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June 11, 1980

Our File: 1561

Department of Indian Affairs
and Northern Development
Northern Affairs Program
P.O. Box 1500
Yellowknife, N.W.T.
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Attention: Mr. A.G. Redshaw, P.Eng.
Assistant Director
Renewable Resources

Dear Sirs:

Cadillac Exploration Limited
Preliminary Environmental Evaluation
Mine, Mill and Camp

We are pleased to submit, on behalf of Cadillac Explorations Limited, twenty (20) copies of the Preliminary Environmental Evaluation for the Mine, Mill and Camp at Prairie Creek.

We trust that your staff will undertake the distribution of these reports to the appropriate regulatory agencies.

Yours very truly,

KER, PRIESTMAN & ASSOCIATES LTD.

J.B. Brodie, for

N.I. Guild, P.Eng.
Manager, Water Resources & Mining
Development Division

JBB/eb

cc: L.C. Morrisroe, Cadillac Explorations Limited
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PRELIMINARY ENVIRONMENTAL EVALUATION

FOR

MINE, MILL AND CAMP

CADILLAC EXPLORATIONS LIMITED

PRAIRIE CREEK PROJECT, N.W.T.

File: 1561

May, 1980

Ker, Priestman & Associates Ltd.
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300 - 2659 Douglas Street
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CADILLAC EXPLORATIONS LIMITED
PRAIRIE CREEK PROJECT

PRELIMINARY ENVIRONMENTAL EVALUATION
MINE, MILL AND CAMP

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1. SUMMARY

Cadillac Explorations Limited propose to bring into production, during 1980 and 1981, their lead-zinc-copper-silver property at Prairie Creek, N.W.T. This report has been prepared for the purpose of outlining in a preliminary way, the project, the environmental setting and potential impacts of the mine, mill and camp development. The impact of the winter access road to the property has been addressed in a separate report submitted earlier.

The Cadillac property is located at approximately 61°33'N latitude and 124°48'W longitude, adjacent to Prairie Creek, 27 miles upstream of its confluence with the South Nahanni River. Twelve mineralized occurrences extend over a zone 6½ miles long within four mineral leases covering an area of 6659 acres. Zone No. 3, which is scheduled for initial production, lies near the confluence of Harrison Creek and Prairie Creek.

Production at a rate of 1000 tons per day is proposed. On the basis of proven, probable and possible ore reserves, a mine life of approximately 6 years could be supported. The presence of as-yet undeveloped reserves within the other mineralized zones would suggest the possibility of further extending the life of the operation.

Mechanized cut-and-fill stoping will be utilized as the mining method, permitting the placement of some of the mill tailings back into the mine. The mill process currently envisaged is a selective flotation of lead, zinc and copper concentrates. The copper concentrate (containing most of the silver) will be shipped by air on a daily basis, with the lead and zinc concentrates stockpiled for annual shipment over a winter road. Alternatives to the proposed flowsheet are currently under investigation.

Wastes from the operation will include sewage, garbage, air emissions from the mine and mill, mine waste rock, mine water and tailings. Sewage will be treated in an extended-aeration, activated-sludge treatment plant, complete with chlorination facilities. Combustible garbage will be burned and incombustible refuse will be landfilled. Emissions to the air would include mine ventilation, diesel generators and emissions from standard mill equipment such as crushers, dryers and the assay laboratory; dust abatement equipment is to be employed on those emissions which require it.

Quantities of waste rock will not be large and this material will find use as fill and in road construction. Drainage from waste rock and from the mine is not expected to be acidic due to the preponderance of carbonate minerals in the host rock.

A number of sites have been identified for potential use as tailings storage, several of which would occupy side-valleys of Prairie Creek and others which would be located at the foot of the slopes bounding the Prairie Creek floodplain. The relative advantages and disadvantages of each have been investigated and it would appear that two sites along Prairie Creek show most promise for development.

Tailings have been shown to have no net acid-generating capability, thus eliminating concern relative to the long-term pollution potential of the pond. Efforts would therefore be directed at ensuring the stability of the impoundment, its long-term protection from flood waters and the treatment of tailings effluent to environmentally-acceptable levels.

Although site-specific information is not available for the fishery of streams near the mine, the following fish species have been identified in Prairie Creek downstream: Arctic grayling, Dolly Varden char, round whitefish, burbot, white sucker and slimy sculpin. Based on a field survey carried out in April, 1980, Harrison Creek (adjacent to the mine) was judged to have a low habitat potential and Prairie Creek was considered to have a low to moderate habitat potential for fish.

The vegetation presently on the site is dominated by a mixture of white and black spruce which grows up to 30 ft. in height. The understory is composed of a variety of shrubs such as juniper, dwarf birch, bearberry, buffaloberry, cinquefoil, Labrador tea and lingonberry. The ground flora is dominated by mosses, lichens and some forbs.

One hundred and twenty-two avian species, forty-eight mammalian species and two herptiles potentially inhabit the region of the proposed development, although, due to lack of suitable habitat, many of these species would not be expected to be present in the immediate vicinity of the mine.

Birds noted which are considered to be rare, endangered or highly sensitive, include the Bald eagle and Trumpeter swan. Both are known to occur in the Nahanni area. Of the 48 potentially occurring mammals, 22 comprise a group which is exploited either recreationally or commercially (6 ungulates and 16 furbearers). None of these 48 species is considered to be rare or endangered although some forms such as woodland caribou, Dall's sheep and grizzly bear are considered sensitive due to their susceptibility to disturbance.

Habitat capability to support wildlife in the immediate vicinity of the minesite appears low. Larger animals observed during earlier years by camp residents include one grizzly bear, three black bears, three wolverine, one wolf and one caribou in the vicinity of the minesite. Although an area 5 miles to the northwest of the camp has been reported to support Dall's sheep and a large herd of woodland caribou has been observed at the south end of the Cadillac property, no animals were seen in these areas during the April, 1980 survey.

The most serious potential environmental impacts which could affect the aquatic or wildlife resources of the area include deposition of waste, erosion and siltation resulting from both construction and operational phases of the mine, potential toxicity from spills, sewage treatment plant and tailings pond effluents and failure of major structures due to washout. General measures have been proposed in order to prevent or minimize these effects and it is fully expected that the development will have a negligible long-term impact on the environment.

Acid generation, a serious problem at many mines, will not develop at Cadillac as determined by laboratory analyses of the tailings and waste rock. The ore itself is a potential acid-generator but as the ore is to be removed from the mine and its presence in a matrix of carbonate rock will counter-balance any acidity generated, mine water should not develop acid conditions.

With respect to socio-economic impacts, the Cadillac mine will not impose any demands on the existing community services, but at the same time, will provide employment opportunities and contribute substantial economic benefits. Cadillac will endeavour, over time, and in co-operation with government, to increase the proportion of benefits directed to the local economy. Thus, the economic impact of the mine is expected to be strongly positive.

Studies relative to the mining development will continue with the further reporting of environmental data collected during the summer of 1980.

2. PROJECT RATIONALE

2.1 Introduction and Acknowledgements

Full-scale production of metal concentrates from the Prairie Creek property of Cadillac Explorations Limited will require, during 1980 and 1981, the phased development of the underground mine (currently underway), expansion of the existing camp, construction of a flotation mill to handle the ore containing lead, zinc, copper and silver, and the establishment of a winter access road to the property.

This report deals with the mine/mill/camp portion of the development, and is intended to complement a similar volume entitled, Preliminary Environmental Evaluation for Winter Access Road (May, 1980). Both reports are to be followed, later in 1980, by a complete Initial Environmental Evaluation (I.E.E.) which will bring together all relevant desk studies, spring and summer field work and concerns of government agencies and the public arising from the preliminary reports.

Several consultants have participated in the preparation of this report. Golder Associates Ltd. advised on geotechnical matters relative to site selection, foundations and tailings dam construction. Environmental input concerning aquatics, wildlife, vegetation, terrain and socio-economics originated with Beak Consultants Ltd. Acid-generation tests were carried out by B. C. Research. Ker, Priestman & Associates Ltd. acted as project manager for the environmental work and, in addition, carried out the hydrology and climate analysis and the conceptual layout of the tailings disposal system.

Most of the project description, including the mining plan and mill process flowsheet has been obtained from the preliminary engineering feasibility study prepared by Kilborn Engineering Ltd. in collaboration with H. Brodie Hicks Engineering Ltd.

A list of the consultants mentioned above is provided in Appendix "A".

This report was commissioned by Cadillac Explorations Limited, who assume responsibility for the statements contained herein:

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Lawrence C. Morrisroe, President

2.2 The Need

The Cadillac project is one of several new mineral developments proposed for the Northwest Territories. Others include: Polaris, Cullaton Lake, Contwoyto Lake, Camlaren and Mactung. One hundred miles to the northwest along the Yukon/N.W.T. border is located Cantung, the nearest operating mine.

The Cadillac mine is isolated from any existing or proposed resource developments, places of habitation or transportation corridors. Construction of a 100-mile winter road to the Liard Highway southeast from the mine will provide the only ground link to the communities of Fort Simpson, Nananni Butte, and ultimately Fort Liard and Fort Nelson. Construction and operation of the mine and road are expected to provide considerable economic benefits to these communities. Further resource development in the region may result from the enhanced access although no specific projects are known at this time.

2.3 Alternatives

A discussion of alternatives is not appropriate relative to the Prairie Creek Mine itself as a mine must be built where the ore is found. However, the No. 3 zone, proposed for initial development, is only one of several potentially exploitable zones on the property (Figure 3). The mineralized structure extends over a distance of some 20 miles, with over 12 known occurrences having been outlined on the Cadillac claims. Once production from No. 3 zone has commenced, a development programme for the other zones may be considered.

The location of a mill to process the ore is somewhat more flexible although there are not many feasible alternatives as any site must also offer suitable land for use in tailings disposal. The mine is located in very rugged terrain, and the Prairie Creek floodplain provides the most attractive sites. Two alternatives considered for construction of a mill were:

1) Caribou Flats on Fast Creek,
2) Prairie Creek near its confluence with Harrison Creek.

Caribou Flats is located along the east fork of Prairie Creek (also known as "Fast" Creek), approximately 10 miles north of the mine (Figure 1). While topographically this area may be well-suited for construction of a mill, it possesses several disadvantages which precludes it from further consideration. The most serious of these is its documented use by caribou, Dall's sheep and moose. In addition to this, road construction between the mine and Caribou Flats would traverse some canyon sections with major construction difficulties and maintenance problems.

Attention has therefore focussed on the second alternative for siting of a mill and camp - a 20 acre area in the vicinity of the confluence of Harrison Creek and Prairie Creek, near the 2850 ft. portal of the mine (Figure 2a). A fully-equipped exploration camp, service and maintenance buildings and fuel storage are presently in place.

The main attributes of the Prairie Creek location are its proximity to the mine and potential tailings pond sites, and the availability of adequate flat ground for plant development. Its location, relative to other ore zones within the claims and the existing 3000 ft. gravel airstrip (Figure 3), add to its attraction.

2.4 Associated Projects

The development of the Prairie Creek mine, camp and mill is considered as a single project for the purpose of this report. Related to this project is a winter access road to the Liard Highway, addressed in a separate document - Preliminary Environmental Evaluation - Winter Access Road.

A decision on construction of an airstrip at or near the eastern end of the winter road has yet to be made.

No other resource developments have been identified relative to this project.

3. PROJECT DESCRIPTION

3.1 Location

The Cadillac property is located at approximately 61°33' N latitude and 124°48' W longitude, on Prairie Creek. The dominant physiographic features of the site are Tundra Ridge and the Headless Range of the Mackenzie Mountains forming peaks up to 5700 ft. These mountains are incised by the southeasterly flowing Prairie Creek which joins the South Nahanni River some 27 miles south of the mine (Figure 1).

3.2 History

The original discovery of mineralization on the property (now known as Zone No. 5) is reported to have been made by an Indian trapper in 1928. Subsequently, the ground appears to have been staked from time to time, but no significant development is recorded until 1958 when Fort Reliance Minerals Ltd. undertook a limited mapping programme. Their claims lapsed in 1965 and were restaked by a local prospector who, in the following year, conveyed them to Cadillac Explorations Limited, which also acquired a 182,590-acre Prospecting Permit. On the expiry of this permit in 1969, Cadillac selected from it 210 claims (6,659 acres) which have been brought to lease. Additional claims have since been acquired.

During the period 1966-69, work comprised bulldozer trenching on a number of the showings and driving of exploratory crosscuts on Zone Nos. 3, 7 & 8. Latterly, this work was directed by the consulting firm of Behre, Dolbear & Company Ltd.

In 1970, the property was optioned by Penarroya Canada Ltee. Under their direction, underground development of Zone No. 3 was further extended, and bulk sampling and preliminary metallurgical testing carried out. Some surface drilling was performed on Zone Nos. 6, 7, 8 & 9. Penarroya discontinued work late in 1970, and after some legal negotiations, Cadillac regained full ownership of the property plus the equipment and inventory on site, subject to an ultimate payment to Penarroya from production.

Since that time, the Company has completed a low-level adit crosscut on the No. 3 Zone together with some minor work on certain of the other zones. In 1979, resampling of the crosscuts on the No. 3 Zone was carried out to provide material for definitive metallurgical testing.

3.3 Development Schedule

The following tentative schedule has been proposed:

Pre-production mine development, commencing .... April, 1980

Winter road construction, commencing .... June, 1980

Construction of Mill, commencing .... September, 1980

Full production - mine & mill, commencing .... October, 1981

3.4 Description of Deposit

From the point of view of economic potential, the most important geological feature of the area is the existence, over a strike length of some 20 miles, of more than 15 occurrences of silver-lead-zinc mineralization. All of these lie along a lineament striking about N 10^{o} E. It is not suggested that continuous mineralization will be found throughout this length, but one potential ore body has already been developed and it seems probable that others may exist. The criteria determining the occurrence of major mineral deposits have not yet been established but may be slight changes in attitude of the major structure or the varying character of the enclosing wall rocks.

On the main leased claim group of Cadillac Explorations, 12 mineralized occurrences have been located over a strike length of 6½ miles (Figure 3). Others are known to exist on the claims recently staked to the north while to the south, within the boundaries of a National Park, still others have been reported.

All of the underlying rocks of the area are sediments of Paleozoic age, chiefly Ordovician and Silurian. These have been faulted and folded. The main mineralized structure is believed to occur along the crest of a major anticline. No plutonic rocks have been observed.

The mineralized structure has been most fully explored on Zone No. 3. Here, on the 3,050-ft. level, a drift has been driven parallel to the structure for a length of 3,200 ft. with crosscuts at 100 ft. intervals. The mineralized vein was encountered in each crosscut. It has been cut, but not further developed in a lower level adit crosscut, 200 ft. below the main level.

The vein strikes approximately N 10^{o} E and dips eastward at 60^{o}. Width varies from a few feet up to 25 ft. and averages about 15 ft.

Mineralized tension fractures striking N 45°W sometimes occur on the easterly side of the main structure. Most are narrow but some may prove to be of economic importance.

Mineralization comprises quartz, calcite, galena, sphalerite, freibergite and minor pyrite and chalcopyrite. Some oxidation may be observed in all of the crosscuts with a tendency to become less away from the surface, although in general, there appears to be a high degree of variability. In the new, low-level adit the amount of oxidation appears lower in the only available intersection.

Work on the other zones within the property is not sufficiently advanced to permit any conclusions with respect to their geological setting.

3.5 Ore Reserves

Ore reserves in the No. 3 Zone, including a mining dilution factor of 15%, are estimated as follows:

Category	Short Tons	Silver Oz/ton	Lead, %	Zinc, %	Copper, %	Cadmium, %
Proven	790,000					
Probable	250,000					
Possible	540,000					
	1,580,000	5.6	10.9	13.5	0.52	0.09

Information available for reserve estimation includes detailed sampling, on the 3,050-ft. level, of crosscuts at 100-ft. intervals over the full length of 3,200 ft. developed to date. Information from several raises driven above the 3,050-ft. level, two of which broke through to surface, demonstrates continuity of mineralization with the same general characteristics as in the horizontal plane. On an upper level, approximately 120 ft. above the 3,050, the vein was drifted on for some 650 ft. but this working is not now open. The low level adit, at the 2,850-ft. level has intersected the vein, showing a width of 12 ft. assaying 11.2 oz/ton silver, 20.9% lead, 3.6% zinc, 0.8% copper and 0.04% cadmium. A number of diamond drill holes, five of which are made use of in the estimate, have been completed below the 3,050-ft. level.

There is a varying degree of oxidation in the deposit. The extent to which this will affect metallurgical recoveries is currently under investigation and hence its significance with respect to ore reserves cannot be estimated at present. The above figures make no distinction between oxide and sulphide mineralization.

As an average, on the 3,050-ft. level, about 20% of the lead and zinc occur in oxide form. It may be expected that this proportion will decrease with distance from surface.

Reserves have been calculated for certain of the other partially developed zones on the property. Classified as probable, these total 365,000 tons grading 4.3 oz/ton silver, 9.2% lead, 9.95% zinc and 0.35% copper. The total of these reserves would support a mine for approximately 6 years at a milling rate of 350,000 tons per year (1,000 tons per day).

3.6 Mining

Mechanized cut-and-fill stoping has been adopted as the optimum mining method (Figures 4, 5 & 6). Alternatives considered were shrinkage and open stoping. The cut-and-fill method minimizes dilution from overbreak and permits more accurate extraction of a pinching and swelling vein, again reducing dilution and ensuring full extraction of the ore. It requires less pre-production development for draw-points and access openings and avoids the possibility of freezing of broken ore under permafrost conditions. Fill will be derived from de-slimed mill tailings supplemented by gravel from surface.

Stoping will be carried out from both of the existing adit levels, the 2,850 and 3,050. The 2,850 will serve as the main haulage level, using conventional tracked equipment. No haulage will be required on the 3,050. Ore from the stopes above this level will be discharged directly to ore passes delivering to chutes on the 2,850. Service requirements on the 3,050 will be supplied by light trackless vehicles.

Pre-production development may be divided into two phases. The first phase consists of the further development of the 2,850 level over the full known length of the structure, or approximately 3,000 feet. Primarily this work will serve to confirm and upgrade the ore reserves but the openings will, in any event, be required for production. It is proposed to drift in the footwall of the vein, as has been done on the 3,050, but rather than crosscutting at 100-ft. intervals, it is proposed that crosscuts be spaced at 400-ft intervals to accord with the stoping plan and that the structure be tested between these crosscuts by diamond drill holes at 25-ft. centres.

The second phase of pre-production development will comprise all of the work necessary to prepare five stopes for mining and will include sub-drifting, ore-pass, manway, fill, and ventilation raising, preparation of draw points and necessary ancillary work.

After production has commenced, a continuing programme of stope development will be required.

Stopes will be 400 feet in length, without intervening pillars. A raise will be driven in the centre of each stope for filling and ventilation, and there will be a manway at each end. A circular, steel mill hole will be raised through the fill at the centre of the stope. Ore will be broken in horizontal breasts, using jack-leg drills. Broken ore will be delivered to the mill hole by light, LHD, air-driven units. These will also serve to spread gravel fill if required, but it is anticipated that most fill will be derived from deslimed tailings. Each fill cycle will be completed by laying a concrete floor.

It is planned to start stoping in the better grade, least oxidized portions of the ore body in order to maximize early financial returns and to permit experience to be gained in metallurgical treatment.

3.7 Milling

The mill flow sheet currently envisaged is shown in Figures 7 & 8. However, the preliminary nature of this flowsheet should be noted.

The average mill composite grade for the estimated zones is 10.9%, 13.5%, 0.52%, 0.1% and 5.6 ounces per ton for lead, zinc, copper, cadmium and silver respectively.

The process plant is designed to treat 1,000 short tons of ore per day, operating seven days per week. Allowing for normal interruptions, it is anticipated that annual throughput will be 350,000 tons.

Three concentrates (copper, lead and zinc) will likely be produced. The copper concentrate, containing a high proportion of silver, will be shipped by air on a daily basis. The lead and zinc concentrates will be stockpiled for annual shipment over a winter road. Dry, covered storage for the latter two concentrates is provided.

A flotation concentrator has been optioned from the Churchill Copper Corporation and is located at the Magnum Property near Fort Nelson, B. C. This concentrator will be moved to Cadillac's Prairie Creek property and supplemented with the additional equipment to meet the designed flowsheet.

Golder Associates have reviewed two alternates for placement of the mill as shown on Figure 2a. One alternate is along the north side of Harrison Creek where camp service buildings are presently located; the other is approximately 2000 feet north of Harrison Creek on higher terrain overlooking one of the potential tailings pond sites (T-2).

a) Crushing

The crushing plant will utilize a two-stage configuration incorporating a jaw crusher in open circuit and a shorthead cone crusher in closed circuit, sized to supply 7,000 tons per week of ½-inch mill feed to the concentrator in two 10-hour daily shifts six days per week.

b) Grinding

Fine ore storage capacity will be sufficient to sustain plant operation over Sunday without a crushing shift. The grinding plant has been sized to reduce 1,000 tons per day of ½-inch feed to 80% passing 200 mesh in a single unit closed circuit with hydraulic cyclones.

c) Flotation

Flow patterns for the selective flotation of lead, copper and zinc (as currently envisaged) are standard and will employ the equipment commonly used for such separations. The copper-lead circuit will be in series with the zinc circuit. The copper-lead rougher concentrate will be reground prior to cleaning. After cleaning, a copper-lead separation is made. A regrind circuit also follows the lead scavenger concentrate followed by one stage of cleaning. A regrind follows the zinc rougher concentrate and then two stages of cleaning.

The flotation tailings will be deslimed through hydraulic cyclones and the deslimed portion will be used as backfill in the mine.

d) Dewatering

The lead concentrate and the zinc concentrate will be dewatered in separate thickener-filter circuits while the copper concentrate volume, being small, will go directly to a filter. Thickener overflows and filtrates are to be returned to individual storage tanks for redistribution to their respective circuits. The zinc and lead dryer exhaust gases are to be wet scrubbed to recover the entrained mineral.

e) Backfilling

This plant is located at the concentrator. Tailings will be deslimed in stages using cyclones. The cyclone overflow will be pumped to the tailings pond. The final deslimed underflow is stored in two (2) 700-ton tanks until required by the mine. Stored tailings will be transferred to a mix tank where cement will be added when required and where pulp consistency will be adjusted. Tailings are then pumped to the mine for placement in the stopes.

3.8 Tailings Disposal

3.8.1 Introduction

Disposal of tailings poses the major environmental difficulty at the Prairie Creek property mainly due to the rugged topography and hydrological constraints. Fortunately, an absence of acid-generating capability of the wastes suggests a favourable outlook for long-term pollution potential; environmental control relative to tailings will therefore focus on physical stability of the impoundment and control of short-term toxicity.

3.8.2 Design Criteria

Pond storage requirements were based on preliminary flowsheet estimates of slurry volumes for the design life of the mine. Because backfilling of tailings sands to the mine is proposed, only a portion of the total tailings solids will require impoundment. Due to the severe climate at the property, an allowance for the formation of permanently-frozen tailings was made, although by judicious operation, it is likely that permanent ice in the tailings pond can be avoided.

Recycle of supernatant tailings pond water is proposed up to the maximum that can be accommodated in the mill. Depending on the location of the tailings pond, its catchment area, the effectiveness of diversion ditches, precipitation events, etc., a discharge from the pond to a watercourse may or may not be necessary. Preliminary estimates of the annual average discharge are provided in Figures 9b through 13b, based on mean, maximum and minimum expected precipitation rates.

The preliminary design criteria may be summarized as follows:

- tailings discharge to pond .... 18.0 short tons/hour of solids @ 35% solids (by weight)
- storage required .... 6.0 years
- permanent freezing of tailings ...... 2 months/year
- precipitation, mean .... 16 inches/year
  maximum .... 24 inches/year
  minimum .... 12 inches/year
- operation period .... 350 days/year

- evaporation .... 10 inches/year
- pond reclaim .... 65% of mill water requirement or 148 US gal/min.

3.8.3 Potential Tailings Pond Sites

A preliminary selection of potential tailings pond sites was made on the basis of 1:50,000 scale government mapping of the region and 1:6000 topographic mapping of the property. Nine sites were identified as shown on Figures 2 and 2a. Several locations would require the placement of short, high dams across tributary streams of Prairie Creek and other locations would require longer, lower dams at the foot of the slopes bounding the broader sections of the Prairie Creek floodplain. Of the nine sites, five were considered to be worthy of further evaluation based on a field investigation in April, 1980; these are discussed individually below, with the critical features summarized in the accompanying table. Geotechnical factors are discussed in Appendix E.

Site T-1

Site T-1 is located in the valley of Harrison Creek which enters Prairie Creek adjacent to the mine portals and the camp (Figure 9a). Storage of tailings for 6 years would require a dam 131 feet high, 550 feet long, containing 350,000 $yd.^3$ of fill. The catchment area is approximately 1905 acres.

The main attributes of T-1 are the proximity to the mine and the resultant short distance required to transport tailings and reclaim water (approximately 1,000 feet). In addition to the favourable economics of short line length, this factor would also reduce the possibility of line breakage, facilitate inspection, and thus minimize the potential for spills.

The main disadvantage of site T-1 is the need to divert Harrison Creek either around or through the pond. Preliminary hydrological investigations have suggested that the 100-year return period flood flow of Harrison Creek would be approximately 900 cfs, requiring a culvert along the creek channel beneath the pond of at least 5.5 ft. diameter, plus an appropriate inlet transition structure and energy dissipator at the exit. If this flow were to be attenuated by allowing the peaks to be temporarily stored within the tailings pond, it might be possible to reduce the culvert diameter to a minimum of 4 feet. A sidehill ditch to handle this flow would be of impractically large dimensions.

SUMMARY OF ALTERNATE TAILING POND LOCATIONS

Pond Ident.	Location	Storage Life	Dam Crest Elev.	Dam Height	Dam Length	Volume of Fill in Dam	Opportunity for Raising or Extending Dam	Catchment Area	Diversion Works Required	Approximate Distance from Mine Area
T-1	mouth of Harrison Creek	6 yr.	3006'	131'	550'	350,000 yd^3	Yes (raise)	1905 ac.	culvert for creek; sidehill ditch	1000'
T-2	N. side of Prairie Creek adjacent to camp	6 yr.	2908'	58'	2800'	640,000 yd^3	Limited (extend to southeast)	189 ac.	backslope ditch; training groyne for small creek	1500'
T-3	N. side of Prairie Creek downstream from camp	6 yr.	2895'	68'	2550'	850,000 yd^3	Yes (extend to southeast)	112 ac.	backslope ditch; training groyne for small creek	2500'
T-4	S. fork of Harrison Creek	6 yr.	3251'	151'	970'	850,000 yd^3	Yes (raise)	808 ac.	culvert for creek; sidehill ditch	3500'
T-5	N. fork of Harrison Creek	6 yr.	3213'	138'	750'	640,000 yd^3	Yes (raise)	728 ac.	culvert for creek; sidehill ditch	3500'

Assuming that Harrison Creek was to be diverted through the pond area by use of a culvert, additional diversion works would be required to intercept local sidehill runoff. The presence of permafrost has shown excavations along north-aspect slopes to result in instability; therefore, for this site (T-4 and T-5 also), ditches could be built on south-aspect slopes only.

A preliminary geotechnical investigation (Appendix E) suggests that because the embankment would be founded in areas underlain by ice-rich permafrost soils and/or weathered rock, construction costs would be high at this site.

In order for the impoundment to safely bypass flood waters after abandonment of the pond, it would be imperative to provide a permanent, stabilized channel through or around the pond in addition to a spillway capable of handling Harrison Creek during a flood of any conceivable magnitude.

Depending on the annual precipitation, a net discharge of pond effluent to Harrison Creek or Prairie Creek could be required (Figure 9b) during normal operation. Seepage could be controlled to any desired rate by the judicious placement of clay, which is thought to be present in quantity near the site.

Site T-2

Site T-2 would be located between the valley wall and Prairie Creek, with the downstream toe of the tailings dam coincident with the existing low river dyke (Figure 10a). It has the same advantage of Site T-1 in terms of proximity to the proposed mill and camp site but does not intercept a major drainageway. However, protection would have to be provided against possible flooding from Prairie Creek. Diversion of hillside runoff as well as the flow from a small creek discharging to the area would also be required.

Storage of tailings for 6 years would require a dam 58 ft. high, 2800 ft. long and containing 640,000 $yd.^3$ of fill. The catchment area is approximately 189 acres. Extra storage may be obtained if it proves possible to excavate dam fill from the proposed pond area.

T-2 area is underlain by a few feet of sand and gravel beneath which is a thick stratum of clay which would aid in seepage control from the pond. This same material could be used to provide an impervious embankment at T-2 or at other dam sites.

The slopes above T-2 are composed of outwash/colluvial sands and gravels at the mouth of the small drainage course which enters at the south end of this area as well as scree deposits from degradation of the shale/limestone slopes above the Prairie Creek valley.

The terrace formed above site T-2 is considered to be a viable choice for location of the mill, as outlined in Appendix E.

Because of the small catchment area, it is possible that a complete recycle of pond water could be effected at this site. The material balance (Figure 10b) suggests that zero discharge might be achievable during all but extreme runoff years. The absence of a major watercourse running through the pond site would permit simple and less costly post-shutdown spillway and drainageways than required for T-1 and other tributary-valley sites.

Site T-3

Site T-3 is located approximately 0.5 mile downstream of the mine where Prairie Creek widens to form a broad flood plain (Figure 11a). As in the case of T-2, this site offers storage between the slopes on the northeast side of Prairie Creek and the river plain. The available storage area is greater than site T-2 with a relatively small catchment area. It offers good potential for future expansion downstream and does not constrict the width of the river channel to the same degree as T-2.

Storage of tailings at this site for 6 years would require a dam 68 ft. high, 2550 ft. long, containing 850,000 $yd.^3$ of fill. The catchment area would be approximately 112 acres.

Alternatively, a lower dam could be constructed which would project further into the Prairie Creek floodplain than the alignment shown on Figure 11a. However, the advantage of a lower dam would probably be offset by the need for greater toe protection from possible flood waters of Prairie Creek.

As in the case of T-2, a diversion ditch would have to be provided along the slopes behind the pond as well as protection from the unnamed stream which enters the area at the south end. Slopes behind the pond are more heavily wooded than at T-2 and would be expected to provide better control of local runoff.

Additional storage might be gained from the area if, as has been suggested by the geotechnical investigations, dam borrow material can be obtained from the pond area.

The same conditions described for T-2 are thought to exist at T-3, relative to seepage control afforded by sub-surface clay deposits.

Zero discharge from this pond appears feasible (Figure 11b).

A permanent spillway and drainageway for passage of slope runoff after abandonment would have to be provided, but could be of more modest dimension than required for T-1 and the other tributary valley sites.

Sites T-4 and T-5

Sites T-4 and T-5 are located approximately 3500 feet from the mine, upstream of T-1 on the south and north forks of Harrison Creek, respectively (Figures 12a and 13a). These tributaries form broader valleys than the site downstream and therefore larger dams are required to impound the same quantity of tailings.

T-4 dam would be 151 ft. high and 970 ft. long, requiring 850,000 $yd.^3$ of fill. T-5 dam would be of slightly smaller dimensions - 138 ft. high, 750 ft. long and require 640,000 $yd.^3$ of fill.

Because these tributaries contain roughly half the flow of the main creek, culverts to contain 100-year flood flows would be a minimum of 4 ft. diameter with inlet transition structures and exit energy dissipators. Culverts following a more modest grade along the side of the pond would have to be a minimum of 7 ft. diameter. Sidehill ditches, in lieu of the aforementioned culverts, would not be practical. However, a sidehill ditch on the south-facing slope to intercept local runoff would be required.

Other factors relative to foundations, seepage control, and post-shutdown hydraulic control would be similar to T-1. However, zero discharge during operation would appear to be possible due to the smaller catchment areas involved.

3.8.4 Mill Sites

Two potential mill sites, identified as P-1 and P-2 (Figure 2a), have been given preliminary evaluation. P-1 is located on the small terrace overlooking tailings pond site T-2 and in conjunction with use of T-2, would facilitate gravity discharge of tailings. Site P-2 is at a lower elevation, near the 2850 foot mine portal, and would require protection from possible flood waters of both Harrison and Prairie Creeks. However, P-2 is closer to tailings pond site T-3. A final selection will have to await a detailed inspection of foundation conditions and may also be dependent on the choice of a tailings pond location.

3.8.5 Summary of Tailings Pond and Mill Site Evaluation

1) This preliminary evaluation has suggested that tailings pond sites T-2 and T-3 on Prairie Creek offer the best potential for impoundment of tailings on the basis of proximity to the proposed mill, embankment foundation conditions, seepage control, hydrological constraints, and potential for full reclaim. The advantage of a smaller and less costly dam at tributary valley site T-1 would appear to be offset by the need for a large stream diversion structure during operation and elaborate post-shutdown hydraulic works.

2) The potential exists for construction of either pervious or impervious impoundments; a combination of both could be employed within separate cells of the same impoundment if desired. The final quality of the tailings effluent, the degree of recycle desired, and confirmation of the availability of impervious clays will all have a bearing on the type of construction to be employed.

3) Two alternate plant sites have been identified near the mine. P-1 would permit conveyance of tailings via a short, gravity-discharge line to pond site T-2, whereas P-2 (near the confluence of Harrison and Prairie Creeks) might be preferred if pond site T-3 were to be utilized.

3.8.6 Tailings Effluent Treatment

The Metal Mining Liquid Effluent Regulations, reproduced in Appendix F, are pertinent to the quality of effluent from the Cadillac mill. In these Regulations, limits are set on total levels of heavy metals, pH and suspended solids for discharges to the environment on the basis that releases below the limits will not prove deleterious to fish or fish habitat.

The process flowsheet for the Cadillac mill has not been finalized; Figures 7 and 8 represent only the preliminary concept for production of separate copper, lead and zinc concentrates. For this flowsheet, a list of potential mill reagents is presented in Section 3.16 and would include sodium cyanide, zinc sulfate and copper sulfate for the selective flotation of the various sulfides.

Other process configurations are also under consideration with a view to obtaining the most favourable contracts for sale of the concentrates. The final choice may dictate the use of other regeants or the deletion of some of those listed in section 3.16.

Although the use of sodium cyanide is contemplated for the depression of sphalerite, quantities involved would be considerably less than those typical of cyanide gold mills. Alkaline chlorination is the method commonly employed for oxidation of cyanide and would be considered at Cadillac if it was required to meet satisfactory environmental levels and was appropriate from a process point of view.

Control of heavy metals would focus on pH control, adequate retention times and settlement of solids. With the high pH of the mill circuit and the protective alkalinity afforded by the carbonate host rock, little difficulty is expected in complying with the Mining Regulations.

The final, and most important, factor with respect to effluent quality, is that a discharge from the tailings pond may not be necessary, depending on the site selected. Whereas, preliminary estimates of discharge rates are presented in the material balances (Figures 9b to 13b) more definitive figures cannot be given until the process flowsheet is finalized and a more complete evaluation of pond sites is completed.

3.9 Waste Rock Disposal

Quantities of waste rock generated from the underground mining operation will not be large. It is estimated that pre-production mining in 1980 will generate approximately 25,000 tons of waste rock and thereafter, approximately 18,000 tons per year would be produced.

This material would be used for fill in various locations around the property including roads and fill benches. As discussed later, waste rock consists of siliceous and carbonate rock which has no net acid-generation capability and, therefore, does not constitute a contaminant source.

3.10 Sewage

Plant and camp sewage will be carried by a sewer line and lift station, if required, to a sewage treatment plant located downstream on the banks of Prairie Creek.

The sewage plant would be sized to accommodate a population of up to 150 at site. The treatment includes comminution, extended aeration, clarification and chlorination of effluent.

3.11 Garbage

Combustible garbage will be burned in an incinerator located on the property in order to discourage the attraction of bears and other animals. Incombustible garbage (glass, non-salvageable drums, plastic containers, scrap metal, etc.) will be landfilled at a site yet to be decided. Covering will be carried out on a regular basis.

3.12 Air Emissions

Emissions to the air from the mine, mill and related facilities will include:

- mine ventilation
- diesel generators
- crushing plant
- concentrate dryers
- reagent mixing areas
- mill ventilation
- vacuum pumps
- assay laboratory

Crushing plant emissions will be provided with a bag filter or wet scrubber. The copper, lead, and zinc dryer gases will be wet-scrubbed to remove particulate matter and traces of sulfur dioxide. Other emissions will not require pollution abatement due to their low rate of discharge and/or contaminant levels.

3.13 Mine Water

The future quantity of mine water is unknown although presently about 30 US gallons per minute is flowing from the lower (2850') portal. During the winter, this water freezes for a considerable distance into the portal and ceases to flow. Water from the upper (3050') adit flows through diamond drill holes and fractures in the rock to the lower level of the mine.

Acid-generation is not expected to be a problem as discussed in section 3.17. Present mine water quality is given in Table 1. The analyses did not reveal any parameters of concern. If necessary, settlement basins will be constructed for the removal of suspended matter from the mine water prior to discharge. Mine water may also be used for process make-up in the mill if suitable from a metallurgical point of view.

3.14 Water Supply

Water will be supplied from a Prairie Creek pumphouse located upstream of the plant, camp and mine facilities. Two vertical turbine pumps, housed in an insulated, heat traced, pumphouse will pump freshwater to a 70,000 US gallon water storage tank located 150 feet above camp or plant grade elevation. The water storage tank, 25-ft. diameter by 25-ft. high, will be of mild steel or equivalent construction (wood stave is suitable) insulated and sheathed for wind protection. There will be an outlet nozzle at 15-ft. elevation to supply the process and domestic water use for the plant. A tank outlet at 1-ft. elevation is reserved for fire protection water supply.

Water supply piping from the river intake to storage tank and from the storage tank to the mill and campsite will be enclosed in a wooden insulated and heat traced utilador.

The fire protection proposed is that all living accommodations, plant, and work areas will be protected by a wet standpipe system with hose bibbs on both interior and exterior wall surfaces of buildings.

Fresh water will be distributed to the camp and plant buildings for use as potable water and process water make-up. A chlorination facility would be included for water treatment.

Process water will be made up from tailings pond decant water and fresh water make-up as required.

3.15 Fuel Handling and Storage

Fuels required by the operation are diesel oil, gasoline, propane and aviation fuel. Estimated consumption is given below:

	Imperial Gallons Per Year
Aircraft - Concentrate and Backhauls	150,000 Aviation Fuel
- Personnel	50,000 Aviation Fuel
Trucks - Concentrate and Backhauls	500,000 Diesel
Mine Vehicles	100,000 Diesel
Mine Compressors	55,000 Diesel
Mine Heating	55,000 Propane
Plant Vehicles - General	70,000 Gasoline
Camp Heating	45,000 Propane
Power House	1,065,000 Diesel

Aviation fuel can be trucked to the Liard River Airstrip (if constructed) from Fort Nelson and all planes can be fueled at this airstrip or at Fort Nelson.

Trucks hauling concentrate normally have spare fuel tankage which will allow all fueling for the round trip at Fort Nelson.

There is a substantial demand for diesel fuel at the plant site for mine vehicles, compressors and the diesel electric plant. An estimate of the total annual consumption of diesel oil at site is 1,200,000 Imperial Gallons. To haul this quantity of oil in three months requires approximately 500 backhaul trips on concentrate trucks taking 2,500 Imperial Gallons of fuel each trip. Gasoline and propane can be hauled in a further 100 backhaul trips.

Only minor fuel storage would be required at the Liard Airstrip. Emergency supplies of aviation gasoline and diesel fuel would be required at perhaps 10,000 Imperial Gallons each.

There is tankage available at the site for storing approximately 280,000 Imperial Gallons of diesel fuel (2 - 105,000 gallon tanks and 1 - 70,000 gallon tank). For ten months supply, an additional 720,000 gallons diesel oil storage would be required.

The annual plant site requirement for propane is 100,000 Imperial Gallons and for gasoline 70,000 Gallons, both requiring new storage tanks.

All fuels will be carefully handled, transported and stored so as to minimize the danger of accidental spills. Tanks will be provided with impermeable berms; storage facilities not already on-site will be located well away from the river. Means will be provided whereby any spills could be reclaimed.

3.16 Mill Reagents

The mill flowsheet has not been finalized and several process alternatives presently being evaluated may result in modifications of the process shown in Figures 7 & 8. However, the following list indicates mill reagents which may be utilized:

lime	copper sulfate
zinc sulfate	xanthate
sodium sulfite	Aerofroth 404
M.I.B.C.	flocculant
sodium cyanide	sodium dichromate

Storage will be provided for a one-year supply of reagents as they must be brought in over the short period the winter road is open. The storage area will be covered for protection from the elements and constructed with a sump and pump-out facility for recovery of spills. Regular inventory checks will be carried out in the mill and in the storage area in order to control losses and monitor usage.

3.17 Acid Generation

Acid-generation tests have been carried out on ore, waste rock and tailings from the laboratory metallurgical tests. These results, given in Appendix "D", indicate that both the waste rock and tailings are strongly acid-consuming, a reflection of the high carbonate content of the host rock. Thus, no concern would be warranted relative to acid drainages from waste rock piles and the tailings pond.

Based on simple chemical tests, ore samples were found to have an acid-generating capability slightly exceeding the acid-consuming capability, a reflection of the high sulfide level of this material. However, the ore minerals are found in a matrix of strongly basic carbonate rocks which would tend to counteract any acid-generation. Thus, concern for mine water acidity would appear to be minimal. A sample of existing water from the 3050' adit, taken in April, 1980 (Table 1) showed no evidence of acidity.

3.18 Abandonment

Upon abandonment, reclamation measures would be carried out in order to return the land to an environmentally satisfactory condition. Reclamation measures would likely include covering and seeding of tailings, stabilization of unstable rock dumps, sealing of mine workings, removal of buildings, and construction of permanent spillways at tailings impoundments.

This subject will be dealt with more fully in a later report.

4. EXISTING ENVIRONMENT

4.1 Climate

4.1.1 General

The area of the mine site and the winter road route is characterized by a continental climate pattern with a very low mean daily temperature.

The temperature changes associated with the beginning and end of the summer season (June - August) are typically rather abrupt. Precipitation is low, with the annual peak occuring in July.

The temperature sequence during the melt period can be a dominant influence on the production of major spring floods.

4.1.2. Records

Long-term temperature and precipitation records are available from the Atmospheric Environment Service for several centres including Fort Simpson, Wrigley, Watson Lake and Fort Nelson. These stations and others within the area are listed in Table 4 and their locations are shown on Figure 14.

Snow cover data has also been recorded at various locations since the early 1960's.

Rainfall data and the Intensity-Duration-Frequency curves are only available for Watson Lake, Fort Simpson and Fort Nelson, and are based on 8 to 11 years of records.

The Atmospheric Environment Service recorded weather at Cadillac Minesite for approximately one year in 1970. Other data has been recorded sporadically since that time.

Evaporation data is very limited.

At the time of writing this report, the long-term abstracts, for all stations except Watson Lake, and the snow cover data were not available.

4.1.3 Temperature

The monthly and annual mean temperatures for the Cadillac Minesite and proposed access road route for the 30 year period 1931 - 1960, have been taken from Department of Transport climate maps and are given in Table 5. The mean annual temperature for this location is 23^{o}F (-5^{o}C). The minimum monthly temperature of -15^{o}F (-26.1^{o}C) occurs in January and the maximum monthly temperature of 58^{o}F (14.4^{o}C) occurs in July.

4.1.4 Precipitation

The monthly and mean annual precipitation for the Study Area has also been taken from Department of Transport mapping, as shown on Table 5. The mean annual precipitation is 16 inches. About 2 inches/month falls during the summer and the annual low of 0.7 inches/month occurs in April.

The climate summary for Watson Lake (Table 5) gives values similar to those obtained from the Climate Maps with a ratio of rain to total precipitation of about .50.

Intensity-duration-frequency rainfall curves for Fort Simpson, Fort Nelson and Watson Lake are reproduced in Figures 15, 16 & 17. The curves for Fort Simpson and Fort Nelson are considered to be more representative of the conditions in the Study Area, in terms of their positions relative to the Mackenzie Mountains.

4.1.5 Evaporation

Mean monthly and annual evaporation for the area is given in Table 5. Again, Climate Mapping was utilized. The maps provide average rates of evaporation from small, natural, open water bodies having negligible heat storage. It is considered that these values could vary ± 25% in any given year. Evaporation from a tailings pond could be reduced by 25%.

Evaporation from snow and ice, although small, can represent a significant portion of annual evaporation. However, data for evaporation from snow and ice is not available.

4.2 Hydrology

4.2.1 General

Runoff shows a marked peak in June, decreasing through the summer and fall to a low in February and March. Groundwater storage would be low in winter due to frozen ground, hence extremely low winter flows occur. For Prairie Creek, the ratio of the June: March average flows is 73:1. The index hydrograph, Figure 18, for flows on Prairie Creek illustrates this seasonal fluctuation.

Periods of ice cover are indicated. Smaller creeks will have a more extreme variation and larger creeks, less extreme. Annual peak flows on the larger drainage basins such as Prairie Creek are usually due to spring snowmelt, but may also be due to widespread rain, whereas, the smaller creeks will produce flash floods as a result of localized thundershower activity.

4.2.2 Records

Published runoff data is available from the Water Survey of Canada. Additional data is being collected by the Water Resources Division of the Department of Indian & Northern Affairs, but no reference index is available at this time.

The relevant stream-gauging stations are listed in Table 6, with their locations shown on Figure 14.

Data from Station 10EC002 (Prairie Creek at Cadillac Mine), and Station 10EC001 (South Nahanni River near Hot Springs) is considered to be the most pertinent to this study.

Because of a shortage of data having a reasonable period of record for small basins (i.e. less than 50 sq.miles), runoff characteristics for small catchments are not known.

4.2.3 Mean Flows

Based on the Prairie Creek and South Nahanni River gauges, the long term water yield for the Study Area is 1.1 cfs per square mile. Mean annual flow in the South Nahanni River is 14900 cfs with a minimum monthly average of 2000 cfs and a maximum monthly average of 50500 cfs.

Mean annual flow in Prairie Creek is 204 cfs, with a minimum monthly average of 10 cfs and a maximum monthly average of 696 cfs, respectively.

The mean annual yield ratio is defined as equivalent volume of annual runoff divided by volume of total annual precipitation. For the Study Area it is equal to 0.9. (Yield ratio is not the same as runoff coefficient (C) which relates rates of runoff and precipitation.)

A Gumbel plot was prepared from the recorded peak flows in Prairie Creek and the South Nahanni River (Fig. 19). These curves, extrapolated to a 100-year return period, provided estimates of peak flows as follows:

$Q_5 = 0.8\ Q_{10}$ where Q_5 = flood flow with 5 year return period
$Q_{25} = 1.3\ Q_{10}$
$Q_{50} = 1.5\ Q_{10}$ where Q_{10} = flood flow with 10 year return period,
$Q_{100} = 1.7\ Q_{10}$
etc.

The unit peak flows (cfs/mi^2) for the two recording stations were plotted for the 10-year return period (Fig. 20). Instantaneous flows for typical small basins of 1 and 10 square mile catchment areas, calculated by the Rational Method, were also plotted on this graph.

The Rational Method gives estimates of peak flows by a formula relating rainfall intensity, runoff coefficient and drainage area. Rainfall intensity was determined from the Fort Nelson I-D-F curves for a 10-year return period, assuming a 50-minute time of concentration for the 1 mi^2 basin and 90-minute time of concentration for the 10 mi^2 basin:

1 mi^2 basin - rainfall intensity 30 mm/hr. (1.2 in./hr.)
10 mi^2 basin - rainfall intensity20 mm/hr. (0.8 in./hr.)

These times of concentration and corresponding rainfall intensities were based on estimates of overland and creek flow velocities at times of peak flow for typical basins in the Study Area.

Runoff coefficient (C) values of 0.3 and 0.5 were considered to be representative of ground conditions during peak rainfalls in the summer. The Suggested Design Curve (Fig. 20) has been drawn through C=0.3 because a C-value greater than this would likely only result from an infrequent combination of events (i.e. less frequently than once in 10 years).

Comparisons were also made with work done previously by others, including the Department of Indian & Nothern Affairs (1979) for the Tungsten, N.W.T. area.

Generally the Suggested Design Curve for the Cadillac Study Area is more conservative than the curves suggested for the Tungsten area. This may be reasonable based on geographical location but, in any case, a more detailed hydrological analysis would be required to give a more confident prediction of peak flows for small basins.

4.2.5 Minimum Flows

Minimum annual flows for South Nahanni River and Prairie Creek have been plotted on Gumbel paper (Fig. 21). From this, minimum unit flows for various return periods can be derived. Creeks draining less than 200 square miles (e.g. Prairie Creek) will apparently freeze completely during the 20 year return period low. The frequency at which a creek will freeze solid will increase as the creek drainage area decreases.

4.3 Aquatics

4.3.1 Fish

Prairie Creek, a tributary of the South Nahanni River, drains the Cadillac Explorations Limited mine area. Near the mine, the following three significant tributaries enter Prairie Creek: Harrison Creek, Galena Creek and Big Quartz Creek.

Fish species reported in the South Nahanni River Basin are presented in Table 7.

Site-specific information is lacking for the fishery resource of watercourses within the sphere of influence of the proposed development. Limited fishery investigations have been conducted on Prairie Creek within Nahanni National Park (approximately 15 - 25 mi. downstream). These resulted in the observation or capture of the following fishes: Arctic grayling, Dolly Varden char, round whitefish, burbot, white sucker and slimy sculpin (R. D. Wickstrom, pers. comm., Scotter, et al. 1971). Dolly Varden char and whitefish sp. have been angled from Prairie Creek near the mine site (C.R. Fast, pers. comm.).

There is no literature or information available on the fishery resources of Harrison, Big Quartz, or Galena Creeks.

Dryden and Stein (1975) have considered the following fish species to be 'numerically significant or form the basis of existing or potential domestic sport or commercial fisheries in the upper Mackenzie Valley': Arctic grayling, lake whitefish, northern pike, burbot, white sucker, longnose sucker and yellow walleye. Chum salmon and Dolly Varden char may also be included on the above list due to their importance to the sport or domestic fishery in the region.

There is no site-specific information available on the food habits of fish species found within the study area. Hatfield et al. (1972) reported that invertebrates contribute significantly to the diet of the following prominent fish species: Arctic grayling, lake whitefish and burbot. White and longnose sucker are also expected to heavily utilize invertebrates as a food source. A list of important orders and families of invertebrates utilized by prominent fish species is included in Table 8.

Although no information is presently available on levels of heavy metals in fish in watercourses within the study area, studies have been conducted (Hatfield et al. 1972) on fish in the Mackenzie River (Tables 9 & 10).

4.3.2 Aquatic Invertebrates

The lower reaches of Prairie Creek (within Nahanni Park) are reported to be utilized by the following aquatic invertebrates (R. D. Wickstrom, pers. comm.):

Gastropoda; Lymnaeidae; *Lymnaea* sp.
Ephemeroptera; Baetidae; *Baetis* sp.
Plecoptera
Diptera; Chironomidae.

There is no information on the aquatic invertebrates, plankton and aquatic macrophytes of the other watercourses in the study area.

4.3.3 Fish Habitat Survey

On April 17 and 18, 1980, Beak conducted visual observations and water sampling at Harrison and Prairie Creeks. Stream habitat was assessed for potential utilization by fish during open water periods. Factors which were judged to have a limiting influence on the utilization of these streams by fish were noted.

Harrison Creek was judged to have low habitat potential as its middle and upper reaches have a relatively steep gradient. Some utilization by fish may be expected near the confluence of the creek with Prairie Creek, where the gradient is significantly reduced.

Although Prairie Creek was approximately 90 per cent ice covered when investigated, the occasional pool interspersed with shallow riffles was observed. No suitable spawning areas were observed during the visual reconnaissance. Prairie Creek was judged to have low to moderate habitat potential for fish utilization.

Water temperatures were measured with hand-held mercury thermometers ($\pm$ 0.5°C) and chemical parameters were determined by using a Model OX-9 Hach kit (DO - $\pm$1 mg/l; pH - $\pm$0.2). In addition, a qualitative assessment of water colour was made.

On April 17, Harrison Creek had a pH of 7.4, a dissolved oxygen concentration of 12 mg/l and a temperature of 32°F. The creek waters were colourless.

Prairie Creek was sampled approximately 1500 ft. downstream of the confluence with Harrison Creek and also near the southern end of the airstrip. At both locations the pH was determined to be 7.7, the dissolved oxygen was 12 mg/l and the temperature was 32°F. The creek water was colourless at both locations.

4.4 Vegetation

The Cadillac property in the Nahanni area of the Northwest Territories lies within the Alpine Forest-Tundra Section of the Boreal Forest (Rowe 1972). This section is essentially an altitudinal transition from the closed forests of the lowlands to alpine tundra on the mountains. The transition is characterized by open stands of stunted white spruce and understories of grass, shrub or bare rock which occur up to treeline at 3,600 to 3,900 feet. Alpine fir dominates on the north and east aspects at this elevation; at lower elevations, black spruce alone, or in combination with white spruce, dominates the same aspects. On the dry south and west aspects, lodgepole pine (*Pinus contorta* var. *latifolia*) or jack pine (*Pinus banksiana*) are the most common species. Other common species are Alaska birch (*Betula papyrifera*), tamarack (*Larix laricina*), trembling aspen (*Populus tremuloides*) and balsam poplar (*Populus balsamifera*) (Rowe, 1972). The soils in the area are predominantly loam to clay on north and east slopes and on low gradients, permafrost occurs at about 48" depths (Steere *et al.*, 1977).

Overall the vegetation of the South Nahanni and Liard River areas is poorly known; however, general vegetation descriptions are available for: Hole-in-the-Wall Lake (Arnold 1961), the Lower Liard River (Jeffrey 1961, 1964) and Glacier Lake (Raup 1947). The bryophytes of the area are relatively well known from the work of Steere *et al.*(1977). Although the general vegetation pattern is known, local variations in the species mix are considerable and dependent on slope, aspect, elevation and substrate type. No vegetation maps or detailed descriptions are available for the area of the Cadillac property.

The area selected for the mine-mill site is situated on the flood-plain of Prairie Creek. The mill site is proposed for sites which are from 15 to 50 feet above creek level.

The vegetation presently on the site is dominated by a mixture of white and black spruces (*Picea glauca, Picea mariana*) which grow up to 30 ft. in height. The understory is composed of a variety of shrubs such as juniper (*Juniperus communis*), dwarf birch (*Betula glandulosa*), bearberry (*Arctostaphylos uva-ursi*), buffaloberry (*Sheperdia canadensis*), cinquefoil (*Potentilla fruticosa*), Labrador tea (*Ledum groenlandicum*) and lingonberry (*Vaccinium vitis-idea*). The ground flora is dominated by mosses, lichens and some forbs. Permafrost in the general area is reported to be at 3 - 5 ft. depths in August.

4.5 Wildlife

4.5.1 Introduction

This section outlines the results of a cursory literature review and field investigation of the wildlife and potential areas of concern relating to wildlife in the vicinity of the proposed Cadillac Explorations Limited minesite.

Objectives of this work were as follows:

1. To assess, within the area of development, the abundance and general distribution of the amphibian, reptilian, avian and mammalian wildlife considered to be of significance with respect to sport, commercial, scientific or aethestic value.

2. To identify rare or endangered species which may be affected by the proposed development.

3. To identify areas which may be critical to the life cycle of wildlife species.

4. To collect available information regarding trapping and game harvests in the area.

A field programme was conducted April 15 - 18, 1980, during which time discussions were held with N.W.T. government biologists in Yellowknife and cursory aerial and ground reconnaissance of the study area was carried out. The study area was loosely defined as the minesite, the mining camp and immediately adjacent lands.

Aerial reconnaissance was conducted in a Bell 206 helicopter. Three observers were used - the pilot and two biologists (positioned on opposite sides of the aircraft). All observations of wildlife were plotted on 1:250,000 scale topographical maps and information relevant to each sighting was recorded on cassette tape.

Ground reconnaissance consisted of general habitat evaluation and wildlife observations made in the vicinity of the minesite.

4.5.2 Sources of Information

A general review of the literature relevant to the wildlife of the Nahanni area was given in the companion document to this report - Preliminary Environmental Evaluation - Winter Access Road, May, 1980. It was noted in the above report that published biological information is only regionally applicable to the proposed Cadillac Explorations Limited development and comes primarily from three general sources: a) unquantitative species lists for herptiles (Hodge 1976), birds (Godfrey 1966) and mammals (Banfield 1974, Youngman 1968, 1975); b) published documents regarding Nahanni National Park (Scotter et al. 1971, Addison 1974); and c) reports directed at assessing potential impacts of other nearby northern developments such as the Pointed Mountain Natural Gas Pipeline in the southeast Yukon (Slaney and Company Limited 1971), the Fort Simpson realignment of the Arctic Gas Pipeline route (Wisely and Tull 1977; Wooley 1974; Wooley and Wooley 1976), the Liard Highway (Donaldson and Fleck 1979; Synergy West Ltd. 1975) and the Mackenzie Highway (Special Habitat Evaluation Group 1972; Lombard North Group Limited 1972, 1973, 1974; L.G.L. Limited 1973; Renewable Resources Consulting Services Limited 1973; Slaney and Company Limited 1974).

Although the above investigations do not define the wildlife resource in the specific area of the minesite, they do provide a regional context with which findings made during the present study may be compared.

4.5.3 Wildlife Reported

A list of wildlife documented as utilizing habitat in the vicinity of the minesite is provided in Table 11 and provisional checklists of mammals and birds potentially occurring in the area are given in Tables 12 and 13 respectively.

One hundred and twenty-two avian species, forty-eight mammalian species and two herptiles potentially inhabit the region of the proposed development, although, due to lack of suitable habitat, many of these species would not be expected to be present in the immediate vicinity of the mine.

Birds noted in Table 13 which are considered to be rare, endangered or highly sensitive, include the Bald eagle and Trumpeter swan. Both are known to occur in the Nahanni area. Of the 48 potentially occurring mammals, 22 comprise a group which is exploited either recreationally or commercially (6 ungulates and 16 furbearers). None of these 48 species is considered to be rare or endangered although some forms such as woodland caribou, Dall's sheep and grizzly bear are considered sensitive due to their susceptibility to disturbance.

Only two amphibians are widely distributed in the Northwest Territories - the Wood Frog (Rana nylvatica) and Boreal Chorus Frog (Pseudacris tristeriata maculata) (Hodge, 1976). The former is exceptional for an amphibian, in that its range extends above the arctic circle to 68°N in Alaska and east into Labrador (Martoff and Humphries 1959). Although the precise factors which limit the northern ranges of anurans (frogs and toads) are imprecisely known, one of the major constraints is a low summer temperature, which reduces the growing season, rather than low winter temperatures. In this respect, the Wood Frog is adapted to northern climates, in having a low embryonic temperature tolerance, a high developmental rate and a high developmental Q_{10} at low temperature (Herreid and Kinney 1967).

In the absence of corroborative literature, it is suspected that only the above two herptile species occur in the vicinity of the mine and only in localized populations.

4.5.4 Wildlife Observations

Habitat capability to support wildlife in the immediate vicinity of the minesite appears low. During BEAK field reconnaissance, one Gray Jay, three red squirrels and two arctic ground squirrels were observed in the camp area (Table 11). Discussions with camp personnel suggested that large-mammal usage of the mine area is both limited and irregular. Mr. R. Fast (pers. comm., 1980) noted that during the period 1968 - 1980 he has observed one grizzly bear, three black bears, three wolverine, one wolf and one woodland caribou in the vicinity of the minesite (Table 11).

Of potential concern is the Dall's sheep range on Folded Mountain, 5 miles northwest of the camp. Herds consisting of ewes and up to 8 - 9 lambs have been observed here (R. Fast, pers. comm., 1980), however little is known of the ungulate usage pattern or overall extent of this range. Similarly, precise information is lacking in regard to range utilization by woodland caribou of an area in the southern portion of the Cadillac Explorations Limited property. Mr. Fast (ibid) noted that up to 100 woodland caribou have been previously observed in this region, although aerial reconnaissance of the site by BEAK in April, 1980 revealed no caribou. During the above reconnaissance, two ptarmigan and a small flock of Snow Buntings were observed.

Few other concerns for the mine area can be registered at this time. Given lack of suitable habitat, concerns for waterfowl are minimal. Although Golden Eagles have been documented in the region (BEAK observations) no nests were observed near the mine and no nesting sites have been reported in the area to date (R. Fyfe, pers. comm., 1980).

Aquatic furbearer habitat is poor in the area of the mine and no traplines presently exist within the mining lease. Similarly, it appears there has been no guiding and outfitting activity in the area.

Mr. S. Miller (pers. comm., 1980) has suggested that grizzly bears are considered to be an important species in the N.W.T. and that hunting of these animals may soon be illegal in the Mackenzie Mountains.

4.6 Geology and Soils

4.6.1 Bedrock Geology

The bedrock geology of the area consists of shales, Middle Devonian and older limestones and dolomites. Table 3 lists the geologic formations at the minesite. The Funeral Formation outcrops at the site and consists of thinly bedded dark grey shale and argillaceous limestone. This is underlain by the Arnica Formation of finely crystalline black dolomite. The rocks weather dark and medium-grey in colour, giving a banded appearance. The Lower Devonian Sombre Formation consists of cryptocrystalline to fine-grained grey dolomite which weathers to produce a light and medium grey banded pattern. These rocks are underlain by undifferentiated Ordovician, Silurian and Devonian grey graptolitic shale, thinly bedded limestone and coarse-grained sandstone. The oldest formation identified in the area is the Middle Ordovician Sunblood Formation. This is a thinly bedded cryptocrystalline grey limestone that weathers orange and pink.

Structurally, the Prairie Creek site is part of the Nahanni Plateau. This is a structural terrace that takes the form of a gentle northeast-facing homocline in this area. Notable structural features are Tundra Thrust, a major east-dipping fault, on the east, and the Gate Fault, on the west. Folding is common.

Mineralization, in the form of silver-lead-zinc occurrences is present along a lineament striking about N 10° E at the site. Minerals present are quartz, calcite, galena, sphalerite, freibergite and minor pyrite and chalcopyrite.

4.6.2 Surficial Geology

The Prairie Creek site lies in an area that shows no evidence of regional or large valley glaciers. Ford (1976) describes this unglaciated zone in South Nahanni Park and states that a few palaeocirques are present in sheltered localities but the valleys are narrower than those in glaciated areas to the west. The valley bottom was covered by a glacial lake during the retreat of the glaciers to the west and east in the Pleistocene Epoch.

The surficial deposits can be divided into two groups: those on the valley floor and those on the valley walls. Alluvial deposits blanket the valley floor. These are sand and gravel deposited by the creeks. Camp personnel report about 6 ft. of gravel overlying 50 ft. of clay overlying more gravels at a well-site. Minor areas or organic deposits may also be present. The valley walls are composed of bedrock outcrops and coarse-grained colluvium.

This portion of the Northwest Territories is in the Zone of Discontinuous Permafrost (Brown 1978) where the permafrost is widespread. The coarse-grained nature of most of the surficial deposits in the area results in good drainage which suggests that for the most part the permafrost will have a low ice content

4.6.3 Soils

The soils of the Mackenzie Mountains have not yet been mapped and the following description is taken from Soils of Canada (Clayton et al. 1977).

The soils are dominantly Brunisolic ones developed on steeply sloping terrain. The dominant soil subgroup (found in more than 40 per cent of the area) is the Orthic Eutric Brunisol while Cumulic Regosols and Rockland are both subdominant (covering more than 20 per cent of the area). In the minesite area, the Brunisols will be present on the gentler slopes and the inactive floodplain while Regosols can be found on the steeper slopes and the active floodplain. Both stony and rocky phases* of these soils will be present.

The soil climate temperature class is Subarctic very cold (mean annual temperature -7 to less than 2°C; mean summer soil temperature 5 to less than 8°C; growing season (greater than or equal to 5°C) less than 120 days). The soil moisture regime is humid (soil not dry in any part for as long as 90 consecutive days in most years).

The soil climate and topography of the area results in a low potential productivity and renders the soils unsuitable for agriculture.

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* Stony and rocky phases are applicable in assessing the suitability of the terrain for agriculture. They are defined as follows:

Stony Phase: excessively stony, being too stony to permit cultivation (boulder and stone pavement).

Rocky Phase: extremely rocky, having sufficient rock outcrop or insufficient depth of soil over rock to make all use of machinery impracticable. The land may have some value for poor pasture or for forestry. Rock outcrops are 10 ft. (3 m) apart or less and cover more than 50% of the area.

4.6.4 Relative Stability of the Deposits

Although field sampling and laboratory analysis of the surficial deposits have yet to be carried out, Monroe (1973) has discussed the relative stability of similar deposits and landforms in the Sibbeston Lake map area, to the east of the Prairie Creek site.

In areas of coarse-grained alluvium, minor slumping may be expected on lake margins and river channels in areas with a veneer of silt; undercutting and bank collapse may occur along channels at high water times; flooding may occur during break-up and summer storms and channel shifting may occur. The coarse-grained nature of the material greatly decreases the chance of ice-rich permafrost being present and results in an overall stable landform.

Mountainous and rocky areas offer the potential for the numerous types of mass wasting common to mountain environments. Steep slopes are prone to rockfalls, slides and active creep, while gullying is common in soft materials. Steep gullies may be the site of mudflows and flash floods. Areas of shale are inherently unstable and subject to mass wasting. In areas where the organic cover is removed or altered, detachment slides and rotational slumping may occur. However, if flat-lying bedrock areas are present away from active slopes, they offer good sites for development.

Eroded and/or eroding river banks and valley walls, whether in bedrock or unconsolidated materials, are subject to mass wasting, if on slopes, and are, for the most part, unstable.

4.7 Community Environment

From north to south, the four major communities in the study area are Wrigley and Fort Simpson (on the Mackenzie River) and Nahanni Butte and Fort Liard (on the Liard River). The small settlement of Jean Marie River is southeast of Fort Simpson, on the Mackenzie River. The settlements of the region generally have a history rooted in the early fur trade, with the Liard River providing the major link between northern British Columbia and the Territories.

Fort Simpson is located on the Mackenzie Highway which provides a road link with Yellowknife, Hay River and Fort Smith to the east. Fort Simpson will soon be connected to Fort Liard and eventually to Fort Nelson by way of the Liard Highway. Scheduled air services connect Fort Simpson with Yellowknife and with Fort Nelson, B. C. The Fort Nelson route also serves Nahanni Butte and Fort Liard. Air charter services are available in the region.

Only Fort Simpson and, to a lesser extent, Fort Liard, are developed communities, with townsite and municipal structures, and there is only a limited functional interdependency present between the communities. Fort Simpson is the major community, with approximately 60% of the region's population. It is also the major transportation node in the region. The region's population is predominantly Indian. In Fort Simpson (1978) the non-Indian population amounts to slightly over 55% of the total but in the region, Indians make up over 70% of the population (Tables 14 and 15).

The population of the area has increased over the past decade by about 260, representing a growth of some 18% between 1971 and 1979. The growth rate of slightly over 2% per annum is somewhat higher than that projected by N.W.T. government planners for the post 1978 period, and possibly will decrease slightly over the coming decade.

There are about 580 people between the ages of 19 - 45 in Fort Simpson and Fort Liard. Age data is not available for the smaller communities, but if the same 40 - 45% proportion holds, it can be assumed that the three smaller communities contain in the order of 130 people in this age group. On this estimation, the total region has slightly over 700 persons, male and female, within the prime working group age (it should be noted that the conventional definition of working age includes those between 15 and 64 years of age).

Projections by the N.W.T. government suggest that the working age group proportion within the population as a whole will slightly increase over the next decade (Populations Projections, Community Tabulations N.W.T. 1978 - 1988, table 6).

Most of the population engages in natural resource based activity, e.g. hunting, trapping and guiding. Employment in the commercial - industrial sector is limited, although in recent years considerable employment has been obtained through highway construction activity, particularly out of Fort Liard. There is also some native handicraft employment, with Jean Marie River particularly well known for this activity.

Indian employment in the wage economy has been increasing in recent years. Much of this increase in the region can be attributed to the active entrepreneurship of the Fort Liard band, supplemented by the activities of the N.W.T. government HIRE NORTH programme, which operates several training camps in the region. Both of these activities have been mainly dependent on highway construction activity, but other sources of contracts, such as airstrip construction, have played a role.

Mr. Deneron, Chief of the Fort Liard Band, has expressed support for the Prairie Creek Mine project during discussions with Cadillac personnel.

5. POTENTIAL ENVIRONMENTAL IMPACTS & MITIGATIONS

The Cadillac Mine is located in a sensitive northern environment, upstream from a National Park. It is recognized that both construction and operation of the mine and related facilities must be carried out with care in order to avoid environmental disturbance. However, several factors combine to limit the potential impact of the mine; these factors include the absence of acid-generating capability of the tailings and waste rock, the use of pond reclaim with the possibility of zero discharge, the proposed treatment of tailings effluent for removal of toxicity, the availability of clays for construction of impermeable dams, combined with the feasibility of constructing permanent, stable impoundments.

Specific potential environmental impacts are discussed below, along with recommendations for mitigations by the Consultants on the project.

5.1 Aquatics

5.1.1 Introduction

Alterations to aquatic ecosystems could potentially affect both spring and fall spawning fish species. These fish will be most sensitive to disturbance during the interval between the beginning of adult spawning migrations and the time when the fry have developed to a relatively resistant stage. Overwintering areas may be highly susceptible to habitat alteration. In north temperate climates the fish fauna of smaller watercourses congregate in the larger water-bodies resulting in regional aggregations of fish populations within localized areas. Therefore adverse impacts on such areas may be of regional significance. Fish populations tend to congregate in deep pools to overwinter and, as flow rates decrease, movement between such pools may be precluded. Potentially high mortality rates may then result from the inability of fish to avoid temporary adverse conditions.

Sensitive time periods in the life histories of the prominent fish species reported from the study region are presented in Table 17.

5.1.2 Debris - Impact

Restrictions of water flow may result from deposition of slash and spoil in aquatic systems during construction clearing operations. Fish movement could be disrupted or important spawning, nursery and rearing areas covered. During winter, ice-covered streams incur an oxygen deficit which may be aggravated by construction activities. The introduction of organics is likely to increase biochemical oxygen demand through bacterial and fungal activity, thus reducing available oxygen levels. A reduction of dissolved oxygen below critical levels may result in mortality of fish or invertebrate fauna.

Debris - Mitigations

Slash or spoil should not be intentionally introduced into water bodies. All materials which enter streams or rivers should be removed with consideration being given to aquatic fauna. This may necessitate removal by hand.

5.1.3 Siltation - Impact

Suspended solids in mine effluent is the most common problem associated with pollution from metals mines in Canada (Clark, 1974). As a result of increased silt loads critical habitats may be rendered unsuitable for use by clear-water organisms until the silt is dispersed by natural scour (likely at the time of the next freshet). Depending on the particle size of sediment and discharge rate of the system, the fine materials that do not settle out immediately will be deposited at varying distances downstream of the area of disturbance. These fines will generally settle along shorelines or in backwater areas.

Silt may enter watercourses during the construction and operating phases as a result of:

1) clearing and site preparation operations,
2) construction of dams or dykes within watercourses,
3) unstabilized earth structures and diversion ditches,
4) inadequately collected or treated runoff from disturbed areas,
5) inadequate retention time of effluent from the tailings pond.

Many of the invertebrates upon which fish feed are sensitive to siltation and may drift away from the area of disturbance or die if loads are too high (Rosenberg and Snow 1975). Although all life history stages of fish species inhabiting a waterbody may be affected by siltation, the early life history stages of fish are particularly sensitive to sedimentation. In severe cases, eggs may be covered, fry incapable of avoiding heavy concentrations of silt will die and many fry will die due to a reduction of in-stream cover. Fish populations tend to congregate in deep pools to overwinter and, as flow rates decrease, movement between such pools may be precluded. During the winter, high silt loads could cause increased mortality rates due to the inability of fish to avoid temporary adverse conditions. Fish migrations may also be blocked or delayed as some fish species avoid entering turbid waters.

Siltation - Mitigations

Material removed during construction of tailings ponds and not used in dam or dyke construction should be stored away from watercourses and stabilized to reduce erosion.

During construction of dams or dykes within watercourses, in-stream activity by construction machinery should be kept to a minimum. Activity should cease for a period each day to allow the system to flush.

Dam and dyke material should be sloped and stabilized to reduce erosion.

Precautions must be taken in the design of the dams and dykes to ensure against their failure during and after operation of the mine. The mill effluent should be retained within the tailings pond for a period long enough to ensure satisfactory settling of sediment.

5.1.4 Toxic Substances - Impact

Watercourses which are subject to the release of pollutants may be adversely affected through mortality of aquatic organisms and the deterioration of habitats. The severity of the impact would depend on the volume, toxicity and timing of the release and the chemical characteristics of the stream. Substances with potential to cause adverse effects include fuels, domestic wastes and mill reagents. Treated mill tailings are not expected to be toxic or reactive, but they might be capable of smothering if a large quantity was released. Mine water quality should be good, based on a current analysis (Table 1) and the alkalinity of water in contact with the carbonate host rock.

Heavy metals are capable of killing fish directly, or creating stress from sub-lethal metal pollution (Stein and Miller 1972). Toxic substances may have a delayed effect on the aquatic system as it is concentrated through the food chain. The severity of an increase of heavy metals above ambient levels in aquatic systems is dependent upon water quality, sediment loads, aquatic vegetation, native benthic organisms and fish fauna. Mine effluents (depending on their quality) have been reported to alter production and densities of phytoplankton and zooplankton as well as alter 'quantity and composition of benthic communities,' (Clarke, 1974).

Toxic Substances - Mitigations

In order to avoid accidental spills, all potentially toxic materials should be stored well away from any waterbody, and/or enclosed by impermeable dykes. Machinery maintenance, refueling or washing should not take place in or near streams, rivers or lakes. Contingency plans should be formulated in case of an accidental spill.

Sewage waste from the camp should receive a high degree of treatment. Tailings effluent should be treated, prior to release to the tailings pond, for the removal of toxic substances such as cyanides and heavy metals used as mill reagents. Adequate retention time should be provided in the tailings pond for further polishing of mill effluent. Monitoring should be carried out routinely to detect any deleterious conditions.

5.1.5 Explosives - Impact

The use of explosives creating shockwaves near a stream could result in the mortality of all life history stages of fish species inhabiting the watercourse. Adverse effects will depend on the force of the charge, the proximity of the watercourse and the physical properties of the materials being blasted.

Explosives - Mitigations

Blasting should be conducted with consideration for fish populations and should be avoided where it would affect important aquatic habitat.

5.1.6 Drainage Alterations - Impact

The alteration of surface and subsurface drainages may disrupt or modify existing drainage patterns. This could result in the reduction of available water in important aquatic habitats. Drainages in muskeg, peatland and wetlands are likely to be most susceptible to alteration or disruption. The use of water for mining and processing ore could also reduce available water in important aquatic habitats if water was extracted from systems having limited flow.

Up and downstream fish movement may be disrupted or blocked by poorly designed stream diversions. Interruption of fish migrations for longer than three days could result in deleterious effects to the local fish populations (Dryden and Stein, 1975). Dams constructed across watercourses may affect migration routes, spawning areas or natural habitat.

Drainage Alterations - Mitigations

Efforts should be made to retain natural drainage patterns. Recycle of tailings pond water should be carried out to the maximum degree possible in order to reduce the need for water from aquatic systems.

Stream diversions should be constructed to simulate the natural morphology of the stream to facilitate fish movements; these factors would include substrate, width, slope and cross-sectional area. Dams, diversions or other structures should not be placed in critical aquatic habitats where possible.

5.1.7 Fishing - Impact

An increase in fishing pressure by construction crews and operating personnel may occur.

Fishing - Mitigations

As the work schedule at the mine will not provide a great deal of recreational time for personnel, substantial fishing pressure is not expected. However, it is anticipated that regulatory agencies would impose restrictions as necessary. The mine management should insist on adherence to fishing regulations.

5.2 Vegetation - Impact

The removal of vegetational cover may have implications to the distribution of permafrost in the area. The removal of the protective vegetational layer may reduce the albedo of the surface and result in thawing of the permafrost.

Vegetation - Mitigations

The mitigation measures which should be considered (where feasible) for permafrost disturbance are:

1. the preparation of a site by the dumping of fill on an undisturbed surface;

2. the establishment of an artificial or natural insulating cover for disturbed surfaces; and

3. the maintenance of natural drainage patterns to avoid ponding.

Reclamation of disturbed areas during operation and upon abandonment should be planned to speed up the process of revegetation and to minimize residual impacts of the development. Detailed studies would be required to identify reclamation vegetation species suitable for use at the mine site.

5.3 Wildlife

5.3.1 Introduction

Concern for potential impacts of a mine on wildlife populations is considerably less than that registered for linear facilities.

Impacts resulting directly from mine activities are anticipated to be site specific. Mine development in itself does not provide public access into previously inaccessible areas and for this reason residual impacts are minimal. Potential effects of mine development on wildlife relate primarily to the following:

1. direct disturbance to wildlife
2. habitat alteration
3. attraction of wildlife

General concerns for wildlife were noted in the report, Preliminary Environmental Evaluation - Winter Access Road, May, 1980. Applicable excerpts from these general concerns are given below.

5.3.2 Disturbance - Impact

Disturbance to wildlife during construction or operation of the mine could include noise, harassment or destruction of nesting, wintering or calving (or lambing) areas.

Disturbance - Mitigations

No such critical nesting, wintering or calving areas have been identified within the development zone around the mine, therefore, concern for direct disturbance should be minimal.

However, disturbance of wildlife due to unnecessary low-level aircraft flights should be avoided. The possession of firearms by camp personnel should be strictly controlled and staff should be prohibited from harassing wildlife.

5.3.3 Habitat Alteration - Impact

Concern for terrestrial habitat centres on three major issues: fire control, protection of raptor nests (tree or cliff) and protection of ungulate winter range and calving/ lambing areas.

Any habitat loss due to fire is considered important. Breeding areas of those birds (primarily raptors) which habitually return to the same nest or area can be damaged, forcing the birds to relocate. However, it is the probability of fire damage to critical wintering habitat for ungulates which is viewed as most serious. Fire damage to summer range may locally displace animals, however, unless the burn is extensive, they are usually capable of finding replacement range during this season, and survival is not jeopardized. However, if winter range is destroyed local populations may be seriously threatened, due to the difficulty of finding replacement range.

Severe cold, combined with restricted mobility due to snow accumulation, results in particularly stressful conditions for ungulates during winter months. At this time many ungulate populations migrate to winter ranges (usually valley bottoms, or south-facing, wind-cleared slopes) where forage is relatively abundant and easily procured. Accumulating snow is usually the most influential factor in dictating the pattern of movement to winter range, and, as the snow-pack develops, animals are forced onto increasingly restricted portions of their range. These restricted, high-quality forage areas are termed 'critical winter ranges' and it is on these that ungulates may concentrate or 'yard' during mid to late winter, and which are generally important to local populations. In years of low snowfall or generally mild winter conditions, these islands of critical habitat may not be heavily utilized; however, in the long term they provide an essential ecological requirement for survival.

Habitat Alteration - Mitigations

Habitat alterations (although not considered critical in the development area) may be minimized by restricting the zone of development to the minimum necessary, and by operating a fire-protection programme which would encompass: a) prevention, b) surveillance and c) control.

5.3.4 Wildlife Attraction - Impacts

Of prime concern is that bears and other opportunistic carnivores should not be attracted by garbage to development activities.

Wildlife Attraction - Mitigations

Measures such as incineration or collection and disposal of all garbage at approved sites should be adopted in order to minimize this concern. Also, personnel should not be permitted to attract, feed, pursue or otherwise disturb any animal.

5.3.5 General

As a general recommendation for the protection of wildlife, an educational programme should be set up in order to foster awareness by construction personnel of environmental sensitivities. Government agencies should be encouraged to participate in this programme.

5.4 Geology and Soils

5.4.1 Impact

The development of the mine and mill at the Prairie Creek site has the potential to adversely affect the geology and soils (hereinafter called the terrain) of the area developed through disturbance of the thermal regime of the permafrost, exposure of the surficial materials to erosion, disturbance to unstable slopes and soil pollution.

Much of the Prairie Creek site is underlain by permafrost. Terrain of this type is very sensitive to changes in its thermal regime and may respond to such changes through subsidence and slope failure. Problems in permafrost terrain are associated with the ice content of the permafrost. Thus, fine-grained materials are potentially a greater problem than coarse-grained ones because of the former's greater water holding capacity and, therefore, greater potential ice content. The coarse-grained nature of most of the surficial deposits in the study area suggests that the ice content of the permafrost may be low. The thermal regime of the permafrost may be disturbed through the direct application of heat to the surface, the removal of the surface vegetation, which acts as an insulator and through the impoundment of water, which has a warming effect on the surface. Heat can be directly applied to the surface from any camp facility or piece of machinery. Site clearing will involve the removal of vegetation, exposing areas of permafrost to melting while the water in the tailings pond will melt any underlying permafrost.

The removal of vegetation during facility layout will also expose the surface to water and wind erosion. This can result in the formation of rilled slopes and increased sediment loads in streams.

Facility development on, or at the foot of, unstable slopes can initiate mass movements. Shale layers within the bedrock formations may be especially sensitive in this regard.

The danger of soil pollution, through spillages of chemicals used for ore processing or through fuel spillages, does exist although the consequences of such pollution are not as great at the Prairie creek site as in areas with agricultural capability.

5.4.2 Mitigations

In order to mitigate any adverse impacts to the terrain, standard construction and operation practices for mountainous and permafrost terrain should be followed. Specific practices will depend on site-specific information, yet to be gathered, but will include the general guidelines listed below:

1. Where possible, avoid disturbing areas of permafrost. If activities on permafrost terrain are necessary, restrict them to as small an area as possible and minimize disturbance to the vegetation.

2. Revegetate cleared areas as soon as possible in order to prevent erosion on exposed slopes. Vegetate the berms around the tailings areas.

3. Monitor slope behaviour at the site.

4. Provide protective berms around fuel storage sites and cover all chemicals.

5.5 Socio-Economics

5.5.1 Study Methods

The socio-economic study was carried out as a field exercise, supported by a review of documents and publications which offered information on government requirements and descriptions of the study area. The field study programme involved two visits to Yellowknife, where discussions were held with various officials of the N.W.T. Government and Federal Agencies, and a more limited visit to the Study Area itself, where discussions were held with locally based government officials and various residents. Contacts were made in Fort Simpson and Fort Liard and the interests of the smaller communities in the study area were assumed to be represented by the contacts made in the two largest communities.

It was not possible to obtain interviews with representatives of the Dene Nation in Fort Simpson, however, direct contact has been made previously by Cadillac Explorations Limited.

The following subsections review the potential socio-economic impacts of the project, along with the mitigation measures proposed.

5.5.2 Government and Local Concerns

The pertinent social and economic policy of the N.W.T. Government is outlined in Policy On Single Resource Communities, (Government of the N.W.T., January 1979) and focuses on several broad concerns. The Policy notes that the government of the N.W.T. supports the orderly exploration and development of resources but expects that such activity will take place under the following constraints:

- The Policy will be effective in cases where new communities are contemplated as part of proposed development, but will also govern cases where existing communities are brought into the development matrix.

- The overall emphasis of the Policy is concern for "...improvement of the general welfare of northern people".

- This concern of the Policy will be best met by "...providing long term employment for northern residents."

- In accordance with that concern, would-be developers are expected to utilize "...the resources and business facilities of existing communities in the proximity of the development", and to maximize local employment by providing training programmes and by introducing "...job rotation schemes to facilitate employment of northern residents".

Where proposed developments comply with these terms, the government may negotiate with the developer a Special Services Agreement, through which the government may contribute to the provision of various municipal, educational, medical and social services and other facilities, in support of the development.

The study programme was designed to elicit government and other concerns regarding the proposed mine's impacts on the region and the N.W.T. generally. An earlier study was prepared dealing with the winter road and possible airstrip on the Liard River. This report identified, evaluated and made recommendations on several areas of government and local concern.

In the case of the mine itself, however, few concerns were expressed by respondents. The major points of issue dealt with the ways and means of maximizing the benefits of the project, and no negative viewpoints were met with in the course of the study.

The local region concern was to have benefits appear at the local level in the form of some employment, significant business opportunities, and general increases in business activity throughout the local economy.

The local views, as identified in the study, emphasize the business-contract opportunities expected from the project. While some direct local employment of labour is looked for, most respondents were of the opinion that there would not be a large number of local residents interested in wage employment at an underground mine.

There were no local reservations expressed regarding the presence of the mine, so far as possible impacts on the environment were concerned. There were some issues raised regarding the winter road, which have been addressed in an earlier report.

The local regional view was that business opportunities should be offered to local interests, and employment should be offered to qualified locals who might wish to take up mine work; on this basis, no apprehensions were expressed regarding the mine.

The government respondents generally agreed with this attitude. However, government concerns go beyond the local region, and government personnel raised matters which departed from the purely local view. In particular, while agreeing that residents of the region might not display a strong interest in wage employment at the mine, government respondents did not accept that this situation in any sense reduced the government's interest in having employment offered to native northerners from other regions of the N.W.T.

In a similar vein, government respondents expressed an interest in opportunities for supply and services from other centres in the N.W.T., and could not agree that, where the local region was not able to support a sufficient level of business to qualify as a supplier to the mine, this released the proponent from local responsibility and allowed him to turn to Fort Nelson as the prime supply base.

5.5.3 Employment

It is estimated that between 210 and 220 employees will be required at the mine. The general categories of employment are shown in Table 16.

The mine will operate under a rotation basis, with the schedule being two weeks in, one week out. There will be a maximum of about 150 workers in camp at any one time, and the camp is designed to that capacity.

The categories of workers required are heavily inclined toward the higher-skilled levels. There will be few jobs of an unskilled nature but a number will involve skills that can be attained through experience on the job.

In addition, there will be lesser-skilled employment opportunities within the contract sectors of work, which will likely include the camp catering and the truck haul system.

The salary and wage levels will necessarily be competitive with other mining operations. Typical professional salaries range from $30,000 a year plus for mining engineers to $50,000 a year for senior management. Other administrative-staff positions will receive salaries in the $25,000 to $40,000 range.

Hourly rates will extend through 13 grades, ranging from a base of $7.15 per hour to $9.44; with shift differentials and a northern allowance, the effective rates will range between $11.88 per hour to $15.13 per hour. An incentive bonus will significantly increase the income received.

In round figures, it is expected that the payroll for the mine, excluding employer contributions to such items as Unemployment Insurance, medical and pension coverage, statutory holidays, etc. will amount to some $6,000,000 per year.

In addition, some salaries and wages will be paid outside of the mine system proper, to various contractors, transportation services and to maintain the logistical system supporting the operation.

5.5.4 Capital and Operating Costs

It is estimated that over $6,500,000 in capital costs will be expended on the site and on other surface facilities. The mine, it is estimated, will absorb over $3,000,000 in capital, while the processing plant will require capital in excess of $11,000,000. In all, the mine will require a capital outlay of close to $40,000,000.

Operating costs are expected to be over $33,000,000 per year, for administration, labour, supplies, contracted services, transportation, etc.

5.5.5 Multiplier Effects

It is not possible to trace the impact of the wage bill or that of the operating expenditures, other than in the most general of terms.

The wage bill will contribute taxes, to an extent determined by such factors as the marital/family status of the employee, the employee's place of residence and the outcome of current tax regulations regarding fringe benefits received by workers.

The multiplier effect of the wage bill (that is, the amount of employment generated by expenditures on goods and services by direct employees) will depend on the domicile of the employees. If the employees are drawn from a wide enough area, the multiplier effect may be relatively small.

The distribution of benefits from the capital and operating expenditures is subject to similar unknowns. The distribution of benefits will depend on the proportion of business that the mine is able to economically direct to N.W.T. suppliers of goods and services, and on the taxation-royalty demands with which the proponent is faced.

5.5.6 Availability of Labour

There is a shortage of skilled labour throughout the mining industry. In particular, tradesmen are in short supply and there is no evidence that the situation will improve in the near future. Labour shortages are especially acute for underground mining operations and a reluctance to accept underground mining as a career is evident among young workers and among those about to enter the labour market. The shortage of journeymen and experienced operators has created a 'seller's market' in the industry, which contributes to the rapid turnover in mine work forces. A recent survey of some selected western mines found an average turnover rate of close to 40% per annum among 28 mines surveyed, and several of the mines had turnover rates in excess of 100% a year (Horsman and Mellor, 1979).

This problem characterizes the entire mining industry but is especially pronounced at northern mines. In competition with more favourably-located operations, northern mines are at a disadvantage in recruiting workers, due to problems of remoteness, relatively harsh climatic conditions and limited opportunities for rest and recreation within reasonably-accessible centres. Moreover, the rationale for community development at remote mine sites is weak, and is discouraged by both worker reluctance to settle in the north and by government opposition to small, single-resource community development. Consequently, most northern mines operate single-men's camps, with only limited provision for family accommodation.

Solutions to the problems of recruitment and retention of experienced, qualified workers have been sought in various ways. The shift rotation system, through which workers can commute from relatively distant points for a period of intensive work, and then returned home for an extended period of rest, has been seen as one possible solution. Shift rotation, provided it is flexible enough, is also seen as being of significance for native northerners, who are thereby given an opportunity for wage employment which also allows them to continue traditional activities during the rest period. A potential problem with shift rotation is that it extends the commuting range to such an extent that it is feasible to by-pass northern communities entirely in the search for labour and to concentrate recruiting efforts in the major centres of the south.

The problem of skill availability has been approached through on-job training programmes and through government-sponsored training schemes. Many such approaches are frustrated by the high turnover rates and, in the case of native northerners, by the period of interim adjustment which is necessary for workers entering novel and unfamiliar employment.

The Cadillac proposal faces these complex problems and the plan is to institute a rotation system which would facilitate local employment and also allow for recruitment in more distant locations; and to provide on-the-job training and advancement of workers who display the interest and capability necessary to benefit from such programmes.

It is recongized by the proponent, and by the respondents interviewed during the study, that the special skills required in underground mining, and the large component of highly skilled-experienced workers in the required work force, will limit the potential for local hiring, particularly during the start-up phase.

However, the proponent does intend to make offers of employment within the local region and it is expected that, over time, the proportion of locals employed might well increase as the combined filtering effects of turnover and local acquisition of skill and experience together act to raise the share of employment going to native northerners.

In addition, the proponent intends to encourage local suppliers of goods and services, including industrial-type services, to bid on the various contracts to be let.

5.5.7 Summary of Socio-Economic Impacts

The proposed mine will be a source of employment opportunity and will contribute substantial economic benefits to the economy at large. The size and distribution of the opportunities and benefits will be functions of the capability and interest of northern residents and businesses in responding to the opportunities offered.

The proposed mine will not impinge on existing communities, nor bring about any sudden, severe pressures on the local, regional or territorial infrastructures. Over time, through on-going co-operation with government, the proportion of benefits directed into the local economy, and elsewhere in the N.W.T., may be expected to increase.

5.5.8 Socio-Economics - Mitigations

In the mattering of hiring, it is recommended that the proponent:

- as early as feasible, contact N.W.T. government and local interests with information on the manning schedule, and name a personnel officer with whom they should maintain contact,

- provide the personnel officer with an aide familiar with the problems of native northerners entering wage employment,
- make an offer of employment in specified categories (10-15% of the required work force might be a reasonable starting point), which will enable government agencies to direct their efforts toward these specific opportunities, and
- ensure that supervisory staff are briefed on the need to take into account cultural attitudes and expectations among native northerners, in order to develop good working relationships on the job.

In the matter of training and advancement on the job, it is recommended that the proponent:

- maintain an open policy toward access to training opportunities, and promote/advance qualified workers in a consistent and non-arbitrary manner, and
- contribute to government programmes, such as HIRE NORTH, by participating in locally based pre-employment training, and by indicating to promising trainees that they will receive preferential attention after completion of their training, and as the openings occur at the mine.

In the matter of shift rotation, it is recommended that the proponent:

- entertain, within the limits of the efficiency of the mine operation, proposals to modify or adjust the in/out periods to accommodate any interests native northerners may have, as related to seasonal activities they traditionally perform.

In the matter of the commuting system, it is recommended that the proponent:

- investigate the feasibility of having pick-up terminals in the N.W.T., as well as in Fort Nelson, to facilitate the employment of qualified native northerns living outside of the southwest region.

In the matter of the purchasing of goods and services, it is recommended that the proponent:

- adapt a preferential policy toward N.W.T. suppliers, where suppliers are able to provide the goods and services on a secure and competitive basis,

- as an on-going policy, make known to potential suppliers the needs of the mine operation and explore the possibility of contributing some management advice to local businesses, and

- where it is economically, administratively, and operationally feasible, organize appropriate units of the operation to facilitate contract and sub-contract involvement on the part of the local and N.W.T. businesses.

6. FUTURE WORK

This report provides a preliminary description of the project proposal and the environmental conditions relative to the Prairie Creek Mine. A considerable amount of additional work is necessary. It is expected that review of this preliminary report by the government, the Proponent, and the Consultants on the project will enable a selection to be made of the locations of the mill and tailings pond.

The following is a general summary of the work proposed to be carried out before submission of a complete Initial Environmental Assessment:

(1) Aquatics

The aquatic assessment to date has consisted of a literature survey and a brief field trip during April 1980 when many of the streams were still frozen. A complete assessment of the biological characteristics of the waters could include plankton, macrophytes, invertebrates, and fish in Prairie Creek, Harrison Creek, and other local streams. Heavy metal levels in sediments and fish tissue should be included.

(2) Vegetation

A field investigation around the minesite should be carried out to permit a complete evaluation to be made of existing vegetation species and to define soil conditions. This assessment would aid in the development of a land reclamation program.

(3) Wildlife

Additional studies at or near the minesite should include a survey of raptor nests and surveillance of areas suspected of containing ungulate populations (Figure 2a inset).

(4) Geology and Soils

As part of the geotechnical evaluation, an investigation of permafrost conditions and physical properties of surface and sub-surface soils will be required.

(5) Hydrology/Climate

Hydrological and climate data are needed, not only for the purpose of environmental assessment, but also for design purposes. Additional work would include:

- installation of a weather station on-site
- placement of flow gauges on Harrison Creek and other streams potentially affected by the operation
- floodplain mapping of Prairie Creek for the determination of backwater curves
- stream sediment analysis (as noted under "Aquatics")
- continued sampling and analysis of streams and mine water
- a more complete assessment of existing climate and hydrological data

(6) Geotechnical

A detailed site inspection of the selected sites for plant and tailings pond construction will be required. The program would include drilling and laboratory investigations to permit an evaluation to be made of permafrost, groundwater, foundation conditions and the availability and engineering properties of borrow materials prior to final design.

(7) Process

Evaluation of alternate processes for the recovery of metal concentrates is currently underway. Following a decision on the mill flowsheet, pilot plant simulation of the process will be carried out in order to determine the effluent quality and any treatment methods required to meet discharge regulations. Specific chemical analyses of tailings would also be included so that any contaminants of particular concern could be identified.

A program for control of hazardous materials and handling of spills will be developed.

(8) Mapping

A field survey will be carried out for the purpose of providing current and accurate topographic mapping of the development site.

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Beak Consultants Limited

Laboratory/3851 Shell Road
Richmond/British Columbia
Canada/V6X 2W2
Telephone (604) 273-1601
Telex 04-508736

TABLE 1

REPORT OF ANALYSIS

Client Ker Priestman & Associates
300 - 2659 Douglas Street
Victoria, B.C.
V8T 4M3

Project: K4404/50

Date received: 25 April 1980

Sample reference	Harrison Creek near mouth	Prairie Ck below Harrison Ck	Prairie Ck near Airstrip	Mine Water - 3050' Level
Total Alkalinity	133	199	199	262
Conductivity	405	487	476	752
pH	7.9	8.1	8.1	8.3
Filtrable Residue	267	320	301	540
Nonfiltrable Residue	13	2	4	4
Sulfate	75	68	60	180
Total Arsenic	<0.005	<0.005	<0.005	0.024
Total Cadmium	<0.005	<0.005	<0.005	<0.005
Total Calcium	32	39	36	65
Total Chromium	<0.01	<0.01	<0.01	<0.01
Total Copper	<0.005	<0.005	0.005	0.005
Total Iron	0.42	0.055	0.065	<0.01
Total Lead	0.011	<0.01	<0.01	<0.01
Total Magnesium	21	25	26	43
Total Nickel	0.015	0.015	0.015	0.007
Total Potassium	0.91	0.50	0.71	1.2
Total Sodium	0.78	1.6	1.7	0.38
Total Zinc	0.14	0.031	<0.005	0.15
Total Molybdenum	<0.05	<0.05	<0.05	<0.05

All results expressed as mg/l except
pH (units), coliform (organisms/100 ml), color (units)
conductivity (umhos/cm), salinity (°/₀₀), turbidity (NTU)

TABLE 2

can test ltd.

1650 PANDORA STREET, VANCOUVER, B.C. V5L 1L6 • TELEPHONE 254-7278

Telex 04-54210

To:

B. C. Research,

3650 Wesbrook Mall,

Vancouver, B. C.

Attention: Mr. Stu Ballentyne.

SEMI QUANTITATIVE SPECTROGRAPHIC ANALYSIS CERTIFICATE

File No 5789 D-2

P.O. 4261

CC: Ker Priestman

Date June 2,1980

We hereby Certify that the following are the results of semi quantitative spectrographic analysis made on tailings samples submitted.

		1	2			1	2
Aluminum	Al	2.		Cerium	Ce	ND	
Antimony	Sb	ND		Cesium	Cs	ND	
Arsenic	As	ND		Dysprosium	Dy	ND	
Barium	Ba	TRACE		Erbium	Er	ND	
Beryllium	Be	ND		Europium	Eu	ND	
Bismuth	Bi	ND		Gadolinium	Gd	ND	
Boron	B	ND		Hafnium	Hf	ND	
Cadmium	Cd	ND		Holmium	Ho	ND	
Calcium	Ca	2.+		Indium	In	ND	
Chromium	Cr	ND		Lanthanum	La	ND	
Cobalt	Co	ND		Lithium	Li	ND	
Copper	Cu	0.1		Lutetium	Lu	ND	
Gallium	Ga	ND		Neodymium	Nd	ND	
Gold	Au	TRACE		Praseodymium	Pr	ND	
Iron	Fe	1.		Rubidium	Rb	ND	
Lead	Pb	*		Samarium	Sm	ND	
Magnesium	Mg	2.+		Scandium	Sc	ND	
Manganese	Mn	0.07		Selenium	Se	ND	
Molybdenum	Mo	ND		Tellurium	Te	ND	
Niobium	Nb	ND		Terbium	Tb	ND	
Nickel	Ni	ND		Thallium	Tl	ND	
Potassium	K	ND		Thullium	Tm	ND	
Silicon	Si	MATRIX		Ytterbium	Yb	ND	
Silver	Ag	0.001		Yttrium	Y	ND	
Sodium	Na	ND		Zirconium	Zr	ND	
Strontium	Sr	0.01		Iridium	Ir	ND	
Tantalum	Ta	ND		Osmium	Os	ND	
Thorium	Th	ND		Palladium	Pd	ND	
Tin	Sn	ND		Platinum	Pt	ND	
Titanium	Ti	0.07		Rhenium	Re	ND	
Tungsten	W	ND		Rhodium	Rh	ND	
Uranium	U	ND		Ruthenium	Ru	ND	
Vanadium	V	0.005					
Zinc	Zn	*					

Sample Identification

Sample 1: K.P. Cadillac # 2

Sample 2:

Percentages of the various elements expressed in these analysis may be considered accurate to within plus or minus 35 to 50% of the amount present

Semi-quantitative spectrographic analytical results for gold and silver are normally not of sufficient degree of precision to enable calculation of the true value of ores. Therefore, should exact values be required, it is recommended that these elements be assayed by the conventional Fire Assay Method. Quantitative and Fire Assays may be carried out on the retained pulp samples

Silicon, aluminum, magnesium, calcium and iron are normal components of complex silicates

MATRIX — Major constituent
MAJOR — Above normal spectrographic range
TRACE — Detected but minor amounts
N D — Not detected
* — Suggest assay (above 0.3%)

All results expressed as Percent

Note: Pulps retained one week

CAN TEST LTD.

F. C. Burgess

TABLE 3

GEOLOGIC FORMATIONS AT THE PRAIRIE CREEK PROJECT SITE
(from Douglas and Norris 1974)

AGE	FORMATION	DESCRIPTION
Middle Devonian	Funeral	shale, dark grey; limestone, argillaceous, thinly bedded
	Arnica	dolomite, finely crystalline, black, banded dark and medium-grey weathering
Lower Devonian	Sombre	dolomite, cryptocrystalline to fine-grained; grey, banded light and medium grey weathering
Silurian		shale, grey, graptolitic; thinly bedded limestone; includes basal coarse-grained sandstone
Upper Ordovician		
Middle Ordovician	Sunblood	limestone, cryptocrystalline, grey, thinly bedded, orange and pink weathering

Table 4

CLIMATOLOGICAL STATION DATA CATALOGUE

Station Number	Station Name (+ Indicates part of record under another name.)	Province	Latitude ° '	Longitude ° '	Elevation (feet)	Periods with no change in program, location or name (*indicates summer only) Began year mo.	Ended year mo.	Synoptic Report	Hourly Weather	Temperature	Precipitation	Rate of Rainfall	Wind Mileage	Soil Temperature	Evaporation	Sunshine	Radiation	Ozone	Upper Air	Snow Survey	Tower	Air Quality	1	2	3	4	Region
2100610	FRANCES LAKE	YT	61 17	129 24	2425	1941 10	1947 09	X	P	X	X		B														W
2100610	FRANCES LAKE	YT	61 17	129 24	2425	1947 10	1948 05	X	P	X	X																W
2100610	FRANCES LAKE	YT	61 17	129 24	2425	1948 09	1949 05			X	X																W
2100612	FRANCES RIVER	YT	60 29	129 08	2274	1973 10						S															W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1938 10	1938 10	X	P	X	X																W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1938 11	1942 02	X	P	X	X		B														W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1942 04	1964 11	X	X	X	X		B														W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1964 12	1966 12	X	X	X	X		B							V							W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1967 01	1969 05	X	X	X	X									V							W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1969 06	1969 09	X	X	X	X					S				V							W
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1969 10		X	X	X	X	X		D		S				V							W
2200597	CADILLAC MINE	NWT	61 32	124 45	2850	1970 01	1970 11			X	X																W
2200620	CAN-TUNG	NWT	62 01	128 21	6000	1973 10						S															W
2202098	FORT SIMPSON	NWT	61 52	121 13	572	1943 03	1943 07	X	P	X	X																W
2202098	FORT SIMPSON	NWT	61 52	121 13	572	1944 02	1946 07	X	P	X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1875 05	1875 11			X																	W
2202099	FORT SIMPSON	NWT	61 52	121 35		1876 11	1877 03			X																	W
2202099	FORT SIMPSON	NWT	61 52	121 35		1877 12	1878 03			X																	W
2202099	FORT SIMPSON	NWT	61 52	121 35		1878 10	1879 05			X																	W
2202099	FORT SIMPSON	NWT	61 52	121 35		1895 11	1895 12			X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1897 03	1902 12			X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1903 05	1904 06			X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1905 01	1908 06			X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1908 07	1921 06	X	P	X	X																W
2202099	FORT SIMPSON	NWT	61 52	121 35		1922 08	1927 10	X	P	X	X																W

(Table 4 - cont'd)

CLIMATOLOGICAL STATION DATA CATALOGUE

Station Number	Station Name (+ Indicates part of record under another name.)	Province	Latitude ° '	Longitude ° '	Elevation (feet)	Periods with no change in program, location or name (*indicates summer only) Began year mo.	Ended year mo.	Synoptic Report	Hourly Weather	Temperature	Precipitation	Rate of Rainfall	Wind Mileage	Soil Temperature	Evaporation	Sunshine	Radiation	Ozone	Upper Air	Snow Survey	Tower	Air Quality	1	2	3	4	Region
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1927 06	1952 01	X	B	X	X																W
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1952 02	1952 08	X	B	X	X					S											W
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1952 09	1952 12	X	B	X	X		B			S											W
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1953 01	1954 02	X	B	X	X		B														W
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1954 03	1955 03	X	B	X	X		B				A										W
2202100	FORT SIMPSON	NWT	61 52	121 21	422	1955 04	1963 10	X	X	X	X		B			S	A										W
2202100	FORT SIMPSON	NWT	61 52	121 21	432	1963 11	1964 05									S	A										W
2202100	FORT SIMPSON	NWT	61 52	121 21	432	1964 06										S											W
2202101	FORT SIMPSON A	NWT	61 45	121 14	576	1963 11	1966 10	X	X	X	X		B														W
2202101	FORT SIMPSON A	NWT	61 45	121 14	576	1966 10	1966 12	X	X	X	X		B							V							W
2202101	FORT SIMPSON A	NWT	61 45	121 14	576	1967 01	1969 05	X	X	X	X									V							W
2202101	FORT SIMPSON A	NWT	61 45	121 14	576	1969 05		X	X	X	X	X								V		a					W
2202723	NAHANNI BUTTE	NWT	61 05	123 23	4500	1974 06 *				X	X																W
2202725	NAHANNI HOT SPRINGS	NWT	61 15	124 02	2000	1973 08						S															W
2202727	NAHANNI VALLEY	NWT	61 03	123 22	700	1974 05				X	X																W
2203922	TUNGSTEN	NWT	61 57	128 15	3750	1966 10	1975 06			X	X																W
2203922	TUNGSTEN	NWT	61 57	128 15	3750	1975 06				X	X	X	B														W
2203943	VIRGINIA FALLS	NWT	61 38	125 48	2000	1973 08						S															W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1943 08	1946 09	X	P	X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1946 10	1946 10		P																		W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1947 06	1947 10	X	P	X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1948 07	1950 09	X	P	X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1950 10	1952 10			X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1953 03	1955 09			X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1955 10	1956 12		D	X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1957 01	1957 06		D	X	X		B														W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1957 07	1958 04		D	X	X																W
2204000	WRIGLEY A	NWT	63 12	123 25	511	1958 05			D	X	X		B														W

Table 5

Climate Summary

Station		J	F	M	A	M	J	J	A	S	O	N	D	Year
Cadillac Study Area [1]	T	-15	-9	8	23	43	55	58	54	42	23	1	-10	23
	P	0.9	0.9	0.8	0.7	2.1	2.0	2.2	2.0	1.5	1.0	1.0	1.0	16.1
	E	-	-	-	-	< 1	3	4	3	2	< 1	-	-	13
Watson Lake [2]	T	-14	-1	13	31	45	56	59	55	46	32	8	-9	27
	R	-	-	-	0.1	0.8	1.9	2.1	1.8	1.6	0.6	0.1	-	9
	P	1.4	1.1	0.9	0.7	0.9	1.9	2.1	1.8	1.7	1.4	1.5	1.6	17

Legend

T - mean daily temperature, ^{o}F

R - monthly rainfall, inches

P - monthly precipitation, inches

E - monthly lake evaporation, inches

1 - from Atmospheric Environment Service, Climate Maps (formerly Department of Transport, Meteorological Branch).

2 - from Atmospheric Environment Service, long term abstract listings

Table 6 Surface Water Data - Reference Index

NORTHWEST TERRITORIES

STATION NO.		DRAINAGE AREA (km²)	GAUGE LOCATION	DISCHARGE RECORDS (*-STAGE ONLY #-MISC.MEAS.) TYPE OF GAUGE, OPERATION	REMARK
10FA002	. TROUT RIVER AT FORT SIMPSON HIGHWAY	9 090	61 08 00 119 49 30	69-79 RC	6 NA
10FB005	. JEAN-MARIE RIVER AT FORT SIMPSON HIGHWAY	1 310	61 27 00 121 15 00	72-73 M# 74-79 MC	NA
10ED001	. LIARD RIVER AT FORT LIARD	222 000	60 14 35 123 28 45	42-58*MS 59 MS 60-62 MC 63-64 MS 65 MC 66-79 RC	5 7 NA
10ED002	. LIARD RIVER NEAR THE MOUTH	277 000	61 44 50 121 13 25	72-79 RC	6 NA
10ED004	. . RABBIT CREEK AT FORT LIARD HIGHWAY	120	60 27 45 123 24 15	78-79 RC	NA
10EB001	. . SOUTH NAHANNI RIVER ABOVE VIRGINIA FALLS	14 600	61 38 00 125 48 00	60-63 RS 64-65 RC 66-67 RS 68-79 RC	7 NA
10EC001	. . SOUTH NAHANNI RIVER NEAR HOT SPRINGS	33 400	61 15 10 124 02 10	59-62 RS 63-79 RC	5 NA
10EB002	. . . . MAC CREEK NEAR THE MOUTH	214	62 12 00 128 45 10	78-79 RC	NA
10EA002	. . . FLAT RIVER AT CANTUNG CAMP	152	61 57 40 128 13 00	59 # 60-62 MS 63 # 73-79 RC	5 NA
10EA003	. . . FLAT RIVER NEAR THE MOUTH	8 500	61 32 00 125 24 20	60-65 RC 66-71 RS 72-79 RC	5 NA
10EC002	. . . PRAIRIE CREEK AT CADILLAC MINE	495	61 33 40 124 48 25	74-79 RC	NA
10ED003	. . BIRCH RIVER AT FORT LIARD HIGHWAY	505	61 20 10 122 05 20	74-79 RC	NA
10GC002	. HARRIS RIVER NEAR THE MOUTH	570	61 52 41 121 17 36	72 R# 73-79 RC	6 NA
10GC003	. MARTIN RIVER NEAR THE MOUTH	2 040	61 53 10 121 37 05	72-79 RC	6 NA
10GA001	. ROOT RIVER NEAR THE MOUTH	9 840	62 28 40 123 25 45	74 RS 75-79 RC	7 NA
10HB003	. WRIGLEY RIVER NEAR THE MOUTH	1 260	63 14 15 123 36 20	76-79 RC	NA
10HB001	. REDSTONE RIVER NEAR THE MOUTH	15 400	63 55 37 125 18 07	63-64 RC 65-70 RS 71-79 RC	5 NA
10HA002	. . TSICHU RIVER AT CANOL ROAD	222	63 18 10 129 47 30	75-79 RC	NAT
10AA001	. LIARD RIVER AT UPPER CROSSING	33 400	60 03 00 128 54 00	60-76 MC 77-79 RC	5 NAT
10AB001	. . FRANCES RIVER NEAR WATSON LAKE	12 800	60 28 26 129 07 08	62 M# 63-79 RC	5 NAT
10AD003	. . . KING CREEK AT KILOMETRE 20.9 NAHANNI RANGE ROAD	13.7	60 56 50 128 55 40	75-79 RC	NAT
10AA002	. . TOM CREEK AT KILOMETRE 34.9 ROBERT CAMPBELL HIGHWAY	435	60 17 26 129 01 14	74-79 RC	NAT
10AD002	. . HYLAND RIVER AT KILOMETRE 108.5 NAHANNI RANGE ROAD	2 150	61 29 00 128 14 10	76-79 RC	NAT
10BD001	. . BEAVER RIVER BELOW WHITEFISH RIVER	7 280	60 07 52 124 53 21	77-79 RC	NAT

M - MANUAL GAUGE
R - RECORDING GAUGE

C - CONTINUOUS OPERATION
S - SEASONAL OPERATION

5 - WATER QUALITY DATA AVAILABLE

7 - SATELLITE DATA COLLECTION PLATFORM INSTALLED

NAT - NATURAL FLOW
REG - REGULATED SINCE 19 . (YEAR SHOWN IF KNOWN)

TABLE 7

FISH SPECIES REPORTED FROM THE SOUTH NAHANNI RIVER

Common Name	Scientific Name
Dolly Varden char	*Salvelinus malma*
lake trout	*Salvelinus namaycush*
lake whitefish	*Coregonus clupeaformis*
round whitefish	*Prosopium cylindraceum*
inconnu	*Stenodus leucichthys*
Arctic grayling	*Thymallus arcticus*
northern pike	*Esox lucius*
lake chub	*Couesius plumbeus*
spottail shiner	*Notropis hudsonius*
longnose dace	*Rhinichthys cataractae*
longnose sucker	*Catastomus catastomus*
white sucker	*Catastomus commersoni*
burbot	*Lota lota*
trout-perch	*Percopsis omiscomaycus*
slimy sculpin	*Cottus cognatus*

Source: Scotter *et al*. 1971

TABLE 8

INVERTEBRATE ORDERS AND FAMILIES FOUND TO BE IMPORTANT FOOD ITEMS (TEN PERCENT OR MORE BY PERCENT OCCURRENCE) IN THE MACKENZIE VALLEY FOR PROMINENT FISH SPECIES

ARCTIC GRAYLING	LAKE WHITEFISH	NORTHERN PIKE
Hymenoptera	Diptera	Ephemeroptera
Ephemeroptera	Chironomidae	
Trichoptera	Hemiptera	
Copepoda	Corixidae	
Collembola		
Diptera		
Chironomidae		
Coleoptera		
Staphylinidae		
Hemiptera		
Corixidae		
Arachnidae		

WHITE SUCKER	YELLOW WALLEYE	BURBOT
Diptera	Trichoptera	Plecoptera
Chironomidae	(less than 10 percent)	Nemouridae
(less than 10 percent)		Diptera
		Chironomidae

TABLE 9

MEAN CONCENTRATION (ppm) OF LEAD, ZINC, COPPER AND CADMIUM IN THE MUSCLE TISSUE OF FISH FROM THREE MACKENZIE RIVER STUDY AREAS, MACKENZIE RIVER, 1971

SPECIES	BASE	N	WT. RANGE (gm)	Pb	Zn	Cu	Cd
Lake whitefish	FS[1]	4	656-2056	0.05	4.70	0.24	0.09
	AR	3	653-2270	0.13	6.99	0.47	0.03
	all	7		0.07	5.34	0.34	0.06
Inconnu	AR	4	398-3547	0.00	3.64	0.28	0.01
Arctic cisco	NW	4	439-662	0.03	8.78	0.56	0.02
	AR	2	539-908	0.01	8.55	0.60	0.02
	all	6		0.02	8.70	0.57	0.02
Northern pike	FS	4	592-2380	0.05	5.00	0.28	0.18
	NW	4	203-1002	0.03	9.02	0.32	0.05
	AR	2	227-284	0.00	6.06	0.27	0.005
	all	10		0.03	6.81	0.29	0.09
Longnose sucker	FS	4	478-1226	0.14	5.38	0.31	0.13
	NW	4	322-1301	0.04	9.51	0.42	0.12
	all	8		0.06	7.44	0.37	0.12

[1] FS - Fort Simpson
NW - Norman Wells
AR - Arctic Red River

Source: Hatfield *et al*. 1972

TABLE 10

MEAN CONCENTRATION (ppm) OF LEAD, ZINC, COPPER AND CADMIUM IN THE LIVERS OF FISH FROM THREE STUDY AREAS, MACKENZIE RIVER, 1971

SPECIES	BASE	N	WT. RANGE (gm)	Pb	Zn	Cu	Cd
Lake whitefish	FS[1]	6	700-1662	0.03	33.52	10.38	0.40
	AR	3	1135-1589	0.06	46.96	29.20	0.00
	all	9		0.04	38.00	16.65	0.27
Broad whitefish	AR	6	1844-2298	0.00	32.79	20.10	0.20
Inconnu	AR	3	3547-	0.21	26.27	11.45	0.05
Arctic cisco	NW	3	662-814	0.00	30.43	3.87	0.08
Northern pike	FS	7	928-3552	0.02	28.64	5.42	0.03
Longnose sucker	FS	5	759-1916	0.17	27.17	2.90	0.29
	NW	3	856-1301	0.00	35.51	5.48	0.54
	all	8		0.10	30.30	3.87	0.38

[1] FS - Fort Simpson
NW - Norman Wells
AR - Arctic Red River

Source: Hatfield *et al*. 1972

TABLE 11

WILDLIFE OBSERVATIONS IN THE VICINITY OF THE CADILLAC EXPLORATION LTD. PRAIRIE CREEK MINESITE

OBSERVATION[1]	DATE OF OBSERVATION
1 Gray Jay[2]	April 1980
3 Red Squirrel[2]	April 1980
2 Arctic Ground Squirrel[2]	April 1980
2 Black Bear (sow and 1 cub)[3]	1968
1 Black Bear[3]	1969
3 Wolverine[3]	1968-79
1 Grizzly Bear[3]	1975
1 Wolf[3]	1979-80 (winter)
1 Woodland Caribou[3]	(N.D.)

[1] See Tables 12 and 13 for scientific names.

[2] Beak observation during field reconnaissance, April 14-16, 1980.

[3] Observation of Mr. R. Fast (pers. comm, 1980).

MAMMALS

TABLE 12

PROVISIONAL CHECK LIST OF MAMMALS IN THE VICINITY OF THE PRAIRIE CREEK MINESITE [1]

COMMON NAME	SCIENTIFIC NAME[2]
SORICIDAE	
Masked Shrew*	*Sorex cinereus*
American Water Shrew*	*Sorex palustris*
Arctic Shrew	*Sorex arcticus*
Vagrant Shrew*	*Sorex vagrans*
Pygmy Shrew	*Microsorex hoyi*
VESPERTILIONIDAE	
Little Brown Bat*	*Myotis lucifugus*
LEPORIDAE	
Snowshoe Hare*	*Lepus americanus*
OCHOTONIDAE	
Collared pika*	*Ochotona collaris*
SCIURIDAE	
Least Chipmunk*	*Eutamias minimus*
Woodchuck	*Marmota monax*
Hoary Marmot*	*Marmota caligata*
American Red Squirrel*	*Tamiasciurus hudsonicus*
Northern Flying Squirrel*	*Glaucomys sabrinus*
Arctic Ground Squirrel*	*Spermophilus parryii*

1 Based on distributional information contained in Banfield (1974), Youngman (1968, 1975), Scotter et. al. (1971)

2 Nomenclature from Banfield (1974).

* Direct observations (actual sighting), or indirect observations (tracks, lodges, dens, dams etc) by BEAK personnel or by those noted in footnote 1.

Table 12(Continued)

CASTORIDAE	
American Beaver*	*Castor canadensis*
MURIDAE	
Deer Mouse*	*Peromyscus maniculatus*
Bushy-tailed Wood Rat*	*Neotoma cinerea*
Northern Bog Lemming	*Synaptomys borealis*
Heather Vole	*Phenacomys intermedius*
Northern Red-backed Vole*	*Clethrionomys rutilus*
Gapper's Red-backed Vole	*Clethrionomys gapperi*
Meadow Vole*	*Microtus pennsylvanicus*
Tundra Vole*	*Microtus oeconomus*
Long-tailed Vole	*Microtus longicaudus*
Chestnut-cheeked Vole	*Microtus xanthognathus*
Muskrat*	*Ondatra zibethicus*
DIPODIDAE	
Meadow Jumping Mouse	*Zapus hudsonius*
ERETHIZONTIDAE	
American Porcupine*	*Erethizon dorsatum*
CANIDAE	
Coyote	*Canis latrans*
Wolf*	*Canis lupus*
Red Fox*	*Vulpes vulpes*

Table 12(Continued)

URSIDAE	
Black Bear*	Ursus americanus
Grizzly Bear*	Ursus arctos
MUSTELIDAE	
American Marten*	Martes americana
Fisher*	Martes pennanti
Ermine (Short-tailed Weasel)*	Mustela erminea
Least Weasel	Mustela nivalis
American Mink*	Mustela vison
Wolverine*	Gulo gulo
Striped Skunk	Mephitis mephitis
River Otter*	Lontra canadensis
FELIDAE	
Lynx*	Lynx lynx
CERVIDAE	
Mule Deer*	Odocoileus hemionus
White-tailed Deer*	Odocoileus virginianus
Moose*	Alces alces
Woodland Caribou*	Rangifer tarandus
Dall's Sheep*	Ovis dalli
BOVIDAE	
Mountain Goat*	Oreamnos americanus

BIRDS

TABLE 13

Provisional Check List of Birds in the Vicinity of the Proposed Cadillac Explorations Limited Minesite [1]

COMMON NAME	SCIENTIFIC NAME[2]
Common loon*	Gavia immer
Red-necked grebe	Podiceps grisegena
Horned grebe*	Podiceps auritus
Trumpeter swan*	Olor buccinator
Whistling swan*	Olor columbianus
Canada goose*	Branta canadensis
Mallard*	Anas platyrhynchos
Pintail*	Anas acuta
Green-winged teal*	Anas carolinensis
Blue-winged teal	Anas discors
American wigeon*	Anas americana
Northern shoveler*	Anas clypeata
Canvasback	Aythya valisineria
Greater scaup*	Aythya marila
Lesser scaup*	Aythya affinis
Common goldeye*	Bucephala clangula
Bufflehead	Bucephala albeola
White-winged scoter	Melanitta deglandi
Surf scoter*	Melanitta perspicillata
Common merganser*	Mergus merganser
Red-breasted merganser	Mergus serrator
Goshawk*	Accipiter gentilis
Sharp-shinned hawk*	Accipiter striatus
Red-tailed hawk*	Buteo jamaicensis
Golden eagle*	Aquila chrysaetos
Bald eagle*	Haliaeetus leucocephalus
Marsh hawk*	Circus cyaneus
Merlin	Falco columbarius
American Kestrel	Falco sparverius
Blue grouse*	Dendragapus obscurus
Spruce grouse*	Canachites canadensis
Ruffed grouse*	Bonasa umbellus
Willow ptarmigan*	Lagopus lagopus

1 Based on distributional information contained in Godfrey (1966), Scotter et al (1971), Slaney Co. Ltd. (1971).

2 Nomenclature from American Ornithologists Union (1957 and revisions by Eisenmann et al (1973, 1976).

* Species observed in the region during studies noted in footnote 1.

Table 13 (Continued)

Rock ptarmigan	Lagopus mutus
White-tailed ptarmigan*	Lagopus leucurus
Sharp-tailed grouse*	Pedioecetes phasianellus
Sora*	Porzana carolina
American coot*	Fulica americana
Common snipe	Capella gallinago
Spotted sandpiper*	Actitis m[illegible]ularia
Solitary sandpiper*	Tringa solitaria
Wandering tattler*	Heteroscelus incanus
Lesser yellowlegs*	Tringa flavipes
Herring gull*	Larus argentatus
Mew gull*	Larus canus
Bonaparte's gull*	Larus philadelphia
Arctic tern*	Sterna paradisaea
Great horned owl*	Bubo virginianus
Hawk owl	Surnia ulula
Great gray owl	Strix nebulosa
Long-eared owl	Asio otus
Short-eared owl	Asio flammeus
Boreal owl	Aegolius funereus
Common nighthawk*	Chordeiles minor
Belted kingfisher*	Megaceryle alcyon
Common (Yellow-shafted) flicker*	Colaptes auratus
Pileated woodpecker	Dryocopus pileatus
Yellow-bellied sapsucker*	Sphyrapicus varius
Hairy woodpecker*	Picoides villosus
Downy woodpecker	Picoides pubescens
Black-backed three-toed woodpecker	Picoides arcticus
Northern three-toed woodpecker	Picoides tridactylis
Eastern kingbird	Tyrannus tyrannus
Eastern phoebe	Sayornis phoebe
Say's phoebe	Sayornis saya
Yellow-bellied flycatcher	Empidonax traillii
Least flycatcher	Empidonax minimus
Western wood pewee	Contopus sordidulus
Olive-sided flycatcher	Nuttallornis borealis
Horned lark*	Eremophila alpestris
Violet-green swallow*	Tachycineata thalassina
Tree swallow*	Iridoprocne bicolor
Bank swallow	Riparia riparia
Barn swallow	Hirundo rustica
Cliff swallow*	Petrochelidon pyrrhonota

Table 13 (Continued)

Gray jay*	Perisoreus canadensis
Common raven*	Corvus corax
Common crow	Corvus brachyrhynchos
Black-capped chickadee*	Parus hudsonicus
Red-breased nuthatch	Sitaa canadensis
American robin	Turdus migratorius
Varied thrush	Ixoreus naevius
Hermit thrush	Catharus guttatus
Swainson's thrush	Catharus ustulatus
Townsend's solitaire*	Myadestes townsendi
Ruby-crowned kinglet*	Regulus calendula
Bohemian waxwing	Bombycilla garrulus
Northern shrike	Lanius excubitor
Red-eyed vireo	Vireo olivaceus
Warbling vireo	Vireo gilvus
Tennessee warbler	Vermivora peregrina
Orange-crowned warbler	Vermivora celata
Yellow warbler	Dendroica petechia
Magnolia warbler	Dendroica petechia
Yellow-rumped (Myrtle) warbler	Dendroica coronata
Bay-breasted warbler	Dendroica castanea
Blackpoll warbler	Dendroica striata
Palm warbler	Dendroica palmarum
Ovenbird	Seiurus aurocapillus
Northern waterthrush	Seiurus noveboracensis
Wilson's warbler	Wilsonia pusilla
American redstart	Setophaga ruticilla
Red-winged blackbird*	Agelaius phoeniceus
Rusty blackbird	Euphagus carolinus
Brown-headed cowbird*	Molothrus ater
Western tanager*	Piranga ludoviciana
Rose-breasted grosbeak	Pheucticus ludovicianus
Evening grosbeak*	Hesperiphona vespertina
Purple finch	Carpodacus purpureus
Pine grosbeak	Pinicola enucleator
Pine siskin	Carduelis pinus
Red crossbill	Loxia curvirostra
White-winged crossbill	Loxia leucoptera
Savannah sparrow	Passerculus sandwichensis
Dark-eyed (Slate-colored) junco*	Junco hyemalis
Chipping sparrow*	Spizella passerina
White-crowned sparrow*	Zonotrichia leucophrys
White-throated sparrow*	Zonotrichia albicollis
Fox sparrow	Passerella iliaca
Lincoln's sparrow	Melospiza lincolnii
Swamp sparrow	Melospiza georgiana
Song sparrow*	Melospiza melodia

TABLE 14

Population Trends

	1971	1976	1977	1978	1979
Fort Liard	263	299	325	327	344
Fort Simpson	855	1,231	1,103	1,080	1,001
Jean Marie River	47	62	49	48	49
Nahanni Butte	66	91	96	94	92
Wrigley	152	143	174	175	163
	1,383				1,649

TABLE 15

Ethnicity (1978)*

	Indian		Eskimo		Other		Total
	#	%	#	%	#	%	#
Fort Liard	310	94.8	--	--	17	5.2	327
Fort Simpson	475	44.0	10	0.9	595	55.1	1,080

* (N.B.: This statistic is not produced for the smaller communities. All three are primarily Indian settlements, with only a small Other component in the population).

Source: Population Estimates,
Statistical Cross Tabulations.
NWTG Statistics Section, Dec. 31/78
with 1979 estimates added

TABLE 16

Site Personnel

Number and Disposition

Area	Total Number	Out of Camp	In Camp or Working (Max.)
Administration	17	0	17
Mine Supervision	8	1	7
Mine Technical	11	2	9
Mine Operating	70	23	47
Mine Maintenance	15	5	10
Process Plant	39	18	21
Services	41	19	22
*Contract Services	12	4	8
TOTAL	213	72	141
Visitor Allowance			9
Maximum Accommodation			150

*Contract Services = 4 Air Crew (2 pilots and 2 Crew)
8 Kitchen

(Source: Kilborn Engineering)

TABLE 17

SENSITIVE TIME PERIODS OF PROMINENT FISH SPECIES PRESENT IN WATERCOURSES WITHIN THE UPPER MACKENZIE DRAINAGE BASIN

	LIFE HISTORY PHASE				
SPECIES	Migration	Spawning	Incubation and Emergence	Nursery	Overwintering
Chum salmon	late September - late October	late September - early November	late April - early May	-	-
Dolly Varden char	mid-August - mid-September	late August - late September	late April - late May	late April - mid-July	early October - early May
Arctic grayling	early May - mid-June	early May - mid-June	late May - late June	early June - mid-July	early October - early May
Lake whitefish	late September - late October	early October - December	early October - May	-	early October - early May
Northern pike	mid-April - early May	mid-May - early July	early June - late July	-	early October - early May
Burbot	-	January - March	May	-	early October - early May
White sucker	early May - early June	early May - mid-June	early June - mid-July	-	early October - early May
Longnose sucker	late April - early May	early May - mid-June	early June - mid-July	-	early October - early May
Yellow walleye	late April - late June	late April - late June	mid-April - mid-July	mid-June - early August	early October - early May

Sources: McPhail and Lindsey (1970), Scott and Crossman (1973) and Foothills Pipe Lines (South Yukon) Ltd. (1979).

APPENDIX A

LIST OF CONSULTANTS

1.	Beak Consultants Ltd. 602 - 1550 Alberni Street Vancouver, B. C. V6G 1A5	G. Nieminen, P. Eng.
2.	H. Brodie Hicks Engineering Ltd. 1199 West Pender Street Vancouver, B. C. V6E 2R1	H. Brodie Hicks, P. Eng.
3.	Golder Geotechnical Consultants Ltd. 224 West 8th Avenue Vancouver, B. C. V5Y 1N5	R. M. Wilson, P. Eng.
4.	Ker, Priestman & Associates Ltd. 300 - 2659 Douglas Street Victoria, B. C. V8T 4M3	N. I. Guild, P. Eng.
5.	Kilborn Engineering (B.C.) Ltd. 101 - 1199 West Pender Street Vancouver, B. C. V6E 2R1	D. R. Beaumont, P. Eng.

APPENDIX B

CONTACTS RELATIVE TO WILDLIFE

Published data on the wildlife resource of the Nahanni area, outside Nahanni National Park, is lacking. For this reason, some information central to this report resulted from discussions with people working in the vicinity of the Cadillac Explorations Limited minesite, or the adjacent region. The help provided by the following people is gratefully acknowledged:

R. Fast	Camp Foreman, Cadillac Explorations Limited Prairie Creek Camp.
R. Fyfe	Research Scientist, Canadian Wildlife Service, Edmonton, Alberta.
S. Miller	Research Scientist, N.W.T. Wildlife Service, Yellowknife, N.W.T.

APPENDIX C

CONTACTS RELATIVE TO SOCIO-ECONOMICS

T. Auchterlonie	May 9/80	Government of the Northwest Territories, Programme Co-ordinator, Hire North, Department of Economic Development and Tourism, Yellowknife, N.W.T.
E. S. Bies		Indian & Northern Affairs Regional Engineer, Transportation Division, Engineering and Architecture Branch, Edmonton, Alberta.
L. Brintnell	May 9/80	Government of the Northwest Territories. Employment Division Officer, Manpower Development Division, Department of Economic Development and Tourism, Yellowknife, N.W.T.
C. Cook	May 8/80	Wildlife Officer, Wildlife Service, Fort Simpson, N.W.T.
D. Cormier	Apr.17/80	Land Use Administration, NWTG.
H. Deneron	May 7/80	Beaver Enterprise, Fort Liard.
J. Donihee	Apr.17/80	Government of the Northwest Territories, Environmental Assessment Biologist, Department of Natural and Cultural Affairs, Yellowknife, N.W.T.
T. Foster	May 9/80	Northwest Territories Canada. Head, Mineral & Petroleum Resources, Planning & Resource Development Division. Department of Economic Development and Tourism.
W. Fournier	May 8/80	Hire North Project Supervisor. Local Counsellor, Fort Simpson.
G. Gallant	May 9/80	Indian & Northern Affairs, Director of Economic Development, Yellowknife, N.W.T.
J. Ganski	Apr.17/80	Land Use Administration, N.W.T.G.
H. Gerein	May 9/80	Government of Northwest Territories. Head, Special Projects, Yellowknife, N.W.T.

D. Hamilton	May 8/80	Sec./Treas., Village of Fort Simpson.
C. Hope	May 9/80	Beaver Explorations, Fort Liard.
B. Larson	May 9/80	Department of Local Government, Government of the Northwest Territories, Yellowknife, N.W.T.
A. MacQuarvie	May 8/80	Interprovincial Pipeline, Fort Simpson.
L. Matthews	Apr.17/80	Government of the Northwest Territories Head,Regional Planning, Department of Planning and Programme Evaluation.
A. Menard	May 9/80	Government of the Northwest Territories. Chief, Town Planning and Lands Division, Department of Local Government, Yellowknife, N.W.T.
R. Milligan	May 9/80	Government of the Northwest Territories. Co-ordinator, Business Development Department of Economic Development and Tourism, Yellowknife, N.W.T.
F. Norwegain		Manpower and Immigration, Canada Manpower Centre, Fort Simpson, N.W.T.
A. Praamsma	May 9/80	Employment and Immigration Canada. Employment Counsellor, Canada Employment Centre, Yellowknife, N.W.T.
H. Reynolds	May 8/80	Environment Canada. Canadian Wildlife Service, Wildlife Biologist - Bison Programme, Edmonton, Alberta.
L. Vertes	May 9/80	Department of Local Government, Government of the Northwest Territories, Yellowknife, N.W.T.
G. Watsyte	May 9/80	Mayor, Village of Fort Simpson.
P. Wood	May 8/80	Water Survey, Environment Canada, Fort Simpson, N.W.T.

APPENDIX D

ACID GENERATION TEST RESULTS

B. C. RESEARCH

APPENDIX D

ACID PRODUCTION POTENTIAL OF CADILLAC PROJECT SAMPLES

Project No. 1-07-217

Prepared for:

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ACID PRODUCTION POTENTIAL
OF CADILLAC PROJECT SAMPLES

SUMMARY

The flotation tailings and waste rock samples from the Cadillac project were classified as non-acid producers since each sample consumed more acid than could be theoretically produced from the contained sulphur. The ore sample was classified as a potential acid producer.

INTRODUCTION

OBJECTIVE

To determine the acid production potential of samples of waste rock, ore, and tailings from Cadillac Explorations Ltd.

BACKGROUND

Many materials that contain sulphur and sulphide minerals can be oxidized microbiologically to sulfuric acid and soluble metal sulfate salts. This phenomenon can result in a potential water pollution hazard if the amount of sulfuric acid which the bacteria produce exceeds the neutralizing capability of the host rock. If acidic drainage water occurs, the microbiological attack on sulphur and sulfides contained in the sample, as well as the microbiologically produced acid, could solubilize heavy metals which could be toxic to aquatic flora and fauna in the area, if they were allowed to enter receiving waters.

B. C. Research has developed a two-part test which allows prediction of the acid producing potential of a particular sample (Appendix 1). This test has been used to analyze the samples from the Cadillac Project.

RESULTS

The Prairie Creek ore sample assayed 9.83% S equivalent to 301 kg H_2SO_4/tonne and had an acid consumption of 260 kg H_2SO_4/tonne. The zinc flotation tailings contained 0.60% S equivalent to 18.4 kg H_2SO_4/tonne and showed an acid consumption of 382 kg H_2SO_4/tonne. The waste rock samples assayed 2.30% S to give a potential acid production of 70.4 kg H_2SO_4/tonne compared to an acid consumption of 495 kg H_2SO_4/tonne. No confirmation tests were performed.

DISCUSSION

The results of the acid production tests indicate that the flotation tailings and waste rock samples are non-acid producers. The ore sample, on the other hand, is a potential acid producer and, in view of the comparable results for acid production and acid consumption, should be subjected to a confirmation test. It must be noted, however, that these tests are performed on finely pulverised material having a high surface area of gangue and acid producing sulphides. In practice, the proportion of acid consuming gangue to acid producing sulphides may change with particle size thus altering the results of some tests, particularly those which are marginal producers or consumers.

B. C. RESEARCH

A. S. Ballantyne, P. Eng.
Senior Research Engineer
Mineral Leaching Studies

A. Bruynesteyn
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TABLE 1

INITIAL ACID PRODUCTION TEST

Sample	% S	Theoretical Acid kg H_2SO_4/tonne	Natural pH 10 g sample + 100 ml H_2O	Acid Consumption kg H_2SO_4/tonne	Potential Acid Producer
KM019 - PRAIRIE CREEK ORE	9.83	301	7.1	260	YES
2252 TEST #25 ZINC FLOTATION TAILINGS	0.60	18.4	7.6	382	NO
WASTE ROCK SAMPLES	2.30	70.4	9.4	495	NO

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 over-estimate 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.

APPENDIX E

GEOTECHNICAL REPORT

GOLDER ASSOCIATES LTD.

APPENDIX E

Golder Associates
CONSULTING GEOTECHNICAL ENGINEERS

REPORT TO
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June 1980 802-1073

APPENDIX E

TABLE OF CONTENTS

1.0 INTRODUCTION

Golder Associates were requested to carry out a preliminary geotechnical appraisal of the potential tailing storage facilities and plant sites at the Cadillac Explorations Ltd. property in the Northwest Territories. The purpose of this study was to inspect potential tailing storage areas and plant sites and to evaluate these in relation to functional suitability and environmental control.

The study was carried out with representatives of Cadillac Explorations Ltd., Ker Priestman & Associates Ltd. and Beak Consultants Ltd.

The site location is shown on the Key Plan, Figure 1.

2.0 PROCEDURE

The field inspection was carried out on April 17 and 18, 1980. Potential sites were located on aerial photographs and topographic maps and were inspected from the air by helicopter and on the ground surface. Additional information was obtained from previous engineering reports prepared by others for the same regional area.

3.0 SITE CONDITIONS

The proposed mine and camp site are located in the Prairie Creek Valley at approximately 61° 34'N latitude, 124° 47'W longitude in the Northwest Territories. The area is typically mountainous and the topography and surface drainage patterns are controlled by the underlying rock units.

Nine alternative tailing storage areas were proposed for assessment as shown on Figure 2, and inspected in the field. Alternatives T1, T4 and T5 are located in the Harrison Creek Valley and its tributaries. Alternative T2 is located on the floodplain of Prairie Creek near the existing campsite location. Alternative T3 is located approximately 3000 ft. downstream of the present campsite on the floodplain on the left bank of Prairie Creek. Alternative T6 is located approximately 6000 ft. downstream of the campsite on the floodplain of Prairie Creek and on the right bank of the creek. Alternatives 7 and 8 are sited in stream valleys tributary to Prairie Creek on the right hand side of the Prairie Creek Valley. Alternative tailing disposal area T9 is located about 4000 ft. upstream of the present camp at the existing air strip location.

Two alternative areas for plant site construction have been selected. Alternative P1 is on the alluvial terrace immediately east of tailing pond alternate T2, and alternative P2 is at the mouth of the Harrison Creek Valley near the existing campsite, as shown on Figure 2.

4.0 SEISMICITY

The mine site is located near the boundary between Zones 1 and 2 of the National Building Code Seismic Zoning Map (1970). This implies a design earthquake acceleration of approximately 3 per cent gravity for a 100 year return period. According to the Pacific Geoscience Center, the closest recorded earthquake epicenter is approximately 350 miles to the northwest of the proposed mine site. Consequently, it is unlikely that bedrock accelerations significantly higher than 3 per cent gravity due to local earthquakes need to be considered in design.

5.0 SOIL CONDITIONS

Limited data are available at this time with respect to the soil conditions at the proposed alternative tailing retention areas and mine plant sites. The data were primarily obtained from air photo interpretation coupled with field observations of the surficial conditions and information from well drilling experience at the mine site.

At the location of alternate T2, one test pit was made with a bulldozer and samples of the underlying soils recovered for inspection and testing in the laboratory.

The overall area is generally rugged with all land forms controlled by the local bedrock topography except in the bottom of the Prairie Creek Valley where substantial thicknesses of alluvial sands and gravels exist. There is evidence, at least at the location of alternate T2, that the floodplain gravels are underlain by a thick layer of glacial clay. It is probable that similar materials exist beneath all of the proposed alternate tailing pond locations sited on the Prairie Creek floodplain since the clay was probably deposited in the valley by a glacial lake formed as a result of ice damming at some point in the Prairie Creek Valley downstream from the present mine site location. There are records of the glacial clays in Nahanni National Park, downstream of the site.

The clay stratum is reported to be at least 40 ft. in thickness at the campsite location and to be underlain by pervious sands and gravels. The clay sample tested had an undisturbed shear strength of approximately 1250 psf and a disturbed shear strength of approximately 190 psf as measured in the laboratory. The material contains approximately 60 per cent of particles smaller than 0.001 mm in diameter, as shown on the graph of grain size distribution, Figure 4, and is, for all practical purposes, impermeable. The permeability is estimated to be of the order of 10^{-8} cm/sec.

The clay will provide both a suitable base material for tailing areas and a suitable material for impermeable sections in tailing embankments if impermeable facilities are required for tailing storage.

At the mouths of valleys tributary to Prairie Creek near the mine site, and at the locations of alternate plant sites P1 and P2, there are substantial accumulations of outwash and/or colluvial sands and gravels overlying the Prairie Creek floodplain. The depths and horizontal extents of these deposits, which may form the foundation soils for the mine plant structures are, at this time, unknown.

The soils and rock in the area are generally frozen to some undetermined depth. The thicknesses of active zones in these permafrost areas will vary according to topographic aspect as well as to soil type and thermal properties, ground cover, and other conditions relating specifically to permafrost.

Information with respect to the depth and the horizontal extents of permafrost in the foundation areas of both the alternate tailing disposal and plant site locations, as well as with regard to the general geotechnical properties of the foundation soils, will have to be gathered and assessed in detail before final design of tailing ponds and embankments and plant foundations is carried out.

6.0 TAILING RETENTION AREAS

6.1 Alternate Locations

Four of the alternative locations proposed as mine plant tailing retention sites are on the Prairie Creek floodplain. These alternatives are designated T2, T3, T6 and T9, as shown on Figure 2. Alternatives T1, T4, T5, T7 and T8 are sited in stream valleys tributary to Prairie Creek.

6.1.1 Site T-2

Alternate T2 is located adjacent to the existing mine campsite. The site has been partially excavated to provide materials for a dyke to protect the existing campsite from encroachment by Prairie Creek flood waters. The dyke has been constructed to a height of approximately 10 ft. above the bed of the Prairie Creek stream course at this location. Alluvial sands and gravels excavated from behind the dyke have been used for construction. The construction controls the river course in the valley invert but has been carried out without constricting the Prairie Creek stream course.

The T2 area is underlain by a stratum of glacial clay with its surface several feet beneath the bottom of the existing excavation. The thickness of the clay stratum is reported to be of the order of 40 ft. at the campsite and to be underlain by pervious sands and gravels. The horizontal extent of the clay stratum is unknown, but it is probable that, due to the method of deposition, it extends for the full width of the Prairie Creek Valley at this location. It is also probable that this deposit exists beneath the locations of the other three alternate tailing retention areas sited on the Prairie Creek floodplain.

A small drainage course exits on the east side of the Prairie Creek Valley above the T2 location. The mouth of this small valley contains a deposit of outwash and/or colluvial sands and gravels forming a terrace several tens of feet above the proposed T2 tailing disposal area. (This terrace is considered to be a viable alternate plant site location, as discussed in Section 7.0). If the T2 alternate is chosen for tailing storage, measures to accommodate the flows from this stream so that they do not infringe on the operation of the tailing ponds will have to be taken.

6.1.2 Site T-3

Alternative tailing storage area T3 is located approximately 3000 ft. downstream of the existing campsite on the left bank of Prairie Creek.

The dominant surficial feature at this location is an alluvial fan formed on the Prairie Creek terrace sands and gravels by a stream exiting from the Mackenzie Mountains on the east side of Prairie Creek. It is probable that the glacial clay stratum found at the location of alternate T2 also exists at this site

The topography at this location, due to the tributary stream alluvial fan deposit, is such that tailing facilities developed in this area could be done on one or more levels.

The potential maximum flow from the tributary stream course is not known. However, if the T3 alternate is chosen for tailing storage, measures to accommodate the flows from this stream will have to be taken so that the operational and long term integrity of the tailing embankments is assured.

6.1.3 Site T-6

Alternative location, T6, for tailing retention is on the Prairie Creek floodplain approximately 6000 ft. downstream from the existing campsite on the right hand side of the stream.

It is probable that subsurface conditions at this location are similar to those at T2 and T3, consisting of alluvial sands and gravels overlying glacial clay.

No stream courses of sufficient size to affect operation of tailing ponds are located in this area.

6.1.4 Site T-9

Alternative location, T-9, for tailing retention, is on the Prairie Creek floodplain at the existing air strip location. It is probable that subsurface conditions at this location are similar to those at T2, consisting of alluvial sands and gravels overlying glacial clay.

The Prairie Creek stream course is controlled, but not constricted, by air strip construction.

No well defined stream channels tributary to Prairie Creek enter this alternative tailing area, consequently, the only water entering tailing ponds constructed at this location, aside from tailing water itself, would be rain and melt waters from the mountain side on the east side of Prairie Creek.

6.1.5 Tributary Valley Sites (T1, T4, T5, T7 and T8)

Potential storage areas in the stream valleys tributary to Prairie Creek are not considered desirable because of a combination of risks due to location, and construction and operational constraints.

There is the possibility of very high flows in these tributary valleys during spring run-off and/or heavy summer rain storms. Construction of tailing embankments near the mouths of tributary valleys would require dams as much as 150 ft. or more in height to allow adequate storage capacity. In addition, the embankments would possibly be founded in areas underlain by ice rich permafrost soils and/or weathered rock. The costs involved in excavating these potentially unstable materials, so that the embankments could be founded on competent materials, could be extremely high. The operation and long term integrity after abandonment of tailing embankments in these tributary valleys would require the construction of bypass channels and spillways to conduct run-off water around the storage areas and safely into Prairie Creek. In the case of the Harrison Creek Valley, for example, this would require a channel and spillway capable of handling very high flows both during mine operation and following mine abandonment. This would clearly involve major and very costly construction and long term maintenance.

6.2 Seepage Control

Seepage control at any of the alternative tailing storage areas sited on the Prairie Creek floodplain can be provided by the glacial clay stratum which underlies the alluvial and outwash deposits at these locations. It has been assumed that the clay stratum exists beneath all of these alternative sites. If this is not the case, and if this material exists only at the location of alternate T2 and beneath the existing campsite, then clay in sufficient quantities to line the bottoms and sides of ponds at alternates T3, T6 or T9, can be borrowed from this source if impervious lining is required. The clay is essentially impervious in its in situ state and embankment sections requiring seepage barriers can be built using clay excavated from within the pond areas, should they be required. If a pond design utilizing exfiltration is desirable, the required dykes could be founded on the natural alluvial stratum.

6.3 Storage Requirements

It is understood that the mine plant will be processing approximately 1000 tons of ore per day. This will result in a mine plant tailing output of the order of 100,000 cu. yds. per year exclusive of any ice build-up from winter operation. Any of the four proposed alternate tailing retention areas located on the Prairie Creek floodplain could be developed to accommodate this amount of tailing storage for the life of the mine, depending upon the height of embankment constructed. However, alternatives T2 and T3 lend themselves most readily to the development of tailing storage systems involving the operation of several cellular ponds with embankments which would probably not have to be in excess of 30 ft. in height. In addition, these alternatives are close to both of the alternative plant sites proposed in this study.

6.4 Design and Construction

Based on the available information, conceptual designs of proposed tailing retention structures have been prepared and are shown on Figure 3. However, final design will be contingent on further more detailed field investigations. Final design should be done in accordance with the criteria detailed in "Pit Slope Manual" (Chapter 9 - Waste Embankments), Energy, Mines and Resources Canada, 1977.

Construction of tailing embankments at any of the alternative locations will involve the standard considerations of seepage control, stability, and optimization of required embankment volumes versus storage capacity. In addition, two problems specific to the Cadillac mine site will have to be addressed, viz. river erosion of the constructed embankments and difficulties related to the possible existance of permafrost in the clay stratum beneath the embankments.

6.4.1 Construction Materials

Construction materials in the form of alluvial sands and gravels exist at all of the alternative tailing retention areas sited on the Prairie Creek floodplain. Clay appears to exist in adequate quantities for those components of the embankments required to provide seepage control and in adequate thicknesses in the bottoms of the floodplain pond areas to provide seepage control in those areas. However, the existence of this deposit at the locations of the selected tailing storage areas will have to be confirmed by field drilling and/or test pitting.

Material for filter zones between the clay and the downstream coarse granular zones in the tailing embankments could be provided by screening the available sands and gravels. However, it may be more economical to use filter cloth for this purpose.

Suitable heavy rock for rip rap to prevent stream erosion along the outside of embankments bordering on Prairie Creek can be easily quarried.

If they are available in suitable quantities, it may be practical to consider use of tailing sands for embankment construction above some established safe minimum height. The lower embankments would be constructed from the alluvial sands and gravels and clays.

6.4.2 Construction Sequence

Decisions with respect to the sequencing of construction as related to initial and stage embankment heights, if staging is to be undertaken, will depend upon further information concerning mine plant operating requirements and long term mine planning. However, space requirements and construction material availability appear to pose no major problems with respect to constructing first class tailing retention facilities for the mine for both its operating life and to satisfy long term abandonment considerations.

The most probable construction sequence will involve full height cell construction allowing several years operation. In order to accommodate winter mill operation, separate winter and summer cell systems should be considered.

7.0 MINE PLANT SITES

Two alternative locations for mine plant construction are proposed. These are shown on Figure 2 as P1 on the alluvial terrace immediately east of tailing retention alternate T2, and P2 near the mouth of the Harrison Creek Valley.

Both of these areas are underlain by outwash sands and gravels probably overlying Prairie Creek floodplain sands and gravels which possibly overlie the glacial clay deposit discussed in Section 6.0. Prior to final design the stratigraphy and properties of the foundation soils at the selected plant site location will have to be determined.

With respect to operational efficiency of tailing disposal, alternate plant site P1, together with alternate tailing retention area T2, is probably the best choice since the plant site is close to and higher in elevation than the tailing storage area which would negate the necessity to pump tails to the tailing ponds. However, plant site P2 and tailing retention area T3 are viable alternatives and should receive appropriate consideration.

Should alternate location P2 be selected, the risk of damage to the plant due to the direct or indirect effects of heavy run-off from the Harrison Creek Valley must be eliminated. A creek training groyne consisting of rip rap must be constructed to control the creek channel as it traverses the fan at the confluence with Prairie Creek. This location is somewhat lower in elevation than P1 which could result in the necessity to pump tails to storage areas at some future time.

It is probable that the mine plant can be founded on spread footings bearing in alluvial sands and gravels. However, no firm comment with respect to suitable foundation types for the proposed mine plant can be made without more detailed knowledge of the soil types and conditions.

8.0 CONCLUSIONS AND RECOMMENDATIONS

1) Four suitable alternate tailing retention sites have been selected. The most desirable are alternates T2 and T3, located on the Prairie Creek floodplain. The alternatives located in stream valleys tributary to Prairie Creek are not considered desirable for reasons of construction, operational and long term maintenance considerations.

2) Two suitable alternate plant sites have been selected. The most preferable site is P1, adjacent to proposed tailing retention area T2.

3) The tailing retention system may be constructed to afford minimal seepage, or alternatively, may be designed as an exfiltration system if desired.

4) Adequate borrow sources are available for most construction materials. These consist of highly plastic clay of low permeability; well graded sand and gravel; and hard durable rock.

5) The tailing embankments should be constructed in cells as required. We suggest that winter and summer ponds be operative as needed to accommodate the seasonal deposition conditions.

6) It is possible that the mill structures can be founded on spread footings bearing in the alluvial sands and gravels. The structures should be located over natural deposits where possible; however, adjacent yard or storage areas may be located on compacted granular fills.

7) No apparent difficult stability or avalanche conditions were noted at any of the selected alternate tailing retention sites or mine plant sites located on the Prairie Creek floodplain.

8) Prairie Creek must be afforded a stable permanent channel through the development area. We recommend that rip rap protection be placed along the entire tailing and/or mill area where they form the creek banks.

9) The recommendations given herein are conceptual and preliminary only. Detailed site investigation must be carried out at the selected locations prior to final design. These investigations should include a field drilling and laboratory program.

We trust that this report contains the information which you require at this time.

Yours very truly

GOLDER ASSOCIATES

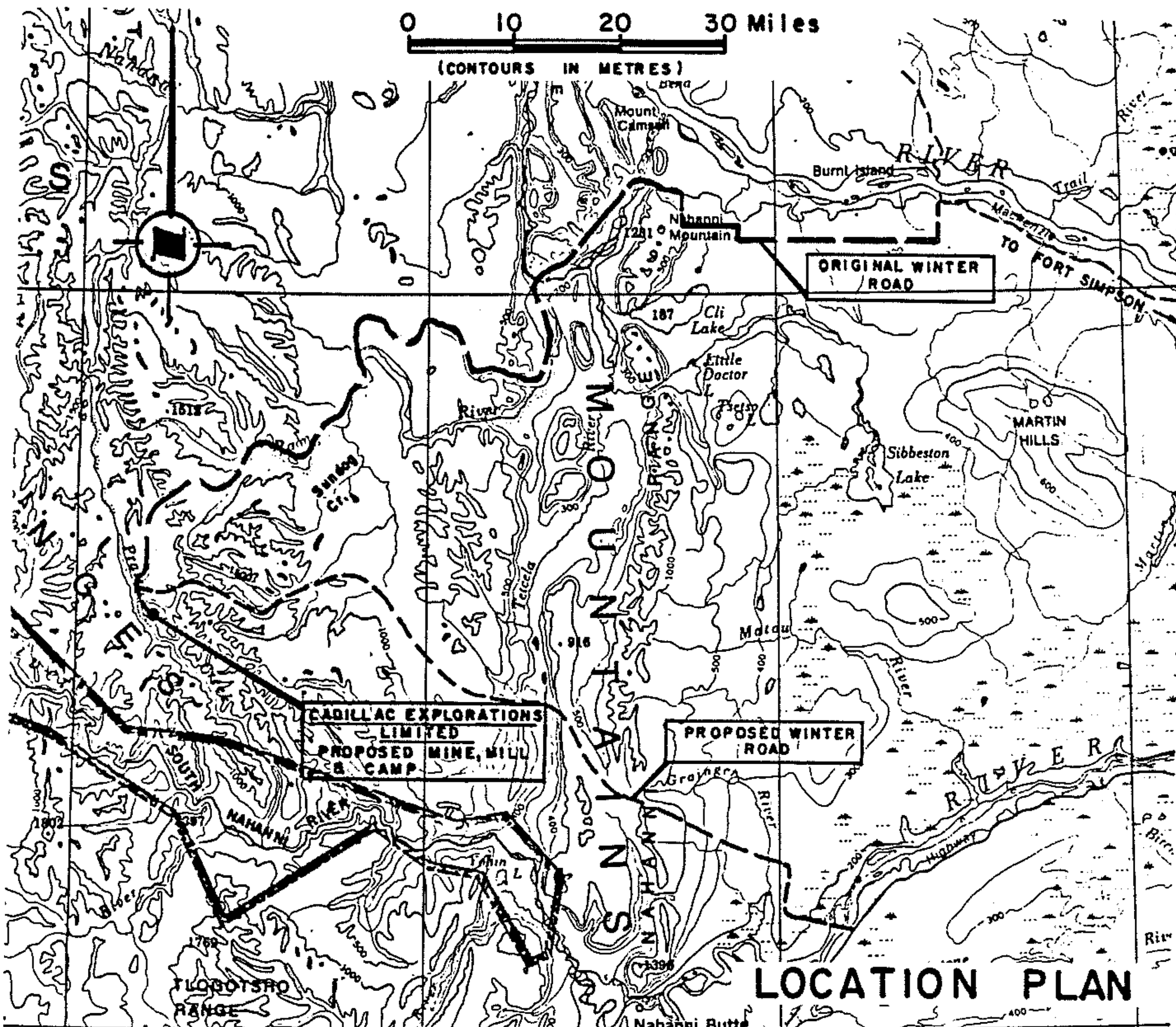
R.M. Wilson, P. Eng.

E.B. Fletcher, P. Eng.

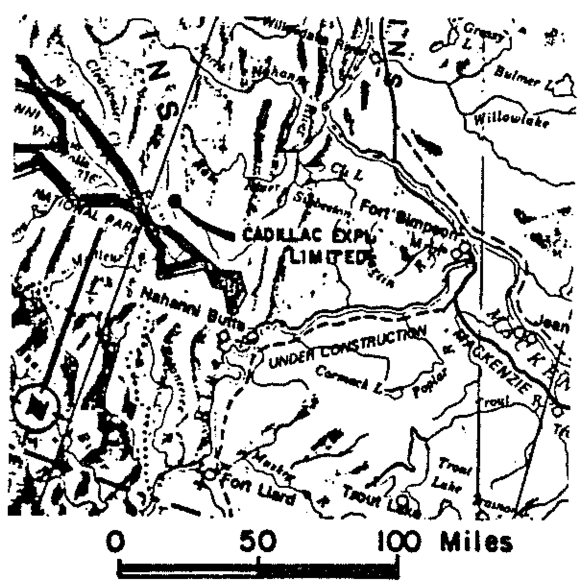
RMW/EBF:rme

802-1073

LOCATION PLAN AND KEY PLAN | Figure 1

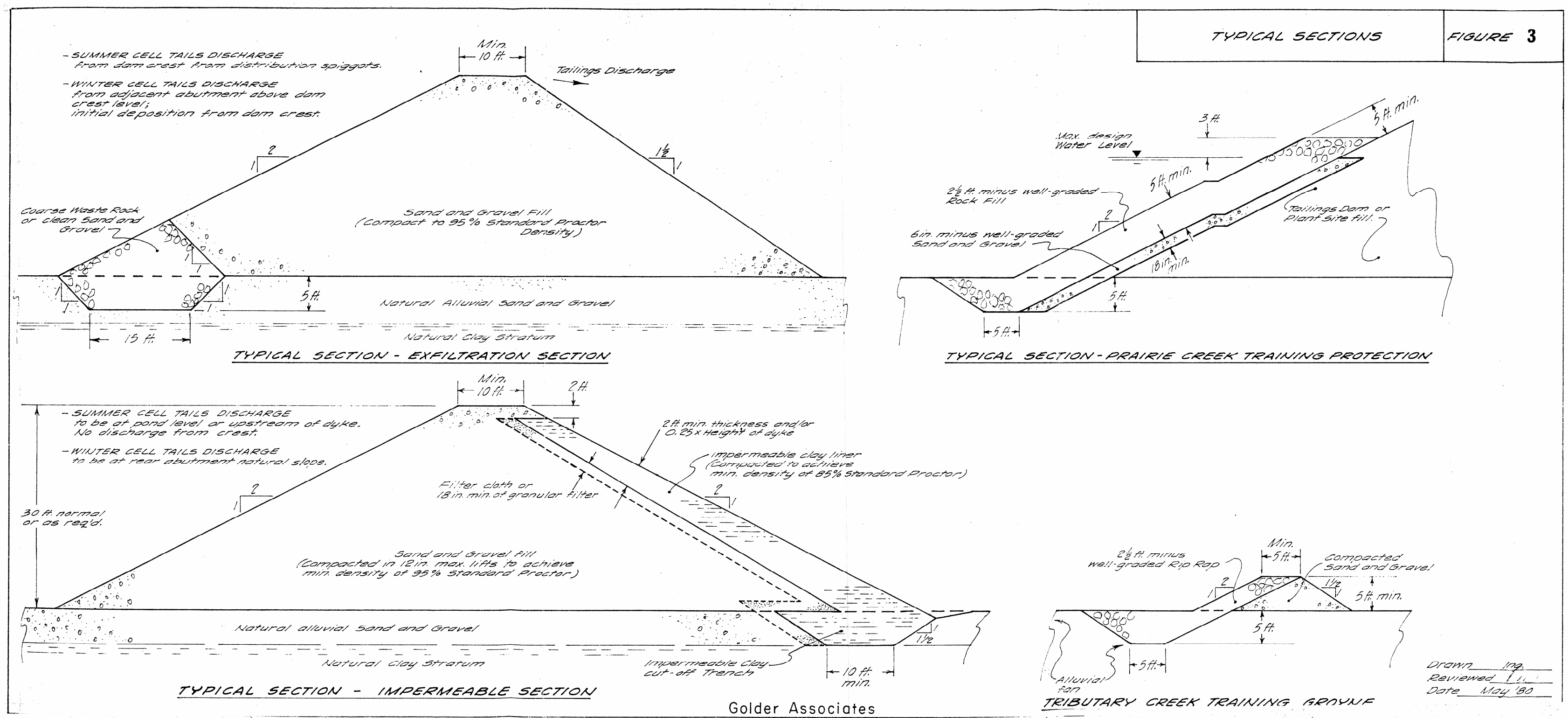


KEY PLAN



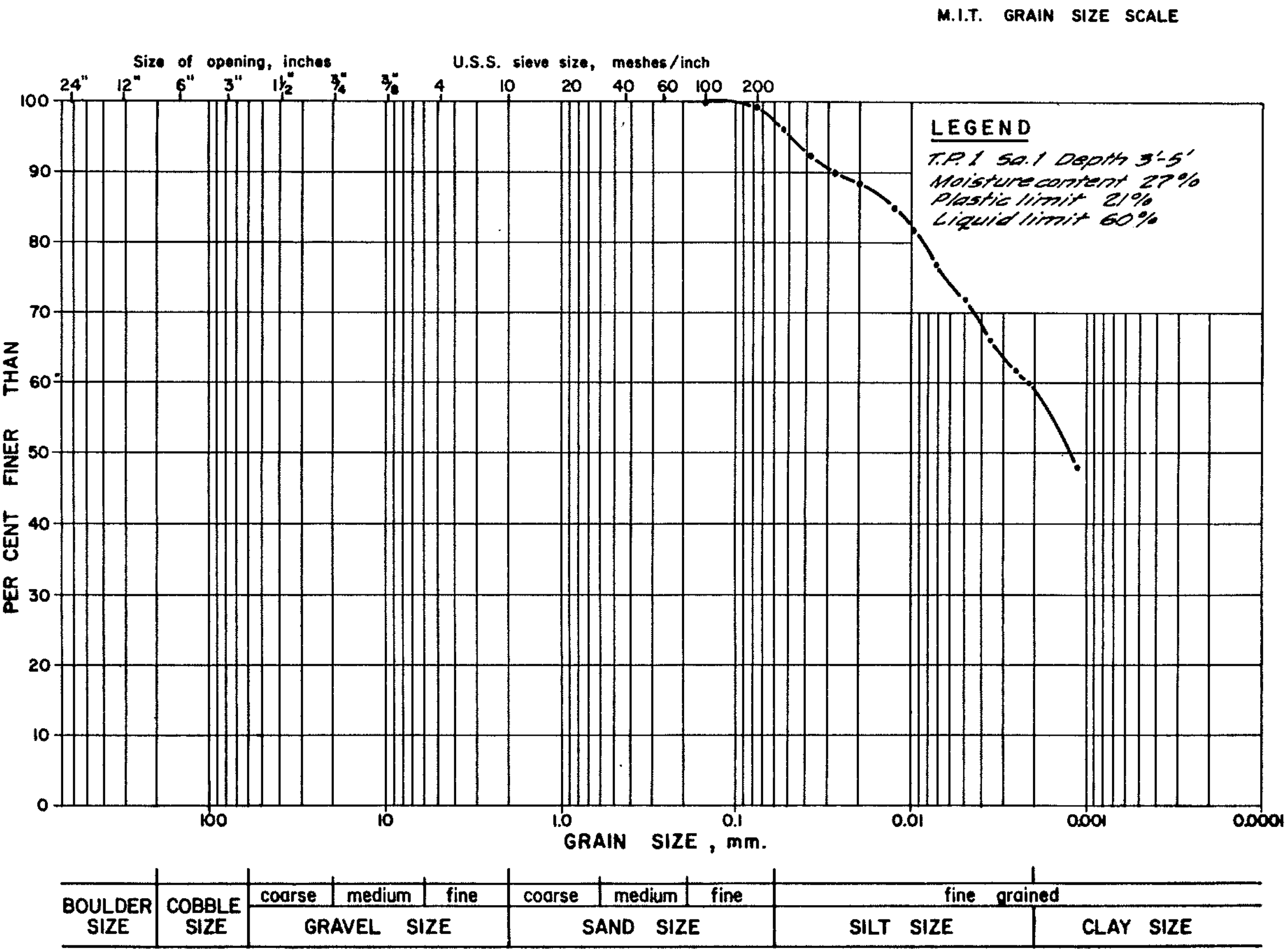
Golder Associates

Project No. 802-1023 Drawn ... Reviewed ... Date May/80


TYPICAL SECTIONS
FIGURE 3
- SUMMER CELL TAILS DISCHARGE from dam crest from distribution spiggots.
- WINTER CELL TAILS DISCHARGE from adjacent abutment above dam crest level; initial deposition from dam crest.
Min. 10 ft.
Tailings Discharge
Course Waste Rock or clean Sand and Gravel
Sand and Gravel Fill (Compact to 95% Standard Proctor Density)
5 ft.
15 ft.
Natural Alluvial Sand and Gravel
Natural Clay Stratum
TYPICAL SECTION - EXFILTRATION SECTION
Max. design Water Level
3 ft.
5 ft. min.
$2\frac{1}{2}$ ft. minus well-graded Rock Fill
6 in. minus well-graded Sand and Gravel
18 in. min.
Tailings Dam or Plant Site fill.
5 ft.
TYPICAL SECTION - PRAIRIE CREEK TRAINING PROTECTION
- SUMMER CELL TAILS DISCHARGE to be at pond level or upstream of dyke. No discharge from crest.
- WINTER CELL TAILS DISCHARGE to be at rear abutment natural slope.
2 ft.
2 ft. min. thickness and/or 0.25 x Height of dyke
Impermeable clay liner (Compacted to achieve min. density of 85% Standard Proctor)
Filter cloth or 18 in. min. of granular filter
30 ft. normal or as req'd.
Sand and Gravel Fill (Compacted in 12 in. max. lifts to achieve min. density of 95% Standard Proctor)
Natural alluvial Sand and Gravel
Natural Clay Stratum
Impermeable Clay cut-off Trench
10 ft. min.
TYPICAL SECTION - IMPERMEABLE SECTION
Golder Associates
$2\frac{1}{2}$ ft. minus well-graded Rip Rap
Min. 5 ft.
Compacted Sand and Gravel
5 ft. min.
Alluvial fan
TRIBUTARY CREEK TRAINING GROYNE
Drawn
Reviewed
Date May '80

GA.101

Project No. 802-1023 Drawn log Reviewed ______ Date May '80



Golder Associates

GRAIN SIZE DISTRIBUTION

Figure 4

APPENDIX F

FEDERAL MINING REGULATIONS

Registration
SOR/77-178 25 February, 1977

FISHERIES ACT

Metal Mining Liquid Effluent Regulations

P.C. 1977-388 24 February, 1977

His Excellency the Governor General in Council, on the recommendation of the Minister of Fisheries and the Environment, pursuant to sections 33 and 34 of the Fisheries Act, is pleased hereby to make the annexed Regulations respecting deleterious substances in liquid effluents from metal mines.

REGULATIONS RESPECTING DELETERIOUS SUBSTANCES IN LIQUID EFFLUENTS FROM METAL MINES

Short Title

1. These Regulations may be cited as the *Metal Mining Liquid Effluent Regulations*.

Interpretation

2. In these Regulations,

"Act" means the *Fisheries Act*; (*Loi*)

"arithmetic mean" means the average value of the concentrations in composite or grab samples collected over the time period required by section 7; (*moyenne arithmétique*)

"composite sample" means

(*a*) a quantity of undiluted effluent consisting of a minimum of three equal volumes of effluent or three volumes proportionate to flow that have been collected at approximately equal time intervals over a sampling period of not less than 7 hours and not more than 24 hours, or

(*b*) a quantity of undiluted effluent collected continually at an equal rate or at a rate proportionate to flow over a sampling period of not less than 7 hours and not more than 24 hours;

(*échantillon composite*)

"deposit" means to deposit or permit the deposit into water frequented by fish; (*rejeter*)

"effluent" includes mine water effluent, mill process effluent, tailings impoundment area effluent, treatment pond or treatment facility effluent, seepage and surface drainage; (*effluent*)

"existing mine" means a mine that came into commercial production before the date of coming into force of these Regulations and that operated on a commercial basis for at least two months in the twelve months immediately prior to that date; (*mine existante*)

"expanded mine" means an existing mine that has increased its production rate by more than 30% of its reference mine production rate; (*mine à production accrue*)

"final discharge point" means the point beyond which the operator of a mine exercises no further control over an effluent; (*point de rejet final*)

"gold mine" means a mine where the gold produced from the mine is recovered in the operation area by the process of cyanidation and accounts for more than 50% of the value of the output of the mine; (*mine d'or*)

"grab sample" means a quantity of undiluted effluent collected at any given time; (*échantillon pris au hasard*)

"metal" includes antimony, bismuth, cadmium, cobalt, copper, chromium, gold, iron, lead, magnesium, mercury, molybdenum, nickel, niobium, silver, tantalum, tin, thorium, titanium, tungsten, uranium and zinc; (*métal*)

"mill process effluent" includes tailing slurries and all other effluent discharged from a milling operation; (*effluents des installations de préparation du minerai*)

"mine" includes all metal mining and milling facilities that are used to produce a metal concentrate or an ore from which a metal or metal concentrate may be produced and all associated smelters, pelletizing plants, sintering plants, refineries, acid plants, and any similar operation where any effluent from such operation is combined with the effluents from mining and milling; (*mine*)

"mine water effluent" means water pumped or flowing out of any underground workings or open pit; (*effluents d'eau minière*)

"Minister" means Minister of the Environment; (*Ministre*)

"new mine" means a mine that did not start commercial production prior to the date of coming into force of these Regulations and that commences commercial production on or after that date; (*mine nouvelle*)

"operation area" includes all the land and works that are used or have been used in conjunction with mining or milling activity and, without limiting the generality of the foregoing, includes open pits, underground mines, buildings, ore storage areas, active and abandoned waste rock dumps, active and abandoned tailings impoundment areas and treatment ponds, cleared or disturbed areas adjacent to those places, structures or areas and ditches, watercourses or water bodies the character of which have been altered by mining activity; (*chantier*)

"reference mine production rate" means the greater of the design rated capacity and the maximum average annual production rate ever achieved during the operating life of a mine prior to the date of coming into force of these Regulations; (*rythme de production de référence*)

"reopened mine" means a mine that resumes production on or after the date of coming into force of these Regulations and that had not been in operation for more than two months in the twelve month period immediately prior to the date of coming into force of these Regulations; (*mine remise en exploitation*)

"surface drainage" includes all surface run-off that flows over, through or out the operation area of a mine and that is contaminated as a result of flowing over, through or out of that area; (*eau de drainage superficiel*)

"tailings impoundment area" means a limited disposal area that is confined by man-made or natural structures or by both; (*dépôt de stériles*)

"total suspended matter" means the non-filterable residue that results from the operation of a mine, that is contained in liquid effluent from the mine; (*matière totale en suspension*)

"treatment pond" means a pond, lagoon or other confined area, other than a tailings impoundment area, used to treat an effluent; (*étang de traitement*)

"undiluted" means not having water added primarily for the purposes of meeting the limits of authorized deposits prescribed by section 5. (*non dilué*)

Application

3. These Regulations apply to every new mine, expanded mine and reopened mine, other than a gold mine.

Substances Prescribed as Deleterious Substances

4. For the purpose of paragraph (*c*) of the definition "deleterious substance" in subsection 33(11) of the Act, the following substances from the operations or processes of a mine to which these Regulations apply are hereby prescribed as deleterious substances:

(*a*) arsenic;
(*b*) copper;
(*c*) lead;
(*d*) nickel;
(*e*) zinc;
(*f*) total suspended matter; and
(*g*) radium 226.

Authorized Deposit of Deleterious Substances

5. (1) Subject to these Regulations, the operator of a mine may deposit a deleterious substance prescribed by section 4 if

(*a*) the monthly arithmetic mean of the concentration in each undiluted effluent of that substance described in an item of Part 1 of Schedule 1 does not exceed the concentration in column I of that item and the monthly arithmetic mean pH of that effluent is not less than the value set out in column I of Part 2 of that schedule;

(*b*) the concentration in a composite sample of each undiluted effluent of that substance described in an item of Part 1 of Schedule 1 does not exceed the concentration in column II of that item and the pH of the composite sample is not less than the value set out in column II of Part 2 of that schedule; and

(*c*) the concentration in a grab sample of each undiluted effluent of that substance described in an item of Part 1 of Schedule 1 does not exceed the concentration in column III of that item and the pH of the grab sample is not less than the value set out in column III of Part 2 of that schedule.

(2) Notwithstanding subsection (1), the operator of a mine may deposit the deleterious substances prescribed by section 4 in any quantity or concentration into a tailings impoundment area designated in writing by the Minister.

ADDITIONAL CONDITIONS OF AUTHORIZATION

General

6. An operator of a mine shall

(*a*) install and maintain facilities of such type as the Minister may in writing approve for sampling and analysing effluents for the purpose of enabling the Minister to determine whether the operator is complying with the limits of authorized deposits prescribed by section 5;

(*b*) take grab or composite samples of each undiluted effluent at its final discharge point on the regular basis prescribed by section 7;

(*c*) analyse the samples referred to in paragraph (*b*) on the regular basis prescribed by section 7;

(*d*) where possible measure or in any other case estimate the volume of each undiluted effluent deposited per month at its final discharge point on the regular basis prescribed by section 9; and

(*e*) within 30 days after the end of each month, send to the Minister a report, in such form as the Minister may in writing approve, containing the information prescribed by section 10.

Frequency of Sampling and Analysis

7. (1) Subject to subsection (2), the sampling and analysis referred to in paragraphs 6(*b*) and (*c*) shall be made

(*a*) once a week, where the arithmetic mean of the concentration in undiluted effluent of a substance described in an item of Schedule 2 in the immediately preceding six months was equal to or greater than the arithmetic mean set out in column I of that item;

(*b*) once every two weeks, where the arithmetic mean of the concentration in undiluted effluent of a substance described in an item of Schedule 2 in the immediately preceding six months was equal to or greater than the arithmetic mean set out in column II of that item but less than that set out in column I of that item;

(*c*) once a month, where the arithmetic mean of the concentration in undiluted effluent of a substance described in an item of Schedule 2 in the immediately preceding six months was equal to or greater than the arithmetic mean set out in column III of that item but less than that set out in column II of that item;

(*d*) once every six months, where the arithmetic mean of the concentration in undiluted effluent of a substance described in an item of Schedule 2 in the immediately preceding six months was less than the arithmetic mean set out in column III of that item; and

(*e*) once a week for the first six months of operation of a mine.

(2) The sampling and analysis of undiluted effluent to determine its pH level shall be made

(*a*) once a week, where the pH of the undiluted effluent was less than 5.0 at any time in the immediately preceding six months;

(*b*) once every two weeks, where the pH of the undiluted effluent was between 5.0 and 5.5 at any time in the immediately preceding six months;

(*c*) once a month, where paragraph (*a*) or (*b*) does not apply; or

(*d*) once a week for the first six months of operation of a mine.

Analytical Test Methods

8. (1) For the purposes of section 5, the concentration in undiluted effluent of a substance described in column I of an item of Schedule 3 shall be determined using

(*a*) the test method referred to in column II of that item as modified by the directions in columns III and IV for procedure and sample preservation respectively; or

(*b*) any other method, approved in writing by the Minister, the results of which can be confirmed by the method referred to in paragraph (*a*).

(2) For the purposes of section 5, the pH of undiluted effluent shall be determined using

(*a*) the test method prescribed by section 221 of the publication "Standard Methods for the Examination of Water and Waste Water", 13th Edition (1971), published jointly by the American Public Health Association, American Water Works Association and the Water Pollution Control Federation; or

(*b*) any other method, approved in writing by the Minister, the results of which can be confirmed by the method referred to in paragraph (*a*).

Flow Measurement

9. The measurement or estimation of volume of undiluted effluent referred to in paragraph 6(*d*) shall be made monthly, unless the lowest frequency of sampling and analysis prescribed by subsection 7(1) is every six months, in which case the measurement or estimation shall be made every six months.

Reporting

10. A report referred to in paragraph 6(*e*) shall contain the following information respecting the month in respect of which the report is made:

(*a*) the arithmetic mean concentrations (in milligrams per liter or picocuries per liter) of the deleterious substances in each undiluted effluent deposited and the arithmetic mean pH of undiluted effluents deposited;

(*b*) the concentrations of deleterious substances in all samples used to determine the arithmetic mean concentrations referred to in paragraph (*a*);

(*c*) the pH of all samples used to determine the arithmetic mean pH referred to in paragraph (*a*);

(*d*) the volume (in Imperial gallons per month) of each undiluted effluent deposited; and

(*e*) the type of sample collection (composite or grab) used for each effluent deposited.

Permitted Variations in Additional Conditions

11. Where the operator of a mine establishes to the satisfaction of the Minister that for scientific and technical reasons a scheme of sampling and analysis, measurement or estimation or reporting referred to in sections 7, 8, 9 and 10 other than at the regular time interval frequencies required by those sections, is sufficient to enable the Minister to determine whether the operator is complying with the limits of authorized deposits prescribed by section 5, the Minister may, in writing, permit the operator to

(*a*) take and analyse samples of each undiluted effluent in accordance with the scheme on a regular basis specified in the permit,

(*b*) measure or estimate the volume of each effluent in accordance with the scheme on a regular basis specified in the permit, or

(*c*) report to the Minister in accordance with the scheme on a regular basis specified in the permit,

and sections 7, 8, 9 and 10 do not apply to the operator if he complies with the scheme on the regular basis specified in the permit.

SCHEDULE I

PART 1

AUTHORIZED LEVELS OF SUBSTANCES

Item	Substance	Column I Maximum Authorized Monthly Arithmetic Mean Concentration	Column II Maximum Authorized Concentration in a Composite Sample	Column III Maximum Authorized Concentration in a Grab Sample
1.	Arsenic	0.5 mg/l	0.75 mg/l	1.0 mg/l
2.	Copper	0.3 mg/l	0.45 mg/l	0.6 mg/l
3.	Lead	0.2 mg/l	0.3 mg/l	0.4 mg/l
4.	Nickel	0.5 mg/l	0.75 mg/l	1.0 mg/l
5.	Zinc	0.5 mg/l	0.75 mg/l	1.0 mg/l
6.	Total Suspended Matter	25.0 mg/l	37.5 mg/l	50.0 mg/l
7.	Radium 226	10.0 pCi/l	20.0 pCi/l	30.0 pCi/l

NOTE: The concentrations are given as total values with the exception of Radium 226 which is a dissolved value after filtration of the sample through a 3 micron filter.

PART 2

AUTHORIZED LEVELS OF pH

Parameter	Column I Minimum Authorized Monthly Arithmetic mean pH	Column II Minimum Authorized pH in a Composite Sample	Column III Minimum Authorized pH in a Grab Sample
pH	6.0	5.5	5.0

SCHEDULE 2

DETERMINATION OF FREQUENCY WITH WHICH UNDILUTED EFFLUENTS ARE TO BE SAMPLED AND ANALYSED FOR PARTICULAR SUBSTANCES

Item	Substance	Column I At least Weekly If Concentration Is Equal To Or Greater Than	Column II At Least Every Two Weeks If Concentration Is Equal To Or Greater Than	Column III At Least Monthly If Concentration Is Equal To Or Greater Than
1.	Arsenic	0.5 mg/l	0.2 mg/l	0.10 mg/l
2.	Copper	0.3 mg/l	0.1 mg/l	0.05 mg/l
3.	Lead	0.2 mg/l	0.1 mg/l	0.05 mg/l
4.	Nickel	0.5 mg/l	0.2 mg/l	0.10 mg/l
5.	Zinc	0.5 mg/l	0.2 mg/l	0.10 mg/l
6.	Total Suspended Matter	25 mg/l	20 mg/l	15 mg/l
7.	Radium 226	10.0 pCi/l	5.0 pCi/l	2.5 pCi/l

NOTE: All concentrations given are total values with the exception of Radium 226 which is a dissolved value after filtering the sample through a 3 micron filter. Radium 226 need be measured in only those mines in which there is radioactive ore.

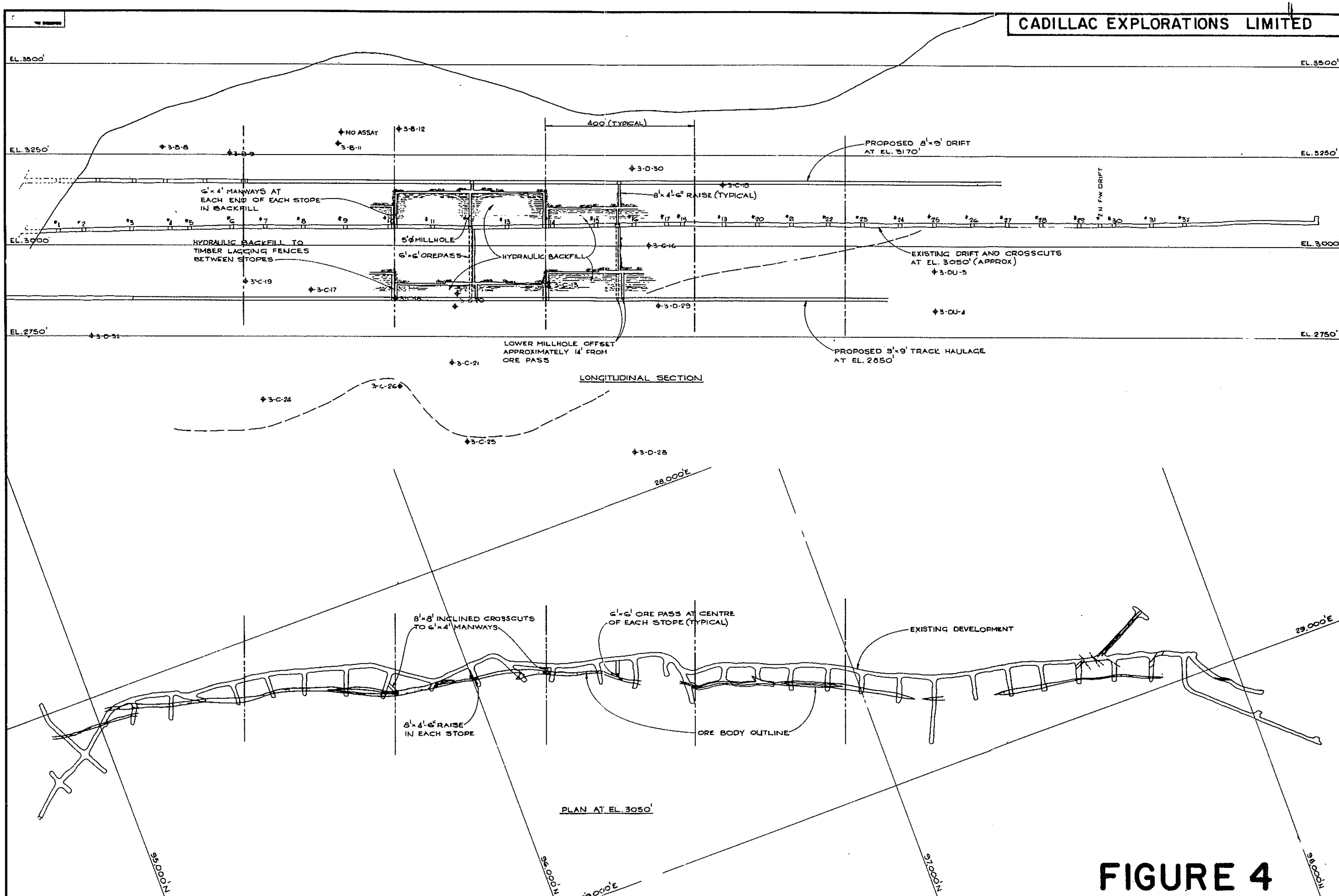


FIGURE 4

SCALE	1:1000
DESIGNED BY	R.H.S. JAN.80
DRAWN BY	P.A.H. JAN.80
CLIENT	CADILLAC EXPLORATIONS LTD
LOCATION	PRAIRIE CREEK N.W.T.
TITLE	PRAIRIE CREEK PROJECT — MINING PLAN AND SECTION
PROJECT No.	7439
DIVISION No.	15
DRAWING NUMBER	200-05-F01

KILBORN

DWG. NO. | REFERENCE DRAWINGS | DESCRIPTION | REVISIONS

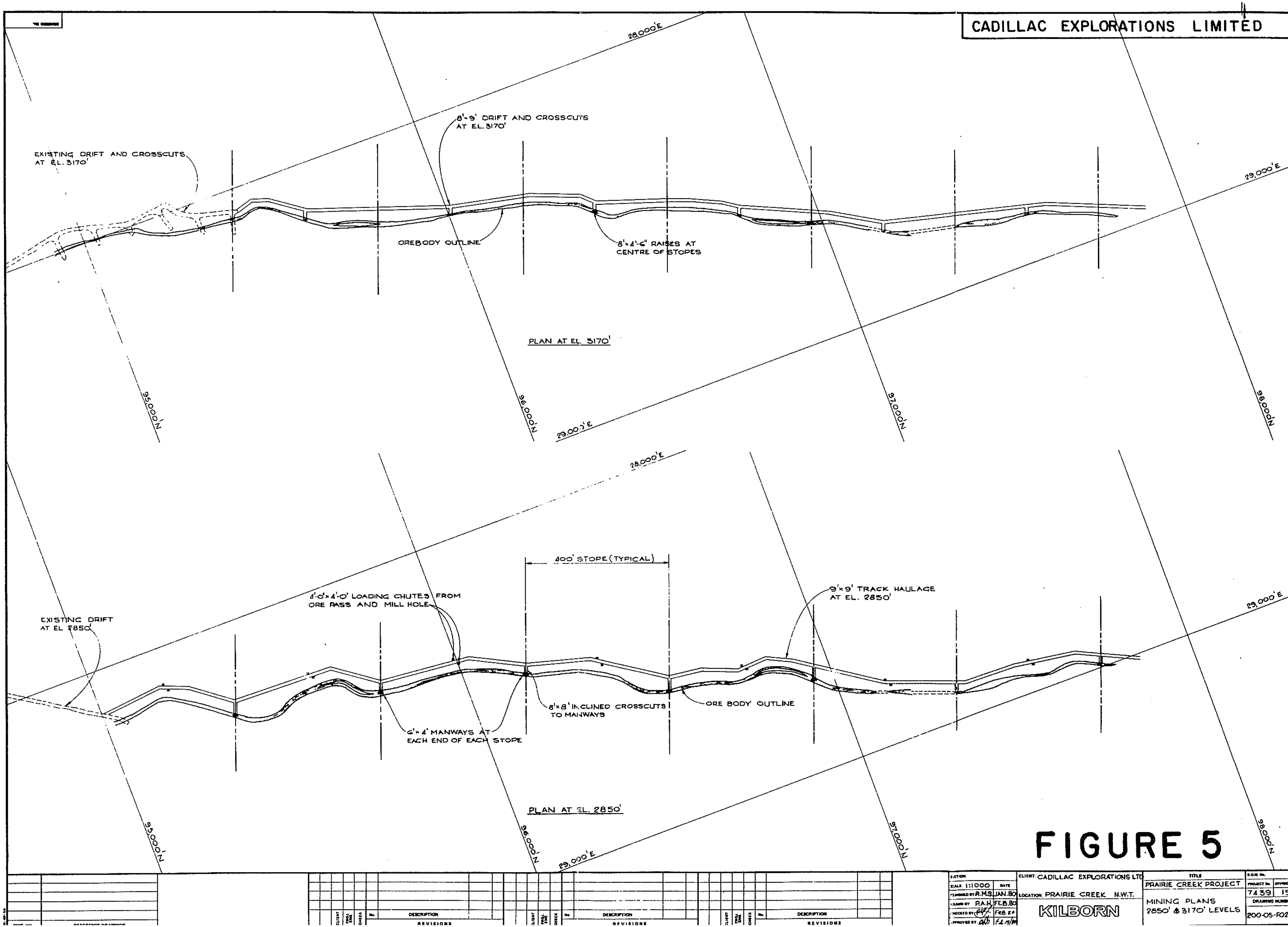

CADILLAC EXPLORATIONS LIMITED
EXISTING DRIFT AND CROSSCUTS AT EL. 3170'
8'-9' DRIFT AND CROSSCUTS AT EL. 3170'
OREBODY OUTLINE
8'x4'-6" RAISES AT CENTRE OF STOPES
PLAN AT EL. 3170'
28,000'E
29,000'E
95,000'N
96,000'N
97,000'N
98,000'N
400' STOPE (TYPICAL)
4'-0"x4'-0" LOADING CHUTES FROM ORE PASS AND MILL HOLE
EXISTING DRIFT AT EL 2850'
9'x9' TRACK HAULAGE AT EL. 2850'
8'x8' INCLINED CROSSCUTS TO MANWAYS
ORE BODY OUTLINE
6'x4' MANWAYS AT EACH END OF EACH STOPE
PLAN AT EL. 2850'
SCALE 1:1000
DESIGNED BY R.M.S. JAN.80
DRAWN BY P.A.H. FEB.80
CLIENT: CADILLAC EXPLORATIONS LTD
LOCATION: PRAIRIE CREEK N.W.T.
KILBORN
PRAIRIE CREEK PROJECT
MINING PLANS 2850' & 3170' LEVELS
7439
15
200-05-F02
DESCRIPTION
REVISIONS

FIGURE 5

CADILLAC EXPLORATIONS LIMITED

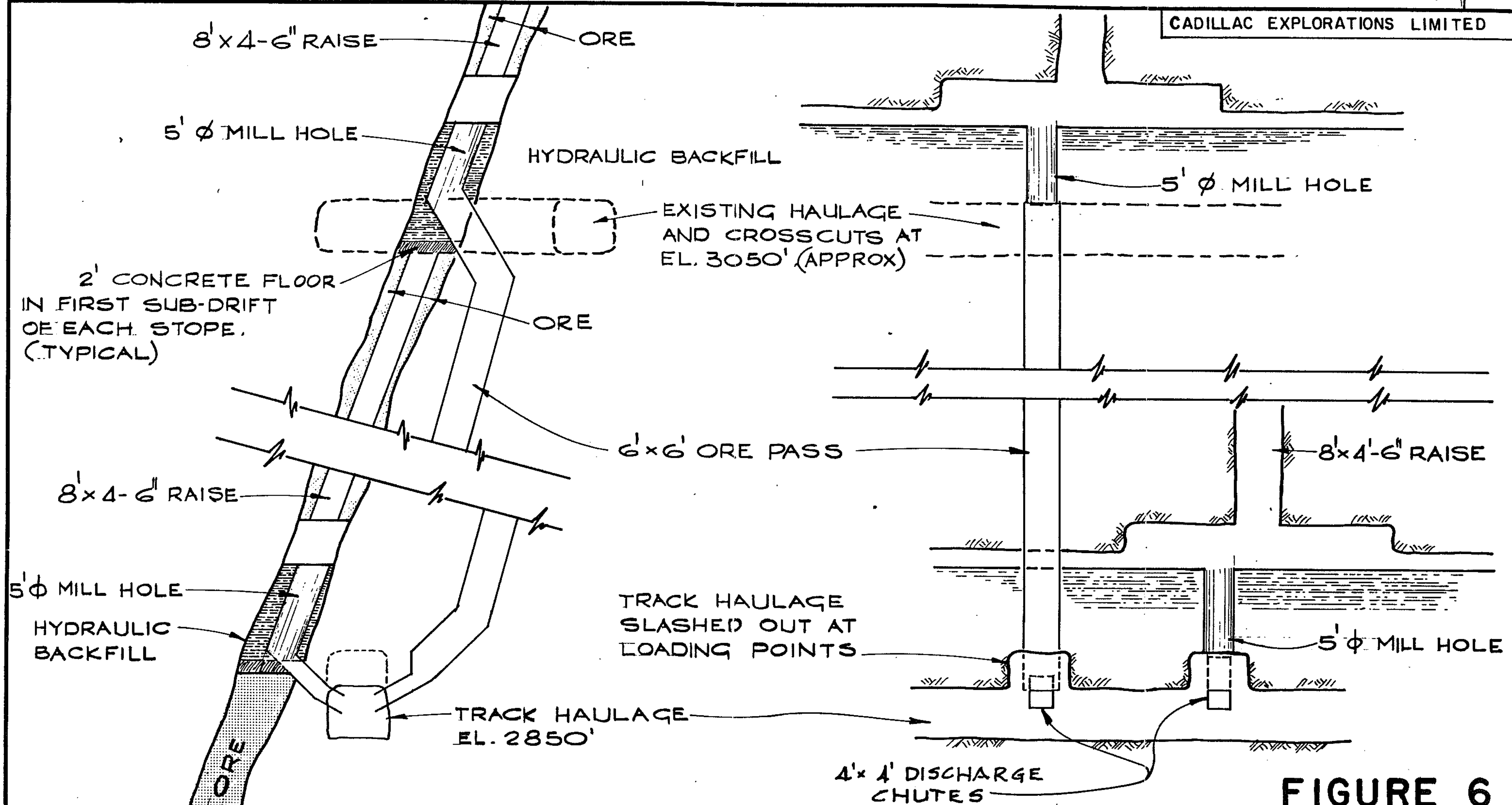


FIGURE 6

REV.	ISSUED FOR	DATE	APPVD.	No.	DATE	REVISION

CLIENT: CADILLAC EXPLORATIONS LTD.

LOCATION: PRAIRIE CREEK N.W.T

KILBORN ENGINEERING (B.C.) LTD.

SECTION | PROJECT No. | AREA No.

DRAWN P.A.H. FEB.80 | CHECKED | EQMT. No.

DATE | APPROVED | PROJ. APPR.

TITLE

PRAIRIE CREEK PROJECT
MINING METHOD
STOPING DETAILS

SHEET No. | CONT. ON | DWG. No. 200-05-F.03 | REV. No.

BCIL 5687B - K.E.

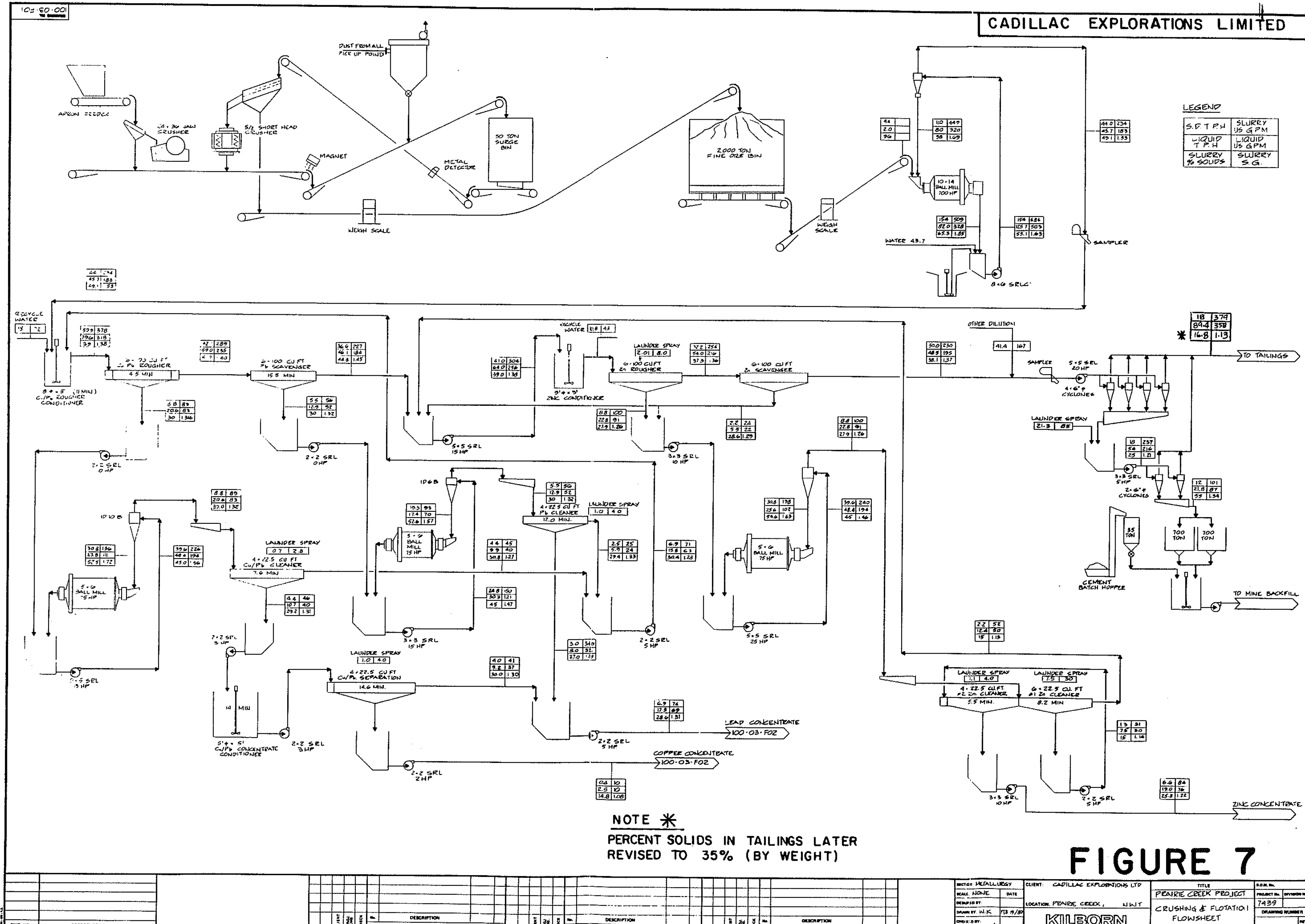
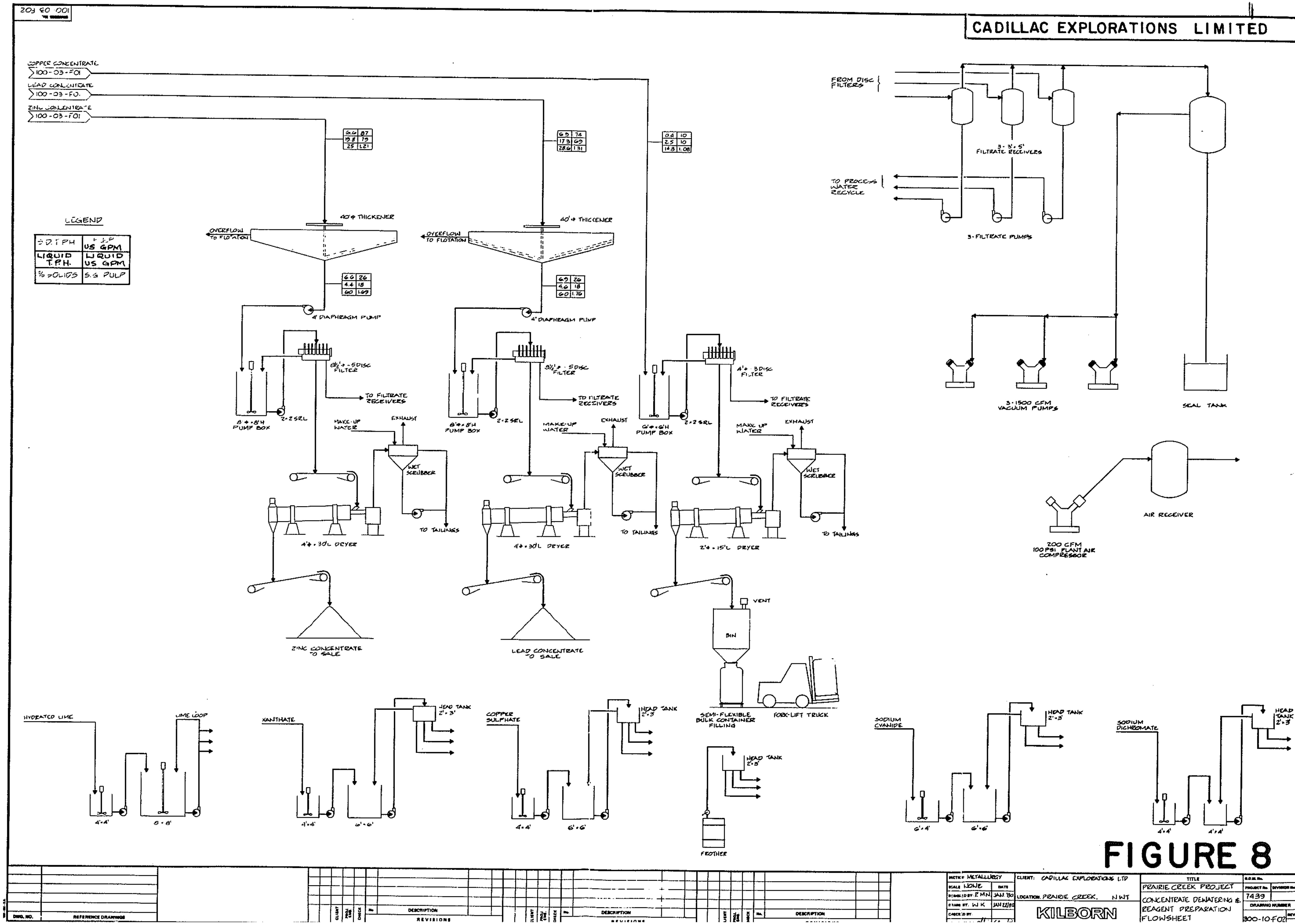
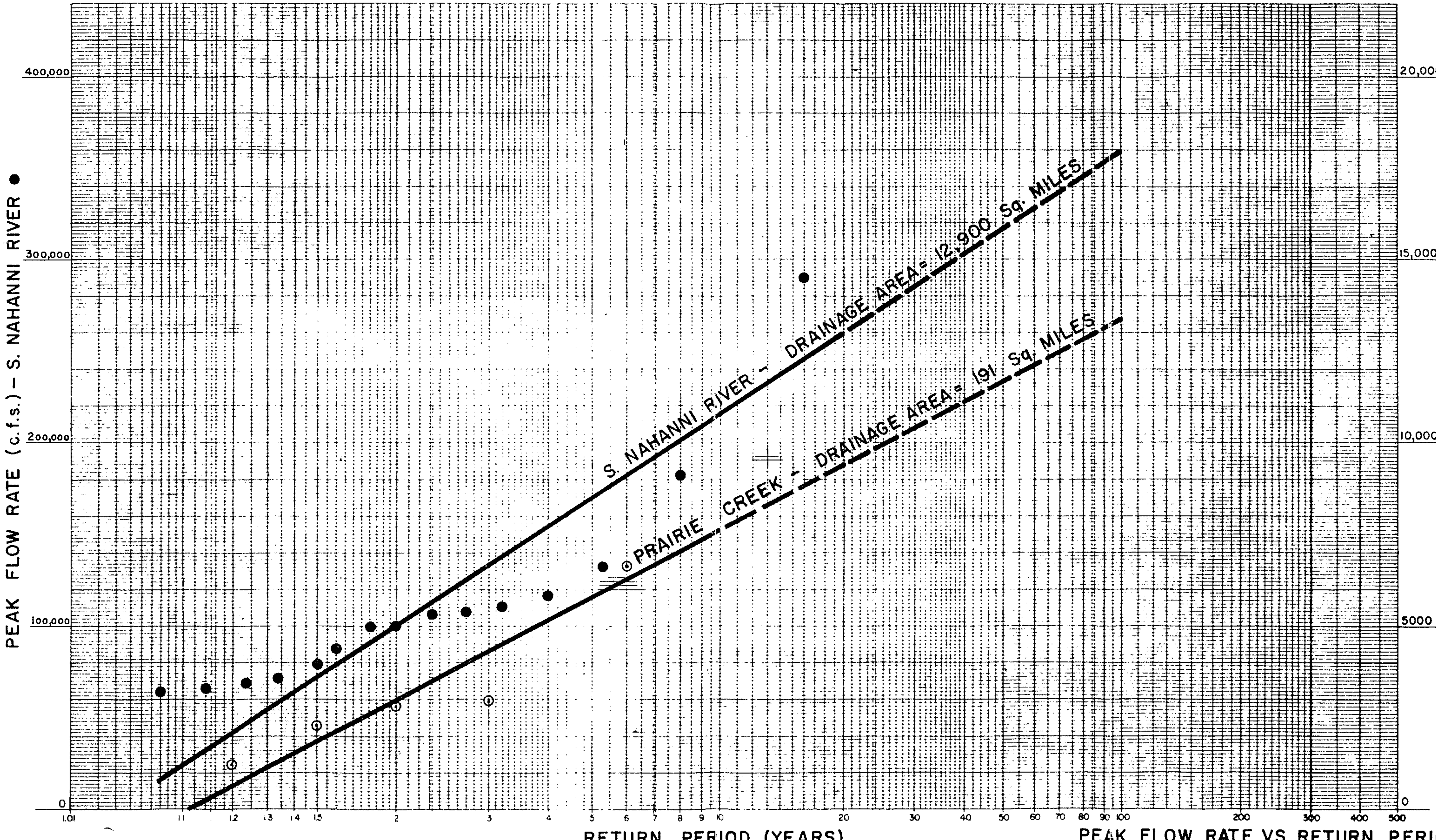

CADILLAC EXPLORATIONS LIMITED
APRON FEEDER
24 x 36 JAW CRUSHER
5 1/2 SHORT HEAD CRUSHER
DUST FROM ALL PICK UP POINTS
MAGNET
METAL DETECTOR
WEIGH SCALE
50 TON SURGE BIN
2000 TON FINE ORE BIN
10 x 14 BALL MILL 700 HP
WATER 43.7
SAMPLER
8 x 6 SRL
LEGEND
S.D.T.P.H
SLURRY US GPM
LIQUID T.P.H
LIQUID US GPM
SLURRY % SOLIDS
SLURRY S.G.
RECYCLE WATER
8 x 8' (11 MIN) Cu/Pb ROUGHER CONDITIONER
6 x 72 CU FT Cu/Pb ROUGHER
6 x 100 CU FT Pb SCAVENGER
RECYCLE WATER
9' x 9' ZINC CONDITIONER
LAUNDER SPRAY
6 x 100 CU FT Zn ROUGHER
6 x 100 CU FT Zn SCAVENGER
OTHER DILUTION
SAMPLER
5 x 5 SRL 20 HP
4 - 6" ø CYCLONES
TO TAILINGS
5 x 5 SRL 15 HP
3 x 3 SRL 10 HP
2 x 2 SRL 0 HP
5 x 6 BALL MILL 75 HP
4 x 22.5 CU FT Cu/Pb CLEANER
7.6 MIN
4 x 22.5 CU FT Pb CLEANER
17.0 MIN
5 x 6 BALL MILL 75 HP
5 x 5 SRL 25 HP
3 x 3 SRL 15 HP
2 x 2 SRL 5 HP
3 x 3 SRL 5 HP
2 - 6" ø CYCLONES
CEMENT BATCH HOPPER
700 TON
TO MINE BACKFILL
4 x 22.5 CU FT Cu/Pb SEPARATION
14.6 MIN.
5' x 5' Cu/Pb CONCENTRATE CONDITIONER
14 MIN
2 x 2 SRL 3 HP
2 x 2 SRL 2 HP
LEAD CONCENTRATE
100-03-F02
COPPER CONCENTRATE
100-03-F02
4 x 22.5 CU FT #2 Zn CLEANER
5.5 MIN.
6 x 22.5 CU FT #1 Zn CLEANER
8.2 MIN
3 x 3 SRL 10 HP
2 x 2 SRL 5 HP
ZINC CONCENTRATE
NOTE *
PERCENT SOLIDS IN TAILINGS LATER REVISED TO 35% (BY WEIGHT)
DWG. NO.
REFERENCE DRAWINGS
DESCRIPTION
REVISIONS
SECTOR METALLURGY
SCALE NONE
CLIENT: CADILLAC EXPLORATIONS LTD
LOCATION: PRAIRIE CREEK, N.W.T.
KILBORN
PRAIRIE CREEK PROJECT
CRUSHING & FLOTATION FLOWSHEET
7439
300-10-F01

FIGURE 7



CADILLAC EXPLORATIONS LIMITED
COPPER CONCENTRATE 100-03-F01
LEAD CONCENTRATE 100-03-F01
ZINC CONCENTRATE 100-03-F01
LEGEND
S.T.P.H. | US GPM
LIQUID T.P.H. | LIQUID US GPM
% SOLIDS | S.G. PULP
6.6 87 19.8 79 25 1.21
6.9 74 17.3 69 28.6 1.31
0.4 10 2.5 10 14.8 1.08
40'φ THICKENER
OVERFLOW TO FLOTATION
6.6 26 4.4 18 60 1.69
6.9 26 4.6 18 60 1.76
4' DIAPHRAGM PUMP
8½'φ - 5 DISC FILTER
4'φ 3 DISC FILTER
TO FILTRATE RECEIVERS
8' × 8'H PUMP BOX
6' × 6'H PUMP BOX
2×2 SRL
MAKE-UP WATER
EXHAUST
WET SCRUBBER
TO TAILINGS
4'φ × 30'L DRYER
2'φ × 15'L DRYER
ZINC CONCENTRATE TO SALE
LEAD CONCENTRATE TO SALE
VENT
BIN
SEMI-FLEXIBLE BULK CONTAINER FILLING
FORK-LIFT TRUCK
FROM DISC FILTERS
3 - 3' × 5' FILTRATE RECEIVERS
TO PROCESS WATER RECYCLE
3 - FILTRATE PUMPS
3 - 1500 CFM VACUUM PUMPS
SEAL TANK
AIR RECEIVER
200 CFM 100 PSI PLANT AIR COMPRESSOR
HYDRATED LIME
LIME LOOP
4' × 4'
8' × 8'
XANTHATE
HEAD TANK 2' × 3'
6' × 6'
COPPER SULPHATE
FROTHER
SODIUM CYANIDE
SODIUM DICHROMATE
DWG. NO.
REFERENCE DRAWINGS
DESCRIPTION
REVISIONS
METALLURGY
SCALE NONE
DATE
DESIGNED BY E M N JAN '80
DRAWN BY W K JAN 22/80
CHECKED BY
CLIENT: CADILLAC EXPLORATIONS LTD
LOCATION: PRAIRIE CREEK, N.W.T.
KILBORN
TITLE
PRAIRIE CREEK PROJECT
CONCENTRATE DEWATERING & REAGENT PREPARATION FLOWSHEET
PROJECT No. 7439
DRAWING NUMBER 300-10-F02
REV

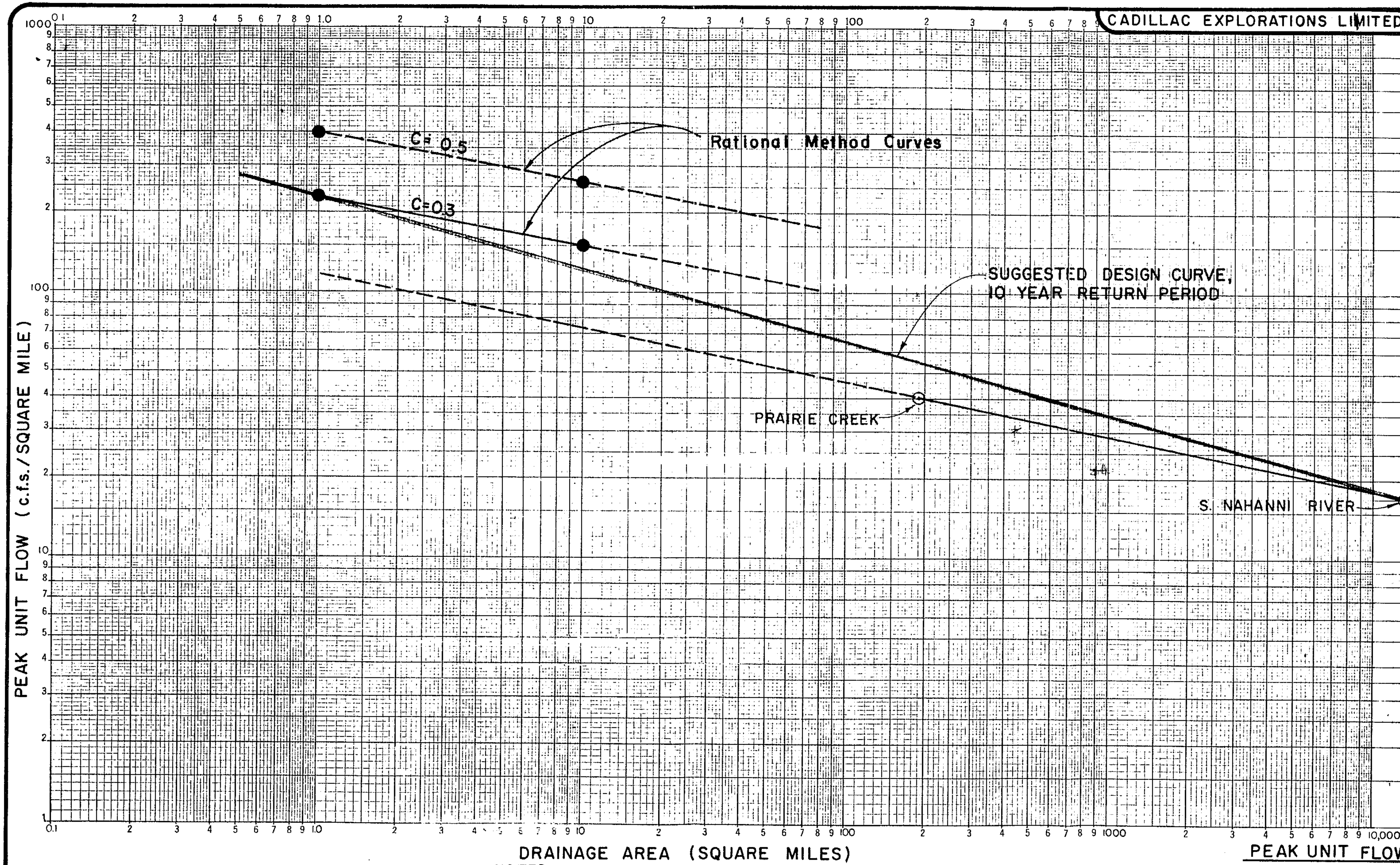
FIGURE 8



PEAK FLOW RATE VS RETURN PERIOD
S. NAHANNI RIVER & PRAIRIE CREEK

FIGURE 19

CADILLAC EXPLORATIONS LIMITED



LEGEND

⊙ BASED ON FREQUENCY ANALYSIS OF STREAMFLOW DATA (SNOWMELT)

● BASED ON RATIONAL METHOD (RAINFALL)

NOTES

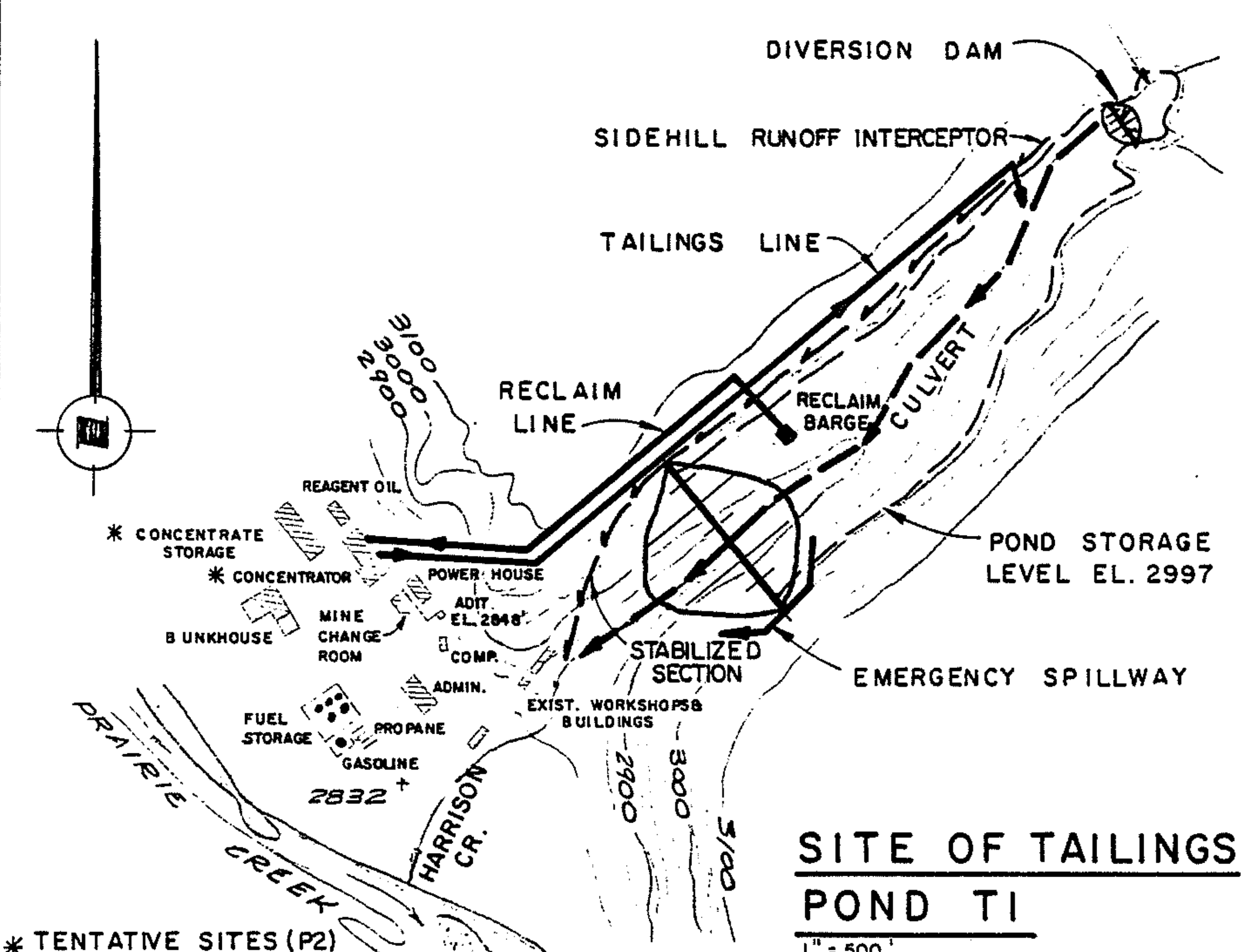
1. ON THE BASIS OF THE STREAMFLOW ANALYSIS, THE FACTORS FOR RETURN PERIODS FOR OTHER THAN 10 YEAR ARE:
   $Q_5 = 0.8Q_{10}$; $Q_{50} = 1.5\,Q_{10}$
   $Q_{25} = 1.3Q_{10}$; $Q_{100} = 1.7\,Q_{10}$
2. C= RUNOFF COEFFICIENT FOR RATIONAL METHOD.

PEAK UNIT FLOW VS DRAINAGE AREA

FIGURE 20

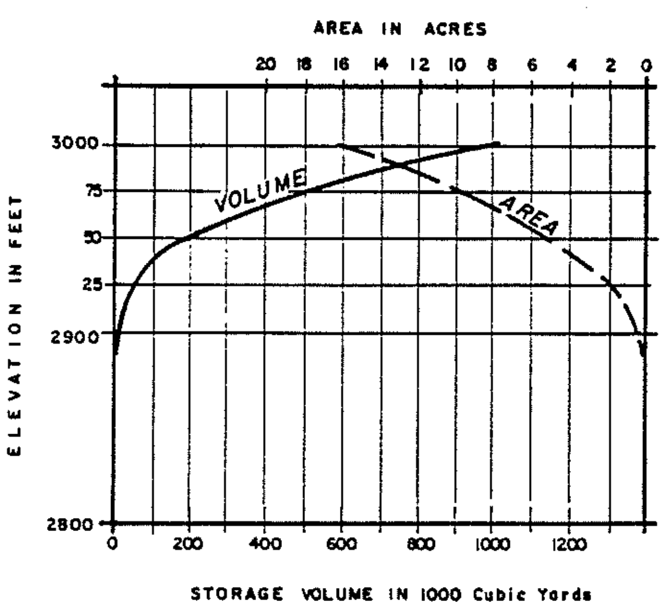
KER, PRIESTMAN & ASSOCIATES LTD.

CADILLAC EXPLORATIONS LIMITED



SITE OF TAILINGS POND T1

1" = 500'



POND VOLUME/AREA CURVE

Dam Crest Elevation = 3006'

Max. Dam Height = 131'

Length of Dam = 550'

Dam Fill Req'd = 350,000 cu.yds.

Life of Pond = 6.0 years*

Total Catchment Area = 1905 Acs.

*Note

If dam borrow material can be taken from behind dam, storage will be increased.

FIGURE 9a

VANCAL - 2988

KER, PRIESTMAN & ASSOCIATES LTD

VANCAL · 2988

KER, PRIESTMAN & ASSOCIATES LTD

CADILLAC EXPLORATIONS LIMITED

MATERIAL BALANCE - TAILINGS POND T1

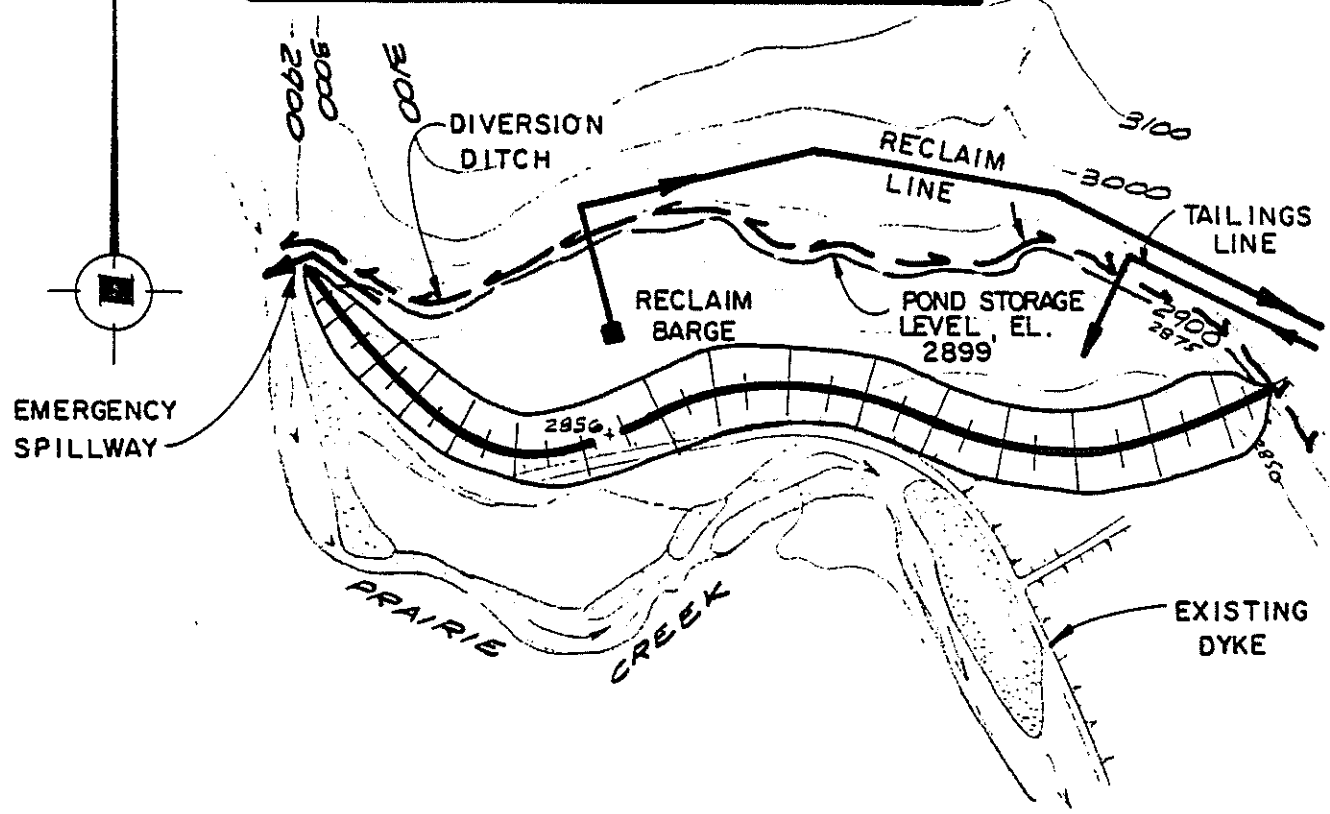
(Quantities in thousand cubic yards, unless otherwise noted)

Year	Assumed Precipitation (in/yr)	(1) Tailings into Pond (2+3) (Note 1)	(2) Water in Tailings Slurry	(3) Solids in Tailings Slurry	(4) Settled Solids + Entrained Water (Note 2)	(5) Permanent Ice Formed (Note 3)	(6) Storage Req'd for Solids + Ice (4+5)	(7) Cumulative Solids + Ice	(8) Direct Precipitation (Note 4)	(9) Runoff (Note 5)	(10) Evaporation (Note 6)	(11) Water Pumped from Pond (1+8+9-4-5-10)		(12) Reclaim to Mill (Note 7)	(13) Water Discharged to Creek (11-12)	(14) Elev. of Solids + Ice (feet)	(15) Minimum Dam Elevation Req'd (Note 8)
												USgpm	1000 yd3				
0-1	12	393.1	333.3	59.8	119.6	45.6	165.2	165.2	26.1	107.4	2.5	143	358.9	358.9	0	2945	2954
1-2	16	393.1	333.3	59.8	119.6	45.6	165.2	330.4	34.7	143.2	5.6	160	400.2	371.3	28.9 (11.6 USGPM)	2963	2972
2-3	24	393.1	333.3	59.8	119.6	45.6	165.2	495.6	52.2	214.9	8.6	194	486.4	371.3	115.1 (46.0 USGPM)	2975	2984
3-6	16	1179.3	999.9	179.4	358.8	136.8	495.6	991.2	104.2	429.6	40.1	157	1177.4	1113.9	63.5 (8.5 USGPM)	2997	3006
6-10	16	1572.4	1333.2	239.2	478.4	182.4	660.8	1652.0	138.9	572.8	81.4	154	1541.9	1485.2	56.7 (5.7 USGPM)	~3011	3020
Total		3931.0	3333.0	598.0	1196.0	456.0	1652.0		356.1	1467.9	138.2		3964.8	3700.6	264.2		

NOTES

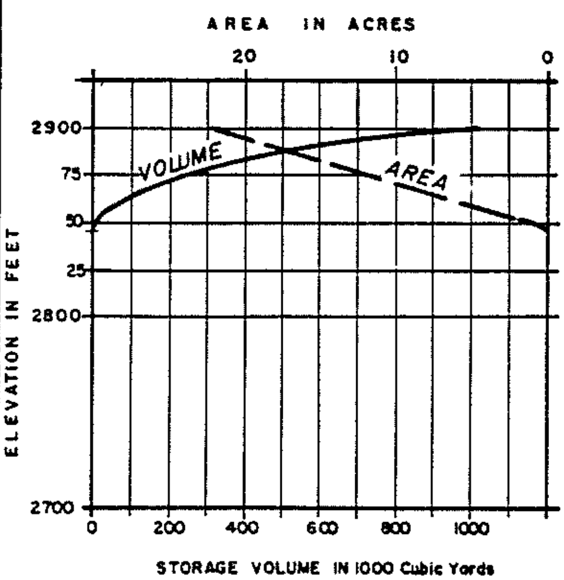
1. Solids to Pond 18.0 short tons/hour; s.g. solids 3.0; tailings slurry 35% solids by weight; production 350 days/yr.
2. Settled Solids contain 25% moisture (by weight).
3. Permanently frozen tailings assumed equiv. to 2 months discharge per year.
4. Pond Area 16 acres; snow considered in terms of water equivalent.
5. Runoff Area (excl. of pond) = 1889 acres; diversion ditch 80 % effective; Yield factor = 0.90
6. Evaporation; 10 in/yr.
7. Max. reclaim to mill 371.3 $\times 10^3$ yds^3/yr.
8. Min. dam elevation = solids + ice + 5' water storage + 4' freeboard.
9. Zero seepage assumed.

CADILLAC EXPLORATIONS LIMITED



SITE OF TAILINGS POND T2

1" = 500'



POND VOLUME/AREA CURVE

Dam Crest Elevation = 2908'

Max. Dam Height = 58'

Length of Dam = 2800'

Dam Fill Req'd = 640,000 cu.yds.

Life of Pond = 6.0 years *

Total Catchment Area = 189 Acres.

Note
If dam borrow material can be taken from behind dam, storage will be increased.

FIGURE 10a

KER, PRIESTMAN & ASSOCIATES LTD

VANCAL - 2988

VANCAL - 2988

MATERIAL BALANCE - TAILINGS POND T2

(Quantities in thousand cubic yards, unless otherwise noted)

Year	Assumed Precipitation (in/yr)	(1) Tailings into Pond (2+3) (Note 1)	(2) Water in Tailings Slurry	(3) Solids in Tailings Slurry	(4) Settled Solids + Entrained Water (Note 2)	(5) Permanent Ice Formed (Note 3)	(6) Storage Req'd for Solids + Ice (4+5)	(7) Cumulative Solids + Ice	(8) Direct Precipitation (Note 4)	(9) Runoff (Note 5)	(10) Evaporation (Note 6)	(11) Water Pumped from Pond (1+8+9-4-5-10)		(12) Reclaim to Mill (Note 7)	(13) Water Discharged to Creek (11-12)	(14) Elev. of Solids + Ice (feet)	(15) Minimum Dam Elevation Req'd (Note 8)
												USgpm	1000 yd3				
0-1	12	393.1	333.3	59.8	119.6	45.6	165.2	165.2	35.3	48.4	6.2	122	305.4	305.4	0	2864	2873
1-2	16	393.1	333.3	59.8	119.6	45.6	165.2	330.4	47.0	68.8	12.0	132	331.7	331.7	0	2876	2885
2-3	24	393.1	333.3	59.8	119.6	45.6	165.2	495.6	70.6	97.2	16.3	151	379.4	371.3	8.1 (13.2 USGPM)	2884	2893
3-6	16	1179.3	999.9	179.4	358.8	136.8	495.6	991.2	141.2	206.4	70.3	128	961.0	961.0	0	2899	2908
6-10	16	1572.4	1333.2	239.2	478.4	182.4	660.8	1652.0	188.2	275.2	122.0	125	1253.0	1253.0	0	~2908	2917
Total		3931.0	3333.0	598.0	1196.0	456.0	1652.0		482.3	696.0	226.8		3230.5	3222.4	8.1		

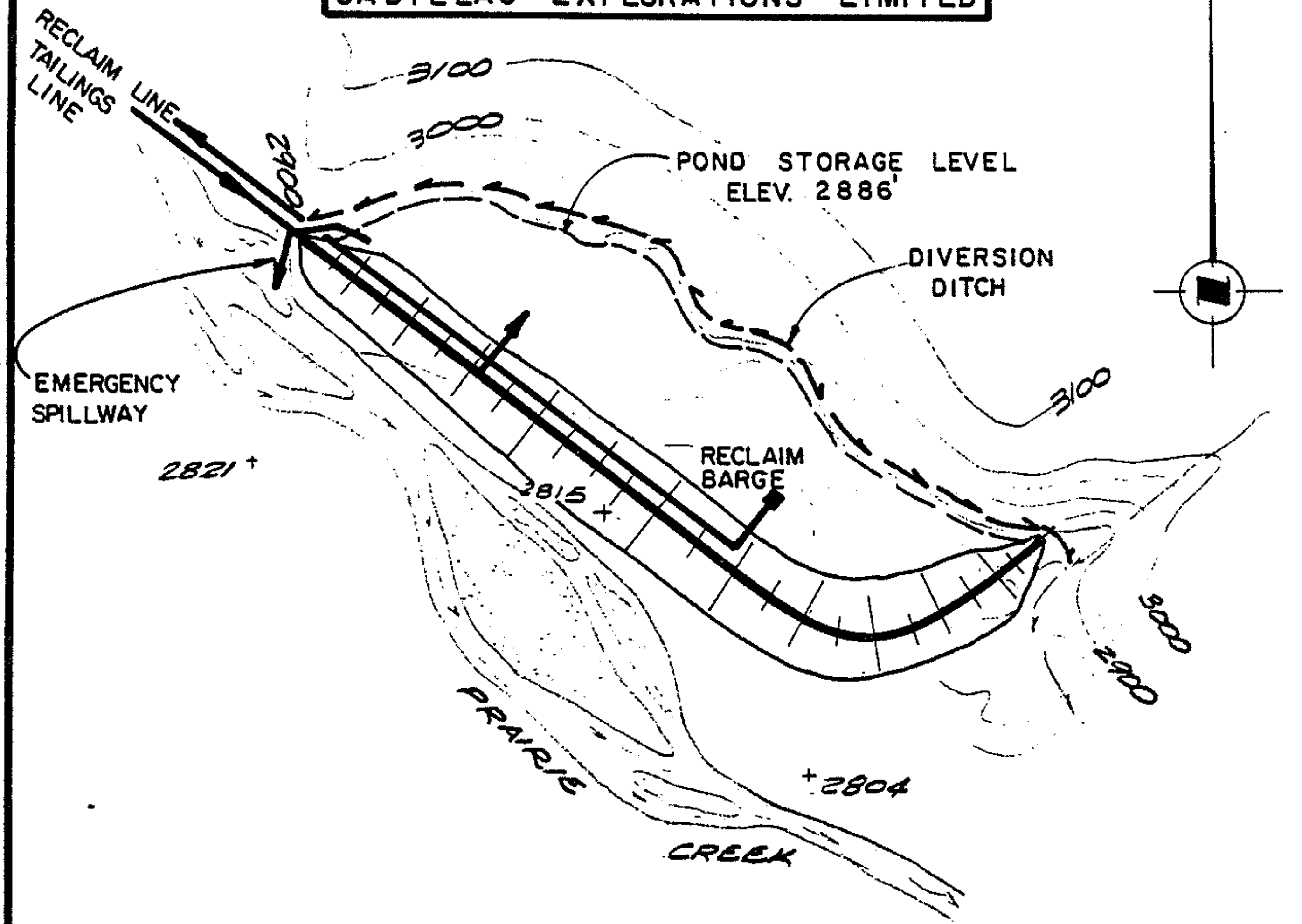
NOTES

1. Solids to Pond 18.0 short tons/hour; s.g. solids 3.0; tailings slurry 35% solids by weight; production 350 days/yr.
2. Settled Solids contain 25% moisture (by weight).
3. Permanently frozen tailings assumed equiv. to 2 months discharge per year.
4. Pond Area 26 acres; snow considered in terms of water equivalent.
5. Runoff Area (excl. of pond) = 163 acres; diversion ditch 80% effective; Yield Factor = 0.90
6. Evaporation; 10 in/yr.
7. Max. reclaim to mill 371.3×10^3 yds^3/yr.
8. Min. dam elevation = solids + ice + 5' water storage + 4' freeboard.
9. Zero seepage assumed.

KER, PRIESTMAN & ASSOCIATES LTD

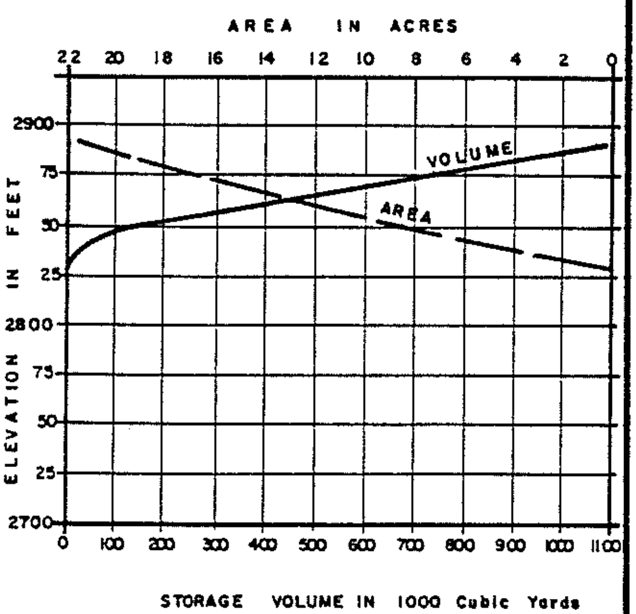
CADILLAC EXPLORATIONS LIMITED

CADILLAC EXPLORATIONS LIMITED



SITE OF TAILINGS POND T3

1" = 500'



POND VOLUME/AREA CURVE

Dam Crest Elevation = 2895'

Max. Dam Height = 68'

Length of Dam = 2550'

Dam Fill Req'd = 850,000 cu.yds.

Life of Pond = * 6.0 years

Total Catchment Area = 112 Acres

* Note.
If dam borrow material can be taken from behind dam, storage will be increased

FIGURE 11a

KER, PRIESTMAN & ASSOCIATES LTD

VANCAL - 2988

MATERIAL BALANCE - TAILINGS POND T3

(Quantities in thousand cubic yards, unless otherwise noted)

Year	Assumed Precipitation (in/yr)	(1) Tailings Into Pond (2+3) (Note 1)	(2) Water In Tailings Slurry	(3) Solids In Tailings Slurry	(4) Settled Solids + Entrained Water (Note 2)	(5) Permanent Ice Formed (Note 3)	(6) Storage Req'd for Solids + Ice (4+5)	(7) Cumulative Solids + Ice	(8) Direct Precipitation (Note 4)	(9) Runoff (Note 5)	(10) Evaporation (Note 6)	(11) Water Pumped From Pond (1+8+9-4-5-10) USgpm	(11) 1000 yd³	(12) Reclaim To Mill (Note 7)	(13) Water Discharged To Creek (11-12)	(14) Elev. Of Solids + Ice (Feet)	(15) Minimum Dam Elevation Req'd (Note 8)
0-1	12	393.1	333.3	59.8	119.6	45.6	165.2	165.2	34.7	26.3	8.1	112	280.8	280.8	0	2852	2861
1-2	16	393.1	333.3	59.8	119.6	45.6	165.2	330.4	46.2	35.0	13.4	118	295.7	295.7	0	2862	2871
2-3	24	393.1	333.3	59.8	119.6	45.6	165.2	495.6	69.4	52.6	16.4	133	333.5	333.5	0	2870	2879
3-6	16	1179.3	999.9	179.4	358.8	136.8	495.6	991.2	138.6	105.0	66.0	115	861.3	861.3	0	2886	2895
6-10	17	1572.4	1333.2	239.2	478.4	182.4	660.8	1652.0	184.8	140.0	110.0	112	1126.4	1126.4	0	2900	2909
Total		3931.0	3333.0	598.0	1196.0	456.0	1652.0		473.7	358.9	213.9		2897.7	2897.7	0		

NOTES

1. Solids to Pond 18.0 short tons/hour; s.g. solids 3.0; tailings slurry 35% solids by weight; production 350 days/yr.
2. Settled Solids contain 25% moisture (by weight).
3. Permanently frozen tailings assumed equiv. to 2 months discharge per year.
4. Pond Area 21.5 acres; snow considered in terms of water equivalent.
5. Runoff Area (excl. of pond) = 90.5 acres; diversion ditch 80% effective; yield factor = 0.90
6. Evaporation; 10 in/yr.
7. Max. reclaim to mill 371.3 × 10³ yds³/yr.
8. Min. dam elevation = solids + ice + 5' water storage + 4' freeboard.
9. Zero seepage assumed.

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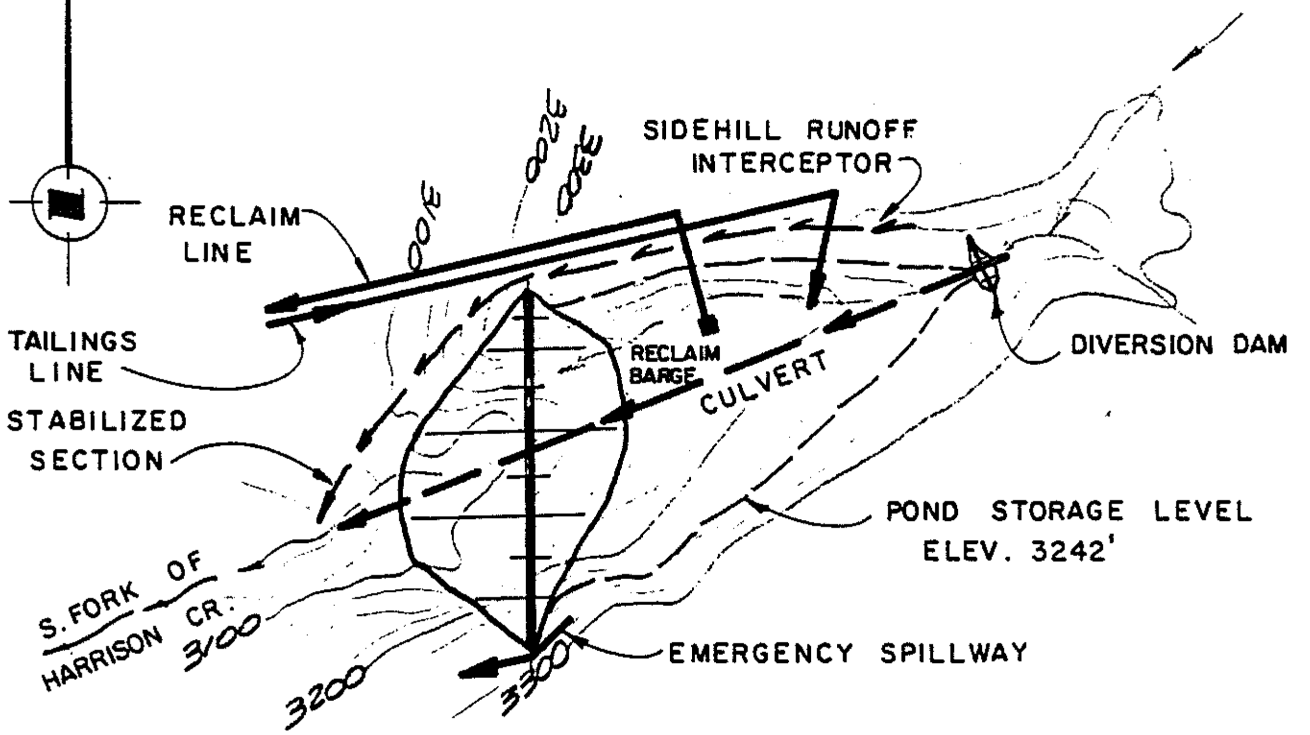
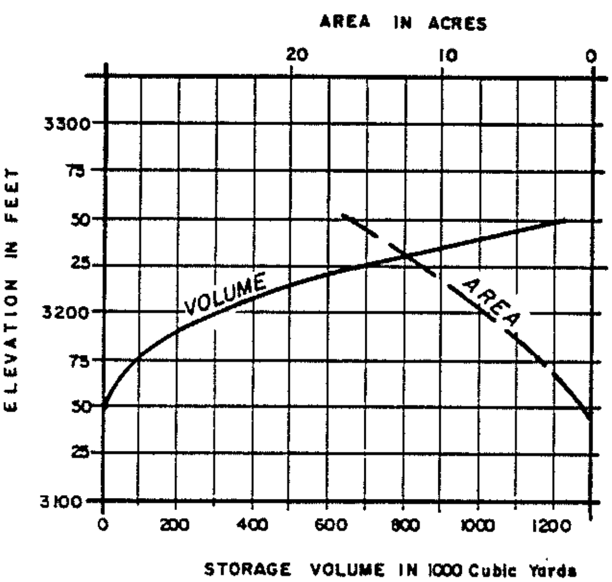


SITE OF TAILINGS POND T4

1" = 500'

Dam Crest Elevation = 3251'
Max. Dam Height = 151'
Length of Dam = 970'
Dam Fill Req'd = 850,000 cu. yds.
Life of Pond = 6.0 years *
Total Catchment Area = 808 Acres

* Note
If dam borrow material can be taken from behind dam, storage will be increased.



POND VOLUME/AREA CURVE

FIGURE 12a

VANCAL - 2988

KER, PRIESTMAN & ASSOCIATES LTD

VANCAL - 2988

MATERIAL BALANCE - TAILINGS POND T4

(Quantities in thousand cubic yards, unless otherwise noted)

Year	Assumed Precipitation (in/yr)	(1) Tailings Into Pond (2+3) (Note 1)	(2) Water In Tailings Slurry	(3) Solids In Tailings Slurry	(4) Settled Solids + Entrained Water (Note 2)	(5) Permanent Ice Formed (Note 3)	(6) Storage Req'd for Solids + Ice (4+5)	(7) Cumulative Solids + Ice	(8) Direct Precipitation (Note 4)	(9) Runoff (Note 5)	(10) Evaporation (Note 6)	(11) Water Pumped From Pond (1+8+9-4-5-10) USgpm	(11) 1000 yd3	(12) Reclaim To Mill (Note 7)	(13) Water Discharged To Creek (11-12)	(14) Elev. Of Solids + Ice (feet)	(15) Minimum Dam Elevation Req'd (Note 8)
0-1	12	393.1	333.3	59.8	119.6	45.6	165.2	165.2	25.7	21.7	4.0	109	271.3	271.3	0	3186	3195
1-2	16	393.1	333.3	59.8	119.6	45.6	165.2	330.4	34.2	29.0	7.1	114	284.0	284.0	0	3204	3213
2-3	24	393.1	333.3	59.8	119.6	45.6	165.2	495.6	51.4	43.5	9.6	125	313.2	313.2	0	3215	3224
3-6	16	1179.3	999.9	179.4	358.8	136.8	495.6	991.2	102.8	87.0	40.1	111	833.4	833.4	0	3242	3251
6-10	16	1572.4	1333.2	239.2	478.4	182.4	660.8	1652.0	137.0	116.0	75.2	109	1089.4	1089.4	0	~3265	~3274
Total		3931.0	3333.0	598.0	1196.0	456.0	1652.0		351.1	297.2	136.0		2791.3	2791.3	0		

NOTES

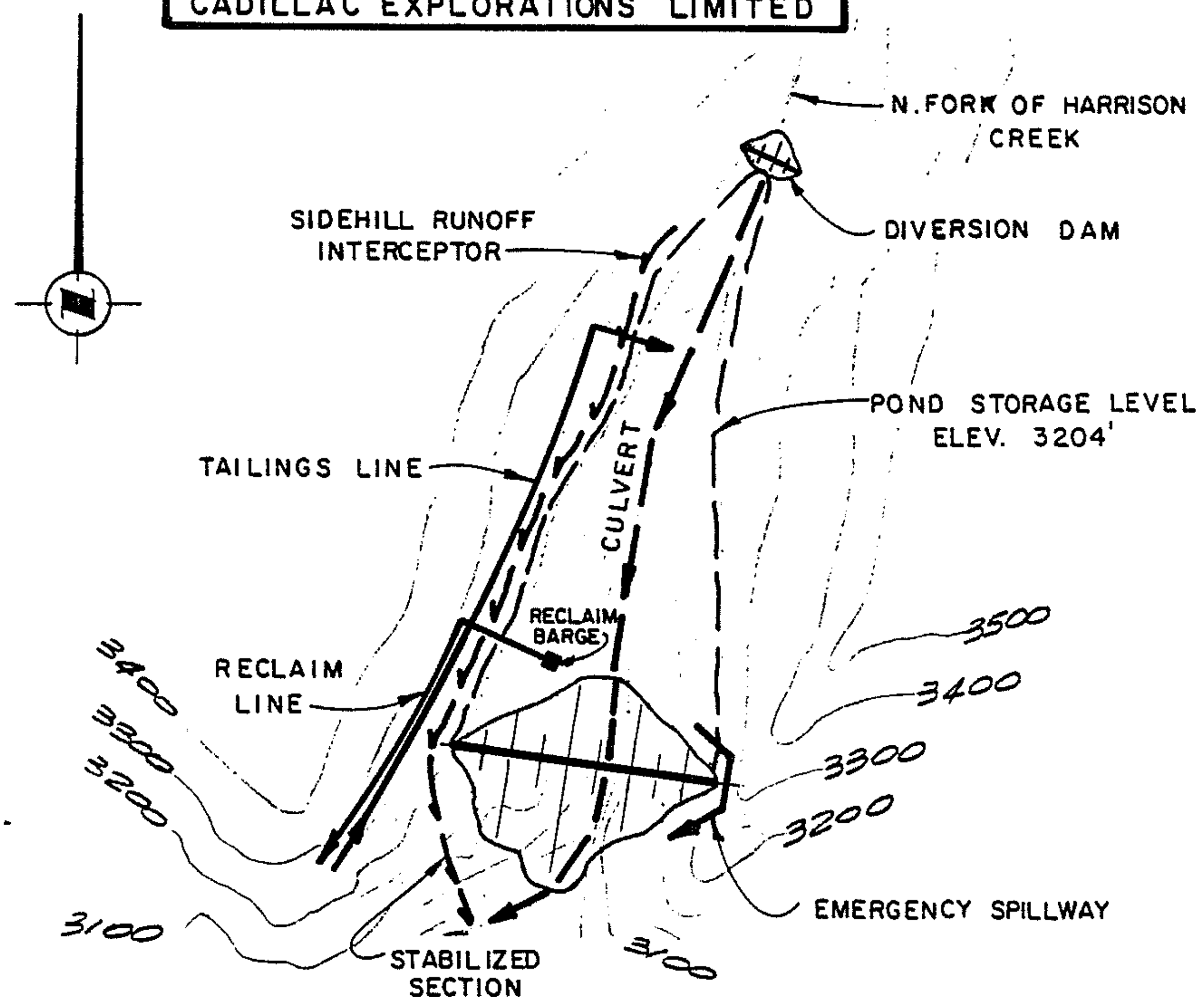
1. Solids to Pond 18.0 short tons/hour; s.g. solids 3.0; tailings slurry 35% solids by weight; production 350 days/yr.
2. Settled Solids contain 25% moisture (by weight).
3. Permanently frozen tailings assumed equiv. to 2 months discharge per year.
4. Pond Area 16 acres; snow considered in terms of water equivalent.
5. Runoff Area (excl. of pond) = 792 acres; diversion ditch 80% effective; yield factor = 0.90
6. Evaporation; 10. in/yr.
7. Max. reclaim to mill 371.3 $\times 10^3$ yds^3/yr.
8. Min. dam elevation = solids + ice + 5' water storage + 4' freeboard.
9. Zero seepage assumed.

CADILLAC EXPLORATIONS LIMITED

KER, PRIESTMAN & ASSOCIATES LTD

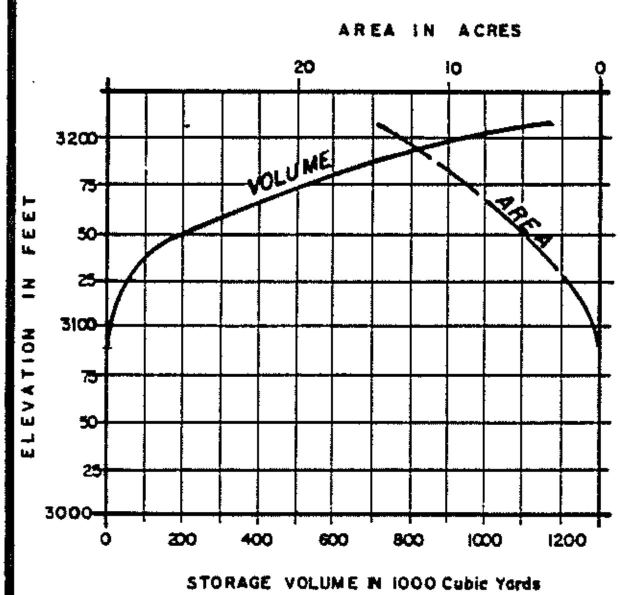
FIGURE 12b

CADILLAC EXPLORATIONS LIMITED



SITE OF TAILINGS POND T5

1" = 500'



POND VOLUME / AREA CURVE

Dam Crest Elevation = 3213'
Max. Dam Height = 138'
Length of Dam = 750'
Dam Fill Req'd = 640,000 cu.yds.
Life of Pond = 6.0 years *
Total Catchment Area. = 728 Acres

* Note
If dam borrow material can be taken from behind dam, storage will be increased.

FIGURE 13a

KER, PRIESTMAN & ASSOCIATES LTD

VANCAL - 2988

VANCAL - 2988

MATERIAL BALANCE - TAILINGS POND T5

(Quantities in thousand cubic yards, unless otherwise noted)

Year	Assumed Precipitation (in/yr)	(1) Tailings Into Pond (2+3) (Note 1)	(2) Water In Tailings Slurry	(3) Solids In Tailings Slurry	(4) Settled Solids + Entrained Water (Note 2)	(5) Permanent Ice Formed (Note 3)	(6) Storage Req'd for Solids + Ice (4+5)	(7) Cumulative Solids + Ice	(8) Direct Precipitation (Note 4)	(9) Runoff (Note 5)	(10) Evaporation (Note 6)	(11) Water Pumped From Pond (1+8+9-4-5-10)		(12) Reclaim To Mill (Note 7)	(13) Water Discharged To Creek (11-12)	(14) Elev. Of Solids + Ice (Feet)	(15) Minimum Dam Elevation Req'd (Note 8)
												USgpm	1000 yd3				
0-1	12	393.1	333.3	59.8	119.6	45.6	165.2	165.2	29.1	27.3	2.5	112	281.8	281.8	0	3140	3149
1-2	16	393.1	333.3	59.8	119.6	45.6	165.2	330.4	38.7	36.4	5.6	119	297.4	297.4	0	3160	3169
2-3	24	393.1	333.3	59.8	119.6	45.6	165.2	495.6	58.2	54.5	8.3	132	332.3	332.3	0	3174	3183
3-6	16	1179.3	999.9	179.4	358.8	136.8	495.6	991.2	116.3	109.2	37.0	116	872.2	872.2	0	3204	3213
6-10	16	1572.4	1333.2	239.2	478.4	182.4	660.8	1652.0	155.0	145.6	71.5	114	1140.7	1140.7	0	~3228	3227
Total		3931.0	3333.0	598.0	1196.0	456.0	1652.0		397.3	373.0	124.9		2924.4	2924.4	0		

NOTES

1. Solids to Pond 18.0 short tons/hour; s.g. solids 3.0; tailings slurry 35% solids by weight; production 350 days/yr.
2. Settled Solids contain 25% moisture (by weight).
3. Permanently frozen tailings assumed equiv. to 2 months discharge per year.
4. Pond Area 18 acres; snow considered in terms of water equivalent.
5. Runoff Area (excl. of pond) = 710 acres; diversion ditch 80 % effective; yield factor = 0.90
6. Evaporation; 10 in/yr.
7. Max. reclaim to mill 371.3 x 10^3 yds^3/yr.
8. Min. dam elevation = solids + ice + 5' water storage + 4' freeboard.
9. Zero seepage assumed.

CADILLAC EXPLORATIONS LIMITED

KER, PRIESTMAN & ASSOCIATES LTD

FIGURE 13 b

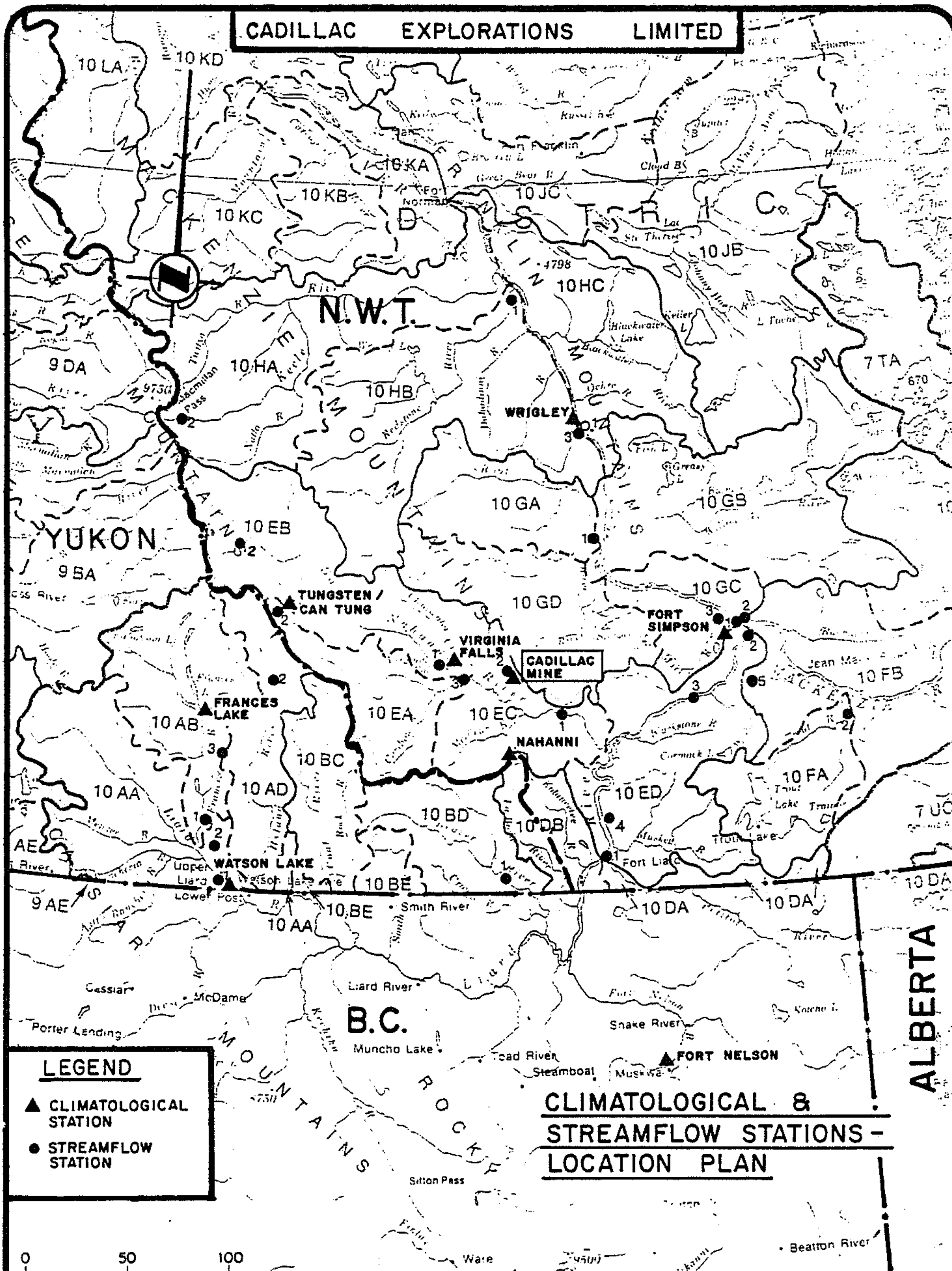


FIGURE 14

KER, PRIESTMAN & ASSOCIATES LTD

95E

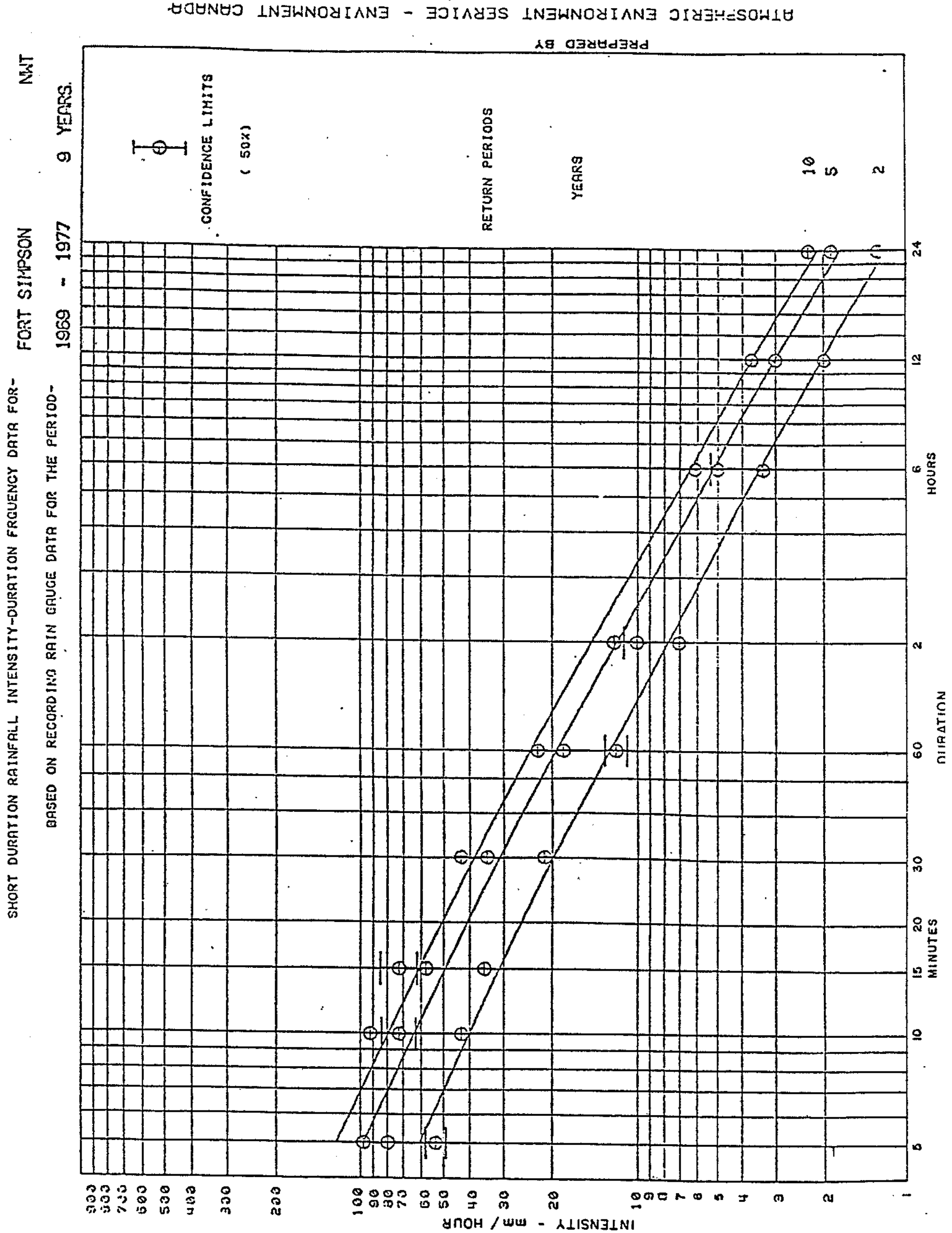
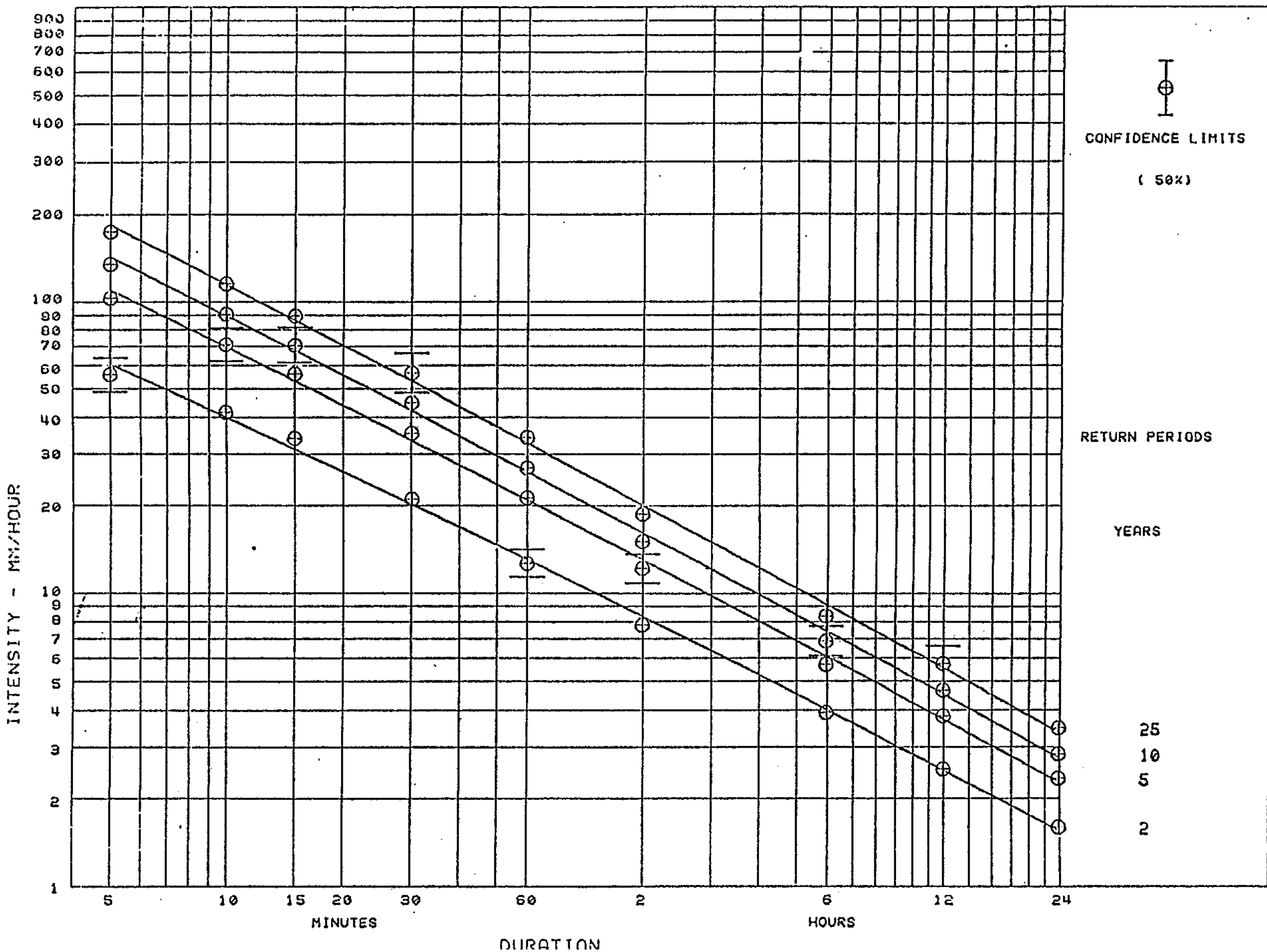

SHORT DURATION RAINFALL INTENSITY-DURATION FRQUENCY DATA FOR-
FORT SIMPSON
NWT
BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD-
1969 - 1977
9 YEARS.
CONFIDENCE LIMITS
(50%)
RETURN PERIODS
YEARS
10
5
2
PREPARED BY
ATMOSPHERIC ENVIRONMENT SERVICE - ENVIRONMENT CANADA
INTENSITY - mm / HOUR
DURATION
MINUTES
HOURS
5
10
15
20
30
60
2
6
12
24

FIGURE 15

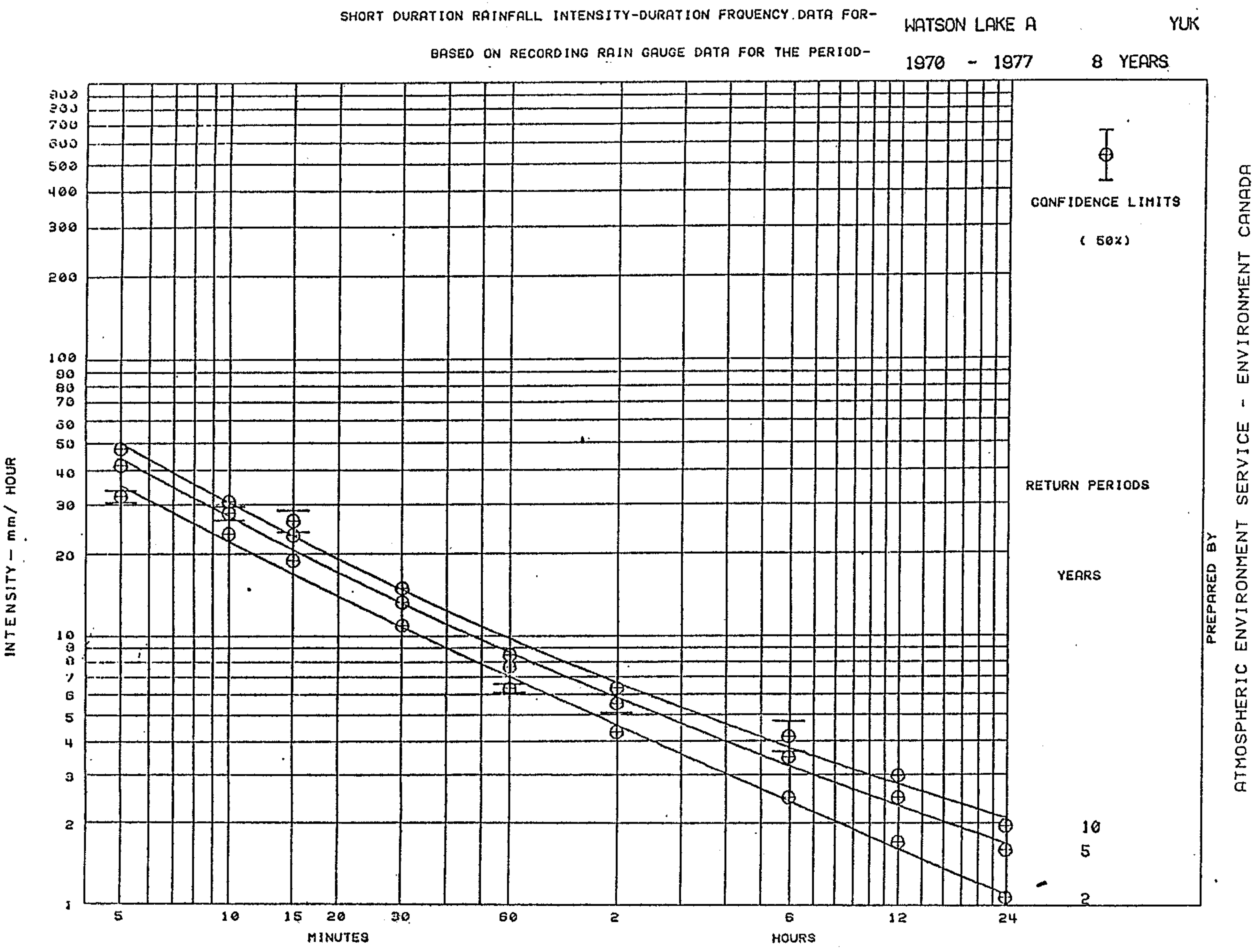
SHORT DURATION RAINFALL INTENSITY-DURATION FRQUENCY DATA FOR- FORT NELSON A BC

BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD- 1966 - 1977 11 YEARS.



ATMOSPHERIC ENVIRONMENT SERVICE - ENVIRONMENT CANADA

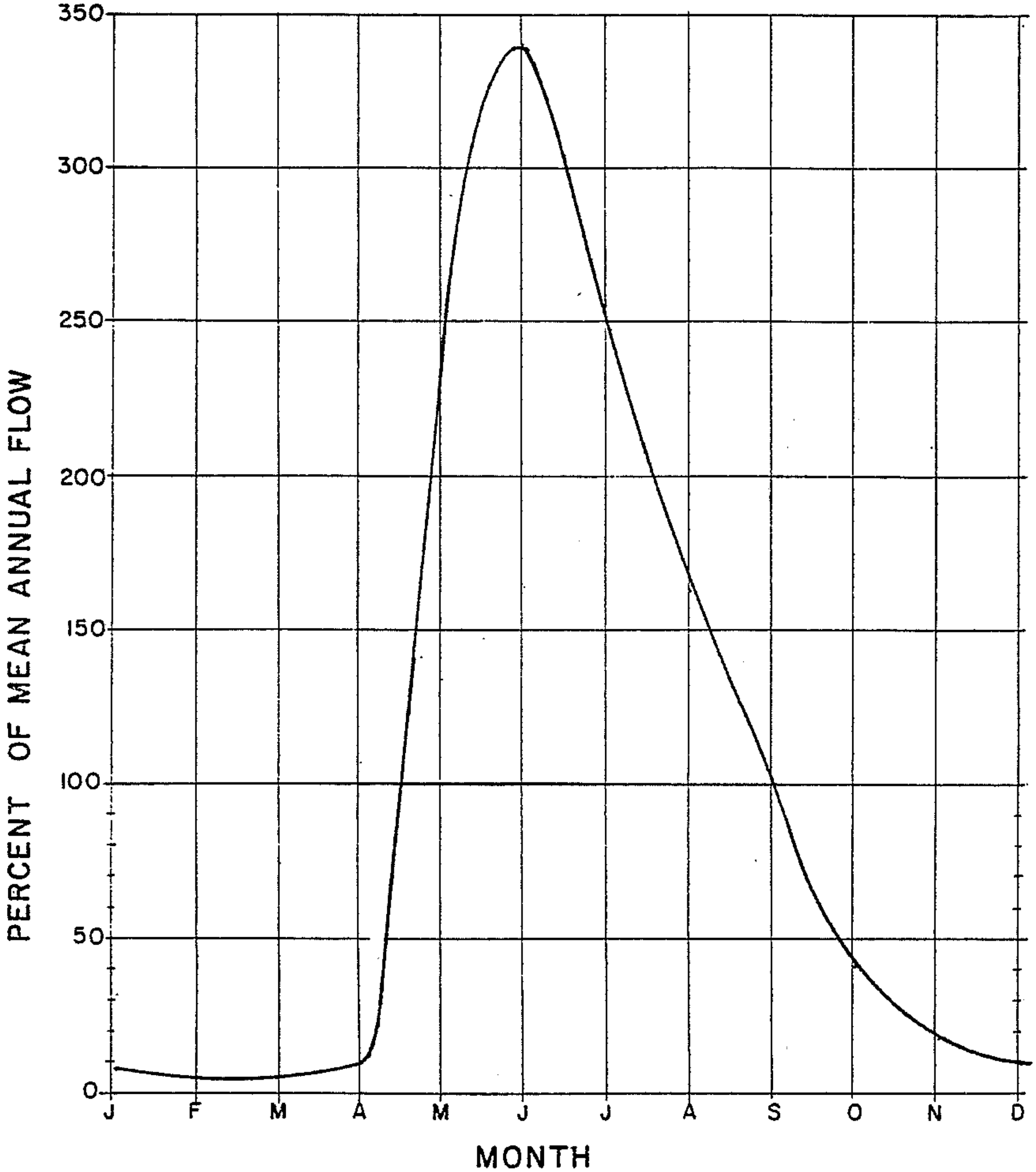
FIGURE 16



SHORT DURATION RAINFALL INTENSITY-DURATION FRQUENCY DATA FOR-
WATSON LAKE A
YUK
BASED ON RECORDING RAIN GAUGE DATA FOR THE PERIOD-
1970 - 1977
8 YEARS
CONFIDENCE LIMITS
(50%)
RETURN PERIODS
YEARS
10
5
2
INTENSITY — mm/ HOUR
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
200
300
400
500
5
10
15
20
30
60
2
6
12
24
MINUTES
HOURS
PREPARED BY
ATMOSPHERIC ENVIRONMENT SERVICE - ENVIRONMENT CANADA

FIGURE 17

CADILLAC EXPLORATIONS LIMITED



MEAN ANNUAL MAXIMUM DAILY FLOW = 970 % OF MEAN ANNUAL FLOW
MEAN ANNUAL MAXIMUM INSTANTANEOUS FLOW = 1600 % OF MEAN ANNUAL FLOW

NOTE

ICE CONDITIONS PRESENT FROM OCTOBER TO EARLY MAY.

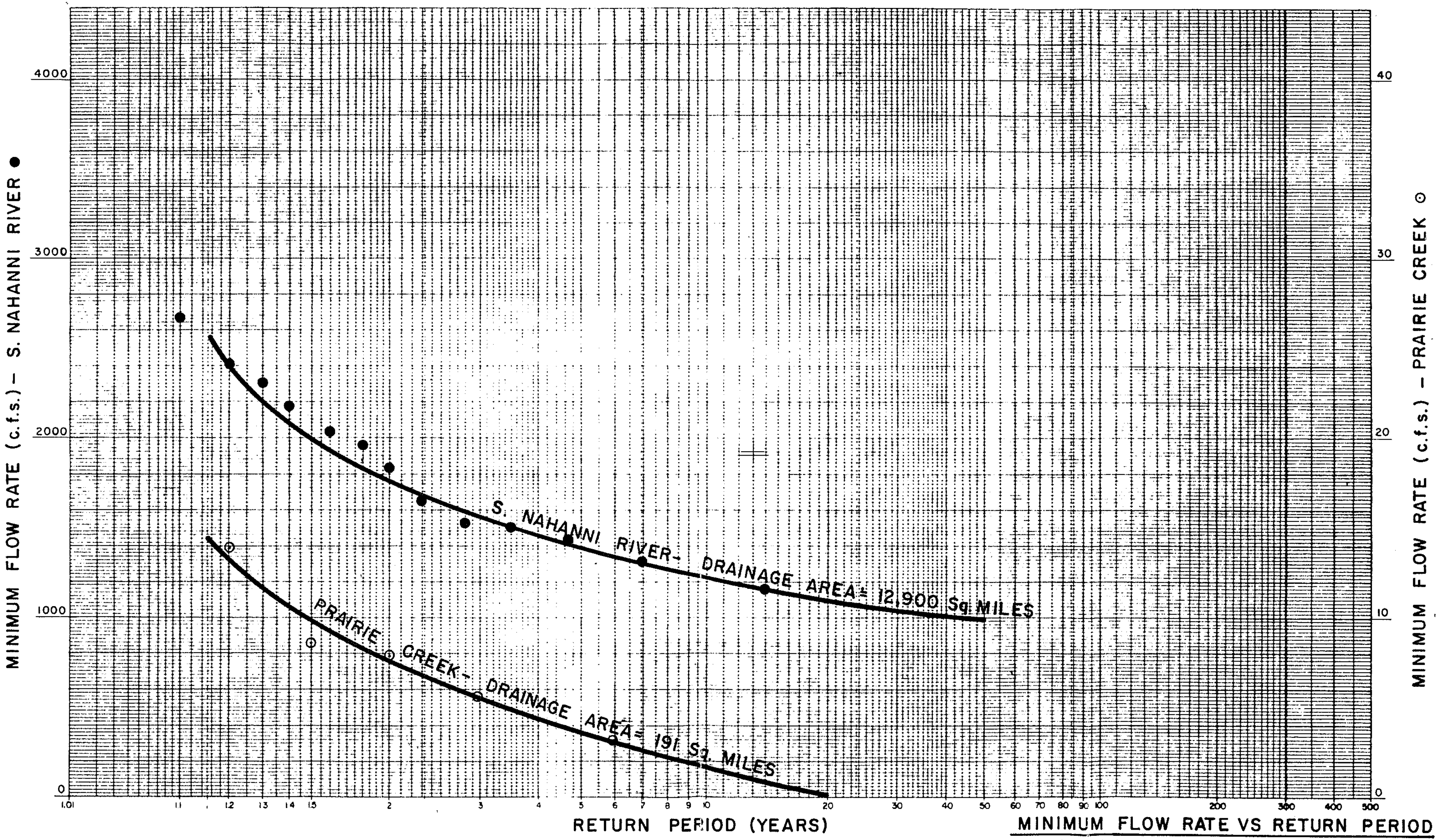
INDEX HYDROGRAPH

PRAIRIE CREEK AT CADILLAC MINESITE

VANCAL - 2988

FIGURE 18

KER, PRIESTMAN & ASSOCIATES LTD



MINIMUM FLOW RATE VS RETURN PERIOD
S. NAHANNI RIVER & PRAIRIE CREEK

FIGURE 21

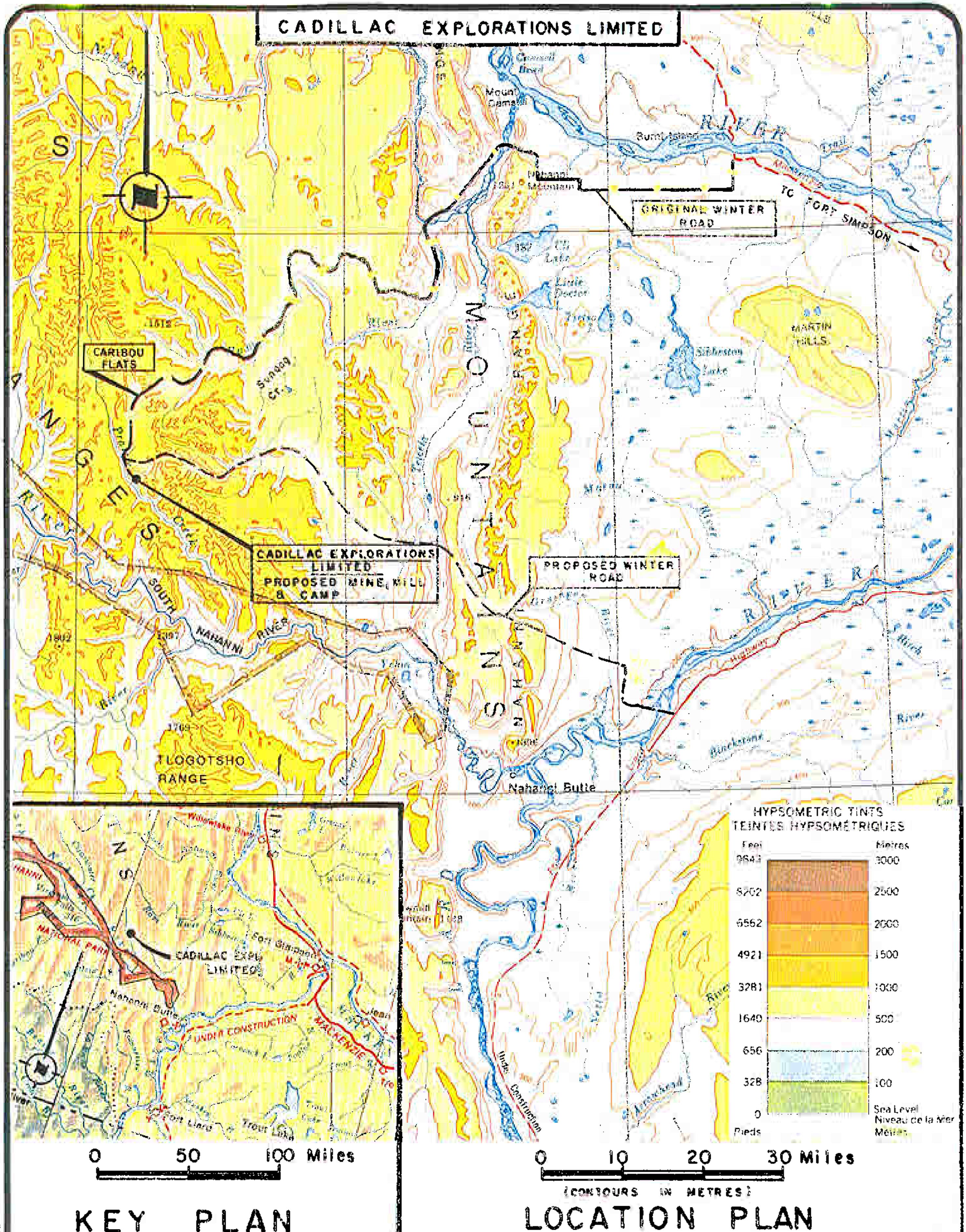
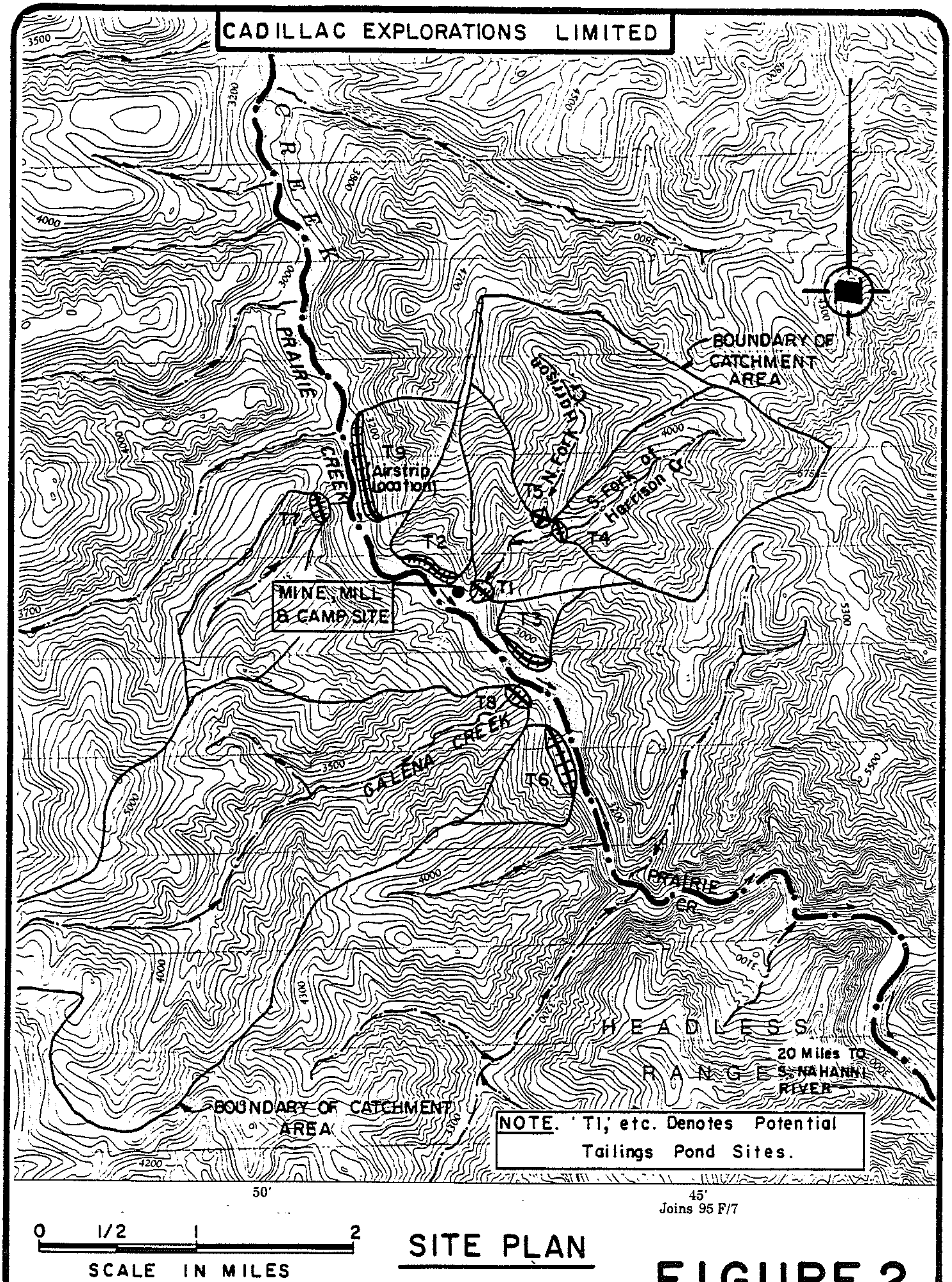


FIGURE I

VANCAL - 2988

KER PRIESTMAN & ASSOCIATES LTD.

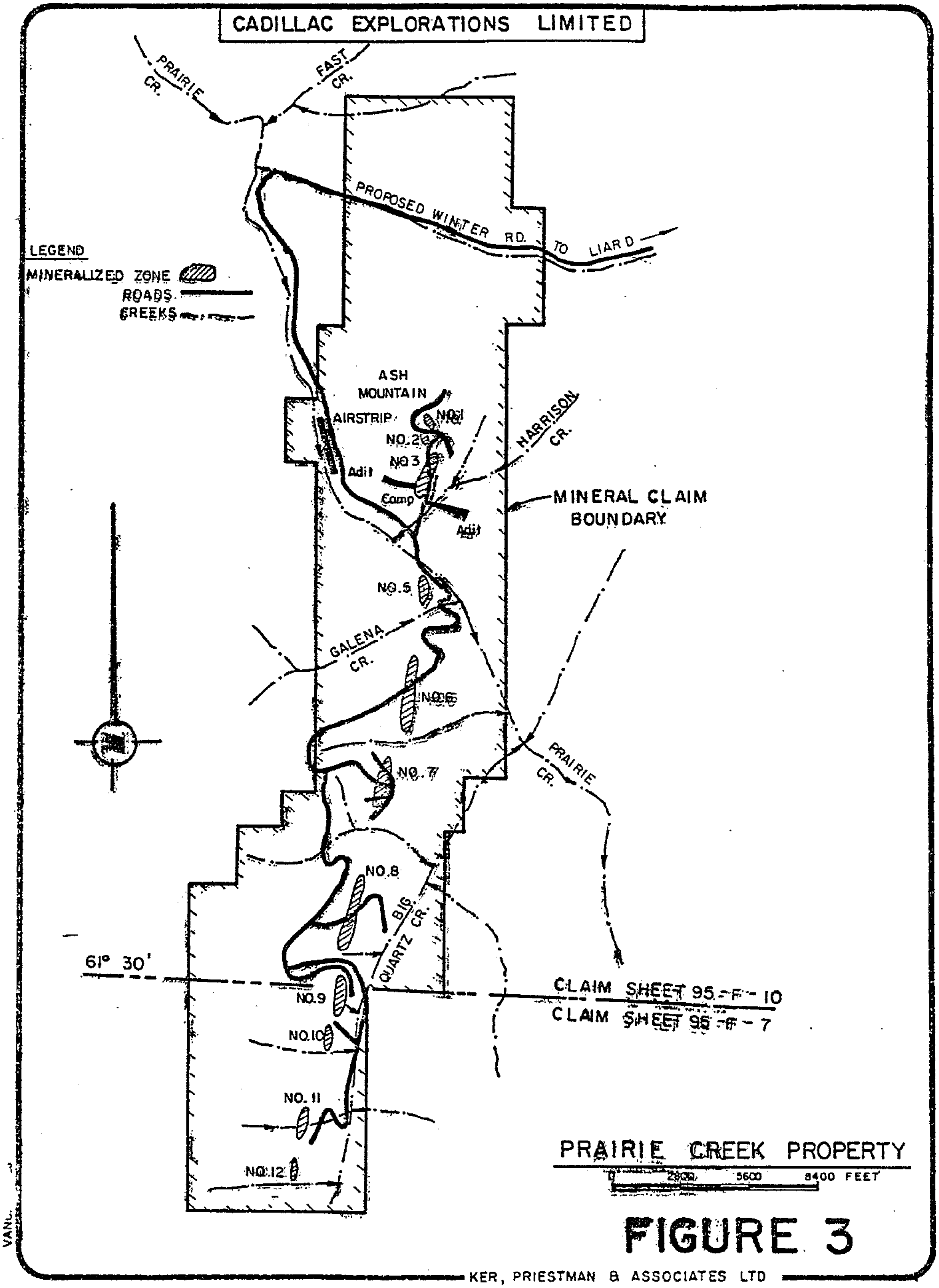


SITE PLAN

FIGURE 2

KER, PRIESTMAN & ASSOCIATES LTD

VANCAL - 2988


CADILLAC EXPLORATIONS LIMITED
PRAIRIE CR.
FAST CR.
PROPOSED WINTER RD. TO LIARD
LEGEND
MINERALIZED ZONE
ROADS
CREEKS
ASH MOUNTAIN
AIRSTRIP
NO.1
NO.2
NO.3
Adit
Camp
Adit
HARRISON CR.
MINERAL CLAIM BOUNDARY
NO.5
GALENA CR.
NO.6
NO.7
PRAIRIE CR.
NO.8
BIG QUARTZ CR.
61° 30'
CLAIM SHEET 95-F-10
CLAIM SHEET 95-F-7
NO.9
NO.10
NO.11
NO.12
PRAIRIE CREEK PROPERTY
0 2800 5600 8400 FEET
FIGURE 3
KER, PRIESTMAN & ASSOCIATES LTD