BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

Ebasco Services of Canada Ltd., Environmental Consultants - Hat Creek Project - Environmental Impact Assessment Report - December 1978 - (Volume 1).

ENVIRONMENTAL IMPACT STATEMENT REFERENCE NUMBER: 31a

JDP

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EBASCO SERVICES OF CANADA LIMITED; Environmental Consultants

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c/o Envirosphere Company
1617 Cole Blvd., Suite 250
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21 December 1979

Mr. John Peirson
B.C.Hydro & Power Authority
Box 12121
555 West Hastings Street
Vancouver, B.C. V6B 4T6

Dear John:

Re: Hat Creek Project
Final EIAR & Environmental Summary

We have reviewed the revised, "Printer's Proof" copies of Volumes 1, 2 and Tables of the Environmental Impact Assessment Report (EIAR) which you sent with your letter of 11 October 1979. I am enclosing herewith marked up pages from the three volumes which require additional corrections. Except as noted below re four tables with errors which are yet to be resolved, after the additional corrections are made ESCLEC will consider the EIAR to be final.

...ificant things ... seen. ...ded pages ... to Word ...ssing Centre 3 Jan 80.

Tables 3.4-10, 3.4-11, 4.1-23 and 4.1-24 in Part Four were found in my review to contain substantial errors in tabulation. The errors we think were the result of changes that were occuring as Strong Hall & Associates continued work on the data base during preparation of the Final Draft EIAR. It may be that bottom-line figures on the tables, which were used in the text, were late corrections, and that corresponding corrections were not made in the body of the tables. Dr. Lesnick is now checking the tables and the corresponding sections of text. I expect his corrections to be provided within a few days. I will forward them to you immediately on receipt.

RGP & ...esnick ... working on this.

I have also reviewed the figures as marked by J.G.Alesi for revision. The marked up volume is sufficient for this purpose. In view of the relatively minor changes, it will not be necessary for me to see copies of the revised figures. I am enclosing copies of four figures requiring further corrections. Upon completion of these indicated changes all of the revised figures are also acceptable to ESCLEC as final.

Page 2
Mr. John Peirson
21 December 1979

~~A signed copy of my letter of 22 June 1978 to F.C. Edwards, which transmitted the Environmental Summary for the B.C.Hydro Composite Report, is enclosed as you requested. The text of the summary is also enclosed.~~ (My recollection is that the signed original of the letter was sent shortly after the text was telecopied from New York.) ~~As I discussed with you by telephone, the summary was based on the ESCLEC impacts evaluations that had been completed at the time it was prepared. I have not updated the summary.~~

~~Nevertheless, the conclusions presented in the summary are considered to adequately characterize environmental impacts of the project. In my judgment the statement in paragraph two of the summary remains valid at the completion of ESCLEC's studies. That is, no major environmental impacts have been identified that would appear to preclude licensing the project.~~

I will be returning your copy (#18) of the draft report under separate cover within the next week. When the Final EIAR is reproduced, I ask that you send me ten (10) complete copies for internal distribution and company files.

Very truly yours,

Frank B. Titus

Frank B. Titus, Ph.D.
Manager
Denver Regional Office

FBT/slr

Telephone: (604) 682-7841 Telex: 04-51296

EBASCO SERVICES OF CANADA LIMITED; Environmental Consultants

1155 West Pender Street, Vancouver, British Columbia, Canada. V6E 2P4

6686.01
6686ECO.01
June 22, 1978

Mr J C Edwards
Coordinator, Detailed Environmental Studies
Hat Creek Project
BC Hydro & Power Authority
555 West Hastings Street
Vancouver, BC V6B 4T6

Dear Mr Edwards:

Re: Hat Creek Project
Detailed Environmental Studies
Environmental Summary for Composite Report

Attached is the final, revised version of the Environmental Summary for incorporation in the Hat Creek Project composite report to the BC Hydro Board of Directors. This report is being telecopied to you today from New York, and clean copy is also being sent by air express.

In the revision an attempt has been made to incorporate the suggestions of BC Hydro reviewers who commented on the earlier draft version. We trust that you will view this version as presenting a balanced description of the project.

As you requested in our meeting of 31 May 1978, this final summary has been prepared in a format for direct insertion into the composite report. In order to provide for this we have addressed only the "most probably" project facilities, except that all three AQCS/stack height alternatives are considered.

Furthermore, we have deleted several sections that appeared in our draft summary, including those on "Major System Design Alternatives" and "Licensing Considerations". We understand that some of the topics in our deleted draft sections will be addressed by BC Hydro personnel in a section on "Principal Areas of Concern". We hope that our draft may have been useful in these areas. Most of the questions and concerns that were raised in the draft summary are still considered to be valid although we recognize that they are not pertinent in the specific context of the environmental summary for the composite report.

The attached final summary addresses impacts in qualitative terms, as did the draft summary. In the period since preparation of the draft, a number of consultants' impact reports have been received by ESCLEC, although they are not yet all in hand. Because of the critical time constraints on ESCLEC/Envirosphere project personnel in producing the EIAR, we have not interrupted the EIAR work to totally rewrite the summary using the latest quantitative data.

We trust that the information presented will provide an adequate environmental summary of the project for the Board of Directors when incorporated with other composite report sections being prepared by BC Hydro.

I will be in telephone contact with you from here in New York, and will answer any questions which you may have regarding the summary.

Very truly yours,

F B Titus, Ph.D.
Manager Regional Office

FBT/ps
Attachment:

cc: J A Rasile

D 2.0 ENVIRONMENTAL SUMMARY

D 2.1 INTRODUCTION

This section supplements and summarizes the Environmental Impact Assessment Report (EIAR) prepared by the coordinating consultant, Ebasco Services of Canada Limited, Environmental Consultants. The EIAR presents a description of baseline environmental conditions and the impacts of development, operation and decommissioning of project facilities. Because project construction and operation would create the major effects, only these phases are addressed in this summary. However, in the subsection on Water Resources Impacts, the potential importance of mine decommissioning is mentioned.

~~No major environmental conflicts have been identified that would appear to preclude licensing the project.~~ This conclusion is based on predictions of the impacts that would occur under unusual conditions (e.g., critical climatic or hydrological conditions) as well as those that would occur under average conditions. Conservative assumptions and analyses have been used in formulating the predictions.

This summary considers environmental effects of only the selected systems for the power plant, mine and offsites facilities. The exception is the Air Quality Control System (AQCS)/stack height configuration, for which three alternatives are considered. Each of the alternatives will meet the ambient air quality guidelines for sulphur dioxide proposed by B C Hydro to the Pollution Control Board. These guidelines are assumed in the EIAR to be applicable. If the Pollution Control Board promulgates more stringent guidelines, the present strategy may have to be reviewed.

The subsections that follow summarize environmental impacts on air quality, water resources, aquatic environments, land resources and socioeconomics.

D 2.2 AIR QUALITY IMPACTS

The most important air quality and meteorological effects of the project result from operation of the power plant and the mine. The specific meteorology/air quality concerns investigated include:

1. Construction effects
2. Effects of plant operation on local ambient air quality levels
3. Regional air quality effects
4. Air quality effects from mining operations
5. Effects of all project components on local climate
6. Effects of the cooling towers on fogging and icing conditions and salt drift deposition
7. Long-range transport and acid rain effects
8. Effects on local and regional visibility conditions

(a) Construction Period

Construction effects on air quality are expected to be minor, assuming that appropriate dust control measures are used.

(b) Operation Period

Diffusion model calculations of power plant stack gas emissions were run for three alternative air quality control system (AQCS) configurations. The calculations show that each would meet the assumed ambient air quality guidelines for sulphur dioxide (SO_2). The configurations are:

1. Meteorological Control System with a 366 m stack
2. Meteorological Control System with a 244 m stack
3. Partial Flue Gas Desulphurization with a 366 m stack

These fall into two classes. The first class, consisting of alternatives 1 and 2, the Meteorological Control System (MCS), would meet the guidelines by reducing stack emissions (by operational constraints such as load shedding or switching to low sulphur coal) only when air quality predictions and/or real-time field monitors indicate that a guideline is likely to be exceeded at any terrain point. The second class, alternative 3, Flue Gas Desulphurization (FGD), would meet the guidelines by continuously reducing SO_2 emissions from the stack.

A measurable increase in SO_2 levels in the local area (within 25 km) should be expected, particularly with the MCS control options. Concentrations approaching the assumed guidelines would occur only on the highest terrain within the local area, and concentrations at lower terrain elevations would be significantly below guideline levels. Increases in other contaminants (particulates, oxides of nitrogen, carbon monoxide, hydrocarbons, and trace elements) due to plant operation are all expected to be small in comparison to the assumed ambient guidelines.

Mining operations, even with wetting and other dust control measures, could produce fugitive dust concentrations in excess of the short-term guidelines in the valleys within a few kilometres of the mine under restrictive meteorological conditions (possibly a few times a year). The annual guideline could also be exceeded in the valleys within a few kilometres of the mine.

Based on a thorough review of the literature pertaining to climatic effects of thermal power generation, on the field program, and on modelling results, it is concluded that project operation would have no appreciable effect on global atmospheric processes, and only minor localized effects on regional and local scale climatic conditions. Waste heat and moisture from the cooling towers could produce slight increases in precipitation. Visible vapor plumes from the cooling towers would occasionally extend to distances of more than 15 km from the generating station. Ground-level fogging and icing should not be a problem due to the plume exit height from the natural draft towers. Evaporation from the ash pond and make-up water reservoir could cause local fogging and/or icing conditions in their immediate vicinities, particularly on cold days during the spring and fall. Predicted salt drift deposition rates from the cooling towers are very small and should cause no adverse effects.

Long-range transport and acid rain effects were also investigated by the meteorology/air quality consultant. These studies indicate that short-term decreases in pH levels of precipitation could occur beneath the plume within about 20 km of the stack during summer showers. Also, because of long-range transport and conversion of SO_2 to sulphates, short-term precipitation pH reductions of lesser magnitude could occur in limited areas at greater distances from the power plant. The extent and magnitude of these effects are extremely difficult to predict. A monitoring program is recommended in the EIAR to ensure that potential problems due to acid rain would be identified.

Fugitive dust from mining activities could reduce visibility in the valleys within a few kilometres of the mine by about 50% under many meteorological conditions, and could reduce it even more under worst-case meteorological conditions. Although the power plant plume would be visible (appear partially opaque) close to the stack, no significant effects from the stack plume on visibility within the 20 km local area are expected. Sulphate formation and particulates far downward of the plant site would have minimal effects on regional visibility.

D 2.3 WATER RESOURCES IMPACTS

(a) Construction Period

(i) Groundwater

Potentially useful groundwater aquifers in the Hat Creek Valley are small and of limited areal extent. Construction activities would not produce any significant effects on groundwater quality if PCB guidelines are met for sewage systems and refuse disposal. Toward the end of the construction stage the maximum groundwater use rate could be about one-third of the groundwater flow rate, but this rate would be temporary and the effects would be localized. The development should not affect the availability of groundwater upstream or downstream from the study area.

(ii) Surface Water

During the construction phase, use of proper sedimentation and erosion control procedures should prevent hydrological impacts due to gullying and stream erosion, and water quality impacts due to wind and water borne sediment. Draining Finney and Aleece Lakes, and the relocation of 9 km of natural Hat Creek channel, would cause localized impacts that should not affect areas outside of the Hat Creek Valley. Pit area dewatering also has the potential to alter the chemical quality of the receiving stream, Hat Creek, and thus treatment measures should be provided.

Construction of project facilities would alienate lands on which about 1.56×10^6 m^3/year (1,268 ac-ft/year) of water is projected for irrigation use in the future. Part, or perhaps all, of this water may be available for the irrigation of other lands, and thus the net impact on water use should be small. The Hat Creek and Finney Creek diversions would block the use of present irrigation conveyance ditches associated with the supply of 3.5×10^5 m^3/year (284 ac-ft/year) of water.

(b) Operation Period

(i) Groundwater

Pit excavation and dewatering would cut the valley alluvial aquifer, but most of the water from dewatering would be discharged to Hat Creek after treatment, thereby minimizing downstream effects.

Drainage from the proposed waste disposal sites in Houth Meadows and Medicine Creek would result in some seepage into the groundwater system, but because the quantity of seepage would be small compared to groundwater flows, impacts should be minimal. Impermeable lining should be used to control seepage from the coal stockpile and low grade waste pile, as the quality of the wastewaters will be extremely poor.

Impacts on groundwater quality from operation of the power plant could occur at the ash disposal sites. However, with suitable controls (base preparation, cutoff walls, and seepage collection-return system), the impact would be limited to the immediate area of the disposal site. Construction and operation of the offsite facilities would not affect the groundwater resource.

(ii) Surface Water

Operation of the mine should have no significant impact on the flow regime of Hat Creek because the mine drainage pumped to Hat Creek after treatment is mainly water which discharges to the creek under natural conditions. The existence and operation of the power plant would have only minor effects on stream flow, except that the alienation of 5 km of Medicine Creek valley by the ash disposal site would reduce the Hat Creek drainage area somewhat. The Hat Creek diversion would have minor effects on downstream flow regime and channel morphology.

Runoff and seepage from the main waste disposal sites, and pumped mine waters, are sources that would require treatment before discharged to Hat Creek in order to meet PCB guidelines and to avoid serious impact. The predicted quality of leachates and runoff from the coal piles, the low-grade waste site and the ash disposal sites indicate that discharge of these waters to Hat Creek should be avoided. Analysis of the remaining discharges indicates that dissolved solids and suspended sediment in Hat Creek would be likely to increase moderately during parts of the year. Nitrogen and phosphorus losses from reclamation fertilization should be controlled to prevent increases in Hat Creek nutrient levels. Water temperatures in the Hat Creek diversion canal during low summer flows would be significantly higher than in the original stream channel.

Project operation could affect the availability of up to 6.0 X 10^5 m^3/year (486 ac-ft/year) of water for irrigation use. Because part of this is for non-consumptive uses in the project, the net impact on irrigation water would be less than this.

(c) Decommissioning Period

Conversion of the mine pit into a lake upon decommissioning would be the most significant impact of this project on water resources in Hat Creek Valley. It would convert Hat Creek into a fully regulated stream and could have detrimental effects on water quality in the stream. Studies should be undertaken to evaluate the alternatives for final mine reclamation. In particular the environmental effects should be carefully considered.

D 2.4 IMPACTS ON AQUATIC ENVIRONMENTS

The Hat Creek Project would directly affect the aquatic ecosystem of the Thompson River and the Hat Creek watershed. Indirect or secondary effects to regional water bodies and stream courses due to long-range transport of airborne pollutants could also occur to a limited extent. The major aquatic resources of concern are the resident fish population of Hat Creek, principally rainbow trout, and the migratory salmonid population of the Thompson River watershed. Although specific impacts could affect such other ecosystem components such as benthic invertebrates or primary producers to a greater or lesser extent, the fish populations are the principal concern to man. Any significant changes at other biological levels of organization would be reflected in a change in the fishery resources of the impacted habitat.

Impacts associated with the project development would include, but not be limited to, the following categories:

1. Habitat modification
2. Habitat loss
3. Intake effects

Habitat modification considers the effects of such factors as water quality degradation, sedimentation and flow reductions on the fish populations of water bodies. Habitat loss results from a project action, such as a creek diversion, which removes an area from utilization by the biota. Intake effects result principally from impingement of juvenile salmonids.

(a) Construction Period

Impacts to aquatic habitats during the construction phase of the project would be of a local nature and would be limited principally to 1) habitat modification associated with unavoidable siltation from construction activities (especially stream crossings), and 2) habitat losses resulting from construction of the intake structure in the Thompson River, road and pipeline crossings of the Bonaparte River, and diversion of Hat Creek and its tributaries. Impacts associated with sedimentation could be ameliorated by limiting activities during critical life history periods, such as spawning seasons, and avoiding critical locales during peak runoff periods. Habitat loss due to diversion of Hat Creek would represent a minor direct loss to the productivity of the watershed. Some additional stress to fish population might result from increased fishing pressure due to recreational fishing by the work force. This stress could be reduced or avoided by prohibiting or limiting fishing in habitats of concern.

(b) Operation Period

Project operation presents the major aquatic ecological concern, as it would affect the aquatic resources on both a local and regional basis. Water withdrawal from the Thompson River could result in the loss of some juvenile salmonids by impingement, but fish protection design parameters incorporated in the design of the proposed intake would minimize potential losses. In addition, potential losses could be reduced significantly if the intake is not operated during critical juvenile migration periods. (Reservoir storage capacity would be sufficient to allow power plant operation to continue during such periods.) Thus the design and operating constraints should result in a negligible impact on the regional salmon fisheries industry. Habitat modification if water quality in Hat Creek is degraded would affect the downstream rainbow trout population adversely. This loss would not be offset by any additional habitat in the diversion canal.

Long-range transport of air pollutants possibly could cause measurable changes in water quality of lakes and stream courses downwind of the project; such effects could be cumulative through the life of the plant. Monitoring could identify any changes. Analysis of the available data suggests however that any such water quality degradations should not exceed acceptable levels.

D 2.5 LAND RESOURCES IMPACTS

The specific land resources for which environmental impact assessment has been undertaken comprise the following:

1. Vegetation and Physical Environment
2. Wildlife
3. Forestry
4. Agriculture

Land alienation during the construction period, and air quality degradation during the operation period, would cause the major effects. In the regional context, impacts on land resources should be moderate. Those related to construction activities would be temporary and mostly limited to actual facility sites. Operational effects on flora and fauna, including those which could result from ambient air quality changes, would all be limited to an area within 25 km of the plant site.

(a) Construction Period

Agriculture is the principal land resource activity that would be affected by construction. Cattle grazing and the organization of existing ranch areas are the two agricultural resource aspects which would be most affected. Construction of the mine and associated waste dumps would alienate land that is regarded as good range and cropland. Plant construction would alienate a smaller area and land that is generally less valuable for grazing.

The loss of forest resources due to construction of the mine and power plant would be minor since the forest productivity of most of the land is poor. A large percentage of the mine area is unforested, and the forestry loss due to mine development has already been deducted from the allowable annual cut.

Some riparian vegetation would be lost by development of the mine. This vegetation is only found along portions of Hat Creek, and it is an important wildlife habitat because of its limited extent in the Valley. Wildlife habitat loss due to construction of the power plant should be minimal.

(b) Operation Period

Operational effects on the flora and fauna of the Hat Creek Valley and environs would result primarily from the degradation of ambient air quality. The three alternative AQCS/stack height alternatives are described in Section D 2.2. As is noted there, each of these would meet the assumed ambient air quality guidelines for SO_2. However, increased SO_2 concentrations still could be expected to cause some short-term effects on vegetation within 25 km of the plant site. These effects should be limited to vegetation growing on the highest elevations in the Clear Range, Arrowstone Hills and Cornwall Hills, where the greatest ambient concentrations of pollutants would occur.

Total protection of vegetation cannot be assured solely by compliance with the assumed guidelines for 3-hour averages because an averaging period at any particular terrain point could include 1 hour or shorter periods with concentrations high enough to affect vegetation. With a meteorological control system (MCS), short-term high concentrations could be expected. With flue gas desulphurization (FGD), in contrast, the maximum short-term concentrations would be significantly lower.

Nevertheless, if a 366 m (1,200 ft) stack with either an MCS or partial FGD control system is provided, the short-term vegetation effects in the upland terrain should be minimal. In comparing the two 366 m stack cases, the partial FGD system should result in less impact on vegetation than the MCS system. If a 244 m (800 ft) stack with MCS is provided, the impact on vegetation should be greater because maximum SO_2 concentrations are predicted to be greater with the shorter stack. The forests and range vegetation found at higher elevations are not economically as productive as those present in other parts of the valley. Therefore, because the most significant air quality degradation would occur at these high elevations, the impact on regional forestry and range vegetation resources would be minimal.

The potential for long-term or chronic SO_2 injury cannot be assessed accurately due to the lack of definitive work or published results on this aspect of air pollution effects on vegetation. If it were to occur it would be most apparent at higher elevations.

Fluoride emitted during plant operation in the gaseous form of HF could be an injurious air pollutant. Extremely low concentrations of HF (in the ppb range) have been reported to be injurious to sensitive species such as Ponderosa pine. The fluoride question cannot be resolved at this time because of wide variation in published and unpublished data on the percentage of fluoride released in gaseous form during coal combustion.

The degradation of ambient air quality should not have an adverse effect on birds or mammals. Other effects of project operation on the fauna should be minimal.

D 2.6 SOCIOECONOMIC IMPACTS

The Hat Creek Project would directly affect local populations residing in the Valley and communities within about 30 kilometres from the Project centre. Population centres outside the local area, such as Kamloops, having economic linkages with the local communities might also be affected. The list below includes some of the major social, political and economic areas of concern that are addressed in the EIAR (not necessarily in order of importance):

1. Population, Income and Employment
2. Housing and Infrastructure
3. Social Adjustment
4. Local Government and Community Services
5. Land Use and Aesthetics
6. Native Indians
7. Recreation
8. Archaeology

⋮

Impacts would be caused not only by intrusion of the Project components on human populations and their economic and social activities, but also by population-induced effects of the Hat Creek Project. Specific casual factors could include resource use changes, labour requirements, expenditure patterns, population in-migration, and aesthetic alterations.

(a) Construction Period

During construction, land use in the Hat Creek Valley would be changed from agriculture to mining and electricity generation. Forest, wildlife and other land resources would be disturbed locally, and this would affect recreational uses. The construction activity would result in an influx of men and material, with associated noise and dust, which at certain times and places might negatively affect the local population, including some Native Indians. Archaeological resources could be affected by the disruption of land and by increased access.

Construction workers and their families would require housing, medical, educational and other community services which could place pressure on existing capacities or strain the financial ability of local communities to provide the additional services. The location of a large and primarily male construction work force in the Hat Creek Valley Camp or in the local communities could be expected to increase some social problems and would require adjustment on the part of the permanent residents.

Significant regional benefits would result from local employment on the project and from increased income and employment cause by project related expenditures in the study area. The total Hat Creek labour forces would peak at more than 3,000 persons by the time the first unit begins operation in the mid 1980's. Subsequent decline of the construction work force and increase of the more permanent operating work force should not be disruptive if business and other community leadership groups plan appropriately.

(b) Operation Period

Most of the operating work force of more than 1,000 persons would reside with their families in the local communities and become assimilated into the social, political and economic fabric. Their income would be beneficial to the local economy. Assuming a reasonable distribution of the operation staff and their families among the communities, the impacts on community infrastructure and services should be minimal in most instances; planning on a regional and local level, would aid in identifying deficient services or potential burdens on governmental units to provide services.

The expenditures made by the operating work force and their families in the study area would generate additional income and employment, which in turn should stimulate in-migration and thus increase the population base. Any purchases made by B C Hydro in the local area during the construction or operation phases would also promote regional economic development.

Although the recreation potential in Hat Creek Valley would be affected, recreation days in the overall study region should increase owing to the population increase. The operation of the plant would slightly degrade the quality of the air shed through airborne contaminants such as sulphur dioxide and and nitrogen oxides, but health-related hazards of such contaminants would be insignificant.

HAT CREEK PROJECT

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY

VOLUME 1

BOOK Nº 11

HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

GENERAL OUTLINE

PART ONE

INTRODUCTION

CONTENTS

TABLES

FIGURES

CHAPTER 1.0 - THE HAT CREEK PROJECT

British Columbia Hydro and Power Authority (B.C. Hydro) proposes to construct and operate a 2000 MW coal-fired powerplant, open pit coal mine and ancillary offsite facilities in the Hat Creek Valley. Hat Creek Valley is located in southcentral British Columbia and is bounded by latitudes $50^{\circ}15'$ and $50^{\circ}50'$, and longitudes $121^{\circ}25'$ and $121^{\circ}45'$.

Hat Creek Valley forms part of the Thompson plateau region which separates the Coast Range from the Monashee Range of the Rocky Mountains. Although characterized as a plateau, the region is marked by dramatic topographic relief. Erosion by large rivers such as the Fraser and Thompson, and smaller streams such as Hat Creek, have dissected the plateau and created a stark, rugged landscape.

Hat Creek Valley varies in elevation from about 490 m above MSL at its lower end near the village of Carquile where Hat Creek joins the Bonaparte River to about 1070 m in the upper valley above the proposed project site. Ridges to the south of the project are 1555 m above MSL and the Cornwall Hills to the southeast area 2010 m above MSL. Peaks of the Marble Range to the north reach elevations of about 2075 m. Maximum elevations between 2196 m and 2320 m are found in the Clear Range to the west. The project site is approximately 16 km southwest of Cache Creek and 80 km west of Kamloops (Fig. 1.0-1).

The project consists of:

1. Development, operation and decommissioning of an open pit mine to exploit 320 Mt of Hat Creek coal from the No. 1 deposit.

2. Construction, operation and decommissioning of four 500 MW net (560 MW gross) coal-fired thermal generation units.

3. Construction, operation and decommissioning of offsite systems which include project access roads, a makeup cooling water supply system, a 69 kV transmission system, creek diversions, an airstrip, construction camps and equipment offloading facilities.

The mine would be located in the floor of upper Hat Creek Valley with the downstream pit rim about 1 km south of the mouth of Marble Canyon at the time of maximum development. The powerplant is proposed to be located on rolling upland terrain about 4 km east of the mine head at an elevation of about 1410 m.

Cooling water for the powerplant, and the relatively small amounts of water for other uses, would be pumped from the Thompson River, approximately 23 km to the east. The cooling water makeup requirements would be minimized by a recirculating system and all blowdown would be consumptively used by other plant systems so that the plant operates in a "no discharge" mode of operation.

For the purpose of this report construction is assumed to begin in 1980 or 1981. Unit 1 of the powerplant is scheduled to begin operation in 1986. This would require completion of the offsite systems and development of the mine by that date. Units 2, 3 and 4 were assumed to begin operation in 1987, 1988 and 1989, respectively.

The Environmental Impact Assessment Report (EIAR) summarizes the relevant environmental and engineering studies conducted in support of the project. Engineering descriptions present the major project systems and alternatives which could affect the environment. Because of the evolutionary nature of complex thermal power developments, the engineering systems presented are subject to continual analysis and revaluation. It should be expected, therefore, that design changes would occur during the subsequent engineering phases. Emphasis would be given to systems for which consumptive resource uses could be minimized and for which environmental impacts have been identified and minimized.

CHAPTER 2.0 - SUMMARY TERMS OF REFERENCE

In June 1976 B.C. Hydro commissioned Ebasco Services of Canada Limited, Environmental Consultants (ESCLEC) to coordinate the detailed environmental studies on the proposed Hat Creek Project. The broad objective of the terms of reference prepared by B.C. Hydro in 1976 and finalized in August 1977 are:

> To identify and evaluate the effects of the proposed Hat Creek coal mine, 2000 MW generating station and ancillary offsite facilities on the natural and cultural environment of the region, and to compare these effects to the development of the area and resources without the project.

B.C. Hydro identified five broad areas of study. These were assigned to consultants for investigation. Table 1.0-1 summarizes the study components and the primary study teams. These organizations were responsible for the preparation of the Environmental Impact Assessment Report (EIAR) technical data base, for the accuracy of the resource inventories and for the professional merit of the impact analyses and conclusions.

As coordinating consultant, ESCLEC administered the detailed environmental studies, transmitted information from the design consultants to the environmental consultants and ensured satisfactory compromises between engineering requirements and environmental constraints. ESCLEC advised B.C. Hydro of areas which required either more intensive analysis or separate investigation. Implementation of these suggestions served either to modify the terms of reference or to initiate new studies. ESCLEC prepared the text of the EIAR based on the consultants' reported results.

The conduct of the detailed environmental studies paralleled the engineering conceptual and preliminary design. This approach permitted continuing liaison between the environmental and engineering investigations. As a result, design features which would mitigate environmental impacts were incorporated early in the project design. Because of the conservative approach used to predict impacts and the inclusion of preliminary design features to mitigate them, it is expected that the final design would further reduce the impacts presented in this report.

CHAPTER 3.0 - PURPOSE AND SCOPE OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT

The EIAR integrates the results of the detailed environmental studies (DES) for the proposed Hat Creek Project. The study team and their respective responsibilities are presented in Table 1.0-1. The purpose of the EIAR is:

1. To summarize and integrate the environmental data.

2. To provide an information base for the development of the Environmental Impact Statement (EIS).

3. To provide a technical basis to identify and recommend environmentally compatible system alternatives for the project.

The EIAR presents the technical results of the local and regional resource inventories and projected environmental impacts caused by construction, operation and decommissioning of a 2000 MW powerplant, open pit mine and offsite support facilities. These studies occurred between June 1976 and June 1978.

Natural and cultural resources are described and projected over the expected 35-year period of powerplant operations. Resources are projected on a with- and without-project basis. The difference between the scenarios is defined as the Hat Creek Project impact.

It is understood that B.C. Hydro, after the licensing procedures are determined, would outline the applicable guidelines and objectives that must be satisfied to obtain necessary approvals, and that thereafter the EIS would be prepared. The EIS would evaluate environmental impacts with reference to the regulatory requirements in the framework of a benefit-cost analysis.

CHAPTER 4.0 - ENVIRONMENTAL IMPACT ASSESSMENT REPORT FORMAT

Environmental studies for the proposed Hat Creek Project are summarized in the EIAR. Descriptions of potential impacts are developed based on a comparison of with-and-without-case projections of natural and cultural resources. Mitigation and compensation measures to ameliorate the potential effects are discussed. It is intended that the EIAR provide the reader with sufficient background information and description to enable evaluation of the consequences of the project from local and regional perspectives. To ensure that this goal is achieved, it is necessary that the reader understand the present status of the natural and cultural resources, the nature of the developments which could affect the environment and the importance of the beneficial and adverse impacts of the project. This report is intended to provide the basis for such understanding.

The EIAR consists of five parts. Part One, entitled "Introduction", describes the purpose, scope and format of the report, the history of the project and the terms of reference.

Part Two, entitled "Description of the Hat Creek Project", is based on project descriptions of the mine and offsite facilities prepared by B.C. Hydro[1,2] and on a project description of the powerplant prepared by Integ-Ebasco[3]. These descriptions were developed from preliminary engineering studies especially for use by the environmental consultants. They characterize the major features of the proposed development and summarize information on engineering systems which could affect the environment.

Part Three, entitled "Environmental Setting without the Project", presents 1. Methodology 2. Resource Inventory and 3. Resource Projections Without the Project. The present natural and cultural resources of Hat Creek Valley and the surrounding region, contemporary constraints and a prediction of their status over 35 years if the project were not constructed are discussed. Part Three discusses meteorology-air quality, socio-economics and noise as well as land and water resources.

Part Four, entitled "Impacts of Project Development" presents the environmental impacts of the Hat Creek Project. Included in Part Four are impacts associated with:

1. Preconstruction activities.

2. Construction activities.

3. Operation activities.

4. Decommissioning activities.

Environmental impacts of the above activities on the terrestrial and aquatic biota, air quality, hydrology, water quality, geology, cultural heritage and socio-economics resources were evaluated to determine mitigation requirements. Most of the information provided in this part of the EIAR is developed from the impact evaluations presented in the Detailed Environmental Studies (DES). However, to ensure complete topical coverage, ESCLEC developed some of the information presented in Part Four.

Part Five entitled "Mitigation, Compensation and Monitoring", discusses specific recommendations made for the Hat Creek Project. It is written on the basis of the DES reports and the project description. Also included is a discussion of proposed environmental monitoring programmes.

CHAPTER 5.0 - PROJECT HISTORY

5.1 THE POWERPLANT

In 1970 the British Columbia Energy Board conducted a study to assess future provincial energy needs through 1990.[1] The results, published in May 1971, predicted a peak provincial electric power demand of 19 984 megawatts (MW) and 112 120 million kilowatt hours (kWh) of annual energy demand by 1990. This projected demand corresponded to an average annual compound growth rate of 7.6 percent for the 20-year period between 1970 and 1990.

To meet the projected electricity load growth, the Energy Board commissioned Montreal Engineering Company (Monenco) to study and recommend the most desirable sequence of electrical plant construction through 1990. A report, entitled "Electric Energy Resources and Future Power Supply" was published in August 1972.[2] Monenco recommended a combined programme of hydro and thermal power development based primarily upon an expansion of hydroelectric generation capacity and on the use of coals from either the East Kootenay or Hat Creek areas.

In 1974 Dolmage, Campbell and Associates inventoried the coal reserves and resources in British Columbia. Their report, entitled "Coal Resources of British Columbia", issued in April 1975, summarized the provincial coal reserves.[3] The study detailed all major provincial reserves and emphasized those on Vancouver Island as well as the vast thermal coal deposits in the Hat Creek and East Kootenay areas. The report indicated that the Hat Creek and East Kootenay deposits had sufficient proven reserves to supply a 2000 MW steam electric generating station for 35 years.

In 1974 B.C. Hydro appointed a task force to evaluate the alternative generation projects and energy resources in terms of their economics, the provincial energy demand and the environment. The task force published its findings in May 1975 in a report entitled "Alternatives - 1975-1990".[4] The authors were cognizant that economic and environmental realities constrained new hydroelectric generation sites to Revelstoke on the Columbia River and to further development of the Peace River. Based upon this analysis they recommended a programme of electric energy development through and beyond 1990.

The task force recommended a mixed programme of gas turbine units for Vancouver Island, installation of 2700 MW at Revelstoke, two coal-fired thermal plants, the McGregor and Kootenay diversions, and a system of peaking units at G.M. Shrum, Mica, Revelstoke and Seven Mile to satisfy the diverse provincial power needs. A coal-fired thermal-electric project burning Hat Creek coal was identified as the overall most economic source of energy after Revelstoke. The report concluded that a programme "...include the development of coal-fired thermal power at Hat Creek as being the most economic way of generating power to meet the electric load growth in the province from 1986 to 1990, based upon information available". Because of this analysis and the strength of the recommendations by the task force, B.C. Hydro investigated a Hat Creek coal-fired thermal-electric station in detail.

B.C. Hydro realized that if the power needs could be satisfied by the first major coal-fired thermal plant in the province, it would evoke concern for protection of the environment. To assess the environmental feasibility of a Hat Creek coal-fired generating station, B.C. Hydro prepared terms of reference for a preliminary environmental impact study.

5.1 THE POWERPLANT - (Cont'd)

In July 1974, B.C. Hydro authorized two groups, B.C. Research and Dolmage, Campbell and Associates, to conduct a preliminary environmental impact study of the proposed 2000 MW Hat Creek power development. The preliminary impact report, completed in August 1975, presented the combined environmental effects of construction and operation of a powerplant located at, or in the vicinity of, the Hat Creek coal deposit.[5] Although the study reported several important environmental concerns, it made no preferred site recommendations. To complete this task, B.C. Hydro commissioned Integ-Ebasco to conduct conceptual design and site evaluation studies.

The Site Evaluation Report, issued in October 1976, identified a site at Harry Lake in Hat Creek Valley as the best location for a coal-fired power station burning Hat Creek coal.[6] The recommended mine mouth site was based upon economic and environmental considerations. Upon completion of the site evaluation study, B.C. Hydro released terms of reference for a 6-month detailed environmental study of the region around Harry Lake. The terms of reference, prepared in accordance with the Coal Development Guidelines, addressed the ecological, socio-economic, meteorological and hydrological facets common to major thermal power development projects.

An analysis of the preliminary results from these studies, and in particular of the ambient air quality and socio-economic effects, compelled the decision within B.C. Hydro that the resource inventory component of the environmental studies extend over one full calendar year. Several topics were also enumerated which, because of their sensitivity, warranted separate study efforts. For example, the Thompson River water intake, the bulk sample programme and studies of the native Indian people each required more treatment than was anticipated at the outset of the studies. As a result, B.C. Hydro broadened the terms of reference to include these special studies, as well as to extend the study period. These early decisions increased both the scope and detail of the project impact assessment.

5.2 THE COAL MINE

The record of Hat Creek coal began when prospective deposits from Hat Creek Valley in central British Columbia were reported in 1877 and 1894 by G.M. Dawson of the Geological Survey of Canada. Exploration of the deposit centered on Hat Creek, where bank erosion exposed coal from the No. 1 deposit. By 1925, three shallow shafts, two short adits and seven drill holes were driven along the creek. Proximate analyses were also obtained on 24 mine samples and 32 drill samples. No further work on the deposit occurred until 1933.[6]

Small scale commercial exploitation of the No. 1 deposit began in 1933. Between 1933 and 1942 a few hundred tonnes of coal per year were produced for sale to local towns and villages. Production ceased in 1942 and no work resumed until 1957 when the property was optioned by Western Development and Power, Limited, a subsidiary of B.C. Electric Company, Limited. At that time one Crown Grant claim was explored extensively by surface diamond drilling. Between 1957 and 1959, 165 proximate analyses were obtained from the drill cores.

Ownership of the one explored Crown Grant claim and two coal licenses on the Hat Creek coal property was transferred to B.C. Hydro when B.C. Hydro was incorporated. Exploration on the property ceased until mid-1974 when B.C. Hydro and Power Authority began definitive drilling of the known deposit.

5.2 THE COAL MINE - (Cont'd)

In 1974, B.C. Hydro acquired coal licenses for most of the upper Hat Creek Valley. Reconnaissance drilling, conducted under the auspices of B.C. Hydro, revealed two coal deposits: the No. 1 deposit at the site of the proposed open pit, and the No. 2 deposit south of Anderson Creek. The former deposit contains estimated reserves of 825 Mt of sub-bituminous coal and the latter 3.1 Gt of coal.

Definitive geological and geotechnical work on the No. 1 deposit continued through 1978 in an effort to refine the knowledge of the Hat Creek No. 1 deposit. Such knowledge is a fundamental prerequisite to the development of an efficient mine plan prior to the initiation of mine preproduction work.

PART ONE

REFERENCES

CHAPTER 4.0 - ENVIRONMENTAL IMPACT ASSESSMENT REPORT FORMAT

1. B.C. Hydro and Power Authority. 1977. Hat Creek Mining Project Engineering Description for Environmental Report. Unpublished. Vancouver, B.C. 59 p.

2. B.C. Hydro and Power Authority. 1977. Hat Creek Project Descriptions, Offsite Facilities. Unpublished. Vancouver, B.C.

3. Integ-Ebasco. 1977. Hat Creek Project Powerplant Description, Revision F. Unpublished. B.C. Hydro and Power Authority. Vancouver, B.C. 70 p.

CHAPTER 5.0 - PROJECT HISTORY

Section 5.1 - The Powerplant

1. B.C. Energy Board. 1971. Electric Power Requirements in British Columbia Projection to 1990. Victoria, British Columbia. 17 p.

2. Monenco Consultants Pacific Ltd. 1972. Report on Electrical Energy Resources and Future Power Supply. British Columbia, 1972-1990. B.C. Energy Board, British Columbia. 36 p.

3. Dolmage, Campbell and Associates, Limited. 1975. Coal Resources of British Columbia. Unpublished. B.C. Hydro and Power Authority. Vancouver, B.C.

4. B.C. Hydro and Power Authority. 1975. Alternatives 1975 to 1990 - Report of the Task Force on Future Generation and Transmission Requirements. Unpublished. Vancouver, B.C. 193 p.

5. Dolmage, Campbell and Associates, Limited and B.C. Research. 1975. Preliminary Environmental Impact Study of the Proposed Hat Creek Development. Published. B.C. Hydro and Power Authority. Vancouver, B.C. 183 p.

6. Integ-Ebasco. 1976. Hat Creek Site Evaluation Study. Unpublished. B.C. Hydro and Power Authority. Vancouver, B.C. 59 p.

PART TWO

DESCRIPTION OF THE HAT CREEK PROJECT

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CHAPTER 1.0 - INTRODUCTION

Part Two of the EIAR presents engineering descriptions of the major project components and alternatives for the mine, powerplant and offsite facilities. Each description was prepared especially for the EIAR and presents engineering details which would have environmental relevance should the project proceed. Because ongoing engineering studies could revise the various systems as knowledge of the project increases, it is likely that changes in the final configuration of project facilities would occur. One objective of the detailed design phase would be to refine each of the selected systems so that environmental impacts identified in the detailed environmental studies could be minimized further.

Chapters 2.0, 3.0 and 4.0 of this Part provide summary descriptions of the powerplant, the mine and the offsite systems associated with the project. The general arrangements of powerplant, mine and offsite facilities are shown in Figs. 1.0-1 and 1.0-2.

CHAPTER 2.0 - POWERPLANT

2.1 GENERAL

The Hat Creek powerplant would utilize coal mined from the Hat Creek open pit and convert the thermal energy into electrical energy to be fed into B.C. Hydro's electrical grid system. The plant site is located about 4 km east of the mine head on a broad hilltop at an elevation of about 1410 m. The description of the plant in this chapter is summarized from a report by B.C. Hydro's engineering consultant.[1]

The powerplant is rated at approximately 2000 MW (net) from four 500 MW units. Each unit would be designed to generate 560 MW gross of which 60 MW would be used for auxiliaries. The first unit would commence commercial operation in January 1986. It is expected to operate at base load for extended periods and, in later years, in a two-shift or intermediate mode with weekend shutdowns. Over the 35-year nominal plant life, the station capacity factor is expected to average 65 percent.

Major features of the powerplant relate to circulating water, coal handling, air quality control, water treatment and ash handling systems. These systems were designed to provide reliable service to the plant and to assure protection of the environment.

The plant is designed to minimize makeup water requirements and to maximize reuse and recycle of water such that waste liquids are not discharged to the surrounding areas. Liquid wastes emanating from plant processes either will be treated or directly reused to convey ash to the disposal areas. The technical details of the powerplant are summarized in Table 2.1-1.

2.2 MAKEUP WATER SUPPLY SYSTEM

Makeup water would be obtained from the Thompson River, pumped approximately 23 km to the plant through an 80 cm diameter pipe, and stored in an $8.3 \times 10^6 m^3$ reservoir near the plant. The river intake and pipeline are classified as offsite systems and are described in Part Two, Chapter 4.0, "The Offsite Systems."

2.3 CIRCULATING WATER SYSTEM

A circulating water system, comprised of cooling towers and steam condensers will be provided to dissipate waste heat from the steam cycle. This system has been designed as a closed cycle with recycling of water to both minimize makeup water requirements and avoid the discharge of liquid effluent to the environment. The intake and water reservoir are described in Section 2.10 of this chapter.

2.3.1 Condenser

The low pressure steam which leaves the steam turbines will be converted to the liquid phase in the condenser. A cooling tower system economic optimization study, including transverse condenser selection, was performed. Based on the results, a 304 stainless steel dual pressure, divided water-box type condenser, with a cooling water flow rate of 8957 L/s is contemplated for each of the proposed units. This cooling water would be recirculated through the cooling towers, with makeup provided from the storage reservoir.

2.3.2 Cooling Towers

Two 116.4 m natural draft hyperbolic cooling towers are proposed for the Hat Creek powerplant. Selection of these towers is the result of an optimization study carried out on several types of cooling tower systems. Normally each tower would serve two units. Condenser cooling water cascades through the tower, where a portion is evaporated and the remainder cooled. The hyperbolic shape of the cooling tower shell and the convection effect as the air is heated induces the air flow through the tower.

In wet cooling towers, only a minor part of the overall cooling effect is by direct heat transfer from warm water to cool air. The major part results from the evaporation of the water. At full load (2000 MW net) and at the cooling tower design conditions of 13.9^{o}C ambient wet bulb temperature, the estimated quantity of water evaporated will be 1.11 m^3/s.

Because of the evaporation losses, the circulating water in the system steadily increases in dissolved solids. To control the dissolved solids concentration, water will be "blown down" from the cooling tower sumps. The cooling towers are expected to operate at approximately 11-14 cycles of concentration to maintain a water balance for the plant. Water from the reservoir will be added to the system to make up for the evaporation, drift and blowdown losses.

Effective drift eliminators can reduce the drift loss in natural draft towers to less than 0.008 percent of the circulating water flow rate. This compares to the evaporation loss of approximately 2.75 percent. Blowdown from the towers would be used in other plant systems to ensure that no liquids are discharged from the plant. Auxiliary equipment would also reject heat to the circulating water system via direct coolers. Spent auxiliary cooling water would be pumped to the cooling tower and used as cooling tower makeup.

2.4 COAL HANDLING SYSTEM

The coal handling systems are designed to process coal, waste rock and overburden from the mine. Primary and secondary powerplant coals would be segregated from solid waste and low grade coal prior to transport overland to the plant. The conveyors would discharge the coal into a surge bin to provide short-term storage of coal delivered to the plant.

From feeders at the bottom of the bin the coal would be conveyed by a system of belt conveyors to the top of the coal silos in the boilerhouse. The conveyor belts would be of fire-resistant material and a fire protection system of the water sprinkler type would be incorporated to protect the system.

Coal dust would be the only potential emission from the system. At transfer points it could rise with the disturbed air and escape the enclosure if controls were not provided. Therefore, all transfer points would be enclosed and a dust control system, consisting of a centralized vacuum system and an automatic baghouse, would remove dust laden air at each transfer point and convey it to the baghouse through ducting. Dust would be separated in the bag house by filter cloth selected to assure that air vented from the vacuum exhausters would meet the Pollution Control Branch emission objectives of 229 mg/m^3.

Additional descriptions of coal mining, transportation and storage are provided in Chapter 3.0, "The Mine".

2.5 AIR QUALITY CONTROL SYSTEMS

The characteristics of the fuel are primary determinants in the selection of air quality control systems (AQCS). The Hat Creek No. 1 Deposit has been classified as sub-bituminous, averaging approximately 13 900 kJ/kg for run-of-mine coal, at 28 percent ash and 20 percent moisture. The heating value of the blended coal delivered to the plant is expected to range from 12 795 to 16 982 kJ/kg. The ash content would range from 32 to 20 percent.

The sulphur content would range from 0.45 to 0.42 percent on a wet basis. This range of sulphur levels would result from coal preparation and blending for consistent heating values. A supply of low sulphur coal (0.21 percent) would also be available if a meteorological control system (MCS) is used to meet ambient sulphur dioxide guidelines.

The following paragraphs describe the systems (or alternatives) which have been selected, based on the above fuel characteristics, to control contaminant emissions and resulting ambient air quality contaminant concentrations.

2.5.1 Particulates

Electrostatic precipitators located behind the air preheaters are proposed to control particulate emissions. These would have an efficiency of 99.5 percent, for conservative coal characteristics, to meet the particulate emission objectives proposed by B.C. Hydro to the Pollution Control Branch.[1]

Electrostatic precipitators remove particulates by the following steps:

1. Transmitting an electrical charge to the suspended particulate matter.

2. Collecting the charged particles on a grounded surface.

3. Removing the collected matter from the grounded surface by means of a rapping and conveying system.

In order to facilitate maintenance and enhance reliability, the precipitator would consist of separate sections in parallel, each section receiving a percentage of the gas flow. Multiple power supplies and fields would be used to minimize the effects of equipment failure.

2.5 AIR QUALITY CONTROL SYSTEMS - (Cont'd)

2.5.2 Oxides of Nitrogen (NO_x)

Nitrogen compounds in coal and the diatomic nitrogen in combustion air are the source of oxides of nitrogen (NO_x) emitted during combustion. These are principally nitric oxide (NO) and secondarily nitrogen dioxide (NO_2). The principal factors controlling the production of NO_2 during coal combustion are flame temperature, amount of excess combustion air and furnace residence time.

Modern boiler burner-windbox designs are arranged to provide minimum air to the primary ignition and combustion zone. The remainder of the combustion air is added via separate air-only ports and mixed with the fuel within the furnace to cause complete combustion before the furnace exit. Design provisions such as these reduce excess air, flame temperature and residence time to a minimum.

For actual operating conditions, with 30 percent excess air at the air heater outlet, NO_x emissions should be well below the B.C. Hydro recommendations to the PCB,[1] and possibly as low as 380 to 480 mg/m^3, depending upon the design of the boiler.

2.5.3 Carbon Monoxide and Hydrocarbons

Carbon monoxide and hydrocarbons occur in flue gas as a result of incomplete combustion. As is the case for control of oxides of nitrogen, control of carbon monoxide and hydrocarbon emissions is accomplished through proper furnace design. It is expected that these contaminants will only be emitted from the stack in trace quantities. However, for purposes of environmental impact assessment, carbon monoxide and hydrocarbon emissions have been calculated on the basis of .05 percent and .015 percent by weight of coal, respectively.

2.5.4 Sulphur Dioxide (SO_2)

Several alternative systems (stack height - AQCS combinations) for the control of sulphur dioxide (SO_2) were under consideration at the time of writing. Analyses conducted early in the environmental studies by the meteorology/air quality subconsultants, Environmental Research & Technology, Inc. (ERT),[2] indicated the need for a stack height in the range of 244 m to 366 m (assuming a single stack with four flues, and depending on the extent of additional control measures) to meet ambient SO_2 guideline levels proposed by B.C. Hydro to the Pollution Control Branch.[1] The additional control measures under consideration include a meteorological control system (MCS), which would control SO_2 emissions on an intermittent basis in response to adverse meteorological conditions, and flue gas desulphurization (FGD), which would control SO_2 emissions continuously. Three of the most likely combinations of stack height and control systems were studied in detail by ERT. These are:

1. MCS with a 244 m stack.

2. MCS with 366 m stack.

3. FGD with 366 m stack.

The following paragraphs describe the MCS and FGD alternative systems for controlling SO_2.

2.5 AIR QUALITY CONTROL SYSTEMS - (Cont'd)

(a) Meteorological Control System (MCS)

An MCS is a systematic plan of defined procedures for reducing contaminant emissions to the atmosphere when predicted or observed meteorological conditions are conducive to high ground-level ambient concentrations. Such control strategies may assume many operational forms; both load reduction and fuel switching programmes have been evaluated quantitatively by ERT for this study.

An MCS normally consists of:

1. A real-time, meteorological and ambient air quality monitoring network.

2. A forecasting staff with the facilities and equipment for producing real-time, local-scale meteorological predictions.

3. A computer-based air quality prediction model.

4. The ability to effect the necessary emission curtailments so as to maintain ground-level ambient concentrations at acceptable levels.

The MCS being considered for Hat Creek would include each of these components. The emission control procedure that is expected to be utilized would be a combination of both load reduction and fuel switching. Which procedure is utilized would be determined by seasonal load demand variations and the degree of emission reduction required. It has been assumed that lower-sulphur coal, with average sulphur content of 0.21 percent and a mean heating value of 17 587 kJ/kg, would be stockpiled for use during periods of adverse dispersion potential in the winter months (November through February). During the remaining months of the year, uniform load reduction of all generating units has been assumed to be the preferred control measure for reducing ground-level concentrations.

MCS operational requirements for the Hat Creek Project include the capability to predict ambient SO_2 concentrations during the fuel switching mode at least 8 1/2 hours in advance; moreover, it has been assumed that a fuel switch, once enacted, will be maintained for at least 3 hours (the minimum averaging time corresponding to control action requirements). Load reduction procedures to decrease emissions by a given amount can normally be implemented much more rapidly than an equivalent fuel switch, since the latter involves delays associated with physically providing the secondary fuel to the boilers. Thus, for MCS applications involving load reduction, forecast lead-time requirements are less critical.

For either mode of MCS operation, a plume transport lag time is inevitable. That is, a change in emission strength at the source would not begin to affect ambient concentrations at a specific downwind point until a certain time interval has elapsed. The duration of this interval depends upon wind speed. This lag time, together with the emission response lag time, would be taken into account in the operational MCS air quality forecasting procedures.

With the MCS control option, the SO_2 emission rate and other stack parameters would, of course, depend on whether the plant was operating with uncontrolled emissions or being controlled by fuel switching or load reduction. During the fuel switching mode, SO_2 stack emissions are expected to be reduced to 5262 kg/h (39 percent of the uncontrolled rate with the primary fuel), at a temperature of 149°C and flow rate of 238 384 m^3/min. With load reduction, SO_2 emission reductions are nearly directly proportional to the reduction in load. At 80 percent load, for example, the expected SO_2 emission rate is 10 953 kg/h (81 percent of the uncontrolled rate), at a temperature of 139°C and a flow rate of 212 090 m^3/min.

(b) Flue Gas Desulphurization (FGD)

An FGD system, as an alternative, would reduce the flue gas emissions. SO_2 emissions from the stack would not exceed 300 ppm (dry) by volume. Thus, ambient air quality would remain within the proposed objectives when burning Hat Creek coal in the powerplant boilers. In order to achieve this level of ambient SO_2 concentration, 60 percent of the flue gas would have to be treated. The treated flue gas would be reheated by mixing it with the untreated portions of the flue gas before entering the stack. As a result of mixing, the temperature of the flue gas flowing through the stack would be above the flue gas dew point and the stack would be operating under "dry" conditions. Also, the degree of reheating achieved by the mixing of treated and untreated portions of the flue gas would provide desirable plume rise characteristics.

The FGD system would consist of two wet SO_2 absorber towers per unit operating at a 90 percent removal efficiency. The flue gas would initially enter the gas cleaning towers downstream of the electrostatic precipitators and the boiler induced draft (ID) fans. Depending on the selection of equipment, additional booster fans could be required in series with the ID fans. The fans would discharge 60 percent of the flue gas into the operating absorbers where SO_2 would be removed utilizing a reactant slurry of pulverized limestone. The untreated portion of the flue gas would flow through a bypass duct and mix with the treated gas downstream of the absorber mist eliminators.

A third stand-by absorber tower would be provided for each unit to improve the FGD system availability and to facilitate full capacity operation. Periodic maintenance on the non-operating module could be conducted at any time without adversely affecting the particulate collection or the performance of the FGD system.

Pulverized limestone slurry would be continually fed into the SO_2 absorption system by a wet ball mill and slurry preparation equipment. The calcium carbonate in the limestone slurry would chemically react with the SO_2 in the absorber to form calcium sulphites and calcium sulphates. The spent slurry containing these products and any excess limestone would continually discharge to a thickener for concentration. The concentrated thickener underflow would be ultimately disposed of in a waste sludge disposal area. Water from the thickener would be returned for use in the slurry system.

The quantity of SO_2 to be discharged from the stack after scrubbing is calculated to be 6259 kg/h (approximately 46 percent of the uncontrolled rate). Flue gas from the scrubbers is expected to have a temperature of 82°C and a flow rate of 262 189 m^3/min.

2.6 WATER TREATMENT SYSTEM

2.6.1 General

The water treatment system includes boiler feedwater treatment designed to provide demineralized water for steam cycle makeup and sootblowing. The water treatment system also provides potable water, and makeup and cooling water for the air conditioning system. Makeup water will come from the reservoir located on the site.

2.6.2 Boiler Feedwater Treatment System

A schematic diagram of the plant's water treatment system is given in Fig. 2.6-1. The design continuous demand for the total water treatment system is approximately 57 L/s.

The treatment of the feedwater cycle makeup at the plant consists of pretreatment and demineralization. Pretreatment removes suspended particulate matter, residual organics and a large portion of the colloidal silica. The pretreatment stage consists of chlorination, coagulation/clarification, filtration and activated carbon filtration.

Following pretreatment, demineralization would remove dissolved solids and ultrafiltration (if required) would remove colloidal silica. The demineralization system would consist of cation exchange, degasification, anion exchange, ultrafiltration and mixed bed demineralization. The entire system for four units would consist of three parallel 50 percent duty trains producing 49.2 L/s of demineralized water.

Operation of the water treatment system would generate a number of wastewaters associated with both the pretreatment and demineralization stages. In the coagulation/clarification process, suspended solids originally contained in the makeup water settle to the bottom of the clarifiers to form sludge. It is estimated that 0.4 L/s of sludge at a 1 percent suspended solids content would be generated daily.

The demineralizer system requires regeneration of the spent exchanger resins. The strong acid cation exchangers would be regenerated once a day, typically utilizing a sulphuric acid solution. The anion exchangers would also be regenerated once a day, typically utilizing a sodium hydroxide solution. Regeneration of the mixed bed polishing demineralizer would occur approximately once every 4 days. The entire station regeneration process would produce a combined wastewater output of approximately 288 m^3/d, which is usually acidic in nature.

The ultrafiltration unit would be backwashed daily. In addition, there would be a continuous discharge of concentrate from this unit. The concentrate and backwash wastewater flow rate is estimated to be 2.6 L/s on an average daily basis.

Demineralizer regeneration wastewater would be conveyed to an equalization/neutralization treatment system for the adjustment of pH to a neutralized range. The ultrafiltration concentrate and backwash water would be recycled to the system at the inlet of the clarifiers.

2.6 WATER TREATMENT SYSTEM - (Cont'd)

2.6.3 Condensate Polisher

A condensate polishing demineralizer design presently being considered consists of two 50 percent capacity mixed bed units for each generating unit. Since the polishing units would be mainly required during and shortly after unit start-up, the duty cycle will allow ample time for regeneration, and therefore no standby capacity will be needed. One of the 50 percent units can be operated to give side-stream polishing during normal operation of the boiler and turbine or during recycling to the hot-well during a unit outage.

The operation of the condensate polishing demineralizer also requires regeneration of the spent exchanger resins. These resins are regenerated on an infrequent basis corresponding to the usage of the unit.

2.7 ASH HANDLING AND DISPOSAL SYSTEM

Ash will be of two major types:

1. Bottom Ash/Slag - combustion products dropped out of the furnace in either dry or molten state, and collected in water impounded hoppers.

2. Fly Ash - fine particles that leave the furnace with the flue gas and are trapped by electrostatic precipitators.

In addition, there would be small quantities of mill rejects which may consist of a variety of coarse, heavy pieces of stone, slate and iron pyrites in dry form. Mill rejects would be rejected by the pulverizers in the course of grinding the coal.

Small quantities of fly ash would be collected in hoppers at points of change in the direction of the flue gas stream such as the economizer and air heater outlets. Economizer ash would consist of coarser particles that would be handled either by the bottom ash disposal system or by the fly ash removal system. The manner of handling economizer ash would depend on the ash system design and its manufacturer. Ash collected in the air heater outlet hoppers would be considered as part of fly ash and would be handled by the same system that removes fly ash from precipitator hoppers.

Mill rejects and pyrites removal and disposal would be incorporated into the bottom ash handling and disposal system. The quantity of mill rejects and pyrites is a function of the type of coal and of the mill construction. It is expected for Hat Creek coal to be approximately 0.5 percent of the firing rate.

2.7.1 Quantities of Ash

The total quantity of boiler solid refuse to be generated is a function of ash content of the coal and the steam generator coal firing rate. For a complete discussion of the ash content in each designated coal type, see Chapter 3.0, "The Mine".

2.7 ASH HANDLING AND DISPOSAL SYSTEM - (Cont'd)

(a) Average Ash Production

The ash production corresponding to the average station load factor and station life (65 percent over 35 years of life), burning "typical coal" and a gross turbine-generator output of 560 MW will be as follows:

6057 t/d for the station*

77.4×10^6 t for the station over its life**

(b) Bottom Ash - Fly Ash Percentage

The proportions of the total ash generated as bottom ash or fly ash cannot be predicted accurately at this time since they are dependent on the ash properties of the coal and boiler design. Experience at the Centralia Generating Station in the State of Washington shows that at times as much as 45 percent of the ash is produced as bottom ash. The balance is carried from the steam generator as fly ash. The average at Centralia is approximately 25 percent bottom ash and 75 percent fly ash. Further testing of the Hat Creek coal and its ash characteristics would establish the ratio more accurately for this project.

Presently the following ranges are being considered:

Bottom Ash:	15% to 45% of total ash
Fly Ash:	85% to 55% of total ash

When these proportions are applied to the maximum and average ash production rates, the following ranges of production rates result:

		Max. Production kg/s/unit***	Average kg/s/unit****	Production over 35 year life at 65% capacity factor, tonnes per four units
Bottom Ash	at 15%	6.06	4.06	11.6×10^6
	at 45%	18.18	12.15	34.8×10^6
Fly Ash	at 85%	34.34	22.93	65.8×10^6
	at 55%	22.22	14.84	42.6×10^6

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* Used to determine average equipment and operating labour requirements for ultimate ash disposal, particularly for dry disposal.

** Used to determine total ash disposal area requirements.

*** Based on worst acceptable coal and maximum steam generator design rating of 488 kg/s.

**** Based on guaranteed turbine generator rating (560 MW) and "typical coal".

2.7 ASH HANDLING AND DISPOSAL SYSTEM - (Cont'd)

To provide margins for the variance in the percentages of bottom ash and fly ash, the plant bottom ash handling system is designed to handle up to 45 percent bottom ash, and the fly ash system is designed to handle up to 85 percent fly ash.

2.7.2 Steam Generator Ash Disposal System

Bottom ash would be removed hydraulically from the water filled hoppers beneath the furnaces by water ejectors or centrifugal pumps. The ash and water would be piped by gravity to the ultimate disposal area at upper Medicine Creek. Mill rejects and pyrites would be removed from their hopper and piped with the bottom ash. Fly ash would be collected dry in hoppers, and would be pneumatically removed and mixed with water for conveyance as a slurry under gravity to the upper Medicine Creek disposal site.

2.7.3 Ash Water

(a) Recirculation

In this "wet" ash disposal scheme the bottom ash slurry would be 15-30 percent solids by weight. Recirculation of transport water from the disposal site would be necessary to conserve water. Average fly ash slurry concentrations greater than 40 percent would be required to avoid the necessity of recirculating transport water. Although this appears feasible, present information indicates that to avoid potential scaling problems a 20 percent slurry concentration would be optimum.

The total return flow of ash transport water from the upper Medicine Creek pond has been estimated to be approximately 223 L/s for an ash slurry concentration of 20 percent for both bottom ash and fly ash, for typical coal and a plant capacity factor of 65 percent.

(b) Water Retained with the Ash

In a flooded ash disposal site the ash would contain two parts water to one part ash by volume. These disposal volumes were calculated on 801 kg/m^3 bulk density, or 0.82:1 by weight, and the ratios were applied to the average ash production rates given previously.

2.7.4 Upper Medicine Creek Ash Disposal Site

The entire volume of ash produced by the plant would be conveyed to an ash disposal site in upper Medicine Creek (UMC) Valley. The UMC disposal area would be developed behind a retaining dam and the site would have a storage capacity of approximately 133.5 Mm^3 at a maximum depth of approximately 100 m.

Preliminary results from a test boring programme indicate that fairly continuous, impermeable rock strata underlie this area. The bedrock is comprised of limestone, altered sedimentary rocks, volcanic rocks and low permeability sedimentary rock. All units, with the exception of the volcanic rocks, have hydraulic conductivities of less than 10^{-8} cm/s. Therefore, the impermeability of the rock would obviate the need for an artificial liner to protect groundwater resources from contamination.

2.8 PLANT WATER BALANCE

Because the powerplant would be operated in a "no liquid discharge" mode, the water balance equates plant makeup flows with plant consumptive flows.[1] The objective of the water balance is to reuse and recycle all discharges produced by those systems to which Thompson River water is provided. The plant water balance involves only plant process waters and rainfall runoff from material storage areas. Uncontaminated plant site runoff would be discharged directly to local creeks.

2.8.1 Systems Makeup

Plant water systems can be divided into primary and secondary water use systems. The distinction is based on the required makeup water quality. Primary water use systems require good quality water, such as treated or untreated Thompson River water, for their efficient and economical operation. These systems would mainly include the circulating condenser cooling water system, the makeup demineralizer system and the potable water supply system. The secondary water use systems can utilize inferior quality water such as blowdown from the primary water use systems. Typically, plant secondary water use systems could include the bottom and fly ash transport systems, and a flue gas desulphurization system.

Condenser cooling water is the largest water use system in the plant. It requires continuous makeup to replenish water lost to evaporation and drift in the cooling tower and to replace the blowdown that is required to maintain water quality parameters within desirable limits. Under the design meteorological conditions of 13.9°C and 60 percent humidity, the tower would evaporate approximately 1098 L/s. Drift is estimated at 3.3 L/s.

Based on cooling tower operation at approximately 14 cycles of concentration, the cooling water system would require makeup flows of approximately 1157 L/s under design meteorological conditions, at rated output and 100 percent capacity factor. Over the life of the plant, an average capacity factor of 65 percent is anticipated. Assuming this, the average annual water consumption would be approximately 621.3 L/s. This would require a makeup flow of approximately 647 L/s.

In addition to the cooling water system, makeup from the Thompson River is required for steam cycle makeup, soot blowing, domestic water supply and the service water system.

2.8.2 Systems Blowdown

The blowdown from the cooling water system would essentially be Thompson River water that has been concentrated approximately 14 times. The quantity of blowdown during maximum rated plant output and design meteorological conditions would be approximately 83 L/s. On an average annual basis, the blowdown would be approximately 50 L/s.

Blowdown rates from other primary water use systems have been estimated as follows:

Demineralizer Regeneration Wastewater		5.0 L/s
Sanitary Wastewater		0.6 L/s
Heating, Ventilating and Air Conditioning		0.2 L/s
Floor Drainage		6.3 L/s
	Total	12.1 L/s

2.8 PLANT WATER BALANCE - (Cont'd)

Water balances for the preferred ash handling schemes are shown in Figs. 2.8-1 and 2.8-2. On these water balances bottom ash and fly ash are both sluiced in a 20 percent slurry concentration.

In order to achieve no liquid discharge, the total blowdown produced by the primary water use systems would be consumed by the secondary water use systems. The main water management technique involved in this scheme is the operation of a closed loop ash sluicing system. Cooling tower blowdown was varied until the total of primary water use system blowdowns was equal to the ash handling system requirements, consisting of ash pond evaporation, water entrained (unavailable for reuse) within the settled ash, and boiler ash hopper evaporation. Recycling ash sluice water causes the chemical constituents leached from the ash to concentrate, thereby increasing sluice water dissolved solids. The return ash sluice water would be treated in a single-stage, lime-soda ash water softening system to maintain calcium and magnesium concentrations below levels which could cause scaling problems.

2.9 SOUND ATTENUATING SYSTEMS

The Hat Creek plant would be designed to meet the in-plant requirements for personnel protection[1] and also to minimize the environmental impact in the nearby residential areas. Primary emphasis would be placed on noise control at the source by using attenuating devices such as acoustic enclosures, silencers and logging. Hearing protective devices would be used by the in-plant personnel only in areas where noise reduction cannot be achieved by feasible engineering methods.

The noise control programme would be carried out during the design stages of the station. It would include both in-site acoustical design such as boiler feed pump enclosures and sound control requirements as part of equipment specifications.

2.10 WATER RESERVOIR

The reservoir would provide surge capacity for the makeup water requirements of the powerplant. The water would be impounded by an earth fill dam approximately 48.8 m high. Overflow is not expected. However, a spillway would direct overflow to the Medicine Creek and runoff diversion ditches if it occurred. The water would flow into the UMC ash disposal area if the overflow exceeded the capacities of these ditches.

Pumps at the reservoir would provide makeup to the cooling towers. The suction pipes would be arranged such that the pumps could operate with the reservoir water level at its minimum and also during freezing conditions.

2.11 YARD DRAINAGE

A system of yard and area drains separate from the plant floor drainage system would be installed at the site to collect, convey and dispose of storm water offsite. It is proposed to convey runoff collected in the plant area into a 1.5 m deep retention pond of approximately 1730 m^3 capacity. This is sufficient to contain the rainfall intensity equivalent to approximately 2 hours duration based

2.11 YARD DRAINAGE - (Cont'd)

upon a return period of 10 years. The pond would drain in an open, grassed ditch to the makeup water reservoir.

2.12 COAL PILE DRAINAGE

If an emergency coal pile is located within the plant boundaries, drainage from the coal pile would be kept separate from the yard drainage system. Runoff from the coal pile would be conveyed to the return ash sluice water treatment system for treatment and reuse.

2.13 SANITARY WASTEWATER

Wastewater from the potable water system would be treated by a package type extended aeration treatment plant. It is expected that this form of treatment could remove 85 percent of the influent biochemical oxygen demand (BOD) and suspended solids. The average daily sanitary wastewater flow is expected to be approximately 0.6 L/s and would be reused in the ash transport system.

2.14 FLOOR DRAINAGE

Plant floor drainage consists of normal maintenance washdowns, equipment drains, abnormal liquid discharges and washdown from areas for servicing equipment that uses lubricants in its function or process. These wastewaters would be collected in a separate drainage system and conveyed to the plant oil/water separator. This oil/water treatment facility would typically consist of a prefabricated unit. Effluent from this system would be reused in the ash transport system.

CHAPTER 3.0 - MINE

3.1 GENERAL

B.C. Hydro holds 650 ha of coal license and Crown grant land in the upper Hat Creek Valley. The No. 1 and No. 2 coal deposits are known to contain in excess of 1 Gt of coal within the conceptual open pits planned for 185 m depths. The coal is classified as sub-bituminous C, averaging approximately 13 900 kJ/kg for run of the mine at 28 percent ash and 20 percent moisture. It is proposed to mine the No. 1 deposit by open pit methods, using trucks, shovels and conveyors, to recover 320 Mt of coal at a production rate sufficient to supply the Hat Creek powerplant.

The description of the mine in this chapter is summarized from a mine project description.[1] The topics described are:

1. Coal preparation and handling.

2. Waste handling.

3. Water use.

The location of the mine in relation to other project facilities is shown in Fig. 1.0-1. The total area disturbed at completion of mining would be 757 ha for the open pit and 263 ha for the waste dumps and associated areas.

As the mine is opened and expanded, the land would be cleared of merchantable timber and topsoil would be removed and stored for later reclamation. Fig. 3.1-1 shows the location of topsoil suitable for reclamation. Before removal of wastes begins Hat Creek would be diverted around the east side of the proposed mine pit, and diversion ditches would be dug to prevent water from flowing into the pit from the west. The ditches would feed into lagoons to settle suspended solids before discharging the water to Hat Creek.

3.2 COAL PREPARATION AND HANDLING

3.2.1 Introduction

The following sequence of coal preparation and handling operations is proposed in transporting coal from the mine to the Hat Creek powerplant:

1. Conveyor transport out of mine pit.

2. Primary crushing.

3. Secondary crushing.

4. Coal stockpiling.

5. Coal reclaim and transport to the powerplant.

3.2.2 Conveyor Transport Out of Mine

Coal would be transferred to conveyors by shovel-loaded trucks at the mine. The trucks would dump the coal into hoppers which would be equipped with grizzlies to reduce coal size to about 60 cm or less. Three parallel conveyors are proposed with one conveyor usually handling coal, a second handling mine wastes (discussed in Section 3.3) and the third a spare. The spare would permit periodic maintenance, conveyor extension as the mine enlarges and repair of breakdowns without disrupting the transport of coal. The conveyors, in fixed installations, would have belt turnovers and deep troughing on the carrying side and troughing on the return side to minimize spillage. All fixed conveyors would be enclosed in removable enclosures large enough to permit maintenance personnel to carry out inspections inside, thus avoiding environmental problems due to dust and weather. The coal handling conveyor would carry the coal to the primary and secondary crushers.

3.2.3 Primary Crushing

The primary crusher would reduce the minus 60 cm to about minus 25 cm. A possible crusher for this duty is a Bradford breaker. The machine has the advantage that while it crushes the coal, it discharges large hard stones separately without crushing. It also rejects to a limited extent large lumps of clay.

3.2.4 Secondary Crushing

Secondary crushers would be required to reduce the minus 25 cm material produced by the primary crushers. Various types of secondary crushers such as hammer mills, Bradford breakers or others could be used. It is assumed that secondary crushing would take place prior to delivery to the stockpile, so that only "small" coal is stockpiled.

3.2.5 Stockpiling

The coal stockpile would serve to:

1. Provide short-term surge capacity to even out differences between mine output and powerplant requirements.

2. Guard against interruption in mine production to ensure continuous coal supply to the powerplant.

3. Carry out a blending function to provide a more consistent coal product to the powerplant.

The coal pile would be adequate to store about 900 000 t. The suggested layout of the coal stockpile area is shown on Fig. 3.1-1. The stockpile area would consist of four piles, each about 760 m long by 61 m wide by 15 m high.

In addition to normal coal storage, provision must be made for about 900 000 t of uncrushed coal produced during the initial development of the mine. This would be trucked, as neither the main conveyors nor the stocking area equipment are likely to be operational at this stage. It is proposed to store this coal immediately north of the permanent stockpile area. The coal in this area could then be gradually reclaimed or retained as an emergency stockpile. Finally, a separate low grade coal dump with capacity for about 46 Mt storage is planned. This coal would be considered unacceptable at the present time but might become usable in the future.

Spontaneous combustion would be avoided by stockpiling coal in a manner which would ensure that air is excluded to the maximum extent possible. Rainfall runoff from the stockpiles would be collected by a surrounding ditch, then diverted to a nearby lagoon (see Section 3.4.2).

3.2.6 Coal Reclaim and Transport to the Power Station

Coal recovered from the stockpile will be directed to a re-crusher to reduce any frozen lumps or accretions to the size acceptable to the powerplant. This unit could be comprised of a scalping screen and hammer mill. From the re-crusher the coal would be delivered by means of trunk conveyors to storage bunkers located in the boilerhouse. The bunkers are expected to hold enough coal to last approximately 12 hours.

3.3 WASTE HANDLING

3.3.1 Solid Wastes

Solid waste materials resulting from the coal mining activities would be removed from the mine for disposal. Solid wastes include:

1. Waste rock located above the coal, consisting of siltstones and clayey siltstones, frequently bentonitic or carbonaceous, with thin bands of volcanic tuff.

2. Interbedded materials consisting mainly of claystones and siltstones, some with swelling clays and iron carbonates.

3. Underlying strata consisting of siltstones, sandstones and conglomerates, some weakly cemented.

4. Surficial materials consisting of till, sand and gravel.

Table 3.3-1 summarizes the loose volume of these materials which would be dumped during each mining stage. A total volume of 840 Mm^3 would be produced during the life of the mine.

3.3.2 Spoil Disposal Areas

Three main spoil dump locations are proposed for storage of the wastes. These are shown on Fig. 3.1-1. Their volumetric capacities are listed in Table 3.3-2. Descriptions of the dump areas are presented below:

1. North Valley Dump - Nine million loose cubic metres of surficial material from the initial conveyor incline excavation prior to start of production would be dumped in the valley immediately to the

north of the conveyor incline. The coal blending and stocking area would be located on a portion of this dump site.

2. Medicine Creek Dump - This dump would store approximately 363 million loose cubic metres of material behind a retaining embankment constructed across the mouth of the valley. It is proposed to store free-draining surficial material here, although it would also be necessary to store 94 million loose cubic metres of pit and segregated waste material during the life of the mine. The dump is also sized to include ash from the powerplant, although present plans are to store the ash separately, as is described in Chapter 2.0.

3. Houth Meadows Dump - This dump would store approximately 467 million loose cubic metres of waste and surficial material in the Houth Meadows Valley behind a retaining embankment.

One of the three conveyors at the mine would transfer pit wastes to the dump areas. Initially, surficial waste would be removed by scrapers, discharging directly to the dump areas. When distances and the route make direct dumping uneconomical, the material would be fed to the conveyor at the mine for transfer to the dump areas.

3.4 WATER USE

3.4.1 Potable Water

It is assumed that the potable water supply would be from the powerplant (see Chapter 2.0). A 570 m^3 storage tank, and water supply pipeline from the powerplant to the mine, could be provided for this purpose.

3.4.2 Pit Dewatering and Rainfall Runoff

Wastewater from pit dewatering and from proposed dewatering activities for mine slope stability, and precipitation runoff from the waste dump and coal stockpile areas, would be directed to lagoons which would serve as sedimentation basins. Most of the water in the lagoons would be used for industrial purposes, including dust suppression and equipment washing. Any discharges of excess water would be into Hat Creek downstream of the pit after the water had been adequately treated.

3.4.3 Sanitary Wastes

A "package type extended aeration sewage treatment plant" would be provided to handle sanitary wastes from the construction camp, mine office and shops area during operation. The treatment process involves comminution, oxidation and possibly chlorination. Treated effluent would be directed to a collection pond for use as a water source for dust control. Sludge, along with solid waste refuse from the shop complex and garbage from the construction camp, is designated for a landfill area.

CHAPTER 4.0 - OFFSITE SYSTEMS

4.1 GENERAL

The offsite facilities are located outside of the mine and powerplant areas, and include the following:

1. Access road.
2. Makeup cooling water supply system.
3. Transmission lines.
4. Creek diversions.
5. Airstrip.
6. Construction camps.
7. Equipment offloading facilities.

The descriptions of the offsite facilities in this chapter are summarized from an offsite project description.[1] The project description emphasizes the preliminary nature of the engineering studies at the time of writing.

4.2 ACCESS ROAD

Access to the Hat Creek Project would be provided by a paved two-lane highway. The road would commence at Highway No. 1 (Trans-Canada Highway) near the Ashcroft Manor, and proceed up Cornwall and MacLaren Creeks and down 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 length would be about 31 km. The proposed route of the access road is shown on Figs. 4.2-1 and 4.2-2.

From Highway No. 1 the road would rise over 900 m to the summit near the powerplant, then drop approximately 600 m from the powerplant to the intersection at Highway No. 12. A short, nearly-level 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 the 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 coal handling area. The total area required for the road right-of-way would be 100 to 120 ha. Of the total area, approximately 70 to 80 ha is covered by forest. The right-of-way corridor would have a minimum width of 30 m, and a maximum width of about 100 m on sections requiring sidehill cuts or high fills. The alignment would make nine creek crossings. Of these, Cornwall, MacLaren, and Medicine Creeks are the most significant. All of these crossings would be made using culverts through the road embankments. Precautions would be taken during culvert installation to minimize disturbance to the creek bed, to maintain creek flows, and to avoid siltation and obstruction of fish passages.

The access road would join two provincial highways. Therefore it is likely that it would become part of the provincial highway system after construction of the Hat Creek Project has been completed. To ensure that the B. C. Department of Highways requirements would be satisfied, arrangements have been made for their participation in the route selection and for assistance with the preliminary design should the project proceed.

4.3 MAKEUP COOLING WATER SUPPLY SYSTEM

4.3.1 Introduction

The proposed water supply system for the Hat Creek Project would take in water from the Thompson River near its confluence with the Bonaparte River, and would pump the water approximately 23 km, with a lift of approximately 1100 m, to the powerplant reservoir in the Hat Creek Valley.

The supply scheme was determined from an evaluation of intake and location alternatives on the basis of economic, environmental and engineering factors. These factors included intake reliability, river quality, total cost and constructibility. The suitability of the intake type and location for river water withdrawal was critical in the development of the selected system. Key system parameters are presented below:

Maximum Flow Rate	1580 L/s
Elevation Difference	1100 m
Pipeline Length (along slope)	23 km
Pipe Diameter	800 mm
No. of Booster Pumping Stations	2
No. of Booster Pumps in Booster Station	5
Booster Pump Motor Power (each)	2600 kW

The maximum flow rate of 1580 L/s is based upon the four units in the powerplant each simultaneously operating at full load of 560 MW (gross) continuously. The actual pumping rate will vary according to powerplant load, and, with considerable makeup storage capacity in the powerplant reservoir, flexibility in the pumping rate will be possible.

4.3.2 Makeup Water Intake

The preferred location of the intake is on the west bank of the Thompson River, 360 m upstream of the mouth of the Bonaparte River.[1] The reasons for proposing this site are as follows:

1. The area is hydraulically acceptable, based on river surveys carried out in January and March 1977.

2. The area is considered geotechnically sound, based on visual observations.

3. An intake upstream of the confluence of the Bonaparte River would avoid taking in the more turbid water of the Bonaparte.

4. Generally, both access and room for construction are good.

5. The Thompson River has a large flow compared with the maximum demand of 1580 L/s (1.58 m^3/s) for the Hat Creek cooling water supply. Maximum recorded flows at Spences Bridge were 4137 m^3/s. The daily mean minimum recorded flow at Spences Bridge is 125 m^3/s. Thus the project demand represents significantly less than 2 percent of the Thompson River flow at its lowest value. The effect of this scheme on the Thompson River downstream is considered negligible.

A pier type intake structure (Fig. 4.3-1) would be utilized to withdraw makeup water from the river.[2] This intake would be oriented almost parallel to the river flow to use the sweeping action of the river to minimize fish entrapment, and to provide sufficient flow along the face of the screens to convey debris past the intake.

The intake would be made up of six individual cells, one of which would be provided for future use or for standby capacity. The screens would be the travelling vertical type and the screening surface would be fabricated from stainless steel wire with 2.5 mm clear openings to comply with Environment Canada requirements. For trash removal the screen baskets would be fitted with hooked lifting lips. These lips would drain away from the screen to avoid entrapment of salmon fry.

The preferred location of a screening system is at the face of an intake. With travelling screens, it is not feasible to mount the screen immediately at the face of the intake because the above-water portion of the screens need protection against ice, and debris. For the Hat Creek intake this protection is provided by a curtain wall in front of the screens, but because the curtain wall would provide an area behind which fish could be trapped, a flow velocity parallel to the screen faces is provided through the space between curtain wall and screens. This flow would enter the intake at the upstream side and exit at the downstream side. The space between curtain wall and screens would thus become part of the river, so that fish which have entered this space would be directed back to the river.

The upstream end of the intake would be equipped with an approach section to ensure that the first upstream screen would also be exposed to the parallel river flow. This approach section would not have a curtain wall so that river flow could enter between curtain wall and screens over the full river depth. Rather, a vertical sectional slide gate would be provided at the end of the approach section. The bottom of this slide gate would automatically follow the river water surface thus acting as a weather barrier. A similar gate would be provided at the downstream end of the intake, between the curtain wall and side wall of the last intake cell.

The width of each cell would be such that the screen approach velocity at minimum river water depth would not exceed 0.12 m/s as stipulated by Environment Canada. This low approach velocity together with the parallel river flow would prevent impingement of salmon fry on the screen. To prevent river solids from settling in the bypass channel and restricting the flow, the bottom of the channel would be sloped away from the screens, thus directing settling solids back to the river. This geometry would place the top of the travelling screen boot 1.7 m above the river bottom, and would leave a water depth on the screen of 1.1 m at design minimum river level.

Normally, intake pumps would start up against a closed valve which slowly opens so that the flow through the screen gradually increases. Furthermore, because the pumps and screens are combined in integral units, the flow through any single screen could not exceed the design rate.

At some existing intakes slide gates are installed in the walls between the pump cells to enable the bypassing of a travelling screen while it is shut down for maintenance. These gates have been purposely left out of this design to preclude the possibility that more than one pump could draw water through one screen, an operating condition which could lead to screen approach velocities in excess of the stipulated maximum of 0.12 m/s.

Because the travelling screens would operate behind fixed trash racks and are exposed to the sweeping action of the river, it is expected that little debris would collect on the screens. Cleaning of the screens would be by high pressure water sprays located at the operating floor. Spray water, together with debris if any, would be returned to the river at the downstream end of the intake.

The bottom of the intake cells would be recessed approximately 2.5 m below the intake sill to create a chamber for grit collection. Removal of grit would be carried out by air lift or other means and returned to the river.

For frost protection, the vertical slide gates at the upstream and downstream ends of the intake would prevent cold air from entering the intake. At the operating floor the debris discharge chute would be equipped with a belt conveyor to facilitate return of ice to the river. Provisions to electrically heat trace trash rack and gate guides, intake sills and screen cloth would be incorporated to prevent icing problems. To ensure that the intake structure and all visible work is aesthetically pleasing, the final designs will be coordinated with the overall project aesthetic and architectural planning.

Preliminary data indicated that the booster pumps generate noise at SPL (sound pressure levels) in the range of 90 to 95 dB(A), while the motors with no insulation have SPL of 105 dB(A) at 3600 rpm. The booster pump motors, since they are of special design, can be ordered with various degrees of sound-attenuating enclosures which can reduce the SPL to approximately 85 dB(A). Proper selection of the pumping station's exhaust-air ducting, roof and wall construction materials can further reduce the sound level to an acceptable value outside the station.

4.3.3 Pipeline

The pipeline would start at the intake structure on the Thompson River and terminate at the north end of the powerplant reservoir, thus traversing about 23 km (Figs. 1.0-1 and 1.0-2). The route has been selected to be reasonably direct, to avoid areas of geotechnical instability and difficult construction, to minimize total installation and operating costs, to avoid Indian Reserve lands and to minimize environmental impacts.

The route was also intended to follow and be part of the proposed Nicola to Kelly Lake transmission line corridor to the extent possible in order to minimize impacts. Subsequently, the transmission line proposed route was changed with a combined corridor not possible. However, the proposed pipeline route has remained unchanged.

4.3 MAKEUP COOLING WATER SUPPLY SYSTEM - (Cont'd)

The route would cross a variety of terrains: the agricultural lands of Lot 378 and of Boston Flats; the rock-dominated slopes of the Trachyte Hills; and the gently sloping forests westward to the plant reservoir. At present, the suburb north of Ashcroft is the only inhabited area near the route. The current extent of development there lies about 110 m to the south of the route, however the route is within town limits.

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 duct-bank 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 28 ha. The remaining 11 ha at lower elevations comprise sage and bunch grasses that would not require clearing. Following completion, the right-of-way would be graded and revegetated, except that the road would be retained for maintenance access. Monthly inspection would ensure that any erosion problems would be quickly controlled.

The surface drainage scheme would control the flow of runoff across or parallel to the right-of-way. For cross-flow drainage, special provisions would only be required at gullies; the provisions could be in the form of paving with cobble stones at the point of crossing to prevent erosion. Where parallel-flow drainage might occur, the objective would be to prevent the backfilled pipe trench from acting as a drainage course. Provisions would be in the form of shallow trenches or depressions to lead runoff away from the right-of-way and direct it towards existing drainage courses. The trenches would be paved where necessary with cobblestones, and would be 25 m to 50 m long depending on local topography.

4.3.4 Plant Reservoir

The pipeline would discharge into inlet works in the reservoir at a point remote from the plant intake, so that the reservoir would act as a settling basin to reduce suspended solids. Because the reservoir contains a large volume of storage, and because its water level could vary over a wide range, the inlet works would consist of an open flume running to the reservoir bottom which would carry the water from the pipeline termination, at the high water level, to the operating water level. At the bottom the inlet would have a hydraulic jump and stilling basin so that erosion of the empty reservoir basin would be prevented. Thus, at low operating levels no additional sediments would be eroded from the reservoir by the flow, and at high operating levels the settling capacity of the reservoir would be utilized to reduce suspended solids levels at the reservoir outlet.

4.4 69 kV NOMINAL TRANSMISSION SYSTEM

4.4.1 Introduction

This section describes the 69 kV transmission system that would supply power for the following:

1. The mine.

2. Powerplant construction.

3. The cooling water system.

4.4 69 kV NOMINAL TRANSMISSION SYSTEM

The Hat Creek powerplant will be connected to the Nicola to Kelly Lake 500 kV transmission line. However, since the development of the 500 kV transmission line is independent of the Hat Creek project and is discussed fully in other engineering reports,[1] a description of the Nicola to Kelly Lake 500 kV transmission line is not presented here.

4.4.2 Mine and Powerplant Construction Power Source

Fig. 4.4-1 shows the basic 69 kV line route proposed for supplying the mine substation and the powerplant construction power substation. Power to the mine substation would be tapped from an existing 69 kV line located near Highway 12.[2] The new 69 kV supply line would cross Highway 12 to the mine substation and would be approximately 1.2 km long. The supply to the construction substation would be taken from the mine substation using two parallel single 69 kV lines approximately 3.6 km long. The right-of-way cross sections would require a maximum of 20.0 m for a single 69 kV circuit, and 30.5 m total for two parallel 69 kV single circuits.

4.4.3 Cooling Water System Power Source

The 69 kV supply to the pumping station would be taken from a proposed new 230/60 substation to be called Rattlesnake Substation. There are two alternative sites for Rattlesnake Substation. Fig. 4.4-2 illustrates these. Site A is approximately 1/2 km from the existing 230 kV lines on land gently sloping to the south. It is approximately 3 km from the highway between Cache Creek and Savona, 1 1/2 km from a subdivision, and approximately 12 km from the pumping station. Site B is approximately 3/4 km east of Site A and lies close to, and to the north of, the existing transmission lines between two creek beds. The site is also approximately 1 1/2 km from the highway between Cache Creek and Savona, 1 1/2 km from the nearest house, and 12 km from the pumping station.

From Sites A or B, the 69 kV tap would cross the highway close to the town of Cache Creek where it is well screened from traffic viewing but within sight of a subdivision. It would then follow the route of the gas pipeline to the high pressure pumphouse located adjacent to the Thompson River just downstream of the mouth of the Bonaparte River. A second stage intermediate pumping station is proposed to be located adjacent to Highway No. 1 just north of the north boundary of Ashcroft Indian Reserve No. 2. The tap to the intermediate pumping station from the proposed line to the Thompson River intake is shown on Fig. 4.4-2.

The 69 kV line from Rattlesnake Substation Sites A or B should be tapped out as shown on Fig. 4.4-2 if the distance between the Rattlesnake Substation and the pumping station is to be kept to 10 to 12 km. Along the section from the tap to the intermediate pumping station, the line would be visible from Highway 1 and from the road linking Highway 1 and Ashcroft. It will also pass in the vicinity of several houses near Boston Flats.

4.4.4 Loop from Existing 69 kV Line to Rattlesnake Substation

It is also proposed to tie the existing 69 kV line (60L29) into the proposed Rattlesnake Substation. To accomplish this, it will be necessary to run a new 69 kV line along the existing 230 kV route to some point between the town of Cache Creek and the Bonaparte Indian Reserve.

4.5 CREEK DIVERSIONS

4.5.1 Introduction

Excavation of open pit No. 1, disposal of pit surficials and mining wastes and disposal of ash from the thermal plant would require diversion of Hat Creek and several smaller tributaries including the upper and lower portions of Medicine Creek, Finney Creek and the area adjacent to Aleece Lake and Lloyd Creek.

4.5.2 Hat Creek Diversion

Hat Creek would be the most significant of the diversions, having an overall drainage area of about 310 km^2. Fig. 4.5-1 shows the general arrangement of the proposed diversion. Based on the conceptual design of Monenco Consultants Pacific Ltd.,[1] this diversion would be accomplished basically with a 7 km long impervious-filled, lined canal on the east side of the Hat Creek Valley, a 2100 m long discharge conduit to return the flow to Hat Creek downstream of the pit and a 15 m high headworks dam immediately downstream of Anderson Creek. The design capacity of this diversion would be about 23 m^3/s with an emergency capacity of about 33 m^3/s. The average annual runoff and diversion flow would be about 0.7 m^3/s. Upstream of the diversion, a retaining dam would be constructed to maintain and equalize flows in Hat Creek.[2]

An alternative diversion scheme that would utilize Hat Creek water as a supplemental water source is being considered.[2] This arrangement would comprise essentially the same canal arrangement as described in the preceeding paragraph except with reduced diversion capacity, a small reservoir and pumphouse where the canal would cross Medicine Creek and a 0.57 m^3/s, 50 cm buried pipeline with a length of about 4570 m up to the main water supply reservoir. Hat Creek storage would be provided at an alternative site downstream of McCormick Creek. The earthfill dam at this site would be about 30 m high and would require a low level outlet works with a capacity equivalent to the canal. An emergency spillway similar to that at the headworks dam would also be provided. The alternative site reservoir would have a normal maximum water level of El. 1052 creating a reservoir 2.4 km long with a surface area of about 120 ha.

4.5.3 Medicine Creek Diversion

(a) Upper Medicine Creek

Depending upon what arrangement is finally adopted for ash disposal, two distinctly different approaches to this diversion are possible. If wet ash disposal in the upper Medicine Creek area (base scheme appears in Fig. 1.0-1) is selected, the diversion would require ditches on both the north and south sides of the valley to intercept and convey water through the divide into MacLaren Creek at El.1295 m. Since it would probably be uneconomical to provide diversion capacity for the probable maximum flood, such maximum flood runoff, together with the runoff below the level of the ditches, would have to flow to the ash pond.

If the area downstream of the base scheme is selected for ash disposal, a reservoir would be created at the base scheme ash pond site. Collected runoff could then be pumped to the main water supply system and utilized as powerplant makeup. Including the currently licensed diversion, the available runoff could total about 0.13 m^3/s as an annual average. With a pumping head of only about 150 m, energy benefits could be substantial.

(b) Lower Medicine Creek

The lower Medicine Creek area may be used for disposal of pit surficials and mine wastes. To prevent erosion and ensure stability of this material, it would be necessary to intercept and convey all runoff to the Hat Creek Diversion canal. Runoff from the drainage area of 18 km^2 would be diverted in ditches.

4.5.4 Finney Creek, Aleece Lake and Lloyd Creek Diversions

Runoff from the Finney Creek drainage area of about 13 km^2 would be diverted by ditch into the canal headworks reservoir (Fig. 4.5-1).

Most of the runoff in the vicinity of Aleece Lake and Lloyd Creek, a drainage area of about 31 km^2 would be diverted around the south edge of the Houth Meadows waste dump in ditches and discharged into Hat Creek. To avoid concentrating the flow to this area, the northern portions of this basin and the waste dump could be drained to the north.

4.6 AIRSTRIP

The Civil Aeronautics Department of Transport Canada has undertaken calibration flights and brief ground reconnaissance of the Cache Creek and Ashcroft area and identified three potential airstrip sites.[1] These sites are shown on Fig. 4.6-1. The drawing also shows typical runway details for an airstrip suitable for most executive type jet aircraft.

Transport Canada has indicated that all three sites appeared to be acceptable from an operational point of view, although more detailed surveys would be required before a final decision could be made. They indicated that they preferred Site C, near Cache Creek, because it had the best ground clearances for aircraft landing and taking off. Site A would be their second choice, with Site B third.

Additional factors that must be considered in selecting the airstrip location are:

1. Location of the site relative to the existing communities and the project site.

2. Present use and ownership of the land.

3. Potential for future expansion of the runway.

4. Cost.

5. Noise disturbance.

4.6 AIRSTRIP - (Cont'd)

4.6.1 Location

All three airstrip sites are relatively close to the existing communities. Sites A and B are closer to Ashcroft while Site C is closer to Cache Creek. Sites A and B are also closer to the Hat Creek Project than Site C via the proposed new project access road up Cornwall Creek.

The following table summarizes the distances from each site to existing communities and to the project.

	Distances in Kilometres		
	Site A	B	C
Ashcroft	9	5	15
Cache Creek	14	10	4
Powerplant	22	23	37
Mine	30	31	45

4.6.2 Use and Ownership of Land

Sites A and B are both within the Cameron Ranch presently owned by B. C. Hydro. Site A is on land used for grazing while Site B is on partly irrigated agricultural land. Site C is on fully irrigated agricultural land within the Emlin Ranch which is privately owned. An airstrip at this location would remove from the ranch all of the land now being irrigated.

4.6.3 Potential for Expansion

Site C could be extended to a length greater than 1500 m. Sites A and B, however, would be limited to maximums of approximately 1500 m and 1350 m, respectively. A runway length of only 1350 m would be restrictive for some of the executive type aircraft under certain load and climatic conditions.

4.7 CONSTRUCTION CAMPS

4.7.1 Introduction

Separate construction camps are proposed for the powerplant and the mine. The camps, as located, offer the optimum combination of ecoromical water supply, convenience of access and residential suitability. The water supply would be drawn from wells to be constructed near Hat Creek, upstream of the initial mine pit. The water would be pumped to both camps. An intermediate pump station would be provided. The following description is summarized from a report on the proposed camp facilities.[1]

4.7 CONSTRUCTION CAMPS - (Cont'd)

4.7.2 Camp Locations

(a) Powerplant Camp

Two factors considered for the location of this camp were the workers' travel distance from the campsite to the powerplant site, and the availability of a camp area of suitable size and grade to facilitate camp construction. Construction work is essentially a single shift operation and will not cause consistent loud noise during the night.

The construction camp for the powerplant requires an area approximately 300 m x 370 m. Areas suitable for a camp site are available north, west and southwest of the powerplant. The most desirable location for this camp would be on the gentle slope on the north side of the plant (Fig. 1.0-1), in the park-like deciduous forest. This forest provides a buffer between camp and construction site and allows attractive settings for the camp units.

(b) Mine Camp

A desirable location for the mine camp is depicted in Fig. 1.0-1. It would be situated in a pine forest in an area gently sloped. This forest would tend to screen the camp from the new project access road, power line and conveyor right-of-way. The water supply line would run through an easily accessible area. The soil in the area appears to be well suited for installation of underground services.

4.7.3 Camp Layout and Services

(a) Layout

Typical camp layouts are illustrated in Figs. 4.7-1 and 4.7-2. These can be modified to suit the local contours and requirements of the project. Each camp would have a centrally located kitchen/cafeteria complex with a recreation hall nearby. The bunkhouses would be located around this complex. Each camp would be surrounded by an access road with parking facilities. A car wash and a limited number of outlets for car heaters would be provided. The spacing between camp units would be 8 m to 10 m to provide fire breaks and privacy.

The layout concept for the camps is based on the purchase and lease of prefabricated units that are assembled onsite into bunkhouses, kitchen and cafeterias and recreation halls. Recent experience indicates that this type of installation is economical. The camps for the Hat Creek Project are to be used for a longer period than normal, and therefore the specifications for camp buildings would make allowance for this extra usage.

Camp services, including water, electric power and sanitary sewers, are designed to function with the maximum camp development or with only the core of the camps installed. Additional residential units would be added and removed as required by the manpower schedule. Telephone services would be provided by the B. C. Telephone Company and pay telephones for the camp population would be located in the recreation halls.

(b) Water Supply

Three alternative methods of providing water for the two construction camps were considered:

1. Local wells drilled near the camps.

2. Transporting water by tank truck from wells near Hat Creek to storage facilities at the camps.

3. Pumping water from wells near Hat Creek to storage facilities at the mining camp and from there to storage facilities at the powerplant camp.

Only method three is recommended because the availability of an adequate supply of groundwater at the powerplant campsite is questionable, and trucking water from Hat Creek would not be economical. The preferred water supply system is shown in diagramatic form in Fig. 4.7-3. It consists of two 30 m deep wells in the aquifer near Hat Creek, upstream of the initial mining activities.

Drill holes in the vicinity indicate a top layer of sand and gravel of considerable depth with water-table levels near ground surface. If the permeability of the aquifer proves unsatisfactory, surface water would be obtained from Hat Creek by means of shallow wells. In either case, the wells would be provided with standard well pumps capable of pumping approximately 4 L/s through a pipeline directly to the storage facilities at the mine camp. From the mine camp the water would be pumped to the powerplant camp. Before the water enters the storage facilities it would be chlorinated as required.

After Hat Creek has been diverted, it would be necessary to replace the wells. It is suggested that a suitable water intake be constructed where the pipeline crosses the diversion channel. This crossing would be less than 1.6 km from the mine camp and near the same elevation. A new set of pumps would have to replace the well pumps. To ensure water free of sediments, a pair of pressure filters would be installed near the storage facilities.

The water supply system is sized to provide 190 L/d per person in the camps. At a maximum combined camp population of 1440 (+20% design safety) the daily demand would be 328 m^3/d. The proposed pumping rate of 4 L/s with a single set of pumps would supply 346 m^3/d into the camp storage facilities. By utilizing the stard-by pumps, this supply could be increased to approximately 600 m^3/d.

(c) Water Distribution and Fire Protection

Potable water distribution and fire protection would be combined in a single system at each camp. Each system would be designed and constructed in accordance with applicable fire codes. The systems would be similar except for the sizes of the storage reservoirs and the detailed piping layouts.

The reservoir at the mine camp would hold 757 m^3 of water while the one at the powerplant camp would hold 1135 m^3 of water. Of these reserves, 379 m^3 at each camp would be allocated for fire protection only. This minimum fire protection reserve can supply 50 L/s for two 65 mm and four 40 mm hose streams for a 2-hour period. The reservoirs would be completely enclosed rubber-coated-nylon-fabric tanks supported by soil embankments. A closed top would prevent contamination and minimize evaporation losses.

A house near each reservoir would contain two potable water pumps, one diesel engine fire pump and all controls. The potable water pumps would supply 32 L/s each and the fire pump would supply 65 L/s at 7 kPa. One potable water pump is expected to run continuously to pressurize the distribution system, with excess water recirculated through a pressure relief valve back into the reservoir. The second potable water would start on pressure drop. The fire pump would start on pressure drop and upon power failure.

To prevent freezing, the piping system would be installed below the frost line or insulated and heat traced. A cart with hoses, nozzles and other fire fighting equipment for use with 65 mm outlets on the 150 mm hydrants would be housed at a central spot in each camp. Four inch hoses would be available in cabinets on both ends of each bunkhouse. These hoses would be connected to standpipes that are part of the internal piping of the bunkhouses.

(d) Sanitary Sewage Treatment and Disposal

Separate sanitary effluent treatment and disposal facilities would be installed at each camp. Because of the cost of a pipeline from the powerplant camp to the mine camp, and the unfavourable conditions for disposing of effluent in the mine camp area, it would be impractical to install one central plant for the two camps.

Each installation would provide full biological treatment to remove at least 80 percent BOD_5 during summer and winter. Each system would provide aerobic oxidation utilizing an open basin with submerged static aerators. The system would be designed with sufficient retention and would not require any primary treatment other than comminution ahead of the basin. Neither would it require sludge removal and disposal. The final effluent would be treated to satisfy the requirements of the regulatory authorities.

The final effluent from the powerplant camp would be directed to an impoundment basin formed by the existing Harry Lake. The preliminary project layout (Fig. 1.0-1) indicates that this lake area also could be developed into a bottom ash impoundment. This basin is expected to have a surface area large enough to evaporate the expected volume of effluent under normal conditions. Any residual effluent would be retained as part of the ash water to be used for transportation of the ash slurry from the powerplant. Chlorination as necessary would be provided as part of the system.

Further studies are required regarding disposal of the final effluent from the mine camp treatment plant and the avoidance of discharge into surface water. The available alternatives are:

1. Deep well disposal.

2. Spray irrigation.

3. Impoundment.

4. Drainage field.

The geological conditions appear to be favourable for deep well disposal. Bore hole records indicate that a dry gravel bed underlies the camp area. However, further geological studies are required to confirm this. Spray irrigation has been used successfully at locations of similar climate even though it is limited to summer operation, and this would necessitate an additional disposal method during the winter period. The contours of the ground in the mining camp area do not allow a natural impoundment basin without interfering with storm water runoff. If an impoundment basin is required for the winter time, it would have to be excavated. The surface soils in the camp area appear to be till with very low permeability. If soils of adequate permeability are found during a detailed soils investigation, construction of a drainage field could be undertaken.

(e) Power Distribution

The power distribution throughout the camps and from the mine camp to the well pumps are assumed to be at 12.47 kV, with step-down transformers at utilization points as required. Street lighting would be provided in camp areas and flood lighting in parking areas. Outlets for electric car block heaters would be installed for 500 cars at the powerplant camp and for 200 cars at the mine camp. A fire alarm system with sirens and locator panel would be provided for both camps. These systems would be hooked up to the internal alarm systems in the bunkhouses. A small standby construction type generator fueled by propane gas would provide emergency electric power for lighting and furnace fans in the cafeteria and recreation hall.

(f) Camp Heating, Ventilation and Air Conditioning

Bunkhouses at the two camps would be heated electrically. Each room would have a unit heater controlled by its own thermostat. A makeup air system would heat fresh air when required and provide positive ventilation. Air conditioning would be provided in the summer. The cafeteria and the recreation hall would have warm air furnaces heated with propane gas. Gas would be used also in the kitchen for cooking and baking.

(g) Catering and Housekeeping Services

B. C. Hydro would engage an industrial catering and housekeeping service. The caterer would be selected before the contract for the camp buildings is awarded and given the opportunity to participate in the detailed layouts of the kitchen and dining room facilities to suit his requirements.

The caterer would be responsible for all services required to manage and maintain the camps, including fire protection, and maintenance of water supply and effluent treatment facilities. Refurbishing of buildings, and major repairs, would be arranged by B. C. Hydro as required. Snow removal and garbage disposal would be part of the general contractor's scope of work. All camp garbage would be disposed of in a suitable landfill meeting all regulatory requirements.

4.8 EQUIPMENT OFFLOADING FACILITIES

During the construction phase, materials and equipment for the project would be shipped from the suppliers by rail. The nearest rail line is some 32 km from the project site. The distance and the terrain make it uneconomical to construct a spur line into the Hat Creek Project site. Consequently, all rail shipments must be trans-shipped by road from a convenient point on the railway.

A trans-shipping terminal would be required at the interface of the rail and the road for transferring the materials from the railcars onto the highway trucks. A number of extremely heavy pieces, weighing up to 300 t, would be delivered to the terminal on special railcars. The terminal would have a derrick to move these loads from the railcars to specially designed trucks. The offloading facilities would also be used as an interim storage yard for material and equipment.

Negotiations are underway with the three major railways for the provision of an offloading area for handling project equipment. Depending on the results of these negotiations the offloading facilities could be located at any of the following sites:

BCR - near Kelly Lake Substation
CNR - J&B Lumber site near Ashcroft
CPR - Spences Bridge

The proposed layout of the offloading facilities is shown on Fig. 4.8-1.

The offloading facilities would require a level 3 ha area, 400 m long by 75 m wide. The area would be graded and surfaced with gravel and crushed rock to a depth sufficient to provide adequate bearing capacity for the trucks and mobile equipment to maneuver around the entire area. The area would be sloped to a minimum grade of 1 percent to provide surface drainage, and ditching would be provided around the perimeter if required. An access road would be built connecting the offloading area to the highway. The terminal area would be enclosed by a 2 m high chain link fence with three strands of barbed wire at the top. Gates would be provided on the roadway area and at the point where the rail spur enters the terminal.

A portable modular building installed on the site would be divided into three sections to serve as an office, lunchroom and washroom.

PART TWO

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PART THREE

ENVIRONMENTAL SETTING WITHOUT THE PROJECT

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CHAPTER 1.0 - INTRODUCTION

Part Three, Environmental Setting without the Project, discusses the collection of data and its use to describe the current status of the environment in the vicinity of the proposed Hat Creek Project. This baseline information provided the basis to identify the impacts from development of the Hat Creek Project presented in Part Four. Part Three presents Baseline Data Collection Methodology (Chapter 2.0); Resource Inventory (Chapter 3.0) and Resource Projections without the Project (Chapter 4.0).

Chapter 2.0 describes the collection of environmental data, the sources, methods of analysis and the rationale for selection of monitoring stations and specific environmental parameters. Data sources for each discipline used to characterize resources generally consisted of:

1. A review of available literature including results of previous field studies.

2. The pre-operational monitoring programmes.

3. Discussions with local residents, and industrial and government officials.

Analytical procedures utilized were standard methods. Monitoring station locations and parameters monitored were selected to provide specific information on potentially sensitive components of the environment.

The characterization of the environmental resources in the vicinity of the Hat Creek Project is based upon the results of the Detailed Environmental Studies. The results are presented in Chapter 3.0 (Resource Inventory). Information on meteorology, air quality, epidemiology, water resources, land resources and socio-economic characteristics on a regional, local and site-specific basis is presented.

Chapter 4.0 projects these environmental resources over 35 years based upon the assumption that the project would not proceed. These baseline forecasts were then compared with the environmental conditions expected during the development and operation of the Hat Creek Project. The difference between the with and without project cases served as the basis for evaluating project impacts.

CHAPTER 2.0 - BASELINE DATA COLLECTION METHODOLOGY

2.1 INTRODUCTION

This chapter describes the sources of the baseline environmental data and the procedures used to collect the data for the Hat Creek Project. Information is provided for meteorology-air quality, epidemiology, water resources, land resources, socio-economics and noise.

2.2 METEOROLOGY - AIR QUALITY

2.2.1 Meteorological Data Sources

(a) Regional

The regional climatological characteristics presented here, and in more detail in Appendix E to the Air Quality and Climatic Effects Report[1], are based primarily on long-term data from the records of the Climatological Service Division of the Atmospheric Environment Service of Canada (AES). Two AES publications extensively used were "Canadian Weather Review"[2] and "Monthly Record: Meteorological Observations in Canada".[3] In addition, the "U.S. Naval Weather Service World-Wide Airfield Summaries"[4] was utilized. Hourly AES surface meteorological data on magnetic tape for Ashcroft (1966-1971), Kamloops (1974-1975), and Lytton (1974-1975), as well as upper air radiosonde (RAOB) observations for Vernon and Prince George, B.C., were used in the regional climatological analysis. A complete listing of the regional meteorological data sources is contained in Appendix A to the Air Quality and Climatic Effects Report.[5]

(b) Local

Site meteorological conditions were determined from one year (1975) of onsite meteorological data obtained from an eight-site preliminary monitoring network developed by B.C. Hydro. Each of the sites was equipped with a mechanical weather station which recorded wind speed, wind direction, temperature, and humidity. This monitoring network is described in more detail in Section 2.2.3, "Onsite Meteorological and Air Quality Monitoring". The locations of the mechanical weather stations are depicted in Fig. 2.2-1. In addition to these onsite measurements, historical climatological data were obtained from several nearby AES weather stations. Table 2.2-1 presents a listing of the locations and elevations of the stations for which data were utilized. Appendix A to the Air Quality and Climatic Effects Report[5] contains a complete discussion of the local meteorological data sources.

Information on the vertical structure of winds and temperature over the Hat Creek Valley was obtained from short-term, intensive studies performed by MEP Company (sponsored and assisted by B.C. Hydro) in both the winter and summer of 1975, and in winter, spring and summer of 1976.[7,8] Data were obtained from minisondes, a series of hygrothermographs on the slopes of the Hat Creek Valley and from a series of constant level balloon flights.

The atmospheric diffusion characteristics of the Hat Creek Valley were investigated through the use of oil-fog and gas tracer studies conducted in the winter, spring and summer of 1976 by

North American Weather Consultants, under the sponsorship of B.C. Hydro.[9] Intensive meteorological measurements were conducted to define ambient conditions during simulated powerplant plume releases. The information from these studies was used to calibrate the air quality prediction models used in estimating the air quality effects of the project.

2.2.2 Air Quality Data Sources

(a) Regional

Long-term ambient air quality data are available for only a few locations in southern British Columbia. The sparcity of data is not a serious problem because there are few emission sources in the region. The paucity of emissions permits one to make reasonable assumptions about baseline ambient air quality. The full-scale, pre-operational, onsite monitoring programme implemented by B.C. Hydro will provide data to verify these assumptions. The air quality data base consists of measurements of ambient particulate levels, dustfall, and sulphation rates taken by the B.C. Department of the Environment, Water Resources Service.[10]

The available data reflect conditions in and near the industrial communities of Kamloops and Squamish. Both communities are well removed from the project site. Consequently, these data cannot be considered representative of the sparsely populated rural area surrounding the proposed project site. Even gross features, such as seasonal trends, are inadequately represented. A complete description of the locations where air quality measurements were taken, as well as the period of record, are given in Appendix A to the Air Quality and Climatic Effects Report.[5]

Other regional air quality data include the results of a survey of the snowpack and stream water acidity in Hat Creek and Wells Gray Park. This survey was conducted by B.C. Hydro on June 3, 1977. Data were analyzed by the Environmental Laboratory of the B.C. Ministry of the Environment. The results were used in the analysis and prediction of precipitation acidity due to Hat Creek sulphur dioxide emissions.

An inventory of particulates, sulphur and nitrogen oxides from Kamloops, Cache Creek, Clinton, and Highland Valley was compiled by B.H. Levelton and Associates, Ltd. under contract to B.C. Hydro in 1977.[11] The results were used qualitatively to discuss contemporary regional air quality as well as in the analysis of the effects of the Hat Creek Project on regional air quality.

(b) Local

A limited amount of total suspended particulates data are available from B.C. Hydro and the Environmental Laboratory of the B.C. Ministry of the Environment for the Hat Creek Valley and Cache Creek beginning in the spring of 1977.[12] Data were collected using the high volume sampler method. The locations of the six stations for which data are available are indicated in Fig. 2.2-2.

Additional local ambient air quality data will be available from the full-scale, pre-operational, onsite monitoring programme implemented by B.C. Hydro. The programme is described in the following section. At the present time, however, data from this programme were not available for use in this report.

2.2.3 Onsite Meteorological and Air Quality Monitoring

B.C. Hydro has established an extensive pre-operational programme to gather meteorological and background air quality information as part of the Hat Creek Detailed Environmental Studies. This programme is described in detail in Appendix H to the Air Quality and Climatic Effects Report;[13] a summary description is provided in this section.

(a) Programme Objectives

The overall objective of the pre-operational monitoring programme has been the compilation of a long-term meteorological and air quality data base for the Hat Creek region. Specifically, the programme was designed to allow B.C. Hydro:

1. To obtain accurate information of the background air quality levels (i.e., sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone, dust, visibility and heavy metals) in the region prior to start-up of the proposed plant.

2. To collect baseline meteorological data in sufficient detail to allow for further evaluation and design of a meteorological control system for the proposed thermal generating plant, should that be the selected sulphur dioxide control system.

3. To collect pertinent meteorological and atmospheric turbulence data for the evaluation and detailed design of cooling towers.

4. To collect meteorological data to add to the state-of-the-art knowledge about the effects of irregular terrain on contaminant dispersion in the vicinity of the proposed plant.

(b) Preliminary Meteorological Monitoring Programme

The implementation of a monitoring programme designed to meet the above objectives is a major undertaking. It was apparent that, because of the time required to establish the necessary comprehensive monitoring programme, onsite data would not be available for use in the detailed environmental studies. Therefore, B.C. Hydro initiated a preliminary meteorological monitoring programme in November 1974 for the purpose of collecting data on the air flow patterns over the irregular terrain surrounding the site of the proposed thermal plant. Data were collected from ground-based stations, from instrumented balloons and from aircraft.

The preliminary programme included eight mechanical weather stations operating in the Hat Creek area (see Fig. 2.2-1). These stations were installed in November and December, 1974, to measure wind speed (collected as wind run), wind direction, temperature and relative humidity at 10 m above the ground. Data from these stations were supplemented during the winter of 1975 by information from four hygrothermographs (which measure temperature and relative humidity) located on the eastern slopes of the upper Hat Creek Valley. Data from the weather stations and hygrothermographs have been routinely reduced to hourly average values for computer analysis and evaluation.

In addition to wind information obtained from the mechanical weather stations, wind data have been collected with a wind sensor which has operated since July 1961 at the junction of the upper and lower Hat Creek Valleys with Marble Canyon. Also, dry bulb temperature, wet bulb temperature, relative humidity and precipitation data have been collected in the upper Hat Creek Valley since November 1960.

During 1975 and 1976 B.C. Hydro sponsored several studies to investigate the boundary layer wind and thermal structure in the Hat Creek Valley. Minisonde studies were conducted by MEP Company during the winter and summer seasons of 1975 and 1976 and during the summer of 1975 and the spring of 1976; additional information was obtained from observations of constant-volume balloon flights.[7,8]

Atmospheric diffusion characteristics and plume trajectories at elevations approaching plume heights have also been studied through the use of oil-fog and gas tracers. These studies were conducted in the winter, spring and summer of 1976 by North American Weather Consultants under a contract with B.C. Hydro.[9]

Data collected during the preliminary monitoring programme form the data base used in the air quality assessment. These data are presented in detail in Appendix A to the Air Quality and Climatic Effects Report.[5]

(c) *Full-Scale Meteorological Monitoring Programme*

The current full-scale meteorological and air quality monitoring programme was designed and constructed by Western Research and Development Ltd. with design assistance by Environmental Research & Technology Inc. as part of the Hat Creek Detailed Environmental Studies. It commenced operation in 1977 and will initially complement and eventually replace the monitoring stations of the preliminary meteorological monitoring programme. This current programme includes four permanent monitoring stations equipped with continuous sensors, monitors and automatic recording and data acquisition instrumentation. The following section presents a brief description of the meteorological monitoring sites; the air quality monitoring will be covered in later discussions.

(i) *Meteorological Monitoring Site Descriptions*

The following four permanent monitoring stations have been established in the general Hat Creek Area:

Site	Location
1	In the Hat Creek Valley near the mine site
2	At the proposed plant site
3	On Pavilion Mountain
4	In the vicinity of the town of Cache Creek

The locations of these stations are indicated on Fig. 2.2-3.

Site 1, the Hat Creek Valley site, is situated near the location of the proposed mine. This site is being used primarily to monitor background air quality levels. However, it is also equipped to monitor wind speed, wind direction, temperature, dewpoint, visibility, solar radiation and precipitation in order to correlate the meteorological conditions with observed variations in air quality and to aid in later estimates of the atmospheric dispersion of emissions from the mine.

Site 2, at the proposed plant site, is used for collecting wind speed, wind direction, temperature, dewpoint, precipitation, evaporation, barometric pressure and turbulence intensity data. These data will provide climatological information for input into cooling tower and stack plume models in future studies. At this site a 100 m metre tower is used to obtain high level turbulence intensity data, wind speed and direction, temperature and relative humidity.

Site 3 is located on top of Pavilion Mountain at an elevation of 2100 m (MSL), and is 23 km northwest of the location of the proposed plant. This site is representative of air quality and meteorological conditions existing at higher elevations within the region of the proposed plant. Meteorological measurements made here are representative of the conditions affecting the transport and dispersion of the plant stack and cooling tower effluents. Wind speed, wind direction, temperature and precipitation data are collected at this site.

Site 4 is located 16 km east of the proposed powerplant site in the Cache Creek area. This site is in a valley about 900 m below the elevation of the proposed plant base and is situated in a growing population center. Monitoring of wind speed, wind direction, temperature and dewpoint is being conducted at this site to provide information for evaluating the general air quality in this area. The equipment is housed in a mobile unit with a 10 m telescoping tower, and thus can be moved for future sampling at other locations.

(ii) Meteorological Monitoring Equipment

The meteorological sensors installed at each of the four monitoring sites reflect the current state-of-the-art of meteorological instrumentation suitable for micrometeorological monitoring. The meteorological equipment at each site is summarized in Table 2.2-2. Complete descriptions and specifications of each of the sensors may be found in Appendix H to the Air Quality and Climatic Effects Report.[13]

(d) Air Quality Monitoring Programme

(i) Air Quality Monitoring Site Descriptions

Air quality monitoring sites have been established in the vicinity of the proposed Hat Creek Plant at the same locations as the meteorological monitoring sites discussed previously. Site 1 (mine) was established to monitor background air quality levels so that potential effects from the proposed powerplant and mining activities can be evaluated. Oxides of nitrogen, suspended particulates, visibility (fog), visibility (haze), ozone and sulphur dioxide are being monitored at this site. Also included at this site are equipment for monitoring sulphation, dustfall, suspended particulates, and corrosion. Site 2 (powerplant) was established primarily as a meteorological monitoring site, but monitoring for suspended particulates, dustfall, sulphation, and corrosion is also conducted. Site 3

(Pavilion Mountain) is considered representative of air quality and meteorological conditions existing at higher elevations. This site was established primarily for monitoring meteorological conditions but is also equipped to monitor dustfall, sulphation and corrosion. Site 4 (Cache Creek) was established primarily for monitoring background air quality levels of oxides of nitrogen and sulphur dioxide. At this location, monitoring is also being conducted for ozone, carbon monoxide, visibility (haze), suspended particulates, sulphation, dustfall and corrosion.

In addition to the primary monitoring sites, several supplementary air quality monitoring sites have been established to gather dustfall, sulphation and atmospheric corrosion data. Dustfall cylinders and sulphation plates are considered semi-quantitative monitors of suspended particulates and sulphur dioxide. Since these devices are relatively inexpensive to install and operate they are used in large numbers to give a general idea of contaminant distribution over a wide geographic area. A total of 16 sulphation and dustfall monitoring sites have been established, including the four major site locations. The locations are shown on Fig. 2.2-4.

Atmospheric corrosion stations are designed to give a semi-quantitative indication of corrosive materials in the atmosphere. Studies indicate that corrosion rates in the atmosphere can be related to atmospheric contaminant concentrations. Eight corrosion stations have been installed in the area as shown on Fig. 2.2-5, including the four major sites.

In addition to the high volume samplers for suspended particulates at three of the four major monitoring sites, three other high volume sampler sites have been established to aid in the determination of existing atmospheric particulate loadings. The six locations are shown on Fig. 2.2-6.

(ii) Air Quality Monitoring Equipment

A list of the air quality monitoring equipment used at each site is provided in Table 2.2-2, along with the meteorological monitoring equipment. A detailed description of the equipment used, including complete specifications, is included in Appendix H of the Air Quality and Climatic Effects Report.[13]

(e) Data Processing and Quality Control

All continuously monitored meteorological and air quality data are recorded on both analog (strip chart) and digital data acquisition systems. Recovery of primary data at each site is accomplished via a digital data logger interfaced to a magnetic tape recorder. Twelve 5-minute average values of each parameter are recorded on magnetic tape each hour with each tape containing approximately 2 weeks of data. The analog data acquisition systems provide a continuous trace for each parameter, and, because of the inherent stability of such equipment, serve as backup to the digital data acquisition systems. The non-continuous parameters (dustfall, corrosion, sulphation and suspended particulates) are recorded manually after laboratory analysis.

2.2 METEOROLOGY - AIR QUALITY - (Cont'd)

Quality control of recorded data is provided in the following manner. Recorded data are checked by computer for accuracy and consistency, and to determine that the data are within predetermined limits of meteorological and air quality reasonableness. Data points found to be outside of these ranges are manually evaluated from the strip charts and invalid records are replaced.

Another aspect of the quality control system consists of a programme of regular instrument calibration. Each of the continuous air quality analyzers is interfaced with an automatic calibration system which automatically checks the calibration of each analyzer every 24 hours, as well, monthly multipoint calibrations and adjustments are carried out on the air quality analyzers. The meteorological instruments are calibrated manually on a routine basis.

2.2.4 Epidemiology

(a) Primary Air Contaminant Data Sources

(i) Epidemiologic Studies

Epidemiological research is the primary vehicle to establish the human health effects response range. Epidemiologic studies are of two types: mortality excesses that occur in response to exposure to air contaminants, and morbidity studies which assess changes in disease patterns or exacerbations of existing disease in relation to changes in the concentration of ambient contaminants. These studies do not, however, yield unequivocal conclusions. This is due to the presence of multiple contaminants and variations in the concentration of each component which make it difficult to associate a health effect in a cause-effect relationship.

(ii) Clinical and Animal Toxicologic Experiments

In controlled human clinical experiments, good medical practice dictates that healthy adults be used rather than a more vulnerable cross section of the population. Of necessity, the dosages which are administered are low and the administration is restricted to relatively short periods of time, disimilar to natural conditions. These restrictions preclude examination of the interaction of multiple contaminants or multiple stresses such as temperature or humidity.

Animal toxicologic studies suffer from the deficiency that, at present, adequate animal models do not exist that relate animal exposure directly to human exposure. As a result, animal toxicological studies have been valuable for identifying harmful pollutants, but they have not been useful in developing guidelines to prevent adverse health effects.

(b) Trace Air Contaminant Data Sources

(i) Health Data Base

Human exposure studies have not been conducted at low contaminant concentrations. As a result, heavy reliance is placed upon animal toxicology studies and data collected during acute and subacute exposure episodes related to occupational scenarios. Data on the health of workers exposed to various contaminants usually does not contain precise contaminant concentration or length-of-exposure information. Also, the synergistic and antagonistic effects of multiple exposures are usually not taken into account in these studies.

(ii) Review of Existing Legislation Pertaining to Trace Contaminants

Existing ambient air quality objectives for trace contaminants, as established by the provinces of British Columbia, Alberta and Ontario, the Canadian Federal Government and the United States Federal Government, were reviewed. Standards for sulphates currently in force in California, Montana and Pennsylvania were assessed.

As a direct result of inadequate monitoring of contaminant concentrations and a lack of specific epidemiological studies, the development of specific regulations for trace contaminants in the ambient air has only occurred in the last few years. Thus, it is not suprising to find that the provinces of British Columbia, Alberta and the Canadian Federal Government do not have ambient air quality objectives for many of the trace contaminants under study. In Canada, only the Province of Ontario has ambient air quality regulations for trace elements. At this time, no limits have been established for sulphates, nitrates, nitrosamines and polycyclic organic matter.

(iii) Predicted Emissions and Ambient Concentrations

During test burn operations on Hat Creek coal 21 elements were analyzed in order to predict trace contaminant emission rates from the Hat Creek Project.[15,16] From this list of 21 elements, 14 trace contaminants were identified for epidemiological study due to their emission rate or their known adverse health effects. In addition, suspended sulphates and nitrates, polycyclic organic matter and nitrosamines were included due to their potential health effects. Potential ground level contaminant concentrations were calculated using a steady-state diffusion model calibrated to the atmospheric conditions of the Hat Creek Valley.[6]

2.3 WATER RESOURCES

2.3.1 Water Quality

(a) Introduction

The objective of the water quality analysis was to characterize the concentrations of surface water and groundwater constituents of the study area. This baseline was utilized to determine changes caused by Hat Creek Project activities.

2.3 WATER RESOURCES - (Cont'd)

(b) Data and Information Sources

(i) Groundwater

There are no existing groundwater quality data available for the Hat Creek Valley. Onsite monitoring provided all necessary baseline data.

(ii) Surface Water

Existing surface water quality data were available from the Ministry of the Environment in the Province of British Columbia,[1] the Department of Fisheries and Environment (DFE) NAQUADAT programmes[2] and a powerplant water requirements report prepared by Calgon Corporation for B.C. Hydro.[3]

(c) Field Investigation Methodology

(i) Groundwater

A. Programmes

Fig. 2.3-1 shows the location of sampling sites for the groundwater programmes. The frequency of sampling for the programmes and the analyses performed are listed in Tables 2.3-1 and 2.3-2.

All domestic wells (DW) in the upper Hat Creek Valley were identified (Fig. 2.3-3) and those not directly supplied from Hat Creek were selected for sampling. Five other sampling programmes were carried out to meet specific information needs. To assess artesian flows in the Hat Creek Valley, a number of test holes were selected for detailed analysis. To determine the hydrogeochemistry in the pit area, a well (Well RH 76-19) was sampled at a depth of 90 m, and a sample was obtained from a bucket auger hole. To assist in the definition of the groundwater regimes in the Medicine Creek area, in Houth Meadows and in the Hat Creek-Marble Canyon divide area, the water quality of several test wells was analyzed. Also, several wells were regularly sampled as part of the Bulk Sample Programme. Well locations (Fig. 2.3-2) were chosen to characterize water quality in spoil and coal storage.

Fig. 2.3-1 shows the location of the surface water sampling stations. Table 2.2-1 shows the sampling dates for the various planned programmes and Table 2.3-4 shows the parameters analyzed. The rationale for selection of sample stations was to place sites above and below the entry of major tributaries on the stream of interest.

B. Sampling and Analytical Procedures

Inaccessible domestic wells were sampled from the house tap after a flushing period. For each programme, samples were collected, preserved, stored and analyzed by standard methods and procedures.[6,7,8,9,10]

(ii) Surface Water

A. Programmes

Fig. 2.3-1 shows the location of the surface water sampling stations. Table 2.3-1 shows the sampling dates for the various planned programmes and Table 2.3-4 shows the parameters analyzed. The rationale for selection of sample stations was to place sites above and below the entry of major tributaries on the stream of interest.

Five additional surface water sampling programmes were initiated to assist specific studies. In the Pit Hydrology Study the intent was to delineate the groundwater composition in the proposed pit area. However, components of the data concern Hat Creek and Aleece Lake and have therefore been incorporated in the surface water section. Additional water quality data (Generation Site Study) were required to establish the suitability of various waters for process use and to help delineate groundwater flow regimes. Monitoring stations were established on Medicine Creek, MacLaren Creek and Pavilion Lake. To determine suspended solid loadings during the freshet period, a number of stations on Hat Creek and the Bonaparte River were selected and sampled daily during periods of the 1977 freshet (Freshet Study). Suspended solid concentrations and algal numbers in the Thompson River determined from samples taken at the Walhachin Bridge (located approximately 21.5 km upstream of the confluence of the Bonaparte and Thompson Rivers) delineated fluctuations of these parameters with reference to intake design. Three surface water stations were also established on Hat Creek In association with the Bulk Sample Programme (Fig. 2.3-2).

B. Sampling and Analytical Procedures

The sampling and analytical procedures used were selected from standard references.[6,7,8,9,10] Hat Creek and Bonaparte River samples were obtained at mid-width and in areas free from turbulence. The Thompson River was sampled 1-2 m from the stream bank. Lake samples for detailed analysis were obtained near the surface.

(d) Laboratory Test Methodology

(i) Introduction

Laboratory leachate tests were undertaken on representative samples of Hat Creek coal and waste materials to predict the quality of leachates under actual site conditions. Samples included three types of high-grade coal (coals A, B and C), low-grade waste coal, waste rock, overburden, fly ash and bottom ash.

(ii) Leachate Test Methodology

In order to determine the quantities of extractable salts in the samples, an accelerated test procedure was adopted.[11] The technique assists in the evaluation of total leachable salts present in the material in a short period of time compared with field experiments which may take many years. Analytical methods for all extracts conformed with standard procedures.[6,7,9]

A. Total Extractable Salts Tests

Three coal samples and eight waste material samples were tested in the laboratory to determine the total quantity of salts extractable by water. Each sample was crushed before testing to facilitate the extraction.

A pre-weighed, crushed sample was agitated for 20 minutes with deionized water and then centrifuged. The aqueous supernatant was decanted and the volume of the remaining slurry made up with fresh deionized water to maintain a water-to-solids ratio of 5 to 1 volume by weight. The procedure was repeated to produce a total of eight extracts which were combined and analyzed for the required parameters.

B. Rate of Release Tests

Three coal samples and four waste material samples were tested to determine the rate of release of water-extractable salts using a percolation column. Preliminary tests demonstrated that no leachate would percolate through very fine unscreened material. Samples were therefore screened and the 2.0 mm fraction was used for laboratory testing.

A pre-weighed quantity of sample was placed above a fibreglass plug in a glass column. A second fibreglass plug was placed above the sample and then deionized water was allowed to percolate through the sample. The leachate was collected at successive 24-hour intervals for 8 days. Individual extracts from the first 5 days of the test were analyzed for all required parameters. For certain parameters, the extraction during the first 24-hour period was so low that analysis of the remaining extracts was not undertaken.

2.3.2 Hydrology

(a) Introduction

Flow regimes and physical characteristics of the major groundwater and surface water bodies of the study area were delineated to assess hydrological impacts on Hat Creek Valley and to ascertain whether the potential impacts could be transmitted to other areas.

(b) Data and Information Sources

(i) Groundwater

The data used to define the groundwater regime were derived from existing reports[12,13,14,15,16], air photographs and also from previous field studies, including a drilling programme.

2.3 WATER RESOURCES - (Cont'd)

(ii) Surface Water

Data from 14 Atmospheric Environment Service climatic stations[17] within the Hat Creek general region were utilized in this study to define a number of water balance variables. Snow accumulation in B.C. is monitored by the Water Investigations Branch of the Ministry of the Environment.[18] Thirteen snow course stations which are located in the Hat Creek region were used to define this parameter. Water Survey of Canada flow records[19] for Hat Creek exist for three sites, which were utilized to ascertain the creek's flow characteristics. For the regional analysis, stream flow records from 85 stations located on the interior plateau of B.C. were analyzed. Floodplain mapping was based partially on aerial photographs taken in September 1976 and partially on field surveys. A wide range of other data, such as topographic maps, air photos and interviews with local residents, form part of the background material on which the surface water inventory is based.

(c) *Field Investigation Methodology*

(i) Groundwater

A. Field Reconnaissance

Field investigations concentrated on potential impact areas in the Hat Creek area and included the Fountain Creek Valley, the Hat Creek Valley and parts of the Cornwall and Oregon Jack Valleys (see locations, Fig. 2.3-3). The objectives of the investigations were:

1. Observe geological and other features which could provide evidence of zones of potential groundwater movement, groundwater discharge zones and groundwater recharge zones.

2. Collect water samples for inorganic chemical and isotope analyses.

3. Determine the location of residences and/or irrigated farm land where wells and developed springs may be located.

B. Interviews with Local Groundwater Users

The information provided by these interviews related to existing wells, springs and other groundwater related features such as seeps and minimum stream flows. Information on seasonal changes in flows and water use were particularly valuable.

C. Borehole Drilling Programme

Five boreholes were drilled in areas close to the proposed Houth Meadows and Medicine Creek waste dumps and the proposed ash pond in upper Medicine Creek Valley (see locations, Fig. 2.3-3). The purpose of these boreholes was to provide groundwater data in areas where potential groundwater contamination could occur. Boreholes were completed as permanent installations with piezometers for both water level measurements and groundwater sampling.

D. Water Sampling for Isotope Analysis

Water samples were collected from boreholes, springs, streams and lakes. Field sampling was designed to obtain a set of regional isotope values covering a variety of accessible ground and surface waters. These background values would provide an average isotope content for local groundwater recharge. To determine the origin of groundwaters, relationships between deuterium and oxygen-18 concentrations were defined. Tritium determinations were made in order to help identify different types of groundwater and to estimate the relative age of the water.

E. Water Level Measurements in Piezometers

The water depths were measured in a number of piezometers installed during this investigation, as well as in piezometers installed during geotechnical investigations in the vicinity of the proposed coal pit. The locations of these piezometers are shown in Fig. 2.3-3.

Piezometric data were used to determine the hydraulic head at various points and subsequently to determine the direction of groundwater flow. The seasonal change in the hydraulic potentials provided data on the recharge characteristics and hydraulic conductivity of the flow systems.

F. Installation of a Weir to Monitor Base Flows in Houth Creek

To determine groundwater base flows, a deep wooden rectangular weir was constructed in Houth Creek, approximately 300 m upstream from its confluence with Hat Creek. The weir was installed on 25 July, 1977 and flows were recorded to 20 October, 1977.

(ii) Surface Water

Field work related to surface water hydrology consisted of three main tasks:

1. Initial inspection of stream channels, lakes, lake outlet controls, irrigation diversions, bridges and culverts. This provided the basis for the detailed planning of the items below.

2. Flow measurements in tributaries to Hat Creek to relate their runoff regime to that of Hat Creek (for which data are available).

3. Channel surveys along typical reaches of Hat Creek downstreams of the proposed development, to serve as a basis for predicting changes in channel morphology.

Most flow measurements were made with a small propeller-type current meter. On several of the small streams monitored, permanent stream gauges are being installed by the Water Survey of Canada, acting on behalf of B.C. Hydro. The data collection periods of this study are listed in Table 2.3-5.

The hydraulic geometry of Hat Creek downstream of the proposed mine was defined by means of cross sections and profiles along typical reaches together with photographs and notes on all relevant morphological features. Water levels were observed at all surveyed cross sections in the Fall of 1976 and in May and June of 1977.

2.3.3 Water Use

(a) Introduction

A primary concern during the design of any new water-using facility is possible infringement on the operations of existing users. Impacts on existing facilities can occur from both water quality and quantity changes.

(b) Data and Information Sources

(i) Groundwater

There are no recorded sources of information on groundwater use in the valley. Unlike surface water development, the landowner is not required to apply for a permit for groundwater development. However, general information was provided through interviews with homeowners and water users in the valley.

(ii) Surface Water

A. Irrigation

The sources of information pertaining to the use of water for irrigation in the Hat Creek, Lower Bonaparte, Cornwall and Oregon Jack drainages were the following: provincial water license data obtained from the B.C. Water Rights Branch;[20] the Agriculture Report;[21] aerial photographs; the Fisheries and Benthos Report;[5] other reports,[22,23] which yielded information concerning potential storage reservoirs in the Hat Creek area; and flow probability curves and water chemistry data derived from the aforementioned baseline studies.

B. Livestock

The sources of information on livestock water use in the Hat Creek Valley were: the Agriculture Report,[21] yielding livestock populations; and a farm structures handbook,[24] providing information on livestock water consumption rates.

2.3 WATER RESOURCES - (Cont'd)

C. Domestic and Municipal

Information on present and potential surface water use for domestic purposes was obtained by examination of water license data,[25] existing and projected population estimates[26] and utilization of per capita water use.[27,28,29]

(c) Field Investigation Methodology

(i) Groundwater

Interviews were carried out with water users. No metered flows were available so estimates of water consumption were made.

(ii) Surface Water

Field work in this area was limited to the observation of irrigation practices in the area at various times during 1976 and 1977. Discussions with Hat Creek Valley ranchers on irrigation practices were also held. Livestock, domestic and municipal water use studies did not require field work.

2.3.4 Aquatic Ecology

(a) Regional

For the purposes of this study, the aquatic environments affected by the project were divided into those located in the vicinity of the site and those in the larger surrounding region. Impacts to the regional aquatic environments would primarily be those related to air contaminants. Boundaries selected to define the region reflect this mode of impact. Thus, boundaries in the direction of the prevailing air movements are more distant from the site than are boundaries up-wind of the site. Regional impacts, if any, would tend to occur after several years of plant operation, over a broad geographic area.

(b) Site-Specific

(i) Thompson River

Baseline information to assess the potential impact to the Thompson River was available in both published and unpublished forms. This was largely a result of concern by governmental organizations because of the river's importance to migratory fish populations.

2.3 WATER RESOURCES - (Cont'd)

(ii) Other Aquatic Environments

Inadequate information was available on the aquatic environments in the immediate site area. Therefore a detailed study of the benthos and fish near the Hat Creek site was sponsored by the B.C. Hydro and Power Authority and performed by Beak Consultants Limited.[5] Field reconnaissance trips were also made to the proposed road and pipeline crossings.

Water bodies other than the Thompson River which could be affected by development of the Hat Creek site include Cornwall Creek, MacLaren Creek, Harry Lake, Finney Lake, an unnamed pond in Hat Creek Valley southwest of the proposed pit-rim dam, Aleece Lake, Hat Creek and its tributaries and the Bonaparte River. Field studies conducted on these water bodies focused on the fish, benthos, and a characterization of the physical habitat. Fish were chosen for study because of their direct value to humans and because they occupy the highest aquatic trophic level. They also provide an indication of the productivity of other trophic levels. Benthic organisms were studied because they provide fish food, especially for salmonids and because they are extremely important in lotic systems where allochthonous input (dedrital contributions originating from the watershed) is often the major source of energy and nutrients.[30,31]

The study effort expended on each aquatic environment depended upon on the degree to which each would be perturbed by the development. Thus, Hat Creek, which would have its channel relocated and would receive discharges from site runoff and the coal mine, and the Bonaparte River, into which Hat Creek flows, were studied more intensively than other water bodies.

A. Habitat

Physical habitat surveys of Harry Lake, the unnamed pond, Cornwall, upper Medicine and MacLaren creeks were performed on 22-23 September, 1977. Water depth, stream width, bottom-type and riparian vegetation were described.

The more intensive sampling programme was also initiated in September, 1976. Additional samples were taken in June, 1977 and August, 1977. Sampling was performed at 18 stations in the vicinity of the Hat Creek site (Fig. 2.3-4). Four stations were located on the Bonaparte River (numbers 1-4), seven stations on Hat Creek (5-7, 10, 14, 14a, 15) and one each on an unnamed creek (8), Finney Creek (9), Medicine Creek (11), Ambusten Creek (12), Anderson Creek (13), Goose/Fish Hook Lake (16), and Finney Lake (17). Finney Creek at station 9 was subterranean and never sampled. The four creeks named are tributaries of Hat Creek.

A quantitative assessment of the physical habitat was made in September at all Hat Creek and Bonaparte River stations except numbers 1 and 14a. Six transects across each water body were established at 3 m intervals at each of these stations, except stations 2 and 3, where only single transects were established. At 0.6 m intervals along each transect, measurements of river depth and velocity were made, except at station 2 where these measurements were made at 1.5 m intervals. Stream velocity was determined at 80 percent of the river depth at the points of measurement. Within a 15.2 m section of stream at each station, the relative occurrence of boulders (30.5 cm), pebbles (7.6-30.5 cm), gravel (0.3-7.6 cm), silt (0.3 cm), and other substrates (logs, etc.) was determined. The ratio of pool to riffle environments, temperature, riparian vegetation, and a qualitative assessment of bank stability were also made for a 15 m section of stream at each station. Attempts at station 1 to obtain data similar to that obtained at the other stations were precluded by deep, swift water. Visual estimates of the various parameters were made from the stream bank.

Physical habitat at tributary sampling stations (numbers 8, 11, 12 and 13) and at Hat Creek station 14a was assessed in a more qualitative manner. Substrate size ranges, stream width, stream depth, pool to riffle ratio, and stream velocity were estimated rather than measured. For example, stream velocity was categorized as either sluggish, rapid or torrential. At the two lake stations (numbers 16 and 17), depth and substrate were estimated and notes concerning aquatic vegetation were taken.

A helicopter survey of those portions of Hat Creek and the Bonaparte River covered by the sampling stations was also made. Pool to riffle ratios, stream substrate, bank stability, riparian vegetation and beaver dams were noted to the extent that they could be observed from the air.

Physical habitat assessments at all stations in June were restricted to qualitative observations similar to those at tributary stations in September. At Hat Creek and Bonaparte River stations, however, stream velocity was estimated by timing floating objects. No observations were made at Lake stations. No observations were made at Ambusten Creek since it had been diverted for irrigation. A helicopter survey was conducted similar to the one in September. The physical habitat survey in August was identical to the one conducted in June, except that no helicopter survey was made. The chemical aspects of the various aquatic habitats were also measured. Water samples were taken at twelve stations (Fig. 2.3-2), and analyzed for a variety of constituents. In addition, dissolved oxygen concentrations were determined at the time of sample collection. Samples were taken in September and December, 1976, and March and May, 1977. Other water quality samples were taken as part of a hydrology study, a generation site study, and certain special collections. The methodology and sampling design for the water quality sampling programme are discussed in detail in Section 2.3-1.

B. Benthos

Sampling for benthic invertebrates was conducted during September 1976 and June and August, 1977 using the same stations as for habitat surveys except station 14a. Six samples were taken at each station. A ponar grab, which sampled a bottom area of 523 cm^2, was used to take benthic samples at the lake stations (16 and 17). All other stations were sampled with a Surber sampler, which samples a bottom area of

929 cm^2. Samples were washed on a 545 μ mesh screen. The retained material was stored in a solution of 10 percent formalin and rose bengal. In the laboratory, samples were sorted, identified, and enumerated. Identification was to general taxonomic group. Organisms from one randomly selected replicate from each station were identified to genus and species when possible. If less than 100 organisms were found in a single replicate, an additional replicate was subjected to the detailed identification procedure.

C. Fish

Fish were sampled by electroshocking at all Hat Creek and Bonaparte River stations, at the mouth of Medicine Creek and at Goose/Fish Hook and Finney Lakes (stations 16 and 17). In addition, tributary streams were visually surveyed for fish. Sampling and surveys were performed in September, 1976, and June and August, 1977. In Hat Creek, a 3 mm square mesh net was used to block the upstream end of the zone to be shocked. Shocking was performed in an upstream direction. Shocking time, length and width of stream section shocked were recorded. Shocking was performed in a similar manner in the mouth of Medicine Creek, but a natural barrier obviated the need for netting. Shocking in the Bonaparte River was limited to near-shore (within 2 m) shallow areas.

All captured fish were identified, measured, and weighed. Sex, parasites, and unusual conditions were noted. Stomachs and 20 scales were removed from up to 10 mountain whitefish, and up to 10 rainbow trout in the size categories 0-100 mm, 101-200 mm, and 200 mm (when specimens were available) at stations 1, 3, 4, 5, 6, 7, 10 and 14. All other fish were released after field measurements were taken. Pool to riffle ratios in the area being shocked were also noted.

Scales from each fish were placed in a numbered envelope and were independently examined in the laboratory by two individuals with a Bausch and Lomb Tri-Simplex Micro-Projector at a magnification of 45x. If age estimates by the individuals were in disagreement, a third measurement was made. If this did not resolve the disagreement, the scales were not used.

Stomachs were wrapped in gauze, numbered, and preserved in 10 percent formalin. In the laboratory, stomach contents were identified and volume determined by water displacement to the nearest 0.01 ml. Food items with volumes less than 0.01 ml were recorded as having a volume of 0.01 ml.

A fyke net with a 6.3 mm square mesh body and 12.7 mm square mesh leads and wings, measuring 12.2 m and 2.7 m long, respectively, was used to sample fish in Finney Lake. The net was set perpendicular to the shore in water 1-2 m deep.

2.4 LAND RESOURCES

2.4.1 Introduction

Several consultants were responsible for the design and implementation of the baseline data acquisition programmes. Physical habitat and range vegetation were investigated by the TERA Environmental Resource Analyst, Ltd. (TERA).[1] Soil data were compiled by Canadian Bio Resources Consultants (CBRC)[1]. Wildlife data were collected by TERA, with the exception of data on big game mammals which were compiled by L.R. Erickson and Associates.[2] Forest inventories were prepared by Reid, Collins and Associates, Ltd.,[3] and the agricultural inventory by CBRC.[4]

The approach employed by each consultant was to gather information from a regional, local and site-specific perspective. In this manner the degree of detail was increased as the scope of the studies focused upon the immediate project site. The regional study area was identical to that defined in the B.C. Hydro Terms of Reference. The local study area was defined by an arbitrary boundary extending 25 km from the centre of the project site. The area referred to as site-specific includes the upper Hat Creek Valley and the proposed access routes to the Thompson River. The study areas are depicted in Fig. 2.4-1.

The level of detail afforded to each study area varied as a function of its importance to the entire project. The methods presented in this report are those needed to compile data important to the proposed development and appropriate to a summary document.

2.4.2 Physical Environment

(a) Study Approach and Rationale

Climate, landforms and soils were selected as the descriptive components of the physical environment, because they influence the distribution, abundance and composition of flora and fauna. The approach was basically comparative in nature. Physical components, described in general terms for the broad region, were compared to detailed descriptions of land areas within the immediate vicinity of the project.

The parameters used to describe climate include precipitation, humidity, temperature and number of sunlight hours. All of these parameters are discussed from a regional and site-specific perspective except insolation (sunlight) for which site-specific data were not available.

Landforms were described on the basis of physiography, slope and relief, bedrock geology and surficial geology. Physiographic aspects were discussed from both regional and site-specific perspectives. Slope was divided into two broad categories; steeplands having greater than 30 percent slope and bottom and uplands having less than 30 percent slope. Bedrock and surficial geology were also discussed from each perspective. Bedrock forms the foundation and source material for soil development, hence is an important factor in describing vegetational patterns on a broad scale.

Soil information was compiled at three levels of detail. Soil orders were identified in the region of the project, soil associations for a 25 km radius around the project site and soil series or modified soil series, depending on the type of information available, were identified in close proximity to the project site.

2.4 LAND RESOURCES - (Cont'd)

(b) *Data Sources and Analysis*

(i) Climate

Climatic data have been recorded at both the Atmospheric Environment Service (AES) monitoring stations and the B.C. Hydro mechanical weather station network in the Hat Creek Valley. This data as assessed and summarized by Environmental Research and Technology, Inc. (ERT)[5] was utilized in this analysis.

(ii) Landforms

Physiographic subdivisions within the regional area were identified from a report on the provincial physiography.[6] Soil mapping[7] correlated with aerial photograph interpretation was also utilized in the determination of physiographic subdivisions and landform categories. A brief aerial and ground reconnaissance was conducted for the purpose of field checking physiographic boundaries.

The description of the regional bedrock and surficial geology was derived from published sources.[8-12] Additional information was obtained from interpretation of aerial photography. Bedrock and surficial geological descriptions of the Hat Creek area were based upon information presented in the literature[13,14] and from a more recent report[15] developed as part of the Detailed Environmental Studies.

(iii) Soils

Regional soil orders were described by grouping the existing soil association information[7] into soil order units.[16] Soil association information on a local scale was derived from provisional mappings[7] and a modified mapping prepared by the government of British Columbia. Soil series data for the portion of the site area in the Thompson and Bonaparte River valleys were obtained from a published study.[17] Modified soil series information was summarized from aerial photograph interpretation and field inspection. Aerial photographs were used to identify and map major physiographic units. Two to three random field inspections per physiographic unit verified the boundaries of the units.

2.4.3 Natural Vegetation

(a) Study Approach and Rationale

(i) Vegetation Description

The Krajina[18,19,20] approach was employed to describe the vegetation indigenous to Hat Creek and the surrounding region. This approach is appropriate to studies where the vegetation of extensive land areas is to be described. It utilizes several successive levels of integration, each providing a greater degree of information than the preceding. Vegetation associations coupled with forest cover types were used to describe the vegetation from a local or site perspective.

2.4 LAND RESOURCES - (Cont'd)

(ii) Biophysical Analysis

The biophysical analysis method described by Lacate[21] was used to define resource sensitivities of selected areas. The biophysical method involved mapping and interpretation of physical and biological parameters. It culminates in the identification of homogenous units or subunits where environmental components are not identified individually, but as integrated systems.

(b) Data Sources and Analysis

(i) Regional Vegetation Descriptions

The regional vegetation description was presented in terms of biogeoclimatic zones. It was based primarily on a single published source[22] and supplemented with field observations. Observations made during the course of other investigations[23-26] in the British Columbia interior were also utilized in the development of regional vegetation descriptions.

(ii) Project Site Area Vegetation

Vegetation descriptions of the Hat Creek Project site area and environs are presented as vegetation associations and forest cover types. These were developed from field reconnaissance and sampling programmes.

A. Field Reconnaissance

The field reconnaissance phase of the project site vegetation programme was used to acquaint field personnel with the sampling area and associated vegetation patterns. During this phase homogenous vegetation associations within the area of the proposed development were selected for quantitative field sampling.

B. Field Sampling

Replicate plots 10 m^2 in area were laid out within each subjectively chosen homogeneous stand.[1] The number of plots was dependent upon the complexity of the vegetation and the stratification within each stand. A total of 90 plots were located throughout the Hat Creek area, most within 25 km of the plant site. Initial sampling was conducted during the fall (20 September -31 October) of 1976 with supplemental sampling late spring of 1977 (May) to ensure that spring ephemerals were sampled.

Physical data, such as slope, elevation, aspect, soil type and topography were recorded for each 10 m^2 plot. The vegetation within each plot was stratified by layer. Species cover as well as total cover were estimated for each strata. Data from replicate plots were compared and reduced to a form suitable for production of the vegetation association descriptions.

Data collected during the field sampling programme were analyzed using a Krajina adaptation of the phyto-sociological techniques developed by the Zurich-Montpellier School.[27] Similar vegetation groups coupled with environmental factors were progressively clustered visually and tabulated.[28] Mean species cover and vegetation strata were used as the major criteria to differentiate and group the field data into vegetation associations. Vegetation associations and forest types were then mapped for the area within 25 km of the plant site.

(iii) Biophysical Analysis

The biophysical analysis employed two levels of integration, the biophysical unit and subunit. Biophysical subunits were developed by integrating climate, landforms, soils and vegetation inventory maps to produce homogenous units. The subunits found within the same biogeoclimatic zones were lumped together forming biophysical units. Any environmental limitations were identified for each unit and the information recorded in tabular format. Resource capabilities for wildlife, forestry and agriculture were then evaluated for each biophysical subunit.

2.4.4 Wildlife

(a) Study Approach and Rationale

The purpose of this study was to determine the status of the wildlife resource in the vicinity of the proposed Hat Creek development. The potential wildlife value of the region and the direct usage of wildlife were also assessed.

The regional study area was identical to that defined in the terms of the reference. The Hat Creek watershed is a natural unit used to report wildlife inventory and usage data and is essentially similar to the local study area used by the other disciplines in the Land Resources Section. It was divided into two zones: the upper Hat Creek watershed (or valley) and the lower Hat Creek watershed (or valley). The study area boundary map (Fig. 2.4-1) shows the study area relationship to the plant and mine site.

(b) Data Sources and Analysis

The primary wildlife resource document used in the preparation of this section was the *Detailed Environmental Studies Land Resources Subgroup, Wildlife Report.*[2]

(i) Major Wildlife Habitat

Most wildlife data have been reported according to the habitats in which wildlife species were observed. Therefore, wildlife habitats were identified from maps of the existing vegetation associations. The wildlife habitat areas differ from the vegetation association areas in two respects:

1. Two or more similar vegetation associations were often lumped into one wildlife habitat unit.

2. Adjustments were made for habitats in which existing vegetation differed from the dominant or climax vegetation.

Wildlife data were collected in all major defined habitats (Table 2.4-1).

(ii) Big Game

The majority of big game species information was derived from published sources. Data on local big game winter and summer ranges and known wildlife migration routes were obtained through personal communications with local experts. Canada and British Columbia Land Inventory Maps[29-32] were used to define ungulate use capabilities in all study areas.

The published data were supplemented by a reconnaissance field trip between 27 July and 3 August 1976 for the Hat Creek Valley, Pavilion and Kelly Lake areas. A summer range aerial survey was undertaken on 17 September 1976 of the known California bighorn sheep ranges on Marble and Shulap Ranges, Yalakom Mountain and Slok Hill. A pellet group transect survey was conducted during the week of 16 to 20 May 977. Vegetation map units identified and described for the local study area[1] were reviewed for their potential as big game range, based on plant species composition, elevation and aspect. Two pellet group transects measuring 152 m long and 3.1 m wide were established in each of nine units selected as potential big game range.

Animal observations and track abundance from British Columbia Land Inventory field maps and notes,[29-34] the B.C. Hydro and Power Authority 1976 aerial survey[35], the B.C. Fish and Wildlife Branch 1975 ground survey in the study area[36] and a 1978 helicopter survey by B.C. Hydro and the B.C. Fish and Wildlife Branch formed the basis of the available data on ungulate winter distribution. This information, in conjunction with a literature review, information solicited from local sources, B.C. Fish and Wildlife Branch, Cache Creek hunter kill data,[37,38] and the results of the pellet group survey provided the basis for the big game input into the biophysical classification system.

(iii) Upland Game Birds

Information concerning upland game birds was derived from published data, personal communication and direct survey. The direct survey was conducted on 26 and 27 April 1977 in the upper Hat Creek and Medicine Creek Valleys. The numbers and species of game birds seen or heard during a 6-minute period at each sampling station were counted. A total of 40 stations, 10 each in Riparian, Ponderosa Pine - Douglas-fir - Bunchgrass, Open Range, and Douglas-fir - Pinegrass habitats were surveyed.

(iv) Waterfowl

A. Resource Inventory

Existing information regarding distribution and numbers of waterfowl in the upper Hat Creek Valley was derived from investigations initiated by Ducks Unlimited and by the B.C. Fish and Wildlife Branch.[39,40] Original Ducks Unlimited data from investigations in 1975 and 1976 were also obtained and utilized in estimating waterfowl populations. Additional breeding waterfowl data were gathered as part of an overall breeding bird survey from 6 July 1976.

During migration, single waterfowl index counts were taken during aerial surveys conducted on 16 September 1976 and 28 April 1977. Additional information regarding species presence and relative abundance was gained from ground surveys conducted in September 1976, and April and May 1977.

B. Wetland Inventory

An inventory and classification of waterfowl habitat in the Hat Creek site area was undertaken. Air photo interpretation verified by ground observations coupled with Ducks Unlimited data, was used to map, classify and count wetlands. Relative accuracy of the breeding waterfowl survey was then assessed and the capability of habitat to support waterfowl was evaluated. The regional perspective was obtained from published land capability data.

An attempt was made to classify wetlands through aerial photograph interpretation, according to the system proposed by Stewart and Kantrud.[41] Strict application of this classification system was not possible on all air photographs and a compromise system was derived. Each wetland was mapped and categorized. Wetland areas and circumference of edge were estimated by an elliptical approximation method.[42]

Physical parameters of 17 wetlands chosen to represent the range of wetland types within the upper Hat Creek Valley were sampled.[2] In each wetland, data regarding appearance of vegetation, depth, water profile and soils were recorded. The pH and specific conductivity were measured in each wetland using narrow-range pH paper and a radiometer conductivity meter.

(v) Birds

Distribution and seasonal bird status data were gathered from the literature.[43-52] Records of birds sighted in British Columbia were searched for species of special interest, such as rare or endangered species and raptors. Discussions were held with local experts, but most information was derived from field observations.

A breeding bird survey was conducted from 3 to 6 July 1976, using a modification of the procedure used by the official North American Breeding Bird Survey.[53-55] Birds were counted and identified at 0.4 km intervals and by recording observations by habitat along predestined routes. Three-minute counts of birds were taken at 20 stations in each of five habitats: Open Range (low and mid-elevation grassland), Riparian, Aspen, Ponderosa Pine - Douglas-fir - Bunchgrass and Douglas-fir - Pinegrass.

(vi) Furbearers

Harvest data from registered traplines and discussions with B.C. Fish and Wildlife biologists were utilized to estimate relative abundances of furbearing species. Trapping done by status Indians is not recorded by the B.C. Fish and Wildlife Branch and is not included in this analysis. Total furbearer harvest information for the province of B.C. was obtained from provincial records.[56]

(vii) Small Mammals

The census programme for small mammals was undertaken from 2 September to 28 September 1976. Small mammals were marked and recaptured. On the basis of the recapture data, estimates of relative abundance for each species captured were established.

Fifteen live-trapping plots were established; three in each of the following five habitats: Open Range, Ponderosa Pine - Douglas-fir - Bunchgrass, Riparian, Aspen and Douglas-fir - Pinegrass. Live-trapping plots consisted of Longworth traps set 10 m apart in seven rows of seven traps. A grid of four rows of 12 traps was used in areas where a 7 x 7 grid would have extended out of the sampled habitat and into surrounding habitat (three Riparian plots and one Aspen plot).

The traps were set for a total of 5 days in each plot. Traps were checked each morning. Mammals were individually marked by toe clipping, fur clipping or some recognizable pattern. All other mammals observed on the plots, but not trapped were counted and recorded. Since reliable regional data regarding species' home range size and trappability were not available, relative abundances of small mammals were based on the minimum number known alive in each trapping grid area.

(viii) Consumptive and Nonconsumptive Use

The term "game animals", as used in this report, refers to species for which hunter licenses are required in British Columbia and is further classified into big game, game birds and furbearing animals. Wildlife resource use is considered under the headings of consumptive and nonconsumptive.

A. Consumptive Use

Big Game

General resident hunting was analyzed within boundaries of Game Management Areas 4, 14 and 15. Data were assessed by reviewing the B.C. Fish and Wildlife Branch survey information for the period 1970 to 1974, inclusive. Resident hunting within the project locale was analyzed using statistics from the Cache Creek check station for the years 1969 through 1974. Nonresident hunting was assessed on the basis of hunter returns filed with the B.C. Fish and Wildlife Branch by guide-outfitters operating in Game Management Areas 4, 14 and 15 from 1970 to 1974.

Waterfowl and Upland Game Birds

Consumptive use of waterfowl was estimated using B.C. Fish and Wildlife Branch Hunter Survey questionnaire results, Cache Creek check station returns,[38] and Canadian Wildlife Service species composition surveys. These sources of information differ in terms of area covered and the way in which data were collected. For the purpose of game bird hunting, information from Game Management Area 14 only was included in the analysis.

Furbearers

The consumptive use of furbearers in the regional study area was determined by examining trapping returns on file with the B.C. Fish and Wildlife Branch. These records were searched for all registered traplines within the regional study area and within the jurisdictions of the Kamloops, Merritt, Lillooet and Clinton conservation offices for the 1971-1972 to 1975-1976 trapping seasons inclusive, with all harvest information use recorded. The results represent a complete tally of all fur legally taken within that time period and area except that taken by status indians.

B. Nonconsumptive Use

Nonconsumptive wildlife use was estimated from information regarding wildlife concomitant with other recreational pursuits. The prime sources of ornithological recreation activity were the nest record cards and the sight record cards on file in the B.C. Provincial Museum.

Rare and Endangered Species

The list of rare or endangered terrestrial vertebrates within the study area were based on compilations of the Canadian Wildlife Service, National Museum of Canada, Canadian Wildlife Federation and the International Union for Conservation of Nature and Natural Resources.[57-62]

2.4.5 Forestry

(a) Study Approach and Rationale

(i) Forest Resources

The study employed a comparative approach whereby data were collected from regional and local study areas, each providing greater detail with increased focus on the actual plant and mine sites. The definition of the regional study area is identical to that described in the terms of reference[63] and includes approximately 23 358 km^2 of land area. The local study area is defined as a 25 km radial circle centered on Harry Lake and encompasses 1963 km^2.

(ii) Insect and Disease Survey

The forest resources of an area are subject to many deleterious agents which degrade the quality of the resource. Insects, diseases, fires and industrial air emissions are but a few of the agents which can have a negative effect on the quality of the forest resource. Insect and disease symptoms can, in most occurrences, resemble or mimic symptoms of exposure to air emissions from fossil fueled facilities. Thus, it is important to identify baseline insect and disease conditions prior to operation of fossil fueled facilities in order that future injury symptoms be attributed to the causal agent.

The approach incorporated both historical and present status information. In contrast to the previously defined study areas, the occurrence of major forest insect pests was identified in an area bounded by 70 Mile House to the north, Ashcroft to the east, Lytton to the south and Lillooet to the west. Seven of the most frequently occurring insects were chosen for closer investigation which included a review of the present status within the vicinity of the Hat Creek Project.

(b) Data Sources and Analysis

(i) Forest Resources

Regional inventories were based solely upon information derived from published survey reports[64-71] for each public sustained yield unit (PSYU) found in the regional, and local study areas. In the context of local area descriptions, the unit survey reports were used solely in the calculation of mean annual increments (MAI).

A. Regional Study Area

The forest resources within the region were described on the basis of forest stands, access, disposition and industries. The published survey reports[64-71] were used to calculate area summaries for crown controlled land. Volumes for each PSYU, which were based on close utilization standards (18 cm + dbh, less decay), were derived from crown forest land volume averages. Area and volume data for privately managed land were obtained from the owners. In all cases, the portion of a PSYU within the boundaries of the regional study area was prorated. The annual allowable cut (AAC) for each PSYU was obtained from published inventory statistics.[69] The accuracy of these statistics was confirmed by the Resource Planning Division of the B.C. Forest Service.[72] Listings of established licenses were obtained from the Kamloops and Cariboo district offices of the B.C. Forest Service. Employment and production statistics of the forest industrial plants for 1975-1976 in the Hat Creek region were determined via telephone surveys of each plant.[73] To supplement this data, 1975 and 1976 production statistics for sawn lumber, plywood and pulp were extracted from recently published economic data.[74]

B. Local Study Area

Forest cover type maps[75] with the associated map area and volume summaries[76-78] were the primary sources used to compile area and volume data by forest types (mature, immature, residual, not satisfactorily restocked and non-commercial cover) for the local study area. Seven productivity categories (good, medium, poor, nonproductive, open range, alpine and cleared) were also identified from the forest cover type maps and summarized to produce a site quality map of the local study area. The mean annual increment (MAI) was converted to an all-inclusive MAI to obtain an estimated allowable annual cut (AAC) for the portions of each PSYU in the local study area.

(ii) Insect and Disease Survey

Information used in the preparation of a baseline insect survey was derived from published records of the Forest Insect and Disease Survey of Canada.[79] This information was supplemented with two reconnaissance flights of the Hat Creek Area conducted during May and August 1976. These two reconnaissances concentrated on the vicinity of the proposed project as well as the surrounding region.

2.4.6 Agriculture

(a) Study Approach and Rationale

The data collected for this effort describe both natural and anthropogenic components. Natural parameters investigated were climate, topography, soil and range vegetation. Anthropogenic components of the agricultural system include land use patterns, agricultural practices, farm and ranch characteristics, market conditions and government policies and programmes. In the agriculture study the site-specific study area was expanded to include the Hat Creek Valley watershed.

(b) Land Capability

Agricultural capability of land is measured as the range of crops which can be supported on a particular land unit. It is largely a function of climatic and edaphic factors and is analyzed in each of the study areas with reference to three broad capability categories: high capability, which can support crop plants; low capability, which can support range plant species; and predominantly nonagricultural land.

(i) High Capability Land

High capability lands are those portions of the regional study area where a wide range of crops and/or hardy cereals and vegetables may be grown (with irrigation). They were defined as Land Capability for Agriculture Class 1-4 on Canada Land Inventory (CLI) published and provisional maps. The CLI land capability classification scheme consists of seven ranked classes developed from analysis of edaphic, climatic and landform features. The classes refer to the range of crop types capable of growing on a particular land and not to crop productivity. Classes 1-3 are considered to be capable of growing a wide range of crops. Classes 4 and 5 denote areas largely restricted to forage production and grazing, while Class 6 consists of native grazing land. Class 7 has no agricultural capability at all. It should be noted that a mapped capability unit sometimes carries two CLI class ratings; an improved rating whereby the capability is determined assuming there is irrigation and/or drainage improvement; and an unimproved rating, whereby the capability assumes no such improvements. High capability land of the local study area was defined as CLI Land Capability Classes (improved) 1 through 5. The area thus delineated essentially includes all irrigable lands. High capability lands of the site-specific area were analyzed in greater detail utilizing soil data from the provincial soil survey[80] and a field survey conducted by CBRC staff.[81] The methodology of the soil survey is summarized in Section 2.4.2.

The analysis of climatic influences on agricultural capability was performed utilizing the climate capability for agricultural maps and publications prepared as part of the CLI programme. These maps (1:125 000) represent one of several considerations incorporated into the CLI agricultural capacity classification of Canadian lands. The CLI ranked climate capability classes range from Class 1, which refers to climatic regimes supportive of the widest range of crop types, to Class 7, indicating climatic extremes which preclude agriculture. For approximately 15 percent of the regional study area where neither published nor provisional (less detailed than published efforts) climate capability for agriculture maps were available, information relevent to the area was obtained from 1:3 500 000 climatic maps prepared by the Geography Department of the University of British Columbia.[82]

(ii) Low Capability Land

Low capability lands were defined as areas where agricultural activity is restricted to grazing and were broadly identified in the regional study area from a map of biogeoclimatic zones originally constructed by Krajina.[22] From analysis of forage suitability of characteristic grass species, three of the six zones occurring in the regional study area were determined suitable for cattle grazing: Ponderosa Pine - Bunchgrass, Interior Douglas-fir and Cariboo Aspen - Lodgepole Pine - Douglas-fir.

Low capability lands of the local study area consist of those areas classified in the CLI land capability for agriculture scheme as Classes 6 and 7, which include range land and nonagricultural land. This area was analyzed according to a tentative classification of land capability for grazing developed by the Soil Survey Division of the B.C. Department of Agriculture.[83] While the Hat Creek basin locale has not been mapped for range capability, provincial Soils Branch personnel have assigned range capability classes to each soil and landform unit delineated on the provincial soil and landforms map of this area. In this system, Class 1 areas have "no important limitations to growth of native forage plants" and Class 5 areas have "severe limitations" to native forage plant growth. The detailed analysis of project site agricultural capability utilized a vegetation map (1:50 000). Vegetation associations occurring in areas of the site not considered as high capability land were evaluated for range capability and productivity.

(c) Productivity

Data on crop yields currently achieved in the study areas were obtained from B.C. Department of Agriculture documents including Production Data Information sheets[84] and Producers; Consensus Costs and Returns.[85] These data were supplemented by consultation with local farmers.

Range productivity data were obtained to permit analysis of current carrying capacities and differences between these and potential levels that may be achieved with good management practices. The variability of range management practices as well as of natural factors (soil, topography and climate) were addressed through examination of several information sources.

The current carrying capacity of local study area rangeland was derived from two sources, B.C. Forest service grazing permit allotments (Kamloops District Office) and a 1969 Forest Service grazing map.[86] The first source was utilized by dividing the areal extent of a particular permit unit by the corresponding number of animal unit months (AUM, where animal unit refers to one 454 kg steer or a cow with calf) allotted to the unit by the Forest Service in 1977. Presumably allotments are dynamic, reflecting current status of forested sections of permit land yet in accord with long-term protection of range resources. For nonpermit grazing lands, comprising approximately one-third of the LSA rangeland, carrying capacities for various vegetation cover types were extracted from the 1969 Forest Service map.[86]

An estimate of cattle numbers currently supported by the Hat Creek Valley was developed through assessment of each of the three feed resources: irrigated valley lowlands, lower-elevation spring grazing lands and higher-elevation summer rangeland. The irrigated valley lands are cropped for hay, which must meet feed needs over the 6 winter months. Hay yields were estimated for each of three general soil conditions.[81] Forage productivity of spring pasture and summer range was derived[85] for each vegetation association as defined in Section 2.4.2. Translation of forage yields into corresponding number of cattle capable of being supported, was achieved with the following assumptions: 55 percent utilization of forage (if exceeded, could lead to long-term deterioration of range productivity); a forage requirement of 300 kg per AUM; and accessibility of the entire range to cattle.

Carrying capacities potentially achievable in the local study area with good range management were extrapolated from estimates of palatable native forage production.[85] The forage yield estimates relate to the five provincial tentative grazing capability classes (see Section 2.4.6(b)(ii), Low Capability Land) and were derived from "measurements of undisturbed native forage in grassland areas and under well stocked lands". Extrapolation to cattle carrying capacities corresponding to the various grazing classes incorporated the three assumptions noted previously.

A second estimate of cattle carrying capacities potentially achievable in the Hat Creek watershed excluding land capable of supporting irrigation agriculture, was derived from data sources other than those previously reported.[85] In this second approach, potential carrying capacities were identified for each vegetation association, for both well stocked and recent clearcut conditions. The basis for assignment of carrying capacity estimates was based on range management publications[87,88] and consultation with staff of the Agriculture Canada Kamloops Research Station.

(d) Agricultural Land Use and Practices

The agricultural land within the project study area was identified through provincial publications, aerial photographs, site observations and interpretation of land ownership patterns and government policies regarding Crown holdings. Land use information for the regional area was obtained from census data referring to the Thompson-Nicola Census Division, boundaries of which are delineated on Fig. 2.4-2. For the local and site analysis, use patterns were identified from interpretation of aerial photographs (1:24,000) taken in September 1976; published present use maps;[89] B.C. Ministry of Agriculture and Ministry of Environment Reports;[90,91] and land tenure patterns. Land tenure patterns were analyzed for identification of rangeland, assuming cattle grazing essentially occurs on Crown lands administered under grazing lease or permit.

2.4.7 Cultural Heritage Resources

(a) Phase I Inventory Methodology

The purpose of the Phase I Cultural Resource Study,[92] conducted by personnel of the Department of Anthropology and Sociology of the University of British Columbia, was to describe the cultural heritage resources of Hat Creek Valley. The work was done under the auspices of the office of the Provincial Archaeologist and contracted by B.C. Hydro in 1976. The 1976 study area consisted of 90.4 km^2 of valley bottomlands and adjacent forested slopes. A stratified random sampling programme with replacement was used. Possible sampling units, each 400 m by 400 m placed north-south and eastwest, called quadrats, were created. Each was classified as either "grassland" or "forest" by the predominant vegetation in the quadrat. Using this criterion of vegetation, the study area was divided (stratified) into 331 grassland quadrats (the grassland stratum) and 234 forest quadrats (the forest stratum) as shown on Fig. 2.4-3. A total of 44 quadrats, 32 for the grassland stratum and 12 for the forest stratum, were selected by random sampling with replacement for field investigation. These quadrats, containing an area of 7.0 km^2 or 7.8 percent of the study area, were then designated for intensive inventory.

Intensive field work to inventory the cultural resources in each quadrat consisted of complete surface observation by field crews of 4-6 members approximately 10 m apart moving in parallel lines, from one edge of the quadrat to the other.

All archaeological "sites" and isolated artifact locations were recorded. An archaeological "site" was defined as the location of past human activity that left meterial remains with an artifact density of six items or more within a 4 m^2 area and/or that left recognizable manipulations or changes of the surface (such as depressions, rock cairns or burnt rock middens).

An artifact "location" was recorded for the presence of a number of items fewer than the arbitrary six items per 4 m^2 area. Items recovered at sites and artifact locations included chipped stone projectile points, ground stone tools, tools fashioned on stone flakes, stone flakes used as tools, and, most often, the waste stone flakes created from the process of chipping other stone tools (debitage).

Sites and artifact locations were located on maps. All surface material on each site located by the quadrat survey was completely collected. Surface cultural features were recorded. Information was also collected on the geomorphologic and current botanical characteristics of each site and each quadrat. Soil samples were taken for each site. In addition, the general condition of each site, the degree of disturbance and the probable activity that caused it were recorded in order to provide a measure of present rates of non-project related impact. A few sites or cultural features in a quadrat were selected for a very limited programme of subsurface testing through excavation in Phase I. The Phase I study located 85 cultural heritage resources sites; 76 in the grassland stratum and 9 in the forest stratum.

(b) Phase II Inventory Methodology

With the general characteristics of the cultural heritage resources base determined by analysis of the sites, artifacts and features located by the Phase I survey, the Phase II research was directed to an assessment of the specific resources likely to be affected by the proposed development in Hat Creek Valley. A multistage study to attempt complete inventory was initiated in 1977. The study area was expanded to include the additional areas within the valley that were subsequently defined as likely alternative project component locations. Research priorities were placed on those areas in the valley that were subjected to impact from preconstruction activities (as from exploratory drilling) or on those areas to be affected early in the proposed construction schedule.

The large size of the study areas again required an initial sampling effort to meet the two objectives of a complete inventory: 1. to determine the specific nature and distribution of sites within each location; and 2. to determine the information content of various site types by subsurface investigation through excavation.

The Phase I sampling grid of quadrats was extended over the other portions of the valley proposed for development to ensure the comparability of the sampling units used in both phases of study. The proposed locations of specific project components were considered as strata to be sampled by random sampling with replacement.

The strata were designated as follows with the number of quadrats within each stratum given in parentheses:

A - Medicine Creek Waste/Ash Dump (18)
B - Upper Medicine Creek Fly/Bottom Ash Dump (18)
C - Harry Lake Powerplant (6)
D - Powerplant Reservoir (8)
E - Upper Medicine Creek Wet Ash Dump (46)
H - Medicine Creek Offsite Areas (72)
I - No. 1 Open Pit Mine (77)
J - Houth Meadows Waste Dump (41)
K - Hat Creek Diversion Reservoir (3)
(F and G are the forest and grassland strata of Phase I sampling)

The locations of these strata in relation to the Phase I grassland and forest strata are shown in Fig. 2.4-4.

Two alternate surface data collection strategies were used in the Phase II inventory. If the quadrat to be sampled lay outside the Phase I study area, then it was subjected to complete intensive surface collection. If the quadrat was within the Phase II study area, a judgemental sampling scheme was utilized, which used as its field method complete collection of material found in transects across the located sites. The placement of the transects, each a path 2 m wide and of the necessary length to cross a site, was guided by considerations of obtaining a 10-20 percent sample of the entire extent of the site, of including the range of apparent artifact densities and of supplementing the site map in reconstructing artifact densities onsite. Transects were oriented with respect to the north-south, east-west grid used throughout the entire cultural resources investigation.

For the first season of the Phase II survey, 80 quadrats were selected by random sampling without replacement for survey, 76 of which were outside the Phase I study area and were to be sampled extensively. Three quadrats proved unsurveyable. In the 77 quadrats surveyed, a total of 104 sites were located containing 34 cultural features. The sites were not distributed evenly throughout the study strata, but showed concentrations within certain strata.

Botanical and palynological data for the Hat Creek Valley were collected during the first season of Phase II investigations. As in Phase I, physiographic information was recorded for each quadrat and site and included observation on landform classification, drainage, slope, exposure, accessibility and the quality of field of view.

Excavation at one site was begun in 1976 and continued during 1977. Subsurface excavations were initiated at selected lithic scatter sites, several of which included a "cultural depression". Upon excavation these depressions were found to consist of layers of thermally fractured rock, charcoal, ash and some carbonized plant remains. The charcoal and plant material was collected for future botanic, radiocarbon and dendrochronological analysis. Fauna remains encountered were also collected for future analysis.

2.4.8 Geology

(a) Study Approach and Rationale

The geology of the project area was surveyed for all natural resources and physical characteristics that could be affected by the Hat Creek Project. Studies emphasized the economic aspects of resource utilization and recovery, as well as fundamental analysis of geologic sturucture, stratigraphy and seismicity.

(b) Data Sources and Analysis

Although regional geologic studies are described in the literature, little detailed information was available on the specific area occupied by the project complex. Methods used to gather and analyze the geologic data related to the areas of interest cited above include field observation, geologic mapping, literature searches, drilling and coring, field sampling, geophysical and geochemical field surveys, aerial photographic interpretation, and extensive laboratory testing and analysis relating to the physical and chemical properties of natural resources and earth materials.

2.5 SOCIO-ECONOMICS

2.5.1 Introduction

Information was collected of a quantitative and qualitative nature in order to describe the historical and existing socio-economic setting and to provide the raw data and inferential base to make projections about future socio-economic levels of activity. Economic, social and political theory provided the basis for selecting explanatory variables. In order to obtain data on these variables for various purposes, direct methods (e.g. sample surveys) and indirect methods (e.g. literature research) were undertaken. Also, extensive information of a qualitative nature was accumulated to assure that all concerns are placed in their proper temporal and spatial context.

2.5.2 Income, Employment and Population

The baseline data on income, employment and population were collected from official government publications, personal interviews with government and union officials, written correspondence and telecommunications. A technical literature search was undertaken in all areas for data and information. The Hat Creek Area Resident Survey, completed in 1977, provided economic and social information on households. In addition local newspapers were examined for relevant information.

2.5.3 Community Land Use

For the purpose of the land use inventory, a map was prepared (Fig. 3.5.2, Chapter 3.0) at a scale of 1:100 000 that is centered on the project and incorporates an area within a 25 km radius in all directions. Existing land use maps for this study area were used as base maps and updated by more recent information. The land use mappings consulted were prepared in 1976 by the British Columbia present land use project as part of the Canada Land Inventory (CLI)*, at a scale of 1:50 000. The CLI mappings were updated through the use of color remote sensing photography taken in September 1976, at a scale of 1:24 000. Land use categories which were given particular attention in the updating process were improved pastureland, built-up areas and mines and quarries. Areas in forest and rangeland categories have not undergone significant change and are, therefore, represented primarily according to the original CLI present land use mappings, dated 1967.

2.5.4 Housing

The statistics provided for the housing market analysis of municipalities were obtained by personal discussions with responsible persons in the housing sector as well as by surveys undertaken by

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* The CLI is a federally approved nation-wide survey of land use and capability for the purpose of land use and resource planning for agriculture, forestry, recreation and wildlife. Each province performs the survey within its own boundaries, with the intent of providing resource development planning at all levels.

the detailed environmental consultant. A physical counting of the housing stock compiled data on housing starts. Vacancy rates were obtained through personal discussions with real estate officials and apartment building owners. Information on construction activity was obtained from building permit data and discussions with local contractors. Price data were released by members of the local real estate trade.

2.5.5 Services

Data and information on the following services offered by governmental units within the Hat Creek study area were inventoried by the sub-consultant: 1. education; 2. health; 3. recreation; 4. social; 5. cultural; 6. corrections; 7. court/judicial; 8. legal; 9. police; 10. fire; and 11. communication service systems. This inventory on services was developed by pooling information obtained from personal communications, official reports, and records of the pertinent public service group.

2.5.6 Recreation

(a) Data Sources

Data for this study were gathered on setting, recreational assets, recreational facilities, recreational activities, capability and constraints. Most data were obtained from published sources prepared by provincial and local agencies. Agency representatives and informed individuals were also contacted. Hat Creek consultant reports dealing with wildlife, fisheries, and aesthetics were reviewed, and discussions were held with project technical personnel in these and related disciplines. Current aerial photographs were interpreted for recreational developments to the extent practicable and 1:50,000 base maps provided information on topography and landforms. Field checks of recreation resources and facilities were also undertaken in the Hat Creek Valley and surrounding areas. Data sources for each topic are summarized in Table 2.5-1.

(b) Analysis Areas

Because project impacts tend to diminish with distance, the examination of recreational phenomena by geographic area is an integral part of the methodology. Four areas were delineated, each of which (except the first) was divided into quadrants, centered on the project site (these areas are shown on Fig. 2.5-1). These quadrants were selected to reflect different impact areas associated with the project. Area A includes the plant, mine site, ash disposal sites, impoundments and all major land impact areas. Area B encompasses Hat Creek Valley surrounding ranges and hills. Here, the greatest impacts could occur from air pollutants discharged by the powerplant. Area C includes major highways and the largest concentrations of human habitation nearest the project. Area D extends beyond Area C to a limit of 100 km to the limit of stack emission effects. This area includes a variety of recreational opportunities and facilities, some of which will probably be used by workers employed at the Hat Creek Project. Area A is about 12 560 ha in extent, Area B 89 500 ha, Area C 274 800 ha and Area D 690 800 ha. The description and analysis procedure is keyed to the geographic areas described beginning first with Areas A and B. Area C is treated separately (within the constraints of available data), followed by Area D, which is treated more generally because it is large and because the recreational impacts it experiences from people living outside the immediate project region are important.

2.5 SOCIO-ECONOMICS - (Cont'd)

2.5.7 Community and Regional Infrastructure

An inventory was developed by the consultant covering the water system, the sanitary sewerage system, solid waste disposal and roads relevant to the communities under consideration. The information was obtained through contact with responsible government agencies in the communities. Information on transportation in the region was obtained from the Ministry of Highways. Consultantions were made with each of the utility companies to determine their capability to provide adequate service.

2.5.8 Local and Regional Government

Financial data and information were collected for the municipalities of Ashcroft, Cache Creek, Clinton and Lillooet; the Regional Districts Thompson-Nicola and Squamish-Lillooet; and School Districts 29 and 30. The Municipal Act, the Ministry of Municipal Affairs, the municipal budgets and local officials were sources or providers of the detailed information.

2.5.9 Social Environment

Information on the social environment of the area was drawn from a number of sources. A major information source was the survey of residents in the study area conducted early in 1977. A questionnaire was administered to a random sample of over 300 persons in 145 households in Ashcroft, Cache Creek, the Hat Creek Valley, Clinton, Lillooet and the surrounding rural areas. Other data gathering techniques used by the consultants in defining the attributes of the social condition include: 1. a review of similar projects and literature on previous projects; 2. a survey of newspapers; 3. an interview schedule with ranchers in the Hat Creek Valley and key persons in the study area; and 4. incorporation of data from other study team members.

2.5.10 Native Indian Studies

The inventory was undertaken without the involvement of the Indian people in the study area or of the Department of Indian Affairs. As a result, information for this study had to be obtained from published statistics, published research materials and reports and personal interviews with government, corporate and private individuals involved with the Indian and non-Indian communities of the study area.

A library search revealed only a limited amount of published material of value to the study. Anthropological and ethnographic references were able to be supplemented when the preliminary inventory of cultural heritage resources in the upper Hat Creek Valley was made available. Several published studies and reports on the difficulties facing Indian people entering the wage economy were utilized in the study. The Canada Census, 1971, provided the most comprehensive data base available for Indian residents of the study area. Personal interviews were held with government departments and agencies providing services to Indian people in the study area as well as local employers and knowledgeable persons.

2.5 SOCIO-ECONOMICS - (Cont'd)

2.5.11 Aesthetic Considerations

(a) Literature Review

Visual analysis methodologies have been described as tools used to identify aesthetic attributes, forecast changes in aesthetic characteristics and to describe the implications of changes in environmental quality and in the potential uses of the environmental resources.

In order to more fully understand current visual analysis principles, techniques, and studies, a literature search and review was conducted. Materials were gathered at the libraries of the University of British Columbia, the University of Washington (state), the Resource Analysis Branch of the Provincial Government, the Thermal Division of B.C. Hydro and Power Authority and at the offices of the co-ordinator of the environmental analysis, ESCLEC. Visual analyses ranging from general principles and procedures to detailed methods of visual impact measurement were reviewed and absorbed.

The results of this review made it clear that there is a consensus and considerable developed technical methodology for classifying and recording visual quality of the natural environment. There is less agreement on methods for measuring the visual impact which man-made elements have on the natural landscape. The basis for the visual analysis methodology which was developed for this study is work done by R Burton Litton, Jr. and the Resource Analysis Branch.

(b) Study Methodology

The methodology employed in the study considered the analysis in three sequential steps. The first step was to assess the existing visual qualities and the visual sensitivity to change within the defined study area. The second step was to describe the causes of visual impact (the plant elements and appurtenant structures) and to evaluate their effect upon the receptors of the existing environment. The third and final task was to determine the importance of the impact, both by judging the quality of the scene imposed upon and judging the magnitude of the impact upon that scene and commenting on courses of action to mitigate or compensate for the impact.

2.6 NOISE

In order to determine sound levels presently existing in the proposed Hat Creek Project environs, a noise survey was conducted during the fall and winter of 1976 and 1977 and during the spring of 1977. Four sites were chosen throughout the valley to obtain readings indicative of the existing noise environment. Sites 1 and 2 were indicative of ambient levels near Highway 12. Site 3 was indicative of the ambient levels near the Hat Creek Road. Site 4 was selected as a sample of the areas removed from the frequently travelled roads. Site 5 at Ashcroft was chosen to be in close proximity to the proposed pumping station. The locations of the sites are shown in Fig. 2.6-1.

Continuous noise measurements were taken at all five monitoring sites to determine the day/night average sound levels, L_{dn}, and the various statistical indices such as L_{10} and L_{90}. These measurements were made using the fast response (125 ms time constant) settings of the noise analyzer to capture peak events such as car passbys. The most predominant noise events were automatically tape recorded so that the most common noise sources at each site could be identified and so that invalid data could be detected. The monitoring schedule is shown in Table 2.6-1.

Periodic measurements were made of the existing ambient levels in octave bands between 31.5 and 8000 Hz. These periodic background measurements were taken using the "slow" response (1 s time constant) on the sound level meter. Other data obtained during the noise measurement period included meteorological variables such as wind speed, temperature and relative humidity.

Meteorological data were collected during the fall by the measuring team at noise monitoring Sites 1 to 4. During winter monitoring at each site, the measurement system was largely unmanned. Meteorological data were obtained from B.C. Hydro weather stations close to the monitoring sites. The locations of these weather stations are shown in Fig. 2.6-1. In addition, wind speed data were automatically recorded on tape whenever noise levels exceeded a preset value. This was to ensure that wind noise resulting from excessive wind speeds greater than 19 km/h did not influence the results. At noise monitoring Site 5 (in Ashcroft) the wind speed was also automatically recorded on tape. Because this monitoring was done on an unmanned basis, other meteorological data had to be obtained from the government weather observer stationed in Ashcroft.

During the fall monitoring, informal traffic counts were obtained by the measuring team at Sites 1 to 4. In the winter, traffic counts were extracted from the tape recordings. At Site 5 estimates of the volume of train traffic were obtained from Canadian National and Canadian Pacific Railways.

At each of the four valley sites, two periods of 24-hour measurements were made during the fall and winter monitoring programmes; one on a weekday and one on a weekend. Due to time lost in moving from one site to another and in calibrating the system, some of the monitoring periods consisted of slightly less than 24 hours. At site 5 (Ashcroft), only one 24-hour measurement was made on a weekday in May 1977.

During the weekday winter monitoring at Site 1 on 9 March 1977 the microphone failed during the evening, hence the nighttime data was rejected and other data obtained previously for a weeknight at this site was used in its place. On 5 March 1977, unmanned monitoring was conducted at Site 4 to obtain data for a winter weekend. Because of high wind conditions followed by occasional calm periods, the dynamic range of the measurement systems proved insufficient and the instrumentation was overloaded during wind gusts. These data were rejected; however, this site was removed from man-made sound so that the data obtained for a weekday approximated ambient sound levels of a weekend at this location.

The noise monitoring system used for the ambient survey consisted of a Bruel & Kjaer Precision Sound Level Meter Type 2204 and Octave Band Filter Set Type 1613, a Model 1945 General Radio Community Noise Analyzer, a Uher Tape recorder Model 4400, and a Bruel & Kjaer Calibrator Type 4230. All of this equipment was battery operated and with the exception of the microphone and an anemometer, was contained in a mobile laboratory.

3.1 INTRODUCTION

Resource Inventory presents the baseline data which characterize regional and local environmental components. These data were collected during the Detailed Environmental Studies (DES) and are utilized to describe the environment in the Hat Creek region.

3.2 METEOROLOGY - AIR QUALITY

3.2.1 Meteorology/Climatology

(a) Regional Climatological Conditions

(i) Winds

The climate of the Hat Creek region is greatly influenced by the interaction of large-scale pressure and wind flow patterns with the regional topographical features. The Coast Range to the west and the Columbia Mountains of the Rockies to the east serve to shelter the area from strong lower-level flows associated with large scale atmospheric circulations aloft. By preventing marine air from penetrating into inland areas, the Coast Range causes interior British Columbia to be classified as having a "continental" climate.

Disturbances (storm systems) in the upper atmosphere vary in location and intensity according to the season of the year. At the latitude of the Hat Creek Valley, the highest frequencies of storm occurrence are in the spring and fall. During these seasons, upper-level winds over Hat Creek are predominantly from the southwest through north. In winter, most storms track to the south, while in summer, most storms pass well to the north. Upper-level winds over Hat Creek are predominantly from the southwest through northwest during these seasons. Surface winds in the region are greatly influenced by local topographic features. Local terrain channeling and mountain-valley circulations make generalizations about regional surface winds difficult, except that the surface winds in the valleys generally flow parallel to the orientation of the valley while mountain winds are more varied.

(ii) Precipitation

Precipitation patterns in southern British Columbia are strongly influenced by terrain. As the prevailing westerly surface winds flow in from the Pacific Ocean and up the slopes of the Coast Range, the maritime air is cooled, causing cloud formation and precipitation. As the winds flow down the eastern slopes they are warmed and dry out. Annual precipitation levels in the interior average only 250 to 500 mm whereas the coastal areas receive over 2000 mm (Fig. 3.2-1). The seasonal distribution is fairly even in the interior, however, coastal areas receive most of their precipitation in fall and winter.

3.2 METEOROLOGY - AIR QUALITY - (Cont'd)

(iii) Temperature and Humidity

Temperature and humidity conditions in the Hat Creek region are also influenced by the presence of the Coast Range which isolates the region from the moderating effects of the Pacific Ocean. This results in relatively large diurnal and seasonal variations in both temperature and relative humidity. Diurnal temperature variations are as much as 14 to 18°C in the summer and 5 to 10°C in the winter; summer average temperatures exceed winter averages by 20 to 30°C.

Seasonal variations in relative humidity values differ by 20 to 30 percent for several sites in the Hat Creek region. Diurnal variations are also large. In addition to these diurnal and seasonal variations, wide variations in both temperature and relative humidity conditions occur among different locations within the Hat Creek region, depending primarily on elevation. Mean annual regional temperatures are presented in Fig. 3.2-2 and average daily temperature ranges for selected regional stations are presented in Table 3.2-1. Regional dewpoint and relative humidity data are presented in Table 3.2-2.

(b) Site Meteorological Conditions

Because of the large differences in elevation and topographic characteristics within the site area, significant differences exist in the local wind, precipitation, temperature and humidity patterns. These differences are evident in the records of the B.C. Hydro mechanical weather station network. The following paragraphs present information obtained from this network as well as from nearby Atmospheric Environment Service (AES) stations.

(i) Winds

The wind roses from an eight-station B.C. Hydro monitoring network reveal wind flow conditions that are indicative of a complex mountain-valley flow regime. Significant day-night variations in both wind speed and direction occur. For example, at the stations within the upper and lower portions of the valleys, a very low speed, down-valley "drainage" flow predominates at night. In fact, nearly one third of the nighttime hours for some of these valley locations exhibit calm conditions (wind speeds less than the starting threshold of the instruments, about 2.4 km/h). Conversely, the daytime winds at these locations are stronger and generally travel upslope in response to surface heating by solar radiation. This day-night variation is much less dramatic at the ridge locations, reflecting the more frequent influence of upper-air winds at these less sheltered locations.

The annual wind rose for the plant site as represented by the data from mechanical weather station WS 7 is presented in Fig. 3.2-3. The prevailing (most frequent) wind direction is from the west followed by west-southwest, north-northwest, and east-southeast. The high directional variability and relatively strong wind speeds (average of about 10 km/h) indicated by the wind rose are consistent with the ridge location, and are, in general, indicative of good diffusion conditions.

The annual wind rose for the mine site, as represented by the data from mechanical weather station WS 5, is depicted by Fig. 3.2-4. The prevailing wind direction is from the south-southwest, followed by south and north. These directions are generally parallel to the valley orientation, with down-valley flow (from the south and southwest) prevalent at night and up-valley flow (from the north) prevalent during the day. Although the average wind speed is similar to that at station WS 7, the directional persistance exhibited is typical of the valley locations and indicates diffusion conditions which are more restrictive than those at the ridge sites.

(ii) Precipitation

Average annual total precipitation in the upper Hat Creek Valley is 317 mm, distributed almost evenly over the year with a slight winter maximum. Although only minimal measurements at the plant site are currently available, a total of 340 to 400 mm of precipitation should generally be expected in an average year, based on data from nearby stations at elevations similar to the plant site.[3] In general, stations at higher elevations in this region receive more precipitation than those at lower elevations. Annual snowfall in the upper Hat Creek Valley averages 1329 mm/a. Estimated plant site snowfall is in the range of 1500 to 2000 mm/a, again based on data from stations at similar elevations.[3]

(iii) Temperature and Humidity

Temperatures in the project area are also strongly elevation dependent. The mechanical weather station nearest the plant site (WS 7) recorded average winter highs and lows of 1.6°C and -2.0°C, respectively, and average summer highs and lows of 21.8°C and 8.6°C during 1975. The lower valley station (WS 1) had average winter highs and lows of -2.9°C and -14.1°C and average summer highs and lows of 20.8°C and 8.4°C during the same period. These large diurnal and seasonal ranges (especially at valley locations) are typical of interior or "continental" climates.

Extremely large diurnal relative humidity ranges are also evident from the onsite measurements. Nighttime humidities exceed daytime values by 20 to 40 percent at stations in the lower valley with the largest ranges in the spring and summer months. Ridge locations are less humid than valley stations at night, but similar to the valley stations during the day.

(c) Influence of Topography on Local Air Flow Patterns

The influence of topography upon local wind fields is evident in the wind speed and direction data obtained from the eight mechanical weather stations. Winds at the valley stations, Stations 1 to 5, follow closely the orientation of the individual valley in which the station is located. In addition, the hills surrounding the Hat Creek Valley appear to shelter the valley from upper-level high speed winds. Data from the three ridge sites, Stations 6 to 8, show frequent southerly and westerly wind components. The winds at these locations are influenced by the large scale weather patterns. The ridge stations thus show a much greater frequency of periods with high wind speeds, while the valley stations, because of their sheltered locations, experience more calms or near calms.

3.2.2 Air Quality

(a) Regional Conditions

The region surrounding the Hat Creek area is generally sparsely populated with very few existing significant sources of anthropogenic emissions. In 1977, B.C. Hydro engaged B. H. Levelton and Associates Ltd. to prepare an inventory of sources of primary contaminants.[4] The inventory provides information regarding the nature and magnitude of particulate matter, sulphur oxides, and nitrogen oxides emissions in the Kamloops, Cache Creek, Clinton, and Highland Valley areas. Based on this document, estimated total emissions from existing and proposed facilities (but not including Hat Creek) in these locales are:

Sulphur oxides (SO_x)	-	102 104 kg/d
Nitrogen oxides (NO_x)	-	20 534 kg/d
Total particulates (TSP)	-	22 845 kg/d

With the exception of a proposed 400 t/d copper smelter near Highland Valley, and a proposed 1000 t/d copper smelter near 70 Mile House, most of the sources are located east of Hat Creek in the Kamloops area.

Existing regional ambient air quality data (dustfall, sulphation and suspended particulates data from the B.C. Department of the Environment) reflect conditions in and near the industrial areas of Kamloops where most of the above emissions occur. Hence, these data are not representative of the sparsely-populated region surrounding the Hat Creek area, where much lower dustfall rates, sulphation rates and concentrations of suspended particulates would be expected. These regional ambient air quality data are, however, presented in Appendix A to the Air Quality and Climatic Effects Report.[5]

B.C. Hydro conducted snow sampling in the Cornwall Hills during the winter and spring of 1976-77 and in Wells Gray Park in June, 1977. These samples were chemically analyzed to provide baseline information for an investigation of potential effects of the powerplant on precipitation acidity. The results from the analyses of samples at the two locations were similar, indicating uniform composition of the regional snowpack. Interestingly, pH values in the snow samples were about 5.5, near the "natural" value for precipitation in equilibrium with atmospheric carbon dioxide. Samples taken from streams originating in the same snowfields showed a pH of approximately 8.0. Apparently, alkaline material in the stream beds neutralizes the acidity of the fresh snow.[2] Detailed results of the analyses are presented in Appendix A to the Air Quality and Climatic Effects Report.[5]

(b) Local Conditions

A summary of the available measurements of total suspended particulates in the Hat Creek Valley and Cache Creek is presented in Table 3.2-3. The locations of these monitoring stations were indicated in Fig. 2.1-1 (Section 2.1.2, Air Quality Data Sources). The data indicate that existing suspended particulate concentrations are very low in the Hat Creek Valley area, with geometric means in the range of less than 10 to about 20 $\mu g/m^3$. The data for Cache Creek (Station 6) are apparently strongly influenced by the location of the monitor with respect to a dirt parking lot and the level of activity in the area. These data are, therefore, not believed to be representative of Hat Creek Valley baseline conditions.

ERTs Air Quality and Climatic Effects Report[3] indicates that 40 $\mu g/m^3$ represents a reasonable but conservative background particulate level in the vicinity of the proposed mine. The report also indicates that a value of 20 $\mu g/m^3$ appears reasonable for the lower Hat Creek Valley. However, only spring and summer data were available at the time their report was written. Based on the more complete data presented in Table 3.2-3, a geometric mean background concentration of 10 to 20 $\mu g/m^3$ appears representative of conditions in the vicinity of the proposed mine and in lower Hat Creek Valley. It is expected that existing particulate concentrations in the vicinity of the proposed plant are even less because of the lower level of dust producing activities in this area.

No historical record of measured ambient concentrations for other contaminants was available for the present study. In view of the project's location in a rural area with very low population density and no significant nearby industry, background values of zero have been assumed throughout ERT's analysis for contaminants other than suspended particulates.[3]

3.2.3 Epidemiology

It is the purpose of this section to summarize the data base from which ambient air quality achievement guidelines have been recommended to B.C. Hydro and Power Authority for their proposed Hat Creek Project. The five commonly occurring air pollutants for which criteria documents have been prepared and for which ambient air quality standards exist in most of the industrialized nations of the world are addressed. These common pollutants are sulphur dioxide (SO_2), total suspended particulates (TSP), nitrogen dioxide (NO_2), carbon monoxide (CO), and photochemical oxidants (O_3).

In addition, a series of trace elements known to exist in varying quantities in the various coal seams throughout the world are addressed. For the most part, ambient air quality standards or guidelines either do not exist for these trace elements or are derived from a severely limited data base. Secondary air pollutants, including sulphates and nitrates, for which no primary ambient air quality standards or guidelines currently exist (except for California, which has a sulphate standard of 25 $\mu g/m^3$, 24 hours average) are also discussed.

(a) Review of Existing Ambient Air Quality Criteria for Primary Contaminants

Primary ambient air quality standards and guidelines for the United States and Canada, both at the federal, provincial and state levels, are summarized in Table 3.2-4. In the U.S., a primary ambient air quality standard is one specifically designated to protect human health with an adequate margin of safety for the most sensitive segments of the population. A secondary standard is one specifically designed to protect against damage to vegetation both in agriculture and forestry. The Canadian federal standards are termed either maximum desirable or maximum acceptable while Canadian provincial guidelines are set at three levels, A, B and C, with level A being the most stringent and level C being the least stringent.

(b) Review of Primary Air Contaminant Emission Rate Controls

Emission rate control criteria for several provinces, states and federal agencies are summarized in Table 3.2-5. Canadian federal emission guidelines for coal-fired powerplants are currently under development and will probably regulate emissions based on mass of coal burned or per unit of heat generated.

(c) Health Based Guidelines for Primary Contaminants

(i) *Sulphur Dioxide*

A. Morbidity Data

Review of the available epidemiological data relative to the adverse health effects of sulphur dioxide for 24-hour exposures indicates a range of response between 120 and 500 $\mu g/m^3$ with the strongest evidence suggesting a range approaching 300 to 400 $\mu g/m^3$. It was the best judgement of the researchers conducting more recent studies that the observed effect at concentrations below 300 $\mu g/m^3$ was due to sulphates and not sulphur dioxide alone.

Health information gathered thus far indicates that no significant increase in morbidity results from long-term exposures to sulphur dioxide at concentrations below 90 $\mu g/m^3$ annual average. In fact, with respect to the increased prevalence of chronic bronchitis in adults and increased acute lower respiratory disease in children, adverse effects are only observed at concentrations in the range of 90 $\mu g/m^3$ to 200 $\mu g/m^3$ annual average.

B. Mortality Data

Epidemiological data exists which are alleged to relate excess mortality to increases in ambient sulphur dioxide concentrations. However, examination of these data *reveals a consistent simultaneous presence of high smoke or particulate concentrations* of 500 $\mu g/m^3$ or higher, during mortality episodes. This is compared to lower particulate concentrations of 300 $\mu g/m^3$ when describing morbidity. The observance of such differences has led researchers to ascribe these effects to the joint interaction of particulates and sulphur dioxide producing sulphates. This has led, in turn, to the current hypothesis that sulphates are the responsible agent in certain health effects.[2]

Most studies have focused on increased mortality during episodic conditions of severe inversion which are not relatable to long-term exposures. Additionally, all study results have been obscured by other subtle effects, effects which are not *contaminant-specific enough to factor out sulphur dioxide or even natural phenomena.* In view of this, attempts to link excess mortality to increased sulphur dioxide levels are very equivocal.

(ii) Total Suspended Particulates

A. Morbidity Data

Review of the available epidemiological data relative to the adverse health effects of suspended particulate matter indicates a range of response between 75 and 375 μg/m^3 with the stongest evidence suggesting a range of 150 to 300 μg/m^3. More recent results indicate that deleterious health effects occurred at particulate matter concentrations below this range. However, in the best judgement of the researchers conducting the studies, these adverse health effects were due to sulphates rather than particulate matter per se.[2]

Information relative to adverse health effects of long-term exposures to particulates indicates increases in morbidity resulting from long-term exposure to particulate matter in the concentration range of 60 to 220 μg/m^3 annual average.

B. Mortality Data

Epidemiological data exist which attempted to relate increases in mortality to increases in ambient suspended particulate concentrations. These data suggest an adverse effect range from 200 to 750 μg/m^3 and as with sulphur oxides, the mortality range overlaps the morbidity threshold. With regard to the question of sulphur oxides, excess mortality is not a very sensitive parameter. Currently, the question of whether specific particulate-borne contaminants are producing adverse health responses below a concentration of 150 μg/m^3 is an issue yet to be resolved.

The 24-hour suspended particulate matter guideline with regard to animal mortality data does not allow a defensible guideline range to be established. The range of 60 to 100 μg/m^3 annual average is supportable on the basis of available data. Once again, a strong possibility exists that specific particulate-borne contaminants may be producing effects below this range.

(iii) Nitrogen Oxides

A. Morbidity Data

Very limited data exist on the response of humans to short-term nitrogen oxide exposure. These data suggest an adverse response range of 2000 to 3000 μg/m^3. Results from long-term human exposure to nitrogen oxide is very limited and these data suggest that effects are adverse in the range of 100 to 600 μg/m^3 annual average.

B. Mortality Data

Currently, there are no short-term studies of human mortality in response to nitrogen oxide. Only animal exposure data are available on excesses in mortality attributed to nitrogen oxide exposures.

3.2 METEOROLOGY - AIR QUALITY - (Cont'd)

(iv) Carbon Monoxide

A. Morbidity Data

Review of the available data relative to adverse effects of carbon monoxide on humans at 1-hour averaging times indicates adverse effects are observed at concentrations ranging from 40 to 360 $\mu g/m^3$. Over an 8-hour averaging time, carbon monoxide concentrations ranging from 15 to 50 $\mu g/m^3$ cause an adverse response. It is noted that the most important physiological changes occur at the lower end of the range.

B. Mortality Data

A carbon monoxide health guideline in the range of 40 to 50 $\mu g/m^3$ (1-hour average) is supportable based on health data. However, because of the diverse physiological effects and acute tendency to alter cardiopulmonary functions, the lower value of the range is preferred. Although insufficient data are available, a health guideline in the range of 15 to 20 $\mu g/m^3$ for an 8-hour average is supportable. As with the 1-hour exposure guideline, the lower end of the range is preferred.

(v) Oxidants

Only morbidity data are available for oxidants. Few studies have been conducted on humans for long-term exposure to oxidants. Review of the relatively more complete short-term data indicates that humans exhibit adverse responses to oxidants at concentrations in the range of 100 to 1500 $\mu g/m^3$ over a 1/2 to 2-hour period. The most reliable data from the standpoint of completeness and physiological significance indicate this range is too broad. Short-term oxidant concentrations in the range of 150 to 300 $\mu g/m^3$ are supportable on the basis of these health data. Oxidants, like carbon monoxide, cause very acute responses in particularly susceptible population subgroups and an attempt should be made to adhere to the lower values in the range.

(d) Ambient Air Quality Standards and Guidelines for Trace Elements

Trace contaminant health effects are discussed in the following section. Particular attention is given to 14 selected trace elements. These include arsenic, beryllium, cadmium, chromium, copper, fluorine, lead, manganese, mercury, nickel, selenium, uranium, vanadium and zinc. The section also examines suspended sulphates, nitrates, polycyclic organic matter and nitrosamines. Ambient trace element air quality standards and guidelines for the United States, and the Provinces of Ontario and British Columbia are summarized in Table 3.2-6.

(i) Arsenic (As)

Although the exact compounds of arsenic in particulates have not been characterized,[8] all forms of arsenic accumulate in body liver, muscles, hair, nails and skin tissue. Chronic exposure to ambient arsenic in severe cases is characterized by nasal septum ulceration, darkening of the skin, keratosis of the palms and soles, malaise and fatigue. Children apparently have an increased sensitivity and accumulate more arsenic in their body tissues than adults.[8]

While arsenic has been implicated as a carcinogen in many occupational and epidemiological studies, several studies have produced contrary evidence regarding the location of the tumors. Arsenic is generally accepted as producing a delayed skin cancer in both industrial and general populations.[8] Although animal toxicology experiments have failed to substantiate the carcinogenic effects of arsenic, chromosomal mutation in tissue culture and teratogenicity have been observed in animal studies.[8,9,10,11]

(ii) Beryllium (Be)

The response of various animal species to toxic beryllium concentrations does not coincide with that of humans.[12] For example, cancer of the lungs and bones in animals has developed which is not typical of humans.[13] However, dermatitis has been produced in animals through beryllium dust exposure, and this symptom does occur in man.

Exposure of workers to air heavily contaminated with beryllium causes delayed acute pneumonitis (lung inflammation). Sensitization to repeated beryllium exposures is also known. Chronic beryllium exposure is characterized chiefly by a granulomatous lung disease. Latent periods of up to 20 years may occur before the onset of this pulmonary cancer. Skin lesions, either from acute or chronic exposures, are also highly characteristic of beryllium exposure. Other organs of the body may develop granulomatous lesions, including the heart.[14] Cancer of the liver, bile duct and gall bladder have all been cited.[8] Pulmonary cancer and other symptoms of chronic beryllium disease have not occurred for ambient occupational concentrations of less than 2 $\mu g/m^3$ for an 8-hour day.

(iii) Cadmium (Cd)

Since cadmium occurs on the smallest particles in fly ash, it is readily respirable and can easily enter the lung, where it is absorbed and transported through the body. Cadmium toxicity is manifested primarily as bone, kidney or pulmonary disease. Long-term ingestion can lead to abnormal bone development, osteoporosis and susceptibility to multiple fractures. Carcinogenic and teratogenic potentials have been shown in animal experiments although cadmium has also been shown to inhibit the immune response in animals.[8]

(iv) Chromium (Cr)

No harmful effects resulting from chromium at normal ambient concentrations have been reported. Epidemiological studies suggest a high incidence of lung cancer in workers associated with the manufacture of chromium chemicals. Animal studies confirm this carcinogenic effect. Long-term exposure to low levels of chromium concentrations in the lungs of the average man increases with age.[15]

(v) Copper (Cu)

Copper is an essential element for man as well as many plants and animals. In man, copper is present in many oxidative enzymes, and is necessary to the formation of haemoglobin. Copper does not accumulate in human tissues with age, although serum copper levels do increase. Inhalation toxicity, although relatively uncommon, is primarily manifested through occupational exposures to high concentrations of copper dusts and fumes.

(vi) Fluorine (F)

Fluorine is not an essential element for normal physiological functioning in the body, although it is one component of animal bones. Fluoride is considered to be beneficial to humans in some instances. Acute exposure to hydrogen fluoride gas causes burns on the skin and intense and sometimes fatal lung irritation.[16] Chronic exposure to extremely high concentrations of atmospheric fluoride is known from occupational scenarios to cause crippling fluorosis (debilitating bone disease). Under normal conditions, inhaled fluoride constitutes a very small portion of the body's total fluoride intake. However, in a few instances, community health effects have been cited in people living near fluoride-emitting industry. Symptoms of hematological changes and general health effects were described. These symptoms are not unique to fluoride exposure, nor are they common in occupational fluoride exposure.[17]

(vii) Lead (Pb)

Lead has long been associated with central and peripheral nervous system disease, renal disease, anemia and effects on haemoglobin formation.[18] The effects of lead on the central nervous system of children are devastating. The threshold values for chronic lead poisoning have been studied, especially with regard to the hypersensitivity of children to low-level lead exposure.[19,20]

Some earlier animal studies show possible carcinogenic effects of lead.[11] Human studies have not borne this out, to date. Teratogenic effects are known in animals[21,22,23] and chromosome aberrations caused by lead have been detected through laboratory experiments. Lead burdens in experimental animals, similar to burdens experienced by man, have been shown to cause decreased resistance to infection and decreased life span.[18]

(viii) Manganese (Mn)

Of the trace elements, manganese is one of the least toxic to mammals.[24] Because of its importance as an activator of different enzymes, manganese is one of the elements essential to man's diet in trace amounts.

Inhalation of manganese dusts and fumes is not a normal exposure route but cases of manganic pneumonia and chronic manganese poisoning have resulted from these occupational exposures. Acute poisoning by manganese is actually rare.[25] Some studies have shown manganese to have a delayed mutagenic effect *in vitro*.[26]

Recent studies have found increasing incidences of pneumonia and respiratory problems in communities near industries where large amounts of manganese dust are emitted. However, the data resulting from epidemiological and occupational experiments is always suspect due to the deficiencies of the experimental methods.

(ix) Mercury (Hg)

Methyl-mercury is the most toxic mercury compound and most probably is not directly emitted through combustion of coal. Since no data exist at this time on the rate of cycling or biotransformation, it is difficult to assess the impact on the biosphere from inorganic mercury emissions to the atmosphere.

Mercury vapor is efficiently absorbed by man with 75 to 85 percent being absorbed at ambient concentrations of 50 to 350 mg/m^3.[27] Chronic exposure to lower doses, characteristically named "mercurialism", produces the insidious onset of long-term symptoms caused by the accumulation and retention of mercury in the brain, testes and thyroid. These long-term symptoms have been shown to be only partially reversible. Renal toxicity is also a classical result of chronic mercury poisoning.[28,29] Humans are exposed to mercury in food, water and air. Thus, with multiple exposure routes and the easy accumulation of mercury in the body, it is difficult to quantify the actual amounts of mercury which cause chronic toxicity.

Both inorganic mercury and the organic mercury secondarily formed in the environment demonstrate teratogenic properties in experimental animals. Animal experiments also suggest that mercury causes decreased reproductive performance. Cell culture experiments have shown that both organic and inorganic mercury cause chromosomal mutation although the former of these has been refuted.[27]

(x) Nickel (Ni)

Nickel may be one of the trace elements essential to human health. However, dependent on the chemical form of nickel, exposure may be harmful. Nickel carbonyl causes a delayed onset of fever, respiratory problems, leucocytosis and cyanosis and can possibly result in death in 4 to 11 days.[30] The toxicity of inorganic nickel compounds and elemental nickel has not been as extensively characterized as that of nickel carbonyl. Animal toxicological experiments have demonstrated that all compounds of nickel are potentially carcinogenic.[30,31] Respiratory changes have been noted in animals inhaling inorganic nickel compounds.[32]

(xi) Selenium (Se)

Selenium is a non-metallic trace element essential to human life and helps to maintain body tissue elasticity.[33] Most reports on the adverse effects to human health due to inhalation of selenium describe industrial exposure to dusts, fumes, and vapors of selenium and its compounds. Elemental selenium is relatively non-toxic, although it has been implicated as causing irritation to the mucous membrances, catarrh, nosebleed, loss of sense of smell and dermatitis.

Selenium has been suggested as being teratogenic in one occupational study on humans.[33] It has been implicated as both a carcinogen and an anticarcinogen in animal toxicological studies.[34,35] Occupational studies of humans exposed to selenium have demonstrated no cancer mortality.[36] Epidemiological studies have shown a relationship between high selenium concentrations in the soil or air and lower incidence of cancer.[37,38,39]

(xii) Uranium (U)

Adverse health conditions related to uranium usually are a result of the highly toxic nature of uranium and its salts, rather than its radioactivity.[40] Generally, uranium causes pathological effects in the kidneys, lungs, liver, cardiovascular, nervous and haematologic systems. Changes in protein and carbohydrate metobolism have also been noted. Chronic exposures have also been cited as inhibiting reproductive activity and affecting uterine development in experimental animals.[40] However, toxicity is a function of relative solubility of the uranium compounds, with more soluble compounds being more toxic.

(xiii) Vanadium (V)

Vanadium is poorly absorbed in mammals when ingested, but more easily absorbed when inhaled. Insoluble forms of vanadium at concentrations over 50 $\mu g/m^3$ are thought to accumulate in the human lung and cause pulmonary irritation.[41] Body turnover for vanadium is thought to be rapid.

Airborne vanadium emitted through coal combustion probably occurs in solid forms in the fly ash. The toxicity of vanadium oxides, which are the most likely compounds in fly ash, is proportional to their valence state. The pentoxide form is the most toxic. Some authors consider vanadium to be a significant health hazard when in a submicron aerosol form. Epidemiological studies of atmospheric vanadium in urban areas suggest a correlation of ambient vanadium with mortality from bronchitis and pneumonia, especially in males.[41]

In animal experiments, exposures to high concentrations of vanadium result in multi-system toxicity and death. Compared to industrial or ambient exposure, these levels are extemely high. Animal experiments using more reasonable exposure levels demonstrate an adverse effect on pulmonary defense.

Some epidemiologic evidence exists which links vanadium to lung cancer and heart disease, but this is by no means conclusive.[42] In fact, animal experimentation supports the fact that vanadium is not carcinogenic.[41]

(xiv) Zinc (Zn)

Illness from zinc occurs primarily as zinc "fume fever". This illness occurs with occupational exposure to fresh zinc oxide fume, usually in concentrations greater than 15 mg/m^3. This tends to be a short-lived illness with complete recovery, even after multiple exposures. Zinc chloride ($ZnCl_2$) is more caustic, and more irritating.

Large doses of both inhaled and ingested zinc have caused death or illness in experimental animals. The concentration levels used, however, are much higher than work-place levels or any ingested amount normally available in the diet.

(xv) Polycyclic Organic Matter (POM)

Polycyclic organic matter (POM) is a large group of ring-structured aromatic hydrocarbons which may have substituted groups attached to one or more rings. POM occurs either as a vapour or, more commonly, as a condensed particulate. Relative to the public health consideration of the proposed Hat Creek powerplant, polycyclic aromatic hydrocarbons (PAH) include, among other hydrocarbons, benzo-a-anthracene and benzo-a-pyrene (BaP). Many of the constituents have been suspected or classed as organic carcinogens.[43]

Of the many adverse human health conditions associated with exposure to polycyclic aromatic hydrocarbons, the most significant is carcinogenic activity. Workers in the fossil fuel-related industries have been shown to have an increased incidence of both skin and lung tumors.[44-48] The cause-effect or dose-response relationships for these tumors have been difficult to ascertain. Recently, animal toxicological experiments have pin-pointed polycyclic organic matter as the carcinogenic agent contained in the derivatives of fossil fuels. However, the majority of these studies are limited to the topical application of POM resulting only in the induction of skin cancer. Toxicologic studies involving inhalation exposures have revealed little valuable information.[45,46]

At ambient atmospheric concentration levels, polycyclic aromatic hydrocarbons have not been proven to cause human tumors.[43,45] In epidemiologic studies, an association has been shown between air contamination and human mortality rates from lung cancer.

(xvi) Suspended Sulphates (SO_4)

Sulphates are secondary contaminants generated by the chemical conversion of sulphur dioxide. A discussion on the atmospheric chemistry of suspended sulphates is beyond the scope of this summary. It is important to point out that the subject of sulphur dioxide conversion to sulphate is under intense investigation by federal agencies and academic institutions in the United States.

Animal studies have revealed that sulphuric acid (H_2SO_4) is the most toxic of all the sulphates being studied.[49] It should be pointed out that the toxicity of the various suspended sulphates is a function of particle size, relative humidity and temperature. The subject of the biological activity of suspended sulphates is highly controversial and cannot at this time be definitely characterized.

The only epidemiological studies that have been conducted on the exacerbation of human health by atmospheric suspended sulphates were those by the United States Environmental Protection Agency under their Community Health and Environmental Surveillance System programme (CHESS).[50] The publication of a report on the findings from CHESS ignited controversy over the toxicology of suspended sulphates. This controversy is presently unresolved.

3.2 METEOROLOGY - AIR QUALITY - (Cont'd)

(xvii) Suspended Nitrates (NO_3)

Suspended nitrates are secondary atmospheric contaminants produced through chemical reactions occurring in the atmosphere. Even though a precise understanding of the processes through which atmospheric suspended nitrates are generated is not currently available, it is obvious that nitric oxide (NO) is the primary precursor to this class of atmospheric contaminants. Nitric oxide is a by-product of the combustion of fossil fuels. It has been speculated that nitrogen dioxide interacts with hydrocarbons and ozone to produce a hazardous organic nitrate known as peroxyacyl nitrate (PAN). This highly reactive molecule is unstable and probably decomposes in such a manner as to produce inorganic nitrate.

No studies have been conducted into the toxicology of inhaled nitrate salts. This is probably due to the complexity of producing a nitrate salt aerosol the size of respirable particles (mass median diameter of 3.0 microns or less).

The United Stated Environmental Protection Agency, through its CHESS studies, produced evidence which suggests that suspended nitrate levels of 2-7 $\mu g/m^3$ will produce an elevated asthma attack rate.[51] The investigators, however, caution that insufficient knowledge concerning the chemical and physical nature of the suspended particulates limits the interpretation of their observation.

(xviii) Nitrosamines (NNA)

The biological activity of the nitrosamines has been studied extensively in experimental animals.[52] So far, every nitrosamine studied has been proven to be carcinogenic in at least one animal species and every animal species studied has proven to be sensitive to at least one nitrosamine. These facts alone are sufficient in establishing the nitrosamine family as being one of the most hazardous in our environment. There have been, however, no human clinical studies conducted on the biological activity of the nitrosamines.

3.3 WATER RESOURCES

3.3.1 Water Quality

(a) Groundwater

The results of the groundwater monitoring programme are presented in Table 3.3-1 (refer to Fig. 2.2-1 for station locations). Analysis of the data indicated that all groundwaters can be placed in one of four categories:

(i) Shallow Groundwater

This water is of the calcium-bicarbonate type and strongly resembles Hat Creek water in its characteristics. This was expected as the alluvium is hydrologically connected to Hat Creek. The locations having this type of water are: all sampled domestic wells (DW) except DW8 and the artesian springs except No. 3 East.

(ii) Intermediate or Surficial Groundwater

These waters exhibit characteristics between that of shallow groundwater and deep bedrock groundwater (sodium and bicarbonate type). The sample locations in this category at the Steel Brothers Well, drill hole RH77-45 in the Houth Meadows area and artesian spring No. 3 East. In the case of the two samples in Houth Meadows, the water is derived from a surficial alluvium which flows through limestone. In the case of artesian spring No. 3 East, the water appears to have travelled a great distance underground, thus permitting sodium-calcium base exchange to take place.

(iii) Deep Permeable Bedrock Groundwater

These waters are characterized by a high sodium content compared to calcium and generally have existed as groundwater for an extended period of time. As a result of this they also exhibit high filtrable residue and specific conductance values. The sample locations exhibiting this type of water are drill hole RH76-19, bucket auger hole No. 7, drill hole RH77-48, and drill hole RH77-49. A comparison of the results among these stations indicates that the zinc concentration of RH76-19 is an apparent outlier (1.97 mg/L compared to <0.015 mg/L for the two stations at Medicine Creek) probably due to contact with the coal deposit.

(iv) Unique Samples due to Special Conditions

There are two sample locations in this category, well No. 3 of the Bulk Sample Programme and well DW8. Water from well No. 3 has apparently percolated through the dry lake immediately adjacent to the well. This dry lake has left a large amount of evaporite deposits. Water feeding well DW8 has apparently come from a different aquifer than that feeding the other wells in the area, and has travelled a greater distance underground. This conclusion is based on the much higher levels of sodium and chloride ions found in this well.

In general, while the groundwaters examined showed many differences, they compared favourably with Canadian Drinking Water Standards.[2] In all cases the drinking water standards for toxic chemicals were met and, with the exception of calcium in one location (well No. 3 of the Bulk Sample Programme), the recommended limits for other chemicals in drinking water were met.

(b) Surface Water

(i) Streams and Rivers

A comparison of the annual water quality means for each watershed is presented in Table 3.3-1. Data for programmes, other than the systematic sampling of Hat Creek and the Bonaparte and Thompson rivers, have not been included in this statistical treatment.

It should be noted that constituent concentrations did not appear to vary between stations on a specific water body for a particular monitoring event.

A. Cations: Trace Metals

Levels of aluminum were very low. With the exception of one measurement, all values reported were less than the minimum detectable concentration (MDC). Arsenic, cadmium, chromium, lead, molybdenum, selenium and vanadium were also found to be below the MDC at all stations.

The dissolved ferrous plus ferric iron content ranged from 0.022 mg/L for the Thompson River to 0.048 mg/L for the Bonaparte River. The World Health Organization's (WHO) recommended limit for iron in drinking water is 1 mg/L. The values found, therefore, are well below the level at which iron begins to cause a water quality problem.

The mercury levels ranged from 0.00029 mg/L for the Bonaparte River to 0.00040 mg/L for the Hat Creek. The Canadian Public Health Standards do not include a standard for mercury, but the U.S. Environmental Protection Agency National Interim Primary Drinking Water Regulations specify 0.002 mg/L.[3] Levels found in the local Hat Creek area should not exert a significant effect on the water quality of the systems examined.

Zinc concentrations above 5 mg/L can cause a bitter astringent taste and opalescence in natural waters. The annual system means for zinc found in this study ranged from 0.007 mg/L for Hat Creek to 0.023 mg/L for the Bonaparte River. These values are well below those that would cause any concern with respect to water quality.

B. Cations: Alkali Earths and Metals

Calcium is present in nearly all natural waters because of its widespread occurrence in rocks and soils. An examination of the data for the different systems shows that calcium is present in appreciable quantities with the calcium to sodium ratio being approximately 3:1. This would tend to indicate that the water has come in contact with calcium bearing minerals. Particularly in the case of Hat Creek, with an annual system mean of 57 mg/L of calcium, there is an indication of a groundwater component which has been in contact with calcium bearing minerals. Concerning lithium, only Hat Creek had a mean annual value greater than the MDC (0.001 mg/L), and this value was only 0.002 mg/L.

Magnesium concentrations are considerably less than calcium in most waters. The Ca:Mg ratio for natural waters computed from equivalents commonly ranges from about 5:1 to about 1:1. The value for this ratio ranges from 1.1 for the Bonaparte River to 1.8 for Hat Creek to 2.9 for the Thompson River. It appears that water in the former two streams has been in contact with either magnesium silicate minerals or dolomite. In the case of the Thompson River, the value of the ratio is almost exactly at mid-range reflecting the size of this watershed with its much larger diversity.

Potassium salts are highly soluble and are among the last to be precipitated as solutions are evaporated. The values found during the survey are all comparably low. Hat Creek exhibited the highest concentration (4.0 mg/L) which would be expected as evaporation is highest in this area.

Sodium takes no part in important precipitation reactions. It may, under some circumstances, participate in base exchange reactions. Sodium values of less than 1 mg/L are very rare. The rather high sodium value for Hat Creek (20 mg/L) when compared to the Bonaparte and Thompson rivers may reflect the combination of low flow and high evaporation that occurs in Hat Creek.

Strontium is one of the most abundant minor constituents of igneous rock and is also important in carbonate sediments. An examination of the results indicates that the water present in Hat Creek has probably been in contact with some form of strontium bearing mineral, as the values obtained are above those that would otherwise be expected.

C. Anions: General

Boron is generally found in natural waters in only trace quantities. The results of this survey indicate that in each water body the boron level is less than the MDC (0.1 mg/L).

Chloride ions are present in all natural waters. In waters associated with sedimentary rocks, concentrations do not usually exceed 5 mg/L. Much of the rock formations in the Hat Creek Valley are sedimentary in origin and correspondingly, the values obtained for chloride for all three systems studied were less than 5 mg/L in all cases.

Fluoride in natural waters has been attributed to solution of micas which contain fluoride. The WHO European Drinking Water Standards set an upper limit of 1.5 mg/L for drinking water. The fluoride content of the systems studied ranged from 0.11 mg/L for the Thompson River to 0.17 mg/L for the Bonaparte River. While the concentrations are low, the results do indicate the presence of some fluoride bearing minerals in the area.

Sulphates of most of the common metallic elements are readily soluble in water. The sulphate ion is also chemically stable in most natural waters. Gypsum and anhydrite are an important source of sulphate in water. In the case of Hat Creek, the results for sulphate, 54 mg/L, tend to indicate that there is a comparatively large groundwater input to this water body and that this groundwater has been in contact with either a gypsum or anhydrite type of rock. The concentration is also above the present Pollution Control Board Level A Objective for sulphate, 50 mg/L.[4]

D. Anions: Nutrients

Somewhat high levels for total Kjeldahl nitrogen were noted. This is probably due to agricultural area runoff. Generally the amount of phosphate present in natural waters is less than 1 mg/L and the nitrogen/phosphorous ratio is approximately 10:1. Similar ratios calculated from the annual system means gives values of 5.6, 8.5 and 7.6 for Hat Creek, Bonaparte and Thompson rivers, respectively. This difference, particularly in the case of Hat Creek, is likely due to input of phosphorous from fertilizer contained in runoff.

E. Organic, Nonionic and Calculated Values

COD, TOC and phenol when considered together are indicators of environmental contamination of an organic nature. Levels of these three parameters were found to be quite low indicating that there is a low level of organic loading to these systems.

As a broad classification, waters with a hardness (as $CaCO_3$) of less than 100 mg/L are considered soft, from 100 to 200 mg/L moderately hard and greater than 200 mg/L very hard.[5] Hat Creek may, therefore, be classified as being very hard (224 mg/L), the Bonaparte River as moderately hard (135 mg/L) and the Thompson River as soft (38 mg/L). The alkalinity levels (as $CaCO_3$) were found to range from 226 for Hat Creek to 147 for the Bonaparte River, to 35 for the Thompson River, tending to follow the alkali earths and filterable residue levels.

F. Physical Data

Most natural waters have pH values ranging from about 5.5 to slightly over 8.0.[5] In all cases the waters sampled were on the alkaline side of the pH scale, ranging from 7.8 for the Thompson River to 8.4 for Hat Creek.

Colour may indicate the possible presence of organic material. Surface waters that leach decaying vegetation and groundwaters that pass through peat, lignite, or other buried plant remains may take on a colour. The low colour levels found for all three systems is a further indication of the low level of organic matter in the water.

Turbidity is caused by the presence of suspended matter. It is an expression of the optical property of a sample of water which causes light to be scattered rather than transmitted in straight lines through the sample. Excessive turbidity therefore, can reduce the photosynthetic process. In general, the average turbidity values for all three water bodies were extremely low (0.81 to 2.1 NTU) but during freshet, values up to 79 NTU were observed in Hat Creek.

Temperature is important, and sometimes critical, for many uses of water. It affects the palatability of water, treatment processes and its suitability as a habitat for aquatic life. For drinking purposes, water with a temperature of 10°C is usually satisfactory.[2, 6] Temperatures greater than 15°C can be objectionable.[6] There is a maximum temperature that each species of fish or other organism can tolerate. For example, rainbow trout can tolerate approximately 23 to 24°C. However, the preferred temperature for this species is in the range of 13° to 17°C.

Fig. 3.3-1 shows the water temperature for two different stations on Hat Creek. From the graph, it can be seen that "Hat Creek near Upper Hat Creek" rarely exceeds 15°C and can, therefore, be classed as having good water quality with respect to temperature. At "Hat Creek near Cache Creek", however, the water temperature during the months of June to September frequently exceeds 15°C and can exceed 20°C during low flow periods. This area could therefore be considered to have only marginal quality with respect to temperature. In the case of the Thompson and Bonaparte rivers, the highest temperatures recorded were 13 and 14°C, respectively, indicating good water quality with respect to temperature.

G. Physical Data: Residues

Based on the results of the freshet monitoring programme and on a graphical discharge related analysis of suspended sediment (non-filterable residue) and dissolved solids (filterable residue) concentrations, predicitions have been made of the load variation for a hypothetical mean discharge year in both Hat Creek and the Bonaparte River. This is shown in Fig. 3.3-2 and Table 3.3-2.

The estimated values indicate Hat Creek runoff is considerably more turbid in the spring than the Bonaparte, and it also yields considerably more dissolved solids per unit area of drainage than does the Bonaparte River.

H. Biochemical Oxygen Demand and Dissolved Oxygen

In this study the BOD at all stations examined was less than the MDC (1 mg/L), again indicating a very low level of biodegradable organic matter in the three systems examined. Correspondingly, the average dissolved oxygen saturation for each water system sampled was above 90 percent.

(ii) Lakes

Two lakes representing two extremes on the water quality spectrum were sampled. Other lakes in the Hat Creek Valley can be considered to exist on a continuum between these two extremes. The two lakes chosen were Goose/Fish Hook Lake and Finney Lake.

Goose/Fish Hook Lake is typical of an alkali slough found in the southern interior of the Province. It contains very high levels of alkali metals and sulphate which result in high values for pH, conductivity and filterable residue (see Table 3.3-1). Finney Lake on the other hand, is more typical of an oligotrophic lake, characterized by relatively low nutrient levels and high levels of dissolved oxygen in the epilimnion. The following trace elements were less than the MDC in both Finney and Goose Fish Hook lakes: aluminum, arsenic, cadmium, chromium, copper, lead and selenium. Of the remaining cations in this group, all of the levels found were similar to those described for Hat Creek.

(iii) Surface Water - Other Programmes

The results of these programmes were utilized to fulfill specific information needs required during the course of these studies. Since the data were not directly utilized for impact assessment, they are omitted from this discussion. The Hydrology, Drainage, Water Quality and Use Report[1] should be consulted for the presentation of these results.

(iv) Comparison with Existing Data

The data collected during this surface water monitoring programme were compared to "existing data" recorded by the Ministry of the Environment,[7] Department of Fisheries and Environment[8] and the Calgon Corporation.[9] In general, all data compare reasonably well although some variation due to spatial and temporal differences in the sampling programmes was noted.

(c) Laboratory Test Results

All laboratory leachate tests were carried out using procedures designed to accelerate the release of extractable salts. The tests were designed to determine the total amounts of water-extractable salts and the relative rate of release of selected parameters. Results of total extractable salts tests are given in Table 3.3-3 while test results on rate of release are presented in Table 3.3-4. It should be noted that this latter table only includes the extractions from Day 1 of the total 8-day programme. It was this initial extraction approximating initial pore volume displacements that was utilized to predict potential leachate values. The Solid Waste Disposal, Coal Storage and Land Reclamation Report[10] should be consulted for the remaining rate of release test results.

3.3.2 Hydrology

(a) Groundwater

(i) Flow Patterns

Both the surficial and bedrock geology of the Hat Creek Valley are very diverse and as a consequence the groundwater flow patterns are complex. In order to simplify the study of these flow patterns, four areas which appear to be potential impact locations have been selected for detailed evaluation.

A. General Flow Systems in Upper Hat Creek Valley

The flow systems in upper Hat Creek Valley can be characterized by groundwater recharge in the upland areas and discharge in the valley bottom. The groundwater typically flows under an approximate hydraulic gradient of 0.1 towards Hat Creek where most of the discharge occurs. These east-west flow patterns are shown in Fig. 3.3-3. The quantity of groundwater which discharges into Hat Creek has been estimated to be between 284 and 568 m^3/d/km of creek bed. Approximately 98 to 99.5 percent of this groundwater reaches the creek through surficial sediments.

In the vicinity of the proposed coal pit, the east bench is well drained. Groundwater discharge on this side of the valley passes through the alluvium and into Hat Creek without any surface discharge. The west bench slopes are less well drained. Springs and seeps are common particularly below the 900 m contour. Observations around Finney and Aleece lakes suggest that these lakes are fed by local perched groundwater flow systems and small streams flowing from the west. Intermittent surface water discharge from these lakes can occur, mainly during the spring freshet. The remainder of the lake water is dissipated mainly as evaporation and only a small amount via groundwater discharge. Evidence for the latter conclusion is substantiated by isotope data.

The only potentially significant aquifers in the main Hat Creek Valley are the valley alluvium and a buried bedrock valley filled with glacio-fluvial sediments northeast of the proposed coal pit.

Valley Alluvium

The depth and width of the aquifer will be variable. The estimated average groundwater flow down valley in this aquifer is 2300 m^3/d. As the aquifer is hydraulically connected to Hat Creek, there will be an interchange of water between the creek and aquifer along the length of the creek channel.

Glaciofluvial Valley

The approximate outline of this valley is shown in Fig. 2.3-3. However, it should be noted that the location of the northern part of this valley has not been probed by drilling and hence its depth and location are only estimates. The channel is approximately 600 m wide and has an estimated average depth of 100 m below the general bedrock surface. The estimated groundwater flow along this valley is 5,000 m^3/d. The discharge from the northern end of the valley probably seeps through alluvium and then into Hat Creek.

B. Houth Creek Basin

The significant geological units and groundwater flow systems within the basin are shown in Fig. 3.3-4. The calculated groundwater flows presented in Fig. 3.3-4 are as follows:

Inflow		Outflow towards the West	
		In limestone	169 m^3/d
From north	72 m^3/d	In till	2 m^3/d
From west	360 m^3/d	In claystone conglomerate	1 m^3/d
TOTAL	432 m^3/d	TOTAL	171 m^3/d

The difference between the two totals, 261 m^3/d, is the estimated groundwater discharge to the ground surface within the Houth Creek basin.

C. Marble Canyon

Marble Canyon is long and narrow and extends from Pavilion Lake to the northern end of the upper Hat Creek Valley. Massive limestone bedrock is exposed along both sides of the canyon. The bottom of the canyon has been partly filled with a glacial and glaciofluvial sediment to an estimated average depth of 50 m.

Based on geologic evidence an aquifer or series of interconnected aquifers appear to extend to Pavilion Lake and beyond its northwestern shores. However, based on topographic and isotope evidence there appears to be a groundwater divide east of Turquoise Lake (see Fig. 3.3-5). Thus, the water seeping from this lake would flow northwest toward Crown and Pavilion lakes. The groundwater flow systems in the canyon are also illustrated in Fig. 3.3-5. Groundwater flows from recharge areas at higher elevations, laterally through limestone bedrock and discharges into the surficial sediment aquifer in the canyon bottom. This groundwater is supplemented by surface runoff which infiltrates into the talus deposits and eventually into the surficial aquifer. The groundwater in this surficial aquifer will then flow in a southeasterly direction from the groundwater divide toward Hat Creek. An estimated groundwater budget for the southeasterly flow is as follows:

Inflows	
Deep seepage in limestone	490 m^3/d
Canyon bottom infiltration	1564 m^3/d
TOTAL	2054 m^3/d

Outflows	
Down valley seepage in surficial sediments	2053 m^3/d
Down valley seepage in limestone bedrock	1 m^3/d
TOTAL	2054 m^3/d

D. Medicine Creek Basin

Most of the bedrock in the Medicine Creek basin is covered with a low permeability till blanket. Alluvium is almost absent in the creek bed. All bedrock units with the exception of some of the volcanic rocks would have hydraulic conductivities less than 10^{-8}m/s and hence, the rate of groundwater flow through these rocks would be very slow. The Medicine Creek Valley follows a geological fault. However, based on data collected to date, the hydraulic conductivity along this fault is only marginally higher than the unfaulted bedrock.

Groundwater recharge will occur mostly in the upland areas and the movement would generally be toward the valley bottom (Fig. 3.3-6). The total seepage flow is estimated to be 35 m^3/d/km along the length of the creek. The estimated down valley groundwater flow at the mouth of Medicine Creek is in the order of 350 m^3/d. Most of this total flow is in the till and less than 1 percent of the flow is estimated to flow in the bedrock along the fault line.

(ii) Water Tables - Seasonal Variations

Monthly piezometric head data have been recorded since November 1976. Data gathered up to November, 1977 have been utilized in this report. These piezometers are located mostly in the vicinity of the proposed pit area (see locations in Fig. 2.3-3) and some are in the Medicine Creek Valley. The general trend in all of the data shows a decline of piezometric heads since November 1976. Based on present data, maximum annual fluctuations of piezometric heads in recharge zones are estimated to be between 3 and 10 m. Maximum annual fluctuations in the discharge area near Hat Creek should be quite small (1 or 2 m) since piezometric heads in this area are largely controlled by the creek level. A similar fluctuation is expected for piezometric levels in the Medicine Creek Valley.

(b) Surface Water

(i) Regional Descriptive Hydrology

A. Thompson River

The Thompson River basin, with its drainage area of approximately 55 000 km^2 drains a large portion of south-central British Columbia. From the outlet of Kamloops Lake to its confluence with the Nicola River, the Thompson drains 7874 km^2 of semi-arid interior plateau, and of this area 5000 km^2 comprise the Bonaparte River basin which includes the 660 km^2 Hat Creek basin.

The flow regime of the Thompson River is dominated by snowmelt runoff in its head water area, the Columbia Mountains, with the contribution from the interior plateau being almost negligible. The most extensive stream gauging records south of Kamloops Lake are available at Spences Bridge, where the drainage area is 54 650 km^2. At the water supply intake site, the drainage area is approximately 13 000 km^2 smaller than at Spences Bridge but the high and low flows should not differ by more than 500 m^3/s and 20 m^3/s, respectively. The maximum and minimum flow frequency curves for the Thompson River near Spences Bridge are shown in Fig. 3.3-7. Both curves have unusually flat slopes, indicating that the year-to-year variation in both freshet peak flow and minimum flow is relatively small.

B. Hat Creek and Bonaparte River

In order to determine how the runoff patterns of the Bonaparte River and Hat Creek compare with the general region, a regional analysis based on annual mean daily peak flows from 85 basins was computed. Basins with significant lake areas, diversions or regulation were omitted from the analysis.

Initially, extreme maximum daily flows were plotted against drainage area as shown in Fig. 3.3-8. All points relating to Hat Creek or to the Bonaparte River fall far below the envelope curve. Linear multiple regressions were then computed on the data, one for μ, (the geometric mean of the flows) and one for σ (the geometric standard deviation). Fig. 3.3-9 is a plot of the observed versus predicted values of μ for the 85 basins included in the regression. All the points relating to Hat Creek or to the Bonaparte River lie far above the line of perfect agreement, which indicates that Hat Creek and the Bonaparte River generate roughly one-third of the flood flows of comparable basins located elsewhere on the Interior Plateau. This is undoubtedly related to the pronounced rain-shadow effect of the Coast Mountains, immediately to the west of the Hat Creek drainage area. In the case of the Bonaparte River, the discrepancy is partly attributable to extensive lake storage, which reduces peak flows.

The regression on the geometric standard deviation was performed in a similar manner (Fig. 3.3-9). The points representing Hat Creek fall close to the line of perfect agreement, indicating that the observed year-to-year variability of floods in the Hat Creek region is reasonably typical for the southern Interior Plateau of B.C. The Bonaparte River is less typical, probably due to its larger basin with significant lake storage.

(ii) Hat Creek Valley Hydrology

A. Precipitation and Snowmelt

The year-by-year variations in total precipitation, total rainfall and greatest 24-hour rainfall are illustrated in Fig. 3.3-10. Data on rainfall intensities of shorter duration than 24 hours are sparse. However, based on the most relevant data available for the present study, appropriate information related to Hat Creek was developed (Fig. 3.3-11).

Total precipitation depends strongly on elevation. The best available data are plotted on Fig. 3.3-12, together with a proposed curve for Hat Creek. The curve is an attempt to fit those data points judged to be most relevant to Hat Creek.

Fig. 3.3-12 can be combined with the area-elevation curves for Hat Creek and Medicine Creek (Fig. 3.3-13), to compute the volume of precipitation at various elevations and subsequently a total mean precipitation input for these basins. For Hat Creek, the total amounts to 394 mm, evenly distributed over the basin area, which can be compared to the 317 mm mean annual precipitation observed at the Hat Creek climatological station located at an elevation of 899 m. The figure for Medicine Creek is 390 mm.

Snow accumulation is also dependent on elevation. This variation can be investigated either on the basis of mean annual snowfall, or on the basis of mean maximum snow water content accumulated in the snow pack. In Fig. 3.3-14 data of both types are plotted against elevation. The proposed curve for Hat Creek fits the most relevant data points as best as possible. From this the average snowpack is computed to be 6.09×10^7 m^3 of snow-water equivalent, or 176 mm over the total basin area. This indicates that approximately 45 percent of the total precipitation input into the basin is incorporated in the snowpack before becoming runoff. The year-to-year variation in snow accumulation is illustrated by the frequency curve of Fig. 3.3-15.

B. Flow Regime

In Fig. 3.3-16, the records for Hat Creek and for the Bonaparte River immediately upstream of Hat Creek and for Hat Creek itself are summarized as 5-day probability curves. The curves summarize the range and seasonal distribution of observed flows. Late August and early September are critical low flow periods. Peaks resulting from heavy rains can occur in summer but do not reach the magnitude of spring freshet flows. The possibility of significant early snowmelt in March or April is not common. The Bonaparte River appears to have a much more regulated flow behaviour. This is due to significant lake storage and its very large drainage basin.

The standard flow-duration curves for the same four sites are shown on Fig. 3.3-17 and the corresponding flood-frequency curves are shown on Fig. 3.3-18. Also shown on Fig. 3.3-18 are the predicted flood frequency curves based on the regional analysis regression equation for μ, the mean daily peak flow, adjusted to the Hat Creek region. In Fig. 3.3-19 the adjusted regional analysis has also been used to obtain flood frequency curves for Harry, Medicine, Ambusten, Anderson, Finney and Houth creeks, the main tributaries of Hat Creek.

Fig. 3.3-20 shows the year-to-year distribution of runoff from Hat Creek. Mean annual runoff, for the station "Hat Creek near Upper Hat Creek" based on 14 years of data, including 1976, is 21.0×10^6 m^3. There is little natural or artificial storage in the Hat Creek drainage area.

In Hat Creek the lowest mean daily flows of the year can occur either in late summer or in mid-winter. Low flow frequency curves for the late summer low, mid-winter low and combined low have been prepared as shown on Fig. 3.3-21. The two low flow periods are quite similar in magnitude but the late summer flows are considerably more variable.

The response of Hat Creek to significant rainstorms has been investigated by searching the stream flow records for rain-caused flood events. The results of the analysis are summarized in Table 3.3-5. Column 8 gives the amount of runoff in the hydrograph as mm over the 350 km^2 drainage basin and Column 9 gives this runoff as a percentage of the rainfall input. It ranges from 1 percent to 10 percent, with the larger values associated with rainstorms during or shortly after the main snowmelt season. The lag (Column 7) appears to be in the order of 24 hours, but it is probably closer to 12 hours for the largest flows. Runoff coefficients (Column 10) for rain peaks in late summer and fall range from 1 percent to 3.5 percent, but for rainstorms occurring during or shortly after the snowmelt season, this goes up to 17 percent. The one event with 30 percent runoff probably reflects high snowmelt conditions. The true runoff coefficients and proportions of runoff are different and probably often smaller than the values shown in Table 3.3-5, since the low elevation of the climatological station will often lead to an under-estimated precipitation.

C. Evaporation and Water Balance

Evaporation and transpiration estimates for specific drainage basins or for large areas (greater than a few square kilometres) are normally obtained from a water balance which can be stated as:

$$E = P - O - S$$

Where P is precipitation input, O is outflow, S is storage change and E is the residual and can be assumed to represent evapotranspiration, as long as the area under study does not have significant groundwater inflows or outflows. The storage change (S) can be neglected if long-term mean values are being considered. Applying this equation to the Hat Creek drainage basin upstream of the stream-gauge at the mine site (drainage area 350 km^2) where the long-term runoff is 60 mm, and using the elevation adjusted mean annual precipitation of 394 mm as input, one obtains an evapotranspiration loss of 334 mm. With proper adjustments for irrigation and diversion losses, the natural runoff would be approximately 75 mm, giving a natural evapotranspiration loss of 319 mm. This can be compared to values of 294 mm and 317 mm reported by the Atmospheric Environment Service.[11] These latter values were developed utilizing a modified Thornthwaite method, applying it to standard climatological data at the Hat Creek station and assuming soil water holding capacities of 100 mm and 200 mm, respectively. Differences are due to the elevation-dependence of the main water balance characteristics.

D. Channel Morphology and Flood Plains

Hat Creek Valley is mainly the result of glacial processes, combined with structural factors and stream erosion by earlier and probably larger streams. Present-day Hat Creek is too small to alter the valley in a major way.

Hat Creek's channel between the proposed mine and the alluvial fan in the Bonaparte River Valley, can be classified as irregular and split to anastomosing and often poorly defined. The valley cross sections show an entrenched or partly entrenched channel, for which lateral development is continuously confined by resistant valley walls or high banks of unconsolidated sediments. The valley flat generally consists of several fragmentary narrow and low terrace levels, and a narrow genetic flood plain, rarely more than a few channel widths wide. The dominant channel bed material is gravel to cobble with some sand.

The channel slope, outside of canyon sections, appears to be about 1 percent and is relatively constant along morphologically homogeneous reaches. On a geologic time scale, Hat Creek is degrading along almost its entire channel length, the alluvial fan at its downstream end being the main exception. The dimensions of such channels are generally most closely related to relatively high flows. Bankfull flows can serve as a rough indicator of channel-forming discharge. Using these levels, flows have been estimated for Reaches 1, 5 and 9 (see Fig. 3.3-23), as 22.4, 24.5 and 9.6 m^3/s, respectively. This can be compared with the 2-year flood at upper Hat Creek of 6.0 m^3/s and indicates that the channel forming discharge is probably in the order of 10 to 25 m^3/s with a return period between 4 and 30 years. A flood plain zone based mainly on the cross section surveys and on vegetative indicators, has been defined on stereo air photographs. It is delineated on Fig. 3.3-22 and 3.3-23. The recurrence interval of flooding is probably quite variable over the flood plains zone, but should generally be in the same order of magnitude as bankfull flows. The Hydrology, Drainage, Water Quality and Use Report should be consulted for more detail on Hat Creek's channel profile and hydraulic geometry.[1]

3.3.3 Water Use

(a) Groundwater

Within the Hat Creek Valley there are 12 domestic wells, and three developed springs. The locations of all wells are shown in Fig. 2.2-1. It is estimated that the domestic water consumption in the Hat Creek Valley is approximately 30 m^3/d. There are no wells or springs which are used for irrigation purposes in the valley, however in some places ditches have been dug to divert a minor amount of groundwater from areas of bogs or seeps into dry soil areas.

A large capacity well supplies wash water for a limestone quarry located in the Marble Canyon area. This well is estimated to deliver 500 m^3/d of which about 75 percent is returned to the groundwater table as infiltrated wastewater.

(b) Surface Water

(i) Irrigation

The following analyses were carried out to estimate the amount of water presently used for irrigation in the study area (Fig. 3.3-24): 1) an analysis of water license information, and 2) an analysis based on a water use model.

3.3 WATER RESOURCES - (Cont'd)

A. Water License Analysis

Hat Creek Drainage

The water license information for the Hat Creek drainage basin was categorized in Table 3.3-6 on the basis of four subregions (refer to Fig. 3.3-24) which contain approximately equal lowland areas of the Hat Creek Valley. A total of 1050 x 10^4 m^3 of water of the Hat Creek drainage is licensed annually for irrigation use. The major source of water is Hat Creek which is licensed for the diversion of 459 x 10^4 m^3.

Of the 1050 x 10^4 m^3, 631 x 10^4 m^3 are licensed for use on land that lies within the Hat Creek drainage basin while 419 x 10^4 m^3 are licensed for use on land that lies outside. Of this latter number, 224 x 10^4 m^3 is licensed for diversion from Medicine Creek into the Cornwall drainage and 158 x 10^4 m^3 are licensed to be diverted to the Oregon Jack drainage. This latter diversion, however, has not been operational for sometime.

In addition to primary irrigation licenses, there are a number of supplemental licenses and some irrigation storage licenses. These are also detailed in Table 3.3-6. A relatively small amount of water is licensed for storage in other areas.

Bonaparte Drainage (south of Township 23)

A total of 1290 x 10^4 m^3 of the surface waters of the Bonaparte drainage (south of Township 23) is licensed for irrigation use (Table 3.3-7). The major source is the Bonaparte River itself. Cache Creek is the next largest source and one irrigation license is held on the Thompson River. A total of 75 x 10^4 of water is under supplemental irrigation license. Storage is licensed for Semlin Lake and a reservoir on the west fork of Cache Creek in the total amount of 66 x 10^4 m^3.

Cornwall and Cheetsum Drainages

A total of 125 x 10^4 m^3 of the waters of the Cornwall and Cheetsum (immediately south of Cornwall) drainages is licensed for irrigation use. The major source is Cornwall Creek. The other five sources in this drainage are licensed for 10 to 18 x 10^4 m^3 each. One supplemental irrigation license is held on waters of Cornwall Creek and storage is licensed for McLean, Fitzellan, Henry and UK lakes.

Oregon Jack and Minaberriet Drainages

Approximately 148 x 10^4 m^3 of the surface waters of the Oregon Jack and Minaberriet (immediately north of Oregon Jack) drainages is licensed for irrigation. Oregon Jack Creek is the primary source, accounting for 136 x 10^4 m^3 of the total of which 92 x 10^4 m^3 of water is held under supplemental irrigation license. Storage is licensed for one pond in the area in the amount of over 68 x 10^4 m^3.

3. Water Use Model Analysis

The amount of water required for irrigation is a function of climate, soil, crop and irrigation system characteristics. In general, this amount is made up of two major components: the irrigation requirement of the crop (water used by the plants); and the amount of water that is lost during the conveyance from source to field and during field application (water not available to the plants). The ratio of the irrigation requirement of the crop to the total amount of water used (i.e. diverted from source) represents an irrigation efficiency value for a particular system.

The model used to determine the irrigation requirement is similar to a computer model used by Agriculture Canada for agricultural areas in British Columbia.[12] The formula used is:

$$IR = R\ ((f \cdot PE) - P - SU)$$

where, IR represents the irrigation requirement of the crop, expressed as a depth of water; R represents a risk factor, which is a function of the risk of not having enough irrigation water to meet the consumptive needs of the crop; f represents a consumptive use factor which is defined as the ratio of consumptive use of water by a crop to potential evapotranspiration; PE represents potential evapotranspiration; P represents precipitation and SU represents storage utilization, which is the amount of water stored in the soil at the start of the season that could be utilized efficiently under normal irrigation scheduling.

The irrigation requirements (IR) determined by this model do not take into account various water losses. These losses are primarily a function of the method of irrigation and type of soil. Two artificial methods of irrigation are used in the Hat Creek Valley: sprinkler irrigation and creek diversion for surface irrigation.

Efficiencies used to estimate present water use were chosen on the low end of the theoretical ranges for each method and are as follows:

	Application Method	
Soil Type	Sprinkler	Ditch Diversion
Upland	60%	50%
Floodplain	70%	60%

The quantity of water presently used to irrigate lands within the Hat Creek Valley was estimated by superimposing the irrigation requirements (IR) developed from the model onto the amount of presently irrigated land and adjusting the total by the water loss efficiency factor.

The results (Table 3.3-8) for both the quartities of land presently irrigated and the estimate of the quantities of water used for irrigation were summarized and reported on the basis of the four subregions defined for the Hat Creek drainage basin (Fig. 3.3-24). The estimate of total water used for irrigation is 679×10^4 m^3/a.

A comparison of this estimate and the water license analysis shows a good correlation for both the quantity of water and the quantity of irrigated land. This would indicate that, in general, irrigation licenses are presently being utilized in full in the Hat Creek Valley.

(ii) Livestock

The quantity of water presently used by livestock in the Hat Creek Valley was estimated to be 65.5 m^3/d. Summer consumption would be greater than this amount and winter consumption would be less. The estimate of the total annual quantity of water presently used by livestock is 2.4×10^4 m^3. This amount represents approximately 0.4 percent of water presently used for irrigation in the Hat Creek Valley.

Estimates of cattle population were not available for other portions of the study area; however, it is judged that the ratio between livestock water use and irrigation water use for the Bonaparte, Cornwall and Oregon Jack drainages would not be radically different from that estimated for the Hat Creek drainage.

(iii) Domestic and Municipal

A. Hat Creek Valley

The total population of Hat Creek Valley including two Indian Reserves (I.R. 1 and 2) is estimated at 110 persons. On the basis of water license data a total water usage of 84 m^3/d is licensed for domestic and stock watering purposes from Hat Creek and its tributaries. Of this amount, 18.2 m^3/d is diverted out of the Hat Creek watershed for use in the Cornwall Creek and Oregon Jack Creek areas. The total withdrawal licensed from Hat Creek downstream of the proposed mine is 25 m^3/d. The licensed quantity for use on Indian Reserve No. 1 and 2 in lower Hat Creek Valley is 13.6 m^3/d.

B. Downstream Bonaparte and Thompson River

The 1976 population estimates for the downstream communities of Cache Creek and Ashcroft are 1050 and 2030 persons, respectively. The rural population, exclusive of the area Indian Reserve inhabitants, is estimated at 220 persons for the unincorporated areas surrounding these centres. The population of Indian Reserve No. 3 north of Cache Creek is estimated to be 100 persons.

Water license data indicate that a total of 9222 m^3/d is licensed for domestic, municipal and industrial purposes from the Bonaparte River between the junction of Hat Creek and the Thompson River. The total licensed withdrawal in this category for Indian Reserve No. 3 (Bonaparte) is 11.3 m^3/d and the total licensed quantity for Cache Creek municipal use is 8070 m^3/d. The remainder is licensed to many other users in this reach, made up of individual withdrawal rights ranging from 2.3 to 726 m^3/d.

The community of Cache Creek obtains its water supply from the Bonaparte River using an infiltration gallery type intake. The current water system intake capacity is approximately 4990 m^3/d. Based on this value and the 1976 population, the average daily demand is approximately 0.91 m^3/d per capita or 955 m^3/d.

The community of Ashcroft presently withdraws its water supply from the Thompson River, downstream of the confluence of the Bonaparte River, via a wet well type intake. The current licensed withdrawal rate is 1815 m^3/d, although, summer demand reaches 7260 m^3/d. Based on the 1976 population, the average daily demand is approximately 0.91 m^3/d per capita or 1847 m^3/d.

The water license data for the Thompson River between Walhachin and Lytton, B.C. indicate a licensed quantity for domestic purposes of 477 m^3/d excluding Ashcroft's licensed amount. The total quantity licensed or in application status for industrial use totals 86 885 m^3/d. The majority of this industrial demand is for the Lornex Mine in the Highland Valley.

C. Cornwall and Oregon Jack Creek Areas

The current population of the Oregon Jack Creek Indian Reserve is 13 persons and a further 40 persons reside on the Ashcroft Indian Reserve No. 1, 2 and 4. It is reported that no people live on the McLean Lake Reserve. The quantity of water licensed for domestic and stock watering purposes in the Cornwall Creek watershed, including domestic water diverted from the Hat Creek basin, is 48.8 m^3/d. The quantity licensed for industrial use is 12.3 m^3/d. The total licensed surface water for domestic and stock watering purposes in the Oregon Jack Creek basin, including surface water from the Hat Creek watershed, is 15.9 m^3/d.

3.3.4 Aquatic Ecology

(a) Regional Aquatic Ecology

The nature of any aquatic system is dependent upon its watershed characteristics.[13-18] Two kinds of watershed effects on aquatic ecosystems exist: those due to the physical geographic influences and those due to human influences. Physical geographic influences include those due to climatology and geology. Human effects on a watershed are a result of land use. In the following sections, the relationships between these factors and the aquatic habitats found in the region surrounding the proposed Hat Creek Project (defined in Part Three, Section 2.2-5) are considered.

After characterizing the aquatic habitats within the region, the biota occupying these habitats are described. Primary emphasis is placed on the fish species because of the large quantity of available information dealing with fish in the region, and also because impacts to fish are of great concern to people. Further, since fish tend to occupy the highest trophic levels in aquatic ecosystems, differences in other communities (lower trophic levels) will also manifest themselves in fish populations.

In addition to the indirect effects humans have on aquatic systems via land use practices within watersheds, humans can directly effect aquatic systems by exploiting fish populations and by competing with the aquatic community for water use. The extent of these occurrences is also addressed.

(i) Watershed Characteristics

A. Geology

The configuration of the drainage basin is the result of long-term geologic processes expecially erosion, applied to the regional geologic terrain. Drainage basin configuration, along with climatic and vegetation characteristics, control seasonal and short-term precipitation runoff rates in streams. Water quality in lakes and streams is affected by the chemistry of the surface water drainage and groundwater inputs. Similarly the chemical characteristics of surface water contributions to streams is affected by rock and soil geochemistry.

B. Climate

The location of the Coastal Range on the western border of the region effectively blocks maritime climatic influences. Temperatures exhibit continental extremes, with average monthly temperatures reaching 21°C in the summer and dropping below -5°C in the winter. Precipitation is generally low and exhibits an orographic pattern. Observed precipitation ranges from less than 250 to 1000 mm/yr with higher values observed at higher elevations. Most locations in the region receive 250 to 500 mm of precipitation per year.

Surface water quality is influenced by climate in several ways. Water temperatures in the region closely approximate average monthly air temperatures. Alkalinity in the region varies from less than 50 mg/L to greater than 400 mg/L. Although partially due to the composition and solubility of soils and rocks, the higher values are also a result of the concentrating effects of a climate where evaporation exceeds precipitation in many areas. These and other water quality parameters for the various regional water bodies are given in Table 3.3-9.

The intermittency of many of the streams in the region can also be attributed to the arid climate.

C. Human Influences

Land use in the watersheds within the region is shown in Fig. 3.3-25. As can be seen, much of the human oriented land uses are concentrated around water bodies. This probably has resulted in higher concentrations of suspended solids and faster runoff because of increased areas of cleared land and an increase in nutrient input from agricultural practices, septic tanks, leaching from garbage dumps, etc.

(ii) Acuatic Biota

Twenty-five species of resident fish have been identified within the region (Table 3.3-10). Many of these species are adapted to cold, flowing water (or lake margins) with gravel or rock substrate. None are rare or endangered.[19] Of the six species of salmonids, brook trout (an introduced species) and kokanee (land-locked sockeye salmon) are not widely distributed within the region. Dolly Varden, rainbow trout, and pygmy and mountain whitefish are more prevalent. In addition to the resident fish, five species of anadromous fish spawn and spend their early life stages within the region. These are sockeye salmon (Oncorhynchus nerka), pink salmon (Oncorhynchus gorbuscha), coho salmon (Onchorhynchus kisutch), chinook salmon (Oncorhynchus tshwaytscha) and steelhead trout (Salmo gairdneri). The significance of the Fraser River system is suggested by the fact that an average of 7 094 000 salmon produced by this system are caught by commercial fishermen each year. When added to the sport and subsistence catch, this number represents excess production (fish not needed to maintain the population size).

The importance of migratory fish to the aquatic ecosystem within the region is dependent upon the density of migrants and the time they spend within a given water body or portion thereof. The density can be highly variable, depending upon site-specific habitat factors. For example, in the Thompson River between 35 and 42 miles, twice as many pink salmon spawn per mile than in the river between 24 to 35 miles. The time spent within a water body is species specific. Pink salmon spawn during alternate years (e.g. 1973, 1975, 1977) in September and October. Migration to the sea occurs in the spring soon after emergence from gravel spawning beds while the young salmon are still in the fry stage. Sockeye salmon adults migrate upriver during the summer, spawn in the fall and the juveniles remain in freshwater for 1 to 2 years before migrating to the ocean in the late spring. Adult chinook salmon exhibit a freshwater life cycle similar to sockeye, but the young of this species can either migrate immediately after hatching or after several years in freshwater. Adult coho salmon migrate upriver from July to December to spawn each year in the fall. Some coho salmon migrate to the sea as fry in the spring and some remain in freshwater for their entire lives. However, most remain one year in freshwater. Steelhead are quite variable in their freshwater life cycle. Upriver migrations occur in the summer or winter, while spawning takes place in spring. Downstream migration of juvenile fish occurs in the spring. The degree to which each species spawns within a given water body within the region, the number of fish travelling through the region to spawn in upstream locations, and the total number of fish spawning in the Fraser River system are given in Table 3.3-11.

Many salmon in the Fraser River system are infected with infectious haemapoitetic necrosis (IHN), the protozoan Trechophyrs sp, the copepod Salmonicola sp, or the lamprey Entorphenus tridentatus. The effects of the other infestations in natural salmon populations are not known, but IHN causes high mortality in hatchery fish.

(iii) Direct Human Effects

A. Fisheries

Fish caught by the region's sport fishery are mostly salmonids, although some burbot are also taken. In the Kamloops area rainbow trout, brook and lake trout, kokanee and steelhead accounted for 57 000, 19 000, and 2000, respectively, of the 102 000 fish taken in 1969-1970. This represented 7.6 percent of the total number of sport fish taken in British Columbia in that year. In the Kamloops area, during the years 1969 and 1970, 79 percent of the anglers preferred to fish lakes rather than streams. Within the region, 731 378 angler days were expended fishing 228 lakes in 1976. Sport fishing in streams appears to be somewhat more specialized. The Thompson River, for example, is known for its steelhead fishing. It accounts for 84 percent (12 013 angler days) of the effort expended in the region by steelhead fishermen.

Regional fish and wildlife personnel provided a general assessment of angling pressure in the region. Green Lake, Kelley Lake, Kelley Creek, Tunkwa Lake and the Thompson River (for steelheads) were thought to be fished at or near the maximum desirable fishing pressure. Other water bodies in the region could evidently withstand greater fishing pressure than they are presently receiving without damage to their fish population.

A large portion of the Canadian and United States commercial salmon fishing is dependent upon the spawning and nursery grounds provided by the Fraser River system. Approximately 33 percent of the total salmon taken in British Columbia originates in the Fraser River system, while 10 percent of the catch is from the Thompson River system. The importance of the region can be assessed in terms of spawning of escapement, given in Tables 3.3-11 and 3.3-12. In addition, an average of approximately 186 000 salmon and steelhead from the Fraser River system are used by Indians each year for subsistence purposes.

B. Enhancement of Fish Population

The region's fish populations are not only exploited by the various fishing categories discussed in the preceding section but also enhanced by various management practices. Most important is the control of the fish catch (e.g. by licensing fishermen, establishing seasons, etc.) to prevent overfishing (i.e. fishing at a rate greater than the optimum sustainable yield). Natural spawning is enhanced by stocking. In past years, rainbow trout, brook trout, kokanee, steelhead, cutthroat trout, Atlantic salmon, and lake trout have been stocked in the region. Numbers of fish stocked are likely to increase in the future as two regional rearing facilities are constructed and become operational. In addition, various stream improvement projects have been undertaken so that migrant spawning would be enhanced. These include fish ladders, spawning channels, and an incubation channel. Additional fish will be spawned in the region in the future when a planned hatchery is built.

C. Competing Water Uses

The location and capacity of major intakes in the region are summarized in Table 3.3-13. The location and volume of major discharges in the region are given in Table 3.3-14.

(b) Site-specific Aquatic Ecology

(i) Thompson River

The Thompson River, formed from the North and South Thompson rivers and flowing out of Kamloops Lake, drains the Thompson Plateau. The fish fauna consists of 13 species, including five species of anadromous salmonids (Table 3.3-15). Much of the required information in Section 2.3.5(a) also applies to this more specific section on the Thompson River. The Thompson River contributes more than 30 percent to the annual catch of Fraser River salmon. River banks and beds which are composed mainly of cobbles and boulders with isolated bars of gravel suitable for spawning are chiefly utilized by pink salmon. The nearest spawning area to the proposed Hat Creek intake site and the confluence of the Bonaparte River is approximately 600 m above the proposed intake site.[21]

The river reach of concern and its relation to the project is shown in Fig. 2.2-4 (see Chapter 2.0). While this study involved no direct sampling of the Thompson in the subject river reach, several qualitative observations were made. The Thompson mainstream serves here as a migratory route for anadromous salmonids and provides some rearing habitat for juveniles and resident adult fish. It is characterized by a relatively deep channel and strong currents. An area of rapids composed of large boulders is apparent at low water just upstream of the confluence with the Bonaparte River. Spawning conditions in this reach are poor, and in many areas the river bottom is covered with boulders 0.3 to 0.6 m in diameter. International Pacific Salmon Fisheries Commission (IPSFC) divers noted no spawning in this region, although a large concentration of spawners did occur on the spawning beds located approximately 600 m above the proposed intake site.[21] There is also some limited utilization of the Bonaparte River in the region below the falls.

The Thompson River is probably best known for its quality steelhead fishing and is considered one of the finest "trophy" producing streams in British Columbia. While catch estimates are not available for just this river segment, B.C. Fish and Wildlife reports that an estimated 732 steelhead were taken from the Thompson River during the 1976-77 season at an average success rate of 0.122 fish/angler/d.[22]

Approximately 20 percent of this region of the Bonaparte River exhibits good spawning habitat. An estimated 611 pink salmon spawned in this section of the river in

1977. In addition, a small but significant run of approximately 25 fish annually spawn in the Bonaparte River.[23] It is likely that some coho and steelhead trout also utilize the available habitat to about the same extent.

(ii) Other

A. Physical Habitat

Hat Creek provides a variety of habitats from its headwaters to its confluence with the Bonaparte River. These habitats range from small pools and beaver dam impoundments to fast flowing water in canyon and chute areas. Hat Creek tributaries provide relatively poor fish habitat compared to Hat Creek itself. Overall, like most other small permanent stream courses of interior British Columbia, Hat Creek appeared to provide good rainbow trout habitat. Some general observations and distinctions can be made when describing Hat Creek in terms of fish habitat.

Using information derived from helicopter flights and the more intensive assessment of habitat parameters at the various sampling stations, Beak Consultants chose to divide Hat Creek into 17 longitudinal zones. On the basis of morphometric characteristics, such as substrata particle size, pool to riffle ratio, bank stability, vegetation cover, etc., these zones can be grouped as shown in Fig. 3.3-26, according to the three habitat types described below:[19]

Type I

Substrata - predominantly boulder, cobble, pebble, and gravel
Pool to Riffle - 30:70 - 0:100
Swift-flowing, commonly steep gradient, deciduous trees and brush
Zones - A, B, C, G, I, L

Type II

Substrata - cobble, pebbles, sand, silt
Pool to Riffle - 80:20 - 15:90
Intermediate but generally varied current and gradient
Beaver dams, varied vegetation type
Zones - E, F, H, K, M, N, O, P

Type III

Substrata - pebble, gravel, sand, silt
Pool to Riffle - 100:0 - 80:60
Less steep but varied gradient, sluggish to moderate current
Beaver dams
Zones - D, J, Q

Sampling station locations are shown in Fig. 2.2-4 and their physical characteristics are described in Table 3.3-16. Location of the Hat Creek station relative to habitat type can be seen in Fig. 3.3-26. Stations 5, 6, and 10 represent Type II habitat and Station 14a is identified as Type III habitat.

Stations 8, 9, 11, 12 and 13 were established on five tributaries to Hat Creek, an unnamed creek, Finney Creek, Medicine Creek, Ambusten Creek and Anderson Creek. These small streams consisted of swift-flowing cool waters for most or all of their length. Pool to riffle ratios for observed stretches of these streams approached 0:100. Finney Creek ran underground for part of its length. Ambusten Creek was intermittent, as its water was diverted for irrigation on a seasonal basis. A partial description of these streams appears in Table 3.3-16, and more detailed information is provided in the Fisheries and Benthos Report.[19]

Stations 1, 2, 3 and 4 are located on the Bonaparte River. These sites would have been described as Type I habitats had the Hat Creek classification scheme been extended to include the Bonaparte River. Pool to riffle ratios of 5:95 and 10:90 were observed and substrates were dominated by pebble and gravel. Water temperatures in the swift-flowing Bonaparte ranged from 11°C to 22°C.

Water quality information for Hat Creek and the Bonaparte River is summarized in Table 3.3-9. Water bodies located within the study area reflect similar microclimatic, geological, and soil conditions and contain waters of high alkalinity.[19] Alkalinity values ranged as high as 800 mg/L with pH between 8.1 and 8.5, reflecting the well-buffered nature of these waters.

B. Benthos

Benthos is the term applied to organisms which live in, or on, available bottom substrates. Animals typically found in these collections include worms, mussels, hydras, protozoans, crustaceans (e.g. amphipods, or shrimp-life animals), and insect larvae. These animals are used as food by fish and wildlife. Salmonids rely heavily on crustaceans and insect larvae. Insect larvae may be picked up by the fish directly from the substrate, or as they float downstream in a characteristic pattern of diel (daily) "behavioral drift".

Type and Abundance of Organisms

A list of organisms present in each of the study areas is given in Table 3.3-17. These organisms are all "macroinvertebrates". Summaries showing which of these genera are dominant, and the taxonomic orders to which they belong, are given in Tables 3.3-18 and 3.3-19. Most of the animals identified in these tables represent clean-water, or pollution-intolerant animals, as would be expected in the Hat Creek Valley. They also reflect an affinity toward rubble, pebble and gravel substrates, which characterized most of the stations.

The density of animals present at each station in September 1976, and June and August 1977, is shown in Tables 3.3-20, 3.3-21 and 3.3-22. These data are presented in terms of habitat types as defined previously. Table 3.3-23 indicates that mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) are abundant in local streams and no one organism consistently dominates samples. Variability among stations within habitats was also considerable (Table 3.3-23). With the exception of lake stations, the range of densities observed within habitats was often as large as it was among habitats. It may be reasonable to treat the study streams as a group of fairly similar environments with respect to their benthic communities. These streams are all basically high altitude, fast flowing, relatively undisturbed systems. Goose Lake and Finney Lake (station 16 and 17) were considerably different, as would be expected.

A general similarity among stations is observed when organisms are arranged in groups, each representing different levels of habitat and/or water quality specificity.[19] This kind of grouping is a classical one for studying gross differences in community structure due to pollution, but it often masks the subtle within-group differences which exist because of adaptation to different physical habitats. Beak Consultants Ltd.[19] created three groups, as follows:

- Mayflies (Ephemeroptera), Dragonflies (Odonata), Stoneflies (Plecoptera), Beetles (Coleoptera), and Caddisflies (Tricoptera).
- Midges (Chironomidae) and other Diptera.
- Aquatic Worms (Oligochaeta).

Percent composition of samples taken in September 1976, June and August 1977, along with substrate composition at those stations, is shown in Table 3.3-24. Based on percent compositions, paired station "affinity indices" were calculated by summing the smaller of the two percentages for each category (e.g. substrate type, or each of the three organism types). Indices between 0 and 100 are formed, and these are plotted on a symmetric, or trellis, diagram. Numerical values are printed in the right half of the matrix, and codes, representing ranges of values, are printed in the left half of the matrix to make interpretation easier.

Similarities in substrate composition among stations are shown in Fig. 3.3-27. It is evident that although there are gross similarities among habitats (as defined previously), substrate composition within habitats varies considerably. For example, Station 1 on the Bonaparte River is more closely related to the Hat Creek stations, than it is to the other Bonaparte River stations. Station 15 more closely resembles Bonaparte River stations 2 to 4, than it does Hat Creek stations. Type I stations (5, 6, 10) are all closely related. Type II stations 14 and 15 are related to substrate, but station 7 fits better into Type I category if substrate alone is considered. Similarity indices based on a benthic group composition (Fig. 3.3-28 and 3.3-29) did not reflect those based on substrate, but it is possible that "station" substrates did not exactly represent the kind of microhabitat where samples were actually taken. With the exception of the two lake stations (16 and 17) and at times the various tributaries (stations 8, 11, 12, 13) and Hat Creek station 15, group composition among stations did not appear to be significantly different. In September 1976 (Fig. 3.3-28), Bonaparte River stations (1 to 4) were similar among themselves, as were Hat Creek stations (in difference between Type I and II habitats). Goose Lake (16) and Finney Lake (17) had a 90 percent between-station affinity, but were quite different from stream stations. These lakes were not sampled in 1977. In June and August, 1977 (Fig. 3.3-29 and 3.3-30) station 15 was distinct from the rest of the stations, probably due to minimal flow in this section (headwaters) of the system.

Diversity of Organisms

A numerical representation of species diversity (Shannon - Weaver Index) was computed for each station and sampling date. The details of this procedure are given in the Fisheries and Benthos Report.[19] In general it is intended to express the evenness with which individuals are distributed among genera ("equitability"), and the number of different genera sampled ("richness") in a single number.

Results of this exercise suggested that benthic diversity increased in a downstream direction in Hat Creek Valley (basically Bonaparte River versus Hat Creek), but statistically there were considerable overlaps in the indices calculated (as shown by measures of precision, or "fiducial limits").[19] One would often expect an increase in diversity with increasing distance downstream, due to an increase in available niches.

Utilization of Benthic Macroinvertebrates by Rainbow Trout

Rainbow trout feed on benthic organisms to the extent that they are available and/or abundant (i.e. the fish are opportunistic).[19] The frequency of occurrence of the most abundant food items in stomachs of Hat Creek and Bonaparte River rainbow trout is presented graphically in Fig. 3.3-31, 3.3-32 and 3.3-33, wherein stomach content is plotted against sampling station. Only trout of the 51 to 100 mm and 101 to 150 mm size categories were examined as these were the only size represented throughout the study area.

The figures do not suggest any consistent spatial trends in the importance of Ephemoptera, Tricoptera, and Diptera to the diet of rainbow trout. Examination of benthic data presented in Tables 3.3-20, 3.3-21 and 3.3-22 indicate that the abundance of these organisms in benthic samples also fails to follow any consistent spatial trends. It appears that neither benthic data or the analyses of stomach contents are capable of demonstrating that water bodies or habitat types differed with respect to the nature of their benthic communities or the utilization of benthic organisms by rainbow trout. Fig. 3.3-31 and 3.3-33 suggest temporal trends in the frequency of occurrence of Ephemeroptera and Diptera in the stomachs of rainbow trout, thereby suggesting seasonal and/or yearly trends in the availability and utilization of these organisms by trout.

Summary and Conclusions

Benthic communities were generally similar throughout the study area. Exceptions included two small lake habitats, and, during summer, the headwaters of Hat Creek. Samples were dominated by organisms which are generally throught of as being pollution intolerant. This was expected in the upper Hat Creek Valley, although some agricultural activity takes place in portions of the system.

Benthic community composition could not be clearly related to habitat type in the Hat Creek and Bonaparte River stream ecosystems. This difficulty was related to environmental variation at the microhabitat level, and typical sampling variation experienced in this kind of a programme. There was some evidence that benthic diversity was greater in downstream portions of the valley.

Rainbow trout tended to feed on organisms which were abundant and/or easily available. Whereas fish population parameters could be related to habitat type (Section 3.3.4(b)(iii)), the composition of their stomach contents could not.

C. Fish

The species composition and relative abundance of fish collected at Hat Creek and Bonaparte River sampling stations during September 1976, June 1977 and August 1977 are presented in Table 3.3-25. A total of 273 specimens representing seven species were collected in the Bonaparte River during the three sampling periods.

Longnose dace was the dominant species (150 individuals) followed by bridgelip sucker (66), leopard dace (26) and rainbow trout (19). Species present in smaller numbers were redside shiner (6), mountain whitefish (6) and brook trout (1). Fewer species were collected from Hat Creek and these exhibited a different order of abundance. Hat Creek collections yielded 632 individuals of five species. Of these five species, rainbow trout were clearly dominant (592), particularly upstream of station 5. Trout were followed by bridgeslip sucker (22), mountain whitefish (10), longnose dace (6) and leopard dace (2). Bridgelip sucker, longnose dace and leopard dace, the dominant species of the Bonaparte River collections, were taken only at the most downstream Hat Creek station (station 5). The apparent restriction of these species to the lower reaches of Hat Creek was either the lack of suitable habitat further upstream or the presence of barriers to migration (beaver dams) or a combination of these two factors. When the fish collection data are considered according to habitat type (as described in Section 3.3.2), it can be seen that the number of fish collected per square meter of stream fished is generally higher at Type III and Type II stations than at Type I station, as shown in Fig. 3.3-34. This observation does not hold for stations 10 and 15 which are Type I and Type II habitats, respectively. This is likely due to the fact that sampling was conducted both upstream and downstream of the station,[10] where pool to riffle ratios were somewhat higher than at the station itself (30:70 as opposed to 10:90). The low densities at station 15 in

September 1976, and August 1977, occurred during periods when water had been diverted for irrigation and can be attributed to fish being concentrated in remaining pools. Densities at Station 15 during June 1977, when flows appeared normal, are probably most representative of densities in this reach of stream.

The tributaries to Hat Creek appear to provide little suitable fish habitat. Anderson and Ambusten Creeks exhibited no fish during the periods sampled. During the July and August 1977 surveys the total flow of Ambusten Creek had been diverted for irrigation. Finney and Unnamed creeks also exhibited little or no flow and no fish during any of the three field surveys. Electroshocking in the lower 10 m of Medicine Creek yielded four rainbow trout in September 1976, ten rainbow trout in June 1977, and two rainbow trout in August 1977. Upstream movement of fish beyond this point appeared restricted by a barrier about 2 m high, although a local rancher stated that some fish (presumably rainbow trout) do occur further upstream. Overall, the potential fish habitat available in the tributaries appeared negligible compared to that existing in Hat Creek.

Sampling efforts and visual examination of Finney Lake in September 1976 failed to reveal any fish. A local rancher stated that the lake was stocked in the past but froze "solid" several years later, resulting in winterkill. B.C. Fish and Wildlife Branch personnel at Kamloops stated that Finney Lake, as well as Aleece Lake, have supported fish in the past and probably could again in the future.[24]

Visual observation of Goose/Fish Hook Lake in September, 1976 yielded no evidence of fish life such as fish rises, wakes or young fish in or near the shoreline vegetation. Lake pH was 9.9 and alkaline deposits were noted along the shoreline.

Age and Growth Characteristics

Length-frequency histograms for rainbow trout are presented by station sampling period in Fig. 3.3-35 and Table 3.3-26. Small rainbow trout (less than 60 mm in total length) were present at all Hat Creek stations in September 1976 and at stations 5, 6, 7 and 10 in August 1977. Scale analysis confirmed that these were young of the year fish (1976 and 1977 year classes, respectively), suggesting that spawning occurs throughout the length of Hat Creek.

Examination of length-frequency histograms by habitat type (Fig. 3.3-36) indicates small fish and thus probably spawning may have occurred more frequently at Type I stations (5 and 6) than at Type II stations (7, 10, 14 and 15). Station 10 is here considered as a Type II habitat, due to the morphometric characteristics of the area above and below station 10 itself, where sampling was actually conducted. Habitat Types I and II also appear to differ with respect to the abundance of larger rainbow trout, with more large fish in evidence at Type II stations.

Statistical significance of observed differences between Type I and II habitats was tested using the Kolmogorov-Smirnov Test,[25] a nonparametric procedure which can be used to test for shifts in frequency distributions. Given the null hypothesis of no difference in the size of rainbow trout in Types I and II habitat, results of this test indicate that differences as extreme or more extreme than those observed in September 1976 and June 1977 should have occurred only with probabilities of 0.001 and 0.1, respectively (Table 3.3-27). The null hypothesis was rejected for these dates. Differences in August 1977 were not extreme enough to reject this hypothesis. High numbers of small rainbow trout at stations 5 and 6 support the contention made by Beak Consultants Ltd. that the riffle areas of lower Hat Creek may serve as spawning habitat and nursery areas for the Bonaparte River as well as Hat Creek rainbow trout populations.

At Bonaparte River stations (1, 2 and 3), young were first collected in June, approximately 1 month earlier than in Hat Creek. These individuals are represented in histograms by specimens less than 60 mm in total length. This suggests that spawning in the Bonaparte River occurred earlier than in Hat Creek and/or that young developed more quickly there.

The past growth of Hat Creek trout population was calculated from scale measurements taken from fish collected in September 1976, June 1977, and August 1977.

The relationship between scale radius and total length was linear. The regression lines for the three sets of data were not statistically different and the data sets were therefore pooled to provide a best estimate of the relationship between length and scale radius:

$$\text{Total length (mm)} = 5.571 + 5.979\ (\text{scale radius})$$
$$\text{Correlation coefficient } (r) = 0.908$$

Individual total lengths at each annulus were determined from measurements along the anterior scale radius and calculated by the formula:

$$ln - c = \frac{Sn}{S}(l - c)$$

Where, ln = length of fish when annulus "n" was formed; c = correction factor for length of fish at scale formation (5.571 mm); Sn = length of scale from focus to annulus "n"; S = length of scale from focus to margin; and l = length of fish at time of capture.

Mean back-calculated total lengths and ranges for rainbow trout in Hat Creek are shown in Table 3.3-28. The general similarity of mean lengths at a given age for the various year classes suggests factors governing growth of rainbow trout in Hat Creek have remained relatively constant the past three or four years. Factors affecting variation in individual growth also appeared to have remained relatively constant. The wide range in observed lengths of fish 1 year and older may be due to an extended spawning time period, to variation in individual growth rates, and/or to error in back calculation. Evaluation of the contribution of each of these sources of error is beyond the scope of this study. Mean back-calculated lengths and the number of age 1-6 rainbow trout collected from Hat Creek stations are plotted in Fig. 3.3-37.

The number of fish 2 years and older appears to be related to habitat type as was suggested by length frequency histograms. Numbers of 2 and 3-year old fish collected at Type I stations (5 and 6) are lower than those for Type II stations (7, 10, 14).

Among rainbow trout of ages 4, 5 and 6 only one fish was collected at Type I stations as opposed to 38 at Type II stations. This difference may be a result of differential mortality rates at the two habitat types or to migration of older fish from Type I into Type II habitat. Since numbers of one year old fish appear higher for Type I than Type II habitat types, differential spawning success does not appear to be the cause of the relatively high numbers of older fish at Type II stations.

There does not appear to be any relationship between numbers of fish and mean back-calculated length (i.e. density dependent growth) as shown in Fig. 3.3-37. This may be due to high variability in both the numbers and lengths or to a true absence of density dependent growth.

No apparent relationship exists between mean back-calculated length and habitat type (Fig. 3.3-38). Therefore, no difference between habitat types with respect to growth can be postulated.

In conclusion, back-calculated age/length data indicates that larger fish (age 2 to 6) are most abundant at stations 7, 10 and 14, with no such trend existing for young (age 1+) trout. This would suggest that Type II habitat is favorable both as a nursery area and as habitat for adult rainbow trout, while the swift-flowing riffle areas at stations 5 and 6 serve primarily as nursery grounds. No relationship between growth and habitat type was observed.

Mean observed total lengths of trout collected (Table 3.3-29) show the same trends such as length variation among stations and among fish from the same year class, as did back-calculated lengths. If the observed mean lengths are plotted successively by year class to provide a general observed growth curve for rainbow trout in Hat Creek, as shown in Fig. 3.3-30, and this curve is compared to that based on back-calculated lengths, the two curves appear similar. The small correction factor (5.571 mm), which is the theoretical fish length at scale information, may account for back-calculated lengths being less than observed lengths. A correction factor of 15 or 20 mm is probably more representative of actual fish length at scale formation and would result in nearly identical curves.

Spawning and Sex Ratios

Examination of gonads of mature fish indicated that rainbow trout in Hat Creek spawned between mid-June and late July. Collection of sexually mature fish at all stations would indicate that spawning occurred the length of Hat Creek. Length difference observed among young-of-the-year rainbow trout support the extended spawning time indicated above.

Numbers and length ranges of sexually mature male and female rainbow trout captured at Hat Creek stations during June 1977 and August 1977 are presented in Table 3.3-30. The smallest male was 110 mm and the smallest female 121 mm. Youngest fish for both sexes were age 1+, although sexually mature fish of this age were uncommon. Sex ratios at each station appeared relatively even.

Condition Factor

Condition factor provides a measure of the relative plumpness of fish. Comparison of condition factors for rainbow trout among stations and between sampling periods provides one indication of the robustness of well-being of individuals in a temporal and spatial framework.

Means and ranges for condition factors of rainbow trout at each station during each sampling period are shown in Table 3.3-31. To minimize any fish-size effects, values were determined for length classes of less than 100 mm and greater than 100 mm.

Mean condition factors of rainbow trout were usually greater than 0.80. Examination of specimens at time of collection showed most were in good condition with few appearing emaciated. The extremely low condition factors (mean 0.29) for rainbow trout less than 100 mm at Station 15 in September 1976 may have been related to the diversion of water for irrigation. Fish were concentrated in remaining pools and may bave caused small fish to spend less time searching for food and more time avoiding possible predation, thus contributing to the low condition factor. September 1976 conditions were in contrast to those in June 1977, when flows appeared normal, and August 1977, when water had been diverted but only small fish were present.

Mean condition factors for rainbow trout less than 100 mm varied more than for larger fish. This may reflect an inherent variation in the length-weight relationship of fish until they attain some larger size. It suggests that the growth or condition of smaller fish may be more sensitive to variation in the diversity and quantity of available food than larger fish, or may vary with time of spawning. Mean condition factors for the study area were found to be similar to the ranges reported for other studies in North America.[25]

Population Estimates

The average number of Hat Creek rainbow trout collected per square meter of stream sampled was calculated for each habitat type during each sampling period and appears in Table 3.3-32. These values were multiplied by the total area of stream thought to be best characterized by each habitat, and summed over habitat types, yielding the population estimates appearing in Table 3.3-32. Total estimates vary little during 1977. However, 1976 and 1977 estimates differ by roughly 10 000 fish. The average number of rainbow trout in Hat Creek, estimated by the above methods, was approximately 24 000.

An assumption made in calculating population size is that fish were distributed uniformly within each habitat, with density equal to that calculated by averaging densities for representative sampling stations. Bias in population estimates, induced by variability in physical habitat, may have been reduced by the habitat classification system used.

An additional assumption made in estimating population size was that electrofishing gear captured 100 percent of fish in the area sampled. Beak personnel[19] contend that very few fish greater than 150 mm in length escaped capture. This observation is consistent with experience that the New York Department of Environmental Conservation (NY DEC) has had in quantitative electrofishing efforts focused on rainbow trout in tributaries to Cayuga Lake. Clifford Creech, NYDEC Regional Fisheries Director, indicated that in sampling streams similar in size and chemistry to Hat Creek, gear efficiency commonly exceeds 90 percent for fish greater than 100 mm in total length. Gear used to catch fish of the 0+ and 1+ age groups (100 mm in length) was probably less efficient. However, population size was calculated only for use in cost benefit analysis. Fish of 0+ and 1+ age have little economic value. Thus, population estimates were made only for fish greater than 100 mm in length.

3.4 LAND RESOURCES

3.4.1 Physical Environment

(a) Climate

(i) Regional Description

The southern interior of British Columbia is dry due to the effectiveness of the Coast Range in blocking the intrusion of moist maritime air. The annual precipitation in the Coast Range at the headwaters of the Stein River is about 2000 mm, while the total mean annual precipitation recorded at stations found to the east of the Coast Range varies from a low of 239 mm in Ashcroft to a high of 403 mm in Williams Lake. The distribution of total annual precipitation is relatively uniform throughout the region (Table 3.4-1).

The highest snowfalls in the region are commonly found at the high altitude locations. Annual snowfalls of 10 m or more are found at specific locations in the Coast Range. Total annual snowfall recorded at the Atmospheric Environment Services (AES) stations in the region of Hat Creek is summarized in Table 3.4-1.

The highest seasonal relative humidity recorded within the region is found during the winter months. Spring and summer values are the lowest recorded, which is indicative of unfavourable growing conditions. The mean annual relative humidities recorded at AES stations in the region are also listed in Table 3.4-1.

The south central region of British Columbia is characterized by a typically continental climate. Continental climates, without the moderating effect of the ocean, exhibit large seasonal temperature fluctuations. Seasonal mean temperatures recorded at AES stations in the region have about a 20°C range between the low winter and high summer temperatures at each station. In the regional area, the frost-free period extends from May to mid-September. The number of frost-free days range from approximately 60 to 140. Generally, stations on hillside areas have a longer frost-free season than the adjacent valley locations.

Approximately 2000 hours of bright sunshine are recorded throughout the region on an annual basis. The total annual number of sunshine hours for five of the AES stations in the region of Hat Creek is listed in Table 3.4-1. On a seasonal basis, spring and summer have the highest number of sunshine hours and winter the least.

(ii) Hat Creek Valley and Project Site Description

The average total annual precipitation recorded at the upper Hat Creek Valley station is 317 mm. This amount is distributed evenly over the entire year. Total annual precipitation predicted to occur at Harry Lake should range from 350 to 400 mm. Annual snowfall from 1500 to 2000 mm. This snow cover occurs earlier in the fall and extends later in the spring than that found in the valley.

The relative humidity values appeared to exhibit a large diurnal fluctuation. Diurnal ranges recorded in the north end of the valley average about 40 percent during the spring and summer, 30 percent in the fall and 20 to 25 percent in the winter.

The mean annual temperature in the valley is 3.2°C. Spring and summer mean temperature are 3.7 and 13.8°C, respectively. Mean daily maximum and minimum temperatures are 11°C and -4°C (Table 3.4-1). Mean temperatures at the Harry Lake site are expected to be slightly higher based on data from other monitors within the area.

(b) Landforms

(i) Physiography

The proposed development is located in the Intermontane Belt between the crystalline plutonic complex of the Coast Mountains and the metamorphic terrain of the Columbia highlands.[2] The Interior Plateau is the dominant physiographic region in the Intermontane Belt. This region has been divided into the Fraser and Thompson plateaus which have been subdivided into a number of smaller, discrete units (see map 4-1, Physical Habitat and Range Vegetation Report).[3] The Hat Creek Valley forms the boundary between the Thompson and Fraser plateaus.

A. Thompson Plateau

The Thompson Plateau has more relief and is smaller than the Fraser Plateau. It is composed of several smaller plateaus and hilly areas with considerable relief. The Tranquille, Douglas, Nicola and Icomen plateaus are characterized by intrusive bedrock terrain with a rolling upland. The highest elevation in the plateau areas is South Forge Mountain (1905 m). The Trachyte and Arrowstone hills also form part of the Thompson Plateau. These areas have more varied bedrock resulting in complex landforms. The highest elevation in the Trachyte hills is Cornwall Mountain at 2036 m. The major valleys in the Thompson Plateau are characterized by extensive glacial benches, glaciofluvial terraces, alluvial fans and deeply incised fluvial channels.

Within the Thompson Plateau, most slopes greater than 30 percent are in the Trachyte and Arrowstone hills. The slopes are the result of complex geological and glacial patterns. There are steep slopes in the Trachyte hills near the Thompson and Hat Creek valleys. Steep slopes adjacent to Oregon Jack Creek are also found in the Cornwall hills. The largest area of moderate slopes on the Trachyte hills is between the lower Hat Creek Valley and Maiden Creek. The Cattle Valley is an area with gentle slopes within the Trachyte hills. Like most of the moderately sloped land this land is commonly used as open range. The Arrowstone hills are essentially an upland plain at an elevation of 1200 to 1300 m. The plain is volcanic in origin and is formed by plateau basalt. The slopes at the extremities of this plain drop abruptly to the Bonaparte River, Deadman Creek and the Thompson River. The Douglas Plateau is a rolling upland plain with the least relief in the region. The mean elevation ranges for subdivisions of the Thompson Plateau do not vary by more than 600 m.

B. Fraser Plateau

The Fraser Plateau consists of two major physiographic units, one includes the Bonaparte Lake and Green Lake plateaus and the other includes the Clear, Marble and Camelsfoot ranges. The highest peak in the Clear Range is Cairn Peak (2326 m). Mount Bowman (2220 m) is the highest peak in the Marble Range. The Fraser River Valley, between the Clear, Marble and Camelsfoot ranges, is deeply incised and exhibits a typically rugged landscape. Lands with slopes greater than 30 percent are found only in the Clear, Marble and Camelsfoot ranges. The areas with steep slopes in the Clear Range are found in the western and southern portions of the range along the Thompson and Fraser rivers. Slopes increase to 60 percent at higher elevations in the range. Flat lands are found in the vicinity of Botanie, Skumka, Fountain and

Cinquefoil creeks. Slopes less than 30 percent are common to the eastern side of the Clear Range and extend into the upper Hat Creek Valley. Gently sloping land (30 percent slope) is found in the valley near Pavillion Lake. The slope of the land in the Camelsfoot Range is predominantly greater than 30 percent. The Marble Range is characterized by an unusual configuration of flat uplands and sheer cliffs. The landscape, called karst topography, exhibits frequent flat uplands bounded by sheer cliffs.

The other major physiographic units within the Fraser Plateau are the Green and Bonaparte Lake plateaus. The Bonaparte Lake and the Green Lake plateaus are characterized by gently rolling plains with abundant lakes. The average elevations of the Green Lake and Bonaparte Lake plateaus are 1000 m and 1200 m, respectively. These plateaus are commonly gently rolling till plains. Sharp relief is found only in the deeply incised stream channels such as the Bonaparte River, Bridge Creek, Dog Creek and Big Bar Creek.

(ii) Bedrock Geology

A. Regional Description

The regional study area for the proposed development is located within three geological provinces, namely: Coast Crystalline Belt, Interior Plateau and the Omineca Belt. The Interior Plateau is the dominant geological province of the regional area. This plateau is bounded by the Coast Mountains to the west and the Columbia Highlands to the east.

A major fault system occurs along the Fraser River. This fault zone separates the Coast Mountains from the Interior Plateau. Secondary and sympathetic faults have occurred within the Marble Range, Clear Range, Trachyte hills and the southern Cascade Mountains. Faults are also evident in the North Thompson River Valley.

The oldest rocks in the region are the metamorphic rocks of the Adams Plateau. They have been dated at 300 million years and consist of gneiss, schists and recrystallized limestone. Slightly younger, metamorphic and intrusive rock from the Triassic and Jurassic periods are found on the eastern edge of the Interior Plateau within the Bonaparte Lake, Tranquille, Nicola and Douglas plateaus. These rocks are also found on the western edge of the Interior Plateau in the Marble Range, Camelsfoot Range, Clear Range, Trachyte Plateau and Icomen Plateau. Thus, the eastern and western borders of the Interior Plateau form a transition zone between two major mountain chains. The centre of the plateau contains either basalt or intrusive rocks which range in age from 60 to 150 million years and reflects less disturbance and uplift.

B. Hat Creek Valley

The bedrock of the Hat Creek area consists of a wide variety of rock units. The oldest unit is the Paleozoic Cache Creek Group which consists of limestone and metavolvanic rocks. Pyroclastic and flow rocks cover much of the area as a result of volcanic episodes which occurred during the Cenozoic Era. The oldest rocks of these episodes are composed of basalt, dacite and rhyolite of the Kamloops Group. This group is exposed on the eastern and western sides of upper Hat Creek Valley. Some sporadic occurrences are also noted in the southern end of the valley. The clastic sequence of the Kamloops Group within the valley has been divided into the Coldwater Beds, the Hat Creek Coal Formation, Medicine Creek Formation and the Finney Lake Beds.[4] The Coldwater Beds consist of sandstone, siltstone and conglomerate. The Medicine Creek Formation is composed of poorly consolidated bentonite, lacustrine claystone and siltstone. The Finney Lake Beds overlie the Medicine Creek Formation. Sandstone and volcanic rocks are both found within the Finney Lake Beds.

Another unit, the Spences Bridge Group, is found to the east of Hat Creek in the Clear Range. This group is composed of volcanic and minor sedimentary rocks. The volcanic rocks, which are accumulations of lavas and pyroclastic rocks consist primarily of andesite and dacite. This group has been dated as early upperstage of the Lower Cretaceous series. A nonconformity separates the Mount Martley Stock, a biotite horneblende granodiorite of Cretaceous Age, from the overlying Spences Bridge Group.

(iii) Surficial Geology

A. Regional Description

The occurrence and distribution of surficial deposits within the region of the proposed development are a result of Fraser glaciation and deglaciation. Rolling till plain, thin till veneer, colluvium and various fluvial-glaciofluvial deposits are the types of surficial deposits found in the regional area. Spatially, the distribution of these deposits conforms to the physiographic units found in the area. The higher elevations have weathered bedrock outcrops which have been turned into colluvium at the lower elevations. The lower sides of the hills and ranges are characterized by a till veneer and grade into till uplands in the flatter portions of region. The impeded drainage conditions found within the Green and Bonaparte Lake plateaus (of the Fraser Plateau) are a result of large pockets of silt and organic deposits on the rolling till plain. As a result of continued weathering, these deposits have been modified into magnesium sulphate potholes, saline lakes and bogs. Windblown deposits on the benchlands of the Thompson River lie over till and glaciofluvial surficial deposits, and have developed into some of the richest agricultural land in the area.

B. Hat Creek Valley

The surficial deposits within the Hat Creek Valley consist of hummocky ground moraine, which forms a thick covering of till, but is reduced to a thin covering on hill tops and areas with steep slopes. There are many occurrences where the bedrock protrudes through the thin covering. Fluvial and glaciofluvial sands and gravels are found on the eastern side of the valley, north of Medicine Creek, and in most of the larger tributaries of Hat Creek. A pattern of coarse till alternating with fine till, which overlies thick deposits (consisting of sand and gravel), occurs on the lower portions of Harry Creek.

Areas of mass wasting are also found within the valley regime. Deposits resulting from preglacial lahars or volcanic mudflows are found exposed as hoodoos or pinnacles. The upper Hat Creek Valley is covered by a preglacial land slide originating from Mount Martley. There are also numerous post glacial slides and earthflows in the upper Hat Creek Valley. An extensive flow slide descended White Rock Creek into the valley. Another slide, most of which is inactive, was found in the area between Finney Lake and Houth Meadows. The headwall of this slide is characterized by numerous ponds. There are numerous "sand boils", which resemble quicksand, in the area south of the proposed mine.

Numerous outcrops occur on either side of the valley, although few are found on the valley bottom. There is a talus slope which formed below volcanic outcrops in the area east of the proposed mine site. Limestone bluffs are common in the southeastern portion of the valley, while limestone outcrops frequently occur along the northern extent of the upper Hat Creek Valley. The western portion is characterized by granitic and volcanic outcrops.

(iv) Soils

A. Regional Soil Orders

Seven soil orders were identified within the region of the proposed development, namely Brunisols, Luvisols, Chernozems, Podzols, Gleysols, Regosols and Organics. The Luvisols and Brunisols are the most commonly occurring orders. Gleysols and Organics are only found in small randomly occurring areas. Chernozemic soils are confined to major valley systems, Podzols to the Coast Range and Regosols to major stream courses.[3]

The Luvisols are characterized by the presence of an alluvial A-horizon overlying a textural B-horizon. They are medium-textured and neutral-to-alkaline in reaction. Luvisol parent material is generally deep glacial till and it is commonly found where the topography is a rolling plateau. This order is widely distributed in numerous smaller parcels throughout the region.

The Brunisolic order is characterized by a rust brown coloured B-horizon covered by a shallow organic surface horizon. Podsolization is very weakly expressed by this horizon and 100 percent base saturation is common in lower horizons. The parent material is colluvium or glaciofluvial materials and is generally coarse-textured. This order is most commonly found in areas with steep to moderately steep topography, such as deeply incised river or creek beds. The Brunisolic order is found within in the Clear Range, along the Stein River in the Coast Range, near the Bonaparte River and near Deadman Creek.

B. Local Soil Associations

Soils within 25 km of the project site were derived from glacial till, glaciofluvial deposits, colluvium, lacustrine deposits and alluvial deposits. Twenty-one associations from three different orders were identified for soils originating on glacial till. These soils are generally of medium texture and are well-drained. Seven associations from two separate orders were found for soils originating on glaciofluvial deposits. These soils are commonly medium-coarse in texture and are well to rapidly drained. Soils originating on colluvium were found to have eight associations from two orders. These soils are medium in texture and well to rapidly drained. One association from a single order was identified for soils originating on lacustrine deposits. These soils are typically fine-textured and well-drained. Two associations from one order were identified for soils originating on alluvial deposits. These soils are medium-textured and imperfectly to poorly drained.

The predominant associations in the vicinity of the proposed mine are Glimpse, Glossey, Frances, Medicine, Maiden and Carson. The associations near the proposed plant and Medicine Creek disposal area include McLaren, McLaren Gisborne, Medicine, Massey, Glimpse and Crown Mountain.[3]

The predominant soil series in the Thompson and Bonaparte River valleys, in terms of total area, are the Anglesey, Cheetsum and Towell. The Basque and Bonaparte series are also prevalent in the area. The Anglesey covers 5.43 km^2. It is derived from glaciofluvial parent material, is well-drained and is important as grazing land. Cheetsum is found on 11.39 km^2 of land. It too is derived from glacial till, is well-drained and underlies significant grazing land. Towell covers 9.53 km^2 and is derived from alluvial-colluvial fan. It is well-drained and is important as pasture and grazing land. The Basque covers 1.13 km^2, is derived from an alluvial fan, and is moderately to well-drained and arable.

A total of 69 different soil series were identified from modified soil series data for lands adjacent to Hat Creek and the northern portion of the eastern side of the valley.[5] The predominant soils found on the plant, mine and ash disposal sites are summarized in Tables 3.4-2 and 3.4-3. The parent material of these soils is commonly glacial till. Soil development and surface textures vary considerably. Drainage characteristics are highly variable, ranging from poor to excessive. The land near the proposed plant site and ash disposal areas is used primarily for grazing.

3.4.2 Natural Vegetation

(a) Regional Biogeoclimatic Zones

(i) Distribution

Eight biogeoclimatic zones occur within the region of the proposed development (Fig. 3.4-1). Four of these are important in a land use context. The dominant biogeoclimatic zone in the regional area is the Engelmann Spruce - Subalpine Fir. This zone, which comprises the major portion of the interior forests of British Columbia, is widely distributed, covering approximately 13 670 km^2 or 40 percent of the regional area.

Interior Douglas-fir Zone is the second most commonly occurring zone in the regional area (Fig. 3.4-2) and covers 11 300 km^2 or 33 percent of the regional area. The Interior Douglas-fir Zone is widely distributed throughout the region, except in the southeastern portion where zones characteristic of higher elevations predominate. Other biogeoclimatic zones making up substantial portions of the region include Ponderosa Pine - Bunchgrass (3253 km^2) and Cariboo Aspen - Lodgepole Pine - Douglas-fir (3495 km^2). The Ponderosa - Pine Bunchgrass Zone occupies the lower elevations in the Fraser, Thompson and Nicola River valleys, while the Cariboo Aspen Lodgepole Pine - Douglas-fir Zone is found only in the northeastern corner of the regional area.

The occurrences of the remaining four zones are limited. The Mountain Hemlock (648 km^2) and Coastal Western Hemlock zones (389 km^2) are found only in the extreme southwest portion of the regional area, with the Coastal Western Hemlock Zone restricted to certain drainages. The Interior Western Hemlock Zone (200 km^2) is only found in the northeastern corner of the regional area and the Alpine Tundra Zone (980 km^2) appears on only the highest mountain peaks in the Coast Range.

(ii) Zonal Descriptions

The Engelmann Spruce - Subalpine Fir Zone, which is dominant in the regional area, does not have as favourable a climate for growth as other zones in the region. The low number of frost-free days suggests a short growing season, although forest productivity is reported to be the second highest of all the zones within the region due to the levels of precipitation. The land within this zone is used for livestock summer grazing, although the amount and quality of forage is relatively low. Some of the basic biotic and abiotic factors characteristic of this zone are summarized in Table 3.4-4.

The second most common zone in the regional area, Interior Douglas-fir, has a more moderate climate than the Engelman Spruce - Subalpine Fir Zone. The importance of livestock grazing and forest utilization attest to the favourable growing conditions in this zone. Like the Engelmann Spruce - Subalpine Fir Zone, grazing activity in the

Interior Douglas-fir Zone is limited to the summer months (Table 3.4-4). Improved pasture and alfalfa production is feasible, although irrigation is required. The logging industry which began in the late 1800s has continued to be an important aspect of the regional industry within this zone.

The Ponderosa Pine - Bunchgrass Zone, which does not occupy as much of the regional area as either the Engelmann Spruce - Subalpine Fir or Interior Douglas-fir zones, has a semi-arid climate and is considered to be a major agricultural zone in British Columbia. Irrigation is mandatory due to the limiting amount of rainfall. Cattle grazing is an important activity within this zone. Forest productivity is the lowest of the forested zones within the regional area, while use by wildlife, principally ungulates and upland game birds, is high. Additional factors of note are summarized in Table 3.4-4.

The Cariboo Aspen - Lodgepole Pine - Douglas-fir Zone is similar to the Interior Douglas-fir Zone, although the climate is slightly more severe as a result of the more northerly location. The severe winter coupled with reduced snowfall restricts the occurrence of many of the tree species found in the Interior Douglas-fir Zone. Forestry and grazing of domestic livestock are the principal activities conducted in this zone. There is some agricultural activity, but the type and productivity of crops are limited due to the relatively short growing season.

The climate of the Alpine Tundra Zone is quite severe, resulting in a limited growing season. Due to the severity of the climate, no agricultural or forestry related activities occur within this zone. Wildlife occasionally utilize these lands for grazing during the summer months. This zone is also important for recreational use and water storage.

The remaining zones, Coastal Western Hemlock, Mountain Hemlock and Interior Western Hemlock have moderate climates and favourable growing conditions. As a result, forest productivity is high and logging is an important form of land use. The Interior Western Hemlock Zone has the highest forest productivity of any of the zones in the regional area. However, the occurrence of this zone is limited to a small area in the northern portion of the regional area. Other parameters of note for these zones are summarized in Table 3.4-4.

On the basis of biogeoclimatic zone descriptions, the regional area of the proposed development can be categorized as important to both agriculture and forestry. Of the three most prominent zones in the region, the Interior Douglas-fir and Engelmann Spruce - Subalpine Fir zones are the basis for important forest industries. In addition, the zones also possess substantial grazing resources. The Ponderosa Pine - Bunchgrass Zone is the major agricultural zone, although the value of the resource is again limited by the availability of water, either irrigation or precipitation.

(b) Local and Site-specific Vegetation Associations

(i) Forest Associations

Fourteen forest associations were identified in the project locale (i.e. within 25 km of the proposed plant site). Each forest association is specific to a particular biogeoclimatic zone with three exceptions, which can occur in several zones due to their tolerance range. The areal extent of each vegetation association, grouped by biogeoclimatic zones, is presented in Table 3.4-5. On the basis of areal extent, the more common associations from a local context are: Engelmann Spruce - Grouseberry; Engelmann Spruce - Grouseberry - Pinegrass; Douglas-fir - Pinegrass and Douglas-fir - Bunchgrass - Pinegrass. The Riparian Association does not occur on large areas of land, yet is still important due, in part, to its high species diversity and productivity.

The Douglas-fir - Pinegrass Association is the most commonly occurring (478.6 km^2) association in the project locale. This association is also the most widespread throughout the Interior Douglas-fir Biogeoclimatic Zone. It occurs on relatively steep, cool slopes or benches on mid-to-upper slopes. It is of some importance from a project perspective, since it occupies large areas in the immediate vicinity of the project area (Fig. 3.4-2). Specifically it is found on the western side of the Hat Creek Valley at the lower elevations of the Clear Range. It is also the predominant association along the Medicine Creek drainage and in the Trachyte hills.

Mature forests of the Douglas-fir - Pinegrass Association are generally dominated by Douglas-fir in the overstory. The understory which is essentially shrub-free is dominated by a uniform cover of pinegrass (Calamagrostis rubescens). However, the forest stands within the project locale are in a seral stage and hence are dominated by ponderosa pine (Pinus ponderosa) at elevations below 1050 m and lodgepole pine at higher elevations. The shrub layer is poorly developed and the common species found are listed in Table 3.4-6. As expected, the herbaceous layer is dominated by pinegrass. The remaining species listed in Table 3.4-6 are commonly found with high presence but with low cover values.

A unique feature of this association in the vicinity of Harry Lake is the occurrence of large stands of quaking aspen (Populus tremuloides). This occurrence may be attributed to the presence of seepage water in the rolling topography, abundance of a limestone derived parent material, and logging, to a minor degree.

The second most common association within 25 km of the proposed development (project locale) is the Engelmann Spruce - Grouseberry. It occupies 197.9 km^2 of the project locale and is the most abundant subalpine association. This association is commonly found on broad ridges and gentle slopes within an elevation range of 1520 to 1850 m. The Engelmann Spruce - Grouseberry Association is limited to the higher elevations in the Coast Range which are west and north of the Hat Creek Valley. For this reason, this association is not of particular importance from a site-specific perspective.

The Engelmann Spruce - Grouseberry Association does not, as previously discussed, occur within the immediate vicinity of the project site. However, since it is found at higher elevations and is subject to fumigations by stack emissions, this association is important and should be described. Some of the basic descriptive features for this association are summarized in Table 3.4-6. Generally, subalpine fir (Abies lasiocarpa) is a major component of the overstory and Engelmann spruce (Picea engelmannii) the dominant species in the climax state of this association. However, in the vicinity of Hat Creek, subalpine fir was found only to exist in isolated stands or as scattered groups of regeneration species. Most stands were found to be composed of mixtures of lodgepole pine (Pinus contorta) and Douglas-fir (Pseudotsuga menziesii var glauca) with Engelmann spruce of minor importance. The species composition was generally found to be more diverse along streams and drainage areas where moisture conditions were more favourable. In most occurrences, canopy coverages were dense ranging from 60-100 percent. The understory is frequently dominated by grouseberry (Vaccinium scoparium) and the remaining shrubs listed in Table 3.4-6 were found to occur sporadically. Coverage of the herbaceous layer is low due to the dense shrub canopy. Species commonly found in this layer are summarized in Table 3.4-6. In terms of usage, logging is the predominant activity conducted in this association. Cattle grazing is minimal due to the lack of palatable grasses, although wildlife utilize this association mainly as summer range.

The Douglas-fir - Bunchgrass - Pinegrass Association occupies 143.0 km^2 of the project locale and generally becomes established on southern exposures with moderate slopes. This association is found near Oregon Jack Creek where it empties into the Thompson River and to the northeast of the Bonaparte River. These areas are not in the immediate vicinity of the development and therefore are not of major significance. This association is also found along the Medicine Creek Valley and to the north and south of Lone Tree Creek (Fig. 3.4-2). These lands are of some importance, because of their proximity to the development.

The Douglas-fir - Bunchgrass - Pinegrass Association is an intermediary between the Douglas-fir - Bunchgrass and Douglas-fir - Pinegrass associations. Generally, the understory is dominated by bluebunch wheatgrass when the canopy species have been disturbed. Pinegrass dominance replaces bluebunch wheatgrass as the canopy closes. The overstory is characteristically Douglas fir with ponderosa pine as a seral species. The dominant species in the shrub layer (Table 3.4-6) occur sporadically and generally have low cover values. The dominant grasses (bluebunch wheatgrass and pinegrass) cover approximately 50 percent of the ground surface. The herbaceous layer is primarily composed of weedy plants as listed in Table 3.4-6.

The Engelmann Spruce - Grouseberry - Pinegrass Association occupies 183.4 km^2 of the project locale. It is commonly found on plateau areas at elevations between 1400 and 1675 m. The association is of particular importance to the site since it is found to the east of upper Hat Creek Valley around Cornwall hills and in the area east of Harry Lake to the north of Medicine Creek. The association also occurs in the Arrowstone hills, which will not be directly affected by the proposed development.

The Engelmann Spruce - Grouseberry - Pinegrass Association is a dry phase of Engelmann Spruce - Grouseberry Association. Engelmann spruce (*Picea engelmannii*) is a seral constituent in this association, although lodgepole pine was found to be the most abundant seral species in most stands. The shrub layer is characterized by a low layer of grouseberry and bearberry (*Arctostaphylos uva-ursi*) and a higher layer of buffaloberry (*Sherpherdia canadensis*), common juniper (*Juniperus communis*) and mountain alder (*Alnus incana*). The remaining shrubs listed in Table 3.4-6 are found less frequently. Pinegrass (*Calamagrostis rubescens*) is the dominant herbaceous species, which covers as much as 95 pescent of the ground surface. Other characteristic species are listed in Table 3.4-6.

The Riparian Association is found along the banks of streams and associated floodplains in the Interior Douglas-fir and Ponderosa Pine - Bunchgrass Biogeoclimatic Zone. It occupies 10.1 km^2 of land area in the project locale (i.e. within 25 km of the powerplant site). Isolated patches of this association are found along the Bonaparte River and tributaries, upper and lower Hat Creek and near the northwestern shore of Pavillion Lake. The most continuous occurrences within the project locale appear to be along Hat Creek (Fig. 3.4-2) and thus are important from a site-specific perspective.

The Riparian Association is a complex perpetual, seral association with a multi-layered dense structure. It is the most species rich and biologically productive area in the project site due to continued water availability throughout the growing season. Black cottonwood (*Populus trichocarpa*) is the dominant canopy species. Other species such as willows (*Salix* spp.), red alder (*Alnus rubra*) and quaking aspen (*Populus tremuloides*) are also common but rarely dominate the canopy layer. The dominant understory species are red osier dogwood (*Cornus stolonifera*), Nootka rose (*Rosa nutkana*), currant (*Ribes lacustre*), snowberry (*Symphoricarpus albus*) and little wildrose (*Rosa gymnocarpa*). A large number of grasses and herbaceous species occur. However, both presence and mean cover are highly variable. Some of the more common herbaceous species are bentgrass (*Agrostis alba*), bromegrass (*Bromus inermis*), horsetail (*Equisetum arvense*), meadowrue (*Thalictrum occidentale*), sweet cicely (*Osmorhiza chilensis*), yarrow (*Achillea millefolium*), dandelion (*Taraxacum officinale*), clover (*Trifolium repens*) and white sweet clover (*Melilotus alba*).

(ii) Grassland Associations

Six grassland associations occur within 25 km of the proposed development (project locale). Three of these associations were found to occur on larger areas of land than the other three. The Big Sagebrush - Bunchgrass was found on 199.9 km^2, Kentucky Bluegrass on 44.6 km^2 and Bunchgrass - Kentucky Bluegrass on 25.6 km^2. However, in the immediate vicinity of the site, the Sagebrush - Bluebunch Wheatgrass Association appears to be more prevalent than the Bunchgrass - Kentucky Bluegrass Association as shown in Fig. 3.4-3.

The most common association, Big Sagebrush - Bunchgrass, is confined to the lower valley slopes generally between 400 and 650 m. This association is found in the

Thompson and Bonaparte River valleys and makes up a substantial amount of the land area in the site vicinity (Fig. 3.4-3).

The Big Sagebrush - Bunchgrass Association is the driest in the project locale. This association is similar to the Sagebrush - Bluebunch Wheatgrass Association which occurs in the Interior Douglas-fir Zone. However, the Sagebrush Bluebunch Wheatgrass Association has a greater species diversity, which is due to increased moisture availability. Big sagebrush (*Artemisia tridentata*) is the dominant shrub, while the others listed in Table 3.3-7 are not as commonly found or have low cover values. The herbaceous layer is dominated by bluebunch wheatgrass (*Agropyron spicatum*) in those areas not overgrazed. In areas where overgrazing has occurred, Sandberg's bluegrass (*Poa sandbergii*), needle and thread (*Stipa comata*), sand dropseed (*Sporobolus cryptandrus*) and downy brome (*Bromus tectorum*) invade and replace bluebunch wheatgrass (Table 3.4-8). Other species common to the herbaceous layer are listed in Table 3.4-7.

The Kentucky Bluegrass Association commonly occurs on all large open range areas at an elevation of from 1200 to 1800 m. This association occurs in the immediate vicinity of the plant around Harry Lake and to the north of Medicine Creek, near the confluence with Hat Creek (Fig. 3.4-3). There are also some isolated occurrences around the McLean Lake area.

The Kentucky Bluegrass Association has a higher soil moisture than the Bunchgrass - Kentucky Bluegrass Association. This results in a greater abundance of Kentucky bluegrass (*Poa pratensis*), a poorly developed shrub layer and a higher species diversity in the herbaceous layer. Although the shrub layer is poorly developed, little wildrose was found frequently within this association. In the herbaceous layer, Kentucky bluegrass commonly forms a complete ground cover. With the exception of bluebunch wheatgrass, the other species listed in Table 3.4-7 were commonly found in this association. It should be noted that the broad-leaved herbaceous species have a presence value of 80 percent, but the cover values are generally less than 5 percent.

The Sagebrush - Bluebunch Wheatgrass Association is not commonly found in the Interior Douglas-fir Biogeoclimatic Zone. It is possible that its occurrence in the valley can be attributed to the high concentrations of bentonite as has been the case elsewhere in the province.[6] This association is localized along the west side of Hat Creek to the north of the Medicine Creek confluence. There is also a small occurrence on the east side of Hat Creek in the vicinity as that found on the west side.

The Sagebrush - Bluebunch Wheatgrass Association has, unlike the Kentucky Bluegrass Association, a well-developed shrub layer which is dominated by big sagebrush. The cover values for big sagebrush range from 35 to 85 percent. As a result of the high cover values, most other shrubs are reduced in occurrence. The remaining shrubs listed in Table 3.4-7 apparently can co-exist with the big sagebrush. Bluebunch wheatgrass dominates the herbaceous layer, while the other species listed in Table 3.4-7 are also frequently found in this association.

(iii) Successional Status

The vegetation within the area defined by a 25 km radius around the project site is primarily in a successional state due to such perturbations as fire, logging and overgrazing. The effects of these perturbations have been most evident in canopy or overstory species. Some shrub or understory species have been largely removed by fire and logging, although most of these species have a tendency to regenerate quickly. The composition of the understory is also determined largely by changes occurring in the canopy.

Common successional tree species within the project locale are lodgepole pine at elevations up to 1065 m, Douglas-fir at elevations up to 1525 m, and ponderosa pine below 1065 m. Douglas-fir, below 1525 m, forms part of the climax forest.

The forest stands within the project locale do contain some climax species. They are usually found as dominant regeneration components, lesser components of mixed successional stands, or as isolated patches of pure climax stands.

(iv) Rare or Endangered Species

No plant species listed as rare or endangered[7,8] were found within 25 km of the proposed development. Several species of showy wildflowers were identified in the project area, but as yet these are not considered rare or endangered. These showy wildflower species include yellow bells (Fritillaria pudica), shootingstar (Dodocathon pauciflorum), spring beauty (Claytonia lancolata) and death camas (Zigadenus venenosus). There are two species which are known to occur near Hat Creek and have been placed on the rare or endangered list, swordfern (Polystichum kruckbergii) and locoweed (Oxytropis podocarpa). These two species were not observed in the locale of the project site.

A plant species checklist of those species encountered during the field studies has been compiled and appears in Table 4-19 of the Physical Habitat and Range Vegetation Report.[3] The species have been categorized by vegetation strata into tree, shrub, grass, herb, lichen and moss layers. The importance of these species to wildlife, man and livestock has also been evaluated. The species, relative abundance, resource use, relative importance and season of use are summarized in Table 4-20 of the Physical Habitat and Range Vegetation Report.[3]

(v) Existing Stress Conditions

A. Grazing

There has been extensive use of the range areas within the project locale by domestic livestock. The extensive use areas are primarily confined to the Interior Douglas-fir and Ponderosa Pine - Bunchgrass zones. On a more site-specific basis, grazing has been very intense in the open range areas found 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 range lands in the Cornwall Mountain area which have been depleted of most palatable vegetation.

Extensive overgrazing of an area usually results in a large scale alteration in species diversity. The palatable species are reduced in number while the unpalatable ones increase. In addition, the range becomes invaded by plant species which could not compete when the range was in an undisturbed state. The decreasing, increasing and invading plant species for the important grasslands in the site locale are listed in Table 3.4-8.

B. Forest Fires

Forest fires have historically been and will continue to be a major disturbing factor in the project locale. The historical pattern and incidence of fires is reflected by the age and distribution of lodgepole pine, which commonly occurs after fires. Other than the evidence offered by the lodgepole pine stands, no other historical information was found during the Detailed Environmental Studies.

(vi) Biophysical Analysis

The area within 25 km of the proposed development was divided into biophysical units. Each biophysical unit possesses similar landform, soil and vegetation which form recurring patterns over the landscape. A total of 91 biophysical units were identified within the project locale (see maps 4-7a and 4-7b, Physical Habitat and Range Vegetation Report).[3] A total of 254 biophysical subunits, which are further subdivisions of the biophysical unit and are based on soil limitations and vegetation associations, were identified. The common biophysical units identified as occurring in the vicinity of the proposed plant and mine site are summarized in Table 3.4-9.

3.4.3 Wildlife

(a) General Description of Major Wildlife Habitats

Game and non-game wildlife populations depend on habitat quality and quantity for perpetuation of their numbers. Regional and local study areas offer a wide range of habitat types for wildlife. Many such habitat types are locally stressed through land use practices such as grazing and logging activities, or through natural stresses (e.g. excessive snowfall, limited rainfall) and have reduced wildlife habitat potential. Major wildlife habitats are summarized below with their component vegetation associations.

Wildlife habitats were identified and mapped within the local study area (Fig. 3.4-4). The relationship between wildlife habitats, vegetation associations, and their areal extent is presented in Table 3.4-10 and discussed below.

Subalpine Krummholz Habitat includes the Engelmann Spruce - Willow - Red Heather Parkland Association and is found at high elevations just below the Alpine Tundra Zone. Most of the area is covered with short willow and dwarf conifers.

The Engelmann Spruce-Lodgepole Pine Habitat covers large tracts of higher elevation forest. Climax vegetation and some seral stages of the Engelmann Spruce - Subalpine Fir associations (Engelmann Spruce - Subalpine Fir - Grouseberry, Engelmann Spruce - Grouseberry - Pinegrass, Engelmann Spruce - Grouseberry - White Rhodedendron, and Engelmann Spruce - Horsetail) occur.

The Douglas-fir-Pinegrass Habitat covers more of the local study area than any other habitat type. Douglas-fir is the climax species for Douglas-fir - Pinegrass, Douglas-fir - Bunchgrass, Douglas-fir - Spirea-Bearberry, and Douglas-fir - Bunchgrass - Pinegrass associations. Douglas-fir dominated habitats also occur as seral stages in some lower elevation Engelmann Spruce - Subalpine Fir vegetation associations.

Ponderosa Pine-Douglas-fir-Bunchgrass Habitat consists mostly of seral stages of Douglas-fir - Bunchgrass, Douglas-fir - Bunchgrass - Pinegrass, and to a lesser extent, Douglas-fir - Pinegrass associations.

Aspen Habitat is dominated by quaking aspen or by a mixture of quaking aspen and conifers. This forest type often occurs as a transitional zone between coniferous forest and open range.

Riparian Habitat is only about 0.5 percent of the local study area, and is characterized by black cottonwood, willows and other shrubs.

Open Range Habitats cover a very wide range of climatic and edaphic conditions. Open, treeless habitat dominated by grasses or grasslike vegetation can be found from low elevations near the Thompson and Fraser rivers to the tops of the highest peaks on steep, dry slopes to waterlogged saline depressions. Open Range Habitats cover 21 percent of the local study area and are summarized below.

The highest elevation grassland-type community is the Alpine Habitat which includes the Mountain Aspen - Sedge and the Highland Grassland associations. Just below the alpine tundra and generally above 1200 m, a band of mid-elevation grassland (Kentucky Bluegrass Association) occurs. This grassland is characterized by a relatively continuous carpet of heavily grazed short grass. On better drained soils, low elevation grassland (Bunchgrass - Kentucky Bluegrass Association) occurs which is characterized by scattered bunchgrass and sizable areas of bare soil.

Two other major open range habitats are recognizable. Sagebrush Habitat types (Sagebrush - Bluebunch Wheatgrass Association) are mostly in the northern half of upper Hat Creek Valley. The Big Sage Habitat type (Big Sagebush - Bunchgrass Association) is widely distributed throughout the Thompson and Bonaparte valleys.

Brush Habitat occurs as an early seral stage following logging or burning of forest communities. Brush habitat is dominated by a 20 to 40 percent cover of shrub species, mainly composed of common snowberry, willow, roses, western shadbush and juniper plus scattered regeneration of lodgepole pine, Douglas-fir and Engelmann spruce with a dense understory of pinegrass.

Available Bog Habitat is small, covering 0.4 percent of the local study area and corresponds to the Willow - Sedge Bog Assoçiaton which occurs over a wide range of elevations whenever topography and drainage conditions favour its formation.

Cultivated Fields cover 2.1 percent of the local study area.

The remaining 0.8 percent of the local study area is categorized as miscellaneous habitats. Exposed rock, lakes, river, urban developments and saline depressions are examples of these habitats. Saline depressions and waterbodies are biologically important and are described in detail in the waterfowl section.

(b) Wildlife Populations

(i) Regional Status

A. Big Game

Big game is an important recreational resource in provincial British Columbia and therefore a major component of natural land resources. This section presents descriptions and local status of big game species occurring in regional and local study areas. Ungulate species are discussed in terms of habitat capability classifications. Non-ungulate species discussions are based on available "preferred" habitat type. In addition, appropriate population trends are presented.

The Canada land inventory ungulate capability classification system based on a scale from class 1 (no significant limitations to the production of ungulates) to class 7 (limitations so severe that there is no ungulate production) was used as a basis in ungulate habitat assessment. Ungulate capability classes 1 to 3 are considered very important wildlife habitat, especially if designated as a winter range.

Population estimates of resident big game species are found in Table 3.4-11. The most important big game species in British Columbia are mule deer (*Odocoileus hemionus hemionus*). Mule deer select southern exposures supporting new plant growth as they move from low elevation winter ranges to alpine and subalpine summer and fall ranges. These habitats are found throughout the regional study area (Fig. 3.4-5). Mule deer numbers in the Hat Creek area increased to a peak in the early 1960s. A considerable decline (20 percent) in female mule deer productivity was recorded in Game Management Area 14 (which includes the local study area) from 1964 to 1974. At the present time, deer numbers are considered to be below average.[9]

Moose (*Alces alces andersoni*) occupy a variety of habitats from valley bottom to high mountain valleys. Highest moose densities occur in forests opened by fire and other forms of timber removal, where willow, birch or aspen have regenerated. Moose are second to deer in recreational value and at present, moose numbers are considered to be below late 1940s population levels.

Mountain goat (Oreamnos americanus) select alpine and subalpine areas for summer range and precipitous rock faces for winter range. The largest concentrations of this species are located in the southwest corner of the regional study area. Mountain goat hunting is locally concentrated in areas such as the northerly parts of the Lower Mainland area and the Cayoosh-Texas Creek area. Approximately 100 000 mountain goats inhabit British Columbia and this comprises 80 percent of the population in North America. The provincial goat population therefore has international significance.

California sheep (Ovis canadensis californiana) and Rocky Mountain bighorn sheep (O.c. canadensis) use mid-to-low elevation grasslands and exposed ridges for winter range, precipitous terrain for lambing grounds and high elevation alpine and subalpine areas for summer range. Juxtaposition of these ranges is very important and is often the factor determining range use by bighorn sheep. California bighorn sheep utilize the Marble, Camelsfoot (Yalakom Mountain, Nine Mile Ridge and Red Mountain) and Shulap ranges and Mission Ridge. Fifty to 150 Rocky Mountain bighorn sheep inhabit the Scarped Range north of the confluence of the Fraser and Thompson rivers at Lytton.[9]

Rocky Mountain elk (Cervus canadensis nelsoni) winter on low elevation south-facing slopes supporting fire-induced seral plant cover and naturally occurring grass/shrub vegetation associations. Summer months are spent in mountain ranges as high as grazing is available. At the present time, there is no hunting season on those animals which are found mainly in the Lytton area.

Mountain caribou (Rangifer tarandus) winter in high elevation mature forests, foraging on arboreal lichens. In the summer, they use a wide variety of succulent plants in alpine and subalpine areas. Valley bottoms are used during spring and fall when snow conditions hinder travel and feeding. The nearest caribou to the Hat Creek area are in the Chilcotin region.

Black bears (Ursus americanus) are found throughout the regional study area. During summer and fall, black bears are widely dispersed and forage on plant and animal foods.

Grizzly bears (Ursus actos horribilis) are scattered throughout the regional study area. In summer they occur largely in Alpine Habitat; in the early spring period, avalanche tracks are a preferred habitat. High elevation meadow is preferred by grizzly bears in the late summer. The greatest concentrations of grizzly bears appear to be in the more isolated mountain terrain in the western, and particularly southwestern, portion of the study area.[9]

Cougars (Felis concolor) occur throughout the study area in a wide variety of habitats. However, they tend to favour rocky and mountainous terrain. Deer are the important prey of this species, consequently, cougar are found where deer concentrate.

Wolves (Canis lupus) occupy a variety of habitats including open plains, forests, mountains and brushlands, where deer, moose, caribou and mountain sheep are prey species. The greatest wolf concentrations can be expected in major moose winter ranges.

B. Upland Game Birds

Regionally, ruffed grouse (Bonasa umbellus), spruce grouse (Cawachites canadensis) and blue grouse (Dendragapus obscurus) are the most common and the most hunted species of upland game birds. Ruffed grouse is the most abundant species and is found in Riparian, Bog and Douglas-fir-Pinegrass Habitats. Spruce grouse are found above the ruffed grouse in the Engelmann Spruce-Lodgepole Pine Habitat. Blue grouse are found principally at forest edge, at timberline and at the Douglas-fir Ponderosa Pine - open range ecotone. Chukar (Alectoris chukar) and sharp-tailed grouse (Pediocetes phasianellus) are locally present and hunted in the Thompson Valley but suitable habitat for these species is limited in comparison to habitat for other grouse species. Both are found in the Big Sage Grassland Habitat. Ring-necked pheasant (Phasianus colchicus) although historically abundant, are becoming scarce.[9]

C. Waterfowl

Land was classified into three capability categories: high, medium or low. A high rating corresponds to Class 1, 2, 3 or 3M (special migration areas). A medium rating corresponds to Class 4 or 5, and a low rating to Class 6 or 7. The distribution of these three waterfowl capability categories within the regional study area (Fig. 3.4-6) indicates that Hat Creek Valley is one of the few areas of high waterfowl capability within 75 km of the proposed mine site.

Areas of medium waterfowl value are scattered throughout the Thompson Plateau. The mountainous regions have a uniformly low waterfowl capability. The Fraser Plateau north of the Thompson Plateau and Marble Range is relatively flat and has extensive areas of medium waterfowl capability.

D. Birds

The local study area avifauna is detailed below. A parallel regional perspective was not attempted because of the disparity of available data.

E. Furbearers

Furbearer species are ecologically and commercially important species. Some such as beaver (Castor canadensis) can modify habitats through damming activities. Others are potentially valuable in the fur pelt trade.

The regional study area, which comprises approximately 3 percent of the province, produces about 1 percent of the fur yield. Lynx, beaver and coyote are the most important species taken in terms of fur value. Fisher, muskrat, mink and bobcat are the next most significant species. Trapping is, however, a marginal enterprise.[9]

F. Small Mammals

In addition to their roles in ecosystem dynamics, small mammals are important prey species for raptor populations and upper trophic level carnivore species. Mammals which should be found within the regional study area are summarized in Table 3.4-12. Also included in this table are comments regarding trophic status and the distribution or relative abundance of these species.

(ii) Site and Vicinity Status

A. Big Game

The Hat Creek watershed consists of 13.1 percent class 3 and 86.9 percent class 4 deer and moose range. Approximately 10.6 percent (7027 ha) is rated as class 3 deer winter range. Wildlife habitat limitations of poor soil moisture, excessive snow depth, restrictive soil depth and adverse exposure or aspect are found in the watershed. Lands most important to local deer and moose are located in the upper drainage of Anderson Creek, between 1050 and 1350 m in elevation on the west side of Hat Creek between Martley and Colley creeks and crossing Hat Creek to Blue Earth Lake, the valley bottom section of Hat Creek where the creek parallels Highway 12, and the north and south ridges of the mouth of the Hat Creek Valley in the Carquille area (Fig. 3.4-5).

During the winter of 1975-76, the Fish and Wildlife Branch surveyed the upper Hat Creek road for ungulate crossing sites. Livestock and dog tracks were observed during the sampling period. However, no wild ungulate tracks were recorded. Scattered deer tracks were recorded at elevations of approximately 1000 to 1300 m on the north banks (southern exposures) of the mouths of Medicine Creek and Langley Lake valleys as well as in the Finney Lake area. Moose tracks were observed in the upper White Rock Creek area along the west side of the Hat Creek Valley at approximately the 1200 m elevation in the Phil, McCormick, Anderson and Martley Creek drainages and Finney Lake.

A winter 1978 helicopter survey by B.C. Hydro and the B.C. Fish and Wildlife Branch resulted in a count of eight mule deer in Ponderosa Pine-Douglas-fir-Bunchgrass, seven in Engelmann Spruce-Lodgepole Pine and four in Douglas-fir-Pinegrass habitats at elevations between 850 and 1830 m on south-facing slopes north of Highway 12. In addition, four deer were counted in the sagebrush/bluebunch wheatgrass habitat at 1040 m elevation on the western side of the valley.

Evidence of cattle activity was found in all wildlife habitats. Low and mid-elevation grasslands exhibited the greatest concentrations of cattle chips.[9]

Deer activity was concentrated in the Sagebrush Habitat at the north end of the upper Hat Creek Valley. The degree of deer use, the vegetation composition, and the elevation (1000 m) of this habitat confirm that it is an important winter range for deer in the surrounding area.

Transects in Engelmann Spruce-Lodgepole Pine, Ponderosa Pine-Douglas-fir-Bunchgrass, and Alpine habitats indicated some deer use. Deer tracks and moderate browsing on several shrub species indicated that the Riparian Habitat is used to a considerable extent by deer.

Little evidence of moose activity was seen in the Engelmann Spruce-Lodgepole Pine Habitat. During the vegetation field surveys, moose pellet groups were found to be abundant in the Bog Habitat, particularly on Pavilion Mountain.

B. Upland Game Birds

Ruffed grouse and blue grouse are common in the upper Hat Creek Valley. No game birds were seen or heard in open range, while seven ruffed grouse were recorded in Riparian Habitat, two ruffed and three blue grouse were recorded in Ponderosa Pine-Douglas-fir-Bunchgrass Habitat, and seven ruffed grouse were recorded in Douglas-fir-Pinegrass Habitat.

Mourning doves (Zenaida macroura) and common snipe (Capella gallinago) were observed in the valley and chukar were seen in the Thompson Valley, south of Ashcroft. Spruce grouse were not observed, but probably occur in the Engelmann Spruce-Lodgepole Pine Habitat in the local study area. In September 1976 a relatively large number of blue grouse were observed at timberline.

C. Waterfowl

Breeding pair counts by Ducks Unlimited and B.C. Fish and Wildlife personnel were made in 10 sections in 1975 and in six sections in 1976. Only wetlands below 1200 m elevation were surveyed. Summing counts for each section (using the better counts for the two sections with overlapping data), resulted in a total of 156 breeding pairs for all 14 sections.

Assuming that 90 percent of the breeding pairs were detected by the ground workers and that the surveyed wetlands were representative of all wetlands, it is estimated that 259 pairs of waterfowl bred in the main Hat Creek Valley. These figures compare with B.C. Fish and Wildlife Branch estimates of 200 ± 50 breeding pairs in the main valley.[9]

In 1976 the B.C. Fish and Wildlife Branch and Ducks Unlimited counted 106 breeding pairs and 40 broods on 10 sections. Thus about 38 percent of the breeding pairs were eventually successful. In 1975 and 1976, ducklings in 43 broods were counted. The mean brood size was 6.1. From these data it has been estimated that approximately 600 ducklings were produced yearly in the upper Hat Creek Valley.[9]

The most severe limitation to waterfowl nesting in the Hat Creek wetlands is the general lack of marsh vegetation. Heavy cattle grazing in the Hat Creek Valley has disturbed the shallow portions of wetlands, removing marsh vegetation. The narrow marsh edges of Hat Creek wetlands additionally limit waterfowl productivity and cover. The invertebrate fauna is well-developed in most ponds. Therefore, an adequate duckling food supply appears to exist in Hat Creek wetlands.[9]

Nesting and brood areas are required for successful waterfowl reproduction. At Hat Creek the two are usually found in separate areas. Nests are located in relatively dense cover at varying distances from water. Dense cover is generally lacking in many parts of the Hat Creek Valley. Good interspersion of nesting cover and brood ponds is crucial to nesting success in the Hat Creek Valley.[9]

Predation is a major mortality factor affecting waterfowl productivity. Brood success of Hat Creek waterfowl appears to be good, which indicates that local predation on waterfowl is probably not great.

In total, 507 waterfowl were counted in the autumn survey and 371 waterfowl were counted in the spring survey in 1977. Both surveys probably sampled a minimum of 75 percent of the wetlands, indicating that approximately 700 and 500 ducks, respectively, were present at the time of sampling. These data do not reflect the total number of waterfowl using the site wetlands during the course of the migration period. Mallards (Anas platyrhynchos), teal (Anas sp) and goldeneye (Bucephala spp) were the most common species. A summary of waterfowl species recorded for the upper Hat Creek Valley and the relative abundance of each species are given in Table 3.4-13.

D. Birds

Sixty-eight species were recorded on breeding bird surveys conducted in five habitats in the Hat Creek watershed. Of the five habitats sampled, the highest numbers of individuals were seen in the Ponderosa Pine/Douglas-fir/Bunchgrass Habitat. The fewest were seen in open ranges. Species diversity was highest in the Riparian and Aspen habitats and was slightly lower but equal in the other habitats. The Riparian Habitat contained the highest number of unique or restricted distribution species. The Aspen Habitat contained the fewest. Only two species were recorded on the owl survey: great horned owl (Bubo virginianus); and screech owl (Otus asio), neither of which was abundant. Information from literature sources and field surveys concerning the presence, seasonal status, relative abundance and habitat preference of Hat Creek avifauna is summarized in Table 3.4-13.

In general, the upper Hat Creek Valley is an excellent area for bird watching. The habitat is open and the birds are much more visible than in the forests of coastal British Columbia. In addition, the avifauna is quite diverse in the upper Hat Creek Valley. Species characteristic of dry, warm zones and those characteristic of cool, moist zones can be found within a few kilometres of each other.

E. Furbearers

The area potentially affected by physical disturbance associated with the mine and thermal plant has no registered traplines in it. The upper Hat Creek region, however, has an abundance of furbearers. Beaver were found along Hat Creek and along most of its tributaries. Many of the more valuable waterfowl wetlands are the result of beaver activity.

A mink (Mustela vison) was observed along Hat Creek, and a short-tailed weasel (M. erminea) and a least weasel (M. nivalis) were captured in live-traps set for mice. The latter species is rare in British Columbia and this capture is well to the southwest of its previously recorded range. No muskrats (Ondatra zibethica) were seen in Hat Creek wetlands but their signs were seen north of Clinton. Coyotes (Canis latrans) were sighted in the Hat Creek Valley. Two black bears were seen, one near Hat Creek and the other in Venables Valley. A wolf (Canis lupus) was observed at Cornwall Peak.

F. Small Mammals

The deer mouse (Peromyscus maniculatus) was the most commonly encountered small mammal. Red squirrels (Tamiasciurus hudsonicus) were in all forested zones and chipmunks (Eutamias amoenus) recorded for only three habitats, although signs were evident in all habitats. Microtine rodents (Microtus spp) were not found to be abundant. Because they undergo regular population fluctuations, microtine rodents may constitute a significant fraction of the small mammal resource in other years.

The Riparian Habitat contains the greatest diversity of small mammals species. Of special note is the capture of a least weasel (Mustela nivalis) in the open range near Harry Lake. Only five specimen records of this species have been reported in British Columbia.

Yellow-bellied marmots (Marmota flaviventris) were commonly observed in the study area. Marmots preferred rockpiles and open ranges and were only observed in the southern two-thirds of the upper Hat Creek Valley. Tracks along Hat Creek indicate that feral cats (Felis domesticus) may be an important component of the local fauna.

(c) Rare and Endangered Species

The concepts of rare species and endangered species differ in a fundamental way. The biological concept of rarity pertains to the distribution and abundance of a species. Specifically, a rare species is one whose number are either widely separated into small sub-populations with reduced interbreeding, or are restricted to a single population. The concept of an endangered species is biologically meaningful only in context of existence through time. Hence, an endangered species is one whose reproductive potential is threatened.

In accepted usage, a species considered as a "rare species" is not endangered, but may be vulnerable owing to its low numbers. "Endangered species" are in immediate danger of extinction (i.e. the particular gene pool which comprises the species or sub-species is immediately subject to being irrevocably lost), and these are categorized as vulnerable, threatened, or critically endangered, depending on the degree of vulnerability. Rare or endangered species occurring or potentially occurring within Hat Creek regional and local areas are listed below.

(i) Rare Species

Tailed Frog (Ascaphus truei)

The tailed frog is unique among amphibians in that it breeds in torrent streams. It is a member of an archaic taxonomic group now represented only by itself and by a species in New Zealand. The tailed frog is not considered endangered, but is listed because it has been rarely collected in southwest British Columbia and because of its unique biological and taxonomic status.

Gopher Snake (Pituophis melanoleucus catenifer)

The gopher snake occurrence is only marginal in British Columbia in the warm, interior dry belt.[11] In British Columbia it is found where small mammals are abundant at lower elevation (below 610 m). The species was probably never abundant in British Columbia but is a common reptile in the western United States.

Least Weasel (Mustela nivalis)

The smallest member of the weasel family is sparsely distributed in northern and central sections of British Columbia. The preferred habitat throughout its range is open lands and deciduous forest. Rarely recorded in the province, the animal captured in the Hat Creek watershed during small mammal trapping operations apparently represents the southernmost record for British Columbia.

Poor Will (Phalaenoptilus nuttallii)

The poor will only occurs in two small areas of Canada: southern interior British Columbia and the Cyprus Hills area of southern Alberta and southwestern Saskatchewan. The bird prefers semi-arid habitat and was found to be an uncommon summer resident of big sage in the project area.

Long-billed Curlew (Numenius americanus)

The distribution of the long-billed curlew in British Columbia is limited to the southern interior region. The species has decreased throughout its range in recent years, perhaps due to habitat disruption. This species was regularly recorded in wetland habitats in the project area and probably nests in grasslands.

Trumpeter Swan (Olor buccinator)

The trumpeter swan, faced with near extinction a few decades ago, has recovered to a considerable extent due to the complete protection which it was given. The species probably breeds in northern British Columbia and winters on the coastal islands. It was recorded as an uncommon spring migrant in wetland and saline depressions in the project area.

Common Loon (Gavia immer)

As with other fish-eaters, pesticide and mercury poisoning is the greatest threat to common loons, although oilspills and hunting are also causes for concern. Loons occur throughout Canada, but generally breed in remote waters, usually only one pair to a lake. Pairs were sighted in McLean and Aleece lakes in the Hat Creek drainge, and appeared to have successfully bred there. Pesticide poisoning seems to be a bigger threat to loons in the eastern part of the species range, but the potential is high everywhere, especially because loons do not breed until they are 4 or 5 years old.

Peregrine Falcon (Falco peregrinus)

The peregrine falcon has been the centre of a controversy regarding endangered and vanishing wildlife species in North America[11-17] (Table 3.4-14). The overall decline in numbers of peregrine falcons is believed to be a result of the accumulation of pesticides in the tissue of the birds, resulting in thin-shelled eggs which are subject to breakage and dehydration. However, Beebe[17] contends that peregrine falcons are neither rare nor endangered in western Canada. Nevertheless, the species has been proven vulnerable and DDT derivatives have been strongly implicated. Since peregrine falcons prey on birds, they are not necessarily immune to the application of pesticides thousands of kilometres to the south. No peregrine falcon was sighted in the upper Hat Creek Valley during spring migration, however, it is conceivable that peregrine falcons do nest within the regional study area.

Bald Eagle (Haliaeetus leucocephalus)

Like the osprey, the bald eagle has undergone a considerable decline over much of the southern and eastern portion of its range due to persistent pesticide poisoning. The species is still relatively common in British Columbia, particularly along the coastal rivers, but was not observed within the project area during the study period.

White Pelican (Pelecanus erythrorhychos)

Only a single colony of white pelicans occurs in British Columbia, at Stump Lake about 100 km east-southeast of the project site. Because of the species' extreme rarity in the region and the vulnerability of the isolated colony to extirpation, the pelican is considered endangered in British Columbia. Elsewhere in Canada, it is listed as vulnerable (because of breeding colony persecution and possible threats from pesticides). The white pelican was recorded as a rare spring migrant through the project area.

Cougar (Felis concolor)

Although the particular sub-species of cougar found in Hat Creek Valley (Felis concolor oregonensis) is not considered rare or endangered, the range and numbers of the species as a whole in Canada have rapidly diminished because of overhunting.[12] The endangered sub-species, missoulensis, probably occurs in the northern portion of the study area, but the details on exact sub-species borders or biological differences are not known.[21] Although beaver, rabbits, birds and mice comprise a portion of their diet, cougars depend primarily on deer for food.

Grizzly Bear (Ursus arctos horribilis)

Like the cougar, the grizzly bear has its stronghold in the west, with most of the Canadian population found in British Columbia and the Yukon. One of the endangered races, the Lillooet grizzly occurs within the study area mainly west of the Fraser River. This race was apparently never abundant and because of heavy hunting pressure is now extremely rare or perhaps already extinct. Although trophy hunting is a real threat to grizzly populations, the greatest threat at present is the encroachment of man on the large wilderness areas required to support the grizzlies.

Wolf (Canis lupus)

The wolf is not considered to be an endangered species in most of Canada. However, history has shown that wolves tend to be extremely vulnerable to the advance of civilization.[21]

California Bighorn Sheep (Ovis canadensis californiana)

This sub-species of bighorn sheep is believed to have formerly occurred throughout most of the southern interior of British Columbia. It is now restricted to separate herds, like the Chilcotin-Riske Creek groups, the Vaseux Lake group, the Ashnola group, and other small groups, including several within the regional area. Decline in bighorn sheep numbers is in part attributable to meat and trophy hunting. Encroachment on their wilderness habitats has resulted in a drastic decrease in suitable habitat, which in turn results in small populations which are more susceptible to the effects of parasites and epidemic diseases such as pneumonia. One of the most severe threats to bighorn populations is competition with domestic livestock for forage, and the transmission of diseases and parasites from domestic sheep to wild sheep. Bighorn sheep are very habitual in their use of summer and winter ranges. Habitat use conflicts occur when domestic livestock summer ranges overlap with bighorn winter ranges.

(ii) Endangered Species

Prairie Falcon (*Falco mexicanus*)

The Canadian range of the prairie falcon encompasses the southern border area, from southeast British Columbia to southern Saskatchewan. It occurs in arid plains and semi-desert habitat. Declining numbers of falcons are due primarily to the presence of pesticide residues (principally DDT, but also heptachlor and dieldrin) which results in soft-shelled eggs, embryo mortality and a high incidence of nesting failures. The limited range of prairie falcons makes the species more susceptible to extinction than species with wider distribution.

Osprey (*Pandion haliaetus*)

This cosmopolitan fish-eating raptor has suffered serious declines throughout much of its range due to poisoning by persistent pesticides. Viable populations still exist along many of the major streams in British Columbia and recent bans on the use of some pesticides give rise to hope that the species will eventually recover. The species was recorded as an uncommon fall migrant in the project area, but apparently did not breed there.

(d) Consumptive and Non-consumptive Use

(i) Consumptive Use

A. Big Game

The regional study area includes portions of Game Management Areas (GMA) 4, 14 and 15. A considerable portion of GMA 15 extends to the east of the regional study area boundary; however, it also includes a large portion of the Lytton-Merritt-Kamloops area. Over 15 percent of the resident hunters in British Columbia hunt GMA 4, 14 and 15 even though these areas account for only about 4.7 percent of the land area in the province. Deer attract the greatest number of hunters. In GMA 4, 14 and 15, approximately 25 000 hunters harvested annually more than 7620 ungulates or 11.7 percent of the estimated ungulate harvest in British Columbia over the period of 1970 to 1974.

From 1969 through 1974 the combined upper and lower Hat Creek watershed provided an annual average harvest of approximately 9.3 deer, 2.7 moose and 0.2 black bears which represent respectively, 28, 34 and 13 percent of the average annual deer, moose and bear harvests in Management Unit 3-17. The north end of upper Hat Creek (Medicine and Anderson Creek drainages) provided annual average harvests of 3.5 deer and 1.7 moose respectively. The Medicine and Anderson Creek harvest represented 70 percent of the deer and 85 percent of the moose reported killed in the upper Hat Creek watershed. The Cornwall Creek area provided an annual deer harvest which was slightly less than that reported for the Medicine and Anderson drainages.

Approximately 11 percent of the deer harvested in GMA 14 are checked through Cache Creek. A higher percentage of the moose (29 percent) and black bear (17 percent) harvest are checked through Cache Creek. Resident hunters who do not pass the Cache Creek station take a high percentage of the deer (89 percent) and moose (71 percent) harvested.

Resident Hunting

The majority of the deer and moose hunters using the regional area reside in the Kamloops area, with the second largest number residing in the Lower Mainland area. The largest percentage of goat and sheep hunters reside in the Lower Mainland area, with the second largest number residing in the Kamloops area.

Non-resident Hunting

The greatest number of guides hunt in GMA 14. Moose are the most abundant big game species harvested, followed by deer, black bear and sheep. The second highest number of guides in the study area utilize GMA 4. Deer, goat, mountain sheep, black bear, moose and grizzly bear (in decreasing order of abundance) are harvested in this area. The lowest number of guides in the study area use GMA 15. Moose and deer are the major game animals harvested there.

Low numbers of grizzly bear are harvested in the study area (0.5 percent of the B.C. provincial average). However, the presence of this species in conjunction with Rocky Mountain and California bighorn sheep and mountain goats makes the area attractive to non-resident hunters.

B. Waterfowl

A portion of the regional study area west of the Fraser River is included in GMA 4, while a portion of the regional study area south and east of the Thompson River is included in GMA 15. These latter two GMA are not included in the present waterfowl analysis, since most of the waterfowl habitats lie outside the regional study area boundary. Consequently, data may not be relevant to the regional study area. More than 7 percent of the provincial hunters are located in GMA 14 and approximately 5 percent of the waterfowl were harvested in this management area.[9]

In 1976, GMA were changed to the much smaller Management Units. Cache Creek Hunter check returns for 1976 are available for the smaller Management Units. Management Unit 3-17 (which includes Hat Creek) is relatively unimportant to regional hunters in comparison to Management Units 3-30 and 3-31. The area around Clinton is nearly an order of magnitude more productive to hunters than the Hat Creek area. The relative importance of Hat Creek to local hunters or those who leave the valley via the Oregon Jack Creek Road cannot be accurately estimated from the Cache Creek check station data.

C. Upland Game

Sharp-tailed grouse, spruce grouse, ruffed grouse and blue grouse are all important game species in the Hat Creek region. A significant portion of the upland game bird hunters and harvesting in the province is centered in GMA 4. The region is particularly significant for chukar hunting, since more than half the B.C. hunters use the area with nearly a third of the provincial harvest taken there.

Harvests from Management Unit 3-17 (including Hat Creek) are very small (only 3 percent) in comparison to harvest from the other two management units. More than four-fifths of recorded harvest comes from Management Unit 3-30, east of Highway 97. Regional upland game bird hunters appear to choose adjacent areas in preference to Hat Creek itself.

(ii) Non-consumptive Wildlife Use

In comparison to other interior localities such as Ashcroft, Cache Creek, Kamloops, 100 Mile House or the Okanagan Valley, few sight records or nest records for the Hat Creek Valley are on file in the B.C. Provincial Museum's records. As the B.C. Provincial Museum nest and sight record schemes solicit records from all interested amateur birdwatchers in the province, the lack of Hat Creek records strongly implies that the valley is not used very much for recreational bird watching.

The nearest active naturalists club is in Kamloops, although some naturalists may be active in Lillooet and Clinton. Hat Creek lies just outside the Kamloops Club area. Hat Creek Valley is a superior area in which to observe birds. Bird species are abundant, diverse and easily visible in the open forests and rangelands. Additionally, the Hat Creek avifauna includes species that are either not found elsewhere or are not as easily found. The potential for recreational nature watching is high, but this resource appears to be underutilized.

Limited access is, in part, responsible for the low level of non-consumptive wildlife use in the Hat Creek Valley. Except for the Cornwall Peak fire lookout road, most of Hat Creek Valley is fenced, privately controlled land. Upper Hat Creek residents have indicated that they actively discourage recreational activities of non-residents within the valley.

(iii) Man-induced Perturbations

Man's activities in the vicinity of Hat Creek have had a significant impact on the abundance and distribution of wildlife. Hunting pressure has eliminated or greatly reduced some species of big game in the past. The project site falls within three game management areas administered by British Columbia Fish and Wildlife Branch. Hunting is now regulated to obtain sustained yields from existing game species. Intensive grazing by cattle is now a major stress on many of the natural habitats and is a factor affecting the capacity of some of these areas to support wildlife (e.g. grazing wetland vegetation destroys waterfowl nesting and brood cover). Lumbering activities in the region have also had a significant impact on wildlife populations. Timber harvesting has been detrimental to some species but has benefited others (e.g. moose have increased their range largely due to the availability of forage in cutover areas). The patterns of existing man-induced stresses appear likely to continue.

3.4.4 Forest Resources

(a) Forest Lands

Approximately 1 731 500 ha of the proposed development region is classified as forest land. This is approximately 3.3 percent of the total forest land within the province of British Columbia and 74 percent of that encompassed by the regional study a. Of the 196 350 ha circumscribed by the local study area (25 km radius), 75 percent is forested land.

Forest land tenure of the study area is summarized in Table 3.4-15. Ninety percent of the forest land in the regional area and 96 percent of that within a 25 km radius of the project is Crown land.

(b) Resource Status

The current status of forest resources is appraised in terms of forest types and standing mature volume. Forest stands are typed as mature, immature, residual (stands which have been disturbed 26 to 75 percent by logging, fire, insects or disease), not sufficiently restocked (NSR, disturbed over 75 percent and not restocked with sufficient numbers of commercial species), and noncommercial cover (NCC, forest land vegetated with non-commercial species).

The status of forests as of 1970 in the regional and local area is summarized in Table 3.4-15. Almost half of the regional and local forest area is classified as mature, of which approximately 93 to 94 percent occurs on Crown land. Residual, NSR and NCC together account for less than 8 to 10 percent of these areas.

Standing mature volume (1970) of each commercial species within the regional and local area is presented in Table 3.4-16. The total volume of mature timber within the region is 135.6 Mm^3 with the three major species, lodgepole pine (38 percent), Douglas-fir (36 percent) and spruce (15 percent) accounting for 89 percent of the volume. In the local study area, Douglas-fir is substantially more abundant, constituting more than half of the total mature volume.

(c) Productivity

The productivity of standing timber is measured using the mean annual increment (MAI) at the rotation age. As potential yields are in large part a function of site conditions, the B.C. Forest Service has evaluated provincial forest land utilizing a system of ranked site classes specific for major commercial species. The four classes recognized by Reid, Collins and Associates,[24] good, medium, poor and low, comprise 9, 35, 54 and 2 percent of the regional study area, respectively. Productive forest land within the local study area is considerably more scarce: 2 percent is classified as good, 25 percent as medium, 71 percent as poor and 2 percent as low. The distribution of site classes in the local study area is portrayed in Fig. 3.4-7. Mean annual increments (MAI) calculated for the various B.C. Forest Service Management units of the regional area range from 1.2 to 2.4 m^3/ha. The corresponding annual allowable cut (AAC) for the local area is 146 189 m^3.

Provincial forest lands are divided into districts administered by the B.C. Forest Service. Within and sometimes straddling districts are smaller divisions created for management purposes. These can be of two types: Public Sustained Yield Units (PSYU) which contain Crown lands and are managed by Forest Service personnel, or Tree Farm Licenses (TFL) placed under private management. Sixty-five percent of the regional study area is located in the Kamloops Forest District and 35 percent in the Cariboo Forest District. The two districts, within the regional area, incorporated a portion of TFL No. 35, which represents 2 percent of the regional forest land, and portions of the following seven PSYU (percentage of regional forest land noted in parenthesis): Big Bar (30), Botanie (20), Kamloops (11), Lac La Hache (13), Nehalliston (6), Nicola (8) and Yalakom (10).

The B.C. Forest Service manages Crown land forest, comprising 90 percent of the regional forest land and some portions of TFL. Forest Service decisions regarding timber harvesting and scheduling are based on harvest applications submitted by lumber companies and the AAC calculated for each PSYU. Available information does not permit accurate projection of future harvesting locations. However, as of January 1977, 24 forestry companies had been alloted some portion of the AAC designated for the seven PSYU (including portions outside of the RSA) noted above.

Sites of present or near-future timber harvesting activities occurring on Crown lands of the local study area are noted in Fig. 3.4-8. There is currently one principal lumber operation in the local area. This company has been authorized to remove timber from the Hat Creek Valley and intends to remain active there until at least 1990.

Also illustrated in Fig. 3.4-8 are two areas proposed for designation as Environmental Protection Forests (EPF). If the areas are accorded this status, timber operations will be prohibited or restricted, due to unstable or steep slopes and/or important wildlife, recreational or aesthetic features.

The proposed EPF near Robertson Creek contains steep slopes conducive to erosion. The EPF located near Pavilion Lake is in the proximity of Marble Canyon Provincial Park and Indian Reserves 3 and 1A.

Regional study area production of forest products in 1976 accounted for 9 percent (171 690 m^3) of the plywood, 6 percent (6300 tons) of the pulp and 5 percent (564 million board feet) of the lumber produced in the province. The one principal lumber concern operating in the local area trucks logs to its sawmill and plywood plant at Savona.

3.4 LAND RESOURCES - (Cont'd)

(d) Forest Stress Conditions

(i) Insects

The occurrence of forest insect pests has been recorded in the region of the project since 1912. The major insect pests recorded are mountain pine beetle (Dendroctonus ponderosae), Douglas-fir beetle (Dendroctonus pseudotsugae), Douglas-fir tussock moth (Orgyia pseudotsugata), Western blackheaded budworm (Acleris gloverana), spruce budworm (Choristoneura occidentalis), satin moth (Stilpnotia salicis) and black pineleaf scale (Nuculaspis californica).

The bark beetles, (D. ponderosae and D. pseudotsugae), have historically been the most destructive, causing damage through reductions in growth and ultimately mortality. D. ponderosae attacks all pine species and is often found associated with D. brevicomis. In general, bark beetles feed beneath the bark of trees causing pitch to flow out of the entry holes. The foliage becomes chlorotic 3-4 weeks after infestation, and in the following season, the leaves may turn reddish brown and abscise. Following these events, the tree may live for only a few years. The most recent outbreak of D. ponderosae in the vicinity of the development was in 1976 when 210 ha of ponderosa pine was killed in upper Hat Creek. The most recent outbreak of D. pseudotsugae in the vicinity of the development was in 1976 when 210 ha of ponderosa pine was killed in upper Hat Creek. The most recent outbreak of D. pseudotsugae in the vicinity of the proposed development occurred in 1975 when 300 redtops were observed in Fountain Valley.

Defoliators, O. pseudotsugata, A. gloverana, C. occidentalis and S. salicis are also considered major forest pests. Defoliators damage trees by devouring foliage while in larval stages. The damage is exhibited by cropped needles, thin, yellow or brown foliage and bare twigs.

O. pseudotsugata is the most commonly occurring defoliator in the project area. It attacks both ponderosa pine and Douglas fir. The last major outbreak was reported in 1948 when 1600 ha near Oregon Jack Creek were defoliated. C. occidentalis is a major pest of Douglas-fir. It is the most active insect in the project area. Severe outbreaks have occurred on the western slopes of the Clear Range. The insect has been particularly active in recent years, as evidenced by the extensive areas of defoliation in the vicinity of Ashcroft.

Scale insects, such as N. californica, attack ponderosa pine, primarily those found on the drier sites in the vicinity of the project. The most common sympton of scale infestation is a chlorosis and senescence of the leaves, ultimately resulting in a thinning of the affected crown. The most recent outbreak was recorded in 1957 to 1959 near Lytton and in the Botanie Valley.

(ii) Disease

No fungal or other tree diseases of major importance have been noted in the region of the proposed development.

(iii) Fire

Forest fires have historically been and will continue to be a major disrupting factor to the forests in the vicinity of the proposed project. The historical pattern and incidence of fires is reflected by the age and distribution of lodgepole pine, which commonly occurs after a fire. On this evidence alone, it appears that fires have been prevalent within the valley and can be expected to occur in a similar pattern in the future.

3.4.5 Agriculture

Agricultural resources of the project study areas are described with reference to climate, land capability, range vegetation, productivity, and agricultural and land use practices. Water resources available for irrigation are described in Section 3.3, Water Resources. Current and potential productivity are addressed separately from land capability because productivity is a function of natural resources and agricultural practices. Section 3.4.5(g), Agricultural Land Uses and Practices, incorporates land use patterns, farming practices and considerations affecting these such as government programmes and policies.

(a) Climatic Factors

Climate varies markedly due to changes in elevation and proximity to large water bodies. Even in areas where climate is most favourable for agriculture, aridity limits dryland farming to drought-resistant forage or cereal crops. With irrigation, areas in the general vicinity of Nicola and Kamloops lakes and large rivers such as the Thompson, Fraser and lower Nicola exhibit CLI Climate Capability for Agriculture (CCA) Class 1 (improved, signifying that irrigation is assumed) conditions. In the CCA system classes range from 1, which allows production of the widest range of crop species, to 7, which precludes agricultural activity.

Class 1 climate is conducive to raising corn, a high value crop, as well as a wide range of vegetables, small fruits, forage crops and cereal grains. Special Class 1b (improved rating) possesses conditions suitable for production of crops which thrive in warm temperatures, such as tomatoes and vine crops. This class occurs regionally on the eastern benches of the Fraser River between Lillooet and Lytton and on the benches of the Thompson River between Ashcroft and Savona.

Thirty percent (598 km^2) of the local study area, principally the valley lands and adjacent benches of the Thompson, Fraser and Bonaparte rivers as well as isolated pockets of the Hat Creek Valley, experience Class 1 climatic regimes. This includes 336 km^2 where special Class 1b conditions occur. Without irrigation ratings in these Class 1 (and 1b) areas range from Class 3 to Class 7.

The benches adjacent to Class 1 areas generally experience climates identified as improved Class 2 or 3. These areas (510 km^2, 26 percent of the local study area) are typically associated with lower-elevation grasslands and can support intensive agriculture if soil characteristics are not limiting. Typical crops cultivable in Class 2 and 3 areas, assuming irrigation and suitable soil and terrain conditions, are hardy vegetables such as cabbage, forage species and certain cereal grains.

Climate capabilities of almost half of the area (855 km^2, 44 percent) range from Class 4 through Class 7. Here, principal climatic restraints on productivity are aridity, a frost-free period less than 60 days, and less than 1900 growing degree days greater than 5^oC. The lower regions of the local study area generally experience Class 4 and 5 climatic conditions, which limit agriculture to cultivation of forage crops (Class 4) and cattle grazing. Areas with Class 6 and 7 (318 km^2, 16 percent of the local study area) climatic capabilities have, respectively, limited or no agricultural potential and are characteristically associated with the higher elevation mountains located in the western portion of the study area.

(b) Regional Land Capabilities

The areal distribution of land capability categories, high, low and very limited is depicted in Fig. 3.4-9. High capability lands can support with irrigation, sustained annual harvesting and are defined as lands identified by the CLI as Land Capability for Agriculture (LCA) improved (irrigation assumed) Classes 1, 2, 3 or 4. The CLI LCA system, which reflects climatic and edaphic variables and includes seven classes, is further described in Section 3.4.6(b). Low capability areas represent mostly grazing land, while those areas demarcated as neither high nor low capability are of only limited agricultural (essentially grazing) value. The composition of the regional study area with reference to these three broad categories, including individual LCA Classes 1, 2, 3 and 4, is summarized in Table 3.4-17.

The most extensive areas of high capability agricultural land, LCA improved Classes 1 to 4, occur primarily in the river valleys and plateaus of the northern portion of the study region (Fig. 3.4-9). Class 1 and 2 lands, however, are largely restricted to areas along the North Thompson River, Merritt-Nicola Lake vicinity, Kamloops vicinity, Fraser River Valley from Lillooet-Lytton, and the Thompson River Valley in the Ashcroft-Cache Creek-Savona area. The general restriction of Class 1 and 2 lands to these locales is a function of climate.

The 210 km^2 of the regional study area identified in the CLI as LCA Class 1 (improved rating), constitute 30 percent of the improved Class 1 capability land in the province (Table 3.4-17). The juxtaposition of this Class 1 land with 16 000 km^2 of land suitable for grazing, renders the regional study area well-suited for beef cattle production.

The portion of the regional study area denoted in Fig. 3.4-9 as supporting little or no agricultural activity, coincides with higher elevations. Biogeoclimatic zones characteristic of much of this portion, Engelmann Spruce - Sub-alpine Fir - Alpine Tundra and Sub-alpine Mountain Hemlock zones, provide only limited forage for cattle.

(c) Local Land Capabilities

(i) High Capability Lands

The distribution of lands theoretically capable of supporting intensive agriculture with irrigation, identified on the basis of CLI LCA improved Classes 1 to 5, is presented in Fig. 3.4-10. Associated areal coverages for each of the LCA classes is included in Table 3.4-18. High capability lands (260 km^2, approximately 13 percent of the local study area occur primarily where climatic variables, particularly duration of frost-free period, number of growing degree days greater than 5.6°C, soil and terrain features are favourable. These areas are situated chiefly in the valleys and benches of the Thompson, Bonaparte and Fraser rivers, on plateaus east of Pavilion, and in approximately 50 km^2 of the Hat Creek Valley. An important component of this intensive agriculture land is the 36 km^2 with Class 1 agricultural capability, located mostly along the Thompson River and Semlin Valley.

(ii) Low Capability Lands

Lands with CLI LCA Classes 6 and 7 (i.e. low capability lands) were assigned grazing capability ratings ranging from 1 to 5. The criteria for assignment were developed by the Soils Division of the B.C. Department of Agriculture as part of a tentative methodology for mapping CLI land capability for grazing. The distribution of higher capability grazing lands (grazing classes 1, 2 and 3) and lower capability grazing lands (grazing Classes 4 and 5) are depicted in Fig. 3.4-10. The higher capability grazing lands occur primarily on the secondary benches adjacent to rivers, and on lower elevations of mountains in the Hat Creek basin.

Approximately 46 percent (907 km^2) of the local study area is identified as higher capability grazing land. This represents an important agricultural resource. Most of these lands are grazing Class 2 or 3. The low capability grazing area, comprising approximately 41 percent (796 km^2) of the local study area, represents a relatively unimportant grazing resource.

(d) Site Area Land Capabilities

(i) High Capability Lands

High capability lands are portrayed in greater detail in Fig. 3.4-11. They comprise approximately 35 percent (72 km^2) of the area delimited by the figure and occur mostly in the eastern portion of the site area, in the vicinity of Ashcroft and Semlin Valley. Within the western portion of the site area (upper Hat Creek Valley) there are approximately 38 km^2 of high capability land, predominantly LCA Class 3. While climatic factors in some portions of the Hat Creek are propitious for irrigated agriculture, soil characteristics in those areas with favourable climate restrict the LCA ratings (improved) to 3 and 4.

A more detailed analysis of high capability land of the site was conducted utilizing soil maps constructed at a scale of 1:24 000. A summary of these findings is included here. From evaluation of the soil maps and CLI CCA maps, five classes of capability for intensive agriculture with irrigation were identified. Classes were assigned to all soil units of the site-specific study area where cultivated crops or irrigated pasture could be supported. The five classes are each associated with a preferred crop (higher value crop) and range from irrigable lands capable of producing the widest range of crops of which tomatoes would be considered preferred, to irrigable lands where intensive agriculture would likely be limited to irrigated pasture. The areal extent of each of the five classes or irrigable land is presented in Table 3.4-19.

(ii) Low Capability Lands

Low capability land incorporates all land units rated LCA classes 6-7. This category constitutes the portion of the site-specific study area for which agricultural activity would be essentially limited to grazing and includes 426 km^2 or 86 percent of the site-specific study area. Further differentiation of grazing land into the five grazing capability classes developed by the Soils Division of the B.C. Department of Agriculture, is mapped in Fig. 3.4-11.

(e) Range Vegetation

Important forage plant species which characterize rangeland of the site and Hat Creek basin and vicinity are noted in Table 3.4-20. The importance of these species reflects palatability and feed value to grazing livestock, as well as relative abundance. Bluebunch wheatgrass (Agropyron spicatum) is particularly valuable and also widespread, occurring as an important component in six of the 20 vegetation associations identified in the local study area (Section 3.4.2). These six associations comprise 127 km^2 or approximately 20 percent of the rangeland within the Hat Creek watershed portion of the local study area.

(f) Productivity

(i) Croplands

Average yields and relative importance of crop types grown in the local study area are presented in Table 3.4-21. Productivity ranges reflect differing management practices and climatic regimes. Alfalfa and orchard grass are particularly important crops. Alfalfa yields can range up to 16 Mg hay/ha on well-managed lands occurring in Class 1b climate capability areas, such as occur along the Bonaparte River near Cache Creek. Corn is increasing in popularity as an annual crop for silage production with potential yields as high as 65 Mg/ha.

(ii) Rangeland

Rangeland productivity is expressed in terms of cattle carrying capacity and reflects management practices as well as adaphic and climatic factors. Carrying capacities currently realized and those potentially achievable with good management practices are discussed.

A. Current Carrying Capacities

Local Study Area

Estimated current carrying capacities of the various grazing permit units administered by the B.C. Forest Service in the local study area are listed in Table 3.4-22. The units employed here to measure carrying capacity are land area (hectares) required to support one animal unit (AU, one steer or one cow and calf) for 1 month, commonly expressed as ha/AUM. In the 1211 km^2 of the local study area managed on a permit basis, carrying capacities range from a high productivity of 0.4 to a low productivity of 54.1 ha/AUM, and average (when weighted for areal contribution) at 6.7 ha/AUM.

The present carrying capacity of non-permit rangeland, the 669 km^2 of private land (including Indian Reserves) and lease rangeland of the local study area, was derived from forage yields mapped in 1969 by the B.C. Forest Service.[27] Utilizing an average carrying capacity calculated for this segment of the local study area, 2.4 ha/AUM, the lower grasslands of the area can support roughly 31 500 AUM. This translates into forage sufficient for 10 000 cattle over a 3-month interval. Although the exact number of cattle maintained in the local study area is not known, estimates indicate there may be on the order of 5000 animals. The high estimate of carrying capacity is likely due to a combination of three factors:

1. The lower rangelands may be in poorer condition than they were 10 years ago when the range map was prepared.

2. The 669 km^2 estimate of areal extent of lower grassland areas within private and lease land may be higher than the grassland areas actually available to cattle.

3. Animals may be grazed on these lands for a period averaging more than 3 months.

Hat Creek Valley

An estimate of cattle numbers presently supported in the Hat Creek Valley (watershed) was developed from analysis of seasonal productivities. The boundaries of the Hat Creek watershed are delineated in Figure 3.4-12. The cow/calf operations characteristic of this area utilize three sources of cattle feed: hayfields from which winter feed is harvested, spring pasture and summer grazing.

The 879 ha of irrigated valley haylands generally exhibit three levels of productivity, depending on soil characteristics. Total production is estimated to be roughly 5398 Mg of hay, which would sustain approximately 3395 animals for seven winter months (assuming 1 month of all pasturing on cropped hay fields). Spring rangelands provide about 3916 AUM, sufficient to support 1958 animals for a 2-month period, while summer rangelands provide about 9141 AUM which support approximately 3047 *animals for the three summer months.*

From comparison of the three seasonal productivities, it is apparent that spring feed production probably limits Hat Creek Valley cattle numbers to rougly 1958 animals. Current numbers of cattle would significantly exceed 1958 if spring grazing were supplemented with extra hay or if hay fields were used as irrigated pasture.

B. Potential Carrying Capacity

Potential carrying capacity is defined here to indicate range carrying capacity likely to be achieved if good management practices maintain native forage production near levels measured for undisturbed conditions. Improvements such as fertilization, irrigation or introduction of exotic plant species are not assumed, nor is water availability for cattle consumption considered.

Potential carrying capacities calculated for the five grazing capability classes tentatively defined by the CLI, are presented in Table 3.4-23. The basis for the calculated carrying capacities is the range of forage productivities, noted in the first column, estimated by the Soils Division of the B.C. Department of Agriculture.[28] Assumptions utilized in translating forage yields into cattle support are noted in Table 3.4-23 and Section 2.4.5(c). Total annual carrying capacity for the local study area, as derived in this table, ranges from 90 445 to 186 606 AUM. A second informational source was employed to calculate potential range carrying capacity for the Hat Creek watershed. Vegetation associations identified in Section 3.4.2 were assigned carrying capacities derived from conversations with provincial staff and from data reported in the literature. Potential carrying capacities calculated in this manner are presented in Table 3.4-24; when summed for the entire watershed, they range from a low (assuming fully stocked forests) of 17 000 AUM/yr to a high (assuming recent clearcut conditions in forested areas) of 36 500 AUM/yr.

From comparison of Table 3.4-23 with Table 3.4-24, it is noted that the estimated carrying capacity of the Hat Creek watershed derived in the latter, 36 505 AUM/yr, is comparable to the lower estimate derived in Table 3.4-23, 32,407. As the two tables were developed from independant data sources, this suggests that the lower estimates included in Table 3.4-23 are more realistic than the higher estimates.

3.4 LAND RESOURCES - (Cont'd)

(g) Agricultural Land Use and Practices

(i) Regional Study Area

A. Land Use

A large portion of the regional study area is considered agricultural land, reflecting extensive use of both open range and forests for cattle grazing. The juxtaposition of productive river valleys, suited for forage production, with large tracts of grazing land favour the cow/calf type of cattle operation which characterizes the agriculture of this area.

The 1976 areal extent of farmland and major crop-cover types of the Thompson-Nicola Census Division are noted in Table 3.4-25. The boundary of this census division is depicted in Fig. 2.4-2 along with the boundary of the regional study area. Farmland is defined to include improved and unimproved deeded and Crown lease land, but does not include Crown rangeland administered on a permit/fee basis. The 5480 km^2 of farmland within the Thompson-Nicola Census Division comprise 23 percent of all the farmland within the province. Of the 580 km^2 improved farmland, 320 km^2 are (as of 1976) devoted to crop production, principally forage crops. Hay is the chief crop, accounting for 88 percent of the total cropland area.

B. Agricultural Land Reserve

Approximately 9190 km^2 or 25 percent of the regional study area have been designated as part of the provincial Agricultural Land Reserve (ALR). The locations of reserves within the province and within the study area are depicted in Fig. 3.4-12 and 3.4-13. Twenty percent of the entire provincial ALR occurs within the study region.

The majority of the ALR within the regional study area are located adjacent to major rivers (excepting the Fraser River south of Lytton) and their tributaries, and on the plateau areas north and west of Clinton. In general, ALR include lands assigned CLI LCA classes 1 through 4, and selected rangelands assigned LCA classes 5 and 6.

C. Farm Characteristics

The number of farms of various size categories, and farm capital values, are presented in Table 3.4-26. Characteristic of cattle operations, farms of the Thompson-Nicola Census Division are relatively larged-sized. More than 70 percent of the farms are greater than 53 ha. The 33 million dollar capital value of livestock supported by the division comprises 17 percent of the livestock value of the province.

Livestock numbers are also reported in Table 3.4-25. Of the 626 farms included in the Thompson-Nicola Census Division 540 or 87 percent reported cattle on inventory at the time of the 1976 census. Little other livestock production occurs in the division with the exception of sheep, numbers of which account for 10 percent of provincial sheep production.

D. Cattle Operations

Beef production in the regional study area is associated with cow/calf ranching operations in which calves are raised for sale to finishing operations located outside of the province. Cattle are maintained by higher elevation grazing lands, mainly Crown land available on a lease or permit basis, and valley cropland usually deeded to the rancher. Most farmers raise forage crops to provide winter feed for their own cattle. To utilize both feed sources, cattle are moved from the lower elevations in summer to graze higher elevation Crown land, and returned to lower elevation range and cropped haylands in the fall. Cattle are normally wintered adjacent to hay production areas, where they are fed forage harvested during the previous summer.

(ii) Local Study Area

A. Land Use and Tenure

Agricultural land use and land tenure patterns are portrayed in Fig. 3.4-14. Approximately 12 percent (243 km^2) of the local study area is deeded (private), 4 percent (79 km^2) Indian Reserve and the remainder, Crown land. Land in the latter category is available for agriculture on either a lease or permit basis. Agricultural leases can be obtained from the provincial government for certain Crown lands that are at least 50 percent arable, while grazing leases are available for selected lands generally not amenable to use on a grazing permit basis. Crown leases, both agricultural and grazing, are administered by the Lands Management Branch of the B.C. Ministry of the Environment; with an agricultural lease, the leasee may opt to purchase the parcel if 80 percent of the arable portion has been placed under cultivation. Grazing permits are administered by the B.C. Forest Service, and are issued for specific areas, numbers of livestock and grazing periods.

Relationships between land tenure and agricultural land uses are summarized in Table 3.4-27. From inspection of the Table and Fig. 3.4-14, it is noted that most of the 45 km^2 of cultivated cropland and irrigated pasture (that is areas of intensive irrigation agriculture) is restricted to deeded lands and Indian Reserves. Approximately 98 percent of the local study area is rangeland, 63 percent of which is administered by the Crown on a permit basis. Grazing use of almost half of the entire available rangeland is restricted by vegetative and terrain features.

Field crops raised in the Hat Creek basin and vicinity are listed along with ranges of yields in Table 3.4-21. The two most important crops are alfalfa and orchardgrass; the former is particularly well-suited to CLI class 1b climate areas (lower benches and valley bottoms of the Fraser, Thompson and Bonaparte rivers) where the long frost-free period permits up to four harvests annually. Other crops which are important to a lesser extent are alsike clover, crested wheatgrass, reed canary grass, timothy and corn.

B. Farm Units

Distribution of major land use and tenure categories among the 13 farm units comprising the local study area, is bar diagrammed in Fig. 3.4-15. A farm unit refers here to the aggregate land area under single management control that functions as a unit for the production of agricultural products. Twelve of the farm units are cattle ranches, while one is a commercial hay operation. The largest operation is Unit 5, comprised of 603 ha of irrigated private and/or lease land, 13 637 ha private and/or lease rangeland, and utilizes 3,360 AUM/yr of permit land. Other major units are 6, 8 and 9.

C. Agricultural Land Reserves

A map of ALR occurring within the local study area is presented in Fig. 3.4-16. The reserves include 529 km^2, representing 27 percent of the land in the study area. Since only 5 percent of the entire province is designated ALR, it can be inferred that the Hat Creek basin and vicinity represents a concentration of agricultural resources.

D. Government Programmes

A total of seven agricultural research plots are maintained in the local study area. Agriculture Canada manages one, the B.C. Ministry of Environment manages two, and the two agencies together operate four. The plots are utilized for investigating range improvement techniques such as reseeding and weed control, and crop productivities.

A recent Agriculture and Rural Development Agreement between British Columbia and the Federal Government provides for funding in excess of 20 million dollars for province-wide range improvement. No estimates are available of the amount of range that could be improved through implementation of this programme within the local (or regional) study area. Lower grasslands along major river courses, such as the Thompson, Fraser and perhaps the Bonaparte River, would likely respond the most to reseeding efforts.

A preliminary Feasibility Study for Oregon Jack Creek Irrigation Proposals has been conducted by the Water Investigation Branch of the B.C. Ministry of the Environment.[29] It was determined that 474 ha of farmland on the benches of the west side of the Thompson River, between Oregon Jack Creek and Cornwall Creek, could be theoretically developed and irrigated. As presently designed, the proposed irrigation scheme would preclude any expansion of irrigated land immediately downstream of the diversion point on Hat Creek (2-1/2 km south of upper Hat Creek).

(iii) Site-specific Study Area

A. Land Use and Tenure

Land use and tenure patterns of the site-specific study area are portrayed in Fig. 3.4-17, which is a larger-scaled version of Fig. 3.4-14 (discussed with reference to the local study area). The location of irrigated lands (cropland and irrigated pasture), important cattle trails and licensed water diversions can also be observed in Fig. 3.4-17. There are approximately 880 ha of irrigated land within the Hat Creek watershed portion of the area, and 870 ha within the lowlands of the Thompson River. Irrigation is practiced mostly on deeded lands. From inspection of Fig. 3.4-17 it is noted that, on a general level, neither vegetation nor terrain severely restrict grazing use in the site area.

B. Agricultural Land Reserve

The distribution of ALR within the site area is depicted in Fig. 3.4-18. The reserves encompass the bottom lands of the Hat Creek Valley, benches and bottom lands associated with the Thompson River and the high capability rangeland in the vicinity of McLean Lake. Approximately 40 percent of the ALR within the local study area is located within the site-specific study area (the boundaries of which are noted in Fig. 2.4-2, Chapter 2.0).

3.4.6 Cultural Heritage Resources

(a) Phase I Inventory

The survey of 44 quadrats comprising the Phase I target sample provided data on 85 prehistoric cultural heritage resources sites. These sites were located in 22 (50 percent) of the 44 quadrats surveyed; in the grassland stratum 13 (40.6 percent) of the quadrats were "empty" of sites; in the forest stratum, 9 (75 percent) of 12 quadrats were "empty".

The average site density per grassland quadrat is 2.37 or 14.84/km^2. In the forest stratum, an average of 0.75 sites were found per quadrat, or 4.69/km^2. The density of prehistoric cultural heritage resources is three times as great in the grassland stratum as in the forest stratum. The mean density of sites in the Phase I survey is 12.06/km^2.

Three main categories of sites were defined: lithic scatters; cultural depressions and rock cairns. A particular site may have a combination of these site categories. The lithic scatter was the dominant site type recorded in both the grassland and forest strata.

Site size exhibits a considerable degree of variation both within and between the forest and grassland strata. In the forest stratum, site size ranges from 8 to 6240 m^2 and mean site size is 1062 m^2 (standard deviation of 2104). Grassland stratum sites exhibit an even greater size range of from 4 to 9404 m^2. Mean site size is 433 m^2 (standard deviation of 1452). There is a trend toward small sites, 50 percent or more of the sites in each strata are less than 100 m^2 in areal extent; only 7 (8.2 percent) sites are larger than 1000 m^2.

Artifact assemblages also display a trend to low frequencies. The density of artifacts provides a useful index to the nature and extent of activities during site occupation. The major artifact category in the surface assemblages is lithic debitage. In the forest stratum, the density values range from 0 to 16.75/m^2, with a mean of 4.2 items (standard deviation of 4.35). The mean debitage density for the grassland stratum is 2.90/m^2 (standard deviation of 3.73). There is a tendency toward low debitage density values with 44.4 percent of the forest stratum sites and 62.2 percent of the grassland sites having densities of less than 2.25 items per m^2.

Estimates of antiquity of the Phase I sites were possible only through the typological cross-dating of assemblages. Only those sites containing artifact types identified as temporal markers in the archeological literature were considered for antiquity estimates. The antiquity of 56 sites was undetermined due to the presence of only debitage or other temporally undiagnostic materials. The tentative temporal assignments of various sites, or components of multicomponent sites, is presented in Table 3.4-28.

These temporal assignments suggest that Hat Creek Valley has been occupied since at least 7000 years before the present (BP) by persons living within the archeological culture known as the Nesikep Tradition. The remains of the earliest cultural traditions known in the interior of British Columbia, the Old Cordilleran, were not present in the Phase I sample.

The Early Nesikep period, from 7000 to 2800 years BP, is characterized by microcores and microblades fashioned from such cores. Microblades are very small lithic blade implements and microcores are the stones from which the blades were struck. During the Late Nesikep period, from 2800 BP to AD 1700, the established man-land relationship is though to have continued essentially unchanged with emphasis on fishing in the major river valleys and an adaptation to hunting and gathering in a dry forest environment, but without the microtool industry. Within the Late Nesikep, a finer temporal division, the Kamloops Phase (1800 to 1000 BP to the historic period) is set off and recognized, in part, by the presence of the distinctive Kamloops side-notched projectile point. Material from the Early and Late Nesikep periods, including some Kamloops points was recovered during the Phase I survey.

The transfer of archeological cultural-temporal sequences constructed in the main part in major river valleys from work done in pithouse villages to material recovered in surface collections in an upland interior tributary valley, must be viewed with caution. The temporal placements must be considered likely hypotheses to be tested by absolute dating, such as radiocarbon age determinations, or by construction of an independant intra-valley cultural sequence. The latter method would take into account likely differences in patterns and purposes of use of sites and resources in the interior, as compared to sedentary river resource-oriented major river valley sites.

(b) Phase II Inventory

Of the 77 quadrats in Phase II sampling, 39 (50.6 percent) quadrats had no sites. A total of 104 archeological sites were located, three of which were historic sites, 97 prehistoric, and four of which had both historic and prehistoric components. Table 3.4-29 presents the total number of prehistoric and historic sites found per sampling stratum and the density of sites for each stratum. Within the 104 sites, 34 cultural features have been identified, of which 17 are prehistoric, mainly cultural depressions and 17 are historic, including remains of log cabins, irrigation systems, as well as depressions.

Twenty-four sites were gridded and collected totally while 80 sites were transected using the judgemental sampling design. After extrapolating the sizes and numbers of artifacts collected from the partially sampled sites to correspond to information gathered from complete sampling, comparisons among sites and strata could be made.

The average size of lithic scatter sites, the most common site category, was 584.45 m^2 (standard deviation of 1,126.0). Small sites, less than 100 m^2, comprised 37 percent of the total number, and large sites, greater than 1000 m^2, 14 percent of the total number. The mean lithic artifact count and the mean debitage density of each stratum which provide a rough measure of intensity of prehistoric use of the stratum, are presented in Table 3.4-30.

Most of the prehistoric sites could not be assigned a date on the basis of chronologically diagnostic artifacts. Thirty-two prehistoric sites were assigned temporal placements which ranged from Early to Late Nesikep, from 7000 BP to AD 1750, while the temporal placement of 69 sites remain undetermined (Table 3.4-31). Several of the historic sites located have potentially datable artifacts but analyses have yet to be done.

In addition to lithic scatters, other prehistoric sites recorded were two midden strains, recognized by dark organic staining of the present surface and artifact material and 15 cultural depressions.

Using a preliminary analysis of site data and of the material recovered from the first year of Phase II survey, a "clustering algorithm" was employed to group the strata by their similarity. The groupings that emerged correspond to physiological boundaries within the valley, with the Medicine Creek/Harry Lake region containing Strata A, B, C, H; Hat Creek bottom lands containing Strata I, K; and Houth Meadow containing Stratum J.

As previously stated, no refined temporal control of the sites located is currently possible. However, the occurrence of eight out of ten sites with a Late Nesikep component in the Houth Meadow should be noted, especially since sites with an Early Nesikep component occur in all three intra-valley regions.

The Medicine Creek/Harry Lake region is distinguished from the other two regions by the occurrence of small sites with low densities of debitage and a relatively high percent of the assemblage being composed of retouched, that is resharpened or reworked, lithic artifacts. There are also fewer sites per unit of space (except within Stratum B), occupying a smaller percentage of land surface than in the other regions. The sites are more uniform in their characteristics, that is, the variation in site size and artifact counts is smaller than in either the Houth Meadow or Hat Creek bottom lands. More than 80 percent of the artifacts are composed of vitreous basalt. There are few cultural depressions on terraces above creeks and there is a tendency toward locating sites near creeks or ravines (50 percent).

The Hat Creek bottom lands have a much larger variation in site size, both in terms of areal extent and number of artifacts. Sites in this region tend to have rather dense artifact deposition (both by item and by weight) and only 60 to 70 percent of the artifacts are made of vitreous basalt. There are many sites in the region which occupy a large (relative to the Medicine Creek/Harry Lake region) proportion of the land surface. There are no cultural depressions, but one midden stain was recorded. Again, there is a tendency for sites to be located near creeks (51 percent).

Houth Meadow stands out from the other valley regions with its high frequency of cultural depressions and of large sites. The mean density (item/m^2) of artifact deposition is not as high as that for sites in the Hat Creek bottom lands but the upper range of artifact density in Houth Meadow is comparable to any area within the valley. Most of these artifacts (90 percent) are made from vitreous basalt. Ground stone artifacts have been recovered only from Houth Meadow sites.

There are many sites in Houth Meadows and they occupy a proportion of the available land surface twice to several times as large as do the sites in the other two regions. Variation in characteristics among the sites is great. Only one midden stain has been recorded. Several Houth Meadow sites (23 percent) also favour creek-side locations.

Subsurface excavations of cultural depressions reveal a structure similar to that described for earth ovens or roasting pits in ethnographic accounts (shallow depressions filled with rock). The abundance of fire-cracked rock and charcoal are undisputable evidence for burning. Ethnographic analogy suggests that root crops were being processed in these pits, but wapiti bones recovered from one depression suggests also the roasting of large mammals. Analysis of floral samples taken from the excavated depressions will contribute to a definition of their use with radiocarbon dating of samples allowing their temporal placement. Ethnographic analogy also suggests patterns of settlement and resource utilization that can be explanations, to be tested as hypotheses, for the distribution of prehistoric sites and the material within them in the Hat Creek Valley.

The Medicine Creek/Harry Lake region has a site and artifact pattern that suggests sporadic utilization of the resources with occupation events being of brief duration. However, the presence of cultural depressions, if they prove to be earth ovens, suggests also an investment of time and energy indicative of the builders' intent to reuse the facility over some length of time. These two patterns of usage are not mutually exclusive and both may be applicable in explaining the formation of the archaeological record.

Houth Meadow and the Hat Creek bottom lands seem to have been areas of more frequent prehistoric activities which deposited durable items. The large, dense sites in both regions suggests the possibility of extended, perhaps seasonal, periods of settlement. For the Hat Creek bottom lands, the very high artifact densities and the utilization of a small portion of the available area, compared to Houth Meadow, suggest that the sites in the bottom lands were formed by the frequent reoccupation of a favoured but restricted environmental niche, the creek terraces. Both these regions also contain small sites with low artifact densities which can also indicate sporadic utilization of each region.

These interpretations of past settlement patterns and resource utilization are hypotheses to be tested by further analyses, survey and excavation. The interpretations themselves are preliminary speculations on prehistoric behaviour from a model for hunting and gathering subsistence and settlement behaviour and from ethnographic analogy.

3.4.7 Geology

(a) Regional Bedrock Geology

(i) Stratigraphy

The project area, bordered by the Clear Range and the Thompson River Valley, lies principally within the Thompson Plateau of British Columbia. Surficial sediments which are thickest in valleys and form thin veneers on hill tops consist predominantly of alluminum, glacial till, ground moraine and drift. Typically, bedrock is only exposed on the steep flanks of hills or gullys.

Throughout the Cenozoic, mass wasting has been an important phenomena in the upper Hat Creek Valley. A variety of deposits consisting of preglacial volcanic mudflows (lahars), landslides and post-glacial earth flows are evident at the site. West of the No. 1 coal deposit there are inactive slides covering an extensive area between Finney Lake and Houth Meadows. Part of this slide is still active, but it should pose no problem to open-pit operations. Surficial materials are, however, very susceptible to gullying and if the surface layer becomes broken, a fine dust tends to form that resists the rooting of plants.

Bedrock consists of a wide variety of rock units (Fig. 3.4-19). Paleozoic limestones and metavolcanic rocks of the Cache Creek Group form the majority of the subcrop in the central part of the project site area. The clastic sequence of the Kamloops Group in the Hat Creek Valley has been divided into the Coldwater Beds, the Hat Creek Coal Formation, the Medicine Creek Formation and the Finney Lake Beds. The Coldwater Beds reaching thicknesses of 1370 m east of the Hat Creek Valley consist of sandstone, siltstone, claystone, conglomerate and minor coal. The Coldwater Beds are overlain by the Hat Creek Coal Formation (490 m thick) that consists mainly of coal with siltstone and claystone partings, and locally thick sections of siltstone, sandstone, claystone and conglomerate. The Medicine Creek Formation, overlying the Hat Creek Formation, consists of poorly consolidated bentonitic, claystone and siltstone. The sandstone and conglomerate of the Finney Lake Beds overlies the Medicine Creek Formation.

(ii) Coal Geology

The coal formations in the upper Hat Creek Valley are divided into two deposits: the No. 1 deposit at the site of the proposed open pit and the No. 2 deposit located south of Anderson Creek (Fig. 3.4-20). The No. 1 deposit contains approximately 825 Mt of subbituminous coal that can be sub-divided into four discrete zones designated A through D. The top most zone, designated as the A-zone, consists of 180 m of interlayered clean coal, clayey coal and clastic rocks. The zone also has a large number of partings and many seams with high inherent ash. Whereas the base of the A-zone is predominantly waste, the average for the entire zone is approximately 20 percent.

The B-zone is predominantly coal 75 m thick with few partings and moderate inherent ash content. Approximately 2 percent of the B-zone is waste. The C-zone is 60 to 110 m thick and is approximately 33 percent waste. The lowest zone, the D-zone, is 60 to 110 m thick and contains the highest grade of coal in the entire deposit. This zone is the most uniformly consistent throughout with just 3 percent waste. In all four zones, the inherent ash and the frequency and thickness of partings increases toward the west. The No. 2 deposit may contain more than 3.1 Gt of coal. This deposit will not be affected by open pit operations.

(iii) Structural Geology

The Hat Creek coal deposit lies in a Tertiary sedimentary basin situated within the Cordilleran Mountain Chain of British Columbia. The basin is one of three within the province located in a similar tectonic environment, the others being the Merritt and Similkameen coal fields.

The Canadian Cordillera consists of two intensely deformed zones, the Eastern and Western Cordillera separated by a heterogeneous, although relatively slightly deformed, interior zone.[31]

The Hat Creek area lies near the west limit of the interior zone which has also been included with the Eastern Cordillera and considered as the Columbian fold belt.[32] The Fraser Fault Zone, trending north-northwest just east of Lillooet, forms the eastern boundary of the Western Cordillera in the area under consideration.

In the Hat Creek area the strong deformation of the Western Cordillera near the Fraser Fault contrasts markedly with the weaker deformation of the Columbian fold belt. Relatively undisturbed Tertiary and Quaternary volcanic rocks overlie the older folded and faulted rocks. During the period when these materials were extruded the whole area was subjected to block and transcurrent faulting resulting from the northwestward movement of segments of the lithospheric plate to the west of the Cordillera.

The regional trend of the structures within the Cordillera are to the northwest and the Hat Creek area conforms to this pattern, although the Fraser Fault Zone at nearby Lillooet has a more northerly trend locally. Some post-Pleistocene tectonic activity has been recorded within the Western Cordillera, but to date, none has been recorded along the Fraser Fault Zone or in the Hat Creek area which is generally regarded as being relatively stable.

Although the geologic structure of the two coal deposits within the upper Hat Creek Valley appear to differ, they are only different parts of the same overall structure within the coal basin. In the No. 1 deposit the structure consists of a syncline flanked on the east by a faulted anticline with an additional syncline further east. The No. 2

deposit is located on the eastern flank of the principal syncline which plunges approximately 15 to 20 degrees to the south. The folds of the coal basin are complicated by transcurrent and normal faults that have displacements of as much as 550 m.

(vi) Seismicity

The Hat Creek Project is located in the Interior Plateau near the eastern margin of the Coast Range. The former physiographic region, in the area of Hat Creek, is classed as a Zone 1 seismic risk based on the Seismic Zoning Map of Canada[4]. The latter region is classed as Zone 2 seismic risk. Between 1899 and 1974 ten earthquakes of Modified Mercalli Intensity II or more have been felt at the site. The largest intensity was 0.02 g; this effect resulted from a 1946 earthquake of magnitude 7.3, with its epicenter in the Georgia Strait near Powell River.

None of the faults in the Hat Creek area are known to be active (Fig. 3.4-19). The nearest fault where significant post-Pleistocene movement has been recorded in the Yalakom Fault Zone, a branch of the Fraser Fault System extending northwestward from Lillooet. A deep-seated displacement measuring 5.0 on the Richter scale was recorded near Relay Mountain in 1926. The main Fraser River Fault System is considered to have been inactive since the Tertiary.

Based on the limited data available, the Dominion Observatory in Victoria has concluded that the maximum acceleration of an earthquake that would probably occur within a return period of 100 years is 0.017 g. It is concluded from this data that the Hat Creek area is a minor seismic risk.

(b) Economic Geology

The potentially exploitable natural resources of the site area were surveyed to provide an inventory of economic resources that may be affected by the project. In projects that require the mining of a fuel source within the site boundaries, resources in addition to fuel may be sterilized by the mining operations.

(i) Fossil Fuels

Other than coal, no additional fossil fuels have been found in the site area. Detailed investigations have confirmed the existence of substantial coal reserves that underlie most of the upper Hat Creek Valley. The two major deposits shown on Fig. 3.4-20 contain approximately 3925 Mt of coal having an average heating value of 16 770 kJ/kg, an average ash content of 37.4 percent, and a fixed carbon content of 30.2 percent. In addition to this, there are large quantities of low-grade coal and carboniferous rocks. Coal waste, that portion of the coal formation having ash content ranging between 69 percent and 79 percent, is also considered a potential resource as it can be blended with the better quality coal for use in fluidized bed combustion systems.

(ii) Minerals

Although confirmed mineral deposits of chromium, gold, copper, silver, molybdenum and epsomite exist within the site area in addition to other unexploited mineral claims, only those resources in the immediate vicinity of the project complex need be considered. Several minor chromite deposits near Cache Creek include the Cache Creek and Cornwall Creek showing (Fig. 3.4-20). The host rocks for these two ore deposits are serpentinite and a diorite stock intruded by small serpentinite plutons. Although these two localities contain a variety of minerals such as chromite, pyrrhotite, limonite, chalcopyrite, chalcocite and garnierite, the mineralization is not of economic interest.

Several mineral claims are recorded within the site area. Of the existing claims within the site area, little published information is available, however, geophysical and/or field surveys conducted as part of the Hat Creek site investigation suggest that no significant mineralization is evident at these localities. Although the geological environment in the site area suggests a potential for base metal mineralization, no evidence of significant ore deposits has been found in the areas proposed for project facilities.

(iii) Rocks

Rock resources within the site area consist of currently exploited deposits of limestone, sand and gravel, as well as, potentially exploitable deposits of claystone and baked claystone that underlie much of the upper Hat Creek Valley. Of the large limestone resources of the region, only a small portion lies within the site area (Fig. 3.4-19). The outcrop of the Marble Canyon Formation in Houth Meadows is the only economically recoverable deposit that will be directly affected by the Hat Creek Project. The limestone north and west of the Houth Meadows waste disposal site is grey, or white, and is finely crystalline and locally brecciated. Samples from four areas within the deposit have an average $CaCO_3$ content of 95.7 percent. Limestone of the quality is probably acceptable for use in cement, mortar, agricultural lime, industrial waste treatment, animal feed, sulphite pulp manufacture, hypochlorite bleach manufacture and water treatment. Economically accessible deposits estimated at 350 Mt lie above the valley floor in Houth Meadows.

The five currently exploited sources of sand and gravel aggregate within the site area are shown on Fig. 3.4-20. The two quarries at Boston Flats produce approximately 5000 t of aggregate per year and the reserves within the east bench at Hat Creek total more than 6.5 Mt. In addition, appreciable amounts of unexploited aggregate deposits of undetermined size are located within the upper Hat Creek and Thompson River valleys. Allumium and colluvium that comprise the river terraces, alluvial fans and glacial landforms are the source of these deposits. Samples collected from the Hat Creek deposit indicate that the aggregate is acceptable for most uses.

Unlithified claystone and siltstone attain appreciable thicknesses within the Medicine Creek and Hat Creek coal formations that underlie approximately 109 km^2 of the upper Hat Creek Valley. Additionally, baked claystone may overlie most of the coal resources in the same area. Bentonite stone may overlie most of the coal resources in the same area. Bentonite and kaolinite are the two clay minerals of potential economic value in the claystone deposits. Precise information on the distribution and chemistry of these two minerals precludes, at this time, a determination of their possible economic uses. However, the properties of these deposits may be suitable as a source of alumina used in the manufacture of aluminum.

The baked claystone deposits, formed as a result of a natural coal fire, are estimated to be in excess of 16 Mt. This material consists of red, orange and yellow, brick-like, baked clay and isolated pockets of grey clinker and is currently being evaluated for its suitability for brick manufacture. It has already proven valuable in road construction and maintenance.

3.5 SOCIO-ECONOMICS

3.5.1 Introduction

The socio-economic resource inventory was undertaken in the areas defined below. These regions contain the important economic and social communities and resource areas that would be subject to potential impact by the Hat Creek Project.

The proposed Hat Creek region is defined by an area bounded on the north by an east-west line through 70 Mile House, on the south by an east-west line drawn through a point 8 miles south of Lytton, on the west by a north-south line through the west end of Seton Lake and on the east by a north-south line through the eastern boundary of Kamloops. In this report the area is referred to as the Hat Creek region, the study region or simply the region. The region is shown in Fig. 3.5-1.

In addition, a second area has been defined as a subset of the region within which the majority of the potential land use and population induced project impacts will occur. This area is bounded by 70 Mile House to the north, Lillooet to the west, an east-west line 20 miles south of Ashcroft to the south and Walhachin to the east. This area is termed the local study area or the local area. It is also illustrated in Fig. 3.5-1.

3.5.2 Population, Income and Employment

(a) Population

(i) Growth Characteristics

The overall population of the Hat Creek region attained a level of 77 300 persons in 1976. Table 3.5-1 provides 1966 to 1976 population statistics for the Hat Creek region and local areas. Although the region has been one of the faster growing areas of the province during the last decade, growth appears to be moving more in line with that of the province as a whole during recent years; i.e. 2.5 percent.

Kamloops, B.C.'s third largest city, with a current population of 58 300 and the major distribution centre for the region, has been the major focal point of growth in the region. Kamloops' growth has corresponded with the level of forest and mineral exploitation in the surrounding hinterland. Although primary industry development has been the basis of Kamloops' expansion, the tertiary and quarternary sectors have become the leading employment sectors. The area also supports a large beef ranching economy with major ranching enterprises and numerous small, often marginal, operations.

Since the early 1970s, both Ashcroft and Cache Creek have experienced a slow growth in population with the two communities increasing by only 5.1 percent during the last 5 years. The sharply curtailed growth in traffic volumes on the Trans-Canada Highway during recent years has been the limiting factor in the case of Cache Creek. Ashcroft's growth was undoubtedly slowed by the decision of Lornex Mines to build the "instant community" of Logan Lake.

Clinton has been experiencing steady population declines since 1966 as a result of forest industry rationalization throughout the area. A close utilization cutting policy has resulted in the demise of small sawmills and the reduction in employment opportunities.

The population of Lillooet, stimulated by the location of a large mill nearby, grew from 1514 in 1971 to a level of 2220 in 1976. The rural population has shown some expansion during the period, but this has been mainly around the fringes of the communities.

(ii) Migration Characteristics

The population of the Hat Creek region is relatively transitory. In-migration has been the primary labour supply source for maintaining the industrial and commercial expansion of the last decade. In 1971, about 43.5 percent of the regional population were in-migrants of the preceeding 5 years. Table 3.5-2 reveals that most persons were migrating from other areas of British Columbia. Inter-provincial migrants accounted for 24.8 percent of all in-migrants, mainly from the prairie provinces and Ontario.

Within the local study area, Ashcroft and Cache Creek have a very high proportion of recent in-migration residents, explaining their rapid population increases during the 1960s. Clinton and Lillooet, more stable communities during that period, show a commensurately higher proportion of long-standing residents.

Among respondents reporting their former residential origin in the Hat Creek Resident Survey, the majority resided in either the Lower Mainland or other areas of interior British Columbia. Over half of the population came from urban centres and about 30 percent from rural areas. Only 9 percent came from other small town environments. The survey also indicated that over two-thirds of the local area's residents had lived in the area for more than 5 years, reflecting the low population growth since 1971 and, likely, the relatively low labour turnover at the Bethlehem and Lornex mines.

3.5 SOCIO-ECONOMICS - (Cont'd)

(iii) Age/Sex Distribution

The regional composition, largely as a result of the influence of Kamloops, is very similar to the province as a whole. However, with the exception of Cache Creek, the local communities contain a significant male bias. Nearly 60 percent of the regional population is below 29 years of age, compared to the provincial average of 53 percent. Also, the proportion of seniors in the region is only 4.9 percent compared to 9.4 percent in the overall province. All communities contain a large male and female population in the 0 to 14 age grouping. A small percentage of the population of Ashcroft and Cache Creek is over 60 years of age, in comparison with both the region and province.

(iv) Family and Household Composition

The average number of children per family in all communities is 1.8, in comparison with the provincial average of 1.6. Average household sizes are larger in the region than the province with 3.6 persons per household as compared to 3.2 persons in the province as a whole.

In comparison to the province, Ashcroft, Cache Creek and Clinton have significantly larger percentages of their populations with five and six individuals per household. Clinton has over double the proportion of households with more than six persons than the provincial average. When compared with the province, all communities within the study area also indicate substantially fewer one-person households.

(v) Marital Status

In the overall region, approximately two-thirds of the population 15 years and over are married, 26.4 percent are single and 6.9 percent are divorced, separated or widowed. This compares very closely with the figures for British Columbia. Ashcroft and Clinton have a relatively high percentage of married persons. The rural areas support the highest proportion of singles, while Ashcroft and Cache Creek contain a high proportion of divorced, separated or widowed persons.

(vi) Education Levels

In general, educational achievement levels are lower in the region than in the province as a whole. A significantly higher proportion of the regional population has attained less than Grade 8, while a lower proportion has obtained Grade 12 or post-secondary education. Ashcroft and Cache Creek show an exceptionally high proportion of individuals achieving Grade 9 to Grade 11 levels, while the Clinton population shows a high percentage of persons with very low and very high educational achievement. It appears that females have a higher level of schooling than men in the region.

(vii) Ethnic Composition

The dominant cultural group is of British origin accounting for over 54 percent of the population. Other ethnic groups and their percent include: German - 9.6; French - 5.4; Scandinavian - 5.3; Native - 4.1. The remaining population denotes a highly diversified cultural ancestry.

(b) Income Characteristics

(i) Total Income

Total income for the Hat Creek region is reported at $177.2 million for 1970 and is estimated at $453.7 million for 1976. In the local study area, total income is reported at $17.8 million for 1970 and is estimated at $42.0 million for 1976. Per capita levels are estimated at $5830 and $5604 for the region and the local area, respectively, in 1976.

The major sources of income among the local study area, the total Hat Creek region, and the province as a whole are compared in Table 3.5-3. The data indicate that both the local area and the region generate a higher proportion of their income through employment than is the case provincially. Self-employment income is significantly higher in the region, particularly in the local area.

(ii) Household Income

Average household income is shown in Table 3.5-4. The region's household income level is about 7 percent lower than the province as a whole. Although levels in Ashcroft are well above the regional average, all other communities are below. Cache Creek has a household income level slightly below the regional average in spite of very high participation rates. Clinton, Lillooet and the rural areas exhibit relatively low participation rates with a high proportion of low payment employment in their occupational mix.

In order to obtain an index of economic well-being, dependency rates are compared with average household income in Table 3.5-4. This indicator reveals an inverse relationship between the dependency rate and the level of income, suggesting that the real economic disparity between higher and lower income areas is greater than that indicated by the average income figure alone. This is particularly applicable to Clinton and Lillooet.

Clinton, Lillooet and the local rural areas have below average household incomes and have a higher than average number of households with incomes below the defined poverty line of $5000. However, Kamloops, which had an average household income 4 percentage points above the regional average, also had a high proportion (21 percent) of households that received less than $5000 in 1970.

(iii) Industrial Earnings

The character and relative stage of development of the local study area in comparison to the region as a whole is typified by Table 3.5-5.

The primary sectors contribute more than one-quarter of the income generated in the local area while they account for slightly more than 10 percent of total regional income. The more balanced economy of the overall region is relatively strong in the manufacturing, construction, transportation and trade sectors.

Average earning levels are generally highest in the mining, forestry and construction sectors. Average weekly earnings in British Columbia by industry are shown in Table 3.5-6. It would appear that average industrial earnings are 8.0 percent higher in Vancouver than in Kamloops, but the difference is steadily narrowing (Table 3.5-7).

(iv) Income Distribution

The distribution of employment income in the local area, and the overall study region is compared to that for British Columbia in Table 3.5-8. The distribution of employment income indicates that a slightly greater percentage of employed persons in the local area have incomes in the upper classes than is the case for the total region or the province as a whole. In contrast, income distribution in Table 3.5-4 shows a low percentage of households in the local area having household incomes in the upper income categories.

(c) *Labour Force and Employment*

(i) Growth Characteristics

The region's labour force has been growing at an average annual rate of 6.5 percent over the decade, reaching an estimated level of 33 600 persons in 1976. Changes in male and female labour force are shown in Table 3.5-9.

Employment expansion during the 1960s and early 1970s covered a broad front of forestry, mining, transportation, government and service industries. Rapid in-migration provided the bulk of the labour force for these developments but, in spite of this inflow, employment growth has generally exceeded labour force increases. Unemployment rates have generally exceeded labour force increases. Unemployment rates have generally been 1 or 2 percentage points below that experienced for the province as a whole.

The local study area contains an estimated 1976 labour force of 3450 persons, representing an average annual growth over the past 10 years of 5.1 percent. The industrial composition of the regional labour force is compared with British Columbia's labour force in Table 3.5-10. The regional labour force is concentrated in the mining, construction and transportation and service sectors. The Highland Valley and Merritt areas contribute the majority of mining industry opportunities and further developments will ensure the continued importance of mining to the region's industrial employment base.

Kamloops is the transportation centre of the Southern Interior and a popular residential centre for some of the trades in the provincial industrial construction labour force. Kamloops has a reasonably diversified retail sector and it attracts major branch administrative services of government and private industry.

The manufacturing sector in the region, while a significant employer, is a substantially smaller contributor to overall regional employment than it is in the province as a whole. Manufacturing that does exist is heavily dominated by wood processing in which the economics of production require proximity between the resource and the processing facility.

With respect to the industrial composition of the local study area, about 20 percent of the industrial labour force is occupied in the primary sector compared to slightly less than 10 percent in the overall Hat Creek region. Community business and personal services represent the largest employment group and, within this sector, food and accommodation employment is dominant.

Logging and sawmilling activity is oriented towards Clinton and Lillooet. The former community is heavily dependent upon sawmill employment. A major mill at Lillooet employs about 20 percent of that community's labour force. However, B.C. Rail and Department of Highways crews are also major employers providing a more balanced economic base than that which exists in Clinton.

Mining has been a major contributor to the growth of the area, particularly in Ashcroft and Cache Creek. Bethlehem and Lornex mines have a combined labour force of about 1050 persons. Ashcroft houses about 265 Bethlehem employees. About 70 Lornex workers reside in Ashcroft and Cache Creek. Mining developments have contributed indirectly to the area's economy through their purchases of local services.

Cattle ranching is the primary economic activity of the rural residents in the local study area. Agriculture employs only 2.5 percent of the regional and provincial labour force in comparison with 5.1 percent of the local area labour force. About 145 persons are engaged in ranching locally, mostly on a permanent basis.

The major non-primary resource contributor to the area's employment is the servicing of tourist and commercial highway traffic. Cache Creek is almost totally dependent on this sector. These industries also comprise a major, although less critical, component of the Clinton economy.

Labour turnover problems in the region's resource sector appear to be minimal, in sharp contrast to the more isolated parts of the Interior. There is, however, a high rate of turnover in the service sector for those jobs that are low paying, seasonal and typically filled by young females.

Most of the supply difficulties occur in the skilled trades required by the resource industries. Heavy duty mechanics, electricians, millwrights, welders and instrument men are generally in short supply.

The age distribution of the regional labour force suggests a pattern typical of resource hinterland areas. Table 3.5-11 indicates that 72.2 percent of the regional labour force is under 44 years of age, compared to 67.2 percent for the province as a whole. The youthful bias occurs mainly in the 25 to 44-year age category, a factor which tends to be reinforced by in-migration.

Table 3.5-11 indicates that the local study area exhibits even higher participation rates than the overall region in both male and female categories. Ashcroft and Cache Creek have extremely high male participation while Clinton and Cache Creek show unusually high female participation.

Marriage tends to significantly lower female participation. This fact is not unique to the region and is generally considered to result from a combination of the preference for non-employment among married women, a lack of suitable employment opportunities, insufficient day care facilities and a lack of appropriate job skills. Involvement in non-traditional occupations, however, is relatively limited.

(ii) Construction Labour Supply

The resident construction labour force in the region is estimated at about 3750 persons in 1976. The most recent available estimates of construction labour supply by trade are presented in Table 3.5-12.

Almost 65 percent of the regional construction work force is unionized and over 75 percent of these members are employed in four trade categories: general labourers, equipment operators, carpenters and electrical workers. All of these trades are represented by unions having regional dispatch jurisdiction for projects in the central part of the province.

For the most part the unionized construction workers are highly mobile, e.g. about 500 members are currently working in Alberta and many are expected to return to the Kamloops area over the next year. The non-unionized construction labour force is less mobile and is primarily occupied in local housing and commercial construction.

The local study area has a resident construction labour force of about 250 persons. Of this total, union officials estimate that there are about 140 construction trade union members: labourers - 40; operating engineers - 40; carpenters - 35; teamsters - 15; plumbers and pipefitters - 5; and electrical workers - 5. The skill categories of the remaining 110 construction workers are unknown, however, it is likely that they are primarily in the semi-skilled trades as reflected by the non-union labour force for the overall region.

(iii) Unemployment

A. Rates and Characteristics of the Unemployed

Unemployment rates in the region are reported to be generally 1 to 2 percentage points below the seasonally adjusted provincial rates. The number of unemployed persons in the total Hat Creek region claiming Unemployment Insurance benefits as of April 28, 1977 is shown in Table 3.5-13. It would appear that the female labour force is experiencing proportionately higher rates of unemployment than males. Unemployment is highest in the traditional female occupations of sales, service and clerical. Regional unemployment in the male labour force is highest in the construction and primary industries. Over 40 percent of the male Unemployment Insurance Commission claimants are occupied in these industries. There are about 990 unemployed male construction workers in the region representing over 26 percent of the construction labour force.

Unemployment rates, as reflected by UIC data, are highest among the youth of the region. Nearly 25 percent of male UIC claimants are between the age of 20 and 24 while this group accounts for only 14 percent of the labour force. Among female participants, both the 20 to 24 and 25 to 34 age groups show disproportionately high unemployment.

In the local Hat Creek area there were 370 persons unemployed as of April 28, 1977, representing about 10 percent of the local labour force. Table 3.5-13 indicates that a similar unemployment pattern by industry to that previously discussed for the region exists in the local area.

B. Seasonal, Cyclical and Structural Aspects of Unemployment

The regional economy's direct and indirect dependency on forestry, agriculture, construction and tourism activity is the prime cause of seasonal unemployment. In addition, a portion of the labour force prefers only to work at certain times of the year. Seasonality is generally more evident in the female than the male labour force.

The structural character of the regional economy also makes it vulnerable to cyclical disturbances. Construction cycles and related fluctuations in lumber demand result in significant variations in regional employment levels. The mining industry, although continually faced with widely fluctuating metal prices, experiences less employment variation than forestry.

Clinton provides an example of a community that has recently suffered the effects of structural unemployment resulting from technological change introduced by the provincial close utilization timber harvesting policy. Unemployment as a result of inadequate educational and vocational skills is also reported to be an important factor in the unemployment situation in the area.[1]

C. Specific Unemployment Concerns

Women

Only 41.6 percent of the women in the region participated in the labour force during 1971, compared to 80.2 percent of men (see Section 3.5.2(c)). In British Columbia as a whole, the growth in female participation has been increasing much more rapidly than for males over the last 15 years.

Adjustments are occurring both in the attitudes of some employers and the attitudes of society at large in accepting the desires of women to pursue employment goals commensurate with their ambitions and capabilities, as well as providing the social institutions necessary to permit the combining of family and employment goals. Women in the Hat Creek region constitute a large potential labour pool. Approximately 65 percent of the women not currently in the labour force have previous work experience.[2]

High School Students

The problems of employment for school dropouts centre on their lack of employment experience and possibly their attitudes towards work. The regional population is generally younger than in other areas of the province, particularly in Kamloops and Cache Creek.

This extensive group, age 15 to 19, represents approximately 10 percent of the regional population and, therefore, should be developed as a potential source of labour and as an investment in the future of the region. This group must also be looked at in terms of the problems which can result if they "drop out" of the education system before completion to take up employment.

Underemployment

Within the Hat Creek region, underemployment no doubt exists. Some women, for example, who are willing to work full time are only able to find part time employment or are only able to work part time due to the absence of adequate child care facilities in the community. The extensiveness of this phenomenon in the region is unknown.

(iv) Existing Training and Retraining Programmes

A. Regional Training Programme Overview

For the purposes of this study, four types of training programmes have been identified: on-the-job training; pre-apprenticeship programmes; apprenticeship programmes; and special programmes. This range of programmes is intended to prepare individuals for employment in the various construction and operating occupations in B.C.

The majority of semi-skilled and skilled trades have apprenticeship programmes which are a mixture of on-the-job training and institutional training. These skilled pre-apprenticeship, apprenticeship and special programmes are sponsored jointly by the Ministries of Education and Labour, Government of British Columbia.

The institutional component of these programmes is offered through the provincial community college systems. The institutions that offer these programmes and will be particularly applicable to this study are:

Cariboo Community College, Kamloops
Okanagan Community College, Kelowna
British Columbia Vocational School, Burnaby (BCVS)
British Columbia Institute of Technology (BCIT), Burnaby
British Columbia Mining School, Rossland

All underground and open pit mining programmes are offered through the B.C. Mining School at Rossland. These programmes are outlined in more detail in the Socio-economic Report.[1]

3.5.3 Land Use

A 1:100 000 scale map showing land use classifications within an approximate 25 km radius of the Hat Creek Project is presented in Fig. 3.5-2. The categories are based upon provincial CLI mappings and are shown in detail in Table 3.5-14.

As can be seen from the land use map, the dominant land cover in the local area is forest (about 75 percent), and a significant portion of this land is used dually for livestock grazing (as indicated by the TK category). The forest land is almost wholly owned by the Crown, with permits for grazing issued to local ranches by the British Columbia Forest Service (Kamloops District). Mature forest represents about 50 percent of the forest cover, with non-commercial forest amounting to only 0.2 percent. The predominant tree species in the "productive" category are Douglas-fir, lodgepole pine, and spruce occurring in pure and mixed stands. Activities associated with the forest industry such as sawmills and plywood plants are all located outside of the 25 km radius.

About 2 percent of the land within the local area is in the improved pastureland category. These lands are found along the two major river valleys, and the Hat Creek Valley. They are used primarily to grow alfalfa and other forage and feed crops. Although limited by topography and moisture deficiencies, this category of land use has expanded significantly since the original inventory mappings were prepared by the CLI in 1967.

The land use categorized as "built-up areas" consists of several small towns and their associated residential, commercial and industrial developments. The villages of Ashcroft, Lillooet, and Cache Creek have exhibited the most significant growth in this category over the past 10 years. Land use patterns in Ashcroft (1976 population, 2030), typical of small older communities, consist of a well-defined commercial core surrounded by residential and industrial uses. However, the town has a number of constraints which could prevent extensive further development: the Thompson River, which curves through

3.5 SOCIO-ECONOMICS - (Cont'd)

the village, and therefore borders it on the southwest and northeast; topographic constraints in the form of high land gradients; an Indian Reserve on the west; and the agricultural land reserve (ALR). ALR lands exist within the municipal boundaries, but because of their high capability when irrigated (Class 1), it is likely that no urban development will be permitted on these properties unless no alternate development areas are available.

The dominant land use features in the Village of Cache Creek (1976 population, 1050) are two highways and the adjacent highway commercial service establishments. Expansion of residential uses are constrained by topography and the ALR. However, the ALR may not prove to be a major constraint because the agricultural capability of the reserved land is not very high, and urban development has been authorized in the past by the British Columbia Land Commission. Within the topographic constraints, small parcels of land are available for residential development and limited commercial and light industrial development.

Other important land uses in the local area in addition to forestry, agriculture and "built-up" categories are mining and recreation. There are approximately 18 known extractive operations within 25 km radius of the project site. Of these, five are gravel or sand quarries, three are chromium mines, two are copper and silver mines, and two are coal deposits (Hat Creek No. 1 and 2). There is also one gold mine and one limestone quarry. The minerals extracted from the four remaining operations are unknown.

Within a 25 km radius are three provincial parks, the nearest of which is Marble Canyon Park (shown in Fig. 3.5-2), located south of Pavilion Lake. The park encompasses approximately 827 acres and offers camping facilities. In 1976, there was an approximate total of 2100 campground party nights at the park.[4] The number of day users is unavailable. Near the park are approximately 24 privately-owned recreational cottages on the east side of Pavilion lake. These are used primarily in the summer months and possibly during the hunting season. The other parks are Cayoosh Park, on the Fraser River near Lillooet and Downing Park, at Kelly Lake to the southwest of Clinton.

3.5.4 Housing

(a) Ashcroft

The existing stocks of single and two family homes, multi-family, and mobile homes consist of 480, 180 and 105 units respectively. With a 1976 census population of 2005, the average household size is 2.62.

Vacancy rates have been very low. As of February 1977, there were approximately 10 dwelling units, (single or two family) on stream, with definite plans for another 10 to 15 units to be constructed in 1977. The majority of homes planned or being built, are believed to be built for speculation. In the short run, the limited availability or supply of serviced lots presents a constraint to further construction.

Three companies in Ashcroft and Cache Creek estimated that they could build 100 to 120 dwelling units per year given sufficient demand with their current staff; by increasing their staff levels, this output could be increased significantly. If the demand for housing increased significantly, builders and developers from Kamloops would very likely move into the area, providing competition for the smaller local firms.

Vacant serviced lots have been marketing at prices in the order of $10,000 to $12,000. An average price for a typical 112 m^2 three bedroom bungalow is $47,000 to $50,000.

Ashcroft and Cache Creek are serviced by three banks and a credit union capable of writing residential mortgages; these hold most of the residential mortgages. Current head office lending policies and lead time for the bank to prepare for unusually high mortgage demands affect the availability of funds.

(b) Cache Creek

The existing stock of single and two family, multi-family, and mobile homes consists of 170, 60 and 112 units respectively.

As in Ashcroft, vacancy rates in Cache Creek have been very low. New residential construction activity is concentrated in the Battel Subdivision in East Cache Creek. Construction plans for 1977 indicate that the majority of 30 additional dwelling to be built will be done on a speculative basis. The estimated output of the local companies operating at full capacity is 100 to 120 additional dwellings units per year.

Prices of serviced lots and housing in Cache Creek are very similar to those found in Ashcroft. Construction costs are generally equivalent to those in Kamloops. The comments on financing capabilities pertaining to Ashcroft are equally applicable to Cache Creek.

(c) Clinton

The existing stocks of single and two family homes, multi-family, and mobile homes consist of 220, 20 and 41 units, respectively. With a current population of 806, the average household size is 2.87.

Vacancy rates in Clinton are somewhat higher than in Cache Creek or Ashcroft As of February 1977, there were no houses being constructed, and there was no evidence of any new units definitely planned for 1977.

Prices of lots and housing are significantly lower than in Cache Creek or Ashcroft. Some serviced lots are selling at $4500 and a 112 m^2 three bedroom bungalow would be priced at approximately $35,000.

Clinton, serviced by the Bank of Montreal, faces the same constraints to residential financing as Ashcroft. Approximately 100 to 150 units could probably be financed locally in Clinton without serious bottlenecks.

(d) Lillooet - including Lillooet Riverside Improvement District

The existing stocks of single and two family homes, multi-family, and mobile homes consist of 490, 52 and 175 units, respectively. With a current population of 2185, the average household size is 3.05.

Vacancy rates have been low, both in single and multi-family dwellings. Approximately 20 to 30 dwelling units were under construction as of February 1977. No information is available regarding the number of additional units planned for 1977.

Prices for serviced lots range from $10,000 to $12,000. The typical 112 m^2 three bedroom bungalow would command a price of $48,000 to $55,000.

3.5.5 Services

(a) Education

The service study area is located within the boundaries of School District 30 (South Cariboo). During the academic year 1976-77, School District 30 had a total of 11 schools in operation and had an enrollment of 2137 students.

Within the service study area and located in Ashcroft, Cache Creek and Clinton there were six schools in operation during the 1976-77 academic year with a total enrollment of 1598 students. Table 3.5-15 contains data with respect to these schools.

(i) Elementary Education

Ashcroft Elementary was built in 1965 with additions in subsequent years. The school has a large activity room, a well-stocked library and outdoor facilities.

Although Coppervale Elementary is the oldest school facility in the study area, it has recently been rebuilt and fireproofed. The school has a full-sized gymnasium with a stage, well-equipped library and outdoor facilities.

Cache Creek Elementary has a large activity room and a well-stocked library. On the school site, there is a small building adjacent to the school that serves as a music room for band and choir practice. Recreation facilities are located on the school grounds. The Clinton Elementary School, which is approximately 10 years old, has a gymnasium, a library and outside facilities.

Between 1967 and 1973 the total enrollment in the elementary schools in the study area had reached 1170, a 38.1 percent increase. From 1974 to 1976, it decreased to 921 elementary students (15.9 percent decrease).

(ii) Secondary Education

In the study area, secondary school classes from Grade 8 to 12 are provided in Ashcroft, and Grade 8 to 10 in Clinton.

Ashcroft Secondary School, in its fourth year of operation in the 1976-77 academic year, had a student population of 573 in 26 classrooms. The school can accommodate 595 students and should have reached its full capacity by the 1977-78 school year.

The school has a well-equipped gymnasium, a multi-purpose room, cafeteria, workshops, an art room, two home economics rooms and outdoor recreation facilities.

Ashcroft Secondary School has an active extra-curricular sports programme and its facilities are used for community recreation clubs and continuing education programmes.

David Stoddard Junior Secondary School in Clinton has an enrollment of 104 students in nine classes. Included in the facility are a gymnasium with a stage, an industrial education room, a home economics room, a typing room, a science room and outside facilities.

The gymnasium in the Clinton Secondary School is used by community groups, and after school hours for extra-curricular sports events. Continuing education classes were held at the school in previous years, but were cancelled in 1976 because of lack of demand.

Since 1967 secondary school enrollment has been increasing by approximately 10 percent each year, reaching a total enrollment of 677 students in October of 1976. As with the elementary schools, there were no plans to change or add any secondary school facilities in the study area. The school board operates a total of 19 school buses throughout the district. The maximum distance travelled by any student is 30 miles one way.

The breakdown for the 1976 budget for School District 30 is given below:[5]

Total operating expenses	$3,679,003
Total non-operating expenses	217,456
Total debt services and capital costs	720,779
Gross total budgeted expenditures	$4,617,238

School districts in B.C. have two major sources of revenue: local property taxation and provincial government grants. For School District 30, provincial grants cover 47.94 percent of the total net budget and local assessments cover 52.05 percent of the net budget.[6]

(iii) Continuing Education

Cariboo College in Kamloops offers continuing education courses in the South Cariboo region. In the year ending June 30, 1977, a total of 42 courses were offered in the South Cariboo region, with a total enrollment of 446 people. Continuing education courses are provided in cooperation with School District 30, and use existing school facilities in Ashcroft, Cache Creek, Clinton and Lytton.

3.5 SOCIO-ECONOMICS - (Cont'd)

(iv) Standards for Education Services System

Information regarding standards for education services can be obtained from Resource Planning Unit, ELUC Secretariat, Province of B.C. in their publication entitled "Provincial Service Requirements and Costs for Proposed Community" which was prepared for Townsite Sub-Committee, September 1976.

(v) Resident Comments on Existing Education Service in Study Area

Residents interviewed in the Hat Creek and area resident survey expressed general satisfaction with the education services in the study area. Those expressing the most satisfaction were households in Ashcroft; Cache Creek and Hat Creek Valley residents were generally satisfied; and Clinton residents were split on their rating of schools with a greater proportion dissatisfied.

(b) Health

(i) Hospital

The Ashcroft and District General Hospital provides a full range of hospital services, including minor general surgery. Any major surgery, orthopedics, or serious burns are taken to Kamloops or Vancouver. Of the 41 beds in the hospital, 33 are used for acute care patients, and eight are used for extended care patients.

Admissions to the hospital have been decreasing steadily over the past 5 years. Average occupancy for Ashcroft has decreased from 49.4 percent in 1974 to 46.2 percent in 1976.

Given the 70 percent occupancy rate suggested by the B.C. Ministry of Health,[7] Ashcroft Hospital could support a patient-day volume of approximately 9000 to 10 000 days; the hospital's 1976 patient-day volume was 6057 days. Based on the 1976 population of 5280 for the service study area, the Ashcroft hospital provides 6.25 beds per 1000 population.

In 1976, the hospital had a staff of 50 that included the hospital administrator and nine department heads.[8] A pathologist from Kamloops visits the hospital regularly. The hospital also has two women's auxiliaries and a group of volunteer teenagers.

The 1976 operating budget for the hospital was $932,809[8] based on a per diem rate of funding and is met almost entirely by provincial grants. In 1977, the Thompson-Nicola Regional District approved $8000 for capital expenditures.

In Ashcroft, the ambulance unit has two ambulances, one full-time employee and volunteer staff. The Clinton ambulance unit began service in early 1977 and has one ambulance that is operated by volunteer staff. The rescue unit of the Ashcroft Fire Department also serves as an ambulance unit.

(ii) Medical and Dental

There are three physicians in Ashcroft, and one physician in Clinton serving approximately 5280 people. Based on discussions with physicians in the service study area, the number of physicians appears to be sufficient to meet the present needs of the area's population.

There are no permanent dentists at present in the service study area and at least one dentist is needed. The Public Health Nurses from Ashcroft operate a preventive dental programme in the schools in the study area.

(iii) Public Health

The South Central Health Unit has a branch office located in Ashcroft that services School Districts 29 and 30; there are offices in Clinton, Lillooet and Lytton for this branch office.

The health unit offers environmental inspection and nursing services concerned with home care, public health and epidemiology. The public health services are directed primarily to the school population and newborn children. There are also VD clinics and some rural mental health programmes. Home nursing care is available in Ashcroft and Cache Creek but not in Clinton at present because of a shortage of nurses in that area.

In 1976, the health unit branch office in Ashcroft was staffed with a health inspector, a senior public health nurse, two public health nurses, two registered nurses for home care programmes (working half time), and one and a half clerks. One additional public health nurse will be added in 1977.[9]

(iv) Mental Health

Mental health problems are dealt with by local physicians, public health nurses, or by referrals to outside specialists. Kamloops has a provincial mental health centre that provides mental health services to the region. A psychiatric social worker comes to the Public Health Office in Ashcroft from the Kamloops Mental Health Centre 1 day per month. There are two psychiatrists located in Kamloops. The Kamloops Family Life Association provides a Crisis Line and a counselling service for residents of the Kamloops region.

(v) Resident Comments regarding Health Services

Cache Creek residents expressed dissatisfaction with the lack of doctors' offices in their village. However, 60 percent of the study area households were satisfied with medical services. Residents said that dentists were needed in the communities. People also complained of the need for more doctors and several additional specialists including an optometrist, chiropractor, pharmacist, nurse and mental health worker. The ambulance service was considered to be satisfactory. The existing standards and recommended guidelines for Health Services are discussed in the Socio-economic Report.[1]

3.5 SOCIO-ECONOMICS - (Cont'd)

(c) Recreation

The recreation resources presently in the service study area provide for public leisure time activities such as ball games, athletic events, swimming, skating, tennis, children's play, banquets, dinners and dances. These activities are either unorganized in nature or organized by recreation clubs in the community. A detailed inventory of the recreation resources for Ashcroft, Cache Creek and Clinton is provided in the Socio-economic Report.[1]

In general, recreation programmes in Ashcroft, Cache Creek and Clinton are initiated and sponsored by local interest groups. Recreation clubs meet regularly in community halls, Legion or Elks halls, private homes, or in schools. Special events take place throughout the year, such as fall fairs, stampedes, dances and community banquets that are also sponsored by local groups. Recreation clubs and associations that are functioning in the service study area include: Brownies, Girl Guides, Royal Canadian Legion, Lions, Elks, Old Age Pensioners Group, hockey league, snowmobile club and swim club. Residents of Cache Creek travel to Ashcroft to use recreation facilities and vice versa.

The Province of B.C. Outdoor Recreation Branch does not employ standards in determining the recreation facilities or staff required in an area. Rather, necessary facilities are determined by expressed demand and willingness to raise funding in local communities.

Of the people responding to the survey, less than 50 percent felt that recreation activities were adequate. Only 38 percent of the households surveyed were satisfied with indoor sports facilities in their towns.

(d) Social

The Ministry of Human Resources has three offices in the study area: Merritt, Lillooet and headquarters for the region in Cache Creek. There is also a sub-office located in the courthouse in Clinton. There is one supervisor for the region. The Cache Creek office is staffed with two social workers, one financial assistance worker and one stenographer. The Cache Creek office has a caseload that is comparable to other Human Resources offices serving similar areas.

The specific programmes of the Ministry offered through the Cache Creek office include the statutory services of social assistance, old age pensioners assistance, day care, homemaker, foster homes, adoptions, child welfare, family service and assistance for handicapped people. There is also a group home for children, a group home for Native Indian children, a special rate foster home, a home for retarded children, a shelter workshop and an alternate education facility. There are 25 foster homes throughout the area.

The Ashcroft-Cache Creek Day Care Society provides the only day care services in the area at a day care and play school centre in Ashcroft. In September, 1976, there was a staff of two, and 1 to 12 children at the centre. The day care centre is licensed for a maximum of 25 children, but has never operated at its full capacity.

The Ministry of Human Resources does not plan its facility or staff requirements on the basis of standards. There are no standards available for day care services.

(e) Cultural

Cultural resources in the service study area provide for a limited range of cultural activities including displays of historic events, arts and crafts shows, occasional travelling musical and theatrical events and library services. Museums are operating in Ashcroft and Clinton with displays of local and regional history.

The libraries offer special programmes throughout the year, such as children's story hours, summer reading programmes for children, films and library tours.

Special events such as concerts or theatre troupes come to the area and perform in community halls and schools. Arts and crafts shows are held periodically. Other events, such as fall fairs, stampedes and community dances, organized by local groups and organizations, occur throughout the year.

Residents felt that there was a definite lack of cultural activities in the area which they defined as including theatres and other evening entertainment facilities. There are no standards available for most cultural services.

(f) Corrections

The provincial Ministry of the Attorney-General provides a Corrections office located in Ashcroft. The office is staffed by a probation officer and a secretary (half-time). The probation officer travels to the communities surrounding Ashcroft as required.

Programmes offered include probationary supervision and diversion programmes for juveniles and adults; family court cases such as applications for maintenance, custody and enforcement and marriage counselling; and provincial and national parole. The probation office also provides preventive programmes such as drug counselling and assistance to Alcoholics Anonymous. The major proportion of the corrections caseload is in probationary supervision.

Although there are no standards defining staff requirements throughout the Province based on population, the Corrections Branch does suggest that a probation officer is usually required in a community when it reaches about 5000 people. Corrections staffing is determined more by caseload and therefore, by crime rate in an area.

(g) Court and Judicial

The following staff would be considered standard for a Provincial Court: judge, court clerk, sheriff, official court reporter, crown counsel and prosecutor. A Provincial Court may sit full-time or part-time. If the court sits part-time, it is served on circuit with the judge, official court reporter and crown counsel travelling from a larger court. The County and Supreme Courts also sit in a number of the Provincial Court centres.

Provincial Courts in the service study area are located in Ashcroft and Clinton. Adult Provincial Criminal Court represents the bulk of activity in both courts. Other levels of court represented in Ashcroft and Clinton are Small Claims Court, Family and Juvenile Court and Superior Court. Provincial Criminal Court sittings have been minimal in Ashcroft and Clinton.

A Provincial Court circuit judge comes to Ashcroft one day per week from Kamloops and to Clinton one and one-half days per month. A County Court judge comes to Ashcroft 1 day per month from Williams Lake. The regional crown counsel in Kamloops appoints a crown counsel on an ad hoc basis to come to court in Ashcroft and Clinton. Small claims and family matters are heard by a Provincial Court judge at the same time as criminal matters.

Sheriff services are provided by the RCMP or by sheriffs from Ashcroft. There is presently the need to add one sheriff to provide sheriff services to courts in Ashcroft, Clinton, Lytton and Lillooet. The Clinton registry was closed in July 1977, because the level of activity was considered to be minimal.

(h) Legal

Legal aid services are provided through a legal office in Ashcroft and another in Cache Creek which operate as agents for the Kamloops Legal Aid Society. The lawyer in Cache Creek feels that there is sufficient workload in the area presently to handle another full-time lawyer and that with any increase in population, this would become essential.

Residents in the study area indicated that they obtained legal services, for the most part, in Kamloops. Opinions on the satisfaction with the service were split. There are no standards available for the provision of legal services in British Columbia.

(i) Police

The RCMP provide police services in the study area through detachments located at Ashcroft and Clinton. They provide police protection, safety education courses and have a public relations department. The total criminal code offences for the Ashcroft and Clinton RCMP detachments have been increasing gradually over the 10-year period.

The Ashcroft detachment has six officers of highway patrol, six on general duty and two stenographers. Also, there is a seven person auxiliary police force, trained in an emergency planning course, that is available in case of a disaster. The Clinton detachment has four general duty officers and one stenographer. Over the next few years, the addition of two officers and one patrol car is planned for the Ashcroft detachment.

The RCMP recommend one police officer per 1000 people in a rural area and one police officer per 750 people in an urban area. The RCMP also recommend three to five general duty officers per police vehicle and two highway patrol officers per police vehicle.

Households in all study area communities were very satisfied with law enforcement, with 85 percent indicating satisfaction.

(j) Fire

Fire services are provided in the study area by volunteer fire departments that are operated and financed by each village. The Office of the B.C. Fire Marshall, recommends that a volunteer fire department should have at least 25 members. The Ashcroft Fire Department consists of 25 firemen, including a Fire Chief, Deputy Fire Chief and four Captains. Their equipment consists of two pumpers and one rescue unit that also serves as an ambulance.

The Cache Creek and Clinton Fire Department each have 18 volunteer firemen, including a Fire Chief and Deputy Fire Chief. The Cache Creek department has one pumper with a rescue ladder. The Clinton Fire Department is equipped with one fire engine.

Although most residents were satisfied with fire protection in the area, Clinton residents expressed more uncertainty and slightly less satisfaction than residents of Ashcroft or Cache Creek.

(k) Communication

The Ashcroft post office is used by approximately 3000 people per month. There are four full-time staff, two part-time staff and two casual staff members. A new Federal building is planned for Ashcroft that would expand the post office to 325 m^2 in size.

The Cache Creek post office serves approximately 2000 people per month. The post office has one postmaster/zone manager, one assistant postmaster, one shift supervisor, five full-time postal clerks and four part-time postal clerks.

The Clinton post office is the smallest of the three post offices in the area, serving approximately 1000 people from Clinton and the rural surrounding area. There are three full-time staff at the Clinton post office. The size of the Clinton facility is more than adequate for its existing operations.

CBC radio and television programmes are received in the three communities in the service study area. There are TV repeaters located within the service study area in Ashcroft, Cache Creek and Clinton that transmit programmes from the CBC affiliate TV station in Kamloops.

A few people in Ashcroft and Cache Creek felt that postal services were poor, although no specific reasons were given. Clinton residents said that television and radio reception were unsatisfactory.

(l) Commercial Services

The commercial facilities of the local study area are essentially located within the communities of Ashcroft, Cache Creek, Clinton and Lillooet. These facilities generally cater to rather small trading area populations as well as the servicing of highway traffic. Kamloops serves as the major regional trading center with a trading area population of 100 000 persons. The existing array of commercial facilities in Ashcroft, Cache Creek and Clinton are identified in Table 3.5-16 and compared to the level of facilities in Merritt.

The area resident survey reveals that Kamloops is the preferred shopping location for about half of the local area residents for household furnishings and clothing. The resident survey also indicated a general satisfaction with the commercial facilities in the local communities, considering the size of the towns. At the present time commercial development in Ashcroft and Cache Creek is in a period of uncertainty.

3.5.6 Community and Regional Infrastructure

(a) Community Infrastructure

(i) Water System

The Ashcroft water system has basic supply capacity for population growth up to a total of 3100. However, there is a lack of storage capacity to provide for adequate fire flows in both north and south Ashcroft.

The Cache Creek water system has base supply capacity for population growth up to a total of 1800. Water supply is derived from the Bonaparte River through an infiltration gallery. Water supply components serving East Cache Creek are inadequate for further new development and provision of adequate fire storage reserves.

The Clinton water supply is derived by gravity from a dam and water impoundment area on Clinton Creek. Although it appears that adequate flow is available in Clinton Creek for the present population, it is suggested that insufficient water licenses are held by the village. The distribution system is generally adequate.

The present water supply system serving the village of Lillooet is considered to be more than adequate for the existing population. In the Lillooet Riverside Improvement District, all components of the supply and distribution system are severely overburdened.

(ii) Sanitary Sewer System

In Ashcroft the present upgrading programme includes consolidation of the collection systems and construction of a high rate activated sludge treatment plant. Upon completion, the upgraded collection and treatment system will adequately handle a population of 5000. Major trunk storm sewerage facilities are not required given the general accessibility of natural drainage features, but several outfalls from the natural drainage courses to the river are required.

Cache Creek has a treatment plant capable of serving a population of 5000 and trunk main facilities with adequate capacity for potential developments. In Clinton, treatment is provided by a series of anaerobic and aerobic lagoons with a service capacity for a population of between 1500 to 2000 persons. A limiting factor is the present Pollution Control Permit which authorizes discharge from a population equivalent of approximately 1200 persons. The trunk sewer main, which is capable of serving by gravity extension all potentially developable properties, has a capacity adequate for a service population of 2700.

Lillooet has a spiragestor type system, which is capable only of primary treatment. A deadline has been issued by the Pollution Control Branch to upgrade the system to provide the equivalent of biological secondary treatment. The collection system is generally adequate for the existing population.

(iii) Solid Waste Disposal

The Village of Ashcroft and Cache Creek utilize a common land fill site located adjacent to the Trans-Canada Highway (Highway No. 1) and midway between the municipalities. The operation of the land fill site is a responsibility of the Thompson Nicola Regional District and the municipalities contribute on a proportionate use basis.

(iv) Roads

Local roads within the Villages of Ashcroft, Cache Creek and Clinton are in generally good condition and adequate for the existing population. Traffic congestion at the intersection of the Trans Canada Highway and Cariboo Highway is experienced on summer statutory holidays and to a lesser degree during the summer holiday period.

(b) Regional Infrastructure

(i) Transportation

Highway No. 1 is a major route connecting the Lower Mainland and the B.C. Interior. It joins Highway No. 97 at Cache Creek, forming one of the most heavily travelled highway intersections in the province. Summer average daily traffic volumes at selected points for the period 1970 to 1976 are presented in Table 3.5-17.

The marked seasonal peaking of traffic volumes during the summer months indicates the importance of Highways No. 1 and No. 97 for tourist and recreational travel. During other months of the year, traffic volumes in the study area are reduced considerably below the summer peak reflecting commercial through traffic and local traffic.

In the absence of any improvements to the existing highway system and the Cache Creek road network, any growth in highway travel by study area residents would lead to further deterioriation in the efficiency of vehicular movements within the region.

(ii) Utilities

At present, B.C. Hydro provides electrical power to Ashcroft, Cache Creek, Clinton and Lillooet. B.C. Telephone provides telephone service in each of the four municipalities and Inland Natural Gas provides service to all municipalities except Lillooet.

3.5.7 Local and Regional Goverment

The functions and responsibilities of village municipalities are specified in the Municipal Act and can generally be classified into two main categories:

1. Legislative control and regulation by by-law.

2. Provision and delivery of community facilities and services.

In the following analysis of municipal financing and budgeting, the primary emphasis is on the costs associated with the provision of the services outlined above and the financial capability of the municipalities to finance these services.

(a) Ashcroft

(i) Historical Expenditures and Revenues

In the table of Historical Expenditures, Table 3.5-18, all capital payments are combined in a single category of fiscal services. The expenditure totals include general government, protective services, transportation, environmental health, public health and welfare, environmental development, recreation and cultural, fiscal services, transfers to reserves, capital from reserves, water works and other services.

Table 3.5-18 contains historical revenue figures for municipalities in the Hat Creek Region during the 1970 to 1976 period. The total revenue figures are aggregated from property tax; sewer, water, garbage; and all other sources.

Summary of Revenues: 1970 - 1976

	1970	1972	1974	1976
Population	1900	1950	2000	2005
Property Tax	$ 44,090	$ 67,130	$138,910	$145,087
Sewer, Water, Garbage	78,323	107,265	145,807	186,638
All Other Sources	56,156	91,867	175,162	268,989
Total Revenue	$178,569	$266,144	$459,879	$600,714

(ii) Assessment and Property Tax Rates

In 1976 the per capita taxable assessment in Ashcroft was approximately $2,350. The two main components of assessed values and their percent contribution are residential (63 percent) and commercial (22 percent), respectively.

(iii) Water and Sewer Services

Current expenditures on the water system are as follows:

Item	Annual Expenditures
Capital - Debt Retirement	$32,110
Operating and Maintenance	57,245
TOTAL	$89,355

The present water rates are:

1. Water utility rate - $5.00/mo or $60.00/yr plus,

2. Frontage tax - $1.64/front m.

Assuming an average lot frontage of 19.8 m, total annual water costs would be approximately $90/yr/user.

(b) Cache Creek

(i) Historical Expenditures and Revenues

The totals in Table 3.5-18 include expenditures on general government, protective services, transportation, health and welfare, and other services for Cache Creek. Expenditures have increased from about $131,000 in 1970 to $480,000 in 1976.

Following is a summary on a biannual basis (1970-1976) of revenues from all sources in the village of Cache Creek.

Summary of Revenues: 1970 - 1976

	1970	1972	1974	1976
Population	1000	1100	1200	1040
Property Tax	$ 27,032	$ 44,577	$101,762	$116,352
Sewer, Water, Garbage	72,559	111,156	108,863	242,402
All Other Sources	32,283	49,222	55,102	63,300
Total Revenue	$131,874	$204,955	$265,727	$422,054

(ii) Assessment and Property Tax Rates

In 1976, the per capita taxable assessment in Cache Creek was $3,997. The two main components of assessed values are residential - 34.6 percent and commercial - 62 percent.

(iii) Water and Sewer Services - User Rates

The existing sanitary sewer system is generally adequate, although a $50,000 upgrading programme is currently being carried out. In 1976, the Village budgeted to receive $19,000 from the provincial government under the provisions of the Sewer Facilities Assistance Grant. With the additional work to be undertaken in 1976 and 1977, it is estimated that this grant will increase to approximately $24,000 per year. Net costs to the village will therefore be $66,000. In 1975, projected revenues from sewer user fees were budgeted at approximately $62,000.

In 1976, the village budgeted to receive $23,300 from the provincial government under the provisions of the Water Facilities Assistance Grant. Net costs to the village are therefore approximately $39,000 per year given the estimated annual capital, and operating and maintenance costs of $44,000 and $18,000, respectively. In 1976, budgeted revenues from user rates were $66,000, resulting in a substantial surplus which will be carried over for use in future years.

(c) Clinton

(i) Historical Expenditures and Revenues

Table 3.5-18 contains a summary on a biannual basis (1970-1976) of actual expenditures on all services provided by the village of Clinton.

Following is a summary of a biannual basis (1970-1976) of revenues from all sources in the village of Clinton.

Summary of Revenues: 1970 - 1976

	1970	1972	1974	1976
Population	1150	890	920	806
Property Tax	$ 12,200	$ 13,000	$ 15,900	$ 26,000
Sewer, Water, Garbage	54,200	60,800	76,400	78,300
All Other Sources	51,500	40,100	68,700	79,100
Total Revenue	$117,700	$113,900	$161,000	$184,400

(ii) Assessment and Property Tax Rates

In 1976, the per capita taxable assessment in Clinton was approximately $2236. The two main components of assessed values are residential - 56 percent and commercial - 42 percent. It is assumed that increases will be proportionate to population increases.

(iii) Water and Sewer Services - User Rates

In 1976, the village budgeted to receive $15,000 from the provincial government under the provisions of the Sewer Facilities Assistance Act. Net costs to the village are therefore estimated to be $33,000 given estimated capital, operating and maintenance costs of $30,000 and $18,000, respectively. In 1976, projected revenues from sewer use fees were budgeted at approximately $32,500.

(d) Lillooet

In general terms, the village does not have a particularly strong assessment base - *the* per capita taxable assessment is approximately $1900. As such, the tax rate is relatively high compared to the other municipalities under consideration - 34.99 mills. It is anticipated that the assessment base will improve significantly if the proposed Federal Penitentiary is taken into the boundaries of the village.

Even though the mill rate in Lillooet is higher than the other communities under consideration, the expenditure per capita, which could be interpreted as level of service, is lower in certain areas of expenditure. Comparison of the per capita expenditures in Lillooet, Ashcroft and Cache Creek illustrates this:

	Expenditure Per Capita ($)		
Village	Recreation	Transportation	General Government
Lillooet	20.75	37.57	49.93
Ashcroft	51.01	58.45	64.98
Cache Creek	53.55	57.98	51.63

3.5.8 Social Environment

The attributes selected to describe the quality of life in the social environment of the small towns in the study area constitute the "human" or social resource that ultimately will be affected by, and, in turn, affect future development.

These attributes have been classified into two major groupings, the social setting and the social conditions. The factors defining the social setting include the population and economic base, historical aspects, the natural environment, accessibility, availability of services, housing, land and other amenities, and the opportunity for employment and income. These factors are discussed in other socio-economic sub-sections of the EIAR. The attributes describing the social conditions within the study area are grouped into three topic areas: social benefits and problems; community cohesion; and the reactions of residents to growth and development. These topical areas are the focus of discussion in the following sections.

(a) Social Benefits

While the majority of the residents moved to the study area for economic or job related reasons, some were drawn to the region because of anticipated environmental and community benefits. Many of the others who arrived for economic reasons said that they have come to enjoy the benefits once they settled. When asked in the resident survey to comment on their feelings regarding the area as a place to live, 70 percent of the total rated it as good or excellent, specifically noting the desirability of the natural setting, the size of the communities and the availability of services. See Table 3.5-19 for the responses by major categories.

Access to outdoor activities was a major benefit, especially in the clean, pollution-free environment and the relatively mild year-round climate. They felt that the outdoors and related recreational activities, both during the summer and the winter, were major attributes of the area.

The residents viewed the small town setting as very favourable. One of the major repeated comments was that the small size of the communities resulted in a friendly atmosphere. Residents of Clinton and Ashcroft noted that their rural setting was much more desirable than a large urban environment. They felt the towns were excellent family oriented communities. Residents were satisfied with the majority of services in their communities, especially physical services and basic social services such as education and law enforcement as well as the availability and the quality of housing in the communities.

Services in Ashcroft were used extensively by residents for their medical, educational and religious needs, while Cache Creek appears to be an entertainment centre. The centrality of the study area within the province was a major factor providing them with quick access to other areas of the region or the province. A significant proportion of the residents drive to Kamloops for services, especially dental, legal and entertainment. Some residents go to Vancouver for major purchases and special services.

(b) Social Problems

Community-related problems and problems associated with the availability and adequacy of some community services are evident in the communities. While criminal offences over the last few years generally have grown in the study area at a rate similar to that of the province, the RCMP have noted a 20 percent decrease in criminal activity in the last year. The RCMP have inferred that the use of alcohol is the most serious problem in the study area based on a significant increase in alcohol related offences from last year.

Welfare and social assistance cases, while fairly heavy, were noted as being at the lowest level in several years. Nearly two-thirds (60 percent) of the caseload resides in Clinton, with 20 percent in Ashcroft and 15 percent in Cache Creek, with single parent families comprising a relatively large proportion of the caseload. A number of service delivery representatives indicated in interviews that marriage breakups were prevalent, however, this was not corroborated by resident survey or government statistics.

It was indicated by the RCMP that an increased use of the Trans-Canada Highway has resulted in a transiency problem in the area, especially in Cache Creek. Teachers in the Ashcroft Senior Secondary School indicated that a high drop-out rate was normal as the students reached 16 and were able to take available low skill, high paying jobs. This has been associated with a perceived increase in juvenile problems related to alcohol and vandalism.

Residents also were concerned with the delivery of some community services in the study area such as cultural, entertainment, variety and competition in shopping and sports facilities and programmes. The major request from residents was for recreational facilities.

The major problem perceived by the residents to be facing the study area is that of employment. While, at present, there is relatively stable employment accompanied by a fairly low unemployment rate compared with the rest of the province, this is a somewhat inaccurate portrayal as many of the unemployed have left the area seeking employment elsewhere.

(c) Community Cohesion - Stability

Historical events have led to a cross section of residents in local communities. On the one hand, there is a relatively stable population of long time residents, notably ranchers and farmers in the rural areas, including the Hat Creek Valley. Then, there is the newer population who have moved in during the last two decades with the advent of mining and other resource extraction enterprises, as well as the increased service sector activities. The stability characteristics can be seen to some extent in Table 3.5-20, Length of Residency in the Study Area. Nearly one-half of the residents have lived in the region for more than 10 years and nearly one-half of these, for 20 years or more. The remaining portion of the residents have lived in the region less than 10 years and are generally the "newcomers" to the area. Those who have lived in the area from 3 years to 15 years (about one-half of the population) arrived in the region during the prime growth period of mining and service sector expansions. Cache Creek and Ashcroft became the prime residential locations for these incoming residents.

Ashcroft notes the largest number of residents living between 11 and 20 years in the community. This was the period during the late 1950s when the first major developments occurred in the Highland Valley. The Hat Creek Valley and Clinton, on the other hand, noted a large percentage of their populations resident for greater than 20 years. From these characteristics, it could be *assumed that the population in the study area is generally very stable. The major reason for coming* to the region has been economic, with nearly three-quarters of the Ashcroft residents stating this as their prime reason for living there.

B.C. Telephone Company representatives indicated that most telephone disconnects were most likely related to out-migration from the study area, rather than internal movements between or within communities.

Information on future resident stability was solicited in a question in the survey directed to young people in the study area communities to determine their desire to work in the area. Nearly one-half of the students indicated an interest in remaining but they were concerned about being unable to find full-time, interesting work. Those expressing interest in leaving indicated that they either intended to continue their education or look for work elsewhere.

With respect to the anticipated residency of the adult population in the community, 40 percent of those sampled stated they would stay as long as possible. An equal percentage indicated that they did not know and expressed concern about the stability of the economic base and the related job market. When asked under what conditions they would leave, many observed that it would be only to seek work elsewhere. Environmental loss and pollution would cause some individuals to move from the study area to find natural amenities in other areas of the province.

(d) Community Cohesion - Participation

Government representatives are elected from the region for both federal (Members of Parliament) and provincial (Members of the Legislative Assembly) governments. Another level of government is the Thompson-Nicola Regional District, the offices of which are located in Kamloops. The Village Councils in Ashcroft, Cache Creek, Clinton and Lillooet, as well as the school board and the health board, are influential in the development activities of their communities.

Several agriculture and ranching associations operate in the Cache Creek, Ashcroft and Clinton areas. Various church groups as well as service organizations are quite active in the immediate area. Most of the towns have a normal number of service organizations, societies, associations, social clubs and civic organizations in comparison to other towns of similar size in British Columbia. There is a lack, however, of volunteer organizations and self-help groups. The ranching and farming residents, the mining and mine industry related residents, and the business and commercial groups in each of the towns take part in the social activities of the area and their communities. The residents have some formal and informal recreation and community related clubs and special social events.

Over one-third of the survey respondents said that their friends had lived there longer than they had. This may indicate that there has been a reasonable level of integration of the newer residents into the existing study area.

Many residents noted that they socialized with friends or went to evening meetings. A few often key participants in community business and government indicated more extensive activities. A substantial group noted that they did not socialize at all, the largest portion located in Ashcroft.

In comparison with the general population, the mining residents seem to have a different pattern of socializing. While many socialize infrequently or not at all outside of their own family, an equal number socialize extensively. This lack of integration does not seem to have resulted in major conflicts in the community and, at present, there seem to be no noticeable problems. Over 40 percent of those surveyed expressed satisfaction with the local government structure, although nearly one-third were uncertain and another quarter were dissatisfied.

A number of local issues were raised during the interview process, as well as in the review of local newspapers. Some revolved around the intercommunity rivalry between towns in the region, especially between Cache Creek and Ashcroft. There have been few successful joint planning ventures and the two communities were not in favour of amalgamation plans put forward to allow for potential sharing of services.

The final indicator of public involvement revolves around resident responses to the planning activities and public announcements made by B.C. Hydro regarding the Hat Creek Project.

(e) Existing Community Cohesion

Each community in the study area presented a reasonably cohesive image. The stability of the residents and their level of participation in community activities generally indicated a commitment to the study area and the individual towns.

Several of the communities seemed more cohesive than others, notably Cache Creek and the Hat Creek Valley. The residents of the Hat Creek Valley have been committed to their ranching lifestyle and the valley. The Cache Creek residents, on the other hand, are working for expansion and development of the economic base of their community.

(f) Attitudes of Residents Towards Growth and Development

Over two-thirds of the residents sampled were in favour of a doubling of the population, many of whom strongly favoured this increase. More than two-thirds favoured a steady population growth while only a few regarded this as unfavourable. A stable or no-growth situation was viewed as favourable by only 38 percent of the residents sampled and unfavourable by an equal number (39.9 percent). With respect to a decline in the population, 80.8 percent felt a declining population was unfavourable.

The urban residents of Ashcroft, Clinton and Cache Creek strongly favour large population increases either within their communties or in the study area. The rural residents, including the Hat Creek Valley population, however, would prefer to see a no-growth or stable situation.

Nearly all residents (88.3 percent) would like a large shopping centre in the study area. The development of a major industry solicited slightly less favourable response than the shopping centre with three-quarters (75.2 percent) of the surveyed residents wanting the development. Of the Hat Creek residents, one-half were undecided about the desirability of a large industry while one-third (31.6 percent) were opposed to it. Ashcroft residents were most unified as 87.2 percent of this town's residents desired the development of a large industry.

The issue of the development of a new town in the area resulted in some indecision by the residents as one-third (32.3 percent) expressed favour at the development of a new town with slightly more residents (39.2 percent) not favouring the new town. Nearly two-thirds of rural and Hat Creek residents expressed disfavour with a new town. With respect to the development of an airport, nearly two-thirds (75.0 percent) of the study area respondents favoured this development.

(g) Attitudes of Residents toward the Hat Creek Project

Three specific sources were referenced in this analysis. These are the resident survey completed by the consultants in April 1977, the telephone opinion poll completed by the Cache Creek Chamber of Commerce in September of 1976 and the newspaper survey undertaken by the consultants during the time of the study (1976 and 1977).

In the resident survey, the attitudes of residents toward the development of the Hat Creek Project were solicited. Two-thirds of the respondents in the study area were in favour of the Hat Creek Project, another 20.7 percent were neither in favour nor opposed and about 12 percent expressed opposition. The residents of Cache Creek, Ashcroft, and Clinton were almost equally in favour of the project. The major opposition was noted by the residents of the Hat Creek Valley with 68.4 percent opposed to the project and 26.3 percent recognizing both the positive and negative aspects. In the valley 5.3 percent favoured the development of the coal mine and thermal generating station.

Greater than 80 percent of the present construction and mine employees favoured the development, while the professional categories indicated less favour. Over three-quarters of the ranching and farming respondents, or the rural residents, were in opposition to it. Those respondents who were unemployed, although a small number, were the group most strongly favouring the project. The majority of people favouring an increase in population and the other potential developments, also strongly favoured the Hat Creek development.

The telephone poll revealed a favourable response from 66.7 percent of the Cache Creek respondents, almost identical with that of the resident survey response of 66.3 percent in favour of the project in the study area.

(h) Resident Concerns Regarding the Hat Creek Project

Over 40 percent of the respondents expressed employment interest, in the Hat Creek Project. Many considered work in construction, operations, or the related commercial and clerical support activities.

In the primary sector over two-thirds of respondents currently employed in mining, forestry and construction related activities expressed interest in work. Twenty percent of the women respondents, one-half of the students, and 60 percent of the unemployed expressed interest in working on the project, should it proceed.

(i) The Hat Creek Valley Community

(i) Physical and Historical Setting

The Hat Creek Valley contains some of the earliest ranches in the region, established over 100 years ago. Since that time, the valley has been dedicated to agricultural production, mainly beef cattle. A small underground coal mine that serviced the study area was in operation several decades ago, but left little mark on the present surroundings.

Some of the original families that settled in the valley are still operating family ranches. These people are important members of the social fabric of the valley and in the surrounding communities. The valley had a population in 1977 varying from 30 to 40 residents, including ranchers, dependents and ranch hands.

While the climate is relatively dry, irrigation has brought some of the land into active production, as well as supporting the grazing of herds of beef cattle. Privately owned land is supplemented by crown grazing leases. While most of the residents work full-time on the ranches, some also support themselves with outside jobs by working on construction or in service jobs in the valley and the surrounding towns. The reported household incomes are generally lower than in the overall study area. However, this is offset by other attributes of their particular lifestyle and a high degree of self-sufficiency.

In addition to the agricultural use of the Hat Creek Valley, residents from the surrounding region have, for many years, used the valley as a recreational area. Hat Creek has provided one of the best grazing and hunting areas in the Cariboo. Many valley residents particularly enjoyed riding and hiking throughout the valley.

Eighty percent of the valley residents indicated that the valley was an excellent place to live with the remainder considering it a good place to live. The majority of the comments centered on the climate, the productivity of the land, the secluded setting and their rural lifestyle.

(ii) Characteristics of the Residents

The 30 to 40 residents and dependents represent approximately ten family groupings within the valley. A number of these people are the descendents of families that originally settled in the valley over a century ago. The actual resident population of the valley fluctuates extensively depending on the season. A few older children and other family members have moved to other communities in the region or to the Lower Mainland for education or employment, but return in the spring, summer or fall of each year for holidays and planting and harvesting activities.

Most of the residents are families with several children. The older residents within the area do not consider themselves as retired, as they work to maintain self-sufficient operations on their holdings. All the residents interviewed, regardless of age, occupation, or income, were firm in their commitment to their ranching lifestyle.

(j) Summary: The Existing Social Environment in the Communities

(i) Cache Creek

The town has a high activity image linked to its location at the intersection of major B.C. Highways. The residents have common objectives related to their service sector economy and are strongly in favour of growth, development and the Hat Creek Project. They have high expectations of the social and economic effects of the project. However, residents also noted a great awareness of potential environmental effects related to development and expressed the need for controls.

(ii) Ashcroft

The town, of some historical significance, is based on resource developments and the railway. It does not appear to have a strongly cohesive community, perhaps due to the influx and continuing turnover of residents. There is a low visible level of public social activities, although many study area services are available in the town. The residents, anticipating needed economic benefits, are in favour of growth, development and the Hat Creek Project.

(iii) Hat Creek Community

The residents of the valley expressed commitment to their ranching lifestyle and the preservation of the natural environment. They form a stable community with strong historical continuity through their families and the land. The residents are in opposition to population growth and development in the study area and strongly opposed to the Hat Creek Project. Many apparently feel bitter, insecure and threatened by project developments and any indecision on the part of B.C. Hydro.

3.5 SOCIO-ECONOMICS - (Cont'd)

(iv) Clinton

Clinton is a physically attractive small town in a quiet rural setting. However, the continuing decline in the forestry industry and the town population, has resulted in an atmosphere of uncertainty and depression within the community, heightened by the visibility of underutilized services and land. The residents are strongly in favour of growth and development, and especially, the Hat Creek Project, hoping that this will reverse the existing decline in activity.

(v) Lillooet

The residents of Lillooet do not seem to identify with the study area, or the present and potential development activities. A strong community identity was not observed by the consultants during the studies. In general, the community is in favour of growth, development and the Hat Creek Project, although uncertainty was expressed due to information gaps regarding the project.

3.5.9 Native Indian Studies

The cultural heritage of the Indian people is examined relating their heritage to their settlement in the Hat Creek area and laying the foundations for understanding current social and economic conditions, and Indian perceptions.

This study was undertaken without the cooperation or involvement of the Indian people of the Hat Creek area, or, except on a very limited basis, of the Department of Indian Affairs (DIA). The local Bands were not willing to cooperate with the B.C. Hydro funded Indian studies until their own studies were underway and they asked DIA to prohibit access to the Department's records by B.C. Hydro consultants.[10]

(a) Definitions

The Indian people of British Columbia commonly are classified into two groups: Status (or Registered) Indians and non-Status Indians. Status Indians are defined as those people coming under the jurisdiction of the Indian Act (1957). Their names appear on the Official Indian Register. Most appear on a specific Band List, but a few are not associated with a specific Band and appear on a General List. The terms Indian Band and Reserve are used as defined by the Indian Act.

Status Indians are not necessarily of Indian racial origin, nor necessarily genetically "more Indian" than those who have chosen enfranchisement, or their offspring. People of Indian racial origin who are not registered under the Indian Act are generally referred to as non-Status Indians.

It is estimated that there are approximately equal numbers of Status and non-Status Indians in British Columbia. In 1975, Department of Indian Affairs statistics showed 52 280 Status Indians in British Columbia. Because the location and the number of non-Status Indians could not be determined, the study is concerned primarily with Indian people living on Reserves in the study area.

Most Bands in British Columbia have grouped themselves into regional Indian District Councils, with boundaries that do not necessarily represent tribal boundaries. The Indian District Councils are usually composed of the elected chief of each Band in the District and act as a body to represent the group interests of the Bands concerned.

The Union of B.C. Indian Chiefs is an organization representing many of the Indian Bands in the Province. It acts as a resource group for member Bands and provides leadership and guidance for its members. The Union has a full-time executive and staff. Each Band has a council to direct its activities.

(b) Definition of Study Areas

It was decided to include in the primary impact study the four Bands whose Reserves are located close to the proposed Hat Creek Project; namely, the Bonaparte, Pavilion, Ashcroft and Oregon Jack Creek Bands. The location of their respective Reserves is shown on Fig. 3.5-3.

It was decided to define a secondary study area encompassing those Indian Bands who had Reserves within a 50 km radius of the proposed thermal generating plant site. This decision brought into the study the Bands who use the facilities and services of Ashcroft and Cache Creek (e.g., Deadman's Creek Band whose children attend school in Ashcroft) and also Bands whose members might be prepared to commute in order to obtain employment at Hat Creek (e.g., some of the Lillooet area Bands).

There are 11 Bands in addition to the four included in the primary study area who have Reserves within the defined secondary area boundaries. They are:

1. Deadman's Creek
2. Cook's Ferry
3. Nicomen
4. Lytton
5. Clinton
6. Fountain
7. High Bar
8. Cayoose Creek
9. Lillooet
10. Bridge River
11. Seton Lake

Their Reserves are also shown in Fig. 3.5-3.

(c) Settlement Patterns and Cultural Considerations

(i) Cultural Heritage and Past Settlement Patterns

Preliminary archaeological research in the upper Hat Creek Valley has recovered evidence of aboriginal settlement and resource utilization which may extend as far back as 7000 years.[11] The basin is inferred to have been utilized in seasonal fishing, hunting and plant gathering activities by nomadic groups. It is probable that this pattern of settlement and subsistence prevailed up to the time of historic contacts.

The Indian Bands in the study area are part of the Interior Salish, a large linguistic group whose territory covers much of the central and southern Interior of British Columbia and stretches south into the States of Washington and Idaho. Fig. 3.5-4 shows the territories of the Interior Salish and Fig. 3.5-5 shows the tribal boundaries of the Shuswap, Thompson and Lillooet Indians; all sub-groups of the Interior Salish. The study area is located at the junction of the boundaries of the three tribal groups. The Pavilion and Bonaparte Bands are Shuswap, while the Ashcroft and Oregon Jack Creek bands are Thompson Indians. Most of the upper Hat Creek Valley was part of the hunting territory of the Thompson Indians from Spences Bridge.[12] The lower reaches of the valley were within the territories of the Bonaparte Band.[13]

The Interior Salish were semi-nomadic where pattern of movement was affected by the seasonal availability of food. The Indians travelled mainly in small family groups but in the winter a number of groups would live together in their semi-permanent settlements. Within tribal boundaries, the land and its resources were regarded as common property for the tribe or kin. When a number of family groups were together, the lifestyle was semi-communal. Decision making tended to be democratic and Band members were consulted on important decisions. It seems likely that this lifestyle remained basically unchanged for thousands of years before white contact, 200 years ago. By the end of the nineteenth century the majority of the present Reserves in the primary study area had been established.

(ii) Retention of Cultural Identity

Cultural identity is characterized by the interaction of a complex set of elements, some physical and some attitudinal. These factors include the use of a particular language, the pursuit of traditional activities and the holding of certain values and attitudes.

The 1971 Census data showed that, while 18 percent of the people identified Indian as the mother tongue, only 8 percent stated that Indian was the language most often used at home, denoting that English is now the predominant language on the Reserves.

The Indian people do not appear to use the social and recreational facilities in the local non-Indian communities to any degree. Social interaction seems to be mainly within their own Reserve and with other Indian communities, a fact which contributes to maintenance of Indian self-identification. Similarly, the Reserve system has been a major factor in maintaining and strengthening Indian cultural identity.

(iii) Present Settlement and Organization

The four Bands in the primary study area have a total of 23 reserves, with a total area of over 63 km^2. These reserves are listed in Table 3.5-21.

Most of the Ashcroft Reserve residents live on Ashcroft Reserve No. 4, located near the junction of Highway No. 1 and the south Ashcroft connector road. There are nine houses on this Reserve, set back some 150 m from the road.

There are some houses on Pavilion Reserve No. 3, about 1.9 km west of the Hat Creek Junction along Highway No. 12, but most of the Pavilion Band members live on the main Reserve, some 8.1 km to the west of the Hat Creek Junction.

It appears that all four Bands function independently, administering their own financial and organizational affairs. Pavilion Band is a member of the Lillooet Indian District Council, while the other three Bands are members of the Thompson River District Council.

(d) Demographic Characteristics

(i) Population

Table 3.5-22 presents total on-Reserve and off-Reserve Status populations for the Bands in the primary and secondary areas. At the end of 1975, the four primary area Bands had 621 members of whom 354 (57 percent) were living on-Reserve. The 11 Bands in the secondary area had a total of 2598 members, of whom 1655 (64 percent) were living on-Reserve. During the last decade, the total Band population of the primary area has been increasing at an average growth rate of 1.9 percent annually compared to 1.3 percent for the secondary area Bands and about 2.0 percent for the Status Indian population in British Columbia as a whole.

The size of Status Indian populations at any point in time is not only a function of birth and death rates, but also of marriage preferences. From the limited statistics available (for 1975 and 1976 only) the birth and death rates for the primary bands are more in line with those for the general population of British Columbia than for the Status Indian population. Because the natural population growth in the area was about 2.4 percent annually over the last decade and the recorded growth was 1.9 percent, out-migration due to marriage preferences appear to play a part in the population growth of these Bands.

The historical relationship between on and off-Reserve populations is shown in Table 3.5-23. Throughout British Columbia there has been a trend of population migration away from the reserves. On-Reserve populations have increased marginally during the past decade while off-Reserve populations have increase by 66.6 percent. Among primary area Bands 44.7 percent of Band members live off-Reserve compared to 36.8 percent throughout British Columbia. The off-Reserve Status population living in the primary area is established for 1971 as follows: Ashcroft - 25; Cache Creek - 35; Lillooet - 40; Clinton - 85; and Rural - 25.

(ii) Age/Sex Characteristics

The Indian population is significantly younger than the non-Indian population of the study area. Among primary Band members, 64 percent are under 25 years of age, compared with 52 percent of the general Ashcroft/Cache Creek area residents, 45 percent of the total British Columbia non-Indian population and 66 percent of the total British Columbia Indian population. In addition, 73 percent of the female Band members are under the age of 25. According to the 1971 Census, the male/female ratio on the primary area Reserves is calculated at 1.1:1. The youthfulness of the Indian population is explained in part by a high birth rate and a low life expectancy. The observed decline of the Indian birth rate in British Columbia accounts for the trend of the age structure toward that of the overall British Columbia population.

(iii) Family Structure

Indian society retains a value system that is significantly different from that of Canadian non-Indian society. Civil marriage, divorce and illegitimacy are not as important as in white society, but family relationships and acceptance of elders are more highly valued.

The 1971 Census data contain information on family and household sizes and structure. They indicate a near constant distribution of family size from 2 persons to 9+ persons, with an average size of 5.7 persons per family. Most families live as a single unit in their own home. Only 10 households in all four bands are shown as containing more than one family. A further 15 households are shown as not containing a family group as such, of which 10 are occupied by a single person.

(e) Labour Force and Employment

(i) Historical Characteristics

The 1971 labour force of Reserve residents has been estimated by the Census at about 100 persons. The labour force can be characterized as young and male dominant but not differing significantly in this respect from the non-Indian communities of the study area. Males comprise over 75 percent of the Indian labour force. Table 3.5-24 provides participation rates by sex for the primary area bands and the local communities. The number of Reserve residents in the experienced labour force by industry is contained in Table 3.5-25 for 1971.

Table 3.5-26 denotes that the Indian labour force was almost fully employed; however, only 60 percent of them had full-time employment. The Ashcroft and Oregon Jack Creek Reserve residents had about 90 percent of the working age population in the labour force and employed mostly on a full-time basis. The main source of employment was mining. All 60 members of the Bonaparte labour force were experienced and employed at the time of the Census however, only half had full-time employment. Agriculture, manufacturing and the service industries dominate their areas of involvement.

Only 10 of 55 working age people for the Pavilion Band were in the labour force. Half had not worked in the previous 18 months and none were employed full-time. No female participated in the labour force and no single industrial category was significant enough to be specified as providing the employment.

3.5 SOCIO-ECONOMICS - (Cont'd)

(ii) *Current Status*

At the time of writing this report the employment situation among the four primary area Bands seems to have declined since 1971 but there are opportunities for future improvement.

Stable, full-time employment is scarce. Bethlehem Copper Mines employ an estimated 8 to 10 Indian people from the Ashcroft and Cache Creek areas. Competition for employment at the mine is very high, especially for entry-level positions. It appears that the Indian employees have, in the main, been with the company for a long time, with some as long as 8 to 9 years. Few, if any Indians are employed at the Lornex Mine.

Since the 1971 Census, three significant, but small-scale sources of Indian employment have been established: The Steel Brothers Canada Ltd. lime plant located on Ashcroft Reserve No. 2; the Basque Ranch owned by the Cook's Ferry Band and the Gulf Agricultural Chemical Plant.

The Steel Brothers plant was opened in 1974 and employs 18 full-time employees. The three management and administrative positions are staffed by non-Indians, but 13 of the 15 hourly-paid full-time employees are Indians. About half of these are Pavilion Band members, one is from the Bonaparte Band and the balance are from the Fountain and Lillooet bands. The plant is unionized, but there is an informal agreement on preferential hiring for local Indians, with Pavilion Band members having first opportunity. In addition to the employment benefits provided, Steel Brothers provide revenue to the Pavilion Band in the form of lease payments.

The Gulf Agricultural Chemicals plant, located on the Ashcroft Reserve and opened in 1974 manufactures explosives for the mining industry. It employs only two people on a full-time basis (one being the non-Indian manager) but approximately six times per month will employ an additional eight people for a single shift.

The Basque Ranch was acquired in 1974 by the Cook's Ferry Band as a land-swap compensatory measure with Bethlehem Copper Ltd. Grazing leases for Crown land are held by the Band in the area. It is estimated that the ranch would likely employ about five people.

Among the four primary area Bands, agriculture offers a limited amount of present and potential future employment both on and off the reserves. It has been estimated that about eight Indians are employed full-time and another eight part-time by the ranches of the Hat Creek Valley.[14] However, use of local Indians as seasonal or part-time ranch hands seems to be decreasing. A recent study assessed the potential for agricultural development on the Bonaparte Reserves and concluded the Reserves had some potential for providing additional full-time agricultural employment.[15]

All four bands in the primary area have Reserve lands that seem to offer potential for employment generation. About 10 full-time positions likely exist in the administration of the four local bands. The retail and service sectors, primarily oriented to the tourist trade, offer employment opportunities in the primary study area. The work is usually seasonal with relatively poor pay.

A reasonable estimate of total Indians working in the service sector would be 10 persons. Much of this employment would be seasonal and part-time. The biggest single source of employment among Reserve residents in the study area at the present time is federally funded, temporary work projects, operated through Canada Manpower. The use of the temporary work projects, the aims expressed in work project application and the stability being experienced among Indian employees, all indicate a growing wish and ability to participate in the wage economy.

About 50 Indian people are currently employed in the primary study area on a regular basis. This is a decrease from the number of employed Reserve residents indicated in the 1971 Census.

The high levels of unemployment were stated repeatedly by Indian groups in their applications for funding under federal temporary work programmes. Also, Canada Manpower information on client registrations, vacancies and placements suggests high unemployment.

(iii) Barriers to Indian Employment

The following is a discussion of general conditions on published sources.[10,16,17] The problems identified have not all been specifically documented for the study area.

Physical isolation of Reserves from employment opportunities and the lack of reliable and independent transportation present employment barriers. Unnecessarily high standards of education and experience are often barriers. The emphasis placed on educational requirements for apprenticeships is particularly significant in presenting barriers to the achievement of tradesmen status by Indians. Both industry and organized labour tend to follow practices that act as barriers to Indian employment.

Social problems, such as alcohol abuse and a developed "structural dependence" on welfare can also form barriers to employment. Prejudice, paternalism and misunderstanding of Indian aims can act as further barriers to Indian employment. Garnisheeing of wages is generally more prevalent among Indian people than among non-Indians and the prospect of encountering such action can form a barrier to seeking employment.

The view that Indians are primarily interested in outdoor activities of a seasonal or short-term nature and have no degree of responsibility, is fairly widespread.[17] The basic misunderstanding and stereotyping of Indians in the minds of employers tend to have the effect of barring employment and of becoming self-fulfilling prophecies.

3.5 SOCIO-ECONOMICS - (Cont'd)

(e) Income

(i) Employment and Transfer Income

Tables 3.5-27 to 29 contain total income, average income and income distribution data for the Bonaparte, Ashcroft/Oregon Jack and Pavilion Bands. The Ashcroft/Oregon Jack Band has an average individual income of about $5400 and income per family of $10,820. In comparison, the general population of the study area in 1970 had average and family income figures of $5460 and $9774, respectively. The Bonaparte Band also had a high proportion of employment but had much lower income levels than the Ashcroft/Oregon Jack Band. Overall the Pavilion Band statistics reflect a low level of employment and income. The distribution of income presented in Table 3.5-29 shows that 75 percent of income recipients received less than $3000 annually in 1971 compared to half that percentage among the non-Indian local area population. Only 3.5 percent of the Indian people, compared to 15 percent of the non-Indian population, earn in excess of $10,000 annually, while nearly 90 percent of the Indian female labour force members earn less than $3000.

(ii) Subsistence Income

The Indian food fishery appears to be the largest natural resource income source for the Indians of the primary area. Hunting provides a marginal real income while the trapping of furbearers is almost non-existent. Indian people also engage in the collection of natural vegetation for food and medicinal purposes. The subsistence economic activities listed in Table 3.5-30 are estimated to represent at least 23 percent of the total income of Indians in the primary study area.

(f) Education, Health and Housing

(i) Education

A recent study carried out in conjunction with the Union of B.C. Indian Chiefs, concluded that education is one of the most important concerns of Indian families.[18] Table 3.5-31 compares the educational achievements of the Bands in the primary study area with those of the Indian population of B.C., the total population of B.C. and the residents of Ashcroft and Cache Creek. The table shows a considerable gap between the education levels of the Indian and non-Indian population. Only 26 percent of the B.C. population has not achieved higher than elementary education, compared to 63 percent for the total Indian population and 56 percent for the on-Reserve residents in the primary study area.

The level of educational achievement in 1971 for Reserve residents is shown in Table 3.5-31. Studies by Stanbury and others have drawn the conclusion that the education gap between Indian and non-Indian people is rapidly closing.[19] There are indications that this is the case within the study area.

During recent interviews with each of the local school principals, with student counsellors and with members of the local school board administration, a number of points received general agreement:

1. Levels of education achievement among local Indian people were increasing.

2. While drop-out rates and absenteeism for Indian pupils were higher than for non-Indians, there was a steady improvement over the years.

3. There was increasing evidence of Indian parental and Band interest and involvement in the school system.

4. Participation by Indian pupils in extra-curricular activity was increasing.

5. Racial harmony in the school had improved.

It is understood that about seven members of the Bonaparte Band alone were engaged in university or post graduate courses and several more are involved in vocational training. Also, an adult upgrading course (Basic Training for Skills Development) has just been established by Canada Manpower in Cache Creek.

(ii) Health

Indian birth rates are considerably higher than the provincial average. However, the rate of birth decline is about 50 percent higher than for the general population. In 1967, the Indian birth rate was about twice that of the general population but, by 1975, the gap had lessened. The 1975-1976 statistics obtained for the Bands in the primary area show a live birth rate of 13.7 per 1000. This is less than the provincial average and almost half of the average for B.C. Indians as a whole.

The crude death rate for Indians throughout B.C. is also falling gradually and is generally in line with that of the provincial average. The most significant difference between Indian and non-Indian death statistics lies in the rates of violent deaths and infant mortality. The provincial violent death rate for Indians is over three times that of the general population. While Indian infant mortality throughout the province is almost twice the provincial average, no such deaths were recorded among Indians in the primary area during the two years for which data are available.

The primary study area is serviced by the Ashcroft District Hospital and by the four-doctor medical center in Ashcroft. In addition, a health nurse from the Federal Department of Health and Welfare, based in Kamloops and a dentist sponsored by the Department of Indian Affairs, visit the reserves on a regular basis. The hospital does not have a resident doctor, but uses the services of the four doctors practicing in Ashcroft. In addition, at least two of the four Bands have a Band member trained as a resident health nurse.

It is the general opinion of the representatives of the Federal Department of Health and Welfare, the Provincial Department of Health, two local doctors and local employers interviewed that there are no significant health problems specific to the Indian population in the study area. The respondents were also of the opinion the Pavilion Band had slightly more medical problems than the other three Bands in the area.

(iii) Housing

The statistics presented in the native Indian study[10] indicate a housing situation common to many Indian reserves consisting of basic houses, many with few or no services. The housing situation on the Pavilion Reserve was worse than on other reserves. Houses were more crowded, at 1.7 persons per room, compared to 0.8 persons per room for local non-Indian housing and no houses are shown as having bath, toilet, or hot water facilities. The Ashcroft/Oregon Jack Creek bands appear to have the best housing situation, with the majority of houses having bath, hot water and toilet facilities and an occupancy of slightly less than one person per room. Observation during the study showed that the houses on the Bonaparte Reserve appeared to be of a better standard than those on the other reserves.

(g) Social and Community Services

(i) Justice

There existed a general consensus among the people interviewed from the RCMP, the courts, the probation service and the B.C. Police Commission, that crime is not a significant problem among the Indian people in the primary study area. Throughout the province, the rate of admission of Indian people to corrective institutions is over three times that of non-Indian[18] and the rate of admissions to probation is nearly three times that of the non-Indian population.

(ii) Human Resources

The Ministry of Human Resources (MHR) has an office in Cache Creek which services an area that contains all primary area Bands except for the Pavilion Band. The DHR provided information for the month of June 1977 that indicated that transfer payments are considerably greater among Indian people than among non-Indians. The off-Reserve and non-Status Indian population within the MHR area is of the order 5 to 10 percent of the total population, but the proportion of Indians among transfer payment recipients is considerably higher. This would indicate that the current unemployment situation among off-Reserve and non-Status Indians is likely to be as significant as it appears to be for on-Reserve Indians.

A recent socio-economic study concludes that throughout B.C. the rate of children-in-care from on-Reserve homes is over six times that of the general population.[18] This large imbalance is not to be found in the study area and the local MHR manager noted that the incidences of having to take Indian children into care were gradually declining. There is no greater problem with respect to children-in-care with the MHR among Indian people than among non-Indians.

3.5 SOCIO-ECONOMICS - (Cont'd)

(h) Natural Resource Utilization

(i) Fishery Resource

A. Introduction

The fishery is important to the Indian populations of the area because the trout fisheries of the numerous lakes and streams of the primary study area are fished by the Indian people as a recreational pursuit. Also, the salmon fishery of the Fraser River system has traditionally played an important role in the economy and culture of the Indian people who settled in its basin. The importance of the fishery varied, however, among the Bands of the basin according to the relative local abundance of fish and other natural food resources.

In general, it is recognized that the fishery resource is less critical to the current way of life of Indian people, than was the case during aboriginal times. However, it must still be considered important in the maintenance of their cultural heritage and as a alternative source of income.

B. Indian Catch

Pacific salmon and steelhead trout are the major species of the inland Indian food fishery. Table 3.5-33 shows the average composition of the reported Indian food catch for the total Fraser River system.

During recent years, the reported Indian sockeye catch has averaged about 205 000 fish. Over 45 percent of this catch has occurred in the middle regions of the Thompson and Fraser Rivers. The reported Indian sockeye catch has accounted for about 13.5 percent of sockeye escapement and 3.0 percent of the total Fraser run.[20]

It has not been possible to estimate the number of fish taken by the bands in the study area. Table 3.5-34 shows the sockeye catch reported in the Fisheries Management areas closest to these bands. An upward trend can be observed in both the reported catch and the number of permits issued to Indian people throughout the Fraser River system during the last decade.

C. Indian Consumption

The average annual consumption of fish, during aboriginal times by Indians within the Fraser River system, has been estimated at 320 kg/capita.[21] On the basis of M.G. Bennett's more recent catch estimates, Indian average annual consumption throughout the Fraser system is implicitly determined to be about 125 kg/capita. If one uses the reported catch estimates of Environment Canada, then average annual consumption is in the order of 40 kg/capita, compared to an average annual fish consumption of 5.8 kg/capita for Canada.[22]

The fish consumption among Indians living in the primary and secondary impact zones is not known. However, it is suggested by Bennett that, whereas fish is the most important staple in the annual food economy of Indians living from Lytton to Mission City and from Quesnel to the headwaters, fish is no more important than game or wild plants to the Indians of the central Fraser system.[21] Assuming that the annual per capita food consumption of Indian people in the Fraser basin is similar to the Canadian average, the subsistence salmon catch would constitute between 5 percent and 19 percent of total food consumed.

D. Economic Value of Subsistence Fishery

The estimated 1972 income value of the subsistence fishery to Indian people is shown in Table 3.5-35. It is estimated that the fishery added between $1.5 million and $6.8 million to the 1972 income of the Fraser basin Indian population. This represents between $90 and $400 income per capita. Assuming Indian fish consumption in the primary study area approximates the average for the basin, the 1972 income value represented for those Reserve Indians is between $32,000 and $142,000.

(ii) Wildlife Resources

A. Hunting

Indians hunt year round throughout the Hat Creek area, both on and off reserves. Because the Oregon Jack and Bonaparte No. 1 and No. 2 reserves afford good winter range, a significant amount of their effort is reported to be on-Reserve.

The major species hunted is mule deer. Limited records exist on reported off-Reserve kills, although data are not available on total kill. The Fish and Wildlife Branch estimates that the total Indian kill ranges between 15 and 30 deer annually in the area.[10] An estimate of the 1976 net food value of the game harvest to the Indian people on-Reserve is determined at between $175 and $1780 or $1.15 and $8.70 per capita.

B. Trapping

The opinions of Fish and Wildlife Branch officers suggest that the importance of trapping has declined substantially and has been reduced to a minimal level. At the present time, there are 21 registered Indian trap lines located in the Clinton, Lillooet and Merrit districts. None are located in the area potentially affected by the Hat Creek Project and the majority are located west of the Fraser River.

No Indian trap line returns are included in the annual fur returns published for the Hat Creek region.[23] However, Indians are not required to report their catch unless they sell the pelts, at which time a royalty must be paid.

C. Vegetation

The gathering of wild berries, plants and roots of various types is usually conducted by the women and children Band members.

D. Agriculture

The Indian people of the primary and secondary study areas are engaged in agricultural activities both as ranch hands and as entrepreneurs. Their involvement includes utilization of Reserve lands, as well as Crown lands.

Land on the Bonaparte Reserves is only partially developed for agriculture. Irrigation is limited to about 8.1 ha on IR No. 3, with water pumped from the Bonaparte River, while several small fields on IR No. 1 are irrigated by gravity flow from numerous small creeks and springs.[15] A few cattle are grazed by Bonaparte Band members and parts of their range are leased to neighbouring Indian and non-Indian ranchers.

There are approximately 325 ha of irrigable land on the three reserves, but over half of this total is contained in fields of less than 8 ha.[15] With the exception of a few small areas, Reserve lands are generally only suitable for irrigated hay crops. Expected alfalfa yields would range between 10 000 and 14 545 kg/ha.[15]

The rangeland of the Bonaparte Reserves has an estimated carrying capacity of 945 Animal Unit per Month (AUM).

The McLean Lake grasslands, owned by both the Bonaparte and Ashcroft bands, is the most productive Reserve rangeland in the area. At the present time, the total Reserve is leased to the Pavilion Band.

Members of the Oregon Jack Creek Band are also involved in agriculture. The current use of Reserve land is unknown, but Band members have grazing rights for 30 cattle on Bonaparte IR No. 1 and No. 2, as well as Crown lands north of Highway 12.

Among bands in the secondary study area, the Cook's Ferry Band has extensive lease holdings south and southeast of Ashcroft and grazing rights for 582 cattle extending from the Oregon Jack Creek Road south of Spences Bridge. The Fountain and Deadman's Creek bands are also known to be involved in agriculture.

Indian people in the primary study area have a number of water licenses for irrigation purposes permitting withdrawals from Hat Creek and the Bonaparte River.

E. Domestic Water

The Indian bands of the primary study area obtain their domestic water supplies from the local rivers, creeks, wells and springs. The source of most of this available water supply is the snow melt from the Clear Range, the Cornwall and Trachyte hills.

F. Minerals

There is no reason to believe that the gravel and limestone quarry operations presently being carried out on Indian reserves will not continue to serve their present role, with the continuation of the appropriate benefits to the bands.

The question of ownership of mineral deposits below Indian reserves has never been settled. The Department of Indian Affairs stated that they knew of no instances where a Band had mined the metallic, coal, or petroleum deposits below its own Reserves. They also pointed out that no Indians had been involved in the execution of the "B.C. Indian Reserves Mineral Resources Act of 1943".

3.5.10 Recreation

(a) Inventory Format

For each of the geographic areas previously described (see Fig. 2.5-1, Chapter 2.0), a common inventory procedure is generally followed which deals with a series of topics which influence recreational patterns. Current data are presented and where available, past trends are described. Topics discussed include: Setting; Recreational Assets; Recreational Facilities; Activities; Land Capabilities; and Constraints.

(b) Setting

With respect to the setting, the areas of greatest interest are A and B (Fig. 2.5-1) which are bounded by the Fraser River to the west, Thompson River to the east, Clinton to the north and Lytton to the south. It is within these areas that the principal physical impacts of the Hat Creek Project would likely occur.

Apart from the deeply incised Fraser River Valley on the west and the less visually dramatic Thompson and Bonaparte River valleys on the east, the most significant landform found in the area is the Hat Creek Valley itself. This elongated, bowl-like valley is made up of flat to rolling terrain which becomes increasingly steeper as it rises to the crests of the Clear and Pavilion ranges on the west and north and the Cornwall and Trachyte hills on the east. The pastoral quality of the valley is enhanced by the irrigated farms, ranches, open pastures and small lakes and creeks, scattered on both sides of Hat Creek from Highway 12 south to Oregon Jack Creek. Various types of vegetation are found in the valleys ranging from scrub grassland to coniferous forests and alpine meadows. The scattered forests adjacent to the farms and ranches gradually merge to cover the sides of the surrounding hills and mountains. Three principal points of access connect Hat Creek Valley with the Fraser and the Thompson-Bonaparte River valleys.

Water bodies are few and small. Hat Creek, the principal stream in the area, is comparatively short and similar to many other creeks found outside the valley. Pavilion and McLean are the principal lakes. Pavilion Lake is sufficiently large to provide an important fishery but is not comparable in size to other lakes outside the area such as Loon and Green Lake.

The vast majority of lands in the Hat Creek Valley are Crown owned. Some privately owned farm lands exist along Hat Creek south of Highway 12. Indian reservations are found along Highway 12 at McLean Lake and along Oregon Jack Creek. Most of the private holdings are used for agricultural purposes with extensive irrigation on both private and Indian reservation lands along the Creek from its headwaters to the junction with the Bonaparte River. Some private lands are posted against hunting.

All Crown lands fall within the jurisdiction of the Lands Branch which leases large areas alongside private lands for agricultural purposes. Beyond the leased areas, grazing permits are in effect. The Parks Branch administers Marble Canyon Provincial Park located south of Pavilion Lake.

(c) Recreation Assets

Within Areas A and B, there are a variety of natural environmental assets, some of which are conducive to recreational pursuits. In general, the Hat Creek Valley cannot be considered as a destination for sightseers although its pastoral charm provides a pleasant diversion. The Pavilion and Clear ranges and the Cornwall and Trachyte hills provide a backdrop to the Hat Creek Valley and are used by hikers and others who visit the Cornwall Lookout and other viewpoints in the area. Although the Hat Creek Valley itself is not an important scenic resource, Marble Canyon, Pavilion Lake and portions of the surrounding hills and mountains do have significant scenic values.

There are no sites of historic importance in the valley, however, 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 (scattered amongst the surface coal rubble) and opalite, particularly along Medicine Creek. In addition to their attributes, many of the lakes and streams in Areas A and B support fish and provide an important recreational resource for anglers. Tributaries to Hat Creek support a negligible fishery whereas several lakes including McLean, Blue Earth, Crown, Langley, Pavilion, Turquoise, Botanie, Kwotlenemo and Pasulko provide angling opportunities. Only Pavilion and McLean lakes appear adequate in size for boating. A private boat launching ramp is available at Pavilion Lake with access from Highway 12. McLean Lake is much more difficult to approach and lies within an Indian reservation. Access can be limited depending on tribal policies and actions.

The flat to rolling terrain of the Hat Creek Valley and surrounding hills are conducive to recreation 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 vegetative zones including waterfowl and upland game consisting of ruffed, spruce and blue grouse. Also of interest are big game including mule deer, moose, bear and California Bighorn Sheep. A number of recreational assets in the Hat Creek Valley and adjacent areas are shown in Fig. 3.5-6.

(d) Facilities

The only private facility in the area is Vic's Lakeshore Camping located on Pavilion Lake. This facility has 4 cabins, 18 camper-trailer sites and a boat launching ramp. Nearby are 24 private cottages, occupied predominantly by people from the Lower Mainland, the same area that provides the bulk of users for the camping facility. Closer to the project site the Parks Branch maintains Marble Canyon Park which has 8 developed and 18 undeveloped campsites, 10 picnic tables and a beach.

Physical development constraints have tended to limit facilities at both Marble Canyon and Pavilion Lake. Future possibilities for public recreation development can be inferred from the designation of recreation reserves by the Parks Branch. Six such reserves are found in Areas A and B including four at Pavilion Lake, all of which have little or no potential for development because of the lack of useable land. Blue Earth Lake is indicated as possessing moderate potential for picnicking and camping but road and grazing conflicts occur. The recreation potential at Langley Lake is indicated as "very low". Recreational facilities within Hat Creek Valley and nearby areas are presented in Fig. 3.5-7.

(e) Recreation Activities

Activities are a basic measure of the impact of recreation on the natural environment. They include a set of specific outdoor activities which can, in some instances, take place simultaneously. Activities range from fishing and hunting to sightseeing, swimming, boating, skating, hiking and others. The bulk of recreation activities takes place during the summer. This is the period when the weather is most conducive to a variety of outdoor pursuits, access to recreation sites is comparatively easy, tourism is at its peak, school is out and holidays are most common. In this respect recreation is a phenomenon of "peaks" with facility use at a maximum generally for only a few months.

(i) Hat Creek Valley (Areas A and B)

Hat Creek Valley recreation is predominantly generated by people who reside outside the area. The resident population of the valley is so small (only 35 residents) that locally generated activities are not considered to be significant.

Information on current recreation activities in the Hat Creek Valley within Areas A and B was obtained from five primary sources: a home interview and site survey; data from provincial agencies; other Hat Creek consultant reports; data on accommodations obtained from accommodation guides; and information on highway volumes obtained from the Ministry of Highways.

At best, the data collected can provide a basis for the approximation of the total amount of recreation activity that can be assumed to occur. Definitive information is lacking on many activities. The data therefore are only representative of conditions and actual numbers can and will vary.

A. Activity Levels

An estimated 40 350 activity days of all types take place in the Hat Creek Valley and adjacent areas. About 22 900 activity days occur in the valley with an additional 9250 and 8700 days estimated for Marble Canyon Park and Pavilion Lake, respectively. There are large variations on the estimates of total activity days by place and particularly by activity type. By inference, the dominant activities are hunting and backroad travel accounting for about 25 percent and 35 percent of all activity days. Hunting takes place throughout the area with location dependent on species sought. Backroad travel is thought 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 recreation facilities are found.

Angling

Fishing occurs along Hat Creek, although as far as is known, no fishing occurs at Harry, Aleece and Finney lakes (the primary water bodies in the vicinity of the plant and mine site). Fishing resources outside the Hat Creek Valley, of which there are many, generally have higher fishing productivity compared with Hat Creek.

Evidence of fishing activity in Hat Creek was obtained from several sources. The Fisheries and Benthes Report[24] stated that B.C. Fish and Wildlife personnel at Kamloops reported 250 to 1000 angler days per year on Hat Creek and that fishing by children from the Indian Reserve and residents from Cache Creek occurs in the lower reaches. The home interview of Hat Creek residents made by Strong-Hall and Associates indicated that residents of nearby communities fished Hat Creek between Anderson Creek and its junction with the Bonaparte for 1493 angler days.[1] Above this area along Hat Creek, 132 were listed as fishing the "general area".

In addition to Hat Creek other important fishing sites near the plant and mine site are Pavilion Lake and Crown and Turquoise lakes in Marble Canyon Park. The Fisheries and Benthes Report[24] indicates that 10 000 angler days occurred on Pavilion Lake in 1976. In addition to its present use, Pavilion Lake is capable of supporting a substantial increase in angling pressure, however, public access is limited. Pavilion Lake has been stocked with rainbow trout since 1930. Crown and Turquoise Lake, located somewhat closer to the project site, sustained 12 000 angler days in 1976.[24] Crown Lake has been stocked annually since 1936. Angling pressure at Crown and Turquoise lakes is limited because of the small size of the lakes and the difficulties encountered by the Parks Branch in expanding campsites. Langley Lake, although not stocked, sustained 1000 angler days in 1976. Blue Earth is stocked with an average of 2000 fish and annual angler days are listed at 1200.

Hunting

Within the greater Hat Creek Valley hunting takes place for several species of wildlife including deer, mosse, bear and game birds including upland game and waterfowl. No specific studies have been made of hunting in the Hat Creek Valley although inferences can be made from other data. A home interview survey indicated that local area residents hunted for 4515 activity days in the Hat Creek Valley and nearby areas in 1976, including the surrounding mountain areas.[1]

Waterfowl are hunted at several lakes in the valley and nearby areas, however, there are conflicting estimates of the number of birds taken. The Canadian Wildlife Service estimated 882 birds taken in 1976, while the Fish and Wildlife Branch data indicates only 195 were taken. Four upland game species are also hunted in the valley including blue grouse, ruffed grouse, spruce grouse and chukar although it is not possible to calculate the actual number of hunter days expended.

Data on big game hunting in the area indicate that 124 deer, 20 moose, 6 black bear and 3 mountain goat were taken in 1976. Hunter days expended in taking these animals were 4872 for deer, 511 for moose, 150 for bear and 62 for goat.

Swimming, Boating

Swimming and boating are water-based recreation activities that can take place at Marble Canyon Park and Pavilion Lake. Boating, however, is not possible at Marble Canyon as the park lacks a launching ramp. Total swimming activity at Marble Canyon Park cannot be directly determined, however, using certain assumptions, total swimming for both local residents and campers is estimated at about 3370 days.

Boating does take place at Pavilion Lake. One estimate of local boating use at Pavilion Lake indicated 13 000 activity days. This figure must be considered high, however, since the Fish and Wildlife Branch estimate of 10 000 angler days at Pavilion Lake is considered to be a more accurate representation of total boating activity. Swimming also occurs at Pavilion Lake but the amount is unknown.

Camping

Camping in the Hat Creek Valley and adjacent areas can only occur at government campsites at Marble Canyon Park or at Vic's Lakeshore Camping. Marble Canyon Park, where camping is free, operates overcapacity due to campers using picnic table sites for overnight stays. The park had an estimated 6354 camper nights during 1976. Vic's campground with 4 cabins and 18 campsites reported 3447 visitor days, all of whom are assumed to have stayed overnight. Sixty-two percent of campers at Marble Canyon are from British Columbia. The balance are from the rest of Canada, the U.S. and elsewhere. Seventy-one percent of visitors to Vic's campsite are from British Columbia with 58 percent from the Lower Mainland.

Sightseeing

Sightseeing is an activity in which most people participate, often in association with other activities. The number of sightseers on and adjacent to the Hat Creek Valley can only be determined by inference from other data sources. Assuming the ratio of local visitors to total Cornwall Lookout visitors holds for all sightseeing activities, a potential 3867 sightseers could visit the upper Hat Creek area. At the northern end of the valley the majority of sightseers would follow Route 12 between Highway 97 and Lillooet. Highway Department trip purpose data for 1972 indicated that 80 to 85 percent of trips on principal highways in the area were social-recreation. Applying the same ratio to Highway 12, there could have been as many as 62 000 sightseers in 1975 passing through the Marble Canyon in the two summer months, assuming 3.0 persons per vehicle.

Local backroad travel in the general lower Hat Creek-McLean Lake-Pavilion Lake area was calculated to account for 3714 activity days for both local and nonlocal recreationists. This activity is assumed to be independent of sightseeing occurring on Highway 12.

Cottaging

Apart from the 24 private cottages on Pavilion Lake in Area B-1, there are no government cottage leases within the study area except for lakes in Area D. No cottage subdivisions are presently pending in the study area but some 34 subdivisions already exist in Areas B and D encompassing 405 leases, virtually all of which are developed. A review of leaseholders at a sample of sites indicated that approximately one-half of the leaseholders were from the Lower Mainland.

B. Capability and Constraints

Capability

Current recreational use in Areas A and B is not necessarily indicative of future use patterns. Two additional factors should be considered: the demand for recreation and the capability of the land to accommodate increased pressure. The capability of the area to accommodate recreational pressure has been derived from the Canada Land Inventory.

Canada Land Inventory

Capability mapping for recreation is designed to provide an estimate of the quantity, quality and location of outdoor recreational lands. The basis of the recreation classification according to the CLI definition is the relative quantity of recreational use that a land unit can attract per year under perfect market conditions, without undue deterioration of the resource base. This assumes a common level of demand and accessibility for each land unit. There are deficiencies in the use of

CLI classifications, in particular, recreation capability rankings, which pose limitations to their reliability as a planning tool. CLI recreation capability rankings ignore present use and accessibility. A high capability designation of an area for intensive recreation activities is virtually meaningless in remote locations where no road system is planned or where private property and conflicting land uses prevail.

For the purpose of this study, land acreages within CLI recreation capability classes were measured for the major portion of Area A. Canada Land Inventory recreation capability classifications in this area are low and moderate. Most of the area has been rated at 5 and 6. However, the classifications do indicate good hunting opportunity for one or two game species in a significant portion of this zone in addition to viewing wetland wildlife along Hat Creek. Despite these potentials for hunting and viewing, recreational activities within this area are restricted by current agricultural use and private ownership of the land.

Recreation capability classifications for Area B are ranked primarily low and moderate. By far the largest portion of this zone is rated 6 which is indicative of extensive areas of terrain with little topographic variation and low capability for recreational use. Highest capabilities occur around water bodies (in this case the lakes in Marble Canyon) for activities including angling, viewing and camping.

Constraints

The agricultural land reserve classification covers a major portion of the Hat Creek Valley. The intent of the Agricultural Land Reserve classification is to retain certain lands in agricultural pursuits to the greatest extent possible.

The Forest Service has undertaken studies of two types of zones of significance to recreation: recreation zones and sight zones. Recreation zones (which are subdivided into primary and secondary based on their recreation value) are found along the Thompson and Bonaparte rivers, in Marble Canyon, at Barnes and Willard lakes and at other smaller lakes within the Hat Creek Valley. Sight zones, which are also subdivided into primary and secondary, are found predominantly along highways and rivers. These zones are indicative of sensitive viewing areas within which special forest cutting practices are in effect.

The Forest Service also provides limited development at recreation sites known as Recreation Project (RPK) areas. Recreation project sites are found at Barnes and Willard Lakes in Area C and at Blue Earth Lake and Three Sisters Creek in Area B. Potential sites are indicated at Cornwall Lookout and at a small lake southwest of Ashcroft.

The Forest Service has also designated areas known as Recreation Reserves. Recreation Reserves are formal map notations of areas of high recreation value and are recognized by all government departments. These areas may or may not be receiving public use at the present time but the recreation values are reserved for the use and enjoyment of the public and cannot be damaged by timber harvesting.

(ii) Area C - The Bonaparte, Thompson and Fraser River Valleys

A. Setting

The major river valleys which predominantly define Area C and surround the Hat Creek Valley are distinctly different from the quiet pastoral quality of the valley itself. To the east of Areas C-2 and C-3 are Highways 1 and 97, both major trunk highways connecting the Lower Mainland with the eastern and northern portions of the province. Cache Creek, Ashcroft and Clinton, the closest major population centers to the project site are found on these routes with shopping and other community facilities available. Comparatively large concentrations of tourist accommodations and recreational opportunities are afforded by the Thompson and Bonaparte rivers, their tributaries, and several nearby lakes which provide sites for fishing and other water oriented recreational pursuits.

To the west, the dramatic Fraser River canyon is a unique scenic resource distinctly different from the arid Thompson River Valley. Backdropped on the west by the Camelsfoot and Pacific Coast ranges, large irrigated farms lie on bench lands abutting the deeply incised river. Lillooet is the only community of importance, with access afforded by Highway 12 between Carquille and Lytton. Highway volumes and tourist accommodations are quite small in number compared to those in the Thompson River Valley.

B. Recreational Assets

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. The Clear Range with attractions for hikers, Botanie Mountain for naturalists and viewers, the Camelsfoot Range for hunters and the Thompson for fishing, canoeing, rafting and viewing are all important assets. The contrast between the Thompson and the Fraser canyons is unique. The Thompson, arid with semi-desert vegetation, contrasts with the richness of the Fraser's coniferous forested slopes. The Bonaparte, minor by comparison, offers much less topographic relief but adds interest with a series of lakes scattered in the valley floor from south of the town of Clinton.

C. Facilities

Compared with Areas A and B, Area C offers a large number of diverse recreational facilities. Concentrations of motel-hotel and camping facilities are available in Cache Creek, Ashcroft, Clinton and Lillooet. For the vacationer in search of a resort and ranch experience, 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 camp sites at Barnes and Willard lakes southeast of Ashcroft. A number of recreational reserves have been established at a variety of locations scattered throughout Area C. Recreation facilities in Area C are shown on Fig. 3.5-8.

There are an estimated 704 accommodation units in Area C, the bulk of which are concentrated in the Cache Creek area. Units in Ashcroft (Area C-3) added to those in C-2 account for two-thirds of all units in Area C. Over 75 percent of all units are hotel-motel units with the balance trailer sites and campsites found distributed about equally in proportion in all four sectors of Area C. Two sites are listed as dude ranches; one in Area C-1, the other in C-3, south of Ashcroft.

Of decisive importance in Area C is the excellent access provided by Highways 1, 97 and 12. The Clinton-Pavilion Road, of much lower standard, offers the opportunity for circumferential travel around the entire area, allowing the interested visitor to partake in a series of changing and dramatic scenic adventures.

D. Recreation Activities

Dominant activities in Area C are dictated largely by the natural resources and facilities available. Angling is an important pursuit with major opportunities available on the Thompson, Bonaparte and Fraser rivers as well as at Barnes, Kelly and other lakes. Sightseeing, either from highways or backroads, is another important activity. Opportunities for swimming are few, however, rafting and canoeing on the Thompson and Fraser rivers are pursued.

Local Resident Activity Days in Area C

Area C accounts for almost 42 000 local community recreation activity days (excluding Lillooet). This represents 40.2 percent of all local resident activity days compared with 14.3 percent for Areas A and B combined. The most popular local resident recreational activity in Area C is angling, accounting for 37 percent of all activity followed by backroad travel which accounts for 32 percent. Hunting is the least important local resident activity in Area C, accounting for 1170 activity days or less than 3 percent of the total.

There are little data available on the proportion of local to non-local activity in Area C. Day use facilities such as Kersey Lake show a dominant local use pattern whereas resorts cater to recreationists living some distance away. A comparison of total local resident angler effort at selected sites in Area C indicates that by far the most important fishing sites are the Thompson River, Barnes Lake and Barnes Creek areas and the Kelly Lake and Creek area. The Bonaparte River - Kersey Lake - Clinton area are also important fishing locations but are much less significant than the others. Hunting is found at Kelly Lake, Clinton, Barnes Lake and at general locations throughout the area. "Lake and shore" activities are found at Pavilion Creek near the Fraser River; Back Valley near Cache Creek; at Barnes Lake, Barnes Creek and the Thompson River. Backroad travel is not site specific. In all cases, reported backroad travel took place in the "general area" distributed predominantly in Areas C-1, C-2 and C-3 which lie generally in vicinity of Highways 97 and 1 and the Clinton Pavilion Road.

Rafting and Canoeing

One recreational activity within Area C that is generally not found in Areas A and B is rafting and canoeing. The Thompson River from Savona to Lytton is one of the most popular rafting routes in British Columbia. There are three commercial rafting outfitters serving the river, which combined, had 820 guests in 1976, up from 310 in 1974. Canoeing is also popular within the study area although the number of participants is unknown. Canoe routes include the Thompson between Savona Provincial Park and Lytton and the Fraser River between Lillooet and Lytton.

E. Capability and Constraints

Capability

Area C has a wide range of topographic variation with an associated wide range of CLI recreation capability ratings and activities. Recreational activities rated most highly are angling, canoeing and viewing of surrounding terrain and interesting landforms. Historic and archeological sites, also rated highly, occur along the Fraser River and adjacent tributaries as well as within major settlements. It is notable that the high capability ratings in this zone do not reflect present levels of use. Except for the Forest Service developments at Barnes and Willard lakes south and east of Ashcroft and Cayoosh Provincial Park at Lillooet, there are no public recreation developments in Class 2 and 3 lands. Public access to the Thompson River is also quite limited.

Class 4 and 5 lands, usually associated with hunting, waterfowl viewing and scenic viewing in general, are distributed relatively evenly throughout Area C where they are located adjacent to lakes and water courses. The major portion of Area C is given a Class 6 rating, which indicates poor capability for recreation.

Constraints

Large areas of the Fraser, Bonaparte and Thompson River valleys within Area C are included in the B.C. Agricultural Land Reserve (ALR). These locations are for the most part found where agriculture is pursued today. Although the intent of the ALR designation is to maintain agricultural activities, conditional use permits can be obtained for recreational developments.

B.C. Forest Service recreation zones, site zones, recreation reserves and recreation projects (RPK) are also found in Area C. Primary recreation zones are found along the Thompson and Bonaparte rivers but not along the Fraser. Primary and secondary sight zones are found along the valleys formed by all three rivers. Recreation project sites are found at Barnes and Willard lakes in Area C.

Ecological Reserves

Ecological Reserves, which are established by an Order-in-Council to protect a unique ecological feature from intrusions, are open to passive recreational use. There is one ecological reserve (ER 65) within Area C, located approximately 21 km northeast of Clinton along the Cariboo highway. The Reserve comprises 190 ha and its unique feature is a stand of northern ponderosa pine.

(iii) Area D - The Peripheral Region

A. Setting

The westerly half of Area D is distinctly different from the eastern portion. To the west of the Fraser River lie the massive Coastal mountains interspersed with rivers and lakes of outstanding scenic beauty. Access to the area is poor compared with Area C and the eastern part of Area D. Partly as a consequence, recreational use is comparatively low, attracting those desiring a more rugged experience. In Area D-1 the Camelsfoot and Shushwap mountain ranges dominate, with the Fraser and Yalakom the major river systems. In Area D-4 Anderson and Seton lakes provide interesting scenic resources while the southern portion of the area contains the rugged Stein River, presently under study as a primative wilderness area.

Quite different characteristics are found to the east in Areas D-2 and D-3. Both areas are characterized by small lakes, most of them stocked with fish, providing an immense angling resource. The area's hilly and rolling terrain is much different from the mountainous areas to the west. Areas D-2 and D-3 are drier, contain major highways and the city of Kamloops (the largest urban centre in the study region). Population levels are higher, access is easier and recreation activity levels are greater in Areas D-2 and D-3 than in D-1 and D-4.

B. Recreational Assets

Due to its size and physiographic diversity, Area D offers a wealth of recreational opportunities. Active recreation is dominated by the numerous fishing lakes. Lakes such as Kamloops, Bonaparte, Green and Loon Lake on the east and Carpenter, Anderson and Seton on the west are of major size. The many smaller lakes scattered northwest and southwest of Kamloops are of equal fishing significance despite several which are inaccessible except by air. Hunting is important throughout the area with the species sought related to terrain and topography. Birds provide much of the hunting experience in the easterly half of Area D while big game is more dominant in the westerly portion. Scenic values are more significant in Areas D-1, D-4 and the southern portion of D-3 with the dominant snowcapped peaks of the Coastal range creating an exciting visual experience.

C. Facilities

Area D is the dominant source of recreational facilities within the study region. Kamloops is the most important single site for tourist accommodation with several hundred hotel and motel units within and nearby the city. Many of the lakes north and south of Kamloops contain hunting and fishing resorts catering to guests from a variety of places with British Columbia and the Lower Mainland the major source of visitors. The Parks Branch maintains several major facilities in Area D including Loon Lake, Lac Le Jeune, Savona and Big Bar Lake parks. Parks Branch facilities are more dispersed than public facilities, many being sited in less accessible areas. An exception is Savona Park which because of its location on Highway 1 attracts many day use visitors. Accommodation units in Area D are shown in Table 3.5-36.

D. Recreation Activities

Total activity day data for Area D is not available. However, limited information on local usage can be derived from one source. 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.[1] The dominant areas in Area D favored by local anglers include Loon, Green, Kelly and Big Bar lakes. Local hunters use the Loon Lake area as well as sites near Machete and Bonaparte lakes. Green Lake is a great favourite for "lake and shore" activities with over 5000 local activity days reported. Backroad travel is scattered widely with the Clinton-Loon Lake, Fraser-Lillooet and Guichon-Highland Valley areas most favoured. "Other" activities are concentrated at Loon Lake, Deadman Creek and the North Thompson-Kamloops area. In total, of the local recreation activities that take place in Area D, far more occur in Area D-2 than in D-3.

Activity data for non-local residents in Area D is generally lacking. However, some fragmentary information on fishing and hunting activity is available. A comparison of total and local fishing activity for some lakes in Area D indicates that local activity forms a very low proportion of the total. Exceptions are Big Bar and Quiltanton lakes where local angler days account for 46.4 percent and 25.4 percent of the total, respectively. Many lakes in Area D are capable of supporting increases in angler pressure. Lakes being fished at capacity at present are in the minority.

Comparative hunting data are even more rudimentary than that available for fishing. Data which are available inferentially supports the finding, made in comparing fishing activity, that except for the Hat Creek Valley and adjacent areas, hunting by local community residents forms a small proportion of the total activity.

3.5 SOCIO-ECONOMICS - (Cont'd)

3.5.11 Aesthetic Considerations

(a) Comparative Analysis of Visual Qualities

Inventory

In addressing the subject of existing visual qualities within the study area, the logical first step is to prepare an inventory of visual resources which exist at present within the previously described study area boundaries. This is accomplished by the definition of "visual units" or individual scenes, made up of a number of elements such as trees, buildings, cliffs and valleys. (The term "visual units" is more presicely defined below.) It is important to note that this analysis differed from analogous ones performed in other disciplines since groups of elements as opposed to the inventorying of individual units was performed.

After the "visual units" are defined, they constitute the inventory of resources for this discipline. They must then be ranked (or judged in a qualitative and quasi-quantitative way) so that their relative importance or lack thereof may be ascertained. The determination of the quality of "visual units" will be subsequently used to assess the degree of degradation to the "visual units" which will result from the Hat Creek Project (Part IV) and determine the needs for and means by which mitigative measures may be instituted (Part V).

The evaluation of the existing visual quality found within the study area is based on the philosophy that receptor reaction is stimulated by the variety, vividness and unity of the scenes viewed. Further, the components of those factors are the form, line, color and texture of the landscape.

Variety focuses the attention of the observer and its presence provides a richness and diversity which stimulates the observer. Its absence tends toward monotony in landforms, rocks, vegetation and water forms. Vividness distinguishes the intensity of the visual experience by giving distinction or producing strong visual cues to the observer. Unity provides the quality whereby parts are joined together into a coherent unit which stimulates a recognizable experience.

Visual units were identified within the study area as a first step in the visual analysis. 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.

Within the defined visual units (Fig. 3.5-9), the degree of unity, variety, and vividness present in each landscape component was evaluated. The elements which were evaluated are as follows:

1. Boundary definition of the visual unit.

2. General configuration of the landforms included in the visual unit.

3. Terrain pattern.

4. Presence (or absence) of water bodies in the visual unit.

5. Features within the visual unit which stand out due to dominant scale, isolation, distinctive shape or other special characteristics.

6. Vegetational patterns.

7. Cultural and land use patterns. These reflect the presence of human occupation and use of the land for field crops, pastures, grazing areas, roads and other man-made elements.

Components were assigned a rank from 1 (low quality) to 7 (high quality). A numeric rank of 4 indicated an average quality for the study area. Each landscape component of each visual unit was ranked and these rankings are found in Table 3.5-37. The sum of the scores for unity, variety and vividness within each visual unit determined its ranking relative to the other units in the study area.

It should be emphasized that this quantifying procedure for establishing the overall visual quality of the units has the implicit subjective value judgements of the observers in it. It undoubtedly reflects the observers' cultural backgrounds, the context within which the observations were made and the sensitivity of the observers to different environmental stimuli. It was, therefore, deemed appropriate to qualify the numeric ranking of each visual unit by adding a description of the overall visual quality of the unit (which is created by the combined effect of all of the landscape components).

In conjunction with the description of visual quality, the sensitivity to man-made changes was evaluated for visual unity. This amounted to a qualitative assessment of the landscape's ability to absorb change or modification. The most important criterion of a unit's visual sensitivity is its visual quality numeric ranking. A high rank indicates a sensitive area where there is a high degree of unity and/or variety and/or vividness which would be disrupted by the imposition of man-made elements. This does not mean, however, that lesser-ranked visual units also would not be affected by man-made elements.

Sensitivity is also a function of the way the man-made changes are displayed or exposed to the observer in the landscape components. The following list represents guidelines for gauging sensitivity to alteration:

1. Changes occurring on higher locations become more apparent to an observer than ones that occur in lower reaches.

2. The greater the sideslope, the greater the exposure of changes that occur on it.

3. Ridgelines and skylines are sensitive to change because of "silhouetting" effects which occur in these places.

4. Changes that occur along shorelines and water courses are sensitive because of the exposure and contrast between man-made and natural elements.

5. Vegetative type, texture and pattern affect visual sensitivity. Elements placed in bunch grass ranges will be conspicuous, whereas there may be opportunities for screening those elements in forested areas.

(b) Visual Unit Assessment

The visual units described in the following assessment are shown in Fig. 3.5-9. Each visual unit evaluation follows the criteria enumerated above and is based on an analysis involving interpretation of aerial photographs, examination of 1:50000 topographic maps, field reconnaissance at ground level and from a helicopter, review of site photographs and a review of pertinent reports by project consultants.

The visual quality of each visual unit was independently evaluated according to the criteria by three members of the study team. The visual units that were evaluated fell into four different categories of visual quality. The highest level were those visual units having outstanding or unique visual qualities. Next were those units with high or above average visual qualities. The third group were those units with average visual qualities and, finally, there were two visual units having fair to poor visual qualities.

The 10 visual units that were evaluated are shown on Figure 3.5-9. These visual units were determined from the topographic features which describe areas having a continuous sense of enclosure. A field observation of the study area verified the extent and location of the visual units. They included 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. In addition, observations were also made of two special features: Cornwall Lookout and Trachyte hills.

(c) Special Features

The nature of the landscape and the characteristics of the project development indicated the need to include features within the study area which were not within the defined visual units. The two special features described below are the Cornwall Lookout and the Trachyte hills.

The visual quality assigned to the two special features was determined from a comparative analysis with the visual units. The qualitative description indicates the general visual quality of each special feature because criteria for landscape components are not appicable to either Cornwall Lookout or Trachyte hills.

(i) Cornwall Lookout - Special Feature - Visual Quality: Outstanding

The Cornwall Lookout provides a special and unique visual experience to the study area. Located on the highest 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 Lake Valley to the east and northeast. Below the lookout there is a unique vista of the Thompson River, Ashcroft and the existing pattern of the valley floor. To the north, the Trachyte hills dominate the vista from the lookout. However, it is the rugged features of the Coast Range and the ability to look down at the Thompson Valley that provide the unsurpassed vistas from the lookout.

(ii) Trachyte Hills - Special Feature - Visual Quality: High

This special feature was selected because of its significance to the development of this project. Although the Trachyte hills extend along the Highway No. 12 corridor, this observation focuses on that part of the Trachyte hills that has been proposed as the plant site. The area contains both forested and open areas. From various points around the proposed plant site, vistas of Highway No. 12, Marble Canyon, upper Hat Creek Valley and Medicine Creek Valley can be seen. The predominant views are down to upper Hat Creek, Marble Canyon and the Highway No. 12 junction.

3.6 NOISE

The L_{10}, L_{50} and L_{90} statistical noise index values measured during the Baseline Noise Monitoring Programme are summarized in Table 3.6-1. The values of Equivalent A - Weighted Sound Level ($Leq_{(24)}$) and Day/Night average sound level, (L_{dn}), obtained at each site are presented in Table 3.6-2. This table also contains values of the day average sound level (L_d) and the night average sound level (L_n), from which the L_{dn} and $Leq_{(24)}$ values were computed. Upon reviewing the data summarized in Tables 3.6-1 and 3.6-2, it appears that in the majority of the cases no significant differences were found between the fall and winter data at the monitoring sites. At Sites 1 and 2, the noise levels are slightly higher on weekdays than on weekends probably due to increased traffic and to more frequent operation from the nearby cement plant (near Site 1). At both of these sites, the ambient levels were found to be controlled by the prevailing traffic on Highway No. 12 and the day/night average sound levels ranged from 44 to 51 dB(A). At sites 3 and 4, the L_{dn} values ranged between 32 and 41 dB(A), controlled by natural sources such as wildlife, wind and rain. At Site 5, the L_{dn} value was found to be 56 dB(A). The predominant noise source was train traffic, although wind noise was significant on the day that monitoring was conducted.

Informal traffic counts were obtained at Sites 1 to 4 for both day and night during the monitoring period. The 24-hour data, which is shown in Table 3.6-3, was obtained in some cases directly by the monitoring team and in other cases by listening to tape recordings made during the monitoring period. Table 3.6-4 shows the meteorological data that was collected by the measuring team at Sites 1 to 4 during fall monitoring. From this table, it appears that only in a few isolated cases was wind speed found to exceed 7.5 km/hr with microphone wind noise contaminating the data. However, when the L_{dn} of Site 5 was calculated based on the nearby train traffic, it was found to have a value of 54.5 dB(A) which agreed closely with the value of 56 dB(A) derived from the measurements. This implied that the measured L_{dn} was influenced primarily by train traffic and not by microphone wind noise.

CHAPTER 4.0 - RESOURCE PROJECTIONS WITHOUT THE PROJECT

4.1 INTRODUCTION

Chapter 4.0 presents predictions of the physical, biological and cultural base in the Hat Creek region through year 2020. The purpose of the chapter on resource projections is to provide a comparative basis to gauge the environmental impact of the Hat Creek Project on the region through the thirty-five year plant life. Forecasts were developed from an analysis of historical and contemporary resource statistics, projection of historical trends and evaluation of discussions with local residents and municipal, regional and Federal government officials. The forecast models used to make predictions account for present conditions, constraints and plans, as well as proposed private and provincial developments.

4.2 METEOROLOGY - AIR QUALITY

4.2.1 Meteorology

Discounting normal climatic fluctuations, the meteorology of Hat Creek Project environs is not expected to vary from its present state in the foreseeable future. The other projects currently planned for the general area around the plant site (based upon an inventory of projected developments prepared by the socio-economic consultant)[1] are all relatively small and located at considerable distances from the plant site. Although these projects may have localized impacts upon climatic conditions (most likely a slight reduction in visibility due to fugitive dust or other particulate emissions), the impacts should not extend to the plant site area.

4.2.2 Air Quality

The Hat Creek Project is isolated from existing and planned industrial sources of sulphur oxides, nitrogen oxides, particulate matter and other air contaminants. Existing and planned industrial facilities may have a measurable impact on their local air quality but their effect upon regional air quality conditions (and the Hat Creek area in particular) would be minimal.[2] The absence of regional impact is attributed to the small size of these facilities and the fact that most are or will be located in deep valleys. This tends to restrict the spread of airborne contaminants to other areas of the region.

4.3 WATER RESOURCES

4.3.1 Water Quality

Unless there is development of other industry or a marked increase in residential dwellings in the Hat Creek Valley, no measurable change in groundwater quality is anticipated. The projected increase in agricultural land of more than 100 percent by the year 2000[1] could result in an adverse effect on Hat Creek nutrient levels. Industrial and municipal development is expected to be minimal and have little impact on surface water quality. Any future activity which would tend to cause increases in Hat Creek water temperatures, such as vegetation clearing, would be detrimental.

4.3 WATER RESOURCES - (Cont'd)

4.3.2 Hydrology

The groundwater hydrology in the study area has not altered substantially in recent times. Existing data suggest that without the proposed project there will be no noticeable hydrogeologic changes in the foreseeable future.

The runoff regime of Hat Creek and its tributaries is stable and would likely remain so without the project. Future irrigation water requirements could be obtained by increasing the capacity of existing diversions or by building new diversions. Upstream storage, however, would be required for any large-scale expansion of irrigation. Storage would reduce spring freshet flows and extend the duration of late summer flows.

4.3.3 Water Use

(a) Groundwater

Unless other industries, municipal subdivisions or irrigation systems are developed using groundwater in Hat Creek Valley, use requirements will remain at present levels.

(b) Surface Water

(i) Irrigation

The projected water use analysis considered two cases: potential use and probable use. Potential use assumes that the amount of irrigable land is limiting while water quantity and quality are not limiting. Probable use considers all significant constraints. Both cases include, as part of the total, lands that are presently irrigated.

A. Hat Creek Drainage

Potential Use

Table 4.3-1 presents the quantity of potentially irrigable lands in the Hat Creek Valley and their associated water use estimates. The water demand in these subregions was estimated by the same modelling methodology utilized for the present use case (Chapter 3.0) with the following exceptions: potentially irrigable lands were substituted in the analysis; and corn was considered in addition to hay and pasture crops. For each of the soil types, irrigation efficiencies implied by the present use analysis were used for potential use.

It was estimated that 4164 x $10^4 m^3$ of water would be required to irrigate all of the 6033 ha of potentially irrigable lands in Hat Creek Valley. This water quantity is approximately six times greater than that presently being used.

Probable Use

Probable irrigation water use is dependent on the availability of irrigable land and the availability of suitable water. Since the constraint of water availability was found to be dominant, it was assumed that irrigation would continue to be used to assist in the production of forage crops. The availability of irrigable land was assumed to be the same as that reported above.

Analysis of potential irrigation water showed that most surface water resources in Hat Creek are suitable for irrigation use. Exceptions include the few scattered alkali lakes.

The quantity of available irrigation water incorporated the results of the Fisheries and Benthos Report[3] and was estimated by subtracting the monthly fishery resource flow requirement from Hat Creek flows corresponding to an 80 percent probability of occurrence (a risk factor of 20 percent). The resultant flows indicated that the fishery requirements during August and September eliminate the possibility of expansion of present all-season irrigation use without additional storage. The fishery resource also requires a two week flushing flow of 1.42 m^3/s. This requirement can generally be met in the last two weeks in June. Assuming that this timing is satisfactory, water is available for expanded agricultural development during May and the first half of June. The maximum amount of water that would be available for storage would approach 1589 x $10^4 m^3$. This figure was calculated by subtracting the flow requirement from the average annual runoff of Hat Creek (above Carquile). The feasibility of developing reservoirs in the Hat Creek drainage basin was not addressed.

A summary of probably water use predicted by the water use model is provided in Table 4.3-2. A total of 1934 ha of land is projected as irrigated by the year 2000 without the proposed Hat Creek project. The associated water quantity is projected to be 1005 x $10^4 m^3$ per year. This is roughly one and one-half times present irrigation use. Of this, 220 x $10^4 m^3$ would have to be provided by development of new storage.

B. Bonaparte, Cornwall and Oregon Jack Study Areas

Potential Use

The B.C. Ministry of Agriculture (BCMA) identified 8137 ha in the Savona-Cache Creek area as having potential for agricultural production with irrigation.[4] This includes 2405 ha that are presently irrigated. An estimate of the amount of irrigable land lying within the Bonaparte, Cornwall and Oregon Jack drainages is 4500 ha. The potential water use associated with this quantity of land was estimated by multiplying the quantity of land by the annual water use rate for the area, 0.91 m, giving a total of 4095 x $10^4 m^3$. This quantity of water is about two and one-half times greater than that presently licensed for irrigation use.

4.3 WATER RESOURCES - (Cont'd)

Probable Use

The BCMA analysis also identified four district areas totalling 1257 ha which because of size and configuration could be practically developed.[4] The Agriculture Report judged that three of these areas, totalling 786 ha, were favorably disposed to probable irrigation development because of their proximity to irrigation water supplies.[1] An additional 151 ha of land was projected to have a good probability of being developed within the lifetime of the proposed project. The total quantity of probable irrigated lands, then, was estimated to be 2656 ha. This includes 1719 ha of presently irrigated land. The associated water use was estimated at 2417 x $10^4 m^3$. This quantity of water is just over 50 percent more than is presently licensed for irrigation use and about 60 percent of the total potential. Sources of additional irrigation water to fulfill the requirements of probable use have not been explored.

(ii) Livestock

By the year 1996, the cattle population supported in the Hat Creek drainage basin was projected in the Agriculture Report to be 3360 animals.[1] The average daily rate of water consumption for a beef animal is 0.033 m^3/day. This yields a daily livestock water consumption of about 111 m^3/day. Annually this is 4.1 x $10^4 m^3$ which is approximately 70 percent more than is presently consumed by livestock.

(iii) Domestic and Municipal

The population from the present to 1990 in the Hat Creek Valley, excluding the Indian Reserves, is expected to remain unchanged or to show a slight increase. Projected changes in the population of the various Indian Reserves, based on the trend from 1965 to 1975, are negligible to slight decreases. Thus the potential domestic use without the Hat Creek Project will approximate the existing use.

The projected populations of Cache Creek and Ashcroft for the year 1990 are 1595 and 3035 persons, respectively.[5] Based on present peak municipal per capita demands in these centers, the projected water use rate for 1990 will be 7580 m^3/d for Cache Creek and 10 854 m^3/d for Ashcroft. The average daily demands based on 0.910 m^3/d per capita would be 1451 m^3/d for Cache Creek and 2760 m^3/d for Ashcroft. No major industrial plants which would have major surface water use are anticipated in either of these centers up to 1990.[5]

4.3.4 Aquatic Biology

(a) Regional

Regional anadromous salmonid populations can be expected to increase due to federal and provincial stock enhancement and restoration efforts. While longterm plans are subject to change and can fall short of expected results, present enhancement plans call for Thompson River stocks to be increased by 500 000 sockeye, 70 000 coho, 20 000 chinook and 4000 steelhead.[3] The exact time frame in which the stocks can be expected to reach proposed levels is not known but it is not unreasonable to assume that the results of this programme, if implemented, could be in evidence by 1985. Additionally, natural pink salmon stocks in the Thompson River have shown a general upward trend over the last twenty years which can be expected to continue. Estimates of potential salmonid production for the Thompson River are given in Table 4.3-3. It is likely that natural stocks would approximate these values during the life of the project.

Resident fish populations are not expected to substantially increase. Fish stocking is used as a management tool to maintain the quality of regional sport fisheries. Population enhancement in certain areas would likely be reflected by increased utilization. However, increased fishing pressure or habitat deterioration could act to reduce fish stocks in certain areas.

(b) Site-Specific

Without the Hat Creek Project, aquatic populations of the subject areas of the Thompson and Bonaparte Rivers and Hat Creek will be similar to those at present. While the area upstream of the falls on the Bonaparte River is probably capable of supporting large numbers of spawning salmon, salmon access to this area is limited. Removal of the falls would provide access to the Bonaparte River. The resident fish populations of the Thompson River intake may increase slightly, reflecting the increased number of juvenile salmonids present in the system as a result of enhancement efforts.

Rainbow trout will continue to be the dominant fish in Hat Creek. Mountain whitefish will also occur throughout Hat Creek, but in much smaller numbers than rainbow trout. Lower reaches of Hat Creek will support fishes such as bridgeslip sucker, longnose dace, leopard dace, and possibly redside shiner.

Total numbers of rainbow trout in Hat Creek will be approximately 20 000. About one-third to one-half of these will occur in lower Hat Creek. Rainbow trout which are longer than 250 mm or older than 6 years will be uncommon in Hat Creek.

Spawning will occur throughout the length of Hat Creek, primarily between mid-June and late July, with fry emerging from late July through September. Lower Hat Creek will be utilized as a spawning ground by rainbow trout migrating upstream from the Bonaparte River. Further upstream movements will continue to be limited by barriers such as beaver dams and the canyon falls.

Trout will utilize food, principally aquatic insects, in about the same proportion as they occur in the environment. The abundance of benthic food resources should be sufficient to support the fish populations.

4.4 LAND RESOURCES

4.4.1 Terrestrial Ecology

(a) Physical Environment

Climate, landforms, bedrock formations, surficial deposits and soils are important components of the physical environment. It is anticipated that the components of the physical environment would not be affected during the period of project operation. The processes by which these components are altered require long periods of time, many times the expected life of the project. Weathering of parent material during soil formation is one of the processes requiring many decades before changes are noticeable. Climatic changes are also long-term processes. Easily recognizable changes are those resulting from land use patterns such as agriculture, forestry and mining. Grazing and cultivation practices in agricultural areas cause changes in soil through either direct disturbance or alterations in vegetation patterns. Forestry activities also cause changes in soils and physiography through access road development and timber harvesting practices. In open pit mining operations the alterations to the physical environment are obvious. It is possible that some small scale changes may occur to the soil component. However these changes can be expected on a localized basis only.

(b) Natural Vegetation

In general, the distribution and species composition of vegetation communities is a function of many factors including soil, climate, fire, logging, diseases, and insect infestations. Each factor is important to a resource projection and should be addressed in the projection process. Naturally occurring factors such as fire and insect infestations are not easily predicted and may or may not influence the vegetation within the expected operational period of the project.

Projected resource changes in the absence of the proposed development would, in a simplistic sense, reflect patterns of succession. It is highly likely, however, that some perturbations may occur and that succession will not be able to proceed naturally. Logging, fire and insect infestation are three major influences which can have an adverse effect on patterns of succession.

The natural vegetation in the locale of the project has already been subjected to each of these perturbations. Logging has disturbed large areas in the vicinity of the project (Fig. 4.4-1). Future logging activity will depend on regeneration and the productivity of the sites (both of which appear to be low). It would also appear that the potential for expansion of the forest industry within the region of the project is low.

No records pin-pointing the occurrence of forest fires within the project locale were available. However, the presence of lodgepole stands reflects the occurrence of past fires. It would appear from the number of lodgepole pine stands within the project locale that forest fires have played a major role in disturbing successional patterns. It is probable that forest fires will continue to be a major factor in the interior forests of British Columbia even though new control techniques have enabled foresters to limit the number, occurrence and size of fires.

Insects have also been a recurring problem in the area. Seven insect pests have infested trees in the project locale on a periodic basis since the first records were kept in 1912 (Section 3.5-5). Based on this historical record, insect infestations can be considered likely perturbations in the future.

(i) Forest Associations

Four dominant forest associations, Engelmann Spruce - Grouseberry, Engelmann Spruce - Grouseberry - Pinegrass, Douglas-fir - Pinegrass, and Douglas-fir - Bunchgrass - Pinegrass, are found within 25 km of the proposed site. Each of these associations is largely in a successional state due to previous fires and logging. Succession in each of these associations will proceed toward climax unless a major perturbation causes the pattern to be altered. The state to which the association would revert or the extent of the delay in the successional trend toward climax would depend largely on the severity and nature of the perturbation. Assuming that the incidence of fire and insect infestations remains at the present level, no changes are expected to occur in the composition of forest canopy trees.

Grazing land within forest associations has been subjected to varying degrees of use and, consequently, to varying degrees of vegetation disturbance. The major effect has been reduction in grass and shrub cover and an increase in weeds and unpalatable species. It is probable that these forest range areas will not change in the future. However, the value of these areas could increase if the reseeding programmes planned by the government are initiated and recommended range management practices followed.

(ii) Grassland Associations

Three grassland associations, Kentucky - Bluegrass, Sagebruch - Bluebunch Wheatgrass and Big Sagebrush - Bunchgrass, are the dominant grassland associations within 25 km of the proposed development. Grazing areas within the grassland associations, like those in the forest associations, have been subjected to heavy grazing pressure and as a result many of the areas are severely overgrazed. The successional patterns of these ranges have been severely retarded and are in a state known as disclimax. The disclimax is caused by the grazing activity which tends to keep the vegetation in a disturbed state. It is estimated that it would take approximately 20-40 years for the climax communities to become established once the grazing pressure is removed. By reducing the grazing pressure, the range areas are projected to remain in their present condition for many years. Any improvement programmes are expected to have only a localized effect.

(c) Wildlife

Two factors appear to be critical in determining the future wildlife resource in the local and regional study areas: the habitat available for wildlife; and the amount of human interference with wildlife activities.

4.4 LAND RESOURCES - (Cont'd)

(i) Habitat

Without the Hat Creek project, the types and variety of wildlife habitat available in the local study area should remain essentially unchanged. No land use in the local study area has great potential for expansion. Livestock grazing is intense in most areas and could not be expanded under present management procedures. Agriculture has already expanded to a limit imposed by the irrigation water supply. Logging and fires have removed most mature stands of marketable forest timber. Beyond 1990, logging may increase when trees of marketable size develop. Recreational use is generally low and, except for sport hunting, is largely confined to Marble Canyon and the Thompson River.

Mining activities are capable of altering the future wildlife environment. Increased open pit mining is planned in the Highland Valley southeast of the local study area. These activities, plus future expansion, could have major impacts on wildlife habitat in the area through habitat loss and disturbance.

A. Waterfowl

Wetland habitat for waterfowl should remain nearly unchanged through the year 2020. Some minor draining or flooding may occur in conjunction with agricultural land use activities. Unless major draining of wetlands for agriculture occurs, however, the effects would be minor. The net positive and negative effects may cancel each other in terms of waterfowl productivity. If, as anticipated, waterfowl habitat remains largely unaffected, the numbers of ducks breeding in both the local and regional study area should remain approximately the same.

B. Upland Gamebirds

Long-term changes in populations of upland gamebirds are not likely to occur in the absence of the Hat Creek Project. Habitats utilized by these birds would remain virtually unchanged, and their capability to support gamebirds would remain the same.

C. Non-Game Birds

No significant changes in non-game bird populations are expected in the local or regional study area. These species are usually not harvested. Because very few major changes are expected in the Hat Creek local and regional study area habitats, few changes are to be expected in the avifauna.

D. Furbearers

Harvesting of furbearers is currently low; hence, populations are probably near maximum within the limits of annual variation typical of many furbearers. The coyote, however, has been harvested in large numbers. Current harvest has not appreciably diminished coyote population numbers. Without drastic changes in habitat or harvest, no changes in furbearer populations are expected.

E. Small Mammals

As with other non-harvested species, no major changes are expected in local or regional small mammal populations if the project does not proceed. Minor changes would occur as the result of habitat succession or other natural phenomena.

F. Big Game

Within the local study area the potential for deer numbers to increase is high while the potential for numbers of mountain sheep, cougar, and elk numbers to increase is moderate. Black and grizzly bear, wolf, and moose numbers are not likely to increase much beyond their current levels. Mountain goat and caribou have no real population growth potential.

Increases in big game numbers are dependent on:

1. Changes in land use practices.

2. Changes in hunting pressures.

3. Changes in hunting limitations imposed by the government.

4. Improvements in game management practices.

Increases in land used for agricultural, lumbering and mining purposes, and for housing will reduce available habitat for big game animals. Agricultural expansion and opportunities for significant increases in lumbering activities are limited and as such will not restrict growth of big game numbers. Mineral and energy reserves and housing development associated with local population growth, will likely reduce potential levels of big game. In some cases, for example, increases in land developed for housing or mining will include areas already stressed by agriculture. In these situations developments will have minimal impact on habitat loss. Consequently, though human population growth and industrial development may be predictable, their effect on wildlife habitat losses and big game population potential will be determined by the location of such developments.

The predicted human population growth in the local study area is nearly twofold while the regional study area growth may be 2.7 times its current level by the year 2020. These increases will likely affect big game numbers by increasing hunter pressures. Additionally, the rise in hunting license sales was more rapid than the general population growth. Most harvests of big game species have been declining in recent years, however, these declines may reflect the cyclical population characteristics as well as increases in the presence of hunters. The rate of big game population increases is directly dampened by the magnitude of this hunting pressure.

If game populations decline at critical rates, governmental restrictions on hunting seasons and bag limited could be instituted to maintain adequate game resources. The future will bring improved game management procedures to augment the standing stock of appropriate populations.

Assuming minimal governmental involvement and no major advances in wildlife management, it is most likely that big game annual standing stock will continue an overall declining trend through the year 2020. Land use practices and increased hunter pressure will create this net loss in population sizes.

G. Rare and Endangered Species

Predicting the future for rare and endangered species is a difficult task. The mere fact that a species is endangered means, by definition, that its continued existence is imperiled. The local and regional study areas are of very little consequence to world populations of any of the rare or endangered species listed in Table 3.4-14. No environmental changes that would affect the ability of the local and regional study areas to support these rare and endangered species are expected.

(ii) Human Activities - Hunting Pressure

Exploitation will likely remain restricted to those species now hunted for sport, trapped for profit or regarded as pests. These sources of mortality are influenced by human demographic changes and resource management. With adequate resource management, wildlife population levels could be maintained at a level to allow continued sport hunting at current or higher levels of harvest.

The situation regarding furbearers may change in time. Relatively little fur is now harvested in the regional study area in comparison to what could be taken. Fur prices, attitudes of trapline owners and government policy regarding registered traplines will influence trapping activities. Thus, considerable latitude exists for an increase in fur harvest.

Demographic changes are expected to affect hunting within the local and regional study areas. Population increases will yield increases in hunter numbers and subsequently may affect hunting pressures. Certain game hunters are generally unwilling to travel far (such as small game hunters). Human population changes in the local study area could therefore alter annual harvests of these various game species. Grouse and black bear are particularly prone to the type of hunting associated with other field activities.

A. Waterfowl

Expected changes in demand for waterfowl will be a function of access to hunting areas. Hunter access should not improve over the next 40 years unless the number of valley residents increases or the number of people who are allowed to hunt the land increases.

B. Upland Gamebirds

Increases in demand (hunter effort) for local upland gamebird resources were estimated in concert with expected population increases and hunter origin distribution. Demographic projections suggest a growth by 2020 of approximately 150 percent in regional hunters and an anticipated population growth of 70 percent in the Lower Mainland.[2] The total increase in demand is equivalent to a yearly increase in demand for upland gamebirds of approximately 1.9 percent.[3]

C. Furbearers

Regional economics indicate that trapping is not currently a viable economic employment alternative in the area. However, individuals may become interested in trapping for marginal income. Granting additional traplines could increase furbearer harvest. The opportunity for expanded furbearer trapping exists because this is an underutilized resource.

Both the local and regional study area offer many attractive features to resident hunters. Consequently, population increases should result in increased hunter pressure. The large metropolitan Lower Mainland area is relatively near, as is the fast growing community of Kamloops. Access to the southwestern portion of the regional study area would be greatly increased by development of the Vancouver-Pemberton-Clinton transportation corridor.

With an existing potential for increasing present big game numbers, the close proximity to Vancouver, the existing good highway connections, and the present good diversity and numbers of big game species, hunter demand in both the local and regional study areas should increase by about 1.5 percent per year.

(d) Forestry

The basic premise upon which the resource projection was developed is that the productive forested lands required for the project would be managed on a sustained yield basis, according to B.C. Forest Service Regulations. The value of the allowable annual cut (AAC) contributed by these lands was used to evaluate the value of the lands should the project not be developed.

(i) Regional Forestry Resources

The regional forestry resources can be affected by such factors as regeneration success, insect infestations, land use requirements, designation of environmental protection forests, and governmental policy decisions. In the project region, which is characteristically dry, regeneration of clear cut areas can take as long as 15-30 years. However, recent cutting philosophies and improved technology have reduced this time interval. Insect infestation and some future land use requirements, such as mining, have been included in the allowable annual cut calculations. Thus, it is not expected to increase in the absence of the proposed development. It may, however, decrease should environmental protection forests be established regionally. No major expansions of the forest industry would be anticipated since most of the AAC for the PSYU's within the region of the project have been allocated to quota holders. The total timber allocation, expressed as a percentage of the AAC, is 79 percent for the Big Bar, 79 percent for Botanie, 95 percent for Kamloops, 57 percent for Lac La Hache, 81.5 percent for Nehalliston, 93 percent for Nicola and 77 percent for the Halahom PSYU. The remaining percentages of the allocations in each PSYU are rarely issued by the Forest Service to quota holders. The remaining timber can be sold to quota holders requiring additional volumes through district forester sales. The regional forestry resource is expected to remain at its current level.

(ii) Project Locale

Logging activity within 25 km of the proposed project site has been centered in the Hat Creek Valley. One company, Evans Products, Ltd., is currently harvesting 102 000 m^3 of timber from two license areas on an annual basis. It is anticipated that harvesting will continue in or near the valley for the next 10 to 15 years. After this time, logging activity will be minimal while regrowth takes place in harvested areas. During the regeneration time, it may be possible for local contractors to obtain permits for some logging of mature or insect infested timber. It is also probable that the existing multiple usage (forestry/grazing) will continue into the future. The forest economy and logging activity are projected to remain at the present level.

The estimated AAC for the project locale is 146 189 m^3. The MAI contribution to the AAC from the area disturbed by the project, should it not be developed, would range from a low of 2400 m^3 to a high of 3300 m^3. The loss to the AAC cut over the 35 year life of the project would range from 84 000 m^3 to 115 500 m^3 or 1.6 to 2.2 percent of the AAC over the 35 year period.

(e) Agriculture

(i) Crop Production

A. Regional Area

The total land area available for crop production in the regional study area is approximately 4427 km^2, if irrigation is practiced. This area represents the sum of all areas with Canada Land Inventory (CLI), land capability for agriculture (LCA), improved (irrigated and/or drained) Classes 1-4. Only a small amount of this land is presently cropped due to restriction of intensive farming to those lands where irrigation is feasible. If one assumes that the extent of crop land within the Thompson-Nicola Census Division, 322 km^2, is a rough approximation of that within the study region, there remains roughly 4000 km^2 of Classes 1-4 land in the study region not currently cropped. Development of this high capability land would depend largely on the availability of irrigation water.

4.4 LAND RESOURCES - (Cont'd)

Most readily accessible surface water has been allotted to present farm operations. Any additional water supplies must be derived from less accessible and more costly sources, exploitation of which will likely require government-sponsored regional irrigation systems. Institution of a regional system in the Ashcroft-Cache Creek-Savona area has been investigated by the B.C. Ministry of Agriculture.[4] Approximately 22.3 km^2 were identified as potentially developable when irrigation system constraints were considered. The economic feasibility of this plan, however, has not been determined.

It is projected that the probable role of irrigation agriculture in the regional study area will continue to be one of support to the beef industry. Forage crops, grass, alfalfa and silage corn, are expected to remain the principal crops. A major increase in vegetable production is not anticipated because of, the sizeable capital investment required, the present excess of available land and processing capability in the Lower Mainland of the province, and the competitive position held by growers in the Pacific Northwest of the United States. Fruit production is not likely to increase as the risk of detrimental winter conditions discourages commercial orchard operations.

B. Local Areas

Approximately 260 km^2 of the local study area have been ranked CLI, LCA Classes 1-5, representing the total acreage available for irrigated agriculture including irrigated pasture. Forty-five km^2 of this is currently irrigated.

Expanded usage of irrigable lands is restricted by the availability of irrigation water and factors outlined with regard to the regional area. Within the local area only limited opportunities exist for development of off-farm irrigation facilities supplying individual farms or ranches. Part of the area considered in the regional Ashcroft-Cache Creek-Savona irrigation plan, discussed above, lies within the local study area[4]. Five distinct locales in the local study area, totaling 1319 ha, are of sufficient size for further consideration. From an evaluation of water availability it appears that 786 ha of this area is more amenable to development than the remainder. This estimate may be low because additional irrigable lands were identified from the soil map of the site. From evaluation of the soil data, there appear to be approximately 1060 ha of land in the Cache Creek-Ashcroft portion of the site area where irrigation schemes appear practicable.

Placement of additional land under irrigation will be influenced by the same factors noted for the regional area. Analysis of resource capability and market conditions indicates that cattle production is likely to continue dominating agriculture in the local area. An additional 700 to 1000 ha of irrigated land, therefore, would most likely be planted to forage crops. Production of silage corn may increase relative to other forage crops, as corn is an important feed for beef cattle "finishing".

C. Site Vicinity

Probable changes in land area placed under irrigation were projected for the entire site-specific study area and its western portion, upper Hat Creek Valley. Of the 65.5 km^2 and 38.2 km^2 of irrigable land in the site-specific study area and upper Hat Creek, respectively, 17.5 and 8.8 are presently irrigated.

Potential and projected amounts of irrigated cropland (including pasture) are summarized in Table 4.4-1. Projection of probable areas assumes that as much land as economically possible would be irrigated, and that the project is not implemented.

Available all-season water in the Hat Creek Valley is already entirely allotted to farming and fisheries. A current surplus of water during the spring season, however, would permit spring pasture irrigation and, if storage works were constructed, all-season irrigation of croplands. For projection of the probable case summarized in Table 4.4-1 it is assumed that a portion of the spring surplus would be stored, and allotted to irrigable lands on the Thompson benchlands with capabilities of supporting tomato and cabbage crops. Stored water would also be diverted to potential cornland of the Hat Creek Valley. The remainder of spring season water which is not stored is likely to be used for spring irrigation of 4.2 km^2 of pasture. In total, 16.2 km^2 of land in the upper Hat Creek Valley would be irrigated.

Along the Thompson River bench lands in the eastern portion of the site-specific study area, a sizeable acreage of irrigable land may be placed under cultivation or improved pasture if a regional irrigation scheme is implemented. The extent of projected "probable" increase assuming development of the Savona-Ashcroft-Cache Creek area, is roughly 1060 ha, which raises the total extent of probable irrigated land in the site-specific study area to 31.7 km^2.

(ii) Cattle Production

A. Regional Area

Grazing lands within the regional study area are generally utilized to their full stocking capacity considering present range conditions. The area could likely support increased cattle numbers if forest clear-cut areas and ranges were reseeded. Industry personnel have suggested that such reseeding could increase regional carrying capacity by 10 to 20 percent.

B. Local Area

The estimated potential carrying capacity of the local study area range is roughly 90 000 AUM or 15 000 cattle for a six month period. Comparison with the current level of range use, 5000 animals, suggests that considerable increase in carrying capacity is possible. As essentially all rangeland is presently grazed, an increase can only be effected through better management practices, particularly reseeding. Range area administered by the Forest Service will probably improve gradually as a result of careful management. Overgrazed lower grasslands will produce higher forage yields within a period of several decades only if a reseeding programme is implemented.

C. Site Vicinity

Projection of cattle production through a 20-year period was performed for the Hat Creek Valley. This topographical unit was selected for detailed analysis because many of the permit grazing lands of the site area are delineated by watershed boundaries, and because it provides a convenient basis for evaluating the interactive effects of various project actions on ranch productivity.

Projection of cattle numbers was conducted in two steps. Productivity of irrigated croplands was estimated from projected amounts of land placed under irrigation or put into pasture, and range productivity estimated for the remaining land. The two estimates of productivity (cropland and rangeland), were then integrated because year-round support of cow herds can be limited by either winter feed (harvested from irrigated lands) or spring and summer range.

The results of a series of steps and assumptions utilized to project probable numbers of cattle from estimated crop and range productivities are summarized in Table 4.4-2. It can be noted that the smallest number of cattle, 3027 AU, would be supported during the summer season. The total number of AU supported on a year-round basis can be increased above this level by supplementing summer forage with all-season pasture and extended use of spring pasture. With these assumptions the projected probable total AU supported by the Hat Creek Valley is 3476. The estimated increase from 2080 to 3476 would be expected to follow a sigmoidal pattern because of relatively sharp increases in spring grazing capacity during the middle of the 20-year interval.

4.4.2 Cultural Heritage Resources

The number of cultural heritage resources sites in the Hat Creek Valley study area may be estimated from the results of the Phase I and Phase II surveys. In Phase I, 331 grassland quadrats were separated from 234 forest quadrats in the stratification of the study area into a grassland stratum and forest stratum. The survey revealed site densities of 2.37 per grassland quadrat and 0.75_0 per forest quadrat. Multiplication of each density by the total number of quadrats in each stratum results in an estimation of 784.5 sites in the grassland stratum and 175.5 sites in the forest stratum, or a total of approximately 960 sites in the Phase I study area.

The Phase I study area was extended to other likely or alternative project component locations for Phase II sampling as shown in Fig. 2-4.4 (Chapter 2.0). Strata B, C, D, E, H, one quadrat of stratum I and 15 quadrats of stratum J are outside the Phase I study area boundaries. Summing the site projections for these strata given in Table 3.4-29 (Chapter 3.0) and calculating the appropriate projection for the external portions of strata I and J (1 quadrat x 2.04 sites/quadrat, 15 quadrats x 1.75 sites/quadrat) adds approximately 361 sites to the previous estimate for a total Phase I and Phase II estimate of 1321 sites in the areas of Hat Creek Valley likely to be affected by project development. It must be appreciated that these are minimal estimates. The existence of buried or otherwise overlooked sites would increase this estimate.

Number of sites alone are not an adequate measure of the significance of an area, (neither is the number of artifacts at a site a sufficient measure of its importance) however, these numbers provide one measure of the present information potential.

Comparisons of the major types of sites (lithic scatters and cultural depressions) found within the valley to their occurrences outside Hat Creek Valley are difficult. Most of the previous archeological work in the Interior of British Columbia was focused on large stratified sites in major river valleys that could provide chronological sequences for "plateau" archeology.

These comparisons indicate that there exists minimal information on cultural heritage resources which are similar to the sample recorded for the upper Hat Creek Valley. In part, this is attributable to the chronological emphasis in most of the previous research, although the potential importance of sites other than winter village settlements such as seasonal, short-term camps has been noted. Due to preservation factors and the nature and duration of activities carried out, these sites are localized surface scatters of stone tools and debitage and are rarely described in any more detail than being lumped under the general term "chipping stations". The lack of detailed research on such site types is often attributed to their poor archeological visibility and minimal artifact contents. This, nevertheless, does not remove the fact that such sites will constitute the only archeologically-observable evidence of the nature and location of late prehistoric short-term occupations and all types of settlement prior to the introduction of pithouses.

Based on present levels of disturbance and ongoing attrition rates, the general location of the Hat Creek Valley and the present patterns of land use have resulted in relatively little archeological impact. The location of the valley has, until recently, put it outside the areas of economic growth, while the utilization of much of the landscape as natural rangeland has resulted in minimal alteration of the land surface. The major agents of disturbance prior to current studies of the proposed Hat Creek Project have been cultivation, logging, and road construction. Thus, the valley is one of the few tributary valleys in the Fraser-Thompson Plateau region that are relatively intact with respect to extensive land alteration. Other particular valley systems in similar environmental contexts and having ethnographic evidence of occupation (such as the Bonaparte, Botanie and Nicola Valleys) have all undergone considerable modification in the bottom lands and lower slopes, resulting in considerable disturbance of the cultural heritage resource base.

In the Hat Creek study, research potential is evaluated mainly in the context of substantive questions of current interest in plateau archeology. Within this context, methodological, theoretical and technical domains are also addressed in designing and carrying out research aimed at answering the substantive question. Many of the problems currently confronting plateau archeology have already been mentioned; lack of prehistoric cultural adaptation biased towards major river valleys, the lack of regionally-applicable chronological sequence of archeological cultures, and an unrepresentative sample of archeological data biased towards larger sites from those areas which have been investigated.

The cultural heritage resources of the upper Hat Creek Valley have the potential to contribute research results in addressing all of the above problem areas. On the basis of present surface and subsurface investigations, there exist numerous "pure" single component sites to provide information on specific chronological periods. The environmental location of the valley provides the archeological resources necessary to fill critical gaps in present knowledge of the range of variation present within the subsistence-settlement system of the region. The results of subsurface investigations at cultural depressions and the survey data in general are "unique" in the extant literature on the prehistory of the Canadian Interior Plateau. The nature of the resource base also provides the opportunity to test new methods and techniques of collecting archeological data from small lithic scatter sites and cultural depression features and analyzing this information to interpret the social and economic organization responsible for their deposition.

4.4.3 Geology

(a) Introduction

The current potential for resource utilization within the project area is closely related to local economic development as high transportation costs typically preclude the commercial viability of establishing remote markets for raw materials. However, as advancing technology creates new uses for raw materials, the natural resources not currently exploitable in the site area may become attractive for local or remote commercial markets. This section explores the potential for alternate uses of these resources by other industries under currently feasible technology consistent with the present knowledge of the resources, their physical and chemical characteristics and abundance.

(b) Fossil Fuels

The demand for Hat Creek coal could conceivably increase in the future. The high ash, low califoric value, and moisture content of these reserves should continue to restrict its use for home heating in local communities. However, its conversion to synthetic natural gas is both technically and economically feasible. Other conversions to methanol, ammonia, coal liquids, coal solids, or in situ synthetic natural gas are less likely because of technical and/or market considerations.

(c) Minerals

Currently there are no known mineral deposits within the project area that are present in sufficient quantity to warrant exploitation. Thus, the probability of future development without the project is low.

(d) Rocks

Existing quantities of limestone and aggregate within the site region should be more than adequate to satisfy future local demand for home and road construction. Although claystone exploitation is not likely, except as a by-product of coal extraction, the baked claystone could be mined as a primary raw material for use in brick manufacture if the physical and chemical properties prove favourable. Estimated reserves of baked claystone are more than adequate to satisfy the future demand for this resource within the project area.

4.5 SOCIO-ECONOMICS

4.5.1 Population, Income and Employment

(a) Population

(i) Method

Population growth expected to occur in the local study area without the Hat Creek Project has been determined utilizing the population model and assumptions described in the Socio-economic Report[1] and is based on the employment projections in Table 4.5-1. For the remaining areas of the overall region, historical trends and future expectations in the relationship between labour force and population provide the forecasting basis.

(ii) Projected Population

The local study area has an estimated 1976 population of 7500 persons and is expected to grow to a level of 9960 persons by 1990. The geographical distribution of the incremental population among the communities of the area is delineated in Table 4.5-2.

Ashcroft and Cache Creek will likely receive about 60 percent of the increment, due primarily to the mining related developments in the Highland Valley. Clinton and Lillooet could expand on the basis of resource and government oriented projects likely to occur in those areas. The unorganized rural areas are not projected to grow significantly throughout the period.

The project-based forecasting technique employed results in block increases in community population. In utilizing the forecast for community planning one must take into consideration the uncertainty surrounding future development projects in the area, pre-project speculation resulting in service sector employment expansion prior to project commencement, and induced employment creation lagging behind direct project employment.

The remaining areas of the overall region report a current population of 69 800 persons, reflecting an average growth of 4.5 percent annually since 1971.

In a recent study, B.C. Telephone forecast an increase in the labour force proportion to 48.5 percent by 1990 for the interior region of the province.[2] The projection assumptions used by B.C. Telephone have been applied to the residual area of the study region. The resulting population estimates are shown in Table 4.5-2. Overall regional population is expected to grow at slightly over 2.5 percent annually to 1990.

(iii) Characteristics of the Incoming Population

The incoming population, primarily due to the increased mining and related processing activities in the Highland Valley, will have characteristics similar to those of a number of typical resource communities in Canada. This will be valid for the direct and indirect work forces related to the mining activities as well as the induced or service population. For this reason, three resource communities have been chosen and representative characteristics chosen from the comparison of these three communities; Grande Cache, Alberta, as well as Sparwood and Mackenzie in British Columbia.

A. Age

The incoming population will be relatively young, with over 33 percent under 15 years of age and almost 40 percent between the ages of 20 and 39. As the work force becomes more established, the number of people over 50 will likely increase, but, in the initial years, only 6 percent will be in this age group, while one percent will be 65 years of age or older.

B. Marital Status

Almost 75 percent of the incoming population 15 years and older are likely to be married. Approximately one-quarter of the families will be young couples with no children, but on an average, there will be two children per family. Most families will have two or three, although there will likely be more with one than with three. Relatively few families will have more than three children, and the average family size is expected to be 3.8.

C. Households

About 37 percent of households formed will contain only one or two persons. The average household size is expected to be 3.3 persons.

D. Education

About 20 percent of people 15 years and over, not attending school, will have no more than a grade eight education, and an additional 41 percent will not have graduated from high school. About three percent of the population group will have a university degree. These population characteristics will have implications for and provide guidance to the provision of housing and community services in the receiving communities.

(b) Income

(i) Projected Income

Income projections without the Hat Creek Project are derived from the population and employment projections found in the Socio-economic Report.[1] The basis for future income forecasts in the local study area is the payroll of direct and indirect employees identified in the report cited above.

Total employment income is then derived utilizing induced income multipliers of 1.22, 1.18, and 1.28 for Ashcroft/Cache Creek; Clinton, and Lilloet, respectively. Total income for the remaining areas of the Hat Creek Region is forecast on the basis of expectations regarding future growth in real income per capita. All estimates are made in terms of 1976 dollars.

The net increase in local area employment income, utilizing a project specific income multiplier approach, will comprise the following components:

1. Total income earned by in-migrants.

2. Total income earned by existing residents not previously in the labour force.

3. Total income earned by existing residents formerly employed less their former earnings.

4. Total income earned by existing residents previously unemployed less their former transfer payment income.

Average mining industry wage levels are assumed at a 1976 level of $17,000/yr.[1] Average wages for the proposed Lillooet prison are assumed at $14,000/yr. The income multipliers for each community used to determine induced income have been listed above. The multiplier estimation model appears in the Socio-economic Report.[1]

In determining net employment income generated as a result of the identified industrial growth pattern, the main conceptual element that needs to be deducted from gross income is the former transfer payment receipts of previously unemployed locals. Average annual Unemployment Insurance Commission (UIC) payments were reported to equal $1034 in 1976.

The total net income increase expected to occur in the local area without the project is shown in Table 4.5-3. Employment income is forecast to increase from an estimated current level of $37.7 million to $55.5 million in 1990. Employment income represented 89.9 percent of total regional income during 1970. Assuming this relationship holds throughout the forecast period, total local income is forecast to rise from $42.0 million to $61.8 million in 1990.

For the remaining areas of the Hat Creek region, income is forecast on the basis of expected growth in real income per capita since data are not available over a time frame suitable for forecasting. Real per capita income in British Columbia has been increasing at an average annual rate of 4.7 percent over the past decade. A comprehensive and recently published provincial forecast projects a long-term growth in real provincial personal income per capita of 2.5 percent annually.[2]

The expected expansions of the Highland Valley mining industry and the Kamloops and Merritt service sectors would result in continued regional income growth but probably not faster than the province as a whole in per capita terms. It is assumed that real per capita income will rise at an annual rate of 3.0 percent in the remaining areas of the Hat Creek region resulting in an increase from $5900 in 1976 to $8925 in 1990.

(ii) Implications of without Project Income Projections

A. Distributional Aspects of Income Growth

Income distribution aspects discussed include geographical distribution, allocations between existing residents and in-migrants, distribution among existing residents and changes in the overall percentage distribution of income classes.

Major mineral developments expected to occur in the Highland Valley will tend to concentrate income growth in that area with Kamloops benefiting. Logan Lake and, to a lesser extent, Ashcroft and Cache Creek will gain a greater share of the incremental regional income generated.

The majority of the recipients of incremental income would continue to be in-migrants, responding to the employment opportunities created. Among existing residents, the recipients of the incremental income generated would include the existing unemployed, individuals previously not in the labour force and individuals switching jobs to take advantage of opportunities providing them with greater 'total' income.

The percentage distribution of income by income class is likely to change significantly in the local study area. There should be a greater concentration of individuals in the upper income group earning more than $15 000 per year; the middle and lower income groups will decline proportionately and the proportion of individuals on low fixed incomes will also decline on relative basis.

A final aspect of structural change that is likely to occur in the local study area is the relative decline of self-employed individuals. With the commercial expansion forecast in Ashcroft and Cache Creek, it is quite likely that some of the marginal operators will not be able to compete.

B. Price Effects of Income Growth

Kamloops, due to its size and proximity to the relevant small communities, will, to a certain extent, act as a buffer in controlling the extent to which economic shocks affect the price of goods and services; the city will be more effective in minimizing price effects on consumer goods and services than on land.

The extensiveness of land speculation is affected by: 1. the degree to which population settlement and associated commercial expansion can be dispersed among alternative settlement locations; 2. the supply of serviced land; and 3. the degree of concentration of land ownership.

The opportunity for minimizing land price effects exists in the developments related to the Highland Valley. Five communities are located within 40 miles of the expected developments and among them could provide the residential alternative necessary to diffuse speculative price pressures.

(c) Labour Force and Employment

(i) *Projected Labour Force Without the Hat Creek Project*

A. Local Study Area

The projections of future local area labour force without the influence of the Hat Creek Project are developed by assessing the basic growth sectors of the area's economy, identifying specific projects that are expected to occur in these sectors, determining employment associated with these projects and estimating the indirect and induced employment generated by these projects.

Industrial Development Potential

The major sectoral determinants of economic growth in the area have been forestry, agriculture, mining, transportation and the servicing of highway traffic. It is expected that development in the foreseeable future will revolve around the mining sector.

The forest industry has historically been an important contributor to the economy of the local area and it is expected to continue to play an important role. However, future development patterns in the area are not expected to be significantly influenced by the forest sector. Most of the available annual allowable cut, under existing management practices, has been allocated, and there are no known plans for future processing expansion.

Limitations imposed by soils, climate, topography, water supply, transport costs and land-use conflicts, preclude development of the agricultural sector much beyond its current status. Some possibilities exist for expansion of horticultural production north of the area which could promote a vegetable bulk freezing plant in Cache Creek, or for expansion of feed lot operations, but both of these are dependent on significant government policy changes. Even if these policy changes occurred, their effects on total agricultural employment would be marginal.

The area's rail system contains the potential for expansion with the proposed B.C. Rail/C.N. Rail Connector between Ashcroft and Clinton. However, recent events surrounding this development suggest that it is unlikely to occur in the foreseeable future.

The servicing of highway traffic has been a fundamental growth component of the Cache Creek economy and is also highly important to Clinton. This growth has

4.5 SOCIO-ECONOMICS - (Cont'd)

stabilized since 1971 in spite of continued growth in traffic. It is reported that some excess capacity still exists throughout most of the year in the food and accommodation sector of the Cache Creek economy.

It is expected that the volume of traffic will continue to grow over the next 15 years but at a substantially lower rate than has occurred during the last decade. A critical determinant of future volumes in the area is the recently announced government decision to proceed with the construction of the Coquihalla Highway.

Without the development of the Coquihalla, traffic growth on Highways No. 1 and No. 97 in the Cache Creek area is expected to grow at between 3.5 percent and 4.5 percent through the mid-1980's. With the Coquihalla, volumes are expected to return to levels occurring in the mid-1970's.

Given these expectations and the existing over-capacity in the food and accommodation sector of the communities servicing highway traffic, it is not expected that significant employment increases will be generated in the local study area to service traffic flows through the forecast period.

By far, the most significant potential for local employment growth over the next 20 years centers on mining developments in the Highland Valley. The extent and timing of the Highland Valley development hinges on the decisions of four mining companies: Bethlehem Copper Corporation; Cominco Ltd.; Lornex Mining Corporation Ltd.; and Teck Corporation. A "most likely" development scenario has been constructed based on personal interviews with mining company and government representatives. Consequently, the expected development pattern to 1990 appears to be as follows:

1. The expansion of Bethlehem Copper's milling capacity from approximately 18 150 t/d at present to 41 000 t/d by 1979. The net employment increment associated with this expansion would be 180 positions.

2. Expansion of Lornex's existing 36 300 t/d milling capacity by 1979 would create an additional 400 jobs.

3. Second-stage development of the Valley Copper deposit with construction of a 45 360 t/d ore concentrator which could be operational by 1985. About 550 jobs would be associated with this development.

4. Construction of either a copper smelter or a copper processing plant (using hydrometallurgical technology) by Cominco during the late 1980's. The direct employment associated with a copper processing plant would be about 425 persons, whereas a smelter, which has a larger minimum economic plant size, would provide about 500 new jobs. It is assumed that a copper processing plant (rather than a smelter) will be constructed in the Highland Valley during the period 1985-1990, creating 425 direct jobs.

5. The development of Teck Corporation's Highmont Mine property, estimated to mill about 22 680 t/d. It is assumed the plant will be producing by 1990 and would employ about 425 persons.

At this time, the best estimate of total future direct employment associated with increased mining and processing activity in the Highland Valley is 2400 new jobs by 1990. However, by 1979, Placer Development Corporation's Craigmont mine will have been exhausted, resulting in the loss of about 350 jobs. The net regional employment increase associated with mining and processing in the study region is therefore reduced to about 2050 jobs.

In addition to the direct operating jobs created, these projects will also involve considerable short-term construction employment. Table 4.5-4 illustrates the general level of construction manpower required. The large mining developments will require between 18 and 30 months for construction and will have an average labour force during that period of about 70 percent of their peak requirements.

Other projects likely to occur in the local study area include:

1. A rock crushing plant commencing operations in 1977 located at Mackerby, providing 40 direct jobs.

2. A federal penitentiary located at Lillooet with an in-service date of 1979 is expected to provide 200 direct jobs.

3. A lime quarry and cement plant at Clinton, expected to be in production by 1981, would provide 125 direct jobs.

4. Extension of the B.C. Hydro transmission network with the construction of two 500 kV transmission lines between the Kelly Lake and Nicola substations. These lines will be constructed through the 1977 to 1988 period with an average annual labour requirement of approximately 115 persons.

Induced Employment Multipliers

The methodology for estimating induced employment multipliers is discussed in the Socio-economic Report.[1] The resultant multipliers for communities within the local area are as follows: Ashcroft/Cache Creek - 1.42; Lillooet - 1.42; and Clinton - 1.35.

Projected Local Labour Force

The total direct, indirect and induced employment increments expected to occur are shown in Table 4.5-5. Total labour force growth associated with this employment expansion has been shown in Table 4.5-1. The average annual growth of the labour force is calculated to be about 2.2 percent.

B. Total Hat Creek Region

In contrast to the project based forecasting approach used for the local study area, employment levels for the remaining areas of the Hat Creek region are projected based on extrapolations of historical trends in the context of expected future development patterns.

The labour force of the local study area, a subregion of the total Hat Creek region, has been forecast to increase from its current level of 3450 to 4635 by 1990. (See Table 4.5-1). The residual area of the region has a current labour force estimated at 30 850 with 85 percent of the total residing in Kamloops.

The future growth of Kamloops will continue to be largely dependent on resource development in its hinterland and on developments which maximize its locational advantage as a transportation nexus. One potential element in Kamloops' future that could alter this established pattern would be government decisions to meaningfully decentralize provincial and/or federal administrations.

The main source of future employment generation in Kamloops will be in the tertiary sectors of the economy. All indications point towards a lower rate of future labour force growth in Kamloops than has been the case in the recent past. Given the magnitude and type of developments that are expected to take place, long-term growth in the order of 3.5 percent would appear reasonable for the foreseeable future. Under this assumption, Kamloops' labour force would grow from its 1976 level of 26 300 persons to about 42 600 persons by 1990.

The remaining areas of the total Hat Creek region include Merritt, Logan Lake, Lytton and rural communities east of Ashcroft and Cache Creek. The growth potential of these areas is essentially tied to expansions in the agriculture, mining and forest industries as well as the growth in highway traffic. The major impetus will come from the previously mentioned mining developments in the Highland Valley.

With this type of development potential, long-term labour force growth in the order of 2.5 percent annually for the other communities of the Hat Creek region would appear reasonable. Under this assumption, the current area labour force of 4550 persons would increase to 6400 persons by 1990.

Projected labour force growth in the total Hat Creek region is shown in Table 4.5-1. It is expected that the region's labour force will increase from 33 775 persons in 1976 to 52 930 persons by 1990 without the influence of the Hat Creek Project.

(ii) Implications of Without Project Employment Projections

The rate and nature of growth expected in the Hat Creek region, without the project, could have a number of structural implications for the regional economy. On a broader scale, the overall development of the provincial economy during the next decade could affect the availability of construction labour throughout the region.

A. Seasonal and Cyclical Stability

The prevailing level and pattern of seasonal unemployment in the region are not expected to undergo any significant changes during the forecast period. This implies no major shifts of labour to the sectors experiencing seasonal unemployment; no technological changes which would reduce seasonal unemployment; and, in the case of tourism, no development of a year-round tourist industry.

The study region's reliance on the forest industry has been a major factor in the deteriorating employment situation experienced during recent years. Sawmilling is highly sensitive to changes in lumber prices, which fluctuate considerably, and is likely to represent a continuing source of imbalance in the region's economy. The level of mining activity in the region is not sensitive to short-term or cyclical variations in prices for primary metals.

According to the scenario developed here, an upswing in both direct and induced construction employment should accompany mining investments in the Highland Valley during the late 1970's to early 1980's.

B. Unemployment Without the Project

Unemployment among males is concentrated in the forestry, construction and transportation sectors while unemployment among females is concentrated in sales, service and clerical categories. Unemployment is disproportionately high among the younger members of the labour force. Women experience proportionately higher unemployment than males.

The level of future unemployment in the study area is closely tied to demand for the region's primary exports, basically forest products, copper, and to a lesser degree, tourism and recreation. The timing of a recovery in export markets is highly uncertain. It is also uncertain whether Kamloops has the ability to attract a significant amount of economic activity which is independent of the exploitation of the region's natural resources.

It was assumed in the scenario for the region's future economic development that activity in the forest industry would return to its pre-recession level, but not increase, and that investment in the copper deposits of the Highland Valley would proceed during the late 1970's and continue through the late 1980's. The scenario constructed here would imply a significant reduction in the level of unemployment in the region during the late 1970's and early 1980's.

C. Construction Labour Supply

Any projections of the future state of the construction industry are perilous due to the sector's instability. Manpower forecasting and planning techniques for this sector are not sophisticated, and subject to uncertainty. Given these complexities, a general survey of possible future industrial and engineering projects in Western Canada, and a broad assessment of factors affecting the future supply/demand situation regarding construction labour has been undertaken.

Construction employment related to possible future investment projects in the region, excluding Hat Creek, is estimated at 7600 man-years over the forecast period 1976-1990. Although it is expected that a more competitive market for construction labour would prevail in B.C. during the late 1970's to early 1980's, it is not anticipated that the projects which would come on stream during that period would experience difficulties attracting construction labour.

4.5.2 Community Land Use

Without the proposed project, it is expected that land uses within a 25 km radius of the project would remain stable in the future with forestry and agricultural activities continuing to dominate.

The potential exists, however, for an intensification of agricultural use in this area. Based upon agricultural capability ratings, approximately 10 percent of the local area has a potential for intensive development (capability classes 1 through 4, improved rating). These lands are located in the valleys and benches of the Thompson, Bonaparte and Fraser Rivers, on the plateaus east of Pavilion, and in the Hat Creek Valley itself. At the present time only about two percent of the area within 25 km of the project is under cultivation.

Similarly, lands with a high capability for grazing (Grazing Capability Classes 1, 2 and 3) are located on secondary benches adjacent to the rivers and at lower mountain elevations in the Hat Creek drainage basin. These lands, which comprise about 50 percent of the 25 km area, are currently in use by local ranchers. However, it has been estimated that the potential carrying capacity for grazing in the area is three times greater than its present carrying capacity. This suggests that in the future the cattle industry may show further expansion in these lands of high grazing capabilities.

The other significant land use in the local area which may be subject to change in the future is mining activity. There currently does not appear to be any economic viability to a further expansion in this sector, however, other than the exploitation of coal resources.

Built-up land use areas will probably expand with the natural growth in population. These changes are expected to be minor, as the population growth forecast for the local area is comparatively modest - an average of 42 percent for the periods 1976-1990 for the communities of Ashcroft, Cache Creek, and Lillooet. Population in the Hat Creek Valley itself is expected to remain stable at 35 individuals.

4.5.3 Housing

(a) Ashcroft

The quantity and type of housing demanded will vary according to the following factors: 1. population increase; 2. ability of prospective consumers to pay for housing; and 3. lifestyle preferences of prospective consumers.

The estimated incremental population of Ashcroft and Cache Creek to 1990 would be approximately 970 and 580, respectively. Without the project, it is projected that Clinton's population would be stable until 1981, when it is anticipated that construction would commence on the Columbia Lime Plant. At that time, it is estimated that the population would increase by approximately 315 people, with the population expected to remain stable until 1990. Lillooet's population is expected to be stable until 1979, at which time the Federal Penitentiary Project is expected to start. At that time, it is estimated that the population would increase by about 500 people. Subsequently, the population is anticipated to remain stable until 1990.

Because the majority of the new Ashcroft residents would be associated with copper mining in the Highland Valley, it is assumed that the average household size and income profile of new families, and the housing mix demanded would be similar to that found in the Village of Logan Lake. The housing mix in Logan Lake is outlined as follows:

	Percent of Total	Estimated Household Size
Single family and duplex	54	3.6
Mobile Homes	21	3.6
Townhouses	4	3.0
Apartments	21	2.1
Average		3.26

The household size estimated for the incremental population in Ashcroft is 3.6, 3.6 and 2.1 for single family and duplex, mobile homes, and multi-family units, respectively. These estimates apply equally in the case of Cache Creek, Clinton and Lillooet.

Table 4.5-6 provides the estimated number of additional dwelling units required to house the expected increased populations in Ashcroft, Cache Creek, Clinton and Lillooet. Because of the stable nature of the population and the existing housing mix, it is anticipated that of the new dwelling units required in Clinton and Lillooet, a higher proportion would be single family dwellings than in Ashcroft or Cache Creek.

4.5.4 Services

Based on relevant standards and population forecasts for the Hat Creek study area without the project, projections of facility, staff, and land requirements, operating costs and capital costs are presented for each service system from 1977-1990. Detailed information regarding the existing services and projected requirements is provided in the Socio-economic Report.[1] A summary of that material is described below for each service system.

(a) Requirements for Education Services System Without the Project

(i) Elementary Education

The graph of elementary student enrollments, Fig. 4.5-1, shows the predicted trends of enrollment from 1976-1990 for the elementary schools in Ashcroft, Cache Creek and Clinton. In these three communities, enrollment is expected to increase gradually and the number of classrooms and staff needed will also increase slightly. Total elementary student enrollment in the service study area is expected to increase from 1976-1990 by 39 percent. Over the time period, 1976-1990, the elementary school enrollment of Ashcroft, Cache Creek and Clinton would increase by 44 percent, 39 percent and 29 percent, respectively. Each of the elementary schools in the study area has sufficient space to accommodate the increase in elementary students for several years.

Clinton's elementary school should reach its capacity by the 1981-82 academic year, two additional classrooms would be sufficient to handle the requirements of the increasing student populations in Clinton from 1981-1990. Ashcroft's elementary student population can be accommodated up to the 1985-86 academic year. From 1985-1990, three extra classrooms will be required in Ashcroft.

In order to maintain the present level of teaching quality in the service study area it is anticipated that by 1990, seven additional teachers would be required in Ashcroft and Cache Creek and three in Clinton.

The operating costs of schools in British Columbia were approximately $1490 per student during the 1975-76 academic year. This cost includes staff salaries and the cost of maintenance and services. Based on 1976 dollars, the increase in elementary student enrollment could result in an increased operating cost of $528,950 in the service study area by 1990.

(ii) Secondary Education

Secondary student enrollment in the service study area is expected to increase over the next 13 years at a rate similar to the anticipated growth in elementary student enrollment. These enrollment projections are shown in Fig. 4.5-1. The secondary school enrollment in Ashcroft from 1976-1990 should increase by 37 percent and the junior secondary school by 35 percent.

Ashcroft's secondary school presently has space for an extra 22 students, and is expected to be operating at full capacity by 1979-80. Eight additional classrooms would be required to handle the increase in students from 1980-1990. The junior secondary school in Clinton has room for an extra 121 students and is not expected to reach its full capacity by 1990.

In Ashcroft, 11 extra staff could be necessary between 1977 and 1990. Three extra teachers could be needed in Clinton between 1979 and 1990.

The additional secondary student enrollment up to 1990 could result in an increased school operating cost in the study area of $333,760 (in 1976 dollars) on the basis of the B.C. average cost per student for the 1975-76 academic year.

(iii) Continuing Education

During the past decade, enrollment in this type of education has quadrupled throughout the province. The continuing education courses in the study area have been available for only 4 years and do not reflect the provincial trend yet. As interest in the courses is increasing in the study area, it is expected that enrollments also would increase in the next few years to reflect the B.C. trend.[3] Changes in the types of courses that are in demand[3] reflect a switching from courses in hobbies and crafts, to college credit courses and courses providing vocational training.

(b) Requirements for Health Services Without the Project

(i) Hospital

The Ministry of Health maintains that an average occupancy of 70 percent is a suitable rate for a hospital of 33 beds and suggests that Ashcroft and District General Hospital could support a patient-day volume of approximately 9000-10,000 days.[4]

In projecting the hospital requirements in the service study area to 1990, the 1976 hospital occupancy rate of 46.2 percent was assumed to remain constant over the 14-year period. Based on the standard of 4.25 hospital beds per 1000 population, the Ashcroft hospital should be able to accommodate the increased population to 1990.

Additional staff would be necessary over the next 14 years to handle any increase in admissions. Assuming the present occupancy rate and the existing ratio of staff to patients remain constant over the 14-year period, the following staff could be required at the Ashcroft hospital:

1979	1 to 5 additional staff
1981	1 to 3 additional staff
1985	1 to 3 additional staff
1987	1 to 3 additional staff
1990	1 to 3 additional staff
Possible Total:	5 to 17 additional staff

The 1976 hospital budget included an approved operation cost of $932,809.

(ii) Medical

Based on the 1976 population of 5280, there is a ratio of one general practitioner for 1320 population in the service study area. Assuming that this standard is maintained, it is anticipated that one additional physician would be required in the service study area over the next 14 years.

(iii) Dental

Based on the standard of one dentist for 2500 population in rural areas in B.C. there is an immediate need for two dentists in the service study area which would meet the needs of the population increase up to 1990. The capital cost of setting up a facility for one dentist is $40,000-$45,000 for a rental office and $65,000-$70,000 in a facility built by the College of Dental Surgeons. The operating costs associated with that office would be $70,000-$80,000 annually.

(iv) Public Health

The Public Health Branch of the Ministry of Health recommends that one additional public health nurse is presently needed in the Ashcroft Public Health office.[5] There are plans to add this extra nurse in 1977. Also, it is felt that a minimum of one home care nurse is needed to provide home care services in Clinton. When these two nurses are added to the Ashcroft office, the staffing should be adequate to meet the needs of the increased population to 1990.

(v) Mental Health

There is an immediate need in the study area for mental health services. The Mental Health Branch of the Ministry of Health suggests that services be initiated in the study area by locating one mental health worker there who would be attached administratively to the Kamloops Mental Health Centre. This mental health worker would require one part-time clerical staff and 25 m^2 of office space. The operating costs would be approximately $26,000/yr.

(vi) Ambulance

The level of ambulance service required in the study area will depend on demonstrated need. One additional full-time employee is presently needed to operate the second ambulance located in Ashcroft. One additional ambulance and one full-time employee should be necessary by 1987 in Ashcroft and Cache Creek.

The operating costs for the ambulances in Ashcroft and Cache Creek could be $30,000-$45,000/yr. The operating costs for the Clinton detachment could vary from $4000-$8000/yr.

4.5 SOCIO-ECONOMICS - (Cont'd)

(c) Requirements for Recreation Services System

Communities in the study area are lacking in recreation facilities and the existing ones are being used at close to capacity. Each community surveyed expressed the need for additional recreational facilities.

Population in the study area is expected to increase by approximately one-third over the next 14 years. Upgrading of existing recreation facilities would assist in meeting the needs of this population growth. The community halls in Ashcroft and Clinton, and the swimming pool in Ashcroft need special attention, as suggested by representatives in the study area.

In addition to the upgrading of existing facilities, the communities in the study area already have reached a size where a demand has been expressed for other recreational resources. The increased population in future years would put further pressure on this demand.

Although recreation facilities are provided within village boundaries, rural residents also make use of these services. In the study area, the rural population wanted the use of curling and bowling facilities and resources for children.

Given the constraint of covering operating costs and the range of response that were received in the survey, it is possible that the future needs of the study area residents could be met by a multipurpose recreation complex that could be used and costs shared jointly by Ashcroft, Cache Creek and Clinton.

(d) Requirements for Social Services System

The Ministry of Human Resources' requirements are determined by caseloads. Because caseload standards are not available, the average population per Human Resources worker for B.C. regions, excluding the Lower Mainland, was applied in calculating requirements for the service study area. Given the population projections, no additional staff or facilities would be necessary to 1990.

(e) Requirements for Cultural Services System

As the population grows, the demand for cultural activities and all forms of entertainment tend to increase. However, there is sufficient space in existing facilities in Ashcroft, Cache Creek and Clinton to accommodate a few additional activities organized by those communities.

Projections of library services in Ashcroft, Cache Creek and Clinton based on the standards of the B.C. Library Development Commission, indicate that the existing facilities and staff of the three libraries would be adequate to 1990.

(f) Requirements for Other Services System

The existing corrections staff would be sufficient to handle any increases in the population in the service study area over the next 14 years. One sheriff is needed presently to provide sheriff services for the area, including Lytton and Lillooet, as well as Ashcroft and Clinton. Other

(iv) Roads

A. Proposed Intersection Improvements

The 1962 Ministry of Highways improvement plan basically involves providing four travelling lanes on both sections of the Trans Canada Highway and the Cariboo Highway. As of December 1977, the Ministry of Highways has no firm schedule to undertake the four laning improvements within Cache Creek. The Ministry of Highways has indicated that these improvements would be required regardless of the extent and timing of population increases in Cache Creek and Ashcroft.

B. Local Roads

Local roads are generally considered to be adequate to accommodate anticipated population increases without the project.

(v) Storm Drainage

No major trunk storm sewerage facilities are required in view of the general accessibility of natural drainage features.

(c) Clinton

(i) Water and Sanitary Sewage System

It is expected that no major improvements would be required to adequately handle the population increments anticipated without the Hat Creek Project.

(ii) Roads

Roads have adequate capacity for the existing population and projected increases to 1990.

(iii) Storm Drainage

No major trunk storm drainage facilities are required in view of the general accessibility of natural drainage features.

(d) Regional Infrastructure

(i) Projection of Traffic Volumes

The Coquihalla Highway will provide an alternative route through the Interior, connecting Hope to Highway No. 5 in the Merritt area, via the Coquihalla Pass, and the Coldstream Valley. The proposed route should be in operation by the mid-1980s, according to current plans.

4.5 SOCIO-ECONOMICS - (Cont'd)

4.5.5 Community and Regional Infrastructure

(a) Ashcroft

(i) Water System

The following improvements are required to adequately service the existing population, as well as the incremental population anticipated to 1990 without the Hat Creek Project: 1. a new water intake; and 2. distribution system in North Ashcroft, reconstruction of Elm Street booster station and supply main improvements.

(ii) Sanitary Sewage System

Once current improvements are completed, additional improvements would be required to accommodate the projected population increases to 1990.

(iii) Roads

Major expenditures on upgrading would not be required to accommodate projected population increases to 1990.

(b) Cache Creek

(i) Water System

If a policy was adopted to limit further development in East Cache Creek and to direct new development into the several vacant areas where adequate capacity exists for complete infilling, there would be no need for upgrading of the existing water system components. The existing inadequacies in available fire flows in the east section would remain uncorrected.

(ii) Sanitary Sewage System

Given a treatment plant with a rated capacity to serve a population of 5000, and trunk main facilities with adequate capacity, improvements would not be required to accommodate population projections to 1990.

(iii) Solid Waste Disposal

The site has ample capacity to accommodate the needs of both communities in the foreseeable future.

1. Each category of expenditures included operating and maintenance costs, capital (debt retirement) and purchase of capital items from general revenue.

2. All estimates are expressed in constant 1977 dollars.

3. It is assumed that sewer, water and garbage services are totally self-sustaining and therefore are excluded from the projection of expenditures.

4. It is assumed that there will be no contributions to a reserve fund.

5. It is predicted that costs will generally rise approximately in proportion with the projected increases in population.

The revenue which must be generated by property taxes is determined by taking the difference between projected expenditures and projected revenues from nonproperty tax sources.

The sections to follow provide budgetary and fiscal related information for the municipalities of Ashcroft, Cache Creek, Clinton and Lillooet.

(b) Projected Expenditures and Revenues

Table 4.5-8 provides the projected expenditures and revenues for the municipalities of Ashcroft, Clinton and Cache Creek. These estimates, based on the projecting approach outlined in the previous section, reflect population growths in these three communities.

(c) Assessment and Property Tax Rates

On the basis of restricted value assessments (as opposed to using current actual values in the determination of individual assessed values), it is projected that assessed values would increase in direct proportion to Ashcroft's population. The property tax rates (mill rates) required to generate the necessary revenue requirements are presented in Table 4.5-8.

For Cache Creek, the proportion of total values represented by commercial values in 1976 is disproportionately high. This proportion is expected to decline as additional residential development takes place. It has therefore been assumed in projecting assessments that the residential component would increase proportionately with population. It has also been assumed that the commercial component would increase somewhat slower, although a sizable shopping center is planned for the community. The projected assessments and mill rates for Cache Creek are found in Table 4.5-8.

Table 4.5-8 also contains the projected property assessments and tax rates for Clinton. Assuming that Clinton does not undertake any major capital works projects, it is expected that tax rates would be maintained at a low level.

The Ministry of Highways estimates that without the Coquihalla Highway, summer traffic volumes at the China-Bar Tunnel on Highway No. 1 would increase from 8500 vehicles/day in 1976 to 13 300 in 1986. An extrapolation of this projection to 1991 results in an estimated volume of 15 700 vehicles/day during that year. Summer traffic volumes just south of Ashcroft average about 90 percent of the levels at China Bar. The Ministry estimates that 1986 volumes on Highway No. 1 with the Coquihalla Highway would approximate levels experienced during 1974.[8] Table 4.5-7 contains these projections.

The projections for Highway No. 97 refer to a point immediately north and south of the junction with Highway No. 12. The summer average daily traffic flow at this point is projected to increase from 6700 to 11 500 vehicles/day between 1976 and 1991.

Summer traffic volumes on Highway No. 12, recorded near Pavilion, are small, averaging about 400 vehicles/day. An extrapolation of historical trends over time indicates an increase to about 550 vehicles/day by 1986 and 600 vehicles by 1991.

Traffic flows recorded intermittently at the Carquile Junction with Highway No. 97 indicate that the volume of traffic at that point on Highway No. 12 is about 50 percent higher than at the point south of Pavilion. It can be expected that traffic volumes west of the Hat Creek Junction would continue to exceed volumes near Pavilion by about 300 vehicles/day (i.e. a total volume of 900 vehicles/day).

(ii) Utility Projections

A. B.C. Hydro

No problems are foreseen in providing electrical supply to Ashcroft, Cache Creek or Lillooet.

B. B.C. Telephone

No problems are foreseen in providing the required additional telephone service in each of the four municipalities.

C. Inland Natural Gas

In each of the three communities of Ashcroft, Cache Creek and Clinton, no problems are foreseen in providing expanded service.

4.5.6 Local and Regional Government

(a) Introduction

In projecting expenditures, the following approach was used:

With provincial government assistance, total annual costs are expected to be reduced to approximately \$95,000. Total costs per capita would not be significantly higher than present costs and as such, rates would not be altered significantly. Without government assistance, it is estimated that user rates would have to be increased by approximately 30 percent to a level of approximately \$120/yr per user.

(ii) Cache Creek

With respect to sewer services, it is anticipated that the existing annual rates of approximately \$120 per residential lot would be adequate for the forecast period. Existing water facilities would generally be adequate to accommodate projected population increases to 1990. The exisint water rates of approximately \$165/yr for an average residential lot are relatively high. No further increases are expected in the near future.

(iii) Clinton

A. Sewer

The existing sanitary sewer system is generally adequate, with only minor extensions required to accommodate an increase in population to 1120. It is therefore anticipated that the existing annual rates of approximately \$75 per residential lot would not have to be increased significantly in the forecast period.

B. Water

Based on the need for upgrading of the water system (alternate groundwater sources, upgrading mains for fire flow), the village has projected that capital expenditures of approximately \$110,000 would be required (equivalent to approximately \$12,000/yr. Under the Water Facilities Assistance Programme, the village would be eligible for an annual grant of approximately \$9000. Resultant costs to the village would therefore be approximately \$31,000. In 1976, projected revenues were \$21,000. As such, existing rates of approximately \$50 per residential lot would have to be increased significantly to approximately \$75-\$80 per lot. The resultant rates would still be relatively low compared with rates in Cache Creek and Ashcroft.

(iv) Lillooet

Although existing water and sewer rates are relatively low, (water - approximately \$77/yr for an average residential lot and sewer - approximately \$50/yr), it is anticipated that rates would have to be increased to finance the improvements required to both systems.

4.5.7 Social Environment

The study area would undergo steady but slow economic growth from the present time until 1990, if the anticipated industrial development projects occur and the Hat Creek Project does not proceed. New

4.5 SOCIO-ECONOMICS - (Cont'd)

(d) Water and Sewer Services

(i) Ashcroft

A. Sewer

The following is an analysis of projected costs for the upgrading of the sewer system, showing costs to the village with and without the existing assistance available from the federal and provincial governments.

		Estimated Annual Costs
1. Capital Costs		
- New Works	$141,200	
- Existing Facilities	24,700	
		$165,900
2. Operating, Maintenance plus Contingencies	54,000	54,000
TOTAL		$219,900

Without any assistance, therefore, the annual cost to the village would be approximately $220,000. With assistance under existing provincial and federal programmes, however, the annual cost to the village is reduced to approximately $100,000. In order to raise this amount, it is anticipated that the following rate structure would be imposed:

1. Sewer utility rate - $6.00/mo or $72.00/yr.

2. Frontage tax - $2.80 per front metre.

Assuming an average lot frontage of 20 m, total annual sewerage costs would be approximately $130/yr per user.

B. Water

The estimated capital cost of improvements required to accommodate population increases in Ashcroft to 1990 is $280,000, which is equivalent to a debt retirement payment of approximately $30,000/yr. Assuming this work is undertaken in 1980, annual costs after that date are estimated as follows:

Item	Estimated Annual Expenditures
Capital - Debt Retirement	$ 62,000
Operating and Maintenance	65,000
TOTAL	$127,000

4.5 SOCIO-ECONOMICS - (Cont'd)

Most communities in the study area would have only minor problems meeting their housing, land and physical infrastructure requirements up to 1990. The adequate provision, location and choice of housing and land would be a major factor in attracting and retaining residents. This, as much as any other factor, would contribute to the quality of life of the residents and the communities in the study area. If the communities wish to take advantage of the situation, steady growth would allow for careful planning to meet community needs.

The valley may return to a state reminiscent of its rural, agricultural past and the residents would be able to continue with their lifestyle. Members of the remaining valley families who have expressed interest in living in the valley may not make that commitment under the circumstances. The grazing and agricultural potential of the valley may be increased if further irrigation is developed, benefiting both the study area and the region. However, plans for the development of the coal deposits by B.C. Hydro would continue to be a factor in the valley residents' plans and, therefore, may affect the implementation of any expansions or improvements they might contemplate.

Issues, however, may arise should the Hat Creek Project not proceed. The social environment of the Hat Creek Valley has been altered by the exploration, bulk sampling and environmental study phases of the Hat Creek Project. Also, B.C. Hydro has major land holdings in the valley and some residents have relocated. The expectations of many residents have been raised in anticipation of the project. Actions already have been taken assuming approval of the Hat Creek Project. If the project does not proceed, these communities and residents would be directly affected.

4.5.8 Native Indian Studies

(a) Demographic Characteristics

The rate of growth for on-Reserve populations would be strongly affected by the perceived relative attractiveness of life on and off the Reserve. An improvement in the levels of Indian employment in the study area, without the Hat Creek Project, would serve to reduce the pressure on Reserve residents to move away in order to obtain employment. The increased financial stability that employment would bring residents is likely to be reflected in a general improvement of the socio-economic environment of the Reserves and, therefore, would probably further serve to negate some of the pressures that have been found to cause Indians to leave their Reserves.

It is forecast, therefore, that the percentage of.Band members leaving the Reserves in the study area would stabilize over the study period. Since the total Band population would increase, the on-Reserve population would also increase. This growth can be expected to be in the order of 110-140 persons to the year 1990.

(b) Labour Force and Employment

Steady economic expansion is being predicted in the local area, largely on the basis of expected mineral-related developments in the Highland Valley. These developments are likely to generate in the order of 2500 permanent direct, indirect and induced opportunities in the area over the next 15 years, as well as a large number of short-term construction jobs. Natural turnover in the present economy of the study area in itself generates a significant number of job opportunities.

mining operations are anticipated in the Highland Valley and Clinton might be the location of a lime and cement plant. Planning is underway for a new federal penitentiary in Lillooet. It is projected that nearly two-thirds of the incoming population would locate in Ashcroft and Cache Creek with relatively small growth in the remaining areas. The communities may not likely be able to absorb the increased population without community disruptions. Regardless, a decision not to build the Hat Creek Project would result in some social impacts on the study area especially in Cache Creek, Ashcroft and the Hat Creek Valley as discussed below.

While there is an immediate need for some services, irrespective of the amount of growth in the study area, other services would be able to accommodate the expected population until 1990. As the availability of services is an important part of the quality of life in any community, the projected service needs should be met if the study area communities plan to develop as stable, cohesive entities. This would be especially important if the Hat Creek Project does not go ahead because of the existing expectations of the residents that action would occur. Some communities like Cache Creek would need to work hard in order to keep the existing residents and attract newcomers.

If the project does not proceed, and the anticipated population growth generated from the other projects is realized, several positive attributes of the community may be enhanced. The first characteristic is the small rural nature of the communities. With a slow but steady growth rate until 1990, the communities most likely would be able to absorb this growth with few problems. This would allow the retention of the small town, friendly atmosphere which so many residents indicated was a major attribute of the community. The communities should continue to keep their family orientation which many residents said was a desirable setting for raising their children. A steady population growth would allow these characteristics to remain as they are now, or, perhaps, be enhanced.

Another desirable attribute of the area is the existing natural environment, offering access to the out-of-doors and associated recreational amenities. With a steady, but relatively small population increase, the recreational amenities of the area would not be over-utilized. The environmental deterioration feared by some residents, from the development of a large industry, would not occur, and, therefore, the environmental quality of the region may not be appreciably affected. Because of this environmental quality the area would retain and possibly continue to draw new residents.

As the steady population growth primarily would be related to mining, the incoming residents probably would have similar demographic characteristics to the existing residents, especially in Ashcroft. Because of this, and the relative stability of the existing communities, it is anticipated that the level of social problems in the communities would see little change, possibly increasing at a rate proportionate to the population increase. The existing problems related to alcohol and juvenile activities can be reduced if the proper services are provided, as discussed previously.

As noted in the Resident Survey, while many people in the study area favoured large increases in the population, an even greater number indicated steady growth as being desirable. The relatively steady growth situation which would develop without the project would allow the communities to support a stable economic base and thus reflects a desirable growth profile. While Ashcroft would probably continue to see some turnover in the mining industry, the population growth over the longer time period may allow further integration of the existing and new residents into the community. Clinton, potentially affected by the development of the lime and cement plant, would see its population stabilize with some growth occurring, which, however, would only take up the existing surplus service capacity.

4.5 SOCIO-ECONOMICS - (Cont'd)

The 1971 survey indicated the need for 1042 new houses, suggesting that the situation is deteriorating. The B.C. Socio-economic Development Commission, in its 1977 report,[11] concluded that old housing, new family formations and perhaps rising expectations, are creating a heavy demand for new units.

Improved housing standards on Reserves would probably be achieved only as a result of improving the employment/credit capability of on-Reserve residents, or by extending the amount of funds available for on-Reserve construction. There are indications that both of these things would happen to some extent in the future. The previous sections on employment and population suggested that the socio-economic status of Indians in the study area would improve in the future and it is understood that the Central Mortgage and Housing Corporation (CMHC) is considering extending the range of on-Reserve programmes.

(e) Natural Resource Utilization

(i) Fisheries

There is some evidence that the Indian catch per capita has been growing in recent years, but the data on which this trend is observed are questionable.[12] It is maintained that Indian salmon consumption per capita would remain fairly stable through the projection period, but that overall consumption would increase commensurate with population growth. The real value of the consumption is expected to increase in line with the historical relationship of fish prices to the general level of prices in the economy. Trout fishing by Indian people in the lakes and streams of the study area is likely to increase in the future provided that stocks are maintained to sustain increased fishing effort.

(ii) Wildlife

Without a major change in the general profitability of trapping, it is considered doubtful that this activity would engage a significant number of Indian people in the future.

Hunting in the hills and meadows of the study area is reportedly a popular activity among Indian males. The current kill by Indians is estimated at about 15-30 mule deer annually.[9] Given the priority hunting rights of Indians, it is considered unlikely that their average kill would decline significantly. On the other hand, without substantial game management inputs, it is unlikely that the resource would expand. The expected result, therefore, is that the kill per Indian hunter would likely decline over time.

(iii) Vegetation

Because the nature or extent of current use is not known it is not possible to make any reasonable judgement as to their future use.

4.5 SOCIO-ECONOMICS - (Cont'd)

There are currently some 70 Indian members of the labour force not regularly employed, and on the order of 100 people would need to be accommodated in the labour force over the next 10-15 years. It would seem reasonable, therefore, that many of these could be employed over that period if the numerous barriers to Indian employment can be overcome. It is the detailed environmental consultant's judgement that the next 15 years will see a substantial decrease in these barriers and a corresponding increase in the level of Indian employment in the study area.

(c) Income

A quantitative projection of Indian income without the Hat Creek Project cannot be confidently developed. However, it is likely that income levels among Band members would rise in real terms if involvement in the wage economy takes place.

(d) Education, Health and Housing

(i) Education

The without project forecasts of student population and facility expansions, developed for the overall Hat Creek socio-economic studies, are not expected to significantly alter or influence the trends in local Indian education. The in-coming population will be mostly non-Indian. However adverse effects on racial harmony and, consequently, Indian educational achievements, will be mainly a factor of the attitude of the local Indian people themselves.[9]

(ii) Health

Without the Hat Creek Project, it is expected that population and economic growth in the study area would increase steadily over the next decade. The future health standards of the Indian people might be expected to reasonably correlate with their economic and social welfare.

The Hat Creek socio-economic study indicates that as long as staff increases are commensurate with population growth, there should be no significant capacity problems among the area's health services that might create particular concerns for the Indian people. The major community deficiencies identified relate to dental and mental health facilities. Health services would be improved for both Indian and non-Indian people in the local area to the extent that population growth encourages the provision of these facilities.

(iii) Housing

It is difficult to predict the extent to which housing conditions on the Reserves within the study area would improve in the future. Inadequate housing is of primary concern to Indian groups and government. The 1973 Biennial Housing Survey carried out by the Department of Indian Affairs showed that of the 6124 homes on Reserves in British Columbia, 1042 were in need of major repair, with an additional 2468 new houses needed.[10]

outdoor experience may find no diminution even if the number of wildlife taken is reduced. Others may range farther afield, penetrating into areas more remote from present activity locations.

(b) Forecasts

(i) Population Growth

An indication of potential recreation demand, particularly in Areas A, B and C, (refer to Fig. 2.5-1, Chapter 2.0), is the forecasted population growth in nearby communities. Population forecasts without the project have been prepared for nearby communities. For the Hat Creek Valley itself, it has been forecasted that population would remain constant at 35 individuals. Growth forecast for nearby communities is comparatively modest, rising about 33 percent over the period from 1976 to 1990. Growth in unincorporated areas was determined to be zero due to annexation of new growth areas by local communities.

(ii) Future Recreational Activity Growth

Recreational pressure on the Hat Creek Valley in the future, as it is today, would be brought about by two groups: those who live nearby and can visit the area and return home within a day; and those who are visitors, staying at nearby public or private facilities. While there are differences by type of activity, total recreation in the valley is estimated at present to be approximately 49 percent non-local and 51 percent local.

In future years these ratios may change, as could the total number of recreation activity days. The changes could depend on many factors among which are the growth in population of both participant groups, recreation activity participation rates, increased per capita and household income, access, the availability of facilities and their cost, and the availability of new or substitute recreation areas to accommodate crowding at existing areas, as well as increased total demand.

Reviewing the available data for past years on highway volumes, private accommodation units, Parks Branch site numbers and use, growth in fishing licenses and other inferential information, the conclusion drawn is that future growth in recreation pressure on the Hat Creek Valley would be more a result of growth in the population of the Lower Mainland and elsewhere than increases in the local area itself. The evidence points to very large numbers of non-local residents on the major highways, the majority of whom are on social-recreational trips (with increasing numbers bringing their accommodation with them). Growth in highway volumes in the past decade, even on major highways, has occurred at twice the rate forecast for local population growth. For local highways, including Highway 12 which provides access to the Hat Creek Valley, increases have been higher, ranging over 100 percent. Local attendance records show that a majority of users of local recreational facilities are from the Lower Mainland, thus it is reasonable to assume that recreational growth would rise accordingly and that local pressures could form a diminishing proportion of the total.

4.5 SOCIO-ECONOMICS - (Cont'd)

(iv) Agriculture

Agricultural potential has been indicated for Reserves No. 1, No. 2 and No. 3.[13] It is suggested that some agricultural development would take place on the Reserves during the next 15 years. Although the cited report suggests a potential irrigable area of 325 ha on the three Bonaparte Reserves, in soil capability terms the economic potential is likely not that high. The lands "are broken into many parcels, some of which are too small for large-scale mechanized agriculture".[13]

It is suggested in the Agriculture Report that there is unlikely to be any major economic incentive to expand agricultural output in the area during the foreseeable future.[14] Even so, it is considered likely that there would be some limited ranching development on the Bonaparte Reserve before 1990. If this involved 25 percent of the irrigable land on Reserve No. 1 and No. 2, this might comprise about 33 ha of irrigated land and would likely require additional grazing land to that available on the Reserves.[14]

(v) Water Resources

In addition to irrigation demands, water would be utilized for domestic purposes. Reserve populations have been projected to approximate 475 persons by 1990. Assuming no major change in per capita water requirements, total use would be in the order of 90 m^3/d. It is not possible to determine whether this demand would require additional water licenses or whether it would be met by an increase in groundwater withdrawels.

4.5.9 Recreation

(a) General Projections

Regardless of whether the Hat Creek Project proceeds or not, there are several overriding issues that could impact recreation in British Columbia, the Hat Creek Valley and surrounding areas. First is the future growth in the provincial population. There is no reason to anticipate any leveling or decline in the number of provincial residents in future years, nor can income levels be expected to drop. Tourism would continue to be promoted and the number of visitors from other areas would, it is hoped, increase, further bolstering the provincial economy. Technology would continue to make mobility easier and the potential for more people to penetrate areas hitherto difficult for access would probably rise. All-terrain vehicles, trail bikes, snowmobiles and other recreation equipment together with extended leisure time would combine to increase pressure on outdoor recreational resources. In response, goverment would have little choice but to continue to limit fishing catches, set hunting bag limits, and reduce pressures on important habitat areas. None of these steps are new. They would likely become more important in future years if the natural resources of the province are to remain productive. The consequences of these forces on recreation can be two-fold; the number of recreationists may rise but the recreation experience may decline - less fish per fisherman, fewer deer per hunter, more people per hectare of beach; or the types and patterns of recreation may change - new activities may substitute for current activities when the rewards become unsatisfactory for the effort expended. This may affect consumptive recreation activities most strongly. In contrast, those hunters or fishermen who are more intent on simply seeking an to use. If and when such an event would occur is unknown, dependant as it is on goverment policy. However the opportunity to reduce pressure at Marble Canyon while at the same time enhancing recreation at Pavilion Lake would appear to be a reasonable course of action.

It is assumed therefore that public access at Pavilion Lake would be improved and activity levels would rise in proportion to increases in highway volumes commencing within the next decade. Overnight use at Marble Canyon Park would remain constant, but day use is assumed to rise in proportion to increases in highway volumes.

Without evidence to the contrary there is no reason to assume that the distribution of activities within the valley by type and location would vary from the distribution estimated at present. The dominant single activity would consist of back road travel followed by hunting and angling. Reduced consumptive success rates per hunter and fisherman can be assumed if no increase in the resource occurs. Whether this would result in a decrease in total activity days is unknown. However, it may be reasonable to assume that sportsmen would be satisfied with lower yields per unit effort or would seek game elsewhere. As the bulk of hunters and fishermen are from British Columbia, pressure would likely increase equally with population province-wide. Improved access to the north may lure hunters to new areas, however, the degree to which this would affect local hunting pressure is unknown.

(iv) Growth in Recreational Activity by Local Area Residents

Activity day data for residents of Hat Creek, Ashcroft and Cache Creek show that an estimated 104 356 activity days occurred in 1976-77. Almost one-third of these activity days was spent angling, approximately 30 percent in back road travel, over 15 percent in "other" activities, slightly less than 15 percent in "lake and shore" activities and 7.6 percent in hunting. About 14 percent of all local recreation takes place in the Hat Creek Valley, and at Pavilion Lake and Marble Canyon. Another major location is the Clinton-Loon Lake area, accounting for about 22 percent of all activities, and the Ashcroft area, which accounts for about 18 percent.

In general, local recreationists show a strong proclivity to partake in activities at sites close to home. For both Clinton residents and Cache Creek-Ashcroft residents, about one-half of all activity days take place within 20 to 30 km of home.

(v) Future Local Recreation Activity Days

There are some data on increases in recreation participation rates for both Canada and British Columbia but none at all for local area residents or for workers at mines and powerplants. It is probable that rates would rise but how rapidly is difficult to determine. Inferential evidence of possible future growth rates can be gleaned from other sources. Fishing licenses for B.C. residents, for example, rose about 54 percent in the past 9 years. Hunting licenses showed an erratic pattern with no pronounced upward trend. Data on park attendance were similarly erratic with an upward trend in attendance

4.5 SOCIO-ECONOMICS - (Cont'd)

The government has encouraged this growth and continues to do so. Tourism is important to the economy of British Columbia as it is to the communities of Cache Creek, Ashcroft, Clinton and Lillooet, all of which endeavor to attract visitors to their areas. Tourists or visitors are recreationists, either active or passive.

(iii) Future Activity Levels

The forecast for growth in recreational activities in the Hat Creek Valley without the Hat Creek Project is based on several assumptions. First, and most decisive is persistence of the existing agricultural land use pattern. Agriculture is the dominant activity in the valley floor, much of the land is irrigated and the potential exists for expanding irrigation to further areas. Deeded, leased and permit lands are all used for hay growing and grazing and there is no reason to assume this pattern would not persist. Further strengthening the case for continuation of the agricultural pattern is the designation of much of the area as agricultural land, indicating government policy to continue and strengthen the existing land use patterns.

Further support for the assumption of no major change in land use pattern is the absence of any existing recreational facilities or proposals for new ones (except for proposals to install primitive facilities at Blue Earth Lake by the Forest Service). There are no major water bodies in the valley to attract development and access is comparatively poor. In addition, Canada Land Inventory interpretations, while pointing to several areas of comparatively low recreational potential, indicate the area has good potential for agriculture (for which it is already used). In addition, areas in the valley denoted as recreational resources appear to have poor potential for development. These assumptions do not imply there will be no growth in recreational activity in the valley. There is no reason to believe, however, that existing patterns will change dramatically. It is assumed therefore that recreational activities will grow in some relation to increases in population (local and non-local) and general visitor tourist activity.

For the non-project case it is assumed for the Hat Creek Valley that future activity day levels would rise at different rates for resident and non-resident recreationists. Growth in resident activity days is assumed to rise at the same rate as the forecasted increase in the population of Cache Creek and Ashcroft (residents of these communities are the dominant source of local recreationsists found in the valley). However, an increase in participation rate of only 5 percent per year is anticipated. Non-local growth is assumed to rise in proportion to highway volume increases on Highway 12 in the vicinity of Highway 97, which have been estimated as 100 percent per decade.

Growth at Marble Canyon and at Pavilion Lake are not assumed to increase at the same rate as the Hat Creek Valley. Marble Canyon campground is already overused and expansion of the site is difficult if not impossible. A more probable answer to future growth is to create a public facility at Pavilion Lake which is large and capable of accommodating more fishing pressure. To create public access would require acquisition of private lands, as recreation reserves along the lake have been evaluated and are impractical it is expected that without the project, increases in traffic volume would result in increases in the ambient noise level by about 1.5 dB (A) and 2.5 dB (A) by 1986 and 1991, respectively. Therefore, it is expected that the future increase in the ambient noise at residences along Highway 12 without the Hat Creek Project would be negligible.

Without the project, the maximum increase in traffic noise levels along Highway 1 and 97 is expected to be about 3 dB (A) and 2.5 dB (A), respectively by 1991, providing the Coquihalla Highway is not built. If the Coquihalla Highway is completed by the mid-1980s, it would be until about 2005 before the traffic noise along Highway 1 around Cache Creek increased by 3 dB (A) above present levels.

4.6.2 Increases in Railway Traffic

Train noise from both the Canadian National (CNR) and Canadian Pacific Railway (CPR) mainlines is the basis for the ambient noise levels at the location of the makeup water intake and riverside pumping station, which are just north of Ashcroft.

Based on current CPR predictions of rail traffic growth through Ashcroft, it is expected that it will take 25 years for the train traffic volume to double and hence cause an increase of 3 dB (A) above the present ambient levels.

4.6.3 Population Changes

Where no dominant sources of noise such as highways, railroads or factories are present, the ambient noise level can be estimated on the basis of population density. Such noise levels increase steadily with increases in community population density. The three major areas where existing human populations would be exposed to noise from the Hat Creek Project (i.e. the Bonaparte Indian Reserve 1, the Hat Creek Valley and the residences near the confluence of the Bonaparte and Thompson rivers), are not expected to see significant increases in population density.[1] Therefore, no significant increases in the existing ambient noise levels are expected in the foreseeable future.

4.6.4 Changes in Land Use

Without the project, no significant changes of land use patterns are expected in the Hat Creek Valley or on the Bonaparte Indian Reserve 1. Also, no significant land use changes are expected in the Trachyte Hills surrounding the plant site or around the proposed site for the makeup water intake at Ashcroft. Consequently, no significant changes in the existing ambient noise levels are expected in the future.[2]

noted in recent years. However, growth in park facilities such as campsites and picnic tables in the region was substantial, with increases ranging close to 200 percent in the past decade. Highway volume increases in the vicinity of the project area have risen between 70 percent and 200 percent in the past 10 years. Growth in accommodation units has also shown a mixed pattern but growth has been strongly upward, particularly from 1965 to 1975 in Area C-2, which lies close to the project site (see Fig. 2.5-1, Chapter 2.0).

Using these increases to infer commensurate rises in recreation activity levels involves a degree of judgment. Although the evidence points to increases in recreation activity to which rises in traffic volumes, recreational facilities and licenses are responding, there is no direct tie between the factors. To ignore past increases as not being indicative of future recreation growth would however be unduly pessimistic. It is assumed therefore that increases in activity rates would rise between 50 percent and 100 percent per decade in future years basedon growth in recreation related facilities and licenses. In applying the increase locally, an assumed 5 percent annual rise in activity rate is forecast for the local study area population.

There is no clear-cut evidence to infer that the future distribution of recreation days would differ markedly from those occurring at present. Local recreation patterns are strongly oriented to sites well within the 100 km study boundary with Areas C-2, C-3, D-2 and D-3 strongly favoured. Only 2.9 percent of total activity days takes place beyond Kamloops, north of 100 Mile House or south of Lytton and Merritt.

4.5.10 Aesthetic Considerations

It is apparent from the preceding sections that:

1. Within the Hat Creek Valley, industrial developments including mining, would be insignificant and located at considerable distances from the proposed powerplant.

2. An intensification of agricultural use in the Hat Creek Valley could occur.

3. Little, if any, physical expansion of existing recreational facilities or new acquisition of recreational lands is anticipated in the Hat Creek Valley.

In conclusion, visual aspects of the Hat Creek Valley and environs are expected to remain virtually unchanged from their present conditions if the Hat Creek Project does not proceed.

4.6 NOISE

4.6.1 Increases in Highway Traffic Volumes

Traffic noise from Highway 12 is the primary source of ambient noise levels at essentially all residences on Bonaparte Indian Reserves No. 1 and 2. Hence, changes in Highway 12 traffic volume would affect these ambient noise levels. Based on traffic predictions made by Strong, Hall & Associates Ltd.,[1]

PART THREE

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