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Hat Creek Coal Liquefaction Project Steering Committee Report

to the
Energy Development Agency
June, 1981

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HAT CREEK
COAL LIQUEFACTION PROJECT

COAL LIQUEFACTION STEERING COMMITTEE
REPORT TO THE
ENERGY DEVELOPMENT AGENCY

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Liquid fuel processing from Hat Creek coal a distant possibility

By PETER COMPARELLI
Sun Victoria Bureau

VICTORIA — Production of gasoline and other liquid fuels from the Hat Creek coal deposits near Lillooet is technically feasible, but unlikely in the near future, Energy Minister Stephen Rogers said Wednesday.

Rogers said it would take a sudden leap in the world price of oil to make an expensive alternate energy project such as Hat Creek coal liquefaction attractive to investors and the provincial government.

"It's a great fallback we have, but I think oil's got to be \$65 to \$70 a barrel before anybody starts putting any money into it."

Social and environmental concerns also would have to be satisfied before the government considers such a project, Rogers added.

The minister's comments followed the release Wednesday of a June 1981 report by government experts. The study was initiated in 1980 after some Japanese companies proposed building a coal liquefaction plant at Hat Creek.

The plant would use 42,000 tons of coal a day to produce a daily total of 54,000 barrels of gasoline, jet fuel, diesel fuel and light fuel

oil — using a South African process whereby the coal is first gasified, then converted to liquid products in synthol reactors.

A coal liquefaction plant would cost \$5.6 billion in 1980 dollars to build and would directly employ 2,300 permanent workers, said the report, which concluded the project would be technically feasible and economically viable.

Since 1981, however, world oil prices have dropped and are expected to rise much slower than previously thought, "making massive investments in such alternate energy projects less attractive . . .," Rogers said.

"However, under the appropriate conditions the province would entertain proposals to develop a new coal-based industry of this kind."

In an interview, Rogers said: "The South Africans were forced into synthetic fuels politically. This project, obviously, would only go ahead if people were forced into it economically."

The proposal was studied independently of B.C. Hydro's plan to build a major coal-fired electrical generating station at Hat Creek. That plan was abandoned when electricity demand stalled.

CLT

HAT CREEK
COAL LIQUEFACTION PROJECT

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PREFACE

At the time that the Hat Creek Coal Liquefaction Project Prefeasibility Studies were carried out the national economy was still expanding and the Hat Creek Thermal Generating Station was scheduled for initial start-up in 1988. Since then the world economy has entered a recessionary period and the Hat Creek Thermal Generating Station Project has been postponed indefinitely. These matters greatly alter the key assumptions on which the study was based and consequently effect the conclusions.

The conclusions reached were valid over a 2 to 4-year delay period, during which the economy may recover to the point where a reevaluation of the economic viability of the project may be justified.

EXECUTIVE SUMMARY

INTRODUCTION

Early in 1980 a group of Japanese companies approached the Government of British Columbia with a proposal to construct a coal liquefaction facility using Hat Creek coal as feedstock. Following overview studies completed under the direction of the B.C. Coal Co-ordinator, the newly established Energy Development Agency (EDA) directed that more detailed prefeasibility level studies be undertaken, based on the Sasol, Fischer-Tropsch coal liquefaction process. A Steering Committee and a Technical Committee were formed under the direction of the Ministry of Energy, Mines, and Petroleum Resources to oversee this work. Six concurrent studies were undertaken to answer broad questions of technical and economic viability and to identify critical areas of uncertainty. These studies are now complete and their findings are briefly presented in this report.

PROJECT FEATURES

The Coal Liquefaction Project would be located adjacent to the 2000 MW Hat Creek Thermal Power Project proposed by B.C. Hydro. The Liquefaction Plant itself would occupy a land area of 400 hectares (ha) (approximately 990 acres) and would employ a permanent operating staff of 2300. For the purposes of this prefeasibility analysis a 5-year final design and construction period commencing in 1983 was developed. This schedule would achieve the January 1988 in-service date assumed for the Coal Liquefaction Project. However, the studies indicate that the construction labour force (a peak construction manpower requirement of 14 500) required to meet this schedule may be difficult to attract. Furthermore, B.C. Hydro has not included the estimated 450 MW electrical

load required by the Coal Liquefaction Project in its load forecast or system plan. This additional supply of electricity could not be made available within the provincial grid until 1990. Other potential scheduling problems are noted in Section 2.8(b).

The design of the Liquefaction Plant is patterned after the commercially demonstrated technology currently in use by the South African Coal Oil and Gas Corporation Ltd. (Sasol). There are two major steps in the Sasol conversion process. First the coal is gasified under pressure with steam and oxygen in Lurgi Gasifiers; then the gas is converted to liquid products in synthol reactors by the Fischer-Tropsch synthesis process. Preliminary analysis of samples of Hat Creek coal confirm that the application of the Sasol coal to liquids process is technically feasible.

The product slate from this process is flexible. Under direction of the EDA and in response to the Japanese companies' expressed interest, the Liquefaction Plant was designed to maximize the production of transport fuels. The product slate (list of major products and by-products) adopted in the studies was:

PRODUCT SLATE - HAT CREEK COAL LIQUEFACTION PROJECT

<u>Product</u>	<u>(t/d)</u>	<u>Percent of Production (%)</u>	<u>Fuel (m³/d)</u>	<u>Equivalent (U.S. bbl/d)</u>
Gasoline	3 569	46	5 105	32 110
Jet Fuel	978	13	1 262	7 940
Diesel Fuel	1 277	16	1 540	9 685
Medium Fuel Oil	106	1	119	750
Mixed Alcohols	465	6	583	3 665
Ethylene	705	9	8 609	54 150
Ammonia	307	4		
Sulphur	155	2		
Liquified Petroleum Gas (LPG)	194	3		
	<u>7 756</u>	<u>100</u>		

It should be noted that this product slate does not represent the optimal production profile from either a technical design or economic and marketing point of view.

Information on other coal conversion technologies was not available to the same level of detail as the Sasol process (see Section 3.3). Since Hat Creek Coal is a low rank (Sub-bituminous), low grade (high ash and moisture) with highly variable physical and chemical properties, the applicable conversion processes are limited. In the future, other conversion technologies may become available, but the Sasol process is the only commercially proven technology available in the time frame envisaged here.

A basic assumption in the analysis is that the proposed Thermal Power Project will proceed regardless of whether the Coal Liquefaction Project proceeds or not. No attempt was made to integrate the designs of the Liquefaction Project and the Power Project, but there will be significant effects on the Power Project if the two go forward simultaneously. As noted earlier, the construction labour requirements of the Liquefaction Project would make it more difficult to obtain the necessary labour force for the Power Project. The two facilities would share a common mining operation that is more than double the size required for the Power Project alone. A preliminary mining concept was developed to serve both facilities as well as to dispose of the ash. The Hat Creek coal deposits are extensive and it is not anticipated that the Liquefaction Project fuel requirements would jeopardize the fuel supply proposed by B.C. Hydro for the Power Project. However, more detailed studies are necessary to confirm that the necessary coal quality required by both facilities can be maintained.

ENVIRONMENTAL AND SOCIAL ANALYSIS

Direct alienation of land and the effects of increased population in the Hat Creek area due to the Coal Liquefaction Project would result in

additional pressures on forest, agriculture, wildlife, fisheries and other resources. Some of these pressures and losses could be mitigated and/or redressed through reclamation at waste disposal and mine sites and via innovative management of recreational land and resource use.

The sources of emission of atmospheric contaminants from the Liquefaction Project have been identified and general characteristics determined. Pollution control technology is available to reduce levels of contaminants to within acceptable pollution control levels, although no specific provincial objectives exist for coal conversion projects. Detailed characterization of pollutants and evaluation of mitigating measures would be necessary if the Liquefaction Project proceeds to more advanced (feasibility) stages of study.

Noise attenuation measures would be necessary to prevent annoyances due to high noise levels in and around the Liquefaction Project site.

The Liquefaction Project would produce social and community changes in the local area including Ashcroft and Cache Creek and possibly the region, including Kamloops. A need is evident for co-ordination of efforts from government agencies and private enterprise to cope with worker in-migration and population growth.

Most of the Liquefaction Project work force would migrate from outside the region, since few regional residents would have the required skills to gain employment on the project. Regional residents would, however, benefit from induced and indirect long-term employment opportunities. The Liquefaction Project would create 2700 direct employment opportunities during operation, and about 2500 induced and indirect employment opportunities.

Housing demand and the need for municipal services would be of concern during construction and early years of operation. While the long-term effects of the Liquefaction Project may produce social diversification

additional pressures on forest, agriculture, wildlife, fisheries and other resources. Some of these pressures and losses could be mitigated and/or redressed through reclamation at waste disposal and mine sites and via innovative management of recreational land and resource use.

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Housing demand and the need for municipal services would be of concern during construction and early years of operation. While the long-term effects of the Liquefaction Project may produce social diversification

to community residents, increased pressures, particularly during construction could have short-term negative effects particularly to Indian Bands living in the area.

ECONOMIC EVALUATION

The Coal Liquefaction Project was evaluated with regard to its commercial viability (private industry's point of view) and its economic desirability (based on the cost to the B.C. economy). The evaluation concluded that, given the base case conditions, the Liquefaction Project could be commercially viable as well as economically attractive. This conclusion is particularly sensitive to the future trend in product prices.

The total capital cost of the Coal Liquefaction Project is \$5.8 billion constant 1980 Canadian dollars expended over a 5-year design and construction period. Assuming a 7 percent annual rate of inflation, this capital cost is equivalent to \$10.4 billion inflated dollars. These estimates assume world-wide procurement and no labour shortages or other bottlenecks. Annual operating costs (net of taxes and interest) are estimated at \$516 million 1980 dollars commencing in January 1989. The capital and operating costs of the facility are assumed to be borne by the private sector participants. Additional public sector costs were estimated at \$809 million 1980 dollars.

Project benefits are comprised of the after tax revenues flowing to the Liquefaction Project's owner from product sales and the taxes accruing to the three levels of government. The base case evaluation assumes that Liquefaction Project products are sold at world market prices, and that world oil prices (net of inflation) will increase from \$36.80/bbl in 1980 to \$54.70/bbl (in 1980 dollars) by the year 2000 (i.e. an annual average growth rate of 2 percent). Assuming a 7 percent annual rate of inflation this oil price is equivalent to \$211.60 inflated dollars by

the year 2000. Since the Coal Liquefaction Project primary products (gasoline, jet fuel and diesel) are substitutes for the products produced from the conventional refining of crude oil, rising crude oil prices mean rising product prices.

The Liquefaction Project would begin paying Provincial property tax and capital tax in years 1984 and 1983 respectively. The Liquefaction Project would not start to pay federal or provincial income taxes until 1996.

The combination of the Coal Liquefaction Project and the proposed Hat Creek Thermal Power Project would result in an expanded, but lower per unit cost, mining operation. The cost savings accruing to the Power Project are estimated to have a 1980 dollar present value equivalent of \$72 million.

The results of the base case evaluation and two important sensitivity tests are summarized below in terms of the percentage rates of return on investment capital.

RETURN ON INVESTMENT CAPITAL

<u>Return on Investment</u>	<u>Base Case: Constant Real Costs; Rising Real Prices</u>	<u>Rising Real Capital Costs; Rising Real Prices</u>	<u>Constant Real Costs; Constant Real Prices</u>
Social Return	10.7%	9.4%	6.1%
Private before Income Tax	11.0%	9.6%	6.7%
Private after Income Tax	9.3%	8.1%	5.5%
Return on Equity* ¹	11.9%	9.6%	4.8%

*¹ Assumes a 75:25 debt to equity ratio and a 5 percent interest rate on debt, net of inflation.

If a 10 percent social return on investment is taken to be the minimum acceptable return, which is recommended by provincial guidelines for assessing public sector investments, then under base case assumptions (including long-term increases in future product prices) the Liquefaction Project could be an attractive economic development opportunity for British Columbia. Rising real capital costs (3 percent per annum over the construction period) do not significantly alter this conclusion. However, assessing the Liquefaction Project with constant real capital costs and constant real product prices (i.e. constant real world oil prices) would put in serious question the commercial viability and economic desirability of the investment. That is the viability of the investment appears to require that world oil prices rise by at least the present value equivalent of 2 percent per year, net of inflation, over the period 1980 to 2000.

A number of the base case assumptions were subject to sensitivity tests (see Section 5.3(c)). The result worth noting here is that delays of 2 years and 4 years actually increase the base case estimated returns.

CONCLUSIONS

The use of Hat Creek coal in a Sasol-type Coal Liquefaction Project appears to be both technically and economically viable. There are adequate coal reserves at Hat Creek to support a 50 000 bbl/d Coal Liquefaction Project and B.C. Hydro's proposed 2000 MW Thermal Power Project. Under the base case assumptions, the Liquefaction Project appears to be commercially viable with a before-tax return on investment of approximately 11 percent. The Liquefaction Project may also be an attractive economic development opportunity for the Province if the environmental and social impacts can be managed.

Although serious potential environmental and social concerns were identified, most of these might be alleviated through careful planning

and design. The project could be built to meet current pollution control objectives. With a peak labour force during construction of 14 500, the availability of a sufficiently large skilled work force could be a major concern.

ACKNOWLEDGEMENTS

The Coal Liquefaction Steering Committee gratefully acknowledges the significant contributions of several government agencies and individuals in the preparation of this report and the supporting prefeasibility reference studies.

The following government agencies and companies participated in the Hat Creek coal liquefaction prefeasibility studies:

- Government Agencies
- Ministry of Energy, Mines and Petroleum Resources
 - Ministry of Environment
 - Ministry of Industry and Small Business Development
 - Ministry of Municipal Affairs
 - Ministry of Transportation and Highways
 - Ministry of Universities, Science and Communications
- Crown Corporation
- British Columbia Hydro and Power Authority

The Coal Liquefaction Steering Committee consisted of the following individuals:

R.L. Evans, Director Conservation and Technology, Ministry of Energy, Mines and Petroleum Resources, Vancouver.

C.B. Guelke, Director of Strategic Planning, B.C. Hydro, Vancouver.

E.R. Macgregor (Chairman), Assistant Deputy Minister, Energy Policy Branch, Ministry of Energy, Mines and Petroleum Resources, Victoria.

L.E. Sivertson, Executive Director, Economic Analysis and Research Bureau, Ministry of Industry and Small Business Development, Victoria.

R.W. Stewart, Chief Executive Officer, Ministry of Universities, Science and Communications, Victoria.

W.N. Venables, Assistant Deputy Minister, Assessment and Planning Division, Ministry of Environment, Victoria.

The Coal Liquefaction Technical Committee consisted of the following individuals:

B.C.E. Duncan, Ministry of Industry and Small Business Development, Victoria.

J.C. Edwards, B.C. Hydro, Vancouver.

R.L. Evans (Chairman), Director Conservation and Technology, Ministry of Energy, Mines and Petroleum Resources, Vancouver.

J.J. Fitzpatrick and W.E. Meeks, B.C. Hydro, Vancouver.

G.F. Nelson, Ministry of Transportation and Highway, Victoria.

G. Paget, Ministry of Municipal Affairs, Victoria.

M.M. Papic, B.C. Hydro, Vancouver.

J.P. Sectar, Ministry of Environment, Victoria.

D.K. Wish and P.R. Willis, B.C. Hydro, Vancouver.

SECTION 1.0 - INTRODUCTION

1.1 BACKGROUND

Early in 1980 a group of Japanese companies approached the Government of British Columbia and proposed that the government investigate the possibility of constructing a coal liquefaction facility in B.C. using Hat Creek coal as feedstock.

Brief in-house overview studies were conducted by a provincial government inter-agency committee, the Coal Liquefaction Task Force, under the direction of the B.C. Coal Co-ordinator, Mr. Graham Kedgley. The Ministry of Environment completed a preliminary assessment of the proposed liquefaction project based on the Sasol, Fischer-Tropsch coal liquefaction process, the only process commercially available for the 1980s. The Ministry reviewed air quality considerations, land use, waste disposal and manpower requirements for construction and operation of the project. The Ministries of Municipal Affairs, Labour, and Industry and Small Business Development investigated possible socio-community effects of a coal liquefaction project.

As a result, the Coal Liquefaction Task Force recommended that a "pre-feasibility" (more detailed overview) engineering study by Fluor Canada Ltd. be initiated so that the government could better evaluate the Japanese proposal. Fluor is the engineer and principal contractor for the design and construction of the Sasol II and III coal liquefaction complexes in South Africa. The Task Force also pointed out the need for clarification of the Federal Government position with regard to export of coal-derived liquid products. Export of the liquefaction products to obtain world oil prices was identified as a critical consideration to the economics of a coal liquefaction project. Investigation of

environmental, social and economic ramifications was also recommended to be done concurrently with the Fluor study.

In July 1980 the Coal Liquefaction Task Force was dissolved and the newly established Energy Development Agency assumed responsibility for the recommended studies.

On 15 September 1980 Federal Energy Minister Marc Lalonde announced that export of coal-based oil would be allowed and the Federal Government was ready to accept applications for export commitments of coal liquefaction products.

The British Columbia Hydro and Power Authority was requested to assist in conducting the prefeasibility studies, as the Authority has the coal licences and Crown grants for the Hat Creek coal deposits, and have done considerable exploration of the deposits in connection with their proposed 2000 MW coal-fired electricity generating project.

A Steering Committee and a Technical Committee (composed of representatives from several government ministries and B.C. Hydro) were established under the direction of the Ministry of Energy, Mines and Petroleum Resources to oversee the prefeasibility study work.

Terms of Reference were developed for six concurrent prefeasibility studies. The studies commenced in September 1980 and are now complete. The findings of these studies are briefly presented in the following report and form the basis for the recommendations and conclusions of the Steering Committee.

1.2 PURPOSE AND SCOPE OF PREFEASIBILITY STUDIES

The prefeasibility studies of a commercial scale Coal Liquefaction Project in British Columbia using Hat Creek coal were undertaken to

provide the Provincial Government with a description and evaluation of the proposed project. The Japanese proposal to purchase the liquid fuel products and possibly provide equity funding for the project required additional information to determine whether the project would be in the best interests of the Province and whether the project warrants further consideration by government or private investors. The studies were designed to provide a prefeasibility level of information required by the Energy Development Agency for their decision whether the proposal should proceed to the more detailed feasibility studies. The scope of the studies completed are intended to answer broad technical and economic questions and to identify critical areas of uncertainty.

The scopes of the prefeasibility studies and the agency or consultant responsible are listed here.

1. Coal Liquefaction Plant⁽¹⁾ - Fluor Canada Ltd. [Numbers in brackets of superscript correspond to the numbered references listed in the Reference Section of this report.]
 - provides engineering information on the coal liquefaction process including a description of design concepts and estimates of capital and operating costs.

2. Support Facilities⁽²⁾ - B.C. Hydro
 - describes land requirements and a tentative site selection for the Coal Liquefaction Plant;
 - reviews and develops proposals for support facilities including solid waste and ash handling and disposal, water and power supply, access road development, construction and operating equipment and material transportation, and construction camp facilities.

3. Mining⁽³⁾ - B.C. Hydro

- provides engineering information on mining systems and equipment, mine maintenance facilities, manpower requirements and the diversion of Hat Creek;
- estimates capital and operating costs for the mining of Hat Creek Deposits No. 1 and No. 2 to supply coal to B.C. Hydro's 2000 MW Thermal Powerplant and the Coal Liquefaction Plant.

4. Product Transportation⁽⁴⁾ - Ministry of Transportation and Highways

- provides economic information on alternate means (road, rail and pipeline) of transporting Coal Liquefaction Plant products to a marine petroleum products terminal.

5. Environmental and Social Analysis⁽⁵⁾⁽⁶⁾ - B.C. Research and Strong Hall & Associates

- describes the environmental and social conditions in the Hat Creek area assuming B.C. Hydro's proposed Thermal Powerplant is already in place, reports on the incremental impacts of the Coal Liquefaction Project, and presents an evaluation of the resource losses due to the project.

6. Economic Evaluation⁽⁷⁾ - Ministry of Industry and Small Business Development

- provides estimates of the expected costs and benefits of the project to the Government of Canada, the Government of British Columbia and private sector participants directly involved in the project. Both commercial viability and economic desirability are reported.

The studies were completed at a cost of approximately 3/4 million dollars excluding B.C. Hydro and B.C. Government in-house costs. Exhibit 1-1 shows the schedule of the prefeasibility studies.

Financial criteria and certain key assumptions were developed for all studies to ensure consistency in estimating costs and evaluating the project.

1.3 KEY STUDY ASSUMPTIONS

Although the six interrelated studies were conducted by different parties evaluating different aspects of the proposal, all of the studies were bound together by a common set of assumptions which constitute the prefeasibility design concept. Several of the key assumptions and their effects on particular studies are noted below:

1. Concurrent Construction and Operation of the B.C. Hydro Thermal Power Project and the Coal Liquefaction Project

This assumption has a significant effect on all the studies. If the two projects proceed simultaneously then the mining operations, support facilities (water supply, ash disposal, camps), and environmental mitigation measures (stream diversion) can be integrated into the joint complex. This intergration appears to offer significant cost savings. One example is the change to a bucket-wheel mining system from the truck-shovel system specified if the Thermal Power Project proceeded alone.

2. Approximate Coal Specifications

The effect of this assumption is primarily technical and economic. The coal quality is known with reasonable assurance during the first half of the projects' life. However, sufficient testing in

coal Deposit No. 2 has not been completed to extend this certainty throughout the assumed 30-year Coal Liquefaction Project operating life. Secondly, the product slate and the preliminary plant design are based on the interpolation of the average known coal specifications and experience of similar plants. Laboratory bench coal tests followed by a full scale coal test are required before the product slate and plant design can be more firmly defined.

3. Product Slate Oriented to Maximize Production of Transport Fuels

The assumed product slate affects the plant design, economic evaluation, and the transportation study. The product slate plays a pivotal role in the project evaluation since the Coal Liquefaction Plant, mining and support facilities design (which affects project costs) have been tailored to meet the specified product mix and volumes, and plant gate revenue projections are built up from price forecasts of the individual products. Alternative product slates that would reduce project costs and/or increase project revenues have not been investigated. The Liquefaction Plant study⁽¹⁾ noted, for example, that substantial improvements in thermal efficiency are possible if methane is not reformed but is used instead to produce substitute natural gas.

4. Offshore Sale of Primary Products at World Oil Prices

The assumption that the Coal Liquefaction Project's primary products (gasoline, jet fuel, diesel fuel and light fuel oil) will be exported offshore is a key assumption in the economic evaluation and the transportation study. World product prices for these crude oil based products significantly improves viability of the project. The offshore sale assumption dictates the need for a port site and transportation facilities from the Coal Liquefaction Plant to port.

5. Forecast of Project Costs and Product Prices

A key assumption in the base case economic evaluation is that project costs will remain constant in real terms (i.e. increase at the rate of general price inflation) while product prices will increase over the period 1980 to 2000. Rising real product prices stem from the forecast increase of world crude oil prices (2 percent annual growth net of inflation).⁽⁷⁾ Sensitivity tests indicate that the results of the economic evaluation are particularly sensitive to this assumption.

**HAT CREEK COAL LIQUEFACTION PROJECT
ACTUAL PREFEASIBILITY STUDY SCHEDULE AND COST**

EXHIBIT 1-1

ACTIVITY DESCRIPTION	1980					1981						
	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	
COAL LIQUEFACTION PLANT STUDY (FLUOR CANADA LTD)												
SUPPORT FACILITIES STUDY (B.C. HYDRO)												
MINING STUDIES (B.C. HYDRO)												
PRODUCT TRANSPORTATION STUDY (MINISTRY OF TRANSPORT & HIGHWAYS)												
ENVIRONMENTAL & SOCIO-ECONOMIC STUDY (BC RESEARCH)												
ECONOMIC EVALUATION (MINISTRY OF INDUSTRY & SMALL BUSINESS DEVELOPMENT)												
COORDINATION ASSISTANCE												
TOTAL PREFEASIBILITY STUDY COST												\$ 760,000
PUBLIC INFORMATION (MINISTRY OF ENERGY MINES & PETROLEUM RESOURCES)	▲ INTRODUCTORY MEETING						▲ NEWS RELEASE TERMS OF REFERENCE					
PREFEASIBILITY STUDY REPORT (COAL LIQUEFACTION STEERING COMMITTEE)												▲ RELEASE PRE-FEASIBILITY STUDY RESULTS
												▲ PRESENTATION TO EDA

* B.C. HYDRO AND B.C. GOVERNMENT IN-HOUSE COSTS NOT INCLUDED

SECTION 2.0 - PROJECT FEATURES

2.1 GENERAL DESCRIPTION

The proposed development at the Hat Creek site is based on a Coal Liquefaction Project capable of producing approximately 8600 m³ per stream day (54 000 bbl/d) of liquid transport fuel products. It would be located adjacent to the B.C. Hydro 2000 MW Thermal Powerplant as shown on Exhibit 2-1. The adjacent open-pit coal mine would supply coal to both the Coal Liquefaction Plant and the Thermal Powerplant over their lifetimes. Some common offsite facilities would be required in order to supply the water requirements, to dispose of ash and to accommodate the construction and operating workforce. Transportation facilities would be required for transporting products to a lower mainland marine terminal.

Design of the Coal Liquefaction Plant would be patterned after the commercially demonstrated technology for coal gasification and downstream processing used by Sasol (South African Coal Oil and Gas Corporation Ltd.). There are two major steps in the Sasol conversion process. First the coal is gasified in Lurgi [Lurgi GmbH, Frankfurt, West Germany] Gasifiers, then the gas is converted to liquid products, i.e., gasoline, jet fuel and diesel fuel, in the Fischer-Tropsch (Synthol) [Process techniques first introduced in Germany in 1920s and developed by Sasol.] units.

2.2 THE HAT CREEK THERMAL POWERPLANT

The Thermal Powerplant proposed by B.C. Hydro would be located on a broad hilltop near Harry Lake, 500 m above and 4 km northeast of the mine area.

The four 500 Mw units in the Powerplant would generate 2000 Mw (net) of electrical power, an amount roughly equal to the present demand of the B.C. lower mainland. At full load the powerplant would burn about 40 000 tonnes (t) of coal per day and, over its planned 35-year life would consume 335 million tonnes (Mt) or about one-half of the known coal reserves in the No. 1 Deposit.

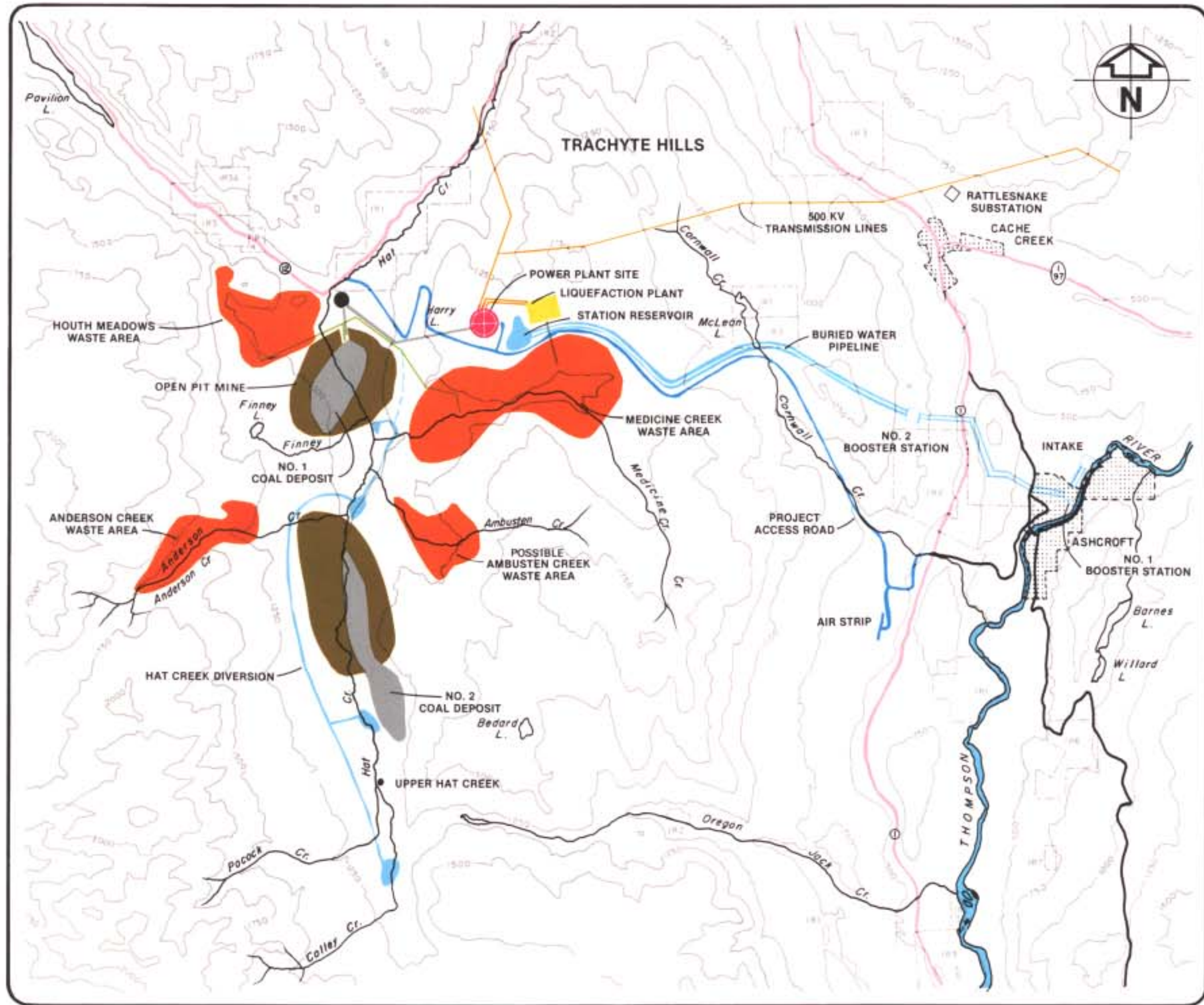
Offsite facilities of the Power Project are components located outside the actual mine and powerplant complexes. Major offsite facilities include the temporary construction camps for a 2300-man peak construction workforce, access roads, powerplant reservoir and water supply system (including a pipeline from the Thompson River), ash disposal, transmission lines, airstrip, equipment unloading facility at a rail location, and creek diversions.

The mine (for No. 1 Deposit), powerplant and offsite facilities would cover a total of approximately 2500 ha (6200 acres), which is less than 4 percent of the Hat Creek watershed. A more complete description is available in Reference 8.

2.3 THE COAL LIQUEFACTION PLANT

The Coal Liquefaction Plant would be located adjacent to the 2000 Mw Powerplant near Harry Lake 500 m above and 7 km northeast of the mine area.

The construction and operation of a Coal Liquefaction Plant would involve several major development components. It would occupy a land area of approximately 400 ha (990 acres); employ approximately 2300 permanent operating personnel, and produce approximately 8600 m³/d (54 000 bbl/d) of transport fuels. The adjacent open-pit coal mine would supply 41 900 t/d of coal to the Liquefaction Plant gasifiers and 12 000 t/d to the Liquefaction Plant steamplant. Over its 30-year



LEGEND

-  POWERPLANT SITE
-  TRANSMISSION LINES
-  MINE MAINTENANCE COMPLEX
-  COAL CONVEYORS
-  LIQUEFACTION PLANT
-  WASTE CONVEYORS
-  PROJECT ACCESS
-  COAL DEPOSIT AREAS
-  OPEN PIT MINE
-  WASTE DISPOSAL AREAS
-  RESERVOIRS, WATER SUPPLY PIPELINE AND HAT CREEK DIVERSION

SCALE — 1:125,000
 2 km 0 km 2 km 4 km 6 km
 CONTOUR INTERVAL — 250 METRES

**HAT CREEK
 PROPOSED COAL LIQUEFACTION PLANT
 COMPLEX MAP**

Figure 2.1

00813 ①

SOURCE: British Columbia Hydro and Power Authority (3)

lifetime the Liquefaction Plant would consume an estimated 540 Mt of coal. Surplus coal fines from the Liquefaction Plant would be consumed by the Thermal Powerplant. The Liquefaction Plant will require an estimated 450 MW of electrical power.

The 8600 m³/d project size is similar in size to the Sasol II (commercially operating) and Sasol III (under construction) projects in South Africa. Other sizes are feasible, although they were not addressed during the prefeasibility studies. A half-size project (4300 m³/d) is conceivable, since a full scale project is made up of two trains of process equipment in the gasification and synthesis areas. Discussions with Fluor Canada Limited has indicated that a half-size project may compare favourably in economic terms with a full-scale project, although detailed analysis would be required to confirm this.

2.4 THE MINE

The Mining Prefeasibility Study⁽³⁾ confirmed that there are adequate coal reserves in the Hat Creek deposits to supply the Coal Liquefaction Plant and the proposed 2000 MW Thermal Powerplant for 30 and 35 years respectively (a total of about 875 Mt) and still have substantial quantities of recoverable coal remaining in No. 2 Deposit. Total coal in the two deposits is estimated to exceed 2 billion tonnes (Gt).

For purpose of the mining study, it was assumed that the No. 1 Deposit would be mined to its economic limit and the No. 2 Deposit would be phased in as the No. 1 Deposit is depleted. The selection of the bucketwheel excavator-conveyor as the major mining system was made because it is the only high-productivity system that can be applied to a deposit of this size and configuration. During peak production years, mining and delivery of approximately 30 Mt of coal per year will be required. A shovel-truck system would be used in those areas where the bucketwheel excavator cannot operate efficiently.

Mining plans have been developed to produce 907 Mt of coal (342 Mt for Thermal Powerplant, 540 Mt for the Coal Liquefaction Plant and 25 Mt for stockpile loss allowance). This would require the removal and disposal of 4066 Mt of overburden and other waste. This represents approximately 4.5 t of waste for each tonne of coal, a stripping ratio of 2.24 m³/t. The split between the two deposits is as follows:

No. 1 Deposit - 567 Mt coal; 1012 x 10⁶m³ waste; 1.78 m³/t stripping ratio;

No. 2 Deposit - 340 Mt coal; 1021 x 10⁶m³ waste; 3.0 m³/t stripping ratio.

The mine would permanently employ an average of about 1200 persons, peaking at 1600 in the 16th to 20th year of operations with the opening of No. 2 Deposit. By comparison the mine workforce for the B.C. Hydro Power Project alone would average about 800.

2.5 SUPPORT FACILITIES

The Coal Liquefaction Plant, like the Thermal Powerplant, requires support facilities for construction and operation including waste disposal facilities, water and power supply, construction camps and equipment and material transporting facilities.

The Coal Liquefaction Plant would produce 200 Mt of ash and spent catalyst over the project life. This volume of waste would be directed to the Medicine Creek valley, which is shown on Exhibit 2-1. Two complete trains of solid waste conveyors, stackers and spreaders, each capable of handling the total waste output from both the Powerplant and the Liquefaction Plant have been proposed. The Powerplant waste would be combined and mixed with the Liquefaction Plant waste and delivered to this Medicine Creek waste disposal area.

Since the Liquefaction Plant would be situated adjacent to the Power-plant, and since the two plants require similar quantities of water, the proposed water supply scheme is to be duplicated. Fresh water from the Thompson River upstream from Ashcroft is to be clarified and pumped through twin 800 mm (32 in) pipelines approximately 22.4 km long, to the common reservoir located between the two plants. A summary of the design data for both water supply systems is given in Exhibit 2-2.

A peak temporary construction water supply of up to 79 L/s will be required during the Coal Liquefaction Project construction period.

Construction camps would have to be built to accommodate the workforce shown in Exhibit 2-3.

Three construction camps with 42 man prefabricated bunkhouses, central kitchen and dining area, recreation buildings, parking area, water supply and sewage disposal systems are to be established adjacent to the construction sites. Each camp will accommodate 4000 to 6000 men and would require 40 to 60 ha of property.

2.6 PRODUCT TRANSPORTATION

The least cost transportation system is concluded to be the batch shipment of gasoline, jet fuel, light diesel, heavy diesel, mixed alcohols and medium fuel oil (together totalling 81.6 percent of production) in a 254 mm (10-inch) pipeline from the Coal Liquefaction Project to a marine terminal in the lower mainland. In addition, a combined road-rail transport system for the remaining products (ammonia, sulphur and liquid petroleum gas) to a lower mainland port would be the most economical transportation alternative. Due to high transportation costs, the most practical use of the ethylene produced would be further upgrading in an ethylene derivative petrochemical plant near the Coal

Liquefaction Project site. Thus transportation beyond the plant gate was not considered.

The main rail, road and pipeline corridors which could be accessed by connecting links from the Hat Creek Valley terminate at three points in the lower mainland: the Vancouver area including Burnaby, the Squamish area (including Furry Creek) and the Roberts Bank area. Preliminary analysis indicates that the least costly alternative is a Squamish area terminus.

2.7 IMPACT OF THE COAL LIQUEFACTION PLANT ON THE B.C. HYDRO THERMAL POWERPLANT

The Hat Creek coal deposits are extensive, with Deposits No. 1 and No. 2 containing in excess of 2 Gt, while the total coal required by the two projects is less than 1 Gt. In terms of the quantity of coal reserves in place there is no danger that the Coal Liquefaction Plant fuel requirement would jeopardize the fuel supply for the Thermal Powerplant.

However, the effect of the Liquefaction Plant coal requirements on coal quality is more complex. The prefeasibility study concludes that it is feasible to design a mine operation which would be able to simultaneously supply coal of an acceptable quality to both the Liquefaction Plant and the Powerplant. A more detailed analysis will be required during the next study phase to verify this.

The additional support facilities required to meet the Liquefaction Plant needs are not expected to cause any significant negative impacts on the Powerplant. In fact, some support facilities costs for the Powerplant would likely be reduced if the Liquefaction Plant is constructed. For instance, the cost of water supply and the cost of ash disposal on a dollar per unit basis should be reduced due to the economics of the larger scale.

The possible advantages of a fully integrated Liquefaction Plant and Powerplant were not investigated in this study, but should be assessed in the next study phase.

2.8 MANPOWER AND CONSTRUCTION SCHEDULE

(a) Schedule Assumptions

During initiation of the Hat Creek Coal Liquefaction Project Prefeasibility Studies, several factors were taken into account to arrive at the "target" project schedule and the assumed in-service date.

These factors included the following:

1. Japanese interests requested the earliest possible date for shipment of product, as early as 1986. However, allowing for feasibility studies and licensing activities, prior to the minimum 5-year design/construction period, the earliest conceivable in-service date was January 1988.
2. Fluor Canada Ltd. cautioned that the United States Synfuels Program and other synfuel plants around the world could compete with the B.C. proposal for the services of Fluor, Lurgi and Sasol. Fluor indicated that a delay early in the project schedule could result in an extension of the schedule later on, if the competing projects bid away the services of these essential firms. However, early initiation of the requisite studies and project construction would ensure avoidance of these possible delays.

It was assumed that B.C. Hydro could provide start-up power for the Coal Liquefaction Project by August 1987.

In order to realize the earliest in-service date, the Fischer-Tropsch liquefaction technology was selected, since it is the only commercially demonstrated technology currently available. The required project schedule as developed by Fluor Canada Limited is shown in Exhibit 2-4.

Fluor advises that this design/construction time table is realistic, having been demonstrated in the Sasol II project.

(b) Potential Scheduling Problems

For consistency, all the prefeasibility studies were conducted on the basis of the assumed January 1988 in-service date. However, Fluor's analysis, as well as the results of the other prefeasibility studies, have identified a number of potential problems resulting from this "target" schedule which may require a need to delay the earliest practical in-service date to 1990.

The problem areas identified include: construction manpower, technical manpower, power supply, mine design and Sasol gasifier tests.

(i) Construction Manpower

A peak construction manpower requirement identified by Fluor of up to 14 500 men (13 000 tradesmen plus 1500 supervisory and support personnel) for the Coal Liquefaction Plant construction is shown in the Construction Schedule Exhibit 2-4. The impact of a work force requirement of this magnitude on the projected labour supply in British Columbia and in western Canada has indicated some potential shortfalls in certain key skills. The parallel timing of the construction of the Hat Creek Thermal Powerplant and several large projects (examples may include Cold Lake, Alsands, Dome's LNG project and other

synfuel projects) will have a major effect on the available construction manpower.

To help alleviate this potential problem Fluor have proposed a 48-hour work week and are prepared to initiate one or a combination of programs including modular construction, incentive programs, training, recruitment programs within Canada and offshore recruitment. Although Fluor contends it should be possible to carry out the project during the planned time frame, lengthening the project construction period may be advantageous.

(ii) Technical Manpower

Fluor's studies show potential shortages for engineers and technicians as well. The total requirement for engineers is approximately 1500, which is close to the estimated total Canadian surplus during the peak (1984/85) design periods. Competition from other large projects will also aggravate the engineering manpower supply problem. Potential shortages appear most critical in project management, process, piping, and controls engineering. However, if Fluor managed the project, most of the engineering could be done in their head office in California. This would mitigate potential technical manpower shortages.

(iii) Power Supply

The Coal Liquefaction Project schedule is highly dependent on receiving power by mid-1987. However, B.C. Hydro anticipates shortages in firm power supply in the mid and late 1980s, even if the Peace Site C and Hat Creek power projects are approved on schedule. B.C. Hydro does not expect to be able to supply

the projected Coal Liquefaction Project load until 1990 at the earliest.

Increased power generation within the Coal Liquefaction Plant is a possible solution that has not been examined in this study.

(iv) Mine Design

The mining study has identified potential problems in the assumed schedule in the time allowed for completing the necessary feasibility studies and associated mine exploration program. The scheduling of the bucketwheel excavator system and Hat Creek diversion to meet a January 1988 in-service date would mean that the preparation of bid specifications and calling of tenders would overlap the feasibility studies as shown in Exhibit 6-2.

(v) Sasol Gasifier Test

The present schedule for production of a 10 000 to 15 000 t sample of Hat Creek coal for shipment to Sasol for an operating scale Lurgi gasifier test, necessary for the final process design details, has been proposed by Fluor for October 1982. The mining study has identified at least 6 months to produce and blend the sample ready for shipment.

To meet this schedule production of the test sample will have to be initiated during the feasibility studies prior to project approval as shown in Exhibit 6-2.

(c) Practical Schedule

A more practical approach to allow more time for planning of feasibility studies, efficient scheduling of key activities, and to ensure that power is available from B.C. Hydro for project operation, would be to defer the in-service date. A 2-year delay in the project in-service date to 1990 would enable discussions with Japanese and private industry to take place before proceeding into the feasibility studies. It would also allow study proponents and financial contributors to be defined. The laboratory coal testing by Lurgi could take place in parallel with the discussion and negotiation sessions.

However, even with a later in-service date feasibility studies should start by January 1982, and will require significant effort between July and October 1981 to define feasibility studies Terms of Reference and to resolve the studies sponsorship.

Notwithstanding the two concerns (Section 2.8(a)) that lead to setting the January 1988 in-service date, the economic evaluation (Section 5.4) and the financial assessment completed by Fluor found that delaying the project 2 to 4 years, or extending the construction period by 1 year, do not have negative economic or financial effects.

EXHIBIT 2-2

WATER SUPPLY DATA

	<u>Coal Liquefaction Plant</u>	<u>Thermal Powerplant</u>
Average consumption	770 L/s (12 250 USgal/min)	725 L/s (11 500 USgal/min)
Maximum demand	880 L/s (14 000 USgal/min)	1260 L/s (20 000 USgal/min)
Design capacity from Thompson river to reservoir	1580 L/s (25 000 USgal/min)	1580 L/s (25 000 USgal/min)
Reservoir capacity		7 x 10 ⁶ m ³ (1850 x 10 ⁶ USgal)
Reservoir storage at consumption of 2140 L/s (34 000 USgal/min)		37 days

EXHIBIT 2-3

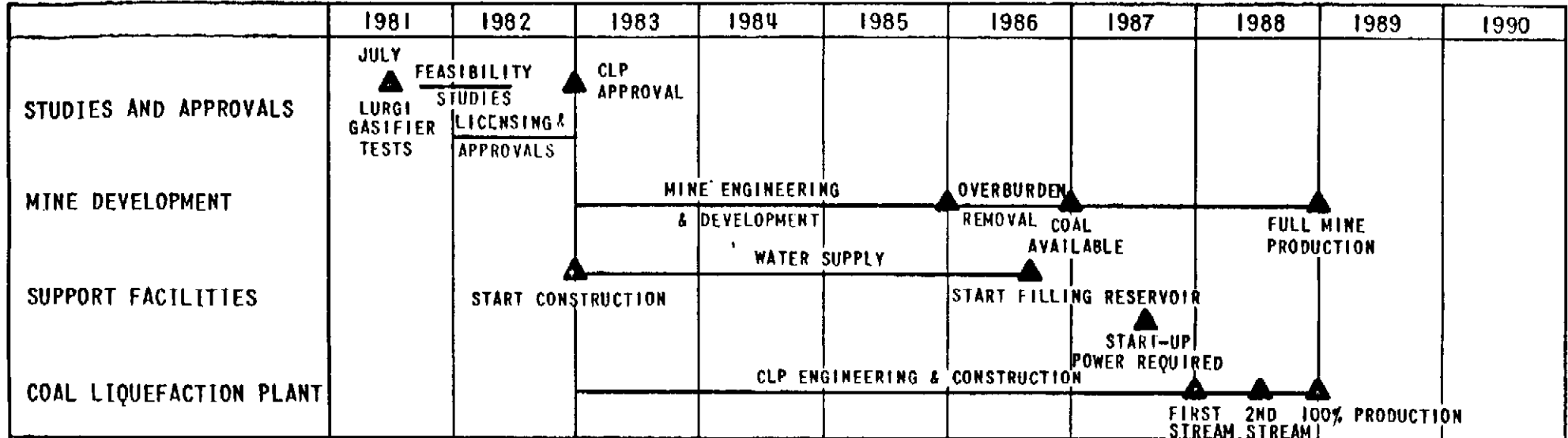
TOTAL CONSTRUCTION MANPOWER REQUIREMENTS FOR THE
THERMAL POWERPLANT, MINE AND COAL LIQUEFACTION PLANT*1

	<u>Thermal Powerplant</u>	<u>Coal Liquefaction Plant*2</u>	<u>Mine</u>	<u>Support Facilities</u>	<u>Total</u>
1982	-	-	-	225	225
1983	232	76	50	255	613
1984	545	5 894	440	210	7 089
1985	1 299	10 050	670	515	12 534
1986	2 102	9 500	530	570	12 702
1987	2 200	7 494	420	115	10 229

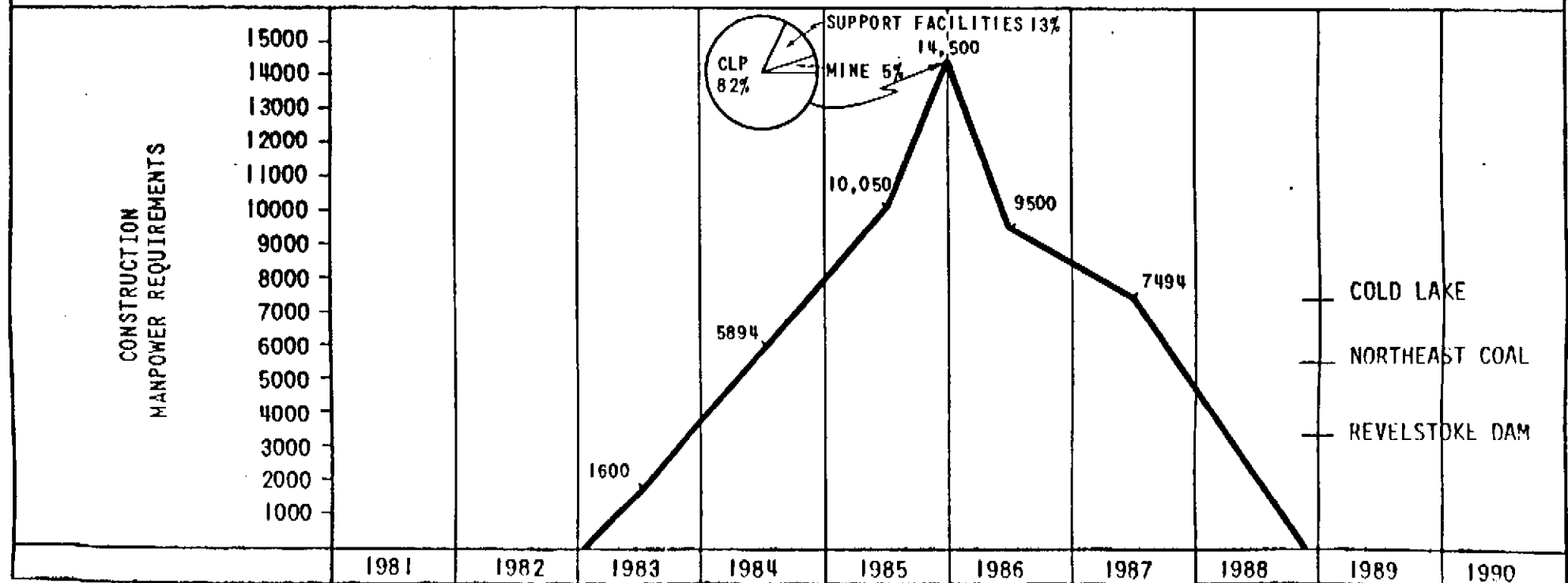
*1 Manpower requirements indicated are averages for the year.

*2 The total peak manpower requirement for the Coal Liquefaction Plant will be 14 500 occurring in late 1985.

HAT CREEK COAL LIQUEFACTION PROJECT CONSTRUCTION SCHEDULE



MANPOWER PLANNING SCHEDULE



SECTION 3.0 - TECHNICAL EVALUATION

3.1 PROCESS DESCRIPTION

The Sasol coal liquefaction process is based on Fischer-Tropsch synthesis of liquid fuels from carbon monoxide and hydrogen which are in turn obtained by gasification of coal with steam and oxygen. The process is schematically shown in Exhibit 3-1.

The first step in the process is coal preparation in which the coal is crushed and screened to between 13 mm and 100 mm size for gasification on one side and to below 13 mm size for steam and power production on the other. Oxygen needed for coal gasification is produced in the air separation plant.

Coal is gasified under pressure with steam and oxygen in the Lurgi gasification plant where raw, impure gas is produced. The raw gas is first washed in a scrubber with a circulating gas liquor. Heat is then recovered from it in a waste heat recovery boiler and the gas is further cooled for purification. Water-insoluble materials (tar oils) in the gas liquor are separated from the aqueous solution and sent to tar refining for recovery of tar products. The aqueous portion of the gas liquor goes to a Phenosolvan solvent extraction process where phenols and ammonia are recovered. Phenols are upgraded to transport fuels and water proceeds to the effluent treatment plant.

The scrubbed and cooled raw gas goes to a Rectisol gas purification plant where all components other than hydrogen, carbon monoxide and methane are removed as completely as possible by absorption in refrigerated methanol. The acid gases (CO_2 , H_2S) stripped from the methanol in the Rectisol unit are processed in a Stretford plant for recovery of sulphur. Regenerated methanol is returned to the process.

The purified synthesis gas is passed to the fluidized bed Synthol reactors where Fischer-Tropsch synthesis reactions take place.

The synthesis products are recovered in a product recovery unit as separate streams of decant oil containing higher molecular weight hydrocarbons, light oil comprised of lower molecular weight species, the aqueous stream containing water solubles, a C₃/C₄ stream, a C₂ stream, a methane stream and a hydrogen rich stream. Most of the hydrogen is recycled to the Synthol reactors; the major portion of methane is reformed to hydrogen and carbon monoxide for recycle; the C₂ fraction goes to an ethylene plant; and the liquid streams produced go to the product refinery for upgrading and purifying to fuels and chemicals.

3.2 MASS BALANCE

The simplified overall mass balance for the Coal Liquefaction Plant is shown in Exhibit 3-2.

The overall yield of liquid fuel products is 0.153 t (0.205 m³, 1.29 bbl) per tonne of gasified coal. Thermal efficiency and product yields are specific to the coal feed, the processes employed and the product slate produced. A different product slate will give different yields and thermal efficiency. Here the product slate has been selected to maximize the production of transport fuels. If methane is not reformed and instead used to produce substitute natural gas, the thermal efficiency would improve to about 50 to 55 percent.

3.3 ALTERNATE CONVERSION ROUTES FOR HAT CREEK COAL

Hat Creek coal is a low-rank (sub-bituminous), low-grade (high ash and moisture) coal with highly variable physical and chemical properties.

The various coal conversion processes are therefore limited in their application to Hat Creek coal.

Sasol indirect coal liquefaction via Fischer-Tropsch synthesis is the only commercially proven technology available. However, there are other direct and indirect coal liquefaction processes in different stages of development which may become available in the future. From a technological and economic point of view the potentially attractive processes for liquefaction of Hat Creek coal are:

- H-Coal (direct liquefaction)
- Liquid Solvent Extraction/Hydrogenation (direct liquefaction)
- Lurgi/Methanol (indirect liquefaction)
- Lurgi/Methanol-to-Gasoline (indirect liquefaction)
- Lurgi/Fischer-Tropsch (indirect liquefaction)

Among the processes listed, only Lurgi/Fischer-Tropsch and Methanol processes have been commercially demonstrated.

The Methanol-to-Gasoline process has been developed by Mobil on a 0.6 m³/d (4 bbl/d) pilot plant scale. Planning is currently underway for a 16 m³/d (100 bbl/d) pilot plant sponsored by The U.S. Department of Energy, Federal Republic of Germany, German industrial participants and Mobil. The Government of New Zealand has also announced plans to build a facility to produce 2000 m³/d (2500 bbl/d) of synthetic gasoline from natural gas using the Mobil process. Full scale commercial demonstration is still at least 10 years away.

The H-Coal process developed by the Hydrocarbon Research Institute is currently being tested on a 100 to 300 m³/d (600 to 1800 bbl/d) pilot plant at Cattletsburg, Kentucky. Full scale commercial plants are expected to be available by the mid-1990s.

The Liquid Solvent Extraction/Hydrogenation process has been developed by the National Coal Board of the United Kingdom on a small 1 kg/h pilot plant. The development of this process seems to be some 5 years behind the H-coal process.

With a suitable coal feed the direct coal liquefaction processes are potentially more efficient and economically more attractive. However, the direct coal liquefaction processes are still in the development stage and the operability of direct coal liquefaction processes has not been proven with high ash coals such as Hat Creek coal. A pilot plant test program would be necessary in order to establish the applicability of any direct liquefaction process to Hat Creek coal.

The choice of the process is also dependent on the desired product output. The use of Fischer-Tropsch technology is better suited for diesel fuel production whereas the methanol to gasoline process is better suited for production of high-octane unleaded gasoline. The possibility of the direct use of methanol as fuel should also not be overlooked. Direct coal liquefaction is suitable for production of synthetic crude feedstock for refinery-type hydrotreating and conversion into gasoline and heavier fuels. For direct coal liquefaction processes the coal characteristics are a critical parameter.

Thus for a Coal Liquefaction Project to be constructed in the late 1980s or early 1990s using Hat Creek coal, the Sasol, Fischer-Tropsch process is the only one available and commercially proven.

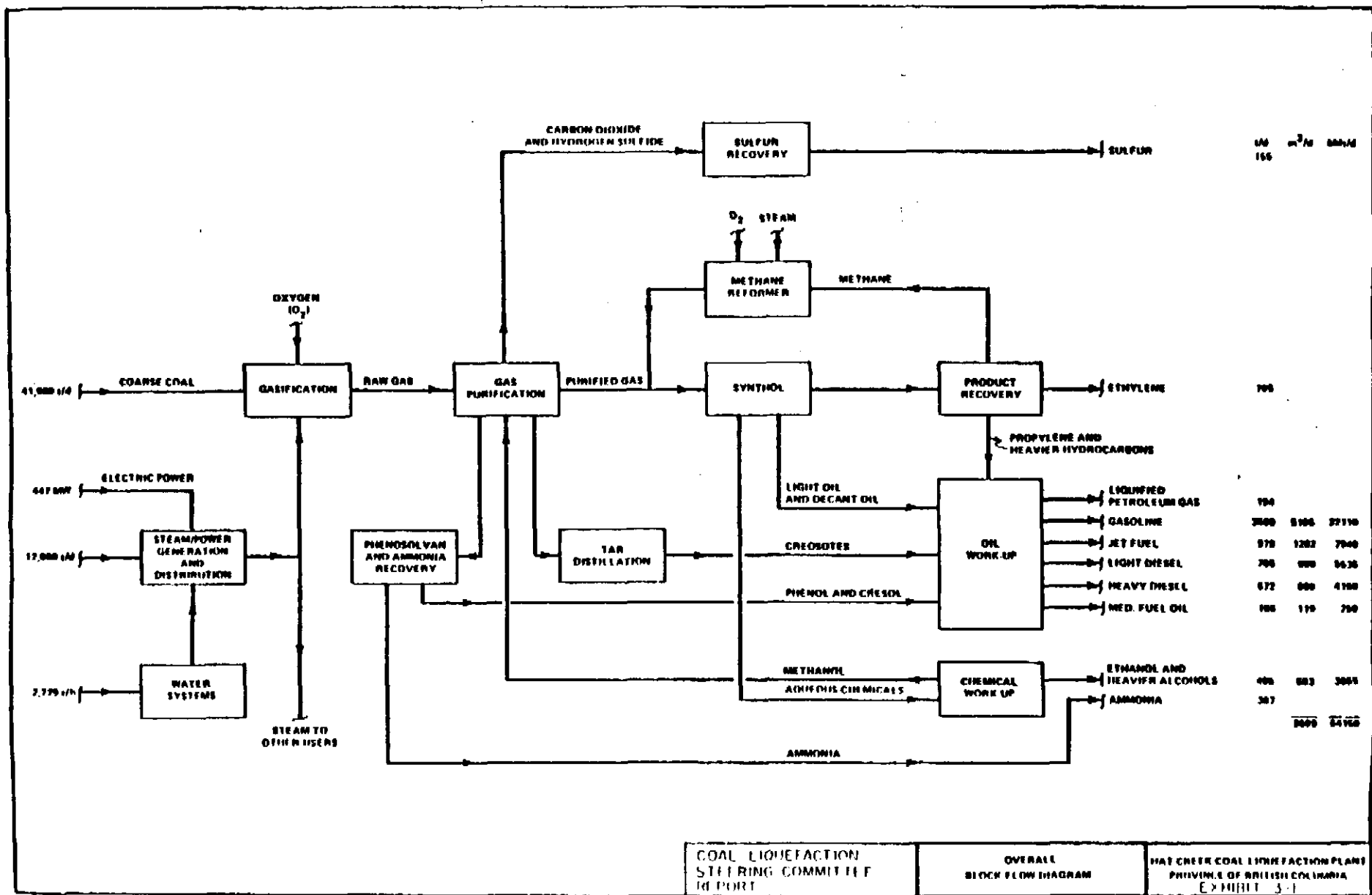


EXHIBIT 3-2

MASS BALANCE FOR THE
HAT CREEK COAL LIQUEFACTION PROJECT

<u>Input</u>	<u>t/d</u>	<u>m³/d</u>
Coal to gasifiers	41 900	
Coal to steam plant	12 000	
Electric power		
 <u>Output</u>		
LPG	194	
Gasoline	3 569	5 105
Jet fuel	978	1 262
Light diesel	705	880
Heavy diesel	572	660
Medium fuel oil	106	119
Alcohols	465	583
Ethylene	705	
Sulphur	155	
Ammonia	307	

SECTION 4.0 - ENVIRONMENTAL AND SOCIAL ANALYSIS

4.1 INTRODUCTION

Prefeasibility evaluations were conducted of the environmental and socio-community implications of the proposed Coal Liquefaction Plant, associated Coal Mine, Support Facilities and Product Transportation alternatives. Environmental assessments were based largely on extrapolation of data and information from existing literature and involved no original field examinations. This section describes the impacts of the Coal Liquefaction Project and, where necessary, some of the Hat Creek Thermal Generating Station impacts are briefly presented for illustrative or comparative purposes. Impacts of the Thermal Plant are reported in detail in B.C. Hydro's Environmental Impact Statement.⁽⁸⁾ The methods of analysis in defining the impacts of the Liquefaction Project are considered sufficiently accurate at the prefeasibility level to identify potentially significant environmental concerns.

4.2 ENVIRONMENTAL RESOURCE IMPACTS

(a) Climate and Air Quality

The meteorological conditions in the Hat Creek area are greatly influenced by its topography. Areas at higher elevations are reported to be well ventilated, while ground-based inversions are frequent in the valley locations where calm winds prevail. The variations in daily and seasonal temperatures are large, particularly in valley areas. Daily fluctuations in the relative humidity in the area are high. The annual average precipitation in the Upper Hat Creek Valley is about 30 cm, distributed more or less evenly over the year with a slightly higher rate during the winter

season. Although the region is quite dry, cloudy skies are frequent and the recorded bright sunshine period is about 2000 h/annum. The ambient air quality data for 1978 and 1979 indicate absence of any significant levels of air pollutants in the area.

The estimated rates of emission of major pollutants - sulphur dioxide, nitrogen oxides, particulates and hydrocarbons, from the Coal Liquefaction Project as well as those from the Thermal Power Project are shown in Exhibit 4-1.

There are currently no Pollution Control Objectives specifically applicable to coal conversion projects such as the Coal Liquefaction Project. Thus the following comments on emissions and ambient air quality pertain to a comparison with the Thermal Power Project and the associated objectives.⁽⁹⁾ It would be prudent to encourage the development of objectives for coal conversion projects prior to the application by the project proponents for approval of the Coal Liquefaction Project.

The Coal Liquefaction Project would unavoidably emit significant amounts of sulphur dioxide, nitrogen oxides and hydrocarbons in the area, for the base case design (partial control of sulphur dioxide). The amounts are comparatively much less than the corresponding rates of emission from the Thermal Powerplant with the exception of hydrocarbons. The rate of emission of sulphur dioxide from the Liquefaction Project could be reduced significantly under the alternate case design (approximately 92 percent removal). The emission of nitrogen oxides could be reduced, if necessary, by available emission control methods. The reported rate of hydrocarbons emissions from the Liquefaction Project is based on the use of the best available control technology.

The emission of particulates, mainly in the form of fly ash from the Liquefaction Project steam plant, could be more efficiently controlled by baghouses than by electrostatic precipitators. The former control equipment would be able to capture submicron particulates containing potentially harmful trace elements. Fluorine has been identified as one such element which may contribute to damage of the receiving environment. However, further investigations are needed before definitive statements can be made on the fluorine emission rate from the Coal Liquefaction Project, on the efficiency of emission control methods and on the pathways followed by fluorine to the receiving environment.

The estimated ground-level concentrations for sulphur dioxide, nitrogen oxides and suspended particulate matter resulting from both the Coal Liquefaction Project and the Thermal Power Project are shown in Exhibit 4-2. Under base case conditions the short-term (1-hour average) concentration of sulphur dioxide and nitrogen oxides could exceed the existing provincial air quality objectives.⁽⁹⁾ The potential impact of these two major contaminants on land based resources such as forestry, agriculture and wildlife, is not expected to be significant. Preliminary assessment of the acid rain effects on aquatic systems due to emissions of sulphur dioxide and nitrogen oxides from the Liquefaction Project does not indicate a potentially serious problem except during the spring snow melt, when the local and regional streams may show rapid increases in acidity. It is essential that further detailed field investigations are carried out on these aspects of the Liquefaction Project impacts during the next phase of the study in order to determine the incremental impact of the major pollutants as well as trace contaminants on the receiving environment.

The effect of the Coal Liquefaction Project's hydrocarbon emissions on the formation of photochemical smog is not considered to be

significant because of the local meteorological conditions. However, the processing of various hydrocarbons are expected to cause some odour problems in the plant area due to fugitive emissions.

Water vapor from the cooling towers of both the Power Project and the Liquefaction Project may cause a slight increase (approximately 1 percent) in precipitation in the area. Slight reduction in visibility in the plant vicinity under certain weather conditions may occur due to cooling tower emissions and particulate emissions from the Power Project and the Liquefaction Project steam plant.

Fugitive emission of dust during construction and mining operation is unavoidable, but could be kept under control by proper dust control measures.

(b) Noise

Increased traffic along Highway 12 over and above that projected for the Thermal Power Project would increase noise to a level that may be annoying for the residents living near the highway. Noise from construction of the Coal Liquefaction Project and construction and operation of the open-pit mines would be annoying to nearby ranchers. Most of the noise would result from the movement of heavy equipment.

The Coal Liquefaction Plant design could incorporate various control methods for noise attenuation. The incremental increase in noise from the Liquefaction Plant is expected to make only a minor contribution to total expected noise levels in the Hat Creek valley.

(c) Land-Based Impacts

The major land-based resources that will be directly or indirectly affected by this project are forestry, agriculture, wildlife and recreation. Land clearing associated with a Coal Liquefaction Plant would alienate an additional 4700 ha of vegetated land over that amount which would be affected by the Thermal Powerplant alone. The combined disturbed area would be 7200 ha. Indirect alienation of land due to plant emissions and land pressures due to human population increases are of more concern than the more direct loss stemming from site preparation. The resource losses due to plant emissions may, however, be of lesser economic significance.

(i) Forestry

Impacts are related to forest areas cleared for the plant, waste dumps, Pit No. 2, and off-site facilities as well as those tree species sensitive to plant emissions. The latter losses are expected due to release of SO_2 and fluorine - an additional 65 percent and 33 percent increase above that of the Thermal Powerplant, respectively. The effect on forest growth could be experienced over a considerable area. Commercially important tree species will be affected, such as lodgepole pine, Engelmann spruce, and Douglas fir. Changes in forest productivity losses due to air emissions, may be expected to increase from 1800 m^3/a with the Thermal Project to 2394 m^3/a with both projects (losses of 594 m^3/a for the Liquefaction Project). This total loss is less than 2 percent of the current estimated annual allowable cut of 146 189 m^3 within a 25 km radius. Few trees would die outright, however, productivity losses resulting from low grade chronic injury may slow tree growth. More study is required to fully assess the impacts on forestry. Increased loss due to insect attack

and disease resulting from reduced tree resistance could make the loss of forest resources higher.

(ii) Agriculture

Most land-use in the Hat Creek valley is for cattle grazing with some potential for hay production. Increased land alienation, emissions, water quality changes, and noise would be the main impact stemming from a Thermal Power Project and a Coal Liquefaction Project. The incremental impact on agriculture, as a result of the Liquefaction Project, would be direct loss of 11 percent of irrigated pasture lands beyond that of the losses due to the Power Project, to give a total loss of 435 ha (26 percent). The loss of spring rangeland would adversely affect the local beef industry. Preliminary estimates indicate a loss of 3 percent of projected herd size due to direct alienation of spring rangeland. Loss of summer rangeland due to the Liquefaction Project would be 2500 ha. This is not considered a significant impact on the regional beef industry as summer rangeland alternatives are available, whereas, spring rangeland alternatives are not. Four ranches would suffer significant loss of land from the Coal Liquefaction Project.

A serious concern is the potential for long-term accumulation of fluorine in forage from combined Thermal Project and Liquefaction Project emissions and subsequent ingestion by cattle, leading to fluorosis in the animals. Such contamination could effectively reduce the suitability of large areas of rangelands to cattle. A more detailed assessment of the impacts of the combined Thermal Project and Liquefaction Project is necessary to accurately predict effects, especially with regard to increased fluorine, SO₂ and trace element

levels in the environment and their effects on agricultural production.

(iii) Wildlife

The valley has moderate limitations for support and production of ungulates. There is a small area (approximately 11 percent of the study area) of important winter range in the valley. Both mule deer and moose are present, but neither species is abundant. The development of Pit No. 2 to meet the Coal Liquefaction Project's coal needs will remove a significant amount of medium to high capability lands suitable for deer. Impact on deer habitat is not considered critical to the regional deer population although most of the deer winter range in the valley would be alienated as the project develops. However, a more detailed assessment of the regional effects of long-term fluorine accumulations on wildlife populations is required. Other impacts of the Liquefaction Project would result from incremental land alienation. This would prevent animal movement, alter migration patterns, or increase vulnerability to road traffic. The extent of these and other adverse impacts will require further study and development of mitigative or compensative measures.

The Coal Liquefaction Project will result in loss of valley wetlands, which are important local waterfowl breeding habitat. Migrating waterfowl use the Hat Creek Valley in fall and spring as a staging area. The decline of wetlands would result in a decrease in waterfowl production in the area.

A major impact on wildlife would stem from increased hunting pressures due to an influx of the large Liquefaction Project work force and related population. In response to the

increased recreational demands on wildlife, resource management activities intended to offset this pressure will place an added imposition on local people who have traditionally had unrestricted access to relatively abundant hunting opportunities. Increased wildlife management will also entail greater manpower requirements by the province. This increase in recreational demand will apply to all forms of outdoor recreation.

(iv) Heritage Resources

Studies have indicated the presence of historical and archaeological sites in the Hat Creek valley. Most of these sites have been undisturbed because of the lack of industrial or residential development. Further studies are required to determine the full heritage resource potential of the valley and the impact of the Liquefaction Project.

(v) Aesthetics

The major visual impact of the Thermal Power Project will be the mine pit, waste and ash disposal sites, the tall flue gas stack and large hyperbolic cooling towers. Visible plumes from the cooling towers and stack would occasionally extend more than 15 km from the powerplant. The Coal Liquefaction Project will produce additional plumes that would further impair visibility and the rural landscape of the Hat Creek area.

(d) Water Quality, Hydrology, Fisheries and Aquatic Life

The water bodies that could be affected by the Coal Liquefaction Project are the Bonaparte, Thompson and Fraser rivers, Hat Creek and surrounding lakes. Surface runoff in Hat Creek is low during

most of the year, averaging less than 1 m³/s in summer. On occasion, Hat Creek has been known to go dry. Impacts on fish resources of the region are expected with the Thermal Power Project due to habitat alienation, changes in water quality and recreational fishing pressures. Additional impacts on fisheries and on other water uses such as agriculture, are expected with the Coal Liquefaction Project.

(i) Water Quality

Water quality impacts are regarded as significant. Maintenance of the present quality and quantity of water in the Hat Creek area is essential for local fisheries and to a lesser extent regional fisheries. The development of Coal Deposit No. 2 to meet the Liquefaction Project coal requirements will involve additional diversion of surface waters in the Hat Creek valley, in particular, Hat Creek. Impacts may include: fish habitat destruction, increased sediment loading, reduced water flows, and elevated water temperatures. A potential loss of spawning habitat in the lower reaches of Hat Creek, presently utilized by rainbow trout from the Bonaparte River, will impact regional fisheries. The full effects on the Bonaparte River are not expected to be significant although further studies are required.

(ii) Groundwater

Impacts in addition to those expected for the Thermal Power Project on the hydrology of the Hat Creek area (surface and groundwaters) can be expected by the development of a Coal Liquefaction Project. In general, the potential for groundwater leaching with the Coal Liquefaction Project is significantly increased due to the need for disposal of additional quantities of ash and sludge. The water quality effects of

leachates from the liquefaction plant's solid wastes have yet to be determined. Acidic mine leachate potential is higher for Deposit No. 2 coal than Deposit No. 1 (proposed to be developed for the Thermal Power Project) due to its higher sulphur content. Concentrations of heavy metals and other trace elements can be expected to be present in the leachate. Runoff from coal stockpiles has also a high potential for acid generation and traces of heavy metals and undesirable dissolved ions. To accommodate the Coal Liquefaction Project, the control of mine-site leachates will require a comprehensive drainage and water management system similar to those developed for the Thermal Power Project proposed by B.C. Hydro.

The water management system would be designed for zero discharge of all low quality waters (leachates, bedrock seepages, mine waters and coal pile runoff). Liquid waste would be disposed of by using it for mine dust control and/or by spray evaporation. Strict maintenance of a water management scheme would be required to maintain zero waste water leaving the Liquefaction Project boundaries.

(iii) Water Contamination from Emissions

There is some potential for emissions from the Coal Liquefaction Project reaching local and regional water resources. The most serious contaminants could be acid rain from emissions of sulphur dioxide and nitrogen oxides and from the halogenated heavy aromatics, which can accumulate in the food web, a process known as biomagnification. The extent and magnitude of these problems are uncertain and would require evaluation during feasibility studies.

There is a potential for acidification of soft water lakes in the region due to long range transportation of sulphur dioxide and nitrogen oxide emissions from the Liquefaction Project. This condition could be minimized by mitigative design methods such as Stretford sulphur recovery plant, flue gas desulphurization and low nitrogen oxide burners on the Liquefaction Project steam plant. A study by B.C. Hydro of potential effects of acid rains resulting from the Thermal Project indicated the potential for short-term rapid increase of stream water acidity during annual spring snow-melt (referred to as acid shock).

This effect would be compounded by the additional emissions from the Liquefaction Project. For the Wells Gray Park watershed, an area of low buffering capacity, additional acidity would require careful examination to confirm that the change is within threshold levels for sensitive biota. While B.C. Hydro estimate that pH changes resulting from the Power Project would have no significant effect on biophysical systems, including aquatic life, an extensive monitoring program is proposed at a variety of sensitive sites. A detailed study of the effects of additional emissions from the Coal Liquefaction Project would be required in the feasibility studies.

Local areas can expect to be affected by the "acid shock" due to rapid snow melt during spring freshet. The semi-arid and alkaline nature of the local area would, however, minimize the effects of acid rain. The impact of acid shock could markedly reduce fish populations over the long-term; an effect already being experienced in industrialized areas of the U.S. and Europe.

(iv) Water Withdrawals

The use of the Thompson River (valuable commercial and recreational fishery river) as a source of process water presents the danger of entrainment of smolts or fry in the intake. The Coal Liquefaction Project and the Thermal Power Project combined water withdrawal requirement would be less than 4 percent of the minimum recorded Thompson River flow. Pink salmon are the most susceptible species to inadvertent capture. The previous design capacity for the thermal power-plant's intake (Thompson River) would be doubled to accommodate the Coal Liquefaction Plant's make-up water.

If the water intake is considered with no mitigating design features then the entrainment of pink salmon fry would be proportionately increased over that estimated under the same criterion for the Thermal Power Project. However, the water intake for the Liquefaction Project could incorporate measures specifically designed to prevent the entrainment of the fry. Further it should be noted that if these design features do not provide adequate protection of fry, then the intake could be shut down for the period of downstream migration (approximately 20 days) by drawing from the water reservoir at the project site. Hence adverse effects on the salmon fishery may be avoided.

Any groundwater withdrawals to meet construction water requirements would significantly affect local groundwater regimes, thereby seriously impacting on domestic and agricultural/irrigation water requirements; since irrigation of forage crops is the major consumptive use of water in the area, any withdrawal of water for the Coal Liquefaction Project would seriously compete with the irrigation needs of the valley.

If alternative plans to construct containment reservoirs on Hat Creek for construction needs are implemented, surface water flows in the creek may be severely curtailed.

This would be a temporary impact until the main water supply system from the Thompson River is installed. Another serious concern may be the long-term build-up of salts and undesirable trace element in soils due to spray irrigation, if the proposed zero discharge of contaminated liquid effluents is implemented. Reclamation of disturbed lands could be seriously curtailed by salt build-up in soils.

(v) Recreational Fishery

The expected increase in recreational demand particularly from the Coal Liquefaction Project construction work force and related populations for fishing could adversely affect regional fisheries. Increased fisheries management would be required at a cost to the province.

(e) Industrial and Public Health Impacts

There are several products, by-products, intermediate products and waste streams associated with the Coal Liquefaction Project which contain substances known to be potentially injurious to health. While some of these have already been identified as carcinogens, mutagens and teratogenes, others are suspected to be so in varying degrees. Actual data on the characterization of these substances are very limited, but investigations are presently being carried out in other countries. Proper design of pump seals, pipe joints and good housekeeping measures, such as ventilation and spill prevention, will be necessary to minimize employee exposure to the substances identified as harmful.

(f) Transportation Modes and Routes

Significant environmental constraints were identified in assessing both the transportation corridor and the marine terminal location of the 10 alternative transportation systems considered. Of the six marine terminal areas evaluated, the Furry Creek/Britannia Beach area appears to offer the least potential environmental impact relative to space availability and site limitations. Five alternative transportation routes were identified for consideration and comparative evaluation at the feasibility level. These are: rail from Kelly Lake to Furry Creek or Britannia Beach; pipeline from Hat Creek to Furry Creek or Britannia Beach; pipeline from Hat Creek to the Cherry Point/Ferndale, Washington area; pipeline from Hat Creek to Roberts Bank; and rail from Ashcroft to Roberts Bank.

4.3 SOCIO-COMMUNITY IMPACTS

Development of the Coal Liquefaction Project in the Hat Creek valley under its assumed schedule would produce profound changes in the socio-economic environment of the local area and possibly the entire region. Two communities in particular, Ashcroft and Cache Creek, which form part of the Thompson-Nicola Regional District would be heavily impacted.

The simultaneous construction of the Liquefaction Project and the Thermal Power Project presents a mammoth challenge to managing impacts that can only be met through innovative co-ordination of the efforts of public and private institutions.

It is expected that most of the Liquefaction Project work force required for construction, operation and support services would come in from outside the region. If the Liquefaction Project and Thermal Power Project proceed, the local area population is expected to swell from the existing 8000 to 31 000 at the peak of construction and level off at

about 24 000 during operation. Without the Liquefaction Project but including the Power Project the population is expected to increase more gradually throughout this time period to about 14 000. Population growth in the local area is illustrated on Exhibit 4-3.

The Liquefaction Project's demand for labour would be almost totally met from outside the region. During construction few regional residents are expected to work on the project as most of the skilled construction workers would be employed on other projects. During operation it is expected that few regional residents would have the required skills to gain employment on the project. Regional residents are expected to benefit from approximately 2500 induced and indirect long-term employment opportunities which would be created.

It should be noted that the technical and economic analysis assumed the construction of an ethylene derivative plant to further process ethylene by-product from the Liquefaction Project. Because ethylene is difficult and costly to transport, the plant could also require a location in the Hat Creek area. The impact of such a development has not been included in the social impact analysis.

Within the provincial context, the availability of skilled workers for the Liquefaction Project would be a major issue. It is likely that significant training effort would be required, particularly for steam engineers, technicians and maintenance personnel.

The level and, in some cases, the quality of commercial and public services in the communities of the local area would eventually be raised as a result of the project. On the other hand, the demands of rapid growth during the early years of the developments would likely produce considerable bottle-necks in the short term, and lower the quality of local services.

In the provision of public services, increased demands will be heavy across all service categories. A partial cost assessment indicates that capital costs of at least \$18.5 million will be required for services expansions. The most significant facility and staffing expansions would occur in education. Between 1984 and 1988, seven new schools would be required within the local School District. For most services, if hardships are to be minimized for local residents and immigrants alike, the normal practice of providing services on demand, rather than in anticipation of demand, will have to be adjusted. There will be a uniquely critical need for co-ordination of efforts among agencies.

Adequate and affordable housing is one of the most important factors in minimizing the social disruption that rapid growth produces. The population growth expected with the Liquefaction Project will require an average of 1100 housing units per year during the 1984 to 1987 period. Much of the land with development potential is currently within the Agricultural Land Reserve. Furthermore it is unlikely that the regional residential construction industry would be able to provide sufficient manpower to meet required housing needs in the time frame envisaged, particularly between 1984 and 1987.

Municipal services would require substantial upgrading in all communities to accommodate the growth resulting from the Liquefaction Project, but there does not appear to be any major physical constraints to this expansion. It is expected that capital expenditures in the order of \$17 million would be required. Large capital expenditures are one important factor which would cause excessively high property taxes in Ashcroft, Cache Creek and possibly Clinton during the early years of Liquefaction Project development. In the longer run, tax burdens are expected to normalize and should not be out of line with provincial norms.

The process of rapid change associated with large population increases would undoubtedly alter the physical and social character of the

receiving communities. Commodity and service shortages, inflation in some sectors, inconveniences occurring in a variety of everyday experiences, social stratification and role changes would probably be the norm rather than the exception during at least the first 4 years of development. These events would be stressful particularly for the existing residents of the area. This stress may give rise to an increased incidence of crime, juvenile delinquency, family break up, child neglect and mental health problems. Once the full operating workforce is in place, community life would tend to stabilize and the increased levels of commercial and public services would likely produce lasting social benefits to community residents.

There are four Indian Bands in the vicinity of the project and one reserve of the Bonaparte Band borders the project site. As such, the Bonaparte Band would be most directly affected by the impacts of the Liquefaction Project. The accommodation of an additional 10 000 construction workers just outside the Bonaparte Reserve could increase the risk of negative interaction between reserve and camp residents.

All bands may experience negative effects on their hunting and food fishing activities. However, increased employment opportunities on the Liquefaction Project could benefit local Indians, providing existing barriers to employment are overcome. If these opportunities encourage off-reserve residents to return to their reserves, increased pressures would occur on currently inadequate and poor housing and sanitary sewage facilities.

EXHIBIT 4-1

SUMMARY OF SIGNIFICANT EMISSIONS TO THE ATMOSPHERE
HAT CREEK THERMAL POWER PROJECT AND COAL LIQUEFACTION PROJECT

Emissions to the Atmosphere	Base Case					Alternative				
	TPP ^{*1} 52% SO ₂ Removal and 366 m Stack (t/d)	CLP ^{*2} Without Steam plant Emissions (t/d)	CLP Steam plant ^{*2} 46% SO ₂ Removal and 244 m Stack (t/d)	CLP Increase Over TPP Base (%)	Combined Total CLP & TPP (t/d)	TPP 85% SO ₂ Removal and 366 m Stack (t/d)	CLP ^{*2} Without Steam plant Emissions (t/d)	CLP Steam plant ^{*2} 96% SO ₂ Removal and 244 m Stack (t/d)	CLP Increase Over TPP Base (%)	Combined Total CLP & TPP (t/d)
Sulphur dioxide (SO ₂)	150	19	78	65	247	44	19	12	20	75
Nitrogen oxides (NO _x)	170	12	52	37	234	170	12	52	-	234
Particulates	17	1.2	1.2	14	19.4	4	1.2	1.2	-	6.4
Fluorine	1.17	(^{*4})	0.39 ^{*3}	33	-	0.36	(^{*4})	0.11	10	-
Carbon monoxide (CO)	18	9	6	83	33	18	9	6	-	33
Hydrocarbons (HC)	5	12	1.6 ^{*5}	272	18.6	5	12	1.6 ^{*5}	272	18.6

^{*1} Emissions estimates obtained from B.C. Hydro's EIS. (8)

^{*2} Emission estimates obtained from Coal Liquefaction Plant Prefeasibility Study. (1)

^{*3} Coal Liquefaction Project steam plant emissions assumed to be 36.5 percent of fluorine in coal feed for base case and 10 percent of fluorine in coal feed for alternate (100 percent) scrubbed case.

^{*4} Coal Liquefaction Project emissions of fluorine were not indicated in Coal Liquefaction Plant Prefeasibility Study. (1)

^{*5} Assumed to be approximately 33 percent of Power Project emissions.

LEGEND

TPP = Thermal Power Project
CLP = Coal Liquefaction Project

EXHIBIT 4-2

SUMMARY OF MAXIMUM AMBIENT CONCENTRATIONS OF
SIGNIFICANT CONTAMINANTS

<u>Species and Average Time</u>	<u>Base Case*¹ ($\mu\text{g}/\text{m}^3$)</u>	<u>Alternate Case*¹ ($\mu\text{g}/\text{m}^3$)</u>	<u>B.C. Ministry of Environment Objectives*³</u>	<u>National Air Quality Objectives*⁵</u>	
				<u>Maximum Desirable</u>	<u>Maximum Acceptable</u>
Sulphur Dioxide					
1 hour	986	304	450 - 900	450	900
3 hours	461	142	375 - 665	-	-
24 hours	275	85	160 - 260	150	300
Annual	7.4	2.4	27 - 75	30	60
Nitrogen Dioxide					
1 hour	510	510	-	-	400
24 hours	140	140	-	-	200
Annual	3.5	3.5	-	60	100
Suspended Particulate* ²					
24 hours	25	8	150 - 200	-	120
Annual	0.6	0.2	60 - 70	60	70
Fluorine					
24 hours	2	0.6	(0.1 - 2.0)* ⁴	-	-

*¹ Emissions as per Exhibit 4-1, 366 m stack for Thermal Power Project, 244 m stack for the Coal Liquefaction Project steam plant.

*² Contribution from Powerplant and Liquefaction Plant plus steam plant only; does not include fugitive emissions from mining, coal handling and coal preparation.

*³ Reference (9).

*⁴ Averaging time not specified for ambient fluorine in the B.C. Objectives.

*⁵ Environment Canada, Air Pollution Control Directorate, November 1978, The Clean Air Act - Compilation of Regulations and Guidelines Ambient Air Quality Objectives.

POPULATION GROWTH IN THE HAT CREEK STUDY AREA

DUE TO COAL LIQUEFACTION PROJECT

LEGEND

LOCAL POPULATION WITH COAL LIQUEFACTION PROJECT:

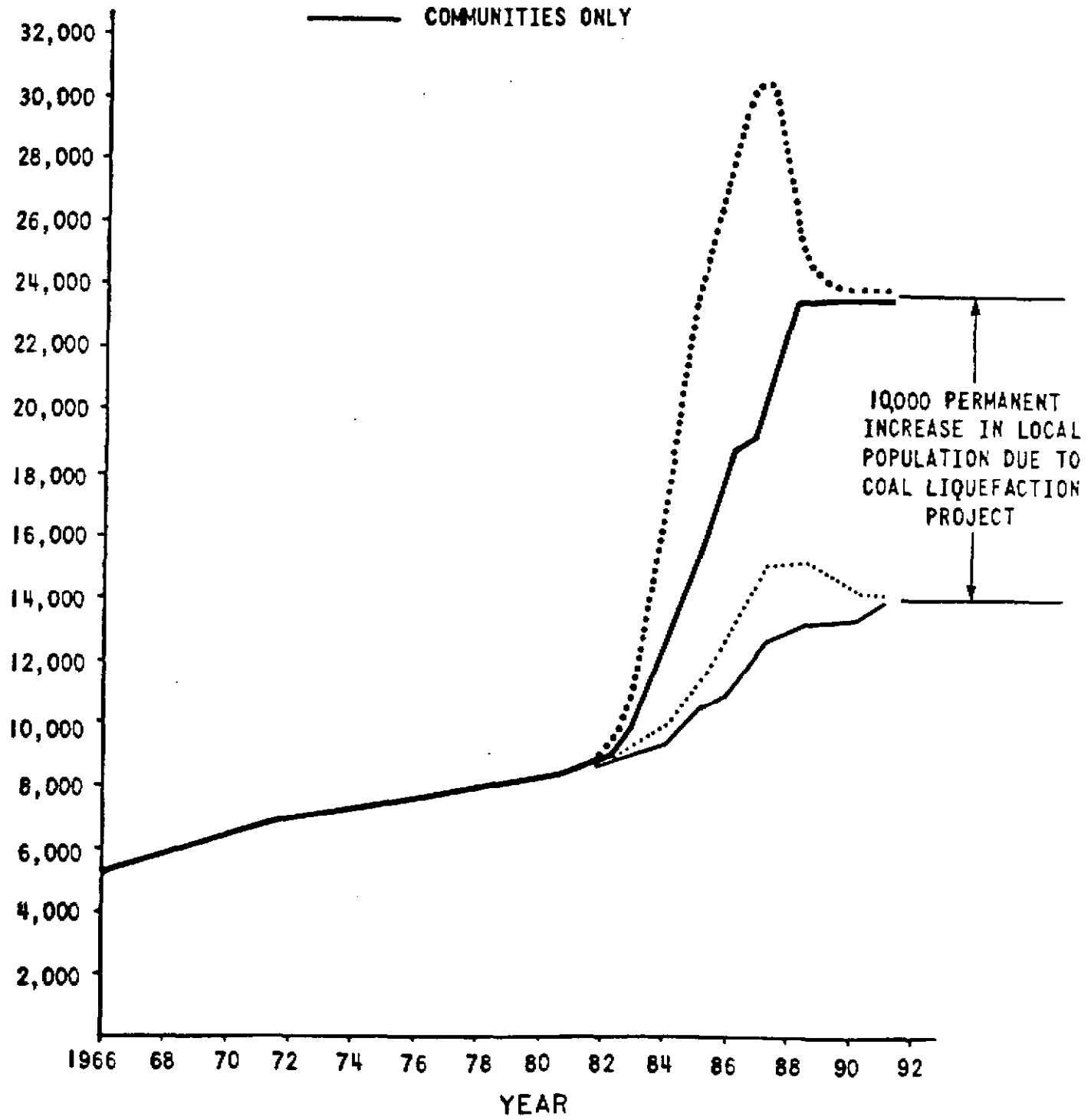
..... COMMUNITIES AND CONSTRUCTION CAMPS

———— COMMUNITIES ONLY

LOCAL POPULATION WITHOUT COAL LIQUEFACTION PROJECT:

..... COMMUNITIES AND CONSTRUCTION CAMPS

———— COMMUNITIES ONLY



SECTION 5.0 - ECONOMIC EVALUATION

5.1 INTRODUCTION

The principal question addressed by the economic evaluation is whether or not the Coal Liquefaction Project represents an economically desirable use of the coal and other natural resources in the Hat Creek area, and of the manpower and capital which it will require. In addition, if the interests of British Columbia are to be successfully promoted, it is essential for the economic evaluation to answer the following questions: Is it possible for the project to be commercially viable from a private sector perspective, while still being economically desirable? How will the incidence of the costs and benefits have to be altered to make it so? What are the financial implications for the three levels of government (federal, provincial and municipal) for alternative distributions of costs and benefits?

The economic evaluation has been completed on a single facility concept which was developed in the study of the Liquefaction Plant⁽¹⁾ with direction from the Energy Development Agency. No attempt has been made to search for the optimum (economic) project concept. That is, alternative plant sizes, product slates or technologies have not been evaluated to determine whether the economic returns can be increased.

For purposes of clarifying the presentation and addressing the series of questions noted above, the evaluation is partitioned into private sector and public sector analyses. These analyses are discussed separately, then summed to provide the overall benefit-cost evaluation necessary to answer questions of economic desirability.

The economic evaluation has been conducted assuming a "base case" project concept drawn from the various studies completed for the Steering Committee. The major "base case" assumptions are:

1. That construction of the Coal Liquefaction Project would commence in July, 1984, with initial production commencing in January, 1988, and extending over a 30-year life (to the end of 2017).
2. That the Coal Liquefaction Project's capital and operating costs remain constant in real terms.
3. That Liquefaction Plant products are sold in international markets, wherein prices increase at an average annual compounded rate of about 2 percent in real terms to the year 2000, and remain constant in real terms thereafter. [Product prices were forecast by the Ministry of Industry and Small Business Development.]
4. That the production processes are designed to maximize gasoline production.
5. That the 2000 Mw Thermal Power Project and related facilities planned for Hat Creek would proceed whether or not the Coal Liquefaction Project goes ahead. Accordingly, it is conceptually correct to attribute to the Liquefaction Project only those costs that are incremental to the Power Project.

At the prefeasibility level of analysis there exists major uncertainties with regard to the project concept. In the case of those uncertainties that have a quantitative impact on the economic evaluation, this analysis attempts to reflect their effects in sensitivity tests. The important results of these tests are presented in Section 5.4.

5.2 PRIVATE SECTOR ANALYSIS

In the private sector analysis the Coal Liquefaction Project is evaluated from the point of view of the private investor. That is, only the expected cash costs and revenues that directly impact on the private investor are relevant to the analysis. The results of this analysis are presented in terms of the before-tax return on investment, the after-tax return on investment and the after-tax return to owner's equity.

Costs, excluding working capital, taxes and interest, consist of the \$5.85 billion (1980 dollars) in capital costs for the Coal Liquefaction Project and its related facilities, expended during the 5-year construction period, and the \$516 million (1980 dollars) in annual operating and maintenance costs, expended throughout the project's 30-year operating life. These estimates have been developed assuming world-wide procurement and no labour shortages or other bottlenecks. Base case expenditure estimates are summarized in Exhibit 5-1.

Revenues are assumed to commence in 1988 with the plant start-up and to continue throughout the 30-year operating life. Cash inflows are generated through the sale of products to offshore and North American markets. Prices for the various primary products (gasoline, jet fuel, diesel fuel and light fuel oil) have been forecast under the assumptions that the final market is Japan and that the conventional refining of world-priced crude oil will continue to set Japanese market prices. With world crude oil prices rising in real terms (i.e. net of inflation) at 2 percent per year until the end of this century (an assumption adopted generally as current conventional wisdom), primary product prices at the Hat Creek Coal Liquefaction Plant gate are forecast to rise an average of 1.4 percent per year over the period 1980 to 2000, and to remain constant in real terms thereafter. [This analysis also assumes that non-energy refining costs and unit transportation costs will remain constant in real terms throughout the forecast period.]

Prices for the various by-products (except LPG and sulphur) [LPG prices are assumed to be based on crude oil prices and sulphur prices are assumed to remain constant in real terms.] have been forecast under the assumption that the conventional refining of natural gas-based petrochemical feedstocks in the United States will continue to set North American market prices. With U.S. oil priced at world levels and with a growing parity between U.S. crude oil and natural gas prices (an assumption adopted by the U.S. Department of Energy), U.S. natural gas prices are forecast to increase at an average annual rate of 6 percent to the end of the century, and by-product prices at the Hat Creek Liquefaction Plant gate are forecast to rise an average of 3.9 percent per year over the period 1980 to 2000, and to remain constant thereafter.

It should be noted that the primary and by-product price forecasts are not based on detailed market studies, and that such in-depth analysis should be undertaken if the project moves to the next level of assessment.

Given the Liquefaction Project product slate and the above methodology for arriving at product prices, annual Liquefaction Plant gate revenues are forecast to rise an average 2 percent per year from \$1.36 billion (1980 dollars) in 1988 to \$1.71 billion (1980 dollars) in 2000 (see Exhibit 5-2).

The 1980 dollars present value equivalents of expected cash costs, taxes and revenues over the life of the project (using a 10 percent discount rate net of inflation) are presented in Exhibit 5-3. The tax payments are more fully discussed in the public sector analysis.

As noted above, the performance of the proposed project from the viewpoint of the private sector is considered before income tax payments (but after capital tax and property tax), without regard to the financing plan, and after income tax payments, assuming a particular debt to

equity ratio. From Exhibit 5-3 it can be seen that the 1980 dollars present value equivalent of total Liquefaction Plant gate revenues of \$7.0 billion exceeds the present value equivalent of before-income-tax costs of \$6.5 billion. [Total capital and operating costs of \$6.1 billion plus property and capital taxes of about \$380 million.] The before-income-tax return on investment that equates the revenue and expenditure streams (i.e. the internal rate of return) is 11.0 percent, net of inflation.

Assuming a debt to equity ratio of 75:25 and an interest rate on debt of 5 percent, net of inflation, the after income tax return on investment for the Coal Liquefaction Project is 9.3 percent, and the after-tax return to owner's equity is 11.9 percent.

On the basis of the above analysis and without regard to the relative riskiness of this project, the base case project concept would appear to be an average before-tax investment and an above average after-tax investment, relative to other investments in the Canadian economy. This observation is based on other studies of the Canadian economy which indicate that the average realized before-tax return on investment is about 10 percent and the average after-tax return on investment is about 7 percent.¹⁰ The implications of the rather low income tax return to senior government from the proposed Coal Liquefaction Project are discussed below in Section 5.3(a).

Little else can be said about the specific attractiveness or commercial viability of the proposed Coal Liquefaction Project to the private sector without input from potential proponents. This is due to the fact that minimum acceptable rates of return on investment and owner's equity are set by internal company policy, and will vary across companies and industries according to such factors as project scale, attitudes toward risk, company size, existing company debt structure and sources of financing.

5.3 PUBLIC SECTOR ANALYSIS

As noted earlier, the private sector analysis and the test of commercial viability do not capture the full range of costs and benefits within the British Columbia economy. To be comprehensive, the analysis must be extended to include public sector costs and returns. We also include in this public sector analysis "third party" or other private sector interests which realize either costs or benefits as a result of the project development.

(a) Costs

Additional project costs that were not included in the private sector analysis are:

1. The economic cost of electric power.
2. Environmental costs.
3. Infrastructure costs.
4. Social costs.

In the private sector analysis, the financial cost of power sold to the Liquefaction Project and the company operating the coal mine was estimated to be 22.6 mills/kw.h in 1980 dollars. [The financial cost of electricity and the social costs of electricity were provided by the B.C. Hydro and Power Authority, Generation Planning Department.] This rate is based on B.C. Hydro's expected future incremental costs of power supply from the Hat Creek Power Project, evaluated at an interest rate of 3 percent net of inflation, which corresponds to B.C. Hydro's direct cost of capital, net of inflation. However, at the 10 percent real rate of return used in the public sector analysis, the social opportunity cost to the British Columbia economy of producing this power has been estimated to be 36.8 mills/kw.h. [The financial cost of electricity and the social costs of electricity were provided by

the B.C. Hydro and Power Authority, Generation Planning Department.]

This difference of 14.2 mills/kW.h is a cost borne by the British Columbia economy. The 1980 dollars present value equivalent of this additional cost is \$273 million (using a 10 percent discount rate). [If the Coal Liquefaction Project were charged the social opportunity cost of electric power, the plant's overall present value equivalent revenue would be reduced by only \$204 million as a result of the concurrent reduction in tax payments. In this case, the Provincial Government (including provincial crown corporations) present value equivalent revenue would increase by \$246 million and Federal Government (including national crown corporations) present value equivalent revenue would decrease by \$42 million. The before and after income tax private rates of return on investment would decline from 11.0 percent and 9.3 percent, respectively, to 10.4 percent and 8.9 percent, net of inflation.]

The value of resource-based commercial productivity losses were estimated.⁵ This analysis quantifies cost estimates for reduced forest productivity and commercial fishery losses only. The estimated 1980 dollars present value equivalent of these losses is less than \$1 million.

The value of lost environmental amenities has not been quantified.

The cost of incremental infrastructure for the Coal Liquefaction Project has not been investigated in the prefeasibility analysis. Since the analysis is based on the assumption that the Hat Creek Thermal Power Project would proceed with or without the Coal Liquefaction Project, the incremental infrastructure cost necessary to service the Coal Liquefaction Project (e.g. public access and construction roads) would likely be small. The cost of providing

product transportation infrastructure is included in the transportation tariffs. The cost of providing community infrastructure and services (e.g. health care, education and law enforcement) is assumed to be covered by the property taxes the Coal Liquefaction Project would generate. An in-depth analysis of these costs should be undertaken if the project moves to the next level of planning.

Social costs (Section 4.3) refer to the important, but intangible, values placed on such things as community identity, quality of life, community stability, and the like. Reductions in these values from levels without the project would be borne by the existing regional population, as distinct from the migrants brought into the area by the Coal Liquefaction Project. No attempt has been made to quantify these costs at this stage, or to mitigate their impact.

(b) Benefits

The public sector benefits identified in the analysis include tax payment to the three levels of government (over and above the cost of providing services), as well as benefits accruing to third parties.

British Columbia would receive payments from taxes levied on invested capital and corporate profits. Under base case assumptions, capital tax payments are calculated to commence in 1983 while corporate profits tax payments do not begin until 1996. The 1980 dollars present value equivalents of these tax receipts are \$44 million and \$286 million, respectively, using a 10 percent discount rate, net of inflation and a 7 percent rate of annual inflation.

Payments to Canada, which are considered as direct benefits, are limited to corporate income taxes. [This study assumes that the

new federal Petroleum and Natural Gas Revenue Tax (PNGRT) introduced in October 1980 with the National Energy Program would not be applicable to revenues from a Coal Liquefaction Plant. This assumption was based on discussions with representatives of both the Financial and Fiscal Analysis Division, Department of Energy, Mines and Resources Canada and the Tax Policy and Federal-Provincial Relations Branch, Department of Finance Canada. If the Liquefaction Plant were subject to the PNGRT the 1980 dollars present value equivalent of the tax would equal \$378 million. This would reduce the before and after income tax private rates of return from about 11.0 percent and 9.3 percent, respectively, to 10.2 percent and 8.3 percent, net of inflation. Given the potential significance of such a tax, the applicability of the new Petroleum and Natural Gas Tax should be re-examined as part of an overall fiscal review if the project proceeds to the next level of planning.] Under base case assumptions, the Coal Liquefaction Project will pay federal corporate income taxes commencing in 1996. Over the life of the Liquefaction Project these tax receipts are calculated to have a 1980 dollars present value equivalent of \$476 million.

At the local level, we have assumed that base case property taxes are just sufficient to cover the costs of providing the community infrastructure and services, and hence no net tax benefits are attributed. Under base case assumptions property tax payments commence in 1984 and have a 1980 dollars present value equivalent of \$339 million.

It should be noted that the tax calculations are preliminary and no attempt has been made to optimize tax payments (i.e. defer or reduce tax liabilities). [Optimizing taxes would have the effect of shifting benefits from the public to the private sector, without affecting total project benefits.] Nevertheless, the analysis indicates relatively low corporate income tax returns to the

Provincial and Federal Governments from the proposed Liquefaction Project. Despite having a 1980 dollars present value equivalent of about \$760 million, income tax receipts represent only 15 percent of the return on total Liquefaction Project investment. The average income tax revenue share realized from investment in the Canadian economy is about 29 percent. The primary reasons for this low corporate income tax return are the capital intensity of the Liquefaction Project and the relatively generous tax treatment afforded energy developments, the net effects of which reduce the effective corporate tax rate and delay the commencement of income tax payments.

The third party benefits recognized at this level of the analysis include cost savings accruing to the Hat Creek Thermal Power Project, increased utilization of provincial capital and labour resources, and technological spin-offs. Only the benefit accruing to the Power Project has been quantified.

Significant cost savings would be realized by the Power Project as a result of expanding the coal mining operation. Using a 10 percent real discount rate, the 1980 dollars present value equivalent of these cost savings to the Power Project is calculated to be \$72 million. However, no attempt was made to adjust this figure for the impact that the altered mining profile would have upon the Power Project (e.g. due to a change in the quality of the coal going to the powerplant).

The Coal Liquefaction Project is a major industrial development. It would have a significant effect within the local, regional and provincial economies. The Liquefaction Project would require materials and services from a range of support industries during the construction period and subsequently during the operating phase. Depending on the status of competing construction projects, it is estimated that provincial supply industries could provide

between 8 percent and 30 percent of the Liquefaction Project's material requirements. The lower figure corresponds to the simultaneous construction of several other large developments in British Columbia and Alberta, which reduces the available capacity of British Columbia support industries. Benefits from the Coal Liquefaction Project would accrue to these industries though increases in productivity only to the extent that existing capacity could be more fully utilized. We have not attempted to quantify the magnitude of these benefits. In addition, provincial labour resources are anticipated to be near full employment with or without the Coal Liquefaction Project, so no provincial benefit is ascribed to the employment effects of the Liquefaction Project.

The Coal Liquefaction Project may also create industrial opportunities in the province from the further processing of the by-products ethylene, ammonia and sulphur. The latter two by-products could support a small export orientated fertilizer plant. The ethylene production is sufficient to support a one-half world scale ethylene derivative plant which could serve domestic and offshore markets. A net provincial benefit arising from these industrial opportunities is implicit in the Liquefaction Plant gate revenues accruing to the Coal Liquefaction Project, since the price paid for these by-products is assumed to be equal to the price which would be paid by competing suppliers. However, neither the technical, environmental, social nor economic aspects of such developments have been addressed.

The potential for technological spin-off benefits were also examined. Since most of the technology embodied in the Liquefaction Plant is proven and under license, as is the technology of the new industrial opportunities which may be created, no public sector benefits of this nature were identified.

Two other impacts of the Coal Liquefaction Project on the public sector were considered: the value of the enhanced security of energy supply; and the project's impact on the overall provincial economy (i.e. effects on provincial price levels, the unemployment rate, etc.). Neither of these aspects have been quantified. Security of energy supply will be enhanced with the Liquefaction Project, however the value to be assigned to this enhanced security is difficult to determine. The macro-economic impacts of the Liquefaction Project will be significant, however whether they can be considered a cost or a benefit will depend upon the state of the economy when these impacts occur. For example, if the Liquefaction Project timing coincided with what would otherwise be a recessionary period, then the macro-economic impacts are more likely to be beneficial. The opposite would be the case if the economy was operating at or near full capacity.

5.4 COST-BENEFIT ANALYSIS

(a) Cost-Benefit Analysis - Base Case

The results of the base case private sector financial analysis and the base case analysis of public sector costs and benefits are now combined to produce the overall base case cost-benefit evaluation of the Coal Liquefaction Project. Whereas the private sector analysis addresses questions of commercial viability, the cost-benefit analysis addresses questions of economic desirability.

The economic evaluation of the base case proposal is summarized in Exhibit 5-4, and shows a social rate of return on investment from the project of 10.7 percent, net of inflation. If a 10 percent social rate of return on investment is taken to be the minimum acceptable rate of return, which is the recommended provincial guideline for assessing public sector investments, then under base

case assumptions the Coal Liquefaction Project could be an attractive economic development opportunity for British Columbia. However, it should be clear that embodied in the base case economic evaluation are cost and revenue estimates which are subject to major uncertainties. These uncertainties are addressed in sensitivity tests, the most significant findings of which are presented below.

(b) Major Sensitivity Tests

In this section the two major areas of uncertainty and risk in the base case economic evaluation are examined: cost estimates and product price forecasts. Specifically, in the base case it is assumed that Liquefaction Project costs would remain constant in real terms at their 1980 levels, while product prices would rise in real terms at an average annual rate of 2 percent per year until the end of the century. The major downside risks inherent in this evaluation are that Liquefaction Project costs would increase in real terms or that product prices would remain constant at their 1980 levels. [It is also possible that product prices could fall in real terms, however this outcome is considered less likely except in the short and/or very long term. A combination of rising costs and constant prices is also considered less likely.]

While it is also true that Liquefaction Project costs may fall and/or that product prices may rise more quickly than 2 percent per year, these outcomes do not pose a risk to the commercial viability or the economic desirability of the proposed investment, as they would tend to increase private and social rates of return. The results of these and other sensitivity tests are presented below in Section 5.4(c).

(i) The Effects of Rising Real Capital Costs

As noted above, the Coal Liquefaction Project's base case capital and operating costs are assumed to remain constant in real terms at their 1980 levels. These costs were developed under the assumptions of world-wide procurement and no labour shortages or other bottlenecks.

However, the best available forecasts predict that British Columbia will face shortages of skilled labour in the 1980s. The possibility also exists that a significant movement on a world-wide scale towards more coal liquefaction projects may result in bottlenecks in procurement or shortages of the specialized machinery and equipment required by the liquefaction plants. The effects of such shortages would likely be to increase the installed cost of the Liquefaction Project above the base case estimate.

To illustrate the potential effects, and therefore the risks, associated with this possibility a sensitivity test has been undertaken assuming that the base case capital cost estimates increase in real terms at the annual rate of 3 percent through the construction period. The results of this sensitivity test are shown in Exhibit 5-4, under the heading "Rising Real Capital Costs; Rising Real Prices".

Escalating capital costs by 3 percent per year increases the 1980 dollars present value equivalent of capital costs by some \$636 million, or about 17 percent. This increases the 1980 dollars present value equivalent of total social costs by about 9 percent over the base case estimate to about \$7.56 billion. Rising capital costs also decrease and defer [income tax payments begin in 1997 rather than in 1996] income tax payments. The primary loser in this respect is the

Federal Government, which has the 1980 dollars present value equivalent of income tax receipts decline by \$57 million. While provincial income tax receipts also decline by \$34 million, this decline is more than offset by increases in property and capital taxes, so that the 1980 dollars present value equivalent of total provincial tax receipts actually increases by \$24 million.

The commercial viability of the project is also diminished. This decline is reflected in the before and after income tax rates of return on investment and the rate of return to owner's equity, which decrease to 9.6 percent, 8.1 percent and 9.6 percent, respectively. However, while the impact of escalating capital costs on the commercial viability of the Coal Liquefaction Project is significant, the risks would not appear to be prohibitive.

The escalation in capital costs decreases the 1980 dollars present value of total net benefits by the full \$636 million, to minus \$303 million. The social rate of return is now 9.4 percent, net of inflation, down from 10.7 percent. As in the case of commercial viability, while this decline is significant it is not considered to be sufficient to make the project economically undesirable.

(ii) The Effects of Constant Real Product Prices

The second major area of uncertainty and risk in the base case economic evaluation is the assumption that, on the average, product prices would rise at 2 percent per year over the period 1980 to 2000. In order to assess the risks associated with this assumption a sensitivity test was undertaken assuming that product prices at the Liquefaction Plant gate remain constant at their 1980 levels. The results of this

REFERENCES

1. Fluor Canada Limited. February/March 1981. Hat Creek Coal Liquefaction Plant Prefeasibility Study Report Executive Summary. British Columbia Energy Development Agency.
2. British Columbia Hydro and Power Authority. February 1981. Prefeasibility Study for Support Facilities associated with a Proposed Coal Liquefaction Plant at Hat Creek.
3. British Columbia Hydro and Power Authority. March 1981. Hat Creek Coal Liquefaction Project Prefeasibility Study Mining. British Columbia Energy Development Agency.
4. Government of British Columbia, Ministry of Transportation and Highways. March 1981. Hat Creek Transportation Study.
5. B.C. Research. May 1981. Environmental Prefeasibility Assessment of the Proposed Hat Creek Coal Liquefaction Project. British Columbia Energy Development Agency.
6. Strong Hall & Associates/B.C. Research. May 1981. Hat Creek Coal Liquefaction Project: Preliminary Assessment of Socio-economic Impacts. British Columbia Energy Development Agency.
7. Government of British Columbia, Ministry of Industry of Small Business Development. June 1981. Economic Evaluation of the Coal Liquefaction Alternative for Hat Creek Coal.
8. British Columbia Hydro and Power Authority. April 1981. Hat Creek Project Environmental Impact Statement.

9.3 percent and 11.9 percent, respectively, in the base case. The social rate of return declines from 10.7 percent in the base case to 6.1 percent with constant real product prices. Such changes would likely have serious implications for the commercial viability and the economic desirability of the proposed Coal Liquefaction Project.

(c) Further Sensitivity Tests

Additional sensitivity tests have been undertaken to determine the impact on the commercial viability and the economic desirability of the Coal Liquefaction Project of: 2 year and 4 year delays in the project schedule; a 25 percent increase and a 25 percent decrease in the capital costs of plant and equipment; [This range was chosen because it coincided with the confidence interval placed on the major plant and equipment cost estimates provided in the study of the Liquefaction Plant.(1)] product prices that rise at an average annual rate exceeding 2 percent per year, [In this case it is assumed that world oil prices increase in real terms by an average 4.3 percent per year from 1980 to 1990, and thereafter revert to an annual rate of increase of 2 percent.] net of inflation; and, a higher coal price. The results of these further sensitivity tests are presented in Exhibit 5-5.

Two conclusions can be drawn from the further sensitivity tests. First, under the base case assumptions of constant real costs and rising real prices, delaying the Liquefaction Project for 2 to 4 years actually improves the economics of the Coal Liquefaction Project. Second, increasing the average annual growth rate of product prices has a major (positive) impact on the economics of the Liquefaction Project, which reinforces observations from the previous section, that the commercial viability and the economic desirability of the Liquefaction Project are extremely sensitive to changes in product prices.

4. Given the base case assumptions pertaining to costs and prices, delaying the project for 2 to 4 years actually improves the commercial viability and the economic desirability of the Liquefaction Project.
5. The Coal Liquefaction Project may create industrial development opportunities in the province from the further processing of the by-products ethylene, ammonia and sulphur. However, neither the technical, environmental, social nor economic aspects of such developments have been addressed.
6. The Coal Liquefaction Project is a major industrial development, and it would have a significant effect within the local, regional and provincial economies. Depending on the status of competing construction projects, it is estimated that provincial supply industries could provide between 8 percent and 30 percent of the project's material requirements. Since provincial labour resources are anticipated to be near full employment without the liquefaction plant, no provincial benefit is ascribed to the employment effects of the project.
7. Since most of the technology embodied in the Coal Liquefaction Plant is proven and under licence, as is the technology of the industrial development opportunities which may be created, no public sector benefits of this nature were identified.
8. Two other impacts of the Liquefaction Project on the public sector were considered: the value of the enhanced security of energy supply; and the project's impact on the overall provincial economy (i.e. effects on provincial price levels, the unemployment rate, etc.). Neither of these aspects have been quantified. Security of energy supply will be enhanced with the project, however the value to be assigned to this

EXHIBIT 5-1

COAL LIQUEFACTION PLANT
 BASE CASE
 CAPITAL COSTS & OPERATING EXPENSES
 (Expressed in Fourth Quarter 1980 Cdn \$)
 All Figures in Millions

<u>Capital Costs*1</u>	<u>Total</u>	<u>10/82</u> <u>12/82</u>	<u>1/83</u> <u>12/83</u>	<u>1/84</u> <u>12/84</u>	<u>1/85</u> <u>12/85</u>	<u>1/86</u> <u>12/86</u>	<u>1/87</u> <u>12/87</u>	<u>1/88</u> <u>3/88</u>
Plant and Equipment	\$5000	\$1	\$ 94	\$720	\$1808	\$1648	\$677	\$ 52
Start-up Costs	88	0	0	0	0	7	60	21
Misc. Capital Costs	277	0	1	12	30	52	114	68
Support Facilities	482	0	108	126	112	82	54	0
TOTAL	\$5847	\$1	\$203	\$858	\$1950	\$1789	\$905	\$141

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<u>Operating Expenses*2</u>	<u>4/88 - 12/88</u>	<u>1/89 - 12/89</u> <u>(Constant thereafter)</u>
Coal	\$ 64,828	\$207,450
Power	26,702	85,448
Other Expenses	199,688	223,504
TOTAL	\$291,218	\$516,402

516M\$

*1 Excludes capitalized taxes and capitalized interest

*2 Excludes property taxes and interest expenses

7. Increased population from both a large construction and an operational work force would place a heavy burden on regional resources (fish, wildlife, recreation) and community infrastructure (roads, hospitals, etc.). Increased resource protection and management, and community planning, by the province will be required to offset these effects.
8. In the short-term, particularly during the peak of the construction period, the quality of public services would be lowered, and property taxes to fund the required upgrading of municipal services would be excessively high.
9. In the long-term, when construction is complete, public and commercial services are predicted to be of a higher quality than they would be without the project, and tax burdens would normalize.
10. Population in the local communities would increase permanently by about 10 000, due to the Coal Liquefaction Project, to an estimated total of 24 000. The Liquefaction Project would create approximately 2700 direct jobs (2300 in the Liquefaction Plant and approximately 400 in the mine, beyond the 800 for the Thermal Power Project alone) and approximately 2500 induced and indirect jobs.
11. The availability of skilled construction workers to make up the required 14 500 peak construction force for the Liquefaction Plant would be a major issue. Significant training efforts would be required.
12. Of the six product shipping terminal areas evaluated, the Furry Creek/Brittania Beach area was found to pose the least potential environmental impact. Further evaluation of selected terminals and transportation routes is required.

EXHIBIT 5.4
COST-BENEFIT EVALUATION - BASE CASE & MAJOR SENSITIVITY TESTS
 (1980 present value equivalents)
 in millions \$, using a 10% real discount rate)

	Base Case: Constant Real Costs; Rising Real Prices ⁹	Rising Real Capital Costs; Rising Real Prices ¹⁰	Constant Real Costs; Constant Real Prices ¹¹
A. COSTS (Net of Taxes)			
1. Capital (1983-1988)	3,703	4,339	3,703
2. Operating & Maintenance (1988-2017)	<u>2,411</u>	<u>2,411</u>	<u>2,411</u>
TOTAL COSTS TO CLP	6,114	6,750	6,114
3. Implicit subsidy on purchased electricity ¹ (1988-2017)	273	273	273
4. Community Infrastructure costs ²	339	339	339
5. Transportation Infrastructure costs ³	197	197	197
6. Net cost of commercial forestry and fishery losses	N/S	N/S	N/S
7. Other net social and environmental costs	N/Q	N/Q	N/Q
TOTAL SOCIAL COSTS	<u>6,923</u> *****	<u>7,559</u> *****	<u>6,923</u> *****

7. Excluding working capital, taxes and interest during construction, the capital investment for the Coal Liquefaction Project including support facilities is \$5.85 billion (± 25 percent) in fourth quarter 1980 Canadian dollars. The financial cost of coal delivered to the project is \$11.32⁴ (1980 dollars including taxes and royalties). Excluding taxes and interest operating costs are estimated at \$516 million (1980 dollars) commencing in January 1989 (costs in 1988 are lower, due to partial Liquefaction Plant production).
8. At this prefeasibility level of analysis, the least cost scheme for transportation of the Coal Liquefaction Project products to the B.C. Coast is a pipeline to a new loading facility at Furry Creek on Howe Sound. Cost of transporting the products, including storage and loading facilities, using this route adds approximately 0.4¢/L to the cost of gasoline.
9. Detailed design and construction of the Liquefaction Plant would take about 60 months requiring a peak labour force of 14 500 in the construction phase. The operating manpower requirements for the Liquefaction Plant would be approximately 2300, while the mine would employ a peak work force of approximately 1600 when Deposit No. 2 is developed.

Significant manpower shortages are likely to occur during project design and construction. These shortages could delay the project's in-service date and/or increase costs.

(b) Environmental and Social Conclusions

1. Identification of air pollution sources and quantification of major contaminants from the Coal Liquefaction Project have indicated some areas of concern. Emissions of oxides of sulphur and nitrogen, could, under certain circumstances,

EXHIBIT 5.4 (Cont'd)

	Base Case: Constant Real Costs; Rising Real Prices ⁹	Rising Real Capital Costs; Rising Real Prices ¹⁰	Constant Real Costs; Constant Real Prices ¹¹
B. BENEFITS			
1. After-tax plant gate revenues (1988-2107)	5,843	5,875	4,540
2. Fed. Income tax (1996-2017) ⁴	476	419	158
3. Prov. Income tax (1996-2017) ⁴	286	252	96
4. Property tax ² (1984-2017)	339	391	339
5. Capital tax (1983-2017)	<u>44</u>	<u>50</u>	<u>44</u>
TOTAL PLANT GATE REVENUES	6,987	6,987	5,177
6. Transportation charges ³	197	197	197
7. Thermal plant coal cost saving ⁵	72	72	72
8. Other net benefits ⁶	<u>N/Q</u>	<u>N/Q</u>	<u>N/Q</u>
TOTAL SOCIAL BENEFITS	7,256 *****	7,256 *****	5,446 *****
C. TOTAL NET BENEFITS	333 *****	-303 *****	-1,477 *****
D. RETURN ON INVESTMENT (Real)			
Social return	10.70%	9.42%	6.07%
Private before income tax ⁷	10.99%	9.63%	6.66%
Private after income tax	9.34%	8.11%	5.49%
Return on equity ⁸	11.91%	9.62%	4.81%

SECTION 7.0 - CONCLUSIONS

7.1 CONCLUSIONS

The results of the engineering, environmental, social and economic prefeasibility studies of the Hat Creek Coal Liquefaction Project allow several significant conclusions to be drawn. The Steering Committee believes that the purpose of the studies as outlined in Section 1.2 have been achieved; thus, the Energy Development Agency and the Provincial Government should have adequate information to decide whether further Hat Creek coal liquefaction activities should proceed. The studies show that the proposed Coal Liquefaction Project is technically feasible, has the potential to be commercially viable and could have positive net benefits (benefit/cost ratio greater than one) to the province under certain financial and economic conditions. The environmental and social impacts of the project appear to be manageable with proper planning and design with mitigation and compensation for impacts.

(a) Engineering and Technical Conclusions

1. It is technically feasible to construct and operate a Sasol, Fischer-Tropsch Liquefaction Project at Hat Creek, B.C. The technology of all portions of the process have been amply demonstrated in commercial installations.
2. The Liquefaction Project is potentially capable of converting 41 900 t of Hat Creek coal per day to approximately 8600 m³ (54 000 bbls) of transport fuels including unleaded gasoline, jet fuel, diesel and medium fuel oil. An additional 12 000 t/d of Hat Creek coal would be required to operate the Liquefaction Project steam plant. By-products including

EXHIBIT 5.5
COST-BENEFIT EVALUATION - FURTHER SENSITIVITY TESTS
 (1980 present value equivalents)
 In millions \$, using a 10% real discount rate)

	Base Case with Two Year Delay	Base Case with Four Year Delay	25% Increase In Capital Costs ¹	25% Decrease In Capital Costs ¹	Tight Market Product Prices ²	\$17.20 Coal Price ³
A. COSTS (Net of Taxes)						
1. Capital	3,032	2,482	4,495	2,910	3,703	3,703
2. Operating & Maintenance	<u>1,974</u>	<u>1,617</u>	<u>2,411</u>	<u>2,411</u>	<u>2,411</u>	<u>2,901</u>
TOTAL COSTS TO CLP	5,006	4,099	6,906	5,321	6,114	6,604
3. Implicit subsidy on purchased electricity	224	183	273	273	273	273
4. Community Infrastructure costs	278	228	339	339	339	339
5. Transportation Infrastructure costs	162	132	197	197	197	197
6. Net cost of commercial forestry and fishery losses	N/S	N/S	N/S	N/S	N/S	N/S
7. Other net social and environmental costs	N/Q	N/Q	N/Q	N/Q	N/Q	N/Q
TOTAL SOCIAL COSTS	<u>5,670</u> *****	<u>4,642</u> *****	<u>7,715</u> *****	<u>6,130</u> *****	<u>6,923</u> *****	<u>7,413</u> *****

¹ The increases and decreases are in the cost of major plant and equipment, estimated by Fluor Canada Ltd. to be \$5 billion within a 25 percent confidence interval (see Exhibit 5.1).

² In this case it is assumed that world oil prices increase in real terms by an average 4.3 percent per year from 1980 - 1990, and thereafter revert to an annual rate of increase of 2 percent.

³ The difference between the cost of coal assumed here and the base case assumption (of \$11.32 per tonne) is treated as a provincial royalty and is shown under the category of "other net benefits".

HAT CREEK COAL LIQUEFACTION PROJECT
 FEASIBILITY STUDIES SCHEDULE, APPROVALS AND COSTS
 (ASSUMED EARLIEST IN-SERVICE DATE JANUARY 1988)

ACTIVITY DESCRIPTION	1981								1982												APPROX. COST (\$000)	
	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC		
COAL LIQUEFACTION PLANT STUDIES						▲	—	—	—	—	—	—	—	—	▲							\$4,000
LURGI LABORATORY TESTS				▲																		50
SUPPORT FACILITIES STUDY						▲	—	—	—	—	—	—	—	—	▲							1,200
ENVIRONMENTAL & SOCIO-COMMUNITY ECONOMIC EVALUATION						▲	—	—	—	—	—	—	—	—	▲							1,150
MINING FEASIBILITY STUDY						▲	—	—	—	—	—	—	—	—	▲							200
BUCKETWHEEL EXCAVATOR STUDY										▲	—	—	—	—	—	—	—	—	—	▲		3,750
MINING BULK COAL SAMPLE FOR SASOL GASIFIER TESTS										▲	—	—	—	—	▲							1,000
MINIMUM FEASIBILITY STUDY COST																				\$11,350		
COAL EXPLORATION DRILL NO. 2 DEPOSIT						▲	—	—	—	—	—	—	—	—	▲					▲	4,000	
GEOTECHNICAL INVESTIGATION OF NO. 2 DEPOSIT						▲	—	—	—	—	—	—	—	—	▲						3,000	
GASIFIER TESTS OF COAL SAMPLE AT SASOL																		▲	—	▲	5,000	
TOTAL FEASIBILITY STUDY COST WITH INVESTIGATION OF NO. 2 DEPOSIT AND SASOL GASIFIER TESTS																				\$23,350		
LICENSING AND APPROVAL										▲	—	—	—	—	—	▲				▲		
										APPLICATION			PUBLIC HEARINGS						CLP APPROVAL			

SECTION 6.0 - FEASIBILITY STUDIES

The next phase of work on the Hat Creek Coal Liquefaction Project, if it is justified, would be engineering and economic feasibility studies and associated environmental and socio-community assessment. The scope of the feasibility studies would include collection and development of all information necessary for confirming the commercial viability of the project and preparing documentation for licensing the project. The feasibility work could proceed once clarification of Japanese and private industry interest is obtained to support the next phase (see the Recommendations in Section 7.0). Significant investment as described in Section 6.3 below would be required for the feasibility stage work.

6.1 PREPARATION FOR FEASIBILITY STUDIES

The prefeasibility reports described in Section 1.2^(1 to 7) identified several studies and investigations needed if the project proceeded to the next phase. These further investigations must be delineated in comprehensive Terms of Reference in preparation for requesting proposals and awarding consultant assignments. Approximately 2 months effort by the Coal Liquefaction Technical Committee would be required to complete the Terms of Reference. Also the process engineering consultant for prefeasibility studies, Fluor Canada Limited, and the gasifier designers, Lurgi GmbH, have recommended that a laboratory test program be completed on Hat Creek coal prior to starting feasibility design studies. The test program would require four 20 kg coal samples, would require approximately 3 months to complete and would cost approximately \$50 000. The results of the tests would enable Lurgi to generally assess the impact of the coal properties on the overall process and substantiate gasification yields.

available from environmental and socio-community work already carried out on B.C. Hydro's proposed 2000 MW Thermal Power Project. Updating and supplementing this information would be required to adequately evaluate the design options.

3. Selection of a Mitigated Design and Definition of Impacts - Once design optimization is completed and satisfactory compromises have been resolved between environmental constraints and engineering or economic requirements in a mitigated project feasibility design, the project impacts can be quantified. Detailed study would be required to clarify the project impacts for economic evaluation and a refined benefit-cost analysis.

The above activities would be accomplished during the feasibility stage using consultants. The process engineering technology for a Sasol type Coal Liquefaction Project can be developed by three companies. Sasol Ltd. is the licensor of the Sasol Synthol process and the only company that has operating experience with the technology, Lurgi GmbH of West Germany is the licensor of the gasification system and Fluor Engineers and Constructors, Inc. of Irvine, California, have the project engineering, construction management and process design experience.

Fluor Canada Ltd. could acquire the expertise and personnel to do some of the feasibility work in Canada, however, most of Fluor's coal liquefaction expertise is in Irvine. During the prefeasibility studies approximately 20 percent of the Fluor contract was completed in Canada and it is anticipated that this percentage could be increased during feasibility studies. Secrecy agreements would be required between the feasibility study proponents and both Sasol and Lurgi at the initiation of the next phase of the work to protect the consultant's technology.