CRITERIA FOR RIVER CROSSING LOCATIONS:
A CASE STUDY APPROACH

by

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ABSTRACT

A comprehensive examination of the process of determining locations for river crossings constitutes the basic subject of this thesis. This process is highly complex and involves a variety of interrelated governmental and technical problems. The various financial and administrative responsibilities of the three levels of Canadian government provide a complicated operational framework within which river crossings and other transportation facilities are located and constructed. Similarly, inter-related locational criteria, such as land use and transportation needs and engineering requirements, pose formidable problems for the design and location of transportation facilities. In order that these inter-related problems are coped with effectively, it is proposed:

That in Canada, the Provincial Government should use a comprehensive planning approach, within a framework of intergovernmental participation, to determine the location of river crossings within the Provincial highway system.

The investigation is limited in scope to an analysis of river crossings that are the constitutional responsibility of the Provincial Governments in Canada. Reference is made to the financing and administration of transportation facilities in British Columbia for purposes of illustration. The administration and financing of highways is discussed in some detail since highways form the physical and functional framework for the planning of river crossings. The term "river crossing" is defined as a bridge or tunnel structure crossing any water barrier.

An examination is made of the three levels of governmental
responsibilities respecting transportation planning and of the need for inter-governmental participation during the process of determining river crossing locations. The examination includes a discussion of the relationship between the role of "executive authority" and the various financial and administrative responsibilities of the Federal, Provincial and Municipal Governments. It is concluded that because of its constitutional responsibilities respecting land use planning and highways, and its dominant financial role in the provision of highway facilities, the Provincial Government should act as the executive authority in the process of determining locations for Provincial river crossings. Regardless, however, of the financial arrangements between levels of government, there should be inter-governmental administrative participation during the process of locating river crossings. In particular, Municipalities having been delegated the responsibility for community planning should be given the opportunity to integrate proposed highway and river crossing facilities with local land use and transportation plans.

It is suggested that a comprehensive planning approach provides for the consideration of all major governmental and technical factors pertinent to the location selection process. It is assumed that the transportation planning process for determining the design and location of overall transportation systems is basic to the comprehensive planning approach.

An examination of the locational criteria related to river crossings confirms the need to consider all significant factors when
determining locations for river crossings. A framework for location selection is developed in order to implement the comprehensive planning approach and to apply effectively the locational criteria to location selection problems.

A case study investigation tests the validity of the hypothesis and the effectiveness of the framework for location selection. The case study concerns the process of determining a location for a Fraser River crossing in the Metropolitan Vancouver, B.C. area nine years ago. The decision to locate a tunnel crossing at Deas Island is evaluated in retrospect through the application of the location selection framework to the overall Fraser River crossing problem.

From the case study analysis, it is concluded that the hypothesis proposed in this thesis is basically valid. The Provincial Government, because of its constitutional and financial responsibilities, should act as the executive authority in determining river crossing locations within the Provincial highway system. Inter-governmental participation, especially administrative, is essential to the integration of Federal, Provincial and Municipal transportation and land use functions. The use of the comprehensive planning approach and its related framework for location selection facilitates the consideration of all significant factors pertinent to the determination of river crossing locations. However, the comprehensive planning approach should be so defined as to include broad transportation and land use policies which would serve as basic guidelines in the process of determining river crossing locations.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>ACKNOWLEDGMENTS</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>v</td>
</tr>
</tbody>
</table>

**CHAPTER**

**I. DETERMINING RIVER CROSSING LOCATIONS: A COMPLEX PLANNING PROCESS**

| The Significance of River Crossings and Their Location Selection | 1 |
| Objectives of the Investigation                                | 6 |
| Scope and Organization of the Study                           | 8 |

**II. GOVERNMENTAL RESPONSIBILITIES FOR TRANSPORTATION**

| Introduction | 14 |
| Federal Level | 15 |
| Provincial Level | 22 |
| Municipal Level | 27 |
| Inter-governmental Participation versus Executive Authority | 30 |
| The Comprehensive Planning Approach                          | 35 |
| Summary                                                   | 37 |

**III. CRITERIA FOR DETERMINING THE LOCATION OF RIVER CROSSINGS**

| Introduction | 40 |
| Planning Criteria | 41 |
| Engineering Criteria | 49 |
| Economic Criteria | 54 |
CHAPTER PAGE

Administrative and Political Criteria .......................... 59
Summary .......................................................... 61

IV. THE APPLICATION OF CRITERIA TO DETERMINE RIVER CROSSING LOCATIONS .............................. 67
Introduction ....................................................... 67
Methods of Location Evaluation ............................... 67
Framework for the Selection of River Crossing Locations .......................... 72
Summary .......................................................... 77

V. CASE STUDY: THE DEAS ISLAND TUNNEL CROSSING ...................................................... 79
Introduction ....................................................... 79
Background to the Study ......................................... 80
Map Showing Alternative Fraser River Crossings, 1955-56 ...................................................... 84
Selection of the River Crossing Location ....................... 85
Location Selection in Retrospect ................................ 104

VI. DETERMINING RIVER CROSSING LOCATIONS: A PLANNING CHALLENGE ................................. 110
The Investigation in Review: Observations and Conclusions ...................................................... 110
Evaluation of the Investigation: Limitations and Criticisms ...................................................... 118

BIBLIOGRAPHY ......................................................... 122
CHAPTER I

DETERMINING RIVER CROSSING LOCATIONS:
A COMPLEX PLANNING PROCESS

I. The Significance of River Crossings and Their Location Selection

Man has always desired to be mobile in order to expand his horizons and to communicate with his fellow-men. Throughout history, the technology of transportation has steadily progressed until today man is able to move with ease through air and across water as well as on land. However, man has been and always will be essentially a land-based animal, dependent for movement primarily upon various modes of land transportation. Consequently, the highway and railroad have been the channels along which man has moved, in wagons, carriages, automobiles, busses and trains. But these rail and vehicular channels themselves are dependent upon another form of transportation facility for their continuity and expansion - the river crossing.

Although they have served man as essential channels of communication and transportation, streams, rivers and water in general have also been obstacles in the way of man's continuous travel. Where a stream is narrow, man has been able to merely step across; but when he is carrying a load it is much easier to lay a plank down and walk across. This plank represents the simplest form of river crossing and it is out of this simple form that all forms of structural river crossings have been developed. Where the water obstacles has been extensive or where
traffic volumes have been small, some form of water transport has provided the means of crossing. But in general, "... where the road meets the river, civilized man's ingenuity usually asserts itself and constructs a bridge in one form or another, so that the road may continue to its destination."\(^1\)

In the Twentieth Century, the advent of the automobile has created a proliferation of streets and highways; and with this phenomenon came also a proliferation of bridges, tunnels and ferries - the river crossings essential to any land-based transportation network. The tremendous growth and pressures of vehicular traffic have resulted in an astounding rate of bridge and tunnel construction in the past several decades on this continent. In the United States alone, it is estimated that over one hundred major bridges have been built in the past thirty years.\(^2\) Currently, there are approximately 300,000 bridges, large and small, in constant use in the United States.

Historically, the selection of locations for river crossings has been a relatively simple matter. Generally, geography and engineering requirements were the only technical factors involved in location selection and crossings were built at the narrowest part of the river and at the point where the river banks could best support bridge foundations or ferry facilities.

Today, however, determining locations for river crossings is a vastly more complex and difficult process. In urban and metropolitan areas especially, location selection is a formidable challenge. In order to accommodate tremendous traffic flows, river crossings must be huge structures which present engineering problems unprecedented in the
history of bridge and tunnel building. In addition to these engineering requirements, there are the problems of land acquisition, disruption of people and buildings, impact on land values, and so on. A structure such as a bridge or tunnel, including its required road approaches, is a dominant feature of the landscape, both visually and functionally. Proper planning of this structure and its location becomes essential if the crossing is to be effectively integrated with the total transportation complex and development pattern of the area it serves.

In order to achieve this integration, all pertinent factors - engineering, economic, political, social, etc. - must be considered in relation to each other. This is a problem of no small stature. Population growth as well as increased mobility and the consequent expansion of cities and metropolitan areas have created unprecedented transportation problems demanding the provision of more and more roads and river crossings. In addition, the accompanying development of residential, commercial, industrial and recreational land uses have created tremendously difficult problems for locating the transportation facilities required to serve people and land uses. Each land use function generates its own traffic, and problems often arise in determining the location for a facility as to the selection of a location which will most efficiently serve all the different types of traffic. Furthermore, the selection of a location must be made with due respect for the impact of the facility on both existing and potential land use and transportation functions.

Another critical issue involved in the selection of river crossing locations is the various governmental transportation
responsibilities for the planning, building, maintaining and financing of these facilities. For example, while the Provincial Government may actually locate and construct a river crossing, the Federal Government will demand a say in its location and design because of the Dominion's interests in shipping and navigation on rivers and harbours. Where the crossing is located within or between Municipal boundaries, the local governments concerned will have a vital interest in the crossing's location because of the possible physical and economic impact it might create within the Municipal limits. There is thus created a complex situation of many interests and responsibilities demanding a high degree of co-operation and co-ordination on both the technical and policy-making levels.

In addition, there exists a strong need for executive leadership from some governmental authority which would have ultimate responsibility for co-ordinating the different agencies involved in the planning of the crossing. Since there is a multiplicity of interests and responsibilities involved in the locating and building of a river crossing, authoritative leadership from one direction is essential to co-ordinate and integrate the administrative and technical activities of the various agencies and authorities concerned.

This, essentially, is the problem investigated in the thesis - the process of determining the locations of river crossings which also encompasses the construction, maintenance and financing of these facilities. This process is generally representative of all location selection processes that are basic to community and regional planning. Furthermore, the problems of inter-governmental participation and
co-ordination within the location selection context are common also to other areas of inter-governmental activity. Thus, the subject discussed in this thesis assumes a broad and general significance, not only for planning and location selection problems, but also for problems of co-ordination and participation involving different levels of government and different governmental departments.

All location selection problems are similar in that a decision must be made as to where a particular land use (structure and/or function) should be located. In most cases, the existing land use pattern and functional relationships are altered, not only in the immediate vicinity of the new facility but at considerable distances as well. It is likely, too, that economic changes in the form of increased or decreased property values will accompany the new land use. In general, the social and functional ecology of the area within which the land is located may be dramatically altered. This implies that every location selection decision involves a multiplicity of inter-related factors - physical, social and economic. Because of this similarity in the factors involved, every location selection problem could be approached basically from the same point of view within the same operational framework. It is therefore suggested that the approach to determining the locations of river crossings as developed in this thesis may be applicable to other location selection problems not concerned with bridges or tunnels.

By the same token, the problems involved in co-ordinating inter-governmental activities with respect to river crossings are common in many respects to other situations that concern different levels of
governments or different departments of the same government. Certainly with respect to the planning of public facilities and land uses in Canada, there has been considerable debate over which government or governmental department should be responsible for which planning function. Each government - Federal, Provincial and Municipal - demands a principal vote on issues involving the allocation of functions and facilities within its jurisdictional authority. At the same time, each government wishes to minimize its financial responsibilities for the same functions and facilities. And regardless of who has executive authority or the major financial responsibility, each government and its respective agencies wish to keep informed of the plans and activities of the other governmental agencies. Regardless, therefore, of the specific situation or problem at hand, there is constantly a need for inter-governmental co-ordination and participation - and often for merely communication. As a result, the form of inter-governmental participation required for the selection of river crossing locations can be generally applicable to other problems of an inter-governmental nature.

II. Objectives of the Investigation

The principal objective of this thesis is to develop an approach to the process of determining locations for river crossings. A further objective is to examine which is the most effective operational framework within which this approach can be best applied. The approach and framework thus established will be of general applicability to all situations involving the selection of river crossing locations. This is to say, the approach and its framework will allow for the specific or
unique circumstances of each situation involving the selection of a location for a river crossing rather than being designed for only one particular set of circumstances. The approach and framework will be established to facilitate the consideration of every principal factor involved in the determination of river crossing locations.

The approach to be developed applies principally to the technical and planning factors pertinent to the location selection process. It is proposed that the concept of "comprehensive planning" must be employed when dealing with the many complex and inter-related factors concerned in the location of a river crossing. Only with a comprehensive planning approach, it is suggested, can all these factors be properly considered and inter-related. In fact, the principle of comprehensiveness implies that all pertinent factors must be considered to the exclusion of none.

In order to implement this approach, it is proposed that an administrative framework be established which would provide for inter-governmental participation and co-ordination. Where there is a need to construct a river crossing, it is recognized that different governments and their different departments will have specific interests in that crossing. In order that each government and each department can operate effectively during the process of locating the river crossing, a framework must be established which facilitates inter-governmental and inter-departmental participation. This participation relates ideally to the administrative, financial and technical functions involved in the process of locating river crossings.

Finally, to ensure that inter-governmental participation is effective and that the comprehensive planning approach is effectively
implemented, it is maintained that there must be a single executive authority - the Provincial Government - to assume the responsibility for determining the final location of river crossings within its Provincial highway system, and for providing the leadership necessary for the establishment of inter-governmental participation.

These proposals are expressed in the hypothesis:

That in Canada, the Provincial Government should use a comprehensive planning approach, within a framework of inter-governmental participation, to determine the location of river crossings within the Provincial highway system.

III. Scope and Organization of the Study

The three key concepts expressed in the hypothesis - Provincial Government executive authority, inter-governmental participation and the comprehensive planning approach - are analyzed in the thesis. Each of these concepts is examined individually within the overall context of the location selection process. The investigation has been limited to the Canadian experience principally because of the governmental aspects discussed. Since the constitutional and administrative frameworks in Britain and the United States differ distinctly from those in Canada, no comparison is attempted between the experiences in these countries and in Canada with respect to determining locations for river crossings. However, where appropriate, examples of general location selection problems were taken from American sources for purposes of illustration.

The investigation in this thesis is largely limited to an analysis of those river crossing facilities that form parts of Provincial highway systems. At the same time, emphasis is placed on the planning of these river crossings on a metropolitan scale. Little reference is
made to the locating of crossings within a purely local or regional planning context.

The study does not include an investigation of the transportation planning responsibilities of each Provincial Government as they relate to the similar functions and responsibilities of the Federal and Municipal Governments. In most cases, generalizations are made with respect to the various financial and administrative responsibilities of the three levels of government relating to the provision of transportation facilities. Special reference is made, however, to various inter-governmental financial and administrative arrangements in British Columbia respecting the provision of highway and river crossing facilities in that Province.

In relation to the financial and administrative roles of the various governments and their agencies involved in locating river crossings, no attempt is made to investigate the whole range of issues that generally require inter-governmental participation or co-ordination. Only those matters of direct relevance to the problem of determining river crossing locations are considered. Furthermore, no detailed investigation is included of the problems of inter-governmental financial participation related to the construction and maintenance of transportation facilities. Regarding highways and river crossings, there is no attempt to investigate potential forms of inter-governmental financial arrangements. Emphasis is placed, instead, on the need for and forms of inter-governmental administrative participation.

Throughout the thesis it is assumed that the transportation planning process is an integral element of the comprehensive planning
approach suggested for determining river crossing locations. This planning process involves the procedure of survey, analysis, design, implementation and re-evaluation with respect to the location, design, construction and functioning of transportation facilities within an overall transportation system. Consequently, there is a vital relationship between this overall process and the process of determining river crossing locations. However, the study does not include a precise definition of this relationship.

The investigation begins with an examination in Chapter II of the existing financial, administrative and legislative conditions under which decisions are made with respect to the provision of river crossings' within Provincial highway systems across Canada. The problem of establishing an "executive authority" in relation to the constitutional, financial and administrative responsibilities of all three levels of government are then analyzed. Chapter II concludes with a description of the "comprehensive planning approach" recommended for application to the process of determining locations for river crossings.

This planning approach involves the consideration of all pertinent governmental and technical factors relating to the selection of river crossing locations. The locational factors relevant to the location selection process are examined in Chapter III under the following headings: planning criteria, including land use and transportation factors; engineering criteria; economic criteria such as construction and land acquisition costs, and administrative and political criteria.

Chapter IV contains a discussion of the application of these
criteria to the selection of river crossing locations. A framework for location selection is developed within which the comprehensive planning approach may be applied.

In order to test the effectiveness of this framework and the validity of the hypothesis in general, a case study is examined in Chapter V. This study concerns the process of determining a Fraser River crossing location in Metropolitan Vancouver nine years ago. The decision to locate a tunnel crossing at Deas Island is evaluated in retrospect by applying the location selection framework to the overall problem as encountered nine years ago.

Finally, Chapter VI concerns the review of the investigation including the summary of observations and conclusions made as well as the limitations of this study.

Although the term "river crossing" includes virtually every type of facility from footbridge to ferry, it will henceforth be taken to include only physical structures serving predominantly vehicular and rail traffic. This restricts the thesis to a discussion of bridges and tunnels and eliminates for consideration such facilities as ferries, aerial tramways and footbridges. However, the term is not meant to include only those bridges and tunnels that cross "rivers" specifically. Rather, structural crossings over bays, inlets, and harbours are within the scope of this thesis since a discussion of only "river" crossings would seem unduly restrictive. However, it is recognized that with modern engineering technology, almost any body of water can be crossed by a bridge or tunnel or a combination of both. The proposed crossing of the English Channel serves as an example of a potential engineering
triumph over sheer distance and other technical difficulties. Despite these future possibilities, the investigation in this thesis will be limited to those situations involving only "conventional" bridge and tunnel crossings.

In most cases throughout the thesis, the term "administrative" refers to the governmental functions of policy-making, planning, constructing and maintaining especially with respect to the provision of transportation facilities. For the purposes of this thesis, the financial responsibilities of government are separate from the administrative functions as defined.

This, then, provides the rationale for the investigation and discussion undertaken in the thesis. The basic problem - the process of determining the locations of river crossings - has been described; an attempt is now made to conduct a meaningful investigation of this complex and challenging subject.
REFERENCES


2 Ibid., p. 13.
CHAPTER II

GOVERNMENTAL RESPONSIBILITIES FOR TRANSPORTATION PLANNING

I. Introduction

The responsibility for the provision of transportation facilities in Canada is vested in numerous public and private agencies. The responsibility varies according to the type of facility and to the area or population it serves. There are different types of responsibilities and these are, basically, constitutional, financial, and administrative. For the purposes of this thesis, "administrative" includes policy-making, planning, construction and maintenance with respect to the various transportation facilities.

There are many examples of overlapping responsibilities involving either a single transportation facility or function in a number of jurisdictional areas or else a single jurisdictional area in which several facilities and functions are located. This overlapping may involve different levels of government, different governmental agencies and departments, or public and private authorities concerned with the same transportation facility or the same geographical area. In this chapter, an attempt is made to identify the principal responsibilities of the three levels of government in relation to the provision of transportation facilities in Canada. The responsibilities of private authorities are not discussed. In addition, this chapter includes a discussion of the problems of inter-governmental financial and administrative participation in relation to the need for an executive
government authority to make final decisions with respect to the location and design of transportation facilities.

Although mention is made of most types of transportation facilities, no attempt is made to discuss them all with respect to governmental responsibilities. The following discussion focusses on the governments and agencies involved in the provision of highway and bridge facilities. The central subject of this thesis concerns "river crossings" which are generally considered as integral parts of highway systems and are consequently included as part of the responsibilities of highway authorities. The location of highways essentially forms the "operational framework" within which river crossings are planned and built. With respect to the various authorities responsible for river crossings, the investigation in this chapter therefore deals extensively with highway authorities and highway systems.

II. Federal Level

Constitutionally, Federal responsibilities for transportation facilities are set out under Sections 91 and 92 of the British North America Act. The principal responsibilities under Section 91 concern shipping and navigation. Regulations governing shipping channels and navigational facilities are the chief considerations involved here. Also important are the Federal responsibilities for harbours which are included under the provisions for shipping and navigation. These responsibilities involve crucial implications for the provision of transportation facilities in and around harbour areas such as rail trackage, wharves, access roads, bridges and tunnels, etc. Federal
jurisdiction over harbour areas is a critical factor to be considered in locating bridge and tunnel crossings across harbour channels.

Under Section 92, which defines the legislative responsibilities for Provincial Governments, the Federal Government is given the authority to regulate and control transportation "undertakings" that are of an inter-provincial or international nature. Thus, railways, airlines, steamship lines, canals and telegraph facilities that connect a Province with any other or others of the Provinces or a foreign country come within Federal jurisdiction. As well, highways and bridges between Provinces or between a Province and the United States technically may be considered as a Federal responsibility. In practice, however, the Federal Government generally assumes only partial responsibility for these facilities, usually in the form of subsidies for construction costs. Administrative control is left with the respective Provinces.

The financial responsibilities of the Federal Government for transportation facilities are relatively limited, especially in relation to highways and bridges. A distinction is made here between direct government expenditures on transportation projects and Federal Crown corporations such as Trans-Canada Airlines and the Canadian National Railway which are financially independent and receive no direct financial support from the Federal budget.

Over the past 50 years, the Federal Government has played a very minor role in the construction and maintenance of highway facilities throughout Canada. This, of course, is related to the constitutional responsibilities for highways assigned to the Provinces by the B.N.A.
Act. Having a limited legal role to play, the Federal Government has consequently declined to extend much financial assistance to Provincial and Municipal authorities for the construction of highway systems.

Over the years, the Federal Government has given financial aid by grants and subsidies to Provinces and Municipalities for specific highway and bridge projects. Only under four programs has any sustained and substantial assistance been given. These four programs are The Canada Highway Act of 1919; projects under the Unemployment Relief Acts; contributions to the railway grade crossing fund, and the Trans-Canada Highway Act of 1949. The first two programs are now no longer active.

The Canada Highway Act authorized an expenditure of $20 million for highway construction over a five-year period and the fund was allocated to the Provinces on the basis of per capita grants. In 1925, the Act was amended to allow extension of the program until 1928. Highway projects under the Unemployment Relief Acts were carried out during the Depression Years. These projects were principally in the form of piecemeal operations initiating the construction of the Trans-Canada Highway.

Under the Trans-Canada Highway Act, the Federal Government agreed to pay one-half of the total cost of construction of a designated highway across the entire nation, through each Province. The agreement specified that the Federal Government would pay 50 per cent of a two-lane highway system, including bridges. Direct administrative control is the responsibility of the individual Provinces. In recent years, traffic demands have necessitated highway and bridge facilities of four or more lanes for selected sections of the Trans-Canada Highway.
Although the 1949 Act specified a two-lane system, the Federal Government's share of the construction costs in these cases has actually amounted to approximately 40 per cent because construction costs do not automatically double with the doubling of the size of the highway facility. By 1962 the Trans-Canada Highway had been completed (although sections of it currently are being replaced or improved) and the Federal Government had paid over $350 million for construction work on this national highway. In addition, the Federal Government has complete financial responsibility for the construction of those portions of the Trans-Canada Highway lying within National Parks. At present, there are about 140 miles of this highway within the limits of these parks.

The Federal Government has also shared financial costs for other highway and bridge projects that are inter-provincial or international in character. For example, the inter-provincial bridge between Cross Point, Quebec and Campbellton, New Brunswick and the international bridge between Campobello Island and the State of Maine were completed with Federal financial assistance. At present, a new Hull-Ottawa inter-provincial bridge is under construction with one-third of its costs being borne by the Dominion. The Provinces of Quebec and Ontario provide the other two-thirds.

One further program under which the Federal Government is financially responsible to some extent for the construction of highway facilities is the "Roads to Resources" program initiated in 1960. The objective of this program is to open up undeveloped areas of each Province and to help bring into production different types of resources. Under this program, the Provinces assume the primary responsibility of
planning, constructing and maintaining these development roads. The Federal Government, however, conceived of the program and plays a major role in determining what roads get built at what standard as well as in paying half the cost of these roads. The Federal contribution towards each Provincial program is a maximum of $7.5 million.

Although the Federal Government has always maintained some participation in the financing of highway facilities throughout Canada, the extent of this participation has been relatively very limited. The Federal Government has yet to recognize officially the national importance of highway systems and the need to play a more extensive role in the financing of these vital transportation systems. Unlike the American Federal Government, which in 1956 initiated the Federal Aid Highway Act that provides for the Federal Government to play a major role in the financing of 41,000 miles of limited access highways, the Dominion Government of Canada has left the financial burden of highway construction squarely on the shoulders of the Provinces; indeed, approximately 85 per cent of all principal and secondary highway facilities in Canada have been financed by the Provincial Governments.

It is interesting to speculate as to the probable pattern of financing that might have developed had the motor vehicle been fully developed in 1867 and its financial implications for government been fully appreciated. It would certainly have been a logical move, in the circumstances of Confederation, to place the responsibility for highway construction with the powerful and well-financed new national government. However, such a move would also have left the control over the location and design of highways and bridges with the central
government. This situation might have posed serious political problems with respect to the development of individual Provinces and areas within the Provinces. Regardless, it is apparent that the Federal Government today is reluctant to play a major financial role in the provision of highway facilities.

The regulatory and control functions of the Federal Government in the field of transportation are discharged by several agencies within the Department of Transport. These agencies include the Board of Transport Commissioners which regulates international bridges and tunnels, the Air Transport Board, the Canadian Maritime Commission and the Air Services Branch of the Department of Transport. Currently, each Board operates independently but reports to the Government through the Minister of Transport.

Construction and maintenance of Federal transportation facilities is generally carried out by the Department of Public Works which constructs and maintains the Trans-Canada Highway within National Parks, certain international and inter-provincial bridge projects, and wharf facilities for ships of the Department. Other construction and maintenance is carried out by the Department of Transport, especially with respect to airport facilities. Maintenance of the Canadian portion of the Alaska Highway has been, until just recently, the responsibility of the Department of National Defence. However, maintenance is now carried out by the Department of Public Works.

At present, there is virtually no formal or official joint administrative participation between the Federal Government and the Provincial and Municipal Governments, in relation to matters of
transportation. This includes matters of technical co-ordination as well as of policy-making. With respect to highway planning, a Federal-Provincial Technical Committee on Transport did exist at one time. This Committee was composed of technical officials of the Federal Department of Public Works and of the Provincial Departments of Highways. The Committee met to study and make recommendations on the technical aspects of the Trans-Canada Highway. Following completion of this highway system, the Committee had largely discharged its functions and currently is not active.

From a planning point of view, the Federal Government has good reason to maintain a keen interest in the highway and bridge plans of Provincial and Municipal Governments. This is in spite of the fact that the Federal Government plays a minor role in the provision of major highway facilities and that no formal framework exists for intergovernmental administrative participation. From a Federal viewpoint, the location and design of Provincial and Municipal highway or bridge facilities should take into consideration the effect these facilities could have on Federal responsibilities such as shipping channels, navigational facilities and railway grade crossings. In some cases, Federal regulations, such as those governing bridge clearance over a shipping channel, will be a key factor in determining the location and design of a highway or bridge crossing. Thus, from the Federal Government's viewpoint, the planning of highways and bridges must be based on consideration for both Federal regulations governing transportation and for specific Federal transportation facilities.

In general, the Federal Government is responsible for several
different types of transportation facilities. Financially, the
Government is largely responsible for the provision of harbour and airport
facilities. Administratively, the Federal Government exercises complete control over shipping and
navigation and transportation "undertakings" of an inter-provincial and international nature. In relation to highway and bridge facilities, the Federal Government has little financial or administrative responsibility. However, because of the national importance of highway systems and their relationship to other transportation facilities within Federal jurisdiction, there is an obvious need for more extensive participation, both financially and administratively, by the Federal Government in matters of highway and bridge planning.

III. Provincial Level

Under Section 92 of the B.N.A. Act, the Provincial Legislatures are given the responsibility for all "local" transportation works and undertakings. Consequently, highways, streets, bridges, ship lines, railways, etc. that are intra-provincial in nature are within Provincial jurisdiction. In fact, virtually every highway and bridge facility in Canada is constitutionally the responsibility of the Province except those that are Federally designated as inter-provincial or international in function. Although the Province is legally responsible for transportation operations within Provincial boundaries, such as the Pacific Great Eastern Railway in British Columbia and the Provincially-owned B.C. Ferry Authority, these operations are still subject to
Federal regulations respecting shipping and navigation, for instance, or rail transport.

In the past there has been controversy regarding jurisdiction over inter-provincial and international commercial highway carriers. This question was referred to the Privy Council who, in 1954, passed judgment to the effect that the Federal Parliament had exclusive jurisdiction over inter-provincial and international highway transport. Later that same year, a Federal-Provincial conference was held on means of implementing this decision. Following this conference, Parliament passed the "Motor Vehicle Transport Act" in June, 1954 which delegated to all Provinces, at their option, the authority to apply to inter-provincial and international highway transport the same regulations respecting certificates of public convenience and necessity and rates as they apply to undertakings operating entirely within the Province. Thus, while ultimate jurisdictional responsibility for inter-provincial and international highway transport rests with the Federal Government, the Provinces share the responsibility for implementing the regulations governing the operations of these particular transport activities.

With the exception of Provincial Crown corporations that operate intra-provincial transportation services (e.g., B.C.'s P.G.E. and the B.C. Hydro Railway), the Provincial Governments assume almost complete financial responsibility for the provision of highways and bridges. All Provincial arterial highways are totally constructed, maintained and financed by the Provincial Governments. The construction and maintenance costs for secondary and tertiary highways and bridges are generally shared with Municipal authorities where these highways lie within
Municipal limits.

The cost sharing arrangements between Provincial Governments and Municipal Governments differ considerably from Province to Province and no standard formula is in practice across Canada. In British Columbia, the Provincial Government pays 50 per cent of the construction costs and 40 per cent of the maintenance costs for secondary highways within the boundaries of District Municipalities and Cities with less than 15,000 population. If the Municipality has less than 1,000 population, the Provincial Government may pay up to 75 per cent of the cost of construction and maintenance. Where a secondary highway is not being properly maintained by a Municipality, the B.C. Department of Highways may, by legislation, carry out the necessary improvements and charge the costs to the Municipality. The B.C. Provincial Government also makes annual grants to Municipalities having a population over 15,000. These grants may not exceed $1,500 per mile per annum for the cost of construction and maintenance of roads forming a necessary link in the Province's arterial highway system.

As indicated earlier, each Provincial Government shares the cost of construction of the Trans-Canada Highway with the Federal Government, each government paying 50 per cent of the cost of a two-lane facility. In B.C., a new portion of the Trans-Canada Highway is currently under construction between Hope and Vancouver. This is a four-lane limited access highway including a four-lane bridge across the Fraser River at Port Mann. The Federal Government's share of the construction costs for this highway and bridge link is approximately 40 per cent.

Technical and administrative responsibilities of Provincial
Governments for highway and bridge facilities are assumed by the respective Provincial Departments of Highways. Other administrative responsibilities are assumed by Crown corporations or authorities established to administer specific transportation services. For example, the B.C. Toll Highway and Bridge Authority, prior to its dissolution this year, was responsible for administering the toll facilities within this Province's highway and bridge system. Other transportation authorities may administer public transit as in the case of the B.C. Hydro and Power Authority.

Although at present there is no formal administrative framework established to accommodate Federal-Provincial participation, there are and have been such frameworks to facilitate Provincial-Municipal administrative participation. In Ontario, the Municipal Roads Branch of the Provincial Department of Highways is responsible for co-ordinating the construction and maintenance activities of the Highways Department and the engineering departments of the Municipalities in the Province. Thus, an effective link is established between local and Provincial highway planning and construction. In Alberta, a similar link on a broader scale is provided by means of the eight Regional Planning Commissions throughout the Province. These Commissions, which are responsible for the preparation of both regional and local plans, are comprised of elected and appointed representatives from the member municipalities and from various Provincial Departments, including the Department of Highways. On a policy-making level, Provincial-Municipal participation is provided for as well as on a technical level where the staffs of the Regional Planning Commissions and of local Engineering and Planning
Departments in effect have direct access to the Provincial Highways Department. In B.C., the Technical Committee for Metropolitan Highway Planning was established in 1955 to study the Lower Mainland's future traffic requirements. Members of this Committee included representatives from the Provincial Department of Highways and from Municipal Planning and Engineering Departments. The Committee's conclusions and recommendations were thus developed on the basis of Provincial-Municipal administrative participation. However, this inter-governmental committee was dissolved in 1959 following publication of its technical reports. Since the planning and construction of highway and bridge facilities is a continuing operation there should be some formal, permanent means to ensure proper co-ordination of Provincial and Municipal policies and plans.

From the Province's planning point of view, the location of highways and bridges is vital to the overall development of the Province. Thus, in considering where to locate a particular facility, the Provincial planners must concentrate on the needs of the Province as a whole, particularly the transportation needs of the total Provincial highway and bridge system. The needs and problems of individual regions, including urban areas, therefore assume Provincial importance only if they relate to inter-regional or overall Provincial transportation requirements. It is frequently difficult to define what is and what is not of "Provincial importance" when dealing with transportation problems in a particular area of the Province. Since the Provincial Government is responsible for a very extensive geographical area relative to any one region of the Province, it is to be expected that the Provincial
authorities will be highly selective in what they designate as being "Provincially important". In any event, however, the Provincial Government must recognize its position of superior financial power when the problem arises of providing a highway or bridge facility within a Municipality.

IV. Municipal Level

In Canada, Municipalities have no direct constitutional responsibilities for transportation facilities or services. What responsibilities they do possess have been delegated to them by the Provincial legislatures, and are thus only financial and administrative responsibilities. This, of course, is the case with all Municipal functions since Municipalities are merely the creations of the Provincial governments and have no constitutional basis of their own.

Municipalities are financially responsible for the construction and maintenance of all local streets and bridges within the Municipalities' jurisdictional limits. As indicated previously, Provincial subsidies are generally granted to Municipalities for the upkeep of roads and bridges that are essential links in the overall Provincial highway system. In addition, the construction costs of secondary highways within Municipal limits are shared with the Provincial government; in B.C., the costs are shared equally. In some

*For sake of clarity, the term "Municipality" is defined to include all Municipal authorities or units subordinate to the Provincial government. A County, Township or Rural Municipality, for example, is considered to be a "Municipality" within the terms of this chapter.
cases, particularly if it is a large City, the Municipality may share in the costs of building a major bridge crossing or highway link. Thus, the new Burrard Inlet Crossing within Metropolitan Vancouver most likely will be partially paid for by the Municipalities it directly serves.

The administration of local streets and bridges is a Municipal responsibility. In addition, local authorities have partial administrative responsibility (i.e., maintenance) for secondary highways within Municipal boundaries. These administrative responsibilities are normally discharged through the Municipal Engineer's office, although the planning of some local streets and bridges may be the joint responsibility of the Planning and Engineering Departments. In British Columbia, the planning of arterial and secondary highway routes in Cities over 15,000 population is a Municipal responsibility. However, in District Municipalities and small Cities, such planning is at present done entirely by the Provincial Government through its Highways Department. Another Municipal administrative responsibility may be the local public transit system as in the case of the Metropolitan Toronto Transit Authority.

A major responsibility of Municipalities is that of preparing and implementing land use plans for the development of the community. Constitutionally, community planning is a Provincial responsibility although Provincial Legislatures across Canada have delegated authority to Municipalities to carry out land use planning on a local basis. This, however, does not absolve the Provinces from their community planning responsibilities. Since the B.N.A. Act assigns the responsibility for community planning to the Provinces, they must ensure that the
development of not only the Province as a whole but local areas as well proceeds according to accepted planning principles. This requires the Provincial planners to recognize and plan for the needs and problems of local areas when involved in the provision of Provincial transportation facilities, public buildings, and other land uses. Thus, when planning the Provincial highway and bridge systems, local factors must be considered by the Provincial authorities as part of their constitutional planning responsibilities.

Transportation facilities form vital elements of any community plan and it is essential that the local planning authorities maintain close working agreements with the transportation authorities of the two senior governments in order to ensure that highways, bridges, railways, etc. are properly located and designed in relation to local needs. However, close working agreements are not always practicable and too often the local authorities plan in ignorance of the intentions of senior government agencies. This is due frequently to the financial basis upon which major transportation facilities are provided. Except for purely local facilities, Municipalities generally do not have the financial resources to share in the costs of constructing major transportation facilities and thus they cannot expect a strong voice in the planning of such facilities. Consequently, a basic conflict is created: that is, major transportation facilities are provided by the Provincial and Federal governments, and although these facilities are crucial to local land use plans which are the delegated responsibility of each Municipality, Municipal authorities are not granted an effective voice in the planning of these facilities because of existing inter-
governmental financial arrangements. Ideally, of course, these financial arrangements ought not to be the basis upon which inter-governmental administrative participation proceeds.

V. Inter-Governmental Participation Versus Executive Authority

In order for the complete range of transportation facilities at each level of government to be properly planned and provided, it is necessary that there be inter-governmental participation in the planning, construction, administration as well as the financing of these facilities. In each case, too, there must be one government agency which acts as the executive authority responsible for making final decisions regarding the type, size, location, design, etc. of the facility in question. At present, the government or government agency serving in the capacity of executive authority derives this role from its position of major financial responsibility in the cost sharing arrangements between governments. That is to say, the government which pays the most has the most influential voice in inter-governmental matters of planning and administration.

Considerable study has been made of the financial relationships between the Federal and the Provincial Governments in relation to the provision of highways and bridges. Because the B.N.A. Act assigned almost full responsibility for providing highway facilities to the individual Provinces, they have had to bear the greatest portion of the costs for the construction and maintenance of these facilities. As a consequence, the Provinces have acted as the executive authority in most inter-governmental situations involving the location and construction of
a highway or bridge.

It has been strongly advocated that the Federal Government should play a much larger financial role in the provision of highways and bridges throughout Canada. Because of their powers of direct taxation and because it collects taxes from motor vehicle sources, the Federal Government is in a strong position to lend considerable financial aid to the Provinces and Municipalities for the provision of highway facilities. There is no particular onus on the Federal Government to participate in the financing of highways and bridges simply because it obtains revenue derived from the automobile as part of its general tax scheme any more than it bears a responsibility to tobacco farmers because it taxes cigarettes. But while the Federal Government is under no onus to share its motor vehicle revenues, it is fair to point out that the very heavy burden of Federal taxation on the automobile user - in the form of excises, customs duties and other imposts on automobiles, parts, tires, etc. - complicates the problem of individual Provinces in attempting to obtain more money from this same source. This fact should at least suggest a more generous attitude in Ottawa towards Provincial highway aid, even if restricted to highways where there is a clearly identified national interest. It should be possible to modify the Trans-Canada Highway agreement, for example, to include other roads having an agreed national importance.

There seems little chance for an increase in the amount of financial participation on the part of Municipalities because of their very limited taxation powers respecting highway transportation. At present, gasoline taxes and motor vehicle licences provide the principal
financial support for highway construction programs and these imposts can be levied only by Provincial Governments. With little hope for an increased financial role in highway construction, Municipalities face the problem of supporting their demands for greater administrative participation in some other way. However, as suggested earlier, Municipalities must be able to have a significant voice in the planning of highways and bridges because of the implications of these facilities for local community development. Thus it is impractical to argue that the Municipalities' degree of financial participation should govern the degree of their administrative participation.

Regardless of who pays how much for what, there is an obvious need for extensive inter-governmental participation on the policy-making and technical planning levels. The problem here appears mainly to be the reluctance of the authorities responsible for the major portion of the construction bill to acknowledge the advice or opinions of the other government agencies which are involved but which do not provide extensive financial assistance. There is also the further problem of the individual Highways Department or Transportation Authority planning solely within its own sphere of interest and ignoring the implications for other departments or authorities. For example, Provincial highway plans have often been kept secret from local authorities almost until the day construction of the facilities began with the result that a transportation system has been designed with no attempt to relate it to local development plans. There is created, therefore, a need for both inter-governmental and inter-departmental co-ordination of plans for transportation and land use, especially in relation to the activities of
Provincial and Municipal Governments. Jackson and Northey in their report on highways and land use, express this need as follows:

There must be a coordinated approach by the responsible departments of government; this degree of co-ordination should operate initially at the provincial level where different Departments may be concerned with different aspects and development implications of the same problem. It should operate again at the local level of jurisdiction because many major roads cross administrative boundaries and thus require a joint approach towards providing for the impact of these roads on local opportunities for land development. Further, there must be integration between the different levels of government when, for example, the decision to build a provincial highway influences development that takes place within the boundaries of a municipality.¹⁰

It is suggested that administrative and planning participation can be established between different levels of government exclusive of inter-governmental financial participation. That is to say, the inter-governmental cost sharing arrangements should not determine the extent of administrative and planning participation of each government or agency. It must become apparent to individual governments and authorities that through participation they can benefit more than if they plan and administer in isolation. Through integrated planning, highway and bridge systems can be better located and designed, thus ensuring that greater benefits accrue to all interests involved.

In order to ensure that inter-governmental participation on matters of highway and bridge planning can be facilitated, some formal administrative framework must be established, ideally on a permanent basis. It is suggested that such a framework could be created along the lines of the "Urban Development Boards" proposed by Dr. H. Peter Oberlander in his study on Public Housing in Canada.¹¹ As described by Dr. Oberlander, these Boards would be created one for each Province and
would be composed of representatives of the Federal and Provincial governments as well as from Municipal governments. The Boards would be responsible for the administration of the National Housing Act and of the respective Provincial Town Planning Acts.

With respect to highway and bridge planning, it is suggested these Boards be called "Highway Transportation Boards", and be composed of representatives from the respective Provincial Highways and Planning Departments; the regional offices of the Federal Department of Transport; the various Municipal Planning and Engineering Departments, plus any other governmental department or authority concerned with highway planning and land use development. These Boards, like those of Dr. Oberlander's, would be created by the Provinces and would be responsible to the Provincial Legislatures through the Ministers of Highways. Since the Provinces are constitutionally responsible for highway and land use planning and must provide the major share of the costs for highway and bridge facilities, the Provincial representative would act as the executive authority and chief co-ordinator.

These Boards, basically would be responsible for administering the respective Provincial Highways Acts, primarily with respect to the planning of highway and bridge facilities. The basic objective of the Boards, however, is to promote the co-ordination of the various governmental agencies' plans and functions in order to provide for the integration of highways and bridges with other transportation facilities and with land use activities. These Highway Transportation Boards would thus constitute a permanent and formal administrative framework that would provide the opportunity for inter-governmental
participation with respect to the planning and administration of highways and bridges and the integration of these transportation facilities with land use activities.

VI. The Comprehensive Planning Approach

In planning for transportation and land use functions and for physical areas, alternative approaches may be taken by the planners and decision-makers. Frequently, a single-purpose approach is taken which stresses only one or a few aspects of the total problem under study. In the planning of a bridge or highway, for example, the approach taken may emphasize only the economic or engineering aspects of the project. Planning decisions in such cases would be based only on how much the particular project would cost or what the foundation and design requirements would be. Consideration for other vital factors would be minimized or ignored altogether.

Similarly, a single-purpose approach might take into account only those factors relevant to a single sphere of jurisdiction whether it be that of a government agency or of a government in general. Examples of this approach can be found in cases where a particular government department plans for its own specific functional responsibilities separately from those of other government departments. In other cases, a single Municipality or Province may consider only those functions or effects of direct relevance to Municipal or Provincial jurisdictional responsibilities. In general, the single-purpose approach is found where single functions, effects, or jurisdictional areas are the only factors considered in the planning process.
Contrasted to this approach is the comprehensive planning approach. In one sense, this can be considered as a multi-purpose approach which encompasses all relevant factors in planning for a function, facility or area. In planning a bridge or highway, for example, the comprehensive planning approach would include an evaluation of all pertinent factors - economic, engineering, land use, social, political, governmental areas, etc. No single factor such as "economy" or "design" or "area" of authority would receive inordinate attention in the decision-making process.

In addition, the comprehensive planning approach treats transportation planning and land use planning as a single subject. The functions of land use and transportation are intimately inter-related. Thus, the planning of these functions requires an approach that provides for the integration of land use and transportation activities. In their report, Jackson and Northey state that:

Only a joint and integrated approach to transportation and land use as mutually interlocking subjects can be productive of a balanced understanding of the several and intimate relationships which are involved.\(^\text{12}\)

One basic principle of the comprehensive planning approach, that of consideration for all jurisdictional responsibilities, has already been discussed in the foregoing sections of this chapter. The other basic principles of this approach involving consideration for all pertinent locational and design criteria will be discussed in the following chapter.

It is suggested that with the ever increasing technical, social and political complexity of our environment, the comprehensive planning
approach is the only approach that provides the opportunity for a rational evaluation of all crucial factors to be considered in making a planning decision. Determining locations for "river crossings" is such a planning decision and involves a multiplicity of complex, interrelated factors in almost every situation. Different levels of government and different governmental departments are likely to be involved as well as innumerable technical considerations such as costs, engineering requirements, land use implications, etc. In order to make the best possible decision in locating river crossings, the executive authority responsible for implementing the recommendations determined through the planning process must employ a comprehensive approach. It is therefore suggested that in planning the bridge and tunnel facilities for Provincial highway systems, the Provincial Government should employ this comprehensive planning approach.

VII. Summary

The responsibility for the provision of transportation facilities in Canada is shared among the three levels of government. The British North America Act assigns specific transportation responsibilities to either the Federal or Provincial Governments. The Provincial Legislatures in turn have delegated certain transportation responsibilities to Municipal authorities and to Provincial Crown corporations. In relation to highway and bridge facilities, the Provinces have almost total financial and administrative responsibility for the provision of these facilities. The Federal and Municipal Governments have considerably fewer responsibilities for the financing, construction and
maintenance of bridges and highways.

The existing arrangement of governmental responsibilities for highways and bridges has given rise to problems involving inter-governmental financial and administrative participation. The Provincial Governments bear approximately 85 per cent of the costs of providing major arterial highways and bridges in each Province. As a result, the Provinces have been given the executive authority in most cases to decide what is built and where; frequently, Provincial decisions do not reflect consideration for Federal or Municipal facilities or responsibilities. In order to ensure that all pertinent jurisdictional responsibilities, such as land use planning and shipping and navigation, are taken into account when planning for highway facilities, it is recommended that a formal administrative framework be established that would facilitate inter-governmental participation on the policy-making and planning levels. This framework would be in the form of individual, Provincially-created Highway Transportation Boards composed of representatives from the Federal, Provincial and Municipal Departments of Highways, Engineering and Planning. Because of their constitutional responsibilities for highways and land use planning, the Provincial Governments would act as the executive authority.

In planning Provincial highways and bridges, the Provincial Government should employ a comprehensive planning approach which allows for the consideration of all pertinent factors that have a bearing on the location and design of a particular facility. Contrasted to this is the single-purpose approach which emphasizes only one or a few of the factors involved in planning highway and bridge facilities.
REFERENCES

1 Canada, "British North America Act". Statutes at Large 31 (Victoria: 1867), c. 3.


5 Ibid., p. 35.


CHAPTER III

CRITERIA FOR DETERMINING THE LOCATION OF RIVER CROSSINGS

I. Introduction

Determining the location for river crossings utilizing a comprehensive planning approach involves the study and analysis of many complex and inter-related factors. Prior to the advent of modern urbanization, site selection for river crossings was a relatively uncomplicated task whereby engineering considerations constituted the principal basis for making a decision as to the proper location for a bridge or tunnel. However, as indicated previously, this problem has evolved into a highly complex process requiring the consideration of a multiplicity of criteria - physical, economic, engineering, political, and so on - in order to determine the best possible location for a river crossing from the point of view of all interests concerned.

The range and variety of factors that must be considered in determining locations for river crossings are identified and reviewed in this chapter. For the sake of clarity and simplicity, the factors are discussed as individual criteria separated from the total transportation planning process. This planning process is basically concerned with the planning of transportation systems involving a number of varied transportation facilities serving an identifiable region such as an urban metropolitan area. The criteria discussed in this chapter would be analyzed by highway and bridge planners at different stages throughout the total transportation planning process. In order to emphasize the
need for careful consideration and evaluation of all pertinent, inter-related factors related to locating a major transportation facility such as a river crossing, these factors are discussed individually in this chapter.

Similarly, in the evaluation of the pertinent locational factors with respect to river crossings, no distinction is made as to whether the crossing is planned as an integral part of an overall transportation or highway system or whether it is an individual project planned separately from a total system of transportation facilities. Since the problem of locating river crossings within a system of Provincial highways is of considerable importance here, it is necessary that the discussion in this chapter be concerned with planning the location of highways in relation to the locations selected for river crossings. Although the criteria discussed here relate principally to river crossings only, they also have a significant relationship with the connecting highway approaches at either end of the crossing. In summary, while the criteria determined in this chapter may certainly be valid for the selection of any river crossing or other transportation facility they are reviewed only in relation with those crossings and connecting approaches that form part of a Provincial highway system.

II. Planning Criteria

Land use. The demand expressed by vehicular movement is due to the spatial separation of functionally related land uses.\(^1\) As expressed by the book title used by Mitchell and Rapkin, traffic is a function of land use.\(^2\) There is thus an intimate inter-relationship between land
use activities and the transportation facilities that serve these activities. There is a continual process of interaction between traffic and land uses and consequently, planning for each type of activity demands consideration for the effects that each will have on the other. This two-way relationship between traffic and land use is illustrated by the following observations made by Jackson and Northey in their report on the impact of highway facilities on land use:

A new highway may generate a demand for residential subdivision, the extension of water mains, the construction of sewers, schools and other elements of municipal growth. Likewise the decision of a municipality to encourage the development of industrial land or to foster residential subdivisions must inevitably make additional demands on the highway system.

Ideally, land use planning and transportation planning should be approached as a single, integrated subject whereby transportation facilities are planned and located simultaneously with the allocation of land uses. Too often, as Mitchell points out,

... a transportation plan is made to serve an independently projected land use pattern. Sometimes a land use plan is made to "fill the interstices" of an independent transportation plan; both are wrong. The objectives and limitations recognized in either the land use plan or the transportation plan should be reflected in both.

However, it may be necessary to plan a particular activity or facility, such as a river crossing, without the benefit of long range transportation and land use plans to guide the planners in their decisions. Nonetheless, recognition of the fact that transportation and land use are integrated activities is essential to the proper siting of transportation and land use facilities. Thus, in determining the location for a river crossing, there must be consideration for the effect of this facility on both existing and potential land use patterns.
as well as for the effect of land use on the crossing itself.

In considering existing land use patterns, the minimization of the disrupting effects of a river crossing or other such facility should be a primary objective. Too often the planners of Provincial highway systems fail to recognize or do not accept the responsibility for the adverse effects that a highway facility can have on local land use activities. The disruption of a neighbourhood, for example, or the isolation of a school, church or other community functions are but some of the conditions planners should strive to avoid in locating transportation facilities. Many of these effects have social implications that involve the personal well-being of the community. Children moving to and from school, the accessibility of shops to housewives, and the general efficient functioning of the community's social-cultural facilities are all potentially susceptible to the adverse impact, if any, of a major transportation facility.

Consideration of future land use patterns involves two objectives. First, there should be an attempt to relate the river crossing to the projected population and land use distribution patterns in order to efficiently serve the traffic generated by this distribution. More important, the location of the river crossing can serve to encourage development and to channel future land use activities into properly allocated areas. In this way, the river crossing and its associated facilities can play instrumental roles in shaping the future environment of a region. There is often, however, the problem of the existence of insufficient or inadequate land use controls in the areas opened up for development by the provision of new transportation facilities. Without
anticipation of land use development induced by new transportation facilities and without the provision of proper controls to accommodate this development effectively areas may be inundated with scattered subdivisions and other land use activities that result in widespread "urban sprawl". In the case of Provincial planning, the Province has the obligation to implement land use controls in unorganized areas and in rural, semi-organized Municipalities through which a highway or river crossing is to be located. Similarly, the Province has the duty to keep the authorities of larger Municipalities informed as to the Province's transportation plans affecting these areas.

In considering both existing and future land use patterns and by recognizing the significant effects transportation facilities can have on the environment, the planners of Provincial highway systems ... should plan highways and bridges to facilitate development of suitable areas, to avoid disruption of existing neighbourhoods, to avoid premature development of fertile lands, to shorten journeys to work, to promote industrial development and so on.⁵

In order that land use activities are considered and planned for in determining the location of transportation facilities, it is essential that there be co-ordination and co-operation between the traffic planners and the land use planners. Criticism is sometimes made of the fact that transportation plans are kept secret from those responsible for land use planning and that ultimately, the land use plan has to be adjusted to meet the requirements of the transportation plan. One writer puts the case in this way:

The planners' trouble is they never get in early enough; the design engineer and the traffic engineer never seem to think of the planners; they've got everything so far advanced that the planner can't even make a sensible suggestion.⁶
However, the situation is not altogether one-sided, since the land use planner must make his presence known and must make every effort to find out what transportation facilities are being planned. Furthermore, the planner should strive to become an effective partner in the total process of land use and transportation planning. One writer expresses this need for co-operation between professionals by stating:

Perhaps the engineer has an obligation in encouraging regional planning and co-operating in the process; the regional planner has the equal obligation in education the engineer with respect to land use and traffic.7

In summary, it should be emphasized again that there must be an integrated approach to the planning of transportation facilities and land use activities. In relation to the determination of locations for river crossing, the utilization of this integrated approach by planners will help ensure that the impact of the crossing on existing and future land use activities and the effect that future land use patterns will have on the facility itself will receive careful consideration. Transportation facilities and land use activities cannot be planned in isolation from each other. A paper by John T. Howard summarizes the case for an integrated approach to the planning of transportation and land use functions:

... If there is to be effective land use planning for a metropolitan area as a whole, with realizable proposals for the organization of residential, industrial and commercial development, the preservation of open space, and the achievement of other objectives of city planning, it must be directly integrated with area-wide highway planning. And if there is to be effective highway systems planning, with major routes of such numbers, directions, capacities, and interconnections as will carry the volumes and perform the functions they were designed for, it must be directly integrated with land use planning at the level of broad decisions on area-wide land use patterns.8
Transportation. A primary consideration in the process of selecting a location for a river crossing or any transportation facility is the type and volume of traffic it is expected to serve. The objective of all transportation facilities is to facilitate the movement of people and goods in the most efficient way possible. In order that the facility may satisfy this objective, it must be so designed and located as to meet the needs of the particular type of traffic it is expected to serve.

Frequently, more than one type of traffic must be accommodated by a crossing, and a conflict arises as to which type should dictate the location and design of the facility. This assumes, of course, that each type of traffic may possibly require a different location of its related facility to serve its function most efficiently. Thus, daily commuter traffic may require a different type of structure and a different location than that required for the efficient movement of purely tourist or inter-regional traffic. At the same time, both types of traffic may be found within the same general area and both may even travel the same "desire" lines. In some cases, a crossing can serve more than one type of traffic, although some types may not be served as efficiently as others. In planning Provincial highway systems, inter-regional traffic is generally of prime importance and the location of the river crossing will be dictated largely by the demands of this particular type of traffic.

Another basic problem arises because of the need to consider both existing and potential traffic patterns. Existing traffic needs may dictate one location for a crossing while consideration of future
traffic demands in relation to future population and land use patterns may dictate another. Generally, it is the planner's duty to determine a location for a crossing that efficiently serves both existing and potential traffic.

In considering alternative locations for river crossings, the location of existing highway and crossing facilities is a crucial factor. In transportation studies, considerable attention is paid to the amount of traffic that would be diverted from existing facilities onto new facilities by crossings at specific locations. The "Trans-bay Traffic Study" which was concerned with crossings for the San Francisco Bay region laid considerable stress on the amount of traffic diverted by each suggested crossing location in making its final recommendations. This diversion of traffic is a crucial factor because of the relief provided for existing traffic facilities and because of the possible positive effects the newly-created traffic flow might have on future land use development in the region served.

Associated with this factor of diverting traffic is the capacity of a crossing or highway facility to induce traffic; that is, to create new traffic movements or patterns. This again has been an important consideration in some transportation studies concerned with locating river crossing sites. The authors of a study involving crossings of Puget Sound in the Seattle area expressed their opinion that "Experience with other traffic facilities indicates that a superior highway or river crossing creates traffic which did not previously exist." However, it is important to ensure that the newly-created volume of traffic is in fact directed to and through areas that have been properly planned for
development, or which are properly safeguarded against adverse effects of traffic.

Although the river crossing may be located and designed separately from other associated transportation facilities, it is essential that the functional relationship between the crossing and the rest of the traffic system be carefully considered when determining the river crossing location. This involves consideration for those facilities not forming integral parts of a Provincial highway system as well as for those that are essential to the efficient functioning of the Provincial facilities. The problem frequently arises as to whether the crossing should dictate the location of the connecting highway approaches or whether the highway facilities should take precedence over the location of the river crossing. In many instances, it is a matter of engineering requirements and costs that ultimately determine which has locational priority. In general, however, it is important that both the crossing and its associated highway connections be planned and located as an integral unit with neither facility taking absolute precedence over the other.

In planning any transportation system or individual facility it is crucial that there be established first broad policies and objectives to serve as guidelines for the transportation planners. Without such objectives river crossings and other facilities run the risk of being located without due consideration for all related elements of the total transportation system. An example of a broad policy statement to guide the planning of a major transportation system and its related facilities is that established for the Pittsburgh Area Transportation Study. The broad objectives of this study were:
... to develop an integrated plan of major highway and mass transportation systems ... designed to serve the projected land uses and to meet the anticipated travel requirements with an improved quality of service within the practical economic ability of the responsible agencies, compatible with the requirements of the ultimate development of the area.11

III. Engineering Criteria

Throughout history, the engineering requirements for bridges, tunnels, highways and other transportation facilities have played the most dominant role in determining where these facilities should be located. Despite the increasing recognition of the need to consider other factors as well, such as land use activities, the location of a river crossing or highway is still significantly influenced by engineering considerations. Indeed, an otherwise ideal location for a river crossing may be rejected because of anticipated construction difficulties. Such was the case involving the selection of locations for a Puget Sound bridge crossing. Two locations that otherwise satisfied most of the Seattle area's transportation and land use requirements were eliminated from final consideration because "... high tidal currents and unusual water depth present unprecedented construction and engineering design problems for these projects."12 Thus, in order that a river crossing or similar project may become a reality, it must be physically feasible from an engineering point of view.

In many instances, however, other considerations are completely subordinated to those involving engineering and design factors. In an effort to provide the most direct highway route or the most efficient river crossing, at the least cost, the engineer often places an inordinate amount of emphasis on the engineering requirements for such
facilities. Completely ignored are such vital considerations as the impact of the highway or crossing on surrounding land use functions, both existing and future. Thus the question is rightfully asked:

Are we to continue locating highways and bridges to merely satisfy engineering requirements of cut, fill and alignment, or are we consciously going to place them in locations calculated to produce the best results in terms of highest and best land use - urban, suburban, and rural? 

However, before wholesale condemnation is made of the engineer and his locational criteria, the requirements for the construction and design of transportation facilities, river crossings in particular, should be recognized and evaluated in relation to the other locational factors.

There is no set procedure which should be followed in the investigation of factors influencing the design or construction of a particular river crossing. Each location studied has its own unique set of engineering or physical factors to be analyzed in relation to the provision of a crossing at that point. Some factors, certainly, are common to almost all situations but the specific nature of these factors may vary considerably from case to case. Thus, there is no standard formula or analytical framework that can be applied to each situation with respect to the structural requirements for a river crossing.

This does not exclude the possibility of there being a standard or common analytical approach to each situation in respect to structural requirements. It is beyond the scope of this thesis, however, to discuss the development of such an approach related solely to structural criteria for river crossings. It is suggested, though, that
the comprehensive planning approach as earlier described is generally applicable to the analysis of purely engineering data.

Of basic importance to the engineer are the site characteristics of each location under study. Drillings must be carried out to determine the size and type of the structure's foundations. Soil stability especially is of vital importance to bridge and tunnel construction. The general topography of the site, too, has an important influence on the length of approaches that must be provided at either end of the crossing. These approaches are generally built so as not to exceed a grade of approximately 3.5 per cent. In some situations, the topography may necessitate the construction of extremely long approaches in order to meet this grade standard, and thus, the river crossing may not be economically feasible for this reason.

The nature and behaviour of the particular body of water involved in locating the river crossing demands close scrutiny and analysis on the part of the engineer. Such factors as the scouring effect of the river or bay on the crossing's foundation supports are most crucial. The permanency of the channel under or over the crossing also has a significant influence on where a crossing facility can be located. Similarly, the silting effects of water action on a tunnel structure may require extensive study and tests. Certainly the depth of water at a proposed location will have a bearing on the design and cost of a structure at this site. In the Puget Sound study cited above, water depth plus abnormal wave action were key factors in the evaluation of alternative crossing locations. In general, the sciences of hydraulics and soils play perhaps the most influential technical role in
determining the locations for river crossings.

Other technical factors as well may have significance in the site selection problem. Of particular importance in Canada are the navigational regulations of the Federal Government affecting waterways. These regulations determine what the minimum horizontal and vertical clearance must be of the crossing over a navigable channel. In some cases, in relation to topography, the required width or height clearance might be such as to necessitate a particularly long span or long approach roads. In either case, the economics of the project might well be prohibitive. In the case of the Deas Island Tunnel in Metropolitan Vancouver, Federal Government rulings on the depth of the tunnel made the economics of the project highly questionable at one stage in the planning of this crossing.\textsuperscript{15}

Federal regulations concerning flight patterns or contours around airports can also have an important influence on the design and location of a river crossing facility. For example, the proposed Sea Island crossing in Metropolitan Vancouver may have its location and design determined largely by regulations governing the flight paths for aircraft at the Vancouver International Airport located on the Island. In almost every case, these Federal regulations respecting navigation and air traffic are rigid and cannot be altered or waived readily because of structural requirements for a proposed crossing.

Regulations and design requirements concerning railway crossings may also be an important factor in the location and design of river crossings. In many cases, railway trackage is located adjacent to a navigable waterway and any crossing over this body of water would have
to provide for adequate clearance of the trackage. Such is the case involving the proposed Burrard Inlet crossing where rail trackage occupies waterfront land on both sides of the Inlet. The highway approaches to any Inlet crossing will have to cross over these rails and the design and location of the approaches therefore will have to be such as to minimize any chance of interference with rail traffic.

The alignment of the crossing with its connecting highway approaches is another important technical factor to be considered in determining river crossing locations. There is no specific rule as to whether the location of the crossing should dictate the alignment of the approaches or vice versa. In the past, highway standards were low and river crossings were nearly always constructed at an ideal location so that the span was the shortest possible, the foundation conditions the best obtainable, and the crossing a square one if at all achievable. As a result, highway alignment often suffered. Even today, highway location may be subordinate to the requirements of a particular crossing structure. This is because the cost of bridge and tunnel facilities are generally many times greater than the cost of an equivalent length of highway. The basic economic question is frequently asked by engineers: "At what span length (size of structure) or at what cost relationship between structure and highway should the structure dictate its location?" Because of the relatively high construction costs per foot of bridge or tunnel, the correct location of a crossing is essential to maintain economy, assuming that economy is of prime importance. In general, the subject of the relation of river crossing location to
highway location contains a great many variables; usually terrain and foundation conditions are the two principal technical variables.¹⁸

One final technical consideration in determining the location of river crossings is the traffic capacity of the particular structure. The number of traffic lanes and decks will determine the size of the crossing which in turn will have a significant bearing on its location.

In summary, it is apparent that there are a great number of varied technical factors to be considered in determining locations for river crossings. Despite the land use planner's insistence that the crossing be properly located in relation to the land use pattern, the engineering requirements of a river crossing are often such that technical factors or construction costs must play a dominant role in the final decision regarding the crossing site.

IV. Economic Criteria

Construction and maintenance costs. As previously mentioned, the river crossing's engineering requirements will determine the cost of constructing the structure at each alternate location. These costs are exclusive of the necessary land acquisition costs associated with each location. In many cases, the construction costs of a particular crossing will determine whether or not the location in question is economically feasible. Often, the terms of reference established for a study investigating alternative locations for a river crossing will specify that the crossing must be the most economical possible. Thus, many studies of river crossings recommend the crossing location that provides
for the least expensive structure. For example, the Chesapeake Bay Bridge in Maryland was located according to this criterion as indicated by the following comment from an article discussing this bridge: "The location selected provided the least expensive crossing." In all fairness, however, it must be pointed out that this particular crossing involved the spanning of an exceptionally wide body of water, so that economics quite logically played the dominant role in determining the crossing's location.

A key factor in determining what type of crossing structure will be built is the materials used in the construction of the crossing. In the case of Vancouver's Deas Island Tunnel, the fact that concrete was more economical than steel resulted in the tunnel being recommended in preference to a bridge crossing. The type and cost of construction materials will therefore have an indirect bearing on the location selected for the crossing.

Similarly, the operating costs for different types of crossings will indirectly influence the location of the facility. These maintenance costs are almost always included in the total costs of the project and may influence which crossing is most economical. Frequently, the governmental authority responsible for the maintenance of the crossing will demand a say in determining the structure's location. This is only in the event that the Provincial Government, which is responsible for the planning and construction of the crossing, does not assume the maintenance responsibility as well.
Land acquisition costs. Most river crossing projects entail the acquisition of substantial parcels of land, principally to accommodate the highway approaches associated with the crossing. In high density, urban areas land acquisition most probably will constitute one of the highest cost factors in relation to the entire river crossing project. It is frequently the objective of the planners to locate the facility and its connecting highway approaches in an area which has as low density as possible. Furthermore, avoidance of high-priced industrial property may be an objective as well, although this is often hard to achieve since industrial facilities are frequently located on waterfront land.

A planning problem is frequently created by the need to reserve well in advance property for the crossing and its connecting highway rights-of-way. In order to avoid making known their plans to property owners who might unfairly raise the price on their land, the planners may be forced to keep their intentions entirely secret. This may account for the fact that local authorities are left out of the planning of Provincial transportation facilities at the early stages because the Provincial planners maintain that complete secrecy is necessary on their part. This seems to be a highly illogical argument, however, since Municipal government authorities are generally interested only in planning for the impact of transportation facilities on their community as a whole and not in "making a killing" from the sale of private or public property for rights-of-way.
General. The total costs for a river crossing project at each alternative location almost always will determine the financial feasibility of that structure at that particular location. While the need to pay so much attention to the costs of a project may be deplored by those concerned with more functional considerations, the fact of the matter is that no crossing will be built unless it can be financed. Those responsible for the financing of the crossing (i.e., the Provincial Government) must constantly be aware of the fact they are spending public funds. Since they are accountable to the Legislature, the Provincial planners must be sensitive to the need to exercise caution when proposing expenditures of the taxpayers' money. This perhaps explains why one Provincial highway planner emphasizes the importance of costs of any transportation project when he states "Highway and bridge location has always been governed by the fundamental principle of overall economy of route."20

It is suggested that there may be a cost figure in relation to each highway or river crossing project beyond which the project's location and design are determined on a purely economic basis. Expressed another way, up to a certain point (i.e., a dollar value) the planning of a highway or river crossing may be based largely on such criteria as traffic volumes and land use requirements. Once the cost of the facility exceeds that particular point or dollar value, then its location and design are based almost solely on cost considerations. However, it is outside the scope of this thesis to determine whether or not such a theoretical cost level actually exists. The contents of some
transportation reports and interviews with planning officials suggest, however, that for each project there is in fact a range of costs that determines whether a particular facility will be located according to primarily non-economic criteria or whether it will be located in accordance with cost factors alone.

Although a location for a crossing may be chosen because it involves the least construction and land acquisition costs, generally costs are not included that relate to land use functions which are disrupted or whose operation is economically impaired by the provision of the crossing. It is possible that the related costs of a selected crossing location if accurately determined could significantly outweigh the construction and land costs of the project at that site. Thus, it might be economically advisable to select a location whose construction and land costs are higher but whose related costs are much lower. Unfortunately, there are few means by which these "related costs" can be accurately identified and measured, and as a result, the obvious construction and land acquisition costs become the sole economic factors in determining the proper location for a crossing. The application of benefit-cost analysis to the problem of determining a location might prove fruitful in accounting for some of the related costs. However, not all effects of a crossing can be readily translated into dollar terms, thus making it difficult to consider every related cost within the benefit-cost analysis. Even if it were possible to determine accurately these related costs, they might not be considered at all significant by the authority providing the crossing since the authority is likely responsible only for direct construction and land acquisition
In summary, the economic criteria by which river crossing locations are evaluated are basically the costs of constructing and maintaining the facility together with the costs of acquiring the land on which the crossing is built. While ideally, perhaps, the location will be determined by other considerations, the final decision as to the proper site for the crossing may ultimately be based on the costs involved.

V. Administrative and Political Criteria

These criteria are closely associated with the governmental responsibilities for transportation services and facilities discussed earlier. They generally involve those authorities both directly and indirectly concerned with determining the location of a river crossing and who each have a say in the location and design of structure. Also involved are strictly political considerations which are usually difficult to identify and evaluate as to their significance in locating a particular crossing or other transportation facility.

As previously mentioned, the financial responsibilities for the construction and operation of a crossing usually dictate which agency has the executive authority in deciding the location for the crossing. In some cases, however, these responsibilities may be shared, in which case the river crossing location is not always a simple matter to determine. For instance, the proposed Burrard Inlet crossing in Metropolitan Vancouver involves several Municipalities in addition to
the Provincial Government, each of which are potentially involved in the financing of the structure. Each, of course, wishes to have an influential vote in deciding where the crossing should be located, especially if they are going to be financially responsible in any way for the construction or maintenance of the facility. While this certainly may not be the key factor in choosing the final location, the governmental and financial issues involved may serve to complicate an already formidable planning problem.

Administrative responsibilities of such authorities as the Federal Department of Transport, the National Harbours Board and the Canadian National Railway quite likely will have an important influence on where river crossing facilities are located and how they are designed and built. In some cases, the planners' proposals regarding river crossing locations may be frustrated by regulations respecting shipping or aircraft, or by the reluctance of authorities to sell or lease property required for the construction of a crossing.

Although difficult to evaluate and generalize about, political factors nevertheless do enter the picture in relation to determining river crossing locations and the location of transportation facilities in general. These factors cannot really be considered as locational criteria in the same sense as the others discussed in this chapter. However, political realities cannot be ignored and often do play a significant role in the planning of transportation facilities and land use functions. The efforts of a single politician had significant results in the selection of a location for a major transportation
facility in the Vancouver area. Mr. George Massey, who was a member of the Provincial Legislature for the Province's Delta riding at the time of location selection, provided influential leadership in a campaign to have Deas Island selected as the location for a Fraser River crossing. Although political pressure can serve as an influential force in any planning situation, politicians generally are concerned with establishing public policy with respect to controlling or guiding the activities of both public and private interests. Thus, the policies established by government may have significant bearing on such things as the allocation of land uses and the provision of transportation facilities. Luther Gulick describes this situation in the following statement:

The vital political problems which arise in government are not the questions of patronage. They are the questions of basic social and economic policy which serve to give fundamental direction to social and economic forces. For example, ... toll rates on bridges will determine the rapidity of suburban development and the rise of real estate values as well as the time of obsolescence of prior investments in ferries and commuter rail services.

VI. Summary

An attempt has been made in this chapter to describe and evaluate the principal criteria on which the location of a river crossing should be based. These criteria constitute those factors with which the comprehensive planning approach is vitally concerned. Planning criteria include the transportation and land use needs of a region. The volume of traffic, the kind of traffic, existing and future traffic demands, and the relationship of a crossing to other transportation facilities and the total transportation system are the key factors to be considered in
relation to transportation. The impact of the crossing on existing and future land use activities, the effect of these activities, in turn, on the crossing itself, the need for planner-engineer co-operation during the crossing's planning stages and, in general, the need for an integrated approach that treats transportation and land use as a single subject are the crucial land use considerations involved in the locating of river crossings.

Engineering criteria include such factors as foundation requirements, the nature of the topography, and hydraulics. Also of importance are regulations governing the horizontal and vertical channel clearances that the crossing must observe, as well as flight contour regulations with respect to airports in the vicinity of the crossing. In many cases, the engineering requirements for a crossing will dominate all others because of their relationship to the costs of constructing the crossing.

The economic criteria involve construction and maintenance costs and land acquisition costs. Construction costs are governed by the design and size of the crossing structure which in turn relate to the engineering requirements encountered at a particular location. Projected operating costs are generally included in the total cost of the project and thus have a bearing on the economic feasibility of the crossing. Land acquisition is a critical factor in many situations, particularly those involving a high density, urban area. It is frequently the objective of highway and bridge planners to avoid all built-up or high-priced property when studying alternative locations for a crossing. It
is suggested that there is perhaps a cost level in relation to every crossing project above which economic considerations are the dominant factor in determining the final location for the crossing.

Administrative and political criteria are closely associated with the factors discussed in the foregoing chapter on governmental responsibilities for transportation planning. Financial and administrative responsibilities may have an indirect bearing on how much executive authority a government or agency can rightfully expect in determining the location for a river crossing. Purely political considerations are difficult to identify and evaluate but nonetheless they may be influential in the site selection process. Certainly public policy as established by political representatives can have a direct bearing on the decisions relating to the location and design of a transportation facility.

While each of these sets of criteria have been discussed more or less individually in this chapter, they are all closely inter-related and none of them play a dominant role in location selection in every situation; however, they all are crucial factors in locating every river crossing. Each different problem involving the determining of a river crossing location has its own unique set of circumstances which will influence which criteria will be most critical in that specific situation. Thus, for example, the location of a river crossing in a wilderness region may be based largely on engineering requirements, while a location in an urban area may be determined principally by cost considerations or traffic volumes. Generally speaking, however, all
these criteria do have an important bearing on every crossing project and it is therefore essential to consider each of them via the "comprehensive planning approach" when determining the proper location for a river crossing.
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14 Interview with Mr. L. Osipov of Phillips, Barratt and Partners, Consulting Engineers, Vancouver, B.C., April 13, 1964.
15 The Vancouver Sun, February 9, 1957.


17 Ibid., p. 218.

18 Ibid., p. 219.


21 The Vancouver Province, July 15, 1959

CHAPTER IV

THE APPLICATION OF CRITERIA TO DETERMINE
RIVER CROSSING LOCATIONS

I. Introduction

The different governmental transportation responsibilities involved in relation to determining the locations for river crossings, as well as the need for inter-governmental participation and the various locational criteria involved in the "comprehensive planning approach" have been described and analyzed. The process of applying these criteria to the actual location selection is discussed below, leading to the development of a systematic approach to the problem of evaluating alternative river crossing locations in order to determine and select one location from among several potential alternatives.

The approach developed does not in itself contain specific measurement factors with which locations can be evaluated or measured as to their relative locational merits. Rather, it is simply a framework within which evaluation, by whatever means is most appropriate in a specific situation, can be carried out. In addition, two common methods of location evaluation are identified and described in relation to the problem of locating river crossings.

II. Methods of Location Evaluation

There are several methods by which planners can evaluate alternative projects or courses of action in order to make the most rational
decision. Two of the most common techniques are benefit-cost analysis and the value-preference scale. Both are directly applicable to the problem of evaluating locations for river crossing projects, but both involve considerable limitations which restrict the usefulness of their application to this problem.

Essentially, benefit-cost analysis is a device to aid the decision-maker in selecting the "best" project or course of action from among alternatives. Benefit-cost analysis has been applied extensively to problems of resource development but as well has been used widely in a variety of other decision-making situations. The analysis seeks to identify, measure and compare the effects, in the form of costs and benefits, of a given decision.\(^1\) Ideally, a ratio of benefits to costs is established and this ratio forms the basis for comparison of alternative projects. Generally, projects in which benefits exceed costs are said to be economically feasible.

The ultimate effectiveness of benefit-cost analysis depends almost entirely on the ability to translate costs and benefits into dollar values for purposes of comparison.\(^2\) All translations are, of course, estimates subject to varying rates of obsolescence due to fluctuations in the value of money itself. A further limitation to this analytical technique is the difficulty of translating many intangible and non-market factors, such as social and aesthetic values, into monetary terms. Frequently in benefit-cost analysis, social and human factors have to be considered in purely descriptive terms because dollar values cannot be readily applied to them. Despite these limitations,
however, benefit-cost analysis does provide a logical framework for the
evaluation of one or more courses of action. It is also a comprehensive
method for dealing with a number of varying factors, including those
which may be highly conjectural in nature. Ultimately, benefit-cost
analysis serves as a useful aid in making decisions involving the
selection of projects or courses of action from among alternatives.

In relation to determining locations for river crossings, benefit-
cost analysis can play a significant role. However, the analysis is not
designed to take into account all the factors or locational criteria
that are involved in selecting locations for river crossings. The fact
that benefit-cost analysis is so dependent upon purely economic
considerations for its effectiveness in evaluating locations or courses
of action prevents it from being applied extensively to the problem of
selecting locations for crossings. Nevertheless, this technique, which
is useful in the analysis and comparison of purely economic factors
concerned with river crossing projects, should be considered as one of
the tools that can be used effectively to assist the planner in
determining the most rational location for a river crossing from a number
of potential alternatives.

The value preference rating scale involves the assignation of
numerical values to individual criteria and then rating each project,
location or course of action according to each of the criteria and its
established value. A total value for each project is ultimately arrived
at and serves as the basis for comparison between the alternative
projects. Using the value-preference scale, not only can alternative
projects be compared in total, but they can be compared, as well, in relation to any one criterion or factor.

A problem associated with this decision-making technique is the difficulty in assigning values to the various factors involved in evaluating alternative projects or locations. An initial decision would have to be made, for example, as to the relative values of such factors as "impact on land use"; "accommodation of future traffic volumes"; "effect on property values", and so on in a situation involving the selection of a river crossing location. Each factor would then be given a numerical value and the alternative crossing locations would be evaluated according to these criteria and their values. The problem would arise in deciding whether land use considerations, for instance, deserved a higher value than, say, the costs of land acquisition. There would be a need for the establishment of an initial policy which would determine which criteria deserved higher values or whether all criteria should receive equal values.

The basic difficulty in applying this value-preference scale to the problem of determining river crossing locations would be encountered in trying to assign a specific value to certain of the criteria or factors on which a final location selection decision ought to be based. Many of the criteria discussed in the foregoing chapter do not lend themselves readily to having a numerical value placed on them. For example, the administrative and political considerations involved in location selection cannot be effectively assessed or measured in precise numerical terms. Other considerations with respect to the impact of a
river crossing on land use activities or the future land use pattern also cannot be measured accurately enough to permit evaluation in numerical terms. The importance of these somewhat intangible factors is nonetheless significant to the determining of river crossing locations, although they may be evaluated effectively only in purely descriptive terms. This is not to say that the value preference scale is not of use to planners concerned with location selection. In relation to certain criteria, it can serve to facilitate comparisons between proposed river crossing locations. As in the case of benefit-cost analysis, the value-preference scale has considerable potential usefulness as an aid in making the most rational decision with respect to locating river crossings.

In general, these two methods of evaluation, benefit-cost analysis and the value-preference scale, can play a significant role, albeit limited, in the selection of locations for river crossings from among alternative choices. Neither method is completely suitable for application to the total problem of determining river crossing locations because of their inherent limitations involving the evaluation of intangible criteria or factors that are highly conjectural in nature. However, benefit-cost analysis and the value-preference scale can be employed within the total process of location selection in relation to the comparison of those factors that lend themselves to precise, concrete measurement. Furthermore, the absence of these techniques and their application would result in a much less scientific process of location selection.
III. Framework for Location Selection

The limitations discussed above in relation to two well-tested and commonly used methods of project evaluation would seem to indicate that there may not be a simple method of effectively comparing and evaluating alternative sites locating river crossings. Possibly an effective method could be devised for this purpose but it quite likely would be highly complex in order to accommodate the complex problem for which it would be designed. It is not within the scope of this thesis to attempt to develop such a complex method of evaluation; this would require extensive time and research. However, it is proposed that an approach or framework be formulated which would serve to ensure the consideration of all relevant factors involved in the problem of determining locations for river crossings.

The basic objective or purpose of this framework is the implementation of the "comprehensive planning approach" by the Provincial Government in determining locations for river crossings within the Province's highway system. As such, the framework would provide for the systematic and comprehensive analysis of all factors pertinent to the problem of selecting a location for a specific river crossing. The framework or approach would not necessarily be a step-by-step process or procedure; rather, it would serve simply as a checklist of essential factors relating to the river crossing and its particular location. Neither would this framework rank these factors according to their importance, although this could be done by the planners in order to facilitate the selection of a river crossing location. It is also not
intended to imply that the application of this framework to a location
selection problem would immediately result in any specific and "right"
solution to the problem; that is, the selection of a "right" location
for a river crossing. Instead, it is intended that all relevant factors
- economic, planning, engineering, political, etc. - can be placed in
some rational order so that all significant effects and ramifications of
a specific river crossing project could be identified, evaluated and
compared with those of alternative crossing projects. The net result
would be a more logical ordering of all factors and their inter-
relationships that have a bearing on the selection of a specific
location for a river crossing. Ultimately, this ordering and analysis
of relevant criteria through the use of the suggested framework would
prepare the way for better and more rational location selection
decisions that might not have been made as readily without the
utilization of such a framework.

As indicated earlier, this framework would serve in essence as a
checklist of all the factors and locational criteria discussed in the
two foregoing chapters that have a significant bearing on the selection
of locations for river crossings. In order to consider all the
advantages and disadvantages of a given location, the application of
this checklist to each location would prove useful. The relative merits
of each location in relation to the relevant criteria most likely would
be expressed in descriptive terms although the application of benefit-
cost analysis or the value-preference scale where appropriate could
provide the planners with more definitive evaluations.
The format of this framework could consist of a master sheet or sheets on which both the checklist of locational factors and the alternative river crossing locations would be placed. Summary comments or descriptions would be provided in the appropriate places with respect to the criteria and the alternative sites. This would facilitate the comparison of locations since the planners could tell at a glance which location offered the best or most advantages in relation to a given criterion. Should the master sheets prove impractical, separate sheets for each location listing all the relevant factors could be prepared. Alternatively, separate sheets for each locational factor or set of factors could be provided listing each alternative site and its locational characteristics in relation to a given factor or set of factors.

Emphasis, however, should not be placed on the format in which this framework or checklist is applied to a location selection problem. Rather, emphasis should be on the principles or objective of the framework - to provide a systematic process by which all significant locational factors and considerations may be systematically taken into account by planners to determine locations for river crossings. The specific factors and considerations may well vary from problem to problem depending upon the circumstances in each situation, but the process should be designed to be applicable to all possible alternatives. Thus, the framework applied one time may not include all the same factors the next time it is used in a location selection problem.

Following, in outline form, is a sample checklist of factors which were discussed in the foregoing chapters and which are generally
significant in relation to the problem of determining river crossing locations. The list is not exhaustive in its detail although its basic headings should account for most principal considerations related to the design and location of river crossings.

A Suggested Framework for the Selection of a River Crossing Location

A. Planning Criteria

1. Land Use
   a) impact of crossing on existing and future land use activities
   b) impact of existing and future land use activities on the crossing
   c) relationship to proposed civic or regional development projects
   d) social implications of the crossings
   e) provision for land use and roadside development controls

2. Transportation
   a) existing and future traffic demands
   b) impact on existing traffic facilities
   c) relationship to total transportation or highway system
   d) type of traffic to be accommodated

B. Engineering Criteria

1. Soils and Foundation Conditions

2. Hydraulics
   a) scour
   b) channel permanency
   c) water depth

3. Topography
   a) grade elevation
   b) length of approaches

4. Design Regulations
   a) navigational
   b) aircraft
   c) railway crossings

5. Alternative Types of Crossing Structures
C. Economic Criteria

1. Land Values
   a) land acquisition costs
   b) impact of crossing on land values

2. Construction and Maintenance Costs
   a) construction
   b) maintenance

3. Breakdown of Total Costs for Crossing

D. Administrative and Political Criteria

1. Government Responsibilities
   a) financial
   b) planning
   c) construction and maintenance

2. Political Factors
   a) existing government policies
   b) political "influences"

The selection of a final location and type of structure for the river crossing would result ultimately from the implementation of the "comprehensive planning approach" using the above framework. The location and design decision would be based on a comprehensive examination and evaluation of all the factors that had a bearing on where a crossing ought to be located and what type of structure the crossing should be. It is true that the final decision might well be made on a purely subjective, unscientific evaluation of the relevant factors involved. However, the mere fact that all factors had been considered in a systematic fashion would permit a reasonably precise and "correct" decision being made.
IV. Summary

An attempt has been made in this chapter to give practical meaning to the "comprehensive planning approach" and its intrinsic objective of systematically examining all factors pertinent to determining locations for river crossings. It is suggested that a simple framework or checklist be developed and used by planners when faced with the problem of recommending locations with respect to river crossings. This framework should include those factors and criteria discussed in previous chapters that have an important influence on where a river crossing should be located and the structural design of the crossing.

The framework would not itself evaluate or measure the locational advantages or disadvantages of any given river crossing location. It is intended instead that evaluation by any means appropriate to a given problem can be made within the overall framework or checklist. The framework should include alternative measurement factors and techniques. The decision-aiding techniques of benefit-cost analysis and the value-preference scale, for example, are potentially useful methods for evaluating alternative projects or locations in relation to certain criteria. However, they are not suitable for application to the total problem of location evaluation because of inherent limitations in their techniques of measurement and comparison.
REFERENCES


2 Ibid., p. 301.
CHAPTER V

CASE STUDY: THE DEAS ISLAND TUNNEL CROSSING

I. Introduction

Thus far, an examination has been made of the basic ideas expressed in the hypothesis initially established in this thesis. It has been suggested that the Provincial Government, in the role of "executive authority", should determine the location of Provincial river crossings through the use of a comprehensive planning approach within a framework of inter-governmental participation. A practical means of applying the comprehensive planning approach was developed in the form of a "framework for location selection".

In order to test the validity of this hypothesis and the "framework for location selection", a case study is investigated in this chapter. The study concerns the problem of determining a location for a major river crossing in the Metropolitan Vancouver, B.C. area. It is intended that this particular location selection problem be analyzed in light of the foregoing discussion concerning the various complex factors involved in determining river crossing locations; namely, governmental transportation responsibilities, inter-governmental financial and administrative participation, locational criteria and the application of these criteria to a location selection problem.

The case study investigation will focus on the Deas Island Tunnel, the Fraser River crossing selected as the best project to meet specific transportation and planning needs of Metropolitan Vancouver in the mid-
1950's. The actual location selection for this crossing took place about nine years ago between 1955 and 1956. The selection of the Deas Island Tunnel created considerable controversy as to its locational advantages and disadvantages relative to other alternative crossing sites. The discussion in this chapter attempts to evaluate the decision to locate the crossing at Deas Island in addition to investigating this particular location selection problem as a whole. Through a discussion and analysis of this specific, practical problem it is hoped that the validity of the hypothesis as well as its limitations will be identified and defined.

II. Background to the Study

The geography of the Metropolitan Vancouver area presents some special problems for the Planning of transportation facilities (Figure 1, p. 84). Until the mid-1950's, Metropolitan development had been largely confined to the Burrard Peninsula, an area of about 95 square miles, plus another 40 square miles on Lulu and Sea Islands. These Islands might be considered a part of the same peninsula, all of which is surrounded by water except for a neck of land about 3-1/2 miles wide. Crossings of the water barriers in this region, therefore, are of vital importance to the growth of Vancouver and its Metropolitan area in general.

Since the area to the north of the Peninsula is largely mountainous and can accommodate only a limited residential population and the area to the west is ocean, there is room for relatively unlimited urban expansion only to the south and east where the water barrier is the formidable Fraser River. The crossing of this particular barrier was,
and still is, of primary importance to land use and transportation planning of the Metropolitan Vancouver community.

Until a crossing of the Fraser River at Deas Island was provided, the Pattullo Bridge at New Westminster was the only major river crossing between the Burrard Peninsula and the suburban areas of Surrey and Delta. Furthermore, this crossing was an integral element of the only major highway route between Vancouver and the United States border as well as the British Columbia interior. The only other crossing that linked the Burrard Peninsula with the southern Metropolitan area was a ferry connecting Lulu Island with Delta, near the community of Ladner. The Ladner ferry's principal function was to enable motorists from Vancouver to reach the recreational areas of Boundary Bay and Point Roberts without having to travel a much longer, circuitous route via the Pattullo Bridge.

In the early and mid-1950's, Surrey and Northeast Delta began to experience urbanization and were soon on their way to becoming principal dormitory suburbs. As urban growth spread to these areas, the Pattullo Bridge gradually became an over-worked traffic facility attempting to accommodate both daily commuter traffic as well as inter-regional traffic from the interior of B.C. and the United States. With traffic congestion increasing on this bridge and potential traffic needs foreseen, demands for a new Fraser River crossing were expressed to the B.C. Provincial Government by citizens and local Municipal authorities alike. The Government indicated that a new crossing would be provided and that studies would be carried out to determine the best location and design for this crossing.
Since the new crossing potentially would have a significant impact on the Metropolitan area's traffic and land use patterns, its proper location became a crucial issue. Varying opinions were expressed as to the proper location for the crossing. Several professional planning and transportation studies not directly sponsored by the Provincial Government recommended sites in the vicinity of the Pattullo Bridge while a strong campaign was waged by the residents of Ladner to have the crossing located in their area. These residents, who felt their community was being unjustly bypassed during the expansion of the urban metropolitan area, had been vociferously demanding a bridge or tunnel to replace the existing ferry crossing since the end of World War II. Their post-war efforts were directed by a local resident, Mr. George Massey, who later became Delta's representative in the Provincial Legislature. Massey organized the Lower Fraser River Crossing Improvement Association to wage the campaign for a new Ladner crossing.

The professional studies were carried out by the Lower Mainland Regional Planning Board and by the Technical Committee for Metropolitan Highway Planning*. This Committee was composed of representatives from the Provincial Department of Highways; the Planning and Engineering Departments of the Municipalities of Vancouver, Burnaby, New Westminster and Richmond; the Lower Mainland Regional Planning Board; the B.C. Electric Railway Company (now the B.C. Hydro and Power Authority), and a firm of engineers, consultants to the Department of Highways. The

*Hereinafter referred to as the "Technical Committee".
Committee's initial chairman was the Provincial Highways Department's chief engineer. The Committee was formed to study the transportation problems and needs of the Vancouver Metropolitan area and its first report in March, 1955 concerned the determination of locations for Fraser River highway crossings. Although the Committee's members, and indeed its first chairman, were Provincial Government representatives, the Committee's reports did not reflect necessarily the opinions or policies of the B.C. Government.

Before selecting a final location for the new Fraser River crossing, the Provincial Highways Department hired several consultants to study the location selection problem and to recommend structures and locations for the crossing. Of these consultants, only one, the Foundation of Canada Engineering Corporation (Fenco) was instructed to consider all land use and transportation aspects of the river crossing problem. The other consultants had much more limited terms of reference and were primarily concerned with recommending specific types of crossings for locations suggested to them by the Government. Thus, the problem of locating a crossing over the Fraser River received extensive study and analysis by a variety of professional "planners" as well as by a group of citizens intensely interested in where the crossing was to be located.

By 1956, several locations for the crossing had been studied by Provincial authorities (Figure 1, p. 84). On the basis of a report by Fenco, the Provincial Department of Highways announced in February, 1956, that a toll-tunnel crossing would be constructed over the Fraser River at Deas Island near the Delta community of Ladner.
In summary, the unique geographical setting of Metropolitan Vancouver presents special problems for the location of transportation facilities in the region. One of the region's dominant physical features is the Fraser River which forms a water barrier between the Burrard Peninsula, including Lulu Island, and the suburban Municipalities of Delta and Surrey. In the early and mid-1950's traffic congestion on the Pattullo Bridge, the only major crossing of the Fraser River at that time, increased with the spread of urbanization to Surrey and Northeast Delta. A new crossing was needed and the Provincial Government promised to provide this crossing.

The new crossing was expected to have a significant impact on the land use and traffic patterns in the Metropolitan area and for this reason, the selection of a location for the crossing became an important and controversial problem. The citizens of one Delta community conducted a strong campaign to have a crossing located in their area. Several professional studies by Government-appointed consultants as well as other planning authorities recommended a number of alternative sites for the crossing. In 1956, the Provincial Government selected Deas Island near Ladner as the location for the new crossing which would be a four-lane tunnel under the Fraser River.

III. Selection of the River Crossing Location

The discussion in this section analyzes in retrospect the Provincial Government's decision to locate the crossing at Deas Island by applying the "framework for location selection" to the problem faced
by the Government in determining a final site. At the same time, the problem is studied from the point of view that no final decision has been made and that alternative locations for the river crossing have not been proposed. In fact, however, the discussion in this section is prejudiced by the fact that locations were recommended by professional "planners" and that a final location was selected. Consequently, emphasis will be placed on the evaluation of the alternative locations for the crossing proposed by the various planning authorities who investigated the problem of determining a location for the Fraser River crossings. Lack of information prevented the evaluation of the various location selection processes used by these authorities to recommend locations.

Planning Criteria

The task of selecting the best location for a Fraser River crossing in 1955-56 was made difficult by the fact that there were no established and officially recognized land use or transportation policies for either the individual Metropolitan Municipalities or the Metropolitan area as a whole. In some situations, therefore, differences of opinion existed as to whether the anticipated impact of a particular crossing location on land use or traffic would be detrimental or advantageous to the Metropolitan communities. The alternative river crossing locations were identified and evaluated by the various planning authorities according to whatever Metropolitan or Municipal transportation and land use objectives these authorities felt were important at the time of location selection.
Land use. The principal land use consideration at the time of location selection was the expansion of the Vancouver Metropolitan region into the suburban and agricultural area of Richmond, Delta and Surrey. Major economic and social problems were developing with the creation of "urban sprawl" and with the encroachment of urban land uses onto fertile agricultural land within these Municipalities. From a planning point of view, it became essential that urbanization take place in consolidated communities in areas suitable for urban development and that prime agricultural soils be preserved. These land use objectives were expressed by one of the reports which studied the river crossing problem:

The channelling of urban development into the higher lands, which can be done without any significant loss of agricultural production and at a minimum cost from the point of view of urban development costs, is imperative from the regional point of view.¹

In the mid-1950's, urbanization was taking place in Surrey and Northeast Delta. Both areas featured high, well-drained land with infertile soils, ideal for urban development. Therefore, it would seem logical that a new Fraser River crossing should have been located to facilitate the trend towards the development of areas such as these which were suitable for urban land uses. A river crossing location which would channel urban growth into suitable areas would thus have to be located in the vicinity of Pattullo Bridge. Two locations were recommended in this area, one at Port Mann and the other at the southern end of Annacis Island. In comparing these locations with another site further west, the Technical Committee stated in their report,

From the point of view of land development, the Annacis and Port Mann crossings are much to be preferred to the Tilbury (Island) crossing. Both would guide urban development into the Surrey Plateau which is high, well-drained and has relatively poor soils.²
However, there was another land use consideration to be taken into account at the time of location selection and it involved the effect suburban growth would have on existing traffic facilities. If urban development was encouraged in Surrey and Northeast Delta by locating a new crossing in the vicinity of the Pattullo Bridge, then heavy commuter traffic would be generated by these suburban areas. This traffic would travel to Vancouver and Burnaby along routes that were then already taxed to capacity, thus contributing to extensive traffic congestion on these roads.

Another land use consideration at this time was the future development of the central and eastern areas of the Burrard Peninsula. These areas at the time of location selection were served by the Lougheed Highway, an unlimited-access route, which also would have been the connecting route between a Port Mann crossing and Vancouver. Therefore, as the Lower Mainland Regional Planning Board pointed out,

...as the center and east of the Burrard Peninsula develop, the Lougheed Highway with its central location will have to carry an increasing load of local traffic. Thus either the existing highway will have to be widened and improved or additional east-west highways will have to be sought if both local traffic and bridge traffic are to be accommodated.3

From this point of view, therefore, a river crossing location close to Pattullo Bridge would not have been particularly advantageous. The Fenco planners made this point in their report, stating "... it is not advisable to provide any river crossing that will increase the loads on Vancouver-Burnaby arteries even though the present capacities could be increased somewhat."4 The Fenco report went on to say that it appeared essential to locate a highway route and crossing which would have been
capable of handling large volumes of traffic and at the same time, redirecting some of the traffic using the existing, heavily-used routes.

From the point of view of the impact of land uses on traffic facilities, river crossing locations other than those near the Pattullo Bridge deserved consideration. However, locations further west of Annacis Island would have directed traffic and urban growth into the prime agricultural areas of Delta. Nevertheless, with the enforcement of strict land use controls, urban development could have taken place without impinging extensively on fertile land. Apparently this was the reasoning behind the Fenco report's recommendation that Delta be opened for urban development. The report said,

Although the Delta area has been considered as reserved for agricultural use, it is believed that suburban development, controlled by the Lower Mainland Regional Board or some similar body, should be given serious consideration.\(^5\)

A river crossing location considerably west of Pattullo Bridge could have possibly directed traffic away from the congested Pattullo Bridge while serving to make Delta accessible for urban growth. It is assumed, however, that strict land use controls would have been implemented in Delta in order to preserve the Municipality's valuable farmland. Two locations, one at Tilbury Island and the other at Deas Island, were suggested as sites for the river crossing. Both locations, it appeared at the time, would have generally satisfied the objective of diverting suburban growth from the Surrey area in order to avoid further traffic congestion on Pattullo Bridge and its connecting arteries, as well as to open up the rural Municipality of Delta for urban development.

In general, there was a conflict of objectives at the time of
location selection in relation to where Metropolitan expansion should take place and what routes the commuter traffic generated by suburban growth should follow. On one hand, it would seem that channelling urban development into the well-drained and infertile areas of Surrey and Northeast Delta by the provision of a river crossing in close proximity to the Pattullo Bridge would be ideal from a land use point of view. But the commuter traffic this development would generate could have possibly created extensive traffic congestion on the roads leading from the crossing into Burnaby and Vancouver. On the other hand, a river crossing location further west at either Tilbury or Deas Island, might have diverted suburban growth into Delta while easing the traffic load on the roads connecting Pattullo Bridge with Downtown Vancouver. At the same time, however, the prime farmlands of Delta would be in serious danger from encroachment by urban expansion unless there were strict Municipal land use controls that would be rigidly enforced.

Transportation. The conflict of land use objectives in determining a location for a Fraser River crossing provided the basis for a similar conflict involving transportation objectives. The need for a new crossing stemmed initially from the need to relieve the congested Pattullo Bridge which had to accommodate heavy commuter traffic from the growing areas of Surrey and Northeast Delta. Origin-destination surveys conducted at the time indicated that 67 per cent of the traffic using Pattullo Bridge in 1953-54 was commuter traffic travelling between Surrey and Vancouver-New Westminster; 9 per cent came from the United States while the Ladner area generated only 5 per cent.6
This traffic, however, did not include weekend recreational traffic travelling to the States or to the Boundary Bay area. Regardless, daily commuter traffic between Surrey and the Burrard Peninsula, both existing and projected, was a primary factor in the process of determining a Fraser river crossing location.

However, as previously indicated, the main routes from the Pattullo Bridge into Vancouver were already heavily taxed with traffic. Another crossing near the existing facility, while efficiently handling the increasing commuter and recreational traffic from south of the Fraser River, at the same time might well create extensive congestion along such primary routes as Kingsway and the Grandview Highway leading to Vancouver. However, the Lower Mainland Regional Planning Board felt that a crossing near Annacis Island would "relieve congestion in New Westminster and along Kingsway." Nevertheless, it appeared that a new Fraser River crossing located close to the Pattullo Bridge would effectively relieve congestion on this facility but would place an unmanageable traffic burden on streets in New Westminster, Burnaby and Vancouver. At the same time, it was desirable from one land use development point of view to encourage suburban growth in Surrey and Northeast Delta which would in turn, however, generate even more commuter traffic to be accommodated by the traffic facilities of Burrard Peninsula.

Had there been an overall transportation system planned for Metropolitan Vancouver at the time, this dilemma might have been resolved with the provision of new highway facilities leading into Vancouver from a new Fraser River crossing. However, no such system had been planned at the time of location selection since Metropolitan
Vancouver was only then beginning to experience rapid urban expansion. As previously mentioned, the Technical Committee had been established to study and make recommendations with respect to a Metropolitan Highway system. Unfortunately, the provision of a new Fraser River crossing required immediate action before an overall transportation system could be studied.

Although no transportation plan had been established for Metropolitan Vancouver, some of the reports did consider the integration of a new Fraser River crossing with potential highway systems serving this region. However, once again a conflict in opinions was apparent. The report of the Technical Committee, for instance, indicated that a future highway system would most likely consist of radial routes leading south and east from the Burrard Peninsula approximately in the vicinity of New Westminster. As a result of this assumption, the report stated:

It is apparent ... that crossings at Annacis Island or Port Mann could be integrated more effectively with the overall highway system than could a crossing further west, such as at Tilbury Island. ... An Annacis crossing especially would produce a closer knit and more flexible highway network in which detours, bypasses and emergency routings would be more easily possible.  

Likewise, the Fenco planners also suggested that a system of radial highways for Metropolitan Vancouver would best serve the potential traffic needs of the region. However, they felt that such a system should feature a highway route leading directly south from Vancouver and then southeast to the United States border. In this way, they argued, the Metropolitan area's traffic patterns could be more efficiently served. The Fenco report recommended that "... the construction of a crossing at Deas Island would be a major step in the
development of a highway system ideally suited to the Greater Vancouver area."

In either case it was evident that the new river crossing should have been located in relation to an overall transportation system for Metropolitan Vancouver. Although two of the major studies involved in determining locations for the new crossing did consider the integration of the crossing with a future highway system, it was obvious that further research was needed to determine what highway routes and river crossing locations would best satisfy the Metropolitan area's future traffic requirements.

It is interesting to speculate as to whether or not the Provincial Government had plans in 1955-56 to develop a ferry service between Vancouver Island and Tsawwassen Beach south of Ladner. Officially, the Government established the need for this transportation link in 1958 and the ferries first began operating in 1960. At that time, of course, the Deas Island Tunnel with its connecting highway had been constructed, providing a very fast and efficient route from the Burrard Peninsula to the ferry terminal. If this ferry service had been planned in 1955-56, this would have had a significant influence on where a Fraser River crossing was to be located. It seems quite possible that, in fact, the Provincial Government in 1955-56 was intending to establish a ferry terminal at Tsawwassen but could not reveal these intentions since the take-over of a private ferry operation was involved.

In general it could be argued that the Provincial Government had justification in determining a river crossing location that would best
serve inter-regional traffic, rather than local commuter traffic. Since the Province is, by constitution, responsible for the provision of a Provincial highway network, it is only logical that the Provincial Highways Department be concerned with inter-regional or Provincial highway traffic when determining locations for river crossings. Ideally, however, a Provincial river crossing should be so located as to serve efficiently both local and inter-regional traffic.

With respect to the land use and transportation factors involved in the problem of determining a location for a Fraser River crossing nine years ago, it appears obvious that there was no location which satisfied all the requirements of land use and traffic. Each location suggested offered several advantages and disadvantages depending on the particular objectives established by those recommending the sites.

From the application of the framework for location selection thus far, it can be concluded that more is required than just consideration of all pertinent land use and transportation factors. In order that those factors can be meaningfully analyzed and evaluated, there should be objectives and policies established with respect to the kind of land use development and traffic patterns that are most desirable for the local areas and the region as a whole affected by a new transportation facility.

From the point of view of the amount of traffic diverted from the congested Pattullo Bridge, the Deas Island location appeared to be quite inadequate. Unless suburban development was re-directed to Delta or a Surrey-Delta ring road was constructed, the Deas Island crossing was
expected to accommodate virtually no commuter traffic between the Burrard Peninsula and the Surrey area. This would mean the Deas Island crossing would handle only about 15 per cent of the normal, daily traffic travelling between the Burrard Peninsula and the southern Metropolitan Vancouver area. On weekends, however, the Deas crossing could be expected to handle considerably more traffic, principally recreational traffic travelling to and from the United States and the Boundary Bay area. Nevertheless, this weekend traffic did not seem a reasonable justification to construct a million dollar crossing at Deas Island.

Engineering Criteria

Foundation conditions. A variety of soil conditions are found along the Fraser River between its mouth and Port Mann. These conditions result in engineering difficulties in some locations that in turn produce high construction costs. In determining a location for the Fraser River crossing in 1955-56, foundation conditions played a significant role in determining the alternative types of crossings and locations.

In the vicinity of Annacis Island and Port Mann, the soils presented few if any construction problems for a river crossing and were generally considered as ideal for foundation purposes. In the vicinity of Tilbury Island, however, extensive peat bog areas are found, although not immediately adjacent to the Fraser River. Assuming that direct highway approaches were made to both ends of a crossing near Tilbury Island, much of the approaches would have to run through peat bog, especially on the Delta side of the river. If not, considerable diversions from the straight line would have to be made, thus adding to
the length and cost of the highway route.

Around the Deas Island location, deep, loose sand is found which, although generally unsuitable for bridge foundations, is suitable for the construction of a tunnel crossing. However, the highway approaches to this location would also have to pass through peat bog areas, especially on Lulu Island. The highway route south of the Fraser River could economically circumvent almost all of the Delta peat bog.

From the point of view of construction foundations, therefore, a river crossing east of Tilbury Island would have offered the fewest engineering problems.

Hydraulics. Engineering requirements with respect to such factors as scour and channel permanency played a relatively minor role in the site selection process in relation to determining the location and design for a Fraser River crossing. In general, most of the locations considered for a crossing featured few if any engineering problems caused by the nature of the river at these locations. Channel stability was common to all locations as was the absence of adverse scouring effects of the river. In considering a tunnel crossing at Deas Island, tests were required to measure the river’s silting effect on the tunnel. It would appear today that this silting effect might prove costly since the maintenance of the required water depth over the tunnel is essential for the movement of deep-sea vessels on the Fraser River.

Topography. The topography of the Annacis Island location for a Fraser River crossing was a critical factor in relation to the construction of highway approaches to the crossing. However, there were
two opposing, professional opinions as to whether the topography facilitated construction of inexpensive approaches or whether it necessitated long, expensive approaches. A report by Phillips, Barratt and Partners, a Vancouver firm of consulting engineers, stated that the contours of the south bank of the Fraser River at the Annacis location were such that only a short approach would be required to a bridge crossing from ground level. On the other hand, the Fenco report stated that because of the high ground on the south side of the river, long, expensive approaches would be required for the Annacis Island crossing. Unless the reports were considering totally different designs for a crossing, there seems little reason why opposite opinions were expressed as to the advantages and disadvantages of the topography at the Annacis location.

Design regulations. Federal navigational requirements with respect to the deep-sea shipping channel in the Fraser River were crucial factors in the design and location of a river crossing. The Fenco planners felt that the Federal regulations calling for a vertical channel clearance of 160 feet and a horizontal clearance of 450 feet made the construction of a bridge crossing at Annacis Island uneconomical. Again, however, the Phillips, Barratt report differed with respect to this construction factor since it recommended for the Annacis Island location a bridge crossing with a 160 foot vertical clearance and a 600 foot horizontal clearance that would cost approximately $7 million dollars less than the bridge crossing considered by the Fenco Report. It can only be assumed that a vast
difference in bridge design accounted for the difference in construction costs quoted by the two reports.

Federal navigation regulations also were a critical issue in relation to the design of the Deas Island Tunnel. The tunnel's designers had allowed for 35 feet of water depth above the tunnel while Federal regulations required a depth of 40 feet. It was maintained by the Provincial Government that this extra 5 feet made the tunnel an uneconomic project. Ultimately, however, the tunnel was designed to allow for 40 feet of water.

Types of crossing structures. Based on the engineering requirements and the physical characteristics of the recommended locations for the Fraser River crossing, alternative types of crossings were suggested for each location. Generally, in every case, there was one type of crossing at each location which was most economical from a construction point of view. Nevertheless, several types of bridge and tunnel designs were suggested for each location. A bridge was recommended for the Port Mann, Annacis Island and Tilbury Island locations. A tunnel crossing was most suitable economically and physically for the Deas Island and Tilbury Island locations.

Economic Criteria

Land values. As far as could be determined, the impact of a new Fraser River crossing on land values was not considered by any of the reports dealing with location selection, and this did not seem to be a principal locational factor at that time. None of the locations
considered for a crossing involved high density, urban development which might have influenced the selection of a site. Certainly land values would be expected to increase in areas directly adjacent to the new crossing and to its connecting highway routes. However, this factor was not critical to the problem of determining a location for the crossing.

Land acquisition costs, as well, were not greatly significant in influencing the evaluation of proposed crossing locations. There were differences in these costs between various locations, but these differences were not that great. Industrial development accounted for the highest land acquisition costs encountered at the Annacis Island location which were about 3-1/2 times as great as land costs at the Deas and Tilbury Island locations. Even so, the Annacis land costs were only $133,500.00 which is a relatively insignificant amount when considering a river crossing project of between $10 and $20 million.

Construction and maintenance costs. The costs of constructing the most economical type of river crossing at the proposed locations varied from a low figure of $10 million for a bridge at Annacis Island to a high figure of $16 million for a tunnel at either Tilbury or Deas Island. However, the $10 million figure was quoted by the Phillips, Barratt report while the Fenco report considered $17 million as the lowest cost for a bridge at Annacis Island. In fact, a Port Mann crossing would have been the cheapest according to the Technical Committee's report, but this crossing was not considered in the final stages of location selection because of the limited traffic capacity of its northern road approach, the Lougheed Highway. Maintenance costs did not
vary significantly between the types of crossings and, like land acquisition costs, were not critical to the total cost for each crossing. Since the differences in construction costs between the alternative river crossing locations were not really significant, these costs did not appear to be a crucial factor in determining the best location for a crossing. At any rate, costs were not singled out in any of the major crossing studies as being of primary importance in the selection of a Fraser River crossing location.

Administrative and Political Criteria

**Governmental responsibilities.** Without exception, the Provincial Government was totally responsible for the financing, planning and construction of the Fraser River crossing project, including its maintenance after it was built. A project such as the Fraser River crossing, which entails great costs, is far beyond the financial scope of any Municipality, except possibly a large City. In the situation involving the Fraser River crossing, the City of Vancouver was not directly involved, and those Municipalities that were, did not have the financial resources to contribute to the cost of the crossing. Furthermore, since the crossing was not planned as part of the Trans-Canada Highway system, the Federal Government could not be expected to participate in the financing of this project. However, Federal navigational regulations necessitate consultation between the Provincial Highways Department and the Department of Transport in Ottawa.

Despite these financial conditions, however, it should have been obvious that there be some kind of Provincial - Municipal participation
during the planning stages of the crossing. In fact there was none. An exception to this statement was the Technical Committee which did provide for inter-governmental planning participation and it can be said that the Committee's recommendations with respect to a Fraser River crossing were arrived at through Provincial-Municipal consultation. However, the Provincial Government chose to ignore the Committee's report on Fraser River crossings even though the Provincial Highways Department's representatives on the Committee concurred with the report's recommendations.\textsuperscript{18}

Since the new crossing was expected to have a significant impact on the development of the suburban Municipalities and the Metropolitan area as a whole, consultation between the local authorities involved and the Provincial planners should have been imperative. Yet one Municipal planning authority stated that his department did not know the exact location of the connecting highway approach to the Deas Island crossing until construction of it began. Even then, he said, he was practically obliged to go to the construction site to determine where the highway was being located in order that maps of the Municipality could show the new route.\textsuperscript{19}

This seems to have been an incredible situation, since the Provincial Government is constitutionally responsible for land use planning in addition to being responsible for highway planning. Although it was foreseen that the new Fraser River crossing undoubtedly would have great impact on the land use and traffic patterns of the Municipalities it would serve in the Metropolitan Vancouver area, the
Provincial Government, and their consultants, made no effort to consult with the Municipalities as to the proper location of the Fraser River crossing and its connecting highway approaches.

Political factors. Since the Provincial Government at the time of location selection had been in power for only three years, its policies with respect to highway and bridge planning and Metropolitan Vancouver development were relatively non-existent. If there were any such Provincial policies at the time of location selection they were not made public. Ideally, as previously indicated, transportation and land use objectives and policies should have been established by the Provincial Government in relation to its highway system and the development of the Vancouver Metropolitan area. Only in this way could a river crossing be located at a site best suited to serving both existing and potential traffic.

Although it is difficult to precisely evaluate their influence on the selection of a Fraser River crossing location, two "political" issues were significant at the time of site selection. One issue involved the efforts of Mr. George Massey and his fellow Ladner residents to have the crossing located at Deas Island. Massey became a Member of the Provincial Legislature for Delta in 1955 and it is feasible that he had considerable influence on Provincial authorities with respect to the selection of a site for the crossing. More significant, perhaps, was the absence of any other individual or citizen's group supporting an alternative river crossing location. The fact that the Ladner residents were so vociferous in their demands for a crossing at Deas Island may
well have helped convince the Provincial Government that this was the best crossing location.

The other political factor involved the question of a toll-crossing. Although not initially proposed by the Provincial Government, tolls might have significantly influenced the selection of Deas Island as the crossing location. If a river crossing had been located at Annacis Island, for example, it would have had to compete with the toll-free Pattullo Bridge. Thus its effectiveness as a traffic facility would have been seriously limited. The Provincial Government was unable to put tolls on the Pattullo Bridge since this crossing was part of the Trans-Canada Highway and was partially financed by the Federal Government which was not in favor of a toll-crossing at that location. In fact, there had been tolls on the Pattullo Bridge prior to the Federal Government's contribution to its construction costs, but they were removed once the Dominion became a financial partner in the bridge.

Since proximity to the Pattullo Bridge did not permit the new Fraser River crossing to be an effective revenue producing facility, a location further west was therefore logical. However, the Deas Island location, as it turned out, was not well-suited for a toll-crossing, since no heavy commuter traffic would use this facility unless extensive residential areas developed in Delta. But since tolls were established on the Deas Tunnel, suburban growth in Delta was discouraged and no commuter traffic developed. Thus, although a toll-crossing would not be a financial success in the Pattullo Bridge area, neither could it become a success further west at Tilbury or Deas Island where only week-
end recreational traffic would produce significant revenue.

IV. Location Selection in Retrospect

The major pertinent factors involved in determining a Fraser River crossing location 1955-56 having been analyzed in retrospect, it becomes clear that no one location was ideally suited for such a traffic facility. Each location, in addition to its advantages, featured drawbacks with respect to either land use development or traffic accommodation or both. Had there been established broad policies or objectives as to the type and location of land use patterns and traffic patterns that were desired for the future Metropolitan Vancouver community, perhaps the location selection problem would have been less difficult.

The construction of the Deas Island Tunnel and its connecting highway route has provided Metropolitan Vancouver with a fast, efficient route to the United States border, the recreational areas around Boundary Bay, and the Vancouver Island ferry terminal at Tsawwassen Beach. Heavy weekend recreational traffic was thus diverted from the Pattullo Bridge. However, little or no daily commuter traffic was diverted. Despite this, the Pattullo Bridge continued to function reasonably efficiently after the tunnel was constructed, although rush-hour congestion became very extensive at this bridge location. The road approaches to either end of the bridge as well as the main arteries leading into Vancouver were improved and enlarged to accommodate increasing traffic volumes.
Suburban development continued throughout Surrey and Northeast Delta following the opening of the Deas Island Tunnel. However, because of the Tunnel tolls, only sporadic urban growth occurred in West Delta where considerable areas of farmland were sterilized by the development of scattered subdivisions after the tunnel was completed. This cannot really be blamed on the Provincial Government, however, since the Municipal authorities in Delta failed to strictly enforce land use controls that would have kept urban growth off of prime agricultural land.

The major criticism of the Provincial Government's decision to locate a Fraser River crossing at Deas Island concerns the matter of priority in crossing locations. Although the Deas Island Tunnel with its related highway system provides an efficient radial route to and from Vancouver, its location does not serve the major commuter traffic between Surrey and the Burrard Peninsula. A crossing located in the vicinity of Annacis Island would have effectively relieved Pattullo Bridge of its heavy traffic burden, although extensive improvements of the Burrard Peninsula arteries might have been necessary to accommodate increased traffic volumes induced by the new river crossing.

The other major criticism of the Provincial Government in relation to this location selection problem concerns the lack of Provincial-Municipal participation during the planning stages of the Fraser River crossing. A better location might well have been selected as a result of such inter-governmental participation. Regardless, the failure of the Provincial Government to recognize its constitutional
planning responsibilities with respect to land use development and the
 provision of highway and river crossing facilities is a serious indict­
 ment of the Government and its Highways Department.

The case study investigation is significant in relationship to
the hypothesis. It is obvious that the financing, planning and
construction of the Fraser River crossing was the sole responsibility of
the Provincial Government since this facility formed an integral part of
a Provincial highway system. It also was obvious that there was an
urgent need for inter-governmental participation between Provincial and
Municipal authorities during the planning stages of the river crossing.
Without this participation, the establishment of policies based on
consideration for both Metropolitan and Municipal traffic and land use
needs was impossible. Consequently, the Fraser River crossing was
located in relation to no overall transportation and land use objectives.
Neither did this lack of inter-governmental participation permit
co-ordination of Provincial and Municipal plans in relation to
transportation and land use development.

Finally, the case study investigation revealed that the various
planning authorities involved, including the Provincial Government, used
basically a comprehensive planning approach to determine locations for a
Fraser River crossing. Furthermore, each authority in effect applied a
"framework for location selection" in order to implement this approach.
However, the assumptions and objectives established by these authorities
varied considerably since no overall transportation and land use policies
had been set as terms of reference common to all the river crossing
studies. Therefore, a limitation is placed on the effectiveness of the use of the comprehensive planning approach in determining locations for river crossings.
REFERENCES


2 Ibid., p. 8.

3 Ibid., p. 9.


5 Ibid., p. 15.


12 Ibid., p. 10.

13 Ibid.


15 Ibid.


18 The Vancouver Province, February 9, 1956.
Statement by Mr. Wm. Kerr, Planner, Municipality of Richmond, personal interview, January 14, 1964.
CHAPTER VI

DETERMINING RIVER CROSSING LOCATIONS: A PLANNING CHALLENGE

I. The Investigation in Review:

Observations and Conclusions

The fundamental purpose of this thesis is to investigate the process of determining locations for river crossings. The hypothesis proposed in this study maintains that in order to determine locations for river crossings within a Provincial highway system, the Provincial government in Canada should use a comprehensive planning approach within a framework of inter-governmental participation.

Locating river crossings is a highly complex process involving the consideration of many inter-related factors, including the various governmental responsibilities for transportation planning, the technical criteria for the selection of crossing locations and the application of these criteria to an actual location selection problem. River crossings serve a vital function in our transportation systems and as well, may have a significant impact on the functional character of our complex urban and regional environments. Determining the proper locations for these river crossings is thus a highly challenging task for planners.

The need for inter-governmental participation. In studying the governmental responsibilities with respect to the provision of transportation facilities throughout Canada, it was found in Chapter II that each level of government was responsible for the financing,
planning, construction and administration of certain transportation
functions and facilities. The financial responsibilities for the
construction and maintenance of highway facilities is of basic
importance to this thesis. It was observed that the Provincial
Governments are constitutionally responsible for the provision of
highways and river crossings in Canada and this has left them with the
major financial and planning responsibility as well for these
transportation facilities. In fact, 85 per cent of all major highways
and bridges in Canada have been built and financed by Provincial
Governments. Unlike the American Federal Government which provides vast
sums of money for the construction of highway facilities in the United
States, the Government of Canada has been reluctant to accept anything
but a limited financial responsibility for the provision of highways and
river crossings. Only those projects involving an inter-provincial or
international transportation facility are built totally or partially with
Federal funds. An important Federal administrative responsibility is the
administration of navigation and aircraft regulations which often have
an important bearing on the location of a particular highway or river
crossing. It is recommended that the Federal Government accept a fuller
share of the financial responsibilities for highway facilities because
of the national importance of these facilities and because of the
extensive financial resources of the Dominion Government.

Municipal Governments with their limited taxation powers and
financial resources are not in a position to contribute significantly to
the provision of highway facilities other than purely local streets and
bridges. However, because they have been delegated the responsibility for local land use planning, it is imperative that Municipalities participate in the planning of those Provincial highways and river crossings which directly affect the land use and traffic patterns within their Municipal jurisdiction.

In order to facilitate Provincial-Municipal and Federal-Provincial participation during the planning of a Provincial transportation facility, it is suggested that a permanent administrative framework be established for each Province that would facilitate inter-governmental participation. The Boards would be composed of representatives from the Provincial Highways and Planning Departments; the regional offices of the Federal Department of Transport; Municipal Engineering and Planning Departments, plus other governmental agencies concerned with transportation facilities or land use development. The Provincial Government representatives on these Boards would act as the "executive authority" in making final decisions with respect to the location and design of Provincial highways and river crossings. This position of executive authority derives from the Province's constitutional and hence financial responsibilities for the provision of these facilities.

The Board's responsibilities basically would be the administration of the respective Provincial Highways Acts so far as the planning of Provincial highway systems is involved. The basic objective of these Boards would be the promotion of co-ordination of the various governmental agencies' plans and functions in order to provide for the integration of highway facilities with other transportation facilities and with land
use functions.

In retrospect, however, it is obvious that these Highway Transportation Boards might be an inefficient means of providing intergovernmental administrative participation. The creation of a series of administrative bodies primarily concerned only with highway facilities could well be criticized as an unnecessary method of planning highways and river crossings. Perhaps if these Boards were to have broader responsibilities that included the planning of all Provincial transportation and land use functions they would serve a more useful purpose.

Despite the potential inefficiency of the proposed Highway Transportation Boards, there still exists a need for inter-governmental administrative participation with respect to the planning of Provincial highway facilities. Unless such participation is achieved, there is a danger that Provincial Governments may locate highways and river crossings without due regard for the integration of these facilities with the land use and transportation functions of Federal Government agencies and of Municipalities in particular.

Selection of river crossings locations. The determination of Provincial river crossing locations involves the consideration of complex and inter-related factors. It is therefore recommended that the Provincial Government in determining river crossing locations should use a "comprehensive planning approach" which provides for the consideration of all factors pertinent to the problem of selecting a location for a crossing. This approach is contrasted to those which emphasize the consideration of only one or a few factors with respect to
The principal locational factors which are basic to the comprehensive planning approach and which relate to the selection of river crossing locations were discussed in Chapter III. These factors include land use and transportation criteria, engineering requirements, economic criteria and administrative and political considerations. It was observed that there is a significant inter-relationship of these factors and that none play a dominant role in the selection of a crossing location in every situation. However, all these factors do have some influence on every river crossing project and it is essential, therefore, to consider each of them during the process of determining a location for any river crossing.

In order to effectively implement this planning approach, it is recommended that a "Framework for the Selection of River Crossing Locations", such as the one suggested in Chapter IV, be applied to the problem of determining locations for Provincial river crossings. This framework would provide for the systematic and comprehensive analysis of all factors pertinent to the problem of locating a river crossing. These factors include not only technical locational criteria but the problems of governmental transportation responsibilities and inter-governmental participation as well.

This location selection framework would serve basically as a check-list of essential locational factors that should be analyzed during the process of determining the river crossing location. The framework itself would not be in the form of a step-by-step process since location
selection situations vary and require different analytical procedures in each case. However, this framework would be applicable in every situation regardless of the specific location selection process used. In general, this framework would include all relevant factors essential to the evaluation of potential alternative river crossing locations. Furthermore, the framework would include such techniques of project evaluation and measurement as benefit-cost analysis and the value-preference scale. It is suggested that through the application of such a location selection framework, decisions respecting the location and design of river crossings would be based on a comprehensive systematic analysis of all factors that had a bearing of the crossing's design and location.

The Deas Island Case Study. Chapter V concerned the examination in retrospect of a practical location selection problem in order to test the validity of the hypothesis that Provincial Governments should use a comprehensive planning approach within a framework of inter-governmental participation to determine locations for Provincial river crossings. The case study analyzed involved the determination of a location for a Provincial crossing of the Fraser River in the Metropolitan Vancouver area approximately nine years ago.

The investigation of the case study included the examination of the major factors pertinent to the problem of locating the river crossing at the time of location selection as well as an evaluation of the Provincial Government's decision to locate the crossing at Deas Island.

It was concluded that the Deas Island location did not effectively
solve the problem that had initially created the need for a new Fraser River crossing, namely, congestion on the Patullo Bridge caused by increasing commuter traffic travelling between the Surrey area and the Burrard Peninsula. Furthermore, the Deas Island crossing was indirectly responsible for areas of prime agricultural land in Delta being sterilized by scattered subdivisions which never fully developed because of the tolls on the tunnel crossing.

However, the Deas Island location was responsible for the diversion of inter-regional and recreational traffic from the Pattullo Bridge. At the same time, this tunnel crossing and its related highway system provided an efficient radial route leading from Vancouver that may eventually form an effective, integral part of an overall highway system for Metropolitan Vancouver. In general, however, it is felt that Deas Island nine years ago was not the most practical location for a new Fraser River crossing. Instead, a crossing located in the vicinity of Annacis Island would have significantly relieved the traffic congestion on Patullo Bridge although it might have necessitated improvements of the roads leading from the crossing to Burnaby and Vancouver.

The case study examination also brought to light the need for broad regional and local transportation and land use policies to serve as guidelines for the planners faced with the task of locating transportation facilities, such as river crossings. It was concluded that a comprehensive analysis of all pertinent locational factors through the application of a location selection framework is not enough to ensure that a river crossing is properly located. There must also be
established broad transportation and land use development objectives against which the pertinent locational factors can be evaluated.

A final conclusion arising from the case study analysis was the fact that the B.C. Provincial Government and their planning consultants failed to consult with local Municipal authorities with respect to the determination of a Fraser River crossing location. Since this crossing played a potentially significant role at that time in shaping the pattern of Metropolitan urban expansion, the failure of the B.C. Government to provide for the co-ordination of Municipal land use development and traffic patterns with its proposed crossing revealed a blatant lack of consideration by the Government for its constitutional planning responsibilities.

It was therefore concluded from the analysis of the application of the "framework for location selection" to the case study problem that the hypothesis initially established is basically valid. The Provincial Government of B.C., because of its constitutional and financial responsibilities, had the executive authority to plan and locate a Fraser River crossing. The use of a comprehensive planning approach by the B.C. Government and other planning authorities permitted consideration of the major factors pertinent to the determination of a Fraser River crossing location. However, it was concluded that this planning approach should be defined to emphasize the need for broad, basic transportation and land use policies to serve as guidelines for planners and against which the various complex locational factors could be evaluated in relation to determining a river crossing location from among potential alternative
locations.

It is difficult to judge in retrospect whether or not Provincial-Municipal participation during the planning stages of the Fraser River crossing would have resulted in a more efficient location being selected. Nevertheless, the potential impact of river crossing facilities on land use and traffic patterns makes it imperative for Provincial Governments to recognize their constitutional planning responsibilities and to determine river crossing locations within a framework of intergovernmental participation, particularly during the planning stages of a river crossing project. Ideally, this participation would also take the form of cost-sharing arrangements between the three levels of government in which the Federal Government assumed a much larger financial role in the provision of highways and river crossing facilities while Municipal Governments contributed to these transportation costs as much as their limited financial resources could reasonably permit.

II. Evaluation of the Investigation: Limitations and Criticisms

Although the study has basically established the validity of the hypothesis, this investigation of the subject of determining river crossing locations has been limited considerably in relation to its scope and assumptions. In some cases, the limitations were not foreseen prior to the actual investigation of the thesis subject, but arose as a result of research into the various problems related to the process of determining locations for river crossings.
A principal limitation or criticism of the investigation relates to the basic assumption that the transportation planning process was an integral element of the comprehensive planning approach and the framework for location evaluation. In fact, no discussion was included concerning the precise relationship of this planning approach and the location selection framework to the total process of transportation planning. This process basically involves a step-by-step procedure of survey, analysis, design, implementation and re-evaluation with respect to locating and constructing a transportation facility or a total transportation system. In addition, this process treats transportation and land use as a single subject and provides for the integration of land use and transportation functions. It must be made clear that this transportation planning process is basic to the effective utilization of the comprehensive planning approach and the framework for location selection.

Another limitation of the investigation concerns the implication that the scale of planning involved was metropolitan and that the planner encounters the greatest difficulties in locating river crossings only within a metropolitan area. However, this is not always the case since the location selection problem may be also highly complex and challenging within a regional context or a purely local context. An investigation should be conducted to determine if other location selection processes should be utilized to locate river crossings in relation to regional or local planning. While the analysis in this study may be valid for most situations involving the selection of river crossing locations,
nevertheless, the observations and conclusions of the thesis may have to be strictly qualified before a valid application is made to situations where the scale of planning is either regional or local.

The investigation may be criticized for its failure to examine fully the potential financial arrangements between the three levels of Canadian government with respect to the provision of highway and river crossing facilities. The study placed considerable emphasis on the need for inter-governmental administrative participation during the planning stages of highways and river crossings, particularly with respect to the co-ordination of Provincial and Municipal transportation and land use functions. However, the subject of analyzing potential forms of inter-governmental financial participation, which is crucial to the whole process of determining Provincial river crossings, was not studied adequately. Thus, the conclusion made in this thesis that the Provincial Government should plan river crossings within a framework of inter-governmental participation relates principally to only administrative (i.e., planning) participation.

Also of vital importance to the location selection process but not fully discussed in this thesis is the need for inter-departmental participation on the same government level. The investigation merely implied that inter-governmental participation includes the co-ordination of the various governmental agencies' functions related to a single level of government.

In general, an examination of the investigation in retrospect reveals that the subject of determining river crossing locations perhaps
is too broad and complex a topic to be both comprehensively and profoundly analyzed in a single thesis study. For example, the problems involved with respect to governmental transportation responsibilities and the need for inter-governmental financial and administrative participation deserve a much more detailed examination than presented in this study. As well, the analysis of the various complex locational factors respecting river crossing locations, and especially their relationship to the total transportation planning process, require fuller treatment than provided in this investigation. Nevertheless, an attempt has been made to present an overall, comprehensive examination of the pertinent factors involved in a complex which presents a formidable challenge to planners; that is, determining locations for river crossings which form an important part of Provincial highway systems in Canada.

In spite of its limitations, the investigation in this thesis has demonstrated the basic validity of the hypothesis:

That in Canada, the Provincial Government should use a comprehensive planning approach, within a framework of inter-governmental participation, to determine the locations of river crossings within the Provincial highway system.

Furthermore, the observations and conclusions made in this study have significant implications for planning research concerned with the development of refined processes for the determination of locations for vital transportation and land use functions.
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