants have to be made first on the basis of protecting human health and then on a comparison of benefits derived from pollution control with the costs of that control. Benefits of pollution control can be generally defined as avoidance of economic damage to natural resources, further protection of public health and reduction in risk of environmental degradation. The costs would be the extra capital and operating expenditures that would be borne by electricity consumers.

The task faced by project planners is shown schematically on Figure 24-1. Costs of environmental control, shown on line A, increase as the level of pollutant emissions is reduced; costs of environmental damage fall (i.e. the benefits of pollution control increase) as pollutants are reduced, as shown on line B. At some point, shown schematically as the "Optimum Level", the sum of the costs of environmental control plus the cost of environmental damage gives the lowest "Total Cost to Society" shown on line C. Further control expenditures would not be economically justified since the additional cost would exceed additional benefits. The best control system is therefore one that involves minimum total costs to society.

The concept of selecting pollution control systems on the basis of costs and resulting benefits is explicitly supported in the provincial Pollution Control Board Objectives (50). The Objectives provide, firstly, for the use of the environment's assimilative capacity within limits that do not lead to unacceptable conditions, and secondly, for adopting pollution control strategies in which the expected benefits justify the costs.

(b) Measuring Benefits and Costs

While pollution control costs are relatively easily estimated, benefits of pollution control are not. To determine benefits from control, it is necessary to establish the levels of pollution that begin to cause environmental damage, and then to measure the costs created by that damage. Certain kinds of environmental damage can be measured in dollar terms, such as the economic value of reduced forest growth due to air emissions. But other kinds of pollution costs, such as effects on overall environmental integrity, cannot be fully measured on an economic basis. Moreover, there is always a degree of uncertainty, or risk, attached to projections of impacts and costs of pollution.




HAT CREEK PROJECT

FIGURE 24.1

# COST FUNCTIONS

*SOURCE: Ebasco Services of Canada Ltd: Environmental Consultants (25)*

TABLE 24-3
PRESENT WORTH OF DIFFERENTIAL
COSTS OF ASH DISPOSAL ALTERNATIVES
DRY vs WET (32,38)
(M$ 1980)

| Discount Rate (%/annum) | Present Worth of Extra Capital and Operating Costs of Wet Ash Disposal |
|---|---|
| 3 | 55.0 |
| 6 | 35.6 |
| 10 | 22.9 |

Since a complete measure of the cost of environmental damage cannot be reliably developed, the best approach is to use indirect measures. Air pollution concentrations which cause environmental damage are the basis upon which regulatory agencies set ambient air quality standards. Ambient pollutant concentrations or quantities in the air at ground level are a more direct indicator of environmental impact than emission levels or quantities leaving the powerplant stack. For example, a given quantity of S02 emission in a valley bottom creates greater risk of environmental damage than the same emission on a hilltop, because higher ambient concentrations would result from releases in the valley where much less dispersion would occur. The evaluation yardstick adopted in this analysis is whether sufficient control is provided to protect human health and to minimize risks to environmental quality. The specific control levels which provide this measure of protection have been established in the scientific literature. They were reviewed by B.C. Hydro and its environmental consultants for the Hat Creek Project as well as by the provincial Pollution Control Board (PCB) (50). The PCB's ambient objectives specify levels of pollutant concentrations which they consider acceptable in that human health is protected and hazards to environmental quality are minimized. The benefits of keeping ambient concentrations within the specified ranges are assumed to be at least as great as the costs. Control of pollutants to a more stringent degree must be evaluated in terms of further reduction in the risk of environmental damage.

In order to facilitate comparisons of air quality strategies, consultants have examined the environmental impacts of employing meteorological control systems with 244 m and 366 m high stacks, and of flue gas desulphurization. The impacts from the proposed project as they relate to air quality (366 m high stack with FGD) are presented in Sections 6.0 through 10.0 and 22.0. In addition to these descriptions the implications of alternative air quality strategies are described in environmental terms, and comparative costs are provided.

This section focuses on control of sulphur dioxide and particulates. Control of these pollutants is analyzed because they are likely to be the most significant gaseous emissions from the Hat Creek Project. An important reason for presenting this analysis is that while the proposed project provides for a high level of environmental protection by meeting provincial Objectives (50), other air quality control strategies could reasonably be considered at lesser costs that would result in greater impacts but which could still be viewed as acceptable.

The analysis begins with a basic powerplant (or base case) at Hat Creek, utilizing pollution control measures which would be adopted as standard powerplant practice in Canada. Then progressively more stringent and more costly environmental mitigation measures are evaluated for the project by weighing their additions to project costs in relation to the value of further pollution control. Three alternatives for SO2 control and three alternatives for control of particulates were considered. These alternatives are evaluated in the following subsections.

(c) The Base Case

Adoption of typical coal-fired powerplant design would lead to a "base case" powerplant for the Hat Creek project with the following specifications. Its location would be at the mine mouth, i.e. in the valley bottom. To control particulate emissions, it would use electrostatic precipitators. For sulphur dioxide control, a high multi-flue stack would be used to disperse the emissions.

Such a powerplant was considered in the site selection studies, and the mine mouth site was shown to be the least costly location from an engineering viewpoint. But, on the basis of meteorological records and gas tracer studies, it was judged that powerplant emissions would tend to be trapped in the valley causing a higher risk of environmental damage. The costs of such damage were not calculated but were considered to be significant enough, even with available flue gas desulphurization equipment, to justify relocating the powerplant on higher ground at the Harry Lake site. Table 24-2 shows the additional cost that would be incurred at the Harry Lake site.

The next step was to determine whether this "base case" powerplant, located 500 m higher in elevation at the Harry Lake site, should incorporate further mitigation measures to control air pollution. Air quality modeling studies undertaken by Environmental Research & Technology Inc.(14) indicated that the powerplant at the Harry Lake site burning performance coal and operating at full load would, on occasion, when unusual atmospheric conditions occur, produce ambient concentrations of S02 and particulates which would exceed the PCB Objectives and would therefore be considered unsatisfactory. These potential exceedances of acceptable ambient levels indicate that environmental damage would result. Although there is no way to measure fully the costs associated with this damage, the benefit criterion outlined above indicates that further expenditures for mitigation are warranted.

(d) Sulphur Dioxide Control

Three different technologies may be considered to mitigate air impacts by reducing the quantity of contaminants released from the powerplant stack. Either coal beneficiation or a meteorological control system (MCS) or both, could be expected to meet most of the air quality Objectives but not the emission objectives. A third alternative, flue gas desulphurization (FGD), would provide greater control of pollutants and allow compliance with all PCB Objectives.

A fundamental criterion for the evaluation of sulphur dioxide control measures was that, as with all other aspects of the project, there should be no adverse effect on health. All cases considered below would meet this criterion.

(i) Coal Beneficiation

Beneficiation improves the quality of coal by washing to reduce some of its impurities. Beneficiation would increase the heating value and reduce the ash, sulphur and trace element content of the coal, and consequently would reduce the total amount of pollutants released into the atmosphere.

It should be pointed out here that there are a number of serious technical problems associated with beneficiation of Hat Creek coal.(43) As a result, specialist consultants came to the following conclusion:

> "The principal conclusion is that all Hat Creek samples show difficult beneficiation characteristics and thus there is no beneficiation process plant scheme which can be recommended for inclusion in the Hat Creek Project at this stage."[16]

However, further consideration of beneficiation would be pursued as operational experience is gained with respect to selective mining and actual production of low grade coals. The estimated costs and benefits of partial and full beneficiation of coal are presented below to provide a measure of the potential of this method for the control of emissions.

A. Costs of Beneficiation

The estimated present value of capital and operating costs for the beneficiation plant are shown in Table 24-4 for both full washing and partial washing. In addition to these direct costs, there are also related indirect costs. The processes would produce tailings and effluents which would require handling, treatment and disposal to avoid adverse effects on water resources. Overall utilization of the coal could decrease with washing as a portion would be lost in the tailings. Greater quantities of coal could therefore be required to offset these process losses.

B. Benefits of Coal Beneficiation

Benefits of coal beneficiation include reduction in the capital and operating costs of the powerplant and reduction in the emission of some contaminants. By allowing the powerplant to operate more efficiently, the total capital and operating costs within the powerplant would be reduced. Ash handling and disposal quantities would be lessened, and the physical size of the boilers may be reduced. These benefits are shown in Table 24-4.

Environmental benefits from coal beneficiation would be derived from the reduction in risk of environmental damage and costs, due to reduced pollutant emissions. Limited laboratory and pilot scale studies indicate that sulphur dioxide emissions could be reduced by approximately 9 percent with partial washing and by 20 to the theoretical maximum of 35 percent with full washing, providing a continuous reduction of air pollutant emissions. However even with full beneficiation and sulphur removal to the maximum theoretical limit the PCB emission Objectives would not be met (Table 24-4). The potential for high ambient concentrations would be reduced with beneficiation, but not to the level considered fully acceptable in terms of PCB ambient Objectives without additional control. No detailed evaluation of the environmental benefits of beneficiation has been undertaken as has been

[16] Cominco - Moneco Joint Venture - Hat Creek Project - Mining Feasibility Report - July 1978 Volume VIII Appendix B.

TABLE 24-4
PRESENT WORTH COSTS OF COAL BENEFICIATION (25,44)
(M$ 1980)

| | Discount Rate (%/annum) | | |
|---|---|---|---|
| | 3 | 6 | 10 |
| Partial | | | |
| Direct costs | 128 | 74 | 41 |
| Less powerplant benefits | -48 | -32 | -22 |
| Net costs | 80 | 42 | 19 |
| Full | | | |
| Direct costs | 317 | 179 | 96 |
| Less powerplant benefits | -117 | -78 | -51 |
| Net costs | 200 | 101 | 45 |

REMOVAL OF SULPHUR DUE TO COAL BENEFICIATION

| | Units | Partial Washing | Full Washing | Unwashed Coal | PCB Emission Objectives |
|---|---|---|---|---|---|
| Emissions at Stack Outlet | | | | | |
| Sulphur dioxide | mg/kJ | 0.52 | 0.45-0.37 | 0.57 | 0.09-0.34 |
| Removal Efficiencies | | | | | |
| Sulphur dioxide removal efficiency (approx.) | % | 9 | 20-35 | N/A | N/A |

done for the MCS cases and flue gas desulphurization. However, qualitatively the reduction in SO2 emissions for full beneficiation and a 244 m stack and MCS would produce benefits intermediate between those for the 244 m stack with MCS case and the 52 percent FGD (SO2 removal) case (see Sections 24.3 (ii) and (iii)).

(ii) Meteorological Control Systems (37)

A meteorological control system (MCS) is a set of procedures to reduce the project's air pollutant emissions when atmospheric conditions are predicted to cause unacceptable ambient concentrations of SO2. The MCS would use either a switch to low sulphur coal or powerplant load reductions to cut back on emissions. At other times, emissions from the MCS controlled powerplant are the same as those shown on table 6-2.

Closely related to the selection of the MCS is the choice of powerplant stack height. A higher stack would better disperse the powerplant's emissions over a wider area and further reduce average ambient concentrations, hence the MCS procedures would have to be invoked less often. Two alternative stack heights were considered, 244 m and 366 m.

A. Costs of MCS

There are two components to costs of the MCS alternatives: the capital and operating costs, and the costs of replacement power. Since the MCS may involve occasional reduction in power output from the project, that power must be replaced by other sources. Generally this power replacement would come from stored water which could be released through a hydroelectric powerhouse. The replacement of Hat Creek power with short-term hydroelectric power involves an opportunity cost, since the released water would no longer be available to produce power when needed in the future. The value of the opportunity cost could range from zero (if the water would not be required for power in the future) to 25 mills/kW.h. The costs of the MCS system with alternative stack heights are shown in Table 24-5, with the power replacement costs valued at 25 mills/kW.h. In winter months the MCS system would normally employ low sulphur coal to reduce ambient concentrations, rather than load reduction. The cost of power replacement in this case would be zero.

The operational success of such a system depends on the forecasters' ability to predict correctly the occurrence of adverse meteorological conditions. The staging of unit additions (500 MW added each year from 1988 to 1991) would provide several years when the powerplant would be operating at a reduced emission rate, presenting a much smaller risk to the environment from prediction inaccuracies, while at the same time developing an extensive data base with which to fine tune the mathematical model used for predicting ground level concentrations.

TABLE 24-5
PRESENT WORTH COSTS OF METEOROLOGICAL CONTROL SYSTEMS (44)
(M$ 1980)

| | Discount Rate (%/annum) | | |
|---|---|---|---|
| | 3 | 6 | 10 |
| 244 m Stack | | | |
| Capital and operating (MCS) | 25 | 15 | 9 |
| Power replacement at 25 mills/kW.h | 18 | 10 | 5 |
| TOTAL | 43 | 25 | 14 |
| 366 m Stack | | | |
| Capital and operating (MCS) | 25 | 15 | 9 |
| Incremental cost of higher stack | 12 | 9 | 5 |
| TOTAL | 37 | 24 | 14 |

1. For 366 m stack, no load reductions are predicted to be necessary.

B. Benefits of MCS

Benefits of the MCS with either stack height would be a reduction in risk of environmental damage from air pollutants compared to the uncontrolled case.

The meteorological control system would reduce the peak ambient concentrations which would otherwise occur during periods when adverse atmospheric conditions do not allow sufficient dispersion of emissions. With this system and either a 244 m or 366 m stack, the project is predicted to operate within the PCB Ambient Objective levels, with the exception of the 1 hour peak $SO_2$ concentration (Table 24-6). This Objective level would be exceeded for short periods each year on limited areas of high ground (Table 24-7). The effect of a higher stack would be to reduce the peak 1 hour sulphur dioxide concentration slightly (Table 24-6) and reduce the area of land subjected to concentrations exceeding the PCB 1 hour Ambient Objective.

The vegetation species affected by the proposed project emissions are summarized in Table 24-8. Details of the distribution of injury by area for the 244 m MCS case are given in Table 7-3. The

TABLE 24-6
MAXIMUM PREDICTED AMBIENT CONCENTRATIONS
DUE TO POWERPLANT STACK EMISSIONS (47,50)
($\mu g/m^3$)

| Contaminant | PCB Objectives (50) | MCS[1] with 244 m Stack | MCS[1] with 366 m Stack | "Proposed Project" FGD[2] with 366 m Stack |
|---|---|---|---|---|
| Stack | | | | |
| Sulphur Dioxide (SO2) | | | | |
| annual average | 25 to 75 | 9.3 | 7.0 | 4.5 |
| 24-hour maximum | 160 to 260 | 260 | 260 | 208 |
| 3-hour maximum | 375 to 665 | 648 | 647 | 366 |
| 1 hour maximum | 450 to 900 | 1730 | 1644 | 825 |
| Nitrogen Dioxide (NO2) | [3] | | | |
| annual average | | 2.4 | 1.8 | 2.5 |
| 24-hour maximum | | 67 | 67 | 116 |
| 1 hour maximum | | 446 | 424 | 460 |
| Carbon Monoxide (CO) | [3] | | | |
| annual average | | 0.5 | 0.4 | 0.5 |
| 24-hour maximum | | 14 | 14 | 25 |
| 1 hour maximum | | 96 | 91 | 99 |

1. Meteorological Control System.

2. Flue Gas Desulphurization - 52 percent SO2 Removal.

3. Ambient level not defined in PCB Objective.

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areal extent over which injury levels above 5 percent occur is estimated to be relatively small. A similar distribution heavily weighted towards the < 5% injury level applies to the 366 m MCS case. For the 244 m MCS case, the total area of vegetation affected is 133 $km^2$, while with the 366 m MCS case this is reduced to 101 $km^2$ The level of injury is also reduced with the higher stack particularly in those species displaying injury levels greater than 5 percent.

The effect of the two MCS cases on forestry is shown on Table 24-9. With the taller stack the loss in mean annual increment (MAI) due to SO2 is about half of that with the shorter stack.

TABLE 24-7
LAND AREAS EXPOSED AND DURATION OF EXPOSURE
TO 1 HOUR AVERAGE AMBIENT CONCENTRATIONS OF SO2
GREATER THAN 900 μg/m³ (14,50)
(Upper PCB Objective)

| Land Areas Exposed ($km^2$) | | | | |
|---|---|---|---|---|
| 244 m Stack + MCS[1] | 366 m Stack + MCS | "Proposed Project" 366 m Stack + FGD[2] | Hours per Annum Exposure to Ambient 1 Hour Concentrations Greater than 900 μg/m³ | Percent of Time |
| 400 | 300 | 0 | 1-9 | less than 0.1 |
| 300 | 200 | 0 | 9-45 | 0.1-0.5 |
| 100 | 40 | 0 | 45-88 | 0.5-1.0 |

1. Meteorological Control System.

2. Flue Gas Desulphurization - 52 percent SO2 Removal.

However, in both cases, losses due to these contaminants are overshadowed by the effect of fluoride emissions.

The degree to which presently irrigated land and land in agricultural capability classes 1 to 5 would be affected is shown in Table 24-10. The expected level of injury is generally less than 5 percent except for one site where an injury of 10 percent is predicted; it should be noted that in some cases powerplant emissions are predicted to have a beneficial effect (51), since they would be a source of sulphur. In progressing from the 244 m + MCS, to the 366 m + MCS cases, less land in agricultural capability classes 1 to 5 is affected whereas only a relatively small benefit is obtained in terms of presently irrigated land.

The effect of the project on wildlife is not greatly influenced by the different air quality control strategies. For both MCS cases the ambient levels of emissions would be well below those known to affect wildlife.

The potential for acid precipitation from either the 244 m stack with MCS or the 366 m stack with MCS would be approximately equal and is predicted to cause a drop in the pH of precipitation and changes in pH of selected water bodies as shown in Table 24-11. None of these changes would result in environmental damage and all waterbodies are expected to remain alkaline (24).

TABLE 24-8
EFFECT OF AIR QUALITY CONTROL SYSTEMS
ON VEGETATION SPECIES AFFECTED[1](16)

| | 244 m/MCS[2] | | 366 m/MCS | | "Proposed Project" 366 m/FGD[3] | |
|---|---|---|---|---|---|---|
| Plant Species | Area Affected ($km^2$/year) | Percent Injury Range | Area Affected ($km^2$/year) | Percent Injury Range | Area Affected ($km^2$/year) | Percent Injury Range |
| Alpine Fir | 1.6 | 1.1-6.4 | 1.2 | 1-4 | - | - |
| Engelmann Spruce | 15.6 | 1-2.2 | 14.2 | 1-2 | - | - |
| Lodgepole Pine | 16.9 | 1-2.2 | 13.8 | 1-2 | - | - |
| Ponderosa Pine | 1.8 | 1-1.6 | 0.3 | 1 | - | - |
| Douglas Fir | 16.7 | 1-3.2 | 8.1 | 1-2 | - | - |
| Trembling Aspen | 0.5 | 2-12 | 0.1 | 4 | - | - |
| Black Cottonwood | 0.2 | 1-2 | - | - | - | - |
| Service Berry | 1.7 | 1-3.2 | 0.7 | 1-2 | - | - |
| Willow | 34.4 | 1-40 | 26.7 | 1-28 | 1.0 | 1-8 |
| Kentucky Bluegrass | 2.2 | 1-14.4 | 1.7 | 1-7 | 0.2 | 2 |
| Pleurozium (Moss) | 38.4 | 1-6.4 | 32.0 | 1-3 | 9.4 | 1-2 |
| Alectoria (Lichen) | 2.7 | 1 | 2.7 | 1 | - | - |
| TOTAL | 132.7 | 1-40 | 101.4 | 1-28 | 10.6 | 1-8 |
| Percent of Total Area Affected | 7 | | 5 | | 0.5 | |

1. Table intended for comparative purposes only - see Section 7.0 for detailed interpretation.

2. Meteorological Control System.

3. Flue Gas Desulphurization - 52 percent removal of SO2.

TABLE 24-9
EFFECT OF AIR QUALITY CONTROL SYSTEMS[1]
ON FORESTRY - MEAN ANNUAL INCREMENT(17)
($m^3$)

| Environmental Parameter | Air Quality Control System | 244 m Stack + MCS[2] | 366 m Stack + MCS | "Proposed Project" 366 m Stack + FGD[3] |
|---|---|---|---|---|
| Mean Annual Increment($m^3$) | | | | |
| - loss due to SO2 | | 132 | 77 | 0 |
| - loss due to fluoride | | 53 100 | 22 900 | 1 800 |
| TOTAL($m^3$) | | 53 232 | 22 977 | 1 800 |
| Resource Loss - Present Worth (6% discount rate)($1980) | | 3.3M | 1.4M | 0.113M |

1. Table intended for comparative purposes only - see Section 8.0 for detailed interpretation.

2. Meteorological Control System.

3. Flue Gas Desulphurization - 52 percent SO2 Removal.

Table 24-5 shows that under "worst case" conditions with power replacement valued at 25 mills/kW.h, it would be financially advantageous to build a higher stack.

(iii)Flue Gas Desulphurization(29,44)

Flue gas desulphurization (FGD) or "scrubbing", provides a continuous reduction of powerplant SO2 emissions. The most accepted FGD system is the non-regenerative "wet" type, which uses lime or limestone as a reagent to extract SO2 and sometimes ash from the flue gases (see Section 3.3(c)). A number of the wet type systems are in operation.

In recent years the "dry" FGD system has been in the experimental stage. The results on a pilot scale have been encouraging. To date no commercial scale systems are in operation although some dry FGD systems are under construction for plants in the U.S.A. Indications are that dry FGD would be less expensive and more environmentally acceptable than the wet system for relatively low sulphur coals like Hat Creek coal.

The British Columbia Pollution Control Board has promulgated emission objectives for sulphur dioxide in the range 0.09 mg/kJ to 0.35

TABLE 24-10
AREAS AFFECTED BY THREE AIR QUALITY CONTROL[1] SYSTEMS ON LAND PRESENTLY IRRIGATED AND AGRICULTURAL LAND CAPABILITY CLASSES 1 TO 5 (51,52)

| Environmental Parameter | Air Quality Control System | 244 m Stack +MCS[2] | 366 m Stack + MCS | "Proposed Project" 366 m Stack + FGD[3] |
|---|---|---|---|---|
| Presently irrigated area affected (ha) | | 17 | 9 | 2 |
| Canada land inventory classes 1 to 5 (ha) | | 213 | 39 | 14 |
| Percent injury range[4] | | 1-10 | 1-10 | threshold |

1. Table intended for comparative purposes only - see Section 9.0 for detailed interpretation.
2. Meteorological Control System.
3. Flue Gas Desulphurization - 52 percent SO2 Removal.
4. Several receptor sites are predicted to have a beneficial effect.

mg/kJ. These emission objectives correspond to the removal of 86% and 46% respectively of the sulphur in coal entering the powerplant. Potential impacts due to acid precipitation are presented for both these cases. In addition an intermediate case of 52% removal (the proposed project) is presented with its associated comparative environmental implications.

A. Cost of FGD

The costs of SO2 removal using wet FGD are shown on Table 24-12 for removal efficiencies of 52%, the proposed project which falls within the upper end of the PCB Objectives range, and 86% which is equivalent to the bottom of the range.

Table 24-13 shows estimated costs for two removal cases using dry FGD. The removal efficency of 46% is that which would comply with the upper end of the PCB Objective range, and 86% is that which would comply with the bottom of the range. Dry FGD at 52% removal was not evaluated and thus the comparison with wet FGD for the partial removal case is not exact.

TABLE 24-11
EFFECT OF DIFFERENT AIR QUALITY CONTROL SYSTEMS ON ACIDITY OF PRECIPITATION AND ON THE pH OF SELECTED WATERBODIES AFTER 35 YEARS OF OPERATION (pH) (24)

| Parameter | Air Quality Control Strategy | 244 m or 366m Stack + MCS[1] | 366 m Stack + Partial FGD[2] 46% $SO_2$[3] Removal | "Proposed Project" 366 m Stack + FGD 52% $SO_2$[4] Removal | 366 m Stack + Full FGD 86% $SO_2$[5] Removal |
|---|---|---|---|---|---|
| Precipitation | | | | | |
| Approx. Short Range pH (50 km radius) | | 4.97 | 5.05 | 5.06 | 5.13 |
| Approx. Long Range pH (200 km radius) (Existing pH approx. 5.65)[6] | | 5.55 | 5.58 | 5.58 | 5.60 |
| Existing and Final pH of Selected Waterbodies after 35 years of Operation | | | | | |
| Adams River (Existing approx. 7.6) | | 7.45 | 7.47 | 7.47 | 7.49 |
| Boss Creek (Existing approx. 7.1) | | 7.08 | 7.08 | 7.08 | 7.08 |
| Pennask Lake (Existing approx. 7.6) | | 7.50 | 7.53 | 7.53 | 7.55 |
| Loon Lake (Existing approx. 8.7) | | 7.17 | 7.32 | 7.34 | 7.45 |
| Thompson River (Existing approx. 7.56) | | 7.53 | 7.54 | 7.54 | 7.54 |
| Clearwater River (Existing approx. 7.56) | | 7.54 | 7.54 | 7.54 | 7.54 |
| Deadman River (Existing approx. 8.2) | | 7.50 | 7.64 | 7.66 | 7.76 |

1. Meteorological Control System.
2. Flue Gas Desulphurization.
3. 46 percent $SO_2$ Removal - Emission of 0.34 mg/kJ - Upper PCB Objective Level.
4. 52 percent $SO_2$ Removal - Emission of 0.27 mg/kJ.
5. 86 percent $SO_2$ Removal - Emission of 0.09 mg/kJ - Lower PCB Objective Level.
6. From calculations based on distilled water in equilibrium with atmospheric carbon dioxide.

B. Benefits of FGD

Table 24-6 shows the expected ambient concentrations with 52 percent SO2 removal and how these compare with the PCB Objectives. The continuous reduction of SO2 emissions would mean that both the average and peak ambient concentrations of SO2 would be reduced. However, it should also be noted that while the ambient concentrations of sulphur dioxide are greatly reduced with FGD, those for the other contaminants increase slightly. This occurs because the cooler, wetter plume from the SO2 removal system would not disperse as effectively. The area affected by exposure to concentrations of SO2 in excess of the PCB Upper Objective of 900 $ug/m^3$ is reduced to zero (Table 24-7).

The effects of these reductions in ambient concentrations on vegetation, forestry and agriculture are shown in Table 24-8, Table 24-9 and Table 24-10. In each case impacts are reduced. For vegetation only three species would be affected to a limited degree whereas the degree of injury to agriculture would be difficult to detect and may even be evident as a benefit via sulphur fertilization. Reduction in forest growth due to SO2 would be eliminated and the effect of fluorides greatly reduced. As noted under the MCS cases the effect on wildlife is not a factor and essentially the same conclusions would apply for this air quality control strategy.

The effect of reduced emissions of sulphur dioxide on the potential for long range transport and acid precipitation has been assessed. The effect of 46 percent, 52 percent or 86 percent removal of SO2 on the pH of precipitation and the water quality of selected water bodies is presented in Table 24-11. As indicated in the table, sulphur dioxide removal would have only a small effect on these parameters.

(iv) Comparison of SO2 Control Systems

The use of beneficiation as a method of SO2 control would be restricted by the inorganic sulphur content of the coal and the degree to which this could be washed from the coal. The maximum theoretical removal would be 35%. Emissions and ambient levels of SO2 would remain in excess of PCB objectives and environmental impacts would be approximately intermediate between the partial FGD and MCS cases. However, an extrapolation of the costs (Tables 24-4, 24-12 and 24-13) indicates that it would be more expensive to install full beneficiation than to employ a 35% FGD system. As a result, beneficiation was rejected as a means of air quality control for SO2.

A meteorological control system with either 244 m or 366 m high stack would be the least costly method for the air quality management of sulphur dioxide emissions. Using MCS, the PCB emission objective for SO2 would be exceeded at all times, while the 1 hour average ambient air quality objective would be exceeded for $< 1\%$ of the time at any location. Environmental impacts would be greater than for any of the candidate FGD cases cited in this section though the higher stack would provide a significant ameliorating effect. Evaluation of the environmental effects as described in this Section indicates that this method of control could be considered a viable option when compared with the high cost of flue gas desulphurization equipment and operation.

TABLE 24-12
PRESENT WORTH COSTS OF WET FLUE GAS DESULPHURIZATION(44)
(M$ 1980)

| | Discount Rate (%/annum) | | |
|---|---|---|---|
| | 3 | 6 | 10 |
| Partial[1] | | | |
| Capital cost | 214 | 171 | 129 |
| Operating cost | 157 | 84 | 41 |
| TOTAL | 371 | 255 | 170 |
| Full[2] | | | |
| Capital cost | 267 | 214 | 161 |
| Operating cost | 232 | 124 | 61 |
| TOTAL | 499 | 338 | 222 |

1. 52 percent SO2 Removal = Emission of 0.27 mg/kJ - Falls within upper PCB Objective level.

2. 86 percent SO2 Removal = Emission of 0.09 mg/kJ - Lower PCB Objective Level.

Flue gas desulphurization at the 52% removal level would allow compliance with all PCB objectives and would result in the virtual elimination of adverse environmental impacts even though the costs of FGD are judged to be substantially greater than the resulting monetised social benefits achieved. On this basis therefore the proposed project includes equipment to remove 52% of the input sulphur. More protection (i.e. greater removal of sulphur dioxide) would be inefficient in social benefit/cost terms because of the high cost of further control, in comparison with the diminishing value of the extra protection obtained.

(e)Particulate Control(29,44)

"Particulates" are small fly ash grains formed by coal combustion in the powerplant boilers. Particulates are carried with the flue gas and collected in the particulate control system before the gases enter the stack. Fly ash contains trace elements; thus the degree and type of particulate control mainly determines the rate of release of certain trace elements in air emissions.

TABLE 24-13
PRESENT WORTH COSTS OF DRY FLUE GAS DESULPHURIZATION(44)
(M$ 1980)

| | Discount Rate (%/annum) | | |
|---|---|---|---|
| | 3 | 6 | 10 |
| Partial[1] | | | |
| Capital cost | 131 | 105 | 79 |
| Operating cost | 85 | 45 | 22 |
| TOTAL | 216 | 150 | 101 |
| Full[2] | | | |
| Capital cost | 199 | 160 | 120 |
| Operating cost | 156 | 83 | 41 |
| TOTAL | 355 | 243 | 161 |

1. 46 percent SO2 Removal = Emission of 0.34 mg/kJ - Upper PCB Objective Level.

2. 86 percent SO2 Removal = Emission of 0.09 mg/kJ - Lower PCB Objective Level.

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Even though there are a number of methods for particulate control, only electrostatic precipitators (ESPs) or fabric filters (FFs) are efficient enough to be considered for the Hat Creek Project. ESPs are the conventional method of fly ash removal in coal-fired powerplants. There are a number of installations which have successfully operated at high collection efficiencies for many years.

Fabric filters, or baghouses, are a more recent technological development. They have certain potential advantages, such as an insensitivity to the physical and chemical properties of the ash, but the porous fabrics of the bags have not been conclusively demonstrated on large coal-fired utility boilers over all operating conditions for long periods. There could be technical problems associated with using fabric filters with Hat Creek coal and 500 MW units. Thus the reliability and operating costs cannot be estimated with the same confidence as for ESPs. If and when fabric filter reliability is conclusively demonstrated on large coal-fired utility boilers, they would be considered in place of electrostatic precipitators.

Benefits of particulate control are the increasing reduction in risk of environmental damage from particulate and trace element emissions with increasing particulate removal efficiencies. Table 24-14 indicates incremental costs of the alternative systems at the various levels of control. These data show the estimated cost of FFs to be lower than ESPs. However, as discussed before there are significant risks associated with selection of FFs and with the FF cost estimates. Until FFs are shown to be satisfactory for large coal-fired powerplant application, ESPs are the only proven system for particulate control on the Hat Creek project.

The proposed project will include electrostatic precipitators that will remove 99.8% of the particulate leaving the boilers. Emissions of particulate will be 0.03 mg/kJ which is below the upper limit of the PCB emission objectives for coal-fired (see Table 6-2). Compliance with these objectives using proven equipment was the primary reason for choosing the selected particulate control strategy. Ambient concentrations of total suspended particulates and trace elements will also be less than or within the PCB Objective range, as reported in Table 6-3 and Table 6-4.

(f) Conclusions

B.C. Hydro has selected an Air Quality Control System (AQCS) of partial flue gas scrubbing and electrostatic precipitators that could ensure that the proposed project is in compliance with the PCB Objectives. However to achieve these levels of contaminants requires the additions of relatively large pieces of equipment. During its review B.C. Hydro has examined various alternative air quality control systems that range from a meteorological control system (not in compliance with all PCB levels) to systems that would meet the lower end of the range of the PCB Objectives. Table 24-15 summarizes the total cost estimates for these various configurations. As a starting point, the Table shows the overall cost of the MCS option. Then the costs of two combinations of systems which achieve all of the upper levels of the PCB Emission Ojectives are presented. It can be seen that an AQCS based on partial dry FGD would be less costly than one based on partial wet FGD, by roughly 132 M$, calculated at 6 percent. Finally the table compares the costs of combinations to achieve most of the lower levels of the PCB Emission Objectives. Again, an AQCS based on full dry FGD is less costly than full wet FGD. In this instance, the difference is 219 M$, calculated at 6 percent discount rate.

## 24.4 SOCIOECONOMIC FACTORS

Mitigation Alternatives

Recommendations for mitigation and compensation were proposed in the socioeconomic studies(61) completed in 1978. B.C. Hydro responses to these proposals will be collated with recommendations from the other detailed environmental studies and will be published in a separate document.

However, two of the important recommendations relate to socioeconomic monitoring and municipal tax shortfalls. It is B.C. Hydro's intention to continue the practice established on other projects. A socioeconomic monitoring program will be funded and an appropriate implementation plan will be determined through discussions with the Thompson-Nicola regional district, provincial agencies and local communities.

TABLE 24-14
INCREMENTAL COSTS AND BENEFITS OF PARTICULATE CONTROL SYSTEMS(29,44)
(M$ 1980)

| System | Present Worth Costs | | | Benefits |
|---|---|---|---|---|
| | Discount Rate (%/annum) | | | |
| | 3 | 6 | 10 | |
| Electrostatic Precipitators | | | | |
| 99.5 Percent Removal | | | | |
| Capital | | | | Complies with PCB(50) |
| Operating | | Base Case | | Ambient Objectives |
| Total | | | | but not Emission Objectives |
| 99.8 Percent Removal | | | | PROPOSED PROJECT |
| Capital | 17 | 14 | 10 | Complies with upper |
| Operating | 3 | 2 | 1 | level of PCB Emission Objectives & Ambient |
| Total | 20 | 16 | 11 | Objectives |
| 99.95 Percent Removal | | | | |
| Capital | 38 | 30 | 23 | Complies with lower |
| Operating | 7 | 4 | 2 | level of PCB Emission Objectives & Ambient |
| Total | 45 | 34 | 25 | Objectives |
| Fabric Filters | | | | |
| 99.97 Percent Removal | | | | |
| Capital | -12 | -10 | -7 | Provides further |
| Operating - (Pwrplnt beneft) | 36 | 19 | 9 | control |
| Net costs | 24 | 9 | 2 | |

B.C. Hydro will provide financial compensation to local governments if it can be demonstrated that the costs incurred, in providing services to the project-induced in-migrant population, exceed the revenues delivered in the forms of taxes, levies and fees.

It is expected that further recommendations for mitigation and compensation will be forthcoming from the socioeconomic update study mentioned in Section 19-1.

These recommendations will form the basis for discussions with the local, regional and provincial governments.

TABLE 24-15
PRESENT WORTH TOTAL COSTS FOR ALTERNATIVE CONFIGURATIONS OF AIR QUALITY CONTROL SYSTEMS(29,44)
(M$ 1980 - Part 1 of 3)

| | Discount Rate (%/annum) 3 | 6 | 10 |
|---|---|---|---|
| 1.0 Meteorological Control System[1] (MCS) | | | |
| MCS and 244 m Stack | | | |
| Capital Costs | | | |
| Powerplant | 1227 | 1009 | 788 |
| MCS | 2 | 2 | 2 |
| Operating costs | | | |
| Powerplant | 1958 | 1048 | 514 |
| MCS(incl monitoring) | 41 | 23 | 12 |
| TOTAL | 3228 | 2082 | 1316 |
| 2.0 Partial[2] Flue Gas Desulphurization (FGD) | | | |
| 2.1 Partial Wet FGD and a 366m stack - Proposed AQCS | | | |
| Capital costs | | | |
| Powerplant | 1236 | 1016 | 794 |
| ESP | 17 | 14 | 10 |
| Wet FGD | 214 | 171 | 129 |
| Monitoring | 2 | 1 | 1 |
| Operating costs | | | |
| Powerplant | 1963 | 1050 | 515 |
| ESP | 3 | 2 | 1 |
| Wet FGD | 157 | 84 | 41 |
| Monitoring | 8 | 5 | 3 |
| TOTAL | 3600 | 2343 | 1494 |

TABLE 24-15
TOTAL COSTS FOR ALTERNATIVE AIR QUALITY CONTROL CONFIGURATIONS
(CONTINUED - Part 2 of 3)

| | Discount Rate (%/annum) | | |
|---|---|---|---|
| | 3 | 6 | 10 |
| 2.2 Partial Dry FGD and a 366 m Stack | | | |
| Capital Costs | | | |
| Powerplant | 1236 | 1015 | 793 |
| Fabric Filters | -12 | -10 | -7 |
| Dry FGD | 131 | 105 | 79 |
| Monitoring | 2 | 1 | 1 |
| Operating costs | | | |
| Powerplant | 1963 | 1050 | 515 |
| Fabric Filters | 36 | 19 | 9 |
| Dry FGD | 85 | 45 | 22 |
| Monitoring | 8 | 5 | 3 |
| TOTAL | 3449 | 2230 | 1415 |
| 3.0 Full[3] Flue Gas Desulphurization (FGD) | | | |
| 3.1 Full Wet FGD and a 366 m Stack | | | |
| Capital costs | | | |
| Powerplant | 1236 | 1016 | 794 |
| ESP | 38 | 30 | 23 |
| Wet FGD | 267 | 214 | 161 |
| Monitoring | 2 | 1 | 1 |
| Operating Costs | | | |
| Powerplant | 1963 | 1050 | 515 |
| ESP | 7 | 4 | 2 |
| Wet FGD | 232 | 124 | 61 |
| Monitoring | 8 | 5 | 3 |
| TOTAL | 3753 | 2444 | 1560 |

TABLE 24-15
TOTAL COSTS FOR ALTERNATIVE AIR QUALITY CONTROL CONFIGURATIONS
(CONTINUED - Part 3 of 3)

| | Discount Rate (%/annum) | | |
|---|---|---|---|
| | 3 | 6 | 10 |
| 3.2 Full Dry FGD and a 366 m Stack | | | |
| Capital Costs | | | |
| Powerplant | 1236 | 1016 | 794 |
| Fabric Filters | -12 | -10 | -7 |
| Dry FGD | 199 | 160 | 120 |
| Monitoring | 2 | 1 | 1 |
| Operating Costs | | | |
| Powerplant | 1963 | 1050 | 515 |
| Fabric Filters | 36 | 19 | 9 |
| Dry FGD | 156 | 83 | 41 |
| Monitoring | 8 | 5 | 3 |
| TOTAL | 3588 | 2324 | 1476 |

1. Estimated emission levels and ambient concentrations are given in tables 6-2 and 6-3.

2. Overall removal of 52% of sulphur dioxide entering the powerplant.

3. Overall removal of 86% of sulphur dioxide entering the powerplant ($SO_2$ emission ≈ 0.09 mg/KJ).

The major mitigation measures evaluated in the previous section would not eliminate all project impacts. Land alienation, creek diversions, and the potential for slight long-term effects of air emissions on forest growth are all examples of impacts which would remain, even with the selection of a 366 metre stack and partial SO2 removal. The question addressed in this section is the extent to which unmitigated impacts should be compensated for either through cash payments or funding of enhancement programs.

## 25.1 B.C. HYDRO'S COMPENSATION POLICY

In the introduction to Part IV the concepts of mitigation and compensation were presented in the context of social benefit/cost analysis. The principle underlying mitigation expenditures is that mitigation should be undertaken to the point where the reduction in resource losses at least equals the cost of the mitigation measure.

If a resource development has negative impacts after all efficient mitigation measures have been included, it is necessary to demonstrate that the cost of those impacts, in addition to project capital and operating costs, do not outweigh benefits; this is the function of a benefit/cost analysis. The case for actually making payments to compensate for resource losses has to be examined separately.

B.C. Hydro has adopted an approach for its recent projects (e.g. Revelstoke Canyon) whereby payments are made for specific programs that enhance resources similar to those lost in the affected region. The principle that has been established for such payments is that these payments should not exceed the value of the resources lost. Thus, at Revelstoke, fisheries enhancement projects are being funded which produce sport fishing benefits comparable to those lost, and at a cost which is roughly equal to the benefits that regional sports fishermen would have realized if the project had not been built.

B.C. Hydro proposes to apply the same principles of compensation for resource losses to the Hat Creek Project. Thus, not all resource losses would be compensated. Where compensation appears appropriate the payments would be tied to programs or projects in the region. Compensation issues associated with environmental and socioeconomic impacts of the proposed project are outlined below. This discussion should be viewed as the first step in a process of discussions with appropriate government agencies which would ultimately lead to the development of a compensation package for the project.

## 25.2 COMPENSATION ISSUES FOR THE HAT CREEK PROJECT

### (a)Environmental Resource Impacts

Section 18.0 presented the results of the evaluation of environmental resource impacts of the project. Potential compensation is discussed under each resource heading. All the values given below are present worths at 1980 price levels using a 6 percent discount rate.

(i) Forestry

Powerplant air emissions and land alienation could result in the loss of economic value in the Hat Creek region of $296 000 due to the loss in allowable annual cut (AAC). Losses from land alienation have been anticipated by the forest service in its harvest allocations and thus there would be no impact on regional forest operations or employment. Pollutant emissions could, however, retard growth in the area sufficiently to reduce AAC in excess of the allowance that has been made for the proposed project.

If the monitoring of vegetation impacts during the project's operation confirms these predicted impacts it may be necessary to compensate operators who would be required to relinquish a small portion of their cutting rights. Because of the uncertainty of the extent of potential impact, compensation payments should be consistent with the results of monitoring.

(ii) Agriculture

About 2770 ha of agricultural land in the Hat Creek area would be affected by the project. The primary impact would not be felt immediately on existing operations but rather over the life of the project in terms of a constraint on the potential size of the beef cattle industry. This is predicted to result in a total economic loss of $76 000.

A number of options exist to enhance regional agriculture, primarily through irrigation of nearby land, which would more than offset these losses. However, there does not appear to be a strong case for pursuing these options. The acquisition of private land holdings provides compensation to the owners. Whether there are additional social values which ought to be attributed to this land, would depend on the provincial government's view of Hat Creek agriclutural values in relation to total provincial agricultural resources. There is no economic argument for compensation over and above the purchase of private land.

(iii) Fish, Wildlife and Outdoor Recreation

Fishing, hunting and general outdoor recreation opportunities in the larger region around Hat Creek are diverse and abundant. Creek diversions and land alienation as a result of the project would remove fish and wildlife habitat (see Sections 12.0 and 15.0) and affect an area currently used for backroad travel and sightseeing (see Section 15.0). The economic value of the activities currently supported by these resources has been estimated at $1.25 million. The opportunities recreationists would have for substituting other nearby sites for any activity they might otherwise have enjoyed in the project area, have not been taken into account.

There would appear to be only a slight case for compensation for these losses. Recreational activity in the region would actually increase with the project because of the increased population. The case for compensation through fish and wildlife enhancement programs would have to be based on a long-term view of the regional supply and demand of recreational resources. The argument that lost resources ought to be replaced through enhancement is not a sufficient case in itself without taking into account the value of the displaced activity.

Small scale enhancement may be warranted to preserve future options for full development later if regional demands begin to exert too much pressure on available resources. Such small scale preservation or enhancement programs should be the limit of the project's liability for fish, wildlife and outdoor recreational compensation. The project would become a central feature of the economic and social development of the immediate region and the provision of services, including outdoor recreation, would in the long-term be the normal responsibility of government.

(iv) Commercial Fishery

The water supply intake for withdrawal of water from the Thompson River has been carefully designed to avoid impacts on valuable commercial salmon species that use the river for spawning and migration. The estimate of the losses reported in Section 18.3 is well within the error of estimate of the numbers of fish and thus the estimate of potential economic loss of $34 000 can be considered insignificant if not unmeasurable. On the basis of these estimates, no compensation would be due. However, should unpredicted impacts occur such as the impingement of unacceptably large numbers of fry on the intake screens it would be necessary to revise both the estimate of the loss and the validity of compensation.

(b) Socio-economic Resources

The discussion provided under Section 24.4 applies to this section as well.

# SECTION 26. ENVIRONMENTAL MONITORING PROGRAMS(27)

## 26.1 INTRODUCTION

Measures to minimize adverse environmental impacts have been incorporated into the designs of the mine, powerplant and offsite developments. Consultants have evaluated the predicted environmental impacts of the project with these measures incorporated. However, because of uncertainties in predicting and evaluating impacts, extensive monitoring would be carried out in the Hat Creek region to quantify and document the actual impacts of the project. Knowledge of the actual effects on the environment would provide a basis for further mitigation.

Monitoring to establish existing conditions would be commenced before development activities start at Hat Creek. During the site preparation and construction phases, emphasis would be placed on measuring the effects of these activities to enable their immediate mitigation if required. Monitoring during the operational phase of the powerplant development would provide a basis for accurate assessment of specific changes in environmental conditions, by comparison with conditions in the preoperational period.

Overall, the environmental monitoring program would provide scientific information to quantify the effects of the project on the atmospheric, terrestrial and aquatic resources of the Hat Creek region. It is expected that the monitoring procedures would be modified, as the project proceeds, to reflect the results and experience obtained during the early stages of the program.

## 26.2 ATMOSPHERIC RESOURCES

Potentially the most significant impacts of the project are associated with the discharge of contaminants to the atmosphere. Monitoring the effects of these emissions would involve collection of data in three areas: meteorology; ambient air quality; and powerplant emissions.

Four permanent meteorological stations have been in operation for several years collecting a variety of meteorological information. One of these sites located near the proposed powerplant site has been in operation since 1978. The site is equipped with a 100 metre tower instrumented at the 10 metre and 100 metre levels to measure temperature, dewpoint temperature, wind speed and wind direction. Atmospheric turbulence is also monitored at the 100 metre level to provide data for estimating plume dispersion potential. Evaporation, and barometric pressure are also presently monitored at this site and in future additional upper level wind and temperature measurements will be carried out on a routine basis. The remaining three meteorological stations, located at Cache Creek, Hat Creek Valley and Pavilion Mountain, will continue to collect temperature precipitation, and wind information.

A network of eight continuous ambient sulphur dioxide ($SO2$) monitors will be established in 1986, 2 years before the first powerplant unit goes into operation. Two of these stations would be located at the population centers of Ashcroft and Cache Creek. Three stations will be located in areas of predicted maximum concentrations on Cornwall Mountain, the Clear Range and in the

Arrowstone Hills. Stations located in the Upper Hat Creek and Semlin Valleys will monitor impacts in important agricultural areas and the remaining station will be located approximately 15 km north-northeast of the powerplant in the predominant downwind direction. Sulphur dioxide and wind information from these sites will be transmitted to the powerplant on a continuous basis. These data will be compiled by computer for the demonstration of compliance with air quality objectives.

Ambient concentrations of nitrogen oxides, ozone and carbon monoxide would also be monitored continuously but on a more limited scale. Total suspended particulate levels would be measured at 12 sites using a network of high-volume samplers. Periodically particulate sizing would be determined and the size fractions analyzed for selected trace elements. These analyses would be co-ordinated with similar sampling of stack emissions.

An extensive monitoring network would be established to measure dustfall, sulphation, fluoridation and corrosion. Sampling would be carried out in the areas of greatest impact, as predicted by the air emission modeling studies and in those areas close to population centres.

The continuous ambient air quality, dustfall, sulphation, fluoridation and corrosion monitoring programs would commence 2 years prior to the start-up of the first boiler. The suspended particulate monitoring would commence 2 years before construction starts. Dustfall would also be measured at selected sites to monitor more closely the effect of construction activities.

Continuous stack monitors would record levels of SO2, NOx and opacity of the emissions from each boiler. Periodic sampling would be carried out on each boiler stack to measure particulates, SO2, NOx and solid and gaseous trace elements as required for compliance with the pollution control permit and to provide data for correlation with other environmental monitoring programs.

Ambient noise levels would be recorded at sites selected on the basis of predicted noise impacts and their proximity to populated areas. A mobile monitoring unit would be employed for this work. Before construction begins (1983), background measurements would be made at various sites and compared with the baseline data in the detailed environmental studies. During the construction period measurements would be made quarterly at each site and at other sites as required. During operation of the mine and powerplant, noise measurements would initially be made quarterly and then annually. Noise emissions from major equipment would be monitored as a normal maintenance procedure during the construction and operation of the mine and powerplant development. At each monitoring site day-night average sound levels, equivalent sound levels, peak sound levels and statistical indices would be calculated. Measurements would be in "A" weighted decibels, the unit of sound commonly used when dealing with the effect of noise on humans.

## 26.3 TERRESTRIAL RESOURCES

Four major terrestrial resource components would be monitored to document effects of air contaminants from the mine and powerplant operations. These would include selected species of natural vegetation, agricultural crops, soils and wildlife. In each case the programs would include a suitable collection of data to characterize existing conditions.

Native vegetation, trees, understory species, lichens and grasslands would be subjected to detailed assessment at regular intervals (approximately 5 years) to determine such factors as productivity, cover, relative abundance and condition. In addition semi-annual or more frequent inspections would be made to document any visual injury symptoms or other changes to plants. Samples for trace element analyses would be collected on an annual basis.

Sampling and monitoring areas would be selected based on predicted contaminant concentrations and general vegetation types. Sensitive and important species would be included where possible and sites would be located where relatively high, medium and low predicted ambient contaminant concentrations would occur.

Monitoring of agricultural crops would include inspections of local crops, with particular emphasis on important field crops such as alfalfa and corn, and establishment of fenced cultivated garden plots of air pollution sensitive species such as beans, gladiolus, tobacco and bluegrass. The cultivated plots would be tended regularly and monitored throughout the growing season for signs of air pollution related injury. Evidence of injury would be further investigated.

A surface soils monitoring network would be established. Samples would be collected annually and analyzed for selected trace elements to document any changes and to provide data for correlation with the vegetation and air quality monitoring programs. Many of the vegetation and soils monitoring sites would be located near the meteorological and air quality monitoring stations, enabling close correlation with other monitoring programs.

The wildlife monitoring program would include annual collection of ruffed grouse and honeybees for trace element analyses. Ruffed grouse are common game birds in the area. Since they consume both vegetation and insects, they would be a good indicator of trace element accumulation. Grouse would be collected in the late summer and fall throughout the region. Honeybees are known to be good indicators of fluoride levels in the environment. A beehive would be established near alfalfa fields in the Hat Creek valley south of the powerplant site.

## 26.4 WATER RESOURCES

Water resources monitoring would include three programs: the quality and flows of ground and surface waters and wastewater discharges, aquatic biology and acid rain studies. These programs would document the effects of the mine development on local surface and groundwaters, as well as the effects of powerplant air emissions on local and regional surface waters.

Groundwater wells would be installed at selected locations to detect changes in local groundwater quality and to monitor effects on downstream groundwater flows. Surface water quality monitoring stations would be located on Hat Creek and other selected water bodies. Samples would be analyzed for a large number of water quality parameters and trace elements. Monitoring would commence 2 years prior to the start of construction. Water level readings and water sampling and analyses would be done every 2 months during the first year to assess seasonal variation. Thereafter monitoring would be done three times a year, in the winter, during the spring freshet, and during low water flow near the end of summer.

During construction, temporary sedimentation lagoon effluent would be monitored to ensure effective control of suspended solids. The draining of the southwest slide area would be carefully monitored to avoid the enrichment of natural creeks.

Flow measurement and recording stations would be installed in Hat Creek, upstream of the maximum level of the headworks dam and downstream of the development area. Flows would be continuously recorded at these stations. The water temperature in Hat Creek would be recorded at the flow monitoring stations above and below the development area. At the downstream location, pH, conductivity, turbidity and sodium concentrations would be continuously monitored by an automated analytical system.

The only discharge of wastewater from the development to surface waters would be from the North and Medicine Creek sedimentation lagoons and the pit rim reservoir. The flow of these discharges would be measured and recorded continuously. Samples for analyses would be collected periodically based on discharge quantities.

Fisheries, habitat condition and benthos surveys would be carried out on Hat Creek and the Bonaparte River. Particular attention would be paid to the condition of bottom sediments. Special samples of fish and benthic organisms would be taken for the analysis of trace element concentrations. These aquatic biological surveys would be done annually in the late summer commencing 2 years before the start of construction. Monitoring of fisheries would also be done on the Thompson River at the site of the water supply intake near Ashcroft. During construction, frequent inspections would be made to ensure that approved construction procedures are followed and adverse effects on fisheries are minimized. During the initial year of operation the intake would be studied to evaluate the effectiveness of the fish protection systems. This would be carried out during the spring downstream migration of young fish. Fish monitoring at the intake would be co-ordinated with provincial and federal fisheries authorities. A routine maintenance program for the intake would ensure that the facilities remain within design specifications over the life of the project.

Although the impact of acid precipitation caused by the powerplant development is predicted to be minor, conditions of the aquatic environments in areas likely to be affected by powerplant emissions would be monitored. Monitoring would be conducted in selected watersheds including such potentially sensitive areas as Adams River, and Hendrix Creek. Additional sites would be selected following a regional survey. A wide range of water quality parameters and trace elements would be determined in addition to aquatic biological information on the type and abundance of phytoplankton and periphyton. Areas nearer to the powerplant site would be monitored in the surface water quality and aquatic biological monitoring programs. Meteorological and air quality data would be obtained from existing government stations in the region, as well as from the monitoring stations included in these environmental monitoring programs. A network to monitor both wet and dry deposition of acidic material would be established.

Collection of surface-water quality samples would be carried out in the early spring during early snowmelt and in the late summer. The collection of biological samples would be carried out in the late summer at selected water quality monitoring sites. Samples of accumulated snow would be collected to supplement the snowmelt studies. Precipitation samples would be collected monthly throughout the year.

The acid precipitation studies would commence 2 years prior to start-up of the first boiler to obtain an inventory of existing conditions.

## 26.5 ENVIRONMENTAL CONTROLS

B.C. Hydro proposes to establish a full-time environmental protection group as soon as construction authorization for the project is obtained (Section 4.0). This group, located at the site, would assume the lead role for all environmental monitoring and would devise and implement field environmental protection measures during the construction activities. It is proposed that personnel with experience in the environmental protection of terrestrial, aquatic and atmospheric resources be included in the site environmental group. However, it is recognized that it would be impractical to provide suitable expertise in all disciplines and therefore use would also be made of other personnel from B.C. Hydro and/or consultants as required. The site environmental protection group would be designed from the outset to remain at site in a similar role to that held during construction once the development is fully operational (see Section 4.0).

## APPENDIX A. REFERENCES


1. B.C. Government - Ministry of Energy, Mines and Petroleum Resources - Bill 52, Utilities Commission Act - August 1980.

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# APPENDIX B. GLOSSARY OF TERMS AND ABBREVIATIONS

| | |
|---|---|
| G | Giga: 1 000 000 000 = $10^9$ |
| ha | Hectare |
| ha.m | Hectare.metre: 10 000 $m^3$ |
| J | Joule |
| k | Kilo: 1000 = $10^3$ |
| kg | Kilogram |
| km | Kilometre |
| L | Litre |
| m | Metre |
| M | Mega: 1 000 000 = $10^6$ |
| $m^3$ | Cubic metre |
| mg | Milligram: 1/1000 g = $10^{-3}$ gram |
| Mg | Megagram |
| mm | Millimetre |
| t | Tonne (1000 kg) |
| µ | Micro: 1/1 000 000 = $10^{-6}$ |
| $\mu g/m^3$ | Micrograms per cubic metre |
| V | Volt |
| W | Watt |
| < | Less Than |
| > | Greater Than |

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| Acidic | Pertaining to an acid or to its properties. Forming an acid during a chemical process. Having a pH less than 7. |
| Activity Day (Recreation) | Defined as one person partaking of a recreational activity for a major part of one day. |
| Acute Injury or Damage | A rapid response to a toxic agent. |
| Aerodynamic Mean Diameter | The parameter most commonly used to describe particle size in aerosol research. It is the mean of a population of particles that have a diameter of a sphere of unit density that has the same settling velocity in air as the particle of interest. |
| Alkaline | Having properties of an alkali. Having a pH greater than 7. |
| Allowable Annual Cut (AAC) | The rate of timber harvesting specified for an area of land. |
| Alluvium | Clay, silt, sand, gravel or similar detrital material deposited by running water. |
| Aloft | In the air, not at ground level. |
| Ambient | Surrounding; especially of or pertaining to the environment about a body, as in ambient air or ambient temperature. |
| AMSL | Above mean sea level. |
| Anadromous | Animals (mainly fish) that feed actively as adults in the sea but migrate into and up freshwater streams where they spawn. Contrast with catadromous, the reverse, where fish, like eels, feed actively as adults in freshwater, then migrate downstream to the ocean where they spawn. |
| Andesite | A common volcanic rock which forms part of a series ranging from rhyolite through dacite and andesite to basalt. The series represents a chemical change which is commonly indicated by a visible change from light to dark colours. |
| Angler-day | Any portion of a day spent fishing by an individual. |
| AQCS | Air Quality Control System. |

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| Aquifer | A water-bearing formation of permeable rock, sand or gravel. |
| Atmospheric Inversion | Climatic condition which tends to trap pollutant emissions in valleys. |
| Attenuation | Gradual reduction in the intensity (concentration). |
| AUM | Animal Unit Month. |
| Average Energy | The average electric energy generated by a powerplant or system over a period of many years. For B.C. Hydro, average energy is computed by simulating project and power system operation with 1940-1975 streamflow records. |
| Bank $m^3$ | Cubic metres in place, before excavation; after excavation volume would be greater. |
| Basalt | See andesite. |
| Bench | Pertaining to open-pit mining where the mining proceeds downwards from the surface in a series of benches or steps. |
| Beneficiation | Using the chemical or physical properties of a mineral to separate waste from the valuable mineral. |
| Benthos | Bottom-dwelling forms of marine life. Also known as bottom fauna (benthic organisms). |
| Bentonitic Claystone | A fine-grained sedimentary rock containing bentonite, which is a clay derived from decomposition of volcanic ash. |
| Biophysics | The hybrid science involving the application of physical principles and methods to the study of structures of living organisms and the mechanics of life processes. Biophysical (adj.). |
| Biota | Animal and plant life characterizing a given region. Flora and fauna, collectively. |
| Biotite Hornblende Granodiorite | A coarser-grained equivalent of a dacite, which cooled from molten rock beneath the surface of the earth. |
| Blowdown | Water rejected from boilers, turbines and cooling towers, etc., in order to maintain water quality. |
| Borrow Area (Pit) | An excavation dug to provide material for fill used elsewhere. |
| Bottom Organisms | Animals of many kinds that live on or in the bottom materials of a river or other body of water. |
| BP | Before the present. |

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| Buffering | The process of neutralizing both acids and bases, thereby maintaining the original acidity or basicity of a solution. |
| Buoyancy | The vertical motion of a plume due to its lower density compared with the surrounding air. |
| Calibrate | To standardize by determining the deviation from a standard so as to ascertain the proper correction factor. |
| Capacity Factor | The ratio of the energy delivered by a generating source over a certain period of time to the maximum energy which could be delivered if the source is operated continuously at Maximum Continuous Rating. |
| Cenozoic | An Era of earth history. |
| CF | Capacity factor. |
| Chlorination | Addition of chlorine or chlorine compounds to water for the purposes of disinfection. |
| Chronic Injury or Damage | A response over an extended period of time to repeated exposures to concentrations of pollutants which in single exposures are insufficient to cause acute symptoms. |
| Chronology | An ordering of artifacts and/or cultural features analogous to their inferred occurrence through time; often divided into named periods. |
| Clarification | The process of removing suspended matter from a liquid. |
| Clastic | The term refers to a rock that is composed of broken and worn fragments of pre-existing minerals, rock particles or shells. |
| Circuit Breaker | Electrical switch. |
| Climatological Station | A station, normally operated on a voluntary basis by private individuals, using official instrumentation to record observations of temperature and precipitation. |
| Coagulant | A material which assists or promotes the agglomeration of small particles thus increasing their rate of settling. |
| Coliform Bacteria | Colon bacilli, or forms which resemble or are related to them. The type species of the genus, occurring as part of the normal intestinal flora in man or animals. |
| Colluvium | Angular fragments of rock varying in size from fines up to gravel-cobbles (64-256 mm) formed on slopes due to erosion. |

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| Conductivity | The ratio of the electric current density to the electric field in a material. |
| Conformably | The term refers to one rock being overlain by another without having an intervening period of erosion. |
| Conglomerate | Gravel made into a rock by cementing or compressing the particles together (compaction). |
| Cretaceous | A span of geologic time and part of the Mesozoic Era. |
| Dacite | Refer to andesite. |
| Day-Night Average Sound Level (Ldn) | The 24-hour average sound level, in A-weighted decibels, obtained after addition of ten decibels to sound levels in the night from 10:00 p.m. to 7:00 a.m. |
| Daughter Radionuclides | Members of a radioactive decay series headed by the parent radionuclide and ended by a stable nuclide. |
| Damage | Effects which clearly reduce the intended value or use of a plant, whether the reduction be in economic, ecologic or aesthetic terms. |
| dBA | (A-weighted decibel) Decibels on the "A" scale - a measure of sound pressure that approximates the frequency response (sensitivity) of the human ear. |
| Debitage | The residual pieces of stone produced in stone tool manufacture, use and maintenance, which are not subsequently used. |
| Decommission | To take out of service. |
| Demographic | Relating to the dynamic balance of a population especially with regard to density and capacity for expansion or decline. |
| Dependable Capacity | The load carrying ability of a station or system under adverse conditions for the time interval and period specified. |
| Deposition | The processes by which pollutants are removed from the atmosphere and deposited on land surfaces. These processes include fallout of dry particulates, absorption of gases and removal by precipitation. |
| Dewatering | Removal of water from solid material. |
| Diffuse | The exchange of gaseous and/or solid parcels between regions in space by small-scale random motion. |
| Direct Alienation | Total replacement by man-made facilities. |

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| Dispersion | The natural process of diluting an emission through diffusion. |
| Drift | The water lost in a cooling tower as mist or droplets entrained by the circulating air, not including the evaporative loss. |
| Ecological | Pertaining to the relationship between living organisms and their environment. |
| Economic Efficiency | Careful and prudent use of resources. |
| Ecosystem | A functional system which includes the organisms of a natural community together with their environment. Derived from ecological system. |
| Entomology | A branch of the biological sciences that deals with the study of insects. |
| Eocene Epoch | A geological time scale in the Tertiary Period. |
| Ephemeral Plant | An annual plant that completes its life cycle in one short moist season; desert plants are examples. |
| Epidemiology | The study of diseases as they affect human health. |
| Equity Factors | The distribution of benefits and costs, i.e. which social groups gain and which ones lose. |
| Equivalents/$m^2$/sec | The deposition rate of hydrogen ions - a measure of the deposition of acidic material. |
| ESP | Electrostatic Precipitator. An air polluton abatement device that removes particulate matter by forcing the gas stream through an electrical field which charges the particles so that they are collected on an electrode. |
| FGD | Flue Gas Desulphurization is an air pollution control process that removes sulphur dioxide (SO2) from combustion gases, after the combustion process, by contacting them with a sorbent to react with SO2. |
| Firm Energy | A supply of electric energy that is available on an assured basis. Firm hydro energy is the level of hydro energy that can be generated throughout the worst historic drought from September 1942 to April 1946. |
| Fluvial | Features or deposits of sediments due to the action of streams. |
| Forage Crops | Crops used as food for animals especially cattle. |
| Freshet | The annual spring rise of streams in cold climates as a result of melting snow. |
| Fugitive Dust | Dust released into the atmosphere at ground level in an unconfined manner (i.e. not through a duct or stack). |

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| Full Load | Powerplant operation such that 2000 MW of power are being produced using performance coal. |
| Fumigation | An effect that occurs when the low level unstable lapse rate reaches the plume and the effluent is suddenly sent downward toward the ground. |
| Game Management Areas | Regional subdivisions of the province formerly used as basis for setting hunting regulations (see Management Unit). |
| Genetic Makeup | The biochemical basis of heredity and variation among individual members of a particular strain or group of individuals. |
| Geohydraulic | Dealing with the character, source and mode of occurrence of underground water. |
| Geotechnical | Relating to the application of the methods of engineering and science to the design of structures and excavation in soil and rock. |
| Glaciofluvial | Pertaining to streams fed by melting glaciers, or to the deposits and landforms produced by such streams. |
| Greenstone | A green rock that results from low grade metamorphism (changes resulting from heat and/or pressure) and the development of three minerals: epidote, chlorite and actinolite. |
| Groundwater | All subsurface water, especially that part that is in the zone of saturation (i.e. aquifer). |
| Hard Water | Water which contains relatively high concentrations of salts, mostly calcium and magnesium. Water in which it is difficult to lather soap. |
| Hummocky | Description of a surface comprised of small ridges or hillocks. |
| Hydrocarbon | An organic compound containing only carbon and hydrogen. |
| Hydrography | Science which deals with the measurement and description of the physical features of the oceans, lakes, rivers, and their adjoining coastal areas, with particular reference to their control and utilization. |
| Hydrology | Science dealing with the properties, distribution and circulation of water. |
| Incubation | Maintenance of chemical mixtures at specified temperatures for varying time periods to study chemical reactions. The act or process of brooding or incubating. |

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| Indigenous | Pertaining to animal or plant species which are native to a given area by natural occurrence. |
| Infrastructure | The underlying foundation or basic framework (as of a system or organization). |
| Ingest | To eat. |
| Injury | All plant responses to air pollution exposures, including reversible effects on metabolism, effects on physiological processes, neurosis, senescence and modifications of growth and development. |
| Invertebrate | An animal lacking a backbone and internal skeleton. |
| Ionizing Radiation | Particles or photons that have sufficient energy to produce ionization directly in their passage through matter. |
| Isopleth | A line drawn through points on a plot at which a given quantity has the same numerical value (or occurs with the same frequency) as a function of the two coordinate variables. |
| Isotropic | Uniform properties in all directions. |
| Lacustrine | That which is derived from processes operating in a lake. |
| Lahar | A mudflow containing volcanic rock and associated with volcanic eruptions. |
| "Lay-down" Area | Area adjacent to project facilities suitable for laying down equipment and dismantled sections of the facility. |
| Leachate | A solution or product obtained by the action of a percolating liquid dissolving out soluble components of a solid material. |
| Lithic Scatter | An archaeological site which consists of stone tools and debitage strewn on the land surface. |
| Lithified | The process of being made into a rock by cementation or compaction. |
| Load Factor | The ratio of average electric load to peak load, usually calculated over a given period. |
| Management Unit | Section of a regional subdivision of the province presently used as a basis for setting hunting regulations (see Game Management Area). |
| Matrix | A rectangular array of numbers or elements containing rows and columns of numbers. |
| MCS | Meteorological Control System. |
| Mean Annual Increment | Annual value growth of harvestable trees. |

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| Metabolism | Biochemical process in living organisms whereby energy is provided for vital processes. |
| Meteorological Station | Any site where an observer or automatic instrument is located and from which weather observations are made. |
| Metavolcanic | It implies that the pre-existing volcanic rock was metamorphosed (changed by heat and/or pressure). |
| Microtine | Subfamily Microtinae. Small burrowing rodents with short legs and stout claws, such as lemming and voles. |
| Mill | A money of account equal to 1/10 cent. |
| Miocene Epoch | A geological time scale in the Tertiary Period. |
| Mitigation | Measures taken in the planning, design, operation and decommissioning phases of projects to prevent adverse impacts on resources. |
| Monitoring | The use of approved instrumentation and/or techniques to measure the presence or effect of a contaminent. |
| Necrosis | Localized death of living tissues such as leaves. |
| Neurosis | A category of emotional maladjustments characterized by some impairment of thinking and judgment, with anxiety as the chief symptom. |
| NO | Nitric Oxide. |
| NO2 | Nitrogen Dioxide. |
| Nitrogen Supersaturation | Concentration of nitrogen in water greater than its value at equilibrium at the same temperature and pressure. |
| Nonconformity | Refer to conformably. |
| Nonfriable | Referring to the property of a substance. Not easily crumbled, pulverized or reduced to powder. |
| Non-sodic | Without sodium. |
| NSR | Not Satisfactorily Restocked. Denuded areas that do not meet minimum stocking requirements of approximately 750 healthy, well-distributed seedlings or juvenile stems per hectare. |
| Nuclide | A species of atom characterized by the number of protons, number of neutrons, and energy content in the nucleus, or alternatively by the atomic number, mass number, and atomic mass. |
| Nutrient | Providing nourishment. |

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| Nutritive Makeup | The composition of an individual or organism as determined by the sum of the processes by which subject takes in and utilizes food substances. Dietary factors can influence toxicity by producing changes in the body composition, physiologic and biochemical functions and nutritional status of an individual. |
| Opportunity Cost | The value of a factor of production (capital, labour or natural resource) in its best alternative employment, i.e. the amount that a factor of production would have earned if not utilized by the Hat Creek development. |
| Outfall | The point at which a sewer discharge empties into a receiving water body. |
| Overburden | Material overlying a mineral deposit or coal seam. |
| Overstory | Upper or uppermost portion of tree foliage. |
| Paleozoic | Refer to Cenozoic. |
| Particulate | Solid or liquid matter in fine particles: soot, dust, aerosols, fumes and mists. |
| Partings | Beds or banks of waste material dividing mineral veins or beds. |
| Peak Capability | The maximum power output that can be supplied by a generating unit station, or system in a stated time period. |
| Performance Coal | Defines the predicted average quality of blended coal which the mine would supply to the powerplant over 35 years. |
| Periphyton | Organisms (as some algae) that live attached to underwater surfaces. |
| Permeability | The capacity of a porous rock, soil or sediment for transmitting a fluid without damage to the structure of the medium. |
| Permian | A period of geologic time in the Paleozoic Era. |
| pH | A term used to describe the hydrogen ion activity of a system. Indicative of the acidity (less than pH 7) or basicity (greater than pH 7) of a solution. |
| Phenology | A branch of science dealing with the relations between climate and periodic biological phenomena such as bird migration or plant flowering. |
| Photochemical Reaction | A chemical reaction influenced or initiated by light, particularly ultraviolet light. |
| Photosynthetic Activity | Process whereby green plants manufacture carbohydrates from carbon dioxide and water in the presence of light energy. |

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| Physiological Process | Biological process. Characteristic of or appropriate to an organism's healthy or normal functioning. |
| Phytoplankton | Planktonic (passively floating or weakly mobile) aquatic plant life. |
| Piezometer | An instrument for measuring pressure or compressibility. |
| Plateau Basalts | Extensive flat-lying basalts that result from fissure (fracture) eruptions rather than more familiar eruptions. |
| Plume Simulation | A simulation, usually mathematical, of the transport, spread and concentration of plume elements in finite time increments. |
| Potable | (Water) suitable for drinking purposes. |
| Probable Maximum Flood | The theoretically greatest flood that is physically possible over a particular drainage area. |
| Pubescent Leaves | Leaves covered with fine soft short hair. |
| Public Sustained Yield Unit (PSYU) | Crown land designated as a Public Sustained Yield Unit under Section 6 of the Forest Act of 1978. |
| Pulmonary Function | The performance carried out by the lungs measured by such tests as forced vital capacity, functional residual capacity and expiratory reserve volume. |
| Pyroclastic | Rocks that originate as fragmental volcanic material that fell through the air under the influence of gravity. |
| Radiation Dose | The amount of energy imparted by ionizing particles to a unit mass of irradiated material at the point of interest. |
| Radionuclide | A nuclide that exhibits radioactivity. |
| Radiosonde | A balloon-borne instrument for the simultaneous measurement and transmission of meteorological data. |
| Radiosonde Profile | Recording of temperature, humidity, pressure and wind measurements at vertical increments using a balloon to carry the instrument package. |
| Radon Daughters | The four radioactive, short-lived decay products of radon: polonium-218, lead-214, bismuth-214, and polonium-214. |
| Reagent | A chemical substance with which another material reacts. |

Recharge (of Groundwater)

Area where groundwater resources receive enhancement from surface supplies (water bodies or precipitation).

Regenerative — State of renewal or restoration.

rem — The unit of biological dose given by the product of the absorbed dose in rads and the relative biological efficiency of the radiation (Roentgen Equivalent Man).

Rhyolite — Refer to andesite.

Riffle — A shallows across a stream bed over which water flows swiftly and is broken into waves by submerged obstructions.

Riparian — Living or located on a riverbank.

Runoff — Surface-flowing water originating from precipitation (rain or snow).

Saline — Consisting of or containing salt.

Saline Depression Communities

Plant assemblages found growing in the salty soils of areas with restricted drainage.

Sediment — A mass of organic or inorganic solid fragmented material, or the solid fragment itself, that comes from weathering of rock and is carried by, suspended in, or dropped by air, water, or ice; or a mass that is accumulated by any other natural agent that forms in layers on the earth's surface such as sand, gravel, silt, mud, fill or loess.

Senescence — The study of the biological changes related to aging, with special emphasis on plant, animal and clinical observations which may apply to man. The part of the erosion cycle at which the stage of old age begins.

Sequential — Repetitive; occurring again and again.

Siltstone — A sedimentary rock intermediate between shale and sandstone conforming in grain size to silt, viz. 0.1 to 0.01 mm.

SO2 — Sulphur Dioxide.

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| Stacker-reclaimer | A coal-handling machine that moves along a conveyor and performs at different times two functions:<br>1. Takes coal from the conveyor and places it in a stockpile (stacker).<br>2. Retrieves coal from a stockpile and places it on conveyor (reclaimer). |
| Steam Line Blow-outs | The cleaning of boiler tubes and main and reheat steam lines by high pressure steam releases. |
| Stock | A body of rock that cooled from molten material below the surface and that has currently an area of less than 102 $km^2$ exposed at the surface of the earth. |
| Stratification | An arrangement or deposition of sedimentary material in layers, or of sedimentary rock in strata. |
| Subalpine Forest Region | Typical forested region of interior British Columbia; generally occurring below 2300 m elevation. |
| Synergism (Synergistic) | The cooperative action of discrete agencies such that the total effect is greater than the sum of the effects taken independently. |
| Terrestrial | Of or pertaining to the earth. |
| Threshold Value | The minimum concentration of a substance (e.g. SO2) necessary to produce an effect (e.g. on living plants). |
| Toxic | Relating to a harmful effect by a poisonous substance on living organisms by physical contact, ingestion or inhalation. |
| Topography | The art or practice of graphic delineation in detail usually on maps or charts of natural and man-made features of a place or region especially in a way to show their relative positions and elevations. |
| Trace Element | An element found in small quantities (less than 1000 parts per million by weight) in a mineral. |
| Trunk Main | A large pipe in a water distribution system. |
| Turbidity | Any condition of the atmosphere which reduces its transparency to radiation, especially to visible radiation. |
| Unconformity | Refer to conformably. |
| Understory | Any underlying layer of low vegetation. |

Unlithified — Unconsolidated sediment not changed to stone or petrified.

Ventilatory Performance — The execution of the exchange of air in the lungs with atmospheric air which has a higher oxygen and lower carbon dioxide content.

Vesicular — That property of a volcanic rock which involves having holes that were gas bubbles in the molten state and that were preserved when the lava solidified on cooling.

Watershed — The total land area which contributes water to the flow of a stream or river (see Runoff).

Yearly Day Night Average Noise Level (YDNL) — The logarithmic average of the day-night average sound levels (Ldn) over a full year.

Zero-Discharge — A discharge system in which there is no formal liquid discharge of process waste waters to a water course. The waste water is disposed of onsite by other means.

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