KER, PRIESTMAN & ASSOCIATES LTD.

Ch. 5 of this report only

ENVIRONMENTAL EVALUATION

FOR

CADILLAC EXPLORATIONS LIMITED

PRAIRIE CREEK PROJECT, N.W.T.

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5. EXISTING ENVIRONMENT

5.1 Climate

5.1.1 General

The equivalent section of the Preliminary Environmental Evaluation (P.E.E.) Reports of May, 1980 covered the initial findings on the climate of the area. Climatic data which has since become available is incorporated into this report.

The minesite is located in the eastern Mackenzie Mountains at an elevation of approximately 2850 feet and 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.

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 3 and their locations are shown on Figure 13.

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.

5.1.2 Temperature

The monthly and mean annual temperatures for Cadillac Minesite have been estimated by examining 12 or more years of record at each of the Tungsten, Fort Simpson and Watson Lake climate stations. The temperature differences at these three stations are not great and, together with a simple correlation with the 10 months of climate data collected at the site in 1970, it is possible to develop reasonably reliable temperature estimates. In general, Cadillac appears to have less extreme temperatures than Fort Simpson or Watson Lake. However, temperatures are very similar to those recorded at Tungsten. The temperatures at these four stations are given in Table 4. The mean annual temperature for Cadillac minesite is estimated as 23° F. The lowest monthly mean of -14° F occurs in January and the highest monthly mean of 55° F. occurs in July.

5.1.3 Precipitation

Monthly and mean annual precipitation figures for the Study Area have also been estimated in the same manner as for temperature. However, the data recorded at the site in 1970 did not correlate well with the surrounding stations. This was partly due to the extreme rainfall which occurred in August (total 8.06 inches) at the minesite. Cadillac appears to have similar precipitation patterns to Fort Simpson through the winter, but in the summer the rainfall is greater than at Fort Simpson, and appears closer to that recorded at Tungsten.

Rainfall and precipitation for the investigated stations are also included in Table 4. It should be noted that the long term precipitation at Fort Simpson and at Watson Lake may not exactly agree with those values given in the table because only the overlapping period of record with Tungsten was studied. Because of the high rainfall in the summer months (like Tungsten) and low precipitation (snow) through the winter (like Fort Simpson), the ratio of rain to total precipitation is .59, higher than the surrounding stations at .50. The mean annual precipitation is estimated at 20 inches. About 3 inches/month falls in the summer and the annual low of 0.8 inches/month occurs in March.

Maximum and minimum annual precipitation for the 10 and 50 year return periods has also been estimated. The maxima are 25 inches and 28 inches, respectively; and the minima are 14 inches and 11 inches, respectively. These values have been estimated through a simple statistical analysis of Cantung and Fort Simpson data then transferring the results to Cadillac using the same prorating factors that were used for mean precipitation.

Use of the intensity-duration-frequency (IDF) rainfall curve for Fort Nelson is recommended for design and is reproduced in Figure 14 because it is based on a longer period of record and gives higher values than either Fort Simpson or Watson Lake. In the one year of data collection at the site, the maximum recorded rainfall in a 24 hour period was 3.52 inches on August 16, 1970. None of the other climate stations studied showed significant rainfalls near that date and the recorded value is greater than ever recorded at the same surrounding stations. Its position on the IDF curve is at the 25 year return period.

Rate of rainfall has been recorded at Virginia Falls, Cantung and Nahanni Hot Springs since 1973 but has not yet been developed as IDF curves.

5.1.4 Evaporation

There were no changes in the available data for mean monthly and annual evaporation. Therefore the evaporation rates given in the P.E.E., which were taken from Climatic Mapping, are also reproduced in Table 4.

5.1.5 Snow Cover

Snow cover data is available for Watson Lake, Norman Wells and Fort Nelson from 1962 to date, and for Tungsten for the two winters ending in 1977 and 1978. The average accumulations at the three longer term stations are similar and their aggregate average is 25 inches. Based on the 2 years of record at Tungsten, the mean snow cover there is probably 50% greater, or 35 to 40 inches annually.

The maximum informally recorded snow depth at the minesite over the last 12 years, however, was only 14 inches, which does not compare well with the surrounding snow cover stations. Consequently, it has not been possible to provide good estimates of snow cover at Cadillac on the basis of projections from these other locations.

5.1.6 Data Collection

The present meteorological data collection programme at the minesite only includes measurement of 12 hour rainfalls. The Atmospheric Environment Service has agreed to provide a rate of rainfall recorder together with the equipment necessary to establish a Climatic Observer Station at the minesite which will complement the two stream crest gauges installed at the site in July, 1980.

5.2 Hydrology

5.2.1 General

Runoff shows a marked peak in June, decreasing through the fall and winter 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 15, 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.

5.2.2 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 5 with their locations shown on Figure 13.

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.

5.2.3 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. The catchment area above this gauge is 12900 sq. miles.

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 catchment area above the Prairie Creek gauge is 191 sq. miles.

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 0.7. (Yield ratio is not the same as runoff coefficient (C) which relates rates of runoff and precipitation).

5.2.4 Peak Flows

Streamflow and Rational Method Analysis

Information presented in this section is based on streamflow records, discussions with J. N. Jasper (Hydrologist for Water Resources Division, Dept. of Indian & Northern Affairs, Yellowknife), and use of empirical calculations such as the Rational Method. The estimation of peak flows for small basins is very uncertain due to the unavailablity of reliable data.

A Gumbel (extremal probability paper) plot was prepared from the recorded peak flows in Prairie Creek and the South Nahanni River (Fig. 16). 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

$Q_{100} = 1.7\ Q_{10}$

The unit peak flows (cfs/mi^2) for the two recording stations were plotted for the 10year return period (Fig. 17). 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 IDF 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 intensity 20 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 to 0.5 were considered to be representative of ground conditions during peak rainfalls in the summer. The Suggested Design Curve (Fig. 17) 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 & Northern Affairs (1979) for the Tungsten, N.W.T. area. Generally the Design Curve for the Cadillac Study Area (Fig. 17) gives higher flood values than those for the Tungsten area.

Streamflow Data Extensions

An isolated analysis of the short period of record on Prairie Creek is not sufficient to make confident predictions of the magnitude of major events. Therefore, an extension of the record was attempted by correlation with longer term records at both stations on the South Nahanni River. Because there was a poor correlation between the recorded peaks on Prairie Creek and those on South Nahanni River no further attempt was made to extend Prairie Creek flow data.

Application of Liard Highway Hydrology Regression Formula

In a report by M. M. Dillon Ltd., the hydrology studies of four other consultants were reviewed and a new hydrological design method was developed for creek and river crossings along the Liard Highway.

The hydrological design method developed in the report uses a regression formula and this was applied to the Prairie Creek and Harrison Creek basins. The 10 and 100 year return period flows obtained for Prairie Creek were 10,500 cfs and 15,800 cfs, respectively; for Harrison Creek they were 780 cfs and 1,180 cfs, respectively. These values compare fairly well with flows obtained from the Design Curve on Figure 17.

The regression formula is very sensitive to the precipitation and mean daily temperature and variations of 2 inches in the mean annual precipitation or of 2^{o} F in the mean daily temperature entered in the formula result in peak flow differing by 25% to 50%. However, the Dillon formula gives good confirmation of the stream-flow and rational method analysis performed initially.

Kinematic Wave Flood Analysis

The Water Resources Division of the Department of Indian and Northern Affairs in Whitehorse has developed a computer model based on the kinematic wave theory of flood runoff routing and on data collected by Water Resources and Water Survey of Canada on smaller streams in the Yukon Territory.

Use of this model by government personnel gave the 10 and 100 year return period flows for Prairie Creek as 2970 cfs and 5010 cfs, respectively; for Harrison Creek flows were 128 cfs and 213 cfs, respectively. These results are not at all in agreement with other stronger and better corroborated evidence. It is felt that they are either in error or that the computer model has been poorly calibrated in the MacKenzie Mountain area. Therefore, the kinematic wave flood analysis has been disregarded.

Summary and Recommended Design Method

After reviewing many of the approaches available for hydrologic design in the area, it is believed the peak flows should be derived from the Design Curve shown on Figure 17. Design flows for Prairie and Harrison Creeks are therefore as follows:

	10 Year Flow (cfs)	100 Year Flow (cfs)
Prairie Creek	11,000	18,000
Harrison Creek	510	870

It must be remembered that the estimation of flood flows by statistical methods, from data with a short period of record, is uncertain at best. Usually flood estimates are not reliable to any great extent beyond the period of record. For example, if there are 15 years of record (as for the South Nahanni River), the 10 year flood can be estimated with confidence and the 15 and 30 year floods with somewhat lesser confidence. Confidence in estimates of the 100 year return period flood is poor. It would be safe to say that the 100 year flood on Prairie Creek at the minesite would fall in the range of 10,000 cfs to 22,000 cfs. Similar ranges would apply to the other small drainage areas.

5.2.5 Maximum Possible Flood (MPF)

From Chow (1964) and Fawkes, the maximum possible flood is the largest flood for which there is any reasonable expectancy in this climatic era. It is used in design where failure could lead to great damage and loss of life. The MPF is rigorously determined through detailed study of storm patterns and/or snowmelt patterns, transposition of the storms to a position that will give maximum runoff and calculation of the flood by unit hydrograph or computerized routing methods. It is assumed that the MPF will not result from a catastrophe such as the failure of an ice dam or similar failure of an earth obstruction.

In this study empirical methods have been utilized to calculate the MPF.

The first of 2 methods which were investigated is an extension of a calculation developed by D. M. Herschfield (1977) for probable maximum precipitation. The basic equation is:

MPF = (mean of recorded annual peaks) + k(standard deviation of the recorded peaks)

A value for k in the Study Area would be between 15 and 20 (Fawkes, pers.com.). This gives an instantaneous MPF of about 38,000 cfs on Prairie Creek. The period of record is extremely short for this type of analysis.

The second method utilizes the results of studies of MPF carried out on the Columbia and Peace Rivers and utilized by SIGMA Resource Consultants Ltd. (1974) in The Development of Power in the Yukon. For the purposes of this work the MPF can be taken as 2.5 times the 25 year return period flood. The calculation gives 34,000 cfs.

The two results are reasonably consistent. However, in order to be conservative, the instantaneous MPF for Prairie Creek is taken as 38,000 cfs.

5.2.6 Flood Elevations and River Dyking

General

MPF and 100-year flood elevations on Prairie Creek and Harrison Creek in the vicinity of the mine have been estimated on the basis of the creek profile and cross sections which were surveyed in August, 1980.

Manning's equation has been used to develop the flood profiles and an estimation of Manning's "n" is from a lengthy discussion in Chow 1959. The value selected is 0.04. At the Prairie Creek gauge site, Water Survey of Canada estimated flows on the basis of the Slope-area Method which involves an estimation of "n". They selected a value of 0.032 for the improved reach immediately upstream from the gauge. However, there is no evidence to support an "n" value as low as 0.032 for design purposes. Manning's formula calculations are based on the assumption of uniform flow since the channel cross-section does not change abruptly. The flow is normally subcritical, hence the calculated flood profiles have been inspected for possible backwater effects and adjusted accordingly.

The design flood velocities are in the range of 7 to 13 feet per second for the 100-year return period flood and 9 to 16 feet per second for the MPF depending on the particular slope and cross section. These velocities are sufficiently high that some form of bank and dyke protection (i.e. riprap) will be necessary to prevent erosion and possible river breakthrough. As there appears to be few fines in the bank and dyke material, downstream siltation, as a result of dyke erosion, should not be a problem. 100-year and MPF flood elevations and their effects are detailed below and a flood profile on Prairie Creek covering the man-made dyke section and the T3 area is shown in Figure 18.

The design flood for the plant-site surround dyking is the 100-year flood plus a 3 ft. freeboard and for the tailings dam is the maximum possible flood. The plant-site and its associated dyking will be abandoned after a period of years but the tailings dam will become a permanent feature and it is intended that its structural integrity be maintenance free.

Airstrip

The airstrip appears to have sufficient elevation to be above the 100-year flood but the road immediately upstream of the air-strip is just below flood elevations. The design flood velocity here is 11 feet per second and the required waterway area is approximately 1700 square feet.

T2 Area

The maximum possible flood elevation is 2 ft. above the top of the natural bank and the existing man-made bank/dyke. Design velocities are 14 ft. per second and the required waterway area is 3000 square ft.

Camp Area

The present camp is built on the Harrison Creek alluvial fan and it is at this natural obstruction that Prairie Creek flow is most constricted.

Opposite the present water supply well there is good freeboard on the present dykes for the 100-year flood but this gradually reduces to zero at the fuel storage area. To prevent possible washout and overtopping, the present dyke should be raised and strengthened downstream from this point and tied into higher ground, preferably the Harrison Creek diversion dyke.

Design velocities in this reach of Prairie Creek are 13 ft. per second with a required waterway area of 1400 sq. ft.

T3 Area

This area is relatively high and clear of the flood waters. There is a natural bank behind the edge of the vegetation and the maximimum possible flood limits would be 1 ft. - 2 ft. above the top of this bank. At the upstream end of this reach the top of the bank has an elevation of approximately 2820 feet with a slope downstream of .008. Material at the toe of a tailings dam should not be placed below this point unless it is protected with riprap.

Design velocities here are 11 ft. per second and the required waterway area is 4000 sq. ft.

Harrison Creek

The present diversion dyke on Harrison Creek appears to have sufficient height to prevent overtopping but it also may be subject to erosion during peak flows, because the 100-year design velocities are 13 ft. per second.

Field Observations on Flood Levels

A check on the calculated design flood levels is often made by comparison with observed high water marks; however, in this analysis, the high water marks only confirmed that the calculated design flood levels were above recent flood levels. The 100-year return period flood elevations just reach the existing bank elevation for the natural sections near the camp area.

5.2.7 Low Flows

Seven day average low flows for the South Nahanni River and Prairie Creek have been plotted on logextremal probability paper (Figure 19). The logextremal paper causes the low flows (which in almost all cases are the same as the annual minimum flows) to plot as a straight line. The 10 year seven day average low flow for Prairie Creek appears to be about 2 cfs. Beyond this period it is difficult to determine whether or not the creek will totally freeze but J. N. Jasper (pers.com.) believes that there is enough groundwater storage in the valley to prevent freeze-up.

5.2.8 Further Data Collection

In order to improve the knowledge of the mechanics of runoff from small creeks, two peak (crest) gauges have been installed at the minesite. With the anticipated complementary installation of a rate of rainfall gauge these gauges should provide valuable data. The peak gauges were provided by Mr. J. N. Jasper of the Water Resources Division, Dept. of Indian and Northern Affairs.

5.3 Water Quality and Sediments

5.3.1 Surface Water

Prior to the initiation of the water quality data collection programmes associated with the environmental assessment of the Cadillac project in 1980, the only previous data available for the creeks and streams in the vicinity of the mine was that collected in 1975 (DIAND 1975). DIAND 1975 results are reproduced in Appendix 6.

The 1980 surface water quality programme involved sampling of Prairie Creek (2 stations) and Harrison Creek on two occasions, during April and July. Stream sampling locations are illustrated on Figure 21. The results of the preoperational baseline water quality monitoring are listed in Tables 6, 7, 8 and 9. Water samples obtained in the 1980 programme were preserved in the field and dispatched to BEAK's laboratory in Richmond, B. C. for analysis.

The baseline surface water quality data indicates the waters of Prairie Creek and Harrison Creek are slightly alkaline in nature, have moderate water hardness and generally low levels of trace elements. In both 1975 (DIAND) and 1980 (BEAK), levels of arsenic, cadmium, chromium, molybdenum and nickel were very low to less than detectable. Mercury (not sampled in 1975) was found to be less than detectable in July, 1980. Copper levels were occasionally in the detectable range in Harrison Creek in the 1975 survey, whereas in 1980 copper was found to be less than detectable on both occasions. Iron was found to range from 0.1 to 2.06 mg/l in Prairie Creek in 1975 whereas in the 1980 data the highest value measured was 0.03 mg/l. Lead values reported in 1975 were generally less than 0.005 mg/l in Prairie and Harrison Creeks. The 1980 data indicates baseline lead values ranging from less than 0.01 mg/l to 0.04 mg/l (total) with little difference in upstream/downstream stations. A value of not greater than 0.03 mg/l for lead is considered desirable to protect freshwater aquatic life (Environment Canada 1979). In 1975 zinc values ranged from 0.006 mg/l to 0.034 mg/l in Prairie Creek whereas Harrison Creek ranged from 0.001 to 0.25 mg/l. In 1980 zinc values ranged from 0.05 to 0.031 mg/l (total) in Prairie Creek to 0.009 to 0.14 mg/l in Harrison Creek. Dissolved values of zinc were found to be considerably less than totals indicating the natural turbidity contains considerable amounts of the element zinc. A maximum value of 0.03 mg/l zinc is considered desirable to protect and maintain freshwater aquatic life (Environment Canada 1979).

5.3.2 Groundwaters

Groundwaters were sampled in the mine site area at four locations as shown in Figure 21. Except for the exploration camp domestic well, all other groundwaters were samples obtained from boreholes drilled in the tailings pond site investigation programme. The waters of the mine camp well and Borehole No. 3 have qualities not dissimilar to Prairie Creek except for a somewhat higher calcium component and lower pH values. Borehole No. 7 in the alternate tailing pond area (T3) was artesian. This groundwater contains considerably higher dissolved solids, mainly calcium and sulfates. Borehole No. 10 in the campsite area also contains higher dissolved solids, sulfate, calcium and magnesium than Borehole No. 3 and the camp well. A high level of zinc (0.76 mg/l) was also found in this groundwater in comparison to the other stations sampled. Borehole logs for the Stations 3, 7 and 10 are included in Appendix 1. It appears that Borehole No. 10 is located in alluvial material in an old Harrison Creek channel whereas all other stations show alluvial material over a significant depth of very stiff lacustrine clay which overlies a buried gravel aquifer.

5.3.3 Mine Water

Mine water from the two existing adits has been sampled on two occasions during the 1980 water quality monitoring programme. The locations of the mine water sampling stations (Portals) are shown on Figure 21. The results of the mine water analysis are shown in Table 8. During the April sampling no water was discharging from either portal (the lower (2850) portal contained ice to the roof level) and thus a sample was collected from free standing water inside the upper (3050) portal. The July sample from the lower portal was taken prior to exfiltration into the ground outside the mine portal entrance and reflects entrained sediment from drilling and mucking operations inside the mine. The levels of trace elements are generally low except for significant levels of iron, lead and zinc in the particulate fraction and a high dissolved zinc level present in the July sampling.

5.3.4 Stream Sediments

Samples of stream sediments were collected from two stations in Prairie Creek (as shown on Figure 21) for determination of pre-operational baseline trace element composition. Sediment samples were sieved to obtain the fine fraction (Minus 16 Mesh) and analyzed for total trace elements following digestion with aqua regia. The results of the sediment monitoring programme are shown in Table 9. The results indicated relatively little difference between the upstream and downstream stations. The sediment fines contain about 16%, 8-9.7% and 28-30% of the major constituents calcium, iron and magnesium, respectively. This compares with 9%, 23% and 21% found by others in the Liard River suspended sediment (Environment Canada, 1973). Levels of minor constituent trace elements are in most cases lower than reported in the Liard River. Lead ranged from 48-56 micrograms per gram in Prairie Creek as compared with 46 in the Liard River. Zinc levels ranged from 93-120 micrograms per gram compared to 170 in the Liard River. Copper ranged from 13-14 micrograms per gram in Prairie Creek compared to 24 in the Liard River system. These sediment analyses on Prairie Creek are considered good baseline data with which to compare any future post-operational monitoring of sediments.

5.4 Aquatic Invertebrates and Fisheries

Data was collected for the aquatic study between July 21 and July 25. The field programme was designed to evaluate fish habitat potential, document present fish habitat utilization and collect information on the benthic invertebrate community along watercourses which could potentially be influenced by the proposed development. In addition, the study was designed to determine metal levels for resident and migrant fish populations in Prairie Creek.

5.4.1 Aquatic Invertebrates

5.4.1.1 General

Biological systems are dynamic, i.e. populations and species composition will change with conditions. This metamorphosis in community composition may be a function of life history of aquatic organisms and/or changes in natural abiotic features of the environment. Industrial operations near water systems may cause changes in aquatic environments and directly influence biological components of the system. The effect of this could be a shift in composition of aquatic organisms to those species better adapted to cope with the altered physico-chemical conditions.

Changes in community structure can be detected with adequate sampling, good pre-operational and control data and the appropriate analysis of information. Continuous monitoring of these changes in biological systems enables the recognition of adverse changes and facilitates remedial action before serious degradation of the environment can occur.

Within the area of the minesite, four benthic invertebrate sampling sites on Prairie Creek and one site on Harrison Creek were established (Figure 21). As shown on Figure 20, benthic invertebrate sampling was also conducted at points approximately 100 yards above and 100 yards below the proposed winter road crossing sites on the following watercourses: Unnamed Creek (Site R2), Unnamed Creek (Site R3), Tetcela River (Site R4), Tetcela River (Site R5), and the Grainger River (Site R7). Fishtrap Creek (Site R6) was sampled in only one location due to the uniformity of the substrate and the observed minimal flows. The Unnamed Creek at Site R1 was sampled only at one site.

At each sampling site, 4 samples were taken with either a standard 144 $in.^2$ Surber sampler or a 78.8 $in.^2$ Eckman dredge. Samples were collected, wherever possible, in areas of similar depth, substrate and current. The collection bag used with the Surber sampler had a mesh size of 0.018 in. (750 microns). The Surber was placed on the substrate with the net extended downstream in the current. Large substrate particles enclosed within the frame of the Surber were scrubbed to dislodge any adhering organisms. The substrate was then disturbed to a depth of approximately 4 in. to dislodge organisms living within the substrate. Each sample was then individually labelled and preserved with 10 per cent formalin. To facilitate sorting of the invertebrates, rose bengal dye was added to the samples at the laboratory. Ekman dredge samples from Fishtrap Creek were washed in the lab through a sieve with 0.02 in. (0.5 mm) mesh to reduce the volume of the sample by removal of extraneous debris.

During the identification phase of laboratory analyses, the following taxanomic references were employed: Pennak (1953), Edmondson (1959), Johannsen (1934-1937), Stewart and Loch (1973), Wood et al. (1963), Allen and Edmunds (1912), Edmunds et al. (1976), Morihara and McCafferty (1979), Needham et al. (1935), Ross (1944), Smith (1968), Wiggins (1977), Baumann et al. (1977), Claasen (1931), Jewett (1959), Needham (1925) and Ricker (1952).

5.4.1.2 Biological Indices

An analysis of community structure was undertaken on benthic invertebrate data employing a series of indices which consolidate several data units into a single comparative index. These data were subjected to a number of tests which were interpreted with regard to river conditions; analyses included the biotic index, dominance, Shannon-Weaver diversity, equitability, richness and Keefe-Bergersen diversity.

Biotic Index

Invertebrates living in or on bottom sediments can be used as indicators of adverse changes in aquatic environments because they display varying degrees of sensitivity to degradation in water quality (Hynes, 1958; Wilhm and Dorris, 1966 and 1968; Cairnes and Dickson, 1971). Natural benthic communities are relatively stable or exhibit predictable oscillations in structure and composition. This phenomenon, coupled with their respective sensitivities to water quality, enables the use of benthic fauna as a biological measure of environmental conditions.

Benthic invertebrate data facilitate the analysis of the effects of alterations in water quality over time. Water quality data are time specific. However, a benthic community at any given time is representative of water quality and general habitat conditions not only at the instant of sampling, but also during periods prior to the actual collection of benthos. The ultimate effect of past environmental conditions is reflected in benthic communities; therefore, it is advantageous to perform biological sampling in conjunction with chemical analyses.

Since benthic organisms exhibit varying degrees of sensitivity to changes in the conditions of an aquatic environment, Beak (1965) has segregated benthos into three groups: those typical of clean water are categorized as pollution sensitive organisms - Group 3; those typically found in moderately polluted waters are labelled as moderately tolerant or facultative - Group 2; and those inhabiting highly polluted waters are classed as pollution tolerant organisms - Group 1. It is important to note that 'pollution' in this sense is not restricted to anthropogenic influences. Natural events (e.g. heavy rains causing sediment erosion) constitute a potential disruptive factor in aquatic systems and may also be regarded as pollution.

Group 3 organisms contain aquatic larval stages of insects which are sensitive to adverse changes in water quality and are the first to disappear if conditions deteriorate. Included in Group 3 are primarily the mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera). These organisms require clean water conditions which include high concentrations of dissolved oxygen, fairly swift currents, low turbidity and relatively low concentrations of toxic chemicals. Group 3 organisms respire primarily by external gill structures. The respiratory surfaces of the organs are extremely sensitive to abrasive action of fine sediments and the negative effects of chemical pollutants.

Group 2 consists of a number of organisms such as leeches (Hirudinea), midges (Diptera), water mites (Hydracarina), clams (Pelecypoda) and others. These organisms can tolerate a moderate amount of water quality degradation. The degree to which tolerance to pollutants is expressed varies according to individual levels.

Group 1 organisms are tolerant of some toxic conditions and low concentrations of oxygen and will survive in areas where less tolerant organisms would be eliminated. Within this group, for example, are some Oligochaetes, leeches and chironomids (Diptera).

The biotic or tolerance index is not a rigid classification scheme. Independent research studies have revealed a hierarchy of invertebrate taxa based on sensitivity to environmental degradation. Consequently, use of these categories has found wide application in the study of aquatic systems that may potentially be impacted by industrial activities.

Dominance Index

Natural biological communities include groups of organisms that are not equally successful. This is a function of the biotic/abiotic restrictions of an environment. A few may dominate a community with the spectrum then extending to groups of intermediate abundance and finally to rare organisms. An index used to measure relative abundance in biological samples was proposed by Simpson (1949).

Shannon-Weaver Diversity Index (H)

An index of diversity was also calculated for each sampling station based on the detailed identification of invertebrates. This method was adopted from information theory in communication engineering (Shannon and Weaver, 1949) by Margalef (1958) and MacArthur(1955) and applied to biological systems.

A simplified biological interpretation of information theory would be that ecological systems (e.g. rivers) act as a source of information and the output of information containing characters are the biological organisms themselves. A definition of ecological diversity is:

> "Diversity is thus equated with the amount of uncertainty (information) which exists regarding the species of an individual selected at random from a population. The more species there are and the more nearly even their representation, the greater the uncertainty (information) and hence the greater the diversity" (Pielou, 1966b).

Equitability Index

An important characteristic of the Shannon-Weaver diversity index is that it provides an objective measure of community complexity by incorporating within this single measure several variables that affect community structure. The primary components of diversity are equitability, or the evenness with which individuals are distributed among sampled genera, and richness, or the number of different genera sampled. A measure of equitability used in this study is presented in Pielou (1966a).

Stability is an inherent property of living systems. Ricklefs (1973) defines stability as the state where, "... variation in some characteristic of a system is less than the variation in a pertinent environmental variable". It is the ability of a system to accommodate environmental changes and dampen the effects of these exogenous forces so any perturbation elicited in the community is of a lesser magnitude. This dampening effect is a direct function of community complexity in terms of organisms and their relative abundance. In general, the more complex a system (high equitability), the greater its stability due to alternate routes of energy transfer (MacArthur, 1955). However, there are limits to the magnitude of change that any system can withstand. Beyond some maximum tolerance level, negative environmental forces will be evidenced in the biotic community by a decrease in stability and a decrease in overall community complexity.

Richness Index

Richness or variety in its simplest form is the number of genera encountered without considering the number of individuals actually examined. It is an indicator of the relative wealth of species or genera in a community (Peet, 1974). This function has been utilized in some studies as a measure of diversity. However, it is not an entirely correct approach to diversity since it does not incorporate the variable of equitability as does the Shannon-Weaver function.

Any richness measure is inherently dependent on sample size; the larger the sample size the greater the opportunity to sample greater numbers of species. This sample size - species number relationship is asymptotic. At some point additional sampling does not result in an increase in the number of species.

An index of richness is, therefore, best expressed with the inclusion of numerical abundance in the sample (Hurlbert, 1971; Shafi and Yarranton, 1973). The index employed in this study was from Margalef (1958).

Keefe-Bergersen Diversity Index(TU)

The Keefe-Bergersen diversity index (TU Index; Keefe and Bergersen, 1977) was developed primarily for use in the assessment of changes in water quality on biological components of aquatic communities. The apparent advantage of this method over other diversity calculations is that a high degree of taxonomic expertise is not required in the identification of invertebrate fauna. Organisms are compared on the basis of shape, colour and size and compared with other specimens in the sample. The basic approach of this method is centred around the theory of runs - "if an organism being examined is identical to the previous organism considered, it is part of the same run, if it is not, it is part of a new run". Therefore, a greater number of runs would indicate greater diversity within a sample. Although this index was designed for more general taxonomic considerations, it can also be applied to detailed taxonomic data. The determination of TU facilitates the calculation of a variance which may be used in test of significance between TU values.

5.4.1.3 Discussion

Detailed taxonomic information from samples collected near the minesite and along the access road are presented in Appendix 3. Tables 10 to 13 summarize benthic macroinvertebrate data. Information obtained during the study period quantify existing conditions of benthic communities inhabiting aquatic systems that may be affected by the mine and access road facilities. These data constitute baseline biological conditions prior to any major development in the area.

In the vicinity of the minesite, populations of invertebrates in Prairie Creek ranged from 94 organisms m^{-2} at Station M2 to 349 organisms m^{-2} at Station M5 (Table 10). Harrison Creek supported 334 organisms m^{-2}. Cobbles and gravel were the primary substrate in Prairie and Harrison Creeks.

In terms of tolerance groups, Group 3 (sensitive) fauna were most abundant at Stations M1, M2 and M3. The ephemeroptera (mayflies) dominated numbers. Stations M4 and M5 exhibited a proponderance of dipterans and nematodes, respectively (Group 2 organisms). The high dominance values at Station M1 and M2 also indicate a great abundance of one particular group of benthic fauna (i.e. Group 3).

The analysis of detailed taxonomic data indicated that Harrison Creek (M3) supported invertebrate communities that were the most complex and the most stable of the minesite complement of stations. Diversity (H and TU) was also high at this sampling location. Harrison Creek exhibited the highest equitability, 0.81, and the highest richness, 3.27, suggesting that Harrison Creek provided a greater variety of niches to benthic inhabitants and the numbers of individuals in the area were distributed quite evenly in the taxa collected.

The Prairie Creek system exhibited fluctuations in diversity, richness and equitability along the study length from Stations M1 through M5 (Table 10). There was no clear indication of significant community change. Chemical analyses of water samples from Prairie Creek showed no significant variation in water quality along the system; consequently, the observed oscillations in community statistics near the minesite are probably related to natural system variability. A comparison of TU diversity values at the upstream Prairie Creek station (M1) and the farthest downstream site (M5) indicated no significant difference in community diversity (Z=1.591, DF greater than 120, P greater than 0.05). These data provide a solid base for future data comparisons.

Table 11 summarizes data for the Ram River tributaries that were sampled as well as a single Prairie Creek tributary. In general, Unnamed Creek (Site R2, Fig. 20) supported the highest population of the three, this being due primarily to the great abundance of black fly larvae (simuliidae). As a result of the high dominance and low equitability, even though richness figures were relatively comparable, Unnamed Creek (Site R2, Fig. 20) exhibited the lowest community diversity. The Prairie Creek tributary supported ephemeropteran and nematode individuals primarily, with Unnamed Creek (Site R3, Fig. 20) supporting relatively low numbers of organisms but exhibiting high diversity levels due to the equitability structure of inhabitants. Cobbles (64-250 mm) and large gravel substrates (16-64 mm) were dominant at these stations.

The Tetcela River appeared to support rather sparse populations of invertebrates (Table 12) with samples ranging from 17 to 51 organisms m^{-2}. Equitability figures were high; however, niche variability was low relative to Prairie Creek stations (cf. Table 10) and the Grainger River (cf. Table 13). Substrates in the Tetcela River were compact consisting primarily of cobbles (64-250 mm) with some silt/clay and small gravel fractions. The nature of the substrate (i.e. compaction) may be responsible for the low numbers of fauna. Such conditions tend to minimize habitat variability thereby influencing variability of potential benthic inhabitants.

Fish Trap Creek (Table 13) was sampled with an Ekman dredge as substrates were composed entirely of silt/clay. Flows were very slow with high concentrations of organic debris instream. Undoubtedly related to substrates and overall habitat condition, the most abundant organisms encountered were dipteran larvae (Group 2) and leeches (Group 1) with low number of mayflies, stoneflies and dragonflies. Richness was relatively high as was system diversity.

The Grainger River stations (Table 13) supported 108 organisms m^{-2} at Station 1 and 404 organisms m^{-2} at Station 2. Relatively high diversity and richness values were noted at these sites. Substrates were composed primarily of sand, gravel and cobbles with the presence of some large boulders.

5.4.2 Fishery Resource

5.4.2.1 General

Investigations were conducted in order to identify the fish species which utilize watercourses within the sphere of influence of the proposed developments, to determine the degree and extent of the habitat utilization by those species, and to assess the habitat potential.

Prairie Creek was sampled at five locations (Stations M1, M2, M4, M5 and M6 (the latter immediately upstream of the delta at the confluence of the S. Nahanni River)). Harrison Creek (Station M3) was sampled near its confluence with Prairie Creek. The following major watercourses which are to be crossed or parallelled by the proposed winter road were investigated during the study (see Figure 20): Unnamed Creek (Site R1), Unnamed Creek (Site R2), Unnamed Creek (Site R3), the Tetcela River (Site R4), the Tetcela River (Site R5), Fishtrap Creek (Site R6) and the Grainger River (Site R7). During the helicopter reconnaissance of the proposed winter road alignment, additional watercourses were evaluated from the air and a physical description of their aquatic habitats is presented in Appendix 4 (Sites R8 to R11). The systems sampled on the ground included all of the watercourses that could potentially support fish populations. All other watercourse crossings along the route were examined from the air and were considered unsuitable as fish habitat because of negligible discharge, barriers, or other criteria.

Electrofishing was carried out by one two-man crew for approximately 275 yards using a Smith-Root Type VII electrofisher. Gillnets composed of 12 yards or 27 yards of 2" or 3" stretched mesh were set at sites M1 and M5 on Prairie Creek. All fish were released unharmed, with the exception of those taken at Prairie Creek sites M1 and M5, which were retained for laboratory analysis of trace metal concentration in muscle tissue.

5.4.2.2 Trace Metal Analysis

Table 14 summarizes trace metal analyses of fish tissue collected from Prairie Creek. Upstream of the minesite (Station M1) samples consisted of 6 slimy sculpin. Downstream samples (Station M5) were comprised of 5 slimy sculpin and 2 Dolly Varden char. Fish samples were bagged, labelled and immediately frozen. In the laboratory, individuals were measured and weighed. Since slimy sculpin individuals were small, dorsal musculature from the 6 specimens from Station M1 and 5 specimens from Station M5 were combined to form a single homogenate from each area.

The Canadian Food and Drug Directorate has established maximum levels of specific metals in consumable tissues, these being:

arsenic	-	5	µg/g
copper	-	100	µg/g
lead	-	10	µg/g
zinc	-	100	µg/g
mercury	-	0.50	µg/g

(All Values in Wet Weight)

It is evident that for these parameters, concentrations were well below the standard. The most noticeable difference between upstream and downstream stations was the concentration of zinc. Also, the difference between sculpins and char is noteworthy.

Sculpins inhabit the bottom of creeks, streams, etc. Consequently, they are closely associated with bottom sediments. Analyses of sediments from upstream and downstream sites indicated concentrations of zinc in the order of 93 µg/g and 120 µg/g, respectively (See section 5.3). Concentration of zinc in slimy sculpin similarly indicated upstream/downstream differences (Table 14). As Dolly Varden char are not a resident species, as are slimy sculpin, and are not bottom-oriented, the zinc content of tissues was not considered significant.

5.4.2.3 Study Methods

The following formulae were used to determine gillnet and electroshocker catch per unit effort (C.P.U.E.) during the July field activities:

$$\text{Electrofisher C.P.U.E.} = \frac{\text{total no. fish caught or identified}}{\text{total no. minutes electrofishing}} = \text{fish/min.}$$

$$\text{Gillnet C.P.U.E.} = \frac{\dfrac{\text{total no. fish caught}}{\text{total length of net (m)}}}{\text{effort (hr.)}} = \frac{\text{fish/m}}{\text{hr.}}$$

Fish catch information is tabulated in Appendix 5.

The physical parameters recorded for the stream were:

1. water colour
2. water temperature
3. wetted width
4. channel width
5. valley flat width
6. mean depth
7. maximum depth
8. bar or island presence
9. bank stability
10. channel stability
11. substrate particle-size
12. degree of shading
13. discharge (measured or estimated)
14. gradient (estimated)
15. pool/riffle ratio
16. vertical stability
17. channel confinement
18. side channel development
19. flow stage
20. flood signs
21. channel pattern
22. floodplain debris
23. channel debris
24. stable debris
25. obstructions to fish migration

Many of these parameters were measured directly while others, such as channel stability, involved qualitative assessments. Water temperatures were measured with a hand-held mercury thermometer ($\pm$ 1°F; 0.5°C). The pH ($\pm$ .2) and dissolved oxygen concentrations ($\pm$ 1 ppm) were measured with a model OX-9 Hach Kit. Stream discharges were determined with a Marsh-McBirney Model 201 electromagnetic current meter. Conductivity was also determined for some of the systems sampled.

5.4.2.4 Results

All physical and chemical data collected at the sampling sites are summarized on data sheets presented in Appendix 4. These parameters are also discussed in the text if judged to influence habitat utilization by fish.

Prairie Creek - General

Prairie Creek originates in an area of high relief in the Manetoe Range of the Mackenzie Mountains. This high-energy tributary of the South Nahanni River is characterized by extensive riffle sections and infrequent, small shallow pools. Prairie Creek appears prone to flooding as numerous dry channels are abundant in the valley flat.

Extensive side, transverse and mid channel bars were also evident. The stream substrate appears to be stable under the observed discharge and is composed primarily of boulder, cobble and gravel-sized particles. On July 22, 1980, the waters of Prairie Creek were colourless with a pH of 7.8, a temperature of 44°F (6.5°C), a dissolved oxygen content of 11 ppm and a conductivity of 265 µmhos/cm.

Prairie Creek was sampled at the following five locations: M1, M2, M4, M5 and M6 (Figure 21).

Fish habitat was similar at all of the sampling sites on Prairie Creek. The following factors were judged to have a limiting influence on the potential utilization of the stream by fish: lack of instream and stream side cover, negligible pool development and apparent low productivity.

Prairie Creek (M1)

On July 22nd, 1980, Site M1 on Prairie Creek was sampled by:

electrofishing - 600 seconds (S), and
gillnetting - 71 hours (h).

The above sampling resulting in the capture or observation of:

Dolly Varden char - (*Salvelinus malma*) - 2 juvenile, and
slimy sculpin - (*Cottus cognatus*) - 11 individuals.

The catch per unit effort was 1.30 for electrofishing and 0 for gillnetting.

Prairie Creek (M2)

Electrofishing was conducted at site M2 for 330 s on July 22, 1980.

The following fishes were observed or captured:

Dolly Varden char - 1 juvenile, and
slimy sculpin - 11 individuals.

The catch per unit effort for electrofishing was 2.18.

Prairie Creek (M4)

Prairie Creek was electrofished in the region of M4 for 239 s on July 22, 1980.

This sampling effort resulted in the capture or observation of:

Dolly Varden char - 1 juvenile, and
slimy sculpin - 16 individuals.

The catch per unit effort for this portion of Prairie Creek sampled by electrofishing was 4.27.

Prairie Creek (M5)

Site M5 on July 22, 1980, was sampled by:

electrofishing - 324 s, and
gillnetting - 16 h.

The above sampling effort resulted in the capture or observation of:

Dolly Varden char - 2 adult, and
slimy sculpin - 13 individuals.

The catch per unit effort was 2.41 for electrofishing and 0.01 for gillnetting.

Prairie Creek (M6)

This region of Prairie Creek was sampled on July 25, 1980, by electrofishing for 414 s.

The following fish were captured or observed:

Arctic grayling - (*Thymallus arcticus*) - 2 fry,
round whitefish - (*Prosopium cylindraceum*) - 1 juvenile, 1 adult,
whitefish sp. - (*Prosopium* sp.) - 2 fry, and
slimy sculpin - 9 individuals.

The catch per unit for electrofishing was 2.17.

Prairie Creek, in the region of the proposed minesite, is utilized by Dolly Varden char as a rearing area and as adult summer habitat. It is not known if Dolly Varden char utilize this section of Prairie Creek for all phases of their life history, however, no young-of-the-year and few suitable overwintering areas were observed. Slimy sculpin were captured in Prairie Creek at all sampling sites.

Although whitefish have been reported to utilize Prairie Creek in the region of the minesite (R. Fast pers. comm.), none were encountered during this study. Juvenile and adult round whitefish and whitefish fry were captured only at M6. Arctic grayling fry were also observed at this location. Burbot (*Lota lota*), white sucker (Catostomus commerson) and Arctic grayling adults have been reported to utilize the lower reaches of the creek (R. D. Wickstrom, 1977). Lake trout (Salvelinus namaycush; no positive identification) have also been reported to utilize the lower reaches of Prairie Creek (L. Comin pers. comm.). In addition, Arctic grayling, longnose sucker (Catostomus catostomus), Dolly Varden char and possible mountain whitefish (P. williamson) are reported to utilize Prairie Creek for a spawning area (Land Use Infor. Ser. 95F).

An aerial examination of the total length of Prairie Creek on July 25, 1980, did not identify barriers or steep stream gradients sufficient to prevent upstream movement of fish into the region near the minesite. It is believed, however, that extensive stretches with steep gradient and the lack of holding areas may discourage migration into upper reaches of Prairie Creek by many fish species found near the confluence with the South Nahanni River.

Harrison Creek (M3)

Harrison Creek, a tributary of Prairie Creek, originates in an area of high relief directly east of the proposed minesite.

When investigated on July 22, 1980, Harrison Creek exhibited only marginal fish potential. The lower reach of the creek exhibited inadequate flow and was occasionally subterranean. The upper reaches of Harrison Creek had a mean depth of 0.5 feet and were characterized by steep gradients and an absence of pool development. Mine water from the lower portal entered Harrison Creek approximately 200 yards upstream of the confluence of Harrison and Prairie Creek.

When sampled on July 22, 1980, the waters of Harrison Creek were colourless with a pH of 7.7, a temperature of 44°F (6.5°C), a conductivity of 410 μmhos/cm and a dissolved oxygen concentration of 11 ppm.

Harrison Creek was electrofished on July 22, 1980, near its confluence with Prairie Creek for 216 s.

The following fish were captured or observed:

slimy sculpin - 7 individuals.

The catch per unit effort for electrofishing was 1.94.

Fish utilization of Harrison Creek upstream of the mouth area is not expected due to steep gradient, absence of pools, low discharge and subterranean flows.

Unnamed Creek (Site R1 on Figure 20)

When investigated on July 23, 1980, the waters of this creek were colourless with a pH of 7.8, a temperature of 45°F (7°C), a conductivity of 310 μmhos/cm and a dissolved oxygen concentration of 9 ppm. This unnamed stream was approximately 16 feet wide and exhibited a mean depth of approximately 1 foot. The stream had tumbling flow and a steep gradient approaching ten per cent (10%).

Due to steep gradient, lack of pools and slow waters, this creek was judged to have no potential as fish habitat.

Unnamed Creek (Site R2 on Figure 20)

This unnamed mountain stream enters the North Nahanni River via Sundog Creek and the Ram River. The proposed winter road alignment closely parallels this high energy stream on the north side for several miles.

The waters of this mountain stream were colourless with a temperature of 45°F (7°C) when investigated on July 24, 1980. The pH was 7.8 and the dissolved oxygen concentration was 9 ppm.

Two waterfalls upstream of the sampling site constitute barriers to the upstream movement of fish into the headwaters.

Electrofishing was conducted for 535 s. on July 24, 1980, below the lower falls. No fish were observed.

The lack of fish utilization may be the result of gradient, limited instream cover and low productivity.

Unnamed Creek (Site R3 on Figure 20)

This small unnamed creek and its many tributaries drain the southwestern slopes of the Ram Plateau before discharging into Sundog Creek.

On July 24, 1980, the waters of this creek were colourless and had a dissolved oxygen content of 8 ppm. The pH was 7.7 and the temperature was 58°F (14.5°C). The unnamed creek was sampled on July 24, 1980, by electrofishing for 337 s.

This sampling effort resulted in the capture or observation of:

Arctic grayling - 2 fry, 3 juvenile.

The catch per unit effort for electrofishing was 0.89. Although instream cover is generally quite limited, debris accumulations and localized undercut banks are utilized by Arctic grayling as nursery and rearing areas. It is suspected that Arctic grayling may also use this section of the creek as a minor spawning area and as adult summer habitat. In addition, longnose sucker, longnose dace (*Rhinichthys cataractae*) and lake chub (*Couesius plumbeus*) have been reported to use the Ram River as a nursery area (Land Use Info. Ser. 95G), and may penetrate upstream into this tributary.

Tetcela River - General (Sites R4 and R5 on Figure 20)

The Tetcela River, a tributary of the North Nahanni River, originates on the southeast facing slopes of the Ram Plateau. The proposed winter road crosses this system at two locations. The westerly crossing site (Site R4) is located apprioximately 0.3 miles upstream of the confluence of the Tetcela River with a large unnamed tributary. The easterly crossing (Site R5) is located approximately 0.8 miles downstream of this confluence.

Tetcela River (Site R4 on Figure 20)

When investigated on July 23, 1980, the Tetcela River was narrow (10 ft.) and shallow (1 ft.) at the location of the proposed winter road crossing site. The water was light grey in colour with a pH of 7.9 and temperature of 52°F (11°C). The conductivity was 290 µmhos/cm and the dissolved oxygen concentration was 10 ppm. Electrofishing was conducted for 300 s on July 23, 1980.

The following fish were captured or observed:

Arctic grayling - 4 fry, 1 juvenile, 1 adult,
lake chub - 15 individuals, and
slimy sculpin - 13 individuals.

The catch per unit effort was 6.80.

The region of the proposed road crossing site was utilized to a limited extent by Arctic grayling as a nursery and rearing area and as adult summer habitat. Although satisfactory Arctic grayling spawning areas were not abundant, this species may spawn in this region of the Tetcela River. Extensive utilization by adult Arctic grayling is not anticipated due to the shallowness of the watercourse and the limited amount of adequate cover.

Tetcela River (Site R5 on Figure 20)

As the unnamed tributary that joins the Tetcela River 0.8 miles upstream of the proposed crossing site is substantially larger than the Tetcela River, the habitat present at the east crossing was considerably different from that at the noted westerly site (Site R4).

The stream width was approximately 35 feet and the mean depth was estimated to be 1.5 feet when investigated on July 23, 1980. The water of the Tetcela River was pale yellow in colour with a temperature of 52°F (11°C), a pH of 7.9, a conductivity of 350 µmhos/cm and a dissolved oxygen concentration of 9 ppm.

A total of 308 s of electrofishing on July 23, 1980, resulted in the capture or observation of:

Arctic grayling - 5 fry, 2 juvenile, 1 adult,
whitefish sp. - 1 fry,
northern pike (*Esox lucius*) - 1 juvenile,
1 juvenile/adult (undetermined maturity)
lake chub - 7 individuals, and
slimy sculpin - 22 individuals.

The catch per unit effort for electrofishing was 7.79.

Arctic grayling utilize this region of the Tetcela River as adult summer habitat and as a nursery and rearing area. Arctic grayling are suspected to utilize the Tetcela River as a spawning area. The region of the proposed crossing site was also utilized by whitefish sp. as a nursery area, and whitefish are suspected to spawn in the area as well. Northern pike, lake chub and slimy sculpin are also present in this section of the Tetcela River.

The observed higher numbers of fish at the eastern crossing of the Tetcela River is likely the result of an increase in the quality of aquatic habitat: mean depth, the number and depth of pools and the availability of cover from bank vegetation and undercuts. Longnose sucker and longnose dace have been reported to utilize portions of the Tetcela River approximately 30 miles downstream of the proposed winter road crossing (Site R5) as a nursery area (Land Use Info. Ser. 95G).

Fishtrap Creek (Site R6 on Figure 20)

Fishtrap Creek originates in a small lake situated west of the Silent Hills and drains a low marsh valley before discharging into the South Nahanni River.

Throughout its length, Fishtrap Creek was characterized by numerous beaver dams, negligible current and dense growth of aquatic macrophytes. When investigated on July 24, 1980, the water was colourless with a pH of 7.9, a temperature of 68°F (20°C) and a dissolved oxygen content of 9 ppm.

No fish were captured or observed during 150 s of electrofishing on July 24, 1980. Fishtrap Creek has very low habitat potential for utilization by prominent fish species other than northern pike (*Esox lucius*).

Grainger River (Site R7 on Figure 20)

The Grainger River originates in the Nahanni Range and flows generally in a southerly direction to its confluence with the Liard River. The winter road crossing is located at a site that was previously used for the same purpose.

On July 24, 1980, the pale amber coloured water of the Grainger River had a temperature of 57°F (14°C), a pH of 7.7 and a dissolved oxygen concentration of 9 ppm.

Electrofishing was conducted at the site on July 24, 1980, for 547 s. Sampling resulted in the capture or observation of:

Arctic grayling - 3 juveniles, and
slimy sculpin - 24 individuals.

The catch per unit effort for electrofishing was 2.96.

The section studied is utilized by Arctic grayling as a rearing area, and slimy sculpins are common. Although extensive utilization of the Grainger River in the vicinity of the proposed winter crossing sites by other prominent fish was not documented, the Grainger River appears to have habitat potential for rearing and adult summer usage. The availability of suitable spawning gravel for regionally prominent fish species is limited at the proposed crossing location. Gravel areas, which provide suitable spawning habitat, exist up and downstream of the proposed crossing (Hatfield et al. 1972).

Northern pike, longnose dace and longnose sucker have been reported to use downstream regions of the Grainger River for rearing (Hatfield et al 1972). Utilization of the lower reaches of the Grainger River as a nursery area by longnose sucker has also been reported. (Land Use Info. Ser. 95G). Adult northern pike, walleye (Stizostedion vitreum) and Arctic grayling have been reported at the mouth of the Grainger River (L. Comin, pers. comm.). As suitable habitat exists in the area of the proposed winter road crossing, utilization of the area by many of the species reported from downstream areas could be expected.

Liard River (Site R12 on Figure 20)

As reported in the Preliminary Environmental Evaluation, the Liard River is utilized as an overwintering area and a suspected spawning migration route for many fish species (Hatfield et al. 1972b, McCart et al. 1974). Longnose sucker, northern pike, walleye, lake cisco (Coregonus artedii) and lake whitefish are reported to be the most common fish in the Liard River (Land Use Info. Ser. 95G, Hatfield et al. 1972a).

5.5 Vegetation

5.5.1 Background

Overall, the vegetation of the South Nahanni and Liard River areas is not well-known. According to Raup (1947), the upland forest of white spruce, jack pine, aspen and balsam poplar, with its accompanying muskegs, is probably the most widespread timber type in southwestern Mackenzie district east of the mountains, that is, the Nahanni Range. Field investigations carried out for this report tend to confirm this statement. West of the Nahanni Range, the vegetation is quite variable, ranging from non-treed wetlands through mixed forest to alpine lichen-dominated communities. No vegetation maps or detailed descriptions of the Cadillac mine area are available; however, a number of studies of vegetation in Nahanni National Park and vicinity have been useful. A field programme was designed to gain more information regarding the vegetation of both the Cadillac mine property and the proposed winter road corridor.

5.5.2 Study Approach

To determine in greater detail the vegetation present on the Cadillac property and adjacent to the proposed winter road, field investigations were carried out in July, 1980. On-site studies concentrated on the mine, mill and camp site, and the preferred tailings pond locations, site T-2 and site T-3. A more general reconnaissance of other potential tailings pond locations was conducted. Vegetation communities along the proposed alignment of the road were determined by aerial observation, supplemented by ground surveys. In all cases, appropriate information obtained from the literature and personal communications has been incorporated into the report.

For each site examined, the general vegetation communities present were determined. Species representative of each community were noted and unknown species were collected for later identification. No attempt was made to quantitatively determine abundance or frequency of each species.

The following sections describe the vegetation of each site, with identification at the species level provided in most cases. If identification at the species level was not possible, genus name only has been given. In the text of the report, common names are used if they exist, with the scientific name being included only at the first point of reference to a species. In some cases, it has been possible to use the common genus name as only one species of that genus was seen. A complete listing of vegetation species by scientific and common names identified at the mine area, tailings pond sites and adjacent to the route of the winter road is included in Table 15.

5.5.3 Site Investigations

5.5.3.1 Mine and Mill Site

The area selected for the mine-mill site (P-2) is situated on the floodplain of Prairie Creek, adjacent to the existing camp facilities. Vegetation is dominated by a mixture of black and white spruce (Picea mariana and P. glauca respectively), which grow up to 30 feet in height. Less frequently occurring trees are balsam poplar (Populus balsamifera) and tamarack (Larix laricina). The understory is composed of a variety of shrubs including several willow species (Salix spp.), netted willow (Salix reticulata), shrubby cinquefoil (Potentilla fruticosa), Canadian buffalo-berry (Shepherdia canadensis), dwarf birch (Betula glandulosa), labrador tea (Ledum groenlandicum), lapland rose-bay (Rhododendron lapponicum)and ground juniper (Juniperus communis). Prostrate shrubs in this area are bog cranberry (Vaccinium vitis-idaea), bearberry (Arctostaphylos uva-ursi) and alpine bearberry (A. rubra).

The ground flora is composed of many species: grass-of-Parnassus (Parnassia palustris L. var. neogaea), fireweed Epilobium angustifolium), willowherb (E. latifolium), yarrow (Achillea millifolium), four-parted gentian (Gentianella propinqua), ragwort (Senecio cymbalarioides), golden saxifrage (Saxifraga aizoides), goldenrod (Solidago decumbens), Siberian aster (Aster sibiricus), white camas (Zygadenus elegans), cut-leaved anemone (Anemone multifida), hedysarum (Hedysarum sp.), fleabane (Erigeron hyssopifolius), showy everlasting (Antennaria pulcherrima), sweet-flowered androsace (Androsace chamaejasme), loco-weed (Oxytropis sp.), eyebright (Euphrasia disjuncta), common butterwort (Pinguicula vulgaris), northern green orchid (Habenaria hyperborea), yellow dryad (Dryas drummondii), white dryad (D. integrifolia), bistort (Polygonum viviparum), horsetail (Equisetum sp.) and at least one sedge (Carex spp.).

The grasses found on the site are a wheatgrass species (Agropyron violaceum), fescue (Festuca altaica), spike trisetum (Trisetum spicatum), northern reed grass (Calamagrostis inexpansa), hairy wild rye (Elymus innovatus), and foxtail barley (Hordeum jubatum). A variety of mosses and lichens also occur at this site.

A cleared area previously proposed as a site for the mill (P1) was found to be almost barren. However, the occasional invading species was noted, including willows, golden saxifrage and a species of wheatgrass (Agropyron violaceum).

5.5.3.2 Tailings Pond Sites

Of the nine potential tailings pond sites originally identified, five were considered to be worthy of further evaluation based on investigations carried our by Ker, Priestman & Associates Ltd. At the time the vegetation field work was conducted, two of these locations (site T-2 and site T-3) had been selected as preferred sites. Thus, detailed vegetation studies focussed on these two sites, with general communities being noted for the remaining three tailings pond sites (sites T-1, T-4 and T-5). It should be noted that sites are identified as T-1, T-2, etc. for ease of reference but only site T-2 is currently being considered for tailings disposal.

Tailings Pond Site T-2

Situated on the Prairie Creek floodplain, immediately to the northwest of the existing campsite, tailings pond site T-2 consists of three general vegetation communities: a spruce forest of similar species composition to the mine-mill site, a younger floodplain vegetation community and a sparsely-vegetated disturbed floodplain gravel area.

The species characteristic of the spruce forest community will not be repeated as they are included in the previous section. The community of greatest extent on tailings pond site T-2 is the floodplain vegetation, dominated by willows interspersed with Canadian buffalo-berry, dwarf birch, shrubby cinquefoil and ground juniper. Relatively young specimens of white and black spruce, balsam poplar, tamarack and aspen (Populus tremuloides) also occur.

Herbs found within this community include Siberian aster, yarrow, grass-of-Parnassus, cut-leaved anemone, four-parted gentian, white dryad, goldenrod (Solidago decumbens), ragwort, Indian paintbrush (Castilleja raupii), fireweed, willowherb, northern green orchid, milk vetch (Astragalus Robbinsii var. minor), and wild strawberry (Fragaria virginiana). The ground cover includes the prostrate shrubs bearberry and alpine bearberry, and sedges, mosses and lichens.

Some of the area in tailings pond site T-2 has been previously disturbed, completely removing vegetation and exposing gravel material. A few species were found to have invaded this disturbed area, including willows, fireweed, willowherb, yarrow, golden saxifrage, white and yellow dryad and several grasses.

Site T-3

Site T-3 is adjacent to Prairie Creek, downstream from the existing facilities of the mine and camp site. The vegetation on this site is a fairly homogeneous black spruce/lichen community. Black spruce is the dominant tree species with the occasional tamarack and white spruce occurring. Shrubs include dwarf birch, water birch (Betula occidentalis), labrador tea, ground juniper, shrubby cinquefoil, willows (one of which was identified as Salix myrtillifolia), bog bilberry (Vaccinium uliginosum), and Canadian buffalo-berry.

Lichens form the dominant ground cover in this black spruce/lichen community. Although extensive collections were not made, an area considered to be representative of lichen growth was sampled and the following species were found: Cladina alpestris, Cetraria cucullata, Alectoria ochroleuca, Thamnolia subuliformis, Dactylina arctica and Cetraria pinastri. Within the same sample area, two mosses were also identified: Dicranum sp. and Pleurozium schreberi. See Table 16 for a listing of lichens and mosses by complete scientific name. Other species found in the ground cover include alpine bearberry, golden saxifrage, four-parted gentian, common pink wintergreen (Pyrola asarifolia), white dryad, lapland cassiope (Cassiope tetragona) and sedge.

Adjacent to Prairie Creek and the existing road, willows become dominant, with more frequent occurrence of shrubby cinquefoil, fireweed, ragwort, horsetail and sedge.

Other Sites

Site T-1 is located in the valley of Harrison Creek in close proximity to the mine portals and existing camp. This steep-sided valley exhibits two distinct vegetation communities, dependent on aspect. The slope with a southeast exposure supports a black spruce/lichen community. A road following this side of the valley to the upper portal has been invaded by horsetail and some fireweed. The other side of the valley with a northwest exposure is more open, characterized by few spruce, some willows and a more dense ground cover of lichens and mosses. Some areas of exposed rock are found and permafrost is known to exist (Ker, Priestman, 1980).

Adjacent to Harrison Creek, a disturbed gravel area supports several pioneer species including willows, horsetail, bearberry, yellow and white dryad, golden saxifrage, willowherb, lapland cassiope, and sandwort (Arenaria rubella). Very young seedlings of white spruce and balsam poplar were also noted. Upstream of site T-1 on the south and north forks of Harrison Creek, sites T-4 and T-5 (respectively) are located. Aerial reconnaissance revealed both valleys to be dominated by black spruce/lichen vegetation, with species composition assumed to be similar to that described for Site T-3.

5.5.3.3 Disturbed Areas

Site investigations of disturbed areas in the vicinity of the Cadillac mine site revealed several colonizing species. The areas examined include the gravel adjacent to Harrison Creek, the dyke between the camp and Prairie Creek, the proposed tailings pond site T-2, the camp site and nearby roads, and the gravel airstrip.

The first of these areas, the gravel adjacent to Harrison Creek, has been relatively undisturbed since 1968 and several species (dominantly willows) have invaded the site. The complete species list for this area is included in the description of site T-1. Proposed mill site P-1 was last disturbed in 1969; occasional regrowth of willow species, golden saxifrage and wheatgrass (Agropyron violaceum) has occurred. The cleared area on the floodplain at tailings pond site T-2 has been invaded by willows, fireweed, willowherb, yarrow, golden saxifrage, white and yellow dryad and several grasses.

The community where vegetation appears to have most successfully re-established is the camp site floodplain adjacent to the mixed spruce forest. Species found here include: willows, netted willow, shrubby cinquefoil, rough cinquefoil (Potentilla norvegica), silverweed (Potentilla anserina), fireweed, willowherb, golden saxifrage, four-parted gentian, yarrow, sweet-flowered androsace and yellow and white dryad. A commonly occurring sedge is northern single-spike sedge (Carex scirpoidea). Grasses are frequent colonizers, the most dominant being a wheatgrass species (Agropyron violaceum); hairy wild rye is also frequently seen. Other species in the disturbed area are foxtail barley, northern reed grass and spike trisetum. One specimen of hair grass (Agrostis scabra) was observed.

The last disturbed site examined for invading species was the gravel airstrip which was built in 1966 and upgraded in 1967. Ongoing use of the airstrip appears to discourage colonizing species as most of specimens noted were along the edges of the landing strip. Species include several willows, white and yellow dryad, golden saxifrage, Siberian aster, fireweed, yarrow, goldenrod (Solidago multiradiata) and dandelion (Taraxicum sp.). Northern single-spike sedge was fairly common. Grasses include wheatgrass (Agropyron violaceum), spike trisetum and northern reed grass. Several volunteer seedlings of white spruce were also noted.

Since the above-named species appear to be natural colonizers, it seems practical to consider them when revegetation studies are undertaken. The grasses, in particular, are practical for reclamation as their seed is more likely to be available in commercial quantities. The dominant colonizer is wheatgrass (Agropyron violaceum); others are hairy wild rye, spike trisetum, northern reed grass and foxtail barley.

5.5.4 Vegetation Along the Winter Road Corridor

5.5.4.1 Introduction

The proposed winter road corridor extends a distance of nearly 100 miles between the Cadillac mine site at Prairie Creek in the Mackenzie Mountains and the Liard River east of Nahanni Butte. Along this distance, it traverses a number of environmental settings, each with a different vegetation component. To determine the vegetation communities through which the road will pass, an aerial reconnaissance was conducted. Where possible, the area was investigated on the ground and more detailed information regarding community structure was obtained. The following sections describe the vegetation communities along the winter road corridor, as determined by field investigations, supplemented by air photo analysis and literature review. The locations where ground investigations of vegetation communities were conducted are shown in Figure 22.

5.5.4.2 Floodplain Community (Site 1 on Figure 22)

The vegetation type which the road most frequently traverses at the beginning of the route along Prairie Creek is the floodplain community. The most dominant species is generally willow if the community is less well-established. In other communities, white spruce becomes important. Detailed species lists of vegetation within the willow-dominated floodplain community are given in the description of tailings pond site T-2 (section 5.5.3.2). In the Prairie Creek valley, the floodplain is flanked by valley walls supporting a black spruce/lichen community as described in section 5.5.3.2.

5.5.4.3 Lichen Dominated Community (Sites 2 and 4 on Figure 22)

As altitude increases along the route, the trees become more openly spaced and lichens begin to dominate the community. At Site 2, the vegetation consists of occasional black spruce and tamarack, as well as willows, bog bilberry and labrador tea. The ground flora is largely lichens with some mosses and bearberry, alpine bearberry, lapland cassiope, common pink wintergreen, white dryad and sedge.

Further examination of this community type was undertaken at Site 4. Species included the occasional stunted black spruce, willows, dwarf birch, water birch, labrador tea, lapland rose-bay, bog bilberry and alpine bearberry. Ground flora consisted of lapland cassiope, white dryad, elephant head (Pedicularis groenlandica), purple saxifrage (Saxifraga oppositifolia), golden saxifrage, crowberry (Empetrum nigrum), northern asphodel (Tofieldia coccinea), smooth woodsia (Woodsia glabella), bistort and sweet-flowered androsace. Northern single-spike sedge and a species of fescue (Festuca altaica) were also noted. Lichens and mosses, the dominant ground cover, were identified as Cladina alpestris, Cetraria cucullata, Alectoria ochroleuca, Thamnolia subuliformis, Dactylina arctica, Cetraria pinastri, Dicranum sp. and Pleurozium schreberi.

5.5.4.4 Barren Areas (Site 3 on Figure 22)

Further increases in altitude bring about a corresponding decrease in vegetative cover. Bedrock outcrops and loose scree slopes inhibit growth and the vegetation is characterized by a thin ground flora of ericaceous shrubs and lichens (Crampton 1973). In areas sufficiently stable to support growth, the occasional dwarfed willow or black spruce is seen.

5.5.4.5 Mixed Forest (Sites 5 and 6 on Figure 22)

A few miles beyond site 4, lower elevations prevail and more dense vegetation is seen. Tree cover becomes almost continuous, dominated by black spruce, with the occasional appearance of white spruce, tamarack and white birch (Betula papyrifera). Balsam poplar appears adjacent to stream beds and scattered throughout the forest. Jack pine (Pinus banksiana) also begins to appear more prominantly. Pure stands of black spruce with a lichen ground cover intrude and may indicate an area of 'frozen peatland'. (S. Zoltai, pers.comm.)

At the crossing of an unnamed tributary to Sundog Creek (site 5) a forested site revealed a tree cover of dominant black spruce with the occasional balsam poplar. Shrubs included willows (Salix spp. and s. myrtillifolia), labrador tea, dwarf birch, bog bilberry, prickly rose (Rosa acicularis), and the prostrate shrubs bearberry and alpine bearberry. Common pink wintergreen, one-flowered winter-green (Moneses uniflora), four-parted gentian, hedysarum sp. horse-tail, and mosses, lichens and the occasional grass species comprised the ground flora.

Closer to the stream, balsam poplar becomes more frequent and the shrubs Canadian buffalo-berry, alder (Alnus sp.), and willows were found. A milk vetch (Astragalus frigidus) was noted as part of the ground flora.

Further along the route, jack pine becomes more prominant and occurs in pure stands as well as scattered throughout the forest. This feature may be the result of past forest fires. During aerial reconnaissance, it was noted that fairly large areas have been burned; apparently, a major fire burned the area in 1942, and several smaller fires have occurred since that date. (Camp personnel, pers. comm.)

The next site that was investigated on the ground was the Tetcela River (site 6). This site is a part of the mixed forest area described above, yet the vegetation sample may reflect a more riparian nature due to its proximity to the Tetcela River. Trees found here include balsam poplar, trembling aspen, white spruce and the occasional jack pine. The shrub layer was comprised of willows, alder (Alnus rugosa), dogwood (Cornus stolonifera), rose (Rosa sp.), Canadian buffalo-berry, wild red raspberry (Rubus ideaus), low-bush cranberry (Viburnum edule), shrubby cinquefoil, ground juniper, twining honeysuckle (Lonicera dioica) and bearberry. A rich herb layer includes wild strawberry, reflexed loco-weed (Oxytropis deflexa), goldenrod (Solidago canadensis and S. decumbens), northern bedstraw (Galium boreale), hedysarum sp. (Hedysarum boreale), Siberian aster, Lindley's aster (Aster ciliolatus), fireweed, yellow dryad, one-sided wintergreen (Pyrola secunda), Siberian yarrow (Achillea sibirica), twin-flower (Linnaea borealis), western meadow rue (Thalictrum occidentale), narrow-leaved hawkweed (Hieracium scabriusculum), grass-of-Parnassus, and bunchberry (Cornus canadensis). Horsetail was observed and wheatgrass (Agropyron sp.), bluejoint (Calamagrostis canadensis) and moss are in evidence.

5.5.4.6 Seasonally Waterlogged Areas (Site 7 on Figure 22)

As the winter road corridor approaches Fishtrap Creek from the west, the vegetation changes from mixed forest to a community more characteristic of increased moisture. These areas are called seasonally waterlogged and display a mixture of treed and non-treed areas. Trees include black spruce, tamarack, white spruce, balsam poplar and white birch. The treed areas merge into treed bogs, willow flats, sedge meadows and open peat bogs (Crampton 1973). No ground examination of the seasonally waterlogged areas was conducted.

This type of terrain continues to the western edge of the Nahanni Range, interrupted only by the Silent Hills Pass upland area where mixed forest vegetation of balsam poplar and jack pine, with tamarack, black spruce and white spruce occurs once more. After crossing another seasonally waterlogged area, the winter road corridor gains elevation towards the Grainger Pass in the Nahanni Range. West of the Pass, the vegetation returns to mixed forest of balsam poplar and jack pine, with white spruce, white birch and stands of black spruce intruding. This cover thins and becomes low-growing in the pass area, with willows becoming more evident.

5.5.4.7 Shrub Meadow Community (Sites 8 and 9 on Figure 22)

East of the Nahanni Range (site 8), the vegetation is dominated by shrub meadow communities with treed and non-treed areas occurring in patterns. Detailed information for this vegetation type was drawn from Reynolds et.al. (1980) and a field site visit. At a shrub meadow site located slightly east of the Grainger Pass, plant species are water sedge (Carex aquatilis), northern single-spike sedge, spike rush (Eleocharis pauciflora), dwarf birch and willows. Associated or understory species are shrubby cinquefoil, sweet gale (Myrica gale), bog rosemary (Andromeda polifolia), horsetail spp. (Equisetum palustre, E. fluviatile), sedge (Carex spp.), alpine bearberry, cinquefoil (Potentilla sp.), cotton grass (Eriophorum scheuchzeri), false asphodel (Tofieldia pusilla), showy everlasting, labrador tea sp. (Ledum sp.), stonecrop (Sedum sp.) and meadow rue (Thalictrum sp.). A second site in this vegetation community was sampled during field investigations (site 9). The area was more densely vegetated than the previous site although it still retained a non-treed appearance from the air. Species include low-growing balsam poplar and aspen, black spruce, willows, alder (Alnus sp.), rose, shrubby cinquefoil, bog bilberry and bearberry. Ground cover was composed of bunchberry, wintergreen (Pyrola sp.), labrador tea, fireweed and Canada anemone (Anemone canadensis).

5.5.4.8 Grainger River Area (Site 10 on Figure 22)

The terrain becomes more rolling two miles west of the Grainger River crossing, and balsam poplar is more prevalent. In general as the Grainger River is approached, vegetation resembles the mixed forest community described in section 5.5.4.5. Black spruce occurs frequently with areas of balsam poplar, aspen and jack pine appearing. Tamarack is associated with the stands of black spruce.

At the Grainger River crossing (site 10), two vegetation communities were sampled: the river edge and the adjacent forested area. The river edge community included willows, balsam poplar, shrubby cinquefoil, common wild rose (Rosa woodsii), dogwood, alder (Alnus sp.), and silverberry (Elaeagnus commutata). Ground flora was composed of goldenrod (Solidago canadensis), wild strawberry, Siberian aster, ragwort, northern green orchid, bronze-bells (Stenanthium occidentale), northern bedstraw, yarrow, star-flowered Solomon's-seal (Smilicina stellata), showy everlasting, wild chives (Allium schoenoprasum), prairie gentian (Gentiana affinis), blue-eyed grass (Sisyrinchium montanum) and false asphodel (Tofieldia glutinosa). Horsetail and water sedge were part of this community as were narrow reed grass (Calamagrostis neglecta), wheatgrass (Agropyron violaceum), timber oat grass (Danthonia intermedia) and sweet grass (Hierochloe odorata).

Adjacent to the river edge community at the Grainger River, a forested area was examined. Species which form this community are balsam poplar, aspen, white spruce, black spruce, tamarack, willows, alder (*Alnus* sp.), Canadian buffalo-berry, low bush cranberry, labrador tea, shrubby cinquefoil and rose. The ground flora consisted of bunchberry, Canada anemone, common pink wintergreen, bastard toad-flax (*Geocaulon lividum*), northern bedstraw, western meadow rue and mitrewort (*Mitella nuda*).

5.5.4.9 Liard Forest

The area between the Grainger River and the Liard River is covered with several species of trees, which may occur as individuals or in pure stands. Species found include balsam poplar, aspen, jack pine*, black spruce, tamarack and white birch. Stands are quite variable, not only in species composition, but in height. A somewhat patterned appearance of different tree densities and heights is exhibited in this area. Crampton (1973) provides further information regarding the vegetation which occurs. Widely scattered dwarfed black spruce, with some tamarack and white birch, which surround scattered depressions containing summer pools, may indicated the presence of a peat plateau. The vegetation in these areas is dominated by labrador tea sp. (*Ledum palustre*). Minor components of the flora are shrubby cinquefoil, bog cranberry, cloudberry (*Rubus chamaemorus*) and horsetail. (Crampton 1973).

5.5.5 Botanical Interpretation

5.5.5.1 Introduction

The Cadillac property and the proposed winter road corridor lie within a region which is considered relatively unexplored in botanical terms. As much of the area has experienced a long glacier-free period, the possibility of locating species of botantical interest is fairly high. This might include the discovery of endemic species, or the occurrence of species previously documented in the literature but whose range is not well-defined.

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* The Liard area is close to the northernmost limit for lodgepole pine (*Pinus contorta* var. *latifolia*), however some interbreeding does occur between this species and jack pine (Scotter 1974). For purposes of this report, all pine in the area is referred to as jack pine, although it is probable some lodgepole pine occurs near the Liard River.

5.5.5.2 Rare Species

Most available information regarding rare flora has been obtained from studies in the vicinity of Nahannni National Park (Marsh and Scotter 1976; Scotter and Henry 1977; Scotter et.al. 1971; Steere, Scotter and Holmen 1977). The presence of unusual habitats such as mineral springs or spray zones from falls may create an environment suitable for species not generally found elsewhere, and therefore of interest. An objective of the field programme was to record any habitats along the route of the winter road or at the mine site which could be considered unusual. The area beside the falls near site 4 presents the possibility of a unique habitat; otherwise, no specialized habitats were noted.

5.5.5.3 Plants of Restricted Range

Most of the species identified during site investigations have been referred to in the botanical literature for the region and are not considered unusual. However, several species are listed as vascular plants of restricted range in the Northwest Territories (Cody 1979). They are as follows:

1. Danthonia intermedia Vasey
2. Anemone canadensis L.
3. Rosa woodsii Lindl.
4. Oxytropis deflexa (Pall.) DC. var. sericea Toff. & Gray
5. Gentiana affinis Griseb.
6. Lonicera dioica L. var. glaucescens

Of the above species, two were collected from locations which extend their known range in the Northwest Territories. These are timber oat grass (Danthonia intermedia), and prairie gentian (Gentiana affinis), both of which were collected at the Grainger River, site 10. The others were noted in locations within their known restricted ranges as described by Cody (1979). All species have distributions outside of the Northwest Territories.

5.5.5.4 Other Collections

Site investigations revealed the presence of three species of further interest:

1. Hedysarum boreale Nutt. var. mackenzii (Richards.) C.L.Hitchc.
2. Astragalus Robbinsii var. minor(Hook.) Barneby
3. Stenanthium occidentale Gray.

The presence of these species in the Northwest Territories has not been reported in the literature examined for this project. In the case of the Hedysarum species, which was collected at the Tetcela River site, modifications of taxonomy may account for the absence of documentation of this particular species. The fairly widespread nature of Hedysarum and the taxonomic uncertainty associated with identification place this species among those considered usual for the Mackenzie region.

The species of milk vetch (Astragalus Robbinsii var. minor) which was collected at the northwest end of tailings pond site T-2 is documented in Hulten (1968). However, the range indicated for this species does not show an extension into the Prairie Creek area. The herbarium at the University of Calgary has no samples of this milk vetch collected from the Northwest Territories, although its distribution into the Mackenzie District is mentioned in a herbarium reference (P. Dickson, pers.comm.).

The third species of interest is bronze-bells (Stenanthium occidentale), which has not been recorded in the Northwest Territories. The collection of this species from the Grainger River site may be considered an important extension of range from its documented occurrence in the southwestern regions of Canada.

It appears that the Prairie Creek study area, and the Grainger River site in particular, may yield valuable botanical information regarding species presence and distribution in the Mackenzie District of the Northtwest Territories. The amount of information obtained during the site investigations emphasizes the relatively unexplored nature of this region.

5.5.6 Revegetation

Reclamation planning for disturbed areas created both during the operation and following abandonment of the Cadillac mine site will aid the process of revegetation. The environment of the mine property is characterized by severe climate and a short growing season. Poor growth conditions on waste rock and tailings materials further restrict natural revegetation. Roads associated with mining activity and exploration disturb the vegetative mat on steep slopes, creating an additional reclamation problem. During field investigations, previously disturbed areas were examined to determine if natural revegetation was occurring. It was found that the more ideal environments, that is, floodplain gravels which are flat-lying, had been colonized by some species. These invading species are described in section 5.5.3.3. The ground cover achieved by colonizers is sporadic, and therefore active reclamation of disturbances will be necessary to restore ground cover.

Materials created during the mining process do not present optimum growing conditions for vegetation. Waste rock may be deficient in both plant nutrients and moisture due to its coarse size and inadequate fines. Tailings pond materials will not be acid-generating, according to tests conducted by B. C. Research (Ker, Priestman, 1980). It is possible that the most serious problem facing the establishment of long-term growth on the tailings pond site may be the presence of salts resulting from the alkaline nature of the host rock. A clay-lined tailings pond in which moisture tends to move to the surface through capillary action rather than draining into the ground water systems may concentrate salts at the surface.

The Cominco operation at Pine Point, Northwest Territories, where lead-zinc ore is extracted from dolomitic limestone host rock, likely represents the most comparable mine situation. At this location, the presence of high levels of salts in the tailings pond occurred over time. (R. Gardiner, pers. comm.). Several species have been used in revegetation of the area; they include alkali grass (Puccinellia nuttalliana) which was transplanted from the Fort Smith area, and agronomic varieties of wheatgrass (Agropyron spp.) and fescue (Festuca spp.). It has been found that the native species establish more successfully.

During experimental evaluation of the Pine Point mine and mill waste as growth media for plants, the following results were obtained:

1. Potential growth limiting factors associated with waste rock disposal areas include deficiencies of essential plant nutrients (Nitrogen, phosphorus, potassium), phosphorus fixation, induced potassium deficiency, moisture stress during periods of infrequent precipitation, winter-kill, compaction on the top surface of the dump and excessive steepness and inadequate fines on the slopes.

2. Growth limiting factors may vary over the surface of the tailings pond as a result of particle segregation during deposition. Deficiencies of nitrogen, phosphorus and potassium will be general over the area. Moisture stress, lack of secondary structure and inadequate aeration may limit plant growth to varying degrees depending on the particle size distribution, moisture holding capacity and related physical characteristics.

The above-mentioned factors may also be associated with waste rock disposal areas and the tailings pond site to be created at the Cadillac mine property.

5.6 Wildlife

5.6.1 Methods

Wildlife surveys were flown in a Bell 206 Jet Ranger helicopter over Cadillac Explorations Limited Prairie Creek minesite and winter road alignment during the period 6 - 10 July, 1980. The surveys were designed to provide information on the general abundance and seasonal distribution of ungulates including woodland caribou (Rangifer tarandus caribou), Dall's sheep (Ovis dalli) and moose (Alces alces), and birds such as cliff-nesting raptors including Golden Eagles (Aquila chrysaetos), Gyrfalcons (Falco rusticolus), Peregrine Falcons (Falco peregrinus) and waterfowl, with particular emphasis on Trumpeter Swans (Olor buccinator).

The surveys were concentrated primarily within a six mile radius of the mine but also included the 'Caribou Flats' area north of the minesite. The most westerly portion of the winter road route was surveyed in conjunction with the coverage of the minesite. Intensive surveys of the Nahanni Range in the 'Grainger Gap' area were flown for Dall's sheep and cliff-nesting raptors. Incidental sightings of moose and signs of beaver activity in the Fishtrap Creek and Silent Hills areas were recorded during waterfowl surveys.

In addition to the aerial surveys, inspections for signs of mammalian wildlife (e.g. tracks, fecal pellets, plus direct observations) and breeding birds were made in the vicinity of the mine. Wildlife observations were also recorded by a team of BEAK fisheries biologists during the course of a 21 - 25 July field investigation.

The extent of the ungulate/raptor survey coverage and waterfowl survey flightlines is illustrated in Figure 24. Flight paths for the ungulate survey generally followed topographic contours and were chosen to provide total survey coverage of the area similar to that described by Comin et. al. (1978) for the 'Block Survey Method'. Although observations were not restricted to a 200 m strip width, as described by Comin, emphasis was placed on this zone. For the waterfowl surveys, all wetlands within 1.2 miles of the proposed winter road right-of-way were numbered and a total of 17 surveyed. As shown in Figure 24, all were east of the Silent Hills.

Cliffs or slopes judged suitable for raptor nesting were surveyed using techniques as discussed by White and Sherrod (1973).

A helicopter was flown parallel to each cliff or slope surveyed at a distance of 100 ft. or greater depending on local wind conditions and slope aspect. Full coverage of each cliff or slope was attained by making one or several passes across the face depending on its vertical height.

All wildlife observations were plotted on 1:50,000 scale topographic maps during the survey and information relevant to each sighting was recorded on cassette tape.

A small mammal trapline was established adjacent to the airstrip to obtain specimens for possible trace metal analysis at a later date. The effort was limited to 87 trap nights.*

5.6.2 Results

Wildlife observations made during the 6 - 10 July, 1980 surveys are illustrated on Figure 24. (Wildlife information from the April, 1980 survey is shown on Figure 23.)

5.6.2.1 Ungulates

In the area of the minesite, the surveys were principally directed at providing information on the general abundance and seasonal distribution of woodland caribou and Dall's sheep. Identifcation of areas of special sensitivity such as calving and lambing, and areas used by nursery bands could not be adequately addressed owing to the timing of the field programme. The surveys covered a large portion of the potential habitat of each species within six miles of the minesite (see Figure 24) and were extended to include 'Caribou Flats' which is reported to be an important area for ungulates (R. Fast 1980 pers. comm.).

Only two woodland caribou and scattered caribou tracks were observed in the vicinity of the minesite during the course of the surveys. Two additional woodland caribou were observed north of the minesite, adjacent to 'Caribou Flats'.

A total of 47 - 49 Dall's sheep were observed during surveys in the vicinity of the minesite and 16 sheep were observed in the 'Caribou Flats' area. Several nursery bands, comprised of ewes, lambs, and frequently yearlings, were observed (see Figure 24). One small group, consisting of two ewes and two lambs, was located less than 800 yards from the Prairie Creek airstrip which services the minesite. The other two bands were 6 and 13 miles respectively, from the minesite. All of the groups were located on or near cliffs; however, it was not possible to determine if those cliffs constituted lambing areas. At the time of the survey, nursery groups had formed and post-lambing movements may have occurred.

The surveys suggest that populations of woodland caribou and Dall's sheep are scattered in the region surrounding the minesite. The ungulate usage pattern and over-all extent of the range will be further investigated by winter surveys to be carried out in 1980/81.

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* One trap-night equals one live trap set and baited for one night.

As discussed in the Preliminary Environmental Evaluation, the capability of habitat to support wildlife in the immediate vicinity of the minesite appears to be low. The pertinent Land Use Information Series map sheet, 95F Virginia Falls (Department of the Environment 1974), states that the zone supports scattered groups of Dall's sheep and woodland caribou and that few of the potential wintering areas available to these species are actually used. Parks Canada data (L. Comin 1980 pers.comm.) indicate that Dall's sheep nursery bands may concentrate as close as three miles southeast of the minesite (20 sheep including 8 lambs were observed near Prairie Creek during a September 1977 survey). BEAK observations included a group of two ewes and two lambs near the Prairie Creek airstrip. The major summer range of Dall's sheep inhabiting the northeastern end of the Park has been estimated to extend nearly to the mine. (L. Comin 1980 pers.comm.).

The surveys of the winter road right-of-way were to focus on possible woodland caribou and Dall's sheep range adjacent to the road alignment in two areas: 1) the Mackenzie Mountains between 'Folded Mountain' and the Sundog Creek tributary crossing and 2) that portion of the Nahanni Range near 'Grainger Gap'. Adverse weather conditions prevented surveys east of Prairie Creek in the Mackenzie Mountains and restricted the survey coverage in the Nahanni Range. In the Nahanni Range, no caribou were observed, six Dall's sheep rams were observed north of 'Grainger Gap' and six sheep, including two lambs, were observed south of 'Grainger Gap'.

The wildlife zone crossed by the most westerly 23 miles of winter road is reported to support scattered groups of woodland caribou and Dall's sheep (Department of the Environment 1974). Areas of special sensitivity include 'Folded Mountain' which may be used for lambing and potential sheep wintering areas along the south-facing slopes above the road. However, it is not known if any of the potential wintering areas are regularly utilized and reports of lambing on 'Folded Mountain' have not been substantiated. An evaluation of the habitat in this area indicates a lack of extensive sedge meadows preferred by woodland caribou (Oosenbrug and Theberge 1980) and this species is expected to occur only in low densities in the vicinity of the road.

Dall's sheep are reported to occur throughout the Nahanni Range (Department of the Environment 1976). The winter distribution of these sheep is not known, however, the south-facing slopes and extensive alpine ridges north of 'Grainger Gap' constitute potential winter range. L. Comin (1980 pers.comm.) has made incidental sightings of Dall's sheep in this area during winter surveys. The lambing sites of this population are unknown.

The winter road alignment east of Mile 23 crosses what is considered to be good woodland caribou and moose habitat. However, the density of deciduous vegetation cover precluded surveying for these species. Observations were opportunistic and made in conjunction with waterfowl surveys. Eight moose were observed between Mile 35 and Mile 68. On 24 July, 1980, three moose were sighted by BEAK fisheries biologists near the winter road route on the western edge of the Ram Plateau.

Based on the survey data, greater numbers of moose than caribou are believed to exist east of Mile 35 along the road route to the Nahanni Range during the summer. The winter distribution of moose in the region is not well documented, however, the Department of the Environment (1976) does indicate that the valleys of the Tetcela River and Fishtrap Creek constitute good moose winter range. The Liard River floodplain is considered excellent winter habitat for moose (ibid.).

The following information concerning the wood bison relocation project being conducted in the Nahanni Butte area was obtained from H. W. Reynolds, Wildlife Biologist, Canadian Wildlife Service, on 27 August, 1980.

Twenty-eight wood bison (Bison bison athabascae), ten of which were equipped with radio collars, were released approximately four miles west of Nahanni Butte on 27 June, 1980. Since their release, all of the radio-collared bison have moved south of the Nahanni and Liard rivers; most have remained within 20 miles of the release point. The whereabouts of the uncollared animals is uncertain and will not be determined until after leaf-fall and snow conditions provide suitable survey conditions.

Eight bison were located 19 August, 1980 in the area where the Liard Highway crosses the Blackstone River. This is approximately four miles south of the eastern extremity of the Cadillac Mines winter access road. On 21 August, 1980, one of the bison in this group was struck by a vehicle on the highway and killed.

Due to an equipment malfunction, none of the bison have been located since 19 August, 1980, but the current distribution is not expected to have changed radically.

The winter distribution of the 27 remaining bison will be determined by aerial surveys.

5.6.2.2 Furbearers

Aquatic furbearer habitat is poor in the area of the mine and no traplines presently exist within the mining lease. Trapping in the area of the Nahanni Range is discussed in section 5.10.

Signs of beaver activity were noted along the entire length of the road alignment east of the Ram Plateau. The observations of lodges and dams were concentrated in the lowlands on either side of the Silent Hills. These areas have been designated as important habitat for beaver by the Department of the Environment (1976). Beaver activity was observed infrequently east of the Nahanni Range.

One wolverine was observed 4.5 miles west of the minesite during the surveys. This incidental sighting is the only additional information collected on this species which is expected to occur throughout the region in low densities.

5.6.2.3 Small Mammals

Small mammals occurring in the general region of Nahanni Park were described by Scotter et. al. (1971) and listed in an earlier report (Ker, Priestman 1980). Small mammal trapping effort in this study was intended for possible trace metal analysis and not to provide new ecological information. However, in 87 trapnights 2 deer mice (Peromyscus maniculatus) and one red-backed vole (Clethrionomys sp.) were trapped. Compared to densities recorded by Scotter and Henry (1977), the density recorded here (3.4 animals per 100 trapnights) is low, but because of its incidental nature this data cannot be considered representative of the study area.

Observations were made of Arctic ground squirrels, principally in the camp area.

5.6.2.4 Other Mammals

Incidental observations of other large mammals, including bears and wolves, were made during the field investigations. One unidentified bear sow with two cubs was observed approximately five miles west of the Grainger River on 24 July, 1980, by BEAK fisheries biologists. On the night of 9 July, 1980, a black bear was chased from the Prairie Creek camp by camp personnel (R. Fast 1980 pers. comm.). Unidentified bear scat was observed along the winter road route approximately two miles north of the mine and below 'Folded Mountain', one-half mile from the road.

Wolves have been reported to prey upon woodland caribou wintering at 'Caribou Flats' north of the mine, however, no wolves or wolf sign were observed during our field studies.

The surveys in this programme were not directed at obtaining information concerning bears and wolves. This factor, combined with the low observability of these species during aerial surveys, and their generally reclusive nature, has resulted in the collection of little data on their distribution and abundance in this region. No denning sites of bears or wolves have been located. Good grizzly bear habitat has been documented by the Department of the Environment (1976) on the Ram Plateau and throughout the Nahanni Range. It is of note that, during the 12 years he has been involved with the mine development, R. Fast (1980 pers.comm.) has only noted four black bears, one grizzly bear, one wolf, and three wolverines in the vicinity of the minesite.

Based on this limited information and a knowledge of the habitat preferences of both species, both black and grizzly bears and wolves are likely present in the minesite area in low densities. Black bears and wolves may be encountered along the entire length of the winter access road while grizzly bears will be found in the mountainous regions traversed by the roadway.

5.6.2.5 Cliff-Nesting Raptors

The second focus of the 6 - 10 July, 1980 surveys was the search for cliff-nesting raptors. No eagle or falcon nest sites were located in the vicinity of the mine. Six Golden Eagle observations comprising a minimum of three individuals (two adults and one immature which was a minimum of one year old) were made at the minesite. Further observations included one unidentified large falcon* four miles southwest of the minesite and one Golden Eagle and two unidentified falcons along a cliff-face immediately southeast of 'Caribou Flats'.

The valley walls along the road alignment, between 'Folded Mountain' and the Nahanni Range, including a number of karst cliffs in the Tetcela River region, appear to possess the potential to support cliff-nesting raptors.

In the Nahanni Range, two active Golden Eagle nests, each containing one eaglet, were located. The nests were on cliffs 1.1 and 2.5 miles, respectively, north of the road route.

No raptor nests were found in the minesite vicinity, however, several Golden Eagle sightings were made. One of these observations included two adult eagles which were apparently displaying territorial behavior. During several minutes of observation, the adult birds pursued and harassed an immature Golden Eagle, which had nearly complete adult colouration. The pair repeatedly dove on, and actually made contact with, the third eagle a number of times before being lost from sight. This observation was made at the Prairie Creek airstrip and is an indication that the mine area may be within the nesting territory of those adult eagles sighted.

Both Gyrfalcons and Peregrine Falcons may breed in the region. The observations made during the surveys were inconclusive concerning the local status of these species. No Peregrine Falcon nests are known from the area (R. Fyfe 1980 pers.comm.). It should be noted that Peregrine Falcons are closely monitored by the Canadian Wildlife Service and other agencies and that many of the nesting sites in northern Canada are documented; Prairie Creek is not included in this documentation.

---

* Based on the dark brown colouration of the bird and observed malar bars, it is probable that this bird was an immature Peregrine Falcon.

Although Gyrfalcons primarily breed further north than the study area, nesting by this species has been reported at similar latitudes elsewhere in northern Canada. Kuyt (1980) documented what he believed to be, at 61° 45'N, the southernmost breeding record for Mackenzie District, N.W.T. and successful nesting by Gryfalcons has been recorded at 60° 45'N in Yukon Territory (R.Eccles 1980 pers. comm.).

Suitable cliff-nesting habitat exists in a number of locations along the winter road. The two active Golden Eagle nests located in the Nahanni Range indicate its utilization by raptors.

5.6.2.6 Waterfowl

In addition to those flightlines directed at surveying a 6 mile section of the Grainger River, 17 ponds or wetlands were surveyed for aquatic birds. Aquatic birds were observed on 16 of these waterbodies and broods were observed on 10.

The most important observation was 6 moulting Trumpeter Swans identified on a small lake east of the Silent Hills. Identification was confirmed by landing and careful examination through a spotting scope. No signs of their breeding were observed. In April, a BEAK team observed swans in a wetland area west of the Silent Hills and well south of the road alignment (Ker, Priestman 1980), but they were not specifically identified. Though no longer considered endangered, Trumpeter Swans are nowhere very common during the breeding season. Further the exact northern limits of their breeding range in the region of Nahanni Park are not known. Breeding records in this area appear to be restricted to recent sightings of adults and young at Yohin Lake at the eastern end of the park (L.N.Carbyn, pers.comm.).

The remaining aquatic birds recorded were ducks, divers (loons and grebes), coots and a few shorebirds. The sightings at each wetland are listed in Table 17. The chief result was the sighting of 14 broods on these 17 ponds for a total of 75 ducklings. Most of these were diving ducks but owing to poor lighting created by an oncoming storm, very few were identified to species. It is believed that a large proportion was surf scoters based on their lack of distinctive markings. Ground surveys at Lake #26 confirmed the breeding of coots and the likely breeding of black terns. This provides further confirmation to Tull's observations that black terns occur as far north as Fort Simpson (L.Carbyn, pers. comm.). No geese were observed in summer but 5 snow geese were sighted in April near the Silent Hills as reported earlier (Ker, Priestman 1980). Recent reviews of the regional avifauna have not identified this species (L.Carbyn, pers. comm.).

5.6.2.7 Breeding Birds

Further to the wetland surveys, records were kept of all sightings of birds, and further records of other investigations were obtained. As a result, the species list presented earlier (Ker, Priestman 1980) has been updated (Table 18).

5.7 Geology and Soils

The geology and soils of the minesite and proposed winter road have been discussed in two previous reports (Ker, Priestman & Associates Ltd. 1980 a, b).

In addition to Crampton's (1973) mention of the soils in the Sibbeston Lake map area in his landscape survey of the upper and central Mackenzie Valley, Tarnocai (1973) has carried out a soil survey of the area. On the floodplain of the Liard River, at the eastern terminus of the road, he mapped Brunisols on the older alluvial terraces and Regosols on the recent alluvial deposits. Poorly drained deposits support Gleysols, most of which contain permafrost. Abandoned channels on the floodplain support Organic Soils and Fibric Cryosols.

From west of the Liard floodplain to the western side of the Nahanni Range, the soils are dominantly Luvisols and Brunisols on well to imperfectly drained mineral deposits. On poorly drained mineral deposits, Gleysolic Cryosols are present. Above timberline, Brunisols displaying the effects of cryoturbation are present. Fibric Cryosols are found on the peat deposits.

The geotechnical study on the soils of the minesite with respect to their engineering properties, is attached as Appendix 1.

5.8 Archeological and Historic Sites

5.8.1 General

No sites have been recorded in the files of the National Inventory of Prehistoric Sites (Ottawa) for the areas that would be affected by the proposed Cadillac development or for the immediately adjacent areas; however, it is significant that there have been no systematic site surveys of these areas with the notable exception of the comprehensive investigations of Nahanni National Park reported by Amsden (1978, 1979).

Despite the absence of archeological and historic data pertaining to the specific area under study, some general comments concerning site location based on the vegetation and physiography of the area are possible. The Boreal Forest vegetation (Alpine Forest - Tundra and Upper Mackenzie Sections) for this area imposes certain restrictions on site surveys (Millar and Fedirchuk 1975). The depth of the forest mat cover and the density of the vegetation often limit the effectiveness of site surveys. In addition, the subsistence strategies practiced in a Boreal Forest environment tend to result in archeological sites that are relatively small in size. In some cases, sites may have been buried by the sand, gravel and silt deposited by the rivers and creeks of the area or may have been damaged or destroyed by erosion along lake, creek, and river banks or by flooding resulting from spring break-up and summer storms. Furthermore, the relatively high soil acidity associated with Boreal Forest vegetation can damage or destroy perishable materials and Boreal Forest cover often precludes the use of air photos for locating sites. Factors such as these have a bearing on the amount of data that would be recovered from this area following conventional methods of site survey.

5.8.2 Archeological Sites

Inferences on existing archeological sites in the area of the proposed Cadillac development must be based on the archeological finds made in Nahanni National Park (Amsden 1978, 1979) and also the Upper Mackenzie area of the Mackenzie Corridor studies (Cinq-Mars 1973), especially Sibbeston, Cli, Little Doctor and Fisherman Lakes.

In very general terms, it appears that single component surface sites located on the banks of lakes, creeks and rivers or on terraces or ridges overlooking streams, lakes or rivers are most typical in the western part of the Upper Mackenzie area. Sites have also been discovered in some of the present-day centres such as Fort Simpson. Millar (1972) has noted that the prehistoric site locations tend to be clustered in the vicinity of lake outlets, although some surface collections of prehistoric materials have been discovered along the lakeshores. However, he questions the extent to which this observation may have been influenced by selectivity in the areas sampled; as Cinq-Mars (1973) has observed, the large lake areas to the west and east of the Mackenzie River are more accessible than the banks or high inland terraces of the Mackenzie.

These sites generally contain a small assortment of lithic material, often including flakes and sometimes points, scrapers, blades and bifaces. The artifacts tend to have few diagnostic traits of use in estabishing site chronology and in postulating cultural relationships among sites. Several complexes of artifacts have been identified at Fisherman Lake (Millar, 1968); the distinctive artifact types of this site have been useful in dealing with poorly identified and undated sites in the Upper Mackenzie area as in the case of the work reported by Dice (1973) in the Sibbeston Lake area approximately 65 miles to the northeast of the Cadillac property. The presence of a distinctive form of 'welded tuff' to a number of sites in this area has led to attempts using neutron activation analyses to determine whether this materal all came from an outcrop in the Tertiary Hills, possible through some form of trade network. In that Amsden's studies of Nahanni National Park correlate archeological data from the park with information available from the general vicinity, they are also a valuable source of information for the area under consideration.

5.8.3 Historic Sites

Historic sites have been recorded at a number of locations in the western part of the District of Mackenzie. The 1976 Land Use Information Series Virginia Falls Map (95 F) indicates the remains of cabins built by early travellers along the Flat River near its confluence with the South Nahanni River. Amsden (1979) found cabins and caches at many of the likely points in Nahanni National Park with early historic sites concentrated in the lowermost portion of the South Nahanni watershed. The Land Use Information Series Sibbeston Lake Map (95 G) indicates that an independent trading post has operated in Nahanni Butte since 1915. The historic Fort Alexander trading post located on the river bank upstream from the mouth of the Willowlake River has been partially excavated (Cinq-Mars 1973). Three historic camp sites were identified on the shores of Cli Lake and one by Fisherman Lake (Cinq-Mars 1973). It is also possible that additional finds of historic cabins and tent camps may be made along the tributary water sources to the Mackenzie River as well as in hunting localities. Millar (1972) has suggested that resource utilization strategies may account to some extent for the site locations indicated by the presently available data. In prehistoric times when fishing was an integral part of the subsistence pattern, sites often appear to have been located at or near lake outlets where the best fishing conditions are present; by contrast, historic sites often appear to be clustered along lake banks adjacent to the main creeks from which the most productive trapping areas are easily accessible.

5.9 Socio-Economics

The socio-economic conditions pertaining to the Cadillac project have been reviewed in earlier reports (Preliminary Environmental Evaluation for Winter Access Road and Preliminary Environmental Evaluation for Mine, Mill and Camp, both May, 1980).

Further discussions concerning these matters are to be held between the proponent and the Resource Development Committee of the Government of the Northwest Territories, so that the socio-economic aspects of the development are in tune with government policy for the N.W.T.

5.10 Resource Use

5.10.1 Furbearers/Trapping

Three trapping areas occur on land transected by the proposed development (D. Bentley, 1980 pers. comm.). The approximate boundaries of these trapping areas are shown on Figure 24 and are described as follows:

Area 1: East of the Nahanni Range between Bluefish Lake ('1st Gap') and the '3rd Gap' to the north (inclusive of the Grainger River Pass, or '2nd Gap').

Areas 2 & 3: These traplines are operated west of the Nahanni Range, between the 1st and 3rd gaps (in a north-south line) and between the Nahanni Range and the Tetcela River (in an east-west line), including the Silent Hills.

None of the above traplines are operated by single individuals. Total yearly fur harvests range from $8,700 to $22,000 for the 1978-79 trapping season (D. Bentley, 1980 pers. comm.). These figures represent a per-trapper income of up to $5,500 per year. Major species harvested included beaver, marten, mink, lynx, weasel and wolverine (few). In addition, five moose and nine woodland caribou were harvested on licences of the above trappers.

In a preliminary description of hunting and trapping areas in the Inuvik and Fort Smith regions, the Department of Renewable Resources (ND) noted that regions in the vicinity of the Nahanni Range (zones NB1 and NB2) produced fur harvests of $8,000 (NB1) and $2,000 (NB2) during 1977-78. This represents an annual income of $1,600 for each of the five trappers in zone NB1, and $2,000 for the single individual trapping in zone NB2.

Initial socio-economic studies conducted by Horsman & Associates suggest that furbearer productivity in the area is low (D. Bentley, pers. comm. 1980).

Comparative fur harvest data from 1977-78 for areas in the Nahanni region show per-trapper annual values of $1,000 for the Sibbeston Lake and Grainger River areas (zones S5 and S6) and $2,000 for the Fort Liard area (zone FL1). Although several factors, including trapper effort, affect trapline returns, the fur harvests noted above are considered low.

5.10.2 Hunting

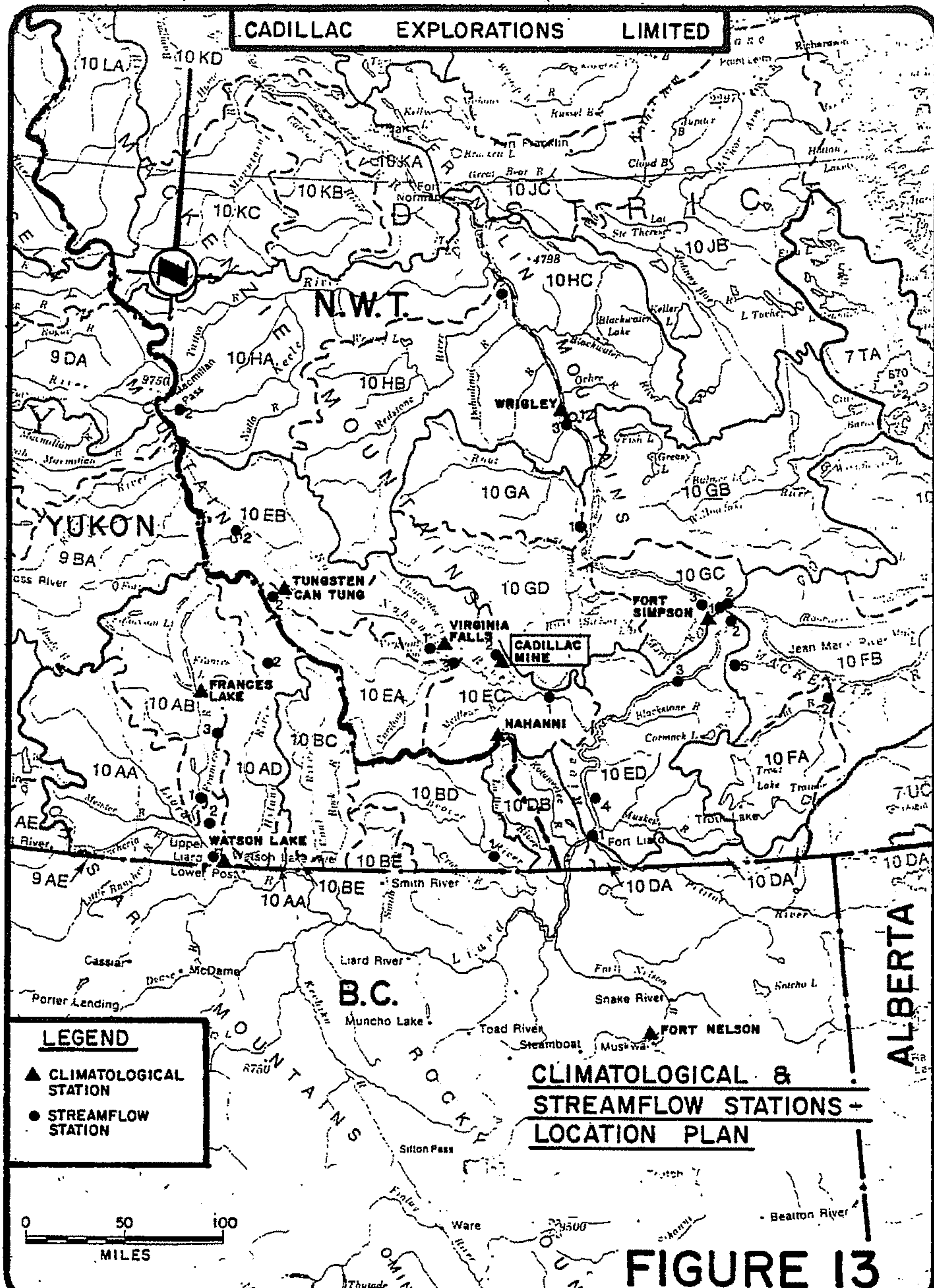
5.10.2.1 Guiding and Outfitting

A summary of the Nahanni Butte Outfitters hunter kill from the area of the proposed development is provided in Table 19. A total of 49 game animals (44 sheep, 4 bear and 1 moose) were taken from this area during the period 1975-1978. None of these animals were harvested within several miles of either the mine or road alignment.

5.10.2.2 Resident Hunter Harvests

Accurate information on the game-harvest by resident hunters is more difficult to obtain.

In a study on the moose of the Lower Liard River Valley, Donaldson & Fleck (1979) reported that Nahanni Butte hunters killed 25 - 30 moose during 1978. The same study notes the moose harvest by Fort Simpson hunters to range from 50 - 65 per year. Although these figures are representative of the general numbers of animals taken in the region, specific hunting areas were not noted and kill sites are not known. Given the comparative inaccessibility of the study area, and the fact that much of the habitat along the winter road is not high-quality moose range, it is considered unlikely that much hunter effort would be directed toward this area.



KER, PRIESTMAN & ASSOCIATES LTD

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

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

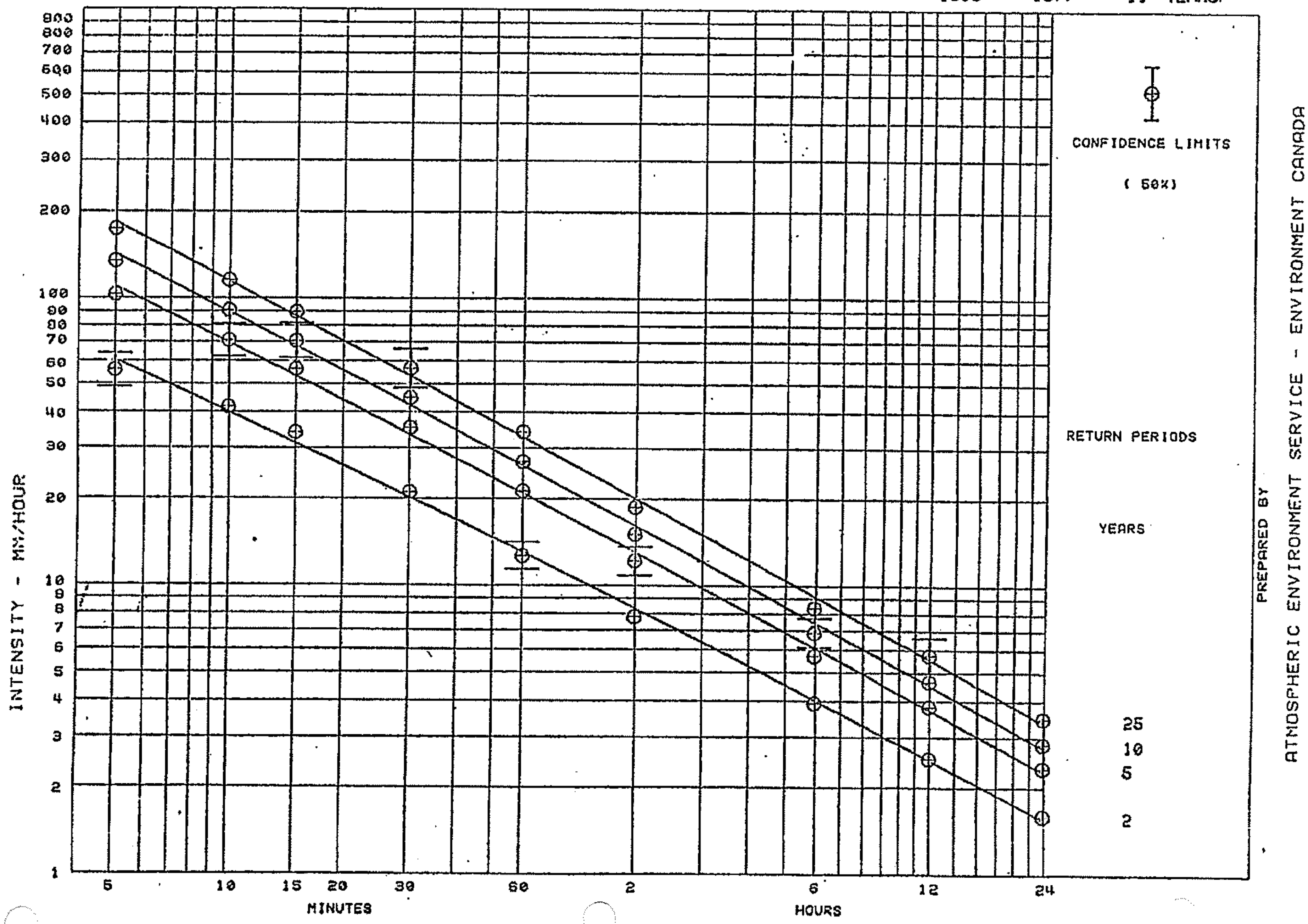
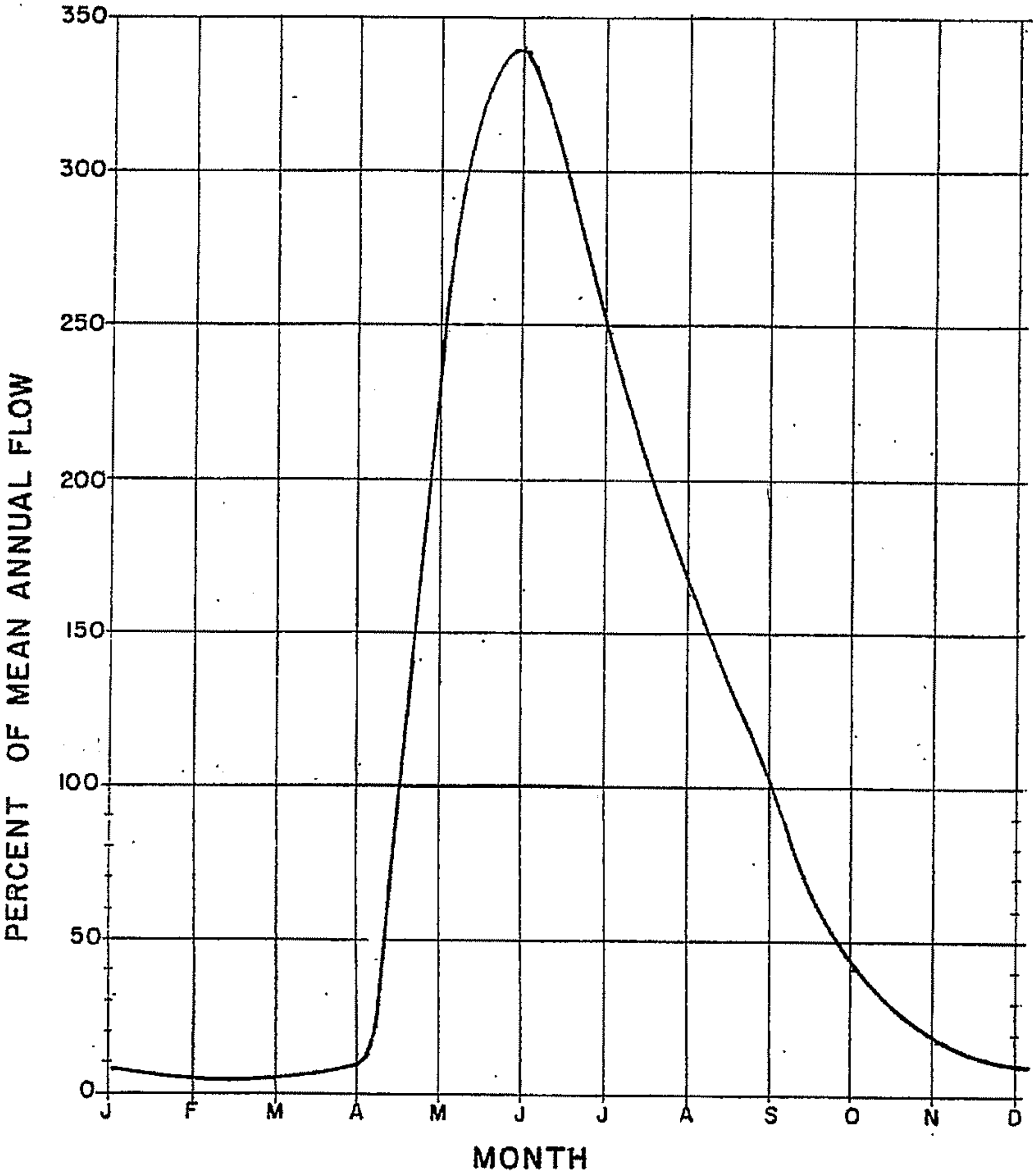


FIGURE 14

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

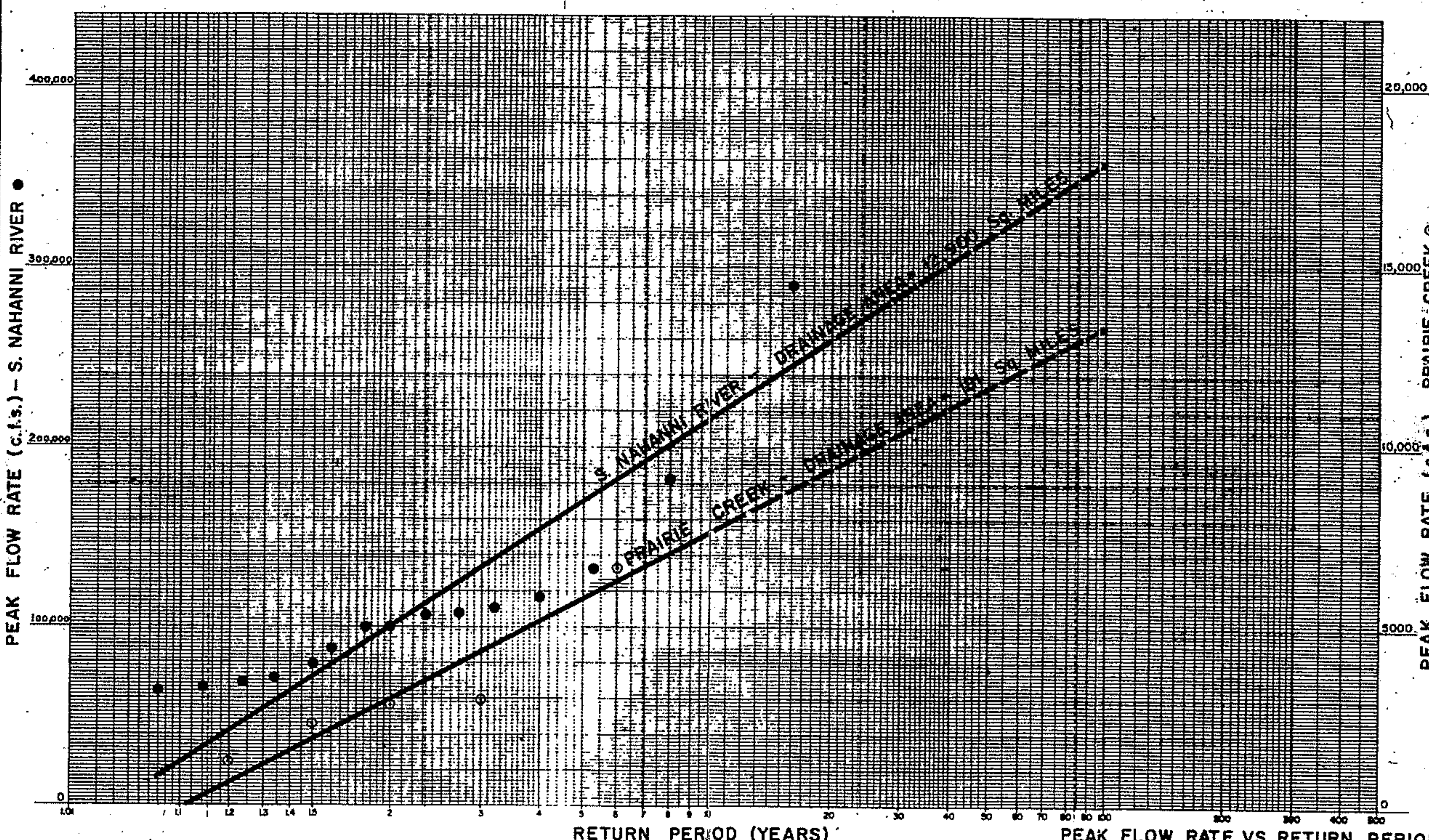
PRAIRIE CREEK AT CADILLAC MINESITE

VANCAL - 2988

FIGURE 15

KER, PRIESTMAN & ASSOCIATES LTD

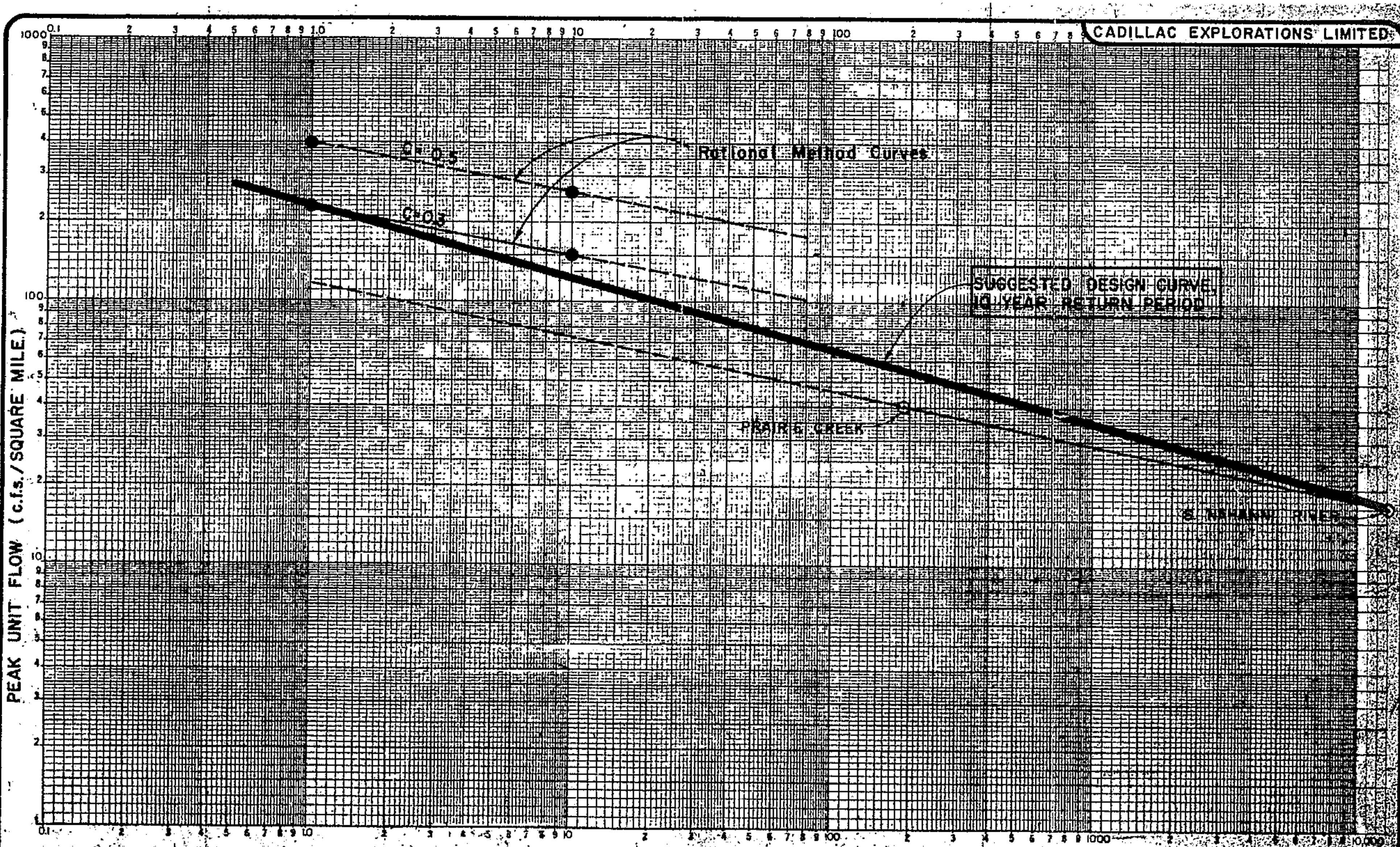
CADILLAC EXPLORATIONS LIMITED



PEAK FLOW RATE VS RETURN PERIOD

S. NAHANNI RIVER & PRAIRIE CREEK

FIGURE 16



LEGEND

- ⊙ BASED ON FREQUENCY ANALYSIS OF STREAMFLOW DATA (SNOWMELT OR RAINFALL)
- ● BASED ON RATIONAL METHOD (RAINFALL)

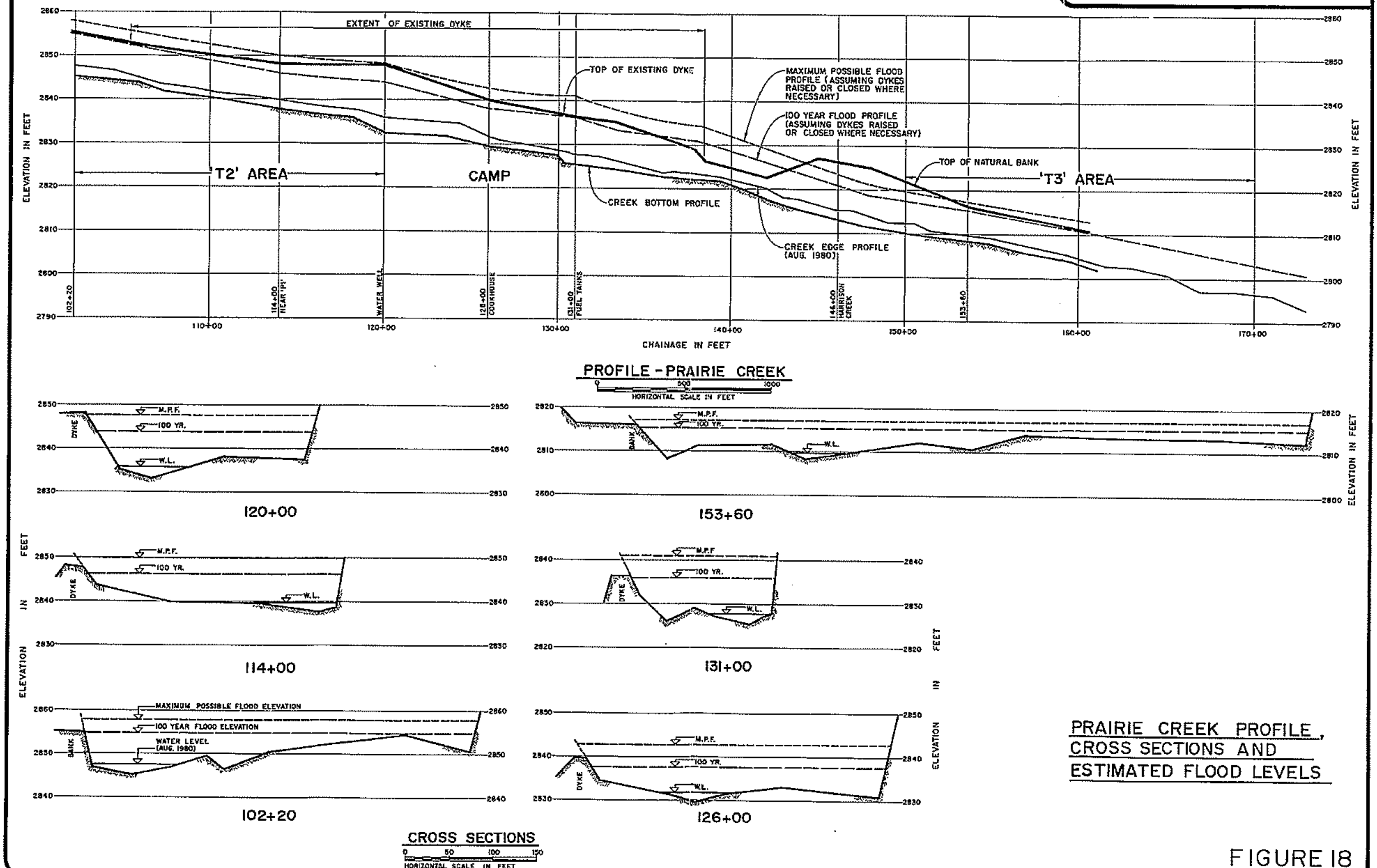
NOTES

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

PEAK UNIT FLOW VS. DRAINAGE AREA

FIGURE 17

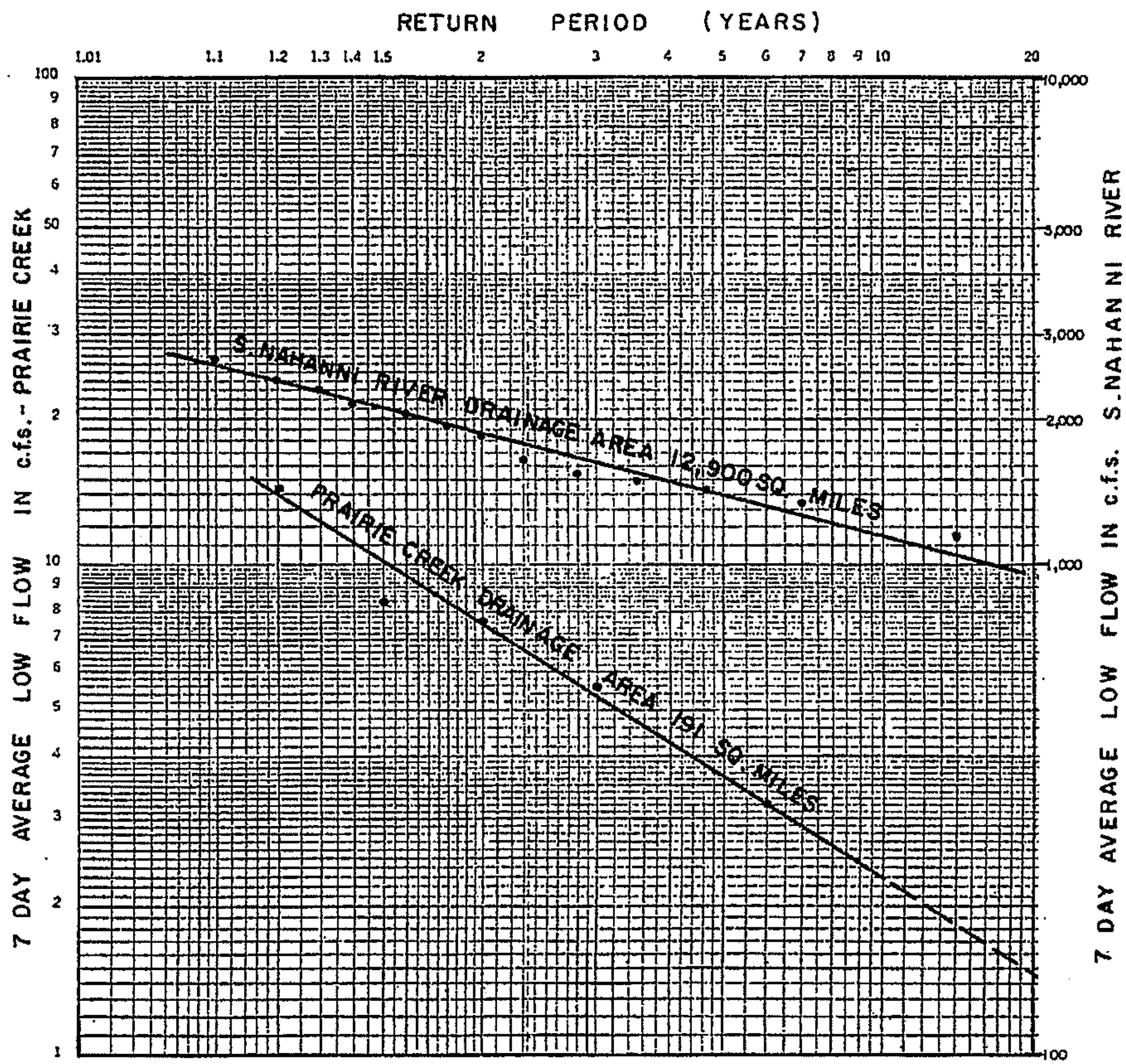
KEN. PRIESTMAN & ASSOCIATES LTD.



PRAIRIE CREEK PROFILE, CROSS SECTIONS AND ESTIMATED FLOOD LEVELS

FIGURE 18

KER, PRIESTMAN & ASSOCIATES LTD.

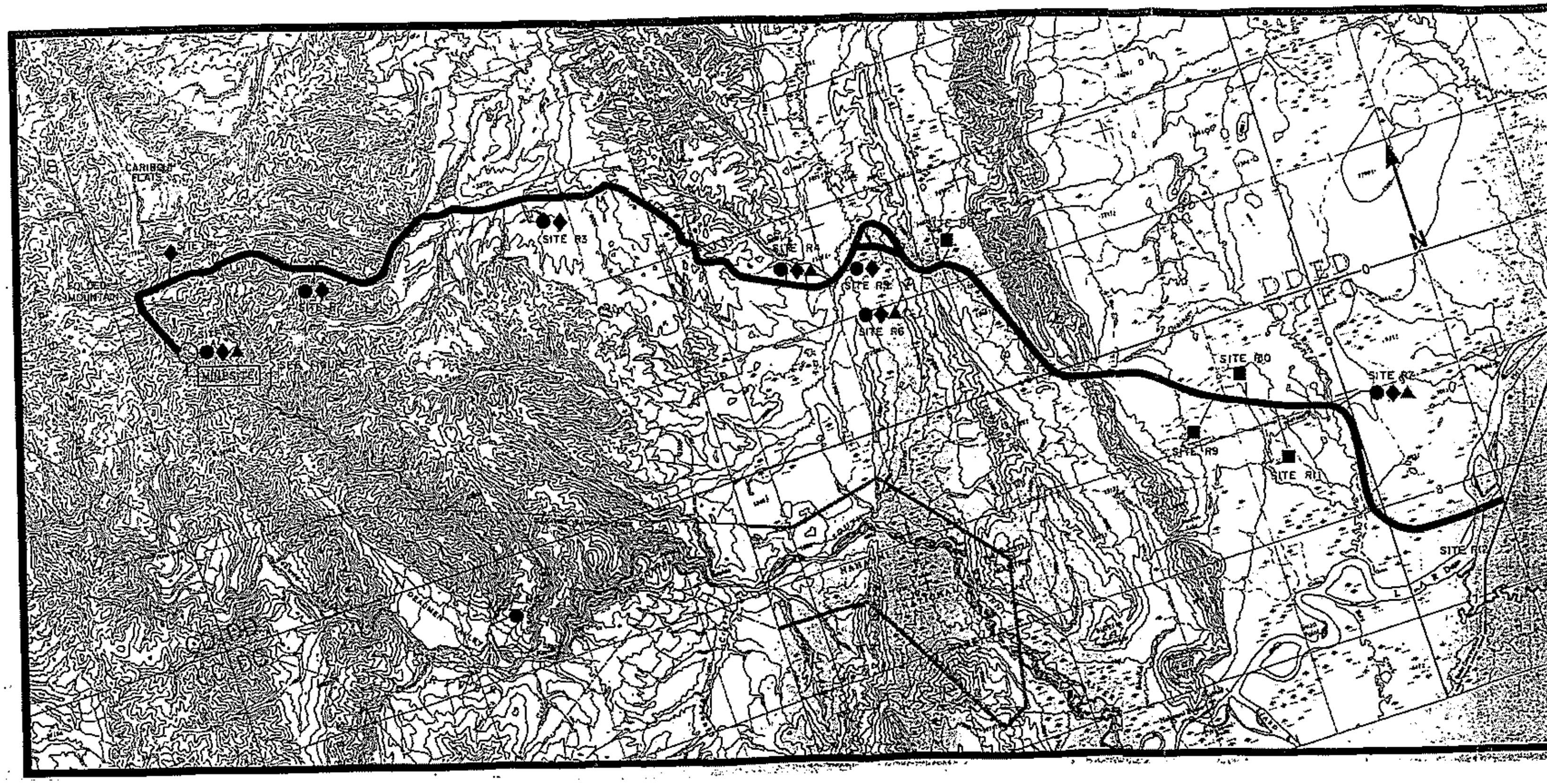


7 DAY AVERAGE LOW FLOWS vs. RETURN PERIOD

S. NAHANNI RIVER & PRAIRIE CREEK

VANCAL - 2988

FIGURE 19



CADILLAC EXPLORATIONS LTD.

WINTER ROAD

WATERCOURSE CROSSING LOCATIONS

SAMPLING STATIONS

- ● FISHERIES
- ◆ BENTHOS
- ▲ WATER QUALITY
- ■ HELICOPTER RECONNAISANCE ONLY

FIGURE 20

beak

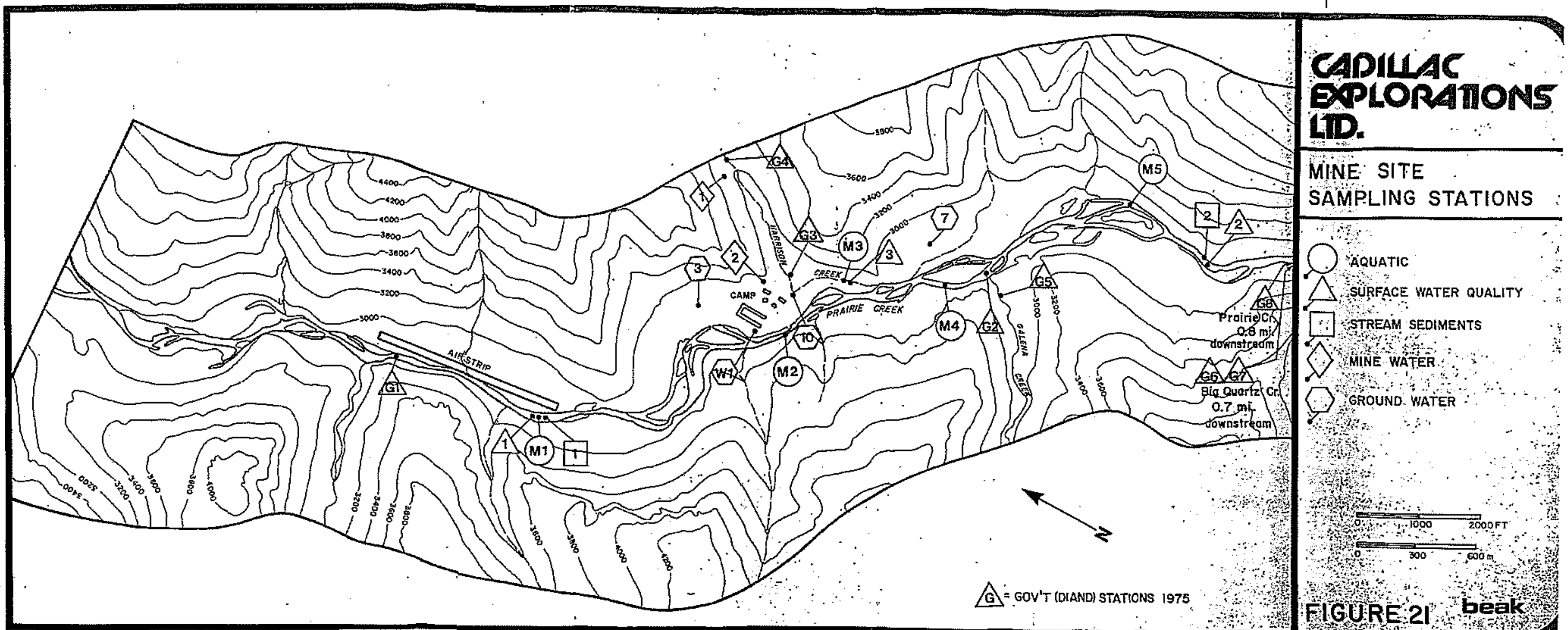
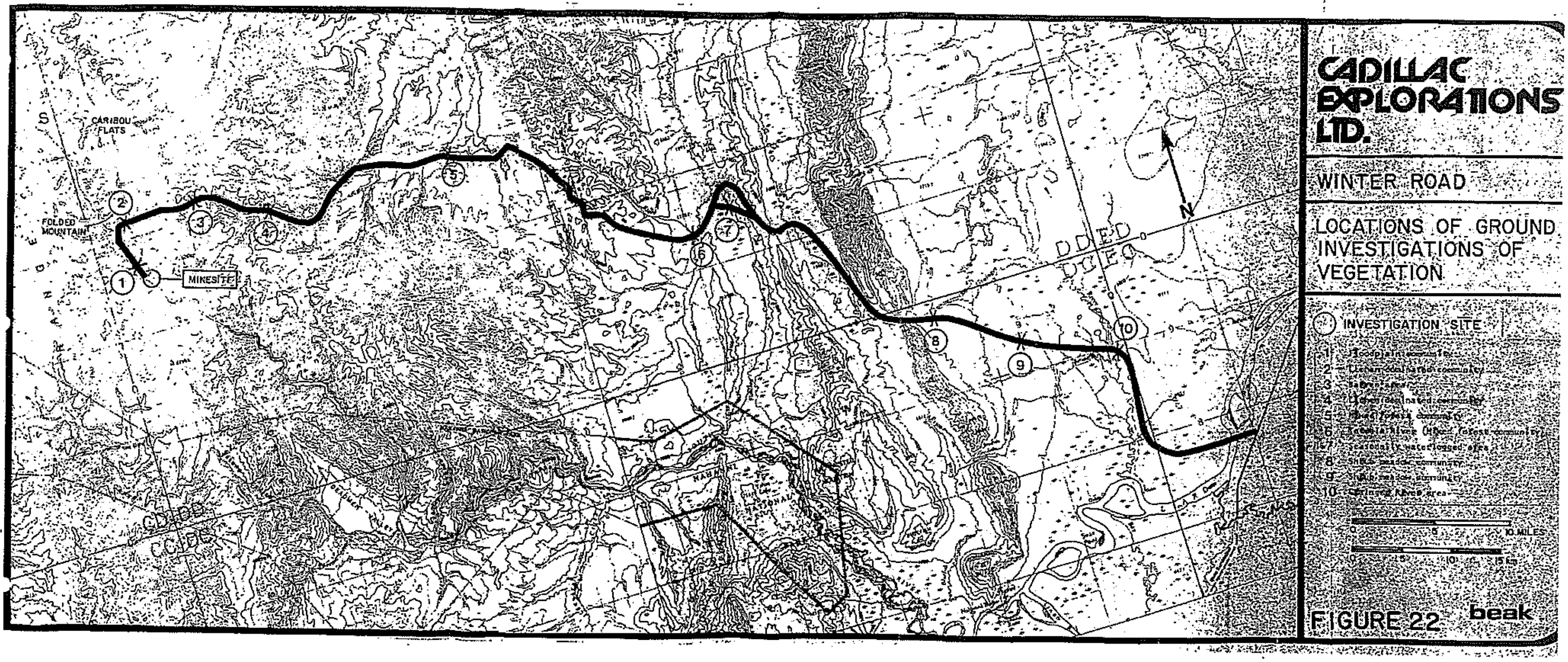
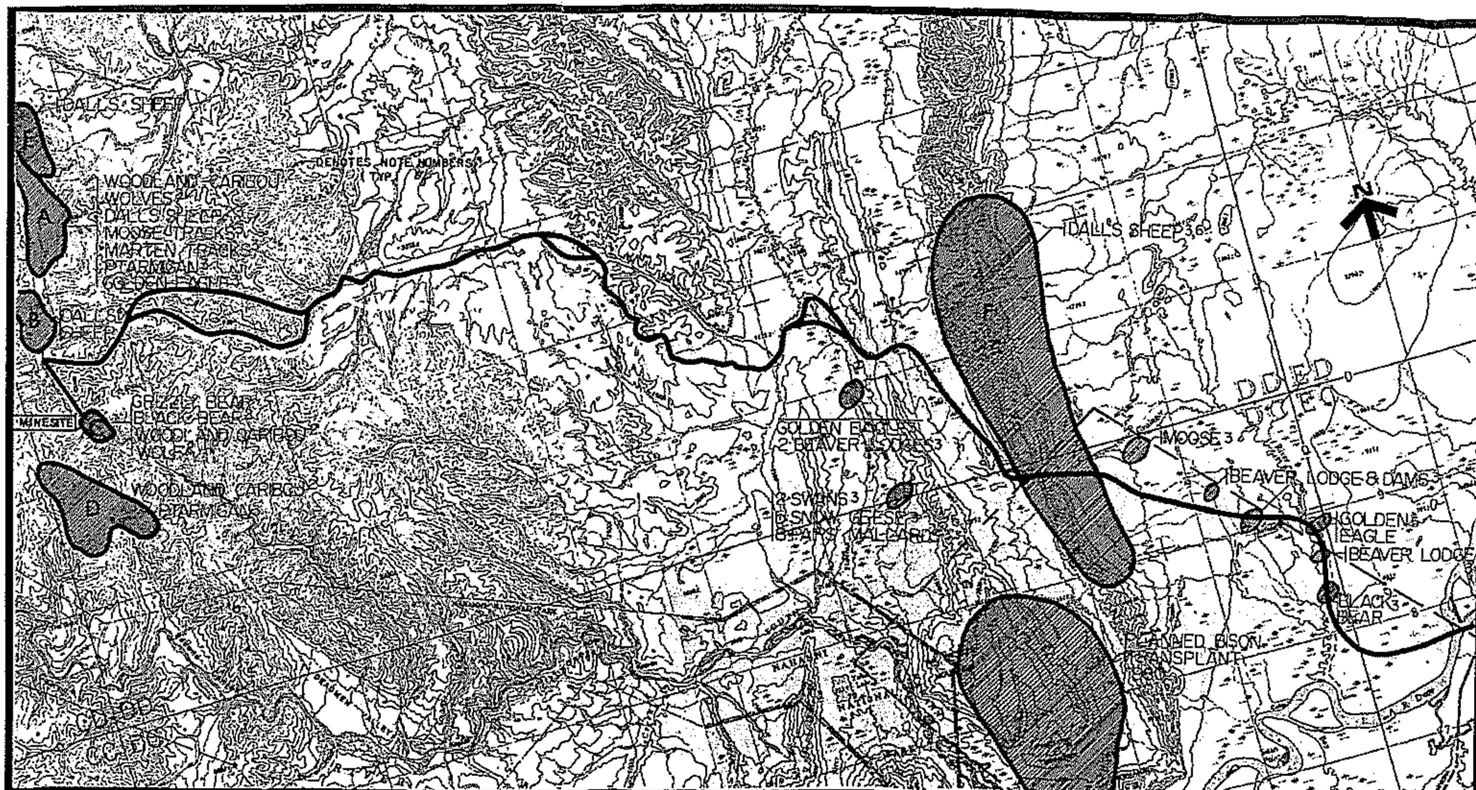

CADILLAC EXPLORATIONS LTD.
MINE SITE
SAMPLING STATIONS
AQUATIC
SURFACE WATER QUALITY
STREAM SEDIMENTS
MINE WATER
GROUND WATER
0 1000 2000 FT
0 300 600 m
G = GOV'T (DIAND) STATIONS 1975
N
AIR STRIP
CAMP
HARRISON CREEK
PRAIRIE CREEK
GALENA CREEK
Prairie Cr. 0.8 mi. downstream
Big Quartz Cr. 0.7 mi. downstream
G1
G2
G3
G4
G5
G6
G7
G8
M1
M2
M3
M4
M5
W1
10
beak

FIGURE 21


CARIBOU FLATS
FOLDED MOUNTAIN
MINESITE
1
2
3
4
5
6
7
8
9
10
N
CADILLAC EXPLORATIONS LTD.
WINTER ROAD
LOCATIONS OF GROUND INVESTIGATIONS OF VEGETATION
INVESTIGATION SITE
1 Floodplain community
2
3
4
5
6
7 Seasonally waterlogged area
8
9
10
0 5 10 MILES
0 5 10 15 km
FIGURE 22
beak



CADILLAC EXPLORATIONS LTD. PROPOSED WINTER ROAD

WILDLIFE INFORMATION LEGEND (APRIL 1980)

ROAD ALIGNMENT

RANGE EVALUATION RE: WOOD BISON TRANSPLANT C.W.S6

NOTES.

1) SCOTTER ET AL. 1971
2) MR. R. FAST, PERS. COMM. CADILLAC MINES FOREMAN. 1980
3) BEAK CONSULTANTS LIMITED, FIELD RECONNAISSANCE, APRIL 1980
4) DR. B. FLETCHER & MR. R. H. WILSON, 1980 PERS. COMM. GOLDER ASSOCIATES, VANCOUVER, B.C.
5) DEPARTMENT OF THE ENVIRONMENT, INDIAN & NORTHERN AFFAIRS LAND USE INFORMATION SERIES, 1976
6) CANADIAN WILDLIFE SERVICE PROJECT. MR. H. REYNOLDS, PERS. COMM. 1980

FOR DESCRIPTION OF OBSERVATIONS SEE SECTION 4.5.4 IN PRELIMINARY ENVIRONMENTAL EVALUATION FOR WINTER ROAD, MAY 1980.

AREAS A TO F HAVE PREVIOSLY BEEN DEFINED AS CONTAINING WILDLIFE POPULATIONS.

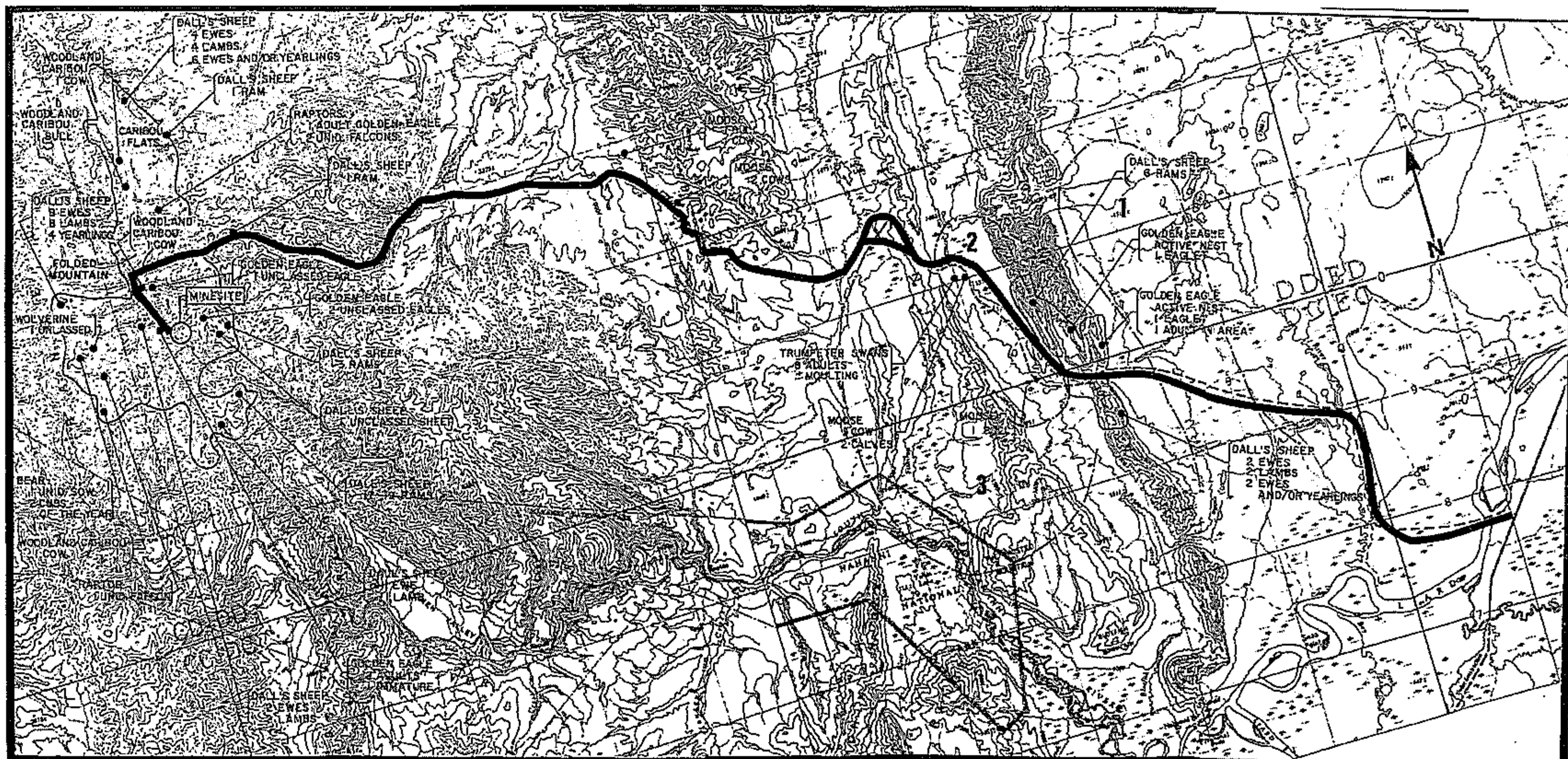
FOR JULY 1980 OBSERVATIONS SEE FIG. 24. PROPOSED ROAD ALIGNMENT SHOWN HERE. SURVEYED OR AS-BUILT ALIGNMENT SHOWN ON FIG. 24.

0 5 10 MILES

0 5 15 KM

FIGURE 23

beak



CADILLAC EXPLORATIONS LTD.

WINTER ROAD

LOCATION OF WILDLIFE OBSERVED JULY 6-9, 1980 & APPROXIMATE TRAPLINE BOUNDARY

NOTE: FOR LOCATIONS OF WILDLIFE OBSERVED DURING APRIL 1980, OR NOTED BY OTHERS, SEE FIG. 23.

APPROXIMATE LIMIT OF DETAILED UNGULATE/RAPTOR SURVEYS, JULY 6-10 1980

APPROXIMATE WATERFOWL FLIGHT LINES, JULY 6-10 1980

APPROXIMATE TRAPLINE BOUNDARIES

0 5 10 MILES

0 5 10 15 km

FIGURE 24

beak

Table 3

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 Temperatures	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														H
2100610	FRANCES LAKE	YT	61 17	129 24	2425	1947 10	1948 05	X	P	X	X																H
2100610	FRANCES LAKE	YT	61 17	129 24	2425	1948 09	1949 05			X	X																H
2100612	FRANCES RIVER	YT	60 29	129 08	2274	1973 10						S															H
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1938 10	1938 10	X	P	X	X																H
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1938 11	1942 02	X	P	X	X		B														H
2101200	WATSON LAKE A	YT	60 07	128 49	2249	1942 04	1964 11	X	X	X	X		B														H
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1964 12	1966 12	X	X	X	X		B							V							H
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1967 01	1969 05	X	X	X	X									V							H
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1969 06	1969 09	X	X	X	X					S				V							H
2101200	WATSON LAKE A	YT	60 07	128 49	2248	1969 10		X	X	X	X	X		D		S				V							H
2200597	CADILLAC MINE	NWT	61 32	124 45	2850	1970 01	1970 11			X	X																H
2200620	CAN. TUNG	NWT	62 01	128 21	6000	1973 10						S															H
2202098	FORT SIMPSON	NWT	61 52	121 13	572	1943 03	1943 07	X	P	X	X																H
2202098	FORT SIMPSON	NWT	61 52	121 13	572	1944 02	1946 07	X	P	X	X																H
2202099	FORT SIMPSON	NWT	61 52	121 35		1875 05	1875 11			X																	H
2202099	FORT SIMPSON	NWT	61 52	121 35		1876 11	1877 03			X																	H
2202099	FORT SIMPSON	NWT	61 52	121 35		1877 12	1878 03			X																	H
2202099	FORT SIMPSON	NWT	61 52	121 35		1878 10	1879 05			X																	H
2202099	FORT SIMPSON	NWT	61 52	121 35		1895 11	1895 12			X	X																H
2202099	FORT SIMPSON	NWT	61 52	121 35		1897 03	1902 12			X	X																H
2202099	FORT SIMPSON	NWT	61 52	121 35		1903 05	1904 06			X	X																H
2202099	FORT SIMPSON	NWT	61 52	121 35		1905 01	1908 06			X	X																H
2202099	FORT SIMPSON	NWT	61 52	121 35		1908 07	1921 06	X	P	X	X																H
2202099	FORT SIMPSON	NWT	61 52	121 35		1922 08	1927 10	X	P	X	X																H

(Table 3 - 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 4

CLIMATIC SUMMARIES

Station		J	F	M	A	M	J	J	A	S	O	N	D	Year
Cadillac*	T	-14	-3	8	25	40	51	55	52	41	24	2	-5	23
	R	0	0	0	.1	1.0	2.3	3.4	2.8	1.9	.3	0	0	11.8
	P	.9	.9	.8	1.0	1.6	2.3	3.4	2.8	2.3	1.9	1.2	.9	20.0
	E	-	-	-	-	< 1	3.	4	3	2	< 1	-	-	13
Tungsten	T	-14	0	8	22	37	49	51	48	38	23	4	-4	22
	R	0	0	0	0	1.1	2.3	3.4	2.8	2.0	.2	0	0	11.8
	P	1.3	1.2	1.1	1.6	1.7	2.3	3.4	2.8	2.4	2.4	1.8	1.1	23.1
Fort Simpson	T	-21	-10	5	29	47	58	62	58	45	28	3	-12	24
	R	0	0	0	.1	.9	1.6	1.8	2.1	1.0	.3	0	0	6.8
	P	.8	.7	.7	.6	1.2	1.6	1.8	2.1	1.2	1.1	1.0	.8	13.6
Watson Lake	T	-17	-5	11	30	44	54	58	55	45	32	4	-9	25
	R	0	0	0	.1	.8	1.9	2.1	1.8	1.6	.6	.1	0	9
	P	1.4	1.1	.9	.7	.9	1.9	2.1	1.8	1.7	1.4	1.5	1.6	17

Legend

T - Mean daily temperature °F

R - Monthly rainfall, inches

* Estimated or derived.

P - Monthly total precipitation, inches

E - Monthly lake evaporation, inches

Table 5 Surface Water Data - Reference Index

NORTHWEST TERRITORIES

STATION NO.		DRAINAGE AREA (km²)	GAUGE LOCATION	DISCHARGE RECORDS (*-STAGE ONLY #-MISC.MEAS.) TYPE OF GAUGE , OPERATION	REMAR
10FA002	. TROUT RIVER AT FORT SIMPSON HIGHWAY	9 090	61 08 00 119 49 30	69-79 RC	6 N
10FB005	. JEAN-MARIE RIVER AT FORT SIMPSON HIGHWAY	1 310	61 27 00 121 15 00	72-73 M# 74-79 MC	N
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 N
10ED002	. LIARD RIVER NEAR THE MOUTH	277 000	61 44 50 121 13 25	72-79 RC	6 N
10ED004	. . RABBIT CREEK AT FORT LIARD HIGHWAY	120	60 27 45 123 24 15	78-79 RC	N
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 N
10EC001	. . SOUTH NAHANNI RIVER NEAR HOT SPRINGS	33 400	61 15 10 124 02 10	59-62 RS 63-79 RC	5 N
10EB002	. . . . MAC CREEK NEAR THE MOUTH	219	62 12 00 128 45 10	78-79 RC	N
10EA002	. . . FLAT RIVER AT CANTUNG CAMP	152	61 57 40 128 13 00	59 # 60-62 MS 63 # 73-79 RC	5 N
10EA003	. . . FLAT RIVER NEAR THE MOUTH	8 500	61 32 00 125 24 20	60-65 RC 66-71 RS 72-79 RC	5 N
10EC002	. . . PRAIRIE CREEK AT CADILLAC MINE	495	61 33 40 124 48 25	74-79 RC	N
10ED003	. . BIRCH RIVER AT FORT LIARD HIGHWAY	505	61 20 10 122 05 20	74-79 RC	N
10GC002	. HARRIS RIVER NEAR THE MOUTH	570	61 52 41 121 17 36	72 R# 73-79 RC	6
10GC003	. MARTIN RIVER NEAR THE MOUTH	2 040	61 53 10 121 37 05	72-79 RC	6 N
10GA001	. ROOT RIVER NEAR THE MOUTH	9 840	62 28 40 123 25 45	74 RS 75-79 RC	7 N
10HB003	. WRIGLEY RIVER NEAR THE MOUTH	1 260	63 14 15 123 36 20	76-79 RC	N
10HB001	. REDSTONE RIVER NEAR THE MOUTH	15 400	63 55 37 125 18 07	63-64 RC 65-70 RS 71-79 RC	5 N
10HA002	. . TSICHU RIVER AT CANOL ROAD	222	63 18 10 129 47 30	75-79 RC	N
10AA001	. LIARD RIVER AT UPPER CROSSING	33 400	60 03 00 128 54 00	60-76 MC 77-79 RC	5 N
10AB001	. . FRANCES RIVER NEAR WATSON LAKE	12 800	60 28 26 129 07 08	62 M# 63-79 RC	5 N
10AD003	. . . KING CREEK AT KILOMETRE 20.9 NAHANNI RANGE ROAD	13.7	60 56 50 128 55 40	75-79 RC	N
10AA002	. . TOM CREEK AT KILOMETRE 34.9 ROBERT CAMPBELL HIGHWAY	435	60 17 26 129 01 14	74-79 RC	N
10AD002	. . HYLAND RIVER AT KILOMETRE 108.5 NAHANNI RANGE ROAD	2 150	61 29 00 128 14 10	76-79 RC	N
10BD001	. . BEAVER RIVER BELOW WHITEFISH RIVER	7 280	60 07 52 124 53 21	77-79 RC	N

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 6

1980 SURFACE WATER QUALITY DATA

Station	Station No. 1 Prairie Creek Near Airstrip			Station No. 2 Prairie Creek Below Harrison Creek			Station No. 3 Harrison Creek Near Mouth		
Date of Sampling (mg/l unless noted)	18/4/80	22/7/80		18/4/80	22/7/80		18/4/80	22/7/80	
Total Alkalinity	199	161		199	193		133	189	
Conductivity	476	354		487	360		405	472	
pH	8.1	8.4		8.1	8.4		7.9	8.5	
Filtrable Residue	301	221		320	218		267	313	
Nonfiltrable Residue	4	3		2	<1		13	<1	
Sulfate	60	D 35		68	D 37		75	D 77	
Arsenic	T <0.005	T <0.005	D <0.005	T <0.005	T <0.005	D <0.005	T <0.005	T <0.005	D <0.005
Cadmium	T <0.005	T <0.005	D <0.005	T <0.005	T <0.005	D <0.005	T <0.005	T <0.005	D <0.005
Calcium	T 36		D 47	39		D 48	32		D 56
Chromium	T <0.01	T <0.01	D <0.01	T <0.01	T <0.01	D <0.01	T <0.01	T <0.01	D <0.01
Copper	T 0.005	T 0.006	D <0.005	T <0.005	T 0.005	D <0.005	T <0.005	T <0.005	D <0.005
Iron	T 0.065	T 0.030	D 0.021	T 0.055	T 0.016	D 0.012	T 0.42	T 0.010	D 0.010
Lead	T <0.01	T 0.039	D 0.042	T <0.01	T 0.034	D 0.035	T 0.011	T 0.042	D 0.040
Magnesium	T 26		D 17	T 25		D 17	T 21		D 28
Nickel	T 0.015	T 0.011	D <0.010	T 0.015	T <0.010	D <0.010	T 0.015	T 0.010	D <0.010
Potassium	T 0.71		D 0.61	T 0.50		D 0.45	T 0.91		D 0.73
Sodium	T 1.7		D 1.8	T 1.6		D 1.1	T 0.78		D 0.06
Zinc	T <0.005	T 0.024	D 0.009	T 0.031	T 0.010	D 0.005	T 0.14	T 0.009	D 0.006
Molybdenum	T <0.05	T 0.002	D 0.002	T <0.05	T 0.002	D 0.002	T <0.05	T 0.002	D 0.003
Nitrate	-	0.16		-	0.18		-	0.37	
Mercury	-	T <0.00025	D <0.00025	-	T <0.00025	D <0.00025	-	T <0.00025	D <0.00025

T = Total D = Dissolved

TABLE 7

1980 GROUND WATER QUALITY DATA

Station	Station No. W1	Station No. 3		Station No.7	Station No.10
	Mine Camp Well	Bore Hole #3 Surface Gravel	Bore Hole #3 Gravel Below Clay	Bore Hole #7	Bore Hole #10
Date of Sampling (mg/l unless noted)	22/7/80	28/8/80	28/8/80	28/8/80	28/8/80
Total Alkalinity	162	167	192	383	214
Conductivity	362	367	460	883	625
pH	8.2	7.8	7.7	7.2	7.4
Filterable Residue	-	245	293	611	443
Sulfate D	39	48	34	140	140
Arsenic D	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium D	<0.005	<0.005	<0.005	<0.005	0.005
Calcium D	46	55	76	130	81
Chromium D	<0.01	<0.01	<0.01	<0.01	<0.01
Copper D	<0.029	<0.005	<0.008	<0.005	<0.005
Iron D	<0.024	0.040	0.030	1.3	0.040
Lead D	<0.039	<0.010	0.010	0.029	0.010
Magnesium D	18	19	21	49	35
Nickel D	<0.010	0.021	0.015	0.029	0.021
Potassium D	0.57	1.1	1.1	1.2	0.9
Sodium D	1.3	3.7	2.2	1.7	0.9
Zinc D	0.023	0.020	0.078	0.17	0.76
Molybdenum D	0.002	0.0032	0.0033	0.0022	0.0023
Nitrate D	0.28	0.13	0.15	<0.05	0.75
Mercury D	<0.00025	0.00082	0.00061	0.00075	0.00078

D = Dissolved

TABLE 8

1980 MINE WATER QUALITY DATA

Station	Station No. 1 Portal @ 3050 Ft. Level		Station No. 2 Portal @ 2850 Ft. Level			
Date of Sampling	18/4/80		22/7/80			
Total Alkalinity		262		262		
Conductivity		752		831		
pH		8.3		8.0		
Filtrable Residue		540		629		
Nonfiltrable Residue		4		386		
Sulfate		180		220		
Arsenic	T	0.024	T	0.002	D	0.008
Cadmium	T	<0.005	T	0.031	D	0.012
Calcium	T	65			D	88
Chromium	T	<0.01	T	<0.01	D	<0.01
Copper	T	0.005	T	0.086	D	0.025
Iron	T	<0.01	T	4.2	D	0.044
Lead	T	<0.01	T	0.27	D	0.10
Magnesium	T	43			D	44
Nickel	T	0.007	T	0.057	D	0.028
Potassium	T	1.2			D	1.87
Sodium	T	0.38			D	2.1
Zinc	T	0.15	T	7.7	D	4.0
Molybdenum	T	<0.05	T	<0.020	D	0.002
Nitrate		-				1.9
Mercury		-	T	0.0035	D	<0.00025

T = Total D = Dissolved

TABLE 9

1980 STREAM SEDIMENT ANALYSIS

Station	Station No. 1	Station No. 2
	Prairie Creek Near Airstrip	Prairie Creek Downstream
Date of Sampling	22/7/80	22/7/80
Micrograms per gram (Dry Basis)*		
Total Arsenic	5.6	5.2
Total Calcium	160,000	160,000
Total Cadmium	3.8	3.8
Total Chromium	11	11
Total Copper	14	14
Total Iron	8,000	9,700
Total Lead	56	48
Total Magnesium	28,000	30,000
Total Mercury	<0.050	0.058
Total Molybdenum	<5.0	<4.5
Total Nickel	29	32
Total Sodium	220	200
Total Zinc	93	120

* Analyses performed on the Minus 16 Mesh size fraction.

TABLE 10 Summary, Benthic Invertebrate Data, July, 1980 (near minesite).

Parameter	STATION*				
	Prairie Crk. M1	Prairie Crk. M2	Harrison Crk. M3	Prairie Crk. M4	Prairie Crk. M5
% Group 3	86	86	63	35	41
% Group 2	14	14	34	64	59
% Group 1	0	0	3	1	0
Mean No./m^2					
Group 3	134	81	210	75	142
Group 2	22	13	113	137	207
Group 1	0	0	11	3	0
Total	156	94	334	215	349
Dominance	0.76	0.76	0.51	0.53	0.52
Diversity (*H*)	2.44	2.13	3.49	2.38	1.70
Total No. Taxa	14	8	20	12	7
Richness	2.57	1.54	3.27	2.05	1.02
Equitability	0.64	0.71	0.81	0.66	0.61
TU Data:					
TU Index	0.6703	0.6684	0.8791	0.7539	0.5987
Variance	0.2376	0.2013	0.0242	0.0409	0.1751

* See Figure 21. All stations sampled with Surber Sampler.

TABLE 11 Summary, Benthic Invertebrate Data, July, 1980 (Prairie Ck. & Ram River tributaries)

Parameter	STATION* Prairie Creek Tributary	Ram River Tributary 1	Ram River Tributary 2
% Group 3	51	5	61
% Group 2	49	95	39
% Group 1	0	0	0
Mean No./m^2			
Group 3	301	56	59
Group 2	288	1148	38
Group 1	0	0	0
Total	589	1204	97
Dominance	0.50	0.91	0.52
Diversity (*H*)	2.02	0.60	2.60
Total No. Taxa	13	13	9
Richness	1.88	1.69	1.75
Equitability	0.54	0.16	0.82
TU Data:			
TU Index	0.6496	0.1332	0.8015
Variance	0.0982	0.2199	0.0445

* Prairie Creek Tributary - Site R1

Ram River Tributary 1 - Site R2

Ram River Tributary 2 - Site R3

All stations sampled with Surber Sampler.

TABLE 12 Summary, Benthic Invertebrate Data, July, 1980 (Tetcela River)

	STATION*			
Parameter	Tetcela R. 1	Tetcela R. 2	Tetcela R. 3	Tetcela R. 4
% Group 3	84	67	35	64
% Group 2	16	33	65	18
% Group 1	0	0	0	18
Mean No./m^2				
Group 3	43	22	16	11
Group 2	8	11	30	3
Group 1	0	0	0	3
Total	51	33	46	17
Dominance	0.74	0.56	0.55	0.48
Diversity ($\bar{H}$)	1.78	1.55	2.46	2.25
Total No. Taxa	5	4	8	5
Richness	1.02	0.86	1.83	1.44
Equitability	0.77	0.78	0.82	0.97
TU Data:				
TU Index	0.6499	0.6021	0.7713	0.8292
Variance	0.1351	0.1665	0.0948	0.0247

* Tetcela River 1 - Site R4 ; upstream of confluence with tributary and upstream of road crossing;

Tetcela River 2 - Site R4 ; upstream of confluence with tributary and downstream of road crossing;

Tetcela River 3 - Site R5 ; downstream of confluence with tributary and upstream of road crossing;

Tetcela River 4 - Site R5 ; downstream of confluence with tributary and downstream of road crossing;

All stations sampled with Surber Sampler

TABLE 13 Summary, Benthic Invertebrate Data, July, 1980 (Fishtrap Creek & Grainger River)

	STATION*		
Parameter	Fish Trap Creek	Grainger River 1	Grainger River 2
% Group 3	6	50	24
% Group 2	60	43	75
% Group 1	34	7	1
Mean No./m^2			
Group 3	217	54	97
Group 2	2359	46	304
Group 1	1348	8	3
Total	3924	108	404
Dominance	0.48	0.44	0.62
Diversity ($\bar{H}$)	3.57	3.78	3.05
Total No. Taxa	37	18	22
Richness	4.35	3.63	3.50
Equitability	0.69	0.91	0.68
TU Data:			
TU Index	0.8395	0.9173	0.7691
Variance	0.0581	0.0116	0.1582

* Fish Trap Creek - downstream of road crossing; Site R6

Grainger River 1 - upstream of road crossing ; Site R7

Grainger River 2 - downstream of road crossing ; Site R7

Fish Trap Creek sampled with Ekman grab;
Other stations sampled with Surber sampler.

TABLE 14 Summary of Trace Metal Analyses On Dorsal Musculature Excised From Fish Collected In Prairie Creek On 23 July, 1980.

Parameter	STATION & SAMPLE			
	M1*	M5		
		1*	2	3
Fish Species	6 Slimy Sculpin	5 Slimy Sculpin	Dolly Varden Char	Dolly Varden Char
Fork Length (mm)	55 - 75	50 - 73	162	301
Weight (gm)	1.6 - 6.0	1.4 - 5.8	60	300
% Moisture	82	81	80	81
Metals (µg/g wet wt.)				
Cadmium	<2.2	<2.4	<2.5	<1.6
Copper	2.2	<2.4	<2.5	<1.6
Arsenic	<0.18	<0.20	<0.21	<0.14
Lead	<4.3	<4.8	<4.9	<3.2
Mercury	<0.050	<0.050	0.076	0.12
Zinc	4.7	7.5	<2.5	<1.6

* Sample for analyses consisted of a homogenate of all the muscle tissue excised from each of the sample groups.

Note: Detection limits varied as a result of variations in the amount of tissue available for analysis.

TABLE 15

VASCULAR PLANTS IDENTIFIED IN THE VICINITY OF THE PROPOSED MINE AND WINTER ROAD[1]

COMMON NAME[2]	SCIENTIFIC NAME
Alder	Alnus spp.
Alder sp.	Alnus rugosa
Alpine bearberry	Arctostaphylos rubra
Aspen	Populus tremuloides
Balsam poplar	Populus balsamifera
Bastard toad-flax	Geocaulon lividum
Bearberry	Arctostaphylos uva-ursi
Bistort	Polygonum viviparum
Black spruce	Picea mariana
Blue-eyed grass	Sisyrinchium montanum
Bluejoint	Calamagrostis canadensis
Bog bilberry	Vaccinium uliginosum L. ssp. alpinum
Bog cranberry	Vaccinium vitis-idaea L. ssp. minus
Bog rosemary	Andromeda polifolia
Bronze-bells	Stenanthium occidentale
Bunchberry	Cornus canadensis
Canada anemone	Anemone canadensis
Canadian buffalo-berry	Shepherdia canadensis
Cloudberry	Rubus chamaemorus
Common butterwort	Pinguicula vulgaris
Common pink wintergreen	Pyrola asarifolia
Common wild rose	Rosa woodsii
Cotton grass sp.	Eriophorum scheuchzeri
Crowberry	Empetrum nigrum
Cut-leaved anemone	Anemone multifida
Dandelion	Taraxicum sp.
Dogwood	Cornus stolonifera
Dwarf birch	Betula glandulosa
Elephant head	Pedicularis groenlandica
Eyebright	Euphrasia disjuncta
False asphodel sp.	Tofieldia glutinosa
False asphodel sp.	Tofieldia pusilla
Fescue sp.	Festuca altaica
Fireweed	Epilobium angustifolium

1 A more complete listing of vascular plants which may occur in the area is found in Scotter and Cody (1974) and Porsild and Cody (1968).

2 Common names follow Moss (1959) with supplementary information from Hulten (1968) and Anderson (1959).

TABLE 15(Continued)

COMMON NAME	SCIENTIFIC NAME
Fleabane sp.	Erigeron hyssopifolius
Four-parted gentian	Gentianella propinqua
Foxtail barley	Hordeum jubatum
Golden saxifrage	Saxifraga aizoides
Goldenrod sp.	Solidago canadensis L. var. salebrosa
Goldenrod sp.	Solidago decumbens
Grass-of-Parnassus	Parnassia palustris L. var. neogaea
Ground juniper	Juniperus communis
Hair grass	Agrostis scabra
Hairy wild rye	Elymus innovatus
Hedysarum	Hedysarum spp.
Hedysarum sp.	Hedysarum boreale Nutt. var. mackenzii
Horsetail	Equisetum spp.
Horsetail sp.	Equisetum fluviatile
Horsetail sp.	Equisetum palustre
Indian paint-brush sp.	Castilleja raupii
Jack pine	Pinus banksiana
Labrador tea	Ledum groenlandicum
Labrador tea sp.	Ledum palustre
Lapland cassiope	Cassiope tetragona
Lapland rose-bay	Rhododendron lapponicum
Lindley's aster	Aster ciliolatus
Loco-weed sp.	Oxytropis sp.
Low-bush cranberry	Viburnum edule
Meadow rue sp.	Thalictrum sp.
Milk vetch sp.	Astragalus frigidus (L.) Gray var. americanus
Milk vetch sp.	Astragalus Robbinsii var. minor
Mitrewort	Mitella nuda
Narrow-leaved hawkweed	Hieracium scabriusculum
Narrow reed grass	Calamagrostis neglecta
Netted willow	Salix reticulata L. ssp. reticulata
Northern asphodel	Tofieldia coccinea
Northern bedstraw	Galium boreale
Northern goldenrod	Solidago multiradiata
Northern green orchid	Habenaria hyperborea
Northern reed grass	Calamagrostis inexpansa
Northern single-spike sedge	Carex scirpoidea
One-flowered wintergreen	Moneses uniflora
One-sided wintergreen	Pyrola secunda
Prairie gentian	Gentiana affinis
Prickly rose	Rosa acicularis
Purple saxifrage	Saxifraga oppositifolia
Ragwort sp.	Senecio cymbalarioides
Reflexed loco-weed	Oxytropis deflexa (Pall.) D.C. var. sericea
Rose	Rosa sp.
Rough cinquefoil	Potentilla norvegica
Sandwort sp.	Arenaria rubella

TABLE 15(Continued)

COMMON NAME	SCIENTIFIC NAME
Sedge	*Carex* spp.
Showy everlasting	*Antennaria pulcherrima*
Shrubby cinquefoil	*Potentilla fruticosa*
Siberian aster	*Aster sibiricus*
Siberian yarrow	*Achillea sibirica*
Silverberry	*Elaeagnus commutata*
Silverweed	*Potentilla anserina*
Smooth woodsia	*Woodsia glabella*
Spike rush sp.	*Eleocharis pauciflora*
Spike trisetum	*Trisetum spicatum*
Star-flowered Solomon's-seal	*Smilacina stellata*
Stonecrop sp.	*Sedum* sp.
Sweet-flowered androsace	*Androsace chamaejasme*
Sweet gale	*Myrica gale*
Sweet grass	*Hierochloe odorata*
Tamarack	*Larix laricina*
Timber oat grass	*Danthonia intermedia*
Twin-flower	*Linnaea borealis*
Twining honeysuckle	*Lonicera dioica*
Water birch	*Betula occidentalis*
Water sedge	*Carex aquatilis*
Western meadow rue	*Thalictrum occidentale*
Wheatgrass	*Agropyron* spp.
Wheatgrass sp.	*Agropyron violaceum*
White birch	*Betula papyrifera*
White camas	*Zygadenus elegans*
White dryad	*Dryas integrifolia*
White spruce	*Picea glauca*
Wild chives	*Allium schoenoprasum* L. var. *sibiricum*
Wild gooseberry	*Ribes oxyacanthoides*
Wild red raspberry	*Rubus ideaus*
Wild strawberry	*Fragaria virginiana*
Willow	*Salix* spp.
Willow sp.	*Salix myrtillifolia*
Willow sp.	*Salix subcoerulea* (tentative)
Willowherb	*Epilobium latifolium*
Wintergreen sp.	*Pyrola* sp.
Yarrow	*Achillea millifolium*
Yellow dryad	*Dryas drummondii*

TABLE 16

LICHENS AND BRYOPHYES IDENTIFIED WITHIN THE STUDY AREA

LICHENS[1]

Alectoria ochroleuca (Hoffm.) Mass.

Cetraria cucculata (Bell) Ach.

Cetraria pinastri (Scop.) S. Gray

Cladina alpestris (L.) Harm.

Dactylina arctica (Hook.) Nyl.

Thamnolia subuliformis (Ehrh.) W. Culb.

BRYOPHYTES[2]

Dicranum sp.

Pleurozium schreberi (Brid.) Mitt.

1 A more complete listing of lichens which may occur in the area is found in Jeffrey (1961).

2 Steere, Scotter and Holman (1977) list bryophytes which occur in the vicinity of Nahanni National Park.

TABLE 17

OBSERVATIONS OF AQUATIC BIRDS AT SPECIFIC WETLANDS LOCATED ALONG THE PROPOSED WINTER ROAD

Wetland	Birds Observed
Grainger River (approximately 10 km adjacent road)	2 Spotted Sandpipers
Lake #2	1 Scaup sp. 1 American Wigeon 3 Duck sp. 1 Grebe sp.
Lake #3	1 Diving Duck ♀ + 7 (brood) 1 Diving Duck ♀ + 6 (brood) 1 Diving Duck ♀ + 8 (brood) 1 unidentified
Lake #4	1 Scaup ♀ + 9 1 unidentified ♀ + 8
Lake #7	1 Yellowlegs sp.
Lake #8	1 Dabbler ♀ + 7
Lake #10	1 Red-necked Grebe
Lake #11	2 Common Loon 1 Surf Scoter ♀ + 5 3 Duck sp. 1 Bonaparte's Gull 2 Yellowlegs sp. 1 unidentified sp.
Lake #12	3 Mallard 1 Bufflehead 1 Bonaparte's Gull 1 unidentified
Lake #14	1 Bufflehead 1 unidentified ♀ + 2 4 unidentified
Lake #15	1 unidentified ♀ + 4
Lake #16	1 unidentified ♀ + 6 1 Common Nighthawk

TABLE 17 - Cont'd.

Lake #17	1 Greater Scaup 4 Duck sp. 1 Common Nighthawk
Lake #18	-------
Lake #19	3 Teal sp. 1 Bufflehead 1 Bonaparte's Gull
Lake #20	1 unidentified ♀ + 3 1 unidentified ♀ + 4 5 unidentified
Lake #26	6 Trumpeter Swans (moulting) 1 Mallard ♀ + 4 1 Coot

TABLE 18

PROVISIONAL CHECK LIST OF BIRDS IN THE VICINITY OF THE PROPOSED CADILLAC MINES WINTER ROAD, N.W.T.[1]

COMMON NAME	SCIENTIFIC NAME[2]
Common loon	Gavia immer
Yellow-billed loon	Gavia adamsii
Arctic loon	Gavia artica
Red-throated loon	Gavia stellata
Red-necked grebe	Podiceps grisegena
Horned grebe	Podiceps auritus
Pied-billed grebe	Podilymbus podiceps
Trumpeter swan	Olor buccinator
Whistling swan	Olor columbinaus
Canada goose	Branta canadensis
White-fronted goose	Anser albifrons
Snow goose	Chen hyperborea
Mallard	Anas platyrhynchos
Gadwall	Anas strepera
Pintail	Anas acuta
Green-winged teal	Anas carolinensis
Blue-winged teal	Anas discors
American wigeon	Anas americana
Northern shoveler	Anas clypeata
Red head	Aythya americana
Canvasback	Aythya valisineria
Greater scaup	Aythya marila
Lesser scaup	Aythya affinis
Common goldeneye	Bucephala clangula
Barrow's goldeneye	Bucephela islandica
Bufflehead	Bucephala albeola
Oldsquaw	Clangula hyemalis
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

1 Based on distributional information contained in Godfrey (1966), Scotter et al (1971), Slaney Co. Ltd. (1971), L. Carbyn (pers. comm.), and BEAK sightings.

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

TABLE 18 - Cont'd.

COMMON NAME	SCIENTIFIC NAME
Red-tailed hawk	Buteo jamaicensis
Swainson's hawk	Buteo swainsoni
Golden eagle	Aquila chrysaetos
Bald eagle	Haliaeetus leucocephalus
Marsh hawk	Circus cyaneus
Osprey	Pandion haliaetus
Gyrfalcon	Falco rusticolus
Peregrine falcon	Falco peregrinus
Merlin	Falco columbarius
American kestrel	Falco sparverius
Blue grouse	Dendragapus obscurus
Spruce grouse	Canachites canadensis
Ruffled grouse	Bonasa umbellus
Willow ptarmigan	Lagopus lagopus
Rock ptarmigan	Lagopus mutus
White-tailed ptarmigan	Lagopus leucurus
Sharp-tailed grouse	Pedioecetes phasianellus
Sandhill crane	Grus canadensis
Sora	Porzana carolina
American coot	Fulica americana
Semi-palmated plover	Charadrius semipalmatus
Kildeer	Charadrius vociferus
American golden plover	Pluvialis dominica
Common snipe	Capella gallinago
Upland sandpiper	Bartramia longicauda
Spotted sandpiper	Actitis macularia
Solitary sandpiper	Tringa solitaria
Wandering tattler	Heteroscelus incanus
Greater yellowlegs	Totanus melanoleucus
Lesser yellowlegs	Tringa flavipes
Pectoral sandpiper	Erolia melanotos
Bairds' sandpiper	Erolia bairdii
Least sandpiper	Erolia minutilla
Semi-palmated sandpiper	Ereunetes pusillus
Stilt sandpiper	Micropalama himantopus
Northern phalarope	Lobipes lobatus
Herring gull	Larus argentatus
Mew gull	Larus canus
Bonaparte's gull	Larus philadelphia
Arctic tern	Sterna paradisaea
Black tern	Chlidoniaw niger
Great horned owl	Bubo virginianus
Hawk owl	Surnia ulula
Barred owl	Strix varia
Great gray owl	Strix nebulosa
Long-eared owl	Asio otus
Short-eared owl	Asio flammeus
Boreal owl	Aegolius funereus
Common nighthawk	Chordeiles minor

TABLE 18 - Cont'd.

COMMON NAME	SCIENTIFIC NAME
Belted kingfisher	Megaceryle alcyon
Common 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 flaviventris
Alder flycatcher	Empidonax traillii
Least flycatcher	Empidonax minimus
Hammond's flycatcher	Empidonax hammondii
Western wood peewee	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
Gray jay	Perisoreus canadensis
Common raven	Corvus corax
Common crow	Corvus brachyrhynchos
Clarke's nutcracker	Nucifraga columbiana
Black-capped chickadee	Parus atricapillus
Boreal chickadee	Parus hudsonicus
Red-breasted nuthatch	Sitaa canadensis
American robin	Turdus migratorius
Varied thrush	Ixoreus naevius
Hermit thrush	Catharus guttatus
Swainson's thrush	Catharus ustulatus
Gray-cheeked thrush	Hylocichla minima
Mountain bluebird	Sialia currucoides
Townsend's solitaire	Myadestes townsendi
Ruby-crowned kinglet	Regulus calendula
Water pipit	Anthus spinoletta
Bohemian waxwing	Bombycilla garrulus
Northern shrike	Lanius excubitor
Starling	Sturnus vulgaris
Red-eyed vireo	Vireo olivaceus
Philadelphia vireo	Vireo philadelphicus
Warbling vireo	Vireo gilvus
Black-and-white warbler	Mniotilita varia
Tennessee warbler	Vermivora peregrina
Orange-crowned warbler	Vermivora celata

TABLE 18 - Cont'd.

COMMON NAME	SCIENTIFIC NAME
Yellow warbler	Dendroica petechia
Magnolia warbler	Dendroica petechia
Yellow-rumped warbler	Dendroica coronata
Black-throated green warbler	Dendroica virens
Bay-breasted warbler	Dendroica castanea
Blackpoll warbler	Dendroica striata
Palm warbler	Dendroica palmarum
Ovenbird	Seiurus aurocapillus
Northern waterthrush	Seiurus noveboracensis
Mourning warbler	Oporornis philadelphia
Common yellow-throat	Geothlypis trichas
Wilson's warbler	Wilsonia pusilla
American redstart	Setophaga ruticilla
Red-winged blackbird	Agelaius phoeniceus
Rusty blackbird	Euphagus carolinus
Brwon-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
Grey-crowned rosy finch	Leucosticte tephrocotis
Hoary redpoll	Acanthis hornemanni
Common redpoll	Acanthis flammea
Pine siskin	Carduelis pinus
Red crossbill	Loxia curvirostra
White-winged crossbill	Loxia leucoptera
Savannah sparrow	Passerculus sandwichensis
Vesper sparrow	Pooecetes gramineus
Dark-eyed junco	Junco hyemalis
Tree sparrow	Spizella arborea
Chipping sparrow	Spizella passerina
Clay-coloured sparrow	Spizella pallida
White-crowned sparrow	Zonotrichia leucophrys
Golden-crowned sparrow	Zonotrichia albicollis
White-throated sparrow	Zonotrichia albicollis
Fox sparrow	Passerella iliaca
Lincoln's sparrow	Melospiza lincolni
Swamp sparrow	Melospiza georgiana
Song sparrow	Melospiza melodia
Lapland longspur	Calcarius lapponicus
Smith's longspur	Calcarius pictus

Table 19

Hunter Return Data* for the Region
of the Proposed Cadillac Explorations Ltd.
Mine & Road Development (1975 - 78), (Zone 12, Area 6).

Hunting Season (Year)	No. of Hunters	No. of Successful Hunters	No. of Game Animals Taken	Sheep	Bear	Moose
1975	14	12	15	12	3	
1976	12	12	10	10		
1977	13	11	9	8	1	
1978	17	14	15	14		1

*Data from Department of Renewable Resources