92I NE023-07

Project 1741

ENVIRONMENTAL REPORT ON AFTON MINES LIMITED PROPOSED MINE-MILL-SMELTER DEVELOPMENT

Prepared for
Afton Mines Limited

B.C. RESEARCH
3650 Wesbrook Crescent, Vancouver, Canada V6S 2L2
Phone (604) 224-4331 • Cable 'RESEARCHBC' • Telex 04-507748

MEMORANDUM FROM J.D. McDonald, P.Eng., Senior Reclamation Inspector.

TO See Attached List.

DEPT. OF MINES AND PETROLEUM RESOURCES

THE DEPARTMENT OF MINES AND PETROLEUM RESOURCES
PARLIAMENT BUILDINGS, VICTORIA, BRITISH COLUMBIA V8V 1X4

DATE March 23rd/76.

Re: Afton Mines Ltd. - Stage II Report - Environmental Report on Afton Mines Limited, Proposed Mine-Mill-Smelter Development. Prepared by B.C. Research.

Enclosed is the Stage II Report on the Afton Mine project. Please review and submit your comments on the proposed project to this office by April 15th, 1976.

The comments will be summarized and submitted to Afton Mines Ltd. Stage III will consist of finalization of the permits and licences required by various statutes.

The Company has listed the licences and permits which have been applied for. The Pollution Control Board will be stating their requirements on completion of their study of the permit applications.

J.D. McDonald, P.Eng.,
Senior Reclamation Inspector.

JDM:jau

Enclosure.

Afton Mines Limited - Environmental Report on Afton Mines Limited Proposed Mine-Mill-Smelter Development - Prepared by B.C. Research - Stage II.

Distribution of Report:

J.W. Peck - Chief Inspector of Mines, Dept. of Mines and Petroleum Resources

P.E. Olson - Senior Inspector - Roads, Dept. of Mines and Petroleum Resources

A. Sutherland-Brown - Chief Geologist, Dept. of Mines and Petroleum Resources

J. Poyen - Director, Mineral Development Division, Dept. of Mines and Petroleum Resources.

D. Smith - Inspector, Kamloops, Dept. of Mines and Petroleum Resources

E. Bowles - Chief Gold Commissioner, Dept. of Mines and Petroleum Resources

B. Pendergast - Fish and Wildlife Branch, Department of Recreation and Tourism

D. Zirul - Special Projects Section, Lands Service, Dept. of the Environment

E. Smith, Grazing Division, Forest Service, Dept. of Forestry

A. Schori - Head, Soils Branch, Dept. of Agriculture

T.A.J. Leach - Water Resources Service, Dept. of the Environment

J. Brodie - Pollution Control Board, Dept of the Environment.

D. O'Gorman - Environment and Land Use Committee Secretariat.

J. Rae - Co-ordinator, Policy Planning Division, Dept. of Economic Development.

G. Harkness - Dept. of Municipal Affairs.

J.A. Dennison - Department of Highways.

LANDS SERVICE
LAND MANAGEMENT BRANCH
COMMUNICATIONS SHOULD BE ADDRESSED TO:
DIRECTOR OF LAND MANAGEMENT
PARLIAMENT BUILDINGS
VICTORIA, B.C.
V8V 1X5

THE GOVERNMENT OF
THE PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF ENVIRONMENT

ATTENTION: D. L. Zirul

FILE No.: 0334556

April 1, 1976

Mr. J. D. McDonald
Chief Reclamation Inspector
Department of Mines

Dear Mr. McDonald:

Re: Environmental Report on Afton Mines Ltd. (N.P.L.) proposed Mine-Mill-Smelter Development; prepared March 2nd 1976 by B.C. Research Ltd.

The subject report seems to be adequate to the Stage I level of assessment. Major deficiencies are noted as required before Stage II projections and plans can be prepared. These deficiencies exist in the area of dispersion climatology, and soils. Partly because of these gaps in baseline information, there is little or no treatment of major impact implications, there are no firm reclamation plans, and there is little indication of how results are to find their way into actual project planning. This is somewhat surprising. This agency expected, apparently in error, a Stage II document. The preliminary nature of environmental impact, impact mitigation and reclamation planning is insufficient for approvals required under Section 11 (6) of the Mines Regulation Act. Until such time as an acceptable Stage II document is presented, with appropriate assurances of incorporation of environmental findings into project design, approvals from this office will be withheld. More specific comments as to the inadequacies of the subject report follow.

The introductory section, specifically the statement of purpose, contains some possibly misleading elements. A statement to the effect that the smelter will create a base for secondary processing of B.C. concentrates may be misleading inasmuch as the smelter proposed is understood to be designed exclusively for the product of the Afton Mine. If a copper smelter is to be involved, with government participation, it would seem that the statement that project economics have dictated the size of the installation, overlooks the possibility of incorporating input from the several ongoing and planned copper mines in the area to the south and east of Kamloops. Statements of Afton's interest in agricultural endeavors are likely "red herring." In other subsections of the introduction, there are comparisons which divert attention away from the

. . . . 2

accumulative aspects of industrial pollution in the vicinity of Kamloops. There are indications that Afton intends to go into the real estate business (the report fails to discuss the environmental implications of this), and there are rather preemptive statements on reclamation performance bonding.

The presentation of some sections of the report is as they were originally submitted by sub-consultants, without integration into a multidisciplinary whole. This is further evidence of the preliminary nature of project planning as it relates to avoidance and mitigation of environmental impact. As a result of major gaps in the data base, there are several instances where contributors to the document have been unable to complete impact assessments, and have resorted to plagiarizing general textbook discussions. Since this applies to all of the consideration of polluting influences, the justification for producing the report at this time is not clear.

The groundwater reconnaisance of the Afton Mine Area - discussions of hydrogeology - appears to be the only environmental assessment which meets Stage II requirements. Meteorology and air quality assessments prepared by Evirocon are classic examples of Stage I investigation relating to a single facet of the environment. There is, however, a tendency to dwell at substantially greater length than is justified on data that is recognized as inadequate for any planning purpose. It is expected that the detailed presentation and belaboured analysis of inadequate existing information was completed only at the insistance of the client. Although similar remarks apply as well to the discussion of soils, and the connection between treatment of these data and the subject of reclamation is tenuous in the extreme, the consultant's meticulous attention to qualification of statements leaves no chance for misunderstanding.

The discussion of terrestial biology contains essentially nothing beyond a repetition of the contents of the "Preliminary" document. Other than for the vegetation community, there is little evidence of field investigation. Most of the information presented can be found in the most general introductory texts. The taxonomic rather than ecological approach, particularly evident in the subsection on wildlife, is of little use in planning. Admittedly, wildlife is a minor concern in respect of the project at hand, but this cannot explain the method of treatment.

The discussion of elements of the aquatic environment is as cursory a treatment as can be imagined. In view of the economic and social significance of the Thompson River fishery, and the impacts of Kamloops city and local industry, the subject warrants more serious attention than it has been given. Some of the insights, and discussion of identified potential impacts, will have to wait until the studies of dispersion meteorology are complete. At that time, it will be necessary also to quantify the "remote chances" of contamination of

. . . . 3

Cherry Creek. Consideration of location of the tailings dam in the vicinity of a fault zone, and an earthquake Zone 2, should at least be documented.

There does not appear to have been any consideration given to the extent of damage which may be caused by earthquake. Inasmuch as the area lies in earthquake Zone 2, is traversed by two faults, and major sections of the pit wall will apparently be in unconsolidated materials, this would appear to warrant some detailed assessment.

There is mention of the matter of settling in the tailings pond. It appears that absolutely critical design problems, relating to water recovery for recycling from the tailings storage area, are not resolved. The proposal to investigate these matters further once operations have commenced is totally unacceptable, and incredible. The implications of the "entirely closed" water system not working are rather serious. If the projected supply of 3300 USGPM is, in fact, required make-up water, the matter of dense vapour and ice fogs in winter and icing of the highway will have to be considered.

Assurances of extended benefits from the water supply once the mine-mill-smelter operation is shut down, are highly conjectural. Supply of the magnitude proposed, the expense of equipment and maintenance, and the matter of planned obsolesance of equipment in considering system economics have obviously not been considered. When a Stage II document can be produced, it will be required to include a detailed water budget, explaining precisely where the 3300 USGPM is to go and how it is justified in a system which purports to be totally closed.

In view of the dryness of the area and the nature of surficial deposits, dust problems may be extreme, given the present course of action. This is not given adequate treatment in the impact assessment. There is a possibility of dust storms obstructing vision on the highway. It is not possible to realistically assess any of these potential impacts without the meteorological data which is only now being gathered. Dust suppression methods and any negative impacts implied by their implementation - the possibilities of interim limited-area reclamation - need to be discussed.

There is no attention given in the report to secondary impacts. The possible impairment of water quality is listed as an impact but the impact and significance of that is not discussed, much less quantified.

One of the more serious concerns relative to the content of the report are the weak attempts at trying to cover the impact mitigation question. There are repeated suggestions for mitigation using the words "should be", without

. . . . 4

any attempt to assess the feasibility of methods proposed, their efficiency in accomplishing what it is intended, or their long term viability in terms of maintenance, necessity and effort. In this respect at least, the report reads as a brief from an environmental pressure group, whose members have little detailed knowledge of the project and insufficient training for practical applications.

The matter of changing to underground mining once the pit is exhausted is, in several instances in the report, dealt with in terms of absolute assurance e.g. "will". Inasmuch as this involves a totally different form of mining, with greater sophistication of equipment and a much more specialized labour force, "will" may be rather misleading. It may also be an excuse for not having adequately assessed the subject of reclamation of the pit.

The suggestion that "impossible economic restrictions" would be imposed by having to reclaim the pit, suggests that the proposed Afton project in its entirety may not be feasible. It will not likely be acceptable to leave the pit, in its proposed location adjacent to a growing city and a recreational area, as a useless and dangerous hole in the ground protected at public expense and inconvenience for all time. It is of note that the Ironmask recreational area has received no mention in the B.C. Research report.

On the broader aspects of reclamation, the lack of integrated planning is evidenced by recommendations which conflict with project limitations. Progressive reclamation is recommended, but at the same time it is pointed out that progressive reclamation will not be possible on all sites because of continuing disturbance. "All" sites is not qualified, but elementary reasoning from statements of planning throughout the report show that sites to be excluded from progressive reclamation are the mine pit, the tailings pond, the waste rock dump, stockpile areas, roads, plant and camp sites, etc. On reclamation of the rock dump areas, the rather cursory treatment of the subject is made even more questionable by casual reference to depressions in the surface which might act as "oasis". An oasis is something quite different from a water trap, with the latter subject to stagnation and salts accumulation. The flatness of the area may be of more hinderence than assistance if there is no provision for gradual water movement across the site. Detail will be required as to the staging of reclamation.

. . . . 5

Although the writer concedes that aesthetics are a perceptual variable, there are certain consistencies inherent in the "human viewpoint" which provide for a standard analytical approach to assessment of visual resources. Use of the indefinite "some" who may find a given installation offensive, dodges the issue of coming to an appropriate definitive statement. Reference in passing to a "vegetated berm" which will screen views (and noise, dust?) from the highway apparently has not taken into account the fact that a dense enough wall of vegetation to screen anything would be ecologically unstable: needing of considerable attention and maintenance. A vegetated berm would also present a visual impact, as a considerable deviation from the natural landscape. Further on the question of aesthetics, the relationship between attraction as a result of inquisitive interest, and the repulsion as a result of repeated interference can shift with time. This is completely overlooked. It would, perhaps, be revealing to assess trends in the number of visitors from Kamloops, and outside of Kamloops, to the petroleum refinery and the Weyerhauser pulp mill over the number of years that these have been in operation.

Afton's hurry to proceed regardless of cost or environmental quality is evident in their having produced a report that is so premature as to provide virtually nothing of value beyond Stage I material, this at a time when they have already (unlawfully) started work on site. The volume of the report relative to its content is undeniable evidence of Afton and their prime consultant having "jumped the gun". It is realized that Afton has sufficient process and plant design information to act on their primary purpose: the volume of the foregoing indicates that they have provided enough "description of project" to raise some questions. The impact assessment/planning process however, is to provide for some controls in keeping with an assurance of responsibility to the public. As yet, no document reviewed by this agency has provided the required assurances.

D. L. Zirul
Biologist, Southern Interior Division
Environmental Services

DLZ/mb

Project 1741

ENVIRONMENTAL REPORT ON AFTON MINES LIMITED

PROPOSED MINE-MILL-SMELTER DEVELOPMENT

Prepared For

Afton Mines Limited
1199 West Hastings Street
Vancouver, B. C.

March 2, 1976

Prepared By

B. C. Research
3650 Wesbrook Crescent
Vancouver, B. C.
V6S 2L2

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

1.0 SUMMARY

Afton Mines Limited (NPL) proposes to develop an open pit copper mine, concentrator and smelter complex at a site near Kamloops, B. C. Construction is planned to commence in 1976 and be completed in 1977. Ore reserves indicate a 14 year period of open pit mining followed by an undetermined period of underground mining.

The mining and construction programs will require relocation of parts of Highway 1/97, oil and gas pipelines, telephone lines, and a B. C. Hydro transmission line.

Water will be supplied for the development, for irrigation of adjacent land and for reclamation by a 24-inch pipeline from Kamloops Lake.

A portion of the waste rock will be used in construction of a tailings dam; the balance will be disposed of on the surface. The disposal area will be withdrawn from use as range or wildlife habitat for a period of about 20 years; ultimately, reclamation of the (contoured) waste by spreading of soil and revegetating will make the area suitable for wildlife or agricultural use. Tests indicate that drainage from the waste rock will not be significantly contaminated.

The ore will be concentrated by gravity and flotation methods. Concentrates will be smelted by the Top Blown Rotary Converter process.

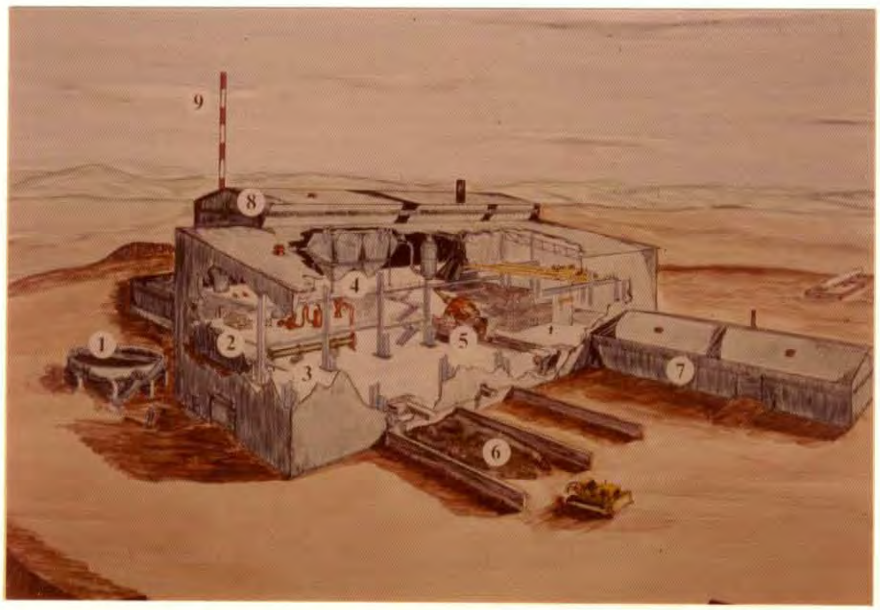
Concentrator tailing and smelter waste will be pumped as a slurry to an impoundment area; after settlement of solids, the water will be recycled to the concentrator. The tailings impoundment area will also receive treated sanitary sewage effluent, and collected surface drainage from the development area. Seepage from the tailings impoundment will be collected behind a secondary dam and returned to the impoundment; there will be no positive discharge of liquid waste to receiving waters. Diversion of Alkali Creek around the tailings impoundment will be required.

Air emissions from the project will meet Level A Standards of the B. C. Pollution Control Branch. The amount of sulphur dioxide emitted will be small in comparison to emissions from existing sources. The dispersion characteristics of gaseous and dust emissions cannot be predicted accurately until further planned meteorological studies are completed. Heavy metals in the air emissions are not expected to cause any direct public health hazard; a detailed program of pre-production sampling, and monitoring during the production phase will be required to ensure

that smelter discharges do not result in hazardous levels of metals in water, soils, plants and animal life in the area. The relatively small (25,000 tons of copper per year) size of the smelter, and use of best practical control technology will result in low levels of emissions compared to smelting operations elsewhere.

The project will result in significant local employment and tax revenue in the Kamloops area. Social services and housing are adequate to accommodate the influx of population, and - using expected growth indices - the eventual closing of the operation will not have a serious economic effect on the area.

Artists Conception of Afton Mine, Concentrator and Smelter.



Artists Conception of Afton TBRC Smelter Showing:

1. Concentrate thickener
2. Concentrate filter
3. Concentrate dryer
4. Feed storage
5. Top Blown Rotary Converter
6. Slag
7. Copper casting and storage
8. Gas cleaning plant
9. Stack

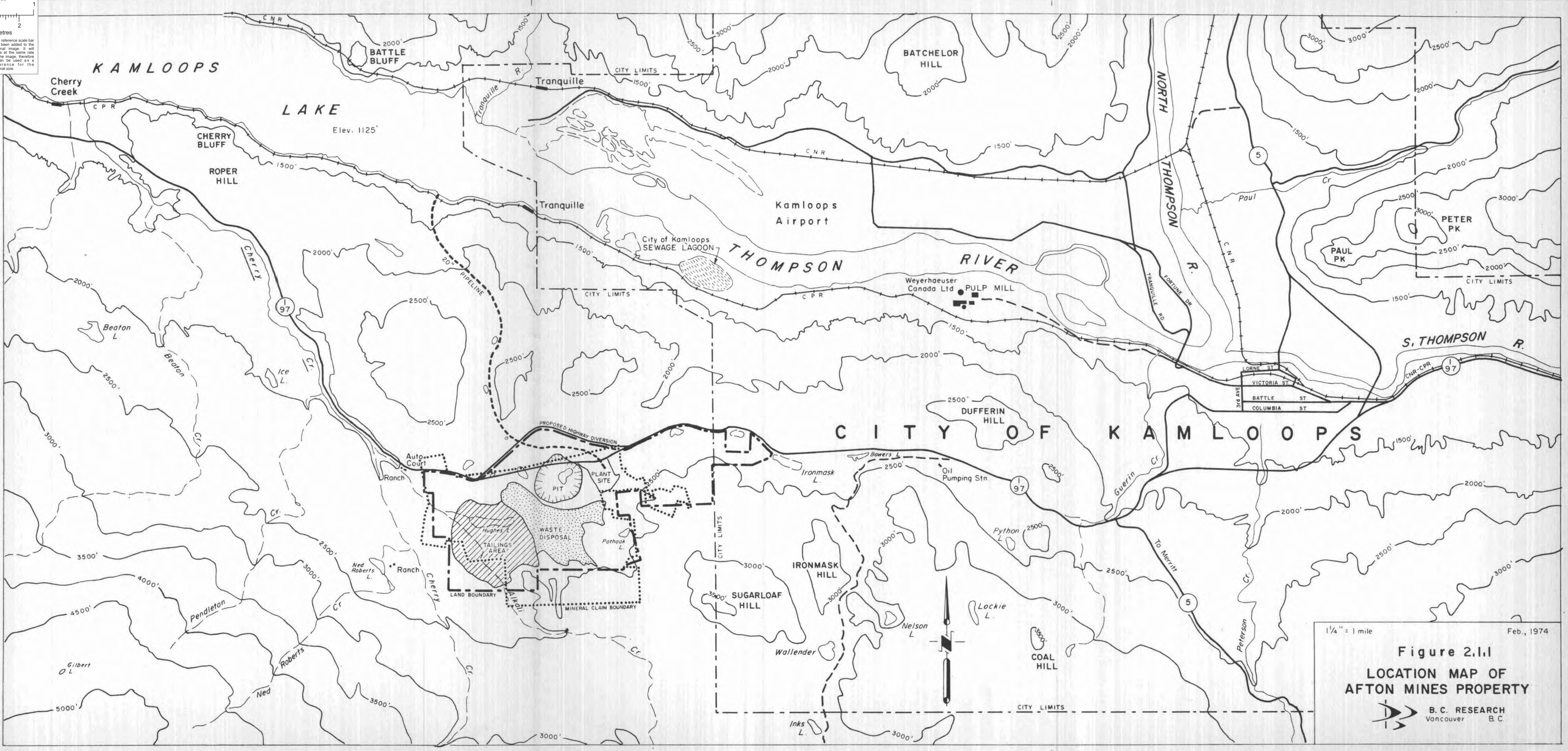


Figure 2.1.1
LOCATION MAP OF AFTON MINES PROPERTY

2.0 INTRODUCTION

2.1 GENERAL DESCRIPTION OF THE PROJECT

Afton Mines Limited(N.P.L.) is a 99% Canadian-owned company. Teck Corporation Ltd., Afton's sponsor, is a Vancouver based company 95% owned by 14,000 Canadian shareholders.

Sugarloaf Ranches Ltd., an affiliate of Afton Mines Ltd., operates a 200 head Hereford ranch on lands adjoining the proposed development area.

Afton Mines Ltd. proposes to surface mine 7000 tons per day of copper ore for processing in an on-site concentrator and smelter seven miles west of the junction of the Trans-Canada Highway 1/97 and the Merritt Highway 5 (Figure 2.1.1). Afton's plan is to mine the ore body by conventional open pit techniques utilizing electric shovels, drills, and diesel trucks. Processing of the ore will be by crushing, semi-autogenous grinding, jigs, conventional flotation, filtering, and drying. Tailings waste will be pumped to a tailings pond where water will be recovered for re-use in the milling process. Water supply for the project would originate from Kamloops Lake through a 24 inch pipeline (Figure 2.1.1). Smelting will be by the Top Blown Rotary Converter process.

Waste rock, which occurs in the open pit zone in an average ratio of 4.2 to 1 of copper ore, would be used for construction of the tailings dam structure and the remainder would be disposed of on the land surface set aside for that purpose, particularly in an area to the east of and adjoining the tailings pond.

Current open pit ore reserves established through a number of years of exploration drilling are set at 34,000,000 tons grading 1% copper, to a depth of 900 ft.

The proposed locations of the open pit, concentrator, smelter, waste rock disposal area, tailings dam and tailings pond, are shown in Figure 2.1.1.

Initial construction would involve a projected temporary work force of approximately 260, about half of whom will be located in an on-site construction camp. An estimated 325 people will be permanently employed in the production phase.

Since the northern portion of the projected open pit lies beneath a portion of Highway 1/97, a B.C. Hydro 25-kv transmission line and B.C. Telephone lines, these would all require relocation to permit safe mining operation with minimum disruption of services. Relocation of the adjacent gas line, and modifications to the oil pipe line will be required.

Several diversions of runoff water will be necessary, as will the diversion of Alkali Creek to Cherry Creek, south of the proposed tailings dam.

2.2 PURPOSE OF THE PROJECT

The purpose of the project is to mine, mill and smelt the known ore reserves, thus creating employment, generating a return on investment to shareholders, and generating taxes to all levels of government through Provincial and Federal income taxes, excise taxes, sales taxes, property and school taxes, petroleum taxes, and other payments associated with licenses, claims, leases and fees.

The construction of the first copper smelter in recent British Columbia history will create a base for secondary processing of B.C. concentrates, a goal long sought by government and labour spokesmen.

A unique aspect of the operation is the provision of irrigation water through the mine water supply pipe line, to more intensively exploit the agricultural base of the land surrounding the mine site. The project will effectively combine mining and agricultural land uses. The supply of irrigation water will also assure more favorable opportunities for mined land reclamation.

2.3 SCHEDULE OF THE PROJECT

Construction of the project is scheduled to commence in March, 1976 and be completed in late 1977.

The decision to proceed with the project was reached in October, 1975, after several years of detailed engineering, pilot plant work and negotiations with banks, customers and the Provincial Government.

2.4 INTERFACE WITH OTHER PROJECTS

Two major industries having air emissions already exist in Kamloops; the Gulf Oil Refinery and the Weyerhaeuser pulp mill. Each has its contribution to air quality in Kamloops, mostly evidenced by odors said to be detectable under certain wind conditions as far west as Savona and east to Chase. A comparison of the other emissions of these plants with the projected emissions of the proposed Afton smelter is given in section 4.1.3 of this report. Projected SO_2 emissions from the Afton project compare favourably with emissions from other developments.

A significant timing conflict between construction of the Afton development and the Hat Creek thermal generating plant is unlikely; the Afton plant is expected to go on stream in late 1977 whereas authorization to proceed with the Hat Creek project is planned for January, 1977.[1]

2.5 PERMITS AND LICENSES

2.5.1 MINERAL PRODUCTION LEASES

Application was made on 27 October, 1975 for three mineral production leases on:

Lot 1029 - Mineral Claims covering 1,479.04 acres
Lot 1030 - Mineral Claims covering 614.30 acres
Lot 1032 - Mineral Claim covering 21.44 acres

2.5.2 POLLUTION CONTROL APPLICATIONS

A. Pollution Control Permit Application (Effluent) - for construction camp - posted 7 November, 1975.

Sewage to be comminuted and retained in an aeration lagoon. Treated effluent will flow to an evaporation pond.

B. Pollution Control Permit Application (Refuse) - Posted 7 November, 1975. Permit application is for disposal of 3½ cubic yards per day of refuse (domestic and inert) material, approximately 30% domestic and 70% industrial waste. Disposal will be by sanitary landfill in mine waste dump area. There will be no incineration or open burning.

C. Pollution Control Permit Application (Emissions) - for Concentrator Air Emissions - posted 4 December, 1975.

This application is for a total of a maximum of 66,000 scfm for a duration of 2 hours/day. Average daily 47,000 scfm.

Air emissions to meet level "A" objectives for particulate and gaseous emissions.

This application consists of the six supplements listed below:

Source	Method of Control	Maximum Discharge (SCFM)
1. Primary Crusher	Bag House	20,000
2. Coarse Ore Stockpile Reclaim	Bag House	10,000
3. Metallic Concentrate Dryer	Nil	3,000
4. Flotation Concentrate Dryer	Scrubber	5,000
5. Minor Emissions		
Bucking Room	Bag House	8,000
Assay Lab	Nil	4,000
Reagent Mixing	Nil	2,000
Welding Shop	Nil	4,000
6. Standby Diesel Generator	Nil	10,000
TOTAL MAXIMUM DISCHARGE		66,000 scfm

2.5.2 POLLUTION CONTROL APPLICATIONS (Cont'd)

D. Pollution Control Permit Application (Emissions) for Smelter Air Emissions - Posted 21 November, 1975.

This application consists of ten supplements. The entire analysis and breakdown of the ten supplements are explained in detail under Section 3.4.3.1.

E. Pollution Control Permit Application (Effluent) for Concentrator Tailings - posted 15 September, 1975.

This application is for the discharge of tailings from the concentrator at a daily rate of 3,860,000 Imperial Gallons to a pond area designed as a totally enclosed system.

This application also includes a supplementary application to discharge treated sewage effluent (when the mine is in operation) into the tailings pond flow. The treated sewage effluent at the rate of 2,000 Imperial Gallons/day is 0.05% of the total tailings discharge.

This application also includes a supplementary application to discharge a maximum of 16,233 Imperial Gallons/day of smelter sludges at 50% density to the tailings effluent. This supplementary effluent would constitute 0.4% of the total tailing discharge.

2.5.3 APPLICATIONS TO WATER RIGHTS BRANCH

A. Kamloops Lake - application for 3300 USGPM for process water and 800 acre feet of irrigation water. Posted September, 1973.

B. Moose Lake - application permit to store 200 acre feet/annum for wild fowl habitat improvement. Posted 12 February, 1976.

C. Pot Hook Lake - application permit to store 27 acre feet/annum for wild fowl habitat improvement. Posted 12 February, 1976.

D. Hughes Lake - application to store 60,000 acre feet of tailings. Posted 30 January, 1976.

E. Sugarloaf Ranches Well - application for permit for 100,000 gallons per day for construction camp use.

F. Alkali Creek Diversion - application for diversion of 1307 acre feet per annum. Purpose of application to divert Alkali Creek from flowing into tailings pond area, and thus protect rights of downstream licenses.

2.5.4 B.C. LAND COMMISSION

Other diverse applications have been made to the B.C. Land Commission for permission to use land within the Agricultural Land Reserve for Non Farm purposes, for permission to remove 455 acres from the Agricultural Land Reserve, for permission to subdivide purchased lands within the ALR.

2.5.5 THOMPSON NICOLA REGIONAL DISTRICT

Application has been made to rezone 455 acres from Agricultural - Forestry zoning to Heavy Industrial zoning.

2.5.6 LANDS BRANCH

Application was made on 29 January, 1976 for two surface leases, one of 180 acres and one of 210 acres. Application has also been made for a water lot lease on Kamloops Lake on 23 January, 1976.

2.5.7 DEPARTMENT OF HIGHWAYS

Approval for relocation of the Trans Canada Highway was requested.

2.5.8 B.C. HYDRO

Applications were made to cross B.C. Hydro Transmission Lines.

2.5.9 PROVINCIAL BOARD OF COMMERCIAL TRANSPORT

Applications are pending submission for modification and alteration of oil and gas pipelines.

2.5.10 CANADA TRANSPORT COMMISSION

Application made to cross C.P. Rail tracks.

2.5.11 FEDERAL DEPARTMENT OF TRANSPORT

Application made for permit for Kamloops Lake pumphouse under the Navigable Waters Protection Act.

2.5.12 DEPARTMENT OF MINES AND PETROLEUM RESOURCES

Reclamation Permit No. MX-10 for Mineral Exploration pursuant to Section 11 of the Mines Regulation Act and Order-in-Council No. 1532 was issued on October 23, 1973 and a $5,000 performance bond posted.

The application for a permit respecting mine reclamation under Section 11 of the Mineral Regulation Act is pending completion of this report. This permit would be renewable every three years and is based on the acreage of ground disturbed. Approximately 650 acres would be used in the first three years of mine operation. This would require a performance bond to be posted for $100,000 to $135,000.

3.0 PROJECT DESCRIPTION

3.1 LOCATION

The Afton orebody is located seven miles west of the junction of the Trans Canada Highway 1/97 and the Merritt Highway No. 5.

The plant site is located approximately 1.5 miles west of the 1972 expanded City of Kamloops westerly limits.

Afton Mines Ltd., over a period of over 3 years has purchased, or acquired options to purchase, and is in process of assigning grazing leases to its ranching affiliate (Sugarloaf Ranches Limited), the following acreage:

Afton Leased Land	1664 acres
Afton Fee Simple Land	1068 acres
Sugarloaf Ranches Leased Land	3220 acres
Sugarloaf Fee Simple Land	1280 acres
TOTAL ACREAGE	7232 acres

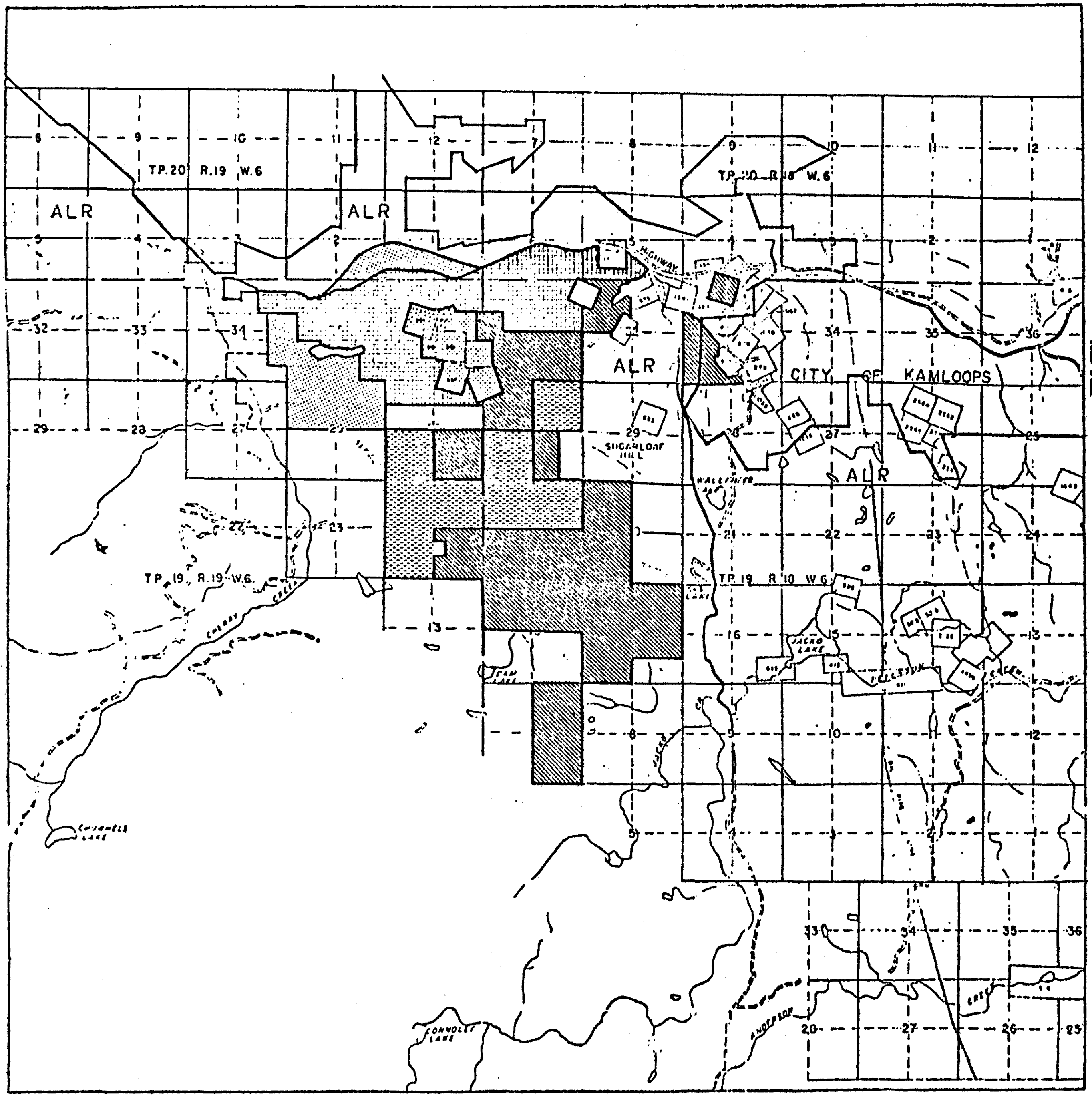
The location of purchased and leased land is shown in Figure 3.1.1.

3.2 SIGNIFICANT PROJECT ELEMENTS

3.2.1 GEOLOGY AND SEISMOLOGY

The Afton deposits are located at the western end of the Ironmask batholith--an intrusive rock composed of a coarse grained gabbrodiorite phase and a fine-grained microdiorite-micromonzonite phase. The batholith is associated with two intrusives--the Cherry Creek and Sugarloaf intrusives--both of which are porphyritic and of later age than the Ironmask batholith. The mineralization is mainly associated with the Sugarloaf and Cherry Creek intrusives and occurs as veins, stockworks and disseminations.

The batholith is intruded into a volcanic series called the Nicola group, which are, in turn, overlain by volcanics and sediments of the Kamloops group. The area has been glaciated and deposits of glacial origin abound. The Kamloops series are basaltic and all are badly weathered and crumbly. The Lake Zone of the Afton deposits appears to be localized at the junctions of two major fault systems. One system comprises a set of overlapping or enechelon faults, trending east to northeast with a dip of 60 to 70 degrees south. These faults are probably an important ore control. The Main Fault is a major part of this system.



LEGEND

- AFTON LEASED LAND (1664 AC)
- AFTON DEEDED LAND (1068 AC.)
- SUGARLOAF GRAZING LEASE (3220 AC.)
- SUGARLOAF DEEDED LAND (1280 AC)

TECK CORPORATION LTD

AFTON MINES LTD

Figure 3.1.1

SURFACE RIGHTS

A second series of faults running generally north-south (northeast to northwest) are found. These are indicated by two topographical lineaments. Post-ore transverse faults are found towards the western end of the ore deposit and apparently dip steeply to the east and west.

Massive native copper occurs in joints, fractures and faults and is a striking feature of the deposits. Copper minerals, in order of abundance are native copper, chalcocite, bornite, chalcopyrite, cuprite, covellite, malachite and azurite.

In the upper part of the supergene zone, relative abundances of copper minerals (wt%)* are as follows:

	West	East
metallic copper	>65	>85
chalcocite	30	10
chalcopyrite	-	1
cuprite/tenorite	>5	trace
other minerals	trace	>1

* adjusted from point-counts of minus 10-mesh material from concentrate samples.

This zone shows evidence of weathering, leaching and oxidation, in places to a considerable depth. Malachite is common to depths of 10 ft. Malachite and azurite are rarely observed in the drill core but have been noted at a depth of 800 ft.

There is also mineralization in the Pothook Zone just west of Pothook Lake (Figure 2.1.1), consisting mainly of chalcopyrite with some native copper. Secondary malachite, azurite and chalcocite are also present. Other minerals present in the area are magnetite and hematite.

General information on the geology of the area is available from references 2 - 5.

The property is located in Zone 2 area where "damage would be moderate in the event of an earthquake"(6).

3.2.2 EXPLORATION

History

Numerous copper occurences have been identified in the general area of the Afton property and considerable exploration and development work has been done on the various properties over the years. Afton, however, is the first discovery of economic significance.

Exploration on the Afton property can be traced back to 1898-99 when a 330 foot shaft was sunk on the Pothook claim. More recently, the following programs have been undertaken:

1951 - 52 Kennco Explorations (Canada) Ltd. completed an electromagnetic survey and then completed 4555 feet of diamond drilling in the vicinity of the Pothook shaft.

1956 - 57 A program was carried out by Graham Bousquet Gold Mines Ltd. and included: another electromagnetic survey, geochemical survey, and geologic mapping.

1958 Noranda prepared a geologic map and drilled nine short diamond drill holes.

1960 New Jersey Zinc: I.P. Survey.

1964 The property was acquired by Afton Mines Ltd. Eleven percussion holes were drilled in the vicinity of the Pothook zone. Thirty-eight holes were drilled during the following year and this was followed by 24 during 1967 and 1969.

1970 Five diamond drill holes totaling 2513 feet were drilled at locations recommended by Chapman, Wood and Griswold in their report of 9 March 1967. Hole 70-4 encountered sub-economic native copper mineralization.

1971 Afton Mines Ltd. began a percussion drilling program in the vicinity of DDH 70-4. This program led to the discovery of mineralization of potential economic significance.

1972 After further drilling early in the year, Afton Mines Ltd. entered into an agreement with Canadian Exploration Limited with the latter company accepting operating and management responsibilities.

1973 to 1976 Teck Corporation Limited and Iso Mines Limited jointly purchased the development agreement previously entered into by Afton Mines Ltd. and have proceeded with further exploration, mine engineering and development. To mid 1975, approximately $2,500,000 had been expanded in exploration and design studies.

Total drilling from 1971 to 1975 inclusive consisted of:

Diamond Drilling	74,100 feet
Rotary Drilling	23,200 feet
Percussion Drilling	55,300 feet
TOTAL	152,600 feet

Total footage of drilling is the equivalent of 28.9 miles.

Approximately 2300 feet of trenching for geologic mapping was conducted in 1973.

Virtually the entire Afton mineral claim block area has now been covered by airborne magnetometer surveys, ground magnetometer survey, Induced Polarization surveys, electromagnetic surveys and geochemical surveys.

The only area to date which has economic significance is the Afton mine site, although further evaluation and exploration work will have to be conducted in the Pothook Shaft area.

On site at present are one house trailer (unoccupied) and a double wide office trailer. Access to the office trailer and diamond drill core storage racks are via an access road off the Trans Canada Highway about 1½ miles east of the Cornwall Lodge Service Station.

3.2.3 MINE

The only efficient method of recovering the near surface ore is by developing an open pit. Pit mineable reserves are estimated at 34,000,000 tons averaging 1.00% copper above a proposed cut-off grade of 0.25%. The initial stripping ratio (ratio of low grade plus waste to ore) is 6.0 to 1.0 and the overall ratio is 4.2. The reserves are sufficient to assure a mine life of 14 years. Preliminary diamond drilling to depth indicates an underground mining potential and therefore operational continuity beyond this point appears reasonably certain. Possible underground mineable reserves are currently placed at 10 million tons averaging 1.55% copper.

During the open pit phase, the mining system will include a conventional truck-shovel haulage system. Pit waste in excess of that required for construction will be placed on dumps near the mine and the ore will be transported to a crushing plant. The dumps will be terraced for aesthetic reasons and will be reclaimed as they reach the ultimate configuration.

Open pit mining will be divided into an interim first stage followed by a step-back to the final pit limits. The information gathered initially on working conditions, rock behaviour and cost factors will allow a more accurate estimation of the ultimate limits.

3.2.4 MILL

The presence of coarse native copper in the Afton deposit necessitates use of a combination of gravity and flotation processes to concentrate the valuable minerals. Following crushing and semi-autogenous primary grinding, the coarse fraction of the ore will be treated in jigs to recover metallic copper. The jig concentrates will be reground and cleaned on shaking tables to produce a high grade (90+%Cu) metallic concentrate. The fine fraction of the ground ore and jig and table tailings will be treated by conventional flotation to produce a cleaned (50+%Cu) concentrate.

3.2.5 SMELTER

The Top Blown Rotary Converter* (T.B.R.C.) process to be used by the Afton Smelter is a combination of a fully operational vessel and new process technology. The equipment has been successfully used in steel plants since 1957 and has proven itself mechanically.

The use of the T.B.R.C. for processing copper concentrates involves a new smelting technique which offers advantages over conventional processes; these include controlled oxidizing, reducing and neutral atmosphere, high operating temperatures, controlled turbulence or mixing and smaller gas volumes. Its use for the treatment of copper concentrates has been proven by full scale tests at the Inco T.B.R.C. installation and pilot plant tests at the Inco research facility in Port Colborne, Ontario.

T.B.R.C. off-gases will be passed through three stages of high volume gas scrubbing to remove 90% or more of the sulphur dioxide produced, essentially all the arsenic, and to reduce mercury emissions to less than four pounds per day. This is lower than level A of the Pollution Control Branch guidelines.

---

* Property of Inco Ltd. licensed by Dravo Corporation.

3.2.6 HIGHWAY RELOCATION

Approximately 2.75 miles of new Trans Canada Highway will have to be built, to allow for the mining operation.

The Highway relocation is located on the South West 1/4 of Section 6, TWP 20, R18; the South 1/2 of Section 1, TWP 20, Range 19 and the South East 1/4 of Section 2, TWP 20, R 19, all west 6th Meridian.

Afton Mines has entered into an agreement to purchase the lands required for the relocation and has the approval of the Department of Highways for the relocation and also for an access road to the mine site, located east of the plant site area.

Acceleration and deceleration lanes and access turnoff, similar to the Logan Lake turnoff have all been designed to meet the Department of Highways specifications.

Afton Mines will be providing the Department of Highways wiht a 200 foot right-of-way adequate for ultimate expansion to a four lane highway. The two lanes to be constructed will be the southernmost two lanes. The highway is designed for 70 MPH.

Cost of the land and cost of the construction of the relocation will be paid by Afton Mines and will be in excess of $700,000.

As well as the mine access turnoff to the south, two farm road turnoffs will be provided to the north, one to Old Roper Field Ranch and one to the Department of Transport access road to the Kamloops Airport beacons.

3.2.7 AFTON MINES LTD. WATER PIPELINE CROSSING OF TRANS CANADA HIGHWAY AND RELOCATION OF THIRD PARTY FACILITIES

The Afton Mines main water supply line will pass under the CPR tracks, the relocated Trans Canada Highway and also under the 138 KV B.C. Hydro main line, B.C. Hydro's 25 KV powerline, the oil transmission pipeline belonging to West Coast Petroleum Ltd., the natural gas transmission pipeline belonging to Inland Natural Gas Company and the B.C. Telephone Company line.

Discussions and negotiations have been held with all the above listed utilities and the requisite permissions to alter easements, modify pipeline routings, and crossings of the relocated Trans Canada Highway are well underway.

It should be noted that the personnel at all levels of the utilities mentioned and the Department of Highways have been most cooperative and extremely helpful in resolving the problems encountered.

As well as the Trans Canada Highway relocation, already discussed under 3.2.6, major changes in utilities will be the raising of the Hydro towers on the 138 KV B. C. Hydro main line, the relocation of the oil pipeline crossing under the new highway, the relocation of 5700 feet of 12 inch gas transmission line and crossing under the new highway, relocation of approximately 2.75 miles of B. C. Telephone line and partial relocation of the B. C. Hydro 25 KV powerline.

The cost of all the above relocations and modifications and the obtaining and alteration of all easements and permits are the responsibility of Afton Mines Limited

3.2.8 ELECTRICAL, NATURAL GAS AND OIL SUPPLY

It is estimated that the project will have a total of approximately 26,000 connected horsepower.

The service will be from the B.C. Hydro 138 kv line immediately north of the mine site.

Transformers	Main HV	138 kv
	Tertiary TV	12 kv
	Low voltage	4.16 kv

Plant motors 250 H.P. and up will be 4.16 kv and below 250 H.P. will be 600 volt.

Approximate connected horsepower per area are estimated at:

Mine	2400 H.P.
Primary Crushing & Stockpile	1000 H.P.
Concentrator	15000 H.P.
Smelter	3800 H.P.
Shops, Office & Laboratory	1000 H.P.
Water Supply	2400 H.P.
TOTAL	25,600 H.P.

Number 2 diesel oil consumption is estimated at 60,000 gallons/month, or 720,000 gallons/annum.

Natural gas consumption per annum is estimated at 150,000 MCF.

3.2.9 DIVERSION OF ALKALI CREEK

There will be no alteration to the drainage pattern of Cherry Creek. However, a branch of Alkali Creek, which is a tributary to Cherry Creek, must be diverted around the tailings pond area to ensure no interference with downstream water licences.

The planned diversion will be made by construction of a small dam on Alkali Creek near the north boundary of the SE 1/4 of Section 26, diversion west to Goat Lake, which straddles the east-west boundary of the NW and SW 1/4's of Section 26, thence northwesterly along a natural drainage through the NW 1/4 of Section 26 and the NE 1/4 Section 27.

Discussions have been held with the property owners of the lands mentioned.

3.2.10 MISCELLANEOUS DRAINAGE CONTROLS

Water licence applications have been posted for construction of dams on Pothook Lake and Moose Lake, with a control valve on Moose Lake. See General Plant Layout plan.

These lakes are ephemeral lakes, and by damming them, it will be possible to create wildfowl habitat. Afton has been corresponding with Ducks Unlimited and the Fish and Wildlife Branch with regard to these two potential sites for wildfowl habitat enhancement programs.

The new wildfowl habitat created, approximately 28 acres, will provide an alternative to the 23 acres currently provided by Hughes Lake.

3.2.11 SUGARLOAF RANCHES LTD.

Sugarloaf Ranches, the former Delnor Ranch, was purchased by Afton in the Spring of 1975, and has been operating since that date as a 200 head cow-calf operation.

Sugarloaf Ranches consists of 1,280 acres of fee simple land and 3,220 acres of grazing leases.

Sugarloaf Ranches will ultimately utilize Afton land which is not being used for mining purposes.

Since Afton has made plans to provide extra pumping capacity in its pipeline from Kamloops Lake, irrigation water will be available for more intensive agricultural activity.

There is the possibility that the ranch may also enter into a program with the Fish & Wildlife Branch to enhance wildlife habitat.

3.3 SOCIAL AND ECONOMIC FACTORS (CONSTRUCTION PHASE)*

3.3.1 Employment

Employment during the construction phase of the Afton Project is expected to average about 180 over a 20month period, commencing in March 1976 and ending in October 1977. Except during the three months of buildup at the beginning of the contract and a similar period at the end, the level of employment will be fairly steady, peaking at about 260 in May 1977, and dropping to about 170 in the December 1976 to February 1977 period.

It is expected that about 50 percent of the construction workforce will be recruited locally. The actual figure will depend on the availability of individuals in the various trades involved, contractual arrangements with the unions, and their job dispatch practices. It is anticipated that there will be a construction camp onsite for about 150 people.

3.3.2 Payroll

The total construction payroll including fringe benefits is estimated at about $7½ million over the 20 months of the contract. It is estimated that approximately one-third of this amount would refer to Kamloops area payrolls.

3.3.3 Purchasing

Equipment purchases are estimated at $30 million. Of this total about $14 million will be in Canada and $1 million of the $14 million will be in British Columbia.

Materials purchase during construction are estimated at $10 million with $5 million of this being in British Columbia. Purchases in the Kamloops area will depend in part on the competitiveness of local prices. Major items in this category are:

Ready-mix concrete	$465,000
Gravel aggregate and sand	200,000
Lumber products	100,000
Diesel oil	110,000

Total purchases in the local area will likely be about one million dollars.

* Some of the information in this section and subsequent sections relating to social and economic impacts is drawn from a report by William Kerr and Associates which forms Appendix 1 of this report.

Payments for professional and other services during the construction phase are estimated at \$5.5 million. Of this \$2.5 million will be in Canada and \$3 million outside Canada, this latter being primarily for smelter design. Of the Canadian total nearly all would be in British Columbia but the expenditure in the local area would be small.

Total capital expenditure would be of the order of \$80 million.

3.3.4 Taxes

Over the period of construction the estimated taxes paid will be as follows:

Federal sales and other taxes	\$1,000,000
Provincial sales tax	2,000,000
Municipal property tax	250,000

3.4 OPERATING CHARACTERISTICS

3.4.1 MINING

Open pit mining will provide the feed for the concentrator for the first 14 years of operation.

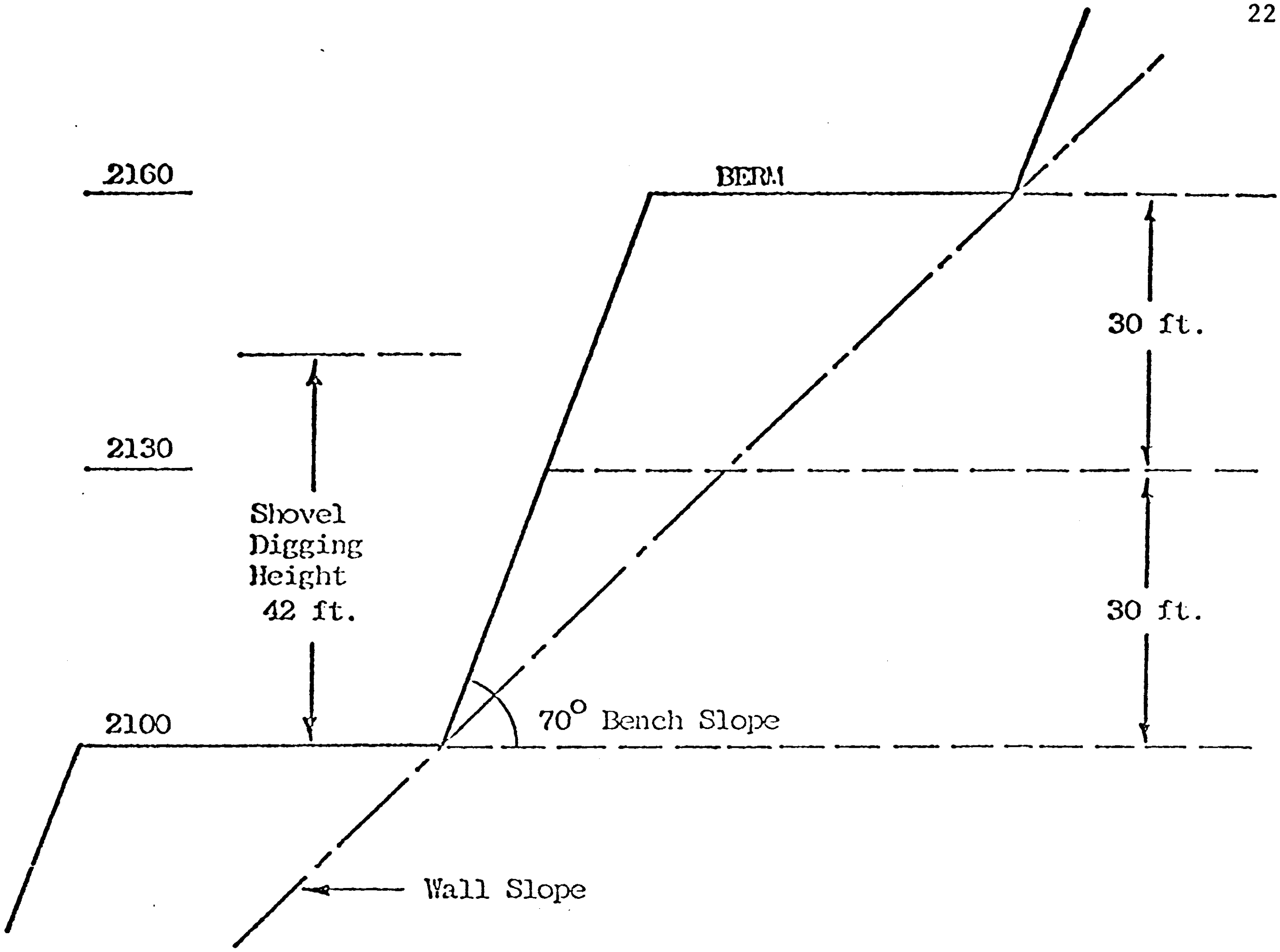
3.4.1.1 PIT DESIGN - CONFIGURATION AND PHYSICAL CONTROLS

The first stage pit is well within the ultimate limits and the information obtained during initial mine production will result in a more accurate estimate of the relevant parameters. The important parameters are a) the determination of the economic pit bottom, and b) the spatial distribution of mineral values.

Accordingly, a manual, two dimensional, sectional pit optimization procedure was accepted. The plans and sections prepared for calculating the mineable reserve were used for pit design purposes. The design procedure involved: a) estimating the optimum pit limits on a section, b) transferring these limits to plan and contouring to describe a rational configuration, c) modifying the design to include a haulage raod and, d) evaluating increments along the pit wall to assure that smoothing and the inclusion of a haul road did not end in a serious departure from an optimal solution. At this time, in the absence of definitive underground mining costs, it is assumed that open pit ore recovery will be maximized. It may well prove advantageous to mine the ore at the bottom of the ultimate pit from underground.

The selection of a pit slope(s) is a critical decision and personnel safety is the most important criterion. Rock-fall can be reduced by minimizing the crest-to-toe slope distance and by accepting a flatter wall slope. Reduced bench heights stabilize berms and reduce the occurrence of rock failures at the crest and on the face. For this reason, it was decided to accept a 30 foot bench height and to establish a safety berm on alternate benches. This height is in the lower limit of bench heights commonly used. The lower height has, of course, the advantage of allowing more selective mining - sorting ore and waste, however, this advantage would be offset, at least in part, by the ensuing higher operating cost. The wall slopes were selected after reviewing the available geotechnical information. A slope of 35 degrees has been used in the west wall, 40 on the north wall which is principally in tertiary sediments, and 45 elsewhere where a more competent dioritic rock if found. Figure 3.4.1.1.1 shows a typical bench-berm configuration.

FIGURE 3.4.1.1.1



	Slope	Berm Width
West Wall	35°	50 ft.
North Wall	40°	35 ft.
Other Walls	45°	25 ft.

The internal pit haulage road is 80 feet wide and is on a 10 percent grade; external roads are 100 feet wide and are on a flatter grade.

3.4.1.2 PRODUCTION SCHEDULE - FIRST FIVE YEARS

Year	Mill Ore tons	Mill Ore % Cu	Low Grade Stockpile	Low Grade Stockpile % Cu	Waste	Stripping Ratio
Preprod'n			455	0.58	2,045	
1	2,500	1.35	1,200	0.36	13,800	6.0
2	2,500	1.35	1,000	0.36	14,000	6.0
3	2,500	1.35	600	0.36	14,400	6.0
4	2,500	0.95			15,000	6.0
5	2,500	0.95			15,000	6.0
	12,500	1.21	3,255	0.39	61,645	6.0

Preproduction mining requirements are summarized in Table 3.4.1.2.1. As shown, five benches would be established during the development stage. Overburden stripping, as required to open these benches, and the construction of ore and waste haulage roads would be contracted.

3.4.1.3 PIT PRODUCTION PLAN

The production plan proposes a mill cut-off of 0.50% Cu during the first three years and 0.25 thereafter. The 0.25 to 0.50% Cu tonnage increment will be placed on a stockpile and it is assumed this ore will be processed at the end of the pit life. Additionally, it is proposed that the mine stockpile the mineralization assaying 0.20 to 0.25% Cu even though, at the moment, the economics of processing this material are questionable. It is believed that this material can be processed either during periods of higher copper price, as a follow-up to the higher grade stockpile (0.25 to 0.50 ore), as a supplement to underground production, or at the end of the property life. This report, however, does not consider this material as ore.

Waste removal has been advanced into the initial production years to obtain a rational transition into the ultimate stage and the stripping ratio (low grade plus waste to ore) has been smoothened to minimize truck fleet modifications. The ratio drops as pit mining approaches the 1500 level.

Annual mine production requirements are summarized in Table 3.4.1.3.1. The waste figures shown include rock and overburden.

TABLE 3.4.1.2.1 PREPRODUCTION PIT DEVELOPMENT

Bench	Lowgrade Stockpile (tons)	% Cu	Waste (tons) Rock	Overburden	Total
2190	-	-	-	120,000	120,000
2160	-	-	-	365,000	365,000
2130	15,000	0.40	210,000	520,000	745,000
2100	300,000	0.60	325,000	390,000	1,015,000
2070	140,000	0.55	115,000	-	255,000
	455,000	0.58	650,000	1,395,000	2,500,000

TABLE 3.4.1.3.1 PIT MINING PROGRAM

Year	Mill Ore tons	Mill Ore % Cu	* LG Stockpile (+0.25% Cu) tons	* LG Stockpile (+0.25% Cu) % Cu	Waste tons	Tons Mined	SR ** (1)
Preproduction			455	0.58	2,045	2,500	3.2
1	2,500	1.35	1,200	0.36	13,800	17,500	6.0
2	2,500	1.35	1,000	0.36	14,000	17,500	6.0
3	2,500	1.35	600	0.36	14,400	17,500	6.0
4	2,500	0.95			15,000	17,500	6.0
5	2,500	0.95			15,000	17,500	6.0
6	2,500	0.75			15,000	17,500	6.0
7	2,500	0.95			15,000	17,500	6.0
8	2,500	1.02			15,000	17,500	6.0
9	2,500	1.02			10,000	12,500	4.0
10	2,500	1.02			7,500	10,000	3.0
11	2,500	1.02			5,000	7,500	2.0
12	2,500	1.02			700	3,200	.3
13	2,500	0.59	(-1,755)	0.39	45	2,545	-
14	1,560	0.39	(-1,500)	0.39	-	1,560	-
	34,060	1.00	(3,255)	0.39	142,490	178,805	

('000) tons

1 Stripping Ratio = Lowgrade plus waste ÷ ore. * LG = Low Grade. ** SR = Stripping Ratio.

3.4.1.4 OPEN PIT EQUIPMENT REQUIREMENTS

1) 3 - 11 c.y. electric shovels c/w dippers and cwts.

2) 11 - 100 ton electric drive haulage trucks

3) 2 - rotary drills (R-45 or equivalent)

4) 1 - self contained mobile air trac type drill

5) 3 - crawler dozers (Cat D8 type), 2 with rippers, 1 with winch, 2 with U-blades and a ripper dozer with an angle blade

6) 1 - rubber tired dozer (Cat 824B type)

7) 2 - graders (Cat 14E and 16G type) with the heavier unit for pit work and the other as a standby

8) 1 - 6 c.y. front end loader (Cat 988 type)

9) 1 - water tank and 1 - sand truck that is convertible into a water truck

10) 1 - 45 ton mobile crane for equipment erection and maintenance

11) 1 - tire manipulator

12) 2 - 5 ton crane trucks (mechanical services)

13) 1 - 5 ton diesel lube truck, equipped with tanks and pumps

14) 1 - flat deck (1 ton) with submersible pumps, jib, hose, 250 cfm at 100 psi compressor

15) 1 - personnel carrier (small bus for transportation of crews at shift change)

16) Radio communication system (10 units)

17) Switch houses, electrical cable, vulcanizing equipment

18) Specialty tools and ancillary equipment

3.4.1.5 POWER REQUIREMENTS

A total of 2400 H.P. will be required for open pit equipment.

3.4.1.6 WASTE ROCK DISPOSAL

Waste dump areas are shown on the general plant layout plans. Afton's waste dumps are somewhat unique in that the topography permits one large flat area, with minimal amounts of terraces compared to open pit mines located on side hills.

The large flat area will also be more amenable to reclamation operations. Depressions could be constructed in the final dump surface, sealed with tailings and lined with overburden, thus creating "oasis" areas, for seeding and planting of trees.

Reclamation of the face slopes can only be commenced after the areas are no longer "active" dump areas. Dumping of overburdens over the broken rock faces will enhance reclamation.

Hydrology and drainage of the waste dump areas are covered in the sections on Waste Rock Leaching Tests and Groundwater Surveys.

3.4.2 MILL

The Afton ore is unique in that it contains a substantial quantity of coarse native copper which necessitates a gravity process in addition to the normal flotation process. During grinding to reduce the ore particles to a size that will allow separation of the copper minerals from waste rock, the metallics tend to flatten rather than be broken up and cannot be reduced to the minus 65 mesh size required for recovery by conventional flotation processes. These coarse pieces must be recovered by gravity processes which utilize their high specific gravity to make the required separation.

A schematic concentrator flowsheet is shown in Figure 3.4.2.1 and a detailed flowsheet (Wright Engineers' Drawing D-794-185-5401) is presented in Appendix 2.

Run-of-mine ore is crushed to minus 8 inches in a 42 in by 65 in gyratory crusher. The crushed ore is suitable as feed to the 28 ft by 12 ft semi-autogenous mill and is conveyed to an open stockpile of 25,000 live tons capacity ahead of the grinding circuit.

Ore is withdrawn from the stockpile through reclaim tunnels at a controlled rate to feed the concentrator at a designed rate of 7000 tpd. The ore is fed directly to the semi-autogenous mill which is the first of two grinding stages. The mill discharge is pumped to cyclones which separate the coarse and fine fractions. The fine fraction from the first stage cyclone combines with the discharge of the 16½ ft by 29 ft ball mill while the coarse cyclone underflow passes over mineral jigs which recover the heavier native copper particles. Primary jig tailing is recycled to the semi-autogenous mill.

The 16½ ft by 29 ft ball mill is also in closed circuit with cyclones and again the cyclone underflow is jigged to remove metallic copper. The cyclone overflow is directed to rougher flotation.

The combined jig concentrates, assaying 20 to 40 percent copper, are dewatered in a classifier and conveyed to a regrind mill where they are further ground to remove more of the gangue minerals. Regrind discharge is cycloned with the cyclone overflow going to four stages of cleaner flotation and the underflow going directly to shaking tables. The table concentrate assays 90+ percent copper and is filtered and dried before being transported to storage ahead of the smelting process. The table tails are recirculated to the regrind circuit.

Rougher flotation concentrate is cycloned with the coarse fraction going to the regrind mill and the fine fraction going directly to

CONCENTRATOR FLOWSHEET

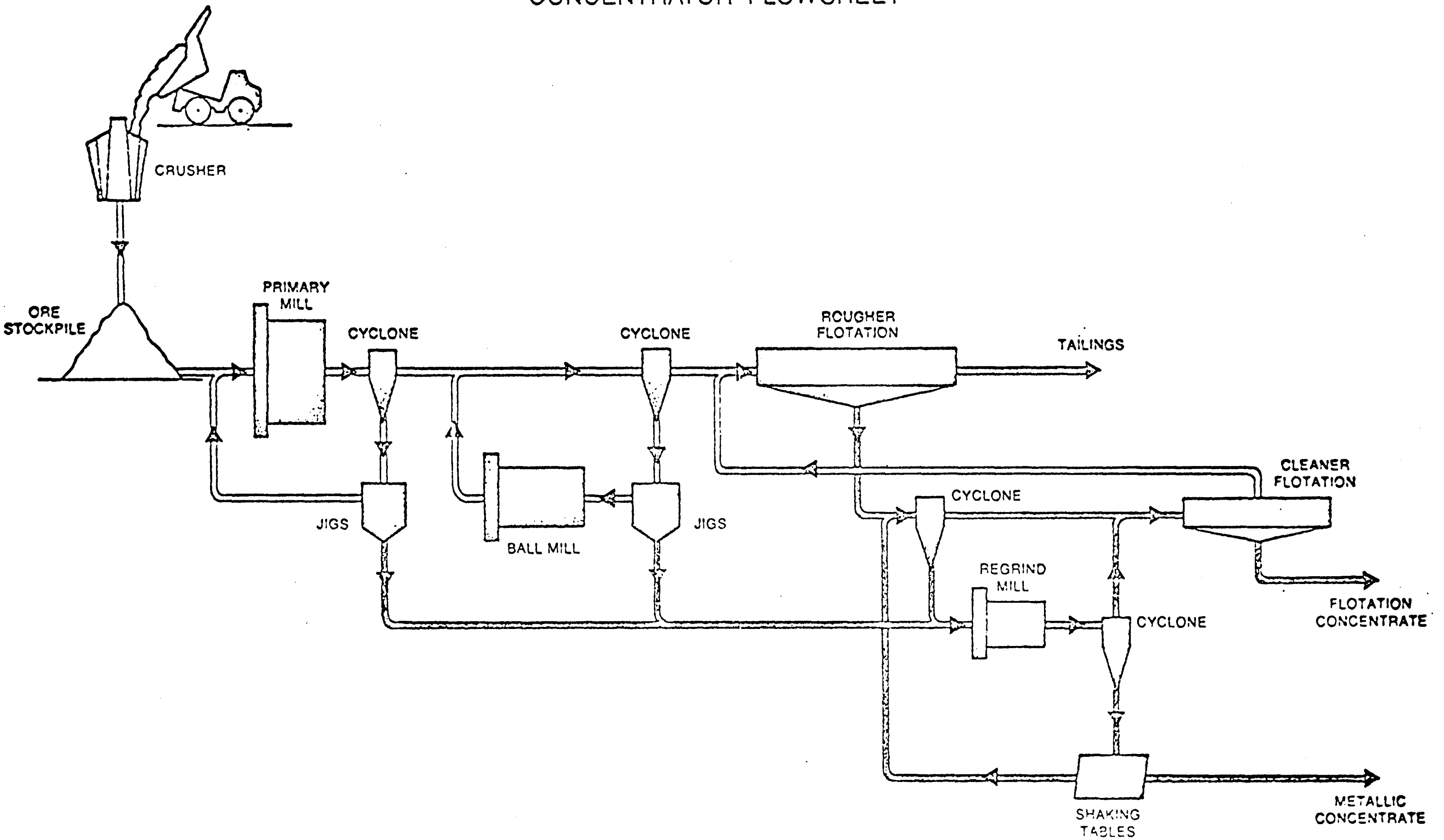


FIGURE 3.4.2.1

the four stages of cleaner flotation. The flotation concentrate assays 50+ percent copper and is pumped to dewatering facilities in the smelter complex.

Detailed analytical data for mill heads and concentrates are presented in Appendix 3.

Estimated mill power requirements are:

Primary Crusher and Stockpile	1,000 H.P.
Concentrator	15,000 H.P.

Tailings (6920 tpd as a 31 wt % slurry) will be deposited in an impoundment area which encompasses Hughes Lake (Figure 2.1.1). The area of the pond after one year of operation will be about 140 acres and the ultimate area will be 470 acres.

Initial plans call for single point discharge of tailings along the north side of the pond supplemented with spigotting as required.

Reclamation programmes will be conducted on areas which have become inactive from a mining standpoint, ie., will not be further disturbed. Reclamation procedure will be based on the results of on-going research and experimental re-vegetation programs.

A water reclamation system will be installed once a pond area of clear water has been established. The reclamation system will recycle pond water to the process water tank feeding the concentrator.

Run-off from natural water courses will be diverted from the impoundment area. Seepage from the pond area will be captured by a secondary recovery dam and will be pumped back to the pond.

Numerous laboratory settling tests on tailings were conducted by Lakefield Research using a variety of flocculants. In these laboratory tests the sand fraction of the tailings settled quickly to a high density but the clay did not compact and resulted in an overall maximum density of about 38% solids. To determine the effect of time on the ultimate compaction density 45 gallon drums of tailings were set aside at the conclusion of pilot plant testing. After 13 months Lakefield Research reported the tailings had settled to 57% solids. Florida phosphate producers who have had an extreme problem with the settling of the fine slime fraction of tailings effluent have found that in time settling has taken place.

Afton Mines will be conducting extensive research into optimizing tailings density once operations have commenced.

3.4.3 SMELTING

The Afton mineralization is unique and this has enabled Afton to consider a smelter for its own copper production. The major portion of the copper in the orebody is present as native copper with a minor portion present as sulphides. The sulphur content of the concentrates is about 5.5% while normal concentrates contain between 25% and 35% sulphur. As a result, SO_2 removal from the smelter off-gas is greatly simplified and the quality of the gas discharged from the Afton smelter should meet "A" Level requirements specified by the Pollution Control Branch.

The proposed smelter will be located eight miles west of the city of Kamloops in the north-east quarter of Section 36, Township 19, Range 19. It will be part of a mine/mill/smelter complex producing approximately 30,000 tons per year of blister copper.

A schematic flowsheet for the smelter is shown in Figure 3.4.3.1, and a more detailed flowsheet is presented in Appendix 4. The smelter facility will receive two products from the Afton concentrator; a metallic concentrate assaying in excess of 90% copper and a flotation concentrate assaying approximately 50% copper. The metallic concentrate will be dry and will be delivered to the smelter by truck, the flotation concentrate will be pumped to a thickener adjacent to smelter where it will be thickened, filtered and dried in a natural gas fired dryer to approximately 4% moisture. Combustion gases from the dryer will pass through a cyclone dust collector and a wet scrubber. Gas volume to the exhaust stack will be 4500 scfm and particulates will be removed to less than 0.05 grains per scf.

Dried concentrates will be delivered to storage bins above the Top Blown Rotary Converter (T.B.R.C.) by bucket elevator. Other products delivered to separate storage bins at this elevation will be lime flux, briquetted electro-static precipitator dust and coke. Dust collection in this area and at conveyor transfer points will require a housekeeping bag house and fan of 20,000 cfm capacity. The bag house will reduce the level of particulates to less than 0.02 grains per scf in the exhaust air stream.

From the storage bins the concentrates are combined with the lime flux and fed to the T.B.R.C. at rates up to 3,000 lbs. per minute. This material is melted using a combination of natural gas and pure oxygen and the gangue materials are slagged off. The cooled slag is returned to the concentrator and combined with the mill feed for regrinding. Residual copper is recovered and the ground slag is disposed of in the tailings pond. The copper in the T.B.R.C. is refined by blowing with oxygen and reducing with coke to high quality blister which is cast into 1200 pound ingots and sold for further refining.

SMELTER FLOWSHEET

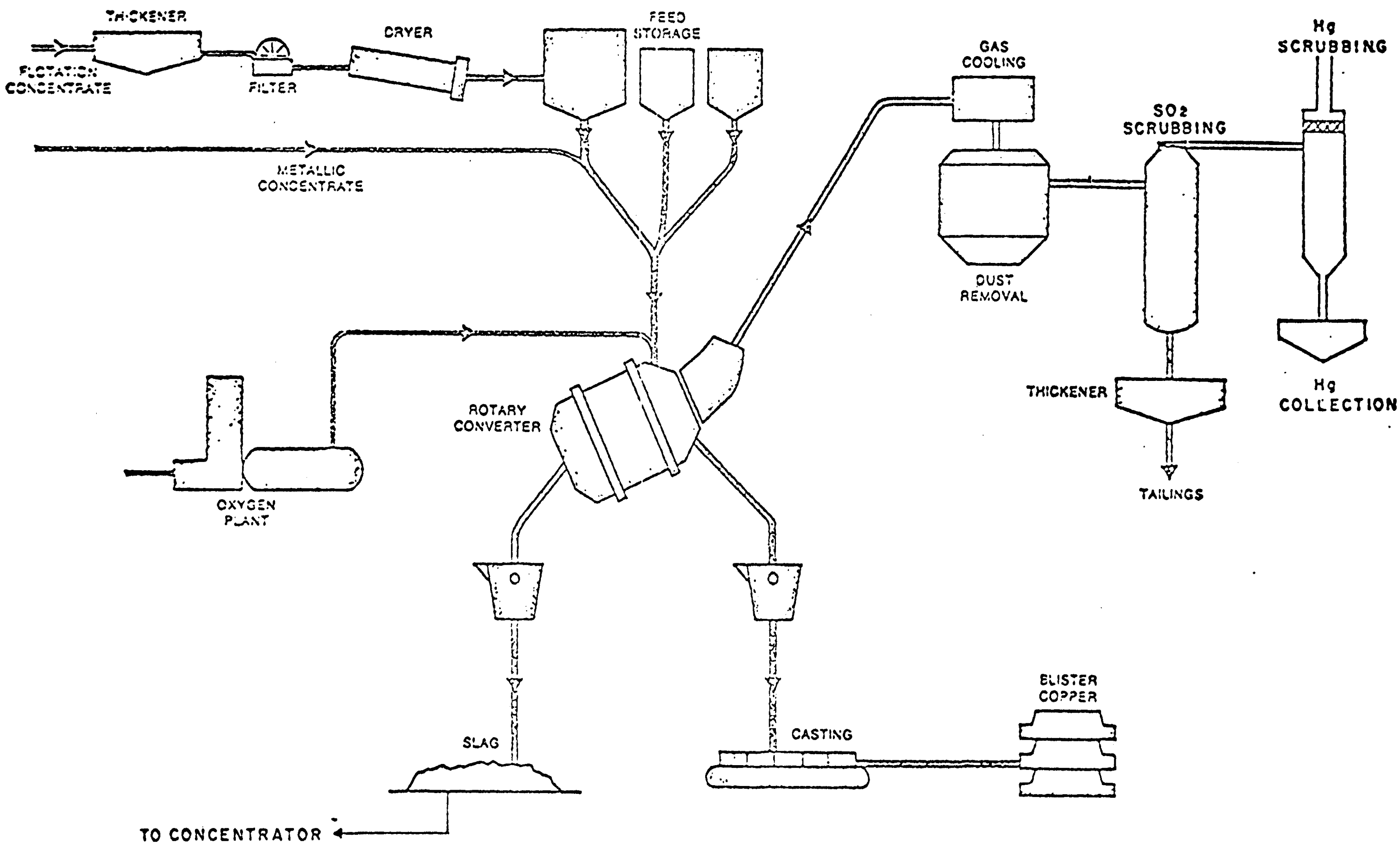


FIGURE 3.4.3.1

The off-gases exit the T.B.R.C. at about 1400°F and are cooled to 650°F in a spray tower prior to passing through an electrostatic precipitator. The precipitator will remove dust carryover to less than 0.05 grains per cf in the off-gas. The collected dust will be briquetted and recycled through the T.B.R.C. during the following heats.

Electrostatic precipitator exit gas contains SO_3, SO_2, Hg and As_2O_3 in the vapour phase and some particulates that escaped the E.S.P. This gas is passed through a venturi scrubber and spray tower where it is scrubbed with up to 2050 gpm of sodium sulphite solution and the gas is cooled to 180°F. As, SO_3, SO_2 and the remaining particulates are removed from the gas. The Hg present in the vapour phase passes through with the scrubber exit gas.

The scrubbing solutions are pumped to a reaction tank where lime is added and the sodium sulphite solution is regenerated for re-use in the scrubbing system. The SO_3, SO_2 and As are precipitated from the scrubbing solution as calcium sulphite, calcium sulphate and calcium arsenate.

The precipitate from the reaction tank is thickened, filtered and pumped to the tailings pond.

The slurry will contain 0.665 tons per day of As as calcium arsenate- $Ca\ (AsO_3)_2.H_2O$ - a material which is insoluable at a pH in excess of 9. Normal pH of the tailings from the concentrator is in excess of 9. The tonnage of sludge per smelter operating day will be approximately 47 tons.

The SO_2 scrubbing system will remove a minimum of 90% of the sulphur in the off-gas and total SO_2 emission will be less than 1.47 tons of SO_2 (0.735 tons equivalent of elemental sulfur) per smelter operating day. Operations of the smelter will be under an ambient air control regime (see below, section 4.1.3) as directed by the Pollution Control Branch.

The gas leaving the SO_2 scrubber is then cooled to 80°F by being passed through a packed tower or venturi scrubber that is being sprayed with 2500 gmp of cooled water. At this temperature the mercury will be eliminated from the gas stream by a mist eliminator. The mercury is collected and stored for sale. Mercury emitted to the atmosphere will total less than four pounds per day.

The cooled gas from the mercury scrubber is then reheated to 300°F before entering the stack and passing into the atmosphere. Stack height has not been fixed as yet and the height will be determined when the Envirocon Climatology and SO_2 dispersion study(See below, Section 4.1.3) has been completed after a one year study.

Smelter air discharge sources, volumes, and particulate loadings are presented in Table 3.4.3.1.

Water consumption in the smelter will be minimal. Approximately 2000 gpm are required for cooling of the T.B.R.C. lance, the mercury scrubbing water and the oxygen vapourizer. The warmed water is then directed to the concentrator for use as process water.

The smelter will require a total of 3800 horsepower.

Table 3.4.3.1 Types and Amounts of Air Emission Discharges from Afton Smelter Complex

	Point of Discharge	Volume of Discharge (SCFM)*	Duration (Hrs./Day)	Total Volume (SCF/Day)	Particulate Loading (Grains/SCF)**	Total Particulate (Grains/Day)
1.	Casting Water Spray Hood	18,181	4	4,363,440	-	-
2.	Preheat Stand and Ladles	2,665	24	3,837,600	-	-
3.	Cooling Tower Vapour	366,000	12	263,520,000	-	-
4.	Housekeeping Baghouses	20,000	24	28,800,000	Less than 0.1	<2,880,000
5.	Pneumatic Lime Filter System	1,000	1	60,000	Less than 0.1	< 6,000
6.	Interior Heating Units	1,136	24	1,635,840	-	-
7.	Building Ventilators	585,000	24	842,400,000	-	-
8.	TBRC	9,840	10	5,904,000	Less than 0.1	< 590,400
9.	Emergency Power Generator	456	0.15	4,104	-	-
10.	TBRC Vent Access Hood	110,000	10	66,000,000	Less than 0.1	<6,600,000
	Total	1,114,278		1,220,624,984		Less than 10,076,400 = 1,439 lb./Day = 0.72 tons/Day

* SCFM = standard cubic ft. per minute.
** 7000 grains = 1 lb.

3.4.4 Social and Economic Factors

3.4.4.1 Employment

Projected employment in mine, mill, smelter, plant services, personnel and safety, engineering and administration is 325 to 350. Of this total is appears that as many as half could be drawn from the existing labour pool in Kamloops area. It is the intention of Afton to train local people for jobs such as heavy duty truck drivers, mill operators, smelter operators, mechanics, etc. The actual percentage of the work force hired locally will abviously depend in some measure on general economic conditions at the time.

3.4.4.2 Payroll

The continuing payroll would, at 1975 rates, be 4.2 million dollars per year, exclusive of fringe benefits. Including fringe benefits it would be approximately $5 million. Average earnings would be about $13,000 per year ($15,600) with fringe benefits) in 1975 dollars, with a high percentage of the hourly rate employees in a relatively small range up and down from that figure.

3.4.4.3 Purchasing

Supplies required for the continuing operations at the mine will include explosives, processing reagents, tires, steel, fuel oil, gas, electricity, lime and oxygen. Virtually all of the purchases will be made in British Columbia but most items will originate outside the Kamloops area. Fuel oil could be the major exception. The total amount of annual purchases is estimated at $6 million. Mechanical replacement parts are not included in this total since they will almost all originate outside British Columbia.

The estimated payments in the form of taxes and duties to the three levels of governments will, for the estimated fourteen year life of the openpit operation be as follows:

Federal: corporate tax, sales tax excise tax and duties	$35 million
Provincial: corporate, mining and sales taxes	$37.5 million
Municipal: property taxes	$10 million

4.0 DESCRIPTION OF THE ENVIRONMENT

4.1 PHYSICAL CONDITIONS

4.1.1 Surface Waters

Cherry Creek and its tributary Alkali Creek drain essentially the entire area adjoining and south of the minesite and flow into Kamloops Lake at a point about seven miles northwest of the proposed open pit. Flow measurements on these creeks were discontinued after 1928 and the records are considered unreliable.

Two water bodies, Hughes Lake (about 28 acres in surface area) and Pothook Lake (an intermittent lake of about 7 acres) exist on the property as well as several small potholes which often dry up completely in the summer.

Results of a groundwater survey are reported in Section 4.1.2. Baseline surface water quality sampling has been conducted by B.C. Research since the initial samples taken on 7 November, 1973. (See below, Section 4.1.1.4).

4.1.1.1 Cherry Creek

The entire course of Cherry Creek remains unaltered by any of the activities of Afton Mines. On Cherry Creek between two and seven miles below the mine property, at least 16 wells(7) exist and are utilized for domestic or irrigation purposes or both. Below the mine property surface water license, including all of Cherry Creek, total 26. The combined groundwater and surface water are 42 in total, between the mine property and Kamloops Lake.

4.1.1.2 Alkali Creek Watershed and Licenses

Afton Mines by virtue of having acquired property will inherit Final Water Licenses 17477 and 17478. F.L. 17478 authorizes the storage of 100 acre feet on Hughes Lake and F.L. 17477 licenses the diversion of 100 acre feet from Alkali Creek at a point near the west end of Hughes Lake. Both these licenses are "supplementary" to Final License 5805 which will be retained by its present holder. Licenses 17477 and 17478 will in all likelihood be waived or cancelled by Afton Mines.

Afton Mines also will be assigned Final License 24275, authorizing 3,000 gallons per day for stock watering at Pothook Lake. This license will be retained for Sugarloaf Ranches Ltd.

An analysis of the runoff from the Alkali Creek stream drainage areas, which all flow from the south or east is based on 12 inches of precipitation per annum at the minesite with an elevation curve for estimating differences.

Ker, Priestman and Associates of Victoria, did calculations on the Alkali Creek watershed in 1975, and the following is based on their analysis.

Overall analysis runoff from the stream drainage areas are taken as 10% of annual precipitation.

Figure 4.1.1.2.1 shows the Alkali Creek Drainage Area and Diversion Plan.

Average annual inflow to Moose Lake and Pothook Lake are estimated at 140 acre feet and 25 acre feet respectively. Afton has posted water license applications for a wildfowl habitat development on these two ephemeral lakes. Moose Lake normally dries up completely each year and Pothook Lake sometimes goes completely dry (as in 1973). By damming the outlets from these lakes, it may be possible to improve wildfowl habitat.

Pothook Lake is currently dammed on the west end and only overflows about every 8 years. Provision can be made on Moose Lake to cause any flood condition to be diverted north, where a natural channel exists to Muskrat Slough on the Trans Canada Highway.

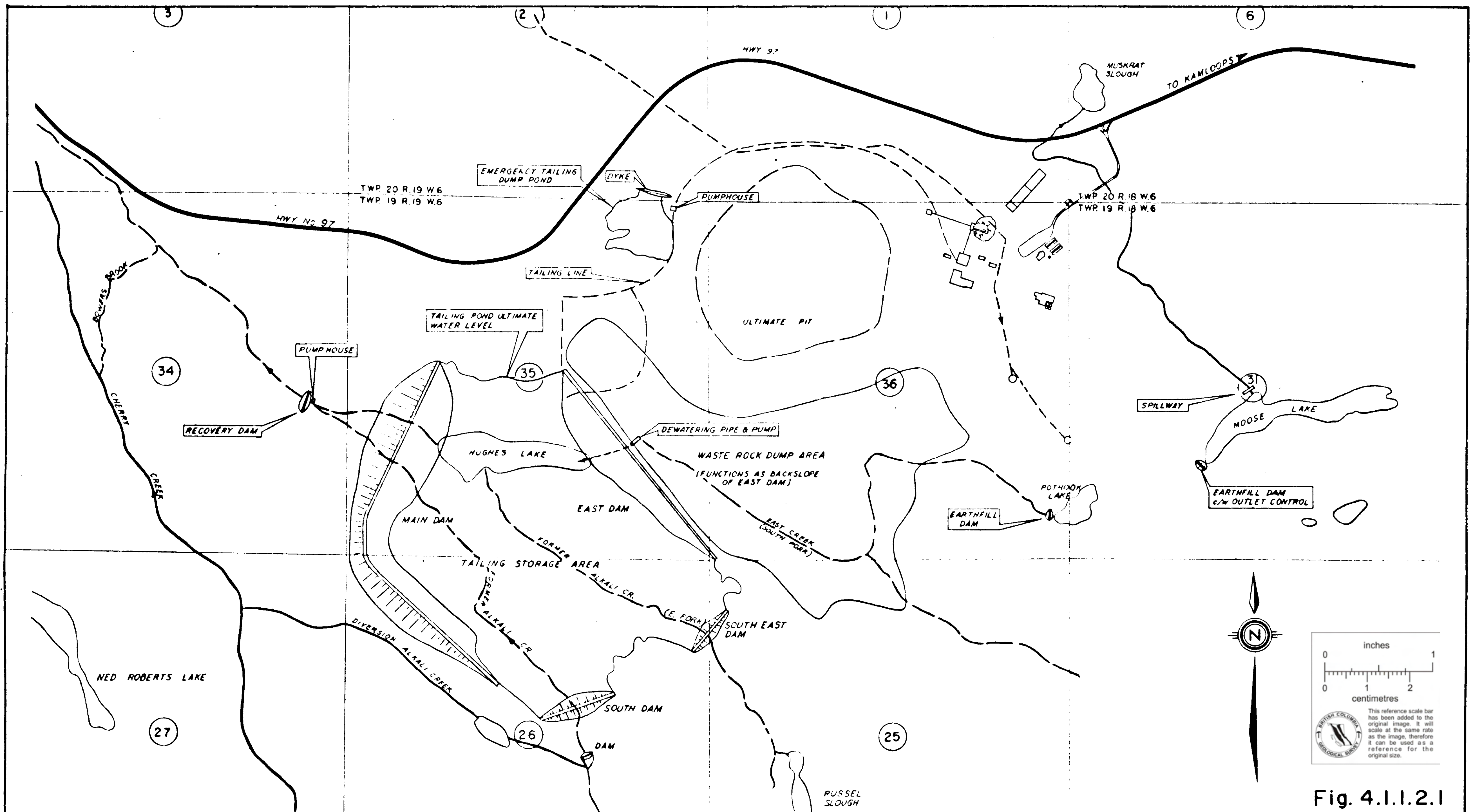
The other drainage ways tributary to Alkali Creek bear no official names, so on Figure 4.1.1.2.1 they have been arbitrarily named East Creek (South Fork), Alkali Creek (East Fork) and Alkali Creek (its proper name).

East Creek (South Fork) and Alkali Creek (East Fork) have estimated annual runoffs of 48 acre feet and 24 acre feet respectively. As their runoff would occur at spring freshet, it is proposed to allow them to enter the tailing impoundment area.

The main branch of Alkali Creek, in its proper location, would run into the tailing impoundment area. Since its estimated annual runoff is approximately 1300 acre feet, it cannot be allowed to enter the tailing impoundment area, without impact on downstream water licenses.

It is proposed to build a dam near the north boundary of the SW¼ of Section 26 and divert the main flow of Alkali Creek west to Goat Lake, which straddles the north boundary of SW¼ of Section 26, thence northwesterly through the NW¼ of Section 26 and the NE½ of Section 27.

Discussions have been held with the property owners of the lands affected by the diversion.



HWY 97
TO KAMLOOPS
MUSKRAT SLOUGH
HWY No 97
TWP 20 R 19 W.6
TWP 19 R 19 W.6
TWP 20 R 18 W.6
TWP 19 R 18 W.6
EMERGENCY TAILING DUMP POND
DYKE
PUMPHOUSE
TAILING LINE
ULTIMATE PIT
TAILING POND ULTIMATE WATER LEVEL
PUMP HOUSE
RECOVERY DAM
BOWERS BROOK
CHERRY CREEK
DEWATERING PIPE & PUMP
HUGHES LAKE
WASTE ROCK DUMP AREA
(FUNCTIONS AS BACKSLOPE OF EAST DAM)
EAST DAM
MAIN DAM
TAILING STORAGE AREA
FORMER ALKALI CR.
(E. FORK)
SOUTH EAST DAM
EAST CREEK (SOUTH FORK)
POTHOOK LAKE
EARTHFILL DAM
SPILLWAY
MOOSE LAKE
EARTHFILL DAM c/w OUTLET CONTROL
DIVERSION ALKALI CREEK
SOUTH DAM
DAM
NED ROBERTS LAKE
RUSSEL SLOUGH
3
2
1
6
34
35
36
31
27
26
25
N
inches
centimetres
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA GEOLOGICAL SURVEY

Fig. 4.1.1.2.1

4.1.1.3 Water Quality

Data on the Afton area water quality is available from three sources: a 1963 study of Kamloops Lake Limnology(8) from Pollution Control Branch samplings at intervals since 1972, and from a periodic sampling by B.C. Research and R.D. Lewis and Associates since November 1973.

Results from the 1963 study of Kamloops Lake are given in Tables 1 and 2 of Appendix 5. The latest study by a Federal Provincial Task Force (9) (available only in summary report form at the time of writing) does not provide the specific water quality data to be contained in a future technical report but indicates that a reduction in phosphorus levels and color would be desirable. Dissolved oxygen levels were high.

A single surface sample from Kamloops Lake (Site 8) on April 26, 1974 had the following characteristics:

Lab pH	7.8
Carbon - total	15 mg/l
organic	10 mg/l
Turbidity	0.88 (NTU)
Specific conductance	164 (μmho/cm)
Suspended solids	6 mg/l
Dissolved solids	79 mg/l
Total solids	85 mg/l
EDTA hardness	55 (mg $CaCO_3$/l)
Colour	12 (APHA units)

The B.C. Pollution Control Branch has maintained a water sampling station (No. 0600057) at the mouth of Cherry Creek since April 24, 1972 (see Figure 4.1.1.3). Analytical results are presented in Table 3 of Appendix 5 and include a limited sampling of Alkali Creek in May, 1975.

B.C. Research sampling sites are shown in Figure 4.1.1.3 and analytical results are presented in Appendix 5 (Tables 4 - 13).

Differences between pH values recorded in the field at the time of sample collection and readings obtained in the laboratory may be due to loss of carbon dioxide from the samples during shipment and analysis in the laboratory.

In January 1976, the levels of dissolved solids and related variables, such as hardness, conductance, alkalinity and total organic carbon in the lake at the pit site were considerably higher than those found during the April, 1974 survey. Dissolved oxygen concentration in the lake was low. Dissolved solids, hardness, sulphate, copper, and zinc in Hughes Lake were also at higher levels than in previous surveys. Concentrations of dissolved constituents in Cherry and Alkali Creeks were at or below the levels found in earlier samplings, with the exception of zinc, which had increased compared with previously measured levels. The coliform count in Alkali Creek and Cherry Creek was high indicating the presence of human sewage or animal wastes.

Compared with surface waters, well waters had higher dissolved solids, specific conductance, hardness and sulfates but lower dissolved metals.

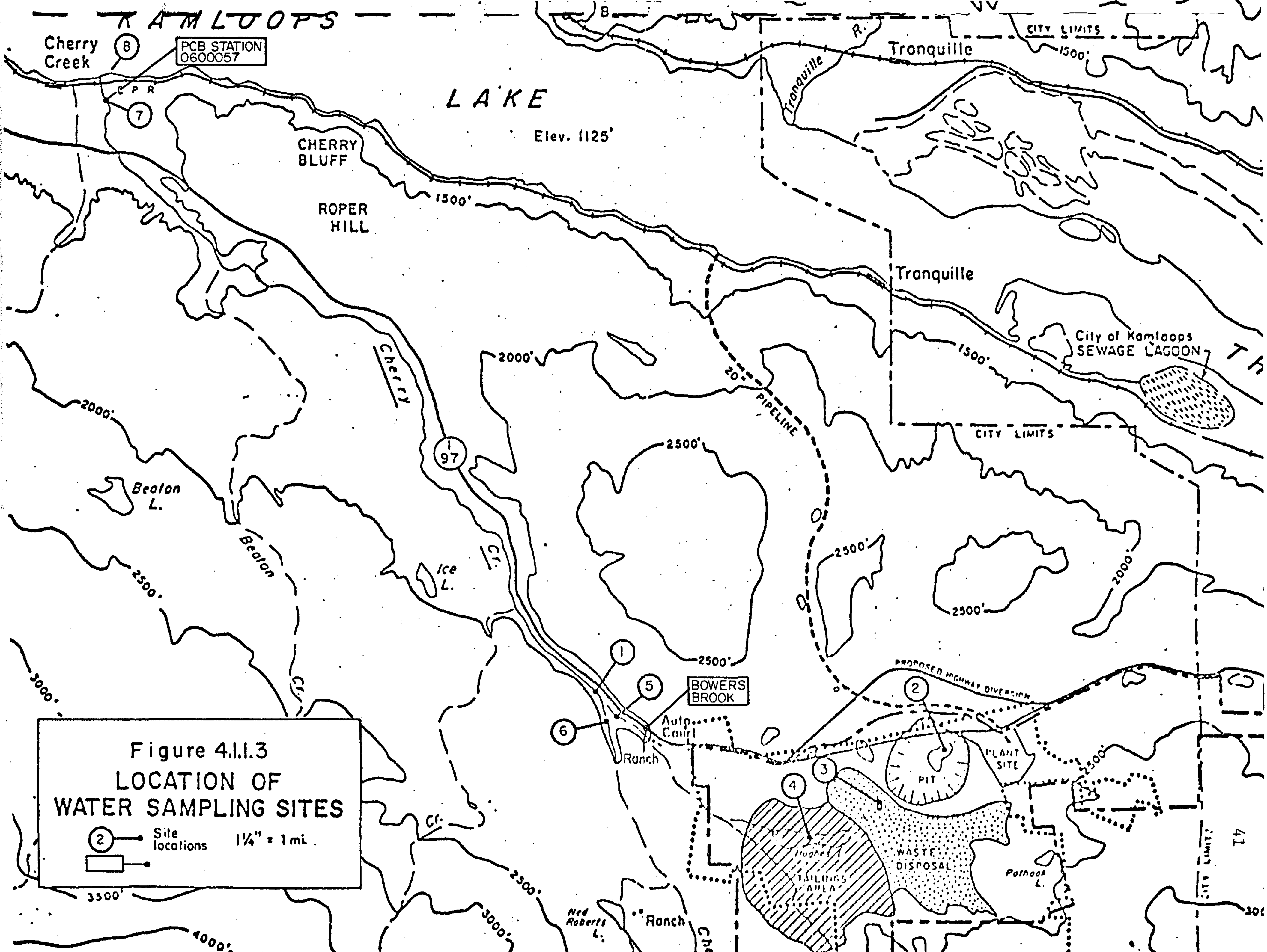


Figure 4.1.1.3
LOCATION OF WATER SAMPLING SITES

4.1.2 GROUNDWATER RECONNAISSANCE

AFTON MINE PROJECT

for

AFTON MINES LIMITED (N.P.L.)

VANCOUVER, BRITISH COLUMBIA

JANUARY, 1976

by

KLOHN LEONOFF CONSULTANTS LTD.

CIVIL AND GEOTECHNICAL ENGINEERS

TABLE OF CONTENTS

Earle J. Klohn
Cyril E. Leonoff
Donald M. Davison
Mark T. Olsen
Earl W. Speer
K. Ian Morrison
James Hunter

Yves G. Bajard
Frederic B. Claridge
Keith Douglass

Robert J. Melling
Accountant

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS
1010 K SHELLBRIDGE WAY, RICHMOND, B.C., CANADA V6X 2W7
TELEPHONE (604) 273-0311, TELEX: 04-507647, CABLE: 'RIPSOIL'

Allan L. Edgeworth
Geoffrey A. Evans
Ken R. Gillespie
Thomas G. Harper
Adrian P. Joseph
Robert Chung-Yi Lo
C.H. (Bob) Maartman
Robert P. Richards
Walter Shukin
Adrian Wightman

Our File: VA 2089

GROUNDWATER RECONNAISSANCE - AFTON MINE PROJECT

January 30, 1976

Project: Afton Mines Limited (N.P.L.)
Location: Kamloops, B.C.
Client: Afton Mines Limited (N.P.L.)
Vancouver, British Columbia

I INTRODUCTION

1.1 Subject of the Report

This report presents the results of a groundwater reconnaissance of the vicinity of the Afton Mine. In particular, the hydrogeology and present groundwater conditions are described, and an assessment is made of the effects that development of the mine will have on groundwater conditions.

Authorization for this report was given by Mr. J.M. Anderson of Afton Mines by a letter dated December 30, 1975.

The report is based on an analysis of all available data relevant to groundwater conditions and a short field investigation of the site by two Klohn Leonoff hydrogeologists on January 7, 1975. References used in this report are listed in Appendix B (page 58).

1.2 Summary of Findings and Proposed Action

It is expected that the waste rock dump will have very little effect on groundwater conditions beyond the immediate vicinity of the dump. No further need of action to control or monitor seepage from the waste rock dump is anticipated.

Little seepage is expected during the starter-dam phase of tailings-pond construction. Any seepage that does occur at this stage will be retained by the seepage recovery dam. No seepage control measures beyond those called for in the dam design are required.

For higher elevations of the tailings pond a number of precautionary measures will be taken for the control and detection of seepage. These are:

(a) Construction of a seepage cut-off trench at the upstream toes of the dams and blanketting of outcrops near the dams with low permeability material. These measures are already specified in dam design.

(b) Installation of three groups of piezometers below the main dam before the start of construction of the starter dam and subsequent monitoring.

(c) Spigotting of tailings along the north ridge to seal off bedrock exposures. Grouting of the bedrock at the north abutments of the dams will be resorted to if spigotting is not fully effective or is precluded by other considerations. However, grouting is more difficult and probably less economical than spigotting.

(d) Mapping and monitoring of groundwater discharge zones in the mine area.

(e) If any significant seepage is detected during filling of the pond additional control measures involving grouting, spigotting, or recovery systems will be resorted to as the case requires.

It is expected that with these precautionary measures ground and surface water outside the immediate vicinity of the mine area will not be significantly affected by groundwater movement from the tailings and waste rock areas.

2 HYDROGEOLOGY AND GROUNDWATER CONDITIONS

2.1 Location, Topography and Hydrology

The Afton mine pit and mine waste areas are located in a shallow valley just south of the Trans-Canada Highway west of Kamloops (see General Plant Layout Drawing No. X-2089-1).

A report by Ker Priestman Associates estimates precipitation in the mine area to be about 12 inches per year and evaporation from open water about 27 inches (Ref. 2). As a result natural recharge to the groundwater reservoir is probably small and occurs mostly at the time of spring snow-melt.

Alkali Creek drains the waste rock and tailings area and a small watershed beyond. It is ephemeral. Runoff from the watershed above the mine area will be largely diverted to Cherry Creek. Cherry Creek derives most of its water from high elevations further south and flows most of the year.

There are 16 known wells near Cherry Creek between 2 and 7 miles below the mine and 26 water licenses on Cherry Creek below the mine (Ref. 3). In addition, water is taken from Bowers Brook which is located between Alkali and Cherry Creeks just above their confluence. This water probably derives largely or completely by seepage from Cherry Creek. It constitutes the nearest known groundwater use downstream from the mine area.

Locations of wells and springs in the mine area are shown in the drawing of General Plant Layout Plus Groundwater Features.

As part of a continuing monitoring program water samples from a number of different points in the mine area and along Cherry and Alkali Creeks have been analyzed (Ref. 4). The groundwater from well #1 south is hard, with 878 mg/l of dissolved solids, including 330 mg/l of sulfate.

2.2 The Mine Project

The locations of the pit, the waste rock dump and the tailings pond are indicated on the drawing of the General Plant Layout.

The pit is planned to reach a depth of about 900 feet, and a diameter at the surface of about 2800 feet, after about 14 years of operation.

A B.C. Research Report indicates that the waste rock is not a potential source of acidic drainage water (Ref. 1).

The maximum water level elevation in the tailings pond will be a few feet below 2400 feet. The finest fraction of the tailings settle out extremely slowly, and recycling of tailings water is planned.

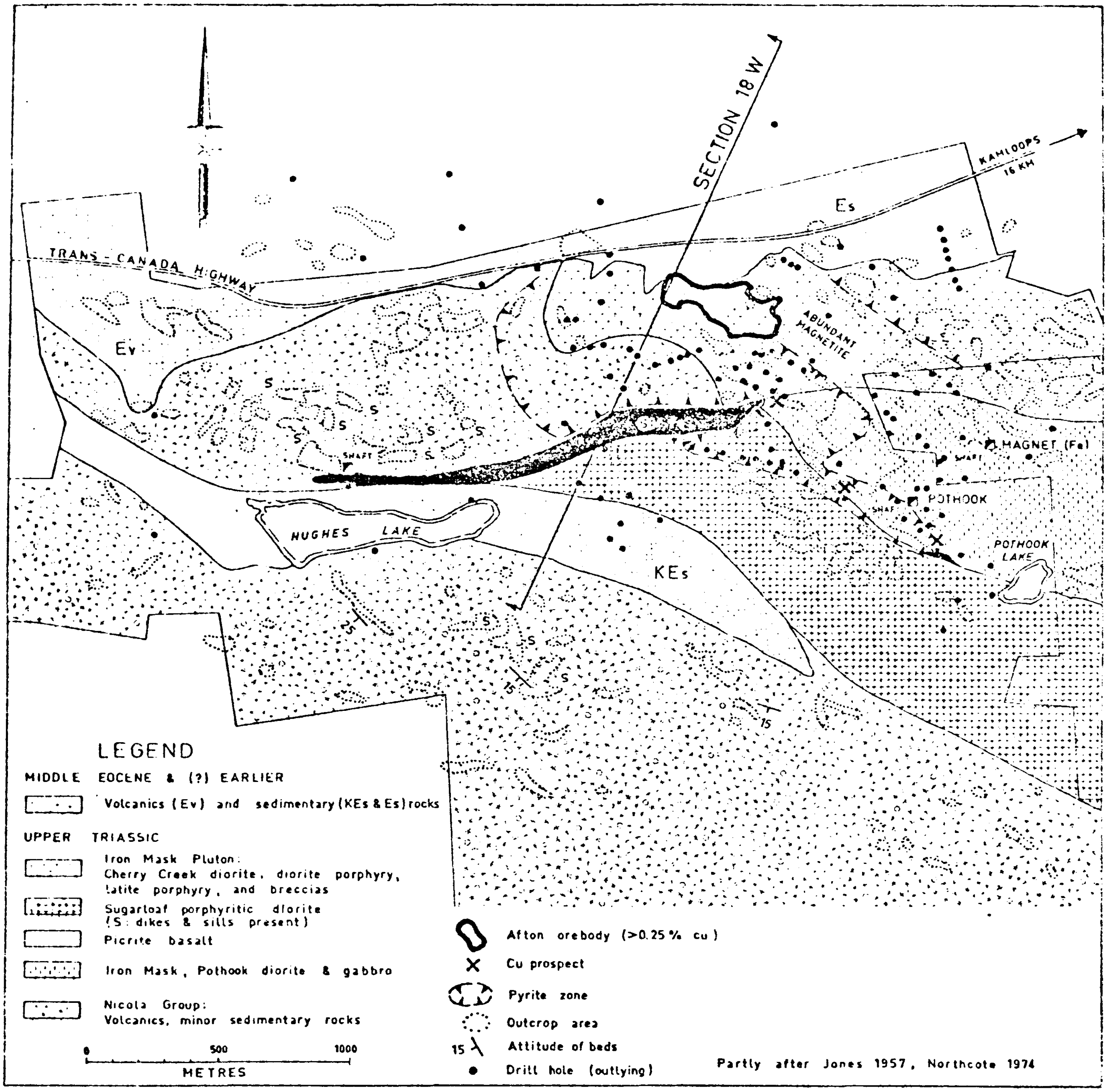
The tailings dams have been designed by Klohn Leonoff Consultants Ltd. (Ref. 6). The upstream faces of the dams will be covered by highly impermeable material. The design also specifies a seepage cut-off trench at the upstream toes of the dams and blanketting of outcrops near the dams with low-permeability material. A seepage recovery dam about 1600 feet downstream from the centreline of the main dam will retain any seepage through or under the north half of the dam.

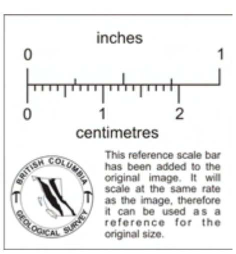
2.3 Hydrogeology

The bedrock geology in the mine area is shown in Figure 1 reproduced from a paper by Carr and Reed (Ref. 5).

About 90% of the area is covered by Pleistocene glacial drift deposited by ice sheets which moved ESE across the area (Ref. 5). The drift consists for a large part of a poor glacial till, with numerous and in places fairly extensive deposits of silt, sand and gravel interbedded in it. The till attains thickness of over 200 feet in the valley bottom, but on the side slopes above elevations of about 2200 feet, the till cover is thin and discontinuous.

Several fault zones have been identified, in the tailings pond and waste rock area. On the whole the faults appear to be relatively impervious to groundwater flow. Drill hole cores indicate considerable cementation of





Geology of the Afton Mine area. Taken without modification from Carr and Reed, 1975(5).

fault zones, and there were only a few instances of lost core or loss of circulation during test drilling in the area.

The contact between the Tertiary sedimentary rock underlying Hughes Lake and the volcanics to the south has been intercepted by two drill holes and appears to be fairly tight. The sedimentary-volcanics contact just north of Hughes Lake is probably similar. A few other isolated zones of more broken and open rock were encountered during drilling as evidenced by loss of core or circulation. In some places, particularly east of Hughes Lake the Tertiary sedimentary rock may have some intergranular permeability.

Two pump tests have been carried out in the mine area, on the Pothook shaft and on a drill hole (S3) east of the plant site, both of which are in the Ironmask pluton. Analysis of recovery data from these tests yields permeabilities of about 4×10^{-6} ft/min for the Pothook shaft and 3×10^{-8} ft/min for the drill hole. These are very low values, akin to dense till or clay.

The bedrock in the tailings pond area is not part of the same formation, but these pump test results indicate that at depth joints in the bedrock are very tight and will conduct very little groundwater. Some deep groundwater movement may occur in more open zones, but the rates of flow are likely to be negligibly small. Near the top of the bedrock, especially at outcrops, joints are generally more open than at depth. Thus some groundwater movement can occur near the bedrock surface unless it is sealed off by a blanket of till or tailings or cut off at the dam abutments by grouting.

The glacial till is generally highly impermeable, but the sands and gravels interbedded with it can be much more permeable. Below the 2200 foot contour the cover of quaternary deposits, mostly till, is almost unbroken and attains thicknesses of more than 200 feet. In situ permeability tests of the till cover are planned at the time of construction of the starter dams.

The permeability of the tailings varies, depending on the fraction of fines that settle out. It is estimated that the settled tailings will have a permeability of about 10^{-5} to 10^{-6} ft/min or less (See Appendix A). This is low value, typical of sandy clay.

2.4 Present Groundwater Conditions

Groundwater levels at the time of the field investigation on January 7, 1976 are summarized in Table I below. The locations of the wells and shafts are shown in the General Plant Layout (Drawing No. X-2089-I).

TABLE I. Groundwater Levels on January 7, 1976

Location	Depth of hole (ft)	Groundwater level below ground surface (ft)
Drill hole S3	760	3
Pothook shaft	±300	±25
Hughes Lake shaft	±50	dry
Well #1 south	135	artesian

Some observations of groundwater levels were also made during the subsoil investigations for the dam foundations (Ref. 6). The depth to the water table varies considerably but is generally greater on the ridges. Only a few springs have been identified in the mine area (see the map of General Plant Layout).

The creeks and watercourses in the mine area are dry for most of the year, but there may be underground flow through the alluvium of the stream beds. Care will therefore be taken to ensure that the foundations of the seepage recovery dam are designed for watertightness, so that any underflow in the streambed will be retained.

Under the present undisturbed conditions the creek beds probably constitute most of the groundwater discharge zones in the mine area. The total groundwater discharge is very slow however, as attested by the small and ephemeral flows in the creeks. The smallness of the groundwater flows is due both to the low permeability of the subsoil materials and the low rate of natural recharge to the groundwater reservoir.

2.5 Effects of Waste Rock Area and Pit on Groundwater Conditions

The waste rock itself will not have any great effect on the groundwater regime other than to reduce evaporation. Some concern has been expressed in the past about the possibility of groundwater pollution by leachates from the waste rock. However, a recent B.C. Research Council Report indicates that there is no potential for acid drainage from the waste rock (Ref. 1).

The pit will eventually be about 900 feet deep and about 2800 feet across. It lies at the bottom of the valley at the north-east end of the mine area. Virtually all groundwater emanating from the waste rock area will collect in the pit and be recycled. In view of the low overall permeability of the bedrock and the till this flow will probably be very small.

These considerations taken together indicate that groundwater from the waste rock area is not likely to have any significant effect on groundwater conditions outside its immediate vicinity. Thus no further need for monitoring or control of seepage from the waste rock area is anticipated.

2.6 Effect of Tailings Pond on Groundwater Conditions

In the tailings pond exposures of permeable materials such as sands and gravels or bedrock outcrops constitute points of potential seepage. A number of precautionary measures will be taken to minimize the seepage, and to detect any seepage that does occur at an early stage so that additional control measures can be taken if necessary. These precautionary measures taken together provide a reasonable assurance that ground and surface water in the vicinity of the mine area will not be significantly affected by the construction of the tailings pond.

The dam design (Ref. 6) specifies a seepage cut-off trench at the upstream toes of the dams to minimize seepage through surficial materials. The design report also calls for blanketting of bedrock exposures near the dams with low-permeability material and recommends that the bedrock exposures along the north ridge be sealed off with spigotted tailings or blanketted with glacial till. A seepage recovery dam downstream from the main dam will retain any seepage beneath the north half of the dam.

The seepage control measures specified or recommended in the design report leave little chance of any significant seepage from the tailings pond. Specific points of concern and additional precautionary measures, largely related to detection of seepage, are described in detail below.

The Starter-Dam Phase

During the starter-dam phase of construction seepage is expected to be very small and will be recycled. The bottom part of the tailings pond, below about 2200 feet, is largely covered by impervious glacial till. The tailings will form an additional low permeability cover over the till. Surficial seepage will be minimized by the seepage cut-off trench. Any seepage that does occur will be retained by the recovery dam. No additional precautionary measures need be taken over and above those specified in the design report (Ref. 6).

South End of Main Dam

At the south-east end of the main dam the seepage cut-off trench, blanketting of outcrops upstream from the dam, plus the sealing effect of the tailings together virtually eliminate the possibility of significant seepage.

A group of 1 to 3 piezometers will be installed before the start of construction of the starter dam at a location approximately indicated on the map of the General Plant Layout. In the unlikely event that monitoring of the water level in these piezometers indicates significant seepage, further investigation can be done and if necessary seepage can be controlled by sealing the area at the appropriate points or the installation of recovery facilities.

The North Ridge

At depth the bedrock of the North Ridge appears to be tight and there is no indication of more open zones extending through the north ridge. Therefore no significant flow in a northerly direction through the main body of the ridge is expected. At the west end of the ridge where the top of the ridge lies only slightly above the maximum pond elevation, some flow through the bedrock surface could occur unless precautionary measures, described below, are taken. The top of the bedrock along the south and west slopes of the north ridge is more open and widely exposed. It could conduct significant amounts of water past the north abutments of the dams if it is not sealed off. Two alternatives for sealing of the bedrock surface are proposed:

(a) Outcrops near the dams will be blanketted with till, and tailings will be spigotted off the north ridge to form a seal between the bedrock and the tailings water. In view of the low permeability of the tailings this method will probably be very effective. Further advantages of this method are that it requires no detailed investigation of the bedrock, and that it further reduces the possibility of seepage through the main body of the ridge. Two groups of 1 to 3 piezometers will be installed at the approximate locations indicated on the map before starter dam construction starts. If monitoring of the water level in these piezometers indicates significant seepage further investigation can be done and if necessary limited grouting can be applied to control the seepage or further recovery facilities can be installed.

(b) At the north abutments of the dams the bedrock under the upstream toes of the dams will be checked for tightness by water injection tests, and grouting will be done where the bedrock is open. Such a grout curtain will serve to seal off seepage past the abutments through the bedrock surface. Two groups of piezometers will be installed as for (a) above to monitor for seepage. This grouting method can be resorted to if other factors preclude spigotting of tailings along the north ridge, but it is more difficult to apply and the total cost of grouting cannot be accurately predicted.

The East Dam

With the precautionary measures described above no significant seepage past the East Dam is expected. Any seepage which does occur is likely to be recovered in the waste rock area or, eventually, in the open pit.

Groundwater Discharge Zones

As a final precaution against any significant seepage escaping from the mine area a groundcheck of all groundwater discharge zones around the mine area will be done twice a year, in late spring and late fall. All such zones will be located on a map and estimates of the rate of flow made. If formation of new discharge areas or significant increases of flow are noted these will be further investigated with regard to possible connection with the mine development.

Respectfully submitted,
KLOHN LEONOFF CONSULTANTS LTD.

G. van der Kamp, Ph.D.

Y. Bajard, D.Sc., P.Eng.

APPENDIX A

PERMEABILITY AND GRAIN-SIZE DISTRIBUTION OF TAILINGS

A representative grain-size distribution curve for the Afton tailings is included in this appendix. Extrapolation of the curve indicates that about 10 per cent of the tailings will be smaller than .001 m m.

The permeability of the tailings can be estimated with the Hazen formula (see for instance, Wilson, Engineering Hydrology, MacMillan 1969, p. 55):

$$k = c\, d_{10}^{2}$$

where k = coefficient of permeability (ft/min.)

c = a constant of value 0.9 to 2.8

d_{10} = the grain size in m m where 10% of the material is finer.

For the Afton tailings, taking c = 1, this equation gives:

$$k = 1 \times (.001)^{2}$$
$$= 10^{-6} \text{ ft./min.}$$

The actual permeability of the tailings will probably range from about 10^{-5} ft./min. to much less than 10^{-6} ft./min. depending on the extent to which the finest fraction, i.e. the slimes, are present. It is emphasized that Hazen's formula applies for sands, but is less reliable for very fine materials such as the Afton tailings. The estimate of permeability given above should therefore be viewed as an indication of order of magnitude only.

COMPANY Afton Mines Ltd. (N.P.L.)

INTER-OFFICE LETTER DATE December 19, 1975.

COPIES TO

S. F. Siscoe

TO J. M. Anderson

FROM: C. V. Sibbald

WHEN FEASIBLE, CONFINE LETTER TO ONE SUBJECT

RE: Afton Tailings Size Analysis

The following results from Test AP3-18 can be considered representative of the size analysis expected for Afton tailings.

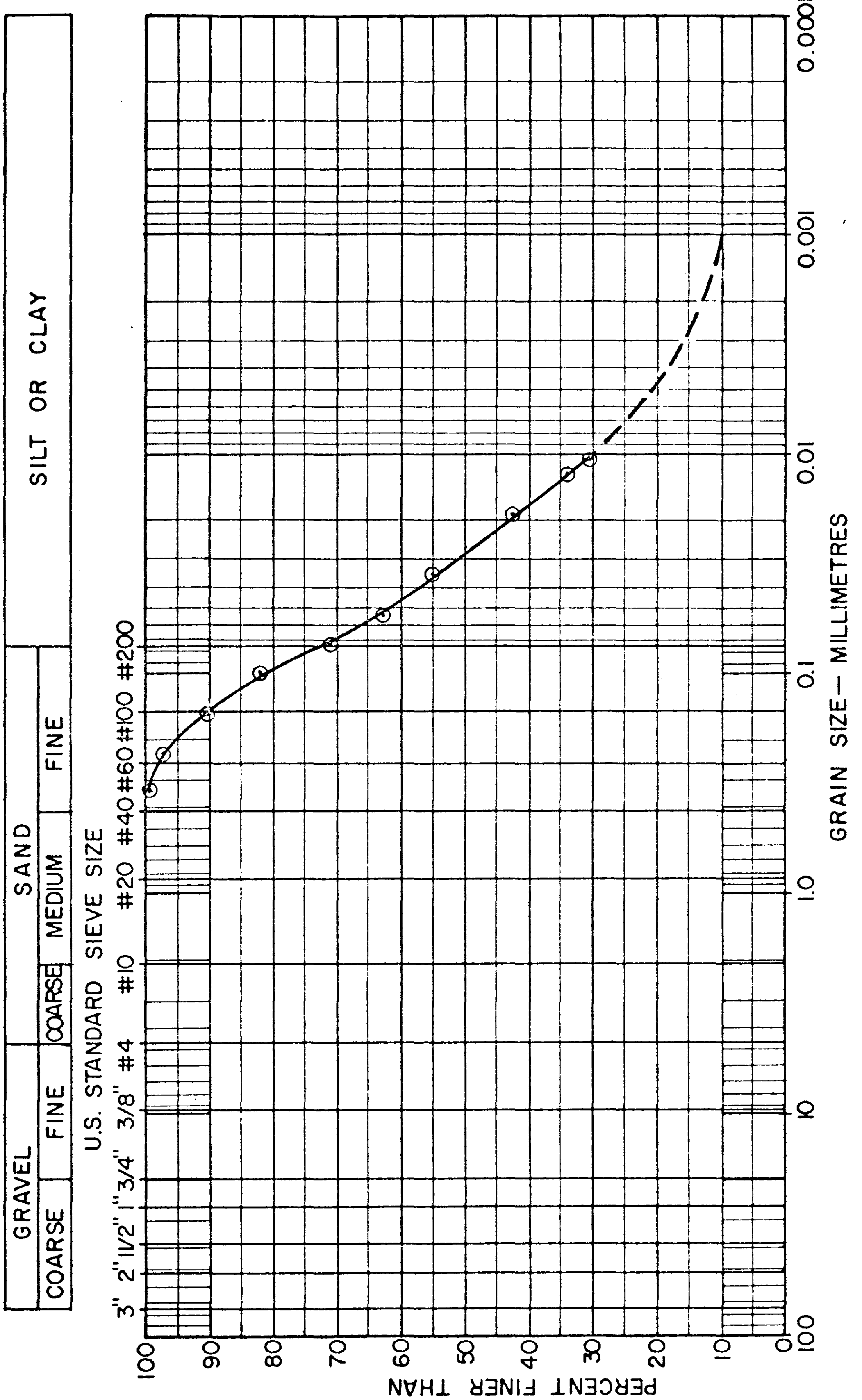
Rougher Flotation Tail - Test AP3-18

Mesh Size (Tyler)	% Weight Retained
+ 48 mesh	0.5
65	2.1
100	6.4
150	9.7
200	10.8
270	7.8
35.6 microns	8.3
27.6	6.4
19.3	6.3
13.3	7.5
10.2	3.9
- 10.2	30.3
Total	100.0

C.V. Sibbald

CVS:baw

GRAIN SIZE CURVE



REMARKS: Based on size analysis from Test AP3 - 18

Klohn Leonoff Consultants Ltd.
CIVIL & GEOTECHNICAL ENGINEERS

JOB No.	VA2089
PROJECT	Afton Groundwater
LOCATION	Kamloops
HOLE No.	DEPTH
DATE	

APPENDIX B

REFERENCES

1. B.C. Research, "Acid Production Potential of Samples from the Afton Property," December, 1975.

2. Ker Priestman Associates Ltd., "Fresh Water Supply for the Afton Mine Project," September, 1973.

3. B.C. Research, "Environmental Statement," Volume I, April 25, 1974.

4. B.C. Research, "Afton Mines Ecologic Survey Baseline Water Quality," Revision of August 14, 1975.

5. J.M. Carr and A.J. Reed, Afton: Geology of a Supergene Copper Deposit," November, 1975.

6. Klohn Leonoff Consultants Ltd., "Report on Tailings Dams - Afton," February, 1975.

4.1.3 METEOROLOGY AND AIR QUALITY

4.1.3.1 Background

To project the impact on ambient air quality from air emissions associated with the operation of the proposed smelter of Afton Mines Limited, the following information is required:

(i) background ambient air quality
(ii) nature and source of emissions from the proposed smelter
(iii) regional controls such as topography and local climatological variations
(iv) the interaction between the regional or local influence and the large-scale or synoptic weather patterns, and
(v) the long-term effect that (iii) and (iv) above have on the dispersion capabilities of the region. This can be referred to as the "dispersion climatology of the region".

Due to the presence of industrial and natural emission sources in the vicinity of Kamloops, a background level of air quality exists within the area of the proposed Afton smelter. To project changes that could be attributed to smelter emissions, the background levels of sulphur dioxide, mercury, arsenic and suspended particulates would be assessed.

The "dispersion climatology" is the frequency of occurrence of various combinations of temperature and wind profiles as related to the diffusion of pollutants emitted to the atmosphere. A detailed assessment of dispersion climatology in the area of the smelter will produce the information required to assess the effect of proposed changes in emission sources.

If 3 to 5 years of comprehensive meteorological data were available, dispersion climatology could be projected and consequently, a frequency distribution of ground level sulphur dioxide concentration could be estimated for present operations and for future changes that are planned. The only long term meteorological data that we are aware of in the Kamloops area are from the Atmospheric Environment Service's surface observing stations at the airport and the PCB Anemometer on top of Dufferin Hill. Although this information will be most valuable in assessing dispersion climatology, additional information is necessary regarding vertical structure of wind and temperature. An attempt to assess dispersion climatology using available data would be unsatisfactory. Mr. Loren Crow, (1974)[10] a well known American Air Pollution Meteorologist, states, "The collection of meteorological data near the ground, even if located right at the site, is a poor substitute for data collected near the primary height range of what can be expected as the effective stack height". From various people in the meteorological field with whom our consultants have exchanged information, and from their experience, it was found necessary to obtain wind and temperature profile data in the area of effective chimney height, which has been anywhere from 200 to 3,000 feet above the base of the chimney. In addition, information at the base of the chimney and in the valley, will help in developing an understanding of local controls.

Another area of concern by experts in the field of atmospheric diffusion is the indiscriminate use of so called engineering formulae. Smith, in a recent paper,(11) in a recent publication of the Air Pollution Control Association discusses the system devised by Pasquil to approximate diffusion climatology. This system approximates atmospheric stability from standard data, such as cloud cover, ceiling height, solar attitude and time of day. Solar attitude refers to the azimuth of the sun and the angle of declination. Concerning this system he states: "My complaint is not with the system itself. It was originally devised by a most capable meteorologist, but it was keyed to the climate of Great Britain and does not produce good results in all other areas:

In the same paper, Smith expounds on the weakness of analysis and application of existing data. In his discussion he states, "It is down-right embarrassing to admit the existing meteorological records are being grossly misused".

There is no single simple engineering type formula available that can, by itself, give the necessary answers regarding atmospheric dispersion. For example, valleys have characteristic flow patterns that vary under differing synoptic conditions; the long Canadian winters are significant in influencing vertical mixing and stability; and limited mixing, an important aspect in diffusion studies, can vary considerably, depending on the season, synoptic conditions and on location topographic effects. All possibilities must be assessed to enable confident projections.

Before projections can be developed with a computer, a well designed study is required to first determine the dispersion climatology and secondly how the local controls that make up the climatology act to disperse effluents emitted to the atmosphere.

It is with this understanding that a one year preoperation ambient air quality survey and dispersion climatology study were developed.

It may be concluded that wind data from Dufferin Hill is too sketchy to be of significance although preliminary investigations show effects of geostrophic rather than topographically influenced winds.

4.1.3.2 Proposed Work Program

At the beginning of 1976, Envirocon Limited and the MEP Company were retained to conduct the ambient air quality program and the dispersion climatology study respectively.

4.1.3.2.1 Ambient Air Monitoring

Proper documentation of background ambient air quality before the addition of a new emission was found to be very beneficial to both the regulatory agencies and the company in making decisions. In this case, a well-planned ambient air monitoring program would enable the projection of contributions that emissions from the Afton smelter would make on existing levels.

The following program was recommended and initiated in early 1976.

TASK: 1

Review and summarize existing ambient air quality meteorological and topographic data for the area.

TASK: 2

Establish three preliminary air monitoring stations based on existing information. They will be located to give representative background levels in the vicinity of Kamloops and the proposed smelter site. Each station will consist of:

(i) one (1) coulometric analyzer for sulphur dioxide concentration
(ii) one (1) constant flow high volume sampler for suspended particulates and arsenic
(iii) one (1) wet impingement train for total mercury
(iv) one (1) canister for total dustfall.

Sulphur dioxide concentrations will be recorded on a continuous basis. Suspended particulates will be collected across two 24-hour periods each week and the filters will be analyzed for arsenic content once per month. Mercury samples will be collected and analyzed twice per week. Dustfall will be determined once per month and solution will be analyzed for mercury, arsenic and copper concentrations once per quarter.

TASK: 3

Install, in addition to three ambient stations, 30 to 40 lead dioxide sulphation plate sites for coverage of Kamloops and vicinity to establish background sulphation rates per month, and indicate areas of influence by existing emissions. Two sulphation plates will be located at the intake of each continuous sulphur dioxide monitor to facilitate an approximate correlation of sulphation rate to average sulphur dioxide level. This approach will allow an assessment of background air quality in the area which may be influenced by smelter emissions.

4.1.3.2.2 Dispersion Study Program

To project the frequency distribution of ground-level concentrations of specified emissions from the smelting complex, the intensity of fumigation, the spatial extent of emissions and the optimum stack height, the following program was established.

TASK: 1

Erect on Sugarloaf Hill a wind and temperature measuring system, and on Dufferin Hill a temperature measuring system to complement the P.C.B. anemometer. These two locations, along with the data obtained on a regular basis from the Kamloops airport within the valley, will form the basic surface wind and temperature network. This network will record wind and temperature data from three different elevations. (Airport approx. 1,200 ft. M.S.L., Dufferin Hill 2,907 ft. M.S.L. and Sugarloaf Hill 3,692 ft. M.S.L.).

TASK: 2

Set up a minisonde station in a representative area near the proposed location of the smelter to obtain temperature and wind profiles to a height of approximately 3,000 feet above the base of the chimney. It is well known that the layer of atmosphere from the surface to 3,000 feet plays an important role in dispersing effluents emitted into the atmosphere. From this location two minisondes will be released each week day. The first near sunrise to obtain a fix on the height and strength of the noctural inversion, and the second in early afternoon for information regarding lapse rate and limited mixing.

TASK: 3

Carry out two intensive field studies to complement the week-day minisonding program; one during the winter and the other during the summer. The intensive field studies will be selected to coincide with those synoptic or large scale meteorological conditions most adverse to good dispersion. The field studies will consist of mini-soundings from the Afton site along with soundings from a second site in Kamloops. In addition, a mobile temperature sensor will obtain the temperature variation in the area.

TASK: 4

Determine dispersion climatology in the area of the proposed Afton smelter by appropriate analyses of data obtained from the field programs as to mixing height, wind variation, lapse rates, inversion and their strength and height, etc. Consequently, the frequency of occurrence of specified ground level concentrations resulting from smelter emissions as well as their spatial distribution can be determined. This includes the frequency with which any specific location may receive specified concentrations.

TASK: 5

Correlate ambient air quality data collected from sampling stations with meteorological conditions and areal topography to give a dynamic model of background air quality conditions.

4.1.3.3 EXISTING DATA

4.1.3.3.1 Ambient Air Quality

In the Kamloops vicinity, the Pollution Control Branch had established an ambient air monitoring network in the city, around the Weyerhaeuser pulp mill and the Gulf refinery over a year ago. Also, one continuous sulphur dioxide monitor had been installed at the boundary of the refinery.

Results of the existing ambient air network were obtained from the B.C. Pollution Control Branch. The data are summarized in Table 4.1.3.3.1.1. Data included concentrations of total dustfall, total suspended particulates, suspended lead particulates and sulphation rate. Raw data of the sulphur dioxide monitor were received and being analyzed. Results will be available at a later date.

For the mining industry, the B.C. Pollution Control Branch has issued objectives for desirable levels of ambient air quality in November 30, 1973. The applicable objectives are presented in Table 4.1.3.3.1.2.

For comparison purposes, the proposed Afton smelter emissions are compared with some of the major emission sources in the Kamloops area. A comparison table is presented in Table 4.1.3.3.1.3.

TABLE 4.1.3.3.1.1.

AMBIENT AIR QUALITY IN THE KAMLOOPS VICINITY

Location*	Sampling Period	Total Dustfall T/sq.mi./mo.	Suspended Particulates ug/cu.m.	Suspended Lead ug/cu.m.	Sulphation Rate mg $SO_4^{=}$/ 100 cm^2/mo
1. Kamloops Airport	03/72-01/76	8.88	76.6	0.312	0.154
2. Oak Street Manor	03/72-03/74	11.86	-	-	0.100
3. Eaton's Building	03/72-09/74	25.89	128.28	1.44	0.216
4. Brockelhurst Secondary	03/72-03/74	10.28	-	-	0.134
5. Floritto Egg Farm	04/72-04/75	16.60	-	-	0.145
6. Federal Building	09/74-01/76	12.13	91.50	-	0.250
7. East of WeyCan Chips	07/75-01/76	138.08	-	-	0.153
8. Kabana Trailer Ct	08/74-07/75	10.20	-	-	0.114
9. Frolek-Bd Mcleod Res.	10/72-11/73	31.13	-	-	-
10. Frolek-Crown Land	10/72-10/73	14.56	-	-	-
11. Frolek-Mf Hartine Res.	10/72-10/73	30.96	-	-	-
12. Frolek-Tm Saxton Res.	10/72-10/73	16.41	-	-	-
13. East of Refinery	07/74-01/76	-	-	-	2.729
14. North of Refinery	07/74-01/76	-	-	-	0.262
15. N-W of Refinery	08/74-01/76	-	-	-	0.471
17. North of Refinery Property LN	11/74-01/76	-	-	-	1.687
18. West of Refinery Property LN	11/74-01/76	-	-	-	1.290

*See Figure 4.1.3.4.3

TABLE 4.1.3.3.1.2

MINING, MINE-MILLING, SMELTING AND ASSOCIATED INDUSTRIES

DESIRABLE LEVELS OF AMBIENT AIR QUALITY

Contaminant	Units	Level A	Monitoring
1. Sulphur dioxide			Continuous (supplemented by sulphation plates).
(a) Annual arithmetic mean	ug/m^3	53	
	ppm	0.02	
(b) 24-hr. conc. (max.)	ug/m^3	266	
	ppm	0.10	
(c) 3-hr. conc. (max.)	ug/m^3	-	
	ppm	-	
(d) 1-hr. conc. (max.)	ug/m^3	199	
	ppm	0.3	
2. Suspended particulate matter			24 hours per week
(a) Total -			
Annual geometric mean	ug/m^3	60	
Max. 24 hrs.	ug/m^3	150	
(b) Lead -			
Annual geometric mean	ug/m^3	2	
Max. 24 hrs.	ug/m^3	4	
(c) Zinc -			
Annual geometric mean	ug/m^3	3	
Max. 24 hrs.	ug/m^3	5	
(d) Cadmium -			
Annual geometric mean	ug/m^3	0.05	
Max. 24 hrs.	ug/m^3	0.1	
3. Dustfall			Collected over one month period.
(a) Residential	mg/cm^2/mo	0.525	
	tons/mi^2/mo	15	
(b) Other	mg/cm^2/mo		
	tons/mi^2/mo	25	
4. Mercury	ug/m^3	1.0	Monthly average.
5. Arsenic compounds			24 hours per week.
Annual geometric mean	ug/m^3	0.2	
Max. 24 hrs.	ug/m^3	1.0	

TABLE 4.1.3.3.1.3

COMPARISON OF AFTON SMELTER AIR EMISSIONS WITH OTHER AIR EMISSIONS IN THE KAMLOOPS AREA

This table is based on calculations made from Pollution Control Branch Air Emissions Applications

COMPANY	EMISSION RATE SCFM [1]	OPERATING PERIOD	PARTICULATES (GRAINS/SCF)[2]	MERCURY	SO_2 (SULFUR-DIOXIDE)	REDUCED SULPHUR COMPOUNDS	LEAD, ZINC CADMIUM ARSENIC
Afton Mines Smelter Stack	9,840	10 hrs.	(Grains/scf less than 0.10) 84 lb/day = 0.04 Tons/day	Less than 4 lb/day	Less than 1.5 tons /day	-	Less than 2.53 lb/day each
Gulf Oil Refinery	70,000	24	(Grains/scf = 0.72) 10,000 lb/day = 5.0 tons/day	-	(1300 PPM)[3] 11.5 tons/day	-	-
Weyerhaeuser Pulp Mill[4]	650,000	24	(Grains/scf = 0.02) 3.9 tons/day	-	(70 ppm) 6.0 tons/day	(0.8 ppm) 200 lb/day	-

1 SCFM - Standard Cubic Feet/Minute

2 7000 Grains = 1 pound

3 Parts per Million

4 1250 Air Dried Tons of Unbleached Pulp/day

4.1.3.3.2 Meteorology

Wind data for Kamloops airport is available for the period January 1953 through December 1971. Visual representations of this data are shown in Figures 4.1.3.3.2. 1 - 5.

Figure 4.1.3.3.2.1 illustrates the mean valley wind speed distribution by month and direction. It may be seen that winter winds are a little stronger than summer winds with the strongest winds being the easterlies and westerlies.

Figure 4.1.3.3.2.2 illustrates the percentage frequency of valley winds by direction and month. The east-west trending may clearly be seen. During the months September through March east winds predominate while in the summer months east and west winds occur equally. It may be noted that due to the valley east-west orientation there is a low occurrence of cross valley winds. Those that do occur are more predominant in the warm summer months and may be attributed to differential heating causing valley-side thermals. Calm winds occur equally throughout the year.

Figure 4.1.3.3.2.3 illustrates the percent frequency of west winds by the hour and month. West winds (as noted above - Figure 4.1.3.3.2.2 are more frequent during the summer months. Over the entire year, west winds are more frequent during daylight hours. However, summer daytime west winds are much more frequent than summer nighttime westerlies. During the winter months west winds are less frequent and they occur equally during the day or night.

Easterly winds are illustrated in Figure 4.1.3.3.2.4. This graph clearly shows the seasonal variation of easterly winds. Winter easterlies are much more frequent than summer easterlies and show very little variation between nighttime and daytime frequencies.

Calm winds are illustrated in Figure 4.1.3.3.2.5. Calm winds are more common during the summer months. The hourly occurrence of these calms is shown to be most prevalent in the early morning hours (before sunrise). The low occurrence of summer daytime calms can be attributed to differential heating patterns that inspire convective currents.

Valley wind patterns can be summarized as follows:

1. Little discrimination of wind speeds by direction or season.
2. Definite east-west trends in the frequency occurrence of winds.
3. Easterly winds are more frequent in the winter than in the summer.
4. Westerly and easterly winds occur equally during the summer months.
5. Convective currents caused by differential heating are important in summer wind patterns.

FIGURE 4.1.3.3.2.1.

	J	F	M	A	M	J	J	A	S	O	N	D
N	4.7	5.7	5.7	7.5	6.9	7.3	7.7	6.3	6.6	4.6	4.9	5.0
NE	7.4	7.9	8.1	7.8	7.2	7.3	7.0	6.7	6.9	8.1	7.7	8.4
E	8.8	8.8	9.9	9.2	8.0	7.8	6.9	6.8	7.5	9.5	9.4	10.3
SE	8.4	8.3	8.9	8.2	7.2	6.6	6.2	6.2	6.6	8.1	9.0	8.5
S	8.1	5.8	9.6	11.7	8.9	9.3	8.5	9.2	9.7	9.1	6.7	7.0
SW	7.5	7.4	[illegible]	10.4	9.1	9.0	8.3	7.9	8.0	8.9	8.3	8.3
W	12.5	9.3	10.6	11.0	10.3	9.2	8.6	8.3	9.8	9.8	11.3	11.8
NW	10.0	9.7	8.9	8.6	7.7	7.4	7.3	6.5	8.6	6.9	7.1	8.9

Kamloops, B.C. - Mean Wind Speed (MPH) by Direction and Month

FIGURE 4.1.3.3.2.2

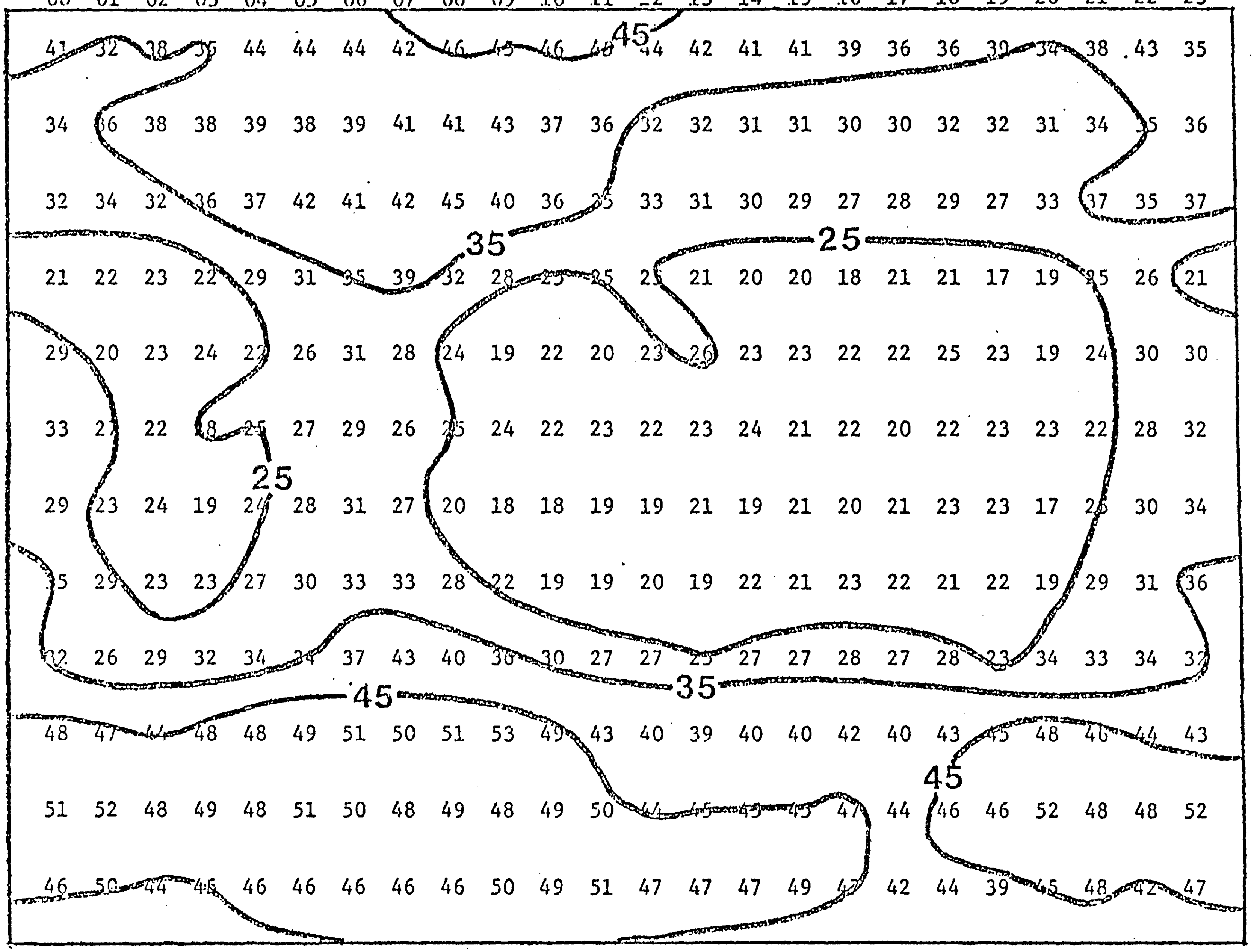
	J	F	M	A	M	J	J	A	S	O	N	D
N	1	1	1	2	2	2	2	1	1	1	1	1
NE	6	5	5	5	5	6	5	5	6	7	7	6
E	43	35	35	25	24	24	23	25	31	45	48	46
SE	8	7	10	8	9	9	9	8	9	9	9	9
S	2	3	4	7	6	7	6	6	4	3	2	1
SW	5	6	9	12	13	13	13	12	9	7	6	5
W	14	15	18	23	24	23	23	21	20	11	11	11
NW	2	2	2	3	3	3	3	3	2	2	1	2
CALM	22	25	17	16	15	15	17	19	18	15	16	18

Kamloops, B.C. - Percentage Frequency Wind Direction
(and Calms) by Months

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
JAN.	13	14	16	15	12	12	14	14	14	14	16	17	16	15	15	14	14	13	10	9	10	14	11	13
FEB.	9	11	9	7	14	15	13	12	13	14	18	17	17	18	17	17	17	14	15	11	11	7	14	9
MAR.	14	14	16	17	13	15	14	17	17	19	21	24	21	20	21	21	21	19	17	16	15	15	13	14
APR.	18	16	17	15	15	14	17	18	23	25	27	31	29	27	27	31	28	27	21	19	17	16	16	18
MAY	13	13	17	10	16	17	18	27	31	32	32	29	28	28	29	29	30	27	22	17	19	16	14	15
JUN.	9	11	11	14	13	14	17	26	31	32	32	28	28	27	27	28	26	23	22	20	15	12	14	13
JUL.	12	13	15	10	14	13	16	23	31	34	32	31	26	25	26	26	28	24	22	15	20	13	15	13
AUG.	8	6	11	9	12	12	13	17	25	30	31	29	30	28	27	28	30	26	22	15	15	8	12	10
SEP.	11	11	10	9	12	13	14	15	20	24	24	25	24	27	25	30	28	23	20	14	9	13	13	12
OCT.	11	9	9	7	9	10	9	9	8	10	11	14	14	17	15	14	14	10	10	7	9	7	6	8
NOV.	8	7	9	10	10	9	11	11	11	12	15	15	14	14	14	12	11	10	9	8	10	11	9	9
DEC.	12	10	11	11	10	11	11	11	11	12	10	13	11	13	12	11	10	11	10	11	10	12	10	11

Kamloops B.C. - Percentage Frequency of West Winds
by Hour and Month (Jan. 1953-Dec. 1971)

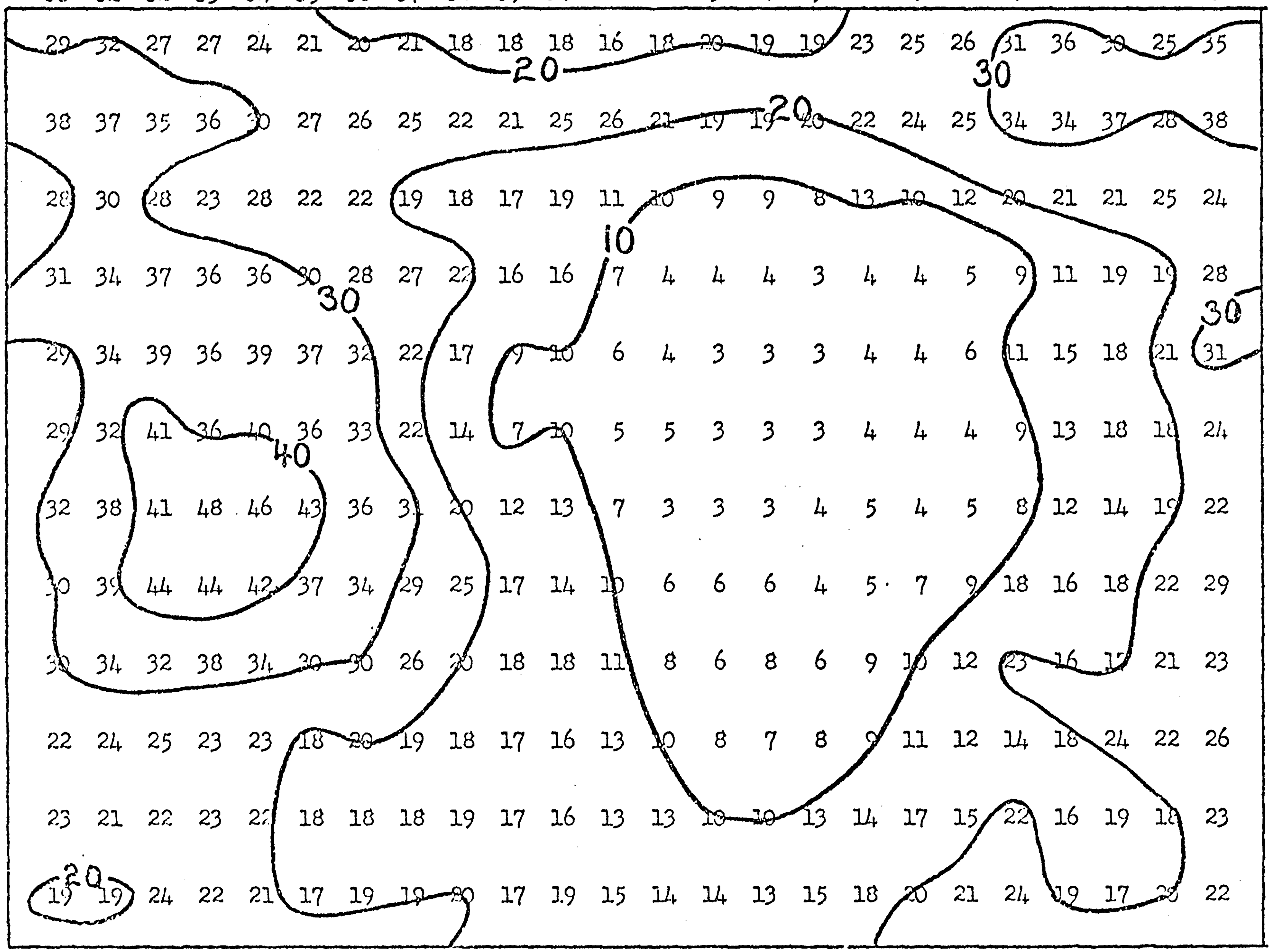
FIGURE 4.1.3.3.2.3



	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
JAN.	41	32	38	35	44	44	44	42	46	45	46	46	44	42	41	41	39	36	36	39	34	38	43	35
FEB.	34	36	38	38	39	38	39	41	41	43	37	36	32	32	31	31	30	30	32	32	31	34	35	36
MAR.	32	34	32	36	37	42	41	42	45	40	36	35	33	31	30	29	27	28	29	27	33	37	35	37
APR.	21	22	23	22	29	31	35	39	32	28	25	25	25	21	20	20	18	21	21	17	19	25	26	21
MAY	29	20	23	24	22	26	31	28	24	19	22	20	23	26	23	23	22	22	25	23	19	24	30	30
JUN.	33	27	22	28	25	27	29	26	25	24	22	23	22	23	24	21	22	20	22	23	23	22	28	32
JUL.	29	23	24	19	24	28	31	27	20	18	18	19	19	21	19	21	20	21	23	23	17	25	30	34
AUG.	35	29	23	23	27	30	33	33	28	22	19	19	20	19	22	21	23	22	21	22	19	29	31	36
SEP.	32	26	29	32	34	34	37	43	40	30	30	27	27	25	27	27	28	27	28	23	34	33	34	32
OCT.	48	47	44	48	48	49	51	50	51	53	49	43	40	39	40	40	42	40	43	45	48	46	44	43
NOV.	51	52	48	49	48	51	50	48	49	48	49	50	44	45	45	45	47	44	46	46	52	48	48	52
DEC.	46	50	44	46	46	46	46	46	46	50	49	51	47	47	47	49	47	42	44	39	45	48	42	47

Kamloops, B.C. - Percentage Frequency of East Winds by Hour and Month (Jan. 1953 - Dec. 1971)

FIGURE 4.1.3.3.2.4



	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
JAN.	29	32	27	27	24	21	20	21	18	18	18	16	18	20	19	19	23	25	26	31	36	30	25	35
FEB.	38	37	35	36	30	27	26	25	22	21	25	26	21	19	19	20	22	24	25	34	34	37	28	38
MAR.	28	30	28	23	28	22	22	19	18	17	19	11	10	9	9	8	13	10	12	20	21	21	25	24
APR.	31	34	37	36	36	30	28	27	22	16	16	7	4	4	4	3	4	4	5	9	11	19	19	28
MAY	29	34	39	36	39	37	32	22	17	9	10	6	4	3	3	3	4	4	6	11	15	18	21	31
JUN.	29	32	41	36	40	36	33	22	14	7	10	5	5	3	3	3	4	4	4	9	13	18	18	24
JUL.	32	38	41	48	46	43	36	31	20	12	13	7	3	3	3	4	5	4	5	8	12	14	19	22
AUG.	30	39	44	44	42	37	34	29	25	17	14	10	6	6	6	4	5	7	9	18	16	18	22	29
SEP.	30	34	32	38	34	30	30	26	20	18	18	11	8	6	8	6	9	10	12	23	16	17	21	23
OCT.	22	24	25	23	23	18	20	19	18	17	16	13	10	8	7	8	9	11	12	14	18	24	22	26
NOV.	23	21	22	23	22	18	18	18	19	17	16	13	13	10	10	13	14	17	15	22	16	19	18	23
DEC.	19	19	24	22	21	17	19	19	20	17	19	15	14	14	13	15	18	20	21	24	19	17	20	22

Kamloops, B.C. – Percentage Frequency Calm Winds by Hour and Month

FIGURE 4.1.3.3.2.5

Wind data is also available for Dufferin Hill for the period, September 1973 through March 1974 and May 1975 through September 1975. These data are illustrated in Figures 4.1.3.3.2.6 - 7.

Dufferin Hill is located south of Kamloops airport and is approximately 1800 feet higher in elevation. Although the data are limited, certain trends may be noticed.

Figure 4.1.3.3.2.6 illustrates wind speeds on Dufferin Hill by direction and month. Wind speeds are generally higher from the southerly direction than from other directions. The main factor on Figure 4.1.3.3.2.6 is to note that the highest wind speeds occur from the southeasterly to south westerly directions. This is markedly different to wind speeds at the Kamloops airport (Figure 4.1.3.3.2.1) which are equally spread seasonally and directionally.

Figure 4.1.3.3.2.7 illustrates the percentage frequency occurrence of wind on Dufferin Hill by month and direction. No isopleths are shown on this diagram as graphical trends are hard to note with the limited data available. Statistical anomolies do occur, however, when compared to Kamloops airport data certain differences may be noted. Along with the expected east-west trendings there appears a large southerly component. This component is due to high altitude geostrophic winds rather than local topographically influenced winds.

4.1.3.4 WORK IN PROGRESS

The proposed preoperational ambient air study and dispersion climatology program were approved on December 18, 1975 by the Pollution Control Branch. The work schedule for the one year study is presented in Figure 4.1.3.4.1.

Both studies have been initiated, preliminary data will not be available until mid-1976.

The sulphation grid has been established and is shown in Figure 4.1.3.4.2. The ambient air monitoring trailers are being constructed and expected to be operational in March, 1976. The locations are tentatively selected and subject to the approval of the Pollution Control Branch.

The daily minisonde program began in the week of February 9, 1976 and the first intensive field study was conducted simultaneously.

	J	F	M	A	M	J	J	A	S	O	N	D
N	9.0	5.0	11.9		6.9	8.3	8.0	7.1	5.2	6.5	5.4	7.2
NE	6.3	4.9	9.3		9.3	7.5	7.9	7.6	6.1	6.8	6.5	6.1
E	9.2	8.8	13.8		10.2	8.2	9.7	9.7	10.4	9.8	11.7	12.0
SE	7.3	9.1	14.7		10.6	6.8	9.3	9.7	8.7	11.0	12.1	12.9
S	7.6	11.8	19.0		10.0	15.1	15.2	14.2	14.3	11.6	14.5	12.3
SW	14.0	11.4	15.2		14.5	15.3	11.9	12.2	9.3	8.4	6.7	9.6
W	9.3	7.9	13.0		21.2	14.4	11.0	11.5	11.6	10.8	9.8	8.7
NW	6.8	8.6	5.3		13.1	12.1	8.6	8.7	8.5	7.9	3.0	9.6

10
15
10

Kamloops Dufferin Hill B.C.-Mean Wind Speed (MPH) by Direction and Month
(Sept/73-Mar/74 and May/75-Sept/75)

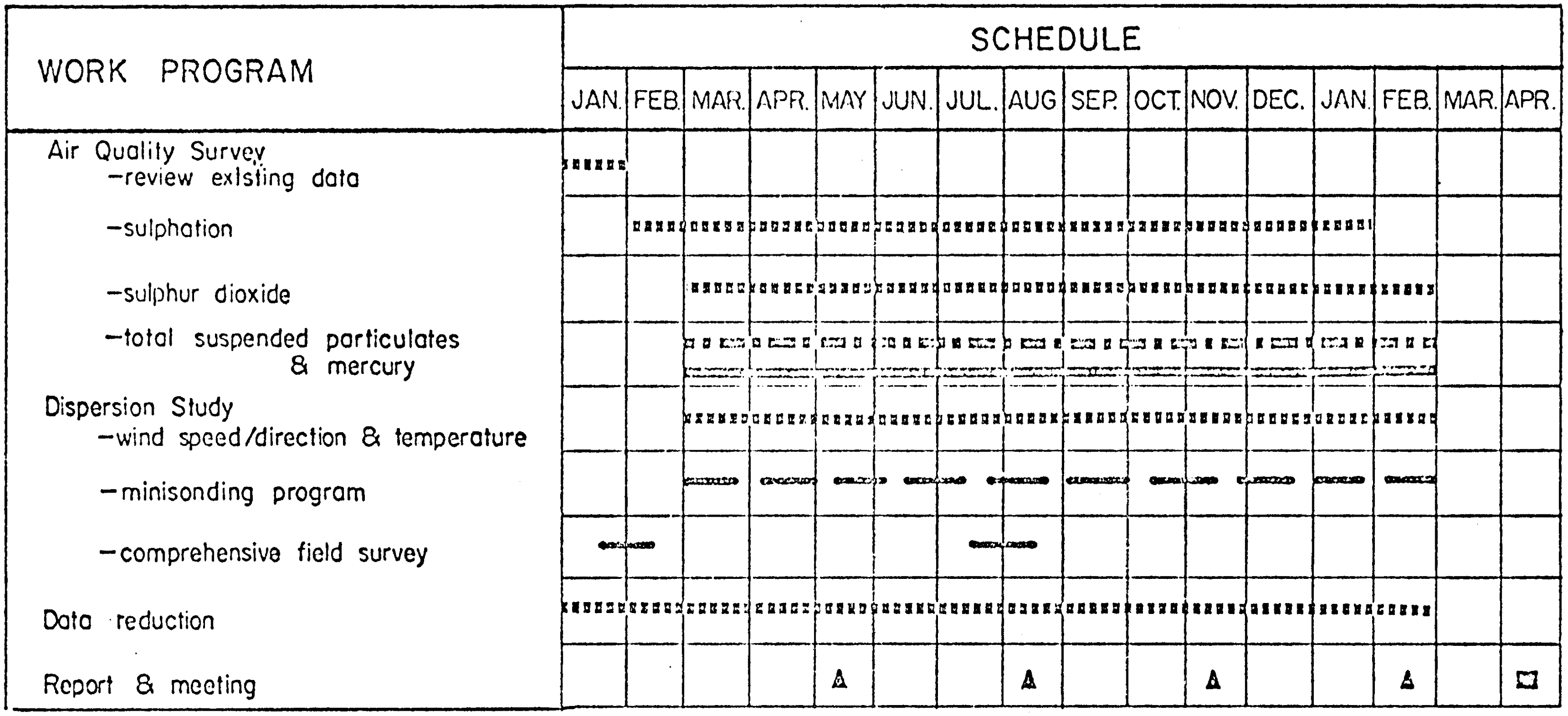
FIGURE 4.1.3.3.2.6

	J	F	M	A	M	J	J	A	S	O	N	D
N	8	1	7		13	22	22	17	12	9	4	5
NE	14	4	8		10	8	14	13	12	10	12	1
E	5	21	16		19	13	12	13	27	26	29	24
SE	13	24	14		5	1	4	2	4	9	8	14
S	10	9	17		14	11	14	21	11	13	5	22
SW	15	11	13		16	10	12	10	8	11	4	8
W	15	14	18		14	27	16	19	18	13	30	14
NW	12	7	2		7	7	3	4	6	2	2	3
CALM	8	9	5		2	1	3	1	2	7	6	9

Kamloops Dufferin Hill B.C. - Percentage Frequency Wind Direction (and Calms) by Months (Sept./73-Mar./74 and May/75-Sept./75)

FIGURE 4.1.3.3.2.7

FIGURE 4.1.3.4.1 **AIR QUALITY SURVEY AND DISPERSION STUDY: AFTON MINES LTD.**



LEGEND

- samples taken on an alternating hourly basis (mercury)
- continuous sampling
- two 24 hour samples per week (suspended particulates)
- two minisonde releases per day
- Δ progress report
- ◻ final report

AFTON MINES LTD.
KAMLOOPS, B.C.

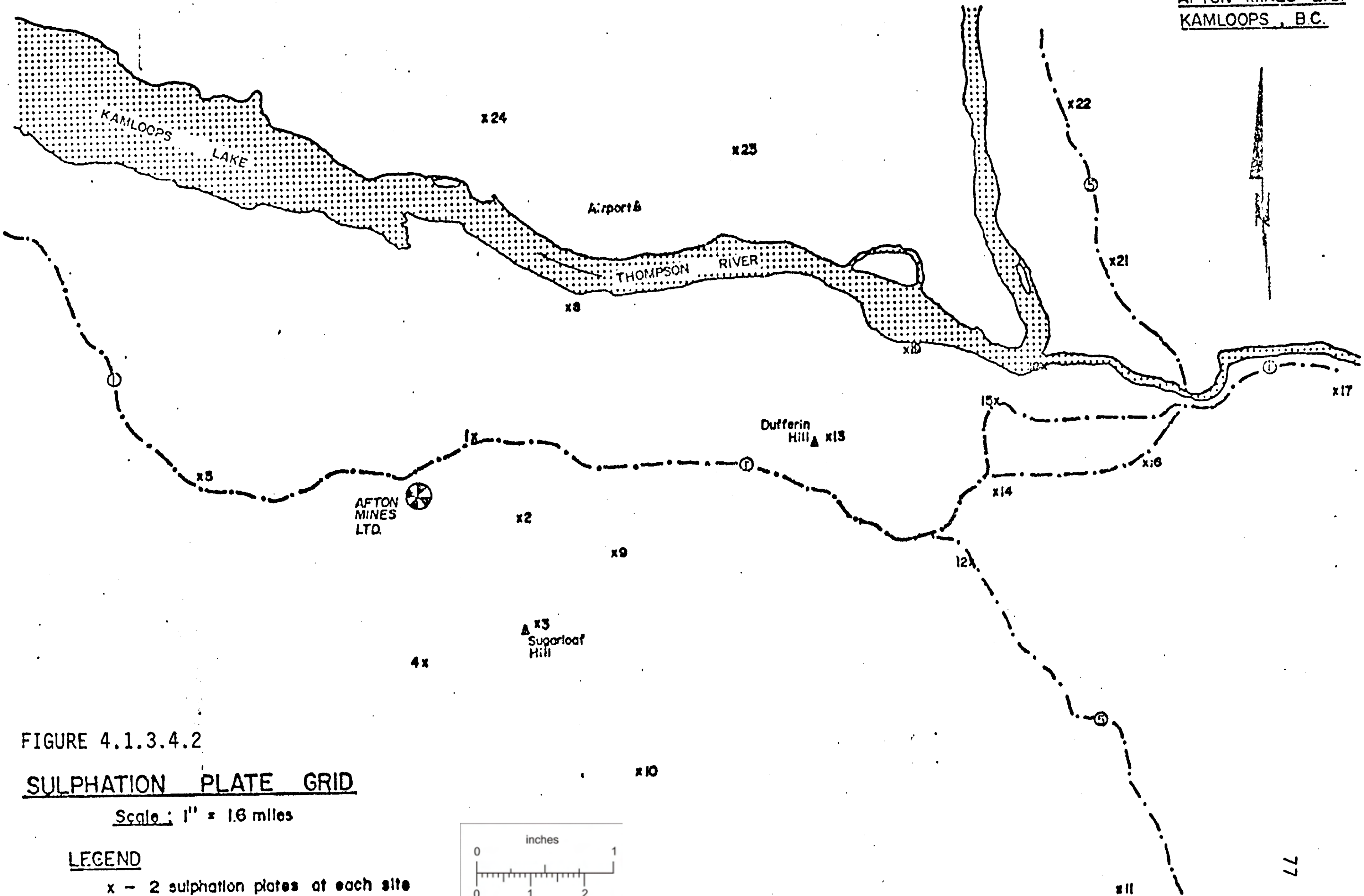


FIGURE 4.1.3.4.2

SULPHATION PLATE GRID

Scale: 1" = 1.6 miles

LEGEND

x – 2 sulphation plates at each site
Δ – meteorological stations

inches 0 1
0 1 2 centimetres

This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.

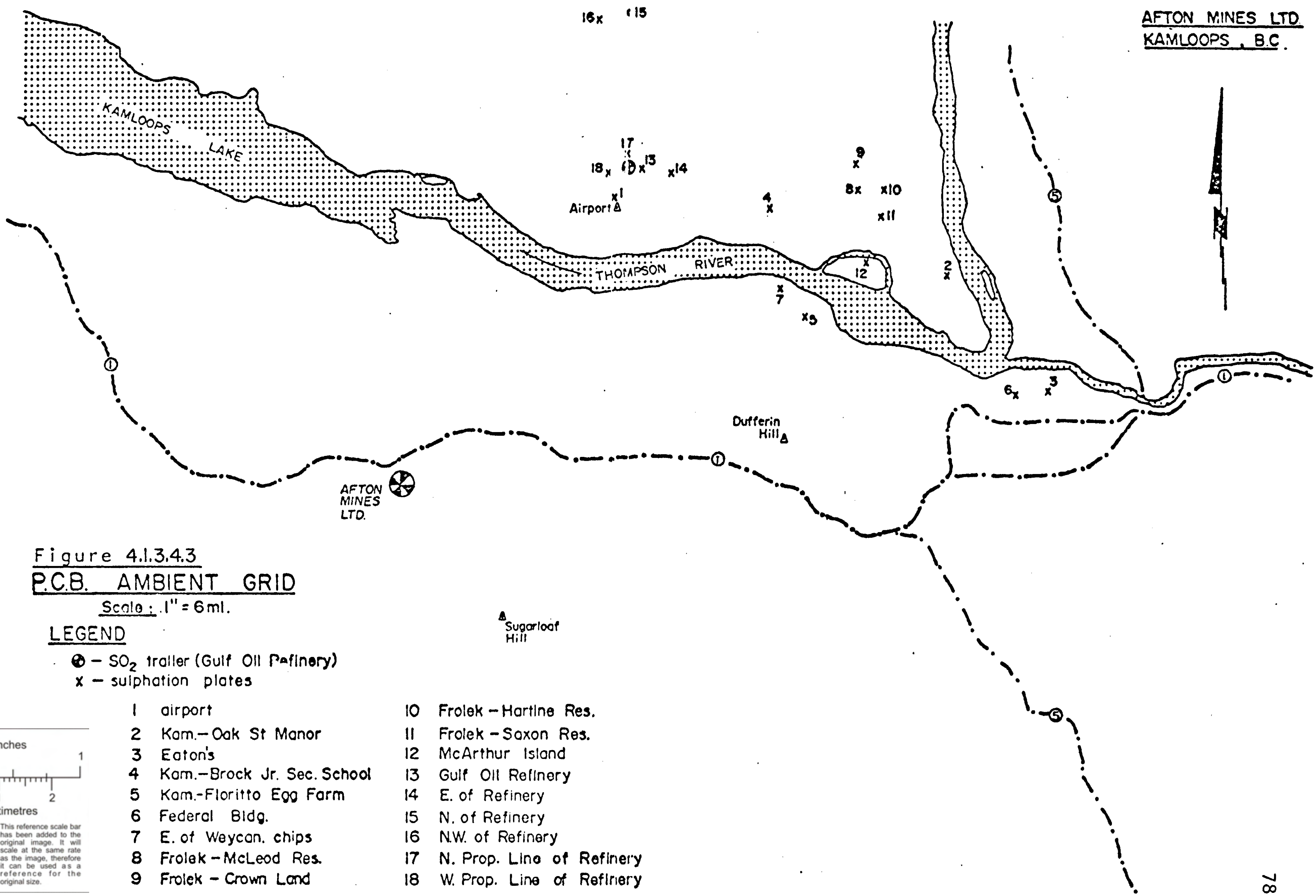


Figure 4.1.3.4.3

P.C.B. AMBIENT GRID

Scale : 1" = 6 mi.

LEGEND

- ⊛ – SO_2 trailer (Gulf Oil Refinery)
- x – sulphation plates

1	airport	10	Frolek – Hartine Res.
2	Kam. – Oak St Manor	11	Frolek – Saxon Res.
3	Eaton's	12	McArthur Island
4	Kam. – Brock Jr. Sec. School	13	Gulf Oil Refinery
5	Kam. – Floritto Egg Farm	14	E. of Refinery
6	Federal Bldg.	15	N. of Refinery
7	E. of Weycan. chips	16	N.W. of Refinery
8	Frolek – McLeod Res.	17	N. Prop. Line of Refinery
9	Frolek – Crown Land	18	W. Prop. Line of Refinery

4.1.4 CLIMATE AND TOPOGRAPHY

The property is located in the Interior Plateau, in the lee of the Coast Mountains. The mean annual precipitation in the area increases with elevations, and ranges from less than 10 inches in the vicinity of Ashcroft to 50 inches on the flanks of the Columbia Mountains east of Kamloops. Generally, about one-third of the annual precipitation falls during January to March. The average precipitation at three stations north and west of Kamloops, April to October during the years 1959 to 1961 was measured as follows:

Elevation (ft)	Precipitation (inches)
1160	5.34
1700	5.26
2275	5.89
2925	7.09
3125	7.41

In comparison, the average total annual precipitation at Kamloops, at 1243 ft elevation, from 1962 to 1971, was 10.57 inches. At Cherry Creek, at 1825 ft elevation, the 1971 average was 14.56 inches.

Within the property, the approximate ground elevations range from 2100 ft to 2600 ft, suggesting a mean annual precipitation of approximately 14 inches to 16 inches.

The prevailing air movement across the Interior Plateau is eastward from the Pacific Ocean. These air masses bring mild temperatures during all seasons, and are the cause of most precipitation in the area. Occasional intrusions of Arctic air during the winter months may lower the temperatures for a few days to -20°F to -30°F.

During the summer, hot and dry desert air from the western United States may penetrate north into the interior of British Columbia for short periods, and be responsible for high summer extreme temperatures exceeding 100°F.

The frost-free period at Kamloops is greater than 150 days. The last spring frost normally is in late April or early May, and the first autumn frost is in early October.

The Interior Plateau between the Cascade and Columbia Mountains occupies many thousands of square miles of the B.C. interior. In the past, through part of the plateau at elevations of 4000 - 4500 ft, the Thompson River and its major tributaries have carved valleys 2500 - 3000 ft deep, reducing the topography to its present series of broad, gently rounded hills.

The Afton Mines claims area is situated on undulating to rolling ground at an elevation of 2100 ft with localized peaks and drumlins extending up to 500 ft above this level. Slopes are relatively gentle, permitting cattle grazing throughout.

Figures 4.1.4.1 and 4.1.4.2 illustrate the general topography of the claims area.

Through a parallel drainage pattern, the Alkali-Cherry Creek system, draining the mine claims area, drops from about 2100 ft to 1124 ft (975 ft) over the 7½ miles northeast to Kamloops Lake.

Figure 4.1.4.1

Western end of Afton property showing Hughes Lake and area of proposed tailings dam. November, 1973 (21731-34A).

Figure 4.1.4.2

Area of proposed open pit; Highway No. 1/97 in background. Location is shown by arrow in Figure .1 above, November, 1973. (21730-21).

4.1.5 SOILS

AFTON MINES RECLAMATION--SOILS STUDY

Project 1741

December 31, 1975

Prepared for:

Afton Mines Limited
1135 West Hastings Street
Vancouver, B. C.

Prepared by:

Dr. L. M. Lavkulich
3468 West 23rd Avenue
Vancouver, B. C. V6S 1K3

with B. C. Research

INTRODUCTION

The consultant has been commissioned by Afton Mines Limited (N.P.L) to evaluate the soils resources of the proposed mine-mill operation located approximately 8 miles west of Kamloops, B.C..

The area was not visited for this phase of the study and thus data evaluation was based on available soils information (preliminary) collected by the Soils Division, British Columbia Department of Agriculture and other published literature pertinent to the study area. The report entitled "Environmental Statement Volume 1" prepared for Afton Mines Limited (N.P.L.) prepared by B.C. Research dated April 1974* served as the base document and Figure 1 of that report served as the base map. As a result of the unique conditions in the study area, with respect to the calcareous nature of the soils and in some instances relatively high salinity, on site examination, soil sampling and analyses would have been beneficial in order to more quantitatively assess the characteristics of the soil resources in relation to long term reclamation procedures.

The soil map and legend obtained from the Soils Division, British Columbia Department of Agriculture was prepared in 1973. The map and report have not been published and thus the information is preliminary. The soil mapping was conducted at a scale of 1:50,000 and thus the smallest realistic geographical area that can be delineated is about 160 acres (map area ½ inch by ½ inch). Thus on-site specific information about the soil resources could not be evaluated.

---

* References for Section 4.1.5 are listed on page 87.

GENERAL DESCRIPTION OF THE SOIL RESOURCES

The dominant soils in the area are Chernozems, commonly called grassland soils. These soils have brownish, organic enriched surface horizons and a calcareous subsoil. In some of the minor depressions are found saline chernozems. These are similar to the brown chernozems but have soluble salt accumulations in the subsoil. In the natural state, salinity is not generally sufficient to be toxic to the native vegetation.

The area is hummocky with slopes commonly between 9 and 30 percent. In two areas, one at the north end of the proposed tailings area and the other at the northeast end of the proposed waste disposal area are found soils shallow (less than 20 inches) to bedrock. Just north of the proposed pit, in the area of the proposed highway diversion, are found some chernozems developed on glacial fluvial deposits which have a sandy to silt loam texture and are somewhat stony. The remaining soils of the study area are developed on silt loam to silty clay loam glacial till.

SOIL PRODUCTIVITY

The chernozemic soils in this region are usually used for grazing unless irrigation water is available. The grasslands in the study area have grazing capabilities of class 2, with some class 3 (Runka, 1973). The main limitation for grazing is the result of aridity. Class 2 soils have an estimated productivity in the natural state of about 500 - 1000 lb per acre per year of natural forage, while class 3 soils have a productivity of 250 - 500 lb. per acre per year. Most of the area proposed to be the tailings area and waste disposal have soils of class 2 capability for natural range. The proposed pit area has dominately a rating of 3. Similar productivity ratings were reported by Maclean and Marchant (1968). In general, therefore the soils of the study area have relatively high productivity for natural grazing, the major limitations to plant growth are possible drought and occasional slight salinity. Without field checking, the extent of salinity both geographically and with depth could not be evaluated.

SPECIFIC SOIL AREAS

Using Figure 1 of B.C. Research's Environmental Statement, Volume 1 (1974) a more detailed description of the soils in relation to designated development follows. Soil nomenclature follows that of the System of Soil Classification for Canada (1974)

Tailings and Waste Disposal Areas

The proposed tailings area is dominated by Orthic Dark Brown Chernozems (50 - 70 % of the area) with the remaining areas having saline Dark Brown and Black Chernozems, usually in the more depressional areas. These areas have the best grazing potential. The soil is a silt loam to silty clay loam and thus of good water holding capacity. It is recommended that this area be stripped of topsoil and stockpiled for future revegetation programs. The actual depth of stripping will have to be determined following on-site examination. The same kinds of soils occur throughout the remaining area within the land or mineral claim boundary to the south.

Pit and Plant Area

The soil resources of the pit and plant area are dominated by Orthic Brown Chernozems (60 - 80 % of the area) with the remaining area having Saline Brown Chernozems. The texture of the soils are silt loams and silty clay loams. It is recommended that the topsoil again be saved from the pit area for future reclamation.

Highway Diversion

No problems are anticipated on these Brown and Dark Brown Chernozems for the proposed highway diversion. The soils should lend themselves to road construction as the deposits are rather well graded and only weakly saline. Revegetation of road banks, borrow areas etc. should pose no serious problems.

SUMMARY

In general the soils of the proposed tailings disposal, waste disposal and pit areas should be stripped of topsoil prior to development for progressive reclamation of the area. The depth of stripping could not be assessed without field inspection. The limitation to depth of stripping is the potential of localized areas of high salinity which should be left intact. It is suggested that before development proceeds an on-site evaluation be conducted. This would include more detailed soil mapping (e.g 1:10,000) soil sampling and analysis for pH; salinity, organic matter and natural fertility. This information could be interpreted in terms of a progressive reclamation program during the developmental and operational life of the mine.

L. M. Lavkulich
Soils Consultant

Approved on behalf of B. C. Research

C. C. Walden,
Head, Division of Applied Biology

REFERENCES

B. C. Research 1974. Environmental Statement--Volume 1. Prepared for Afton Mines Limited (N.P.L.) Division of Applied Biology, B. C. Research, Vancouver, B. C. V6S 2L2.

Canada Soil Survey Committee, 1974. The System of Soil Classification for Canada. Agriculture Canada, Ottawa.

Runka, G. G. 1973. Methodology--Land Capability for Agriculture, B. C. Land Inventory (C.L.I.). Soil Survey Division, B. C. Department of Agriculture, Kelowna, B. C.

McLean, A. and Marchand, L. 1968. Grassland Ranges in Southern Interior of British Columbia. Canada Agriculture, Publ. 1319, Ottawa.

4.2 TERRESTRIAL BIOLOGY

4.2.1 HABITAT TYPES AND LAND USE

Information on habitat types and present land use in the development area is presented in tabular form in Tables 4.2.1.1 and 4.2.1.2. Figure 4.2.1.1 shows a habitat type map of the area.

A number of vegetation communities exist on the approximate 2700 acres owned or under grazing leases. In decreasing order of magnitude, these are presented by simplified potential or climax vegetation units, together with their present vegetation.

1. Big Sagebrush-Bluebunch Wheatgrass Range

Present Vegetation

Overgrazed seral range - this grazing-induced community comprising roughly 2074 acres includes big sagebrush and rabbitbrush as the predominant increaser species, with pasture sage, junegrass, Sandberg bluegrass, needle-and-thread, and western wheatgrass present in very minor amounts. Bluebunch wheatgrass was not observed and range condition is poor, with 60-70% bare ground observed between plants.

In the Ironmask Area, bordering the eastern boundary of grazing leases, Canada Department of Agriculture, Research Station range test plots in areas of fair-to-poor-condition range at approximately the same altitude contain the following species:

GRASSES AND SEDGES

Needle and thread	Sandberg gluegrass
Downy Brome	Columbia needlegrass
Sand dropseed	

FORBS

Yarrow	Lambs quarter (extra species)
Dwarf pussytoes	Fleabane species
Rockcress	Brittle pricklypear
Plaintain	Russian thistle

SHRUBS

Pasture sage
Big sagebrush
Rabbitbrush

Table 4.2.1.1

HABITAT TYPES IN THE AFTON MINING PROPERTY

	Total approximate acreage	APPROXIMATE ACREAGE PER VEGETATION COMMUNITY						
		1	2	3	4	5	6	7
Total property	2700	2074	41	33	267	166	44	75
Total occupied by mine operation	1031	-	-	-	-	-	-	-
Ultimate pit	139	118	-	-	-	6	1	14
Tailings pond and dam	472	305	34	22	57	12	7	35
Waste dump	368	307	-	-	27	34	-	-
Plant site	52	49	-	-	1	2	-	-

Legend

1. Sagebrush grassland
2. Cultivated fields
3. Drainageway
4. Forested areas
5. Saltgrass community
6. Bulrush community
7. Waterbodies

Table 4.2.1.2

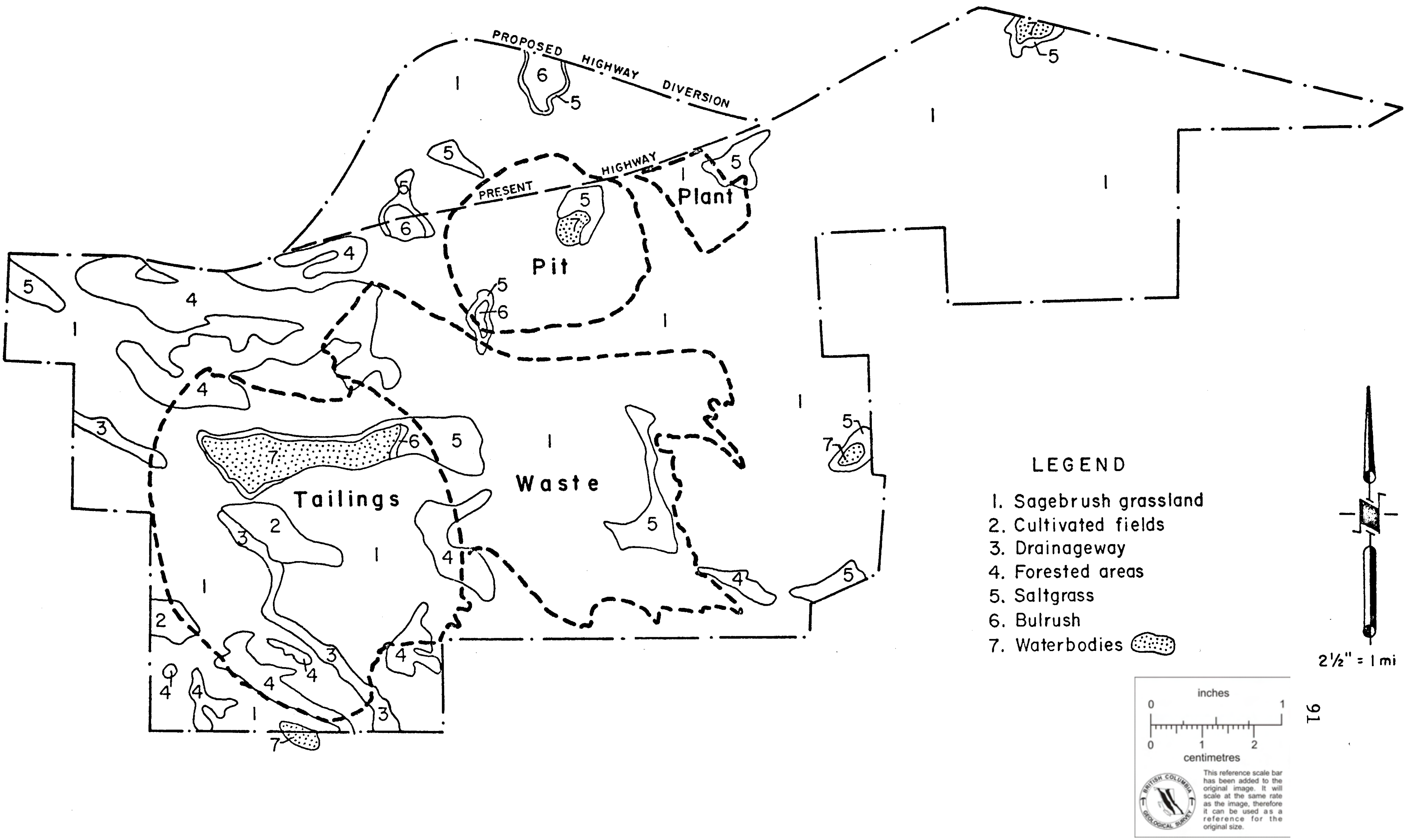
PRESENT LAND USE IN THE AFTON MINING PROPERTY

	Total approximate acreage	ACREAGE PER LAND USE CLASS					
		1	2	3	4	5	6
Total property	2700	2338	50	6	112	94	100
Total occupied by mine operation	1031	-	-	-	-	-	-
Ultimate pit	139	125	-	-	-	-	14
Tailings pond and dam	472	309	50	-	72	6	35
Waste dump	368	365	-	-	-	3	-
Plant site	52	52	-	-	-	-	-
Highway relocation	37	30	-	-	-	1	2
Fresh water pipe	34	24	-	-	-	10	-
Gas pipe relocation	7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Legend

1. Open grassland
2. Improved pasture and forage crops
3. Swamp, marsh and bog
4. Nonproductive woodland on a productive site. Evidence of grazing on the forest range.
5. Immature productive woodland. Evidence of grazing on the forest range.
6. Water surfaces

Figure 4.2.1.1
HABITAT TYPES OF THE AFTON MINES PROPERTY



2. Cultivated Fields

Two small fields, comprising roughly 31 acres, within the seral range area to the south of Hughes Lake, have been seeded with an alfalfa-timothy mixture. The established stand is apparently productive with flood irrigation. Another 10 acres near the southwest land boundary has been used to cultivate alfalfa.

3. Drainageway Community

This is possibly an edaphic climax of unit c below, but differs in being highly dependent upon surface or near-surface water supply. Plant species include Douglas maple, ponderosa pine, juniper, cherry, rose, buckbrush, willow and birch. The total area is approximately 33 acres.

Present Vegetation

Aspen occurs in groves, with scattered individuals of juniper, willow, cherry, rose, buckbrush, Douglas maple, clover and pinegrass. This community is represented primarily in the bed of Alkali Creek which is free-flowing only during runoff but probably flows underground through much of the year.

4. Ponderosa Pine-Bunchgrass Range

This community is represented by approximately 267 acres of forested range in the ecotone between the ponderosa pine zone and the Douglas fir zone. The B.C. Forest Service classifies the area as a "poor" site, in terms of forest production, with immature ponderosa pine and small numbers of Douglas fir on the south and southwest exposed portion of the unit and Douglas fir with some pine on the east and northeast exposed slopes. The majority of the trees are small and immature, ranging in height from 36 to 65 ft and in age from 81 to 100 years. There are a few mature fir and pine present, veterans from past fires.

In the climax condition, bluebunch wheatgrass should dominate as understory vegetation and abundant rough fescue and Idaho fescue should be present.

Present Vegetation

This poor-condition range contains big sage as an invader species, rabbitbrush, pasture sage, needle-and-thread Sandberg bluebunch, junegrass, wheatgrass species and an assortment of forbs.

5. Salt Grass Community

This is possibly an edaphic condition of the big sagebrush wheatgrass zone and occurs in a few small areas of salt flats to the east of Hughes Lake, at and near the proposed pit site, and near the plant site. Dominant vegetation is salt grass, (of little forage value) with a bordering cover of foxtail barley, also of little value for forage. The total acreage comprises approximately 166 acres.

6. Bulrush Community

This 19-acre lake-side community is dominated by soft stem bulrush bordering Hughes Lake, a water body which has been dammed to provide water storage near the southwest corner of the property.

The present land use categories compiled from the Canada Land Inventory data are presented in Table 4.1.4.2. Of the total 2700 acres, 2338 acres (86.6%) are classified as open grassland, 94 acres (3.5%) are classified as immature productive woodland, 100 acres (3.7%) are classified as water surfaces, 112 acres (4.1%) are classified as nonproductive woodland on a productive site, 50 acres (1.8%) are classified as improved pasture and forage crops and the remaining six acres (<1%) are classified as swamp marsh and bog.

Information supplied by the Provincial Lands Branch, Kamloops indicated that in 1973, range condition was fair to poor on grazing leases held by three ranches on the Afton mineral claims.

4.2.2 WILDLIFE MAMMALS

Although Banfield (12), (Appendix 6), lists 51 mammals whose ranges coincide with the Afton property, only 9 have been observed or reported by company personnel and the former owner on site, and by the Fish and Wildlife Branch, Kamloops. These are chipmunk, pocket gopher, muskrat, procupine, fox, coyote, bobcat, mule deer and moose. Undoubtedly, there are more small mammal species in the area than are listed here.

The potential for ungulate production in the entire claim area is moderately high. The Canada Land Inventory rates the area as winter range for deer and moose, with moderately high productivity, limited mostly by moisture deficiency.

Mule deer are reported to use relatively open areas of the mine property from March to early May, feeding on the sages and grasses. According to the former property owner, the deer population, formerly a nuisance around haystacks, has decreased over past years. However, a herd of seven mule deer were observed north of Highway 1/97 by company personnel in the fall of 1973.

The B.C. Fish and Wildlife Branch (Kamloops) reports that mule deer cross the highway in the vicinity of the proposed open pit.

Only one moose has been seen on the Afton property by the former owner in 23 years.

4.2.3 AVIFAUNA

Appendix 7 is a check list from the literature of the birds whose breeding ranges coincide with the Afton property area but does not include species which migrate through the area but do not breed there.

The Canada Land Inventory classifies the capability of lands for waterfowl production on the Afton Mines property as follows:

	TOTAL	ACREAGE PER CAPABILITY CLASS		
	Acreage	Class 4	Class 5	Class 7
Total property	2700	161	6	2533
Ultimate pit	139	20	-	119
Tailings pond / Tailings dam	472	42	-	330
Waste dump	368	-	-	368
Plant site	52	-	-	52
Highway relocation	37	3	-	34
Freshwater pipe	34	-	-	34
Trans. pipe relocation	7	n.a.	n.a.	n.a.

Legend

Class 4 Lands having moderate limitations to the production of waterfowl

Class 5 Lands having moderately severe limitations to the production of waterfowl

Class 7 Lands having such severe limitations that almost no waterfowl are produced

The capability of the mining property for waterfowl production is limited. Roughly five and a half percent of the property lands, including Hughes Lake and other, minor water bodies, have some capability for waterfowl production. The remainder of the land is semiarid, and the limitations to the production of waterfowl are severe.

According to Afton Mines personnel on site, four broods of ducks (unidentified) were present on Hughes Lake in 1975, indicating that nesting does occur on the mine property. A major use of the waterbodies on the property is likely for resting and staging of waterfowl during migration. The following waterfowl species were observed on April 26, 1974: goldeneye, buffehead, coot, lesser scaup, mallard, widgeon, pintail, and redhead. A single killdeer was also observed at the edge of Hughes Lake.

Information provided by the Department of Forestry and the Fish and Wildlife Branch, Kamloops, indicate that sharptail grouse range west from Ironmask Hill, north of Sugarloaf Hill to the south boundary of the mine's surface property at the city limits. According to the former property owner, sharptail grouse winter in the drainageway plant community of Alkali Creek near the southwest end of the property adjoining Hughes Lake. Pheasant populations have decreased markedly over the past few years whereas ravens and magpies using the area have apparently increased in numbers.

4.2.4 REPTILES AND AMPHIBIANS

According to G. C. Carl (13, 14) the range of the following list of amphibians and reptiles coincide with the Afton property:

Long-toed salamander	Ambystoma macrodactylum krausei
Western spadefoot toad	Scaphiopus hammondi
Northwestern toad	Bufo boreas boreas
Pacific tree-toad	Hyla regilla
Western spotted frog	Rana pretiosa pretiosa
Northern wood frog	Rana sylvatica*
Leopard frog	Rana pipiens*
Northern alligator lizard	Gerrhonotus coeruleus principis
Rubber boa	Charina bottae utahensis
Yellow-bellied racer	Coluber constrictor mormon
Gopher snake	Pituophis melanoleucus deserticola
Northwestern garter snake	Thamnophis sirtalis tetrataenia
Wandering garter snake	Thamnophis elegans vagrans
Pacific rattle snake	Crotalus viridis
Western painted turtle	Chrysemys picta belli

---

* Near limits of known range.

4.2.5 INSECTS

Although an insect survey has not been carried out for the property, exploration personnel report the presence of mosquitos, near water bodies, unidentified flies, horseflies, cicadas, and in common with most range areas in B.C., grasshoppers.

Other insects might include midges and other forms with a partially aquatic life history. Soil based insects are probably present.

4.2.6 RARE AND ENDANGERED SPECIES

Rare and endangered species of wildlife which may occur in the general area of the Afton property include the following birds: bald eagle, osprey prairie falcon and peregrine falcon; and one species of reptile, the yellow-bellied racer. (15)

4.3 AQUATIC ENVIRONMENT

4.3.1 HABITAT DESCRIPTION

Water bodies located within the mining property include the one-half mile long Hughes Lake which drains into Alkali Creek near the western property boundary. A much smaller lake, Pothook Lake, is situated immediately west of the eastern property boundary. Several small salt marshes also exist on the mining property.

Alkali Creek transects the southwest corner of the property, running in a north westerly direction to its confluence with Cherry Creek, which drains into Kamloops Lake. Water quality data, presented in Section 4.1.1.3 indicate that both Hughes Lake and Cherry Creek can sustain faunas of benthic and pleagic organisms, although the water in both drainages is hard.

4.3.2 FISH

Fish have not been reported in Hughes Lake either by the former owner or by the Fish and Wildlife Branch, Kamloops. Cherry Creek produces a small native rainbow trout fishery which is not heavily utilized because of limited public access.

Kamloops Lake serves as a rearing area for juvenile coho, chinook, and sockeye salmon and lies on an important migration route for the abundant Adams Lake stock (8).

4.3.3 BENTHOS AND PLANKTON

Because of time limitations, B.C. Research has not conducted on-site evaluations of benthos and plankton in waters relating to the Afton project. These studies should be carried out at intervals starting in the spring of 1976.

4.4 SOCIO ECONOMIC FACTORS

4.4.1 POPULATION DISTRIBUTION AND TRENDS

The City of Kamloops has been one of the Province's fastest growing cities. The urban area has a population of about 60,000, most of which is now encompassed by the May 1, 1973 enlargement of the City boundaries. Kamloops School District, with a population of 55,000 at the 1971 Census, was given a projected population of over 70,000 in 1976 in B.C. Research's "British Columbia Population Projections 1974-1996". The 70,000 figure may be somewhat high as it was a projection of the 1961-1971 growth rate, and was not based on a detailed analysis of recent growth factors for the area. The high growth rate of recent years reflects the substantial industrial and trade expansion of the area, and the importance of Kamloops as a regional centre. The recession of the past year, the current low level of activity in construction and the poor fortunes of the forest industry have been hard on Kamloops, and there is no better reflection of this than the number of houses on the market at the present time. A sample survey indicated that 16% of the houses in Kamloops are vacant and in addition there are 400 empty apartments.

4.4.2 LAND USE PATTERNS

The proposed Afton open pit lies 1½ miles west of the new city boundary and is within Electoral District J, a subdivision of the Thompson Nicola Regional District. The small portion of Afton optioned grazing leases shown as actually lying within the city will not be part of the area affected. Electoral District J is sparsely settled, and at the 1971 census contained only 1,000 people in its entire 1,377 square miles. Since the Afton claims cover approximately 3.4 square miles, and the proposed development only 1½ square miles, the conflicts with existing settlement patterns are minimal. There is a trailer court and a ranch residence about 1½ miles west of the proposed pit, and another ranch residence about 1½ miles southwest. There are also a few other properties in the Cherry Creek area which runs generally northwest of the mine site for a distance of about 7½ miles.

Average daily traffic on the Trans-Canada west of the intersection with Route 5 was measured at 10,000 vehicles per day in 1972, and for 1962 it was only 1,875. Although 1975 data are not yet available at the time of writing, it is expected to show a further increase to nearly 12,500.

4.4.3 REGIONAL ECONOMIC BASE

The 1974 manufacturing payroll in the Kamloops area was $20.6 million, and gross income of the populatin exceeded $310 million. Major forest products employers are Weyerhaeuser and Balco, with about 600 employees each. The major copper mining area of Highland Valley is not far away (Lornex is 47 miles from the city), and a cement plant and other industries are complemented by a large service industry payroll. The city's strategic location with respect to rail, road, and air networks has accounted for much of the impetus to growth. Other industries contributing substantially to the economy of the Kamloops area are transportation, ranching, recreation and travel.

The infrastructure of the Kamloops area (i.e. roads, schools, hospital, water and sewage systems) has kept pace with population growth.

4.4.4 ARCHAEOLOGY AND HISTORY

The earliest record of settlement in the vicinity of the Afton property area dates back to 1860 at the mouth of Cherry Creek at Kamloops Lake. The Hudson's Bay Company, a year earlier, had rejected Cherry Creek as a suitable site for their proposed farm, although early fur traders had found the valley to provide good pasture for their horses.

The chief crops grown during the 1860's and 1870's were potatoes and barley. An orchard was also planted during the period. One of the finest ranches in the interior of B.C. (Cherry Creek Ranch) was developed during the following years. Hughes Lake was named after a retired sailor who settled at Cherry Creek in 1880 in the vicinity of the lake, on the lands where the Afton Mine claims are now located.

Early mining records date back to 1890, when the Glen Iron Mine was developed at the mouth of Cherry Creek. The mine later became unprofitable and was closed by 1900.

Gold-copper ore was discovered in 1896. Several small mining operations had short life spans, the most endurable being the Python, near Python Lake which was active at intervals for 10 years. At Roper Hill, the Copper King had shipped ore for a brief period. However, the Ironmask, later as Kamloops Copper Company, was the only mine in the area to achieve steady production. In 1913, 75 men were employed before a fire caused a serious setback. The enterprise never fully recovered.

Mr. Bjorn O. Simonsen, Provincial Archaeologist, advises that no known sites of archaeological value exist on the claims area.

5.0 ENVIRONMENTAL IMPACTS AND MITIGATIONS OF EXPLORATION AND CONSTRUCTION

The following environmental factors have been used to evaluate the potential impacts of the proposed project.

Aquatic Factors

Surface - stream alignment
- stream discharge
- water quality
- invertebrates
- fish habitat
- fish

Sub-surface - water table
- water quality

Terrestrial Factors

Topography
Soils
Big Game habitat
Waterfowl
Upland Birds

Land Use

Agricultural Land Reserve
Grazing Land
Cropland
Outdoor Recreation

Air Quality

Noise

Traffic Patterns

Aesthetic Value

Note: No archaelogical sites were discovered by the Provincial Archaelogist in 1974.

5.1 For exploration the following project activities will be discussed:

1. Crew site acitivity
2. Public access
3. Road construction
4. Drill sites and trenches.

Exploration is now virtually complete. Activity of the exploration crews have not been reported to have had any effects on the listed environmental factors. Public access has been limited since the property is fenced and protected by a locked gate. New road construction by the Afton exploration personnel has been very limited; roads used were already in place as a result of previous exploration by another company. However, some minor topographic change has occurred and soils disturbed on an Agricultural Land Reserve used for grazing. Dusting likely occurred through road use during the dry summer months. Traffic noise would be minimal.

In this relatively flat semi-arid area, the construction of drill sites and the 2300 ft of trenches for exploration has resulted in moderate disturbance of topography, soils, grazing land. Again, fugitive dust would have been raised during the summer months.

Since the exploration activity has been confined to a great extent to areas which are slated for mining, no restoration of disturbed areas is planned.

In summary, exploration has produced moderate disturbance of soils creating dust and removal of some grazing land. No mitigation is planned.

5.2 Potential Impacts of Construction

5.2.1 For the mine, the major project activities are described as 1) overburden removal, 2) overburden dumping and stockpiling, 3) highway diversion, 4) relocations of oil and gas pipeline, telephone line and partial relocation of 25 KV transmission line.

Overburden removal may first require pumping of the seasonal pot hole overlying the pit. Because of extremely high dissolved solids at times during the year (see Table 5, Water Quality, Appendix 5). This water should not be permitted to enter a watercourse used for either drinking or irrigation. How overburden removal will affect the groundwater table is not known at this time but topographic change and soil disturbance will occur. A detailed soil survey is planned to determine those soils which should be isolated and those to be saved for reclamation stockpiling. Both big game habitat and a migration path will be removed as will the seasonal pot hole used by waterfowl for resting and staging. Alternate routes are available for deer crossing the highway; the creation of wildfowl habitat in Pothook and Moose Lakes should compensate for the loss of the seasonal pothole on the proposed pit.

With the removal of surface soils and vegetation, grazing land totalling 125 acres will be lost; it is possible that range improvement practices planned for the adjoining Sugarloaf Ranch will compensate for this loss.

Removal of the 6-acre pothole will reduce available Class 4 CLI recreation capability and may be visually offensive to some. Noise from machine activity and any blasting required may be unavoidable but should be attenuated as the pit is deepened.

Overburden dumping and stockpiling for dam building and reclamation fill will affect seasonal watercourses (see Section 4.1.1) alignment and discharge and may affect the water quality for downstream users through increased suspended sediments unless care is taken with both materials handling and seasonal timing. Topographic change and soil disturbance will occur through transport and dumping. Grazing for cattle and wildlife will be reduced and unless roads are watered, dusting will be a problem. Equipment noise will be unavoidable as will the altered appearance of the landscape.

5.2.2 The highway diversion is unavoidable if the pit is to be developed. Planning would allow for the diversion to be built with relatively unobstructed traffic flow until final connection with the present highway. The project will cost some $700,000 for land and construction, generating employment but will also result in the removal of grazing land, and wildlife and waterfowl habitat. Equipment noise will be unavoidable and upon completion, the new highway section will overlook the mine mill operation. It is suggested that Afton Mines consider building an earthwork berm between the highway and the pit. When planted, the berm would provide an effective visual and sound barrier.

Combined, the relocations of the oil and gas pipelines, the telephone line will have much the same impact as highway construction but reclamation plantings should compensate for range disturbance. It is recommended that roads required be kept to a minimum. Some inconvenience will be experienced by the users of the relocated facilities during reconnection. No danger to the facilities is expected through blasting in the open pit.

5.2.3 For construction of the proposed mill, the parameters which could have an effect on the environment are:

- the water pipeline
- crew site activity
- site leveling
- road construction
- major buildings
- chemical storage
- soil stockpiling
- waste and tailings dams

Stream alignment and discharge of Alkali Creek must be modified to protect the waste and tailings dams and to ensure downstream water supplies. Since Alkali Creek already joins Cherry Creek below the mine property, diverting Alkali Creek to Cherry Creek above the property should not change the chemical quality but unless carefully carrie' out could result in an increased level of suspended solids from the new channel.

Other potential modifications of water quality, (mainly erosion products) could be caused by construction of the water pipeline from Kamloops Lake, site levelling, road construction and the soil stockpile. Drainage controls should ensure containment of erosion products and early reclamation of disturbed areas should be planned.

The effect on groundwater of the construction of the water pipeline to Kamloops Lake is unknown at this time but water intake screening must meet the Canada Dept. of the Environment Fisheries and Marine Service specifications and the provisions of Section 28 of the Fisheries Act.

Topographic features, soils, local vegetation, game habitat, habitat and range will be affected by most of these operations. The waste dump and tailings ponds will also remove 34 acres from planted forage production. In some measure waterfowl habitat created by damming Pothook and Moose lakes should compensate for the loss of Hughes Lake to tailings pond use. Reclamation planting to recreate the 22 acres of drainage--way community (Table 4.2.1.1) elsewhere would be very desirable to provide wintering areas for wildlife, particularly sharptail grouse.

Most of the mill construction activity will generate dust unless carefully controlled by area watering. Aesthetically, the view of this activity may be displeasing to some. Construction of the berm previously mentioned would screen the view from the highway earthwork berm.

5.2.4 The impacts of <u>smelter</u> <u>construction</u> are somewhat similar to those of plant construction under the following headings:

- crew site activity
- road construction
- site levelling
- major building erection
- chemical storage
- soil stockpiling

Possible short heavy rains (gulleywashers), might in the absence of drainage control facilities, result in erosion of disturbed soils which would impair downstream water quality through increased suspended sediments. Soil disturbance will occur in road construction, site levelling, and of course soil stockpiling. Fugitive chemicals where uncontrolled could also enter watercourses although the likelihood is remote.

Erosion products reaching Cherry Creek might reduce the capability of fish support. However surface drainage control structures should provide the necessary control.

Soil disturbance and topographic change will be inevitable but soil retential for subsequent reclamation should provide some mitigation. Swift reclamation planting of soil stockpiles should assist in reducing dusting during high winds.

Big game habitat will be reduced although not critically in view of the available supply of similar sagebrush grassland (Table 4.2.1.1). The effect of smelter construction on sharptail grouse is not known at this time but the important winter habitat in the drainageway community will have been removed during tailings pond construction. This community should be restored elsewhere through saving and planting stock (seeds and cuttings) prior to removal.

Construction crews have been known to harass and overharvest wildlife in areas adjacent to large projects. In the interests of personnel safety and wildlife protection, it is recommended that a no-shooting zone be established around the project.

A total of approximately 49 acres of grazing land and Class 4 (moderate) recreation land will be used by the combined mill and smelter (Table 4.2.1.1).

Air quality may be impaired through uncontrolled fugitive dust.

Equipment noise will be unavodable but reduced at the highway with the use of a berm baffle. From the highway, contrast between a rural setting and industrial activity can be similarly reduced by a planted berm adjoining the highway.

Traffic loads might be expected to increase with construction activities which include transport of materials and movement of personnel during non-work hours.

5.2.5 In summary, exploration and construction has or may cause moderate topographic change, alienation of an Agricultural Land Reserve, localized impairment of air quality through uncontrolled fugitive dusting, equipment noise, reduced outdoor recreational capability, for some, reduced aesthetic values, and minor temporary disruptions in the use of highways, oil and gas facilities, electric power and telephone.

Aquatic factors include diversion of Alkali Creek, an ephermeral stream to join Cherry Creek above instead of below the mine property, possible impairment of water quality through increased suspended sediments or products of erosion, reduction of waterfowl breeding and staging in Hughes Lake and the pit pothole, and possible conflict with the fishery resource at the Kamloops Lake water supply intake. Unknown factors include the effects of the water pipeline and the pit overburden removal on groundwater table and quality.

Possible adverse terrestrial effects include removal of grazing lands and 34 acres of cultivated forage cropland, removal of soils from productivity during stockpiling for reclamation, removal of big game habitat and modification of road crossing for deer, and the removal of drainageway community as winter habitat for sharptail grouse. Unknown effects are those on endangered species, carnivores and furbearers, other small mammals and song birds.

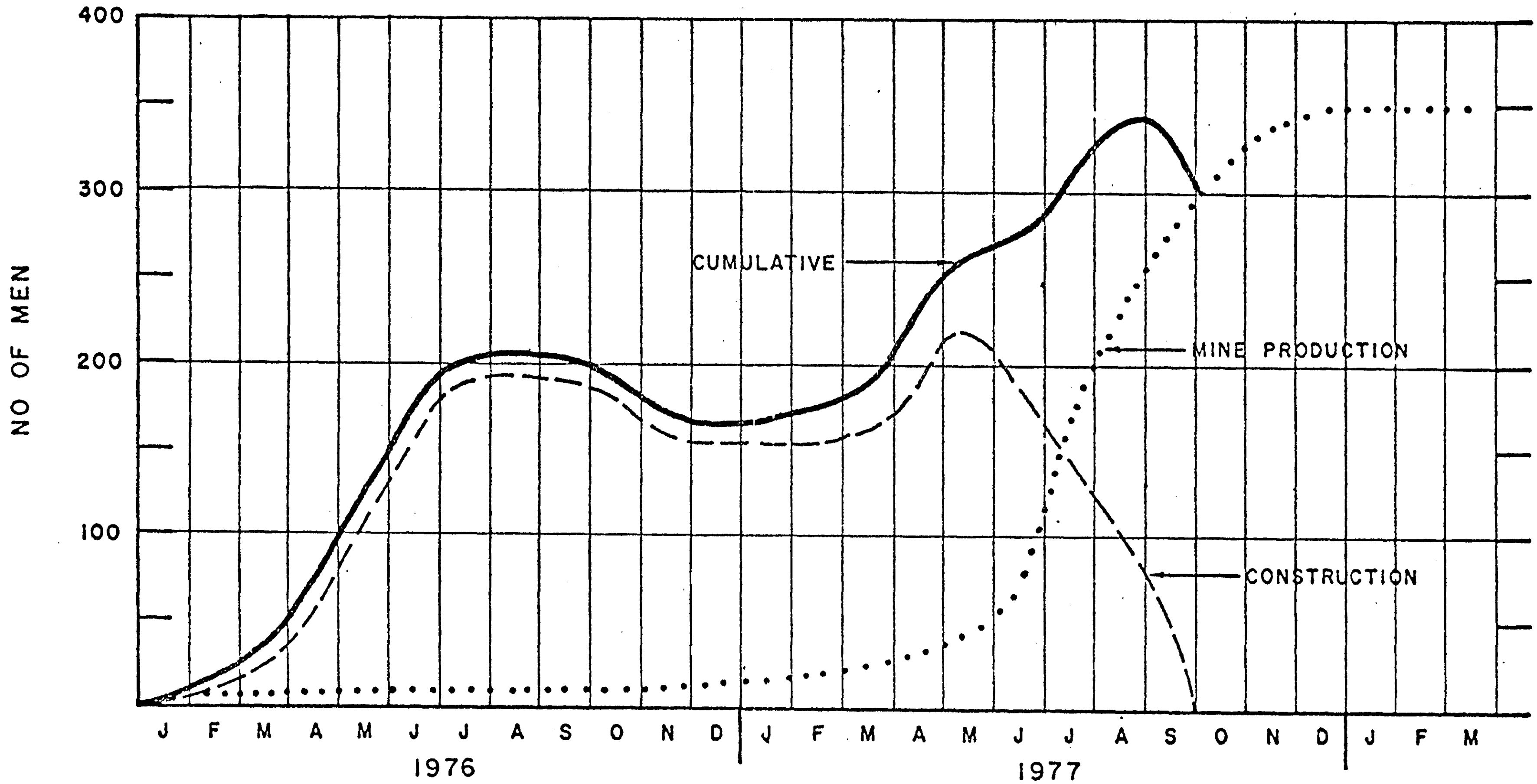
Beneficial impacts include a bolstering of local Provincial and Federal tax bases and increased employment with attendant community benefits.

Mitigations suggested are: area watering for dust control, the construction of a planted berm to screen noise and view of the operation from the highway, lining the diversion canal of Alkali Creek with a non-eroding material, creation of replacement waterfowl habitat by damming Pothook Lake and Moose Lake (already planned), use of a Federally approved intake structure at Kamloops Lake (already planned), range improvement of adjoining Afton Mines land and Sugarloaf Ranches land to compensate for lost productivity in lands required by the proposed project complex, prompt reclamation of disturbed soil areas (which will remain undisturbed by later activity), prompt reclamation of soil stockpiles, replacement, if possible, of a like area of drainageway community to that removed and further observations of songbirds, small mammals, and any possible endangered species listed in Section 4.2.6.

5.3 SOCIO-ECONOMIC CONDITIONS

The impact of employment at the Afton project will be dealt with more fully under Section 6.0, "Environmental Impacts and Mitigations of Operation and Post Operation". Much of what is said in that section applies to the construction stage. Since employment on operations will start its major build-up as construction employment is only just starting its rapid descent from its peak about May 1977, there will be a period of overlap (see Figure 5.4.1). However, at the peak of the overlap the total will not likely be significantly higher than the employment during ongoing operations and part of the construction force would still be in the construction camp. If the Hat Creek development of B.C. Hydro goes ahead as planned there would be a period of about a year in which overlap between the two projects occurred. However, it seems unlikely that Kamloops would feel any adverse effects from this overlap.

Currently there is reported to be a 16% vacancy rate in houses in the Kamloops area. Under these circumstances there will be no problem of housing shortage for those of the construction force that wish to bring their families to Kamloops for the period of the project. On the contrary an influx of poential home buyers (although relatively few in number) would have the beneficial effect of firming up the currently depressed housing market.



AFTON MINES LTD.
MANPOWER SCHEDULE

FIGURE 5.4.1

6.0 ENVIRONMENTAL IMPACTS AND MITIGATIONS OF OPERATION AND POST OPERATION

The same environmental parameters are used to evaluate potential impacts of project activities of operation and post operation as were used for exploration and construction. For review, they are:

Aquatic Factors

Surface - stream alignment
- stream discharge
- water quality
- invertebrates
- fish habitat
- fish

Sub-surface - water table
- water quality

Terrestrial Factors

Topography
Soils
Big Game habitat
Waterfowl
Upland Birds

Land Use

Agricultural Land Reserve
Grazing Land
Cropland
Outdoor Recreation

Air Quality

Noise

Traffic Patterns

Aesthetic Value

Note: No archaeological sites were discovered by the Provincial Archaelogist in 1974.

6.1 MINING OPERATION IMPACTS AND MITIGATIONS

Proposed project activities are outlined as follows:

pit drainage
ramp drainage
road drainage
area drainage
overburden dump
waste rock dump
mining
drilling and blasting
reclamation
ore transport to crusher
future undergrounding

Stream alignment and discharge were discussed in the previous section on dam construction as it affects Alkali Creeks. Since all pit and area drainages will be collected and discharged to the tailings pond, their potential impact will be discussed under tailings disposal in section 6.2.

Mining and possible future underground mining will have an as yet undetermined effect on the groundwater table. No other effect on water such as water quality is anticipated.

Irreversible topographic change will occur in mining. The possibility of using the open pit for waste and tailings disposal is remote at this time since present information suggests the feasibility of underground mining at the cessation of open pit operations.

How reclamation can soften topographic change of the pit operation is not known at this time but from the configuration it is unlikely that any but a near-surface cosmetic effect can be achieved. To return all waste rock and overburden to the pit would impose impossible economic restrictions on the whole operation.

The overburden waste and waste rock will be used to progressively increase the necessary height of the tailings dam and any excess overburden will be stockpiled for filling and levelling the waste rock dump. Soils beneath stockpile areas should be allowed to remain intact. After stockpile removal, soils should subsequently recover their capability to support vegetation.

Both the overburden and waste rock dumps will remove some wildlife range capable of being restored by final reclamation once final contouring is completed, but not immediately. The time frame for return of affected land to production is of the order of 20 years.

As the construction and size of the tailings pond and waste dump progress, the available area of Hughes Lake will decrease, removing all waterfowl support capability. In the meantime, it is anticipated that, through water accumulation and retention, the size of both Pothook and Moose Lake should increase and with establishment of lake edge plantings, provide mitigation for waterfowl habitat lost.

Adjoining the increased edges of the expanded lakes and in their natural drainage courses (should seepage permit), some possibility exists for the establishment of drainageway communities (see Table 4.2.1.1) as replacement for those lost to tailings dam construction. The provision of replacement winter habitat containing shelter and seed food for sharptail grouse would be extremely desirable as a mitigation for habitat lost.

Progressive reclamation on all mine disturbed areas will not be feasible until most mining operations cease since dumps will be "live" and restoration - involving recovering by overburden and soil - will necessarily be delayed until contouring is completed.

Where possible, reclamation should be scheduled prior to cessation of mining activities. The company is committed, by bond, to provide completely acceptable restoration of the entire property (see Section 2.5.1.2).

Fugitive dust resulting through use of roads during the dry summer months may occur, unless controlled, as the major impairment to air quality for the mining operation. Above the pit, where possible, reclamation should be taking place to assist in dust control through establishment of irrigation supported vegetation.

Equipment noise and ore removal by blasting will be unavoidable. For blasting, it is recommended that shots be fired at irregular intervals during the work day to avoid irritation to the closest neighbours (see 4.4.2). The noise of ore transport trucks may be unavoidable but somewhat reduced by topography, distance, wind direction, and barometric pressure.

From the highway, aesthetic contrasts between the operation and the natural setting should be muted by the suggested planted berm (see Section 5.0). Also, progressive reclamation inside the property should reduce the aesthetic impact to some degree.

A test program (see Section 6.1.1 below) has indicated that the probability of acidic (i.e. significantly contaminated) drainage from the waste dump is effectively nil due to the alkalinity of the rock.

6.1.1 Acid Production Potential of Samples from the Afton Property

SUMMARY

Seven samples of waste rock from the Afton Mines property were examined for their acid production potential. None of the samples examined were a potential source of acidic drainage water.

INTRODUCTION

OBJECTIVE

To assess the potential for the formation of acidic drainage water due to microbiological oxidation of sulfide minerals contained in samples of Afton Mines waste rock.

BACKGROUND

Many sulfide minerals can be oxidized microbiologically to sulfuric acid and soluble metallic sulfate salts. This phenonenon can result in a water pollution hazard if the amount of sulfuric acid which the bacteria produce exceeds the neutralizing capability of the sample or the surrounding host rock.

If acidic drainage water occurs, the microbiological attack on sulfides contained in the sample, as well as the microbiologically produced acid, can solubilize heavy metals which would be toxic to aquatic flora and fauna in the area if they were allowed to enter receiving waters.

Afton Mines Ltd. is developing a copper deposit near Kamloops in British Columbia. Test drilling has produced samples of the various types of mineralization encountered on the property. A preliminary environmental study of the Afton property (1)* indicated that a potential for microbiological acid production might exist. Accordingly drill logs and drill cores were examined by Dr. R.O. McElroy of B.C. Research and Mr. A.J. Reed, Geologist, with the objective of obtaining a suitable number of samples that would represent all the types of waste rock to be excavated during development so that the potential production of acidic drainage waters could be assessed accurately.

B.C. Research has developed a two-part test which allows prediction of the acid producing potential of a particular sample. This report presents the results of our evaluation of the samples submitted by Afton Mines Ltd.

* Reference numbers for Section 6.1.1 only. These references are listed on p. 114.

MATERIALS AND METHODS

SAMPLES

Following a review of core logs, appropriate sections were selected to represent the major rock types present; sections which contained relatively large amounts of sulphide mineralization or anomalous mineralization (marcasite) were also identified for sampling. Seven individual samples (Table 1) were made up from drill core rejects and brought to B.C. Research November 13, 1975. The samples were crushed and pulverized, and 10 g portions were used for the initial chemical test as outlined in Appendix 1.

STAFF

This investigation was carried out by the Mineral Microbiology Group of the Division of Applied Biology. Miss H. Kurtz was responsible for the acid production test, assisted by Mr. L. Gutiérrez. Miss M. Lewis was responsible for the copper and sulfur analyses. Dr. R.O. McElroy in consultation with Dr. D.W. Duncan was responsible for the interpretation of the experimental results and preparation of the report.

RESULTS

INITIAL TEST (CHEMICAL)

The sulfur contents and the equivalent sulfuric acid contents of the various samples are shown in Table 1. The highest sulfur content (2.4%) was in a sample of Nicola volcanic material. This was equivalent to 144 lb of sulfuric acid/ton.

All of the samples examined had a natural pH in excess of 9 and as shown in Table 1, they all consumed more acid than they could theoretically produce if all the sulfur contained were converted to sulfuric acid. It was therefore concluded that none of the samples examined could be an excess acid producer.

CONFIRMATION TEST (BIOLOGICAL)

The confirmation test was not carried out on these samples since the chemical test had shown they could not produce excess sulfuric acid.

DISCUSSIONS AND CONCLUSIONS

The experimental results indicate that all the samples examined consumed more sulfuric acid than they could theoretically produce without lowering the pH into the leaching range. The addition of acid in these tests was stopped once the experimental amount had been exceeded and thus the values reported do not record the maximum acid consumption. In fact, as shown in Table 1, the final pH obtained with the various samples was above 7 except for the Nicola volcanic sample where the final pH was 5.3 and the chalcopyrite-pyrite mineralization sample where the final pH was 5.9.

Without development of an acidic pH in waste dump material, dissolution of contained heavy metals (primarily copper) by percolating water will be negligible. Therefore no extraordinary measures will be required to prevent leaching.

The possibility was recognized that the copper contained in the sub-ore grade mineralization could be recovered by chemical leaching. The addition of 91.1 lb of sulfuric acid per ton to this sample lowered the pH to 4.6, whereas the addition of 149 lb per ton was required to lower the pH to 2.0. This amount of acid extracted 31.7% of the copper contained in the sample at an acid consumption to copper release ratio of 76:1.

R. O. McElroy
Extractive Metallurgist.

Approved on behalf of B.C. Research

C.C. Walden
Head, Division of Applied Biology.

ACKNOWLEDGEMENT

The assistance provided by Mr. A.J. Reed, P. Eng. in review of the property geology and core logs, and in obtaining the test samples is gratefully acknowledged.

REFERENCES

1. B.C. Research; Environmental Statement Vol. 1, Prepared for Afton Mines Ltd., April 25, 1974.

TABLE 1: ACID PRODUCTION POTENTIAL OF AFTON SAMPLES

Sample	Drill Hole (footage)	Description	% Cu	% S	Theoretical Acid Production lb/ton	Natural pH	Acid Consumption lb/ton	Final pH during test	Potential excess acid producer
1	73-36 (70-130)	Nicola formation; pyrite veinlets, potassium feldspar and chlorite	<0.03	0.45	27.0	9.2	> 30	7.5	No
2	72-12 (400-410)	Iron mask formation; suggested marcasite, propyllitic alteration, pyrite with calcite veinlets	<0.03	0.21	12.6	10.1	> 15	7.9	No
3	73-7 (340-600)	Greywacke, various tertiary sediments	<0.03	0.26	15.6	9.9	> 20	7.8	No
4	73-37 (610-620)	Nicola volcanics; high in pyrite	<0.03	2.40	144.0	9.7	>147	5.3	No
5	73-1 (350-380)	Clayey waste	<0.03	0.04	2.4	10.0	> 5	8.1	No
6	72-16 (130-190)	Chalcopyrite-pyrite mineralization	0.14	0.79	47.4	9.7	> 49	5.9	No
7	72-16 (490-600)	Sub-ore grade, native copper mineralization	0.31	0.03	1.8	10.0	> 2	8.3	No

APPENDIX 1

APPENDIX I

TEST PROCEDURES FOR EVALUATING ACID-PRODUCING POTENTIAL OF ORE AND WASTE ROCK

INITIAL TEST (CHEMICAL)

Sample

The sample selected must be taken in such a manner that it is truly representative of the type of mineralization being examined. A composite made up of split drill core or of randomly selected grab samples should be satisfactory. The number of samples to be examined will depend on the variability of the mineralization and must be left to the discretion of the geologist taking the samples. The bulk sample is crushed to a size which can be conveniently handled, (i.e. -2 in.) and then thoroughly mixed and approximately a 2-lb portion split out, by coning and quartering. This sample is then pulverized to pass a 100 mesh screen and used for assay, the titration test, and the confirmation test if necessary.

Assay

The pulverized sample is assayed in duplicate for total sulfur, using a Leco furnace. The total sulfur assay value is expressed as pounds of sulfuric acid per ton of sample, assuming a 1:1 conversion factor, which is the acid-producing potential of the sample.

Titration Test

Duplicate 10-g portions of the pulverized sample are suspended in 100 ml of distilled water and stirred for approximately 15 minutes. The natural pH of the sample is then recorded and the sample titrated to pH 3.5 with 1.0 N sulfuric acid with a radiometer automatic titrator. The test is continued until less than 0.1 ml of acid is added over a 4-h period. The total volume of acid added is recorded and converted to lb per ton of sample. This is the acid-consuming ability of the sample, i.e.

$$\text{acid-consuming ability (lb/ton)} = \frac{\text{ml of 1.0 N } H_2SO_4 \times 0.049 \times 2000}{\text{wt of sample in g}}$$

$$\text{or for a 10-g sample} \quad = \text{ml of 1.0 N } H_2SO_4 \times 9.8$$

Interpretation

If the acid consumption value (in lb of acid per ton of sample) exceeds the acid-producing potential (lb per ton) then the sample will not be a source of acid mine drainage and no additional work is necessary. If the acid consumption is less than the acid-producing potential, the possibility of acid mine water production exists and the confirmation test is conducted.

CONFIRMATION TEST (BIOLOGICAL)

Sample

The remaining portion of the pulverized sample is ball-milled (wet) for 2 to 3 h to produce a 400 mesh sample which is dried overnight at 105°C.

Shake-Flask Leaching Test

Duplicate 30-g portions (or a smaller amount if the sulfide content exceeds 2%) are placed in 250 ml Erlenmeyer flasks with 70 ml of a nutrient medium containing 3 g/l $(NH_4)_2SO_4$; 0.10 g/l KCl; 0.50 g/l K_2HPO_4; 0.50 g/l $MgSO_4 \cdot 7H_2O$; 0.1 g/l $Ca(NO_3)_2$. Add sufficient sulfuric acid (either 12 or 36 N) to bring the pH to 2.5. Shake the flasks for approximately 4 h and the pH should be between 2.5 and 2.8. If necessary add additional acid until the pH remains in that range, and then inoculate the flasks with 5 ml of an active culture of Thiobacillus ferrooxidans. Record the weight of the flasks and contents. Plug the flasks with a loose cotton plug and incubate at 35°C on a gyratory shaker.

The experimental leaching flasks are returned to their original weight before sampling by adding distilled or de-ionized water. Monitor the pH and concentration of a dissolved metal, e.g. iron, copper or zinc, for the first three days to ensure that the pH remains below 2.8. Thereafter, monitor every second day until microbiological activity has ceased, i.e. the pH no longer drops or the dissolved metal concentration remains constant.

When microbiological activity has ceased, add half the weight of feed used originally (i.e. 15 g), shake 24 h and record the pH. If it is greater than pH 3.5, terminate the test. If it is 3.5 or less, again add half the weight of feed (i.e. 15 g) and shake for 24 h. If the pH is less than 3.5 or greater than pH 4, the experiment is terminated. If the pH is between 3.5 and 4.0, the sample is shaken an additional 48 h and the final pH value recorded.

Interpretation

The object of this test is to determine if the sulfide-oxidizing bacteria can generate enough sulfuric acid from the sulfides present to satisfy the sample's acid demand. Experience has shown that not all sulfide minerals are amenable to microbiological attack nor do they all oxidize completely, so the acid-producing potential indicated by the sulfur assay may overestimate the danger. If the bacteria generate the acid, microbiological action will continue on a self-sustaining basis if it becomes established, and acidic mine water will result. In this test, the acid demand is satisfied initially by adding sulfuric acid. This permits the bacteria to generate the maximum amount of sulfuric acid from the sample concerned. Once microbiological action has ceased, half the original sample weight is added. If there has not been sufficient acid production, the pH will approach the natural pH of the sample (i.e. above pH 3.5) and the sample is reported as not being a potential source of acid mine water. If the pH remains at 3.5 or below, the remainder of the sample is added and the sample is shaken for up to 72 h before measuring the final pH. If the pH is still in the leaching range, i.e. pH 3.5 or below, there is a strong possibility that natural leaching will occur and acid mine drainage will be produced. If the pH is above 3.5, there is no possibility of acid mine drainage occurring.

If the sample produces excess acidity, there is the possibility of metal recovery by microbiological leaching. A measure of this potential can be obtained by estimating the percentage of the contained metal which has been solubilized during the leaching test. Under such circumstances, it may be desirable to promote microbiological action as a means of recovering valuable metals from a waste material. In such a system, suitable precautions must be taken to prevent the metal and acid-rich leach waters from entering the natural drainage system of the surrounding area.

6.2 MILLING OPERATION IMPACTS AND MITIGATIONS

Projected activities possibly causing impact include:

- milling operation
- air emissions
- tailings disposal
- surface drainage
- water demand
- viewpoint

Apart from the noise generated by the milling equipment, the possibility exists of chemical and product spills contaminating soils, and ultimately water courses. Drainage controls to contain and direct wastes to disposal areas are planned.

Air emissions from the plant (Sec. 2.5.2) will total 66,000 scfm maximum with an average daily value of 47,000 scfm. Assuming that particulate emissions from the primary crusher and coarse ore stockpile reclaim will have the same analysis as the head samples, that emissions from the flotation concentrate drier will be flotation concentrate and those from the bucking room will be ore grade then the following calculations can be made.

		*PARTICULATE EMISSIONS				METALS - POUNDS PER DAY					
Source	scfm	grains /min	lb/hr	hours /day	lb/day	Cu	Cd	Pb	Hg	Zn	As
Crusher	20,000	2000	17.1	16	274	5.5	-	0.014	-	-	-
Stack reclaim.	10,000	1000	8.6	24	206	4.1	-	0.010	-	-	-
Metall. dryer	3,000	nil	-	-	-	-	-	-	-	-	-
Conc. dryer	5,000	500	4.3	16	68.4	32.0	0.0007	0.048	0.0066	0.056	0.342
Bucking room	8,000	800	6.8	8	54.7	1.1	-	0.003	-	-	-
	46,000				603.1	42.7	0.0007	0.075	0.0066	0.056	0.342

*** PCB Level "A" standard is 0.1 grains per standard cubic foot per minute (0.1 g/SCFM)**

These emission calculations are probably maximum since the efficiency of bag houses are guaranteed at 0.02 g/SCFM.

Without some knowledge of dispersion patterns for the area it is not possible to provide a detailed impact of these emissions. The toxicity of heavy metals is discussed in the smelter emission section following.

Tailing will be disposed from the mill through a 1½ mile long pipeline to a 470 acre pond bracketing Hughes Lake. The average daily discharge will comprise 3,860,000 gallons of slurry which will be treated by sedimentation and storage of both solids and liquids. There will be no positive discharge into the receiving environment. Groundwater and surface waters outside the mine area will not be significantly affected (see Section 4.1.2). Inactive disturbed areas will be reclaimed.

Seepage control will be accomplished with a recovery dam below the main dam and water will be returned to the main pond for re-use in the mill.

Should the tailing pipeline fail in operation, an emergency tailing dump pond is provided to isolate the spill (see Figure 4.1.1.2.1).

Similarly, pit, road, ramp and area drainage will be directed to the tailing pond where it will be isolated.

The possibility of acidic drainage from the waste is effectively nil due to the composition of the waste rock (see Section 6.1.2).

Surface drainage control will be provided by the dam structures on ephemeral watercourses surrounding the tailing pond (see Figure 4.1.1.2.1).

Separation of the clay/slime fraction of tailing for water recovery in the tailing storage area may become a problem in operation. As shown in Section 3.4.2, laboratory tests showed that the sand fraction of tailings settled quickly but the clays did not compact and remained at a density of 38% solids. After 13 months, settling produced a density of 57% solids. Further investigation into improving the separation of the clay fraction in tailings is planned once operations have commenced.

The addition of treated sewage wastes (200 gal/day) and 50% density smelter sludge (16,233 gal/day to the tailing storage) should not affect downstream water quality significantly (Section 4.1.2).

Overall, the tailing storage area including dam structures will remove 472 acres of wildlife habitat, the distribution of which is shown in Table 4.2.1.1.

Present land use of this area is shown in Table 4.2.1.2.

Total reclamation planting will not be possible until the milling operation ceases. The company plans to carry out experimental planting and reclamation research aimed at selecting the most favourable plant species and communities for the tailing pond.

Water demand for process and irrigation reclamation purposes is 3300 USGM and 800 acre feet per year respectively. This is to be pumped from Kamloops Lake where supply is not a problem.

6.3 IMPACTS AND MITIGATIONS OF SMELTER OPERATION

Smelter activities which could have an impact on the environment are emissions of sulphur dioxide (SO_2), heavy metals, effluents and slags, water demand, surface drainage and copper transport.

The effects of emissions of SO_2 and heavy metals are discussed in following sections 6.3.1 and 6.3.2 respectively.

Sluge effluent disposed of in the tailings storage pond will have no significant effect on water quality outside the pond.

Slag from the smelter will be returned and reground in the mill to further extract copper from it, a form of recycling.

Water demand for the smelter will be 2000 gpm and used for cooling, processing, and pollution control. Warmed water is returned to the concentrator (mill) for re-use.

Surface drainage control will be required to avoid carrying any spillage of toxic materials to adjoining water bodies.

Transport of copper ingots for processing elsewhere may increase traffic loads to some extent.

Should the sulphur content of concentrates increase markedly in future, existing SO_2 control may have to be bolstered by the addition of a sulphuric acid plant.

6.3.1 ENVIRONMENTAL IMPACT OF SULPHUR DIOXIDE EMISSION

The environmental impact of sulphur dioxide will be considered in terms of the effect on plant life, humans and animal life.

It has been generally established that vegetation (particularly certain species) are far less tolerant to SO_2 than are humans and animal life. Sensitivity of plants to SO_2 varies between species as well as with the vegetative state of the plant. As a result of extensive studies in Sudbury, Ontario (Dreisinger and McGovern, 1970,(16) trembling aspen and buckwheat were found to be most susceptible to SO_2 damage, having a SO_2 intensity factor tolerance of 74 which corresponds to the following dosages:

0.95 ppm for 1 hour
or 0.55 ppm for 2 hours
or 0.35 ppm for 4 hours
or 0.25 ppm for 8 hours

The above dosages correspond to recorded plant exposures which if equalled or exceeded, could result in damage. At the other end of the scale, Pinus resinota has been reported as being resistant to SO_2 concentration as high as 2.5 ppm for 2 hours (Berry, 1971,(17)). Generally, tolerance of most plant species is less than 1.5 ppm SO_2 for one hour exposure. However, prolonged exposure can increase resistance to SO_2. It has been reported (Zahn, 1970, (18)) that even cereals sensitive to SO_2 were found to have increased resistance after long exposure to low SO_2 levels. A study on Pinus strobus (Costanis, 1971, (19)) also reported that susceptible trees were most sensitive during a 6-8 week period when new needles were elongating.

The effects of SO_2 on humans and animal life can be delineated into discomfort effects and damaging effects. In the former category, the threshold for odour has been reported (Leonardos et al, 1969 (20)) to be 0.47 ppm. This threshold is for an average person who has no prior exposure, and will increase with increased exposure time.

Available data on the physiological effects of SO_2 are conflicting. One report (Stern, 1968, (21)) states that no adverse effects on health could be found when industrial workers, who had been exposed to daily SO_2 concentrations ranging from 1 to 25 ppm for periods of 1-19 years. Another source (U.S. Dept. of H.E.W., 1970, (22)) states that chronic effects of higher incidence of nasopharyngitis, cough, expectoration, shortness of breath and other signs of respiratory distress have been observed in industrial workers exposed for years to SO_2 concentrations up to 37 ppm. It is unlikely that SO_2, by itself, can be considered hazardous when short term concentrations are in the order of 1 ppm.

There is however, a synergistic effect between SO_2 and aerosols (particulates) which greatly enhances the physiological impact of SO_2 (U.S. Dept. of H.E.W (22)). This could be due to SO_3 forming sulphuric acid after being absorbed by the particulate. Urban air pollution episodes may arise when SO_2 exceeds 0.2 ppm on a 24-hour average. Those likely to be affected are individuals with chronic pulmonary disease or cardiac disorders, or very young or very old individuals(23).

An interesting anomaly exists in the effects of SO_2 on animals. According to a German study (Kaemmerer, 1972, (24)) ruminants tolerate considerably higher amounts of sulphites in the feed than to monogastric animals. Thus ruminants can be fed dry pulp containing 1000 ppm sulphite without harm.

A comparison of the potential emission of SO_2 from the Afton smelter and other emissions in Kamloops (Table 4.1.3.3.1.3) shows that Afton would discharge less than 1.5 tons per day compared to 11.5 and 6.0 tons per day for the refinery and pulp mill respectively. The Canada Dept. of Agriculture Research station has indicated that damage to vegetation attributable to existing emissions has not been observed in the Kamloops area.

Under existing Level A ambient air quality requirements of the Pollution Control Branch, the Afton smelter could not continue operation if levels exceeded those specified.

6.3.2 METAL EMISSIONS

Anticipated emission levels of lead, zinc, cadmium and arsenic are each less than 0.003 grains/scf, and of mercury less than 4 lb/day (0.0047 grains/scf) from the mill and smelter complex(25). At an emission rate of 9,840 scfm during a 10 hr operation period per day, the maximum daily output of lead, zinc and cadmium each is 2.5 lbs/day.

The extent of diffusion by wind of emission products from the mill and smelter has not yet been determined, since sufficient meteorological data are lacking for the area. For this reason, potential impacts of air borne trace contaminants can be described only in general terms and with reference to effects elsewhere as result of smelter emissions.

Heavy metals emitted by the Afton smelter vary in their degree of toxicity to the various components of fauna and flora. High levels of zinc, lead and cadmium from smelter emission were observed in soil and vegetation samples from the vicinity of a zinc smelter in Palmerton, Pennsylvania, following 75 years of operation (26). Field and laboratory studies on the impact of the observed metal loadings on vegetation and soil organisms were carried out. The results of the studies supported the conclusion that zinc, possibly acting synergistically with cadmium, had affected the soil microbial flora by direct toxicity. This in turn had lead to secondary environmental effects including destruction of nearby vegetation and poor recovery of vegetation following forest fires in the general fallout area.

Results obtained at Palmerton and from other, similar studies have demonstrated that high levels of zinc and cadmium in uncontrolled smelter emission may lead to detrimental environmental effects if the period of operation continues for a sufficient length of time. However, it may be emphasized that emissions from the Afton smelter will be closely controlled with respect to metallic emission levels. The time period involved before significant concentrations of emitted metals would accumulate in soils and vegetation could be very long, the actual number of years depending on wind dispersion of stack emissions and on the fallout rate of the contained metals.

Mercury concentrations in Afton emissions may be slightly higher than the concentrations of lead, zinc, cadmium and arsenic. Elemental mercury in nature is converted into other mercury compounds including the extremely toxic methyl mercury. Chemical compounds of mercury are obsorbed by soils, river bottom sediments, plants and other organisms. Mercury is especially dangerous since small amounts occurring in the diet of animals and man over a period of time may lead to irreversible detrimental effects. At a maximum emission rate of 4 lbs per day of mercury, the total amount of mercury emitted into the atmosphere over a projected 14-year operational period of the open pit mine would be 9.3 metric tons of mercury. The corresponding figure for zinc, lead, cadmium and arsenic is 5.8 tons. The metals will be dispersed into the environment covering an area of unknown size depending on dispersion and fallout rate. Even dispersion over an area of 2000 square miles would result in maximum average annual fallout of mercury amounting to 0.5 grams per acre. This would equal the annual fallout rate in Sweden(27) where environmental cycling and the effects of mercury have been investigated in some detail. However, the actual fallout from smelter emissions generally are highest in the immediate vicinity of the smelter, tapering off with distance under influence of prevailing wind directions and eventually becoming indistinguishable from natural background levels. It is therefore of considerable importance that metal loadings in soil and flora near the mine should be monitored by intermittent sampling and analyses after the Afton smelter goes into operation. This would help to safeguard against build-up to potentially noxious levels in grazing areas and drainages feeding Kamloops Lake.

Dustfall metal concentrations are already being monitored at the site (see Section 4.1.3).

Based on the maximum allowable figure for mercury of 4 lbs/day, the mercury concentration in stack emissions would be less than 0.17 grains/m^3 or 10.8 mg/m^3. Standards set by the American Conference of Governmental Industrial Hygienists and called Threshold Limit Values (TLV) called for maximum non-alkylated mercury levels in air of 0.05 mg/m^3 as safe for industrial exposure(4).

The 10.8 mg/m^3 (maximum) of mercury in the stack emission must be diluted 216 fold before the TLV standard of 0.05 mg/m^3 of mercury in the emission plume is attained. This is an very modest dilution requirement. Emissions from the recovery boiler stacks of pulpmills frequently are diluted 1000 fold by the time the plume has descended to the ground level from a stack height of between 500 and 600 ft. Ultimately the ground level dilution of stack emissions at Afton will depend on a number of parameters including stack height, specific gravity of the emissions, temperature, and wind mixing factors. Stack height can be designed to ensure that an adequate dilution is attained under the prevailing wind regime.

The U.S. Environmental Protection Agency has permitted mercury ore processing facilities and mercury chlor-alkali plants to emit 5.0 lbs of mercury per day. The allowance is based on an ambient air average 30-day concentration of one microgram per cubic meter (1 mg/m^3) of mercury as sufficient to protect public health and is based on a highly conservative atmospheric disperison model(28). With a maximum emission of 4 lbs/day of mercury, and lower concentrations of zinc, cadmium, lead and arsenic, the potential impact on public health may therefore be considered negligible.

A certain amount of metals from smelter emissions may eventually find its way into Cherry Creek, Alkali Creek and possibly other drainages leading into Kamloops Lake. Some might be expected to precipitate directly into the lake itself. All five metals emitted in recognizable quantities at Afton are toxic to aquatic life including fish when concentrations exceed certain minimum levels. Water sampling and analysis for these metals at selected sampling points is included in the overall monitoring program of environmental impacts after the mine and smelter start-up. Any increase in metal levels above the naturally occurring background levels should be closely checked against documented lethal and sub-lethal levels of each metal to important species of fish and other organisms in the local fresh water bodies.

It is stressed that the Afton Smelter is governed by ambient air quality. Level A requirements of the Pollution Control Branch (Table 4.1.3.2). If the smelter does not meet these requirements, it must cease operation until it does.

6.4 POST OPERATIONS

Figure 6.4.1 shows the topographic profile through the property after mining. The final configuration of the tailing storage area and the waste rock dump will be flat topped, permitting maximum use of agricultural machinery in reclamation activity.

Post operation activities causing environmental impact, are shaping of waste piles, transport of overburden and soils, grading of soils and reclamation planting, water supply, facilities removal, and the disposition of the final open pit.

Shaping of waste piles will have a currently unknown effect on air and water quality of the area but should provide beneficial topographic effects. Equipment noise will be inevitable.

Soil transport will also have an unknown effect on water and air quality through creation of fugitive dust in dry summer weather.

Soil grading and successful reclamation planting will compensate for creation of immediate dust and ultimately provide dust control and cattle and wildlife forage and habitat. In final flat surface configuration of dumps and ponds it is Afton's intent to excavate depressions sealed with tailings and overburden for planting of trees as an "oasis" for wildlife.

The final use of the open pit excavation is conjectural. Whether it can function as a lake is not known at this time. Fencing may be necessary to avoid a hazard to cattle, wildlife and humans.

Providing pumping equipment is intact, the freshwater pipeline and pumping system would be available for the relatively water-short area.

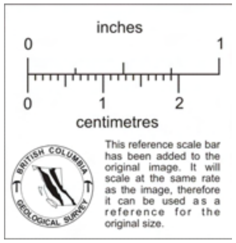
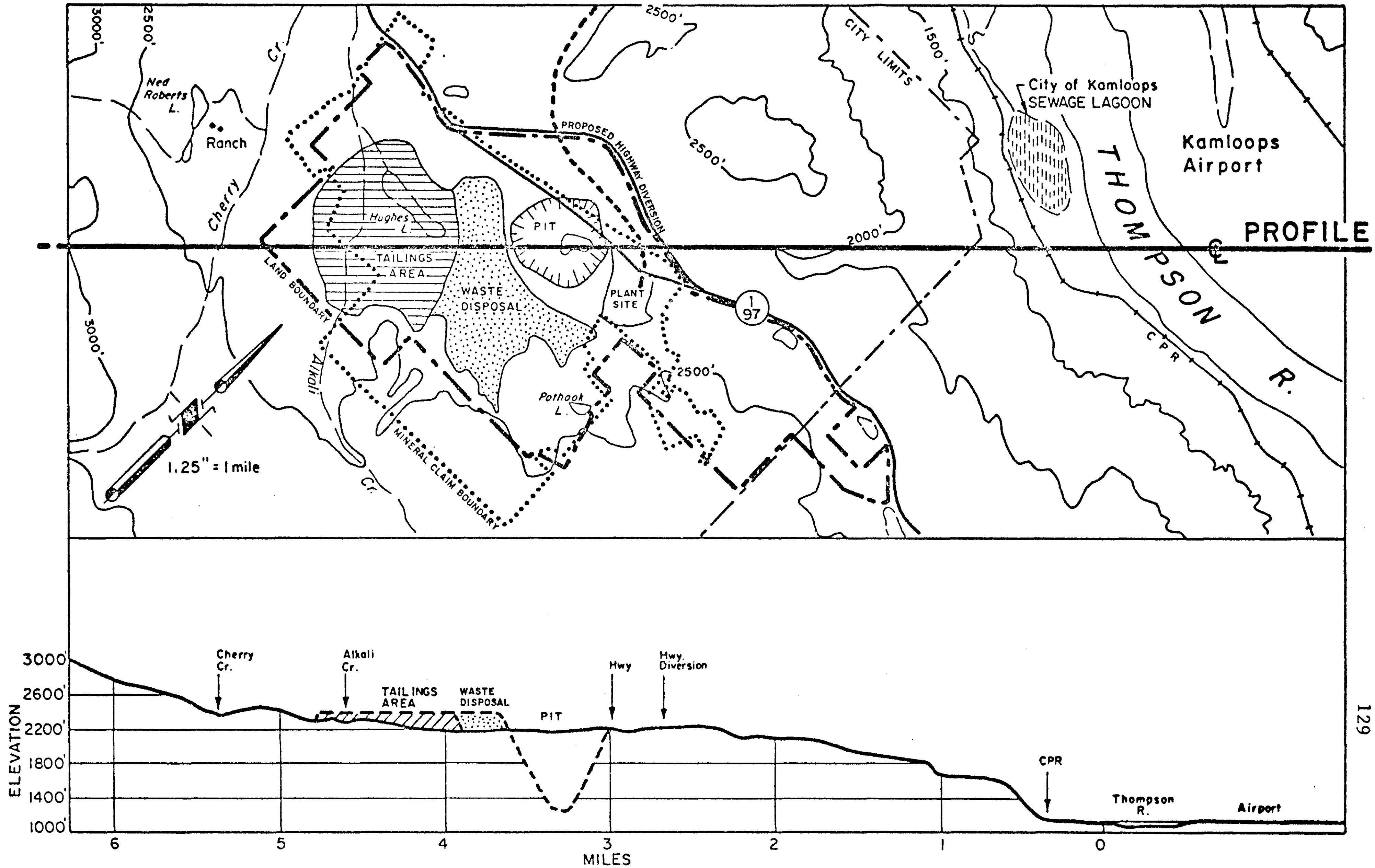


Figure 6.4.1
TOPOGRAPHIC PROFILE NE - SW THROUGH AFTON MINE PROPERTY



6.5 SOCIO-ECONOMIC CONDITIONS

In the latest of a series of annual studies for the Mining Association of B.C.(29) it was determined that for each direct employee of a mining company in B.C., there were 2.8 other workers in the Province in jobs based on the mining industry. It was also determined that the mining industry in B.C. supported 7.9 other workers in Canada for each worker directly employed. On the basis of 296 employees at Afton, a further 829 persons might be expected to be employed in British Columbia, and 2,338 in Canada. The multiplier effect of employment in the Kamloops area is hard to estimate but for as large a centre of population as this, it will be substantial. Jobs will develop in retail and wholesale businesses, in various service industries catering both to the public and to industry and in professional fields.

The increase in assessment base and tax revenue will benefit all levels of government in differeing ways, both directly and indirectly - i.e. through the operation itself and through the jobs it creates. The mine would be of considerable added value to the provincial economy and could provide an encouraging lift to mining development which has been suffering a decline in B.C. An ongoing beneficial effect of the project will be the presence of an assured water supply by the pipeline from Kamloops Lake after the mine exhausted.

In the case of the nearby trailer court (1½ miles west) it seems likely that any possible unfavorable environmental developments will be offset by a considerable increase in potential business.

Studies elsehwhere suggest that blasting will not cause structural damage to any existing structures. Noise from both blasting and operating equipment will be heard in varying degree by the few residents in the general area and by passers-by on the highway.

With respect to traffic, the factors to consider are the added impact of commuting workers vehicles, the entry of trucks onto the highway, and the visual impact of the site on passing motorists. As the percentage of existing traffic, the increase induced by the Afton operation will not be very large. Entry and exit facilities and the proposed highway relocation have been discussed with the Department of Highways and will conform with their recommendations. The relocation of about 2.75 miles of Trans-Canada Highway in the immediate vicinity of the mine is not expected to be a major construction task, but would provide about $0.7 million worth of contract work, depending upon final design and costs at that time. Its location on a stretch of the route noted for its high incidence of accidents has been recognized by the Department of Highways in its preliminary design.

The visual impact of the project on passing traffic will no doubt be considered unsatisfactory by some people. Conversely, however, the tourist attraction value of an operating open-pit mine will be considerable - people now drive 25 miles out of their way to view the Highland Valley workings, whereas this one is handily adjacent to a major travel route. The Company after discussion with the Regional District has identified a possible site for a viewpoint which overlooks the mine site.

With the current oversupply of housing and a major new housing development projected there should be no shortage of housing facing employees coming from other areas. An important factor in the whole situation is the relatively high level of average annual earnings, employees can generally afford to buy even at present price levels.

Bearing in mind the size of the workforce, the slow-down in the local economy of the first year and the plans for new housing, there should be no special strains on the infrastructure as a result of the Afton project.

Open pit operations are planned to continue for 14 years, after which there will be a conversion to underground operations which might well continue for a good many years. With even a conservative growth rate in the area the population increase will be such that the discontinuance of operations, when it does occur, would not be expected to have a serious impact.

7.0 ALTERNATIVES

7.1 ALTERNATIVE METHODS OR MEANS

Since the location of the ore body cannot be changed, the only alternative with respect to the mining of the ore is the method to be employed.

Open pit mining is more efficient, permits a higher level of extraction (% of ore body which can be mined) and permits a longer life for the operation. Ultimately, when the open pit reaches its maximum depth, underground methods will be necessary. Underground methods will result in higher operating costs, more dilution from waste rock, a higher cut-off grade, resulting in some copper being left behind, and a more highly specialized workforce.

7.2 ALTERNATE SITES OR ROUTES

The location of the tailings pond allows for the maximum storage potential available in the area. The location of the waste rock dump is the best site available and optimizes reclamation potential. The highway relocation is such that it minimizes the length to be rebuilt and yet permits improvement of the highway standards. The pump house location and pipeline system at Kamloops Lake was selected by consultants, experts in their field. Fundamentally the various alternatives were considered and the best selection was made on the basis of minimum cost and environmental impact and maximum efficiency.

7.3 ALTERNATE SYSTEMS DESIGNS

A major alternative considered in systems design was conventional grinding versus semi-autogenous grinding in the milling circuit.

Semi-autogenous grinding was selected on the basis of lower capital and operating costs, accepting the fact that available operating time would be slightly slower with the semi-autogenous system.

Consideration was given to a number of smelting processes, and the T.B.R.C. was selected. The T.B.R.C. was selected over the electric smelting process and a hydrometallurgical process and conventional smelting.

Conventional smelting simply is not economic for the magnitude of operations planned for Afton.

The electric smelting and hydrometallurgical processes are not feasible due to higher capital costs for the former and lower metal recoveries for the latter.

8.0 PRINCIPAL AUTHORS AND INVESTIGATORS

Name	Organization
I.V.F. Allen	B.C. Research
J.M. Anderson	Teck Corporation
Y. Bajard	Kloehn Leonoff Consultants Ltd.
A. Bohn	B.C. Research
A. Bruynesteyn	B.C. Research
R. Drozd	Teck Corporation
G. Van der Kamp	Kloehn Leonoff Consultants Ltd.
W. Kerr	W. Kerr and Associates
L.N. Lavkulich	U.B.C.
R.O. McElroy	B.C. Research
C.N. Sibbald	Teck Corporation
S.F. Siscoe	Teck Corporation
D.S. Smith	B.C. Research
K. Tsang	Envirocon Consultants
D.R.C. Wright	B.C. Research

9.0 REFERENCES

(1) B.C. Research Dommage Campbell "Preliminary Environmental Impact Study of the Proposed Hat Creek Development" 1975.

(2) Cockfield, W.E. Geology and Mineral Deposits of Nicola Map Area, British Columbia, Memoir 249, Geological Survey of Canada.

(3) Millar, C.F. The Afton discovery. Western Miner, February, 1973.

(4) McIntosh, G. Geological Report on the Afton Ore Deposit, November, 1973.

(5) Canadian Exploration, "Geology of Afton Mines Limited Property". Internal report to Afton Mines.

(6) Department of Mines and Technical Surveys 1957 "Atlas of Canada" Earthquake Probability.

(7) Smuin, D.E., District Engineer, Water Rights Branch, Kamloops, private communication.

(8) Ward, F.J. Limnology of Kamloops Lake, IPSFC Bulletin XVI, 1964.

(9) Federal Provincial Task Force.

(10) Crow, Loren W. (1974) Collection and Analysis of Meteorological Data for Environmental Impact Assessment at Remote Sites. Presented at the 67th Annual Meeting of the Air Pollution Control Assoication, Denver, Colorado, June 9-13, 1974. #74-125.

(11) Smith, Maynard E. (1974) Deficiencies in Data and Analysis for Environmental Impact Statements. Presented at the 67th Annual Meeting of the Air Pollution Control Association, Denver, Colorado, June 9-13, 1974. #74-126.

(12) Banfield, A.W.F. The Mammals of Canada, University of Toronto Press, Toronto, 1974.

(13) Carl, G.C. 1966. The Amphibians of British Columbia. Handbook No. 2. B.C. Provincial Museum, Department of Recreation and Conservation. Queens Printer, Victoria. 63 p.

REFERENCES cont'd

(14) Carl, G.C. 1968. The Reptiles of British Columbia. Handbook No. 3. B.C. Provincial Museum, Department of Recreation and Conservation. Queens Printer, Victoria. 65 p.

(15) Anon. Endangered Wildlife in Canada, Canadian Wildlife Federation, Ottawa, 1970.

(16) Dreisinger, M.F. and P.C. McGovern. "Monitoring Atmospheric Sulphur Dioxide and Correlating its Effects on Crops and Forest in Sudbury Area". Proceedings of the Impact of Air Pollution on Vegetation, April 7-9, 1970, Toronto, Ontario.

(17) Berry, C.R. "Relative Sensitivity of Red, Jack and White Pine Seedlings to Ozone and Sulphur Dioxide". Phytopathology, 61 (2): 231-232 (1971).

(18) Zahn, R. "Effects of Combined Subliminal and Toxic Doses of Sulphur Dioxide on Plants". Staub, 30 (4): 162-164 (1970).

(19) Costanis, A.C. "Effects of Ambient Sulphur Dioxide and Ozone on Eastern White Pine in a Rural Environment". Phytopathology, 61 (6): 717-720 (1971).

(20) Leonardos, G., D. Kendall and N. Barnard. "Odor Thresholds Determinations of 53 Odorant Chemicals". J. APCA, 19: 91-95 (1969).

(21) Stern, A.C. "Air Pollution, Vol. I (2nd Edition) Academic Press, New York, 1968.

(22) National Emission Standards Study. Appendix - Vol. I, U.S. Dept. of Health, Education and Welfare, March 1970.

(23) Goldstein, I.F. and G. Block. "Asthma and Air Pollution in Two Inner City Areas in New York City". J. APCA, 24 (7): 665-670 (1974).

(24) Kaemmerer, K. "Toxicological Significance of Sulphite Fed to Ruminants". Zucker, 25 (4): 123-127 (1972).

REFERENCES cont'd

(25) Application for permit under Pollution Control Act, 1967 (Emissions). The British Columbia Gazette, January 2, 1976.

(26) Jordan, M.T. and M.P. Lechevalier. 1975. Can. J. Microbiol. 21: 1855-1865.

(27) Baker, D.P. Final Environmental Statement for the Jim Bridger Thermoelectric Generation Project, U.S. Bureau of Land Management, Department of the Interior, 1972.

(28) Mercury in man's environment. Proceedings of the symposium 15-16 February 1971. Royal Soc. Can.

(29) "The British Columbia Mining Industry in 1974", Price Waterhouse & Co. September 1975, p. 40.

APPENDIX 1

A Supplement To The

"Environmental Impact Statement"

Prepared for

Afton Mine

by

B.C. Research

Supplement Prepared By:

William Kerr & Associates
P.O. Box 1314
Vernon, B.C. 545-3124

SYNOPSIS

The sum of the social economic impacts of the Afton Mine development on the Kamloops area will be of a positive and beneficial nature. The benefits of mine operations will vary with the personnel policy established, increasing directly as the ratio of local people hired increases. To a lesser extent, but of equal concern because of the immediacy of hiring, this is true for the construction hiring as well, but in this case it will be the contractor and the unions rather than the developer that exercise control.

That the impacts will be positive is due to lingering unresolved and unmitigated socio-economic effects of Kamloops early 70's boom. This boom started with pulpmill and cement plant construction employing 700 or more men. It was sustained by mining activity, road building, housebuilding, and then the mica Dam. This activity has terminated abruptly. Plans for 1976 highway and hydro line construction have been drastically curtailed, housing has all but stopped. Population has decreased, high construction unemployment exists along with high residential vacancy rates.

Given this localized recession-like condition, any activity produces a net benefit. The least benefit would be realized if every mine employee were imported. The sum of the social economic impacts, to the extent summation is a valid concept, would still be positive. Kamloops could readily accommodate the employees and dependants which would only amount to a 2% population increase. There would be no significant service defficiencies in any sector nor cultural assimilation problems. The benefits would then accrue to a limited sector of the economy (realtors, landlords, merchants, etc.).

The costs of this option have to be viewed as the economist views those he terms "opportunity costs". The cost is in fact the loss of the opportunity to mitigate the present unemployment and all real costs of the social disfunction attendant therewith. (Stress induced alcohol related problems, marriage breakdowns, etc., that tax social, human resource, and medical services etc.).

Were Afton and their contractors to hire a high percentage of local people, the benefits would be particularly desirable - growth in a desirable nondisruptive increment but also of a remedial nature.

THE PUBLIC CONCERN

While a high level of public opinion and unsolicited expression surrounds the development, little of it is of a socio-economic nature. Public statements, letters to the editor and the like are all oriented towards wildlife, water and atmosphere considerations. Neither newspaper nor the library maintain a clipping file. However, scanning of recent issues and interviews with the "Sentinel" newstaff support this observation.

The city planner reported some public concern about "starting on another round of rampant growth". He, of course, realized that such concern was unwarranted. Other issues such as the inclusion of the property within city boundaries for taxation purposes have largely involved government administrators.

Opinion solicited by the writer on a casual basis had a common optimistic theme as most people felt it would relieve the existing economic problems.

THE HIRING QUESTION

As almost all of the socio-economic effects hinge on the hiring action of both contractor and mine, some consideration is warranted. The obvious solution of hiring locally has some rather formidable constraints as well as considerable possibilities.

At all levels, the mine will be under pressure to hire experienced people, and experienced people are few in Kamloops. This pressure will be exerted by those with operational responsibilities. Starting a mine, mill and smelter is a sufficiently difficult task without training added. Supervisors with any degree of self-interest will look for experience. Clearly, supervisory personnel will be imported and they will be under heavy pressures from old associates in other areas seeking employment at Kamloops. Not only from those looking for better positions but also from a great number who will find Kamloops a very attractive place to work. Amongst the country's hundreds of mines, few sites offer the climate, amenities and recreational opportunities of Kamloops.

It is anticipated that union and other employee associations will exert pressure on behalf of their members. Some of this could be attributed to mine closures and cutbacks of recent years. Any closure in the next 18 months will create irresistable pressure.

On the other hand, the nature of this mine and of mill work generally is such that inexperienced employees can be quickly operational. Because the mine is open pit, it will not require the particular breed of people who can work underground. Nor will it require the rather unique underground machinery. Apart from scale, open pit machinery is not usually unlike conventional loading and trucking machinery. Adaptation is then relatively easy to people with logging and construction background. The mill operations, except for actual reagent treatment, are of a materials handling and reducing nature. Many jobs involve the monitoring of large but rather simple machinery.

Mine, mill and smelter have large maintenance needs and hence a number of conventional trades people like machinists and welders, will be required.

The office, staff services and store personnel are also available locally for most positions.

Both the mine and construction company have been in contact with local Canada Manpower offices and unions. It is reported by CMC and union people that both have demonstrated interest in local hiring.

OPERATIONS

General

The scale of most of the impacts of mine operations is such that no impact management programs are seen as necessary. Reviewing the impacts, it is clear their beneficial effects are relative to the degree workers are imported. In considering the beneficial effects it is useful to start by considering the situation of minimum benefits, that is where all labour is imported. Even for that case no special action should be required.

Population Impact Potential

Approximately 350 employees with up to 900 or so dependents will be involved. Employment in operations will be of non-seasonal continuous nature. Approximately one-third of the employees will be on evening and midnight shifts. Peak employment will not occur until late in 1977. Payroll of the full complement exclusive of fringe benefits would be approximately $4.4 million (at 1978 rates).

The demographic breakdown of Kamloops population and that of selected mining communities is comparable.*

Age	Kamloops	Regl. District	Trail	Timmins	Noranda
60 +	7	6.4	9.9	8.1	4.5
20-59	50	51.2	55.8	50.8	51.6
0 -19	43	42.4	34.3	41.1	43.9

The imports would not be of this configuration as few would have retired dependants but this would be the ultimate trend.

*Data on Kamloops and Regional District from Kamplan.
Other data from 1971 Census.

The labour force breakdown as of June 1972 is as follows:

LABOUR FORCE ESTIMATES FOR KAMLOOPS AND B.C.

Work Category	North & South Kamloops June, 1961		Greater Kamloops June, 1972		British Columbia May, 1972	
	Labour Force	% of Total	Labour Force	% of Total	Labour Force	% of Total
Agriculture	67	1.1%	100	0.5%	25,000	2.9%
Forestry	158	2.6%	150	0.7%	26,000	3.0%
Fishing & Trapping	3	-	-	-	3,000	0.3%
Mining	61	1.0%	100	0.5%	15,000	1.7%
Manufacturing	642	10.7%	1,700	8.2%	148,000	16.9%
Construction	432	7.2%	4,000	19.3%	60,000	6.8%
Transportation & Communication facilities	1,133	18.9%	2,350	11.4%	91,000	10.4%
Trade: Wholesale	264	4.4%	1,000	4.8%	52,000	5.9%
Retail	828	13.8%	3,400	16.4%	113,000	12.9%
Finance, Insurance & Real Estate	217	3.6%	850	4.1%	41,000	4.7%
Community Business & Personal Services	1,690	28.1%	6,200	30.0%	251,000	28.6%
Public Administration	517	8.6%	850	4.1%	52,000	5.9%
Total for all Industries	6,012	100%	27,000	100%	877,000	100%

* B.C. Total only includes work force

Sources: Canada Manpower
KAMPLAN Commercial - Industrial Questionnaire

Worthy of note is the more than 9 fold increase of the construction labour force in a decade and the fact that as a percentage, it is 3 times greater than the province-wide percentage. There is reason to believe this has even increased since June 1972.

The 350 employees of the mine will be but 1.3% of the 1972 labour force of 27,000.

The 1,200 and 1,300 employees' household members will be 2% to 2.2% of the 60,000 estimated population of the city. (This population estimate is that of the city planner). Estimates are abased on Census data and the 1972 election enumeration updated with building permit data. 1975 estimates were 62,000 but have been modified down for vacancies and unsold houses.

Housing

Rental accommodation is readily available in Kamloops. CMHC, the B.C. Assessment Authority, local realtors and developers estimate there are almost 400 apartments or similar rental units available. Some small rental accommodations are under construction and 96 new rental units are slated for an immediate start (Abacus Cities Ltd.). The reports of the authorities are confirmed by the daily 100 to 120 separate ads in the classified section of the Kamloops News. Up to 25% of these ads indicated that two or more units were available for rent. Rentals run in the $225 to $270 per month range for 2 and 3 bedroom apartments.

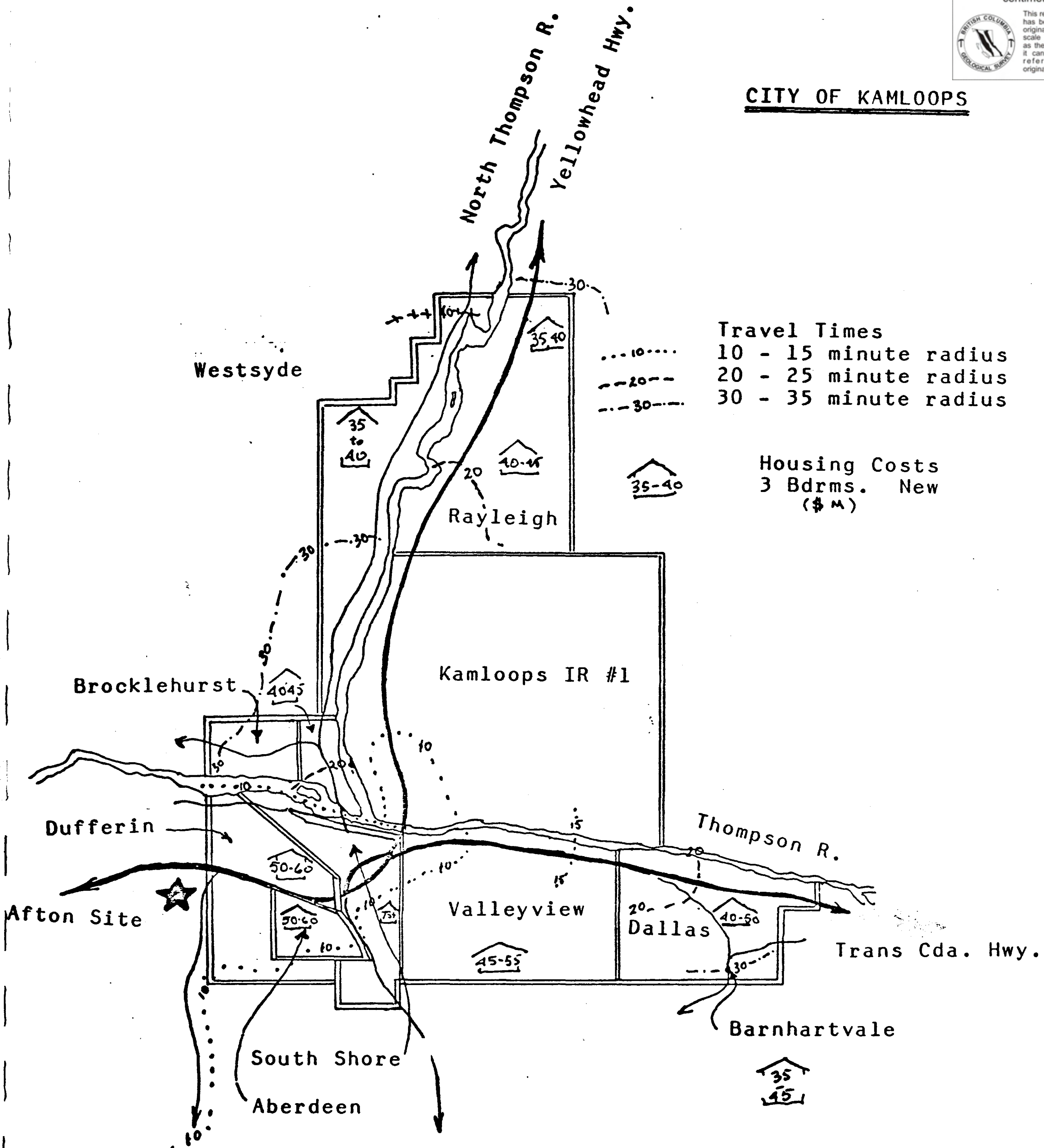
Freehold & Strata title housing is available. While prices vary from district to district, there are new three bedroom houses listed at $40,000 to $45,000 (which given the vacancy level could likely be purchased for 10% less) in several areas within 25 minutes drive of the mine. Mine employees who's average 1975 salary would be $13,000 could only qualify for mortgages in the $30,000 range. Accordingly, only the more senior or those with substantial proceeds from the sales of homes at other sites could easily buy conventional housing. Price ranges and driving times are displayed on the attached map.

Those without sizeable down payments and wages at or below the average could qualify for AHOP housing. A very aggressive Assisted Home Ownership Plan housing program has seen more than 400 houses built in the area. Many are still listed at less than $30,000. Payments under this program are less than the usual scale for similar sized mortgages. Actual payments vary with the applicants' circumstances but can be lower than $200 a month.

A recent survey conducted by the City of Kamloops indicated that 16% of housing accommodation was vacant. It was based on a 10% sample yielding 171 units of 1,056 vacant. This would then indicate some 1,700 empty houses.

A breakdown of the housing inventory as of January 1973 indicates very roughly the inventory of sectors of the supply. It does not agree closely with the survey data above as duplex, triplex, etc. are included with houses.

	Single Family Duplex, Triplex	Condominiums Townhouses	Apartments
Barnhartvale	369	-	-
Brocklehurst	2,043	299	177
Dallas	323	-	-
Dufferin	167	10	-
Heffley Creek	60	-	-
Kamloops (Old City)	5,752	503	2,419
Rayliegh	193	-	-
Valleyview	782	75	175
Westsyde	1,123	90	-
Other	147	-	-
	10,959	977	2,771


CITY OF KAMLOOPS
North Thompson R.
Yellowhead Hwy.
Travel Times
10 - 15 minute radius
20 - 25 minute radius
30 - 35 minute radius
Housing Costs
3 Bdrms. New
($ M)
Westsyde
Rayleigh
Kamloops IR #1
Brocklehurst
Dufferin
Afton Site
Thompson R.
Valleyview
Dallas
Trans Cda. Hwy.
Barnhartvale
South Shore
Aberdeen
35-40
40-45
50-60
45-55
40-50
35 45

* Mobile Home facilities are limited and no spaces are available.
* The serviced lot inventory is more than adequate
* Future construction is difficult to predict. A massive development in the Aberdeen area close to the mine is planned. It would encompass some 2,300 acres. The timing and phasing of this development is not readily available and is under review according to local sources. This is certainly understandable given present conditions.

The market is not expected to do more than improve gradually according to local sources and this seems reasonable.

We must then conclude that adequate housing inventories would still exist in 1977 even if all employees were imported.

City Services

Given that the houses are in fact in place, services such as water, sewage, etc., must be adequate. They are certainly to approved standards or the housing wouldn't exist. City Planners report that this is indeed so as Kamloops always overbuilt.

Commercial Services

Given the small number of employees (wage earners) and the general recession condition that exists, the impact of the mine will be small but beneficial.

Medical Health, Police, Fire, Social Services, etc.

A maximum 2% increase in the population dispersed through most of the non-core area of Greater Kamloops will have no significant impact.

Traffic

Given the present driving times and accommodation inventories, it is unlikely that imported workers would settle in the north-west sector of the city. This then should not increase traffic at the bridge crossing. On the other hand, a large segment of the present labour pool reside in that area and if they are employed at the mine, the problem could increase. With two-thirds of the staff on the day shift, some 100 cars from this area might be expected.

Once the mill is in operation, traffic will not be a serious problem as the highway has a substantial capacity serving 12,000 or more vehicles a day in the summer now. The tourist traffic peaks will not coincide with the morning shift change and fortunately the evening change, when tourist traffic is still high, only will involve, for the most part, a right turn onto the highway.

The relocation of the highway will allow an opportunity for access reconstruction if problems are encountered.

Student Impact

Again this is subject to importing of workers. The total importation could involve at most some 400 students. This would seriously press schools in some areas. However, it is unlikely all workers would be imported and those who are, are likely to be more senior. It is likely a lot of their children will be working in college or similar programs.

Most parents consider the availability of schools (crowding and shifts, etc.) when looking for a home. Accordingly, it is recommended that up-to-date information respecting school facilities be made available to any "imports".

The following statistics are presented to show that excess capacities existed in the school system as of 1973. Because construction of schools has continued and growth has tempered we are assured vacancies still exist. However, there continues to be defficiencies in certain areas and the situations in individual schools may be different from that in 1973.

School District 24 is responsible for elementary through secondary education for the City and the remainder of the School District. Within the City limits, the School District operates some 24 elementary, 5 junior secondary and two senior secondary schools.

SCHOOL STATISTICS FOR THOSE SCHOOLS IN THE KAMLOOPS METROPOLITAN AREA AS OF JANUARY 1, 1973

A. 1973 ENROLMENT
B. Sept 30/75 ENROLMENT
C. STUDENT CAPACITY
D. COMMENTS

School	A.	Sept 30/1975 B.	C.	D.
Brocklehurst Elem	240	290	264	Grades 1-4 only
Parkcrest	490	470	528	A new school - opened September 1972
Kay Bingham	505	537	528	
George Hilliard	513	528	528	
A. E. Perry	512	534	528	
John Tod	433	342	528	Decreasing enrolment
North Kamloops Elem.	461	371	528	Decreasing enrolment
Arthur Hatton	443	357	528	Decreasing enrolment
Overlander	190	175	264	Decreasing enrolment
Fitzwater	70	106	60	Currently being expanded to a 9-room school for Educationally handicapped
Westsyde Elem.	510	440	528	Recently completed to this size
Arthur Stevenson	497	513 513	396	Four portables will be replaced in next building program
Beattie	475	480	528	
Stuart Wood	183	207	231	Decreasing enrolment
Allan Matthews	219	197	264	Decreasing enrolment roughly ½ bussed in
Lloyd George	429	373	528	Decreasing enrolment
George Slater	240	249	264	Enrolment will start to decline next year
Rayleigh	252	294	231	Extra enrolment housed in portable
Heffley Creek	33	67	56	Grades 1-3 only
Ralph Bell	306	300	363	
Marion Schilling	427	409	528	
Dallas Elementary	289	326	358	Growing
Robert L. Clemitson	242	469	297	A new school and growing
Barnhartvale	11	0	25	May be closed in near future
	7970	8034	8881	

Less than 1% increase over 1973

Secondary Schools

	Sept 30/75		
Brocklehurst Jr. Sec.	888	683	Grade 8-10 and growing
McArthur Park Jr.	1050	1028	Grade 8-10
Norkam Secondary	1108	1035	Grade 10-12 changing to grade 11-12 in future
Westsyde Jr. Sec.	868	410	Grade 8-10 will expand to grade 8-12
John Paterson Jr. Sec.	703	922	Grade 8-10
Kamloops Secondary	948	1004	Grade 10-12 changing to grade 11-12 in future
Valleyview Jr. Sec.	619	639	
SaHalt	510	Not yet built - first stage 600 pupils	
	6694	5721	

17% increase
(8% increase if SaHalt omitted)

Area (Primary School)	Excess Capacity in Students--Spaces (1976)
Barnhartvale	55
Brocklehurst	116
Dallas	69
Heffley Creek	23
North Kamloops	233
Rayleigh	deficiency
South Kamloops	269
Westsyde	deficiency - new school under construction 1976
Valleyview	158

CONSTRUCTION

Labour Force Accommodation

The 1976 B.C. Tourist Directory lists 1,467 hotel and motel rooms available in the area. Therefore, if any moderate number of construction workers are brought in they could be accommodated in the local hotels if a camp were not built.

Labour Force Availability

The following information on current availability of union personnel was obtained at local hiring halls:

Trade/Union	Mine estimate average no.	Contractor estimate peak	Union Comments
Carpenters Carpenters Union United Brotherhood Carpenter & Joiners, Aime Dupont	20	50	170 available now no supply problem in future 100 men available from Mica site
Labourers/Construction & general labourers local #602, Ms. B. Beckett	20	50+	225 available now no supply problem foreseen
Electricians Int'l Brotherhood of Electrical Workers Mr. Wayne DeDalley	15	30	100+ men available now no problem fore- seen
Operating Engineers/Intl'l Union of Operating Eng. William Hammond	5	20	80+ men available no supply problem

Note: this union has 20 to 30 men in their mining section available as well as a training facility in Vancouver where some of their 750 men available and on the board in the Kamloops, Okanagan and Kootenay areas could be restrained.

Teamsters, Int'l Teamster Loc. 213 Kelowna	3	n/a	No problems

Iron Workers	30	
Pipe Fitters	25	Dispatching of Kamloops
Painters	5	based members is handled from
Sheet metal workers	20	Vancouver dispatch offices
Heating and Ventilating	5	
	160	

Traffic and Transport

It is anticipated that congestion at the site may occur when the combined work force of operating and construction people peak along with construction deliveries. If any problems should develop one possibility to consider would be a bus service to various city points. Alternatively, staggered reporting and quitting times could be considered. The staggering of hours is of course more effective with longer daylight hours of the summer when congestion is greatest.

Other Impacts

The relatively small size of the work force reduces the likely incidence of other problems. Given that at least 50% and possibly many more of the force could be local, adverse social impacts will not likely be felt.

Kamloops has seen construction camps and construction forces of considerably larger size. When Weyerhauser was built the force approached 500 men. No significant problems are recalled by city planners or newspaper personnel.

APPENDIX 3

ANALYSES OF ORE AND CONCENTRATE

SEMI-QUANTITATIVE SPECTROGRAPHIC ANALYSIS -
LABORATORY COMPOSITE HEAD SAMPLES EAST AND WEST
1800 FT. TO 1400 FT. ELEVATION

Element	East	West	Element	East	West
Aluminum (Al_2O_3)	H	H	Manganese	.2%	.2%
Antimony	-	-	Magnesium (MgO)	5 - 10%	5 - 10%
Arsenic	-	-	Molybdenum	.001%	.001%
Barium	.1%	.1%	Neodymium (Nd_2O_3)	-	-
Beryllium (BeO)	-	-	Nickel	.005%	.005%
Bismuth	-	-	Phosphorous	-	-
Boron	-	-	Silver	.1 oz/t	.1 oz/t
Calcium (CaO)	3%	3%	Silicon (SiO_2)	H	H
Cadmium	-	-	Sodium (Na_2O)	M	M
Cerium (CeO_2)	-	-	Strontium	.1%	.05%
Chromium	.01%	.01%	Tantalum (Ta_2O_5)	-	-
Cobalt	.005%	.005%	Thorium (ThO_2)	-	-
Columbium (Cb_2O_5)	-	-	Tin	-	-
Copper	1 - 2%	1 - 2%	Titanium	.5%	.5%
Gallium	.001%	.001%	Tungsten	-	-
Germanium	-	-	Uranium (U_3O_8)	-	-
Iron (Fe)	5%	4%	Vandium	.02%	.02%
Lanthanum (La_2O_3)	-	-	Yttrium (Y_2O_3)	.001%	.001%
Lead	.005%	.005%	Zinc	-	-
Lithium (Li_2O)	-	-	Zirconium (ZrO_2)	-	-

Figures are approximate.

Code: H - High, approximately 10 to 100% range.
M - Medium, approximately 1 to 10% range.
L - Low, approximately 0.1 to 1% range.
Other elements (-) looked for but not found.

SEMI-QUANTITATIVE SPECTROGRAPHIC ANALYSIS - LABORATORY COMPOSITE HEAD SAMPLES EAST AND WEST 1800 FT. ELEVATION TO SURFACE

Element	East	West	Element	East	West
Antimony	-	-	Palladium	<.005 oz/t	<.005 oz/t
Arsenic	-	-	Phosphorous	-	-
Barium	.05%	.05%	Platinum	-	-
Beryllium (BeO)	-	-	Silver	<.1 oz/t	<.2 oz/t
Bismuth	-	-	Strontium	.1%	.1%
Boron	.03%	.01%	Tantalum (Ta_2O_5)	-	-
Cadmium	-	-	Thorium (ThO_2)	-	-
Cerium (CeO_2)	-	-	Tin	-	-
Chromium	<.01%	<.01%	Titanium	.2%	.3%
Cobalt	<.01%	<.01%	Tungsten	-	-
Columbium (Cb_2O_5)	-	-	Uranium (U_3O_8)	-	-
Copper	1%	M	Vanadium	.01%	.01%
Gallium	.001%	.001%	Yttrium (Y_2O_3)	-	-
Germanium	-	-	Zinc	-	-
Gold	<.01 oz/t	<.01 oz/t	Zirconium (ZrO_2)	-	-
Indium	-	-			
Lanthanum (La_2O_3)	-	-	Aluminum (Al_2O_3)	H	H
Lead	.005%	.007%	Calcium (CaO)	2%	2%
Lithium (Li_2O)	-	-	Iron (Fe)	2%	2%
Manganese	.2%	.1%	Magnesium (MgO)	5%	5%
Mercury	-	-	Silica (SiO_2)	H	H
Molybdenum	<.001%	<.001%	Sodium (Na_2O)	M	M
Neodynmium (Nd_2O_3)	-	-	Potassium (K_2O)	1%	1%
Nickel	.002%	.003%			

Figures are approximate.

Code: H - High, approximately 10 to 100% range
M - Medium, approximately 1 to 10% range
L - Low, approximately 0.1 to 1% range
Other elements (-) looked for but not found
< - indicates less than

AFTON CONCENTRATE ANALYSES

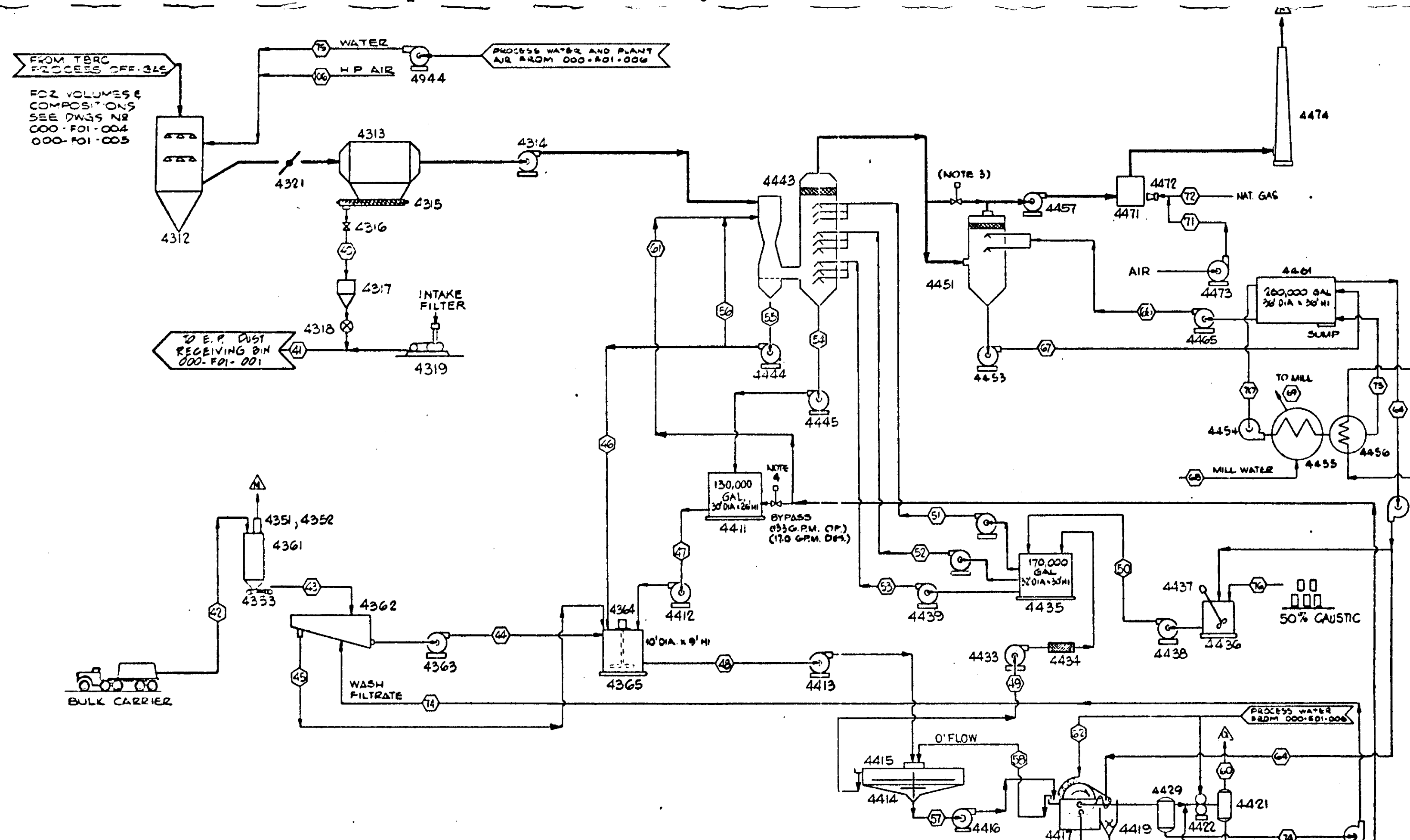
Production, Years 1 to 4

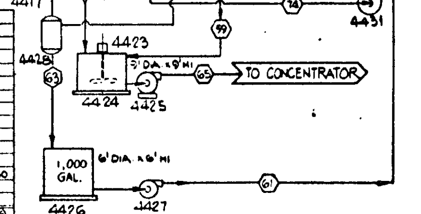
Constituent	Metallic Concentrate Average	Flotation Concentrate Average	Combined Concentrate Average
Cu	97.88	46.75	65.77
Fe	0.12	6.31	4.01
Bi	0.003	0.003	0.003
Cd	0.0001	0.001	0.0007
Co	$<$0.001	0.003	0.002
Pb	0.002	0.07	0.045
Hg	0.0132	0.0096	0.0109
Mo	$<$0.001	0.003	0.002
Ni	0.001	0.009	0.006
Zn	0.005	0.082	0.054
As	0.007	0.50	0.40
Sb	0.006	0.041	0.028
F	0.0003	0.003	0.002
S	$<$0.05	5.53	3.49
P	0.013	0.046	0.034
SiO_2	0.79	21.49	13.79
Al_2O_3	0.19	6.67	4.26
CaO	0.17	2.14	1.41
MgO	0.059	2.46	1.57
Na_2O	-	1.41	-
K2O	-	0.90	-
Total	99.31	93.99	
Au	0.584	1.479	1.146
Ag	7.62	5.08	6.03
Pt	-	0.010	-
Pd	-	0.106	-
Se	0.0008	0.0023	-
Te	$<$0.001	$<$0.0010	-

NOTE: Au, Ag, Pt and Pd in oz/ton, other analyses in percent.
$<$ - indicates less than

APPENDIX 4

SMELTER FLOWSHEET





MATERIAL BALANCE

STREAM NO	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
DESIGN																			
SOLIDS DTPH																			
SLURRY SP.G.					1.284				1.022									1.212	
SLURRY GPM					9.12				270.4									28	22
WATER GPM						681	17.5	237		242		413	413	413	1222	1317.5	300		
SOLIDS % BY WT.									3.7									30	
NAT GAS SCFM @ 77°F																			
AIR SCFM @ 77°F																			
TEMP (MAX) °F							90		186	185		185	185	185	190	190	190		
CAUSTIC @ 50% GPH											3.0								
LIME LB/HR			3000	1770															
CAUSTIC @ 50% LB/DAY																			
OPERATING																			
SOLIDS DTPH																			
SLURRY SP.G.					1.284				1.022									1.212	
SLURRY GPM					7.60				211.6									22	0
WATER GPM						0	14	190		189		330	330	330	976	1049	1035		
SOLIDS % BY WT									3.7									30	
NAT GAS SCFM @ 77°F																			
AIR SCFM @ 77°F																			
TEMP (MAX) °F							190		186	85		185	185	185	190	190	190		
CAUSTIC @ 50% GPH											0.25								
LIME LB/HR			3000	1475															
CAUSTIC @ 50% LB/DAY																			

STREAM NO	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
DESIGN																		
SOLIDS DTPH																		
SLURRY SP.G.							1.30											
SLURRY GPM							19.6											
WATER GPM	5		17.0	8.7	17.0	8.5		3111	3194	1250	1250	1250			1250	8.7	30	
SOLIDS % BY WT.							40											
NAT GAS SCFM @ 77°F														40				
AIR SCFM @ 77°F													1400					
TEMP (MAX) °F								75	110	63	75	80			80			
CAUSTIC @ 50% GPH																		
LIME LB/HR																		
CAUSTIC @ 50% LB/DAY																		930
OPERATING																		
SOLIDS DTPH																		
SLURRY SP.G.							1.30											
SLURRY GPM							15.3											
WATER GPM	3		13.3	7.0	13.3	6.6		2489	2555	1000	1000	1000			1000	7.0	24	
SOLIDS % BY WT							40											
NAT GAS SCFM @ 77°F														55				
AIR SCFM @ 77°F													1100					
TEMP (MAX) °F								75	110	63	75	80			60			
CAUSTIC @ 50% GPH																		
LIME LB/HR																		
CAUSTIC @ 50% LB/DAY																		200

NOTES:

1. WORK THIS DWG. WITH DWGS. 000-F01-001, 006 & 007.
2. FOR LEGEND SEE DWG. 000-F01-005.
3. OFFGAS BYPASS TO BE OPERATED ONLY WHEN Hg FLOW IS BELOW PCB REQUIREMENTS
4. FILTRATE BYPASS TO STORAGE TANK 4411 TO BE OPERATED WHEN VENTURI SCRUBBER IS NOT OPERATING
5. SYMBOL △ REPRESENTS EMISSION QUANTITIES SEE CHART ABOVE.

NO	DATE	DESCRIPTION	BY	CK	APP

REVISIONS

FOR APPROVAL NOT APPROVED FOR CONSTRUCTION

ISSUE NO. 3 DATE PRINTED 1-17-76

DENVER OPERATIONS OFFICE | ENGINEERING CONSTRUCTION DIV.

AFTON MINES LTD

KAMLOOPS, B. C.

PROCESS OFF-GAS FLOW DIAGRAM

DRAVO

CONTRACT NO M-7157

DRAWING NO. 000-F01-002

EQUIPMENT NUMBER	QUANTITY	DESCRIPTION
1900		BELT CONVEYORS
1911	1	Filter Cake Conveyor, Reversible
1913	1	Storage Reclaim Conveyor
1914	1	Reversing Shuttle Conveyor
1915	1	Charging Conveyor
1916	1	Storage Reclaim Conveyor
2710		MOBILE EQUIPMENT
2712	1	Front End Loaders
2713	1	Power Sweeper
2715	1	Pallet Hand Truck
	1	
3910		RECEIVING
3911	1	Concentrate Thickener Mechanism
3912	1	Thickener Underflow Pump
3914	1	Truck Scale
3916	1	Thickener Tank
3917	1	Thickener Overflow Tank
~~3918~~	1	~~Thickener Overflow Return Pump~~
3950		MATERIAL PREPARATION
3951	1	Agitator
3952	1	Filter Feed Pump
3953	1	Disc Filter
3954	1	Filter Receiver
3955	1	Vacuum Pump
3957	1	Sump Pump
3959	1	Rotary Dryer with Feeder
3961	1	Dryer Combustion Package
3964	1	Dryer Cyclone
3965	1	Dryer Cyclone Rotary Valve
3966	1	Dryer Scrubber
3967	1	Scrubber I.D. Fan
3968	1	Scrubber Discharge Pump
3969	1	Dryer Discharge Screw Conveyor
3971	1	Dryer Discharge Sampler
3973	1	Slurry Surge Tank
3975	1	Drag Conveyor
3976	1	Bucket Elevator, Conc.
3977	1	Bucket Elevator, Reclaim
4110		CHARGING
4111	1	Bag Type Dust Collector
4112	1	Baghouse I.D. Fan
4113	1	Weigh Belt Feeder, Flotation Concentrates
4114	1	Weigh Belt Feeder, Metallics
4115	1	Weigh Belt Feeder, Coke
4116	1	Weigh Belt Feeder, Burned Lime
4117	1	Bin, Concentrate Storage
4118	1	Bin, Metallics Storage
4119	1	Bin, Coke Storage
4121	1	Bin, Burned Lime Storage
4122	1	E.P. Dust Receiving Bin
4123	1	Bin Filter E.P. Dust
4124	1	Rotary Valve
4125	1	Agglomerator
4126	1	Bin, E.P. Dust Storage
4127	1	Weigh Belt Feeder, E.P. Dust
4128	1	Concentrate Live Bin Bottom
4150		TBRC
4151	1	Top Blown Rotary Converter
4152	1	TBRC Refractory Lining
4153	1	TBRC Lube Pump
4154	1	Rotate Motor Cooling Blower
4155	1	TBRC Hood & Additive Chute
4156	1	TBRC Hood Refractory
4157	1	TBRC Hood Opening Mechanism
4158	2	Process Lance
4159	1	Lance Positioning Mechanism
4161	1	5T, Lance Handling Hoist
4162	1	Burn-In Lance
4163	1	Burn-In Lance Blower
4164	1	Vent Access Hood Exhaust Fan
4165	1	5T, Reline Hoist
4166	1	1T, Burn-In Lance Hoist
4167	1	Refractory Reline Cage
4168	1	Computer, Table Top
4169	Lot	Refractories, Misc.
4171	1	Charge Chute Positioning Mechanism
4173	1	3T, Refractory Hoist
4174	1	TBRC Heat Shield

EQUIPMENT NUMBER	QUANTITY	DESCRIPTION
4210		MOLTEN MATERIAL HANDLING
4211	1	2T, Ladle Reline Jib Crane
4212	1	Ladle Preheat Burner
4213	1	Preheat Exhaust Fan
4217	3	Slag Ladle
4218	Lot	Slag Ladle Refractories
4219	2	Discard Slag Launder
4221	3	Copper Ladle
4222	Lot	Copper Ladle Refractories
4224	3	Slide Gate Valve
4225	1	Mounting Assembly & Jigs
4226	2	Hydraulic Unit, Slide Gate Valves
4227	1	Ladle Transfer Car
4229	1	Hot Metal Crane
4231	2	Charge Box
4232	1	Platform Scale
4233	1	Slag Exhaust Fan
4234	2	Slag Ladle Preheat Stand
4235	1	Copper Ladle Preheat Stand
4236	1	Ladle Repair Stand
4237	1	Ladle Turntable
4238	Lot	Refractories, Misc.
4239	1	Repair Hoist, Hot Metal Crane
4250		COPPER CASTING
4251	2	Launder Preheat Burner
4252	1	Copper Casting Machine
4253		Cast Iron Molds
4254	1	Pouring Ladle
4255	2	Pouring Ladle & Mold Preheat Burner
4256	1	Mold Dressing Tank
4257	1	Mold Dressing Agitator
4258	1	Mold Dressing Pump
4259	1	Spray Hood Exhaust Fan
4261	1	Vertical Sump Pump
4262	1	Apron Stacker Feed Conveyor
4263	1	Copper Cake Stacker
4264	1	Apron Stacker Storage Conveyor
4265		Strapping Equipment
4266	1	Platform Scale
4267	1	Casting Service Crane
4268	1	Copper Casting Launder
4310		GAS CLEANING
4311	1	Flue Duct Refractory
4312	1	Process Gas Cooling System
4313	1	Electrostatic Precipitator
4314	1	Process Gas Fan
4315	1	E.P. Screw Conveyor
4316	1	Double Dump Valve
4317	1	Pneumatic Conveying Feed Hopper
4318	1	Rotary Feeder
4319	1	Pneumatic Conveying Blower
4321	1	Process Gas Damper
4322	Lot	Refractories, Gas Cooler
4350		MILK OF LIME PREPARATION
4351	1	Quicklime Bin Filter
4352	1	Quicklime Bin Filter Exhauster
4353	1	Quicklime Weigh Belt Feeder
4361	1	Quicklime Storage Bin
4362	1	Quicklime Slaker
4363	1	Slaker Discharge Pump
4364	1	Reaction Tank Agitator
4365	1	Reaction Tank
4410		SO_2 SCRUBBING
4411	1	Spent Scrub Liquor Storage
4412	1	Spent Scrub Liquor Pump
4413	1	Reaction Tank Discharge Pump
4414	1	Sludge Thickener Tank
4415	1	Sludge Thickener Mechanism
4416	1	Sludge Thickener Underflow Pump
4417	1	Sludge Filter with Wash Sprays
4419	1	Filter Discharge Repulper
4421	1	Filter Receiver
4422	1	Filter Vacuum Pump
4423	1	Sludge Disposal Agitator
4424	1	Sludge Disposal Tank
4425	1	Sludge Disposal Pump
4426	1	Filtrate Tank
4427	1	Venturi Feed Pump
4428	1	Filtrate Receiver
4429	1	Wash Receiver
4431	1	Slaker Wash Filtrate Feed Pump
4433	1	Thickener Overflow Pump
4434	1	Line Filter
4435	1	Regenerated Scrubber Liquor Discharge
4436	1	Caustic Dilution Tank
4437	1	Caustic Tank Mixer
4438	1	Caustic Feed Pump
4439	3	Scrubber Feed Pumps
4443	1	Venturi SO_2 Scrubber
4444	1	Venturi Discharge Pump
4445	1	Spray Tower Discharge Pump

EQUIPMENT NUMBER	QUANTITY	DESCRIPTION
4450		MERCURY SCRUBBING
4451	1	Mercury Scrubber
4453	1	Mercury Scrubber Discharge Pump
4454	1	Heat Exchanger Recycle Pump
4455	1	Mercury Removal Heat Exchanger
4456	1	Oxygen Vaporizer
4457	1	Mercury Scrubber I.D. Fan
4461	1	Heat Exchanger Mill Water Storage Tank
4462	1	Storage Tank Bleed Pump
4465	1	Mercury Scrubber Feed Pump
4471	1	Stack Reheat Firebox
4472	1	Stack Reheat Burner
4473	1	Stack Reheat Blower
4474	1	Stack
4500		AIR & HVAC
4501	1	Process Air Compressor
4502	1	Plant Air Compressor
4503	1	Instrument Air Dryer
4504	1	Air Receiver
4505	19	Roof Ventilators
4506	22	Supply Fans Wall Mounted
4507	1	Blower-Filter Unit
4508	1	Packaged Water Cooled Air-Conditioning Unit
4509	6	Indirect Fired Make-Up Air Heaters
4511	4	Exhaust Fan-Ceiling Mounted
4920		GAS
	1 Lot	Natural Gas Pipeline
4930		OIL
4936	1	Diesel Fuel Day Tank
	1	Diesel Fuel Pipeline
4940		WATER
	1 Lot	Water Pipeline
4942	1	Lance Water Storage Tank
4943	2	Lance Water Pump
4944	1	Gas Cooling Water Pump
4950		OXYGEN
	1	Oxygen Pipeline
6000		ELECTRICITY
		Electric Power
6016	1	Emergency Power Generator

DATE | DESCRIPTION | BY
REVISIONS

FOR APPROVAL NOT APPROVED FOR CONSTRUCTION

ISSUE NO. 3 DATE PRINTED 1-17-76

DENVER OPERATIONS OFFICE | (ENGINEERING CONSTRUCTION DIV.)

NO. | BY | J.E.
REVISIONS

AFTON MINES LTD
KAMLOOPS, B. C.

LEGEND TO FLOW DIAGRAMS

DR. [illegible] | SCALE [illegible] | CHK'S [illegible]
CH'K'D [illegible] | SECT [illegible] | APP'D [illegible]
J.E. [illegible] | CODE [illegible] | CONTRACT NO. M-7157

Dravo

DRAWING NO. 000-F01-003 | REV. C

APPENDIX 5

SURFACE WATER QUALITY: ANALYTICAL DATA

Table 1

RESULTS OF ANALYSES OF WATER SAMPLES FROM KAMLOOPS LAKE AND THE THOMPSON RIVER AT TRANQUILLE. VALUES ARE GIVEN AS PPM*

Factor	MARCH 19-22					JULY 16-20					OCTOBER 16-18				
	A	C-2 10 feet	C-2 400 feet	D-2 10 feet	D-2 300 feet	A	C-2 10 feet	C-2 400 feet	D-2 10 feet	D-2 300 feet	A	C-2 10 feet	C-2 400 feet	D-2 10 feet	D-2 300 feet
Total															
Dissolved Solids	68.8	63.4	62.8	61.0	59.8	38.1	43.7	60.0	43.0	49.6	52.4	50.8	55.4	40.1	56.8
Volatile Solids	27.3	26.3	26.8	27.0	22.2	18.6	20.9	26.0	20.2	28.8	20.4	19.8	17.9	13.8	21.8
Fixed Solids	41.5	37.1	36.0	34.0	37.6	19.5	22.8	34.0	22.8	21.9	32.0	31.0	37.5	26.3	35.0
Silica (SiO_2)	2.6	2.3	2.3	2.2	2.1	2.8	3.7	3.5	4.7	3.9	0.4	0.5	0.4	0.4	0.5
Total Iron	0.1	0.1	0.1	0.1	0.1	1.0	0.6	0.8	0.7	1.0	4.5	1.8	2.0	1.6	1.8
Calcium	15.7	13.9	13.8	13.3	13.3	9.0	10.4	13.1	10.3	10.9	12.0	12.0	13.5	11.1	13.1
Sodium	2.4	2.3	2.4	2.0	2.0	1.2	1.2	2.1	1.9	1.7	1.7	1.3	1.3	0.8	1.3
Magnesium	2.5	2.1	2.2	2.0	2.2	1.3	1.5	2.3	1.5	1.8	2.0	2.0	2.5	1.9	2.5
Sulphate (SO_4)	7.7	7.1	7.9	6.4	6.4	6.6	6.9	11.0	6.5	7.0	7.9	7.3	7.9	7.4	8.1
Potassium	<1.0	<1.0	<1.0	<1.0	<1.0	0.9	0.8	1.1	0.8	1.0	0.9	0.8	0.9	0.8	0.8
Chloride	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Lead							< 0.002								
Zinc			< 0.001												
Copper			0.001												

From p. 28 "Limnology of Kamloops Lake" F. J. Ward, Bulletin XVI IPSFC, 1964.

Table 2

LEVELS (IN PPM) OF PHOSPHORUS AND NITROGEN IN KAMLOOPS LAKE IN 1963*

Date	C-2 10 FT					C-2 400 FEET					D-2 10 FT					D-2 300 FT				
	N	NH_3	N[1]	PO_4[2]	PO_4[2]	N	NH_3	N[1]	PO_4[2]	PO_4[2]	N	NH_3	N[1]	PO_4[3]	PO_4[3]	N	NH_3	N[1]	PO_4[2]	PO_4[3]
March	0.44	0.012	0.07	<0.003		0.40	0.012	0.06	<0.003		0.44	0.018	0.07	<0.003		0.44	0.012	0.06	<0.003	0.
April	0 34	<0.04	0.10	<0.004		0.35	<0.02	0.07	<0.001		0.35	<0.01	0.07	<0.001		0.35	<0.02	0.07	<0.003	
May	0.27	0.02	0.11	0.006	0.020	0.18	0.02	0.11		0.007	0.18	0.01	0.14		0.020	0.18	0.010	0.09		0.007
June	0.34	<0.01	0.10	<0.003	0.023	0.47	<0.01	0.08	<0.003	0.018	0.42	<0.01	0.10	<0.003	0.023	0.42	0.020	0.09	<0.003	0.030
July	0.18	<0.01	0.07	<0.002	0.012	0.35	<0.02	0.07	<0.002	0.013	0.18	<0.01	0.09	<0.002	0.013	0.31	<0.02	0.06	<0.002	0.012
August	0.18	0.03	0.11	<0.002	0.015	0.35	0.05	0.07	<0.002	0.019	0.18	<0.02	0.10	<0.002	0.018	0.27	<0.02	0.08	<0.002	0.016
September	0.09	<0.01	0.09	<0.002	0.019	0.35	<0.02	0.09	<0.002	0.023	0.09	<0.01	0.09	<0.002	0.017	0.27	<0.02	0.08	<0.002	0.022
October	0.35	<0.02	0.08	0.007	0.026	0.61	<0.01	0.07	0,009	0.084	0.26	<0.01	0.07	0.009	0.053	0.61	<0.01	0.07	0.006	0.040
November	0.28	0.01	0.07	0.007	0.011	0.44	<0.02	0.05	0.007	0.011	0.30	<0.01	0.09	0.007	0.010	0.44	<0.02	0.06	0.007	0.011

1. Total nitrogen other than nitrates   2. Inorganic phosphate   3. Total phosphate

* From Page 29 "Limnology of Kamloops Lake" F. J. Ward Bulletin XVI IPSFC, 1964

Table 3

WATER SAMPLE TEST RECORD*

Sample point: Cherry Creek at Cherry Creek mouth PCB Station 0600057

Date	Apr. 24/72	Jun. 19/72	Sept. 6/72	Dec. 7/72	Mar. 7/73	June 14/73
Time	2:00	2:05	3:00	1:30	3:50	9:20
Alkalinity, total (as $CaCO_3$)	357	166	291	534	300	355
Calcium	-	-	-	-	82.5	82.6
Color (units)	10	25	20	15	5	20
Conductance Micromhos/cm	1000	460	730	1345	830	-
Copper	0.02	0.02	0.007	0.001	0.006	0.004
Hardness (as $CaCO_3$)	-	-	-	-	354	428
Lead unfiltered	< 0.003	<0.003	<0.003	<0.003	<0.001	<0.001
Magnesium dissolved	-	-	-	-	-	54.0
unfiltered	-	15.0	34.0	82.5	37.5	53.5
Manganese unfiltered	0.06	0.07	0.08	0.28	0.06	0.09
Nitrate nitrogen (N)	] 0.22	0.20	0.30	0.53	0.28	0.18
Nitrite nitrogen (N)				0.007	0.007	<0.005
Ammonia nitrogen (N)	] 0.27	0.56	0.43	0.47	0.10	0.37
Organic nitrogen (N)						
Total nitrogen (N)	0.49	0.76	0.73	1.01	1.39	0.55
pH	8.0	8.0	8.5	8.0	8.2	-
Phosphate, total (P)	0.050	0.018	0.103	0.114	0.070	0.076
Solids, dissolved	718	277	508	934	582	626
Solids, suspended	1.7	61	4	14	18	2
Solids, total	720	338	512	948	600	628
Sulfate	243	50	131	264	181	161
Temperature (°C)	9	14.5	15	0.0	3	-
Turbidity (Jackson units)	1.3	16	4.1	13	3.3	1.0
Zinc	0.02	0.040	<0.005	< 0.005	< 0.005	<0.005

* Data courtesy Pollution Control Branch, Kamloops

Table 3 (continued)

WATER SAMPLE TEST RECORD*

Sample point: Cherry Creek at Cherry Creek mouth PCB Station 0600057

Date	Dec. 5/73	Mar. 11/74	June 4/74	Sept. 16/74	Nov. 28/74
Time	13:40	13:00	13:10	14:05	
mg/l (unless otherwise noted)					
Alkalinity, total (as $CaCO_3$)	338	152	156	322	326
Arsenic, dissolved		<0.005			
Calcium, dissolved	84	38.9	44.6	79.0	75.0
Carbon, T.O.C.					
, T.I.C.					
Chloride, dissolved					
Chromium, dissolved					
Colour, True (Rel. units)	10	60	40	15	10
, TAC					
Conductance, Lab (micromhos/cm)	843	530	450	825	870
, Field (micromhos/cm)	600	510	440	890	890
Copper, total	0.005	0.004			
, dissolved		0.003		0.001	<0.001
Cyanide		<0.01			
Faecal coliform (MPN/100 ml)					
Hardness (as $CaCO_3$)	407	187	187	380	389
Iron, dissolved		0.2		<0.1	<0.1
Lead, total	<0.001				
, dissolved					
Magnesium, dissolved	48	20.8		43	41.4
Manganese, total	0.10				
Nitrogen, Nitrate (N)	0.07	0.21	0.03	0.04	0.08
Nitrogen, Nitrite (N)	<0.005	0.012	<0.005	<0.005	<0.005
Nitrogen, Ammonia (N)					
Nitrogen, Kjeldahl (N)	0.27	3.0	0.43	0.37	0.30
Nitrogen, Organic (N)					
Nitrogen, Total (N)	0.34	3.22	0.46	0.41	0.38

Table 3 (continued)

WATER SAMPLE TEST RECORD*

Sample point: Cherry Creek at Cherry Creek mouth PCB Station 0600057

Date	Dec. 5/73	Mar. 11/74	June 4/74	Sept. 16/74	Nov. 28/74
Time	13:40	13:00	13:10	14:05	
Mercury, total (mg/1)					
, dissolved (mg/1)					
Oxygen, dissolved	7.4	6.6			
pH, Lab (rel. units)		8.0	8.0	8.2	8.1
, Field (rel. units)	8.4	7.8	8.7	8.3	7.8
Phosphate, ortho (P)					0.047
, total (P)	0.053	0.900	0.115	0.078	0.065
Silica, reactive				20.7	18.5
Solids, dissolved	592	368	310	588	560
, suspended					
, total	602	630	346	590	570
Sulfate	151				
Temperature (^{o}C)	2	2	12	14.1	3
Turbidity (Jackson units)	2.1	92	16	1.6	3.2
Zinc	<0.005				

* Data courtesy of Pollution Control Branch, Kamloops

Table 3 (continued)

WATER SAMPLE TEST RECORD*

Sample point: Cherry Creek at Cherry Creek mouth PCB Station 0600057

Date	Mar. 12/75	May 5/75	July 23/75	Nov. 12/75	Jan. 21/76
Time	12:30	15:40	15:00	12:10	11:10
mg/l (unless otherwise noted)					
Alkalinity, total (as $CaCO_3$)	331	337	354	402	369
, phnl		9.5	9.7		
Arsenic, dissolved	0.006				
Calcium, dissolved	72.6	96.0	81.0	102	99.8
Carbon, T.O.C.		8	19	8	<1
, T.I.C.		78	70	106	87
Chloride, dissolved	8.3			9.5	
Chromium, dissolved	<0.005				
Colour, True (Rel. units)	20				
, TAC		9	24	12	12
Conductance, Lab (micromhos/cm)	990	916	850	1050	1010
, Field (micromhos/cm)	1000		875	1000	950
Copper, total					
, dissolved	<0.001		0.003	0.003	0.002
Cyanide					<0.01
Faecal coliform (MPN/100 ml)				<2	
Hardness (as $CaCO_3$)	433	439	392	488	475
Iron, dissolved	<0.1		<0.1	0.1	<0.1
Lead, total					
, dissolved	<0.001				<0.001
Magnesium, dissolved	61.1	48.5			54.8
Manganese, total					
Nitrogen, Nitrate (N)	0.43	0.17	0.20	0.10	0.25
Nitrogen, Nitrite (N)	0.009	<0.005	0.005	0.006	0.005
Nitrogen, Ammonia (N)	0.528	0.019			
Nitrogen, Kjeldahl (N)	0.91	0.27	0.71	0.47	0.37
Nitrogen, Organic (N)	0.380	0.25			
Nitrogen, Total (N)	1.349	0.44	0.915	0.576	0.625

Table 3 (continued)

WATER SAMPLE TEST RECORD*

Sample point: Cherry Creek at Cherry Creek mouth PCB Station 0600057

Date	Mar. 12/75	May 5/75	July 23/75	Nov. 12/75	Jan. 21/76
Time	12:30	15:40	15:00	12:10	11:10
Mercury, total (mg/l)				<0.05	0.05
, dissolved (mg/l)				<0.05	-
Oxygen, dissolved	11.5		9.4	11.3	13.0
pH, lab (rel. units)	8.3	8.3	8.5	8.1	8.3
, field (rel. units)	8.0				
Phosphate, ortho (P)	0.112	0.046	0.047	0.049	
, total (P)	0.148	0.08	0.114	0.075	0.053
Silica, reactive	17		20.4	22.1	18.9
Solids, dissolved	676	680	610	710	698
, suspended					
, total	682	684	620	716	702
Sulfate				182	189
Temperature, (^{o}C)	1.0		23.9	9.5	0.5
Turbidity (Jackson units)	2.6		4.2	2.9	2.0
Zinc	<0.005				

* Data courtesy of Pollution Control Branch, Kamloops

TABLE 4

SITE 1 - CHERRY CREEK BELOW CONFLUENCE WITH ALKALI CREEK

Measurement	November 30, 1973	April 26, 1974	June 5, 1975	January 27, 1976
BOTTOM CONDITION	-	Rocks & Gravel	-	-
Estimated Flow (cfs)	-	-	-	1
Water Temperature (°C)	-	4.0	11.4	3
Air Temperature (°C)	-	-	-	9
Dissolved Oxygen (mg/l)	-	13.7	-	11.7
pH - Field	-	8.5	-	7.9
- Laboratory	8.1	7.9	7.9	8.3
Carbon - Total (mg/l)	-	66	-	63
- Organic (mg/l)	-	14	19	3
Turbidity (NTU)	0.53	0.19	19	1.8
Specific Conductance (μmho/cm)	-	646	342	545
Solids - Suspended (mg/l)	-	<1	100	3
- Dissolved (mg/l)	646	389	235	399
- Total (mg/l)	-	389	335	402
EDTA Hardness (mg $CaCO_3$/l)	405	300	148	287
Alkalinity (mg $CaCO_3$/l)	-	270	120	250
Colour (APHA units)	-	<5	80	4.5
Sulfate (mg SO_4/l)	-	-	50	78
Oil and Grease (mg/l)	-	-	<2	3
Cyanide (mg/l)	-	-	0.0005	<0.002
Total Mercury (mg/l)	-	-	-	<0.00005
Dissolved Fluoride (mg/l)	-	-	-	0.11
Dissolved Arsenic (mg/l)	-	<0.015	0.001	0.0008
Dissolved Copper (mg/l)	0.0025	0.0038	0.005	0.003
Dissolved Iron (mg/l)	0.004	0.011	0.059	0.036
Dissolved Lead (mg/l)	<0.002	<0.0005	<0.0005	<0.001
Dissolved Molybdenum (mg/l)	-	-	0.010	0.008
Dissolved Zinc (mg/l)	0.001	-	0.050	0.06
Dissolved Antimony (mg/l)	-	-	-	<0.01
Dissolved Cadmium (mg/l)	-	-	-	<0.001
Coliforms (MPN/100 ml) - Confirmed	9200	-	-	220
- Faecal	70	-	-	140
Total Phosphorus (mg P/l)	0.053	-	-	0.055
Nitrate (mg N/l)	0.100	-	-	0.209
Nitrite (mg N/l)	<0.001	-	-	0.005

TABLE 5

SITE 2 - LAKE AT PIT SITE

Measurement	April 26/74	January 27/76
BOTTOM CONDITION	ORGANIC OOZE	-
Estimated Flow (cfs)	-	-
Water Temperature (^{o}C)	-	0.5
Air Temperature (^{o}C)	-	6.0
Dissolved Oxygen (mg/1)	-	4.1
pH - Field	-	7.8
- Laboratory	8.1	8.6
Carbon - Total (mg/1)	26	164
- Organic (mg/1)	17	76
Turbidity (NTU)	4.9	17
Specific Conductance (μmho/cm)	1644	28,200
Solids - Suspended (mg/1)	9	10
- Dissolved (mg/1)	1113	38,350
- Total (mg/1)	1122	38,360
EDTA Hardness (mg $CaCO_3$/1)	245	7,400
Alkalinity (mg $CaCO_3$/1)	80	410
Colour (APHA units)	37	37
Sulfate (mg SO_4/1)	-	25,000
Oil and Grease (mg/1)	-	<2
Cyanide (mg/1)	-	<0.002
Total Mercury (mg/1)	-	<0.00005
Dissolved Fluoride (mg/1)	-	0.12
Dissolved Arsenic (mg/1)	-	0.008
Dissolved Copper (mg/1)	-	0.020
Dissolved Iron (mg/1)	-	0.040
Dissolved Lead (mg/1)	-	<0.001
Dissolved Molybdenum (mg/1)	-	0.006
Dissolved Zinc (mg/1)	-	0.05
Dissolved Antimony (mg/1)	-	<0.01
Dissolved Cadmium (mg/1)	-	<0.001
Coliforms (MPN/100 ml) - Confirmed	-	<2
- Faecal	-	<2
Total Phosphorus (mg P/1)	-	0.276
Nitrate (mg N/1)	-	0.005
Nitrite (mg N/1)	-	0.005

TABLE 6

SITE 3 - POTHOLE NE OF HUGHES LAKE

Measurement	April 26/74
Bottom condition	organic ooze
Temperature (^{o}C)	-
Dissolved oxygen (mg/l)	-
pH - field	-
- laboratory	8.4
Carbon - total (mg/l)	30
- organic (mg/l)	19
Turbidity (NTU)	2.9
Specific conductance (μmho/cm)	1721
Solids - suspended (mg/l)	8
- dissolved (mg/l)	1384
- total (mg/l)	1392
EDTA Hardness (mg $CaCO_3$/l)	260
Alkalinity (mg $CaCO_3$/l)	85
Color (APHA units)	36
Sulfate (mg/l)	-
Oil and grease (mg/l)	-
Cyanide (mg/l)	-
Dissolved Arsenic (mg/l)	-
Dissolved Copper (mg/l)	-
Dissolved Iron (mg/l)	-
Dissolved Lead (mg/l)	-
Dissolved Molybdenum (mg/l)	-
Dissolved Zinc (mg/l)	-
Coliforms (MPN/100) - confirmed	-
- faecal	-
Total phosphate (mg/l)	-
Nitrate (mg/l)	-
Nitrite (mg/l)	-

TABLE 7

SITE 4 - HUGHES LAKE

Measurement	April 26/74	June 5/75	January 27/76
Bottom Condition	Organic ooze	-	-
Estimated Flow (cfs)	-	-	-
Water Temperature (^{o}C)	-	17.5	0.5
Air Temperature (^{o}C)	-	-	5.0
Dissolved Oxygen (mg/l)	-	-	10.6
pH - Field	-	-	7.6
- Laboratory	8.5	8.3	8.6
Carbon - Total (mg/l)	58	-	134
- Organic (mg/l)	23	32	18
Turbidity (NTU)	1.45	2.2	2.2
Specific Conductance (μmho/cm)	1249	1723	1920
Solids - Suspended (mg/l)	3	16	7
- Dissolved (mg/l)	916	1341	1841
- Total (mg/l)	919	1357	1848
EDTA Hardness (mg $CaCO_3$/l)	370	593	772
Alkalinity (mg $CaCO_3$/l)	185	400	476
Colour (APHA units)	37	60	20
Sulfate (mg SO_4/l)	-	536	820
Oil and Grease (mg/l)	-	<2	2
Cyanide (mg/l)	-	0.0035	<0.002
Total Mercury (mg/l)	-	-	<0.0005
Dissolved Fluoride (mg/l)	-	-	0.23
Dissolved Arsenic (mg/l)	-	0.004	0.003
Dissolved Copper (mg/l)	-	0.0067	0.016
Dissolved Iron (mg/l)	-	0.014	0.019
Dissolved Lead (mg/l)	-	<0.0005	<0.001
Dissolved Molybdenum (mg/l)	-	0.005	0.007
Dissolved Zinc (mg/l)	-	0.0036	0.06
Dissolved Antimony (mg/l)	-	-	<0.01
Dissolved Cadmium (mg/l)	-	-	<0.001
Coliforms (MPN/100 ml)-confirmed	-	-	<2
-faecal	-	-	<2
Total Phosphorus (mg/P/l)	-	-	0.212
Nitrate (mg N/l)	-	-	0.034
Nitrite (mg N/l)	-	-	0.0096

TABLE 8

SITE 5 - ALKALI CREEK ABOVE CONFLUENCE WITH CHERRY CREEK

Measurement	April 26/74	June 5/75	January 27/76
Bottom Condition	Clay-Gravel	-	-
Estimated Flow (cfs)	-	4.5	0.5
Water Temperature (°C)	8.5	14.0	1.0
Air Temperature (°C)	-	-	8.0
Dissolved Oxygen (mg/l)	12.8	-	11.6
pH - Field	8.2	-	7.7
- Laboratory	8.4	7.9	8.2
Carbon - Total (mg/l)	77	-	65
- Organic (mg/l)	16	20	3
Turbidity (NTU)	0.30	1.2	1.1
Specific Conductance (μmho/cm)	932	1287	625
Solids - Suspended (mg/l)	2	5	<1
- Dissolved (mg/l)	659	1038	498
- Total (mg/l)	661	1043	498
EDTA Hardness (mg $CaCO_3$/l)	430	529	319
Alkalinity (mg $CaCO_3$/l)	335	356	253
Solour (APHA units)	15	35	4.5
Sulfate (mg SO /l)	-	440	138
Oil and Grease (mg/l)	-	2	2
Cyanide (mg/l)	-	0.0007	<0.002
Total Mercury (mg/l)	-	-	<0.00005
Dissolved Fluoride (mg/l)	-	-	0.13
Dissolved Arsenic (mg/l)	<0.015	0.003	0.0007
Dissolved Copper (mg/l)	0.0027	0.0045	0.003
Dissolved Iron (mg/l)	0.014	0.029	0.015
Dissolved Lead (mg/l)	0.0022	<0.0005	<0.001
Dissolved Molybdenum (mg/l)	-	0.007	0.008
Dissolved Zinc (mg/l)	-	0.006	0.05
Dissolved Antimony (mg/l)	-	-	<0.01
Dissolved Cadmium (mg/l)	-	-	<0.001
Coliforms (MPN/100 ml)-confirmed	-	-	>24,000
-faecal	-	-	>24,000
Total Phosphorus (mg P/l)	-	-	0.064
Nitrate (mg N/l)	-	-	0.086
Nitrite (mg N/l)	-	-	0.006

TABLE 9

SITE 6 - CHERRY CREEK ABOVE CONFLUENCE WITH ALKALI CREEK

Measurement	November 7/73	April 26/74	June 5/75
Bottom condition	-	Sand-Gravel	-
Temperature ($^{\circ}C$)	-	9.0	10.6
Dissolved oxygen (mg/l)	-	11.6	-
pH - field	8.3	8.1	-
- laboratory	-	8.0	7.5
Carbon - total (mg/l)	-	68	-
- organic (mg/l)	-	14	21
Turbidity (NTU)	0.46	0.25	15
Specific conductance (μmho/cm)	-	658	185
Solids - suspended (mg/l)	-	1	85
- dissolved (mg/l)	363	420	139
- total (mg/l)	-	421	224
EDTA Hardness (mg $CaCO_3$/l)	245	320	100
Alkalinity (mg $CaCO_3$/l)	-	275	90
Color (APHA units)	-	5	85
Sulfate (mg/l)	-	-	13
Oil and grease (mg/l)	-	-	3
Cyanide (mg/l)	-	-	0.003
Dissolved Arsenic (mg/l)	-	<<0.015	0.001
Dissolved Copper (mg/l)	0.0016	0.0023	0.0046
Dissolved Iron (mg/l)	0.004	0.012	0.037
Dissolved Lead (mg/l)	<0.002	<0.0005	<0.0005
Dissolved Molybdenum (mg/l)	-	-	0.011
Dissolved Zinc (mg/l)	0.003	-	0.0061
Coliforms (MPN/100)-confirmed	-	-	-
-faecal	-	-	-
Total phosphate (mg/l)	0.027	-	-
Nitrate (mg/l)	0.065	-	-
Nitrite (mg/l)	<0.001		
Staff gauge reading	-	-	1.5

Note: There was no water flow at this site on January 27, 1976.

TABLE 10

SITE 7 - CHERRY CREEK NEAR KAMLOOPS LAKE

Measurement	November 30/73	April 26/74	June 5/75	January 27/76
Bottom Condition	-	Rock-Gravel	-	-
Estimated Flow (cfs)	-	-	-	1
Water Temperature (°C)	-	12.0	12.0	0.5
Air Temperature (°C)	-	-	-	9.0
Dissolved Oxygen (mg/l)	-	11.2	-	11.6
pH - Field	8.0	8.2	-	7.8
- Laboratory	-	8.4	7.9	8.5
Carbon - Total (mg/l)	-	77	-	89
- Organic (mg/l)	-	16	18	6
Turbidity (NTU)	0.33	0.30	91	35
Specific Conductance (μmho/cm)	-	932	401	875
Solids - Suspended (mg/l)	-	2	297	60
- Dissolved (mg/l)	372	659	264	717
- Total (mg/l)	-	661	561	777
EDTA Hardness (mg $CaCO_3$/l)	245	430	180	451
Alkalinity (mg $CaCO_3$/l)	-	335	158	345
Colour (APHA units)	-	15	100	9
Sulfate (mg SO /l)	-	-	65	200
Oil and Grease (mg/l)	-	-	2	2
Cyanide (mg/l)	-	-	0.004	<0.002
Total Mercury (mg/l)	-	-	-	<0.00005
Dissolved Fluoride (mg/l)	-	-	-	0.15
Dissolved Arsenic (mg/l)	-	<0.015	0.002	0.001
Dissolved Copper (mg/l)	0.0018	0.0024	0.005	0.009
Dissolved Iron (mg/l)	0.007	0.008	0.070	0.110
Dissolved Lead (mg/l)	<0.002	0.0068	<0.005	<0.001
Dissolved Molybdenum (mg/l)	-	-	0.015	0.012
Dissolved Zinc (mg/l)	0.007	-	0.030	0.07
Dissolved Antimony (mg/l)	-	-	-	<0.01
Dissolved Cadmium (mg/l)	-	-	-	<0.001
Coliforms (MPN/100 ml)-Confirmed	-	-	-	540
-faecal	-	-	-	240
Total Phosphorus (mg P/l)	0.014	-	-	0.268
Nitrate (mg N/l)	0.065	-	-	0.244
Nitrite (mg N/l)	0.003	-	-	0.028

TABLE 11

BOWERS BROOK

Measurement	August 28, 1975
Estimated flow (cfs)	-
Temperature (°C)	-
Dissolved oxygen (mg/l)	-
pH - field	-
- laboratory	7.4
Carbon - total (mg/l)	54
- organic (mg/l)	4
Turbidity (NTU)	0.3
Specific conductance (μmho/cm)	420
Solids - suspended (mg/l)	<1
- dissolved (mg/l)	310
- total (mg/l)	310
EDTA Hardness (mg $CaCO_3$/l)	225
Alkalinity (mg $CaCO_3$/l)	204
Color (APHA units	5
Sulfate (mg/l)	43.6
Oil and grease (mg/l)	3.2
Cyanide (mg/l)	0.005
Dissolved Arsenic (mg/l)	0.001
Dissolved Copper (mg/l)	0.0072
Dissolved Iron (mg/l)	0.016
Dissolved Lead (mg/l)	<0.0005
Dissolved Molybdenum (mg/l)	0.010
Dissolved Zinc (mg/l)	0.0078
Coliforms (MPN/100) - confirmed	-
- faecal	-
Total phosphate (mg/l)	-
Nitrate (mg/l)	-
Nitrite (mg/l)	-

TABLE 12

WELL #1 NORTH

Measurement	June 5/75
Estimated flow (gpm)	3
Temperature (^{o}C)	9.5
Dissolved oxygen (mg/l)	-
pH - field	-
- laboratory	7.5
Carbon - total (mg/l)	-
- organic (mg/l)	5
Turbidity (NTU)	0.10
Specific conductance (μmho/cm)	1158
Solids - suspended (mg/l)	2
- dissolved (mg/l)	878
- total (mg/l)	880
EDTA Hardenss (mg $CaCO_3$/l)	533
Alkalinity (mg $CaCO_3$/l)	320
Color (APHA units)	<5
Sulfate (mg/l)	330
Oil and grease (mg/l)	<2
Cyanide (mg/l)	0.0005
Dissolved Arsenic (mg/l)	0.004
Dissolved Copper (mg/l)	0.0022
Dissolved Iron (mg/l)	0.004
Dissolved Lead (mg/l)	<0.0005
Dissolved Molybdenum (mg/l)	0.007
Dissolved Zinc (mg/l)	0.015
Coliforms (MPN/100) - confirmed	-
- faecal	-
Total phosphate (mg/l)	-
Nitrate (mg/l)	-
Nitrite (mg/l)	-

TABLE 13

WELL NO. 2 SOUTH

Measurement	January 27, 1976
Estimated Flow (gpm)	332
Water Temperature (°C)	5.0
Air Temperature (°C)	5.0
Dissolved Oxygen (mg/l)	3.5
pH - Field	6.2
- Laboratory	8.1
Carbon - Total (mg/l)	80
- Organic (mg/l)	1
Turbidity (NTU)	0.2
Specific Conductance (μmho/cm)	1,080
Solids - Suspended (mg/l)	<1
- Dissolved (mg/l)	954
- Total (mg/l)	954
EDTA Hardness (mg $CaCO_3$/l)	585
Alkalinity (mg $CaCO_3$/l)	324
Colour (APHA units)	1
Sulfate (mg SO_4/l)	377
Oil and Grease (mg/l)	<2
Cyanide (mg/l)	<0.002
Total Mercury (mg/l)	<0.00005
Dissolved Fluoride (mg/l)	0.20
Dissolved Arsenic (mg/l)	0.006
Dissolved Copper (mg/l)	0.001
Dissolved Iron (mg/l)	0.027
Dissolved Lead (mg/l)	<0.001
Dissolved Molybdenum (mg/l)	0.005
Dissolved Zinc (mg/l)	0.024
Dissolved Antimony (mg/l)	<0.01
Dissolved Cadmium (mg/l)	<0.001
Coliforms (MPN/100 ml) - Confirmed	<2
- Faecal	<2
Total Phosphorus (mg P/l)	0.048
Nitrate (mg N/l)	<0.005
Nitrite (mg N/l)	<0.001

APPENDIX 6

CHECK LIST OF MAMMALS WHOSE RANGES COINCIDE WITH THE AFTON MINES PROPERTY*

COMMON NAME	LATIN NAME
Masked shrew	Sorex cinereus cinereus
Vagrant shrew	Sorex vagrans obscurus
American water shrew	Sorex palustris navigator
Pigmy shrew	Microsorex hoyi washingtoni
Little brown bat	Myotis lucifugus carissima
Long-eared bat	Myotis evotis evotis
Long-legged bat	Myotis volans
California bat	Myotis californicus californicus
Silver-haired bat	Lasionycteris noctivagans
Townsend's big-eared bat	Plecotus townsendii pallescens
Big brown bat	Eptesicus fuscus pallidus
Hoary bat	Lasiurus cinereus
American pika	Ochotona princeps brooksi
Snowshoe hare	Lepus americanus pallidus
Yellow pine chipmunk	Eutamias amoenus affinus
Yellow-bellied marmot	Marmota flaviventris avara
American red squirrel	Tamiasciurus hudsonicus streatori
Northern flying squirrel	Glaucomys sabrinus columbiensis
Northern pocket gopher	Thomomys talpoides incensus

cont'd

APPENDIX 6 (continued)

COMMON NAME	LATIN NAME
Great Basin pocket mouse	Perognathus parvus lordi
American beaver	Castor canadensis sagittatus or leucodontus
Deer mouse	Peromyscus manicalatus artemisiae
Bushy-tailed wood rate	Neotoma cinerea occidentalis
Gapper's red-backed vole	Clethrionomys gapperi saturatus
Northern bog lemming	Synaptomys borealis dalli
Heather vole	Phenacomys intermedius intermedius
Muskrat	Ondatra zibethicus osoyoosensis
Meadow vole	Microtus pennsylvanicus drummondii
Long-tailed vole	Microtus longicaudus mordax
House mouse	Mus musculus domesticus
Meadow jumping mouse	Zapus hudsonicus tenellus
American porcupine	Erethizon dorsatum nigrescens
Coyote	Canis latrans lestis
Wolf	Canis lupus columbianus
Red fox	Vulpes vulpes abietorum
American black bear	Ursus americanus cinnamonum
Grizzly bear	Ursus arctos
American marten	Martes americana abietinoides
Fisher	Martes pennanti
Ermine	Mustela erminea richardsonii
Long-tailed weasel	Mustela frenata nevadensis

cont'd

APPENDIX 6 (continued)

COMMON NAME	LATIN NAME
American mink	Mustela vision energumenos
Wolverine	Gulo gulo luscus
American badger	Taxidea taxus jeffersonii
Striped skunk	Mephitis mephitis hudsonica
River otter	Lutra canadensis evexa
Mountain lion	Felis concolor oregonensis
Lynx	Lynx lynx canadensis
Bobcat	Lynx rufus pallescens
Mule deer	Odocoileus hemionus hemionus
Moose	Alces alces andersoni

*Source: Banfield, A.W.F. 1974. The Mammals of Canada. University of Toronto Press. Toronto. 438 p.

APPENDIX 7

CHECK LIST OF BIRDS WHOSE BREEDING RANGES COINCIDE WITH THE AFTON PROPERTY AREA+

ORDER GAVIIFORMES (Loons)

Common loon

ORDER PODICIPEDIFORMES (Grebes)

Red-nicked grebe
Horned grebe
Eared grebe
Western grebe*
Pied-billed grebe

ORDER CICONIIFORMES (Herons)

American bittern

ORDER ANSERIFORMES (Geese, Ducks)

Canada goose
Mallard
Gadwall
Pintail
Green-winged teal
Blue-winged teal
Cinnamon teal
American widgeon
Northern shoveler
Redhead
Ring-necked duck
Canvasback*
Lesser scaup
Common goldeneye
Barrow's goldeneye
Bufflehead
Harlequin duck
White-winged scoter
Ruddy duck
Hooded merganser
Common merganser

ORDER FALCONIFORMES (Hawks, Falcons)

Goshank
Sharp-skinned hawk
Cooper's hawk
Red-tailed hawk
Golden eagle*
Bald eagle
Marsh hawk
Osprey
Prairie falcon
Peregrine falcon*

cont'd

Merlin
American kestrel

ORDER GALIIFORMES (Grouse, Pheasants)

Blue grouse
Spruce grouse
Ruffed grouse
White-tailed ptarmigan
Sharp-tailed grouse
California quail*
Chuckar*

ORDER GRUIFORMES (Cranes, Rails)

Sandhill crane
Virginia rail
Sora
American coot

ORDER CHARADRIIFORMES (Shorebirds, Gulls)

Killdeer
Common snipe
Long-billed curlew
Spotted sandpiper
Wilson's phalarope*
Black tern

ORDER COLUMBIFORMES (Doves)

Mourning dove

ORDER STRIGIFORMES (Owls)

Screech owl
Great horned owl
Pygmy owl
Burrowing owl
Barred owl*
Great gray owl
Long-eared owl
Short-eared owl
Saw-whet owl

ORDER CAPRIMULGIFORMES (Goat suckers)

Poor-will
Common nighthawk

cont'd

ORDER APODIFORMES (Swifts, Hummingbirds)

Black swift
Vaux's swift
Rufous hummingbird
Calliope hummingbird

ORDER CORACIIFORMES (Kingfishers)

Belted kingfisher

ORDER PICIFORMES (Woodpeckers)

Common flicker
Pileated woodpecker
Lewis's woodpecker
Yellow-bellied sapsucker
Hairy woodpecker
Downy woodpecker
Black-backed three-toed woodpecker
Northern three-toed woodpecker

ORDER PASSERIFORMES (Perching Birds)

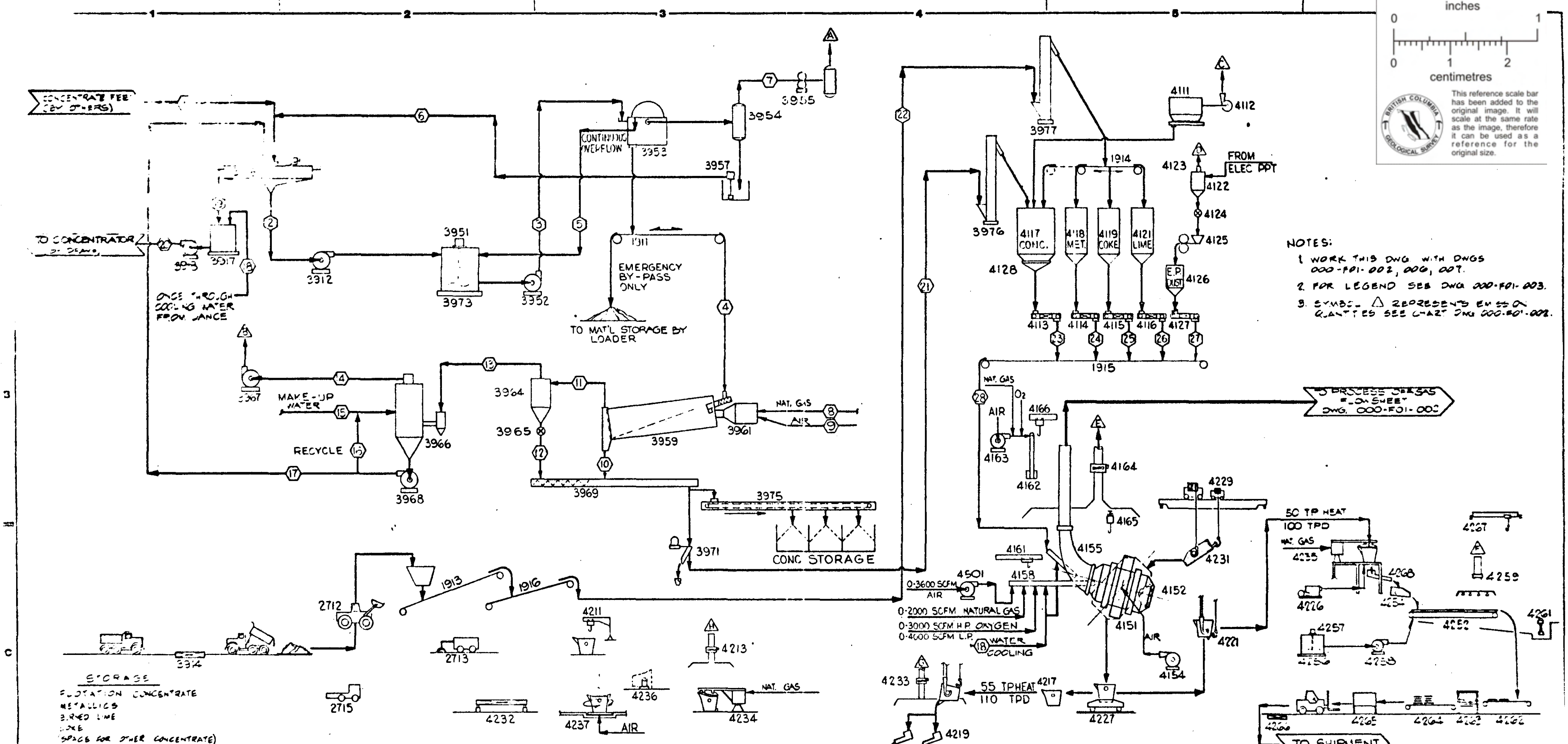
Eastern kingbird
Western kingbird
Willow flycatcher
Least flycatcher*
Hammond's flycatcher
Dusky flycatcher
Western flycatcher
Western wood pewee
Olive-sided flycatcher
Horned lark
Violet-green swallow
Tree swallow
Bank swallow
Rough-winged swallow
Barn swallow
Cliff swallow
Gray jay
Steller's jay
Black-billed magpie
Common raven
Common crow
Clark's nutcracker
Black-capped chickadee
Mountain chickadee
Boreal chickadee
White-breasted nuthatch
Red-breasted nuthatch
Brown creeper
American dipper
House wren

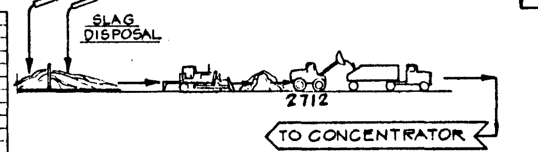
cont'd

ORDER PASSERIFORMES (Perching Birds) cont'd

Winter wren
Long-billed marsh wren
Rock wren
Gray catbird
American robin
Varied thrush
Hermit thrush
Swainson's thrush
Veery
Western bluebird
Mountain bluebird
Townsend's solitaire
Golden-crowned kinglet
Ruby-crowned kinglet
Water pipit
Bohemian waxwing
Cedar waxwing
Common starling
Solitary vireo
Red-eyed vireo
Warbling vireo
Orange-crowned warbler
Nashville warbler
Yellow warbler
Yellow-rumped warbler
Townend's warbler
Northern waterthrush
MacGillivray's warbler
Common yellowthroat
Wilson's warbler
American redstart
House sparrow
Bobolink
Western meadowlark
Yellow-headed blackbird
Red-winged blackbird
Northern Oriole
Brewer's blackbird
Brown-headed cowbird
Western tanager
Black-headed grosbeak
Lazuli bunting
Evening grosbeak
Cassin's finch
House finch
Pine grosbeak
Gray-crowned rosy finch
Pine siskin
American goldfinch
Red crossbill

cont'd





MATERIAL BALANCE

DESIGN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SOLIDS DTPH	4.70	6.09	2.75	9.135	3.04	0				6.365	2.74	2.2	.54		0
SLURRY SPG	1.19	2.08	2.08	3.05	[illegible]	1.0				4.31	-	-	-		1.0
SLURRY GPM	78.93	18	36	14.25	9	-				6.177	-	-	-		-
WATER GPM	75.14	13.10	26.2	6.95	6.55	12.7				1.065	VAPOR	0	VAPOR		43
% SOLIDS BY WT	20	65	65	84	65	0				96		100			0
AIR SCFM @ 77°F							1000		1243						
NAT GAS SCFM @ 77°F								83							
H_2O SCFM @ 77°F															
TOTAL DRY GAS SCFM @ 77°F															

DESIGN	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
SOLIDS DTPH	1.71	.54	0	0	0	9.4	19	90	90	20	20	10.5	120		
SLURRY SPG	1.04	1.04	1.0	1.0	1.0										
SLURRY GPM	131.56	41.51	-	-	-										
WATER GPM	130	41.01	470	115.75	586.75	2.4	4	15	7.4	4.2	4.2	0	19		
% SOLIDS BY WT	5	5	0	0	0	94	95	96	98	95	95	100	96		
AIR SCFM @ 77°F															
NAT GAS SCFM @ 77°F															
H_2O SCFM @ 77°F															
TOTAL DRY GAS SCFM @ 77°F															

OPERATING (STREAM NO.)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SOLIDS DTPH	4.70	[illegible]	[illegible]	[illegible]	1.61	0				5.64	2.41	1.91	0.50	0	
SLURRY SPG	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.00									
SLURRY GPM	[illegible]	15	29	[illegible]	5	11									
WATER GPM	[illegible]	[illegible]	21	6.2	3.5	11				1.4					40
% SOLIDS	20	65	65	84	65	0				94.3		100			
AIR SCFM @ 77°F							1000		869						
NAT GAS SCFM @ 77°F								83							
H_2O SCFM @ 77°F											1030		1030	1240	
TOTAL DRY GAS SCFM @ 77°F											3270		3270	3270	

OPERATING (STREAM NO.)	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
SOLIDS DTPH	1.7	0.50				7.55	19	75	15	15	12	7.5	95		
SLURRY SPG	1.04	1.04													
SLURRY GPM	131	39													
WATER GPM	130	33	420	113	533	1.4	4	12.5	1.2	3.2	2.5	0	15		
% SOLIDS	5	5				95.7	95	96	98	95	95	100	96		
AIR SCFM @ 77°F															
NAT GAS SCFM @ 77°F															
H_2O SCFM @ 77°F															
TOTAL DRY GAS SCFM @ 77°F															

FOR APPROVAL — NOT APPROVED FOR CONSTRUCTION

ISSUE NO. 2 DATE PRINTED 1-17-76

This drawing, including the information it contains, is the property of Dravo Corporation. It is submitted only in connection with the transaction to which it pertains and must not be used in any manner detrimental to the interest of Dravo Corporation. The drawing is not to be copied and must be returned upon request.

DENVER OPERATIONS OFFICE — (ENGINEERING CONSTRUCTION DIV.)

NO	DATE	DESCRIPTION	BY	CH	APP
		REVISIONS			

AFTON MINES LTD

KAMLOOPS, B.C.

PROCESS FLOW DIAGRAM

DR	SCALE NTS	CHF S.E.
CH	SECT PAG	APP'D
J.E.	CODE	CONTRACT NO M-7157

Dravo

DRAWING NO 000 F01-001 — REV 0

APPENDIX 7 cont'd

ORDER PASSERIFORMES (Perching Birds) cont'd

White-winged crossbill
Rufous-sided towhee
Savannah sparrow
Vesper sparrow
Lark sparrow
Dark-eyed junco
Chipping sparrow
Clay-colored sparrow*
Brewer's sparrow
White-crowned sparrow
Golden-crowned sparrow*
Fox sparrow
Lincoln's sparrow*
Song sparrow

---

‡ Source: Godfrey, W.E. 1966. The Birds of Canada. National Museum of Canada. Bull. No. 203, Biol. Series No. 73. Queen's Printer. Ottawa, 428 p. (This list does not include migrant species which may pass through the area but do not breed there.)

* Near limits of breeding range.