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LIARD HIGHWAY STUDY

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LIARD HIGHWAY STUDY

for

PUBLIC WORKS CANADA
WESTERN REGION

by

synergy

MAY, 1975

INTER - DISCIPLINARY COORDINATION IN
LAND USE AND ENVIRONMENTAL PLANNING

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May 9th, 1975

Mr. F. Kimball,
Project Manager Northern Roads
Public Works Canada
Western Region
10th Floor, One Thornton Court
P.O. Box 488
EDMONTON, Alberta
T5J 2E7

Dear Sir:

RE: ENVIRONMENTAL ASSESSMENT - LIARD HIGHWAY - CONTRACT NO. A13-74

This report culminates our work in providing your Department with the environmental data to enable the final design and construction of the Liard Highway in the Northwest Territories.

This report has taken the posture of environmental assessment, with planning guidelines, towards the control of use, rather than being purely a definition of environmental impact. We trust the methods employed and the information supplies will provide valued data towards the final planning and towards future studies required to complete the project.

It was our pleasure working with your Department.

Yours very truly
SYNERGY WEST LIMITED

M. Simpson

M.E. Simpson, P.Eng.
Director

MES:cm

ACKNOWLEDGEMENTS

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SYNOPSIS

The Liard Highway is proposed to connect Fort Simpson Northwest Territories via Fort Liard Northwest Territories to Fort Nelson British Columbia. This study assesses the impacts of highway development on the natural environment for the section of highway within the Northwest Territories and makes recommendations towards minimizing detrimental effects and maximizing advantageous features.

The report has been prepared in a format to display the philosophy and recommendations for final highway design that will enable construction sensitive to all values.

The major conclusions and recommendations are:

1 The highway presently exists or has been predetermined. On a macro-scale it is favorably situated. On a micro-scale modification and planned development control is required to minimize impacts and satisfy demands.

2 A management strategy reflecting multiple use of resources with minimum environmental deterioration is recommended. The ethic is preservation first, development second.

3 Controlled use of the highway is considered the method by which minimum impact will occur. A development control corridor along the highway with land use policies is recommended.

4 Sensitive construction techniques are suggested to preserve natural aesthetics.

5 Moose are the primary big game species affected. Methods of controlled access have been suggested.

6 Preservation of the fishery affected by the roadway has regional importance. Bridges have been recommended at several locations.

7 The socio-economic impact on Fort Liard will be great. Further study is required.

The incorporation of these recommendations and the more detailed recommendations within the report into the design and construction is ultimately important.

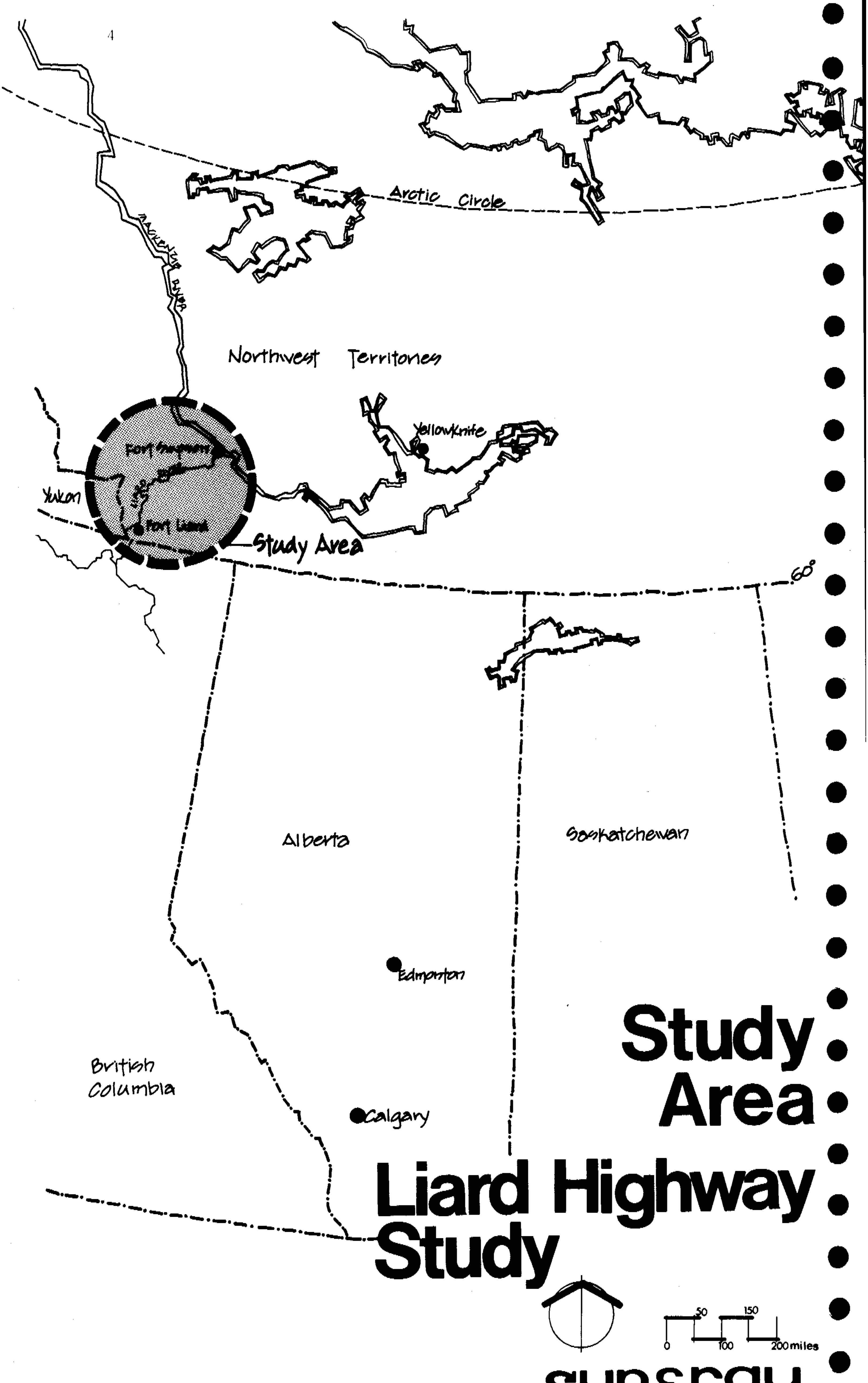
CONTENTS

INTRODUCTION

This study was originally intended to be an Environmental Impact Study for the Fort Simpson/Fort Liard Highway, however, due to budget restraints and due to the fact that portions of the roadway were completed, or right-of-way had been cleared and centreline cut, the posture of the study took one of being that of environmental assessment and planning for the minimization of environmental impact. The Terms of Reference were modelled on those for the MacKenzie Highway where final route selection had not been made and the freedom of determining the least sensitive transportation route was possible. In essence the Terms of Reference have been answered; however, certain aspects have been modified to reflect this planning approach versus the pure impact analysis which provides only baseline data for planning.

In view of this planning approach the report has been sub-divided and arranged to firstly display the overall physical and development aspects of the region. This is displayed by Regional Maps with complementary text. Upon gaining this regional perspective the highway is broken down into sections based on air photography in correlation to the drawings for construction by the Department of Public Works. Each of these sections is dealt with in regards to identifying naturally sensitive areas, aesthetic conditions, certain engineering criteria, and development potentials. Finally, the detailed analysis is summarized, again at a regional scale, to display the overall planning concepts and the major environmental sensitivities.

To utilize this report it is suggested that the detailed section maps be used as direct reference for planning, but that decisions based on the detailed analysis always relate to the overall regional influence and concept.



Study Area

Liard Highway Study

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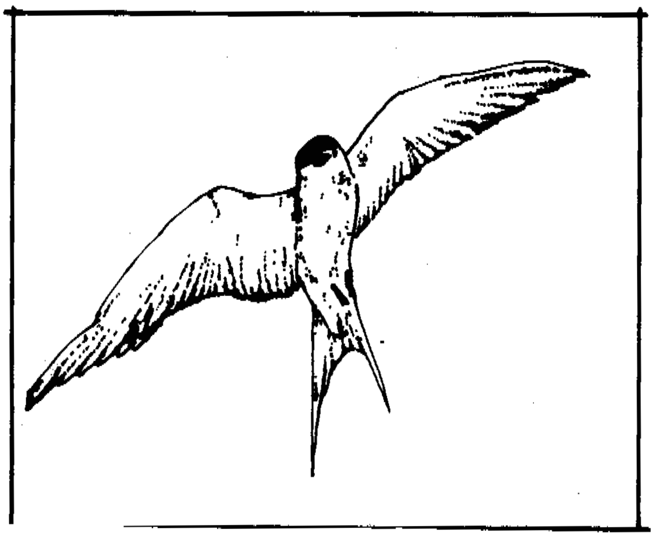
METHODS EMPLOYED

The generation of basic data relative to the area was accomplished through conventional library research. A list of selected references is attached to this report. A general overview of the study area was done by helicopter by most of the investigators on the study, to give them an appreciation of the general terrain for purposes of analysis. During two of these flights time-lapse photography was obtained which provided an office record and tool by which alignment, visual qualities, and general terrain analysis could be done. Interpretation of air photo mosaics provided by the Department was done to determine vegetation types relative to wildlife habitat and for general alignment considerations.

Specific studies were done to establish wildlife concentrations and distributions and a fish sampling study was conducted on the major streams influenced by the highway.

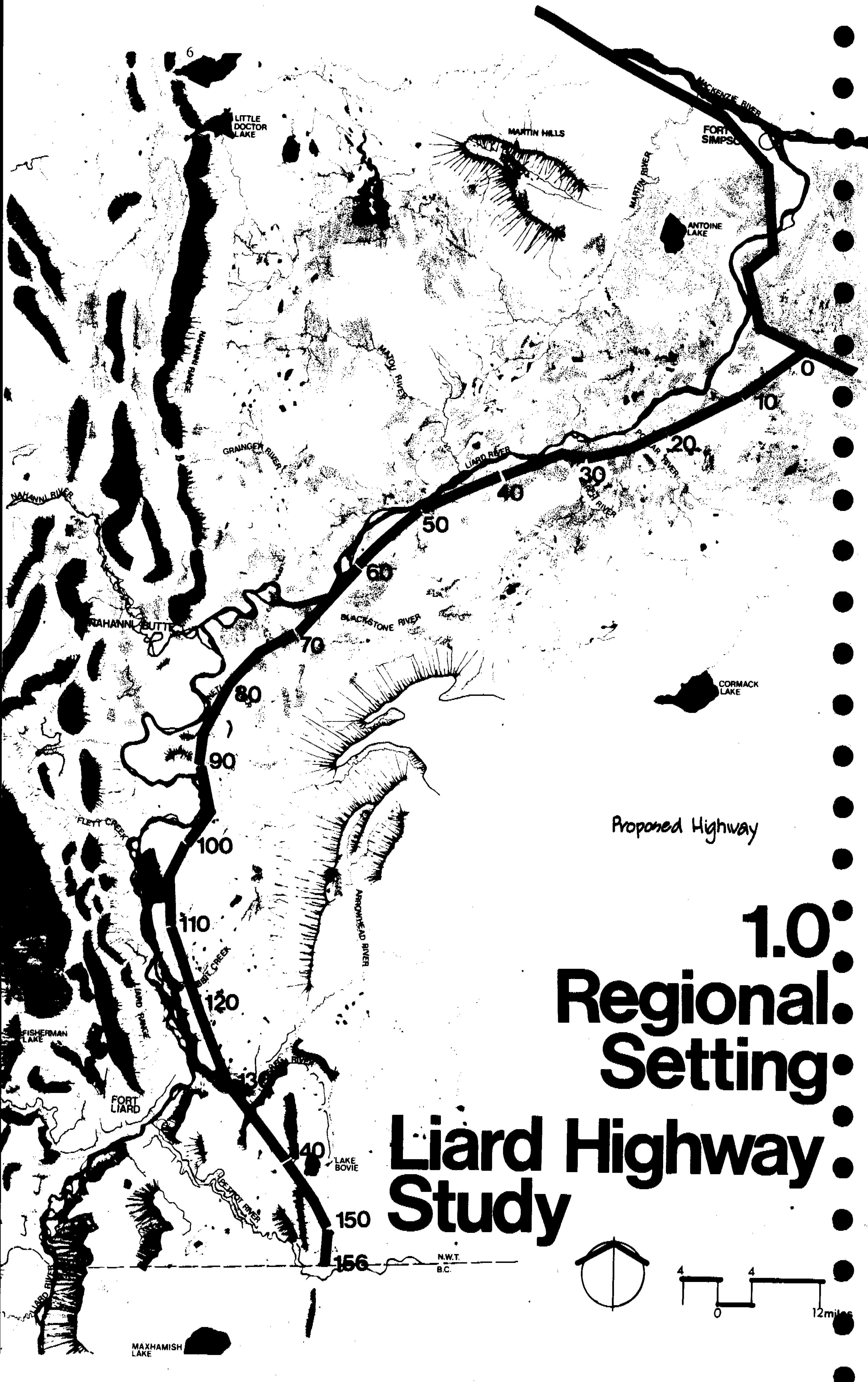
Studies by other sub-consultants that were referenced in this work are the hydrology studies conducted by UNIES Limited and geotechnical available studies conducted by Thurber Consultants Limited. Of particular value and applicability to this area were the detailed studies completed by other consultants along the MacKenzie Highway.

Attempts have been made to keep the report concise.



1.0 Regional Setting

Liard Highway Study



SECTION I

This section has been organized to display the natural physical characteristics of the immediate region along the highway, followed by demands that may be applied due to highway access. Synthesis of the information occurs in Section II

STUDY AREA

The highway study area is located from the 60th parallel North to 61 degrees, 30 minutes North and from latitude 121 degrees, 15 minutes West to 123 degrees, 30 minutes, being the southwest corner of the Northwest Territories. The area is governed by the Northwest Territorial Government, seated at Yellowknife and falls under the jurisdiction of the Federal Government, Department of Indian and Northern Affairs. The area is bounded on the west by the Yukon Territory, on the southwest corner by the province of British Columbia and on the south by the province of Alberta. Map 1.0 shows the proposed highway location.

MANAGEMENT ALTERNATIVE

Land within any region can only be developed and utilized to its greatest potential if an overall management philosophy provides the guidance towards accomplishing desired goals. The range of management scenarios or strategies ranges from one of complete protection, a preservationist point of view, to the other extreme of no-control, complete development and exploitation of all aspects. The preservationists point of view normally dictates public ownership and control of land exclusively for the public interest, whereas uncontrolled development allows public and private enterprise to prevail with little control. Obviously, there is a reasonable compromise between these extremes. At this point the highway traverses a previously undeveloped area. It is recommended that without an exhaustive analysis of Territorial and Federal Government objectives within this area, that a management strategy stressing protection of the natural environment is appropriate. This posture takes substance because an existing rich, natural environment exists, whereas resource development is presently an unproven possibility. Ultimately, however, the intent would be to use the renewable and non-renewable resources in an integrated manner so as to reduce conflicts between uses and to minimize environmental deterioration.

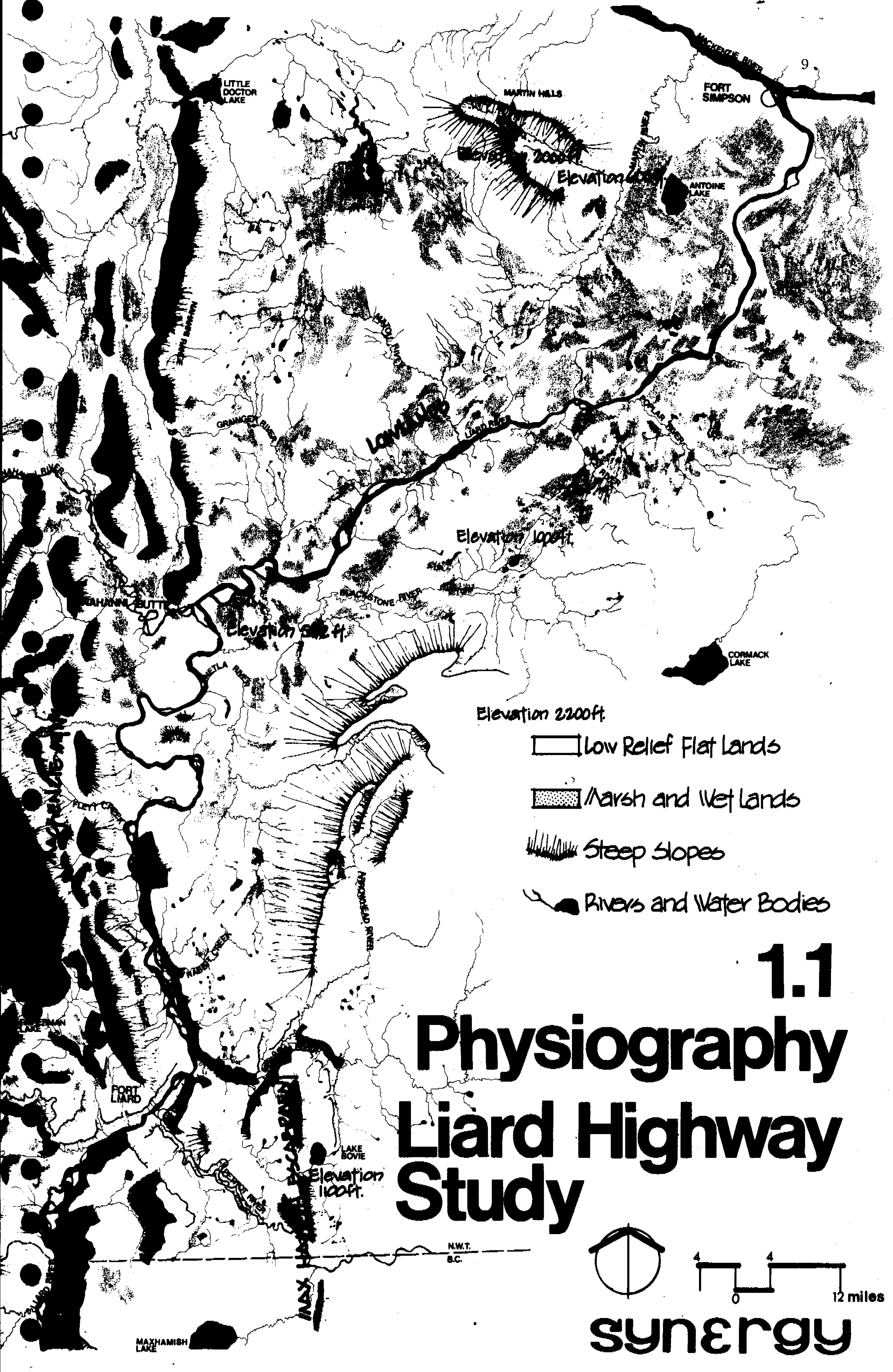
The recommendations within this report are based on this generalized strategy.

PHYSIOGRAPHY

The landscape character of the area surrounding the proposed Liard Highway has evolved under the combined influences of the Liard River and past glacial history. Dissected by the Liard River and its tributaries, the land is characterized on its western border by the MacKenzie Mountains and to the east by the foothills and gently undulating terrain of the MacKenzie Lowlands.

The main mountain chains are those of the Liard Range to the southwest and the Nahanni Range to the northwest. These two ranges are separated by the south Nahanni River, but together form the southernmost extension of the MacKenzie Mountain system. From the general basin floor at approximately 1,000 to 1,500 feet above sea level, the mountain ranges rise to peaks of between 4,000 and 5,000 feet above sea level. The rocks forming the Liard Range are composed primarily of Carboniferous sandstones, shales, cherts and limestones, while those of the Nahanni Range include Middle Devonian limestones and dolomitic limestones overlying siliceous limestones and dolomites of Silurian age. The predominant feature is the isolated Nahanni Butte, which forms a landmark in the area

The gently rolling hills and plateaux of the MacKenzie Lowlands take their character from glacial depositional features, mainly in the form of drumlinoid ridges and fluted glacial tills through which flow a number of tributaries to the Liard River. Significant bedrock outcrops are rare in this portion of the area, being confined primarily to the steep ground immediately adjacent to the southern section of the Liard


MACKENZIE RIVER
FORT SIMPSON
MARTIN HILLS
LITTLE DOCTOR LAKE
ANTOINE LAKE
MARTIN RIVER
Elevation 2000 ft.
LIARD RIVER
POPLAR RIVER
GRAINGER RIVER
Elevation 1000ft.
BLACKSTONE RIVER
NAHANNI BUTTE
Elevation 500 ft.
CORMACK LAKE
Elevation 2200ft.
Low Relief Flat Lands
Marsh and Wet Lands
Steep Slopes
Rivers and Water Bodies
1.1
Physiography
Liard Highway
Study
FORT LIARD
LAKE BOVIE
Elevation 1100ft.
N.W.T.
B.C.
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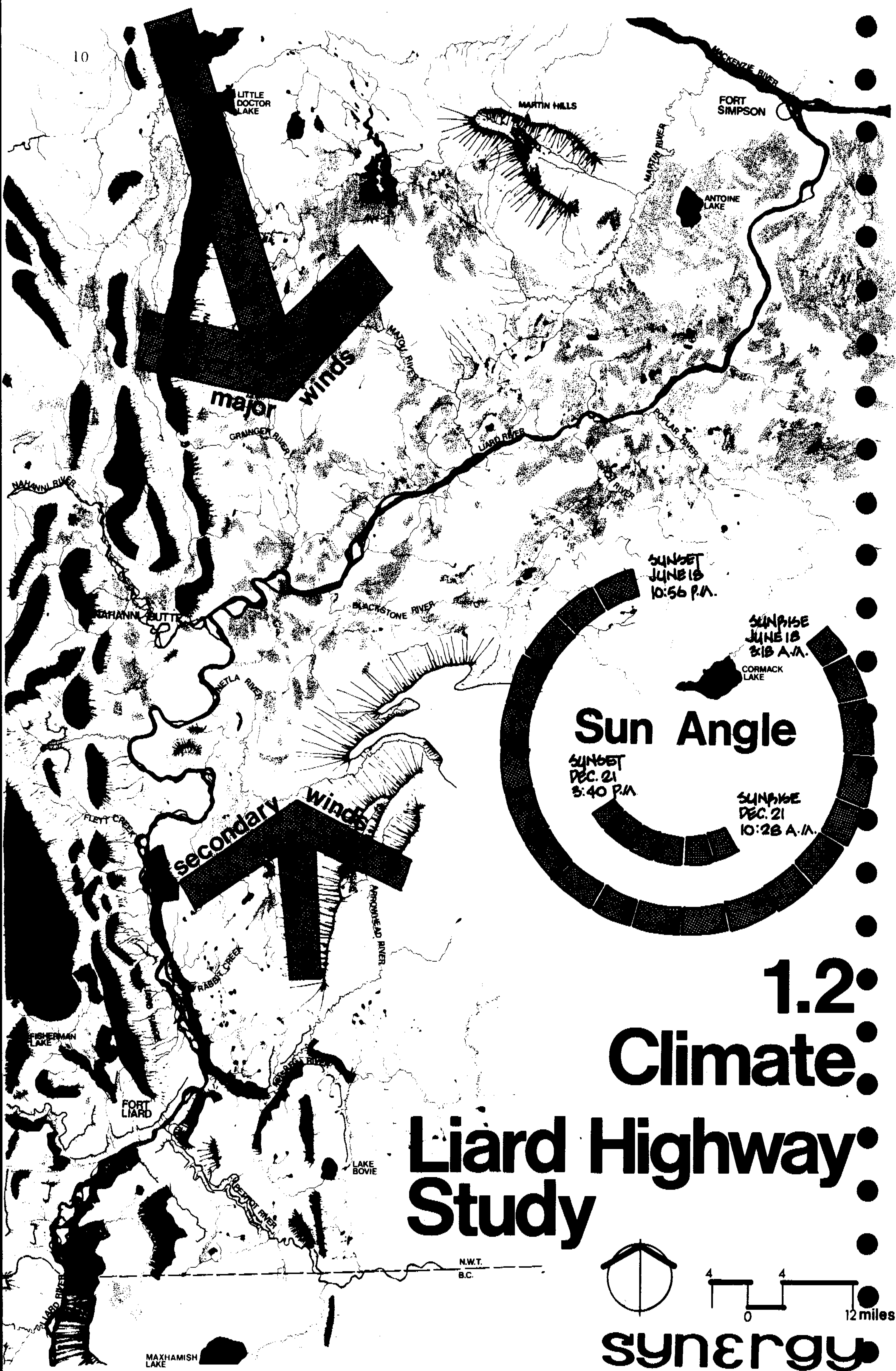

1.2 Climate

Liard Highway Study

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River. North of the Liard River, after it has turned to flow eastward following its confluence with the South Nahanni River, the land shows less relief until the Martin Hills are reached, and there it rises to elevations of approximately 2,000 feet above sea level.

Numerous tributaries enter on both sides of the Liard River. The major rivers draining the lowlands are those of the Poplar, Birch, Matou, Blackstone, Grainger, Netla, Muskeg and Petitot. These rivers are characterized by extreme meanderings, and the accompanying formations of oxbows and gravel bars. A number of fast-flowing creeks originate in the mountainous region, but the major river feeding the Liard River from the mountains is the South Nahanni River. This is a river of braided channels, typical of shallow meltwaters laden with sediments.

The Liard River itself flows approximately northward from the British Columbia border, and between there and the entrance of Flett Creek, it is heavily braided with many mid-channel islands and smaller gravel bars. Between its confluence with Flett Creek and the entrance of the Blackstone River, the Liard River undergoes major meanders, with the number of islands being decreased. Well-defined old channel bars and meander scars are evident along either bank in this region. Downstream of the Blackstone River, the Liard flows eastward and runs a straighter course, flanked by steep banks which rise to over 100 feet above the river's surface. Both recent and older flood plain terraces of the Liard River are obvious throughout its course, but are most apparent between the British Columbia border and its confluence with the Blackstone River. Two sets of major rapids occur along the Liard, one opposite Flett Island, and the second approximately 10 miles upstream from the MacKenzie Highway.

CLIMATE

Meteorological records have been kept at Fort Simpson since a weather station was established there in 1875. At the present time, two additional stations are operated, one at Fort Liard and the second at

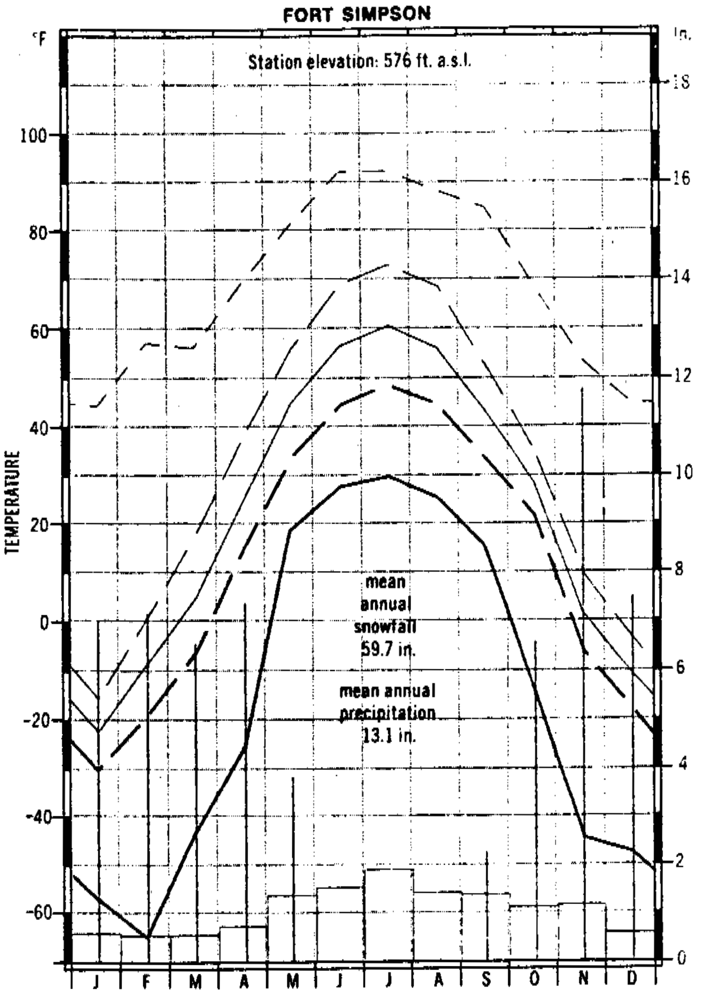
Trout Lake, both of which report to the District Weather Office at Fort Simpson. Data from all three stations are combined into a general meteorological report issued for Fort Simpson.

Collated data for monthly temperatures and precipitation records are shown in the accompanying Figure 1 for the period 1963 to 1970. Freeze-up and breakup dates for the Liard River at Fort Simpson are also given. Similar data for the river at Fort Liard show that these events occur approximately one week earlier. The area is within the sub-arctic climatic region and it lies within the discontinuous permafrost zone. Further discussion of climatic conditions will be given in specific reference to other factors in the following sections of the report.

FIGURE 1

CLIMATIC CHARACTERISTICS

FORT SIMPSON



Period of records: 1963-1970

Sources: Long-term climatic abstract listings and preliminary new period (1941-1970) normal print-outs, Atmospheric Environment Service, Department of the Environment.

Extreme maximum temperature
Mean daily maximum temperature
Mean daily temperature
Mean daily minimum temperature
Extreme minimum temperature
Mean snowfall
Mean total precipitation

FREEZE-UP AND BREAK-UP DATES

FORT SIMPSON

	FIRST PERMANENT ICE	COMPLETE FREEZE-OVER	FIRST DETERIORATION OF ICE	WATER CLEAR OF ICE
LIARD RIVER				
Period of records	1931-1969	1931-1969	1928-1970	1957-1970(13)*
Earliest date*	Oct. 6	Oct. 23	April 14	May 6
Mean date	Oct. 23	Nov. 23	May 5	May 18
Latest date	Nov. 2	Dec. 10	May 19	May 31

SOILS

The soils of the Liard Highway Corridor are largely influenced by the process associated with the Liard River and the surrounding land. From the 60th parallel north to Mile 100, soils have formed on fairly well drained, sloping land, which lies between the Liard Range in the west and the Eastern Hills. Where the Eastern Hills recede away from the river at mile 100, the soils become a complex mosaic of several types, reflecting the complex history of river meandering across ancient and recent flood plains. This mosaic lies within the stretch between mile 100 and mile 70. North of mile 70 to mile 0, the pattern of soil type again becomes less complex. Here, where the river flows through fairly level, poorly drained land, the area away from the well drained river terraces is dominated by muskeg.

Through combined factors of climate, geology, vegetation, and time, a number of soil types have developed. Parent material consists of either Pleistocene glacial drift or post-Pleistocene alluvium. In ~~either~~ each case, the age of these deposits are recent. This, combined with a cool, dry climate, has resulted in weakly developed soils. Day (1966) indicates that the groups best illustrating this weak development are the Brown Wooded soil groups, covering 36 percent of the area, and the Regosol group, covering 9 percent. In better drained areas atop other deposits, the Gray Wooded soil group has developed, covering about 6 percent of the area. In the poorest drained areas, the dominant soil types are Gleysols, Humic Gleysols, and Organic soils which cover 9, 10 and 17 percent of the area respectively.

Mile-by-Mile Comments

Notes relating to soils presented here are based upon work conducted by Day (1966). He classified the soil types according to series (soils similar in parent material, morphology, drainage, relief and other exterman characteristics) and sub-divided these into types (soils grouped according to similar textures). The following mile-by-mile comments relate to that area delineated by the road right-of-way. (reference map 1.0).

Mile 0 to Mile 33

This section is uniformly covered by the Poplar Loam and Silty Clay Loam of the Orthic Brown Wooded soil group. These are brownish colored, well drained soils, which are weakly acidic to mildly alkaline. The soil horizon lies atop a greyish base-saturated parent material that is calcareous. Preliminary cropping experiments indicate that these are good arable soils, suitable for general farm crops.

Throughout the area there are enclaves of Grainger Peat soils of the Organic group. Occurring on poorly drained sites on level topography, these are reddish-brown peats, usually frozen below 18 inches. Both soil types are stone-free.

These soils are amenable to natural revegetation if they are mechanically stable.

Mile 33 to Mile 36

This section is covered by Nahanni Loam, which is a member of the Orthic Regosol group. These are well drained soils, occurring on level and irregularly gently sloping land developed on recent river terraces which are less than 40 feet above the river level.

These soils are moderately well supplied with organic matter and nitrogen, but are low in phosphorus. With fertilization these soils are conducive to cropping since they are well drained, friable, with good moisture retention. Applications of nitrogenous and phosphatic fertilizers would assist revegetation procedures.

Mile 36 to Mile 65

This section is underlain by a well drained river terrace, 40 to 75 feet above the river. It is covered by Netla Clay Loam and Silty

Clay Loam, members of the Orthic Brown Wooded Group. These soils have a thin organic surface layer and are underlain by a greyish silty clay loam parent material.

These soils are well drained and friable. Their nutrient content is low; however, a fertilization program would rectify this condition.

Mile 65 to Mile 68

Nahanni Loam (see discussion Mile 33 to 36)

Mile 68 to Mile 86

This section is covered by Petitot Loam, a member of the Orthic Brown Wooded subgroup, and one of the major soil types of the Liard Valley. These soils occur on well drained, ancient river terraces, some 75 feet above the river. They have developed on stone-free, calcareous, loamy, alluvium. The topography is mostly irregularly moderately and strongly sloping. Some eroded river banks are steeply sloping.

These soils have a fair to good moisture-holding capacity, are well drained and permeable. However, they are low in nutrients. The nutrient level could be improved by moderate applications of fertilizers.

Mile 86 to Mile 93

This short section is covered by Martin River Loamy Sand, which has developed on sand dunes. Consequently, they are relatively coarsely textured. These rapidly to well drained soils have developed on stone-free, calcareous loamy sand or sand, and belong to the Orthic Brown Wooded subgroup.

The topography ranges from strongly to moderately sloping on the flanks of the dunes to level on the tops of the dunes.

Because these soils are rapidly drained and have been shown to be poor in fertility, care must be taken so as to keep disturbance of vegetation to a minimum.

Mile 93 to Mile 97

Netla Clay Loam and Silty Clay Loam. (see discussion Mile 36 to 65)

Mile 97 to Mile 133

Petitot Loam. (see discussion Mile 68 to 86)

These soils are intersected at minor stream valleys with areas of eroded riverbanks, where a variety of disturbed soil materials occur. Along the valley of the Muskeg River at Mile 128 to Mile 130, is a section of Liard Fine Sandy Loam and Loam. These are described below.

Mile 133 to Mile 135 (Fort Liard)

Liard Fine Sandy Loam and Loam, belonging to the Organo Regosol subgroup occur along the length of this section. These are well drained, but poorly developed, recent soils, with little horizon differentation. They have developed on young terraces 40 feet above the river and consist of calcareous loam or fine sand loam alluvium.

The topography is level to gently sloping. The soils are permeable, well drained and well supplied with nitrogen. These are well adapted for cultivation. However, a fertilization program should be implemented to provide phosphorus.

Mile 135 to Mile 143

Petitot Loam. (see discussion mile 68 to 86)

Mile 143 to Mile 156.7

Available soil information for this section is not complete. However, it is believed that the area is dominated by a continuation of the Petitot Loam, at least in the well drained areas. Poorly drained areas are likely covered by gleysols or organic peats, which may be frozen below 18 inches.

AGRICULTURAL POTENTIALS FOR SOILS

Agricultural enterprises are presently limited to backyard plots in the settlements of Fort Liard and Fort Simpson, although the Canada Department of Agriculture Experimental Farm was established at Fort Simpson in 1948 to determine the agricultural capabilities of this area. The farm was closed in 1970. The limitations to agriculture in the Liard River Valley arise primarily from climatic conditions and distributions of soils with agricultural capabilities. The following is intended to provide only some of the most salient information regarding agricultural potentials.

The climatic requirements for crop production north of 55^{o} latitude are listed as follows (Harris et al, 1972):

- A period of 80 days free of killing frosts
- A vegetative period of 110 days
- An accumulation of 1,000 growing-degree days
- An adequate precipitation level during the growing season.

Similar data recorded at the Fort Simpson Experimental Farm over a 20 year period are given below:

- A period of 119 days free of killing frosts
- A vegetative period of 138 days
- An accumulation of 1,825 growing-degree days
- A deficient precipitation level of 7.2 inches during the vegetative period.

Special methods and equipment, together with selection of suitable crop types, can also be employed to overcome some shortcomings in local climatic conditions.

According to a classification of soil capabilities (Day, 1966) for agriculture, approximately 25 percent of the soils (454,400 acres) of the Liard River Valley are capable of supporting sustained production of common field crops. The most productive of these soils consist of loams and fine sandy loams, and belong to the Liard Soil Series, an organo-regosol type found on the recent flood plains of of the southern section of the Liard River (section south of Mile 68). Limitations to these soils are primarily climatic in nature, although work at the Fort Simpson Experimental Farm has indicated that the application of fertilizers will improve their productivity significantly. A further 25 percent are marginal for crop production due mainly to physical constraints, and 18 percent are suitable only for permanent pasture and hay productions. The remaining soils have severe limitations and are suited only for wildlife and forestry practices.

The soils with the best agricultural capabilities are also those supporting forest stands with the best forestry potentials. The practical potential for agriculture is small. Multiple land uses (i.e. forestry and agriculture) should be co-ordinated to ensure optimal use of the land.

VEGETATION

The analysis of vegetation has been done on the basis of air photo interpretation, confirmation from time lapse photography, visual observation during wildlife surveys, and a single field survey. The maps in section II display the general vegetation character along the highway.

The vegetation through which the Liard River Highway runs may be divided into two broad types for the purposes of this study - forest and muskeg. The forested areas will be treated again in a following section dealing with the forest resources, and will also be discussed with regard to its value for wildlife habitat.

The forest vegetation is comprised of a number of different types, classified according to the dominant species composition, and to structural and other environmental factors. A detailed description of the forest types has been given in a previous report (Jeffrey, 1964), and in order to maintain continuity, descriptive terminology will follow this author's report wherever possible. The highway is located mainly in the MacKenzie Lowlands and has little immediate effect upon the

MacKenzie Mountain region. Hence, only limited discussion will be given to this latter region.

The various forest types treated here are: the White Spruce, Black Spruce, Mixedwood, and Deciduous Forests. Brule and Riparian vegetation are also described. These forest types are displayed in sections along the highway corridor, and impacts are stated under development recommendations, (Section II).

White Spruce Forests

These forests are found on the terraces and flood plains. Although the predominant mature tree species is white spruce (Picea glauca), other species such as white birch (Betula papyrifera), or balsam poplar (Populus Balsamifera) are also found. In some areas the mature trees form a dense canopy with a poorly developed understory. Elsewhere, the main understory species are alders (Alnus spp.), rose (Rosa spp.), and dogwood (Cornus stolonifera). White spruce forests are mainly of fire origin, and may contain trees of over 100 years of age.

Because of their fairly dense canopies, these forests allow only a moderate to low occurence of shrub species. Their browse value to moose, therefore, are fairly low, but they do serve as important shelter in the winter months.

These stands occur generally on stable, well drained soils. Disturbance of these forest types involves no unique complications aside from aesthetic considerations. Where mineral soil is exposed and where the canopy is opened, regeneration will follow fairly rapidly on stable soil.

Black Spruce Forests

These forests are found on the MacKenzie Lowlands and Terraces, associated with soils subject to poor drainage, often forming around bogs and muskeg areas (see section on muskeg following). Typically, they are located in inter-drumlinoid ridges, creek bottoms, and on the lower slopes. Tamarack (*Larix laricana*) is also frequently found growing among the black spruce (*Picea glauca*), together with jack pine (*Pinus bansiana*) and white birch in some stands. Common understory species include: horsetails (*Equisetum spp.*), dogwood, alders and bog birch (*Betula glandulosa*).

Black spruce forests are associated with poorly drained organic peat soils which are commonly frozen 8 to 18 inches below the surface. Removal of vegetation on these areas would result in a thaw of the permafrost which, in turn, would result in soil erosion. Disturbance of these areas should be kept to a minimum.

Mixedwood Forests

Mixedwood forests are composed of mature trees of both coniferous and deciduous species. These are found growing on the MacKenzie Lowlands, on the terraces, and the flood plains. The dominant coniferous species is white spruce, usually in association with the deciduous trembling aspen (*Populus tremuloides*). Black spruce and balsam poplar also occur as scattered mature trees in some of these forest stands. The understory shrub growth is comprised of various mixtures of alder, dogwood, rose, birch and high bush cranberry (*Viburnum edule*). These forests are of fire origin. phrasing?

These forests grow generally on well-drained podzolic soils. A disturbance of the soil limited to the removal of the leaf litter probably enhances regeneration. However, disturbance of the soil should not go deeper than this. Selective cutting could be employed along the road right-of-way to preserve large trees and their aesthetic quality.

Deciduous Forest Types

There are three forest types included here under this class. In each type dominant trees are deciduous species. The three types are the Mixed Leaftree, the Trembling Aspen, and the Balsam Poplar forests.

The mixed leaftree forests contain various mixtures of mature trembling aspen, white birch, and balsam poplar, growing on the ancient and recent flood plains. Main understory species include: white spruce, white birch, willow, rose, high bush cranberry, dogwood, buffalo berry (Shepherdia canadensis), and currant (Ribes spp.). These forests originated after fire.

The trembling aspen forests are limited to the terrace region, and often contain some mature white birch. In this forest type, the understory contains alder, dwarf birch, rose, high bush cranberry, white spruce, dogwood, and buffalo berry. As with many other forests in the Liard River Valley, they are of fire origin.

The third type of deciduous forest contains balsam poplar as the dominant mature tree species. These usually grow in pure stands along the recent flood plains. Alder, dogwood, and rose are the common understory species. Balsam poplar forests, situated as they are near the Liard River, are frequently subject to flooding.

Disturbance of the floor of these forests should involve only removal of the leaf litter to enhance regeneration.

Brule Vegetation

It is apparent that almost all the forest types growing in the Liard River Valley of the Northwest Territories, are of fire origin. During the regrowth following a fire, but before the trees have reached pole size, the vegetation thus formed is called Brule, and is composed largely of deciduous tree species. Most of the Brule vegetation in this area of the Liard originated from the severe fires during the summer of 1942, and is found in all regions except the Mackenzie Mountains. It is characterized by a very dense shrub layer and considerable fallen timber. On the Mackenzie Lowlands and terraces, immature trembling aspen is the dominant species, along with white birch, and some willows and alders, being most common on the flood plains. Rose is the most common shrub on all sites.

Since Brule vegetation occurs extensively throughout the region, any removal of this cover by highway construction would not involve significant loss of this habitat type for wildlife. Forest fires are ongoing occurrences. Assuming that fire suppression will never be 100 percent effective, this vegetation will continue to be replaced.

Riparian Vegetation

Riparian vegetation grows along the Liard River on the recent flood plains. It contains primarily willows (Salix spp.), alders, and immature balsam poplar. Vegetation of this type is under the influences of flooding, ice scour and deposition of alluvial material, which together tend to maintain this normally successional stage. The riparian vegetation growing along the river banks and on the gravel bars and mid-channel islands is noticeable for its even-sized, but banded, growth appearance. Variable width strips of the three main species are seen to increase in height with increasing distance from the water. Such banding is the result of the three surficial forces described above.

This vegetation group is rich in wildlife habitat quality, due to the mosaic effect of the banded growth. Many of the plant species occupying recent flood plains and sand bars are valuable forage species to moose, i.e. willow. Although the succession of this vegetation is a dynamic process following the changing river morphology, the process is slow in comparison to fire-created habitat. In view of this and the value to wildlife, this vegetation type should not be disturbed. Due to the placement of the highway alignment away from the stream banks, this should not present a problem.

Muskeg

The muskeg vegetation community has been more accurately termed the black spruce/bog community by Jeffrey (1964). It is a very variable plant community, dominated by black spruce (Picea mariana), on poorly-to-very poorly-drained sites. On a continuum of increasingly better drainage, the black spruce/bog community becomes the black spruce/feathermoss forest found on slopes and at somewhat greater relative elevation.

On the continuum from very poorly-drained sites, in which there is standing water, through the less poorly-drained sites, the sequence of bryophyte dominance is roughly as follows:

Sphagnum spp.

Sphagnum spp. - Tomenthypnum nitens

Tomenthypnum nitens - Sphagnum spp.

Tomenthypnum nitens - Hylocomium splendens

Hylocomium splendens - Tomenthypnum nitens

A pure and total feathermoss ground cover dominated by Hylocomium splendens is characteristic of the black spruce/feathermoss forest.

Muskeg soils are deep (8" to 40"), organic, usually frozen and overlie impermeable fluvial deposits. The tree roots lie on the frozen peat under 7 - 12 inches of Sphagnum or moss.

improbable

On bog sites having standing water, the tree cover, black spruce and its constant associate tamarack, are sparse. The trees occur singly or in small groups situated on mounds or "islands" raised a few inches above the water. Tree height is seldom more than 30 feet and usually less than 20 feet, even at age 100. The shrub cover of Labrador Tea (Ledum groenlandicum), bog birch, willow, bilberry (Vaccinium uliginosum) and cranberry (Vaccinium vitis-idaea) also occurs mainly on the mounds, but can be present liberally between the mounds, where the standing water is of limited seasonal duration. Sedges grow in the water in locations where they are not choked by Sphagnum or moss.

With increasingly better drainage, as evidenced by a decrease in the area of standing water and a decreasing cover of Sphagnum, the tree, shrub, and herb covers become more evenly distributed, not being restricted to the mounds and islands for survival. Paper birch (betula papyrifera) and jack pine (Pinus banksiana) occur occasionally, but tree growth remains poor. On the drier bog sites, black spruce can occur in "doghair" density, to the exclusion of almost all shrubs.

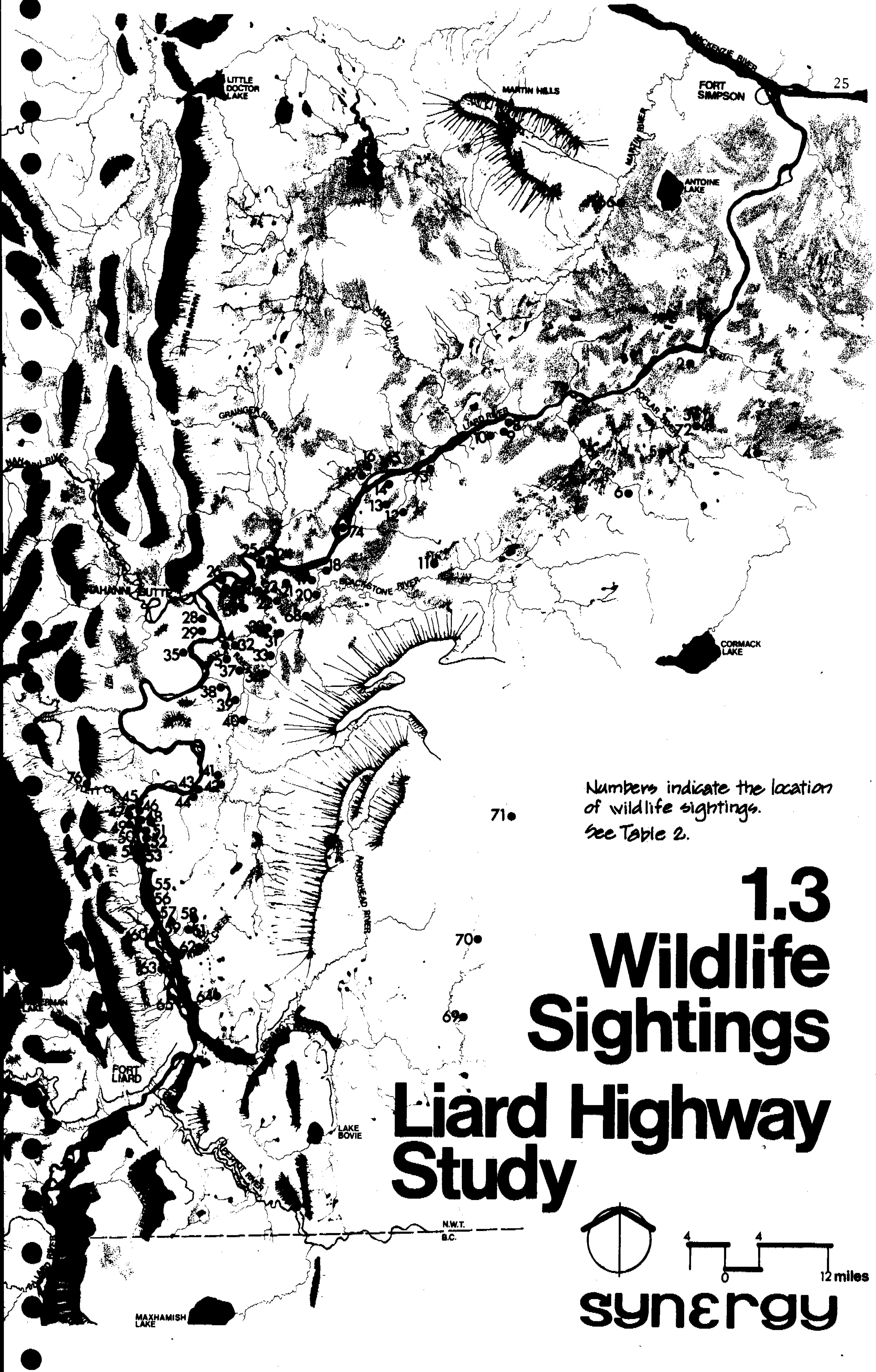
The ultimate of the continuum, the black spruce/feathermoss forest, is characterized by full stocking of black spruce having about 50% crown closure and tree heights of 50 feet plus at age 80. The thick mat of feathermoss, dominated by Hylocomium splendens, covers 75% to 100% of the ground, to the exclusion of all shrubs and nearly all herbaceous species, except an occasional orchid or lily.

Comments made earlier regarding the disturbance of black spruce vegetation apply here as well. Disturbance of muskeg should be kept to a minimum.

WILDLIFE

The effects on wildlife, particularly big game species, will likely be the greatest impact resulting from new highways and increased accessibility by man. Actual construction of the Liard Highway poses little direct impact on wildlife other than the short term impact of construction workmen. In fact, regrowth in cleared areas will produce wildlife forage. Hunting is and will be the major impact, and regulation of hunting is the primary means of control. Establishing regulations and means of enforcement are beyond the scope of this study. However, the control of highway use, through planned facilities, is possible to a degree, and it is this aspect that is dealt with herein.

Fifty years ago ecosystems in the north were only resources to a few. Today, through new accessibility, they are resources to many. To control the harvesting and preserve the resource for future generations is most important. Planning for the future is difficult, since ecosystems are dynamic. Particularly in the Liard region, where fire plays such an important role in controlling feeding and shelter areas, the rate of change can be rapid. Highways create an altered microenvironment, which is beneficial to certain species and detrimental to others.



Numbers indicate the location of wildlife sightings. See Table 2.

1.3 Wildlife Sightings

Liard Highway Study

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TABLE 1

Species List of Large Mammals and Game Species Found in the Lower Liard River Valley

Common Name	Scientific Name *
Muskrat	Ondatra zibethicus spatulatus
Beaver	Castor canadensis canadensis
Hoary Marmot	Marmota caligata oxytona
Red Squirrel	Tamiasciurus hudsonicus preblei
Northern Flying Squirrel	Glaucomys sabrinus sabrinus
Snowshoe Hare	Lepus americanus mcfarlani
Marten	Martes americana actuosa
Ermine	Mustela erminea richardsonii
Least Weasel	Mustela nivalis rixosa
Mink	Mustela vison lacustris
Wolverine	Gulo gulo luscus
Otter	Lontra canadensis preblei
Red Fox	Vulpes vulpes abietorum
Coyote	Canis latrans incolatus
Wolf	Canis lupus occidentalis
Black Bear	Ursus americanus americanus
Grizzly Bear	Ursus arctos
Lynx	Lynx lynx canadensis
Moose	Alces alces andersoni
Caribou	Rangifer tarandus caribou
Dall Sheep	Ovis dalli dalli
Mountain Goat	Oreamnos americanus

* Nomenclature follows Banfield, 1974

The big game mammals and larger mammal species inhabiting the Liard River Valley are listed in Table 1. The most abundant species of big game is the moose, and is found throughout the area. Other species of particular importance are the fur-bearing mammals, which have significance for the trapping economy of the residents of Fort Simpson, Nahanni Butte, and Fort Liard.

TABLE 2

WILDLIFE SIGHTINGS

Species	Number of Individuals	Number Code
Moose	1	1, 2, 3, 4, 5, 7, 8, 10, 11, 14, 18, 19, 20, 21, 22, 23, 25, 26, 30, 31, 35, 38, 49, 51, 61, 62, 63, 66, 68, 69, 70, 72, 73.
	2	6, 12, 13, 15, 16, 24, 27, 32, 36, 39, 41, 42, 48, 50, 52, 23, 54, 55, 56, 64, 65, 67, 71.
	3	9, 17, 29, 33, 37, 40, 46, 47, 57, 60.
	5	28, 34.
	6	43.
	7	44, 45, 59
Wolves	6	74
Fox	1	75
Bear	1	76

Moose

The distribution and movements of moose are mainly determined by the availability and quality of suitable habitat (Canadian Wildlife Service 1973). Moose undertake seasonal migrations or movements in the Liard River Valley, and are most concentrated during the winter months (see Appendix 1). It is during this period of the year, when environmental conditions are most severe, that suitable winter habitat becomes a critical factor for their survival. During the winter and late spring, the moose in the Liard Valley are concentrated along the River, particularly on the mid-channel islands. Along the river banks and especially on the islands, the mixture of preferred browse species, such as willows, dogwoods, aspen and poplar, together with adequate shelter, are found. It is important to note that the riparian habitats, created by the erosional forces of ice and water along the Liard River change much more slowly and less radically than successional growth generated by fire. It is therefore, very important to protect these riparian areas. Although moose concentrate in these riparian habitats during the winter periods and early spring, they are generally more dispersed at other times of the year, and are to be found mainly away from the Liard River itself. Many moose move up the tributaries of the Liard River to spend the summer along their banks and at the small ponds and lakes, where they feed on the rich growths of aquatic plants. However, some individuals may remain near the Liard River, especially in such favourable habitats as are found between the confluences of the Netla and Blackstone Rivers with the Liard River.

The seasonal movements of moose in the Valley make them especially vulnerable during the winter months. Winter range is limited in extent and distribution (Canadian Wildlife Service, 1973), and also concentrates what is usually a dispersed population into a relatively limited area. This is particularly important when the route of the proposed Highway is considered, as it passes relatively close by the main wintering areas, therby providing increased and ready access. With increased hunting of the species, it is not only these local areas which could be depleted, but the population as a whole. Similar concentrations of moose along major waterways and on mid-channel islands have been reported for the MacKenzie River (Lombard North Group, 1973).

Other movements of moose in the lower section of the Liard River Valley have been known to the native peoples. The Game Branch personnel from Fort Simpson (M. Tennert, personal communication) report that moose cross the Liard River at the Poplar River during the fall, and also that during this period the animals may move into the mountain regions for a short period before returning to lower elevations when snow depths increase.

The Liard Highway may also affect the moose in other ways by providing new access for their movements and again expose them to increased exploitation. Moose have been observed to use cut-lines and cleared right-of-ways for travelling in many areas in this section of the Liard River Valley, as they often afford better travel routes and require less expenditure of valuable energy reserves. Regrowth of preferred browse species occurs along these cleared routes and adds to the attraction for the moose. The incidence of road kills (vehicle-moose) is difficult to predict. By further observation, certain travel routes might be sign posted. Access across the highway via stream crossings is possible if bridges are constructed at critical locations.

typical evidence of browse

The field surveys conducted by Synergy determined the general importance of moose within the region. It was recommended that a further detailed field trip be conducted in the fall of 1974 to further establish critical areas and populations. This further study was to be conducted by the Canadian Wildlife Service and at this time, the results are not known, however, they should be considered prior to final design considerations.

Caribou

Although woodland caribou occur in the area, populations appear to be small and dispersed. Most reports of caribou come from the Trout Lake region, where a small herd ranges year-round, and from the Martin Hills area, which apparently is close to the present southerly limit of caribou migration. They seldom appear to move to within close proximity of the proposed Liard Highway, and seasonal migration across the highway is not evident. If they did, however, hunting pressure on them would likely increase. To illustrate this point, the Game Warden from Fort Simpson reported that several years ago six caribou appeared close to Fort Simpson, and within a very short time all but one of the animals were killed by local residents.

Caribou habitat is very critical. The fire-lichen-caribou ecosystem is in very delicate balance, normally occuring at elevations above that of the highway. The construction of the highway and direct use of the highway is apparently not going to affect caribou in the region. However, subsequent resource development accessing from the highway must consider this impact.

Dall Sheep

Dall Sheep are inhabitants of the mountain regions, and are found in the MacKenzie Mountains of the Lower Liard Valley. Although not immediately affected by the presence of the highway, they could become more vulnerable to guided hunting pressure with the increased access provided by the highway.

Large Carnivores

Grizzly bear, black bear, and wolf, as with the other big game species would also become more vulnerable to hunting pressure as access to their home ranges is increased. For facilities planned along the Liard Highway, it is essential that adequate measures be taken for garbage disposal to ensure that no bear-human problems of this nature are created, which would result in the reduction of the bear species in the area. These same constraints apply to the development of construction camps along the highway, and in these cases, limitations of fire-arms should also be enforced for construction personnel during the short construction period.

Fur-bearing Mammals

One of the most important fur-bearers in the Liard River Valley is the beaver. The species is widely distributed throughout much of the area as shown by the Land Information map series and Wildlife Atlas prepared by the Canadian Wildlife Service (1973). Beaver activity was particularly evident during studies by Synergy personnel between the Poplar and Birch rivers on both sides of the highway. Trapping presently occurs in these areas and signs of this activity were evident during game survey flights. While actual counts on beaver were not done, observations confirmed the accuracy of the Land Use Information maps.

Trapping records for Fort Simpson and Fort Liard show that besides the beaver, other species also important to the trapping economy of the area are lynx, squirrel, muskrat and marten. It should be noted that the highway location transects many traditional trapping areas and will thus alter them to some degree. Many fur-bearing mammals, particularly the carnivorous species, may increase in numbers following the construction of roads and cut-lines. These increases are usually local and are the result of an increase in the habitat of the small rodents which comprise a large portion of the carnivores diet. It is difficult to predict where this may occur and there is no evidence of concentrations at this time. At the same time, these routes also increase human access and hunting and trapping may also increase as a result. However, the change in socio-economic status of the residents due to new accessability and opportunities has, in other areas, shown a marked decrease in occupational trapping. Since fur-bearers are not desired sport species, it is the opinion of this study that the effect of highway construction will not significantly affect the present status.

Beaver also present some problems for road construction and maintenance, as they may dam culverts and other drainage ways. Solutions to these problems have been sought in studies associated with the MacKenzie Highway construction (Lombart North, 1973). The highway does not transect actual ponded areas and the crossings at the Poplar, Birch and Blackstone rivers are of sufficient size (i.e. bridges or large culverts) that little concern for this problem need exist. There may be several adjacent ponds and concern over damming of culverts may be thwarted by placing the largest elliptical culvert possible at those locations. There was only one observed location where this exists at approximately Mile 29.5.

Birds

An inventory of waterfowl habitat for nesting has been made by the Canadian Wildlife Service (1973), and shows that the area has generally limited potential for providing good waterfowl nesting habitat. The region is west of the major migratory bird flyways. The most important areas occur at the confluence of the Liard and MacKenzie Rivers, and to the northwest of this area to the west of Fort Simpson. These areas therefore are somewhat removed from the present study area and unless major drainage activities were planned which affected these nesting areas, little problem is envisaged from the construction of the Liard Highway. The numerous lakes and ponds within the areas abounding the Liard Highway are also used by waterfowl as staging areas during their spring and fall migrations. However, the great abundance of these bodies of open water in the area will unlikely be affected by the construction of the Liard Highway or by the increased access to hunters which it would afford. None of these water bodies is subject to drainage and they are sufficiently removed from the highway so as to protect them from hunting pressure.

A second significant group of birds besides the waterfowl are the raptors, the predatory birds which include owls, hawks, and falcons. Only four raptors were observed during the field surveys and no nesting areas were discovered. Questions to locals indicated few raptors near the highway. It is felt that these species likely occur north and west of the Liard River, in the mountainous area, where better nesting habitat exists. The falcons are probably most vulnerable to human activities, especially the endangered Peregrine falcon. While no individuals of this species were definitely observed during this study, the area appears to offer excellent nesting sites, especially along the steep cliffs of the Liard River banks. The major potential problem for the falcons from humans is not hunting, but from the removal of young for falconry purposes. Further study on the raptor populations in the lower Liard River Valley is necessary to determine if any possible areas of conflict exist. However, these are considered slight at this time.

Observations

a The most abundant game species is moose. Critical areas must be respected. (See Map 1.3)

b Habitat for fur-bearers is widespread throughout the highway location. Direct conflict appears slight. Indirect trapping and hunting pressure may increase.

c No endangered species were identified.

d The general densities of wildlife appear low adjacent to the highway. This is advantageous in reducing the possible number of human-animal encounters but, on the other hand, any amount of hunting could significantly reduce the percentage of animals in what appears to be a delicate ecosystem balance.

e Construction of the highway will not, in itself, cause a major wildlife impact. The users of the highway create the impact.

f Future side access for resource development or other uses, could create greater impacts (i.e. forestry).

g Air support for construction should be minimized, particularly in winter when disturbance of animals can easily cause exhaustion and death.

Suggestions

a Highway crossings with seismic lines be planted to prevent easy off-highway spotting of moose.

b A hunting moratorium be instituted for a minimum of two years to allow re-establishment of species and definition of critical travel routes. This would not apply to subsistence hunting or occupational trapping.

c Construction crews be forbidden hunting privileges.

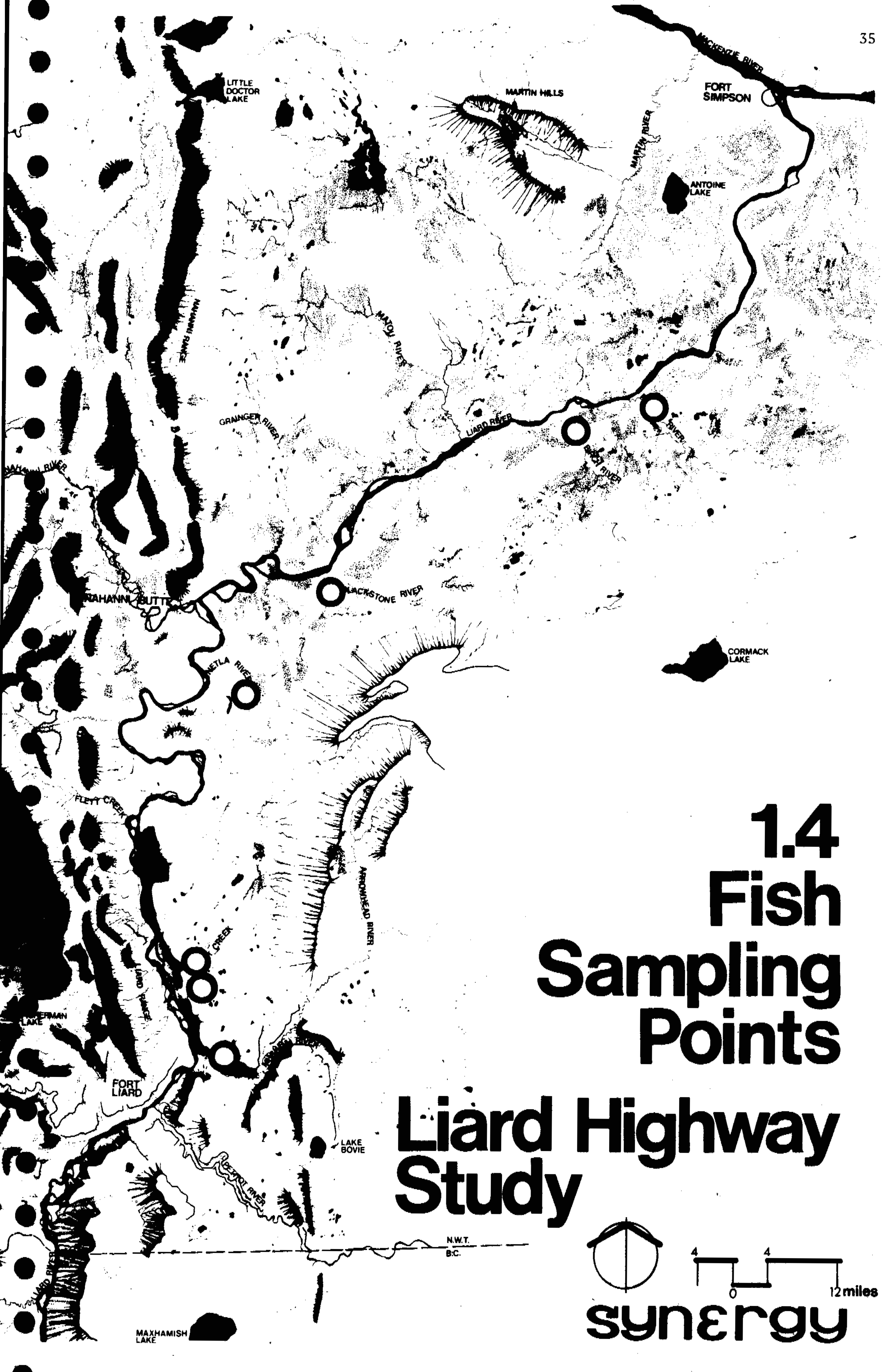
d Complete incineration of garbage at construction sites be strictly enforced.

e Forestry logging practices appear to be the most likely conflict with moose habitat. Mozaic cutting methods could provide needed winter shelter and in subsequent years, good feeding areas.

f Direct flight lines between destinations be maintained at minimum 2,000 foot elevation. Avoid critical moose habitat during winter.

FISH

The effect on fish due to highway stream crossings is probably the most controllable and predictable environmental impact. Sampling procedures and the level of knowledge are sufficiently advanced,



1.4 Fish Sampling Points

Liard Highway Study

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enabling design and protective measures required to minimize the impact of construction. It is only necessary to establish the importance of the fishery and the species composition in order to plan adequately. Far more difficult to control is the impact of sport fishing during critical periods due to new accessibility. This is primarily a jurisdictional matter of regulation and enforcement. However, a measure of protection can be accomplished through detailed site planning, which can provide ease of access and facilities to direct use.

This report section establishes the local and regional importance of the fishery and recommends development solutions. Again, these are shown on the detailed maps in Section II.

Fish Species in the Liard River and its Tributaries

The Liard River and its tributaries offer a wide variety of habitats for several species of fish. In collections made in the Fort Simpson area of the MacKenzie and Liard Rivers during 1971 (Hatfield *et.al.* 1972) 13 different species were found to be present. Table 3 illustrates the percent species composition of fish caught by gill net. Northern pike and lake whitefish dominated the catch throughout the sampling period with lesser numbers of walleye, flathead chub, longnose sucker, grayling, and white sucker as well as other species. In addition to the data on the Liard River, reports are available on several collections which have been made on three tributaries to the Liard River (Poplar, Birch, Blackstone) which fall within the study area (Hatfield *et.al* 1972; Stein *et.al*.1973; Dryden *et.al*.1973). In these tributaries species such as grayling, trout perch, lake chub, longnose dace, and longnose sucker were found to be present. Table 4 lists species collected or observed in tributaries to the Liard River.

Spawning Areas

In the Liard River system the tributary streams play an important part in providing many fish species with spawning areas and nursery areas. For piscivorous fish such as pike and walleye the tributary streams provide spawning areas for forage fish as well as their own young. Heavy silt loads on the Liard River require most fish species to migrate to silt-free streams for spawning. The upstream spawning run is usually followed by a downstream movement of spawned-out adults. Adults of some species may remain in the tributary streams until just before freeze up, when they move to deeper water along with young of the year. Selected characteristics of several species found in the Liard River and some of its tributary streams are given in Table 6.

A general account of potential spawning areas in the Liard River and its tributaries is to be found in the report by Hatfield et.al (1972). The high silt load of the Liard makes it unsuitable as a spawning and nursery area. However the great diversity of fish species at the mouth of the Liard indicates the river may serve as an important migratory route for spawning fish. A comparison of the estimated potential spawning areas available in the major tributaries of the lower Liard River surveyed by Hatfield et. al is shown in Table 5

Between Fort Simpson and Nahanni Butte, the five major tributaries surveyed have an estimated 2.2 million square yards of potential spawning gravel. Two of these tributaries (Grainger and Matau) are outside of the study area and contain about one-tenth of the total potential spawning area. No data are available on the Muskeg River, although its drainage area is by far the largest of any stream in the study area, and potential spawning areas probably exceed those in the Blackstone River (Table 5). As noted in Table 5, certain of the tributaries have restrictions which may reduce the availability of the potential spawning areas.

Swimming Performance

A number of studies have been undertaken to assess the swimming performance of various species of fish (Brett, 1964; Blaxter and Dickson, 1959; Brett 1967). It appears fish are capable of both steady perform-

TABLE 3 PERCENTAGE COMPOSITION OF FISH SPECIES COLLECTED IN SELECTED TRIBUTARY STREAMS OF THE LIARD RIVER - DATA COVERS COLLECTIONS MADE IN 1971 DRYDEN ET AL & 1974 SYNERGY

Site	No.of Fish	Grayling	Lake Whitefish	Mountain Whitefish	Pike	Trout - Perch	Walleye	Lake Chubb	Longnose Dace	Burbot	Spottail Shiner	Emerald Shiner	Slimy Sculpin	Longnose Sucker	White Sucker
Poplar River	65	7.6			12.3	10.7		3.0	3.6	1.5			15.3	44.6	1.5
Lower Birch River	75	3.2				6.6		28.	14.6				13.3	5.3	
Lower Blackstone River	168	8.3	1.1	1.1	2.3	4.7	4.7	14.2		0.5	2.9	3.5		55.9	
Upper Blackstone River	28	25.9						18.5						55.5	
Lower Netla River	4		75.		25.										
East Fork Netla River	14							57.1					35.7		
South Fork Netla River	8	12.5					12.5						62.5	12.5	
Rabbit River	1												100.		
Trib.	3							33.3						33.3	33.3
Lower Muskeg River	25					36.		36.	4.				4.	16.	4.
Upper Muskeg River	6												50.	50.	
ALL SITES	391	12.8	1.2	0.5	3.2	7.3	2.0	17.9	3.5	0.7	1.2	1.5	9.5	37.5	0.7

TABLE 4

Fish Species Caught or Observed in
Tributaries to the Liard River

Common Name	Scientific Name
Grayling	*Thymallus arcticus*
Mountain whitefish	*Prosopium williamsoni*
Lake whitefish	*Coregonus clupeaformis*
Northern pike	*Esox lucius*
Trout-perch	*Percopsis omiscomaycus*
Walleye	*Stezostedion vitreum*
Lake chub	*Couesius plumbeus*
Longnose dace	*Rhinichthys cataractae*
Burbot	*Lota lota*
Spottail shiner	*Notropis hudsonius*
Emerald shiner	*Notropis atherinoides*
Slimy sculpin	*Cottus cognatus*
Longnose sucker	*Catostomus catostomus*
White sucker	*Catostomus commusoni*

Source: Hatfield *et. al.* 1972; present study.

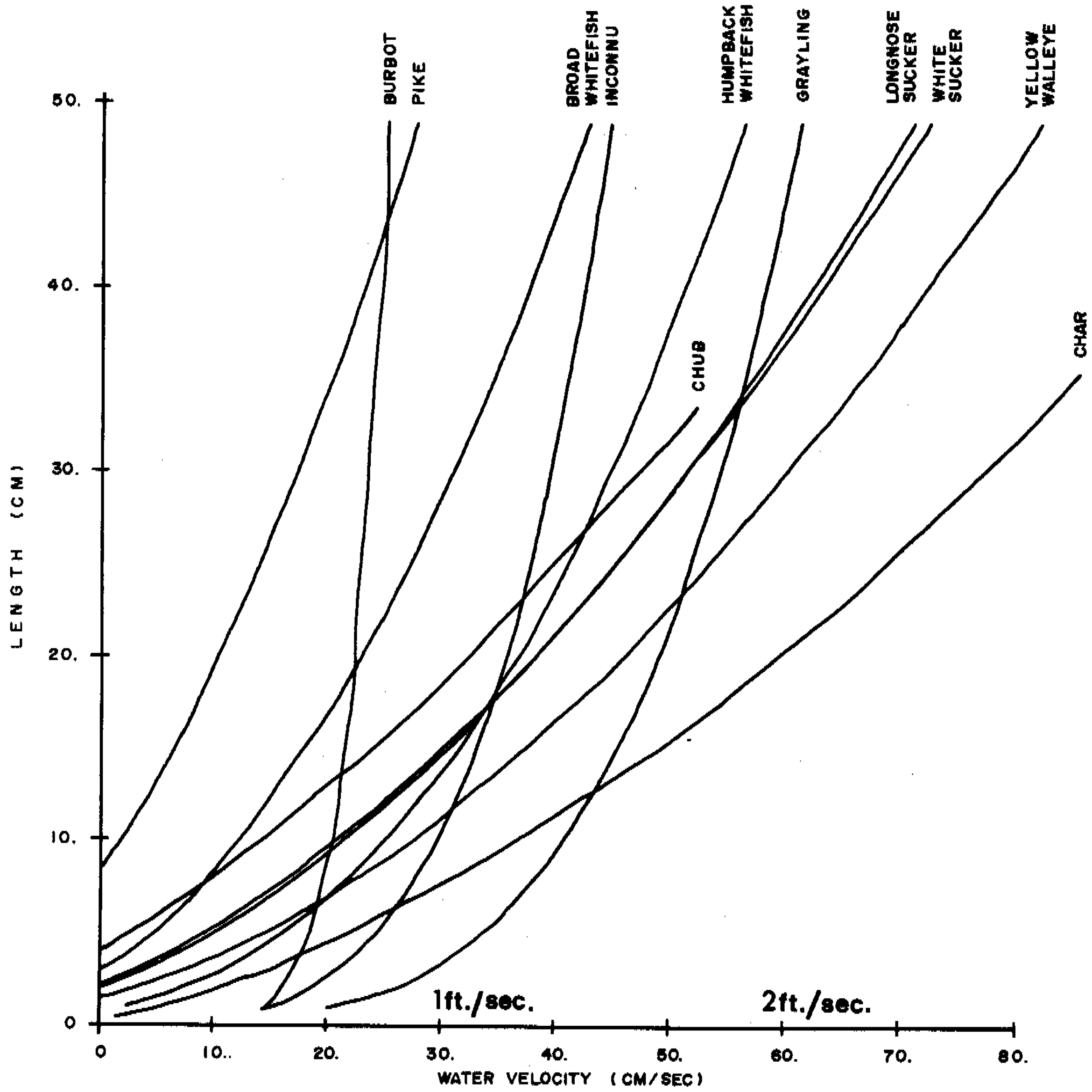
TABLE 5

Comparison of Potential Spawning Areas for Major
Tributaries of the Lower Liard River
(From Hatfield *et. al.* 1972)

Tributary	Length (Mi)	Length Surveyed	Potential Spawning Gravel (sq. yds)	Comments
Poplar River	62	40	788,000	
Birch River	37	37	63,000	Falls and beaver dams present
Blackstone River	60	60	1,162,000	Low water levels reduce potential
Grainger River	42	42	271,000	Beaver dams present
Matou River	51	51	Nil	No significant spawning areas

ance of indefinite duration as well as burst swimming at speeds 3-4 times maximum sustained speed, but lasting only 12-24 seconds. Bainbridge (1960) has indicated the maximum distance a fish is able to travel in still water during burst swimming would be in the range of 40 meters. Jones (1973) has noted the mean length of culverts in use on the MacKenzie Highway is around 55 meters, with the maximum near 100. Distances such as these could not be traversed by burst swimming, but are more likely to be covered by steady performance near the maximum sustainable speed.

Jones et.al (1974) have recently characterized the swimming performance of fish species from the MacKenzie River area. Laboratory and field studies were structured to give a measure of the maximum steady swimming performance (critical velocity) which could be maintained for ten minutes. Critical velocities for several fish species likely to be found in the Poplar River are given in Table 6. Figure 2 illustrates the relationship between fork length and ability to move 100 meters against water velocities of 0-80 cm/sec. in 10 minutes (Jones et.al 1974). The curves can be used to establish maximum allowable water velocities for obstacles of various lengths where passage by fish is intended. For example, the Poplar River culverts which are 190 feet (59 M) would allow passage of adult grayling (25-30 cm.) if water velocities were 60 cm/sec. (1.9 ft/sec.) or less. Northern Pike would require maximum water velocities of 30 cm/sec. (1.0 ft/sec.) or less for passage. J.M. Millen (1974) stated, "It is difficult to resolve laboratory and field data on swimming performance, however, water velocities of 5 ft/sec. appear to be rather high." He stated, for example, that a few pike at Frog Creek were able to make it through a culvert at 5 ft/sec. but were in a damaged condition. These water velocities may seem unreasonable slow; however, water of sufficient velocity to block fish passage through a culvert, may not in a stream due to the effect of the stream substrate. Fish move from one dead water area to another behind natural objects in the stream substrate (Renewable Resources, 1972).



THE RELATIONSHIP BETWEEN FORK LENGTH AND ABILITY TO MOVE 100 M. AGAINST WATER VELOCITIES OF 0-80 CM/SEC. IN 10 MINUTES.

The same curves may also be used to indicate the ability to make progress against these currents over shorter distances. For instance, to cross a 50 m barrier in 10 min, the curves should be shifted 8 cm/sec to the right; to cross a 25 m barrier in 10 min, the curves should be shifted 12 cm/sec to the right. The line for char is derived from the hypothetical equation $V = 17\ L^{0.5}$ and represents the measured value in these experiments.

SOURCE: AN EVALUATION OF THE SWIMMING PERFORMANCE OF SEVERAL FISH SPECIES FROM THE McKENZIE RIVER. - D.R. JONES, U.B.C.

FIGURE 2

TABLE 6

Characteristics of Fishes From the Liard River and Tributary Streams

Species	Age at Maturity (years)	Length at Maturity (cm)	Length at 0+ Year (cm)	Time of Spawn	Water Temp. During Spawn (°C)	Critical Velocity (cm/sec)	References
Northern pike	2-3	20-35	9.5	May-July	7-16	30	Hatfield *et. al.* 1972 Stein *et. al.* 1973 Jones *et. al.* 1974
Arctic grayling	6-9	25-30	4.7	May-June	8-10	70	Hatfield *et. al* 1972 McCart *et. al.* 1972 Jones *et. al.* 1974
Longnose sucker	5-6	35	5.0	May-June	8-16	70	Hatfield *et. al.* 1972 Stein *et. al.* 1973 Jones *et. al.* 1974
Flathead chub	-	-	-	-	-	50	Jones *et. al.* 1974
Burbot	3-4	20-30	5.2	February	1.5	30	Hatfield *et. al.* 1972 Cahn 1936 Jones *et. al.* 1974
Longnose dace	2	-	-	May	15	-	Bartnik 1970
White sucker	-	-	-	May-June	10	60	Geen *et. al* 1966 Jones *et. al.* 1974 Hatfield *et. al.* 1972
Trout perch	-	-	2.5	June	10	55	Hatfield *et. al.* 1972 Magnuson & Smith 1963 Jones *et. al.* 1974

Low water levels can also adversely affect swimming performance and minimum depths of 3-5 inches have been recommended (Oregon State Game Commission, 1971; Renewable Resources, 1972).

R. Scarce (Pers. comm. 1974) notes present designs utilizing a seven-day delay migration. McCart et. al (1972) noted, however, an almost spontaneous (within 24 hours) movement of grayling after peak flood conditions. Renewable Resources Consulting Services Limited (1972) state:

> We feel that there are probably reasonable limits for grayling moving upstream during the spring spawning migration. Because they are close to spawning and because of the short duration of success, the maximum seven-day delay period suggested in the Fisheries Service Highway Guidelines (Anonymous, 1972) seems excessive and might have serious consequences for populations in streams where delays of this length were an annual occurrence.

Sites Examined

During 1974 attempts were made to collect fish from all of the major streams within the study area. Between June 28 and July 2 samples were collected by use of an electro-fishing apparatus and seining from 13 different sites (Map 1.4). Samples were taken, whenever possible, at sites near the proposed road crossings. Data on species, size and weight were collected in the field while aging was done in the laboratory using otoliths preserved in glycerine.

A total of 205 fish of 11 species were collected from the 13 sites. Data on the fish collected during 1974 are shown in Tables 7 to 13. For a more complete understanding of the distribution of fish species in the study area the present data was taken together with that of Dryden et.al (1973) to give a total of 397 fish collected or observed. Table 3 illustrates the percent composition of fish species in the combined collections from selected tributary streams of the lower Liard River.

Poplar River

Published reports (Dryden et. al 1973) and the present data

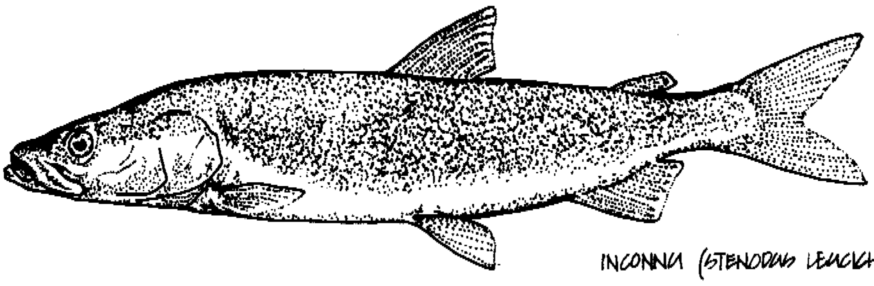
(Table 4) indicate at least nine species of fish are present in the Poplar River. Longnose sucker make up the largest portion of fish present, with lesser numbers of slimy sculpin, northern pike, trout-perch, grayling, and other species (Table 3).

Northern pike make up the majority of the catch from the Liard River (Table 3) and formed 12.3 percent of the fish collected in the Poplar River. No other stream in the study area had as large a percentage of pike.

A single young of the year grayling was collected upstream from the road crossing indicating at least some spawning had taken place. The present road crossing (installed winter 1970-71) has effected a barrier to migration for four years. During 1974 only 4.6 percent of the fish collected in the Poplar River were grayling, which is considerably lower than that found in the Birch, lower and upper Blackstone and Netla River. It is believed that the adult breeding stocks have been severely damaged. J.M. Millen stated in 1972:

> We have now sustained these losses to one year class of grayling. If the obstruction is removed in the next construction season (1973), the grayling stocks will not be severely damaged because the adult breeding stocks have not yet been severely damaged.

Millen also stated, "If plans are made to remove the obstruction within the next two years (1973 and 1974), we can take specific measures to protect the breeding population". It would appear four years of obstruction have caused considerable damage to the breeding population. A previous detailed report entitled "Environmental Impact" Poplar River 1974 by Synergy is appended.



INCONNU (STENODUS LEUCICHTHYS)

TABLE 7

Summary of Fish Collections at Poplar River 1974

Location	Species	Age	No.	Length (mm) $\bar{x}$	Length (mm) (Range)	Weight (g) $\bar{x}$	Weight (g) Range
Upper & Lower (FS74-1)	Grayling	0	1	37.0	(37)	0.3	(0.3)
	Trout-perch	5	1	39.0	(39)	0.8	(0.8)
		6	5	43.2	(42-44)	1.0	(0.95-1.15)
	Lake chub	3	1	35.0	(35)	0.3	(0.3)
		4	1	53.0	(53)	1.9	(1.9)
	Slimy sculpin	4	1	44.0	(44)	0.9	(0.9)
	Longnose sucker	1	22	41.5	(31-55)	0.9	(0.3-2.2)
Upper FS74-13	Grayling	0	1	32.0	(32)	1.0	(1.0)
	Pike	0	1	27.0	(27)	0.7	(0.7)
	Slimy sculpin	2	7	44.1	(41-47)	1.5	(1.4-1.8)
	Total		43				

Birch River

Six species of fish are known to be present in the Birch River. Dryden et.al (1973) listed data on fish collected in 1971 and Table 8 lists additional data collected by Synergy personnel during 1974. Of the 75 fish collected from the lower Birch River, a large number (32%) were immature grayling indicating this river may be of considerable importance as a grayling spawning area. Although a 3 M. falls located approximately 8 Kl. upstream limits fish migration, more grayling were collected in the lower Birch than in any other river within the study area (Table 3). Important forage species made up the remainder of the catch from the lower Birch River.

A comparison of potential spawning areas (Table 5) in the Birch with that of other tributaries to the Liard indicates the Birch has a relatively small amount of potential spawning area. Fish catches in the section of stream below the falls, on the other hand, indicate the spawning areas in that section may be of high quality for grayling.

The proposed crossing is approximately one mile downstream of the stream section judged to be the best potential spawning area in the Birch River (Hatfield et.al 1972)

TABLE 8

Summary of Fish Collections at Birch River 1974

Location	Species	Age	No.	Length (mm) x̄	Length (mm) (Range)	Weight (g) x̄	Weight (g) Range
Lower Birch FS74-12	Grayling	0	17	34.6	(29-38)	0.5	(0.3-0.6)
	Lake chub	0-1	1	25.0	(25)	0.1	(0.1)
		2	2	44.0	(39-49)	1.1	(0.6-1.6)
	Total		20				

Blackstone River

Eleven species of fish are known to be present in the Blackstone River. Dryden et.al (1973) listed species caught during 1971. Additional data was collected by Synergy personnel during 1974. The 195 fish collected from four sites on the Blackstone River represent nearly half (49%) of all fish collected or observed in streams in the study area. Longnose sucker made up the majority of fish (55%) caught at both upper and lower Blackstone River sites (Table 3).

The large number of fish collected in this stream is an indication of the importance of potential spawning area which is estimated at 1,162,000 square yards (Table 5). This large area makes it one of the more important streams in the study area. Collections by Synergy personnel in the upper reaches yielded significant numbers of young grayling (Table 3) and indicate little or no obstructions to migration for this species.

Several fish species, including mountain whitefish, walleye, spot-tail shiner, and emerald shiner were collected in the lower reaches of the Blackstone River but not at any other sites in the study area.

TABLE 9

Summary of Fish Collections at Blackstone River 1974

Location	Species	Age	No.	Length (mm) $\bar{x}$	Length (mm) (Range)	Weight (g) $\bar{x}$	Weight (g) Range
Lower Blackstone Above Crossing FS74-8	Lake chub	2	2	27.0	(27)	0.3	(0.3)
		3	21	33.9	(28-45)	0.6	(0.3-1.1)
	Burbot	3	1	98.0	(98)	6.5	(6.5)
Lower Blackstone Below Crossing FS74-9	Grayling	0	13	31.6	(26-38)	0.4	(0.2-0.6)
	Mountain whitefish	3	2	83.5	78-89	6.5	(4.7-8.4)
	Trout-perch	4	1	41.0	(41)	0.4	(0.4)
		5	1	55.0	(55)	1.9	(1.9)
	Longnose sucker	1	8	53.3	(41-67)	1.9	(0.8-3.6)
Lower Blackstone Tributary Below Crossing FS74-9A	Grayling	4	1	116.0	(116)	18.2	(18.2)
	Lake chub	5	1	69.0	(69)	4.4	(4.4)
	Longnose sucker	2	1	46.0	(46)	1.7	(1.7)
		3	1	100.0	(100)	12.3	(12.3)
Upper Blackstone FS74-11	Grayling	0	7	26.5	(23-29)	0.2	(0.2-0.2)
	Lake chub	4	5	60.0	(51-66)	3.0	(2.1-3.9)
	Slimy sculpin	3	3	41.3	(37-45)	0.6	(0.4-0.8)
	Longnose sucker	1	13	46.9	(42-52)	1.3	(0.8-2.1)
	Total		81				

Netla River

Collections made in 1974 at three sites on the Netla River yeilded 26 fish of six species (Table 10). Lake chub and slimy sculpin were the most numerous species, with lake whitefish, pike, grayling and burbot making up the remainder of the catch (Table 3). No young of the year fish were collected, a fact which may indicate spawning areas are some distance upstream from the collection sites.

No data are available on the amount of potential spawning areas in the Netla River.

TABLE 10

Summary of Fish Collections at Netla River 1974

Location	Species	Age	No.	Length (mm) x̄	Length (mm) (Range)	Weight (g) x̄	Weight (g) Range
Below Crossing FS74-10	Lake whitefish	5	1	325.0	(325)	548.0	(548)
		6	1	340.0	(340)	631.0	(631)
		7	1	374.0	(374)	898.0	(898)
	Pike	6	1	540.0	(540)	870.0	(870)
Above Crossing South Fork	Grayling	4	1	113.0	(113)	17.9	(17.9)
	Lake chub	4	1	62.0	(62)	4.2	(4.2)
	Slimy sculpin	3	3	40.0	(35-43)	1.2	(0.9-1.4)
		6	2	68.5	(62-75)	3.2	(2.9-3.4)
	Longnose sucker	3	1	53.0	(53)	2.0	(2.0)
Above Crossing East Fork	Lake chub	3	1	49.0	(49)	1.5	(1.5)
		4	4	62.5	(59-66)	3.1	(2.4-3.7)
		5	3	75.6	(71-79)	5.2	(4.1-6.3)
	Burbot	4	1	234.0	(234)	78.9	(78.9)
	Slimy sculpin	3	4	42.7	(41-46)	0.8	(0.7-1.0)
		5	1	64.0	(64)	2.8	(2.8)
	Total		26				

Rabbit Creek

A single slimy sculpin was collected downstream of the proposed crossing at Rabbit Creek (Table 11). These data indicate this stream is of relatively low importance in relation to other sites in the study area.

TABLE 11

Summary of Fish Collections at Rabbit Creek 1974

Location	Species	Age	No.	Length (mm) x̄	Length (mm) (Range)	Weight (g) x̄	Weight (g) Range
Below Crossing FS74-4	Slimy sculpin	4	1	53	(53)	1.2	(1.2)
	Total		1				

Unnamed tributary

One specimen each of three species (lake chub, longnose sucker, and white sucker) were collected from a small unnamed tributary of the Liard River between Rabbit Creek and the Muskeg River (Table 12). This stream is probably of relatively low importance in relation to other sites in the study area.

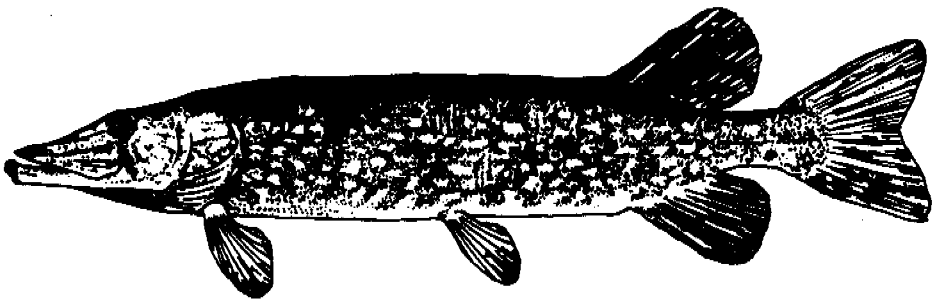
TABLE 12

Summary of Fish Collections at Tributary
Next to Rabbit Creek 1974

Location	Species	Age	No.	Length (mm)		Weight (g)	
				$\bar{x}$	(Range)	$\bar{x}$	Range
Below Crossing FS74-3	Lake chub	3	1	42	(42)	0.8	(0.8)
	Longnose sucker	3	1	61	(61)	2.6	(2.6)
	White sucker	1	1	37	(37)	0.7	(0.7)
	Total		3				

Muskeg River

A total of 31 fish representing six species were collected from sites on the lower and upper Muskeg River (Table 13). This river drains by far the largest basin in the study area and undoubtedly offers a wide variety of fish habitats. The two sites sampled provide only a minimal amount of data for analysis. Trout-perch, lake chub, and longnose sucker made up the majority of the catch (Table 3). Conspicuously absent from the catch are grayling, pike, whitefish, and walleye.



NORTHERN PIKE (ESOX LUCIUS LINNAEUS)

TABLE 13

Summary of Fish Collections at Muskeg River 1974

Location	Species	Age	No.	Length (mm) x̄	(Range)	Weight (g) x̄	Range
Lower Muskeg Above Crossing FS74-2	Trout-perch	3	2	33.5	(32-35)	1.0	(1.0)
		5	2	41.5	(41-42)	1.6	(1.5-1.7)
		6	4	63.0	(61-65)	3.9	(3.5-4.5)
		7	1	73.0	(73)	5.3	(5.3)
	Lake chub	0-1	3	26.6	(23-29)	0.7	(0.6-0.7)
		2	3	34.3	32-39	0.9	(0.8-1.0)
		3	3	45.3	(42-52)	1.8	(1.5-2.3)
	Longnose dace	-	1	25.0	(25)	0.6	(0.6)
	Slimy sculpin	4	1	65.0	(65)	3.7	(3.7)
	Longnose sucker	1	3	35.6	(33-37)	1.2	(1.1-1.2)
		2	1	60.0	(60)	3.2	(3.2)
	White sucker	1	1	34.0	(34)	1.0	(1.0)
Muskeg Headwaters FS74-7	Slimy sculpin	4	1	59.0	(59)	2.6	(2.6)
		5	1	67.0	(67)	4.1	(4.1)
		6	1	81.0	(81)	6.5	(6.5)
	Longnose sucker	2	1	84.0	(84)	7.9	(7.9)
		3	1	115.0	(115)	34.6	(34.6)
		4	1	135.0	(135)	37.4	(37.4)
	Total		31				

The maintainance of viable populations of game and commercial species of fish is of importance to both the visiting angler and to the native residents. It is therefore essential that species which migrate up the tributaries of the Liard River to spawn continue to do so. The streams important for protection are the Poplar, Birch, Blackstone, Netla and Muskeg rivers.

In the southern section of the Liard Highway a problem will potentially occur at Bovie Lake. This lake is typical of most northern lakes in that it is susceptible to fishing pressure. Bovie Lake has been fished by native peoples from prehistoric times and is currently fished by a few families from Fort Liard each year. However, with the ready access provided by the Liard Highway fishing pressure will very likely be increased as a result and consequently the fishing potential and productivity of the lake will be greatly impaired unless adequate safeguards are ensured.

ARCHAEOLOGY AND HISTORY

No on-site archaeological investigations have been carried out in the areas immediately adjacent to the proposed Liard Highway, although a number of studies have been made in surrounding areas. From these latter studies, together with interpretation of aerial photographs of the highway alignment, it is possible to draw some conclusions and to make predictions regarding the archaeological potential of the area. Predictions made from aerial photography have been found to be 80 per cent accurate in most instances. A scale of priorities of potential archaeological sites is given at the end of this section.

The location of the proposed Liard Highway probably conforms to one of the major aboriginal routes of movement along the Liard River. The temporal extent of this prehistoric and historic utilization pattern, is currently unknown. However, on the basis of archaeological information from surrounding areas, it is probable that the general area has been occupied by man for at least 8-10,000 years. Evidence of occupation was often meager, subject to rapid disintegration, and is often difficult to find. However, within a framework of changing environmental conditions, areas of maximum utilization can be postulated and examined.

Should be difficult only once

Strategies employed by prehistoric man for securing required resources were probably based on a "minimax" concept, ie. acquire a maximum amount of resources with a minimum of effort and time. The resulting territorial and seasonal round settlement patterns are supported in the ethnographic literature on the boreal forest Athabaskans (Honigman 1946, 1954; Jenness 1932; Mason 1946; Osgood 1932; Morris 1972). This pattern maximizes use of concentrated seasonal availability of resources such as waterfowl, fish, woodland caribou, or bison. Construction of fish weirs in autumn on streams for winter usage often involved 60 to 80 persons resulting in relatively large habitation sites. Good fishing lakes were occupied by minimal size groups during winter, with small and large animal trapping and hunting being a nearly-continuous supplemented activity. With spring break-up, the fishing declined in importance and the reliance on small and large mammals increased. Camps during this period were small and dispersed, frequently in riverine ecozones. Summer saw a renewal of lake and river fishing, mainly with nets, with small groups once again accumulating in lake inlet or outlet areas, along particularly favourable larger streams, often at confluences of major streams, or on the lower reaches of tributaries. Particularly favourable campsites during the late prehistoric period at this time of year were river terraces, near the mouths of large tributaries or between a river and a lake.

During the early prehistoric period, the area is known to have been the range of now-extinct bison species (Gordon 1969; J. Turner 1973 personal communication). Paleontological sites have been recorded for the area below the Blackstone River along the Liard. The distribution of archaeological sites for this period is understandably difficult to decipher, but locations similar to the preceding would be important. Further, hilltop or lookout sites would similarly be important.

Known archaeological sites are scattered around the Liard River Valley. The two major areas in which studies have been carried out are at Fisherman Lake, 15 air miles due west of Fort Liard, and along the shores of the three major lakes situated on the eastern side of the Nahanni Range, almost 40 miles due west of Fort Simpson. Most of these sites would appear to be dating back to around 8,000 years B.C., although earlier dates have been suggested for some sites. Preliminary investigations at Bovie Lake have reported artifacts, and the lake is still in use during the summer by local families. A similar period of continuous use had been reported for Sibbeston Lake, one of the lakes west of Fort Simpson.

Historically, the Liard River has provided a major route for the activities of the two major trading companies of the Canadian North, the Hudson Bay and North West Companies. Fort Simpson was established as a post of the Hudson Bay Company in 1804. It was first called Fort of the Forks and was later named Fort Simpson after Sir George Simpson. The following year, 1805 saw the North West Company founded at Fort Liard. The Liard River was not only used as a means of travel between these two posts and other parts of the north, but also as a means of entering the Yukon Territory. It was, however, regarded as one of the most hazardous waterways of the north and held in fear by the traders who had to travel it, particularly in the sections upstream of the area of the present study. As a result of the efforts of Robert Campbell, who later became a Chief Factor of the Hudson's Bay Company, the Liard route to the Yukon was abandoned in favour of a more northerly, but less strenuous, passage.

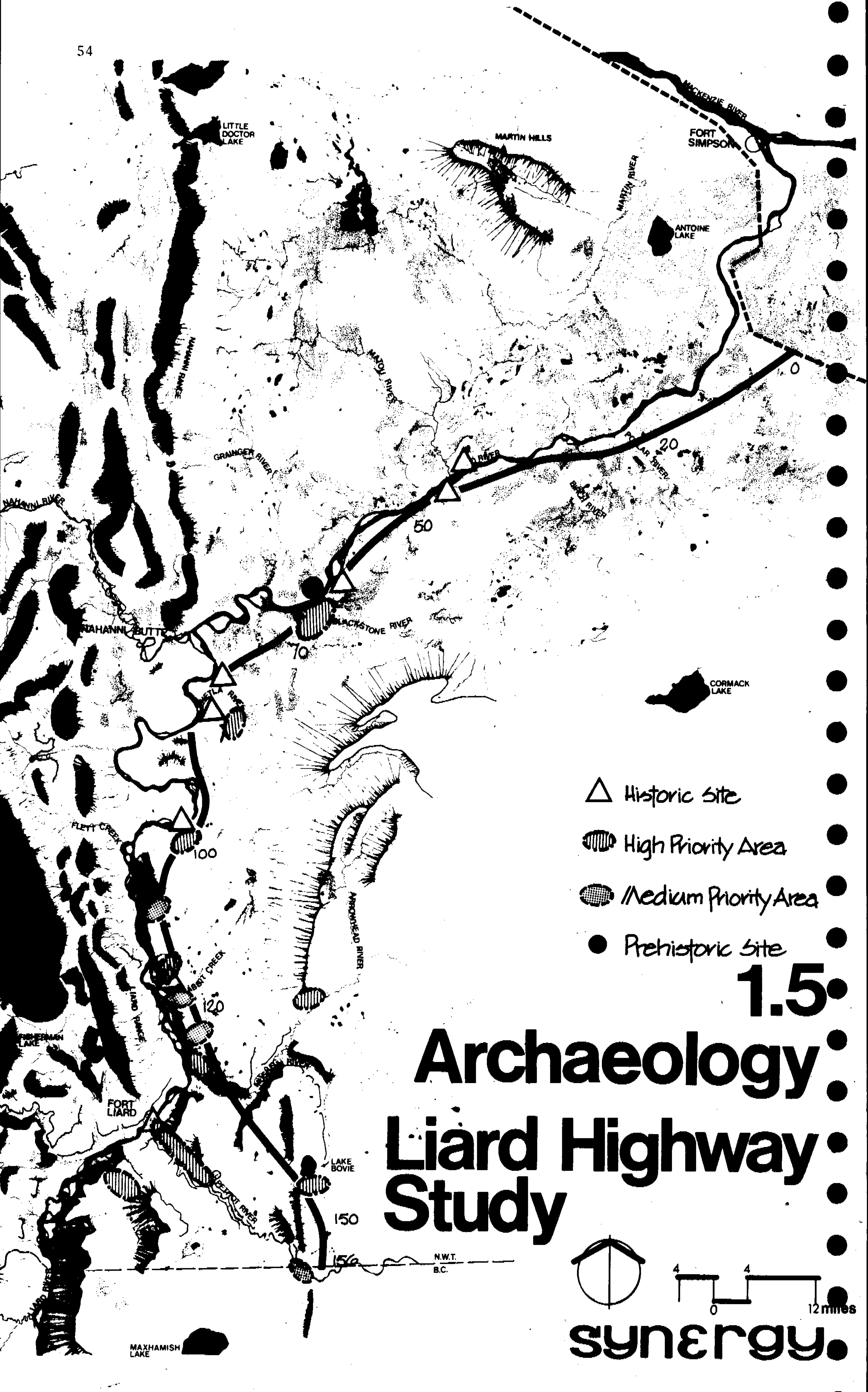
Besides Fort Liard, a second major settlement along this section of the Liard River is situated at Nahanni Butte, at the confluence with the south Nahanni River.

Numerous cabins are found scattered along the banks of the Liard River, some abandoned, but others still used at various times of the year. These cabins, almost without exception, are situated on the highway side of the Liard River.

On the basis of ethnographic data and known archaeological site locations in the MacKenzie Valley, route classification for the Liard Highway was thus defined.

a) high priority - areas of greatest archaeological sensitivity, with greatest probability of discovery; confluence of rivers or rivers and streams
b) medium priority - areas considered to be less sensitive archaeologically, but containing some possibility of site existense and discovery; higher stream crossings; high ridges
c) low priority - low-lying areas where probability of locating sites is considered at a minimum.

Preliminary Rating of Liard Highway Route:



1.5 Archaeology

Liard Highway Study

synergy

a) MP 65 - HIGH PRIORITY - highway approaches confluence of Blackstone and Liard Rivers

b) MP 96 - HIGH PRIORITY - historic cabin with possibly prehistoric component at confluences of stream with Liard River; stream crossing

c) MP104 - MEDIUM PRIORITY - possible lookout station on knoll

d) MP111 - HIGH PRIORITY - creek crossing at confluence with Liard River

e) MP115 - MEDIUM PRIORITY - creek crossing

f) MP120 - MEDIUM PRIORITY - creek crossing

g) MP124 - MEDIUM PRIORITY - creek crossing

h) Muskeg River Crossing - HIGH PRIORITY - known archaeological site

i) Fort Liard - HIGH PRIORITY - known archaeological sites

j) Bovie Lake - HIGH PRIORITY - known existence of archaeological sites (MacNiesh 1954)

k) Confluence of small streams with Petitot River - MEDIUM TO HIGH PRIORITY - favoured fish trap areas

l) Betalamea Lake - HIGH PRIORITY - reported artifacts; reported intensive historic utilization (out of study influence)

m) Petitot River, JaRt - 1-3 Area - HIGH PRIORITY - known archaeological sites

n) Small Lake - MEDIUM PRIORITY - across Petitot River (m) location above - possibly similar occupation to (m)

o) Petitot River and High Ridge - MEDIUM TO HIGH PRIORITY - game lookout and fishing on river

p) Petitot River and Maxhamish Creek confluence - HIGH PRIORITY - known prehistoric and historic utilization of Maxhamish Lake area.

Historic sites occurring along the proposed route were identified on the highway location map at the following approximate mileages:

MP 43 - cabin

MP 62 - cabin

MP 96 - cabin

MP 114 - cabin across from Big Island

MP 129 - cabin at Muskeg River

MP 80 - cabins at Netla River and upstream on Netla.

Several historic sites have been reported from the Fort Liard area:

a) John Klondike's cabin - opposite Fort Liard

b) Wind Moye's cabin - opposite Fort Liard

c) Confluence of Small Creek with Liard - opposite Fort Liard

d) Historic buildings - Fort Liard.

It should be noted that these sites also potentially represent prehistoric occupations.

Approximately six miles upstream from the confluence with the Muskeg is a chert quarry, located in the Arrowhead Lakes region of the Arrowhead River.

The Map 1.5 displays the location and priority of these sites. The sites are also recorded in Chapter # on the detailed maps and appropriate development recommendations are made for each location.

The ultimate objective of the archaeological program is the identification, conservation, preservation and salvage of significant archaeological sites, for the purpose of interpretation and explanative reconstruction of archaeological materials. This is most efficiently achieved by a multi-phase program.

Firstly, a preliminary overview. This phase is exemplified by this report in which the route selection has been assessed in terms of extrapolated prehistoric land utilization strategies resulting in a classification of hypothetical archaeological probabilities. Secondly, an initial study of identified moderate and high potential areas, prior to major earth work, to further determine site value and to possibly establish protective or salvage methods. Thirdly, based on the foregoing, an orientation of construction personnel.

In order to inform and acquaint personnel involved with the highway construction with the nature and importance of archaeological materials, a series of briefing sessions is proposed. Such sessions are deemed necessary for recognition of archaeological materials and potentially significant archaeological sites, as well as for implementation of precautionary measures to ensure preservation of archaeological materials.

During or after construction, archaeological surveillance is required in order to evaluate any sites discovered during actual construction. Should any be located, their value will be assessed in terms of potential damage or loss of information through secondary activities resulting from the use of the completed highway.

The final phase of field investigation concerns salvage excavation of sites considered of important archaeological interpretive potential, particularly those endangered directly by highway construction, auxiliary construction or use.

It is important to note that archaeological sites are protected by the Territorial Government. The destruction of sites and the removal of archaeological material is prohibited under the Northwest Territories Archaeological Site Regulations (SOR/60-31).

In an effort to inform and instill appreciation for cultural heritage in the public users of the highway, it is proposed that select historic and prehistoric sites be either interpreted or preserved as museum exhibits. Archaeological values integrated with values of other disciplines could provide tourists with the interesting natural and cultural history represented along the Liard Highway.

SETTLEMENTS

The following settlements will be affected by new and improved access.

Fort Liard

Fort Liard with a population of approximately 325, mostly of native origin (7 or 8 white residents) is the only settlement directly affected enroute by the highway. This community has a new Hudson's Bay store, R.C.M.P. post, school and nursing station. A 3,000 foot airstrip is maintained throughout the year and radio contact is established with outside areas.

This community has existed in relative isolation since its foundation. At present supplies are flown in weekly. The only other contacts with the outside are infrequent visits by exploration companies and freight barges in summer.

The primary occupation is trapping and hunting. Although it is difficult to determine the exact amount of resource harvesting, conversations with wildlife officers, licence reports and observations have provided the following. Table 14 shows the recorded harvest for the 1972-73 season. This season is considered to be representative. On the average it is estimated that a maximum of one moose per family per season is harvested. The statistics reported are likely inflated since hunters tend to boast and record more kills than actual but this is counteracted by the infrequent large kill by individual hunters who are then afraid to report the actual kill. It can only be assumed that Table 14 is probably a minimum record.

The connection of Fort Liard by highway to Fort Simpson (135 miles) and to Fort Nelson (110 miles) will assuredly create major changes in the community. The infra-structure will likely increase supportive of renewable and non-renewable resource development and in support of service requirements along the highway. The socio-economic impact is likely to be great. Traditional occupations will change or be lost entirely. Additional money and accessibility will mobilize the community.

Approximately 80 percent of the present income in the community results from hunting and trapping. These occupations will be significantly reduced or will disappear with the advent of new opportunities.

In respect of the previous isolation of the community and in respect of the known difficulty of citizens in remote areas to adapt to spontaneous change it is imperative that several advance studies be done prior to completion of the highway and the access to the community. Firstly, a socio-economic impact study and, secondly, with the findings of this first study and in recognition of resource development a community plan establishing the regional role and direction for orderly development.

Nahanni Butte

This small settlement of 80 persons is situated on the south bank of the Nahanni River just upstream from the confluence with the Liard River. This population is composed of two white residents and the remainder native. The impact of the Liard Highway on this community should be small until connecting access is provided.

The major occupation of the residents was previously hunting and trapping. However, in recent years construction and exploration employment opportunities through "Hire North" have almost eliminated the trapping activity and have reduced the big game hunting activity. Table 14 displays this fact.

Fort Simpson

Fort Simpson at Mile 295 of the MacKenzie Highway is situated 37 miles from the intersection of the Liard Highway and MacKenzie Highway and effectively serves as the northern terminus of the Liard Highway.

The population is approximately 850 and a full range of services exist. This community is likely to become a major distribution centre for a large region of the north. The MacKenzie Highway the Liard Highway, enlarged air facilities and the possible 1.8 MMBD pumping station for the adjacent Arctic gas pipeline all contribute to this likelihood.

? The presence of Fort Simpson negates the need for any major service developing at the intersection of the highways.

The completion of the Liard Highway will certainly increase freight and tourist traffic to Fort Simpson, however, the magnitude of this impact on the community is considered small in comparison to the recent change resultant from the MacKenzie Highway. Further determination of the effects on Fort Simpson are beyond the scope of this study.

Hunting activity from Fort Simpson related to the accessible 30 miles of the Liard Highway is estimated at 12 to 15 moose. Since construction of the MacKenzie Highway trapping has decreased rapidly and during the 1974-75 winter there is evidence that no trapping was done in this area. *what was it ?*

The total resource harvest within the highway region does not appear to be excessive. Moose certainly predominate with black bear second. It is expected that the total harvest by traditional hunters and trappers will decrease; however, this reduction can easily be reversed by sport hunting unless regulations and enforcement are applied. It is recommended that the present level of harvesting has been sustained for many years and that the total harvest be regulated at this level. Consideration of cyclical trends could vary this from year to year.

TABLE 14

BIG GAME RECORDS

Location	1970-71					1971-72					1972-73				
Fort Simpson															
Moose	139					120					55				
Caribou		44					26					19			
Sheep			0					0					0		
Black Bear				66					0					33	
Goat					0					0					0
Fort Liard															
Moose	84					70					59				
Caribou		5					2					0			
Sheep			5					2					0		
Black Bear				31					30					11	
Goat					0					1					0
Nahanni Butte															
Moose	24					46					12				
Caribou		0					17					0			
Sheep			3					0					2		
Black Bear				9					0					6	
Goat					0					0					0
Totals															
Moose	247					226					126				
Caribou		49					45					19			
Sheep			8					2					2		
Black Bear				106					30					50	
Goat					0					1					0

TABLE 15

TRAPPING ACTIVITY FOR THE SEASON 1972-73

Species	Fort Simpson	Fort Liard	Nahanni Butte	Trout Lake	Total
Otter	4	0	0	0	4
Black Bear	4	6	3	14	27
Mink	186	105	0	8	299
Muskrat	315	225	3	2	545
Fisher	2	4	0	0	6
Marten	467	157	4	29	657
Fox	23	6	1	1	31
Beaver	1001	384	34	0	1419
Weasel	93	24	0	8	125
Lynx	611	584	11	30	1236
Wolf	18	9	0	0	27
Squirrel	402	455	0	9	857
Wolverine	11	3	0	0	14
Coyote	3	3	0	0	6

The statistics for Fort Simpson represent only Fort Simpson. The amount of trapping activity related to the area associated with the highway has not been disaggregated.

ENGINEERING CRITERIA

The Alignment Report, Liard Highway, Northwest Territories, by Public Works Canada, dated January, 1975 provides what is considered to be the final engineered alignment for the Liard Highway from Mile 0 to Mile 156.7, including the Fort Liard access road.

The general alignment is basically a good one and it is only in the detail of the alignment that comment is might be provided. The proposed alignment, part of which is presently existing, has been designed under normal engineering criteria for a Rural Arterial Undivided (RAU) 60 miles per hour highway according to Canadian Good Roads Association (CGRA) Standards. Within the standards the present alignment has been surveyed on the normal tangent, dog-leg basis and in certain sections where topography permits there are extremely long tangents which bear little sensitivity to the minor topographical and vegetative features of the surrounding landscape. It is recommended that, still within the standards, curvilinear alignment be considered where possible in order to mould the roadway into the landscape taking full advantage of all natural features and providing what is considered to be a less-monotonous and more-scenic drive. It is recognized that the cost of survey is small in comparison to the long-term, beneficial effects of a more pleasant roadway. There are several advantages that can be gained from proper curvilinear parkway design. Firstly, it is questionable that 4, 5 mile and longer tangents in fact result in the road being located on the best soils whereas a curvilinear alignment could seek out better soil conditions. Secondly, the curvilinear parkway satisfies scenic roadway criteria for tourism and provides general aesthetics for the road user. Thirdly, the landscape through which most of the Liard Highway passes is somewhat monotonous being low-relief and the interest gained from the road can be that on a micro-scale through curvilinear consideration of small natural features such as changes in vegetation type, old river meanders, and stream crossings.

Throw up
Carefully
is the only
copy we h

In general the main criteria of the roadway should be that, although it follows the path of least resistance on a macro-scale, it should on the micro-scale, as viewed from the road, take on a character more sensitive to the surroundings, and the potentials for user comfort and satisfaction.

The technique used for evaluating on an aesthetic basis the present road alignment and the proposed road alignment was to fly the route utilizing time-lapse photography (16mm photography at a fixed number of frames per second) from two elevations--that at about 1,000 feet and also at a level of approximately 100 feet above the roadway--this photography was taken for most of the length of the roadway, however, weather conditions did not permit complete coverage. On the basis of the photography and in review of the latest alignment report development recommendations are noted within Section II of this report on the detailed series of maps. The recommendations are noted relative to the air photo mosaics contained within the alignment report and it is suggested that, for final design, the design team reference from the drawings within this study to the alignment report.

The highway, in its present condition, sub-divides itself into basically three distinct sections as far as the flexibility in alignment is permitted. The first 30 miles of the highway are essentially complete and changes in alignment are not reasonable. Within this section, however, it is necessary to conduct a clean-up program during the final trimming of the roadway. The incidence of visual disturbing items within this first 30 miles is considered severe. Appendix 3 notes the number and type of problems that exist. These occur almost every quarter-mile along this section. The magnitude and severity of these disturbances vary.

From approximately Mile 30 to Mile 65 at the Blackstone River, the right-of-way has been cleared and the number of disturbances is less than the first 30 miles, however, there are still a number of typical problems which exist. It is considered, within this cleared right-of-way section, that changes in alignment are not feasible unless for factors other than aesthetic. The third section from Mile 67 onward allows more flexibility in modification on the micro-scale to the general alignment proposed. It is within this section that curvilinear aspects might be incorporated to a larger degree and greater control exercised over construction procedures.

There are only a limited number of construction situations that create problems and that require consideration. Each of these is discussed independently below.

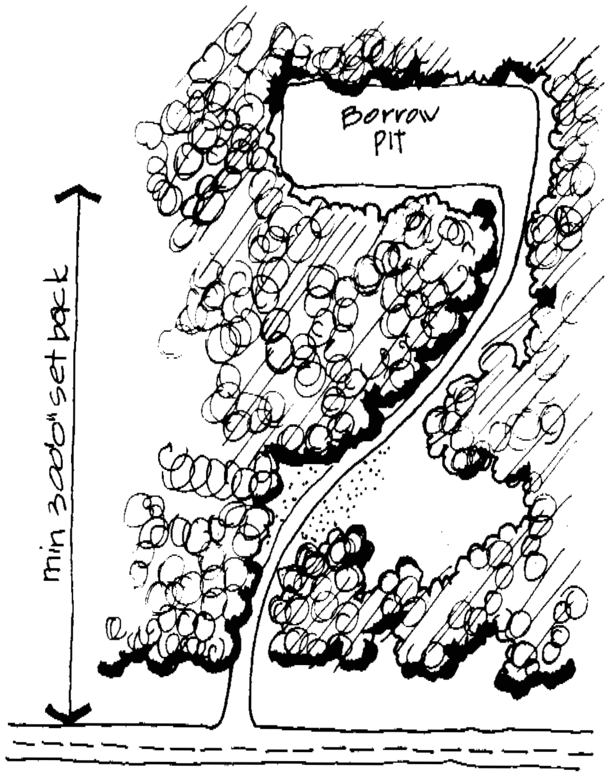
Borrow-Pits

Along the presently constructed portion of the roadway, borrow-pits probably constitute the major visual impact as viewed from the road. Several problems exist. Generally borrow-pits are located too close to the right-of-way with inadequate tree buffers to shield them visually. Buffers of between 0 and 100 feet exist at present and the practice of straight cutting the borrow-pit has caused collapse and sloughing of the treed fringe thus reducing its effective shielding. This thin buffer is also subject to windfall and dieback due to lack of protection. It is recommended that a minimum screen of 300 feet be provided to new borrow-pits. The sides of the borrow-pit area should also be tapered to allow natural revegetation to occur. A slope of 2-½ to 1 is recommended. Borrow does not necessarily have to be taken from this distance. It is possible to incorporate shallow borrow areas within the right-of-way and to treat them visually through selective clearing and revegetation. This technique provides stable roadway foundations and minimum haul distances. Details 1 & 2 show the proposed solutions.

Existing borrow pit as viewed from the road

NEW BORROW PITS · DETAIL 1

A New borrow pits should not spoil the scenic quality of the landscape.



New pits should be located a minimum 300' away from the clear cut highway right-of way.

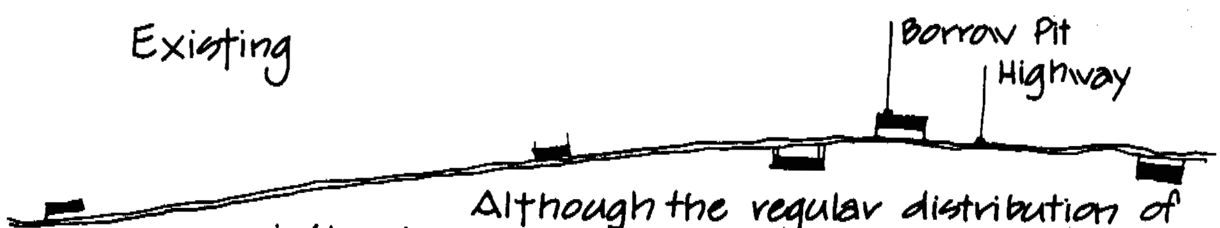
Access roads into a pit should be curved to obstruct views directly into the excavated area. One access is preferred.

Access roads should be only as wide as is necessary to accommodate traffic.

Entrances should be screened by planting.

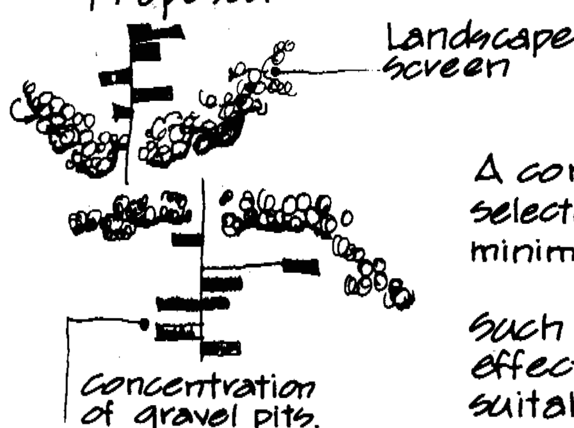
B New borrow pits need not be spread out so widely along the highway.

Existing



Although the regular distribution of existing borrow pits provides convenient, short haul sources of fill, there is wide spread disruption to the landscape.

Proposed



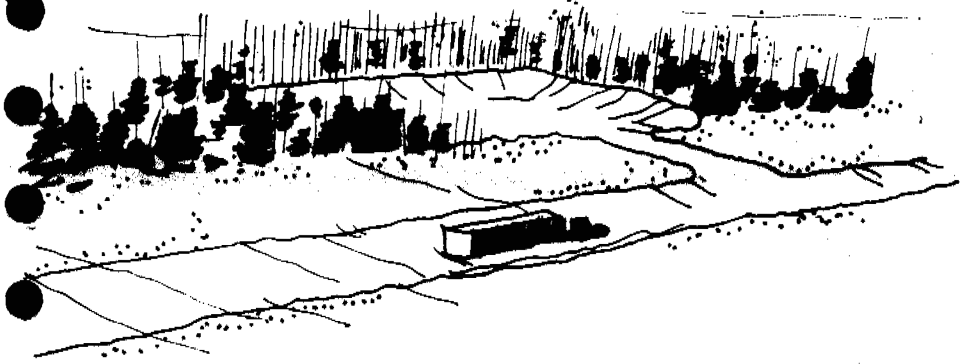
A concentration of borrow pits in selected areas along the highway minimizes widespread disruption.

Such large scale excavation requires effective screening and it might be suitable for recreational or scenic development.

OLD BORROW PITS · DETAIL 2

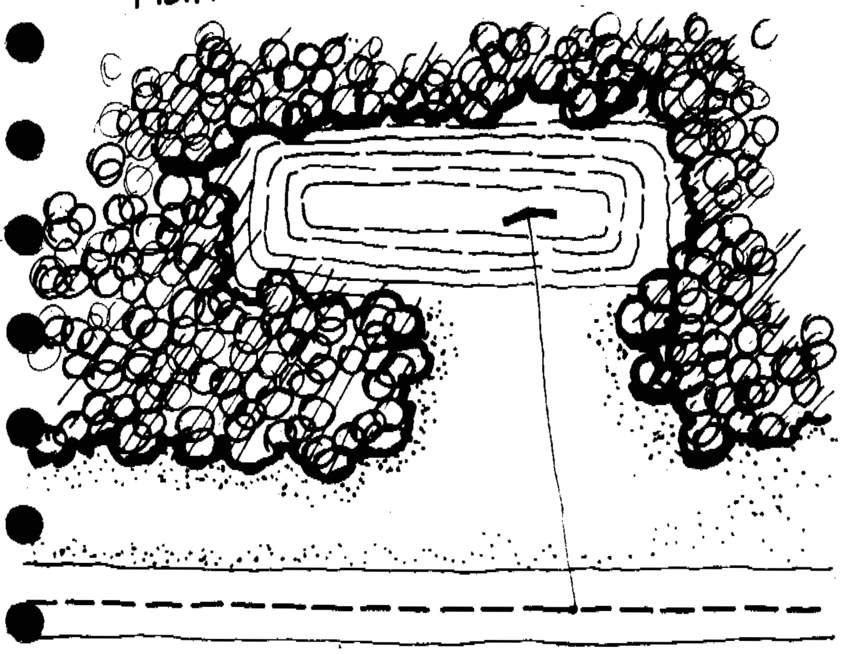
Existing:

Perspective



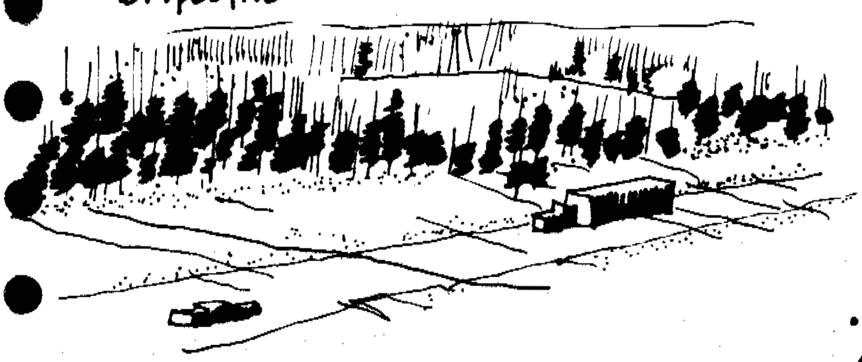
• Borrow pit is exposed to views of motorists.

Plan



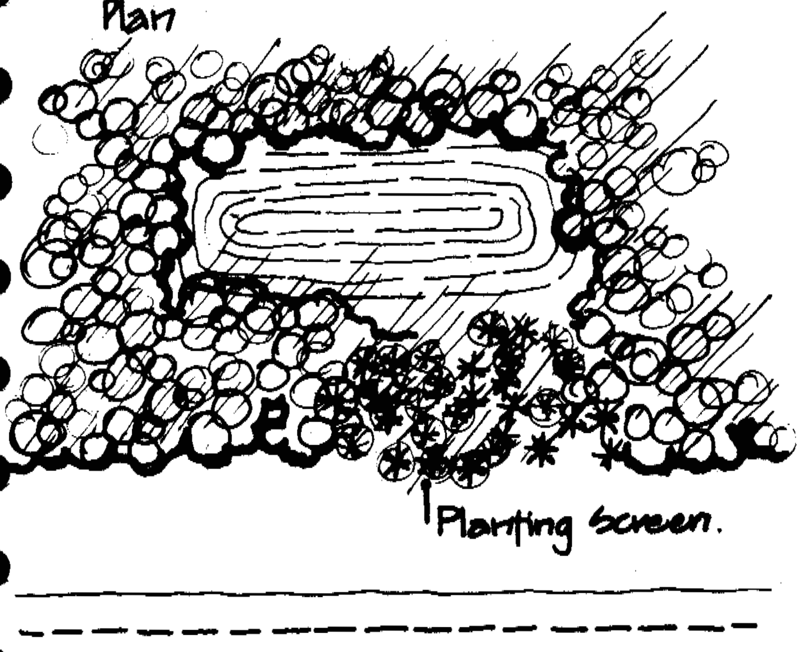
Proposed:

Perspective



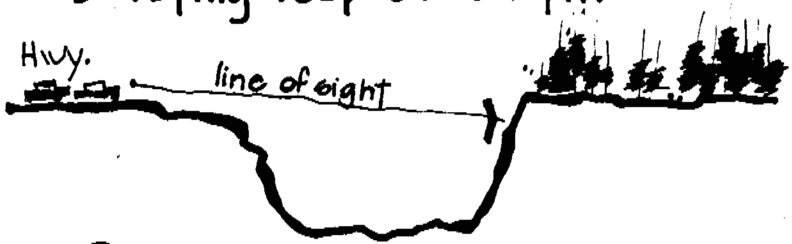
• New tree plantings screen the unsightly excavation.

Plan



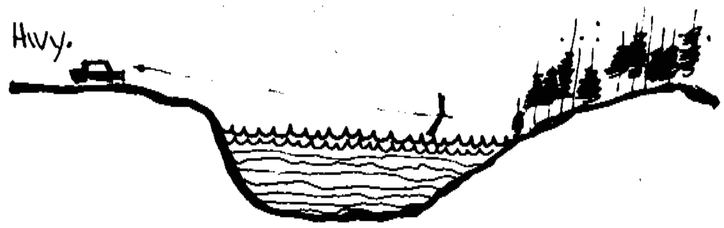
B. Other borrow pits that cannot be screened from view may be treated naturalistically by blending with the surrounding landscape.

Existing Deep Borrow Pits



•The exposed face of the pit is clearly visible from the road.

Proposed

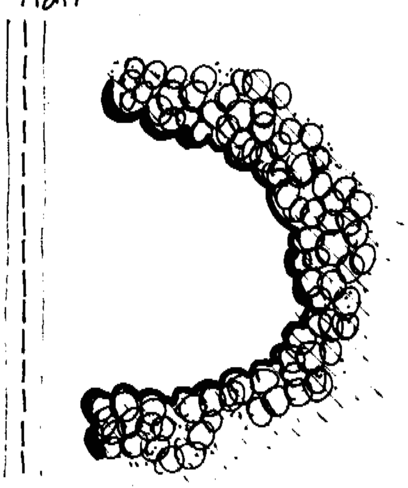


Face visible from the road is reduced to a more gentle slope and planted. Excavation is filled with water.

Existing Shallow Borrow Pits

•An expanse of disturbed vegetation exists.

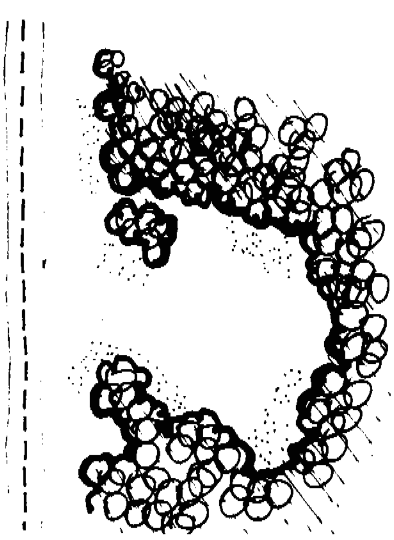
Plan



Proposed

•Regrade and plant to grass, selective clearing to soften treed fringe and regular shapes.

Plan



Stream Crossings

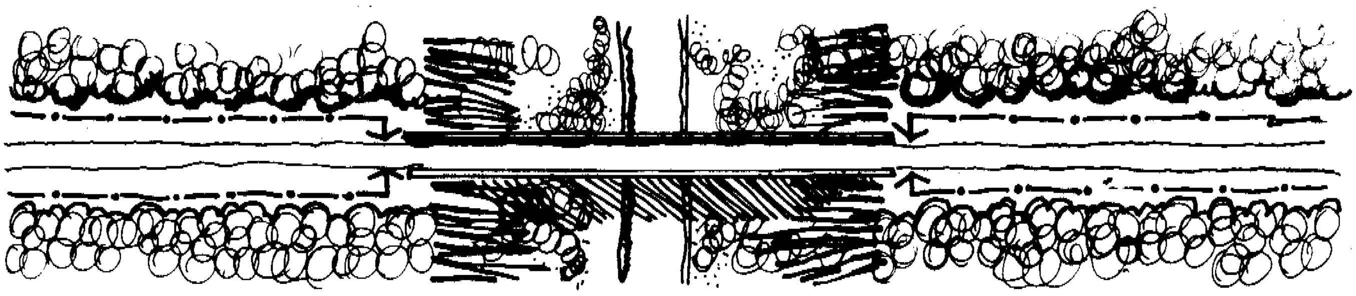
The cost of stream crossings in these remote locations becomes a very significant part of highway construction. It is, however, necessary to make these crossings multi-functional since they normally generate points of interest or points of relief for the traveller. The approach and treatment of the crossings is ultimately important if it is desired to capitalize upon the visual change and to provide the traveller with the satisfaction of a different view.

A long tangential approach to a stream crossing eliminates the element of surprise whereas a curvilinear approach can provide the traveller with a greater visual impact and a degree of surprise that provides greater satisfactions (see detail 3). These considerations normally require minor modification. Each bridge crossing is dealt with in detail in Section II.

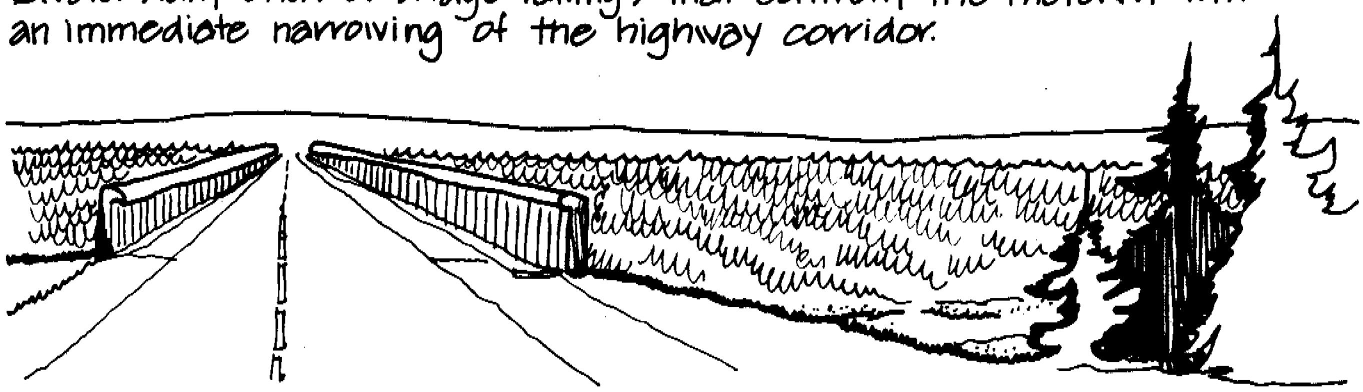
scenic quality of stream crossings.

RIVER CROSSINGS • DETAIL 3
HIGH LEVEL CROSSINGS

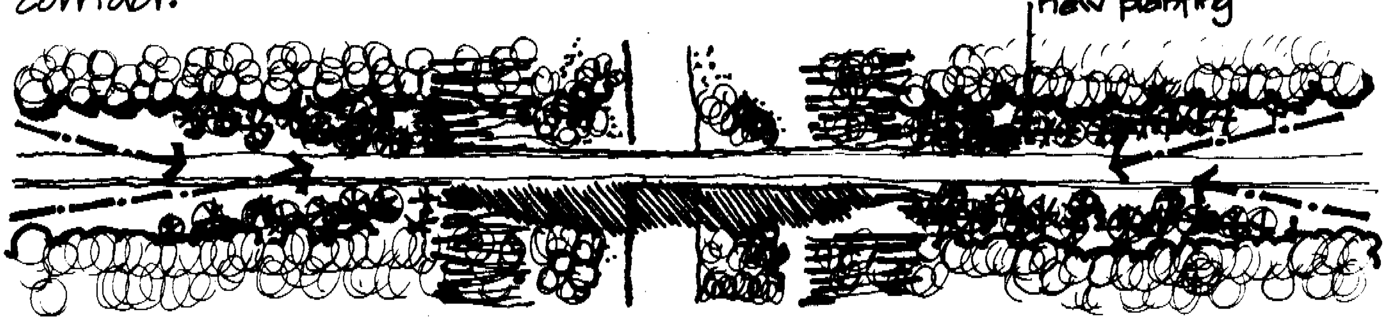
A Passing from a wide, clear-cut highway right-of-way onto a narrow bridge is an abrupt transition that should be avoided.



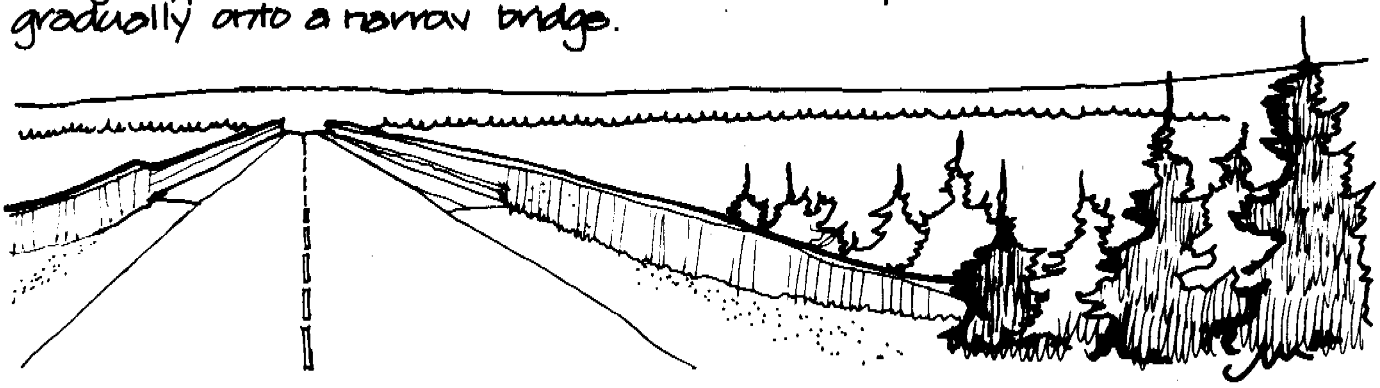
Avoid blunt ends of bridge railings that confront the motorist with an immediate narrowing of the highway corridor.



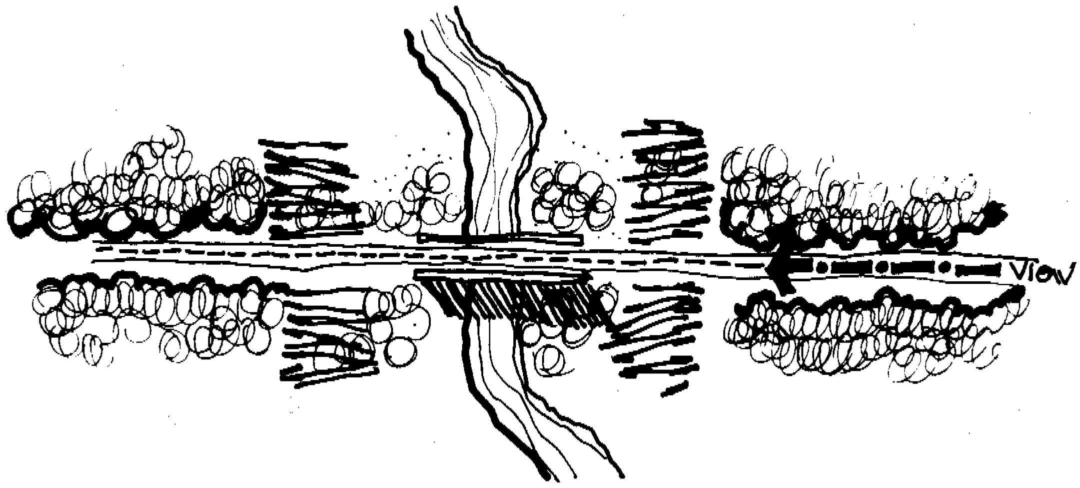
B A gradual narrowing of the right-of-way makes movement onto the bridge a smooth transition from a wide to a narrow transportation corridor.



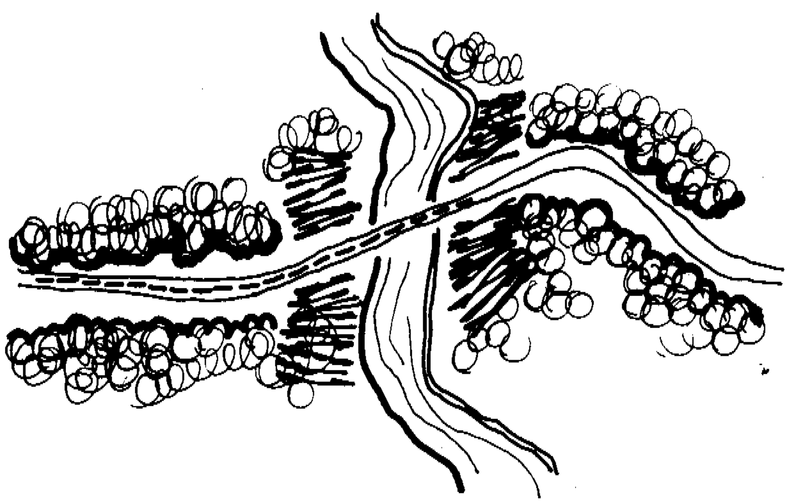
Bridge approaches that tie back into the landscape ease traffic more gradually onto a narrow bridge.

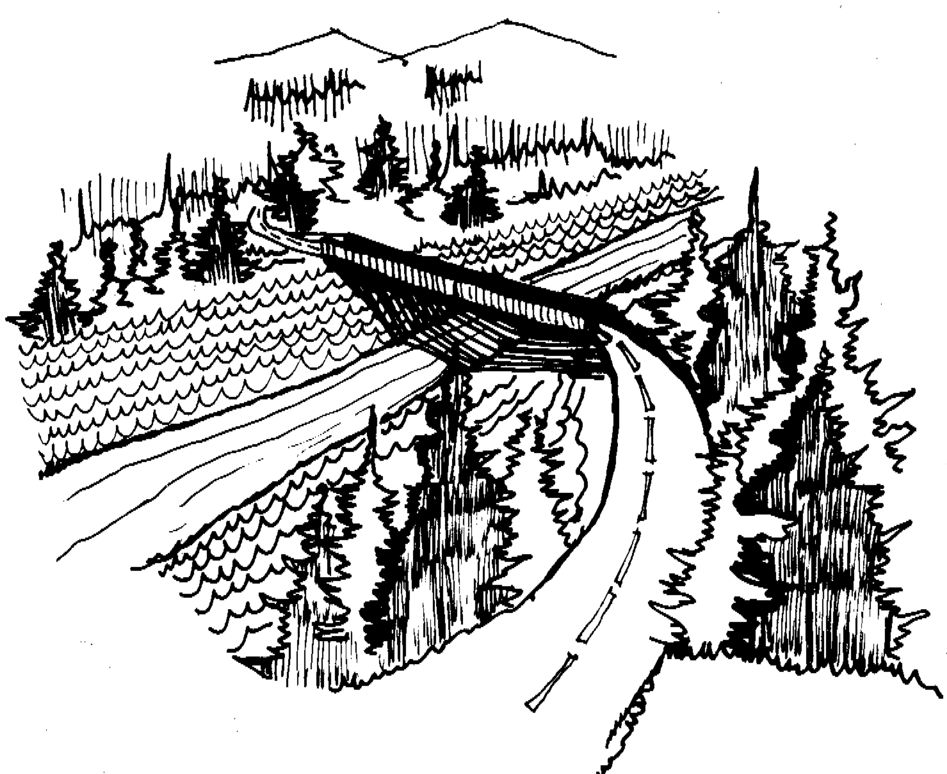


C. Long tangential approaches to river crossings are uninteresting and do not prepare the motorist for a change in roadway.



D. Curvilinear approaches taking advantage of terrain features can provide interest along the highway.

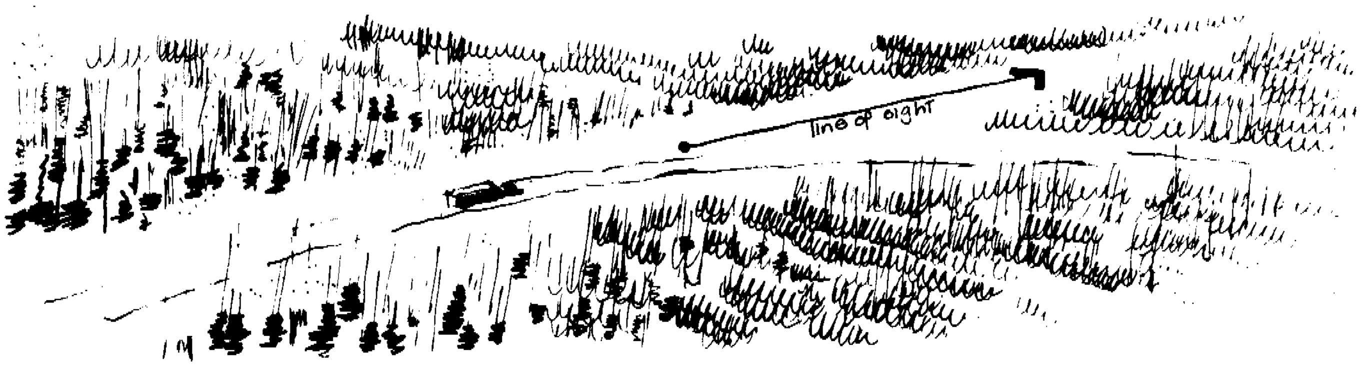




SEISMIC LINE TREATMENT ·DETAIL 4

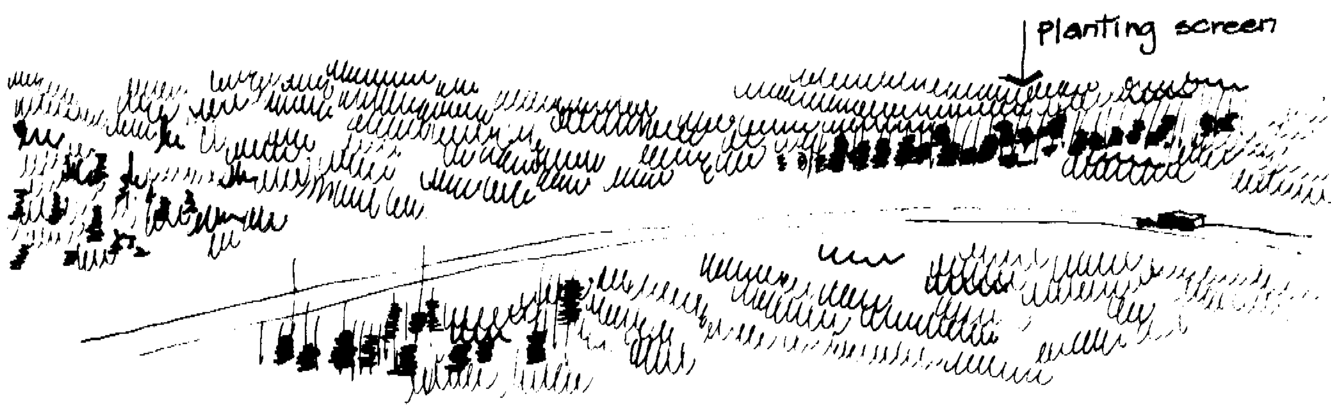
A

Road alignments are occasionally located for short distances along seismic lines. When they turn off the clear-cut line. A misleading divergence of visual alignment and road alignment is created.

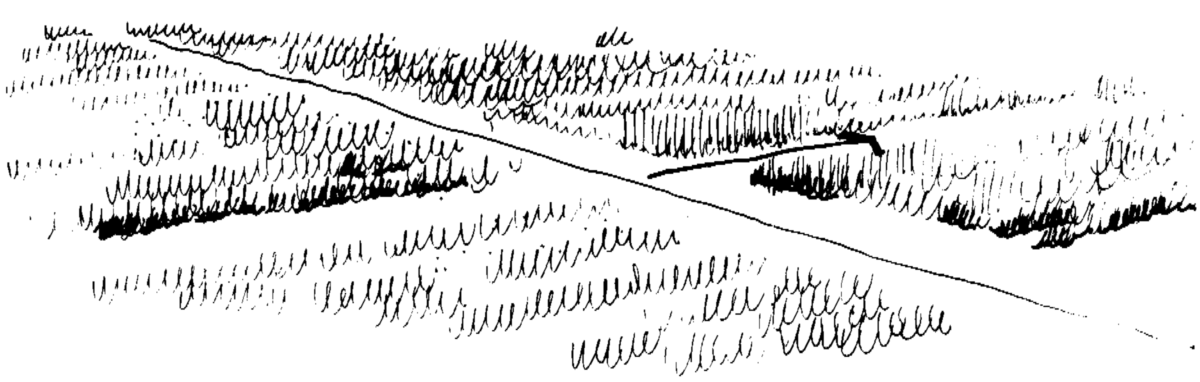


Views along seismic lines that are angular to or are extensions of a road's right-of-way should be screened off by plantings to inforce the road alignment, except when views are of significant scenic potential.

B.



Seismic lines that perpendicularly cross the road alignment have less visual impact on the motorist passing by but they should also be planted to avoid wildlife spotting.



Seismic Lines and Access Roads

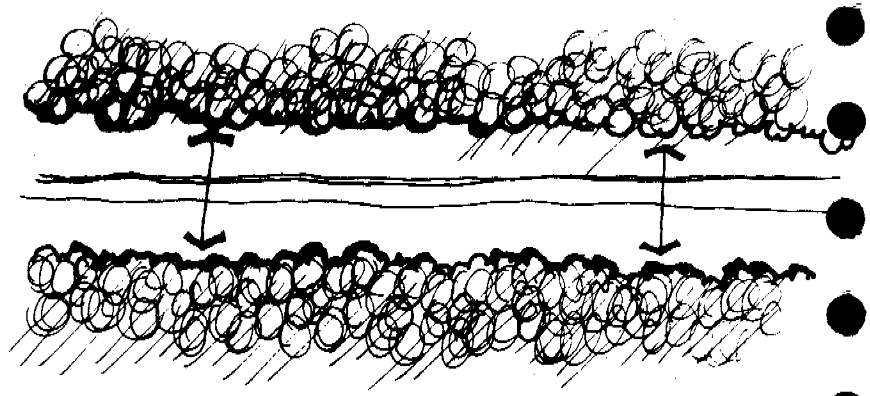
The sharp linearity of seismic lines is particularly disturbing visually within a topography where extreme meandering of streams and rivers occurs (see detail 4). It is recommended that most seismic lines, where they intersect the highway, be treated by methods of selective clearing and planting in order to minimize the visual impact and to also reduce the possibility of spotting wildlife from the highway. Access roads should have 90 degree intersections but within a relatively short distance beyond the right-of-way should curve to eliminate the straight tangential view from the highway and to reduce the effect of spotting wildlife for hunting purposes.

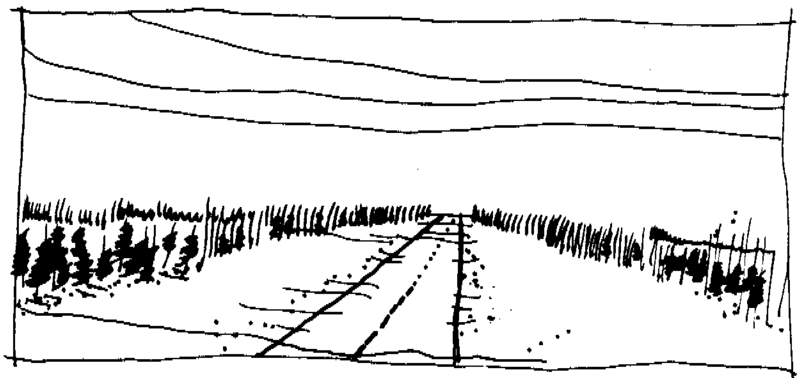
Typical seismic line highway confluence

RIGHT OF WAY MANAGEMENT • DETAIL 5

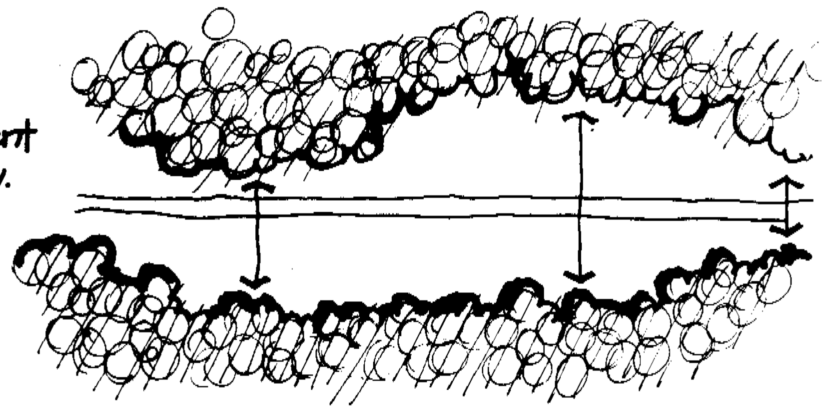
Forest

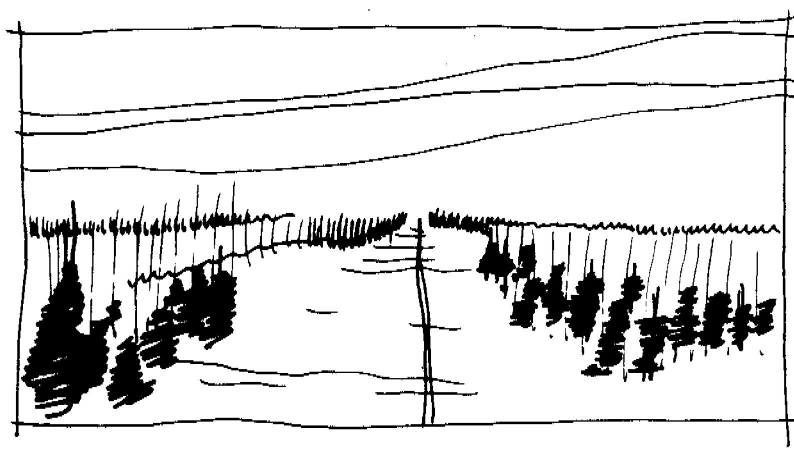
A A clear cut right of way through tree cover should not have rigidly parallel sides that visually reinforce a long, straight, monotonous corridor.





B A right of way with spatial interest should have forest planting setback at different distances from the highway. New rights of way should be cut to create this open and closed spatial sequence. Old clear cut rights of way should be selectively cut and planted to create similiar effects.

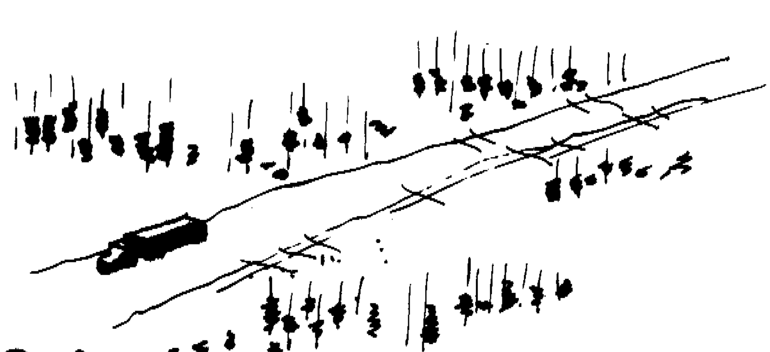




Muskeg

In muskeg dwarf trees, shrubs, and ground covers should be encouraged to advance back toward the road if the right-of-way is already clearcut. This is an extremely slow and difficult process, thus initial clearing of future rights of way should be restricted to only that necessary for construction.

Usual



Preferred

Right-of-way Management

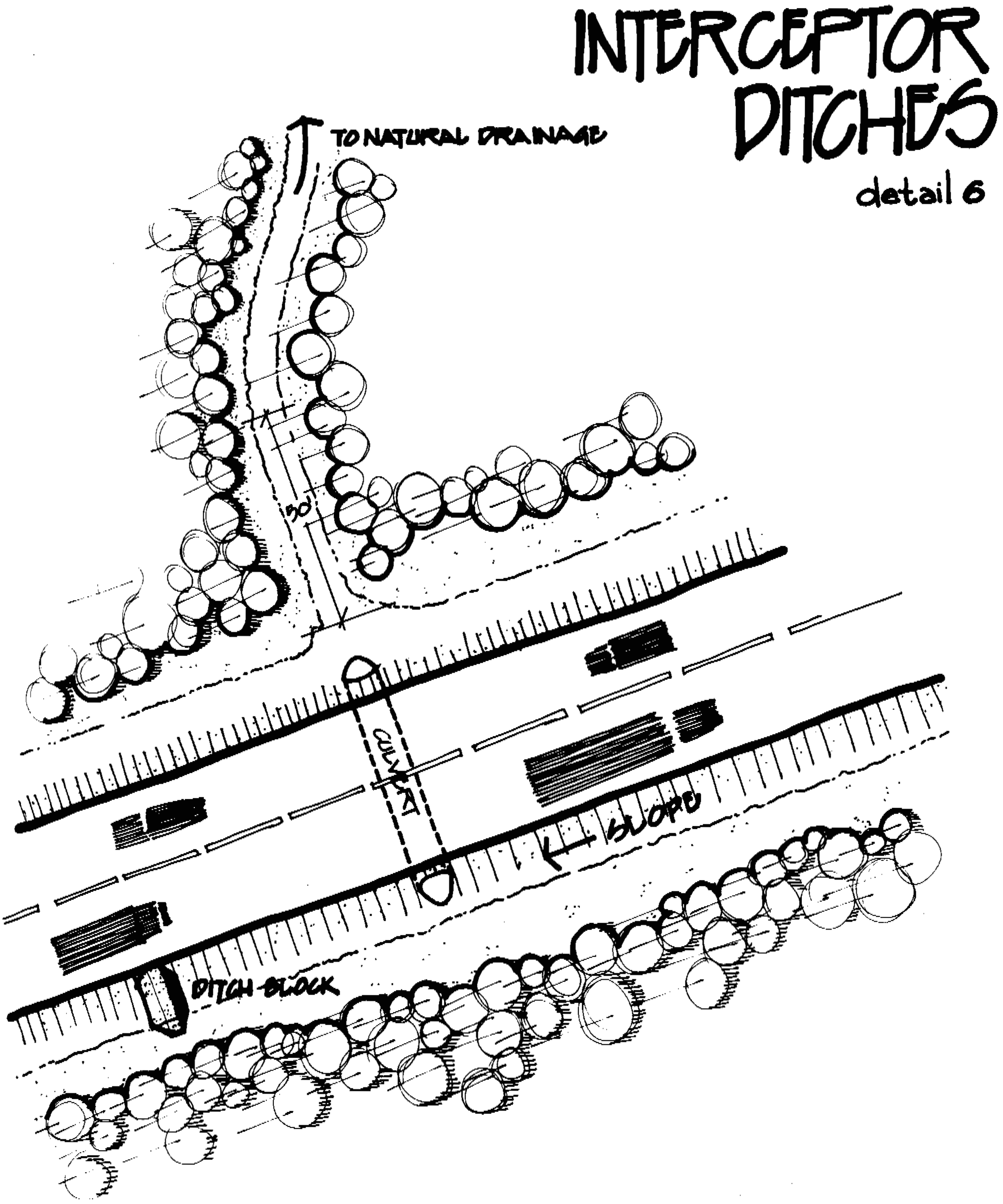
Right-of-way management is defined as control over the visual character of the cleared roadway. The technique of selective clearing has been utilized to some degree on the MacKenzie Highway. In fact selective clearing implies both clearing and planting on a selective basis in order to reduce channelization of the roadway due to parallel treed fringes and to soften corners and provide sight distances without complete clear-cutting practices. (see detail 5) This technique of right-of-way development, combined with curvilinear alignment, can create a pleasant varying experience from the roadway which results in a relaxed and satisfied traveller. The intent of this practice is to create an edge condition which is softened so that it simulates the natural successional edge conditions that occur within the environment through which the road passes. The re-growth rate in this region is relatively slow so that selective clearing, rather than selective planting should predominate. The methods of selective clearing and revegetation are discussed more fully within the revegetation section of this report.

Interceptor Ditches

Drainage ditches, called interceptor ditches, are necessary in many instances to direct water from low points? within the right-of-way into natural drainage channels. The past practice has been to excavate a straight-line trench away from the road in a down-sloping position for a distance of 100 to 150 yards. The excavation from the ditch is normally piled into windrow on one side and the general appearance of the untreated ditch and the straight alignment is visually disturbing on a minor scale. It is suggested that where necessary these ditches be taken at right angles to the highway for a short distance beyond the right-of-way and then curved into the natural terrain so that there is a visual break in the ditch alignment and that within the right-of-way and within the sight distance from the highway the excavation be cleaned and tapered so that it will revegetate naturally (see detail 6). Care must be taken to

but it's hard on the back

place these interceptor ditches so that they drain into natural drainage patterns adjacent to the roadway. In particular where the road approaches the banks of the Liard River or steep banks adjacent to other streams the creation of additional water within drainage courses can cause significant erosion and subsequent sloughing of steep banks. If at all possible, the drainage from the interceptor should be dispersed into natural ponds, low-lying areas, and should not be channelized directly to riverbanks (reference: Stability of River Banks and Slopes Along the Liard River and MacKenzie River, N.W.T. by J. Chyurlia, 1972). A minimum amount of clearing adjacent to the interceptors should be conducted.



Slash Disposal

Within the constructed portion of the right-of-way the disposal of slash (duff disposal) has been accomplished by physically pushing at close intervals, (500 yards) piles of slash and rubbish into the treed edge of the right-of-way. Due to the linear and straight, treed edge of the right-of-way, these small intrusions are visually disturbing. Although they are small individually, the number and frequency of occurrence becomes a very distracting aspect from the road. There are several solutions that might be considered for this condition: Firstly, that all slash and cleared material be disposed of within the right-of-way by burning, burial or mulching. Due to the thin, fragile soil mantle existing within this region, mulching is a favourable solution in order to provide soil stability and compost for future soil development. This technique has not been utilized within the North where in fact its advantages are large relative to the possible costs involved. There presently exists industrial equipment capable of mulching and rototilling all but the largest growth within this area.

Stabilities

Some concern over slope stability relative to stream embankments should be expressed on the basis of a report "Stability of River Banks and Slopes Along the Liard River and MacKenzie River, N.W.T." by J. Chyurlia 1972. In this report two basic types of failure were identified; surficial sloughing of riverbanks and rotational and transitional failures involving a large amount of slope material. One such rotational transitional slide occurred on the Liard near the confluence of the Poplar River in 1969. Accelerated [Active] bank erosion through vegetation removal or concentrated water courses should result in failures. Care should be exercised over placement of the road or facilities too close to steep stream banks. Removal of vegetation should not occur and right-of-way drainage should be dispersed into the natural system.

Hydrology

The hydrology studies for the stream crossings were conducted and reported on by UNIES Limited. A review of these reports displays numerous small stream crossings which are adequately handled by the use of culverts.

The report also recommends a number of bridges as listed below:

	Location	Remarks
1.	65 + 80	20 foot span
2.	424 + 80	Skewed 40 foot span
3.	454 + 00	20 foot span
4.	572 + 20	20 foot span
5.	640 + 00	20 foot span
6.	729 + 20	20 foot span
7.	884 + 00	20 foot span
8.	Poplar River	Existing culverts--bridge recommended
9.	1388 + 70	20 foot span
10.	Birch River	140 foot span
11.	Blackstone River	4 span, 300 feet
12.	3539 + 80	2 span, 120 feet
13.	Netla River	2 span, 130 feet
14.	Muskeg River	600 foot bridge

From the fisheries point of view the Poplar, Birch, Blackstone, Netla, Muskeg Rivers have an importance in supporting spawning and feeding areas for fish species within the region and bridges at these locations are endorsed for that reason.

Although not surveyed by the Hydrology Consultant or sampled by Synergy, Bovie Creek could be an important stream supporting a known domestic fishery within Bovie Lake. It is suspected that fish feeding areas up Bovie Creek are quite likely; in view of this, consideration of a bridge at this location should be given.

Within Section II several other locations for bridges are suggested, based upon difficult cuts and fills.

REGIONAL INFLUENCES

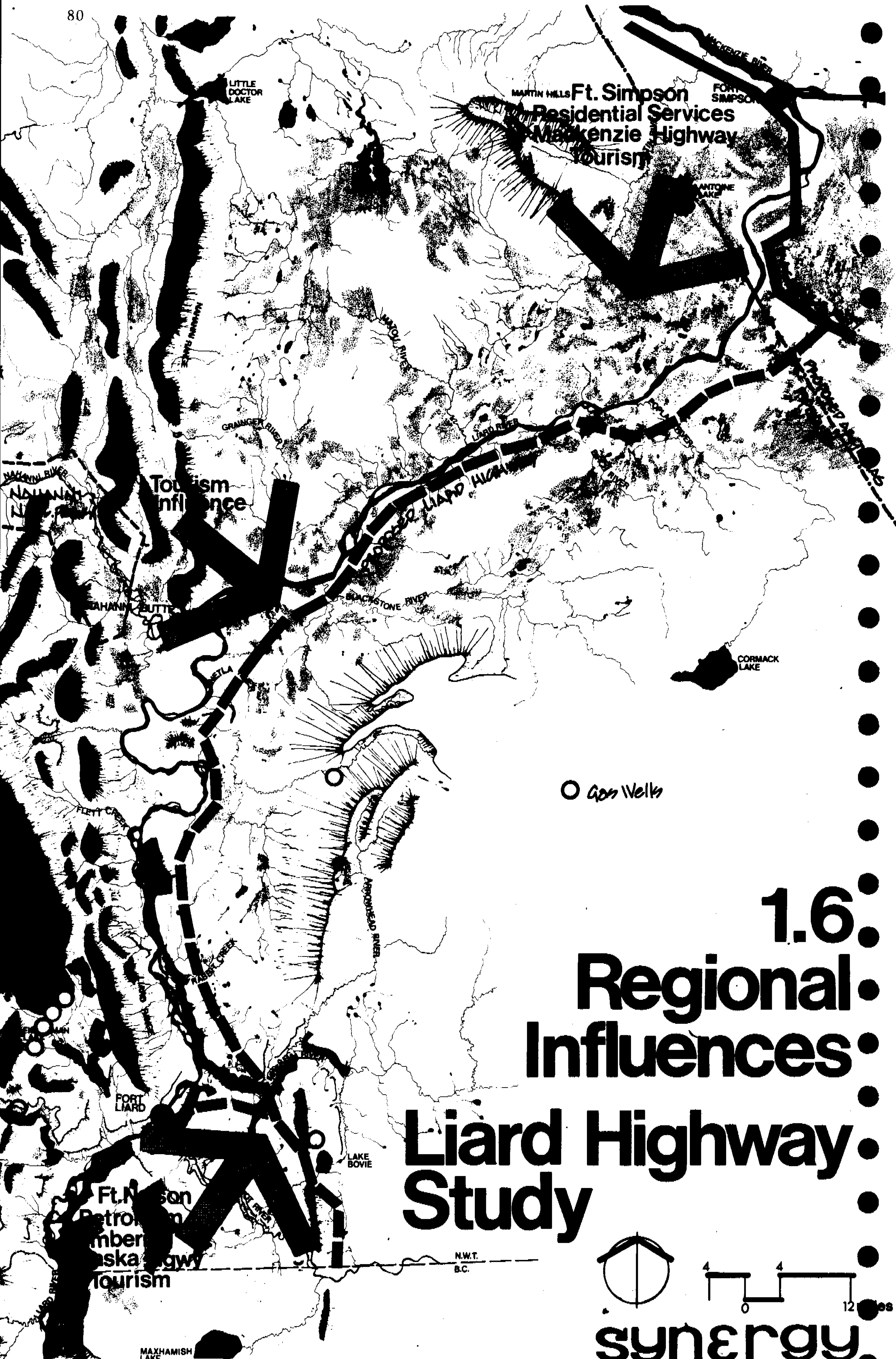
This report section is intended to place in perspective the pressures on the natural environment due to development potentials that will be released upon completion of the highway. No attempt has been made to predict when such developments might occur.

Non-renewable Resources

The study area falls within the Nahanni Mining District of the Northwest Territories under the jurisdiction of the Territorial Government seated in Yellowknife.

There are no active oil, gas or mineral sites presently operated in this section of the Liard River Valley. However, nearby exploration, gas plants and mines have utilized two transportation routes which pass through the area. The Liard River has provided a barge route from Fort Simpson and the Poplar River Landing, and the Old Fort Simpson Trail (a winter road) has also been used for transportation of supplies and equipment. This latter route runs almost due south from Fort Simpson to the British Columbia border. The two transportation routes have been used by companies involved in the Beaver River Plant located on the northern border of British Columbia, and the Pointed Mountain Gas Field which lies approximately 20 miles northeast of Fort Liard. Some exploration of copper deposits has been made along the Liard River near the Matou River. The cost of transporation is a major factor affecting the companies utilizing the present transporation routes. They have indicated that they will take advantage of the Liard Highway upon its completion.

It can be expected that an increase in exploration and extraction will result from the reduction in transportation cost. The effect of access roads and seismic activity on wildlife and vegetation must be considered.



1.6 Regional Influences

Liard Highway Study

synergy

Forestry Resources

Original field work was not done to determine forestry potentials. Reliance was placed upon previous study, air photos and casual observations during air flights.

At the present time there are no major logging operations active in this section of the Liard River Valley. A small sawmill was operated until 1930 near Sawmill Mountain (opposite Mile 90) and the closest active sawmills are presently located at Fort Simpson and at Fort Nelson.

The most important tree species for forestry in the Liard River Valley is the white spruce (Picea glauca). This species occurs throughout the area in both pure and mixed stands, but is found mainly in the MacKenzie Lowlands especially on the recent floodplains of the southern section of the Liard River between Nahanni Butte and Fort Liard. It is these stands on the recent floodplains which have the greatest potential for logging activity (Slaney and Company 1969), due to a combination of accessibility, coniferous stand volumes and forest growth (Jeffrey, 1964). The second most important forestry areas are the mixed wood stands growing on the terraces and floodplains, and the white spruce forests of the intermediate floodplains. Forestry management of these areas will likely be based upon a coniferous saw-timber economy. An inventory of forestry resources has been made by F.F. Slaney and Company (1969).

Apart from inundations of the recent floodplains, fire is the most significant influence on forest growth in the Liard River Valley. A serious, prolonged and extensive series of fires occurred in the region during the summer of 1942. The majority of Brule vegetation found throughout the valley is a product of these fires. As previously stated, the area with the highest potential for forestry operations also falls in the same area as the soils with the greatest capability for agriculture, and also in the major wildlife wintering zone. The construction of the Liard Highway will provide access to this area and hence could, through logging, reduce valuable winter shelter for such big-game species as moose. However, with careful and controlled exploitation of these resources, perhaps by using mosaic cutting, minimal effects could be made on the moose population. In fact during regeneration periods the habitat may be imprcved somewhat as feeding areas for the moose. However, it must be stressed that no matter how abundant the food resources are, moose require adequate shelter during the winter period, and during extreme inclement weather, particularly in late winter. Shelter requirements may take precedence over food requirements for adequate energy conservation.

Access during logging operations should be planned and controlled so as to minimize the access for hunting (during the winter and fall periods), particularly in the areas bordering the Liard River.

The primary forestry area lies west of Fort Liard and the Petitot River. This area contains the bulk of cutable saw-timber in the region and falls outside the highway study area. The second most important area occurs on the mid-channel islands and on the banks of the Liard River. Although dispersed in pockets these areas are economic because logs can be floated and boomed on the river. However, these areas are also important for wildlife and if forestry operations are established would be visually disruptive to river travellers. The loss of merchantable timber from the highway right-of-way is slight.

In the 1969 Slaney report the viability of a forest products industry was proven and the strong possibility of a manufacturing plant at Fort Liard was proposed. The effect of such an industry on this community would be very significant.

In the Proceedings of the Intergovernmental Seminar held at Inuvik, N.W.T. June 1972, the following statement was recorded:

> "The forest resources in the Territories' half of the MacKenzie Basin are centred in the Liard River and Slave River Valleys. Initial estimates place the N.W.T. volume of merchantable

> timber at 2.0 billion cubic feet, and it is probable that resource will be harvested once transportation facilities are suitable and economic."

A large portion of this resource occurs in the Yukon and British Columbia.

It appears, therefore, that the access provided by the Liard Highway may accelerate development of a forest industry. The environmental impact of logging can far outweigh the impact of highway construction.

Transporation

The closest rail head to the study area is presently at Fort Nelson, however, an extension by the Pacific Great Eastern Railway is now under study to Nelson Forks, 60 miles from Fort Liard. The possible extension of this railway into the Fort Liard area and possibly as far as Fort Simpson could be reasonable in the forseeable future based on the forestry potential within the area and the service to Fort Simpson as a regional distribution centre.

The MacKenzie Highway is complete past the intersection of the Liard Highway and thus, with the completion of the Liard Highway to Fort Nelson, effectively forms a loop in the southern portion of the Territories which will realize additional transport and tourist traffic. The impact of this traffic on the region will be that requiring service facilities in order to control use.

Tourism and Nahanni National Park

The development of the Liard Highway will effect a convenient link for travel between the MacKenzie Highway and Fort Nelson, British Columbia, and thus should provide a high potential usage by tourists. Considering the importance of the Liard River as an historical route for the early traders, it would appear that an interpretive program could be developed at suitable locations along the highway describing the activities of the prehistoric indians. Preservation of historic and archaeological sites from despoilation is imperative. Fish and wildlife resources also provide potential for interpretive amenities.

In addition to the above, the Nahanni National Park will probably be one of the largest single attractions for tourists to this area.

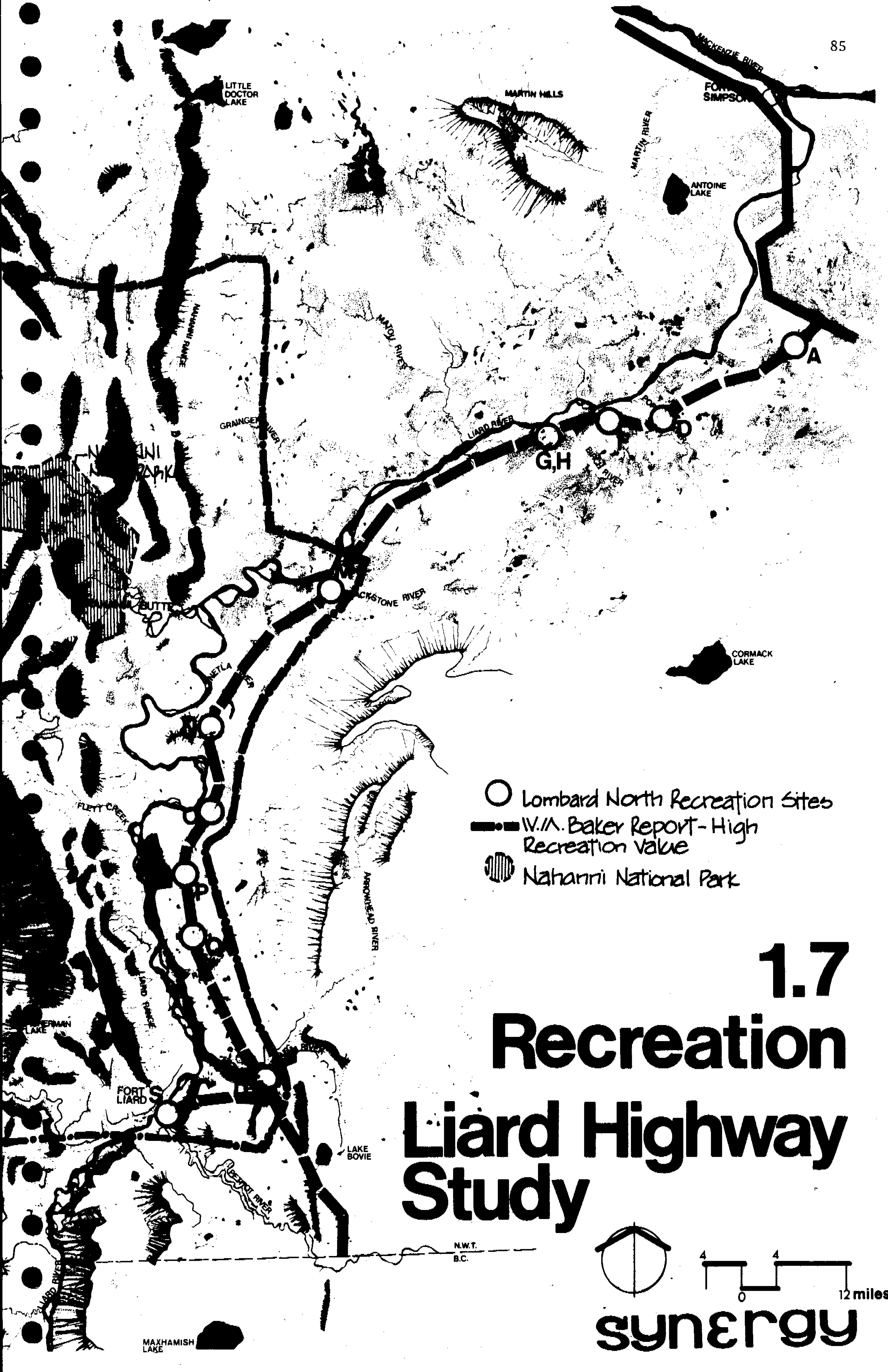
Nahanni National Park is a 1,840 sqare mile wilderness area surrounding the South Nahanni River. This park is infamous? due to its wild river nature, its rich historical character, the existence of hot springs and the major Virginia Falls. Already the park has proven to be of high recreation potential from the point of view of white-water canoeists. However, it is imperative that strict control is required of canoeists to the park, to ensure that only adequately outfitted and experienced parties be allowed to travel the South Nahanni River and its tributaries, owing to the dangerous nature of the waterways. The park also offers the opportunity for jet boat trips up the South Nahanni River to the spectacular Virginia Falls. Currently three outfitters conduct these trips by boat from Fort Simpson or Nahanni Butte, and with the increased access provided by the highway this traffic could increase. Future access to Nahanni Butte from the Liard Highway should also be given very careful consideration to minimize environmental disturbance and to ensure that access is not provided to areas with high game populations, thus seriously reducing their potentials.

Consultation with the National and Historic Parks, Planning Branch, has determined that access is being considered seriously at this time. The detailed plans (Section II) indicate the preferred junction point for this access for consideration in final planning. This location is suggested on the basis of the least impact.

Recreation Activities

Map 1.7 displays a number of identified recreational tourism points, based on previous study by other consultants.

The following is a listing of primary and secondary sites from the



1.7 Recreation

Liard Highway Study

synergy

Lombard North report.

Secondary A	-	Scenic view point and roadside picnic site
Primary D	-	Development complex, camping and picnicking
Secondary F	-	Camping and picnicking along river access trail on the upper bank
Secondary G,H	-	Picnic sites access to Birch River
Primary M	-	Camping and picnicking best on north river bank
Secondary N	-	Picnic site, access trails, scenic corridor along highway
Secondary O	-	Viewpoint, roadside picnic site
Secondary P	-	Firetower, viewpoint, access to scenic trail along Liard River
Secondary Q	-	Roadside picnic, access to trail along edge of Liard River
Primary R	-	Camping and picnicking
Primary S	-	Development complex, camping and picnicking.

These recommendations have been considered and have been incorporated where suitable.

Another report by W.M. Baker delineates an area of high recreation value encompassing the highway from Mile 65 to Mile 140.

The techniques utilized to determine recreation potentials have not been conventional planning techniques of overlay or matrix analysis, since these were considered too sophisticated for the amount of detail available within this region. However, it is appropriate, based on the available detail, to choose preferred sites for recreation development, based on the visual survey, transportation logistics, and a general knowledge of tourism characteristics and demands. There is very little hard data available with which to do definitive recreation planning. Therefore, the concepts developed have been based on subjective analysis and past experience.

Extensive passive recreation activities such as highway travelling (sight-seeing), demand visual integrity in preserving a natural landscape vista for the traveller. In recent years, it has been common to develop a limit of vision or a visual corridor which is protected aesthetically. The detailed maps within Section II indicate the approximate limit of visual experience as perceived from the highway right-of-way. It would be reasonable as a minimum, to define a visual corridor of sufficient width to incorporate this limit of vision and to provide protection to that limit.

Along the corridor there are points of interest, based upon breaks in topography, viewpoints, river crossings, changing views, opportunities for fishing, canoeing and camping, archaeological and possibly paleontological sites, which may be interpreted into a series of educational opportunites.

The protection of other values, i.e. archaeology, wildlife, fish, can be maintained to a certain degree by placement and provision of recreation facilities.

The multiple use of sites should be considered. For example, an original construction site could be planned to be finally developed into a campground, rest stop, picnic site, etc. In conjunction with locating recreation facilities, it has been recognized within remote northern regions, that emergency facilities for shelter during extreme winter conditions should be provided along highways approximately every 30 miles. These also can be identified with recreational facilities.

In keeping with the natural aesthetic character of the region, it is suggested that construction of facilities be done with traditional log-building techniques. This is a durable, warm construction method, suitable to the capabilities of local craftsmen. Most materials are available on site; logs for building and sphagnum moss for chinking.

SECTION II

DETAILED PLANNING CRITERIA AND ENVIRONMENTAL ASSESSMENT

This section provides the working data to enable the final detailed design considerations of the highway and also to provide the basis for future detailed land planning adjacent to the highway so that orderly development and control of land use may prevail in the future. The study area has been broken into fifteen segments, based on aerial, mosaic photography. The data displayed is a compilation of that determined throughout the study process. All data is not shown. Only those areas considered critical to construction and use of the highway have been noted. The column - "Development Recommendations" - is the guide for final highway engineering to adapt and incorporate the requirements to satisfy natural physical, wildlife, visual and user requirements.

The present highway may also be conveniently broken into three reasonably distinct portions. Firstly, that portion which is constructed from the MacKenzie Highway to the Birch River crossing, approximately 31 miles. Section two that from the Poplar River to the Blackstone River, a distance of about 46 miles, which has a 100 foot cleared right-of-way. Thirdly, the section from the Blackstone to the Northwest Territories/British Columbia border, which has a combination of hand-cut and machine-cut centreline. In dealing with these three sections, the recommendations and assessments have been based upon; in the first section relative to rehabilitation and modification of the existing right-of-way in order to primarily improve the visual aspects of the highway and to prevent off-highway access into construction areas, seismic cuts, etc. Within the second section there is a larger degree of control that might be exercised over construction activities through the judicious placement and operation of borrow pits, slash deposits, and right-of-way maintenance. Finally, the third section allows for minor realignments and essentially complete control over right-of-way development and construction proced - ures in order to satisfy all factors involved. The development recommendations, therefore, apply in context to each of these sections.

Complementing the detailed maps are a series of design sketches and notes depicting methods of treatment for visual aspects and physical development, such as recreation points, river crossings, and right-of-way treatment.

Recommendations are directed towards the variety of problems defined along the highway. Many of the recommendations can only be implemented directly in the field by qualified individuals relative to the particular aspect under consideration, i.e. the extent of planting and the extent of selective cutting would be best determined on-site by a landscape architect or a technician trained in this subject. This section primarily provides the directive towards detailed on-site construction.

REVEGETATION

During the course of studies on the MacKenzie Highway and the Arctic Gas Pipeline, consultants and Public Works Canada conducted a series of germination trials and revegetation trials within conditions similar to those experienced along the Liard Highway. The extensive analysis done for the Arctic Gas Pipeline has provided a knowledge base adequate to recommend certain revegetation procedures.

On the maps within this section areas critical for revegetation are noted under Development Recommendations. The choice of these areas has been based on soil type, slope, soils stability, and aesthetics. It should be noted that observations along the first 30 miles of the highway indicated that after a period of two years, natural revegetation had become well established. This was evidenced by poplar growth which had attained a height of 30 to 36 inches. A variety of broad-leafed weeds had also established. The rate of natural revegetation appears to be adequate in many areas. Stable soil conditions may be all that are necessary to allow for adequate regrowth.

The highway region is essentially out of the permafrost area and thermodegradation would not be expected. The following grass species are recommended for seeding: Boreal Creeping Red Fescue, Frontier Reed, Canary Grass, Nugget Kentucky Blue Grass, Blue Joint, and Meadow Foxtail.

Site Preparation

1 Remove duff layer. In most cases this would be automatically removed during construction of the right-of-way

2 Scarify the seed bed. This can be done after final grading by harrowing, preferably longitudinally across slopes, to prevent surface erosion. This roughening has also been done by the use of cross-tracking by caterpillar equipment, which provides small seed pockets due to track configuration and lugs.

3 Certain friable soils, subject to wind erosion, may require mulching. A straw mulch is preferable. However, within right-of-way development along the highway, it is expected that pockets of organic material may be uncovered and these should be salvaged for mulching and top dressing purposes.

Seeding and Fertilizing

The amount of fertilizer is recommended to be maintained at the absolute minimum required to assist germination and establish growth within the first year. A continued program of fertilization is not recommended. Nitrogen and phosphate in a mixture of 3 to 1, applied at the rate of approximately 100 pounds per acre, appears to be applicable within this area. Urea is the best type of nitrogen fertilizer and should be utilized beacuse of its greater economy. A seeding rate of 50 pounds per acre should provide an adequate catch. This rate may be reduced if tested seed is used. Custom mixtures and application rates may be necessary for specific sites.

Plantings

To avoid mechanical shock in transplanting, it is recommended that hydraulic transplanters be used for tree species. The extent of transplanting required to shield seismic cuts, etc. is beyond any reasonable hand-planting methods. This also allows the transplanting of larger tree stock, which we suggest be in the 6 to 10 foot range. Smaller stocks for slope stability can be hand-planted. Recommended stock is white spruce, jack pine, wild rose, and willow.

Application Methods

The methods of application and planting are known to Public Works. It is, however, recommended that large tree stock be mulched and that irrigation be provided during the first year. The replanting in the field must necessarily be detailed by a qualified landscape architect.

FIRE CONTROL

The construction of the Liard Highway has the effect of increasing the land value per acre for many uses, including forestry. Consequently, the cost per acre of value for fire suppression also increases, due to the change in a fire problem from natural lightning to fires created by the public using the highway system. The Territorial Government is therefore faced with a changing fire concern and a decision as to the degree of suppression must be made. Along certain areas of the highway, the decision to fight a fire or not is important. The critical timber area appears to be from Mile 95 to Mile 157, whereas the remainder from (0 to 95), is of lower value. Most timbered stands occur on mid-channel islands of the Liard River, or along the banks of the Liard, and little merchantable timber is on the low-lying table land. Pre-suppression techniques or insurance policies are expensive, and not a popular method of spending public funds. Pre-suppression by controlled fires is still experimental, and would appear to be premature for this area. Public safety and economic aspects of fire control should be integrated with wildlife needs related to seral vegetation.

There presently exists one fire tower at approximately Mile 104, which would appear to cover the first portion of the best timbered area. Decisions on further fire protection remain with the Territorial Government.

Fire Control During Construction

The following suggestions are made to minimize the causes of fire and to allow early control of fire created during construction.

1 Winter clearing and burning, if at all possible. Clearing is more easily done during winter months when forest stock is frozen. However, the trees are normally sheared off at ground level, leaving the stumps and trash on ground surface to be removed during summer construction. Winter clearing may be burned in early fall or late spring, when snow cover still exists. If at all possible, summer clearing should be stock-piled until snow conditions in the fall. If summer burning is found to be necessary, it should be done in accordance with fire/weather conditions - i.e. no wind, high relative humidity. Light fires in the late afternoon or evening, and patrol to watch for holdover ground fires, particularly in old, dry muskeg areas, where peat deposits may exist.

2 Assuming reasonably large amounts of cut and fill within the first 95 miles, duff and humus layers may be disposed of in thin layers within the roadbed proper. Avoid pushing duff or humus layers into standing timber and avoid windrowing or mounding of wet debris and/or mounding of wet debris and covering with dirt, since, if a fire generates within these conditions, extinguishing is very costly.

3 Allow sufficient room between standing timber and burning piles to avoid scorching and to provide maximum protection. Cut and fill slopes should be limited, and a minimum of vegetation should be encouraged for slope stability, preferably low-growing grasses and shrubs.

4 Note should be taken of the Cladonia moss or Caribou moss, which occurs in black spruce, muskeg areas. This is very sensitive to relative humidity and contributes to the rapid spread of fire. Identification should be reported.

General Fire Equipment Required During Construction

1 Provide 300 gallon to 500 gallon slip-on tanks, mounted in trucks or skid-mounted to be pulled behind equipment. Pumps, i.e. John Bean, can be obtained with the slip-on tanks or power pumps and hose can be included with the water reservoir. Each construction crew working independently should be provided with this system.

2 A supply of hand tools, plus the water equipment, should be with the burning crews at all times.

3 Road equipment should be on hand with radio contact with the Forest Service for any required assistance.

4 Construction crews should be provided with a training program in fire techniques and prevention measures.

Contractors and the Forest Service should maintain close liaison to discuss burning procedures, regular joint inspections, and permit systems, or other control measures required, especially during the fire season. A penalty clause might be considered on all contracts in order to promote care and control and avoid unnecessary negligence.

necessary negligence is OK?

Fire Control After Construction

The following suggestions are made for the control of fire after completion of the highway. These suggestions are subject to the overall government policy with regard to fire concern.

1 Sign the highway. Consider cost benefit of fixed education system along the highway route, at least during the high fire hazard period.

2 Media coverage and other public information systems. Encourage public reporting of fires.

3 Careful recreation planning with adequate sources of water in low fire hazard areas.

4 Consider summer establishment of ranger headquarters at Nahanni Butte and Fort Liard. Radio equipment for road maintenance crews might be considered and lightning incidence should be studied and patterned.

5 Consideration of summer fire crews established at the major recreation camping areas. These crews may also serve a dual purpose in public assistance and information and campground maintenance, as well as fire protection.

6 Determine the level of fire bombing surveys and helicopter support from Fort Simpson and Fort Liard. A centralized dispatch system controlling air movement and manpower support could be established in both areas.

7 Establish safe water pick-up points at lakes along the highway for float aircraft - i.e. DeCanso.

8 Fire ecology with regard to wildlife effects should be part of the management plan.

WASTE DISPOSAL

The control of all wastes is important to prevent pollution, avoid wildlife conflicts, and for general appearance. Historically, housekeeping at construction camps has been notoriously poor. The temporary nature of the location does not engender responsibility and respect.

The following suggestions are made towards minimizing effects of waste disposal.

1 Sanitary Waste

Lavatory waste, wash water, and kitchen water can be dispersed through a tile field. Fields should be located so that dispersion is completed away from natural drainage courses.

Water closet waste - Public Works Canada has tested a variety of water closets from vacuum to propane. It is suggested that the individual incineration water closet or humus toilet is most applicable, since the amount of maintenance is minimum and the disposal of ash is insignificant.

2 Solid Waste

Burning of burnable solid waste, excepting plastics and rubbers, is suggested. This should be done on a daily basis. Small commercial propane fired incinerators are available, which can also accept kitchen waste. For small crews, a simple burning barrel, equipped with a screen spark arrestor, may be sufficient. Burning should occur late in the day, when wind is normally low and light conditions allow supervision. unclear

Unburnables should be collected and buried in old borrow areas that are removed from natural drainage courses.

3 Oils and Greases

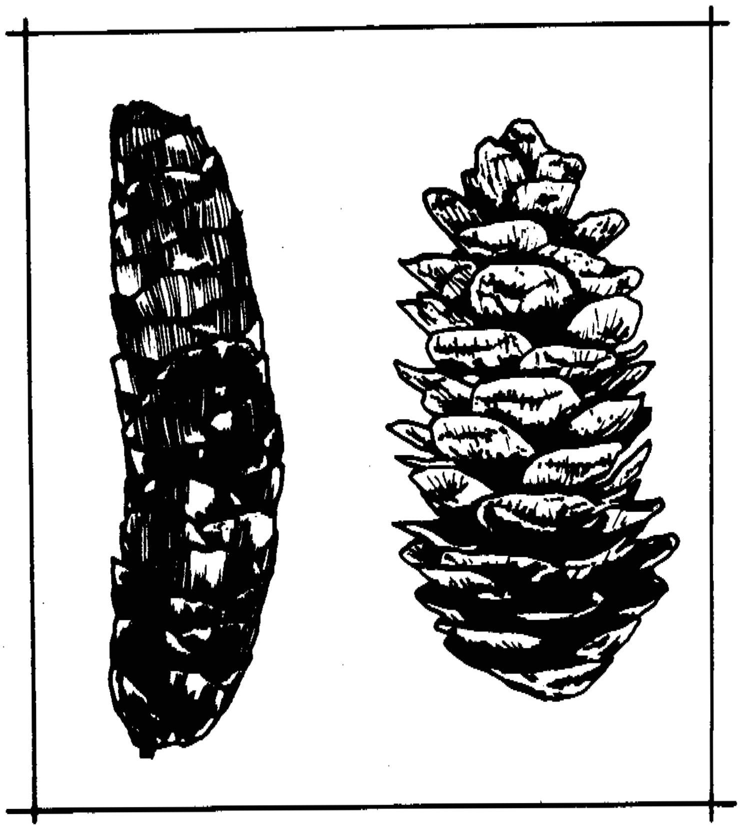
All used oils and greases should be recovered. Much of the construction equipment is serviced on-the-spot, and used oil and grease disposed on the ground. Contracts should require the recovery of all used oil which could be collected at a central location (i.e. Fort Simpson) and then transported to the nearest recycling plant (Edmonton-Turbo Resources) It is expected that the cost of collection and delivery will be offset by the purchase price. Forty-five gallon drums are the most convenient method of handling.

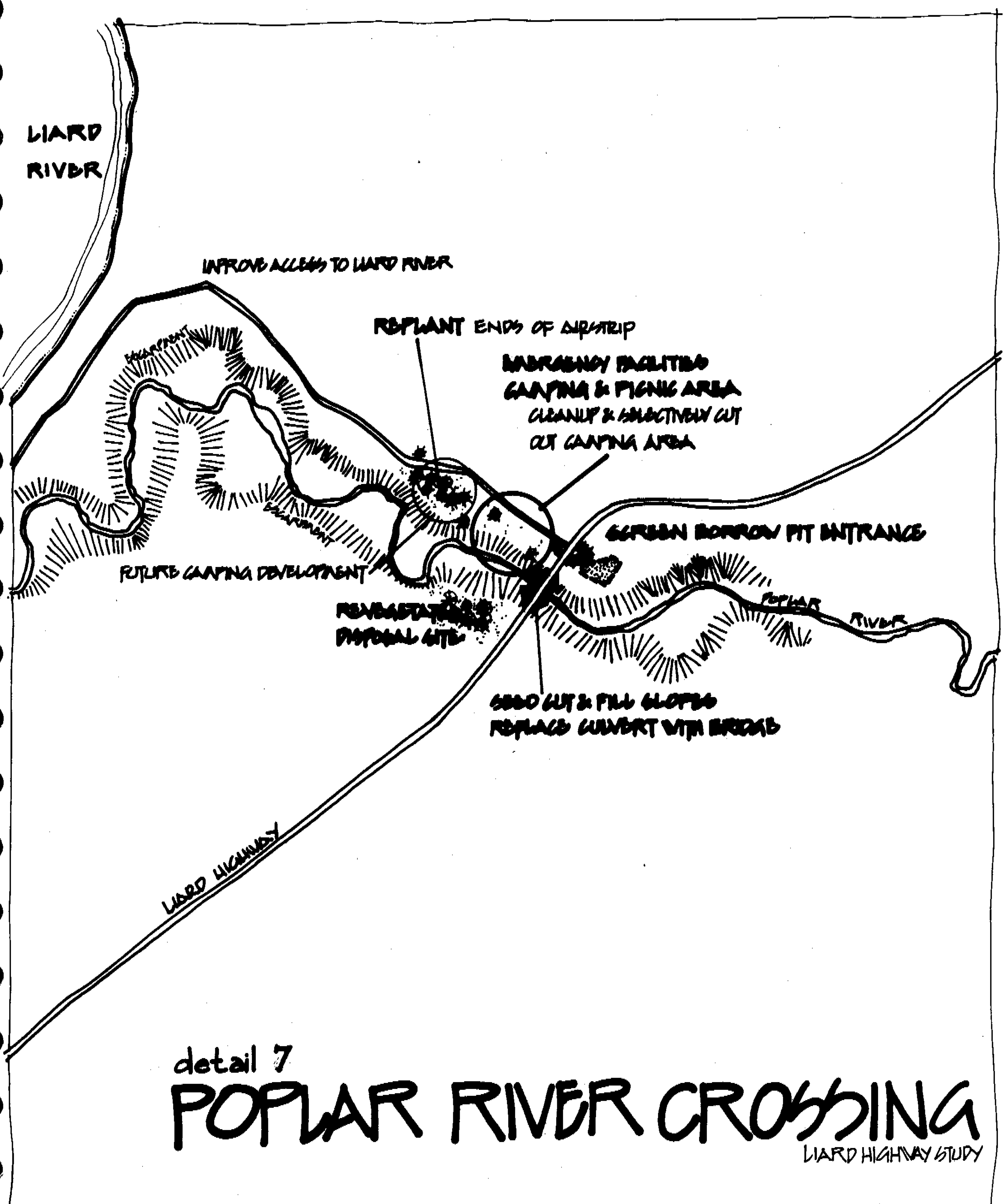
4 General Housekeeping

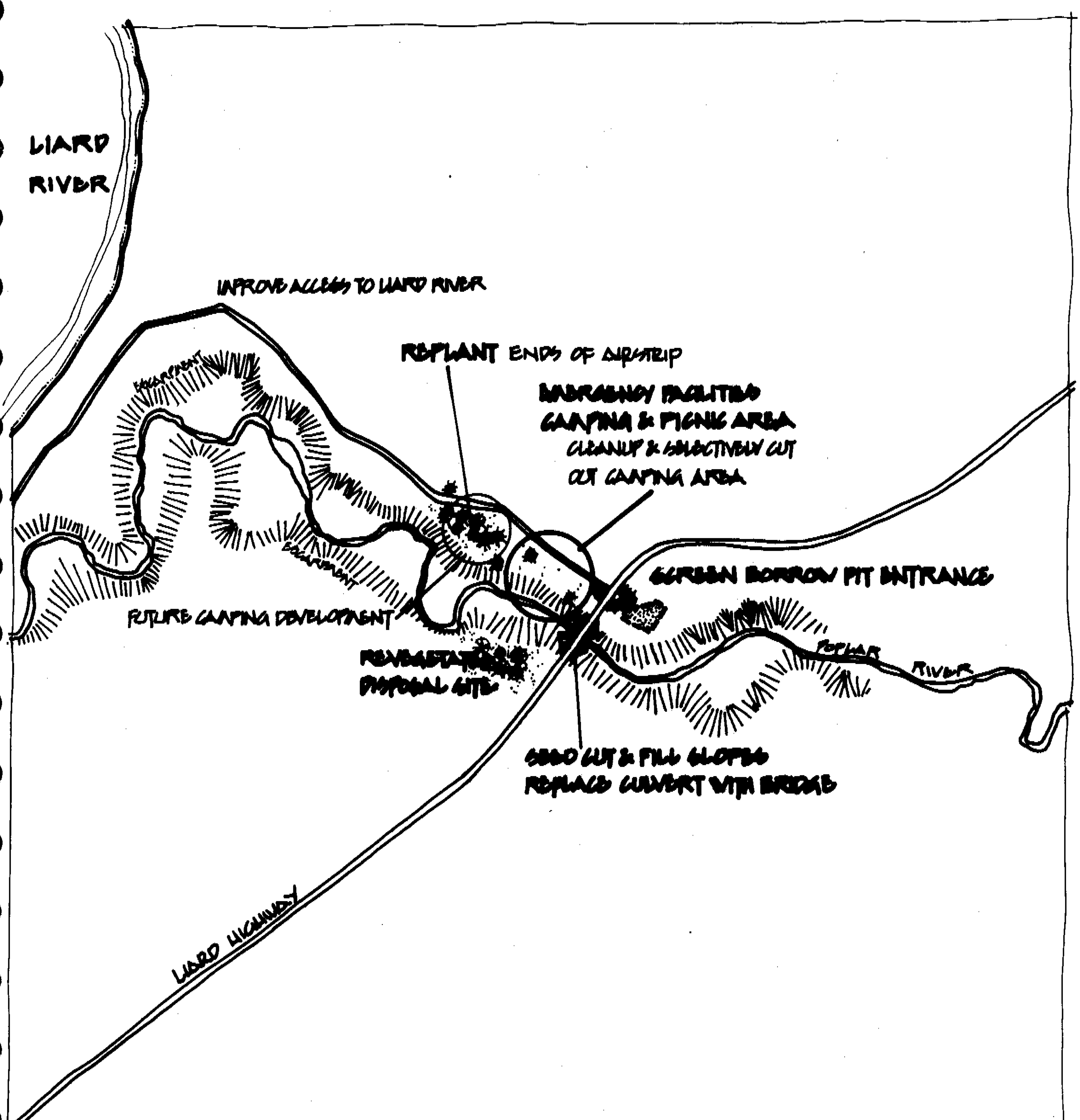
Upon completion of a camp, all unnatural materials should be removed. Holes, pits, piles should be filled or spread toward the natural contours.

5 Pesticides

Any form of general pesticide suppression should be avoided. Personal applications are preferred.



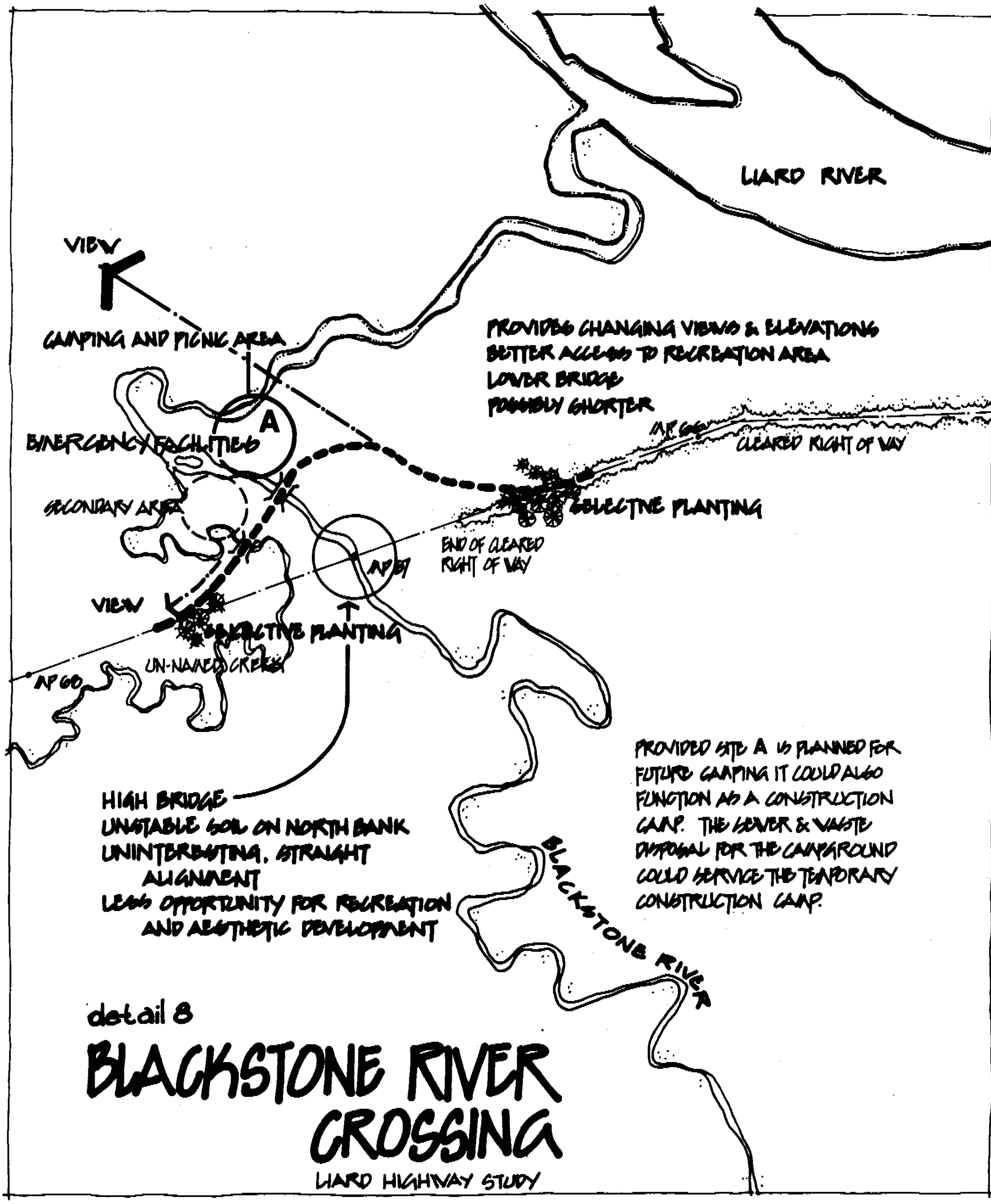

LIARD RIVER
IMPROVE ACCESS TO LIARD RIVER
REPLANT ENDS OF AIRSTRIP
EMERGENCY FACILITIES
CAMPING & PICNIC AREA
CLEANUP & SELECTIVELY CUT
OUT CAMPING AREA
SCREEN BORROW PIT ENTRANCE
ESCARPMENT
FUTURE CAMPING DEVELOPMENT
REVEGETATE
DISPOSAL SITE
POPLAR RIVER
SEED CUT & FILL SLOPES
REPLACE CULVERT WITH BRIDGE
LIARD HIGHWAY
detail 7
POPLAR RIVER CROSSING
LIARD HIGHWAY STUDY

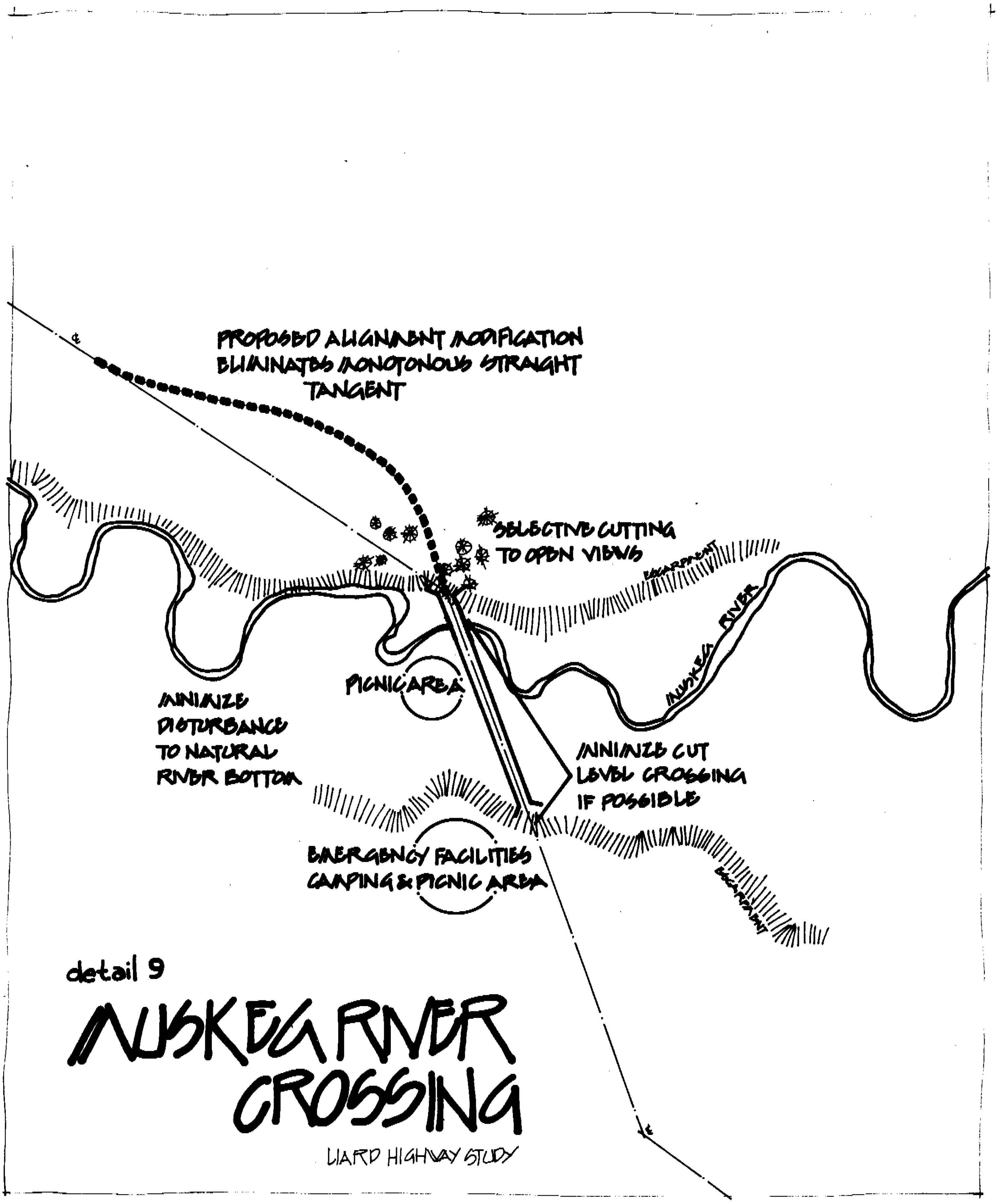


detail 7

POPLAR RIVER CROSSING

LIARD HIGHWAY STUDY


LIARD RIVER
VIEW
CAMPING AND PICNIC AREA
A
EMERGENCY FACILITIES
SECONDARY AREA
VIEW
SELECTIVE PLANTING
UN-NAMED CREEK
MP 60
MP 57
PROVIDES CHANGING VIEWS & ELEVATIONS
BETTER ACCESS TO RECREATION AREA
LOWER BRIDGE
POSSIBLY SHORTER
CLEARED RIGHT OF WAY
SELECTIVE PLANTING
END OF CLEARED
RIGHT OF WAY
HIGH BRIDGE
UNSTABLE SOIL ON NORTH BANK
UNINTERESTING, STRAIGHT
ALIGNMENT
LESS OPPORTUNITY FOR RECREATION
AND AESTHETIC DEVELOPMENT
PROVIDED SITE A IS PLANNED FOR
FUTURE CAMPING IT COULD ALSO
FUNCTION AS A CONSTRUCTION
CAMP. THE SEWER & WASTE
DISPOSAL FOR THE CAMPGROUND
COULD SERVICE THE TEMPORARY
CONSTRUCTION CAMP.
BLACKSTONE RIVER
detail 8
BLACKSTONE RIVER
CROSSING
LIARD HIGHWAY STUDY

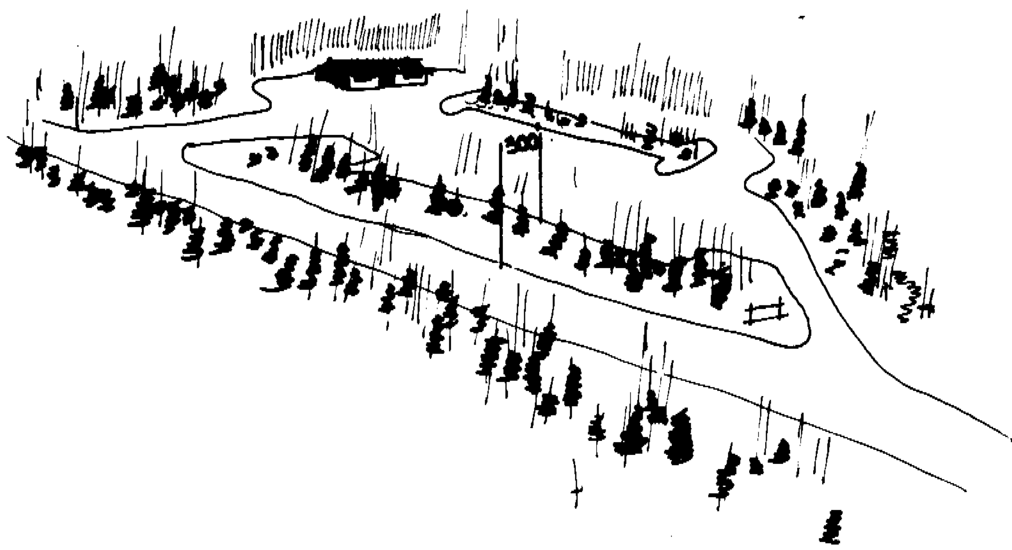

PROPOSED ALIGNMENT MODIFICATION ELIMINATES MONOTONOUS STRAIGHT TANGENT
SELECTIVE CUTTING TO OPEN VIEWS
ESCARPMENT
MUSKEG RIVER
PICNIC AREA
MINIMIZE DISTURBANCE TO NATURAL RIVER BOTTOM
MINIMIZE CUT LEVEL CROSSING IF POSSIBLE
EMERGENCY FACILITIES CAMPING & PICNIC AREA
ESCARPMENT
detail 9
MUSKEG RIVER CROSSING
LIARD HIGHWAY STUDY

REST STOPS • DETAIL 10

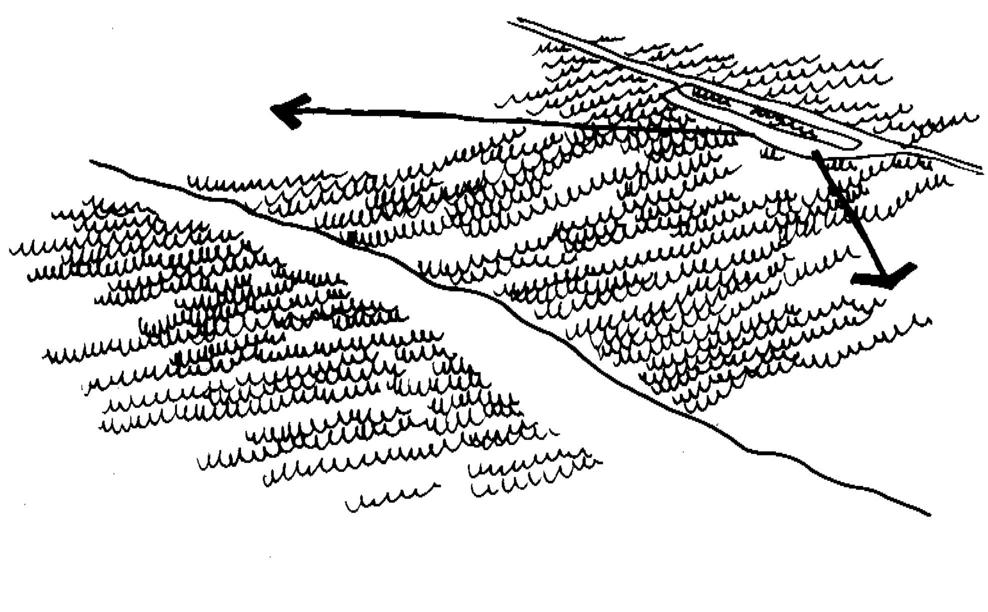
A Roadside turnoffs should be located to provide adequate rest stops.

The interval for spacing would relate both to driving comfort and frequency of occurrence of recreational, scenic features and emergency shelters.

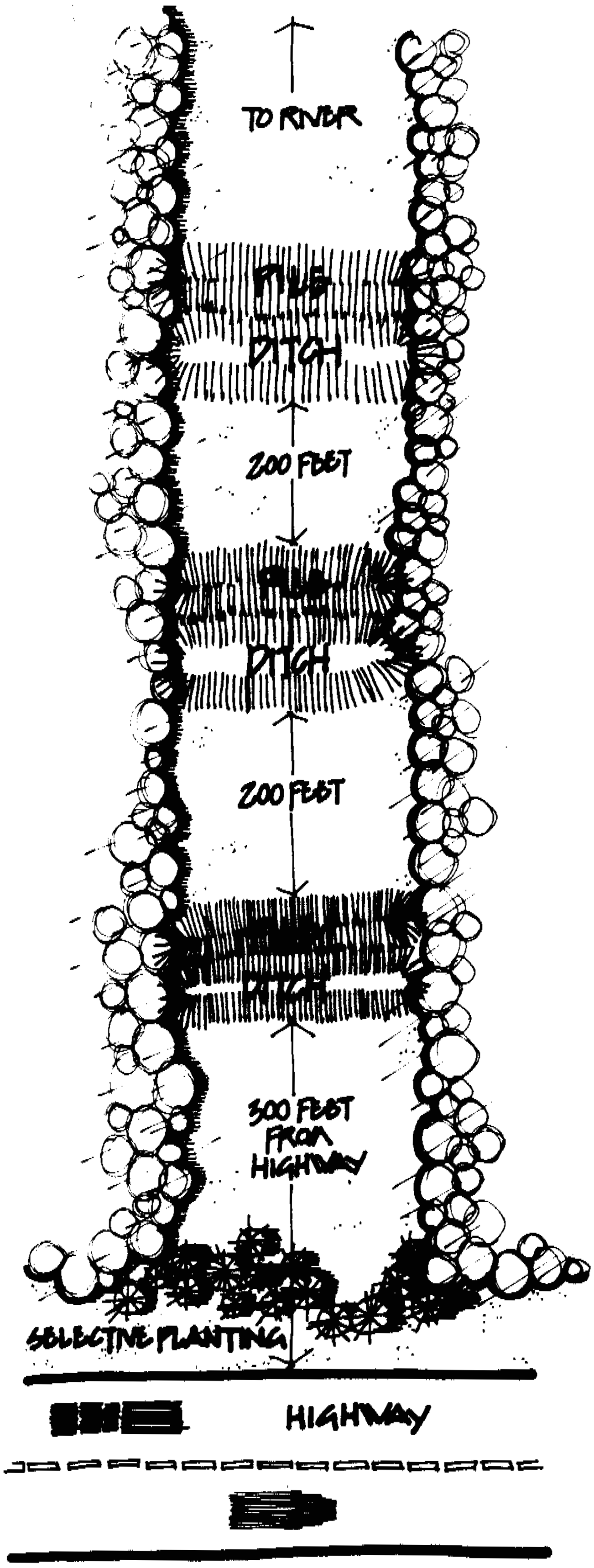
Turnoffs should blend well into the landscape yet remain clearly visible and accessible.

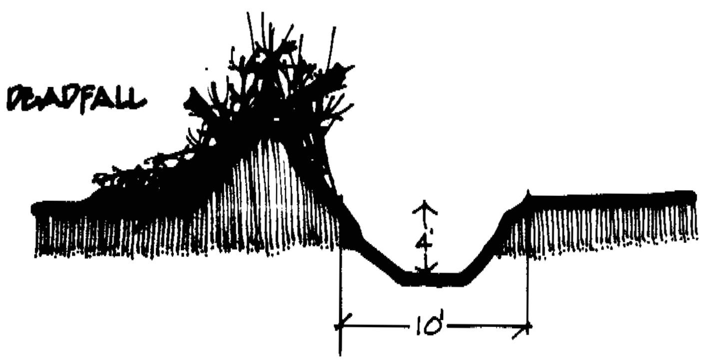


B Roadside turnoffs should also relate to significant scenic features, such as vistas across adjacent lakes, the Liard River and surrounding landscape.



ACCESS BARRIERS TO SEISMIC LINES
detail 11





Liard Highway Study

Legend

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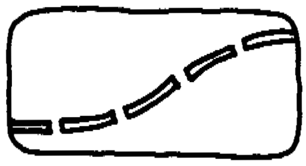
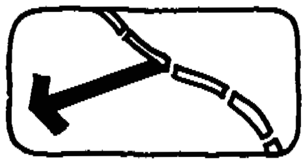
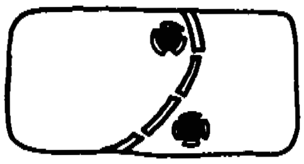
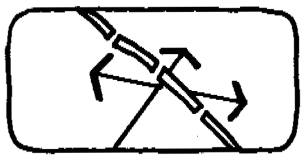
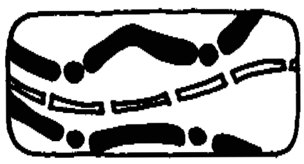
Graphic Inventory

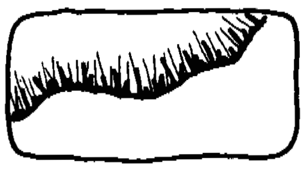

Proposed Liard Highway Right of Way

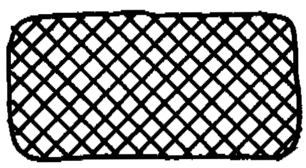

Major open views from the highway.

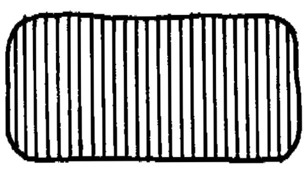

Existing borrow pits created during alignment construction.

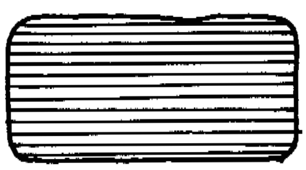

Seismic lines

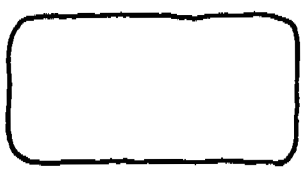

Approximate limit of visual experience as perceived from highway right of way.

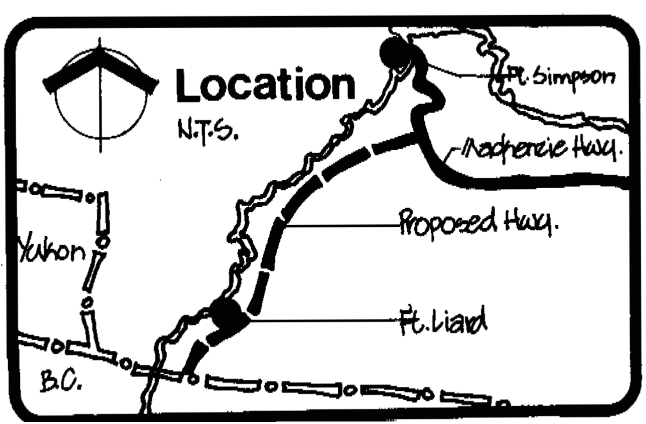

Steep slope.


Coniferous tree cover primarily

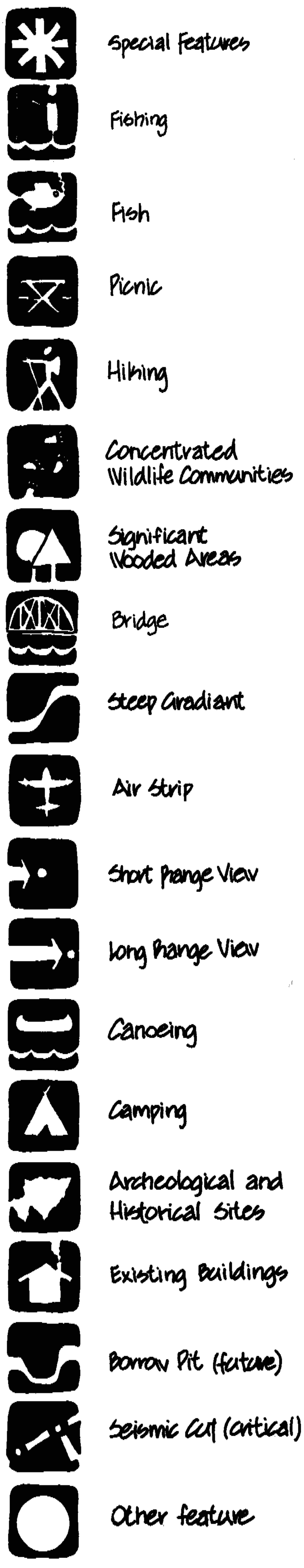

Deciduous tree cover -primarily


Mixed tree cover.


Muskeg.



Factor Symbols



Methodology

For the purposes of this study we have chosen to graphically illustrate those physical elements adjacent to the road right-of-way which offer potential for added user interest or act as constraints to development. It should be noted that, in general, only those elements which occur immediately adjacent to or are perceived from the proposed highway right-of-way have been considered. The factors are scenic features, recreation potential, wildlife communities, archaeological and historical sites, engineering criteria.

SCENIC FEATURES: The character of the landscape, as viewed from the road, has been graphically indicated by outlining the limits of vision as a heavy dashed, dotted line. Within this limit of vision certain major views have been identified as long- or short-range views. The limit of vision feature is intended to provide guidance towards the selective clearing and right-of-way development concepts. It also indicates to some degree the visual experience anticipated by the road user as he travels the highway. The indicated long- and short-range views are points where developed views may be created through selective clearing or minor road realignment.

RECREATION POTENTIAL: These points are identified for their outdoor recreation value such as hiking, fishing, canoeing, picnicking, camping. Only the primary sites have been chosen and indicated for consideration at this stage of development.

WILDLIFE COMMUNITIES: This factor is an indication of concentrations of wildlife for critical habitat.

ARCHAEOLOGICAL AND HISTORICAL SITES: Areas of potential archaeological importance and identified historical sites are noted.

ENGINEERING CRITERIA: The factors identified here are existing eyesores such as seismic lines, borrow-pits, duff deposits. Also identified are minor relocations to take advantage of other aspects. Recommendations for stream crossings are also noted.

Overlying the mapping is an indication of the type of tree cover and an indication of steep slopes or other natural features that bear consideration. Complementing these maps are a series of detailed sketches and recommendations pertinent to typical problems. It should be recognized that not all situations have been covered but that sufficient examples of each case have been provided to establish the format for all situations.

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Study Area

1 ½ 0 2 Miles

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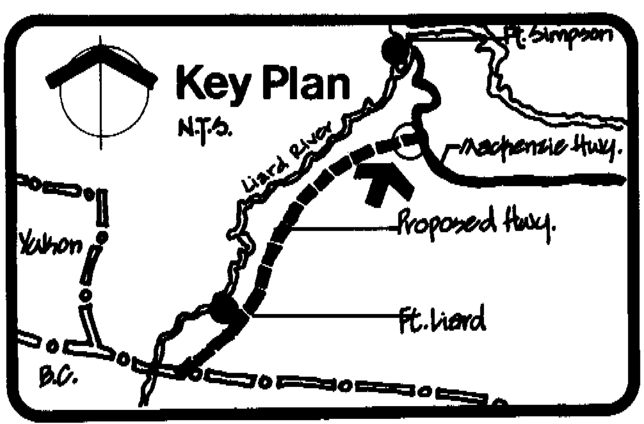

Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch/Hist. Sites | Engineering Criteria

Development Recommendations

- In general seismic lines, borrow pits and duff deposits require attention to mile 32.
- Intersection identification. 24 hour service only ? limit other development. Y-tee intersection suggested.
- Emergency airstrip only, no further development.
- Maintain present maintenance depot.
- See details 2 and 4.
- See detail 2
- Secondary scenic viewpoint and roadside picnic area not applicable (Lombard North)
- See detail 2
- Entrance screens
- Selective cutting and planting. Critical entrance.
- In direct line of sight on corner. Selective planting. Regrade pit to shore narrow tree buffer.
- Bad area, selective planting required. Creek conflicts with borrow pit and seismic cuts.
- Shield entrances. Detail 2.
- Selective clearing to meld in cleared corner.
- Clear cut PI requires selective clearing and planting to blend in.
- Where possible R.O.W. drainage should be directed to old borrow pits which act as silt traps and may revert to semi-natural water bodies supporting wildlife and waterfowl in the future.

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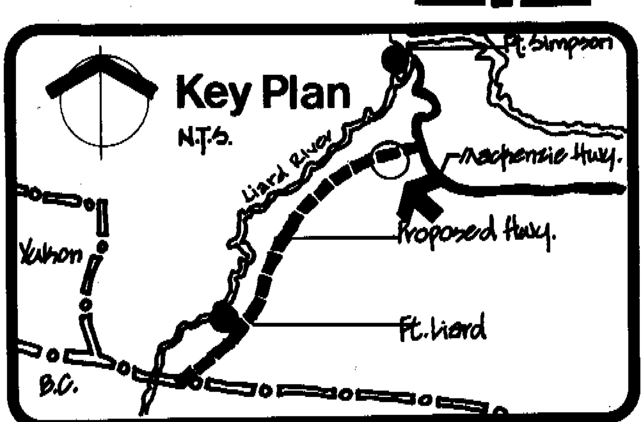
2.2

Key Plan

N.T.S.



Mileage

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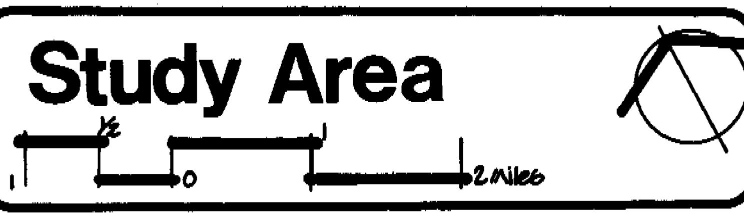
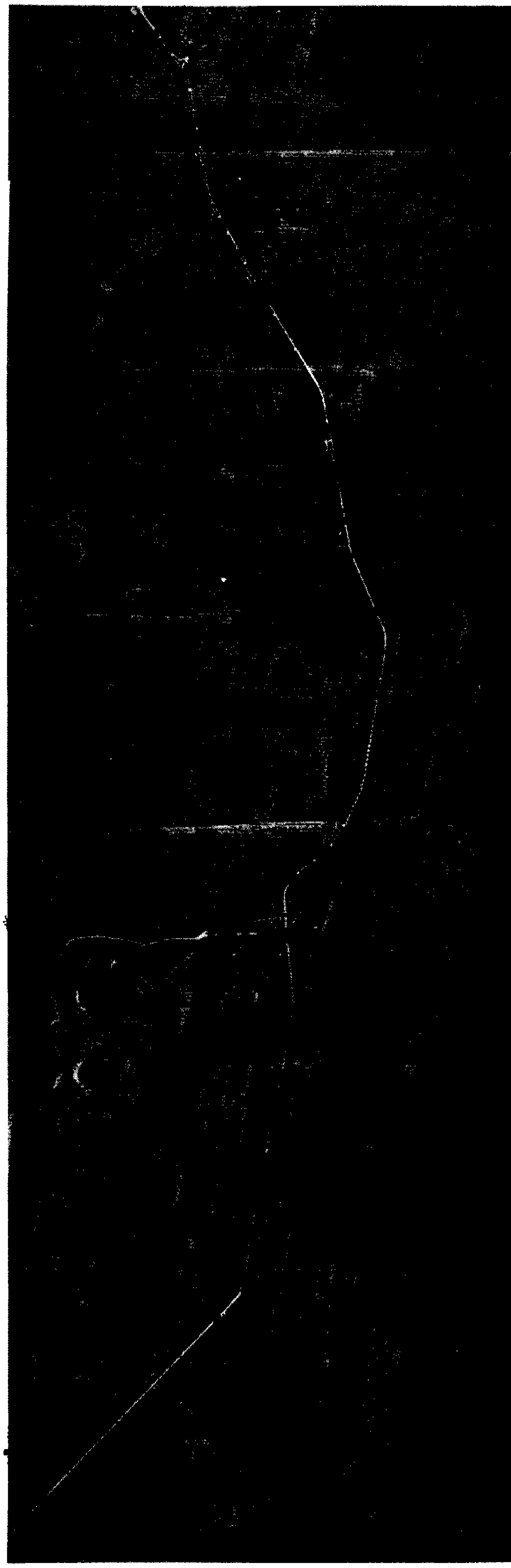
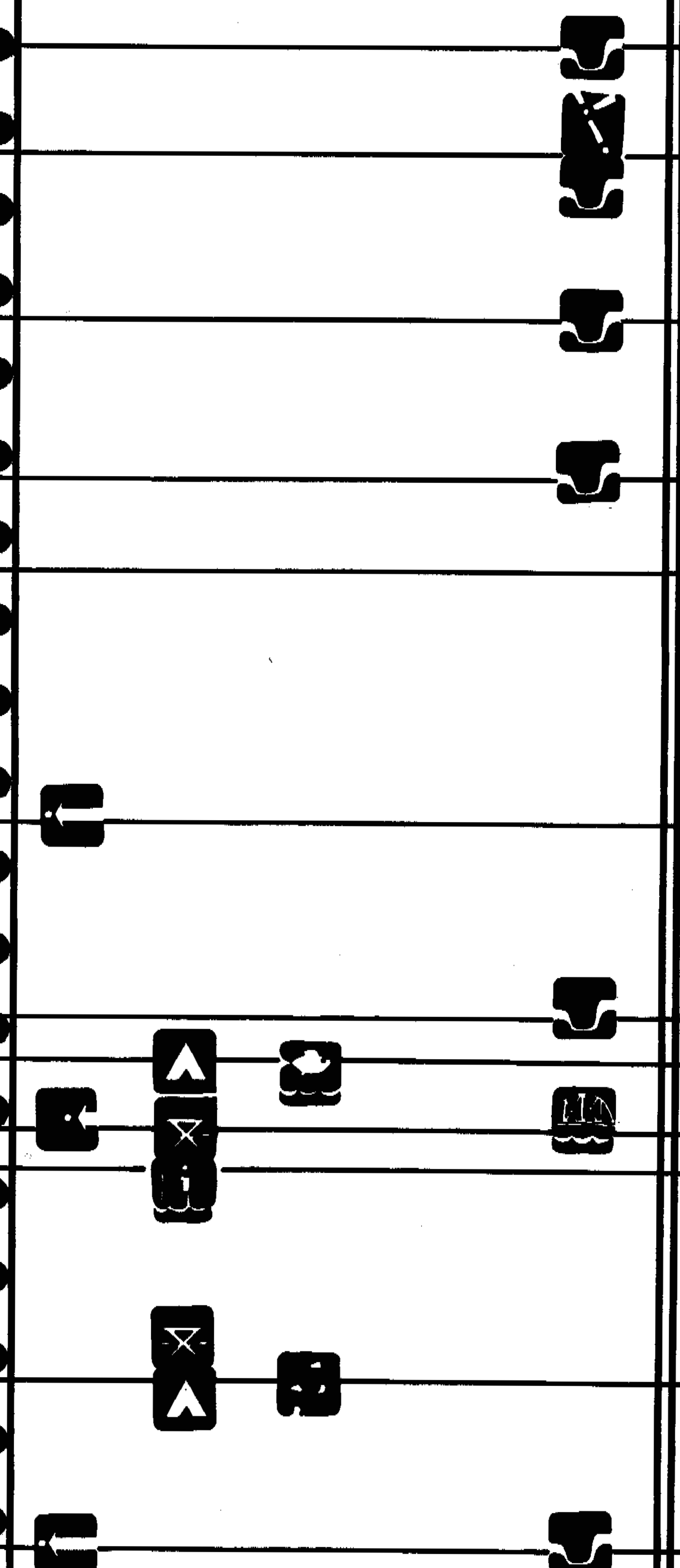
Study Area





Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria



Development Recommendations

- Very disturbing visually. Detail 3.
- Distant planting to screen cut lines very disturbing pit requires large amount of rehabilitation. See details.
- See detail 3.
- Provide new planting associated with rehabilitating borrow pit to alleviate stretch with no view restriction. Detail 3
- Visual shielding of the future pipeline R.O.W. Highway R.O.W. intersection.
- First view of Nahanni Butte, some clearing may improve view.
- Detail 2
- Rehabilitate construction camp into campground.
- A bridge is recommended for the fisheries.
- Develop access to Liard River. Developed viewpoint.
- Extensive revegetation required, Bad disposal site at Mile 21.7 See detail 7.
- Moose migrate across Liard in fall, likely travel route up Poplar River, substantiates requirement for bridge.
- Selective cutting may improve view, screen planting. Detail 2.
- All borrow pits require entrance screening See detail 2.

Liard Highway Study

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2.3

Mileage

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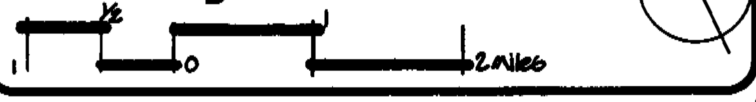
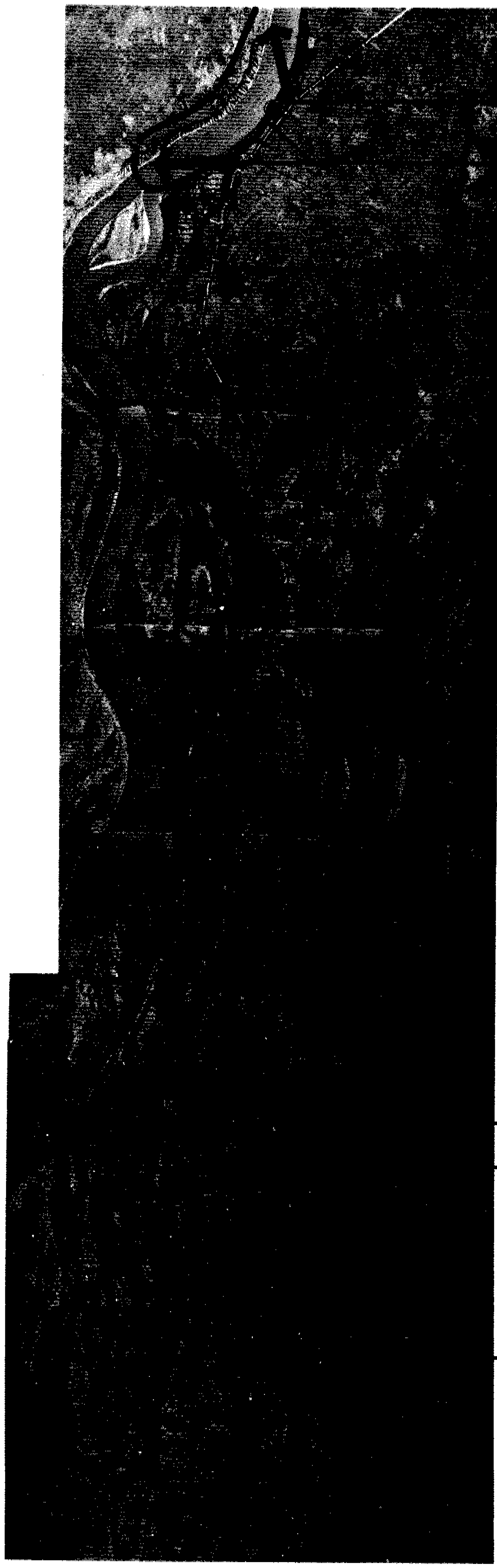
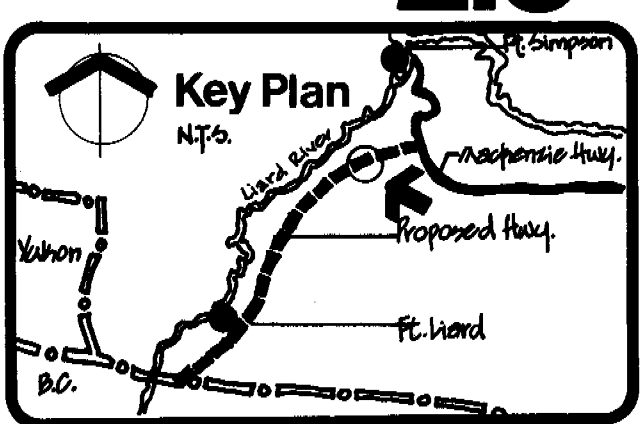
Study Area





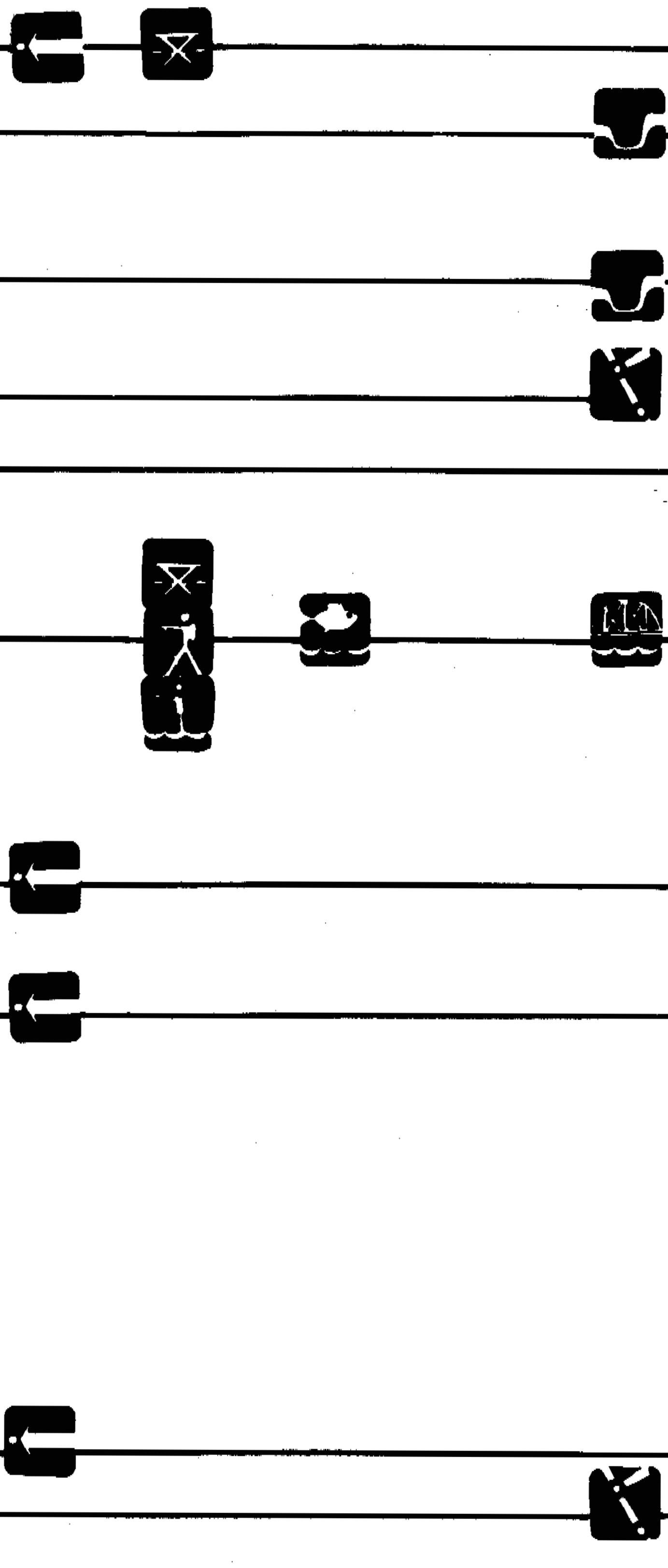
Key Plan

N.T.S.



Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch/Hist. Sites | Engineering Criteria



Development Recommendations

- Viewpoint on escarpment and short hiking trail.

Note: Rehabilitation of borrow pits may be necessary due to possible bank instabilities recommend further investigation. Obvious severe erosion.

- Provide new planting to alleviate long stretch with no view constriction and to rehabilitate borrow pit.
- Mile 31 - Approximate end of constructed road.
- Develop trail (R.H. bank) to Liard escarpment. Viewpoint.
- Possible selective cutting to open views.
- Deep cut slope treatment may be required, revegetation assisted by topsoil and nitrogen phosphorous fertilizer.
- Develop view. Selective cutting.
- Parallel seismic line requires selective planting at intersections.
- Old centre line cut requires entrance screening
- Generally in this area drainage of R.O.W. should be collected (frequently) and dispersed into the natural system. Ditch blocks form effective silt traps and prevents erosion.

3 times a week at least!

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2.4

Study Area

Mileage

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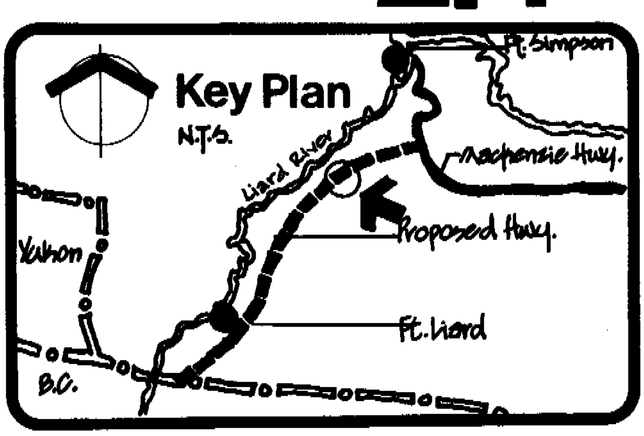

Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch/Hist. Sites | Engineering Criteria

Development Recommendations

★R.O.W. MANAGEMENT CAN BE PRACTISED BY SELECTED CUTTING. DETAIL 5.

- Selective clearing and cutting.
- Numerous difficult seismic cuts or ℄ cuts to shield
- Shield entrance
- Possible borrow of organic material within R.O.W. for top dressing. Fertilizer required to assist revegetation.
- Selective clearing to provide view to Nahanni Butte.
- Shield entrance. Detail 4.
- Detail 4
- Extensive selective clearing to alleviate long distance of view constriction. Suggest corner remain as cleared. Don't reduce curvature neccessitating further clearing.
- Generally in this area drainage of R.O.W. should be collecting frequently and dispersed into the natural system. Ditch blocks form effective silt traps and prevent erosion.

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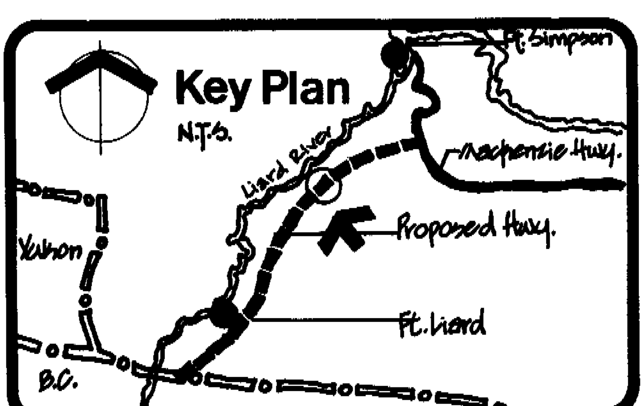
2.5



Mileage

56
57
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59
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65
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67

Study Area

Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria

Development Recommendations

★R.O.W. MANAGEMENT CAN BE PRACTISED BY SELECTED CUTTING. DETAIL 5.

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- Numerous difficult seismic cuts or ℄ cuts to shield
- Shield entrance
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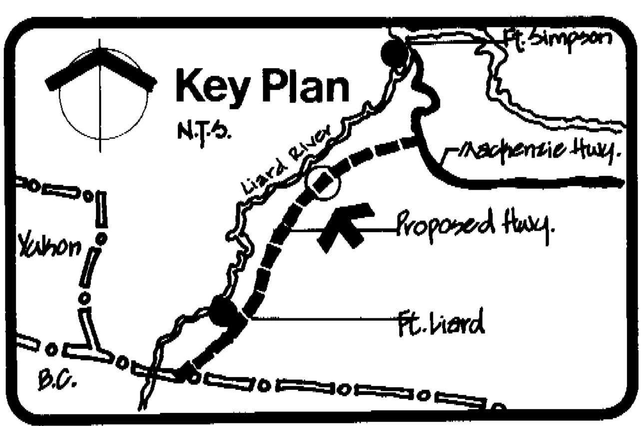
2.5



Mileage

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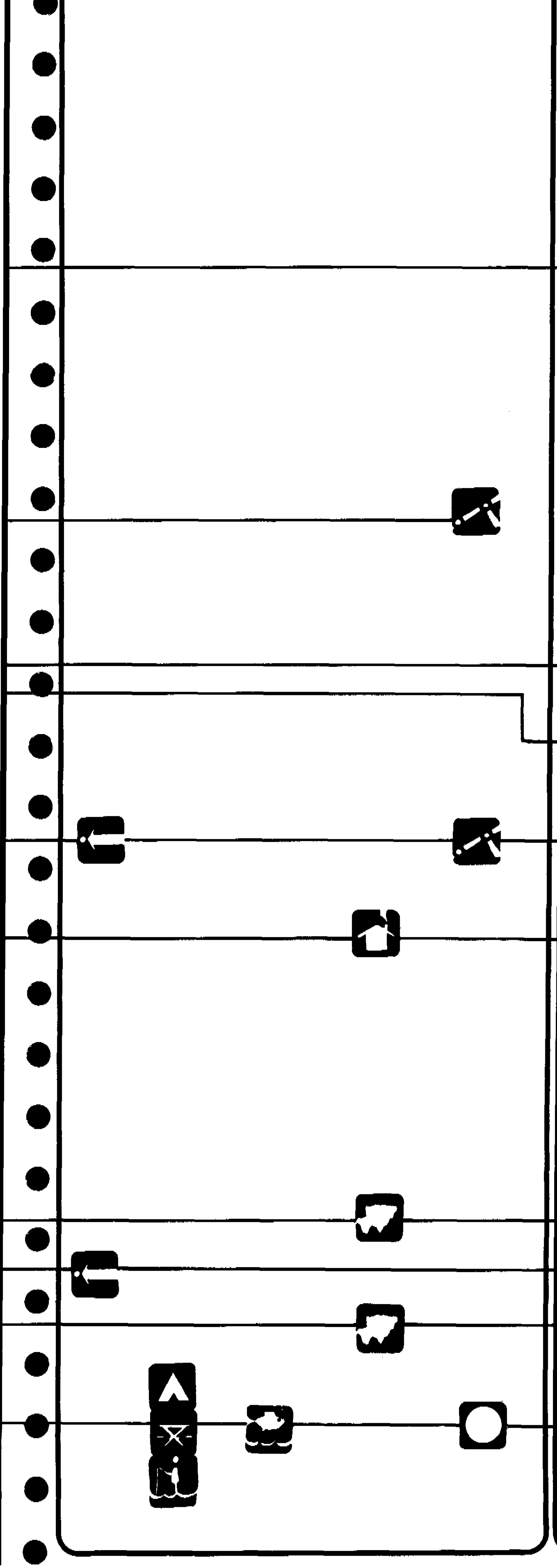
Study Area

1 ½ 0 1 2 Miles

Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria



Development Recommendations

- The details of R.O.W management will have to have to be applied in the field, on site to alleviate this long tangent. Detail 5.
- Selective clearing
- ★ LONG 11 MILE TANGENT IS MOST DIFFICULT ASPECT ALONG THIS PART OF THE ROUTE. R.O.W. MANAGEMENT RECOMMENDED.
- 34' FILL Projected. Prefer more fill, less cut.
- Difficult confluence of seismic lines. Screen entrances. Detail 4.
- Existing cabin-no development.
- High priority prehistoric site. Prevent access.
- Request arch. survey on site prior to clearing potential area.
- Gravel deposits recommended by Geo-Tech would be destructive to fish, high potential archaeological area and recreation potential
- Mile 67 end of cleared R.O.W. emergency shelter.
- Suggested revision at Blackstone River Crossing - see Detail 7.
- Provide barriers to river on Seismic lines - this section of highway. Detail 11.

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2.6

Mileage

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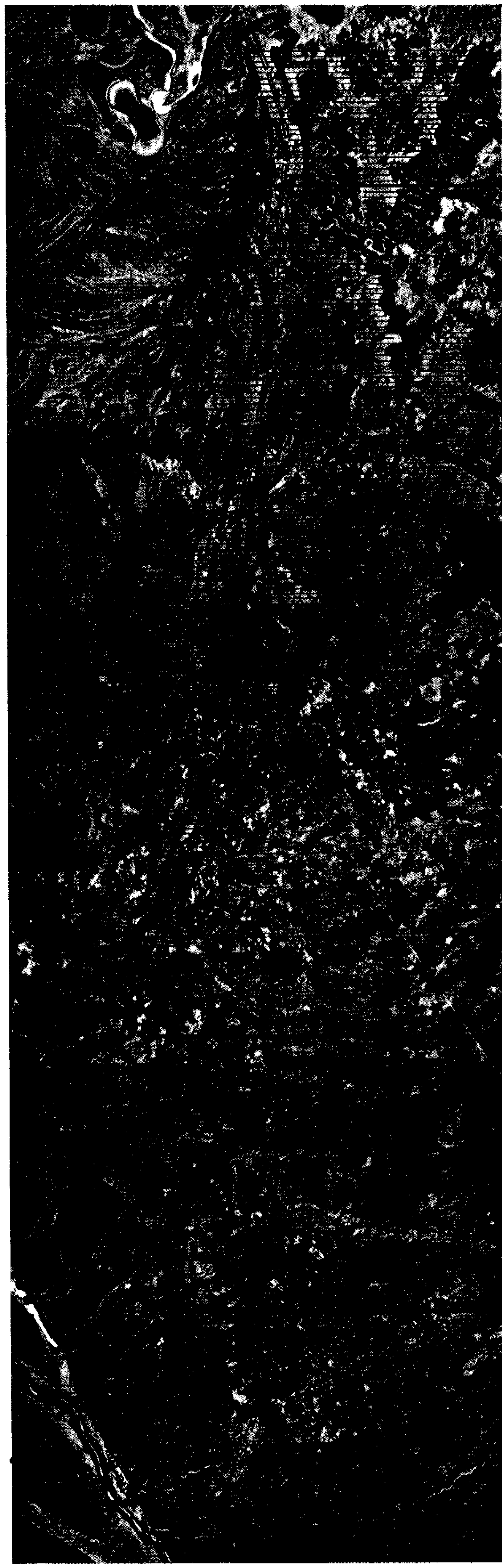
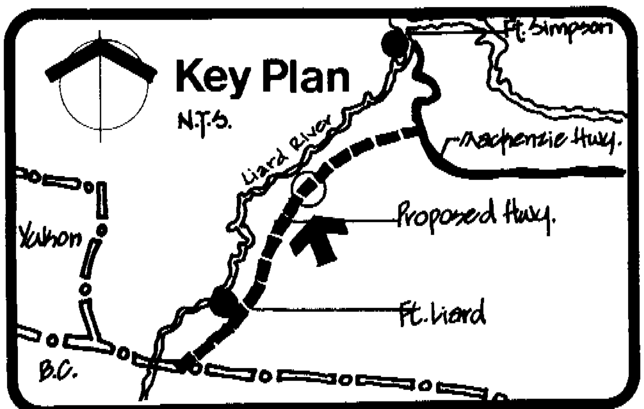
Study Area

1 ½ 0 2 Miles



Key Plan
N.T.S.



Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria

Development Recommendations

*THE OPPORTUNITY IS PRESENT FOR R.O.W. MANAGEMENT & CURVILINEAR ALIGNMENT FOR THE REMAINDER OF THE HIGHWAY. CLEARING SHOULD BE SUPERVISED ON SITE BY A LANDSCAPE ARCHITECT.

- Significant forest area.
- The alignment from mile 72-78 is good and displays interesting curvilinear alignment.
- Numerous seismic entrances require shielding. See Detail 4.
- Possible selective clearing to open views to Nahanni Butte.
- The extension of the alternate between mile 81-83 follows a recommended alternate by GeoTech. It appears to miss muskeg and falls on better subgrade.
- Revegetation in this section assisted by moderate applications of fertilizers.
- Provide barriers to river in seismic lines lines in this section of highway. See Detail 11.

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2.7

Mileage

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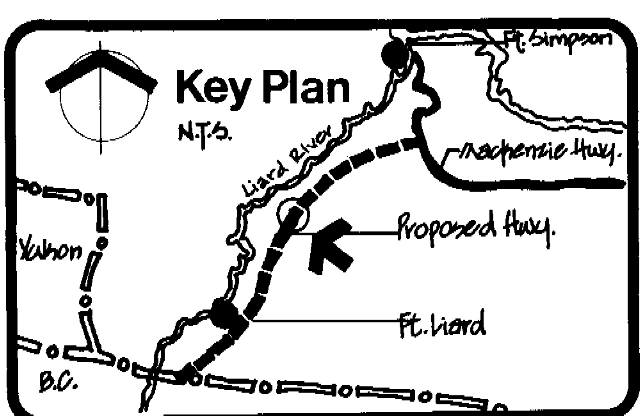
Study Area

½ 1 0 2 Miles



Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch/Hist. Sites | Engineering Criteria

Development Recommendations

- The possible alternate route from mile 81 to 83 is recommended to break up 3 mile tangent. It reduces the depth of fill at culvert crossing.
- Consider selective clearing mile 83-84 to open up view.
- Avoid disturbance of river slopes and bottom. Emergency facilities. Disturbance of vegetation is critical. Minimize. See Detail 10.
- Future access to Nahanni Butte preferred at this location. No development zone, only identification.
- Selectively plant old centre line cut.
- Possibly incorporate seismic cut into selective clearing to open viewpoint. Provide barriers for snowmobile access to river.
- Soften corner.
- Provide barriers in seismic lines to prevent access to river in this section of highway. See Detail 11.

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Study Area

½ 1 0 1 2 Miles

Mileage

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- 99
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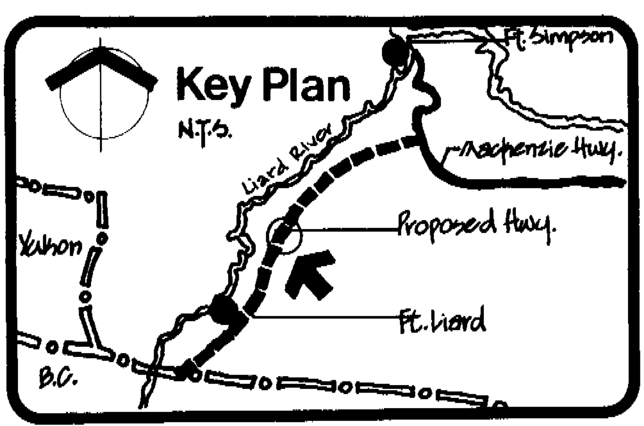
- 102
- 103
- 104
- 105

2.8



Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria

Development Recommendations

- Critical moose habitat.
- Viewpoint development. Avoid disturbing creek banks and bottoms. Deep gully (100ft.±). A bridge should be seriously considered with minimum approach cuts, would also possibly provide moose travel route.
- Cabin, interpret into hiking trail, do archaeology survey prior to clearing.
- Difficult confluence of R.O.W. and seismic lines. Alignment shift to avoid intersection and relieve long (3mile) tangent suggested.
- Follow old centre line cut 2° curve back to mile 103-provides better approach to hill.
- Trail to viewpoint at firetower.
- Maintain as major landscape area. Avoid straight cut R.O.W. practice. Selective cutting and curvilinear alignment suggested.
- There could be seepages or springs due to hill and perched muskeg. Field check.
- Hiking access to escarpment viewpoint. Increase curve to swing tangent back 2500'-3000'.
- Critical moose area. Trail development should physically restrict snowmobiles.
- Note: Barriers in seismic cuts to river should be installed to prevent winter snowmobile access to prime moose habitat. See detail 11.

Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria

Development Recommendations

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- Viewpoint development. Avoid disturbing creek banks and bottoms. Deep gully (100ft.±). A bridge should be seriously considered with minimum approach cuts, would also possibly provide moose travel route.
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- Trail to viewpoint at firetower.
- Maintain as major landscape area. Avoid straight cut R.O.W. practice. Selective cutting and curvilinear alignment suggested.
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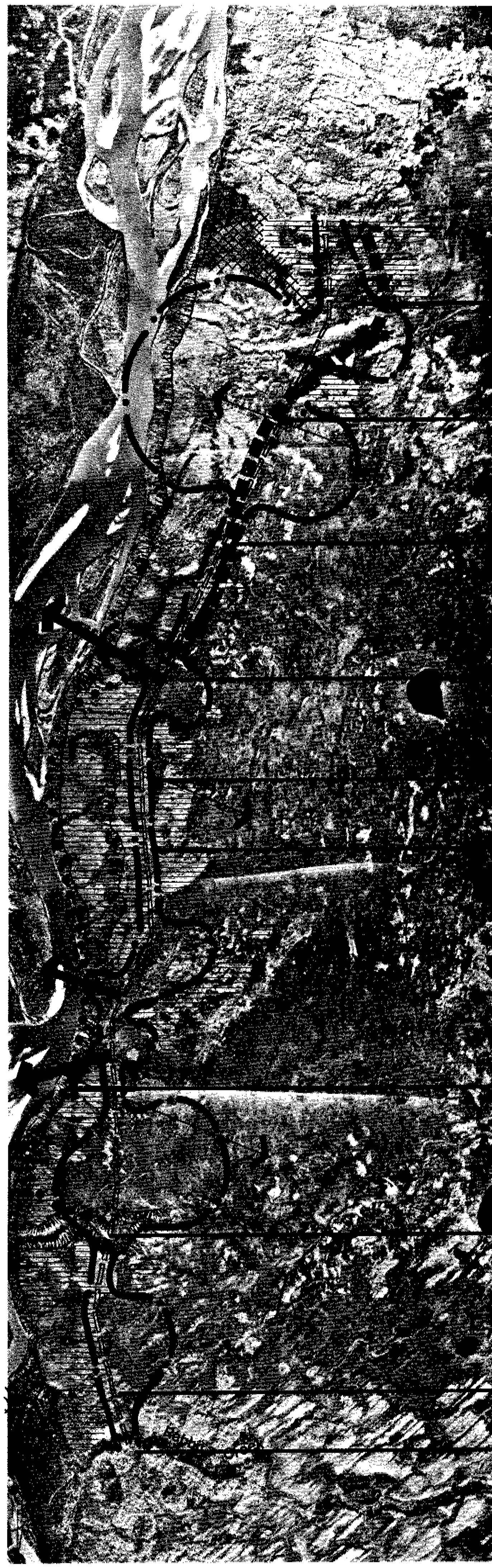
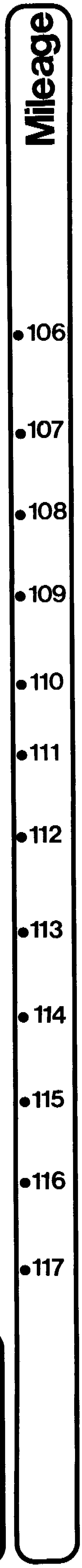
Study Area





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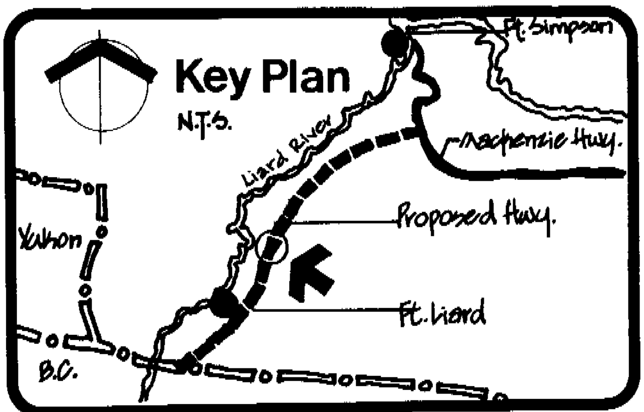
2.9



Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria

Development Recommendations

- Added curvilinear treatment breaks up tangent Mile 107 to 111.
- Develop panorama viewing points. Selected clearing.
- Long tangent (3 Miles). Suggest shifting R.O.W. east 1000 to 2000 feet which also misses old, messy survey cut between Mile 109-110.
- Old burn area, Develop views to river flood plain, possible day use area, emergency shelter & possible construction camp. Detail 10.
- Final geotechnical testing may result in minor modifications to avoid bedrock. Mile 107-112.
- Possible selective clearing to open up short view between Mile 111 – 113.
- Interpretation cabin, hiking trail.
  On site archaeological survey should be done at stream crossing prior to clearing.
- Alignment should allow view to Liard River flood plain, hiking access to escarpment.
- Selective planting on old cat cut centre line.
- Request on site archaeological survey prior to clearing
- Borrow pits should occur east of R.O.W. if possible to preserve the river side.

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2.10

Study Area

1 ½ 0 2 Miles

Mileage

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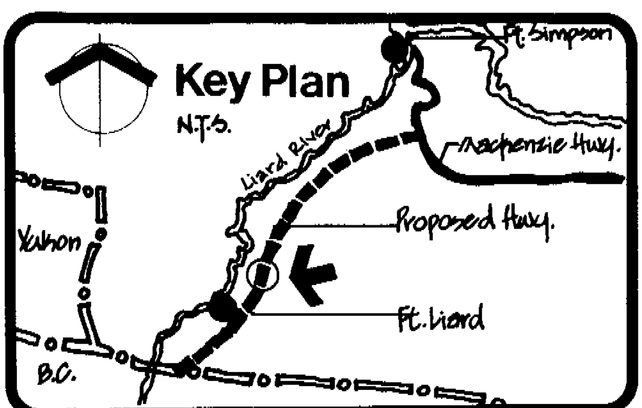

Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria

Development Recommendations

- Alignment should be adjusted to maximize valley view. Care not to disturb creek bottom. Hydrology consultant recommended culverts. Aesthetics dictate consideration of a bridge, considering the length and height of fill required.

- Move alignment 1000 - 1500 feet.

*THIS SECTION REQUIRES A GREATER DEGREE OF CURVATURE EMULATING THE LIARD RIVER BANK.

- Field survey prior to and during clearing

- Note:
  Extremely long monotonous alignment from mile 118-128. Sweeping, curvilinear alignment recommended.

- Moving alignment 1500-2000 feet avoids edge of muskeg and possible perma-frost.

- Field survey prior to and during clearing.
- Proposed alternate recommended to provide relief. 3°-4° curves recommended.

- Carry curve approx. 1000 feet over.

- Detail 4

- Viewpoint development - selective clearing. Recommend extending tangent from mile 127 - 1500 - 2000 feet. and intersecting tangent to mile 130. This increases curvature and creates a more interesting approach to the Muskeg River crossing.

- Borrow pits should occur east of R.O.W. if possible to preserve riverside.

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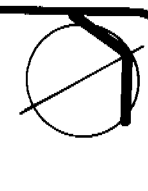
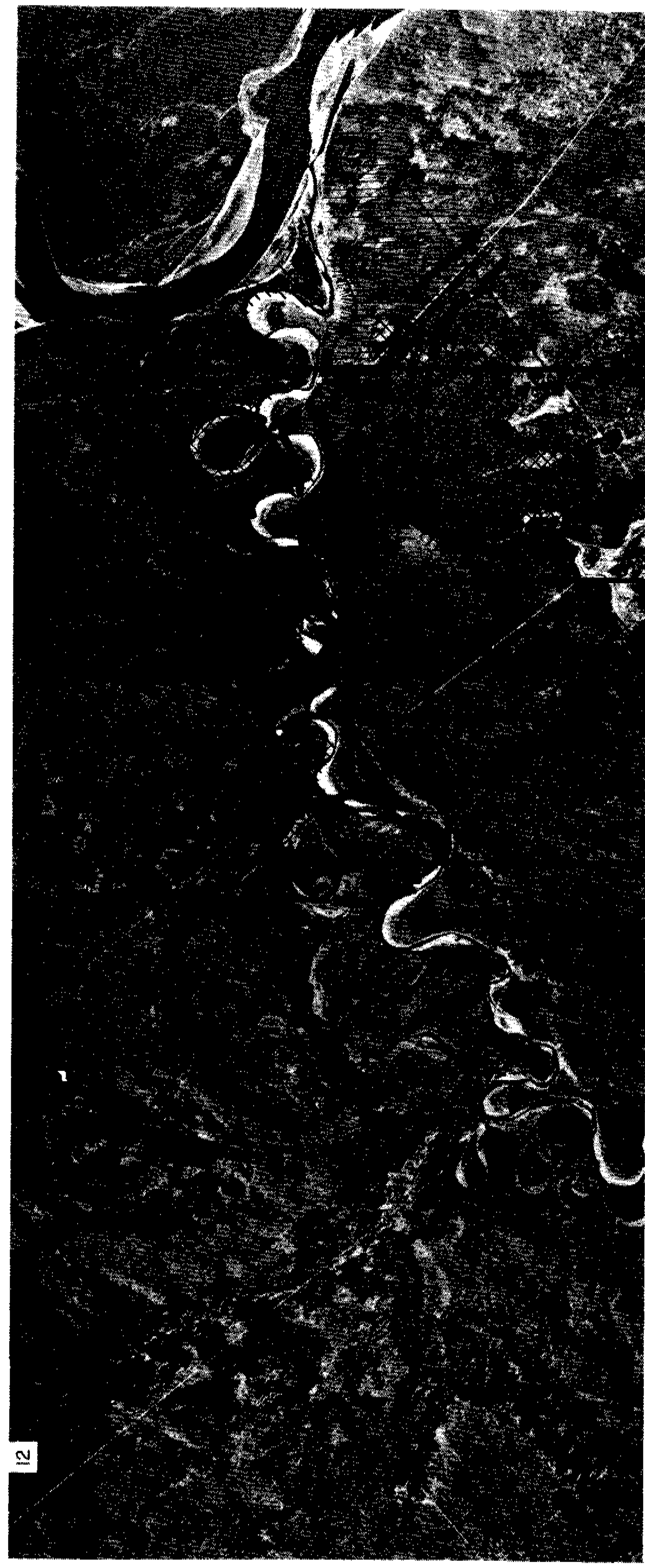
Study Area





Mileage

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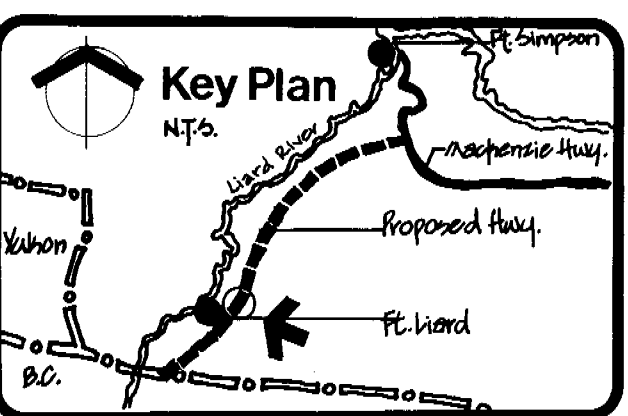
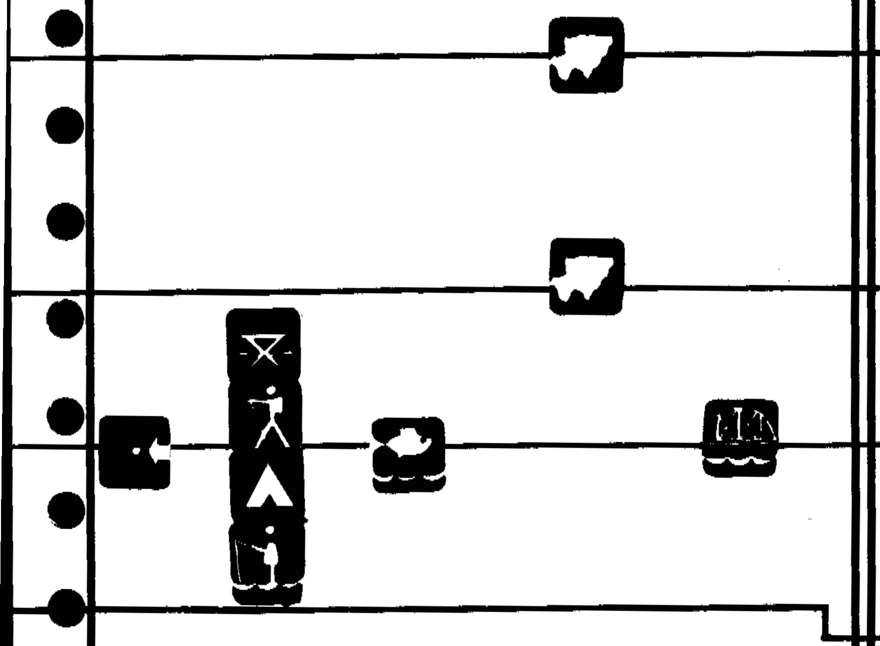


Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria



Development Recommendations

- Cabin. Prevent access. No Development.
- Request archaeological field survey prior to clearing.
- Minor alignment modification. Long bridge affords views, access to flood plain, emergency facilities. Avoid disturbing river bottom. Hiking trail on escarpment. See Detail 9 Recommendation.
- Intersection identification. Do not clearcut. Consider large intersection and selective cutting to provide sight lines.
- Revegetation should be assisted with phosphorous.

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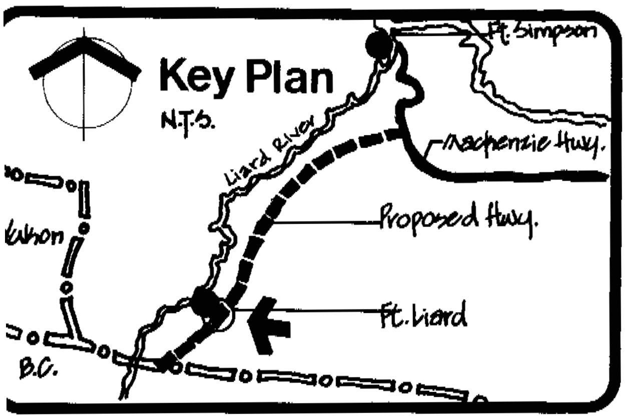
2.12

Key Plan

N.T.S.



Mileage

131

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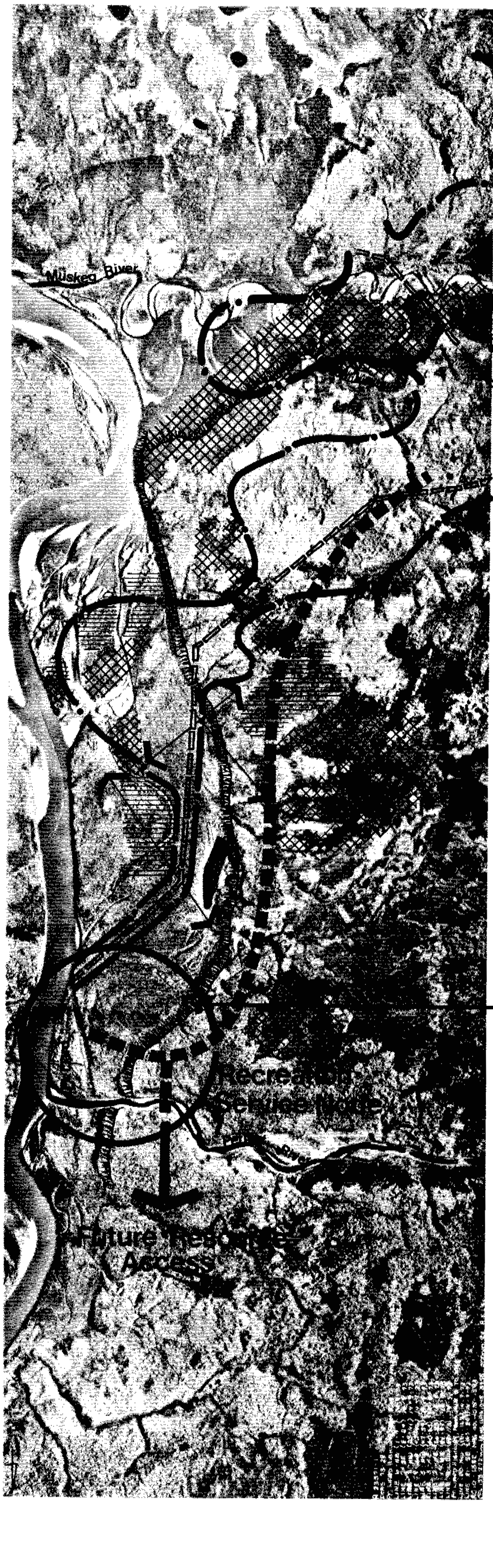
7.5

Study Area

1 ½ 0 1 2 Miles



Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria

Development Recommendations

★ MAJOR IMPACT ON COMMUNITY REQUIRES DETAILED STUDY.

- Proposed major relocation of access to escarpment. Relocation would provide an easier grade into Fort Liard, reduces visual disturbance to the community and frees lower area for future development. R.O.W. would be maintained on glacial till and avoid problems associated with a high water table and flood plain silt, sand and organics. Selective cutting could further enhance view. See detail 9.
  Future resource access across the Petitot River to the primary forest area would be facilitated.

DISCONTINUITY
[illegible]

Factors

Scenic Features	Recreation Potential	Wildlife Communities	Arch./Hist. Sites	Engineering Criteria

Development Recommendations

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2.13

Mileage

Study Area

1 ½ 0 1 2 miles

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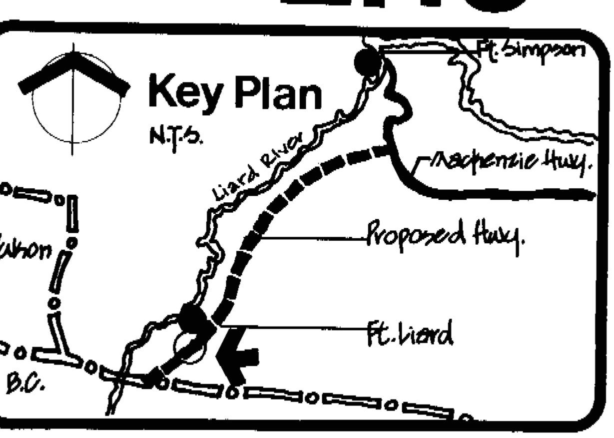
Key Plan
N.T.S.



Factors

Scenic Features	Recreation Potential	Wildlife Communities	Arch./Hist. Sites	Engineering Criteria

Development Recommendations

★ THE ALIGNMENT WANDERS FROM TREED TO LOW-RELIEF MUSKEG. THE OPPORTUNITY EXISTS FOR SELECTIVE CUTTING TO BLEND THE ENTRANCES AND EXITS FROM TREED TO NON-TREED AREAS. THIS MUST BE DONE ON SITE DURING INITIAL CLEARING BY A QUALIFIED LANDSCAPE ARCHITECT.

- Detail 4
- Screen entrances to old centre line cut. Selective cutting could open up views.
- Carry curve at mile 136.5 to move alignment to better soils and to provide greater curvature.

Liard Highway Study

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Study Area

1 ½ 0 2 miles

Mileage

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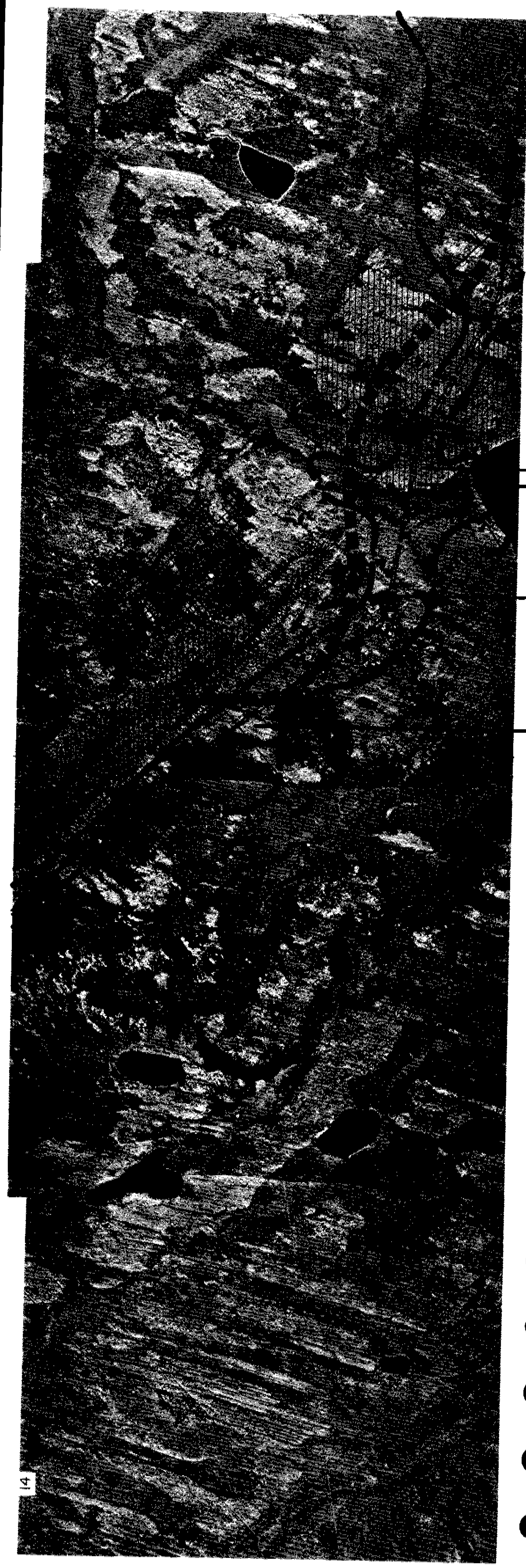

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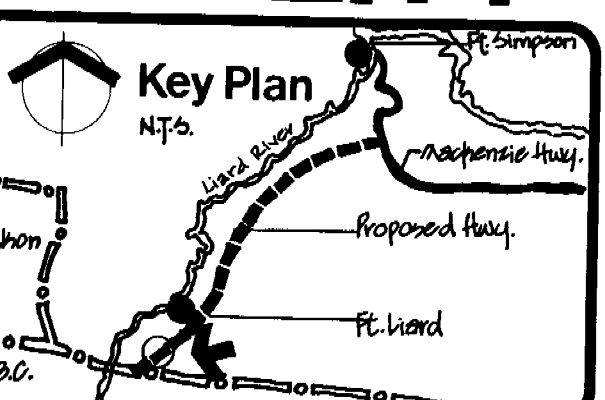
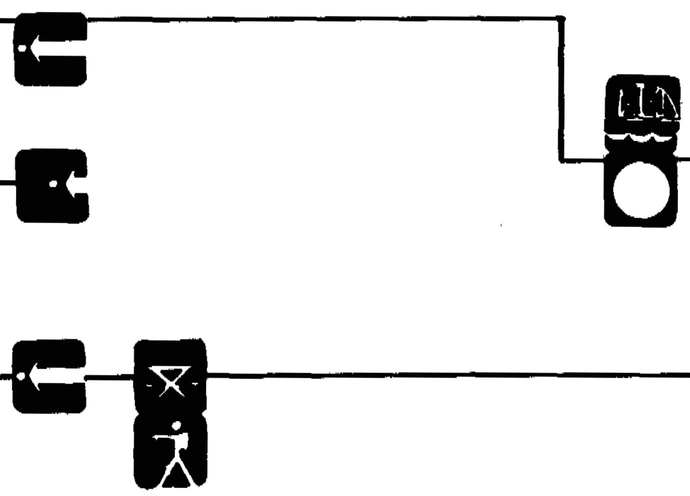


Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria



Development Recommendations

* THE ALIGNMENT WANDERS FROM TREED TO LOW-RELIEF MUSKEG. THE OPPORTUNITY EXISTS FOR SELECTIVE CUTTING TO BLEND THE ENTRANCES AND EXITS FROM TREED AND NON-TREED AREAS. THIS MUST BE DONE ON SITE DURING INITIAL CLEARING BY A QUALIFIED LANDSCAPE ARCHITECT.

- Mile 146 relocates highway west 5000 feet to provide maximum buffer to Bovie lake to protect historical fishery from overuse. Shorter stream valley crossing.

- Bridge over Bovie Creek recommended for protection of possible fishery feeding & spawning areas in lieu of three 120" culverts recommended for hydrology. Prevent access to lake Bovie to protect domestic fisheries and archaeological values.

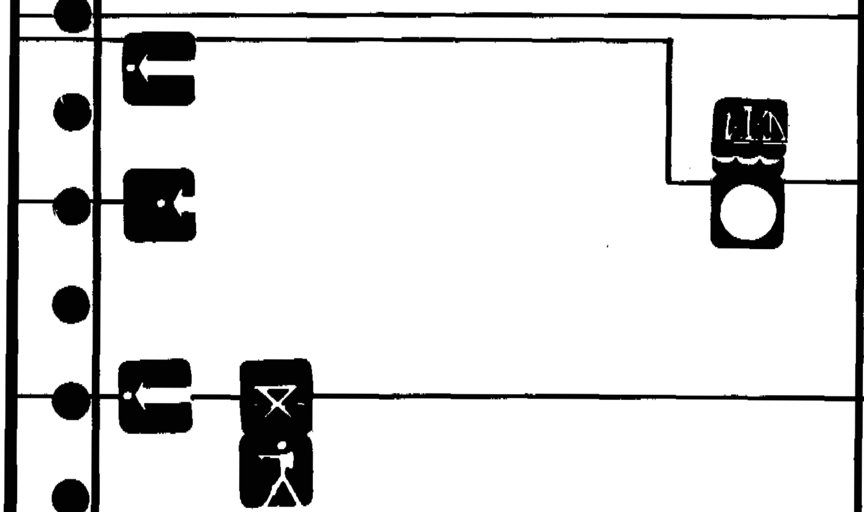
- Develop hiking trail to old road up Max Hamish escarpment to viewpoint and picnic area. Possible prehistoric lookout. Check archaeological values prior to development.

Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria

Development Recommendations

✱ THE ALIGNMENT WANDERS FROM TREED TO LOW-RELIEF MUSKEG. THE OPPORTUNITY EXISTS FOR SELECTIVE CUTTING TO BLEND THE ENTRANCES AND EXITS FROM TREED AND NON-TREED AREAS. THIS MUST BE DONE ON SITE DURING INITIAL CLEARING BY A QUALIFIED LANDSCAPE ARCHITECT.



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- Develop biking trail to old road up Max Hamish escarpment to viewpoint and picnic area. Possible prehistoric lookout. Check archaeological values prior to development.

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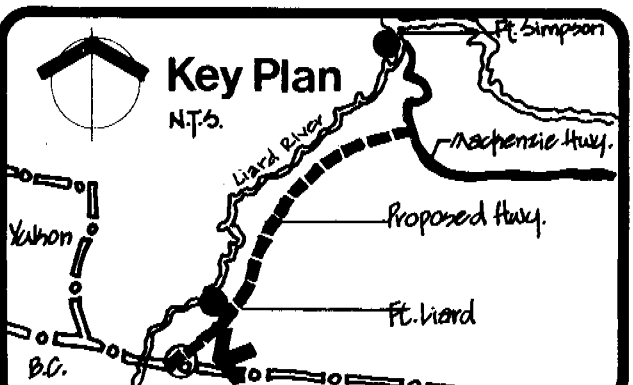
2.15

Mileage

•153
•154
•155
•156
•156.7

Study Area



Factors

Scenic Features | Recreation Potential | Wildlife Communities | Arch./Hist. Sites | Engineering Criteria

Development Recommendations

* THE ALIGNMENT WANDERS FROM TREED TO LOW RELIEF MUSKEG. THE OPPORTUNITY EXISTS FOR SELECTIVE CUTTING TO BLEND THE ENTRANCES AND EXITS FROM TREED AND NON-TREED AREAS. THIS MUST BE DONE ON SITE DURING INITIAL CLEARING BY A QUALIFIED LANDSCAPE ARCHITECT.

- See Detail 4.
- High priority area just outside study limits.
- Identification of 60th Parallel crossing. End of Study Area.
- Emergency facilities.
- Clearing and cross survey cuts are extremely bad within B.C. portion. The motorist will certainly appreciate the sensitivity apparent when he crosses the 60th Parallel.

SECTION III

RECOMMENDATIONS

Stemming from the previous two sections, it is possible to summarize the recommendations as follows:

1 On a macro-scale the highway is favorably situated. On a micro-scale, however, modification and rehabilitation is required to satisfy all demands.

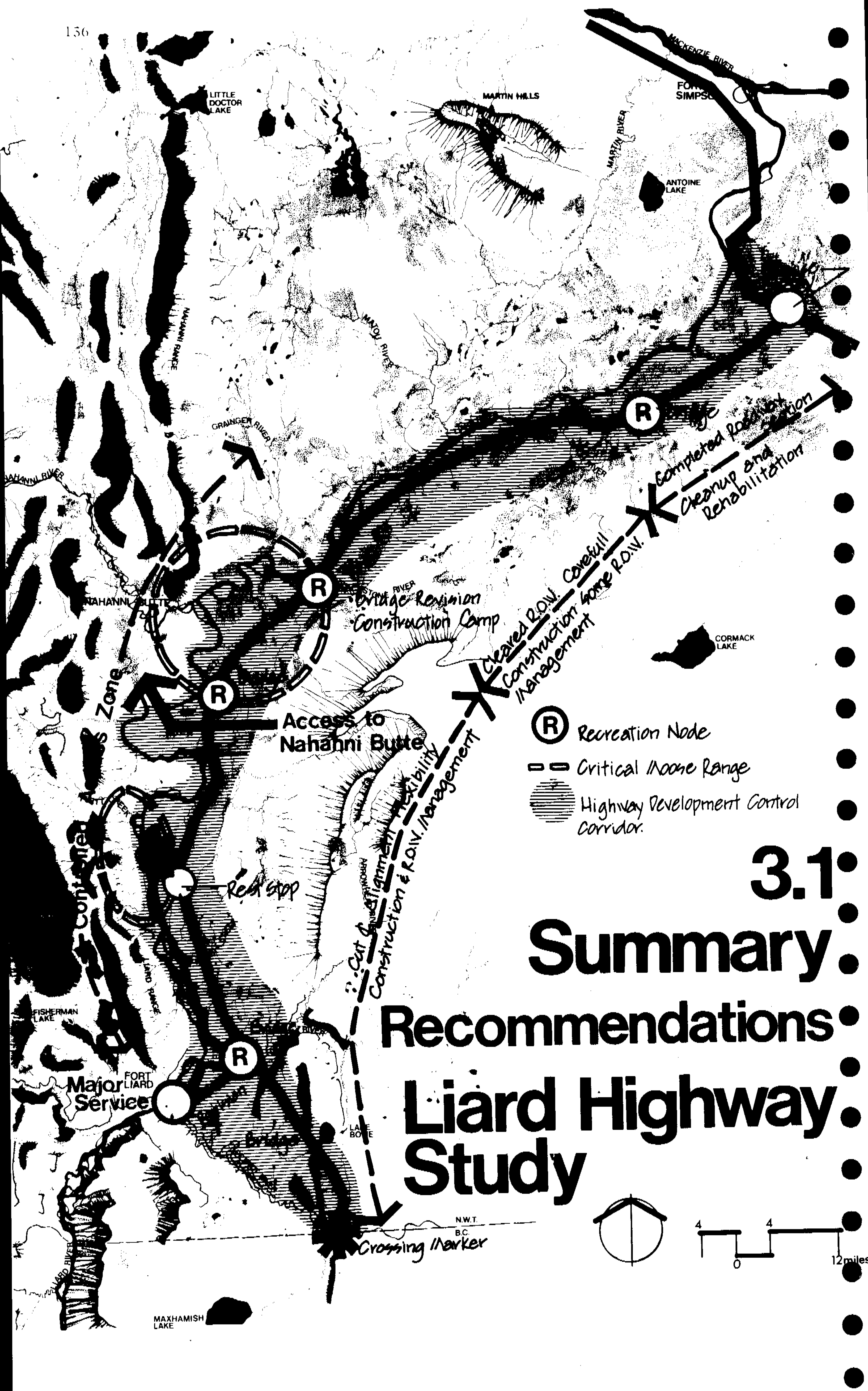
2 The highway is presently existing or has been pre-determined. The least impact is based upon identification of sensitivities and planned development control to minimize impacts.

3 Adopt a management strategy reflecting multiple use of resources with minimum environmental deterioration, under the ethic of preservation first, development second.

4 A development control corridor be established along the highway bounded on the west by the Liard and Petitot rivers and on the east by a buffer of approximately 2 miles (See Map 3.1). Land use policies should be established in order to require prior planning, approval, and permitting for multiple uses within the management strategy for the corridor.

5 Controlled use of the highway is considered the method by which minimum impact will occur. Recreation persuits are considered to be the use requiring control that must be specifically provided for in the public interest. Throughout the corridor, the landscape is generally only interrupted by major stream crossings. These have been chosen as recreation nodes, requiring detailed development to control use. The logic behind these choices is based upon the following:

- unique breaks in the highway corridor



3.1 Summary Recommendations

Liard Highway Study

- water-based recreational activities, i.e. fishing
- uncontrollable use of these areas, if undeveloped
- ease of surveillance and ease of maintenance of a limited number of specific locations.

The multiple use of these recreation nodes is also recommended. They should provide emergency facilities for highway travellers, particularly during winter conditions. The suggested site at Mile 67 may also provide a temporary construction camp.

The following recreation nodes have been recommended.

- Poplar River
- Birch River
- Blackstone River
- Netla River
- Mile 111
- Muskeg River

The infrastructure of Fort Liard is expected to provide the major service and recreational facility en-route.

The fisheries values at these locations are obvious. The critical spring migration normally occurs prior to the tourist season, and the sport fishing of these streams during that period would be primarily limited to residents of the region. It would be reasonable to expect licensing control over the fisheries throughout this area.

Wildlife values at the Blackstone and Netla River areas are significant. These two points occur in what has been identified as primary moose winter habitat. It is felt that hunting will occur in any event, and that facilities should be developed to allow ease of surveillance and enforcement.

6 Previous construction of a culvert crossing at the Poplar River has effected a major impact on the fisheries of that stream. The almost complete loss of migration capabilities past this

crossing could have effectively reduced the fisheries within the region by approximately 25%. Removal of the Poplar River crossing and construction of a bridge are recommended, which, hopefully, will enable the re-development of the fishery in this stream. This, however, is likely to take many years.

7 Considering the loss of fishery at the Poplar River, bridges are recommended at the Birch, Blackstone, Netla, Muskeg and possibly Bovie Creek crossings, in order to not compromise the fishery within the remainder of the region. With the exception of the Bovie Creek crossing, bridges are recommended by the hydrology consultant at these locations.

8 It is expected that these river valleys possibly form travel routes for big game species and terrestrial fur-bearers. Construction of bridges would enable maintenance of these routes under the highway and thus, hopefully, reduce road kills.

9 Bridges at these locations are also incorporated into the recreation nodes and provide a higher degree of aesthetics. Bridges have traditionally attracted people, and fishing from and beneath bridges is a typical recreational endeavour.

10 Within the recommended development control corridor, the vista from the road has been indicated. This is intended to provide guidance for on-site detailed right-of-way management with regards to selective clearing within the constructed 30 miles of the highway, and also within the cleared right-of-way section to Mile 67. It is expected that selective clearing will be required in order to alleviate strong parallel tree edges. This, coupled with the planting of intrusions in the treed edge, such as duff deposits, seismic lines, and borrow-pits, is intended to improve the overall general aesthetic of the highway. The degree to which this might be reasonably done must be determined on-site in the field.

11 The impact of access to Fort Liard is considered to be significant. It is recommended that socio-economic studies be done and detailed community planning be conducted.

12 A major revision is recommended to the access to Fort Liard, as detailed within the report.

13 A major revision is recommended at the Blackstone River crossing as detailed in the report.

14 A recommended point of intersection for future access to Nahanni Butte has been indicated. It is considered that this location potentially provides the least impact on wildlife. However, this must be substantiated by further study.

15 From Mile 67 to the British Columbia border, the opportunity for right-of-way management and curvilinear alignment exists. A number of alignment shifts have been recommended, based firstly on curvilinear concepts and, secondly, in certain cases, upon seeking out better foundation conditions. The additional road length is considered a reasonable investment towards improved highway aesthetics. Again, within this section of the roadway, right-of-way management is possible, and it is recommended that initial right-of-way clearing be done to a minimum width (80 feet, plus or minus), and additional right-of-way development be done on a selective clearing basis with a qualified landscape architect in the field. Construction practices should be maintained within the cleared right-of-way.

16 New borrow-pits should be established on the basis of detailed plans noting access, tree buffers, depth, size and future rehabilitation. It is recognized that certain of the better pits will be required on a continuing basis for future maintenance. These should be provided with gates at the edge of the right-of-way and the possibility of permanent maintenance camps would be best predicated on association with these pits.

17 Barriers for access to prime wildlife areas are recommended as detailed within the report.

18 From Mile 67 to the British Columbia border, consideration should be given to increasing the lengths of horizontal curves to smooth the tangents into a flowing, curvilinear alignment in accordance with the suggested alignment changes.

19 The profiles and vertical alignment of the highway have not been studied. It is recommended, however, that cut and fills be maintained at a minimum, and that cuts are more severe than fills due to the possibility of encountering permafrost at gulley locations and the subsequent sloughing of slopes and tree fringes. The natural undulations along this highway are not severe and cut and fill should be minimized in order to provide as much interest in the vertical alignment for the highway traveller as possible. This will compensate somewhat for the lack of visual interest and the long tangential alignment within the first 67 miles.

20 Selective clearing should occur during early winter when the ground is frozen and there is little snow cover so that vegetation can be sheared off at ground level with little disturbance to the vegetation mat.

21 Scheduling construction timing should respect certain critical, natural cycles. Firstly, construction of bridge crossings should not occur from spring break-up to the completion of fish migration, late April to early July. From Mile 30 to Mile 67, the highway traverses extensive wetland areas. Although the inhabitants of these areas have endured one construction season of right-of-way clearing and no evidence of impact is available, further construction adjacent to these areas might be delayed during the spring season (to mid-May) to protect the young of the year.

22 Construction practices at river bridge crossings must be careful not to cause downstream siltation of spawning gravels.

23 It is expected that there will be an overall reduction in wildlife resource harvesting by natives within the region However, this could be substantially offset by sport hunting. It is recommended that a moratorium on hunting for a period of two years be instituted within the region (Excepting subsistence hunting and trapping) to allow re-establishment of wildlife.

24 It is recommended that the sport fishing season be limited during the up-stream migration and that fishing at the Poplar River be prohibited until completion of a bridge and recovery of the fishery is determined.

25 In general, the access from the highway should be limited to identified and controlled points. This necessitates screen planting on seismic cuts, unused access roads, old centreline cuts, borrow-pits, etc. This is a general condition from Mile 0 to Mile 67, but if care is taken during construction, this should be avoided to a large extent over the remainder of the highway.

26 It is recommended that a natural and historical interpretive program be developed along the highway.

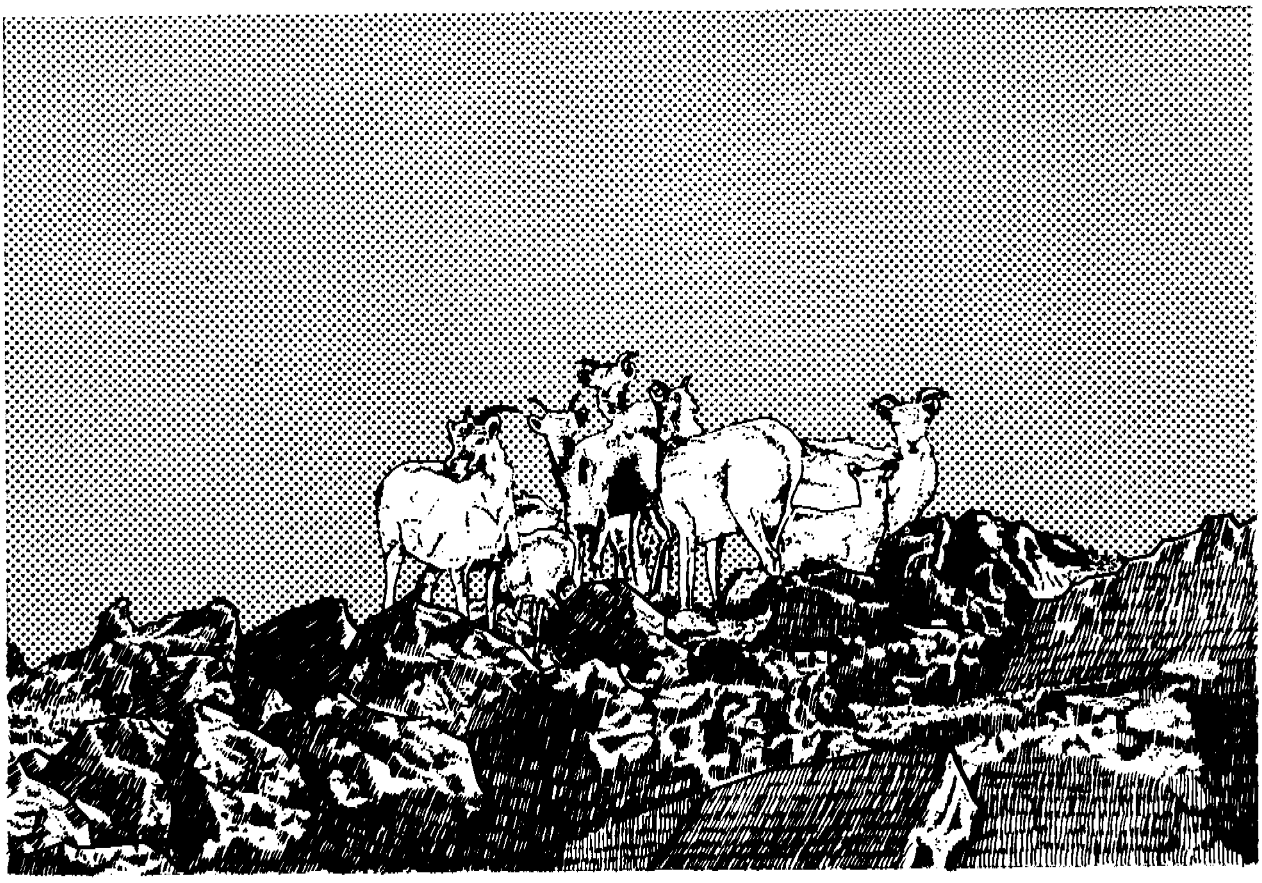
27 The utilization of existing borrow areas for other uses does not appear feasible due to the high water table which has caused flooding of most pits. Large shallow borrow areas could be considered for this purpose; however, the cost of reclamation appears to be greater than the cost of properly establishing these facilities in other areas.

28 Consideration of future power distribution should not follow the highway but should occur east of the highway development control boundary along existing seismic lines.

29 The environmental impact appears to be minimal for all raptors. Few birds were spotted and no nesting areas were identified. Should they exist, it is expected that they will relocate with the possible maximum loss of one season's productivity.

30 The major potential impact on wildlife will be on the moose population and this impact is not expected from the actual construction, but from the users of the highway. Recommendations have been made in this regard.

31 It is recommended that this consultant be allowed the opportunity to comment on the final engineering design.



APPENDIX I

WILDLIFE SURVEYS

In order to obtain information on the seasonal distributions and movements of wildlife species, five survey flights were made over the area surrounding the Liard Highway in 1974, supplemented by observations made during the fish survey. Flights were made in either Bell 206 Jet Ranger or Hughes 500 C helicopters on the 6th and 7th of March, 24th and 25th April, and on the 16th of October. The fish study enabled observations to be made between the 28th of June and 2nd of July. At least two observers, in addition to the pilot, were present on every flight. Survey flights were conducted from 500 to 1,000 feet above the ground, and gave adequate visibility for the existing ground cover. The flight path taken during the surveys usually followed a zig-zag pattern over the proposed highway route, because the purpose of the survey was to determine distributions rather than to estimate population size. Oscillations away from the highway route were usually made to three miles on either side, but greater distances were travelled up the major tributaries to the Liard River and on the MacKenzie Mountain side of the river.

Sightings of wildlife species, their tracks, feeding and bedding areas, and the general habitat types used, were recorded in a notebook and plotted onto maps during the survey flights. For the purposes of these surveys, three general habitat types were recognized: open - usually muskeg regions, but also including openings in mature forest; semi-open - trees between 5 and 15 feet (approximately) in height, including Brule; and mature forest - dense stands of trees estimated to be greater than 15 feet in height. These three types were further modified according to the local landform and species composition of the aboreal vegetation. Three types of deciduous tree species could generally be distinguished: *Populus*, *Betula* and

Salix. These areas surveyed generally proved to be a rich mosaic of the various habitat types.

Results

Map 1.3 shows the locations of wildlife sightings made during the flight surveys.

Flights Made on the 6th and 7th of March, 1974

Moose:

During these survey flights a total of 125 moose were sighted in 63 observations. However, it was estimated that at lease 26 moose were counted twice during separate flights over the same area. Therefore, the maximum number of individual moose observed would be approximately 99. This is not to be taken as a population estimate for the area, because of the nature of the present survey and the flight path. Census flights require quite different flight paths and methodology (Bergerud and Manuel, 1969).

No individuals with antlers were observed, and at the elevations flown, sexes could not be distinguished. Aging was limited to recognising calves (approximately 7 months of age), and, because a number of lone animals were observed, the figure obtained for calves can only represent a minimum relative count. Of the 99 moose counted, 13 were classified as calves. No reliable estimate of productivity can be made from these data because: (a) sex ratios of moose have been found to vary considerably between different areas and so an estimate of the sex ratio could not be justified from the present data, and (b) sexes could not be distinguished.

It is clear from the data shown on Map 1.3 that the majority of moose were observed in the areas immediately adjacent to the Liard River and on its mid-channel islands, or on the major tributaries and their flood plains. The habitat types utilized by the moose during this

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It is clear from the data shown on Map 1.3 that the majority of moose were observed in the areas immediately adjacent to the Liard River and on its mid-channel islands, or on the major tributaries and their flood plains. The habitat types utilized by the moose during this late winter period are shown in Table M. These data show that the moose were using primarily the semi-open areas, predominated by an overstory of deciduous species. Observations of tracks, however, also indicated that the moose were using the numerous cut-lines adjacent to the cleared highway right-of-way, as well as the right-of-way itself. Also, although some feeding activity was evident, the nature of the tracks suggested that they were using these cleared routes mainly for travelling between more favored feeding areas. Similar travel trails were observed along creek and river beds covered by ice (including the Liard River), but in these regions browse species were more frequent, as were signs or direct observations of feeding activity. No major trails or migration patterns could be detected, partly as a result of the short duration of this survey, and also due to the presence of fresh snow which had fallen a few days earlier.

The majority of signs and direct observations of feeding by moose, indicate that during this period they were feeding primarily on the deciduous species above the snow, but which did not exceed 15 feet in height. All three types, Populus, Betula and Salix, appeared to be eaten. However, two observations indicated that moose were foraging for food beneath the snow. Both of these observations were made in open areas surrounded by mature forest.

Two landings were made during these survey flights, one on Big Island, and one between Beaver Water Creek and the Liard River. At both sites signs of moose activity were quite evident, showing that they were browsing on Populus, Betula and Salix. Snow depths were similar at each location, being approximately 30 to 36 inches deep, and consisting of soft powder snow with no crusting except in the old tracks. When these conditions occurred, Des Meules (1964) and Peck (1970) found that the moose would move into the denser mature forested areas. If snow conditions in the Liard River Valley were to change in a similar fashion, it would be likely that they would not move far from

TABLE M

Number of Moose Sighted in Each Habitat Type

in the Vicinity of the Proposed Fort Simpson/Fort Liard Highway

HABITAT TYPES

	OPEN		SEMI-OPEN			MATURE		
	Muskeg	Clearing in Mature Forest	Island - Deciduous	Riverine/ Flood plain - Deciduous	Mixed - Deciduous/ Coniferous	Pure Deciduous	Mixed	Pure Coniferous
Number of individuals observed (percentage)	3 (3.0)	3 (3.0)	30 (30.3)	30 (31.3)	26 (26.3)	6 (6.1)	- -	- -
	(6.0)		(87.9)			(6.1)		

these riparian habitats as denser forested areas were invariably adjacent to these semi-open areas. On non-riparian habitats, the moose were usually to be found in old burn sites or Brule vegetation, where there was ample evidence of regrowth of their favored browse species. However, in many of these Brule sites, the criss-cross of fallen burned timber of the previous forest cover could have impeded their movements, and thus accounted for the relatively limited use made of these otherwise favorable areas.

Wolf:

A pack of six wolves was sighted on an island in the Liard River, opposite Mile 60 of the proposed highway. Their tracks showed that they had been moving south along the snow covered ice of the Liard River. Following our sighting of them, the pack moved onto the north bank of the Liard River. The wolves were obviously disturbed by the presence of the helicopter, and in their flight, it was quite evident that they encountered difficulty in running through the deep powder snow. What appeared to be wolf tracks were also sighted on the Liard River opposite to Sawmill Mountain. With the snow conditions at this time, which appeared to hamper running by the wolves, but did not appear to affect the moose, it is unlikely that any serious predation occurred on the moose. No signs of chases or kills were observed during these flights.

No other sightings were made of animals except for several raven. However, tracks of small mammals were quite evident throughout the area. These appeared to belong to hares and probably to foxes and lynx. Signs of active trapping were also evident, particularly around the Poplar River crossing, and around the settlements of Fort Liard and Nahanni Butte.

Flights made on the 24th and 25th of April

The weather conditions during these flights were markedly different from those experienced during the March surveys. Temperatures during the April surveys ranged between 18°f in the mornings to 40°f by midday. These temperatures were mild enough for a variety of animals to be active, including butterflies (Mourning Cloaks), mosquitoes, grasshoppers, spiders, and also chipmunks. Snow cover varied from completely bare areas to depths of 24 inches, depending upon location and exposure. Unlike the deep snow depths of March, the snow was dense and often compacted, making travel on the ground by the observers difficult. Sun-cupping of tracks made it impossible to determine their age or origin, especially those observed from the air.

Moose:

Only two moose were observed during this survey, an adult cow and calf of the previous year. They were spotted in an open, old riverine area, between Bay Creek and the Liard River about three miles to the south of Swan Point (see Map 1.3) opposite Mile 70.

As stated earlier, melting of the tracks in the snow made it difficult to judge their age. Tracks were observed throughout the survey area, but were concentrated along the tributaries of the Liard River and in open and semi-open areas containing favored browse species. The freshest tracks were observed between the Netla and Blackstone Rivers, along the Blackstone River, east of the Poplar River, and upstream along the Netla River from the highway crossing.

It was apparent that the moose were utilizing different areas than in March. It appeared that they were much more dispersed and moving up the tributaries on both sides of the Liard River. A flight 4 miles up the South Nahanni River also showed signs of moose activity.

During several landings it was possible to observe the browse species upon which the moose had been feeding. It appeared that by ocular methods the preference of browse species was in the following order of preference:

Willow	(*Salix* spp.)
Dogwood	(*Cornus stolonifera*)
Aspen	(*Populus tremuloides*)
Poplar	(*Populus balsamifera*)
Alder	(*Alnus incana*)
Paper birch	(*Betula papyrifera*)

Among the willows, two growth forms were evident - a generally small shrub type with numerous red or yellow shoots, frequently browsed by the moose, and taller grey-colored willow with little available new shoots and much dead material. The moose appeared to utilize the small shrub growing willows quite heavily, particularly on the islands and the distinction between this type and the taller grey-colored willows was very evident at a landing on the Netla River area (see Figure 0). It was evident from the light to moderate hedging on the island willows that they may not have used these areas each winter or only for relatively short periods, but before a definite statement can be made, a more thorough study should be undertaken, including several more surveys during the winter periods. The youthfullness of the deciduous growth on these islands, especially along their edges, suggested subsequent regrowth following frequent destruction by ice or flooding, or by the formation of new substrate by deposition, or from a combination of these three factors.

Dogwoods were heavily used along the Blackstone River and showed signs of severe hedging (see Figure 0). It appeared to be utilized at other locations wherever it occurred, except in the immediate vicinity of the Poplar River crossing. Young aspen and poplar were also used by moose at most locations. Observations along the highway right-of-way at the Blackstone River crossing, indicated that the moose had used these species as they encountered them on their travels along the cleared way. They did not appear to have used this cleared line in the Blackstone area for extensive feeding,

by the moose were almost entirely composed of young growth, supports the findings of Halter and Martin (1960) on winter habitat requirements of moose. Movement off the islands between the time of the March survey and the April flights may have, in part, been stimulated by thinning and breaking up of the river ice, together with traditional seasonal migration patterns.

The Game Warden from Fort Simpson reported traditional fall movements of the moose across the Liard River by its confluence with the Poplar River in the late fall, and movements between Antoine Lake and Cli Lakes well to the north of the Liard River.

If the observations of moose concentrations along the Liard River during the March survey were exceptional, and moose in this region are generally more dispersed along the tributaries of the Liard, the potential increase in hunting through increased access from the road, would therefore modify the predictions made in the report of the March survey. However, these comments would still be subject to any other planned developments, such as mining or logging activity, for the area and associated with the proposed highway.

Bear:

A single bear was observed on the banks of Flett Creek behind Sawmill Mountain. Unfortunately, due to circumstances, positive identification of the species could not be made as the bear moved off into dense timber. It is possible that the bear was not fully out of winter hibernation and was responding to the mild weather at the time of the survey.

Other information regarding bears comes from the Fort Liard and Fort Simpson/Jean Marie River trapping records. Between 1965 and 1970, 63 bears were brought to Fort Liard and from Fort Simpson/Jean Marie River 58 bears were returned. A decline (of unknown origin) occurred in the latter returns only. The Game Officer from Fort Simpson reports that bears are often used as target practice by road travellers, and a number have been found with wounds apparently as the result of this activity.

Wolf:

Tracks of wolves moving east along an old moose trail were found during a landing at the Blackstone River crossing. The animals were moving along the trail of the moose in the opposite direction, and it is possible that they were using this trail as it afforded easier travelling. The moose trail had resulted in a compaction and hardening of the snow and the wolf tracks were not very deep.

Information provided by the Fort Simpson Game Officer showed that in his area there is a bounty of $40 on wolves. This, he feels, is of benefit to the wolves because the alternative is for he or his staff to go and poison any wolf which causes problems with trap lines, and this results not only in the killing of the problem animal, but also of other wolves and many other species of wildlife. There are approximately 20 to 22 requests for wolf bounties per year, and this relatively small number may, in part, be the result of certain superstitions held by some of the local native peoples, especially those living around the Trout Lake area. Fur records for 1965 to 1970 show 62 wolves returned at Fort Simpson/Jean Marie River, and 32 from Fort Liard.

Caribou:

The caribou are found on either side of the Liard river, around the Trout Lake area and in the Martin Hills. No observations or signs of this species were made during either the March or April surveys.

Birds:

Three sightings of waterfowl were made, and consisted of a pair and a group of three mallards, and one pair of Harlequin ducks. All seven birds were seen along the Blackstone River. In addition, a third sighting of mallard was made, out of the study area, and also 14 Canada geese, all at the junction of the Liard and MacKenzie Rivers. All sightings were of flying birds. Open water along the tributaries and in the form of ponds was evident throughout the area.

Potential nesting sites for falcons and other birds of prey were evident along the steep and high banks frequently seen along the Liard River, and on the uplifted and tilted outcrop of rock to the southwest of Nahanni Butte. Two buteos were sighted during the survey, an unidentified hawk, and what appeared to be a rough-legged hawk in the vicinity of the Poplar River.

Flights made Between the 28th of June and the 2nd July

During the fish sampling study, it was possible to make observations of wildlife on flights between sample locations.

Moose:

A total of five moose were sighted during this period. All but two of these were adult bulls, with antlers in velvet. The other two animals were an adult cow, accompanied by her calf of the year. All male moose were alone, and all five individuals were observed either along the upper ends of the tributaries of the Liard River or in or by the ponds and lakes with abundant aquatic plant growth. At the fish sampling locations, it was possible to observe that the fresh signs of moose browing confirmed the observations of favoured species made in the earlier surveys. The moose were well dispersed away from the Liard River in contrast to the observations earlier in the year. In some areas, particularly along the Muskeg and upper reaches of the Netla Rivers, there were signs of severe hedging on willows, dogwood, and rose.

Birds:

A female goldeneye and 5 or 6 young were seen on a small tributary of Rabbit Creek. Two male goldeneye and a number of mallard were also observed in the lower Netla region, where the river is surrounded by extensive ponds and marsh areas.

No other sightings of wildlife were made during this period, although the observations of the helicopter pilot made throughout the summer supported the observations of moose distributions made during this period. Only one black bear was spotted at the D.P.W. field camp at Bovie Lake. Other sightings of black bear were made by D.P.W. field crews along the cut-lines to the west of Bovie Lake.

Flight made on the 16th October

Low cloud hampered observations during this flight, especially in the area north of the Blackstone River. In this region, snow covered the ground but appeared to be no more than 6 inches in depth. In the southern area there was less snow, and around Bovie Lake the ground was clear of snow.

Moose:

Two moose were observed during this flight. Both were lone adult bulls. Their antlers were clear of velvet in both observations. One male was observed between the Liard River and the highway right-of-way, opposite Mile 43 in a semi-open area browsing on willow. The second was sighted approximately 4 miles east of the highway, opposite Mile 15, standing in a young Brule area with a heavy ground cover of cross-crossed fallen timber.

Besides following the usual zig-zag flight path over the entire length of the proposed highway route as far south as the British Columbia/Northwest Territories border, flights were made into areas in which moose had been during the summer. Recent signs and tracks of moose were mainly found near the Liard River, suggesting that along with the observations of the two males, the moose were moving back from their summer areas towards the river. Relatively fresh signs and tracks were seen in the area to the west of the highway route between the Netla and Blackstone rivers. This area is designated as the best class of winter habitat on the Atlas maps prepared by the Canadian Wildlife Service (1973) and from the observations made during 1974, this would lead to the conclusion that this area, along with the islands of the Liard River, are of great significance for the moose population in this region. Every effort should therefore be made to ensure that minimal disturbance be made in these locations, especially if a feeder road is planned to link the settlement of Nahanni Butte with the Liard Highway.

Fox:

A single fox was sighted in the marsh flats of the lower Netla River area. Numerous other tracks of small mammals were seen throughout the area where snow was present.

Birds:

Five snow geese were observed at the Poplar River crossing and appeared to have been resting on the water before being disturbed by the appearance of the helicopter. Upstream along the Blackstone a relatively small falcon, colored brown and slate grey, was observed, but positive identification was not possible. A bald eagle was sighted just east of the confluence of the South Nahanni River with the Liard River.

No other sightings of wildlife were made during this flight, although four observers, including the pilot, were present. Reports from the Game Officer at Fort Simpson indicated that moose on the north side of the Liard River moved towards the Ram River in the spring and that a salt lick along the Ram River was used by caribou in the fall. A second lick in Deadman's Valley was known to be used by sheep and caribou.

APPENDIX 2

January 22, 1974
Project 6311

Public Works Canada
Western Region
10th Floor, One Thornton Court
P. O. Box 488
Edmonton, Alberta

ATTENTION: Mr. A. L. Perley, Manager
Western Road Program

Dear Mr. Perley:

RE: Environmental Impact Study -
Fort Simpson--Fort Liard Highway

This interim report is intended to provide the environmental considerations necessary to resolve the physical crossing of the Poplar River. We have attempted to be definitive in our conclusions and recommendations to facilitate the final design by the agencies involved.

The final environmental impact report on the Fort Simpson--Fort Liard Highway will incorporate this interim report.

Respectfully submitted

SYNERGY WEST LTD.

M. E. Simpson

M. E. Simpson, P. Eng.
Project Director

AUTHORIZATION

This report is prepared under Department of Public Works Contract A13/74. The "terms of reference" specifically applicable to the Poplar River are as follows:

- conduct environmental surveys and studies for the primary purpose of assessing environmental impact
- advise concerning ways of remedying environmental damage
- provide advice to bridge agencies on the design and construction of bridges and approaches
- assess stream and river crossings in relation to fish passage and impact on aquatic habitat
- advise on alternative fish passage structures
- suggest restoration of fish habitats damaged by development activities.

THE PROBLEM

In 1971 two 18 foot diameter by 190 foot long metal culverts were installed at the Poplar River crossing. A formal complaint was laid in July, 1972 by Environment Canada - Fisheries. Correspondence dated November 2nd 1972 Environment Canada Fisheries by J.M. Millen, Head, Environment Quality Section, Winnipeg, Manitoba states: "My conclusion is that the most feasible way to provide effective fish passage at this site is to rebuild the crossing, providing a considerably greater waterway. The Poplar River crossing as presently installed is an unacceptable obstruction to the migration of a significant fish population."

This complaint effectively stopped further construction and resulted in this contract (A13/74). The problem was reinforced in report by

Renewable Resources Consulting Services Limited in 1972. "Two culverts in place on the Poplar River since 1971 are thought to present a barrier to fish migration". Evidence for this effect is presumably based on observations of large numbers of Arctic Grayling (Thymallus arcticus) downstream from the culverts which were unable to overcome the high water velocities in the culverts.

INVENTORY

The site was visited in the fall of 1973 by Synergy personnel. The relationship and import of the Poplar River within the region was determined and a detailed photographic assessment was made.

This report is based upon all known developed information relative to the crossing. Development of new information and additional inventory within the time constraints was impossible.

STREAM CHARACTERISTICS

These data were provided by Unies Limited in their report "Hydrological Study, Fort Simpson/Fort Liard Highway, Report on Air Photo Assessment of Catchments December, 1973".

Channel characteristics - braided, structure controlled, be ded, 1,000 feet wide flood plain, 250 feet normal width of flood channel, 150 feet width of stream, even profile, deeply incised valley, discordant tributary streams, light flood plain vegetation and no normal flood channel vegetation.

Basin characteristics - linear level type, drainage structure controlled, dentritic.

No backwater from Liard due to very steep gradient. Incised channel system. Cormack Lake outlet 50 feet wide meandering channel, not incised. Lakes in northwest of basin poorly connected and may be seasonal. Cormack Lake may have some winter flow.

FLOW CHARACTERISTICS FROM UNIES LTD. JANUARY, 1974

Factor	Frequency	Mean Daily Peak Flood (cfs)	Velocity (fps)	Depth (ft)	Flow Duration (days)
snowmelt	50 year	22500	8.3	9.0	less than 1
snowmelt	30 year	19200	8.0	8.5	less than 1
rainfall	50 year	13500	7.3	7.5	2.6
rainfall	30 year	11500	7.1	7.1	4.5

Specific flows and water velocities at the times of observations are not available.

TABLE 1

FISH BIOLOGY

Species

Several species of fish are known to be present in the Poplar River during the open water period. The only available information on species composition and population sizes is contained in a series of reports on the fish resources of the MacKenzie River Valley (Hatfield et al, 1972; Stein et al, 1973; Dryden et al, 1973). Table 2 lists species caught or observed in the Poplar River and Cormack Lake during 1971. While the species listed are known to be present, there several other species which must be considered potential inhabitants of the Poplar River. Three species found in the nearby Birch River which might also be found in the Poplar River are: Lake Chub, Slimy Sculpin and Brook Stickleback. The Liard River contains Humpback Whitefish, Broad Whitefish, Lake Cisco, Yellow Walleye, Flathead Chub and other species, which may also be found in the Poplar.

The few fish collected in the Poplar are not sufficient to establish percent species composition. Data are available, however, from collections made in the Fort Simpson area of the MacKenzie and Liard Rivers during 1971 (Hatfield et al, 1972). Figure 1 illustrates the percent species composition of fish caught by gill net. Northern Pike and Humpback Whitefish dominated the catch throughout the

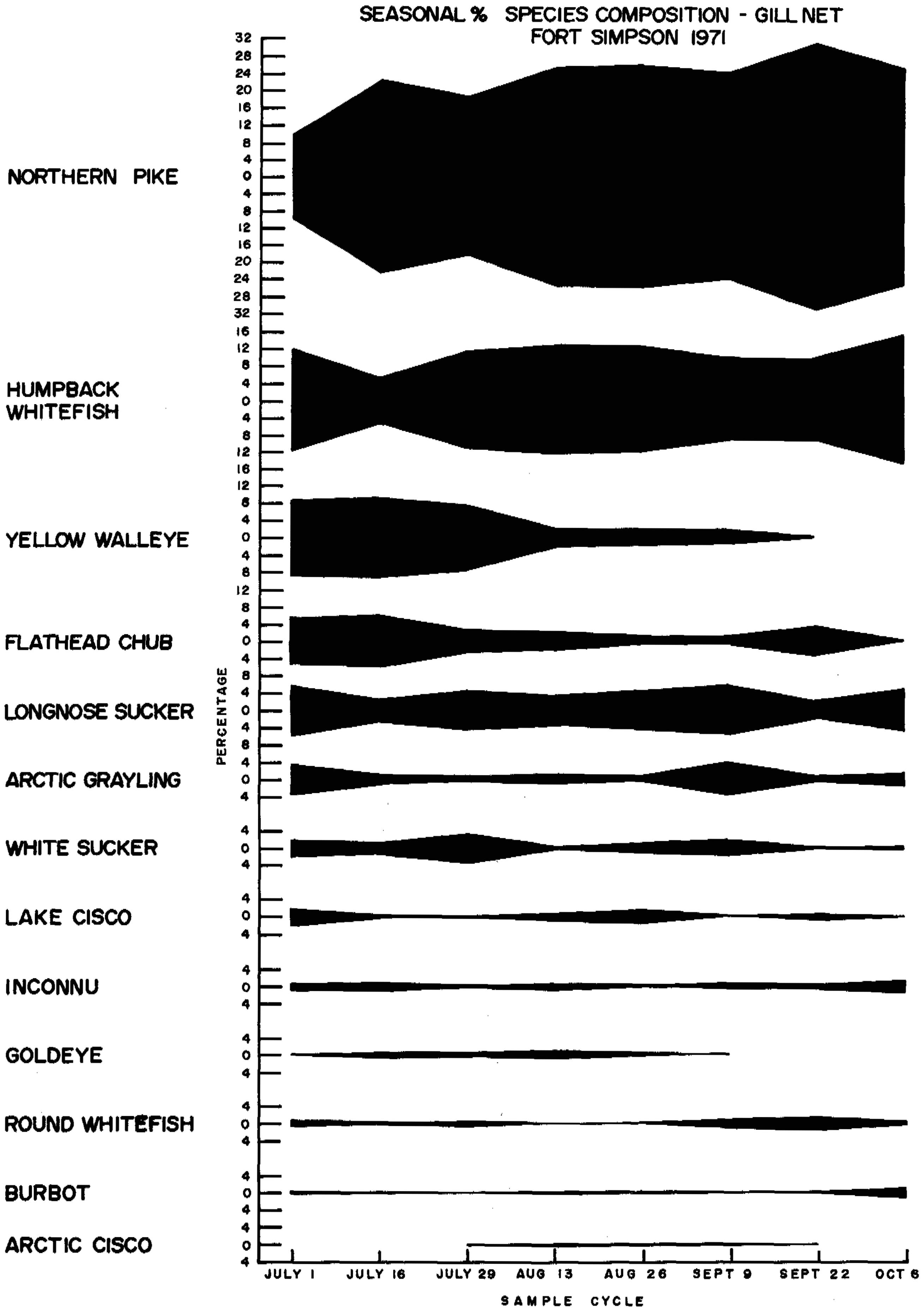


FIG. 1. SEASONAL CHANGE OF GILL NET CATCH COMPOSITION - FORT SIMPSON 1971

SOURCE: FISH RESOURCES OF THE MacKENZIE RIVER VALLEY, INTERIM REPORT I VOLUME I - 1972 ENVIRONMENT CANADA.

FIGURE 1

sampling period with lesser numbers of Yellow Walleye, Flathead Chub, Longnose Sucker, Arctic Grayling, and White Sucker, as well as other species. Until further information is available, it is not unreasonable to assume the percent species composition of the Poplar resembles that found in the Fort Simpson area.

Heavy silt loads in the Liard River require most fish species to migrate to silt-free streams for spawning. The upstream spawning run is usually followed by a downstream movement of spawned-out adults. Adults of some species may remain in the tributary streams until just before freeze-up when they move to deeper water along with young of the year. Characteristic for several species likely to be found in the Poplar River are given in Table 3.

FISH SPECIES CAUGHT OR OBSERVED IN THE POPLAR RIVER
DURING 1971 (from Dryden et al, 1973)

Location	Date	Species	Number
Lower Poplar	June 23	Northern Pike	1
Lower Poplar	June 24	Burbot	1
Upper Poplar	June 23	Northern Pike	2
Upper Poplar	June 24	Longnose Sucker	3
		Longnose Dace	
		Arctic Grayling	3
		Trout-Perch	1
Cormack Lake	August 25	Northern Pike	4
		Longnose Sucker	4
		White sucker	1

TABLE 2

CHARACTERISTICS OF FISHES FROM THE POPLAR AND NEARBY RIVERS

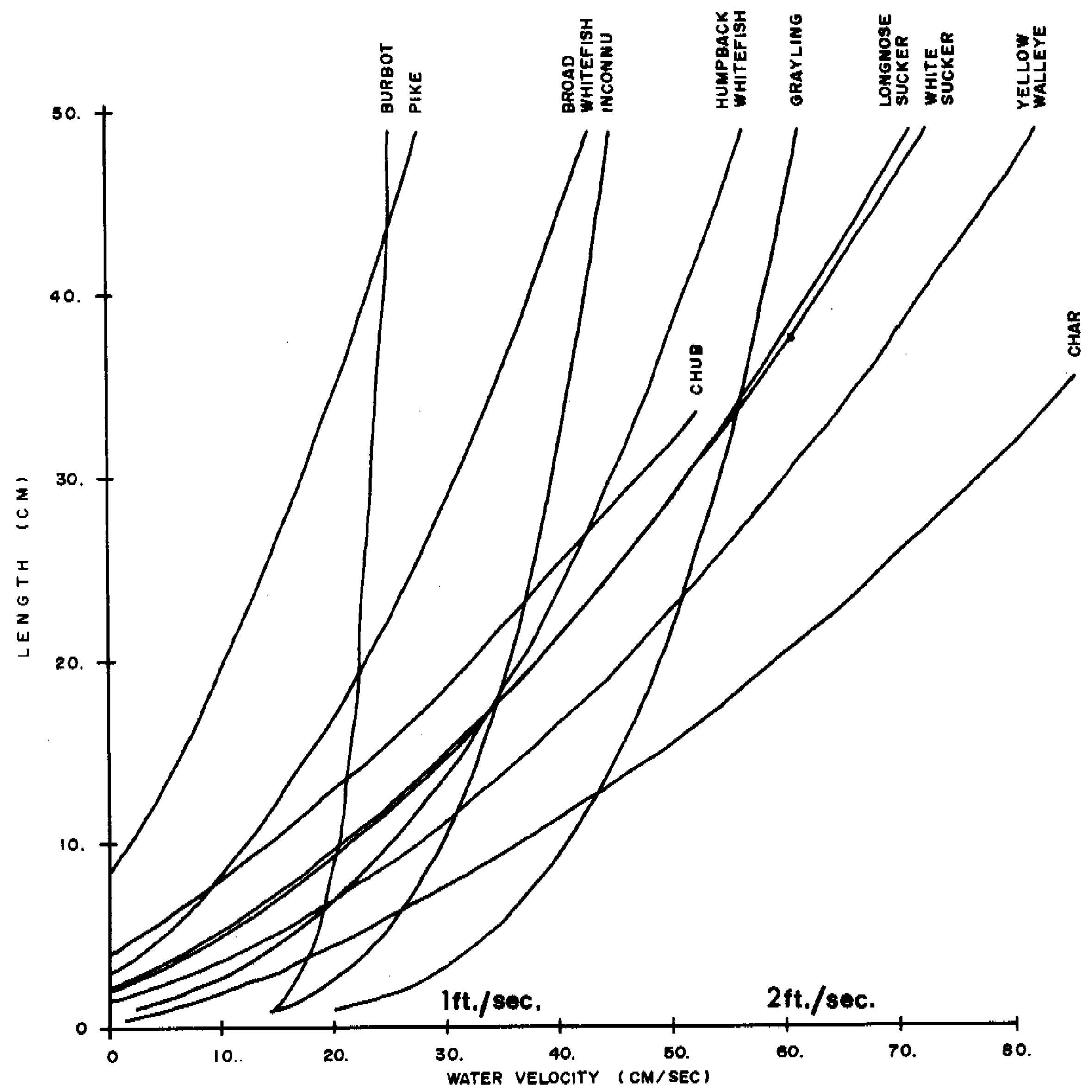
Species	Age at Maturity (years)	Length at Maturity (cm)	Length at 0+ Year (cm)	Time of Spawn	Water Temp. During Spawn (^{o}C)	Critical Velocity (cm/sec)	References
Northern Pike	2-3	20-35	9.5	May-July	7-16	30	Hatfield et al 1972 Stein et al 1973 Jones 1973
Arctic Grayling	6-9	25-30	4.7	May-June	8-10	70	Hatfield et al 1972 McCart et al 1972 Jones 1973
Longnose Sucker	5-6	35	5.0	May-June	8-16	70	Hatfield et al 1972 Stein et al 1973 Jones 1973
Flathead Chub	-	-	-	-	-	50	Jones 1973
Burbot	3-4	20-30	5.2	February	1.5	30	Hatfield et al 1972 Cahn 1936 Jones 1973
Longnose Dace	2	-	-	May	15	-	Bartnik 1970
White Sucker	-	-	-	May-June	10	60	Geen et al 1966 Jones 1973 Hatfield et al 1972
Trout Perch	-	-	2.5	June	10	55	Hatfield et al 1972 Magnuson & Smith 1963 Jones 1973

TABLE 3

SWIMMING PERFORMANCE

A number of studies have been undertaken to assess the swimming performance of various species of fish (Brett, 1964; Blaxter and Dickson, 1959; Brett, 1967). It appears fish are capable of both steady performance of indefinite duration as well as burst swimming at speeds 3-4 times maximum sustained speed but lasting only 12-24 seconds. Bainbridge (1960) has indicated the maximum distance a fish is able to travel in still water during burst swimming would be in the range of 40M. Jones (1973) has noted the mean length of culverts in use on the MacKenzie Highway is around 55M, with the maximum near 100M. Distances such as these could not be traversed by burst swimming, but are more likely to be covered by steady performance near the maximum sustainable speed.

Jones (1973) has recently characterized the swimming performance of fish species from the MacKenzie River area. Laboratory and field studies were structured to give a measure of the maximum steady swimming performance (critical velocity) which could be maintained for 10 minutes. Critical velocities for several fish species likely to be found in the Poplar River are given in Table 3. Figure 2 illustrates the relationship between fork length and ability to move 100M against water velocities of 0-80 cm/sec. in 10 minutes (Jones, 1973). The curves can be used to establish maximum allowable water velocities for obstacles of various lengths where passage by fish is intended. For examples, the Poplar River culverts which are 190 feet (59M) would allow passage for adult Grayling (25-30 cm) if water velocities were 60 cm/sec. (1.9 feet/sec.) or less. Northern Pike would require maximum water velocities of 30 cm/sec. (1.0 foot/sec.) or less for passage. J.M. Millen stated "It is difficult to resolve laboratory and field data on swimming performance, however, water velocities of 5 feet/sec. appear to be rather high." He stated for example that a few pike at Frog Creek were able to make it through a culvert at 5 feet/sec. but were in a damaged condition. R.L. Dryden (memo October 27th 1972) notes a clear span of 90 feet to 100 feet is



THE RELATIONSHIP BETWEEN FORK LENGTH AND ABILITY TO MOVE 100 M. AGAINST WATER VELOCITIES OF 0-80 CM/SEC. IN 10 MINUTES.

The same curves may also be used to indicate the ability to make progress against these currents over shorter distances. For instance, to cross a 50 m barrier in 10 min, the curves should be shifted 8 cm/sec to the right; to cross a 25 m barrier in 10 min, the curves should be shifted 12 cm/sec to the right. The line for char is derived from the hypothetical equation $V = 17\ L^{0.5}$ and represents the measured value in these experiments.

SOURCE: AN EVALUATION OF THE SWIMMING PERFORMANCE OF SEVERAL FISH SPECIES FROM THE MacKENZIE RIVER. - D.R. JONES, U.B.C.

FIGURE 2

required to allow migration. This is based upon flood criteria approximately ½ that of the projection of Unies Limited. These water velocities may seem unreasonably slow. However, water of sufficient velocity to block fish passage through a culvert, may not block passage in a stream, due to the effect of the stream substrate. Fish move from one dead water area to another behind natural objects in the stream substrate (Renewable Resources, 1972).

Low water levels can also adversely affect swimming performance and minimum depths of 3-5 inches have been recommended (Oregon State Game Commission, 1971; Renewable Resources, 1972).

R. Scace (personal communication, 1974) notes present designs utilizing a seven day delay migration. McCart et.al (1972) note, however, an almost spontaneous (within 24 hours) movement of grayling after peak flood conditions. Renewable Resources Consulting Services Ltd. (1972) state:

> We feel that there are probably reasonable limits for grayling moving upstream during the spring spawning migration. Because they are close to spawning and because of the short duration of success. The maximum seven-day delay period suggested in the Fisheries Service Highway Guidelines (Anonymous, 1972) seems excessive and might have serious consequences for populations in streams where delays of this length were an annual occurrence.

SPAWNING AREAS

A general account of the Liard River and its tributaries is to be found in a report by Hatfield et. al (1972). Generally, the high silt load of the Liard makes it unsuitable as a spawning and nursery area. A great diversity of fish species at the mouth of the Liard indicates the river may serve as an important migratory route for spawning fish. A comparison of the estimated potential spawning areas available in the major tributaries of the lower Liard River surveyed by Hatfield is shown in Table 4.

Between Fort Simpson and Nahanni Butte the five major tributaries of the Liard have an estimated 2.2 million square yeards of potential spawning gravel (Table 4). Of this estimated total, nearly 1/3 is in the Poplar River. The other tributaries have restrictions reducing their potentials. It is therefore estimated that the Poplar River represents approximately 50% of the potential for the lower Liard River system.

From this data, one can see the Poplar River is a major potential spawning area. Extensive pools with intermittent rapids indicate excellent spawning areas.

EVALUATION

The data available allows only a very limited evaluation of the fish resources of the Poplar River. Seven species of fish are known to occur in the Poplar with at least 3 others likely to be found there. The presence of immature Longnose Sucker, Longnose Dace, Arctic Grayling, and Trout-Perch, indicate that these species and probably others, utilize the Poplar as a spawning area.

The present river crossing has effected a barrier to migration for two years. We believe that adult breeding stocks will be severely damaged if the migration of 1974 is not permitted. J.M. Millen stated in 1972: "We have now sustained these losses to one year class of Grayling. If the obstruction is removed in the next construction season (1973), the Grayling stocks will not be severely damaged." The deterioration of breeding stock will accelerate almost exponentially this year and the next because the age of the breeding stock will be 3 to 4 years and natural depletion will increase. Millen also states: "If plans are made to remove the obstruction within the next two years (1972 and 1974), we can take specific measures to protect the breeding population".

The importance of the Poplar River necessitates that we do not place undue restrictions on this potential spawning area.

COMPARISON OF POTENTIAL SPAWNING AREAS
FOR MAJOR TRIBUTARIES OF THE LOWER LIARD RIVER
(from Hatfield et al, 1972)

Tributary	Length (mi.)	Length Surveyed	Potential Spawning Gravel (sq. yds.)	Comments
Poplar River	62	40	788,000	
Birch River	37	37	63,000	Falls and beaver dams present.
Matau River	51	51	nil	No significant spawning areas.
Blackstone River	60	60	1,162,000	Low water levels reduce potential.
Grainger River	42	42	271,000	Beaver dams present.

TABLE 4

WILDLIFE BIOLOGY

Field data are very limited on mammal and waterfowl populations in the vicinity of the Poplar River Crossing. It appears that the Canadian Wildlife Service has not done specific studies in this region (Dr. W. Stevens personal communication). Judging from the limited information available in the Land Use Information Map Series, the crossing does not significantly influence any major mammal or waterfowl populations, *per se*. The major influence is probably through increased access to hunters and trappers.

The area can be expected to have reasonably good moose populations. The general habitat type appears to be muskeg, and should be fairly uniformly productive for moose. The Poplar River is not extensively braided and because of this, it would not have exceptional attractiveness for moose. What willows and other shrubs exist along the river valley will be a preferred winter food source.

The muskrat-beaver association in the Poplar drainage basin is also limited. According to the Land Use Information Map Series, trapping in this area is "a relatively recent development and appears to be largely a part-time activity of men employed on road construction nearby".

The map further points out that, "nevertheless, the area is particularly well used during the spring beaver hunt, and there are indications that at least one trapper may begin operating on a regular basis in the near future." To protect the beaver-muskrat association, care should be taken to avoid stream siltation and artificial fluctuations in water level. Since the crossing is in close proximity to the confluence of the Poplar and Liard Rivers, these considerations are minor.

Given that the road is completed, the potential mammal and waterfowl uses of the area will not be significantly altered by the type of river crossing that is chosen.

The crossing will not affect any critical flora associations.

ARCHAEOLOGICAL RESOURCES

There are no known prehistoric or historic restrictions on the present crossing or its redevelopment.

RECREATION VALUE/AESTHETICS

We identify the Poplar River Crossing as a primary recreational node along the highway. A number of factors predicate this choice, one of significance is the sport fishing value. This value is considered greater for the Poplar than any other stream along the highway. The proximity to Fort Simpson presupposes significant use by residents.

The visual characteristics of open channel structures are superior to earth fill structures. The report was not intended to provide detailed advice on this aspect. Final determination of the crossing type would consider the aesthetics and will be the subject of further work.

CONCLUSIONS

1 The importance of the fisheries resource of the Poplar River within the lower Liard River system is recognized. To protect and maintain this resource, the following criteria must be considered in design of the river crossing

- removal of the present obstruction prior to spring break-up 1974 to allow migration within the following limits.
- a stream velocity of 2 fps for straight culverts
- a stream velocity of 5 fps or the natural velocity, whichever is greater, when natural conditions are assimilated
- a maximum 3 day delay in migration due to velocities above recommended limits
- a minimum water depth of 5 inches or natural stream conditions
- a study of the fisheries resource, specifically spawning success after removal of the obstruction, during the 1974 season and at lease one year after construction
- construction affecting the river channel must be prevented from spring break-up to the completion of upstream migration (approximately late April to early July).

2 There are no restrictions due to fauna and flora

3 There are no archaeological restrictions

4 Sport fishing is considered to high a high recreation value

5 Aesthetics will be determined during the final design stage

6 The preferred crossing type is that which provides a natural stream bottom (i.e. bridge). The second preference is a

crossing type approaching natural conditions (i.e. multi-plate arch; open bottom, submerged culverts with natural bottoms). The least preferred is provision of artificial means of fish passage similar to recommendations made by Renewable Resources Consulting Services Limited (1972) in their "Preliminary Report, Culverts and Fish Passage MacKenzie Highway Overview Study".

7 The following recommendations apply to the actual construction

- excess fill materials should not be wasted to existing deposits (i.e. west bank) but should be placed in old borrow-pits
- erosion control be placed in approach ditches to control siltation
- fills be stabilized to prevent erosion minimize retard
- to prevent erosion, existing river banks should not be further cleared
- construction be curtailed during upstream migration

8 That consideration be given to removing the obstruction during 1974 to allow for further detailed study of the fisheries resource of the Poplar River system and to verify this report and that the solution be accomplished in 1975.

APPENDIX 3

Record of Visual Highway Inventory Trip, October 3rd 1973, Mile 0 to Mile 30.6

Mile 0 is the junction of the MacKenzie Highway with the Liard Highway. The corners have been cut at this location, making a large cleared area. This will require some study as far as identification of highways and whether or not service facilities should be incorporated at this location.

Mile 0.3	Access road
Mile 0.7	Highways Maintenance Depot - why was this not incorporated with adjacent old construction camp ? Simple road entrance does not appear to present a problem. Camp is basically screened from highway vision.
Mile 1.0	Access to old construction camp. Suggest this might be required to service maintenance area. It would also seem reasonable that this old camp area, which is cleared, be incorporated into future extensions for this maintenance depot. Astute signing for identification of this location may be considered.
Mile 1.4	Borrow-pit on corner of highway that visually will require attention.
Mile 1.7	Rough interceptor ditch - requires trimming and planting.
Mile 1.9	Drainage ditches requiring work and clean-up.
Mile 2.1	Access to small borrow area. Screening of entrance a problem.
Mile 2.2	Second access to small borrow area.
Mile 2.3	Seismic line - visual problems. Entrance screening possible.
Mile 2.6	Small borrow pit. Common entrance problems.
Mile 3.2	Interceptor ditch - requires trimming and work.
Mile 4.0	Large double borrow-pit. Requires treatment for stabilization and screening of entrances. Cannot see any possible other use.
Mile 4.6	Very bad area - seismic running in two directions, plus borrow-pit, all converging into a mess.
Mile 4.8	Another interceptor requiring consideration.

Mile 14.3	Exposed borrow-pits. Typical entrance and stability problems.
Mile 14.4	Seismic lines. Visual problems.
Mile 14.8	Bad borrow-pit, water. Creek drainage through 7 foot culvert. Field interpretation required.
Mile 15.5	Borrow-pit plus culvert. Two entrances requiring consideration.
Mile 17.1	Shallow borrow-pit. Entrance problems.
Mile 17.3	Shallow borrow-pit, exposed to road. Very bad. Visual considerations.
Mile 17.7	Seismic lines - could soften by selective cutting on hump, 300 feet in from roadway. Field design.
Mile 17.8	Interceptor - long and straight. Possible interruption required.
Mile 18.1	Seismic lines - visual problems again.
Mile 18.3	Borrow-pit - big. Bad entrance problem to entrances.
Mile 18.9	Borrow-pit with water. Entrance and stability considerations.
Mile 19.0	Duff deposit - major deposit area.
Mile 20.0	Duff deposit and drainage channel.
Mile 20.2	Duff deposit loop - two entrances.
Mile 20.7	Seismic - visual entrances.
Mile 20.8	Side cuts - duff deposits.
Mile 21.3	Borrow pit. Typical problems.
Mile 21.9	Old seismic line or centreline cut. Field interpretation.
Mile 22.1	Major gravel pit at Poplar River. This may be incorporated into Poplar River Development.
Mile 22.3	Poplar River - existing construction camp. Small airfield. Access approximately three miles to Liard River. This entire area requires a detailed field analysis to determine potential and future uses. It is one of three accessible river crossings. Has breaks in a relatively flat channelized highway.
Mile 22.4	Bad disposal site. Exposed to view of the Poplar River. Field considerations required.
Mile 22.6	Culvert with ditch blocks.
Mile 22.7	Soil disposal area. Duff disposal. Seismic line.
Mile 22.9	Culvert with ditch blocks.
Mile 23.0	Duff deposit.
Mile 23.5	Borrow-pit - shallow - water filled. Entrance problems.
Mile 23.7	Culvert with ditch blocks.

Mile 24.1	Borrow-pit. Typical entrance problems to access.
Mile 25.0	Seismic both ways. Selective cutting could improve view to mountians. Close off east extension - small side cut and culvert - re-hab. required.
Mile 25.2	Small pit.
Mile 25.4	Duff deposit.
Mile 25.8	Interceptor - needs work and trimming.
Mile 26.0	Seismic lines - borrow pit. Bad aspect. Site evaluation required.
Mile 26.1	Interceptor - requires trimming.
Mile 26.6	Culvert. Looks like possible interceptor required. Should field locate and plan.
Mile 26.9	Borrow-pit - full of water. Two access problems.
Mile 27.2	Duff deposit.
Mile 27.3	Interceptor.
Mile 27.7	Seismic interceptor. Side cut for duff deposit or seismic requires clean-up, visual interruption, etc.
Mile 28.0	Culvert and interceptor to river bank. Sould consider river bank erosion problem.
Mile 28.4	Interceptor to river bank. Check erosion.
Mile 28.8	Interceptor to river bank requires clean-up. Check bank erosion.
Mile 29.0	Borrow-pit. Check access to river. Natural drainage channel shows recent severe erosion. May not be advisable to put more water through an interceptor to this area.
Mile 29.1	The natural interceptor draining into the above borrow area should be changed, due to possible bank instabilities.
Mile 29.5	Interceptor ditch to river bank.
Mile 29.7	Borrow-pit. Possible view to river. Should consider other uses.
Mile 29.8	Seismic line and corner. Visual interruption required.
Mile 30.1	Interceptor partly developed. Should plan in field.
Mile 30.2	Road - is this required ? Can it be removed and blocked off ?
Mile 30.3	Probable culvert and interceptor should meander in and to the left.
Mile 30.6	End of developed roadway.

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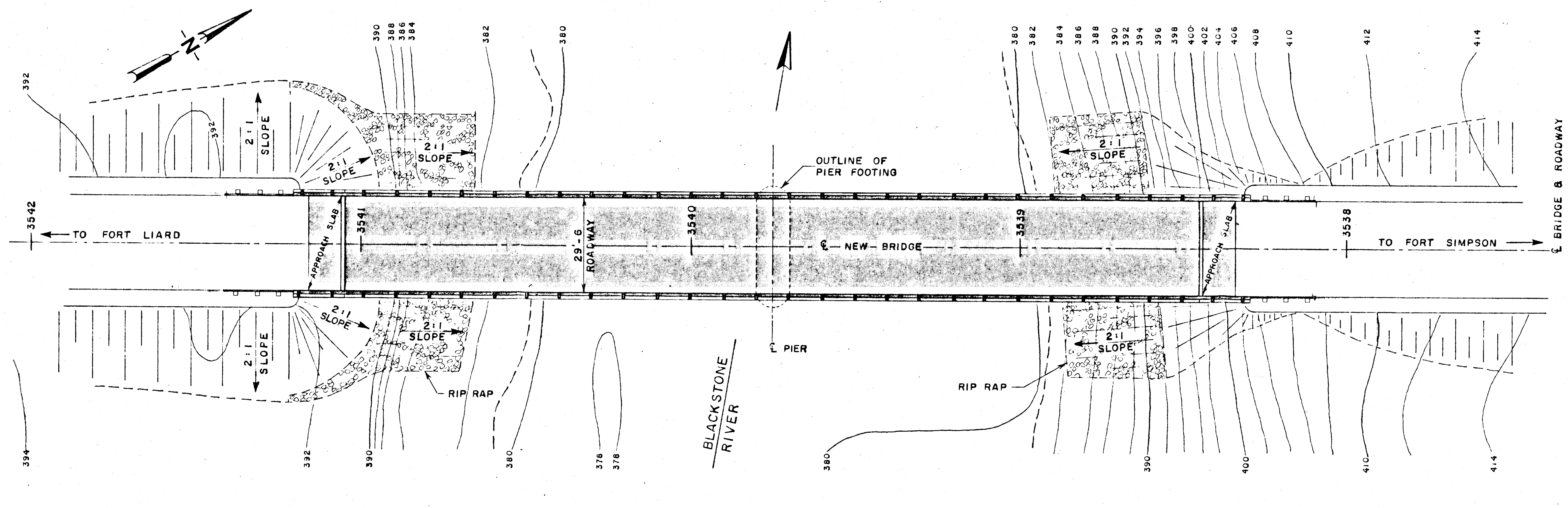
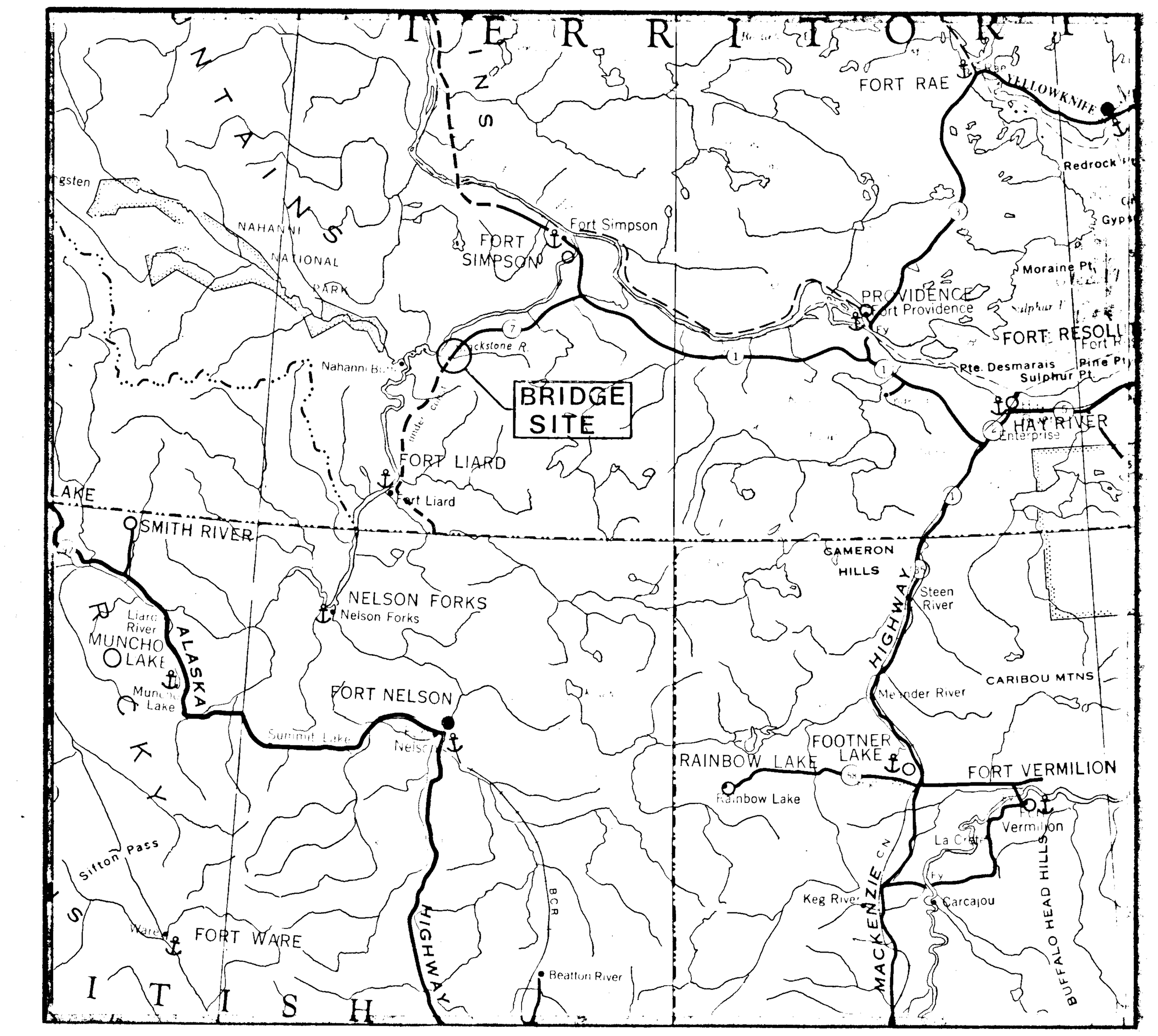
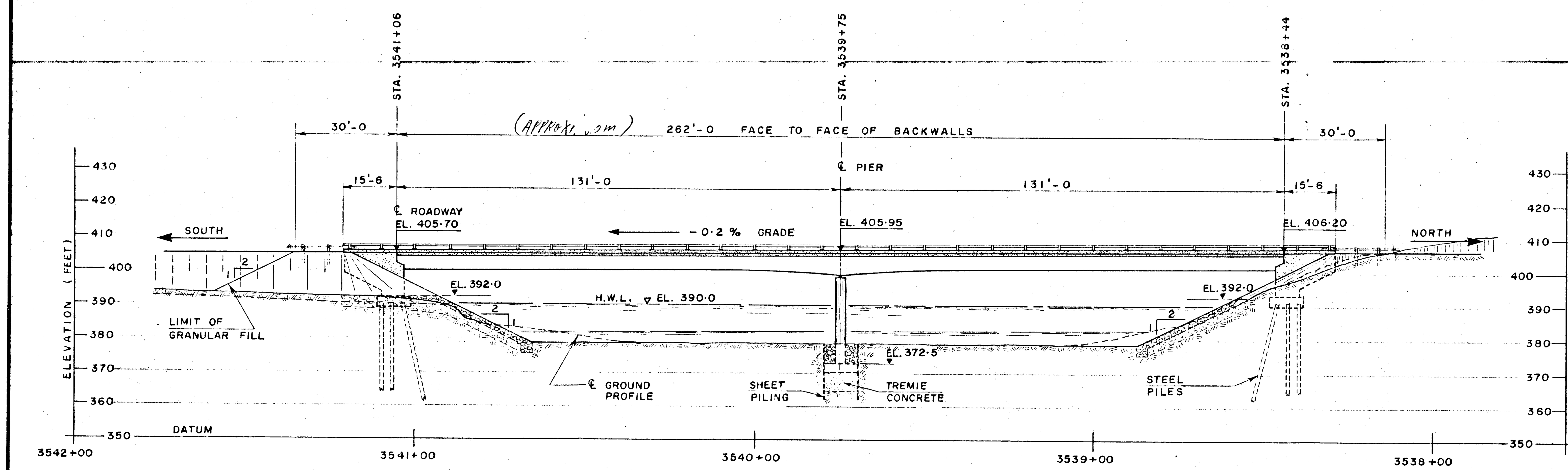


P L A N

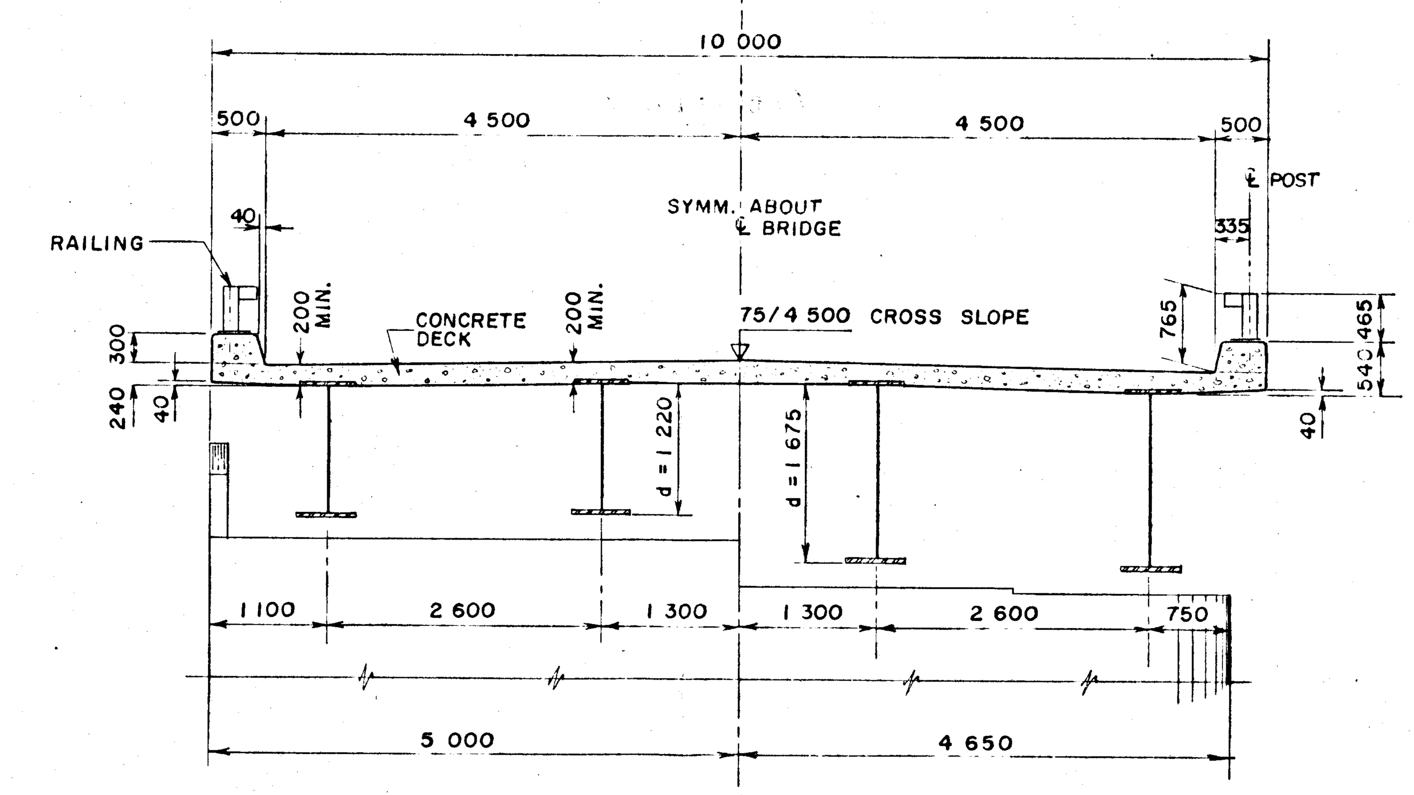


LOCATION PLAN

SCALE 1 INCH = 50 MILES



E L E V A T I O N



TYPICAL DECK SECTION

DIMENSIONS IN SI UNITS

NOTES

1. ALL DIMENSIONS ARE IN IMPERIAL UNITS EXCEPT AS NOTED. SI UNITS WILL BE USED IN FINAL DESIGN.
2. HIGHWAY PROFILE HAS BEEN LOWERED BY APPROXIMATELY 4' TO EL. 406±.
3. FURTHER GEOTECHNICAL INFORMATION IS REQUIRED.

PRELIMINARY

Public Works Canada / Travaux public Canada

Design and Construction Branch
Conception et Construction

Transportation Directorate
Direction des Transports

Structures (Bridges) Section
Section des ouvrages d'art (ponts)

A. detail no. / détail no.
B. location drawing no. / sur dessin no.
C. drawing no. / dessin no.

revisions / révisions

project title / titre du projet

BLACKSTONE RIVER BRIDGE
LIARD HIGHWAY MILE 67.0
NORTH WEST TERRITORY

drawing title / titre du dessin

GENERAL LAYOUT

project no. / no. du projet: 085903

drawing no. / dessin no.: P 1 of / de

Date: 77-12-20

H.J.B.

D.P.W. 700 B (revised april 1,1977)