BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

British Columbia Hydro and Power Authority, System Engineering Division - A Re-evaluation of Air Quality and Climatic Effects of the Proposed Hat Creek Project - December 1979

ENVIRONMENTAL IMPACT STATEMENT REFERENCE NUMBER: 47

A RE-EVALUATION OF AIR QUALITY AND CLIMATIC EFFECTS OF THE PROPOSED HAT CREEK PROJECT

CONTENTS

Section	Subject	Page
1.0	INTRODUCTION	1 - 1
	1.1 Purpose	1 - 1
	1.2 Background	1 - 2
	1.3 Areas of Reassessment	1 - 13
	1.4 Methodology for Reassessment	1 - 25
2.0	REASSESSMENT OF MAJOR CONTAMINANT IMPACTS	
	2.1 Powerplant	2 - 1
	2.2 Mine	2 - 8
3.0	TRACE ELEMENTS	3 - 1
	3.1 Powerplant	3 - 1
	3.2 Mine	3 - 7
4.0	OTHER AREAS OF ASSESSMENT	
	4.1 Construction Activities	4 - 1
	4.2 Offsite Developments	4 - 1
	4.3 Climatic Effects	4 - 1
	4.4 Visibility Restrictions	4 - 1
	4.5 Other Industrial Development	4 - 2
5.0	CONCLUSIONS	
	5.1 Summary	5 - 1
	5.2 Comparison With PCB Objectives	5 - 7
	REFERENCES	

TABLES

Table No.		
1-1	Contaminant Emission Rates Used in the Original ERT Studies for the Hat Creek Project	1 - 4

CONTENTS - (Cont'd)

TABLES - (Cont'd)

Table No.		Page
1-2	Stack Parameters and Flue Gas Properties for Base-Load Emissions of the Proposed Hat Creek Generating Plant as used in the Original ERT Studies	1 - 5
1-3	Maximum Predicted Ground-Level Sulphur Dioxide Concentrations Within 25 km from the Hat Creek Generating Station with Meteorological Control and 244 m Stack from the Original ERT Study	1 - 7
1-4	Analysis of Air Quality Effects of the Hat Creek Project for 9 Trace Elements as Presented by ERT in June, 1978	1 - 12
1-5	Changes in Estimates of Concentrations of Various Trace Elements in Hat Creek Coal (Dry Basis)	1 - 15
1-6	Comparison of Previous Design Data for Hat Creek Project Cooling Towers with Current Design Data	1 - 18
1-7	A Comparison of the Fractions of Total Trace Elements Contained in the Coal Which Were Assumed to be Emitted in the Previous Work and the Fractions Currently Assumed	1 - 23
1-8	Summary of New PCB Pollution Control Objectives for Mining, Smelting and Related Industries	1 - 24
2-1	Annual-Average Concentrations of Major Contaminants in μg/m³ for Coded Isopleths	2 - 3
2-2	Annual-Average Deposition Rates in $g/m^2/s \times 10^{-9}$ for Sulphur Dioxide at Coded Isopleths	2 - 5
3-1	Trace Element Emission Rates from the Powerplant as used in the Original ERT Work and as Currently Estimated	3 - 2
3-2	Change in Emission Rate for Various Contaminants During Fuel Switching	3 - 4
3-3	Maximum Trace Element Concentrations in μg/m³ Resulting from Powerplant Emissions	3 - 5

CONTENTS - (Cont'd)

TABLES - (Cont'd)

Table No.		Page
3-4	Annual-Average Trace Element Concentrations in $\mu g/m^3 \times 10^3$ Corresponding to Coded Isopleths Resulting from Powerplant Emissions	3 - 6
3-5	Annual-Average Trace Element Deposition Rates in $\mu g/m^2/a$ for Coded Isopleths Resulting from Powerplant Emissions	3 - 8
3-6	Ambient Trace Element Concentrations Resulting from Mine Dust Emissions in $\mu g/m^3$	3 - 10
3-7	Annual-Average Deposition Rates for Trace Elements Resulting from Mine Dust in $\mu g/m^2/a$	3 - 11
5-1	A Summary of Changes to the Hat Creek Project Air Quality Assessments	5 - 2
5-2	A Comparison of Hat Creek Project Emission Rates with PCB Ojectives	5 - 8
5-3	A Comparison of PCB Ambient Concentration Objectives for Major Contaminants with Hat Creek Project Impact Predictions for the Powerplant	5 - 8

APPENDICES

Appendix No.	
A	Effects of the Hat Creek Project on the Regional Air Shed

SECTION 1.0 - INTRODUCTION

British Columbia Hydro and Power Authority (B.C. Hydro) proposes to construct a coal-fired electric generating station, and open-pit coal mine and associated support facilities in the Hat Creek valley of British Columbia. This document is intended to update the analyses of air quality and climatic effects of the Hat Creek Project that have been prepared to date in light of changes which have occurred in plans or data used in these analyses.

1.1 PURPOSE

It is recognized that any major industrial development (such as the Hat Creek Project) undergoes a continuous process of evolution. From its inception through its construction and even into its operation, the development must respond to changes in the available data base, improvements in related technology, and new regulatory proceedings. Any assessment made of such a development can only be reflective of the evolution of the project at the time the assessment is made. Analyses of air quality and climatic effects of the proposed Hat Creek Project were carried out primarily in 1977 and early 1978.[1] An environmental impact statement (EIS) is now being prepared, and it will reflect changes in the project design and data bases that have occurred since the detailed air quality studies were performed. In addition the analysis techniques themselves have undergone an evolution in the period since the detailed air quality studies were performed.

The purpose of this document is to provide a technical evaluation of air quality and climatic effects of the Hat Creek Project as it is proposed at the time of the EIS. It is neither practical nor necessary to completely redo the detailed air quality studies. Rather the method is to utilize the original studies as a basis, and to address only those areas where significant changes have occurred. Specifically, these changes can be grouped into four categories:

1.1 PURPOSE - (Cont'd)

1. Changes in the available data on which the assessments were based.
2. Changes in the plans or design of the facility.
3. Technical advances in the analysis techniques used.
4. Changes in the standards of comparison which were used as a measure of the effects of the project.

In addition confirmation of the assumptions and reflections on an expanding climatic data base were addressed.

1.2 BACKGROUND

The original detailed studies of air quality and climatic effects of the proposed Hat Creek Project were conducted by Environmental Research and Technology (ERT), Inc.[1] based upon tentative plant design then available. Their assessment was based on the results of computer modelling of the various sources of contaminant emissions, and the resultant concentrations in the ambient air surrounding the project. Sulphur dioxide was identified as the primary pollutant of concern, but analyses were also conducted for oxides of nitrogen, particulates, carbon monoxide, hydrocarbons, a variety of trace elements, and atmospheric reaction products. The plant was assumed to be at full load on all four units all year round.

(a) Initial Studies

The analysis of air quality and climatic effects was based on four individual studies:

1. Modelling of the powerplant stack emissions within a radius of 25 km (local-scale).

2. Modelling of the powerplant stack emissions at distances from 25 to 100 km from the stack (regional scale).

3. Modelling of the cooling tower plume.

4. Modelling of dust emissions from the mining operations.

Each of these studies is discussed separately in the following sections.

(i) Powerplant Stack Study - Local Scale

Ground-level concentrations of the various contaminants were predicted by a Gaussian-plume based air quality model. Emission rates used as inputs to the model were as shown in Table 1-1. Sulphur dioxide (SO_2) emissions were calculated by assuming a heating value of the coal of 14 650 kilojoules per kilogram (kJ/kg) on an "as received" basis, with a mean sulphur content of 0.45 percent "as received". Other contaminant emissions were calculated as described in the table. For the various trace elements, impacts were actually calculated from two separate emission estimates. The earlier estimates were revised before an appendix specific to trace element effects was prepared. Those shown in the table are the latter emission rates. Other emission parameters used by the model are shown in Table 1-2.

Concentrations were calculated using a sequential set of meteorological data. That is, hourly observations of wind speed, wind direction, atmospheric stability, and other parameters are put into the model 1-hour at a time and analysed individually. Running averages are kept to determine 3-hour, 24-hour and

TABLE 1-1

CONTAMINANT EMISSION RATES USED IN THE ORIGINAL ERT STUDIES FOR THE HAT CREEK PROJECT[1]

Contaminant	Symbol	Emission Rate (kg/d)
Sulphur dioxide	SO_2	324 768
Nitrogen oxide	NO	82 489[1]
Nitrogen dioxide	NO_2	124 759[1]
Total particulates	TSP	40 000[2]
Carbon monoxide	CO	18 043[3]
Total hydrocarbons	HC	5413[4]
Arsenic	As	17.2[5]
Cadmium	Cd	0.35[5]
Chromium	Cr	5.2[5]
Copper	Cu	5.93[5]
Fluorine	F	281[5]
Lead	Pb	4.36
Mercury	Hg	7.07[5]
Vanadium	V	16.1[5]
Zinc	Zn	12.9[5]
Sulphate	$SO_4^{=}$	No emission - Atmospheric reaction product
Nitrate	NO_3^{-}	No emission - Atmospheric reaction product

---

[1] Emission calculated on the basis of 600 ppm NO_x in the stack with equal parts by volume of NO and NO_2.

[2] Emission calculated on the basis of a maximum of 0.1 grains per standard cubic foot in the exhaust gas.

[3] Emission calculated on the basis of 0.45 kg CO per ton of coal.

[4] Emission calculated on the basis of 0.14 kg HC per ton of coal.

[5] Emissions calculated from the test burn sample analysis and a coal consumption rate of 42 630 t/d.

TABLE 1-2

STACK PARAMETERS AND FLUE GAS PROPERTIES FOR BASE-LOAD EMISSIONS OF THE PROPOSED HAT CREEK GENERATING PLANT AS USED IN THE ORIGINAL ERT STUDIES

Stack Base Elevation (MSL)	
(m)	1418
(ft)	4650
Stack Height	
(m)	244 or 366
(ft)	800 or 1200
Inside Diameter of Flue (four flues for four units in one stack)	
(m)	7
(ft)	23
Flue Gas Temperature	
(°C)	149
(°F)	300
Volumetric Flow Rate (per flue)	
(M^3/min)	62 204
(ACFM)	2.195×10^6

annual-average concentrations. For the local-scale study meteorological data were taken from a 10 m tower located very near the powerplant site. These were corrected to stack height (244 m or 366 m) by a stability-dependent power-law formula. The results of plume tracer studies carried out in the vicinity of the proposed powerplant were used to develop site-specific dispersion parameters for the study.

Concentrations were calculated at an array of locations arranged along 16 radial directions from the stack, out to a distance of 25 km. Maximum predicted SO_2 impacts are shown in Table 1-3. Further information on the spatial distribution of annual-average concentrations and on the concentrations of other contaminants can be found in the ERT summary report.[1]

(ii) Powerplant Stack Study - Regional Scale

A similar modelling study to the local-scale study was carried out on a 25 to 100 km regional scale. A Gaussian-plume based air quality model was also used in this assessment, but here the primary interest was in establishing chemical reaction products and deposition behavior.

Meteorological inputs used in this study were taken from twice daily upper air measurements at Vernon, B.C., and were combined into a statistical format for long-term average calculation. Thus, short-term concentrations could not be calculated. Only sulphur dioxide and its consequent reaction products, nitrogen oxide and its consequent reaction products, and particulate emissions were considered in this analysis.

TABLE 1-3

MAXIMUM PREDICTED GROUND-LEVEL SULPHUR DIOXIDE CONCENTRATIONS WITHIN 25 km FROM THE HAT CREEK GENERATING STATION WITH METEOROLOGICAL CONTROL AND 244 m STACK FROM THE ORIGINAL ERT STUDY

Averaging Time	Maximum Concentration ($\mu g/m^3$)
1-hr	1730
3-hr	622
24-hr	260
Seasonal	
Winter	5.8
Spring	17.2
Summer	10.9
Fall	9.2
Annual	9.3

The analysis in the regional study assumed emissions to be released from a 366 m stack with no SO_2 controls. Maximum annual-average SO_2 concentrations were 1.7 μg/m^3. Maximum deposition of SO_2 was calculated to be less than 0.1 μg/m^2/s. The impacts for other contaminants can be found in the ERT summary report.

(iii) Cooling Tower Study

Impacts from the proposed cooling towers were analysed using two models. The first model was a numerical model to calculate the occurrence of fogging and icing episodes as well as visual obscuration caused by the plume. The second model analysed the effect of water droplets (called drift) from the cooling towers. ERT conducted analyses for both natural and mechanical-draft cooling towers. A configuration of two natural draft cooling towers was recommended as the most desirable of the alternatives.

The conclusions of the study were that precipitation would increase by less than 1 percent annually in the immediate vicinity of the site. Visible plumes from the cooling towers were predicted to occasionally extend to 15 km, but shadowing by the plume was not expected to occur more than 20 hours per year at distances greater than 2 km. No occurence of ground-level fogging or icing was predicted although a small increase in ground-level humidity was viewed as a possible occurence in the cooling tower vicinity. Cooling tower drift deposition was predicted to have a maximum value of 4700 kg/km^2/a at a distance of 1 km east of the cooling towers.

(iv) Mine Study

An air quality modelling study was conducted to determine ground-level concentrations of particulates which would result from the mining operations. These emissions, frequently referred to as fugitive dust, originate from the handling of coal, waste rock and surficial materials, blasting, traffic on unpaved roads, open stockpiles and wind erosion from newly exposed areas. A total emission rate of 2 288 800 kg/a was calculated. These emissions were used in a multi-source Gaussian-plume diffusion model to predict ground-level concentrations of suspended particulates at locations in and around the mine.

The meteorological data used in this analysis were taken at a height of 10 m by a mechanical weather station in Upper Hat Creek valley. Maximum 24-hour concentrations were determined by examining the data set to identify a series of "worst cases". Nine such cases were identified and analysed. Annual concentrations were determined by statistical analysis of the entire data set.

Maximum 24-hour concentrations of suspended particulates calculated by the model were 400 μg/m^3. Highest annual-average concentrations were calculated to be 250 μg/m^3. In this analysis no accounting was made for particle size ranges or deposition properties.

(b) Subsequent Studies Performed by ERT

Based on the original modelling studies, special investigation was subsequently undertaken in two areas: trace element redistribution, and the effects of long-range transport and the implications of acid precipitation.

1.2 BACKGROUND - (Cont'd)

(i) Trace Element Analysis

The analysis of trace element redistribution began with an analysis of 73 separate elements. This number was then reduced to 21 elements based on toxicity potential to plants and animals and then to nine elements ascertained to be of greatest environmental concern. The various processes leading to redistribution were: leaching from coal and waste piles, and air quality effects caused by powerplant emissions. This document is concerned only with air quality and related effects.

The analysis of ambient air concentrations of trace elements was based solely on the powerplant SO_2 modelling assuming a stack height of 366 m. Trace element deposition analysis did include an accounting for effects of the cooling tower drift, but was also primarily based on the SO_2 modelling. In the initial work, estimates of trace elements were used to calculate both 24-hour and annual-average concentrations for a number of trace elements. However, subsequent to the preparation of the trace element appendix, many of the elements to be considered were changed and the emission rates were re-estimated. The trace element appendix, however, did not analyse for 24-hour concentrations.

The methodology for the analysis in the appendix was to calculate an emission rate by multiplying the measured emission rate from the test burns by the ratio of the trace element content in average coal in the mine to the trace element content in the coal burned in the tests. These emission rates are then ratioed to the SO_2 emission rate to calculate annual-average concentrations. Finally, the concentrations were multiplied by an assumed deposition velocity of 0.1 cm/s to calculate deposition rates. This latter technique is a very approximate way of determining deposition rates. It was carried out only for the local scale (within 25 km). No accounting was made for trace elements which might become entrained into the atmosphere in the form of mine dust. The results of the calculations are shown in Table 1-4.

(ii) Acid Precipitation

A special modelling study was conducted to determine the effects of long-range transport and the implications of acid precipitation resulting from the Hat Creek Project. The study also investigated the deposition of major contaminant species and their reaction products. This study itself was a reassessment of previous work done as part of the regional-scale modelling. In this study which, for convenience, will be called the acid precipitation study, the modelling was very similar to that used in the regional-scale study, but here the model was modified to include consideration of both wet and dry atmospheric removal processes for plume contaminants, and the effects of sulphur and nitrogen compounds on precipitation. The study used essentially the same input data as the previous work, including the assumption that the emissions would be released from a 366 m stack with no controls on SO_2 emission rate. The meteorological data, however, were augmented to include precipitation data from 34 stations in southern British Columbia. Also, the calculations were carried out to a distance of 200 km from the stack.

TABLE 1-4

ANALYSIS OF AIR QUALITY EFFECTS OF THE HAT CREEK PROJECT FOR 9 TRACE ELEMENTS AS PRESENTED BY ERT IN JUNE, 1978

Trace Element	Concentration in Coal (mg/kg)	Amount Entering[1] Boiler (kg/d)	Emission Rate (kg/d)	Max. Ground[2] Level Concentration (μg/m³)	Max. Deposition[2] Rate (μg/m²/a)
Arsenic (As)	7.8	332.0	17.2	0.0003	9.5
Cadmium (Cd)	<0.48	<20.4	0.35	0.000005	0.16
Chromium (Cr)	100	426.00	5.20	0.00008	2.5
Copper (Cu)	43	1030.0	5.93	0.00009	2.8
Fluorine (F)	137	5840.0	281.0	0.004	126
Lead (Pb)	<6.6	<281.0	4.36	0.00007	2.2
Mercury (Hg)	0.14	5.96	7.07	0.0001	3.2
Vanadium (V)	140	5960.0	16.1	0.0002	6.3
Zinc (Zn)	25	1065.0	12.9	0.0002	6.3

---

[1] Based on coal consumption rate of 42 600 t/d.

[2] Annual averages.

The conclusions of the study were that no measurable effects should result from increases in acid precipitation caused by the Hat Creek Project. Annual average deposition rates for SO_2 and other contaminants were plotted with maximum values for SO_2 being approximately 40×10^{-9} $g/m^2/s$. Reductions in the pH of precipitation were expected to fall as low as 4.6 to 4.9 from normal values of 5.0 to 5.5. The report also contains considerable analysis of the biological and water quality effects of this acidification. The analysis indicated that there would be no effect on soils, vegetation and animal or fish populations.

1.3 AREAS OF REASSESSMENT

As mentioned previously there are four major areas where changes have occurred that necessitate reassessment. Each of these areas will be discussed in turn.

(a) Changes in Data Bases

(i) Coal Characteristics

The mining and blending processes and thus the characteristics of the coal to be burned at the Hat Creek Project have been refined since the original ERT work was completed. This has allowed a better estimate to be made of the sulphur content and heating value of the coal. Current estimates indicate that sulphur content ("as received") of average blended coal will be 0.39 percent instead of the 0.45 percent used in the original ERT work. This is counterbalanced to some degree by a reduction in heating value of the coal to 13 700 kJ/kg from the value of 14 650 kJ/kg used in the previous work. The end result is that the emission rate of SO_2 will be somewhat changed from the original value.

In addition the concentration of other potential contaminants in the coal has been revised from the original assessment. Table 1-5 shows the concentrations of 23 trace elements as originally estimated and as currently estimated. The values shown in the table are averages of many samples. In many cases the standard deviation from these mean values is quite substantial.

(ii) Combustion Rate

The combustion rate of coal has also changed from the value used in the previous work. At that time emissions of trace elements and other contaminants were calculated on the basis of 42 630 metric tonnes per day (t/d) of coal being burned. Current estimates for the coal consumption rate are approximately 40 000 t/d.

(iii) Meteorological Data

The meteorological data on which the local-scale modelling study, the cooling tower modelling study, and the mine modelling study were based consisted of 1 year (1975) of values collected from a network of 10 m towers on site. As of this writing there are four full years of reduced data from this same network which can be compared to the single year used previously. This has been done and is documented elsewhere.[2] Although there are a few isolated differences noted by the comparison, in general, 1975 data are representative of longer-term normals.

(iv) Reclamation Potential of Mine Waste

In addition to the above data, there is new information which affects the analysis of mine dust emissions. Reclamation trials conducted during the bulk

TABLE 1-5

CHANGES IN ESTIMATES OF CONCENTRATIONS OF VARIOUS TRACE ELEMENTS IN HAT CREEK COAL (DRY BASIS)

Element	Concentrations in Coal from Original ERT Work (mg/kg)	Current Estimates of Concentration in Coal (mg/kg)
Antimony	<0.47	0.5
Arsenic	7.8	8.5
Beryllium	0.38	0.64
Boron	15.0	<18.0
Cadmium	<0.48	<0.33
Chromium	100.0	71.0
Cobalt	5.8	5.8
Copper	43.0	42.0
Fluorine	137.0	118.0
Lead	<6.6	5.6
Manganese	<200.0	213.0
Mercury	0.14	0.13
Molybdenum	4.9	2.3
Nickel	33.0	24.0
Selenium	<1.0	<0.77
Silver	<0.5	<0.4
Thallium	<0.1	<0.5
Thorium	<3.0	5.73
Tin	<0.76	0.83
Tungsten	<0.1	<1.0
Uranium	<2.3	2.2
Vanadium	140.0	109.0
Zinc	25.0	35.0

sampling program show that vegetation can be readily established on most of the waste materials from the mine. The results of these tests indicate that revegetation of the waste dumps may eliminate much of the wind erosion from these areas which made up the largest single dust source in ERT's analysis. It also appears evident from the amount of clayey materials in the pit waste, that there will be significant crusting. This will help to eliminate wind erosion from the waste dumps. ERT has recently estimated that this should reduce total mine emissions by as much as 30 percent.

(b) Changes in Plans or Designs

(i) Powerplant Stack Design and SO_2 Controls

In the original ERT work, three separate cases for the main powerplant emissions were treated. These included a 366 m stack height with a flue gas desulphurization (FGD) unit, a 366 m stack height with a meteorological control system (MCS) and a 244 m stack height with an MCS. The plans have now been finalized and the 244 m stack height with a meteorological control system has been selected. The original report assumed the stack in each case to exhaust gases to the atmosphere at the rate of 249 000 m^3/min. It is now estimated that the stack will exhaust gases at the rate of 260 000 m^3/min. In all cases the plant was assumed to be at full load for all four units all year round.

(ii) Cooling Tower Plans

The plans for the cooling towers have changed. In the original ERT work, four separate cooling tower designs were considered. The selected design called for two natural draft towers. The design parameters used in the original study and those now planned are compared in Table 1-6.

(iii) Mine Plans

The plans for the mine have also changed. Recent data have indicated that vegetation will grow readily on waste piles. Also the amount of exposed area should decrease as an effort will be made to avoid stripping areas until necessary. In addition, areas which are exposed and must remain so for long periods of time will be sprayed with soil binder. All of the above procedures should substantially reduce the emission of fugitive dust resulting from wind erosion of exposed areas. Other changes to the mine plan which will contribute to a reduction in emissions are the spraying of water or binding agents on the coal storage piles, the reduction in the number and size of some of the storage areas, and the use of telescopic chutes and water sprays on the stackers.

(c) Technical Advances Affecting the Assessment

(i) SO_2 Deposition

The study of long range transport and the implications of acid precipitation (the acid precipitation study) which was recently added to the original ERT studies, represents an improvement in the assessment of the regional scale deposition for sulphur dioxide and other contaminants. The report is a complete document and will not be requoted here. However, many of the conclusions of this report can be used to refine the analysis in other areas, most notably trace element deposition.

TABLE 1-6

COMPARISON OF PREVIOUS DESIGN DATA FOR HAT CREEK PROJECT COOLING TOWERS WITH CURRENT DESIGN DATA

DESIGN CONDITIONS

	Previous Study	Current Data
Ambient wet bulb temperature	13.9°C	13.9°C
Approach	12.8°C	12.8°C
Range	18.7°C	18.9°C
Circulating water flow rate/tower	20 422 l/s	18 925 l/s

PHYSICAL DIMENSIONS

Base diameter	-	102 m
Top diameter	67.1 m	-
Cooling tower height	116.4 m	134 m

EFFLUENT PROPERTIES

Ambient Temp. in °C		Exit Air Temp. in °C (100% Saturated)		Air Flow Rate per Tower in Actual m³/s	
Dry Bulb	Wet Bulb	Previous	Current	Previous	Current
-(15.0)	-(16.3)	28.9	19.7	13 470	21 600
-(15.0)	-(15.0)	29.4	20.0	13 508	21 750
10.0	-(3.3)	36.7	31.9	12 393	17 370
10.0	10.0	36.7	33.9	12 393	18 025
32.2	23.9	42.2	43.9	12 006	13 950

DRIFT PROPERTIES

	Previous Study	Current Data
Drift rate	0.008%	0.008%
Cooling tower cycles of concentration	14	20
Salt emission rate/tower	2.46 g/s	3.08 g/s

1.3 AREAS OF REASSESSMENT - (Cont'd)

(ii) NO Emissions Rate

The original analysis for oxides of nitrogen used emissions based on a concentration of 600 ppm in the exhaust gases. These emissions have been re-evaluated using an emission factor approach. Considerable research into the formation of oxides of nitrogen has proceeded since the original ERT work. It is known that virtually all the oxides of nitrogen in the flue gas will be in the form of nitrogen oxide (NO) and will transform via chemical reaction to nitrogen dioxide (NO_2) in the atmosphere after emission. A value of 0.3 grams per megajoule (g/mJ) of coal burned has been assumed for all oxides of nitrogen.[3] The deposition of oxides of nitrogen has also been treated in the acid precipitation study. In that study, however, the previous emission values were used and a 366 m stack height was used.

(iii) Particulate Emission Rate

The previous work calculated total particulate emissions by assuming a grain loading in the exhaust of 0.1 grains per standard cubic foot. Particulate emissions have been re-evaluated by examination of the ash content in the coal, the proportioning of ash during combustion into bottom ash or fly ash, and the efficiency of the proposed electrostatic precipitation.

(iv) Mine Assessment

Considerable technical development into methods for assessing the impacts of mining operations has proceeded since the original work was done. In particular it is now recognized that the particulates produced by mining operations are generally larger in mass mean diameter than those from a coal-fired boiler, for example. As a result mine dust will experience rapid deposition and consequently rapid reduction in concentration downwind. Such effects were not considered in the original work. It is clear that concentrations of mine dust were significantly overestimated by the neglect of such effects.

(v) Trace Elements

The area most significantly affected by technical advances is the assessment of the impacts of trace element redistribution. In the trace element appendix to the ERT report, concern was focused on nine elements: arsenic, cadmium, chromium, copper, fluorine, lead, mercury, vanadium and zinc. More recent investigation has developed the need to broaden the study to include an additional 14 elements: antimony, beryllium, boron, cobalt, manganese, molybdenum, nickel, selenium, silver, thallium, thorium, tin, tungsten and uranium. In the previous work the only source of trace element redistribution through atmospheric processes was the emissions resulting from the combustion of coal in the powerplant. While for most of the regions investigated in the original work this is still the case, the areas surrounding the mine will experience a larger trace element redistribution from the trace element content in the fugitive dust generated by the mining operations.

Analysis of both ground-level concentrations and deposition rates were based in the trace element appendix to the original study solely on the local-scale modelling of the powerplant emissions. In the re-evaluation it is apparent that, immediately surrounding the mine both ground level concentrations and deposition will be controlled by mine dust emissions. For the remainder of the region, ground-level concentration impacts can be adequately defined by the local-scale SO_2 modelling. However, the acid precipitation study has identified that deposition patterns can be more accurately addressed than in the original studies. Thus deposition patterns of trace elements from the powerplant emissions should be defined by the results of the acid precipitation study.

A critical process in establishing emission rates of trace elements is the determination of the fraction of the trace element in the coal which is emitted as a result of combustion. Some elements such as mercury tend to vaporize during combustion and as a result are emitted in substantial portion in the gaseous phase. Others such as tungsten tend to be carried along with the fly ash and thus substantial fractions are captured by the electrostatic precipitation. Still others (most of the elements considered) have behavior somewhere between these two characteristics. In the original work, ERT used measured values during two test burns conducted by B.C. Hydro to determine the fraction of each element which is emitted. Examination of recent literature has revealed that for several elements a significant difference exists between the values measured during the test burns and the experience of other research efforts. Since the analysis of test burn results was not able to close the mass balance on many of the elements, it is necessary (to ensure that the analyses are conducted on a conservative basis) to increase the percentage that is emitted for certain elements. A comparison of previous values and current estimates in shown in Table 1-7.

One additional technical advance which affects the trace element analysis concerns averaging times. In the trace element appendix concentrations were calculated for annual-average values only. In this analysis it is desired in addition to predict maximum 24-hour and 3-hour concentrations. The maximum concentrations can be calculated from the model predictions for SO_2. However, the meteorological control system used to control SO_2 concentrations below certain threshold values utilizes two control strategies: fuel switching and load reduction. For load reduction actions the trace element concentrations will also be reduced; however, for fuel switching actions, the effect on trace element concentrations varies from element to element. For many of the elements the low sulphur coal which will be used as the secondary fuel is also low in trace element concentration. Among these elements are fluorine, mercury, copper, arsenic and others. For this reason the SO_2 model predictions will be used to estimate maximum 24-hour and 3-hour trace element concentrations.

(d) Changes in the Standards of Comparison

Since the original ERT work was completed, the Pollution Control Board of the Ministry of the Environment for British Columbia has published new pollution control objectives for the mining, smelting and related industries. The objectives contain both ambient concentration ranges and emission rate ranges. Table 1-8 summarizes the new objectives for those contaminants which are of interest for the

TABLE 1-7

A COMPARISON OF THE FRACTIONS OF TOTAL TRACE ELEMENTS CONTAINED IN THE COAL WHICH WERE ASSUMED TO BE EMITTED IN THE PREVIOUS WORK AND THE FRACTIONS CURRENTLY ASSUMED

Element	Symbol	Previous Work Assumed Percent Emitted (%)	Current Value[1] Assumed Percent Emitted (%)
Antimony	Sb	0.57[2]	1.0
Arsenic	As	6.4	Not changed
Beryllium	Be	0.05[2]	1.5
Boron	B	1.2[2]	5
Cadmium	Cd	2.1	Not changed
Chromium	Cr	0.15	Not changed
Cobalt	Co	0.3[2]	Not changed
Copper	Cu	0.4	2
Fluorine	F	6.0	63
Lead	Pb	1.9	3
Manganese	Mn	0.2[2]	1.1
Mercury	Hg	148	100
Molybdenum	Mo	0.5[2]	5
Nickel	Ni	0.5[2]	1.0
Selenium	Se	1.0[2]	25
Silver	Ag	0.2[2]	Not changed
Thallium	Tl	0.1[2]	Not changed
Thorium	Th	0.11[2]	Not changed
Tin	Sn	0.5[2]	Not changed
Tungsten	W	0.1[2]	Not changed
Uranium	U	0.09[2]	1
Vanadium	V	0.3	Not changed
Zinc	Zn	1.5	Not changed

---

[1] Selected as representative of literature values [4,5,6,7,8,9,10] and Hat Creek coal characteristics.

[2] For these elements emissions were not analysed in the original work. The values shown above are those which would result from analysis of test burns.

TABLE 1-8

SUMMARY OF NEW PCB POLLUTION CONTROL OBJECTIVES FOR MINING, SMELTING AND RELATED INDUSTRIES

Contaminant	Ambient Concentration Range ($\mu g/m^3$)		Emission Rate Units	Emission Rate Range	
Sulphur dioxide			mg/kJ fuel	0.09	0.34
Annual arithmetic mean	25	50			
24-hour maximum	160	260			
3-hour maximum	375	665			
1-hour maximum	450	900			
Oxides of nitrogen (as NO_2)	none	none	mg/kJ fuel	0.15	0.3
Suspended particulates			mg/kJ fuel	0.01	0.04
Annual geometric mean	60	70			
24-hour maximum	150	200			
Trace Elements[1]			(None for coal-fired boilers)[2]		
Antimony	0.1	0.5	mg/mol	0.16	0.27
Arsenic	0.1	1.0	mg/mol	0.16	0.27
Beryllium	0.005	0.1	none	none	
Cadium	0.05	0.3	mg/mol	0.05	0.27
Chromium	0.05	0.1	none	none	
Copper	0.25	2.5	mg/mol	0.16	0.27
Fluorine	0.1	2.0	mg/mol	0.02	0.2
Lead	1.0	2.5	mg/mol	0.16	0.27
Mercury	0.1	1.0	mg/mol	0.03	0.27
Molybdenum	0.1	2.5	none	none	
Nickel	0.01	0.1	none	none	
Selenium	0.1	0.5	none	none	
Uranium	0.01	6.0	none	none	
Vanadium	0.05	1.0	none	none	
Zinc	1.0	2.5	mg/mol	0.16	0.27

---

[1] No averaging time is specified. If a need arises, the PCB will establish times on a case by case basis.

[2] There are no specific emission limits for trace elements from coal-fired boilers. Those shown in the table are general values intended to apply to a variety of industries.

1.3 AREAS OF REASSESSMENT - (Cont'd)

Hat Creek Project. For ambient levels background concentrations must be taken into account if comparisons are to be made to a project.

1.4 METHODOLOGY FOR REASSESSMENT

The changes to the data bases, designs and analysis techiques have been identified in the previous sections. The following sections will discuss the effect of these changes on the assessment of air quality effects of the Hat Creek Project. The effects have been divided into those involving major contaminants (sulphur oxides, nitrogen oxides, total particulates, carbon monoxide and hydrocarbons), and those involving trace elements. Those categories are further separated into impacts of the powerplant and impacts of the mine. The two are expected to have separate areas of impact so that the analysis of the mine is assumed to completely define impacts in a region immediately surrounding the mine, while the analysis of the powerplant emissions is assumed to define impacts elsewhere.

An examination was made of the changes to the design of the cooling towers. It was felt that, given the generally small impact defined in the original study and the relatively small changes to the design, that a full reassessment was not necessary. This is further supported by the increase in height of the proposed cooling towers, which will enhance the dispersion of the tower exhaust. Therefore the impacts defined in the original ERT report are assumed to be valid for the current cooling tower design.

SECTION 2.0 - REASSESSMENT OF MAJOR CONTAMINANT IMPACTS

2.1 POWERPLANT

As in the original ERT work, the analysis of impacts resulting from the powerplant emissions is based solely on the modelling for sulphur dioxide.

(a) Sulphur Oxides

Several of the changes mentioned in Section 1.0 influence the estimation of sulphur oxide impacts. These include:

1. Change in the sulphur content of the coal.
2. Change in the heating value of the coal.
3. Change in the combustion rate of coal.
4. Change in the flue gas flow rate.
5. The emergence of new meteorological data.

In addition the selection of a 244 m stack height with a meteorological control system (MCS) as the primary SO_2 control system eliminates the need for optional stack heights and changes the impacts for areas where only the 366 m stack height was modelled.

Items 1, 2 and 3 above all have an influence on the sulphur dioxide emission rate which formed the basis for all analysis of sulphur oxide impacts. Regardless of the stack height or other emission parameters, the previous study used an emission rate of 324 768 kilograms per day (kg/d) of SO_2. Using the influences of items 1, 2 and 3 above, a new emission rate of 312 000 kg/d is calculated based on operation of all four units at full load year round. In making both these estimates it has been assumed that all of the sulphur in the coal is combusted to SO_2 and emitted. There is evidence that some of the sulphur, perhaps as much as 5 percent, is not exhausted but retained in various portions of the ash. The neglect of this fraction helps ensure that emissions are conservatively estimated (overpredicted).

The increase in flue gas flow rate will result in greater plume rise and as a result generally lower concentrations. It is not possible to accurately assess the reduction without remodelling, but the expected increase in plume rise is approximately 3 percent which would probably not result in significant concentration reductions.

The effect of the emergence of new meteorological data is also difficult to quantify without additional modelling. This is particularly true for 24-hour and 3-hour predictions. However, an indication of the effects can be obtained by examining the annual-average impacts. One important meteorological function which influences the concentration at any point is the frequency of occurence of wind in the downwind direction of that point. The highest annual-average concentrations were predicted to occur at Cornwall Hill which is located to the southest of the plant. An examination of the frequency of occurence of wind from the northwest shows that during the single year of data used by ERT, wind from this direction occured 13.4 percent of the time while the longer term average for the same site is 12.5 percent. While this is by no means conclusive it is indicative that the additional meteorological data collected at the same site should not give significantly different maxima if used in the analysis.

The installation of a 100 m tower on site to collect meteorological data has been completed. However, sufficient data from this system has not been reduced to allow an assessment.

(i) Concentrations

As the above analysis indicates, the change to the analysis of SO_2 concentrations is very small for those areas where the case of a 244 m stack with an MCS has been treated. The MCS itself contributes to this conclusion. The nature of an MCS is to specify control actions when necessary to avoid a given threshold value. Thus the maximum concentrations for a properly operating MCS can generally be expected to be just below the maximum allowable value. For this reason, even though slight changes are expected in the emission rate, plume rise and meteorological conditions, the maximum impacts can be expected not to vary.

Thus, the impacts of Table 1-3 and the annual average isopleths of Fig. 2-1 can be used to define the impacts of sulphur dioxide emissions within 25 km. In the figure, isopleths of contaminant concentration are labelled as A, B, C, D, E and F. Table 2-1 shows the SO_2 concentrations which correspond to each of the isopleths.

TABLE 2-1

ANNUAL-AVERAGE CONCENTRATIONS OF MAJOR CONTAMINANTS IN μg/m³ FOR CODED ISOPLETHS

	Isopleth Code[1]					
Contaminant	A	B	C	D	E	F
Sulphur dioxide	9.0	7.0	5.0	3.0	1.0	0.1
Nitrogen oxide	1.8	1.4	1.0	0.6	0.2	0.02
Nitrogen dioxide	2.8	2.2	1.5	0.9	0.3	0.03
Total particulates	0.95	0.74	0.53	0.32	0.11	0.01

---

[1] See Fig. 2-1.

For regional scale concentrations it is not possible to quantify the changes because the original study assumed a 366 m stack height with no SO_2 controls. However, given the generally low concentrations and insignificant impacts predicted, along with the decrease in importance of stack height with downwind distance, it can be concluded that the regional scale concentrations of both SO_2 and its reaction product, sulphate ($SO_4^=$), as shown in Figs. 5-18 and 5-20 of ERT's report[1], are applicable to the current project plans.

(ii) Deposition

The analysis of long range transport and the implications of acid precipitation, which has been documented in a later appendix to the original ERT work, includes a revision and improvement to the original assessment of SO_2 and $SO_4^=$ deposition patterns. Although the study assumed contaminants to be released from a 366 m stack, and utilized the previous emission rates, meteorology, and stack parameters, the conclusions stated in the above section on concentrations can also be applied here. Thus, the impacts of SO_2 and $SO_4^=$ deposition are judged to be most accurately defined by the acid precipitation study. Fig. 2-2 has been prepared as a combined wet and dry SO_2 deposition plot. The values to be assigned to the various isopleths have been coded and are presented in Table 2-2. For values of $SO_4^=$ deposition, the reader is referenced to the acid precipitation study.[11]

TABLE 2-2

ANNUAL-AVERAGE DEPOSITION RATES IN g/m²/s x 10^{-9} FOR SULPHUR DIOXIDE AT CODED ISOPLETHS

Isopheth Code	SO_2 Deposition Rate
A	40
B	30
C	20
D	10

(b) Oxides of Nitrogen

A change in the basis for calculating the emission rate of oxides of nitrogen (NO_x) combined with a change in coal heating value and consumption rate has resulted in a new emission rate for NO_x. Using the emission factor of 0.3 gm/J, an emission rate of 165 000 kg/d is calculated for NO_x. This represents a reduction from the original value of 207 000 kg/d based on 600 ppm in the stack exhaust. Most impact analyses for NO_x are concerned primarily with impacts of NO_2. As mentioned previously, it is thus necessary to assume a conversion of NO to NO_2 since most of the NO_x in the stack gas is in the form of NO. In the previous work the assumption was made that, for the local scale modelling, 50 percent of the NO (by volume) had been converted to NO_2. This assumption has been retained for this analysis. Thus the assumed emission rates for NO and NO_2 are 65 000 kg/d and 100 000 kg/d respectively. For the regional scale modelling a conversion of 80 percent was assumed in the original work. Since the acid precipitation report has already reanalysed the deposition patterns using a more dynamic approach, it has been viewed not necessary to revise this 80 percent assumption. Rather, the revision to the local-scale modelling and the acid precipitation study form the impact analysis for NO_x.

2.1 POWERPLANT - (Cont'd)

(i) Concentrations

The SO_2 modelling has been used to estimate annual-average NO and NO_2 concentrations. Fig. 2-1 and Table 2-1 depict these impacts. Maximum 24-hour or 3-hour concentrations for NO_x in the original study were estimated from SO_2 impacts. Since the PCB has not published control objectives for these ambient concentrations, it was not viewed necessary to make such assessments in the current work. In any case such assessment would be difficult since the short-term SO_2 concentrations are controlled by the MCS. (Unlike the annual-average concentrations where the MCS has a very minor effect.) While the load reduction options would result in lower concentrations of NO_x, the effect of fuel switching actions on NO_x emission rate is uncertain. The maximum 1-hour average concentration of NO_2 is estimated to be 526 $\mu g/m^3$.

(ii) Deposition

The analysis of long range transport and the implications of acid precipitation forms the basis for the assessment of NO_x deposition impacts. The reader is referenced to that document.[11] As mentioned for SO_2, the emission rate and stack height used in that report are not in keeping with the current estimates, but it is felt that the deposition rates calculated in that study represent a reasonable assessment.

(c) Particulates

The analysis of total particulate emissions in the original ERT work estimated emissions by assuming an exhaust gas loading of 0.1 grains per standard cubic foot. More recently, particulate emissions have been calculated from the ash fraction (25.5 percent, which equals 10 200 t/d), the partitioning into bottom ash (25 percent, which equals 2550 t/d), and fly ash (75 percent, which equals 7650 t/d), and the efficiency of the electrostatic precipitator in capturing the fly ash (99.55 percent). The end result is that emissions of particulates are calculated to be approximately 34 400 kg/d. This is a reduction from the previous value of 40 000 kg/d.

(i) Concentrations

Concentrations of total suspended particulates (TSP) are calculated from the SO_2 impacts by the ratio of emission rates. Fig. 2- 1 and Table 2-1 show the annual-average concentrations of TSP. Maximum 24-hour concentrations can be estimated from the SO_2 projections by the same ratio, because the low sulphur coal is also low in ash content and requires less consumption for the same electrical output due to its higher heating value. For this reason both fuel switching and load reduction actions will result in substantially lower particulate emission rates. Maximum 24-hour concentrations of TSP are thus reduced to 28 $\mu g/m^3$ from the values for the previous study of 32 $\mu g/m^3$.

(ii) Deposition

The analysis of long range transport and the implications of acid precipitation forms the basis for the assessment of TSP deposition. The reader is referenced to that document.[11] As mentioned for SO_2, the emission rates and stack height used in that study are not in keeping with current estimates, but it is felt that the deposition rates calculated in that study represent a reasonable assessment.

(d) Carbon Monoxide

Despite the slight reduction in coal consumption rate, the relatively insignificant impacts of carbon monoxide (CO) have not warranted a reassessment. Given the accuracy of the approach, the assessments of CO impacts in the original ERT study are viewed to be currently valid.

(e) Hydrocarbons

Despite the slight reduction in coal consumption rate, the relatively insignificant impacts of hydrocarbon emissions have not warranted a reassessment. Given the accuracy of the approach, the assessment of hydrocarbon impacts in the original ERT study are viewed to be currently valid.

2.2 MINE

The original ERT work identified the only contaminant produced by the Hat Creek Project mining operations to be fugitive dust. While this is still the case, the entrainment of mine dust into the atmosphere will result in the redistribution of trace elements. This effect was not analysed in the original ERT work. Trace element impacts will be discussed in the next section. Here we are concerned only with the contribution of mine dust to ambient particulate levels.

Significant changes to the mine plans and technical advances in the science of mine dust impact assessment necessitate a complete revision of the conclusions of the original ERT study. It is now concluded that impacts calculated in the original ERT work are significant overpredictions resulting from an overly conservative approach. Specifically, the conservative elements to the original approach include:

2.2 MINE - (Cont'd)

1. The lack of accounting for control measures which B.C. Hydro now plans to implement to control dust levels, including extensive watering and application of soil binder.

2. The absence of consideration for the large particle sizes of mining dust emissions and consequent rapid deposition.

3. The neglect of terrain influences, in particular the absence of consideration for the subsurface (as much as 200-300 m) origin of many of the emissions.

4. The assumption that worst cases were low wind speed cases combined with the assumption that dust emissions are independent of wind speed. (This resulted in maximum emissions at the same time as worst-meteorology which would not be the case in reality.)

ERT was asked to review their original assessment in light of the above elements and the improvements which have taken place. Their conclusion was:

> "It is clear that in the immediate vicinity of any dust producing operation (within a few feet) high concentrations will be observed. However, our best judgement in light of the previous discussions and the CMJV analysis is that concentrations outside the pits, at distances greater than half a kilometer from these major sources, should fall below the guideline values of 60 $\mu g/m^3$ for annual concentrations and 150 $\mu g/m^3$ for 24-hour maximum concentrations".[12]

(i) Concentrations

It was not considered necessary to completely redo the modelling study for the mine. Rather it was felt that impacts could be ascertained by interpretation of the above conclusions. The maximum impacts of

60 μg/m^3 and 150 μg/m^3 referred to by ERT include the ambient background concentration. Thus the impacts of the mine dust itself will be less than these values. Ambient background has been measured at 20 μg/m^3 but it is recognized that the addition of the mine may remove some of the existing sources of particulates and replace them with mine dust. As a worst case it can be assumed that the value of 60 μg/m^3 at 1/2 km from the mine consists totally of mine dust. For maximum 24-hour concentrations it is difficult to assign a background value to the concentrations. Unusual meteorological conditions can cause dust storms in any agricultural region which can substantially increase particulate concentrations. Ignoring large contributions from non-project related sources, maximum 24-hour concentrations of 150 μg/m^3 are assumed to also result totally from mine dust emissions as a worst case.

It is impossible to make concrete statements regarding the spatial distribution of these concentrations without considerably more analysis. However, the evidence suggests that mine dust particle sizes are very large[13] and concentrations decrease rapidly with distance away from the source. For this reason the impacts of mine dust are expected to be confined to the immediate vicinity of the mine.

(ii) Deposition

Deposition of mine dust was not calculated in the previous study. There is considerable evidence to indicate that mine dust particulates are very large[13], and consequently will undergo rapid deposition. The value of 0.1 cm/s used as a deposition velocity for particulates from the powerplant stack in the original

ERT work is reflective of much smaller particles. PEDCO[13] has measured size ranges of particulates from mining operations. Examination of their data indicates that the bulk of the mine dust particles fall in the size range between 10 and 30 μm. A value of 1 cm/s has been selected to represent the deposition velocity of particles in this size range based on consideration of Stoke's Law calculations for spheres of uniform diameter falling in calm air.[14]

It was not viewed as necessary to revise the estimates of deposition on a theoretical basis as in the analysis of long range transport and the implications of acid precipitation. Rather the simplified approach of multiplying ground-level concentrations by assumed deposition velocity was used to estimate deposition. The approach yields a maximum deposition value for mine dust of 0.6 $\mu g/m^2/s$.

As for concentrations it is not possible to define the spatial distribution of deposition patterns. The influenced areas, however, are assumed to be confined to the immediate vicinity of the mine.

SECTION 3.0 - TRACE ELEMENTS

As with the major components, the study of trace elements can be divided into two general categories: those resulting from the mining of coal, and those resulting from the burning of coal to generate electricity. In this reassessment the effect on trace element redistribution which might result from changes in the cooling tower plans and consequent changes in the drift deposition have been assumed to be small and have been neglected. The source of changes to the assessment for trace elements is a revision to the amount of each trace element which is contained in the coal and an improvement in the methods used to estimate concentrations and deposition patterns.

3.1 POWERPLANT

The method used to estimate effects of trace elements released to the atmosphere by the powerplant stack in the original ERT study was to multiply model predictions for SO_2 by the ratio of the trace element emission rate to that of SO_2. The use of such ratios in this analysis has not changed, but it has been necessary to revise the emission rates and the SO_2 model predictions as discussed previously.

The trace element feed rates to the boiler can be calculated from the coal consumption rate of 40 000 t/d and the trace element concentration in the coal as shown in Table 1-5. (The trace element concentrations are expressed on a dry basis so only the dry fraction of the coal consumption rate, 76 percent, should be used.) Of this feed rate a certain percentage is emitted to the atmosphere. This percentage differs for each element based on its own chemical and physical properties and has been estimated in Table 1-7. In this way emission rates for each of the trace elements have been calculated and compared to the emission rates used in the original ERT analysis in Table 3-1.

TABLE 3-1

TRACE ELEMENT EMISSION RATES FROM THE POWERPLANT AS USED IN THE ORIGINAL ERT WORK AND AS CURRENTLY ESTIMATED

Element	Symbol	Emission Rate (kg/d) Previous Work	Emission Rate (kg/d) Current Estimate[1]
Antimony	Sb	Not analysed	0.15
Arsenic	As	17.2	17
Beryllium	Be	Not analysed	0.29
Boron	B	Not analysed	28
Cadmium	Cd	0.35	0.21
Chromium	Cr	5.2	3.2
Cobalt	Co	Not analysed	0.53
Copper	Cu	5.93	26
Fluorine	F	281	2300
Lead	Pb	4.36	5.1
Manganese	Mn	Not analysed	70.0
Mercury	Hg	7.07	4.0
Molybdenum	Mo	Not analysed	3.5
Nickel	Ni	Not analysed	7.3
Selenium	Se	Not analysed	5.9
Silver	Ag	Not analysed	0.02
Thallium	Tl	Not analysed	0.02
Thorium	Th	Not analysed	0.19
Tin	Sn	Not analysed	0.13
Tungsten	W	Not analysed	0.03
Uranium	U	Not analysed	0.67
Vanadium	V	16.1	9.9
Zinc	Zn	12.9	16

---

[1] Calculated by multiplying coal consumption rate (40 000 t/d) by the dry fraction of the coal (0.76), and by the trace element fractions (Table 1-5) and finally by the fraction of the trace elements which are emitted (Table 1-7).

3.1 POWERPLANT - (Cont'd)

(a) Concentrations

The estimate of ground-level trace element concentrations in the trace element appendix to the original ERT work was done only for the local-scale modelling and only for the case of a 366 m stack height. In this reassessment, trace element concentrations have also been restricted to the local-scale, because highest concentrations are expected within this radius. The case treated, however, is for a 244 m stack with an MCS. In addition the trace element appendix did not address 3-hour and 24-hour maximum concentrations, which have been addressed here.

The use of model predictions for an MCS to calculate trace element concentrations, particularly for short averaging times, could be viewed as questionable because the MCS is intended only to control SO_2 concentrations. The methods used to effect this control are switching to low sulphur coal and reduction of load. While the load reduction actions will clearly result in reduced trace element emissions, the effect of fuel switching on trace element emissions varies from element to element. A comparison of the change in emission rate during a fuel switching action for SO_2 and various trace elements is shown in Table 3-2. While there is considerable variability, the general nature is a reduction for most elements.

Trace element concentrations have thus been calculated using the ratio of emission rates and maximum impacts are presented in Table 3-3. Annual-average concentrations are calculated for the isopleths shown in Fig. 2-1 and presented in Table 3-4.

(b) Deposition

In the previous work deposition of trace elements was calculated for the local-scale only and was based on ground-level concentrations and an assumed deposition velocity. However, when

TABLE 3-2

CHANGE IN EMISSION RATE FOR VARIOUS CONTAMINANTS DURING FUEL SWITCHING

Contaminant	Symbol	Percent of Normal Emissions During Fuel Switching
Sulphur dioxide	SO_2	53
Antimony	Sb	NQ[1]
Arsenic	As	46
Beryllium	Be	92
Boron	B	137
Cadmium	Cd	75
Chromium	Cr	65
Cobalt	Co	65
Copper	Cu	58
Fluorine	F	60
Lead	Pb	67
Manganese	Mn	74
Mercury	Hg	77
Molybdenum	Mo	83
Nickel	Ni	38
Selenium	Se	65
Silver	Ag	NQ
Thallium	Tl	NQ
Thorium	Th	110
Tin	Sn	85
Tungsten	W	NQ
Uranium	U	75
Vanadium	V	61
Zinc	Zn	69

---

[1] NQ - not quantifiable due to inadequate data.

TABLE 3-3

MAXIMUM TRACE ELEMENT CONCENTRATIONS IN μg/m^3 RESULTING FROM POWERPLANT EMISSIONS[1]

Element	Symbol	3-hour	24-hour	Annual
Antimony	Sb	0.00029	0.00012	0.0000043
Arsenic	As	0.033	0.014	0.00049
Beryllium	Be	0.00056	0.00023	0.000008
Boron	B	0.052	0.022	0.00077
Cadmium	Cd	0.0004	0.00017	0.000006
Chromium	Cr	0.0061	0.0026	0.000092
Cobalt	Co	0.001	0.00042	0.000015
Copper	Cu	0.050	0.021	0.00075
Fluorine	F	4.4	1.8	0.066
Lead	Pb	0.0098	0.0041	0.00015
Manganese	Mn	0.13	0.056	0.002
Mercury	Hg	0.0077	0.0032	0.00012
Molybdenum	Mo	0.0067	0.0028	0.0001
Nickel	Ni	0.014	0.0058	0.00021
Selenium	Se	0.011	0.0047	0.00017
Silver	Ag	0.000038	0.000016	0.00000057
Thallium	Tl	0.000038	0.000016	0.00000057
Thorium	Th	0.00036	0.00015	0.000005
Tin	Sn	0.00025	0.0001	0.0000037
Tungsten	W	0.000057	0.000024	0.00000086
Uranium	U	0.0013	0.00054	0.000019
Vanadium	V	0.019	0.008	0.00028
Zinc	Zn	0.031	0.013	0.00046

---

[1] No comparison is given here between previous work and these estimates are for the current work because the original ERT studies did not address these impacts.

TABLE 3-4

ANNUAL-AVERAGE TRACE ELEMENT CONCENTRATIONS IN $\mu g/m^3$ x 10^3 CORRESPONDING TO CODED ISOPLETHS[1] RESULTING FROM POWERPLANT EMISSIONS[2]

Element	Symbol	Isopleth Code A	B	C	D	E	F
Antimony	Sb	0.0042	0.0032	0.0022	0.0014	0.00046	0.000046
Arsenic	As	0.47	0.37	0.26	0.16	0.052	0.0052
Beryllium	Be	0.008	0.0063	0.0045	0.0027	0.00089	0.000089
Boron	B	0.75	0.58	0.42	0.25	0.083	0.0083
Cadmium	Cd	0.0058	0.0045	0.0032	0.0019	0.00065	0.000065
Chromium	Cr	0.089	0.069	0.049	0.03	0.01	0.001
Cobalt	Co	0.015	0.011	0.0082	0.0049	0.0016	0.00016
Copper	Cu	0.72	0.56	0.4	0.24	0.08	0.008
Fluorine	F	64	50	35	21	7.1	0.71
Lead	Pb	0.14	0.11	0.079	0.047	0.016	0.0016
Manganese	Mn	1.9	1.5	1.1	0.65	0.22	0.022
Mercury	Hg	0.11	0.086	0.062	0.037	0.012	0.0012
Molybdenum	No	0.10	0.075	0.054	0.032	0.011	0.0011
Nickel	Ni	0.2	0.16	0.11	0.067	0.022	0.0022
Selenium	Se	0.16	0.13	0.09	0.055	0.018	0.0018
Silver	Ag	0.00035	0.00043	0.00031	0.00019	0.00062	0.000062
Thallium	Tl	0.00055	0.00043	0.00031	0.00019	0.00062	0.000062
Thorium	Th	0.0053	0.0041	0.0029	0.0018	0.00059	0.000059
Tin	Sn	0.0036	0.0028	0.002	0.0012	0.004	0.0004
Tungsten	W	0.00083	0.00065	0.00046	0.00028	0.000092	0.0000092
Uranium	U	0.019	0.015	0.01	0.0063	0.0021	0.00021
Vanadium	V	0.27	0.21	0.15	0.091	0.03	0.003
Zinc	Zn	0.44	0.34	0.25	0.15	0.049	0.0049

---

[1] See Fig. 2-1.

[2] For comparison to original ERT work see Table F7-2 in Appendix F of the original ERT study.

the report on long range transport and the implications of acid precipitation was completed it became apparent that most significant deposition areas for the major contaminants were outside this local-scale. Since this later analysis of major component deposition was a more theoretical treatment of this process, it was decided to use the deposition patterns in the acid precipitation report to calculate deposition patterns for trace elements in this reassessment. Within the acid precipitation report deposition rates have been presented for sulphur oxides, nitrogen oxides and particulates. Despite the fact that many of the trace elements are in particulate form, it was decided to use the SO_2 deposition patterns to calculate all trace element deposition. The reasons for this selection are as follows:

1. The SO_2 deposition patterns were higher and thus represented the more conservative approach.
2. The SO_2 deposition patterns accounted for a greater percentage of the emission rate. The use of the particulate deposition patterns would have left a much greater percentage of the emitted trace elements completely unaccounted for.

Deposition patterns, as in the original study, have been calculated only for annual-average rates. Table 3-5 is coded to Fig. 2-2 and presents the annual-average deposition rates for each trace element.

3.2 MINE

In the previous ERT work no estimate was made of trace element concentrations or deposition rates resulting from trace elements in the mine dust. However, close to the mine it is clear that these effects will dominate over the effects of the powerplant. The

TABLE 3-5

ANNUAL-AVERAGE TRACE ELEMENT DEPOSITION RATES IN μg/m²/a FOR CODED ISOPLETHS[1] RESULTING FROM POWERPLANT EMISSIONS

Element	Symbol	Coded Isopleth			
		A	B	C	D
Antimony	Sb	0.58	0.44	0.29	0.15
Arsenic	As	66	50	33	17
Beryllium	Be	1.1	0.84	0.56	0.28
Boron	B	105	79	52	26
Cadmium	Cd	0.82	0.61	0.41	0.20
Chromium	Cr	12	9.3	6.2	3.1
Cobalt	Co	21	1.5	1.0	0.51
Copper	Cu	101	76	50	25
Fluorine	F	8900	6700	4500	2200
Lead	Pb	20	15	9.9	5.0
Manganese	Mn	270	200	140	68
Mercury	Hg	16	12	7.8	3.9
Molybdenum	Mo	14	10	6.8	3.4
Nickel	Ni	28	21	14	7.1
Selenium	Se	23	17	11	5.7
Silver	Ag	0.078	0.058	0.039	0.019
Thallium	Tl	0.078	0.058	0.039	0.019
Thorium	Th	0.74	0.55	0.37	0.18
Tin	Sn	0.5	0.38	0.25	0.13
Tungsten	W	0.12	0.087	0.058	0.029
Uranium	U	2.6	2.0	1.3	0.65
Vanadium	V	38	29	19	9.6
Zinc	Zn	62	47	31	16

---

[1] See Fig. 2-2.

analysis of mine dust has been identified as an area where major revision to the original work has been attempted. Only rough approximations to the actual concentrations and deposition rates have been projected. These were not the result of computer modelling analysis, but rather approximations based on judgements of consultant engineers and scientists. In order to develop trace element concentrations and deposition rates from these estimates it is necessary to assume that trace element concentrations in the particulate emissions are the same as those in the coal. This may not be the case since much of the dust is generated by exposed rock and soil areas as well as the handling of materials other than coal. However, a considerable amount will be coal dust, and thus the assumption has been adopted.

(a) Concentrations

Concentrations of trace elements in the ambient air at ground level around the mine are calculated by multiplying the ambient air particulate concentrations by the various elements. Table 3-6 shows annual-average concentrations and maximum 24-hour concentrations.

(b) Deposition

Deposition of mine dust has been presented for annual average rates in Section 2.0. These results are used to calculate trace element deposition rates resulting from mine dust by multiplying the mine dust deposition rates by the trace element content of the coal. The results of this calculation are presented in Table 3-7.

It is important to realize that trace elements in mine dust are still bonded in their original state. Unlike the trace elements from the powerplant, they have not undergone the processes of combustion. It is necessary for the mine dust related trace elements to be leached from the material they are bonded to in order be released to the environment.

TABLE 3-6

AMBIENT TRACE ELEMENT CONCENTRATIONS RESULTING FROM MINE DUST EMISSIONS IN μg/m³

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

---

[1] Annual averages are arithmetic averages.

TABLE 3-7

ANNAUL-AVERAGE DEPOSITION RATES FOR TRACE ELEMENTS RESULTING FROM MINE DUST IN μg/m²/a

Element	Symbol	Highest Deposition Rate
Antimony	Sb	7.3
Arsenic	As	120
Beryllium	Be	9.1
Boron	B	260
Cadmium	Cd	4.7
Chromium	Cr	1010
Cobalt	Co	82
Copper	Cu	600
Fluorine	F	1700
Lead	Pb	82
Manganese	Mn	3100
Mercury	Hg	1.9
Molybdenum	Mo	3.2
Nickel	Ni	350
Selenium	Se	11
Silver	Ag	5.7
Thallium	Tl	7.3
Thorium	Th	82
Tin	Sn	12
Tungsten	W	15
Uranium	U	32
Vanadium	V	1600
Zinc	Zn	500

SECTION 4.0 - OTHER AREAS OF ASSESSMENT

4.1 CONSTRUCTION ACTIVITIES

There are no available data to indicate the need to revise the conclusions of the original ERT report regarding impacts of construction activities.

4.2 OFFSITE DEVELOPMENTS

The conclusions of the original ERT work regarding the impacts of the access road and the airstrip are assumed to be valid. There are no available data which would change these assessments.

4.3 CLIMATIC EFFECTS

Despite the larger air flow rate in the cooling towers there is little change to the heat released to the atmosphere by the cooling tower. Given this, there is no cause to revise the assessment of climatic effects on precipitation, thermal alterations, snow cover persistence and depth, or ground-level fogging and icing. Similarly, there is no cause to revise the assessment of macroscale climatic effects.

4.4 VISIBILITY RESTRICTIONS

Visibility impacts in the original study were divided into those caused by the powerplant and those caused by the mine dust. The sulphate in the downwind powerplant plume was said to reduce visibility by 6 percent. Since there is little change in the SO_2 emission rate and consequently no changes in the regional sulphate concentrations, this assessment is still viewed to be valid. The mine dust effect on visibility was assessed using the change in annual-average concentrations of dust at the southern boundary of the Indian Reserve just north of the mine. This change was from a pre-construction level of 20 $\mu g/m^3$ to a post-construction level of 80 $\mu g/m^3$. Current estimates indicate that this post-construction level should be no greater than 60 $\mu g/m^3$, thus reducing the visibility impacts. Previously, the visual range at which fine detail could be seen was said to be reduced from 14.6 km to 3.6 km. Now the reduction is expected to be to 4.9 km. Similarly, for moderate and coarse detail the reductions are now expected to be from 36 km to 12 km and from 54 km to 18 km, respectively (instead of the previous reductions to 9 km and 13.5 km respectively).

An important point about these reductions is that the influence of particle sizes has been neglected. As previously mentioned, mine dust particles have relatively large mass mean diameters and as a result are larger than the most effective size range for visibility reduction (0.1 to 1.0 μm is the most effective size range).[14] As a result the visibility reductions quoted above are conservative estimates and probably considerably worse than any actual visibility reduction which may be experienced as a result of the mine operation.

4.5 OTHER INDUSTRIAL DEVELOPMENT

In the original ERT work the analysis of other industrial developments was based on the source inventory prepared by B.H. Levelton and Associates. Since that time, B.H. Levelton has revised their document. Existing sources are primarily located in the Kamloops area and SO_2 emissions from these sources are estimated by Levelton to be 12 600 kg/d. The PCB has provided comment that this value is too high and that values from 5650 kg/d to 6770 kg/d are more accurate. In addition, there are two copper smelters being considered for construction in the study area. Each of these may provide major contribution to the area's SO_2 emissions. The larger of the two smelters, (1000 t/d) near 70 Mile House, B.C. has been estimated by Levelton to have an emission rate, when constructed, of 137 000 kg/d. Similarly, the other proposed smelter (400 TPD) is to be located in the Highland valley area and would produce SO_2 emissions at the rate of 3660 kg/d. *Recent information by the U.S. EPA on the emission rate of* SO_2 *from* copper smelters indicates that emission rates from uncontrolled copper smelters can be as much as four times greater than the estimates for the 70 Mile House smelter.

It is evident that the addition of these two smelter operations to the study area could greatly influence SO_2 concentrations in the area. Currently, there is little chance for interaction of the Hat Creek plume with the existing sources located primarily in the Kamloops area. The annual-average predictions for SO_2 concentrations resulting from the Hat Creek Project in Kamloops are less than 1.0 $\mu g/m^3$. This prediction was made assuming Kamloops to be at the same elevation as the stack base. In actuality, Kamloops is roughly 1000 m lower than the plant site elevation. It is very unlikely that the Hat Creek plume would have any significant impact on the Kamloops area which is over 80 km distance from the plant.

However, if either of the two proposed copper smelters were to be built there is considerable chance for interaction with the Hat Creek plume. The Highland valley area is only 45 km from the plant site and the 70 Mile House area is roughly 55 km from the plant site. In addition, both areas are much higher in elevation than the Kamloops area. The difference in elevation between each of these sites and the Hat Creek site is only a few hundred metres. While annual-average concentrations resulting from the Hat Creek Project in both these areas *have only been predicted to be around 1.0* $\mu g/m^3$, the occurence of an unusual meteorological condition could cause the combined effect of either of the sources with the Hat Creek plume to be significant. Further conclusions cannot be drawn without modelling analysis of these potential sources.

SECTION 5.0 - CONCLUSIONS

5.1 SUMMARY

The initial assessment of the Hat Creek Project has been revised and several revisions to the data bases, design, and analysis techniques have been used in a reassessment of the air quality and climatic effects of the project. Despite the changes, it was not viewed necessary to revise the impact assessment for sulphur dioxide impacts. Nitrogen oxide and particulate emissions were reduced and as a result a slight downward revision was made to the impact assessment for these contaminants. No change was made to the assessments of carbon monoxide or hydrocarbons. The acid precipitation study, which has recently been completed, represents a revision in itself of the original sulphur oxides, nitrogen oxides and particulate deposition rates.

The two areas which received the most extensive revision were the analysis of mining dust emissions, and the redistribution of trace elements. For mine dust all impacts were extensively reduced due to new mine plans and a better understanding of these emissions. For trace elements, the changes involved the addition of new elements, revisions to the emission rates for many elements, the analysis of contribution to trace element redistribution from mine dust, and the inclusion of new averaging times in the analysis.

A summary table, Table 5-1, has been prepared to depict all changes to both the emission rates and the concentration impacts. The changes to deposition impacts are shown in the text.

TABLE 5-1

A SUMMARY OF CHANGES TO THE HAT CREEK PROJECT AIR QUALITY ASSESSMENTS

Contaminant	Powerplant Impacts Previous	 Revised	Mine Impacts Previous	 Revised
Sulphur dioxide SO$_2$				
emission rate (kg/d)	324 768	312 000	None	None
3-hr max. conc. (μg/m^3)	622	622	-	-
24-hr max. conc. (μg/m^3)	260	260	-	-
annual-average conc. (μg/m^3)	9.3	9.3	-	-
Nitrogen oxide NO				
emission rate (kg/d)	82 489	65 000	None	None
annual-average conc. (μg/m^3)	2.3	1.8	-	-
Nitrogen dioxide NO$_2$				
emission rate (kg/d)	124 759	100 000	None	None
1-hr max. conc. (μg/m^3)	657	526	-	-
annual-average conc. (μg/m^3)	3.5	2.9	-	-
Total particulates TSP				
emission rate (kg/d)	40 000	34 400	6 270	NR[1]
24-hr max. conc. (μg/m^3)	32	28	400	150
annual-average conc. (μg/m^3)	1.1	1.0	250	60
Carbon monoxide CO				
emission rate (kg/d)	18 043	NR	None	None
1-hr max. conc. (μg/m^3)	96.1	96.1	-	-
8-hr max. conc. (μg/m^3)	18.6	18.6	-	-
24-hr max. conc. (μg/m^3)	14.4	14.4	-	-
annual-average conc. (μg/m^3)	0.5	0.5	-	-
Total hydrocarbons HC				
emission rate (kg/d)	5413	NR	None	None
annual-average conc. (μg/m^3)	0.2	0.2	-	-
Antimony Sb				
emission rate (kg/d)	NA[2]	0.15	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.00029	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.00012	NA	0.000057
annual-average conc. (μg/m^3)	NA	0.0000043	NA	0.000023

TABLE 5-1 - (Cont'd)

	Powerplant Impacts		Mine Impacts	
Contaminant	Previous	Revised	Previous	Revised
Arsenic As				
emission rate (kg/d)	17.2	17	NA	NA
3-hr max. conc. (μg/m^3)	NA	.033	NA	NA
24-hr max. conc. (μg/m^3)	NA	.014	NA	0.0013
annual-average conc. (μg/m^3)	.0003	.00049	NA	0.00051
Beryllium Be				
emission rate (kg/d)	NA	0.29	NA	NA
3-hr max. conc. (μg/m^3)	NA	.00056	NA	NA
24-hr max. conc. (μg/m^3)	NA	.00023	NA	0.000096
annual-average conc. (μg/m^3)	NA	.000008	NA	0.000038
Boron B				
emission rate (kg/d)	NA	27	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.052	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.022	NA	0.0027
annual-average conc. (μg/m^3)	NA	0.00077	NA	0.0011
Cadmium Cd				
emission rate (kg/d)	0.35	0.21	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.0004	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.00017	NA	0.00005
annual-average conc. (μg/m^3)	.000005	0.000006	NA	0.00002
Chromium Cr				
emission rate (kg/d)	5.2	3.2	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.0061	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.0026	NA	0.011
annual-average conc. (μg/m^3)	.00008	0.000092	NA	0.0043
Cobalt Co				
emission rate (kg/d)	NA	0.53	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.001	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.00042	NA	0.00066
annual-average conc. (μg/m^3)	NA	0.000015	NA	0.00026
Copper Cu				
emission rate (kg/d)	5.93	26	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.05	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.021	NA	0.0063
annual-average conc. (μg/m^3)	.00009	0.00075	NA	0.0025

TABLE 5-1 - (Cont'd)

	Powerplant Impacts		Mine Impacts	
Contaminant	Previous	Revised	Previous	Revised
Fluorine F				
emission rate (kg/d)	281	2300	NA	NA
3-hr max. conc. ($\mu g/m^3$)	NA	4.4	NA	NA
24-hr max. conc. ($\mu g/m^3$)	NA	1.8	NA	0.018
annual-average conc. ($\mu g/m^3$)	.004	0.066	NA	0.0071
Lead Pb				
emission rate (kg/d)	4.36	5.1	NA	NA
3-hr max. conc. ($\mu g/m^3$)	NA	0.0098	NA	NA
24-hr max. conc. ($\mu g/m^3$)	NA	0.0041	NA	0.00084
annual-average conc. ($\mu g/m^3$)	.00007	0.00015	NA	0.00034
Manganese Mn				
emission rate (kg/d)	NA	70.0	NA	NA
3-hr max. conc. ($\mu g/m^3$)	NA	0.13	NA	NA
24-hr max. conc. ($\mu g/m^3$)	NA	0.056	NA	0.024
annual-average conc. ($\mu g/m^3$)	NA	0.002	NA	0.0097
Mercury Hg				
emission rate (kg/d)	7.07	4.0	NA	NA
3-hr max. conc. ($\mu g/m^3$)	NA	0.0077	NA	NA
24-hr max. conc. ($\mu g/m^3$)	NA	0.0032	NA	0.00002
annual-average conc. ($\mu g/m^3$)	.0001	0.00012	NA	0.0000078
Molybdenum Mo				
emission rate (kg/d)	NA	3.5	NA	NA
3-hr max. conc. ($\mu g/m^3$)	NA	0.0067	NA	NA
24-hr max. conc. ($\mu g/m^3$)	NA	0.0028	NA	0.00035
annual-average conc. ($\mu g/m^3$)	NA	0.0001	NA	0.00014
Nickel Ni				
emission rate (kg/d)	NA	7.3	NA	NA
3-hr max. conc. ($\mu g/m^3$)	NA	0.014	NA	NA
24-hr max. conc. ($\mu g/m^3$)	NA	0.0058	NA	0.0027
annual-average conc. ($\mu g/m^3$)	NA	0.00021	NA	0.0011
Selenium Se				
emission rate (kg/d)	NA	5.9	NA	NA
3-hr max. conc. ($\mu g/m^3$)	NA	0.011	NA	NA
24-hr max. conc. ($\mu g/m^3$)	NA	0.0047	NA	0.00012
annual-average conc. ($\mu g/m^3$)	NA	0.00017	NA	0.000046

TABLE 5-1 - (Cont'd)

	Powerplant Impacts		Mine Impacts	
Contaminant	Previous	Revised	Previous	Revised
Silver Ag				
emission rate (kg/d)	NA	0.02	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.000038	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.000016	NA	0.000046
annual-average conc. (μg/m^3)	NA	0.00000057	NA	0.000018
Thallium Tl				
emission rate (kg/d)	NA	0.13	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.000038	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.000016	NA	0.000057
annual-average conc. (μg/m^3)	NA	0.00000057	NA	0.000023
Thorium Th				
emission rate (kg/d)	NA	0.19	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.00036	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.00015	NA	0.00086
annual-average conc. (μg/m^3)	NA	0.000005	NA	0.00034
Tin Sn				
emission rate (kg/d)	NA	0.03	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.00025	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.0001	NA	0.000095
annual-average conc. (μg/m^3)	NA	0.0000037	NA	0.000038
Tungsten W				
emission rate (kg/d)	NA	0.03	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.000057	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.000024	NA	0.00011
annual-average conc. (μg/m^3)	NA	0.00000086	NA	0.000046
Uranium U				
emission rate (kg/d)	NA	0.67	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.0013	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.00054	NA	0.00033
annual-average conc. (μg/m^3)	NA	0.000019	NA	0.00013
Vanadium V				
emission rate (kg/d)	16.1	9.9	NA	NA
3-hr max. conc. (μg/m^3)	NA	0.019	NA	NA
24-hr max. conc. (μg/m^3)	NA	0.0079	NA	0.016
annual-average conc. (μg/m^3)	.0002	0.00038	NA	0.0065

TABLE 5-1 - (Cont'd)

Contaminant	Powerplant Impacts Previous	Powerplant Impacts Revised	Mine Impacts Previous	Mine Impacts Revised
Zinc Zn				
emission rate (kg/d)	12.9	16	NA	NA
3-hr max. conc. (μg/m³)	NA	0.031	NA	NA
24-hr max. conc. (μg/m³)	NA	0.013	NA	0.0053
annual-average conc. (μg/m³)	.0002	0.00046	NA	0.0021

---

[1] NR - not revised.

[2] NA - not analysed.

5.2 COMPARISON WITH PCB OBJECTIVES

Table 5-2 shows a comparison of Hat Creek Project emission rates with PCB emission objectives for mining, smelting and related industries. It can be seen from the table that the Hat Creek Project exceeds the PCB objectives for SO_2, particulates and fluorine although the fluorine level is not specific to powerplants. A comparison of major contaminant ambient concentrations with PCB objectives is shown in Table 5-3. It is not possible to make such a comparison for trace elements, since the PCB objectives do not specify an averaging time. It can be seen from the table that only 1-hour SO_2 concentrations are predicted to be in excess of the objectives. However, it is necessary to add background concentrations to the Hat Creek predictions for comparison with these values. Background SO_2 concentrations are essentially zero, but TSP concentrations have been measured to be between 20 and 40 $\mu g/m^3$ in the Hat Creek valley. Even with these values considered the TSP concentrations are still well within compliance with the objectives.

TABLE 5-2

A COMPARISON OF HAT CREEK PROJECT EMISSION RATES WITH PCB OBJECTIVES[15]

Contaminant	Units	PCB Objective	Hat Creek Project
Sulphur dioxide	mg/kJ fuel	0.09 to 0.34	0.57
Nitrogen oxides	mg/kJ fuel	0.15 to 0.3	0.3
Suspended particulates	mg/kJ fuel	0.01 to 0.04	0.06
Trace elements[1]			
Antimony	mg/mol	0.16 to 0.27	0.000016
Arsenic	mg/mol	0.16 to 0.27	0.0019
Cadmium	mg/mol	0.05 to 0.27	0.000023
Copper	mg/mol	0.16 to 0.27	0.0029
Fluorine	mg/mol	0.02 to 0.2	0.25
Lead	mg/mol	0.16 to 0.27	0.00056
Mercury	mg/mol	0.03 to 0.27	0.00044
Zinc	mg/mol	0.16 to 0.27	0.0018

---

[1] The trace element emission rates are general values intended to apply to a variety of industries, not specific to thermal powerplants.

TABLE 5-3

A COMPARISON OF PCB AMBIENT CONCENTRATION OBJECTIVES FOR MAJOR CONTAMINANTS WITH HAT CREEK PROJECT IMPACT PREDICTIONS FOR THE POWERPLANT

Contaminant	PCB Objective (μg/m³)	Hat Creek Project (μg/m³)
Sulphur dioxide (SO_2)		
1-hr max. conc.	450 to 900	1730
3-hr max. conc.	375 to 665	622
24-hr max. conc.	160 to 260	260
annual-average conc.	25 to 75	9.3
Suspended particulates (TSP)		
24-hr max. conc.	150 to 200	28
annual-average conc.	60 to 70	1.0

REFERENCES

1. Environmental Research and Technology, Inc. (ERT). April 1978. Air Quality and Climatic Effects of the Proposed Hat Creek Project, Summary Report. ERT Document No. 5074-F.

2. Emslie, J.H. 19 July 1979. Meteorological Data Comparisons for Hat Creek - 1975 Versus Long-Term Normals. B.C. Hydro internal report.

3. Cichanowicz, E.J. June 1979. Controlling Oxides of Nitrogen. EPRI Journal. pp. 22-27.

4. Curtis, K.E. 7 April 1977. Trace Element Emissions from the Coal-Fired Generating Stations of Ontario Hydro. Ontario Hydro report No. 77-156-k.

5. Lim, M.Y. May 1979. Trace Elements from Coal Combustion - Atmospheric Emissions. IEA Coal Research, London, Report No. ICTIS/TR05.

6. Meserole, F.B., K. Schwitzgebel, R.A. Magee, R.M. Mann. 10-15 December 1978. Trace Element Emissions from Coal Fired Power Plants. ASME Winter Annual Meeting, San Francisco, CA.

7. Lövblad, G. March 1977. Trace Element Concentrations in Some Coal Samples and Possible Emissions from Coal Combustion in Sweden. Institute for Vatten-Och Luftvardsforskning, Stockholm, Sweden.

8. Onclov, J.M., R.C. Ragaini, and A.H. Biermann. August 1979. Emissions and Particle-Size Distributions of Minor and Trace Elements at Two Western Coal-Fired Power Plants Equipped with

Cold-Side Electrostatic Precipitators. Environmental Science and Technology.

9. Gladney, E.S., G.E. Gordon, and W.H. Zoller. 1978. Coal Combustion: *Source of Toxic Elements in Urban Air. Journal of* Environmental Science and Health. Vol. A13, No. 7, p. 481-491.

10. Kaakinen, J.W., K.M. Jorden, M.H. Lawasani, and R.E. Wert. September 1975. Trace Element Behavior in Coal-Fired Power Plant. Environmental Science and Technology. Vol. 9, No. 9.

11. Environmental Research and Technology, Inc. (ERT). June 1979. Air Quality and Climatic Effects of the Proposed Hat Creek Project, Appendix I - Long Range Transport and the Implications of Acid Precipitation. ERT Report No. 5074-F-I.

12. Personal Communication. 12 July 1978. Letter of K.D. Winges of ERT, Westlake Village, CA., to J.C. Edwards of B.C. Hydro, Vancouver, B.C.

13. PED Co. 1978. Survey of Fugitive Dust from Coal Mines. Prepared for U.S. EPA. Document No. EPA-908/1-78-003.

14. Covert, D.S., R.J. Charlson, and N.C. Ahlquist. A Study of the Relationship of Chemical Composition and Humidity to *Light* Scattering by Aersols. Journal of Applied Meteorology. Vol II, p. 968-976.

APPENDIX A

EFFECTS OF THE HAT CREEK PROJECT ON THE REGIONAL AIR SHED

A.1 MAJOR CONTAMINANTS

Regional concentrations of major contaminants have been calculated during the course of the investigation into long range transport and the implications of acid precipitation for the proposed Hat Creek Project. Unfortunately, isopleths of ambient concentrations were not presented in the documentation of this work, Appendix I to the report Air Quality and Climatic Effects of the Proposed Hat Creek Project, prepared by Environmental Research and Technology. It is possible, however, to obtain such isopleths by "back calculation" from the annual average dry deposition plots presented in Appendix I. This is done by dividing the deposition isopleths by the deposition velocities assumed to characterize dry deposition. This is mathematically shown as follows:

$$\chi = \frac{D}{U_d}$$

Where: χ = ground-level annual-average concenetration

D = isopleth of annual average deposition from the figs. I5-2, I5-4, I5-6, I5-8 and I5-9 in Appendix I

U_d = deposition velocity

The values for deposition velocity used in the report are as follows:

A.1 MAJOR CONTAMINANTS - (Cont'd)

Contaminant	Deposition Velocity ,U_d (m/s)
SO_2	0.01
NO_x	0.01
$SO_4^=$	0.001
NO_3^-	0.001
TSP	0.001

Using this technique ground level concentrations have been calculated for SO_2, $SO_4^=$, NO_x, NO_3^- and TSP. Fig. 1 represents isopleths of annual average SO_2 concentration in µg/m^3. Figs. 2, 3, 4 and 5 are similar figures for $SO_4^=$, NO_x, NO_3^- and TSP, respectively.

From the figures it can be seen that annual average SO_2 concentrations are between 1.0 and 1.5 µg/m^3 in Kamloops. It is not possible without further modelling to establish maximum 3-hour or 24-hour concentrations at this distance, but it is very unlikely that there would be any significant (greater than 5 µg/m^3 for 24-hour concentrations, or greater than 25 µg/m^3 for 3-hour concentrations) impact on the Kamloops area from the Hat Creek plume due to the large difference in elevation between the two areas (approximately 1000 m) and the long distance between the two areas (80 km).

A.2 TRACE ELEMENTS

Trace element concentrations are calculated for each of the isopleths in Fig. 1 by the ratio of emission rate of the trace element to that of SO_2. Table 1 shows these concentrations.

TABLE 1

TRACE ELEMENT CONCENTRATIONS CODED TO FIGURE 1

($\mu g/m^3 \times 10^{-3}$)

Element	Symbol	Trace Element Concentration for SO_2 Isopleths 2.0	1.5	1.0	0.5
Arsenic	As	0.1	0.019	0.052	0.026
Beryllium	Be	0.0018	0.0013	0.00089	0.00045
Boron	B	0.17	0.12	0.083	0.042
Cadmium	Cd	0.0013	0.00097	0.00065	0.00032
Chromium	Cr	0.02	0.015	0.0098	0.0049
Copper	Cu	0.16	0.12	0.08	0.04
Fluorine	F	14	11	7.1	3.5
Lead	Pb	0.031	0.023	0.016	0.0079
Mercury	Hg	0.025	0.018	0.012	0.0062
Molybdenum	Mo	0.022	0.016	0.011	0.0054
Selenium	Se	0.036	0.027	0.018	0.0091
Strontium	Sr	0.032	0.024	0.016	0.008
Thorium	Th	0.0012	0.00088	0.00059	0.00029
Uranium	U	0.0041	0.0031	0.002	0.001
Vanadium	V	0.061	0.046	0.03	0.015
Zinc	Zn	0.099	0.074	0.049	0.025

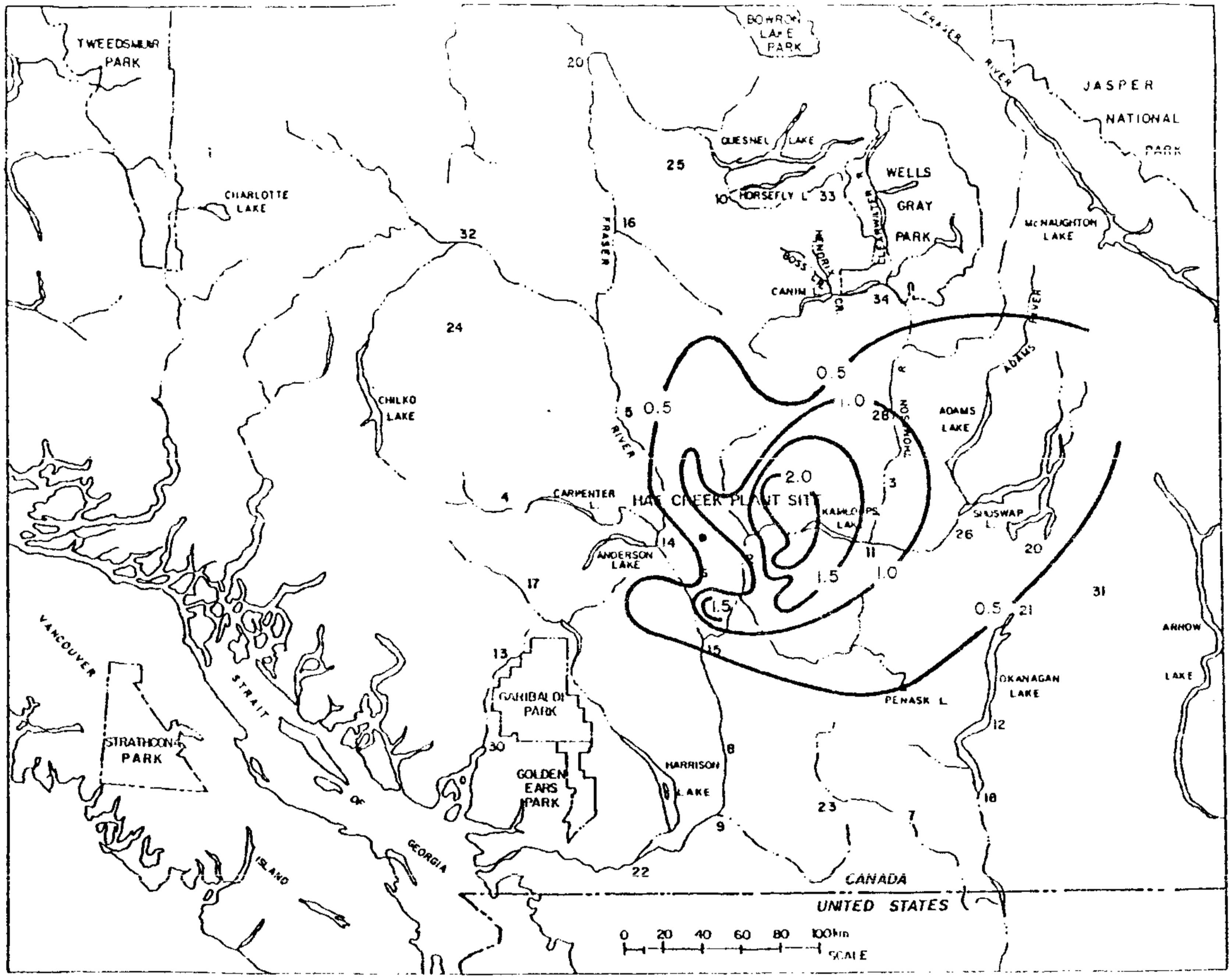

Figure I. Isopleths of Predicted Annual Average SO_2 Concentrations Due to Hat Creek Project Emissions (ug/m^3)

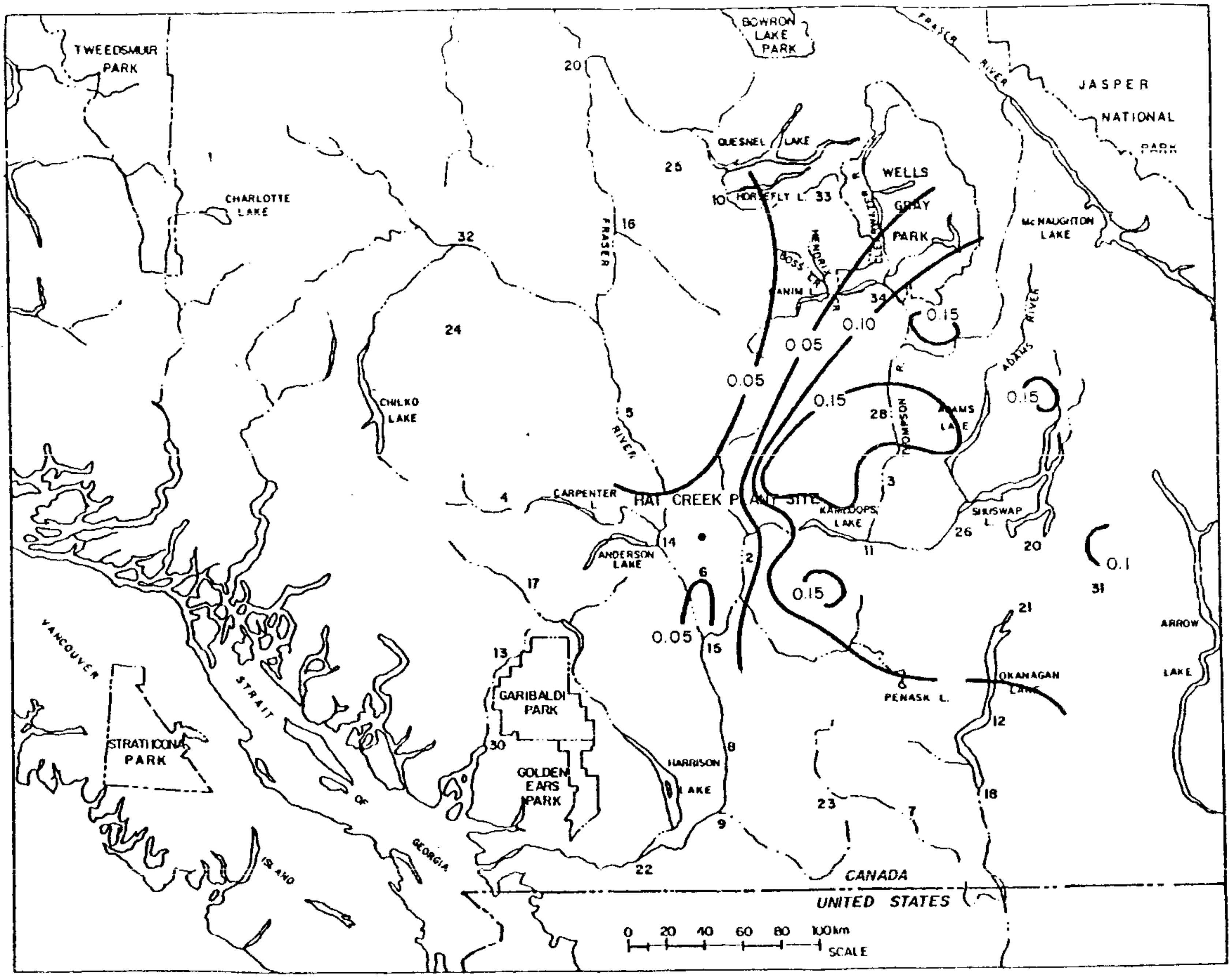

Figure 2. Isopleths of Predicted Annaul Average $SO_4^=$ Concentrations Due to Hat Creek Project Emissions (ug/m^3)

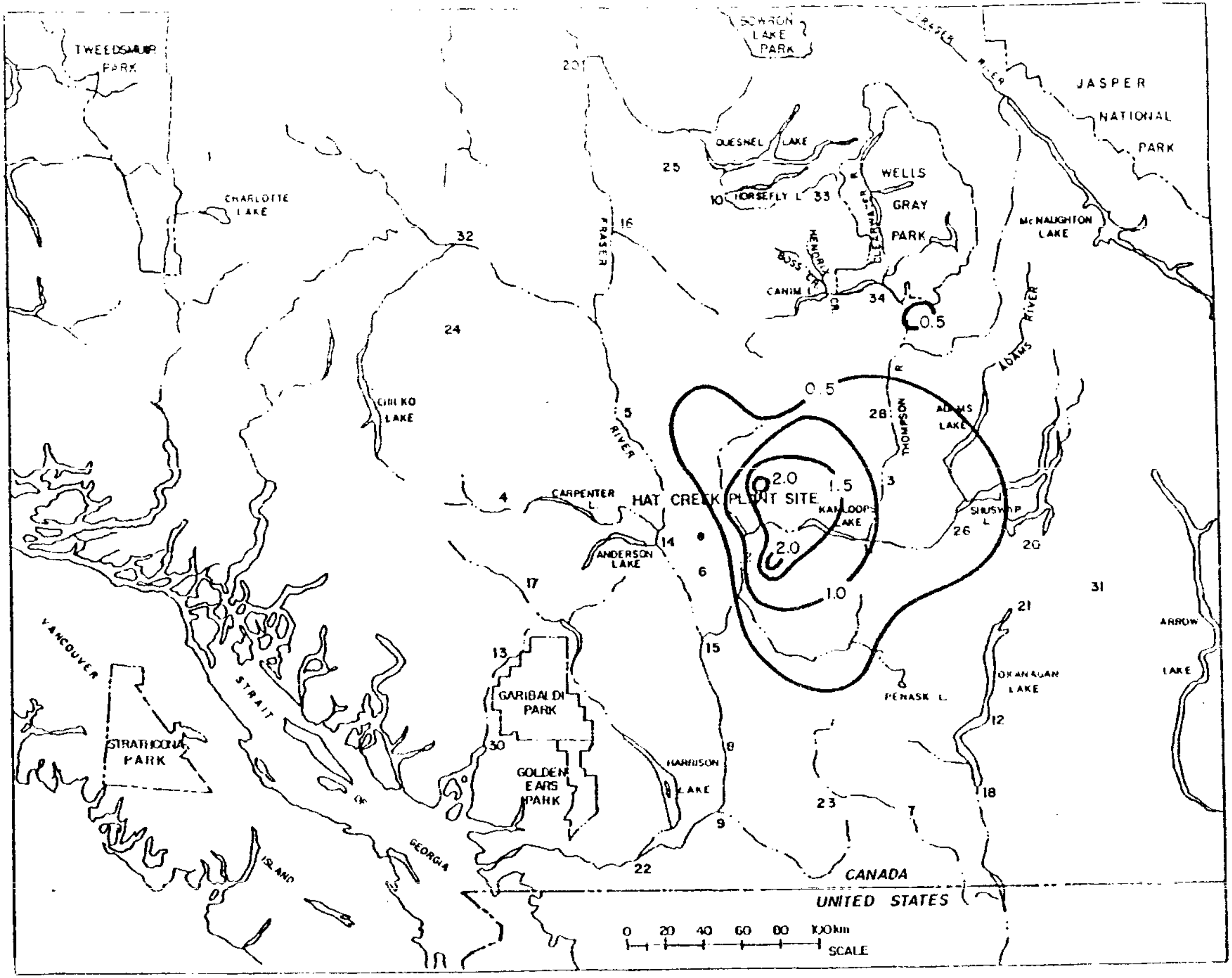

Figure 3. Isopleths of Predicted Annual Average NO_x Concentrations Due to Hat Creek Project Emissions (ug/m^3)

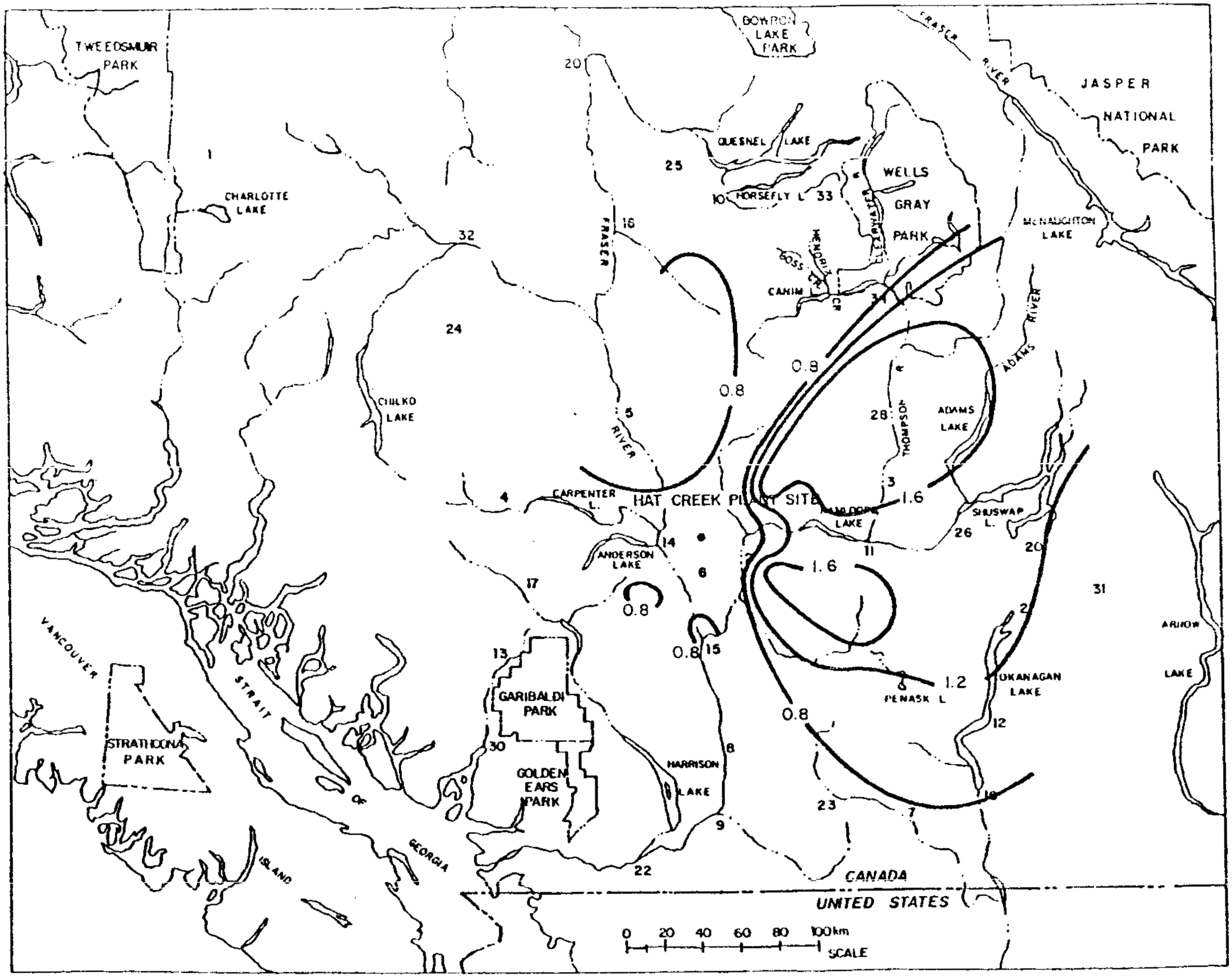

Figure 4. Isopleths of Predicted Annual Average NO_3^- Concentrations Due to Hat Creek Project Emissions (ug/m^3)

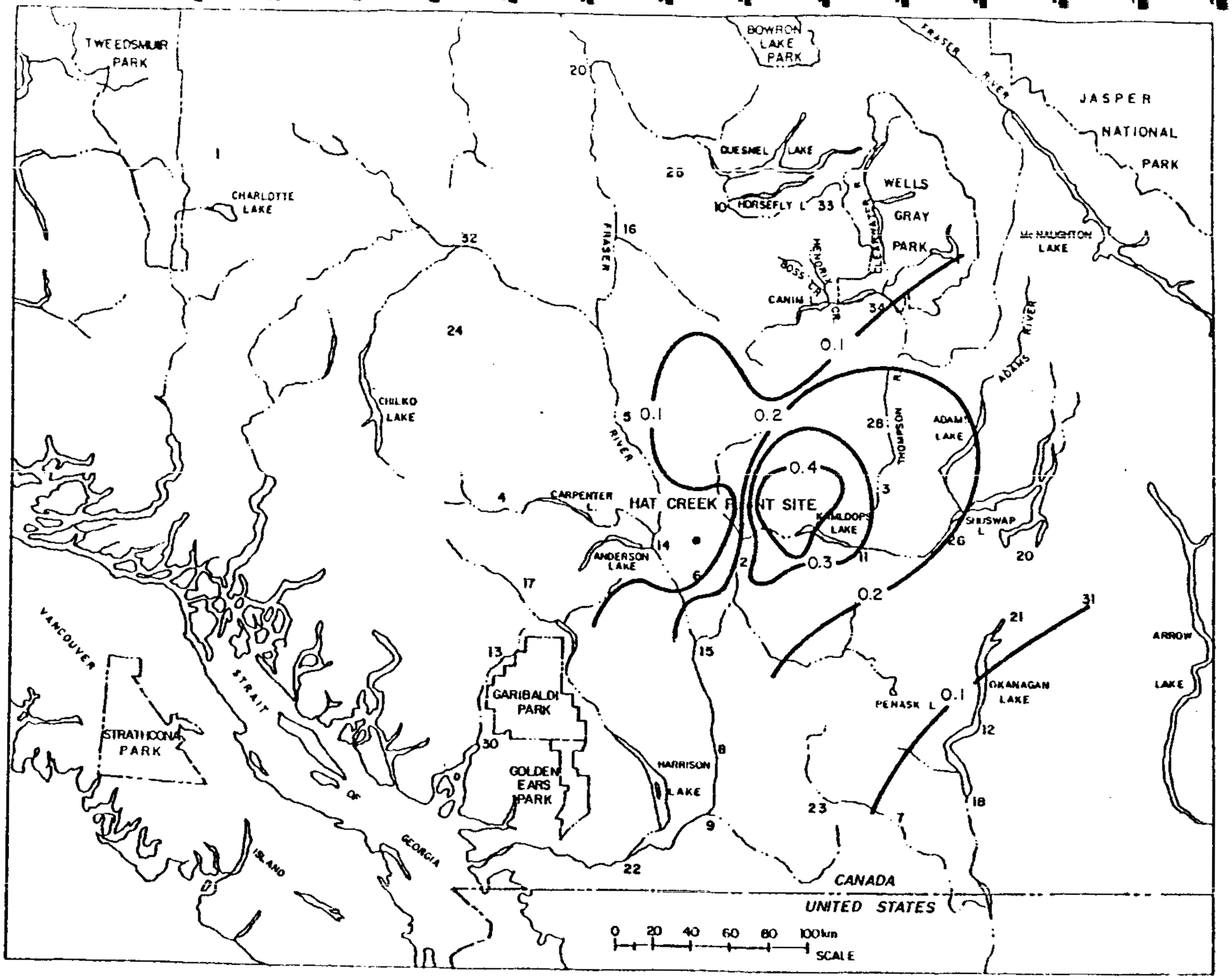

Figure 5. Isopleths of Predicted Annaul Average TSP Concentrations Due to Hat Creek Project Emissions (ug/m^3)