EXECUTIVE SUMMARY

Background and Purpose

The concept of providing a fixed transportation link between the Island of Newfoundland and Labrador across the Strait of Belle Isle has been the subject of discussion for many years. In early 2004, the Public Policy Research Centre of Memorial University, acting on behalf of the Government of Newfoundland and Labrador requested a proposal from independent consultants to conduct a study of fixed link concepts at a pre-feasibility level. In April, 2004, the Policy Centre awarded a contract for the study to Hatch Mott MacDonald.

In keeping with the Terms of Reference, the study was undertaken in four distinct phases as follows:

- Phase 1 – Background and Research.
- Phase 2 – Engineering and Technical Feasibility Options Analysis.
- Phase 3 - Economic and Business Case Analysis.
- Phase 4 - Financing Considerations.

Overview of Previous Work

The most relevant work in the study area is that carried out over a 10-year period in the 1970's and early 1980's by the Lower Churchill Development Corporation (LCDC). This comprehensive program of site investigations and engineering studies related to the crossing of the Strait, for the purposes of electricity transmission, by means of a tunnel constructed in the deep Precambrian granite underneath the Strait. The tunnel was to be created using drill-and-blast methods and, by being in this zone, potential problems with water ingress and fragmented rock in the upper sedimentary layers would be avoided. By late 1979, however, as more sophisticated studies of the risk associated with iceberg scour problems were conducted, it was concluded that a trenched submarine cable crossing route could be selected. Information obtained from approximately 40 reports on various aspects of the crossing, made available to the study by Newfoundland and Labrador Hydro, formed the basis of the study background.

Other Relevant Fixed Links & Tunnels Worldwide

In order to obtain an appreciation of the parameters relating to major fixed links and to make a comparison with the subject fixed link, a review was conducted of eight tunnels, causeways and bridges. The review showed that the costs varied from $10 million per kilometre for the Laerdal Tunnel in Norway to $700 million per kilometre for the Channel Tunnel, illustrating that the location and characteristics of the project can have a dramatic effect on the cost of the facility.

The Environment and Geology of the Study Area

The Strait of Belle Isle, generally speaking, is an inhospitable area in which to carry out major surface-related construction because of its unpredictable weather, high currents, sea ice and icebergs. The depth of the Strait varies significantly over its length with the area of the shortest crossing containing water as deep as 100m.

The geology of the Strait in the vicinity of the shortest crossing consists of a sedimentary layer of sandstones and limestone that is overlain by soil of various depth and constituency. Underlying this layer of rock is an approximately 500 metre thick layer of Precambrian granitic gneiss that varies from 130 metres below the ground surface on the Labrador side to 475 metres below on the Newfoundland side. An item of some concern is the potential for water ingress through the less competent sedimentary layer.

Assessment of Alternative Fixed Link Concepts

Three basic fixed link concepts were studied: bridge, causeway with bridges, and tunnel. In the case of a tunnel, the options were further divided into bored, drill and blast, and immersed tube (ITT). Both road and rail modes were considered for the tunnel option. Initial capacity assessment indicated that the projected traffic could be accommodated with excess capacity by a two lane above ground facility or with appropriate capacity by a single lane tunnel operated periodically in each direction by road vehicles or by roll-on/roll-off shuttle trains

For each of these concepts, the route across the Strait was taken as that between Pointe Amour and Yankee Point, which is the shortest distance, at 18 kilometres.

Bridge

A bridge crossing of the Strait would present very large risks, including design, construction and operation issues relating to the iceberg zone, and deep water depths and difficult weather conditions. Because of the water depths in the Strait and the need to minimize the exposure of structures to iceberg loadings, it is clear that the largest possible spans and, hence, suspension bridges of 2 kilometre spans would be used. A clearance of at least 50 metres is needed between the bridge deck and sea level to accommodate vessels and icebergs. All of the bridge piers would have to be protected by berms in order to withstand impact forces from icebergs.

Causeway

A causeway across the Strait of Belle Isle would be an ambitious undertaking, although with possibly lower risk than for a full bridge concept. While a causeway would still need one or more bridges, it could cope more easily with ice and icebergs and the bridge piers could be integrated into the causeway for protection. Foundations and anchoring for the bridges would still be very challenging; however, the number of foundations would be less. An obvious major environmental risk is the possible effects that such a structure could have on marine life and on the current regime in the area. For the purposes of this study, it has been assumed that two openings, spanned by bridges, would be needed in the causeway and that these would be located at the position of the shipping lanes.

Tunnels

Most of the risk factors associated with a surface crossing of the Strait of Belle Isle are eliminated with a tunnel that is constructed below the seabed. For an ITT, the risk of iceberg impact still exists. An immersed tube tunnel would consist of a series of connected and sealed pre-fabricated tunnel units within a pre-dredged trench in the seabed. The tunnel units are floated to their required location and sunk to their final position. The tunnel elements would have to be protected either by being buried below the depth of iceberg scour or by having sufficient protection to absorb the energy of an iceberg.

One of the primary risks associated with drill-and-blast or bored tunnels relates to the potential for water ingress through faulted and fragmented rock. For the electrical transmission cable tunnel, planned in the 1970's, the concern relating to water ingress caused the selection of a deep alignment at 400-500 metres below sea level. This placed the tunnel in the Precambrian gneiss layers that were considered to be significantly less permeable than the sedimentary rock layers above. For a transportation tunnel, such a deep alignment is not an option since with typical transportation downgrades and upgrades, the length of tunnel dictated would be prohibitively expensive. Fortunately, developments in tunnel excavation techniques in recent years have made possible a shallower tunnel within the sedimentary layer.

Two excavation techniques are available; these are drill-and-blast excavation and bored tunnels utilizing a tunnel boring machine. For the drill-and-blast excavation, water ingress must be reduced by grouting ahead of the tunnel face to seal water paths. This is not absolutely reliable in preventing water ingress and therefore a separation from the seabed of approximately 60 metres was selected for this analysis. For the bored tunnel option, the tunnel lining is installed immediately as the tunnel is progressed, water ingress is prevented and a higher alignment is possible. A bored tunnel would be constructed by a pressurized face tunnel boring machine (TBM). This type of TBM is designed to apply pressure to the excavation face to support the ground and to counteract water pressure in fractures and fissures. For this study, the highest practicable alignment, with about 10 metres of rock cover was selected. Because a drill & blast tunnel would be located further down in the sedimentary layer, the road and rail options are 0.3 kilometre and 4.4 kilometres longer than the respective tunnels constructed using TBM.

Comparison Summary of Alternatives

Table 1 provides a comparative summary of all alternatives based on the road and rail options.

Table 1 – Summary Comparison of Options for the Fixed Link

Option	Construction Cost ($millions 2004 dollars)	Annual Operating Cost ($millions 2004 dollars)	Risk Level	Preliminary Schedule (years)
Road Options				
TBM Bored Tunnel	1,559	6.8	Moderate	12.2
Drill & Blast Tunnel	1,800	6.8	High	17.8
Immersed Tube Tunnel	4,810	6.8	High	14.7
Bridge	4,227	16.9	Extreme	15
Bridge / Causeway	10,123	4.3	High	18
Rail Options				
TBM Bored Tunnel	1,184	7.64	Moderate	10.7
Drill & Blast Tunnel	2,272	7.64	High	23.8
Immersed Tube Tunnel	3,814	7.64	High	15

The table illustrates that a TBM bored tunnel would have the lowest cost and risk, and a rail option would be less costly than a road option. A shuttle train in a TBM bored tunnel is therefore the preferred concept. The total development cost, including interest during construction and escalation, for the preferred concept would be approximately $1.7 billion.

Implementation Schedule

In all cases, three years were allowed for additional studies, field investigations, environmental assessment and other planning activities, and two years were allowed for detailed design for a total of 5 years prior to start of construction.

Using two TBM's, one from each side of the Strait and a seven-day work week provides the shortest construction and commissioning period for the rail tunnel of 5.7 years for a total project implementation time of 10.7 years.

Regulatory and Environmental Issues

Of the concepts addressed, a tunnel will have the least effect on the environment, in particular the physical environment of the Strait. The potential large scale oceanographic and climatic effects that might be wrought by a surface crossing such as a causeway and bridge would be avoided. In the Strait itself, there would be very little or no effect from the actual tunnelling process or from the traffic once the tunnel is completed.

The principal concern with respect to the tunnel itself is likely to be the disposal of the excavated material. Overall, while the project would be a major undertaking over a long construction period, its nature is such that there would not likely be major environmental concerns that are outside the realm of a typical heavy construction and earth moving project.

A complete assessment of the environmental implications and requirements would be required to be undertaken at a later stage of the project.

Economic and Business Case Analysis

Three scenarios for addressing the crossing have been analysed. These are as follows:

a) The Base Case – a bored, 2 TBM, tunnel with a railway shuttle;
b) An Upgraded Ferry Link
c) The Base Case augmented by income from an installed HVDC transmission line

The period for planning, design and construction of the facility is 11 years and the operating period examined is 30 years, for a total economic life cycle of 41 years.

Transportation demand projections were developed based on an understanding of the existing markets served. Future potential demand for a fixed link can come from; new developments to attract tourism and induced demand; new economic developments to attract long term commercial vehicle traffic and; major projects that can generate elevated demand for defined periods.

New growth in tourism could result from creation of new national and provincial parks, expansion of tourism infrastructure including accommodations and dining facilities, and successful major advertising campaigns. The Maritimes and Ontario are the largest sources of tourism. Tourism in Newfoundland and Labrador is growing at an increasing rate. The projection, therefore, with or without a fixed link will be to sustain recent trends of 3.5% growth.

Figure 1 shows comparative driving distances and times between Quebec City and St. John's and using the existing Trans-Canada Highway through the Maritimes, using the Trans-Labrador Highway (when completed) to a new fixed link, and using a new Quebec north shore highway (when completed) to a new fixed link. It can be seen that driving distances for travellers using a fixed link would be similar to those on the Trans-Canada Highway.

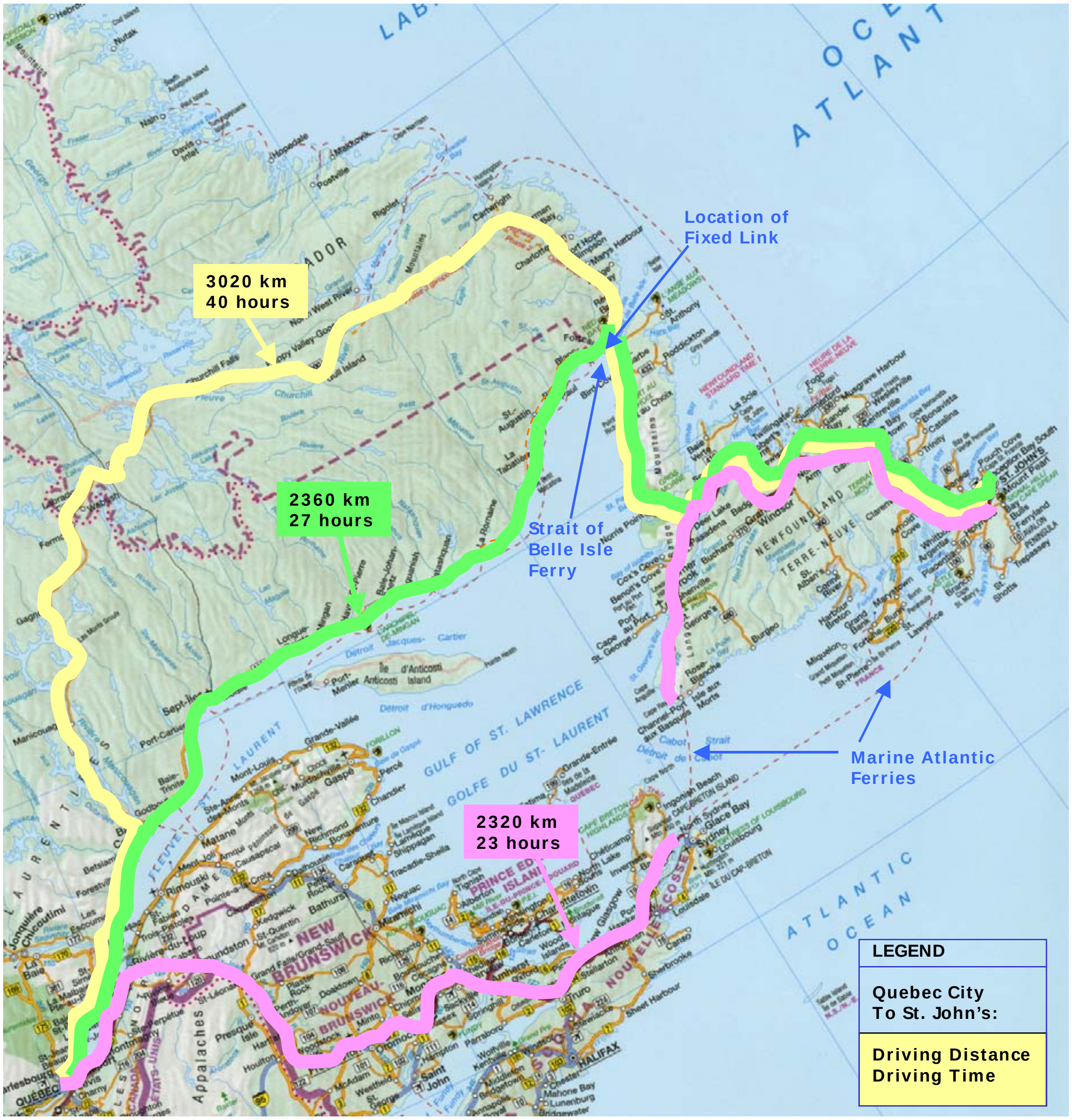

Figure 1 – Travel Distances

In determining traffic projection for a fixed link, three types of changes were evaluated.

- One time surge in demand of 30%, primarily affecting local and business traffic;
- One time diversion from Marine Atlantic of 13 % to 15 % to a new fixed link;
- Sustained annual growth of 1.5 % to 4.75 % (depending on type of travellers).

Somewhat more modest increases in traffic were projected for an upgraded ferry.

Revenues for a fixed link and for the upgraded ferry were calculated on the basis of existing *Apollo* tolls. For the augmenting that results from the inclusion of a HVDC cable, the avoided costs were established from costs for a submarine cable, supplied by Newfoundland and Labrador Hydro.

A profile of operations and maintenance costs was developed for the analysis cases. Combining these O & M costs with projected revenues and invoking a discount rate of 7.5 percent (10 percent nominal less 2.5 percent inflation) results in the operating cash flow.

The economic evaluation results are shown in Table 2. Net Present Values (NPV), Internal Rates of Return (IRR) and Benefit Cost Ratios (BCR) are calculated where they are applicable for the cases studied.

Table 2 Economic Evaluation Results

LEVEL	CASE	NPV	IRR	BCR
		$ millions 2004	%	#
Internal Returns	BASE CASE	- 648	- 9.5%	0.07
	HVDC	- 554	-2.1%	0.25
	FERRY UPGRADE	- 164	N/A	0.13
Internal Returns & Economic Returns	BASE CASE	- 559	-5.2%	0.20
	HVDC	- 466	-1.0%	0.37
	FERRY UPGRADE	- 116	N/A	0.38
Internal Returns & Economic Returns & Social Returns	BASE CASE	- 333	-1.3%	0.53
	HVDC	- 240	1.6%	0.68
	FERRY UPGRADE	- 114	N/A	0.39

Sensitivity analyses were undertaken and showed low sensitivity to variations in traffic, high sensitivity to capital costs, relatively low sensitivity to operation and maintenance costs, and high sensitivities to social discount rate and inflation rate.

Financing Considerations

Because the business case for a fixed link would be difficult to justify on the basis of the results of the economic analysis, any financing arrangements would require an infusion of public funds. This is not unusual in the case of such infrastructure. Of the various potential financing mechanisms addressed in this study, some form of Public Private Partnership (PPP) was considered to be the most applicable.

Conclusions

A tunnel bored using modern tunnel boring machines under the Strait of Belle Isle, at its narrowest point, is the most technically and economically attractive alternative.

The construction cost of a bored tunnel would be approximately $1.2 billion in 2004 dollars. The total development cost for financing purposes, including escalation and interest during construction would be approximately $1.7 billion. The construction period would be six years and an additional five years would be required for planning, additional studies and investigations and environmental assessments, for an overall development period of 11 years.

Based on traffic projections over a 30-year period, the most economic tunnel arrangement would be an electric train shuttle, operating through a single tunnel with staged operation in each direction, that conveys road vehicles on custom-designed rail cars.

The economic and business case analysis showed that a fixed link could not be financed privately under normal economic and business case criteria. This result, however, may be considered not unusual in the realm of public transportation infrastructure.

Including costs and revenue for the transmission lines has an effect on the overall viability of the fixed link. Incorporating the HVDC cables in the fixed link rather than constructing a submarine installation, reduces the capital cost to an HVDC proponent by approximately $390 M. This cost reduction includes the cost of the cable, for which a rental would be charged by the fixed link proponent.

Of the financing methodologies addressed, some form of PPP (Public Private Partnership) arrangement would appear to be the most appropriate. An infusion of approximately $1.4 billion from public sources would be required to make the proposition attractive to the private sector.