SPARE

AFTON MINES LTD. (N.P.L.)
P.O. BOX 937
KAMLOOPS, B.C.
V2C 5N4

REPORT IN SUBSTANTIATION
OF AN APPLICATION
FOR RENEWAL OF PERMIT NO. M-112
AUTHORIZING SURFACE WORK
PERSUANT TO SECTION 11
MINES REGULATION ACT

R.H. Collier, P.Eng.

April, 1980

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INTRODUCTION

This report is submitted in support of an application to renew Permit M-II2 Authorizing Surface Work. Only summary background information is presented in this report unless changes have occurred in particular areas since the Permit was issued in October, 1976. For detailed background information the reader is referred to the following two previously submitted reports:

Afton Mines Ltd. (N.P.L.): Application for Permit Respecting Reclamation under Section 11 of the Mines Regulations Act, Vancouver, B.C., April 1976.

B.C. Research: Environmental Report on Afton Mines Limited Proposed Mine-Mill-Smelter Development, Vancouver, B.C., March 2, 1976.

1.0 BACKGROUND INFORMATION

1.1 Location

The Afton mine is located adjacent to the south side of Highway No. 1 16 km west of the centre of the City of Kamloops.

1.2 Land Tenure

The area actively used by Afton for mining, processing and waste disposal activities is held by three production leases, one mineral lease and one mining lease for a total of 883 hectares. A surface lease of 50 hectares covers the plant-site area. In addition to these areas Afton holds unsurveyed mineral claims adjacent to the leases and holds other surface rights by title and grazing lease.

1.3 Climate

The property is located in the Interior Plateau in the lee of the coast mountains. As such it is in an area that is sheltered from the effects of moist, cool Pacific air and thus experiences low rates of precipitation and high summer temperatures. These conditions combine to cause high levels of evapo-transpiration and give rise to a moisture index which is among the lowest in the province. The moisture index is a measure of the water available for optimum plant growth during the growing season (Farley, 1979).

It was originally anticipated (B.C. Research, 1976, p.79) that annual precipitation at the property would average 350 to 400 mm per year. However, significantly lower rates have been recorded since observations began in July, 1977 particularly over the last two years. Naturally, this fact has adversely effected the success of Afton's revegetation programs during this period. A summary of climatic observations follows:

1.3 Climate Cont'd

Year	Temperature (°C)			Precipitation (mm)
	Mean Max.	Mean Min.	Mean	Total
1977*	13.2	2.7	8.0	232.2
1978	11.8	0.6	6.6	272.0
1979	13.1	0.9	7.0	129.5
Average	12.6	1.1	7.0	207.0

* Six months from July to December only.

1.4 Geology of the Deposit

The 520 m long Afton orebody is tabular in shape striking at about N70° W and dipping 55° S. With an average width of 90m it widens and deepens westward and has been explored to a depth of 600m. The deposit is largely supergene to a depth of 400m containing native copper and chalcocite. The underlying hypogene ore mineralization is mostly bornite and chalcopyrite. At the time of writing reserves mineable by open pit methods stood at 19 million tonnes at a grade of 0.96% Cu, 0.50 g/t Au and 3.7 g/t Ag.

The orebody is located at the western end of the Ironmask Batholith which is of dioritic to syenitic composition. It intruded into the contemporaneous volcanic rocks of the Upper Triassic Nicola group which are in turn overlain by sedimentary and volcanic rocks of the Tertiary Kamloops Group and by unconsolidated glacial deposits. (See figure 1)

From a reclamation viewpoint the waste material may be divided into three categories:

1. Unconsolidated glacial deposits.
2. Tertiary sediments some strata of which have a high clay content and weather to a soil consistency over several months.
3. Triassic diorite and volcanics and the Tertiary volcanics which are strong and stable.

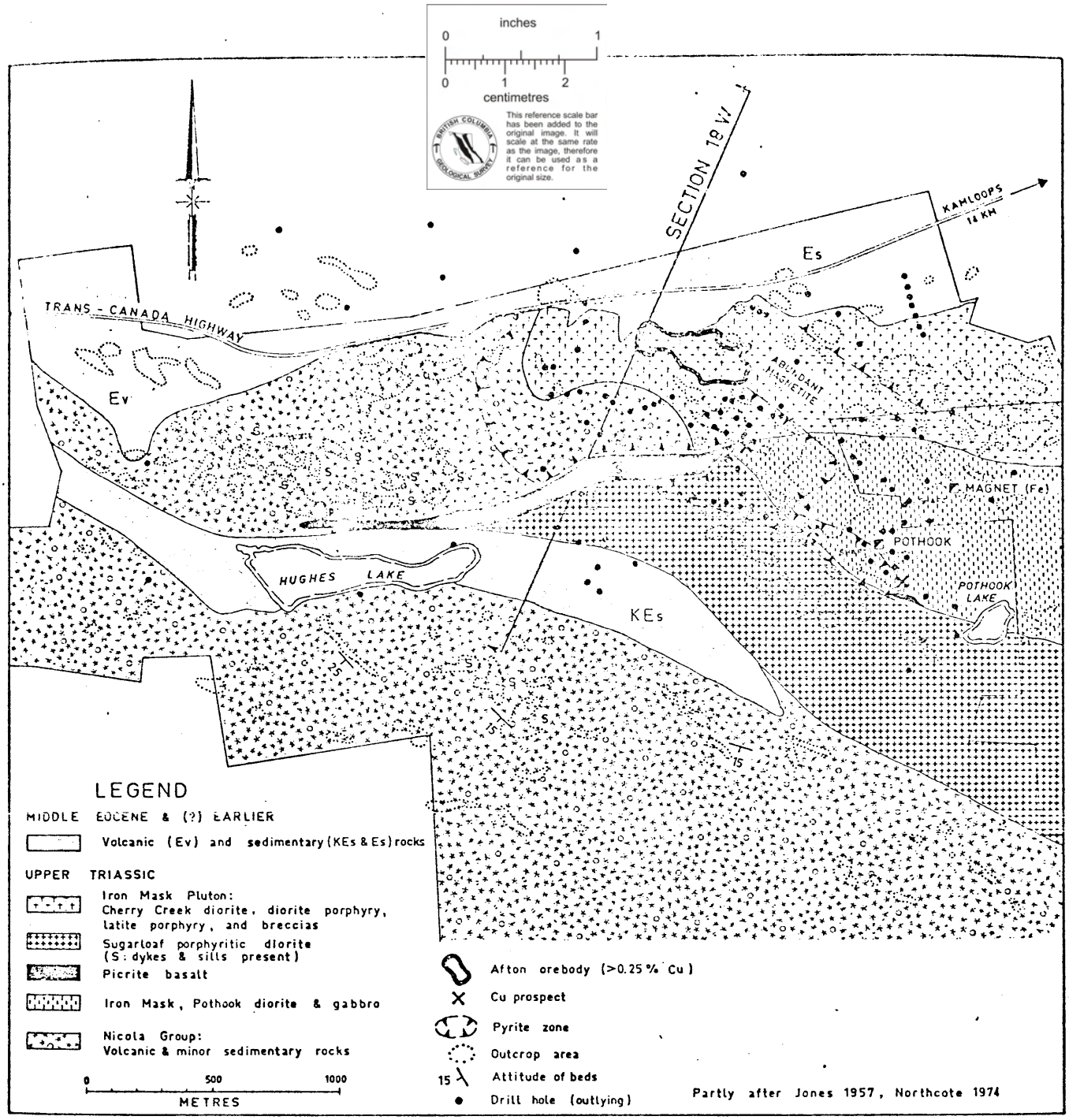


FIGURE 1A Geological map of the Afton property.

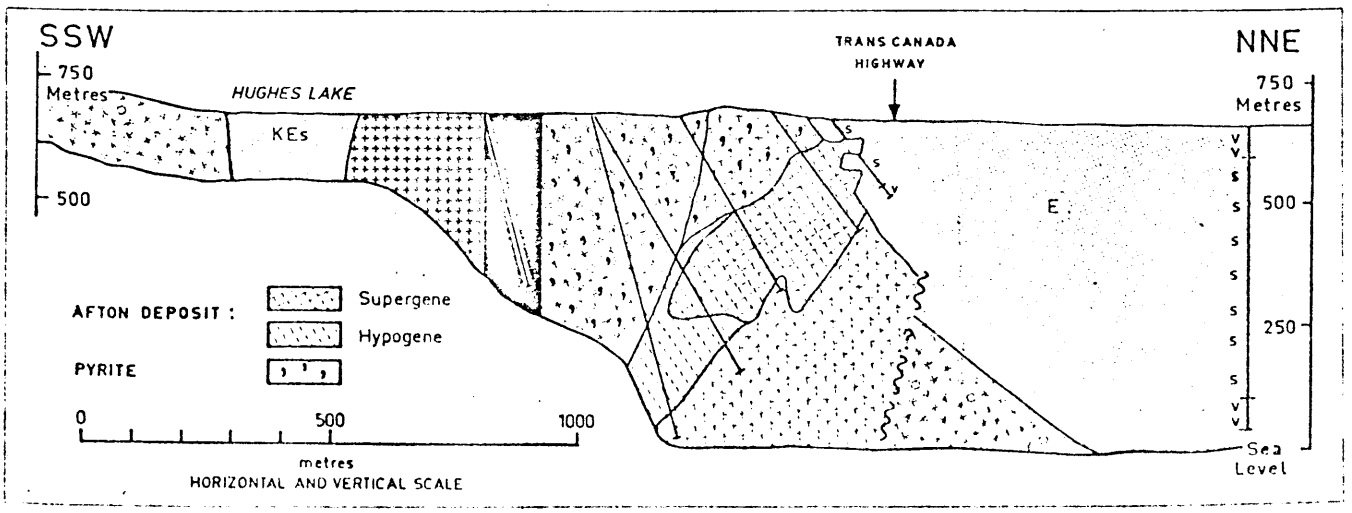


FIGURE 1B- Vertical geological section of the Afton property on 18W (extended). Legend as for Figure 1A

After Carr & Reed, 1975, p. 379

1.5 Surface Water: Drainages, Quality, Hydrology & Fisheries:

The minesite is located on a bench overlooking Kamloops Lake to the north. Drainage from the south west of the property flows into Kamloops Lake via Cherry Creek whose course is unaffected by mining activities. Its tributary, Alkali Creek, formerly flowed into what is now the tailings pond area, but has now been diverted to enter Cherry Creek further south. There is some drainage into two small lakes to the northeast, Pothook Lake and Moose Lake, but these have yet to overflow into channels which pass to the south of the waste dump area and through the plantsite area respectively. (See Figure 2).

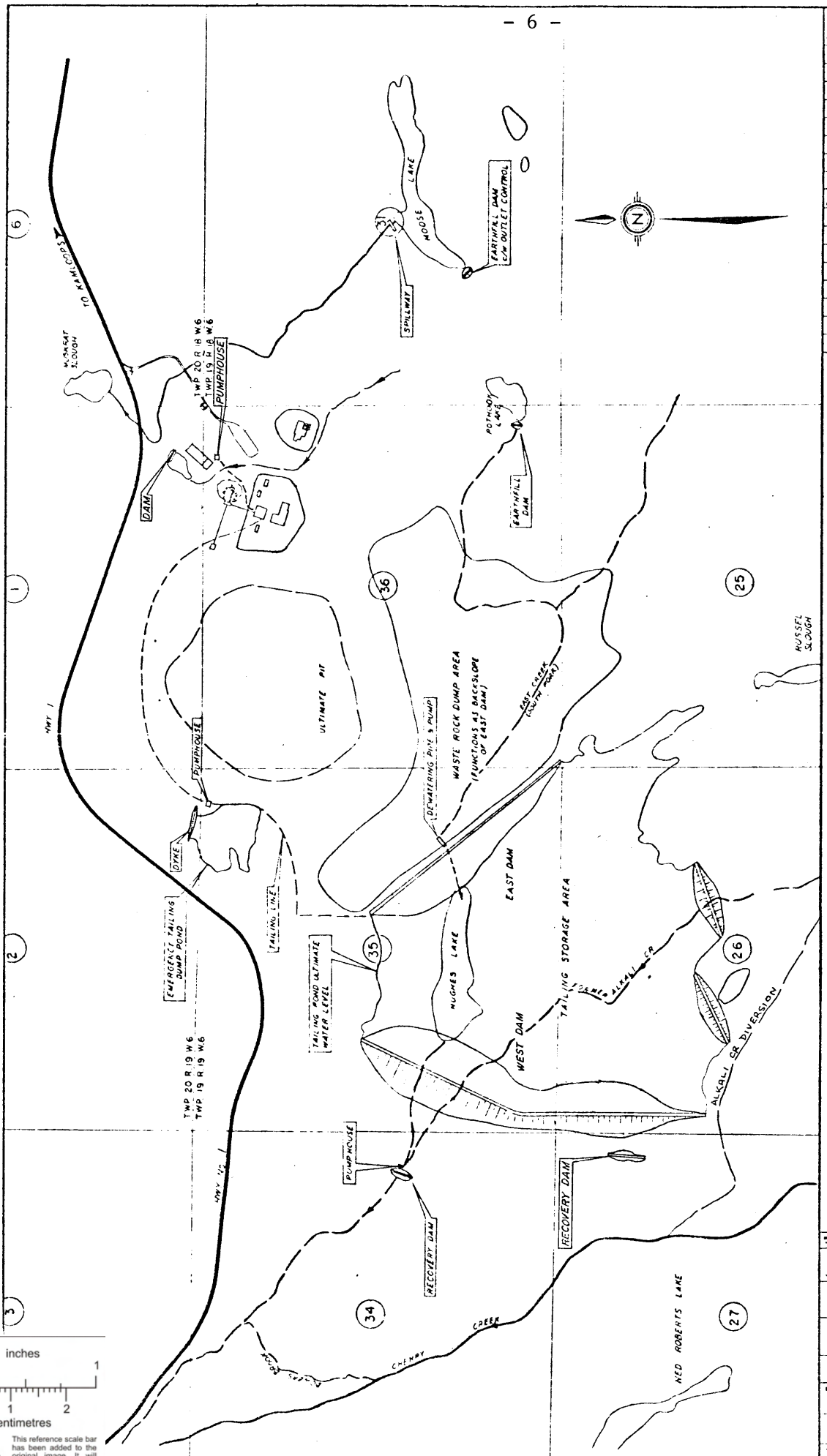
Water quality and hydrology data have been previously reported (B.C. Research, 1976, pp. 37-41, 96) therefore this information is not repeated here. No fish have been observed in the small ponds near the minesite. The rainbow trout fishery reported does not occur in the stretch of Cherry Creek adjacent to the property as this creek is dry for much of the year.

1.6 Groundwater: Quality & Quantity

Detailed information has previously been submitted regarding groundwater quality and quantity (B.C. Research, 1976, PP. 42-54, App. 5). In summary the mine area is regarded as making little contribution to the groundwater regime due to the low precipitation and high evaporation rates observed. Since both the bedrock and the majority of the surficial deposits have been found to have low permeability there is little groundwater flow through the property. The flow that occurs is thus mostly confined to creek beds with the rate of discharge being very slow as attested by the small ephemeral flows in the creeks.

1.7 Soils & Surficial Geology

The Afton property is largely overlain with drumlinized



PURCHASE ORDER

CHK. VALUED TO ISSUED	NUMBER	DESCRIPTION

WORK TO CONTR.	ASSOCIATED DRAWINGS

SCALE IN FEET
ELEVATIONS ARE GEODETIC

ISSUE	
CERTIFIED FOR CONSTRUCTION	

TECK CORPORATION LTD.
ISO MINES LTD.

AFTON MINES LTD.

FIGURE 2

SUBJECT ALKALI CREEK DRAINAGE AREA AND DIVERSION PLAN

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.

BRITISH COLUMBIA GEOLOGICAL SURVEY

1.7 Soils & Surficial Geology Cont'd

till deposited by an icesheet moving southeast. The till varies in thickness from 0 to 30 m. Kames, eskers, moraines and glacial outwash channels were formed over small areas of the drumlinized till during the retreat of the icesheet.

The dominant soils in the area are Brown Chernozems commonly called grassland soils. The topography of the area is level to gently rolling. Saline Dark Brown to Black Chernozems are found in depressed areas. The majority of the soils are developed on silt loam to silty clay loam glacial till and have a medium texture. A calcareous layer is generally found in the subsoil at the 30 cm level. The soils have been reported to be generally neutral to slightly alkaline, however soil tests conducted in conjunction with reclamation projects have indicated moderate to high alkalinity (pH 8 to 9) and high salinity in some areas. Available nitrogen is generally low.

1.8 Vegetation

A detailed description of the vegetation communities and their distribution is reported by B.C. Research, 1976, pp. 88-93. The majority of the area can be described as typical dryland interior seral range. Due to overgrazing the once dominent native blue bunch wheatgrass has been largely replaced by big sagebrush and rabbitbush. Of minor importance is the Ponderosa pine-bunchgrass range characterised by immature Ponderosa pine and small numbers of Douglas fir. The B.C. Forest Service classifies the area as a "poor" site in terms of forest production. Additionally there are small drainageway, saltgrass and bulrush communities and an area that has been cultivated for hay production.

1.9 Wildlife

Of the 51 mammals whose range coincides with the property

1.9 Wildlife Cont'd

only the following nine have been observed: chipmunk, pocket gopher, muskrat, porcupine, fox, coyote, bobcat, mule deer and moose. The deer population in the mine area had decreased markedly before mining development began and only one moose has been observed on the property in the last 23 years.

Approximately five and a half percent of the property area was available for wildfowl production. The water bodies are more important in their availability as resting and staging points for wildfowl during migration. Goldeneye, buffehead, coot, lesser scaup, mallard, widgeon, pintail, redhead and killdeer have been observed.

Sharptail grouse have been observed to winter in the drainageway plant community of Alkali Creek. Pheasant populations had decreased markedly in the years preceeding the mine development but magpie and raven numbers have increased.

Detailed lists of species whose range is thought to coincide with the Afton mine property have been prepared by B.C. Research (1976, pp. 93-96, Appendices 6, 7).

1.10 Land Capability & Use

1.10.1 Agriculture

Approximately 300 hectares, or 75% of the land area to be disturbed fell into the catagory of sagebrush grassland. The soils in the mine area are suitable for grazing use, however several factors combine to reduce this potential productivity. The low rates of precipitation and high rates of evapotranspiration combine to produce a low moisture index. The moderate to high alkalinity and salinity also reduce productivity. Figure 3 illustrates the land capability for agricult-

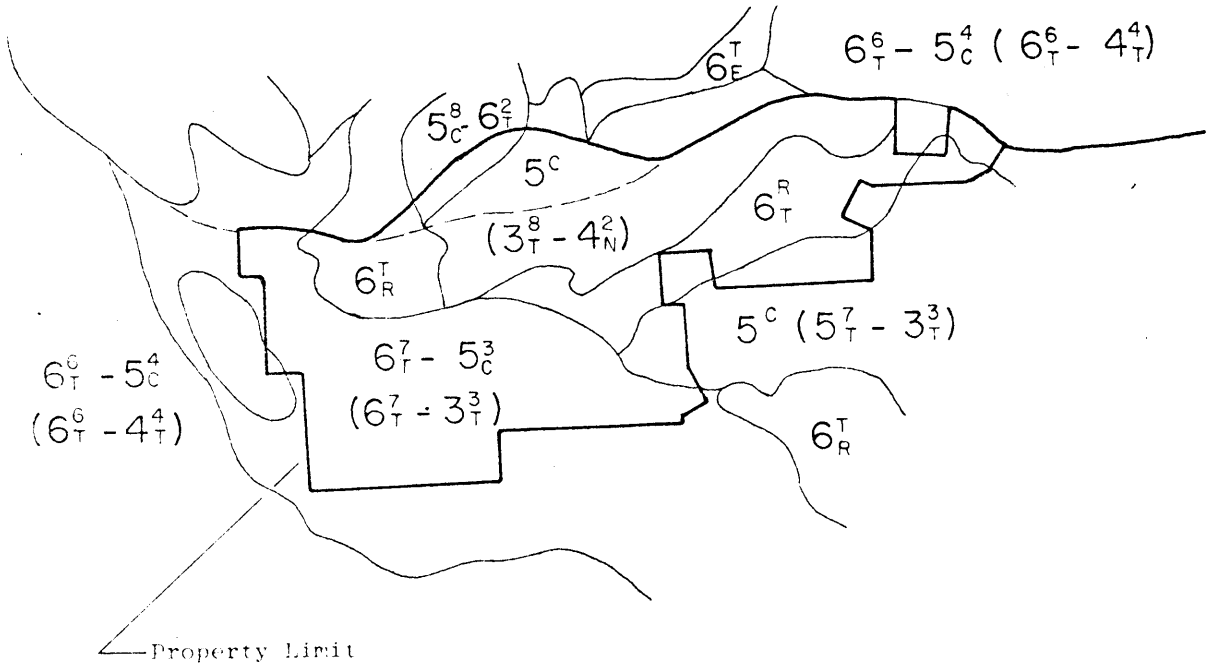


FIGURE 3

LAND CAPABILITY MAP

Large arabic numbers denote capability classes and capital letters denote subclasses. Small arabic numerals placed after each class numeral as superscripts denote the portion of each class out of a total of 10. The extent to which land can be improved enclosed by parenthesis.

Class 3: Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices.

Class 4: These soils have severe limitations that restrict the range of crops or require special conservation practices or both.

Class 5: These soils have very severe limitations that restrict their capability to produce perennial forage crops, and improvement practices are feasible.

Class 6: These soils are capable of only producing perennial forage crops and improvement practices are not feasible.

T: Topography is a limitation.

N: These soils have enough soluble salts to adversely affect crop growth or restrict the range of crops that may be grown.

R: Presences of bedrock near the surface restricts agricultural use.

C: This subclass denotes a significantly adverse climate for crop production as compared to the median climate which is defined as one with significantly high growing season temperatures to bring field crops to maturity and with sufficient precipitation to permit crops to be grown without a serious risk of partial or total crop failures.

B.C. Department of Agriculture, 1973.

1.10 Land Capability & Use Cont'd

1.10.1 Agriculture Cont'd

ural purposes. The range condition in the immediate property area is considered poor (B.C. Research, 1976, p. 88) with 60 to 70% bare ground observed between plants. This is a result of historic overgrazing.

An irrigated, cultivated hay field of approximately 15 hectares will be disturbed by mining activities. Although, with irrigation, land productivity can be markedly improved the lack of water resources in the mine area has restricted this development.

1.10.2 Forestry

About 35 hectares of forested land will be disturbed. As previously described the site is considered "poor" by the B.C. Forest Service and is characterised by small, immature Ponderosa pine ranging in height from 11 to 20 m and in age from 81 to 100 years. The few mature Douglas fir and pine present are veterans of past fires.

1.10.3 Recreation

The recreation potential is poor since there are no fishing lakes and little game. Recreational uses involving all terrain vehicles would conflict equally with the ranching and mining uses because in the former case fences are destroyed, cattle harassed and vegetation uprooted.

2.0 MINING PROGRAM

2.1 Description Of Mine, Mill and Smelter

Conventional open pit methods using electric shovels and drills and diesel trucks are employed to extract 61 700 t/d from the mine of which 7700 t are ore. The open pit is currently 910 m long, 690 m wide and 130 m deep.

The mill employs primary crushing and semi-autogenous and ball mills for comminution followed by a combination of gravity methods, using jigs and tables, and flotation methods. Transportation to the smelter is by truck in the case of the native copper gravity concentrate and by slurry pipeline in the case of the flotation concentrate.

Dewatering of the flotation concentrate takes place in the smelter. Both concentrates are reduced to form a blister copper product in the top blown rotary converter.

2.2 Development Schedule

Afton came into commercial production in May, 1978. Currently ore reserves are sufficient to allow mining by open pit methods to continue until the end of 1986. The open pit will then measure 1280 m long by 910 m wide and be 300 m deep. During this time the waste dumps will continue to grow in both lateral and vertical extent. Therefore dump reclamation activities will be restricted to those areas that have become inactive and to large scale field trials to determine the optimum methods.

Recovery of the low grade stockpiles will likely commence at the time that open pit mining ceases. Feasibility studies into continuing mining by underground methods are ongoing. It is not yet known by what length of time the mine life could be extended by proceeding with underground mining.

2.2 Development Schedule Cont'd

However, underground mine development, commencing with shaft sinking, would need to begin no later than 1984. The additional area to be disturbed by this development would be minimal.

2.3 Waste Disposal

Solid waste disposal takes four forms: waste rock from the open pit, tailings from the mill, used refractory brick and copper sculls from the smelter and scrap metal and refuse from various parts of the mine operations.

2.3.1 Scrap Metal and Refuse

Scrap metal will be sold and removed from the property, and in the case of copper scrap will be recycled through the smelter. Under the terms of Pollution Control Permit No. PR-4368 refuse is buried in rock waste dumps.

2.3.2 Smelter Solid Wastes

The bulk of the solid wastes from the smelter are recycled. Slag is reintroduced to the concentrator via the primary crusher. A small dump adjacent to the smelter holds mostly used refractory brick which will be recycled through the concentrator, copper sculls which will be recycled through the smelter and some ferrous scrap that will be sold. Sludges from the sulphur dioxide recovery process are pumped to the concentrator for addition to the tailings.

2.3.3 Tailings Disposal

Afton's tailings dams are unconventional in that they are more akin to water retention dams than tailings dams. This design approach is necessary because of the high level of water that is against the tailings dam faces, occurring because a large volume of water must be retained in the dam due to the slow settlement rate of the tailings.

2.3.3 Tailings Disposal Cont'd

All together six dams were designed by Klohn Leonoff Consultants Ltd. which will require approximately 20 million m^3 of material for construction. The dams will be built to provide storage for approximately 70 million m^3. The two main dams are the East Dam which will be 1,100 m long, with an average height of 55 m and the West Dam which will be 1200 m long with an average height of 50 m.

There are two smaller dams, the South Dam which will be 85 m long, with an average height of 8 m and the South-East Dam which will be 60 m long, with an average height of 5 m. The last two dams will be smaller than the South and South-East Dams and will be located downstream of the West Dam as seepage recovery dams.

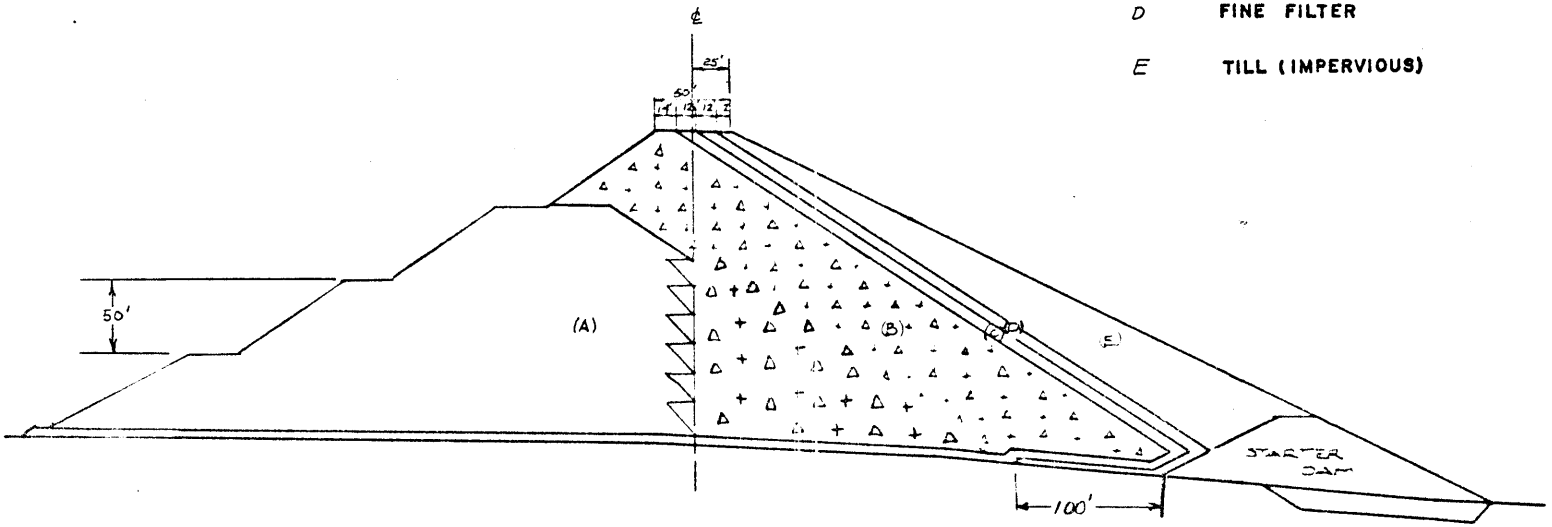
The East and West tailings dams are designed with a triangular section of rock, sealed by an impervious membrane of compacted glacial till. The rock section consists of general rock fill and compacted rock fill. The zone of compacted rock fill will act as a semi-rigid section designed to reduce differential settlements in the impervious glacial till. Between the till and the compacted rock fill there will be two filter zones, a fine filter zone and a coarse filter zone. Figure 4 is a typical section of the West tailings dam showing its terraced downstream face which should enhance reclamation potential.

The dams are regularly monitored through the use of piezometers and a settlement gauge to ensure that their stability is maintained and that seepage is controlled.

2.3.4 Waste Dumps

Currently almost 50% of the mine waste is used in the construction of the tailings dams. This volume includes most

ZONE	MATERIAL
A	GENERAL ROCKFILL
B	COMPACTED ROCKFILL
C	COARSE FILTER
D	FINE FILTER
E	TILL (IMPERVIOUS)



TYPICAL TAILING DAM SECTION FIGURE 4

2.3.4 Waste Dumps Cont'd

of the glacial till overburden which is used to form the impervious upstream layer. The strong, hard diorite is used for construction of the filter zones, after crushing, and for construction of the compacted and general rockfill zones.

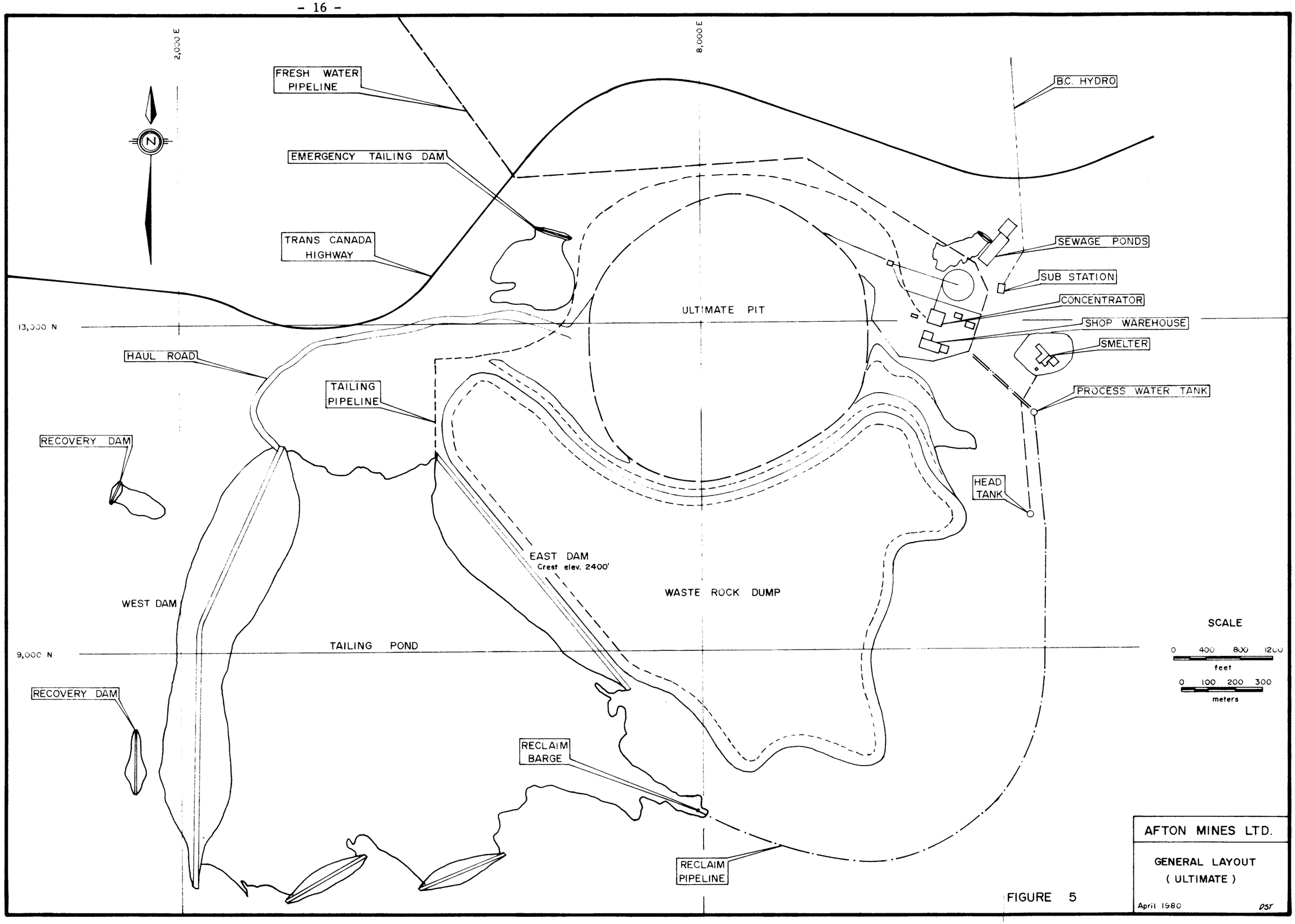
A small tonnage of ore and low grade material has been stockpiled but these dumps will be remined before operations cease.

The remaining waste material is dumped in two areas while most of the waste till is either stockpiled or transported directly to reclamation project sites. Most of the waste rock is hauled to the main waste dump area south of the open pit. The western part of this dump area is contiguous with the East Tailings dam. Since part of the waste volume will be deposited as valley fill and due to the generally moderate relief of the terrain the final dump configuration will be that of a flat plateau. To facilitate reclamation the maximum lift will be 30 m and the overall slope of the dump face will be 28^{o}. Only on the northern face of the dump overlooking the pit should the total height of the dump exceed 30 m.

The other waste dump area is a small valley fill to be placed north of the West Tailings dam.

2.3.5 Stockpiling Of Soil And Overburden

During preproduction development several till stockpiles were placed. These are highlighted on the air photo mosaic, (Figure 13) and contain a total volume of 38 500 m^3. This material arose from plantsite preparation, pit stripping and from excavations for the foundations of the tailings dams. A further till stockpile having a volume of approximately 158 000 m^3 has been placed adjacent to the south-west corner of the open pit. However, some of this material may be required for tail-



2.3.5 Stockpiling Of Soil And Overburden Cont'd

ings dam construction. Approximately 30 000 m^3 was transported directly to Reclamation Area No 1 where it is being used to cover a deposit of strongly saline mud that was excavated from the open pit area. As explained previously till is a valuable resource as it is required for the construction of the tailings dams. At the present time most of the till mined in the open pit is used for this purpose.

Since the topsoil layer is usually less than 30 cm thick it is not practically or economically feasible to segregate it from the till beneath, nor would the yield be significant.

2.4 Drainage Controls

Due to its favourable topographic location Afton has been able to control all drainage that passes close to or through disturbed areas. The major water course in the area is Cherry Creek (Figure 2) which is unaffected by mine development. Its tributary, Alkali Creek, formerly flowed into the tailings pond area but has been diverted so that it meets Cherry Creek further south. This action was necessitated by the need to protect the rights of downstream water licence holders.

The small flows that arise from south-east of the Pothook Lake area are controlled by the waste dump configuration. No water has had to be pumped from the dewatering well illustrated. Any silt from the waste dump would flow north to be trapped at the base of the east tailings dam or by the open pit.

No overflows have been recorded from Moose Lake. However, if this situation were to occur the water would pass to the east and clear of the plantsite. Runoff arising from the plantsite area, including the area surrounding the course ore stockpile is contained in a pond adjacent to the sewage evap-

2.4 Drainage Controls Cont'd

oration lagoons and is pumped to the tailings pond.

Since the downstream face of the west tailings dam is composed of strong, hard rock little silt should arise from this source but would in any case, be trapped by the two seepage retention ponds.

Regular monitoring of the Cherry Creek watershed is conducted under the terms of the Pollution Control Permit No. PE-3904. Results are reported to the Pollution Control Branch.

2.5 Surface Development

The following table summarizes the surface development associated with the mine at the end of each year shown. It does not include range or habitat improvement projects. The plantsite area includes administration buildings and the area shown as tailings includes both the pond and dam area. The small additional area to be disturbed by surface development and related to potential underground mining has not been included.

Table 1: Projected Surface Development

	Area Disturbed (ha)						
	1979	1980	1981	1982	1983	1984	Final
Roads	24	24	24	24	24	24	24
Plantsite	31	31	31	31	31	31	31
Pit	52	56	56	58	60	60	60
Dumps	88	99	111	122	133	144	178
Tailings	80	93	106	118	131	143	187
Stockpiles	9	9	10	10	10	10	0
	284	312	338	363	389	412	480

3.0 RECLAMATION PROGRAM

3.1 Reclamation Objectives

The major long term objective of Afton's reclamation program is to return the area to a close approximation of its pre-mining use, that is as a source of forage for ungulates. This will not be possible in some areas, namely the open pit itself and some areas of relatively steep slopes such as some of the faces of the waste dumps and the West tailings dam. In the latter case, revegetation will be attempted to improve the resistance of the slopes to erosion and enhance their aesthetic value. Much of this activity will not be able to occur until close to the end of the mine life - when the areas concerned will not be re-disturbed.

In the near term the objectives are to reclaim as much of the disturbed areas as possible by replanting with grassland species. It is also an objective to provide mitigation against the effects of land occupation for mining purposes by replacement of wetlands and by enhancing the productivity of rangelands adjacent to the mining area.

3.2 Reclamation Staff And Equipment

The resources of both the Environmental Engineering department and the Mine Engineering department are available for reclamation programs. The Environmental Engineering Department is headed by Mr. Jim Robertson, P.Eng. who reports directly to the Mine Manager. Mr. Robertson has two full time Environmental Technicians reporting to him. The Mine Engineering department, headed by Mr. Alan Reed, P.Eng., employs three engineers and several technicians who are available for reclamation planning and supervision.

Students are hired each summer to assist with reclamation projects. The workforce of the Pit and Surface Departments is

3.2 Reclamation Staff And Equipment Cont'd

also available for reclamation activities. In addition Mr. Max Leavens, manager of Afton's affiliated company, Sugarloaf Ranches Ltd., and his hands provide assistance.

Heavy earthmoving equipment such as bulldozers, scrapers, graders, loaders, trucks and the large rome disk are available for site preparation activities and the movement of materials. Sugarloaf Ranches provides agricultural equipment for ploughing, seeding, harrowing, haying and tree planting. Use has been made of the British Columbia Ministry of Agriculture's range seeding equipment. Afton owns a portable herbicide spray unit which is used for weed control. 750 m of aluminum irrigation pipe and associated hardware is on hand.

3.3 Past Programs

3.3.1 Reclamation Research

The 1976 B.C. Research Environmental Report represents the culmination of research efforts conducted prior to production. Of significance in regard to reclamation were the studies on terrestrial and aquatic ecology and on soil and mine waste properties. Particularly important were the studies that demonstrated that there was no possibility of acid drainage water being formed from the waste rock dumps.

The research showed that the soils, although not suited to high forage productivity in their natural state, were not being utilized to their potential. Knowing this it was felt that Afton could go a long way towards mitigating against the effects of the withdrawal of land from its grazing role by improving the surrounding rangeland.

3.3 Past Programs Cont'd

3.3.1 Reclamation Research Cont'd

Ducks Unlimited performed surveys of the wildfowl populations on the lakes in the area of the mine, and together with Ker, Priestman and Associates Ltd., consulting engineers, co-operated with Afton to design improvements to Pothook and Moose Lakes so that the habitat lost when Hughes Lake became part of the tailings area could be replaced.

Subsequent to the commencement of production research has mostly been concentrated on developing revegetation methods for those areas immediately available for reclamation and on developing range improvement techhiques. A large number of soil analyses have been carried out and Interior Reforestation Co. Ltd., and W. Hubbard, P. As have been retained at various times to advise on or conduct reclamation programs.

Additionally the B.C. Ministry of Agriculture has given advice and provided equipment for range seeding projects.

Routine sampling and analysis of soil and vegetation around the mine area has shown that the levels of heavy metals, particularly copper, have increase in the immediate area (3 km radius) since the baseline data was collected. Research is continuing to determine the extent of the affected area and to confirm observations (Robertson, 1980) that although some levels are increasing others are decreasing. A literature search is underway to investigate metal toxicity in cattle.

Due to the alkaline and saline nature of the soils carefully controlled irrigation procedures are required to avoid concentrating salts in the topsoil. Mr. Hubbard's

3.3 Past Programs Cont'd

3.3.1 Reclamation Research Cont'd

advice was sought on this topic.

Soils analysis of the till stockpiles and of excavated area in till have shown consistently high levels of alkalinity and salinity. This is due to the exposure of the subsoils in which salts are concentrated. The topsoil does not suffer from these problems to such a great degree and naturally has higher levels of organic matter and available nitrogen. However, as previously mentioned, it is virtually impossible to segregate the thin layer of topsoil. Therefore in addition to further research into irrigation methods to reduce salinity and alkalinity and into determination of well adapted species more attention will be paid in future to developing the Tertiary sedimentary rocks as a reclamation planting medium. There is no lack of quantity of this material. Due to the high clay content of these rocks, they weather rapidly, forming a soil which appears to have good moisture retension properties.

Since climatic and soil conditions are similar at B.C. Hydro's Hat Creek project, reclamation research there has been monitored and a field trip made to view the results and discuss progress with Hydro's personel and consultants. It is expected that at least one of the seed mixes developed for use at Hat Creek will be tried at Afton.

3.3.2 Wildfowl Habitat Improvement

In an effort to mitigate against the loss of Hughes Lake as a staging area and breeding ground for waterfowl two small lakes have been dammed to increase their size.

3.3 Past Programs Cont'd

3.3.2 Wildfowl Habitat Improvement Cont'd

A man-made island has been constructed on one of the lakes. A pipeline has been constructed from an artesian well to provide a supplemental water supply to Pothook Lake. Moose Lake derives its water from natural drainage and from a creek that has been diverted into it. Due to the low levels of precipitation recorded over the past two years the water level of Moose Lake has dropped to the extent that it dries up during the summer. However in its first spring of operation several hundred ducks were observed using it as a resting point during the spring.

To help arrest the decline in pheasant population, pheasants have been introducted to the area around Alkali Creek on Sugarloaf Ranch land. The success of this program is uncertain due to the abundance of coyotes in the area.

3.3.3 Range Improvement

Range improvement projects take two forms: non-irrigated range seeding and irrigation projects. The first range seeding project at Afton was undertaken in October, 1977 as a demonstration program by the B.C. Ministry of Agriculture. A 16 hectare area was disked, seeded and packed in two passes using specially developed equipment which is heavy enough to destroy the big sagebrush which infests the area. Seeding rates were 9.0 kg/ha of crested wheatgrass (Nordan or Summit) and 1.1 kg/ha of alfalfa (Rambler or Roamer) which was innoculated prior to mixing with the wheatgrass. Afton fenced the plot to prevent premature grazing of the seedlings and applied 46-0-0 fertilizer at a rate of 224 kg/ha in October 1978. Grazing has now commenced as illustrated in figure 7A. The plot is clearly visible to the west of the mine access road in figure 11C.

3.3 Past Programs Cont'd

3.3.3 Range Improvement Cont'd

Figure 6
Range seeding demonstration plot east of the Afton Plantsite. Salt pond typical of the area in the foreground. (April, 1980)

A small variety plot containing ten different species was set up by Agriculture Canada and the B.C. Ministry of Agriculture at the site.

The Ministry of Agriculture has provided the following production data for the main plot seedings (B.C. Ministry of Agriculture, 1979).

Figure 7A:
Sugarloaf Ranch cattle grazing the range seeding plot (April, 1980)

Figure 7B:
Typical rangeland vegetation directly across the Trans-Canada Highway from the range seeding plot. (April, 1980)

3.3 Past Programs Cont'd

3.3.3 Range Improvement Cont'd

1978 Total Production	
Crested Wheatgrass	541 kg/ha
Other Grass Species	304 kg/ha
Adjacent Vegetation (Grasses)	198 kg/ha

1979 Spring Production	
Unfertilized Crested Wheatgrass	504 kg/ha
Unfertilized Other Grasses	81 kg/ha
Fertilized Crested Wheatgrass	916 kg/ha
Fertilized Other Grasses	304 kg/ha
Adjacent Vegetation	176 kg/ha

This data shows that even without fertilization range seeding has produced yields of crested wheatgrass that are approximatley 180% higher than that of the adjacent species. After fertilization yields of 420% higher than that of adjacent grasses have been recorded.

In the fall of 1979 the Ministry of Agriculture was contracted to range seed a further 12 hectares in the area immediately north of the primary crusher (Reclamation Area No. 4). 7.8 kg/ha of Nordan Crested Wheatgrass and 2.8 kg/ha of Roamer Alfalfa were applied. Fertilizer will not be applied until the grass seed has become established. Early fertilization has been found to aid weeds to out compete the grass seed.

After soil sampling Afton's first irrigation plot of 8 hectares (Reclamation Area No. 2) was cultivated in the fall of 1978, using the heavy rome disk towed by a D8 tractor. Careful design of the irrigation method was required to ensure that salts are not leached up into the topsoil. Water is obtained from the mine water supply pumped from Kamloops Lake, a

3.3 Past Programs Cont'd

3.3.3 Range Improvement Cont'd

distance of 4.8 km over a head of 375 m. Distribution is by 250 m of 200 mm and 500 m of 100 mm aluminum irrigation pipe, 40 sprinkler heads and associated hardware. The set time was 11.5 hours and the application rate was 5.8 mm/hr. The system can be clearly seen in operation north of the open pit in figure 11A.

Unfortunately the project met with limited success in the first year as germination rates were low. It is felt that the alfalfa/orchard grass seed mix was covered to too great a depth. Seeding is to be repeated.

3.3.4 Reclamation Projects

Reclamation is restricted to areas that will not be redisturbed. In summary this involves recontouring where necessary after construction activity, seeding and in some cases fertilization. Those areas available generally include cuts and fills in the plantsite area and rights of way for pipelines, power and telemetry lines. A tree planting program has been pursued in the area of the sewage lagoons.

3.3.4.1 Knapweed Spraying

Knapweed is a virulent weed type which has infested tens of thousands of hectares in southern British Columbia. Areas without good perennial forage cover are particularly susceptible to weed infestation. Personnel from Afton, after taking a course offered by the Ministry of Agriculture, were licensed to apply the herbicide Picloran (Tordon), which has proved effective against the weed. Spraying equipment has been purchased and over seven hectares have been treated, some areas more than once. Tordon is a residual poison which remains active

Figure 8A:
Irrigation plot showing alfalfa plants. Little of the orchard grass germinated. (April, 1980)

Figure 8B:
Vegetation adjacent to the irrigation plot. (April, 1980)

3.3 Past Programs Cont'd

3.3.4 Reclamation Projects Cont'd

3.3.4.1 Knapweed Spraying Cont'd

for three or four years after application. Although specific to broadleaved weeds newly germinating grass may also be killed. This effect has caused the postponement of some seeding programs and research is currently underway to determine when it will be safe to seed. The problem of knapweed infestation has highlighted the necessity to establish a good ground cover on disturbed soil as soon as possible.

3.3.4.2 Revegetation

A program of hydroseeding and tractor broadcast seeding was contracted to Interior Reforestation Co. Ltd. in the fall of 1976 to treat cuts and fills in the plantsite area, the highway realignment and the pipeline and road relocations. Approximately 7.3 hectares of cuts and fills along the relocated highway were hydroseeded as follows:

Mulch, Sylva Fibre	1 120 kg/ha
Fertilizer, 16-20-0	280-335 kg/ha
Seed/Legume Mix	62 kg/ha
Nordan Crested Wheatgrass	60%
Tall Fescue	15%
Streambank Wheatgrass	15%
Vernal Alfalfa (Innoculated)	10%
Cover Crop, Fall Rye	45 kg/ha

The same seed and fertilizer was applied to a further 2.6 hectares along the highway right-of-way and the realigned natural gas pipeline right-of-way. These areas were first harrowed with a special land harrow.

About 2.6 hectares of cuts and fills around the plantsite area were hydroseeded with a similar mulch/

3.3 Past Programs Cont'd

3.3.4 Reclamation Projects Cont'd

3.3.4.2 Revegetation Cont'd

fertilizer/seed mix. As it was thought that the conditions at the plantsite would be less severe in terms of exposure and alkalinity a slightly different seed mixture was substituted.

Nordan Crested Wheatgrass	50%
Creeping Red Fescue	20%
Streambank Wheatgrass	20%
Vernal Alfalfa (Innoculated)	10%

Growth on the more exposed south and west facing slopes has been noticeably less satisfactory than on the more sheltered slopes. Figure 9 clearly illustrates this. However, it is expected that growth rates will increase in years when precipitation returns to normal. Due to the regular grading and winter applications of gravel to the plantsite areas vegetation on fill slopes has mostly been lost. Revegetation of these slopes will not be attempted again until production ceases.

During the fall of 1977 further grading and seeding was completed. The areas receiving work were the tailings seepage dam (1.2 ha), berms around the sewage lagoons (0.2 ha), the cut behind the pit shop (1.0 ha) and the two dams at Moose Lake (2.4 ha). Each of these areas was first graded before seed at the rate of 56 kg/ha and 16-20-0 fertilizer at the rate of 335 kg/ha were applied using broadcast hand seeders. Except that Slender Wheatgrass was substituted for Streambank Wheatgrass the same seed mixture was employed as was used by Interior Reforestation for the 1976 plantsite program. The same seed mixture and fertilizer rates were also used in a program of reclamation of drill sites on the Sugarloaf Ranch. The sites totalled 0.2 ha in area.

Figure 9A:
Relocated Trans-Canada Highway cut seeding. North facing slope. (April, 1980)

Figure 9B:
Relocated Trans-Canada Highway cut seeding. South facing slope. (April, 1980)

3.3 Past Programs Cont'd

3.3.4 Reclamation Projects Cont'd

3.3.4.2 Revegetation Cont'd

In 1978 a total of 7.3 ha was seeded and fertilized. An area of 2.6 ha above the sewage evaporation lagoons was extensively cultivated using the bulldozer-rome disk combination, fertilized and seeded. The 7 000 m buried telemetry cable network was first recontoured using hand rakes and together with the newly constructed 4 000 m reclaim pipeline right-of-way was seeded and fertilized. A seed mixture consisting of 50% Nordan Crested Wheatgrass, 30% Slender Wheatgrass and 20% Fall Rye was applied using broadcast hand seeders at the rate of 56 kg/ha. 16-20-0 fertilizer was applied at the rate of 335 kg/ha.

1979 saw the seeding of the embankment of the north-west haulage road, which serves the west Tailings Dam. This road was constructed using various types of run of mine waste. The embankment was first sampled and soil analyses performed. These analyses revealed the typically high salt and pH conditions and low nitrogen content. The 0.8 ha area was seeded and fertilized by hand using 11 kg of grass seed and 270 kg of 16-20-0 fertilizer. Unfortunately part of this area was redisturbed and seeding will have to be repeated.

3.3.4.3 Dump Reclamation

Reclamation Area No. 1 consists of 6 ha of muds excavated from the salt pond that was originally within the open pit area. Although their high salinity was recognised (Lavkalich, 1976) it was predicted that these soils would be particularly valuable for use as topsoil dressing due to their good physical properties. Thirty soil analyses of the material on the dump revealed very high salinity,

3.3 Past Programs Cont'd

3.3.4 Reclamation Projects Cont'd

3.3.4.3 Dump Reclamation Cont'd

moderate to high alkalinity and very low levels of available nitrogen. After consultation by W. Hubbard, P. Ag, the area was graded and disked in 1978 to remove hollows that would result in the concentration of salts. In view of the very fine nature of the soils which would give rise to low permeability it was concluded that the suggested irrigation program to leach out the salts would not be successful. Figure 10 clearly shows the saline nature of the soils with very little vegetation growing after three years. Therefore in 1979 dumping of more suitable fill material was commenced with the aim of covering the muds to a depth of at least three metres. This project is ongoing but cannot be completed until a low clearance B.C. Telephone Co. pole line is relocated along with the highway. The Ministry of Highways and Transportation projects that this will occur within the next five years.

Figure 10:
Saline mud dump showing till caping material. (April, 1980)

3.3 Past Programs Cont'd

3.3.4 Reclamation Projects Cont'd

3.3.4.4 Tree Planting

In an effort to provide a visual screen around the sewage evaporation lagoons north of the plantsite twelve Ponderosa pine and twelve Douglas fir were transplanted onto the north berm of the lagoons in the fall of 1977. These trees were spaced at 7.5 m intervals. This program failed because these native species could not tolerate the moisture provided by the high water table in the berms.

The program was repeated in 1979 using deciduous nursery trees between 2 and 2.5 m in height. Four of each of the following species were planted: Mayday, Chinese Elm, Northwest Poplar and Russian Olive. It is too early to evaluate the success of these plantings but at the time of writing the Mayday and Northwest Poplar in particular seem to be doing well. Additional trees, possibly including better adapted coniferous species will be planted when the results of the current program are determined.

3.4 Reclamation Program For The Next Five Years

3.4.1 Reclamation Research

Several different seed mixtures have been used in past reclamation programs. A systematic evaluation of the productivity of the mixtures will be done to give guidance for future programs. This will be repeated routinely each year beginning in 1980 and will be coupled with regular soils analysis to determine fertilization requirements.

3.4 Reclamation Program For The Next Five Years Cont'd

3.4.1 Reclamation Research Cont'd

Commencing in 1980 waste dump revegetation test plots will be constructed. An area of approximately 0.5 ha will be set aside on the waste dump. The different types of waste rocks and overburden found at Afton will be imported to the site in sufficient quantity to give meaningful results. The success of different seed mixtures and fertilizer combinations will be tested. Over the next five years this test program will be expanded to include study of the effects of thin cappings of the materials found to have the best potential as planting media. Since direction of exposure is an important factor in determining reclamation success further plots will be set up in different locations. It is expected that by 1983 test areas on the dump faces will be in place.

Testwork on tailings is hampered by the fact that they are only exposed in one small, remote area of the pond. Therefore during 1980 plans will be devised to obtain a quantity of tailings in a location suitable for vegetation testing.

3.4.2 Wildfowl Habitat Improvement

In view of the unsatisfactory performance over the past two years of Moose Lake as a year round wildfowl habitat Ducks Unlimited has recommended that work should be done at two additional sites, Russel Slough and East Slough. Russel slough is currently used by waterfowl all year. It has been proposed to raise the level of the slough by about 30 cm by building a 90 cm high, 30 m long dam to include a control structure. It is possible that diverting Alkali Creek through a 200 m long

3.4 Reclamation Program For The Next Five Years Cont'd

3.4.2 Wildfowl Habitat Improvement Cont'd

ditch and constructing a 1.5 m high, 60 m long dam the level of East Slough could be raised by about 75 cm. Ducks Unlimited are to provide engineering plans and cost estimates for these projects this year. The implementation of these plans will be contingent upon obtaining the necessary water licences for the diversion and storage of water and upon the rationalization of conflicts with Sugarloaf Ranch cattle feeding areas.

3.4.3 Range Improvement

The newly seeded area (Reclamation Area No. 4) is to be fertilized after the grasses have become established. Subsequently soil testing will be routinely carried out to determine if and when further fertilization is necessary.

Elevated levels of heavy metals, notably copper, have been detected in native grasses surrounding the plantsite. Research is currently underway to determine the levels in the range seeded areas, and to determine if these levels would be toxic to cattle or affect the quality of the resulting meat. If it is proven that the anticipated levels are not high enough to cause a danger to the cattle a further 10 ha east of the plantsite will be range seeded and fenced this fall. Subject to Sugarloaf Ranches ability to spare land for the two or three year non-productive period after seeding it is expected that an additional 10 ha will be seeded each year.

The irrigation area (Reclamation Area No. 2) will be expanded to 14 ha in 1980. The area will be disked and reseeded with a mixture that has yet to be deter-

3.4 Reclamation Program For The Next Five Years Cont'd

3.4.3 Range Improvement Cont'd

mined. Providing that excessive levels of heavy metals are not found the area will be hayed annually after establishment.

Reclamation Area No. 3 is situated between the northwest haul road and the relocated Trans Canada Highway. This six hectare area is crossed by both the old Kamloops-Savona road and the old Trans-Canada Highway both of which pass through cuts. Rock outcrops are also present. It is planned to level this area with waste rock, cap it with a suitable revegetation medium and plant it using a rangeland seed mix. It is possible that the area could be irrigated also as it is within 400 m of a water source. Little work can be done in this area until the B.C. Telephone Co. pole line mentioned in connection with Reclamation Area No. 1 is moved which should occur within the next five years.

3.4.4 Revegetation Projects

3.4.4.1 Knapweed Spraying

Spraying for the control of knapweed will continue on a regular basis as required.

3.4.4.2 Revegetation

As a result of the annual review of past reclamation projects mentioned in section 3.4.1 the need for some further work in these areas will undoubtedly become apparent. Further minor disturbances of the land will also occur from time to time. It is Afton's policy to attempt to establish ground cover over disturbed areas of soil as soon as possible to prevent weed infestation.

3.4 Reclamation Program For The Next Five Years Cont'd

3.4.4 Revegetation Projects Cont'd

3.4.4.2 Revegetation Cont'd

A review will be conducted in 1980 to detail the work that will be necessary to complete reclamation of the area between the plantsite and the Trans-Canada Highway. This 25 ha area has received work in the past in the form of knapweed spraying, tree planting, recontouring and revegetation. Some of the necessary future work will include removal of disused power poles, grading and revegetation of the original Trans-Canada route, removal of the overflow sewage evaporation pond as it is no longer needed, revegetation of the borrow pit and dam constructed to impound plantsite run off water, grading and revegetation of the old Kamloops-Savona road, grading and revegetation of unnecessary minor access roads, and planting additional trees around the sewage lagoons.

A test plot will be established on the small section of the old highway to determine if satisfactory growth can be achieved after ripping the ashphalt. Further trees may be planted this fall if a conclusive evaluation can be made of the success achieved with last years plantings. Based on the recomendations of the review described above a major project will be initiated in 1981 to complete the work with follow up fertilization and seeding as necessary.

Further work will be necessary this year in the 3.6 ha area disturbed by installation of the tailings reclaim pipeline. Fertilizer will be applied and touch up seeding will be done as necessary. Some minor re-

3.4 Reclamation Program For The Next Five Years Cont'd

3.4.4 Revegetation Projects Cont'd

3.4.4.2 Revegetation Cont'd

grading is still to be completed. A test seeding will be conducted in 1980 on part of the north face of the tailings line embankment north of the open pit. The 0.7 ha area will then be seeded and fertilized in 1981. Approximately 1000 m of tailings line is to be moved in 1981. It is expected that about 50% of this route or about 0.5 ha will become available for reclamation in 1982 as it will not be redisturbed. Approximately 0.6 ha will be seeded and fertilized in the smelter and water tank area in 1980.

3.4.4.3 Dump Reclamation

Since it is expected that all dump area, with the exception of the mud dump area, will remain active over the next five years dump reclamation will be restricted to the research program outlined in section 3.4.1.

As previously mentioned dumping of till will continue on the mud dump area (Reclamation Area No. 1) until halted by the B.C. Telephone pole line. Final grading of some of the area should be possible in 1981 after which ploughing and seeding can commence. This area may also be irrigated eventually.

3.4.4.4 Tree Planting

In addition to the tree planting program described in the area of the sewage evaporation lagoons, it is planned to establish a row of trees adjacent to the south edge of the Trans-Canada highway to act as a visual barrier between the highway and the plantsite. During 1980 research will be carried out to establish

3.4 Reclamation Program For The Next Five Years Cont'd

3.4.4 Revegetation Projects Cont'd

3.4.4.4 Tree Planting Cont'd

the parameters for a field trial to be implemented probably in the fall. The parameters will include: species or combinations of species, age and size of trees, planting method and timing, fertilization and tending requirements. The field trial will be monitored and possibly expanded in 1981 with full scale planting proposed for 1982.

Table 3: Five Year Projection Of Anticipated Mining And Reclamation
(Totals represent totals to end 1984)

	Development						Reclamation																	
	Disturbed Area (ha)						Recontoured Area (ha)						Seeded/Planted Area (ha)						Fertilized Area (ha)					
Year	1980	1981	1982	1983	1984	Tot.	1980	1981	1982	1983	1984	Tot.	1980	1981	1982	1983	1984	Tot.	1980	1981	1982	1983	1984	Tot.
Roads						24	1					1	4	1	1			17	2	6	3	2	2	17
Plantsite						31			4			6			6			12		1	7	1	1	12
Pit	4	0	2	2		60																		
Dumps	11	12	11	11	11	144	1	1	1	3	2	8	1	1	1	3	2	8	1	1	2	2	2	6
Tailings	13	13	12	13	12	143		1				2		1				2		1	1	1	1	2
Stockpiles	—	1	—	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	28	26	25	26	23	412	2	2	5	3	2	17	5	3	8	3	2	39	3	9	13	6	6	37
Habitat Improvement								4				14		1				3			1			3
Range Seeding													10	10	10	10	10	78	12	10	10	10	10	60
Irrigation								—				—	14	—	—	—	—	14	14	—	—	—	—	14
								4				4	24	10	10	10	10	95	26	10	11	10	10	85

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Figure 11A
Scale 1:6500

Figure 11B
Scale 1:6500

Figure 11C
Scale 1:6500

FIGURE 13

AFTON MINES LTD. (N.P.L.)

PAST AND FUTURE RECLAMATION PROJECTS

McElhanney

McElhanney Surveying & Engineering Ltd

1200 West Fender Street, Vancouver B.C., Canada

Scale - 1" = 400' Approx		
Contour Interval -		
Date - June, 1979	Photography	Drawn April, 1980
Job No. - 06387 - 2		
Sheet No. - 1 of 1		

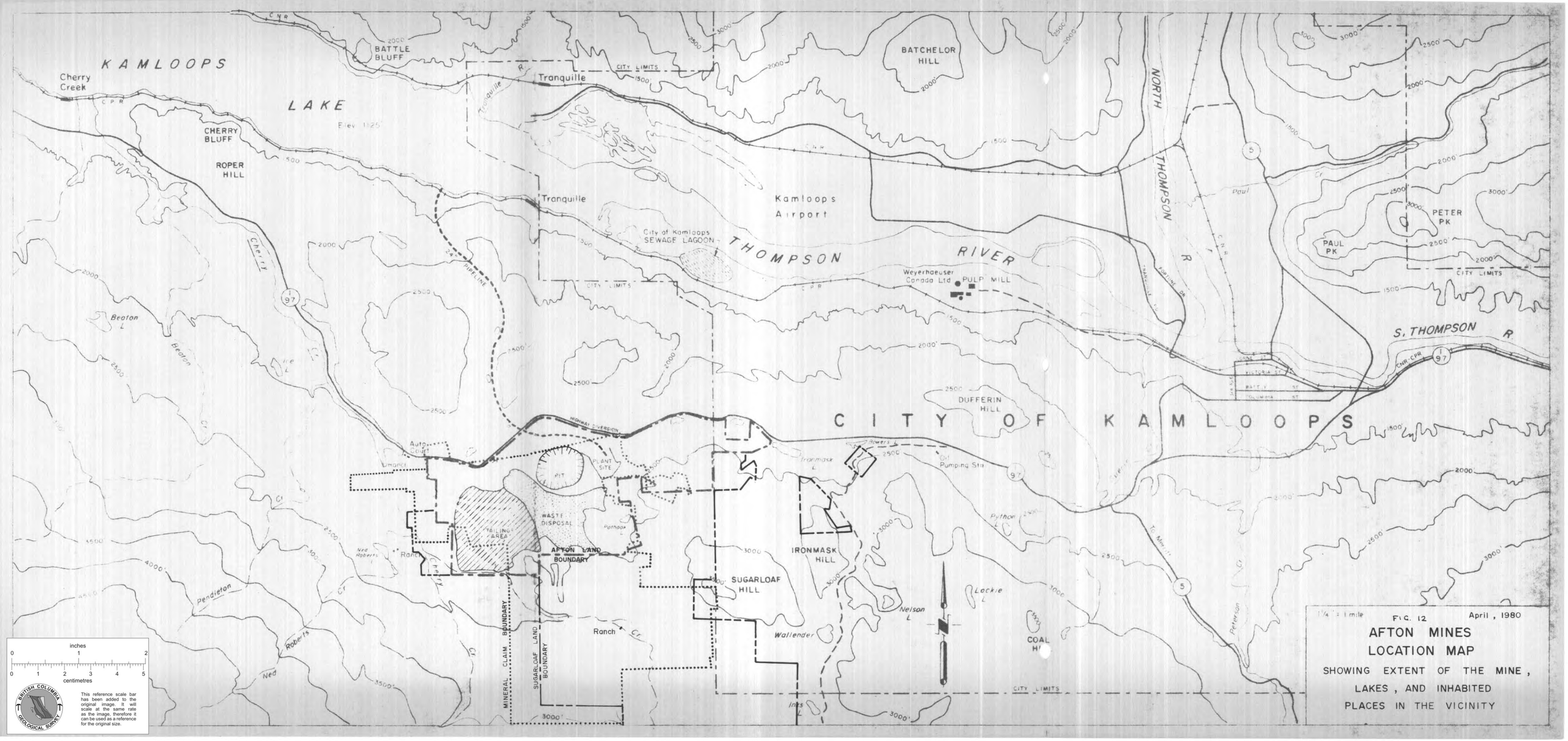

FIG. 12 April, 1980

AFTON MINES LOCATION MAP

SHOWING EXTENT OF THE MINE, LAKES, AND INHABITED PLACES IN THE VICINITY