ASSESSING ALTERNATIVE TRANSPORTATION INVESTMENTS FOR ISOLATED NORTHERN COMMUNITIES: A CASE STUDY OF CROSS LAKE, MANITOBA

By

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ABSTRACT

Three transportation alternatives are investigated in this practicum for the isolated northern Manitoba community of Cross Lake. These alternatives include: (1) a proposal to continue investing in the existing winter road/ferry system; (2) a proposal to upgrade the existing system by extending the all-weather road closer to the community; and, (3) a proposal to replace the existing system with an all-weather road. The analysis is conducted from the viewpoint of a Provincial Government decision-maker.

Benefit-cost and least-cost methods are employed in the comparison of results. In the quantitative portion of the study, capital, operational and mainentance costs associated with transportation infrastructure are examined for winter road, ferry and all-weather road modes. User costs and user cost savings for freight transport are also studied. The sensitivity of results is determined in relation to changing discount rates and the level of air-freight diverted to road transport when alternatives to the existing transportation system are considered.

Unquantifiable concerns are discussed to inform the decision-maker of the economic, environmental, resource development, social, and to some extent,the administrative and political consequences of each investment option.

The outcome of the analysis is the recommendation that the Provincial Government decision-maker invest in the all-weather road option. Limitations of the study methods are deliniated, particularly those which restrict the

quantification of results. Additional recommendations indicate ways to improve future transportation studies, especially studies of other isolated and remote northern Manitoba communities.

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I INTRODUCTION

A. The Study Problem

This study deals with the problem of selecting a transportation delivery system for an isolated northern community. It is designed and presented as a case study for Cross Lake, Manitoba. While it aspires to recommend the preferred investment choice to a Provincial Government decision-maker from among three alternative projects, its main intention is to identify and illustrate the treatment of major economic costs and benefits which characterize the problem.

Least-cost and benefit-cost methods are applied in the analysis using quantifiable data pertaining to infrastructure investment costs, operating and maintenance requirements and costs or cost savings attributable to the transport of goods. Quantified results are supplemented by discussions of unquantified factors of significance to the decision-maker. The latter include natural resource development potentials, impacts on commercial and transportation operators serving the community, and social and environmental consequences of investment.

The transportation projects investigated involve combinations of conventional air service, ferry, winter road and all-weather road modes of transport.

B. Background to the Problem

Up to the present time, transportation facilities serving Manitoba's more inaccessible northern settlements have been provided to satisfy the need for basic supplies for day-to-day living and local economic development. The modes of transport found to be the most economical for this level of service have been air transport and winter roads: the former ensuring the provision of time-valued goods[1]; the latter providing a less costly means of supplying heavy, bulky and low-priority goods.

Although they have satisfied the initial requirements demanded of them, the existing systems are now on the verge of becoming inadequate. Expanding community populations, increased educational standards, escalating consumer prices and elevated lifestyle expectancies are just a few of the factors characterizing northern growing pains and contributing to the need for change. The most obvious indicators of stress are the high levels of unemployment and welfare. These indicators are used to justify demands for additional community services and local employment programs. Such demands have been monitored for some time by groups such as the Northern Working Group (Manitoba 1971), expressed vigorously and repeatedly by community representatives, and reflected in recent Provincial Government policy guidelines (Manitoba 1973) and the mid-north development strategy proposed by the Canadian Council on Rural Development (Canada 1976 a).

In order to alleviate the worsening situation, transportation improvements are among the first remedies to be suggested. Many of the

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1 Time-valued goods include high priority items such as medical supplies, mail, perishables and passengers.

communities making demands espouse the advantages of developing new transportation systems without also anticipating the disadvantages. They see transportation as playing its vital role in reducing freight and passenger travel costs, creating new markets for local resources and products, offering greater opportunities for social exchange and, among other things, widening the employment catchment area for the locally unemployed. They do not always see the problems stemming from transportation, such as: out-migration of community populations, loss of cultural identity, and in-migration of non-local people or economic influences.

Indeed, transportation developments are often assumed to be the key to solving most, if not all, community problems. This assumption can not usually be justified. Transportation facilities by themselves are only tools which expedite and assist community development. They must be supported by the presence of natural resources and prepared human resources in order to do more than reduce living costs and increase social exchange.

Ideally, therefore, the evaluation of proposed transportation investments should be comprehensive in nature. Economic, social, natural resource, environmental, financial and political considerations should be taken into account so that the host of relevant costs and benefits can be identified, weighed and processed by the decision-makers. Since public funds are usually used for transportation facilities, the term 'decision-makers' typically refers to political representatives who rely upon technical personnel to supply the factual grist for decisions which are made on the basis of political preferences and selection criteria acknowledging the project of least cost and/or maximum benefit to society.

Aspiring towards comprehensive analysis, the present study selects quantifiable economic aspects of transportation investments as its primary focus in accordance with Dorfman's opinion (1965:2), that

> " . . . the process of political decision can be sharpened significantly by removing as many aspects as possible from the realm of unsupported opinion and emotive rhetoric . . . public decisions have been made noticeably more rational and consistent through submitting all project proposals to the discipline of comparing measureable costs with measureable benefits. At the very least, such a process enables attention to be focused on the question of whether the unmeasureable benefits are deemed impressive enough to justify sustaining the measureable costs that they entail."

Secondary emphases are placed upon unquantifiable concerns of social, environmental, political and economic consequence.

C. The Study Objectives

The first objective of the study is to illustrate the usefulness of cost-benefit and least-cost methods as analytical tools when comparing quantifiable economic aspects of northern transportation investments.

Secondly, the analysis attempts to reveal data limitations which affect transportation investment decision-making. By identifying where data are limited, recommendations are made for improvements to future studies.

The final objective is to suggest to the Provincial decision-maker the most appropriate investment for the case study community of Cross Lake, Manitoba.

D. The Case Study

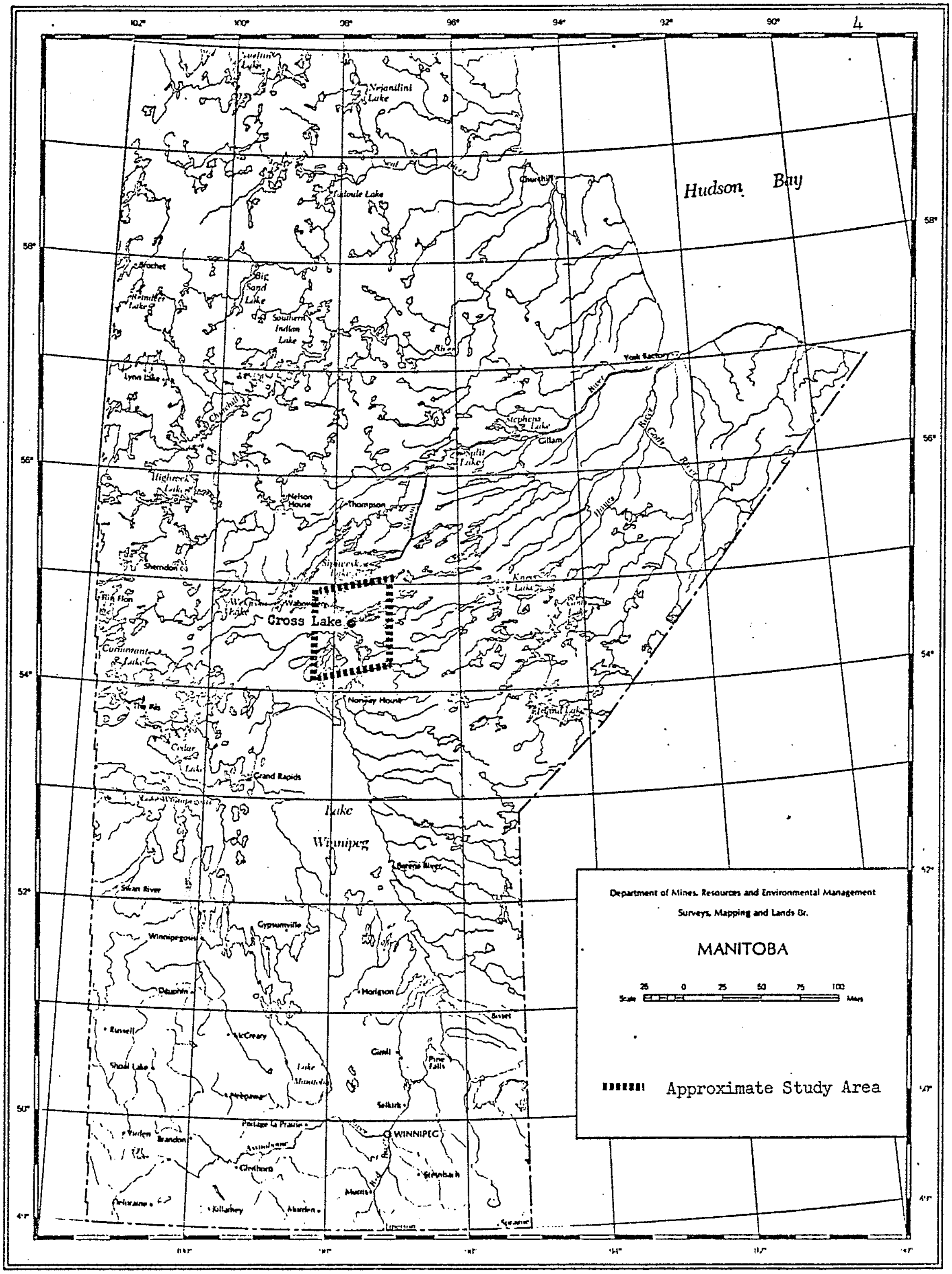
1. Why Has Cross Lake Been Selected For The Case Study ?

Cross Lake is an isolated northern Manitoba community generally characterized by a welfare economy. Minimal resource development has occurred since the days when hunting, fishing and trapping provided an acceptable level of self-sufficiency for the residents. Curiously, while the present situation persists, it is suspected that potential for recreation, forestry, commercial fishing and other resource development exists. This potential could be realized with an improved surface transportation link between the community and the outside world (Teillet et al. 1977).

Therefore, Cross Lake has been selected for this study because it is suspected that its economy can receive a substantial boost as a result of surface transportation improvements.

2. Community Background Information

Cross Lake is located in the heartland of Manitoba where the Nelson River empties into Cross Lake (Map 1). It is 327 air miles north of Winnipeg and 77 air miles south of Thompson. Nearby communities, with which there is a social or business link, include Norway House (45 miles south), Wabowden (39 miles northwest) and



Map 1 The Study Area

Jenpeg (13 miles southwest), a hydro construction camp.

While referred to as a single community, the population of approximately 2,400 (1977) is divided physically and politically. Physically, the settlement is spread along several miles of both the east and west Nelson River banks (Map 2). The two halves, connected by water and ice-assisted transportation, developed somewhat independently until 1970 when a suspended footbridge was built.[1]

Politically, a division exists between the Indian and non-Indian portions of the population. Eighty-five percent of the people are registered Swampy Cree Indians belonging to the Cross Lake Band. They live on reserve land and are governed by the Cross Lake Chief and Band Council under the auspicies of the Federal Department of Indian Affairs and Northern Development. The other fifteen percent are Metis and white people who live on Provincial Crown land adjacent to the reserve (east bank only). These people have a mayor and Community Council under Provincial jurisdiction. Because these two factions are affiliated with two different levels of senior government, they operate under different financial rules, regulations and incentives. As a result, co-operative action between Councils is made difficult and community growth, as a whole, is complicated.

Community facilities include churches, schools, a medical clinic, a fire station, offices for local government,

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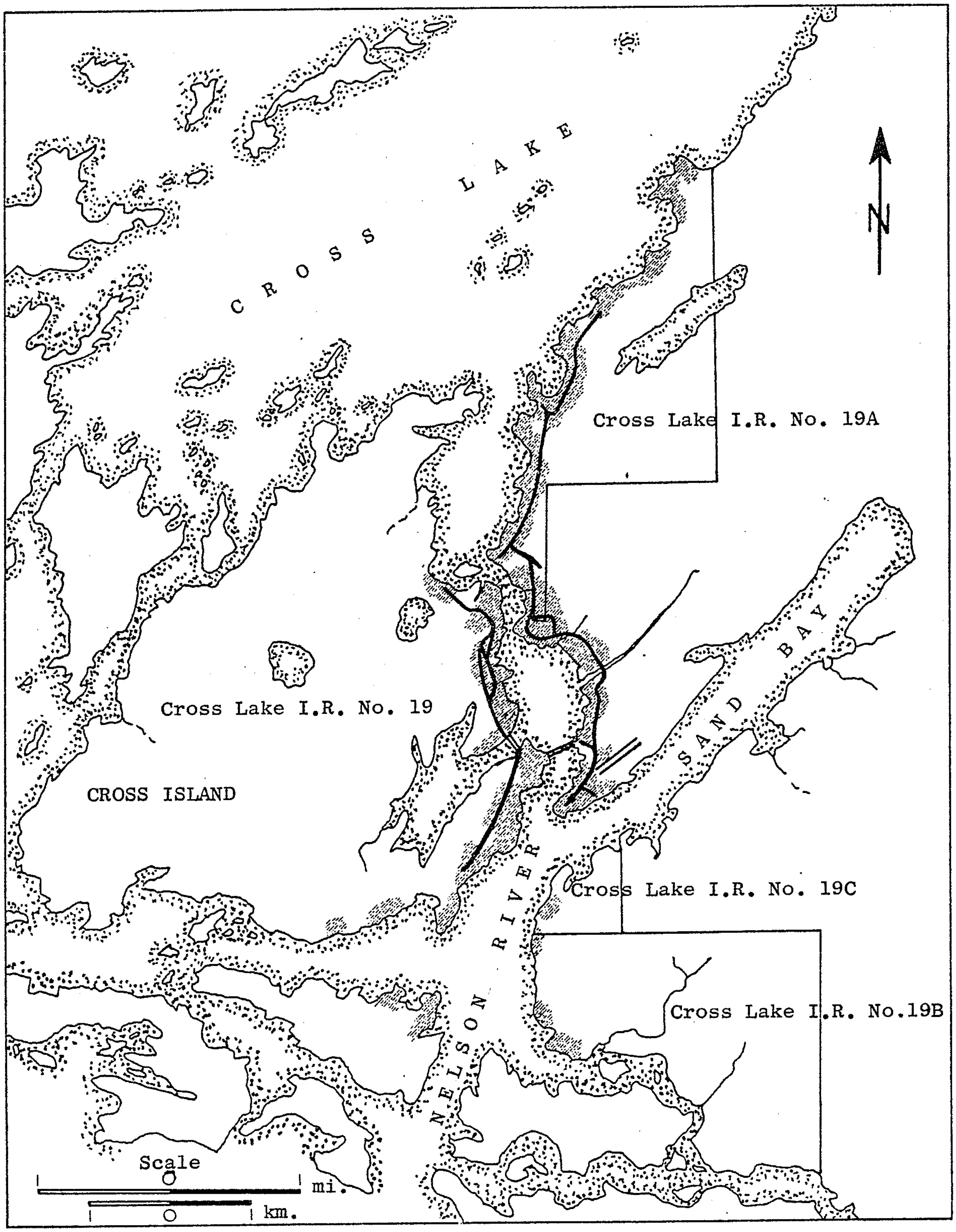
1 Schools, for example, were built on both sides of the river. Major developments such as the Hudson Bay store, churches and airstrip favoured the east side.



Map 2 The Community of Cross Lake

a post office and one large store (the Hudson Bay store). Recreation facilities include two community halls, sports fields, two outdoor hockey rinks, a beach and a pool hall. There is also a small restaurant, mechanics shop and general store. Police services are provided by two band constables, one community constable and the R.C.M.P. There is no centralized sewer or water system. Telephone and television are available, as well as a locally operated radio station.

Internal transportation facilities include gravel and dirt roads with causeways across streams and swampy shoreline areas. Although the footbridge is the only permanent link across the Nelson River, the river itself is a major internal transportation system which most people live near in order to utilize.

External transportation services are provided by air, water and winter road. These are discussed at greater length in the description of the existing transportation system below.

Finally, the major problem in the community is high unemployment. In 1976, for example, 65% unemployment left 80% of the population dependent upon social assistance payments (Teillet et al. 1977:43-47). In that year, the equivalent of 189 jobs was available from an asortment of full-time, part-time and seasonal employment.[1,2] Another 339 jobs were required to meet community needs. With half the population under the age of fifteen, the unemployment situation is predicted to become much worse unless

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1 This figure excludes non-natives (about 32) who were hired from outside the community ie. nurses, teachers, ministers and Hudson Bay staff.

2 Job types include: (full-time) teacher aides, Jenpeg construction workers, office/store/air terminal staff, public works personnel; (part-time) school bus drivers, janitors, water delivery men; and, (seasonal) house construction crews, trappers, fishermen, hunters, winter roads crews and loggers.

dramatic new opportunities are somehow made available.[1] Currently, economic activities are dominated by basic community services. Resource development, including trapping, commercial fishing and forestry, offers some hope for the future but at present contributes only to seasonal, low-income employment.

3. The Transportation Investment Options

Given the present situation at Cross Lake, three transportation investment alternatives have been selected for investigation on behalf of the Provincial decision-maker.[2] The first alternative requires that the existing transportation system be continued. The second and third alternatives are new proposals requiring the extension and completion of an all-weather road into the community, respectively. Each option is described as follows:

(a) Continuing the Existing System (Option 1)

The existing transportation system at Cross Lake is comprised of three service modes (Map 3). Air traffic is accommodated year-round by a Class D airstrip,[3] and in the summer and winter by a seaplane landing area. Also in the summer, a ferry is able to navigate the twelve miles between Whiskey Jack Portage, the nearest highway terminus,

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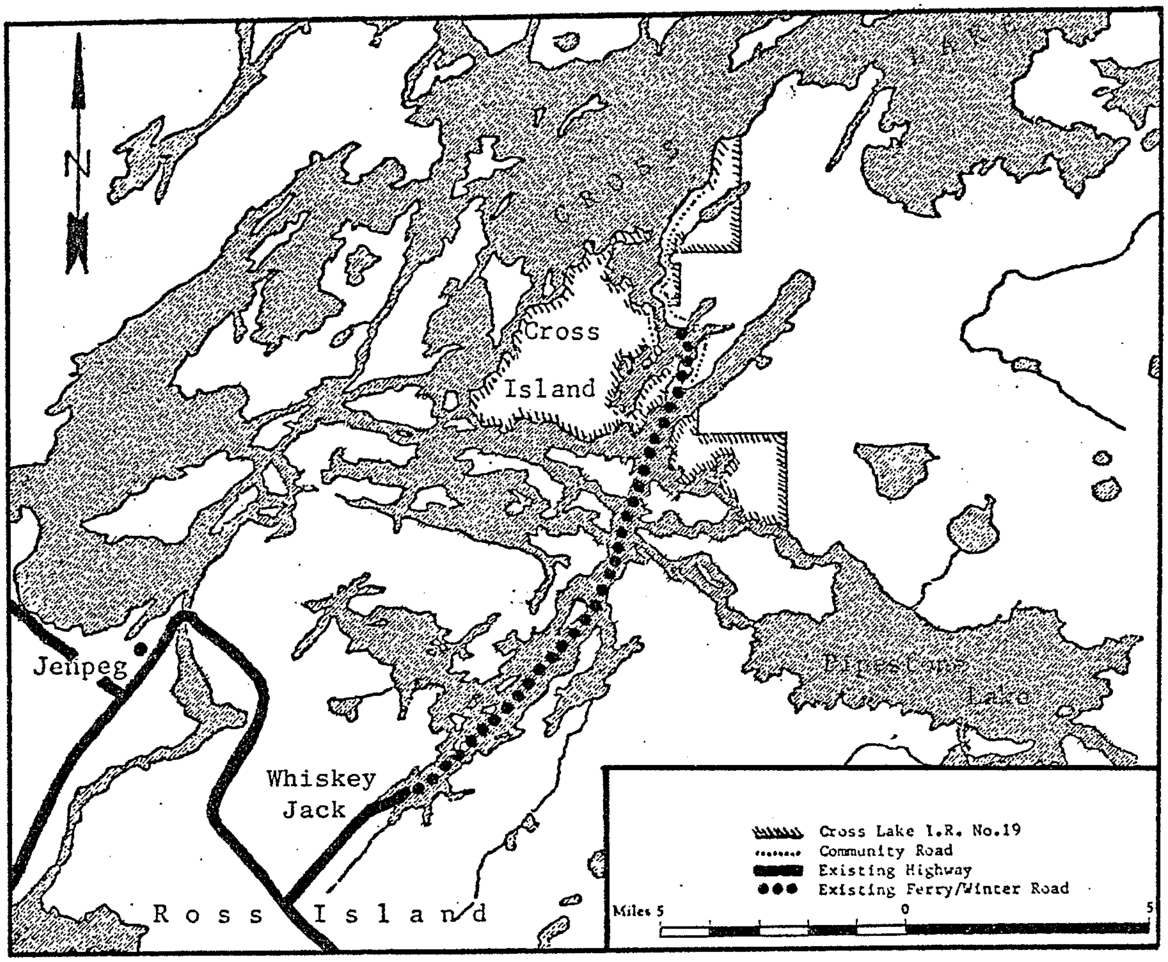
[1] Calculations indicate that to achieve full employment within fifteen years, given the 1976 needs and estimated labour force growth, 51 jobs must be created per year (Teillet et al.1977:47).

[2] These alternatives have been suggested in a Manitoba Department of Highways communication (Manitoba 1977).

[3] A Class D airstrip permits the landing of aircraft which have a maximum take-off weight of not greater than 35,000 pounds (Canada 1975).



Map 3   The Existing Transportation System

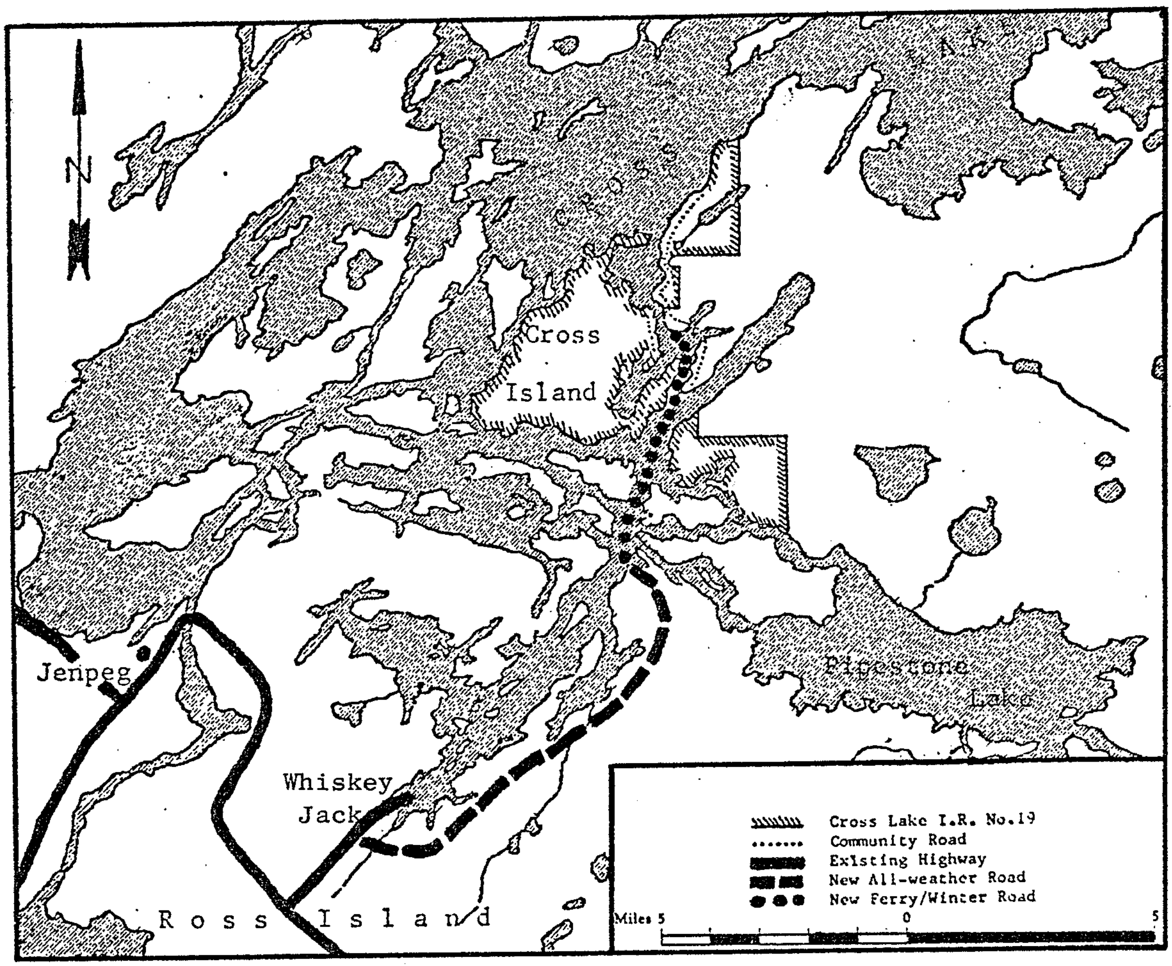
and the community. This ferry is capable of boarding transport trailers as well as private vehicles during its May to October season. In the winter, after freeze-up occurs (late November to December), a winter road is constructed along the same route as that travelled by the ferry. This temporary road is usually servicable until early April.

(b) A Partial All-weather Road/Ferry System (Option 2)

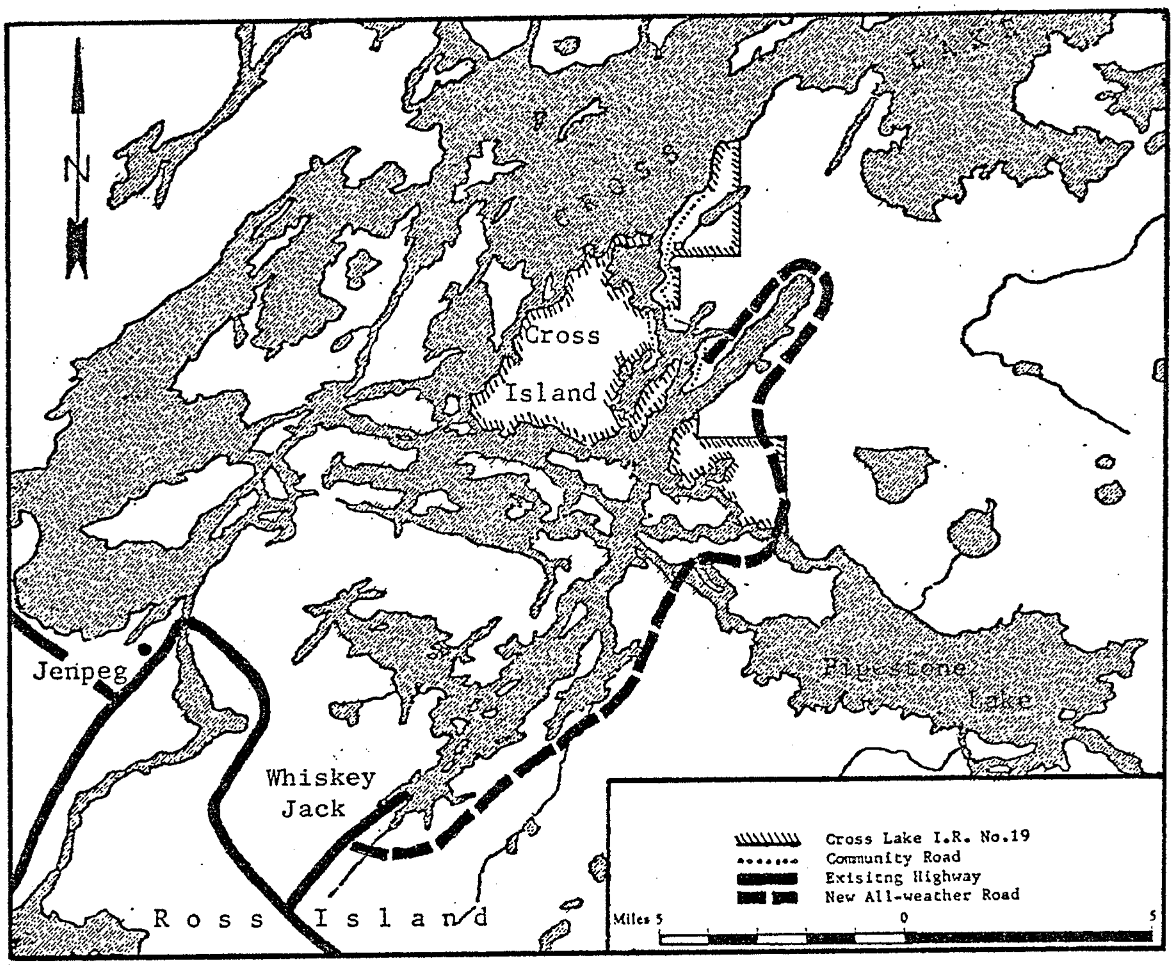
This investment alternative assumes an extension of the existing all-weather road which currently terminates at Whiskey Jack Portage (Map 4). By extending the road eleven miles along the east side of the Nelson River, the ferry route connecting the community would be shortened to five miles. The winter road distance would likewise be reduced. The existing airstrip and sea-plane bases would be maintained as at present.

(c) A Complete All-weather Road (Option 3)

The third alternative proposes to replace the existing system with a 20.5 mile all-weather road which would follow the route of the partial all-weather road (Option 2) and then continue along the eastern shoreline, crossing Pipestone Lake and entering the community from the southeast (Map 5). Such a road would eliminate the seasonality of the existing



Map 4 The Partial All-weather Road/Ferry Investment Option



Map 5 The Complete All-weather Road Investment Option

system. The present air service facilities would be retained.

E. The Assumptions

Nine major assumptions are relevent to the quantitative portion of the Cross Lake case study. They, along with comments on their appropriateness, are as follows:

1. A twenty-five year study period is appropriate for the comparison of quantified costs and benefits.

The duration of the study period over which costs and benefits are compared is normally equivalent to the estimated physical or technological life of the investment (Edge 1971:17). In the present analysis, the proposed all-weather roads and ferry facilities, built to standard and/or maintained properly, have a life expectancy of twenty-five years before replacements are required.

2. Relative prices remain static over the study period.

By this assumption, disproportionate increases or decreases in real prices of one sector of the economy versus another are not taken into account. The future will no doubt show that some real price changes will occur due to factors such as energy cost increases and shifting consumer markets. However, to incorporate them into the analysis at this time is considered too speculative.

3. Winnipeg is the sole origin and destination point associated with the transport of Cross Lake freight. Therefore, freight transport costs can be estimated on the basis of Winnipeg-Cross Lake freight rates.

Certainly some freight traffic passes between Cross Lake and other communities besides Winnipeg, such as Norway House, Wabowden and Thompson. However, available freight records clearly indicate that the vast majority of air and truck freight goes to or from Winnipeg.

4. The capacity of the existing airstrip is adequate to meet the demands of the next twenty-five years.

Since the airstrip can accommodate DC-3's and smaller carriers common to the service of northern communities (ie. Twin Otters), enlargement of the facility is not considered necessary during the study period.

5. The growth in volume of community freight is directly proportional to the historically derived population growth rate (3.6%).

While it would be more accurate to relate freight volumes to levels of disposable income of consumers, there is not an adequate data base to establish such a linkage for Cross Lake at present. Therefore, this assumption is used to facilitate the calculation of future freight volumes and transport costs.

6. Where freight is transported by tractor trailer or charter flight, the cost of freight delivery assumes the carrier is loaded to its maximum capacity so that the number of required trips are kept to a minimum.

By and large, carriers travelling into northern communities are at or near (and sometimes over) permissible load limits. To assume otherwise would be to assume inefficient management; a practice which would not be tolerated by either consumers or shippers.

7. The mix of freight types (ie. charter, scheduled, regular or special freight) is constant for each transport mode regardless of the amount of freight diverted from one mode to another because of the choice of investment.

Mixes of freight types are calculated in the analysis using current freight volumes. Therefore, they represent the basic requirements of a community with high unemployment and minimal income. To assume that these mixes would not remain constant would be to say that consumers would significantly alter their spending habits during the study period (ie. they would buy more high-cost freight goods relative to low-cost freight goods than they do at present). However, in order to change spending habits, incomes would have to rise to levels considered unlikely for the bulk of Cross Lake residents in the next twenty-five years.

8. Unit costs for operating or maintaining transport facilities are constant and independent of traffic volumes and weather.

Year to year costs for operating and maintaining transport facilities, especially roads, will certainly vary with traffic volume and weather. Some years may be higher or lower than the calculated costs but, by the assumption, such highs and lows are considered to even out over the long run.

9. Consumers realize the full cost saving resulting from an investment proposal to replace existing high-cost transport (ie. air service) with low-cost transport (ie. all-weather road service).

This assumption implies that operators of new low-cost services can not charge consumers higher prices than those considered competitive in order to skim off a portion of the user's cost savings derived from the investment. Competitive processes among transportation firms and the setting of Provincial ceilings on freight rates support this assumption.

F. The Study Method

The analytical methods employed in the case study are those of benefit-cost and least-cost analysis. The application of these methods to transportation investment options has been gided by previous work done by the World Bank and the Canadian Surface Transportation Administration (Adler 1971; MPS et al. 1974). Supplementing the results of the quantitative analysis are discussions of unquantified factors which further contribute to the understanding of investment alternatives by a Provincial decision-maker.

In the quantitative portion of the study, monetary costs and benefits associated with each investment are compared over the twenty-five year study period. Discount rates of 0% to 12% are used in net present value calculations to test the sensitivity of results to changing interest rates.[1] Publicly financed costs are seen to include those for infrastructure, operation and maintenance of constructed facilities and equipment. In the least-cost analysis, the estimated cost of transporting freight also contributes to total project costs. This type of cost is perceived as a social cost which is as important to the Provincial decision-maker's investment choice as public revenue expenditures.[2]

In the benefit-cost analysis, infrastructure cost differences and benefits, in the form of user cost savings, jointly contribute to the comparison of the two new investment options with the existing transportation system.

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[1] The discount rate is the real social rate of return by which the value of future expenditures or revenues are related to the present. This rate is often thought of as the difference between a future investment rate of return and a future inflation rate.

[2] In the present analysis, such costs influence the quantitative analyses as if they were, in fact, direct costs to the Provincial decision-maker rather than direct costs only to users (ie. consumers).

Finally, because user costs and user cost savings are dramatically affected by diversion of freight from air to road transport modes when new transport systems are chosen over the existing system, the sensitivity of results is tested against different levels of diversion to illustrate the impact of this important variable on investment choice.

The qualitative portion of the study supplements the quantified investment analysis. Brief accounts are given of the environmental and social impacts of each proposed investment. Also, the economic development potential for each investment is discussed as it relates to the study area's capacity for supplying both natural resource development and local commercial opportunities.

Study conclusions and recommendations reflect the outcome of both quantiative and qualitative investigations. The limitations of the study are reviewed and, in light of these, investment advise is provided for the Provincial government decision-maker and recommendations are made for improving future studies.

II LITERATURE REVIEW

A. Introduction

This chapter presents a literature review dealing with:

1. The desireability of project versus systems analysis when choosing a general approach to compare transportation investment choices.

2. A summary of benefit-cost theory as it applies to private and public projects.

3. A description of least-cost analysis.

4. The historical application of benefit-cost and least-cost analyses to transportation projects proposed for developing regions.

5. Specific studies which are relevant to the comparison of transportation systems in northern Manitoba, especially the Cross Lake area.

B. Selecting A General Analytical Approach

At the outset of an analysis, certain conditions of study must be decided upon. These include the definition of the problem, a statement of objectives and conceptualization of the method to be used. In studies involving the comparison of transportation alternatives, two approaches, either project or systems analysis, can be selected to provide guidance when establishing these conditions (Roberts and Dewees 1971:1-2).

Of the two approaches, systems analysis is the most all-encompassing. With it the transport network is conceived as an interdependent entity in which the impact of new transportation projects is evaluated in relation to the existing network and other new projects. A good systems analysis normally involves a description of the transport system itself, its technology, its use and its interaction with the 'network-defined' economy. Such an approach involves a multitude of input variables and resultant configurations that must be considered. Consequently, the use of large-scale computer simulation models becomes necessary.

Simulation models are expensive, difficult and frustrating to build. Most are only at an experimental stage, and, as Kresge and Roberts point out (1970:156-157) they have many drawbacks associated with their requirements for: "(1) a good deal of specific (transportation) engineering; (2) an advanced computer technology and capability; (3) experience with the design and empirical estimation of economic growth models; and, (4) an ability to estimate behavioral parameters relating changes in economic and physical phenomena to changes in the relevant social and economic system."

While attractive on a theoretical level, such a method depends upon many inhibiting practical factors including not only the model structure and its doubtful ability to represent important system interdependencies, but also complex data inputs, the specification of objective functions and a host of other regulatory, investment and pricing criteria. Consequently, the majority of transport investment decision-makers forego the compelling but elusive advantages of the systems approach and opt for project analysis.

As an alternative, project evaluation is directed at assessment and choice of project proposals; with the customary concept of a project being a 'link-addition' or 'link-replacement' for the existing transportation network. Unlike systems analysis, this approach restricts its scope by adopting the goal of maximizing net social gains within the <u>local</u> economy affected by the project. Non-local interdependencies tend, therefore, to be excluded from consideration. The significance of this characteristic depends upon whether short or long-term planning is the goal. In the short-run, interdependencies may well be of little consequence; in the long-run, they are more likely to be important and may justify an attempt at using systems analysis (Meyers and Strazheim 1970:2-5).

Disadvantages of project analysis, other than those relating to interdependencies, include: (1) its reliance upon uncertain estimates of future transport demand and technology; (2) its assumption that the 'link-addition' can be accurately evaluated as a subunit of the entire transportation network; (3) its inability to measure demand changes due to the new transportation investments, thereby offering only a first approximation relative to the result aspired to by systems analysis; and, (4) its distorting of results due to the unspecific treatment of 'unquantifiable' factors (ie. social or external factors) (Meyers and Strazheim 1970:4-8; Adler 1967:36-38).

The main advantages of the method, relative to systems analysis, are: (1) its ability to present a comparative evaluation within a reasonable length of time; (2) its lower cost; (3) its more manageable data requirements; and, (4) its capacity to present results in an easily understandable manner for use by decision-makers. It is on the strength of these advantages, therefore, that the project approach is deemed appropriate for the present case study.

C. Benefit-Cost Analysis: A General Summary

Prest and Turvey provided one of the first widely accepted definitions of benefit-cost analysis (1965:683):

> "Cost-benefit analysis is a practical way of assessing the desireability of projects, where it is important to take a long view (in the sense of looking at repercussions in the further, as well as the nearer, future) and a wide view (in the sense of allowing for side-effects of many kinds on many persons, industries, regions, etc.), ie. it implies the enumeration and evaluation of all the relevant costs and benefits."

This definition still retains its validity although the strict theoretical condition of accounting for all costs and benefits 'to whomsoever they may accrue' has given way to less rigorous treatments of non-quantifiable and intangible economic and social project considerations.

Another more modern definition of the method is given by the Treasury Board of Canada (Canada 1976:3). This definition indicates benefit-cost analysis as being that of an important aid to today's public decision-making.

> "Benefit-cost analysis is a method of evaluating the relative merits of alternative public investment projects in order to achieve efficient allocation of resources. It is a way of identifying, portraying and assessing the factors which need to be considered in making rational economic choices."

In practice, for private business, the process of benefit-cost analysis typically begins by examining the technical feasibility of alternative projects. Next, the estimated streams of benefits (revenues) and costs are determined over the expected economic life of each investment. The streams are then discounted at an appropriate interest rate to yield the present value estimate of benefits and costs. Finally, the alternatives are compared, usually by matching the net present values (i.e. present value of benefits minus present value of costs). Based on this investment criterion, the project with the highest net present value is considered the most acceptable.[1]

In the case of public sector investment analysis, the same basic procedures apply. There are, however, significant differences which arise. These are generally due to the wider perspective necessary in assessing benefits and costs of public projects. No longer can projects be appraised solely on the basis of their technical and financial feasibility. Many social, economic and environmental relationships, not considered in the private case, become important within a politically oriented decision-making framework.

These new considerations generate a miriad of problems. For example, the use of the dollar standard becomes more difficult and

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1 Benefit/cost ratios which are greater than 1.0 (ie. where benefits exceed costs) are also used to determine a preferred investment.

less meaningful. Dollar values must be imputed for certain factors because no market value can be identified. Market prices may have to be adjusted because they do not reflect true social costs and benefits. Important social impacts may be impossible to quantify because there are non-efficiency objectives, secondary effects or externalities to consider.

Under such circumstances, the role of benefit-cost analysis becomes one of identifying trade-offs between efficiency objectives and non-efficiency objectives, and providing decision-makers with both quantified dollar measures and qualitative indicators of all benefits and costs so as to ensure the best possible information base for decisions.

Other problems, of a technical nature, that arise in the application of benefit-cost analysis include: the choosing of an appropriate method of project comparison (i.e. benefit-cost ratio, net present value, internal rate of return); the selection of discount rates; the determination of a reasonable economic life for an investment; and, the difficulty in discriminating between projects which fit into benefit-cost analysis' realm of partial equilibrium analysis and those which extend into the realm of general equilibrium analysis (i.e. large-scale projects) for which a systems approach is warranted. Advice on the handling of these problems is provided in a host of benefit-cost literature reviews (Prest and Turvey 1965; Dasgupta and Pearce 1972; Weiner and Deak 1972; Wolfe 1973; Harrison 1974; and, Mishan 1975).

D. Least-Cost Analysis: A Summary

The determination of the least-cost investment alternatives is a useful technique for examining alternative ways of carrying out a project, particularly when the main focus of the decision-maker is on costs to be incurred.

In this method, all capital, maintenance, operating and other costs for each alternative are estimated throughout the study period and converted by the discounting method to cumulative present values of total project cost. By this means, alternatives with different types and magnitudes of costs are placed on a comparable basis. The alternative with the lowedt total project cost is then identified and selected as the most desirable on economic grounds.

However, it can only be used to justify a project when all alternatives, including that of not carrying out the project, are included in the analysis. It is often used to determine, as its name implies, the least cost of the alternatives to carry out a project which has been established as necessary by other means (Edge 1971:15). For example, the provision of some type of transportation services to isolated northern communities can be considered a necessary public investment which may be viewed by a government decision-maker as a situation requiring the lowest outlay of public revenues.

The application of least-cost analysis faces problems similar to benefit-cost analysis, including: the selection of appropriate discount rates and the estimation of the value of social, environmental and economic factors which are difficult to quantify.

E. Applications of Benefit-cost and Least-cost Analyses to Transportation Problems in Developing Regions

In the present study, the analysis is directed towards the evaluation of transportation investments proposed for an underdeveloped area. It is, therefore, particularly useful to investigate the literature in search of analogous applications of the benefit-cost and least-cost techniques.

Unfortunately, of all the voluminous literature published on the subject of benefit-cost or least-cost analysis, little refers to projects in developing regions. Of that portion, only a handful of publications relate to the choosing of transportation alternatives. Even then, the tendency has been for analysis to dwell on the economic-efficiency aspects of investment rather than to explore the elusive developmental and social effects as well.

Adler has made one of the most substantial contributions to the theory and application of benefit-cost analysis in appraising transportation projects (Adler 1967;1972). He deals extensively with the measurements of economic benefits arising from transport investments. These benefits include: reduced operating expenses for users of new facilities; the stimulation of economic development; time savings; fewer accidents and damages; and increased comfort and convenience. He points out that in an underdeveloped area, the most important benefits are likely to be the reduced operating expenses and the consequences of stimulated economic development. He admits, however, that little research has been done on the relationship between transportation and development, and while acknowledging the importance of developmental considerations, he holds clear and justifiable reservations about their inclusion in project analysis. In addition to measurement of benefits, Adler also advises on measurement of costs.

Few other authors have attempted to deal with the complexities to which Adler has directed his efforts. Barrell (1971) and Harrison (1974) present fine general reviews of transportation-related literature, as do Weiner and Deak (1972), but they do not propose detailed methods to solve problems of evaluating time-savings or other subjective parameters. Even Stokes (1968) and Soberman (1966), both of whom have analyzed rare cases of transportation investment alternatives in developing regions, confine their analyses to quantifiable factors.

Of great importance, however, is the Canadian Surface Transportation Administration-sponsored report "Cost Trade-off Between Vehicle and Way Facility" (MPS et al. 1974). This study defines a hypothetical remote community in the north and applies benefit-cost analysis to several transportation investment options. Although the study is theoretical, it is most useful as a practical guide to the present analysis because it deals with the full range of economic considerations, including facility construction, operation and maintenance costs, user cost savings for freight and passengers, generated traffic, and development benefits such as inventory cost reductions, social benefits and natural resource development.

F. Reference Material of Use in the Case Study

Comprehensive analyses of transportation investments in northern Canada are not numerous, and those which make specific reference to Manitoba are very few in number. There are, however, a few key studies which have been used in preparing this case study.

One of the first major works on transportation in Manitoba was the Province of Manitoba Inquiry into Northern Transportation (Manitoba 1969). This extensive work records: the history of the land, the people and the economy in relation to transportation growth; the character, adequacy and requirements of the contemporary transportation network (including discussions of all conventional and some unconventional transport modes); and, the role of governments in transportation policy- and decision-making. In short, it is a compendium of reference material that, while not dealing with specific methods of project analysis, is useful in orienting the reader to the Manitoba situation.

The Northern Manitoba Freight Study (McKenzie et al. 1973) is a more detailed, factual presentation of transportation information. It focuses on the analysis of freight rates and volumes for all remote and isolated Manitoba communities, but is somewhat superficial in its support of individual community analysis.

The most recent reference report is the Manitoba Northlands Transportation Study (Hickling-Johnston 1975). This study is a truly comprehensive document which deals with transportation data for both the industrialized north and the remote north. It has been an especially useful guide for the present study since it contains up-to-date economic information.

Beyond these major works, there are several reports and documents which are specific in their references to Cross Lake. These are identified, where appropriate in the text of the case study.

III COSTS OF PROVIDING TRANSPORTATION INFRASTRUCTURE

A. Introduction

This chapter presents cost estimates for construction, operation and maintenance of each transport mode contributing to the three transportation alternatives under consideration. These are the most obvious and direct costs by which the economic worth of the alternatives can be determined.

Operating and maintenance costs for the Cross Lake airstrip are excluded from the following calculations. They were found to be unnecessary for consideration because they are, in effect, taken to be constant for each transportation option over the 25-year study period, 1978 to 2003. The justification for this exclusion is derived from the reasoning that the existing airstrip will be required for scheduled air service and emergency landing uses despite any decreases in traffic volume resulting from changes in surficial access to the community.

In keeping with the desire to evaluate the current economic status of the opyions, all costs are expressed in 1977 dollars. In addition, the analysis assumes that unit costs do not undergo real growth during the study period. This assumption may not be entirely realistic for the future, however, since certain components such as fuel costs can be expected to show relative price increases (real growth) which must necessarily be reflected in the cost types dealt with in this chapter. However, the assumption is useful in providing a base level of comparison from which further discussions of key variables, such as energy costs, can stem.

B. Option 1: Continuing the Existing System

If each of the other transportation options were rejected, it is apparent that the existing system (Map 3) would continue to operate since it is the currently approved standard of service for Cross Lake. Costs of continuing such a system are calculated here for its winter road and ferry modes of service. In the context of the benefit-cost analysis, these costs can be thought of as cost savings, or benefits, when the alternative transportation investments are chosen.

1. Winter Road Costs

In order to understand the nature of winter road costs, it is important to know something about methods of preparing and maintaining the roads themselves.

Although there are no generally accepted standards for winter road construction, certain guidelines and practices have been developed through experience.[1] Typically, the initial requirement in constructing a winter road is to select and clear-cut a right-of-way during the summer months when weather

[1] These guidelines and practices are detailed in Appendix 1.

conditions are amenable to such work. Then, with the onset of winter, providing there is sufficient snowfall and sustained freezing temperatures, the actual travelling surface is prepared using snow-packing equipment and water pumps to strengthen ice bridges along the route. Brush, logs, moss and gravel are used, as well as snow, to fill holes or obstructions before the final surface is groomed by dragging and grading.

Each year the road is reconstructed in the same manner, with the exception that very little bush clearing is needed along the right-of-way after the first year. The quality of the road, which affects travel times and therefore freight rates, is generally consistent from one year to the next. Indeed, in areas where the road is land-based, some upgrading may occur incidental to the annual construction and maintenance activities.

Poor weather delays the opening of the road and may even raise costs when, for example, snow must be hauled to fortify the roadbed in low snowfall years or ice bridges must be rebuilt.

Under normal conditions, however, freeze-up occurs in early November around Cross Lake, with construction beginning towards the end of the month and ending in the first two weeks of January. This schedule allows an average operating period for the road of about twelve weeks, making the closing date near the end of March (Lowther 1976-77; Seppala 1974-75).

In addition to construction costs, annual costs for maintenance, administration, and winter road vehicle monitoring, with air and ground supervision, are incurred. Such costs are generally dependent upon weather, traffic volume, type of vehicular traffic, management and supervisory practices, and the time period of operation (McKenzie et al. 1973:200). In the present analysis each of these factors is considered to be constant.

1977 estimates for the winter road costs are given in Table 1. They are based upon 1977 winter road unit costs for Cross Lake (Lowther 1977), a twelve week operating period and a twelve mile road length. Cumulative costs, shown in Table 2, are calculated for the years 1978, 1978-79 and 1978-2003. The first two periods reflect the costs of maintaining the existing system during the construction phases of the two alternative investment options.[1] The latter is the cost of continuing the existing system for the full twenty-five year study period without alternative investments.

2. Ferry Costs

For approximately six months of the year, May through October, there are ice-free conditions at Cross Lake. During this time, water travel is permitted between the ferry dock at Whiskey Jack Portage, where the existing highway terminates near the south end of Cross Lake, and the community.

Up to and including the shipping season of 1977, only private entrepreneurs navigated this waterway. They hauled consignments of freight by barge at contract prices. Early in

[1] Selection of the road/ferry system (Option 2) requires maintenance of the winter road in 1978 while road construction is in progress. Similarly, selection of the all-weather road system (Option 3) requires 1978-79 winter road expenditures.

TABLE 1

OPTION 1: 1977 BASE-YEAR WINTER ROAD COSTS

	Construction	Maintenance	Monitoring & Field Supervision	Aircraft Monitoring	Administration	Total
Unit Cost[a] (1977$)	1,100/mi.	71.2/mi.-wk.	20.9/mi.-wk.	16.0/mi.-wk.	26.8/mi.-wk.	-
1977 Cost (000$)	13.2	10.3	3.0	2.3	3.9	32.7
% Breakdown	40	32	9	7	12	100

[a] Unit costs are derived from the 1977 Northern Winter Roads Report (Lowther 1977).

TABLE 2

OPTION 1: CUMULATIVE WINTER ROAD COSTS
(1977 000$)

Discount Rate		0%	8%	10%	12%
1978	Discount Factor[a]	1	0.926	0.909	0.893
	Cost	32.7	30.3	29.7	29.2
1978	Discount Factor	2	1.783	1.736	1.690
to 1979	Cost	65.4	58.3	56.8	55.3
1978	Discount Factor	25	10.675	9.077	7.843
to 2003	Cost	817.5	349.1	296.8	256.5

[a] Appendix 2 elaborates upon the method used to calculate discount factors.

1977, however, the Provincial Government endeavoured to implement a scheduled ferry service over the same route. This new service began its first full operating season in the Spring of 1978, after performance tests are conducted in the Fall of 1977. It is therefore appropriate that this service be included as a component of the 'Existing System' which is considered effective between 1978 and 2003.

As a subsidized public facility, the new ferry will offer several advantages over the private barges, including: increased load capacity; the elimination of cargo unloading and loading; drive-on service for all types of conventional highway vehicles; scheduled runs; and, much reduced transport charges.

The costs associated with the operation and maintenance of the new ferry and its equipment will not be known precisely until after the trial runs. Therefore, given the ferry's design specifications, a series of estimates is used to determine the required costs for the present analysis. The components of cost are discussed in detail in Appendix 3. Table 3 summarizes the 1977 base-year estimates. The cummulative costs of the ferry operation are presented in Table 4. A route distance of twelve miles has been used and the number of trips has been determined according to a schedule of two runs per day in a five day work week for six months of the year (May 1 to October 31).

TABLE 3

OPTION 1: 1977 BASE-YEAR FERRY COSTS

Cost Type	1977 Annual Cost[a] (000 $)	% Breakdown
Operator Salaries	25.8	32
Fuel Cost	14.7	19
Maintenance	17.8	23
Administration	8.0	10
Insurance	7.3	9
Dock Maintenance	5.4	7
Total Cost	79.0	100%

[a] See Appendix 3 for detailed cost calculations.

TABLE 4

OPTION 1: CUMULATIVE FERRY COSTS (1977 000$)

Discount Rate/Year	0%	8%	10%	12%
1978 Cost[a]	79.0	73.2	71.8	70.5
1978-79 Cost	158.0	140.9	137.1	133.5
1978-2003 Cost	1,975.0	843.3	717.1	619.6

[a] Discount factors are taken from Table 2.

C. Option 2: Providing A Partial All-weather Road/Ferry System

As an alternative to continuing the existing system, there is the proposal to construct an all-weather road from the present Jenpeg-Norway House highway to the south side of Pipestone Lake (Map 4). From that point, the seasonal modes of ferry and winter road would provide transportation to the community of Cross Lake. The costs of constructing, maintaining and operating this system are discussed below.

1. All-weather Road Costs

The construction cost estimate for building the required all-weather road is drawn from a preliminary engineering report (Manitoba 1977). This report was prepared using topographic maps, aerial photos and on-site investigation information.

Although air photo interpretation and terrain classification were utilized in the preparation of the report it was not a detailed analysis. Therefore, the costs derived from it are considered to be preliminary and are probably slightly higher than the true cost which would be indicated through contract bidding.

The cost estimate is based upon the Provincial Highway Design Standard No. 9. This class of road is gravel surfaced with a twenty-four foot travelling width. Appendix 4 presents the construction geometrics of such a road and a brief description of the terrain it would be built upon.

With a road length of approximately eleven miles and no major structures such as bridges required, construction could be completed in one year, 1978. Using maintenance costs of $700 per mile per year and the estimated capital costs, which average $85,000 per mile, the cumulative costs of providing this new road are calculated and shown in Table 5.

TABLE 5

OPTION 2: ALL-WEATHER ROAD COSTS
(1977 000$)

Cost Type	Spending Years	Discount Rate (%/Year) 0%	8%	10%	12%
Construction	1978	935.0[a]	865.8	849.9	835.0
Maintenance	1979-2003	184.8	75.1	62.9	53.5
Total Cost	1978-2003	1,119.8	940.9	912.8	888.5

[a] Discount factors are derived from those seen in Table 2.

2. <u>Ferry Costs</u>

A ferry system similar to that discussed in the existing transportation system is assumed to be used for this option as well. Indeed, it is reasonable to suspect that the same ferry would be diverted from the present route to begin operation between the new road's terminus near Pipestone Lake and the community in 1979, after road construction is completed.

The only construction required specifically for the ferry would be the building of a dock where the highway ends.

The dock could be built in 1978 at the estimated cost of $45,000 (1977$).[1] The costs of operating and maintaining the ferry would be the same as those calulated for the existing ferry per annum, except for the fuel costs.[2] The fuel costs are anticipated to differ for two reasons: (1) the travelling distance of the ferry is reduced from twelve miles to five miles; and,(2) the shorter distance would allow one more scheduled run per operating day. Table 6 presents the cumulative costs of providing the ferry mode in the second transportation investment option.

TABLE 6

OPTION 2: DOCK AND FERRY COSTS
(1977 000$)

Cost Type	Spending Years	Discount Rate (%/Year) 0%	8%	10%	12%
Dock Construction	1978	45.0[a]	41.7	40.9	40.2
Ferry Costs	1979-2003	1,764.0	716.6	600.4	510.8
Total Costs	1978-2003	1,809.0	758.3	641.3	551.0

[a] All discount factors are derived from Table 2.
Source: Manitoba Department of Renewable Resources and Transportation, Construction Division, Personal Communication, August 1977.

3. <u>Winter Road Costs</u>

In addition to the all-weather road and ferry modes of transport, this alternative also requires the provision of a

[1] This estimate for the cost of dock construction includes the costs the landing area, dolphins, mole facing and earth fill (Personal communications with the Construction Division, Man. Dept. of Renewable Resources).

[2] Detailed in Appendix 3 .

winter road along the channel where the summer ferry operates. The costs of building and maintaining such a road are determined using the unit costs for 1977 that are shown in Table 1. With a road length of five miles and a twelve week operating period, the 1977 annual cost for the road is found to be $13,600. The cumulative costs corresponding to this figure, over the project period 1979 to 2003, are given in Table 7.

TABLE 7

OPTION 2: WINTER ROAD COSTS
(1977 000$)

Discount Rate (%/Year)	0%	8%	10%	12%
1979-2003 Winter Road Costs	326.4[a]	132.6	111.1	94.5

[a] Discount factors from Table 2.

D. Option 3: Providing A Complete All-weather Road

The final alternative to be considered for Cross Lake is that which provides an all-weather road as a replacement for the existing ferry and winter road services (Map 5).

The cost estimate for this road is taken from the same engineering report as that used for the partial all-weather road of option two (Manitoba 1977). A two year construction period is anticipated because of the longer route (20.5 miles) and the two causeway crossings required at Pipestone Lake. The construction costs are divided equally among the construction years and the maintenance costs are determined at the rate of $700 per mile per year, as before. Table 8 summarizes these costs.

TABLE 8

OPTION 3: ALL-WEATHER ROAD COSTS
(1977 000$)

Cost Type	Spending Years	0%	Discount Rate (%/Year) 8%	10%	12%
Construction	1978	1,700.0[a]	1,574.2	1,545.3	1,518.1
	1979	1,700.0	1,457.4	1,404.9	1,355.2
Maintenance	1980-2003	330.1	127.6	105.3	88.3
Total Cost	1978-2003	3,730.1	3,159.2	3,055.5	2,961.6

[a] Discount factors from Table 2.
Source: Manitoba Department of Highways, Operations Division, Interdepartmental Report, June 1977.

E. Summary

The construction, operation and maintenance costs associated with each transportation option are listed in Table 9. From this list the least cost system for the twenty-five year study period, at any of the chosen discount rates, is the existing winter road/ferry system (Option 1). The next least costly option is the partial all-weather road/ferry system (Option 2) and finally there is the all-weather road proposal.

Regarding the sensitivity of costs, it should be noted that the choice of discount rate dramatically influences the relationship between the investment alternatives although it does not alter their rank. Undiscounted costs, for example, indicate a margin of approximately $500,000 between alternatives. As the discount rate increases, however,

TABLE 9

CONSTRUCTION, OPERATION & MAINTENANCE COST SUMMARY
(1977 000$)

Investment Option & Transport Mode	1978-2003 Cost @ % Discount/Year			
	0%	8%	10%	12%
1. Continuing with the Existing System				
Winter Road	817.5	349.1	296.8	256.5
Ferry	1,975.0	843.3	717.1	619.6
TOTAL COST	2,792.5	1,192.4	1,013.9	876.1
2. Providing a Partial All-weather Road/Ferry System				
All-weather Road	1,119.8	940.9	912.8	888.5
Ferry	1,809.0	758.3	641.3	551.0
Winter Road	326.4	132.6	111.1	94.5
TOTAL COST	3,265.2	1,831.8	1,665.2	1,534.0
3. Providing a Complete All-weather Road				
All-weather Road TOTAL COST	3,730.1	3,159.2	3,055.5	2,961.6

this cost margin increases to the point where the cost of a lower ranked option is almost double that of the next most attractive option. Thus, the estimated cost of the existing system, when discounted at 12% per year, is about one-quarter the cost of the all-weather road system. Less extreme discount rates of 8% and 10% reduce the cost differential only slightly. These relationships are illustrated in Figure 1.

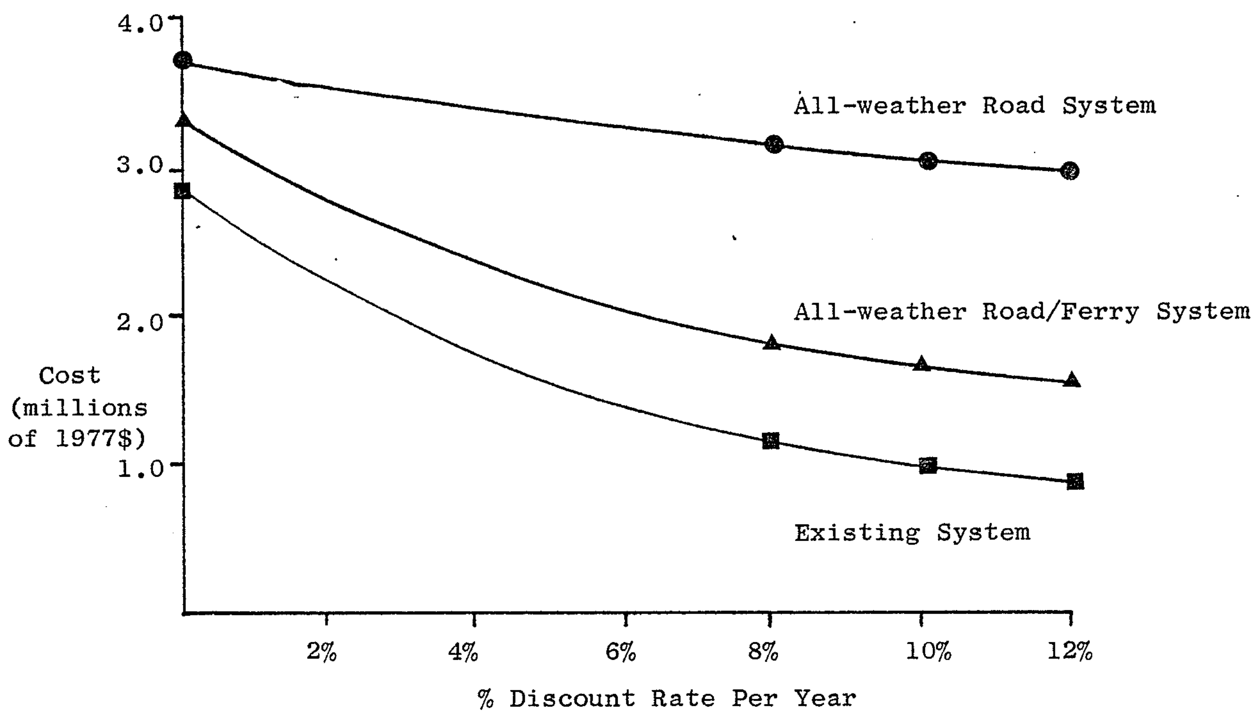

Figure 1 The effects of discount rates upon the costs of alternative transport systems.

In summary, then, the existing transport system is seen to be the least cost investment when construction, operation and maintenance costs are considered. For the Provincial Government decision-maker, who is directly responsible for bearing such costs, the existing system will no doubt be preferred unless additional costs and benefits are shown to favour one of the new investment options.

The following chapter looks at user costs and cost savings for freight and passenger traffic as additional considerations which characterize investment choice. For the most part, these costs and benefits will be borne by the local residents who are served by the chosen transport system. Their significance to the public-minded decision-maker, beyond the direct costs or cost savings associated with the transport of government sponsored goods, is that they contribute to the net social value of each investment and may therefore determine the ultimate choice.

IV DETERMINATION OF USER COSTS AND USER COST SAVINGS

A. Introduction

By selecting one transport system over another, choices are made not only between the costs of providing infrastructure but also between the costs absorbed by future users of the system. In the present analysis, for example, it has been shown that the replacement of the existing system must result in a substantial overall increase in infrastructure costs. Alternatively, however, the examination of user costs presented in this chapter indicates that replacement of the existing facilities by the alternative options reduces the cost burden to future transportation users because freight can be diverted to lower-cost modes.

In the context of benefit-cost analysis, such reductions in user costs, both for freight and passengers, are benefits of the alternative transport systems. These benefits, or cost savings, offset infrastructure costs. The degree of the offsetting effect will help identify the most economical investment choice in the final benefit-cost comparison.

In this chapter, the user cost savings consist of the differences in transport charges resulting from the diversion of normal passenger and freight traffic from the existing system to either of the optional transport systems. The value of the diverted traffic is estimated by calculating the differences in total user costs with and without the existing system. Special attention is given to the identification and evaluation of freight volumes and rates. Freight and passenger cost savings are dealt with separately.

B. The Growth Rate of Freight Volumes

The requisite for ascertaining freight related user cost savings is a thorough understanding of both the future freight volumes and the future freight rates for each system involved in the analysis. Herein, the general approach in finding freight volumes is to determine an annual growth rate for community freight, based on historical information, and apply it to 1977 base-year volumes per transport mode. The determination of freight rates is simplified by the assumption that market prices remain constant over the economic study period. Because of this assumption, current transport charges can be used without considering problems of extrapolation into the future.

As for the estimation of an annual growth rate for freight volumes, it was found at the outset of the analysis that historical freight records were insufficient for the purpose intended. Consequently, a direct relationship was assumed between the observed population growth at Cross Lake and the volume of goods required by the community in the base year.

Using annual census data,[1] a population growth rate of 3.6%

[1] Source: Dept. of Indian Affairs annual Band census figures(for registered on-site residents only). These used in lieu of total community figures.

per annum has been calculated for the years 1971 to 1975. This value is applied throughout the ensuing analysis to the 1977 base-year freight volumes as a means of determining future freight. It is also used to adjust historical freight volumes (pre-1977) to the 1977 standard.

C. Base-Year Freight Volumes

In this section, base-year freight volumes are determined for each of the modes of service which contribute to the transportation systems. These modes include air, ferry, winter road and all-weather road.

1. Air Freight

The estimated air freight volumes for each transport investment option are shown in Table 10. These represent 1977 base-year volumes that are hauled between Winnipeg and Cross Lake by wheeled aircraft.

TABLE 10

BASE-YEAR AIR FREIGHT VOLUMES[a]
(000 lbs.)

Transport Option	Air Freight Type		
	Scheduled	Charter	Total
1. The Existing System	121.2	980.6	1,101.8
2. Partial All-weather Road/Ferry	121.2	980.6	1,101.8
3. Complete All-weather Road	88.5	715.6	804.1

[a] Refer to Appendix 5 for details of Base-Year Air Freight Volume calculations.

The two freight categories, scheduled (11% by volume) and charter freight (89%), are separated because different freight rates apply to them.[1] A third category common to air-transport, express freight, is not included, even though it also warrants a unique tariff, because express volumes were found to be insignificant at Cross Lake.

Community airstrip 'Activity Summaries', as compiled for the Manitoba Department of Northern Affairs, were used in determining the 1975 air freight volume transported by the existing system. The 1977 estimate was obtained by applying the 3.6% annual growth rate to the 1975 figure. Appendix 5 elaborates upon the treatment of the historical data.

The provision of a partial all-weather road with a shortened ferry link (Option 2) is deemed to have little or no impact on the volume of air freight going in and out of Cross Lake. The ferry route would not be so much shorter that the shipping season would be altered. Therefore, a decline in air-freight due to stronger competition from the less expensive surface modes need not be considered. Furthermore, while the number of scheduled ferry crossings would be increased by the new investment, the existing system is considered more than suffucient for transporting the projected freight. This means that the advantages of the new service are realized more by the passenger traffic than by the freight traffic.

With the completion of an all-weather road (Option 3),

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[1] The % breakdown of freight by type was determined by comparing the scheduled air-freight records of Midwest Airlines Ltd. (1974) with the total freight records of the Department of Northern Affairs.

which ties the existing highway network to the now isolated community of Cross Lake, some air-freight can be expected to be diverted to the reliable and inexpensive surface mode. Especially susceptible to diversion will be freight otherwise delivered by air during the 'freeze-up' and 'break-up' periods when no alternative, and competing, surface transportation is available.[1]

To calculate the amount of air-freight diverted, the base-year figures for the existing system have been used. The average air-freight volume per month in the competing seasons has been subtracted from that of the non-competing seasons. The result is a value for the surplus freight volume per month which is solely attributable to the monopoly power of the existing air service and is clearly susceptible to truck delivery when the road opens. The total air-freight loss, some 27% of the present system's volume, is apportioned to scheduled and charter flights according to the breakdown seen in the existing system. This loss is considered to be the minimum amount of air-freight diverted as a result of the all-weather road being constructed. It has been suggested (MPS et al. 1974) that up to 99% of the present air-freight in such a case would be diverted.[2] The prediction of that kind of radical change may be realistic for Cross Lake but it can not be justified because of community data limitations and insufficient experience with similar developments elsewhere in northern Manitoba.

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[1] At Cross Lake freeze-up occurs in November and December and break-up occurs in April and May.

[2] Appendix 7 contains a detailed analysis of the sensitivity of Option 3 costs and benefits to changes in the percentage of air-freight diverted. Note, also that PMLP Consultants Ltd. (1975) support the MPS conclusion regarding air freight diverted.

2. Ferry Freight

The ferry freight volume accomodated by the existing transport system is estimated at about 848.5 thousand pounds in 1977. This figure has been arrived at through consultations with the major suppliers and shippers at Cross Lake.[1] The same base-year figure is applicable to the ferry utilized in the Second Option for investment since no additional traffic was seen to be generated by the diversion of air-freight. The final investment choice, the complete all-weather road, would of course require the elimination of the ferry and complete diversion of its traffic to road transport.

The annual ferry freight haul is broken down in to two categories, regular freight and special freight, because of discrimination in the freight rate structure. Special freight is the name designated cargo that must be either heated or refigerated while in transit. Regular freight is all other cargo. The former is subject to rates 10% higher than the corresponding regular freight tariff rates.

Approximately 20% of the total freight is assigned as special freight (169.7 thousand pounds for the existing system in 1977). This figure is in rough agreement with the quantities of consumer goods estimated for delivery during the base-year period.

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[1] The major suppliers at Cross Lake are: The Hudson's Bay Co., Dept. of Indian Affairs and Northern Development and Manitoba's Dept. of Northern Affairs and Manitoba Hydro. M & S Freight Ltd. has been the major shipper up to and including the season of 1977.

3. Winter Road Freight

The 1975-76 Winter Roads Report (Lowther 1976) has served as the data source for the 1977 base-year winter road freight volumes for the existing transport system. The 3.6% growth rate has been used to adjust the reported data which is shown by commodity type in Table 11.

TABLE 11

1977 WINTER ROAD FREIGHT VOLUMES
(000 lbs.)

Commodity Type	Freight Volume
Fuel (Barrel)	458.6
Fuel (Bulk)	2,094.8
Building Materials	534.3
Machinery and Equipment	504.0
Consumer Perishables	870.4
Other Consumer Goods	229.2
Other Items	254.9
Backhaul	534.2
Total Freight	5,480.3
Sub-Groups - Regular Freight	4,384.2
- Special Freight	1,096.1

Note that all goods are transported by truck and are thus subject to categorization as special and regular freight. Because a winter road is still required in the partial all-weather road option, these same freight volumes are also the bases for projection in that system. With the provision of a complete all-weather road in 1980 (Option 3), there is no need for a winter road and all freight otherwise carried on it is diverted.

4. <u>All-Weather Road Freight</u>

Freight transported on the partial all-weather road/ ferry system is discussed previously, under 'Ferry Freight'. All-weather road freight, in this section, refers strictly to the cargo destined to travel along the complete all-weather road linking Cross Lake and the existing Provincial Highway network (Option 3).

This freight (Table 12) is composed of diverted air-, ferry-, and winter road freight that, in the absence of Option 3, would be carried by the alternative systems.[1]

TABLE 12

1977 BASE-YEAR ALL-WEATHER ROAD FREIGHT (OPTION 3)
(000 lbs.)

Type of Diverted Freight[a]	Regular	Special	Total
Air	238.2	59.5	297.7
Ferry	678.8	169.7	848.5
Winter Road	4,384.2	1,096.1	5,480.3
Total All-weather Road Freight	5,301.2	1,325.3	6,626.5

[a] Amounts of diverted freight are discussed by type in the foregoing text.

[1] See discussions on each freight type for explanations of diverted freight.

D. Freight Rates

Where it has been possible, 1977 commercial freight rates are used for the different transport modes serving Cross Lake. In lieu of established rates, where necessary, rates are calculated according to their dependency upon factors such as: origin-destination distance (ie. Winnipeg-Cross Lake); type of transport vehicle; size of average load; travel speed; and the special, regular, scheduled or charter status of the cargo.

1. Air-Freight Rates

Freight rates are derived for the two cargo types, scheduled and charter cargo. The rate used for scheduled freight, \$0.23 per pound, is the same as that charged by the scheduled air carrier serving Cross Lake out of Winnipeg, Perimeter Aviation Ltd. (previously Midwest Airlines Ltd.) as of September 1977. The charter rate for the Winnipeg-Cross Lake run, \$0.2224 per pound, is calculated according to the formula shown in Appendix 6. All charters are assumed to be flown by DC-3 aircraft which refuel on the return trip at Norway House, about 45 miles south of Cross Lake.

Both the scheduled and charter rates apply to air-freight regardless of the choice of transportation system investment.

2. Ferry Freight Rates

Because the scheduled ferry service at Cross Lake had not begun while this report was being prepared, current ferry freight rates were unavailable for use. Therefore, the rates have been estimated.

A rather complicated formula has been worked out in order to estimate an appropriate rate for the transport of freight by truck and ferry between Winnipeg and Cross Lake. This formula has three components of cost which contribute to the overall freight rate:

(a) The cost of carrying goods by truck between Winnipeg and the ferry dock: This cost is obtained from the published trucker tariffs (Manitoba Trucking Association 1977[1]).

(b) The cost of the ferry fee paid by the shipper: At Cross Lake, a $25 one-way fee is to be charged each truck that boards the ferry.

(c) The cost of the trucker's time while travelling on the ferry: In the present analysis, this cost is estimated by determining the equivalent distance the truck would travel by road during its ferry passage and then finding the published tariff corresponding to the whole trip assumming it were made by road. Subtracting the tariff found in the first component of the formula from this revised tariff gives the marginal cost estimate for the value of the time a particular truck spends on the ferry. The actual cost of trucker's time while on the ferry is calculated by deducting 15% of this marginal cost as an irrelevant fuel charge, since the trucks do not have to

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1 These tariffs increased by 5% effective September 1977. The increased rates are used in this study.

consume fuel while sitting on the ferry.

Because both the existing system and the partial all-weather road option require ferry services, the freight rate formula is applied in each case. Details of the calculations are presented in Appendix 6. Note, that special freight rates are 10% higher than the regular freight rates. The results of the calculations are as follows:

Transport Option	Freight Rate (1977 $/lb.) Regular	Special
1. Existing System	0.0165	0.0182
2. Partial All-weather Road/Ferry System	0.0155	0.0171

3. Winter Road Freight Rates

A formula similar to that used in deriving the ferry freight rates is used for the winter road freight rates. In this case, there is no ferry fee. Furthermore, fuel costs are included in estimating the cost of truckers' time while travelling on the winter roads. There is also an allowance for increased driver's wages during winter road travel. Appendix 6 illustrates the computations necessary for all but the all-weather road option, in which there is no requirement for a winter road.

The freight rates calculated are as follows:

Transport Option	Freight Rate (1977 $/lb.) Regular	Special
1. Existing System	0.0156	0.0172
2. Partial All-weather Road/Ferry System	0.0146	0.0161

4. All-Weather Road Freight Rates

The estimated all-weather road freight rates for 1977 are taken directly from the published tariff listings (Manitoba Trucking Association 1977:57)[1]. Based on a truck load of 45,000 pounds and a one-way travelling distance of approximately 483 miles, the regular freight rate is found to be $1.39 per hundred weight (cwt). The corresponding special rate for the run is $1.53/cwt.

E. Freight Delivery Costs

Having determined the freight volumes and rates applicable to each transport mode in each investment alternative for the base-year of 1977, the ground-work is set for the calculation of the corresponding freight delivery costs. Thus, by applying the 3.6% freight growth rate and the appropriate discount rates for sensitivity analysis, the cumulative future cost estimates for freight delivery are found over the twenty-five year study period.

Tables 13 through 19 reveal the results of such calculations for

[1] The rates in this publication were subject to a 5% increase as of September 1977. The revised rates are used in this analysis.

TABLE 13

1977 FREIGHT COST FOR EXISTING SYSTEM

	Air Service		Ferry/Road		Winter Road		TOTAL
	Scheduled	Charter	Regular	Special	Regular	Special	
1977 Freight (000 lbs.)	121.2	980.6	678.8	169.7	4,384.2	1,096.1	7,430.6
Freight Rate ($/lb.)	0.2300	0.2224	0.0165	0.0182	0.0156	0.0172	--
1977 Total Cost (000$)	27.9	218.1	11.2	3.1	68.4	18.9	347.6

TABLE 14

CUMULATIVE FREIGHT COST FOR EXISTING SYSTEM
(1977 000 $)

% Discount Rate/Year	0%	8%	10%	12%
Discount Factor[a]	1.036	0.959	0.942	0.925
1978 Cost	360.1	333.3	327.4	321.5
Discount Factor	2.109	1.879	1.829	1.780
1978-79 Cost	733.1	653.1	635.8	618.7
Discount Factor	40.893	15.222	12.570	10.577
1978-2003 Cost	14,214.4	5,291.2	4,369.3	3,676.6

[a] See Appendix 2 regarding derivation of discount factors.

TABLE 15

1977 FREIGHT COST FOR PARTIAL ALL-WEATHER ROAD/FERRY SYSTEM

	Air Service		Ferry/Road		Winter Road		TOTAL
	Scheduled	Charter	Regular	Special	Regular	Special	
1977 Freight (000 lbs.)	121.2	980.6	678.8	169.7	4,384.2	1,096.1	7,430.6
Freight Rate ($/lb.)	0.2300	0.2224	0.0155	0.0171	0.0146	0.0161	--
1977 Total Cost (000$)	27.9	218.1	10.5	2.9	64.0	17.6	341.0

TABLE 16

CUMULATIVE COST FOR PARTIAL ALL-WEATHER ROAD/FERRY SYSTEM
(1977 000$)

% Discount Rate/Year	0%	8%	10%	12%
Discount Factor[a]	39.857	14.263	11.628	9.652
1979-2003 Cost	13,591.2	4,863.7	3,965.1	3,291.3

[a] See Appendix 2 regarding derivation of discount factors.

TABLE 17

1977 FREIGHT COST FOR ALL-WEATHER ROAD SYSTEM

	Air Service		All-weather Road		TOTAL
	Scheduled	Charter	Regular	Special	
1977 Freight (000 lbs.)	88.5	715.6	5,301.2	1,325.3	7,430.6
Freight Rate ($/lb.)	0.2300	0.2224	0.0139	0.0153	--
1977 Total Cost (000$)	20.4	159.2	73.7	20.3	273.6

TABLE 18

CUMULATIVE COST FOR ALL-WEATHER ROAD SYSTEM
(1977 000$)

% Discount Rate/Year	0%	8%	10%	12%
Discount Factor [a]	38.784	13.343	10.741	8.797
1980-2003 Cost	10,611.3	3,650.6	2,938.7	2,406.9

[a] See Appendix 2 regarding derivation of discount factors.

TABLE 19

USER COST SUMMARY: FREIGHT

(1977 000$)

Investment Option	Operating Period	% Discount Rate/Year 0%	8%	10%	12%
1. Continuing with the Existing System					
Existing System	1978-2003	14,214.4	5,291.2	4,369.3	3,676.6
2. Providing a Partial All-weather Road/Ferry System					
Existing System	1978	360.1	333.3	327.4	321.5
All-weather Road/Ferry/ Winter Road System	1979-2003	13,591.2	4,863.7	3,965.1	3,291.3
TOTAL USER COST	1978-2003	13,951.3	5,197.0	4,292.5	3,612.8
3. Providing a Complete All-weather Road					
Existing System	1978-1979	733.1	653.1	635.8	321.5
All-weather Road System	1980-2003	10,611.3	3,650.6	2,938.7	2,406.9
TOTAL USER COST	1978-2003	11,344.4	4,303.7	3,574.5	3,025.6

the three investment options. Table 19 summarizes the freight delivery costs associated with each option. From this table, the all-weather road system (Option 3) is seen to have a cost advantage of 20-25% over the existing and partial all-weather road/ferry systems (Options 1 & 2). The latter systems differ in cost by less than 2%, regardless of the discount rate selected, with the partial all-weather road/ferry system being slightly less costly than the existing system. These results, based solely upon freight delivery costs, indicate a reversal of the rank of investment options seen at the end of Chapter 3 at which point only construction, operations and maintenance costs are analyzed.

Freight costs, as illustrated in Figure 2, are particularily sensitive to the choice of discount rate. For all options, costs discounted at 8% per year are approximately one-third those which are not

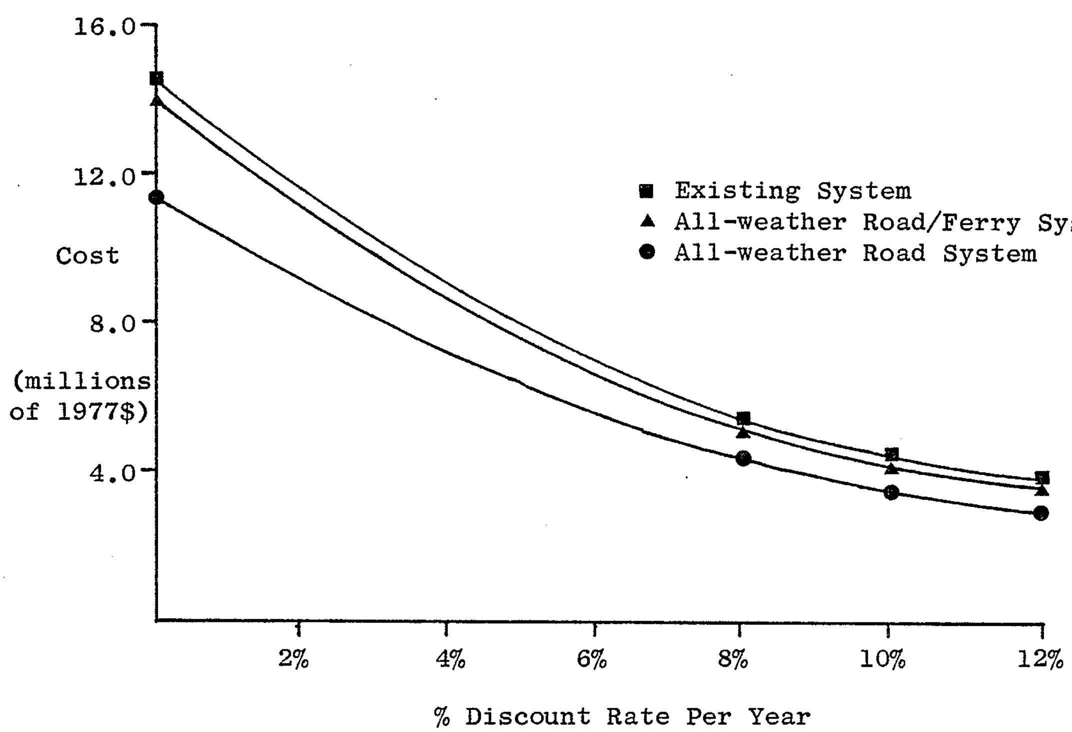

Figure 2 The effects of discount rates upon freight delivery costs for alternative transport systems.

discounted. A further 30% reduction in estimated real costs is seen when a 12% annual discount rate is applied.

F. User Cost Savings: Freight

For the purposes of benefit-cost analysis, the existing system freight costs can be considered as standards against which cost changes attributable to the alternate systems can be measured. When the cost, for example, of an alternative investment is greater than that of the existing system a net loss would result from the decision to choose the alternative; on the other hand, when the cost of an alternative investment is less than that of the existing system a net gain, or user cost saving, would be observed which would be a benefit of the choice to invest in the alternative system. In the present case, it has been noted that the user costs for freight delivery are higher for the existing system than either optional system. Consequently, user cost savings, as shown in Table 20, can be calculated for use in the benefit-cost summary of the concluding chapter of this study.

TABLE 20

USER COST SAVINGS: FREIGHT
(1977 000 $)

Transport Option	% Discount Rate/Year			
	0%	8%	10%	12%
1. The Existing System	-	-	-	-
2. Partial All-weather Road/Ferry System	263.1	94.2	76.8	63.8
3. Complete All-weather Road System	2,870.0	987.5	794.8	651.0

G. Passenger Costs and Cost Savings

The treatment of passenger data should, theoretically, parallel that of freight. By determining the number of passengers travelling on existing transport modes, the origins and destinations of these passengers as they travel to and from Cross Lake, the historical growth rates of traffic, and the average costs for each mode and trip length, a total figure for passenger costs associated with continuance of the existing transport system could be found. Then, by estimating the volumes of passenger traffic diverted from existing modes to the new or improved modes as well as the average travel costs of all passengers, the total passenger costs for each alternative transport investment could be derived. The differences in the total passenger costs of each system would indicate the passenger cost savings due to different transport investment decisions.

This process of determining passenger costs is, however, far easier described than carried out. The primary reasons for difficulty are the quality of data and the complexity which arises when attempts are made to define average costs for passengers travelling by the various transport modes.

The quality of available historical data, regardless of mode, is generally poor for the existing transport system. The relatively recent interest in such data can be cited as the main reason for poor quality. Only within the past few years have efforts been made to establish information recording systems which detail the activities of isolated northern communities. Unfortunately for this aspect of the study, these information systems, while being reasonably efficient at recording freight data, are not yet sufficiently refined to provide good passenger statistics.

Consideration of existing air and winter road passenger information illustrates some of the problems regarding its use. In the case of air passenger data, the Manitoba Department of Northern Affairs 'Activity Summaries' are used to faithfully record numbers of passengers per month who utilize the Cross Lake airstrip. Because this information does not specify the origin, destination or flight type (schedule, charter or private) of passengers, appropriate user costs can not be applied to passenger numbers so as to allow calculation of modal travel costs. Similarily, in the case of winter road (and ferry) data, only the numbers of private vehicles which traverse the route are recorded. Origins, destinations and the numbers of persons per vehicle, all of which are necessary for passenger cost estimations, are unknown. As a result of information deficiencies, therefore, it is impossible to accurately estimate passenger travel costs for the existing transport system. Without this estimate, it is equally impossible to attach passenger costs to the alternative investments thereby permitting the calculation of passenger cost savings.

Even if the statistical problems associated with the quality of data were alleviated, it should be noted that, unlike the freight calculations, the estimation of passenger costs is complicated by subjective human preferences and valuations. To some extent, passenger costs can be measured by the price of a transit ticket or the cost of operating a private vehicle, but these measures only represent the readily quantifiable part of a trip's value to a traveller. Subjective elements, that are difficult to quantify, such as the value of time in transit and the value of a transport mode's comfort and convenience, should also be accounted for. Normally, subjective items are translated into monetary terms by analyzing the results of a detailed field survey which has sampled them. This type of survey has not been conducted for passenger travel in isolated northern areas, and while it would be invaluable to passenger cost estimations it would also require considerable time and effort that are beyond the scope of the present analytical study.

Despite the fact that a quantified presentation of passenger costs can not be provided, there are certain conclusions that can be drawn about such costs that shed light upon the preferred choice of transport investment alternatives. For example, the replacement of the existing system by the partial all-weather road/ferry system will reduce travelling time for passengers since the time-consuming portion of the trip, the portion spent on the ferry, will be reduced from about 2 hours to 5/6 hour. This reduction in time can be considered an unquantified benefit of the new system.

Similarily, the replacement of the existing system by the all-weather road alternative will also reduce the travelling time for surface passengers. Rather than spending 2 hours on the ferry or 1.5 hours on the winter road, the all-weather road traveller will spend about 25 minutes traversing the equivalent distance. A slightly lesser time saving would be observed in relation to the partial all-weather road/ferry system. In addition, because the new all-weather road would be a low cost and time efficient mode, it is not unreasonable to expect some diversion of air passenger traffic from the levels currently witnessed for the existing system. This type of diversion would be parallel to that discussed for freight and, if passenger costs were readily determined, could be expressed as reduced costs and therefore passenger cost savings attributable to the all-weather road system. Finally, since an all-weather road would constitute a reliable, year-round transport system there would be some possibility that traffic would be generated by it over and above traffic which would result from passenger diversions from other modes and the normal growth of existing surface traffic volumes.[1] This generated traffic would be of economic and social benefit to the community of Cross Lake in that those persons who may not have travelled previously could travel on the lower cost all-weather road because it fitted their budget. Generated traffic could also be considered a cost of a new investment, however. As a cost it would not be economic in nature, rather it would probably be the social cost inflicted on community residents by the pressure of new and undesireable visitors (ie, tourists, sportsmen etc.) who would otherwise have remained away from the area.

By way of summary, it would seem that, without quantifying and establishing the magnitude of passenger costs and cost savings, there would be a definite cost advantage resulting from the decision to replace the existing system by the all-weather road system and a lesser advantage if the partial all-weather road/ferry system were chosen.

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[1] It is conceivable that the replacement of the existing system by the partial all-weather road/ferry system would also generate some new traffic because travel time would be reduced. However, the degree of traffic generation could not be expected to be equivalent to that of the all-weather road system because of the differences in system reliability.

H. Summary

This chapter has investigated the user costs and user cost savings associated with the three choices of transportation investment. Both freight and passenger costs have been discussed; the former have been fully quantified and therefore permit numerical evaluations to be made between alternatives, the latter were not quantified because of limited data and therefore are useful only in the subjective ranking of alternatives.

Regardless of their quantifiable or unquantifiable nature, both the freight and passenger cost analyses have concluded that the least cost investment alternative, based solely on user costs, is the all-weather road system, followed by the partial all-weather road/ferry system and then the existing system.

Because the all-weather road system is the least cost system, it is also desinated as having the greatest user cost savings attributable to it, relative to the cost of the existing system. Over the twenty-five year study period, these cost savings are estimated to be between $2,870,000 (when costs are not discounted) and $651,000 (when a 12% discount rate is employed). Such cost savings are more than ten times those attributable to the partial all-weather road/ferry system.

To a transport system user, the results of this chapter would indicate the all-weather road system as the preferred investment option. Contrarily, the results of Chapter 3 would, to a public decision-maker, indicate the existing system as being preferred. In order to determine the socially preferred investment, or that which maximizes the net social value of investment, it is in the interest of the Provincial Government analyst to amalgamate the results of these two chapters and then consider the outcome in relation to unquantifiable factors influencing the final investment decision.

Consequently, the next chapter of the analysis deals with the amalgamation of the quantifiable results and yields appropriate investment conclusions. It is followed by a brief summary of unquantifiable factors important to the case study and, finally, the concluding chapter which documents general conclusions and recommendations pertinent to the decision-maker's responsibility of selecting the optimum transportation investment.

V THE TREATMENT OF QUANTIFIABLE CASE STUDY RESULTS

A. Introduction

This chapter summarizes the quantifiable results of the Cross Lake case study. Earlier calculations regarding infrastructure costs and user costs, or user cost savings, have been amalgamated in both least-cost and benefit-cost analyses. From these analyses are derived recommendations which are specific for the case study.

The sensitivity of the analyses to changing discount rates is determined for the benefit of decision-makers coping with uncertain interest rates. In addition, since uncertainty in the quantity of air freight diverted to road transport was of concern when examining All-weather Road System user costs, the impact of changing the percentage of air freight diverted is also investigated.

B. The Least-Cost Analysis

When conducting a least-cost analysis, the procedure is to identify all quantifiable costs, and benefits if applicable, and total them to arrive at an overall project cost. By comparing total project costs the decision-maker is able to facilitate his selection for investment by employing the criterion which establishes the best investment as being that of least cost.

This procedure has been followed in the present study. Table 21 summarizes the infrastructure and user costs calculated in Chapters III and IV, respectively. It also lists the total project costs associated with each of the three major investment alternatives.

From the results shown in Table 21, it is seen that the main contribution to total project cost is by user costs although the significance of the user cost input is very sensitive to an increasing discount rate. Using the least cost criterion, the Existing System is the most attractive investment choice in all but one situation. That situation exists when

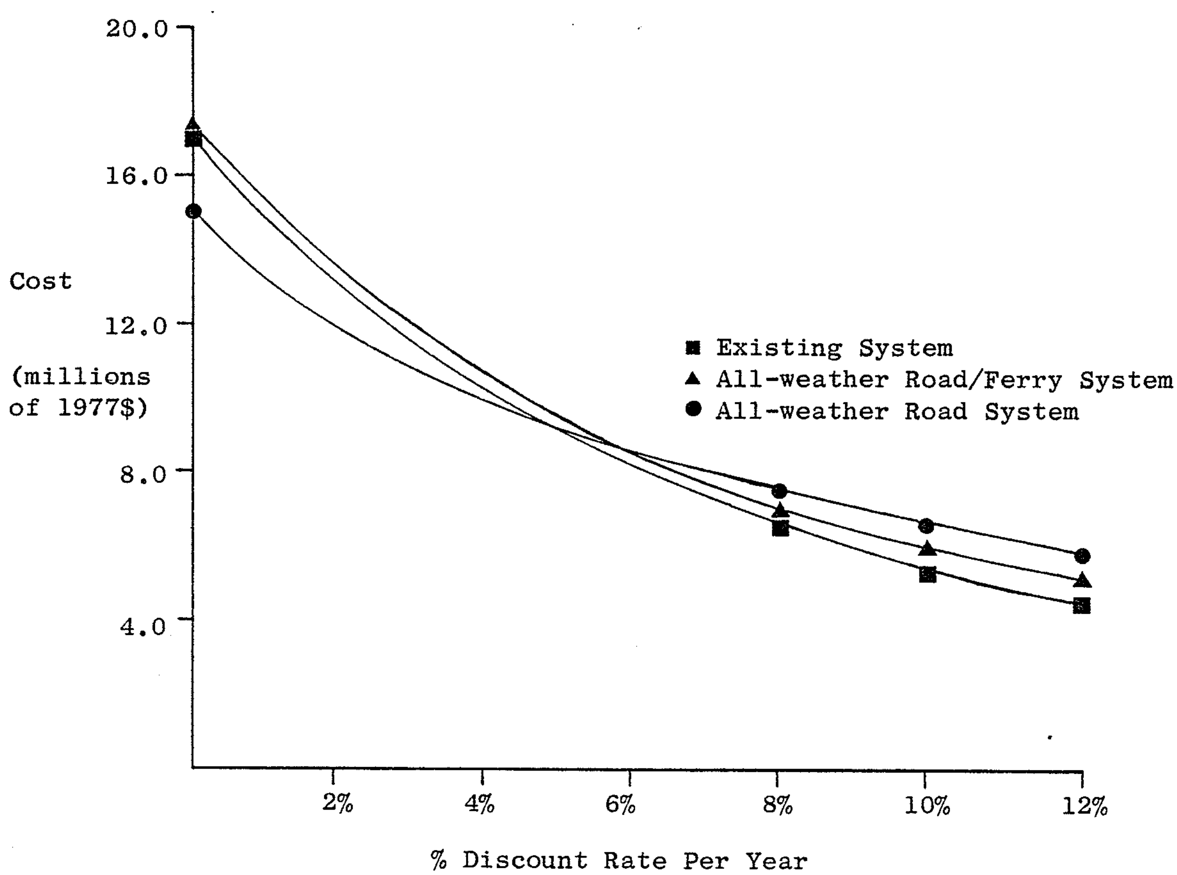

Figure 3 The effects of discount rates upon the total cost of implementing alternative transportation investment systems.

TABLE 21

PROJECT COST SUMMARY
(000$ 1977)

Cost Type	% Rate of Discount	Investment Option 1.Existing System	2.Road/Ferry	3.All-weather road
Infrastructure Costs[a]	0	2,792.5	3,265.2	3,730.1
	8	1,192.4	1,831.8	3,159.2
	10	1,013.9	1,665.2	3,055.5
	12	876.1	1,534.0	2,961.6
User Costs[b]	0	14,214.4	13,951.3	11,344.4
	8	5,291.2	5,197.0	4,303.7
	10	4,369.3	4,292.5	3,574.5
	12	3,676.6	3,612.8	3,025.6
Total Cost	0	17,006.9	17,216.5	15,074.5
	8	6,483.6	7,028.8	7,462.9
	10	5,383.2	5,957.7	6,630.0
	12	4,552.7	5,146.8	5,987.2

[a] Derived in Chapter III, infrastructure costs are costs of maintaining and constructing alternative transportation systems over the 1978-2003 period.

[b] User costs are costs of transporting freight items via alternative transportation systems 1978-2003 as calculated in Chapter IV.

, as depicted in Figure 3, the discount rate is less than 5% per annum. If the discount rate is less than 5% the All-weather Road System is the least cost alternative; higher discount rates favour the Existing System.

The All-weather Road/Ferry System option has a higher cost than the Existing System regardless of discount rate. It is, however favoured over the All-weather Road option provided the discount rate is greater than 6% per annum.

From the above observations, it follows that the value of the discount rate critically influences the investment choice made by the decision-maker. Given the current investment climate, therefore, it is important to realize that the eight to twelve percent range of discount rates is the most realistic to consider.[1] Within this range, the Existing System is the least cost investment choice.

Despite the ranking of investment options that has been so far determined, the potential investor should be aware of the value of "cost differences" that exist between options. For example, in the eight to twelve percent range of discount rates Table 21 shows that the Existing System is between one-half and one and one-half million dollars less expensive than either alternative investment. These cost differences apply over the twenty-five year study period. They are approximately equivalent to a cost difference of twenty to sixty thousand dollars per year. Given this information, a perspective on investment choice is provided to the decision-maker. The perspective does not alter an investment choice made according to the least cost criterion, but it may facilitate the association of costs with unquantifiable factors, social, administrative, political or developmental, which also influence

1 The 8 to 12% range of discount rates, or interest rates, is in line with the current and expected rate of return yielded by similar investments.

the decision-maker's final decision.

C. The Benefit-Cost Analysis

The procedure followed in benefit-cost analysis is to determine project benefits and costs, to evaluate them and to calculate each project's benefit/cost ratio. Then the best investment choice is made by selecting the project with the highest benefit/cost ratio; a ratio which usually exceeds 1.0, thereby indicating that benefits outweigh costs.

In this case study, the results of the benefit-cost analysis are summarized in Table 22. The benefits determined in the analysis are equal to the user cost savings associated with the choosing of either the Road/Ferry System or the All-weather Road System, respectively, over the Existing System. These user cost savings represent the reduction in freight costs achieved by adopting a new transportation system. Note, as a point of interest for local residents, that the freight cost savings are approximately ten times greater for the All-weather Road System than for the Road/Ferry option. The costs determined in the benefit-cost analysis are the Net Infrastructure Costs. Such costs are equivalent to the sum of construction, operating and maintenance costs for each new investment option less those of the Existing System.

Table 22 also records the net present value, or the difference between the present value of benefits and the present value of costs, for each investment choice. These net present values are similar to the "cost differences" discussed in the above least-cost analysis and they warrant similar observations.

TABLE 22

PROJECT BENEFIT-COST SUMMARY

(000$ 1977)

Cost or Benefit	% Rate of Discount	Investment Option 1. Existing System	2. Road/Ferry	3. All-weather Road
User Cost Savings[a]	0	-	263.1	2,870.0
	8	-	94.2	987.5
	10	-	76.8	794.8
	12	-	63.8	651.0
Infrastructure Costs[b]	0	2,792.5	3,265.2	3,730.1
	8	1,192.4	1,831.8	3,159.2
	10	1,013.9	1,665.2	3,055.5
	12	876.1	1,534.0	2,961.6
Net Infrastructure Costs[c]	0	-	472.7	937.6
	8	-	639.4	1,966.8
	10	-	651.3	2,041.6
	12	-	657.9	2,085.5
Net Present Value[d]	0	(2,792.5)	(3,002.1)	(860.1)
	8	(1,192.4)	(1,737.6)	(2,171.7)
	10	(1,013.9)	(1,588.4)	(2,260.7)
	12	(876.1)	(1,470.2)	(2,310.6)
Benefit/Cost Ratio[e]	0	-	0.56	3.06
	8	-	0.15	0.50
	10	-	0.12	0.39
	12	-	0.10	0.31

[a] Calculated in Chapter IV, p.62.
[b] Calculated in Chapter III, p.44.
[c] Infrastructure costs of options 2 and 3 less those of the Existing System.
[d] User Cost Savings less Infrastructure Costs for each investment choice.
[e] User Cost Savings divided by Net Infrastructure Costs.

Finally the benefit/cost ratios are listed in Table 22. These ratios have been derived by dividing total project benefits by total (net) project costs. A ratio greater than one indicates that it is advantageous to choose the alternative investment under consideration rather than the Existing System since the former's benefits will exceed its costs. As seen from the numerical results and the graphical presentation of Figure 4, only one situation yields a ratio greater than one. In that situation the All-weather Road System is favoured, providing the discount rate is

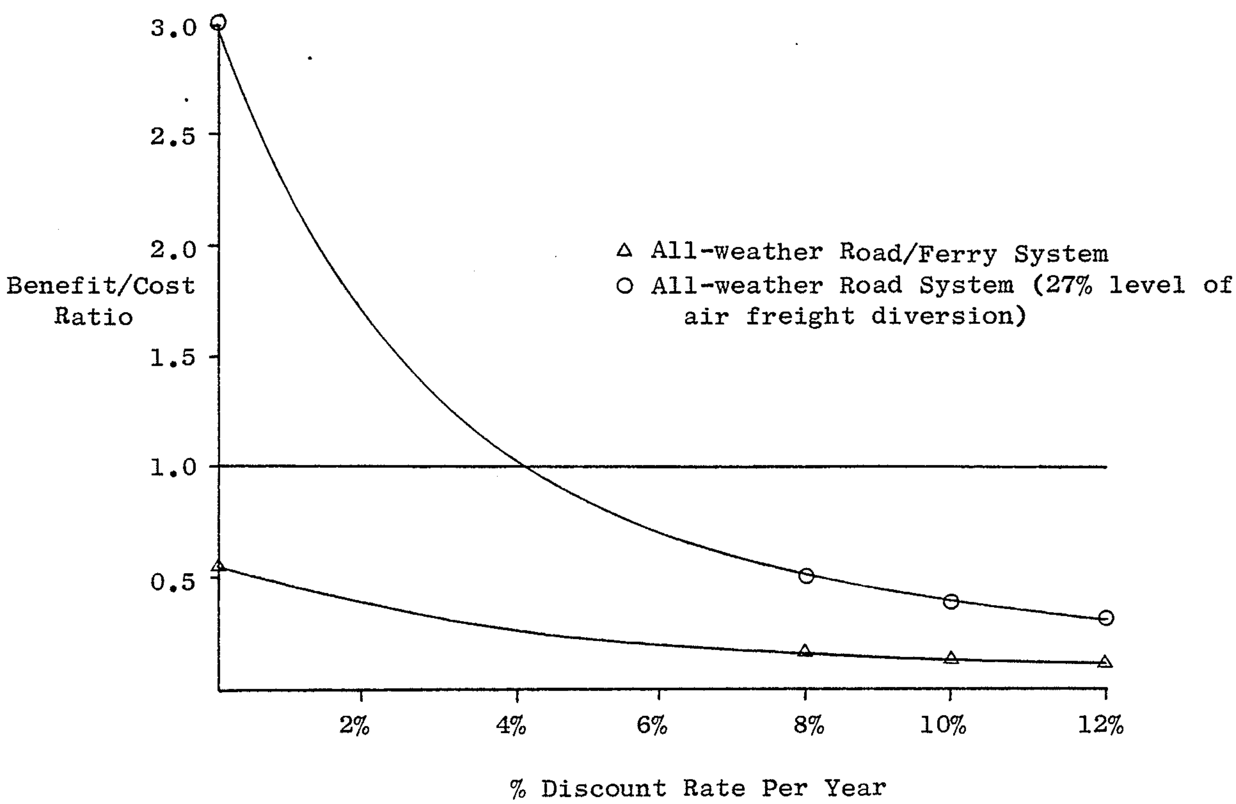

Figure 4 The effects of discount rates upon benefit/cost ratios of alternative investment options.

less than 4 % per annum. The Road/Ferry System is never the most attractive investment.

These results correspond exactly with those observed and discussed in the least-cost analysis. The benefit of one type of analysis over the other is not great, therefore, since both lead the decision-maker to the same conclusion. Benefit-cost ratios provide numerical values which readily distinguish the optimum investment choice. However, the ratios do not indicate, as do the least cost results and the net present values, the magnitude of project "cost differences". In cases where these cost differences are not large in relation to the overall costs of alternatives being considered, they are of particular importance to the decision-maker. For, they may alter the final investment choice when weighed against unquantifiable project concerns. This possibility will be recalled from previous discussions(p. 74).

D. A Sensitivity Analysis: The Effect of Diverting Air Freight to Road Transport

The foregoing least-cost and benefit-cost analyses have evaluated the All-weather Road System in relation to the Existing transportation system using the assumption that a minimum amount (27%) of the existing system's air freight would be diverted to lower cost road transport if the new option were chosen.[1] Because there is reason to consider this level of air freight diversion lower than realistic[2], it is considered prudent

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1 The method by which the 27% level of air freight diversion has been calculated is discussed in Chapter IV (p. 51).

2 MPS et al suggest that up to 99% of the air freight might be diverted.

at this point in the analysis to test the sensitivity of the all-weather road option to changing levels of diverted air-freight and to observe the impact of such changes on the attractiveness of the all-weather road (Option 3) investment.

To this end, the benefits and costs of Option 3 have been recalculated using 0%, 50%, 80% and 100% levels of air-freight diversion. The results of the recalculations are presented in Appendix 7 and are summarized as they pertain to the least-cost and benefit-cost methods of analyses in Figures 5 and 6, respectively.

Figure 5 shows that the greater the volume of air-freight diverted the less the total project cost, and therefore, the more attractive the all-weather road option. Focusing on the 8 to 12% range of discount rates, if more than 60% of the air-freight is diverted, Option 3 becomes an increasingly more suitable investment choice. It becomes indisputably preferred when 100% of the air-freight is diverted to road transport.

Similar observations result from an analysis of Figure 6. The benefit-cost ratio increases as the amount of air-freight diverted increases. Therefore, the closer the situation is to 100% air-freight diversion, the more attractive the all-weather option is compared to the existing transportation system.

Because the sensitivity of Option 3 to the amount of air-freight diverted is so dramatic, the decision-maker is cautioned to consider the issue of air-freight in more detail than presented in this study; that is to pin-point the appropriate level of diversion and establish it as being higher than the minimum level of 27%. In this way the validity of accepting

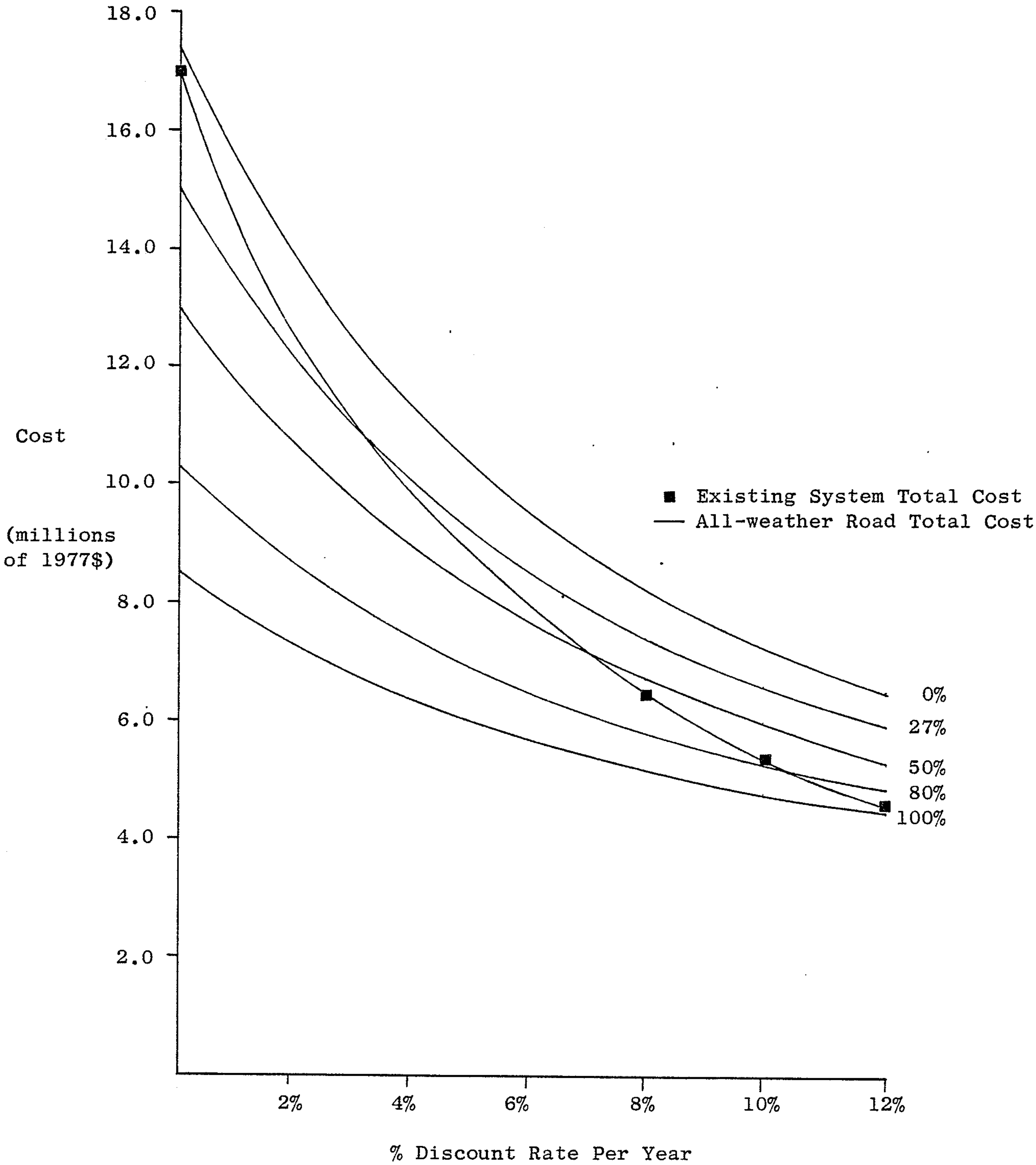
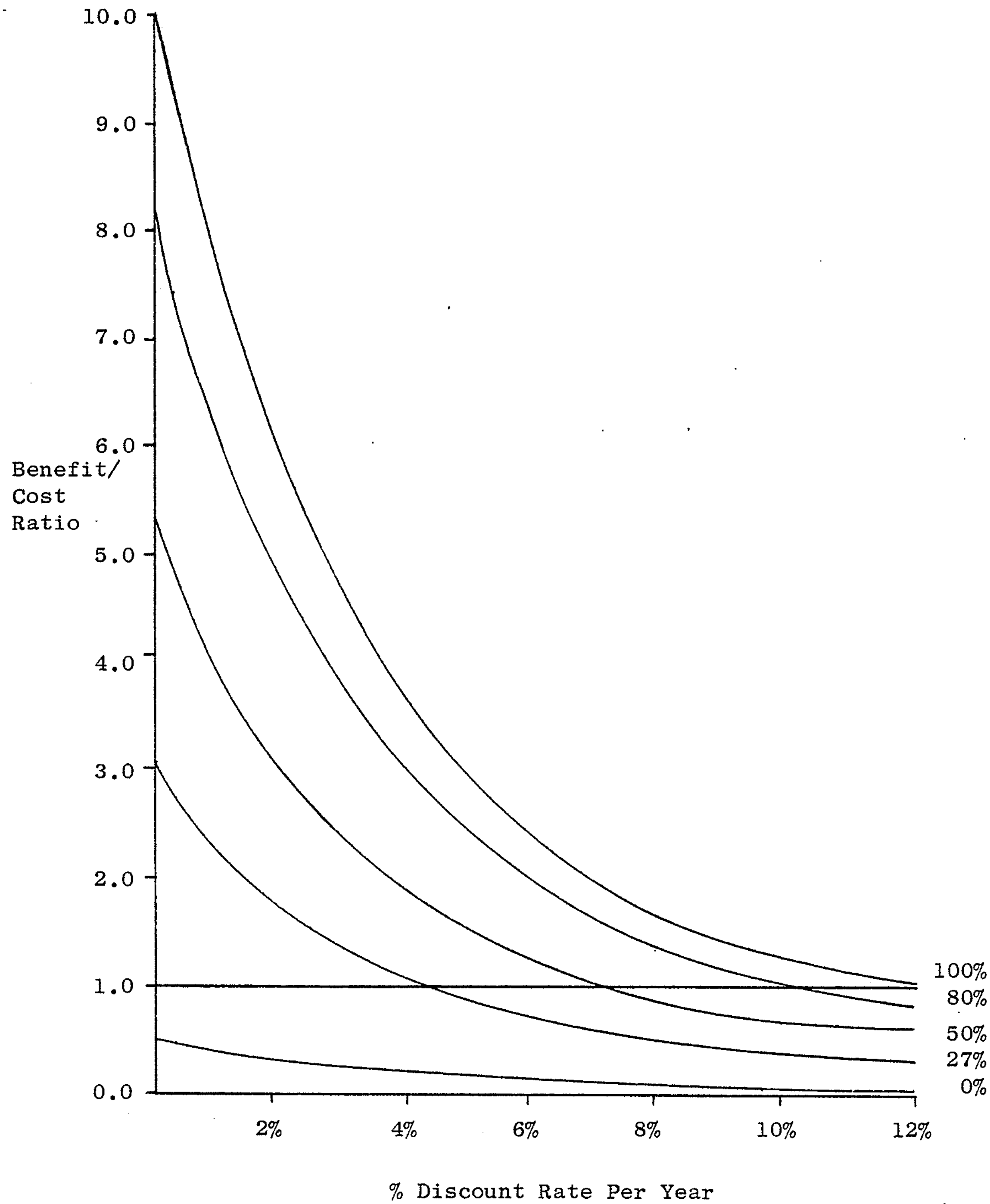


Figure 5 The sensitivity of All-weather Road System implementation costs to varying percentages of Air Freight diverted(from the Existing System) to road transport (new system).



<u>Figure 6</u> The sensitivity of All-weather Road System benefit/cost ratios to changes in percentages of air freight (from the Existing System) transferred to road transport (new system).

or rejecting the All-weather Road investment option will be reinforced. In the event that further study is prohibited, the decision-maker is encouraged to rely upon the MPS et al (1974) air freight diversion level of 99%.[1] The reason for this advice is that the MPS figure reflects a trend witnessed in several other remote or isolated norther communities. Therefore, to the extent that a trend exists, it is reliable in relation to the Cross Lake study. Using the 99% level, the optimum investment, according to least cost and benefit/cost ratio criterion, is the All-weather Road System for all discount rates 0 to 12%.

E. Summary

In summary, the benefit-cost and least-cost analyses both indicate that the Partial All-weather Road/Ferry Option is less attractive an investment than either alternative, regardless of the discount rate used. It, therefore, is not recommended pending the outcome of Chapter VI's discussion of additional unquantified considerations.

The decision as to which of the remaining two options should be chosen is not as straight-forward. As shown in Figure 7, the choice depends upon which combination of "% Air Freight Diverted" and "% Discount Rate" is considered reasonable. However, since evidence in this chapter indicates that high discount rates (8-12%) and high levels of air freight diversion (greater than 90%) are 'most probable', the Complete All-weather Road System is favoured over the Existing Cross Lake Transportation System

[1] PMLP Consultants Ltd. (1975) have also investigated levels of air freight diversion for isolated northern communities. They utilize a 100% level of diversion for cases similar to that of Cross Lake.

and is considered the best investment choice for the decision-maker. This recommendation, of course, relies upon quantified information only. It remains to be seen whether the following discussions of qualitative factors also supports an all-weather road investment.

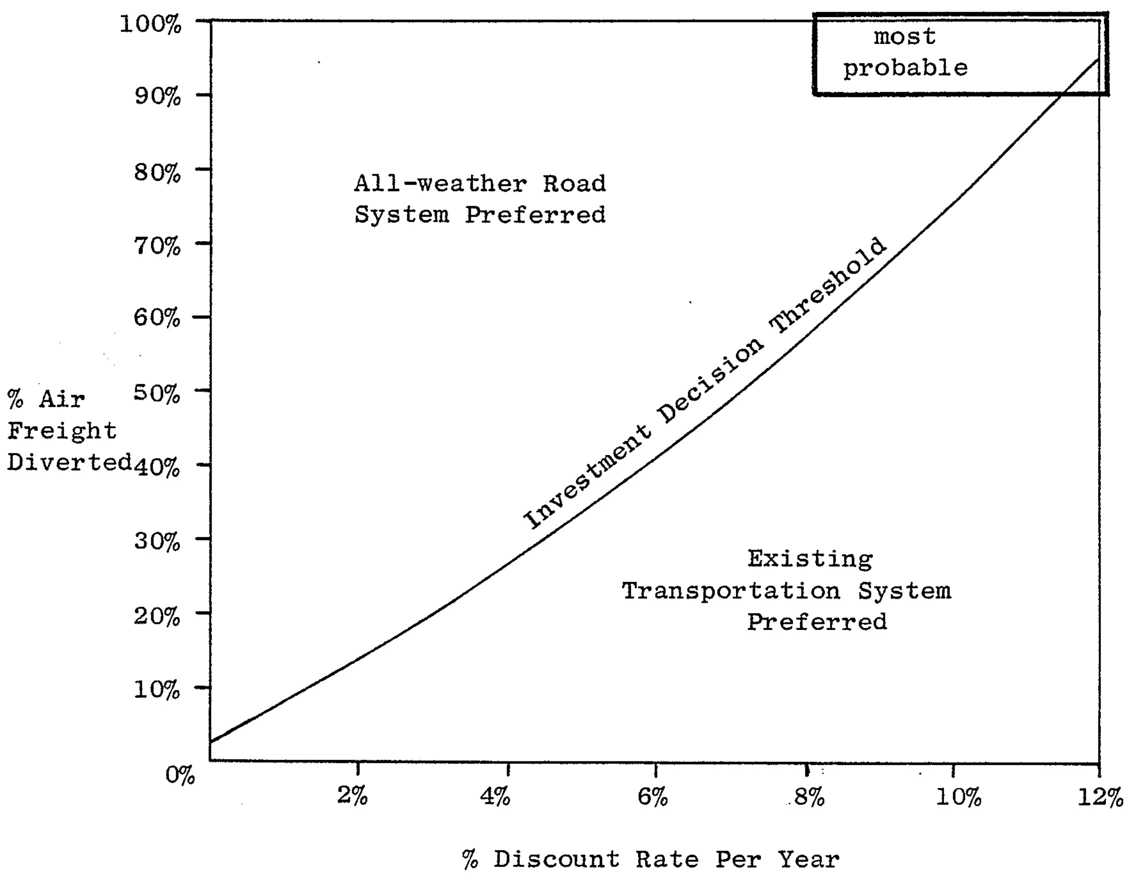


Figure 7 The relationship between % Discount Rate Per Year and % Air Freight Diverted in determining the preferred investment choice.

VI ADDITIONAL CASE STUDY CONSIDERATIONS

A. Introduction

To this point, the analysis has dealt with quantifiable economic factors. In this chapter, some additional but unquantified factors are presented which are considered pertinent to investment decision-making. These factors are both economic and non-economic. Together with the quantified results, they are intended to describe the wide range of considerations the case study involves.

Within the chapter, the following are discussed in relation to the Cross Lake investment alternatives:

- biophysical impacts: water regime; land and vegetation; fish; and, wildlife
- resource development potentials: mining and aggregate extraction; commercial fishing; agriculture; recreation; trapping; and, forestry
- impacts on commercial and service industry
- impacts relating to the Provincial Government
- impacts for local residents

The observations made for each of these study areas depict benefits (advantages) and/or costs (disadvantages) as they are perceived by the parties impacted. For the Provincial Government decision-maker, such information yields a balanced perspective of the investment problem when weighed alongside the quantified data.

B. Biophysical Impacts

Included among biophysical impacts are the physical and biological changes associated with each transportation investment alternative. These are direct impacts due to construction and/or operation of all-weather roads, winter roads and ferry services. They do not include indirect and future impacts arising from commercial or industrial development.

1. Water Regime

The water regime includes chemical and physical properties pertaining to water quality and quantity. For the Cross Lake study, transportation activities may affect the water regime of the Nelson River, Pipestone Lake, Cross Lake and lesser tributaries in the downstream drainage system.

At the present time, there is minimal impact on the Cross Lake area's water regime by either the infrequent ferry service, which does not appreciably add to motorized water traffic, or the winter ice-road, which creates minor ice flow problems during Spring break-up. Both alternative investments under consideration would reduce current impacts by reducing or eliminating lake-surface travel.[1]

2. Land and Vegetation

While the building of a road necessitates the clearing of vegetation and alterations to local drainage patterns, the proposed

[1] These impacts of transportation are relatively minor when considered alongside those of the Lake Winnipeg water control scheme (including the Jenpeg generation plant) which dramatically affects water levels, colour, turbidity, chemical content, and bacterial quality (Cole 1974: Lake Winnipeg, Churchill and Nelson Rivers Study, Appendix 4-C).

road developments, in particular the all-weather road option with the road running into the community, minimize physical impacts in ways which are also economically efficient by:

- using glacial landforms such as moraines and esker-kame complexes as road rights-of-way, where sand and gravel material is readily available and drainage problems are reduced (ie. along the north shore of Pipestone Lake and the area just south of the town)

- adopting an inland route which avoids ecologically sensitive shoreline areas except where lake crossings are necessary

- avoiding peat plains where drainage problems arise and discontinuous permafrost is sometimes encountered, and

- passing throught recent (1971-73) forest fire areas where mature vegetative growth need not be removed (ie. south and east of the community).

3. Fish

The positive or negative impacts of transportation changes are expected to be negligible for reasons similar to those cited in the foregoing discussion on the water regime. The only exception might occur in the case of the all-weather road crossing at Pipestone Lake, where causeways will have some effect on local spawning grounds and fish migration.

4. Wildlife[1]

Moose and woodland caribou are the dominant ungulates in the Cross Lake area. Moose are estimated to have populations of 0.4 to 1.5 animals per square mile. The higher concentrations of moose are in the shoreline and low-lying areas which are avoided in the routing of roads, therefore the impact of proposed transportation changes is minimized.

As for woodland caribou, only two herds are known to frequent the area, one near Norway House and one which utilizes the islands on Cross Lake for calving. Neither of these herds is common to the locale of the proposed roads.

The variety of furbearing animals common around Cross Lake, including muskrat, beaver, otter, ermine and fisher, are not expected to be dramatically affected by road construction or operation because of their water-life orientation.

Finally, transportation impacts on bird species living around Cross Lake are anticipated to be minimal especially since the area is not noted as a major breeding ground or flyway for either common or rare species.

C. Resource Development Potentials

The replacement of the existing Cross Lake transportation system by either a partial or complete all-weather road would provide improved

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1 Teillet et al. 1977: page 19.

year-round access to natural resources in the community area. Therefore, provided resources are sufficient for economic development, activities such as mining, commercial fishing, recreation, agriculture, trapping and forestry may be seen as developmental benefits arising from transportation changes. The following discussions explore the possibility of such benefits.

1. Mining and Aggregate Extraction

Geological studies (Rousell 1962; Davis et al. 1962) indicate that there is no known potential for mineral extraction closer than the Wabowden copper mine, about fifty miles northwest of Cross Lake.[1]

A number of high quality aggregate (sand and gravel) deposits have been identified in the Cross Lake area (Manitoba 1975). One high grade deposit, of approximately ten square miles, is found along the northwest shore of Pipestone Lake. Another medium grade deposit extends a few miles east and south of the community. The right-of-way of the all-weather road option passes through both of these deposits making them readily available for future road construction and developmental work. For the community, however, transportation changes will have only a minor impact since the ample nearby deposit is already being used for road, airstrip and other construction and maintenance activities.

2. Commercial Fishing

The provision of either new transportation alternative

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[1] This mine is in the process of shutting down. While in operation Cross Lake residents have received no direct employment or other economic benefits from it.

would not provide Cross Lake fishermen with access to new commercial fishing lakes or easier access to those fished now.[1] An all-weather road would, however, reduce or eliminate two major problems currently encountered by the Cross Lake Fishing Co-op (Teillet et al. 1977:23).

The first problem is that fishermen have inadequate holding facilities for the volume of fish caught. The second problem is that Cross Lake Air Service, which flys the fresh catch to trucks waiting in Wabowden, has difficulty keeping up with the volumes supplied by the fishermen.

By accommodating truck service right to the fishermens' dock, an all-weather road system would be a substantial developmental benefit which would: eliminate the need for additional fish storage capacity; eliminate the need for high-cost air transport of fish; and, because of cost reductions, result in increased incomes to fishermen.[2]

3. <u>Agriculture</u>

At the present time, there are no commercial farming or market garden activities in the Cross Lake area. Neither are these types of developments to be encouraged by road access improvements since the agricultural soil capability throughout the area is generally low, characterized by severe topographical, water and climatic limitations.[3]

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1 Cross, Pipestone and Walker Lakes are fished exclusively by Cross Lake residents (members of the Co-op). Drunken, Kiskittogisu, Playgreen and Kiskitto Lakes are fished by other communities as well (Manitoba 1975).

2 Because the Co-op is currently filling allowed quotas, cost reductions would only permit industry expansion if quotas are increased.

3 Indicated by the Canada Land Inventory "Land Capability Analysis" (Canada 1976b).

4. Recreation

The major benefit of extending the all-weather road towards the community of Cross Lake for sportsmen would be that they would have a few miles less water travel to get to areas which are already accessible by boat.

For enthusiasts of sportsfishing, the northeastern reaches of Cross Lake and its tributaries would be a little nearer. The angling potential of the entire Cross Lake area is not promising, however, because whitefish, an unpopular angling species, comprises about 75% of the stock. Access to lakes offering popular laketrout fishing (ie. Black Rabbit, Cotton and Molson Lakes) would not be significantly improved. As a result of these factors, surface transportation improvements would be unlikely to lead to the development of tourist enterprises such as fish camps.

For hunters of moose and caribou, road construction would permit land access, in addition to water access, to many miles of favourable habitat along the east shore of Cross Lake and around Pipestone Lake (Webb 1973). Although these species, moose in particular, are hunted at present, it is unclear how hunting pressure would be affected by road development.

As for duck and goose hunting, the fact that the Cross Lake area is not a major breeding or staging ground accounts for the small amount of attention it receives at present and indicates that hunting pressure will not change much if the area becomes more accessible. Undoubtedly, the major northern duck hunting and goose hunting areas will still be around The Pas and the Hudson Bay coast, respectively.

Other recreational opportunities include canoeing, wilderness camping, pleasure boating, ski-doing and cross-country skiing. These activities are enjoyed in abundance throughout the north, therefore local transportation changes in the relatively isolated Cross Lake area are not expected to alter present-day activity patterns significantly.

5. Trapping

The Cross Lake Registered Trapline Section (R.T.L.) encompasses 5,612 square miles. Furbearers trapped in this huge area, in order of diminishing value of pelts harvested in 1975/76, include muskrat, beaver, otter, fisher, lynx, mink, weasel and other species.[1]

Because the R.T.L. is large and mostly inaccessible by roads existing or proposed, the choice of transportation investment matters little to Cross Lake trappers. Even in cases where Cross Lake residents make use of roads to get closer to their traplines a new all-weather road would be a small improvement over the winter road currently available during prime trapping months (early to mid-winter).

Some increase in incomes may be realized by local trappers if freight costs for pelts are reduced as road transport becomes available. However, since most trappers sell their pelts at the community Hudson Bay store, store policy on buying prices would still determine income changes. Given market factors, such as

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[1] Source: Department of Renewable Resources, Wildlife Section, Government of Manitoba, 1975/76 records.

the fluctuating public demand for long-haired furs and year-to-year changes in harvest volumes and quality, small changes in freight costs are of minimal importance.

6. Forestry

Available resource inventories indicate that forestry offers the greatest potential for economic development in the Cross Lake area (Manitoba 1974; Manitoba 1975).[1] Ample volumes of both coniferous and deciduous merchantable timber are available within a twenty-five mile radius of Cross Lake. Quantities are sufficient to meet the domestic needs of Cross Lake as well as supply timber for export out of the area. The economic feasibility of export, however, requires detailed marketing, operating and transportation cost analysis to determine the degree of profitability.

Although Manitoba Forestry Resources Ltd. (Manfor) of The Pas has been active in the Jenpeg-Wabowden area, relatively little timber harvesting has occurred east of the Nelson River and Cross Lake. In 1977, the Cross Lake Community Council was awarded a relatively small timber permit allowing 400 cords of wood to be harvested along the Oxford House winter road.[2] As well as being used for community works, a portion of this wood supplied the Pakwagan Corporation, a log house fabrication plant at Jenpeg. Other community activity has been limited to the collection of wood for home-heating fuel and small construction projects (Teillet

[1] Although these are the most recent inventories, some modifications are necessary to account for flooding due to Lake Winnipeg and Jenpeg water control structures, fire loss and timber operations which have reduced timber stocks in recent years.

[2] Even this small permit enabled the employment of eighteen Cross Lake residents.

et al. 1977:38).

The interest voiced by several parties to harvest timber around Pipestone Lake and on the east side of Cross Lake is an indication of the developmental potential which exists. Manfor, Pakwagan and the communities of Cross Lake and Norway House have all expressed their wish to participate in forestry developments there. Although winter roads have accommodated the small amount of activity to date, the construction of an all-weather road as far as Pipestone Lake would certainly make timber export economical. A road all the way to the Cross Lake community would be additionally attractive since, for community residents,it would open the possibility of a sawmill operation which could provide much needed employment, local lumber and export products with markets in nearby Norway House and beyond.

D. Impacts on Commercial and Service Industry

Existing retail operations at Cross Lake, as in most other remote or isolated native communities, are monopolized by the Hudson Bay store. Therefore, if the existing transportation system is developed further, the Bay stands to enjoy reduced transportation costs which it may or may not choose to pass on to community consumers. If freight cost savings are passed on via lower prices, the store has the option of expanding its stock and capitalizing upon the consumers' increased spending power. Such a policy may not appreciably increase profits but it would contribute to better health and a higher standard of living in the community because fresher, more nutritional foods, would replace bulk foods supplied at present.

Perhaps a more significant benefit to retailers which would result from the construction of an all-weather road into Cross Lake would be the opportunity to reduce inventories. With year-round trucking services possible, large inventories now necessary during freeze-up and break-up would be eliminated. As a result, the cost of storage facilities and storage time would be minimal yielding a potential cost reduction to both the retailer and the consumer.

Along with these benefits, improved transportation may have negative implications for the Bay. For example, lowering of transport and inventory costs will increase the likelihood of competitors as well as other types of non-competitive operators. Competition, of course, is in the best interests of community residents and it is hoped that Cross Lake's economy could be further vitalized by competitive processes. However, the strong monopoly power of the Bay and the traditional, habitual role it plays in the northern settlement will remain significant obstacles to competition.

For existing air freight and passenger firms (ie. Cross Lake Air Service, Lamb Air, Perimeter, etc.) the impact of upgrading the current transportation system would be substantial, particularly if an all-weather road were to go into the community. As indicated in the calculation of user cost freight savings (Chapter IV), up to 99% of present air freight and an appreciable precentage of passenger traffic stands to be diverted to ground transport. While diversion of business may benefit the majority of Cross Lake consumers, the airlines would be pressured to reduce the frequency of scheduled flights, increase costs for remaining users or abandon their businesses because profit margins are unacceptable.

For trucking firms, the greatest advantage of improved road access would result from increased freight volumes due to diverted air freight. With an all-weather road into Cross Lake, a year-round service could be provided by truckers rather than only winter and summer service. In addition, lower Provincial freight rates would result when the community became linked to the Provincial road network. A lowering of rates means a reduction in gross revenues to truckers per unit weight of goods moved. Such a decrease would be unlikely to translate into net profit losses, however, because truckers could also expect cost savings due to lower winter maintenance costs, reduced driving times and shorter turnaround times for loading and unloading goods.

For other ground transport firms, such as those offering bus, taxi and delivery services, new business opportunities may become cost-efficient with the provision of an all-weather road into Cross Lake.

E. Impacts Relating to the Provincial Government

In addition to costs of construction, maintenance, operation and equipment already quantified in the foregoing analysis, the Provincial Government will absorb administrative and replacement costs (for roads and equipment) for existing and proposed transportation systems. Such costs will be offset by a number of benefits which may include the following:

- transportation costs savings for government goods and personnel delivered to and from the community

- reductions in government inventory costs ie. especially for fuel and building materials

- stimulated local, regional and Provincial economies via resource and commercial development

- reduced social assistance payments due to increased employment via either out-migration to available jobs and/or local development[1]

- increased political support from those groups and persons receiving net benefits from the investment decision

F. Impact for Local Residents

With the choosing of an alternative transportation investment over the existing system, local residents could observe the following costs and benefits which, in general, would be greater in degree for the complete all-weather road system than for the road/ferry system.

Potential costs of changing the existing sytem include:

- minor environmental impacts which affect trapping, fishing and hunting

- loss of community privacy due to influxes of tourists and developers

- cultural shock which may accompany rapid economic changes

[1] Reduced welfare payments will also be a benefit important to the Federal Government if employment opportunities are generated for registered native residents (ie. more than 85 % of the population) since assistance to these people is a Federal responsibility.

- loss of winter road and ferry-related employment (construction operation and maintenance jobs)

- decrease in frequency of scheduled air services because of high percentages of freight and/or passenger traffic diverted to ground transport

- out-migration of community residents (may also be perceived as a benefit)

Potential benefits of changing the existing transportation system include:

- reduced isolation; year-round access to the Provincial road network will promote social opportunities with other communities

- reduced road-travel times

- lower store prices; competitive shopping

- opportunity to consume more perishable, fresh foods and fewer bulk foods; may improve nutrition and standard of living

- reduced freight costs for the export of local fish, furs and timber products

- opportunities for local business and employment development ie. handicraft sales, campground operations, guiding for hunting and fishing, sawmill and logging operations, service station, etc.

- possibility of obtaining bus service to the community; a new low-cost mode of transport for residents to travel out of the community

- greater opportunity to have seasonal and full-time employment outside the community but still reside in it

- the likelihood of short-term employment for some residents during new road construction and permanent employment relating to on-going maintenance duties

G. Summary

The foregoing discussions of alternative investment impacts and resource development potentials yield valuable knowledge for the Provincial Government decision-maker. This knowledge leads to the following conclusions:

1. Biophysical impacts are not a significant determinant for the decision-maker. While they may be important in other instances, such impacts are expected to be small for all proposed investment options in this case study.

2. The potential for economic growth through resource development is:

(a) Not enhanced by simply maintaining the existing transportation system.

(b) Expected to be moderately high for the extended all-weather road/ferry alternative. This option would offer some new opportunities for aggregate extraction, recreation, and forestry south of Pipestone Lake and east of Cross Lake.

(c) Anticipated to be the highest if the all-weather road option is chosen. Resource areas, in addition to those made accessible by the extended road/ferry system/ could contribute to the development of aggregate extraction, recreation and especially commercial fishing and forestry.

3. The choice of investment will have a variable, and somewhat unpredictable impact on commercial and service-oriented business. The existing transportation system will favour the Bay's monopoly position and high price air service; it will not encourage new business growth. The extended road/ferry system might provide limited opportunities for commercial and road transport expansion, with the latter at the expense of existing air service operations. The all-weather road system would open the door for commercial competition and growth, as well as displacement of air services (ie. Cross Lake Air Service) by less costly road transport services.

4. For local residents, the choice of investment will affect both their social and economic welfare. While the impact of replacing the existing transportation system is uncertain, the effect of maintaining it is predictable. There will be continued high unemployment with about 80% of the population receiving social assistance in a community plagued with drug, alcohol, health, loss of culture and identity problems. Provincial cutbacks in northern hydro development and completion of current projects

(ie. the Jenpeg plant) will eliminate many existing jobs, boost unemployment and reduce local economic activity in general. Prices, although high, will probably climb higher due to factors such as rising energy costs and residents will be left with less autonomy than they now have.

Choosing to extend the all-weather road but maintaining a ferry link with the community would provide some resource development options which could provide residents with employment and offset job losses in the hydro sector. The major advantage of this investment option may be the potential for jobs without exposing the community to much cultural shock.

With an all-weather road, the community would gain the most freedom for economic growth. Since many of the social problems stem from low unemployment, this investment choice is very attractive. However, economic growth, if too rapid can bring on new social problems or accentuate existing problems if people suffer cultural shock and can not adapt to changes quickly (Hickling-Johnston 1975:'The Native North' pp.32-47). Therefore, while the provision of an all-weather road can create opportunities, the net value of actual developments to local residents also depends upon additional factors, such as:

- the degree of difference between community cultural traits and types of development taking place
- the rate of development in and around the community
- the role the community has in regulating development
- the skills residents have and the training they receive

to permit them to partake in developmental opportunities

- the emphases of Provincial and Federal programs which are intended to facilitate education, encourage business development, provide social services, etc.

5. Both Federal and Provincial Governments can decrease their transportation and inventory costs by upgrading the existing transportation system.

Furthermore, job creation through new resource and commercial development will reduce welfare payments as long as unemployed residents are the recipients of new jobs. This factor is highly significant in determining an investment choice since only a few jobs need be created in order to offset the additional investment costs of either the partial road/ferry or all-weather road options.[1]

Finally, provided public costs can be reduced, or increased only slightly, and social costs accruing to local residents are kept to a minimum, a government decision to replace the existing transportation system will not be a great political gamble; it may even have political rewards if local residents and developers (ie. of commercial or natural resource opportunities) realize significant benefits.

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[1] The least-cost analysis revealed that the existing system, based upon quantified results, was no more than $60,000 per year less expensive than the all-weather road option (ie. where 27% air freight diversion and a 12% discount rate were used, p.74). For 1976-77, Department of Indian Affairs social assistance payments averaged approximately $3,000 per year per unemployed employable resident (Canada 1977). Therefore, if 20 unemployed persons can be hired full-time welfare payments will be reduced by $60,000 making the all-weather road option as attractive as investing in the existing system. A similar calculation indicates that the creation of 8 jobs will give a cost advantage to the partial road/ferry system.

In summary, it appears that the all-weather road option, based upon qualitative discussions, is the most progressive investment choice for the Provincial Government decision-maker. Contrary to the static inclination of the existing system and of greater degree than enabled by the partial all-weather road/ferry option, the all-weather road offers definite opportunities for commercial and resource development. These opportunities are needed to alleviate the social and economic doldrums currently facing Cross Lake.

There is no doubt that some negative elements (ie. cultural shock, in-migration of undesired people, some jobs going to non-residents) will accompany such an investment. However, it is important to realize that regardless of the transportation investment made, significant control over community and resource development remains in the hands of the Provincial decision-maker in the form of financial incentive programs for business, manpower training programs, quotas for commercial fishing, forestry and mining permits, etc. Therefore, by judicious management of these tools of government, negative spin-offs of the transportation investment may be minimized.

VII CONCLUSIONS AND RECOMMENDATIONS

A. Usefulness of the Analytical Methods

The benefit-cost and least-cost methods used in the study have produced similar results. In each case, the all-weather road system has been determined as the most economic investment, followed by the existing Cross Lake transportation system and the partial all-weather road/ferry system.

This similarity of results is not surprising, since the same cost components were used in each method and the benefits of the benefit-cost analysis (ie. user cost savings) were derived directly from costs (ie. user costs). Under these circumstances, it is irrelevant to the final outcome which method is chosen to compare investment alternatives.

Limitations to the methods have been of two types. First, the inability to quantify many of the developmental impacts arising from investment choices has limited comprehensive cost comparisons in the least-cost analysis and an overall perspective on the balance of benefits and costs potential to the benefit-cost analysis. Second, the assumptions used in the study have had limiting effects, to varying degrees, on the results. Briefly stated, the assumptions introduced and described in Chapter I (pp. 15-18) included:

- a twenty-five year study period
- static relative prices over the study period
- all freight traffic travels between Winnipeg and Cross Lake
- the existing airstrip does not require upgrading
- future freight volumes are proportional to future population estimates (determined by a constant growth rate)
- freight carriers carry maximum loads
- the mix of freight types (ie. special versus regular) remains constant
- unit costs for operation and maintenance remain constant
- consumers realize full cost savings due to rate decreases

Since similar assumptions are common to contemporary transportation studies, these are not out of order. However, it is hoped that future analyses can improve upon assumptions such as "static relative prices", "single origin/destination freight travel" and "the proportional relationship of freight volumes and population" which have been made primarily because of data restrictions.

B. Recommendations for Future Studies

In the course of the case study, a number of data restrictions were identified. Since they were thought to be typical for many remote and isolated northern Manitoba communities, the following recommendations are considered relevant to the improvement of future studies:

1. Passenger traffic should be recorded for air travel to and from northern communities. Also, periodic surveys should be conducted to permit estimation of traffic on ferries and winter roads. Records should reveal passenger origin, destination and status of travel (ie. private, charter or scheduled service), preferably on a monthly basis.

This information would enable passenger costs and cost savings to be calculated; factors which may be as significant as freight costs and cost savings to the selection of a transportation investment alternative.

2. Winter road freight monitoring records and procedures should be maintained as at present by the Provincial Government for several years in succession. Such action will enable the determination of base-year freight volumes which have greater statistical significance and reliability than those used in the present study.

3. More information should be collected regarding income sources and levels for residents of specific northern communities. This information should be related to existing consumer spending patterns, then extrapolated into the future to estimate how consumer preferences might change as incomes grow or diminish. Such data would permit the estimation of future freight volumes and mixes of freight on the basis of disposable income and preferences rather than the less accurate indicator, population growth.

4. Attitudes of community residents should be polled before and after the decision is made to invest in a transportation system. In this way, perceptions and impacts of the investment may be correlated for the benefit of future studies. Particular emphasis should be placed upon social and cultural factors since information is especially limited for these at present.

5. The potential for commercial and natural resource development and employment opportunities may be better assessed by interviewing potential business and resource developers to determine what role specific transportation improvements play in encouraging business expansion.

C. Recommendation For Investment

As a result of both quantitative and qualitative investigations, and not withstanding the limitations and recommendations for further studies discussed above, the Provincial decision-maker is advised to invest in the Complete All-weather Road Option for Cross Lake. This investment is considered appropriate for the following reasons:

1. It is the least cost alternative for the Provincial Government given the assumptions to which the analysis is subject and the evidence supporting high discount rates and high levels of air freight diversion. In addition, unquantified cost advantages, in the form of passenger cost savings will make it an even more attractive investment.

2. It offers developement and employment opportunities which the other two options can not claim to the same degree. These opportunities are desperately needed by Cross Lake residents to fight their welfare situation and reduce social problems. For the Provincial Government, such opportunities translate into potential for economic stimulus in some sectors of the provincial economy (ie. forestry and commercial fishing) and, at the very least, reductions in welfare payments as employment increases.

Finally, it should be noted that a transportation investment does not lead to economic and social improvements by itself. An investment facilitates change by opening new doors for development. From that point onward, private initiative and the judicious application of government programs (both Federal and Provincial in the case of Cross Lake) play determining roles in proving the potentials which promoted the investment in the first place.

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APPENDICES

APPENDIX 1

WINTER ROADS:

CONSTRUCTION AND SAFETY GUIDELINES

A. Construction Guidelines

Although there are no generally accepted standards for winter road construction, certain guidelines and practices have been developed through experience. The following considerations, as adapted from the Unies report, "Report on Winter Road and All-weather Road Route: Cross Lake to Oxford House" (1974)[1], are indicative of such experience when a winter road route is being selected:

(1) General Location

Shallow, heavy to moderately timbered swamps, level sand and gravel ridges or silty clay deposits all provide a suitable road bed. Generally rock ridges or deep open swamp should be avoided where possible, as should areas of continuous or sporadic permafrost. It is difficult to build and maintain a road on an irregular rock surface and difficult to achieve a solid road bed in open wet areas. Although permafrost affected soils are initially no problem, there is a tendency for degradation and depression to take place with continued use as a result of disturbance of the protective humus layer.

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[1] Unies Ltd. (1974) pp. 26-31.

(2) Gradient

Gradient is the major consideration in determining the location of a winter road. Sustained gradients of over 4% or even short sharp pitches in the road will invariably cause problems, particularily for tractor-trailer units. Unless the grade is cut to mineral soil and deeply frozen, a progressive deep failure of the road-bed will occur. Surface sanding will not correct the problem which can be corrected only by rebuilding the entire road bed by flooding and freezing or placing granular fill. For this reason, and because surface traction presents driving hazards, hills should be avoided wherever possible. Where it is necessary to climb a gradient, the approach should be long and straight and the gradient cut to firm ground and gravelled or frozen with water to increase the strength of compacted snow.

(3) Right-of-Way

The width of right-of-way required for a winter road is less than that required for an all-weather access road. Right-of-ways are generally prepared by bulldozing a width of 40 to 50 feet without necessarily disturbing the humus layer. Levelling and filling using brush, moss, stumps and logs is done in rough areas. Other material is windrowed at the right-of-way edge. No allowance for ditching or for full snow removal is made since much of the snow is required for road construction.

Standing timber should be left as close as possible to the road to prevent drifting and to protect the road surface from the sun. The prepared travelling surface varies in width, but 24 feet seems a reasonable width in protected areas where large trucks are to be used.

(4) Aspect

The road should be protected as much as possible from the sun. Where possible, it should be located on the north side of ridges and the prepared surface should be placed on the southerly side of the cleared area if a choice is available.

(5) Crossings

Crossings of minor and major streams and lakes must be undertaken where ice can readily form or be formed. It is often necessary to timber over minor flowing streams or deep wet areas with ground water movement. Major rivers can be crossed in wide reaches without particular risk, but the selection, preparation and maintenance of the crossing requires special judgment and care. Generally, rivers will be open or covered with a rough and variable ice cover where appreciable velocities are encountered. Downstream of major lakes, open water will occur at low velocities as a result of above freezing temperature. At these points, the building of ice-bridges presents a certain risk and it is preferable to cross well downstream or on the lake ice upstream of the outlet. On a well controled road, it is possible to build and rely upon thickened lake-ice formed by plowing off the protective snow cover. This practice requires that equipment be available at the lake when there is 4-5 inches of ice and that all successive snowfalls are removed. It is also necessary to patrol the ice road and to seal cracks to prevent deterioration and breaks. On longer roads with limited equipment or supervision, these practices are not always possible and long ice crossings are either avoided or flooded to build a more durable surface.

B. Safety Guidelines For Ice-based Winter Roads

The following ice-based winter road load tolerance levels are used as guides in assessing roads built or operated under the jurisdiction of the Manitoba Department of Northern Affairs. They are especially relevant to the winter road leading into Cross Lake since it, for the most part, traverses an ice surface.

TABLE 23 SAFETY GUIDELINES FOR ICE-BASED WINTER ROADS

Inches of Clear Blue Ice[a]	Safe Load	Interval Between Loads (feet)
2	one person	-
3	group (single file)	16
8	car (2 ton gross)	65
10	small truck ($2\frac{1}{2}$T)	82
12	8 ton gross	115
15	10 "	131
20	25 "	"
25	45 "	164
30	70 "	"
36	110 "	"

[a] Blue ice is twice as strong as slush ice. Clear river ice is 15% weaker than clear lake ice.

Sources: Lumberman's Saftey Association and The Pulp and Paper Institute of Canada.

APPENDIX 2

CALCULATION OF DISCOUNT FACTORS[1]

The discount factors used in the case study have been calculated using two formulae. The following sample calculations, taken from the analysis, illustrate the use of each formula:

A. In instances where the numerical value of an estimated expenditure is to remain constant in each future year of expenditure, the discount factor depends upon the chosen discount rate (ie. interest rate) and the number of years from the present value year (ie. base year) the expenditure will be made. The formula used to calculate a discount factor given these conditions is:

$$\text{Discount Factor} = \frac{(1 + i)^n - 1}{i(1 + i)^n}$$

where, n = the number of years lapsing between the base year and the final year of expenditure

i = the annual discount rate, or interest rate (%).

When the discount rate is multiplied times the constant annual expenditure, the resultant figure is the cumulative present value of the *n* years' expenditure.

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1 Refer to C.G. Edge's *A Practical Manual on the Appraisal of Capital Expenditures* (1971) and similar texts for discussions of discount rates (interest rates), the derivation of formulae and the application of discounting methods.

<u>Sample 1</u> With the base year being 1977 and the discount rate at 10%, the discount factor for the two year expenditure period 1978-1979 (see Table 2, p. 35) is calculated as:

$$\text{Discount Factor}_{1978-1979} = \frac{(1 + 0.1)^2 - 1}{0.1\,(1 + 0.1)^2} = \underline{1.736}$$

<u>Sample 2</u> The discount factor for 1980-2003 (23 years), using base year 1977 and a 10% discount rate, is found by subtracting the 1978-1979 (2 years) discount factor from the 1978-2003 (25 years) discount factor.

B. If an estimated expenditure calculated for the base year is expected to increase by a fixed percentage in each subsequent year of expenditure, the following formula is used to calculate the discount factor:

$$\text{Discount Factor} = \left(\frac{1 + g}{i - g}\right)\left[1 - \left(\frac{1 + g}{1 + i}\right)^n\right]$$

where, n = the number of years lapsing bewteen the base year and the final year of expenditure.

i = the annual % discount, or interest,rate.

g = the annual % growth rate of the expenditure.

When this discount factor is multiplied by the annual (base year) expenditure, which grows at rate <u>g</u>, the resultant figure is the cumulative present value of <u>n</u> years' expenditure. In the analysis, these factors are calculated in relation to user costs which increase according to the 3.6% annual population growth rate.

Sample 3 With 1977 as the base year, the discount rate as 10% and the expenditure graoth rate as 3.6%, the discount factor (see Table 14, p. 59) for 1978 is:

$$\text{Discount Factor}_{1978} = \frac{(1 + 0.036)}{0.1 + 0.036} \quad 1 - \left(\frac{1 + 0.036}{1 + 0.1} \right)^{1}$$

$$= \underline{1.829}$$

Sample 4 The 1979-2003 discount factor (10.741), under conditions similar to those described in Sample 3, is found (see Table 14, p. 59 and Table 16, p. 60) by subtracting the 1978 discount factor (1.829) from the 1978-2003 discount factor (12.570).

APPENDIX 3

CALCULATION OF FERRY COSTS

A. Ferry Type

The ferry to be operated by the Provincial Government, under the supervision of the Manitoba Department of Renewable Resources and Transportation Services (Marine Transportation and Construction Division), has the following general description and specifications:

General Description

Designer - Robert Allan Ltd. (Naval Architects; Vancouver)
Gross Weight - 300,000 lbs.(150T)
Design Speed - 6-8 knots
Drive - two outboard propulsion-steering units (hydralic with right-angle drive) having approximately 125 BHP @ 1800RPM
Ramps - hydraulic at both ends
Crew - 1 captain
- 1 mate
- 2 deckhands

Ancillary Facilities - pilot house; passenger deck house; crews' quarters (minimal)
Storage Tanks - 1 sewage (500 Imp. gals.)
- 2 oil fuel (750 Imp. gals.)
- 1 fresh water (500 Imp. gals.)
- miscellaneous oils (40 Imp. gals.)

Principal Dimensions

Lenght Overall	112' - 0"
Lenght Waterline	100' - 0"
Breadth, Moulded	34' - 0"
Breadth, Over Sponsons	42' - 0"
Depth, Moulded	7' - 0"
Maximum Draught (hull)	3' - 6"

Carrying Capacities

Complement (passengers and crew)	100 persons
Load	180,000 lbs. or 16 cars or two high loads @ GVW 94,000 lbs.

Lifesaving Equipment

- 1-14 person Class 2 lifeboat (150 cu. ft.)
- 2-16 person inflatable rafts
- 4 liferings, 2 with heaving lines
- 100 lifejackets (10 for children)

Classifications

Canadian Coast Guard - Minor Waters II
Lifesaving Equipment Class VI
Firefighting Equipment Class B

B. Ferry Costs: The Existing System

Data obtained fron the Canadian Surface Transportation Administration's report, "Cost Trade-Off Between Vehicle and Way Facility" (1974), has been used, except where noted, as a guide in identifying and determining ferry costs for a one year operating period, 1977. Included among the relevant costs are the following:

1. Operator Salaries

Crew	Wage Rate/Mon.[a] ($)	Annual Work Period	Salary/Year ($)
Captain	1,400	6 months	8,400
Mate	1,100	6 months	6,600
Deckhands(2)	900 x 2	6 months x 2	10,800
Total Annual Salary Costs			$25,800

[a] Estimated by Dept. of Renewable Resources and Transportation Services (Sept./77).

2. Fuel Costs

Calculation of the 1977 ferry fuel cost is based upon an assumed operating period of six months (May through October) during which the ferry makes two scheduled runs per day for five days a week. The fuel consumption of the engines is taken to be 8 Imp. gallons per operating hour for each engine with allowances for expected idling time. The cost of fuel is found using the following formula:

$$\text{Fuel Cost/Yr. (1977\$)} = \frac{dFpT}{s} = \underline{\underline{\$14,666}}$$

where,

d = round trip distance = 24 miles
F = fuel consumption (2 engines) = 16 Imp. gals./hr.
p = fuel price = 0.868 \$/Imp. gal.[1]
T = number of round trips per year = 264
s = travel speed = 6 mph.

3. Maintenance Costs

Estimated maintenance costs are based on several factors for a six month operating year:

(a) Minor maintenance, including cleaning, painting, and the repair of dents and deck, will be necessary. The crew is assumed responsible for such maintenance. The cost of supplies (paint, tools, etc.) will be approximately $2,000 per year.

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[1] This fuel price is composed of: The Winnipeg wholesale price for drum diesel fuel 0.771 $/gal. (Shell Canada rate effective September 1977) and the cost of shipping 0.097 $/gal. (Winnipeg to Jenpeg @ the tariff rate for 45,000 lbs./load $1.15/cwt and a fuel weight of 8.4 lbs./gal.).

(b) The hydralic ramps will require preventive maintenance as well as some unscheduled maintenance. The crew will be responsible for most of this work. The cost to maintain both ramps will average $550 per month or $3,300 per operating year.

(c) The cost of maintenance to the engines and drive equipment will include the cost of parts, equipment and the labor of a mechanic. This cost will average $1,500 per month or $9,000 over the year.

(d) During the off season, the ferry will undergo a complete overhaul in dry dock. This work will be done by a staff maintenance mechanic. The cost including parts, equipment and the probable need to ship the propellers out for major repair, is estimated at $3,500. This figure includes the approximate cost of transporting the ferry to and from the docking site.

(e) Total maintenance cost = $17,800 per year (1977$).

4. Administration Costs

The captain and the mate will handle all of the administrative duties throughout the year. The only additional administrative cost will result from the need for winter docking facilities, minimal office space, and supplies. The yearly cost of such requirements is estimated at $8,000 per year.

5. Insurance Costs

At a rate of 1.5% per year of the capital cost of the ferry and its equipment, the insurance cost will be $7,290 in 1977. The capital cost used in this calculation is $486,000 where some $460,000 is attributed to the construction cost of the ferry and $26,000 is the estimated cost of the engines and their installation.[1]

6. Maintenance Costs for the Ferry Approaches

Monthly maintenance of the two ramps will be necessitated by the seasonal changes in water level. In addition, the approaches to the ramps must be kept servicable. Including the cost of equipment, material and labor this cost will average $900 per month making the annual cost $5,400.

7. SUMMARY: Ferry costs for the existing system.[2]

Cost Type	Annual Cost (1977$)
Operator Salaries	25,800
Fuel Costs	14,666
Maintenance	17,800
Administration	8,000
Insurance	7,290
Dock Maintenance	5,400
Total Cost	$78,956

1 These capital costs have been obtained from the ferry's contractor (Purvis Navcon: Selkirk,Manitoba) and the engine supplier (Detroit Diesel: Winnipeg, Manitoba).

2 Miscellaneous costs, such as those for operating licences and inspections, are assumed to be included with the capital costs of the ferry. Capital costs are considered sunk costs in the analysis.

APPENDIX 4

ALL-WEATHER ROADS :

DESIGN STANDARD AND TERRAIN DESCRIPTIONS

A. Design Standard

The all-weather road cost estimates used in the present analysis are based upon the No. 9 Provincial Road Design Standard, as defined by the Manitoba Department of Highways.

TABLE 24

HIGHWAY DESIGN STANDARD NUMBER 9

Highways Design Standard[a]		9	
Estimated 20-Year A.A.D.T.[b]		under 100	
Number of Lanes		two lane	
Terrain		flat	other
Design Speed (mph.)		50	50
Curvature (maximum degree)		6	9
Gradient (maximum percent)		5	8
Stopping Sight Distance (ft.)		475	350
Passing Sight Distance (ft.)[c]		2,000	1,700
Surface Type		gravel	
Lane Width (ft.)		N.A.	N.A.
Shoulder Width (ft.)		N.A.	N.A.
Roadbed Width (ft.)		24	24
Right-of-way (ft.)		130	130
Structures	Clear Width (ft.)		
	- under 99' long	24	24
	- over 99' long	24	24
	Loading	H20 - S16 - 44	
	Vertical Clearance	16	16

[a] In general, these standards are a minimum, to be bettered when feasible, but to be lowered when heavy economic penalty results.

[b] Annual Average Daily Traffic volume attributable to this road design.

[c] Passing sight distance should be on a minimum 20% of any one mile, and a minimum of 50% in any ten miles.

B. Terrain Descriptions

1. Option 2: The Partial All-weather Road/Ferry System.

The all-weather road route proposed in this transportation system, commences at the southern tip of Cross Lake near the existing ferry dock and all-weather highway terminus. Cost estimates in the study have been determined by the Operations Division of the Manitoba Department of Highways according to the following mile-by-mile terrain description of the route:

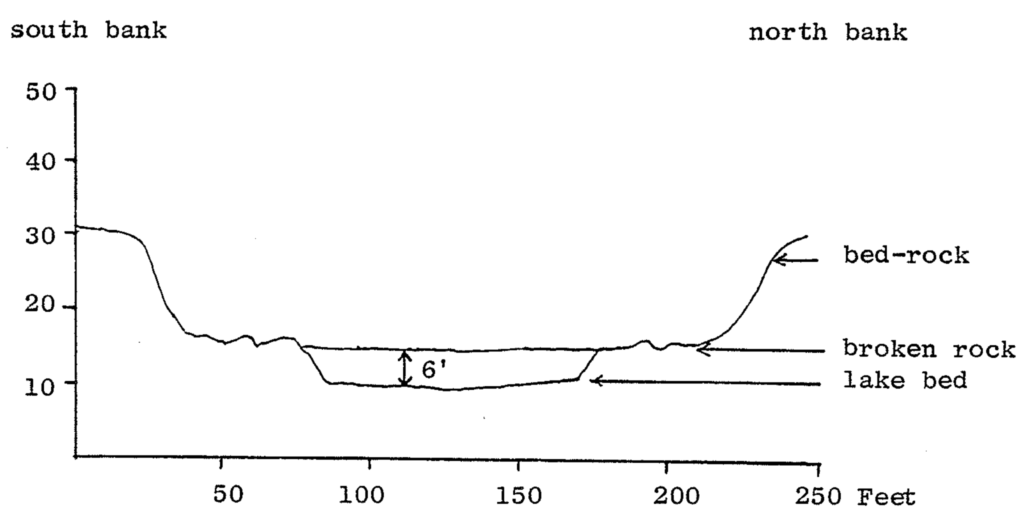
Miles	Terrain Description
0 - 2	An abundance of borrow is available in this area of predominantly fine sand. With the exception of a one-thousand foot low wet area, the excavation yardage is expected to be fairly light along this section.
2 - 7	Muskeg and discontinuous rock outcrops ten to fifteen feet high characterize this area. Shallow borrow sites will likely be available. Soil material is wet, sandy silt.
7 - 11	Terrain in this area consists of a silty clay with occassional low rock outcrops. A crossing will be required across a shallow bay with land fills in the nature of ten to fifteen feet for a distance of approximately four hundred feet. An open waterway will be required for drainage purposes and culverts

should meet the needs. The sides and bottom of this bay appear to be bed-rock.

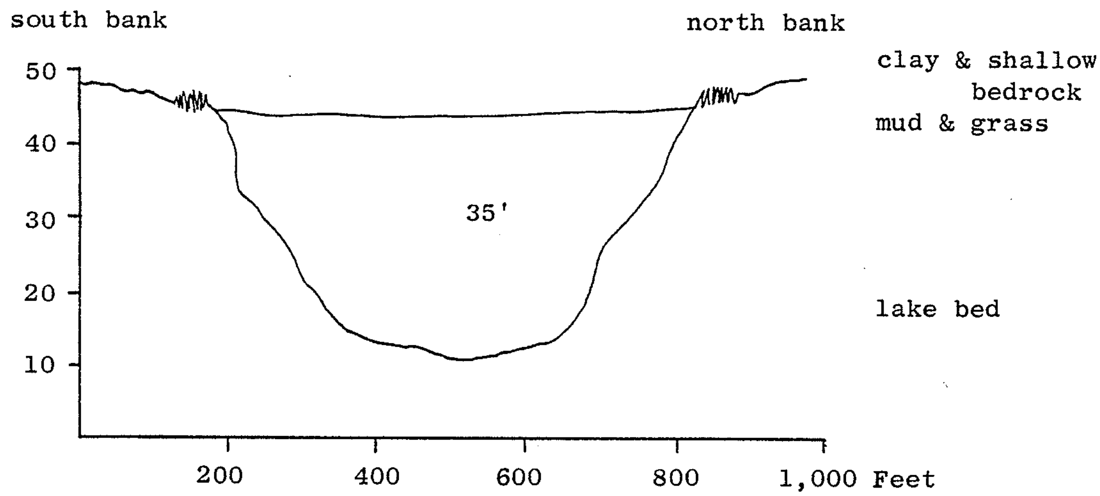
2. Option 3: The Complete All-weather Road System.

The first nine miles of this proposed road are routed along the same pathway as that described for the partial all-weather road/ferry system. The remaining portion of the 20.5 mile road is described below:

Miles	Terrain Description
0 - 9	As above.
9 - 11	Two major causeway and bridge crossings are required in this section of the route at the west end of Pipestone Lake. These are illustrated in the following diagrams:



Crossing # 1



Crossing #2

Borrow material could easily be obtained and good growths of Black Spruce and Poplar are available.

11 - 16.5 A number of creeks run through this section into Cross Lake. Culverts will suffice for these waterways. The area is comprised of a clay soil with a heavy growth of Black Spruce and Poplar.

16.5 - 17.5 A sand and gravel deposit extends along this section and approximately one mile northeast beyond the road location. Ample borrow is therefore available in addition to the solid road foundation.

17.5 - 20.5 This area is predominately clay silt. Some road work has been done on the section and a partly roughed-in road for winter truck traffic is in existence. There is an approximate fifteen foot top width with no gravel.

C. Ferry Costs: The Partial All-weather Road/Ferry System

The same types of costs as those seen for the existing ferry will apply to the ferry operating as part of the all-weather road/ferry system. Indeed, the magnitude of the costs are expected to be the same, except for the fuel costs, since the same ferry (type) will be used; only the operating schedule and the route length will change.

Assuming that the ferry will operate on a schedule which maximizes the number of trips to the community, it can be shown that the new system, because of the shorter travelling distance, will permit three round trips per day as opposed to the two trips being made by the existing ferry. In terms of fuel costs, the shorter route will offset the costs of increasing the frequency of service.

Fuel costs are calculated in a manner similar to that seen for the existing ferry:

$$\text{Fuel Cost/Yr. (1977\$)} = \frac{dFpT}{s} = \underline{\underline{\$9,166}}$$

where,

d = round trip distance = 10 miles
F = fuel consumption (2 engines) = 16 Imp. gals./hr.
p = fuel price = 0.868 $/Imp.gal.
T = number of round trips per year = 396
s = travel speed = 6 mph.

The resulting total annual operating and maintenance cost for the ferry in the alternative transport system is, therefore, $73,456 in 1977 dollars.

APPENDIX 5

1977 BASE-YEAR AIR-FREIGHT VOLUMES

The 1974-75 ans 1975-76 community airstrip 'Acivity Summaries' of the Manitoba Department of Northern Affairs have been used to determine the 1975 calendar year air freight volume for the existing transportation system at Cross Lake.[1] The 1977 estimate was obtained by applying the 3.6% annual growth rate to the 1975 figure.

The 1974-75 Activity Summary indicated a total air freight volume of 896,000 pounds delivered to Cross Lake. Since monthly volumes were not available for this fiscal year, the known number of scheduled and charter flights (per month) were used to derive monthly cargo estimates. The following formula was employed in the calculation:

$$\text{Monthly Cargo} = \frac{\text{number of scheduled \& charter flights/month}}{\text{total no. of scheduled \& charter flights/yr.}} \times \text{Total cargo/yr.}$$

Inherent in this formula are the assumptions that:

1. only scheduled and charter flights carried cargo into the community.
2. private, military and government wheeled planes and seaplanes did not carry significant cargos.
3. both scheduled and charter flights carried constant loads throughout the 1974-75 fiscal year.
4. the ratio of scheduled to charter flights was approximately constant per month.

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[1] 1975 was chosen as the base year for extrapolation of freight volumes because it was found to be the most recent year for which reliable data could be obtained.

From the derived monthly freight information, the January to March data for 1975 was made available.

In the 1975-76 Activity Summary, cargo volumes were recorded for all but the months of April, May and June of 1975. For these months a similar formula as that just presented was used to calculate the remaining information required to estimate the 1975 calendar year freight volume for Cross Lake. The resultant freight volumes, by month, are shown in the following table. Note, that passenger numbers which are included here as well were accurately recorded on a monthly basis in the Activity Summaries.

TABLE 25

1975 & 1977 AIR FREIGHT ESTIMATES
(000 pounds)

Month	Freight Volume	Passengers
January (1975)	59.0	615
February	62.2	614
March	44.4	602
April	95.0	1,110
May	70.4	922
June	59.0	798
July	59.2	964
August	91.2	1,084
September	58.6	643
October	100.0	758
November	197.4	1,150
December	130.2	837
TOTALS - 1975	1,026.6	10,097
1977	1,101.8[a]	11,560[b]

[a] 3.6% annual growth rate applied to 1975 figure.

[b] 7.0% annual growth rate applied (Davidson 1976:20).

APPENDIX 6

FREIGHT RATE CALCULATIONS

A. Charter Air-Freight Rates

The calculation of charter air-freight rates is, in general, dependent upon variables such as: the type of air carrier chosen (which determines payload capacity, rate of fuel consumption and fuel requirements for required landings and take-offs); the distances to destinations and emergency landing strips (which dictate fuel supply and hence the magnitude of the payload); published tariff rates (which is a flat charge per mile travelled); and, the cost of fuel purchased on route.

In the simplest cases, the charge for air-freight delivery is equivalent to the appropriate tariff rate times the round-trip distance. In such cases, the plane carries enough fuel to allow for travel to and from the destination point, as well as that required for an emergency landing at the nearest alternate airstrip. The payload of the carrier is governed by its inverse relationship with the quantity of fuel carried. Hence, a longer round-trip distance means more fuel and less cargo can be transported than on a shorter round-trip distance.

In certain situations, because of the tradeoff between payload size and distance, it may be more economical to have the carrier refuel en route than to attempt the entire run on one load of fuel. Such is the case for charter flights travelling between Winnipeg and Cross Lake. By doing cost comparisons, it can be shown that the most economical way to transport goods into Cross Lake is to adjust the payload according to the fuel load required to go from Winnipeg to Cross Lake and then on to nearby Norway House where refuelling is possible. This procedure maximizes the payload size and reduces the per pound freight rate so that the reduction easily offsets the additional costs of an extra take-off and landing and the more expensive northern fuel.

The following sequence of calculations has been used to determine the DC-3 air charter freight rate for goods being carried from Winnipeg to Cross Lake. The symbols used in the calculations are defined in the accompanying table.

Symbol	Definition	Value[a]
d_1	distance - origin to cargo destination (Winnipeg to Cross Lake)	284 n.miles
d_2	distance - destination to refuelling station (Cross Lake to Norway House)	39 n.miles
d_3	distance - refuelling point to origin (Norway House to Winnipeg)	246 n.miles
c	DC-3 average fuel consumption	540 lbs./hr.
s	DC-3 average air speed	145 knots
L	landing allowance for DC-3 (fuel)	200 lbs.
T	takeoff and taxi allowance for DC-3	140 lbs.
R	emergency reserve allowance for DC-3	400 lbs.
MXW	maximum carrier weight - DC-3	27,000 lbs.
w	approximate tare weight of DC-3	18,000 lbs.
p	price differential per gallon of fuel at refuelling point versus origin	0.15 $/gal.
D	weight of fuel per gallon (aviation fuel)	7.2 lb./gal.
t	published flat rate tariff (St. Andrews Airways Ltd.July 1977)	$2.25 /statue mile $2.59 /naut. mile

[a] Sources of Values: mileages - Manitoba Dept. of Northern Affairs "Flight Information Map" (1974); DC-3 data - Gov't of Canada Dept. of Transport Air Transportation Administration; tariff rate - St. Andrews Airways Ltd. July 1977.

1. Fuel Load Calculation

$$\text{Fuel Load} = F = (d_1 + d_2)\frac{c}{s} + 2(L + T) + R$$

$$= \text{approximately } 2{,}300 \text{ lbs.}$$

2. Payload Calculation

$$\text{Payload} = P = MXW - (w + F)$$

$$= 6{,}700 \text{ lbs.}$$

3. Excess Fuel Cost Calculation (additional cost to refuel at Norway House)

$$\text{Excess Cost} = Cx = \frac{d_3 cp}{sD}$$

$$= \$19$$

4. Charter Air-Freight Rate

$$\text{Charter Rate} = \frac{t\,(d1 + d_2 + d_3)}{P} + Cx$$

$$= 0.2224 \text{ \$/lb.}$$

B. Ferry/Road Freight Rates

1. The Existing System (Option 1)

(a) The cost of carrying goods from Winnipeg to the ferry dock at Whiskey Jack is dependent upon the 463 mile distance and the average size of the truck's load. Assuming a 45,000 lb. load on each truck, a freight rate of 0.0127 \$/pound (Manitoba Trucking Association - Sept. 1977) is applicable to this portion of the trip.

(b) Assuming a one-way ferry fee of $25, each truck must pay $50 to go to and from Cross Lake by ferry. At 45,000 pounds per truck, this fee, when passed on to the client as part of the freight rate is equivalent to $0.0011 per pound.

(c) Assuming the ferry travels its 12 mile route at an average speed of 6 mph, the trip would take 2 hours. In an equivalent time, a truck could travel 100 miles at an average road speed of 50 mph. This means that, as an approximation, a truck driving to the ferry dock and then proceeding to Cross Lake by ferry could, in terms of time spent, have travelled some 563 miles (463 plus 100 miles).

The trucker's tariff equivalent to a 563 mile trip with a 45,000 pound load is $0.0159 per pound. Reducing the difference between this tariff and the tariff representing the trip from Winnipeg to the dock ($0.0127/lb.) by 15% (which is the estimated allowance for a truck's unused gas while sitting on the ferry) yields a rate [($0.0159 - 0.0127) x 85% = $0.0027] approximating the value of a trucker's time per pound of freight while on the ferry.

(d) From the foregoing descriptions, the ferry/road freight rate for <u>regular</u> freight is found to be ($0.0127 plus $0.0011 plus $0.0027 equal to) <u>$0.0165 per pound</u>.

(e) The special freight rate is 10% greater than the regular rate or <u>$0.0182 per pound</u>.

2. The Partial All-weather Road/Ferry System (Option 2)

Freight rate calculations for this system are similar to those described for the existing transport system.

(a) The published trucker's tariff for a 45,000 pound load being transported from Winnipeg to the new ferry dock at Pipestone Lake (474 miles) is $0.0130 per pound (Manitoba Trucking Association - Sept. 1977).

(b) A one-way ferry fee of $25 per truck, translates into a unit cost of $0.0011 per pound of freight for a 45,000 pound truck load on the round trip.

(c) Assuming an average ferry speed of 6 mph, each truck would spend 5/6 hours making the 5 mile ferry crossing. For a trucker, this time is equivalent to a distance of 41.7 miles when travelling at an average 50 mph. This means that, as an approximation, a truck driving to the ferry dock and then proceeding to Cross Lake by ferry could, in terms of time spent, have travelled about 516 miles (474 plus 41.7 miles). The tariff rate for such a trip is $0.0146 per pound. Reducing the difference between this tariff and the Winnipeg-to-dock tariff ($0.0130/lb.) by 15% as an unused gas allowance yields a rate (0.0146 - 0.0130) x 85% = $0.0014/lb. approximating the value of a trucker's time per pound of freight while on the ferry.

(d) Ferry/road regular freight rate is, therefore, $0.0144 per pound (ie. $0.0.0130 + $0.0011 + $0.0014).

(e) The ferry/road special freight rate is 10% greater than the regular freight rate or $0.0171 per pound.

C. Winter Road Freight Rates

Winter road freight rate calculations are similar to those seen for the ferry/road systems except for three factors: (1) there is no equivalent to a ferry fee; (2) the unused gas allowance is not deducted from the rate because gas is, in fact, used while trucks cross on a winter road; and, (3) a traditional danger pay allowance for drivers is accomodated by the doubling of the wages earned during the time required to travel the winter road.

1. The Existing System (Option 1)

(a) The published tariff rate for goods being trucked the 463 miles from Winnipeg to the start of the winter road is $0.0127 per pound for 45,000 pound loads.

(b) Trucks are assumed to travel at an average 8 mph on winter roads. Because of this abnormally slow pace, relative to highway travel, excess time is spent on winter roads that is not allowed for in the calculation of published tariffs. Therefore, in this report, a value is estimated using the trucker's time as a base rather than the actual distance travelled.

At 8 mph, the 12 mile route is covered in 1.5 hours. Normally, a truck travelling at 50 mph could go 75 miles in this time. Consequently, the Winnipeg-Cross Lake is equivalent to a 538 mile journey (463 plus 75 miles). With a 45,000 pound load, this distance warrants a tariff of $0.0151 per pound of which $0.0024/lb. (ie. $0.0151 - 0.0127) is attributable to winter road travel.

(c) Drivers travelling on winter roads are customarily granted increased wages because of the added responsibility and hazard associated with their task. In the present calculation, this factor is allowed for by a doubling of the current hourly wage ($7/hour) during the winter road travelling time. That is, where 1.5 hours are required to traverse the winter road, an additional cost of $10.50 per 45,000 pound truck load or $0.0005 per pound is incurred.

(d) From the above information the regular winter road freight rate is found to be $0.0156 per pound (ie. $0.0127 + $0.0024 + $0.0005).

(e) The special winter road freight rate, being 10% greater than the regular rate is, therefore, $0.0172 per pound.

2. The Partial All-weather Road/Ferry/Winter Road System (Option 2)

The winter road freight rates associated with this system are calculated as they were for the existing transport system.

At 8 mph, the 5 mile road is travelled in 0.625 hours which is equivalent to 31.25 miles by truck at 50 mph. The total Winnipeg -Cross Lake trip is, therefore, equal to about 505 miles (ie. 474 plus 31.25 miles). This distance warrants a tariff of $0.0144 per pound of which \$0.0130/lb. is attributable to the highway portion of the journey and the remainder to the winter road portion. The driver's allowance at \$7/hour for 0.625 hours amounts to about \$0.0002/lb. assuming a 45,000 truck load. Hence, the regular freight rate estimated for this transport option is \$0.0146 per pound (ie. \$0.0144 + \$0.0002). Increasing this rate by 10% yields the special freight rate of \$0.0161/lb.

APPENDIX 7

ANALYSIS OF ALL-WEATHER ROAD SYSTEM SENSITIVITY TO DIVERSION OF AIR FREIGHT

A. Introduction

Chapter IV presents the calculation of freight volumes and user costs associated with the three major investment alternatives for the study period 1978 to 2003. In the case of the All-weather Road System (Option 3), 27% of the air freight accommodated by the Existing System is expected to be the minimum amount to be diverted to the less expensive road transport mode.[1] Furthermore, it is suggested that up to 99% of the air freight might possibly be diverted.[2]

Because there is such a vast difference between the minimum and "possible" levels of air freight diverted, and because of the uncertainty as to what the "actual" level of diversion will be, the following sensitivity analysis is seen to provide decision-makers with an important guide when the final investment choice is to be made.

Throughout the analysis presented in the text, a 27% level of air freight diversion has been used when calculating All-weather Road System results. In the sensitivity analysis, 0%, 50%, 80% and 100% levels of air freight diversion are used in similar calculations to yield a range of results which depict Option 3's sensitivity to air freight diversion.

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1 Chapter IV p.51.

2 See reference: MPS Associates Ltd. and Trimac Consulting Services Ltd. 1974. Cost Trade-Off Between Vehicle and Way Facility (Volume II, pp. 11-15).

B. The Sensitivity Analysis

Table 26 illustrates the calculation of 1977 (base year) user costs associated with the transport of air freight given the variety of diversion levels chosen. Note that with 0% air freight diverted the user cost is the same as that calculated for the Existing transportation system.

When air freight user costs are combined with 1977 base year road freight user costs, as shown in Table 27, the resultant total fright cost provides the base year figure from which cumulative freight costs are derived for the 1978-2003 study period. Cumulative freight costs, or user costs, have been determined using the discount factors and method reported in Chapter IV (pp.58-64). These costs are recorded in Table 28 along with the corresponding infrastructure costs and total costs for each alternative.

By deducting user costs associated with the existing transportation system from those of the all-weather road system (and each of its variations depending upon the amount of air freight diverted) the user cost savings due to the choice of one system over the other are found. In this sensitivity analysis, Table 29 lists user cost savings calculated as in Chapter IV (p. 58).

Table 29 also provides a summary of relationships between benefits and costs for the all-weather road system alternatives. Total benefits are represented by user cost savings. Total costs are represented by project infrastructure costs as determined in Chapter III (p. 43). Net Present Values are computed for all options according to their characteristic discount rate and level of air freight diverted. These NPV figures illustrate the increasing attractiveness of the all-weather road option as the discount rate declines or the percentage of air freight diverted increases.

TABLE 26

CALCULATION OF 1977 ALL-WEATHER ROAD AIR FREIGHT USER COSTS[a]

% Air Freight Diverted	A/W Road System Air Freight (000lbs.)			1977 Air Freight Cost (000$ 1977)		
	Total	Scheduled (11%)	Charter (89%)	Scheduled	Charter	Total
0	1,101.8[b]	121.2	980.6	27.9[c]	218.1[d]	246.0
27	804.1	88.5	715.6	20.4	159.2	179.6
50	550.9	60.6	490.3	13.9	109.0	122.9
80	220.4	24.2	196.2	5.6	43.6	49.2
100	-	-	-	-	-	-

[a] User costs related to air freight transport for Option 3.
[b] Estimate of 1977 air freight transported via the Existing transportation system (see Chapter IV p.49).
[c] Scheduled air freight rate in 1977: 0.23 $/lb. (p.54).
[d] Charter air freight rate in 1977: 0.2224 $/lb. (p.54).

TABLE 27

CALCULATION OF 1977 TOTAL (ROAD & AIR) FREIGHT COSTS
ALL-WEATHER ROAD OPTION 3

% Air Freight Diverted	Air Freight Diverted (000 lbs)	Total Road Freight (000 lbs)	Road Freight Cost[b] (000 1977$)	Air Freight Cost[c] (000 1977$)	Total (User) Freight Cost[d] (000 1977$)
0	-	6,328.8[a]	89.7	246.0	335.7
27	297.7	6,626.5	94.0	179.6	273.6
50	550.9	6,879.7	97.6	122.9	220.5
80	881.4	7,210.2	102.2	49.2	151.4
100	1,101.8	7,430.6	105.4	-	105.4

[a] 1977 Base year road freight without a contribution from diverted air freight (calculated in Chapter IV, p.53).

[b] Road freight is a mixture of regular freight (80%) and special freight (20%) . Each freight type has its own freight rate which combines according to percentage contribution to yield an overall road freight rate ie. 80% of 0.0139 $/lb. plus 20% of 0.0153 $/lb. yields the rate applied above 0.01418 $/lb. (see p. 57).

[c] Calculated on foregoing Table.

[d] Summation of Road and Air Freight User Costs.

TABLE 28

SENSITIVITY OF ALL-WEATHER ROAD SYSTEM COSTS TO % OF AIR FREIGHT (EXISTING SYSTEM) DIVERTED TO ROAD TRANSPORT (000 1977$)

Cost Type	% Rate of Discount	% of Existing System's Air Freight Diverted to All-weather Road Travel (of Option 3) 0%	27%[a]	50%	80%	100%
Infrastructure Costs[b]	0	3,730.1	3,730.1	3,730.1	3,730.1	3,730.1
	8	3,159.2	3,159.2	3,159.2	3,159.2	3,159.2
	10	3,055.5	3,055.5	3,055.5	3,055.5	3,055.5
	12	2,961.6	2,961.6	2,961.6	2,961.6	2,961.6
User Costs[c]	0	13,752.9	11,344.4	9,285.0	6,605.0	4,820.9
	8	5,132.3	4,303.7	3,595.2	2,673.2	2,041.5
	10	4,241.6	3,574.5	3,004.2	2,262.0	1,767.9
	12	3,571.9	3,025.6	2,356.1	1,950.6	1,545.9
Total Cost	0	17,483.0	15,074.5	13,015.1	10,335.1	8,551.0
	8	8,291.5	7,462.9	6,754.4	5,832.4	5,200.7
	10	7,297.1	6,630.0	6,059.7	5,317.5	4,823.4
	12	6,533.5	5,987.2	5,317.7	4,912.2	4,507.5

[a] All-weather Road System costs at the 27% air freight diversion level are calculated in the main text of the analysis.

[b] Infrastructure costs are calculated in Chapter III. The costs do not vary with % Air Freight diverted.

[c] User costs are calculated as in Chapter IV.

TABLE 29

BENEFIT-COST SUMMARY FOR ALL-WEATHER ROAD SYSTEM ILLUSTRATING EFFECTS OF % AIR FREIGHT DIVERTED TO ROAD TRANSPORT (000 1977$)

Cost or Benefit	% Rate of Discount	All-weather Road System: % air freight diverted			
		0%	50%	80%	100%
User Cost Savings[a]	0	461.5	4,929.4	7,609.4	9,393.5
	8	158.9	1,696.0	2,618.0	3,249.7
	10	127.7	1,365.1	2,107.3	2,601.4
	12	104.7	1,320.5	1,726.0	2,130.7
Infrastructure Costs[b]	0	3,730.1	3,730.1	3,730.1	3,730.1
	8	3,159.2	3,159.2	3,159.2	3,159.2
	10	3,055.5	3,055.5	3,055.5	3,055.5
	12	2,961.6	2,961.6	2,961.6	2,961.6
Net Infrastructure Costs[c]	0	937.6	937.6	937.6	937.6
	8	1,966.8	1,966.8	1,966.8	1,966.8
	10	2,041.6	2,041.6	2,041.6	2,041.6
	12	2,085.5	2,085.5	2,085.5	2,085.5
Net Present Value[d]	0	(3,268.6)	1,199.3	3,879.3	5,663.4
	8	(3,000.3)	(1,463.2)	(541.2)	90.5
	10	(2,927.8)	(1,690.4)	(948.2)	(454.1)
	12	(2,856.9)	(1,641.1)	(1,235.6)	(830.9)
Benefit/Cost Ratio[e]	0	0.49	5.26	8.12	10.02
	8	0.08	0.86	1.33	1.65
	10	0.06	0.66	1.03	1.27
	12	0.05	0.63	0.83	1.02

[a] Calculated as in Chapter IV.
[b] Calculated as in Chapter III.
[c] Road System infrastructure costs less Existing System infrastructure costs ie. 0%-2,792.5; 8%-1,192.4; 10%-1,013.9; 12%-876.1 (see Chapter III).
[d] User Cost Savings less Infrastructure Costs for each investment choice.
[e] User Cost Savings divided by Net Infrastructure Costs.

Finally, Table 29 shows the ratio of user cost savings to net infrastructure costs. These benefit/cost ratios relate the attractiveness of the All-weather Road System compared to the Existing System.

C. Summary

As seen from the information in Table 28, a dramatic reduction in total project cost is witnessed as the percentage of air freight diverted increases. When compared to the cost of the Existing System, certain of the all-weather road alternatives are preferred because they are of lower cost.[1] For example, under all discount rate conditions the alternative which assumes 100% air freight diversion is the least-cost investment choice. If the discount rate is 10% or less, the 80% level of diversion gives the investment advantage to the all-weather road system. If the level of air freight diversion drops below about 60%, the discount rate must be less than 8% in order to favour the all-weather road system.

When scrutinizing the net present values for each alternative, the same type of relationships are observed between the Existing System and the All-weather Road system as have been discussed in reference to total project costs. The advantage of deriving the net present value is that the dollar value of an alternative's benefit/cost discrepancy is readily isolated. Such a dollar value is an additional determinant which is of use to the decision-maker when weighing unquantifiable factors.and

The benefit-cost ratios shown in Table 29 provide an immediate

[1] Figure 4, Chapter V, p.77, illustrates the cost relationships discussed here.

indication of the degree of acceptability attached to each alternative. They do not provide information about the numerical difference between costs and benefits, as do the net present values, other than their ratio.